Deutsche Physikalische Gesellschaft DPG

DPG-Frühjahrstagung 2025 der Sektion Materie und Kosmos (SMuK)

DPG Spring Meeting 2025 of the
Matter and Cosmos Section (SMuK)

with the Divisions

Extraterrestrial Physics, Gravitation and Relativity, Particle Physics, Plasma Physics, Radiation and Medical Physics, Theoretical and Mathematical Physics

and the further Division

Physics Education,

as well as the Working Groups

Accelerator Physics, Equal Opportunities, Physics, Modern IT and Artificial Intelligence, "Young DPG"

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31 March – 4 April 2025

Georg-August-Universität Göttingen

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Content

Dear Participants,

Welcome to the DPG Spring Meeting of the Matter and Cosmos Section (SMuK) on the campus of the University of Göttingen.

Our Spring Meetings are the DPG's flagship events for promoting scientific exchange — both for internal communication within the DPG and for exchange with researchers from all over the world. We expect a total of up to 10,000 guests at our Spring Meetings, which will once again make the DPG conferences the largest platform for scientific exchange in the field of physics in Europe this year. The comprehensive inclusion of presentations by young scientists in the conference program is also a unique selling point at both national and international level. This is by no means a matter of course: on the one hand, this is due to the well-coordinated cooperation of our many committed conference organisers in the DPG and the support of our DPG office in Bad Honnef. On the other hand, it is thanks to the generous support of the universities that are excellent hosts for our conferences. For a whole week, the universities are almost entirely dedicated to physics and thus become internationally visible "beacons" of physics research.

We are also working on making our conferences even more international, in the spirit of „Science bridges cultures." I am therefore very pleased that the DPG communication programme, which enables young scientists to actively participate in DPG conferences at the earliest possible stage of their scientific training, has been expanded thanks to the generous support of the Wilhelm und Else Heraeus-Stiftung: by awarding additional scholarships to young scientists from the countries supporting the electron storage ring "SESAME" in the Middle East as well as from Central and Eastern European countries to participate in our conferences. Another example is the Symposium on Quantum Mechanics and Gravity organized together with our partners from Denmark. Strengthening and fostering international scientific exchange cannot be overestimated — especially in these times!

As the world's largest physics society, the DPG is one of the main initiators of this year's "International Year of Quantum Science and Technology" (IYQ). The DPG is taking the lead in Germany in implementing the IYQ proclaimed by the UN. The formulation of quantum mechanics, the foundations of which were laid in Göttingen in 1925, created a lasting basis for our physical understanding of nature. To mark this occasion, the city Göttingen will be awarded the title „Historic Site" by the European Physical Society on 1 April. Quantum technologies have changed our daily lives and have become pillars of our prosperity, which is why we are celebrating their achievements and highlighting their future prospects. Under the motto "Quantum2025 — 100 years is just the beginning..." within the framework of IYQ, a wide variety of events and activities are being organized and coordinated by DPG (see quantum2025.de) I would like to thank all those who are contributing to the success of the quantum year!

The success of this Spring Meeting is only possible with the greatest commitment. I would like to express my sincere thanks to everyone involved. First of all, I would like to thank the University of Göttingen for their hospitality and support. Many thanks also to the Wilhelm und Else Heraeus Stiftung for generously supporting all DPG Spring Meetings. I would also like to thank the participating DPG Divisions and Working Groups for organising the scientific programme. My special thanks also go to the local organising committee at the University of Göttingen, Prof. Arnulf Quadt, Faculty of Physics, and his team. Finally, I would like to thank the DPG Head Office for its support of all Spring Meetings.

I wish you a great DPG Spring Meeting at the University of Göttingen with many new insights and excellent discussions!

Prof. Dr. Klaus Richter

President
Deutsche Physikalische Gesellschaft e. V.

Deutsche Physikalische Gesellschaft DPG

2nd DPG Fall Meeting

of the Deutsche Physikalische Gesellschaft

Quantum Physics

Topics:

- **Quantum Physics in Research and Technology**
- **The Path to the Modern Quantum World**
- **Applications of Quantum Technologies**

Joint Meeting of the

- **Atomic, Molecular, Quantum Optics and Photonics Section (SAMOP)**
- **Condensed Matter Section (SKM)**
- **Matter and Cosmos Section (SMuK)**

100 years ago, Göttingen played a central role in creating quantum physics as we know it today. In 1925 Werner Heisenberg, then an assistant at the Göttingen Institute for Theoretical Physics, published his famous article "Quantum-Theoretical Re-Interpretation of Kinematic and Mechanical Relations". This article marks the beginning of quantum mechanics and therefore the United Nations, the German Physical Society (DPG) and numerous Physical Societies around the world will celebrate 2025 as the "Year of Quantum Science and Technology".

The activities of the Quantum Year 2025 in Germany will culminate in an international conference in Göttingen (2nd DPG Fall Meeting, Sept. 8-12, 2025). The meeting will cover the present status and perspectives of all fields of modern physics reigned by quantum mechanics (condensed matter physics, atomic and molecular physics, quantum optics, elementary particle physics, quantum information and computing, and many others) as well as the historical roots of quantum mechanics and conceptual questions that still challenge us today.

Apart from high profile speakers covering all fields of modern physics there will be contributed sessions, all together creating a unique opportunity to look across the boundaries of individual research topics under the umbrella of quantum physics.

Save the Date!
8-12 Sep 2025

quantum25.dpg-tagungen.de

8-12 September 2025

Local and Scientific Organisers:

Prof. Dr. Stefan Kehrein
Institut für Theoretische Physik
Friedrich-Hund-Platz 1
37077 Göttingen

Prof. Dr. Thomas Weitz
I. Physikalisches Institut - Experimentalphysik
Friedrich-Hund-Platz 1
37077 Göttingen

Conference Venue:

Georg-August Universität Göttingen, Zentrales Hörsaalgebäude,
Platz der Göttinger Sieben 5, 37073 Göttingen

Abstract Submission: 31 March - 6 June 2025

Organisation

Organiser
Deutsche Physikalische Gesellschaft e. V.
Hauptstraße 5, 53604 Bad Honnef
Phone +49 (0) 2224 9232-0
Email dpg@dpg-physik.de
Website www.dpg-physik.de

Local Organiser
Prof. Dr. Arnulf Quadt
II. Physikalisches Institut
Georg-August-Universität Göttingen
Friedrich-Hund-Platz 1, 37077 Göttingen
Email goettingen25@dpg-tagungen.de

Scientific Organisation

Chair of the Matter and Cosmos Section (SMuK)
Prof. Dr. Anna Bakenecker
TU Darmstadt, Fachbereich etit
Merckstraße 25, 64283 Darmstadt
Email anna.bakenecker@tu-darmstadt.de

Chairs of the Participating Divisions

(DD)	Physics Education	–	Prof. Dr. Susanne Heinicke (susanne.heinicke@uni-muenster.de)
(EP)	Extraterrestrial Physics	–	Dr. Miriam Sinnhuber (miriam.sinnhuber@kit.edu)
(GR)	Gravitation and Relativity	–	Prof. Dr. Luciano Rezzolla (rezzolla@itp.uni-frankfurt.de)
(MP)	Theoretical and Mathematical Physics	–	Prof. Dr. Johanna Erdmenger (erdmenger@physik.uni-wuerzburg.de)
(P)	Plasma Physics	–	Prof. Dr. Jan Benedikt (benedikt@physik.uni-kiel.de)
(ST)	Radiation and Medical Physics	–	Dr. Anna Bakenecker (bakenecker@dpg-mail.de)
(T)	Particle Physics	–	Prof. Dr. Johannes Haller (johannes.haller@uni-hamburg.de)

Chair of the Participating Working Groups

(AKBP)	Accelerator Physics	–	Prof. Dr. Ulrich Schramm (u.schramm@hzdr.de)
(AKC)	Equal Opportunities	–	OStR Agnes Sandner (akc@dpg-physik.de)
(AKjDPG)	"Young DPG"	–	Simon Neuhaus (neuhaus@jdpg.de)
(AKPIK)	Physics, Modern IT and Artificial Intelligence	–	Dr. Tim Ruhe (tim.ruhe@tu-dortmund.de)

Symposia
SYAS – Awards Symposium
SYDK – Quantum Mechanics and Gravity: Current Status
SYMD – SMuK Dissertation Prize 2025
SYSF – Turbulence in Space and Fusion Plasmas

Organisation of the Exhibition of Scientific Instruments and Literature
DPG-Ausstellungs-, Kongreß- und Verwaltungsgesellschaft mbH
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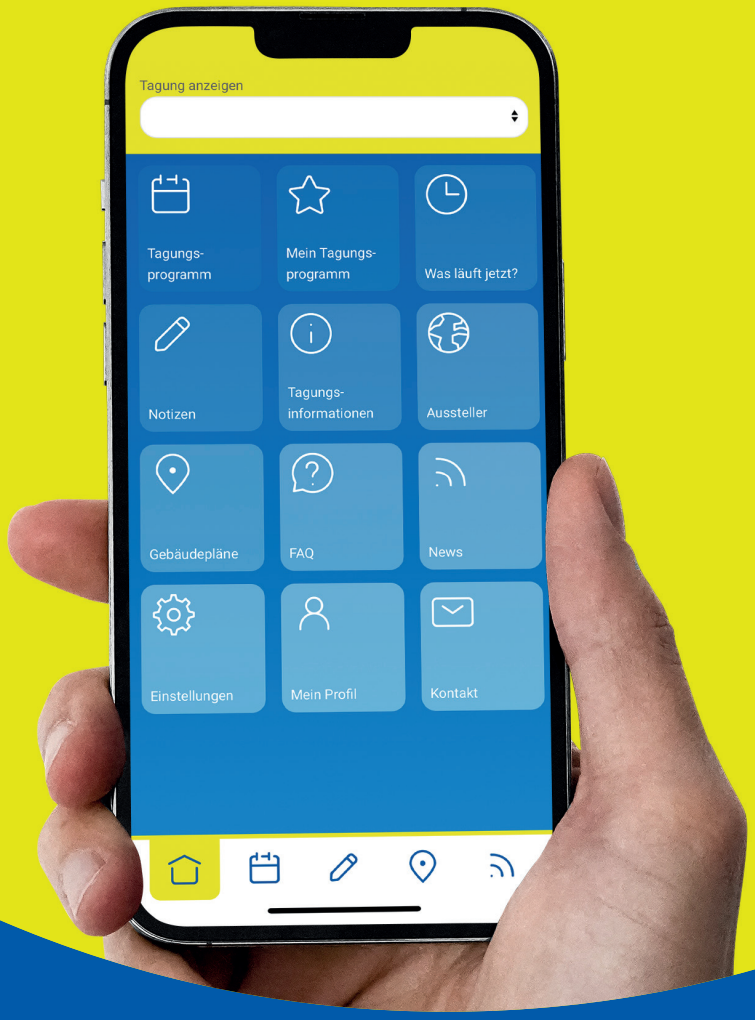

DPG

Laden im App Store

JETZT BEI Google Play

Navigate the Spring Meeting with the DPG App!

The DPG app informs you about the conference programme, the venues and the exhibitors. Features such as your personal conference calendar and detailed floor plans simplify finding your way around the conference!

for iOS

for Android

Explore conference contributions on the new DPG Map.

CURRENTLY IN BETA

Dive into our network visualization and find related contributions.

Visit our platform at map.dpg-verhandlungen.de

Programme
The scientific programme consists of **1,446** contributions:

8	Plenary talks
1	Evening talk
4	Prize talks
83	Invited talks
14	Invited Overview talks
16	Invited Topical talks
2	Lunch talks
1,066	Talks
7	Group Reports
245	Posters

The programme stated in this document corresponds to the status of the programme publication February 5, 2025 and will not be updated!

Information for Participants

The conference will be held March 31 – April 4, 2025.

Conference Information

Conference Venue
Universität Göttingen
Zentrales Hörsaalgebäude
Platz der Göttinger Sieben 5
37073 Göttingen

The conference will take place in the Central Lecture Hall Building (ZHG) of the University of Göttingen and in seminar rooms in neighbouring buildings. For a detailed map of the campus and the buildings please see “Maps” at the end of this document.

Conference Office / Information Desk
The conference office and the information desk are located in seminar room 0.168 (ground floor) of the Oeconomicum building (opposite the main entrance to the main lecture hall building). The opening hours are the following:

		Registration	Information Desk
Monday	March 31	08:00 – 19:00	08:00 – 19:00
Tuesday	April 1	08:00 – 16:45	08:00 – 19:00
Wednesday	April 2	08:00 – 16:45	08:00 – 21:00
Thursday	April 3	08:00 – 16:45	08:00 – 19:00
Friday	April 4	08:00 – 12:00	08:00 – 13:00

You will receive your name tag, a receipt for your conference fee, food and drink vouchers for the welcome evening at the registration. The name tag must be worn visibly during the entire conference.

The organisers, the staff of the conference desk, and the student assistants will be identifiable by name tags and Φ-T-shirts in a uniform colour. Please contact them if you have any questions.

Do not hesitate to enquire about all necessary information concerning the conference, orientation in Göttingen, accommodation, restaurants, going out, and cultural events at the information desk.

Presentations
Scientific presentations will be held either orally or by poster and will be given in English (conference language) or German.

All lecture halls will be equipped with a projector (16:9) or monitor (16:9) and a computer. Speakers are requested to upload their presentations on the conference website one day before the corresponding session. An email with the access data and the upload deadlines will be sent to the lecturers before the conference. If you require to change your uploaded contribution, you may again upload the document at the latest 4 hours before the session (not the talk) starts. In any case you should also bring a copy of your presentation on an USB drive as a backup.

The file formats accepted for all parallel sessions are pdf and Powerpoint. Own laptops cannot be used for the presentation. The presentations will be transferred to the provided PCs/laptops in the lecture hall before the session.

All lecture halls will be opened, at the latest, 30 minutes prior to the talks. Speakers are requested to be in the lecture hall at least 20 minutes prior to the start of the session, reporting to the chairperson of the session as well as the technical staff, to ensure that the presentation upload was successful, and to receive a brief introduction to the equipment in the lecture hall. If you need other presentation facilities, please ask for availability at the information desk as soon as you arrive at the conference.

Usually, presentations will have the following durations:

- For contributed talks a total of 15 minutes including discussion time and speaker change (12 min talk + 3 min discussion/speaker change).
- For invited talks a total of 30 minutes including discussion time and speaker change (25 min talk + 5 min discussion/speaker change).
- For plenary talks 45 minutes without discussion time.

For further information please contact the division or working group at which you will be giving the presentation.

Poster Presentations

The site for poster sessions is located at the foyer of the lecture hall building. Posters must fit within a rectangle 85 cm wide and 120 cm high (DIN A0, portrait format!).

The poster boards will be marked with the number according to the scientific programme. Authors are asked to mount their poster once the poster board with the corresponding poster number is prepared. Usually this will be arranged in the morning, or one hour before the session when there are several poster sessions per day. Each poster should display the number according to the scientific programme.

For the mounting of the poster please use the prepared pins/strips at the poster frame or contact the available student staff. The presenting authors should be at hand for discussion at their poster during at least half of the poster session and should note this time at the poster. The posters have to be removed after the session. **Any posters remaining on display will be removed and disposed without requesting your permission.** The conference management accepts no liability for the posters.

Broadcast of Plenary Talks

All plenary talks will be presented in lecture hall ZHG011 and broadcast in lecture hall ZHG010.

Wilhelm and Else Heraeus Communication Programme

Important notes for participants who apply for a grant in the WEH Communication Programme:

At the beginning of the conference you will receive an identification form at the conference office. Your participation in the conference must be certified at the conference office. At the end of the conference, you may leave this certificate with DPG staff members at the conference office (preferably) or submit it to the DPG head office (DPG-Geschäftsstelle, Hauptstr. 5, 53604 Bad Honnef, Germany) by **April 18, 2025 at the latest.** For more detailed information refer to *weh.dpg-physik.de*.

The Deutsche Physikalische Gesellschaft thanks the Wilhelm and Else Heraeus Foundation for the generous financial support of young academic talents. We hope that young physicists will continue to benefit from the offered opportunity for active scientific communication at DPG meetings. A total of about 41,900 young academics were supported by this programme so far.

Communication / Internet Access

The University of Göttingen is a member of the eduroam union. If your university is also part of the eduroam union, you can use the university WiFi in all buildings via your own eduroam account. Alternatively, you can use the "guest on campus" network or receive corresponding credentials at the information desk.

Catering

Coffee breaks: Coffee and tea are offered for free in the foyer of the lecture hall building during the breaks.

Lunch: The "Zentralmensa" right next to the central lecture hall building and the "Mensa am Turm" in 100m walking distance offer plenty of opportunities for lunch at moderate prices (self-payment). Only payment by cards (Debit, Credit, Google Pay, Apple Pay) is possible in the mensa. Please wear your badge to get staff or student prices. In the city centre there is a large selection of opportunities to get a meal or a snack.

Cloakroom
Participants are asked to look carefully after their wardrobe, valuables, laptops, and other belongings. The organisers decline any liability. In the foyer of the ZHG building you will find a cloakroom managed by student assistants. The opening hours are as follows:

Monday	March 31	08:30 – 21:30
Tuesday	April 1	08:30 – 20:30
Wednesday	April 2	08:30 – 19:00
Thursday	April 3	08:30 – 19:00
Friday	April 4	08:30 – 14:00

Notice Board
All changes to the conference programme (i.e. cancellation of presentations, change of rooms, etc.) are also transferred directly to the online version of the programme which will be updated continuously and is available in different formats (sorted by publication date, filterable by conference parts and as an rss-feed). Please use the form *goettingen25.dpg-tagungen.de/programm/notice-board* to notify changes or cancellations.

Lost Property
You can hand in lost property at the information desk. You can also collect your lost property there.

Liability Exclusion
Participants are asked to look carefully after their wardrobe, valuables, laptops and other belongings. There can be no liability assumed.

SAY CHEESE!
The DPG Spring Meetings are basically public to the press. Please note: On behalf of DPG, photos and videos will be recorded during the Spring Meetings. In the context of public relations, these recordings (as the case may be) will be published on our website, in social media or within prints of the DPG for example.

Tactfulness
All participants are requested to contribute to a successful and enjoyable conference through respect and tactful behaviour. Please contact the conference office or the local conference organisers in the event of disturbances. §§ 9 and 12 of the DPG's Statutes are applicable.

CO_2 Compensation for the DPG conferences
By decision of its council, the DPG will compensate for fossil CO_2 emissions resulting from mobility for DPG conferences and committee meetings.

Acknowledgement
The Deutsche Physikalische Gesellschaft (DPG) and the local organisers want to thank the following institutions for supporting the conference:

- the Wilhelm and Else Heraeus Foundation, Hanau
- the University of Göttingen
- and all staff, who make the success of the conference possible.

Social Events

Welcome Address
The opening address will be given by the local conference organisation on Monday, March 31, from 11:00 until 11:30 in the lecture hall ZHG 011.

Welcome Evening
Monday, March 31, 18:45 – 21:30
On Monday, the Welcome Evening will be held in the foyer of the lecture hall centre to which all registered participants are kindly invited. Snacks and drinks will be served. Register in time (08:00 to 19:00) and do not miss the opportunity to meet people in informal atmosphere. Please wear your name tag which you have received during registration. **Vouchers for food and drinks are handed out at the registration.** Please note: The local "Young DPG" will organise a Science Slam during the Welcome Evening.

Exhibition of Scientific Instruments
From Tuesday, April 1, to Thursday, April 3, there will be an exhibition of scientific instruments and literature in the foyer of the lecture hall centre. Companies (see list of exhibitors at the end of this booklet) will present their products. Opening hours are from 10:30 to 18:00. All conference participants are welcome to attend the exhibition. The entrance is free.

Awarding of the SMuK Dissertation Prize 2025
On Tuesday, 1 April, at 11:00, the awards ceremony for the SMuK Dissertation Prize will take place in the ZHG 011. The aim of the prize is to recognise outstanding scientific work and its excellent presentation in a lecture. Talks by the four finalists will be given at the symposium (SYMD) on Monday.

Prize Talks
The following prize talks will be held during the conference (in chronological order):

Robert-Wichard-Pohl-Prize 2025
Tuesday, 1 April, 11:05, ZHG011
Prof. Dr. Rita Wodzinski, Universität Kassel
„Zum Verhältnis von Physikdidaktik und Physikunterricht"

Georg-Kerschensteiner-Prize 2025
Tuesday, 1 April, 11:35, ZHG011
Dr. Silke Stähler-Schöpf, Max-Planck-Institut für Quantenoptik, Garching
„(Quanten-)Physik für alle mit dem PhotonLab"

Hertha-Sponer-Prize 2025
Tuesday, 1 April, 12:05, ZHG011
Dr. Janna Katharina Behr, Deutsches Elektronen-Synchrotron (DESY), Hamburg
„Searching for the fingerprints of new phenomena with top quarks"

DPG-Lehrerpreis (DPG-Teachers' Prize) 2025
Tuesday, 1 April, 13:30, Theo. 0.135
Matthias Harnischmacher, Gymnasium an der Gartenstraße, Möchengladbach
„Physikunterricht im 21. Jahrhundert gestalten: MakerSpace, Deeper Learning & innovative Prüfungsformate für mehr Schüler:innenmotivation"

Awarding "EPS Historic Site"
On Tuesday, April 1, 18:00 – 19:30, in the Aula am Wilhelmsplatz, the city Göttingen will be awarded the title "EPS Historic Site" by the European Physical Society. The programme can be found here:
https://goettingen25.dpg-tagungen.de/veranstaltungen/verleihung-eps-historic-site
The event will be broadcast to lecture halls ZHG010 and ZHG011.

Charity concert „The Magic of Science and Music“

für 18:45 Uhr

On Wednesday, 2 April 2025, at 18:45 and 20:30 in the Aula am Wilhelmplatz, a benefit concert entitled „The magic of science and music“ will take place. This evening event is a special cultural highlight of the spring conference of the German Physical Society and a contribution to the UNESCO „International Year of Quantum Science and Technology“ on the occasion of the 100th anniversary of the development of quantum mechanics. The event is organised by the Georg-August-Universität Göttingen and the Rotary-Club Göttingen.

für 20:30 Uhr

The donations received at the benefit event will go to the Göttingen women‘s shelter and to the Göttingen St. Michael lunch club. Admission is free. However, due to the limited number of seats, we kindly request that you register in advance.

Physik: Erkenntnisse und Perspektiven — A Publication for Everyone (in German)!

The title ‘Physik: Erkenntnisse und Perspektiven’ (Physics: Findings and Perspectives) refers to a publication by the DPG, created by nearly 200 authors on a voluntary basis. It provides a detailed exploration of the fundamentals of physics, current research and future developments. It provides readers with engaging and inspiring insights into the world of physics!

The publication is available at www.physik-erkenntnisse-perspektiven.de – complemented by exclusive video interviews. Printed copies can also be ordered by covering the shipping costs.

For interested readers: Experience the brand-new book live!

Join us for the book launch on Thursday, 3 April, from 12:30 to 13:00, ZHG007. You will have the opportunity to pick up a free copy – while stocks last!

Public Evening Talk

Thursday, April 3, 19:30 – 20:30, Paulinerkirche

Dr. Steffen Korn will speak about *„Von Quanten und Kollisionen – Göttingen trifft Genf“*.

The Public Evening Talk is open for the interested public and all conference participants. It will be held in German. The entrance is free of charge.

Following this, there will be an optional joint visit to the special quantum exhibition in the Forum Wissen until 22:00.

Members‘ Assemblies of the Divisions

During the conference, the members‘ assemblies of the participating divisions will take place. Please refer to the scientific programme for the time and place of the meetings.

Deutsche Physikalische Gesellschaft DPG

2025

Quantum2025

100 years
is just the beginning...

- Quanta in Science and Quantum Technologies
- Playful Quantum Science and Quantum Science in Schools
- Quanta in Music, Philosophy, Art and Literature
- Quanta in the Professional world, Career and Society
- The Path to the Modern Quantum World and beyond

quantum2025.de

INTERNATIONAL YEAR OF Quantum Science and Technology

quantum2025.org

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www.dpg-physik.de

Synopsis of the Daily Programme

Monday, March 31, 2025

11:00	ZHG011		**Welcome Address**
			Plenary Talks
11:30	ZHG011	PV I	The solar magnetic field and variability •Sami K. Solanki
12:15	ZHG011	PV II	The Role of Applications in the History of Quantum Mechanics •Christian Joas

SYHQ

			Invited Talks
09:00	ZHG010	SYHQ 1.1	Heisenberg's Umdeutung •Alexander Blum
09:30	ZHG010	SYHQ 1.2	Representing quantum physics: The role of notation in the construction of quantum mechanics •Arianna Borrelli
10:00	ZHG010	SYHQ 1.3	The Nobel committee's position on quantum mechanics: Nominations, evaluations and decisions •Karl Grandin
14:00	ZHG010	SYHQ 2.1	Model and Target: Von Neumann's Mathematische Grundlagen •Michael Stöltzner
14:30	ZHG010	SYHQ 2.2	Tracing the dissemination of quantum mechanics: A comparative approach •Roberto Lalli
15:00	ZHG010	SYHQ 2.3	Quantum Mechanics and 'Aryan Physics' •Mark Walker
16:00	Forum Wissen	SYHQ 3.1	Women in the History of Quantum Physics •Margriet van der Heijden
16:30	Forum Wissen	SYHQ 3.2	Molecular WiHQP Vignettes: Hertha Sponer and Elizabeth Monroe •Patrick Charbonneau
17:00	Forum Wissen	SYHQ 3.3	Grete Hermann: A pioneer of the philosophical debate about the foundations of quantum mechanics and a political activist •Andrea Reichenberger
			Sessions
09:00	ZHG010	SYHQ 1	History of Quantum Mechanics I: Revolution, Representation, Reevaluation
14:00	ZHG010	SYHQ 2	History of Quantum Mechanics II: Foundation, Dissemination, Politicization
16:00	Forum Wissen	SYHQ 3	Women in the History of Quantum Mechanics: The Project and its New Insights

SYMD

			Invited Talks
14:15	ZHG011	SYMD 1.1	Fluid-dynamic description of heavy-quark diffusion in the quark-gluon plasma •Federica Capellino
14:45	ZHG011	SYMD 1.2	Fast and faithful effective-one-body models for gravitational waves from generic compact binaries •Rossella Gamba
15:15	ZHG011	SYMD 1.3	Nuclear Structure Near Doubly Magic Nuclei •Lukas Nies
15:45	ZHG011	SYMD 1.4	Optimisation strategies for proton acceleration from thin foils with petawatt ultrashort pulse lasers •Tim Ziegler
			Session
14:15	ZHG011	SYMD 1	SMuK Dissertation Prize 2025

Monday, March 31, 2025

EP

Invited Talks

16:45	ZHG005	EP 1.1	The new planet formation theory •Joanna Drazkowska
16:45	ZHG101	EP 2.1	Sunrise III 2024: Flight and first scientific results •Andreas Korpi-Lagg

Sessions

16:45	ZHG005	EP 1	Planets and Small Bodies I
16:45	ZHG101	EP 2	Sun and Heliosphere I

GR

Invited Talk

16:45	ZHG008	GR 1.1	Classical post-newtonian gravitational fields in quantum mechanics •Domenico Giulini

Session

16:45	ZHG008	GR 1	CQG I

MP

Session

16:45	ZHG001	MP 1	Quantum Mechanics

P

Invited Talks

13:45	ZHG102	P 1.1	On the way to a fusion power plant •Felix Warmer
13:45	ZHG006	P 2.1	Nanosecond pulse generators for gas discharges •Tom Huiskamp
14:45	ZHG006	P 2.4	Multimodal Diagnostic Approaches and Interactive Analysis of Mode Transitions in the kINPen Plasma Jet Interacting with Surfaces •Torsten Gerling
16:15	ZHG102	P 3.1	Flux Pumping for High Performance Tokamak Scenarios •A. Bock
16:15	ZHG006	P 4.1	Plasma wind tunnel and plasma propulsion •Georg Herdrich
17:00	ZHG006	P 4.3	Force profile and charge estimation of a single particle in the sheath of a dual-frequency CCP •Jessica Niemann

Sessions

13:45	ZHG102	P 1	Magnetic Confinment Fusion/HEPP I
13:45	ZHG006	P 2	Atmospheric Plasmas and their Applications I
16:15	ZHG102	P 3	Magnetic Confinment Fusion/HEPP II
16:15	ZHG006	P 4	Low Pressure Plasmas and their Applications I

T

Sessions

16:45	ZHG010	T 1	Searches/BSM I (HNL, ETmiss+X)
16:45	ZHG104	T 2	Higgs Physics I (HH and trilinear coupling)
16:45	ZHG105	T 3	Higgs Physics II (BSM Higgs)
16:45	VG 0.110	T 4	Detectors I (Scintillators)
16:45	VG 0.111	T 5	Silicon Detectors I (ATLAS + CMS)
16:45	VG 1.101	T 6	Silicon Detectors II (Belle II, Tristan)

Monday, March 31, 2025

T

16:45	VG 1.102	T 7	Detectors II (Gaseous Detectors)
16:45	VG 1.103	T 8	Top Physics I (tt+X)
16:45	VG 1.104	T 9	Flavour Physics I
16:45	VG 1.105	T 10	Neutrino Astronomy I
16:45	VG 2.101	T 11	Data, AI, Computing, Electronics I (Statistical Methods, Applications)
16:45	VG 2.102	T 12	Data, AI, Computing, Electronics II (Data Management, Workflow)
16:45	VG 2.103	T 13	Sustainability
16:45	VG 3.101	T 14	Methods in Astroparticle Physics I
16:45	VG 3.102	T 15	Cosmic Rays I
16:45	VG 3.103	T 16	Neutrino Physics I
16:45	VG 3.104	T 17	Neutrino Physics II
16:45	VG 4.101	T 18	Methods in Particle Physics I (Calo, Jets, Tagging)
16:45	VG 4.102	T 19	Search for Dark Matter I

DD

Invited Talk

14:00	ZHG103	DD 1.1	100 Jahre Quantenphysik – und was haben wir daraus gelernt? •Stefan Heusler

Sessions

14:00	ZHG103	DD 1	Eröffnung und Hauptvortrag I
15:15	Theo 0.136	DD 2	Hochschuldidaktik I
15:15	Theo 0.135	DD 3	Quantenphysik I
15:15	Theo 0.134	DD 4	KI I
15:15	OEC 1.163	DD 5	Astronomie I
15:15	OEC 1.162	DD 6	Inklusion
16:45	Theo 0.136	DD 7	Workshop Standards Lehrkräftebildung
16:45	Theo 0.135	DD 8	Quantenphysik II
16:45	Theo 0.134	DD 9	Lehrkräftebildung I
16:45	OEC 1.163	DD 10	Physikalische Praktika
16:45	OEC 1.162	DD 11	Außerschulische Lernorte

AKBP

Session

16:45	ZHG004	AKBP 1	Electron Accelerators I

AKjDPG

Invited Talk

13:00	ZHG007	AKjDPG 1.1	Introduction to direct dark matter searches •Daniel Wenz

Session

13:00	ZHG007	AKjDPG 1	jDPG Tutorium – Dark Matter

18:45	Foyer ZHG	**Welcome Evening** (for registered participants)

Tuesday, April 1, 2025

Plenary Talks

09:00	ZHG011	PV III	The Dawn of Multimessenger Astrophysics •Anna Franckowiak
09:45	ZHG011	PV IV	Equipping the Next Generation: Quantum Education and Workforce Development in the U.S. •Heather Lewandowski

SYAS

11:00	ZHG011		**Awarding of the SMuK-Dissertation Prize 2025**

Prize Talks

11:05	ZHG011	SYAS 1.1	Zum Verhältnis von Physikdidaktik und Physikunterricht •Rita Wodzinski (Laureate of the Robert-Wichard-Pohl-Prize 2025)
11:35	ZHG011	SYAS 1.2	(Quanten-)Physik für alle mit dem PhotonLab •Silke Stähler-Schöpf (Laureate of the Georg-Kerschensteiner-Prize 2025)
12:05	ZHG011	SYAS 1.3	Searching for the fingerprints of new phenomena with top quarks •Katharina Behr (Laureate of the Hertha-Sponer-Prize 2025)

Session

11:00	ZHG011	SYAS 1	Awards Symposium

SYHQ

Session

18:00	Aula am Wilhelmsplatz and broadcast in ZHG011/ZHG10	SYHQ 4	EPS historic site event

EP

Invited Talks

13:45	ZHG005	EP 3.1	Atmospheric modelling from ground to lower thermosphere •Claudia Stephan
14:45	ZHG005	EP 3.4	Beauty and hazards created by the terrestrial magnetosphere •Elena Kronberg
13:45	ZHG101	EP 4.1	The Solar Orbiter Mission and the Polarimetric and Helioseismic Imager instrument: new opportunities for novel science •Gherardo Valori
16:45	ZHG005	EP 5.3	Heliosphere as a natural laboratory of turbulence and plasma nonlinearities •Yasuhito Narita
16:15	ZHG101	EP 6.1	Decoding coronal loops: Structure and dynamics •Sudip Mandal

Sessions

13:45	ZHG005	EP 3	Near-Earth Space I
13:45	ZHG101	EP 4	Sun and Heliosphere II
16:15	ZHG005	EP 5	Near-Earth Space I & Planets and Small Bodies II
16:15	ZHG101	EP 6	Sun and Heliosphere III

GR

Invited Talk

13:30	ZHG008	GR 2.1	Beyond the thick accretion disk model: external influences and their observational consequences •Audrey Trova

Tuesday, April 1, 2025

GR

Sessions

13:30	ZHG008	GR 2	Relastro I
14:15	ZHG007	GR 3	Rel. Geodesy
16:15	ZHG008	GR 4	GW I
16:15	ZHG007	GR 5	CQG II

MP

Invited Talks

13:45	ZHG001	MP 2.1	Mathematics of moire materials •Simon Becker
14:15	ZHG001	MP 2.2	Approaches to Discrete Holography •René Meyer

Sessions

13:45	ZHG001	MP 2	Mathematical Materials Science and AdS/CFT
16:15	ZHG001	MP 3	Particle Physics and AdS/CFT

P

Invited Talks

11:00	ZHG102	P 5.1	Mode activity at the Wendelstein 7-X stellarator – Turbulence driven Alfvén modes •S. Vaz Mendes
11:00	ZHG006	P 6.1	Spatially and temporally resolved electric fields in an RF-APPJ measured by E-FISH •Inna Orel
13:45	ZHG102	P 7.1	Impurity Transport in Wendelstein 7-X: Basics and Experimental Observations •Birger Buttenschön
13:45	ZHG006	P 8.1	Status and outlook for CO_2 conversion with microwave plasmas •Ante Hecimovic
14:45	ZHG006	P 8.4	Plasma activation of low-energy molecules using the example of nitrogen •Mariagrazia Troia
16:15	ZHG102	P 9.1	In-vessel and depth-resolved hydrogen isotope composition analysis in JET by LIBS operated on a remote handling arm •Rongxing Yi

Sessions

11:00	ZHG102	P 5	Magnetic Confinment Fusion/HEPP III
11:00	ZHG006	P 6	Atmospheric Plasmas and their Applications II
13:45	ZHG102	P 7	Magnetic Confinment Fusion/HEPP IV
13:45	ZHG006	P 8	Atmospheric Plasmas and their Applications III
16:15	ZHG102	P 9	Plasma Wall Interaction
16:15	ZHG Foyer 1. OG	P 10	Poster Session I

ST

Invited Talks

16:15	ZHG003	ST 2.1	Photonenzählende Detektoren: Der nächste Schritt in der klinischen CT-Bildgebung •Thomas Stein
16:45	ZHG003	ST 2.2	Life-view 3D endoscopy for colorectal cancer screening based on MHz optical coherence tomography •Maik Rahlves
17:15	ZHG003	ST 2.3	Engineering Precision Medicine with Magnetic Imaging Techniques •Ioana Slabu

Tuesday, April 1, 2025

ST

Sessions

13:45	ZHG003	ST 1	Computational Methods and Simulation
16:15	ZHG003	ST 2	DPG meets DGMP: Future Perspectives on Tomographic Imaging Techniques

T

Sessions

13:45	ZHG011	T 20	Invited Topical Talks I
13:45	ZHG010	T 21	Invited Topical Talks II
12:35	ZHG011	T 22	Annual Meeting of Young Scientists in High Energy Physics
16:15	ZHG010	T 23	Searches/BSM II (Non-collider)
16:15	ZHG104	T 24	Higgs Physics III (boson final states)
16:15	ZHG105	T 25	Higgs Physics IV (BSM Higgs)
16:15	VG 0.110	T 26	Axions/ALPs I
16:15	VG 0.111	T 27	Silicon Detectors III (ATLAS + CMS production)
16:15	VG 1.101	T 28	Silicon Detectors IV (SiPMs, HG timing)
16:15	VG 1.102	T 29	Detectors III (Scintillators)
16:15	VG 1.103	T 30	Top Physics II (Properties)
16:15	VG 1.104	T 31	Flavour physics II
16:15	VG 1.105	T 32	Neutrino Astronomy II
16:15	VG 2.101	T 33	Data, AI, Computing, Electronics III (ML in Jet Tagging, Misc.)
16:15	VG 2.102	T 34	Data, AI, Computing, Electronics IV (DAQ, Detector Electronics)
16:15	VG 2.103	T 35	Electroweak Physics I (Weak Mixing Angle, Tau Production)
16:15	VG 3.101	T 36	Methods in Astroparticle Physics II
16:15	VG 3.102	T 37	Cosmic Rays II
16:15	VG 3.103	T 38	Neutrino Physics III
16:15	VG 3.104	T 39	Neutrino Physics IV
16:15	VG 4.101	T 40	Methods in Particle Physics II (Misc.)
16:15	VG 4.102	T 41	Search for Dark Matter II

DD

Prize Talk

13:30	Theo 0.135	DD 13.1	Physikunterricht im 21. Jahrhundert gestalten: MakerSpace, Deeper Learning & innovative Prüfungsformate für mehr Schüler:innenmotivation •Matthias Harnischmacher (Laureate of the Lehrerprize 2025)

Sessions

13:30	Theo 0.136	DD 12	Hochschuldidaktik II
13:30	Theo 0.135	DD 13	Preisträgervortrag
14:10	Theo 0.135	DD 14	Praxisblick
13:30	Theo 0.134	DD 15	KI II
13:30	OEC 1.163	DD 16	Astronomie II
14:45	Theo 0.136	DD 17	Hochschuldidaktik III
14:45	Theo 0.135	DD 18	Neue / Digitale Medien
14:45	Theo 0.134	DD 19	KI III
14:45	OEC 1.163	DD 20	BNE
14:45	OEC 1.162	DD 21	Lehr-Lernforschung I
16:15	ZHG Foyer 1. OG	DD 22	Poster – Anregungen Unterricht
16:15	ZHG Foyer 1. OG	DD 23	Poster – Astronomie
16:15	ZHG Foyer 1. OG	DD 24	Poster – Außerschulische Lernorte
16:15	ZHG Foyer 1. OG	DD 25	Poster – Bildung für nachhaltige Entwicklung
16:15	ZHG Foyer 1. OG	DD 26	Poster – Hochschuldidaktik
16:15	ZHG Foyer 1. OG	DD 27	Poster – Lehr-Lernforschung
16:15	ZHG Foyer 1. OG	DD 28	Poster – Lehreraus- und -fortbildung
16:15	ZHG Foyer 1. OG	DD 29	Poster – Neue / digitale Medien
16:15	ZHG Foyer 1. OG	DD 30	Poster – Neue Konzepte

Tuesday, April 1, 2025

DD

16:15	ZHG Foyer 1. OG	DD 31	Poster – Praktika und Experimente
16:15	ZHG Foyer 1. OG	DD 32	Poster – Quantenphysik
16:15	ZHG Foyer 1. OG	DD 33	Poster – Geschichte und NoS
18:00	ZHG103	DD 34	Mitgliederversammlung

AKBP

Invited Talk

16:00	ZHG004	AKBP 3.1	SRF accelerating cavity design for the future circular collider •shahnam gorgi zadeh

Sessions

13:45	ZHG004	AKBP 2	Novel Accelerator Concepts I
16:00	ZHG004	AKBP 3	AKBP Accelerator Prize Talks
16:30	ZHG Foyer 1. OG	AKBP 4	AKBP Posters

AKjDPG

Invited Talks

12:30	ZHG007	AKjDPG 2.1	Overview of selected medical physics topics for young scientists •Jens Weingarten
19:00	ZHG008	AKjDPG 3.1	From a clean lab to dirty barns •Sonja Zeißner
19:25	ZHG008	AKjDPG 3.2	From Academia to Actuarial: Bridging Science and Business •Reinke Sven Isermann
19:50	ZHG008	AKjDPG 3.3	Enabling the future through light - Product Line Manager at Excelitas •Julia Granget
20:15	ZHG008	AKjDPG 3.4	Podium discussion with the three speakers •Michael Lupberger

Sessions

12:30	ZHG007	AKjDPG 2	jDPG Tutorium – Medical Physics
19:00	ZHG008	AKjDPG 3	yHEP Physicists Beyond Academia
21:30	ZHG Foyer EG	AKjDPG 4	Bier & Brezel

10:30	ZHG Foyer EG	**Exhibition of Scientific Instruments**

Wednesday, April 2, 2025

Plenary Talks, Lunch Talk

09:00	ZHG011	PV V	Quantum field theory, quantum reference frames and the type of local algebras •Christopher Fewster
09:45	ZHG011	PV VI	Image-guided radiotherapy for cancer treatment: recent developments and future innovations •Daniela Thorwarth
12:30	ZHG007	PV VII	DFG funding opportunities for Early Career Researchers •Manuel Krämer

SYSF

Invited Talks

13:45	ZHG101	SYSF 1.1	Addressing turbulence questions in the Wendelstein 7-X stellarator device – a combined experimental and theoretical approach •Josefine Proll
14:15	ZHG101	SYSF 1.2	Particle acceleration and transport in astrophysical, magnetized turbulent plasmas •Martin Lemoine
14:45	ZHG101	SYSF 1.3	Turbulence in the young solar wind, results from Solar Orbiter and Parker Solar Probe •Robert Wicks
15:15	ZHG101	SYSF 1.4	Digital Solutions for EUROfusion •Volker Naulin

Session

13:45	ZHG101	SYSF 1	Turbulence in Space and Fusion Plasmas

EP

Invited Talk

16:15	ZHG005	EP 9.1	A JWST View of Exoplanet Atmospheres: Everything We Dreamed Of, and More •Laura Kreidberg

Sessions

11:00	ZHG005	EP 7	Planets and Small Bodies III
12:15	ZHG101	EP 8	Members' Assembly
16:15	ZHG005	EP 9	Exoplanets and Astrobiology

GR

Invited Talk

11:00	ZHG008	GR 6.1	Black hole dynamics from a mathematical perspective •Dejan Gajic

Sessions

11:00	ZHG008	GR 6	BH Physics I
13:30	ZHG008	GR 7	Cosmo I, Relastro II, GW II
13:30	ZHG007	GR 8	GW III
16:15	ZHG Foyer 1. OG	GR 9	Poster

MP

Invited Talks

11:00	ZHG001	MP 4.1	Focusing dynamics for 2d Bose gases in the instability regime •Lea Boßmann
16:15	ZHG001	MP 7.1	How the „gauge principle" derives from physical principles •Karl-Henning Rehren

Wednesday, April 2, 2025

MP

17:45	ZHG001	MP 7.5	A BPS Road to Holography: Decoupling Limits and Non-Lorentzian Geometries •Niels Obers

Sessions

11:00	ZHG001	MP 4	Dynamics and Chaotic Behaviour
13:45	ZHG001	MP 5	Theory of Machine Learning
14:45	ZHG001	MP 6	Members' Assembly
16:15	ZHG001	MP 7	Quantum Field Theory I and Conformal Field Theory
16:15	ZHG002	MP 8	Waves, Relativity and Quantization
16:15	ZHG Foyer 1. OG	MP 9	Poster Session: Many-body Theory

P

Invited Talks

11:00	ZHG102	P 11.1	Ab initio path integral Monte Carlo simulation of warm dense matter •Tobias Dornheim
11:00	ZHG006	P 12.1	Using dusty plasmas to measure low-electron sticking coefficients of dielectric materials •Armin Mengel
13:45	ZHG006	P 14.1	Carbon Dioxide Splitting in Dielectric Barrier Discharges: Power Dissipation and Plasma Chemistry •Ronny Brandenburg
14:45	ZHG006	P 14.4	Insights into Mode Transitions and Reactive Species Densities in a Micro Cavity Plasma Array •David Steuer

Sessions

11:00	ZHG102	P 11	Laser Plasmas
11:00	ZHG006	P 12	Complex Plasmas and Dusty Plasmas I
12:20	ZHG102	P 13	Members' Assembly
13:45	ZHG006	P 14	Atmospheric Plasmas and their Applications IV
16:15	ZHG102	P 15	Astrophysical Plasmas
16:15	ZHG006	P 16	Complex Plasmas and Dusty Plasmas II
16:15	ZHG Foyer 1. OG	P 17	Poster Session II

ST

Invited Talk

13:45	ZHG009	ST 4.1	Mixed ion beams for treatment monitoring: recent developments and future prospects •Elisabeth Renner

Sessions

11:00	ZHG003	ST 3	Radiation Monitoring and Dosimetry
13:45	ZHG009	ST 4	Accelerators for Medical Applications
16:15	ZHG003	ST 5	Detector Physics

T

Invited Overview Talks

11:00	ZHG011	T 42.1	Direct neutrino-mass measurements – current and next generations •Magnus Schlösser
11:30	ZHG011	T 42.2	Mapping out the Higgs Boson: Highlights from the LHC Experiments •Elisabeth Schopf
12:00	ZHG011	T 42.3	Computing at the LHC and its transformation towards the HL-LHC •Sebastian Wozniewski
13:45	ZHG011	T 43.1	Advances in Silicon Detectors •Matthias Hamer

Wednesday, April 2, 2025

T

14:15	ZHG011	T 43.2	Exploring the dark universe: the experimental quest for axions and ALPs •Julia K. Vogel
14:45	ZHG011	T 43.3	Overview on coherent elastic neutrino nucleus scattering and successful first detections •Janina Hakenmüller
15:15	ZHG011	T 43.4	Shifting paradigms in Gravitational-wave Astrophysics •Imre Bartos

Sessions

11:00	ZHG011	T 42	Invited Overview Talks I
13:45	ZHG011	T 43	Invited Overview Talks II
16:15	ZHG010	T 44	Searches/BSM III (Long-lived, Misc.)
16:15	ZHG104	T 45	Higgs Physics V (HH and Trilinear Coupling)
16:15	ZHG105	T 46	Higgs Physics VI (top-Higgs Coupling)
16:15	VG 0.110	T 47	Axions/ALPs II
16:15	VG 0.111	T 48	Silicon Detectors V (R&D, Simulation)
16:15	VG 1.101	T 49	Detectors IV (Scintillators)
16:15	VG 1.102	T 50	Detectors V (Misc.)
16:15	VG 1.103	T 51	Top Physics III (Cross Sections, Entanglement)
16:15	VG 1.104	T 52	Flavour Physics III
16:15	VG 1.105	T 53	Neutrino Astronomy III
16:15	VG 2.101	T 54	Data, AI, Computing, Electronics V (Anomaly Detection, Event Selection)
16:15	VG 2.102	T 55	Data, AI, Computing, Electronics VI (DAQ and Trigger)
16:15	VG 2.103	T 56	Electroweak Physics II (Multi-boson Processes)
16:15	VG 3.101	T 57	Gamma Astronomy I
16:15	VG 3.102	T 58	Cosmic Rays III
16:15	VG 3.103	T 59	Neutrino Physics V
16:15	VG 3.104	T 60	Gravitational Waves
16:15	VG 4.101	T 61	Methods in Particle Physics III (Tracking)
16:15	VG 4.102	T 62	Search for Dark Matter III

DD

Invited Talk

14:45	ZHG103	DD 45.1	Moderne Physik, moderne Bildung: Zukunftsperspektiven für den Physikunterricht im Wandel •Magdalena Kersting

Sessions

11:00	Theo 0.136	DD 35	Workshop Studienreformforum
11:00	Theo 0.135	DD 36	Quantenphysik III
11:00	Theo 0.134	DD 37	Lehrkräftebildung II
11:00	OEC 1.163	DD 38	Geschichte / NoS
11:00	OEC 1.162	DD 39	Lehr-Lernforschung II
13:30	Theo 0.136	DD 40	Hochschuldidaktik IV
13:30	Theo 0.135	DD 41	Analysen
13:30	Theo 0.134	DD 42	Digitale Medien – Smartphone
13:30	OEC 1.163	DD 43	Sprache
13:30	OEC 1.162	DD 44	Lehr-Lernforschung III
14:45	ZHG103	DD 45	Hauptvortrag II und Verabschiedung

AKBP

Sessions

11:00	ZHG004	AKBP 5	Particle Sources
13:45	ZHG009	AKBP 6	Accelerators for Medical Applications
16:15	ZHG004	AKBP 7	Novel Accelerator Concepts II and FELs

Wednesday, April 2, 2025

AKjDPG

			Session
19:00	ZHG007	AKjDPG 5	jDPG/yHEP Discussion on current topics relevant to young researchers

AKPIK

			Sessions
13:45	ZHG001	AKPIK 1	Theory of Machine Learning
16:15	ZHG Foyer 1. OG	AKPIK 2	AKPIK Poster Session

10:30	ZHG Foyer EG	**Exhibition of Scientific Instruments**

18:45	Aula am Wilhelmsplatz	**Charity concert „The Magic of Science and Music“** (free entrance)
20:30	Aula am Wilhelmsplatz	**Charity concert „The Magic of Science and Music“** (free entrance)

Thursday, April 3, 2025

Plenary Talks, Lunch Talk

09:00	ZHG011	PV VIII	The ESA Euclid mission: a journey to understand the dark side of the universe •Guadalupe Cañas-Herrera
09:45	ZHG011	PV IX	Negative hydrogen ion sources – utilizing low temperature plasmas in ITER's neutral beam systems •Ursel Fantz
12:30	ZHG007	PV X	Book Launch – Physik: Erkenntnisse und Perspektiven (in German) •Sarah Köster, •Claus Lämmerzahl

SYDK

Invited Talks

10:45	ZHG008	SYDK 1.1	String Theory at the Edges of Relativity •Niels Obers
11:15	ZHG008	SYDK 1.2	The Quantum Einstein Equations in Loop Quantum Gravity •Kristina Giesel
11:45	ZHG008	SYDK 1.3	Causal Dynamical Triangulations: Lattice quantum gravity reloaded •Renate Loll
12:15	ZHG008	SYDK 1.4	Taming Quantum Gravity: insights from Asymptotic Safety •Alessia Platania

Session

10:45	ZHG008	SYDK 1	Quantum Mechanics and Gravity: Current Status

EP

Invited Talk

16:15	ZHG101	EP 12.1	The Influence of Intermittent Turbulence on Solar Energetic Particle Transport: Modelling and Observations •Frederic Effenberger

Sessions

11:00	ZHG Foyer 1. OG	EP 10	Poster Session
13:45	ZHG101	EP 11	Sun and Heliosphere IV
16:15	ZHG101	EP 12	Sun and Heliosphere V

GR

Invited Talk

13:30	ZHG008	GR 10.1	Probing the cosmic large-scale structure beyond the average •Cora Uhlemann

Sessions

13:30	ZHG008	GR 10	Cosmo II
14:15	ZHG007	GR 11	BH Physics II, GW IV
16:15	ZHG008	GR 12	GW V
17:00	ZHG008	GR 13	Members' Assembly

MP

Invited Talk

14:00	ZHG001	MP 10.1	Quantum field theory, quantum reference frames and the type of local algebras •Christopher Fewster

Sessions

14:00	ZHG001	MP 10	Operator Algebras
16:15	ZHG001	MP 11	Quantum Field Theory II
16:15	ZHG002	MP 12	Concepts of Physics

Thursday, April 3, 2025

P

Invited Talks

11:00	ZHG102	P 18.1	Simulating W erosion, transport, and deposition in Ne-seeded discharges in ITER with full-W wall •Christoph Baumann
11:00	ZHG006	P 19.1	A plasma process model for high power impulse magnetron sputtering discharges •Martin Rudolph
13:45	ZHG102	P 20.1	First applications of the kinetic ion transport module in the EMC3-EIRENE code package •Derek Harting
14:40	ZHG102	P 20.3	Simulating boundary turbulence in fusion reactors in different confinement, ELM and detachment regimes •Wladimir Zholobenko
13:45	ZHG006	P 21.1	Vacuum UV spectroscopy at atmospheric pressure plasmas utilizing silicon nitride membranes •Luka Hansen
14:45	ZHG006	P 21.4	Hybrid fluid/MC simulations of radio-frequency atmospheric pressure plasma jets •Mate Vass
16:15	ZHG102	P 22.1	High-resolution optical emission spectroscopy of neutral W lines: comparing near-threshold sputtering of W with different crystal orientation in PSI-2 •Marc Sackers
16:15	ZHG006	P 23.1	Electric Field Determination for Fundamental and Applied Discharge Physics •Tomas Hoder

Sessions

11:00	ZHG102	P 18	Codes and Modeling/HEPP
11:00	ZHG006	P 19	Low Pressure Plasmas and their Applications II
13:45	ZHG102	P 20	Magnetic Confinment Fusion/HEPP V
13:45	ZHG006	P 21	Atmospheric Plasmas and their Applications V
16:15	ZHG102	P 22	Plasma Wall Interaction/HEPP
16:15	ZHG006	P 23	Atmospheric Plasmas and their Applications VI

ST

Invited Talk

17:15	ZHG003	ST 9.1	Making Surgery Intelligent: From Autonomous Systems to the Intelligent OR •Jannis Hagenah

Sessions

11:00	ZHG003	ST 6	Medical Imaging and Treatment Monitoring
13:45	ZHG Foyer 1. OG	ST 7	Poster Session
16:15	ZHG003	ST 8	Particle Radiography
17:15	ZHG003	ST 9	Keynote Session
17:45	ZHG003	ST 10	Prize Ceremony and Closing Session
18:15	ZHG003	ST 11	Members' Assembly

T

Invited Overview Talks

11:00	ZHG011	T 63.1	Neutrino properties from the laboratory and the cosmos •Thomas Schwetz-Mangold
11:30	ZHG011	T 63.2	Highlights from Standard Model physics at the LHC in the precision era •Daniel Savoiu
12:00	ZHG011	T 63.3	Cosmological results from the Dark Energy Spectroscopic Instrument •Daniel Gruen

Thursday, April 3, 2025

T

Sessions

11:00	ZHG011	T 63	Invited Overview Talks III
13:45	ZHG011	T 64	Invited Topical Talks III
13:45	ZHG010	T 65	Invited Topical Talks IV
16:15	ZHG010	T 66	Searches/BSM IV (BSM with Tops, LQs)
16:15	ZHG104	T 67	Higgs Physics VII (HH and Trilinear Coupling)
16:15	ZHG105	T 68	Higgs Physics VIII (CP)
16:15	VG 0.110	T 69	Strong Interaction / QCD
16:15	VG 0.111	T 70	Silicon Detectors VI (MAPS, Mighty Tracker)
16:15	VG 1.101	T 71	Detectors VI (Gaseous Detectors)
16:15	VG 1.102	T 72	Detectors VII (Calorimeters)
16:15	VG 1.103	T 73	Flavour Physics IV
16:15	VG 1.104	T 74	Flavour Physics V
16:15	VG 1.105	T 75	Neutrino Astronomy IV
16:15	VG 2.101	T 76	Data, AI, Computing, Electronics VII (Generative AI, MC Generators)
16:15	VG 2.102	T 77	Data, AI, Computing, Electronics VIII (Fast ML, Triggers)
16:15	VG 2.103	T 78	Gamma Astronomy II
16:15	VG 3.101	T 79	Methods in Astroparticle Physics III
16:15	VG 3.102	T 80	Cosmic Rays IV
16:15	VG 3.103	T 81	Neutrino Physics VI
16:15	VG 3.104	T 82	Neutrino Physics VII
16:15	VG 4.101	T 83	Methods in Particle Physics IV (Lepton Reconstruction)
16:15	VG 4.102	T 84	Search for Dark Matter IV
19:00	ZHG104	T 85	Members' Assembly

AKBP

Sessions

11:00	ZHG004	AKBP 8	Diagnostics
13:45	ZHG004	AKBP 9	Novel Accelerator Concepts III and Hadron Accelerators
16:15	ZHG004	AKBP 10	Novel Accelerator Concepts IV and Applications
18:20	ZHG004	AKBP 11	Members' Assembly

AKC

Invited Talks

11:00	ZHG009	AKC 1.1	Lucy Mensing: Forgotten Pioneer of Quantum Mechanics •Gernot Münster
11:30	ZHG009	AKC 1.2	The Spectrum of He^+ as a Proving Ground for Bohr's Model of the Atom: A Legacy of Williamina Fleming's Astrophysical Discovery •Bretislav Friedrich
12:00	ZHG009	AKC 1.3	Unethical Behavior in Academia: Forms, Causes, and Countermeasures •Daniel Leising

Sessions

11:00	ZHG009	AKC 1	AKC
12:45	ZHG009	AKC 2	Women in Physics Lunch

AKPIK

Session

16:15	Theo 0.134	AKPIK 3	Machine Learning in Particle- and Astroparticle Physics

Thursday, April 3, 2025

10:30	Foyer ZHG EG		**Exhibition of Scientific Instruments**

			Evening Talk
19:30	Paulinerkirche	PV XI	Von Quanten und Kollisionen – Göttingen trifft Genf •Steffen Korn

Friday, April 4, 2025

EP

			Invited Talks
09:00	ZHG101	EP 13.1	High-Mass X-Ray Binaries: Living Together with a Black Hole •Lidia Oskinova
13:30	ZHG101	EP 15.1	Nucleosynthesis of heavy elements in the hot and dense plasmas of explosive astrophysical environments •Daniel Siegel
			Sessions
09:00	ZHG101	EP 13	Astrophysics I
11:00	ZHG101	EP 14	Astrophysics II
13:30	ZHG101	EP 15	Astrophysics III

GR

			Sessions
09:00	ZHG008	GR 14	Relastro III
11:00	ZHG008	GR 15	Cosmo III

T

			Invited Overview Talks
11:00	ZHG011	T 105.1	Galactic Astrophysics with H.E.S.S. •Lars Mohrmann
11:30	ZHG011	T 105.2	Physics in the era of big data: AI in particle and astroparticle physics •Jonas Glombitza
12:00	ZHG011	T 105.3	What the LHC tells us about the top quark, the heaviest particle in nature •Matthias Komm
12:30	ZHG011	T 105.4	The flavor intensity frontier: latest results from Belle II and LHCb •Daniel Greenwald
			Sessions
09:00	ZHG010	T 86	Searches/BSM V (Misc.)
09:00	ZHG104	T 87	Higgs physics IX (Charm and Tau Final States)
09:00	ZHG105	T 88	Miscellaneous
09:00	VG 0.110	T 89	Axions/ALPs III
09:00	VG 0.111	T 90	Silicon Detectors VII (ATLAS + CMS phase-2)
09:00	VG 1.101	T 91	Silicon Detectors VIII (MAPS, misc.)
09:00	VG 1.102	T 92	Detectors VIII (Gaseous Detectors)
09:00	VG 1.103	T 93	Top Physics IV (Misc.)
09:00	VG 1.104	T 94	Flavour Physics VI

Friday, April 4, 2025

T

09:00	VG 1.105	T 95	Outreach
09:00	VG 2.101	T 96	Detectors IX (Calorimeters)
09:00	VG 2.102	T 97	Data, AI, Computing, Electronics IX (AI-based Object Reconstruction)
09:00	VG 2.103	T 98	Electroweak Physics III (W/Z Production and Properties)
09:00	VG 3.101	T 99	Methods in Astroparticle Physics IV
09:00	VG 3.102	T 100	Cosmic Rays V
09:00	VG 3.103	T 101	Neutrino Physics VIII
09:00	VG 3.104	T 102	Neutrino Physics IX
09:00	VG 4.101	T 103	Methods in Particle Physics V (Event Reconstruction, PID)
09:00	VG 4.102	T 104	Search for Dark Matter V
11:00	ZHG011	T 105	Invited Overview Talks IV

AKBP

Sessions

09:00	ZHG004	AKBP 12	Radiofrequency and Instrumentation I
11:00	ZHG004	AKBP 13	Radiofrequency and Instrumentation II

AKPIK

Session

09:00	Theo 0.134	AKPIK 4	Simulation and Workflows

Plenary, Lunch, and Evening Talks

Plenary Talk PV I Mon 11:30 ZHG011

The solar magnetic field and variability — •Sami K. Solanki — Max Planck Institute for Solar System Research, Göttingen

The solar magnetic field influences many aspects of the Sun, including its activity and its brightness variability. Solar activity manifests itself in numerous ways, such as the presence of sunspots and faculae on the solar surface, of a hot corona, bright flares and mighty coronal mass ejections. The variations in solar brightness are important for the atmosphere of the Earth, which receives almost all of its energy from the Sun and which is consequently influenced by changes in this irradiation. In recent years there has been considerable progress in both the theoretical and observational study of solar magnetism and variability, not least thanks to work that has been done at the Max Planck Institute for Solar System Research. The talk will present some of the highlights of this research, including realistic radiation-MHD simulations of solar magnetic features in the solar atmosphere, observations of the solar magnetic field with novel instrumentation and from unusual vantage points, as well as studies of archives of historic and prehistoric solar variability.

Plenary Talk PV II Mon 12:15 ZHG011

The Role of Applications in the History of Quantum Mechanics — •Christian Joas — Niels Bohr Archive, Copenhagen — Department of Science Education, University of Copenhagen

In my talk, I will challenge the conventional division between foundations and applications in physics and explore how physicists throughout the history of quantum mechanics have applied the theory and extended its scope beyond its original domains. Rather than merely solving specific problems, many applications of quantum mechanics to new domains (scattering, complex atoms, molecules, solids, nuclei) were drivers of conceptual innovation and played pivotal roles in shaping both the theory and its interpretation. I will illustrate this with a few examples from the early history of quantum mechanics. Without these applications, which are often dismissed as merely derivative extensions, the textbooks of quantum mechanics would look very different. There is untapped potential for physicists, historians, and philosophers to delve deeper into the applications of quantum mechanics. This perspective not only enriches historical studies and broadens the focus to include developments in fields that conventional wisdom considers less fundamental, but also provides tools for understanding contemporary developments in fields like quantum information and quantum computing, where practical applications carry considerable weight.

Plenary Talk PV III Tue 9:00 ZHG011

The Dawn of Multimessenger Astrophysics — •Anna Franckowiak — Ruhr-Universität Bochum, Germany

The recent discoveries of high-energy astrophysical neutrinos and gravitational waves have opened new windows of exploration to the Universe. Neutrinos can escape dense environments from where photons can not reach us and travel undeflected through the Universe. In combination with measurements of electromagnetic radiation, neutrinos can help to solve long-standing problems in astrophysics and probe physics in extreme environment that otherwise are hardly accessible to laboratory experiments. They are key to unraveling the origin of cosmic rays.

Recent multimessenger observations reveal TeV-PeV neutrino production in interactions of cosmic rays in our own galaxy and in distant galaxies when massive stars explode or the central supermassive black hole accretes large amounts of matter. This talk will summarize recent discoveries and give an outlook on new experiments and possible future breakthroughs.

Plenary Talk PV IV Tue 9:45 ZHG011

Equipping the Next Generation: Quantum Education and Workforce Development in the U.S. — •Heather Lewandowski — JILA and Department of Physics, University of Colorado, Boulder, USA

Quantum sensing, networking and communication, and computing have garnered significant attention due to their transformative potential and advantages over traditional technologies. The second quantum revolution has not only advanced technological frontiers, but also created a growing need for STEM graduates equipped with quantum-specific expertise. Preparing students to be successful in this rapidly evolving field requires empowering them with a range of technical and professional skills and knowledge.

I will present findings from extensive studies of both the landscape of quantum education in the U.S. and insights from the quantum industry. These findings include an overview of existing programs (e.g., certificates, minors, degrees) and courses across the U.S., as well as an analysis of key industry activities, job profiles, and the skillsets valued across roles. Additionally, I will highlight our local initiatives to bridge the gap between education and industry needs. These efforts include experimental training embedded in lab courses and a novel, two-semester, project-based course. In this course, student teams collaborate on industry-sponsored projects to develop practical skills in areas such as nanofabrication and servo electronics, alongside essential professional competencies like project management, communication, and budget planning.

Plenary Talk PV V Wed 9:00 ZHG011

Quantum field theory, quantum reference frames and the type of local algebras — •Christopher Fewster — Department of Mathematics, University of York, York, UK

Algebraic quantum field theory (AQFT) assigns a von Neumann algebra to each bounded spacetime region, generated by the associated observables. Under reasonable assumptions, these algebras are all isomorphic to a specific von Neumann algebra of type III_1 [1], leading to significant physical differences between quantum field theory and quantum mechanics. Recently, Chandrasekaran, Longo, Penington and Witten (CLPW) [2] have argued that the inclusion of gravity can require the introduction of an "observer", and that the physical observables constitute an algebra of type II. This talk will explain these developments and their significance, without assuming familiarity with von Neumann algebras or AQFT. I will focus on the CLPW model and an operationally motivated generalisation [3], which reinterprets the observer as a quantum reference frame (QRF), and sheds light on the roles of gravity and the QRF/observer.

[1] D. Buchholz, C. D'Antoni, and K. Fredenhagen, The Universal Structure of Local Algebras, Comm. Math. Phys. 111 (1987) 123-135.

[2] V. Chandrasekaran, R. Longo, G. Penington, and E. Witten, An algebra of observables for de Sitter space. JHEP 2023(2) 1-56.

[3] C.J. Fewster, D.W. Janssen, L.D. Loveridge, K. Rejzner and J. Waldron, Quantum Reference Frames, Measurement Schemes and the Type of Local Algebras in Quantum Field Theory, Comm. Math. Phys. 406 (2025) 19:1-87.

Plenary Talk PV VI Wed 9:45 ZHG011

Image-guided radiotherapy for cancer treatment: recent developments and future innovations — •Daniela Thorwarth — Section for Biomedical Physics, Department of Radiation Oncology, University of Tübingen, Germany

Cancer treatment with radiation therapy has experienced significant innovations in the last two decades, leading to highly precise and personalized treatments today, allowing to deposit high energy doses in the tumor while sparing critical healthy tissue as much as possible.

Modern high-precision radiation treatments are delivered using image-guided radiotherapy systems. During this presentation, an overview of recently developed hybrid systems for online image-guided radiotherapy will be given, including CT-adaptive radiotherapy, magnetic resonance-guided radiotherapy and also image-guided particle therapy approaches. In addition to an introduction to the technical and physical realization of the hardware systems, potential and challenges related to radiation dose deposition in tissue, dosimetry and assessment of biological tissue properties will be highlighted. Moreover, current and future innovations aiming at real-time adaptation of radiotherapy treatment beams for moving targets will be discussed.

Lunch Talk PV VII Wed 12:30 ZHG007

DFG funding opportunities for Early Career Researchers — •Manuel Krämer — Deutsche Forschungsgemeinschaft e.V., Kennedyallee 40, 53175 Bonn

The German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) is the central organization for third-party funding of basic research in Germany. It offers a broad spectrum of funding opportunities from individual grants to larger coordinated programmes.

This talk will give an overview of the funding programmes that are tailored to Early Career Researchers. These funding schemes facilitate, for example, research stays abroad or the establishment of a junior research group. I will focus the talk on the Walter Benjamin Programme, the Emmy Noether Programme as well as the Heisenberg Programme and I will explain the different scopes and aims of these programmes.

Plenary Talk PV VIII Thu 9:00 ZHG011

The ESA Euclid mission: a journey to understand the dark side of the universe — •Guadalupe Cañas-Herrera — European Space Agency, Noordwijk, the Netherlands

Euclid is a medium-class space mission led by ESA, with contributions from NASA, selected in October 2011 and successfully launched in July 2023. Its primary objective is to shed light on the nature of Dark Matter, which constitutes about 25% of the Universe's energy content, and Dark Energy, which makes up approximately 70% and is believed to drive the current accelerated expansion of the Universe.To achieve these goals, Euclid is creating the most comprehen-

sive and precise 3D map of the Universe by surveying one-third of the sky. Understanding Dark Matter and Dark Energy requires performing a demanding statistical analysis to compare Euclid*s data to cosmological models using two complementary probes: weak gravitational lensing and galaxy clustering. In this talk, I will provide an update on the Euclid mission since its launch, discuss its key science objectives, oand explain how we construct theoretical predictions for its primary observables to achieve Euclid's ultimate goal: understand the dark Universe. I will also present the latest forecasts on cosmological parameters and extended models preparing ahead of the internal Euclid first cosmological data release.

Plenary Talk PV IX Thu 9:45 ZHG011

Negative hydrogen ion sources - utilizing low temperature plasmas in ITER's neutral beam systems — •Ursel Fantz and IPP NNBI Team — Max-Planck-Institut für Plasmaphysik

Large and powerful negative hydrogen ion sources (H-, D-) will be used at the international fusion experiment ITER to deliver after acceleration and neutralization energetic beams of neutral particles (H, D) to the tokamak. These beams will be used for heating and current drive, but also for plasma diagnostics. The inductively coupled plasma source (ICP) operates at low gas pressure (0.3 Pa) using a frequency of 1 MHz and a total power of 800 kW to illuminate an area of 1 x 2m. The ion source relies on surface conversion of hydrogen atoms and positive hydrogen ions into negative ions at a low work function converter surface, for which caesium is injected into the low temperature plasma. The latter introduces temporal and, together with the magnetic filter field, a spatial component into the otherwise stable plasma, which adds to the challenge of generating up to 60 A of homogeneously extracted negative ions for up to an hour. The diagnostics and modelling of the plasma and the extraction provide access to exciting aspects of plasma physics. The development of such negative ion sources follows the European step-ladder approach to meet the ITER target parameters. The development phases, the status and the challenges, as well as the way forward, are discussed.

Lunch Talk PV X Thu 12:30 ZHG007

Book Launch – Physik: Erkenntnisse und Perspektiven (in German) — Joachim Ullrich[1], Ulrich Bleyer[1], •Sarah Köster[2], •Claus Lämmerzahl[3], Dieter Meschede[4] und Lutz Schröter[1] — [1]Deutsche Physikalische Gesellschaft e. V., Bad Honnef — [2]Universität Göttingen, Institut für Röntgenphysik, Göttingen — [3]Universität Bremen, Weltraumwissenschaft ZARM, Bremen — [4]Universität Bonn, Institut für Angewandte Physik, Bonn

Join us for the book launch of the new DPG publication. You will have the opportunity to pick up a free copy – while stocks last!

The title "Physik: Erkenntnisse und Perspektiven" (Physics: Insights and Perspectives) refers to a publication, which was produced on a voluntary basis by almost 200 authors. It provides a detailed exploration of the fundamentals of physics, current research and future developments. The book offers readers an engaging and inspiring insight into the world of physics! The publication is also available at www.physik-erkenntnisse-perspektiven.de – along with exclusive video interviews. Printed copies can also be ordered by covering the shipping costs.

Evening Talk PV XI Thu 19:30 Paulinerkirche

Von Quanten und Kollisionen – Göttingen trifft Genf — •Steffen Korn — II. Physikalisches Institut - Georg-August-Universität Göttingen

Der Vortrag nimmt die Zuhörer mit auf eine faszinierende Reise durch die Geschichte und Gegenwart der Quantenphysik. Beginnend mit den revolutionären Entdeckungen des frühen 20. Jahrhunderts, als Physiker in Göttingen die Grundsteine der Quantenmechanik legten, beleuchtet der Vortrag Schlüsselkonzepte wie den Welle-Teilchen-Dualismus und die Quantenverschränkung. Göttingen, einst Epizentrum dieser wissenschaftlichen Revolution, wurde in den 1920er Jahren zum Ausgangspunkt für eine Entwicklung, die bis in die moderne Teilchenphysik reicht. Der Bogen spannt sich von den Arbeiten von Born und Planck, getrieben von dem Bedürfnis zu verstehen, "Was die Welt im Innersten zusammenhält", bis hin zu den monumentalen Experimenten am CERN in Genf. Dort, am ATLAS-Experiment des Large Hadron Collider (LHC), prallen Teilchen mit ungeheurer Energie aufeinander, um Antworten auf die grundlegensten Fragen des Universums zu finden. Wie die Erkenntnisse der Quantenmechanik bis heute die Suche nach neuen Teilchen und Kräften im Universum prägen, wird anschaulich erklärt und in den Kontext aktueller Forschung gestellt. Freuen Sie sich auf eine spannende Mischung aus historischer Wissenschaftsgeschichte, physikalischen Einsichten und modernen Entdeckungen - von Göttingens Quantenpionieren bis zu den Teilchenkollisionen der Gegenwart.

Awards Symposium (SYAS)

jointly organised by
the Physics Education Division (DD) and
the Particle Physics Division (T)

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Overview of Prize Talks and Sessions

(Lecture hall ZHG011)

Prize Talks

SYAS 1.1	Tue	11:05–11:35	ZHG011	**Zum Verhältnis von Physikdidaktik und Physikunterricht** — •Rita Wodzinski
SYAS 1.2	Tue	11:35–12:05	ZHG011	**(Quanten-)Physik für alle mit dem PhotonLab** — •Silke Stähler-Schöpf
SYAS 1.3	Tue	12:05–12:35	ZHG011	**Searching for the fingerprints of new phenomena with top quarks** — •Katharina Behr

Sessions

SYAS 1.1–1.3	Tue	11:00–12:35	ZHG011	**Awards Symposium**

Sessions

– Prize Talks –

SYAS 1: Awards Symposium

Time: Tuesday 11:00–12:35 Location: ZHG011

Announcement of the SMuK Dissertation Prize 2025 winner.

Prize Talk SYAS 1.1 Tue 11:05 ZHG011

Zum Verhältnis von Physikdidaktik und Physikunterricht — •Rita Wodzinski — Universität Kassel — Laureate of the Robert-Wichard-Pohl-Prize 2025

In der Begründung zur Verleihung des Robert-Wichard-Pohl-Preises wird u.a. die Unterrichtsnähe meiner bisherigen wissenschaftlichen Tätigkeit herausgehoben. Der Vortrag geht deshalb der Frage nach, in welchem Verhältnis die Physikdidaktik eigentlich zur Unterrichtspraxis steht und welche Randbedingungen dieses Verhältnis prägen. Aus der Analyse und Reflexion der Entwicklungen in der Physikdidaktik sollen mögliche Konsequenzen für zukünftige Entwicklungen abgeleitet werden.

Prize Talk SYAS 1.2 Tue 11:35 ZHG011

(Quanten-)Physik für alle mit dem PhotonLab — •Silke Stähler-Schöpf — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching — Laureate of the Georg-Kerschensteiner-Prize 2025

Seit 2011 ist das Schülerlabor PhotonLab die Anlaufstelle für alle, die mehr über Laser, Licht und Quanten wissen möchten. Hier gibt es viele Versuche, die Schülerinnen und Schüler nach Anleitungen auf iPads selber durchführen können.

Oberstufenschüler können in die Welt der Quanten eintauchen und von unserem Einzelphotonenexperiment bis zum Workshop Vom "Qubit zum Quantencomputer" an Hand des Mach-Zehnder-Interferometers einiges über die Quantenphysik lernen.

Zur Vor- und Nachbereitung haben wir interaktive Bücher entwickelt, die auf kurzweilige Art mit Animationen, Videos und Quizzen die Grundlagen der einzelnen Experimente vermitteln.

Um auch kleineren Kindern diese faszinierende Welt näher zu bringen, haben wir das Hörspiel "Alice im Quantenland" entwickelt. Hier lernt Alice auf spielerische Art grundlegende Phänomene der Quantenphysik kennen. Das Hörspiel steht in den gängigen Podcast-Apps zur Verfügung.

Zusätzlich sind wir auch mit einzelnen Experimenten auf Messen, Tagen der offenen Tür, im Deutschen Museum etc. für die breite Öffentlichkeit präsent. www.photonworld.de

Prize Talk SYAS 1.3 Tue 12:05 ZHG011

Searching for the fingerprints of new phenomena with top quarks — •Katharina Behr — DESY, Hamburg — Laureate of the Hertha-Sponer-Prize 2025

New phemonena may be more difficult to spot at the LHC than commonly assumed. Unlike the Higgs boson discovered in 2012, which was identified as a clear, localised peak on top of a smooth background distribution, additional heavier Higgs bosons or axion-like particles could manifest themselves as much more complicated interference patterns if they decayed primarily to a top-antitop quark pair. While much more challenging to identify and treat statistically, these interference patterns, like fingerprints, would carry valuable information about the properties of the new particles.

In this talk, I will present a comprehensive search for interference patterns on the ATLAS Run-2 dataset. For the first time, a consistent and proper statistical treatment of signal-background interference is presented. The search provides stringent constraints on previously unexplored parameter spaces of models with an extended Higgs sector or dark matter.

Symposium Quantum Mechanics and Gravity: Current Status (SYDK)

jointly organised by
the Theoretical and Mathematical Physics Division (MP) and
the Gravitation and Relativity Division (GR)

Johanna Erdmenger
Julius-Maximilians-Universität Würzburg
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The symposium is devoted to highlighting the recent status of research on quantum gravity. It combines the view of four experts working on different approaches to quantum gravity, namely string theory, loop quantum gravity, dynamical triangulations and asymptotic safety.

Overview of Invited Talks

(Lecture hall ZHG008)

Invited Talks

SYDK 1.1	Thu	10:45–11:15	ZHG008	**String Theory at the Edges of Relativity** — •Niels Obers
SYDK 1.2	Thu	11:15–11:45	ZHG008	**The Quantum Einstein Equations in Loop Quantum Gravity** — •Kristina Giesel
SYDK 1.3	Thu	11:45–12:15	ZHG008	**Causal Dynamical Triangulations: Lattice quantum gravity reloaded** — •Renate Loll
SYDK 1.4	Thu	12:15–12:45	ZHG008	**Taming Quantum Gravity: insights from Asymptotic Safety** — •Alessia Platania

Sessions

SYDK 1.1–1.4	Thu	10:45–12:45	ZHG008	**Quantum Mechanics and Gravity: Current Status**

Sessions

– Invited Talks –

SYDK 1: Quantum Mechanics and Gravity: Current Status

Time: Thursday 10:45–12:45 Location: ZHG008

Invited Talk SYDK 1.1 Thu 10:45 ZHG008

String Theory at the Edges of Relativity — •Niels Obers — Niels Bohr Institute

The quest for a consistent theory of quantum gravity is one of the most important challenges in theoretical physics. In the landscape of physical theories, quantum gravity resides at the corner where all fundamental constants*Newton*s constant, the speed of light, and Planck*s constant*are finite. Recently, it has become clear that there is rich physics at the edges of relativity, considering respectively the large (non-relativistic) and small (ultra-local or Carrollian) limits of the speed of light. These limits naturally lead to non-Lorentzian geometries, known as Newton-Cartan and Carrollian geometry, revealing a much richer structure of gravity than previously appreciated.

Such non-Lorentzian limits naturally arise in string theory and holography, offering promising pathways toward more tractable models for studying the quantum structure of space and time. This includes exploring the quantum constituents of black holes and gravity at its extremes. I will first introduce the physics and geometric formulation of these limits in the context of gravity, establishing their foundation. Then, I will discuss their role in string theory and holography, highlighting recent advances.

Invited Talk SYDK 1.2 Thu 11:15 ZHG008

The Quantum Einstein Equations in Loop Quantum Gravity — •Kristina Giesel — FAU Erlangen-Nürnberg, Department of Physics, Erlangen Center for Astroparticle Physics, Germany

Loop quantum gravity is a candidate for a theory of quantum gravity that takes general relativity as its classical starting point. In the canonical approach, the quantum theory is obtained by applying a canonical quantization to general relativity. To this end, the techniques known from quantum field theory, which are used in the standard model of particle physics, need to be generalized in order to apply them to general relativity, in which the geometry of spacetime is a dynamical quantity. The dynamics of the quantum theory is described by the so-called quantum Einstein equations, the quantum analog of the Einstein equations. After a brief introduction to the ideas and concepts of loop quantum gravity, we will discuss recent applications in symmetry reduced models in loop quantum cosmology and the quantum gravitational collapse with a special focus on the physical properties and implications of these models.

Invited Talk SYDK 1.3 Thu 11:45 ZHG008

Causal Dynamical Triangulations: Lattice quantum gravity reloaded — •Renate Loll — Radboud University, Nijmegen, The Netherlands

Lattice methods are a powerful tool to investigate quantum field theories beyond perturbation theory, as demonstrated by the impressive successes of lattice QCD. Due to the dynamical character of spacetime in gravity, putting quantum gravity on the lattice faces formidable obstacles, which for a long time were thought to be insurmountable. Key to overcoming them is to adapt the lattice regularization such that both the dynamical and the Lorentzian character of spacetime are built in from the outset. This is realized by the use of causal dynamical triangulations (CDT), which capture the inherent **compatibility** between the principles of quantum theory and general relativity.

Lattice quantum gravity based on CDT is well-tested and operational, using state-of-the-art Monte Carlo simulations. It has opened a computational window near the Planck scale, where "numerical experiments" can be performed, giving for the first time quantitative information on the spectra of geometric observables characterizing quantum gravity nonperturbatively, with unexpected results. Remarkably, a quantum spacetime has been shown to emerge from this primordial soup of quantum fluctuations, displaying large-scale properties of a de Sitter universe. There is a concrete and promising roadmap, focusing on the properties of these quantum fluctuations, to connect fundamental quantum gravity to early-universe cosmology.

Invited Talk SYDK 1.4 Thu 12:15 ZHG008

Taming Quantum Gravity: insights from Asymptotic Safety — •Alessia Platania — NBI, University of Copenhagen

Asymptotically safe gravity is a candidate for a consistent and predictive quantum theory of gravity that is grounded on quantum field theory and the modern Wilsonian understanding of renormalization. Since its inception, significant efforts have been put in corroborating the 'asymptotic safety conjecture' the existence of an interacting fixed point of the gravitational renormalization group flow, serving as a consistent ultraviolet completion of gravity, and making the theory non-perturbatively renormalizable. This talk will review the current state-of-the-art of the field, highlighting recent advancements in understanding the theoretical structure of the theory and testing its internal consistency. Emphasis will be placed on the role of matter, the infrared structure of the theory, and its connection to other quantum gravity approaches. Phenomenological implications of asymptotically safe gravity for cosmology and black hole physics will also be discussed. Finally, challenges and open questions will be outlined, thus providing a roadmap for future research.

Joint DPG and EPS History of Quantum Physics Symposium (SYHQ)

jointly organised by
the German Physical Society (DPG) and
the European Physical Society (EPS)

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On the occasion of the centenary of quantum mechanics and in conjunction with the Historic Site award of the EPS for Göttingen, a symposium on the history of quantum mechanics is held at the the DPG Spring Meeting in Göttingen.

Overview of Invited Talks

(Lecture hall ZHG010 and Forum Wissen)

Plenary Talk

PV II	Mon	12:15–13:00	ZHG011	**The Role of Applications in the History of Quantum Mechanics** — •Christian Joas

Invited Talks

SYHQ 1.1	Mon	9:00– 9:30	ZHG010	**Heisenberg's Umdeutung** — •Alexander Blum
SYHQ 1.2	Mon	9:30–10:00	ZHG010	**Representing quantum physics: The role of notation in the construction of quantum mechanics** — •Arianna Borrelli
SYHQ 1.3	Mon	10:00–10:30	ZHG010	**The Nobel committee's position on quantum mechanics: Nominations, evaluations and decisions** — •Karl Grandin
SYHQ 2.1	Mon	14:00–14:30	ZHG010	**Model and Target: Von Neumann's Mathematische Grundlagen** — •Michael Stöltzner
SYHQ 2.2	Mon	14:30–15:00	ZHG010	**Tracing the dissemination of quantum mechanics: A comparative approach** — •Roberto Lalli
SYHQ 2.3	Mon	15:00–15:30	ZHG010	**Quantum Mechanics and 'Aryan Physics'** — •Mark Walker
SYHQ 3.1	Mon	16:00–16:30	Forum Wissen	**Women in the History of Quantum Physics** — •Margriet van der Heijden
SYHQ 3.2	Mon	16:30–17:00	Forum Wissen	**Molecular WiHQP Vignettes: Hertha Sponer and Elizabeth Monroe** — •Patrick Charbonneau
SYHQ 3.3	Mon	17:00–17:30	Forum Wissen	**Grete Hermann: A pioneer of the philosophical debate about the foundations of quantum mechanics and a political activist** — •Andrea Reichenberger

Sessions

SYHQ 1.1–1.3	Mon	9:00–10:30	ZHG010	**History of Quantum Mechanics I: Revolution, Representation, Reevaluation**
SYHQ 2.1–2.3	Mon	14:00–15:30	ZHG010	**History of Quantum Mechanics II: Foundation, Dissemination, Politicization**
SYHQ 3.1–3.3	Mon	16:00–18:00	Forum Wissen	**Women in the History of Quantum Mechanics: The Project and its New Insights**
SYHQ 4	Tue	18:00–21:30	Aula am Wilhelmsplatz with broadcast to ZHG010 and ZHG011	**EPS historic site event**

Sessions

– Invited Talks –

SYHQ 1: History of Quantum Mechanics I: Revolution, Representation, Reevaluation

Time: Monday 9:00–10:30 Location: ZHG010

Invited Talk SYHQ 1.1 Mon 9:00 ZHG010

Heisenberg's Umdeutung — •Alexander Blum — LMU München

What did Heisenberg actually think he was doing when he constructed the foundations of matrix mechanics in May/June 1925? Later on, he would famously (and vehemently) argue for a probabilistic interpretation against Schrödinger. But in the summer of 1925, months before Schrödinger would publish his wave equation, Heisenberg's interpretation was far more tentative and far more concerned with aspects of spectroscopy. In my talk, I will analyze what meaning Heisenberg initially ascribed (and didn't ascribe) to the matrix elements in the theory he was building.

Invited Talk SYHQ 1.2 Mon 9:30 ZHG010

Representing quantum physics: The role of notation in the construction of quantum mechanics — •Arianna Borrelli — Technische Universität Berlin

The relationship between physical notions and the mathematical structures expressing them is an issue of primary importance in the history and philosophy of science. Historical evidence suggests that, when investigating the relationship between physics and mathematics, one should pay attention to the notations mediating it: spoken or written words, drawings, symbols and more. The history of quantum mechanics offers a very good example of how new physics and new mathematics can emerge as one, and of how notation plays a central role in shaping both.

Invited Talk SYHQ 1.3 Mon 10:00 ZHG010

The Nobel committee's position on quantum mechanics: Nominations, evaluations and decisions — •Karl Grandin — Royal Swedish Academy of Science, Stockholm, Sweden

The recognition of quantum mechanics within the framework of the Nobel Prize in Physics illustrates not only its groundbreaking impact on theoretical physics but also the evolving criteria for scientific distinction in the early 20th century. Werner Heisenberg was awarded the 1932 Nobel Prize in Physics, received in 1933, for his foundational contributions to quantum mechanics, particularly the formulation of matrix mechanics. That same year, Erwin Schrödinger and Paul Dirac shared the 1933 Nobel Prize in Physics, acknowledging their work on wave mechanics and the relativistic quantum theory of the electron, respectively.

Nominations for Heisenberg and Schrödinger began as early as 1928, gaining momentum in subsequent years, reflecting the scientific community*s growing appreciation of their contributions. By contrast, Dirac*s nominations were initially fewer, highlighting differing trajectories in the recognition of theoretical achievements. In 1933, all three physicists received special evaluations from the Nobel Committee, with the first such evaluations for Heisenberg and Schrödinger emerging only in 1931.

SYHQ 2: History of Quantum Mechanics II: Foundation, Dissemination, Politicization

Time: Monday 14:00–15:30 Location: ZHG010

Invited Talk SYHQ 2.1 Mon 14:00 ZHG010

Model and Target: Von Neumann's Mathematische Grundlagen — •Michael Stöltzner — University of South Carolina, Columbia, SC, USA

Based on joint work with Hilbert and Nordheim in 1927 and amended with a detailed discussion of measurement, von Neumann's 1932 'Mathematische Grundlagen der Quantenmechanik' was generally considered as the definitive formulation of the theory in rigorous mathematical terms. Especially the no-hidden-variable theorem was often read as a philosophically motivated finality claim. Accordingly, it became attacked by proponents of alternative interpretations, in the case of John Bell even together with mathematical physics as such. But this misunderstands the place that the book had in von Neumann's own work – he quickly moved on from Hilbert spaces to operator algebras – and in his increasingly opportunist understanding of mathematics. Understanding the context of von Neumann's book, including why he stressed the uniqueness and non-extendibility of quantum mechanics, helps to understand the multiple roles his work would play shortly after his death when a renaissance of mathematical physics took place in quantum field theory, and eventually also in atomic physics.

Invited Talk SYHQ 2.2 Mon 14:30 ZHG010

Tracing the dissemination of quantum mechanics: A comparative approach — •Roberto Lalli — Politecnico di Torino, Turin, Italy

The dissemination of quantum mechanics presents significant methodological challenges to historians of science. Exploring how quantum knowledge circulated after 1925, scholars have often adopted case study approaches tailored to specific artifacts, sociocultural settings, or conceptual debates, such as foundational controversies.These diverse perspectives reflect the complexity of tracing knowledge transfer, as the choice of sources*textbooks, conference proceedings, papers, letters, or other materials*critically shapes the narratives constructed. In this talk, I review the methodologies used to study the dissemination of quantum physics and then adopt a comparative approach, focusing on the roles of industrial laboratories, international institutions (such as IUPAP), as well as a network analysis of scientific publications. By analyzing these distinct yet interconnected contexts, I aim to identify patterns and dependencies in the circulation of quantum knowledge, shedding light on the broader historiographical implications of studying its diffusion across scientific, industrial, and institutional landscapes.

Invited Talk SYHQ 2.3 Mon 15:00 ZHG010

Quantum Mechanics and 'Aryan Physics' — •Mark Walker — Dept. of History, Union College, Schenectady, NY USA

This talk will examine the political and ideological attacks made by the Nobel laureate Johannes Stark against quantum mechanics and the scientists associated with it, both during the Weimar Republic and the Third Reich. I will also discuss how established scientists like Werner Heisenberg fought back.

SYHQ 3: Women in the History of Quantum Mechanics: The Project and its New Insights

Time: Monday 16:00–18:00 Location: Forum Wissen

Invited Talk SYHQ 3.1 Mon 16:00 Forum Wissen

Women in the History of Quantum Physics — •Margriet van der Heijden — Eindhoven University of Technology (TU/e), The Netherlands

The narratives of the development of quantum mechanics are as "male-dominated" as this subfield of science itself, science historian Massimiliano Badino noted some nine years ago. The book Women in the History of Quantum Physics: Beyond Knabenphysik aims to challenge these conventional "all-male" narratives. In sixteen chapters, the authors – all members of the international and interdisciplinary working group Women in the History of Quantum Physics – analyse the work and lives of women who contributed to quantum developments in the twentieth century. Not the handful of famous women like Marie Skłodowska Curie, Maria Goeppert Mayer and Lise Meitner, but the women who remained in the shadows, had to interrupt their careers or whose work was overlooked. By analysing and comparing their lives and work, themes can be distilled that are relevant to understanding why women's participation in physics research remains low even today. I will explore some of these themes and illustrate them with the lives and experiences of some of the protagonists of the book chapters.

Invited Talk SYHQ 3.2 Mon 16:30 Forum Wissen

Molecular WiHQP Vignettes: Hertha Sponer and Elizabeth Monroe — •Patrick Charbonneau — Duke University, Durham, NC, USA

Hertha Sponer spent her early years in Göttingen, at the center of the quantum revolution. Training as an experimentalist under Peter Debye and then heading James Franck's spectroscopy labs as his assistentin uniquely positioned her to contribute to the development of quantum theory and to the emergence of molecular physics. She did so by providing novel interpretations of hitherto unexplained spectrographic data, and by suggesting new applications of the theory to diatomics. Her name has nevertheless been largely written out of scientific accounts of these years. Extant descriptions almost exclusively concern her postwar years at Duke. By that time quantum theory was well established, and her research had pivoted in other directions.

Elizabeth Monroe did not spend time in Göttingen, but trained with two scientists who did: Emmy Noether at Bryn Mawr and John E. Lennard-Jones at Cambridge. Her PhD work on computational methods for solving the electronic structure of simple diatomics followed from that influence. World War II, however, took her away from quantum mechanics. She joined John G. Kirkwood at Cornell to study hard sphere crystallization and later worked on the Manhattan project to develop implosion technology. Following the birth of her son, who suffered from a severe developmental disability, she took up public advocacy, building on her training to move research and policy forward. Others took up computational quantum chemistry.

Invited Talk SYHQ 3.3 Mon 17:00 Forum Wissen

Grete Hermann: A pioneer of the philosophical debate about the foundations of quantum mechanics and a political activist — •Andrea Reichenberger — TU Munich

Grete Hermann, the first doctoral student of mathematician Emmy Noether and private assistant of philosopher Leonard Nelson, was one of the early contributors to the foundations of quantum mechanics. She was also one of Göttingen's most important philosophers. With the advent of National Socialism, Hermann, like many of her colleagues, left Göttingen. While other émigrés had a lasting impact on physics and mathematics abroad, after the war, Hermann instead chose to return to her home country in 1946. As a political activist in the anti-fascist resistance and in post-war education and politics, she played a key role in the social democratic development of the Federal Republic of Germany. A common thread through her work are the Kantian questions: What can I know? And what should I do? My talk explores Hermann's answers to both of these.

30 min. discussion

SYHQ 4: EPS historic site event

Time: Tuesday 18:00–21:30 Location: Aula am Wilhelmsplatz with broadcast to ZHG010 and ZHG011

About 105 min. lecture programme followed by a reception at the Alte Mensa.

Symposium SMuK Dissertation Prize 2025 (SYMD)

jointly organised by
the divisions of the Matter and Cosmos Section (SMuK)

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The Matter and Cosmos Section, with its divisions Extraterrestrial Physics (EP), Gravitation and Relativity (GR), Hadronic and Nuclear Physics (HK), Theoretical and Mathematical Physics (MP), Plasma Physics (P), Radiation and Medical Physics (ST), and Particle Physics (T), awards a dissertation prize in recognition of outstanding research in the context of a doctoral thesis and its excellent communication. The award committee selects up to four candidates from the nominations who will present their doctoral theses at this symposium. The winner will be announced at the beginning of the Awards Symposium (SYAS) on Tuesday at 11 am.

Overview of Invited Talks and Sessions

(Lecture hall ZHG011)

Invited Talks

SYMD 1.1	Mon	14:15–14:45	ZHG011	**Fluid-dynamic description of heavy-quark diffusion in the quark-gluon plasma** — •Federica Capellino
SYMD 1.2	Mon	14:45–15:15	ZHG011	**Fast and faithful effective-one-body models for gravitational waves from generic compact binaries** — •Rossella Gamba
SYMD 1.3	Mon	15:15–15:45	ZHG011	**Nuclear Structure Near Doubly Magic Nuclei** — •Lukas Nies
SYMD 1.4	Mon	15:45–16:15	ZHG011	**Optimisation strategies for proton acceleration from thin foils with petawatt ultrashort pulse lasers** — •Tim Ziegler

Sessions

SYMD 1.1–1.4	Mon	14:15–16:15	ZHG011	**SMuK Dissertation Prize 2025**

Sessions

– Invited Talks –

SYMD 1: SMuK Dissertation Prize 2025

Time: Monday 14:15–16:15 Location: ZHG011

Invited Talk SYMD 1.1 Mon 14:15 ZHG011

Fluid-dynamic description of heavy-quark diffusion in the quark-gluon plasma — •Federica Capellino — GSI Helmholtzzentrum Darmstadt

Relativistic heavy-ion collisions are a powerful tool to explore the phase diagram of Quantum Chromodynamics (QCD). Under the extreme energy conditions reached within these experiments, nuclear matter undergoes a transition to a deconfined phase, in which the active degrees of freedom are quarks and gluons, known as quark-gluon plasma (QGP). The characterization of the QGP and its transport properties constitutes one of the main goals of the high-energy nuclear physics program worldwide. Heavy quarks, i.e., charm and beauty, have long been established as excellent probes to characterize the QGP. Due to their large mass, heavy quarks can be produced only via hard partonic scattering processes that take place at the very beginning of the collision, before the QGP is formed. In this talk, I will present a new way of describing heavy-quark dynamics in the QGP based on fluid dynamics. On the one hand, our model allows us to phenomenologically access QCD properties such as the heavy-quark spatial diffusion coefficient. Secondly, it pursues the idea of a universal effective description unifying light and heavy degrees of freedom. It poses the fundamental question of whether the behavior of a complex system like the QGP, which spans over three orders of magnitude in mass scales (from MeV to GeV), can be described by a few macroscopic thermodynamic quantities defined in local kinetic equilibrium.

Invited Talk SYMD 1.2 Mon 14:45 ZHG011

Fast and faithful effective-one-body models for gravitational waves from generic compact binaries — •Rossella Gamba — UC Berkeley, Berkeley (CA), USA — Penn State University, University Park (PA), USA

The detection and analysis of gravitational waves (GWs) from compact binary systems rely on precise modeling of the expected signals. However, accurately modeling GWs emitted by coalescing binary black hole (BBH) and binary neutron star (BNS) systems remains a formidable challenge due to the complexity of the underlying physical processes.

In this talk, I will summarize my efforts toward the development of computationally efficient and accurate models for GWs emitted by generic compact binary systems within the effective-one-body framework. The term "generic" here encompasses both the nature of the binary components – black holes, neutron stars, or mixed systems – and the diverse properties influencing their evolution, including eccentricity, spin effects, and matter interactions. I will then discuss their application to real GW data analysis.

Invited Talk SYMD 1.3 Mon 15:15 ZHG011

Nuclear Structure Near Doubly Magic Nuclei — •Lukas Nies — CERN

In this contribution, we investigate the strong force in atomic nuclei, i.e. the way nucleons arrange themselves in a many-body system governed by the repulsive Coulomb interaction and the attractive strong interaction. We will focus on nuclear structure near nuclei with a "magic number" of Z protons and N neutrons, so-called doubly-magic nuclei, exhibiting a particularly stable configuration with respect to neighboring nuclei. Within the nuclear shell model, similar to the atomic shells, the magic numbers indicate shell closures accompanied by energy gaps. Nuclei at double-shell closures and their direct vicinity provide an important playground to benchmark nuclear theories and models that aim to predict the intricate interplay of the nucleons that lead to enhanced nuclear binding energies, significant changes in charge radii and transition strengths, etc. Of particular interest are nuclear isomers, long-lived excited states, in which the nucleon configuration is altered, resulting in a modification of their nuclear properties despite having the same number of protons and neutrons. In ^{99}In, one proton away from the important doubly-magic nucleus ^{100}Sn, we found the isomeric state exhibiting contrasting trends in binding energies and compared these with nuclear electromagnetic moments. In ^{79}Zn, near the doubly-magic nucleus ^{78}Ni, we discovered that the isomer shows signs of shape coexistence, which has strong implications on the magicity of ^{78}Ni. In this presentation, we will revisit these two isomers and put them into a greater context in modern nuclear theory.

Invited Talk SYMD 1.4 Mon 15:45 ZHG011

Optimisation strategies for proton acceleration from thin foils with petawatt ultrashort pulse lasers — •Tim Ziegler — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — TUD Dresden University of Technology, Dresden, Germany

Laser-driven plasma accelerators can produce pulsed multi-MeV ion beams with high peak currents by irradiating solid materials with ultra-intense laser pulses. This innovative concept attracts much attention for various multidisciplinary applications as a compact and energy-efficient alternative to conventional accelerators. The maturation of plasma accelerators from complex physics experiments to turnkey particle sources for practical applications requires breakthroughs in the generated beam parameters, their robustness and scalability.

In this work, new benchmarks for accelerator performance and understanding of the underlying interaction physics were achieved through combining innovative laser diagnostics, advanced measurement techniques and hybrid simulation approaches. This enabled precise tuning of interaction conditions for optimized performance in established acceleration regimes and facilitated the exploration of relativistically transparent targets. The results from this advanced regime far exceeded previous records, demonstrating the immense potential of this technology. The strategies outlined provide a roadmap for advancing and integrating plasma accelerators into scientific, industrial, and medical fields.

Symposium Turbulence in Space and Fusion Plasmas (SYSF)

jointly organised by
the Extraterrestial Physics Division (EP) and
the Plasma Physics Division (P)

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Overview of Invited Talks and Sessions

(Lecture hall ZHG101)

Invited Talks

SYSF 1.1	Wed	13:45–14:15	ZHG101	**Addressing turbulence questions in the Wendelstein 7-X stellarator device - a combined experimental and theoretical approach** — •Josefine Proll, Paul Mulholland, MJ Pueschel, Maikel Morren, Gavin Weir, Ksenia Aleynikova, Adrian von Stechow, Pavlos Xanthopoulos, Gabriel Plunk, the W7-X Team
SYSF 1.2	Wed	14:15–14:45	ZHG101	**Particle acceleration and transport in astrophysical, magnetized turbulent plasmas** — •Martin Lemoine
SYSF 1.3	Wed	14:45–15:15	ZHG101	**Turbulence in the young solar wind, results from Solar Orbiter and Parker Solar Probe** — •Robert Wicks, Utsav Panchal, Julia Stawarz, Stefan Lotz, Du Toit Strauss, Amore Nel
SYSF 1.4	Wed	15:15–15:45	ZHG101	**Digital Solutions for EUROfusion** — •Volker Naulin

Sessions

SYSF 1.1–1.4	Wed	13:45–15:45	ZHG101	**Turbulence in Space and Fusion Plasmas**

Sessions

– Invited Talks –

SYSF 1: Turbulence in Space and Fusion Plasmas

Time: Wednesday 13:45–15:45 Location: ZHG101

Invited Talk SYSF 1.1 Wed 13:45 ZHG101

Addressing turbulence questions in the Wendelstein 7-X stellarator device - a combined experimental and theoretical approach — •Josefine Proll[1,2], Paul Mulholland[2], MJ Pueschel[2,3], Maikel Morren[2], Gavin Weir[1], Ksenia Aleynikova[1], Adrian von Stechow[1], Pavlos Xanthopoulos[1], Gabriel Plunk[1], and the W7-X Team[1] — [1]Max Planck Institute for Plasma Physics, Greifswald, Germany — [2]Eindhoven University of Technology, Eindhoven, The Netherlands — [3]DIFFER, Eindhoven, The Netherlands

With the advent of stellarators optimised for low collisional transport such as Wendelstein 7-X (W7-X), turbulence has become one of the main obstacles to a working fusion reactor. Tapping into the free energy of gradients in density and temperature, turbulence will cause outward transport of heat and particles and severely limit the achievable core density and temperature and thus the reactor performance. With W7-X, we can directly probe turbulence in the flexible magnetic geometry and compare against state-of-the-art gyrokinetic codes. In this talk, I will present recent findings on electrostatic and electromagnetic turbulence in W7-X, e.g. how, at much lower normalised plasma pressure beta than previously anticipated, kinetic ballooning modes appearing below the MHD threshold can lead to an increase in ITG turbulence or that heat-pulse propagation experiments confirm rather benign transport caused by electron-temperature gradient modes. I will close with an outlook of unanswered questions both from theory and experiment and how we plan to address them on W7-X.

Invited Talk SYSF 1.2 Wed 14:15 ZHG101

Particle acceleration and transport in astrophysical, magnetized turbulent plasmas — •Martin Lemoine — Astroparticule & Cosmologie (APC, CNRS, Universite Paris-Cite), F-75013 Paris, France

How charged particles are transported in phase space in magnetized turbulence is a broad topic in plasma physics with fundamental applications in astrophysics, from solar system plasmas to the more extreme plasmas of the high-energy multi-messenger universe. In its most standard formulation, such transport is described by a quasilinear formalism that ascribes pitch-angle scattering and momentum diffusion to wave-particle interactions. This talk examines an alternative picture, in which transport is rather mediated by coherent/intermittent structures. It will discuss the possibility that spatial transport occurs through localized interactions with sharp magnetic field bends and that particle acceleration can take place through interactions with coherent velocity structures. Finally, it will discuss these findings in the broader context of recent (kinetic and magnetohydrodynamic) numerical simulations of particle transport and acceleration.

Invited Talk SYSF 1.3 Wed 14:45 ZHG101

Turbulence in the young solar wind, results from Solar Orbiter and Parker Solar Probe — •Robert Wicks[1], Utsav Panchal[1], Julia Stawarz[1], Stefan Lotz[2], Du Toit Strauss[3], and Amore Nel[2] — [1]Northumbria University, Newcastle, NE1 8ST, UK — [2]South African National Space Agency, Hermanus, 7200, South Africa — [3]Center for Space Research, North-West University, Potchefstroom, 2522, South Africa

Five years of observations by Parker Solar Probe (PSP) and Solar Orbiter (SO) have revolutionised our view of the inner heliosphere, challenged established theories of solar wind acceleration and heating, and demonstrated the essential interaction of kinetic plasma physics and large-scale structure. Unexpected revelations include the prevalence of ion beams, kinetic waves, and magnetic inversions commonly called switchbacks - all key ingredients of the reorganisation of energy that defines the young solar wind.

In this talk, we will review results from PSP and SO that show that the inner 0.4 au of the heliosphere plays a role as significant as the coronal source region in determining the properties of the solar wind. Here, the young solar wind undergoes processes that modify the structure of the plasma as energy is exchanged between electromagnetic, kinetic, and internal energy of particle populations. In particular, we will look at the initialisation of turbulence, the dissipation of energy and its impact on ion and electron distributions as the highly structured near-coronal wind expands and evolves into the solar wind.

Invited Talk SYSF 1.4 Wed 15:15 ZHG101

Digital Solutions for EUROfusion — •Volker Naulin — EUROfusion — DTU, Lyngby, Denmark

EUROfusion is the European consortium uniting the efforts of 27 countries to advance towards a DEMO fusion device and support ITER in achieving its goal of a fusion power amplification of a factor of 10. As part of this mission, EUROfusion runs 16 Theory, Simulation, Validation, and Verification (TSVV) projects, which are dedicated to advancing the understanding of fusion plasma physics and enabling robust, predictive simulations. These efforts rely on professionally developed and validated codes, ensuring reliability and accuracy in capturing the complex physics of fusion systems.

Significant progress has been made in understanding plasma confinement, but larger challenges remain, particularly regarding the complex, multiscale, and nonlinear dynamics of fusion plasmas. Turbulence, the primary driver of transport processes, is being addressed by High-performance numerical codes, which have been instrumental in providing detailed insights so far, but new approaches are needed to address the remaining challenges.

Artificial intelligence (AI) and machine learning (ML) offer powerful tools to uncover missing physics. Surrogate models approximate the complex behavior of fusion plasmas. These methods can provide valuable insights into strongly nonlinear processes, such as structure formation and non-local transport, enabling better predictions and control of plasma dynamics.

Physics Education Division
Fachverband Didaktik der Physik (DD)

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Übersicht über Hauptvorträge, Fachsitzungen und Workshops

Hörsaal: ZGH103
Seminarräume: OEC 1.162, OEC 1.163, Theo 0.134, Theo 0.135, Theo 0.136
Poster: ZHG Foyer 1.OG

Plenarvortrag der Didaktik

PV IV	Tue	9:45–10:30	ZHG011	**Equipping the Next Generation: Quantum Education and Workforce Development in the U.S.** — •Heather Lewandowski

Preisträger-Vorträge in SYAS und DD

SYAS 1.1	Tue	11:05–11:35	ZHG011	**Zum Verhältnis von Physikdidaktik und Physikunterricht** — •Rita Wodzinski
SYAS 1.2	Tue	11:35–12:05	ZHG011	**(Quanten-)Physik für alle mit dem PhotonLab** — •Silke Stähler-Schöpf
SYAS 1.3	Tue	12:05–12:35	ZHG011	**Searching for the fingerprints of new phenomena with top quarks** — •Katharina Behr
DD 13.1	Tue	13:30–14:10	Theo 0.135	**Physikunterricht im 21. Jahrhundert gestalten: MakerSpace, Deeper Learning & innovative Prüfungsformate für mehr Schüler:innenmotivation** — •Matthias Harnischmacher

Hauptvorträge

DD 1.1	Mon	14:00–15:00	ZHG103	**100 Jahre Quantenphysik - und was haben wir daraus gelernt?** — •Stefan Heusler
DD 45.1	Wed	14:45–15:45	ZHG103	**Moderne Physik, moderne Bildung: Zukunftsperspektiven für den Physikunterricht im Wandel** — •Magdalena Kersting

Fachsitzungen

DD 1.1–1.1	Mon	14:00–15:00	ZHG103	**Eröffnung und Hauptvortrag I**
DD 2.1–2.3	Mon	15:15–16:15	Theo 0.136	**Hochschuldidaktik I**
DD 3.1–3.3	Mon	15:15–16:15	Theo 0.135	**Quantenphysik I**
DD 4.1–4.3	Mon	15:15–16:15	Theo 0.134	**KI I**
DD 5.1–5.3	Mon	15:15–16:15	OEC 1.163	**Astronomie I**
DD 6.1–6.3	Mon	15:15–16:15	OEC 1.162	**Inklusion**
DD 7.1–7.1	Mon	16:45–18:45	Theo 0.136	**Workshop Standards Lehrkräftebildung**
DD 8.1–8.4	Mon	16:45–18:05	Theo 0.135	**Quantenphysik II**
DD 9.1–9.4	Mon	16:45–18:05	Theo 0.134	**Lehrkräftebildung I**
DD 10.1–10.4	Mon	16:45–18:05	OEC 1.163	**Physikalische Praktika**
DD 11.1–11.4	Mon	16:45–18:05	OEC 1.162	**Außerschulische Lernorte**
DD 12.1–12.3	Tue	13:30–14:30	Theo 0.136	**Hochschuldidaktik II**
DD 13.1–13.1	Tue	13:30–14:10	Theo 0.135	**Preisträgervortrag**
DD 14.1–14.1	Tue	14:10–14:30	Theo 0.135	**Praxisblick**
DD 15.1–15.3	Tue	13:30–14:30	Theo 0.134	**KI II**

DD 16.1–16.3	Tue	13:30–14:30	OEC 1.163	**Astronomie II**
DD 17.1–17.3	Tue	14:45–15:45	Theo 0.136	**Hochschuldidaktik III**
DD 18.1–18.3	Tue	14:45–15:45	Theo 0.135	**Neue / Digitale Medien**
DD 19.1–19.3	Tue	14:45–15:45	Theo 0.134	**KI III**
DD 20.1–20.3	Tue	14:45–15:45	OEC 1.163	**BNE**
DD 21.1–21.3	Tue	14:45–15:45	OEC 1.162	**Lehr-Lernforschung I**
DD 22.1–22.1	Tue	16:15–17:45	ZHG Foyer 1. OG	**Poster – Anregungen Unterricht**
DD 23.1–23.1	Tue	16:15–17:45	ZHG Foyer 1. OG	**Poster – Astronomie**
DD 24.1–24.2	Tue	16:15–17:45	ZHG Foyer 1. OG	**Poster – Außerschulische Lernorte**
DD 25.1–25.3	Tue	16:15–17:45	ZHG Foyer 1. OG	**Poster – Bildung für nachhaltige Entwicklung**
DD 26.1–26.7	Tue	16:15–17:45	ZHG Foyer 1. OG	**Poster – Hochschuldidaktik**
DD 27.1–27.10	Tue	16:15–17:45	ZHG Foyer 1. OG	**Poster – Lehr-Lernforschung**
DD 28.1–28.5	Tue	16:15–17:45	ZHG Foyer 1. OG	**Poster – Lehreraus- und -fortbildung**
DD 29.1–29.8	Tue	16:15–17:45	ZHG Foyer 1. OG	**Poster – Neue / digitale Medien**
DD 30.1–30.8	Tue	16:15–17:45	ZHG Foyer 1. OG	**Poster – Neue Konzepte**
DD 31.1–31.9	Tue	16:15–17:45	ZHG Foyer 1. OG	**Poster – Praktika und Experimente**
DD 32.1–32.14	Tue	16:15–17:45	ZHG Foyer 1. OG	**Poster – Quantenphysik**
DD 33.1–33.2	Tue	16:15–17:45	ZHG Foyer 1. OG	**Poster – Geschichte und NoS**
DD 34	Tue	18:00–20:00	ZHG103	**Mitgliederversammlung**
DD 35.1–35.1	Wed	11:00–12:30	Theo 0.136	**Workshop Studienreformforum**
DD 36.1–36.4	Wed	11:00–12:20	Theo 0.135	**Quantenphysik III**
DD 37.1–37.4	Wed	11:00–12:20	Theo 0.134	**Lehrkräftebildung II**
DD 38.1–38.4	Wed	11:00–12:20	OEC 1.163	**Geschichte / NoS**
DD 39.1–39.4	Wed	11:00–12:20	OEC 1.162	**Lehr-Lernforschung II**
DD 40.1–40.3	Wed	13:30–14:30	Theo 0.136	**Hochschuldidaktik IV**
DD 41.1–41.3	Wed	13:30–14:30	Theo 0.135	**Analysen**
DD 42.1–42.3	Wed	13:30–14:30	Theo 0.134	**Digitale Medien – Smartphone**
DD 43.1–43.3	Wed	13:30–14:30	OEC 1.163	**Sprache**
DD 44.1–44.3	Wed	13:30–14:30	OEC 1.162	**Lehr-Lernforschung III**
DD 45.1–45.1	Wed	14:45–15:45	ZHG103	**Hauptvortrag II und Verabschiedung**

Mitgliederversammlung des Fachverbands Didaktik der Physik

Dienstag 01.04.2025 18:00–20:00 ZGH103

- Genehmigung der Tagesordnung
- Genehmigung des Protokolls der MV vom 27.02.2024
- Berichte aus den Arbeitsgruppen
- Termine
- Verschiedenes

Sessions

– Invited Talks, Prize Talks, Group Reports, Contributed Talks, and Posters –

DD 1: Eröffnung und Hauptvortrag I

Time: Monday 14:00–15:00 Location: ZHG103

Invited Talk DD 1.1 Mon 14:00 ZHG103

100 Jahre Quantenphysik - und was haben wir daraus gelernt? — •Stefan Heusler — Wilhelm Klemm Str. 10

Nur die Quantentheorie ist in der Lage, mehrmals 100 Jahre alt zu werden. Bereits im Jahr 2000 feierte die DPG in einer Jubiläumswoche "100 Jahre Quantentheorie", wobei Bezug auf die Herleitung des Strahlungsgesetzes am 14. Dezember 1900 von Max Planck auf einer Sitzung der Deutschen Physikalischen Gesellschaft in Berlin Bezug genommen wurde. Diesmal wird "100 Jahre Quantentheorie" ein ganzes Jahr lang gefeiert: Die Vereinten Nationen haben das Jahr 2025 zum Internationalen Jahr der Quantenwissenschaft und -technologie ausgerufen, wobei Bezug auf die revolutionären Arbeiten genommen wird, die vor allem in Göttingen um 1925 entstanden waren. Die in dieser Zeit gefundenen abstrakten, mathematischen Konzepte der Quantentheorie sind bis heute Grundlage einer Vielzahl technologischer Anwendungen, was die immense gesellschaftliche Bedeutung der Quantenphysik begründet.

Seit Jahrzehnten ist Quantenphysik fester Bestandteil des Schulcurriculums, und wird durch die neuen KMK-Vorgaben in ihrer Bedeutung weiter gestärkt. Im Vortrag geben wir einen Überblick über die aktuelle, hohe Dynamik auf dem Gebiet der Didaktik der Quantenphysik, die von sehr verschiedenen und sich teils widersprechenden Interessen gesteuert wird, und hinterfragen dabei kritisch den Bildungswert von Quantenphysik für allgemein bildende Schulen.

DD 2: Hochschuldidaktik I

Time: Monday 15:15–16:15 Location: Theo 0.136

DD 2.1 Mon 15:15 Theo 0.136

Förderung spezifischer Wissensarten für die Studieneingangsphase Physik — •Kai Cardinal[1], Julia-Marie Tocco[2], Andreas Borowski[3], Philipp Schmiemann[2] und Heike Theyssen[1] — [1]Universität Duisburg-Essen, Didaktik der Physik — [2]Universität Duisburg-Essen, Biology Education Research and Learning Lab — [3]Universität Potsdam, Didaktik der Physik

Im Rahmen des Projekts EASTER (Einfluss der Förderung spezifischer Wissensarten auf den Studienerfolg in Biologie und Physik) erfolgte eine gezielte Förderung der Wissensarten Konzeptverständnis und Wissensanwendung in Physik. Konzeptverständnis beschreibt die Fähigkeit physikalische Konzepte zu verstehen und zu beschreiben. Die Fähigkeit zur Wissensanwendung umfasst das Finden eines geeigneten (Lösungs-)Ansatzes sowie die Ausarbeitung der Lösung unter Nutzung allgemeiner Rechenfähigkeiten. Beide Wissensarten sind prädiktiv für den Studienerfolg im ersten Fachsemester (Binder et al., 2019). In zwei Interventionsgruppen wurde die Wissensanwendung mittels Lösungsbeispielen (N = 44) und das Konzeptverständnis mittels Begriffsnetzen (N = 40) gefördert. Eine Kontrollgruppe (N = 51) erhielt keine Förderung. Im Vortrag werden die Konzeptionen der Fördermaßnahmen und deren Wirkungen auf die adressierten Wissensarten vorgestellt.

DD 2.2 Mon 15:35 Theo 0.136

Adaptive (digitale) Auffrischungsangebote in der Studieneingangsphase zur Reduktion von Studienabbrüchen — •Caroline Wortmann[1] und Elena Schmitt[2] — [1]TU Dortmund, Deutschland, Fakultät Physik — [2]TU Dortmund, Deutschland, Qualitätsmanagement Studium und Lehre

Das Verbundprojekt beVinuS.nrw (TU Dortmund, BU Wuppertal, RWTH Aachen) hat sich zum Ziel gesetzt, Studienabbruchquoten in MINT-Studiengängen, die aufgrund mangelnder schulischer Mathematik-Kompetenzen in der Studieneingangsphase zustande kommen, zu reduzieren. Dazu werden fakultätsspezifische, vorlesungsabgestimmte, digitale Selbsttests zu den mathematischen Kompetenzen und ein darauf aufbauendes, digitales Selbstlernangebot auf Grundlage bestehender OER -Inhalte entwickelt, um die im Selbsttest diagnostizierten Kompetenzdefizite zu schließen. Darüber hinaus wird ein Katalog mit digitalen Selbstlerneinheiten und Präsenzangeboten an der TU Dortmund zusammengestellt, um disziplinübergreifende Kompetenzen (z.B. Lernstrategien, Umgang mit Prokrastination) zu schulen. Um das Angebot sinnvoll in das Studium zu integrieren, wird außerdem ein Reformmodell entwickelt, das erlaubt, die individualisierte Regelstudienzeit durch Nutzung der Angebote parallel zur Studieneingangsphase um ein Semester zu erhöhen.

An der Fakultät Physik der TU Dortmund startete die Pilotphase im WS 2024/25. Der Vortrag beleuchtet die Konzeption des Programms, das entwickelte Angebot in der Fakultät Physik sowie erste Ergebnisse und mögliche Weiterentwicklungen.

DD 2.3 Mon 15:55 Theo 0.136

Physik als Nebenfach im Studium - Wie kann man die Physik attraktiver machen? — •Irina Schneider — Institut für Experimentelle und Angewandte Physik www.ieap.uni-kiel.de Christian-Albrechts-Universität zu Kiel Leibnizstraße 19 24098 Kiel

Die Studierenden Physik als Nebenfach haben oft Probleme damit, bei der Physik richtig anzukommen, sie sind sich oft unsicher, ob sie den Lernstoff richtig verstehen. Das führt zu Blockaden im Lernprozess. Oft sind die Blockaden auch zusätzlich durch einige negative Erfahrungen mit der Physik in der Schule verursacht. Wie kann man den Studierenden hier helfen? An der Universität Kiel versuchen wir verschiedene Lernformen anzuwenden, um die Physik für Studierende attraktiver und auch transparenter zu machen, um ihnen zu zeigen, wie faszinierend spannend und interessant Physik wirklich ist. Das hilft tatsächlich, die Blockaden und Hindernisse im Lernprozess langsam zu überwinden.

DD 3: Quantenphysik I

Time: Monday 15:15–16:15 Location: Theo 0.135

DD 3.1 Mon 15:15 Theo 0.135

Förderung funktionaler Denkweisen Lernender durch Einführung der Dirac-Notation im Quantenphysikunterricht — •Fabian Hennig[1], Kristof Tóth[2], Joaquin Veith[1] und Philipp Bitzenbauer[1] — [1]Institut für Didaktik der Physik, Leipzig, Deutschland — [2]Institute of Physics and Astronomy, Budapest, Hungary

Schülervorstellungen in der Quantenphysik lassen sich häufig auf ein zu wenig elaboriertes Modellverständnis der Lernenden zurückführen. Ein sich in bisherigen empirischen Untersuchungen bewährtes Modell beschreibt dieses Verständnis dabei in zwei unabhängigen Dimensionen: Gestalt- und Funktionstreue. Insbesondere letztere Dimension ist von besonderer Bedeutung für den Physikunterricht, da Konzeptverständnis Lernender signifikant mit dem Grad der Funktionstreue korreliert ist. Wie dieser Grad an Funktionstreue gezielt gefördert werden kann, ist jedoch noch Gegenstand aktueller Forschung. Wir präsentieren dazu die Ergebnisse einer quasiexperimentellen Vergleichsstudie mit N=133 Lernenden, in der ein funktionales Modellverständnis des Photons gefördert werden soll durch eine formalistische Schreibweise, welche auf Dirac-Notation beruht. Mit Blick auf die Ausprägung des Grads der Funktionstreue im Denken der Lernenden zeigen sich im Posttest zwischen beiden Gruppen signifikante Unterschiede. Ebenso nahm in beiden Gruppen der Grad der Funktionstreue im Denken der Lernenden signifikant zu.

DD 3.2 Mon 15:35 Theo 0.135

Quantenphysik in Klasse 9: Ergebnisse einer Entwicklungs- und Evaluationsstudie — •Carsten Albert[1,2] und Gesche Pospiech[2] — [1]Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden — [2]Professur für Didaktik der Physik, Fakultät Physik, Technische Universität Dresden

Quantenphysik spielt eine zentrale Rolle in der modernen Wissenschaft und Technologie und gewinnt daher auch in der Bildung an Bedeutung. Mit dem Ziel, grundlegende Prinzipien der Quantenphysik bereits einer jungen Zielgrup-

pe zugänglich zu machen, wurde im Rahmen eines Promotionsprojektes ein Unterrichtskonzept zur Quantenphysik für Lernende der Klassenstufe 9 entwickelt, das die Grundidee von Quantencomputern als abschließendes Anwendungsbeispiel einbindet.

Das Konzept führt Prinzipien der Quantenphysik anhand eines Zweizustandssystems ein (Spin-First-Ansatz), während auf das Wellenkonzept verzichtet wird. Der Kurs entstand im Rahmen eines DBR-Ansatzes auf Basis grundlegender Design-Prinzipien sowie durch mehrfache Entwicklungszyklen. Das Unterrichtskonzept umfasst insbesondere auch konkrete Unterrichtsmaterialien, darunter ein Lehrbuch.

Im Schuljahr 2023/24 wurde das Unterrichtskonzept in einer Feldstudie in Zusammenarbeit mit 23 deutschsprachigen Schulen umfassend im Mixed-Methods-Design evaluiert. Die Ergebnisse belegen sowohl die Praxistauglichkeit als auch die Lernwirksamkeit des Ansatzes und dienen als Grundlage für abschließende Optimierungen der Materialien.

Der Vortrag gibt einen Einblick in den beschriebenen Ansatz sowie in die Ergebnisse der Evaluation.

DD 3.3 Mon 15:55 Theo 0.135

Quantentechnologien in der Schule: Unterricht zwischen Allgemeinbildung und Berufsorientierung — •Gesche Pospiech und Moritz Förster — Fakultät Physik, TU Dresden, Dresden

Im Bereich der Quantentechnologien wird ein wachsender Bedarf an spezifisch ausgebildeten Fachkräften erwartet. Ein Beitrag dazu, diesen Bedarf mittel- und langfristig zu decken, besteht darin (zukünftigen) Lehrkräften die Kompetenzen zu vermitteln, berufsorientierenden Unterricht mit realistischen Einblicken in das Berufsfeld zu gestalten.

Um dieses Ziel zu erreichen, wurde ein universitärer Kurs konzipiert, welcher neben theoretischen Grundlagen zum Thema ein didaktisch angeleitetes Industriepraktikum in den Quantentechnologien zum Kern hatte. Die Erfahrungen des Praktikums wurden durch die teilnehmenden Lehramtsstudierenden in der Konzeption einer berufsorientierenden Unterrichtseinheit verarbeitet, welche erprobt wurde.

In einem explorativen Studiendesign wurden leitfadengestützte Interviews durchgeführt, um zu untersuchen, welche Kenntnisse und Einstellungen Lehramtsstudierende zum Bereich der Quantentechnologien haben, wie sich der Kurs auf diese auswirkt und inwiefern die Gestaltung berufsorientierender Unterrichtskonzepte gelingt. Die Ergebnisse deuten darauf hin, dass die Lehramtsstudierenden Quantentechnologien als interessant und für den Unterricht geeignet, die Konzeption von berufsorientierenden Unterrichtsstunden zum Thema allerdings als herausfordernd empfinden.

Im Vortrag werden die Ergebnisse der Interviewstudie präsentiert.

DD 4: KI I

Time: Monday 15:15–16:15 Location: Theo 0.134

DD 4.1 Mon 15:15 Theo 0.134

Bewertung der fachlichen Korrektheit und des Nutzens von KI-Feedback durch Schülerinnen und Schüler — •Holger Maus — IPN Kiel

Automatisiertes Feedback bietet die Möglichkeit, Schülerinnen und Schüler im Lernprozess individuell zu unterstützen. Durch elaborierte Prompting-Strategien kann die Qualität des Feedbacks verbessert werden, jedoch lassen sich Fehler im Feedback nicht vermeiden. Daher ist es entscheidend, dass Schülerinnen und Schüler kritisch mit dem Feedback umgehen.

Gehen Schülerinnen und Schüler mit Fehlvorstellungen an physikalische Probleme heran, können diese von einem entsprechend geprompteten Sprachmodell erkannt und im Feedback aufgezeigt werden. Es ist jedoch auch möglich, dass diese Fehlkonzepte nicht erkannt oder sogar verstärkt werden. Hier stellt sich die Frage, wie Schülerinnen und Schüler die Rückmeldung einschätzen, wenn Fehlkonzepte in Frage gestellt werden oder durch das Sprachmodell Fehlkonzepte generiert werden.

Der Beitrag untersucht, wie Schülerinnen und Schüler Feedback in Bezug auf fachliche Korrektheit und den Nutzen für ihren Lernerfolg einschätzen, das durch ein gepromptetes Sprachmodell (GPT-4o) generiert wurde. Diese Einschätzung wird mit der fachlichen und fachdidaktischen Qualität des Feedbacks verglichen. Ausgewertet werden die Daten von Teilnehmerinnen und Teilnehmern der PhysikOlympiade in Deutschland, die physikalische Problemstellungen in einer Webanwendung bearbeiten und ein automatisiertes Feedback erhalten.

DD 4.2 Mon 15:35 Theo 0.134

KI-generiertes Feedback zu Reading Logs im Rahmen von einführenden Experimentalphysik-Veranstaltungen im Inverted Classroom Format — •Kathleen Falconer, Stefan Hoffmann, André Bresges, Luc di Lucia und Vittorio Iannuzzi — Universität zu Köln, Gronewaldstr. 2, 50931 Köln

Reading Logs werden seit mehr als 2 Jahren systematisch in fachlichen und didaktischen Physikveranstaltungen im Inverted-Classroom-Format im Bachelorstudium eingesetzt. In den Reading Logs (auch Learning Assessment Journals oder Logbücher genannt) sollen die Studierenden durch Leitfragen zu einem reflektierten Umgang mit neuen physikalischen Inhalten angeleitet werden. (MacIsaac, Schadschneider). Abhängig vom didaktischen Zweck können RL vor oder nach dem Unterricht eingesetzt werden. Hier werden sie vor dem Unterricht verwendet als eine Möglichkeit, die physikalischen Konzepte einzuführen. Die Studierenden analysieren und reflektieren die Materialien, formulieren offene Fragen und erreichen so eine bessere Vorbereitung für Activities und Problemlösen in den Präsenzveranstaltungen. Die Lehrenden erhalten dadurch eine Möglichkeit Probleme zu identifizieren und diese in der Gestaltung der Präsenzphase angemessen zu berücksichtigen. Im Learnig-by-Teaching-Konzept (Universität zu Köln) erhalten Physikstudierende die Möglichkeit, sich früh im Studium erlernte Inhalte in kleinen Lehr-Situationen zu erproben.

DD 4.3 Mon 15:55 Theo 0.134

Formatives Feedback durch generative KI in verschiedenen Lernumgebungen — •Stefan Küchemann[1], Steffen Steinert[1,2], Karina Avila[1,2] und Jochen Kuhn[1] — [1]Ludwig-Maximilians-Universität München, München, Deutschland — [2]RPTU Kaiserslautern-Landau, Kaiserslautern, Deutschland

Die Zahl der Lernumgebungen, die generative KI einsetzen, hat in den letzten zwei Jahren stetig zugenommen. Einer der wichtigsten Mechanismen für das Lernen mit generativer KI ist die Bereitstellung von formativem Feedback mittels Large Language Models (LLMs). Es gibt jedoch eine Reihe von Bedenken bezüglich generativer KI, wie z.B. die Unzuverlässigkeit des Outputs und mögliche Verzerrungen. In diesem Vortrag geben wir einen Überblick über verschiedene Lernumgebungen in der Physik, in denen erfolgreich formatives Feedback mittels LLMs gegeben wird. Dabei sind die LLMs so eingestellt, dass sie verschiedene Arten von selbstregulierten Lernprozessen, wie motivationale, metakognitive und kognitive Prozesse, unterstützen können. Erste Ergebnisse zeigen, dass LLMs in der Tat in der Lage sind, Lernende durch formatives Feedback effektiv zu unterstützen. Auf Basis dieser Ergebnisse diskutieren wir, wie die Herausforderungen mit generativer KI überwunden und die Chancen genutzt werden können.

DD 5: Astronomie I

Time: Monday 15:15–16:15 Location: OEC 1.163

DD 5.1 Mon 15:15 OEC 1.163

Zwischen Historie und Moderne: Digitalisierung, Auswertung und Didaktisierung historischer Sternspektren für die Verwendung im Master of Education — •Marvin zur Mühlen — Max-Planck-Institut für Astronomie, Heidelberg

Friedrich Küstner stellte 1904 eine Methode vor, mit der er aus dem Spektrum eines Sterns die Astronomische Einheit bestimmen konnte. Seine Berechnungen basierten auf zwei Reihen von Spektralaufnahmen desselben Sterns, die zu unterschiedlichen Jahreszeiten aufgenommen wurden. Durch den Doppler-Effekt konnte so eine Verschiebung der Spektrallinien gemessen und aus der Verschiebung die Astronomische Einheit berechnet werden. Zu diesem Zwecke führte Küstner zwischen 1904 und 1907 eine Reihe von Spektralaufnahmen verschiedener Sterne durch. Einige dieser Aufnahmen wurden bis heute noch nicht ausgewertet. In der kürzlich abgeschlossenen Masterarbeit des Vortragenden wurde einer dieser Sätze historischer Sternspektren mithilfe von Möglichkeiten der Moderne ausgewertet. Der Vortrag umreißt einleitend die methodischen Schritte, die unternommen wurden, um die historischen Aufnahmen der Spektren zu digitalisieren und anschließend computergestützt auszuwerten. Im Zentrum des Beitrags steht die Vorstellung didaktischen Materials, das für die Verwendung im Master of Education Physik erstellt wurde. Dabei wird erläutert, wie die historischen Spektren in didaktisches Material für Studierende des Physik-Lehramts eingebunden wurden und weiter wie durch ein mit heutigen Mitteln erstelltes

Spektrum eine Verknüpfung zwischen Historie und Moderne hergestellt werden könnte.

DD 5.2 Mon 15:35 OEC 1.163

Authentizität in Lernumgebungen mit astronomiehistorischen Bezügen — •Simon F. Kraus — Haus der Astronomie, Heidelberg

Im Hinblick auf das Interesse von Lernenden an bestimmten Lernumgebungen spielt auch der Aspekt der empfundenen Authentizität eine wesentliche Rolle. Im Rahmen eines aktuell laufenden Projekts, welches die Nutzung eines robotischen Teleskops mit Bezügen zur Astronomiegeschichte verknüpft, stellt sich daher die Frage, auf welchen Wegen ein möglichst hohes Maß an empfundener Authentizität von Anfang an erzielt werden kann und wie sich dessen Niveau in der Implementierungsphase erheben lässt. Die Kombination eines robotischen Teleskop mit historischen Bezügen schafft dazu zunächst eine doppelte – d. h. räumliche und zeitliche – Ferne zum Untersuchungsgegenstand und -instrument, wodurch die Ausgangsbedingungen zunächst ungünstig erscheinen. Der Beitrag stellt dazu die besonderen Herausforderungen innerhalb des Projekts den Erkenntnissen der fachdidaktischen Forschung zur Authentizität von Lernumgebungen gegenüber und versucht, erste Lösungsansätze zu skizzieren.

DD 5.3 Mon 15:55 OEC 1.163

Sichtweiten ins Weltall - so weit das Auge trägt — •Michael Vollmer — FB Technik, TH Brandenburg

Sichtweiten auf der Erde liegen im Allgemeinen maximal bei etwa 500 km, aber wie weit reicht unser Auge in den Nachthimmel? Die physikalische Herangehensweise ist in Bezug auf ein Kontrastkriterium ähnlich derjenigen der Sichtweite auf der Erde, dabei wirkt die Himmelsleuchtdichte als Hintergrund selbstleuchtender Objekte im Weltall [1,2]. Neben maximaler Entfernungen für das Auge noch sichtbarer Sterne werden auch die am weitesten entfernten Objekte und Phänomene diskutiert, die Menschen mit bloßem Auge gerade noch wahrnehmen können.

[1] M. Vollmer, Physik in unserer Zeit 54/5, 222-230 (2023)
[2] M Vollmer, Lehrbuch: Optik und ihre Phänomene, Springer (2025)

DD 6: Inklusion

Time: Monday 15:15–16:15 Location: OEC 1.162

DD 6.1 Mon 15:15 OEC 1.162

Astronomie gemeinsam mit einem blinden Schüler - Inklusiver Unterricht in der Oberstufe eines allgemeinbildenden Gymnasiums — •Ekhardt Preuss — Dr.-W.-André-Gymnasium Chemnitz, 09112 Chemnitz, Henriettenstr. 35

Seit 2012 lernen am Dr.-W.-André-Gymnasium Chemnitz Sehbehinderte Schülerinnen und Schüler gemeinsam mit den Sehenden im inklusiven Unterricht.

Von 2020 bis 2022 belegte erstmalig ein blinder Schüler den Oberstufenkurs im Fach Astronomie.

Dazu wurden Unterrichtskonzepte teilweise vollkommen neu erarbeitet und einige bisher nicht bekannte Unterrichtsmittel wie z. B. ein taktiler und gleichzeitig für Sehende benutzbarer Himmelsglobus entwickelt. Es konnten alle im Lehrplan vorgegebenen Ziele erfüllt werden.

Die nicht unbedingt zu erwartende Erfahrung wird dokumentiert, dass inklusiver Unterricht aus der Interaktion heraus sowohl für blinde Schülerinnen und Schüler als auch für die Sehenden zu einem Zusatzgewinn und tieferem Verständnis der stofflichen Inhalte im Vergleich zu den jeweils gewohnten Unterrichtsformen führen kann.

DD 6.2 Mon 15:35 OEC 1.162

Weiterentwicklung der Differenzierungsmatrix zum Thema Energie im inklusiven Unterricht — •Andreas Schulz[1], Stefan Brackertz[1], Thoms Jockweg[2] und Andreas Kissenbeck[2] — [1]Universität zu Köln — [2]Gesamtschule Köln Holweide

Prozesse im Universum sind zwingend an Energieumwandlungen gebunden. Dazu wurde ein Unterrichtskonzept entworfen und erstmals erprobt. Die Evaluierung der Durchführung zeigte (PhyDidB 22923, S. 1), dass eine Weiterentwicklung geboten erscheint, die hier vorgestellt wird. 1.) Fächerübergreifende Aspekte sollen weiter ausgebaut werden. Dabei werden künftig auch biologische Prozesse in einem insgesamten naturwissenschaftlichen Curriculum mit einbezogen. 2.) Ebenso bewährt hat sich das Arbeiten in Kleingruppen, die heterogen zusammengesetzt sind. Dies stärkt die Kooperation und Kommunikation. 3.) Die von den Schüler*innen (SuS) gewählten Wege durch die Matrix waren sehr unterschiedlich und nicht immer systematisch angelegt. Hier muss eine deutlich gezieltere einführende Hinführung in das Konzept und die Verwendung der Matrix im Plenum (Klassenverband) erfolgen. 4.) Das gesellschaftliche Konzept wird modifiziert mit Hinblick auf eine breiter angelegte und fächerübergreifendere Betrachtung von Energieumwandlungs-Prozessen im Kosmos. Dabei spielen astronomische Phänomene und deren physikalische Zusammenhänge eine stärkere Rolle als bisher, was bei allen SuS (und vor allem in gleicher Weise bei Jungen und Mädchen!), wie verschiedene Untersuchungen gezeigt haben, auf großes Interesse stößt. Dieses weiterentwickelte Konzept für den inklusiven Unterricht wird hier vorgestellt.

DD 6.3 Mon 15:55 OEC 1.162

Inklusive Physikdidaktik und rechte Ideologie — •Stefan Brackertz und Andreas Schulz — Universität zu Köln

Soweit sich die Physikdidaktik bisher mit Inklusion befasst hat, ging es meistens darum, wie sich gelingender inklusiver Physikunterricht gestalten lässt.

Allerdings steht inklusive Physikdidaktik zusätzlich und akut vor noch ganz anderen Herausforderungen, denn Inklusion ist insgesamt infrage gestellt: Mehrere Bundesländer haben das Gendern in der Schule verboten und versuchen damit Vielfalt unsichtbar zu machen; die gesellschaftliche Rechte erstarkt und knüpft mehr oder weniger offen ideologisch an die NS-Zeit an, die einen "homogenen Volkskörper" und die "Auslöschung der Differenz"[1] propagierte und in der u.a. Andersdenkende, Jüd*innen, Homosexuelle und Behinderte systematisch weggesperrt oder sogar ausgelöscht wurden. Ausgehend von der bildungsphilosophischen und pädagogischen Debatte nach dem Zweiten Weltkrieg wollen wir zu bestimmen versuchen, was inklusive Physikdidaktik rechter Ideologie entgegen setzen kann.

[1] Lamp, Fabian. "Soziale Arbeit im Nationalsozialismus: Der homogene Volkskörper und die Auslöschung der Differenz". In: Soziale Arbeit zwischen Umverteilung und Anerkennung: Der Umgang mit Differenz in der sozialpädagogischen Theorie und Praxis, Bielefeld: transcript Verlag, 2007, pp. 57-66. https://doi.org/10.1515/9783839406625-002

DD 7: Workshop Standards Lehrkräftebildung

Time: Monday 16:45–18:45 Location: Theo 0.136

Group Report DD 7.1 Mon 16:45 Theo 0.136

Standards und Qualität der Lehrkräftebildung - eine Weiterführung der Diskussion — Andreas Borowski[1], •Susanne Heinicke[2], Friederike Korneck[3], Josef Riese[4] und Heike Theyssen[5] — [1]Universität Potsdam — [2]Universität Münster — [3]Goethe-Universität Frankfurt — [4]Universität Paderborn — [5]Universität Duisburg-Essen

In Weiterführung eines Workshops auf der GDCP 2024 zu "Fachdidaktische (Mindest-)Standards in der Physik" wollen wir uns im Rahmen der DPG-Frühjahrstagung weiter austauschen und mögliche Handlungsbedarfe identifizieren sowie Handlungsschritte diskutieren. Bei den Diskussionen sollen neben den aktuellen Forschungsergebnissen auch die aktuellen Entwicklungen bezüglich der unterrichtlichen Anforderungen, der Studierendenzahlen im Physik-Lehramtsstudium, der alternativen Ausbildungswege und der Neugestaltung von Studiengängen in den Blick genommen werden.

DD 8: Quantenphysik II

Time: Monday 16:45–18:05 Location: Theo 0.135

DD 8.1 Mon 16:45 Theo 0.135

Praxisorientiertes Fortbildungskonzept für Lehrkräfte mit Selbstlerneinheiten zur Quantenphysik — •Stefan Aehle[1], Kim Kappl[2] und Philipp Scheiger[2] — [1]Arbeitsgruppe Fachdidaktik der Physik und Astronomie, Friedrich-Schiller Universität Jena — [2]Abteilung Physik und ihre Didaktik, 5. Physikalisches Institut, Universität Stuttgart

Seit der Aktualisierung der Bildungsstandards für das Fach Physik durch die Kultusministerkonferenz 2020 und die darauffolgende Implementierung neuer Inhalte in die Lehr- und Bildungspläne ist der Bedarf an Lehrerfortbildungen zur Quantenphysik bundesweit stark gestiegen. Viele sowohl junge als auch erfahrene Lehrkräfte haben im Laufe ihrer universitären Ausbildungsphase keine adäquate quantenmechanische Ausbildung erfahren. Zusätzlich gibt es durch neue Schulinhalte einen Bedarf an ebenso neuen Unterrichtsmaterialien. Um diesem Bedarf gerecht zu werden, befassen sich inzwischen vielerorts Landesinstitute und universitäre Arbeitsgruppen mit passenden Fortbildungsangeboten. Die Ergebnisse einer Kooperation zweier Arbeitsgruppen der Universität Stuttgart und der Friedrich-Schiller-Universität Jena in Form eines praxisorientierten Fortbildungskonzepts mit Selbstlerneinheiten und experimentellem Fokus werden in diesem Vortrag vorgestellt und auf dazugehörigen Posterbeiträgen vertieft.

DD 8.2 Mon 17:05 Theo 0.135

Quantum Skills in der Lehrkräftebildung - Kognitiv aktivierende Lehre im Lehramtsstudium der Quantenphysik — Nils Kugler, Felix Fritschle und •Philipp Scheiger — Physik und ihre Didaktik, Universität Stuttgart, 70569 Stuttgart

Mit seinem Diskussionspapier "Quantum Skills in der Lehrkräftebildung" fordert der Stifterverband die Vermittlung von Kompetenzen zu stärken, die in einer Welt wichtig sind, in der Quantentechnologien zunehmend an Bedeutung gewinnen. Für die universitäre Ausbildung von Lehrkräften sollte deshalb neben den Vorlesungsinhalten auch der übrige universitäre Lehrbetrieb an die Bedürfnisse von Lehramtsstudierenden angepasst werden. Im Vergleich zum konventionellen Lehrbetrieb mit Hausaufgaben und Übungsserien können mit interaktiven und kognitiv aktivierenden Ansätzen die Inhalte wesentlich effektiver vermittelt werden. Dieser Beitrag stellt die Ergebnisse eines Projekts zur Entwicklung neuer Lehr- und Lernmaterialien vor, die den Empfehlungen des Diskussionspapiers entsprechen. Damit soll die fachliche Ausbildung verbessert werden und gleichzeitig kann die methodische Vielfalt angehenden Lehrkräften als Vorbild für das spätere Berufsleben dienen. Es werden Methoden verwendet, deren aktivierender Charakter bereits nachgewiesen wurde. Dazu zählen das Lernen mit Lösungsbeispielen, die Versprachlichung und Verbildlichung von Formeln, aktivierende Tutorials und die Peer Instruction.

DD 8.3 Mon 17:25 Theo 0.135

Exploring Qubit Representations: Expert Evaluations and Empirical Insights on Visual-Graphic Representations — •Linda Qerimi[1,2,3], Sarah Malone[4], Eva Rexigel[5], Sascha Mehlhase[2,3], Jochen Kuhn[1], and Stefan Küchemann[1] — [1]LMU, Munich — [2]MQV, Munich — [3]MPQ, Garching near Munich — [4]Saarland University, Saarbrücken — [5]RPTU, Kaiserslautern

Visual-graphic representations play a crucial role in teaching quantum physics (QP) by bridging abstract concepts and learners' understanding. Grounded in Ainsworth's Design Function Task (DeFT) Framework (2006), we developed a category system to evaluate the features of qubit representations. We had 21 experts from four different countries use this category system to analyze four qubit-representations bloch sphere, circle notation, quantum bead, and Qake model. Significant differences emerged in visualizing concepts such as quantum measurement, superposition, and probabilistic behavior. Notably, quantum beads were rated as significantly more salient, demonstrating strong potential to effectively direct learners' attention. The findings underscore the diversity and complexity involved in designing representations in QP and QT while laying the groundwork for further empirical research. Building on the expert evaluations, we are conducting a study to examine how salient representations, such as the quantum bead, influence learners task performance, cognitive processing, and learning outcomes compared to the Bloch sphere. Through expert evaluation and the follow-up study, this work seeks to improve teaching resources and advance understanding of QP and QT.

DD 8.4 Mon 17:45 Theo 0.135

Entwicklung und Evaluation von Kursen zu Quantentechnologien: Basics, Myths und mehr im Rahmen des QTIndu-Projekts — •Ismet N. Dogan[1], Dagmar Hilfert-Rüppell[1], Franziska Greinert[1], Malte S. Ubben[2] und Rainer Müller[1] — [1]Technische Universität Braunschweig, IFdN, Physik und Physikdidaktik — [2]Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften, Institut für Didaktik der Physik

Im Rahmen des Projekts "Quantum Technologies Courses for Industries" (QTIndu) werden Lernmaterialien zu Quantentechnologien entwickelt und evaluiert. Ziel ist es, der steigenden industriellen Bedeutung der Quantentechnologien der zweiten Generation gerecht zu werden sowie Fachkräfte aus der Industrie aus-, weiter- und fortzubilden. Im Vortrag wird der aktuelle Stand des QTIndu-Projektes vorgestellt. Hierzu wird ein Einblick in das Evaluationskonzept des Kurses sowie in erste Ergebnisse der Evaluation eines Einstiegskurses gegeben. Dieser Einführungskurs verknüpft grundlegende Konzepte der Quantenphysik mit relevanten Anwendungsbereichen und wird mithilfe der IOOI-Methode (Input/Output/Outcome/Impact) hinsichtlich affektiver Variablen untersucht. Die Untersuchung bietet die Grundlage für eine Überarbeitung des Einstiegskurses. Außerdem fließen die Ergebnisse auch in die Konzeptionierung und Entwicklung neuer Kurse ein. Im Vortrag wird auf die Entwicklungen weiterer Kurse eingegangen und der aktuelle Stand in der Entwicklung sowie weiterer Evaluationsvorhaben erläutert.

DD 9: Lehrkräftebildung I

Time: Monday 16:45–18:05 Location: Theo 0.134

DD 9.1 Mon 16:45 Theo 0.134

Einfluss von Eigenschaften der Innovation auf den Transfer in die Schulpraxis — •Nils Haverkamp, Alexander Pusch und Stefan Heusler — Institut für Didaktik der Physik, Universität Münster

Während einige Innovationen aus der didaktischen Forschung und Entwicklung, wie beispielsweise Phyphox, großflächig und regelmäßig in der Schulpraxis eingesetzt werden, war der Transfer für viele andere Beispiele nicht (so) erfolgreich. Der Erfolg des Transferprozesses hängt von unterschiedlichen Faktoren ab, die sich in Anlehnung an Gräsel [1] den Lehrkäften, der Innovation selbst oder der Interaktion/Kommunikation zwischen Universität und Schule zuordnen lassen.

Um den Transferprozess zu beschreiben, wurde für die Schule das Concerns-Based Adoption Model vorgeschlagen [2], in dem unter anderem Stufen in diesem Prozess benannt werden, in denen sich Lehrkräfte mit unterschiedlichen Überlegungen und Bedenken auseinandersetzen.

Diese theoretischen Modelle sollen auf die Low-Cost-Experimente zur Wellenoptik, die im Rahmen des O3Q-Projektes entstanden sind, übertragen werden. Im Vortrag werden erste Ergebnisse dieser Übertragung auf die entwickelten Experimente vorgestellt.

[1] Gräsel, C. (2010). Stichwort: Transfer und Transferforschung im Bildungsbereich. Zeitschrift für Erziehungswissenschaft, 13(1), 7-20.

[2] Hall, G. E., Wallace, R. C. & Dossett, W. F. (1973). A Developmental Conceptualization of the Adoption Process Within Educational Institutions. Austin, TX.

DD 9.2 Mon 17:05 Theo 0.134

Teil-fachfremdes Unterrichten im Fach Naturwissenschaften aus der Sicht von Lehrkräften — •Jasper Cirkel, Stefan Halverscheid und Susanne Schneider — Universität Göttingen

Das Verbundfach Naturwissenschaften ist in der deutschen Schullandschaft ein verbreitetes Fach in der Sekundarstufe I von Gesamtschulen, das Elemente der Biologie, Chemie und Physik vereint. Die Lehrkräfteausbildung konzentriert sich jedoch auf zwei wählbare Schulfächer und viele Naturwissenschaftslehrkräfte sind in nur einer Bezugsdisziplin regulär ausgebildet und können daher als teil-fachfremd bezeichnet werden. Wie gehen die Lehrkräfte damit um, dass sie in höchstens zwei, oft nur in einem Fach ausgebildet sind? Diese Interview-Studie mit $N = 15$ semistrukturierten Leitfadeninterviews, ausgewertet mit qualitativer Inhaltsanalyse und deduktiv-induktiver Kategorienbildung untersucht, wie Naturwissenschaftslehrkräfte diese Situation wahrnehmen, welche Herausforderungen sie mit welchen Ressourcen begegnen und welche Professionelle Identitäten(en) sie dabei zeigen. Dabei lassen sich sowohl *NaWi-Lehrkräfte* als auch *Fachspezialisten* ausmachen.

DD 9.3 Mon 17:25 Theo 0.134

Verbesserung der Physiklehrkräfteausbildung: Was wird benötig? — •Andreas Härtel, Andreas Fuchs und Thomas Filk — Physikalisches Institut, Universität Freiburg

Momentan findet in Deutschland eine Befragung der Physiklehrkräfte zu deren Wahrnehmung ihres absolvierten Physik(lehramts)studiums statt, welche durch die Universität Freiburg und die Deutsche Physikalische Gesellschaft durchgeführt wird. Ich werde diese Studie kurz vorstellen und einen ersten Einblick auf vorläufige Ergebnisse präsentieren. Die Ergebnisse geben Hinweise darauf, welche Inhalte des Physikstudiums in Lehramtsstudiengängen (anders) gelehrt werden sollten als in Fachstudiengängen. Die Studie schließt damit an einschlägige Studien zur Qualität des Physikunterrichts und -studiums an.

DD 9.4 Mon 17:45 Theo 0.134

Performanzorientiertes Prüfen im Lehramtsstudium Physik — •Christoph Vogelsang und Lea Grotegut — PLAZ-Professional School of Education, Universität Paderborn

Angehende Lehrkräfte fühlen sich durch das Studium oft nur wenig auf die spätere Berufstätigkeit vorbereitet und haben Schwierigkeiten, erworbenes Wissen mit den Anforderungen der beruflichen Praxis zu verbinden. Dies wird dadurch verstärkt, dass der Schwerpunkt von Prüfungen im Lehramtsstudium häufig auf dem Erfassen von Wissen liegt (z.B. in Klausuren). Mögliche Alternativen bilden Prüfungsverfahren, die typische berufliche Handlungen in komplexitätsreduzierten Settings simulieren, bspw. durch den Einsatz von Schauspieler*innen. Angelehnt an im Medizinstudium etablierte Prüfungsformate wurde daher eine Objective Structured Teaching Examination (OSTE) für das Lehramtsstudium im Fach Physik entwickelt. Sie besteht aus einem Prüfungsparcours, in dem an sieben Stationen typische berufliche Handlungssituationen standardisiert simuliert werden (orientiert an den Kompetenzbereichen Unterrichten, Erziehen, Beurteilen, Innovieren, KMK, 2022). Der OSTE wurde bisher mit 42 Studierenden an verschiedenen Universitäten erprobt und die Sicht der Teilnehmenden auf das Format erfasst. Insgesamt schätzten sie das Format als sehr authentisch und relevant bezogen auf den Lehrkräfteberuf ein. Kritischer beurteilt wurde die Vergleichbarkeit von Leistungen und die fehlende Vorbereitung auf derartige Prüfungen im Studium.

DD 10: Physikalische Praktika

Time: Monday 16:45–18:05 Location: OEC 1.163

DD 10.1 Mon 16:45 OEC 1.163

Rubenssches Flammenrohr in Stereo — •Dominik Giel — Hochschule Offenburg, Center for Learning and Teaching, Badstr. 24, 77652 Offenburg

Das Rubensche Flammrohr ist ein Demonstrationsversuch zur Visualisierung stehender Wellen. In der klassischen Form überlagert sich die einlaufende Welle in einem gasgefüllten Rohr mit ihrer an einem festen Ende entstehenden Reflexion zu einer stehenden Welle, deren Ortsabhängigkeit durch die Flammenhöhe an vielen kleinen Bohrungen gleichen Durchmessers visualisiert wird. Im klassischen Aufbau wird die einlaufende Welle durch einen einzigen Lautsprecher außerhalb des Rohres erzeugt und durch eine Membrane ins Rohr gekoppelt. Diese Membrane bildet ein offenes Ende, das zweite Ende ist hingegen in der Regel ein festes Ende, also eine reflektierende Platte. Im Beitrag wird eine Modfikation des Versuchs vorgestellt, bei dem beide Rohrenden als offene Enden ausgeführt werden, an denen jeweils gegenläufige Welle aus unterschiedlichen Lautsprechern eingekoppelt werden. Die meisten Audio-Geräte (Laptop, Smartphone, Verstärker) verarbeiten zwei Kanäle, so dass diese Umstellung kaum zusätzlichen Aufwand erfordert. Durch Wahl der relativen Phase zwischen linken und rechtem Kanal lassen sich nun die Maxima der resonanten stehenden Welle im Rohr verschieben, um den Einfluss der Phase bei einer stehenden Welle zu erläutern.

DD 10.2 Mon 17:05 OEC 1.163

Der bunte Praseodym:YLF Experimental-(Klasse1) Laser für Gymnasien und Grundpraktika — •Ilja Rückmann[1] und Walter Luhs[2] — [1]Uni Bremen, FB1, Otto-Hahn-Allee 1, 28359 Bremen — [2]Freiburger Str. 33, 79427 Eschbach

Basierend auf dem erprobten Sicherheitskonzept des cw-Rubin Experimental-Lasers wurde ein Pr:YLF Experimental-(Klasse 1) Laser entwickelt und so die Verfügbarkeit von sicheren "Schul-Lasern" erweitert. Zum Erlernen der Laser-Funktionsweise steht nun auch ein Vier-Niveau Laser in Laserklasse 1 zur Verfügung. Der Pr:YLF gestattet Laserbetrieb auf verschiedenen Wellenlängen und ist ein Kandidat für einen Weißlichtlaser.

Der vom Rubin-Experimental-Laser bewährte Aufbau mit Pump-Diodenlaser, justierbarem hemisphärischen Resonator, Experimentierbereich mit Steckplätzen und Raspberry-PI Kamera wurde übernommen. Die Strahlführung im Plexiglas-Rohr sowie die Codierung der Elemente sorgen dafür, dass der Laserstrahl gut beobachtbar ist, aber keine Laserstrahlung austreten kann (Laserklasse 1), da bei nicht sicherer Positionierung der Laser abschaltet. Um Laserbetrieb auf verschiedenen Linien zu realisieren, muss nur der planare Einkoppelspiegel gewechselt werden. Der Auskoppelspiegel reflektiert breitbandig.

Insgesamt sind mit dem Pr:YLF ohne zusätzliche Schutzmaßnahmen über 10 Experimente sowohl zur Funktionsweise (z.B. Spektren, Lebensdauern, Einstein-Koeffizienten, Resonatorjustage , Laserschwellen, Spiken, TEM-Moden) als auch Experimente mit dem Laser möglich.

DD 10.3 Mon 17:25 OEC 1.163

Physikalische Praktika neu gedacht: Chancen durch Digitalisierung und KI. — •Johannes Marczinkowski, Rebekka Murati, Cedric Kessler, Ralph Ernstorfer und Nina Owschimikow — Institut für Optik und Atomare Physik, TU Berlin, 10623 Berlin

In nie dagewesenem Umfang können hochauflösende und umfangreiche Datensätze generiert werden, deren Analyse und Management ein neues Bottleneck zum Erkenntnisgewinn darstellt. Damit umzugehen gehört, wie das Experimentieren selbst, zu professionellen Fähigkeiten der Experimentierenden und ist damit als Ausbildungsinhalt zu einem zentralen Thema aufgerückt. Eine Folge von Digitalisierung und insbesondere generativer KI ist, dass die Betrachtung physikalischer Effekte, die traditionell in Praktika vermittelt werden, über Simulationsdarstellungen, Augmented Reality, interaktive Programme, etc. erlernt werden können. Damit wird in den Praxisformaten Raum geschaffen, um die erweiterten praktischen Fähigkeiten in vollem Umfang zu vermitteln. Wir zeigen, wie Gestaltungsmöglichkeiten durch die Digitalisierung es erlauben, die experimentellen Ansätze von Messen und Messgeräten auf Daten- und Messunsicherheiten zu erweitern. Mit modernen Messgeräten werden komplexe Experimente und datenintensive Lernumgebungen realisiert. Durch digitales Mess- und Labordatenmanagement werden moderne Analyseverfahren, wie ML-Algorithmen und KI-gestützte Auswertungen, direkt in die Ausbildung integriert. Die Digitalisierung von Physikpraktika erlaubt es, Studierende praxisnah auszubilden, aktuelle Technologien zu nutzen und sie auf moderne Anforderungen der Wissenschaft und Industrie 5.0 vorzubereiten.

DD 10.4 Mon 17:45 OEC 1.163

Dynamische Kompetenzentwicklung durch Projektversuche im Fortgeschrittenenpraktikum Physik mit ChatGPT-Unterstützung — •Franz-Josef Schmitt — Institute of physics, Martin-Luther-Universität Halle-Wittenberg

Diese Studie stellt unser Projektpraktikum vor, das im Fortgeschrittenenpraktikum unserer Bachelor- und Masterstudiengänge in Physik integriert ist. Dieser Ansatz befähigt die Studierenden, sich in ihren selbst entwickelten Projektversuchen schrittweise weiterzuentwickeln und so von einem traditionellen Praktikum zu einem dynamischeren, studierendenzentrierten Lernen mit Eigenverantwortung für den Projektverlauf zu erwachsen. Im Mittelpunkt dieses Ansatzes steht die Beteiligung der Studierenden an der Formulierung und Entwicklung einer Projektidee und des experimentellen Designs. Um ihre Ideen zu verbessern und zu verfeinern, führen die Studierenden strukturierte Interviews mit ChatGPT durch und erhalten so Verbesserungsvorschläge für ihr Projekt. Je nach Qualität ihrer Ideen und dem Fortschritt des Projekts können die Studierenden ihre Projekte in einem zyklischen Prozess der Entwicklung, Umsetzung, Dokumentation und Diskussion mit Betreuern zu Projekten XXL ausbauen, während vorab zugeteilte Standardexperimente wegfallen. Die Projektexperimente fördern Kreativität, kritisches Denken und ermöglichen ein tieferes Eintauchen in die Materie. Einige dieser Projektversuche fanden als neue Standard-Laborexperimente Eingang in die Praktika.

DD 11: Außerschulische Lernorte

Time: Monday 16:45–18:05 Location: OEC 1.162

DD 11.1 Mon 16:45 OEC 1.162

Auswirkungen eines MINT-Projekts auf die Motivation und die Selbstwirksamkeit — •Tessa Horenburger, Dina Al-Kharabsheh und Anne Geese — TU Braunschweig, Institut für Fachdidaktik der Naturwissenschaften, Abt. Physik und Physikdidaktik

Der Frauenanteil im MINT-Bereich ist noch immer gering. Um dies zu ändern, können Projekte durchgeführt werden, die die Selbstwirksamkeit fördern. Das Projekt changING regio, das vom Exzellenzcluster SE2A der TU Braunschweig im Bereich der Gleichstellung gefördert wird, folgt diesem Ziel. Schülerinnen der 11. und 12. Klasse aus Niedersachen konnten sich dafür anmelden und einen Einblick in die Arbeit von Wissenschaftler:innen bekommen. Dabei sollten sie unter anderem weibliche Vorbilder kennenlernen und ihre berufliche Entscheidung, in den MINT-Bereich zu gehen, unterstützt werden. Zunächst fanden wöchentliche Videokonferenzen als eine inhaltliche Vorbereitung statt. Darauf folgten fünf Tage in Braunschweig, bei denen die Institute besucht und Experimente durchgeführt wurden. Die Schülerinnen haben vor Beginn und nach dem Ende des Projektes einen Fragebogen ausgefüllt. Es folgte zudem ein Interview und nach zwei Monaten wurde der Fragebogen erneut bearbeitet. Die Ergebnisse der Auswirkungen auf die Selbstwirksamkeit, die Motivation und das Interesse wurden durch Mixed-Methods ausgewertet. Dabei zeigte sich, dass die Selbstwirksamkeit und die Motivation gefördert werden konnten. Hinsichtlich des Interesses zeigten sich nur individuelle Steigerungen.

DD 11.2 Mon 17:05 OEC 1.162

Digitale Akademie der Physik: Brückenbau zwischen Forschung und Curriculum — •Marlene Doert[1], Johannes Albrecht[1], Dominik Elsässer[1], Nele McElvany[1], Annika Ohle-Peters[1], Christoph Hanhart[2], Alexander Lenz[3], Klaus Desch[4] und Annika Thiel[4] — [1]TU Dortmund — [2]FZ Jülich — [3]U Siegen — [4]U Bonn

Forschungsergebnisse aus der Teilchen-, Astro- und Quantenphysik rufen quer durch alle Alters- und Gesellschaftsgruppen Begeisterung und großes Interesse hervor. Der Wunsch derartige Naturphänomene zu verstehen ist eine wichtige Triebfeder für die Studien- und Berufswahl junger Menschen, die zu erfolgreichen Laufbahnen in Wissenschaft, Industrie und dem Bildungssektor führen. Gleichzeitig geschieht eine Integration solcher Fortschritte in die Lehr- und Bildungspläne nur auf Zeitskalen, die deutlich länger sind als die Zeit, in der sie öffentliche Aufmerksamkeit genießen und zu Studien- oder Berufsentscheidungen inspirieren. Mit dem Ziel, eine Brücke über diese Kluft zwischen aktueller Forschung und schulischen Curricula zu bauen, stellen wir eine hybride Akademie für Quanten-, Teilchen- und Astrophysik vor, die sich an Schüler:innen der gymnasialen Mittel- und Oberstufe richtet. In mehreren Bögen von digitalen Vorlesungen und begleitenden Übungen, gepaart mit vor-Ort-Besuchen in Forschungsstätten, sollen Schüler:innen Einblicke in Schlüsselfelder der modernen Physik bekommen, die weit über die Schulphysik hinausreichen. Wir geben einen Überblick über das Projekt sowie die bildungswissenschaftliche Begleitung und Evaluation und präsentieren einen Pilot-Bogen zur Quantenphysik.

DD 11.3 Mon 17:25 OEC 1.162

Blickwinkel von Lehrkräften auf außerschulische Angebote zur MINT-Interessenförderung — •Maria Hinkelmann und Heidrun Heinke — RWTH Aachen University

Im Projekt Labs on Tour werden MINT-Angebote der Universität an Schulen gebracht, um Jugendliche niederschwellig für MINT-Themen zu begeistern und Hemmschwellen zu senken. Dafür werden Materialien von Schülerlaboren mobil gemacht und in vierwöchigen Kursen mit je 90-minütigen Einheiten nachmittags an den Schulen in dafür angelegten MINT-AGs durchgeführt. Eine MINT-AG läuft über ein Halbjahr und umfasst drei unterschiedliche Kurse verschiedener Schülerlabore. Die Schüler:innen haben somit die Möglichkeit verschiedene MINT-Bereiche kennenzulernen und sich, losgelöst vom Unterricht und ohne Leistungsdruck, auszuprobieren. Betreut werden die Kurse von studentischen Hilfskräften (SHK) der Schülerlabore. Die verantwortliche Lehrkraft ist lediglich für die Werbung und Anmeldungen in der Schule zuständig sowie für die Aufsicht während der AG. Das Konzept stößt von allen Seiten auf sehr großen Zuspruch. Sowohl die Schülerlabore, SHK, Schulen als auch Schüler:innen melden außergewöhnlich positives Feedback zurück. Um das Projekt weiterzuentwickeln und die erfolgreichen Mechanismen auf andere Projekte übertragbar zu machen, wurden mit Lehrkräften, welche eine AG betreut haben, Interviews geführt und ausgewertet. Diese beleuchten die Meinungen der Lehrkräfte zum Ablauf der AG sowie ihren Blickwinkel auf interessenweckende Themen und wichtige, allgemeingültige Merkmale für erfolgreiche außerschulische Angebote zur MINT-Interessenförderung.

DD 11.4 Mon 17:45 OEC 1.162

Komplementär vernetzte Bildungsangebote erforschen — •Jonas Tischer und Michael Komorek — Institut für Physik, Carl von Ossietzky Universität Oldenburg

Im Projekt ReBiS wird erprobt, wie sich außerschulische MINT-Bildungsangebote systematischer als bisher in den Fachunterricht integrieren lassen. Ziel ist, das Potenzial des Außerschulischen für die Entwicklung der MINT-Fächer und ihrer Verknüpfungen besser auszuschöpfen. Vier Schulen und sechs außerschulische Lernorte kooperieren im von der Deutschen Telekom Stiftung geförderten Projekt. Die bislang beteiligten elf ReBiS-Schulklassen befassen sich über ein Schuljahr hinweg mit Problemfeldern, die für einzelne Schulfächer zu komplex sind, für deren Verständnis aber fachspezifische Kompetenzen benötigt werden (etwa der Umgang mit dem Klimawandel oder der ambivalente Umgang mit Kunststoffen). Pro Schulklasse sind unterschiedliche Schulfächer beteiligt, aus denen heraus jeweils außerschulische Lernorte aufgesucht werden, die interdisziplinäre Aspekte einbringen. ReBiS wird empirisch begleitet. Berichtet wird über die Ergebnisse von 35 qualitativen Leitfadeninterviews mit den beteiligten Lehrkräften und außerschulischen Pädagogen. Erfragt wurden ihre subjektiven Überzeugungen dazu, wie komplexe Problemfelder im MINT-Fachunterricht aufgeschlossen werden können, wie sich dazu außerschulische Lernorte bereichernd einbeziehen lassen und wie unter realen Schulbedingungen eine Komplementarität von schulischer und außerschulischer MINT-Bildung gelingen kann. Die Ergebnisse gehen in die Akquise neuer Schulen und die Optimierung des Ansatzes ein.

DD 12: Hochschuldidaktik II

Time: Tuesday 13:30–14:30 Location: Theo 0.136

DD 12.1 Tue 13:30 Theo 0.136

Physikspezifische Betrachtungsweisen zur Förderung des Formelverständnisses — •Julia Hofmann[1], Josefine Neuhaus[1], Andreas Müller[2] und Pascal Klein[1] — [1]Universität Göttingen, Deutschland — [2]Universität Genf, Schweiz

Ein tiefgreifendes Verständnis mathematischer Gleichungen und Formeln sowie der Umgang damit sind zentrale Ziele des Physikstudiums. Ein angemessener Umgang mit Formeln beinhaltet deren Analyse, kritische Bewertung und Überprüfung der Plausibilität vor dem Hintergrund des physikalischen Kontexts. Für die Physik typische Methoden und Denkweisen, die dabei häufig Anwendung finden, sind das Betrachten von Dimensionen, Kovariationen sowie von Spezial- und Grenzfällen. Obwohl derartige Betrachtungsweisen von Lehrenden als essentiell erachtet werden, werden diese in der Regel nicht explizit in Lehrveranstaltungen vermittelt und eingeübt. Die hier vorgestellte Untersuchung zielt darauf ab, einerseits die Ausprägung der Betrachtungsweisen bei Studierenden zu erfassen und andererseits deren Entwicklung durch gezielte Förderung zu unterstützen. Zu diesem Zweck wurden bestehende Übungsaufgaben um die genannten Betrachtungsweisen angereichert und im begleitenden Übungsbetrieb einer Elektromagnetismus-Vorlesung für Zweitsemesterstudierende implementiert (N = 116 zum Prä-Zeitpunkt). Begleitend zur Leistungsmessung wurde die Einschätzung der Relevanz und des Selbstkonzepts bezüglich der vier Betrachtungsweisen untersucht, um die Wirksamkeit des Ansatzes zu analysieren.

DD 12.2 Tue 13:50 Theo 0.136

Chunkingprozesse beim Lesen und Schreiben von Formeln — •Josefine Neuhaus[1], Pascal Klein[1] und Andreas Müller[2] — [1]Universität Göttingen — [2]Université de Genève

Chunking bezeichnet eine kognitive Strategie, bei der Informationen zu sinnvollen Einheiten zusammengefasst werden. Diese Strategie zur Prozessierung von Informationen ermöglicht dem Arbeitsgedächtnis die Verarbeitung von mehr Information, was sich beispielsweise in einem schnelleren Erfassen von Sinnzusammenhängen äußert. In verschiedenen Disziplinen, darunter in der Lese- und Schreibforschung, wurde Chunking bereits intensiv erforscht. Die Ergebnisse legen nahe, dass die Größe einzelner Chunks mit zunehmender Expertise anwächst und von der Länge sowie der Vertrautheit des Inhalts abhängt. Die vorgestellte Studie untersucht, ob sich diese Erkenntnisse auf fachspezifische Formeln übertragen lassen. Mithilfe von Eye-Tracking wird analysiert, wie sich

Chunking-Prozesse im Leseprozess manifestieren. Parallel dazu wird mit Hilfe von Handschriftaufzeichnung und Analyse der Schreibdynamik untersucht, welche Chunks im Schreibprozess sichtbar werden, wenn Proband:innen Formeln aus den Bereichen Mechanik und Elektrodynamik lesen und reproduzieren. Darüber hinaus wird die Abhängigkeit der Chunking-Prozesse von der Vertrautheit mit der konkreten Formel, dem physikalischen Kontext und der Darstellungsform untersucht. Die Untersuchung zielt darauf ab, tiefere Einsichten in die kognitiven Prozesse beim Verstehen und Anwenden physikalischer Formeln zu gewinnen.

DD 12.3 Tue 14:10 Theo 0.136

Blickdatenanalyse disziplin-spezifischer Repräsentationen in der Physik — •Larissa Hahn, Josefine Neuhaus und Pascal Klein — Universität Göttingen, Deutschland

Repräsentationen sind für das naturwissenschaftliche Lernen und Problemlösen unerlässlich, insbesondere in der Physik. Für die Analyse der Lern- und Problemlöseprozesse im Umgang mit visuellen Repräsentationen nutzen aktuelle Untersuchungen zunehmend Eye-Tracking. Blickdaten visualisieren das prozedurale Vorgehen von Lernenden im Umgang mit Repräsentationen, decken repräsentationsspezifische, visuelle Strategien auf und können eine empirische Basis zur Konzeption multi-repräsentationaler Lehr-Lern-Umgebungen darstellen. Dieser Beitrag präsentiert Ergebnisse verschiedener Blickdatenanalysen im Umgang mit typischen, visuellen Repräsentationen der Physik (z. B. Vektorfelder, Hertzsprung-Russell-Diagramm, Wellenpulsdiagramm, Skizzen und Formeln zur Mechanik) und gibt ein Einblick, was wir durch Eye-Tracking über disziplin-spezifische Repräsentationen und ihre Verwendung lernen können. Beispielsweise ist die koordinatenspezifische Evaluation elektrischer (Vektor-)Felder mit achsenparallelen Blickbewegungen assoziiert. Bei der Beurteilung der Geschwindigkeit einzelner Punkte eines Wellenpulses zeigt sich eine expertenhafte visuelle Vorgehensweise darüber hinaus in einem Blickverhalten, das mit der Imagination der Wellenlinie zu einem späteren Zeitpunkt verknüpft werden kann. Neben fachdidaktischen Schlussfolgerungen findet eine methodische Reflektion der Eye-Tracking-Methode beim (multi-)repräsentationalen Lernen und Problemlösen statt.

DD 13: Preisträgervortrag

Time: Tuesday 13:30–14:10 Location: Theo 0.135

Prize Talk DD 13.1 Tue 13:30 Theo 0.135

Physikunterricht im 21. Jahrhundert gestalten: MakerSpace, Deeper Learning & innovative Prüfungsformate für mehr Schüler:innenmotivation — •Matthias Harnischmacher — Gymnasium an der Gartenstraße, Mönchengladbach — Träger des DPG-Lehrerpreises 2025

Der Vortrag gewährt einen spannenden Einblick in die Gestaltung unseres Physikunterrichts, im Einklang mit den Anforderungen des 21. Jahrhunderts. Im Zentrum stehen der Aufbau eines Makerspaces, der Einsatz alternativer Prüfungsformate und die Integration von Deeper Learning, ergänzt durch praxisorientierte Unterrichtsbeispiele.

Zunächst wird die Einrichtung des Makerspace vorgestellt, der den SuS eine handlungsorientierte Auseinandersetzung mit physikalischen Konzepten ermöglicht. Durch die Verbindung von Theorie und Praxis werden kreative Prozesse angestoßen und die Lernmotivation gesteigert.

Anhand konkreter Beispiele wie dem Bau eines elektrischen Hauses in der 6. Klasse, dem Raketenbau in Klasse 8 und einer Energiekonferenz in Klasse 10 wird der Unterrichtsansatz des Deeper Learning vorgestellt. Dabei wird aufgezeigt, wie projektbasiertes Lernen und eigenständiges Problemlösen die physikalische Begeisterung der SuS stärkt und ein langfristiges Interesse und tiefgehendes Verständnis für physikalische Phänomene fördert.

Darüber hinaus werden alternative Prüfungsformate wie Escaperooms und OSPEs vorgestellt.

Zusammenfassend bietet der Vortrag wertvolle Einblicke in praxisorientierte Ansätze zur Transformation des Physikunterrichts.

DD 14: Praxisblick

Time: Tuesday 14:10–14:30 Location: Theo 0.135

DD 14.1 Tue 14:10 Theo 0.135

Eigenverantwortliches Arbeiten – Einstellungen und Erfahrungen von Lehrkräften in Bayern — •Julius Baptist Hlawatsch, Heiko Müller und Axel Enders — Universität Bayreuth, Bayreuth, Deutschland

Eigenverantwortliches Arbeiten (EVA) ist im bayerischen LehrplanPlus für das G9 als verpflichtender Bestandteil im Fach Physik ab der elften Jahrgangsstufe verankert. Physiklehrkräfte müssen dadurch ihre Unterrichtspraxis anpassen. Während in anderen Bundesländern, z. B. in Baden-Württemberg, sowie in reformpädagogischen Ansätzen bereits Erfahrungen in diesem Bereich vorliegen, stellt diese Unterrichtsmethode für bayerische Physiklehrkräfte teils eine neue Herausforderung dar. In unserer qualitativen Interviewstudie wurden Gymnasiallehrkräfte verschiedener Erfahrungsstufen – einschließlich Lehrkräfte mit Quereinstieg – zu ihren Einstellungen und Erfahrungen bezüglich EVA befragt. Erste Ergebnisse zeigen, dass Lehrkräfte vor allem hinsichtlich der praktischen Umsetzbarkeit und der Effektivität von EVA im Physikunterricht verunsichert sind. Dieser Beitrag präsentiert zentrale Ergebnisse der Interviewstudie und leitet daraus konkrete Bedarfe sowie Handlungsempfehlungen für die professionelle Unterstützung von Physiklehrkräften bei der erfolgreichen Umsetzung von EVA ab.

DD 15: KI II

Time: Tuesday 13:30–14:30 Location: Theo 0.134

DD 15.1 Tue 13:30 Theo 0.134

Individuelle Unterstützung des Transfers von Mathematik in die Physik durch KI-Chatbots — •Julia Lademann und Sebastian Becker-Genschow — Universität zu Köln, Gronewaldstr. 2, 50931 Köln, Deutschland

Verständnisprobleme im Physikunterricht seitens der Schülerinnen und Schüler sind nicht selten an mangelnde mathematische Kompetenzen geknüpft. Oft basieren sie aber auch auf der Schwierigkeit, die im Rahmen des Mathematikunterrichts erworbenen Fähigkeiten auf die Inhalte des Physikunterrichts zu übertragen. Die Ursachen für diese Schwierigkeiten sind nicht für alle gleich. Generative KI kann daher an dieser Stelle mit der individuellen Förderung durch Chatbots eine mögliche Lösung darstellen. Dazu wurde ein auf ChatGPT basierender Custom Chatbot entwickelt, der die Schülerinnen und Schüler bei der Anwendung von Mathematik im Physikunterricht gezielt und personalisiert unterstützen soll. In einer ersten Studie wurde untersucht, wie sich das Lernen mit von diesem Chatbot generierten Erklärungen auf das Lernerleben sowie die Lernleistung in einem mathematischen und physikalischen Lernkontext auswirkt, insbesondere im Hinblick auf die notwendige Transferleistung auf den physikalischen Kontext. Erste Auswertungen zeigen signifikante Unterschiede zwischen Experimental- und Kontrollgruppe hinsichtlich des Lernerlebens zugunsten des KI-generierten Materials. Diese Ergebnisse deuten darauf hin, dass das Lernen mit KI-Chatbots einen positiven Effekt auf das Lernerleben von Schülerinnen und Schülern haben kann, und eröffnen den Raum für weiterführende Forschung.

DD 15.2 Tue 13:50 Theo 0.134

Adaptive Unterstützung durch generative KI beim Lösen physikalischer Probleme — •Fabian Kieser[1], Paul Tschisgale[2], Holger Maus[2], Stefan Petersen[2], Knut Neumann[2] und Peter Wulff[1] — [1]Pädagogische Hochschule Heidelberg, Deutschland — [2]Leibnitz-Institut für die Pädagogik der Naturwissenschaften und Mathematik, Kiel, Deutschland

Das Lösen physikalischer Probleme ist ein anspruchsvoller kognitiver Prozess, der mehrere Phasen umfasst. Zunächst müssen physikalische Konzepte auf die Problemsituation angewandt werden. Darauf aufbauend muss eine geeignete Lösungsstrategie ausgewählt, umgesetzt und abschließend evaluiert werden. Für Lernende stellt dies eine Herausforderung dar, da Lösungsstrategien erforderlich sind, die über einfache Einsetzverfahren oder sogenannte "Plug-and-Chug"-Methoden hinausgehen. Neuartige KI-Technologien, insbesondere große Sprachmodelle, bieten hier Potenziale, indem sie Lernende adaptiv während

des Problemlöseprozesses unterstützen können. Durch gezieltes Prompting kann diese Unterstützung weiter optimiert und spezifisch auf die Bedürfnisse der Lernenden zugeschnitten werden. Solche Technologien können somit zur Förderung von Problemlösefähigkeiten beitragen. Der vorliegende Beitrag untersucht Interaktionsmuster von Teilnehmenden der Physik-Olympiade, die während des Problemlöseprozesses Unterstützung durch ein spezifisch gepromptetes Sprachmodell (GPT-4o) erhalten. Insbesondere wird analysiert, inwiefern das System adaptiv auf die individuellen Problemlöseprozesse der Teilnehmenden reagiert.

DD 15.3 Tue 14:10 Theo 0.134

Interaktion mit KI-gesteuerten Nicht-Spieler-Charakteren in Serious Games — •Caroline Wermann, Jochen Kuhn und Stefan Küchemann — Ludwig-Maximilians-Universität München, Deutschland

Aufgrund ihres potenziell disruptiven Charakters werden Quantentechnologien nahezu jeden Aspekt unseres Lebens beeinflussen. Deshalb ist es wichtig, aktuelle Forschung zugänglich und leicht verständlich zu machen. Serious Games bieten die Möglichkeit, Inhalte auf vereinfachte und interaktive, aber vor allem unterhaltsame Weise zu präsentieren.

Diese Studie untersucht den Einfluss von Scaffolding durch einen KI-gesteuerten Nicht-Spieler-Charakter (NPC) auf den Lernzuwachs und die kognitive Belastung der Spieler beim Spielen eines Serious Games zum Thema Quantentechnologien. Insgesamt nahmen 152 Personen (Schüler, Studenten und Personen der allgemeinen Öffentlichkeit) an der Studie teil. Sie wurden in drei Gruppen aufgeteilt. Die Kontrollgruppe erhielt keinerlei Hilfestellung. In Gruppe 1 konnten die Spieler mit dem NPC chatten, um Feedback oder Hinweise zu erhalten. In Gruppe 2 konnten sie entweder chatten oder den NPC bitten, den nächsten Schritt der Lösung durchzuführen.

Die Studienergebnisse zeigen, dass die Teilnehmenden unabhängig vom Ausmaß des Scaffolding einen signifikanten Lernzuwachs haben. Während für extraneous und germane cognitive load keine Gruppenunterschiede gefunden wurden, ist der intrinsic cognitive load in Gruppe 2, der Gruppe mit dem umfassendsten Scaffolding, signifikant niedriger.

DD 16: Astronomie II

Time: Tuesday 13:30–14:30 Location: OEC 1.163

DD 16.1 Tue 13:30 OEC 1.163

Schatten des Sonnensystem - Vorstellungen von Lernenden über das Sonnensystem — •Maximilian Alexander Loch[1,3], Malte Ubben[2] und Emmanuel Rollinde[1] — [1]Laboratoire de Didactique André Revuz CY Cergy Paris Université, Paris, France — [2]Institut für Didaktik der Physik Universität Leipzig, Leipzig, Deutschland — [3]Institut für Didaktik der Physik Universität Münster, Münster, Deutschland

Auch wenn die Einführung von Astronomie als Unterrichtsfach in NRW bereits eine Zeit zurückliegt, stellt sich weiterhin die Frage wie es in den Unterrichtsalltag von Lehrkräften eingefügt werden kann. Welche Grundlagen besitzen Lernende bereits, auf denen solch eine Einführung basieren sollte? Dazu haben wir die mentalen Modelle Lernender der Jahrgangsstufen 4 bis 11 zum Thema Sonnensystem untersucht. Unsere Stichprobe umfasst 20 Klassen mit einer gesamten Größe von insgesamt N=400. Wir analysierten und kategorisierten diese Zeichnungen, wodurch sich 4 Attribute zur Darstellung der "Gestalt" herausbildeten. Diese Attribute, namentlich "Verteilung", "Hierarchie", "Vollständigkeit" und "Detailreichtum" bieten eine bessere Einordnung von vorherigen "Edge Cases" und legen Grundlagen für die Antwort auf die Frage der Existenz und Art der Gestalten. Zusätzlich wurde, durch die Betrachtung der Frage, welche Änderungen die Lernenden im Laufe eines Erdjahres im Sonnensystem erwarten, eine bessere Repräsentation des funktionalen Teils der mentalen Modelle beschrieben, welche in anfänglichen Zügen einen Einfluss der Intervention durch Sequenzen des Erasmus+ Projektes "Aristarchus" darlegen.

DD 16.2 Tue 13:50 OEC 1.163

Vom Weltall ins Schulheft: Erprobung astronomischer Sachaufgaben im Mathematikunterricht — •Eleen Hammer und Holger Cartarius — AG Fachdidaktik der Physik und Astronomie, Friedrich-Schiller-Universität Jena, 07743 Jena

Astronomie ist ein faszinierendes und interdisziplinäres Fachgebiet in den Naturwissenschaften. Es findet jedoch in der Sekundarstufe I nur in wenigen deutschen Bundesländern als eigenständiges Fach Eingang in den Lehrplan. In den vergangenen Jahren wurde ein theoretisch fundierter und praxisnaher Ansatz entwickelt, um astronomische Inhalte auf motivierende Weise im Mathematikunterricht zu integrieren.

Die so entwickelten astronomischen Sachaufgaben für den Mathematikunterricht wurden sowohl durch Lehrkräfte getestet als auch in verschiedenen Schulen erprobt. Die Stichprobe umfasste 186 Schüler der Klassenstufen 6 bis 10. In diesem Vortrag werden die Ergebnisse dieser Erprobung der Aufgaben detailliert vorgestellt.

DD 16.3 Tue 14:10 OEC 1.163

Vom Weltall ins Klassenzimmer mit der "Shared Universe Engine" — •André Bresges, Stefanie Walch und Benjamin Rott — Universität zu Köln, Mathematisch-Naturwissenschaftliche Fakultät

Die Exzellenzinitiative "Our Dynamic Universe" (https://dynaverse.astro.uni-koeln.de) der Universitäten Köln und Bonn, des Max-Planck Institutes für Radioastronomie, des DLR und des Forschungszentrums Jülich setzt sich Ziele in außergewöhnlichen Maßstäben: Auf der einen Seite der Skala soll die "Shared Universe Engine" eine Simulation des Universums bereit stellen, die aktuelle Forschungsdaten einbezieht und im "Expert Mode" einen KI-gestützten Zugriff auf die physikalischen Eigenschaften an jeder Stelle und zu jedem Zeitpunkt des Universums ermöglicht. Auf der anderen Seite soll ein "Education Mode" allen Interessierten, und insbesondere auch Schulklassen, die Möglichkeit geben sich an Spitzenforschung zu beteiligen und die individuelle Neugierde zu stillen. Basierend auf den in Köln etablierten Konzepten des Design Thinkings und des Design Based Research erarbeiten wir in unserem großen Netzwerk aus Schulen und Lehr-Lernlaboren Lösungen, die im Unterricht wirklich funktionieren, Schüler*innen durch eigene Programmiererfahrung einen Blick hinter die Kulissen ermöglicht und die sich in Lehrerfortbildungen vermitteln lassen. Eine Vision ist, allen Schüler*innen im Physikunterricht die Grundlage einer sich neu entwickelnden Astro-Informatik zu vermitteln und so einen fachbezogenen Zugang zur informatorischen Grundbildung zu ermöglichen.

DD 17: Hochschuldidaktik III

Time: Tuesday 14:45–15:45 Location: Theo 0.136

DD 17.1 Tue 14:45 Theo 0.136

Interaktiver Blended Learning Kurs für die Mathematischen Methoden der Mechanik und Elektrodynamik — •Lydia Kämpf und Frank Stallmach — Institut für Didakik der Physik, Universität Leipzig

Die Mathematikausbildung im Lehramtsstudium Physik ist an der Universität Leipzig während der ersten zwei Fachsemester mit einem interaktiven Blended Learning Kurs in die Experimentalphysikmodule Mechanik und Elektrodynamik eingebettet. Die Physikvorlesungen geben den thematischen Rahmen vor, nach dem die benötigten mathematischen Werkzeuge just-in-time eingeführt und im Laufe der Kurse spiralcurricular vertieft werden.

Die anfängliche Selbstlernphase wird durch einen Moodle-Kurs strukturiert, der für jede Session zwei interaktive Videos, ein zusammenfassendes Skript und weiterführende interaktive Aufgaben beinhaltet. Das erste Video führt die reinen mathematischen Inhalte ein. Im zweiten Video wird die Mathematik auf aktuell relevante Themen der Physikvorlesung angewendet. Im zugehörigen Präsenzseminar wird das erlernte Wissen gemeinsam an weiteren relevanten Beispielen vertieft.

In diesem Vortrag wird der interaktive Kurs für die Mathematischen Methoden zur Mechanik mit den entsprechenden OER-Materialien vorgestellt. Die während der Kursentwicklung und Evaluierung gewonnen Ergebnisse empirischer Studien zur Akzeptanz des Kurses und zum Langzeitwissen der Studierenden werden anhand ausgewählter Themen interpretiert.

DD 17.2 Tue 15:05 Theo 0.136

Gelingende & effektive Zusammenarbeit beim Physik lernen in hybriden Gruppen: die Rolle von Audio, Video und Smartboards — •Michael Griesbeck und Silke Deschle-Prill — Technische Hochschule Rosenheim, Hochschulstr. 1, 83024 Rosenheim

Lehrveranstaltungen mit Möglichkeit zur Online-Teilnahme steigern die Flexibilität der Studierenden und können zugleich zukunftsrelevante Kompetenzen fördern. Dies gilt insbesondere für die hybride Gruppenarbeit, ein studierendenzentriertes und aktivierendes Lehrformat, bei dem Studierende in Präsenz und Online-Teilnehmende synchron in kleinen Teams interaktiv zusammenarbeiten. Damit der Lernerfolg von Online-Teilnehmenden dem der Präsenzteil-

nehmenden gleichwertig werden kann und das hohe Niveau einer rein in Präsenz wie beim SCALE-UP Raum- und Lehrkonzept durchgeführten Lehrveranstaltung erreicht, müssen anspruchsvolle technische und didaktische Voraussetzungen geschaffen werden. Im Rahmen des Projekts HigHRoQ wurde an der TH Rosenheim ein innovativer Lehrraum eingerichtet, der mit seiner hochwertigen technischen Ausstattung speziell auf die Anforderungen hybrider Lehrformate abgestimmt ist. Dieser Beitrag untersucht die aus Sicht der Studierenden und Lehrenden zugeschriebene Bedeutung, Nutzung sowie Funktionalität der im Raum realisierten audiovisuellen und kollaborativen Kommunikationskanäle für eine gelingende, effektive Zusammenarbeit in den hybriden Teams. Zudem werden die mittels studentischer Befragungen und Lehrveranstaltungsbeobachtungen untersuchte Wirkung hinsichtlich des ICAP-Frameworks vorgestellt und Vergleiche zum reinen Präsenzformat gezogen.

DD 17.3 Tue 15:25 Theo 0.136

Mit dem ICAP-Modell aktive Lernprozesse in der Physik-Hochschullehre planen und klassifizieren — •Claudia Schäfle, Silke Stanzel und Christine Lux — Technische Hochschule Rosenheim, Hochschulstr. 1, 83024 Rosenheim

Das ICAP-Modell (Chi et al., 2014) bietet eine vierstufige Taxonomie (*I* Interactive, *C* Constructive, *A* Active und *P* Passive), das studentische Lernen hinsichtlich ihres kognitiven Engagements zu klassifizieren. Dabei wird das von außen beobachtbare Verhalten in Kombination mit den von Studierenden erzeugten „Produkten" (z.B. mündliche und schriftliche Äußerungen) bewertet. Die ICAP-Hypothese postuliert eine Hierarchie der ICAP-Stufen $I > C > A > P$ in Bezug auf die Tiefe der zu erwartenden Lernergebnisse.

In diesem Beitrag wird der Einsatz des ICAP-Modells im Rahmen von Physiklehrveranstaltungen für Ingenieurstudierende vorgestellt. Diese finden nach dem SCALE-UP Raum- und Lehrkonzept statt, in dem Studierende in kleinen Teams an Gruppentischen Lernaktivitäten wie Peer Instruction, Tutorials nach McDermott et al., Experimente oder Aufgaben mit Whiteboards bearbeiten. Das ICAP -Modell dient einerseits der gezielten Planung der Lernaktivitäten. Andererseits werden in der Lehrveranstaltung in Zwei-Minuten-Intervallen die Tätigkeiten der Studierenden und der Lehrperson erfasst und hinsichtlich des ICAP-Modells eingeordnet. Damit wird untersucht, welche ICAP-Stufen durch welche Lernaufgaben erreicht werden. Diese Erkenntnisse dienen der Reflexion der Lehre und damit der Verbesserung des Einsatzes und der Weiterentwicklung von Lernaktivitäten.

DD 18: Neue / Digitale Medien

Time: Tuesday 14:45–15:45 Location: Theo 0.135

DD 18.1 Tue 14:45 Theo 0.135

PUMA : Optiklabor in der Praxis - erste Erfahrungen mit der interaktiven WebAR-Simulation — •Stefan Kraus und Thomas Trefzger — Julius-Maximilians-Universität Würzburg

Das PUMA (Physikunterricht mit Augmentierung) Optiklabor stellt eine webbasierte Augmented Reality Umgebung zur Verfügung, die Schülerinnen und Schülern neue Experimentiergelegenheiten jenseits von Realexperiment und Bildschirmsimulation schafft. Als digitales Schülerexperimentierset verwenden die Jugendlichen auf dem Tisch verteilte Papiermarker. Der Blick „durch" Smartphone oder Tablet-PC ergänzt Geräte wie Laser, Kerzen, Schirme usw., die für den Anfangsunterricht der Optik benötigt werden. Mit diesen Gegenständen kann im dreidimensionalen Raum frei experimentiert werden. Dank des browserbasierten Ansatzes entfällt die Notwendigkeit einer Installation, was einen flexiblen Einsatz ermöglicht.

Im Schuljahr 2024/25 wird die WebApp in der Sekundarstufe I bayerischer Realschulen und Gymnasien erprobt. Begleitend füllen die Schülerinnen und Schüler Fragebögen zu technischen und affektiven Aspekten, wie auch Fachwissen aus. Der Vortrag bietet einen Einblick in die Erfahrungen der ersten Hälfte der teilnehmenden Klassen bezüglich und stellt die eigens implementierte Webplattform der Studie vor.

DD 18.2 Tue 15:05 Theo 0.135

Der ESP-32 im Kontext MINT — •Kristina Holmann und Angela Fösel — Didaktik der Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg

Der ESP32 ist ein beliebter Mikrocontroller in der Welt der Elektronik und des Internet of Things (IoT). Für den Einsatz im Physik- und Technikunterricht ist er hervorragend geeignet: Er verfügt über eine Vielzahl an intern verbauten Sensoren, und bei fast allen Modellen bietet der ESP-32 Bluetooth Low Energy (BLE) Konnektivität. Im Vortrag wird der ESP-32 mit Blick auf den Einsatz im MINT-Unterricht charakterisiert. Der Fokus liegt hierbei auf der Nutzung der Sensoren sowie auf dem Einsatz eines modernen, modular aufgebauten, computergestützten Messwerterfassungssystems mit Option auf BLE-Konnektivität. Für die Praxis relevante Unterschiede gegenüber dem Mikrocontroller-Board Arduino sowie dem Mini-PC Raspberry Pi werden kurz erläutert. Exemplarisch werden kreative schülerrelevante Projekte vorgestellt, die auf einem ESP-32 basieren und zeigen, dass der ESP-32 den MINT-Unterricht um digitale Medien bereichert und zugleich spielerisch zu einem kompetenzorientierten Unterricht einlädt. Mit dem ESP32-CAM-Modul werden Objekte erkannt und identifiziert, indem die Bilddaten analysiert und interpretiert werden. Ein zweites Projekt umfasst ein Anemometer, das in Verbindung mit dem im ESP32 integrierten Hall-Sensor die Windgeschwindigkeit misst. Im Bereich der Automatisierung wurde ein Bewässerungssystem realisiert, das Bodenfeuchtigkeitssensoren nutzt und Ventile steuert, um Pflanzen automatisch mit Wasser zu versorgen.

DD 18.3 Tue 15:25 Theo 0.135

Einflüsse von multimodaler Interaktion und Vorwissen auf räumliche Kontiguität in Experimenten — •Dane-Vincent Schlünz[1], Stephan Dutke[2] und Daniel Laumann[1] — [1]Institut für Didaktik der Physik — [2]Institut für Psychologie in Bildung und Erziehung, Universität Münster

Das Spektrum digitaler Technologien als Ergänzung von Experimenten erfordert empirische Befunde zur lernwirksamen Gestaltung multimedialer Lernumgebungen. Die Cognitive Theory of Multimedia Learning bildet die Grundlage für empirisch geprüfte Designprinzipien. Hierzu gehört das Prinzip der räumlichen Kontiguität zwischen verbal und piktorial präsentierter Information. Ob dieses Prinzip auch in Experimenten gilt, die durch Augmented Reality erweiterte Gestaltungs- und Handlungsmöglichkeiten aufweisen, wurde bisher nur in Ansätzen empirisch untersucht. Studien zeigen hinsichtlich kognitiver Belastung und Lernzuwachs bislang konträre Ergebnisse im Vergleich zu klassischen Medien (Text, Bild). Für ein vertieftes Verständnis erscheinen Untersuchungen relevant, die weitere mögliche Faktoren wie die multimodale Interaktion mit der Lernumgebung und das Vorwissen der Lernenden einbeziehen. Im Rahmen eines durch Augmented Reality erweiterten Experiments zu optischer Polarisation werden in einer Interventionsstudie im 2x2-Design (hohe/geringe räumliche Kontiguität und mit/ohne Interaktion) untersucht, wie räumliche Kontiguität in einem AR-Setting kognitive Belastung und Lernerfolg beeinflusst. Die Stichprobe umfasst N=150 Studierende der Biowissenschaften, Pharmazie und Landschaftsökologie.

DD 19: KI III

Time: Tuesday 14:45–15:45 Location: Theo 0.134

DD 19.1 Tue 14:45 Theo 0.134

ChatGPT im Lehr-Lern-Labor: Potenziale eines KI-basierten Assistenten bei der Entwicklung von Experimentierumgebungen — •Patrick Herz, Jens Damköhler, Wolfgang Lutz und Thomas Trefzger — Julius-Maximilians-Universität, Würzburg, Deutschland

Seit der Veröffentlichung von ChatGPT im November 2022 hat Künstliche Intelligenz (KI) unzählige neue Möglichkeiten zur Unterstützung unseres Alltags geschaffen. Auch im Bildungsbereich eröffnen sich durch KI neue Möglichkeiten zur Erweiterung bestehender Lehrformate und -methoden, beispielsweise durch den Einsatz von Chatbots als unterstützenden Lehrassistenten.

Vor diesem Hintergrund wurde ein KI-gestützter Chatbot in ChatGPT für ein Lehr-Lern-Labor auf Basis didaktischer Prinzipien entwickelt und durch gezieltes Prompt-Engineering optimiert, um Studierende bei der Entwicklung von Experimentierumgebungen für Schülerinnen und Schüler zu unterstützen. Die Akzeptanz des Chatbots wurde nach einer mehrwöchigen Nutzung durch die Studierenden mittels leitfadengestützter Interviews evaluiert. Die Interviews orientierten sich an den Determinanten des Technologieakzeptanzmodells (TAM).

Der Vortrag stellt die Entwicklung und den Einsatz des Chatbots vor und gibt einen ersten Einblick in die Ergebnisse der Interviews. Darüber hinaus werden Chancen und Grenzen des Ansatzes für die Unterstützung von Lehrkräften diskutiert.

DD 19.2 Tue 15:05 Theo 0.134

Hacky teaching: Nutzung von Hackathons zur Überwindung von Einstiegshürden — •Yoav G. Pollack[1], Komal Bhattacharyya[1], Patrick Zimmer[1,2], Gerrit Wellecke[1,2], Krishna Iyer V S[1,3], Anas Hussin[1], Emily Klass[1] und Raffaele Mendozza[1] — [1]University of Göttingen, Göttingen, Germany. — [2]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany. — [3]Indian Insitute of Science Education and Research, Pune, India.

Hackathons sind kurze, intensive Veranstaltungen, bei denen die Teilnehmer in Teams zusammenarbeiten, um innerhalb weniger Tage vorgegebene Computerprobleme zu lösen oder neue Projekte zu entwickeln. Wir schlagen solche Hackathons als Lehrmethode vor, die darauf abzielt, die Einstiegshürden in ein neues Tool, Thema oder wissenschaftliche Disziplin zu überwinden, und diskutieren ihre Vorteile. Außerdem berichten wir über zwei solcher *akademischen* Hackathons, die in Göttingen zum Thema Zytoskelett-Simulationen durchgeführt wurden, und stellen einige Beispielergebnisse vor.

DD 19.3 Tue 15:25 Theo 0.134

Integration von KI-Werkzeugen in die Physikdidaktik: Potenziale für nachhaltiges Lernen in der Physik — •Jannik Henze[1], André Bresges[1] und Sebastian Becker-Genschow[2] — [1]Institut für Physikdidaktik, Universität zu Köln, Köln, Deutschland — [2]Digitale Bildung, Universität zu Köln, Köln, Deutschland

Die Integration von Künstlicher Intelligenz (KI) in die Physikdidaktik eröffnet innovative Möglichkeiten, um Lehr-Lern-Szenarien und datenbasierte Analysen sowie konzeptuelles Lernen neu zu gestalten. Ein Vergleich zwischen einem KI-gestützten Werkzeug, einem speziell entwickelten ChatGPT-basierten Chatbot und traditionellen Excel-Methoden wirft die Fragen auf, wie diese unterschiedlichen Ansätze die Entwicklung analytischer Fähigkeiten beeinflussen und inwiefern sie die emotionale Einbindung und Motivation der Lernenden fördern. Im Fokus stehen dabei Überlegungen, wie KI-Technologien nicht nur physikalische Konzepte auf innovative und zugängliche Weise vermitteln, sondern auch welches Potenzial für Lernerfolge sie bieten können. Diese Untersuchung bietet Einblicke in die Möglichkeiten einer effektiven und nachhaltigen Integration von KI in die physikalische Bildung und wirft gleichzeitig neue Perspektiven für zukünftige Bildungsansätze auf.

DD 20: BNE

Time: Tuesday 14:45–15:45 Location: OEC 1.163

DD 20.1 Tue 14:45 OEC 1.163

Schülerinnen forschen zum Klimawandel - Inquiry-based learning im außerschulischen Kontext zur Förderung von Selbstwirksamkeit, Wissen und Einstellungen zu Klimaphysik — •Paula Becker[1], Andrea Westphal[2], Annelie Schulze[2] und Peter Wulff[1] — [1]Pädagogische Hochschule Heidelberg — [2]Universität Greifswald

Obwohl Frauen in MINT-Studiengängen zunehmend vertreten sind, bleibt insbesondere in Physik der Anteil von Mädchen und Frauen auf Schul- und Hochschulebene niedrig. Studien zeigen, dass geschlechtsspezifische Unterschiede in Interessen, Selbstwirksamkeit und Wertvorstellungen im Zusammenhang mit dem langfristigen Engagement in einem Fach stehen. Unklar ist weiterhin, mit welchen praktischen Ansätzen diese Faktoren nachhaltig gestärkt werden können. Vor diesem Hintergrund wurde im Rahmen des BMBF-Projekts "Young Scientists für Future" eine Projektwoche entwickelt, die fachdidaktische und (sozial-)psychologische Erkenntnisse zu strukturellen, sozialen und inhaltlichen Faktoren für inklusive Physiklernumgebungen berücksichtigt und sich gezielt an Schülerinnen richtet. Die Teilnehmerinnen befassen sich hierbei mit den physikalischen Zusammenhängen des Klimawandels und führen, begleitet durch weibliche Mentorinnen, ein Forschungsprojekt zu einer eigenen Fragestellung durch. Im Rahmen des Tagungsbeitrags sollen Ergebnisse zu Effekten der Intervention auf physikbezogene Selbstwirksamkeit, Interesse und Fachwissen vorgestellt und Implikationen für die Gestaltung geschlechterinklusiver Physiklernumgebungen diskutiert werden.

DD 20.2 Tue 15:05 OEC 1.163

"Ich bin mittendrin in der Katastrophe" - Ergebnisse aus Interviews mit Schüler:innen nach dem Besuch des Schülerlabors Labs4Future — •Franziska Beisler, Jonathan Grothaus und Thomas Trefzger — Emil-Hilb-Weg 22, 97070 Würzburg

Das Schülerlabor Labs4Future (9. Jgst, 2x6h) versucht eine Form interdisziplinärer, naturwissenschaftlicher Bildung zu praktizieren, die nicht bei der Wissensvermittlung stehen bleibt, sondern den Lernenden Wege in wirksames Handeln aufzeigt. Doch wie lässt sich dieser Prozess - Klimahandeln und seine Determinanten - beforschen?

Dieser Vortrag blickt auf eine qualitative Datengrundlage zur Evaluation von Labs4Future. Ausgewählte Schüler:innen wurden in Interviews zu Labs4Future befragt. Untersucht wurde, wie sich die Einstellungen der Interviewten zu gesellschaftlichen und individuellen Aspekten des Klimawandels unterscheiden. Die Erkenntnisse wurden aus umweltpsychologischer Perspektive systematisch interpretiert.

Zentrale Methoden des Labs4Future wurden auch an einer Schule in Norwegen durchgeführt, mit anschließenden Interviews in Kleingruppen. Der internationale Vergleich der Schülerinterviews ermöglicht vertiefte Einblicke in jugendliche Wahrnehmungs- und Handlungsmuster. Im Vortrag werden erste Ergebnisse der Studie präsentiert.

DD 20.3 Tue 15:25 OEC 1.163

Wie misst man Klimahandeln? Erkenntnisse aus dem Schülerlabor Labs4Future — •Jonathan Grothaus, Franziska Beisler und Thomas Trefzger — Emil-Hilb-Weg 22, 97070 Würzburg

Das Schülerlabor Labs4Future (9. Jgst., 2x6h) versucht eine Form interdisziplinärer, naturwissenschaftlicher Bildung zu praktizieren, die nicht bei der Wissensvermittlung stehen bleibt, sondern den Lernenden Wege in wirksames Handeln aufzeigt. Doch wie lässt sich dieser Prozess, also Klimahandeln und seine Determinanten, beforschen? Dieser Vortrag blickt auf die quantitative Datengrundlage (n=250) zur Evaluation von Labs4Future: Wie verhalten sich die psychologischen Testinstrumente zu Klimaangst, Selbstwirksamkeit und Normen in der speziellen Zielgruppe der 9. Jahrgangsstufe? Welche Instrumente erfassen die für Klimabildung relevanten Wissensdomänen und Handlungsarten und lässt sich im PRE-POST Vergleich eine Entwicklung feststellen?

DD 21: Lehr-Lernforschung I

Time: Tuesday 14:45–15:45 Location: OEC 1.162

DD 21.1 Tue 14:45 OEC 1.162

Freihand-Experimente zum Unterrichten des Impuls als direkt beobachtbare Größe — •Bruno Hartmann — Humboldt-Universität Berlin

Wir präsentieren eine neuartige Methode zum direkten Messen des Impuls. Die Grundidee ist Impulseinheiten einzuführen, die wir in Stoßversuchen abzählen können. Wenn wir zwei Pendelkörper frontal gegenüber anordnen, können wir direkt beobachten, ob beide Körper kollidieren, zusammenhaften und gemeinsam ruhen bleiben. Wir können systematisch die Anzahl der Masseneinheiten erhöhen und, mit den bekannten Starthöhen für ein Pendel, können wir auch Vielfache einer Einheitsgeschwindigkeit einstellen und somit den Impuls nach der Geschwindigkeit und Masse quantifizieren. Mit einer Analyse dieses Messprinzips in anschaulichen Gedankenexperimenten zur verbotenen Konstruierbarkeit von Perpetuum Mobile Maschinen erweitern wir schließlich das Prinzip der Energie mit der Impuls Erhaltung. Die Beispiele wurden im Physik Unterricht am Gymnasium getestet und evaluiert.

DD 21.2 Tue 15:05 OEC 1.162

Interviewstudie zu Modellen einfacher Stromkreise: Ein qualitativer Vergleich von Elektronengas- und Wasserfallmodell — •Katharina Leibfarth[1], Jan-Philipp Burde[1], Ulrich Trautwein[1] und Peter Gerjets[2] — [1]Universität Tübingen — [2]IWM Tübingen

In der Physik sind viele Größen und Konzepte abstrakt, unanschaulich oder nicht direkt beobachtbar, beispielsweise die elektrische Spannung in einem Stromkreis. Daher liegt es nahe, bei der unterrichtlichen Behandlung von elektrischen Stromkreisen auf entsprechende Analogien bzw. Modelle zurückzugreifen. Die fachdidaktische Forschung hat sich bisher primär auf die Entwicklung und Evaluation einzelner Modelle des einfachen Stromkreises fokussiert; vergleichende Analysen zur Akzeptanz bzw. Lernförderlichkeit der Modelle fehlen bisher jedoch weitgehend.

Vor diesem Hintergrund wurden Akzeptanzbefragungen mit Lernenden zu verschiedenen Modellen durchgeführt. Im Vortrag wird das Elektronengasmo-

dell mit dem Wasserfallmodell, die beide insbesondere die Veranschaulichung der elektrischen Spannung in den Mittelpunkt stellen, verglichen. Neben der Akzeptanz durch die Lernenden liegt der Fokus des Vortrags auf deren Konzeptverständnis sowie möglichen Lernendenvorstellungen.

DD 21.3 Tue 15:25 OEC 1.162

Von Ferromagnetismus zu Antiferromagnetismus: Lernlaborbaustein für ein tieferes Verständnis von Magnetis-mus — •Manuel Schleicher und Olaf Krey — Didaktik der Physik, Universität Augsburg

Im Rahmen des Transregional Collaborative Research Center (TRR360) findet fachphysikalische Forschung zu eingeschränkter Quantenmaterie (Constrained Quantum Matter, ConQuMat) statt. Das Outreach-Projekt hat es sich zur Aufgabe gemacht, die Lücke zwischen schulphysikalischem Wissen und Grundlagen zum Verständnis von Quantenmaterie zu schließen. Ein erster Lernlaborbaustein zielt darauf ab, die Kenntnisse über Magnetismus von Schülerinnen und Schülern der 7. und 8. Klassenstufe zu erweitern. Aufbauend auf dem vertrauten Konzept des Ferromagnetismus werden experimentbasierte Lernumgebungen entwickelt, in denen die zentralen Konzepte von Dia-, Para- und Antiferromagnetismus vermittelt werden. Als zentrales Konzept zur Beschreibung von Magnetismus wurden die magnetischen Momente eingeführt. Die Ursache dieser wurde auf Basis des Bohrschen Atommodells erklärt und mit Pfeilen dargestellt. In qualitativen Interviews werden die mentalen Modelle zu den unterschiedlichen Magne-tismus-Formen analysiert. Dazu werden die Vorstellungen der Schüler*innen nach dem Durchlaufen des Lernlabors erfasst und mit denen von Physikstudierenden verglichen. Darüber hinaus wird die didaktische Rekonstruktion der Sachinhalte der Lernlaboreinheit in Akzeptanzbefragungen an Dritten untersucht und von fachdidaktischen Experten bewertet.

DD 22: Poster – Anregungen Unterricht

Time: Tuesday 16:15–17:45 Location: ZHG Foyer 1. OG

DD 22.1 Tue 16:15 ZHG Foyer 1. OG

Wind als Kontext für das erste und zweite Newtonsche Gesetz sowie Kraftdiagramme — •Bianca Watzka[1], Yultuz Omarbakiyeva[2], Larissa Hahn[3], Pascal Klein[3], Ingrid Krumphals[4] und Thomas Rubitzko[5] — [1]RWTH Aachen University, Aachen, Germany — [2]Otto von Guericke University Magdeburg, Magdeburg, Germany — [3]University of Goettingen, Goettingen, Germany — [4]University of Teacher Education Styria, Graz, Austria — [5]University of Education Ludwigsburg, Ludwigsburg, Germany

Lehrkräfte nutzen häufig Reibungsfreiheit als Idealannahme, um das erste und zweite Newtonsche Axiom zu vermitteln. Neben der Planetenbewegung bietet der geostrophische Wind (horizontaler Wind entlang von Isobaren) ein reales Bewegungsszenario mit vernachlässigbarer Reibung. Dieses natürliche Phänomen dient als anschaulicher Kontext, um Newtons erstes und zweites Axiom sowie Kräftediagramme im Unterricht zu behandeln.

Das Poster stellt den Kontext und die physikalischen Grundlagen vor. Im Fokus stehen die Kräfte, die auf Luftpakete in großen Höhen wirken, sowie ein Vergleich mit Winden in Bodennähe, bei denen Reibung eine bedeutende Rolle spielt. Darüber hinaus werden konkrete Aufgabenbeispiele präsentiert, die Schülerinnen und Schülern ein tieferes Verständnis für Wind und die dabei wirkenden Kräfte ermöglichen.

DD 23: Poster – Astronomie

Time: Tuesday 16:15–17:45 Location: ZHG Foyer 1. OG

DD 23.1 Tue 16:15 ZHG Foyer 1. OG

Heute wissen wir, wie das Universum aussieht! ...oder? Vorstellung einer digitalen Lernumgebung zur Vorläufigkeit naturwissenschaftlichen Wissens am Beispiel der Geschichte der Astronomie. — •Katja Cramer und Yvonne Webersen — Universität Paderborn

Wenngleich Vorläufigkeit ein zentraler Aspekt naturwissenschaftlicher Erkenntnisgewinnung ist, wird er im schulischen Kontext eher selten thematisiert. Vor diesem Hintergrund wird eine digitale Lernumgebung vorgestellt, die den Vorläufigkeitsaspekt am Beispiel der historischen Veränderung des Weltbildes beleuchtet. Zielgruppe der Lernumgebung sind Schüler:innen der 9.-13. Jahrgangsstufe. Mithilfe der interaktiven, digitalen Lernumgebung können Schüler:innen zum einen die historische Entwicklung der Vorstellung unseres Universums von den antiken Weltbildern des Aristoteles und Ptolemäus über die kopernikanische Wende bis hin zu den Erkenntnissen von Kepler, Galilei und Newton selbstständig nachvollziehen. Zum anderen bietet ein begleitendes Arbeitsblatt den Schüler:innen die Möglichkeit, darüber zu reflektieren, dass naturwissenschaftliches Wissen vorläufig ist, aber dennoch über einen wissenschaftlichen Konsens abgesichert werden kann.

DD 24: Poster – Außerschulische Lernorte

Time: Tuesday 16:15–17:45 Location: ZHG Foyer 1. OG

DD 24.1 Tue 16:15 ZHG Foyer 1. OG

Mobiles Physiklabor im Industriemuseum – ein Design-based research-Projekt — Michael Komorek und •Kai Bliesmer — Institut für Physik, Carl von Ossietzky Universität Oldenburg

Im Industriemuseum Nordwolle in Delmenhorst werden authentische Maschinen der Garnproduktion und der Elektrifizierung in einer Führung historisch kontextualisiert. Dieser geschichtlich eingebetteten Primärerfahrung fehlte es bisher an Elementen der Interaktion, die nun durch Experimentierstationen des mobilen Schülerlabors physiXS realisiert wurden. Achtklässler:innen untersuchten an den Stationen Energiewandlungen, mechanische und elektrische Antriebe und zukünftige Energiequellen wie Wasserstoff. Das Geschichtliche stellte dabei den relevanten Kontext für das Physikalische dar und die physikalischen Erkenntnisse halfen, die Museumserfahrung experimentell zu reflektieren. In einem ersten Design-based research-Zyklus konnten Synergieeffekte zwischen Ausstellung/Führung und Experimenten nicht erreicht werden. Ein zweiter DBR-Zyklus führte zur Integration von Problemlöseanteilen. Beide Zyklen führten auf Generalisierungen hinsichtlich einer komplementären Kopplung von Ausstellung/Führung und Experimenten. Ein dritter DBR-Zyklus setzt nun erstens an den didaktischen Strukturierungen von Führung und Experimentierstationen an, zweitens an der räumlich-zeitlichen Positionierung der Stationen innerhalb der Ausstellung/Führung und drittens wird eine systematische Einbettung des Museumsbesuchs in den Schulunterricht vorgenommen. Im dritten Zyklus wird zudem die empirische Methodik zur Erhebung von Schülerkognitionen ausdifferenziert.

DD 24.2 Tue 16:15 ZHG Foyer 1. OG

Elektronen- und Ultraschallmikroskopie ab Klasse 8 im Schülerlabor — •Franz-Josef Schmitt — Institut für Physik, Martin-Luther-Universität Halle-Wittenberg

In unserem Schülerlabor für Elektronen- und Ultraschallmikroskopie der Heinz-Bethge-Stiftung im Institut für Physik bieten wir eine einzigartige Lernumgebung, die traditionellen Unterricht durch den Einsatz modernster Mikroskopie für die Klassen 8-12 bereichert. Dieses Programm ermöglicht es Schülerinnen und Schülern, mikroskopische und makroskopische Strukturen nicht nur theoretisch zu studieren, sondern sie direkt zu erleben und zu analysieren und auf vielfältige Weise die Welleneigenschaften von Stahlung und Teilchen bei der direkten Anwendung zu erleben. Durch die Kombination aus Licht- und Elektronenmikroskopie und die Ultraschallmikroskopie, die interne Strukturen von Proben ohne Beschädigung visualisiert, eröffnen wir eine neue Dimension des Lernens. Der Ansatz verfolgt neue Methoden der Wissenstransposition, um das Interesse an naturwissenschaftlichen Fächern zu steigern. Die Betreuung erfolgt durch Tutorinnen und Tutoren aber auch Studierende im Lehramt im Rahmen des Fortgeschrittenenpraktikums Physik.

DD 25: Poster – Bildung für nachhaltige Entwicklung

Time: Tuesday 16:15–17:45 Location: ZHG Foyer 1. OG

DD 25.1 Tue 16:15 ZHG Foyer 1. OG

Mission Impossible? – Bewusstseinsbildung für naturwissenschaftliche Grundlagen des Klimawandels — •Helena Franke[1], Christopher Ludwig[2], Daniel Werner[3], Christian Siegel[1] und Philipp Bitzenbauer[1] — [1]Institut für Didaktik der Physik, Universität Leipzig, 04103 Leipzig — [2]Gymnasium Am Breiten Teich, 04552 Borna — [3]Christian-Gottfried-Ehrenberg-Gymnasium, 04509 Delitzsch

Im Schülerlabor zur Bildung für nachhaltige Entwicklung (BNE) an der Universität Leipzig setzen sich Schülerinnen und Schüler der Mittelstufe aktiv mit den Ursachen des Klimawandels und dem eigenen CO_2-Fußabdruck auseinander. Ein interaktives Whiteboard mit den Aufgabenstellungen zu acht verschiedenen Missionen ermöglicht die Einbindung von Videos, Diagrammen und Experimentieranleitungen sowie Applets wie GeoGebra und Particify zur Ergebnissicherung. Die einzelnen Missionen sind nach dem 5E-Modell von Bybee aufgebaut: Sie beginnen in einer Engagement-Phase mit FakeNews oder provokanten, individuellen Meinungen und enden in einer Evaluationphase, in der die Lernenden die eigene Rolle im Kontext der Klimakrise reflektieren und eigene Handlungsoptionen entwickeln. Die Einstellungen von N = 37 Lernenden zum Klimawandel wurden im Rahmen einer Evaluation sowohl vor als auch nach dem Besuch des Schülerlabors mit Hilfe eines an den ROSE-Fragebogen von Schreiner und Sjøberg angelehnten Instruments erhoben. Auf dem Poster werden die Konzeption des Schülerlabors, seine inhaltliche und didaktische Gestaltung sowie die Ergebnisse der Evaluation vorgestellt.

DD 25.2 Tue 16:15 ZHG Foyer 1. OG

Transformative BNE im Kontext Wasser: Projekt Aqua Citizens — •Michael Komorek, Kai Bliesmer und Tjorben Meyer — Institut für Physik, Carl von Ossietzky Universität Oldenburg

Aqua Citizens ist ein von der DBU gefördertes Projekt der transformativen BNE, in dem das Regionale Umweltbildungszentrum RUZ Oldenburg, der Oldenburgisch-Ostfriesische Wasserverband OOWV und die Physikdidaktik der Universität Oldenburg kooperieren. Ausgangspunkt ist, dass mit Wasser als Lebensgrundlage und Bedrohung zentrale Zukunftsaufgaben verbunden sind. Aqua Citizens ist ein Citizen Science-Projekt, das mit mobilen Schülerlaborangeboten angereichert wird. Jugendliche sammeln an ihrem Wohnort Wasserdaten und werten diese gemeinsam aus. Zudem befragen sie Bürger:innen nach ihrem Umgang mit Wasser. Sie entscheiden partizipativ, welche Aspekte untersucht und welche Transformationsbedarfe fokussiert werden. Sie entwickeln eigene Transformationsvorschläge und aktivieren damit Bürger:innen und politisch Verantwortliche. Insbesondere nicht-gymnasiale Schulen, Jugendliche auf dem Land und Mädchen sollen einbezogen werden. Das Poster berichtet über die Befragung von Jugendlichen. In einem problemzentrierten Interview (Witzel 2000) werden ihr Wissen und ihre Lösungsideen zu Starkwetterereignissen, Überschwemmungen und Dürren erfragt. Darüber hinaus wird erhoben, wie relevant sie durch Citizen Science gewonnene Erkenntnisse für Wissenschaft und Gesellschaft einschätzen und wie sie glauben, mit Transformationsvorschlägen Gehör zu finden. Die Interviews werden kategorienbasiert ausgewertet (Kuckartz 2022).

DD 25.3 Tue 16:15 ZHG Foyer 1. OG

Educative Curriculum Materials zum Treibhauseffekt - Lehrendenmaterial für den Physikunterricht — •Ivo Naake und Thomas Wilhelm — Institut für Didaktik der Physik, Goethe-Universität Frankfurt

Der Treibhauseffekt bietet eine gute Möglichkeit, auch im Physikunterricht Klimabildung zu betreiben. Bisher gibt es jedoch wenige, empirisch untersuchte Materialien, die sich speziell auf den Physikunterricht beziehen. Von Sarah Wildbichler wurden Materialien entworfen, die Lernendenvorstellungen berücksichtigen und bereits in Laborsettings getestet wurden. Diese Materialien werden weiterentwickelt und im regulären Schulunterricht evaluiert.

Auf dem Poster werden zunächst die zentralen Elemente des Materials vorgestellt. Dazu gehören das Energiegleichgewicht, die Wechselwirkung zwischen Strahlung und Materie und der anthropogene Treibhauseffekt. Außerdem werden typische Lernendenvorstellungen, die durch das Material berücksichtigt werden, vorgestellt.

Zu den Materialien fehlen bisher Unterstützungen für Lehrer:innen, wie sie diese gut in ihren Unterricht integrieren können. Deshalb wird auf dem Poster auch aufgezeigt, wie Material aussehen könnte, das Lehrpersonen bei der selbstständigen Durchführung der Unterrichtsreihe unterstützen kann. Dafür werden educative features vorgestellt, die ein solches Material beinhalten könnte. Ziel ist es, dass daraus ein Material entsteht, mit dessen Hilfe Lehrkräfte selbstständig den Treibhauseffekt im Physikunterricht behandeln können.

DD 26: Poster – Hochschuldidaktik

Time: Tuesday 16:15–17:45 Location: ZHG Foyer 1. OG

DD 26.1 Tue 16:15 ZHG Foyer 1. OG

DIAMINT-Physik: Lernverlaufsdiagnostik für die Studieneingangsphase — Jana Mergemeier[1], •Dietmar Block[1], Knut Neumann[2] und Irene Neumann[2] — [1]Institut für Experimentelle und Angewandte Physik, Universität Kiel — [2]IPN, Kiel

Die hohen Abbruchzahlen in Kombination mit den sinkenden Anfangszahlen im Studiengang Physik und einem Lehrkräftemangel in Physik begründen, warum es notwendig ist, gezielt in der Studieneingangsphase mit Unterstützungsangeboten anzusetzen. Zudem stellt der Übergang von der Schule zur Hochschule die Studierenden durch selbständigeres Arbeiten, eine höhere Inhaltsdichte, ein neues Umfeld und den ersten eigenen Haushalt vor eine Vielzahl an Herausforderungen. Ziel des Projekts ist es daher, die Studierenden zu Beginn ihres Studiums passgenau zu unterstützen. Dies soll durch die Identifikation individueller Schwierigkeiten und gezielte Hilfestellungen möglichst zeiteffizient geschehen, um die Studierenden nicht zusätzlich zu belasten und ihnen einen reibungsarmen Start ins Studium ermöglichen. Realisiert werden soll dies durch wöchentliche Tests zu mathematischen und physikalischen Inhalten und Hilfestellungen, die den Studierenden basierend darauf empfohlen werden. Die Vision ist, ein Tool zu entwickeln, dass Lernverläufe erkennt und kategorisiert, sodass auf Basis dessen den Studierenden Hilfestellungen geben werden, die sowohl den Kenntnisstand als auch Präferenzen im Lernverhalten und Faktoren der Persönlichkeit berücksichtigen. In dem Beitrag werden das Konzept, die einzelnen Bestandteile und Überlegungen zu Ansätzen und Varianten präsentiert.

DD 26.2 Tue 16:15 ZHG Foyer 1. OG

DIAMINT-Physik: Erfahrungen und Ergebnisse — •Jana Mergemeier[1], Dietmar Block[1], Knut Neumann[2] und Irene Neumann[2] — [1]Institut für Experimentelle und Angewandte Physik, Universität Kiel — [2]IPN, Kiel

Die Studieneingangsphase des Physikstudiums stellt für viele Studierende eine echte Herausforderung dar, weshalb es Unterstützungsangeboten geben sollte, die Studierende möglichst gut unterstützen. In diesem Beitrag werden die ersten Ergebnisse einer Lernverlaufsdiagnostik bezüglich der Inhalte und des Nutzungsverhalten der Studierenden vorgestellt und evaluiert, um diese im nächsten Schritt zu optimieren. Fokussiert werden Ergebnisse zur Arbeitsbelastung, dem Lernfortschritt und dem Studienverhalten der Studierenden im ersten Semester. Dabei wird auch auf die mathematischen Vorkenntnisse und den mathematische Kompetenzerwerb der Studierenden im ersten Studienjahr eingegangen. Ausgehend von den Erfahrungen der ersten Umsetzungen werden zudem die wesentlichen Hürden präsentiert, die aufgetreten sind. Es wird diskutiert, welche Möglichkeiten realisierbar sind, um diesen Schwierigkeiten der Umsetzung in Zukunft entgegenzuwirken. Hierbei wird unter anderem die Effizienz einer Testung durch Selbsteinschätzung evaluiert und gegen eine Umsetzung mit adaptiver Testung abgewogen. Ein zweiter Schwerpunkt liegt auf der Evaluation der Nutzung der Lernverlaufsdiagnostik sowie der Nutzung von zusätzlichen Lernangebote im Allgemeinen für Studierenden im ersten Semester des Physik- Studiums.

DD 26.3 Tue 16:15 ZHG Foyer 1. OG

Multi-repräsentationale Lernaufgaben zur Vektoranalysis in der Studieneingangsphase — •Larissa Hahn[1], Alexander Voigt[2], Philipp Mertsch[2] und Pascal Klein[1] — [1]Universität Göttingen, Deutschland — [2]RWTH Aachen, Deutschland

Um Vektorfeldkonzepte wie Divergenz oder Rotation in physikalischen Kontexten anzuwenden, ist ein solides Verständnis ihrer Grundlagen erforderlich. Bisherige empirische Forschungsergebnisse bei Studierenden zeigten hierbei Schwierigkeiten auf, die sich z.B. auf die visuelle Interpretation von Richtungsableitungen zurückführen lassen. Im Einklang mit lerntheoretischen Erkenntnissen wird daher der Einsatz multipler Repräsentationen bei der Vermittlung dieser Konzepte empfohlen. Auf Basis der empirischen Vorarbeiten wurden Lernaufgaben entwickelt, die einen visuellen Zugang zur Vektoranalysis anhand von multiplen Repräsentationen (MR) ermöglichen und Zeichenaktivitäten sowie ein interaktives Vektorfeld-Visualisierungswerkzeug integrieren. Diese MR-Lernaufgaben wurden in die begleitenden Übungen einer Elektromagnetismus-Vorlesung an der Universität Göttingen implementiert (N = 81). Die Wirksamkeitsanalyse ergab höhere Lerneffekte der MR-Lernaufgaben im Vergleich zu

traditionellen, rechenbasierten Aufgaben. Eine Implemenation der Lernaufgaben in die begleitenden Übungen einer Vorlesung zu mathematischen Methoden der Physik im zweiten Studiensemester an der RWTH Aachen steht bevor. Dieser Beitrag präsentiert zum einen die Lernaufgaben sowie Ergebnisse der ersten Wirksamkeitsanalysen und stellt zum anderen die Studie zur Implementation an der RWTH Aachen vor.

DD 26.4 Tue 16:15 ZHG Foyer 1. OG

Belastungserleben von Lehramtsstudierenden in der Studieneingangsphase Physik — •Deniz C. Senel[1,2], Simon Z. Lahme[1], Josefine Neuhaus[1] und Pascal Klein[1] — [1]Universität Göttingen — [2]RWTH Aachen University

Die Studieneingangsphase Physik ist angesichts hoher Abbruchquoten für viele Studierende potenziell belastend. Da Studierende des Hauptfachs und gymnasialen Lehramts zu Studienbeginn häufig gemeinsam Physik-Fachvorlesungen besuchen, bedarf es einer studiengangsspezifischen Betrachtung des Belastungserlebens, gerade auch mit Blick auf den hohen Physiklehrkräftemangel. Aufbauend auf vorangegangenen Messungen des Belastungserlebens im ersten Studienjahr wurden daher an der Universität Göttingen leitfadengestützte Gruppeninterviews mit Physikstudierenden – insbesondere des Lehramts – durchgeführt. Diese zielten darauf ab, mehr über die Belastungsquellen und Wünsche nach Unterstützungsmaßnahmen zu erfahren. Die für das Physik-Lehramtsstudium spezifischen Aussagen aus sechs Interviews (N = 18 Studierende) wurden in einem Kategoriensystem zusammengeführt. Entsprechende Belastungsquellen sind etwa die als unzureichend empfundene Passung zwischen Studieninhalten und späteren beruflichen Anforderungen, die hohe fachliche Komplexität sowie eine als gering wahrgenommene Wertschätzung von Lehramtsstudierenden. Gleichzeitig werden Wünsche nach stärkerer Theorie-Praxis-Verknüpfung und curricularen Differenzierungen in den Fachveranstaltungen geäußert.

DD 26.5 Tue 16:15 ZHG Foyer 1. OG

Belastungserleben in der Studieneingangsphase Physik: Aktuelle Befunde und Perspektiven — •Simon Z. Lahme, Josefine Neuhaus und Pascal Klein — Universität Göttingen

Angesichts hoher Abbruchquoten und vielfältiger Herausforderungen für Studierende in der Studieneingangsphase Physik wird an der Universität Göttingen seit nun mehr drei Jahren das Belastungserleben der Physik(-lehramts-)studierenden im ersten Studienjahr untersucht. Dabei kommen sowohl regelmäßige Online-Umfragen zur Messung des Belastungserlebens als auch Leitfaden- und Aufgaben-gestützte Gruppendiskussionen zum Einsatz. Die Daten liefern aus der Perspektive der Studierenden ein umfassendes Bild des Belastungserlebens im Semesterverlauf, der zugrundeliegenden Belastungsquellen sowie möglicher Unterstützungs- bzw. Gegenmaßnahmen. Daraus ergeben sich vielfältige Perspektiven für die weitere Beforschung der Studieneingangsphase sowie die Entwicklung, Implementation und Evaluation entsprechender Maßnahmen. Ein derartiges Forschungs- und Entwicklungsprogramm lässt sich auch in andere Institutionen und Studiengänge transferieren.

DD 26.6 Tue 16:15 ZHG Foyer 1. OG

Modellierung von Blickbewegungen bei der Beurteilung von Divergenz — •Niklas Weiss, Yvonne Kretzer, Larissa Hahn, Pascal Klein und Stefan Klumpp — Institut für Dynamik komplexer Systeme, Göttingen, Germany

Die Fähigkeit, Formeldarstellungen visuell zu interpretieren, ist eine grundlegende Komponente des Verständnisses von mathematischen und physikalischen Konzepten. Diese Übersetzungsleistung wird bei der Beurteilung der Divergenz zweidimensionaler Vektorfelder relevant. Bei einer Eye-Tracking Studie mit 141 Studienanfängern (Klein et al. 2021) wurde gezeigt, dass systematische Augenbewegungen in horizontaler und vertikaler Richtung bei der Lösung solcher Probleme ein korrektes Vorgehen andeuten. Auf diesen Beobachtungen aufbauend wurde ein Modell entwickelt, welches Augenbewegungen durch eine symbolische Dynamik repräsentiert und als diskreter Markov-Prozess simuliert werden kann. Der Vergleich von Beobachtung und Simulation zeigt eine Überrepräsentation sich wiederholender horizontaler und vertikaler Sakkaden. Dies kann als Anwendung einer Strategie zur korrekten Beurteilung der Divergenz interpretiert werden. Diese Erkenntnissen ermöglichen Vorhersagen über die Korrektheit der Beurteilung des Vektorfelds aus den Blickbewegungen. Dabei wird die Vorhersagekraft verschiedener Machine-Learning-Modelle miteinander verglichen.

DD 26.7 Tue 16:15 ZHG Foyer 1. OG

Ein interdisziplinäres Seminar für Lehramtsstudierende der Naturwissenschaften — •Giulia Pantiri[1], Lea Mareike Burkhardt[2], Thomas Wilhelm[1], Volker Wenzel[2], Arnim Lühken[3], Dieter Katzenbach[4] und Fatime Beka[3] — [1]Institut für Didaktik der Physik, Uni Frankfurt — [2]Abteilung Didaktik der Biowissenschaften, Uni Frankfurt — [3]Institut für Didaktik der Chemie, Uni Frankfurt — [4]Institut für Sonderpädagogik, Uni Frankfurt

Im Projekt E2piMINT arbeiten Vertreter*innen aus den Fachdidaktiken Biologie, Chemie und Physik mit der Sonderpädagogik zusammen, um ein inklusives und interdisziplinäres MINT-Unterrichtskonzept für die Sek. I zu entwickeln, zu erproben und zu evaluieren. Dafür wurde jeweils ein Projekttag zum Thema Farben und zum Thema Kleben und Haften konzipiert, bei dem die Schüler*innen mit Experimentierkisten arbeiten. Im Rahmen des Projekts wurde ein Seminar für Lehramtsstudierende der Naturwissenschaften (Gymnasium, Haupt- und Realschule, Förderschule) entwickelt, das im SoSe 2024 stattfand und den Studierenden die Möglichkeit bot, sich aktiv an der Entwicklung der Experimentierkisten zum Thema Kleben und Haften zu beteiligen. Dabei konnten sie sich mit Personen aus anderen Fächern austauschen und die inklusiven Merkmale der Kisten kennenlernen. Während des Seminars nahmen sie auch an einer Lehrkräftefortbildung teil und erprobten die selbst entwickelten Materialien mit verschiedenen Schulklassen. Auf dem Poster werden das Seminar und Beispiele der dabei entstandenen Materialien vorgestellt. Außerdem werden Vorteile, Grenzen und Verbesserungsmöglichkeiten des Seminars diskutiert.

DD 27: Poster – Lehr-Lernforschung

Time: Tuesday 16:15–17:45 Location: ZHG Foyer 1. OG

DD 27.1 Tue 16:15 ZHG Foyer 1. OG

Kopfübungen im Physikunterricht – Wahrnehmung der Methode durch Lehrkräfte und Analyse der Aufgabenbearbeitungen — •Martin Dickmann und Heike Theyssen — Universität Duisburg-Essen

Im Physikunterricht steht häufig die Einführung neuer fachlicher Konzepte im Vordergrund, während das regelmäßige Üben und Anwenden bereits gelernten Wissens oft vernachlässigt wird. Als ein möglicher Ansatz, um dieses Problem zu lösen, wurde die in der Mathematikdidaktik erprobte Methode der „vermischten Kopfübungen“ für den Physikunterricht der Sekundarstufe I adaptiert. Ziel ist es, durch regelmäßigen Wissensabruf die langfristige Verfügbarkeit von Grundwissen zu fördern.

Im Rahmen einer Vergleichsstudie haben sieben Lehrkräfte die Übungsmethode in sieben Schulklassen der Jahrgangsstufe 9 an fünf Gymnasien in NRW erprobt. Das Poster präsentiert zentrale Ergebnisse zur Wahrnehmung der Übungsmethode durch die Lehrkräfte sowie die Analyse der Bearbeitungsqualität der Kopfübungsaufgaben durch die Schüler:innen und die theoriebasierte Bewertung der Aufgabenkomplexität.

DD 27.2 Tue 16:15 ZHG Foyer 1. OG

Entwicklung und Validierung eines Testinstruments zu einfachen Stromkreisen — •Benjamin Gross[1], Jan-Philipp Burde[1], Augustin Kelava[1], Judith Glaesser[1], Lana Ivanjek[2] und Salome Flegr[3] — [1]Universität Tübingen — [2]Universität Linz — [3]Technische Universität Dresden

Um das konzeptionelle Verständnis von Studierenden bezüglich einfacher elektrischer Stromkreise sowie das Vorliegen verbreiteter Lernendenvorstellungen bei Studierenden besser zu erfassen, wurde ein neues Testinstrument entwickelt. Zu den Konzepten Strom, Spannung, Widerstand, Energie und dem Systemcharakter von Stromkreisen wurden dabei literaturbasiert zunächst die jeweils dokumentierten Lernendenvorstellungen identifiziert und hierzu anschließend zweistufige Multiple-Choice-Items entwickelt bzw. aus bestehenden Instrumenten adaptiert. Mit Hilfe einer Expertenbefragung wurde u. a. die Formulierung der Items überarbeitet sowie die Antwortcodierung überprüft. Nach einer Erhebung mit N = 164 Studierenden aus der Studieneingangsphase wurden die psychometrischen Eigenschaften des Testinstruments quantitativ untersucht. Dies umfasste Methoden der klassischen Testtheorie wie Item-Schwierigkeit, -diskriminierung und klassische Reliabilitätsmaße. Weiterhin wurden Faktorenanalysen (EFA/CFA) u.a. auf Basis sparsamer Bifaktormodelle durchgeführt, um die angenommene Struktur der Zuordnung von Items zu Konstrukten zu prüfen. Auf dem Poster werden das Testinstrument sowie die wesentlichen Ergebnisse der genannten Analysen vorgestellt.

DD 27.3 Tue 16:15 ZHG Foyer 1. OG

Experimentieren = Interesse? - Offenheit beim Experimentieren zum Thema Klima — •Christopher Jörgens, Cornelia Geller und Hendrik Härtig — Universität Duisburg-Essen

Das Fach Physik und andere MINT-Fächer leiden nach Krapp und Möller während der Schulprogression unter einem Rückgang des Interesses. Potvin und Hasni konnten dies grundsätzlich bestätigen, zeigen jedoch auch, dass das allgemeine Interesse am Experimentieren bei Schüler:innen stabil bleibt. Diese Diskrepanz könnte sich erklären lassen, wenn sich Interesse beim Experimentieren in unterschiedliche Dimensionen wie Interesse am Kontext, Interesse am physikalischem Inhalt und Interesse an der Tätigkeit, aufspaltet (Häußler & Hoff-

mann). Eine solche Mehrdimensionalität könnte auch dazu führen, dass Experimentieren aufgrund des höheren Autonomieerlebens zwar grundsätzlich interessensförderlich sein kann, sich dies in Untersuchungsergebnissen aber nicht eindeutig bestätigt (z.B. Tesch & Duit und Abrahams). Es besteht die Vermutung, dass sich die unterschiedlichen Dimensionen im Gesamtkonstrukt möglicherweise ausgleichen. Um die Zusammenhänge zwischen den verschiedenen Dimensionen des Interesses mit dem Autonomieerleben beim Experimentieren quantifizieren zu können, ist eine Studie mit einer Experimentierumgebung im Kontext Klima geplant. Dabei werden verschiedene Offenheitsgrade des Experimentierens nach Bauer et al. durch unterschiedliche Vorstrukturierungen in digitalen Laborbüchern realisiert und deren Effekte auf das Autonomieerleben und die Interessensarten untersucht. Auf dem Poster werden das Studiendesign und erste Materialien präsentiert.

DD 27.4 Tue 16:15 ZHG Foyer 1. OG

Entwicklung eines Fragebogens zur Implementation physikdidaktischer Innovationen — •Jakub Knebloch und Thomas Wilhelm — Goethe-Universität Frankfurt am Main

Seit fünfzig Jahren werden in der Physikdidaktik fortlaufend neue Ideen, neue Unterrichtskonzepte und neue Unterrichtsmaterialien entwickelt. In retrospektiver Betrachtung lässt sich feststellen, dass ein Großteil der Innovationen nicht, kaum oder erst sehr spät im Klassenzimmer ankamen.

Um die Ursachen zu ergründen, wurden fünfzehn halboffene Interviews mit Physiklehrkräften durchgeführt, in denen sie mittels vorbereiteter Leitfragen ihre Überlegungen zu den Ursachen der beschriebenen Problematik und zu Verbesserungsmöglichkeiten äußern sollten. Aus den Interviews wurden acht Kategorien zu beschriebenen Ursachen der Problematik herauskristallisiert. Mit diesem Wissen wurde ein Fragebogen entwickelt, der mit Experten aus der Praxis bezogen auf die inhaltliche Validität überprüft wurde pilotiert wurde. Auf dem Poster werden die Ergebnisse des Fragebogens der Pilotierungsphase vorgestellt.

DD 27.5 Tue 16:15 ZHG Foyer 1. OG

Eye-Tracking-Studie zum Zusammenhang zwischen kognitiver Belastung und Lernerfolg bei der Anwendung von Kraftdiagrammen — •Yultuz Omarbakiyeva[1], Larissa Hahn[2], Pascal Klein[2], Ingrid Krumphals[3] und Bianca Watzka[4] — [1]Otto von Guericke University Magdeburg, Magdeburg, Germany — [2]University of Goettingen, Goettingen, Germany — [3]University of Teacher Education Styria, Graz, Austria — [4]RWTH Aachen University, Aachen, Germany

Das Verständnis der kognitiven Anforderungen beim Lösen von Aufgaben zu Kraftdiagrammen ist entscheidend für die Entwicklung effektiver Lehrmethoden und die Förderung komplexer Problemlöseprozesse.

Das Poster präsentiert eine Studie, die kognitive Prozesse beim Lösen von Aufgaben zu Kraftdiagrammen im Kontext Wind untersucht. Die Studie analysiert die Blickbewegungen und die kognitive Belastung von Studierenden bei der Bearbeitung von Aufgaben mit Kraftdiagrammen mit zwei und drei Kräften. Aufgaben zum Bodenwind (drei Kräfte) erweisen sich dabei als schwieriger als Aufgaben zum Höhenwind (zwei Kräfte). Diese Ergebnisse werden durch die Analyse der kognitiven Belastung und Eye-Tracking-Daten bestätigt.

Die Ergebnisse verdeutlichen den Einfluss der kognitiven Belastung auf die Problemlöseleistung und unterstützen die Entwicklung spezifischer Unterrichtsansätze zur Optimierung von Lernprozessen.

DD 27.6 Tue 16:15 ZHG Foyer 1. OG

An analysis of demographic and educational factors affecting secondary student's performance in hellenic national physics competitions — •Nikolaos Papadimitriou[1], Rizos-Theodoros Chadoulis[2], Kostas Vourlias[3], Stelios Orfanakis[4], and Denis Vavougios[5] — [1]Physics Dept., Univ. Patras — [2]Informatics Dept., Aristotle Univ. Thessaloniki — [3]Pefka High School — [4]OpenUp, Panhellenic Sci. Assoc. of Innovation — [5]Physics Dept., Univ. Thessaly

The Hellenic Physical Society organizes annual national physics competitions for students at various educational levels. This study examines the performance patterns of secondary school students focusing on demographic and educational factors such as origin, gender and school type. Anonymized data from student responses to competition questions were analyzed using detailed statistical methods to identify common areas of difficulty, alternative ideas and knowledge gaps. The questions were classified based on the physics area they address, the task type, the assigned difficulty level and the underlying alternative ideas. By examining response patterns and success rates, we explored performance disparities among different student demographics, paying particular attention to differences in knowledge levels related to educational environment and background. Our findings provide valuable insights into student learning patterns and performance challenges, offering perspectives to improve competition frameworks and refine educational aspects, with an emphasis on targeted support for diverse demographic groups and fostering a more inclusive learning environment that addresses specific educational needs across various backgrounds.

DD 27.7 Tue 16:15 ZHG Foyer 1. OG

Expertise messen - Weiterentwicklung eines Testinstruments zu Problemschemata in der Mechanik — •Katja Plicht und Josef Riese — Universität Paderborn

Die Expertise einer Person kann in der Physik durch die Untersuchung ihrer Problemlöseleistung bestimmt werden. Die Expertiseforschung identifiziert in diesem Zusammenhang Problemschemata als zentrale Gelingensbedingung eines erfolgreichen Problemlöseprozesses. Problemschemata werden als kognitive Strukturen beschrieben, die im Verlauf des Expertiseerwerbs ausgebildet werden und Informationen über Anwendungsheuristiken und Lösungsansätze beinhalten, sodass bei der Identifikation einer Problemklasse bereits bestehende Lösungsstrategien genutzt werden können.

Für die empirische Evaluation der Expertise von Lernenden müssen somit entsprechende Testinstrumente vorliegen. Trotz ihrer hohen Relevanz fehlt es jedoch an empirischen Untersuchungen von Problemschemata. In der vorliegenden Arbeit wird daher eine Operationalisierung des Konstrukts und dessen Umsetzung in einem Testinstrument vorgestellt. Dabei wird die Güte anhand der Daten mehrerer Semester und Kohorten zusammenfassend diskutiert.

DD 27.8 Tue 16:15 ZHG Foyer 1. OG

Lesson Study Plus: Potentiale und Herausforderungen — •Christiane Richter, Kai Bliesmer und Michael Komorek — Institut für Physik c. v. Ossietzky-Universität Oldenburg

Die Lesson Study erlaubt eine Form der Unterrichtsforschung, bei der Schülerlernen im Fokus steht und bei der durch Beobachtung der Lernendenhandlungen Rückschlüsse auf abgelaufene Lernprozesse gezogen werden (Knoblauch 2017; Mewald 2019). In Praxismodulen nutzen wir den Planungsansatz *Backbone*, der zwischen Sicht- und Tiefenebene unterscheidet (Richter & Komorek 2017)), und verknüpfen diesen mit der Lesson Study. Ihre Planung erproben die Studierenden in einer Kooperationsschule; eine Person der Studierenden unterrichtet, während die anderen Studierenden das Handeln je eines Lernenden beobachten. In der anschließenden Auswertung wird versucht, aus den Beobachtungen auf kognitive Prozesse der Lernenden zu schließen. Die beobachteten Handlungen von Lernenden, die abgeleiteten Kognitionen und die Planungen werden anschließend systematisch aufeinander bezogen. Obwohl es sich bei der Lesson Study um eine effektive Methode handelt, um die Oberflächenstruktur des Unterrichts zu erfassen, mangelt es ihr an Indikatoren, mit denen auf die Tiefenstruktur geschlossen werden kann. Dadurch ergibt sich die Herausforderung, die Methode der Lesson Study der theoretischen Fundierung hinsichtlich des Planungsansatzes Backbone anzupassen. Der Lösung dieses Problems versuchen die Autoren näher zu kommen.

DD 27.9 Tue 16:15 ZHG Foyer 1. OG

Binnendifferenziertes Experimentieren zur Förderung der Variablenkontrollstrategie im Unterricht — •Tobias Winkens, Nicolas Hartrumpf und Heidrun Heinke — RWTH Aachen University

Der Beitrag fokussiert auf das Experimentieren unter Anwendung der Variablenkontrollstrategie (VKS) mit einem expliziten binnendifferenzierten Förderansatz. Als unterrichtstauglicher Ansatz berücksichtigt er das Vorwissen der Lernenden als Ausgangslage und baut darauf Lerngelegenheiten auf. Die theoretische Basis bilden die vier aus der Literatur bekannten VKS-Teilfähigkeiten zur Interpretation (IN), Identifikation (ID) und Planung (PL) kontrollierter Experimente sowie das Verständnis der fehlenden Aussagekraft konfundierter Experimente (UN). Mithilfe teilfähigkeitsspezifischer Arbeitsblattvorlagen werden Experimente zur VKS implementiert, sodass zu jedem Experiment leicht vier Arbeitsblattversionen mit unterschiedlichem Schwierigkeitsgrad erzeugt werden können. Damit wurden zwei Lernzirkel mit den fünf gleichen experimentellen Aufbauten, aber verschiedenen Anleitungen erstellt. Ein Lernzirkel umfasst die vorwiegend einfachen Teilfähigkeiten (2xIN, 2xID, 1xPL) und ein anderer die schweren Teilfähigkeiten (3xPL, 2xUN). In einer ersten Erhebung (N=87) in drei gymnasialen 7. Klassen wurden die SuS gemäß ihrer Pre-Test-Ergebnisse in leistungshomogene Kleingruppen (2-3 SuS) eingeteilt und durchliefen in diesen eine Intervention aus einer Einführung, der Lernzirkeldurchführung sowie einer Sicherung und absolvierten zum Abschluss den Post-Test. Die Ergebnisse dieser Erhebung werden auf dem Poster vorgestellt.

DD 27.10 Tue 16:15 ZHG Foyer 1. OG

Laserphysik im Lehr-Lern-Labor: Wie Lernumgebung und Disposition die intrinsische Motivation beeinflussen — •Roman Kuhr, Lukas Maczewsky und Heidi Reinholz — AG Didaktik der Physik, Universität Rostock, Mecklenburg-Vorpommern

In den letzten Jahrzehnten ist die Zahl der Schülerlabore und Lehr-Lern-Labore deutlich gestiegen (Engeln, 2004). Diese Entwicklung erfolgte insbesondere vor dem Hintergrund des Fachkräftemangels mit dem Ziel, das Interesse von Kindern und Jugendlichen für den MINT-Bereich zu fördern (Haupt, 2013). Die Wirksamkeit solcher Maßnahmen wird häufig anhand der Veränderung der intrinsischen Motivation untersucht. Zahlreiche Studien weisen darauf hin, dass der Besuch eines Schüler- oder Lehr-Lern-Labors einen temporären positiven

Effekt auf die intrinsische Motivation haben kann (Simon, 2019; Pawel, 2009; Zehren, 2009).

Im Lehr-Lern-Labor PhySch an der Universität Rostock wurde ein Projekt zum Thema Laserphysik für die Sekundarstufe II entwickelt, das im Hinblick auf seine Wirkung auf die intrinsische Motivation evaluiert wurde. Untersucht wurde, inwiefern bestimmte Einflussfaktoren der Lernumgebung sowie individuelle Dispositionen zur Veränderung der intrinsischen Motivation führen. Mithilfe von Fragebögen und Korrelationsanalysen wurden Prädikatoren aus fünf Durchgängen über zwei Semester hinweg identifiziert.

DD 28: Poster – Lehreraus- und -fortbildung

Time: Tuesday 16:15–17:45 Location: ZHG Foyer 1. OG

DD 28.1 Tue 16:15 ZHG Foyer 1. OG

Einsatz von 3D-Druckern im (inklusiven) MINT-Unterricht — •Simon Höfting, Moritz Langer und André Bresges — Universität zu Köln / Institut für Physikdidaktik

Der Einsatz von 3D-Druckern im Bildungsbereich bietet großes Potenzial, den MINT-Unterricht, zum Beispiel durch individualisierte Lehrmittel, praxisnah und inklusiv zu gestalten. Trotz dieses Potenzials werden 3D-Drucker an Schulen bisher selten genutzt, unter anderem, da Lehrkräfte häufig unzureichend geschult sind. Im Rahmen des lernen:digital-Projektes ComeMint wurde ein Workshop entwickelt, der Lehrkräfte und Lehramtsstudierende befähigt, den 3D-Drucker zielführend im Unterricht einzusetzen.

In diesem zweiteiligen Workshop steht die spielerische Vermittlung der 3D-Druck-Pipeline im Mittelpunkt, von der ersten Idee bis zum fertigen Produkt. Die Teilnehmenden entwerfen und drucken ein eigenes Katapult, wobei sie physikalisches Vorwissen anwenden und kreative Lösungen entwickeln. Die zweite Sitzung dient der Präsentation der gedruckten Objekte, der Reflexion der Designentscheidungen und der Nachbereitung der Drucke.

Das Poster stellt neben dem Workshopkonzept auch den Entwicklungsprozess des Workshops nach dem Double-Diamond-Ansatz vor und zeigt, wie durch iterative Anpassungen ein Fortbildungsmodell entstand, das flexibel auf verschiedene Zielgruppen übertragbar ist. Ziel des Posters ist es, Einblicke in die Verbindung von Designmethodik und didaktischer Entwicklung zu geben, um innovative, praxisorientierte Lehrkonzepte zu fördern.

DD 28.2 Tue 16:15 ZHG Foyer 1. OG

MINT-Unterricht mit digitalen Medien adaptiv gestalten — •Jasmin Moser[1], Richard Schulte[1], Frank Seeberger[1], Linda von Sobbe[2], Ulrike Franke[1], Anneke Schmidt[1], Jan-Philipp Burde[1], Walther Paravicini[1], Stefan Schwarzer[1] und Andreas Lachner[1] — [1]Universität Tübingen, Deutschland — [2]Deutsches Institut für Erwachsenenbildung, Bonn, Deutschland

Adaptiver Unterricht, also die gezielte Anpassung von Unterricht an die Voraussetzungen der Lernenden, ist eine vielversprechende Möglichkeit mit der zunehmenden Heterogenität an Schulen umzugehen. Dabei kann der Einsatz digitaler Medien die Umsetzung eines adaptiven Unterrichts erleichtern. Im Rahmen des Projektes MINT-ProNeD wurde eine Lehrkräftefortbildung zu adaptivem MINT-Unterricht in Form eines Moodle-Selbstlernkurses entwickelt. Dieser Kurs ermöglicht es Lehrkräften, sich die Grundlagen adaptiven Unterrichtens sowie dessen Umsetzung mit und ohne digitale Medien anzueignen. In Kooperation mit einer Physiklehrkraft wurden als physikspezifische Anwendung der Inhalte des Selbstlernkurses digitale Unterrichtsmaterialien mit H5P für den Optikunterricht in der Sek I erstellt und erprobt. Diese beinhalten sowohl unterschiedliche Lernpfade als auch elaboriertes, automatisiertes Feedback als Elemente adaptiven Unterrichts. Das Poster stellt die Konzeption des Selbstlernkurses zu adaptivem MINT-Unterricht sowie die physikspezifischen adaptiven Unterrichtsmaterialien vor.

DD 28.3 Tue 16:15 ZHG Foyer 1. OG

Online-Selbstlernkurs zu digitalen Medien im Physikunterricht — •David Weiler[1], Jan-Philipp Burde[1], Kasim Costan[2], Rike Grosse-Heilmann[3], Christoph Kulgemeyer[2], Armin Lässer[4], Katja Plicht[3], Josef Riese[3] und Thomas Schubatzky[4] — [1]Universität Tübingen — [2]Universität Bremen — [3]Universität Paderborn — [4]Universität Innsbruck

Die fortschreitende Digitalisierung stellt die Lehrkräftebildung vor große Herausforderungen. Während Junglehrkräfte schon von Veränderungen in der Lehrkräfteausbildung profitieren, wurden viele der berufstätigen Lehrkräfte nicht angemessen auf die Möglichkeiten der Digitalisierung vorbereitet. Der Kompetenzverbund lernen:digital widmet sich daher der gezielten Unterstützung dieser Lehrkräfte bei der Entwicklung digitalisierungsbezogener Kompetenzen. Im zugehörigen Verbundprojekt ComeMINT wurde unter anderem ein Online-Selbstlernkurs zum Einsatz digitaler Medien im Physikunterricht entwickelt, der auf Vorarbeiten aus der Lehrkräfteausbildung sowie auf einer Erhebung von Bedürfnissen praktizierender Physiklehrkräfte aufbaut. Der Online-Selbstlernkurs ermöglicht den Erwerb grundlegender Kompetenzen zum Einsatz physikspezifischer digitaler Medien, wie z. B. digitaler Messwerterfassung, Augmented Reality oder Simulationen. Das Poster stellt den Aufbau und die Inhalte des Online-Selbstlernkurses vor.

DD 28.4 Tue 16:15 ZHG Foyer 1. OG

Analyse von Lehrkräfte-Netzwerken und deren Nutzung — •Ramona Schauer-Bollig und Heidrun Heinke — RWTH Aachen University, I. Physikalisches Institut IA

Ein wesentlicher Aspekt fachdidaktischer Forschung ist die Weiterentwicklung schulischen Unterrichts. Neben der Entwicklung von Lehrinnovationen zählt dazu insbesondere auch deren gelungene Implementation in der Schulpraxis. Eine zweckdienliche Strategie ist der symbiotische Implementationsansatz, der durch einen Austausch zwischen Wissenschaft und Praxis geprägt ist. Lehrkräfte-Netzwerke mit gleichzeitiger Beteiligung von Akteuren aus Hochschulen stellen eine Option dar, einen solchen Austausch zu ermöglichen. Mit dem Forschungsvorhaben wird der Frage nachgegangen, wie geeignete Rahmenbedingungen für nachhaltig wirksame Lehrkräfte-Netzwerke aussehen können und ob etablierte Netzwerke ein gangbarer Weg sind, physikdidaktische Lehrinnovationen in der Schule erfolgreich zu implementieren. In einem ersten Schritt werden dazu etablierte Netzwerke sowie deren Nutzung durch Lehrkräfte untersucht. Dabei interessiert insbesondere, inwiefern diese Lehrkräfte-Netzwerke einen praktischen Mehrwert für den eigenen Unterricht der Teilnehmenden bieten und dabei auch der Implementation physikdidaktischer Lehrinnovationen dienen (können).

DD 28.5 Tue 16:15 ZHG Foyer 1. OG

Was motiviert Schüler*innen Lehramt zu studieren? — •Lion Cornelius Glatz[1], Teemu Loh[2], Pauline Czora[2], Mark Ullrich[2], Holger Horz[2] und Roger Erb[1] — [1]Institut für Didaktik der Physik, Goethe-Universität Frankfurt — [2]Pädagogische Psychologie, Goethe-Universität Frankfurt

Vor dem Hintergrund rückläufiger Studierendenzahlen im Physik-Lehramt und im Lehramt generell, stellt sich die Frage, was Schüler*innen motiviert ein Lehramtsstudium zu beginnen, welche Vorstellungen über den Lehrberuf sie haben, und welche Erwartungen an den Berufsalltag als Lehrkraft existieren.

In einer Mixed-Methods-Erhebung an hessischen Schulen werden deswegen Schüler*innen, die kurz vor dem Abitur stehen, zu ihrer Motivation bei der geplanten Berufswahlentscheidung und zu ihren Erwartungen an den zukünftigen Beruf, bzw. ihr angedachtes Studium oder Ausbildung befragt, mit einem besonderen Fokus auf den Schüler*innen, die ein Lehramtsstudium in Betracht ziehen. Dabei interessiert nicht nur, welche Motive für die Wahl eines Lehramtsstudiums ausschlaggebend sind, sondern auch inwiefern sich diese über den Verlauf des Studiums ändern. Aus diesem Grund ist die Studie als (quasi-)längsschnittliche Erhebung geplant, die sowohl Abiturient*innen als auch Studierende in den Blick nimmt. Ein besonderer Fokus ist auf die Wahl der Fächer, speziell aus den Naturwissenschaften, gerichtet.

In diesem Beitrag wird eine detaillierte Vorstellung des Studiendesigns vorgenommen.

DD 29: Poster – Neue / digitale Medien

Time: Tuesday 16:15–17:45 Location: ZHG Foyer 1. OG

DD 29.1 Tue 16:15 ZHG Foyer 1. OG

Entwicklung einer GeoGebra basierten AR-Umgebung zur Polarisation von Licht — •Joaquin Veith, Samuel Horn, Judith Schmid und Philipp Bitzenbauer — Professur für Physikdidaktik, Universität Leipzig, Vor dem Hospitaltore 1, 04103 Leipzig

Empirischen Erhebungen zufolge ist der Einsatz von Augmented Reality (AR) Umgebungen besonders dann lernförderlich, wenn Lerninhalte abstrakt sind, bspw. in der Wellenoptik oder der Quantenphysik. Gerade in diesen Bereichen ist jedoch ein erheblicher Mangel an AR-Umgebungen zu verzeichnen. Wir stellen daher eine neu entwickelte AR-Umgebung zum Thema Polarisation von Licht

vor, die niederschwellig und einfach zu implementieren mittels GeoGebra realisiert wurde. Auf dem Poster stellen wir Ergebnisse einer Feldstudie mit N=120 Schülerinnen und Schülern vor, mit der die AR-Umgebung evaluiert wurde. Sich an die Ergebnisse dieser Studie anschließende Forschungsziele werden vorgestellt.

DD 29.2 Tue 16:15 ZHG Foyer 1. OG

Exploration von Einstellungen Studierender zum Einsatz von ChatGPT beim Lernen von Physik — •Antonia Bauer[1], Eleonore Becker[2], Joaquin Veith[2] und Philipp Bitzenbauer[2] — [1]FAU Erlangen-Nürnberg, Didaktik der Physik — [2]Universität Leipzig, Institut für Didaktik der Physik

Diese Studie untersucht die Einstellungen und Erfahrungen von Physik-Studierenden im Umgang mit ChatGPT beim Lernen von Physik. Zur Analyse der Einstellungen wird das ABC-Modell herangezogen, das die affektive, kognitive und verhaltensbezogene Dimension integriert. Darüber hinaus werden die spezifischen Erfahrungen dieser Gruppe systematisch erfasst, um Einblicke in praktische Nutzungsmuster sowie mögliche Herausforderungen im Umgang mit ChatGPT zu gewinnen.

DD 29.3 Tue 16:15 ZHG Foyer 1. OG

AR Physics Table: Interaktive Experimentiertische für das experimentelle Lernen im Schülerlabor — •Fabian Bernstein[1,2] und Thomas Wilhelm[2] — [1]TECHNOSEUM Mannheim — [2]Goethe-Universität Frankfurt a. M.

Interaktive Aufprojektionssysteme eröffnen innovative Möglichkeiten, Schülerexperimente durch digitale Augmentierungen zu erweitern. Diese reichen von der Visualisierung physikalischer Konzepte wie Kräfte und Felder über die Bereitstellung praktischer Hilfestellungen bis hin zur Umsetzung immersiver Lernszenarien, die auf narrativen oder spielbasierten Ansätzen beruhen. Im Kontext eines Schülerlabors bieten Aufprojektionssysteme entscheidende Vorteile gegenüber Head-Mounted Displays: Sie sind kostengünstiger, robuster und fördern kollaborative Arbeitsweisen, wodurch ein flächendeckender Einsatz im Schülerlabor überhaupt realisierbar erscheint. Während bisherige Forschung zu AR-Systemen in der physikalischen Bildung oft auf Machbarkeitsstudien oder kleine Anwendungsszenarien - wie universitäre Praktika mit wenigen Teilnehmenden - beschränkt bleibt, verfolgt das am TECHNOSEUM Mannheim entwickelte System einen praxisorientierten Ansatz. Unter dem "KISS"-Paradigma (Keep It Simple, Stupid) wird bewusst auf komplexe Computer-Vision-Technologien verzichtet, um stattdessen Robustheit, Skalierbarkeit und Alltagstauglichkeit in den Vordergrund zu stellen. Ziel ist es, didaktische Innovationen flächendeckend zugänglich zu machen und den dauerhaften Einsatz dieser Technologie in Schülerlaboren zu ermöglichen.

DD 29.4 Tue 16:15 ZHG Foyer 1. OG

Ressourcennutzung beim Problemlösen - eine Eyetracking Studie — •Jonas Deppe und Gunnar Friege — Leibniz Universität Hannover, IDMP-AG Physikdidaktik, Welfengarten 1A, 30167 Hannover

Um herauszufinden, wie Lernende Wissensressourcen beim Problemlösen verwenden, wurde Lehramts-Studierenden mit Fach Physik (N=14) ein schwieriges, unbekanntes Problem aus der Elektrizitätslehre vorgelegt, in welchem es um die Berechnung eines Ersatzwiderstandes geht.

Beim Problemlösen war es ihnen möglich, physikalisches Wissen nachzuschlagen. Eine Teilgruppe nutzte dazu ein vorgegebenes Glossar mit Formeln und Erklärungen. Die zweite Teilgruppe durfte das Internet verwenden und dort frei nach Informationen suchen.

Das Vorgehen beim Problemlösen, Lösungsergebnis und die Nutzung der Wissensressource wurden erhoben, ausgewertet und analysiert.

DD 29.5 Tue 16:15 ZHG Foyer 1. OG

Physik im Kontext Seismologie — •Angela Fösel und Dominik Hinz — Didaktik der Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg

Der Raspberry Shake 1D Vertikalbewegungs-Seismograph kombiniert einen Raspberry Pi Mini-Computer, ein vertikales Geophon, einen 24-Bit-Digitizer und eine nahezu Echtzeit-Datenübertragung. Dieses modulare System ist in der Lage, Erdbeben sowie alltägliche Vibrationen zu detektieren.

Während der RS1D ein kostengünstiges und dennoch durchaus professionelles Instrument für Seismologinnen und Seismologen ist, haben wir als Physikerinnen und Physiker dieses computerbasierte Messsystem genutzt mit dem Ziel, Physik im Kontext Seismologie zu unterrichten.

Wir beschreiben im Detail, wie der Seismograph funktioniert. Wir präsentieren die Detektion von Bodenbewegungen sowohl von Erdbeben als auch von alltäglichen Vibrationen anhand ausgewählter Beispiele. Dabei konzentrieren wir uns auf den Physikunterricht im Kontext der Seismologie und präsentieren didaktische Ideen zum Lernen über Akustik, zur Nutzung von Messsystemen und zur Anwendung wissenschaftlicher Methoden.

DD 29.6 Tue 16:15 ZHG Foyer 1. OG

Entwicklung und Einsatz digitaler Medien in der Vermittlung des Krümmungsbegriffs der Allgemeinen Relativitätstheorie über Sektormodelle im Physikunterricht: Effekte auf Lernerfolg, Motivation und Kognitive Belastung — •Stefan Grüne, Ute Kraus und Corvin Zahn — Institut für Physik, Universität Hildesheim, Universitätsplatz 1, 31141 Hildesheim

In diesem Beitrag wird eine Unterrichtskonzeption nach Wilhelm et al. (2021) zum Krümmungsbegriff der Allgemeinen Relativitätstheorie vorgestellt. Ziel ist es, das Konzept der Krümmung mithilfe von Sektormodellen nach Zahn & Kraus (2014) anschaulich zu vermitteln und eine quantitative Bestimmung an zwei Beispielen gekrümmter Flächen zu ermöglichen. Das Konzept existiert sowohl in analoger als auch in digitaler Form und leistet einen Beitrag zu einer schultauglichen Vermittlung der Relativitätstheorie. Darüber hinaus soll eine laufende Vergleichsstudie Aufschluss über Unterschiede zwischen dem Einsatz analoger und digitaler Medien in der Vermittlung physikalischer Inhalte geben. Im Detail erhebt die Vergleichsstudie Daten zu Wissenserwerb, Motivation und kognitive Belastung. Die Studie wird in zwei Wellen stattfinden, die nacheinander zwei Ausprägungen in der Nutzung digitaler Medien nach SAMR (Puentedura, 2014) mit analogen Medien vergleichen. Während zunächst digitale Medien auf S-Niveau nach SAMR in der Studie eingesetzt werden, um den reinen Effekt der Digitalisierung zu testen, wird in einer folgenden Welle das digitale Material auf A- bzw. M-Niveau nach SAMR mit analogen Medien verglichen.

DD 29.7 Tue 16:15 ZHG Foyer 1. OG

Smartphone-gestützte Experimente zur Quantenphysik — •Johannes Schlaf, Dominik Dorsel, Sebastian Staacks, Christoph Stampfer und Heidrun Heinke — I. & II. Physikalisches Institut A, RWTH Aachen University, Deutschland

Gängige Schulexperimente zur Quantenphysik sind häufig komplex und/oder stellen eine Art "Black Box" für Schülerinnen und Schüler dar, welche nicht vollständig verstanden wird. Zudem wird typischerweise kostenintensives Equipment benötigt, sodass anstelle von Schülerexperimenten häufig nur Simulationen durchgeführt werden. Aus diesem Grund wurden Schülerexperimente zur Quantenphysik mit übersichtlichen, leicht verständlichen Aufbauten entwickelt, welche das schülereigene Smartphone für die Messdatenerfassung und -darstellung nutzen. Hierbei handelt es sich (i) um ein Analogieexperiment zur quantenkryptographischen Übertragung von Schlüsseln mithilfe des BB84-Protokolls sowie (ii) um ein Experiment zur Bestimmung des Planck'schen Wirkungsquantums. Um den Einsatz des letzteren Experiments zu erleichtern und den Kostenfaktor zu senken, wurden die Aufbauten als einfach zu realisierendes DIY-Projekt ausgelegt. Im Wintersemester 2024/25 wurden beide Experimente im physikalischen Praktikum für Chemiestudierende an der RWTH Aachen pilotiert und hinsichtlich ihrer Usability evaluiert. Auf dem Poster werden die Experimente sowie erste Ergebnisse der Evaluierung vorgestellt.

DD 29.8 Tue 16:15 ZHG Foyer 1. OG

Visualisierung mathematisch-physikalischer Konzepte mit *Manim*: Möglichkeiten und Einsatz in der (universitären) Lehre — •Carlo von Carnap und Pascal Klein — Universität Göttingen, Deutschland

Die Python-Bibliothek *Manim* (***m**athematical **anim**ations*) wurde ursprünglich von Grant Sanderson für die Animationen seines Youtube-Kanals *3Blue1Brown* entwickelt. Die einfache Handhabung der Bibliothek und die damit verbundene geringe Einstiegshürde machen *Manim* zu einem äußerst geeigneten Werkzeug für den Einsatz in der (universitären) Lehre. *Manim* ermöglicht es Dozierenden, Inhalte durch präzise und anschauliche Animationen zu präsentieren und gleichzeitig den Erstellerinnen die behandelten Inhalte weiter zu vertiefen.

In diesem Vortrag wird das Potenzial von *Manim* zur Darstellung mathematischer und physikalischer Konzepte vorgestellt. Anhand exemplarischer Kurzanimationen zu Themen wie Wegintegralen in der Mechanik, Integralsätzen in der Elektrodynamik oder Koordinatentransformationen wird gezeigt, wie diese in Vorlesungen genutzt werden können um komplexe Sachverhalte verständlich und visuell ansprechend zu vermitteln.

Solche Animationen können die universitäre Lehre im Sinne des Lernens mit multiplen Repräsentationen bereichern, indem sie abstrakte Konzepte greifbarer machen. Darüber hinaus werden sowohl die Möglichkeiten als auch die Grenzen der Bibliothek diskutiert.

DD 30: Poster – Neue Konzepte

Time: Tuesday 16:15–17:45 Location: ZHG Foyer 1. OG

DD 30.1 Tue 16:15 ZHG Foyer 1. OG

Educational Escape Room der Physik mit European Board Game Konzepten — •Sascha Albert Bräuninger[1], Damian Alexander Motz[1,2], Matthias Lüpke[1] und Hermann Seifert[1] — [1]Institute for General Radiology and Medical Physics, University of Veterinary Medicine Hannover Foundation, Bischofsholer Damm 15, 30173 Hanover, Germany — [2]Institute of Sanitary Engineering and Waste Management, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany

Der hier vorgestellte educational Escape Room (ER) der Physik ist ein inverser Escape Room aus zwei Räumen mit zwei komplementären Raum- und Lichtkonzepten, d.h. das Hauptziel ist das Betreten des zweiten Raumes. Der ER umfasst 10 überwiegend experimentelle Rätsel der Physik aus den Bereichen Mechanik (Kinematik, Kräfte), elektrischer Gleich- und Wechselstrom, Optik, Absorption von Röntgenstrahlung, Thermodynamik, Magnetismus, Atom/Molekülphysik sowie 16 Nebenrätsel (Europuzzles) ergänzt durch ein Siegpunktesystem angelehnt an European Board games (Eurogames). Die Physikrätsel sind obligatorisch und der ER ist langfristig und nachhaltig in den Lehrkatalog (Wahlbereich) eines Studienganges (hier Tiermedizin) übernommen worden. Details: https://arxiv.org/abs/2406.15454 | https://doi.org/10.15487/tiho.13_2024.6

DD 30.2 Tue 16:15 ZHG Foyer 1. OG

Konzipierung eines Workshops im MILeNa-Programm: MINT-Lehrkräfte von morgen fördern — •Peer Bruns, Christina Lüders, Maria Hinkelmann, Tobias Winkens und Heidrun Heinke — RWTH Aachen University

Seit Jahren werden die Auswirkungen des bestehenden Lehrermangels immer deutlicher und es ist kein Ende absehbar. Das Programm MILeNa zur MINT-Lehrkräfte-Nachwuchsförderung versucht diesem Mangel entgegenzuwirken, indem Oberstufenschüler*innen eigene Lehr-erfahrungen machen sollen, um eine bewusste Studienentscheidung treffen zu können. Hierfür wurde ein Workshop entwickelt, in dem am Programm teilnehmende Oberstufenschüler*innen einen Kurs zum Thema "Magie oder MINT?" gemäß dem Prinzip des forschenden Lernens zur Durchführung mit jüngeren Schüler*innen erstellen können. Die am Lehramt interessierten Oberstufenschüler*innen erhalten die Möglichkeit, durch Planung und Durchführung des Kurses einen unterrichtspraktischen Einblick in den Beruf zu erhalten. Zusätzlich soll bei Unterstufen-Schüler*innen durch das Thema Magie eine Interessenförderung im MINT-Bereich erreicht werden. Um die Bedürfnisse und Wünsche der am Programm MILeNa teilnehmenden Schüler*innen möglichst gut einbeziehen zu können, wurde eine Bedarfsanalyse in Form eines Fragebogens mit 27 MILeNa-Teilnehmer*innen durchgeführt. Auf dem Poster werden die Ergebnisse dieser Umfrage sowie das entwickelte Workshopkonzept präsentiert.

DD 30.3 Tue 16:15 ZHG Foyer 1. OG

"Upho" - ein Gesellschaftsspiel zur Darstellung physikalischer Größen — •Nele Hack, Ramona Schauer-Bollig und Heidrun Heinke — RWTH Aachen University

Beim Game-based Learning können basierend auf bestehenden Spielkonzepten neue Spiele entwickelt werden, um spielerisch Fachinhalte zu vermitteln. Es ist förderlich, wenn das grundlegende Regelwerk den meisten Schüler*innen bekannt ist. Sind darüber hinaus das Konzept und die Regeln des Spiels möglichst einfach gestaltet, können sie auch von denjenigen Schüler*innen schnell erarbeitet werden, denen das zugrundeliegende Gesellschaftsspiel nicht geläufig ist. Dieses Konzept lässt sich auch mit Themen aus dem Physikunterricht umsetzen. In diesem Unterricht soll Kommunikation über physikalische Phänomene erlernt und physikalisches Wissen systematisiert werden. Eine wichtige Grundlage dafür ist die korrekte Darstellung physikalischer Größen. Deshalb wurde das Gesellschaftsspiel "Upho" entwickelt, das an das bekannte Spiel "Uno" angelehnt ist. Die Spieler*innen sollen damit üben, Größen, Formelzeichen, Einheiten und Formeln als solche zu erkennen und die zur selben physikalischen Größe gehörenden einander zuzuordnen. Das Spiel kann flexibel an verschiedene Themenbereiche angepasst werden, soll motivationsfördernd wirken, den Unterricht auflockern und ohne großen Material- oder Zeitaufwand eine Lerngelegenheit bieten. Auf dem Poster wird das Spiel vorgestellt und erste Erfahrungen mit dem Einsatz werden berichtet.

DD 30.4 Tue 16:15 ZHG Foyer 1. OG

Implementation modularer Smartphone-Experimente im Physikunterricht — •Marija Herdt und Heidrun Heinke — I. Physikalisches Institut IA, RWTH Aachen, Deutschland

Viele Lehrkräfte verfolgen bei der Implementation von Unterrichtsinnovationen an Schulen eine steinbruchartige und pragmatische Nutzung von zur Verfügung gestellten Unterrichtsmaterialien. Mit einem alternativen Implementationsansatz wird dem Rechnung getragen, um so die Akzeptanz für Innovationen nachhaltig zu erhöhen. Dies wird am Beispiel der kostenfreien App phyphox für den Physikunterricht der Sekundarstufe I umgesetzt, die den Einsatz des Smartphones als mobiles Messinstrument ermöglicht. Das entwickelte Unterrichtskonzept beinhaltet eine Einführungsstunde, welche durch einen modularen Lernzirkel Einblicke in die verschiedenen Sensoren des Smartphones und deren Nutzbarkeit in Experimenten liefert. Darauf aufbauend werden den Lehrkräften low-cost Experimentiersets bereitgestellt, welche modulare Arbeitsblätter, Begleitmaterial sowie das experimentelle Zubehör in Klassengröße zu zahlreichen Schülerexperimenten aus verschiedenen Inhaltsfeldern des Kernlehrplans enthalten. Diese können die Lehrkräfte nach eigenem Ermessen in ihren Unterricht integrieren. Der Ansatz soll einen niederschwelligen Zugang zu einem unterrichtlichen Einsatz digitaler Messwerterfassung unter Nutzung von Smartphones ermöglichen, wozu Lehrkräfte in ersten Erprobungen bereits positive Rückmeldungen gaben. Im Poster werden das Konzept der Einführungsstunde und die Zusammensetzung der Experimentiersets vorgestellt sowie eine Übersicht zur Implementationsstudie gegeben.

DD 30.5 Tue 16:15 ZHG Foyer 1. OG

Unterstützung in der Studieneingangsphase - Der Reformstudiengang Physik Plus — •Christina Lüders, Stefan Roth und Heidrun Heinke — RWTH Aachen University

Besonders in den MINT-Studiengängen sind hohe Abbruchquoten zu verzeichnen. Nach Neugebauer et al. (2019) finden 47% aller Studienabbrüche in den ersten beiden Fachsemestern statt. Bei der Unterstützung der Studierenden sollte man also in der Studieneingangsphase ansetzen. An der RWTH Aachen gibt es neben den klassischen Bachelorstudiengängen Physik und Lehramt Physik seit dem WS 2021/22 auch den Reformstudiengang Physik Plus. In diesem absolvieren die Bachelor-Studierenden das Physikstudium statt in sechs Semestern in acht Semestern. Daher können besonders in der Studieneingangsphase ergänzende unterstützende Veranstaltungen angeboten werden. Seit dem WS 2019/20 wurden sukzessive Daten in der Studieneingangsphase der Physikstudiengänge erhoben um Eingangsvoraussetzungen, Wahrnehmungen und Wünsche der Studierenden zu erfassen. Die Daten wurden in Form von Fragebögen und Interviews erhoben. Die Befragung hat ergeben, dass sich die Studierenden der unterschiedlichen Studiengänge signifikant in ihren Eingangsvoraussetzungen unterscheiden. Die ergänzenden Interviews ermöglichen einen tiefergehenden Einblick in die Wahrnehmungen und Wünsche der Studierenden des Studiengangs Physik Plus. Auf dem Poster wird der Studiengang Physik Plus mit aktuellen Studierendenzahlen vorgestellt sowie ein Einblick in die Eingangsvoraussetzungen, Wahrnehmungen und Wünsche dieser Studierenden gegeben.

DD 30.6 Tue 16:15 ZHG Foyer 1. OG

MINT-Lehrkräfte von morgen: Berufsorientierung und Praxiserfahrung im MILeNa-Programm — •Christina Lüders[1], Tobias Winkens[1], Maria Hinkelmann[1], Christian Salinga[1], Carina Göbels[1], Leonie Jung[2], Julia Tocco[2], Heike Theyssen[2], Bernadette Schorn[3] und Heidrun Heinke[1] — [1]RWTH Aachen University — [2]Universität Duisburg-Essen — [3]Rheinische Friedrich-Wilhelm-Universität Bonn

Das MILeNa Programm zur MINT-Lehrkräfte-Nachwuchsförderung hat sich zum Ziel gesetzt dem sich verschärfenden Mangel an MINT-Lehrkräften entgegenzuwirken. Der Grundgedanke ist es, dass Schüler:innen der Oberstufe in der Phase der Berufsentscheidung einen vertieften Einblick in den Beruf einer MINT-Lehrkraft erhalten. Dabei werden sie von der eigenen Schule und von einer nahegelegenen Hochschule begleitet. Von Hochschulen werden z.B. Lerngelegenheiten in Form von Workshops angeboten, in denen Grundlagen zur Gestaltung von Unterricht vermittelt werden. An den eigenen Schulen erhalten die Schüler:innen durch Lehrgelegenheiten die Möglichkeit praktische Erfahrungen als Lehrkräfte zu sammeln. Ergänzt wird das Programm durch weitere Angebote der Hochschulen zur Berufs- und Studienorientierung. Auf dem Poster werden die Struktur des MILeNa Programms sowie Umsetzungsmöglichkeiten unterschiedlicher Hochschulen und Schulen vorgestellt.

DD 30.7 Tue 16:15 ZHG Foyer 1. OG

Artikel-Memory zum Klimawandel: Förderung kritischer Informations- und Medienkompetenz im Physikunterricht — •Julia Hädrich, Linus Bräumer und Rita Wodzinski — Didaktik der Physik, Universität Kassel

Ergebnisse aktueller Studien (ICILS, 2023) zeigen bei deutschen Schüler:innen einen signifikanten Rückgang computer- und informationsbezogener Kompetenzen wie die Suche nach Informationen und ihre sichere Bewertung, die für den Umgang mit der Informationsflut und Fehlinformationen im Internet notwendig sind. Das Modell der kritischen Informations- und Medienkompetenz von Schiefner-Rohs (2012) stellt einen geeigneten Rahmen dar, um sich der Thematik aus fachdidaktischer Sicht zu widmen. Der Förderung der kritischen Informations- und Medienkompetenz im Physikunterricht widmet sich die Unterrichtsmethode des Artikel-Memorys. Die Lernenden setzen sich dabei selbstständig mit realen Artikeln zum Klimawandel auseinander. Über eine Konfrontation mit glaubwürdigen und unglaubwürdigen Inhalten werden sie für Fehl-

informationen sensibilisiert. Auf dieser Grundlage identifizieren die Lernenden Kriterien, die eine Einschätzung der Glaubwürdigkeit ermöglichen. Die identifizierten Kriterien können dann in existierende Modelle zur Bewertung von Informationen wie dem CRAAP-Test (Blakeslee, 2004) eingebunden werden. Die Evaluation des Konzepts war Gegenstand von zwei studentischen Abschlussarbeiten. Das Poster stellt die Methode und die Ergebnisse der Arbeiten vor.

DD 30.8 Tue 16:15 ZHG Foyer 1. OG

Was macht das K in MINKT? - Ein Review zu Ansätzen von MINKT / STEAM in der naturwissenschaftlichen Bildung — •Nathalie Wolke und Susanne Heinicke — Universität Münster

Der Begriff der STEM-Bildung (Science, Technology, Engineering, Mathematics) ist eng verwandt mit dem im deutschsprachigen Raum gebräuchlichen Konzept der MINT-Bildung (Mathematik, Informatik, Naturwissenschaften, Technik). Beide Ansätze zielen darauf ab, interdisziplinäres Denken, die naturwissenschaftlich-technische Bildung und insbesondere das Interesse an ihr unter Lernenden zu fördern.

Durch die Integration künstlerischer Elemente (Arts) wurde, insbesondere inspiriert durch die Design Thinking-Bewegung und innovative Pädagogiken, in den 2010er Jahren das Konzept auf STEAM erweitert. Dabei bleibt jedoch noch unklar, welche kreativen/künstlerischen Aspekte "Arts" umfassen soll. Im deutschsprachigen Raum prägte sich etwas später der noch wenig verbreitete Begriff der MINKT-Bildung, bei dem ebenfalls unterschiedliche Aussagen zu finden sind, ob das "K" für Kunst oder Kreativität steht.

Diese Uneindeutigkeiten, sowie die Frage nach der Gestaltung und Effektivität solcher Konzepte führen zu einem Bedarf nach Klärung. Daher widmet sich der Posterbeitrag dem Review bestehender wissenschaftlicher Befunde und Beschreibungen von MINKT/STEAM-Ansätzen. Ziel ist es, die aktuelle Landschaft der Forschung zusammenzutragen und hieraus Forschungsfragen bezüglich der Umsetzung und Effektivität solcher unterrichtlichen Konzepte abzuleiten.

DD 31: Poster – Praktika und Experimente

Time: Tuesday 16:15–17:45 Location: ZHG Foyer 1. OG

DD 31.1 Tue 16:15 ZHG Foyer 1. OG

Ein Low-Cost Lichtsensormodul mit Browser-basierter Auswertung für Experimente zur Wellenoptik — •Nils Haverkamp, Alexander Pusch und Stefan Heusler — Institut für Didaktik der Physik, Universität Münster

Im Projekt Open 3 Quantum (o3q.de) ist ein modulares Low-Cost System für Experimente zur Wellen- und Quantenoptik entwickelt worden. Das modulare System wurde um einen Lichtsensor erweitert, mit dem weitere quantitative Messungen durchgeführt werden können. Die Messwerte des Low-Cost-Lichtsensors lassen sich komfortabel per Wifi im Browser von Smartphones, Tablets oder PCs anzeigen. Mit dem Sensor können beispielsweise quantitative Messungen zum Gesetz von Malus, zur Polarisation von unterschiedlichen Lichtquellen und zum Interferenzverhalten in unterschiedlichen Interferometern des O3Q-Systems durchgeführt werden. Auf dem Poster werden der Sensor sowie einige der möglichen Experimente mit exemplarischen Messergebnissen vorgestellt.

DD 31.2 Tue 16:15 ZHG Foyer 1. OG

Wie zeige ich es denn nun? Demonstrationsexperimente gestalten — •Malte S. Ubben[1], Alexander Pusch[2], Julia Welberg[2] und Paul Schlummer[2] — [1]Universität Leipzig, Institut für Didaktik der Physik — [2]Universität Münster, Institut für Didaktik der Physik

Das Vorführen von Experimenten ist in der Praxis mit einer Vielzahl von Herausforderungen verbunden, die sowohl das Verständnis des Publikums als auch die technische Umsetzung betreffen. Solche "Verständnis-Stolpersteine" können die Wahrnehmung der Kernkonzepte erschweren und die gewünschte didaktische Wirkung der Experimente beeinträchtigen.

Basierend auf dem gleichnamigen Buch werden auf diesem Poster beispielhaft praxiserwachsene Hinweise zur Optimierung von schulischen und universitären Demonstrationsexperimenten gegeben. Besonderes Augenmerk liegt dabei auf der didaktischen Klarheit und der Anpassung der Experimente an die Zielgruppe.

DD 31.3 Tue 16:15 ZHG Foyer 1. OG

Entwicklung und Evaluation eines Smartphone-Experiments zur Förderung der Kompetenzbildung im Bereich der cyberphysischen Systeme in der Studieneingangsphase — •Christian Effertz[1], Marina Hruska[1], Dominik Dorsel[2], Mosab Abumezied[2] und Heidrun Heinke[2] — [1]Fachbereich 8, FH Aachen University of Applied Sciences — [2]I. & II. Physikalisches Institut A, RWTH Aachen University

Die fortschreitende Digitalisierung von Produktionsprozessen, zum Beispiel in Fertigung und Logistik, erfordert von Studierenden ingenieurwissenschaftlicher Studiengänge ein vertieftes Verständnis cyberphysischer Systeme, insbesondere in Bezug auf Design und Integration von Sensor-Aktor-Systemen. Das physikalische Praktikum bietet in diesen Studiengängen eine frühzeitige Möglichkeit, Kompetenzen in diesem Bereich aufzubauen und nachfolgende Lehrveranstaltungen vorzubereiten. Hierfür sind keine teuren Neuanschaffungen erforderlich: Die in nahezu jedem Smartphone integrierten Sensoren können kostengünstig und effektiv genutzt werden, um Bewegungsabläufe zu überwachen. Im Rahmen des Projekts Physik.SMART, gefördert durch die Stiftung Innovation in der Hochschullehre, wurde ein bestehender Versuch aus der Rotationsdynamik gezielt durch den Einsatz kostengünstiger Komponenten und der App phyphox modifiziert. Diese App ermöglicht die Nutzung von Smartphone-Sensoren zur Erfassung von Messdaten und verknüpft klassische Experimente mit modernen Technologien. Der Beitrag beschreibt die Entwicklung der Modifikation sowie eines Testinstruments zur Evaluation und erste Erfahrungen.

DD 31.4 Tue 16:15 ZHG Foyer 1. OG

Entwicklung von Lernzirkelstationen zur Variablenkontrollstrategie mit geringem Materialaufwand — •Stephanie Gehnen, Tobias Winkens und Heidrun Heinke — RWTH Aachen University

Eine zentrale Fähigkeit beim Experimentieren ist die Variablenkontrollstrategie (VKS), die die vier Teilfähigkeiten zur Interpretation, Identifikation und Planung kontrollierter Experimente sowie das Verständnis über die fehlende Aussagekraft konfundierter Experimente umfasst. Auf Basis der Plattform FLexKom (vgl. Goertz, 2022) wurden Lernzirkelstationen mit einem geringen Materialaufwand entwickelt, welche Haushaltsgegenstände als Experimentiermaterialien nutzen. So soll ein einfacherer Zugang zu Experimenten zur Förderung der VKS geschaffen werden. Es wurden drei Stationen für Schüler*innen der Mittelstufe konzipiert, die verschiedene Gebiete der Mechanik behandeln. Eine Station untersucht die Flugweite von Papierfliegern anhand des Abwurfwinkels und der Papierstärke. In der zweiten Station wird die Aufprallhöhe eines Tennisballs nach dem ersten Aufprall unter Berücksichtigung des Innendrucks sowie der Fallhöhe des Balls erkundet. Diese Station lässt sich in zwei Varianten (analoge Zeitmessung und vereinfachte Videoanalyse) durchführen. Als dritte Station wird die Falldauer von selbstgebauten Fallschirmen in Abhängigkeit des Materials und der Größe des Fallschirms betrachtet. Für jede Station sind zudem vier verschiedene Arbeitsblätter zur Förderung von je einer der vier VKS-Teilfähigkeiten entwickelt worden. Im Zuge eines Ferienprogramms wurde die Handhabung der Experimente erprobt (N=19).

DD 31.5 Tue 16:15 ZHG Foyer 1. OG

Selbstwirksamkeitserwartung bezüglich des Experimentierens - ein Erhebungsinstrument für Studierende — •Paula Andrich und Cornelia Geller — Universität Duisburg-Essen

Experimentalpraktika sind ein zentraler Baustein des Physikstudiums, ihre Wirkungen auf die Fähigkeiten und Einstellungen von Studierenden sind jedoch noch wenig untersucht, was auch auf einen Mangel valider Instrumente zurückzuführen ist. Daher präsentiert dieses Poster die Entwicklung eines Fragebogens, der die Selbstwirksamkeitserwartung (SWE) von Physikstudierenden bezüglich des Experimentierens im universitären Kontext erfasst. Insbesondere für komplexe Handlungen wie das Experimentieren gilt die Selbstwirksamkeitserwartung als wesentlicher Einflussfaktor auf den Handlungserfolg.

Das in mehreren Überarbeitungszyklen entwickelte Instrument wurde im Sinne eines argumentbasierten Ansatz zur Validierung in verschiedenen Teilstudien qualitativ und quantitativ untersucht. Die Ergebnisse werden auf dem Poster diskutiert, ein Fokus liegt dabei auf der Dimensionalität der SWE und der Abgrenzung zu verwandten Konstrukten.

DD 31.6 Tue 16:15 ZHG Foyer 1. OG

Nachhaltiges Labordatenmanagement: Der Weg von spezialisierten Experimenten zu standardisierten Metadaten — •Cedric Kessler, Johannes Marczinkowski, Rebekka Murati, Ralph Ernstorfer und Nina Owschimikow — Institut für Optik und Atomare Physik, TU Berlin, 10623 Berlin

Eine nachhaltige und wiederverwendbare Dokumentation von Messdaten ist ein zentrales Element guter wissenschaftlicher Praxis. Dabei spielen Metadaten, die Informationen über die Daten selbst bereitstellen, eine entscheidende Rolle. Die Standardisierung der Dokumentation physikalischer Experimente ist jedoch über die Disziplinen hinweg noch nicht abgeschlossen und bleibt eine Herausforderung. Diese Heterogenität, kombiniert mit der Vielfalt analoger und digitaler Messinstrumente und deren individuellen Daten- und Metadatenformaten, erschwert die Vermittlung von Prinzipien des Forschungsdatenmanagements im Laborpraktikum.

Am Beispiel eines Experiments zur Detektion kosmischer Strahlung beleuchten wir die Anforderungen, die eine nachhaltige Dokumentation, insbesondere bei nicht wiederholbaren Experimenten, erfüllen muss. Elektronische Laborbücher zeigen dabei vielversprechende Potenziale, indem sie eine strukturierte und konsistente Erfassung von Daten und Metadaten erleichtern. Diese Ansätze müssen jedoch so gestaltet werden, dass sie den Studierenden die Grundlagen des Datenmanagements praxisnah und effektiv vermitteln.

DD 31.7 Tue 16:15 ZHG Foyer 1. OG

PrintedLabs: 3D printed optics experiments — •Thorsten Schumacher, Svenja Hofmann, and Markus Lippitz — Experimental Physics III, University of Bayreuth, Germany

Experiments are at the heart of physics. A successful experiment requires many decisions, ranging from the choice of equipment and procedures to the evaluation of uncertainties and surprising results. Ideally, students should be able to experience all of this in their laboratory experiments. While it is common to design experiments with many degrees of freedom to give students experience in mechanics and electrodynamics, laboratory experiments in optics tend to guide students more closely. In addition, optics laboratory equipment is either far removed from that used in research laboratories or expensive.

We set out to build laboratory equipment for optical experiments using 3D printing. This allows us to use large quantities of components in student labs, similar to those used in real research labs. In addition, we have also developed specialised components, such as a spectrometer or telescope, that can compete with commercial equipment that is ten times more expensive. We are targeting undergraduates and especially those who want to become teachers, as the designs and experiments are openly available [1], including for use in schools.

[1] https://printedlabs.uni-bayreuth.de/

DD 31.8 Tue 16:15 ZHG Foyer 1. OG

Einführung des elektronischen Laborbuchs eLabFTW im Fortgeschrittenen Praktikum — •Christian T. Steigies, Thomas Jürgens, Victor de Manuel Gonzalez und Thomas Trottenberg — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel

Im Wintersemester 2024/25 wurde vom Rechenzentrum der Christian-Albrechts-Universität zu Kiel ein Prototyp für das elektronische Laborbuch eLabFTW aufgebaut, der im Fortgeschrittenenpraktikum der Physik eingesetzt wird. Dazu wurden für ein Drittel der Versuche des Praktikums Vorlagen erstellt, die in die Nutzung des elektronischen Laborbuchs einführen. Für die übrigen Versuche ist es den Studierenden freigestellt, ob sie weiterhin ein analoges, oder das elektronische Laborbuch (ohne Vorlage) verwenden wollen. Am Ende des Semesters wird das Praktikum evaluiert, wir berichten über die Erfahrungen und Probleme bei der Nutzung des elektronischen Laborbuches.

DD 31.9 Tue 16:15 ZHG Foyer 1. OG

CLEOPATRA - Ein Teilchendetektor für den Unterricht — •Laura Rodríguez Gómez, Annika Hoverath, Jochen Kaminski, Klaus Desch, Johannes Streun und Ina Thierkopf — Physikalisches Institut, Universität Bonn

In den Bereichen Strahlung, Materie und Kernphysik gibt es wenig forschungsnahe Realexperimente für den Physikunterricht. Durch ihre Aktualität würden sich aber gerade diese Themen für einen Forschungseinblick im Unterricht eignen. Das CLEOPATRA-Projekt bietet einen Teilchendetektor als Experiment für den Physikunterricht der gymnasialen Oberstufe. In einer Unterrichtseinheit mit dem Detektor beschäftigen sich Lernende mit kosmischer Hintergrundstrahlung und vermessen die Winkelverteilung atmosphärischer Myonen. Der eingesetzte Teilchendetektor ist eine sogenannte Zeitprojektionskammer. Dies ist ein gasgefüllter Detektor, mit dem Teilchenspuren in 3 Dimensionen und quasi in Echtzeit aufgenommen und visualisiert werden können. Die so entstehenden Daten können digital ausgewertet werden, sodass anhand des Experiments Konzepte des Arbeitens mit digitalen Datenmengen vermittelt werden können. Dieser Vortrag stellt das CLEOPATRA-Projekt vor. Dazu gehören neben dem Detektor auch Unterrichtsmaterialien und eine Software zur Visualisierung und Auswertung der Daten. Im Rahmen eines Workshops wurde das Projekt erstmals mit Lernenden erprobt. Es werden Eindrücke aus dieser ersten Durchführung präsentiert.

DD 32: Poster – Quantenphysik

Time: Tuesday 16:15–17:45 Location: ZHG Foyer 1. OG

DD 32.1 Tue 16:15 ZHG Foyer 1. OG

Didaktische Rekonstruktion photopolarisierbarer Flächen und Membranen — •Dennis Lafeld und Holger Cartarius — AG Fachdidaktik der Physik und Astronomie, Friedrich-Schiller-Universität Jena, 07743 Jena

Im Rahmen des Graduiertenkollegs PhInt (Photo-Polarizable Interfaces and Membranes) erfolgt die Erforschung der Photoaktivität von Oberflächen und Membranen. So soll beispielsweise untersucht werden, ob lichtinduzierte Schaltprozesse benutzt werden können, um die Polarität und Permeabilität von Lipid-Membranen gezielt zu beeinflussen und zu steuern.

Ein zentraler Bestandteil von PhInt ist die didaktische Aufarbeitung der Forschungsergebnisse und deren Kommunikation an die breite Öffentlichkeit. Hierfür sollen (Analogie-)Experimente für Schülerlabore, Unterrichtsmaterialien und Exponate für das Deutsche Optische Museum erstellt werden. Die Erarbeitung dieser Materialien erfolgt durch enge Kooperation der Mitarbeitenden im Projekt, um sowohl die fachwissenschaftliche als auch die fachdidaktische Perspektive einzubeziehen.

In diesem Vortrag sollen ein Überblick über die Forschung von PhInt gegeben sowie erste Ideen zur didaktischen Rekonstruktion der Forschungsergebnisse vorgestellt werden.

DD 32.2 Tue 16:15 ZHG Foyer 1. OG

Praxisorientiertes Fortbildungskonzept für Lehrkräfte mit Selbstlerneinheiten zur Quantenphysik * Fokus auf die Wesenszüge der Quantenphysik und Analogiemodelle — •Stefan Aehle[1], Kim Kappl[2], Philipp Scheiger[2] und Holger Cartarius[1] — [1]Arbeitsgruppe Fachdidaktik der Physik und Astronomie, Friedrich-Schiller Universität Jena — [2]Abteilung Physik und ihre Didaktik, 5. Physikalisches Institut, Universität Stuttgart

Anknüpfend an einen gleichnamigen Beitrag werden hier Ergebnisse der Kooperation zweier Arbeitsgruppen der Universität Stuttgart und Friedrich-Schiller-Universität Jena vorgestellt, die daran arbeiten, einen Teil des hohen Bedarfs an Lehrerfortbildungen zur Quantenphysik zu decken. Dieser Beitrag geht genauer auf Inhalte praxisorientierter Selbstlerneinheiten ein, die, basierend auf den Wesenszügen der Quantenphysik, Materialen für den Schulunterricht bereitstellen. Neben der Vermittlung theoretischer Grundlagen stehen Analogieversuche und starker experimenteller Bezug im Fokus des Unterrichtskonzepts. Lehrkräften soll es so ermöglicht werden, sich möglichst effektiv auf das eigene Unterrichten vorzubereiten und die vorgestellten Materialien und Quellen einzusetzen. Mit Hilfe einer Analogie zum quantenmechanischen Messprozess und weiteren optischen Experimenten wird der Vergleich von klassisch-physikalischer und quantenphysikalischer Perspektive genutzt, um den Einstieg in das komplexe Themenfeld zu vereinfachen.

DD 32.3 Tue 16:15 ZHG Foyer 1. OG

NV-Zentrum Magnetometer und sein didaktisches Konzept — •Simon Koppenhöfer, Philipp Mauz, Philipp Scheiger und Ronny Nawrodt — 5. Physikalisches Institut, Abt. Physik und ihre Didaktik, Pfaffenwaldring 57, 70569 Stuttgart

Das stärkere Auftreten von quantenmechanischen Themen in den neuen Bildungsplänen, wirft die Frage nach Experimenten und Anwendungsbeispielen auf. Experimente rund um das NV-Zentrum im Diamanten versprechen diese Lücke zu füllen, da sie bei Raumtemperatur, im sichtbaren Wellenlängenbereich und vergleichsweise günstig realisierbar sind.

Dieser Beitrag präsentiert experimentelle Aufbauten, wie auch dazugehörige didaktische Konzepte für Schulen, Schülerakademien und Schülerlabore. In den didaktischen Konzepten spielen zusätzliche (Analogie-) Experimente rund um die Themen Termschemata, Fluoreszenz und Spin eine zentrale Rolle.

DD 32.4 Tue 16:15 ZHG Foyer 1. OG

Praxisorientiertes Fortbildungskonzept mit Selbstlerneinheiten zur Quantenphysik - Fokus auf dem Nachweis der Quantennatur des Lichts und der Erzeugung einzelner Photonen — •Kim Kappl[1], Stefan Aehle[2] und Philipp Scheiger[1] — [1]Arbeitsgruppe Physik und ihre Didaktik, 5. Physikalisches Institut, Universität Stuttgart — [2]Arbeitsgruppe Fachdidaktik der Physik und Astronomie, Friedrich-Schiller Universität Jena

Anknüpfend an einen gleichnamigen Beitrag werden hier Ergebnisse der Kooperation zweier Arbeitsgruppen der Universität Stuttgart und Friedrich-Schiller-Universität Jena vorgestellt, die daran arbeiten, einen Teil des hohen Bedarfs an Lehrerfortbildungen zur Quantenphysik zu decken. In diesem Beitrag wird ein didaktisches Konzept rund um die Eigenschaften einzelner Photonen näher erläutert. So wird beispielsweise in einem interaktiven, aktivierenden Moodle-Kurs die Erzeugung einzelner Photonen basierend auf Grundlage der Spontaneous Parametric Down Conversion (SPDC) vorgestellt.

DD 32.5 Tue 16:15 ZHG Foyer 1. OG

Das Modell des eindimensionalen Potentialtopfs und seine Grenzen * Von den KMK Standards in den Unterricht am Beispiel von Farbzentren in Salzen — •Philipp Mauz, Simon Koppenhöfer, Philipp Scheiger und Ronny Nawrodt — Physik und ihre Didaktik, Universität Stuttgart, 70569 Stuttgart

Das verstärkte Auftreten von quantenmechanischen Themen in den neuen Bildungs- und Lehrplänen, wirft die Frage nach Experimenten und Anwendungsbeispielen auf. Auch das Modell des eindimensionalen Potentialtopfs wird in den KMK-Standards explizit genannt. Ein möglicher Grund dafür ist, dass für dieses theoretische Konstrukt der Quantenmechanik die Schrödingergleichung mit Schulmathematik gelöst werden kann. Gleichzeitig sollen aber auch die Grenzen dieses Modells diskutiert werden. Für eine ausführliche physikalische Betrachtung, sollte dieses Modell daher auch an Experimenten getestet und überprüft werden. Häufig werden hierfür Farbstoffe als Anwendungskontext gewählt. Diese sind für Schülerinnen und Schüler (SuS) aber kaum zugänglich und, die zum Modell am besten passenden Stoffe, oft gesundheitsschädlich. Farbzentren in Salzen bieten hier ein anderes (eventuell besser geeignetes) Anwendungsfeld des Potentialtopfes für die Schule. SuS sollten mit ihrem Vorwissen in der Lage sein Hypothesen selbst zu entwickeln, die anschließend experimentell überprüft werden können. Dieser Beitrag stellt die physikalischen Hintergründe, die experimentelle Umsetzung und mögliche Anwendungen in der Schule vor.

DD 32.6 Tue 16:15 ZHG Foyer 1. OG

Praxisorientiertes Fortbildungskonzept mit Selbstlerneinheiten zur Quantenphysik * Fokus auf Verschränkung und das quantenmechanische Weltbild — •Philipp Scheiger[1], Kim Kappl[1] und Stefan Aehle[2] — [1]Physik und ihre Didaktik, Universität Stuttgart, 70569 Stuttgart — [2]AG Fachdidaktik der Physik und Astronomie, Friedrich-Schiller-Universität Jena, 07743 Jena

Anknüpfend an einen gleichnamigen Beitrag werden hier Ergebnisse der Kooperation zweier Arbeitsgruppen der Universität Stuttgart und Friedrich-Schiller-Universität Jena vorgestellt, die daran arbeiten, einen Teil des hohen Bedarfs an Lehrerfortbildungen zur Quantenphysik zu decken. In diesem Beitrag wird das quantenmechanische Weltbild im Kontext der Verschränkung diskutiert. Das notwendige Hintergrundwissen, mögliche Umsetzungen in der Schule und die Implementierung im Selbstlernkurs (aktivierende Moodle-Kurse) werden vorgestellt.

DD 32.7 Tue 16:15 ZHG Foyer 1. OG

Evaluierung eines Einstiegskurses zu Quantentechnologien hinsichtlich des längerfristigen Einflusses auf die Lernenden — •Ismet N. Dogan[1], Dagmar Hilfert-Rüppell[1], Franziska Greinert[1], Malte S. Ubben[2] und Rainer Müller[1] — [1]Technische Universität Braunschweig, IFdN, Physik und Physikdidaktik — [2]Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften, Institut für Didaktik der Physik

In der Industrie besteht ein Bedarf an Fachkräften zu Quantentechnologien. Gleichzeitig lassen sich kaum systematisch entwickelte Lernmaterialien zu dieser Thematik vorfinden. Das Projekt "Quantum Technologies Courses for Industries" (QTIndu) wirkt diesen Problemen entgegen, indem entsprechende Lernmaterialien für die Aus-, Weiter- und Fortbildung von Fachkräften zu Quantentechnologien entwickelt, evaluiert und überarbeitet werden. Unser Einstiegskurs verbindet die Wesenszüge der Quantenphysik mit relevanten Quantentechnologien, um eine anwendungsorientierte, kontextbasierte Lernbasis zu schaffen sowie theoretische Aspekte der Quantenphysik einzuführen. Ein Kapitel dieses Einstiegskurse wurde im Rahmen der IOOI-Methode auch hinsichtlich des längerfristigen Einflusses auf Lernende quantitativ evaluiert. Das Poster gibt einen Überblick zu dem Aufbau des Einstiegskurses und dem Evaluationskonzept sowie einen Einblick in erste Ergebnisse.

DD 32.8 Tue 16:15 ZHG Foyer 1. OG

Versuchsangebote für Schulen im Rahmen von MasterClass-Workshops — •Tim Overwin, Azadeh Ghanbari und Rainer Müller — Institut für Fachdidaktik der Naturwissenschaften, Abt. Physik und Physikdidaktik, TU Braunschweig, Deutschland

MasterClass-Workshops bieten Schulklassen aus Braunschweig und Umgebung seit 2019 die Möglichkeit, einen Einblick in aktuelle physikalische Versuche und Forschung zu bekommen. Dabei sollen Interesse, Motivation und das Verständnis von meist quantenmechanischen Phänomenen gefördert werden. Die Workshops werden mit höheren Klassenstufen von Gymnasien oder Gesamtschulen entweder mobil in den Schulen oder in der TU durchgeführt. Aktuelle Versuche beschäftigen sich unter anderem mit Quantenkryptographie, -computing und -sensorik.

DD 32.9 Tue 16:15 ZHG Foyer 1. OG

Didaktische Rekonstruktion zur Quantenbildgebung — •Dustin-Philipp Preissler und Holger Cartarius — AG Fachdidaktik der Physik und Astronomie, Friedrich-Schiller-Universität Jena, 07743 Jena

Moderne Themen der Quantenphysik halten Einzug in die Lehrpläne. Ein anwendungsorientiertes Beispiel ist Quantenbildgebung. Die Grundidee kann bereits auf Basis des Mach-Zehnder-Interferometers verstanden werden, weshalb sich eine Beschäftigung mit diesem Thema in Rahmen von Schülerlaboren eröffnet. Dieser Vortrag möchte die Grundlagen zweier Quantenbildgebungsverfahren, namentlich Quantenbildgebung mit undetektierten Photonen und Ghost Imaging anreißen. Anschließend wird erörtert, wie man Mach-Zehnder-Interferometer modifizieren kann, die sie für die Bildgebung interessant machen. Dafür werden wir die Fähigkeit zur Interferenz von Quantenobjekten genauer betrachten und Schwierigkeiten in der Realisierung eines Versuchsaufbaus erörtern. Wir entwickeln dazu erste Ideen für einen Versuch, der in einem Schülerlabor verwendet werden könnte.

DD 32.10 Tue 16:15 ZHG Foyer 1. OG

Entwicklung einer Versuchsanleitung zu Interferenz-Experimenten mit Einzel-Photonen im Rahmen eines Quantenoptik-Praktikums — •Felipe Laumen, Sebastian Nell, Ralf Detemple und Heidrun Heinke — . Physikalisches Institut IA, RWTH Aachen University

Quantenphysik ist nicht nur in Nachrichten, Literatur und Unterhaltung inzwischen omnipräsent, sondern auch fester Bestandteil der Curricula im Physikunterricht. Unter anderem soll das Auftreten oder Ausbleiben eines Interferenzmusters in Interferenzexperimenten mit „Welcher-Weg"-Informationen bei Quantenobjekten wie Photonen erklärt werden. Daran anknüpfend beschäftigt sich das vorgestellte Projekt mit Interferenz-Phänomenen von Einzelphotonen. Unter Verwendung eines Quantenoptik-Kits der Firma Thorlabs® wurde eine Versuchsanleitung entwickelt, mit der Schülerinnen und Schüler der Oberstufe und Bachelor-Studierende im Physik-Praktikum Einzel-Photonen-Interferenz und darauf aufbauend den Quantenradierer erkunden. Der wiederholte Vergleich von klassischen und quantenmechanischen Beschreibungen macht auf Gemeinsamkeiten sowie Unterschiede aufmerksam und hat das Potential, Schülervorstellungen aufzudecken. Das Poster beschreibt theoretische Grundlagen und die experimentelle Umsetzung. Dann werden die Experimente Einzel-Photonen-Interferenz und Quantenradierer vorgestellt und Ergebnisse sowie Überlegungen bei der Entwicklung der Versuchsanleitung präsentiert. Dies eröffnet Einblicke in die laufende Entwicklungsarbeit des Quantenoptik-Praktikums an der RWTH Aachen.

DD 32.11 Tue 16:15 ZHG Foyer 1. OG

Praxiserfahrung mit Versuchsaufbauten zur Quantenoptik und Konzeption einer didaktisch reduzierten Versuchsanleitung — •Nils Thormann, Sebastian Nell, Ralf Detemple und Heidrun Heinke — I. Physik. Institut IA, RWTH Aachen University

Der Vermittlung von quantenphysikalischen Konzepten wird sowohl in der Schule als auch in Hochschulen eine wachsende Bedeutung zugemessen. Gerade die Quantenoptik ist dabei ein spannendes Forschungsfeld. Im Rahmen einer Abschlussarbeit wurden mithilfe des Quantum Optics Educational Kits des Herstellers Thorlabs® einerseits für Schülerinnen und Schüler der gymnasialen Oberstufe, andererseits für Studierende früher Semester physikalischer und physiknaher Studiengänge experimentelle Zugänge zu Grundlagen der Quantenoptik eröffnet. Aufbauend auf gesammelten Praxiserfahrungen in Montage, Justage und Versuchsdurchführung sowie -auswertung wurde eine didaktisch reduzierte Versuchsanleitung konzipiert, die die genannten Zielgruppen gleichermaßen adressiert. Die theoretischen Grundlagen wurden dabei so weit elementarisiert, dass allen Zielgruppen ein adressatengerechter Zugang ermöglicht wird. Für einen möglichst niederschwelligen Zugang wurden für zentrale Montage- und Justageschritte Videoanleitungen realisiert. Dabei kann nach der konzipierten Anleitung die Versuchsanordnung je nach Präparation der Ausgangslage im Anforderungsniveau hinsichtlich der Montage und Justage der optischen Bauelemente variiert werden. Nach Erprobung, Evaluation und anschließender Überarbeitung ist ein Einsatz der konzipierten Anleitung im Schülerlabor und in physikalischen Praktika der Hochschule geplant.

DD 32.12 Tue 16:15 ZHG Foyer 1. OG

A Fundamental Path to Quantum Physics: The Space Paradox — •Hans-Otto Carmesin — Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen

Quantum physics is a very successful field of science with omnipresent relevant applications in everyday life. An exciting question is still, what is the fundamental reason for the dynamics and postulates of quanta?

A paradox is an apparent contradiction, the solution of which provides a deeper insight. Can we derive quanta and their dynamics with help of a paradox?

In present-day science, space is usually modeled as a single entity. However, special relativity shows that this view is paradoxical. As a consequence, space is a statistical average of rapidly moving volume portions. Their dynamics provides and explains the Schrödinger equation and the quantum postulates (Carmesin 2022, 2025).

Derivations as well as experiences with teaching are presented.

Carmesin, H.-O. (2022): Explanation of Quantum Physics by Gravity and Relativity. PhyDid B Internet Journal, pp 425-438. Carmesin, H.-O. (2025): On the Dynamics of Time, Space and Quanta. Berlin: Verlag Dr. Köster.

DD 32.13 Tue 16:15 ZHG Foyer 1. OG

Supporting problem solving in Quantum Technologies with multiqubit state visualizations — •Jonas Bley[1], Eva Rexigel[1], Alda Arias[1], Lars Krupp[1,2], Nikolas Longen[1], Paul Lukowicz[1,2], Stefan Küchemann[3], Jochen Kuhn[3], Maximilian Kiefer-Emmanouilidis[1,2], and Artur Widera[1] — [1]RPTU Kaiserslautern in Kaiserslautern-Landau — [2]DFKI Kaiserslautern — [3]LMU München

The two-level quantum system, also called a qubit, is at the core of quantum technologies (QT). It finds universal application in all pillars of QT: Sensing, Communication, Computation and Simulation. When learning QT, stakeholders with and without prior training in quantum physics are confronted with complex properties and operations in multi-qubit systems. Visualization is likely a useful tool to overcome these barriers. The Hadamard gate is universally used to create and destroy superpositions, which are essential for quantum technological applications. In an eye-tracking study, we investigated the conditions under which task solvers benefit from the dimensional circle notation (DCN) visualization in terms of performance and cognitive load, when solving questions about the Hadamard gate in two- and three-qubit systems. We find that participants, when presented with visualization in addition to the mathematical Dirac notation, experience less intrinsic and extraneous cognitive load in general, and that they benefit in terms of performance under certain conditions. The findings have implications for teaching in QT and open new avenues for further research.

DD 32.14 Tue 16:15 ZHG Foyer 1. OG

Quantenschlüsselerzeugung im Physikunterricht — •Gina Kleinsteinberg, Johanna Lohmann, Oliver Burmeister und Moritz Waitzmann — Leibniz Universität Hannover

Mit der Einführung der Bildungsstandards für die Sek. II wurden die Begriffe Zustand, Präparation und Superposition in den niedersächsischen Lehrplan integriert. Lernende mit erhöhtem Anforderungsniveau sollen diese anhand von polarisiertem Licht erläutern können. Zusätzlich soll eine technische Anwendung der Quantenphysik thematisiert werden (Nieders. Kultusministerium, 2022).e Eine passende Anwendung ist die Quantenschlüsselerzeugung nach dem BB84-Protokoll, bei dem Zufallsbits durch Polarisationszustände von Photonen erzeugt werden (Bennett & Brassard, 2020). Um die Quantenschlüsselverteilung im Physikunterricht lernendenzentriert zu gestalten, wurde in Zusammenarbeit mit der nieders. Multiplikatorengruppe NUN eine Web-App entwickelt. Mit dieser App können Lernende die Schlüsselerzeugung und die Simulation eines Lauschangriffs durchführen. Das Poster stellt Ideen und Umsetzung der App vor. Teilnehmende können die App direkt ausprobieren.

Bennett, C. H., & Brassard, G. (2020). Quantum cryptography: Public key distribution and coin tossing.

Niedersächsisches Kultusministerium (Hrsg.). (2022). Kerncurriculum für das Gymnasium gymnasiale Oberstufe die Gesamtschule gymnasiale OberstufeDas Berufliche GymnasiumDas AbendgymnasiumDas KollegPhysik.

DD 33: Poster – Geschichte und NoS

Time: Tuesday 16:15–17:45 Location: ZHG Foyer 1. OG

DD 33.1 Tue 16:15 ZHG Foyer 1. OG

Die (Un)Sichtbarkeit von Physikerinnen im Physikunterricht und die Entwicklung von science identity von Schülerinnen — •Eva Glomski, Marco Daniel Riese und Marcus Kubsch — Freie Universität Berlin, Berlin, Deutschland

Die Repräsentation von Frauen in der Physik ist in Lehrplänen und Unterrichtsmaterialien gering. Dieses Poster zeigt auf, wie durch die gezielte Einbindung von Physikerinnen entlang typischer Themenfelder des Physikunterrichts die science identity und das Interesse von Schülerinnen gestärkt werden könnte. Mithilfe biographischer Profile wird gezeigt, wie diese Wissenschaftlerinnen mit spezifischen physikalischen Themen in Verbindung stehen und gleichzeitig inspirierenden Widerstand gegen gesellschaftliche Hürden symbolisieren. Dabei werden unterschiedliche Ansätze, wie man die Wissenschaftlerinnen in den Unterricht einbaut, gegenübergestellt und diskutiert. Ziel ist es, durch gendersensiblen Physikunterricht nicht nur die Vielfalt im Fach Physik zu betonen, sondern auch positive Identifikationsmöglichkeiten für Schülerinnen zu schaffen.

DD 33.2 Tue 16:15 ZHG Foyer 1. OG

Die Perspektive der Forschenden - Was sollen Schüler*innen über Wissenschaft lernen? — •Lea Herbst[1] und Verena Spatz[2] — [1]Didaktik der Physik, Fachbereich Physik, TU Darmstadt — [2]Didaktik der Physik, Fachbereich Physik, TU Darmstadt

Im Rahmen des Outreach-Programmes des SFB 1245 'Atomkerne: Von fundamentalen Wechselwirkungen zu Struktur und Sternen' der TU Darmstadt werden Unterrichtsmaterialien und Handreichungen für Lehrkräfte entwickelt. Diese haben das Ziel, die Vermittlung adäquater Vorstellungen zu Nature of Science (NOS) und Nature of Scientific Inquiry (NOSI) zu unterstützen. Diese Vermittlung ist im Sinne von Scientific Literacy ein Bestandteil des Bildungsziels für naturwissenschaftlichen Unterrichts, wobei auch Lehrkräfte in diesem Bereich oft unzureichendes Professionswissen aufweisen. An der Entwicklung der Materialien sind Lehrkräfte sowie Forschende des SFB 1245 beteiligt, um sowohl Wünsche und Bedarfe aus schulischer Perspektive sinnvoll umzusetzen als auch ein realistisches Bild von Wissenschaft darzustellen. In der fachdidaktischen Begleitstudie soll dabei erhoben werden, inwiefern diese Zusammenarbeit die Vorstellungen der beteiligten Lehrkräfte zu NOS und NOSI positiv beeinflusst. In einem ersten Schritt wurden zur Herausbildung von NOS- und NOSI-Schwerpunktaspekten für die Materialien u.a die Forschenden des SFB 1245 dazu befragt, was Schüler*innen aus ihrer Sicht über Wissenschaft lernen sollen. In diesem Beitrag werden die Ergebnisse dieser Befragung dargestellt.

DD 34: Mitgliederversammlung

Time: Tuesday 18:00–20:00 Location: ZHG103

Alle Mitglieder des Fachverbands Didaktik der Physik sind herzlich eingelanden.

DD 35: Workshop Studienreformforum

Time: Wednesday 11:00–12:30 Location: Theo 0.136

Group Report DD 35.1 Wed 11:00 Theo 0.136

Zahllose didaktische Verbesserungsideen und dennoch bleibt alles beim Alten? — •Barbara Obwaller[1,4], Stefan Brackertz[2,4], Annemarie Sich[2,4], Lisa Marie Lehmann[3,4], Simon Tautz[4], Jonathan Moeller[5,4] und Manuel Längle[6,4] — [1]Universität Innsbruck, Studienvertretung Physik — [2]Universität zu Köln, Fachschaft Physik — [3]Nikhef, Amsterdam — [4]Studienreform-Forum Physik — [5]TU Dresden, Fachschaft Physik — [6]Uni Wien

Als sinnlos empfundene Lehrveranstaltungen gehören zum Alltag an Universitäten, sowohl für Studierende als auch für Lehrende. Beispiele für solche Formate sind etwa Vorrechen-Übungen, geprägt von angespannter oder gelangweilter Stille, fehlender Interaktion und vom-Blatt-abschreiben, Literaturseminare, in denen Professor*innen mit PostDocs diskutieren und die restlichen Anwesenden nicht folgen können, oder Praktika in denen historisch korrekt das Fadenpendel 100 Mal ausgelenkt wird, um genug Daten für eine Fehlerrechnung zu haben. Beispiele, wie es besser geht, gibt es inzwischen zahlreich. In diesem Workshop wollen wir die Frage umdrehen und uns im Vorfeld gesammelte Negativbeispiele ansehen:

- Warum sind die Negativbeispiele Negativbeispiele? Und gibt es darüber überhaupt Einigkeit?
- Was lässt sich daraus für die sinnvolle Gestaltung von Lehre lernen?
- Was hindert(e) die Beteiligten, es anders zu machen?
- Welche Lösung wurde ausprobiert und wie waren die Erfahrungen damit?

DD 36: Quantenphysik III

Time: Wednesday 11:00–12:20 Location: Theo 0.135

DD 36.1 Wed 11:00 Theo 0.135

QuantenSchafkopf: Quantenphysik spielerisch greifbar machen — •Ludwig Nützel[1], Philipp Bitzenbauer[2] und Michael Hartmann[1,3] — [1]Lehrstuhl für Theoretische Physik 2, Friedrich-Alexander-Universität Erlangen-Nürnberg, Deutschland — [2]Institut für Didaktik der Physik, Universität Leipzig, Deutschland — [3]Max-Planck-Institut für die Physik des Lichts, Erlangen, Deutschland

Schafkopf ist ein traditionelles Kartenspiel, das in Abwandlungen in großen Teilen Deutschlands und Mitteleuropa verbreitet ist. QuantenSchafkopf erweitert die bestehenden Schafkopfregeln und macht hierdurch die Quantenkonzepte Superposition, Verschränkung und Kollaps der Wellenfunktion spielerisch zugänglich. Obwohl den erlaubten Spielzügen eine mathematische Beschreibung der Quantenphysik zugrunde liegt, kann das Spiel ohne jegliche mathematische Vorkenntnisse gespielt werden und bietet daher Potential für die didaktische Aufbereitung der Quantenphysik. In dem Vortrag werden neben dem Spiel selbst auch Möglichkeiten zur Implementation in Physikunterricht oder die Aus- bzw. Weiterbildung von Lehrkräften vorgeschlagen.

DD 36.2 Wed 11:20 Theo 0.135

Eine interaktive Wanderausstellung zur Vermittlung von Quantenphänomenen — •Anja Kuhnhold, Jannis König, Andreas Fuchs, Thomas Filk und Andreas Buchleitner — Physikalisches Institut, Albert-Ludwigs-Universität, Freiburg, Deutschland

Im Rahmen des vom Bundesministerium für Bildung und Forschung geförderten Projekts Q-Bus [1] erstellen wir eine Wanderausstellung mit Exponaten und (Analog-)Experimenten, mit denen wir Schülerinnen und Schülern, Lehrkräften und allgemein Interessierten Quantenphänomene näherbringen und erläutern wollen. Wir verwenden dabei sowohl bereits entwickelte und erprobte Materialien, wie 3D-gedruckte Optik-Experimentiersets [2] und Experimentier-Kits zum quantisierten Leitwert [3], als auch neue Konstruktionen, wie eine mechanische Paul-Falle mit manuellem Antrieb.

In dem Beitrag wird über erste Einsätze unserer Exponate bei einer Wissenschaftsmesse, einer Schülerakademie sowie in verschiedenen Klassenstufen einer Schule berichtet.

[1] https://www.quantentechnologien.de/forschung/foerderung/quantum-aktiv-outreach-konzepte-und-open-innovation-fuer-quantentechnologien/q-bus.html
[2] https://o3q.de/
[3] https://www.quantum2025.de/quantum2025/quanten-spielerisch-und-in-der-schule/schulversuch-der-quantisierte-leitwert

DD 36.3 Wed 11:40 Theo 0.135

Von den Anfängen zur Anwendung: 5 Jahre Competence Framework for Quantum Technologies — •Franziska Greinert und Rainer Müller — Technische Universität Braunschweig, IFdN, Physik und Physikdidaktik

Das European Competence Framework for Quantum Technologies (CFQT) ist der europäische Referenzrahmen zur Standardisierung der QT-Bildung. Es bietet eine gemeinsame Sprache zu Themen und Konzepten rund um QT mit Beschreibungen von Kompetenzleveln, strukturiert in der Content Map und dem Proficiency Triangle. Zusätzlich werden in den sogenannten Qualification Profiles typische Qualifikationen aufgezeigt, die für die Arbeit im QT-Kontext relevant sind. So kann das CFQT etwa für die Definition von Lernzielen, die Planung von Bildungsangeboten oder den Vergleich von Qualifikationen genutzt werden.

Das CFQT basiert im Wesentlichen auf zwei Studien: einer iterativen Fragebogenstudie in Anlehnung an die Delphi-Methode (2020/2021) und der Analyse von 34 Interviews mit Fachkräften aus der Industrie (2023). Diskutiert werden die Einflüsse dieser Studien auf das CFQT bzw. die drei Teile des CFQT (Content Map, Proficiency Triangle und Qualification Profiles) sowie Anwendungsfälle des CFQT in Deutschland, der EU und weltweit.

DD 36.4 Wed 12:00 Theo 0.135

Von der Stimmgabel zur Matrizenmechanik — •Oliver Passon — Bergische Universität Wuppertal

Dieser Vortrag zeigt die gedankliche Verbindung, die zwischen elementaren akustischen Phänomenen und der Quantenmechanik in der Formulierung von Heisenberg, Born und Jordan besteht. Es zeigt sich dadurch, dass die Matrizenmechanik nicht bloß von historischer, sondern auch von didaktischer Bedeutung ist.

DD 37: Lehrkräftebildung II

Time: Wednesday 11:00–12:20 Location: Theo 0.134

DD 37.1 Wed 11:00 Theo 0.134

Einstellung von Lernenden zum Einsatz von (interaktiven) Experimentiervideos — •Mathias Ziegler und Lisa Stinken-Rösner — Universität Bielefeld, Deutschland

Schülerexperimente bieten Lernenden die Möglichkeit, physikalische Arbeitsweisen praktisch anzuwenden (Girwidz, 2020). In bestimmten Unterrichtsszenarien ist der Einsatz von Schülerexperimenten jedoch nicht möglich, beispielsweise bei fehlenden Versuchsmaterialien oder aus Sicherheitsgründen. Als Alternative, bei der der handlungsorientierte Charakter von Experimenten erhalten bleibt, können (interaktive) Experimentiervideos in Betracht gezogen werden (Stinken-Rösner, 2023). Lehrkräfte stehen (interaktiven) Experimentiervideos grundsätzlich positiv gegenüber (Meier et al., 2022). Allerdings besteht noch ein Forschungsdesiderat hinsichtlich der Einschätzung der Lernenden zum Umgang mit (interaktiven) Experimentiervideos als eigenständiges Lernmedium bzw. in Kombination mit Realexperimenten sowie zu Vor- und Nachteilen des Mediums aus der Sicht der Lernenden. Zur Erfassung dieser Forschungslücke erfolgt im Rahmen des Projekts LFB-Labs-digital eine Erprobung des Mediums mit mehreren Schulklassen. Die Lernenden erarbeiten physikalische Fragestellungen selbstständig unter Verwendung von (interaktiven) Experimentiervideos. Die Erhebung der Einstellung der Lernenden gegenüber dem Medium erfolgt anhand eines Fragebogens (vgl. Stinken-Rösner & Laumann, 2023). Darüber hinaus werden die Arbeitsergebnisse der Lernenden sowie ihr schriftliches Feedback bezüglich Vor- und Nachteilen des Einsatzes von (interaktiven) Experimentiervideos analysiert.

DD 37.2 Wed 11:20 Theo 0.134

Kompetenzen zur Gestaltung von Experimentierphasen — •Teresa Tewordt und Lisa Stinken-Rösner — Universität Bielefeld, Bielefeld, Deutschland

Experimentieren im Physikunterricht kann das konzeptuelle Verständnis, die Aneignung naturwissenschaftlicher Methoden sowie die Entwicklung experimenteller Fähigkeiten auf Seiten der Lernenden fördern (Idris, 2022). Hierfür müssen Experimentierphasen von der Lehrkraft geplant und gezielt in den Unterrichtskontext eingebettet werden. Dies erfordert spezifische Kompetenzen, welche bisher theoretisch jedoch erst wenig bis gar nicht ausdifferenziert wurden (von Aufschnaiter & Blömeke, 2010). Dabei sollte gerade das Wissen über jene Kompetenzen den Ausgangspunkt zur Gestaltung und Evaluation der Wirksamkeit von (fachdidaktischen) Laborpraktika für angehende Physiklehrkräfte auf universitärer Ebene darstellen. Anhand eines KI-gestützten Systematic Literature Reviews (Tewordt & Stinken-Rösner, im Druck) wurden eine erste Version eines Kompetenzrahmen sowie operationalisierbare (Teil-)Kompetenzen für die Gestaltung von Experimentierphasen im Physikunterricht identifiziert und in einem zweiten Schritt mit Expert:innen aus der zweiten Phase der Lehrkräftebildung validiert. Das resultierende Modell stellt eine Art übergeordneten Erwartungsrahmen dar, der für Studium und Referendariat angelegt werden kann. Gleichzeitig bildet er die Grundlage, um die Kompetenzentwicklung angehender Physiklehrkräfte zu beschreiben. Entsprechende Ergebnisse eines Performanztestes (erster Messzeitpunkt einer Längsschnittstudie, Studierende des ersten Mastersemesters) werden vorgestellt.

DD 37.3 Wed 11:40 Theo 0.134

Experimentieren lernen - Selbstwirksamkeit stärken? — •Cornelia Geller, Paula Andrich, Martin Dickmann und Heike Theyssen — Universität Duisburg-Essen

Experimentierpraktika stellen in der universitären Ausbildung wesentliche Bausteine dar, die vielfältige Fähigkeiten - wie z.B. den Umgang mit Geräten oder unsicheren Daten - vermitteln sollen. Allerdings benötigen Studierende nicht nur diese Fähigkeiten, sondern auch das Vertrauen in sie. So haben sich Selbstwirksamkeitserwartungen (SWE) bei Lehramtsstudierenden bereits als wesentliche Einflussfaktoren auf das Professionswissen und die Qualität des zukünftigen Unterrichts erwiesen.

An der Universität Duisburg-Essen werden zur Stärkung der SWE bereits frühzeitig im Lehramtsstudium experimentalpraktische Lehrformate eingesetzt, die das Experimentieren außerhalb einer klassischen Praktikumsstruktur ermöglichen. Dabei werden pro Versuch Aufgaben mit unterschiedlicher Offenheit gestellt, die einzelne methodische Entscheidungsprozesse (wie z.B. die Wahl einer Messrate) fördern sollen, während andere in ihrer Komplexität bewusst reduziert werden. Um den Einfluss dieser Lehrangebote auf die SWE der Stu-

dierenden in Bezug auf die Planung, Durchführung und Auswertung von Experimenten zu untersuchen, wurde ein Fragebogen entwickelt und im Pre-Post-Design eingesetzt.

Im Vortrag werden die Lehrangebote sowie die Ergebnisse der begleitenden Fragebogenstudie vorgestellt und bezüglich der Passung von Ziel und Wirkung diskutiert.

DD 37.4 Wed 12:00 Theo 0.134

Schwingungen und Wellen in Alltagskontexten — •Lutz Kasper und Jan Winkelmann — PH Schwäbisch Gmünd

Schwingungen und Wellen sind allgegenwärtig im täglichen Leben. Sie erklären physikalische und technische Phänomene auf allen Skalen vom ganz Großen, dem Universum, bis zum submikroskopischen Bereich. Unter fachwissenschaftlicher Perspektive bilden Schwingungen und Wellen theoretische Bestandteile aller Teildisziplinen der Physik ab, von der Mechanik und Optik bis zur Elektrodynamik und Quantenphysik. Schwingungen und Wellen lassen sich in einer anderen Kategorisierung ganz verschiedenen Alltagskontexten zuordnen. Sie stellen eine Grundlage dar für Musik und Akustik. In der Medizin begründen sie vielfältige diagnostische und therapeutische Verfahren. Schließlich ist auch die technische Umsetzung unserer Telekommunikationsprozesse angewandte Schwingungs- und Wellenlehre. Unter fachdidaktischer Perspektive besteht der besondere Wert des Themas darin, dass eine für die Lernenden erkennbare horizontale und vertikale Vernetzung zwischen den Teilgebieten der Physik und darüber hinaus hergestellt wird. So lassen sich begriffliche Konzepte und Modellvorstellungen, die für die Mechanik entwickelt wurden, auf weitere für den Unterricht relevante Gebiete der Physik übertragen.

Im November 2023 fand eine WE-Heraeus-Fortbildung für angehende und praktizierende Lehrkräfte zu vielfältigen Alltagskontexten von Schwingungen und Wellen statt, die 2025 bei Springer Nature als Buch veröffentlicht wird. Im Vortrag werden die Inhalte übersichtsartig und in ihrem Zusammenhang vorgestellt.

DD 38: Geschichte / NoS

Time: Wednesday 11:00–12:20 Location: OEC 1.163

DD 38.1 Wed 11:00 OEC 1.163

Wissenschaftsverständnis von Physiker:innen: Zwei Fallbeispiele aus einer Lehrkräftefortbildung — •Linda Zwick und Rita Wodzinski — Universität Kassel, Institut für Physik

Im Kasseler SFB ELCH ist ein Transferprojekt eingebunden, das sich die Förderung des Wissenschaftsverständnisses von Lehrkräften zum Ziel gesetzt hat. Dabei werden drei zentrale Aspekte von Nature of Science (NOS) besonders berücksichtigt: (1) die Erkenntnisgewinnung in naturwissenschaftlicher Forschung, (2) das Zusammenspiel von Theorie und Experiment in der Physik und (3) die Zusammenarbeit und Kollaboration unter Physiker:innen.

An der letzten Lehrkräftefortbildung im Projekt waren eine Theoretische Physikerin und ein Experimentalphysiker aktiv beteiligt. Der Vortrag beleuchtet ihre Vorstellungen zu den genannten NOS-Aspekten und deren Veränderungen durch ihr Mitwirken an der Fortbildung. Die Ergebnisse werden mit physikdidaktischen Perspektiven abgeglichen und diskutiert.

DD 38.2 Wed 11:20 OEC 1.163

Über (Pseudo)wissenschaften sprechen - Reflexionsanlässe im Physikunterricht — •Yvonne Webersen — Universität Paderborn

Nicht nur in den sozialen Medien, auch in Nachrichten oder in der Werbung werden Schüler:innen mit Fehlinformationen und Pseudowissenschaften konfrontiert: Beispiele lassen sich in Bezug auf den Klimawandel, COVID-19, aber auch in der Vermarktung pseudowissenschaftlicher Produkte (z.B. basierend auf Quantenheilung, Orgonstrahlung oder freie Energien) finden. Um diesen Informationen angemessen begegnen zu können, sind im Sinne der Ausbildung einer Science Media Literacy Kenntnisse über die Nature of Science (NOS) bzw. Nature of Science in Society (NOSIS) nötig. Im Vortrag werden Unterrichtsmaterialien vorgestellt, die von Studierenden mit dem Ziel entwickelt wurden, im Physikunterricht Reflexionsanlässe über (Pseudo)wissenschaften zu schaffen, z.B.: "Heute wissen wir, wie das Universum aussieht!"...oder? Eine digitale Lernumgebung zur Geschichte der Astronomie mit dem besonderen Fokus auf die Vorläufigkeit naturwissenschaftlicher Erkenntnisse; "WaveGuard - eine Handyhülle gegen Strahlung und für besseren Schlaf" Lernmaterialien zur Anwendung fachlicher und überfachlicher Strategien, um Pseudowissenschaften zu entlarven; "Wie experimentieren eigentlich Physiker:innen?" Videointerviews als Reflexionsanlässe über schulisches und wissenschaftliches Experimentieren.

DD 38.3 Wed 11:40 OEC 1.163

Snellius' Brechungsgesetz und das Phänomen der optischen Hebung — •Thomas Quick und Johannes Grebe-Ellis — Bergische Universität Wuppertal

Das Brechungsgesetz, auch als Snelliussches Gesetz bekannt, beschreibt die Änderung der Ausbreitungsrichtung von Licht beim Übergang zwischen Medien unterschiedlicher optischer Dichte. Snellius leitete dieses Gesetz im Jahr 1621 nicht aus einem Lichtmodell ab - wie später Descartes (1627) -, sondern formulierte es auf der Grundlage explorativer Untersuchungen der optischen Hebung. Indem er das Verhältnis optischer und haptischer Positionen unter Wasser getauchter Objekte für gegebene Blickwinkel untersuchte, identifizierte er eine Beziehung, die dem Sinusgesetz der Brechung entspricht, aber näher am Phänomen formuliert ist: das "Hebungsgesetz".

In unserem Beitrag zeigen wir, wie sich experimentelle, fachliche und erkenntnismethodische Untersuchungen zur optischen Hebung im historischen Kontext von Snellius' Entdeckung auf Mittelstufen- und Oberstufenniveau integrieren lassen. Wir analysieren Snellius' Hebungsgesetz, zeigen dessen Äquivalenz zum Sinusgesetz der Brechung, präsentieren Snellius' "experimentum elegans" in einer modernen Form und diskutieren seine "Kathetus-Regel" für die vertikale Hebung. Dies mündet in eine verallgemeinerte Theorie der Bildentstehung, die sagittale und meridionale Abbildungen unterscheidet. Abschließend erörtern wir die "Refractaria" (Hebungskonchoide), die Kurve, welche die optische Hebung einer unter Wasser liegenden horizontalen Gerade beschreibt.

DD 38.4 Wed 12:00 OEC 1.163

Schweben, Sinken, Steigen. Der Öltröpfchen-Versuch als Zugang zur Elementarladung und Brownschen Bewegung — •Julia Bloemer — Europa-Universität Flensburg

Das Öltröpfchen-Experiment zählt zu den bekanntesten Experimenten der Physikgeschichte. Zu Beginn des 20. Jahrhunderts gelang es damit Robert A. Millikan und seinem Doktoranden Harvey Fletcher, die Elementarladung präziser zu bestimmen als je zuvor. Bis heute sind angepasste Versionen der Apparatur in den Lehrsammlungen von Schulen und Universitäten zu finden. In Lehrmaterialien wird das Experiment meist anhand der sogenannten Schwebemethode beschrieben, bei der ein Öltropfen durch Anlegen einer Spannung in Schwebe gehalten wird. Diese Darstellung weicht jedoch von den historischen Angaben ab. Millikan und Fletcher entschieden sich früh, stattdessen Sink- und Steiggeschwindigkeiten der Tropfen zu messen, da die Brownsche Bewegung die Daten der Schwebemethode unbrauchbar machte. Dazu schalteten sie die Spannung in kurzen Abständen an und wieder aus. Der Vortrag untersucht, wie sich die Berücksichtigung dieser historischen Messpraxis auf den Unterricht zum Öltröpfchen-Experiment auswirken kann. Zudem wird die Frage diskutiert, ob die Apparatur auch für Experimente zur Brownschen Bewegung im Unterricht sinnvoll eingesetzt werden kann.

DD 39: Lehr-Lernforschung II

Time: Wednesday 11:00–12:20 Location: OEC 1.162

DD 39.1 Wed 11:00 OEC 1.162

"Mach dein Gehirn fit für Physik" - Einfluss einer Growth Mindset Lerneinheit — •Laura Goldhorn[1], Thomas Wilhelm[1] und Verena Spatz[2] — [1]Institut für Didaktik der Physik, Goethe-Universität Frankfurt — [2]Didaktik der Physik, Technische Universität Darmstadt

Mehrere unabhängige, internationale Studien zeigen, dass Schüler*innen mit einem (fachbezogenen) Growth Mindset einen besseren Umgang mit herausfordernden Lernsituationen haben, unabhängig von ihrem tatsächlichen Könnens- und Wissensstand. Die eigenen Erhebungen zeigen, dass sich Schüler*innen zu Beginn des Physikunterrichts in der 7. Jahrgangsstufe überwiegend dem Growth Mindset zuordnen lassen, doch schon im ersten Lernjahr verändert sich diese Verteilung: immer mehr Schüler*innen sind von einer notwendigen Physik-Begabung überzeugt und vertreten somit ein physikbezogenes Fixed Mindset. Die Lerneinheit "Mach dein Gehirn fit für Physik" ist als fachbezogene Mindset-Intervention entwickelt worden, um diesem Mindset-Shift entgegenzuwirken. Angelehnt an die allgemeinen Mindset-Interventionen nach Yeager und Dweck

und mit der Einübung einer Lernstrategie an das Fach Physik geknüpft, kann die Lerneinheit curriculumsunabhängig in der Sekundarstufe 1 eingesetzt werden. In einer ersten Studie im Pre-Post-Design wurde die Lerneinheit mit verschiedenen Lerngruppen durchgeführt. Die Wirkung der Intervention auf das physikbezogene Mindset der Schüler*innen wird im Vortrag vorgestellt - auch in Abhängigkeit von Jahrgangsstufe, Geschlecht und Leistungseinschätzung.

DD 39.2 Wed 11:20 OEC 1.162

Motivation durch Wahl: Autonomieförderung im Physikunterricht — •Laura Pannullo — AG Physik und ihre Didaktik, Universität Bielefeld

Motivation ist aus Sicht der Physikdidaktik und aus Perspektive von Lehrkräften ein zentrales Ziel des Physikunterrichts. Nach der Selbstbestimmungstheorie von Deci und Ryan entsteht (intrinsische) Motivation dann, wenn Grundbedürfnisse wie Autonomie, Kompetenz und soziale Bezogenheit erfüllt werden. Insbesondere das Autonomieerleben spielt dabei eine entscheidende Rolle. Vor diesem Hintergrund stellt sich die Frage, wie Physikunterricht gestaltet werden kann, der das Autonomieerleben fördert. Wahlmöglichkeiten gelten in der Theorie als effektive Maßnahme zur Förderung von Autonomie und konnten in anderen Bereichen und Kontexten bereits positive Effekte auf affektiv-motivationale Merkmale zeigen.

Der Beitrag widmet sich dieser Fragestellung und präsentiert Ergebnisse aus zwei Studien, in denen Wahlmöglichkeiten in Experimentierphasen als autonomiefördernde Maßnahme untersucht wurden. In den Studien wurde analysiert, inwiefern die Implementation von Wahlmöglichkeiten die Motivation und die Selbstwirksamkeitserwartung von Schüler*innen beeinflusste. Der Beitrag stellt die Ergebnisse vor und bietet Impulse für die schulische Praxis auf Basis der vorgestellten Ansätze.

DD 39.3 Wed 11:40 OEC 1.162

Das Interesse von Schülerinnen und Schülern an physikalischen Themen — •Hermann Lidberg und Roger Erb — Institut für Didaktik der Physik - Goethe-Universität Frankfurt am Main

Welche naturwissenschaftlichen Kontexte von Jugendlichen als interessant angesehen werden, wurde in groß angelegten quantitativen Studien wie der IPN-Interessensstudie und der internationalen ROSE-Studie systematisch untersucht. Nach Zoechling (2023) lassen sich Kontexte anhand des Anteils der Jugendlichen, die sie als interessant empfinden, hierarchisch in mehrere Stufen einordnen. Dies deutet darauf hin, dass physikalische Inhalte von Jugendlichen nur dann als interessant bewertet werden, wenn sie in spezifischen, als relevant wahrgenommenen Kontexten eingebettet sind.

Um die Ursachen zu ermitteln, warum bestimmte Kontexte von Jugendlichen als interessant wahrgenommen werden und welche sozialen, persönlichen und gesellschaftlichen Faktoren dabei für sie von Bedeutung sind, wurde auf Basis von Interviews mit Jugendlichen ein Fragebogen entwickelt. Mit diesem soll erfasst werden, wann, wie und in welchen Kontexten Interessen von Jugendlichen entstehen und wie sich Jugendliche mit ihren Interessen beschäftigen. Außerdem wird untersucht, ob es dabei Unterschiede zwischen Themen gibt, die Jugendliche im Allgemeinen interessieren, und physikalischen Themen, die die Jugendlichen als interessant ansehen.

Im Rahmen des Beitrags werden sowohl die Entwicklung des Fragebogens als auch erste Ergebnisse aus der Pilotierung vorgestellt.

DD 39.4 Wed 12:00 OEC 1.162

Wie hängen Personenmerkmale von Lernenden mit dem Fachinteresse und der Kurswahl Physik in der Sekundarstufe II zusammen? — •Julia Welberg, Susanne Heinicke und Daniel Laumann — Institut für Didaktik der Physik, Universität Münster

Im Sinne der Person-Gegenstands-Theorie (POI) ist Interesse bestimmt durch die Beziehung einer Person mit einem Interessengegenstand. Zahlreiche Studien haben sich dazu mit unterschiedlichen Interessengegenständen (z. B. Themenfelder, Kontexte) beschäftigt und deren Wirkung auf das Interesse einer Person untersucht. Andersherum existieren allerdings kaum fachdidaktische Studien, die sich näher mit den Merkmalen einer Person über Gender hinaus beschäftigen und Zusammenhänge zu Fachinteresse und Kurswahl Physik untersuchen. Dabei kann eine detaillierte Kenntnis der Person über Gender hinaus hilfreich sein, um über die diversitätssensible Gestaltung von Physikunterricht und davon ausgehend über Kontexte und Methoden nachzudenken.

Im Beitrag werden neben Gender weitere Personenmerkmale (Big Five, Neigung zu einer empathisierenden und systematisierenden Denkweise, Kognitionsbedürfnis und Neugierde) genutzt und deren Einflüsse auf Fachinteresse und Kurswahl Physik diskutiert. Die Stichprobe umfasst dabei Schülerinnen und Schüler der Sekundarstufen I und II unterschiedlicher Gymnasien und Gesamtschulen in Nordrhein-Westfalen.

DD 40: Hochschuldidaktik IV

Time: Wednesday 13:30–14:30 Location: Theo 0.136

DD 40.1 Wed 13:30 Theo 0.136

Wahrnehmung UDL basierter Selbstlernmaterialien im Physikstudium — •Leonie Jung, Martin Dickmann, Anita Stender und Heike Theyssen — Universität Duisburg-Essen

Heterogenität von Lernenden ist auch an Universitäten längst Realität. Bei der Gestaltung fachlicher Lernprozesse wird die Individualität der Studierenden jedoch selten explizit berücksichtigt, was das "Ankommen" im Studium erschweren kann. Deshalb wurde für den Lehramtsstudiengang für die Sekundarstufe I Physik an der Universität Duisburg-Essen Lernmaterial systematisch nach Prinzipien des Universal Design for Learning (UDL) gestaltet, um den Studienanfänger:innen einen barrierearmen Zugang zu neuen fachlichen Konzepten zu ermöglichen. In dem Studiengang wird ein "flipped classroom" Konzept, ergänzt um wöchentliche Hausübungen, umgesetzt. Das Konzept setzt voraus, dass die Studierenden sich vor und nach den Präsenzsitzungen individuell mit den Lernmaterialien auseinandersetzen. In diesen Selbstlernphasen sollen die angebotenen Lernmaterialien maßgeblich dazu beitragen, Barrieren, wie geringe Motivation, Verständnis- oder Zugangsprobleme zu überwinden. Deshalb setzt hier die Umsetzung des UDL an. Während des Einsatzes der Lernmaterialien wurden unter anderem mit Hilfe von retrospektiven Interviews, Daten zur Nutzung, Akzeptanz und subjektiven Wirksamkeit der Materialien erhoben. Im Vortrag werden die Umsetzung der UDL-Prinzipien sowie erste Ergebnisse zur Wahrnehmung dieser Umsetzung durch die Studierenden vorgestellt.

DD 40.2 Wed 13:50 Theo 0.136

Der studentische Umgang mit Messungen und Messunsicherheiten in einem als Projektlabor konzipierten Einführungsmodul zur Physik und Messtechnik — •Andreas Modler — Berliner Hochschule für Technik, Luxemburger Straße 10, 13353 Berlin

Im Bachelorstudiengang Medizinphysik an der Berliner Hochschule für Technik wurde im ersten Studiensemester ein Projektlabor als Modul zur Physik und Messtechnik neu geschaffen. Es werden die Lernziele, der Aufbau und Ablauf des Labors vorgestellt, wie es inzwischen zweimal durchgeführt wurde. Die praktische Anwendung der Bestimmung und Berechnung von Messunsicherheiten nach dem gängigen internationalen Leitfaden zur Angabe der Unsicherheit beim Messen (GUM) ist ein wesentliches Lernziel des Labors. Der Physics Measurement Questionnaire (PMQ) [1] wurde zur Messung des Lernzuwachses und Überprüfung des Lernerfolgs zu Beginn und Ende der Lehrveranstaltungen durchgeführt. Der PMQ besteht aus Fragebögen mit offenen Beispieldiskussionen, die das Verständnis des Messens und der Messunsicherheiten testen. Es wird das Vorgehen bei der Auswertung der Fragebögen erklärt. Die Ergebnisse der Vor- und Nachtests werden vorgestellt. Die gemessenen Lernzuwächse werden mit jenen in der Literatur verglichen und in Beziehung gesetzt.

[1]: Allie, Saalih; Buffler, Andy; Campbell, Bob; Lubben, Fred (1998). First*year physics students* perceptions of the quality of experimental measurements. International Journal of Science Education, 20(4), 447*459.

DD 40.3 Wed 14:10 Theo 0.136

Katze vs. Teilchen: Wirkung kontextbezogener Aufgaben im Physikstudium — •Pascal Klein[1], Josefine Neuhaus[1] und Andreas Müller[2] — [1]Universität Göttingen — [2]Universität Genf

Wir modellieren eine Katze als Punktteilchen, das sich in einem von Menschen induzierten Potential bewegt. Durch die Einführung einer Bewegungsgleichung, die das Potential, Reibungseffekte und zufällige Kräfte berücksichtigt, lassen sich charakteristische Verhaltensweisen von Katzen physikalisch beschreiben. Beispielsweise können Phänomene wie das Verweilen auf dem Schoß einer Lieblingsperson, das Nichtreagieren auf Rufe oder die sogenannten "Zoomies" (plötzliche Rennanfälle) aus der Dynamik des Systems nachvollzogen werden. Aus lernpsychologischer Sicht könnten solche authentischen Kontexte Interesse und Motivation der Studierenden fördern. Gleichzeitig besteht die Möglichkeit, dass der Kontext von den physikalischen Prinzipien ablenkt oder lediglich als unterhaltsamer Zusatz wahrgenommen wird. Um diese Effekte zu untersuchen, wurde eine Pilotstudie mit Studierenden des ersten Fachsemesters durchgeführt. Die Interventionsgruppe bearbeitete Aufgaben mit Bezug zur Katzen-Mensch-Interaktion, während die Kontrollgruppe äquivalente, kontextfreie Aufgaben (Potential und Teilchen) erhielt. Ziel war es, Unterschiede in Motivation, Verständnis und Transferleistung zwischen den Gruppen zu analysieren. Die Modellierung basiert auf dem Artikel "On cat-human interaction from the viewpoint of physics: An equation of motion" von Anxo Biasi, veröffentlicht im November 2024 im American Journal of Physics.

DD 41: Analysen

Time: Wednesday 13:30–14:30 Location: Theo 0.135

DD 41.1 Wed 13:30 Theo 0.135

Ziele und Motivation von Lehrkräften im Spannungsfeld Lehrplan — •Heiko Müller, Julius Baptist Hlawatsch und Axel Enders — Universität Bayreuth, Bayreuth, Deutschland

In den letzten 20 Jahren wurden in den bayerischen Lehrplänen viele Veränderungen vorgenommen, die über eine reine Neuordnung der Inhalte weit hinausgehen. Ein tragender Gedanke ist es, einen Rahmen für einen vielfältigeren Zugang zur Physik und einen breiteren Kompetenzerwerb zu bieten. Bei der Lehrplanerstellung überwiegt aber noch der klassische Top-Down-Ansatz, wobei lediglich einzelne Lehrkräfte mitwirken. Dabei könnte die Erfahrung von praktizierenden Lehrkräften wertvolle Rückkopplung geben, um den Lehrplan als hilfreiche Struktur zu optimieren, so dass er von den Lehrkräften als Ermöglichungsraum wahrgenommen wird. In unserer qualitativen Interviewstudie wurden Gymnasiallehrkräfte verschiedener Erfahrungsstufen – einschließlich Lehrkräfte mit Quereinstieg – dazu befragt, welche Ziele sie selbst mit ihrem Unterricht verfolgen, inwiefern sie die Vorgaben des Lehrplans als unterstützend für ihre Arbeit sehen und wie sich die Neuerungen auf ihre Motivation ausgewirkt haben. Der Beitrag fasst die Ergebnisse zusammen und will aufzeigen, dass es eine zentrale Aufgabe ist, die Lehrkräfte von den positiven Aspekten neuer Methoden zu überzeugen, um Entwicklungsbereitschaft zu verstärken und neue Konzepte erfolgreich zu machen.

DD 41.2 Wed 13:50 Theo 0.135

Analyse aktueller physikdidaktischer Dissertationen — •Daniel Laumann[1], Johannes Grebe-Ellis[2], Susanne Heinicke[1], Horst Schecker[3], Heike Theyssen[4] und Thomas Wilhelm[5] — [1]Universität Münster — [2]Universität Wuppertal — [3]Universität Bremen — [4]Universität Duisburg-Essen — [5]Goethe-Universität Frankfurt

Physikdidaktische Forschung ist inhaltlich und methodisch breit gefächert. Forschungsschwerpunkte mit großer Nähe zu fachlichen Inhalten sind ebenso vertreten wie solche mit stark empirisch-bildungswissenschaftlicher oder -psychologischer Prägung. Während einige Arbeiten theoretisch-konzeptionelle Analysen ohne explizite Schlussfolgerungen für die Bildungspraxis liefern, stellen andere Arbeiten umfassende Konzeptionen für Physikunterricht bereit.

Zur Analyse physikdidaktischer Forschung wurde im Rahmen der Initiative *Quo vadis Physikdidaktik* in einem mehrstufigen Verfahren ein zehn Kategorien umfassender Kodierleitfaden zur Analyse physikdidaktischer Dissertationen entwickelt und hinsichtlich empirischer Gütekriterien geprüft.

Der Beitrag stellt den Aufbau des Kodierleitfadens sowie Ergebnisse seiner Anwendung auf N = 143 physikdidaktische Dissertationen der Jahre 2016-2021 im deutschsprachigen Raum vor. Die Ergebnisse dienen der Analyse aktueller Forschungsschwerpunkte bezüglich Inhalten und Methoden der deutschsprachigen Physikdidaktik.

DD 41.3 Wed 14:10 Theo 0.135

Using a rocket activity to empower students for conceptual and pedagogical learning — •Stefan Hoffmann, Kathleen Falconer und André Bresges — Universität zu Köln, Gronewaldstr. 2, 50931 Köln

Im Learning-by-Teaching-Konzept (Universität zu Köln) erhalten Physikstudierende bereits früh im Studium die Möglichkeit, das Vermitteln fachlicher Inhalte in kleinen Lehr-Lern-Situationen zu erproben und eine gemeinsame Sprache des Physikunterrichtes zu entwickeln. Ablauf: In der Experimentalphysik-Vorlesung wird mit den Physikstudierenden eine Activity zur Physik von Raketen durchgeführt. Dabei werden verschiedene Techniken in arbeitsteiliger Gruppenarbeit angewendet. Im gezeigten Beispiel wird der Flug einer Wasserrakete analysiert: Wie kann man eine möglichst große Höhe erreichen, welche Form hat die Flugbahn und wie sind die Einflussgrößen hierauf? Die Gruppen wählen aus den folgenden Techniken zur Analyse des Raketenflugs: Videoanalyse, Triangulation, visuelle Beschreibung der Flugbahn. Nach der Durchführung der Raketenflug-Activity findet eine ausführliche Reflexion statt. Reflexionsfragen sind z.B.: *Wobei hattest du Probleme? *Was hat dir beim Verständnis geholfen? *Was hätte dir beim Verständnis geholfen? *Wie würdest in einer Unterrichtsstunde für die Primarstufe-Studierenden vorgehen? Zum Abschluss erstellen die Lehramtsstudierenden eine Stundenplanung, in die Sie ihre Vorerfahrungen einfließen lassen.

DD 42: Digitale Medien – Smartphone

Time: Wednesday 13:30–14:30 Location: Theo 0.134

DD 42.1 Wed 13:30 Theo 0.134

Vorlesungsbegleitendes und smartphonegestütztes Experimentieren in den Grundlagenvorlesungen der Experimentalphysik. — •Dominik Dorsel, Sebastian Staacks, Mosab Abumezied, Christoph Stampfer und Heidrun Heinke — I & II Physikalisches Institut A RWTH Aachen University

Typischerweise sind die Grundvorlesungen der Experimentalphysik und das eigenständige Experimentieren von Studierenden aus logistischen Gründen zeitlich voneinander getrennt. Ein wichtiger Grund dafür ist die Hürde des bereitzustellenden Experimentier-Materials, welches parallel zur Vorlesung in ausreichender Stückzahl verfügbar sein muss. Mithilfe von smartphonegestützten Experimenten kann dieses Problem entschärft und somit die Zeit zwischen theoretischer Konzeptvermittlung und praktischem Experiment minimiert werden. Im Projekt Physik.SMART der Stiftung "Innovation in der Hochschullehre" wurden verschiedene solcher Experimente in den vorlesungsbegleitenden Übungsbetrieb implementiert. Konkret wurden experimentabhängige Materialien wie beispielsweise Federn und Faden in Ergänzung zu den eigenen Smartphones der Studierenden zur Verfügung gestellt. Außerdem wurde durch bereitgestellte externe Sensormodule, welche über Bluetooth Low Energy mit dem Smartphone verbunden werden, die Experimentiermöglichkeiten deutlich erweitert, wodurch vielfältige Experimente in der Mechanik, Elektrizitätslehre oder Wärmelehre ermöglicht wurden. In diesem Beitrag werden mögliche Experimente, genutzte Experimentiermaterialien und gewonnene Erfahrungen präsentiert.

DD 42.2 Wed 13:50 Theo 0.134

Einbindung der Smartphonekamera in phyphox — •Sebastian Staacks, Gaurav Tripathee, Lena Crump, Johannes Schlaf, Heidrun Heinke und Christoph Stampfer — I. & II. Physikalisches Institut A, RWTH Aachen University

Die an der RWTH Aachen University entwickelte quelloffene Experimentierapp "phyphox" wird um eine leistungsfähige Bildanalyse-Funktion erweitert. Durch die Echtzeitverarbeitung von Kamerabildern können in der ersten Ausbaustufe der Funktion photometrische Größen bestimmt und über die flexiblen Analyse- und Darstellungsfunktionen der App verknüpft werden. Neben einfachen Messungen von beispielsweise der Leuchtdichte oder dem Farbwert sind so weitere Analysen und Messkonfigurationen möglich. So kann der Zeitpunkt der Überschreitung einer Schwelle ähnlich einer Lichtschranke der Zeitmessung dienen oder Eigenschaften des Bildes können gegen Größen der internen Smartphonesensoren aufgetragen werden. Hierbei ergibt sich auch die Notwendigkeit die umfangreichen Parameter der Kamera dem Experiment und dem Niveau der Lernenden anpassen zu können.

Im Vortrag werden die neuen Funktionen vorgestellt, erste Experimente für den Lehreinsatz gezeigt, Besonderheiten und Grenzen der Smartphonekamera als Messgerät diskutiert und ein Ausblick auf weitere geplante Funktionen gegeben.

DD 42.3 Wed 14:10 Theo 0.134

Evaluation Smartphone-gestützter Experimentieraufgaben im ersten Studienjahr — •Simon Z. Lahme[1], Dominik Dorsel[2], Heidrun Heinke[2], Pascal Klein[1], Andreas Müller[3], Christoph Stampfer[2] und Sebastian Staacks[2] — [1]Universität Göttingen — [2]RWTH Aachen University — [3]Universität Genf

Smartphones bieten Studierenden durch ihre Sensoren und die Konnektivität mit externen Sensorboxen die Möglichkeit, mit nur wenig Equipment außerhalb von Laborpraktika zu experimentieren. An der Universität Göttingen und der RWTH Aachen University wurden daher Smartphone-gestützte Experimentieraufgaben in den Übungsbetrieb der Mechanik-Erstsemestervorlesung implementiert, einmal als längere Projektarbeit und einmal als Set kürzerer, wöchentlicher Übungsaufgaben. Die studentische Wahrnehmung des Lernprozesses mit den Aufgaben und die affektive Wirkung (Neugier, Interesse, empfundene Authentizität, etc.) wurden mit Fragebögen evaluiert. Die Daten erlauben einen Vergleich zwischen diesen beiden Implementationsansätzen sowie weiteren Aufgabenformaten (klassische Übungsaufgaben und Programmieraufgaben). Die Smartphone-Experimente erzielen etwas geringere affektive Wirkungen als die klassischen Übungsaufgaben, aber höhere als die Programmieraufgaben. Angesichts dessen, dass die Smartphone-Experimentieraufgaben „on the fly" neu in die Lehre integriert wurden, während sich die klassischen Übungsaufgaben über viele Jahre etabliert haben, sind diese Ergebnisse vielversprechend. Sie legen nahe, dass sich Smartphone-gestützte Experimentieraufgaben erfolgreich in die Studieneingangsphase Physik implementieren lassen.

DD 43: Sprache

Time: Wednesday 13:30–14:30 Location: OEC 1.163

DD 43.1 Wed 13:30 OEC 1.163

Hürden bei der Nutzung von Repräsentationen beheben — •Kerstin Gresens und Hendrik Härtig — Universität Duisburg-Essen

Sowohl einzelne als auch multiple Repräsentationen werden im naturwissenschaftlichen Unterricht häufig eingesetzt (Opfermann et al., 2017). Dabei dienen Repräsentationen dem Verstehen, Untersuchen und Lösen von Problemen (Corradi et al., 2012). Um im Unterricht mit Repräsentationen zu arbeiten, müssen die Lernenden verschiedene Repräsentationsformen nutzen können (Cock, 2012). Da sich für Physik gezeigt hat, dass Hürden im Umgang mit Repräsentationen noch an Universitäten vorhanden sind (Nguyen & Rebello, 2009), kann davon ausgegangen werden, dass die Hürden auch im Schulunterricht auftreten. Hierzu fehlen aber empirische Belege. Aus diesem Grund wurde das Projekt in zwei Phasen aufgeteilt. In der ersten Phase wurden Hürden bei einzelnen Repräsentationen im Physikunterricht mit Hilfe der Lauten Denken-Methode identifiziert. In der zweiten Phase wurde eine Interventionsstudie im Prä-Post-Kontrollgruppendesign mit der Fokussierung auf die identifizierten Hürden durchgeführt. Hierbei sollen Lernende Wissen über Repräsentationen erwerben und anwenden. Die Interventionsgruppe erhält ein explizites Training zum Umgang und Nutzen der verschiedenen Repräsentationsformen, sowie die Übersetzung zwischen diesen. Die Kontrollgruppe nutzt dieselben Repräsentationsformen, ohne ein explizites Training erhalten zu haben. Erste Ergebnisse zeigen, dass besonders Lernende mit geringem Vorwissen vom expliziten Training profitieren.

DD 43.2 Wed 13:50 OEC 1.163

AufGezeichnet gelernt - Lernen mit Zeichnungen im Kontext physikalischer Inhalte — •Peter Michael Westhoff und Susanne Heinicke — Universität Münster

Inhalte des Physikunterrichts sind für Schülerinnen und Schüler meist komplex und abstrakt. Zur Veranschaulichung dieser Inhalte existieren unterschiedliche Arten von Visualisierungen. Dabei ist die Diskussion des Einsatzes multimedialer Darstellungen und der Wechsel zwischen Darstellungsformen mittlerweile ein eigenes Forschungsgebiet. Bei diesen Studien stehen meist vorgegebene und standardisierte Visualisierungen (z. B. Diagramme) im Vordergrund der Diskussion. Weniger bekannt ist, wie die schülereigene Erstellung von (weniger standardisierten) Grafiken den Lernprozess unterstützen kann. Um dieser Frage nachzugehen, wurde eine multimethodische Studie mit Prä-Post-Vergleich mit Lernenden der Klassen 8 und 9 durchgeführt. Dabei wurden den Teilnehmenden zu physikbezogenen Texten fertige Grafiken zum Betrachten (Variante 1), zum Abzeichnen (Variante 2), zu ergänzende Grafiken (Variante 3) vorgelegt oder sie wurden gebeten, selbst Grafiken frei zu erstellen (Variante 4). Im Beitrag werden die Daten aus dieser Studie vorgestellt und in Hinblick auf Selbstwerteinschätzungen der Lernenden in Bezug auf Kreativität, kognitiver Belastung und Lernzuwachs diskutiert.

DD 43.3 Wed 14:10 OEC 1.163

Fachphysik und Fachdidaktik entwickeln gemeinsam interaktive Formate der Wissenschaftskommunikation — •Kai Bliesmer — Carl von Ossietzky Universität Oldenburg

Aktuelle Forschungsthemen für die Öffentlichkeit aufzubereiten, ist eine Kernaufgabe der Wissenschaftskommunikation, die sich im Rahmen der Third Mission als wichtiger Bestandteil des universitären Aufgabenspektrums etabliert hat. Hierzu ist eine enge Zusammenarbeit zwischen Fachphysik und Physikdidaktik erforderlich, da bei der Aufbereitung von aktuellen Forschungsthemen die Expertise der Fachwissenschaft zwingend erforderlich ist und nur gemeinsam sichergestellt werden kann, durch Entwicklungsforschung Formate zu entwickeln, die sich als fach- und adressatengerecht erweisen. Um die Zusammenarbeit zu strukturieren und in klare Phasen zu untergliedern, hat sich das Modell der Didaktischen Rekonstruktion als Arbeitsgrundlage bewährt. Der Beitrag schildert an zwei Beispielen wie eine solche Zusammenarbeit zwischen Fachphysik und Physikdidaktik entlang der Didaktischen Rekonstruktion gestaltet werden kann. In beiden Fällen ist jeweils ein interaktives Format der Wissenschaftskommunikation realisiert worden: Zum einen ist in Kooperation mit Kolleg:innen des Arbeitsbereichs Quantenmaterialien aus Deutschland und dem Irak ein Escape-Game zur Photolumineszenz-Spektrometrie entstanden. Zum anderen wurde gemeinsam mit dem SFB Hörakustik ein Schülerlabor realisiert, für das eine vereinfachte Version eines sogenannten Kunstkopfes entwickelt wurde, mit dem Schüler:innen Experimente zum Binauralen Hören durchführen können.

DD 44: Lehr-Lernforschung III

Time: Wednesday 13:30–14:30 Location: OEC 1.162

DD 44.1 Wed 13:30 OEC 1.162

Analoges Problemlösen auf dem Prüfstand: Reproduzierbarkeit und neue Erkenntnisse — •Marco Seiter und Heiko Krabbe — Ruhr-Universität Bochum

Unter Analogietransfer (Analogical Transfer) versteht man die Verwendung von Analogien oder Metaphern, um eine neue Problemstellung in Analogie zu einem bereits gelösten Problem zu bewältigen (Gick & Holyoak, 1983; Schmid, 2006). Transfer bei analog formulierten Problemsituationen bezieht sich dabei nicht auf direkt vergleichbare Oberflächenmerkmale, sondern auf strukturelle Ähnlichkeiten zwischen den Problemen (Schmid, 2006).

Bisherige Studien (für einen Überblick siehe z.B. Gray & Holyoak, 2021) konnten nachweisen, dass ProbandInnen, welche zunächst eine Geschichte mit einer bestimmten Lösungsstrategie lesen, im Anschluss signifikant häufiger Lösungen mit dieser Strategie in Bezug auf eine analoge Problemgeschichte produzieren. Für einen erfolgreichen Transfer mussten strukturelle Verbindungen zwischen den Zielperspektiven der Geschichten hergestellt werden. Ein oberflächlicher Vergleich war nicht ausreichend. Zudem konnte nachgewiesen werden, dass der Effekt umso größer wird, je größer die Ähnlichkeit zwischen den Problemgeschichte ist.

Erste Replikationsversuche von Seiter & Krabbe (2024) konnte die oben genannten positiven Ergebnisse nicht bestätigen. Um dies genauer aufzuklären wurden weitere Studien zum Analogem Problemlösen durchgeführt. Der Vortrag gibt einen Überblick über den aktuellen Stand der Erkenntnisse.

DD 44.2 Wed 13:50 OEC 1.162

Testen "Verständnisaufgaben" immer das Verständnis? — •Thomas Filk — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Die provokante Frage, ob Verständnisaufgaben wirklich das Verständnis testen, hat mindestens zwei Aspekte: (1) Es gibt Verständnisaufgaben (z.B. im FCI), auf die die richtigen Antworten durch die Fragestellungen nicht eindeutig sind und gerade von Schülerinnen und Schülern vor dem Hintergrund der KMK-Bildungsstandards bzw. der Bildungspläne (oder vergleichbarer Ländervorgaben) gar nicht oder zumindest nicht aus einem wirklichen Verständnis heraus beantwortet werden können. (2) Es gibt oftmals scheinbar sehr einfache Verständnisfragen, die selbst bei einem nachweislich vorhandenen Verständnis des physikalischen Sachverhalts nicht sofort beantwortet werden können. In meinem Vortrag werde ich Beispiele für beide Formen von Verständnisaufgaben geben und die Frage aufwerfen, wie das Verständnis für physikalische Konzepte und Zusammenhänge wirklich getestet werden kann.

DD 44.3 Wed 14:10 OEC 1.162

Verständnis als Schlüssel zur Physik: 5 Jahre Forschung zu Gestalt- und Funktionalitätstreue — •Malte S. Ubben und Philipp Bitzenbauer — Universität Leipzig, Institut für Didaktik der Physik

Durch die kognitiven Dimensionen der Gestalt- und Funktionalitätstreue konnte eine standardisierte Beschreibung der Entwicklung von Verständnisprozessen in der Quantenphysik erstellt werden. In den vergangenen fünf Jahren haben verschiedene empirische Studien wesentlich dazu beigetragen, die beiden Dimensionen der Verständnisentwicklung genauer zu untersuchen und zu beleuchten.

In diesem Vortrag werden die Ergebnisse empirischer Studien der letzten fünf Jahre zusammengefasst und präsentiert. Der Schwerpunkt liegt dabei auf Studien zur Konzeptentwicklung in der Quantenphysik, ergänzt durch Erkenntnisse über die Verwendung der Dimensionen auch in der Beschreibung von Konzeptentwicklung anderer physikalischer Gebiete am Beispiel der Astronomie und außerfachlich im Bereich der Gruppentheorie. Diese Ergebnisse bestätigen und erweitern die Dimensionen der Gestalt- und Funktionalitätstreue und liefern auch einige offene Fragen für zukünftige Untersuchungen.

DD 45: Hauptvortrag II und Verabschiedung

Time: Wednesday 14:45–15:45 Location: ZHG103

Invited Talk DD 45.1 Wed 14:45 ZHG103

Moderne Physik, moderne Bildung: Zukunftsperspektiven für den Physikunterricht im Wandel — •Magdalena Kersting — University of Copenhagen, Copenhagen, Denmark

Die Physikdidaktik steht vor der Herausforderung, den Physikunterricht für das 21. Jahrhundert neu zu denken. Dieser Vortrag präsentiert drei zukunftsweisende Perspektiven aus der skandinavischen und internationalen Forschungspraxis. Die erste Perspektive widmet sich der Integration der Quantenphysik und weiterer Gebiete moderner physikalischer Forschung, wie Astrophysik oder Klimaforschung, in den Schulunterricht. Am Beispiel eines innovativen dänischen Weiterbildungsprogramms für MINT-Lehrkräfte wird aufgezeigt, wie die praxisnahe Zusammenarbeit zwischen Lehrkräften und Forschenden zur Entwicklung innovativer Unterrichtskonzepte führt. Die zweite Perspektive thematisiert die Förderung naturwissenschaftlicher Grundbildung durch einen sprachsensiblen und wissenschaftsphilosophisch reflektierten Physikunterricht. Die dritte Perspektive untersucht das Potenzial generativer künstlicher Intelligenz für den Physikunterricht. Anhand konkreter Beispiele wird diskutiert, wie diese Technologie als kollaborativer Partner im Lernprozess fungieren kann - sei es bei der Unterstützung individueller Lernwege oder der Entwicklung forschend-entdeckender Unterrichtsszenarien. Der Vortrag schließt mit einer Synthese dieser drei Perspektiven und zeigt auf, wie ihre Verschränkung zu einem Physikunterricht beitragen kann, der fachlich fundiert, methodisch innovativ und gleichzeitig inklusiv ist - und damit den Anforderungen einer sich wandelnden Bildungslandschaft gerecht wird.

Extraterrestial Physics Division
Fachverband Extraterrestrische Physik (EP)

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Overview of Invited Talks and Sessions

(Lecture halls ZHG101 and ZHG005; Poster ZHG Foyer 1. OG)

Plenary Talk of EP

PV I	Mon	11:30–12:15	ZHG011	**The solar magnetic field and variability** — •Sami K. Solanki

Invited Talks

EP 1.1	Mon	16:45–17:15	ZHG005	**The new planet formation theory** — •Joanna Drazkowska
EP 2.1	Mon	16:45–17:15	ZHG101	**Sunrise III 2024: Flight and first scientific results** — •Andreas Korpi-Lagg, H.N. Smitha, Sami K. Solanki, Achim Gandorfer, Alex Feller, Tino Rierthmüller, Pietro Bernasconi, Thomas Berkefeld, Jose Carlos del Toro Iniesta, Yukio Katsukawa, Sunrise III Team
EP 3.1	Tue	13:45–14:15	ZHG005	**Atmospheric modelling from ground to lower thermosphere** — •Claudia Stephan
EP 3.4	Tue	14:45–15:15	ZHG005	**Beauty and hazards created by the terrestrial magnetosphere** — •Elena Kronberg
EP 4.1	Tue	13:45–14:15	ZHG101	**The Solar Orbiter Mission and the Polarimetric and Helioseismic Imager instrument: new opportunities for novel science** — •Gherardo Valori
EP 5.3	Tue	16:45–17:15	ZHG005	**Heliosphere as a natural laboratory of turbulence and plasma nonlinearities** — •Yasuhito Narita
EP 6.1	Tue	16:15–16:45	ZHG101	**Decoding coronal loops: Structure and dynamics** — •Sudip Mandal
EP 9.1	Wed	16:15–16:45	ZHG005	**A JWST View of Exoplanet Atmospheres: Everything We Dreamed Of, and More** — •Laura Kreidberg
EP 12.1	Thu	16:15–16:45	ZHG101	**The Influence of Intermittent Turbulence on Solar Energetic Particle Transport: Modelling and Observations** — •Frederic Effenberger
EP 13.1	Fri	9:00– 9:30	ZHG101	**High-Mass X-Ray Binaries: Living Together with a Black Hole** — •Lidia Oskinova
EP 15.1	Fri	13:30–14:00	ZHG101	**Nucleosynthesis of heavy elements in the hot and dense plasmas of explosive astrophysical environments** — •Daniel Siegel

Invited Talks of the joint Symposium SMuK Dissertation Prize 2025 (SYMD)

See SYMD for the full program of the symposium.

SYMD 1.1	Mon	14:15–14:45	ZHG011	**Fluid-dynamic description of heavy-quark diffusion in the quark-gluon plasma** — •Federica Capellino
SYMD 1.2	Mon	14:45–15:15	ZHG011	**Fast and faithful effective-one-body models for gravitational waves from generic compact binaries** — •Rossella Gamba
SYMD 1.3	Mon	15:15–15:45	ZHG011	**Nuclear Structure Near Doubly Magic Nuclei** — •Lukas Nies
SYMD 1.4	Mon	15:45–16:15	ZHG011	**Optimisation strategies for proton acceleration from thin foils with petawatt ultrashort pulse lasers** — •Tim Ziegler

Invited Talks of the joint Symposium Turbulence in Space and Fusion Plasmas (SYSF)

See SYSF for the full program of the symposium.

SYSF 1.1	Wed	13:45–14:15	ZHG101	**Addressing turbulence questions in the Wendelstein 7-X stellarator device - a combined experimental and theoretical approach** — •Josefine Proll, Paul Mulholland, MJ Pueschel, Maikel Morren, Gavin Weir, Ksenia Aleynikova, Adrian von Stechow, Pavlos Xanthopoulos, Gabriel Plunk, the W7-X Team
SYSF 1.2	Wed	14:15–14:45	ZHG101	**Particle acceleration and transport in astrophysical, magnetized turbulent plasmas** — •Martin Lemoine
SYSF 1.3	Wed	14:45–15:15	ZHG101	**Turbulence in the young solar wind, results from Solar Orbiter and Parker Solar Probe** — •Robert Wicks, Utsav Panchal, Julia Stawarz, Stefan Lotz, Du Toit Strauss, Amore Nel
SYSF 1.4	Wed	15:15–15:45	ZHG101	**Digital Solutions for EUROfusion** — •Volker Naulin

Sessions

EP 1.1–1.4	Mon	16:45–18:10	ZHG005	**Planets and Small Bodies I**
EP 2.1–2.5	Mon	16:45–18:15	ZHG101	**Sun and Heliosphere I**
EP 3.1–3.6	Tue	13:45–15:45	ZHG005	**Near-Earth Space I**
EP 4.1–4.7	Tue	13:45–15:45	ZHG101	**Sun and Heliosphere II**
EP 5.1–5.6	Tue	16:15–18:15	ZHG005	**Near-Earth Space I & Planets and Small Bodies II**
EP 6.1–6.7	Tue	16:15–18:15	ZHG101	**Sun and Heliosphere III**
EP 7.1–7.4	Wed	11:00–12:05	ZHG005	**Planets and Small Bodies III**
EP 8	Wed	12:15–13:30	ZHG101	**Members' Assembly**
EP 9.1–9.7	Wed	16:15–18:15	ZHG005	**Exoplanets and Astrobiology**
EP 10.1–10.22	Thu	11:00–12:30	ZHG Foyer 1. OG	**Poster Session**
EP 11.1–11.8	Thu	13:45–15:45	ZHG101	**Sun and Heliosphere IV**
EP 12.1–12.6	Thu	16:15–18:00	ZHG101	**Sun and Heliosphere V**
EP 13.1–13.5	Fri	9:00–10:30	ZHG101	**Astrophysics I**
EP 14.1–14.6	Fri	11:00–12:30	ZHG101	**Astrophysics II**
EP 15.1–15.9	Fri	13:30–16:00	ZHG101	**Astrophysics III**

Members' Assembly of the Extraterrestial Physics Division

Wed 12:15–13:30 ZHG101

Sessions

– Invited Talks, Contributed Talks, and Posters –

EP 1: Planets and Small Bodies I

Time: Monday 16:45–18:10 Location: ZHG005

Invited Talk EP 1.1 Mon 16:45 ZHG005

The new planet formation theory — •Joanna Drazkowska — Max Planck Institute for Solar System Research, Göttingen, Germany

The classical theory of planet formation originated when our knowledge about planets was limited to the Solar System alone. The numerous discoveries of exoplanet systems have compelled a revision of this theory, aided by cutting-edge observations of circumstellar disks and precise laboratory studies of Solar System materials. Nonetheless, the formation of planets remains one of the major unsolved problems in modern astrophysics. In this talk, I will outline the emerging paradigm in which centimeter-sized dust aggregates, colloquially known as pebbles, take center stage. Focusing on the early stages of planet formation, we will examine the growth process of tiny dust grains into pebbles, as well as the formation of planetesimals, the first gravitationally-bound building blocks that precede today's asteroids and comets. Finally, I will present the latest results of numerical models revealing a likely scenario of the formation of massive planet chains.

EP 1.2 Mon 17:15 ZHG005

First results of JUICE-SWI from the Lunar Earth Gravity Assist maneuver — •Paul Hartogh, Christopher Jarchow, Ladislav Rezac, and Miriam Rengel — Max-Planck-Institut für Sonnensystemforschung, Göttingen

The Submillimetre Wave Instrument (SWI) is part of JUICE (JUpiter ICy moons Explorer). JUICE is the first Large Class mission (L1) of the ESA's Cosmic Vision programme. SWI will investigate the stratosphere of Jupiter (general circulation, chemistry, isotopic composition) and the atmospheres and surfaces of the Galilean satellites (dynamic and kinetics, molecular and isotopic composition, composition of volcanic and potential cryovolcanic plumes) in the far infrared in two submillimeter wave bands (500 and 250 micrometers). In August 2024 the JUICE spacecraft passed Earth and Moon during the LEGA (Lunar Earth Gravity Assist). During the lunar gravity assist SWI observed the rotational ground states of water vapor (ortho- and para water) in nadir mode. During the Earth flyby, numerous observation modes were executed, observing the Earth atmosphere in nadir and limb modes. Of particular interest are the 250 micrometers results, because the Earth was observed for the first time from space with high resolution techniques in this range of the electromagnetic spectrum. This talk will present the first results of the LEGA data analysis and illustrate the power of submillimeter wave observations in investigating physical processes.

EP 1.3 Mon 17:30 ZHG005

TRIPLE-IceCraft - a Melting Probe for the Exploration of Subglacial Lakes in Antarctica in Preparation for the Icy Moons — •Dirk Heinen[1], Jan Audehm[1], Clemens Espe[2], Mia Giang Do[1], Marco Feldmann[2], Gero Francke[2], Fabian Schöttler[2], Christopher Wiebusch[1], and Simon Zierke[1] — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]GSI - Gesellschaft für Systementwicklung und Instrumentierung mbH, Aachen, Germany

The TRIPLE project, initiated by the German Space Agency at DLR, is researching Technologies for Rapid Ice Penetration and subglacial Lake Exploration. TRIPLE aims to explore the subglacial ocean of Jupiter's moon Europa. The mission will be preceded by a technology demonstration in Antarctica. To access the subglacial water reservoir, a drill or melting probe must first penetrate the ice. The TRIPLE-IceCraft melting probe is a modular payload carrier system designed to transport arbitary scientific payloads through the ice. The design is capable of traversing several hundred metres of ice, penetrating into a subglacial ocean or lake, and later returning to the surface. The TRIPLE-IceCraft has been tested in an analogue scenario on the Ekström Ice Shelf in Antarctica in 2023 and 2024. In this talk we present the TRIPLE-IceCraft design and the results of the test campaigns.

EP 1.4 Mon 17:45 ZHG005

A MEMS-based Miniaturized Fabry-Perot Spectrometer for Lunar Exploration — •Matthias Grott[1], Jörg Knollenberg[1], Lynn Miller[1], Christian Althaus[1], Toni Grossmann[2], Julia Wecker[2], Jörg Martin[2], Andreas Ihring[3], Boris Jung[1], and Konstantinos Vasiliou[1] — [1]German Aerospace Center, Institute of Planetary Research, Berlin, Germany — [2]Fraunhofer Institute for Electronic Nano Systems, Chemnitz, Germany — [3]Leibniz Institute of Photonic Technology, Jena, Germany

Rock forming minerals as well as organic compounds show distinct spectral features in the mid and long infrared wavelength range that can be used to characterize materials in-situ. We have developed a spectrometer prototype based on a micro-electromechanical system (MEMS) Fabry-Perot filter using thermopile detectors that covers the 8 to 11 μm wavelength range. The mass of the instrument's sensor head is expected to be less than 100 g and the total electronics mass is estimated to be 100 g without housing, making the instrument suitable for applications on small landed exploration platforms and CubeSats. The instrument design and results from the initial instrument characterization will be presented.

Poster pitch: EP 10.13 (Becker), EP 10.14 (Schmit)

EP 2: Sun and Heliosphere I

Time: Monday 16:45–18:15 Location: ZHG101

Invited Talk EP 2.1 Mon 16:45 ZHG101

Sunrise III 2024: Flight and first scientific results — •Andreas Korpi-Lagg[1], H.N. Smitha[1], Sami K. Solanki[1], Achim Gandorfer[1], Alex Feller[1], Tino Rierthmüller[1], Pietro Bernasconi[2], Thomas Berkefeld[3], Jose Carlos del Toro Iniesta[4], Yukio Katsukawa[5], and Sunrise III Team[1,2,3,4,5] — [1]MPS, Göttingen — [2]JHUAPL, Laurel, USA — [3]KIS, Freiburg, Germany — [4]IAA, Granada, Spain — [5]NAOJ, Tokyo, Japan

Sunrise III completed a highly successful science flight in July 2024 on a stratospheric balloon. The seeing-free observing conditions and the high optical quality of the telescope combined with the superb pointing and image stabilization system delivered diffraction-limited images to the three science instruments, spanning a wavelength range from the near-ultraviolet (SUSI, 309-417 nm), over the visible (TuMag, 517-525 nm), to the near infrared (SCIP, 765-855 nm). The flight was controlled from the Göttingen Operations Center at MPS.

The high activity level of the Sun allowed Sunrise III to observe a wide variety of solar features: Maps and sit-and-stare scans of quiet-sun and plage regions, sunspots, pole and limb from the two spectropolarimeters and the imaging spectropolarimeter allow seamless determination of the atmospheric conditions including the magnetic field vector with an unprecedented combination of spatial resolution and height coverage, from the deep photosphere to the upper chromosphere.

I present a summary of the flight, and an overview of the Sunrise III observations with a few early highlights from all three science instruments.

EP 2.2 Mon 17:15 ZHG101

Solar small-scale magnetic elements in the ultraviolet — •Ajay Kumar Yadav[1], Natalie Krivova[1], Tino Riethmüller[1], Smitha Narayanamurthy[1], Sami Solanki[1], Durgesh Tripathi[2], Anamparambu Ramaprakash[2], Andreas Korpi Lagg[1], Alex Feller[1], and Achim Gandorfer[1] — [1]Max Planck Institute for Solar System Research, Göttingen, Germany — [2]Inter-University Centre for Astronomy and Astrophysics, Pune, India

Solar UV irradiance is crucial for the chemistry and ozone balance in the terrestrial atmosphere and, thus, its variations could influence the climate. Existing models attributing irradiance vari- ability to solar surface magnetism have been very successful in reproducing the total and some of the spectral irradiance measurements. However, significant discrepancies between various data and models persist in the range 200*400 nm. The brightness contrast of small-scale magnetic features, which strongly depends on the magnetic field strength, their position on the solar disk, and the wavelength, can provide critical constraints and help resolving the existing discrepancy. UV data suitable for such an analysis were not available until recently. This has changed with the launch of the Aditya-L1 mission carrying the Solar Ultraviolet Imaging Telescope (SUIT) and the third

flight of the ballon-borne Sunrise-3 telescope. We will present initial results from the analysis of the available images of the Sun at UV wavelengths in the range 200*400 nm

EP 2.3 Mon 17:30 ZHG101

Towards a reconstruction of the annual solar Irradiance over the past 9 millennia — •Duresa Temaj[1], Natalie Krivova[1], Sami Solanki[1], Illya Usoskin[2], and Bernhard Hofer[1] — [1]Max planck institute for solar system research, Goettingen, Germany — [2]Space Climate Research Unit, University of Oulu, Finland

Space-based observations of solar irradiance since the 1970s revealed its variability, but these records are too short to reliably assess solar impact on Earth's climate. Therefore, irradiance reconstructions are needed, which requires proxies of past solar activity. The longest direct proxy is the sunspot number, recorded for the past 400 years. We employ the Spectral And Total Irradiance REconstructions (SATIRE) model, using the sunspot number as input, while also accounting for the emergence of small-scale magnetic features, to reconstruct solar irradiance from direct sunspot observations.

Furthermore, concentrations of cosmogenic isotopes, e.g. 14C and 10Be, in terrestrial archives, allow reconstructions of sunspot numbers over nine millennia, albeit at a decadal resolution, except the last millennium. Thus, solar cycles remain unresolved. Based on previous findings that cycle strength and length correlate well with the mean solar activity, we study the relationships between the decadally averaged sunspot numbers and solar cycle parameters. We validate this approach using synthetic records constructed from telescopic data and find a fair agreement with the observed record. We apply the derived relationships to reconstruct the annual sunspot number and then irradiance over the nine Millennia.

EP 2.4 Mon 17:45 ZHG101

Global inertial oscillations of the sun — •Laurent Gizon — Max-Planck-Institut für Sonnensystemforchung, 37077 Göttingen — Georg-August-Universität Göttingen, Institut für Astrophysik und Geophysik, 37077 Göttingen

Global oscillations of the Sun consist of two known classes: the well-studied 5-minute acoustic oscillations, which are used in helioseismology, and the recently discovered inertial oscillations with periods on the order of the Sun's rotation period (Gizon et al. 2021). All observed inertial modes propagate more slowly than the equatorial rotation rate and, due to latitudinal differential rotation, these modes have critical latitudes where their phase speeds match the local rotation rate. Linear forward modeling indicates that the mode eigenfrequencies and eigenfunctions are highly sensitive to the Sun's internal differential rotation, as well as to poorly understood properties of solar convection zone, such as the superadiabatic temperature gradient. Additionally, nonlinear simulations (Bekki et al. 2024) suggest that the high-latitude modes with the largest amplitudes are baroclinically unstable and play a significant dynamical role in shaping the Sun's internal rotation profile. In this presentation, we will present a progress report on this highly promising new field of solar physics.

EP 2.5 Mon 18:00 ZHG101

Nonlinear saturation mechanism of solar high-latitude inertial modes — •Muneeb Mushtaq, Damien Fournier, and Laurent Gizon — Max-Planck Institute for Solar System Research, Goettingen, Germany

At high latitudes the solar rotation rate drops fast with increasing latitude and is linearly unstable. In this presentation we discuss the nonlinear saturation mechanism, which controls the amplitude of the high-latitude solar inertial modes. Using nonlinear numerical simulations of purely toroidal modes on the sphere, we show that the bifurcation is supercritical.This justifies the use of the weakly nonlinear theory to model the development of the disturbance amplitude and to determine to what value it saturates. We find a simple relationship between the mode amplitude and the linear growth rate of the mode.

EP 3: Near-Earth Space I

Time: Tuesday 13:45–15:45 Location: ZHG005

Invited Talk EP 3.1 Tue 13:45 ZHG005

Atmospheric modelling from ground to lower thermosphere — •Claudia Stephan — Leibniz Institute of Atmospheric Physics at the University of Rostock, Kühlungsborn, Germany

The mesosphere and lower thermosphere (MLT) extend from an altitude of approximately 50 km to a few hundred kilometres. Highly dynamic physical processes in the MLT are driven by solar and magnetospheric forcing from above and by meteorological disturbances from below. The MLT layer is of increasing societal relevance as its weather directly affects the functionality of ground- and space-based communication and navigation systems. In addition, it hosts a growing number of satellites that monitor weather and climate or support critical technologies. Long-term trends in the MLT are mainly driven by increasing concentrations of anthropogenic carbon dioxide (CO2), which is responsible for large negative temperature trends of about -1.6 K/decade in the mesosphere. Atmospheric waves are associated with variability in winds, temperature and pressure on time scales of minutes to days. In particular, gravity waves are essential for coupling all atmospheric layers, from the troposphere to the thermosphere, but are difficult to treat in numerical models. Exascale computing allows global-scale simulations with horizontal grid spacings in the range of 1-10 km. In such models, resolved orography and non-orographic gravity wave sources provide a realistic wave forcing of the overlying atmosphere with explicitly simulated vertical energy and momentum transport. We extend these efforts to the MLT.

EP 3.2 Tue 14:15 ZHG005

A global picture of the ionosphere response to solar wind during equinox — •Claudia Borries — DLR, Institut für Solar-Terrestrische Physik

The ionosphere can change significantly with the solar wind conditions. Especially during storm conditions, e.g. the impact of an interplanetary coronal mass ejections, large deviations from quiet conditions can be observed in different ionospheric observables. Modelling and predictions of ionospheric storm conditions is a great challenge because of the large variability in the storm characteristics and so far, there is no global model, which is capable in reproducing ionosphere storm conditions. In our study, we analyse the Total Electron Content (TEC) with respect to its response to solar wind conditions with the goal to extract general characteristics for different regions, local times and delays to solar wind variability. Statistical analysis is applied on the TEC map data provided by the International GNSS Service for the period 2005-2023. We compare these general characteristics with a recent very strong storm in May 2024 to show, how well they agree with actual storm characteristics.

EP 3.3 Tue 14:30 ZHG005

Atmospheric impact of the extreme geomagnetic storm of May 10/11, 2024 — •Miriam Sinnhuber — Karlsruher Institute of Technology, Karlsruhe, Germany

On May 10-11, two CMEs arriving within few hours initiated a geomagnetic storm with a DST of around -400 nT in the main phase. With a Kp of 9 for several hours, the threshold for an *extreme* geomagnetic storm was reached for the first time since the Halloween storm in October/November 2003, and polar lights were clearly visible well into magnetic midlatitudes. Proton fluxes were enhanced for several days, reinforced by a third CME arriving on May 13; however, they were distinctly lower than for the Halloween SPE of October 2003, making this a fairly moderate solar proton event. Analyses of satellite data-sets MLS/AURA and ACE-FTS/SCISAT show a moderate ozone loss in the high-latitude upper mesosphere, as well as increases of NO and N2O in the upper mesosphere at magnetic mid-to high latitudes. The spatial structure of the response is consistent with a moderate solar proton event, but it appears to be weaker than, e.g., the response to the much more moderate geomagnetic storm of April 2010. However, a direct comparison is difficult as the instruments used to assess the April 2010 or Halloween storms are inoperable now. This emphasizes on the one hand the large spread of possible impacts of geomagnetic storms, on the other hand the need for continuing global observations.

Invited Talk EP 3.4 Tue 14:45 ZHG005

Beauty and hazards created by the terrestrial magnetosphere — •Elena Kronberg — LMU, Munich, Germany

Space weather activity during the current solar cycle maximum draws our attention to striking phenomena, such as auroras seen at unusually low latitudes. It also raises concerns about whether modern technology is sufficiently protected from space hazards. In this talk I will discuss magnetospheric mechanisms that generate auroral features such as spirals. These mechanisms also make powerful particle accelerators. Energetic particles at 100s of keV are responsible for lost observation time in astrophysical X-ray missions such as XMM. They may damage observations from the prospective magnetospheric mission SMILE. Machine learning based models of the charged particle population are derived to mitigate such costly losses. Magnetospheric dynamics also leads to changes in the atmosphere, which in the long term may affect planetary habitability.

EP 3.5 Tue 15:15 ZHG005

Space Weather monitoring and research with new ground-based monitoring capabilities during the maximum of Solar Cycle 25 — •Jens Berdermann, Martin Kriegel, Daniela Banyś, Mainul Hoque, David Wenzel und Dmytro Vasylyev — Deutsches Zentrum für Luft- und Raumfahrt e.V., Kalkhorstweg 53, 17235 Neustrelitz, Germany

By reaching the maximum of solar cycle 25 the influence of space weather is becoming increasingly visible, with phenomena like radio bursts, solar flares and geomagnetic storms occurring more frequently and also with impact on technical systems. Therefore, we have set up a ground-based space weather observation system to continuously monitor the actual space weather situation and related conditions in the upper atmosphere. The system combines a CALLISTO receiver to track solar radio bursts in the frequency range from 10 to 1,600 MHz covering HF, VHF and L-band spectrums, a VLF GIFDS receiver for solar flare detection as well as a high rate GNSS receiver for monitoring ionospheric scintillations. The prototype system is being operated at the Multi-instrument Ionospheric Radio observation Array (MIRA), a measurement field at the DLR site in Neustrelitz, to conduct the final testing and performance analysis. The expansion to other locations in Europe and worldwide in cooperation with partner institutions is intended and it will further increase the coverage. In this presentation, we will show the system's benefits for space weather research and services based on the analysis of the latest events from the maximum of solar cycle 25.

EP 3.6 Tue 15:30 ZHG005

Simulations of the CHerenkov Atmospheric Observation System (CHAOS) — •Pierre Bornfleth, Hannes Ebeling, and Ava Pohley — Christian-Albrechts-Universität zu Kiel

The Earth is continuously exposed to high-energy charged particles, so-called Galactic Cosmic Rays (GCRs). When these particles hit the Earth's atmosphere, they create a cascade of secondary particles. CHAOS uses a new detector design developed at the Department of Extraterrestrial Physics at Kiel University by a team of students to measure the different particle species of the primary GCRs above the so-called Regener-Pfotzer Maximum. To perform these measurements a combination of multiple solid state detectors and a bismuth germanium oxide (BGO) scintillator is used to measure the energy depositions of the particles. The use of an additional Cherenkov aerogel scintillator allows to separate between electrons and protons. Because electrons are much lighter than ions, electrons with energies above ~ 1.1 MeV will trigger the Cherenkov detector whereas ions with the same energy are much slower and will not trigger the Cherenkov detector. CHAOS flew on a stratospheric balloon as part of the BEXUS program in early Oktober 2024. In this talk I present a comparison between simulations of the detector and the measurements of the flight to identify which particles were measured and what energy they had.

EP 4: Sun and Heliosphere II

Time: Tuesday 13:45–15:45 Location: ZHG101

Invited Talk EP 4.1 Tue 13:45 ZHG101

The Solar Orbiter Mission and the Polarimetric and Helioseismic Imager instrument: new opportunities for novel science — •Gherardo Valori — Max Planck Institute for Solar System Research (MPS), Göttingen, Germany

Solar Orbiter is a joint ESA-NASA mission that was launched in 2020 on a strongly eccentric orbit around the Sun, with closest perihelia at 0.28 AU. The Polarimetric and Helioseismic Imager is the vector magnetohraph onboard Solar Orbiter (SO/PHI), and it is composed of the Full-Disc Telescope (FDT) images the entire solar disk, while the High-Resolution Telescope (HRT) observes a smaller part of the solar disk at high resolution.

With an orbit of about six months around the Sun, SO/PHI is the first magnetograpgh providing maps of the photospheric vector magnetic field from viewpoints away from the Sun-Earth line, including from the far side of the Sun. This opens new science opportunities and novel boundary conditions for data-driven and data-inspired numerical simulations, such as following active regions for much longer periods of time, faster synoptic maps, and the stereoscopic resolution of the 180-degree ambiguity.

Starting from spring 2025, SO started to raise significantly above the ecliptic, providing full spectropolarimetric observations of the solar poles for the first time, which will be crucial for the quantitative constraint of the magnetic field in heliospheric models. Finally, SO/PHI is also the forerunner of the Photospheric Magnetic-field Imager (PMI) onboard the forthcoming L5 mission Vigil.

EP 4.2 Tue 14:15 ZHG101

The inferred active region magnetic field at different vantage points: an analysis with SO/PHI and SDO/HMI — •Jonas Sinjan[1], Johann Hirzberger[1], Daniele Calchetti[1], Sami K. Solanki[1], Gherardo Valori[1], Xiahong Li[1], David Orozco Suárez[2], Julián Blanco Rodríguez[3], and Hanna Strecker[2] — [1]Max-Planck-Institut für Sonnensystemforschung, Göttingen, Deutschland — [2]Instituto de Astrofísica de Andalucía, Granada, Spain — [3]Universitat de València, Parterna-Valencia, Spain

The open flux problem is currently an unsolved mystery, representing a 2-3 factor mismatch between the open flux measured at 1 AU and that via remote sensing of the solar atmosphere and extrapolated to 1 AU. One explanation is that the open flux at the photosphere is underestimated, in particular in the polar regions. Until now it was impossible to test this with observations: Solar Orbiter (SO), with its on board magnetograph (the Polarimetric and Helioseismic Imager, PHI) has made this a reality such that the photospheric magnetic field can be observed simultaneously from two different vantage points.

First the impact of the viewing angle on the inferred magnetic field, open or closed, can be evaluated. From 12 - 17th October 2023 Solar Orbiter observed an active region (NOAA 13465) together with SDO/HMI, with an angular separation of 60-80 degrees. This dataset allows for the μ-correction (which assumes the field to be radial) to be observationally tested for the first time. A comparison will be shown of the evolution and magnitude of the magnetic field inferred by SO/PHI-HRT with that from SDO/HMI at these different vantage points.

EP 4.3 Tue 14:30 ZHG101

Stereoscopic disambiguation of solar vector magnetic fields using observations from SO/PHI and SDO/HMI — •Xiang Li, Gherardo Valori, Daniele Calchetti, Sami Solanki, Johann Hirzberger, and Jonas Sinjan — Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany

The solar vector magnetic field is inferred from spectropolarimetric observations of the polarization in magnetically sensitive spectral lines. However, the transverse component has a 180° ambiguity in its orientation. Traditional single-view methods for resolving the ambiguity require assumptions on the properties of the photospheric magnetic field. The Polarimetric and Helioseismic Imager (PHI) on board Solar Orbiter (SO) makes it possible to remove the ambiguity purely using observations from two vantage points. The Stereoscopic Disambiguation Method (SDM), which was developed based on this idea, has been successfully tested on simulated data and first science data acquired from the High Resolution Telescope (SO/PHI-HRT) in spring 2022. In this work, we applied the SDM to a number of SO/PHI-HRT datasets and corresponding datasets from the Helioseismic and Magnetic Imager (HMI) on board Solar Dynamics Observatory (SDO). The SDM successfully disambiguates the vector magnetograms in strong field areas, and for a large range of separation angles between the viewpoints. We analyzed quantitative diagnostic metrics on different observational configurations to explore factors that may affect the reliability of the SDM in localized areas. Furthermore, a possible improvement of SDM is proposed based on a detailed analysis of the SDM equations.

EP 4.4 Tue 14:45 ZHG101

First results on coronal magnetic field modelling with Solar Orbiter data — •Thomas Wiegelmann, Xiaohong Li, Sami K. Solanki, and Gherardo Valori — MPI for Solar System Research, Göttingen, Germany

Understanding the coronal magnetic field is crucial for studying almost all solar physical processes. To do so we extrapolate the measured photospheric magnetic field vector into the solar corona and beyond. For large-scale modeling, we use a stationary MHD approach to reconstruct the global coronal and interplanetary magnetic field up to approximately ten solar radii. In the inner corona, below about 2.5 solar radii, where solar wind flow and plasma forces are negligible, we apply a nonlinear force-free field model. In the thin layer between the photosphere and the corona, where plasma forces become significant, a magnetohydrostatic model is employed. We present initial results demonstrating how vector magnetograms from the Polarimetric and Helioseismic Imager (PHI) aboard Solar Orbiter can enhance coronal magnetic field models and deepen our understanding of the Sun. Key contributions from Solar Orbiter include high-resolution magnetic field measurements and unique observations of polar regions. Finally, we discuss how these new data sets can be combined with global coronal magnetic field models based on observations from the Solar Dynamics Observatory (SDO).

EP 4.5 Tue 15:00 ZHG101

Unveiling the dynamics and thermal structures of the jet base from SO high-resolution observation — •Xiaohong Li — Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany

Solar jets, characterized by small-scale plasma ejections along open magnetic field lines or the limbs of large-scale coronal loops, play a crucial role in the dynamics of the solar atmosphere. Solar Orbiter (SO) enables us to investigate the structure of solar jets with much higher spatial and temporal resolutions and from different angles. Using the EUI/HRI data, we observed firework-like structures, which are the dynamic manifestations of the jet base. This bright structure is located above the magnetic neutral line, the region where reconnection occurs. Numerous flows spread out from the reconnection point to the surrounding area at speeds exceeding 100 km/s. By analyzing the evolution of the magnetograms from PHI/HRT, we identified a clear flux cancellation process at the footpoint of the jet. Testing different extrapolation methods, including potential field, nonlinear force-free field, and magnetohydrostatic field, we find the jets display fan-spine structures. The base flows are confined within the fan structure, with the highest flow speed near the null point. Additionally, the temperature peaks near the null-point, proving that persistent magnetic reconnection drives the recurrent jets. These high-resolution observations provide new insights into the complex dynamics and thermal structures at the base of solar jets, advancing our understanding of their formation and contribution to solar atmospheric phenomena.

EP 4.6 Tue 15:15 ZHG101

Diffraction limited solar spectro-polarimetry and first steps towards solar many-line inversion — •J. Hölken[1], H.-P. Doerr[1,2], A. Feller[1], M. van Noort[1], T. L. Riethmüller[1], S. K. Solanki[1,3], W. Cao[4,5], J. Kang[6], J. Chae[6], and E.-K. Lim[7] — [1]Max-Planck-Institut für Sonnensystemforschung, Germany — [2]Thüringer Landessternwarte, Germany — [3]School of Space Research, Kyung Hee University, Republic of Korea — [4]Big Bear Solar Observatory, USA — [5]New Jersey Institute of Technology, USA — [6]Astronomy Program, Seoul National University, Republic of Korea — [7]Korea Astronomy and Space Science Institute, Republic of Korea

In this contribution we present the first diffraction limited spectro-polarimetric data from a 1.6 meter telescope with unprecedented spatial and outstanding spectral resolution.

To explore the performance of image restoration of high resolution solar spectra we extended the FISS instrument installed at the Goode Solar Telescope (GST) by spectro-polarimetric capabilities, a fast context imager, and a large format spectrograph camera. The resulting instrument can accommodate a spectral range in excess of 30 Å. This allows for the simultaneous full Stokes observation of more than 160 solar absorption lines.

In contrast to stellar physics, for solar spectra the simultaneous observation and interpretation of only a few lines is still typical. Here, we combine for the first time the information of more than 80 lines. In comparison to results from a line-doublet inversion, we find more fine-structure and better constrained values.

EP 4.7 Tue 15:30 ZHG101

Probing chromospheric fine structures with an Hα proxy using MURaM — •Sanghita Chandra[1], Robert Cameron[1], Damien Przybylski[1], Sami Solanki[1], Patrick Ondratschek[1], and Sanja Danilovic[2] — [1]Max Planck Institute for Solar System Research, Justus von Liebig Weg, 37077 Göttingen, Germany — [2]Institute for Solar Physics, Dept. of Astronomy, Stockholm University, Albanova University Center, 10691 Stockholm, Sweden

The solar chromosphere is composed of dynamic fine structures that remain poorly understood. Using the MURaM-ChE code, which incorporates NLTE physics for chromospheric modeling, we simulate an enhanced network element. The results reveal finely structured features resembling rapid red and blue-shifted excursions (RREs and RBEs) in the Hα wings and dynamic fibrils in the line core. We devise a proxy for the Hα spectral line that identifies similar features rooted in network patches, that may play a critical role in supplying mass and energy to the solar corona. One such feature, an RBE with a Doppler shift of 37 km/s, forms through flux emergence and reconnection events, with Lorentz forces expanding the field and driving a jet-like flow. This feature originates in the mid chromosphere (2-4 Mm above the surface), has a lifetime of 246 seconds, reaches 3.4 Mm in length, and exhibits lateral motion. Strong viscous and resistive heating at its onset propagates a heating front at Alfvenic speeds.

EP 5: Near-Earth Space I & Planets and Small Bodies II

Time: Tuesday 16:15–18:15 Location: ZHG005

EP 5.1 Tue 16:15 ZHG005

Preliminary Results of the CHerenkov Atmospheric Observation System (CHAOS) from the 2024 Balloon Experiments for University Students (BEXUS) Campaign — •Hannes Ebeling, Pierre Bornfleth, and Ava Pohley — Christian-Albrechts-Universität zu Kiel

The Earth is continuously exposed to high-energy charged particles, so-called Galactic Cosmic Rays (GCRs). When these particles hit the Earth's atmosphere, they create a cascade of secondary particles. CHAOS uses a new detector design to measure the different particle species of the primary GCRs above the so-called Regener-Pfotzer Maximum. To perform these measurements, a combination of multiple solid state detectors and a bismuth germanium oxide (BGO) scintillator is used to measure the energy depositions of the particles. The use of an additional aerogel Cherenkov scintillator allows to separate between electrons and protons. Because electrons are much lighter than ions, electrons with energies above ~ 1.1 MeV will trigger the Cherenkov detector whereas ions with the same energy are much slower and will not trigger the detector. Developed by a team of students at the Department for Extraterrestrial Physics at Kiel University, CHAOS flew on a stratospheric balloon as part of the BEXUS programme in fall 2024. In this talk I present the preliminary results from CHAOS's balloon flight.

EP 5.2 Tue 16:30 ZHG005

Investigation of the occurrence of significant deviations in the magnetopause location: Solar wind and foreshock effects — •Niklas Grimmich[1], Adrian Pöppelwerth[1], Martin Owain Archer[2], David Gary Sibeck[3], Ferdinand Plaschke[1], Wenli Mo[4], Vicki Toy-Edens[4], Drew Lawson Turner[4], Hyangpyo Kim[5], and Rumi Nakamura[5] — [1]Institut für Geophysik und Extraterrestrische Physik, Technische Universität Braunschweig, Braunschweig, Germany — [2]Department of Physics, Imperial College London, London, UK — [3]NASA Goddard Space Flight Center, Greenbelt, Maryland, USA — [4]Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland, USA — [5]Space Research Institute, Austrian Academy of Sciences, Graz, Austria

Recent studies have shown that some effects of upstream conditions on the location of the magnetopause may still be poorly understood, as deviations between empirical models and in situ observations are quite common. Using data from three multi-spacecraft missions to near-Earth space (Cluster, THEMIS and MMS), we can investigate the occurrence of these magnetopause observations. We test whether the deviant magnetopause crossings are statistically associated with foreshocks and/or different solar wind types, and show that in at least 40% of the cases the foreshock can be responsible for the large deviations in magnetopause position. In addition, two distinct classes of solar wind are found to be more frequently associated with the occurrence of magnetopause deviations: the "fast" solar wind and the solar wind plasma associated with transient events.

Invited Talk EP 5.3 Tue 16:45 ZHG005

Heliosphere as a natural laboratory of turbulence and plasma nonlinearities — •Yasuhito Narita — Institut für Theoretische Physik, Technische Universität Braunschweig, Braunschweig, Germany

Heliosphere is a spatially extended domain of the solar plasma expanding radially away from the Sun with a supersonic speed, and has a length scale of about 100 astronomical units. The heliosphere serves as the largest laboratory of turbulence to us, in which various complex and irregular motions of plasma and magnetic field can be studied in detail using in-situ spacecraft. Understanding the nonlinear processes constituting heliospheric plasma turbulence has immediate implications to various research fields in space and astrophysics: turbulent dynamo mechanism generating a large-scale magnetic field, acceleration and scattering of cosmic rays, and mass and angular momentum transfer problem particularly important in the rotating system like accretion disks. Early spacecraft measurements in 1960s hinted that the heliospheric plasma is apparently in the fully-developed turbulent state, for the energy spectrum of the magnetic field fluctuations is reminiscent of the inertial range of fluid turbulence. While a number of spacecraft observations, theoretical modelings, and numerical simulations successfully contributed to build a rough picture of plasma turbulence in the heliosphere, many questions remain still unanswered. I review recent observational studies of heliospheric turbulence focusing on the inner heliosphere such as Parker Solar Probe, Solar Orbiter, and BepiColombo cruise to Mercury, and also review critically theoretical pictures and concepts.

EP 5.4 Tue 17:15 ZHG005

Kinetic simulations of Helium in the Hermean plasma environment — •Fabio Prencipe[1,2], Markus Fränz[1], Harald Krüger[1,3], Norbert Krupp[1], Daniel Heyner[2], and Ferdinand Plaschke[2] — [1]Max-Planck-Institute for Solar System Research, Göttingen, Germany — [2]Institute of Geophysics and Extraterrestrial Physics, TU Braunschweig, Braunschweig, Germany — [3]Planetary Exploration Research Center, Chiba Institute of Technology, Narashino, Japan

Helium was first detected in the Hermean exosphere by the Mariner 10 spacecraft. Sources of the Hermean helium population include outgassing, capture of solar wind He^{2+}, and interstellar pickup He^{+}. Different processes can lead to a

change in ionization of helium, e.g. photoionization by solar radiation. Ionized helium can be convected and lost from the plasma environment because of the interaction of the Hermean magnetic field with the solar wind. The abundances of the different helium species in the different Hermean regions are an indicator of the respective dominant helium sources and losses.

The aim of this study is to model the different species of helium in the Hermean magnetosphere in preparation for the arrival of the ESA spacecraft Bepi Colombo. Simple MHD simulations of Mercury's magnetosphere are combined with kinetic simulations of helium atoms. The kinetic simulations include ionization and loss processes in order to investigate the evolution of the different helium species. A statistical analysis of the helium atoms is used to study the ratios of the helium species in the different regions of the Hermean environment.

EP 5.5 Tue 17:30 ZHG005

Solar wind velocity reconstruction at Mercury using MESSENGER bow shock and magnetopause crossings. — •Daniel Heyner[1], Lars Klingenstein[1], Kristin Pump[1], Sae Aizawa[2], Daniel Schmid[3], and Ferdinand Plaschke[1] — [1]IGEP, TU Braunschweig, Braunschweig, Germany. — [2]LPP, CNRS-Ecole Polytechnique-Sorbonne Université, Paris, France. — [3]IWF, Austrian Academy of Sciences, Graz, Austria

The solar wind plays a critical role in shaping planetary magnetospheres, particularly Mercury's, which is highly sensitive due to its weak intrinsic magnetic field and proximity to the Sun. Solar wind flow speed influences the magnetosphere's aberration angle, tilting it relative to the Mercury-Sun line, and the subsolar standoff distances of both the bow shock and magnetopause.

This study reconstructs solar wind speeds using bow shock and magnetopause crossings observed by MESSENGER's magnetometer. By fitting empirical models to the aberration angle and treating subsolar standoff distances as parameters, we reveal a strong correlation that prevents independent determination of these values. Combining multiple crossings allows us to constrain the aberration angle more effectively. Here, we present the first statistical results, comparing them to average boundary shapes and positions, offering insights into Mercury's magnetospheric dynamics.

EP 5.6 Tue 17:45 ZHG005

Investigation of Mercury's Bow Shock Crossings — •Kristin Pump, Daniel Heyner, and Ferdinand Plaschke — Institut für Geophysik und extraterrestrische Physik, TU Braunschweig

Mercury's intrinsic magnetic field is an obstacle to the supermagnetosonic solar wind and thus a bow shock and magnetopause form. The characteristics of the magnetopause depend on various parameters such as the heliocentric distance (~ pdyn) and the IMF orientation. In theory the bow shock shape and location depend on the Mach number which could not be shown for Mercury's bow shock with in-situ data so far.

In this study we analyze bow shock crossings observed by MESSENGER. From the magnetic shock parameters, we retrieve the Mach number (as a function of plasma beta). This enables new possibilities of evaluating the shape and location of Mercury's bow shock under different upstream conditions. We demonstrate our analysis by showing some specific cases and provide a statistical overview. We compare our findings to heliospheric MHD simulations and Parker Solar Probe measurements. The discovered relationship between the bow shock position and solar wind conditions can enhance our comprehension of the highly dynamic processes in Mercury's space environment.

Poster pitch: EP 10.10 (Bender), EP 10.11 (Pöppelwerth), EP 10.12 (Kleimann)

EP 6: Sun and Heliosphere III

Time: Tuesday 16:15–18:15 Location: ZHG101

Invited Talk EP 6.1 Tue 16:15 ZHG101

Decoding coronal loops: Structure and dynamics — •Sudip Mandal — Max Planck Institute for Solar System Research, Göttingen, Germany

Coronal loops, distinguished by their bright, curved, tube-like appearance, are among the most recognizable features of the solar corona. These loops are fundamental building blocks of the solar corona, making it essential to understand their properties in order to unravel the dynamics of the upper solar atmosphere. Despite several years of research, some of the key fundamental properties of these structures remain a mystery. For example, are these loops truly tube-like or sheet-like structures? If they are tube-like, are their cross-sections circular or elliptical? How do loops maintain their shape over several pressure scale heights, contrary to theoretical predictions? In this talk, I will provide key insights into these questions within the context of ESA's Solar Orbiter mission. Additionally, I will discuss the dynamics of these structures, particularly how coronal loops act as excellent waveguides that allow magnetohydrodynamic (MHD) waves to propagate and dissipate their energy at coronal heights, thereby contributing to the ongoing effort to solve the long-standing coronal heating problem.

EP 6.2 Tue 16:45 ZHG101

Robust yet rare coronal loops observed by EUI on board solar orbiter — •Vasantharaju Naganna and Hardi Peter — Max Planck Institute for Solar System Research, Göttingen, Germany

Coronal loops are the most common intensity features in the coronal filtergrams. However, their true nature and morphology are still debatable. By studying variations of cross-sectional properties along the loop and in time, we can understand the structure and heating of these loops. In this study, we investigated the cross-sectional intensity profiles, both spatially and temporally, of two unique coronal loops, observed in the periphery of two distinct active regions by the Extreme Ultraviolet Imager (EUI) on board Solar Orbiter. The main results of this study are 1. The lifetimes of these two loops (L1 > 120 min & L2 > 45 min) are longer than the typical coronal cooling timescales. 2. The loops exhibited an almost constant width, both spatially and temporally (width for L1 about 2.1 Mm, and for L2 about 1.3 Mm), indicating that the loops are stable cylindrical structures. 3. The loop widths are greater than 6-8 pixels of EUI, indicating that the loop cross-section is uniformly filled on well-resolvable scales. 4. We present observational evidence that the loops are not braided, which strongly suggests that the non-expanding nature of these loops with height cannot be attributed to the twist of the magnetic field lines. We conclude that these coronal loops are steady cylindrical structures of uniform cross section that exist for an unusually long time in the corona, which raises questions on which processes ensure the remarkable stability of these loops and our understanding of the coronal magnetic field structure.

EP 6.3 Tue 17:00 ZHG101

Rapid Coronal Variability — •Abhas Pradhan[1], Lakshmi Pradeep Chitta[1], and Hardi Peter[1,2] — [1]Max Planck Institute for Solar System Research, Goettingen, Germany — [2]Institut für Sonnenphysik (KIS), Freiburg, Germany

Solar coronal loops are heated to temperatures exceeding 1 MK, despite the photosphere being only ~5700K. The mechanisms sustaining such extreme temperatures in the corona remain unclear. One hypothesis is that nanoflares, small-scale transient magnetic reconnection events, heat the corona. These nanoflares are thought to create rapid UV/EUV variability at the footpoints of coronal loops. High-resolution observations are required to quantify this variability, which in turn will inform us the occurence and energy contribution of nanoflares to coronal heating. Solar Orbiter's EUI offers higher-resolution coronal observations over several hours, complemented by PHI magnetograms providing photospheric magnetic field data at matching resolution. We analyzed high-resolution EUI 174 Å images (180km/pixel, 5s cadence) of an active region core, along with bright points and the diffuse corona, to detect these rapidly varying events. We find frequent occurrences of such rapid events in moss regions and bright points, typically every 3 to 5 minutes, while diffuse regions show almost no rapid activity. The lifetimes and wait-times of rapid events in bright points and moss show similar patterns, remaining consistent despite changes in the underlying magnetic topology. Our study offers better insights to constrain nanoflare-based heating models and processes responsible for mass and energy injection into the hot loops.

EP 6.4 Tue 17:15 ZHG101

1D hydrodynamics simulations of impulsively heated short loops to explain the origin of EUV brightenings in the quiet Sun. — •Antoine Dolliou[1,2], James Klimchuk[3], Susanna Parenti[2], and Karine Bocchialini[2] — [1]Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany — [2]Université Paris-Saclay, CNRS, Institut d'Astrophysique Spatiale, 91405 Orsay, France — [3]NASA Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt, MD 20771 USA

The Sun upper atmosphere, the corona, is maintained to more than 1 MK, through processes that are still not fully understood. One of the main theories of the coronal formation suggests that the energy is dissipated through small scales (< 1E24 erg) and impulsive processes (Parker et al., ApJ, 1988). On 2020 May 30, the High Resolution Imager EUV (HRIEUV), onboard Solar Orbiter, was used to detect small (400 to 4000 km), short lived (10 to 100 s) EUV brightenings in the quiet Sun. Their contribution to coronal heating and their physical origin is actively studied. The aim of this work is to understand their physical origin. To do so, we simulate impulsively heated short loop, using the 1D hydrodynamics code HYDRAD (Bradshaw et al., A&A, 2003). We use two types of loops with distinct

thermal behavior: cool (T < 0.1 MK) and hot (T > 0.1 MK) loops. The synthetic light curves of HRIEUV, SDO/AIA and Solar Orbiter/SPICE are computed and compared with those obtained from observations. The results showed that cool loops are good candidates to explain the physical origin of EUV brightenings, contrary to most hot loops models.

EP 6.5 Tue 17:30 ZHG101

A blowout jet in a self-consistent model of a solar coronal hole region — •Yajie Chen[1], Hardi Peter[1,2], Damien Przybylski[1], Lakshmi Pradeep Chitta[1], and Sudip Mandal[1] — [1]Max-Planck Institute for Solar System Research, 37077 Goettingen, Germany — [2]Institut für Sonnenphysik (KIS), 79110 Freiburg, Germany

Solar blowout jets are a distinct subclass of ubiquitous EUV and X-ray coronal jets. Most existing numerical models of blowout jets rely on prescribed initial magnetic field configurations or manual modifications of the magnetic field in the photosphere to trigger the jets. In this study, we first construct a comprehensive self-consistent 3D radiation MHD model of a solar coronal hole region, extending from the upper convection zone to the lower corona. Subsequently, we synthesize emissions in several EUV and X-ray passbands and identify a blowout jet self-consistently created in the model. The jet initially appears as a standard jet but later evolves into a blowout jet. The jet has a width of ~10 Mm and a lifetime of ~10 minutes. The plasma speeds within the jet reach approximately 180 km/s, and we also find a faint component in the synthesized X-ray images propagating at Alfvén speeds of ~500 km/s, which can be attributed to heating fronts. The corresponding magnetograms in the modeled photosphere show signatures of flux emergence and cancellation. These characteristics match well with those observed in blowout jets. By examining the magnetic field lines in and around the jet base, we validate the scenario that the jet is triggered by magnetic reconnection between the newly emerged twisted closed loops and the pre-existing open field lines.

EP 6.6 Tue 17:45 ZHG101

Comprehensive simulations of solar prominences — •Lisa-Marie Zessner, Robert Cameron, Sami K. Solanki, and Damien Przybylski — Max Planck Institute for Solar System Research, Göttingen, Germany

Solar prominences are cool and dense plasma clouds suspended in the hot solar corona. The heavy prominence plasma is supported against gravity by the magnetic field. Solar prominences are common features in the solar atmosphere, with diverse properties: they can have very different sizes, lifetimes, dynamics, and fine structures. If they become unstable, they can erupt and form the core of coronal mass ejections. Many aspects of their physics are still unknown, including their formation mechanism. We use the radiative magnetohydrodynamic code MURaM to simulate the formation and dynamics of a prominence in the solar atmosphere. MURaM includes the relevant physical processes to simulate the solar photosphere, chromosphere, and corona.

We create a stable, dipped magnetic arcade configuration in a 3D simulation box and let it evolve. In the course of the simulation, a solar prominence forms self-consistently. First, a dense plasma seed ejected from the chromosphere randomly settles into a magnetic dip of the field configuration and gets cooled by radiative losses. The resulting pressure drop then drives a strong inflow of hot plasma that condenses onto the feature. In this way, a dynamic, cool, and dense structure is built up in the solar corona. In this contribution, I will present the formation mechanism and properties of the simulated prominence for different setups of our configuration.

EP 6.7 Tue 18:00 ZHG101

Ubiquitous magnetic reconnection in filament eruptions revealed by Solar Orbiter at perihelion — •Song Tan[1,2], Alexander Warmuth[1], and Frédéric Schuller[1] — [1]Leibniz-Institut für Astrophysik Potsdam (AIP), An der Sternwarte 16 14482 Potsdam, Germany — [2]Institut für Physik und Astronomie, Universität Potsdam, Potsdam, Germany

Using unprecedented high-resolution observations (105 km/pixel) of Solar Orbiter Extreme Ultraviolet Imager, we reveal ubiquitous magnetic reconnection events in a failed filament eruption. Magnetic reconnection occurs between the filament and the surrounding magnetic field structures, with frequency and type far exceeding previous observations. These ubiquitous reconnections significantly affect the stability and eruption dynamics of the filament, leading to simultaneous coronal jets and failed eruptions. We propose a "magnetic erosion effect" concept, emphasizing the importance of frequent, fine-scale magnetic reconnection during the filament evolution.

EP 7: Planets and Small Bodies III

Time: Wednesday 11:00–12:05 Location: ZHG005

EP 7.1 Wed 11:00 ZHG005

Collecting a regolith sample from a near-Earth asteroid (NEA): A very fast sample return mission opportunity — •Martin Hilchenbach[1], Thorsten Kleine[1], Bastian Gundlach[2], Jens Biele[3], Stephan Ulamec[3], Tra-Mi Ho[4], Jan Thimo Grundmann[4], Carsten Güttler[3], Markus Patzek[3], Moritz Goldmann[3], Oliver Stenzel[1], Christian Rengglı[1], Norbert Krupp[1], and Matthias Noeker[1] for the APOSSUM-Collaboration — [1]Max-Planck-Institute for Solar System Research, Göttingen, Germany — [2]Universität Münster, Institut für Planetologie, Münster, Germany — [3]Deutsches Zentrum für Luft- und Raumfahrt (DLR-MUSC), Cologne, Germany — [4]Institute of Space Systems (DLR), Bremen, Germany

The close flyby of asteroid (99942) Apophis would offer a unique opportunity to collect and return a regolith sample. The European Space Agency (ESA) is currently exploring the possibility within the RAMSES mission study to observe Apophis before its closest approach to Earth on Friday, April 13, 2029. We present the findings of our concurrent engineering (CE) studies evaluating the feasibility of a sample return capsule, named APOphiS SUrface saMpler (APOSSUM). The APOSSUM design envisions a detached, touch-and-go mission with semi-autonomous navigation and thruster-based control, collecting regolith using rotating brushes. By mid-March 2029, the capsule would be guided towards Earth, with a velocity offset of only a few tens of meters per second relative to the asteroid.

EP 7.2 Wed 11:15 ZHG005

Dust Measurements with the DESTINY+ Mission to the Active Asteroid (3200) Phaethon — •Harald Krüger[1,2], Masanori Kobayashi[2], Ralf Srama[3], Tomoko Arai[2], and DESTINY Dust Science Team[1,2,3] — [1]MPI für Sonnensystemforschung, Göttingen, Germany — [2]PERC, Chiba Institute of Technology, Narashino, Japan — [3]Institut für Raumfahrtsysteme, Universität Stuttgart, Germany

The DESTINY+ spacecraft will be launched by the Japanese Space Agency JAXA in 2028. The main mission target will be the active asteroid (3200) Phaethon, with a close flyby in 2030. Together with two cameras on board, the DESTINY+ Dust Analyzer (DDA) will perform in-situ measurements at Phaethon to solve essential questions related to the evolution of the inner Solar System, including heating processes and compositional evolution of small solar system objects. Phaethon is believed to be the parent body of the Geminids meteor shower and may be a comet-asteroid transition object. Such objects can likely provide information to better understand the nature and origin of mass accreted onto Earth. DDA is an upgrade of the Cassini Cosmic Dust Analyzer (CDA) which very successfully investigated the dust environment of the Saturnian system. DDA is an impact ionization time-of-flight mass spectrometer with integrated trajectory sensor, which will analyse sub-micrometer and micrometer sized dust particles. We give an overview of the DESTINY+ mission, the Dust Analyzer DDA and the science goals for the analysis of Phaethon dust, as well as interplanetary and interstellar dust to be measured en route to Phaethon.

EP 7.3 Wed 11:30 ZHG005

"Dark Comets" among the Near-Earth Asteroids — •Jessica Agarwal[1], Nicholas Attree[2], Pedro Gutierrez[2], Oriel Humes[1], and Manuela Lippi[3] — [1]TU Braunschweig, Germany — [2]Instituto de Astrofisica de Andalucia, Granada, Spain — [3]INAF, Osservatorio astrofisico di Arcetri, Firenze, Italy

The "dark comets" are a handful of near-Earth asteroids (NEAs) that have their orbits perturbed by a non-gravitational acceleration inconsistent with radiative processes of momentum transfer like radiation pressure and the Yarkowsky effect (Seligman et al., 2023, 2024, Farnocchia et al. 2023).

Asymmetric outgassing has been suggested as the next straightforward explanation of this acceleration, despite, but not inconsistent with a non-detection of emitted dust. Taylor et al. (2024) propose a model where the sublimating region would be located near the poles, and the rotation axes of the "dark comets" would have to be highly tilted. Thermophysical models (e.g., Schoerghofer & Hsieh, 2018), however, predict that, if at all, ice can be preserved in asteroids this close to the sun only in permanently shadowed polar regions, requiring a near-zero tilt.

This contribution reviews the available evidence concerning the "dark comets" and discusses the implications for the distribution and preservation of volatiles (i.e. water ice) in the asteroid population.

References: Seligman et al. (2023), PSJ, 4, 35; Seligman et al (2024) PNAS, 121, 51; Farnocchia et al. (2023), PSJ, 4, 29; Schoerghofer & Hsieh (2018), JGRP, 123, 2322.

EP 7.4 Wed 11:45 ZHG005

Investigating the activity of the disrupted asteroid 62412 (2000 SY178) — •Maria Mastropietro[1,2], Oriel Humes[1], Yoonyoung Kim[3], and Jessica Agarwal[1,2] — [1]Institut für Geophysik und Extraterrestrische Physik, TU Braunschweig, Germany — [2]Max Planck Institute for Solar System Research, Göttingen, Germany — [3]Department of Earth, Planetary and Space Sciences, UCLA, Los Angeles, USA

Dust emission from asteroids is often attributed to sublimation of exposed ice, causing comet-like activity in main-belt comets, or disruption from impacts or fast rotation, which in some cases can also expose subsurface ice for sublimation.

Asteroid 62412 (2000 SY178) exhibited dust emission after its 2013 perihelion, likely due to rotational destabilization due to its nature as a fast rotator [1]. Our analysis of archival data and pre-2024 perihelion observations shows significant changes in the asteroid's lightcurve amplitude and brightness after the 2013 activity, indicating changes in its shape and size.

If confirmed, the absence of reactivation in later perihelion passages may result from a lack of exposed ice or low surface temperatures due to high perihelion distance (2.9 AU).

[1] Sheppard, S. S. & Trujillo, C. 2015, AJ, 149, 44

Poster pitch: EP 10.15 (Markkanen)

EP 8: Members' Assembly

Time: Wednesday 12:15–13:30 Location: ZHG101

All members of the Extraterrestrial Physics Division are invited to participate.

EP 9: Exoplanets and Astrobiology

Time: Wednesday 16:15–18:15 Location: ZHG005

Invited Talk EP 9.1 Wed 16:15 ZHG005

A JWST View of Exoplanet Atmospheres: Everything We Dreamed Of, and More — •Laura Kreidberg — Königstuhl 17, 69117 Heidelberg

The recent launch of the James Webb Space Telescope (JWST) has revolutionized the field of exoplanet atmosphere characterization, thanks to its unprecedented sensitivity and broad wavelength coverage. In this talk, I will give a tour of the latest JWST results for transiting exoplanets, from gas giants down to rocky worlds. For the largest planets, I'll focus on the complex physical processes recently revealed in their atmospheres, including photochemistry, 3D effects, and cloud formation. Pushing down to smaller worlds, I'll share the first measurements of chemical composition for the elusive sub-Neptune population, and address the question of whether water worlds exist. In closing, I will give an update on the rapidly evolving topic of rocky planet characterization, including which (if any) rocky planets have atmospheres at all, and what their possible atmospheric compositions could be.

EP 9.2 Wed 16:45 ZHG005

How to improve the initial stellar characterisation of faint stars with transiting planets? — •Matthias Ammler-von Eiff[1], Daniel Sebastian[2], Jie Yu[3], Chen Jiang[1], and Eike W. Guenther[4] — [1]MPI for Solar System Research, Germany — [2]School of Physics and Astronomy, University of Birmingham — [3]School of Computing, Australian National University — [4]Thuringian State Observatory, Germany

The study of planetary systems in different Galactic environments is particularly interesting. These systems can be distant so that the host stars can be too faint for a precise characterisation with asteroseismology, interferometry, or ground-based spectroscopy. Also, extinction plays an important role.

An accurate determination of the host star parameters is essential to characterise planets in their orbit. In order to better understand the limitations for faint host stars and to identify possible solutions in preparation of PLATO, we reviewed the stellar parameters of all 36 CoRoT targets with planets detected.

We identified independent constraints, for instance from stellar density based on transit light curves and from distance from Gaia. We compared those to published estimates of extinction and effective temperature. This way, we can find out how accurate stellar parameters are and derive extinction more accurate than before. Eventually, we can derive the radii of the host stars in a homogeneous way. To our knowledge, this is the first time that the full set of CoRoT host stars is characterised with precise distances from Gaia.

EP 9.3 Wed 17:00 ZHG005

WASP-121 b's transmission spectrum observed with JWST/NIRSpec G395H reveals thermal dissociation and SiO in the atmosphere — •Cyril Gapp for the WASP-121 b JWST/NIRSpec transit-Collaboration — Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany

WASP-121 b has been established as a benchmark Ultra-Hot Jupiter, serving as a laboratory for the atmospheric chemistry and dynamics of strongly irradiated extrasolar gas giants. Here, we present and analyze WASP-121 b's transmission spectrum observed with NIRSpec G395H onboard the James Webb Space Telescope (JWST) and find evidence for the thermal dissociation of H_2O and H_2 on the planet's permanent day side. Additionally, we detect SiO at a statistical significance of 5.2 σ. Constraining the abundance of SiO and abundance ratios between Silicon and volatile atoms in WASP-121 b's atmosphere could help discriminate between possible migration histories of the planet. The three-dimensional nature of thermal dissociation on WASP-121 b's day side and recombination on its night side, however, poses a challenge to constrain molecular abundances and elemental abundance ratios from the transmission spectrum. To account for this, we implemented an atmospheric model in the `NEMESIS` framework that splits the planet's atmosphere into day side and night side. A retrieval applying our atmospheric model to WASP-121 b's transmission spectrum favors a higher H_2O abundance on the night side than on the day side, demonstrating the impact of hemispheric heterogeneity when attempting to constrain WASP-121 b's bulk H_2O inventory.

EP 9.4 Wed 17:15 ZHG005

Modeling the astrosphere of LHS 1140 — •Klaus Scherer[1], Konstantin Herbst[2], Eugene Engelbrecht[3], Stefan Ferreira[3], Jens Kleimann[1], and Juandre Light[3] — [1]Institut für Theoretische Physik IV, Ruhr-Universität Bochum, — [2]nstitut für Experimentelle and Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Germany — [3]Centre for Space Research, North-West University, 2520, Potchefstroom, South Africa

We have studied the 3D multifluid MHD structure of the LHS 1140 astrospheres. We discuss the shock structure of the stellar wind of LHS 1140 using four different models: HD and MHD single-fluid models, as well as multifluid models for both cases, including a neutral hydrogen flow from the interstellar medium. It is shown that the 3D multifluid positions of the termination shock differ remarkably from those found in the 3D ideal-single fluid hydrodynamic case. Here, we discuss especially the problems in choosing the stellar wind as well as the interstellar medium parameters. We present and discuss models with different initial parameter..

EP 9.5 Wed 17:30 ZHG005

Venus as an Exoplanet: Effect of varying stellar, orbital, planetary and atmospheric properties upon composition, habitability and detectability — •John Lee Grenfell[1], Jörn Helbert[1], Gabriele Arnold[1], Konstantin Herbst[2], Miriam Sinnhuber[3], and Heike Rauer[1,4] — [1]Department of Extrasolar Planets and Atmospheres (EPA), German Aerospace Centre, Berlin — [2]Centre for Planetary Habitability, University of Oslo — [3]Institute for Meteorology and Climate Research, Karlsruhe Institute of Technologie (KIT) — [4]Institute for Geological Sciences, Free University of Berlin

The newly selected Venus missions EnVISION and VERITAS (Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy) offer new opportunities for studying Venus but will also contribute to furthering our knowledge of Venus as an exoplanet. Hot rocky planets are favored targets due to generally more frequent transits than cooler Earth-like objects. In this work we simulate Venus as an exoplanet varying stellar, orbital, planetary and atmospheric parameters and study the effect upon atmospheric composition, climate and spectral detectability with the LIFE (Large Interferometer For Exoplanets) telescope.

EP 9.6 Wed 17:45 ZHG005

The Influence of Stellar Energetic Particles (SEPs) on the Atmosphere of Rocky Explanets — •Andreas Bartenschlager[1], M. Sinnhuber[1], J. L. Grenfell[2], N. Iro[2], B. Taysum[2], and K. Herbst[2] — [1]KIT, Karlsruhe — [2]DLR, Berlin

New instruments (JWST) open up the possibility of studying the composition of exoplanetary atmospheres in habitable zones. On explanets around active and quite M-stars like TRAPPIST-1 and LHS1140, the impact of SEPs and GCRs on the atmosphere plays an important role and is investigated with the ion chemistry model ExoTIC (Herbst et al. 2022). We perform model experiments with differ-

ent N_2- or CO_2-dominated atmospheres, depending on the initial CO2 partial pressure, as well as humid and dry conditions (Wunderlich et al. 2020). A further specification is the distinction between dead and alive atmospheres, whose composition is characterized by initial lower/higher O_2 fractions. New modules give the possibility to simulate the ion chemistry's impact on the atmospheric composition of multiple ionization events with different strengths and frequencies, based on the observed flaring frequency of TRAPPIST-1 and the permanent GCR impact on LHS1140b. Preliminary results show a significant impact of SEP events on the chemical composition of the atmospheres, including biosignatures such as O_3 and N_2O, especially in the recovery of the ozone layer after multiple SEP events. These changes have an impact on the observed transmission spectra. The strength and structure of these impacts depend on the initial composition, in particular on the availability of O_2, N_2 and H_2O.

EP 9.7 Wed 18:00 ZHG005

Extraterretrial life? — •Karin Moelling — Institute of Medical Microbiology (IMM), Gloriatr 30, 8006 Zürich

Life on Earth is the only one we now of. Could there be life on one of the stars or exoplanets in the Universe? The main elements for life on Earth are "CHNOPS", which are universal and can give rise to nucleic acids, lipids and aminoacids, the essential macromolecules of terrestrial life. Life is characteized by repliction and evolution in response to environmental conditions.The simplest biomolecule for life om Earth is RNA,ribozymes or viroids. Also all metabolic processes in all species are very similar,and suggest a single origin, based on water, carbon and oxygen - are they also biomarkers for extraterrestrial life? On Earth life created its own living conditions, such as cyanobacteria which produced the toxic oxygen, now a biomarker of life. However, unaerobia live without oxygen. In meteorites 80 AA can be detected while we are only using 20. Our genetic code would not allow coding for them. Could there be different metabolism, genetic codes, biomarkers which lead to other forms of life. Could they be designed by alphaFold and AI, which may help us find unknown forms of life? Extremophiles and unique Earth properties will be discussed.

EP 10: Poster Session

Time: Thursday 11:00–12:30 Location: ZHG Foyer 1. OG

EP 10.1 Thu 11:00 ZHG Foyer 1. OG

The NASA Landolt mission — •Peter Plavchan — Mason Space Center MS 6D5, 4400 University Drive, George Mason University, Fairfax, Virginia, 22030 USA

The NASA Landolt mission is a timely PIONEERS program that will provide significant improvement in the accuracy of photometric measurements of absolute stellar fluxes. This will be accomplished with a high accuracy National Institute of Standards and Technology (NIST) calibrated suite of single-mode fiber-fed laser beacons which will be observable from selected ground-based observatory stations. Landolt will improve the photometric accuracy to <0.5% at visible (VIS) and near-infrared (NIR) wavelengths for >60 target stars. Such measurements can only be achieved by a space-based orbiting artificial star, where the physical photon flux is accurately known. Accuracy of absolute flux zero points is now the leading error budget term in the characterization of stars, be they standard stars or exoplanet hosts. Similarly, the accuracy of the ratio of the VIS/NIR absolute flux calibration zero point is the limiting error budget term in the Supernovae (SNe) Ia cosmological constraints on dark energy, a key science goal of the Nancy Grace Roman Space Telescope (Roman) and Vera C. Rubin Observatory (Rubin). Consequently, Landolt will enable the refinement of dark energy parameters, improve our ability to assess the habitability of terrestrial worlds, and advance fundamental constraints on stellar evolution.

EP 10.2 Thu 11:00 ZHG Foyer 1. OG

The Astropy Project: a community effort for a common software developent platform in Python — •Derek Homeier — Aperio Software Ltd. — The Astropy Team

Astropy is a project developing a common core platform for astronomical software in Python. Since the early 2010s Python has been recognised as a powerful alternative to data analysis platforms like IDL or Matlab, or compiled languages like Fortran and C++, for scientific data processing in the astrophysics research community. Numerical computation and visualisation needs led to significant contributions to evolving modules like Numpy and Matplotlib; yet individual needs also started to set off a proliferation of independent solutions. Astropy was created to foster an ecosystem of interoperable astronomy packages, sharing common coding standards and data APIs, to allow and actively encourage contributors from the community to invest their development work into a widely usable professional package.

A decade later this has made Python+Astropy now the dominant data-processing platform in astrophysical research. It is the basis for many observatories' data analysis tools, including STScI and JWST, and has a partner project in heliophysics, Sunpy. These efforts have been recognised by awards such as the IOP Publishing Top Cited Paper and most recently the Lancelot M. Berkeley-New York Community Trust Prize for Meritorious Work in Astronomy, and they are for the first time funded on a mid-long term basis under the NASA ROSES programme. With this growth the project has also evolved into a more formally organised and structured system.

EP 10.3 Thu 11:00 ZHG Foyer 1. OG

Water Megamasers: Rare Cosmic Beacons for Accurate SMBH Masses and Hubble Parameter Constraints — •Ahlam Farhan — Boğaziçi University, physics department, Istanbul, Turkiye

Extragalactic water vapour maser emission at 22 GHz (H2OMM) has been traced with remarkable accuracy to within a few parsecs of accretion discs around supermassive black holes (SMBHs). High-resolution VLBI observations demonstrate their ability to measure SMBH masses beyond the Milky Way and constrain the Hubble parameter to within 4% accuracy, as the Megamaser Cosmology Project (MCP) shows.

Despite these capabilities, H2OMMs are rare, with only 200 detections among over 6,000 surveyed galaxies. The complex and poorly understood physical conditions required for their formation, make it challenging to pinpoint the ideal galaxies to hunt new maser galaxies. Statistical studies are therefore crucial to identify trends that can guide future surveys toward higher detection rates.

Our study focuses on Active Galactic Nuclei (AGN) properties and highlights that galaxies with luminous dense gas tracers (e.g., HCO+, HCN) and weak 6.4 keV Fe Kα emission are more likely to host H2OMMs. These findings offer a pathway to optimise future searches, enhancing both cosmological measurements and our understanding of AGN environments.

EP 10.4 Thu 11:00 ZHG Foyer 1. OG

Stochastic High Frequencies in massive stars — •Julieta Paz Sanchez Arias[1], Suryani Guha[1,2], and Alejandra Christen[3] — [1]Astronomical Institute, Czech Academy of Science, Fričova 298, 251 65 Ondřejov, Czech Republic. — [2]Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic. — [3]Instituto de Estadistica, Universidad de Valparaiso, Valparaiso, Chile.

The light curves of massive OB stars are known to be affected by red noise, which translates into a power excess in the low-frequency range. The origin of these stochastic low frequencies has been proposed to be convection and/or granulation at the stellar surface, internal gravity waves stochastically excited, and inhomogeneities in the winds of massive stars. However, the underlying physics of their origin is still poorly understood. Thanks to a new mathematical method for frequency analysis (the Empirical Mode Decomposition method), we have found frequencies excited at high frequency ranges in massive stars, which seem to be connected also with a stochastic process. In this work, we present numerical experiments with ARFIMA processes to model stochastic high frequencies (SHF) signals and detailed frequency analysis of a group of massive stars observed with TESS mission that exhibit SHF. The presence of these newly detected SHF provides additional tools to understand the origin of the red noise in massive stars.

EP 10.5 Thu 11:00 ZHG Foyer 1. OG

Near-infrared characterization of evolved massive stars in M31 and M33 — •Michaela Kraus[1], María Laura Arias[2], Michalis Kourniotis[1], Andrea Torres[2], Lydia Cidale[2], and Marcelo Borges Fernandes[3] — [1]Astronomical Institute AV CR, Ondrejov, Czech Republic — [2]Universidad Nacional de La Plata, Argentina — [3]Observatório Nacional, Rio de Janeiro, Brazil

The upper region of the Hertzsprung-Russell diagram is populated by massive stars in a diversity of evolutionary states, and the classification of these stars is often based on observed characteristics exclusively in the optical spectral range. The near-infrared regime provides useful complementary information that can help resolving ambiguities in stellar classification and add valuable information about circumstellar envelopes or late-type companions. We present new, near-infrared medium-resolution K-band spectra for a sample of seven evolved massive stars, four in M31 and three in M33. Based on the spectral appearance of the objects, we classify three objects as B[e] supergiants, of which two are found to be surrounded by dense and warm molecular gas rings. One B[e] supergiant and one Luminous Blue Variable display dense ionized winds, and one object is possibly a Luminous Blue Variable in outburst. The spectra of the remaining two objects indicate the presence of the red supergiant. Whether these are physical companions to the hot objects or they are just close in projection needs to be investigated.

EP 10.6 Thu 11:00 ZHG Foyer 1. OG

OCEANS - Overcoming challenges in the evolution and nature of massive stars — •Michaela Kraus and The OCEANS Consortium — Astronomical Institute AV CR, Ondrejov, Czech Republic

Massive stars are the cornerstone of the dynamic and chemical evolution of the cosmos, enriching it as they evolve with chemically processed material that is blown away from their surface by energetic winds and eruption processes. Despite their importance, their evolution from cradle to death as spectacular supernova explosions still poses many mysteries due to crucial knowledge gaps in the physical processes taking place in their interior and atmosphere and the mutual influence by close-by siblings. This poster presents the project OCEANS funded by the European Union. Our goal is to elucidate the physical properties and evolution of massive stars impacted by companions, as well as their contribution to the generation of gravitational waves. For this, we established a multidisciplinary, international network of researchers from Europe and America with expertise in various disciplines, and with background in both theory and observations. We exploit the avalanche of public data archives and develop machine learning algorithms to detect massive stars in binary and multiple systems, classify them, and create statistically meaningful samples for diverse evolutionary states. We also develop progressive methods of signal processing for the analysis of the stellar properties, and cutting-edge numerical codes to unveil the impact of stellar interaction and mass ejection on the evolution of the stars and stellar systems.

EP 10.7 Thu 11:00 ZHG Foyer 1. OG

Revealing the pulsation-induced mass loss of blue supergiants and its interplay with the interstellar medium — Michaela Kraus, Julieta Sánchez Arias, Peter Németh, Michalis Kourniotis, •Olga Maryeva, Dieter Nickeler, Suryani Guha, and Kuljeet Saddal — Astronomical Institute of the Czech Academy of Sciences, Ondrejov, Czech Republic

Massive stars play an important role in many astrophysical processes: from the formation of heavy elements in the Universe to a significant influence on the evolution of their host galaxies and star formation. One of the key parameters required to accurately model these processes, alongside luminosity, is the mass-loss rate. In the talk we will present a new ambitious project devoted to the determination of the mass loss rate for blue supergiants (BSGs) – evolutionary phase through which all massive stars pass. The goal of the project is to quantify the total amount of mass loss of BSGs from their winds and pulsations as improved input to stellar evolution calculations, and to gain insight into the mutual interaction between stellar pulsations, winds and their impact on shaping the local interstellar medium. In order to achieve our goal, we will combine calculation of the evolution and internal structure of massive stars (MESA code); computation of pulsations (GYRE code); stellar atmosphere and wind modeling (CMFGEN) – with collected time-series of spectroscopic and photometric observations. Also, we will use the obtained wind parameters in 2D and 3D magneto-hydrodynamics calculations to study its interaction with the interstellar medium.

EP 10.8 Thu 11:00 ZHG Foyer 1. OG

New Insights into Stellar Activity through Simultaneous High-Resolution Spectroscopy and Photometry — •Jakob Adamczewski[1,2] and Eike Günther[2] — [1]Göttingen University, Göttingen, Germany — [2]Thüringer Landessternwarte, Tautenburg, Germany

To address unresolved questions about activity processes, one of the most active systems, UY Pic A, in the PLATO southern field was observed using simultaneous TESS photometry and ground-based high-resolution spectroscopy with the PLATOSpec spectrograph. Our study aims to determine the sizes of coronal loops, establish the relationship between radial velocity variations and starspot dynamics, and investigate the effects of magnetic coupling between two active stars and potentially their planets.

EP 10.9 Thu 11:00 ZHG Foyer 1. OG

Stellar activity in the solar system and beyond: Earth as an exoplanet — •Alexander Siebelts — Karlsruher Institut für Technologie(KIT)

With their increasing number of discoveries, research in the habitability of exoplanets becomes an increasing topic of interest. In several cases, atmospheres on exoplanets have already been detected. Even if we assume that an Earth-like atmosphere is present on an exoplanet in the habitable zone around its host star, the orbital and stellar conditions it lives in have a profound effect on the climatological conditions of its atmospheres, the weather, and ultimately the habitability. In the scope of a Master's thesis, several experiments have been conducted to research the effect that changes on orbital parameters have on the climatological conditions on such an exoplanet. With the climate model ICON, simulations of Earth have been done as an Earth-like exoplanet. In a first step, the research included the adaptation of the solar spectrum, the topography and composition of its surface and the magnetic field, but was later limited to the obliquity and eccentricity of the planet's orbit, the distance and solar intensity simulated by the solar constant, and the angular velocity of the planet. The model simulations provide insight into the changes in the atmospheric dynamic and climatology under extreme conditions. While the changes made to the obliquity show a more realistic transformation of the extent of Earth's seasons, the changes made to the angular velocity provide unrealistic results. The effect of all parameters is heavily outweighed by the changes made to the solar constant.

EP 10.10 Thu 11:00 ZHG Foyer 1. OG

EPP-climate link by reactive nitrogen polar winter descent:science studies for the EE11 candidate mission CAIRT — •Stefan Bender[1], Bernd Funke[1], Manuel López Puertas[1], Maya Garcia-Comas[1], Gabriele Stiller[2], Thomas von Clarmann[2], Michael Höpfner[2], Björn-Martin Sinnhuber[2], Miriam Sinnhuber[2], Quentin Errera[3], Gabriele Poli[4], and Jörn Ungermann[5] — [1]IAA-CSIC, Spain — [2]KIT, Germany — [3]BIRA, Belgium — [4]IAP "Nello Carrara", Italy — [5]FZJ, Germany

Polar winter descent of NOy produced by energetic particle precipitation (EPP) in the mesosphere and lower thermosphere affects polar stratospheric ozone by catalytic reactions. This, in turn, may affect regional climate via radiative and dynamical feedbacks. NOy observations by MIPAS/Envisat during 2002–2012 have provided observational constraints on the solar-activity modulated variability of stratospheric EPP-NOy. These constraints have been used to formulate a chemical upper boundary condition (UBC) for climate models in the context of solar forcing recommendations. ESA's Earth Explorer 11 candidate Changing Atmosphere Infra-Red Tomography (CAIRT) will observe the atmosphere from about 5 to 115 km with an across-track resolution of 30 to 50 km within a 500 km wide field of view. CAIRT will provide NOy and tracer observations from the upper troposphere to the lower thermosphere with unprecedented spatial resolution. We present the science studies to assess its potential to advance our understanding of the EPP-climate link and to improve upon the aforementioned constraints in the future.

EP 10.11 Thu 11:00 ZHG Foyer 1. OG

Amplitudes of Magnetopause Surface Waves: Comparison of THEMIS Observations with MHD Theory — •Adrian Pöppelwerth[1], Niklas Grimmich[1], Rumi Nakamura[2], and Ferdinand Plaschke[1] — [1]Institut für Geophysik und Extraterrestrische Physik, TU Braunschweig, Braunschweig, Deutschland — [2]Institut für Weltraumforschung, Österreichische Akademie der Wissenschaften, Graz, Österreich

The Earth's magnetopause is the boundary between the terrestrial and the interplanetary magnetic fields. Variations in solar wind pressure and structures originating from the solar wind or foreshock regions induce constant dynamic motion of this boundary. In addition, a high velocity shear between the magnetosheath and magnetospheric plasmas can trigger the Kelvin-Helmholtz instability. All these interactions can generate waves on the magnetopause, which can either propagate along the magnetopause towards the nightside or form standing surface waves. These surface waves excite fluctuations within the ambient plasma on either side of the magnetopause and allow them to propagate away from the source region. According to magnetohydrodynamic (MHD) theory, the amplitude of these waves should decrease exponentially with distance from the boundary.

With the multi-spacecraft mission Time History of Events and Macroscale Interactions during Substorms (THEMIS), we are able to observe surface waves at different distances from the magnetopause. Here we present preliminary findings that compare these spacecraft observations with predictions from MHD theory.

EP 10.12 Thu 11:00 ZHG Foyer 1. OG

An exact analytical solution for the weakly magnetized flow around an axially symmetric paraboloid, with application to magnetosphere models — •Jens Kleimann[1] and Christian Röken[2] — [1]Theoretische Physik IV, Ruhr-Universität Bochum, Germany — [2]Institut für Philosophie, Universität Bonn, Germany

Rotationally symmetric bodies with longitudinal cross sections of parabolic shape are frequently used to model astrophysical objects, such as magnetospheres and other blunt objects, immersed in interplanetary or interstellar gas or plasma flows. We discuss a simple formula for the potential flow of an incompressible fluid around an elliptic paraboloid whose axis of symmetry coincides with the direction of incoming flow. Prescribing this flow, we derive an exact analytical solution to the induction equation of ideal magnetohydrodynamics for the case of an initially homogeneous magnetic field of arbitrary orientation being passively advected in this flow. Our solution procedure employs Euler potentials and Cauchy's integral formalism based on the flow's stream function and isochrones. Furthermore, we use a particular renormalization procedure that allows us to generate more general analytical expressions modeling the deformations experienced by arbitrary scalar or vector-valued fields embedded in the flow as they are advected first toward and then past the parabolic obstacle. Finally, both the velocity field and the magnetic field embedded therein are generalized from incompressible to mildly compressible flow, where the associated density distribution is found from Bernoulli's principle.

EP 10.13 Thu 11:00 ZHG Foyer 1. OG

Permittivity sensor for radar measurements and complex permittivity analysis of the ice crust on Jupiter's moon Europa — •Fabian Becker, Enrico Ellinger, and Klaus Helbing — Bergische Universität Wuppertal, Wuppertal, Deutschland

The icy moons in our solar system are gaining significant attention as targets for upcoming space missions. This interest stems from the substantial reservoirs of liquid water hidden beneath their icy surfaces, which could potentially harbour conditions suitable for extraterrestrial life. Following the era of orbital missions that have studied moons like Europa, Ganymede, Callisto, and Enceladus, the next step is to design and deploy lander missions.

Our approach to exploring the ice crust and potentially traversing the thick ice layer to reach the liquid water beneath involves using melting probes. For these probes, a specialized sensor system has been developed to measure the surrounding ice's complex permittivity ε_r^*. This sensor system will provide valuable preliminary information about the structure and composition of the moon's ice crust, offering key insights into its physical and chemical properties.

This poster will demonstrate how such a sensor is integrated into a melting probe, the precision with which it measures both the real and imaginary components of permittivity and the underlying principles of its operation. Furthermore, it will highlight how advanced calibration techniques and simulations have enabled more accurate measurements, enhancing the sensor's performance and reliability.

EP 10.14 Thu 11:00 ZHG Foyer 1. OG

Integration of Scientific Payloads into the TRIPLE-IceCraft Melting Probe for the Exploration of Subglacial Lakes — •Max Schmit[1], Jan Audehm[1], Clemens Espe[2], Marco Feldmann[2], Gero Francke[2], Mia Giang Do[1], Christoph Günther[1], Dirk Heinen[1], Lukas Michels[1], Fabian Schöttler[2], Christopher Wiebusch[1], and Simon Zierke[1] — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]GSI - Gesellschaft für Systementwicklung und Instrumentierung mbH, Aachen, Germany

Europa, one of Jupiter's moons, is a top contender in the search for extraterrestrial life, with evidence suggesting a global ocean beneath its icy crust. Upcoming missions aiming to explore this hidden water reservoir will require drilling through Europa's thick ice shell. The TRIPLE projectline (Technologies for Rapid Ice Penetration and Subglacial Lake Exploration) is initiated by the German Space Agency at DLR to develop the key technologies for such missions. The TRIPLE-IceCraft is a modular melting probe designed to carry a range of scientific payloads through ice. These payloads include the nanoAUV, a small autonomous submarine, instruments for in-situ water analysis and a forefield reconnaissance system. Integrating these payloads into the TRIPLE-IceCraft structure is crucial for exploring subglacial lakes and will pave the way for future missions to explore Europa's subglacial ocean. This poster highlights the integration of these scientific payloads into the TRIPLE-IceCraft and presents initial test results.

EP 10.15 Thu 11:00 ZHG Foyer 1. OG

Characterizing cometary dust: Insights from advanced modeling of scattered light — •Johannes Markkanen — Institut für Geophysik und Extraterrestrische Physik, TU Braunschweig, Germany

Analyzing the scattered light produced by cometary dust particles can provide valuable insights into their physical properties, including size, morphology, and composition. However, interpreting this scattered light presents significant challenges for standard computational methodologies. Moreover, the solutions to inverse problems are often non-unique, suggesting that reliance on a single observable may lead to potentially erroneous conclusions.

In this presentation, I will offer a comprehensive analysis of the observed polarization and color in cometary comae, utilizing cutting-edge numerical light-scattering solvers. I will demonstrate that integrating multi-instrument observations with self-consistent numerical light scattering and dust dynamical modeling can substantially enhance the reliability of the derived physical properties of cometary dust. Additionally, this approach allows us to investigate potential ongoing non-stationary processes, such as fragmentation and sublimation, within the coma.

EP 10.16 Thu 11:00 ZHG Foyer 1. OG

Non-thermal motions in the solar corona — •Arjun Kannan, Hardi Peter, Yajie Chen, and Damien Przybylski — Max Planck Institute for Solar System Research, 37077 Göttingen, Germany

Almost all spectra from the Solar atmosphere show a line width in excess of the pure thermal broadening. Extreme UV (EUV) emission lines are formed in the transition region and the corona under optically thin conditions. Hence, the non-thermal broadening of these lines is expected to be mainly due to non-resolved motions, e.g., waves or turbulence. However, observations show that non-thermal motions in the upper solar atmosphere do not depend on spatial resolution, hinting at a mechanism operating well below currently resolvable scales. So far, general 3D models have failed to reproduce the observed non-thermal motions. Our study aims to investigate the latest high-resolution 3D models of the quiescent Solar regions to see if, at sufficient resolution, these models match observations. We synthesize emission in the respective EUV line and calculate the spectra to derive a synthetic map of the non-thermal line width, which can then be compared to real observations. This will provide insights into the extent to which the current 3D MHD models represent the solar upper atmosphere. This proof is essential for the future inclusion of these models in interpreting the data from new complex coronal spectroscopic observations, particularly with the upcoming MUltislit Solar Explorer (MUSE).

EP 10.17 Thu 11:00 ZHG Foyer 1. OG

Chromospheric Fe I lines in the NUV solar spectrum — •Edvarda Harnes[1,2], Smitha Narayanamurthy[1], Andreas Korpi-Lagg[1,3], Damien Przybylski[1], and Sami Solanki[1] — [1]Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany — [2]Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [3]Aalto University, Department of Computer Science, Konemiehentie 2, 02150 Espoo, Finland

In the near-ultraviolet (NUV) solar spectrum there are several Fe I lines that show very broad profiles typical of chromospheric lines. The diagnostic potential of these spectral lines is largely unexplored due to a lack of high-resolution observations. With the successful flight of the SUNRISE III balloon-borne observatory we have for the first time full spectro-polarimetric data at high spatial resolution of this region, and ground-based observatories can also observe the broad Fe I lines around 400 nm. The goal of this work is to investigate and discuss the formation properties of these spectral lines and their suitability for interpreting observations. An initial investigation was done by synthesizing a selection of lines in the FAL one-dimensional semi-empirical solar atmosphere models using the non-LTE radiative transfer code RH. We found that the lines are significantly affected by overionization in the wings and scattering in the chromospheric line cores. The next step is to investigate the lines in a dynamic atmosphere of a 3D radiation-MHD model, made with the chromospheric extension of MURaM, and results from this will be presented.

EP 10.18 Thu 11:00 ZHG Foyer 1. OG

Diagnostics of comprehensive simulations of the chromosphere — •Patrick Alexander Ondratschek[1], Damien Przybylski[1], H.N. Smitha[1], Robert Cameron[1], Sami K. Solanki[1], and Jorrit Leenaarts[2] — [1]Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany — [2]Institute for Solar Physics, Stockholm, Sweden

The chromosphere is a region of the solar atmosphere above the photosphere and below the millions of Kelvin hot corona. It is a place of extremes where multiple physical transitions take place. In the photosphere, the dynamics are dominated by the plasma pressure. As the density decreases with height, the magnetic field becomes dynamically important. The detailed processes that heat the chromosphere and provide the mass for the corona are only poorly understood. Many studies of the chromosphere are based on a few strong spectral lines that carry the necessary diagnostic potential to infer physical quantities such as e.g. temperature, velocity, and magnetic field. These spectral lines form under nonlocal thermodynamic equilibrium conditions and are difficult to interpret. We aim to understand line formation in the solar chromosphere by synthesizing spectral lines from numerical models. Previous models of the solar chromosphere resulted in too-faint intensities and too-narrow line widths when compared with observations. We use a new model of the chromosphere simulated with the MURaM-ChE code to study the formation of the Mg II h&k and Ca II 8542 lines. We find an improved match with the observations, signifying a step forward in our understanding of the chromosphere.

EP 10.19 Thu 11:00 ZHG Foyer 1. OG

Helium at the terrestrial planets - recent spacecraft observations — •Markus Fränz and Harald Krüger — Max-Planck-Institut fuer Sonnensystemforschung, 37077 Goettingen, Germany

The Sun is a primary source of Helium in the inner solar system. At the terrestrial planets radio active decay can also contribute to the Helium budget in the exospheres. The third source of Helium is the interstellar neutral gas. Recent missions to planet Mercury are giving new interesting insights on the role of the different sources. The MESSENGER spacecraft was launched in 2004, and between March 2011 and April 2015 it was the first spacecraft in orbit around Mercury. The FIPS instrument on board MES- SENGER measured the ion composition in the vicinity of Mercury and in the inner solar system. We aim to determine the origin of He+ ions in the inner solar system and in the environment of Mercury, continuing earlier work by Gershman et al. (2013). We have analyzed measurements of He+ and He2+ ions made by the FIPS instrument during the interplanetary cruise phase of MESSENGER and its entire orbital mission at Mercury. We de- termined the spatial distributions of He+ ions in the regions sampled by MESSENGER during that period and compare the spectra to a similar observation by the MPPE-MSA instrument onboard BepiColombo. We here consider two possible sources of He+: (1) interstellar neutral helium ionized close to Mercury and (2) solar He2+ ions converted close to or at the surface

of Mercury. We also compare the observed densities with a simple model of the ionization of the interstellar helium flow.

EP 10.20 Thu 11:00 ZHG Foyer 1. OG

Simulation of sunspots in the chromosphere and further comparison of the results with observations — •Aswathi Krishnan Kutty, Robert Cameron, Damien Przybylski, and Sami Solanki — Max Planck Institute for Solar System Research, Goettingen

At the photospheric level, sunspots consist of a dark central umbra, scattered with umbral dots, surrounded by a filamentary penumbra that is on average considerably brighter than the umbra but darker than the surrounding quiet Sun. In the photosphere, the nearly horizontal Evershed flow is directed outward from the outer edge of the umbra along penumbral filaments. On the other hand, the flow is reversed in the chromosphere, the layer just above the photosphere where the plasma flows inwards and towards the umbra. Radiative MHD codes by, e.g., Heinemann et al. (2007) and Rempel et al. (2009) have been used to simulate sunspots at the photosphere and below. The chromospheric component of the atmosphere near and above a sunspot is not well understood from a theoretical perspective. In this poster, we will present preliminary simulations extending the previous simulations higher into the solar atmosphere.

EP 10.21 Thu 11:00 ZHG Foyer 1. OG

Investigating high-speed outflows from a coronal hole with UV spectroscopy — •Mario Roco-Moraleda[1], Luca Teriaca[1], Pradeep Chitta[1], Ziwen Huang[1], Hardi Peter[1,2], and Sami Solanki[1] — [1]Max-Planck-Institut für Sonnensystemforschung, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany — [2]Institut für Sonnenphysik (KIS), Georges-Köhler-Allee 401a, 79110 Freiburg, Germany

Coronal holes have been known since decades to be the main source regions of the solar wind. Recent very high resolution observations from the HRIEUV telescope of the EUI instrument on Solar Orbiter show evidence that the fast solar wind and the Alfvénic slow wind originate from largely unipolar, open field region characterized by low emission in coronal lines (T = 1 MK). Those observations draw a connection between speeds on the plane of sky of about 100-150 km/s at a few tens of megameter above the solar surface and picoflare jets, with kinetic energy content in the range of 10^21 to 10^24 erg, at the base of the corona in these dark areas.

However, classical spectroscopic observations (line of sight velocities) in lines formed at the base of the corona (T=0.6 MK) do not show evidence of upflow velocities above about 10 km/s, difficult to reconcile with the HRIEUV observations.

We revisit high quality SUMER observations of an on-disk equatorial coronal hole. We perform a very accurate wavelength calibration and analysis of the spectral profiles to detect signature of high-speed flows occurring at spatial scales below 1" resolution of the instrument.

EP 10.22 Thu 11:00 ZHG Foyer 1. OG

A new categorization of coronal dimmings — •Bernhard Kliem and the ISSI Team Coronal Dimmings — University of Potsdam, Institute of Physics and Astronomy, 14476 Potsdam

A new, physics-based categorization of coronal dimmings has recently been proposed by an ISSI International Team "Coronal dimmings and their relevance to the physics of solar and stellar coronal mass ejections" (Veronig, Dissauer, Kliem, Downs et al. 2025, LRSP, subm.) The new categories were defined by considering the magnetic flux systems involved in solar coronal mass ejections (CMEs) and the principal magnetic reconnection processes between them. These are proposed to replace the morphology-based traditional categories of Core and Secondary Dimmings. They are expected to aid the physical interpretation of the often complex dimming morphologies. The flux systems are: the erupting core flux (a magnetic flux rope, MFR), the strapping flux (external poloidal field) yielding force-free MFR equilibrium, closed exterior flux, and open flux (an ambient coronal hole). The principal reconnection processes are: strapping-strapping ("flare") reconnection, rope-strapping reconnection, rope-exterior reconnection, rope-open-flux reconnection, and leg-leg reconnection of the erupting flux rope. These lead to Stationary, Shrinking, and Moving Flux-rope Dimmings, Strapping-flux Dimmings, Exterior Dimmings, and Open-flux Dimmings. Schematics and illustrative examples will be shown.

EP 11: Sun and Heliosphere IV

Time: Thursday 13:45–15:45 Location: ZHG101

EP 11.1 Thu 13:45 ZHG101

Magnetic structure of coronal dark halos — •Jonathan Nölke[1], Johann Hirzberger[1], Hardi Peter[1,2], Sami Solanki[1], and Pradeep Chitta[1] — [1]Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany — [2]Institut für Sonnenphysik (KIS), Freiburg, Germany

At low temperatures around 1 MK, distinct regions of the solar corona exhibit emission levels significantly below those of the quiet Sun. A prominent example are dark halos surrounding active regions, which are sometimes misidentified as coronal holes (CH). While the well-studied CHs owe their darker appearance to open magnetic field lines, the formation mechanism of dark halos remains unclear.

On 5 November 2021, Solar Orbiter and the Solar Dynamics Observatory observed the dark halo surrounding active region NOAA 12893. One of its patches overlaps with an adjacent CH, providing a unique opportunity to directly compare the two phenomena.

The magnetic field underneath the dark halo is weaker than in brighter areas. At its outer boundaries, it shows even lower field strengths than those typically found in the quiet Sun. In contrast to the reduced coronal emission at temperatures around 1 MK, at higher temperatures the emission is stronger. This shows a clear difference to CHs, which characteristically exhibit reduced emission at these temperatures. We further demonstrated that unlike the embedded CH, the dark halo patches are magnetically closed.

Our combined EUV and magnetic field observations suggest that dark halos result from reduced heating.

EP 11.2 Thu 14:00 ZHG101

High-resolution observations of small-scale activity in coronal hole plumes — •Ziwen Huang[1], Chitta Lakshmi Pradeep[1], Luca Teriaca[1], Regina Aznar Cuadrado[1], Hardi Peter[1,2], Sami K. Solanki[1], Thomas Wiegelmann[1], and Ferdinand Plaschke[3] — [1]Max Planck Institute for Solar System Research, Göttingen, Germany — [2]Institut für Sonnenphysik (KIS), Freiburg, Germany — [3]Institut für Geophysik und extraterrestrische Physik, Technische Universität Braunschweig, Braunschweig, Germany

Coronal hole plumes, largely radial ray-like structures located in coronal holes, are key targets for studying magnetohydrodynamic waves and solar wind origins. The plume bases are riddled with small-scale transients. We study three plumes within an equatorial coronal hole observed on 13 October 2022 by the High Resolution EUV telescope, part of EUI on board Solar Orbiter. By applying two different identification techniques, we detect tens to hundreds of small-scale brightenings at the plume bases. The statistical analysis of their properties (intensity, lifetime, area, shape, velocity) indicates that the majority of the observed brightenings are characterized by their small-scale nature, transient behavior, and display slightly elongated morphologies near the plume bases. Most of the brightenings appear to move with a velocity component in the plane of sky of less than 10km/s. Their de-projected 3D velocities are found to be substantially lower than the apparent outflow velocities (about 100km/s) detected at greater heights. We propose that the base brightenings may be related to either wave-driven Type I spicules or interchanging reconnections.

EP 11.3 Thu 14:15 ZHG101

Quasi-separatrix-layers channel solar wind outflows in coronal hole — •Kamlesh Bora, Pradeep Chitta, Yajie Chen, and Damien Przybylski — Max-Planck Institute for Solar System Research, 37077 Göttingen, Germany

Observations indicate that small-scale, transient jetlets at the base of plumes and upflows within coronal holes contribute substantially to the mass and energy flux of the solar wind. We use three-dimensional radiation magnetohydrodynamic (MHD) simulations of a coronal hole plume, conducted with the MURaM code, to examine the magnetic origins and driving mechanisms of these upflows/jets in the solar atmosphere. Our simulations show that interactions between the magnetic field of the plume with the surrounding like-polarity magnetic patches creates a strong quasi-separatrix layer (QSL), characterised by a filamentary fine structure. We analyse the resulting plasma flows and temperature structure, comparing them with synthesised 174 Å Extreme Ultraviolet Imager (EUI) emission at this QSL. We noted a transition from cooler downflows in the lower atmosphere to persistent hotter upflows in the corona at the QSL, with a substantial mass flux of $10^{-8} g\ cm^{-2}\ s^{-1}$, that could in principle be channelled as the solar wind outflow. Our simulations go beyond the traditional picture of upflows originating from an interchange reconnection between open and closed field lines, and show the important role of QSLs in the formation of the solar wind.

EP 11.4 Thu 14:30 ZHG101

Insights into the energy partition of solar flares and STIX spectral response calibration via simultaneous X-ray spectral fitting of CH-2 XSM and SO STIX data. — •Jake Mitchell[1], Alexander Warmuth[1], Frederic Schuller[1], Song Tan[1], Fanpeng Shi[1], Bhuwan Joshi[2], and Mithun N.P.S[2] — [1]Leibniz

Institute For Astrophysics, Potsdam, Germany — [2]Udaipur Solar Observatory, Udaipur, India

Understanding the energy partition between thermal and non-thermal particles during the flaring process is an essential component in achieving a more holistic view of the physical processes that drive solar flares. Using both PyXspec and the python based Sunkit-Spex we analyse data from a sample of 18 flares selected due to a co-alignment of the Chandrayaan-2 XSM (Solar X-ray Monitor) and the Solar Orbiter STIX instrument. Contemporaneous data from these two instruments enables simultaneous fitting of the relatively soft and hard X-ray spectra respectively. We compare results from individual and simultaneous fits to the XSM and STIX data and investigate the effect of the inclusion of the softer X-rays from XSM into the modelling process whilst also gaining valuable insights into the intercalibration between XSM and STIX.

EP 11.5 Thu 14:45 ZHG101

CoSEE-Cat: the Comprehensive Solar Energetic Electron Event Catalogue — •Alexander Warmuth, Frederic Schuller, Song Tan, and Jake Mitchell — Leibniz-Institut für Astrophysik Potsdam (AIP)

We present a comprehensive catalogue of solar energetic electron (SEE) events derived from joint observations of remote-sensing and in-situ instruments on Solar Orbiter. The Energetic Particle Detector (EPD) is used to characterize the properties of energetic electrons in-situ and obtain injection times at the Sun. Timing, position, and magnitude of corresponding X-ray flares are identified with the Spectrometer/Telescope for Imaging X-rays (STIX), which is complemented by the Extreme Ultraviolet Imager (EUI) which provides additional context on the flare evolution and eruptive phenomena. The Metis coronagraph and the SoloHI heliospheric imager characterize the associated coronal mass ejection. Finally, type III radio bursts detected by the Radio and Plasma Waves (RPW) instrument are used to link the eruptive solar events to the SEE events detected in-situ. We discuss the contents of the catalogue, how the various parameters were determined, and discuss statistical results on SEE events obtained from the catalogue.

EP 11.6 Thu 15:00 ZHG101

STEREO REleASE: Real time solar energetic proton forecasting — •Henrik Dröge[1], Bernd Heber[1], Alexander Kollhoff[1], Patrick Kühl[1], Olga Malandraki[2], and Arik Posner[3] — [1]Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Germany — [2]National Observatory of Athens, Athens, Greece — [3]NASA/HQ, Washington, DC 20546, USA

Sudden Solar Energetic Particle (SEP) events can have a major impact on technology and humans in space. Therefore forecasts and early warning systems working to support those missions are desirable. One example is REleASE, which utilizes the close correlation of near relativistic electrons and the slower but more hazardous protons. The original HESPARIA REleASE system uses electron measurements from SOHO/EPHIN and ACE/EPAM to issue short term warnings before there is a significant flux increase of >20 MeV protons at L1.

We now adapted the method to work with the High Energy Telescope (HET) and the Solar Electron Proton Telescope (SEPT) on board of STEREO-A. The resulting forecasts are publicly available in real time. With now two REleASE systems operational we have the unique possibility to directly compare the forecasts from different points in the heliosphere and test the accuracy depending on the magnetic connection.

Furthermore, we gained valuable insights from adapting the method to the SEPT that uses the magnet/foil technique to separate electrons from ions, which can pose several difficulties.

EP 11.7 Thu 15:15 ZHG101

Evolution of fundamental and harmonic sources in LOFAR type III radio burst images — •Christian Vocks[1], Mario Bisi[2], Bartosz Dabrowski[3], Diana Morosan[4], Peter Gallagher[5], Andrzej Krankowski[3], Jasmina Magdalenic[6], Gottfried Mann[1], Christophe Marque[6], Barbara Matyjasiak[7], Hanna Rothkaehl[7], and Pietro Zucca[8] — [1]Leibniz Institute for Astrophysics Potsdam (AIP), Germany — [2]RAL Space, United Kingdom — [3]University of Warmia and Mazury, Olsztyn, Poland — [4]University of Turku, Finland — [5]DIAS, Dublin, Ireland — [6]Royal Observatory of Belgium, Brussels, Belgium — [7]Polish Academy of Sciences, Warsaw, Poland — [8]ASTRON, Dwingeloo, Netherlands

We present LOFAR observations of an M class flare with intense type III radio bursts. Some isolated burst have a fundamental-harmonic structure, but for most bursts this is not visible due to a rapid succession of bursts. Spectroscopic imaging with LOFAR shows type III bursts as a compact source for a given frequency. The intensity varies with burst evolution, and transient dual-source structures appear. We interpret these as signatures of fundamental and harmonic emission, the latter from a higher location in the corona. Fundamental-harmonic pairs, e.g. fundamental emission at 35 MHz and harmonic emission at 70 MHz, should originate from the same plasma volume. Differences in their positions and intensity variations are expected since radio wave transport effects in the corona, like scattering and refraction, should affect fundamental more than harmonic emission. Analyzing such differences therefore allows for quantifying these effects.

EP 11.8 Thu 15:30 ZHG101

Temperature anisotropy instabilities of solar wind electrons with regularized Kappa-halos resolved with ALPS — •Dustin Schröder[1], Horst Fichtner[1], Marian Lazar[1,2], Daniel Verscharen[3], and Kris Klein[4] — [1]Ruhr-Universität Bochum — [2]Katholieke Universiteit Leuven — [3]University College London — [4]University of Arizona

Space plasmas in various astrophysical setups are often hot & diluted, making them highly susceptible to waves/fluctuations, which are generally self-generated & maintained by kinetic instabilities. In this sense, we have in-situ observational evidence from the solar wind & planetary environments, which reveal not only wave fluctuations at kinetic scales of electrons & protons, but also non-equilibrium distributions of particle velocities. We report on the progress made in achieving a consistent modeling of the instabilities generated by temperature anisotropy, taking example of those induced by anisotropic electrons: whistler & firehose instabilities. The effects of the main electron populations, the quasi-thermal core & the suprathermal halo indicated by the observations, are captured. The low-energy core is bi-Maxwellian, & the halo is described for the first time by a regularized bi-κ-distribution (RKD), which was recently introduced to fix the inconsistencies of standard κ-distributions. In the absence of an analytical RKD dispersion kinetic formalism, the dispersion relation & (in)stability properties are directly solved numerically using the Aribitrary Linear Plasma Solver (ALPS). The results have an increased degree of confidence, considering the successful testing of ALPS on previous results.

EP 12: Sun and Heliosphere V

Time: Thursday 16:15–18:00 Location: ZHG101

Invited Talk EP 12.1 Thu 16:15 ZHG101

The Influence of Intermittent Turbulence on Solar Energetic Particle Transport: Modelling and Observations — •Frederic Effenberger — Ruhr-Universität Bochum

The detailed understanding and ultimately the ability to forecast solar energetic particle (SEP) events is critical in our efforts to mitigate space weather risks. I will discuss current issues in SEP modelling and observations, highlighting the capabilities under development at Ruhr-University Bochum. Of particular interest are coherent features in the solar wind turbulence that can influence particle transport behaviour. Synthetic fields to study particle transport are typically generated from superpositions of Fourier modes with a prescribed power spectrum and uncorrelated random phases, bringing the advantage of covering a wide range of turbulence scales at manageable computational effort. However, almost all of these models to date only account for second-order Gaussian statistics and thus fail to include intermittent features, as observed in more realistic but expensive direct magnetohydrodynamic simulations. We have developed novel methods to account for such shortcomings, including a minimal Lagrangian map approach. We investigate the particle transport properties by solving a large number of particle orbits in these synthetic turbulence realisations and specifically look for non-diffusive regimes and non-standard energy dependences resulting from the intermittency of the generated fields. Applications to SEP transport and acceleration and their connections to recent observations by Parker Solar Probe and Solar Orbiter will be discussed.

EP 12.2 Thu 16:45 ZHG101

Modeling superdiffusive Particle Motion with truncated Lévy Flights* — •Magdalena Litwin[1,2], Sophie Aerdker[1,2], Lukas Merten[1,2], and Horst Fichtner[1,2] — [1]Theoretical Physics IV, Plasma Astroparticle Physics, Faculty for Physics and Astronomy, Ruhr University Bochum, 44780 Bochum, Germany — [2]Ruhr Astroparticle and Plasma Physics Center (RAPP Center), Germany

In the heliosphere, power-law profiles of high-energetic particles at shocks have been observed. These observations point to anomalous, non-Gaussian, transport behavior that might result from intermittent magnetic field structures. Previous studies showed that the power-law distributions can be described by a Lévy flight model. One limitation of such models is that the mean square displacement diverges. In Lévy walk models a spatio-temporal coupling leads to a finite mean-square displacement. We present a similar approach, a truncated Lévy flight model where the mean-square displacement is well-defined. The trun-

cated Lévy flights are simulated with a modified version of the public software framework CRPropa 3.2. The resulting spatial distributions of the new model are compared to those obtained with non-truncated Lévy flight and Lévy walk models. First applications of particle transport at a shock are presented. *supported by SFB1491

EP 12.3 Thu 17:00 ZHG101

Superdiffusive acceleration at heliospheric shocks — •Horst Fichtner[1,2], Sophie Aerdker[1], Frederic Effenberger[1], Lukas Merten[1], and Dominik Walter[1] — [1]Institut fuer Theoretische Physik IV: Ruhr-Universitaet Bochum — [2]Research Department Plasmas with Complex Interactions, Ruhr-Universitaet Bochum

A classical paradigm for the acceleration of energetic particles is the diffusive shock acceleration. For many years this first-order Fermi process was the preferred one to explain the origin of Galactic cosmic rays and of various heliospheric populations, like anomalous cosmic rays or solar energetic particles. In recent years, the evidence has increased, that anomalous transport leading to superdiffusive shock acceleration appears to play a role in the energization of charged particles at shocks. Corresponding numerical simulations have to be based on the solution of fractional partial differential equations, either via finite difference methods or equivalent stochastic differential equations. In the talk both methods will be briefly described, their results for selected cases will compared, and open questions will be discussed. *supported by SFB1491

EP 12.4 Thu 17:15 ZHG101

Modulation of 1 GV protons - comparison of SOHO/EPHIN to AMS-02 fluxes — Bernd Heber[1], •Malte Hörlöck[1], Stefan Jensen[1], Patrick Kühl[1], Lisa Romaneehsen[1], and Holger Sierks[2] — [1]Christian-Albrechts-Universität Kiel, Kiel, D — [2]Max-Planck-Institut für Sonnensystemforschung, Göttingen, D

The Electron Proton Helium INstrument (EPHIN) aboard SOHO is designed to measure high-energy particles and is operating since 1995. It provides energy spectra of protons in the energy range from 4 to about 800 MeV. Above 50 MeV the $\frac{dE}{dx}$ – $\frac{dE}{dx}$- and Bowtie-method is used to determine the energy dependent flux. To validate the measurements, we used published proton fluxes from 2011 to 2019 obtained by the Alpha Magnetic Spectrometer (AMS-02) which is a state-of-the-art particle physics detector designed to study cosmic rays and provides proton fluxes from ≈ 400 MeV to 100 GeV. Here we present the methods and their results that lead to an agreement with AMS-02 within 20% for protons with energies between 400 and 700 MeV. This work received funding from the BMWI (50OC2302,50OC2404) and the EU (101135044 - SPEARHEAD).

EP 12.5 Thu 17:30 ZHG101

Energy spectra of 300 keV to 1 MeV electrons from the SOHO Electron Proton Helium INstrument (EPHIN) — •Stefan Jensen[1], Bernd Heber[1], Alexander Kollhoff[1], Patrick Kühl[1], and Holger Sierks[2] — [1]Institut für Experimentelle und Angewandte Physik, Christian Albrechts-Universität zu Kiel, Germany — [2]Max Planck-Institut für Sonnensystemforschung, Göttingen, Germany

The origins of energetic electrons with energies ranging from a few tens of keV to tens of MeV in the inner heliosphere are manifold. They include Galactic Cosmic Rays, Jovian electrons as well as sporadic Solar Energetic Electron (SEE) events. Their energy spectra provide insights into the acceleration at the source and transport processes in the heliosphere. The SOlar and Heliospheric Observatory (SOHO) was launched December 1995 with the Electron Proton Helium INstrument (EPHIN) measuring electrons from 150 keV to several MeV. However, its measuring capability was reduced due to the failure of two detectors in 1997 and 2017, respectively. Thus from 2017 onwards only two electron channels, one in the range from 150 keV to one MeV and one broad channel that measures between 300 keV and 10 MeV. In this contribution we present a new data product for electron spectra based on the onboard histograms. This data product has the advantage of providing the total energy loss in the first two detectors with good statistics compromising energy resolution and counting statistics. Using the bow-tie method we were able to derive the flux in several energy channels between 300 keV and about 1 MeV. We present first results and compare them with instruments from other missions.

EP 12.6 Thu 17:45 ZHG101

Refining the GEANT4 model of EPHIN — •Malte Hörlöck[1], Bernd Heber[1], Stefan Jensen[1], Patrick Kühl[1], and Holger Sierks[2] — [1]Christian-Albrechts-Universität, Kiel — [2]Max-Planck-Institut für Sonnensystemforschung, Göttingen

The Electron Proton Helium INstrument (EPHIN) aboard SOHO is designed to measure electrons, protons and Helium. It is operating since 1995. GEANT4 simulations are extensively used to produce response functions needed to obtain primary quantities (like fluxes) from the quantities that EPHIN provides. Starting from an idealized model representing the nominal design of EPHIN and using calibration measurements performed at the Hahn-Meitner-Institut in Berlin, we demonstrate the development of a refined model including deadlayers, more precise detector dimensions and a model representing the SOHO spacecraft. This work received funding from the BMWI (50OC2302,50OC2404) and the EU (101135044 - SPEARHEAD).

EP 13: Astrophysics I

Time: Friday 9:00–10:30 Location: ZHG101

Invited Talk EP 13.1 Fri 9:00 ZHG101

High-Mass X-Ray Binaries: Living Together with a Black Hole — •Lidia Oskinova — Potsdam University, Potsdam

What happens when the life of a massive binary star takes a dramatic turn, and one of its companions collapses into a neutron star or black hole? The answer lies in high-mass X-ray binaries (HMXBs) systems where the transfer of mass from a giant star onto its compact companion generates extraordinary strong X-ray radiation.

HMXBs are among the most enigmatic and fascinating objects in cosmos, serving as natural laboratories for studying fundamental astrophysical processes. In this talk, I will present a holistic view of HMXBs, connecting their properties to the broader story of stellar lifecycles. We will delve into the intricate dynamics between donor stars and their black hole or neutron star companions, with a special focus on the rare and intriguing HMXBs hosting black holes. Recent improvements in understanding of these systems provide fresh insights into their astrophysical significance.

Finally, I will explore HMXB populations across galaxies, illustrating how X-ray observations with modern powerful X-ray telescopes uncover secrets about compact objects and their pivotal role in the Universe.

EP 13.2 Fri 9:30 ZHG101

ComPol - A Compton polarimeter in a Nanosat — •Matthias Meier[1,2], Carlo Fiorini[4], Peter Hinderberger[1,2], Philippe Laurent[3], Martin Losekamm[1,2], Susanne Mertens[1,2], Jonas Schlegel[1,2], Lorenzo Toscano[4], and Michael Willers[1,2] — [1]Excellence Cluster ORIGINS, Garching, Germany — [2]Technical University of Munich, Munich, Germany — [3]Alternative Energies and Atomic Energy Commission, Paris, France — [4]Polytechnic University of Milan, Milan, Italy

It is hardly possible to resolve the geometry of astrophysical compact objects due to their small size. One way to indirectly learn about their structure are polarization measurements. Especially in the hard X-ray range polarization data is still partially missing. Therefore, the aim of the CubeSat mission ComPol is to fill this gap and to improve the physical model of the black hole binary system Cygnus X-1.

The detector system is composed of a Silicon drift detector (SDD) used as a scatterer and a CeBr3 calorimeter to capture the full Compton kinematics. From the measured interaction points and energies it is possible to perform an event-wise reconstruction and infer the polarization of the initial radiation.

The talk will give an overview of the scientific motivation, the underlying physics, the detector setup and its performance. This research is supported by the Excellence Cluster ORIGINS which is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy - EXC-2094-390783311

EP 13.3 Fri 9:45 ZHG101

Newly discovered nebulae around Galactic B-type stars and their origins — •Olga Maryeva[1], Péter Németh[1], Sabina Mammadova[2], Sergey Karpov[3], Michaela Kraus[1], Lydia Cidale[4], and Anahi Granada[5] — [1]Astronomical Institute, Czech Academy of Sciences, Czech Republic — [2]Shamakhy Astrophysical Observatory, Baku, Azerbaijan — [3]Institute of Physics of the Czech Academy of Sciences, Prague, Czech Republic — [4]Instituto de Astrofísica de La Plata, La Plata, Argentina — [5]Universidad Nacional de Río Negro, San Carlos de Bariloche, Argentina

The mass loss in massive stars is an important process that determines their future evolution and affects on circumstellar environment. Besides of the continuous outflow of matter in the form of stellar winds, massive stars undergo sporadic ejections that lead to the formation of circumstellar envelopes. For today it remains unclear at what stage of evolution the first mass ejection occurs and what instabilities lead to it. We present the results of a study of four B-type stars which circumstellar nebulae have recently been found in the archive of the Wide-field Infrared Survey Explorer. Two of our objects PY Gem and HD253659 are Be stars showing emission double peak Hα profiles. The collected spectral and photomet-

ric monitoring data showed that HD253659 has strong photometric variability with an amplitude of 0.3 mag in addition to the Hα profile variability. The other two stars HD215575 and BD+141106 have spectra of usual B-type stars on the main sequence. Spectral analysis, numerical modeling, as well as high proper motions argue that these two objects undergone merging in the past.

EP 13.4 Fri 10:00 ZHG101

On the existence and (non-)uniqueness of null points of flows and magnetic fields as prerequisites for the existence of astropauses — •Dieter Nickeler[1], Kuljeet Singh Saddal[1,2], and Rodrigo Meneses[3] — [1]Astronomical Institute AV CR, Ondrejov, Czech Republic — [2]Charles University, Prague, Czech Republic — [3]Universidad de Valparaiso, Chile

The existence of null points of vector fields is prerequisite for the spanning of separating surfaces. Such surfaces guarantee that topologically disjoint field lines of the corresponding vector fields exist on each side of the separatrix. The existence of separatrices allows to define so-called pauses, e.g. magnetopause (a magnetic separatrix) or astropause (like the heliopause). To analyse the structure of fields with null points, we focus on the stationary approximation. Besides the topological perspective, other physical constraints can require the existence of null points.

We investigate the case of a non-monotonous pressure distribution driving stationary counterstreaming MHD flows such as the interstellar medium flows and the outer stellar wind flows. For a purely ideal hydrodynamical problem, and demanding on the regularity of all involved fields and their derivatives, we demonstrate that the existence of an extremum of the thermal or plasma pressure at a certain point in the generic three-dimensional case automatically implies that this point is also a stagnation point (= null point of the plasma flow). An extended analysis is performed for ideal MHD and further for MHD with additional, general non-ideal terms.

EP 13.5 Fri 10:15 ZHG101

3D Resistive MHD Perspectives on the Localized Dynamics at the Apex of an Astropause — •Kuljeet Singh Saddal[1,2], Dieter Nickeler[1], and Rodrigo Meneses[3] — [1]Astronomický ústav AV CR, Ondřejov, Czech Republic — [2]Charles University, Faculty of Mathematics and Physics, Praha, Czech Republic — [3]Universidad de Valparaíso. General Cruz 222, Valparaíso

The dynamical interaction zones where stellar winds collide with the interstellar medium, known as astrospheres, are characterized by complex hydrodynamic (HD) or magnetohydrodynamic (MHD) discontinuities. Central to this interaction is the astropause, a boundary separating stellar wind and interstellar flows, whose structure is governed by fluid flow separatrices. In the MHD framework, the presence of a magnetic null point and a velocity stagnation point near the apex of the astropause is essential. Assuming these points coincide, we derive exact solutions to the resistive MHD equations in three-dimensional space. The topology of the magnetic field and two free parameters describes the nature of these solutions. We identify flows that traverse the magnetic field separatrices, i.e., the fan plane and spine line, potentially enabling the identification of true reconnective solutions. The goal of this analysis is to identify and differentiate reconnective and non-reconnective solutions based on specific criteria. Using these solutions, we calculate dissipation rates and derive thermodynamic properties, such as pressure and temperature, at the apex. This enables the computation of radiance and the generation of synthetic sky maps for comparison with observational data.

EP 14: Astrophysics II

Time: Friday 11:00–12:30 Location: ZHG101

EP 14.1 Fri 11:00 ZHG101

3D radiative MHD simulations of starspots — •Tanay Veer Singh Bhatia, Mayukh Panja, Robert H. Cameron, and Sami K. Solanki — Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany

The contribution of starspots to stellar variability comprises one of the largest sources of uncertainty in detecting and characterizing exoplanets. Existing methods to account for this variability do not take into account the detailed physical nature of starspots. We compute realistic 3D radiative MHD near-surface models of starspots with substantial penumbrae on cool main-sequence stars using the MURaM simulation code. This work is an improvement on the the previous starspot models in a slab geometry. The umbra, penumbra and the quiet star for all starspots are distinct, not only in intensity and temperature, but also in thermodynamic and velocity structure. These models represent a significant step towards modeling contribution of starspots to stellar lightcurves.

EP 14.2 Fri 11:15 ZHG101

Spatio-temporal correlation in incompressible MHD turbulence — •Raquel Mäusle and Wolf-Christian Müller — Technische Universität Berlin, Berlin, Germany

Turbulent flows are ubiquitous on Earth and throughout the universe, playing an important role in many astrophysical plasmas. Three-dimensional magnetohydrodynamic (MHD) turbulence exhibits a direct energy cascade, driven by the nonlinear interaction of colliding Alfvén wave packets. Our aim is to study the temporal and spatial properties of the energy transfer process by computing the spatio-temporal correlation between turbulent fluctuations of various length scales. The fluctuations are measured in direct numerical simulations in the co-moving Quasi-Lagrangian reference frame, which eliminates the large-scale sweeping effect. The single-time correlation between fluctuations parallel and perpendicular to the local magnetic field gives insight into the shape of the turbulent structures, whereas the multi-time correlation allows a measurement of the time scales involved in the cross-scale energy transfer and the propagation of Alfvén wave packets. In both cases, our results show a strong indication of critical balance behavior.

EP 14.3 Fri 11:30 ZHG101

Modeling fast charged particle transport in strong magnetic turbulence — •Jeremiah Lübke[1], Patrick Reichherzer[2], Sophie Aerdker[3], Frederic Effenberger[1,3], Horst Fichtner[3], and Rainer Grauer[1] — [1]Institut für theoretische Physik I, Ruhr-Universität Bochum, 44801 Bochum, Deutschland — [2]Department of Physics, University of Oxford, Oxford OX1 3PU, United Kingdom — [3]Institut für theoretische Physik IV, Ruhr-Universität Bochum, 44801 Bochum, Deutschland

The transport of energetic charged particles in strong magnetic turbulence is a highly complex phenomenon. Inspired by recent work on the role of the fieldline curvature in this problem, we investigate the interplay between pitch-angle scattering and fieldline geometry by means of test particle simulations in isotropic MHD snapshots. We characterize the magnetic field as coherent when its local curvature radius is larger than the current gyroradius of the particle, and find distinct transport behavior in either case. Guided by our observations, we develop stochastic models based on a competition between compound diffusion along coherent fieldlines and diffusive scattering. Finally, we discuss implications on synthetic turbulence models and avenues to a transport theory based on a generalized master equation.

EP 14.4 Fri 11:45 ZHG101

MHD simulations of turbulent galactic outflows — •Jens Kleimann and Horst Fichtner — Theoretische Physik IV, Ruhr-Universität Bochum, Germany

Simulations of the wind-filled halos of starburst galaxies are performed in the framework of magnetohydrodynamics (MHD), suitably extended to track additional turbulence-related quantities. These quantities comprise the turbulent energy density, the cross-helicity, and the turbulent correlation length scale. First, the occurrence of an unexpected large-scale hydrodynamic flow instability, the cause of which can be linked to the galaxy's mass, is described and discussed. The full system of equations is then solved for a typical lower-mass galaxy until a steady state is reached. The talk concludes with an analysis of the resulting turbulent properties within the galactic halo and a quantification of the associated particle diffusion parallel and perpendicular to the large-scale magnetic field.

EP 14.5 Fri 12:00 ZHG101

Relativistic test-particle transport and acceleration in MHD jets — •Patrick Günther, Karl Mannheim, and Sarah M. Wagner — Julius-Maximilians-Universität Würzburg

Extragalactic jets show continuum emission across the entire electromagnetic spectrum and variability on all observed timescales. Modelling this non-thermal emission can be achieved by simultaneously describing the kinetics of relativistic particles and the fluid-dynamical bulk plasma in the jet. We solve a time-dependent transport equation by means of stochastic differential equations, which describes the propagation of particles in the background of a MHD-simulated jet and includes effects such as diffusive shock acceleration and stochastic acceleration. Using this hybrid MHD-kinetic approach, we aim to study the effect of the multiple shocks with varying strengths and obliquities on the resulting non-thermal particle distributions in MHD jet simulations. The time-dependency of the simulation makes the extraction of light curves at any wavelengths possible.

EP 14.6 Fri 12:15 ZHG101

Can We Analytically Predict the Variability of Blazars? — •Vito Aberham and Felix Spanier — Institut für Theoretische Astrophysik, Universität Heidelberg, Albert-Ueberle-Str. 2, 69120 Heidelberg, Germany

Active galactic nuclei (AGN) are known for their variable emission. We apply an evolving two-zone model to their hybrid jets containing both electrons and protons, allowing for the emission of neutrinos. The dominant source of variability, these AGN jets are characterized by the main cooling process triggering the SED's high-energy peak. We choose blazars with proton synchrotron radiation as the predominant emission mechanism for high energies, while electron synchrotron radiation drives the low energy emission. We defer the case of cascades dominating the emission to future work. Including both their acceleration and cooling in the respective zones, we obtain the particle distributions by solving two coupled PDEs while neglecting the effect of second-order Fermi acceleration. We then calculate the photon density, which, combined with the proton distribution, yields the emerging neutrino flux. We infer the according light curves and neutrino fluxes in specific energy bands, enabling comparisons to a wide range of observed blazars. To fully leverage our analytical result's dependency on the free model parameters, we introduce a public tool capable of simulating blazar flares, which allows for rapidly cross-checking numerical simulations at low computational cost. We thus developed the ability to not only predict the variability of any proton-synchrotron dominated blazar analytically but also enhance the quality of simulations.

EP 15: Astrophysics III

Time: Friday 13:30–16:00 Location: ZHG101

Invited Talk EP 15.1 Fri 13:30 ZHG101

Nucleosynthesis of heavy elements in the hot and dense plasmas of explosive astrophysical environments — •Daniel Siegel — Universität Greifswald

Gravitational-wave and multi-messenger astronomy shed light on the astrophysics of black holes and neutron stars and also allow for unique probes of fundamental physics. I will discuss recent results on how the mergers of neutron stars as well as other explosive systems such as the death of massive, rotating stars (collapsars) give rise to the formation of heavy elements in the universe. In particular, I will discuss recent results at the interface of numerical relativity, relativistic astrophysics, neutrino physics as well as nuclear astrophysics, and highlight how multi-messenger astronomy may lead to answers of a 70-year old fundamental question in physics: How does the Universe create its heaviest elements?

EP 15.2 Fri 14:00 ZHG101

Time-dependent modeling of radiative processes in pulsar wind nebulae generated by neutron-star mergers — •Eric Schneider[1], Michael Müller[1], and Daniel Siegel[1,2] — [1]Institute of Physics, University of Greifswald, Greifswald, Germany — [2]Department of Physics, University of Guelph, Guelph, Ontario, Canada

Emission from pulsar wind nebulae (PWNe) and the thermal emission of kilonovae (KN) have traditionally been studied as separate phenomena, associated with distinct astrophysical origins. A pulsar wind nebula is composed of a relativistic leptonic plasma powered by a pulsar typically found in supernova remnants. The leptons cool down through a variety of radiative processes, giving rise to distinct non-thermal emission. A KN is a thermal electromagnetic transient driven by the radioactive decay of neutron-rich nuclei, which are synthesized by the rapid neutron-capture process in the dense plasma outflows from neutron star mergers.

Recent models suggest PWNe may also form in binary neutron star mergers, driven by long-lived remnant neutron stars. These PWNe differ from their supernova counterparts because of their high compactness and high photon densities, requiring new theoretical approaches.

We present a unified model for PWNe evolution and electromagnetic emission, together with a generalized KN model that incorporates the presence of a PWN. We generate a catalog of combined non-thermal and thermal emission to aid interpretation of future merger observations and to constrain properties of merger remnants.

EP 15.3 Fri 14:15 ZHG101

Neutrino-cooled accretion disks around massive black holes and their potential as sites for r-process nucleosynthesis — •Javiera Hernández Morales and Daniel M. Siegel — Institute of Physics, University of Greifswald

The astrophysical origin of about half of the elements heavier than iron, synthesized through rapid neutron-capture (the *r*-process), is still uncertain. Among proposed sites—neutron-star mergers and collapsars—a common scenario is the formation of a black hole surrounded by an accretion disk. A necessary condition for the *r*-process to occur in outflows from such disks is a neutron-rich environment, which these disks can achieve through neutrino-cooling. However, the minimum rate at which a black hole needs to accrete to activate this mechanism is still an open question. We employ a one-dimensional, general-relativistic model of accretion disks with weak interactions to explore the parameter space of black-hole mass, accretion rate, and α-viscosity, and study the effect of these parameters on the accretion flow and the presence of neutron-rich material. We find that disks with larger accretion rates reach a lower proton fraction Y_e, with neutron-rich plasma extending over increasingly wider ranges in radii. We show that the characteristic accretion rates that describe the efficiency of cooling, the opaqueness to neutrinos and the trapping of neutrinos in the accretion flow follow power-law relations with black-hole mass and α-viscosity. Our results suggest that disks around black holes with masses ranging from $\sim 3M_\odot$ to $\sim 10^3 M_\odot$ could launch neutron-rich outflows and thus be possible sites for the nucleosynthesis of the heaviest elements in the Universe.

EP 15.4 Fri 14:30 ZHG101

Ignition of weak interactions and r-process outflows in massive, 'supercollapsar' accretion disks — •Aman Agarwal[1] and Daniel Siegel[1,2] — [1]Institute of Physics, University of Greifswald, D-17489 Greifswald, Germany — [2]Department of Physics, University of Guelph, Guelph, Ontario, Canada, N1G 2W1

The core collapse of rapidly rotating massive ($\sim 10M_\odot$) stars ("collapsars") and the resulting hyperaccreting black holes represent a leading model for the central engines of long-duration gamma-ray bursts (GRBs) and promising sources of neutron-rich plasma outflows for *r*-process nucleosynthesis. We perform three-dimensional general-relativistic magnetohydrodynamics simulations to explore the neutronization of accretion flows from progenitors with masses above the pair-instability mass gap to the regime of massive PopIII stars (black-hole mass range $M_\bullet \sim 80 - 1000\ M_\odot$). We find that neutron-rich accretion flows develop above an "ignition" accretion rate $\dot{M}_{\rm ign}$, which, in good agreement with analytical estimates, scales as $\dot{M}_{\rm ign} \propto M_\bullet^{4/3} \alpha_{\rm eff}^{5/3}$ up to $M_\bullet \sim 1000 M_\odot$, with $\alpha_{\rm eff}$ being the effective Shakura-Sunyaev disk viscosity. We discuss the implications of very early r-process enrichment through such astrophysical events in the light of recent detections of massive stars by the James Webb Space Telescope and reflect upon their potential as multi-messenger sources of both electromagnetic ("super-kilonovae") and gravitational waves for third-generation gravitational-wave detectors.

EP 15.5 Fri 14:45 ZHG101

Signatures of Exploding Supermassive PopIII Stars at High Redshift — •Cédric Jockel — Max Planck Institute for Gravitational Physics, Potsdam, Germany

Recently, supermassive black holes (SMBHs) of $\sim$ 100 million solar-masses have been discovered at high redshifts of $z \sim 9-11$. These large masses so early in the universes history pose severe challenges to our understanding of SMBH formation. One possible formation channel is the direct collapse of rapidly accreting PopIII stars that form in large collapsing halos of primordial gas and grow up to a million solar masses. Our recent studies and also work by other groups show that they eventually collapse and produce powerful supernova-like explosions of 10^{55} erg that last over 10 years. Modelling the observational signatures and prospects of their explosions will give us crucial insight on the early stages of SMBH formation. In this talk, I present our recent work on the observability of these supermassive star explosions including the computation of the luminosity, photometry and colour evolution. In our model, we study the scenario where massive ejecta are released during the collapse and explosion and interact with the surrounding dense cloud via shocks. These shock interactions power emissions of up to $\sim 10^{45-47}$ erg/s in the source frame and lead to easily observable signals in JWST and EUCLID. Due to the long explosion timescale of over 10-15 years, the transients will be observed over a period of a few hundred years due to redshift and might be confused photometrically with persistent high-redshift sources such as little red dots.

EP 15.6 Fri 15:00 ZHG101

Beobachtungskampagnen und theoretische Modellierung von Lichtkurven verschmelzender Schwarzer Löcher — •Julian Sommer — Ludwig-Maximilians-Universität München, München, Deutschland

Schwarze Löcher mit Massen von mehreren Dutzend bis Hunderten Sonnenmassen werden vorwiegend in den Regionen aktiver Galaxienkerne, genauer gesagt in den Akkretionsscheiben supermassiver Schwarzer Löcher, vermutet. Die Interaktion des Verschmelzungsprodukts mit dem umliegenden Gas kann zu elektromagnetischen Signaturen führen, die sich in Form von Flares äußern. Die Dauer eines solchen Flares kann sich über Tage bis Wochen erstrecken und lässt sich als Lichtkurve beschreiben. In diesem Vortrag werden erste Ergebnisse der theoretischen Modellierung solcher Lichtkurven vorgestellt und mit unseren Beobachtungen verglichen, um das Verhältnis zwischen Theorie und Praxis zu analysieren. Unsere Beobachtungskampagnen zu Gravitationswellendetektionen durch LIGO/Virgo/KAGRA werden mit dem 2,1-Meter-Wendelstein-

Teleskop durchgeführt, das sowohl den 3KK-Imager als auch den Wide-Field-Imager nutzt.

EP 15.7 Fri 15:15 ZHG101

Probing the effects of magnetic fields on ultra-high energy cosmic ray arrival directions at the Pierre Auger Observatory — •Berenika Čermáková for the Pierre-Auger-Collaboration — Karlsruhe Institute for Technology, Karlsruhe, Germany

When ultra-high-energy cosmic rays (UHECRs) travel from sources to Earth, they are deflected by extragalactic and galactic magnetic fields. Since the deflection depends on the charge of the nuclei, UHECRs with very high magnetic rigidity propagate almost ballistically. Consequently, when detected on Earth, the arrival directions point near their origin. Hence, backtracking the high-rigidity UHECRs could set a limit on different source classes.

However, indirect detection of UHECRs poses challenges in obtaining information about their energy and mass simultaneously. Machine learning-based mass estimators show the potential to improve the reconstruction of mass-sensitive variables, such as the depth of the shower maximum.

In this contribution, we investigate the effect of the galactic magnetic field on the propagation of the UHECRs using neural network-based mass estimators. We test different scenarios of source distributions. In particular, we present the developed methodology to test the hypothesis that sources follow the distribution of matter in space, hence the Supergalactic plane. We use data from the Pierre Auger Observatory.

EP 15.8 Fri 15:30 ZHG101

Precise Reconstruction of Neutrino Event Energy Using Deep Learning — •Severin Magel, Chiara Bellenghi, Elena Manao, and Rasmus Ørsøe for the IceCube-Collaboration — Technical University of Munich, TUM School of Natural Sciences, Department of Physics, James-Franck-Straße 1, D-85748 Garching bei München, Germany

The first ever 5σ detection of an astrophysical neutrino source has long been chased by neutrino telescopes like IceCube and KM3NeT. Achieving a high statistical significance in detecting these sources is partially limited by the precision of variable reconstructions for the incoming neutrino direction and energy. We investigate the potential of state-of-the-art deep learning architectures like Graph Neural Networks (GNN) and transformers to improve classical algorithms and obtain a more precise neutrino energy prediction. We force the model to recognise general patterns in the detector response by training it on all signatures left in the detector by the different neutrino interaction channels. This pre-trained architecture is then fine-tuned for the reconstruction of specific neutrino events that are eventually used in various analyses not limited to the search for an astrophysical neutrino sources. In this presentation, I will outline the technical challenges and the physics-oriented results from these efforts.

EP 15.9 Fri 15:45 ZHG101

Simulation-based inference has its own Dodelson-Schneider effect (but it knows that it does) — •Jed Homer[1,2], Oliver Friedrich[1,2,3], and Daniel Gruen[1,2,3] — [1]University Observatory, Faculty of Physics, Ludwig-Maximilians-Universität, Scheinerstr. 1, 81677 Munich, German — [2]Munich Center for Machine Learning (MCML) — [3]Excellence Cluster ORIGINS, Boltzmannstr. 2, 85748 Garching, Deutschland.

Making inferences about physical properties of the Universe requires knowledge of the data likelihood. A Gaussian distribution is commonly assumed with a covariance matrix estimated from a set of simulations. The noise in such estimates causes two problems: it distorts the parameter contours, and it adds scatter to the location of those contours. For non-Gaussian likelihoods, an approximation may be derived via Simulation-Based Inference (SBI). It is often implicitly assumed that parameter constraints from SBI analyses are not affected by the same problems as parameter estimation, with a covariance matrix estimated from simulations. We investigate whether SBI suffers from effects similar to those of covariance estimation in Gaussian likelihoods. SBI suffers an inflation of posterior variance that is equal or greater than the analytical result in covariance estimation for Gaussian likelihoods for the same number of simulations. The assumption that SBI requires a smaller number of simulations than covariance estimation for a Gaussian likelihood analysis is inaccurate. Despite these issues, we show that SBI correctly draws the true posterior contour given enough simulations.

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Overview of Invited Talks and Sessions

(Lecture halls ZHG008 and ZHG007; Poster ZHG Foyer 1. OG)

Invited Talks

GR 1.1	Mon	16:45–17:30	ZHG008	**Classical post-newtonian gravitational fields in quantum mechanics** — •Domenico Giulini
GR 2.1	Tue	13:30–14:15	ZHG008	**Beyond the thick accretion disk model: external influences and their observational consequences** — •Audrey Trova, Eva Hackmann, Vladimir Karas, Jiří Kovář
GR 6.1	Wed	11:00–11:45	ZHG008	**Black hole dynamics from a mathematical perspective** — •Dejan Gajic
GR 10.1	Thu	13:30–14:15	ZHG008	**Probing the cosmic large-scale structure beyond the average** — •Cora Uhlemann

Invited Talks of the joint Symposium SMuK Dissertation Prize 2025 (SYMD)

See SYMD for the full program of the symposium.

SYMD 1.1	Mon	14:15–14:45	ZHG011	**Fluid-dynamic description of heavy-quark diffusion in the quark-gluon plasma** — •Federica Capellino
SYMD 1.2	Mon	14:45–15:15	ZHG011	**Fast and faithful effective-one-body models for gravitational waves from generic compact binaries** — •Rossella Gamba
SYMD 1.3	Mon	15:15–15:45	ZHG011	**Nuclear Structure Near Doubly Magic Nuclei** — •Lukas Nies
SYMD 1.4	Mon	15:45–16:15	ZHG011	**Optimisation strategies for proton acceleration from thin foils with petawatt ultrashort pulse lasers** — •Tim Ziegler

Invited Talks of the joint Symposium Quantum Mechanics and Gravity: Current Status (SYDK)

See SYDK for the full program of the symposium.

SYDK 1.1	Thu	10:45–11:15	ZHG008	**String Theory at the Edges of Relativity** — •Niels Obers
SYDK 1.2	Thu	11:15–11:45	ZHG008	**The Quantum Einstein Equations in Loop Quantum Gravity** — •Kristina Giesel
SYDK 1.3	Thu	11:45–12:15	ZHG008	**Causal Dynamical Triangulations: Lattice quantum gravity reloaded** — •Renate Loll
SYDK 1.4	Thu	12:15–12:45	ZHG008	**Taming Quantum Gravity: insights from Asymptotic Safety** — •Alessia Platania

Sessions

GR 1.1–1.4	Mon	16:45–18:30	ZHG008	**CQG I**
GR 2.1–2.5	Tue	13:30–15:35	ZHG008	**Relastro I**
GR 3.1–3.4	Tue	14:15–15:35	ZHG007	**Rel. Geodesy**
GR 4.1–4.5	Tue	16:15–17:55	ZHG008	**GW I**
GR 5.1–5.4	Tue	16:15–17:35	ZHG007	**CQG II**
GR 6.1–6.3	Wed	11:00–12:25	ZHG008	**BH Physics I**
GR 7.1–7.7	Wed	13:30–15:50	ZHG008	**Cosmo I, Relastro II, GW II**
GR 8.1–8.4	Wed	13:30–14:50	ZHG007	**GW III**
GR 9.1–9.19	Wed	16:15–18:15	ZHG Foyer 1. OG	**Poster**

GR 10.1–10.5	Thu	13:30–15:35	ZHG008	**Cosmo II**
GR 11.1–11.4	Thu	14:15–15:35	ZHG007	**BH Physics II, GW IV**
GR 12.1–12.2	Thu	16:15–16:55	ZHG008	**GW V**
GR 13	Thu	17:00–18:15	ZHG008	**Members' Assembly**
GR 14.1–14.4	Fri	9:00–10:20	ZHG008	**Relastro III**
GR 15.1–15.4	Fri	11:00–12:20	ZHG008	**Cosmo III**

Members' Assembly of the Gravitation and Relativity Division

Thursday 17:00–18:15 ZHG008

Sessions

– Invited Talks, Contributed Talks, and Posters –

GR 1: CQG I

Time: Monday 16:45–18:30 Location: ZHG008

Invited Talk GR 1.1 Mon 16:45 ZHG008

Classical post-newtonian gravitational fields in quantum mechanics — •Domenico Giulini — Leibniz Universität Hannover — ZARM Bremen

The problem of coupling classical gravitational fields to quantum-mechanical systems is considered within post-newtonian approximation schemes. I will show how to compute the approximate Hamiltonian for the centre-of-mass and internal dynamics of an electromagnetically bound two-particle system. This, in turn, can be used to derive algebraic expressions for phases in light-pulse atom-interferometers of various geometries. Finally I will comment on some conceptual issues that we encountered in this field. The talk will be based on doi: 10.1103/PhysRevA.100.052116, 10.1103/PhysRevD.109.022008, 10.1088/1361-6382/ad079c.

GR 1.2 Mon 17:30 ZHG008

Understanding gravitationally induced decoherence parameters in neutrino oscillations using a microscopic quantum mechanical model — Alba Domi[1], Thomas Eberl[1], Max Joseph Fahn[2], Kristina Giesel[1], Lukas Hennig[1], Ulrich Katz[1], •Roman Kemper[1], and Michael Kobler[1] — [1]Friedrich-Alexander Universität Erlangen-Nürnberg, Germany — [2]Università di Bologna, Italy

In this talk, the role of gravitationally induced decoherence in open quantum systems is explored in the context of neutrinos. A microscopic quantum mechanical model introduced by Blencowe and Xu is applied to neutrino oscillations, motivated by the coupling between neutrinos and the gravitational wave environment suggested by linearised gravity. The analysis demonstrates that, for neutrino oscillations in vacuum, gravitationally induced decoherence matches phenomenological models, with decoherence parameters exhibiting an inverse quadratic energy dependence. When matter effects are included, the decoherence parameters depend on the varying matter density across the Earth's layers. Moreover, the form of the decoherence parameters is explicitly derived from the microscopic model, providing a physical interpretation. This talk is based on the work in "Understanding gravitationally induced decoherence parameters in neutrino oscillations using a microscopic quantum mechanical model", published in JCAP, 2024, 11, 006.

GR 1.3 Mon 17:50 ZHG008

The nature of gravity — •Piero Nicolini — Universität Triest, Triest, Italien — INFN, Triest, Italien — Johann Wolfgang Goethe-Universiät Frankfurt am Main, Frankfurt am Main, Deutschland

Gravity is well known at the classical level, both in Newtonian and GR terms. However, understanding gravity at the fundamental level requires a quantum formulation. In this talk I will review recent findings on the static interaction between two point-like masses to reveal that the conventional attractive nature of gravity is only a low-energy effect.

GR 1.4 Mon 18:10 ZHG008

LISA - a data perspective — •Sarah Paczkowski — Max Planck Institute for Gravitational Physics (Albert Einstein Institute), D-30167 Hannover, Germany — Leibniz Universität Hannover, D-30167 Hannover, Germany

The Laser Interferometer Space Antenna (LISA) is an ESA-led mission to observe gravitational waves from space. In this presentation, I will introduce LISA from a data perspective, focusing on the anticipated characteristics of the data in terms of gravitational wave signals and noise sources from the instrument. I will also discuss the strategies employed to mitigate noise during data processing on Earth and the projected timeline for data availability.

GR 2: Relastro I

Time: Tuesday 13:30–15:35 Location: ZHG008

Invited Talk GR 2.1 Tue 13:30 ZHG008

Beyond the thick accretion disk model: external influences and their observational consequences — •Audrey Trova[1], Eva Hackmann[1], Vladimir Karas[2], and Jiří Kovář[3] — [1]University of Bremen, Center of Applied Space Technology and Microgravity (ZARM), 28359 Bremen, Germany — [2]Astronomical Institute, Czech Academy of Sciences, Boční II 1401, Prague, 141 00, Czech Republic — [3]Research Centre for Theoretical Physics and Astrophysics, Institute of Physics, Silesian University in Opava, Bezručovo nám. 13, 746 01, Opava, Czech Republic

The strong gravity regime near black holes and neutron stars provides an exceptional laboratory for testing General Relativity. Accretion disks extend deep into this regime, reaching down to the horizon scale. Various accretion disk models have been developed to better understand the complex phenomena at play. Among them, the thick accretion disk, the simplest analytical model, that considers only gravity and a perfect fluid, captures key features of these objects.

In this talk, we will explore different variants of the thick accretion disk model, incorporating additional effects such as an external magnetic field influencing the charge of the fluid, the deformation of the central object, and the presence of an external mass distribution that can mimic the self-gravity of the disk itself. We will discuss the implications of these factors on the disk's geometry, density, and pressure distribution. Furthermore, we will analyze their impact on observational signatures of black hole accretion disks, particularly in the context of high-frequency quasi-periodic oscillations (HFQPOs).

GR 2.2 Tue 14:15 ZHG008

Magnetic field dynamics in isolated neutron stars: insights from GRMHD simulations — •Aurora Capobianco — Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, 07743, Jena, Germany

The internal magnetic field topology and equilibrium configurations of neutron stars are thought to play a fundamental role in determining the nature and strength of astrophysical phenomena. We model the development of the super strong magnetic fields in neutron stars using the General Relativistic Magneto-HydroDynamic (GRMHD) code AthenaK. In this talk, I will present the long-term evolutions of isolated neutron stars with an outer dipole-like field and various initial internal magnetic-field configurations, exploring the growth times of the various instability-driven oscillation modes and turbulence. I will highlight how resolution impacts the magnetic field evolution due to instabilities that arise from small-scale effects and discuss future developments.

GR 2.3 Tue 14:35 ZHG008

Realistic models of general-relativistic differentially rotating stars — •Marie Cassing[1] and Luciano Rezzolla[1,2,3] — [1]Institute for Theoretical Physics, Frankfurt am Main, Germany — [2]Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany — [3]School of Mathematics, Trinity College, Dublin, Ireland

General-relativistic equilibria of differentially rotating stars are expected in a number of astrophysical scenarios, from core-collapse supernovae to the remnant of binary neutron-star mergers. The latter, in particular, have been the subject of extensive studies where they were modelled with a variety of laws of differential rotation. Starting from accurate and fully general-relativistic simulations of binary neutron-star mergers with various equations of state, we establish the time when the merger remnant has reached a quasi-stationary equilibrium and extract in this way realistic profiles of differential rotation. This allows us to explore how well traditional laws reproduce such differential-rotation properties and to derive new laws of differential rotation that better match the numerical data. In this way, we have obtained a novel and somewhat surprising result: the stability line computed from the turning-point criterion can have a slope that is not necessarily negative with respect to the central rest-mass density, as previously found with traditional differential-rotation laws. For stellar models reproducing well the properties of the merger remnants, the slope is actually positive, thus reflecting remnants with angular momentum at large distances from the rotation axis, and hence with cores having higher central rest-mass densities and slower rotation rates.

GR 2.4 Tue 14:55 ZHG008

Can a collapsing White Dwarf power a long GRB with kilonova? — •Luis Felipe Longo Micchi — Friedrich-Schiller Universität, Jena, Deutschland

In this talk, I will present the results of axisymmetric simulations of accretion-

induced collapse (AIC) of rapidly rotating, magnetized white dwarfs. Using general relativistic neutrino magnetohydrodynamics, we explore how strong magnetic fields and rotation during collapse drive the formation of relativistic jets and neutron-rich outflows. These findings offer a compelling explanation for the observed properties of long gamma-ray bursts (LGRBs) like GRB 211211A and GRB 230307A, including their associated kilonovae. I will discuss how our models reproduce the energy and duration of these LGRBs and their accompanying kilonovae without fine-tuning, highlighting AIC as a significant astrophysical site for heavy r-process element production.

GR 2.5 Tue 15:15 ZHG008

Listening to the long ringdown: a novel way to pinpoint the equation of state in neutron star cores — •Christian Ecker — Goethe University Frankfurt

Multimessenger signals from binary neutron star (BNS) mergers are promising tools to infer the largely unknown properties of nuclear matter at densities that are presently inaccessible to laboratory experiments. The gravitational waves (GWs) emitted by BNS merger remnants, in particular, have the potential of setting tight constraints on the neutron-star equation of state (EOS). In this talk I will present a novel and tight correlation between the ratio of the energy and angular momentum losses in the late-time portion of the post-merger signal, i.e., the *long ringdown*, and the properties of the EOS at the highest pressures and densities in neutron-star cores. By applying this correlation to post-merger GW signals, I will show a significant reduction of the EOS uncertainty at densities several times the nuclear saturation density, where no direct constraints are currently available.

GR 3: Rel. Geodesy

Time: Tuesday 14:15–15:35 Location: ZHG007

GR 3.1 Tue 14:15 ZHG007

Synchronization and Simultaneity in Geodesy — •Bennet Grützner — ZARM, Universität Bremen

A crucial task in geodesy is the synchronization of extended clock networks. For synchronization of these networks a transitive, global notion of simultaneity is needed. As is standard in geodesy and astrophysics, the time coordinate is most commonly used to provide a foliation of space-time into hypersurfaces of simultaneity. Here, we look at the mathematical background and explore the most general formulation of simultaneity in general relativity, extending the concepts used so far. In particular, the differences between time coordinates and synchronization coordinates will be discussed, including some counter-intuitive examples, as well as applications in geodesy such as synchronization with ACES on the ISS.

GR 3.2 Tue 14:35 ZHG007

Chronometry in spacetime: a clock-based global height system — •Dennis Philipp[1,2], Asha Vincent[3], Christian Lisdat[4], and Juergen Mueller[3] — [1]ZARM, University of Bremen, Germany — [2]Faculty of Physics, University of Bremen, Germany — [3]Institute for Geodesy, Leibniz University Hannover, Germany — [4]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Ongoing efforts aim at achieving a globally uniform and consistent International Height Reference System as a global standard for accurately determining physical (height-)coordinates across the world. Near the Earth's surface, two stationary standard clocks that are separated by 1 cm in height have a redshift of about 10^{-18} according to Einstein's theory of General Relativity (GR).

We present a definition of clock observables and chronometry in GR, leading towards a relativistic definition of i) a gravity potential, ii) a notion of chronometric height, and iii) generalized geopotential numbers. Clock comparison in this framework allows for accurate height determination in high-performance clock networks, in which frequency differences can be observed between clock sites and corresponding gravity potential differences can be derived. Height values can be represented by geopotential numbers and measured potential differences between clock locations in a dedicated clock network can be used to estimate the transformation parameters between regional reference frames to resolve distortions. A simulation study is presented that focusses on height systems in Europe and South America to demonstrate the potential impact and benefit of clock-based height systems.

GR 3.3 Tue 14:55 ZHG007

General relativistic geodesy: description of GRACE constellations — •Florian Seemann, Eva Hackmann, and Claus Lämmerzahl — ZARM, University of Bremen, Bremen, Germany

For a global coverage of geodetic measurements one has to go to space. The most succesful geodesy missions are the completed GRACE mission and the ongoing GRACE Follow On mission which revealed many unknown facts about the system Earth. Further geodesy missions using intersatellite laser ranging are under development worldwide. With laser ranging changes of the distance between two satellites can be determined better than 1 nm precision. In this presentation a general relativistic description of this type of geodetic measurement is developed. This includes also perturbation forces which originate, e.g., from the atmospheric drag.

GR 3.4 Tue 15:15 ZHG007

Laser Interferometry in Space for Gravity Recovery: Current and Future Missions — •Pallavi Bekal[1,2], Vitali Müller[1,2], Malte Misfeldt[1,2], Martin Weberpals[1,2], Reshma Krishnan Sudha[1,2], Laura Müller[1,2], and Gerhard Heinzel[1,2] — [1]Max Planck Institute for Gravitational Physics (AEI), Hannover, Germany — [2]Leibniz University Hannover (LUH), Hannover, Germany

The Gravity Recovery and Climate Experiment (GRACE) mission's success in measuring the Earth's gravity field provided a path for future twin-satellite gravity missions with more accurate instrumentation. Consequently, after 15 years of operation, GRACE was succeeded by GRACE follow-on (-FO) in 2018. GRACE and GRACE-FO use the conventional microwave instrument (MWI) to measure the distance between the two spacecraft. Since the range is sensitive to the temporal and spatial changes in the Earth's gravity, its measurement calculates global monthly maps of Earth's mass distribution. GRACE-FO, additionally, hosts the first-ever space laser interferometer, the laser ranging interferometer (LRI). The LRI is a technology demonstrator that measures the range of three orders of magnitude more accurately than the MWI, i.e., at the sub-nanometer scale over short timescales. Hence, the future gravity missions GRACE-C(ontinuity) and Next Generation Gravity Mission (NGGM) will only host an evolved LRI-like instrument. We will present our research activities in analysing the LRI data to detect and remove short disturbances, as well as the experiments on the scale factor measurement system (SFMS) and steering mirror (FSM) that improve its implementation for future missions.

GR 4: GW I

Time: Tuesday 16:15–17:55 Location: ZHG008

GR 4.1 Tue 16:15 ZHG008

Predicting black-hole spins from hierarchical mergers of binary black holes — •Angela Borchers[1,2], Claire Ye[3], and Maya Fishbach[3] — [1]Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Callinstraße 38, 30167 Hannover, Germany — [2]Leibniz Universität Hannover, Callinstraße 38, 30167 Hannover, Germany — [3]Canadian Institute for Theoretical Astrophysics, 60 St George St, University of Toronto, Toronto, ON M5S 3H8, Canada

Stellar black holes often form binaries in dense stellar clusters. When these binaries merge, they produce remnant black holes, which, after some time, might find a black hole companion and merge again. We call these hierarchical mergers. Previous studies have shown that the spin distribution of black holes in hierarchical mergers peaks at 0.69, independent of the initial black hole spins and the merger generation. However, these mergers can produce recoil kick velocities large enough for remnants to be ejected from their clusters, which means they will not contribute to the black-hole spin distribution in the cluster. We have investigated what are the spins of black holes from hierarchical mergers when recoil kicks are considered. In this talk, I will show that the distribution of retained black holes is not identical to the distribution of all black holes. Besides, I will discuss how the distribution depends on the black-hole birth spins and the merger generation. Our results complement earlier studies in understanding the characteristics of black holes formed in hierarchical mergers, which is essential when identifying the formation origin of black holes from gravitational-wave observations.

GR 4.2 Tue 16:35 ZHG008

Fixing the dynamical evolution of self-interacting vector fields — •Marcelo Rubio — GSSI - L'Aquila, Italy

I will discuss the Cauchy problem of self-interacting massive vector fields, and explain why they often face instabilities and apparent pathologies. After showing that these issues are due to the breakdown of the well-posedness of the cor-

responding initial-value problem, I will characterize the well-posedness breakdowns and explicity show that they can be avoided by fixing the equations in a suitable way. As an application, I will numerically show that no Tricomi-type breakdown takes place in the quadratic case, and investigate initial configurations which lead to gravitational collapse and the formation of black holes.

GR 4.3 Tue 16:55 ZHG008

Full-spectrum analysis of gravitational waves from binary neutron star mergers — •Giulia Huez — Friedrich-Schiller-University of Jena, Jena, Germany

The gravitational-wave (GW) observation of the full-spectrum (inspiral-merger-postmerger) of a binary neutron star (BNS) merger can convey unique information on the nuclear matter that constitutes these compact objects. BNS are optimal targets for next-generation ground-based GW detectors, which would give the possibility to measure the astrophysical parameters with a higher precision with respect to current detectors. Thus, the development of waveform models for the full GW spectrum of BNS mergers is fundamental in order to minimize biases in the parameter estimation processes.

In this talk, a full Bayesian analysis of GWs from inspiral to postmerger is presented. I will review the waveform template used, based on effective-one-body model and numerical relativity simulations, and show preliminary results on neutron star matter properties.

GR 4.4 Tue 17:15 ZHG008

Probing gravity using black hole ringdown — •Pratik Wagle[1], Dongjun Li[2], Yanbei Chen[3], and Nicolas Yunes[2] — [1]Max Planck Institute for Gravitational Physics, Potsdam, Germany — [2]University of Illinois at Urbana Champaign, Urbana, IL, USA — [3]California Institute of technology, Pasadena CA, USA

The detection of gravitational waves from compact binary mergers by the LIGO/Virgo collaboration has opened new avenues for testing relativistic gravity. With future ground- and space-based gravitational wave detectors, we are poised to extract further insights into astrophysical events and investigate the implications for Einstein's theory of relativity in contexts where gravitational fields are both strong and dynamical. In this presentation, I will discuss recent advancements in the study of gravitational perturbations related to gravitational wave ringdown. I will highlight the necessity for these investigations and outline prospective research directions. Central to my discussion will be a novel approach that enables us to derive a "modified Teukolsky equation", a set of linear, decoupled differential equations that characterize the dynamical perturbations of non-Kerr black holes through the radiative Newman-Penrose scalars Ψ_0 and Ψ_4. This foundational work facilitates the examination of gravitational waves emitted during the ringdown phase of black hole coalescence within beyond GR frameworks applicable to black holes of any spin. Additionally, I will discuss the application of this approach in the context of a quadratic theory of gravity, where the metric and scalar fields exhibit non-minimal coupling, and calculate the QNM frequencies.

GR 4.5 Tue 17:35 ZHG008

Neural Network Assisted Reduced Order Modeling of Black Hole Mergers — •Julian Luca Berg[2], Frank Ohme[1], and Thomas Wick[2] — [1]Max Planck Institute for Gravitational Physics, Hannover, Germany — [2]Leibniz University Hannover, Germany

Since 2015, the detection of gravitational waves gives us the possibility to study objects in the universe such as black holes and neutron stars. By parameter estimation, we can approximate properties of these objects. This includes the masses, spins, and distances. To perform reliable parameter estimation, it is important to have precise and fast models for the corresponding gravitational waves. One approach to speed up numerical computations is reduced order modeling. In this presentation, an approach by J.S. Hesthaven and S. Ubbiali is applied to gravitational wave models that performs reduced order modeling with neural networks. Therein, a neural network is built that can quickly compute a reduced order model for a given set of parameters such that the solution is still a reliable approximation. Our approach is substantiated with some numerical simulations.

GR 5: CQG II

Time: Tuesday 16:15–17:35 Location: ZHG007

GR 5.1 Tue 16:15 ZHG007

Circular light rays in a general-relativistic medium — •Volker Perlick — Faculty 1, University of Bremen

In the 1970s Marek Abramowicz introduced a potential on spherically symmetric and static spacetimes whose corresponding equipotential surfaces he called the "relativistic Von Zeipel cylinders" because they are the relativistic analogues of the Von Zeipel cylinders known from Newtonian gravity. A characteristic feature of this potential, and of its generalisation to axisymmetric and stationary spacetimes which was introduced a few years later, is in the fact that its critical points give the location of circular lightlike geodesics. In this talk I will discuss a further generalisation of this potential whose critical points are the circular light rays in an isotropic medium. The medium may be non-dispersive or dispersive. The case of a cold plasma will be treated in particular. With the help of this potential several known theorems on the existence or non-existence of circular light rays can be extended from the case of light propagation in vacuum to the case of light propagation in a medium.

GR 5.2 Tue 16:35 ZHG007

Low velocity test of the speed of gravity — Eva Hackmann and •Claus Lämmerzahl — ZARM and GOC, University of Bremen, Bremen, Germany

The weak field approximation of the Einstein field equations are similar to the Maxwell equations. Furthermore, in analogy to the Maxwell equations also the Einstein equations cann be given a pre-metric form with a constitutive tensor. On the one hand, from this constitutive tensor the wave propagation can be derived. On the other hand, the various parts of the constitutive tensor can be measured by observing particle motion in the gravitational field. Restricting to isotropic constitutive quantities one obtains as a particular consequence, that from the gravitational attraction together with the Lense-Thirring effect the constitutive tensor can be determined. That means the speed of gravity can be calculated from the constritutive tensor and compared to the speed of light which agree on the level of 1%. This provides an independent test of the speed of gravity compared with the measurements provided by multimessenger observations of gravitational wave events.

GR 5.3 Tue 16:55 ZHG007

Standing waves in Bopp-Landé-Thomas-Podolsky generalised electrodynamics — •Altin Shala[1] and Volker Perlick[2] — [1]Center of applied space technology and microgravity — [2]University of Bremen

We investigate the feasibility probing BLTP generalized electrodynamics with standing wave experiments in terms of energy requirements. Two kinds of media are researched vacuum and two fluid cold plasma. Dispersion relations are found and compared. A new transversal plasma mode is found which has a lower energy requirement than the thick plasma like BLTP vacuum.

GR 5.4 Tue 17:15 ZHG007

relativistic dynamics of electrical matter in minkowski force — •Bin Su — Institut für Theoretische Physik TU-Berlin, Germany

Based on invariant and objectivity of physical law is an invariant formulation of the dynamics proposed for the interaction of the electrical matter under electromagnetic field, which may be completely called the relativistic dynamics in Minkowski force of electrical matter of points mass . Starting from these two relativistic principles - invariant physical law and constant light velocity [1] an initial charge beyond the initial mass of moving electrical matter is at first put forward according to corresponded relativistic dynamical equation. The dependence of the moving charge on its movement, velocity, leads the initial charge into the kinetic charge of the matter accompanied by its kinetic mass. We discuss then a relativistic mass to charge ratio of electron under a magnetic field as an application of this dynamical equation and get a new formulation of the mass to charge ratio, which might be more precisely than that in classical formulation [2]: if the Electrons move very more slowly than that of light then it approximates to classic one well-known.

[1] A. Einstein, *Grundzüge der Relativitätstheorie*, S42-S50, Springer Verlag, 12.1954 [2] Metzler Physik, S 232, www.schroedel.de

GR 6: BH Physics I

Time: Wednesday 11:00–12:25 Location: ZHG008

Invited Talk GR 6.1 Wed 11:00 ZHG008

Black hole dynamics from a mathematical perspective — •Dejan Gajic — Institut für Theoretische Physik, Universität Leipzig, Brüderstraße 16, 04103 Leipzig

I will present an overview of recent mathematical results on the dynamics of spacetimes arising from initial data perturbations of Kerr black holes, both from linear and nonlinear point of view. An important role is played by extremal black holes, which exhibit novel dynamical features, such as instabilities and criticality.

GR 6.2 Wed 11:45 ZHG008

Unmasking Black Hole Mimickers in Higher-Curvature Gravity — •Michael Florian Wondrak — Department of Astrophysics/IMAPP, Radboud Universiteit, Nijmegen, The Netherlands — Department of Mathematics/IMAPP, Radboud Universiteit, Nijmegen, The Netherlands

In higher-curvature gravity, Birkhoff's theorem no longer applies, i.e. the Schwarzschild black hole is no longer unique, but widens to a family of black hole mimickers, namely naked singularities and wormholes. Some naked singularities seem undistinguishable from Schwarzschild when the accreted matter is treated as pressureless in a simple analytical way. Closer to reality, however, with (beyond-GR)MHD simulations, those naked singularities can be ruled out by BH imaging as they dynamically form a hot and bright mass accumulation around the would-be horizon. So not only impacts the accuracy in modeling accreted matter the potential of ruling out BH mimickers, it also allows to constrain a variety of quantum-gravity theories based on their low-energy predictions.

GR 6.3 Wed 12:05 ZHG008

Wave optical imaging by a point-source scattering for a TNdS black hole — •Felix Willenborg[1,2], Dennis Philipp[1,2], and Claus Lämmerzahl[1,2] — [1]Zentrum für angewandte Raumfahrt und Mikrogravitation (ZARM), University of Bremen, 28359 Bremen, Germany — [2]Gauss-Olbers Center, c/o ZARM, University of Bremen, 28359 Bremen, Germany

The Taub-NUT spacetime is a curious solution of the Einstein's vacuum field equation due to the presence of conical singularities and their different interpretations for NUT charges $N \neq 0$. Gravitational lensing maps have shown the twisting of a background for light- and time-like geodesics, as well as the observation of the conical singularity in the Bonnor interpretation.

Several methods offer a theoretical description of these observations. Already mentioned are ray-optical methods by geodesics or the calculation of the scattering by the so-called amplification factor F by the description of time-delays t_d. In our work, we describe the calculation by a full wave equation using the Teukolsky equation, which allows access to all frequencies. To obtain fully analytical solutions, a small cosmological constant is considered, generalising the solution to Taub-NUT-de Sitter (TNdS). We observe the scattering of a monochromatic point source to an observer at a larger distance from the black hole. Afterwards, we briefly discuss the method and present results for Schwarzschild-de Sitter at very low frequencies in a wave-optical approach as a simple model. Finally, we present results for TNdS and how these change with the parameter variation.

GR 7: Cosmo I, Relastro II, GW II

Time: Wednesday 13:30–15:50 Location: ZHG008

GR 7.1 Wed 13:30 ZHG008

Backreaction and Cosmic Butterflies: what simulations can tell us about inflation — •Angelo Caravano — Institut d'Astrophysique de Paris, France

In this talk, I will describe how lattice simulations can improve our understanding of the inflationary epoch of the Universe. I will focus on two examples: first, a model of axion inflation where the inflaton couples to a gauge field via a Chern-Simons interaction; and second, a single-field inflation model with a localized deviation from slow-roll. I will demonstrate how nonlinear effects significantly impact the inflationary dynamics and their predictions, even in cases conventionally believed to be under perturbative control. This makes lattice simulations essential for interpreting both large-scale observables (like large-scale structure and the CMB) and small-scale observables (such as primordial black holes and gravitational wave backgrounds).

GR 7.2 Wed 13:50 ZHG008

Non-linear structure formation in Horndeski gravity — •Ashim Sen Gupta — Bielefeld University, Bielefeld, Germany

Precision cosmology is poised to enter a new era with the advent of Stage IV surveys, such as the Legacy Survey of Space and Time (LSST) and the Euclid satellite. With it will come the ability to probe scales of the universe where non-linear gravitational physics plays a strong role in the formation of large-scale structures (LSS). This provides an opportunity to constrain the elusive set of Modified Gravity (MG) theories with screening mechanisms, theories which can evade classical tests of General Relativity (GR). In this talk, I shall discuss my development of the hybrid particle-mesh code, Hi-COLA. It can rapidly simulate matter clustering for the Horndeski class of scalar-tensor theories. I will also discuss the phenomenology uncovered through the use of Hi-COLA, and present an analysis of the effects that give rise to the enhancements of the Horndeski matter power spectrum relative to GR. I shall additionally touch on my work to extend the scope of Hi-COLA to include the rarely-simulated K-mouflage gravity. Finally, I will conclude with an evaluation of the cutting edge in numerically predicting matter clustering for modified gravity, through which we will see the promise in the prospects of bridging theory and observation that will enable the application of Stage IV constraints.

GR 7.3 Wed 14:10 ZHG008

Resolving σ_8 tension with time-varying gravitational constant — •Tilek Zhumabek[1], Azamat Mukhamediya[2], Hrishikesh Chakrabarty[1], and Daniele Malafarina[1] — [1]Department of Physics, School of Sciences and Humanities, Nazarbayev University, Astana 010000, Kazakhstan — [2]Department of Electrical and Computer Engineering, School of Engineering and Digital Sciences, Nazarbayev University, Astana 010000, Kazakhstan

We consider a modified gravity model, dubbed GCDM, with running gravitational constant $G(a)$, to test its imprints on the growth of structure. Using Redshift Space Distortion (RSD) measurement results, we show a tension at the 3σ level between the best fit ΛCDM and the corresponding Planck18/ΛCDM parameters ($w_0 = -1$, $\Omega_m = 0.31$, $\sigma_8 = 0.81$). Unlike many modified gravity based solutions that overlook the scale dependence and model specific background evolution, we study this problem in the broadest possible context by incorporating both factors into our investigation. We obtain the model specific background quantities and perform a full perturbation analysis of the model to demonstrate a scale dependence in the growth equation. Fixing the scale to $k = 0.1h$ Mpc^{-1} and introducing a specific functional form for $G(a)$ with one free parameter, we conducted likelihood analysis of RSD selected data. This analysis reveal that GCDM can bring the tension level within 1σ while maintaining the deviation from Newton's gravitational constant at the fifth order.

GR 7.4 Wed 14:30 ZHG008

Tidal resonances of stars in precessing orbits around a spinning black hole — •Matteo Stockinger[1] and Masaru Shibata[1,2] — [1]Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut), Am Mühlenberg 1, Potsdam-Golm, Germany — [2]Center for Gravitational Physics and Quantum Information, Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto, Japan

Tidal disruptions of stars on the equatorial plane orbiting Kerr black holes have been widely studied. However thus far, there have been fewer studies of stars in inclined precessing orbits around a Kerr black hole.

We use the tensor virial equations to analyze perturbatively the influence of the precession on the star.

We show the presence of possible resonances in these systems for typical physical parameters of black hole-neutron star binaries in close orbits or of a white dwarf/an ordinary star orbiting a supermassive black hole.

This suggests the presence of a new instability before the tidal disruption limit is encountered in such systems.

GR 7.5 Wed 14:50 ZHG008

Simulating Relativistic Binary-Single and Binary-Binary Encounters — •Felix Heinze and Bernd Brügmann — Friedrich-Schiller-Universität Jena, Theoretisch-Physikalisches Institut, Fröbelstieg 1, 07743 Jena

The motion of N bodies under their mutual gravitational interaction has been a central problem in astrophysics and celestial mechanics for centuries, dating back to 1687, when Isaac Newton published his Principia. Despite centuries of progress, gravitational N-body systems remain a rich and active field of research, with binary-single and binary-binary encounters forming an important subset of interest in astrophysics. For N>2, even Newtonian systems generally defy analytical solutions, exhibiting complex dynamics and chaotic behavior. For the problem of N black holes moving in close proximity and at high speeds, relativistic effects must be taken into account, introducing additional complexity to the solutions.

In this talk, we will present the first results of a series of fully relativistic simulations of black hole binary-single and binary-binary encounters using the numerical relativity code BAM. These simulations reveal intricate dynamics and characteristic waveforms that are absent in (Post-)Newtonian N-body simulations or fully relativistic simulations limited to two black holes. The results highlight the importance of relativistic effects in shaping the outcomes of close black hole interactions and provide new insights into their gravitational wave phenomenology.

GR 7.6 Wed 15:10 ZHG008

Stochastic gravitational wave background from Cosmic B-L Symmetry breaking — •Alexander Schneider, Gudrid Moortgart-Pick, and Tom Krokotsch — University of Hamburg, Hamburg, Germany

The stochastic gravitational wave background could be a window in the early universe, possibly even before the decoupling of the cosmic microwave background. Studying in detail such a stochastic gravitational background is therefore also a possible way to find physics beyond the standard model.

A proposed background rises due to the spontaneous B-L symmetry breaking, occurring around the grand unification scale in certain cosmogical models.

In the talk, we concentrate in particular on the question, whether the gravitational waves produced in such an event could be detected with future high frequency detectors.

GR 7.7 Wed 15:30 ZHG008

Scattering and dynamical capture of two black holes — •Simone Albanesi — Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, 07743, Jena, Germany — INFN sezione di Torino, Torino, 10125, Italy

All gravitational wave (GW) events detected by the LIGO-Virgo-KAGRA collaboration have been generated by the coalescence of compact binaries, mostly binary black holes. The dynamics of these systems typically circularize by the time they enter the detector's sensitivity band, resulting in signals with monotonically increasing frequency. However, dense astrophysical environments, such as globular clusters, may host populations of black holes undergoing scatterings and dynamical captures, resulting in significantly richer phenomenologies that strongly deviate from the quasi-circular scenario. Full Bayesian analysis suggest that the event GW190521 may have originated from such a system, highlighting the need for accurate descriptions to fully exploit the scientific potential of current and future gravitational wave detectors. We study scatterings and dynamical captures for comparable mass spin-aligned systems, using the semi-analytical effective-one-body model TEOBResumS-Dalí and numerical relativity simulations performed with the code GR-Athena++. We focus, in particular, on the transition from unbound to bound orbits in the low energy regime. Challenges and future steps, both on the numerical and analytical fronts, are also discussed.

GR 8: GW III

Time: Wednesday 13:30–14:50 Location: ZHG007

GR 8.1 Wed 13:30 ZHG007

Systematic Errors In Gravitational Waveform Models — •Max Melching[1], Frank Ohme[1], and Sumit Kumar[1,2] — [1]Max Planck Institute for Gravitational Physics, Callinstraße 38, 30167 Hannover, Germany — [2]Utrecht University, Heidelberglaan 8, Utrecht 3584 CS, Netherlands

Measurements of gravitational wave source properties rely on waveform models in order to compare the detector data with theoretical signal predictions and find the best-fitting parameters. However, the waveform models used today are not entirely faithful representations of numerical relativity due to the high computational cost of generating accurate simulations. Instead, several approximate models are used, which can lead to differences in the inferred results. Therefore, it is crucial to be able to describe and understand model-induced uncertainties, so-called systematic errors.

To date, however, there is no universal way to do so. In this talk, I will introduce geometric ideas from the Fisher-matrix formalism that allow interpreting signal differences as measurement uncertainties in the associated parameter space. This includes a discussion of the estimates derived in this formalism, e.g. about their accuracy. Additionally, I will talk about the interplay between systematic errors and the calibration uncertainty of gravitational wave detectors, addressing questions like: How to build up a reliable framework to account for them in parameter estimation? Can the two types of errors be distinguished? Which of them is dominant?

GR 8.2 Wed 13:50 ZHG007

Systematic Biases in Estimating the Properties of Black Holes Due to Inaccurate Gravitational-Wave Models: Part I — Arnab Dhani[1], •Sebastian H. Völkel[1], Alessandra Buonanno[1,2], Hector Estelles[1], Jonathan Gair[1], Harald P. Pfeiffer[1], Lorenzo Pompili[1], and Alexandre Toubiana[1] — [1]Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Am Mühlenberg 1, Potsdam 14476, Germany — [2]Department of Physics, University of Maryland, College Park, MD 20742, USA

Gravitational-wave observations of binary black-hole coalescences are expected to address outstanding questions in astrophysics, cosmology, and fundamental physics. Realizing the full discovery potential of upcoming LIGO-Virgo-KAGRA observing runs and new ground-based facilities hinges on accurate waveform models. We present a comprehensive state-of-the-art analysis of binary black hole waveform systematics. Using linear-signal approximation methods and Bayesian analysis, we start to assess our readiness for what lies ahead using two state-of-the-art quasi-circular, spin-precessing models: `SEOBNRv5PHM` and `IMRPhenomXPHM`. Future progress in analytical calculations and numerical-relativity simulations, crucial for calibrating the models, must target regions of the parameter space with significant biases to develop more accurate models. Only then can precision gravitational wave astronomy fulfill the promise it holds. In this talk, part 1 of 2, we outline the importance of such studies, introduce waveform modeling and statistical methods. Review and discussion of our results will be provided in another talk as part 2. [arXiv:2404.05811]

GR 8.3 Wed 14:10 ZHG007

Systematic Biases in Estimating the Properties of Black Holes Due to Inaccurate Gravitational-Wave Models: Part II — Arnab Dhani[1], Sebastian H. Völkel[1], Alessandra Buonanno[1,2], Hector Estelles[1], Jonathan Gair[1], •Harald P. Pfeiffer[1], Lorenzo Pompili[1], and Alexandre Toubiana[1] — [1]Max-Planck-Institute for Gravitational Physics, Am Mühlenberg 1, 14476 Potsdam — [2]Dept. of Physics, University of Maryland, College Park, MD 20742, USA

Gravitational-wave observations of binary black-hole coalescences are expected to address outstanding questions in astrophysics, cosmology, and fundamental physics. Realizing the full discovery potential of upcoming LIGO-Virgo-KAGRA observing runs and new ground-based facilities hinges on accurate waveform models.

This talk is part 2 of two talks presenting an in-depth study of the impact of parameter estimation biases due to imperfect waveform models. Using the techniques presented in part 1, we analyse in depth three prototypical binaries expected to occur in future GW detectors, and find potentially large errors in the estimated parameters (among them component masses and distance) if today's waveform models are utilised. We furthermore highlight were in BBH parameter space significant parameter estimation errors are most likely, and how widespread and how severe they are.

GR 8.4 Wed 14:30 ZHG007

Fighting Gravity Gradient Noise with Gradient-Based Optimization at the Einstein Telescope — •Patrick Schillings and Johannes Erdmann — III. Physikalisches Institut A, RWTH Aachen University

The Einstein Telescope is a third-generation, underground gravitational wave detector that will allow us to measure gravitational waves with significantly improved precision. Its 'xylophone' arrangement is designed to extend the frequency range down to a few Hertz. To improve the sensitivity of the low-frequency interferometer, one needs to mitigate the gravitational effect of density fluctuations in the surrounding rock caused by seismic activity, which result in so-called Newtonian noise in the detector. To achieve that, an array of seismometers will be installed around the mirrors. Expensive boreholes will have to be drilled in order to place these seismometers, which will limit the total number of seismometers that can be placed for a given budget. Therefore, the available resources should be used optimally in terms of predicting the Newtonian noise from the seismometer data. This talk will focus on a differential approach to this optimization problem, which leads to an improvement in terms of noise reduction and runtime compared to methods that were used before.

GR 9: Poster

Time: Wednesday 16:15–18:15 Location: ZHG Foyer 1. OG

GR 9.1 Wed 16:15 ZHG Foyer 1. OG

Quantum gravity without trouble — •René Friedrich — Strasbourg

Lorentzian spacetime, incredibly, proves to be a 100-year-old optical illusion, an impossible object: The banal fact of the non-zero length of worldlines of lightlike light rays shows us that spacetime diagrams and spacetime manifolds have Euclidean metric, because if they were Lorentzian (pseudo-Riemannian), the length of lightlike phenomena would be zero. Accordingly, spacetime is not fundamental, it is mere observation, and the underlying Lorentz-invariant real universe (compatible with quantum mechanics) consists of worldlines in absolute 3D space, each worldline being parameterized by its respective proper time. - Regarding gravity, we can use the fact that gravity may be described not only as curved spacetime, but also equivalently as gravitational time dilation in threedimensional flat space: A comparison Schwarzschild metric / Minkowski metric shows that the difference between flat and curved spacetime can be entirely reduced to gravitational time dilation. - Quantum gravity in only one sentence: Gravity in the form of gravitational time dilation slows down the proper time frequency of the worldlines of quantum systems with mass that are parameterized by their respective proper time. - More: Quantum gravity without trouble, Quantengravitation ohne Mühe, La gravité quantique sans peine.

GR 9.2 Wed 16:15 ZHG Foyer 1. OG

Comment on the Sommerfeld Fine Structure Constant tension — •Manfred Geilhaupt — HS Niederrhein Mönchengladbach

In todays physics, the fine-structure constant (alpha) is a fundamental physical constant which quantifies the strength of the electromagnetic interaction between elementary charged particles. The constant alpha was introduced in 1916 by Arnold Sommerfeld. However, alpha still is an unsolved theoretical and even experimental physical problem up to now! Alpha from atomic interferometric experiments shows a large difference compared to their high accuracy:

1. 2018 Parker et al. 1/137.035999046(27), atomic interferometer experiment
2. 2020 Morel et al. 1/137.035999206(11), atomic interferometer experiment
3. 2011 More et al. 1/137.035999084(15), quantum hall experiment. The 2011 last experimental von Klitzing constant RK=25812.807442(30)Ohm accuracy can be increased by an order of magnitude today. So the RK=e^2/h makes the difference.
4. 2019 form Codata given alphaC= 1/137.035999177
5. 2019 from Codata given alphaRKC=1/137.035999127 based on RKC= 25812.807450(00)Ohm (exact defined) does not match. The presentation contains two answers to the question about tension. Critics appreciated. (A. Einstein: Ein Problem kann man nicht mit der Denkweise lösen, durch die es entstanden ist.)

GR 9.3 Wed 16:15 ZHG Foyer 1. OG

What was before the Big Bang? — •Jürgen Brandes — Karlsbad, Germany

The Einstein interpretation (EI, classical general theory of relativity) says: Before the Big Bang there was nothing, neither space, nor time, nor space-time. But the EI is contradicted by the measurement of two different Hubble constants, because the expansion of the universe cannot take place at two different speeds at the same time. That leaves the Lorentz interpretation (LI): The Big Bang is the explosion of a supermassive object. Its mass must come from somewhere. The simplest assumption: by accretion from emissions from neighboring galaxy clusters on a large scale analogous to the growth of galaxy nuclei on a small scale. This is supported by the observation of galaxies older than the Big Bang [1]. **The main objection:** Supermassive objects are black holes and cannot explode. The proposed solution can also be found at *www.grt-li.de* or [2].

[1] Labbé, I., van Dokkum, P., Nelson, E. *et al.* A population of red candidate massive galaxies 600 Myr after the Big Bang. *Nature* 616, 266*269 (2023) and Olivia Dittrich Berliner Morgenpost 6.3.2023

[2] J. Brandes, J. Czerniawski, L. Neidhart: *Special and general relativity for physicists and philosophers* VRI: 2023, chapter 21, 22, page 279

GR 9.4 Wed 16:15 ZHG Foyer 1. OG

Die Dimensionale Physik erklärt den Aufbau der Naturkonstanten c, G und h nur aus der ART heraus — •Christian Kosmak — Working Group Dimensional Physics, Würzburg

In der Theorie der Dimensionale Physik wird der Ansatz gewählt, dass eine Raumzeitdichte die Quelle der Raumzeitkrümmung ist. Jegliches Masse-Energie-Äquivalent ist eine direkte geometrische Abbildung in der Raumzeit selbst. Dadurch erhält die Raumzeit Grenzen zu einer höherdimensionalen Raumzeit und in unendlich vielen niederdimensionalen Raumzeiten. Diese Grenzen bestimmen den Aufbau der Naturkonstanten c, G und h. Das Plancksche Wirkungsquantum und dadurch die Compton-Wellenlänge eines beliebigen Objektes (Raumzeitdichte) ergeben sich zwingend aus der Struktur der Raumzeit. Dies bedeutet, dass die Allgemeine Relativitätstheorie vorgibt, wie die Quantenfeldtheorie aufgebaut sein muss. Die Raumzeit ist nicht nur eine dynamische Bühne, sondern der einzige Akteur. Internetseite: https://dimensionale-physik.de/ YouTube-Kanal: https://www.youtube.com/@DimensionalePhysik

GR 9.5 Wed 16:15 ZHG Foyer 1. OG

Relativity. Exclusively a speed problem. — •Osvaldo Domann — Stephanstr. 42, 85077 Manching, Germany

Space and time are variables of our physical world that are intrinsically linked together. Laws that are mathematically described as *independent of time*, like the Coulomb and gravitation laws, are the result of repetitive actions of the *time variations* of linear momenta. To arrive to the relativistic transformation equations Einstein omitted the physical interaction of light with the measuring equipment, interaction which makes that light speed is the same in all inertial frames. The results of the omission are transformation rules that show the unphysical time dilation and length contraction. The Lorenz transformation applied on speed variables instead of space and time, as shown in the proposed approach, is formulated with absolute time for all frames and integrates the physical interactions at measuring instrument, which produce the constancy of light speed in all inertial frames. Special relativity with its wrong time dilation and length contraction is used by our theorists to explain experimentally measured data that cannot be explained with the standard model. The results are models like general relativity as the theory for gravitation, a wrong geometric theory not compatible with quantum mechanics. The methodology used by our theorists is equal to the one used to defend geo-centrism. Instead of accepting the new approach of helio-centrism, wrong epicycles were added to geo-centrism resulting in a catastrophic standard model. More at www.odomann.com

GR 9.6 Wed 16:15 ZHG Foyer 1. OG

Impact of Topological Structures on Neutron Star Rotation and Their Observational Significance — •Debojoti Kuzur — Raghunathpur College, Purulia, West Bengal, India

Rotational irregularities are an important observational feature of most pulsars, often manifesting as glitches which are sudden increases in spin angular velocity. Despite extensive study, the underlying mechanism of these glitches remains unresolved. In this research, we explore the role of nontrivial topological defects, specifically Nambu-Goto type cosmic strings, in influencing pulsar spin irregularities. These one-dimensional defects, formed during symmetry-breaking phase transitions, can interact with neutron stars when trapped within their cores.

Our findings suggest that such cosmic strings can couple their tension with the star's angular velocity, resulting in abrupt rotational changes characteristic of pulsar glitches. Additionally, we examine how this coupling could generate detectable gravitational waves, comprising both continuous and burst-like components. The evolution of string cusps within neutron star cores and changes in the star's mass quadrupole moment due to rotation may produce distinctive gravitational wave signatures, potentially detectable by advanced LIGO (advLIGO) within its noise threshold.

This study establishes a possible link between cosmic strings, pulsar glitches, and gravitational wave emissions, offering a framework to test the existence and astrophysical effects of topological defects through observational data.

GR 9.7 Wed 16:15 ZHG Foyer 1. OG

The identification of dark matter — •Albrecht Giese — Taxusweg 15, 22605 Hamburg

The main theme of the dark matter phenomenon is that the galaxies, and also the stars around the galaxies, are rotating at too high a speed. It is considered to be one of the biggest problems in modern physics. This is because the traditional explanation of dark matter as particles, or alternatively a modified law of gravity (MOND), has been largely disproved. This concerns the assumption of special particles due to 'dynamical friction' around big galaxies with orbiting dwarfs, and MOND due to the motion distribution in dwarf galaxies.

The observable spatial distribution of the dark matter effect around galaxies and clusters leads to a solution, because it is identical to the distribution of photons. The result is a different - mass-independent - law of gravity. This contradicts Newton's law of gravity and Einstein's GRT, but is consistent with all observations. And so it is also a test of Einstein's interpretation of relativity.

This solution gives correct quantitative results where data exist, without using free parameters.

Further info: ag-physics.org/gravity

GR 9.8 Wed 16:15 ZHG Foyer 1. OG

Quantum gravity by elimination of spacetime - From the 4D manifold to Lorentz-invariant 1D worldlines — •René Friedrich — Strasbourg

The current interpretation of general relativity (based on the concept of Einstein and Grossmann in 1913) is a sort of "astrometry": Curved spacetime is perfect for astronomical observation and experimental physics, but not for theoretical

physics because it is complex, redundant and does not admit the smooth decantation of fundamental conclusions (including quantum gravity). Moreover, since 1905 we know that each particle is following its own clock, that there is no common absolute time axis, and, by consequence, that spacetime is no longer a fundamental notion as it was within Newtonian spacetime. - And gravity? It will also be shown that gravity is perfectly equivalent to gravitational time dilation, acting on onedimensional worldlines in uncurved threedimensional space, paving the way for a worldline-based concept that is compatible with quantum mechanics: Worldlines of quantum systems with mass are parameterized by their respective proper time frequency, and gravity in the form of gravitational time dilation is just modifying this frequency of the worldline. - Book: Quantum gravity without trouble, Quantengravitation ohne Mühe, La gravité quantique sans peine.

GR 9.9 Wed 16:15 ZHG Foyer 1. OG

Über den Wirklichkeitsgehalt der Materie — •Roland Schmidt — Schwalbenweg 21, 34225 Baunatal

In der Newtonschen Theorie ist Wirklichkeit der determinierte Ablauf eines objektiven und allgemein geltenden Geschehens. In der relativistischen Nachbesserung geht dieser absolute Charakter verloren. Es lassen sich nunmehr ausschließlich subjektiv erlebte Wirklichkeiten gegeneinander abgleichen. Der Umstand, dass diese Subjektivierung durch die klassische Elektrodynamik erzwungen wird, scheint keineswegs zufällig; spielt doch bei der metaphysischen Betrachtung subjektiver Wahrnehmung die Idee vom Licht eine ganz entscheidende Rolle. Allerdings sind subjektive Wahrnehmungen allein auf klassischer Grundlage nicht erklärbar. Das abschließende Vordringen elektromagnetischer Potenzialität in die zerebralen Zusammenhänge eines Subjekts erfordert nämlich Ansätze quantenphysikalischer Art. Ich werde zeigen, dass sich die Aufspaltung der physikalischen Theorie in einen klassischen und quantenmechanischen Zweig durch eine Subjektivierung der elektromagnetischen Wechselwirkungen beheben lässt. Demnach resultieren alle klassischen Kategorien wie Raum, Gegenwart oder das Dasein gegenständlicher Bedeutsamkeiten aus einem grundlegenden Symmetriebruch, der mit dem Erleben zerebral-feststellender Zustandssysteme einhergeht. Empirischer Ausdruck davon ist die kosmologische Rotverschiebung, die in meiner subjektivierten Auslegung aus dem Umstand folgt, dass die elektromagnetische Trägheit grundlegender Teilchen gegen den kosmologischen Ereignishorizont hin allmählich verschwindet.

GR 9.10 Wed 16:15 ZHG Foyer 1. OG

Zur Dynamik des Raumes, oder: Was ist Zeit? — •Heinrich Feuerbach — Warschau,Polen

Die Frage danach, was "Zeit" eigentlich ist, ist die wohl tiefgründigste Frage der Physik. Bisher wurden Zeit und Raum als ein globaler, statischer Hintergrund betrachtet oder als eine Bühne, vor der sich die physikalischen Prozesse abspielen. Der Autor stellt das Gegenteil vor: Raum und Zeit als aktive Mitspieler. Dazu wird der Raum als äußerst dynamisch angenommen.

Mit diesen vier Postulaten:

1. Der Raum expandiert in vier Dimensionen mit Lichtgeschwindigkeit; 2. Diese Expansion ist Zeit; 3. Zeit ist äquivalent zur Lichtgeschwindigkeit; 4. Masse ist ein Widerstand zur Raumexpansion und antivalent zur Zeit

entsteht eine erweiterte geometrische Erklärung für die Gravitation.

Die gravitative Zeitdilatation und -Feldstärke ergeben sich inhaltlich und mathematisch direkt aus diesen Postulaten. Darüberhinaus werden folgende Begriffe eingeführt:

- Relative Lichtgeschwindigkeit; - Geschwindigkeitserhaltungssatz; - Strömungs-Widerstands-Prinzip; - Lokale Zeit; - Zeitliche Höhe; - Oberraum; - Gravitativer Widerstand.

Mathematisch wird aus den Postulaten eine DGL formuliert und deren Lösung für den Schwarzschildfall vorgestellt. Die Vierdimensionalität der Raumzeit selbst wird über Quaternionen abgebildet. Abschliessend werden mögliche Tests, neue Vorhersagen, und der Zusammenhang zur ART beschrieben.

GR 9.11 Wed 16:15 ZHG Foyer 1. OG

Kaluza from particles to galaxies — •Thomas Schindelbeck — IRAEPH Mainz

Reducing Kaluzas original ansatz to inserting the electromagnetic potentials into a 5D metric and dropping all other assumptions provides a coherent, consistent and quantitative description of phenomena related to particles and particle interaction, e.g.

1) with boundary condition spin 1/2 a convergent series of quantized particle energies, with limits given by the energy values of the electron and the Higgs vacuum expectation value,

2) electromagnetic and gravitational terms will be linked by a series expansion,

3) minor terms in the metric will give a term in the order of magnitude of vacuum density / cosmological constant,

4) the interpretation as a 5D deSitter space gives an expression for the Baryonic Tully Fisher Relation of galactic rotation curves that can be traced back to the particle level.

The model can be expressed ab initio, i.e. without free parameters.

https://zenodo.org/record/3930485

GR 9.12 Wed 16:15 ZHG Foyer 1. OG

Visualizing Curved Spacetime: Curvature Approximation with Cosmological Sector Models via a Web App — •Vassilios Marakis, Corvin Zahn, and Ute Kraus — Universität Hildesheim

The sector model provides a visualization of curved spacetime by dividing the coordinate space into discrete blocks of flat Minkowski space. By applying the Regge calculus and block-to-block transformations, it is possible to approximate the curvature values of the Riemann curvature tensor at specific points in spacetime. Through a web application, we study the effectiveness of this visual approach in estimating these values and examine how increasing the refinement of the coordinate space improves the accuracy of the approximation. This method is demonstrated using a cosmological example featuring a positive cosmological constant.

GR 9.13 Wed 16:15 ZHG Foyer 1. OG

Discoveries at the Time Triangle of Sun, Earth and Moon — •Hans-Otto Carmesin — Athenaeum, Harsefelder Str. 40, 21680 Stade — Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen

Navigation in space requires reliable and precise clocks on spacecrafts and celestial bodies. For instance, these are essential in order to measure the light travel distance in an interplanetary mission. In order to achieve such time standards in the interplanetary space, general relativity is used, and convenient as well as appropriate frames of reference must be developed (Ashby 2024).

An analysis of the triple Sun, Earth and Moon exhibits an unrealistic idealization inherent to present - day relativity (Carmesin 2025). This analytic result is equivalently transferred to GPS satellites, and these permanently confirm this result empirically.

In general, physically realistic frames can obtained with help of a classical key measurement. This overcomes the idealization and provides precise and reliable frames for interplanetary navigation and beyond. More generally, a wave function is provided that is fundamental in the dynamics of space.

Ashby, Neil; Patla, Bijunath R. (2024): A Relativistic Framework to estimate Clock Rates on the Moon. The Astronomical Journal, 168 (112), 14pp. Carmesin, H.-O. (2025): On the Dynamics of Time, Space and Quanta. Berlin: Verlag Dr. Köster. More information: https://www.researchgate.net/profile/Hans-Otto-Carmesin

GR 9.14 Wed 16:15 ZHG Foyer 1. OG

Solar-like Flares Generated in Strongly Magnetised Binary Neutron Star Merger Remnants — •Jinliang Jiang[1], Harry Ho-yin Ng[1], Michail Chabanov[1,2], and Luciano Rezzolla[1,3,4] — [1]Institute for Theoretical Physics, Goethe University, Max-von-Laue-Str. 1, 60438 Frankfurt am Main, Germany — [2]Center for Computational Relativity and Gravitation School of Mathematical Sciences, Rochester Institute of Technology, 85 Lomb Memorial Drive, Rochester, New York 14623, USA — [3]School of Mathematics, Trinity College, Dublin 2, Ireland — [4]Frankfurt Institute for Advanced Studies, Ruth-Moufang-Str. 1, 60438 Frankfurt am Main, Germany

We investigate the impact of the magnetic-field strength on the long-term (i.e., 200ms) and high-resolution (i.e., 150m) evolutions of the "magnetar" resulting from the merger of two neutron stars with a realistic equation of state. For sufficiently large magnetic fields, we observe the loss of differential rotation in the merger remnant and the generation of magnetic flares in the outer layers of the remnant that have several similarities with solar flares. These flares, that are driven by various magneto-hydrodynamics instabilities and in particular by the Parker instability, are responsible not only for intense and collimated Poynting flux outbursts, but also for low-latitude emissions. The novel long-term phenomenology presented here offers the possibility of seeking corresponding signatures from the observations of short gamma-ray bursts and hence revealing the existence of a long-lived strongly magnetized remnant.

GR 9.15 Wed 16:15 ZHG Foyer 1. OG

Artemis, the Lunar Standard Time and Beyond — •Hans-Otto Carmesin — Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen

The currently running Artemis project includes the implementation of a Moon station. For it, a Standard Lunar Time is currently being developed. For that purpose, and in general, appropriate reference frames must be developed (Ashby 2024, p. 1). I present a symmetry transformation that provides appropriate reference frames in general (Carmesin 2025). These symmetry based frames provide especially simple laws of general relativity: essentially the laws proposed by Einstein. These appropriate frames are confirmed by the Spacelab and by GPS satellites. I predict the times shown by clocks at various places in the universe: at Earth, at spacecrafts, at the Moon, at planets and at other celestial bodies. The Artemis mission can test some typical predictions.

Ashby, Neil; Patla, Bijunath R. (2024): A Relativistic Framework to estimate Clock Rates on the Moon. The Astronomical Journal, 168 (112), 14pp.

Carmesin, H.-O. (2025): On the Dynamics of Time, Space and Quanta. Berlin: Verlag Dr. Köster.

More information: https://www.researchgate.net/profile/Hans-Otto-Carmesin

GR 9.16 Wed 16:15 ZHG Foyer 1. OG

Analysis of Global Time Dilation — •Yang Jacky[1] and Hans-Otto Carmesin[1,2,3] — [1]Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen — [2]Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — [3]Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade

We analyze the global concept of time. Firstly, we use the global flatness of space, in order to derive a global uniform evolution of time. Thereby, we use the ΛCDM model with a homogeneous universe.

Secondly, we extend that theory by heterogeneity. For it, we apply the linear growth theory. As a theoretical tool, we use the volume dynamics, see Carmesin (2024).

Thirdly, we analyze the data of the Hubble tension, in order to derive a global time evolution therefrom.

In all cases, we evaluate the age of the universe. Thereby, we use cosmological parameters achieved by the Planck collaboration (2020).

Fourthly, we analyze the global time evolution by comparing and critically discussing the above three methods.

Carmesin, H.-O. (2024): How Volume Portions Form and Found Light, Gravity and Quanta. Berlin: Verlag Dr. Köster.

Planck Collaboration (2020): Planck 2018 results. VI. Cosmological parameters. Astronomy and Astrophysics, pp 1-73.

GR 9.17 Wed 16:15 ZHG Foyer 1. OG

Investigation of the Dynamics of Space and Energy at a Black Hole — •Renner Ivan[1], Neumann Jeremy[1], and Carmesin Hans-Otto[1,2,3] — [1]Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — [2]Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — [3]Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen

We investigate the dynamics of space and energy at a black hole. For it, we use the exactly derived dynamics of volume in nature (Carmesin 2024). Thereby, we use computer experiments. In particular, we study the simultaneous formation, annihilation and propagation of volume portion in a statistical manner at a black hole. Hereby, we discover critical values that characterize the dynamics at a macroscopic level. We compare our findings with observation.

Carmesin, H.-O. (2024): How Volume Portions Form and Found Light, Gravity and Quanta. Berlin: Verlag Dr. Köster.

Akiyama, Kazunori and others (2019): First M87 Event Horizon Telescope Results. IV. Imaging the Central Supermassive Black Hole. The Astrophysical Journal. 875, pp 1-17.

GR 9.18 Wed 16:15 ZHG Foyer 1. OG

Universal Quantization Discovered with Special Relativity — •Hans-Otto Carmesin — Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen

Quantum physics is a very successful field of science with omnipresent relevant applications in everyday life. An exciting question is still, what is the fundamental reason for the fact of quantization.

Curved space, light waves and gravity provide the fact of quantization with a universal constant of quantization (Carmesin 2023). This result is improved here: The used conditions are minimized. Thus, the achieved insight is maximized. Here, the only used conditions are flat space, light waves and reflection. The result shows that quantum physics is a very fundamental and ideal fact of nature (Carmesin 2025).

In teaching, the Doppler effect is analyzed in the context of a radar control.

Carmesin, H.-O. (2023): Students Exactly Derive Quantization and its Universality. PhyDid B, FU Berlin, pp 39-44.

Carmesin, H.-O. (2025): On the Dynamics of Time, Space and Quanta. Berlin: Verlag Dr. Köster.

More information: https://www.researchgate.net/profile/Hans-Otto-Carmesin

GR 9.19 Wed 16:15 ZHG Foyer 1. OG

Discovery of Real and Idealized Frames with GPS Satellites — •Hans-Otto Carmesin — Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen

The GPS navigation system is omnipresent in modern traffic and navigation (Ashby 2024). Moreover, the GPS satellites provide very precise and multiply related measurements of space and time. Students from class 10 can analyze such relations with linear and quadratic equations, including their inverse terms.

Thereby, they discover an idealization inherent to the present - day theory of special relativity and of general relativity (Carmesin 2025). This analytic result is permanently confirmed empirically by the working of the GPS navigational system.

In general, a symmetry transformation provides realistic frames. This provides fundamental insights about time, space and frames that are essential for the navigation of spacecrafts in interplanetary space and beyond.

Ashby, Neil; Patla, Bijunath R. (2024): A Relativistic Framework to estimate Clock Rates on the Moon. The Astronomical Journal, 168 (112), 14pp.

Carmesin, H.-O. (2025): On the Dynamics of Time, Space and Quanta. Berlin: Verlag Dr. Köster.

GR 10: Cosmo II

Time: Thursday 13:30–15:35 Location: ZHG008

Invited Talk GR 10.1 Thu 13:30 ZHG008

Probing the cosmic large-scale structure beyond the average — •Cora Uhlemann — Bielefeld University, Germany

The cosmic web of structure arises from the delicate interplay between the gravitational pull of dark matter and the accelerated expansion driven by dark energy. Galaxies form within this intricate skeleton of dark matter, making galaxy surveys powerful laboratories for exploring fundamental physics. The Euclid space telescope will map the distribution of galaxies across most of the sky, spanning over 10 billion years of cosmic history. Analysing billions of galaxies across vast cosmic volumes poses a significant big-data challenge, involving complex nonlinear physics and non-Gaussian statistics often simplified by relying on averages. I will describe how we can squeeze out more information by probing the cosmic large-scale structure beyond the average of standard forward models and statistical analyses. I will illustrate how ultralight dark matter creates quantum wave effects that dress the cosmic web and explain how it can help us to go beyond the average of standard forward models. Additionally, I will highlight the power of one-point statistics, which provide unique and complementary information to the commonly used two-point statistics, and show how these can be accurately predicted and utilised.

GR 10.2 Thu 14:15 ZHG008

Betti Functionals as Probes for Cosmic Topology — Ralf Aurich and •Frank Steiner — Institute for Theoretical Physics, Ulm University, Albert-Einstein-Alle 11,89060 Ulm

The question of the global topology of the Universe (cosmic topology) is still open. In the LCDM concordance model,it is assumed that the space of the Universe possesses the trivial topology of R^3, and thus that the Universe has an infinite volume. We study one of the simplest non-trivial topologies given by a cubic 3-torus describing a universe with a finite volume. To probe cosmic topology, we analyze certain structures in the cosmic microwave background (CMB) using Betti functionals and the Euler characteristic evaluated on excursion sets, which possess a simple geometrical interpretation. Since the CMB temperature fluctuations are observed on the sphere S^2 surrounding the observer, there are only 3 Betti functionals, beta_k(nu), k=0,1,2 (nu is the temperature threshold). Analytic approximations of the Gaussian expectations for the Betti functionals and an exact formula for the Euler characteristic are given. It is shown that beta_0 and beta_1 decrease with an increasing volume of the cubic 3-torus universe. Comparing with 4 Planck 2018 sky maps, it is found that the betas of the Planck maps lie between those of the torus universes with side-lengths L=2.0 and L=3.0 in units of the Hubble length. These results give a further hint that the Universe has a non-trivial topology. Ref.: Universe 2024, 10, 190

GR 10.3 Thu 14:35 ZHG008

Connecting Field-level and Summary Statistics — •Ivana Nikolac, Fabian Schmidt, and Beatriz Tucci — Max Planck Institut fur Astrophysik, Karl Schwarzschild Straße 1, 85748 Garching, Germany

Current methods for extracting cosmological information from galaxy distributions typically involve modelling and analysing the power spectrum or the 2-point correlation function. Expanding beyond the power spectrum can unveil significantly more information, including better constraints on dark energy and inflation models. Employing a Lagrangian EFT-based forward model, LEFTfield, other summary statistics can be investigated. These can then be used to obtain the posterior of the cosmological and bias parameters through simulation-based inference (SBI). A primary goal is to assess how the cosmological constraints obtained through SBI compare with those derived from field-level inference.

GR 10.4 Thu 14:55 ZHG008

Simulation-based inference has its own Dodelson-Schneider effect (but it knows that it does) — •Jed Homer[1,2], Oliver Friedrich[1,2,3], and Daniel Gruen[1,2,3] — [1]University Observatory, Faculty of Physics, Ludwig-Maximilians-Universität, Scheinerstr. 1, 81677 Munich, Germany — [2]Munich

Center for Machine Learning (MCML) — [3]Excellence Cluster ORIGINS, Boltzmannstr. 2, 85748 Garching, Deutschland.

Making inferences about physical properties of the Universe requires knowledge of the data likelihood. A Gaussian distribution is commonly assumed with a covariance matrix estimated from a set of simulations. The noise in such estimates causes two problems: it distorts the parameter contours, and it adds scatter to the location of those contours. For non-Gaussian likelihoods, an approximation may be derived via Simulation-Based Inference (SBI). It is often implicitly assumed that parameter constraints from SBI analyses are not affected by the same problems as parameter estimation, with a covariance matrix estimated from simulations. We investigate whether SBI suffers from effects similar to those of covariance estimation in Gaussian likelihoods. SBI suffers an inflation of posterior variance that is equal or greater than the analytical result in covariance estimation for Gaussian likelihoods for the same number of simulations. The assumption that SBI requires a smaller number of simulations than covariance estimation for a Gaussian likelihood analysis is inaccurate. Despite these issues, we show that SBI correctly draws the true posterior contour given enough simulations.

GR 10.5 Thu 15:15 ZHG008

Constraining Mixed Dark Matter Scenarios in the Framework of Perturbation Theory — •Safak Celik and Fabian Schmidt — Max Planck Institute for Astrophysics, Garching bei München, Germany

In this study, we explore the dynamics of mixed dark matter scenarios, focusing on the interplay between cold dark matter (CDM) and warm dark matter (WDM) components. Utilizing perturbation theory techniques, we analyze the evolution of perturbations in a cosmological context where CDM constitutes the primary dark matter component, while WDM, characterized by a weakly interacting, thermally produced mass in the eV-keV range, serves as a secondary component. While the effects of WDM on the linear power spectrum, governed by its mass and abundance, are well-documented, our research delves into the non-linear evolution of these systems. We particularly investigate the role of isocurvature perturbations between the two dark matter components and their impact on the evolution process. Employing a 1-loop galaxy power spectrum, we conduct a Fisher forecast analysis to constrain key parameters, including the fraction and mass of the WDM component and galaxy bias parameters, while examining the degeneracies among them. Our findings enhance the understanding of mixed dark matter models and their implications for cosmological observations.

GR 11: BH Physics II, GW IV

Time: Thursday 14:15–15:35 Location: ZHG007

GR 11.1 Thu 14:15 ZHG007

Autoparallels around a Schwarzschild black hole with GM/r^2-torsion profile — •Jens Boos — KIT, Karlsruhe, Germany

We consider the autoparallel motion of test bodies around a Schwarzschild black hole endowed with a non-trivial torsion field scaling as GM/r^2, where M denotes the ADM mass of the black hole. By explicitly constructing a set of four orthogonal and commuting generalized Killing vectors and deriving their autoparallel conserved quantities we demonstrate the complete integrability of the equations of motion. Additionally, we study the qualitative orbital dynamics via effective potentials. Throughout, we compare the properties of the autoparallels (straightest possible paths) to that of the geodesics (shortest possible paths) and find notable discrepancies.

GR 11.2 Thu 14:35 ZHG007

Perturbations on Schwarzschild Geodesics — •Merlin Böschen and Eva Hackmann — ZARM, Universität Bremen

In binary systems with extreme or intermediate mass ratios, the motion of the secondary object is approximately geodesic. However, perturbations from the gravitational self force as well as from material in the vicinity of the central object can significantly influence the trajectory of the secondary particle. In this presentation we first discuss the framework of osculating geodesics in a Schwarzschild spacetime for different parametrisations of the worldline. Subsequently, we analyse several sources of perturbations in an astrophysical extreme mass ratio system, in particular perturbations due to an accretion disc.

GR 11.3 Thu 14:55 ZHG007

Investigation of the Impact of Wind Turbines on the Einstein Telescope — Marc Boxberg[2], •Tom Niggemann[1], Niklas Nippe[1], Achim Stahl[1], and Florian Wagner[2] for the Einstein Telescope-Collaboration — [1]III. Physikalisches Institut B, RWTH Aachen University — [2]Geophysical Imaging and Monitoring RWTH Aachen University

Wind turbines, critical to renewable energy production, can generate seismic noise that may interfere with highly sensitive observatories, such as the planned Einstein Telescope (ET). Direct and gravitational couplings are a limiting factor for detection of gravitational waves in the low-frequency range. The importance of selecting and adapting wind turbine designs to minimize seismic noise is highlighted. This talk will discuss and evaluate the influence of various wind turbine tower constructions—namely, lattice (girder) masts, wooden towers, steel towers of different heights, and hybrid towers—on seismic noise propagation, with a particular focus on their impact on the ET.

GR 11.4 Thu 15:15 ZHG007

Forecasting Seismic Noise with Deep Learning for Gravitational Wave Detection — •Waleed Esmail[1], Alexander Kappes[1], Stuart Russell[2], and Christine Thomas[2] — [1]Institut für Kernphysik, Universität Münster, 48149 Münster, Germany — [2]Institut für Geophysik, Universität Münster, 48149 Münster, Germany

The Einstein Telescope (ET) is a third-generation gravitational wave observatory. As a ground-based detector, it is susceptible to seismic noise, particularly at low frequencies. Accurately predicting seismic waveforms can help mitigate the impact of seismic noise, thereby enhancing the detector's sensitivity. This study utilizes the power of deep learning algorithms for their ability to model complex systems, to precisely predict the 3-component seismic waveforms. Our approach focuses on training a model to use initial earthquake waves (P-waves) to predict subsequent, more destructive waves (S-waves and surface waves). The training process utilizes synthetic seismograms embedded in realistic noise, with the synthetic data generated using realistic source parameters and Green*s function databases derived from a 1D Earth model.

GR 12: GW V

Time: Thursday 16:15–16:55 Location: ZHG008

GR 12.1 Thu 16:15 ZHG008

Close, but no Merger: Challenges in Parameter Estimation for Black Hole Hyperbolic Orbits — •Joan Fontbuté — Friedrich-Schiller Universität

In this talk, I will be introducing a surrogate numerical-relativity model for close hyperbolic encounters between equal-mass black holes with aligned spins. This model spans a range of impact parameters and spin components, focusing on key gravitational wave emission multipoles. It closely matches numerical relativity simulations, with mismatches below 0.1%. Despite the model's accuracy, I'll argue that parameter estimation proves challenging due to strong degeneracies in the parameter space, even for high signal-to-noise ratios (SNRs). This suggests that detecting such events may require third-generation detectors. However, certain parameter combinations proposed in this project may still provide evidence of these encounters using the current ground-based detectors, provided they are astrophysically meaningful.

GR 12.2 Thu 16:35 ZHG008

Subdominant multipole asymmetries in gravitational waves from binary black-hole mergers — •Jannik Mielke[1,2], Shrobana Ghosh[1,2], and Frank Ohme[1,2] — [1]Max Planck Institute for Gravitational Physics (Albert Einstein Institute), D-30167 Hannover, Germany — [2]Leibniz University Hannover, D-30167 Hannover, Germany

In some binaries, the spins of the black holes are not aligned with the system's orbital angular momentum. This causes the spins to precess and leads to an asymmetric emission of gravitational waves. Interestingly, multipole asymmetries which describe this asymmetric emission, are strongly related to the final kick of the remnant black hole and are the critical element in fully describing precession. Despite the astrophysical significance of kicks and precession, multipole asymmetries contribute only minimally to the overall signal strength. Consequently, the majority of current gravitational-wave models do not incorporate

them. Moreover, the role of subdominant multipole asymmetries has not been investigated exhaustively. Therefore, this talk discusses the physics of multipole asymmetries, which I present through a systematic study of numerical relativity simulations. In addition, the importance of subdominant multipole asymmetries for the kick calculation will be demonstrated and I give a short outlook for their detectability with third generation detectors.

GR 13: Members' Assembly

Time: Thursday 17:00–18:15 Location: ZHG008

All members of the Gravitation and Relativity Division are invited to participate.

GR 14: Relastro III

Time: Friday 9:00–10:20 Location: ZHG008

GR 14.1 Fri 9:00 ZHG008

Magnetic field configurations in Binary Neutron Star Mergers — •William Cook — Theoretisch-Physikalisches Institut, Friedrich-Schiller Universitat, Fröbelstieg 1, 07743 Jena

Magnetic field configurations inside isolated neutron stars are poorly constrained, and purely poloidal configurations are known to suffer from instabilities. We perform simulations of isolated neutron stars to investigate the development of these instabilities and the growth of toroidal field components. We then investigate the impact of the magnetic field configurations that develop in isolated stars in the context of binary neutron star mergers. Simulations are performed using the exascale-ready numerical relativity codes GR-Athena++ and AthenaK, the designs of which we also discuss

GR 14.2 Fri 9:20 ZHG008

^{56}Ni production in neutrino-driven winds from long-lived binary neutron star merger remnants — •Maximilian Jacobi[1], Fabio Magistrelli[1], Eleonora Loffredo[2], Giacomo Ricigliano[3], Sebastiano Bernuzzi[1], David Radice[4], Almudena Arcones[3,5], Albino Perego[6], and Domenico Logoteta[7] — [1]Friedrich-Schiller-Universität Jena, Germany — [2]INAF - Osservatorio Astronomico d'Abruzzo, Teramo, Italy — [3]Technische Universität Darmstadt, Germany — [4]The Pennsylvania State University, USA — [5]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany — [6]Universitá di Trento, Italy — [7]Università di Pisa, Italy

We investigate the nucleosynthesis and kilonova light curve based on long-term binary neutron star merger simulations incorporating a two-moment neutrino-transport scheme. The ejecta are evolved up to 100 days using axisymmetric radiation-hydrodynamics simulations coupled in-situ to a complete nuclear network. We find that the neutrino-driven wind from the post-merger remnant is proton-rich, resulting in the production of iron-group elements. We explore the consequences of the altered nucleosynthesis on the kilonova light curve and spectrum. The observation of features associated with proton-rich nucleosynthesis could serve as a smoking gun for the presence of a long-lived neutron-star remnant in future kilonova observations.

GR 14.3 Fri 9:40 ZHG008

Simulations of BNSM ejecta with online nuclear calculations and atomic opacities — •Fabio Magistrelli — TPI, FSU Jena

Understanding the details of r-process nucleosynthesis in binary neutron star mergers (BNSM) ejecta is key to interpreting kilonova observations and identifying the role of BNSM in the origin of heavy elements. I will present predictions for light curves and composition results obtained from ray-by-ray radiation-hydrodynamic simulations of BNSM ejecta (extracted from hundreds-of-ms long ab-initio numerical relativity simulations) with an online nuclear network. The ejcta evolution includes charged particles and gamma-rays thermalization, and composition-dependent opacities obtained from atomic calculations. Comparing the results with other initialization procedures and opacity models, I will discuss the correspondent systematic uncertainties on the final predictions for kilonova light curves and element production.

GR 14.4 Fri 10:00 ZHG008

Robustness of the FO-CCZ4 Formulation Compared to GHG — •Mads Sørensen[1], Daniela Cors[2], David Hilditch[3], and Bernd Brügmann[1] — [1]Theoretisch-Physikalisches Institut , Jena, Germany — [2]Department of Applied Mathematics and Theoretical Physics (DAMTP), University of Cambridge, Cambridge, United Kingdom — [3]Center for Astrophysics and Gravitation (CENTRA), Instituto Superior Técnico, University of Lisbon, Lisbon, Portugal

Numerical relativity relies on robust formulations of Einstein's field equations to simulate strong gravitational fields, like black-hole mergers, and for example extract gravitational-wave signals from them. We are interested in the stability of our simulations and thus on the hyperbolicity of the formulations we use. A first-order conformal covariant Z4 (FO-CCZ4) formulation has shown to successfully manage to simulate moving puctures in 3 dimensions with a higher-order discontinuous Galerkin (DG) scheme. Making the FO-CCZ4 of high interest for various simulations. In this work, we focus on testing the robustness of this formulation by comparing it with the Generalised Harmonic Gauge (GHG) formulation. We have implemented FO-CCZ4 in the pseudo-spectral code *bamps*, with different shift and slicing conditions. We then compare the behaviour of FO-CCZ4 versus GHG for simple initial data.

GR 15: Cosmo III

Time: Friday 11:00–12:20 Location: ZHG008

GR 15.1 Fri 11:00 ZHG008

Self-similarity of small-scale cosmic structures — •Matthias Bartelmann — Institut für Theoretische Physik, Universität Heidelberg

Based on the saddle-point method within kinetic field theory, and independently on the asymptotic analysis of solutions of the Liouville equation, it has been possible to show that the power spectrum of cosmic density fluctuations necessarily develops an asymptotic behaviour with the wave number k proportional to k^{-3}. I will outline the arguments leading to this result, and discuss implications for virialization and for the self-similarity of cosmic structures.

GR 15.2 Fri 11:20 ZHG008

Velocity statistics of cosmic large-scale structure from Hamiltonian particle dynamics — •Marvin Sipp — Institut für Theoretische Physik, Universität Heidelberg, Deutschland

We present a novel approach to analytically calculating the evolution of velocity statistics of cosmic large-scale structure in cold dark matter.

It is based on a path-integral formulation for the Hamiltonian dynamics of an ensemble of classical particles, specialised to the self-gravitating case on an expanding background. Density and momentum statistics can be extracted by applying suitable operators to the generating functional. The full theory contains the complete phase-space information of the interacting particle ensemble. In practice, we solve the free theory and include interactions perturbatively, reminiscent of other statistical or quantum field theories. The theory can be reformulated in terms of macroscopic fields, leading to an efficient partial resummation of the microscopic perturbative series. Going to higher orders in this perturbation theory is equivalent to integrating higher moments of the BBGKY hierarchy. We thus avoid the shell-crossing problem of standard Eulerian perturbation theory (without introducing effective parameters), allowing for the generation of vorticity in initially irrotational systems and making our framework particularly interesting for studying the evolution of velocity statistics.

We show how n-point momentum statistics can be extracted from the free theory, how gravitational interactions can be included and partially resummed, and present the resulting two-point statistics of the momentum density and density-momentum cross-correlations.

GR 15.3 Fri 11:40 ZHG008

Orientation systematics in the multi-messenger inference of the Hubble constant — •Michael Müller — Universität Greifswald, Greifswald, Germany

Multi-messenger observations of coalescing binary neutron stars are a direct probe of the expansion history of the universe and carry the potential to shed light on the disparity between low- and high-redshift measurements of the Hubble constant H_0. To measure the value of H_0 with such observations requires

pristine inference of the luminosity distance and the true source redshift with minimal impact from systematics. A significant uncertainty in the measurement of the former with gravitational waves (GWs) arises from the poorly constrained orientation of the merging binary system relative to the observer. However, observations of the electromagnetic (EM) counterpart emission from the highly collimated relativistic jet, present in the post-merger phase, can provide strong constraints on the orientation of the source and thus inform the distance inference from the GW data. In **arXiv:2406.11965**, we investigate the consequences of a potential disparity between system orientations obtained from the EM and GW data, which, if not carefully treated when combining observations, can bias the inferred value of H_0. Already small misalignments of $3^\circ - 6^\circ$ between the inherent system orientations for the GW and EM emission can bias the inference by $\mathcal{O}(1 - 2\sigma)$ if not taken into account. I will discuss complications with the interpretation of the system orientation in the post-merger phase and present a summary of the core findings of this investigation.

GR 15.4 Fri 12:00 ZHG008

FLRW Constants of the Motion and the Issue of Their Fine-tuning — •Marc Holman — Utrecht University, Utrecht, Netherlands

It seems to be contended at times that quantum gravity considerations could in principle provide justification for a "blindfolded creator" view on the initial value of the curvature parameter, Ω, in FLRW models. That is, even though there are no sound classical motivations for adopting a uniform probability distribution on initial values of Ω, according to such a line of thought, there could in principle exist quantum gravity motivations to that extent. Here it is shown explicitly - in agreement with previous assertions made by the author - that for the radiation- and dust-filled FLRW models of nonzero curvature, a uniform measure on Ω for Planck-scale initial conditions necessarily entails large amounts of fine-tuning in FLRW constants of the motion. This means that, unless there exist specific reasons for fine-tuning these physical constants, a flatness problem in the fine-tuning sense does not exist, whether quantum gravity motivated or not. Time permitting, comments will also be made on more recent arguments, which purport to establish the existence of a flatness problem in the above sense using Bayesian analysis.

Theoretical and Mathematical Physics Division
Fachverband Theoretische und Mathematische Grundlagen der Physik (MP)

Johanna Erdmenger
Julius-Maximilians-Universität Würzburg
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Overview of Invited Talks and Sessions

(Lecture halls ZHG001 and ZHG002; Poster ZHG Foyer 1. OG)

Invited Talks

MP 2.1	Tue	13:45–14:15	ZHG001	**Mathematics of moire materials** — •Simon Becker
MP 2.2	Tue	14:15–14:45	ZHG001	**Approaches to Discrete Holography** — •René Meyer, Pablo Basteiro, Giuseppe Di Giulio, Johanna Erdmenger, Zhuoyu Xian, Jonathan Karl, et. al.
MP 4.1	Wed	11:00–11:30	ZHG001	**Focusing dynamics for 2d Bose gases in the instability regime** — •Lea Bossmann
MP 7.1	Wed	16:15–16:45	ZHG001	**How the "gauge principle" derives from physical principles** — •Karl-Henning Rehren
MP 7.5	Wed	17:45–18:15	ZHG001	**A BPS Road to Holography: Decoupling Limits and Non-Lorentzian Geometries** — •Niels Obers
MP 10.1	Thu	14:00–14:30	ZHG001	**Quantum field theory, quantum reference frames and the type of local algebras** — •Christopher Fewster

Invited Talks of the joint Symposium SMuK Dissertation Prize 2025 (SYMD)

See SYMD for the full program of the symposium.

SYMD 1.1	Mon	14:15–14:45	ZHG011	**Fluid-dynamic description of heavy-quark diffusion in the quark-gluon plasma** — •Federica Capellino
SYMD 1.2	Mon	14:45–15:15	ZHG011	**Fast and faithful effective-one-body models for gravitational waves from generic compact binaries** — •Rossella Gamba
SYMD 1.3	Mon	15:15–15:45	ZHG011	**Nuclear Structure Near Doubly Magic Nuclei** — •Lukas Nies
SYMD 1.4	Mon	15:45–16:15	ZHG011	**Optimisation strategies for proton acceleration from thin foils with petawatt ultrashort pulse lasers** — •Tim Ziegler

Invited Talks of the joint Symposium Quantum Mechanics and Gravity: Current Status (SYDK)

See SYDK for the full program of the symposium.

SYDK 1.1	Thu	10:45–11:15	ZHG008	**String Theory at the Edges of Relativity** — •Niels Obers
SYDK 1.2	Thu	11:15–11:45	ZHG008	**The Quantum Einstein Equations in Loop Quantum Gravity** — •Kristina Giesel
SYDK 1.3	Thu	11:45–12:15	ZHG008	**Causal Dynamical Triangulations: Lattice quantum gravity reloaded** — •Renate Loll
SYDK 1.4	Thu	12:15–12:45	ZHG008	**Taming Quantum Gravity: insights from Asymptotic Safety** — •Alessia Platania

Sessions

MP 1.1–1.4	Mon	16:45–18:05	ZHG001	**Quantum Mechanics**
MP 2.1–2.5	Tue	13:45–15:45	ZHG001	**Mathematical Materials Science and AdS/CFT**
MP 3.1–3.4	Tue	16:15–17:35	ZHG001	**Particle Physics and AdS/CFT**
MP 4.1–4.4	Wed	11:00–12:30	ZHG001	**Dynamics and Chaotic Behaviour**
MP 5.1–5.3	Wed	13:45–14:45	ZHG001	**Theory of Machine Learning (joint session MP/AKPIK)**
MP 6	Wed	14:45–15:45	ZHG001	**Members' Assembly**
MP 7.1–7.5	Wed	16:15–18:15	ZHG001	**Quantum Field Theory I and Conformal Field Theory**
MP 8.1–8.4	Wed	16:15–17:35	ZHG002	**Waves, Relativity and Quantization**
MP 9.1–9.4	Wed	16:15–18:15	ZHG Foyer 1. OG	**Poster Session: Many-body Theory**
MP 10.1–10.4	Thu	14:00–15:30	ZHG001	**Operator Algebras**
MP 11.1–11.3	Thu	16:15–17:15	ZHG001	**Quantum Field Theory II**
MP 12.1–12.4	Thu	16:15–17:35	ZHG002	**Concepts of Physics**

Members' Assembly of the Theoretical and Mathematical Physics Division

Wednesday 14:45 - 15:45 ZHG001

- Bericht und Planung
- Aussprache
- Wahl des/der Sprecher:in
- Wahl der Beiratsmitglieder
- Verschiedenes

Sessions

– Invited Talks, Contributed Talks, and Posters –

MP 1: Quantum Mechanics

Time: Monday 16:45–18:05 Location: ZHG001

MP 1.1 Mon 16:45 ZHG001

Advances in quantum dynamics of photons in curved spacetime — •David Edward Bruschi — Institute for Quantum Computing Analytics (PGI-12), Forschungszentrum Jülich, Jülich, Germany

General relativity and quantum mechanics are the two frameworks through which we understand Nature. To date, they have been successful at providing accurate predictions of natural phenomena in their respective domains of validity. Many attempts to find a unified theory of Nature that can describe all of observable phenomena have been tried with varying degrees of success. Regardless, the quest for unification remains open, and therefore continues.

One avenue for investigating the overlap of general relativity and quantum mechanics that is less ambitious but can still provide potentially observable and measurable predictions is that of (low energy) quantum field theory in curved spacetime viewed through the lens of quantum information. In recent years, a great deal of attention has been given to this approach, which has provided novel and intriguing insights into phenomena that can be tested in the laboratory.

We present updates on the investigation into the quantum nature of the gravitational redshift, seeking to understand which are the quantum dynamics that lead to the effective classical observable effect. We present the current state-of-the-art and discuss novel discoveries. We also discuss the place that this avenue of research has in the broader context of relativistic and quantum physics.

MP 1.2 Mon 17:05 ZHG001

Quantum tunneling time via time-of-arrival operators — •Philip Caesar Flores[1], Dean Alvin Pablico[2,3], and Eric Galapon[2] — [1]Max-Born-Institute, Max-Born Straße 2A, 12489 Berlin, Germany — [2]National Institute of Physics, University of the Philippines Diliman, 1101 Quezon City, Philippines — [3]niversity of Northern Philippines, 2700 Vigan City, Ilocos Sur, Philippines

We construct all possible time-of-arrival operators via canonical quantization of the classical time-of-arrival and demonstrate that the tunneling time vanishes for all these operators, regardless of the ordering rule between the position and momentum observables.

MP 1.3 Mon 17:25 ZHG001

The GHZ state and Bohmian positions — •Robert Helling — Ludwig-Maximilians-Universität München

In the Bohmian interpretation, particle positions are realistic that is they have definite values even when not being observed. We realise the GHZ state in terms of position observables at different times and argue that violations of Bell type inequalities pose challenges to this realistic nature of positions. They can be avoided at the price of giving up predictability for outcomes of measurement at multiple times for observables that can be computed with textbook quantum mechanics.

MP 1.4 Mon 17:45 ZHG001

Quantum Analytical Mechanics: What is it and what is it good for? — •Wolfgang Paul — Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle

The question whether the Schrödinger equation has to be considered the complete description of (non-relativistic) quantum phenomena or not, has occupied a part of the physics community since the famous controversy between Einstein and Bohr at the 1927 Solvay conference. Based on Nelson's derivation of the Schrödinger equation from the Newtonian dynamics of a time-inversion invariant diffusion process in 1966, by now a complete theory of quantum analytical mechanics has been developed. I will present its structure and discuss applications to the tunneling phenomenon, the dynamic stability of the hydrogen atom in the ground state and the violation of Bell's inequalities in the Einstein-Podolski-Rosen-Bohm thought experiment.

M. Beyer, W. Paul, Foundations of Physics **54**, 20 (2024).

MP 2: Mathematical Materials Science and AdS/CFT

Time: Tuesday 13:45–15:45 Location: ZHG001

Invited Talk MP 2.1 Tue 13:45 ZHG001

Mathematics of moire materials — •Simon Becker — ETH Zurich, CH

We review recent developments in the field of moire materials from a mathematics perspective. Starting from effective one-particle models for magic angle twisted bilayer graphene, we continue to interacting theory and models for twisted semiconductors (TMDs).

Invited Talk MP 2.2 Tue 14:15 ZHG001

Approaches to Discrete Holography — •René Meyer[1], Pablo Basteiro[1], Giuseppe Di Giulio[1,2], Johanna Erdmenger[1], Zhuoyu Xian[1,3], Jonathan Karl[1], and et. al.[1] — [1]Institute for Theoretical Physics and Astrophysics, Julius-Maximilians-Universität Würzburg, 97074 Würzburg — [2]Stockholm University, AlbaNova, 10691 Stockholm — [3]Freie Universität Berlin, Arnimallee 14, 14195 Berlin

I will review recent progress towards a discrete version of the AdS/CFT duality based on hyperbolic lattices. After an introduction to these lattices, I will show that the Breitenlohner-Freedman stability bound for a scalar field on such hyperbolic tilings is unaffected by the type of lattice, and present a realization of this bound in a hyperbolic electric circuit [1]. I will then present simulations [2] of a scalar field on a hyperbolic lattice with a black hole horizon, which successfully recover not only the conformal scaling of two- and three-point functions, but also determine a discretely quantized black hole temperature. In the second part of the talk, I will discuss XXZ type spin chains on the aperiodic space obtained by cutting off a hyperbolic tiling at a large radial distance. I will discuss the emergence of a non-trivial disordered fixed point [3], the logarithmic scaling of the entanglement entropy, and the effective central charge of that fixed point. I will end with an outlook on recent work on aperiodic chains of coupled SYK quantum dots [4]. [1] Phys. Rev. Lett. 130 (9), 2023; [2] Phys. Rev. Lett. 133 (6), 2024; [3] SciPost Physics 13 (5), 2022; [4] 2410.23397.

MP 2.3 Tue 14:45 ZHG001

Random Matrix Universality as a tool in 2d Quantum Gravity: Beyond the orientable case — •Torsten Weber[1], Jarod Tall[2], Fabian Haneder[1], Marco Lents[1], Juan Diego Urbina[1], and Klaus Richter[1] — [1]Universität Regensburg, Regensburg, Deutschland — [2]Washington State University, Pullman, USA

In recent years the discovery of an AdS/CFT-like correspondence of quantum JT gravity and a distinct matrix model has led to an intense cross-fertilisation of the a priori distinct fields of quantum gravity and quantum chaos. In this spirit we use random matrix universality, ubiquitous in quantum chaos, and study its implications on JT gravity. Specifically we focus on the spectral form factor (SFF), a prime example of universality on the matrix model side and thus a key characteristic of quantum chaos. While in the orientable setting the study reveals the perturbative expansion of the SFF in JT gravity to show behaviour non-perturbative from the point of view of random matrices and cancellations within key geometric quantities to match the universal prediction, this becomes even more interesting when including unorientable contributions. This is due to perturbative contributions in this setting, requiring regularisation and being more complicated to compute already, even at the regularisation-independent level showing apparent deviations from the universal prediction. We show how these deviations can be made sense of for the regularisation independent part by employing a bootstrapping-like argument and how this leads to agreement, and thus a strong sign for the presence of chaos, in full unorientable JT gravity.

MP 2.4 Tue 15:05 ZHG001

The chiral SYK model in holography — •Konstantin Weisenberger[1], Alexander Altland[1], Nele Callebaut[1], and Dmitry Bagrets[2] — [1]Universität zu Köln — [2]Forschungszentrum Jülich

We propose a (1+1)-dimensional chiral extension of the SYK model which in the infrared limit is described by the (1+1)-dimensional generalization of the Schwarzian action, namely the Alekseev-Shatashvilli (AS)-action. This action

has been proposed to govern boundary gravitons in pure AdS3 gravity, giving our model the interpretation of capturing fluctuations around the BTZ saddle point. From the AS-action, correlation functions of Majorana operators can be calculated by means of Liouville field theory on the hyperbolic disk, where we solve two-point functions and out-of-time-order correlation functions using semi-classical methods. In accordance with general expectations, this theory encodes the vacuum block of a 2d CFT, leading to the expected maximal Lyapunov exponent.

MP 2.5 Tue 15:25 ZHG001

Towards identifying a genus expansion in the Selberg trace formula — •Fabian Haneder, Juan Diego Urbina, Torsten Weber, and Klaus Richter — Universität Regensburg, Regensburg, Deutschland

Jackiw-Teitelboim (JT) gravity has been a useful tool for advancing our understanding of several features believed to be generic in quantum gravity, such as the density of states (exponentially growing for black hole systems), wormholes and topological expansions of the gravitational path integral.

Key progress in doing so has been made using random matrix universality, both for orientable [Saad et al., arXiv:2210.11565, Weber et al., Weber et al., 2023 J. Phys. A: Math. Theor. 56 205206] and unorientable [Weber et al., J. High Energ. Phys. 2024, 267 (2024), Tall et al., arXiv:2411.08129] JT gravity, establishing the quantum chaoticity of the theory. In an effort to go beyond the universal regime, we use periodic orbit theory, which has been used precisely to derive universality, and study non-universal features, for quantum chaotic systems.

After reviewing recent success [Haneder et al., arXiv:2410.02270] in capturing the exact (leading genus) density of states and wormhole amplitude of JT gravity with a single quantum chaotic system, we report on our progress in identifying a topological expansion, reminiscent of the one in JT gravity, in the same system, a particle moving on a high-dimensional hyperbolic manifold. To describe the system, we make use of the Selberg trace formula, which renders periodic orbit theory exact.

MP 3: Particle Physics and AdS/CFT

Time: Tuesday 16:15–17:35 Location: ZHG001

MP 3.1 Tue 16:15 ZHG001

An Effective Hadronic Field Theory for B-Meson Decays at Large Recoil — •Jack Jenkins, Thorsten Feldmann, and Jaime del Palacio Lirola — University of Siegen

We construct an effective hadron Lagrangian for heavy-meson decays into light energetic particles. In this theory the dynamical degrees of freedom are given by quasi-static heavy meson fields coupled to soft and collinear pions, kaons and eta mesons. We give a few examples of how weak-decay operators in soft-collinear effective theory can be represented in the effective hadronic Lagrangian, and discuss potential phenomenological applications.

MP 3.2 Tue 16:35 ZHG001

Composite Higgs models and the AdS/CFT Correspondence — Johanna Erdmenger, Werner Porod, and •Deepali Singh — Julius-Maximilians-Universität Würzburg, Germany

Symmetry groups and their representations play a crucial role in understanding fundamental physics, from particle phenomenology to holographic duality. Symmetries have also given us an insight into solving issues like the hierarchy problem. One such example is the framework of Composite Higgs models which addresses the hierarchy problem by interpreting the Higgs boson as a pseudo-Nambu-Goldstone boson arising from a global symmetry breaking. We will discuss how AdS/CFT offers powerful tools to study Composite Higgs scenarios by leveraging the duality between strongly coupled gauge theories and weakly coupled gravitational theories in one higher dimension. In particular, we will consider models in which the global group SU(4)xSU(4) gets broken to the diagonal SU(4). We will use gauge/gravity duality to calculate the spectrum of bosonic bound states emerging in Composite Higgs models.

MP 3.3 Tue 16:55 ZHG001

Quasi-static time evolution of the speed of sound and sound attenuation in Bjorken expanding holographic plasma — •Matthias Kaminski[1], Jun Zhang[1], Durdana Ilyas[1], Marco Knipfer[2], and Casey Cartwright[3] — [1]University of Alabama, Tuscaloosa, AL, U.S.A. — [2]FAU Erlangen-Nurnberg, Erlangen, Germany — [3]Utrecht University, Utrecht, Netherlands

The speed of sound is a key parameter for characterizing equilibrium states, but sound waves also propagate through media far from equilibrium, such as the quark-gluon plasma created in heavy-ion collisions. Using $\mathcal{N} = 4$ Super-Yang-Mills theory as a toy model, this study numerically explores the time evolution of the speed and attenuation of sound modes in a plasma undergoing a Bjorken expansion after being prepared in a far-from-equilibrium state. These results provide new insights into the dynamic properties of sound modes in anisotropic and rapidly evolving plasma systems.

MP 3.4 Tue 17:15 ZHG001

Three-dimensional gravity as Kodaira-Spencer theory — Johanna Erdmenger, Jonathan Karl, Jani Kastikainen, René Meyer, and •Henri Scheppach — Institut für Theoretische Physik und Astrophysik, Julius-Maximilians-Universität Würzburg, D-97074 Würzburg, Germany

Twisted holography provides a promising framework for exploring holographic dualities beyond the strict large N limit. However, a formulation of the duality in the traditional form is lacking. In this talk, I will present a construction to identify degrees of freedom of three-dimensional gravity in six-dimensional Kodaira-Spencer (KS) theory, featuring prominently in twisted holography. The construction works by embedding solutions of 3D gravity with a negative cosmological constant into a 6D manifold whose complex structure solves the KS equations of motion. This allows us to apply the well-understood holographic dictionary for 3D gravity and 2D conformal field theories to twisted holography. Furthermore, the construction allows for an embedding of black hole geometries into KS theory.

MP 4: Dynamics and Chaotic Behaviour

Time: Wednesday 11:00–12:30 Location: ZHG001

Invited Talk MP 4.1 Wed 11:00 ZHG001

Focusing dynamics for 2d Bose gases in the instability regime — •Lea Bossmann — FAU Erlangen-Nürnberg

We consider the dynamics of a 2d Bose gas with singular attractive interactions in the instability regime, where the corresponding focusing nonlinear Schrödinger equation (NLS) has a blow-up. We show that the evolution of the condensate is effectively described by this NLS for all times before the blow-up. Moreover, we prove the validity of the Bogoliubov approximation for the fluctuation dynamics, resulting in a norm approximation of the many-body dynamics. This is joint work with Charlotte Dietze and Phan Thành Nam.

MP 4.2 Wed 11:30 ZHG001

Chaotic Quantum Scattering and Supersymmetry: Exact Distributions in the Symplectic Case — •Nils Gluth and Thomas Guhr — Universität Duisburg-Essen, Duisburg, Deutschland

Scattering theory is a powerful tool with applications to a large variety of different systems in quantum physics and in the physics of classical waves. Often, such systems are complex or in a broad sense chaotic, calling for statistical approaches, in particular Random Matrix Theory. A few years ago, we put forward a variant of the Supersymmetry method to exactly calculate full distributions of scattering matrix elements and cross sections. Here, we focus on the previously not considered symplectic symmetry class which is relevant for certain spin systems. We exploit similarities in superspace to the unitary as well as to the orthogonal class. We extend and reformulate previous work on the corresponding supermanifolds.

MP 4.3 Wed 11:50 ZHG001

Complex symmetric, self-dual, and Ginibre random matrices: Analytical results for three classes of bulk and edge statistics — •Noah Ayguen — Bielefeld University, Bielefeld, Germany

The energy eigenvalues of chaotic quantum systems are expected to follow random matrix statistics, where closed systems relate to Hermitian random matrices while open systems with complex eigenvalues relate to non-Hermitian matrices. The random matrix model depends on the corresponding symmetry class of the physical systems under consideration. Recently, based on numerics, it has been conjectured that among such classes of non-Hermitian random matri-

ces only three different local bulk statistics of complex eigenvalues exist. Motivated by these new insights, we find new analytic results for expectation values of characteristic polynomials, using the technique of Grassmann variables. The simplest representatives of these 3 bulk statistics are the Gaussian ensembles of well-known complex Ginibre matrices, complex symmetric, and complex self-dual random matrices. In the Cartan classification scheme of non-Hermitian random matrices they are labelled as class A, AI† and AII†, respectively. (Based on joint work with G. Akemann, M. Kieburg, P. Päßler arXiv:2410.21032)

MP 4.4 Wed 12:10 ZHG001

Quantum chaos and complexity from string scattering amplitudes — •Aranya Bhattacharya[1] and Aneek Jana[2] — [1]Institute of Physics, Jagiellonian University, Lojasiewicza 11, 30-348 Krakow, Poland — [2]Centre for High Energy Physics, Indian Institute of Science, C.V. Raman Avenue, Bangalore 560012, India

We introduce Krylov spread complexity in the context of black hole scattering by studying highly excited string states (HESS). Krylov complexity characterizes chaos by quantifying the spread of a state or operator under a known Hamiltonian. In contrast, quantum field theory often relies on S-matrices, where the Hamiltonian density becomes non-trivially time-dependent rendering the computations of complexity in Krylov basis exponentially hard. We define Krylov spread complexity for scattering amplitudes by analyzing the distribution of extrema, treating these as eigenvalues of a fictional Hamiltonian that evolves a thermo-field double state non-trivially. Our analysis of black hole scattering, through highly excited string states scattering into two or three tachyons, reveals that the Krylov complexity of these amplitudes mirrors the behavior of chaotic Hamiltonian evolution, with a pre-saturation peak indicating chaos. This formalism bridges the concepts of chaos in scattering and state evolution, offering a framework to distinguish different scattering processes.

MP 5: Theory of Machine Learning (joint session MP/AKPIK)

Time: Wednesday 13:45–14:45 Location: ZHG001

MP 5.1 Wed 13:45 ZHG001

Time Series Analysis of machine learned Quantum Systems — •Kai-Hendrik Henk and Wolfgang Paul — Martin-Luther-Universität Halle-Wittenberg, Halle(Saale), Deutschland

The Rayleigh-Ritz variation principle is a proven way to find ground states and energies for bound quantum systems in the Schrödinger picture. Advances in machine learning and neural networks make it possible to extend it from an analytical search from a subspace of the complete Hilbert space to the a numerical search in the almost complete Hilbert space. Here, we extend the Rayleigh-Ritz principle to Nelson's stochastic mechanics formulation of non-relativistic quantum mechanics, and propose an algorithm to find the osmotic velocities $u(x)$, which contain the information of a quantum systems in this picture (*Phys. Rev. A 108, 062412*). Motivated by experiments by the Aspelmeyer group at the University of Vienna using quantum levitodynamics (see for example *Nature 595, 373-377 (2021)*), we apply the algorithm to the harmonic oscillator, the Gaussian and the Lorentzian potential and analyze them using methods from time series analysis and phase portraits.

References: *Henk, K.-H., and Paul, W. Machine learning quantum mechanical ground states based on stochastic mechanics. Phys. Rev. A 108 (Dec 2023), 062412*

MP 5.2 Wed 14:05 ZHG001

Opening the Black Box: predicting the trainability of deep neural networks with reconstruction entropy — •Yanick Thurn[1], Ro Jefferson[2], and Johanna Erdmenger[1] — [1]Institute for Theoretical Physics and Astrophysics, Julius-Maximilians-University Wuerzburg — [2]Institute for Theoretical Physics, and Department of Information and Computing Sciences, Utrecht University

An important challenge in machine learning is to predict the initial conditions under which a given neural network will be trainable. We present a method for predicting the trainable regime in parameter space for deep feedforward neural networks (DNNs) based on reconstructing the input from subsequent activation layers via a cascade of single-layer auxiliary networks. We show that a single epoch of training of the shallow cascade networks is sufficient to predict the trainability of the deep feedforward network on a range of datasets (MNIST, CIFAR10, FashionMNIST, and white noise). Moreover, our approach illustrates the networks decision making process by displaying the changes performed on the input data at each layer, which we demonstrate for both a DNN trained on MNIST and the vgg16 CNN trained on the ImageNet dataset.

MP 5.3 Wed 14:25 ZHG001

Analytic continuation of Greens functions with a neural network — •Martin Rackl, Yanick Thurn, Fakher Assaad, Anika Götz, René Meyer, and Johanna Erdmenger — Julius-Maximilians University Würzburg, Am Hubland, 97074 Würzburg, Germany

An important problem in many-body physics is to reconstruct the spectral density from the imaginary-time domain Greens function. Typically, this Greens function is generated by Monte Carlo methods. As the one-point fermionic kernel diverges for large frequencies, the numerical noise present generically causes instabilities. A standard method to tackle the reconstruction of the spectral density is the maximum entropy method (MaxEnt). In this paper, we follow a different approach and use a convolutional neural network for obtaining the spectral density for a given imaginary time Greens function. The network is very sensitive to the nature of the training data that we create using random Gaussians. Here we improve the training data set available by considering collision centres for Gaussians rather than uniformly distributed Gaussians. Our network is constructed in such a way that its output fulfils the positive semidefiniteness of the spectral density and is ppropriately normalized. We compare the results of this network with results of MaxEnt for the same problem. This com- parison is performed for different cases: artificial test data, spin-charge separation in the 1d Hubbard model. Using the Wasserstein distance as metric, we find that the network performs in the same order of magnitude of accuracy as MaxEnt.

MP 6: Members' Assembly

Time: Wednesday 14:45–15:45 Location: ZHG001

All members of the Theoretical and Mathematical Physics Division are invited to participate.

MP 7: Quantum Field Theory I and Conformal Field Theory

Time: Wednesday 16:15–18:15 Location: ZHG001

Invited Talk MP 7.1 Wed 16:15 ZHG001

How the "gauge principle" derives from physical principles — •Karl-Henning Rehren — University of Göttingen

Gauge theory is a most successful paradigm to explain the interactions of the Standard Model. Yet, it remains notoriously unclear what it actually "means" in terms of physical reality, where only gauge-invariant quantities are observable.

I discuss an "autonomous" approach to explain the (same, of course) interactions of the SM without invoking gauge theory [1]. The S-matrix is computed in terms of "string-localized" free fields, which are necessary in order to reconcile interactions of quantum particles with the physical principles of Hilbert space, locality and covariance. Some of the resulting interacting quantum fields will inherit string-localization – a most desirable feature of physical relevance, e.g., in order to make the Gauß Law of QED compatible with Einstein Causality.

I will sketch how the weak interactions, QCD, and even gravitons are covered by string-localized QFT as well.

[1] K.-H. Rehren *et al*: Found. Phys. 54 (2024) 57

MP 7.2 Wed 16:45 ZHG001

Driven conformal field theory and circuit complexity — •Jani Kastikainen[1], Johanna Erdmenger[1], and Tim Schuhmann[1,2] — [1]Institute for Theoretical Physics and Astrophysics and Würzburg-Dresden Cluster of Excellence ct.qmat, Julius-Maximilians-Universität Würzburg, Am Hubland, 97074 Würzburg, Germany — [2]Department of Physics and Astronomy, Ghent University, 9000 Ghent, Belgium

Driven quantum systems exhibit a large variety of interesting and sometimes exotic phenomena. In this talk, I study driven two-dimensional conformal field

theories (CFT) from spacetime and quantum information geometric points of view. I show that a large class of quantum circuits can be realized by coupling the CFT to time-dependent background fields. In particular, unitary time-evolution of the CFT in a background metric is equivalent to a quantum circuit generated by the Virasoro algebra, known as a Virasoro circuit. Similarly, turning on a source for a primary operator deforms the Virasoro circuit in a non-trivial way. Complexity of these circuits may be measured using the Fubini-Study circuit complexity whose properties I will analyze.

MP 7.3 Wed 17:05 ZHG001

Scale- without Conformal-Invariance in Gauge/Gravity Duality — •Mario Flory and Lavish Chawla — Jagiellonian University, Cracow, Poland

In Gauge/Gravity Duality, the isometries of the bulk spacetime determine the symmetries of the dual field theory. This lies at the heart of both AdS/CFT and its generalisations to non-relativistic theories for example. In this talk, we will try to construct models of bulk spacetimes that break the full conformal symmetry present in AdS space down to only scale-invariance in combination with Poincaré invariance. From the field theory point of view, there are well known no-go theorems that forbid unitary theories with such a symmetry, at least in certain dimensions. Our main interest is whether a dual no-go theorem from the bulk point of view exists. To address this question, we discuss a tension that arises between three conditions on the bulk spacetime: A local geometrical condition (Killing algebra of the bulk), a global condition (topology of the bulk) and a physical condition (null energy condition in the bulk).

MP 7.4 Wed 17:25 ZHG001

Number theoretic properties of two-dimensional conformal field theories — Hans Jockers[1], Pyry Kuusela[2], and •Maik Sarve[3] — [1]Johannes-Gutenberg Universität Mainz — [2]Johannes-Gutenberg Universität Mainz — [3]Johannes-Gutenberg Universität Mainz

Many two-dimensional conformal field theories with enhanced symmetry algebras, known as rational conformal field theories, are examples of non-trivial strongly interacting quantum field theories. These additional symmetries render the theories exactly solvable through algebraic methods. It is therefore a natural question to ask how these rational conformal field theories are distributed within the broader space of all two-dimensional conformal field theories. In this talk, I will demonstrate how number theoretic properties of rational conformal field theories can be used to formulate this distribution problem in a mathematically rigorous way and to provide novel insides.

Invited Talk MP 7.5 Wed 17:45 ZHG001

A BPS Road to Holography: Decoupling Limits and Non-Lorentzian Geometries — •Niels Obers — Niels Bohr Institute, Copenhagen, Denmark

I explore decoupling limits that lead to matrix theories on D-branes, focusing on their BPS nature and the emergence of non-Lorentzian target space geometries. In these limits, D-branes experience instantaneous gravitational forces, and when applied to curved geometries, it is shown that a single decoupling limit leads to the AdS/CFT correspondence. By applying two such limits, we generate new holographic examples, including those with non-Lorentzian bulk geometries.

We also examine the relationship between matrix theories and non-relativistic string theory, and their uplift to M-theory. Finally, we demonstrate that reversing these decoupling limits corresponds to deformations of matrix theories, connecting them to the TTbar deformation in two dimensions. These deformations provide a new perspective on the near-horizon brane geometry and lead to TTbar-like flow equations for the Dp-brane DBI action.

MP 8: Waves, Relativity and Quantization

Time: Wednesday 16:15–17:35 Location: ZHG002

MP 8.1 Wed 16:15 ZHG002

Impulsbasierte One-Way-Wellengleichung für die analytische Wellenberechnung in inhomogenen und anisotropen Medien — •Hans-Joachim Raida — 53639 Königswinter

Die konventionelle, in der Akustik und der Physik "standardmässig" verwendete (Two-Way)Wellengleichung 2. Ordnung $(\frac{1}{c^2}\frac{\partial}{\partial t^2} - \Delta)\vec{s} = \vec{0}$ [$\vec{s}$ =Verschiebungsvektor) beschreibt Stehwellenfelder für den trivialen Spezialfall eines homogenen isotropen Mediums. Wegen der Doppelableitungen ist die Lösung mathematisch recht aufwändig bzw. wegen der skalaren, quadrierten Wellengeschwindigkeit c^2=$(+c)^2$=$(-c)^2$ sind die Richtungen der Einzelwellen nicht eindeutig. Oft fehlen analytische Lösungen und es wird auf Näherungslösungen ausgewichen. Zudem können "Artefakte" entstehen. – Im Jahr 2014 wurde die impulsbasierte One-Way-Wellengleichung 1. Ordnung $(\frac{\partial}{\partial t} + \vec{c}\cdot\nabla)(E\vec{s}) = \vec{0}$ aufgestellt und in 30 Veröffentlichungen (DAGA, MDPI et al.) unterschiedliche Teilaspekte behandelt. Die One-Way-Wellengleichung ist – dank einer "kombinierten Feldvariable" ($E\vec{s}$) – sehr viel einfacher zu lösen als die Wellengleichung 2. Ordnung und die Vektor-Wellengeschwindigkeit $\vec{c}$ definiert eindeutig die Wellenausbreitungsrichtung. Die impulsbasierte "One-Way-Theorie" ist relevant für die bekannten akustischen sowie elektromagnetischen Wellen in inhomogenen oder anisotropen Medien. Nur für o.g. Spezialfall des homogenen isotropen Mediums (d.h. $\nabla\vec{c}$=**0**) ist der d'Alembert-Stehwellen-Operator $\Box$=$(\frac{1}{c^2}\frac{\partial}{\partial t^2} - \Delta)$ gleich dem Produkt aus zwei One-Way-Wellenoperatoren $(\frac{\partial}{\partial t} + \vec{c}\cdot\nabla)(\frac{\partial}{\partial t} - \vec{c}\cdot\nabla)$.

MP 8.2 Wed 16:35 ZHG002

Relativistic addition of velocities in a five-dimensional spacetime — •Roland Alfred Sprenger — Herford, Germany

Another method of adding relativistic velocities is shown. It uses a fifth dimension of spacetime rotating the coordinate system of the Minkowski diagram into it and thus is an indication of the existence of a fifth dimension. As proof of correctness of the rotation method it is derived from the addition theorem of velocities. Photographs of a hardware model and diagrams of a computer-generated model illustrate how to find the resulting velocity by the rotation into the five-dimensional spacetime. Alongside the paradox is resolved that any velocity added to lightspeed results in lightspeed.

MP 8.3 Wed 16:55 ZHG002

How come the quantum? Testing a proposal for the origin of Planck's quantum of action — •Christoph Schiller — Motion Moutain Research, Munich

Answers to Wheeler's question "How come the quantum?" are rare. The main reasons are presented and an answer going back to an approach by Dirac is proposed. The proposal implies a topological origin of Planck's quantum of action. The proposal is checked against numerous requirements and experiments that include non-commutativity, probabilities, spinor wave functions, Heisenberg's indeterminacy relation, the Schrödinger equation, and the Dirac equation. Complete agreement with observations is found. A model for particle mass and several experimental predictions are deduced. Unexpectedly, the checks with observations also eliminate all possible alternatives and thus provide arguments for the uniqueness of the proposal. The proposal confirms that quantum mechanics, quantum field theory, particle physics, and physical space are emergent.

Details and publications at https://motionmountain.net/research

MP 8.4 Wed 17:15 ZHG002

The missing link between quantum theory, general relativity and string theory: $c\,m\,day/r_{Earth's\ equator}{}^2 = 2/\pi$ — •Helmut Christian Schmidt — LMU, Munich, www.physics-beyond-standard-model.com

Quantum theory, general relativity and string theory are mathematically correct, but not complete. What can a person see? This can only be explained by a thought experiment. The light beam in the Michelson interferometer rotates in the same way as a Foucault pendulum. The experiment is only finished when one rotation is complete. The laboratory table for normalizing m and s rotates once a day, while a pendulum on the north pole indicates the sidereal time. Assuming a number chain for particles, we get: The spin corresponds to the apse line and is always orthogonal to the largest neighboring object and gives the gravity. For the system of Earth and photon, the pivot point of the angular momentum is the earth's surface. This gives $\sqrt{\pi/2\ c\ m\ day} = r_{Earth\ equator}(NN489m)$ Normalizing to electron, the energy of an electron is: $E_e = g_{freq}\pi + 1 - g_{pot}/\pi$. An algorithm is derived from a Christoffel symbol and similar to a lattice gauge calculation, even without the four interaction constants. It provides exact rest masses for neutrons, protons, muons, tauons, quarks u, d, and pions. The theory can be applied to the inner planetary system and the cosmos and explains quantum entanglement and the hierarchy problem.

$m_{Neutron}/m_e = (2\pi)^4 + (2\pi)^3 + (2\pi)^2 - (2\pi)^1 - 1 - (2\pi)^{-1} + 2(2\pi)^{-2} + 2(2\pi)^{-4} - 2(2\pi)^{-6} + 6(2\pi)^{-8} = 1838.6836611$

If $c\ m\ day/r_{Earth's\ equator}{}^2 = 2/\pi$ is assumed to be true, there are a number of consequences: Formulas for action, energy and centers of gravity can be summarized in a single line by polynomial $P(2\pi)$. $E_{neutron}/E_e = P(2\pi)$ is representative of all neutral objects, with the shortest formula consisting of 10 summands (3x3+1). The orbital periods result from 3 spatial dimensions $2^3 = 8$ as polynomial P(8). For example, for the system of observer, earth and bound moon, the orbital period of the moon is $month = 1/2(8^2 - 8 - 1 - 3/8) = 27.3\ days$. Further precise calculations for orbits and orbital periods in the solar system are given. It is important that the information from 2 real objects is also combined and

stored in the cerebral network using the same algorithm as $E_{neutron}/E_e = P(2\pi)$ in virtual objects at a common point in time. This would explain the anthropic principle from theoretical physics.

h, G_N and c^5 result in a common constant:

$hG_N c^5 s^8/m^{10}\sqrt{\pi^4 - \pi^2 - \pi^{-1} - \pi^{-3}} = 0.999991$

This leads to an estimate for H0 and the wavelength of the CMBR. The polynomials $P(2\pi)$ give rise to new questions in physics, especially regarding Hilbert's 6th problem.

www.researchgate.net/publication/383976153

MP 9: Poster Session: Many-body Theory

Time: Wednesday 16:15–18:15 Location: ZHG Foyer 1. OG

MP 9.1 Wed 16:15 ZHG Foyer 1. OG

Exact solutions of interacting spinor Bose gases — •Hannes Köper[1] and Thomas Gasenzer[1,2] — [1]Kirchhoff-Institut für Physik, Universität Heidelberg, Im Neuenheimer Feld 227, D-69120 Heidelberg, Germany — [2]Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, D-69120 Heidelberg, Germany

The quantum matrix non-linear Schrödinger equation in one spatial dimension describes an integrable model of two non-relativistic SU(2) multiplets with quartic interaction between their coupled states. Due to the matrix structure of the field operators involved, the non-linear term includes spin-changing processes not captured by a plain density-density interaction. In spite of the complexity of these spin changing terms for the general $m \times n$ matrix field, symmetry analysis reveals a very simple picture in terms of Casimir operators of an associated Jordan-Schwinger representation of $\mathfrak{su}(n)$. We solve the model explicitly for the case where both multiplets are spin-1/2 giving rise to a 2×2 matrix field theory. The model is expected to describe e.g. the interactions between different hyperfine states in a Bose gas of hydrogen-like atoms. From its solution we derive exact thermodynamic quantities for the few- and many-body systems.

MP 9.2 Wed 16:15 ZHG Foyer 1. OG

Exploring Strong Correlations and Strong Disorder in Fermionic Systems: Independent Investigations — •Saurabh Kumar — Institute for Theoretical Physics, University of Cologne, Zülpicher Straße 77, D-50937, Köln, Germany

This work addresses the challenges of analyzing strongly interacting and disordered fermionic systems, focusing on two independent projects. Both projects utilize the superbosonization formula as a key analytical tool.

The first project develops a general analytical framework for studying strongly interacting systems, with a specific focus on the one-dimensional Hubbard model at half-filling. The approach utilizes bosonization within the functional integral framework, but challenges arise in defining the continuum limit in time. To overcome this, we integrate renormalization techniques into the bosonization scheme. A full implementation of these ideas is planned for future research.

The second project examines strongly disordered fermion systems in symmetry class D. Motivated by recent proposals of novel spontaneous symmetry breaking (SSB) phenomena in class A, we explore similar phenomena in class D systems. Starting with a general formulation of supersymmetric field theory applied to disordered class D systems, we focus on the strong disorder limit. We also analyze a specific system of monitored free fermions, which exhibits measurement-induced phase transitions. While we propose a reformulation of the theory to offer a fresh perspective, a comprehensive exploration of novel SSB phenomena in class D remains an open question for future investigation.

MP 9.3 Wed 16:15 ZHG Foyer 1. OG

Wegner model in high dimension: Self-consistent approximation — •Julian Arenz — Cologne University, Zülpicher Straße 77, 50937 Köln

Assuming the self-consistent theory of localization due to Abou-Chacra, Anderson and Thouless (AAT), we study the $N = 1$ Wegner model in the regime of strong disorder and high dimension.

While it is traditionally believed that the Wegner model possesses only two phases (metallic and insulating), we investigate the existence of a third phase with spontaneously broken U(1) symmetry. We do so by using a supersymmetric integral equation which follows from the AAT self-consistency equation for the advanced and retarded Green's function.

In the process, we uncover solutions that are neither of metallic nor of insulating type (they break a U(1) symmetry but have a non-compact symmetry). We propose that these solutions correspond to the novel phase and describe fractal eigenstates and singular continuous spectrum.

MP 9.4 Wed 16:15 ZHG Foyer 1. OG

An analogue of the Meissner effect for a SU(2)-Yang-Mills field — •Philipp Wagner[1] and Martin Zirnbauer[2] — [1]Hahnenstraße 23, 50354 Hürth-Efferen — [2]Institut für Theoretische Physik, Zülpicher Straße 77a, 50937 Köln

The decay of the electromagnetic field in a superconducting material, described by the Meissner-Ochsenfeld effect, is a well-known phenomenon of solid state physics. Here we consider an analogous situation for the weak interaction in the presence of a Higgs condensate. Mathematical foundations from Yang-Mills theory are used to set up the Lagrangians for both the Yang-Mills field and the Higgs field. Based upon these structures, an adapted London equation with an adapted London penetration depth is derived for a SU(2)-Yang-Mills field interacting with a spacetime-independent Higgs condensate. It is shown that all gauge bosons of the weak interaction individually exhibit the same phenomenological behavior as the electromagnetic field in a superconductor.

MP 10: Operator Algebras

Time: Thursday 14:00–15:30 Location: ZHG001

Invited Talk MP 10.1 Thu 14:00 ZHG001

Quantum field theory, quantum reference frames and the type of local algebras — •Christopher Fewster — Department of Mathematics, University of York, York, UK

This talk will be a more technically-oriented discussion of the material presented as a plenary talk with the same title during the conference.

QFT assigns local algebras of type III_1 to bounded open spacetime regions. However it has been argued that in some gravitational situations one must include an observer. This happens in particular for the static patch of de Sitter spacetime. Further, the physical observables should be joint observables of the combined QFT-observer system that are invariant under the joint time-evolution of the static patch and observer Hamiltonian. This algebra turns out to be of type II_1 [1]. In this talk, I will describe some of the details of a recent generalisation [2] which places the discussion of [1] on a more operational basis using QFT measurement schemes [3] and by reinterpreting the observer as a quantum reference frame.

[1] V. Chandrasekaran, R. Longo, G. Penington, and E. Witten, An algebra of observables for de Sitter space. JHEP 2023(2) 1-56.

[2] C.J. Fewster, D.W. Janssen, L.D. Loveridge, K. Rejzner and J. Waldron, Quantum Reference Frames, Measurement Schemes and the Type of Local Algebras in Quantum Field Theory, Comm. Math. Phys., 406 (2025) 19:1-87

[3] C.J. Fewster and R. Verch, Quantum fields and local measurements, Comm. Math. Phys. 378 (2020) 851-889

MP 10.2 Thu 14:30 ZHG001

Black Hole Microstates and the Factorisation puzzle — •Jonathan Karl, Souvik Banerjee, and Johanna Erdmenger — Julius-Maximilians-Universität Würzburg

In holography, two manifestations of the black hole information paradox are given by the non-isometric nature of the bulk-boundary map and by the factorisation puzzle. By considering time-shifted microstates of the eternal black hole, we demonstrate that both these puzzles may be simultaneously resolved by taking into account non-local quantum corrections that correspond to wormholes arising from state averaging. This is achieved by showing, using a resolvent technique, that the resulting Hilbert space for an eternal black hole in Anti-de Sitter space is finite-dimensional with a discrete energy spectrum. The latter gives rise to a transition to a type I von Neumann algebra.

MP 10.3 Thu 14:50 ZHG001

Local Structure of Twisted Araki-Woods Algebras — •Ricardo Correa da Silva and Gandalf Lechner — Department of Mathematics, FAU Erlangen-Nürnberg, Erlangen, Germany

Finding models for local nets of von Neumann algebras and understanding the relative commutant $\mathscr{M} \cap \mathscr{N}'$ for the inclusion $\mathscr{N} \subset \mathscr{M}$ is a central problem in Algebraic Quantum Field Theory.

In this talk, a family of von Neumann algebras $\mathscr{L}_T(H)$ with respect to a twist T and a standard subspace H will be introduced and it will be discussed that the

Fock vacuum is separating for these algebras if, and only if, the twist T satisfies two physically motivated conditions: crossing-symmetry and the Young-Baxter equation. Furthermore, some properties of the relative commutant of the inclusion $\mathscr{L}_T(K) \subset \mathscr{L}_T(H)$ will be presented.

MP 10.4 Thu 15:10 ZHG001

Finite Temperature States on Crossed Product Algebras — •Johannes Grosse, Ricardo Correa da Silva, and Gandalf Lechner — FAU Erlangen-Nürnberg, Department Mathematik

In this work, we study the finite temperature behaviour of a (1 + 1)-dimensional fermionic quantum field theory of two particle types. As the thermal equilibrium behaviour of one particle type is well-known, the main work focuses on extending thermal equilibrium states from a theory consisting of one particle type to that of two particle types. The issue of extending thermal equilibrium states can be naturally framed in the language of Tomita-Takesaki modular theory and crossed product algebras.

MP 11: Quantum Field Theory II

Time: Thursday 16:15–17:15 Location: ZHG001

MP 11.1 Thu 16:15 ZHG001

Implementing a Causal Measurement Scheme for Quantum Fields — •Jan Michael Mandrysch — Institut für Quantenoptik und Quanteninformation, Wien, Österreich

While measurement processes in standard quantum mechanics are well understood, the extension of these ideas to quantum field theory (QFT) remains a key challenge. In particular, ensuring that measurements respect fundamental principles such as relativistic causality is crucial. A persistent issue concerning measurements in QFT is, though, that microcausality alone is insufficient to prevent superluminal signaling. In this talk, I will present a concrete scheme for measuring real linear scalar fields, grounded in the Fewster-Verch measurement framework. This approach fully respects the principles of relativistic covariance, locality, and causality, offering a robust solution to the challenges of measurement in QFT.

MP 11.2 Thu 16:35 ZHG001

Large deviations in mean-field quantum spin systems — •Christiaan van de Ven[1] and Matthias Keller[2] — [1]Weierstraße 52, 52349 Düren — [2]Institut für Mathematik, Universität Potsdam, Karl-Liebknecht-Straße 24-25, 14476 Potsdam

Continuous fields of C*-algebras form an important ingredient for describing emergent phenomena, such as phase transitions and spontaneous symmetry breaking. In this talk, I consider the continuous C*-bundle generated by increasing symmetric tensor powers of the complex (lxl) matrices, which can be interpreted as abstract description of mean-field theories defining the macroscopic limit of infinite quantum systems. Within this framework I discuss the principle of large deviations for the local Gibbs state in the high temperature regime and characterize the limit of the ensuing logarithmic generating function. To this end, it has proved necessary to demonstrate the existence of a semiclassical analog of the Baker-Campbel-Hausdorff formula, defined in terms of a series of nested Poisson brackets.

MP 11.3 Thu 16:55 ZHG001

Gauge invariance of topological charges of Noether current — •Christian Hembd — Montebellunastrasse 5, 73447 Oberkochen

Free (complex) quantum fields have an associated Noether current due to global phase invariance of their Lagrangian. By help of the degree of a mapping and the index of a zero known from algebraic topology it is possible to define Lorentz invariant topological charges of the Noether current. These charges are invariant under a group of local transformations of the quantum field. For the case of a free fermion field this leads to SU(2) gauge invariance.

MP 12: Concepts of Physics

Time: Thursday 16:15–17:35 Location: ZHG002

MP 12.1 Thu 16:15 ZHG002

The Limits of Mathematics in Physics — •Grit Kalies[1] and Duong D. Do[2] — [1]HTWD University of Applied Sciences, Dresden, Germany — [2]The University of Queensland, Brisbane, Australia

Mathematics is considered the language of physics. Starting from idealizations and kinematics, geometric-mathematical physics emerged. By analyzing processes regarding their causes and the functional dependencies of energies, we identify shortcomings in the basic energy concepts of physics, which cannot be remedied with mathematics. While formal transformations of process equations such as integration are mathematically correct, they do conceal vital physical information, suggesting that mathematics should be used with caution. We propose a physically justified approach that reconciles the mechanical, quantum mechanical and thermodynamic energy concepts and provides a revised interpretation of E = mc^2. Our results suggest that geometric approaches were built too early on a shaky physical foundation, leading to undesirable developments in recent centuries. G. Kalies, D. D. Do, AIP Adv. 14, 115225 (2024)

MP 12.2 Thu 16:35 ZHG002

What physically characterizes the present? — •Matthias Kölbel and Werner Ahrendt — welträtsel.org

Albert Einstein was convinced that time is what you measure by a clock. According to him, the concept of 'now' has no place in physics. In fact, the physical theories available to date do not provide a comprehensive explanation why time flows and what characterizes the present in the flow of time. The phenomenon of time continues to puzzle physicists and philosophers alike.

We try to solve part of this puzzle by finding out what could physically characterize the present. To do this, we conduct a thought experiment, a modified version of the well-known twin paradox. Our thought experiment suggests that the flow of time is associated with a relative change in the magnitude of the physical quantity known as action, which occurs in the same way for all physical objects.

This consideration has several interesting consequences: Firstly, it becomes understandable why all laws of motion in physics can be derived from the principle of least action. Secondly, it leads to the unexpected conclusion that the redshift of light from distant galaxies is not due to an expansion of space, as usually assumed, but is rather due to the age of the light.

To test our hypothesis and its consequences, we propose a key experiment.

MP 12.3 Thu 16:55 ZHG002

Theoretical physics based on focal-point representation of particles. — •Osvaldo Domann — Stephanstr. 42, 85077 Manching

Physical laws describe the relations between variables as interactions. General relativity describes them as geometric relations, what makes it inappropriate for the description of gravitation and incompatible with quantum mechanics. The problem of the Standard Model in general is the very primitive static representation of subatomic particles with the energy of a resting particle concentrated in a small volume (Point-Like). This representation forces the introduction of carriers (fictitious particles) to explain interactions between them. All alternative approaches like Strings, Loops, Vortex, etc., use the same static and concentrated representation and have therefor the same problems to explain interactions. The proposed approach describes particles as focal points of rays of fundamental particles (FP) with angular momenta where the energy is stored. The four forces (electromagnetic, strong, weak and gravitation) are mathematically deduced as scalar and vector products between the angular momenta of FP. The resulting gravitation description has two force components, the Newton and an Ampere component that explains the flattening of galaxies curve. It is compatible with quantum mechanics. No dark matter is required. More at www.odomann.com

MP 12.4 Thu 17:15 ZHG002

Physikalische Grundbegriffe - relational definiert — •Martin Hohelüchter — Uni Münster/Westf.

Masse kann nur paarweise auftreten und ist daher keine Eigenschaft.

2. und 3. Newtongesetz $\mathbf{0}=m_1\mathbf{b}_1+m_2\mathbf{b}_2=\mathbf{F}_1+\mathbf{F}_2(=\mathbf{F}=m\mathbf{b})$ legen nahe: Masse ist relativ; sie basiert auf einer Relation, der Zerlegung.

Ein zerlegbarer Körper a und seine Teile a_i haben je einen Ort im 4-dim. metr. Raum. Der Ort von a ist durch die Orte der a_i darstellbar: $\mathbf{u}(a)=\Sigma k_i\mathbf{u}(a_i)$ mit $\Sigma k_i=1$

Für Dichotomien heißen die beiden Koeffizienten bei gleichen Vorzeichen je a-Massen, bei verschiedenen Vorzeichen je elektro-magnetische a-Ladungen.

Trichotomien führen analog zu Farb- bzw. schwachen (Kern)Ladungen.

Nicht Trichotomien, wohl aber Dichotomien sind iterierbar; für sie gilt das Assoziativgesetz.

Spaltung von $\mathbf{u}$ in Zeit und Raum $\mathbf{u}=(\mathbf{t},\mathbf{x})$ ergibt jeweils $(\mathbf{t},\mathbf{x}(t))=\Sigma k_i(t)(\mathbf{t},\mathbf{x}_i(t))$ mit $\Sigma k_i(t)=1$

1. Ableitung nach der Zeit führt zu
$(\mathbf{1},\mathbf{v}(t))=\Sigma k_i(t)(\mathbf{1},\mathbf{v}_i(t))$ mit
$k_i(t)\mathbf{1}=:\mathbf{e}_i(t)$ a-Energie, $k_i(t)\mathbf{v}_i(t)=:\mathbf{p}_i(t)$ a-Impuls von a_i zur Zt t.
2. Ableitung nach der Zeit ergibt
$(\mathbf{0},\mathbf{b}(t))=\Sigma k_i(t)(\mathbf{0},\mathbf{b}_i(t))$ mit $k_i(t)\mathbf{b}_i(t)=:\mathbf{F}_i(t)$a-Kraft von a_i z.Zt t

Speziell wird nicht Masse durch Kraft, sondern mech. Kraft durch Masse definiert. Die Sätze der Mechanik sind so beweisbar.

Alle Teile streben jeweils zum Ort des Ganzen. Für die Teile einer Masse-Dichotomie heißt dies Streben Gravitation.

Plasma Physics Division
Fachverband Plasmaphysik (P)

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Overview of Invited Talks and Sessions

(Lecture halls ZHG102 and ZHG006; Poster: ZHG Foyer 1. OG)

Plenary Talk of the Plasma Physics Division

PV IX	Thu	9:45–10:30	ZHG011	**Negative hydrogen ion sources - utilizing low temperature plasmas in ITER's neutral beam systems** — •Ursel Fantz, IPP NNBI Team

Invited Talks

P 1.1	Mon	13:45–14:15	ZHG102	**On the way to a fusion power plant** — •Felix Warmer
P 2.1	Mon	13:45–14:15	ZHG006	**Nanosecond pulse generators for gas discharges** — •Tom Huiskamp, Jeroen Van Oorschot, Chiel Ton, Guus Pemen
P 2.4	Mon	14:45–15:15	ZHG006	**Multimodal Diagnostic Approaches and Interactive Analysis of Mode Transitions in the kINPen Plasma Jet Interacting with Surfaces** — •Torsten Gerling, Hans Höft, Sander Bekeschus, Markus M. Becker, Klaus-Dieter Weltmann, Philipp Mattern
P 3.1	Mon	16:15–16:45	ZHG102	**Flux Pumping for High Performance Tokamak Scenarios** — •A. Bock, A. Burckhart, G. Pucella, F. Auriemma, D. Keeling, D. King, C. Challis, V. Igochine, R. Schramm, J. Stober, T. Pütterich, R. Fischer, J. Hobirk, N. Hawkes, H. Zhang, E. Joffrin, M. Baruzzo, C. Piron, P. Jacquet, JET Contributors, the ASDEX Upgrade Team
P 4.1	Mon	16:15–16:45	ZHG006	**Plasma wind tunnel and plasma propulsion** — •Georg Herdrich, Hendrik Burghaus, Clemens Kaiser, Johannes Oswald, Adam Pagan, Alexander Schlitzer, Martin Eberhart, Stefan Löhle, Constantin Traub, Marcel Pfeiffer, Stefanos Fasoulas
P 4.3	Mon	17:00–17:30	ZHG006	**Force profile and charge estimation of a single particle in the sheath of a dual-frequency CCP** — •Jessica Niemann, Viktor Schneider, Holger Kersten
P 5.1	Tue	11:00–11:30	ZHG102	**Mode activity at the Wendelstein 7-X stellarator - Turbulence driven Alfvén modes** — •S. Vaz Mendes, K. Rahbarnia, H. Thomsen, C. Büschel, J. Riemann, C. Slaby, R. Kleiber, A. Könies, M. Borchardt, J.P. Bähner, A. von Stechow, Wendelstein 7-X Team
P 6.1	Tue	11:00–11:30	ZHG006	**Spatially and temporally resolved electric fields in an RF-APPJ measured by E-FISH** — •Inna Orel, Nikita Lepikhin, Zoltan Donko, Dirk Luggenhölscher, Uwe Czarnetzki
P 7.1	Tue	13:45–14:15	ZHG102	**Impurity Transport in Wendelstein 7-X: Basics and Experimental Observations** — •Birger Buttenschön, Thomas Wegner, Thilo Romba, Daihong Zhang, Felix Reimold, Alice Bonciarelli, the W7-X Team
P 8.1	Tue	13:45–14:15	ZHG006	**Status and outlook for CO_2 conversion with microwave plasmas** — •Ante Hecimovic, Christian K. Kiefer, Arne Meindl, Rodrigo Antunes, Ursel Fantz
P 8.4	Tue	14:45–15:15	ZHG006	**Plasma activation of low-energy molecules using the example of nitrogen** — •Mariagrazia Troia, Katharina Wiegers, Andreas Schulz, Matthias Walker
P 9.1	Tue	16:15–16:45	ZHG102	**In-vessel and depth-resolved hydrogen isotope composition analysis in JET by LIBS operated on a remote handling arm** — •Rongxing Yi, Rahul Rayaprolu, Gennady Sergienko, Erik Wuest, Marc Sackers, Timo Dittmar, Sebastijan Brezinsek

P 11.1	Wed	11:00–11:30	ZHG102	**Ab initio path integral Monte Carlo simulation of warm dense matter** — •Tobias Dornheim
P 12.1	Wed	11:00–11:30	ZHG006	**Using dusty plasmas to measure low-electron sticking coefficients of dielectric materials** — •Armin Mengel, Isabel König, Lorin S. Matthews, Franz X. Bronold, Franko Greiner
P 14.1	Wed	13:45–14:15	ZHG006	**Carbon Dioxide Splitting in Dielectric Barrier Discharges: Power Dissipation and Plasma Chemistry** — •Ronny Brandenburg, Milko Schiorlin, Volker Brüser
P 14.4	Wed	14:45–15:15	ZHG006	**Insights into Mode Transitions and Reactive Species Densities in a Micro Cavity Plasma Array** — •David Steuer, Henrik van Impel, Volker Schulz-von der Gathen, Marc Böke, Judith Golda
P 18.1	Thu	11:00–11:30	ZHG102	**Simulating W erosion, transport, and deposition in Ne-seeded discharges in ITER with full-W wall** — •Christoph Baumann, Juri Romazanov, Sebastian Rode, Andreas Kirschner, Sebastijan Brezinsek, Tom Wauters, Richard Pitts
P 19.1	Thu	11:00–11:30	ZHG006	**A plasma process model for high power impulse magnetron sputtering discharges** — •Martin Rudolph, Daniel Lundin, Jon Tomas Gudmundsson
P 20.1	Thu	13:45–14:15	ZHG102	**First applications of the kinetic ion transport module in the EMC3-EIRENE code package** — •Derek Harting, Dirk Reiser, Christoph Baumann, Sebastian Rode, Juri Romazanov, Sebastijan Brezinsek, Heinke Frerichs, Alexander Knieps, Yuhe Feng
P 20.3	Thu	14:40–15:10	ZHG102	**Simulating boundary turbulence in fusion reactors in different confinement, ELM and detachment regimes** — •Wladimir Zholobenko, Andreas Stegmeir, Kaiyu Zhang, Konrad Eder, Jan Pfennig, Christoph Pitzal, Philipp Ulbl, Matthias Bernert, Michael Griener, the ASDEX Upgrade Team
P 21.1	Thu	13:45–14:15	ZHG006	**Vacuum UV spectroscopy at atmospheric pressure plasmas utilizing silicon nitride membranes** — •Luka Hansen, Görkem Bilgin, Hendrik Kersten, Jan Benedikt
P 21.4	Thu	14:45–15:15	ZHG006	**Hybrid fluid/MC simulations of radio-frequency atmospheric pressure plasma jets** — •Mate Vass, Peter Hartmann, Zoltan Donko, Ihor Korolov, Thomas Mussenbrock, Julian Schulze
P 22.1	Thu	16:15–16:45	ZHG102	**High-resolution optical emission spectroscopy of neutral W lines: comparing near-threshold sputtering of W with different crystal orientation in PSI-2** — •Marc Sackers, Oleksandr Marchuk, Stephan Ertmer, Sebastijan Brezinsek, Fredric Granberg, Arkadi Kreter
P 23.1	Thu	16:15–16:45	ZHG006	**Electric Field Determination for Fundamental and Applied Discharge Physics** — •Tomas Hoder

Invited Talks of the joint Symposium Turbulence in Space and Fusion Plasmas (SYSF)

See SYSF for the full program of the symposium.

SYSF 1.1	Wed	13:45–14:15	ZHG101	**Addressing turbulence questions in the Wendelstein 7-X stellarator device - a combined experimental and theoretical approach** — •Josefine Proll, Paul Mulholland, MJ Pueschel, Maikel Morren, Gavin Weir, Ksenia Aleynikova, Adrian von Stechow, Pavlos Xanthopoulos, Gabriel Plunk, the W7-X Team
SYSF 1.2	Wed	14:15–14:45	ZHG101	**Particle acceleration and transport in astrophysical, magnetized turbulent plasmas** — •Martin Lemoine
SYSF 1.3	Wed	14:45–15:15	ZHG101	**Turbulence in the young solar wind, results from Solar Orbiter and Parker Solar Probe** — •Robert Wicks, Utsav Panchal, Julia Stawarz, Stefan Lotz, Du Toit Strauss, Amore Nel
SYSF 1.4	Wed	15:15–15:45	ZHG101	**Digital Solutions for EUROfusion** — •Volker Naulin

Sessions

P 1.1–1.5	Mon	13:45–15:55	ZHG102	**Magnetic Confinment Fusion/HEPP I**
P 2.1–2.6	Mon	13:45–15:45	ZHG006	**Atmospheric Plasmas and their Applications I**
P 3.1–3.4	Mon	16:15–18:00	ZHG102	**Magnetic Confinment Fusion/HEPP II**
P 4.1–4.4	Mon	16:15–17:45	ZHG006	**Low Pressure Plasmas and their Applications I**
P 5.1–5.4	Tue	11:00–12:35	ZHG102	**Magnetic Confinment Fusion/HEPP III**
P 6.1–6.5	Tue	11:00–12:30	ZHG006	**Atmospheric Plasmas and their Applications II**
P 7.1–7.5	Tue	13:45–15:55	ZHG102	**Magnetic Confinment Fusion/HEPP IV**
P 8.1–8.6	Tue	13:45–15:45	ZHG006	**Atmospheric Plasmas and their Applications III**
P 9.1–9.3	Tue	16:15–17:15	ZHG102	**Plasma Wall Interaction**

P 10.1–10.54	Tue	16:15–18:15	ZHG Foyer 1. OG	**Poster Session I**
P 11.1–11.4	Wed	11:00–12:15	ZHG102	**Laser Plasmas**
P 12.1–12.4	Wed	11:00–12:15	ZHG006	**Complex Plasmas and Dusty Plasmas I**
P 13	Wed	12:20–13:20	ZHG102	**Members' Assembly**
P 14.1–14.5	Wed	13:45–15:30	ZHG006	**Atmospheric Plasmas and their Applications IV**
P 15.1–15.6	Wed	16:15–17:45	ZHG102	**Astrophysical Plasmas**
P 16.1–16.5	Wed	16:15–17:30	ZHG006	**Complex Plasmas and Dusty Plasmas II**
P 17.1–17.49	Wed	16:15–18:15	ZHG Foyer 1. OG	**Poster Session II**
P 18.1–18.4	Thu	11:00–12:35	ZHG102	**Codes and Modeling/HEPP**
P 19.1–19.5	Thu	11:00–12:30	ZHG006	**Low Pressure Plasmas and their Applications II**
P 20.1–20.5	Thu	13:45–15:50	ZHG102	**Magnetic Confinment Fusion/HEPP V**
P 21.1–21.6	Thu	13:45–15:45	ZHG006	**Atmospheric Plasmas and their Applications V**
P 22.1–22.3	Thu	16:15–17:35	ZHG102	**Plasma Wall Interaction/HEPP**
P 23.1–23.6	Thu	16:15–18:00	ZHG006	**Atmospheric Plasmas and their Applications VI**

Members' Assembly of the Plasma Physics Division

Wednesday 12:20–13:20 ZHG102
Small snack included :-)

- Report
- Election of the new board members
- Miscellaneous

Sessions

– Invited Talks, Contributed Talks, and Posters –

P 1: Magnetic Confinment Fusion/HEPP I

Time: Monday 13:45–15:55 Location: ZHG102

Invited Talk P 1.1 Mon 13:45 ZHG102

On the way to a fusion power plant — •Felix Warmer — Max Planck Institut für Plasmaphysik

The pursuit of controlled nuclear fusion for sustainable energy generation has long been a focal point of scientific research. Recent demonstration of significant energy gain in fusion experiments has triggered a wave of excitement around the world. In particular, a number of large, privately funded fusion startup companies have emerged that aim to bring fusion power to the grid. Is fusion power within our grasp? This talk will discuss the state-of-the-art in fusion reactor design, explore the remaining challenges, and sketch the way forward, focusing on magnetic confinement and the Stellarator concept.

P 1.2 Mon 14:15 ZHG102

Avenues to steady-state turbulence suppression at Wendelstein 7-X — •Markus Wappl, Sergey Bozhenkov, Jürgen Baldzuhn, Sebastian Bannmann, Håkan Smith, Edgardo Villalobos, and Pavlos Xanthopoulos — Max Planck Institute for Plasma Physics, Greifswald, Germany

Plasma scenarios of transient turbulence suppression, featuring improved energy confinement and high ion temperature, are well known at W7-X. By means of injecting neutral beams or frozen hydrogen pellets, the electron density gradient can be momentarily increased which suppresses ITG-driven turbulent heat transport in the ion channel to nearly zero. However, collapse of the density gradient and return to conventional turbulent heat transport usually occurs after only a few confinement times.

Recent plasma scenario development suggests paths to steady-state turbulence suppression. A newly commissioned steady-state pellet injector along with careful adjustment of microwave heating power allows to maintain the increased density gradient. In addition, a self-ordering process leading to a similar density gradient and turbulence suppresion is observed in microwave heated plasmas at low power, following boronization of the first wall.

This talk provides an overview of a large turbulent transport database obtained by power balance analysis. Several transient and steady-state turbulence-suppressed plasma scenarios are discussed in detail and compared to gyrokinetic transport simulations. An outlook to future steady-state turbulence-suppressed scenarios is given.

P 1.3 Mon 14:40 ZHG102

Introduction of a 3D global non-linear full-f particle-in-cell model for runaway electrons in JOREK — •Hannes Bergstroem[1], Shi-Jie Liu[1], Vindoh Bandaru[2], and Matthias Hoelzl[1] — [1]Max Planck Institute for Plasma Physics, Garching b. M. — [2]Indian Institute of Technology Guwahati, Assam

Disruptions are a major challenge for ensuring reliable tokamak operation. The acceleration of electrons to relativistic energies, so-called *runaway electrons* (REs), being a significant concern for future large scale devices like ITER. Accurately predicting the formation and deposition of REs is critical for optimizing machine design and implementing effective disruption mitigation systems. This requires advanced modeling that captures the interplay between REs and the plasma, including the large-scale MHD activity characteristic of disruptions. The non-linear 3D extended MHD code JOREK provides a powerful framework for investigating disruption and RE dynamics. This talk introduces recent enhancements to JOREK, incorporating a hybrid fluid-kinetic model where REs are represented kinetically and coupled to the non-linear MHD equations through a full-f particle-in-cell approach. The model offers precise insight into the phase space distributions, drift dynamics, and transport and losses of REs in stochastic magnetic fields. Benchmarks are conducted for both 2D and 3D configurations, with results showing good agreement with analytical predictions. Additionally, a particularly challenging non-linear case with high relevance for large tokamaks is presented: a benign termination of REs triggered by a rapid burst of MHD activity.

P 1.4 Mon 15:05 ZHG102

Gyrokinetic instabilities and turbulence in stellarators — •Linda Podavini, Per Helander, Gabriel G Plunk, and Alessandro Zocco — Max-Planck-Institut für Plasmaphysik, Wendelsteinstraße 1, 17491 Greifswald, Germany

The stellarator Wendelstein 7-X (W7-X) is designed to achieve reduced neoclassical transport through magnetic field optimization. Its confinement properties are thus predominantly determined by turbulence, which arises from instabilities active at kinetic scales. The stability of these turbulence-driving modes depends on various plasma parameters, such as the strength of temperature and density gradients, the mirror ratio, and the rotational transform of the confining magnetic field, for instance. Adjusting these parameters offers a pathway to optimising performance in W7-X and future stellarators alike. In this contribution, we present numerical investigations of kinetic plasma turbulence in W7-X within the context of gyrokinetic theory, paying attention to possible improvements in operating scenarios and performance. The high sensitivity of these instabilities on plasma parameters underscores the need for a unified theoretical framework capable of providing rapid stability proxies. The theory of upper bounds on the growth rates of local gyrokinetic instabilities addresses this need by offering results that are independent of magnetic geometry and several plasma parameters. However, comparisons with gyrokinetic simulations highlight the crucial role of magnetic geometry in achieving quantitatively accurate results.

P 1.5 Mon 15:30 ZHG102

Reduced kinetic modelling of shattered pellet injection in ASDEX Upgrade — •Peter Halldestam[1], Paul Heinrich[1], Gergely Papp[1], Mathias Hoppe[2], Matthias Hölzl[1], István Pusztai[3], Oskar Vallhagen[3], Rainer Fischer[1], and Frank Jenko[1] — [1]Max Planck Institute for Plasma Physics, Garching b. München, Germany — [2]Royal Institute of Technology, Stockholm, Sweden — [3]Chalmers University of Technology, Göteborg, Sweden

Plasma-terminating disruptions are a critical outstanding issue for reactor-relevant tokamaks. ITER will use Shattered Pellet Injection (SPI) as its disruption mitigation system to reduce heat loads, vessel forces, and to suppress the formation of runaway electrons. In this work we demonstrate that reduced kinetic modelling of SPI is capable of capturing the major experimental trends in ASDEX Upgrade SPI experiments, such as dependence of the radiated energy fraction on neon content, or the current quench dynamics. Simulations confirm the experimental observation of no runaway electron generation with neon and mixed deuterium-neon pellet composition. We also show that statistical variations in the fragmentation process only have a notable impact on disruption dynamics at intermediate neon doping, as was also observed in experiments.

P 2: Atmospheric Plasmas and their Applications I

Time: Monday 13:45–15:45 Location: ZHG006

Invited Talk P 2.1 Mon 13:45 ZHG006

Nanosecond pulse generators for gas discharges — •Tom Huiskamp, Jeroen Van Oorschot, Chiel Ton, and Guus Pemen — Eindhoven University of Technology, Eindhoven, The Netherlands

Gas discharges generated by nanosecond high-voltage pulses have gained attraction for a number of reasons, but mainly because they are very efficient for a variety of (environmental) plasma applications such as air pollution control, nitrogen fixation, synthesis of chemicals, materials processing, plasma medicine and others. Specifically, researchers have noted that the pulse duration and the rise time of the applied high-voltage pulse have a significant influence on the radical yield of the transient plasmas generated with nanosecond pulses; shorter pulses result in higher yields. With the need to study gas discharges generated by these short pulses comes the need to understand how to generate those pulses and to understand the interaction between the pulse source and the discharge. In this contribution, we will explore the different methods with which to generate nanosecond high-voltage pulses, how the interaction between the pulse source and the discharge may influence the source and the discharge and how to optimize the energy transfer from the pulse source to the discharge.

P 2.2 Mon 14:15 ZHG006

Properties of microarcs in atmospheric pressure air in a presence of metal vapour — •Margarita Baeva[1] and Dirk Uhrlandt[2] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Institute of Electrical Power Engineering, University of Rostock, Rostock, Germany

Electric discharges in presence of metal vapours can be found in various applications, e.g. in switching devices and welding arcs. In low-voltage, low-current switching devices, an electric arc in metal vapours occurs during the early contact opening. A bridge of molten metal can be built and it can break at temperatures close to the boiling temperature of the material so that the gap between the electrodes is filled with metal vapour. The metal atoms are easily ionized due to their low ionization potential and a discharge ignites.

In this contribution, we report results from modelling studies of microarcs in atmospheric pressure air-copper vapour mixtures. The effects of copper metal vapour on the microarc properties and plasma chemistry are studied. Findings demonstrate the spatial structure of the microarc and the behaviour of the plasma parameters for various ratios of the air and metal vapour concentrations, and the length of the inter-electrode gap.

The work is funded by the German Research Foundation (DFG) Project number 524731006.

P 2.3 Mon 14:30 ZHG006

modeling of the ion wind for a surface barrier discharge used for gas conversion — •soad mohsenimehr[1], sebastian wilczek[2], thomas mussenbrock[3], and achim von keudell[1] — [1]Experimental Physics II, Reactive Plasmas, Ruhr University Bochum, D*44780 Bochum, Germany — [2]Technische Hochschule Georg Agricola, Bochum, Germany — [3]Chair of Applied Electrodynamics and Plasma Technology, Ruhr University Bochum, D-44780 Bochum, Germany

The ion wind in a surface dielectric barrier discharge (SDBD) plays a crucial role in generating and manipulating the flow field through its electrohydrodynamic force (EHD). This work employs a twin SDBD consisting of an aluminium oxide plate (190*88*0.63 mm) covered by a nickel grid printed on both sides in a comb-like pattern and generated at atmospheric pressure using damped sinusoidal voltage waveforms at kHz frequency. A Schlieren diagnostic was performed and compared with computational fluid dynamic simulation to investigate the flow pattern. This work presents how the EHD force was calculated from a direct time-dependent plasma simulation by the nonPDPSIM platform and incorporated, after proper scaling, into the steady-state flow simulation by COMSOL. Finally, the comparison between numerical simulation and experimental results is reported. It is shown that the origin of the EHD force is not only given by the streamer propagation dynamics but more importantly by the relaxation phase of the boundary region above the dielectric during the decay of the plasma channel.

Invited Talk P 2.4 Mon 14:45 ZHG006

Multimodal Diagnostic Approaches and Interactive Analysis of Mode Transitions in the kINPen Plasma Jet Interacting with Surfaces — •Torsten Gerling[1], Hans Höft[1], Sander Bekeschus[1,2], Markus M. Becker[1], Klaus-Dieter Weltmann[1], and Philipp Mattern[1] — [1]1Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Department of Dermatology and Venerology, Rostock University Medical Center, Rostock, Germany

The dynamic interactions of the effluent of the cold atmospheric pressure plasma jet kINPen and surfaces is investigated, focusing on the identification and characterization of distinct operational modes: conductive, transient, and free modes. By evaluating the influence of the surface distance on the plasma characteristics, the critical role of multimodal diagnostic techniques in monitoring mode shifts is explored including electrical measurements, high speed imaging, optical emission spectroscopy (OES), and acoustic analysis. Each diagnostic method revealed valuable insights into the discharge modes associated with a specific distance of the kINPen to the surface. The individual response of the detection methods to the mode shifts is compared and discussed. As data management emerges as a new challenge and burden in scientific research, this study highlights how leveraging these demands can inspire innovation and enhance scientific discovery. By providing the evaluated data in an interactive fashion, the results are prepared to support an individual exploration.

P 2.5 Mon 15:15 ZHG006

thermal characteristics of microarray DBD in helium — •Yue Cheng[1], Henrik van Impel[1], David Steuer[1], Judith Golda[1], and Marc Böke[2] — [1]Plasma Interface Physics, Ruhr-University Bochum, D-44801 Bochum, Germany — [2]Experimental Physics II: Physics of Reactive Plasmas, Ruhr-University Bochum, D-44801 Bochum, Germany

The urgent demand for efficient and sustainable chemical processes has driven interest in plasma-assisted catalytic methods, particularly for n-butane conversion, for their ability to promote energy-efficient reactions. Reaction kinetics and conversion rates are highly temperature-dependent, making it critical to investigate the effects of elevated temperatures on plasma chemistry. To address this, we optimized our reactor specifically for high-temperature applications. The reactor incorporates a neodymium magnet embedded in a MACOR carrier as the grounded electrode. A heating system positioned beneath the magnet, capable of reaching up to 350°C. A 40μm zirconium dioxide dielectric layer separates the magnet from a nickel grid, which is cut into two 1*1 cm squares with 1 mm gaps featuring substructures of 100 μm and 150 μm. The entire assembly is stabilized using a quartz frame and cover. Experimental results reveal a significant increase in rotational temperature with rising discharge surface temperature, with larger cavity structures exhibiting higher rotational temperatures. This temperature potentially reduces the activation energy for n-butane reactions, thereby enhancing reaction rates and promoting intermediate formation. This work is supported by DFG within SFB1316 (A6).

P 2.6 Mon 15:30 ZHG006

Tuning plasma chemistry by various excitation mechanisms for the H_2O_2 production of atmospheric pressure plasma jets — •Steffen Schüttler, Niklas Eichstaedt, and Judith Golda — Ruhr-University Bochum, Universitätsstraße 150, 44801 Bochum, Germany

Atmospheric pressure plasmas (APPJs) are widely used in various fields of research and applications. There are plenty of different APPJs designed with various geometries and excitation mechanisms ranging from μs and fast ns pulses pulsed at kHz frequencies to RF-driven waveforms. A direct comparison of these APPJs is challenging as the different excitation mechanisms at different geometries are barely comparable. In this work, a capillary plasma jet was used that is operable at kHz pulsing with a high voltage pulse with μs or ns rise time and a sinusoidal voltage pulse at 13.56 MHz (RF) at the same plasma jet geometry [1]. The effect of the excitation mechanisms on the production of H_2O_2 was investigated by treating liquids and measuring the H_2O_2 concentration in the treated liquid. The plasma jet is operable under all excitation mechanisms up to a plasma power of 1.5 W. An increased humidity admixture and higher plasma powers lead to enhanced H_2O_2 production under all excitation mechanisms. The fast ns pulses and the RF operation show similar results, while the μs operation is less effective.

This work is supported by the DFG within CRC 1316 (Subproject B11, project number 327886311).

[1] S. Schüttler et al 2025 J. Phys. D: Appl. Phys. 58 025203

P 3: Magnetic Confinment Fusion/HEPP II

Time: Monday 16:15–18:00 Location: ZHG102

Invited Talk P 3.1 Mon 16:15 ZHG102

Flux Pumping for High Performance Tokamak Scenarios — •A. Bock[1], A. Burckhart[1], G. Pucella[2], F. Auriemma[2], D. Keeling[3], D. King[3], C. Challis[3], V. Igochine[1], R. Schramm[1], J. Stober[1], T. Pütterich[1], R. Fischer[1], J. Hobirk[1], N. Hawkes[3], H. Zhang[1], E. Joffrin[4], M. Baruzzo[2], C. Piron[2], P. Jacquet[3], JET Contributors[5], and the ASDEX Upgrade Team[6] — [1]MPI for Plasma Physics, Garching, Germany — [2]ENEA, Frascati, Italy — [3]CCFE, Abingdon, United Kingdom — [4]CEA, Saint-Paul-lez-Durance, France — [5]see author list of J. Mailloux et al. 2022 Nucl. Fusion — [6]see author list of H. Zohm et al., 2024 Nucl. Fusion

Viable tokamak fusion power plant scenarios must exhibit high energy confinement and magnetohydrodynamic (MHD) stability. To this end, the anomalous redistribution of magnetic flux caused by a central continuous self-regulating saturated MHD mode ("flux pumping") can be of great benefit: it clamps the central safety factor q to 1, i.e. limits the core magnetic field line helicity, thereby preventing the occurrence of periodic reconnection events known as sawtooth crashes which can take place whenever $q < 1$. This not only avoids the performance-degrading crashes, but can also prevent secondary resistive instabilities and their potentially disastrous consequences. Ultimately, flux pumping can result in a peaked plasma current profile just shy of sawteeth, giving additional stability against ideal MHD instabilities.

This contribution will present recent experimental evidence of flux pumping from the ASDEX Upgrade and JET tokamaks, including initial modelling results.

P 3.2 Mon 16:45 ZHG102

Hybrid kinetic-MHD and gyrokinetic simulations of the fishbone instability with JOREK and ORB5 — •Felix Antlitz[1], Xin Wang[1], Matthias Hoelzl[1], Guido Huijsmans[2,3], Philipp Lauber[1], Thomas Hayward-Schneider[1], and Alexey Mishchenko[4] — [1]Max Planck Institute for Plasma Physics, Garching b. M., Germany — [2]CEA, Saint-Paul-Lez-durance, France — [3]Eindhoven Univer-

sity of Technology, Eindhoven, Netherlands — [4]Max Planck Institute for Plasma Physics, Greifswald, Germany

Energetic particles (EPs) will play a central role in future burning plasma experiments, as they can strongly interact with the bulk plasma and drive magnetohydrodynamic (MHD) instabilities. For instance, the so called fishbone instability is the result of an internal kink mode destabilized by EPs in tokamaks. In this contribution, we first describe numerical simulations using the nonlinear extended MHD code JOREK, whose kinetic module is used to include EPs with a particle-in-cell technique. JOREK uses a full-f formulation for the EPs and evolves the MHD equilibrium consistently in time. Second, results from simulations with the global electromagnetic gyrokinetic code ORB5 are presented. This uses a gyrokinetic (or drift-kinetic) description not only for the fast ions, but also for the thermal ions and electrons. The two codes are run in both the linear and nonlinear regimes and the effect of the differences between the two models implemented in the codes are discussed.

P 3.3 Mon 17:10 ZHG102

Progress of Machine Learning-based Real Time Control Applications and SPI Shard Tracking at ASDEX Upgrade — •Johannes Illerhaus[1,2], Wolfgang Treutterer[1], Bernhard Sieglin[1], Alexander Bock[1], Rainer Fischer[1], Matthias Gehring[1], Paul Heinrich[1,2], Ondrej Kudlacek[1], Mohammad Miah[1,2], Gergely Papp[1], Tobias Peherstorfer[3], Thomas Zehetbauer[1], Udo von Toussaint[1], Hartmut Zohm[1], Frank Jenko[1], and the ASDEX Upgrade Team[4] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [2]Technische Universität München, Garching, Germany — [3]Technische Universität Wien, Vienna, Austria — [4]see the author list of U. Stroth et al. 2022 *NF* 62 042006

Machine Learning (ML) is a versatile tool with unique benefits in different applications of magnetic confinement fusion research, particularly in plasma control. This contribution will discuss the progress of integrating ML models into **A**SDEX **Upg**rade's (**AUG**'s) **D**ischarge **C**ontrol **S**ystem (**DCS**) and towards an ML-based automated video analysis of a **S**hattered **P**ellet **I**njection (**SPI**) dataset from a test series in search of the optimal setup configuration for the ITER SPI system. A focus will be put onto the DCS integration, where a generic pipeline for quick integration of different ML models as augmentations to the DCS was constructed using real time GPU inference. The pilot project of this pipeline is a real-time capable high-fidelity electron density profile reconstructor, which now runs in routine operation during the ongoing AUG experimental campaign.

P 3.4 Mon 17:35 ZHG102

Neural Networks as Solution Ansatz for the Ideal Magnetohydrodynamic Equilibrium Problem — •Timo Thun[1], Andrea Merlo[2], and Daniel Böckenhoff[1] — [1]Max-Planck-Institute for Plasma Physics, Wendelsteinstraße 1, 17491 Greifswald, Germany — [2]Proxima Fusion, Am Kartoffelgarten 14, 81671 Munich, Germany

Quick and accurate solvers for the fixed-boundary ideal magnetohydrodynamic (MHD) equilibrium problem in non axisymmetric magnetic fields can accelerate stellarator optimisation, facilitate high-fidelity real-time control and enable other data-driven algorithms. Unfortunately, current MHD equilibrium solvers either require high computational wall-time or suffer from a lack of accuracy. Solvers based on Neural Networks (NN) enable very fast inference by transferring the bulk of computational load to model training and the creation of datasets, possibly overcoming this dilemma. Recent work presented a fast NN based ideal MHD surrogate model in the magnetic configuration space defined by the stellarator research device Wendelstein 7-X, using a dataset calculated by conventional solvers and the ideal MHD equilibrium force-residual. Training without a dataset removes implicit biases of its solution strategy and avoids computational costs associated with its creation. We present simple NN models trained solely on the physics-based force residual that achieve comparable or better flux surface averaged force residuals than conventional solvers.

P 4: Low Pressure Plasmas and their Applications I

Time: Monday 16:15–17:45 Location: ZHG006

Invited Talk P 4.1 Mon 16:15 ZHG006

Plasma wind tunnel and plasma propulsion — •Georg Herdrich, Hendrik Burghaus, Clemens Kaiser, Johannes Oswald, Adam Pagan, Alexander Schlitzer, Martin Eberhart, Stefan Löhle, Constantin Traub, Marcel Pfeiffer, and Stefanos Fasoulas — Institut für Raumfahrtsysteme, Pfaffenwaldring 29, 70569 Stuttgart

More than 4 decades of experience have been gained in the field of electric propulsion (EP). Respective developments are summarized and foremost results are highlighted. The types of EP systems are not considered as to be competitive as it is shown by system analyses. Correspondingly, ion thrusters, Hall thrusters, thermal arcjets, or magnetoplasmadynamics (MPD) thrusters are preferable depending on the mission. Several advanced plasma propulsion designs have been developed and characterized. Among them are TIHTUS, steady state applied field MPD thrusters, PPTs, IEC-based thrusters and advanced Helicons. These devices have been characterized and show potential for future missions. With the heritage in high-power EP it was a train of thought to modify these such that they could be operated e.g. with air to emulate high enthalpy flows. Four plasma wind tunnels are in operation enabling modeling verification, the characterization and qualification of materials and the development of instrumentations (flight). The talk will also highlight the CRC ATLAS assessing VLEO. E.g. advanced Helicon-based thrusters are candidates for air breathing EP. ATLAS is far beyond: There are aspects as material characterization, modeling, enabling technologies and mission application.

P 4.2 Mon 16:45 ZHG006

Characterization of E- to H-mode transition in inductively coupled argon-hydrogen plasma — •Marimel Mayer, Mikhail Pustylnik, Hubertus Thomas, and Daniela Zander — DLR Institut für Materialphysik im Weltraum, Cologne, Germany

Hydrogen-containing plasma is a promising alternative for CO_2 emission-free iron ore reduction [1]. In many applications, operation of inductively coupled plasma in the H-mode is favorable for higher process rates [2]. A low-temperature inductively coupled argon-hydrogen plasma is characterized at the transition from E- to H-mode to determine plasma parameters for iron ore reduction processes.

A modified Gaseous Electronics Conference reference cell with a radio-frequency antenna powered at 13.56 Hz serves as plasma reactor [3]. Operating pressures are in the range of 5 Pa to 50 Pa in an argon-hydrogen (9:1) gas mixture. The plasma is monitored during the mode transition by an inline voltage, current and phase measurement, optical emission spectroscopy and microwave interferometry. Consequently, transition threshold powers, plasma densities, hydrogen dissociation degrees and electron temperatures are evaluated.

[1] Sabat, K.; Murphy, A. doi: 10.1007/s11663-017-0957-1 (2017)
[2] Ahr, P. et al. doi: 10.1088/0963-0252/24/4/044006 (2015)
[3] Miller, P. et al. doi: 10.6028/jres.100.032 (1995)

Invited Talk P 4.3 Mon 17:00 ZHG006

Force profile and charge estimation of a single particle in the sheath of a dual-frequency CCP — •Jessica Niemann, Viktor Schneider, and Holger Kersten — Institute of Experimental and Applied Physics, Christian-Albrechts-University, Kiel, Germany

Optically trapped microparticles have emerged as valuable non-invasive probes for exploring plasma environments. Using optical tweezers, particle probes can be positioned in regions such as the sheath, which are often inaccessible by conventional diagnostics, enabling precise investigations of local plasma properties. In this study, force profiles acting on trapped microparticles are measured in the sheath of a dual-frequency capacitively coupled plasma (CCP). The discharge is generated by the superposition of two harmonics (13.56 MHz and 27.12 MHz) with a variable phase angle between them. By systematically varying the phase angle, parameters such as the sheath edge position, the maximum electric field force, and the evolution of the particle charge are determined. Additionally, the averaged particle charge is independently estimated by calculating the mechanical work required to move the particle through the sheath, providing a benchmark for evaluating electric field models. Comparisons with models, including matrix sheath theory and Child-Langmuir law, as well as simulation results, reveal good agreement and validate the potential of this approach as suitable diagnostic.

P 4.4 Mon 17:30 ZHG006

Plasma spectroscopy with a mid-infrared optical frequency comb — Ibrahim Sadiek[1,2], Norbert Lang[1], and •Jean-Pierre H. van Helden[1,2] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Faculty of Physics and Astronomy, Ruhr University Bochum, Bochum, Germany

Non-thermal molecular plasmas play a crucial role in numerous industrial processes and hold significant potential for driving essential chemical transformations. Precise information on the molecular composition of the plasma, on the absolute concentrations and temperatures of the reactive species in the plasma, their population distribution among the quantum states and their reaction kinetics is essential for understanding and optimizing plasma processes. We develop and apply frequency comb-based spectroscopy techniques, offering a unique combination of broad bandwidth and high spectral resolution, enabling the simultaneous detection of multiple species in the plasma. We report on an air-spaced virtually imaged phased array (VIPA) spectrometer that resolves the

modes of a mid-infrared frequency comb with a repetition rate of 250 MHz [1]. We demonstrate its capabilities by measuring high-resolution spectra of molecular species generated in plasmas containing hydrogen, nitrogen, and methane at a pressure of 1.5 mbar. The compact and practical air-spaced VIPA spectrometer exploits the full potential of a stabilized frequency comb, making it suitable for a wide range of spectroscopic applications in plasmas. This work is funded by the DFG - project number 499280974

P 5: Magnetic Confinment Fusion/HEPP III

Time: Tuesday 11:00–12:35 Location: ZHG102

Invited Talk P 5.1 Tue 11:00 ZHG102

Mode activity at the Wendelstein 7-X stellarator - Turbulence driven Alfvén modes — •S. Vaz Mendes[1], K. Rahbarnia[1], H. Thomsen[1], C. Büschel[1], J. Riemann[1], C. Slaby[1], R. Kleiber[1], A. Könies[1], M. Borchardt[1], J.P. Bähner[2], A. von Stechow[1], and Wendelstein 7-X Team[1] — [1]Max-Planck-Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany — [2]MIT Plasma Science and Fusion Center, MA 02139, USA

In the optimized stellarator Wendelstein 7-X, magnetic fluctuation measurements reveal the excitation of Alfvén eigenmodes (AEs) in electron cyclotron resonance heated plasmas, despite the absence of a normal fast-particle driving source. This work presents an explanation for AE excitation via ion-temperature-gradient (ITG) turbulence. The detected AEs (Mirnov-measurements) in the range $50 < f < 450$ kHz are consistent with ellipticity, toroidicity, and non-circularity induced AEs. Density fluctuations (Phase Contrast Imaging measurements) indicated dominant ITG turbulence in these plasmas. The amplitudes of AEs and density fluctuations show a correlation for different magnetic field configurations. Moreover, in turbulence-reduced regimes, caused by peaking of the density profile via pellet injection, a reduction in the AE amplitude is found. Non-linear gyrokinetic simulations using the EUTERPE code revealed simultaneous excitation of zonal flow activity and generation of AEs driven by ITG turbulence. They also show that ITG modes are necessary to excite AEs above their initial low level.

P 5.2 Tue 11:30 ZHG102

Characterization of low frequency electromagnetic modes in the W7-X core and scrape-off layer plasma — •Dario Cipciar[1], Carsten Killer[1], Jiri Adamek[2], Kian Rahbarnia[1], Christian Brandt[1], Olaf Grulke[1,3], Neha Chaudhary[1], Henning Thomsen[1], and W7-X Team[1] — [1]Max-Planck-Institut fur Plasmaphysik, Wendelsteinstr. 1, 17491 Greifswald, Deutschland — [2]Institute of Plasma Physics of the CAS, U Slovanky 2525/1a, 18200 Prague 8, Czech Republic — [3]Department of Physics, Technical University of Denmark, Lyngby, Denmark

Global low-frequency electromagnetic oscillations of m=1 type are often observed in the Wendelstein 7-X stellarator. These modes significantly modulate the plasma stored energy and can appear as harmonic oscillations or as intermittent bursts, depending on the magnetic configuration. The bursty mode activity occurs in scenarios with large stationary magnetic islands just inside the last closed flux surface. In this case, a particularly strong effect on the plasma confinement is observed, via the effect of bursts on the density gradient and a gradient-associated temporary suppression of cross-field losses. Further, both continuous and bursty mode activity is observed in the Scrape-Off Layer using electric probes. The fluctuations of the poloidal electric field, electron temperature and density is captured using an array of Langmuir and ball-pen probes and used to calculate the perpendicular transport parameters. A Ball-pen probe in a swept regime (20 kHz) is used to measure the fluctuations of ion temperature, crucial for the material sputtering of the first wall due to transiently high Ti.

P 5.3 Tue 11:55 ZHG102

Turbulent magnetic fluctuations in plasma edge — •Kaiyu Zhang, Wladimir Zholobenko, Andreas Stegmeir, and Frank Jenko — Max Planck Institute for Plasma Physics, Garching, Germany

Small magnetic fluctuations are inherently present in a magnetic confinement plasma due to turbulent currents. These fluctuations flutter the background field lines, thereby reshaping the turbulence, which is investigated with GRILLIX, a global full-f fluid turbulence code using a locally field-aligned scheme. This study introduces a real-time high-pass filter to screen the magnetic fluctuations in turbulence, based on which the magnetic flutter effect is implemented. The implementation is verified by the method of manufactured solution and validated in the full-size simulations for the edge and scrap-off layer of Asdex Upgrade tokamak. The magnetic flutter in the drift-Alfvén-wave is found to reduce ExB transports by decreasing the phase shift between potential and density fluctuations, imparting stabilizing factors of 2 in the low confinement conditions and up to 100 in high confinement conditions. These findings establish the flutter stabilization as a fundamental aspect of edge turbulence. In reactor-relevant small edge-localized-modes (ELMs) regimes, the magnetic fluctuations form substantial Maxwell stresses, which flatten the radial electric field and weaken the associated flow shear near the separatrix. This facilitates the growth of the quasi-coherent mode driven by the kinetic-ballooning-mode, ultimately contributing to increased flutter transport of particles, conducive to avoiding Type-I ELMs and alleviating the heat exhaust challenge.

P 5.4 Tue 12:20 ZHG102

Investigation of Density-Potential Coupling as Agent for the Interplay of Particle and Momentum Transport in Drift Wave Turbulence — •Ralph Sarkis, Bernhard Schmid, Günter Tovar, and Mirko Ramisch — IGVP, University of Stuttgart, Germany

The experimental investigation of turbulent transport dynamics in the edge of magnetically confined plasmas highlights the coupling of density and potential fluctuations in the interplay of particle and momentum transport. At the TJ-K stellarator, a poloidal Langmuir-probe array is set up to simultaneously measure density and potential fluctuations, providing spatiotemporal observations of particle transports and Reynolds stress. While both transport phenomena rely on con- flicting density-potential coupling conditions, experimental measurements exhibit a shared local region of maximum levels. Dynamics investigations reveal an inverse temporal relation of particle and momentum transport, substantiated by their strong correlation and anti-correlation with the density-potential decoupling, respectively. The spectral decomposition of the coupling parameter emphasizes the role of small-scale contributions in the drift-wave dominated transports' formation. Furthermore, the occurrence of zonal flows appears to alter the transports' dependence on the coupling. Both particle and momentum transport appear to be decorrelated from the density-potential coupling during zonal flows. This phenomenon is elucidated by analyses of spectral energy transfer between small-scale fluctuations in density and potential and meso-scale shear flows.

P 6: Atmospheric Plasmas and their Applications II

Time: Tuesday 11:00–12:30 Location: ZHG006

Invited Talk P 6.1 Tue 11:00 ZHG006

Spatially and temporally resolved electric fields in an RF-APPJ measured by E-FISH — •Inna Orel[1], Nikita Lepikhin[1], Zoltan Donko[2], Dirk Luggenhölscher[1], and Uwe Czarnetzki[1] — [1]Ruhr University Bochum, Institute for Plasma and Atomic Physics, Bochum, Germany — [2]Institute for Solid State Physics and Optics HUN REN Wigner Research Centre for Physics, Budapest, Hungary

Spatially and temporally resolved electric fields in a self-sustained radio frequency atmospheric plasma jet (RF-APPJ) in a helium:nitrogen mixture are measured by electric field induced second harmonic generation (E-FISH). It is shown that the electric field in the bulk of the RF-APPJ is unexpectedly high, having an amplitude of about 1.6 kV/cm, and that it exhibits a phase shift of approximately -0.2π relative to the voltage waveform [1]. The electron density in the bulk is estimated from the measured phase shift between the electric field and the applied voltage by using an equivalent RC-circuit model for the discharge. Comparison of the measured electric field with the results of ab initio Particle-in-Cell/Monte Carlo collisions (PIC/MCC) simulations reveals excellent agreement. Special attention is paid to the calibration of the E-FISH measurement which includes removal of polarity sensitive artifacts.

The work is supported by the DFG funded SFB1316 Project "Transient atmospheric plasmas - from plasmas to liquids to solids".

[1] I Orel et al 2025, submitted to Plasma Sources Sci. Technol.

P 6.2 Tue 11:30 ZHG006

Applied machine learning for electron density measurements of an atmospheric plasma torch — •Christos Vagkidis, Alf Köhn-Seemann, Stefan Merli, Mirko Ramisch, Andreas Schulz, and Günter Tovar — IGVP, University of Stuttgart, Germany

Atmospheric plasma torches are considered a promising approach for the decomposition of waste gases. In order to enhance their performance, it is crucial

to accurately measure the plasma properties. One of the most important properties of the plasma is the electron density.

In this work, a deep neural network is used to predict the electron density distribution of an atmospheric plasma torch. The neural network is trained on data obtained from 3D simulations, carried out with the COMSOL Multiphysics software. In the simulation domain, a microwave beam is propagating through the plasma and the beam power is monitored after the interaction with the plasma. A 1D cut of this power, calculated perpendicularly to the direction of propagation, is used as training data for the neural network.

Experimental data are obtained through a similar set-up. A network analyzer is used to measure the microwave beam power. By moving the detecting antenna of the network analyzer perpendicularly to the plasma torch the beam power is measured. The beam power profile is then fed into the neural network, which in turn estimates the electron density of the torch with very good accuracy.

P 6.3 Tue 11:45 ZHG006

The role of metastable atoms on the dissociation of CO_2 in the COST Reference Microplasma Jet — •Alexander Schicke, Amira Nouira, Sebastian Burhenn, Marc Böke, and Judith Golda — Plasma Interface Physics, Ruhr-Universität Bochum, 44801 Bochum, Germany

The dissociation of CO_2 has become a growing topic in recent years. There are many applications, including decarbonising the atmosphere and producing carbon for chemicals and fuels. When adding CO_2 to an rf plasma, the dissociation can nearly double using argon instead of helium as a feed gas, because of the lower excitation and ionisation energies. Consequently, the assumption was made that the dissociation of CO_2 is dominated by electron impact dissociation and dissociation via Penning collisions with metastable atoms.

Therefore, to quantify which part the metastable atoms play in the COST Reference Microplasma Jet, the respective densities of helium and argon metastable atoms were measured while changing the ratio of He/Ar in the feed gas. The metastable atom densities were measured via tunable diode laser absorption spectroscopy (TDLAS), which allows the simultaneous measurement of both densities with high spatial resolution. With this 2D maps of the discharge channel can be created, which gives us in-depth information on the dissociation of CO_2.

This work is funded by the projects A3 and B2 of the CRC 1316.

P 6.4 Tue 12:00 ZHG006

Open-source tools for interactive preselection and analysis of large image datasets — •Philipp Mattern[1], Richard Krieg[2], Hans Höft[1], Torsten Gerling[1], and Markus M. Becker[1] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]University of Greifswald, Greifswald, Germany

To gain a holistic understanding of complex phenomena in plasma processes, it is often necessary to combine several high-resolution diagnostics and extensive parameter variations. This results in large data sets that are difficult to access using conventional methods and analysis tools. This contribution introduces two open-source tools developed at INP Greifswald for efficient data handling and image analysis: WOLKE and BLITZ. BLITZ enables rapid loading, visualization, and statistical evaluation of large image collections—handling more than 20,000 images (exceeding 20 GB) in under a minute—without requiring specialized hardware. Its matrix-based approach allows swift calculation of key parameters even for massive datasets. WOLKE provides a web-oriented layout and filtering framework for interactively preselecting image data based on user-defined criteria (e.g., mean, entropy, sharpness, operation parameter combinations, timestamps, EXIF information or any pre-calculated value). Filtered subsets identified in WOLKE can be seamlessly examined and further analyzed within BLITZ. This combination creates a highly adaptable workflow for data exploration, evaluation, and presentation, effectively responding to evolving research demands in plasma physics and beyond.

P 6.5 Tue 12:15 ZHG006

Laser Optical Loop for highly repetitive laser measurements by a single laser pulse — •Nikita Lepikhin, Dirk Luggenhölscher, and Uwe Czarnetzki — Institute for Plasma and Atomic Physics, Ruhr University Bochum, Germany

A Laser Optical Loop (LOL) approach is proposed to achieve high repetition rates of laser pulses by using each single laser shot several times. As a result, measurement speed of laser based experimental techniques can be accelerated significantly, e.g. Electric Field Induced Second Harmonic generation (E-FISH), Two-Photon Absorption Laser Induced Fluorescence (TALIF), Thomson scattering, etc. Several optical schemes are proposed to form the optical loop and to trap the laser emission. The feasibility of the suggested method is demonstrated using the example of the E-FISH technique.

Acknowledgements: The work is supported by the DFG funded SFB1316 Project "Transient atmospheric plasmas - from plasmas to liquids to solids".

P 7: Magnetic Confinment Fusion/HEPP IV

Time: Tuesday 13:45–15:55 Location: ZHG102

Invited Talk P 7.1 Tue 13:45 ZHG102

Impurity Transport in Wendelstein 7-X: Basics and Experimental Observations — •Birger Buttenschön[1], Thomas Wegner[1], Thilo Romba[1], Daihong Zhang[1], Felix Reimold[1], Alice Bonciarelli[1,2], and the W7-X Team[1] — [1]Max Planck Institute for Plasma Physics, Greifswald, Germany — [2]Politecnico di Milano, Italy

The presence of impurities in a fusion plasma can have significant influence on the plasma performance. While impurities generally dilute the fuel and thus reduce fusion efficiency, their line radiation is often used in the boundary plasma to reduce power fluxes to plasma-facing components. A high concentration of impurities in the confined plasma and the resulting radiation, however, is a critical loss channel for plasma energy and can lead to a radiative collapse of the plasma.

In the optimized stellarator Wendelstein 7-X, plasma scenarios featuring high energy and particle confinement inherently tend to accumulate impurities in the plasma center due to inwards directed neoclassical convective transport in the turbulence reduced ion-root regime. Understanding the (impurity) transport mechanisms is therefore a crucial step on the path to maintaining plasma performance by adjusting the impurity content and radiation within tolerable ranges.

This talk will give an overview on impurity transport in stellarators, introducing both theoretically expected transport mechanisms and suitable impurity transport diagnostics. Recent findings on the impurity transport in W7-X will be presented.

P 7.2 Tue 14:15 ZHG102

Characterizing scenarios of suppressed anomalous impurity transport in W7-X — •Thilo Romba[1], Felix Reimold[1], Sebastian Bannmann[1], Alejandro Banon Navarro[2], Hugo Cu Castillo[2], Oliver Ford[1], Peter Zsolt Poloskei[1], Markus Wappl[1], Thomas Klinger[1], and the W7-X team[3] — [1]Max Planck Institute for Plasma Physics, Greifswald, Germany — [2]Max Planck Institute for Plasma Physics, Garching, Germany — [3]O. Grulke et al 2024 Nucl. Fusion 64 112002

In view of dilution and radiative losses, the understanding and subsequent tailoring of impurity transport in fusion plasmas depicts a crucial step towards self-sustained burn. While the impurity transport in the Wendelstein 7-X stellarator is typically benign [Geiger19], certain experimental scenarios exhibit a central accumulation of impurities with transport of impurities reducing to neoclassical level [Romba23].

This work aims to characterize such scenarios. While a high density is identified as a necessary condition for impurity peaking to occur, no fundamental dependence on magnetic field configuration is identified. In addition to high density, a local normalized density gradient a/L_{n_e} above unity is identified as a necessary, yet not sufficient, condition for impurity accumulation to occur. Transport simulations across impurity species with different charges Z are found to match with neoclassical transport predictions, indicating a suppression of anomalous transport across impurities.

P 7.3 Tue 14:40 ZHG102

Prototype Coils and Engineering Design for the EPOS Stellarator — •Paul Huslage[1], Tristan Schuler[2], Pedro Gil[1], Dylan Schmeling[1,3], Diego A. R. Orona[1,4], Elisabeth von Schoenberg[1,5], Robert Luerbke[1], Jason Smoniewski[1], and Eve V. Stenson[1] — [1]Max-Planck Institut für Plasmaphysik — [2]SchulerTec — [3]Columbia University — [4]Massachusetts Institute of Technology — [5]Concordia University

The EPOS stellarator (a tabletop device to confine electron positron plasmas) will use high-temperature superconductors (HTS) to generate its quasi-axisymmetric magnetic field. Non-planar, non-insulated coils made from rare-earth barium copper oxide (ReBCO) tapes will be used to create a 2 T magnetic field on axis and enable a plasma volume of ~10 L.

In this contribution, we present the results of the hardware test campaign in preparation of the EPOS experiment design and assembly. During this effort, we are designing, manufacturing, and testing a series of coils from planar manufacturing demonstrators to a full-size, full-current coil.

Results from the coils tests inform the design of the EPOS stellarator. We will present the current state of the engineering design, as well as the road map for manufacturing and assembly.

P 7.4 Tue 15:05 ZHG102

Exploration of Instabilities in Weakly Magnetized Plasmas: A Hybrid Gyrokinetic Approach. — •Sreenivasa chary Thatikonda[1], Felipe nathan De Oliveira lopes[1], Aleks Mustonen[2], Karen Pommois[2], Rainer Grauer[2], Daniel Told[1], and Frank Jenko[1] — [1]Max planck institute for plasma physics, Garching, Germany — [2]Ruhr-Universität Bochum, Germany

Instabilities, turbulence, and reconnection in weakly magnetized plasmas, such as those encountered in the solar wind, present significant challenges to our understanding of plasma dynamics. High-frequency dynamics of space plasmas challenge the foundational assumptions of Gyrokinetic theory, especially for ions. To overcome these constraints, we developed a hybrid gyrokinetic model that preserves Gyro/Drift kinetic physics for electrons while integrating full kinetic physics for ions. The hybrid gyrokinetic model was incorporated into the Super Simple Vlasov (ssV) code. The code was verified against standard benchmark configurations after numerical diffusion, oscillations, and Ampere cancellation issues were effectively resolved. In particular, this study uses the hybrid-gyrokinetic framework in the ssV code to investigate the dynamics of Lower Hybrid Drift Instabilities (LHDIs) in reconnecting current sheets. Temperature, mass ratio, and plasma beta are among the parameters that are methodically investigated. Among the important findings are the analyses of growth rate dependences on temperature ratios, mass ratios, plasma beta, and the temporal development of electric field amplitudes. Future work will validate these results through comparisons with in-situ reconnection data from MMS.

P 7.5 Tue 15:30 ZHG102

Dependence of turbulent transport on the divertor flux expansion in ASDEX Upgrade — •Jan Pfennig, Wladimir Zholobenko, Andreas Stegmeir, Konrad Eder, Kaiyu Zhang, and Frank Jenko — Max Planck Institute for Plasma Physics, 85748 Garching b. Muenchen, Germany

Predictive turbulence simulations represent a key tool to describing and understanding the anomalous transport of particles and energy across magnetic flux surfaces of tokamak fusion devices, which is commonly believed to be the main factor determining their confinement properties, and thus economic viability. Previously, extensive validation efforts for the locally field-aligned fluid turbulence code GRILLIX against ASDEX Upgrade attached L-Mode have been performed and resulted in good agreement with both mean-field and turbulence diagnostics. As a successive step, simulations with similar physical parameters but in the geometry of the new AUG upper divertor are performed for different levels of low-field side divertor flux expansion. Due to the global, full-f capabilities of GRILLIX it is possible to connect the effect of local changes in magnetic geometry to both local and global changes in the turbulent transport. By these means it is possible to disentangle the purely geometrical gain in exhaust performance by poloidal flux expansion from that of turbulent cross-field transport. The simulation results show a strong influence of the flux expansion on divertor heat flux peaking while global properties such as input power, edge confinement time, outboard mid-plane profiles and in fact the turbulence in the complete plasma edge remain nearly unchanged.

P 8: Atmospheric Plasmas and their Applications III

Time: Tuesday 13:45–15:45 Location: ZHG006

Invited Talk P 8.1 Tue 13:45 ZHG006

Status and outlook for CO_2 conversion with microwave plasmas — •Ante Hecimovic, Christian K. Kiefer, Arne Meindl, Rodrigo Antunes, and Ursel Fantz — Max Planck Institute for Plasma Physics, Boltzmannstr. 2, D85748 Garching b. München

Carbon dioxide (CO_2) gas is regarded as a valuable building block in a non-fossil fuel economy, and if captured from the atmosphere it allows creating a closed carbon cycle, leading to net zero emissions. Low temperature plasmas have the potential to contribute to the field of CO_2 utilization through unique reaction pathways that are not accessible by other conversion technologies. The reaction pathways in the plasma can be driven either by electrons, a combination of electron-driven and heavy species driven mechanisms, or by elevated temperatures (2000-6000 K). In this contribution, conversion of CO_2 into CO using the microwave plasmas in large pressure range (1-1000 mbar) is presented, demonstrating effect of these mechanism on the achieved conversions. Relatively high conversion rates obtained in the microwave plasmas could potentially be applied in an industrial process. Two main obstacles towards the application: gas separation in the plasma effluent, and up-scaling towards CO flow rates compatible with the Fischer-Tropsch process are discussed.

P 8.2 Tue 14:15 ZHG006

High power atmospheric microwave plasma torch for CO_2 conversion — •Marc Bresser, Katharina Wiegers, Stefan Merli, Andreas Schulz, Matthias Walker, and Günter Tovar — IGVP, University of Stuttgart, Germany

Due to global warming and the increase in Earth's surface temperature the concentration of CO_2 in the atmosphere and the CO_2 pollution must be reduced. A renewable alternative to the use of fossil fuels in the chemical industry, as one of the largest producers of CO_2, must be found. An attractive way is to utilize CO_2 as a starting chemical to generate a sustainable alternative and close the carbon cycle. An innovative process is a microwave plasma to activate CO_2. The generated CO can then be used together with hydrogen form renewable resources such as electrolysis to produce synthesis gas. This process has the advantage of on-demand operation with fluctuating and intermitted electric energies. In this work, a 2.45 GHz atmospheric microwave plasma torch is used to convert CO_2 into CO. The torch is operated in a reverse vortex flow configuration. A nozzle behind the torch prevents the back reaction of the product gas. To analyze the cold product gas, the conversion was measured using absorption Fourier-transform infrared spectroscopy, mass spectrometry, and a X-Stream gas analyzer from Emerson. The influence of microwave power and CO_2 gas flow on the conversion was investigated. Based on the conversion values, the energy efficiency was determined. The plasma process achieved maximum conversions of up to 21 % and an energy efficiency of over 40 %.

P 8.3 Tue 14:30 ZHG006

Process optimization of iron oxide (in-flight) reduction in a high-performance microwave argon-hydrogen plasma torch — •Jonas Thiel, Simon Kreuznacht, Marc Böke, and Achim von Keudell — Experimental Physics II - Reactive Plasmas, Ruhr University Bochum, Bochum, Germany

Using an argon-hydrogen microwave plasma torch, the experiments aim at advancing nearly climate-neutral iron ore reduction. These atmospheric-pressure hydrogen plasmas provide advantages such as faster reduction rates, lower energy consumption, in-flight treatment, and scalability compared to other methods. The experimental setup can be used in two operation modes: exposing defined sample amounts to the plasma effluent or directly injecting iron oxide powder into the gas flow for in-flight treatment. A swirl-like flow pattern is employed to shield the reactor's quartz tube from the hot core. However, for the latter case, this swirl also leads to particles being adhered to the wall before reaching the collection system. Therefore, an optimization of the process parameters assisted by fluid simulations examining particle trajectories, residence times, and melting/evaporation behavior under varied flow and geometric conditions is crucial for efficient long-term in-flight treatment. In addition, optical emission spectroscopy and X-ray diffraction are employed to analyze on the one hand plasma properties as gas temperature and electron density/temperature, and on the other hand the reduction degree of treated samples.

Invited Talk P 8.4 Tue 14:45 ZHG006

Plasma activation of low-energy molecules using the example of nitrogen — •Mariagrazia Troia, Katharina Wiegers, Andreas Schulz, and Matthias Walker — Institute for Interfacial Engineerinf and Plasma Technology, University of Stuttgart, Stuttgart, Germany

A key chemical in the manufacture of fertilizers is nitric acid, usually produced via the well-established combination of the Ostwald and the Haber-Bosch processes, with an average energy cost that amounts to 2% of the world*s total, and a side production of several greenhouse gases. An ongoing global effort is being currently carried out in order both to achieve climate neutrality and to reduce the overall production costs of raw chemicals. Plasmochemical processes open up attractive alternative routes, thanks to their flexible, on-demand operating mode which allows for an in-loco production of the fertilizers precursor NOx at low costs. In the current work, a commercially available microwave atmospheric plasma torch is used to synthesize NOx from dry air over a wide set of operating parameters. Resulting concentrations, comparable to the current state-of-the-art for plasma processes, have been further improved by optimizing the gas management in the plasma volume and in its after-glow region, by means of a custom-made nozzle with different geometries and operating principles. High-speed camera measurements and characterization via emission spectroscopy further elucidate the chemistry taking place in the plasma phase. Paired with extensive *cold* gas numerical simulations, they offer promising avenues for further improvements of the NOx yield thus obtained.

P 8.5 Tue 15:15 ZHG006

Nanosecond resolved vibrational kinetics of CO_2 in CO_2/N_2 mixtures: experiment and model — •Christian Alexander Busch[1], Tiago Silva[2], Vasco Guerra[2], Nikita Lepikhin[1], Inna Orel[1], Jan Kuhfeld[1], Dirk Luggenhölscher[1], and Uwe Czarnetzki[1] — [1]Ruhr University Bochum, Institute for Plasma and Atomic Physics, Bochum, Germany — [2]Instituto Superior Técnico, Institute for Plasmas and Nuclear Fusion, Portugal

In this work, the vibrational kinetics of CO_2 in a ns-pulsed near-atmospheric

pressure plasma jet operated in a CO_2/N_2 mixture is studied experimentally [1] and by modeling using the LisbOn KInetics codes (LoKI). This discharge allows for a temporal separation and thus an independent study of the excitation during the discharge pulse and the V-V and V-T transfer in the afterglow. The densities of individual rovibrationally excited states of CO_2 are measured with ns resolution by absorption spectroscopy using a quantum-cascade laser.
Notably, a short-lived non-equilibrium was observed between the populations of the Fermi resonant states and the bending mode. Additionally, the excitation of the asymmetric stretch mode was found to deviate from a commonly applied scaling law.
The work was supported by the DFG funded SFB1316 project *Transient atmospheric plasmas - from plasmas to liquids to solids*. IPFN activities were supported by FCT - Fundação para a Ciência e Tecnologia under projects UIDB/50010/2020, UIDP/50010/2020, LA/P/0061/202 and PTDC/FIS-PLA/1616/2021.
[1] Christian A Busch et al 2025 *J. Phys. D: Appl. Phys.* **58** 065202

P 8.6 Tue 15:30 ZHG006

Impact of a plasma window arc discharge on the transmission properties of a 48-Ca heavy ion beam — •Andre Michel, Fateme Ghaznavi, Michael Händler, Adem Ates, Marcus Iberler, and Joachim Jacoby — Goethe Universität Frankfurt

With the increase of particle beam energies and intensities in accelerator facilities around the world, a reliable technique for the separation of accelerator vacua to high-pressure targets is needed where conventional techniques such as differential pumping stages or solid membranes might fail. A promising technique that allows the transmission of such ion beams even at short distances is the so-called plasma window [1]. It is based on a cascaded arc discharge that enables the active control of the pressure gradient depending on the selected working gas, flow rate and arc current.

In 2018 the Plasma Physics department of Goethe University Frankfurt developed a prototype of the plasma window, which has since been optimized for its purpose as an active pressure separation component in particle accelerators. As part of its further development, the plasma window has been successfully used to demonstrate the transmission of a heavy ion beam while maintaining the pressure gradient up to 10h in a single run.

This contribution gives an insight into the plasma physical properties as well as the operating parameters of the developed plasma window and highlights its impact on the properties of the transmitted ion beam.

[1] Hershcovitch, A., J. Appl. Phys., AIP Publishing, 1995, 78, 5283

P 9: Plasma Wall Interaction

Time: Tuesday 16:15–17:15 Location: ZHG102

Invited Talk P 9.1 Tue 16:15 ZHG102

In-vessel and depth-resolved hydrogen isotope composition analysis in JET by LIBS operated on a remote handling arm — •Rongxing Yi[1], Rahul Rayaprolu[1], Gennady Sergienko[1], Erik Wuest[1], Marc Sackers[1], Timo Dittmar[1], and Sebastijan Brezinsek[1,2] — [1]Forschungszentrum Jülich GmbH, IFN-1 Plasmaphysics, Jülich, GERMANY — [2]HHU Düsseldorf, Faculty of Mathematics and Natural Sciences, Düsseldorf, GERMANY
As the world's most successful Tokamak, JET achieved a groundbreaking milestone in nuclear fusion during its final deuterium-tritium experimental campaign (DTE-3) last year by setting a new world energy record. However, one critical safety aspect, the fuel retention distribution within the vessel walls after DTE-3, remains an unresolved challenge. To resolve it, a laser-induced breakdown spectroscopy (LIBS) system has been deployed. Compactly integrated into a laptop-sized box, the setup is mounted on a remote handling arm inside the JET vessel. Spectral data collected through this system is transmitted via long optical fibers to multiple spectrometers for analysis. The laser achieves a surface and depth resolution of 130 μm and 180 nm on tungsten, respectively. Additionally, a high-flux Littrow spectrometer gives high sensitivity for detecting hydrogen isotopes. By utilizing the remote handling arm with the LIBS setup, over 800 positions were analyzed within the vessel, providing both global distribution and depth profiles of retained hydrogen isotopes.This approach represents a method in understanding fuel retention, crucial for improving the safety and wall material design of future fusion reactors.

P 9.2 Tue 16:45 ZHG102

Experimental Investigations of the Hydrogen Isotopes Retention and Permeation in Boron Coatings — •Eduard Warkentin[1,2], Anne Houben[1], Marcin Rasinski[1], Hans Rudolf Koslowski[1], Timo Dittmar[1], Bernhard Unterberg[1,2], and Christian Linsmeier[1,2] — [1]Forschungszentrum Jülich GmbH, Institut of Fusion Energy and Nuclear Waste Managment - Plasmaphysics (IFN-1), Jülich 52425, Germany — [2]Ruhr-Universität Bochum, Faculty of Physics and Astronomy, Bochum 44801, Germany
Fuel permeation and retention in fusion reactor wall materials are important issues for plasma operation and safety reasons in ITER. The loss of the hydrogen isotope tritium, which will be used as fuel, has to be estimated and prevented. Due to the change of the ITER first wall material from Be to W, oxygen and other impurities in the vessel are not sufficiently gettered by a W wall. A thin boron layer which is applied during the regular wall conditioning phase can solve the problem and a more efficient plasma operation can be obtained. In order to investigate hydrogen retention and permeation of boron coatings, pure boron layers were fabricated by magnetron sputter deposition on W and steel substrates. After characterization, the deuterium permeation flux was measured and the layer permeation was obtained. Boron coated samples were exposed to different deuterium plasma and ion loadings in order to investigate retention via nuclear reaction analyis (NRA) and thermal desorptions spectroscopy (TDS).

P 9.3 Tue 17:00 ZHG102

Depth-resolved deuterium retention profiles in displacement-damaged tungsten with laser-induced ablation quadrupole mass spectrometry — •Christoph Kawan[1,2], Sebastijan Brezinsek[1,2], Timo Dittmar[1], Erik Wüst[1,2], Thomas Schwarz-Selinger[3], Liang Gao[1], and Christian Linsmeier[1] — [1]Forschungszentrum Jülich GmbH, IFN-1 Plasmaphysics, 52425 Jülich, GER — [2]Mathematisch- Naturwissenschaftliche Fakultät, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf, Germany — [3]Max-Planck-Institut für Plasmaphysik, Boltzmannstrasse 2, 85748 Garching, Germany
Future fusion devices will operate with the hydrogen isotopes deuterium (D) and tritium (T) as fuel gases and tungsten (W) as wall material. The released high energetic neutrons from DT fusion reactions cause displacement damage in the W lattice and increase fuel retention by trapping and diffusion, leading to decreased reactor performance. Therefore, diagnostics are required to quantify the D and T content. Laser-induced ablation quadrupole mass spectrometry (LIA-QMS) is a promising method with good depth resolution and absolute quantification and can be combined with traditional diagnostics, such as laser-induced breakdown spectroscopy (LIBS). This study compares LIA-QMS D profiles with LIBS and nuclear reaction analysis (NRA) on self-damaged W samples. LIA-QMS shows a higher sensitivity (< 0.1 at% D at 75 nm average ablation) than LIBS. Qualitatively, LIA-QMS can reproduce the NRA depth profiles, but quantitatively, LIA-QMS underestimates the total content by a factor of ~ 3.

P 10: Poster Session I

Time: Tuesday 16:15–18:15 Location: ZHG Foyer 1. OG

P 10.1 Tue 16:15 ZHG Foyer 1. OG

Development of a planar dielectric barrier discharge for plasma and surface studies — •A.A. Ben Yaala[1], R. Antunes[1], T. Höschen[1], S. Buchberger[1], A. Meindl[1], A. Hecimovic[1], and U. Fantz[1,2] — [1]Max Planck Institute for Plasma Physics (IPP), 85748 Garching b. München, Germany — [2]University of Augsburg, 86149 Augsburg, Germany
The growing demand for ammonia in fertilizers, chemical industry and energy storage drives the need for production methods compatible with an electrified energy system. Plasma-catalysis offers a promising alternative to the traditional Haber-Bosch process, with potential for decentralization and renewable energy integration. The Dielectric Barrier Discharge (DBD) is the most extensively studied plasma discharge for ammonia synthesis due to its operating temperatures, which facilitate catalyst activation and improve reaction selectivity. While plasma-catalysis synergism in DBD has been demonstrated in several works, the detailed plasma-surface interactions remain an underexplored area. In this contribution, a newly developed planar DBD reactor, which permits an easier access to plasma and surface diagnostics, will be presented. This planar DBD is assembled in a setup with in-vacuo access to X-ray Photoelectron Spectroscopy

(XPS), whereby surface characterization of a catalytic material deposited on the ground electrode can be done without breaking the vacuum. Preliminary work on formation of NH_3 in N_2-H_2 plasmas as well as surface analysis of the exposed electrode will be presented.

P 10.2 Tue 16:15 ZHG Foyer 1. OG

Hybrid FTIR setup for gas sampling and in-situ analysis for low-temperature, high-pressure plasmas — •Francesco Franco[1,2], Arne Meindl[1], Ante Hecimovic[1], Rodrigo Antunes[1], and Ursel Fantz[1,2] — [1]Max Planck Institute for plasma physics, Boltzmannstr. 2, D-85748 Garching b. München — [2]University of Augsburg, Universitätsstr. 1, D-86159 Augsburg

Fourier Transform InfraRed (FTIR) spectroscopy is a flexible, fast and sensitive diagnostic based on the absorption of broadband infrared light from molecules with net electric dipole. This technique can be applied to the qualitative and quantitative analysis of cold gas products and in-plasma reactive species, here in the context of low-temperature, high-pressure plasma reactors for gas conversion (e.g. NH_3, CO_2 and CH_4 into N_xH_y, CO and C_xH_y). Important plasma parameters, such as chemical composition and vibrational state distributions, can be derived with FTIR. In this contribution, the development and calibration steps of a new FTIR apparatus are presented, featuring a commercial interferometer and an external and movable detector for both in-situ and gas sampling experimental operation. This configuration deviates from the standard application of these instruments and requires custom hardware implementations. Since FTIR is very sensitive to moisture and environmental contaminants, solutions for atmosphere control along the beamline, between the interferometer and the detector, are outlined, together with technical features of the setup. To carry out quantitative analysis from infrared absorption spectra, the challenges and approaches to calibration of the instrument are discussed.

P 10.3 Tue 16:15 ZHG Foyer 1. OG

Characterization of different DCSBD designs using plasma diagnostics — •Henry von Wichert[1], Jianyu Feng[2], Tobias Hahn[1], and Holger Kersten[1] — [1]Institute of Experimental and Applied Physics, Christian-Albrechts-University, Kiel, Germany — [2]Department of Plasma Physics and Technology, Masaryk University, Brno, Czech Republic

Atmospheric pressure plasma jets are effective for treating surfaces. To modify larger areas efficiently, a curtain-shaped jet can be used by positioning two surface barrier discharges (DCSBDs) facing each other. Here, we characterize different designs of the jets and the DCSBD units themselves by various diagnostics.

The energy flux from the discharge to the substrate was measured at different distances and power levels using passive thermal probes. These were compared with the total electrical power consumed by the discharge, estimating the energy efficiency of the setup.

Spectral profiles of the DCSBDs were measured by OES to check for variations within the plasma, and high-resolution brightness profiles were captured. These optical measurements are compared with the energy flux data to better understand the relationship between the total power used, the area covered by the discharge, and the intensity of the plasma in the illuminated region.

Using a high-speed-camera, the short-term behavior of the filaments of the discharge could be compared with the average distribution of the plasma on the surface, as measured by long-exposure photographs.

P 10.4 Tue 16:15 ZHG Foyer 1. OG

Elechtrochemical investigation of microsecond plasma-in-liquid treated copper surfaces — •Neil Dominik Unteregge, Pia Victoria Pottkämper, and Achim von Keudell — Ruhr-Universität Bochum, Bochum, Deutschland

The aim of this project is to investigate the production of hydrogen peroxide and its effects on copper oxide surfaces. This interaction leads to the growth of copper oxide nanocrystals, which are valuable catalysts for the electrochemical reduction of CO2. However, the catalysts activity decreases during operation in an electrochemical cell. In this project an in-liquid plasma is ignited in distilled water, which creates many reactive species with varying lifetimes, such as hydrogen peroxide, molecular oxygen and hydrogen, as well as solvated electrons. This plasma is powered using high voltages and microsecond pulses. The energy dissipated in each pulse triggers the phase transition to water vapor and allows dissociation in the plasma state. As a result, so-called plasma activated water (PAW) is obtained. The concentration of hydrogen peroxide in PAW is determined by absorption spectroscopy using the reaction of hydrogen peroxide with ammonium vanadate as sensor. PAW is then brought into contact with the copper oxide surfaces to induce the nanocrystal growth. The copper oxide surfaces are analyzed by SEM and cyclic voltammetry.

P 10.5 Tue 16:15 ZHG Foyer 1. OG

Investigation of a microwave plasma torch for conversion of CO_2 and CH_4 molecules — •Clemens Kranig[1], Christian K. Kiefer[1], Arne Meindl[1], Ante Hecimovic[1], and Ursel Fantz[1,2] — [1]Max Planck Institute for Plasma Physics, Boltzmannstr. 2, D85748 Garching b. München — [2]University of Augsburg, Universitätsstr. 1, D-86159 Augsburg

Using a microwave plasma for converting various gaseous molecules, e.g. CO_2 or CH_4, into value-added molecules like CO and H_2, is a promising technology. For the case of CO_2 high conversion rates have been demonstrated as well as comparably short start-up times, which synergizes well with fluctuating renewable energy supplies. The microwave torch generates a low-temperature plasma in the pressure range from several millibars to atmospheric pressure. The plasma is characterized by gas temperatures ranging from 2000-6000 K, which enable endothermic reactions, such as CO_2 conversion ($CO_2 \rightarrow CO + \frac{1}{2}O_2$), methane pyrolysis ($CH_4 \rightarrow 2H_2 + C_s$), and dry reforming of methane ($CO_2 + CH_4 \rightarrow 2CO + 2H_2$). Due to the high temperature in the effluent, one key challenge is the reduction of recombination. Other challenges are the desired selectivity accompanied by sufficient energy efficiency, as well as the deposition of carbon black at critical locations in the reactor. This contribution will focus on using pure CH_4 or a gas mixture of CO_2 and CH_4 for the production of H_2 or syngas. The analysis of the composition of the product gases is challenging, as e.g. solid carbon and condensed water are not detected using the gas analysis techniques (gas chromatography or mass spectrometry).

P 10.6 Tue 16:15 ZHG Foyer 1. OG

Nitrogen fixation and H_2O_2 production by an atmospheric pressure plasma jet — •Jannis Kaufmann, Steffen Schüttler, and Judith Golda — Plasma Interface Physics, Ruhr University Bochum, Bochum, Germany

Atmospheric pressure plasmas are widely used for nitration fixation. Atmospheric pressure plasma jets are suitable sources of reactive species delivered into liquids. The addition of H_2O leads, for example, to the production of H_2O_2 as shown by a capillary plasma jet. Adding nitrogen to the humidified feed gas, nitrogen fixation can be performed by the capillary plasma jet investigated in this work [1]. We used various diagnostics for measuring the concentration of different species in plasma-treated liquid: spectrophotometry (hydrogen peroxide, nitrite), fluorometry (ammonia) and amperometry (hydrogen peroxide). We show that a small admixture of nitrogen (between 0.1 and 1 %) already leads to a lower concentration of hydrogen peroxide. Instead, the plasma produced nitrogen-containing species such as nitride and ammonia. Low frequency pulsing of the RF signal can be used to tune plasma chemistry in our system. Given an additional admixture of oxygen to the system, the hydrogen peroxide production can be increased, while no ammonia is generated. Furthermore the production via hydroxyl radicals was shown to be the main production channel for hydrogen peroxide and nitrite.

This work is supported by the DFG within CRC1316 Project B11

[1] S. Schüttler, J. Kaufmann, J. Golda, Plasma Process. Polym. 2024; 21:e2300233. https://doi.org/10.1002/ppap.202300233

P 10.7 Tue 16:15 ZHG Foyer 1. OG

Formation of stable species in atmospheric-pressure coaxial DBDs in argon-tetramethylsilane mixtures — •Marjan Stankov[1], Lars Bröcker[2], Nickolas Steppan[2], Claus-Peter Klages[2], Markus M. Becker[1], and Detlef Loffhagen[1] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Institute for Surface Technology, Technische Universität Braunschweig, Braunschweig, Germany

The formation of stable species in atmospheric-pressure dielectric barrier discharges (DBDs) operated in argon with small admixtures of tetramethylsilane (TMS) has been investigated with the help of modelling and experiment for gas residence times up to 8 ms. The DBD reactor studied consists of two borosilicate glass tubes in a coaxial configuration with a gap of 1 mm. It is powered by a 4 kV sinusoidal voltage at 86.2 kHz. The modelling study employs a time-dependent, spatially one-dimensional fluid-Poisson method including a complex plasma chemistry for Ar-TMS mixtures considering about 90 species and 700 reactions. It is accompanied by measurements using Fourier-transform infrared (FTIR) spectroscopy for the analysis of stable molecules in the effluent gas. Satisfactory agreement between calculated and measured number densities of several stable species is generally found. In particular, the analysis for admixtures of up to 100 ppm TMS reveals that trimethylsilane is the primary silicon-containing species generated and that methane becomes the predominant hydrocarbon. The work has been funded by the Deutsche Forschungsgemeinschaft (DFG) - project number 504701852.

P 10.8 Tue 16:15 ZHG Foyer 1. OG

Spatially resolved optical emission spectroscopy on a dielectric barrier discharge for plasma-assisted catalysis — •Kerstin Sgonina[1], Alexander Quack[1], and Jan Benedikt[1,2] — [1]Institute of Experimental and Applied Physics, Kiel University, Germany — [2]Kiel Nano, Surface and Interface Science (KiNSIS), Kiel University, Germany

Energy efficient and decentralized performance of catalytic reactions for the means of converting excess energy into chemicals is one of the important research topics nowadays. Plasma-assisted catalysis could provide one possible solution as it is available on demand and works even without external heating. Non-equilibrium atmospheric pressure plasmas are used to dissociate and excite gaseous molecules, which can then react at the surface of the catalyst to form the desired products. For efficient plasma-assisted catalysis reactions, the fast

product removal is crucial, which can be achieved by specific reactor designs or tailored materials. A reactor was designed aiming the fast product removal and enabling testing powder-like and porous materials for their catalytic effect. Spatially resolved optical emission spectroscopy was used to analyze the discharge properties and structure, and to study the role of the catalyst in the process. The dielectric barrier discharge is operated at different frequencies and voltage amplitudes. By using CO_2 and H_2, the methane formation is investigated via mass spectrometry.

P 10.9 Tue 16:15 ZHG Foyer 1. OG

Diagnostic capabilities of Setup for Imaging of Radicials Interacting with Surfaces (IRIS) — •Robin Minke[1], Robin Labenski[1], Marc Böke[2], Achim von Keudell[2], and Judith Golda[1] — [1]Plasma Interface Physics, Ruhr-University Bochum — [2]Experimental Physics II, Ruhr-University Bochum

The novel field of plasma catalysis involves complex chemistry, making it difficult to identify the underlying causes and effects between catalysts and plasma. Methods are needed to isolate specific processes to understand their contribution in the overall chemistry. To enhance the insight of how plasma-generated molecules interact with surfaces, a low-pressure chamber setup for Imaging of Radicals Interacting with Surfaces (IRIS) has been developed. In this setup, radicals produced by an ECR discharge are accelerated through a differential chamber into the main chamber, forming a molecular particle beam that collides with a substrate surface. Spatially resolved Laser-Induced Fluorescence (LIF) is employed to monitor the density of a chosen radical species in the incoming and outgoing beam, revealing insights into its surface chemistry. The substrate temperature can be controlled between 300 and over 1000 K, making this setup ideal for studying the interplay between molecules and temperature-driven catalysts. Providing the diagnostic capabilities of the setup, using OH molecules is a starting point for the study of other molecules and their interactions with different substrate surfaces.

P 10.10 Tue 16:15 ZHG Foyer 1. OG

Untersuchungen der Plasmareduktion von Mangan in wässriger Lösung — •Daniel Tasche[1,2], Kai Bröking[1,2,3], Mirco Weber[1], Christoph Gerhard[1,4] und Wolfgang Viöl[1,5] — [1]HAWK, Hochschule für angewandte Wissenschaft und Kunst, Fakultät Ingenieurwissenschaften und Gesundheit, Göttingen, Deutschland — [2]Technische Universität Clausthal, Fakultät für Natur- und Materialwissenschaften, Clausthal Zellerfeld, Deutschland — [3]Max-Planck-Institut für Multidisziplinäre Naturwissenschaften, Göttingen, Deutschland — [4]Politecnico di Milano, School of Industrial and Information Engineering, Mailand, Italien — [5]Fraunhofer IST - Anwendungszentrum für Plasma und Photonik, Göttingen, Deutschland

Dieser Beitrag beschäftigt sich mit der plasmainduzierten Reduktion des Manganions in wässriger Lösung. Ein Atmosphärendruckplasma wird über einer manganionenhaltigen Lösung gezündet, wodurch sich die Oxidationsstufe des Mangans verändert. Die Reduktion findet innerhalb der Plasma-Flüssigkeit-Grenzfläche statt. Zusätzlich wird eine Strömung durch das Plasma in der Lösung induziert, wodurch es zu einer Durchmischung der flüssigen Phase kommt. Die Ausbreitung sowie die chemischen und physikalischen Eigenschaften des Prozesses werden durch die hyperspektrale Bildgebung orts-, zeit- und spektralaufgelöst beobachtet. Dadurch sind hochauflösende Analysen der charakteristischen Absorptionsbanden unterschiedlicher Oxidationsstufen des Manganions und der Lichtemission des Plasmas möglich. Durch die Untersuchungen ergeben sich Prozessparameter wie Reduktionsraten und Bestandteile im Plasma.

P 10.11 Tue 16:15 ZHG Foyer 1. OG

Stereoscopic observation of the interaction of fast particle agglomerates with a dusty plasma — •Daniel Maier, Christina Knapek, André Melzer, Daniel Mohr, and Stefan Schütt — Institute of Physics, University of Greifswald, Germany

Fast objects moving through a dispersive medium can interact in various ways and create a variety of phenomena (e.g. Mach cones). The investigation of this interaction has been a topic of research for long times.

Such interactions were observed in experiments with a dusty plasma under microgravity using the "Zyflex" chamber. A cloud of micron sized particles in a low temperature plasma was disturbed by fast particle agglomerates that were unintentionally accelerated to high velocities during the experiments. This disturbance leads to dust-free cavities behind the agglomerates that vary in form and size due to the velocity of the agglomerate and the angle of its moving direction in relation to the plane of the plasma that is illuminated by the laser. Using a stereoscopic camera set-up consisting of four high-speed cameras with a resolution of 2.1 MP at a frame rate of 200 fps it is possible to calculate the spatial position of the dust particles and their movements during the interaction with the fast agglomerates in three dimensions.

In this contribution observations of the described interaction for agglomerates with different velocities and moving angles will be shown focussing on the velocities and density of the surrounding dust particle as well as the spatial characteristics of the the dust-free cavity.

This project has been funded under the DLR grant 50WM2161.

P 10.12 Tue 16:15 ZHG Foyer 1. OG

Microwave cavity resonance spectroscopy (MCRS) and double probe (DP) measurements as nanodusty plasma diagnostic tools — •Andreas Petersen[1], Johanna Vogt[2], Michael Friedrichs[2], Jens Oberrath[2], and Franko Greiner[1,3] — [1]Institute of Experimental and Applied Physics, Kiel University, 24118 Kiel, Germany — [2]South Westphalia University of Applied Sciences, 59494 Soest, Germany — [3]KiNSIS, 24118 Kiel, Germany

Measuring plasma parameters like n_e and T_e in a nanodusty plasma is still a challenge as it requires a non-invasive diagnostic method. An excellent candidate for this purpose is MCRS. Only electrons are affected, as the probing microwave frequency is $\omega > \omega_p$. The approach can be described well for a sealed cavity with N ports. However, analysing nanodusty plasmas requires additional access to the cavity (holes, slits). A theoretical model of the cavity modes and the coupling of the ports is required. We present a suitable experimental cavity design and compare to numerical models. Furthermore, double probe measurements in an argon plasma inside the cavity are considered, as they are a good stepping stone for the diagnosis of nanodusty plasmas.

We gratefully acknowledge funding by Deutsche Forschungsgemeinschaft (DFG), Project No. 531667910

P 10.13 Tue 16:15 ZHG Foyer 1. OG

COMPACT: Project Status and Research Data Managment — •Daniel P. Mohr[1], Christina A. Knapek[1], Stefan Schütt[1], Daniel Maier[1], Andre Melzer[1], and COMPACT Collaboration[2] — [1]University of Greifswald, Institute of Physics, Greifswald, Germany — [2]International: CA, US, SE, DE

Complex, or dusty, plasmas consist of micrometer-sized grains that are injected into a low-temperature noble gas discharge. The grains become charged and interact with each other via a screened Coulomb potential. On ground, gravity compresses the system and prevents the formation of larger, three-dimensional particle clouds.

The future complex plasma facility COMPACT will allow the investigation of large three-dimensional complex plasmas under microgravity conditions aboard the International Space Station (ISS).

COMPACT is a project with international scientific contributions, funded by space agencies (DLR, NASA). The industry phase B is currently underway and will be finished in 2025.

Data generated by experiments on the ISS are of significant importance, as repeating an experiment can be extremely challenging and time-consuming. Therefore, it is crucial to design data management and handling strategies at an early stage to ensure efficient and reliable data processing.

We will present the objectives of COMPACT, the project status, and first concepts for the handling of research data acquired with COMPACT following the FAIR principles.

This work is funded by DLR/BMWi (FKZ 50WM2161).

P 10.14 Tue 16:15 ZHG Foyer 1. OG

3D EM-simulation of the influence of non-ideal cavities on their resonance behaviour to be applied in microwave cavity resonance spectroscopy — •Johanna Vogt[1], Michael Friedrichs[1], Andreas Petersen[2], Franko Greiner[2], and Jens Oberrath[1] — [1]South Westphalia University of Applied Sciences, 59494 Soest, Germany — [2]Institute of Experimental and Applied Physics, Kiel University, 24118 Kiel, Germany

To extract plasma parameters from a plasma, active plasma resonance spectroscopy (APRS) was developed, which works by measuring the frequency response of a plasma subjected to a wide-band radio frequency signal. The resulting spectrum is analysed, and with the use of a model, the electron plasma frequency is calculated. This in turn is used for determining the plasma electron density. A specific version of APRS is microwave cavity resonance spectroscopy (MCRS), in which an electromagnetic (EM) wave is coupled into a resonant cavity containing a plasma. Due to its non-invasive character, MCRS is a good candidate to be applied in nanodusty plasma.

The spectrum of a cavity is influenced by its geometry and materials. To determine plasma parameters from these spectra, detailed knowledge of this influence is necessary. To this extent, the results of a 3D EM simulation of the influence of several non-ideal alterations on the resonance spectrum is investigated and compared to an ideal cylindrical cavity.

This project was funded by Deutsche Forschungsgemeinschaft (DFG), Project No. 531667910, which we gratefully acknowledge.

P 10.15 Tue 16:15 ZHG Foyer 1. OG

Towards automated processing and re-use of open-access content in LTP research — •Markus M. Becker[1], Hans Höft[1], Ihda Chaerony Siffa[1], Muhammad Haris[2], Sarah Dellmann[2], and Markus Stocker[2] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]TIB – Leibniz Information Centre for Science and Technology, Hanover, Germany

In research on low-temperature plasmas (LTP), a wide range of devices, methods and materials are mainly used in table-top experiments. Model-based simulations are often used in conjunction with laboratory experiments to investigate,

optimise or develop new plasma processes and applications. This leads to a large number of widely spread, heterogeneous research results, which are difficult to compare and can hardly be brought together. However, this is essential to form a robust overall understanding of the very complex mechanisms and effects in LTP. This contribution deals with modern techniques and exploits the advantages of Open Access (OA) to meet these challenges. OA publications from LTP research are collected in the central public repository "Renate" and converted into a machine-readable format. This enables machine learning-based processing and interpretation of OA publications on the used devices, methods, materials, etc., and ultimately their structured storage in the "Open Research Knowledge Graph" (ORKG). In future, the knowledge extracted and semantically described in this way will be easier to find and aggregate and can therefore be re-used to gain new research insights using data-driven methods.

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P 10.16 Tue 16:15 ZHG Foyer 1. OG

Exploration of modern techniques for optimising plasma modelling procedures — Aleksandar P. Jovanović[1], Marjan Stankov[1], Robert Wagner[1], Ihda Chaerony Siffa[1], Aleksandar Trokicić[2], Marko D. Petković[2], and •Markus M. Becker[1] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Faculty of Sciences and Mathematics, University of Niš, Niš, Serbia

Understanding the physical and chemical processes relevant to plasma generation is particularly important due to its broad technological potential. To gain a deeper understanding of these processes, numerical modelling is often applied. Plasma models often need to account for many particle species and reactions, leading to a large system of partial differential equations, which needs to be solved numerically. In addition, fine meshes are required to resolve the sheath regions, which further increases the number of degrees of freedom and prolongs calculation time. Therefore, a big challenge in plasma modelling is to find an efficient way to solve these equations. To tackle this challenge, modern techniques for simplification and optimisation of plasma modelling procedures are investigated and discussed. The studied approaches include automating geometry and refined mesh generation supported by image processing, a reinforcement learning-based time-stepping and the use of tailored preconditioners for iterative solvers. The results of applying these techniques to model a positive streamer in air and an RF discharge in argon at low pressure are presented and discussed.

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P 10.17 Tue 16:15 ZHG Foyer 1. OG

Electrons interacting with dielectric slabs — •Franz Xaver Bronold and Felix Willert — Institut für Physik, Universität Greifswald, 17489 Greifswald, Germany

As a preparatory step for computing secondary electron emission probabilities for dielectrically coated electrodes used in dielectric barrier discharges, we investigate–from a microscopic solid-state physics point of view–the interaction of electrons with dielectric slabs of finite thickness. Whereas for a halfspace geometry, only electron backscattering (including secondary emission) has to be considered, it is now also required to quantify electron transmission through the slab. Leaving aside the interaction of the transmitted electrons with the metal supporting the dielectric layer,we describe in this contribution how the slab's energy and angle-resolved transmission and backscattering functions can be obtained from the invariant embedding principle used by us so far for modeling secondary emission from halfspaces [1]. Both functions enter the equation determining electron backscattering from the dielectric-metal heterostructure comprising the barrier discharge's electrode. Representative data for SiO_2, described by a semiempirical randium-jellium model, are shown as a function of layer thickness, in addition to the Möbius scheme used for numerically integrating the set of matrix Riccati/Sylvester differential equations, arising in slab geometry, in contrast to their algebraic counterparts appearing in the modeling of halfspaces. [1] F. X. Bronold and F. Willert, Phys. Rev. E **110**, 035207 (2024). Supported by Deutsche Forschungsgemeinschaft (DFG, German Research Foundation)–495729137.

P 10.18 Tue 16:15 ZHG Foyer 1. OG

Solving the Spatially Dependent Boltzmann Equation for Electrons with Physics-Informed Neural Networks — •Ihda Chaerony Siffa[1], Detlef Loffhagen[1], Markus M. Becker[1], and Jan Trieschmann[2] — [1]Leibniz Institute for Plasma Science and Technology (INP), Felix-Hausdorff-Straße 2, 17489 Greifswald, Germany — [2]Kiel University, Kaiserstraße 2, 24143 Kiel, Germany

Physics-informed neural networks (PINNs) are an exciting new research area in the field of scientific machine learning. They offer an alternative approach to numerically solving partial differential equations (PDEs) in both forward and inverse problem settings with great flexibility. This study investigates the application of PINNs to solve the spatially one-dimensional electron Boltzmann equation in two-term approximation, which is relevant for the study of non-local effects in weakly ionized, non-thermal plasmas. An attention-based neural network architecture is developed to prevent the convergence to incorrect or trivial solutions of the PDEs as encountered by other architectures in solving this kinetic equation. Numerical experiments are conducted for argon plasmas considering homogeneous electric fields with varying values using a conventional numerical method and the PINN approach. The results from PINNs show good agreement with the reference solutions (obtained from the conventional approach) for the considered cases, which further strengthens PINNs' position as an alternative to solve this type of equation, paving a way for more efficient and accurate fluid-Poisson plasma simulations.

P 10.19 Tue 16:15 ZHG Foyer 1. OG

Local projectors for sparse storage of Basis Projection Operators. — •Nathan Marin[1,2] and Stefan Possanner[1] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Technische Universität München, Garching, Germany

In this project, we developed a custom set of commuting local projection operators for the De-rham complex based on a new set of quasi-interpolation points. These new local projectors maintain the same convergence rate of the global projectors, replicate the basis functions, and have an execution time in the same order of magnitude as the global projectors if run in parallel (the local projectors are about twice as slow as the global projectors). All while having the added advantage of producing a significantly sparser matrix for the Basis Projection Operators (even when compared with other Local Projectors), which allow us to store said operators in the PSYDAC Stencil-matrix format.

P 10.20 Tue 16:15 ZHG Foyer 1. OG

Development and validation of optimized grids for simulations of erosion and impurity transport — •Lukas Maximilian Ellerbrock[1,2], Christoph Baumann[1], Andreas Kirschner[1], Henri Kumpulainen[1], Berkant Palazoglu[1], Juri Romazanov[1], Sebastijan Brezinsek[1,2], and Christian Linsmeier[1,3] — [1]Forschungszentrum Jülich IFN-1, Jülich, Germany — [2]Heinrich-Heine-Universität, Düsseldorf, Germany — [3]Ruhr-Universität, Bochum, Germany

Fusion reactors require precise numerical predictions of plasma-wall interactions and impurity transport. Such predictions can be provided by numerical tools like the 3D Monte-Carlo simulation code ERO2.0. The present work deals with improvements of the ERO2.0 code regarding the numerical grid layout with the goal to optimize precision and computing power.

Until recently, simple rectangular grids were used to store the input distributions of plasma parameters like density and temperature coming from codes like SOLPS. However, the spatial resolution of these rectangular grids is limited due to memory reasons. This limitation can lead to artefacts in the simulation results. Therefore, a new code version introduced flexible field-aligned grids to improve the spatial resolution.

To verify the development, test simulations are applied for tungsten erosion in the future DEMO reactor and further improvements are made to optimize the precision of the code.

P 10.21 Tue 16:15 ZHG Foyer 1. OG

Calculating non-axisymmetric heat loads on plasma-facing components from infrared measurements in W7-X — •Sebastian Thiede[1], Marcin Jakubowski[1], Yu Gao[1], and Peter Manz[2] — [1]Max-Planck-Institut für Plasmaphysik, Teilinstitut Greifswald, Germany — [2]Institut für Physik, Universität Greifswald, Greifswald, Germany

The edge topology of the Wendelstein 7-X stellarator has a complicated 3D structure. This is also true in particular for the deposited heat on plasma-facing components (PFCs). Local heat flux patterns are a valuable source of information for edge physics. The C++ code DELVER was newly developed to infer the surface heat flux distribution on PFCs from infrared measurements. For cuboid divertor tiles, consisting of multiple material layers, it uses an implicit finite-difference approach and an operator splitting technique to calculate this heat flux. It features arbitrary problem dimension, orthotropic material properties that can be arbitrary functions of temperature, non-equidistant orthogonal grids and flexible boundary conditions. A python interface was also developed for more convenient usage. DELVER has been tested against a simple analytical case, other codes, and was assessed on experimental data from W7-X.

P 10.22 Tue 16:15 ZHG Foyer 1. OG

Towards Implementing a Hirshman-Sigmar Type Collision Operator in the Gyrokinetic Code GENE-X — •Andrew Ivan Sulimro, Philipp Ulbl, and Frank Jenko — Max Planck Institute for Plasma Physics

The performance of future magnetic confinement fusion power plants is primarily influenced by the turbulence-driven quality of plasma confinement and heat exhaust. High-fidelity gyrokinetic simulations are key tools to investigate turbulence in fusion devices. The `GENE-X` gyrokinetic code is designed to simulate such situations in the complex geometry of the edge and scrape-off layer regions.

One of the important aspects influencing the accuracy of a gyrokinetic solver is the physics realism of the collision model. In the current state, the gyrokinetic code `GENE-X` is equipped with the Lenard-Bernstein/Dougherty (LBD) operator which is a lightweight alternative to the Fokker-Planck operator. However, the LBD operator lacks the accuracy to study different plasma components, such as

impurities. As the collision frequency is proportional to the square of the ion charge, a realistic collision operator is especially crucial for studying high-Z impurities.

In this work, a more accurate collision operator of Hirshman-Sigmar type is implemented into GENE-X. This new operator can capture additional effects, such as an accurate pitch-angle scattering and the velocity dependence of the collision frequency, which are not accounted for by the LBD operator. The models involved and the numerical aspects of the implementation will be presented and discussed.

P 10.23 Tue 16:15 ZHG Foyer 1. OG

Inclusion of MHD effects in the transport description of tokamak plasmas — •Federico Stefanelli, Emiliano Fable, Clemente Angioni, and Hartmut Zohm — Max-Planck-Institute for Plasma Physics, 85748 Garching, Germany

This project aims to include MHD effects in the transport description of tokamak plasmas, in particular Sawtooth Cycles, Magnetic Flux Pumping and Neoclassical Tearing Modes (NTMs). Including such effects is relevant for a comprehensive transport description, as solving the transport equations provides the drive for MHD instabilities, and the non-linear evolution of such instabilities affects transport. Furthermore, many MHD effects, such as the Sawtooth Cycles or the NTMs, must be avoided or controlled, as they could lead to a loss of performance or disruptions. On the other hand, Magnetic Flux Pumping can provide a desirable operational regime for future machines, with a sawtooth-free core and an optimal redistribution of the core current. Reduced models for such effects would be then relevant for tokamak control applications. The approach followed in this work will be to implement reduced models for the triggering and evolution of such effects in the ASTRA transport code, to be validated on ASDEX Upgrade discharge. For the Sawtooth Cycles and the NTMs, these models will be taken from the literature, while for magnetic flux pumping it will be necessary to develop the reduced model as well.

P 10.24 Tue 16:15 ZHG Foyer 1. OG

Full-wave Simulations of Helicon Waves for Plasma Wakefield Accelerators — •Luis Carlos Herrera Quesada[1], Nils Fahrenkamp[2], Stefan Knauer[2], Peter Manz[2], Günter E.M. Tovar[1], and Alf Köhn-Seemann[1] — [1]IGVP, Universität Stuttgart, Stuttgart, Germany — [2]Universität Greifswald, Greifswald, Germany

This study aims to understand the propagation and dissipation of helicon waves in plasma wakefield systems and to investigate the influence of different antenna geometries on the efficiency of helicon wave excitation. Furthermore, the evolution of the radial plasma density gradient on the efficiency of coupling to the helicon wave is investigated.

The 3D finite-difference time-domain (FDTD) code FOCAL enables full-wave simulations and theoretical analysis, which is used to solve Maxwell's equations coupled to the fluid equation of motion for electrons in a cold magnetized plasma. In parallel, a Finite Element Method (FEM) analysis is carried out using the COMSOL Multiphysics code package. As a first step for simulation scenarios, the device parameters and the geometry of VINETA.75, located at the University of Greifswald, are implemented in the numerical model. In addition, external cooperation with the teams of the MAP device at the University of Wisconsin-Madison, and the PROMETHEUS-A and AWAKE experiments at CERN is planned.

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P 10.25 Tue 16:15 ZHG Foyer 1. OG

3D full-wave simulation of the O-SX mode conversion process — •Alf Köhn-Seemann[1], Bengt Eliasson[2], Simon Freethy[3], Roddy Vann[4], and Thomas Wilson[3,4] — [1]IGVP, University of Stuttgart, Germany — [2]SUPA, Department of Physics, University of Strathclyde, Glasgow, U.K. — [3]Culham Centre of Fusion Energy, Culham, U.K. — [4]York Plasma Institute, University of York, U.K.

Electron Bernstein waves (EBWs) provide a method to heat over-dense plasmas, whose electron plasma density exceeds the cut-off density of an injected electromagnetic wave. EBWs are very well absorbed at the electron cyclotron resonance frequency and its harmonics, even for low electron temperatures. They can furthermore drive significant toroidal net currents. This makes them particularly interesting for spherical tokamaks which often have only a small or no central solenoid and rely therefore on non-inductive current drive. EBWs are electrostatic waves, requiring them to be coupled to externally injected electromagnetic waves. Here we present 3D numerical simulations of the coupling process with the novel finite-difference time-domain code FOCAL. Simulation results from a feasibility study for the spherical tokamak MAST Upgrade are presented and related numerical challenges are discussed.

P 10.26 Tue 16:15 ZHG Foyer 1. OG

Study of Quasi-Symmetry in Stellarator Designs: Impact of Coil Parameters on Device Robustness — •Elisa Buglione-Ceresa, Pedro Gil, and Eve Stenson — Max Planck Institute for Plasma Physics, Garching

This study investigates the role of quasi-symmetry (QS) in stellarators, focusing on its sensitivity to various design parameters. QS is crucial for confining trapped charged particles and plasma in toroidal magnetic fields. In a quasi-symmetric stellarator the magnetic field strength can exhibit symmetry along a specific coordinate, providing the confinement of guiding center trajectories. The research examines three stellarator configurations, analyzing the impact of coil number, coil separation, coil complexity (λ), and manufacturing imperfections (simulated as Gaussian perturbations with amplitude σ and characteristic length L) on QS. The studied equilibria include the APEX-EPOS configuration and reactor-sized designs with quasiaxisymmetry and quasihelical symmetry for precise plasma confinement. Using REGCOIL for coil design optimization and SIMSOPT for perturbations, we applied Gaussian perturbations to simulate realistic manufacturing conditions. Results show that QS decreases with increasing perturbations, highlighting its sensitivity to manufacturing tolerances. This study also investigates how QS changes with varying coil numbers, separation, and complexity. These findings provide critical insights into optimizing coil design, including performance of the field accuracy at reactor relevant dimensions, offering valuable guidelines for designing stellarators that balance high performance with practical feasibility.

P 10.27 Tue 16:15 ZHG Foyer 1. OG

Coupling of fluid neutrals with gyrokinetic plasma in the edge turbulence code GENE-X — •Sabine Ogier-Collin, Philipp Ulbl, Wladimir Zholobenko, and Frank Jenko — Max-Planck Institute for Plasma Physics, Garching bei München, Germany

Understanding turbulent transport in the plasma edge and scrape-off layer (SOL) is essential for managing heat and particle exhaust while maintaining effective core confinement in magnetic confinement fusion (MCF) reactors. In these regions, the abundance of neutral particles and their interactions with the plasma significantly influence radial profiles and thus gradient-driven instabilities, particle transport across the separatrix, and blob dynamics in the SOL.

GENE-X is a first-principles code designed to simulate edge and SOL turbulent transport in realistic magnetic geometries, including X-points. We present the first coupling of a continuum full-f gyrokinetic model with a fluid model for neutrals. The evolution of the neutrals density is captured by a pressure-diffusion equation, where the diffusion is driven by charge exchange collisions. Plasma-neutral interactions - such as ionisation, recombination and associated radiation - are included via special Krook operators.

Following verification, relaxation studies have been carried out to assess the impact of inelastic plasma-neutrals reactions on plasma distribution functions and equilibration dynamics. In addition, a first case study in divertor geometry is presented, demonstrating the potential of the coupled model for turbulence simulations in MCF devices.

P 10.28 Tue 16:15 ZHG Foyer 1. OG

Characterization of pure-electron plasmas in APEX-LD — •Veronika C. Bayer, Adam Deller, Alex Card, and E. V. Stenson — Max Planck Institute for Plasma Physics, Garching b. München, Deutschland

We describe the development of diagnostics for studying stably confined pure-electron plasmas in a compact levitating dipole trap (APEX-LD). The existing diagnostics confirm collective behaviour. However, they provide incomplete means to analyse the plasma potential or the density profiles. New diagnostics, an electron beam probe and a retractable target probe, will collect the data necessary to analyse these properties. Further insights into collective behaviour from these new diagnostics will be used to prepare APEX-LD for pulsed positron injection and the trapping of pair plasmas.

P 10.29 Tue 16:15 ZHG Foyer 1. OG

Generation and diagnostics of an inverted fireball (IFB) discharge in an rf plasma — •Viktor Schneider[1], Jan Krieger[1], Johannes Grünwald[2], Gerhard Eichenhofer[3], and Holger Kersten[1] — [1]Institute of Experimental and Applied Physics (IEAP), Kiel University — [2]Gruenwald Laboratories GmbH — [3]4A-Plasma

In this work, an inverted fireball (IFB) [1,2], i.e. a secondary plasma within a hollow grid anode cage, was generated and investigated in a radio frequency plasma. IFBs have a significantly increased plasma density, a homogeneous plasma potential and are, therefore, potentially interesting for application in PECVD processes [3-4]. The ignition conditions for the IFB plasma were determined and special features regarding the influence of the rf plasma on the IFB, in particular the bias voltage of the rf electrode, were studied. The IFB plasma was investigated using a Langmuir probe, optical emission spectroscopy (OES) and a passive thermal probe (PTP) [5]. Good agreement was obtained between the diagnostics for the behavior of the IFB with parameter variation using OES and PTP.

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P 10.30 Tue 16:15 ZHG Foyer 1. OG

Characterization of Reflected Light Properties in PIC Simulations — •Vidisha Rana[1,2], Milenko Vescovi[1,2], Marvin E.P. Umlandt[1,2], Franziska Paschke-Brühl[1,2], Richard Pausch[1], Pengjie Wang[1], Tim Ziegler[1,2], Karl Zeil[1], Ulrich Schramm[1,2], and Thomas Kluge[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf — [2]Technische Universität Dresden

Laser-driven ion accelerators offer several advantages over the conventional ones due to their potential of achieving high accelerating gradients over small distances. Recent experiments have demonstrated that one can achieve significantly high proton energies by modifying the temporal profile and controlling the spectral phase of laser pulses, specifically using Group Velocity Dispersion (GVD). However, the entire mechanism still needs to be understood.

Reflected light properties provide a powerful diagnostic tool for understanding these interactions and optimizing proton energies. Experiments involving high-intensity ultrashort laser pulses interacting with thin foils reveal prominent spectral shifts across changing Group Velocity Dispersion (GVD) values. These shifts can offer valuable insights into plasma dynamics, relativistic surface motion, and laser contrast effects, which have a direct impact on proton energies but remains difficult to interpret solely through experiments. This challenge can be addressed by employing PIC codes to simulate these interactions to analyze the underlying mechanisms. By bridging this gap, this work aims to advance our understanding of laser-plasma interactions.

P 10.31 Tue 16:15 ZHG Foyer 1. OG

Radiation emission from relativistic electron bunches interacting with plasma density gratings — •Sophie Opara and Götz Lehmann — Heinrich-Heine-Universität Düsseldorf

The interaction between high-intensity light waves and transient periodic density modulations of underdense plasma has been proven to be a fruitful concept for plasma-based optics in the context of high-power lasers. The plasma density gratings, driven by the ponderomotive force of overlapping laser pulses, can have substantial amplitudes, up to more than 100% in the nonlinear regime. The modulations then subsequently can act e.g. as Bragg-type mirror, polarizer or wave-plate for probe pulses of high intensity. Their holographic nature allows even to convert between different types of laser beams, e.g. from Gaussian to Gauss-Laguerre type. Even concepts for plasma-based pulse compressors for chirped-pulse amplification have been developed. The interaction of density modulated plasma with highly energetic particle beams on the other hand is less well studied, mostly in the context of beam transport through plasmas. In our present work we study the interaction of beams in strongly density modulated systems in the context of radiation generation.

P 10.32 Tue 16:15 ZHG Foyer 1. OG

Plasma-based volume holograms for creation of relativistic Gauss-Laguerre laser beams — •Götz Lehmann and Karl-Heinz Spatschek — Heinrich-Heine-Universität Düsseldorf

Gauss-Laguerre (GL) laser beams have received growing interest in the field of high-intensity laser-plasma interactions over the past years due to their particular doughnut-like intensity distribution, their particular field configuration in the focal region and also for their orbital angular momentum. At moderate intensites, i.e. far away from the ionization-threshold of any material and thus even further away from the (relativistic) intensities discussed in literature, GL beams are obtained e.g. by passing a Gaussian beam through a spiral phase plate, imprinting a helical structure on the phase distribution within the beam. For relativistic focal intensities such solid-state material solutions are not feasible. Plasma-based holograms offer an alternative route to mode conversion. In our work, we show how to write transient plasma density gratings into underdense plasma that then subsequently will act as a hologram and convert Gaussian laser pulses into LG pulses of relativistic intensities.

P 10.33 Tue 16:15 ZHG Foyer 1. OG

Turbulence in Molecular Clouds - A laboratory for understanding waves in partially ionized media — •Christian Heppe[1], Alexei Ivlev[2], and Frank Jenko[1] — [1]IPP, Garching (DE) — [2]MPE, Garching (DE)

Plasma in space are are found in a partially ionized state only. Thus, we need to consider the interaction between ionized and neutral gases. Since the coupling between both gases is modelled via collisions we expect, on scales smaller than their collision frequencies, the gases to increasingly decouple while on larger scales the gases to move in unison. This has immediate consequences for MHD waves in the medium requiring a deviation from a single-fluid treatment, i.e. two-fluid MHD (2FMHD). Although 2FMHD predicts "decoupling gaps" for MHD modes in which propagation is prohibited or strongly damped, simulations of 2FMHD turbulence do not show such a gap. This suggests that within the framework of ideal 2FMHD an as of yet unknown process that mediates energy through this gap is present. As Molecular Clouds (MCs) are of generally high interest in Astrophysics and Astronomy due to their role in star formation and Cosmic Ray (CR) propagation, while covering a vast variety of plasma conditions under turbulent conditions over a wide range of scales, they pose as an ideal "laboratory" to empirically improve current understanding of MHD waves in partially ionized media.

P 10.34 Tue 16:15 ZHG Foyer 1. OG

Thermal and DC Electrical Conductivities of Hydrogen at the Insulator-to-Metal Phase Transition from Ab Initio Calculations — •Martin Preising[1], Ronald Redmer[1], and Marcus Knudson[2] — [1]University of Rostock — [2]Sandia National Labs, USA

The metallisation of fluid hydrogen under high pressures has a profound impact on planetary science [1]. While most experimental campaigns report transition pressures between 100 and 225GPa, a 2015 campaign reports significantly higher pressures around 300GPa [2].

Understanding and resolving this discrepancy requires calculations of thermal conductivities of shocked hydrogen in the vicinity of the metallisation, including ionic thermal conductivities [3].

We report on DC electrical conductivities, thermal electronic and thermal ionic heat conductivities from ab initio simulations. We employ the vdW-DF1 and vdW-DF2 exchange-correlation functional due their superior ability to predict experimental conductivities of dense hydrogen [4].

Electronic contributions show an increase of several orders of magnitude across the metallisation transition. The ionic thermal conductivities do not significantly change but provide the main contribution to the total thermal conductivity in the non-metallic and a significant contribution in the metallic regime.

[1] MP, RR et al., Astrophys. J. Suppl. Ser. 269, 47 (2023)
[2] MK, RR et al., Science 348, 6242 (2015)
[3] M. French, New J. Phys. 21, 023007 (2019)
[4] MK, MP, RR et al. Phys. Rev. B 98, 174110 (2018)

P 10.35 Tue 16:15 ZHG Foyer 1. OG

Particle acceleration in core-collapse supernova remnant — •Samata Das[1,2], Robert Brose[2], Dominique M.-A. Meyer Meyer[3], Martin Pohl[2,4], and Iurii Sushch[5] — [1]Theoretische Physik IV, Fakultät für Physik Astronomie, Ruhr-Universität Bochum, 44780 Bochum, Germany — [2]University of Potsdam, 14476 Potsdam, Germany — [3]Institute of Space Sciences , 08193 Barcelona, Spain — [4]DESY, 15738 Zeuthen, Germany — [5]Gran Sasso Science Institute, 67100 L'Aquila, Italy

The complex environments around core-collapse supernova remnants (SNRs) from their massive progenitors, shape spectra and morphology of non-thermal emissions from remnants. We study the effects of hydrodynamics and magnetic field of circumstellar medium on particle acceleration and emission from remnants. We use RATPaC and PLUTO code where hydrodynamic equations with transport equation for CRs and scattering magnetic turbulence, induction equation for magnetic field evolution solved in 1-D spherical symmetry. Our study shows the SNR propagation through hot bubble, for example, bubble by $60 M_{\odot}$, reduce significantly the sonic Mach number of SNR shock that persistently softens the particle spectra with spectral index 2.5, and steepens the radio spectra. SNR with 20 $M_{\odot}$ Red-Super giant progenitor produces steep radio spectra, and soft pion-decay gamma-ray spectra, briefly during the interaction of the SNR shock with the dense RSG shell. For old remnants inside shocked ISM, we got softer pion- decay emission, consistent with the observed gamma-ray emission

Acknowledgement: Supported by SFB1491

P 10.36 Tue 16:15 ZHG Foyer 1. OG

Particle Acceleration and Emission Signatures in Relativistic AGN Jets — •Nikita Nikita[1], Frank Rieger[1], Bhargav Vaidya[2], and Frank Jenko[1] — [1]Max Planck Institute for Plasma Physics (IPP), Boltzmannstraße 2, 85748 Garching, Germany — [2]DAASE, IIT Indore, Simrol, 453552, India

Relativistic outflows from AGNs can extend up to kilo-parsec scales, exhibiting complex morphologies. Using 3D relativistic magnetohydrodynamic (RMHD) simulations of rotating jet using PLUTO, we explore the role of dynamical instabilities in shaping complex jet morphologies and their synchrotron emission. Our analysis based on simulations of a continuously injected jet suggests that current-driven instabilities, notably the $|m| = 1$ mode, generate ribs-like structures that are seen in some of the recent radio galaxies using MeerKat. In the simulations of the restarted jet, the kink-instability driven ribs-like structures were formed closer to the nozzle. In both cases, the jet dissipates its magnetic energy through these instabilities, transitioning to a more kinetic energy dominant state. The synchrotron emission modeled in these simulations considers only diffusive shock acceleration. Stochastic acceleration, however, can become relevant in large-scale jets at sufficient magnetization, where strong shocks are absent, and turbulent magnetic fields dominate. As a next step, we aim to incorporate stochastic turbulent acceleration into PLUTO using a semi-analytical approach. These findings will contribute to a deeper understanding of the multi-scale processes driving particle acceleration and emission in AGN jets, bridging numerical simulations with observations.

P 10.37 Tue 16:15 ZHG Foyer 1. OG

Understanding the Role of Plasma Instabilities in Blazar-Induced Pair Beams: Laboratory Simulations and Astrophysical Implications — •Suman Dey and Günter Sigl — II. Institut für Theoretische Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

The interaction of TeV photons from blazars with the extragalactic background produces a relativistic beam of electron-positron pairs streaming through the intergalactic medium, producing a cascade through up-scattering low-energy photons. Plasma instability is considered one of the underlying energy-loss processes of the beams. We employed particle-in-cell (PIC) simulations to study the plasma instabilities of ultra-relativistic pair beams propagating in a denser background plasma, using the parameters designed to replicate astrophysical jets under laboratory conditions. We have investigated the parameter regime where the electromagnetic modes are suppressed, aligning with the physically relevant criteria of Blazar-induced beams. We have used an astrophysically realistic non-Maxwellian distribution for the beam particles, improving upon previous studies. We investigated the interplay between the magnetic field forming from localized currents and transverse beam momentum spread. We calculated the physical limit of density contrast at which the beam achieves optimal suppression of electromagnetic instabilities in laboratory experiments. We extrapolated the non-linear feedback of instability where the beam is energetically broadened. We observed that the instability generates a negligible angular broadening for Blazar-Induced beams.

P 10.38 Tue 16:15 ZHG Foyer 1. OG

Influence of ELMs on O-X mode conversion efficiency — •Shibangi Majumder, Christos Vagkidis, and Alf Köhn-Seemann — IGVP, University of Stuttgart, Germany

Edge Localized Modes (ELMs) constitute a continuous relaxation of the edge plasma pressure gradient. The respective perturbation of the electron plasma density profile can perturb microwaves injected into the plasma for heating purposes. This is particularly true for mode coupling processes like the O-SX-B mode conversion, where an injected O-mode couples to an SX-mode near the cut-off layer. The SX-mode is then reflected and propagates to the upper-hybrid resonance, where it can couple to electron Bernstein waves, which are electrostatic waves that are very well absorbed at the electron cyclotron resonance. The efficiency of the O-SX coupling depends strongly on the injection angle with respect to the background magnetic field. In this work, we explore the effect of ELMs on the O-SX coupling with an FDTD code, providing thus insights into the interplay between ELM-induced edge conditions and microwave heating performance. This further can contribute to a deeper understanding of plasma heating and confinement mechanisms in fusion experiments.

P 10.39 Tue 16:15 ZHG Foyer 1. OG

Study on Fast Electrons Generated in the Stellarator Experiment TJ-K — •José Ignacio Fernández Gómez, Alf Köhn-Seemann, and Mirko Ramisch — IGVP, University of Stuttgart, Germany

The TJ-K stellarator is equipped with a microwave heating system capable of delivering power at three frequencies: 3 kW at 2.45 GHz, 3 kW at around 8 GHz, and 6 kW at around 14 GHz. While the bulk electron temperature is typically around 10 eV, fast electrons with energies ranging from several 100 eV to 100 keV are found in various experimental scenarios. In this work, the trajectories of these fast electrons are simulated in the 3D magnetic field geometry of TJ-K. It is found that these particles, when comparing movement parallel and anti-parallel to the magnetic field, can result in toroidal net currents if the drift surfaces differ sufficiently. Configurations resulting in toroidal net currents are identified and the underlying physics processes are discussed. Selected scenarios are experimentally analyzed to measure the toroidal net current, providing a basis for validating the simulation outcomes.

P 10.40 Tue 16:15 ZHG Foyer 1. OG

Self-consistent eddy and halo current coupling of a 3D non-linear MHD plasma with 3D realistic wall structures — •Raffaele Sparago[1,2], Javier Artola[2], Matthias Hoelzl[1], Nicola Isernia[3], Guglielmo Rubinacci[4], Nina Schwarz[2], Salvatore Ventre[5], and Fabio Villone[3] — [1]Max Planck Institute for Plasma Physics, Boltzmannstraße 2, 85748 Garching, Germany — [2]ITER Organization, 13067 St. Paul Lez Durance Cedex, France — [3]Università degli Studi di Napoli Federico II, Via Claudio 21, 80125 Napoli, Italy — [4]CREATE Consortium, Via Claudio 21, 80125 Napoli, Italy — [5]Università di Cassino e del Lazio Meridionale, Via Gaetano di Biasio 43, 03043 Cassino, Italy

An adequate modeling of the electromagnetic interaction of a magnetized plasma with the surrounding machine's conductors is paramount for the correct replication of 3D plasma dynamics. Reproductions of the latter provide useful predictions regarding the evolution of MHD modes and the electromagnetic forces acting on the vacuum vessel when said modes trigger disruptions. The here presented modeling efforts involving the 3D FEM non-linear MHD code JOREK have accomplished the self-consistent coupling of eddy currents in a full MHD physics scenario, with the related validation and simulation, employing the wall code STARWALL. This contribution also features the latest progress concerning the self-consistent coupling of halo currents (which flow from the plasma to the wall and viceversa) with the 3D wall code CARIDDI; this is essential for the prediction of the related rotating sideways forces that could pose a serious threat to future machines.

P 10.41 Tue 16:15 ZHG Foyer 1. OG

Density and Temperature Profiles from Upper Divertor Spectroscopy — •Hannah Lindl[1], Ralph Dux[1], and The ASDEX Upgrade Team[2] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]See author list of H. Zohm et al, 2024 Nucl. Fusion

Reducing the power load on material surfaces is essential for prolonging the lifetime of plasma facing components. The final goal is to reach plasma detachment, resulting in reduced heat and ion fluxes onto the divertor target. We can accomplish this by significantly reducing the electron temperatures T_e near the target plates compared to the upstream values, resulting in effective ion recombination before they make contact with the first wall.

A new measurement technique based on divertor spectroscopy is proposed to determine T_e profiles in the upper divertor region of ASDEX Upgrade (AUG), where we can observe the plasma with high fidelity. This enables us to obtain local data for all spectroscopic accessible quantities by a fit similar to an Abel transform. We aim to calculate $T_e(r)$ in diverted plasmas by measuring local electron densities n_e through Stark broadening of the high-n deuterium Balmer lines D_δ and D_ϵ. Furthermore, we calculate line emissivity profiles $\epsilon_L(r)$ via a deconvolution of the spectral radiance L. Assuming Saha equilibrium is established between high-n and continuum states of deuterium, we estimate $T_e(r)$ by combining $n_e(r)$ with $\epsilon_L(r)$.

In this contribution, the technique is applied to first measurements of the upper divertor spectroscopy in upper single null discharges at AUG and first n_e and T_e profiles in this region are shown.

P 10.42 Tue 16:15 ZHG Foyer 1. OG

Analysis of the electrostatic potential distribution and drifts in island divertor geometries using fluid turbulence simulations — •Tobias Tork[1], Felix Reimold[1], David Bold[1], Brendan Shanahan[1], Sergei Makarov[1], Peter Manz[2], and the W7-X Team[1] — [1]Max Planck Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany — [2]Institute of Physics, University of Greifswald, 17489 Greifswald, Germany

In fusion devices, particle and heat exhaust pose a significant challenge. The island divertor concept was developed to address the exhaust problem. In this concept, the magnetic field is perturbed and forms magnetic islands at rational flux surfaces. These islands are intersected by target plates and divert particle and heat fluxes to the targets. In the island divertor of the stellarator Wendelstein 7-X, large poloidal ExB-velocities have been observed. These velocities are expected to significantly contribute to the transport of particle and energy. Current state of the art stellarator simulations are not incorporating drift effects. There is thus little knowledge about the electrostatic potential distribution and hence the ExB-drifts in an island divertor. To address this issue, the 3D-turbulence model Hermes-2 is used. It is applied to simplified geometries that mimic the island divertor topology. As Hermes-2 is a hot-ion drift reduced fluid model, it contains the electrostatic potential and thus the drift effects. The latter will be analyzed on mean field solutions to understand the electrostatic potential distribution and the impact of drifts and currents on the plasma parameters and the transport in the island.

P 10.43 Tue 16:15 ZHG Foyer 1. OG

A new method to characterize instabilities in fusion plasmas using the soft x-ray multicamera system at Wendelstein 7- X — •Charlotte Büschel, Christian Brandt, Henning Thomsen, Kian Rahbarnia, Sara Vaz Mendes, Edith Victoria Hausten, and Wendelstein 7-X Team — Max Planck Institute for Plasma Physics, Greifswald, Germany

Soft x-ray tomography is widely used in fusion experiments for the reconstruction of two-dimensional density profiles. The soft x-ray multi-camera tomography system (XMCTS) installed in Wendelstein 7-X consists of 20 pinhole cameras [C. Brandt et al. 2020]. Each camera has 18 photodiodes, measuring the line-integrated soft x-ray emissivity of the plasma. As the emissivity is strongly related to the plasma density, the fluctuating part of the signal can be used to analyze instabilities propagating in the plasma. Electrostatic and electromagnetic instabilities affect the particle and energy transport within a plasma and are one of the main reasons for particle and energy losses. To control or even prevent instabilities, their characterization regarding amplitude, frequency, radial location, poloidal structure and propagation direction is important. A new method has been developed to analyze the 360 line-integrated signals of the photodiodes to determine the radial location and the poloidal structure of instabilities with poloidal mode numbers up to m=20. The workflow of the analysis is presented based on artificial data.

P 10.44 Tue 16:15 ZHG Foyer 1. OG

The isotope dependence of the ASDEX Upgrade pedestal structure — •Roxána Takács[1], Michael Dunne[1], Benedikt Zimmermann[1,2], and the ASDEX Upgrade Team[3] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Department of Applied Physics and Applied Mathematics, Columbia University, New York, USA — [3]See author list of H. Zohm et al, 2024 Nucl. Fusionhttps://doi.org/10.1088/1741-4326/ad249d

Future fusion devices, such as ITER, will operate with a deuterium-tritium mixture, whereas current experiments use mainly deuterium or hydrogen. Studying the isotope dependence is, therefore, crucial to accurately predict the performance of these future fusion devices. Previous studies have demonstrated positive isotope mass scaling of the thermal energy confinement time in H-mode plasmas. This phenomenon has been observed in several major tokamaks, including JET [C.F. Maggi], JT-60U [H. Urano], ASDEX [M. Bessenrodt-Weberpals] and ASDEX Upgrade [P. A. Schneider]. To further investigate the isotopic dependence, this analysis compares different isotopic plasmas from the ASDEX Upgrade tokamak, focusing on the pedestal region to understand the specific phenomena where isotopes play an important role. Different main isotopic discharges with matched engineering parameters were selected for comparison. The analysis includes comparison of kinetic profiles (temperature, density, and pressure profiles), stability analysis against peeling-ballooning (PB) modes, and investigation of inter-ELM transport differences.

P 10.45 Tue 16:15 ZHG Foyer 1. OG

Bayesian inference of plasma parameters in the island divertor of W7-X — •Linnéa Björk[1], Felix Reimold[1], Sehyun Kwak[1], Daniel Böckenhoff[1], Udo von Toussaint[2], Sebastian Grosinger[3], and The Wendelstein 7-X Team[1] — [1]Max Planck Institute for Plasma Physics, Greifswald, Germany — [2]Max Planck Institute for Plasma Physics, Garching, Germany — [3]Lund University, Department of Physics, Lund, Sweden

The W7-X stellarator is a 3D fusion device with a complex geometry, which make diagnostic measurements of the plasma sparse. This is especially true for the boundary region, known as the scrape-off layer (SOL). Here so-called island divertors are located which manage exhaust for particles and heat. In this region, the plasma interacts with toroidally discontinuous divertor plates, which can lead to strongly toroidally localized effects. Assessing the physics and transport phenomena in this region is therefore not trivial. By using a Bayesian analysis approach, datasets from different diagnostics can be combined in order to obtain information about the underlying plasma parameters, such as the electron density and temperature distributions. This knowledge will ultimately help deepen the understanding of transport at the boundary.

In this contribution, first steps into a Bayesian analysis framework focusing on inference of plasma parameters in the boundary region will be presented. This includes outlier-robust 1D profile fits of electron density and temperature and progress on building a 2D framework for parameter regression.

P 10.46 Tue 16:15 ZHG Foyer 1. OG

Commissioning of a dispersion interferometer for disruption studies at ASDEX Upgrade — •Andrew Moreau[1,2], Alexander Bock[1], Kai Jakob Brunner[3], Riccardo Nocentini[1], Emre Sözer[1], Andreas Burckhart[1], Jens Knauer[3], Thomas Pütterich[1,2], and the ASDEX Upgrade team[4] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Ludwig Maximilian University, Munich, Germany — [3]Max Planck Institute for Plasma Physics, Greifswald, Germany — [4]See author list of H. Zohm et al, 2024 Nucl. Fusion

Disruptions are off-normal events where thermal and particle confinement are lost in magnetic confinement plasma devices. Future reactors carry a high risk of unmitigated disruptions causing unacceptable force and heat loads for the health of the devices. It is essential to develop instruments which can reliably track quantities, such as electron density, through the entire phase of disruptions and their mitigation schemes as we learn to characterize and control the plasma state.

At ASDEX Upgrade, two systems have measured line-integrated electron density, a 195μm interferometer and a 10.6μm two-colour interferometer. These interferometers either refract heavily during disruptions or are extremely noisy from incomplete vibration compensation and both suffer from ambiguities in the phase tracking (fringe jumps). We present the commissioning of a dispersion interferometer, probing at 5.3μm, which uses second-harmonic coherence conservation to intrinsically eliminate vibrational noise and is more resilient against refraction and fringe jumps from the shorter wavelength.

P 10.47 Tue 16:15 ZHG Foyer 1. OG

A new imaging diagnostic for ASDEX Upgrade divertor fluctuation studies — •Manuel Herschel[1,2], Michael Griener[1], Tim Happel[1], Tilmann Lunt[1], and The ASDEX Upgrade Team[3] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Technical University of Munich, Physics Department, Chair for Plasma Edge and Divertor Physics, 85747 Garching, Germany — [3]see author list of H. Zohm et al, 2024 Nucl. Fusion 64 112001

In magnetic confinement fusion devices, so-called divertors are used to distribute heat loads on the wall and control impurity influxes into the main plasma volume. Recently, the ASDEX Upgrade fusion experiment has been equipped with a new flexible upper divertor to study various power exhaust scenarios.

To investigate the effect of the different divertor configurations in ASDEX Upgrade, powerful diagnostics are necessary. In this work, a novel multi-color gas puff imaging system is presented. The system consists of a fast helium injection valve to excite localized light emission from helium neutrals and an optical setup including an image splitter, spectral filters and a fast camera. The diagnostic is optimized for timescales below 10 μs and a spatial resolution of around 1 cm. The simultaneous imaging of two spectral lines allows compensation of shadowing effects. This enables the observation of fast turbulent structure dynamics in the divertor region.

The final setup and the design choices behind the components are presented, as well as the progress towards first measurements under various plasma conditions.

P 10.48 Tue 16:15 ZHG Foyer 1. OG

Overview of a MANTIS-II installation in AUG for runaway electron studies using synchrotron imaging — •Andres Orduna[1,2], Andreas Burckhart[1], Gergely Papp[1], Tijs Wijkamp[3], Mathias Hoppe[4], Artur Perek[5], Yanis Andrebe[5], Tilmann Lunt[1], Ralph Dux[1], and ASDEX Upgrade Team[1] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Ludwig-Maximilians-Universitat Munchen — [3]Dutch Institute for Fundamental Energy Research — [4]KTH Royal Institute of Technology, Stockholm, Sweden — [5]Ecole Polytechnique Fédérale de Lausanne, Swiss Plasma Center

Study of energy and pitch angle dynamics of runaway electrons (RE) in present-day tokamak experiments requires the analysis of the RE momentum-space distribution function. Synchrotron radiation (SR) imaging using multispectral systems has proven capable of providing this information in TCV and AUG. As a consequence, the multispectral imaging system MANTIS consisting of 6 filtered cameras is planned to be installed in AUG.

Three of the filters are dedicated to SR imaging to constraint the distribution function. Since the SR is emitted along the velocity vector of the electrons, the view port needs to be carefully selected. Camera images using each filter and view are simulated using the SOFT synthetic diagnostic framework. Finally, the cameras have to be placed at a distance from the toroidal field coils and protected from the neutron flux to avoid malfunction and image noise.

P 10.49 Tue 16:15 ZHG Foyer 1. OG

Investigation of benign edge scenarios with the tokamak design suite DYT — •Fabian Leindecker[1,2], Teobaldo Luda[2], Mike Dunne[2], Emiliano Fable[2], Tom Bleher[2], Matthias Willensdorfer[2], Alexander Bock[2], Elisabeth Wolfrum[1,2], and the ASDEX Upgrade Team[3] — [1]Institute of Applied Physics, TU Wien, Vienna, Austria — [2]Max-Plank-Institut für Plasmaphysik, D-85748 Garching, Germany — [3]See Zohm et al 2024 for the ASDEX Upgrade Team

The Design Your Tokamak (DYT) program suite is a collection of modules aiming to explore different configurations and establish reliable boundaries for possible machine designs. In the presented work DYT was used to examine the minimal in-plane coil-to-coil force acting on poloidal field coils during operation in small ELM regimes. The operation within the small ELM regime is determined using the shaping parameters and the normalized pressure gradient in the pedestal region. By comparing various plasma elongations for ASDEX-Upgrade, JET, ITER, and DEMO scenarios, the study identifies a favorable plasma shape that reduces the maximum force exerted on the coils. Building on this approach and recognizing the importance of impurity seeding for power exhaust in large machines like ITER or DEMO, a module to investigate the radiated power within the separatrix for different impurities will be implemented into the simulation tool. The objective is to generate insights and a tool that may enhance the safe and effective construction of future fusion reactors.

P 10.50 Tue 16:15 ZHG Foyer 1. OG

MHD equilibrium reconstructions for Wendelstein 7-X stellarator including soft x-ray emission data — •Edith Hausten[1], Kian Rahbarnia[1], Henning Thomsen[1], Christian Brandt[1], Charlotte Büschel[1], Sara Vaz Mendes[1], and Samuel Lazerson[2] — [1]Max Planck Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany — [2]Gauss Fusion GmbH, Parkring 29, 85748 Garching bei München, Germany

In fusion experiments such as the Wendelstein 7-X Stellarator, knowledge about the plasmas MHD equilibrium is of crucial importance for the interpretation of measurements and to obtain several quantities that are not measured directly. The equilibrium can be reconstructed from experimental data by using the STELLOPT code [S. Lazerson 2015 Nucl. Fusion 55]. It uses an optimization algorithm to find the equilibrium that best matches measured target values of various diagnostics. Currently, the code is being enhanced to incorporate measurements of the XMCTS camera system, a diagnostic measuring the plasmas soft x-ray emissivity within a poloidal plane. The aim is to improve the quality of reconstructions, especially with respect to the Shafranov shift, which can be inferred from soft x-ray observations as previously demonstrated. The Shafranov shift is the outward shift of the magnetic axis compared to the vacuum field, and is increasing in strength with rising plasma beta. First results of reconstructions

employing the new STELLOPT feature are presented with a focus on high energy discharges and the obtained Shafranov shift size is compared to analytical estimations as well as pure experimental measurements.

P 10.51 Tue 16:15 ZHG Foyer 1. OG

Helium transport using gas puff modulation at Wendelstein 7-X — •Sali Beppler, Thilo Romba, Felix Reimold, and The W7-X Team — Max Planck Institute for Plasma Physics, Greifswald, Germany

In fusion plasmas, decreased performance due to impurity dilution is to be minimized. As the fusion ash helium is produced in the core region of the plasma but needs to be pumped at the edge, its transport properties are of great interest.

The helium transport in Wendelstein 7-X plasmas is evaluated. A modulated source is introduced to make use of the time dependent term in the transport equation. This restricts the determined transport coefficients more strongly than a conventional steady state approach. The scenario is modeled using the 1D-transport solver pySTRAHL. In order to analyze the sensitivity of input and fitting-parameters, synthetic data is generated. Following the synthetic assessment, the method is applied to experimental W7-X data, aiming to assess changes in helium transport across different magnetic configurations. Besides no fundamental differences across the configurations, a high sensitivity to misalignments in the line of sight geometry is identified.

P 10.52 Tue 16:15 ZHG Foyer 1. OG

Toward a nonlinear Schrödinger equation description for geodesic-acoustic-modes in tokamaks: Analytic gyrokinetic studies of the nonlinear self-interaction — •David Korger[1,2,3], Emanuele Poli[1], Fulvio Zonca[3], and Matteo Falessi[3] — [1]Max-Planck-Institut für Plasmaphysik, Garching, 85748, Germany — [2]Ulm University, Ulm, 89081, Germany — [3]Center for Nonlinear Plasma Science and C.R. ENEA Frascati, C.P. 65, 00044 Frascati, Italy

The geodesic-acoustic-mode (GAM) is a plasma oscillation observed in fusion reactors with toroidal geometry and is recognized to be the nonstationary branch of the zonal flows (ZFs). Prior studies have established that, as a direct consequence of nonlinear gyrokinetic theory, the GAM dynamics is well described by an equation of Schrödinger type - i. e., an equation whose linear contribution is exactly of the same form as the linear Schrödinger equation, while the nonlinear dynamics necessitates an integro-differential expression.

The presented work takes a closer look into the nonlinear contributions by deriving approximate, but well-defined, analytic expressions from the (exact) integro-differential operators. At the lowest order of accuracy, prior numerical studies anticipate the retrieval of a cubic nonlinear Schrödonger equation. This may come unexpected since nonlinear interactions usually have a quadratic structure, such as e. g. the $E\times B$-nonlinearity. The third power is found to stem from an interaction of quadratic structures generated by the GAMs (with oscillation frequencies that are either zero or twice the GAM frequency) with the GAM itself.

P 10.53 Tue 16:15 ZHG Foyer 1. OG

Force optimization for novel stellarator-tokamak hybrid coils — •Annika Zettl[1,2] and Sophia Henneberg[1] — [1]Max Planck Institut für Plasmaphysik — [2]Universität Greifswald

The novel perturbed tokamak concept seeks to leverage the strengths of both tokamaks and stellarators in a hybrid machine for magnetic confinement fusion. In recent work, S. Henneberg and G. Plunk (2024), as well as T. Schuett and S. Henneberg (2024) introduced a quasi-axisymmetric (QA) design that offers several advantages, including a low aspect ratio for a large plasma volume, fast particle confinement, and simple coil geometry. As a proof of principle, they developed an initial coil set using conventional poloidal and toroidal tokamak coils along with on single type of nonplanar stellarator coils. However, engineering constraints beyond simple geometrical measures were not considered in their design. This study focuses on optimizing the coils for different candidate configurations to closely match the plasma boundary and maintain the desired QA properties, while incorporating practical buildability limitations. To achieve this, we successfully employed a two-stage optimization process, utilizing a new method by S. Hurwitz et al. (2024) to calculate the forces acting on the coils.

P 10.54 Tue 16:15 ZHG Foyer 1. OG

Design system identification input or the dynamics of the radiated power in Wendelstein 7-X — •Anastasios Tsikouras, Felix Reimold, Maciej Krytzowiak, and Georg Schlisio — Max Planck Institute IPP, Greifswald, Germany

Heat dissipation from the plasma is critical for safe long-pulse operation and reactor-relevant scenarios in all magnetic confinement fusion devices. Impurity seeding in the edge region of the plasma dissipates a portion of its power in all directions by radiation. This action leads in reduced heat loads carried in the last plasma layer in contact with materials, as well as reduced plasma edge temperature. Efficient control of this radiated power necessitates a feedback control system. In Wendelstein 7-X stellarator we aim to design such a feedback system. The seeding actuator is a fast piezo-electric valve [1]. The recently operating divertor bolometry system will provide the radiated power signal. An effective controller requires identifying the dynamics of the investigated plant. This means how the output reacts to different input signals. The success of this identification depends highly on the input signal. For this purpose, we design a multisinusoidal input signal to excite the plant. We excite chosen frequencies within specified limits and perform system identification. The experimental time and the time constants of our system dictate these limits. Preliminary results show moderate but noticeable excitation of the system, with the quality evaluated by the coherence function. This function provides quantitative assessment of the excitation on a 0 to 1 scale.

[1] Griener et al. Rev. Sci. Instrum. 88, 033509 (2017)

P 11: Laser Plasmas

Time: Wednesday 11:00–12:15 Location: ZHG102

Invited Talk P 11.1 Wed 11:00 ZHG102

Ab initio path integral Monte Carlo simulation of warm dense matter — •Tobias Dornheim — Center for Advanced Systems Understanding (CASUS), Görlitz, Germany — Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Dresden, Germany

Understanding matter at extreme densities, temperatures and pressures is important for the modeling of astrophysical objects (e.g. giant planet interiors) and technological applications (most notably inertial confinement fusion) alike. Yet, the intricate interplay of effects such as Coulomb coupling, quantum degeneracy, and strong thermal excitations renders the rigorous theoretical description of such warm dense matter (WDM) challenging.

Here, I present an overview of a number of recent developments in the ab initio path integral Monte Carlo (PIMC) simulation of WDM. While being computationally demanding, PIMC is exact within the given error bars and, thus, constitutes a valuable benchmark for computationally more efficient but potentially less accurate methods such as density functional theory (DFT). Moreover, these simulations open up new avenues for the interpretation of X-ray Thomson scattering (XRTS) measurements, which is a key method of diagnostics for experiments with extreme states of matter. As a practical example, we consider a recent XRTS experiment on strongly compressed beryllium carried out at the National Ignition Facility (NIF) in Livermore, for which we find a significantly lower density based on both ab initio PIMC and DFT simulations compared to previously used chemical models and radiation hydrodynamics calculations.

P 11.2 Wed 11:30 ZHG102

Utilization of quasi-neutral plasma to enhance coherent light emission in free electron lasers — •Cagri Erciyes, Matteo Tamburini, and Christoph H. Keitel — Max Planck Institute for Nuclear Physics, Heidelberg

The behavior of relativistic quasi-neutral plasma and the corresponding enhancement of coherent light emission are investigated by examining the free electron laser (FEL) setup. A key characteristic of the lasing mechanism in FELs is microbunching, which leads to the concentration of beam charges into slices shorter than the radiation wavelength, thereby enhancing coherent radiation. We investigate microbunching and coherent emission in FELs when quasi-neutral beams (either electron/positron or electron/proton) rather than a pure-electron bunch are utilized. The possibility of denser beams is expected to lead to an enhancement of power gain via the microbunching mechanism. Due to the sensitivity of the lasing process to initial conditions, both Self-Amplified Spontaneous Emission (startup from shot noise) and seed laser mechanisms are explored.

P 11.3 Wed 11:45 ZHG102

The 40 mJ, kHz front-end and pre-amplifier of the KALDERA drive laser for plasma-acceleration — •Cora Braun[1,2], Caterina Vidoli[1], Juan B. Gonzalez-Diaz[1], Christian Werle[1], Timo Eichner[1], Thomas Hülsenbusch[1], Lutz Winkelmann[1], Guido Palmer[1], and Andreas R. Maier[1] — [1]Deutsches Elektronen Synchrotron DESY, Hamburg, Germany — [2]Institute for Experimental Physics, University of Hamburg, Hamburg, Germany

Scaling the repetition rate of laser-plasma accelerators from a few Hz towards the kHz range is a crucial step to enable future applications like free-electron lasers or direct synchrotron-injection. Moreover, a laser high-repetition rate enables

active stabilization of crucial laser parameters which will support sub-percent energy spread and energy stability from the plasma accelerator. The KALDERA laser system at DESY will drive such a high repetition rate laser-plasma accelerator. The setup and commissioning of the first project phase, aiming for 100 Hz, 0.5 J, <30 fs pulses, is currently being completed. In this contribution the layout and performance of the in-house developed KALDERA kHz front-end and its subsequent cryogenic kHz-Ti:Sa pre-amplifier will be presented. We report on the performance of the individual subsystems and how they are interfaced to generate 40 mJ of pulse energy with sub-percent stability.

P 11.4 Wed 12:00 ZHG102

Towards studying the collective effects of laser driven ion acceleration. — •Erin G. Fitzpatrick, Laura D. Geulig, Maximlian J. Weiser, Runjia Guo, and Peter G. Thirolf — Ludwig-Maximilian-University

The ultra-high ion bunch density offered from laser-driven ion acceler- ation may affect the stopping behavior in matter via collective effects and ultimately enable to establish new nuclear reaction schemes like the 'fission-fusion' mechanism, aiming to generate extremely neutron- rich isotopes near N=126 [1]. One prerequisite needed for the realiza- tion of this mechanism is laser driven heavy ions with extremely high bunch densities(10^{22}-10^{23} cm^{-3})[1]. Experimental campaigns at different PW class lasers resulted in the acceleration of gold ions with bunch densities of about 10^{13} cm^{-3} (10^{16} cm^{-3}) at 1mm (100 μm) from the target [2]. At the Center for Advanced Laser Applications (CALA) we are working towards measuring collective effects in laser-driven ion bunches, like a potential reduction in stopping power. First experiments focused on proton bunch energy deposition in stopping materials downstream (0.1mm) from the ion source and demonstrated that we must consider shot-to-shot fluctuations of the ion bunch properties and damage caused to the stopping material through transmitted laser energy. An overview of the current results and developing experimental design is given.

[1] D. Habs et al., Appl. Phys. B 103, 471-484 (2011)
[2] F.H. Lindner et al., Sci. Rep. 12, 4784 (2022)

P 12: Complex Plasmas and Dusty Plasmas I

Time: Wednesday 11:00–12:15 Location: ZHG006

Invited Talk P 12.1 Wed 11:00 ZHG006

Using dusty plasmas to measure low-electron sticking coefficients of dielectric materials — •Armin Mengel[1], Isabel König[1], Lorin S. Matthews[2], Franz X. Bronold[4], and Franko Greiner[1,3] — [1]Institute of Experimental and Applied Physics, Kiel University, Germany — [2]Center for Astrophysics, Space Physics, and Engineering Research, Baylor University, Waco, TX, USA — [3]Kiel Nano, Surface and Interface Science KiNSIS, Kiel University, Germany — [4]Institut für Physik, Universität Greifswald, Greifswald, Deutschland

Low-energy electron sticking coefficients are of high technological interest, even though their measurement proves challenging using conventional means. Precision measurements using single dust particles confined in a low-pressure plasma have now been utilized to quantitatively determine the low-energy electron sticking coefficient of silica. The results show that dielectric and metallic surfaces in a plasma differ in charge substantially. To apply this promising measurement scheme to a broader range of materials, charging models for non-spherical particles are needed in place of the spherical capacitor model used for spherical particles. Measurements and simulations of sphere aggregates are compared against the smallest enclosing sphere (SES) model and the orientation averaged equivalent sphere (OAES) model, as well as the numerically calculated capacitance, allowing to extend the sticking measurements to non-spherical grains of dielectrics.

P 12.2 Wed 11:30 ZHG006

Measuring Diffusion in Dusty Plasma Using Differential Dynamic Microscopy — •Yang Liu and Dietmar Block — IEAP, Christian-Albrechts-Universität, D-24098 Kiel, Germany

Differential Dynamic Microscopy (DDM) is an emerging Fourier-space-based measurement technique that extracts dynamic information similarly to light scattering, combining the sensitivity of scattering with the direct visualization advantages of microscopy [1]. In this study, we propose a new method for measuring diffusion in dusty plasma using DDM. We assume that particles interact via a screened Coulomb potential and generate a series of images that allow to extract the particle motion and to quantify the accuracy and effectiveness of DDM analysis. The particle dynamics are obtained from Langevin dynamic simulation [2, 3]. The results show that, due to the micro frictional damping arising from a neutral gas background, the effects of hydrodynamic interactions (HIs) between multiple particles can be neglected. This study extends the applicability of the DDM method to Yukawa systems, thereby enabling accurate characterization of the diffusion behavior of strongly interacting particles.

References [1] R. Cerbino and V. Trappe, Phys. Rev. Lett. 100, 188102 (2008). [2] M. Gu, Y. Luo, Y. He, M. E. Helgeson, and M. T. Valentine, Phys. Rev. E 104, 034610 (2021). [3] Y. Liu and D. Block, Phys. Plasmas 31, 103701 (2024).

P 12.3 Wed 11:45 ZHG006

Bow shock formation in a dusty plasma flowing around an obstacle under microgravity — •Stefan Schütt, Christina Knapek, Daniel Maier, Daniel Mohr, and André Melzer — University of Greifswald, Greifswald, Germany

Dust flows around an obstacle in three-dimensionally extended dust clouds have been investigated on parabolic flights. As the obstacle, a tungsten wire has been installed in the midplane between the electrodes of a parallel plate radio-frequency discharge. A periodic dust motion was generated by superimposing a low-frequency modulation on the electrodes, shifting the dust cloud between the electrodes. Due to the periodic nature of the dust motion, several shocks could be observed at varying dust densities. When the dust flow was transonic or supersonic, bow shocks were formed upstream of the wire and propagated away from it at a constant speed. However, at the dust densities needed for the shock formation, dust-density waves also occurred and the two phenomena often intermingled. The role of the streaming ions in driving the shock is therefore discussed. At carefully chosen parameters, it was possible to observe only the bow shock while suppressing the waves. It is reasoned that the shock is excited independently from dust-density waves by a density increase upstream of the obstacle.

This work was supported by DLR grants 50WM1962 and 50WM2161.

P 12.4 Wed 12:00 ZHG006

Investigation of dust density waves in binary systems — •Natascha Blosczyk and Dietmar Block — Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany

The wave dynamics in monodisperse dusty plasmas are quite well understood. Theoretical predictions of dispersion relations have been verified in a number of experiments with self-excited or driven waves. For binary systems the situation is different. In general the wave properties will depend on the system properties like mixing ratio, charge ratios and local order. In this work an approach to evaluate the wave dynamics is presented for binary systems in experiments. The waves are driven with a laser manipulation system which launches plane wave fronts into the binary system. The measured system response in terms of particle trajectories is analyzed with the so-called Hilbert-transform which allows to measure with spatial resolution the wave frequency and wave number. This allows us to investigate the wave dispersion in these binary systems. Further, we are able to test whether the local particle arrangement affects the wave propagation. This contribution will show typical results and discuss prospects and limitations of this approach.

P 13: Members' Assembly

Time: Wednesday 12:20–13:20 Location: ZHG102

All members of the Plasma Physics Division are invited to participate.

P 14: Atmospheric Plasmas and their Applications IV

Time: Wednesday 13:45–15:30 Location: ZHG006

Invited Talk P 14.1 Wed 13:45 ZHG006

Carbon Dioxide Splitting in Dielectric Barrier Discharges: Power Dissipation and Plasma Chemistry — •Ronny Brandenburg[1,2], Milko Schiorlin[1], and Volker Brüser[1] — [1]Leibniz-Institut für Plasmaforschung und Technologie e.V., Greifs-wald — [2]Universität Rostock, Institut für Physik

The conversion of carbon dioxide to carbon monoxide (CO), oxygen and ozone in planar volume dielectric barrier discharges (DBDs) is studied. The type of the electrodes, the barrier material, the barrier thickness, the discharge gap, the flow rate, the high voltage frequency and amplitude as well as the electrode area are varied systematically. Power dissipation is studied by voltage-charge plots based on an adapted equivalent circuit and the Manley-equation for discharge power is generalized for the occurrence of parasitic capacitances and so-called partial surface discharging. The energy yield of CO (EY) results in similar values of about 25 g/kWh in pure carbon dioxide within the specific input energy (SIE) range 20 - 2000 J/L, independent on the above mentioned parameters. SIE higher than 3000 J/L yield a slightly lower EY. A comparison with various other DBD-reactors is done and the role of SIE as a scaling parameter is discussed. Funded by German Federal Ministry of Education and Research (BMBF) and European Union NextGenerationEU under grant 033RC030D.

P 14.2 Wed 14:15 ZHG006

Multi-PMT System and 0-D Chemical Modeling for Analyzing Atomic Oxygen Production in Micro Cavity Plasma Arrays — •Henrik van Impel, David Steuer, Volker Schulz-von der Gathen, Marc Böke, and Judith Golda — PIP & EP2, Ruhr-University Bochum, D-44801 Bochum

Dielectric barrier discharges (DBDs) have numerous applications, including ozone generation and the treatment of volatile organic compounds, which can be further enhanced by integrating catalysts. Understanding the underlying processes requires fundamental knowledge about the generation of reactive species. In this study, we investigated atomic oxygen production within a micro cavity plasma array, a customized surface DBD confined to micrometer-sized cavities. Using optical emission spectroscopy, we analyzed the plasma chemical processes. The discharge was operated in helium with a 0.25% molecular oxygen admixture at atmospheric pressure, using a 15kHz 600V triangular excitation voltage. High dissociation degrees were observed with helium state enhanced actinometry (SEA). Utilizing a multi-photomultiplier system proved effective for monitoring the discharge, especially following the temporal evolution of the atomic oxygen density or dissociation degree, making it highly suitable for industrial applications. To further confirm the consistency of the measurements, we developed a simple 0-dimensional chemical model.

The project is funded within project A6 of the SFB 1316.

P 14.3 Wed 14:30 ZHG006

In situ XRD and XAS at Plasma Treatment of Ce(IV)-O-Clusters and Ce(IV)-MOFs — •Alexander Quack[1], Diletta Morelli Venturi[2], Hauke Rohr[2], Tim Graupner[2], Anastasia Molokova[3], Kirill Lomachenko[3], Kerstin Sgonina[1], Malte Behrens[2,4], Norbert Stock[2,4], and Jan Benedikt[1,4] — [1]Institute of Experimental and Applied Physics, Kiel University — [2]Institute of Inorganic Chemistry, Kiel University — [3]European Synchrotron Radiation Facility (ESRF), Grenoble — [4]Kiel Nano, Surface and Interface Science (KINSIS), Kiel University

The utilization of non-thermal atmospheric pressure plasmas, to supplement the existing chemical industry by using access renewable resources, allows for the potential usage of less heat resilient catalysts like metal-organic-frameworks (MOFs). While some MOFs are observed to be stable, while other MOFs are not, the exact processes of decomposition of the MOFs has not directly been investigated.

We have developed a dielectric barrier reactor with an open optical axis to allow for in situ x-ray analysis of material within the plasma. The plasma operates with H_2 gas combined with Ar or CO_2 at 20 kHz at 10-15 kV_{pp} and can be externally heated up to 200 °C. This design was employed during the beam-time of CH-7281 at BM-23 at the European Synchrotron Radiation Facility (ESRF) to treat clusters and MOFs containing cerium. The chemical stability of these compounds was analyzed using in situ x-ray diffraction (XRD) and x-ray absorption spectroscopy (XAS).

Invited Talk P 14.4 Wed 14:45 ZHG006

Insights into Mode Transitions and Reactive Species Densities in a Micro Cavity Plasma Array — •David Steuer[1], Henrik van Impel[1], Volker Schulz-von der Gathen[2], Marc Böke[2], and Judith Golda[1] — [1]Plasma Interface Physics, Ruhr-University Bochum, D-44801 Bochum, Germany — [2]Experimental Physics II: Physics of Reactive Plasmas, Ruhr-University Bochum, D-44801 Bochum, Germany

Micro-cavity plasma arrays are promising for plasma-catalytic research due to their ability to ignite plasma in direct contact with catalytic surfaces. A critical aspect of their application lies in the generation of reactive species within the cavities. He/O2 systems are ideal for studying these species, offering reduced complexity while oxygen plays a crucial role in oxidizing target gases or activating surfaces. Optical emission spectroscopy measures O-densities within the cavities, while laser-based methods analyze areas outside the discharge. A diffusion model connects these regions, revealing that atomic oxygen is generated exclusively inside the cavities, with dissociation degrees close to 100%. Transport out of the cavities is governed by diffusion and ozone formation. Varying oxygen admixtures reveals a shift from a homogeneous glow discharge (<1%) to a filamentary discharge at higher oxygen concentrations. This transition, evident in parameters as current, power, and electric field, significantly impacts conversion efficiency. Fine-tuning of the discharge mode provides a pathway to enhance plasma-catalytic performance. This work is supported by DFG within SFB1316 (A6).

P 14.5 Wed 15:15 ZHG006

The Impact of Electrohydrodynamic Forces on Vortex Formation and Flow Behavior in sDBD Systems — •Dominik Filla[1], Alexander Böddecker[1], Mate Vass[1], Ihor Korolov[1], Thomas Mussenbrock[1], and Sebastian Wilczek[2,3] — [1]Department of Electrical Engineering and Information Science, Ruhr-University Bochum, D-44780, Bochum, Germany — [2]TH Georg Agricola University, D-44787, Bochum, Germany — [3]enaDyne GmbH, D-04103, Leipzig, Germany

The efficient conversion of greenhouse gases and volatile organic compounds (VOCs) remains a significant challenge for environmental sustainability and innovative chemical processes. Surface dielectric barrier discharges (sDBDs) driven by nanosecond pulses offer a promising approach to address these challenges by leveraging the complex interplay between discharge and fluid dynamics. This study investigates the coupling between electrohydrodynamic (EHD) forces induced by positive and negative streamers and gas flow in He/N_2 sDBD systems. Using 2D plasma-fluid simulations, we evaluate the impact of EHD forces on vortex formation and flow behavior. Numerical results reveal that streamers produce localized EHD forces, subsequently driving flow dynamics and shaping overall gas flow patterns in the system. The simulations show high qualitative agreement with experimental data, including particle image velocimetry and schlieren measurements. This work highlights the potential of plasma-assisted flow control to advance the understanding and optimization of gas flow processes in dielectric barrier discharge systems. Supported by the DFG via SFB 1316.

P 15: Astrophysical Plasmas

Time: Wednesday 16:15–17:45 Location: ZHG102

P 15.1 Wed 16:15 ZHG102

Can a Compressible Jet Sustain Significant Turbulence in a (Magnetized) Turbulent Environment? — •David Kube[1], Gabriele Camerlengo[2], Wolf-Christian Müller[1,3], and Jörn Sesterhenn[2] — [1]Centre of Astronomy and Astrophysics, Technische Universität Berlin — [2]Chair of Applied Mechanics and Fluid Mechanics, Universität Bayreuth — [3]Max-Planck/Princeton Center for Plasma Physics

The interaction of turbulence and jets is ubiquitous throughout the universe. A particularly intriguing example is the supersonically turbulent ISM, where the underlying driving mechanisms for turbulence remain insufficiently understood. Protostellar jets are promising candidates, as they are seen to impact the interstellar gas dynamics on parsec scales. Therefore, we aim to investigate the universal characteristics of jet-turbulence interactions using a simplified setup to identify fundamental mechanisms of potential importance for more complex configurations like star and structure formation. To address if a compressible jet can sustain turbulence in a decaying turbulent medium, we perform DNS of a jet impacting a turbulent cloud covering various combinations of the jet Mach number M_j and the RMS Mach number of the cloud $M_{t,\mathrm{rms}}$. Furthermore, the influence of the magnetic field is assessed by comparing results from MHD simulations with those obtained by solving the compressible Navier-Stokes equations.

In this talk, we discuss the numerical setup being used in the study and show first results demonstrating that for specific combinations of M_j and $M_{t,\mathrm{rms}}$, notable interaction between the jet and the cloud occurs.

P 15.2 Wed 16:30 ZHG102

Nonmetal-to-metal transition in liquid hydrogen using density functional theory and the HSE XC functional — Armin Bergermann, Lucas Kleindienst, and •Ronald Redmer — Institut für Physik, Universität Rostock, D-18051 Rostock

We investigate the first-order liquid-liquid phase transition in fluid hydrogen, which is accompanied by a nonmetal-to-metal transition. We use a combination of density functional theory for the electrons and molecular dynamics simulations for the ions. By employing the nonlocal Heyd-Scuseria-Ernzerhof (HSE) exchange-correlation functional, we accurately determine the equation of state and the corresponding coexistence line. Additionally, we calculate the electrical conductivity using the Kubo-Greenwood formula and find jumps in the coexisting region, which is characteristic of a first-order transition. Our new predictions are compared with previous theoretical results and available experimental data [1]. Thereby, we find that the strongly constrained and appropriately normed (SCAN) exchange-correlation functional provides an excellent balance between computational cost and accuracy. [1] A. Bergermann, L. Kleindienst, R. Redmer, J. Chem. Phys. (accepted).

P 15.3 Wed 16:45 ZHG102

Marginal Role of the Electrostatic Instability in the GeV Scale Cascade Flux from 1ES 0229+200 — •Martin Pohl[1,2] and Mahmoud Alawashra[1] — [1]Deutsches Elektronen-Synchrotron DESY, Platanenallee 6, 15738 Zeuthen, Germany — [2]Institute for Physics and Astronomy, University of Potsdam, D-14476 Potsdam, Germany

TeV gamma rays from blazars spawn relativistic pair beams that should generate detectable GeV-scale cascade emission, yet this component is absent in the observed spectra of some blazars. One interpretation is the deflection of the electron-positron pairs by a weak intergalactic magnetic field. Alternatively, electrostatic beam-plasma instabilities could drain the beam energy before the pairs produce the cascade emission. Recent studies suggest that particle scattering is the primary feedback of these plasma instabilities, rather than energy loss. In this work, we quantitatively assess the arrival time of secondary gamma rays at Earth as a function of the beam scattering by the electrostatic instability. Our findings reveal that the time delay of the GeV secondary cascade arrival due to instability broadening is on the order of a few months, which is insufficient to account for the missing cascade emission in blazar spectra. In this study, we have not yet included linear Landau damping of the plasma oscillations caused by the MeV-band cosmic-ray electrons. The impact of this damping on the nonlinear evolution of the beam-plasma system will be studied in future work.

P 15.4 Wed 17:00 ZHG102

Particle acceleration at oblique high-Mach-Number shocks propagating in a turbulent medium — •Eloise Moore[1], Karol Fulat[2], Michelle Tsirou[3], and Martin Pohl[1,3] — [1]Institute of Physics and Astronomy, University of Potsdam, D-14476 Potsdam, Germany — [2]Department of Astronomy, University of Wisconsin-Madison, Madison, WI 53706, USA — [3]DESY, Platanenallee 6, 15738 Zeuthen, Germany

Astrophysical collisionless shocks are efficient particle accelerators, however, some pre-acceleration mechanism is needed for electrons to participate in diffusive shock acceleration. We investigate how pre-existing turbulence could modify the shock structure, plasma instabilities, and ultimately particle acceleration. The particle-in-cell (PIC) method provides a kinetic description of a system from first principles of collisionless plasma. Using the PIC code THATMPI, we performed novel simulations of oblique non-relativistic high-Mach-number shocks propagating into an upstream with pre-existing turbulence. We consider decaying compressive turbulence with density fluctuations of amplitude around 15%, consistent with measurements of the local interstellar medium. We find that the turbulence was able to modify the properties of the shock-reflected electrons that drive plasma instabilities ahead of the shock front. While we find that the energy spectrum of the downstream electrons shows a non-thermal tail for both homogeneous and turbulent simulated environments, the latter indicates more efficient electron acceleration. We conclude that the presence of turbulence plays a key role in the pre-acceleration mechanisms at play.

P 15.5 Wed 17:15 ZHG102

Measuring the Free-Free Opacity of Hydrogen at Stellar Interior Conditions Using the National Ignition Facility — •Samuel Schumacher[1], Julian Lütgert[1], Ronald Redmer[1], Mandy Bethkenhagen[8], Laurent Masse[7], Dirk Gericke[2], Siegfried Glenzer[5], Tilo Döppner[6], Tina Ebert[6], Gareth Hall[6], Otto Landen[6], Markus Schölmerich[6], Charles Starrett[3], Nathaniel Shaffer[4], Laurent Divol[6], Benjamin Bachmann[6], Steve MacLaren[6], Clement Trosseille[6], Shahab Khan[6], and Dominik Kraus[1] — [1]Universität Rostock — [2]Warwick University — [3]Los Alamos National Laboratory — [4]University of Rochester — [5]SLAC — [6]Lawrence Livermore National Laboratory — [7]CEA — [8]Université Lyon

The opacity of stellar matter is critical for modeling stellar interiors, primarily composed of hydrogen and helium. It determines where convection becomes the dominant energy transport mechanism.

Stellar interior modeling is challenging due to dense plasma conditions, with temperatures of hundreds of eV and densities 800 times that of solid matter. These conditions pose significant computational challenges and remain largely unexplored experimentally.

To address this, we conducted the first hydrogen absorption experiments at stellar interior conditions at the National Ignition Facility, the only facility capable of reproducing such extreme states. We present a modeling approach avoiding costly hydrodynamic simulations and enabling rigorous uncertainty estimates of our measurement through Bayesian analysis.

P 15.6 Wed 17:30 ZHG102

Stereoscopic observations reveal coherent morphology and evolution of solar coronal loops — •B. Ram[1], L. P. Chitta[1], S. Mandal[1], H. Peter[1], and F. Plaschke[2] — [1]Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany — [2]Institut für Geophysik und extraterrestrische Physik, Technische Universität Braunschweig, Braunschweig, Germany

Coronal loops are bright, arched structures of magnetically confined, million-Kelvin plasma in the solar corona. The mechanisms responsible for heating these loops remain poorly understood. Investigation of the three-dimensional spatial morphology and temporal evolution of coronal loops will offer better insights into the underlying heating mechanisms. Some studies suggest that coronal loops may be optical illusions, resembling veils created by folds in two-dimensional sheets of plasma. Stereoscopic observations are, therefore, crucial to clarify their true morphology. We used high-resolution observations from the Extreme Ultraviolet Imager (EUI) on the Solar Orbiter and the Atmospheric Imaging Assembly (AIA) on the Solar Dynamics Observatory to stereoscopically analyse coronal loops in an active region. Our analysis reveals that the loops exhibit nearly circular cross-sectional widths and consistent intensity variations along their lengths over a timescale of 30 minutes. These findings suggest that coronal loops are three-dimensional coherent plasma bundles that outline magnetic field lines indicating nanoflare heating rather than emissions caused by randomly aligned wrinkles in two-dimensional plasma sheets along the line of sight, as proposed by the 'coronal veil' hypothesis.

P 16: Complex Plasmas and Dusty Plasmas II

Time: Wednesday 16:15–17:30 Location: ZHG006

P 16.1 Wed 16:15 ZHG006

Plasma surface interaction at objects at floating potential — •Dietmar Block and Sören Wohlfahrt — IEAP der CAU Kiel, Leibnizstr. 15, 24118 Kiel

A plasma as an ionized gas has markedly different properties than a normal gas. Especially the free electrons and ions can be used to trigger and enhance chemical reactions. Therefore, low-temperature plasmas are a working horse of material processing. From etching via deposition to catalytic reactions a huge variety of processes are subject of research or already used in applications. For most of them the plasma surface interaction is strongly influenced by the plasma sheath region, which has significantly different properties than the plasma bulk region. To study the chemical processes in such plasmas is not trivial. The standard approach uses ex-situ diagnostics, i.e. the treated surface is extracted from the plasma device and transferred to a diagnostic device. This approach has some limitations: the surface might change during this process and to resolve the chemical processes temporally is difficult. However, for spherical dust grains it is possible to realize an in-situ Mie-scattering diagnostic which is powerful enough to give detailed information on chemical reaction at the surface and surface modifications. Starting with a brief introduction of the diagnostic itself, this contribution will discuss the surface modification observed in-situ.

P 16.2 Wed 16:30 ZHG006

Dust acoustic wave properties in varying discharge volumes — •Christina A. Knapek[1,2], Mierk Schwabe[2,3], Victoriya Yaroshenko[2,4], Peter Huber[2], Daniel P. Mohr[1,2,3], and Uwe Konopka[5] — [1]Institute of Physics, University of Greifswald, 17489 Greifswald, Germany — [2]Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt, 51147 Köln, Germany — [3]Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institut für Physik der Atmosphäre, 82234 Oberpfaffenhofen, Germany — [4]Institut für

Solar-Terrestrische Physik, Deutsches Zentrum für Luft- und Raumfahrt, 17235 Neustrelitz, Germany — [5]Physics Department, Auburn University, Auburn, Alabama 36849, USA

Properties of self-excited dust acoustic waves under the influence of active compression of the dust particle system were experimentally studied in the laboratory and under microgravity conditions (parabolic flight). Ground based laboratory experiments clearly show that wave properties can be manipulated by changing the discharge volume, its aspect ratio, and thus the dust particle density. Complementary experiments under microgravity conditions, performed to exclude the effects of gravity inflicted sedimentation and anisotropic behavior, were less conclusive due to residual fluctuations in the planes acceleration indicating the need for a better microgravity environment. A theoretical model, using plasma parameters obtained from particle-in-cell simulations as input, supports the experimental findings. It shows that the waves can be described as a new observation of the dust acoustic mode, which demonstrates their generic character.

P 16.3 Wed 16:45 ZHG006

Electron sticking coefficients of dusty plasma relevant materials — •Franko Greiner, Isabel König, and Armin Mengel — Institute of Experimental and Applied Physics, Kiel University, 24118 Kiel, Germany

A relative measurement approach [1] was employed to determine the low-energy sticking coefficient $\bar{s}$ of dielectric materials frequently utilized in "dust in plasma" research, including silica, melamine formaldehyde (MF), and polymethyl methacrylate (PMMA). The new $\bar{s}$ values offer valuable insights for analyzing experiments involving different materials or their mixtures, facilitating more accurate comparisons and improved experimental design. Additionally, more precise values of $\bar{s}$ are necessary to enhance the simulation of discharge systems with dielectric electrodes.

[1] A. Mengel et al. PRL 2024,
https://doi.org/10.1103/PhysRevLett.133.185301

P 16.4 Wed 17:00 ZHG006

Three-dimensional FTLE analysis of fluid dusty plasmas under weightlessness — •Andre Melzer, Christina Knapek, Daniel Maier, Daniel Mohr, and Stefan Schütt — Institute of Physics, University of Greifswald

We have performed experiments on dusty plasmas under the weightlessness conditions of parabolic flights where the dust particles form an extended homogeneous dust cloud. The particle trajectories have been recorded using a four-camera stereoscopic camera system. From that, the three-dimensional particle trajectories have been determined using both a machine-learning particle reconstruction technique and the deterministic shake-the-box algorithm. From the trajectories, fluid parameters, flow fields and finite-time Lyapunov exponent (FTLE)-based fluid structures have been calculated and analyzed. The FTLE analysis indicates that the fluid behavior changes during the course of the parabola. Furthermore, it is demonstrated that the machine-learning based approach allows to reliably characterize the dynamic states by comparison with the shake-the-box algorithm.

P 16.5 Wed 17:15 ZHG006

Modern imaging polarimetry as diagnostics for plasma-grown nanoparticles: Challenges and first results — •Alexander Schmitz, Andreas Petersen, and Franko Greiner — IEAP, Kiel University, Kiel, Germany

Full-Stokes Mie polarimetry is an established diagnostic technique for plasma-grown nanoparticles. It enables the in situ measurement and monitoring of the particle size and complex refractive index. Both parameters are also essential for other diagnostics, such as dust density measurements via extinction. Expanding prior 1D measuring techniques to an imaging polarimeter system presents a number of challenges, such as precise alignment and impurities and aberrations in commercially available polarization optics.

To solve this, a calibration method based on the null-space method for the device's transfer matrix has been applied to a new high-resolution, imaging polarimeter. First 2D polarisation measurements on a dust cloud have been conducted and the spatial and temporal evolution of the particle size evaluated.

P 17: Poster Session II

Time: Wednesday 16:15–18:15 Location: ZHG Foyer 1. OG

P 17.1 Wed 16:15 ZHG Foyer 1. OG

Assessing the validity of simplified models to describe the island divertor — •Nassim Maaziz, Felix Reimold, Vicoria Winters, David Bold, Sergei Makarov, Yühe Feng, and The W7-X Team — Max Planck Institute for Plasma Physics, 17491 Greifswald

In a nuclear fusion reactor power and particle exhaust is crucial. In stellarators the island divertor concept has been proposed as an exhaust solution. In essence a resonant component of the magnetic field creates a chain of magnetic islands around the core. These islands divert heat and particles towards the material interface. This concept is utilized in the W7-X stellarator and shows promising performance [1]. However, particle exhaust is less efficient in stellarators than in tokamaks. Increasing the plasma density at the target (plasma-surface-interaction zone) is required to improve it. The density in the divertor depends on the particle, energy, and momentum transport. Understanding the transport in the 3D island divertor is challenging. Hence, simplified models have been developed to describe the island divertor. This work assesses the validity of a simplified model: the stellarator two-point model [2]. Model predictions are compared to simulations of an island divertor geometry performed with the 3D self-consistent fluid code EMC3- EIRENE. Past comparisons claim that the simplified model is able to describe EMC3-EIRENE simulations [3], but our results indicate that the applied simplifications are not valid. In particular, we have identified that momentum losses are more complex, and that parallel heat convection and explicit particle sources cannot be neglected. [1]NF611060032021 [2]NF468072006 [3]PPCF530240092011

P 17.2 Wed 16:15 ZHG Foyer 1. OG

Implementation and exploitation of new bolometer electronics at ASDEX Upgrade — •Alessandro Mancini and Matthias Bernert — Max Planck Institute for Plasma Physics, Garching, Germany

Bolometry is a diagnostic technique employed in magnetic confinement nuclear fusion machines, like tokamaks and stellarators. It measures the full electromagnetic power (visible to soft X rays, without spectral information) radiated by fusion plasmas. This measure is essential for the global power balance of a fusion reactor. Foil ('resistive') bolometers are a type of bolometer which use thin metallic foils that heat up upon radiation absorption. The foils are connected to resistors, arranged as Wheatstone bridge, whose electrical resistance varies according to their temperature. The bolometer cameras are connected to an electronic system that provides an excitation voltage waveform and measures the bridges response voltage, from which the incident radiation power can be inferred. An amplitude demodulation algorithm is used to obtain the real time incident power. So far only a square waveform has been used for the ASDEX Upgrade foil bolometers. New electronics have been designed at ASDEX Upgrade, capable of driving different excitation waveforms. With this contribution an amplitude demodulation technique for sinusoidal waveforms, which is implemented on an FPGA, is presented, with the goal of improving the signal quality and time resolution of foil bolometers. The new system has been tested in the laboratory and in the current ASDEX Upgrade experimental campaign.

P 17.3 Wed 16:15 ZHG Foyer 1. OG

3D nonlinear MHD simulations with kinetic neutrals and impurities — •Mate Szucs[1], Matthias Hoelzl[1], Andrés Cathey[1], Yu-Chih Liang[1], and Sven Q. Korving[2] — [1]Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching b. M., Germany — [2]ITER Organization, 13067 St. Paul Lez Durance Cedex, France

In reactor-scale tokamaks like ITER, both transient and stationary heat and particle fluxes pose significant threats to plasma-facing components and the safe operation of the machine. Stationary fluxes can be mitigated by "detaching" the divertor using neutral or impurity atoms, which effectively act as a neutral cushion. This detached state can be disrupted by transient heat fluxes originating from MHD edge instabilities, such as type-I or even small ELM, a phenomenon known as burn-through. Therefore, predicting such transients under realistic scrape-off layer (SOL) conditions, which enable the modeling of detachment, is crucial.

The JOREK nonlinear MHD code is routinely used to predict large and small ELM regimes, among other phenomena. The base fluid model has been coupled with kinetic neutral and impurity extensions, allowing for the simultaneous simulation of transient MHD and SOL processes. In this contribution, the first 3D simulations of small ELM burn-through and X-point Radiator Regime (XPR) are presented.

P 17.4 Wed 16:15 ZHG Foyer 1. OG

Towards Modeling Pellet-Produced Plasmoid Dynamics in Stellarators with JOREK — •Carl Wilhelm Rogge[1], Ksenia Aleynikova[1], Pavel Aleynikov[1], Rohan Ramasamy[2], Matthias Hoelzl[2], and Nikita Nikulsin[3] — [1]Max-Planck-Institut, 17491 Greifswald, Germany — [2]Max-Planck-Institut, 85748 Garching, Germany — [3]Dept. of Astrophysical Sciences, Princeton University

Pellet injection will be vital for refueling future tokamak and stellarator reactors. While pellet plasmoid physics has been extensively studied in tokamak magnetic

geometries, understanding it in stellarator geometries remains less comprehensive. In particular, the non-axisymmetry of the equilibrium field in stellarators increases the complexity of numerical analysis.

However, recent advancements in the stellarator extension [Nikulsin 2022] of the JOREK non-linear 3D MHD code, which employs a reduced MHD model for stellarator geometry, show significant promise in addressing this challenge. Consequently, this project aims to leverage JOREK to deepen the understanding of pellet plasmoid dynamics, with a particular focus on perpendicular drifts in stellarators.

We benchmark computed plasmoid dynamics with the expected analytical solutions [Aleynikov 2019, 2024]. A good agreement is demonstrated when the plasmoid expands predominately along the field line using an appropriate heating model. Different heating models for the pellet-plasmoid are implemented in JOREK and compared.

P 17.5 Wed 16:15 ZHG Foyer 1. OG

A novel optimization approach for stellarator design — •Issra Ali, Alan Goodman, and Ryan Wu — Max-Planck-Institut für Plasmaphysik, Greifswald, Germany

Stellarators are a class of fusion reactor candidates which confine a hot plasma in a toroidal shape using powerful magnetic fields. One of stellarators' great strengths is their vast design space, which offers incredible flexibility in their physical properties. This flexibility is exploited via numerical optimization to carefully mold magnetic field geometries and corresponding coil designs to maximize confinement quality.

Gradient-based optimization methods are the industry standard for stellarator and coil optimization problems, and have recently proven effective in finding reactor-relevant stellarator designs. However, these problems are often multimodal and highly sensitive to initial conditions, meaning that gradient-based methods are at best unlikely to find global minima, and at worst unable to converge altogether without careful selection of initial conditions and optimizer hyperparameters. Global optimization methods, such as Bayesian Optimization, may offer a better way to explore the entire parameter space, but tend to scale poorly to high-dimensional problems such as stellarator optimization. Moreover, they do not exploit gradient information, which is a powerful tool in high-dimensional optimization spaces. In this work, we present a novel global optimization method that seeks global optima while still being guided by gradients.

P 17.6 Wed 16:15 ZHG Foyer 1. OG

Plasma termination studies in LHD and W7-X — •Hjördis Bouvain[1], Andreas Dinklage[1], Naoki Tamura[1], Hiroe Igami[2], Hiroshi Kasahara[2], Kieran McCarthy[3], Daniel Medina-Roque[3], Wendelstein 7-X Team[1], and LHD Experiment Team[2] — [1]Max Planck Institute for Plasma Physics, Greifswald, Germany — [2]National Institute for Fusion Science, Toki, Japan — [3]Laboratorio Nacional de Fusion, CIEMAT, Madrid, Spain

Control of potentially occurring plasma terminating events is crucial for safe operation of large fusion devices. In tokamaks, disruptions, caused by current driven instabilities, lead to rapid loss of stored kinetic and magnetic energy. Stellarators, however, are more resilient since the poloidal field is generated from external coils, avoiding the loss of magnetic energy. Thermal quenches, due to large impurity influxes, are barely investigated in stellarators. These can cause significant damage to the wall material if the heat loads exceed a critical threshold, making the development of mitigation measures necessary. Intentional injection of large amounts of tungsten impurities via TESPEL in LHD and W7-X plasmas to study thermal quenches in more detail are investigated. Radiative losses along propagating cold fronts may induce termination, but below a critical threshold of impurity amounts the plasma may recover to stored energies prior perturbation. Application of additional electron heating extended the plasma cooling phase; thus, different heating strategies were explored. Results suggest that, in stellarators, less efforts for mitigating termination events are needed due to their higher operational resilience.

P 17.7 Wed 16:15 ZHG Foyer 1. OG

Effect of stray magnetic fields on particles in the Wendelstein 7-X neutral beam box — •Lucas van Ham[1], Samuel Lazerson[2], Björn Hamstra[3], Paul McNeely[1], Norbert Rust[1], Dirk Hartmann[1], Sergey Bozhenkov[1], and the W7-X Team[1] — [1]Max Planck Institute for Plasma Physics — [2]Gauss Fusion GmbH, Germany — [3]Eindhoven University of Technology

A new comprehensive model for calculating ion trajectories inside the neutral beam injection (NBI) system of Wendelstein 7-X (W7-X) is presented. The model consists of two parts: First, the magnetic materials code MUMAT calculates the magnetic response of ferritic materials (including NBI shielding) to the magnetic field produced by the main W7-X coil system. This code has been verified through application to a scenario with a known magnetic field. Second, the Monte Carlo particle following code BEAMS3D follows particles through the resulting magnetic field and estimates heat loads on NBI components.

MUMAT calculations of the magnetic field inside the NBI system predict significant fields (>10 Gauss) inside the NBI neutralizer, indicating that stray magnetic fields penetrate the NBI system. Subsequent BEAMS3D simulations predict that heat loads on NBI components shift vertically due to this neutralizer field. These shifts agree qualitatively with experimental observations, and a quantitative comparison with infrared imaging and calorimetry is planned.

The NBI system is essential for achieving high performance plasmas in W7-X, and this new model can help improve NBI reliability and develop paths towards longer NBI heat pulses.

P 17.8 Wed 16:15 ZHG Foyer 1. OG

Simulations of the X-point Radiator in ASDEX Upgrade with Kinetic Neutrals and Impurities in JOREK — •Yu-Chih Liang[1,2], Andres Cathey[1], Matthias Hoelzl[1], Ulrich Stroth[1,2], Sven Korving[3], Mate Szuecs[1,2], Felix Antlitz[1,2], Daniël Maris[3], JOREK Team[1], and ASDEX Upgrade Team[1] — [1]Max Planck Institute for Plasma Physics, 85748 Garching, Germany — [2]TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — [3]Eindhoven University of Technology, 5612 AZ Eindhoven, The Netherlands

The problem of power exhaust in the future thermonuclear fusion reactors, such as ITER and DEMO, necessitates operation regimes that can avoid extreme heat fluxes onto plasma-facing components. One promising regime is the X-point radiator (XPR), a cold, dense, and highly radiative plasma region that forms above the X-point of the single-null magnetic configuration in a tokamak plasma. This poster presents axisymmetric (2D) simulations of the XPR regime using the nonlinear magnetohydrodynamic (MHD) code, JOREK, extended with a kinetic particle framework for neutral deuterium particles and impurities. Three simulations are presented: one with a quasi-stationary XPR, one with the XPR moving vertically upwards and turning into an unstable solution (MARFE), and one with the XPR moving vertically downwards and being lost. These three simulations show JOREK's capability of simulating time-varying XPR, and they provide a baseline for the transition to 3D simulations, so the MHD activities and their interaction with the XPR can be studied.

P 17.9 Wed 16:15 ZHG Foyer 1. OG

Assessment of Radiation Asymmetries employing the new Imaging Bolometer diagnostic at W7-X — •Kevin Andrea Siever[1], Gabriele Partesotti[1], Felix Reimold[1], Glen Wurden[2], Fabio Federici[3], Byron Jay Peterson[4], and Kiyofumi Mukai[4] — [1]Max-Planck Institute for Plasma Physics, Greifswald, Germany — [2]Los Alamos National Lab, New Mexico, United States — [3]Oak Ridge National Lab, Tennessee, United States — [4]National Institute for Fusion Science, Toki, Japan

Estimation of the plasma radiation distribution is a key aspect in the context of power exhaust optimization. This is particularly demanding in Stellarators due to the intrinsically 3D plasma geometry. The InfraRed Video Bolometer (IRVB) diagnostic provides wide spatial coverage both in the poloidal and toroidal directions, enabling direct observation of the emission gradients in the divertor region. Here we combine its data with that from the resistive bolometry systems to quantify the emissivity asymmetries at Wendelstein 7-X. First of all, the thermal properties of the bolometer foil need to be calibrated to allow correct inference of the impinging power. Using synthetic simulations of the calibration process allows to identify the optimal procedure and settings.

Given the IRVB measurements, we then employ the 2D radiation patterns obtained from the resistive bolometers to generate reference patterns with constant emissivity along the field lines. Comparing with the latter allowed us to isolate better the features of interest and to assess the toroidal gradients in the plasma emissivity

P 17.10 Wed 16:15 ZHG Foyer 1. OG

Gyrokinetic studies of dominant instabilities in different particle transport regimes in Wendelstein 7-X — •Nico J. Guth, Josefine H. E. Proll, Sebastian Bannmann, Oliver P. Ford, and Gabriel G. Plunk — Max Planck Institute for Plasma Physics, Greifswald, Germany

One of the key aspects for ensuring efficient and stable fusion energy production in a future stellarator is to accurately predict the plasma density profiles and their time evolution. In a stellarator, ions and electrons stream freely along magnetic field lines, leading to nested toroidal surfaces of nearly constant density (and temperature). Thus, the main interest of the study of particle transport lies in the perpendicular (radial) direction, with a goal of understanding which plasma conditions lead to favourable density peaking near the magnetic axis and which conditions degrade particle confinement. Optimized stellarators, like Wendelstein 7-X (W7-X), are specifically tailored to reduce the average outward drifts of trapped particle orbits, leading to reduced neoclassical transport. Experiments have however shown that transport is larger than predicted, which can be attributed to turbulent processes in the plasma on the gyroradius scale. Recent experimental work (Bannmann et al 2024) indicates a change in turbulent particle diffusivity (and convectivity) above a critical density gradient. Using gyrokinetic simulations, this qualitative change is investigated with a focus on changes in dominant instabilities as well as simple quasi- linear estimates of the corresponding fluxes.

P 17.11 Wed 16:15 ZHG Foyer 1. OG

Fluid Turbulence Modelling of Magnetic Islands in Stellarators — •Miguel Madeira, Sophia A. Henneberg, and Brendan Shanahan — Max-Planck-Institut für Plasmaphysik, Wendelsteinstr. 1, 17489 Greifswald, Germany

Understanding scrape-off layer (SOL) turbulence is crucial for advancing nuclear fusion technology, particularly in improving plasma confinement and performance. While extensive efforts have been dedicated to developing plasma fluid turbulence codes, most applications have focused on tokamak configurations. With the recent success of Wendelstein 7-X (W7-X) and the rising interest in stellarators, multiple codes have now been adapted for three-dimensional simulations and are ready to be leveraged for future physics studies.

This research aims to enhance the understanding of SOL turbulence around magnetic islands in stellarators, specifically focusing on W7-X, by utilizing two fluid turbulence codes, BSTING and GRILLIX. The flexible coil system of W7-X enables control over its magnetic islands' locations and sizes. Notably, when the 5/5 island chain is inside the last closed flux surface, a transition to improved electron transport has been observed. This state is characterized by higher plasma energy and periodic sawtooth crashes within the island region, known as island localized modes (ILMs). The frequency and amplitude of these crashes correlate with the island size.

Given the critical role of magnetic islands in improved confinement scenarios and the island divertor design for future stellarator reactors, this work explores how they influence turbulence behavior.

P 17.12 Wed 16:15 ZHG Foyer 1. OG

Improvement of impurity transport studies at Wendelstein 7-X by integration of 2D X-ray emission data — •Alice Bonciarelli[1,2], Birger Buttenschön[1], Felix Reimold[1], Christian Brandt[1], and The W7-X Team[1] — [1]Max-Planck-Institut für Plasmaphysik, Greifswald — [2]Politecnico di Milano, Italy

Impurities play an important role in fusion plasmas, since their presence and distribution have a strong influence on the plasma performance: the actual amount must be kept under control, within a suitable range defined by the need to avoid plasma dilution and radiation cooling (upper limit), and by their protective function with respect to the plasma facing materials from high power fluxes (lower limit). The impurity transport determines their distribution and it can be described by convection and diffusion coefficients. These coefficients can be determined from experiments and we use the transport code pySTRAHL to forward model the impurity density evolution for given coefficients. These can, in turn, can be used to predict synthetic line-integrated signals of various diagnostics using the atomic data available in the ADAS database. It is then possible to compare the measured and simulated data using Bayesian inference analysis to obtain more realistic transport coefficients. To increase the accuracy of transport coefficients as determined by spectroscopy alone, a fast 2D x-ray tomography system is introduced into this framework. The necessary methods of data reduction and first results of the extended set of diagnostics are shown in this contribution.

P 17.13 Wed 16:15 ZHG Foyer 1. OG

Landau Damping for Non-Maxwellian Distribution Functions — •Riccardo Stucchi[1,2] and Philipp Lauber[1] — [1]Max Planck Institute for Plasma Physics — [2]Technical University of Munich

Landau damping is one of the cornerstones of plasma physics. In the context of the mathematical framework developed by Landau in his original derivation of Landau damping, we examine the solutions of the linear Vlasov-Poisson system for different equilibrium velocity distribution functions, such as the Maxwellian distribution, kappa distributions, and cut-off distributions without and with energy diffusion. Specifically, we focus on the full set of roots that the dispersion relation of the linear Vlasov-Poisson system generally admits, and we wonder if the full structure of solutions might hint at a deeper understanding of the Landau damping phenomenon.

P 17.14 Wed 16:15 ZHG Foyer 1. OG

Frequency-sweeping calibration source for the dual-frequency CTS radiometer at W7-X — •Daniel Straus, Dmitry Moseev, Sergiy Ponomarenko, Laurent Krier, Heinrich Laqua, Stefan Marsen, and Torsten Stange — Max-Planck-Institut für Plasmaphysik, Wendelsteinstr. 1, 17491 Greifswald, Germany

The Collective Thomson Scattering (CTS) diagnostic at the Wendelstein 7-X stellarator must be calibrated. The current calibration process involves using two thermal sources, one roughly at room temperature and the other at -196 C (boiling point of nitrogen), with the black body radiation emitted by each source being significantly different. The CTS receiver works at two frequency bands: 138.5-141.5 GHz and 171-177 GHz, and it is important that the receiver is absolutely calibrated in both bands. These black body sources produce weak signals which require hours long averaging times in order to achieve an acceptable signal-to-noise ratio. With such time scales, the receiver electronics experience systematic drifts which also need to be accounted for, making the overall calibration procedure long and cumbersome. In this contribution, we will discuss the design and first results of a new sweeping calibrator that replaces the black body sources. This calibrator consists of a tunable continuous wave THz source, followed by attenuators, waveguide switches and a directional coupler, which splits the incoming signal into two distinct power levels. The THz source and other components are carefully characterized to protect receiver electronics from high power. The calibration tool is integrated with the CTS receiver and allows quick semi-automatic calibration.

P 17.15 Wed 16:15 ZHG Foyer 1. OG

Towards efficient accelerated 3D nonlinear MHD simulations with the finite element code JOREK — •Patrik Rác, Matthias Hölzl, and Ihor Holod — Max Planck Institute for Plasma Physics, Garching, Germany

Enabling next-generation simulations of realistic magnetic confinement fusion devices is crucial for understanding and controlling large-scale plasma instabilities. Current simulation codes, such as JOREK, are designed to run on traditional supercomputers but have yet to be optimized for efficient execution on modern accelerated platforms. With the increasing prevalence of accelerator architectures, like GPUs, in high-performance clusters, JOREK requires adaptation to harness the performance of these new systems. We ported the matrix construction and the iterative solver of the time-stepping loop to GPUs. Our approach aims for portability and minimal code changes, allowing scientists to continue working on the code and easily integrate future changes. We achieve this by combining OpenMP and highly optimized GPU libraries. By optimizing the code structure for GPU offloading and eliminating synchronization overhead through coloring the finite element mesh, we obtain comparable performance to the original CPU implementation, paving the way for fully integrated JOREK simulations on GPU-accelerated clusters. Future work will explore novel preconditioning methods, designed to run efficiently on accelerated hardware, with the possibility of harnessing machine learning for further acceleration.

P 17.16 Wed 16:15 ZHG Foyer 1. OG

Characteristics of the SOL ion-to-electron temperature ratio on W7-X with an island divertor configuration — •Jiankun Hua[1,2], Yunfeng Liang[1,2,3], Alexander Knieps[2], Kaixuan Ye[2,3], Carsten Killer[4], Erhui Wang[2], and Pei Ren[2] — [1]International Joint Research Laboratory of Magnetic Confinement Fusion and Plasma Physics, Huazhong University of Science and Technology, Wuhan, China — [2]Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung Plasmaphysik, Jülich, Germany — [3]Institute of Plasma Physics, Chinese Academy of Sciences, Hefei, China — [4]Max-Planck-Institut für Plasmaphysik, Greifswald, Germany

The ion temperature, Ti, in the scrape-off layer (SOL) plays a critical role in understanding diverter plasma transport in magnetic confined fusion research. Previous studies have shown SOL Ti is typically higher than the electron temperature, Te. Moreover, as the ion collisionality (υ) increases, the ion-to-electron temperature ratio (τ) decrease accordingly. Experiments in the W7-X device, which employs an island divertor configuration, are consistent with earlier observations made in tokamaks. However, the Ti profile is non-monotonic due to the influence of the open magnetic island structure in SOL. Ti inside the island is lower than at the island boundary. When SOL plasma transitions from an attached state to a detached state by ramping up upstream plasma density, the υ increases, and both Ti and Te decrease in the SOL. Meanwhile, the relation between τ and υ remains consistent with the attached plasma, so the τ further decrease under the detachment.

P 17.17 Wed 16:15 ZHG Foyer 1. OG

A functional perturbation theory for rapid analysis of orbits and tori in magnetic confinement fusion research — •Wenyin Wei[1,2,3], Alexander Knieps[1], Jiankun Hua[1,4], and Yunfeng Liang[1,2,4] — [1]Forschungszentrum Jülich GmbH, Institute of Fusion Energy and Nuclear Waste Management - Plasma Physics, Jülich, Germany — [2]ASIPP, Hefei, China — [3]USTC, Hefei, China — [4]HUST, Wuhan, China

This work presents a functional perturbation theory (FPT) that efficiently computes how orbits shift and tori deform under perturbation by considering the magnetic field as a function argument for these geometric objects. This approach acknowledges topological significance, inspired by the discovery from mature 3D magnetohydrodynamic simulations (e.g., EMC3-EIRENE, JOREK), which have revealed the distinctive lobe structure intertwined with stable and unstable manifolds of the outermost X-cycle (the field trajectory consists of X-points at all cross-sections). In practice, without delicate hardware acceleration, FPT completes computations in seconds for three-dimensional configurations like Wendelstein 7-X and almost instantly for tokamaks, offering near-real-time insights for device optimization and control. Based on this swift speed, FPT can guide experimental decisions by quickly predicting how coil setups or plasma responses affect magnetic topology, indicating whether flux surfaces remain intact or break into island chains. The framework is expected to support more agile, precise operations in existing fusion devices and inform the design of advanced configurations.

P 17.18 Wed 16:15 ZHG Foyer 1. OG

Deuterium Uptake and Isotope Exchange in Tungsten Displacement Damaged at High Temperature — •Laurin Hess[1,2] and Thomas Schwarz-Selinger[2] — [1]Technische Universität München, Arcisstr. 21, 80333 München — [2]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching b. München

Retention of hydrogen fuel in tungsten is an active area of research, as it is an integral part of modelling the tritium inventory and certification of future fusion reactors. It has been shown that hydrogen retention significantly increases due to displacement damage produced by 14 MeV fusion neutrons. Over the last years, basic understanding of the behaviour of hydrogen in point defects was acquired. However, damage at high temperatures can also produce nm-sized voids. Only little research has been done to examine the behaviour of hydrogen in these voids. To improve the understanding of hydrogen in nm-sized voids, tungsten single crystals were self-damaged by irradiation with 20 MeV tungsten ions at 1370 K and decorated with different fluences of 5 eV deuterium from a low-temperature plasma. The retention of deuterium was measured via ^{3}He Nuclear Reaction Analysis as a function of D fluence. In addition, the exchange of retained deuterium with protium has been studied by exposing deuterium-decorated samples to different fluences of 5 eV protium.

P 17.19 Wed 16:15 ZHG Foyer 1. OG

Thermal-Hydraulic Modelling of Plasma Facing Components using OpenFOAM — •Ahmet KILAVUZ[1,2], Rudolf Neu[1,2], Jeong-Ha You[1,3], and Boštjan Končar[4] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Technical University of Munich, Garching, Germany — [3]University of Ulm, Ulm, Germany — [4]Jožef Stefan Institute, Ljubljana, Slovenia

Plasma-facing components, like divertor targets in fusion reactors, operate under extreme thermal and hydraulic conditions, including high heat and mass fluxes and elevated pressures. Under such conditions, boiling phenomena occur in cooling channels, and boiling models are highly sensitive to flow conditions, complicating the creation of accurate models. OpenFOAM, an open-source CFD software, provides a customizable platform for developing these models. This study develops and evaluates conjugated heat transfer models in OpenFOAM for divertor-relevant conditions. Material properties were included as a function of temperature. The solver results were compared to ANSYS Fluent predictions, experimental measurements, and empirical correlations. The agreement between the two solvers was observed for temperature and velocity predictions, including armor surface and inner pipe temperatures, velocity profiles, and volume fractions. Both solvers aligned well with experimental data. Differences between single-phase model predictions and experimental data highlight the need to incorporate boiling effects for accurate thermal predictions in plasma-facing components.

P 17.20 Wed 16:15 ZHG Foyer 1. OG

Temperature-dependent grain boundary permeation in tungsten investigated by hydrogenography — •Fahrudin Delic, Armin Manhard, and Udo von Toussaint — Max Planck Insti tute for Plasma Physics, 85748 Garching, Germany

The temperature-dependent permeation of deuterium through grain boundaries in tungsten has been studied using a newly developed hydrogenography technique, which employs patterned films to laterally resolve hydrogen fluence density on the back side of the permeation samples. Primarily, a tungsten oxide layer was developed as a hydrogen indicator that could withstand greater temperatures than previously used yttrium, and a method for reliably quantifying the results was established. Ion-driven permeation with constant deuterium fluence was conducted using 50 μm thick recrystallized tungsten samples at various exposure temperatures. The temperature-dependent permeation indicated that the permeation fluence density of hydrogen isotopes in grain boundaries is dominant up to 660 K, with an increasing number of grain boundaries favorable for hydrogen transport as the temperature rises. At 660 K, a halo of hydrogen fluence density forms around several permeating grain boundaries, suggesting a desorption of hydrogen isotopes from grain boundaries and the initial signs of the transition towards predominant bulk permeation

P 17.21 Wed 16:15 ZHG Foyer 1. OG

Influence of the presence of deuterium on damage evolution in tungsten — •Z Shen, T Schwarz-Selinger, M Zibrov, and A Manhard — Max-Planck-Institut für Plasmaphysik, Boltzmannstrasse 2, Garching D-85748, Germany

The influence of the presence of deuterium (D) on damage evolution at elevated temperatures was studied for self-ion irradiated tungsten (W). W samples were irradiated by 20.3 MeV W ions at room temperature to the peak damage dose of 0.23 dpa and loaded with a low-temperature D plasma at 370 K to decorate the created defects. To study the evolution of the defects with D being present, samples were heated during plasma loading to 4 different temperatures, ranging from 470 K to 770 K. The annealing time was calculated by the rate equation modelling code TESSIM-X. For comparison, annealing experiments at each temperature were carried out also in vacuum. Nuclear reaction analysis (NRA) was used to determine the D depth profile and thermal desorption spectroscopy (TDS) was used to measure the total retention and de-trapping energy of D. Decorating the samples after annealing again with the same D plasma at room temperature shows decreased D retention with increasing annealing temperature both for plasma annealing and vacuum annealing. The presence of D during annealing has only a small stabilization effect for the defects.

P 17.22 Wed 16:15 ZHG Foyer 1. OG

Expanding the physics modeling capabilities of ASTRA from core to SOL and from tokamak to stellarator towards application in a multi-device flight simulator — •Fabian Solfronk[1,2], Emiliano Fable[1], Hartmut Zohm[1,2], Roberto Bilato[1], and the ASDEX Upgrade Team[3] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching, Germany — [2]Ludwig-Maximilians-Universität München, 80539 München, Germany — [3]see the author list of H. Zohm et al. 2024 NF 64 112001

This work aims at augmenting the ASTRA transport code capabilities of simulating magnetic confinement fusion devices. In parallel, two avenues are pursued:

First, a few options for a reduced, theory-based scrape-off-layer (SOL)/exhaust model will be explored and implemented to allow simulations of seeded discharges and discharges with both low and high-recycling regimes displaying either impurity flush-out or detachment. Application to ASDEX Upgrade and future devices like ITER and DEMO, where the FENIX flight simulator (to which ASTRA is coupled) is being deployed, is foreseen.

Second, the implementation of an equation for the current diffusion compatible with a vacuum helical field (as in a stellarator device) will be pursued. After which, the inclusion of reduced models for stellarator physics may be initiated. The goal is to develop a tool that can be used for both tokamak and stellarator-reduced modeling, paving the way for a flight simulator that can also simulate stellarators.

P 17.23 Wed 16:15 ZHG Foyer 1. OG

Gyrokinetic pedestal studies varying shaping in AUG — •Facundo Sheffield[1], Tobias Goerler[1], Lidija Radovanovic[2], Elisabeth Wolfrum[1], Frank Jenko[1], and the ASDEX Upgrade team[3] — [1]Max-Planck-Institut für Plasmaphysik — [2]Institute of Applied Physics, TU Wien — [3]See author list of H. Zohm et al, 2024 Nucl. Fusion https://doi.org/10.1088/1741-4326/ad249d

The pedestal region in tokamak plasmas plays a critical role in determining overall confinement and performance, yet the interplay between turbulence and plasma shaping within this region remains to be fully understood. In this work, we present a comprehensive characterization of pedestal instabilities and their sensitivity to plasma shaping effects using the gyrokinetic code GENE. Key turbulence modes, including kinetic ballooning modes and electron temperature gradient modes (ETG), are identified and compared in differently shaped ASDEX Upgrade equilibria to assess their impact on transport and stability. Further insights into the nature and characterization of ion-frequency ETG modes are discussed. The influence of shaping parameters, mainly triangularity and elongation, is systematically explored with linear and global nonlinear simulations. The findings presented reveal novel dependencies between pedestal turbulence properties and shaping.

P 17.24 Wed 16:15 ZHG Foyer 1. OG

Investigation of Wendelstein 7-X Scrape-Off Layer Characteristic by Helium Line Ratio Spectroscopy — •Foisal B.T. Siddiki[1,2], Oliver Schmitz[2], Maciej Krychowiak[1], Erik Flom[3], Frederik Henke[1], Dorothea Gradic[1], and W7-X team[1] — [1]Max Planck Institute for Plasma Physics, Germany — [2]University of Wisconsin-Madison, USA — [3]Thea Energy, USA

Heat and particle transport in the Wendelstein 7-X(W7-X) scrape-off layer (SOL) significantly influences the performance of its divertor, which serves as the heat and particle exhaust system. To optimize the divertor concept, it is essential to understand the transport phenomena within the SOL, which can be achieved by studying plasma parameters like electron temperature (T_e) and the density (n_e). As a way of measuring the basic plasma parameters in the W7-X SOL, the diagnostic systems used consist of a gas injection system and multiple spectrometers with different spectral resolutions. They observe one upper and one lower divertor unit (downstream position) and for the first time also in the midplane area (upstream position). Line ratio spectroscopy based on a collisional radiative model of atomic helium is used to infer n_e and T_e. The helium beam diagnostic at W7-X has been thoroughly validated and widely utilized to map plasma parameters within the island divertor. The T_e , n_e profiles presented here in this work were measured using all three systems under various conditions, including detached and impurity-seeded plasmas. A comparison of the T_e , n_e profiles obtained at the downstream and upstream positions will be presented.

P 17.25 Wed 16:15 ZHG Foyer 1. OG

Modeling of the spatial and temporal dynamics of Cs in large negative hydrogen ion sources using the CsFlow3D code — •Daniele Mussini, Adrian Heiler, Christian Wimmer, Dirk Wünderlich, and Ursel Fantz — Max-Planck-Institut für Plasmaphysik (IPP), Boltzmannstr. 2, 85748 Garching

Negative ion-based sources for ITER's neutral beam injectors (NBI) rely on the production of negative hydrogen ions on a low work function converter surface

(plasma grid, PG). To reduce the work function of the PG (< 2eV), Cs is continuously evaporated into the source forming a layer on the PG. However, the plasma-surface interaction and the resulting redistribution of Cs inside the source lead to a temporally unstable and inhomogeneous layer. This is a key aspect to be investigated and understood in order to perform long pulses at ITER's requirements (several hundred s in H, 3600s in D). For this purpose, the Monte-Carlo Test-Particle code CsFlow3D is exploited. CsFlow3D models the Cs dynamics in the source, for which several input parameters (plasma parameters, electromagnetic fields, sticking coefficients, etc.) are required. The current target is to model the Cs dynamics during long pulses for the BATMAN Upgrade source in hydrogen. To validate the code, a synthetic laser absorption diagnostic (TDLAS) for the quantification of neutral Cs densities along different line-of-sights is implemented to compare to experimental results. This contribution presents the results of the code after the implementation of input parameters resulting from a fluid code and the benchmark of the code against experimental TDLAS results.

P 17.26 Wed 16:15 ZHG Foyer 1. OG

Impact of fishbone modes to core microturbulence with global gyrokinetic simulations — •Davide Brioschi[1], Alessandro Di Siena[1], Roberto Bilato[1], Alberto Bottino[1], Thomas Hayward-Schneider[1], Alexey Mishchenko[2], Emanuele Poli[1], Alessandro Zocco[2], and Frank Jenko[1] — [1]Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany — [2]Max Planck Institute for Plasma Physics, Greifswald 17491, Germany

Fishbone instabilities (FBs) are a class of macroscopic plasma modes which develop inside tokamaks around rational surfaces. Theoretical and experimental results show a correlation between the development and/or sustainment of ITBs inside tokamak plasmas and the destabilization of FBs. These studies point out the need for a self-consistent description of the interaction of FBs with plasma microturbulence, i.e. the main driving mechanism of turbulent transport inside tokamaks detrimental for plasma confinement. Our work wants to study such an interaction through gyrokinetic simulations performed with the code GENE and ORB5, including both the n=m=1 FB (with n and m tororidal and poloidal mode number respectively) and the ion temperature gradient (ITG) mode branches inside the plasma. Multiscale interaction between turbulence, global FB structures and zonal flows is studied via dedicated nonlinear simulations, starting from results obtained through linear ones used to identify the ideal subset of the parameters space where all these modes are present at once.

P 17.27 Wed 16:15 ZHG Foyer 1. OG

First successful plasma start-up with X2 ECRH at a reduced field of 1.8T at W7-X — •Niklas Simon Polei, Torsten Stange, Heinrich Peter Laqua, Kai Jakob Brunner, Juan Fernando Guerrero Arnaiz, Georg Schlisio, and W7-X Team — Max-Planck-Institut für Plasmaphysik, 17491 Greifswald, Germany

At Wendelstein 7-X (W7-X) the nominal magnetic field strength is 2.5T, but operation at a lower magnetic field strength is desired to achieve higher plasma beta (ratio of kinetic and magnetic pressure). The electron cyclotron resonance heating (ECRH) operates at 140GHz, corresponding to third harmonic (X3) heating at 1.8T. A plasma start-up is not possible with X3-heating, but one gyrotron was successfully tuned to 101GHz for an X2 start-up with 250kW. A multi-pass scenario was developed to ensure six passes close to the magnetic axis to increase the effective power in the first few milliseconds and allow a plasma breakdown even at low power. Neutral beam injection (NBI) with a power of 3MW was expected to be able to takeover the plasma from the X2 ECRH, increasing the electron temperature up to 1keV, so that X3 ECRH can take over.

The foreseen start-up scenario was successfully demonstrated in the last operational phase OP 2.2. The X2 ECRH alone can create a central plasma with a peak temperature of several keV and line integrated densities above $5 \cdot 10^{18} m^{-2}$. The plasma can be taken over by the NBI to increase temperature and density, for subsequent X3 ECRH take-over to maintain a steady plasma. This enables the low field operation of W7-X.

P 17.28 Wed 16:15 ZHG Foyer 1. OG

First measurements of divertor conditions in the new ASDEX Upgrade upper divertor — •Felix Albrecht[1,2], Dominik Brida[1], Tilmann Lunt[1], Bernhard Sieglin[1], Ou Pan[1], and the ASDEX Upgrade team[3] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Technical University of Munich, Physics Department E28, Garching, Germany — [3]see author list of H. Zohm *et al.* 2024 *Nucl. Fusion* **64** 112001

The divertor is a crucial component for any magnetic confinement fusion machine, which enables efficient pumping of impurities and fusion-produced helium, as well as density and power exhaust control. In the divertor, the magnetic field lines of the outermost part of the plasma, the so-called Scrape-Off Layer (SOL), are intersected by a wall component, the divertor target, which experiences very high power loads. The target heat flux must be limited by the seeding of impurities, which radiate power away. However, a power plant divertor could require seeding rates which would be unacceptably high for the plasma core. A possible solution are Alternative Divertor Configurations (ADCs), which can help to induce detachment at lower impurity concentrations by enhanced control of the field configuration in the divertor region.

At the tokamak ASDEX Upgrade (AUG), the upper divertor has recently been equipped with additional coils to study a variety of ADCs, for the first time in a machine with high heating power and a tungsten wall. This contribution presents the first Langmuir probe measurements in the new upper divertor of AUG, and compares the divertor conditions between different field configurations.

P 17.29 Wed 16:15 ZHG Foyer 1. OG

The avalanche source for a 3D particle in cell model of runaway electrons — •Fiona Wouters[1], Matthias Hoelzl[1], Hannes Bergstroem[1], Guido Huijsmans[2,3], and Jan van Dijk[2] — [1]Max Planck Institute for Plasma Physics, Boltzmannstraße 2, 85748 Garching, Germany — [2]Eindhoven University of Technology, Groene Loper 3, 5612 AE Eindhoven, the Netherlands — [3]CEA, IRFM, 13115 Saint-Paul-lez-Durance, France

Disruptions, i.e. major instabilities in which plasma confinement is lost, are a significant threat to tokamak operation. During a disruption the resistivity of the plasma increases as the thermal energy is quickly lost, causing the current to decrease. Due to the self-inductance of the plasma this leads to the generation of a strong parallel electric field. As the friction force experienced by fast electrons in a plasma has the peculiarity that it decreases with increasing electron velocity, this electric field can accelerate some fast electrons to relativistic velocities. These so-called runaway electrons (REs) can then exponentially multiply due to large-angle collisions with thermal electrons in what is known as the runaway avalanche. Because the avalanche is exponentially sensitive to the pre-disruption plasma current, this can lead to multi-MA RE beams in large future devices such as ITER, which may cause severe localized wall damage. Simulations including the RE sources in realistic 3D fields are needed to further the understanding of RE generation and losses and develop viable mitigation scenarios. For this purpose the avalanche source was implemented in the 3D nonlinear extended MHD code JOREK.

P 17.30 Wed 16:15 ZHG Foyer 1. OG

Turbulence imaging in the scrape-off layer of Wendelstein 7-X — •Floris Scharmer[1], Adrian von Stechow[1], Sean Ballinger[2], Seung-Gyou Baek[2], James Terry[2], Carsten Killer[1], Olaf Grulke[1,3], and the W7-X Team[1,4] — [1]Max Planck Institute for Plasma Physics, Greifswald, Germany — [2]MIT Plasma Science and Fusion Center, Cambridge, USA — [3]Department of Physics, Technical University of Denmark, Lyngby, Denmark — [4]See O. Grulke et al 2024 Nucl. Fusion 64 112002

Understanding the dynamics of the edge plasma is crucial for magnetic confinement fusion experiments, as it significantly impacts both core performance and plasma exhaust. In the Wendelstein 7-X stellarator experiment, a 2D poloidal cross section of the island scrape-off layer plasma is imaged with a gas puff imaging diagnostic. This system measures the fluctuations in H_α line emission, a proxy for plasma fluctuations, at a high spatio-temporal resolution by increasing the local light emission with an external neutral gas puff. In the latest operation phase (2024), the diagnostic capabilities were upgraded with the ability to use a high-resolution camera, which can be swapped with the existing avalanche photodiode detector array as needed. This enhancement allows for the study of turbulence statistics with higher spatial resolution and over a larger field of view, including the last closed flux surface. The turbulence statistics (e.g. skewness) have distinct features corresponding to the magnetic geometry and also depend on the operational regime. In this contribution, the results of the first measurements of the diagnostic extension are presented.

P 17.31 Wed 16:15 ZHG Foyer 1. OG

Improving the signal to noise ratio of a TALIF diagnostic ap- plied to a hydrogen plasma for enhanced hydrogen EDF de- termination — •Julian Hörsch, Christian Wimmer, and Ursel Fantz — Max-Planck-Institut für Plasmaphysik, Boltzmannstraße 2, 85748 Garching bei München, Germany

Two photon Absorption Laser Induced Fluorescence (TALIF) is a plasma diagnostic technique that can be used to measure the density and energy distribution function (EDF) of atomic hydrogen. The simultaneous absorption of two photons leads to the excitation of ground state hydrogen atoms to the n=3 level and a subsequent fluorescence decay to the n=2 level. The fluorescence decay emits Balmer H-alpha radiation, which can be detected for density and EDF measurements. Since the plasma emits strong H-alpha radiation, weak fluorescence signals received from TALIF are difficult to measure. The determination of the EDF requires an accurate measurement of the line profile, particularly in the wings of the line profile. For that it is important to distinguish the signal from the background noise. To be able to measure these wings of the EDF and thus the predicted deviations from a Maxwellian EDF, optimizations of the detector and the optical setup such as laser focusing and beam compression are investigated.

P 17.32 Wed 16:15 ZHG Foyer 1. OG

Plasma dynamics analysis with the fast helium beam at W7-X — •Sebastian Hörmann[1,2], Michael Griener[1], Maciej Krychowiak[3], Dorothe Gradic[3], Erik Flom[3], Mohammad Foisal Siddiki[3], Adrian von Stechow[3], Carsten Killer[3], Felix Reimold[3], Stepan Sereda[3], Ulrich Stroth[1,2], the ASDEX Upgrade Team[1], and the W7-X Team[3] — [1]Max-Planck-Institut für

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Understanding and quantifying particle and energy transport at the plasma edge region is crucial for magnetic confinement fusion devices, as it determines plasma performance and wall loads. For the thermal helium beam systems in the island divertor of the stellarator W7-X, a new polychromator system with 1 MHz time resolution was installed, which is 25000 times faster than the existing system. This allows to measure and characterise turbulent structures, such as plasma edge modes and filaments and correlate their properties with plasma parameters. The diagnostic system measures within two magnetically connected divertors, which, in combination with the multi-purpose manipulator, enables the study of long-range correlation of modes. Utilising a collisional-radiative model, the diagnostic can measure fast density and temperature variations associated with plasma modes and filaments. It also provides high temporal resolution measurements of the detachment process in the divertor. This poster presents the design and implementation of the diagnostic and discusses the first results.

P 17.33 Wed 16:15 ZHG Foyer 1. OG

Investigation of perpendicular transport effects in W7-X divertor islands using 2D plasma parameter measurements with MANTIS. — •Joey Louwe, Felix Reimold, Valeria Perseo, Victoria Winters, Henry Greve, Thomas Klinger, Michael Griener, and W7-X team — Max Planck Institute for Plasma Physics, 17491 Greifswald/85748 Garching, Germany

To enhance the performance of fusion experiments, such as Wendelstein 7-X (W7-X), the divertor concept is employed to efficiently exhaust plasma particles, impurities and heat from the plasma. Both stellarators and tokamaks employ divertors, though their designs differ. W7-X implements the Island Divertor, which utilizes magnetic islands to divert and guide particles and heat along magnetic field lines to target plates. Compared to typical tokamak divertors, the stellarator divertor field lines have a significantly lower pitch angle, making perpendicular transport effects more significant. This study aims to characterize these perpendicular transport effects utilizing the Multispectral Advanced Narrowband Tokamak Imaging System (MANTIS) being build for the W7-X reactor. By integrating MANTIS with active gas puff imaging and helium impurity injections, we can measure specific spectral lines to create 2D images of electron density and temperature of the divertor islands. Additionally, the EMC3-EIRENE simulation code is employed in the determination of optimal helium injection positions, identifying six strategic locations for effective coverage of the divertor island region.

P 17.34 Wed 16:15 ZHG Foyer 1. OG

Towards a deeper understanding of the pronounced increase in co-extracted current density in H-/D- negative ion sources for fusion — •Joey Rubin, Niek den Harder, and Ursel Fantz — Max Planck Institute for Plasma Physics

Negative ion sources for fusion face stringent operational demands. ITER's sources must achieve a current density of 329 A/m^2 for H^- ions over 1000 s and 286 A/m^2 for D^- ions over 3600 s. Negative ions are generated on caesiated surfaces through the conversion of precursors formed in RF-drivers. Electrons are inherently co-extracted with the negative ions and must be removed from the beam before full acceleration. Magnets embedded in the extraction grid deflect and collect these electrons. During long pulses, the co-extracted electron current density increases, particularly in deuterium operation, limiting the pulse duration. At the ELISE test facility, which hosts a half-ITER-size source, a comprehensive set of diagnostics has been used to investigate the physics behind this phenomenon, and strategies to counteract it have been developed. This contribution reviews the current understanding of the mechanism driving the growth of co-extracted electron current density, highlighting the varying growth rates seen during beam extraction. Correlations with caesium dynamics and potential variations are discussed, along with open questions.

P 17.35 Wed 16:15 ZHG Foyer 1. OG

Calibration and Operation of the Imaging Motional Stark Effect Diagnostic at ASDEX Upgrade — •Lea Hollendonner[1], Alexander Bock[1], Andreas Burckhart[1], Thomas Pütterich[1], Rainer Fischer[1], and the ASDEX Upgrade Team[2] — [1]Max Planck Institute for Plasma Physics, 85748 Garching, Germany — [2]See author list of H. Zohm et al, 2024 Nucl. Fusion

Detailed knowledge on the current density distribution in the core of the plasma is essential in many research topics in the field of magnetic confinement nuclear fusion, examples comprising the investigation of sawtooth instabilities, flux pumping, or advanced scenario development. Experimentally, the current density distribution can be reconstructed from measurements of the magnetic field pitch angle. Of all diagnostics capable of measuring the field pitch angle in the plasma core, the Imaging Motional Stark Effect (IMSE) diagnostic offers the highest resolution. Moreover, it provides a two-dimensional image instead of data from a limited amount of channels. In order to routinely operate the IMSE with high resolution, the calibration must be equally accurate. Fine-tuning of the IMSE calibration is challenging and open to optimization. This work presents the state of the IMSE diagnostic at ASDEX Upgrade and investigates possibilities to improve the calibration of the diagnostic.

P 17.36 Wed 16:15 ZHG Foyer 1. OG

The role of turbulence and radial electric field in the achievement of high-performance regimes in W7-X — •Bojana Stefanoska[1], Daniel Carralero[2], Teresa Estrada[2], Thomas Windisch[3], Emmanouil Marakoudakis[2], José Luis Velasco[2], and the W7-X team[3] — [1]Max Planck Institute for Plasma Physics, 85748 Garching, Germany — [2]Laboratorio Nacional de Fusion. CIEMAT, 28040 Madrid, Spain — [3]Max Planck Inst. for Plasma Physics, 17491 Greifswald, Germany

Prolonged operation of the NBI system during the 2023 W7-X campaign refined a high-performance scenario combining NBI and ECRH heating. The NBI+ECRH high-performance (HP) phase exhibits a substantial increase in ion temperature and plasma energy. To study this scenario, the Doppler reflectometry (DR) system was upgraded with an E-band reflectometer, enabling core measurements of density fluctuations and the radial electric field E_r in high-density discharges.

DR measurements show that density fluctuation amplitude decreases as a strong density gradient builds during the pure NBI phase. The strong dependence of turbulence amplitude on the gradient ratio η_i indicates ITG-like turbulence in the core. E_r profiles remain flat before the HP phase and form a strong negative E_r well during it, accurately predicted by neoclassical simulations. Further turbulence reduction is observed in the HP phase, correlating with regions of strong radial electric field. These findings highlight the role of high density gradients in suppressing ITG-like turbulence, enabling improved performance with additional heating.

P 17.37 Wed 16:15 ZHG Foyer 1. OG

Quantification and analysis on the formation of a secondary strike line in the Wendelstein 7-X stellarator — •Sebastian Dräger[1], Thierry Kremeyer[1], Yu Gao[1], Robert Wolf[1,2], and Felix Reimold[1] — [1]Max Planck Inst. for Plasma Physics, 17491 Greifswald, Germany — [2]Technical University of Berlin, Strasse des 17. Juni 135, 10623 Berlin, Germany

In future magnetic confinement fusion reactors, efficient particle exhaust is essential for sustained operation. Helium ash, generated during fusion reactions, and other impurities must be removed to enable steady-state fusion and maintain plasma stability. Since ionized particles are confined by magnetic fields, their removal requires neutralization. For this purpose, Wendelstein 7-X (W7-X) employs an island divertor system. Magnetic islands intersect with target plates, where particles neutralize upon contact, allowing their exhaust. These interactions form high-intensity regions known as strike lines. The divertor plates are meticulously engineered to endure the plasma's heat flux. However, unexpected shifts in heat flux topology pose a significant risk to their integrity.

Recent observations at W7-X have revealed under certain operational conditions the formation of a secondary strike line [1]. This phenomenon, identified through infrared imaging and H_α photon emission, represents a notable change in the heat flux pattern. A precise quantification of the secondary strike line and an analysis of its dependence on plasma parameters is presented.

[1] Yu Gao et al 2024 Nucl. Fusion **64** 076060

P 17.38 Wed 16:15 ZHG Foyer 1. OG

Hybrid kinetic-MHD simulations of interactions between tearing modes and runaway electrons in JOREK — •Shijie Liu[1], Hannes Bergstroem[1], Tong Liu[2], Haowei Zhang[1], and Matthias Hoelzl[1] — [1]Max Planck Institute for Plasma Physics, Garching b. M., Germany — [2]Dalian University of Technology, Dalian, China

Runaway electrons (REs) are of particularly importance to the safe operation of tokamaks. Electrons may be accelerated by the large toroidal electric field arising during a major disruption. Without adequate mitigation measures, these energetic electrons may eventually hit the first wall of the device focusing on an extremely localized area, which poses a serious threat to the safe operation of the device. To predict the runaway dynamics during a disruption and develop mitigation strategies, the mutual interaction between REs and the bulk plasma should be carefully considered.

In this work, we focus on developing a self-consistent coupling of the full-f relativistic PIC model for REs to the background plasmas with a guiding center treatment, using the nonlinear extended MHD code JOREK. The accurate representation of the radial force balance of a circular axisymmetric RE beam is verified by comparing to analytical results. Moreover, a comparison to the 3D tearing modes linear theory is done for the MHD simulation with REs. Finally, non-linear results are presented for tearing modes in the presence of runaway electrons with different Δ'.

P 17.39 Wed 16:15 ZHG Foyer 1. OG

In-situ Uptake Measurement and Modelling of Deuterium Atoms in Self Damaged Tungsten at Different Temperatures — •Abdulrahman Albarodi, Thomas Schwarz-Selinger, and Mikhail Zibrov — Max-Planck-Institute for Plasma Physics, Garching bei München

Self-damaged tungsten samples (damage dose 0.23 dpa) were exposed to low energy deuterium (D) atoms (< 5 eV) at 400, 500 and 600 K to investigate D uptake and D retention at different temperatures. The time evolution of the D depth profile was observed in-situ with ^{3}He nuclear reaction analysis at different uptake times. Thermal desorption spectroscopy was performed ex-situ to determine the bulk and surface model parameters. A modified surface coverage-dependent model was used to describe the results and extended to lower temperatures in the tungsten samples. The extended model was implemented in TESSIM hydrogen transport simulations. Effects of grain boundary diffusion on D depth profile evolution were also investigated by comparison with results from a D atom exposure experiment on a tungsten single crystal at 500 K.

P 17.40 Wed 16:15 ZHG Foyer 1. OG

Validation of a Comprehensive First-Principles-Based Framework for Predicting the Performance of Future Stellarators — •Don Lawrence Carl Agapito Fernando[1], Alejandro Bañón Navarro[1], Daniel Carralero[2], Jose Luis Velasco[2], Arturo Alonso[2], Alessando Di Siena[1], Felix Wilms[1], Frank Jenko[1], and W7-X Team[3] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [2]Laboratorio Nacional de Fusión, CIEMAT, Madrid, Spain — [3]Max-Planck-Institut für Plasmaphysik, Greifswald, Germany

Validation studies are necessary to ensure the accuracy of simulation predictions relative to experimental results. In this poster, we showcase the results of the successful comprehensive validation of the GENE-KNOSOS-Tango simulation framework for predicting the steady-state plasma profiles in a stellarator. This framework couples the gyrokinetic turbulence code GENE, the neoclassical transport code KNOSOS, and the transport code Tango in a multiple-timescale simulation loop.

We perform ion-scale kinetic-electron and electron-scale adiabatic-ion flux-tube simulations to evolve the density and temperature profiles for four OP1.2b W7-X scenarios. The simulated profiles show excellent quantitative agreement with experimental data, while turbulence properties, such as density fluctuations and heat diffusivities, match the trends extracted from diagnostic measurements. The validation of the GENE-KNOSOS-Tango framework enables us to make credible predictions of physical phenomena in stellarators and reactor performance.

P 17.41 Wed 16:15 ZHG Foyer 1. OG

ECRH Power deposition and Te perturbation investigations using dynamic ECE analysis — •Vaishnavi Murugesan, Matthias Hirsch, Gavin Weir, Juan Fernando Guerrero Arnaiz, Neha Chaudhary, and Robert Wolf — Max Planck Institute for Plasma Physics

At Wendelstein 7-X, the plasma electron temperature profile is derived by assuming that the Electron Cyclotron Emission (ECE) behaves like a blackbody radiation from a certain layer in the plasma. When the plasma is heated using Electron Cyclotron Resonance Heating (ECRH), the microwave beams are absorbed in a thin layer where they are in resonance with the gyration frequency of the electrons. When the ECRH beam power is modulated, perturbations in plasma temperature are initiated, that propagate away from the deposition zone. This modulation is observed as an immediate response in the ECE signals. The goal of this work is to study this zone of power deposition.

A first approach is to do a conditional averaging over the modulation periods and deriving a slope of the local dT/dt that allows the calculation of the power deposition profile. To study the temperature profile during these modulation events, the radiometers should sample at a rate that is at least twice the collision rate of the electrons during these events. For this, a high frequency-resolution radiometer backend called the ZOOM system, has been upgraded to help monitor the power deposition zones at high sampling rates.

P 17.42 Wed 16:15 ZHG Foyer 1. OG

Divertor island studies with GRILLIX — •Barnabas Csillag, Andreas Stegmeir, Christoph Pitzal, Marion Finkbeiner, and Frank Jenko — Max Planck Institute for Plasma Physics, Garching, Germany

The global, electromagnetic, drift-reduced, trans-collisional Braginskii fluid turbulence code GRILLIX has been recently adapted to stellarator geometry. However, in order to perform comprehensive simulations of the Wendelstein 7-X Scrape-Off Layer (SOL) plasma, it is necessary to reconsider the treatment of boundary conditions in the model. So far the Immersed Boundary Approach (IBA) has been applied in GRILLIX, and using that the code was able to produce high fidelity tokamak edge-SOL simulations in diverted geometry. Nevertheless, the 3D geometry of the W7-X island divertors could present an insurmountable obstacle with such approach.

To examine the effects of boundary condition treatments in GRILLIX, a simplified divertor island geometry is investigated. In this test environment a circular toroidal magnetic field is applied with helical perturbations superimposed on it, creating the magnetic islands at a rational surface. In this model the magnetic islands can be intersected with poloidal target plates that are following the helical shape of the islands, similarly to the divertor plates of Wendelstein 7-X. Such setup is suitable to test the boundary condition treating methods, like the already implemented IBA, or if it is not found sufficient, for instance the Leg Value Fill scheme.

P 17.43 Wed 16:15 ZHG Foyer 1. OG

Simulation of fully global electromagnetic turbulence in the stellarator W7-X — •Yann Narbutt[1], Ksenia Aleynikova[1], Matthias Borchardt[1], Ralf Kleiber[1], Alexey Mishchenko[1], Edilberto Sánchez[2], and Alessandro Zocco[1] — [1]Max Planck Institute for Plasma Physics, Wendelsteinstraße 1, 17489 Greifswald — [2]Laboratorio Nacional de Fusión, CIEMAT, Avda. Complutense 40, Madrid 28040

Magnetic confinement fusion needs high values of $\beta = \langle p \rangle / (B^2/2\mu_0)$, the ratio of plasma pressure to magnetic pressure, to achieve high performance. Moderate β can be beneficial for ion-temperature-gradient suppression. However, when β exceeds a certain threshold, the so-called kinetic ballooning mode (KBM) and other electromagnetic instabilities may be destabilized. These instabilities, driven by plasma pressure gradients and inherently electromagnetic, can result in strong outward-directed heat fluxes, thereby degrading plasma confinement, as has been shown by global nonlinear simulations. While KBMs have been successfully studied linearly and nonlinearly in the Wendelstein 7-X stellarator using flux-tube simulations, it has also been demonstrated that the instability tends to become most unstable as it develops a global structure on the magnetic surface. Utilizing the global gyrokinetic code EUTERPE electromagnetic instabilities and turbulence are investigated in the stellarator Wendelstein 7-X at β-values of 1%, 2.5% and 4%.

P 17.44 Wed 16:15 ZHG Foyer 1. OG

Tightest possible energetic bounds on local gyrokinetic instabilities — •Paul Costello and Gabriel Plunk — Max Planck Institute for Plasma Physics, Greifswald, Germany

The turbulence in fusion plasmas, which hampers their performance in many respects, is best understood with gyrokinetic theory. Recent work has shown that energetic upper bounds on the growth of turbulence causing gyrokinetic instabilities can be derived by seeking optimal modes, states of the gyrokinetic equation which maximise the growth of an energy norm [2]. Typically, an energy norm is chosen which is a nonlinear invariant of the gyrokinetic equation, such that the bounds are valid linearly and nonlinearly.

The growth of unstable linear eigenmodes, which are the focus of much theoretical and numerical work, is also bounded by the optimal mode growth rate. A natural question, which we seek to answer in this work, is, "How tightly can the linear eigenmode growth be bounded?" We find that using a special energy norm which is not a nonlinear invariant in most systems gives an upper bound equal to the growth of the most unstable linear eigenmode. This energy norm is a sum of projection coefficients in the linear eigenmode basis and is positive definite by the completeness of these modes [2]. Systems for which this energy norm is a nonlinear invariant are free from subcritical turbulence and may form a simple paradigm for turbulence saturation [3].

[1] G. G. Plunk & P. Helander. JPP 2022.
[2] K. M. Case. Annals of Physics 1959.
[3] G. G. Plunk. Phys. Plasmas 2015.

P 17.45 Wed 16:15 ZHG Foyer 1. OG

Feedback Controlled Phase Contrast Imaging at Wendelstein 7-X — •Max Zimmermann[1], Adrian von Stechow[1], Jan-Peter Bähner[2], Søren Kjer Hansen[2], Sean Ballinger[2], Olaf Grulke[1,3], Eric Edlund[4], Miklos Porkolab[2], and The W7-X Team[1] — [1]Max Planck Institute for Plasma Physics, 17491 Greifswald, Germany — [2]MIT Plasma Science and Fusion Center, Cambridge, MA 02139, USA — [3]Technical University of Denmark, 2800 Kongens Lyngby, Denmark — [4]SUNY Cortland, Cortland, NY 13045, USA

The phase contrast imaging (PCI) diagnostic at Wendelstein 7-X (W7-X) is used for detection of core turbulence density fluctuations [E.M. Edlund et al. 2018 Rev. Sci. Instrum. 89 10E105]. This is done by imaging electron density fluctuations using a CO_2 laser. The laser is aligned using several mirrors, some of which are attached to the outer vessel of W7-X and are therefore subject to vibrations from auxiliary systems (e.g. vacuum pumps). These vibrations lead to movements of the image plane and are visible in the PCI signal as low frequency components up to 250 Hz. A reduction of these vibrations leads to increased beam position stability and a higher signal saturation limit for PCI signals. A digital RST feedback controller is designed and implemented, which together with a piezo-based fast steering mirror and a four quadrant detector forms an active vibration compensation system. The controller design is validated by frequency response measurements and its impact on plasma fluctuation signals is evaluated.

P 17.46 Wed 16:15 ZHG Foyer 1. OG

Comparision of absolute calibration techniques for the Thomson scattering diagnostic at W7-X — •Jannik Wagner, Golo Fuchert, Ekkehard Pasch, K. Jakob Brunner, Jens Knauer, Sergey A. Bozhenkov, Matthias Hirsch, Robert C. Wolf, and W7-X Team — Max Planck Insitute for Plasma Physics, Germany

Thomson scattering is a cornerstone diagnostic for determining plasma electron density and temperature in many nuclear fusion experiments, such as Wendelstein 7-X (W7-X). To reconstruct these parameters, absolute spectral calibration

factors of the diagnostics' optical detection system are required. At W7-X, two calibrations are performed to determine these factors: A relative spectral calibration and an absolute calibration using Raman scattering of Nd:YAG laser pulses in Nitrogen. The relative calibration of the system is needed for electron temperature measurement, interpretation of the absolute calibration and extension of the latter into wavelength ranges inaccessible by Raman scattering. A recent study [1] proposes that Rayleigh scattering of laser pulses from a wavelength tunable optical parametric oscillator (OPO) in Argon could serve as a standalone-source for the absolute calibration. The calibration method has the potential to drastically reduce the systematic errors occurring from a strong dependence of the absolute calibration factors on the accuracy of the wavelength measurement in the spectral range of the Raman scattered signal. In this work, the conventional Raman calibration procedure is compared with the promising direct measurement using an OPO.

[1] E.R. Scott et al. JINST 14 C10033 (2019)

P 17.47 Wed 16:15 ZHG Foyer 1. OG

Towards a standard Diagnostic for not absorbed Electron Cyclotron Resonance Heating power at Wendelstein 7-X — •Jonas Zimmermann, Torsten Stange, Heinrich Laqua, Dmitry Moseev, and Johan Oosterbeek — IPP Greifswald

Electron cyclotron resonance heating (ECRH) at 140 GHz is the primary heating method of the Wendelstein 7-X device, a magnetically confined plasma experiment with the goal to demonstrate 30 minute plasma operation. Gaussian beams, with a power of about 1 MW each, are radially injected into the plasma, propagate as plasma waves, and are absorbed at the resonance where their frequency matches the 2nd harmonic of the electron cyclotron frequency. Non-absorbed radiation leaves the plasma and hits the wall opposite to the ECRH launchers. During long pulse operation, even a small percentage of non-absorbed power is sufficient to cause critical head loads on directly hit components. Therefore, a primary objective is to deposit the power only in the plasma and to guarantee the optimal parameters for polarization and direction of the beam. The wall opposite to the ECRH launchers is equipped with an antenna array called Electron Cyclotron Absorption (ECA) diagnostic, capable of detecting the power density and sensitive to the polarization of the transmitted beams. It is planned to use this diagnostic to routinely measure the fraction of non-absorbed power caused by various plasma effects or incorrect beam parameterization. This poster presents initial results of the ECA diagnostic on absorption, refraction, and beam parameter changes, and outlines steps toward a quantitative absorption diagnostic.

P 17.48 Wed 16:15 ZHG Foyer 1. OG

Characterisation of the assimilation of shattered pellets injected into a fusion plasma — •Ansh Patel[1], G Papp[1], A Matsuyama[2], S Jachmich[3], ASDEX Upgrade Team[4], and EUROfusion Tokamak Exploitation Team[5] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Kyoto University, Uji, Kyoto, Japan — [3]ITER Organization, St. Paul-lez-Durance, France — [4]See the author list of H. Zohm et al, Nucl. Fusion 2024 — [5]See the author list of E. Joffrin et al, Nucl. Fusion 2024

A disruption mitigation system (DMS) is necessary for reactor-relevant tokamaks like ITER to ensure the preservation of machine components throughout their designated operational lifespan. To address the intense heat and electromagnetic loads during a disruption, a shattered pellet injection (SPI) system will be employed. The SPI system involves injecting material into the plasma in the form of a cryogenic pellet that is shattered on a bent tube before entering the plasma. The penetration and assimilation of the injected material is influenced by various SPI parameters, including the fragment sizes, speeds, composition and the injection scheme. In this contribution, the material assimilation during SPI in the ASDEX Upgrade tokamak is characterized. The influence of different SPI parameters and different injection schemes on assimilation is carried out to determine optimal parameters for mitigation. The spatial distribution of material ablation and assimilation was carried out. Experimental analysis is also complemented with modelling with the 1.5D INDEX code to understand the plasma dynamics and its dependence on the aforementioned SPI parameters.

P 17.49 Wed 16:15 ZHG Foyer 1. OG

Fast Surrogate Modeling of Radio-Frequency Minority Heating at ASDEX Upgrade — •Michael Sieben, Markus Weiland, Roberto Bilato, and ASDEX - Team — Max-Planck-Institute for Plasma Physics

Auxiliary heating is essential to achieve the burning plasma conditions in fusion reactors. Radio-frequency waves in the Ion Cyclotron Range of Frequency (ICRF) are one of the possible auxiliary heating system in present devices and planned for ITER. The combined full-wave and Fokker-Planck code package TORIC-SSFPQL [1] provides accurate heating profiles for transport modeling in view of discharge analysis and design. However, long computation times pose challenges for fast transport simulations and real-time applications. We present a fast neural network (NN) surrogate model that reproduces minority heating profiles in deuterium-hydrogen plasmas at the ASDEX Upgrade (AUG) research reactor with real-time capability and high accuracy - comparable to an approach reported for NSTX and WEST [2]. We highlight possible directions for future work that could improve model accuracy - particularly by accounting for second harmonic heating and integrating equilibrium parameters into the model, which has been found to play a relevant role at AUG.

[1] M. Brambilla and R. Bilato. Nuclear Fusion, 49(8):085004, 2009. [2] Á. Sánchez-Villar, Z. Bai, et al. Nuclear Fusion, 64(9):096039, 2024.

P 18: Codes and Modeling/HEPP

Time: Thursday 11:00–12:35 Location: ZHG102

Invited Talk P 18.1 Thu 11:00 ZHG102

Simulating W erosion, transport, and deposition in Ne-seeded discharges in ITER with full-W wall — •Christoph Baumann[1], Juri Romazanov[1], Sebastian Rode[1], Andreas Kirschner[1], Sebastijan Brezinsek[1,2], Tom Wauters[3], and Richard Pitts[3] — [1]FZ Jülich, Germany — [2]HHU Düsseldorf, Germany — [3]ITER Organization, France

Plasma-wall interaction processes like erosion are a challenge for efficient long-term operation of fusion devices. Numerical modelling of such processes is inevitable to get better understanding of experiments in present day machines like AUG, but also to make predictions for future machines like ITER. Especially the recent re-baselining to a full Tungsten (W) ITER requires dedicated studies on seeding impact on first wall erosion due to higher W sputter yields as compared to hydrogen isotopes in the plasma fuel. The present work therefore investigates W erosion and migration in Ne-seeded Q=10 H-mode ITER plasmas using the three-dimensional Monte-Carlo code ERO2.0. The code calculates both the erosion under ion or charge-exchange neutral impact and the migration of eroded impurities through the plasma, including atomic processes like ionization/recombination, as well as impurity re-deposition/re-erosion. The simulations reveal highly-charged Ne and W self-sputtering to be the main source of erosion, which is related to high far-SOL temperature conditions for electrons, 20 eV, and ions, 40 eV. The contribution of D on W erosion in contrast is smaller by two orders of magnitudes. In addition, strong W net deposition is observed in the inner divertor, indicating strong W transport into the divertor.

P 18.2 Thu 11:30 ZHG102

Structure-preserving Hybrid Code, STRUPHY: Energy-conserving Hybrid MHD-driftkinetic Model — •byung kyu na[1,2], stefan possanner[1], xin wang[1], and yingzhe li[1] — [1]Max Planck Institute for Plasma Physics, Boltzmannstraße 2, 85748 Garching, Germany — [2]Technical University of Munich, Boltzmannstraße 3, 85748 Garching, Germany

A Python package STRUPHY (STRUcture-Preserving HYbrid codes) features a collection of PDE solvers based on Geometric finite element method (FEEC) and Particle-in-cell method (PIC). One of the main applications of the STRUPHY is a simulation of hybrid MHD-kinetic systems in curved three-dimensional spaces where the bulk plasma is treated as MHD fluid and energetic particles (EPs)are described kinetically. We introduce energy-conserving hybrid MHD-driftkinetic models which were newly implemented in STRUPHY. Existing hybrid MHD-kinetic models often suffer from not conserving the total energy, especially when reduced kinetic models are used to describe EPs such as driftkinetic or gyrokinetic. However, this property was recently restored by adding additional terms derived from variational principles. The capabilities and properties of the implemented scheme will be investigated with the preliminary results of the ITPA benchmark case.

P 18.3 Thu 11:55 ZHG102

A Stochastic Variational Principle for a Two-Fluid Model Arising in Fusion Plasma Physics — •Sayyed Amin Raiessi Toussi[1], Omar Maj[1], and Tomasz Tyranowski[2] — [1]Max Planck Institute for Plasma Physics, D-85748 Garching, Germany — [2]Faculty of Electrical Engineering, Mathematics and Computer Science, University of Twente, 7522NH Enschede, The Netherlands

This work proposes a stochastic variational principle for a quasi-neutral, two fluid model of a plasma in a fixed magnetic field, including dissipative effects

such as particle diffusion, viscosity and heat fluxes. The variational formulation is motivated by the development of a variational smooth particle method for transport simulation in complex stellerator geometries. In the absence of dissipative effects the model admits both a Lagrangian and a corresponding Euler-Poincaré reduced variational principle. The main variables in the Lagranigan picture are the fluid flows, which describe the displacement of the ion and the electron fluid, respectively. Dissipative effects are incorporated by stochastic perturbation of the underlying flows, closely following the work of Chen et al [X. Chen, A. B. Cruzeiro and T. Ratiu, J. Nonlinear Sci. 33, 5 (2023)]. In this formulation elements of the theory of compressible, viscous flows are combined with Lagrangian constraints coming from quasi-neutrality. Finally, using particle methods, we will present a semi-discretized version of the proposed variational principle.

P 18.4 Thu 12:20 ZHG102

Energy- and angle-dependent boundary condition for the electron kinetics of a plasma — •Clemens Hoyer[1], Felix Willert[1], Gordon K. Grubert[2], Detlef Loffhagen[3], Markus M. Becker[3], and Franz X. Bronold[1] — [1]Institut für Physik, Universität Greifswald, 17489 Greifswald, Germany — [2]Universitätsrechenzentrum, Universität Greifswald, 17489 Greifswald, Germany — [3]Leibniz-Institut für Plasmaforschung und Technologie, 17489 Greifswald, Germany

For an electron Boltzmann equation we derive a Marshak type energy- and angle-dependent boundary condition, containing the electron microphysics inside the wall. It uses the electron surface scattering kernel [1], describing electron reflection as well as secondary emission from a microscopic solid-state physics point of view. We incorporate the kernel within an Legendre polynomial expansion approach for solving the electron Boltzmann equation [2], but the kernel can be also used for PIC-MCC simulations of the plasma's electron kinetics. Numerical results for an argon plasma in contact with a silicon surface are presented, showing the significance of the microphysics-based boundary condition compared to an energy- and angle-independent phenomenological one. [1] F.X. Bronold and F. Willert, Phys. Rev. E **110**, 035207 (2024). [2] M. M. Becker, G. K. Grubert, and D. Loffhagen, Eur. Phys. J. Appl. Phys. **51**, 11001 (2010). F.X.B. and F.W. acknowledge support by Deutsche Forschungsgemeinschaft (DFG, German Research Foundation)–495729137.

P 19: Low Pressure Plasmas and their Applications II

Time: Thursday 11:00–12:30 Location: ZHG006

Invited Talk P 19.1 Thu 11:00 ZHG006

A plasma process model for high power impulse magnetron sputtering discharges — •Martin Rudolph[1], Daniel Lundin[2], and Jon Tomas Gudmundsson[3,4] — [1]Leibniz Institute of Surface Engineering (IOM), Leipzig, Germany — [2]Plasma and Coatings Physics Divsion, Linköping University, Linköping, Sweden — [3]Science Institute, University of Iceland, Reykjavik, Iceland — [4]Division of Space and Plasma Physics, KTH Royal Institute of Technology, Stockholm, Sweden

High-power impulse magnetron sputtering (HiPIMS) processes are widely used for thin-film deposition. They rely on pulsed high discharge currents to generate a dense plasma that promotes the ionization of sputtered atoms. The ionization region model (IRM) is a semi-empirical model of the HiPIMS process. Its advantage is its computational speed, a critical factor for a process model designed to explore the vast parameter space in HiPIMS. Using the IRM, the influence of external discharge parameters on relevant internal plasma parameters can be disentangled. In this contribution, we show how the electron density in the ionization region scales with the peak discharge current, while the electron temperature scales with the sputter yield of the target material. A fraction of the ionized sputtered atoms is drawn back to the target due to its negative voltage, resulting in their loss from the deposition process. Consequently, a higher ionization of sputtered species is inherently linked to a reduction in the deposition rate. We demonstrate how these two parameters can be optimized when developing a HiPIMS process.

P 19.2 Thu 11:30 ZHG006

Investigations of EUV-induced low density hydrogen plasma in a stand-alone high-intensity irradiation setup — •Adelind Elshani[1], Linus Nagel[1], Ismael Gisch[1], Sascha Brose[1,2], Hendrik Kersten[3], Annika Bonhoff[1], Thorsten Benter[3], and Carlo Holly[1,2] — [1]RWTH Aachen University TOS, Aachen — [2]Fraunhofer Institute for Laser Technology ILT, Aachen — [3]University of Wuppertal, Physical and Theoretical Chemistry, Wuppertal

The interaction of high-intensity EUV radiation with low-pressure hydrogen gas induces a low-density hydrogen plasma. Understanding the underlying chemical and dynamic processes is essential yet complicated due to plasma formation complexity. Influencing variables are often correlated, making it challenging to investigate relevant quantities independently in existing setups. Investigations that decouple these variables are crucial for a deeper understanding of EUV-induced plasmas. The developed stand-alone high-intensity irradiation setup (EUV-HIEX) reduces complexity and allows the investigation of fundamental dependencies with mostly unbiased parameters. High-intensity exposures are achieved with high spectral purity around 13.5 nm, high vacuum quality, and symmetrical vacuum chamber geometry. Coupling diagnostics enables detailed studies of plasma-induced chemistry and dynamics. Additionally, a modeling framework is developed to link experimental data with theoretical models. The presentation covers the key components of the EUV-HIEX setup, the modeling framework, and the first experimental results, along with an analysis of simulation results regarding electron dynamics.

P 19.3 Thu 11:45 ZHG006

Characterization of a combination sensor for the diagnostic of process plasmas — •Daniel Zuhayra[1], Caroline Adam[1], Michael Weise[2], Thomas Trottenberg[1], and Holger Kersten[1] — [1]Christian-Albrechts-Universität zu Kiel — [2]Optotransmitter-Umweltschutz-Technologie e.V.

Energy and particle fluxes significantly impact the surface properties of a substrate in contact with a plasma. Therefore, process control of these parameters by plasma diagnostic methods is of special interest for industrial applications. In this study, we characterized an in-house build, combination diagnostic comprised of a Retarding-Field-Analyzer (RFA) and a Passive-Thermal-Probe (PTP), called Retarding-Field-Thermal-Probe (RFTP), for the study of energy and particle fluxes. The PTP acts as the collector of the RFA and, thus, enables the nearly simultaneous measurement of ion energy distribution and energy influx. Thereby, it is possible to split the energy flux contributions of ions and neutrals. The functionality of the diagnostic was tested in a capacitively coupled plasma (CCP) at a frequency of 13.56 MHz, a conventional direct current magnetron (DC-magnetron), a radio frequency magnetron (RF-magnetron) and in HiPIMS at various discharge conditions. The results reveal an operational area for the RFTP at pressure < 10 Pa and moderately high discharge power, limited by the dimensions, heat capacity and grid transparency of the probe.

P 19.4 Thu 12:00 ZHG006

Characterization of a plasma source for atomic tritium — •David Frese for the KAMATE-Collaboration — Tritiumlabor Karlsruhe am Institut für Astroteilchenphysik, KIT

The Karlsruhe Tritium Neutrino (KATRIN) experiment will determine a neutrino mass with a sensitivity of <0.3 eV by electron spectroscopy of the tritium beta-decay spectrum. In order to improve the sensitivity on the neutrino mass down to inverted mass ordering range or below new technologies are necessary. One proposed improvement is to use atomic tritium instead of molecular tritium. In the beta-decay of the T-atom, the intrinsic molecular broadening of about 0.4 eV is absent in the beta-decay spectrum.

The first step in generating a source based on tritium atoms is the dissociation of T_2. Therefore, various atomic tritium dissociators need to be commissioned and characterized. To address this challenge, the joint Karlsruhe Mainz Atomic Tritium Experiment (KAMATE) group was established to investigate potential atomic tritium sources. The performance of commercial dissociators is studied initially by non-radioactive hydrogen and deuterium, before transitioning to experiments with substantial amounts of tritium.

This talk presents the dissociation concept of a plasma source and highlights its advantages and disadvantages. The plasma operation may sputter off boron nitride from the cavity walls which would be detrimental for the operation. This process will be investigated in a dedicated setup. After that, the atomic fraction of the plasma dissociator outlet is studied by mass spectrometry.

P 19.5 Thu 12:15 ZHG006

Plasma Sheath Tailoring for Advanced 3d Plasma Etching: Effects of Mask Geometry and Etching Materials — •Elia Jüngling, Gerardo Gutiérrez, Marc Böke, and Achim von Keudell — Ruhr University Bochum, Germany

Three-dimensional (3D) etching of materials by plasmas represents a significant challenge for microstructuring applications to produce advanced sensors, optics and microfluidics. Previously, we proposed the use of a local magnetic field in combination with a metallic mask to manipulate the plasma dynamics above the substrate and have achieved asymmetric etching profiles [1]. The experiments were explained regarding the $\vec{E}\times\vec{B}$ drifts during the local sheath expansion in the RF plasmas. This controls the plasma density distribution above and the transport to the surface.

This concept is further investigated for the application of glass and Si 3d etching in an Ar/CF4 plasma. In the case of glass, the effect of spatially different etch-

ing rates is significantly more pronounced than that of silicon. This is presumed to be due to the differences in the etching chemistry of silicon vs. glass. Furthermore, the effect of different mask geometries has been explored. It has been demonstrated that the mask shape influences both the redeposition of sputtered CF-containing polymers from the mask surface onto the substrate and the etching profiles.

[1] Jüngling et al. Plasma sheath tailoring by a magnetic field for three-dimensional plasma etching. Appl. Phys. Lett. 12 Feb 2024; 124 (7): 074101.

P 20: Magnetic Confinment Fusion/HEPP V

Time: Thursday 13:45–15:50 Location: ZHG102

Invited Talk P 20.1 Thu 13:45 ZHG102

First applications of the kinetic ion transport module in the EMC3-EIRENE code package — •Derek Harting[1], Dirk Reiser[1], Christoph Baumann[1], Sebastian Rode[1], Juri Romazanov[1], Sebastijan Brezinsek[1,2], Heinke Frerichs[3], Alexander Knieps[1], and Yuhe Feng[4] — [1]FZ-Jülich, Institute of Fusion Energy & Nuclear Waste Management - Plasma Physics — [2]HHU Düsseldorf, Faculty of Mathematics and Natural Sciences — [3]UW - Madison, Department of Engineering Physics — [4]MPG Institute for Plasma Physics

Impurity seeding in the scrape off layer plasma as well as controlling the contamination of the core plasma by high Z impurities are essential for ITER baseline scenarios. While fluid models are often used to describe impurity transport, short-lived lower ionization stages of high-Z impurities (e.g., W, Ar) may require a kinetic treatment due to their non-Maxwellian velocity distributions. To address these kinetic effects, the EMC3-EIRENE code package has been extended with a trace kinetic ion transport module in guiding center approximation. This module includes grad-B drifts, mirror-force effects and anomalous cross-field diffusion. Benchmarks with the kinetic ion transport code ERO2.0 showed fair agreement, validating the implementation. First simulations of a tungsten source in the ITER divertor region under an attached, medium-density L-mode plasma scenario demonstrate the module's capabilities. These advancements enhance predictions of impurity transport and plasma contamination control, crucial for ITER and future fusion devices.

P 20.2 Thu 14:15 ZHG102

About recent progress in collisional-radiative modelling of molecular hydrogen plasmas — •Richard Christian Bergmayr, Dirk Wünderlich, and Ursel Fantz — Max Planck Institute for Plasma Physics, Garching, Germany

Collisional-radiative (CR) models for molecular hydrogen are crucial for the quantitative analysis of molecular emission from low temperature plasmas (e.g. fusion divertor plasmas) and are suited to predict effective rate coefficients for neutral kinetic codes (e.g. EIRENE) in order to understand the extent to which molecules contribute to the detachment process. The accuracy of CR model predictions is limited by the availability of accurate reaction probabilities as model input. The latest advances in molecular input data motivate the development of a fully ro-vibrationally resolved CR model for molecular hydrogen. A multi-stage approach is pursued, in which population models with different detail level of (ro-vibrational) resolution are composed based on the Yacora solver. These models utilize specifically for their purpose composited databases of recent reaction probabilities, are successfully benchmarked on various experiments (e.g. divertor plasmas, linear devices and small scale laboratory experiments) and are employed for different, dedicated fields of applications. This includes the first time quantification of the influence of spin-mixing processes, post-processing EDGE2D-EIRENE JET L-mode profiles in comparison to predictions by the AMJUEL database (which is used as a standard in EIRENE) and unprecedentedly accurate, ro-vibrationally resolved Fulcher-α band emission predictions.

Invited Talk P 20.3 Thu 14:40 ZHG102

Simulating boundary turbulence in fusion reactors in different confinement, ELM and detachment regimes — •Wladimir Zholobenko[1], Andreas Stegmeir[1], Kaiyu Zhang[1], Konrad Eder[1], Jan Pfennig[1], Christoph Pitzal[1], Philipp Ulbl[1], Matthias Bernert[1], Michael Griener[1], and the ASDEX Upgrade Team[2] — [1]MPI for Plasma Physics, Garching, Germany — [2]see author list of H. Zohm et al., 2024 Nucl. Fusion

Magnetic confinement fusion reactors must combine high plasma energy confinement with manageable heat exhaust. Both are determined to a large degree by turbulent transport across the very plasma edge. While present day experiments focus on finding optimal regimes of operation, only first-principles based computer simulations can make reliable extrapolations to future fusion reactors.

This contribution focuses on recent progress with the GRILLIX code in understanding high-confinement, detached and ELM-free regimes on the ASDEX Upgrade tokamak. Transitions between various micro-instabilities, their nonlinear dynamics and interaction with large-scale flows are shown to be important for the understanding of the varying plasma edge conditions. For optimal operation, plasma shaping and the control of the scrape-off layer and divertor dynamics are critical.

Turbulence is a multi-scale, chaotic, dynamical phenomenon. Simulating it challenges todays top tier supercomputers, in particular for even larger future machines. Therefore, optimized model complexity and software design are key to facilitate fusion reactor predictions.

P 20.4 Thu 15:10 ZHG102

Plasma turbulence modeling in detached regimes — •Konrad Eder, Wladimir Zholobenko, Andreas Stegmeir, Matthias Bernert, David Coster, and Frank Jenko — MPG-IPP, Garching, Germany

Predictive studies of the plasma edge in fusion reactors – particularly towards detachment – require self-consistent modeling of turbulent transport involving an interplay of plasma, neutral gas, and impurities.

We present extensions to the edge turbulence code GRILLIX, which applies a drift-fluid plasma model and a diffusive neutral gas model. The latter has been upgraded to a 3-moment fluid, i.e. neutral gas density, momentum, and pressure. Particle recycling is modeled by introducing novel boundary conditions compatible with the Flux-Coordinate-Independent (FCI) approach, on which GRILLIX is based and which enables it to handle complex diverted geometries.

In simulations of an attached ASDEX-Upgrade (AUG) L-mode discharge we first investigate how the model extensions affect neutrals and plasma near the divertor. Next, the updated model is validated against a fully detached AUG discharge featuring an L-mode X-point radiator (XPR) as part of an L-H transition. We are able to reproduce the XPR structure (radiating >80% of input power), a first-of-its-kind for turbulence simulations, and find the simulations to be in good agreement with experimental measurements at the Outboard-midplane and the divertor. Finally, we analyze distinct interchange-type turbulence found near the XPR structure, which helps elucidate our understanding of the XPR regime.

P 20.5 Thu 15:35 ZHG102

Helium exhaust studies in ASDEX Upgrade with a quadrupole mass spectrometer — •Simon Krumm[1,2], Athina Kappatou[1], Volker Rohde[1], Thomas Pütterich[1,2], Andreas Redl[1], and the ASDEX Upgrade Team[3] — [1]Max-Planck- Institut für Plasmaphysik, 85748 Garching, Germany — [2]Ludwig-Maximilians-Universität München, 80539 München, Germany — [3]see the author list of H. Zohm et al. 2024 NF 64 112001

Helium is the product of the fusion reaction used in future fusion power plants. Thermalised helium dilutes the fuel and has to be efficiently removed to sustain the fusion process. To understand and optimise helium exhaust processes, diagnostics are necessary to measure helium from the plasma core all the way to the pump ducts. To measure helium in the pump ducts and to determine pumping speeds, quadrupole mass spectrometers are used. However, the low mass difference between molecular deuterium and helium makes mass spectrometry challenging. We present the application of the Threshold Ionisation Mass Spectrometry (TIMS) method to accurately measure He and D partial pressures with high time resolution. Following its performance characterisation in a laboratory we then utilise the diagnostic in ASDEX Upgrade plasmas to study helium exhaust dynamics and to determine the helium pumping speed achieved with ASDEX Upgrades's new activated charcoal coated cryopump.

P 21: Atmospheric Plasmas and their Applications V

Time: Thursday 13:45–15:45 Location: ZHG006

Invited Talk P 21.1 Thu 13:45 ZHG006

Vacuum UV spectroscopy at atmospheric pressure plasmas utilizing silicon nitride membranes — •Luka Hansen[1,2], Görkem Bilgin[1], Hendrik Kersten[3], and Jan Benedikt[1,2] — [1]Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany — [2]Kiel Nano, Surface and Interface Science KiNSIS, Kiel University, Kiel, Germany — [3]Institute for pure and applied mass spectrometry, University of Wuppertal, Wuppertal, Germany

Vacuum ultraviolet (VUV) radiation is crucial for several applications including, e.g., the biomedical field or photocatalysis. A fundamental problem is the transfer from VUV radiation produced in an atmospheric pressure environment into the vacuum for further diagnostics, as typical window materials like LiF or MgF_2 are not suited for this transfer due to their cut off wavelength at 115 nm. Different approaches have been pursuit in the past to overcome this problem involving, e.g., differential pumping [1] or an aerodynamic window [2].

A new approach is utilizing a ultra-thin Si_3N_4 membrane with a thickness of 20 nm as entrance window. These membranes can withstand the pressure gradient of one atmosphere and showed resistance against plasma and plasma-generated species [3].

This approach allows to resolve spectra down to 58.4 nm (He resonance line) and reveal interesting self-absorption effects of noble gases influencing previously reported VUV spectroscopy measurements.

[1] F. Liu *et al.*, 2020 *Plasma Sources Sci. Technol.* **29** 065001
[2] J. Golda *et al.*, 2020 *Plasma Process. Polym.* **17** 201900216
[3] L. Hansen *et al.*, 2023 *Thin Solid Films* **765** 139633

P 21.2 Thu 14:15 ZHG006

controlled synthesis of NO and helium metastable measurement in atmospheric pressure RF plasma — •Siqi Yu, Steijn Vervloedt, Laura Chauvet, and Achim von Keudell — Ruhr-Universität Bochum, Bochum, Germany

Non-thermal plasma catalytic technology has promising potential to improve gas conversion efficiency. Our research focuses on nitrogen oxide synthesis, especially NO production, because of its broad range of applications in biological processes. NO_x species are generated in a parallel-plate atmospheric pressure RF plasma from N_2/O_2 admixed to helium. The concentrations are measured by FTIR spectroscopy using a multi-pass cell. The results show that NO's is further oxidized with increasing oxygen admixture and ozone generation. It can be controlled by increasing the surface temperature and by using a catalytic material that preferentially quenches O_3. Helium metastable species act as an energy pool and play a crucial role during the discharge. Broadband absorption spectroscopy is used as an in-situ method to measure absolute densities of atomic $He(2^3S_1)$ and molecular $He_2(a^3\Sigma_u^+)$ metastable species. A 1D global model is developed to fit the experimental data and analyze metastable generation and destruction mechanisms. The helium metastable induced desorption of adsorbed water causes a decay of the metastable density along the plasma channel. Surface materials with a lower work function exhibit stronger secondary electron emission, affecting the local heating at the plasma boundary sheath. This increases the rate for $He(2^3S_1)$ and $He_2(a^3\Sigma_u^+)$ conversion.

P 21.3 Thu 14:30 ZHG006

Impact of Long-Term Stability of Atmospheric Pressure Plasmas on Vacuum UV Spectroscopy — •Görkem Bilgin[1], Luka Hansen[1,2], and Jan Benedikt[1,2] — [1]Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany — [2]Kiel Nano, Surface and Interface Science KiNSIS, Kiel University, Kiel, Germany

The diagnostic of vacuum ultraviolet (VUV) photons generated by atmospheric pressure plasmas is challenging due to strong absorption of VUV photons in air and common window materials like lithium fluoride (LiF) and magnesium fluoride (MgF_2) [1]. Ultra-thin silicon nitride (Si_3N_4) membranes (20 nm) can withstand the pressure gradient and are resistant to plasma exposure, enabling VUV spectroscopic measurements.

During the operation of a capillary jet plasma source [2], the electrodes and plasma heat up, altering matching and reducing power input to the plasma. Stable operating conditions are essential to investigate potential changes in the Si_3N_4 membranes (e.g., chemical composition, transmission). Therefore, the existing setup was upgraded with a liquid cooling system.

VUV spectra with and without cooling highlight the need for active cooling to ensure stable operation. A stable VUV photon source is essential for studying long-term effects on the membrane. Additionally, the plasma source's tunability is shown by measuring VUV spectra while varying the working gas mixture.

[1] J. Golda *et al.*, 2020 *Plasma Process. Polym.* **17** 201900216
[2] T. Winzer *et al.*, 2022 *J. Appl. Phys.* **132** 183301

Invited Talk P 21.4 Thu 14:45 ZHG006

Hybrid fluid/MC simulations of radio-frequency atmospheric pressure plasma jets — •Mate Vass[1,2], Peter Hartmann[2], Zoltan Donko[2], Ihor Korolov[1], Thomas Mussenbrock[1], and Julian Schulze[1] — [1]Chair of Applied Electrodynamics and Plasma Technology, Ruhr-University Bochum, 44780 Bochum, Germany — [2]Institute for Solid State Physics and Optics, HUN-REN Wigner Research Centre for Physics, 1121 Budapest, Hungary

Radio-frequency (RF) driven atmospheric pressure micro plasma jets have a wide range of industrially relevant applications. In order to optimize them, a quantitative understanding of how the neutral species densities build up along the jet channel is needed. This is a result of the complex interplay between multiple processes on different timescales. While fluid simulations are usually employed for the description of these jets, they are unable to account for kinetic effects in case of the electrons, which however directly influences the plasma chemistry. Fully kinetic simulation methods, such as PIC/MCC, are, on the other hand, too impractical at atmospheric pressure, particularly for the complex gas mixtures relevant to applications. In this talk, a hybrid simulation method is presented, leveraging the time scale separation of physical processes and the kinetic description of electrons. The method combines a fluid model for charged and neutral species and a Monte Carlo module for electrons only. This approach achieves significant speedup compared to fully kinetic simulations while maintaining accuracy. Simulations of a He/O_2 mixture are presented, showing excellent agreement with experimental results.

P 21.5 Thu 15:15 ZHG006

Tunable diode laser absorption spectroscopy of all four Ar*($3p^5$4s) states in a pulsed-operated single-filament dielectric barrier discharge at atmospheric pressure — •Levin Krös[1], Hans Höft[1], Jean-Pierre H. van Helden[1,2], and Ronny Brandenburg[1,3] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Faculty of Physics and Astronomy, Ruhr University Bochum, Bochum, Germany — [3]Institute of Physics, University of Rostock, Rostock, Germany

Dielectric barrier discharges (DBDs) are a common plasma source for plasma enhanced chemical vapour deposition (PECVD), i.e. of thin functional films. Excited argon species have sufficient energy to dissociate or ionise molecular species and thus influence the discharge dynamics. Tunable diode laser absorption spectroscopy is utilised to measure absolute number densities of the Ar*($3p^5$4s) states. Detailed knowledge of the population distribution of the four lowest energetically excited states of argon (Ar*($3p^5$4s) states, i.e. the resonance states ($1s_2$, $1s_4$) and the metastable states ($1s_3$, $1s_5$)), is of major interest for the benchmarking of numerical models to tailor the operating parameters for PECVD, e.g., the characteristics of the applied high-voltage pulse and the gas flow rate. We report the first results of density measurements of these states in a pulsed-operated DBD with a 3 mm gas gap flown through with argon at atmospheric pressure. This work is funded by the DFG (project number: 504701852).

P 21.6 Thu 15:30 ZHG006

N-butane conversion in an RF plasma combined with a catalyst — •Fatma-Nur Seferoglu[1], Steijn Vervloedt[2], and Achim von Keudell[2] — [1]Institute of Fusion Energy and Nuclear Waste Management, Forschungszentrum Jülich GmbH, Jülich, GERMANY — [2]Experimental Physics II, Ruhr-University, Bochum, GERMANY

Volatile organic compounds (VOCs) such as n-butane can negatively impact the environment, contribute to air pollution and can affect human health. Plasma catalytic systems are a promising technology for VOC removal. These systems, particularly in-plasma catalysis, can be very complex due to numerous chemical and physical processes that can take place simultaneously. Recently, different reaction kinetic models for the plasma-assisted conversion of n-butane have been proposed. However, the key reaction channels are still not fully known yet. In this work, a capacitively coupled plasma is generated at 13.56 MHz in atmospheric pressure between two plane-parallel electrodes spray-coated with MnO_2 as a catalyst. Fourier-Transform Infrared spectroscopy has been performed for a helium flow of 250 sccm and two different gas admixtures O_2: C_4H_{10}: He = 0.135%: 0.124%: 99.741%, and CO_2: He = 0.81%, to determine the species concentration inside the plasma-catalytic system. The comparison between the experiment and the proposed models reveals that O_2 adsorption is less dominant than CO_2 adsorption on the catalytic surface in the case of the oxygen-deficient n-butane conversion. In all cases, electron-impact CO_2 dissociation plays a mayor role in the plasma-catalytic system.

P 22: Plasma Wall Interaction/HEPP

Time: Thursday 16:15–17:35 Location: ZHG102

Invited Talk P 22.1 Thu 16:15 ZHG102

High-resolution optical emission spectroscopy of neutral W lines: comparing near-threshold sputtering of W with different crystal orientation in PSI-2 — •Marc Sackers[1], Oleksandr Marchuk[1], Stephan Ertmer[1], Sebastijan Brezinsek[1,2], Fredric Granberg[3], and Arkadi Kreter[1] — [1]Forschungszentrum Jülich GmbH, Institute of Fusion Energy & Nuclear Waste Management - Plasma Physics — [2]HHU Düsseldorf, Faculty of Mathematics and Natural Sciences — [3]University of Helsinki, Department of Physics

Seeding gas ions, like Ar, having a kinetic energy of ≈ 100 eV, dominate the erosion of the plasma-wetted areas during the quiet phases of the discharges in fusion reactors. These ions create near-threshold sputtering. Thus, the collisional cascade stays within the surface layers, and the distribution function of the sputtered atoms can depend strongly on the crystallographic structure. Molecular dynamics simulations suggest precisely such a behavior for the erosion of W by low-energy Ar ions.

However, experimental studies of the near-threshold erosion of tungsten by seeding gas impurities are severely lacking. This contribution presents near-threshold erosion experiments of tungsten samples by Ar ion bombardment at the linear plasma device PSI-2. The modeling of the line shape emitted by sputtered W provides, via Doppler broadening, insights into the angular and velocity distribution functions. This contribution presents how to account for all relevant line broadening and splitting mechanisms. Notably, the line shape measured depends strongly on the crystallographic plane exposed to the plasma.

P 22.2 Thu 16:45 ZHG102

Manufacturing and testing of optimized composite heat sinks for plasma-facing component applications — •Robert Lürbke[1,2], Alexander von Müller[2], Bernd Böswirth[2], Henri Greuner[2], Johann Riesch[2], Georg Schlick[3], and Rudolf Neu[1,2] — [1]Technical University Munich, 85748 Garching, Germany — [2]Max Planck Institute for Plasma Physics, 85748 Garching, Germany — [3]Fraunhofer Institute for Casting, Composite and Processing Technology IGCV, 86159 Augsburg, Germany

In future magnetic confinement fusion reactors, plasma-facing components (PFCs) of the divertor will be subjected to high heat loads and intense neutron irradiation. This requires the development of reliable materials and robust component designs. An established state-of-the-art divertor PFC design is the so-called tungsten monoblock concept, which exhibits good damage resilience but is restricted in its width requiring a large number of PFCs. The so-called flat-tile is another well-known design option, which exhibits good heat removal capabilities, but there are basic concerns about the structural integrity of the material joints. In this study, we demonstrate the manufacturing and testing of a design that combines the advantages of both abovementioned PFC design approaches with an optimized tailored composite. Such composite structures are manufactured by infiltrating additively manufactured tungsten preforms with a copper (alloy) matrix. The contribution summarizes the results of high heat flux tests on different PFC mock-up specimens that were tested under cyclic loading at heat loads up to 20 MW/m^2.

P 22.3 Thu 17:10 ZHG102

Engineering tool for the mitigation of target loads at leading edges in multi-configuration island divertors — •Antara Menzel-Barbara[1,2], Joris Fellinger[2], Rudolf Neu[1,3], Dirk Naujoks[2], and Michael Endler[2] — [1]TUM, Munich, Germany — [2]IPP, Greifswald, Germany — [3]IPP, Garching, Germany

The Wendelstein 7-X divertor is designed to intersect magnetic field lines at shallow angles. Because of inevitable steps between divertor components, small exposed areas called *leading edges* can be intersected almost perpendicularly by magnetic field lines and thus receive highly increased heat fluxes. Traditionally, mitigating leading edges involves tilting the divertor target or chamfering the problematic edges. However, as W7-X is capable of operating various magnetic configurations, this can lead to particle fluxes impinging from opposing directions on the same target surface, exposing new leading edges when mitigating one. The tool presented here allows to demonstrate that while such overlapping particle deposition patterns are manageable, achieving good separation is essential for relaxed tolerances and reduced manufacturing complexity. Furthermore, methods for achieving this separation are explored via field-line tracing creating divertor geometries from scratch for single configurations. By maintaining incidence angles below critical thresholds, overloads can be avoided. By identifying shadowed regions, divertor targets can be designed for compatibility with multiple configurations, while eliminating overlapping leading edges. It is envisioned to use this tool to explore divertor solutions optimized for particle exhaust, cost and ease of installation.

P 23: Atmospheric Plasmas and their Applications VI

Time: Thursday 16:15–18:00 Location: ZHG006

Invited Talk P 23.1 Thu 16:15 ZHG006

Electric Field Determination for Fundamental and Applied Discharge Physics — •Tomas Hoder — Masaryk University, Brno, Czech Republic

The electric field is one of the key parameters describing gas discharges and their dynamics. The spatiotemporal distribution of the electric field is crucial not only for calculating local electron-driven chemistry but also, more broadly, as a central parameter for validating computational models and developing or cross-checking new diagnostic methods. In this contribution, we will discuss the evaluation of the electric field using multiple methods, primarily optical emission and laser spectroscopy based. We will demonstrate the application of these methods for understanding barrier discharges, both within the discharge volume and on dielectric surfaces, and briefly assess the applicability of each method. Special attention will be given to the comparison of experimental results with computer simulations. Examples from both fundamental and applied industrial research will be presented and discussed.

P 23.2 Thu 16:45 ZHG006

Ion energy distributions of a DBD-plasma jet impinging on surfaces — •Daniel Henze, Laura Chauvet, and Achim von Keudell — Experimental Physics II Reactive Plasmas, Ruhr-Universität Bochum

Ion energy distribution functions (IEDFs) originating from a kHz-DBD plasma helium jet expanding into open air were measured using a molecular beam mass spectrometer (MBMS). The plasma jet produces quickly propagating ionization waves as guided streamers. The species' transition into the MBMS occurs either through a 40μm metallic or 50 μm ceramic orifice. The analysis of the time-resolved IEDFs using the metallic orifice revealed that ions initially impacting on the surface are predominantly sampled at a reference energy, which is determined by the seeding of ions into the supersonic expanding helium beam formed when transitioning into the MBMS. After the impact, ions are continuously sampled at an energy a few 0.1 eVs higher than the reference. This is resolved by postulating a positive space-charge region in front of a positively charged surface. However, using the ceramic orifice, much broader IEDFs are observed. These IEDFs are in agreement with simulations by Babaeva and Kushner [2013 J. Phys. D: Appl. Phys. 46 125201].

P 23.3 Thu 17:00 ZHG006

Spatio-temporal ignition pattern in sinusoidal-driven dielectric barrier discharges — •Hans Höft[1], Markus M. Becker[1], and Ronny Brandenburg[1,2] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Institute of Physics, University of Rostock, Rostock, Germany

Dielectric barrier discharges (DBDs) driven by sinusoidal high-voltage (HV) waveforms feature distinct spatio-temporal ignition pattern, which differs significantly from pulsed-operated DBDs, and are of importance for the performance of plasma-chemical reactors. This was investigated using a spatially 1D multi-filament DBD arrangement with a 1 mm gap (dielectric alumina, 1 mm around each rod electrode) and a lateral gap length of ≈ 10 mm in synthetic air at 1 bar. Electrical measurements were synchronised with iCCD and streak camera recordings to obtain information on the number of filaments and their spatio-temporal inception during the positive and negative half-cycle of the applied sinusoidal HV waveform with 11 and 14 kV_{pp} at 10 kHz. It was found that the filament positions are fixed in both HV half-cycles corresponding to current pulse series. There are alternating positions during one half-cycle, i.e. the deposited surface charges prohibit the ignition for the same polarity of the HV waveform. This pattern, however, is stable only for some subsequent periods. Furthermore, the spatial stability disappears for higher HV amplitudes, when more than two filament series occur during one half-cycle of the HV waveform.

This work was funded by the Deutsche Forschungsgemeinschaft (DFG), project number: 535827833.

P 23.4 Thu 17:15 ZHG006

Impact of ambient humidity on the OH distribution in the effluent of an atmospheric pressure plasma jet — •Robin Labenski[1], Sebastian Burhenn[1], Maike Kai[1], Pia Pottkämper[1], Marc Böke[2], Volker Schulz-von der Gathen[2], and Judith Golda[1] — [1]Plasma Interface Physics, Ruhr-University Bochum — [2]Experimental Physics II, Ruhr-University Bochum

Atmospheric plasma jets are essential in fields like plasma medicine, as they can generate and deliver reactive oxygen and nitrogen species (RONS) to specific targets. A detailed understanding of their generation mechanisms and interactions with the ambient atmosphere is critical, particularly for hydroxyl (OH) radicals. This study examines OH dynamics in the COST microplasma jet (COST-Jet) using helium (He) as the feed gas. By employing laser-induced fluorescence (LIF) spectroscopy, absolute OH densities are mapped in three dimensions. Varying the humidity in both the feed gas and ambient air, the contributions of plasma and post-plasma processes to OH generation are analyzed. When water vapor is added to the feed gas, uniformly high OH densities ($1 * 10^{14}$ cm^{-3}) are observed near the nozzle, followed by rapid axial and radial decay. In contrast, ambient humidity alone produces one order lower OH densities, localized at the effluent-air boundary. Higher ambient humidity shifts the OH density peak closer to the nozzle as humidity infiltrates deeper into the effluent. This work is supported by project PlasNOW and in collaboration with projects B2 and B11 of SFB1316

P 23.5 Thu 17:30 ZHG006

Surface processes during plasma-based nitrogen fixation — •Steijn Vervloedt and Achim von Keudell — Experimental Physics II, Ruhr University Bochum, Bochum, Germany

Nitrogen fixation is a vital part of artificial fertiliser production. Plasma-based gas conversion is an alternative to thermal catalytic processes currently used by the chemical industry, because it is better suited to work for a decentralised and varying energy supply of renewable energy. The efficiency of these plasma-based processes might even be improved by introducing a catalyst. In this contribution, we present our results on the surface composition of an iron foil in direct contact with a nitrogen containing plasma. A low-pressure RF plasma is ignited in N_2/O_2 and N_2/H_2 gas mixtures to study surface processes related to NH_3 and NO_x synthesis, respectively. Infrared reflection absorption spectroscopy probes the surface composition in-situ. This technique yields reflectance spectra that show a fingerprint of the surface groups on the foil. The results in a N_2/O_2 plasma show the formation of N_xO_y species on the surface and O_3 in the gas phase. The N_2/H_2 plasma results show the change in the oxidation state of the iron foil and the incorporation of nitrogen species. The interplay between these species can be used to devise a kinetic model of these surface mechanisms.

P 23.6 Thu 17:45 ZHG006

Influence of Nanosecond Pulsed Plasmas in Liquids on Copper Surfaces — •Pia-Victoria Pottkämper, Sven Weller, Neil Unteregge, Katharina Laake, and Achim von Keudell — Ruhr-Universität Bochum

One application of plasmas in liquids is the modification of metal surfaces. In this project a plasma is ignited at an electrode immersed in liquid using high voltages, nanosecond pulses and fast rise times. The plasma and plasma-activated liquid is then used to modify a coppper surface. The plasma causes a dissociation of water molecules, leading to the creation of many different reactive species with varying lifetimes such as molecular oxygen and hydrogen, solvated electrons and hydrogen peroxyde. These species elicit different reactions that lead to the modification of the copper sample. It is possible to reduce the surface or to initiate growth of nanostructures depending on the experimental conditions. The changes are monitored via FTIR spectroscopy, SEM and cyclic voltammetry. The creation of uniform copper oxide nanocubes has been observed under certain conditions. One application of these structures is the catalysis of the electrochemical reduction of CO2. During this reaction the activity of these catalysts decreases over time. The in-liquid plasma could be used to re-oxidize or create such catalytic surfaces. It is postulated that by combining an in-situ in-liquid plasma treatment with such a catalysis setup the lifetime of the catalytic surfaces can be extended.

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Overview of Invited Talks and Sessions

Plenary Talk

See plenary section for details.

PV VI	Wed	9:45–10:30	ZHG011	**Image-guided radiotherapy for cancer treatment: recent developments and future innovations** — •Daniela Thorwarth

Invited Talks

ST 2.1	Tue	16:15–16:45	ZHG003	**Photonenzählende Detektoren: Der nächste Schritt in der klinischen CT-Bildgebung** — •Thomas Stein
ST 2.2	Tue	16:45–17:15	ZHG003	**Life-view 3D endoscopy for colorectal cancer screening based on MHz optical coherence tomography** — •Maik Rahlves, Awanish Singh, Madita Göb, Sazgar Burhan, Simon Lotz, Wolfgang Draxinger, Berenice Schulte, Marvin Heimke, Tillmann Heinze, Mario Pieper, Thilo Wedel, Mark Ellrichmann, Robert Huber
ST 2.3	Tue	17:15–17:45	ZHG003	**Engineering Precision Medicine with Magnetic Imaging Techniques** — •Ioana Slabu
ST 4.1	Wed	13:45–14:15	ZHG009	**Mixed ion beams for treatment monitoring: recent developments and future prospects** — •Elisabeth Renner, Hermann Fuchs, Matthias Kausel, Claus Schmitzer
ST 9.1	Thu	17:15–17:45	ZHG003	**Making Surgery Intelligent: From Autonomous Systems to the Intelligent OR** — •Jannis Hagenah

Invited Talks of the joint Symposium SMuK Dissertation Prize 2025 (SYMD)

See SYMD for the full program of the symposium.

SYMD 1.1	Mon	14:15–14:45	ZHG011	**Fluid-dynamic description of heavy-quark diffusion in the quark-gluon plasma** — •Federica Capellino
SYMD 1.2	Mon	14:45–15:15	ZHG011	**Fast and faithful effective-one-body models for gravitational waves from generic compact binaries** — •Rossella Gamba
SYMD 1.3	Mon	15:15–15:45	ZHG011	**Nuclear Structure Near Doubly Magic Nuclei** — •Lukas Nies
SYMD 1.4	Mon	15:45–16:15	ZHG011	**Optimisation strategies for proton acceleration from thin foils with petawatt ultrashort pulse lasers** — •Tim Ziegler

Sessions

ST 1.1–1.6	Tue	13:45–15:15	ZHG003	**Computational Methods and Simulation**
ST 2.1–2.3	Tue	16:15–17:45	ZHG003	**DPG meets DGMP: Future Perspectives on Tomographic Imaging Techniques**
ST 3.1–3.6	Wed	11:00–12:30	ZHG003	**Radiation Monitoring and Dosimetry**
ST 4.1–4.7	Wed	13:45–15:45	ZHG009	**Accelerators for Medical Applications (joint session ST/AKBP)**
ST 5.1–5.4	Wed	16:15–17:15	ZHG003	**Detector Physics**
ST 6.1–6.4	Thu	11:00–12:00	ZHG003	**Medical Imaging and Treatment Monitoring**
ST 7.1–7.6	Thu	13:45–15:45	ZHG Foyer 1. OG	**Poster Session**
ST 8.1–8.4	Thu	16:15–17:15	ZHG003	**Particle Radiography**

ST 9.1–9.1	Thu	17:15–17:45	ZHG003	**Keynote Session**
ST 10	Thu	17:45–18:00	ZHG003	**Prize Ceremony and Closing Session**
ST 11	Thu	18:15–19:15	ZHG003	**Members' Assembly**

Members' Assembly of the Radiation and Medical Physics Division

Thursday 18:15–19:15 ZGH003

Sessions

– Invited Talks, Contributed Talks, and Posters –

ST 1: Computational Methods and Simulation

Time: Tuesday 13:45–15:15 Location: ZHG003

ST 1.1 Tue 13:45 ZHG003

Geant4 Tool for Characterizing and Optimizing Albedo Dosimeters: Impact of Filter Configuration and Material Composition — •Suliman Harbaji[1], Kevin Kröninger[1], Andria Michael[1], Jörg Walbersloh[2], and Jens Weingarten[1] — [1]Technical University Dortmund, Dortmund, Germany — [2]Materials Testing Office, Dortmund, Germany

Thermoluminescence albedo dosimeters are employed to measure neutron and photon whole-body doses resulting from occupational radiation exposure. These dosimeters operate based on the albedo effect, in which neutron radiation is backscattered by the body and subsequently detected by the dosimeter components.

The albedo dosimeters consist of an arrangement of four detectors embedded in neutron absorbers, commonly referred to as filters. A critical factor in dosimeters functionality is the configuration of these filters. Additionally, the composition and thickness of the filters have a significant influence on the detection efficiency.

For a detailed characterization of albedo dosimeters and their functionality, a simulation tool was developed using Geant4. The study focuses on neutron interactions with the dosimeter under various filter configurations, material compositions, filter thicknesses, and detector material thicknesses. The results of the simutation provide valuable insights into optimising the detection properties and therefore improving the measurement accuracy of albedo dosimeters.

In this talk, the developed Geant4 tool and the results of the simulations will be presented and discussed.

ST 1.2 Tue 14:00 ZHG003

Experimental tuning of Geant for Cherenkov radiation of electrons — Yazeed Balasmeh, •Daniel Berker, Ivor Fleck, and Lars Maczey — Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen

Geant4 is a powerful tool and indispensable for the investigation of particle interactions as well as detector developments. But since there exists a variety of parameters, it is possible to make too idealistic simulations. Verifying a simulation by an experimental setup is a proper way to achieve simulations as realistic as possible. The aim of this talk is to experimentally verify the production of Cherenkov radiation as simulated in Geant4.

The main setup consists of a Strontium-90 source, placed in a vacuum chamber, whose emitted electrons with energies up to 2.2 MeV are bent in a homogeneous magnetic field with an adjustable field strength between 20 mT and 80 mT. After passing through the magnetic field, the electrons will hit a PMMA layer producing Cherenkov photons, that are detected by a SiPM array. A collimator in front of the PMMA reduces the energy spread to values below 5%. The setup is calibrated with Bismuth-207 to confirm the energy of the electrons after passing through the magnetic field.

This talk presents the current status of the experiment and underlines the importance of the interplay between simulation and experimental verification. In conclusion, I want to discuss my results regarding the development of a Cherenkov Compton camera.

ST 1.3 Tue 14:15 ZHG003

Fast dose predicition for treatment planning in matRad — •Ruben Trimpop[1], Carsten Burgard[1], Tobias Cremer[2], Cornelius Grunwald[1], Kevin Kröninger[1], Florian Mentzel[2], Marco Schlimbach[1], and Jens Weingarten[1] — [1]TU Dortmund — [2]Formerly TU Dortmund

Microbeam radiation therapy (MRT) is a preclinical method for tumor treatment, demonstrating potential for improved post-treatment outcomes. The method employs a multi-slit collimator to produce dose peaks with high dose rates, separated by valleys of lower dose rates. This method of spatially segmenting the beam, combined with applying high dose rates over a short amount of time, called FLASH-Therapy, enhances the survivability rate of healthy tissue.

A major impediment to the utilisation of this method is the large amount of time it takes for dose prediction using conventional methods. Previous research has successfully used Machine Learning (ML) networks to significantly reduce the required time for dose prediction.

In this work a ML network is integrated into matRad, an open source software for radiation treatment planning, developed for research purposes, substituting matRads internal dose prediction with a ML based dose prediction. This is one of the first steps to fully enable treatment planning for MRT.

This presentation will showcase the first results of ML integration into matRad, highlighting the advantages of ML-based dose prediction for MRT.

ST 1.4 Tue 14:30 ZHG003

Improving Brain Tumor Characterization Using Generative Neural Networks and Raw MRI Data — •Marco Schlimbach, Jens Kleesiek, Kevin Kröninger, Moritz Rempe, and Jens Weingarten — TU Dortmund University

Characterizing brain tumors from MRI scans remains a significant challenge in clinical practice. Determining the specific tumor type often requires invasive biopsies, which hold risks for patients. Research efforts aim to improve non-invasive tumor characterization by using machine learning techniques. However, despite significant advancements, the accuracy of these methods has not yet reached the level needed to reliably replace biopsies. Current state-of-the-art algorithms commonly rely on reconstructed MRI images optimized for human interpretation. These images are the result of complex reconstruction pipelines that discard the raw phase information.

This study investigates the diagnostic potential of raw MRI data, which retains phase information and provides a more comprehensive representation of scanned tissue. A novel workflow is introduced to generate synthetic raw MRI data, including both healthy scans and scans with lesions. By leveraging generative machine learning techniques alongside raw MRI data, this approach aims to reveal new features and insights that could enhance non-invasive tumor characterization.

ST 1.5 Tue 14:45 ZHG003

Autoencoder-based Anomaly Detection in MRI Raw Data — •Jessica Mnischek, Jens Weingarten, Kevin Kröninger, and Marco Schlimbach — TU Dortmund

Tumor distinction in medical imaging remains a challenging task due to the subtle differences between various tumor types and abnormal tissues. Magnetic Resonance Imaging (MRI) is a powerful diagnostic tool widely used in the detection and monitoring of tumors, providing detailed visualization of soft tissues.

To enhance diagnostic accuracy, machine learning methods have been increasingly applied to MRI data. Among these methods, autoencoders have demonstrated potential in detecting subtle differences between healthy and diseased scans. By training on healthy datasets, they learn compact, efficient representations of typical tissue patterns. When applied to diseased datasets, the reconstruction error can highlight anomalies, thereby facilitating the detection of irregularities that may indicate the presence of disease.

This study investigates the application of autoencoders to raw MRI data, which preserves the complete acquired information, including both magnitude and phase components. In contrast, standard MRI analyses mostly rely only on magnitude information. By working directly with raw MRI data, this approach explores the potential of utilizing phase information to more effectively differentiate between healthy and tumor-affected tissues.

ST 1.6 Tue 15:00 ZHG003

Cycle GAN-Based Style Transfer for Image Registration between Clinical and HiP-CT — Lukas Johanns[1], Michael Windau[1], Lucas Cremer[1], •Claire Walsh[2], Joe Jacob[2], Joseph Brunet[3], Paul Sweeney[4], and Stijn Verleden[5] — [1]TU Dortmund — [2]UCL London — [3]ESRF Grenoble — [4]Cancer Research UK — [5]UZA Antwerp

Registration is an image processing algorithm that enables the alignment of scans across domains. It finds applications in disease tracking and research, in the operating room, and as a preprocessing step for other machine learning algorithms.

However, registration across modalities requires careful tuning and preprocessing of the dataset, as different domains are often difficult to compare.

To improve the performance of registration algorithms, a Cycle-GAN model for style transfer is used as a preprocessing step. This model transfers the style of the target domain to the input image to enhance registration performance. This project investigates the performance and feasibility of such a deep learning model applied to Clinical-CT scans and high-resolution/high-contrast HiP-CT scans (Hierarchical Phase Contrast Tomography). In this talk, the concepts of registration and Cycle-GANs are briefly introduced. Afterwards, the results of our style-transfer network are presented, followed by a discussion of a future feasibility study for registration.

ST 2: DPG meets DGMP: Future Perspectives on Tomographic Imaging Techniques

Time: Tuesday 16:15–17:45 Location: ZHG003

Invited Talk ST 2.1 Tue 16:15 ZHG003

Photonenzählende Detektoren: Der nächste Schritt in der klinischen CT-Bildgebung — •Thomas Stein — Klinik für Diagnostische und Interventionelle Radiologie, Freiburg, Deutschland

Die Computertomographie hat sich als verlässliche Schlüsseltechnologie in Medizin und anderen Disziplinen etabliert. Nun halten Photonenzählende Detektoren (PCDs) verstärkt Einzug in die medizinische Bildgebung. PCDs erfassen einzelne Röntgenphotonen und ermitteln deren Energie, anstatt Signale, wie bisher, nur zu integrieren. Dadurch kann die räumliche Auflösung verbessert werden und unterschiedliche Gewebestrukturen sowie Materialien lassen sich präziser diskriminieren, was eine verfeinerte, spektrale CT-Bildgebung ermöglicht und damit die Patientenversorgung verbessert. Die Vorteile gehen über die bisherige Dual-Energy-CT hinaus: Spektrale Methoden erlauben, verschiedene Substanzen simultan zu analysieren und Artefakte zu reduzieren. Neue Kontrastmittel könnten damit besser identifiziert und die Diagnostik gesteigert werden. Darüber hinaus eröffnen Kooperationen mit der Grundlagenforschung ein erweitertes Spektrum an Untersuchungs- und Anwendungsmöglichkeiten, sodass neue Einsatzfelder erschlossen und wissenschaftliche Erkenntnisse gezielter vorangetrieben werden können. Fortschritte in der Signalverarbeitung, etwa durch iterative Rekonstruktionen und maschinelles Lernen, sorgen dafür, dass diese Weiterentwicklungen auch praktikabel werden. Die Photonenzähltechnologie stellt einen Quantensprung in der CT dar, erfordert jedoch weitere Forschung, um bestehende Herausforderungen zu meistern und ihr volles Potenzial auszuschöpfen.

Invited Talk ST 2.2 Tue 16:45 ZHG003

Life-view 3D endoscopy for colorectal cancer screening based on MHz optical coherence tomography — •Maik Rahlves[1], Awanish Singh[1], Madita Göb[1], Sazgar Burhan[1], Simon Lotz[1], Wolfgang Draxinger[1], Berenice Schulte[2], Marvin Heimke[3], Tillmann Heinze[3], Mario Pieper[4], Thilo Wedel[3], Mark Ellrichmann[2], and Robert Huber[1] — [1]Institute of Biomedical Optics, University of Lübeck, Lübeck, Germany — [2]Interdisciplinary Endoscopy, Medical Department 1, University Hospital Schleswig-Holstein, Campus Kiel, Kiel, Germany — [3]Center of Clinical Anatomy, Institute of Anatomy, Christian-Albrechts University Kiel, Kiel, Germany — [4]Institute of Anatomy, University of Luebeck, Luebeck, Germany

Colorectal cancer has one of the highest incidence rates among all types of cancer, which requires high resolution 3D imaging techniques for tissue layer differentiation for screening and tumor staging. We present our latest results on life-view 3D colorectal endoscopy based on Fourier-Domain Mode Locking Optical Coherence Tomography. The endoscope features a radially out-coupled rotating OCT-Laser beam. Our approach enables axial resolution of about 10 microns in tissue at A-scan rates of 3.4 MHz, which allows for screening large tissue areas as well as tissue layer differentiation. Solutions to common challenges such as Laser-triggering and non-uniform rotational scanning are presented. We present 3D images of human tissue obtained from ex-vivo body donor measurements. Furthermore, future prospects and preliminary results on novel OCT-imaging modalities are discussed.

Invited Talk ST 2.3 Tue 17:15 ZHG003

Engineering Precision Medicine with Magnetic Imaging Techniques — •Ioana Slabu — Institute of Medical Engineering, Helmut Schmidt University Hamburg — Institute of Applied Medical Engineering, Helmholtz Institute, Medical Faculty, RWTH Aachen University

Magnetic imaging techniques such as magnetic resonance imaging (MRI) and magnetic particle imaging (MPI) are of great interest in precision medicine. They have the potential to contribute to tremendous developments in two of the most challenging issues of today's healthcare: (i) early and precise detection of diseases with minimally invasive methods, and (ii) personalized therapy with high success rates and low side effects. This potential is largely driven by the development of image-guided therapies with magnetic nanomaterials, which are applied as contrast agents in MRI and as tracers MPI. Medical devices (e. g. stents, drug carriers) doped with magnetic nanomaterials are designed to respond to magnetic external stimuli, allowing them to sense, interact with, and adapt to their environment according to the therapeutical need. The talk focusses on the concept and realization of image-guided therapies based on such devices, highlighting the huge advantage of their *in vivo* monitoring in MRI and MPI.

ST 3: Radiation Monitoring and Dosimetry

Time: Wednesday 11:00–12:30 Location: ZHG003

ST 3.1 Wed 11:00 ZHG003

Dosimetry for sub-relativistic electrons and their potential use in radiotherapy — •Julian Freier[1], Leon Brückner[1], Stefanie Kraus[1], Julian Litzel[1], Bastian Löhrl[1], Christoph Bert[2], Luitpold Distel[2], and Peter Hommelhoff[1,3] — [1]Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen — [2]Department Strahlenbiologie, Universitätsklinikum Erlangen, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91054 Erlangen — [3]Department Physik, Ludwig-Maximilians-Universität München (LMU), 80799 München

The acceleration of electrons based on nanophotonic structures may lead to dice-sized accelerators, emitting electrons with energies in the sub-MeV to MeV regime for potential use in radiotherapy [1,2,3]. Leveraging electron energies in the keV range and their proposed high biological efficiency [4], we present a method for calibrating EBT3 GafChromic films for low-energy electrons to be used in future experiments in biology. The used setup employs an ultrafast electron source, utilizing photoemission from a sharp nano-tip array that enables irradiation of cells with electrons up to 50keV for comparison with x-ray samples. This method allows to estimate the biological impact of such electron radiation on cells. References [1] England, et al., Rev.Mod.Phys.86.4 1337 (2014)[2] Chlouba, Shiloh, Kraus, Brückner, et al. Nature 622, 476 480 (2023) [3] Broaddus, et al. PRL 132, 085001 (2024) [4] Tye, et al, R.Soc. Open Sci.11240898 (2024)

ST 3.2 Wed 11:15 ZHG003

Investigating Regenerating Profiles for TL-Dos Detectors — •Paula Harnisch[1], Kevin Kröninger[1], Jörg Walbersloh[2], and Jens Weingarten[1] — [1]TU Dortmund — [2]MPA NRW

Reliable personal monitoring is essential for occupational radiation exposures. Lately, a thermoluminescence-based monitoring system was developed by MPA Dortmund and TU Dortmund, offering the advantage of reusable detectors. This study systematically examines the effects of different regeneration profiles on the lifetime dose signal and the fading characteristics of TL-DOS detectors.

Regeneration, the process of thermally exciting electrons trapped during radiation exposure, restores the detector to a baseline, signal-free state, making it ready for reuse. Traditionally, detectors are briefly heated to a high temperature post-readout, but recent findings suggest this method may not fully reset the signal. To address this, alternative regeneration profiles are being explored, with promising potential to reduce or even eliminate signal fading in TL-DOS detectors.

This presentation will provide an introduction to TL-DOS detector functionality and an overview of the various regeneration profiles tested, highlighting advancements toward improved detector reliability and longevity.

ST 3.3 Wed 11:30 ZHG003

Development of an H*(10) neutron dosimeter based on the TL-DOS for neutron and gamma dose measurements at TRIGA reactor Mainz — •Andria Michael[1], Kevin Kröninger[1], Marion Schulte[2], Jörg Walbersloh[2], and Jens Weingarten[1] — [1]University of Dortmund, Dortmund, Germany — [2]Materials Testing Office, Dortmund, Germany

The PhyBioN project, involving the TU Dortmund, Materialprüfungsamt Nordrhein-Westfalen, and University Medical Center Mainz, aims to address critical gaps in neutron radiation research by providing precise neutron dosimetry and improving our understanding of the radiobiological effects of neutron exposure.

The TRIGA Mark II research reactor at the University of Mainz, equipped with a graphite thermal column, provides a source of thermalized neutrons suitable for the study of radiobiological effects of neutron exposure. For this study, the neutron field in the thermal column must be characterized. An ambient neutron dosimeter, H*(10), is being developed, specifically tailored for the TRIGA Mainz reactor. The dosimeter is based on the TL-DOS, which uses the thermoluminescence (TL) effect for personnel monitoring in photon fields. The design and optimization of the neutron dosimeter are conducted using Monte Carlo simulations. The dosimeter response is characterized using neutron reference fields and correction factors for angular and energy dependencies are defined. This talk will present the status of the dosimeter development and the measurements obtained at the TRIGA reactor.

ST 3.4 Wed 11:45 ZHG003

Development of an electronic read out board for analog and digital data acquisition of a semiconductor neutron detector — •Janina Bolles, Kevin Kröninger, Jens Weingarten, and Alina Landmann — TU Dortmund University

Neutrons are biological highly effective particles which leads to an increased health risk in work and research spaces where neutron or neutron/photon mixed fields are present. This includes medical facilities like nuklear and radiation medicin, nuclear reactor facilities and also the field of aeronautics and astronautics. Therefore, a proper neutron dosimetry is highly relevant to ensure radiation protection in such working areas. Still, the biological consequences and dosimetry of neutrons are afflicted by rather large uncertainties due to the complexity of neutron interactions. This work contributes to the optimization of measurement methods to estimate the neutron flux by developing a semiconductor detector for real time measurements. For the neutron detection a silicon diode with a boron carbide converter was designed previously within this project. Now, for a more compact read out handling and a faster data acquisition a first prototype of an electronic read out board was developed including an integrating amplifier and a simple pulse shaper. For future board versions more noise filtering components and a digitial read out system are intended. We will present first results of the neutron detection with the improved read out design.

ST 3.5 Wed 12:00 ZHG003

Update on Radiation Measurements on the International Space Station with the RadMap Telescope — •Martin J. Losekamm[1,2], Thomas Berger[3], Liesa Eckert[4], Luise Meyer-Hetling[1,2], Peter Hinderberger[1,2], Stephan Paul[1,2], and Thomas Pöschl[5] — [1]Technical University of Munich, School of Natural Sciences — [2]Excellence Cluster ORIGINS — [3]German Aerospace Center, Institute of Aerospace Medicine — [4]Technical University of Munich, School of Engineering and Design — [5]European Organization for Nuclear Research (CERN)

The RadMap Telescope is a radiation monitor with two sensors — a tracking calorimeter made from scintillating-plastic fibers and a silicon-diode dosimeter — operating on the International Space Station. In this contribution, we give an update on the current status of the experiment and the ongoing analysis of data gathered in three modules of the station. We also present a selection of preliminary results. Our work is funded by the German Research Foundation (DFG, project number 414049180) and under Germany's Excellence Strategy – EXC2094 – 390783311.

ST 3.6 Wed 12:15 ZHG003

Reconstructing Particle Tracks with the RadMap Telescope — •Luise Meyer-Hetling[1], Liesa Eckert[2], Peter Hinderberger[1], Martin J. Losekamm[1], Stephan Paul[1], and Thomas Pöschl[3] — [1]School of Natural Sciences, Technical University of Munich, Garching, Germany — [2]School of Engineering and Design, Technical University of Munich, Ottobrunn, Germany — [3]CERN, Geneva, Switzerland

The RadMap Telescope is a compact multi-purpose radiation detector developed to provide near-real-time monitoring of the radiation aboard crewed and uncrewed spacecraft. We operated a first prototype on the International Space Station (ISS) for an in-orbit demonstration of the instrument's capabilities. Its main sensor consists of a stack of scintillating-plastic fibers whose arrangement allows the three-dimensional tracking and identification of cosmic-ray nuclei by reconstruction of their energy-loss profiles. In this contribution, we give an overview of the current status of the track reconstruction. We describe our neural-network-based reconstruction methods and present the performance of the trained convolutional network on simulated detector data. We also discuss the progress of the analysis of real data gathered on the ISS and the applied preliminary tracking methods. Our work is funded by the German Research Foundation (DFG, project number 414049180) and under Germany's Excellence Strategy - EXC2094 - 390783311.

ST 4: Accelerators for Medical Applications (joint session ST/AKBP)

Time: Wednesday 13:45–15:45 Location: ZHG009

Invited Talk ST 4.1 Wed 13:45 ZHG009

Mixed ion beams for treatment monitoring: recent developments and future prospects — •Elisabeth Renner[1], Hermann Fuchs[2], Matthias Kausel[3,1], and Claus Schmitzer[3] — [1]Atominstitut, TU Wien, Vienna, Austria — [2]MedUni Wien, Vienna, Austria — [3]MedAustron, Wiener Neustadt, Austria

In recent years, the use of mixed ion beams has been proposed as a method for treatment monitoring in ion beam therapy. A promising candidate in this context is a $^{12}C^{6+}$ beam with a small $^{4}He^{2+}$ contribution. The similar charge-to-mass ratios of these two ion species enable their simultaneous acceleration in medical synchrotrons. Being extracted at almost the same energy per mass, $^{4}He^{2+}$ features a range in matter approximately three times that of $^{12}C^{6+}$. This opens the possibility for tumor treatment with $^{12}C^{6+}$ while simultaneously performing $^{4}He^{2+}$ imaging downstream of the patient.

In 2024, the first successful delivery of a mixed $^{12}C^{6+}/^{4}He^{2+}$ beam in a clinical facility was achieved at MedAustron. Instead of being generated in a single ion source, as realized at GSI in late 2023, the two ion species were mixed during the injection into the synchrotron, before being simultaneously accelerated and extracted into the research irradiation room. There the ion mix was characterized using radiochromic films, low-gain avalanche diode detectors, and a configuration of two ionization chambers separated by multiple PTW RW3 slabs.

This talk provides a general overview of recent breakthroughs in mixed ion beam delivery, discusses technical challenges, and explores the future potential for treatment monitoring in ion beam therapy.

ST 4.2 Wed 14:15 ZHG009

Beam Dynamics and Energy Variation in H-Type Drift Tube Linac for Proton Eye Therapy — •Ali Almomani — Physics Department, Yarmouk University, 21163 Irbid, Jordan

In this study, we investigate the beam dynamics of a proposed H-type drift tube linac (DTL) designed for proton therapy in eye cancer treatment, utilizing the KONUS (Kombinierte Null Grad Struktur) beam dynamics approach and LORASR code. The linac design accelerates protons from 3 MeV to 70 MeV across six cavities with 140 accelerating gaps along a 20-meter structure, operating at a frequency of 325.244 MHz. To ensure transverse beam focusing and beam matching, 11 triplet quadrupole lenses are distributed along the linac. The beam dynamics analysis yielded optimized values for drift tube lengths and gap distances, and simulations showed 100% beam transmission efficiency. The design demonstrated low emittance growth, with less than 20% transversely and 90% longitudinally, ensuring a highly focused beam. The output beam emittances are smaller than what cyclotron can offer, facilitating the generation of a pencil beam capable of scanning the tumor volume from one point to another. Additionally, energy variation options allow flexible beam energy adjustment between 58 and 70 MeV, enabling customizable treatment depths. The energy variation may be realized by varying the gap of voltage levels. The simulation results indicate a stable structure even in the presence of machine errors, supporting further development for RF simulations and mechanical modeling. The overall outcomes are promising, confirming the feasibility of the design for proton therapy applications.

ST 4.3 Wed 14:30 ZHG009

Beam spot diagnostics of highly focused electron beams in therapeutic X-Ray generators via Optical Transition Radiation — •Thomas Beiser[1] and Kurt Aulenbacher[2] — [1]Helmholtz-Institute Mainz, (Germany), GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt (Germany) — [2]Helmholtz-Institute Mainz, (Germany), GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt (Germany), Johannes Gutenberg-University, Mainz (Germany)

Optical Transition Radiation (OTR), which is commonly used for beam diagnostics in accelerators at high energies (e.g. MeV to GeV electrons), allows for beam spot diagnostics of intense and highly focused electron beams in therapeutic X-Ray generators with energies as low as 100 keV, using off-the-shelf camera equipment.

ST 4.4 Wed 14:45 ZHG009

Development of a Fast Extraction Method to Extract High Intensity Short Pluses at ELSA — •Leonardo Thome, Klaus Desch, Dennis Proft, and Michael Switka — Physikalisches Institut der Universität Bonn

The electron accelerator facility ELSA delivers electron beams up to 3.2 GeV energy, extracted via slow resonance extraction from the stretcher ring in an extraction cycle of typically 10 s. Currently ongoing studies for radiation therapy, investigating the FLASH effect, require short beam pulses reaching from ns to ms. In a preliminary operation mode the booster synchrotron is already used to deliver electrons beam pulses of 1.2 GeV energy with fixed length of 250 ns to irradiate cell samples. To cover higher energies up to 3.2 GeV and different pulse lengths ranging from ns up to several ms, a fast extraction method from the stretcher ring is developed. The concept and realization by different techniques such as a repurposing of the existing injection kickers for extraction or utilizing a dispersive orbit to extract the beam is evaluated.

ST 4.5 Wed 15:00 ZHG009

First Results from Cell Irradiation Experiments with Ultrahigh-Energy Electrons (UHEE) at ELSA — •Susanne Spaeth[1], Manuela Denz[2], Klaus Desch[1], Stephan Garbe[2], Frank Giordano[3], Barbara Link[3], Carsten

Herskind[3], Barbara Link[3], Dennis Proft[1], and Leonardo Thome[1] — [1]Physikalisches Insitut der Universität Bonn — [2]Klinik für Strahlentherapie und Radioonkologie, Universitätsklinikum Bonn — [3]Klinik für Strahlentherapie und Radioonkologie, Universitätsklinikum Mannheim

A new approach to improve radiotherapy is the use of the so-called FLASH effect, a phenomenon characterised by significantly reduced toxicity in healthy tissue at high dose rates (>40 Gy/s). This effect potentially broadens the therapeutic window, improving tumour control while minimising side effects. At the electron accelerator facility ELSA, the FLASH@ELSA project utilises ultra-high energy electrons (UHEE) to study their effect on tumour cells. Electrons with energies of 1.2 GeV are delivered in sub-microsecond pulses via the booster synchrotron, enabling dose rates up to 10 MGy/s due to the short pulse lengths of 250 ns. Cell samples are irradiated within a water phantom, with dosimetry performed using radiochromic films and luminous screens. Further the FLASH irradiation at ELSA is compared to conventional radiotherapy using a medical linear accelerator (Varian TrueBeam STx) at the University Hospital Bonn. This comparison provides the first survival curves contrasting FLASH and conventional irradiation.

ST 4.6 Wed 15:15 ZHG009

Dosimetry of broadband electrons from laser-plasma accelerators — •Antonio Tarzikhan[1], Arpad Lenart[2], Chuan Zheng[1], Thomas Heinemann[1], Constantin Aniculaesei[1], Mirela Cerchez[1], and Bernhard Hidding[1] — [1]Institute of Laser- and Plasmaphysics, Heinrich Heine University, Düsseldorf, Germany — [2]University of Strathclyde, Glasgow, Scottland

Laser-plasma accelerators (LPA) offers compact sources of highly relativistic electron beams for various applications. This study focuses on the dosimetry of broadband electron beams, which are accelerated using the Arcturus laser system at the University of Düsseldorf with laser pulse energies of several millijoules sufficient to accelerate electrons to kinetic energies in the mega-electronvolt range, resulting in an energy distribution characterized by a shallow penetration and high dose deposition at the surface. These electron beams are therefore ideally suited for the treatment of skin cancer. We present the design and calibration of various diagnostics components and report on first experimental results obtained in a recent measurement campaign, incorporated with simulations to optimize the parameters used for the characterization of the electron beam energy- and angular-distribution and the charge calibration to determine the dose. Additionally, accelerated electron beams from intrinsic ultra-short bunch durations, are excellent candidates for FLASH radiotherapy and thus, minimizing damage to surrounding healthy tissues. This highlights the potential of LPA as a new technology in medical physics.

ST 4.7 Wed 15:30 ZHG009

Acoustic tracing of dose deposition of laser accelerated ion-bunches by modulation of the depth-dose curve — •Jeannette Cadeggianini, Alexander Prasselsperger, Anna-Katharina Schmidt, and Jörg Schreiber — Ludwig-Maximilian-Universität, München, Germany

A high-repetition-rate online dose reconstruction method is crucial for accelerated particle applications. Ionoacoustic measurements determine monoenergetic ion energies by recording acoustic signals generated by localized thermal expansion in the Bragg region. These waveforms encode the ion beam's energy and spatial distribution.

However, this method depends on pronounced spatial energy density gradients, which are absent in laser-accelerated ion beams, which exhibit broad, exponential energy spectra. To address this, we introduce TIMBRE (Tracing Ionoacoustic Modulations of Broad Energy Distributions), which uses modulator foils to create steeper energy deposition gradients. These foils serve two functions: due to the materials the stopping power in the foils is higher than in the interspaces, generating an acoustic wave at each interface because of the steep pressure gradient. Simultaneously, each foil reduces the amplitude of the signals from shallower foils, compressing the dynamic range.

By unfolding the measured acoustic traces with the corresponding analytic model, TIMBRE reconstructs depth dose distributions of laser-accelerated ion bunches. It offers a real-time diagnostic, supporting modern accelerators operating at Hz-level repetition rates and beyond.

ST 5: Detector Physics

Time: Wednesday 16:15–17:15 Location: ZHG003

ST 5.1 Wed 16:15 ZHG003

Neutron Dosimetry with Diamond Sensors — •Jennifer Schlüss[1], Christian Bäumer[2], Kevin Kröninger[1], and Jens Weingarten[1] — [1]TU Dortmund University — [2]West German Proton Therapy Center Essen

Neutron dosimetry is increasingly important in proton therapy, as neutron emissions provide valuable information on energy deposition within the body. However, neutron dosimetry presents challenges due to the complex interaction characteristics of neutrons. Diamond detectors offer a promising approach, as natural carbon-12 captures fast neutrons (E_{kin} > 6.2 MeV) and emits detectable alpha particles directly within the diamond sensor. This makes diamond detectors exclusively sensitive to fast neutrons. Enhancing the detector's sensitivity to both fast and thermal neutrons is a key objective. To achieve thermal neutron detection, we propose coating the diamond sensor with a converter layer, such as ^{6}LiF, with a high thermal neutron absorption cross-section. Using the Geant4 simulation platform, we examined neutron interactions and energy deposition in the detector, with simulations covering both thermal and fast neutron interactions to assess the response under different neutron energy ranges. Simulation results indicate that a ^{6}LiF-coated diamond sensor effectively measures both thermal and fast neutrons. A prototype is ready for initial neutron flux measurements in proton therapy, with further testing planned to fully characterize its detection capabilities across the neutron spectrum.

ST 5.2 Wed 16:30 ZHG003

Hardware Testing for the Construction of a Compton Camera Prototype — Yazeed Balasmeh, Daniel Berker, Ivor Fleck, and •Lars Maczey — Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen

Well-established detector systems for medical imaging such as PET or SPECT can only efficiently resolve source positions for gamma energies up to 600 keV. Compton cameras have been able to exceed the range to higher energies, but to date are limited to energies below 1 MeV. The Compton camera under construction at the University of Siegen pursues the novel approach of tracking the electron of a Compton scattering process based on its production of Cherenkov radiation, in the hope of overcoming the current limitations and creating new fields of study.

In this talk, I present first results obtained towards the construction of a Compton camera prototype, focusing mainly on the characterisation of hardware components, including UV-sensitive SiPMs from Broadcom Inc. and Hamamatsu Photonics, scintillation crystals such as GAGG and LGSO as well as readout ASICs such as the TOFPET2 ASIC from PETsys Electronics or the KLauS chip developed by the University of Heidelberg. Regarding SiPMs, bias optimisation is discussed to ensure both a good noise behaviour and good detection efficiency. Results from depth of interaction measurements and energy calibrations performed by scintillator-based setups and the development of a multi-channel SiPM detection system are also presented.

ST 5.3 Wed 16:45 ZHG003

Studies for the development of a pixel detector for proton therapy — •Alina Hild, Kevin Kröninger, Hendrik Speiser, and Jens Weingarten — TU Dortmund University

For various applications in proton therapy, it is important to know the deposited energy and the linear energy transfer (LET), as the latter directly relates to the relative biological effectiveness (RBE) of the protons. Due to their good spatial resolution and radiation hardness, pixelated silicon detectors are a suitable choice for the measurement of these quantities.

This talk presents some ideas for determining specifications for a new monolithic active pixel sensor (MAPS) that is being developed specifically to meet the requirements of proton imaging. The detector should be capable of simultaneously measuring the LET and the deposited dose, while handling the high fluxes and relatively high deposited energies that occur.

In an initial study, measurements of the signal current in a silicon detector were taken at the Westdeutsche Protonen Zentrum (WPE) to evaluate the mean energy dose. The talk summarizes these measurements and provides an outlook on other required quantities.

ST 5.4 Wed 17:00 ZHG003

MaPSA quality control for the CMS phase-II detector upgrade — •Leticia Rosa[1,2], Andreas Nuernberg[1], Doris Eckstein[1], and Andreas Mussgiller[1] — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg — [2]University of Hamburg, Hamburg, Germany

The Phase-II upgrade of the CMS detector aims to equip the outer tracker with new silicon sensor modules to handle the increased luminosity of the LHC. These modules integrate strip and pixel layers to enable precise position measurements, which will be placed in the inner layers of the outer tracker. The pixelated silicon sensor layer, paired with its readout chips, forms the macro-pixel sub-assembly (MaPSA). This presentation discusses the quality control procedures performed at DESY by the CMS Phase-II Tracker Upgrade group in Hamburg.

ST 6: Medical Imaging and Treatment Monitoring

Time: Thursday 11:00–12:00 Location: ZHG003

ST 6.1 Thu 11:00 ZHG003

Spatially resolved mid-IR spectroscopy on healthy and cancerous lung tissue — •Maximilian Schmock[1], Tobias Steinle[1], Cleo-Aron Weis[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Institute of Pathology, Heidelberg University Hospital, Heidelberg, Germany

Cancer diagnosis is complex and can take a long time. To support and accelerate this process, the possibilities of mid-IR spectroscopy are investigated. Therefore, a widely tunable IR-laser (from 1.3 to 20 μm) is used to perform sweep-measurements on histological samples of human lung tissue. In combination with a x-y-stage, spatially resolved measurements are performed as well. We demonstrate that with this setup, different spectral features can be highlighted depending on the wavelength, with a spatial resolution of around 20 μm. For this task, the entire spectrum between 2.7 μm and 12 μm can be used. A standardized control system that controls the entire experiment allows for fast switching between different measurement types and direct feedback on the recorded data.

ST 6.2 Thu 11:15 ZHG003

Towards Clinical Use of Range Monitoring in Heavy-Ion Therapy — •Sebastian Schroeder[1], Devin Hymers[1], Olga Bertini[2], Johann Heuser[2], Joerg Lehnert[2], Christian Joachim Schmidt[2], and Dennis Muecher[1] — [1]Institute for Nuclear Physics, University of Cologne, Cologne, Germany — [2]GSI, Darmstadt, Germany

Interaction Vertex Imaging (IVI) is a proposed method for online range monitoring in heavy-ion therapy which will help ensure correct Bragg peak (BP) positioning, and could act as a safety interlock, pausing irradiation if incorrect BP depth is detected. IVI tracks secondary ions produced by beam-patient interactions, and calculates the origin of each secondary ion as the closest approach of its track to the treatment beam. This data is used to determine BP range shifts with sub-mm precision. The tracking hardware is a purpose-built system, using sensors developed by GSI for the Compressed Baryonic Matter experiment. These highly segmented, double sided silicon strip detectors have a 58 μm pitch, and cover a large sensitive area of up to 72 cm^2. These detectors are coupled to readout electronics capable of count rates up to 250 kHz per segment. To test IVI with this system under clinical conditions, measurements were performed at the Heidelberg Ionenstrahl-Therapiezentrum. PMMA phantoms of 16 cm and 32 cm diameter were irradiated at BP depths of 27-80 mm and 27-160 mm respectively. A 9 mm air gap was also introduced in the phantom, as a first step towards measuring inhomogeneities. These results, as well as next steps towards anthropomorphic phantoms, will be discussed.

ST 6.3 Thu 11:30 ZHG003

Monitoring of beam shape and position with an HV-CMOS detector matrix in ion beam therapy — •Baudry Bartels[1], Alexander Dierlamm[1,2], Ulrich Husemann[1], Markus Klute[1], Ivan Perić[2], Bogdan Topko[1], and Hui Zhang[2] — [1]Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT) — [2]Institute for Data Processing and Electronics (IPE), Karlsruhe Institute of Technology (KIT)

Ion beam therapy has been proven to be an efficient treatment for cancer with less damage to healthy tissue compared to photon beam therapy.

A beam monitoring system is essential for ensuring a precise execution of the treatment plan. To increase the treatment precision, an online imaging of the target tissue during irradiation is beneficial. Magnetic resonance imaging (MRI) gives high tissue contrast without additional irradiation dose, and MRI-guided ion beam therapy is being established. This requires a magnetic field tolerant sensor system offering precise beam measurements and fast readout.

We are developing a beam monitor based on HV-CMOS detectors to meet the challenging requirements. A small prototype matrix has been built and commissioned. For user friendliness, a graphical user interface with implemented quick data analysis has been designed to provide the beam characteristics.

ST 6.4 Thu 11:45 ZHG003

Development of a Compton Camera for Biological and Medical Imaging — •Yazeed Balasmeh, Daniel Berker, Ivor Fleck, and Lars Maczey — Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen

The Compton Camera offers a novel, collimator-free imaging technology based on Compton scattering, addressing the need for advanced imaging systems capable of detecting high-energy gamma rays above 1 MeV. Its versatility makes it suitable for medical imaging applications, real-time dosimetry, and dynamic adjustments in particle beam therapies, particularly in cancer treatment.

In this talk, I will present the development of a novel Compton Camera at the University of Siegen, designed for high-energy gamma ray imaging. The system features an enhanced scattering layer to increase interaction probability and generate Cherenkov photons, allowing precise determination of interaction depth and electron trajectories. Measuring the scattered gamma ray and recoil electron energies enables accurate source localization. Incorporating electron tracking further improves spatial resolution by narrowing the possible gamma ray path. Additionally, GEANT4 simulations were employed to optimize device geometry and compare different scintillation materials, with depth of interaction (DOI) measurements validated against experimental results to refine performance.

ST 7: Poster Session

Time: Thursday 13:45–15:45 Location: ZHG Foyer 1. OG

ST 7.1 Thu 13:45 ZHG Foyer 1. OG

Update on the Development of a ^{10}BNNT-based Neutron Detector — •Kim Tabea Giebenhain[1], Anna Becker[2], Lara Dippel[1,2], Markel Fix Martinez[2], Dzmitry Kazlou[1], Hans-Georg Zaunick[1], Klemens Zink[2], and Kai-Thomas Brinkmann[1,2] — [1]II. Physikalisches Institut, Justus-Liebig-Universität, Gießen, Germany — [2]LOEWE Research Cluster for Advanced Medical Physics in Imaging and Therapy (ADMIT), Technische Hochschule Mittelhessen, Gießen, Germany

BNNT (Boron Nitride Nanotubes) is a material with excellent mechanical and thermal properties. Enriched with ^{10}B, an isotope of Boron with a high thermal neutron capture cross-section, it can be used as a neutron-sensing element by measuring the decay products of the ^{10}B(n,α)-reaction.

Two prototypes based on a ^{10}B-enriched BNNT mat coupled to inorganic scintillators (BGO and GaGG, respectively) have been developed. The detector systems are read out by a Photomultiplier tube.

Both systems were tested initially for their capabilities as neutron detectors at the DT neutron source at HZDR, Dresden. Those tests and their results will be discussed in the contribution.

This work is part of the ADMIT consortium and financed with funds of LOEWE

ST 7.2 Thu 13:45 ZHG Foyer 1. OG

The influence of tumor tissue vascularization on temperature in Magnetic Hyperthermia — •Viorica-Monica Moisiuc and Iordana Astefanoaei — Faculty of Physics, Alexandru Ioan Cuza University of Iasi, Romania

Magnetic hyperthermia is an innovative and promising method in cancer treatment, based on the ability of magnetic nanoparticles to generate heat under the influence of a high-frequency electromagnetic field, aiming to destroy cancer cells by locally increasing the temperature [1, 2]. This work investigates the impact of tumor vascularity on the thermal heating process in therapy, considering that the structure and density of blood vessels in the tumor can significantly influence nanoparticle distribution and, therefore, the uniformity of temperature distribution in the tissue. A model has been developed to allow a detailed analysis of heat transfer in vascularized tumor tissue, taking into account the magnetic field parameters and the properties of the magnetic systems used. The study highlights the potential of magnetic hyperthermia to generate optimal therapeutic temperatures and contribute to the selective destruction of tumor tissues, emphasizing the advantages of this method in oncological therapy through its ability to provide more precise control over thermal effects on the target tissue.

ST 7.3 Thu 13:45 ZHG Foyer 1. OG

Development of a BaF-Plastic Phoswich Detector for Fast Neutron Detection — •Lara Dippel[1,2], Kai-Thomas Brinkmann[1,2], Hans-Georg Zaunick[1,2], and Dzmitry Kazlou[1] — [1]II. Physikalisches Institut, JLU Gießen — [2]LOEWE Research Cluster for Advanced Medical Physics in Imaging and Therapy (ADMIT), TH Mittelhessen University of Applied Sciences, Giessen, Germany.

This poster presents the initial development steps of a Phoswich detector designed for fast neutron detection. The detector comprises a Barium Fluoride (BaF) crystal optically coupled to a thin plastic scintillator, with the system read out via a photomultiplier tube (PMT) on the BaF side. Particle discrimination is evaluated using pulse shape discrimination (PSD) techniques and integral versus amplitude histograms, enabling the identification of different particle types. The system was tested using Na-22, Sr-90, and an AmBe neutron source, as well as cosmic particles. For comparison, reference measurements were conducted with a standalone BaF detector to assess the particle identification capabilities

and potential advantages of the Phoswich configuration. This work is part of the ADMIT consortium under Project Part A, which focuses on estimating spectral neutron fluxes for therapy in tumor treatment applications.
This project is financed with funds of LOEWE - Landes-Offensive zur Entwicklung Wissenschaftlich-ökonomischer Exzellenz, Förderlinie 2: LOEWE-Schwerpunkte.

ST 7.4 Thu 13:45 ZHG Foyer 1. OG

Reconstruction Techniques for electron CT Measurements using Multiple Scattering — •Aenne Abel[1,2], Leticia Braga da Rosa[1,2], Paul Schuetze[1], Malinda De Silva[1], and Simon Spannagel[1] — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg — [2]University of Hamburg, Hamburg, Germany
Electron CT (eCT) is a new imaging method, which uses multiple scattering of electrons to determine the material budget of objects. This method could be used as the imaging method for flash radiotherapy with Very High Energy Electrons (VHEE, 50-250 MeV). A pencil beam of MeV range electrons passes through the sample under test. The beam widening caused by Coulomb scattering in the sample is dependent on the sample's material budget and is measured using a single planar silicon pixel sensor (Timepix3) placed downstream of the sample. First studies have been performed at DESY Hamburg to test this method. The results and the current status are presented in this poster with a focus on reconstruction algorithms.

ST 7.5 Thu 13:45 ZHG Foyer 1. OG

Development of a Real-Time PbWO4-based Detector System for Depth Dose Distribution Measurement in Clinical Proton Therapy — •Niclas Fiedler[1], Kai-Thomas Brinkmann[1], Dzmitry Kazlou[1], Hans-Georg Zaunick[1], and Kilian-Simon Baumann[2] — [1]Justus Liebig University, Giessen, Deutschland — [2]Technische Hochschule Mittelhessen, Giessen, Deutschland
Proton therapy has emerged as a highly precise form of radiotherapy, leveraging the unique dose deposition characteristics of ions to maximize tumor dose while sparing surrounding healthy tissues. However, the presence of heterogeneous media can significantly broaden the Bragg peak and obscure the distal fall-off, a phenomenon quantified by the modulation power.

This project introduces a novel PbWO4-based detector system designed for real-time measurement of the depth dose distribution in proton therapy. The clinical aim is to employ a high-energy, low intensity beam and position the detector posterior to the patient, where the system achieves accurate and most importantly fast quantification of the modulation power, whilst minimizing patient radiation exposure. The real-time measurement capabilities provide rapid feedback, allowing the substitution of slow, conventional peak finders, whilst enhancing treatment adaptability in clinical settings without compromising workflow efficiency. *Supported by THMconnectsFCMH.*

ST 7.6 Thu 13:45 ZHG Foyer 1. OG

Work towards a small scale detector array for cosmic showers based on scintillation detectors — •Erik Euler, Hans-Georg Zaunick, Kai-Thomas Brinkmann, Marvin Peter, Simon Glennemeier-Marke, and Mohammed Hassan — Justus Liebig University, Gießen, Germany
The detectors from the MuonPi Cosmic Detector Project are used to measure muons from cosmic air showers (secondary cosmic radiation). A MuonPi utilizes a plastic scintillation detector with a silicon photomultiplier (SiPM) for signal read out by RaspberryPi-based data acquisition. A larger, distributed detector array with 16 single detectors based on the MuonPi hardware, but with large plastic scintillator bars (100 x 100 x 10 cm), is currently under construction in Giessen. Its final goal, beside the mere detection of shower events, is to determine the direction of the shower through time-of-flight measurements and its special orientation in combination with the MuonPi Network.
Over the course of the last year a working prototype of the detector array was built and tested in the lab. The current setup consists of three working detector bars, the main part of the array's central data acquisition with a prototype of the FPGA-based event analysis. The current status of the project as well as the next steps will be presented.

ST 8: Particle Radiography

Time: Thursday 16:15–17:15 Location: ZHG003

ST 8.1 Thu 16:15 ZHG003

Online Adaptive Radiotherapy with Silicon Detectors — Kevin Kröninger, Hendrik Speiser, •Annsofie Tappe, Helen Thews, and Jens Weingarten — TU Dortmund
Proton therapy is a relevant modality of radiation therapy used to treat cancer, offering the main advantage of a well-defined proton range. Knowing the exact range is crucial in proton therapy to minimize radiation exposure to healthy tissues and ensure the correct tumor dose.
Anatomical changes in the patient between treatments significantly impact proton range. Therefore, an imaging technique is required to monitor these changes. One potential solution is a proton radiography system that can be used behind the patient in the beam axis.
We currently study the realization of a two-plane imaging system, consisting of two silicon pixel detectors and an intermediate absorber. This setup measures a two dimensional image of the water equivalent thickness (WET) of the patient along the beam axis during the treatment. A trigger for plan adaption could be given when the measured WET deviates from the expected value.
As part of a master thesis, this system is being implemented in the Monte Carlo simulation tool Allpix^2, to optimize the prototype and the post processing of the measured data. With simulations, we aim to improve data analysis and make first predictions of the feasibility in online adaptive proton therapy. To evaluate this, we want to determine the WET accuracy and precision with this system.
The talk will provide a short introduction of proton radiography, introduce the two-plane system and showcase simulated WET images.

ST 8.2 Thu 16:30 ZHG003

A Two Plane Proton Imaging System Using ATLAS FE-I4 Pixel Detectors — •Hendrik Speiser[1], Claus Maximilian Bäcker[2], Christian Bäumer[2], Johannes Esser[2], Kevin Kröninger[1], Annsofie Tappe[1], Helen Thews[1], and Jens Weingarten[1] — [1]TU Dortmund — [2]West German Proton Therapy Center Essen
For years, proton therapy is increasingly being used to treat cancer because of its well-known advantages, such as the high dose precision of protons. However, exploiting this precision requires improved imaging techniques to ensure accurate patient positioning and dose delivery. One such technique is proton radiography, where an image of the water equivalent thickness (WET) distribution of the patient is taken measuring the residual proton energy.

Former studies showed the feasibility of proton radiography using a single radiation hard ATLAS FE-I4 pixel detector. To improve the WET resolution of the resulting images, a second pixel detector of the same kind and a water equivalent absorber between both detectors are used. Proof-of-concept simulation studies of the so-called Two-Plane-System showed promising results. Thus, the aim of the project is to realize such a system and investigate the yielded WET resolution. To this purpose, prototype measurements were conducted at the West German Proton Therapy Centre in Essen.

This talk will briefly introduce the Two-Plane-System. Subsequently, the first results of the prototype measurement using ATLAS FE-I4 pixel detectors and future steps of the project are presented.

ST 8.3 Thu 16:45 ZHG003

Simulations of detector setups for Helium Radiography and CT — Alexander Dierlamm[1], Tim Gehrke[2], Ulrich Husemann[1], Oliver Jäkel[2], Maria Martisikova[2], and •Linus Schlee[1] — [1]Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT) — [2]Medical Physics in Radiation Oncology, German Cancer Research Center (DKFZ), Heidelberg
For the precise irradiation treatment of cancers that are located near critical tissues, ion beam therapy has been developed as an efficient and highly conformal treatment compared to x-ray therapy. Compared to the established methods with proton or carbon beams, helium provides a higher linear energy transfer than protons while causing less secondary radiation than heavier nuclei like carbon. To obtain higher precision with helium therapy, precise knowledge of the integrated stopping power of the affected region is needed. In future, the imaging for the treatment planning could be performed by the same He ions but at higher energies compared to the therapeutic range. In this talk, research on detector setups involving helium beams is presented. With the Allpix^2-Framework, the path of ions through a plexiglass-phantom (PMMA) and the resulting hits and signals of different detector setups are simulated. With subsequent analysis of simulated detector data on the positions and deposited energies of tracked particles, the goal is to optimise the setups to achieve higher measurement accuracy. The simulations are based on and compared to existing setups at the German Cancer Research Center (DKFZ).

ST 8.4 Thu 17:00 ZHG003

First experimental time-of-flight-based helium radiography of a mouse phantom — •Felix Ulrich-Pur[1], Ashish Bisht[2], Thomas Bergauer[3], Tetyana Galatyuk[1,4,5], Albert Hirtl[6], Matthias Kausel[6,7], Mladen Kis[1], Barbara Knäusl[8], Yevhen Kozymka[4], Wilhelm Krüger[4], Sergey Linev[1], Jan Michel[1], Jerzy Pietraszko[1], Christian Joachim Schmidt[1], Michael Träger[1], Michael Traxler[1], and Matteo Centis Vignali[8] — [1]GSI Helmholtzzentrum für Schwerionenforschung GmbH —

[2]Fondazione Bruno Kessler — [3]Austrian Academy of Sciences, Institute of High Energy Physics — [4]Technische Universität Darmstadt — [5]Helmholtz Forschungsakademie Hessen für FAIR — [6]TU Wien, Atominstitut — [7]EBG MedAustron — [8]Medical University of Vienna, Department of Radiation Oncology

Ion computed tomography (iCT) is an imaging modality for the direct measurement of the relative stopping power (RSP) distribution inside the patient. To reconstruct the RSP map, the traversed path and corresponding energy loss of ions passing through the patient have to be estimated. While this is usually done via a tracking system and a separate calorimeter, we present a so-called time-of-flight (TOF) iCT system that uses only one detector technology, namely Low Gain Avalance Diodes (LGADs), for both tracking and the energy loss measurement. In this contribution, first ion images, recorded with the TOF-iCT system, will be shown, including a proton radiograph of an aluminium stair phantom and a helium radiograph of a mouse phantom.

ST 9: Keynote Session

Time: Thursday 17:15–17:45 Location: ZHG003

Invited Talk ST 9.1 Thu 17:15 ZHG003

Making Surgery Intelligent: From Autonomous Systems to the Intelligent OR — •Jannis Hagenah — Center for Digital Surgery, University Medical Center Göttingen, Göttingen, Germany

Automatization in surgery holds the potential to significantly increase patient outcomes, minimize risks, and provide a sufficient answer to demographic change and staff shortage. However, surgery remains one of the most challenging medical disciplines to automize. This is due to a combination of high risks, a vast inter-patient variability, the amount of different sensing modalities, the necessity to physically interact with tissue as well as the collaborative nature of the field. Recent advances in robotics and Artificial Intelligence hold the potential to overcome these challenges and step forward towards intelligent operating rooms that optimally support the human team. This talk will present modern approached to digital surgery, the possibilities of merging cognitive system and collaborative robots into surgical procedures and highlight the interdisciplinary nature of the path towards fully intelligent ORs.

ST 10: Prize Ceremony and Closing Session

Time: Thursday 17:45–18:00 Location: ZHG003

In this last session we would like to take the opportunity to thank all participants for their attendance and contributions. We will announce the winner of this years award for the *Best contribution in the radiation and medical physics division at the DPG Spring Meeting 2025*. We welcome everyone to celebrate all prize winners and a successful conference with us, to provide some final feedback and to take the chance to meet again the other participants of this meeting.

ST 11: Members' Assembly

Time: Thursday 18:15–19:15 Location: ZHG003

Members' Assembly of the Radiation and Medical Physics Division

Particle Physics Division
Fachverband Teilchenphysik (T)

Johannes Haller
Universität Hamburg
Institut für Experimentalphysik
Luruper Chaussee 149
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Overview of Invited Talks and Sessions

(Lecture halls ZHG010, ZHG011, ZHG104, ZHG105,
VG 0.110, VG 0.111, VG 1.101, VG 1.102, VG 1.103, VG 1.104, VG 1.105,
VG 2.101, VG 2.102, VG 2.103, VG 3.101, VG 3.102, VG 3.103, VG 3.104, VG 4.101, and VG 4.102)

Invited Overview Talks

T 42.1	Wed	11:00–11:30	ZHG011	**Direct neutrino-mass measurements - current and next generations** — •Magnus Schlösser
T 42.2	Wed	11:30–12:00	ZHG011	**Mapping out the Higgs Boson: Highlights from the LHC Experiments** — •Elisabeth Schopf
T 42.3	Wed	12:00–12:30	ZHG011	**Computing at the LHC and its transformation towards the HL-LHC** — •Sebastian Wozniewski
T 43.1	Wed	13:45–14:15	ZHG011	**Advances in Silicon Detectors** — •Matthias Hamer
T 43.2	Wed	14:15–14:45	ZHG011	**Exploring the dark universe: the experimental quest for axions and ALPs** — •Julia K. Vogel
T 43.3	Wed	14:45–15:15	ZHG011	**Overview on coherent elastic neutrino nucleus scattering and successful first detections** — •Janina Hakenmüller
T 43.4	Wed	15:15–15:45	ZHG011	**Shifting paradigms in Gravitational-wave Astrophysics** — •Imre Bartos
T 63.1	Thu	11:00–11:30	ZHG011	**Neutrino properties from the laboratory and the cosmos** — •Thomas Schwetz-Mangold
T 63.2	Thu	11:30–12:00	ZHG011	**Highlights from Standard Model physics at the LHC in the precision era** — •Daniel Savoiu
T 63.3	Thu	12:00–12:30	ZHG011	**Cosmological results from the Dark Energy Spectroscopic Instrument** — •Daniel Gruen
T 105.1	Fri	11:00–11:30	ZHG011	**Galactic Astrophysics with H.E.S.S.** — •Lars Mohrmann
T 105.2	Fri	11:30–12:00	ZHG011	**Physics in the era of big data: AI in particle and astroparticle physics** — •Jonas Glombitza
T 105.3	Fri	12:00–12:30	ZHG011	**What the LHC tells us about the top quark, the heaviest particle in nature** — •Matthias Komm
T 105.4	Fri	12:30–13:00	ZHG011	**The flavor intensity frontier: latest results from Belle II and LHCb** — •Daniel Greenwald

Invited Topical Talks

T 20.1	Tue	13:45–14:15	ZHG011	**An introduction to gas electron multipliers and their time to shine during the CMS phase 2 upgrade** — •Shawn Zaleski
T 20.2	Tue	14:15–14:45	ZHG011	**Searches for rare Higgs boson decays** — •Martina Laura Ojeda
T 20.3	Tue	14:45–15:15	ZHG011	**Novel opportunities with the LHCb Software Trigger** — •Titus Mombächer
T 20.4	Tue	15:15–15:45	ZHG011	**Dark sector searches with invisible and displaced signatures at Belle II** — •Giacomo De Pietro
T 21.1	Tue	13:45–14:15	ZHG010	**The KM3NeT Ultra-High Energy Neutrino and its Possible Astrophysical Origins** — •Massimiliano Lincetto
T 21.2	Tue	14:15–14:45	ZHG010	**Multimessenger astronomy with ultra-high-energy cosmic rays and high-energy neutrinos** — •Foteini Oikonomou

T 21.3	Tue	14:45–15:15	ZHG010	**Peering into the Cosmos from Deep Underground – Astroparticle Physics with Xenon Detectors** — •Christian Wittweg
T 21.4	Tue	15:15–15:45	ZHG010	**Feebly Interacting Particles in the Early Universe** — •Mathias Becker
T 64.1	Thu	13:45–14:15	ZHG011	**Performance of the ATLAS New Small Wheels** — •Fabian Vogel
T 64.2	Thu	14:15–14:45	ZHG011	**Top quark and friends** — •Jan van der Linden
T 64.3	Thu	14:45–15:15	ZHG011	**Searching for New Physics in Soft Unclustered Energy Patterns** — •Alexander Lory
T 64.4	Thu	15:15–15:45	ZHG011	**Alignment and calibration at the LHCb experiment** — •Biljana Mitreska
T 65.1	Thu	13:45–14:15	ZHG010	**Searching for Axions and other Light Bosons at DESY** — •Jacob Egge
T 65.2	Thu	14:15–14:45	ZHG010	**14 years of coordinated outreach for particle physics: methods, impact and prospects** — •Saskia Plura, Uta Bilow, Michael Kobel, Achim Denig, Heike Vormstein, Mirco Christmann
T 65.3	Thu	14:45–15:15	ZHG010	**The Emerging Population of Seyfert Galaxies as Neutrino Sources in IceCube** — •Chiara Bellenghi, Tomas Kontrimas, Elena Manao
T 65.4	Thu	15:15–15:45	ZHG010	**First detection of neutrinos in water-based liquid scintillator at ANNIE** — •Johann Martyn

Invited Talks of the joint Symposium SMuK Dissertation Prize 2025 (SYMD)

See SYMD for the full program of the symposium.

SYMD 1.1	Mon	14:15–14:45	ZHG011	**Fluid-dynamic description of heavy-quark diffusion in the quark-gluon plasma** — •Federica Capellino
SYMD 1.2	Mon	14:45–15:15	ZHG011	**Fast and faithful effective-one-body models for gravitational waves from generic compact binaries** — •Rossella Gamba
SYMD 1.3	Mon	15:15–15:45	ZHG011	**Nuclear Structure Near Doubly Magic Nuclei** — •Lukas Nies
SYMD 1.4	Mon	15:45–16:15	ZHG011	**Optimisation strategies for proton acceleration from thin foils with petawatt ultrashort pulse lasers** — •Tim Ziegler

Invited Talks of the joint Awards Symposium (SYAS)

See SYAS for the full program of the symposium.

SYAS 1.1	Tue	11:05–11:35	ZHG011	**Zum Verhältnis von Physikdidaktik und Physikunterricht** — •Rita Wodzinski
SYAS 1.2	Tue	11:35–12:05	ZHG011	**(Quanten-)Physik für alle mit dem PhotonLab** — •Silke Stähler-Schöpf
SYAS 1.3	Tue	12:05–12:35	ZHG011	**Searching for the fingerprints of new phenomena with top quarks** — •Katharina Behr

Sessions

T 1.1–1.7	Mon	16:45–18:30	ZHG010	**Searches/BSM I (HNL, ETmiss+X)**
T 2.1–2.8	Mon	16:45–18:45	ZHG104	**Higgs Physics I (HH and trilinear coupling)**
T 3.1–3.7	Mon	16:45–18:30	ZHG105	**Higgs Physics II (BSM Higgs)**
T 4.1–4.6	Mon	16:45–18:15	VG 0.110	**Detectors I (Scintillators)**
T 5.1–5.6	Mon	16:45–18:15	VG 0.111	**Silicon Detectors I (ATLAS + CMS)**
T 6.1–6.6	Mon	16:45–18:15	VG 1.101	**Silicon Detectors II (Belle II, Tristan)**
T 7.1–7.5	Mon	16:45–18:00	VG 1.102	**Detectors II (Gaseous Detectors)**
T 8.1–8.6	Mon	16:45–18:15	VG 1.103	**Top Physics I (tt+X)**
T 9.1–9.6	Mon	16:45–18:15	VG 1.104	**Flavour Physics I**
T 10.1–10.7	Mon	16:45–18:30	VG 1.105	**Neutrino Astronomy I**
T 11.1–11.5	Mon	16:45–18:00	VG 2.101	**Data, AI, Computing, Electronics I (Statistical Methods, Applications)**
T 12.1–12.6	Mon	16:45–18:15	VG 2.102	**Data, AI, Computing, Electronics II (Data Management, Workflow)**
T 13.1–13.4	Mon	16:45–17:45	VG 2.103	**Sustainability**
T 14.1–14.5	Mon	16:45–18:00	VG 3.101	**Methods in Astroparticle Physics I**
T 15.1–15.6	Mon	16:45–18:15	VG 3.102	**Cosmic Rays I**
T 16.1–16.6	Mon	16:45–18:15	VG 3.103	**Neutrino Physics I**
T 17.1–17.6	Mon	16:45–18:15	VG 3.104	**Neutrino Physics II**
T 18.1–18.7	Mon	16:45–18:30	VG 4.101	**Methods in Particle Physics I (Calo, Jets, Tagging)**
T 19.1–19.8	Mon	16:45–18:45	VG 4.102	**Search for Dark Matter I**
T 20.1–20.4	Tue	13:45–15:45	ZHG011	**Invited Topical Talks I**
T 21.1–21.4	Tue	13:45–15:45	ZHG010	**Invited Topical Talks II**
T 22.1–22.1	Tue	12:35–13:45	ZHG011	**Annual Meeting of Young Scientists in High Energy Physics**

T 23.1–23.7	Tue	16:15–18:00	ZHG010	**Searches/BSM II (Non-collider)**
T 24.1–24.6	Tue	16:15–17:45	ZHG104	**Higgs Physics III (boson final states)**
T 25.1–25.6	Tue	16:15–17:45	ZHG105	**Higgs Physics IV (BSM Higgs)**
T 26.1–26.6	Tue	16:15–17:45	VG 0.110	**Axions/ALPs I**
T 27.1–27.8	Tue	16:15–18:15	VG 0.111	**Silicon Detectors III (ATLAS + CMS production)**
T 28.1–28.6	Tue	16:15–17:45	VG 1.101	**Silicon Detectors IV (SiPMs, HG timing)**
T 29.1–29.5	Tue	16:15–17:30	VG 1.102	**Detectors III (Scintillators)**
T 30.1–30.6	Tue	16:15–17:45	VG 1.103	**Top Physics II (Properties)**
T 31.1–31.8	Tue	16:15–18:15	VG 1.104	**Flavour physics II**
T 32.1–32.7	Tue	16:15–18:00	VG 1.105	**Neutrino Astronomy II**
T 33.1–33.6	Tue	16:15–17:45	VG 2.101	**Data, AI, Computing, Electronics III (ML in Jet Tagging, Misc.)**
T 34.1–34.8	Tue	16:15–18:15	VG 2.102	**Data, AI, Computing, Electronics IV (DAQ, Detector Electronics)**
T 35.1–35.6	Tue	16:15–17:45	VG 2.103	**Electroweak Physics I (Weak Mixing Angle, Tau Production)**
T 36.1–36.6	Tue	16:15–17:45	VG 3.101	**Methods in Astroparticle Physics II**
T 37.1–37.6	Tue	16:15–17:45	VG 3.102	**Cosmic Rays II**
T 38.1–38.7	Tue	16:15–18:00	VG 3.103	**Neutrino Physics III**
T 39.1–39.6	Tue	16:15–17:45	VG 3.104	**Neutrino Physics IV**
T 40.1–40.7	Tue	16:15–18:00	VG 4.101	**Methods in Particle Physics II (Misc.)**
T 41.1–41.7	Tue	16:15–18:00	VG 4.102	**Search for Dark Matter II**
T 42.1–42.3	Wed	11:00–12:30	ZHG011	**Invited Overview Talks I**
T 43.1–43.4	Wed	13:45–15:45	ZHG011	**Invited Overview Talks II**
T 44.1–44.8	Wed	16:15–18:15	ZHG010	**Searches/BSM III (Long-lived, Misc.)**
T 45.1–45.8	Wed	16:15–18:15	ZHG104	**Higgs Physics V (HH and Trilinear Coupling)**
T 46.1–46.8	Wed	16:15–18:15	ZHG105	**Higgs Physics VI (top-Higgs Coupling)**
T 47.1–47.8	Wed	16:15–18:15	VG 0.110	**Axions/ALPs II**
T 48.1–48.10	Wed	16:15–18:45	VG 0.111	**Silicon Detectors V (R&D, Simulation)**
T 49.1–49.6	Wed	16:15–17:45	VG 1.101	**Detectors IV (Scintillators)**
T 50.1–50.4	Wed	16:15–17:15	VG 1.102	**Detectors V (Misc.)**
T 51.1–51.8	Wed	16:15–18:15	VG 1.103	**Top Physics III (Cross Sections, Entanglement)**
T 52.1–52.8	Wed	16:15–18:15	VG 1.104	**Flavour Physics III**
T 53.1–53.8	Wed	16:15–18:15	VG 1.105	**Neutrino Astronomy III**
T 54.1–54.8	Wed	16:15–18:15	VG 2.101	**Data, AI, Computing, Electronics V (Anomaly Detection, Event Selection)**
T 55.1–55.9	Wed	16:15–18:30	VG 2.102	**Data, AI, Computing, Electronics VI (DAQ and Trigger)**
T 56.1–56.7	Wed	16:15–18:00	VG 2.103	**Electroweak Physics II (Multi-boson Processes)**
T 57.1–57.8	Wed	16:15–18:15	VG 3.101	**Gamma Astronomy I**
T 58.1–58.7	Wed	16:15–18:00	VG 3.102	**Cosmic Rays III**
T 59.1–59.9	Wed	16:15–18:30	VG 3.103	**Neutrino Physics V**
T 60.1–60.7	Wed	16:15–18:00	VG 3.104	**Gravitational Waves**
T 61.1–61.8	Wed	16:15–18:15	VG 4.101	**Methods in Particle Physics III (Tracking)**
T 62.1–62.9	Wed	16:15–18:30	VG 4.102	**Search for Dark Matter III**
T 63.1–63.3	Thu	11:00–12:30	ZHG011	**Invited Overview Talks III**
T 64.1–64.4	Thu	13:45–15:45	ZHG011	**Invited Topical Talks III**
T 65.1–65.4	Thu	13:45–15:45	ZHG010	**Invited Topical Talks IV**
T 66.1–66.7	Thu	16:15–18:00	ZHG010	**Searches/BSM IV (BSM with Tops, LQs)**
T 67.1–67.10	Thu	16:15–18:45	ZHG104	**Higgs Physics VII (HH and Trilinear Coupling)**
T 68.1–68.9	Thu	16:15–18:30	ZHG105	**Higgs Physics VIII (CP)**
T 69.1–69.8	Thu	16:15–18:15	VG 0.110	**Strong Interaction / QCD**
T 70.1–70.9	Thu	16:15–18:30	VG 0.111	**Silicon Detectors VI (MAPS, Mighty Tracker)**
T 71.1–71.8	Thu	16:15–18:15	VG 1.101	**Detectors VI (Gaseous Detectors)**
T 72.1–72.9	Thu	16:15–18:30	VG 1.102	**Detectors VII (Calorimeters)**
T 73.1–73.9	Thu	16:15–18:30	VG 1.103	**Flavour Physics IV**
T 74.1–74.8	Thu	16:15–18:15	VG 1.104	**Flavour Physics V**
T 75.1–75.9	Thu	16:15–18:30	VG 1.105	**Neutrino Astronomy IV**
T 76.1–76.10	Thu	16:15–18:45	VG 2.101	**Data, AI, Computing, Electronics VII (Generative AI, MC Generators)**
T 77.1–77.8	Thu	16:15–18:15	VG 2.102	**Data, AI, Computing, Electronics VIII (Fast ML, Triggers)**
T 78.1–78.8	Thu	16:15–18:15	VG 2.103	**Gamma Astronomy II**
T 79.1–79.8	Thu	16:15–18:15	VG 3.101	**Methods in Astroparticle Physics III**
T 80.1–80.7	Thu	16:15–18:00	VG 3.102	**Cosmic Rays IV**
T 81.1–81.8	Thu	16:15–18:15	VG 3.103	**Neutrino Physics VI**
T 82.1–82.8	Thu	16:15–18:15	VG 3.104	**Neutrino Physics VII**
T 83.1–83.10	Thu	16:15–18:45	VG 4.101	**Methods in Particle Physics IV (Lepton Reconstruction)**
T 84.1–84.10	Thu	16:15–18:45	VG 4.102	**Search for Dark Matter IV**

T 85	Thu	19:00–20:00	ZHG104	**Members' Assembly**
T 86.1–86.6	Fri	9:00–10:30	ZHG010	**Searches/BSM V (Misc.)**
T 87.1–87.5	Fri	9:00–10:15	ZHG104	**Higgs physics IX (Charm and Tau Final States)**
T 88.1–88.6	Fri	9:00–10:30	ZHG105	**Miscellaneous**
T 89.1–89.6	Fri	9:00–10:30	VG 0.110	**Axions/ALPs III**
T 90.1–90.6	Fri	9:00–10:30	VG 0.111	**Silicon Detectors VII (ATLAS + CMS phase-2)**
T 91.1–91.6	Fri	9:00–10:30	VG 1.101	**Silicon Detectors VIII (MAPS, misc.)**
T 92.1–92.6	Fri	9:00–10:30	VG 1.102	**Detectors VIII (Gaseous Detectors)**
T 93.1–93.4	Fri	9:00–10:00	VG 1.103	**Top Physics IV (Misc.)**
T 94.1–94.6	Fri	9:00–10:30	VG 1.104	**Flavour Physics VI**
T 95.1–95.5	Fri	9:00–10:15	VG 1.105	**Outreach**
T 96.1–96.6	Fri	9:00–10:30	VG 2.101	**Detectors IX (Calorimeters)**
T 97.1–97.6	Fri	9:00–10:30	VG 2.102	**Data, AI, Computing, Electronics IX (AI-based Object Reconstruction)**
T 98.1–98.6	Fri	9:00–10:30	VG 2.103	**Electroweak Physics III (W/Z Production and Properties)**
T 99.1–99.6	Fri	9:00–10:30	VG 3.101	**Methods in Astroparticle Physics IV**
T 100.1–100.5	Fri	9:00–10:15	VG 3.102	**Cosmic Rays V**
T 101.1–101.6	Fri	9:00–10:30	VG 3.103	**Neutrino Physics VIII**
T 102.1–102.6	Fri	9:00–10:30	VG 3.104	**Neutrino Physics IX**
T 103.1–103.6	Fri	9:00–10:30	VG 4.101	**Methods in Particle Physics V (Event Reconstruction, PID)**
T 104.1–104.6	Fri	9:00–10:30	VG 4.102	**Search for Dark Matter V**
T 105.1–105.4	Fri	11:00–13:00	ZHG011	**Invited Overview Talks IV**

Members' Assembly of the Particle Physics Division

Thursday 19:00–20:00 ZHG104

Sessions

– Invited Overview, Invited Topical, and Contributed Talks –

T 1: Searches/BSM I (HNL, ETmiss+X)

Time: Monday 16:45–18:30 Location: ZHG010

T 1.1 Mon 16:45 ZHG010

Simulation of heavy neutral lepton production and decays with the Sherpa event generator — •Antonia Bähr — TU Dresden - Institute for Nuclear and Particle Physics

The physics of neutrinos still pose some questions, particularly why they are so much lighter than other leptons. One explanation for this is the seesaw mechanism, where right-handed neutrinos are introduced to the Standard Model. This results in the Lagrangian density not only containing a Dirac but also a Majorana mass term. Because of this, there are two neutrino mass eigenstates, a light and a heavy one. The light neutrino is expected to be the one that has already been observed in numerous experiments, while the heavy one would be a new kind of particle, a heavy neutral lepton. Since the heavy neutral lepton would mostly be right-handed, it is not easily detectable as it would not be affected by any of the fundamental forces, apart from gravity. However, current research at the LHC investigate the decay products of heavy neutral leptons, in order to prove their existence. To achieve this, we are simulating the production of heavy neutral leptons in proton-proton collisions and their decay using Sherpa, a Monte Carlo event generator for the simulation of high-energy reactions.

In this study, we will especially include the hadronic decays of the heavy neutral leptons and the vertex offsets, as heavy neutral leptons are relatively long lived particles and therefore do not decay immediately. In this talk I will present the first results from these simulations in context of a typical LHC setup.

T 1.2 Mon 17:00 ZHG010

Search for heavy neutral leptons in decays of W bosons using leptonic and semi-leptonic displaced vertices in center-of-mass energy of 13 TeV p p collisions with the ATLAS detector — •Marzieh Bahmani — Humboldt university, Berlin, Germany

In this talk, I will present a search for long-lived heavy neutral leptons (HNLs), which are produced through the decay of a W-boson into a muon or electron and an HNL. We investigate two distinct decay channels: a leptonic channel, where the HNL decays into two leptons and a neutrino, and a semi-leptonic channel, where the HNL decays into a lepton and a charged pion. This search is based on 140 fb-1 of proton-proton collision data in center-of-mass energy of 13 TeV, collected by the ATLAS detector during Run 2 of the LHC. I will discuss the results within the context of both single-flavor and multi-flavor mixing scenarios and their implications for future searches in this exciting area of particle physics.

T 1.3 Mon 17:15 ZHG010

Searching for type I seesaw mechanism in a two Heavy Neutral Leptons scenario at FCC-ee — Sehar Ajmal[1], Patrizia Azzi[2], •Sofia Giappichini[3], Markus Klute[3], Orlando Panella[1], Matteo Presilla[3], and Xunwu Zuo[3] — [1]INFN Perugia, Perugia, Italy — [2]INFN Padova, Padova, Italy — [3]KIT, Karlsruhe, Germany

This contribution reports the search for heavy neutral leptons (HNL) in the type I seesaw mechanism at the Future Circular Collider in its e+*e* stage (FCC-ee), considering an integrated luminosity of 204 ab^{-1} collected at the Z pole. The study examines two generations of heavy neutral leptons produced in association with Standard Model (SM) neutrinos and decaying to a purely leptonic final state. This theoretical framework can explain neutrino oscillations and other open questions of the SM, providing a broader perspective on the relevance of this experimental search. The analysis is performed using a fast simulation of the IDEA detector concept to study potential HNL interactions at the FCC-ee. The sensitivity contours are obtained from a selection of kinematic variables aimed at improving the signal-to-background ratio for the prompt production case. In the case of long-lived HNLs, the background can be almost fully eliminated by exploiting their displaced decay vertices. The study shows that the FCC-ee has a significant sensitivity to observing these objects in a region of the phase space not accessible by other experiments.

T 1.4 Mon 17:30 ZHG010

Searching for heavy neutral leptons at the NA62 experiment in beam dump mode — •Jonathan Schubert — Max-Planck-Institut for Physics (Werner-Heisenberg-Institut), Boltzmannstr. 8, 85748 Garching, Germany — Technical University of Munich, TUM School of Natural Sciences, Physics Department, Chair for Data Science in Physics, 85748 Garching, Germany

Heavy neutral leptons are a commonly considered hypothetical class of particles with the potential to explain several puzzles of fundamental physics. The NA62 experiment at the CERN SPS can be operated in beam-dump mode, where 400 GeV protons are dumped on an absorber. Due to the large number of interactions in the dump feebly interacting particles like heavy neutral leptons may be produced abundantly. Their downstream decays could be observed with excellent sensitivity using the existing detector apparatus. We report on the status of the first search at NA62 for such decay signatures.

T 1.5 Mon 17:45 ZHG010

Search for new physics in the electron plus missing transverse momentum channel using Run-3 CMS data — Thomas Hebbeker, Kerstin Hoepfner, •Mirac Noyan Özdemir, Valentina Sarkisovi, Alexander Schmidt, and Karl Joseph Schumacher — III. Physikalisches Institut A, RWTH Aachen University

There are many Beyond the Standard Model (BSM) theories that predict new particles in the final state with a high-energy lepton and missing transverse momentum as their experimental signature. Now, using the newly acquired data of the CMS detector from the ongoing Run-3 at an unprecedented center-of-mass energy of 13.6 TeV, a new window is opened for searches in the high-energy regions.

This talk presents the main ideas behind a high-energy physics search and the analysis strategy in the electron plus missing transverse momentum channel. First results, like the comparison of 2022+2023 data to the Standard Model background, the resulting exclusion limit on the Sequential Standard Model (SSM) W' boson mass, as well as the variable coupling strength limit and a model independent (MI) limit, are being shown.

T 1.6 Mon 18:00 ZHG010

Search for New Physics in Events With an Energetic Jet and Missing Transverse Momentum With the ATLAS Experiment — •Moritz Hesping, Volker Büscher, Christian Schmitt, and Duc Bao Ta — Johannes Gutenberg Universität Mainz

A wide range of theories beyond the Standard Model predict particles which only weakly interact with SM particles. If such particles are produced in collisions at the Large Hadron Collider, they are invisible to the detector. However, their presence can be inferred from a large missing transverse momentum when they recoil off a highly energetic jet. This requires a precise estimation of the SM processes resulting in a similar signature, such as the production of Z bosons decaying to neutrinos.

Searches for new physics in such events have been previously carried out at the ATLAS experiment using the full 140 fb^{-1} dataset of the LHC Run 2 (2015-2018). This talk shows the progress of an updated analysis using data from the ongoing LHC Run 3, which has already exceeded Run 2 in luminosity, including an overview of the analysis strategy and data-simulation comparisons in the control regions.

T 1.7 Mon 18:15 ZHG010

Search for new physics in the final state with a tau lepton and missing transverse momentum. — •Valentina Sarkisovi, Kerstin Hoepfner, Alexander Schmidt, and Thomas Hebbeker — III. Physikalisches Institut A

Various Beyond the Standard Model (BSM) theories anticipate the existence of new particles that could decay into final states characterized by the presence of a charged lepton and missing transverse momentum (pT_miss) as their most distinctive experimental signature. The CMS detector at the CERN LHC is used to hunt for novel physics in the high mass region of final states containing a tau lepton and pT_miss. Efficient identification and reconstruction of TeV tau leptons, good description of the high mass region and effective search for the wide range of BSM models are crucial in a tau + pT_miss search for such phenomena. CMS data recorded in 2022 and 2023 in pp collisions with the center-of-mass energy of 13.6 TeV have been analysed. This talk addresses the key concepts of the analysis techniques employed in the search for new physics in the final state with a tau lepton and pT_miss, including various theoretical interpretations. Models with enhanced coupling to third generation leptons are of special interest.

T 2: Higgs Physics I (HH and trilinear coupling)

Time: Monday 16:45–18:45 Location: ZHG104

T 2.1 Mon 16:45 ZHG104

Status for Run3 in the $HH \longrightarrow b\bar{b}\tau^+\tau^-$ channel with the CMS Experiment — •Bogdan Wiederspan, Nathan Prouvost, Ana Andrade, Marcel Rieger, Philip Keicher, Anas Haddad, Tobias Kramer, and Peter Schleper — University Hamburg, Hamburg, Germany

Since its discovery at the Large Hadron Collider (LHC) in 2012, the Higgs boson advanced our understanding of the Standard Model. Despite significant progress, several of its fundamental properties and couplings remain elusive. Among these is the concrete form of the Higgs potential, which depends on the still-undiscovered trilinear self-coupling, often denoted in the kappa framework as κ_λ. The Di-Higgs production with subsequent decays into pairs of bottom quarks and tau leptons, holds particular interest to probe aforementioned coupling, due to its combination of a strong identifiable signature and substantially large statistics.

Given the challenges posed by the small predicted cross section of Di-Higgs processes and the large background contribution, machine learning proves to be an essential tool for enhancing the sensitivity of searches. This talk presents the current efforts of developing a stronger discriminator trained with partial Run3 data recorded with the CMS experiment, to classify events in the $HH \longrightarrow b\bar{b}\tau^+\tau^-$ channel and further increasing sensitivity.

T 2.2 Mon 17:00 ZHG104

Search for Di-Higgs Pair Production in the bbtautau decay channel using Run2+Run3 Data with the ATLAS Detector at the LHC. — •Bhupesh Dixit[1,2], Carl Gwilliam[3], Jordy Degens[4], and Katharina Behr[5] — [1]University of Liverpool, United Kingdom — [2]DESY, Hamburg — [3]University of Liverpool, United Kingdom — [4]University of Liverpool, United Kingdom — [5]DESY, Hamburg

Di-Higgs studies provide the possibility of probing the full shape of the Higgs potential via constraints on the Higgs trilinear coupling. Among all the di-Higgs decay channels, di-Higgs decays to two b-jets and two tau-leptons lies in the sweetspot for the study of di-Higgs owing to its relatively low background and significant branching ratio, making it the most sensitive channel among the ATLAS Run-2 searches for the study of Higgs self-coupling. Using Run2+Run3 data with improved analysis techniques a significant improvement is expected in the sensitivity to Higgs boson pair production. I will present an overview of the analysis strategy and current status with emphasis on the estimate of the important background from SM ttbar production.

T 2.3 Mon 17:15 ZHG104

Phase Space Optimization for the $b\bar{b}\tau^-\tau^+$ Di-Higgs Analysis using Machine Learning with the CMS Experiment — Ana Andrade, •Anas Haddad, Philip Keicher, Tobias Kramer, Nathan Prouvost, Marcel Rieger, Peter Schleper, and Bogdan Wiederspan — Institute for experimental physics, University of Hamburg, Hamburg, Germany

This year marks the twelfth anniversary of the Higgs boson discovery. Yet, many of its properties and couplings remain unexplored. Particularly interesting are the couplings producing a Di-Higgs system in the final state, which are modulated as κ_λ and κ_{2V} in the κ-framework and pose a significant challenge for analyses due to the extremely low cross-sections of their production processes.

Since an efficient usage of the available data is crucial in such analyses, the selection is an important part and decisive for all following analysis steps and resulting measurements. However, one is always confronted with the dilemma of having to trade off higher event statistics for large background contamination in the selected phase space, or vice versa.

This study aims to move away from a fully cut-based selection, usually based on a certain topology, towards a more data-driven approach. The latter utilizes a NN on top of a loose preselection with the goal of optimizing the event selection in the search for Di-Higgs production in the $b\bar{b}\tau^-\tau^+$ channel and enhancing the sensitivity of this analysis.

T 2.4 Mon 17:30 ZHG104

Neural-network-based di-tau mass reconstruction in Higgs boson pair production in the final state with two b quarks and two tau leptons — •Jonathan Pampel, Tatjana Lenz Lenz, and Jochen Dingfelder — Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn

The Higgs boson self interaction could not yet be observed at the Large Hadron Collider due to the rarity of associated processes, such as Higgs boson pair production. Upper limits on the Higgs self-coupling strength have been set using ATLAS and CMS pp data from LHC Run 2. Run 3 data will improve the limits on the HH production cross section and on the Higgs self coupling.

Tau leptons provide a relatively distinct signature (triggering) during data taking and with a probability of about 6% for Higgs bosons to decay into tau pairs, this process is rather frequent. However, the most abundant decay mode for Higgs bosons is the decay into two b quarks. The HH->bb$\tau\tau$ decay mode benefits from both advantages.

One of the challenges of studying this decay mode is the reconstruction of the invariant mass of the di-tau system. This has long been done using a fitting tool – the missing mass calculator (MMC) – which performs well, but is computationally expensive and sometimes does not converge. To mitigate this issue, a neural network (NN) can be used since its evaluation is faster and there is no convergence issue.

This talk will present the training and the performance of the NN-based method for di-tau mass reconstruction, applied to ATLAS pp collision data from Runs 2 and 3.

T 2.5 Mon 17:45 ZHG104

Study of b+tau triggers in the $HH \rightarrow bb\tau\tau$ analysis with the ATLAS experiment — •Pim Bijl, Karl Jakobs, Benedict Winter, Christian Weiser, and Yingjie Wei — Insitute of Physics, Albert Ludwigs Universitaet, Freiburg, Germany

In order to search for di-Higgs production at the Large Hadron Collider (LHC) with the ATLAS experiment, a very efficient event selection is necessary. The first step in the event selection are triggers that decide what LHC collision events are kept for further analysis. This talk will present a study of newly introduced triggers that target the presence of a b-quark jet and a hadronically decaying tau lepton. These triggers are of great interest to the search for di-Higgs production, as they target the signature of the $HH \rightarrow bb\tau\tau$ decay channel. This decay channel has one of the largest branching ratios of di-Higgs decays and provides a clean decay signature. A comparison will be made to the efficiency of the triggers that are currently in use in the $HH \rightarrow bb\tau\tau$ search. Finally, the impact of the new triggers on the sensitivity to the production of di-Higgs in the $bb\tau\tau$ decay channel will be summarized.

T 2.6 Mon 18:00 ZHG104

Improving the sensitivity to the Higgs boson self-coupling in the $HH \rightarrow bb\tau\tau$ channel with the ATLAS experiment — •Katharina Häussler[1], Karl Jakobs[1], Karsten Köneke[2], Yingjie Wei[1], Christian Weiser[1], and Benedict Winter[1] — [1]University of Freiburg — [2]University of Göttingen

The Standard Model (SM) predicts final states with multiple Higgs bosons, involving processes with Higgs boson self-interactions, which have yet to be observed experimentally. Higgs boson pair production provides the most sensitive test of triple Higgs boson self-interactions and the $bb\tau\tau$ final state presents a good compromise between expected signal yield and background contamination, making it one of the three golden channels to explore this phenomenon.

This talk focuses on improvements that can be made in future analyses to increase the sensitivity to the Higgs boson self-coupling modifier κ_λ. Significant deviations from the SM prediction would provide a strong indication of physics beyond the Standard Model.

T 2.7 Mon 18:15 ZHG104

$\tau\tau$ background estimation with the τ-embedding method of CMS in Run3 — •Jannik Demand, Christian Winter, Artur Gottmann, Roger Wolf, and Günter Quast — ETP, Karlsruhe Institute of Technology, Karlsruhe, Germany

In $H \rightarrow \tau\tau$ analyses a major source of background are genuine tau leptons, mostly originating from $Z \rightarrow \tau\tau$ decays. The τ-embedding method is a method to estimate this background from data, by replacing muons in selected events in data with simulated τ-decays. This talk will explain the method and gives a report on its applicability on Run3 data.

T 2.8 Mon 18:30 ZHG104

BSM X → YH searches in bb$\tau\tau$ final states with the CMS experiment — •Quanshan Li, Moritz Molch, Nikita Shadskiy, Roger Wolf, and Ulrich Husemann — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

BSM theory introduces additional Higgs bosons with different masses next to the Standard Model Higgs boson H. This talk presents a search for the decay of a heavy scalar boson X into two lighter scalar bosons Y and H with the data recorded during the LHC Run 2.

To distinguish the signal from backgrounds, a parametric neural network is used, enabling the training and evaluation of one single deep neural network for various X and Y mass hypotheses. Data-driven methods are utilized for background estimation. In addition, a comparison of the background prediction with data is shown in control regions.

T 3: Higgs Physics II (BSM Higgs)

Time: Monday 16:45–18:30 Location: ZHG105

T 3.1 Mon 16:45 ZHG105

Search for light pseudoscalar Higgs bosons in the four-kaon final state with the CMS detector — Nils Faltermann[1], •Johannes Hornung[1], Markus Klute[1], and Benedikt Maier[2] — [1]Karlsruhe Institute of Technologie, Karlsruhe, Germany — [2]Imperial College, London, United Kingdom

Since the discovery of the Higgs boson, extensive measurements of its properties have set upper limits on the branching ratio of its yet undetected decay modes. The branching ratio encompasses immediate decays into SM particles that are not detectable, as well as decays into BSM particles. This talk focuses on a search for Higgs boson decays into pairs of hypothetical pseudoscalar Higgs bosons a, as predicted in models like the NMSSM. Specifically, the search strategy, current status, and expected limits of an analysis targeting prompt decays H -> aa -> KKKK using data collected by the CMS detector during Run 2 of the LHC will be discussed.

T 3.2 Mon 17:00 ZHG105

Higgs Mass Predictions in the CP-Violating High-Scale NMSSM — •Christoph Borschensky[1], Thi Nhung Dao[2], Martin Gabelmann[3], Margarete Mühlleitner[1], and Heidi Rzehak[3] — [1]Karlsruher Institut für Technologie, Germany — [2]PHENIKAA University, Hanoi, Vietnam — [3]Albert-Ludwigs-Universität Freiburg, Germany

In a supersymmetric theory, large mass hierarchies can lead to large uncertainties in fixed-order calculations of the SM-like Higgs mass. A reliable prediction is then obtained by performing the calculation in an effective field theory (EFT) framework, involving the matching to the full supersymmetric theory at the high scale to include contributions from the heavy particles, and a subsequent renormalization-group running down to the low scale.

In my talk, I report on the prediction of the SM-like Higgs mass within the CP-violating Next-to-Minimal Supersymmetric extension of the SM (NMSSM) in a scenario where all non-SM particles feature TeV-scale masses. The matching conditions are calculated at full one-loop order using two approaches. These are the matching of the quartic Higgs couplings as well as of the SM-like Higgs pole masses of the low- and high-scale theory. A comparison between the two methods allows for an estimate of the size of terms suppressed by the heavy mass scale that are neglected in a pure EFT calculation as given by the quartic-coupling matching. The calculation is implemented in a new version of the public program package NMSSMCALC.

T 3.3 Mon 17:15 ZHG105

Planck Safe Phase Transitions in a Complex Singlet Model — •Moritz Bosse and Gudrun Hiller — TU Dormund University, Dortmund, Germany

In this work, we investigate the implications of Beyond the Standard Model Higgs portal couplings on vacuum metastability and strong first-order electroweak phase transitions (SFOEWPT), which are necessary for electroweak baryogenesis. The analysis focuses on the minimal but phenomenologically rich complex singlet model (CxSM) that also provides potential dark matter candidates. It is shown that portal couplings allow for the stabilization of the vacuum up to the Planck scale while simultaneously enhancing the strength of the phase transition to become a SFOEWPT. By adopting Planck safety as a guiding principle for bottom-up model building, we derive new bounds for different dark matter scenarios compatible with SFOEWPTs. The results show that there is significant parameter space available for Planck-safe phase transitions in the CxSM and we explore how this parameter space can be probed at the LHC and beyond.

T 3.4 Mon 17:30 ZHG105

Electroweak spin-1 resonances in Composite Higgs models, pt. 1 — Rosy Caliri[1], •Jan Hadlik[1], Manuel Kunkel[1], Werner Porod[1], and Christian Verollet[2] — [1]Institut für Theoretische Physik und Astrophysik, Universität Würzburg, Germany — [2]Institut de Physique des 2 Infinis de Lyon (IP2I), 69100 Villeurbanne Cedex, France

Composite Higgs models offer an elegant solution to the hierarchy problem by assuming that the Higgs boson is not an elementary particle but a composite state. The Higgs emerges as a pseudo-Nambu-Goldstone boson due to spontaneous symmetry breaking within a new strongly interacting sector. The resulting low-energy dynamics are described by the Coleman-Callan-Wess-Zumino (CCWZ) formalism. These models predict a rich spectrum of additional bound states, including vector resonances, which can arise naturally from an extended hidden global symmetry that is fully gauged. We investigate models where the unbroken subgroup of the strong sector contains $SU(2)_L \times SU(2)_R$ and demonstrate that a generic prediction of these models is the existence of two neutral and one charged spin-1 resonance that mix significantly with the electroweak gauge bosons. Consequently, these states are of considerable interest for phenomenological studies.

T 3.5 Mon 17:45 ZHG105

Electroweak spin-1 resonances in composite Higgs models pt.2 — •Rosy Caliri[1], Jan Hadlik[1], Manuel Kunkel[1], Werner Porod[1], and Christian Verollet[2] — [1]Institut für Theoretische Physik und Astrophysik, Uni Würzburg, D-97074 Würzburg, Germany — [2]Institut de Physique des 2 Infinis de Lyon (IP2I), 69100 Villeurbanne Cedex, France

Composite Higgs theories with partial compositeness are gauge theories, where the Higgs boson arises as a pseudo-Nambu-Goldstone boson (pNGB) and top-partners appear as bound states of three hyperfermions coming from a UV completion. These models offer a promising solution to the Higgs sector's Naturalness problem and predict extra pNGBs and spin-1 resonances. Our focus is on the electroweak spin-1 resonances. We find that three of those states have an important mixing with the SM gauge bosons, allowing their single production in Drell-Yan like processes at LHC. We explore the rich LHC phenomenology of these states and find scenarios where their masses could be as low as 1.5 TeV.

T 3.6 Mon 18:00 ZHG105

Seesaw mechanism in the Georgi-Machacek model — •Colin Heckmeyer[1], Heidi Rzehak[2], and Emilia Welte[1] — [1]Institut für theoretische Physik, Universität Tübingen — [2]Physikalisches Institut, Universität Freiburg

The current experimental measurements of the Higgs properties conform so far with the Standard Model (SM), however allow also for a more complex Higgs sector than the SM one. This opens the door for various extensions, one of which is the Georgi-Machacek model (GM). This model includes a complex SU(2) Higgs triplet state, a real SU(2) Higgs triplet state, and a real SU(2) Higgs doublet state. It is particularly appealing because it allows for the introduction of a type II seesaw mechanism term, an interaction term between the complex triplet and the leptons, generating a mass term for neutrinos. In this model, the neutrinos are assumed to be Majorana particles.

In this talk, a model combining the GM and the seesaw mechanism is introduced. Within this model, the leading-order (LO) decay of an SM-like Higgs boson is presented. One of the key features of the GM is maintaining the rho parameter at unity at LO. The rho parameter is a conserved quantity of custodial symmetry. This symmetry, however is violated at next-to-leading order (NLO) and requires taking custodial symmetry violating terms at LO into account for a proper renormalization procedure. Using this approach, a NLO analysis of the decay of the SM-like Higgs boson is discussed.

T 3.7 Mon 18:15 ZHG105

A note on the Brout-Englert-Higgs mechanism — •Jochum van der Bij — Albert-Ludwigs Universitaet Freiburg, Deutschland

To generate masses for the particles in the standard model a Brout-Englert-Higgs (BEH) field is necessary. However a field is not a particle. I present here a construction whereby the BEH-field has a partly continuous spectrum. The theory is a renormalizable theory beyond the textbook examples. It is only mildly constrained by the LHC data. In order to fully test the theory both an e+e- collider and a muon collider are needed. These experiments can give us information about extra dimensions beyond the three known ones, that are not accessible to charged particles.

T 4: Detectors I (Scintillators)

Time: Monday 16:45–18:15 Location: VG 0.110

T 4.1 Mon 16:45 VG 0.110

Track position reconstruction with of a fiber-structured plastic scintillator detector (using a likelihood-based method) — Alessia Brignoli[1], Andrew Picot Conabo[1], Valery Dormenev[2], Christian Dreisbach[3], Karl Eichhorn[3], Jan Friedrich[3], Heiko Markus Lacker[1], Martin J. Losekamm[3], Anupama Reghunath[1], Christian Scharf[1], Ben Skodda[1], Valerian von Nicolai[1], Ida Woestheinrich[1], Hans-Georg Zaunick[2], and •Jasmin Weiss[1] — [1]Humboldt-Universität zu Berlin — [2]Justus-Liebig-Universität Gießen — [3]Technische Universität München

The CheapCal project aims to develop a low-cost, position-sensitive sampling calorimeter based on plastic scintillators. A prototype detector has been de-

veloped with 32 wavelength-shifting (WLS) fibers embedded in perpendicular grooves on the front and the back of a $(25 \times 25 \times 0.7)$ cm^3 scintillator plate. The WLS fibers are read out on both ends by Silicon Photomultipliers. The relatively short light attenuation length of the extruded scintillator material limits the photon collection primarily to fibers adjacent to a particle hit. We will present results from 100 GeV muon test beam data, comparing a weighted arithmetic mean hit position reconstruction technique with a likelihood-based approach. We acknowledge funding from BMBF, grant number 05H2021.

T 4.2 Mon 17:00 VG 0.110

Time resolution of a wavelength-shifting fibre structured plastic scintillator detector — Alessia Brignoli[1], Andrew Picot Conaboy[1], Valery Dormenev[2], Christian Dreisbach[3], Karl Eichhorn[3], Jan Friedrich[3], Heiko Markus Lacker[1], Martin J. Losekamm[3], Anupama Reghunath[1], Christian Scharf[1], Ben Skodda[1], Anubandh Sreekeessoon[1], Valerian von Nicolai[1], Jasmin Weiss[1], •Ida Wöstheinrich[1], and Hans-Georg Zaunick[2] — [1]Humboldt-Universität zu Berlin — [2]Justus- Liebig-Universität Gießen — [3]Technische Universität München

The CheapCal project aims to create a cost-effective, position-sensitive sampling calorimeter using extruded plastic scintillators. The prototype detector consists of a $(25\times25\times0.7)$ cm^3 scintillator plate with 32 wavelength-shifting (WLS) fibers embedded in perpendicular grooves on its front and back surfaces. Silicon photomultipliers read out the WLS fibers on both ends. Due to the scintillator's short light attenuation length, photons generated in the scintillator by charged-particle hits are collected primarily by the fibers closest to the particle hit.

We will present the timing measurement results obtained in the lab using a radioactive Sr-90 source and Kuraray Y-11 fibers with charge-sensitive preamplifiers. Combining the timing information from the closest fibers to the source position, we achieved a timing resolution below 750 ps(standard deviation). We are performing additional studies on improving time resolution using alternative WLS fibers such as Kuraray YS-2 and alternative pre-amplifiers optimized for time resolution.

T 4.3 Mon 17:15 VG 0.110

Opaque Scintillators for Neutrino Physics — Christian Buck[1], Benjamin Gramlich[1], and •Stefan Schoppmann[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]JGU Mainz, Exzellenzcluster PRISMA$^+$, Detektorlabor, Staudingerweg 9, 55128 Mainz, Germany

A new scintillator system was developed based on admixtures of wax in organic scintillators. The opacity and viscosity of this gel-like material can be tuned by temperature adjustment, wax concentration, and wax type. Whereas it is a colourless transparent liquid at high temperatures, it has a milky wax structure below.

Due to its light confinement, the scintillator system is expected to exhibit unprecedented particle ID via the topology of energy depositions. Moreover, a high degree of metal loading is feasible, e.g. in the context of searches for double beta decays or neutron capture.

In this presentation, the production and properties of such a scintillator as well as its advantages compared to transparent scintillator are described.

T 4.4 Mon 17:30 VG 0.110

Wavelength shifting fibers with high photon capture rate — •Bastian Kessler and Sebastian Böser for the NuDoubt-Collaboration — JGU Mainz - Institut für Physik

Wavelength-shifting optical fibers are commonly used to collect light from large detector volumes and guide towards photosensors, making them particularly interesting for water Cherenkov or scintillator based detectors. However, one problem is their low photon capture rate, leading to a degradation in the energy resolution of fiber-based detectors.

Building on previous work, it was shown that the photon capture rate can be increased by optimizing the design of the photon absorption zone. In this work, this concept was applied to wavelength shifting fiber to increase the light output of the hybrid opaque scintillator experiment NuDoubt^{++}.

However, the first prototype fibers suffer still from a relative high attenuation, losing this advantage for fiber lengths over 2 meters and losing efficiency compared to commercial fibers. In this presentation we will discuss about the further development of the fibers and the effect of adapted production methods on the attenuation length.

T 4.5 Mon 17:45 VG 0.110

Development of an integrated photon and phonon detector for use with scintillators — •Ashish Jadhav, Christian Enss, Andreas Fleischmann, Daniel Hengstler, Cagla Mahanoglu, Ioana-Alexandra Nitu, Christian Ritter, Andreas Reifenberger, Daniel Unger, and Loredana Gastaldo — Kirchhoff Institute for Physics, Heidelberg University

The AMoRE project searches for $0\nu\beta\beta$ decay in ^{100}Mo using scintillating crystals coupled with metallic magnetic calorimeters (MMCs) operated at 20mK. The current setup utilizes separate phonon and photon detectors to simultaneously measure the crystal's temperature rise and emitted light. We present the development of an integrated photon-phonon detector (P2) for a potential improvement in energy resolution and background suppression. In the P2 design, the central part of a 3" silicon wafer is separated from the rest of the wafer by trenches produced through silicon etching, leaving only six narrow bridges for thermal connection. This central part serves as a photon detector with the MMC sensor having stripline geometry and thermally isolated from the rest of the wafer by trenches produced through silicon etching techniques. The outer region of the wafer hosts three MMC units that are coupled to the scintillating crystal to monitor temperature changes. This configuration would help study a position-dependent signal shape, improving event discrimination for multi-site events. The primary challenges in developing a P2 detector are the fabrication of the thermally isolated photon absorber area and the reliable, support-free mounting of the scintillating crystal onto the wafer.

T 4.6 Mon 18:00 VG 0.110

Development of a Novel Te-doped Liquid Scintillator with Slow Light Emission for $0\nu\beta\beta$-Decay Searches in a Hybrid Neutrino Detector — •Hans Theodor Josef Steiger[1], Manuel Böhles[2], Matthias Raphael Stock[1], Meishu Lu[1], Ulrike Fahrendholz[1], Ronja Huber[1], Lothar Oberauer[1], Franz von Feilitzsch[1], and Michael Wurm[2] — [1]Physik-Department, Technische Universität München, James-Franck-Str. 1, 85748 Garching, Germany — [2]Johannes Gutenberg Universität, Staudingerweg 7, 55128 Mainz, Germany

It is a long-standing paradigm that organic scintillators allow excellent energy resolution but no directional reconstruction. Here we show the foundation for overcoming this by scintillators with slow light emission, paving the way for hybrid detectors that combine the advantages of Cherenkov and scintillation detectors. In such slow liquid scintillators, it is possible to reconstruct directional and topological information from Cherenkov light, while the high light yield of an organic scintillator ensures excellent energy resolution and low thresholds necessary for many applications in neutrino and particle physics such as the search for the $0\nu\beta\beta$ decay. We also developed a novel loading technique for these scintillators with 130Te and show studies of fundamental properties of these scintillators and the novel dopant. This work is supported by the Clusters of Excellence PRISMA+ and ORIGINS and the Collaborative Research Center 1258.

T 5: Silicon Detectors I (ATLAS + CMS)

Time: Monday 16:45–18:15 Location: VG 0.111

T 5.1 Mon 16:45 VG 0.111

The operational experience and performance of the ATLAS SCT during LHC Run-3 operations — •Alessandro Guida — Humboldt University, Berlin, Germany

The ATLAS SemiConductor Tracker (SCT) restarted operations in LHC Run-3. The SCT successfully operated in LHC Run-2 (2015-2018) which came with high instantaneous luminosity and pileup conditions that were far in excess of what the SCT was originally designed to meet. Similar conditions are now faced during the on-going Run-3 and first significant effects of radiation damage in the SCT are observed.

This talk will summarise the operational experience, challenges and performance of the SCT during the first years of Run-3 operations. The observation and prospect of radiation damage on SCT silicon strip sensors will also be presented.

T 5.2 Mon 17:00 VG 0.111

Thermal cycling in Aachen and grading procedures for 2S modules for the CMS Phase-2 Tracker Upgrade — •Max Beckers[2], Lutz Feld[1], Nina Höflich[2], Katja Klein[1], Martin Lipinski[1], Alexander Pauls[1], Oliver Pooth[2], Nicolas Röwert[1], Vanessa Oppenländer[1], and Lennart Wilde[2] — [1]I. Physikalisches Institut B, RWTH Aachen University — [2]III. Physikalisches Institut B, RWTH Aachen University

For the CMS Phase-2 Outer Tracker upgrade, new silicon strip detector modules consisting of two silicon strip sensors, so-called 2S modules, are developed and produced. This process is distributed along multiple assembly centers worldwide.

RWTH Aachen University will build around 1000 2S modules. The assembled modules are then shipped to DESY, where they are thermally cycled in the "Burn-in" setup. In addition, a multi module cold box is available in Aachen to perform thermal cycles for up to 4 modules.

The POTATO software is the centrally developped software to validate the test

results and apply the grading procedures. The gradings are based on different electrical and readout parameters of the module and then stored in the central database.

This talk presents the cold box setup at Aachen together with cyclings performed on preproduction 2S modules. In addition to the cycling results, the grading procedures are explained, and the POTATO software is presented.

T 5.3 Mon 17:15 VG 0.111

Thermal qualification of the silicon detector modules for the Phase-2 upgrade of the CMS Outer Tracker — •Niyathikrishna Meenamthuruthil Radhakrishnan, Alexander Dierlamm, Ulrich Husemann, Markus Klute, Stefan Maier, Lea Stockmaier, Tobias Barvich, and Bernd Berger — Karlsruhe Institute of Technology, Karlsruhe, Germnay

The LHC is about to enter its high-luminosity era in 2029. In order to prepare the particle detectors to deal with the high particle rate and radiation damage, the detector components must be upgraded. One upgrade project is the replacement of the tracking system of the CMS detector. The new Outer Tracker will consist of two types of silicon sensor modules: 5592 PS modules which are made of one pixel sensor and one strip sensor and 7608 2S modules with two strip sensors.

Production and testing of these modules are carried out at 10 sites and one of the centers producing the 2S modules is KIT. In the tracker, these modules will be operated with a coolant temperature of around -35. It must be verified that the modules can function flawlessly at this temperature prior to installation in the detector. In order to do that, modules are placed inside a thermally insulated box with active cooling, called burn-in station, to perform temperature cycles and expose the modules to thermal stress for up to 48 hours. The electrical functionality of the modules is monitored during this period.

The talk will give a summary of the current status of the burn-in station at KIT and present the thermal qualification of the station as well as results with the first production modules.

T 5.4 Mon 17:30 VG 0.111

ITk Pixel DCS: Pixel System Monitoring Readout — •Anne Gaa and Stan Lai — Friedrich-Hund Platz 1, 37077 Goettingen

The ATLAS experiment is developing the new Inner Tracker (ITk) in preparation for the High-Luminosity LHC Upgrade. The ITk pixel Outer Barrel demonstrator, as a system prototype, recently passed its final design review phase in preparation of the construction of the finished detector. The Detector Control System (DCS) is responsible for monitoring and controlling the detector and its sub-systems.

Part of the DCS is the readout chain of the Monitoring of Pixel System (MOPS), which provides an independent monitoring of the temperature and voltage of the front-end pixel modules. The MOPS-Hub is the bidirectional interface between the local DCS station and the MOPS chips. The MOPS chips are connected via CAN buses to an FPGA, which sends the monitored data over an OPC UA server to the local DCS control station. Testing sites for the Outer Barrel local supports, as well as the OB demonstrator will use the next iteration of the MOPS readout in the near future, featuring a new FPGA and a new OPC UA server. The OPC UA server will gain the functionality to read and write to the shared register on the FPGA via its device classes. As a first step, this server will be developed in the environment of a register simulation. This talk presents new developments of the MOPS readout.

T 5.5 Mon 17:45 VG 0.111

Testing of ATLAS ITk pixel detector modules — Markus Cristinziani[1], Qader Dorosti[1], •Luke Hammer[1], Stefan Heidbrink[2], Lasse Jäderberg[1], Nils Krengel[1], Nico Malinowski[1], Denise Müller[1], Jason Müller[1], Noah Siegemund[1], Waldemar Stroh[2], Wolfgang Walkowiak[1], Jens Winter[2], Michael Ziolkowski[2], and Alessia Zuev[1] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Elektronikentwicklungslabor Physik, Universität Siegen

The upcoming High-Luminosity LHC upgrade will significantly increase the LHC's instantaneous luminosity by a factor of 5 starting in 2030. The ATLAS detector upgrade introduces a comprehensive, all-silicon inner tracking system (ITk), comprising sophisticated silicon strip and pixel modules that will completely replace the existing Inner Detector. At the University of Siegen, modules of the Outer Barrel Pixel detector will be assembled and tested, requiring complex setups and intensive quality control procedures to ensure the precision, functionality and reliability of each detector module. In this talk these test setups will be presented. They comprise a comprehensive electrical testing system with integrated interlock mechanisms to protect module integrity during characterization, and a sophisticated thermocycling setup designed to assess module performance after extreme temperature variations.

T 5.6 Mon 18:00 VG 0.111

Quality Control Tests of ITK Pixel Modules — •Ruben Förster, Jörn Grosse-Knetter, and Arnulf Quadt — II. Physikalisches Institut, Georg-August-Universität Göttingen

The High Luminosity upgrade of the Large Hadron Collider (HL-LHC) presents significant challenges for the subcomponents of the ATLAS experiment. Consequently, it necessitates the construction of an all-silicon Inner Tracker (ITk) able to deal with increased particle fluxes and radiation levels.

ITk will feature both hybrid pixel and strip detectors, with the pixels forming the inner part. The ITk pixel detector will consist of about 10,000 separate modules, with approximately 600 of them expected to be processed at the University of Göttingen.

Performing Quality Control (QC) tests is vital to ensure the performance of the modules at the time of installation and during the promised 10 years of operation. The QC tests evaluate the overall functionality and electrical properties of the modules, as well as the performance of individual pixels. QC tests are conducted at different stages of the production process to ensure that the modules are within the specifications and that no damage has occurred during the previous assembly steps. As part of the preproduction phase, work has been undertaken to ensure the feasibility of performing QC tests while also automating and optimizing the processes to ensure that modules can be produced in a timely manner.

T 6: Silicon Detectors II (Belle II, Tristan)

Time: Monday 16:45–18:15 Location: VG 1.101

T 6.1 Mon 16:45 VG 1.101

Performance study of the proposed Belle II vertex detector upgrade — •Lukas Herzberg[1], Benjamin Schwenker[1], Thibaud Humier[1,2], and Ariane Frey[1] — [1]Georg August-Universität Göttingen, Göttingen — [2]DESY, Hamburg

The proposed Belle II vertex detector upgrade intends to replace the current vertex detector (VXD), consisting of pixel and strip subdetectors with a unified silicon pixel detector (VTX). This upgrade is scheduled to take place during long shutdown 2 in 2032. The main purpose of the vertex detector in Belle II is to improve the analyses of time dependent *CP* violation. To quantify the impact of the upgrade on performance, we investigated three variables.

The *effective flavor tagging efficiency* is a measure of how good the detector can differentiate between B^0 and $\overline{B}^0$ which directly affects the statistical power of any *CP* violation analyses in the B^0 system. The *reconstruction efficiency* is the fraction of correctly reconstructed events. The *vertex resolution* is the accuracy of the decay positions. It is measured separately for the two B mesons in the event. These three performance variables can be measured in simulation for both the VXD and the VTX. Finally a fit of the unitary triangle parameter β was performed as an example of a full time dependent *CP* violation analyses.

T 6.2 Mon 17:00 VG 1.101

Investigation of high backside currents in DePFET pixel sensors for the Belle II experiment using dedicated test structures — Florian Bernlochner, Jochen Dingfelder, •Georgios Giakoustidis, and Botho Paschen — University of Bonn, Germany

For the Belle II experiment at KEK (Tsukuba, Japan) the KEKB accelerator was upgraded to deliver e^+e^- collisions at a center-of-mass energy of E_{CM} = 10.58 GeV and it has reached a record-breaking instantaneous luminosity of $4.7 \cdot 10^{34}\ cm^{-2}s^{-1}$. During the so-called Long Shutdown 1 (LS1) the innermost part of the Belle II detector, the initially descoped PiXel Detector (PXD1) with 20 modules, based on Depleted P-channel Field Effect Transistor (DePFET) technology, was replaced by a fully-populated, two-layer PXD with 40 modules. As the detector closest to the experiment's interaction region, the PXD is most exposed to radiation from the accelerator. Throughout the operation of the PXD1 a steady increase of backside current with irradiation was observed in several modules. Doping-profile measurements and electric field simulations show that this is a consequence of (partially) shorted guard rings at the backside leading to high electric fields and avalanche current multiplication. Irradiation results of dedicated test structures to further investigate the mechanism will be presented.

T 6.3 Mon 17:15 VG 1.101

Characterization of new BELLE-type DePFET pixel test-structures — •Erik Büchau, Florian Bernlochner, Jochen Dingfelder, Georgios Giakoustidis, and Jannes Schmitz — University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany

Silicon-based detectors are a fundamental component of particle tracking systems in modern High Energy Physics (HEP) experiments. The BELLE II experiment in Japan employs the Depleted P-channel Field Effect Transistor (DePFET) technology in its PiXel Detector (PXD), taking advantage of its low material

budget while keeping low intrinsic noise at high signal-to-noise ratio. DePFET pixel technology is subject to extensive research and development, leading to the production of a new technology variation, PXD13. Due to its similarity to the existing PXD9 design, the PXD13 mini-matrices can be tested using the same infrastructure. Dedicated full system demonstrators (Hybrid5), containing the minimum amounts of all necessary components, are used for laboratory tests and characterization. First characterization results on transistor level, as well as signal response studies on Belle-type PXD13 mini matrices will be covered in this talk.

T 6.4 Mon 17:30 VG 1.101

Investigation of TID damage in the Drain Current Digitizer chip of the Belle II Pixel Detector — •Nikolas Pässler, Jannes Schmitz, Georgios Giakoustidis, Jochen Dingfelder, and Florian Bernlochner — University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany

The Belle II experiment at the SuperKEKB collider in Tsukuba, Japan, explores e^+e^- collisions at a center-of-mass energy of 10.58 GeV and achieved a record luminosity of $4.7 \cdot 10^{34}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$. During the Long Shutdown 1 (LS1) from 2022 to 2023, the initial partially installed PiXel Detector (PXD1) was upgraded to a fully-populated two-layer PXD with 40 modules. These modules consist of a 250×768 pixel matrix, based on Depleted P-channel Field Effect Transistor (DePFET) technology and 3 types of row control and readout ASICs. As the PXD is positioned closest to the interaction region, it has to withstand the highest radiation levels.

Radiation damage leads to increasing levels of noise in the Drain Current Digitizer (DCD) ASIC. Since the exact nature and manifestation of this noise are not yet well understood, further investigation and the development of enhanced calibration routines are required.

In this talk, results from a dedicated X-ray irradiation campaign for the DCD will be presented, focusing on identifying and disentangling the noise effects from the rest of the system. Strategies for mitigating these issues will also be discussed.

T 6.5 Mon 17:45 VG 1.101

Towards Sterile Neutrino Detection: TRISTAN Detector Characterization with a UV-Light-Induced Electron Source — •Daniela Spreng for the KATRIN-Collaboration — TUM School of Natural Sciences - Physics Department, Garching, Germany

The search for keV-scale sterile neutrinos, a potential dark matter candidate, is a major goal in neutrino physics. These neutrinos, if they exist, create subtle distortions in the beta-decay spectrum due to their mixing with active flavors. The KATRIN experiment aims to detect these effects using TRISTAN, a modular multi-pixel silicon drift detector.

This talk focuses on the operation of three TRISTAN detector modules integrated into a KATRIN-like setup. We present characterization measurements of the detector's electron response, emphasizing tests with a UV-light-induced electron source. This partial implementation is a crucial step toward validating the system's performance and readiness to detect sterile neutrino signatures.

This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6).

T 6.6 Mon 18:00 VG 1.101

Characterization of TRISTAN Detector Modules in a KATRIN-like Detector Section with 83mKr — •Christian Forstner for the KATRIN-Collaboration — TUM School of Natural Sciences - Physics Department, Garching, Germany

Sterile neutrinos, a minimal extension of the Standard Model of particle physics, are a promising dark matter candidate if their mass is in the keV-range. The Karlsruhe Tritium Neutrino experiment (KATRIN) will be equipped with a multi-pixel silicon drift detector array, the TRISTAN detector, to search for a keV-scale sterile neutrino signature in the tritium β-decay spectrum. This measurement will follow the completion of KATRIN's neutrino mass measurement campaign. In this work, we report on the first simultaneous operation of three TRISTAN detector modules. The detector system has been installed in a KATRIN-like detector section and is characterized using a 83mKr source. This talk will focus on the first light observed with the detectors to validate the progress of the system and its readiness for the sterile neutrino operation.

This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6).

T 7: Detectors II (Gaseous Detectors)

Time: Monday 16:45–18:00 Location: VG 1.102

T 7.1 Mon 16:45 VG 1.102

Development of a 3D read-out scheme for drift-tube chambers — Davide Cieri, Francesco Fallavolita, Oliver Kortner, Sandra Kortner, Hubert Kroha, •Nick Meier, Giorgia Proto, and Elena Voevodina — Max-Planck-Institute for Physics, Garching, Germany

Current drift-tube chambers only measure the coordinates of charged particle trajectories in the plane orthogonal to their anode wires. This limitation is usually overcome by a second set of detectors providing the coordinates along the anode wires. In this contribution the development of a 3D read-out scheme utilizing the propagation delay of the signals between both ends of a tube is presented. A achievable spatial resolution of about 20 cm along the wire is demonstrated for ATLAS monitored drift-tube chambers. This is limited by the resolution of the ATLAS TDC. Improvements with higher resolution TDC are under investigation for applications of drift tube detectors in experiments at future circular electron position and hadron colliders.

T 7.2 Mon 17:00 VG 1.102

Small-Diameter Muon Drift Tube Detector Chambers for the ATLAS Phase-II Upgrade: Performance Testing and Certification with New Readout — •Bastian Wesely, Fan Zhou, Oliver Kortner, Hubert Kroha, Nick Kube, Nick Meier, and Elena Voevodina — Max-Planck-Institute for Physics, Munich, Germany

To meet the requirements of the High-Luminosity LHC (HL-LHC), the Muon Drift Tube (MDT) chambers in the inner barrel layer (BIS) of the ATLAS muon spectrometer are being replaced with small-diameter Muon Drift Tube (sMDT) chambers. These advanced chambers will be integrated with triplets of thin-gap Resistive Plate Chambers (RPCs) to enhance the acceptance and robustness of the barrel muon trigger system. The sMDT chambers, designed with drift tubes that are half the diameter of the original MDT chambers, deliver an order-of-magnitude improvement in background rate capability. A total of 96 new sMDT chambers were constructed between January 2021 and September 2023 at two production sites. 50% of these chambers were produced at the Max Planck Institute for Physics (MPP) in Munich, and they are now being equipped with final readout electronics at BB5, CERN. In this contribution, we will present the certification methods and performance test results from the CERN BB5 facility, comparing them with the initial testing campaign conducted at the Max Planck Institute for Physics.

T 7.3 Mon 17:15 VG 1.102

Quality Control Framework for the CMS Drift Tube Electronics Upgrade — Dmitry Eliseev, •Nils Esper, Thomas Hebbeker, Kerstin Hoepfner, Markus Merschmeyer, Carsten Presser, and Alexander Schmidt — III. Physikalisches Institut A, RWTH Aachen University

The Drift Tube (DT) system is one of the muon subdetectors in the barrel region of the Compact Muon Solenoid (CMS) experiment. As part of the Phase-2 Upgrade for the High-Luminosity Large Hadron Collider (HL-LHC), the electronics of the DT system will be upgraded. This includes exchanging the minicrate electronics, which are mounted on each DT chamber. The new electronics feature the On-Board Electronics for Drift Tubes (OBDT) boards, responsible for the time-precise hit acquisition from the chamber front-ends and upstreaming of the hit data. The OBDTs also provide slow control functionalities for the chamber infrastructure. As part of the upgrade efforts, quality control instruments and procedures have been developed to be deployed at the minicrate assembly sites and at CERN. This talk describes the current status of the Phase-2 Upgrade activities, focussing on the minicrate testing framework.

T 7.4 Mon 17:30 VG 1.102

Upgrade of the MDT Front-end Electronics of the LMU Cosmic Ray Facility — •Eshita Kumar, Otmar Biebel, Valerio D'Amico, Stefanie Götz, Daniel Grewe, Ralf Hertenberger, Nirmal Mathew, Nick Schneider, Chrysostomos Valderanis, and Fabian Vogel — LMU München

As part of the Phase-II Upgrade of the ATLAS Muon Spectrometer for the High Luminosity LHC (HL-LHC), a new and enhanced trigger and readout system for the Monitored Drift Tube (MDT) chambers is being installed. To evaluate the Phase-II upgrades on an MDT chamber outside the ATLAS detector and independently of ongoing upgrade activities at CERN, the LMU Cosmic Ray Facility (CRF) in Garching serves as an ideal testing site. Equipped with two fully operational MDT chambers and scintillators for triggering, the facility has been

upgraded with Phase-II front-end electronics to facilitate a comprehensive test. These new front-end electronics are tested using the MiniDAQ readout system. In this talk, the current status of the project and first results will be shown. A comparison between the performance of the original CRF electronics and the new Phase-II electronics will be presented.

T 7.5 Mon 17:45 VG 1.102

Development and Implementation of a new Trigger System in the LMU Cosmic Ray Facility for Level-0 MDT Trigger Processor Testing — •Nick Schneider, Otmar Biebel, Valerio D'Amico, Stefanie Götz, Ralf Hertenberger, Eshita Kumar, Chrysostomos Valderanis, Fabian Vogel, Daniel Grewe, and Nirmal Mathew — LMU München

The Phase-II Upgrade of the ATLAS Muon Spectrometer for the High Luminosity LHC (HL-LHC) includes the installation of a new and more efficient trigger and readout system for the Monitored Drift Tube (MDT) chambers. One of the components is the new Level-0 MDT Trigger Processor (L0MDT). The LMU Cosmic Ray Facility (CRF) is a test stand equipped with two ATLAS series production MDT BOS chambers and a scintillator hodoscope for triggering. It could be used to test L0MDT under realistic conditions. Since it is running on unsupported legacy electronics an upgrade to ALTAS Phase-II standard has to be done first. This also ensures that the CRF remains operational in the future. For the new electronics an upgrade of the trigger system is needed. In addition the regular Phase-II trigger path has to be changed such that it fits the specifications of the CRF including emulators for not yet available electronics. This talk will cover the operating principal and the hardware implementation of this new trigger system and will present some first results. The readout electronics will not be covered in this talk. A first aim after the full upgrade of the trigger and the readout electronics is to enable full testing of L0MDT in a realistic environment.

T 8: Top Physics I (tt+X)

Time: Monday 16:45–18:15 Location: VG 1.103

T 8.1 Mon 16:45 VG 1.103

Measurement of the associated production of top quark pairs with a photon at $\sqrt{s}$ = 13.6 TeV with the ATLAS detector — Diptaparna Biswas[1], Beatrice Cervato[1], Markus Cristinziani[1], Carmen Diez Pardos[1], Ivor Fleck[1], Arpan Ghosal[1], Gabriel Gomes[1], •Jan Joachim Hahn[1], Vadim Kostyukhin[1], Nils Krengel[1], Buddhadeb Mondal[1], Stefanie Müller[1], Sebastian Rentschler[1], Elisabeth Schopf[1], Katharina Voss[1], Wolfgang Walkowiak[1], Adam Warnerbring[1], and Tongbin Zhao[1,2] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Shandong University, China

The production of top quark pairs in association with a photon ($t\bar{t}\gamma$) is an important process to investigate the coupling between the photon and the top quark. Precise measurements of this interaction allow testing the Standard Model (SM) and set limits on physics beyond the SM phenomena which affect the electroweak couplings of the top quark. The increased centre-of-mass energy of 13.6 TeV and luminosity of the ongoing LHC Run 3 allow for more precise measurement of this process, compared to the recent result for Run 2. In this talk, the ongoing measurement of the $t\bar{t}\gamma$ production using Run 3 data taken with the ATLAS experiment is presented, including first data-driven measurements of relevant background processes.

T 8.2 Mon 17:00 VG 1.103

Event classification for the measurement of differential cross-sections in single-top + photon events at the ATLAS experiment with $\sqrt{s}$ = 13 TeV — •Lucas Cremer[1], Nils Julius Abicht[1], Tomas Dado[2], and Andrea Helen Knue[1] — [1]TU Dortmund, Experimentelle Physik — [2]CERN

After the observation of single-top quark production in association with a photon at the ATLAS experiment, differential cross-sections of this process are measured. The resulting distributions will be unfolded and interpreted in terms of effective-field-theory operators.

An important step in the analysis is the classification of signal and background events. This classification will be used to define a signal region enriched with $tq\gamma$ events, allowing for a stable unfolding of observables sensitive to physics beyond the Standard Model. A deep feed-forward neural network is trained to classify the events based on the kinematic properties of the objects in the final state. Furthermore, the sensitivity of various high-level variables is studied to optimize the performance of the neural network. The training is applied to the complete ATLAS Run-2 dataset, corresponding to an integrated luminosity of 140 fb^{-1}.

T 8.3 Mon 17:15 VG 1.103

Search for $t\bar{t}\gamma\gamma$ production in lepton+jets channel in pp collisions at $\sqrt{s}$=13 TeV with the ATLAS detector — Diptaparna Biswas[1], Beatrice Cervato[1], Markus Cristinziani[1], Carmen Diez Pardos[1], Ivor Fleck[1], •Arpan Ghosal[1], Gabriel Gomes[1], Jan Joachim Hahn[1], Vadim Kostyukhin[1], Nils Krengel[1], Buddhadeb Mondal[1], Stefanie Müller[1], Sebastian Rentschler[1], Elisabeth Schopf[1], Katharina Voss[1], Wolfgang Walkowiak[1], Adam Warnerbring[1], and Tongbin Zhao[1,2] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Shandong University, China

The top quark pair production ($t\bar{t}$) in association with one or more photons is a key Standard Model process for measuring the strength of the electroweak coupling of the top quark with the photon. While the production of $t\bar{t}$ with one photon is well-studied, the rarer $t\bar{t}$ production with two photons ($t\bar{t}\gamma\gamma$) still remains unobserved. The $t\bar{t}\gamma\gamma$ process is not only a good candidate for probing the electroweak coupling of the top quark, but it is also an irreducible background to the $t\bar{t}$ production in association with a Higgs boson decaying to two photons. Understanding the $t\bar{t}\gamma\gamma$ process can help tighten constraints on anomalous electric and magnetic dipole moments, through which new CP-violating sources can manifest. The talk will discuss the ongoing efforts in the search for the $t\bar{t}\gamma\gamma$ process in the single-lepton $t\bar{t}$ decay channel using the full Run 2 dataset collected by the ATLAS detector at $\sqrt{s}$ = 13 TeV.

T 8.4 Mon 17:30 VG 1.103

Measurement of tt+X (heavy flavour) processes at the CMS experiment — •Rufa Kunnilan Muhammed Rafeek, Ulrich Husemann, and Emanuel Pfeffer — Institute of Experimental Par- ticle Physics (ETP), Karlsruhe Institute of Technology (KIT)

Top quark - antiquark pairs (tt) produced in association with other particles (X) where X can be the Higgs boson, Z/W boson or QCD-initiated heavy flavour jets (bb/cc), plays a significant role in experimental studies at the LHC. The analysis is challenging as these processes, particularly when the bosons decay into heavy flavour quarks, like for example, tt+H(bb) and tt+bb or tt+Z(bb), share the same signature and very similar kinematic features. These high jet multiplicity final states create ambiguities in the reconstruction and identification of these processes and thus, it is hard to differentiate them from each other. The complex task of simultaneously measuring these tt + X processes is addressed by exploring advanced ML techniques such as Graph Neural Networks. The primary objective is to distinguish the additional heavy flavour jets (not part of the tt-system). This differentiation is crucial for subsequent multi-class event classification, encompassing categories such as tt + bb, tt + (bb), tt + (bb) and tt + cc. Effectively, this involves two classification tasks: a binary classification to identify additional jets and a multi-class classification for event categorization, culminating in promising classification results for tt+X events. In this talk, an overview of the ongoing analysis, designed with the Run-2 data of the LHC using the tt single lepton channel, is given.

T 8.5 Mon 17:45 VG 1.103

Search for vector-like leptons and the $t\bar{t}$+heavy flavour jets modelling — •Mahsana Haleem — JMU-Würzburg, Würzburg, Germnay

Vector-like fermions are predicted by several phenomenological models that extend the Standard Model (SM) with renormalisable frameworks to address the hierarchy problem. Examples include the SU(4) × SU(3)' × SU(2)$_L$ × U(1)' theory, also known as the 4321 model, and composite Higgs models. At the LHC, vector-like leptons can be produced via electroweak interactions, leading to rich and intriguing signatures within the 4321 model framework. Through decay chains involving the vector leptoquark, these particles can produce diverse final states, including multiple top quarks, b-quarks, neutrinos, and charged leptons. The sensitivity of this search depends significantly on the precise modeling of the SM top-quark pair production in association with heavy-flavor jets. In this talk, I will present recent ATLAS measurements of $t\bar{t}$+b-jets, along with the results of the ATLAS search for vector-like leptons.

T 8.6 Mon 18:00 VG 1.103

Development of General Purpose $t\bar{t}$ + X and t + X Classifiers with ATLAS — •Clinton Gonsalves, Steffen Korn, and Arnulf Quadt — I Physikalisches Institut, Georg-August-Universität Goettingen, Friedrich-Hund-Platz 1, 37077 Goettingen

The study of $t\bar{t}$ + X and t + X processes is important for understanding the Standard Model (SM) and exploring potential new physics beyond it. These processes involve the production of a top quark pair ($t\bar{t}$) or a single top quark (t) in association with an additional boson, such as a W, Z, Higgs boson (H), or a photon (γ). Accurately identifying these events is crucial for measuring properties such as the top Yukawa coupling in $t\bar{t}$ + H production and for studying rare electroweak processes such as associated t − Z production. However, the rarity of these events and their similarity to background processes, such as $t\bar{t}$ + jets, make their classification challenging.

This talk presents the development of a neural network-based classifier for $t\bar{t}+X$ and $t+X$ events. The classifier is trained on kinematic variables, event-level observables such as transverse momentum p_T^{Miss} and missing transverse energy E_T^{Miss}, and object counts, including jets, leptons, and b-tagged jets. The neural network architecture is optimised to effectively distinguish signal events from background events by learning correlations in the input features.

T 9: Flavour Physics I

Time: Monday 16:45–18:15 Location: VG 1.104

T 9.1 Mon 16:45 VG 1.104

Search for $B^+ \to K^{*+}\tau\ell$ with hadronic tagging at the Belle II experiment — •Lara Fuchs, Torben Ferber, Pablo Goldenzweig, and Raynette van Tonder — Institute of Experimental Particle, Karlsruhe Institute of Technology, Karlsruhe, Germany

Current measurements of semileptonic B meson decays are in tension with Standard Model predictions, giving rise to a plethora of proposed New Physics models to explain the observed results. These models not only incorporate lepton flavor violation, but also predict significantly enhanced rates for lepton flavor violating decays involving second- and third-generation leptons. Among these processes, flavor-changing neutral current transitions such as $b \to s\tau\ell$ are further suppressed, and thus especially sensitive to New Physics contributions.

In this talk, we present the status of the first search for $B^+ \to K^{*+}\tau\ell$, conducted at the Belle II experiment, located at the SuperKEKB asymmetric e^+e^- collider. We employ a hadronic tagging approach where the accompanying B meson in $e^+e^- \to \Upsilon(4S) \to B^+B^-$ events is fully reconstructed via hadronic decay chains. The complete knowledge of the tag-side particle's four-momentum combined with the well-known event energy allow for a direct determination of the invariant mass of the system recoiling against the $B_{\text{tag}}K^{*+}\ell$ system. This provides a reliable method for signal extraction despite the presence of missing energy in the decay, making Belle II an excellent experiment for conducting this search.

T 9.2 Mon 17:00 VG 1.104

CP violation in $\tau \to K^0 h(\geq 0\pi^0)\nu_\tau$ decays at Belle * — •Katarina Dugic[1,2], Daniel Greenwald[1], and Stephan Paul[1] — [1]Technical University Munich — [2]Max Planck Institute for Physics

In 2012, Babar measured a CP-violating decay-rate asymmetry in $\tau \to K_S\pi(\geq 0\pi^0)\nu_\tau$ that deviates from the standard-model prediction by 2.8σ. We present studies for measuring this asymmetry in $\tau \to K^0 h(\geq 0\pi^0)\nu_\tau$ using data from the Belle experiment.

*Funded by the DFG under Germany's Excellence Strategy - EXC2094 - 390783311 and BMBF Verbundforschung (05H21WOKBA BELLE2).

T 9.3 Mon 17:15 VG 1.104

Study of $B \to D(^*)\pi\ell\nu$ decays — Florian Bernlochner, Markus Prim, Valerio Bertacchi, and •Nada Gharbi — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

The excited states of charmed D mesons beyond the 1S ground state are not well explored and entails a lot of puzzles. One such puzzle arises from the observation that the masses of the $D_0^*(2300)$ and $D_{s0}^*(2317)$ mesons, as reported by the Particle Data Group, are nearly equal: $M_{D_0^*(2300)} \simeq M_{D_{s0}^*(2317)}$. This mass similarity contradicts expectations from SU(3) flavor symmetry breaking, which should account for the strangeness of the $D_{s0}^*(2317)$. Beyond the quark model, these excited charmed mesons can be interpreted as hadronic molecules. Using unitarized chiral perturbation theory (UChPT), it has been theoretically shown that the true SU(3) flavour partner of the $D_{s0}^*(2317)$ is the $D_0^*(2100)$, resolving this mass discrepancy and providing a compelling explanation for the observed phenomena and other puzzles. To investigate this theory, we analyse Belle II data focusing on the invariant mass spectrum of the $D^{(*)}\pi$ system from the decay $B \to D^{(*)}\pi\ell\nu$. By extracting the S-wave contribution in this spectrum, one can make a comparison between the Belle II data and the UChPT predictions. A deeper understanding of the $B \to D^{**}\ell\nu$ decays could significantly reduce the systematic uncertainties in the measurement of $\mathrm{R}(\mathrm{D}^{()})$, a key observable that points to possible deviations from the Standard Model.

T 9.4 Mon 17:30 VG 1.104

Partial-Wave Analysis for $B \to J/\psi K\pi$ at Belle and Belle II — •Martin Bartl, Stefan Wallner, and Hans-Günther Moser — Max-Planck-Institut für Physik, München

We will present initial input-output studies based on simulated data for a partial-wave analysis (PWA) of $B^0 \to J/\psi K^+\pi^-$ at Belle and Belle II. The PWA disentangles contributions from numerous intermediate resonances, e.g. K^* mesons in the $K\pi$ subsystem. We will discuss the search for exotic, i.e. non qq, states, which may appear in the $J/\psi K$ and $J/\psi\pi$ subsystems, complementing recent observations by LHCb.

In addition, we will present plans to study isospin related channels, e.g. $B^+ \to J/\psi K^+\pi^0$ and $B^+ \to J/\psi K_S^0\pi^+$.

T 9.5 Mon 17:45 VG 1.104

Dalitz analysis of $B^- \to D^+\pi^-\pi^-$ and $\overline{B}^0 \to D^+\pi^-\pi^0$ — Florian Bernlochner, Markus Prim, Valerio Bertacchi, Agrim Aggarwal, and •Melisa Akdag — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn, Germany

Recent studies have provided strong evidence that the D_0^* meson is better described by an amplitude modeled using unitarized chiral perturbation theory rather than a traditional Breit-Wigner distribution. This finding underscores the importance of a more nuanced approach to modeling these states. The $D^+\pi^-\pi^-$ decay is dominated by a loop diagram that includes the ρ meson, resulting in significant theoretical uncertainties. To mitigate these uncertainties, we directly access the ρ meson in the analysis by incorporating the isospin conjugated modes which include the π^0 via the decay chain $\overline{B}^0 \to D^+\rho^-$ into our considerations. To achieve these goals, it is crucial to analyze not only the $B^- \to D^+\pi^-\pi^-$ final state, which the LHCb experiment can measure with high precision, but also decays involving neutral pions, emerging from $\overline{B}^0 \to D^+\pi^-\pi^0$, where the Belle II experiment can uniquely contribute. This allows us to study the orbitally excited charmed mesons, the D_0^* and the D_2^* in the $D\pi\pi$ final state, and the D_1, D_1' and D_2^* in the $D^*\pi\pi$ final state. By studying both processes we can test heavy quark spin symmetry in these final states.

T 9.6 Mon 18:00 VG 1.104

Group summary: Plans for hadron spectroscopy analyses at LHCb using Run 3 data — Mikhail Mikhasenko and •Marian Stahl — Ruhr University Bochum, Bochum, Germany

The LHCb experiment has undergone a major upgrade to be able to collect data at a five-fold increased instantaneous luminosity during Runs 3 and 4 of the LHC. With the removal of the hardware trigger, the detectors are readout at the LHC collision rate of 30 MHz and the data is processed in real-time by a heterogeneous two-stage software trigger. This leads to improved efficiencies in the event reconstruction, in particular that of fully hadronic decay channels. For spectroscopy, this opens up possibilities to search for particles with low production rates, or to measure properties of known states with improved precision or in new decay modes. I will give a comprehensive overview of LHCb's potential for spectroscopy measurements in Run 3 and highlight topics of the immediate effort within the German spectroscopy community.

T 10: Neutrino Astronomy I

Time: Monday 16:45–18:30 Location: VG 1.105

T 10.1 Mon 16:45 VG 1.105

Classification of incoming neutrino events in IceCube using machine learning — •Sophie Loipolder, Rasmus Ørsøe, and Chiara Bellenghi for the IceCube-Collaboration — Technical University of Munich, Munich, Germany

In neutrino telescopes, event topologies differ depending on the neutrino flavor, the energy and the interaction type. For the reconstruction of the energy and direction of an incoming event, it is best to know the event type in advance to apply the suitable reconstruction algorithm for the respective topology.

This presentation discusses the development and implementation of a neural network-based classifier designed to improve the identification of event topologies in IceCube, a neutrino telescope located at the South Pole. Considering the continuous advances in machine learning, this approach aims to enhance the performance of existing methods currently in use for the classification of real-time neutrino event topologies.

T 10.2 Mon 17:00 VG 1.105

Machine Learning Tools for IceCube-Gen2 — •Francisco Javier Vara Carbonell and Alexander Kappes for the IceCube-Gen2-Collaboration — Universität Münster, Institut für Kernphysik

Machine learning tools, especially neural networks, have triggered a revolution in many areas, including neutrino astronomy. They have great potential for future neutrino telescopes such as IceCube-Gen2 with a large number of small photomultipliers. Neural networks are well suited to tackle high-dimensional problems and can naturally incorporate the segmentation of these new optical sensors. Moreover, they have a fast inference time compared to conventional algorithms, which enables the processing of the high event rates expected from IceCube-Gen2. This talk will present potential applications of neural networks in IceCube-Gen2 in areas such as simulation, event reconstruction and noise reduction, covering the current state of their development and implementation.

T 10.3 Mon 17:15 VG 1.105

Stacking Likelihood Analysis of Extreme Blazars with IceCube Public Data — •Juan Manuel Cano Vila[1,2], Chiara Bellenghi[1], and Paolo Padovani[3] — [1]Technical University of Munich, TUM School of Natural Sciences, Department of Physics, James-Franck-Straße 1, D-85748 Garching bei München, Germany — [2]Arnold Sommerfeld Center, Ludwig-Maximilians University, 80333 Munich, Germany — [3]European Southern Observatory, Karl- Schwarzschild-Straße 2, D-85748 Garching bei München, Germany

Since the confirmation of the existence of high-energy astrophysical neutrinos more than 10 years ago, researchers have been trying to identify which kind of objects emit them. The results have been limited, and the origin of the majority of this astrophysical neutrino flux remains unknown. For the last few years, IceCube has released several datasets to the public that allow any research group to test their hypothesis. One of the available tools designed to study this data is SkyLLH, an open source Python package that provides a framework for implementing custom likelihood functions and executing log-likelihood ratio hypothesis tests. In this project, we developed a new functionality to perform stacking log-likelihood analysis, where one studies the joint signal from multiple selected sources, which enhances the statistics by a population-wide study and allows to test different hypothesis by selecting the weights of each source of the population. We apply this tool to a selected population of blazars characterized by their extreme luminosities in radio and γ-rays.

T 10.4 Mon 17:30 VG 1.105

Investigating the connection of blazars to IceCube alert events with public data — •Julian Kuhlmann and Francesca Capel — Max-Planck-Institut für Physik, Garching, DE

The IceCube collaboration has recently found evidence for neutrino emission from TXS 0506+056. Different mechanisms in various emission regions have been invoked to explain the combined neutrino and multi-wavelength observations. Motivated by spatial associations of IceCube alert events with blazars, such as TXS 0506+056, we analyse a sample of similar blazars for neutrino emission, using a Bayesian hierarchical analysis framework. Utilising the framework's capability of handling many free parameters we go beyond power-laws and employ neutrino spectra typical of proton-gamma interactions. We further use priors on spectral parameters informed by lepto-hadronic modelling of multi-wavelength observations. Among the sample blazars, three sources stand out with considerable association probabilities to neutrino events. Unaccounted for systematics in event reconstruction, as well as limited simultaneous multi-wavelength data currently pose the largest restrictions on firmly identifying the sources of high-energy alert events.

T 10.5 Mon 17:45 VG 1.105

Determination of Systematic Uncertainties in Air Shower Production — •Celina Kortmann — Technische Universität Dortmund

In experimental astrophysics, physical quantities are estimated from measurements using various reconstruction techniques. The physical results can have large systematic uncertainties depending on the properties of the detectors, the analysis, and its underlying assumptions.

Our goal is to quantify and understand the systematic uncertainties associated with predictions based on Monte Carlo simulations in air shower physics. This study is of particular interest for neutrino experiments such as IceCube, whose background consists of atmospheric neutrinos and muons, and IACTs such as MAGIC, whose background contains protons and heavier nuclei, inducing air showers with a pattern similar to gamma rays. In the past, measurements of the atmospheric muon and muon-neutrino flux and of the proton flux have been made.

Using CORSIKA, a program for Monte Carlo simulations of air showers, we compare the fluxes resulting from the same showers to estimate the correlation between the muonic and electromagnetic components of air showers. The current state of the analysis is presented.

T 10.6 Mon 18:00 VG 1.105

Combined sensitivity of JUNO and Super-K on the Black Hole Fraction — •Tim Charissé[1,2], George Parker[2], David Maksimović[2], and Michael Wurm[2] — [1]Helmholtzzentrum für Schwerionenforschung, Planckstrasse 1, D-64291 Darmstadt, Germany — [2]Johannes Gutenberg-Universität Mainz, Institute of Physics and EC PRISMA+

The Diffuse Supernova Neutrino Background (DSNB) is the integrated signal of neutrinos emitted by all core-collapse supernovae (CCSNe) that occurred in the visible universe. Studying it offers insights into the inner workings of CCSNe as well as cosmological properties. The Jiangmen Underground Neutrino Observatory (JUNO), which will soon begin data taking, and the already established Super-Kamiokande (Super-K) detector are promising candidates to measure the DSNB in the near future.

While most CCSNe explode and leave behind a neutron star, an undetermined fraction of CCSNe do not explode due to prior black hole formation and hence cannot be seen by optical telescopes. However, these black hole-forming CCSNe still emit a massive amount of neutrinos which have a different spectral contribution to the DSNB than those emitted by exploding CCSNe. Therefore, the overall fraction of CCSNe that are black hole-forming might be inferred from a measurement of the DSNB spectrum. We are investigating the potential sensitivity of combined DSNB measurements by JUNO and Super-K to the black hole fraction.

T 10.7 Mon 18:15 VG 1.105

Search for the DSNB in JUNO: Development of new Methods for Background Event Identification — •Matthias Mayer, Lothar Oberauer, Hans Steiger, Simon Basten, Ulrike Fahrendholz, Meishu Lu, Konstantin Schweizer, Korbinian Stangler, and Raphael Stock — Physik-Department, TU München, James-Frank-Str. 1, 85748 Garching b. München, Deutschland

The diffuse supernova neutrino background (DSNB) describes the constant flux of neutrinos from past core-collapse supernovae over the entire visible universe. The Jiangmen Underground Neutrino Observatory (JUNO), a 20 kton liquid scintillator detector, expects to observe the DSNB through the inverse beta decay (IBD) detection channel. While other ν_e sources will cause irreducible background in the IBD channel, we aim to reduce non-IBD backgrounds such as spallation-induced fast neutrons and atmospheric neutrino NC interactions by careful pulse-shape discrimination (PSD). For this talk, I compare the performance of different PSD techniques regarding the fiducial volume choice for the DSNB search and look at recent measurements for the energy dependence of the neutron fluorescence time profile in the JUNO scintillator. I will also give an outlook into our recent publication regarding the DSNB detection potential. This work has been supported by the Clusters of Excellence PRISMA+ and ORIGINS as well as the DFG Collaborative Research Center "NDM" (SFB1258) and the DFG Research Units 2319 and 5519.

T 11: Data, AI, Computing, Electronics I (Statistical Methods, Applications)

Time: Monday 16:45–18:00 Location: VG 2.101

T 11.1 Mon 16:45 VG 2.101

Performance measurements of Tau identification tools in ATLAS — •David Dahiya, Christian Schmidt, Arno Straessner, and Asma Hadef — Technische Universität Dresden

Tau leptons are fundamental in a variety of Standard Model and Beyond Standard Model processes currently being studied at the LHC. Their identification is crucial for exploring new physics, as they often serve as key signatures in searches for novel particles and interactions. This work focuses on improving Tau Lepton Identification (TauID) by conducting performance measurements and comparing different TauID models. Current tau identification approaches utilize Recurrent Neural Networks (RNNs), which are trained on a combination of tracks, clusters, and high-level variables to produce a predictive score for each tau candidate. However, recent advancements in machine learning introduce Graph Neural Networks (GNNs) as a promising alternative. GNNs are trained on jet and track-level variables and exploit graph-based attributes to predict features such as vertex position, jet flavor, and track origin, potentially offering a more robust and detailed analysis. This study provides a comparison of the performance of RNN-based and GNN-based models to evaluate the impact of GNNs' added complexity on tau identification. Additionally, GNNs are used to compare and evaluate tau fake factors based on a control data set using the latest Run 3 data.

T 11.2 Mon 17:00 VG 2.101

Adaptation and Optimization of Large Radius Tracking in Athena — •Doğa Elitez[1], Paul Gessinger[1], and Lucia Masetti[2] — [1]CERN — [2]Johannes Gutenberg University of Mainz

Large Radius Tracking (LRT), is a specialized tuning of charged particle track reconstruction algorithms, designed for particles originating far from the main interaction point. It has been integrated into the ATLAS experiment's primary particle reconstruction workflow as of Run-3. For the upcoming High Luminosity upgrade of the LHC, the inner detector is planned to be replaced by an all-silicon inner tracker, ITk, and the implementation of tracking algorithms plays a crucial role. This presentation describes the work focusing on the necessary adaptation and optimization of the LRT workflow within the offline ATLAS track reconstruction software, the Athena framework. The effectiveness of the LRT workflow, strongly linked to both physics and computing performance, is also examined in this study.

T 11.3 Mon 17:15 VG 2.101

Making your analysis reusable with model-agnostic likelihoods and their serialization — •Lorenz Gärtner[1], Thomas Kuhr[1], Slavomira Stefkova[2], Danny van Dyk[3], Lukas Heinrich[4], Méril Reboud[5], Nikolai Krug[1], and Malin Horstmann[4] — [1]LMU, Munich, Germany — [2]University of Bonn, Bonn, Germany — [3]IPPP Durham, United Kingdom — [4]Technical University Munich, Germany — [5]Université Paris-Saclay, France

What constitutes a "signal" in particle physics? Typically, a signal is defined by a specific physical process of interest. Using simulations, we approximate the probability densities of such processes and compare them to known backgrounds through likelihood-based methods.

What happens when parameters for the process need to be revised? What if more precise theoretical predictions become available? How can we search for an entire class of similar processes parameterized by multiple variables? Moreover, can we leverage results from multiple analyses to constrain these parameters?

We address these questions with a simple and efficient reinterpretation approach. We construct model-agnostic likelihoods by employing kinematic reweighting techniques, enabling flexible exchanges of signal models and inference on underlying physical parameters. This method's generality ensures compatibility across analyses, while its straightforward serialization facilitates easy distribution and reuse.

To demonstrate the power and simplicity of our approach, we use the likelihoods of the Belle II $B^+ \to K^+ \nu\bar{\nu}$ analysis to constrain theory parameters.

T 11.4 Mon 17:30 VG 2.101

Hypothesis tests and model parameter estimation on data sets with missing correlation information — •Lukas Koch — JGU Mainz

Ideally, all analyses of normally distributed data should include the full covariance information between all data points. In practice, the full covariance matrix between all data points is not always available. Either because a result was published without a covariance matrix, or because one tries to combine multiple results from separate publications. For simple hypothesis tests, it is possible to define robust test statistics that will behave conservatively in the presence on unknown correlations. For model parameter fits, one can inflate the variance by factor to ensure that things remain conservative at least up to a chosen confidence level. In this talk I will describe a class of robust test statistics for simple hypothesis tests, as well as an algorithm to determine the necessary inflation factor for model parameter fits.

T 11.5 Mon 17:45 VG 2.101

Impact and improvement of handling uncertainties regarding R(D) and R(D*) combining algorithms — •Stefanie Meinert, Ilias Tsaklidis, Florian Bernlochner, and Markus Prim — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

Unexplained phenomena like the matter-antimatter asymmetry and neutrino masses motivate precise measurements of Standard Model (SM) parameters. Testing Lepton Flavor Universality (LFU), which predicts equal coupling of all lepton flavors to the W boson, offers a promising approach to uncover new physics. The analysis of $R(D)$ and $R(D^*)$ in semileptonic B decays is ideal due to its theoretical predictability and experimental accessibility.

HFLAV combined results from LHCb, BaBar, Belle, and Belle II to estimate $R(D)$ and $R(D^*)$, finding deviations of 1.6σ and 2.5σ from SM predictions. Their χ^2-based Combination Code (CoCo), which accounts for statistical and systematic correlations, yields a significance of 3.31σ relative to the SM, indicating potential new physics.

These results rely on assumptions and approximations about systematic correlations, and inconsistent reporting of uncertainties challenges result combinations. Using HFLAV data, we explore the impact of systematic uncertainty variations and present a first average of $R(D)$ and $R(D^*)$ from three internal Belle II measurements via likelihood combinations, leveraging pyhf and SysVar, a Python-based package developed at the University of Bonn for consistent treatment of systematic uncertainties.

T 12: Data, AI, Computing, Electronics II (Data Management, Workflow)

Time: Monday 16:45–18:15 Location: VG 2.102

T 12.1 Mon 16:45 VG 2.102

Adaptation of the HammerCloud visualization to state-of-the-art tools - online and offline — •Lea Kuttler, Michael Böhler, and Markus Schumacher — Institute of Physics, Albert-Ludwigs-University Freiburg, Freiburg, Germany

HammerCloud (HC) is a framework for automated testing designed to monitor the resources of the Worldwide LHC Computing Grid (WLCG). It uses test jobs that mimic realistic physics analysis or production jobs to identify potential issues within the infrastructure of WLCG computing sites.

HC's web interface provides site administrators with detailed insights and visual summaries of test results. After almost two decades of successful operation, these visualizations, which previously relied on Google Image Charts, were upgraded to interactive Highcharts, offering a more dynamic, and user-friendly experience.

Complementing the detailed insights available on the HC website, the Tier-2-Report provides a broader overview by summarizing important test metrics over weekly or monthly periods to analyze overall performance trends. The generation of these Tier-2-Reports is fully automated, using a tool initially developed to present and discuss HC statistics for the GridKa cloud. A recent update has made this tool applicable for generating similar reports for any other cloud. Additionally, this update introduced a redesigned report layout and enhanced representations of test metrics.

This contribution presents the updated methods for visualizing and discussing test results within the HC framework.

T 12.2 Mon 17:00 VG 2.102

A new document server and publication process tool for Belle II — •David Koch and Thomas Kuhr — Ludwig-Maximilians-Universität

An integral part of working in science and in large collaborations in particular is the documentation of work in progress and results, be it in the form of slides, internal notes and reports or papers targeted for publication. Especially the latter however involves much more than just a single document. The process starts from an analysis and includes writing multiple versions of a draft that has to go through many stages and internal approvals until it can be submitted to a journal. The Belle II experiment recently launched its own in-house developed document server, PubDB, that is also a tool to follow the entire process of bringing an analysis to publication. In this talk we show how Belle II uses PubDB to implement its publication procedure policy in a uniform, streamlined and traceable manner. We share ideas and lessons learned that are valuable to the community as a whole.

T 12.3 Mon 17:15 VG 2.102

Orchestrated columnar-based analysis with columnflow — •Mathis Frahm, Johannes Haller, Philip Keicher, Nathan Provoust, Marcel Rieger, Daniel Savoiu, Peter Schleper, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

The large datasets and increasing complexity of modern physics analysis in high energy collider physics pose a major challenge to the analysis workflows. Systems are required that can efficiently process large amounts of data, while keeping the execution of the complete analysis manageable. In this talk, we present Columnflow, a tool for columnar-based data analysis. Columnflow provides an orchestrated, yet flexible workflow that automatically handles the bookkeeping of results and dependencies. Typical analysis tasks such as propagation of systematic uncertainties, machine learning applications, and statistical inference are transparently integrated into the workflow. The implemented workflow allows the use of distributed computing resources and is fully configurable, yet accessible to newcomers.

T 12.4 Mon 17:30 VG 2.102

Pre-cache tests with the WLCG Tier-2 centre GoeGrid and the NHR HPC cluster Emmy using workflows of the ATLAS collaboration at the LHC — •Inga Łakomiec, Saidev Polisetty, Arnulf Quadt, and Sebastian Wozniewski — II Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

The GoeGrid centre in Goettingen is one of the WLCG Tier-2 sites and contributes to the ATLAS job processing and data storage. The HPC cluster Emmy

by the National High Performance Computing (NHR) has been successfully connected with GoeGrid and ATLAS jobs can be run on its resources. However, there is no large local mass storage at Emmy for the WLCG operations. Therefore, data for jobs that are processed at Emmy is currently provided by the GoeGrid storage. A transition of storage and computing resources to the Helmholtz Centres and NHR sites respectively from the university based Tier-2 centres is planned in Germany in the next years. Since some NHR clusters will serve as a big computing centres without a large local mass storage, there is a need to prepare proper caching solutions and validate them.

Small local storage can be available at Emmy for the WLCG tasks after the storage centralisation. The current ATLAS workflow management has been tested for Emmy computing resources together with the small local storage (pre-cache) instance at GoeGrid. Results will be presented for the different number of CPU cores used by heavier workloads exclusively or a mix of production jobs. Then, the transfer and deletion of data in terms of a small disc size will be shown.

T 12.5 Mon 17:45 VG 2.102

Research Data Management at HZDR with HELIPORT — •Stefan E. Müller[1], Thomas Gruber[1], Oliver Knodel[1], Mani Lokamani[1], David Pape[1], Martin Voigt[1,2], and Guido Juckeland[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Technische Universität Dresden, Dresden, Germany

The researchers at the Helmholtz-Zentrum Dresden-Rossendorf rely on a large variety of tools and systems when it comes to administer research data. The project planning phase (proposal submission to a beamtime proposal management system, creation of data management plans and data policies), the documentation during experiments or simulation campaigns (electronic laboratory notebooks, wiki pages), backup- and archival systems as well as the final journal and data publications (using collaborative authoring tools, meta-data catalogs, software and data repositories, publication systems) are all processes which involve research data management. Also, modern research projects often require to interact with a variety of software stacks and workflow management systems to allow reproducibility on the underlying IT infrastructure. The "HELmholtz ScIentific Project WORkflow PlaTform" (HELIPORT), which is currently developed by researchers at HZDR and their collaborators, facilitates the management of research data and metadata by providing an overarching guidance system which combines all the information by interfacing the underlying processes. It also includes a workflow engine which can be used to automate processes like automated data publication or data analysis.

T 12.6 Mon 18:00 VG 2.102

Status and Plans for the CMS Grid at Aachen — Manuel Giffels[1], •Alexander Jung[2], Thomas Kress[3], Martin Lipinski[4], Andreas Nowack[3], Valentina Sarkisovi[2], Alexander Schmidt[2], and Shawn Zaleski[2] — [1]Institut für Experimentelle Teilchenphysik, KIT — [2]III. Physikalisches Institut A, RWTH Aachen — [3]III. Physikalisches Institut B, RWTH Aachen — [4]I. Physikalisches Institut B, RWTH Aachen

From 2025 onwards, the German CMS Grid Tier-2 model will evolve to incorporate external storage from Helmholtz centers and CPU resources provided by the NHR consortium.

In this presentation, we will provide an overview of the current status and outline our plans for utilizing NHR resources for this purpose, with a focus on the Aachen CMS Grid.

T 13: Sustainability

Time: Monday 16:45–17:45 Location: VG 2.103

T 13.1 Mon 16:45 VG 2.103

Users help shaping the path to a sustainably operated VISPA computing cluster — Niclas Eich, Johannes Erdmann, Martin Erdmann, Benjamin Fischer, •Paul Gilles, Tim Hauptreif, and Jan Kelleter — RWTH Aachen University

As climate change progresses, it is evident that computing for physical research needs to become more sustainable. Although the capacity of renewable energy resources is increasing every year, we are currently still dependent on the use of fossil electricity generation. Due to the dynamic nature of renewable energy, it is essential to target smart, adaptive power consumption for more sustainable research.

In this talk, we will present approaches and results within the VISPA project to show users their personal energy consumption in the computing cluster and enable them to automatically schedule their HTCondor jobs based on the availability of renewable energy. We also present our digital twin of the VISPA cluster, which is primarily used to develop and test new resource-saving planning methods.

T 13.2 Mon 17:00 VG 2.103

Photovoltaics for MAGIC telescopes — •Katharina Kürschner and Tristan Franziskus Gradetzke — TU Dortmund, Germany

The energy supply for the MAGIC telescopes on the Canary Island of La Palma, Spain, poses a particular challenge due to its remote location. The feasibility of using photovoltaic technologies are being investigated, with a focus on concentrated photovoltaics (CPV). CPV systems potentially offer higher efficiencies than conventional photovoltaic systems by using lenses or mirrors to concentrate light, but they are technically more demanding and more expensive. At present, the MAGIC telescopes are only used at night as Cherenkov telescopes. Since the MAGIC telescopes already have mirrors, the possibility of using these mirrors for energy generation during the day is being examined. Such a concept has not yet been implemented and could provide an innovative solution to the energy challenges faced by telescopes. Various aspects of CPV are compared with conventional solar systems to assess their suitability for meeting the energy needs of the MAGIC telescopes. The current status of the analysis and initial results will be presented in this talk.

T 13.3 Mon 17:15 VG 2.103

Sustainability at Belle II — Fabian Becherer[2], Florian Bernlochner[3], Lorenz Gärtner[1], Andreas Gellrich[2], David Koch[1], •Thomas Kuhr[1], Caspar Schmitt[1], and Christian Wessel[2] — [1]LMU München — [2]DESY Hamburg — [3]Rheinische Friedrich-Wilhelms-Universität Bonn

In the Belle II collaboration, a discussion of the sustainability topic began in 2023. A survey showed that many Belle II members care about the topic. A grassroots initiative formed and made first estimates of the footprint due to detector operation, computing, and travel.

T 13.4 Mon 17:30 VG 2.103

Know Your Footprint: Evaluating the Environmental Footprint of Individual Researchers — Valerie Lang[1], Naman Kumar Bhalla[1], •Simran Gurdasani[2], and Pardis Niknejadi[2] — [1]Albert-Ludwigs-Universität Freiburg, Freiburg, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Hamburg and Zeuthen, Germany

Mitigating the environmental impact of particle physics is essential for addressing the broader challenges of sustainability, particularly given the resource-intensive nature of the field. The *Know your footprint* initiative, developed within the young High Energy Physicists Germany, provides a self-evaluation survey to quantify an individual's professional footprint by considering four key areas: Experiment, representing the large infrastructure within HEP collaborations; Institute, accounting for emissions from research institutes and universities; Computing, covering resource consumption for data analysis and simulations; and Travel, related to business trips for conferences, workshops, and meetings. The methodology behind the survey is presented, along with a first look at the data collected during its first year of activity. The *Know your footprint* initiative aims to raise awareness, facilitate data-driven discussions, and encourage the adoption of more sustainable research practices within the community.

T 14: Methods in Astroparticle Physics I

Time: Monday 16:45–18:00 Location: VG 3.101

T 14.1 Mon 16:45 VG 3.101

Construction, Calibration, and Operational Plans of the Acoustic Module for the IceCube Upgrade — •Andreas Nöll, Jan Audehm, Jürgen Borowka, Pierre Dierichs, Mia Giang Do, Christoph Günther, Dirk Heinen, Joëlle Savelberg, Christopher Wiebusch, and Simon Zierke — III. Physikalisches Institut B, RWTH Aachen University

The IceCube Neutrino Observatory is a cubic kilometer-sized detector located at the geographic South Pole, consisting of 5160 Digital Optical Modules (DOMs). In the Antarctic summer 2025/26 more than 700 new modules will be installed as part of the IceCube Upgrade. These include ten Acoustic Modules (AMs), capable of transmitting and receiving acoustic signals between 5 and 30kHz. Additionally, up to 30 acoustic receivers will be located in new DOMs. The goal of

these devices is to improve the geometry calibration based on multilateration of the measured acoustic propagation times, as well as enhance our understanding of the acoustic properties of the ice. This talk presents the construction and calibration of AMs, including the acoustic transducer and its internal electronics, as well as an overview of the planned operations of this system.

T 14.2 Mon 17:00 VG 3.101

Development and Construction of the Wavelength-shifting Optical Module for the IceCube Upgrade — •Yuriy Popovych[1], Sebastian Böser[1], Enrico Ellinger[2], Klaus Helbing[2], Adam Rifaie[2], Lea Schlickmann[1], and Nick Schmeisser[2] for the IceCube-Collaboration — [1]Johannes Gutenberg-Universität Mainz — [2]Bergische Universität Wuppertal

The Wavelength-shifting Optical Module (WOM) is an innovative photosensor concept set to be deployed in the IceCube Upgrade during austral summer 2025/26. Utilizing wavelength-shifting and total internal reflection techniques, the WOM is well suited for detecting low-energy neutrinos thanks to its low noise rate. Its photosensitive area consists of a cylindrical tube coated with wavelength-shifting paint, which converts UV-photons and guides them to coupled Photomultiplier Tubes (PMTs) at both ends. This optical design decouples the photosensitive area from the PMTs, achieving a high signal-to-noise ratio and effective coverage of the UV-region of the Cherenkov spectrum.

A total of 11 WOMs are planned for deployment, with 5 already shipped. This presentation will provide insights into the production process, highlight key engineering challenges, and discuss results from optical acceptance testing. Additionally, recent design improvements and the production status of the second batch, scheduled for shipment this summer, will be featured.

T 14.3 Mon 17:15 VG 3.101

In-situ Calibration Routines for IceCube Upgrade mDOMs without Artificial Light Sources — •Carolin Klein[1] and Summer Blot[2] — [1]Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany — [2]DESY, Zeuthen, Germany

Calibration is crucial for the success of every physics experiment. Over the last decade, the IceCube Neutrino Observatory has yielded important results in neutrino astronomy and neutrino oscillations. Building on this progress, the IceCube Upgrade project is set to expand the current detector array during the austral summer 2025/26. It will enhance the detector's overall sensitivity and lower its energy threshold by reducing the spacing between strings, enabling more detailed studies of atmospheric neutrinos.

In this talk, in-situ calibration routines without artificial light sources for the IceCube Upgrade multi-PMT digital optical modules (mDOMs) are proposed. This includes the calibration of the mDOM mainboard electronics using front-end pulsers, as well as the PMT gain and relative transit time calibration using the natural radioactivity from the glass vessel. The latter approach allows for a long-term monitoring of the PMT gain and the relative transit time without downtimes of the modules. First results of the routines will be presented in this talk.

T 14.4 Mon 17:30 VG 3.101

Drone-Based Calibration of AugerPrime Radio Antennas at the Pierre Auger Observatory — •Alex Reuzki, Maximilian Straub, and Martin Erdmann — III. Physikalisches Institut A, RWTH Aachen

Radio emissions of extensive air showers can be observed at the Pierre Auger Observatory with the AugerPrime radio detector (RD). As part of the AugerPrime upgrade, RD is being installed on 1660 water-Cherenkov detectors on an area of about 3000 km^2 and consists of dual-polarized Short Aperiodic Loaded Loop Antennas (SALLA). To achieve high measurement precision, RD needs to be well-calibrated, which requires the antenna response pattern to be well-known. We introduce a method to measure the directional response of the SALLA using a well-defined biconical antenna mounted to a drone. The drone-based setup possesses active stabilization and precise pointing with the use of a gimbal. Additionally, the drone's position is tracked using differential GPS with $\mathcal{O}$(cm) precision. This setup allows us to precisely extract the antenna response pattern from any direction in the frequency range of 30 − 80 MHz. In a recent in-situ campaign, calibration measurements of the AugerPrime radio detector have been performed. The measurements are interpolated using information field theory to obtain the full antenna response pattern for all directions and frequencies. First results are presented and compared to simulations.

T 14.5 Mon 17:45 VG 3.101

Reconstruction of Extensive Air Showers from Radio Detector Data using Information Field Theory — •Simon Strähnz[1], Tim Huege[1,2], Philipp Frank[3], and Torsten Ensslin[3] — [1]Karlsruher Institut für Technologie, Deutschland — [2]Astrophysical Institute, Vrije Universiteit Brussel, Belgien — [3]Max Planck-Institut für Astrophysik, Garching, Deutschland

Using radio detectors for cosmic rays is a very appealing approach, as they are cost-effective, have a duty cycle of nearly 100% and can directly probe the electromagnetic component of extensive air showers. However, reconstructing the electric field from the measured voltages in an antenna by unfolding the antenna response comes with several challenges, mainly because of measurement noise. These issues could be solved by Bayesian inference. The challenge with that approach is that the electric field is continuous, which would lead to an infinite-dimensional latent space. Information field theory (IFT) has been developed to deal with this problem and allow for Bayesian reasoning on fields. We will present a signal model that can be used with IFT based inference algorithms that can successfully reconstruct the electric field measured by a single antenna. The performance of this method has been demonstrated with Monte Carlo simulations of air shower radio signals. We will also show extended models being developed to combine the data from all antennas in a given array and reconstruct entire events. Since Bayesian inference provides the posterior distribution, this method also provides an estimate of the uncertainty of the measured field.

T 15: Cosmic Rays I

Time: Monday 16:45–18:15 Location: VG 3.102

T 15.1 Mon 16:45 VG 3.102

Beamforming with the SKA-Low array for detection of gamma rays at PeV energies. — •Subhadip Saha[1,2] and Tim Huege[1] for the SKA High-Energy Cosmic Particles Science Working Group-Collaboration — [1]Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany — [2]Indian Institute of Technology Kanpur, Kanpur, India.

SKA-Low (Square Kilometer Array) is globally recognized as the next-generation radio-astronomical observatory at frequencies below 350 MHz. We are focusing on its dense core region and aim to perform beamforming with thousands of antennas to detect the radio emission from particle showers initiated by cosmic or gamma rays in the atmosphere. Beamforming is expected to lower the radio-detection threshold for air showers considerably. With thousands of these antennas, the beamforming approach has significant potential to lower the detection threshold down to as low as 1 PeV. The strength of the beamformed signal can be scaled with the number of antennas and energy to estimate the number of antennas required to detect these low-energetic energetic air showers. We are investigating how far the detection threshold can essentially be brought down with the beamforming application and if the detection of PeV gamma rays would be possible.

T 15.2 Mon 17:00 VG 3.102

Advancing Cosmic-Ray Studies with LOFAR and the LORA Scintillator Array — •Stuti Sharma[1] and Anna Nelles[1,2] for the LOFAR-Cosmic ray key science project-Collaboration — [1]ECAP, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Zeuthen, Germany

The Low Frequency Array (LOFAR) is a radio telescope with antenna fields across Netherlands and Europe. Designed to observe the radio sky at low frequencies, it also provides precision measurements of the radio emission of cosmic-ray air showers in the range of 30-80 MHz. Central to LOFAR's cosmic-ray key science project is the LOFAR Radboud Air Shower Array (LORA), an array of 40 scintillation detectors in LOFAR's dense core. LORA measures particle densities from air showers, serving as a trigger for the LOFAR antennas and providing initial estimates of shower direction, energy, and core position. It detects cosmic rays above 1e16 eV, with nanosecond timing ensuring precise reconstruction of shower geometry and radio footprint. The LORA upgrade doubled the detector count, expanding the effective area and increasing trigger rates for high-energy events by 45%. This enhancement reduces composition bias and improves sensitivity to proton and iron primaries, essential for exploring the galactic-to-extragalactic cosmic-ray transition. Our goal is to incorporate data from LORA into the radio reconstruction framework, facilitating both standalone and integrated analyses of cosmic ray in particle and radio data.

T 15.3 Mon 17:15 VG 3.102

Monitoring Large-Scale Radio-Detection Arrays with Machine Learning — •Johann Luca Kastner for the GRAND-Collaboration — Karlsruher Institut für Technologie, Institut für Astroteilchenphysik

In recent years, radio-detection techniques, such as those employed in the GRAND experiment, have emerged as a promising method for detecting ultra-high-energy cosmic rays (UHECRs). One of the key advantages of radio detection is its cost-effectiveness, allowing for the deployment of large arrays that can cover vast areas necessary for measuring the low fluxes of UHECRs. However,

this comes with the challenge of monitoring the functionality of a massive number of antennas (up to tens of thousands) over a vast area (tens of thousands of km^2). In this talk, we will present an approach to addressing this challenge using a combination of dimensionality reduction (UMAP) and clustering (DBSCAN) algorithms applied to periodically triggered monitoring data of a GRAND prototype setup. Our method aims to identify malfunctions and periods of poor operation, enabling efficient maintenance and optimization of the radio-detection system.

T 15.4 Mon 17:30 VG 3.102

The holy grail of air shower triggers: Tests towards a self-standing radio trigger at the Pierre Auger Observatory* — •Jannis Pawlowsky and Julian Rautenberg for the Pierre-Auger-Collaboration — Bergische Universität Wuppertal, Wuppertal, Germany

The Pierre Auger Observatory is the largest facility for the detection of ultra-high-energy cosmic rays. Key aspects to achieve the highest sensitivity are the particle triggers, which are responsible for maximizing station data read-out of reconstructable air showers within limited communication bandwidth. This system works excellent for the majority of hadron-induced air showers. However, it can be improved for air showers induced by neutral primaries such as photons and neutrinos. A radio trigger implemented for the AugerPrime Radio Detector provides an alternative when particle detectors become less efficient. The feasibility of such a radio trigger is heavily dependent on the noise environment, dominated by anthropogenic sources.

This work presents the efforts made to develop a bandwidth-compatible trigger. The design of the trigger is discussed, which was also employed in multiple field tests. The results of these tests are shown, yielding conclusions on the radio noise environment at the Observatory and the compatibility of the trigger with the communication bandwidth. Furthermore, planned improvements are discussed.

* *Supported by BMBF Verbundforschung Astroteilchenphysik Vorhaben 05A23PX1*

T 15.5 Mon 17:45 VG 3.102

Status of the antennas at the IceCube Surface Array Enhancement — •Megha Venugopal for the IceCube-Collaboration — Institute of Astroparticle Physics (IAP), Karlsruhe Institute of Technology, Germany

IceCube is a cubic km detector at the South Pole comprising two main components, the neutrino detector that measures neutrinos in-ice, the IceCube Neutrino Observatory and IceTop, a surface cosmic-ray detector constituting 81 pairs of ice-filled Cherenkov tanks. An extension with multiple stations, each station equipped with 8 elevated scintillators and 3 antennas, was planned on the IceTop footprint to complement existing measurement methods and to serve as part of a larger surface array for IceCube-Gen2. In early 2023, the scintillators of the single deployed station of the IceCube Surface Enhancement were upgraded, increasing the dynamic range and enabling the reconstruction of more coincident air showers. An updated dataset combining data from radio and IceTop detectors is presented. Additionally, the current status of the deployment of new stations is discussed.

T 15.6 Mon 18:00 VG 3.102

Status and Performance of the Scintillation detectors of the IceCube Surface Array Enhancement — •S Shefali for the IceCube-Collaboration — Institut für Astroteilchenphysik, Karlsruher Institut für Technologie (KIT), Karlsruhe, Germany

The IceCube Neutrino Observatory is a multipurpose detector which includes a unique surface array, IceTop, highly instrumental for cosmic-ray studies in addition to its capability of vetoing for astrophysical neutrino searches for the IceCube in-ice instrumentation. An enhancement of the surface array, with scintillation and radio detectors, in order to facilitate multi-component cosmic ray studies, as well as improving the IceTop detectors calibration by accounting for the snow accumulation on them, has been ongoing. The existing prototype station was upgraded with improved Scintillation detectors at the beginning of January 2023. This contribution will discuss the performance of the scintillation detectors following the 2 years of successful air shower measurements with this upgrade.

T 16: Neutrino Physics I

Time: Monday 16:45–18:15 Location: VG 3.103

T 16.1 Mon 16:45 VG 3.103

Recent advances in the search for $0\nu\beta\beta$ decay of 76Ge with LEGEND-200 — •Moritz Neuberger for the LEGEND-Collaboration — Physik-Department E15 Technische Universität München James-Franck-Straße D-85748 Garching Germany

The LEGEND collaboration's objective is to detect neutrinoless double-beta ($0\nu\beta\beta$) decay in ^{76}Ge using state-of-the-art enriched high-purity germanium (HPGe) detectors. In its first phase, LEGEND-200, the experiment has collected physics data for over a year, employing 140 kg of HPGe detectors in a liquid argon cryostat. This talk presents the results of the $0\nu\beta\beta$ decay analysis based on this data set. Furthermore, we will provide updates on integrating additional HPGe detectors and discuss auxiliary studies used to develop our background model further.

This research is supported by the DFG through the Excellence Cluster ORIGINS EXC 2094 - 390783311, the SFB1258, and by the BMBF Verbundprojekt 05A2023.

T 16.2 Mon 17:00 VG 3.103

Muon Veto of LEGEND-200: Analysis and Simulations — •Gina Grünauer — Physikalisches Institut, Eberhard Karls Universität Tübingen

The **L**arge **E**nriched **G**ermanium **E**xperiment for **N**eutrinoless $\beta\beta$ **D**ecay (LEGEND) is an phased experimental program dedicated to the search for neutrinoless double beta ($0\nu\beta\beta$) decay of ^{76}Ge. To reach the aimed discovery sensitivity for a half-life of more than 10^{28} years, a background rate of less than 10^{-5} cts/(keV·kg·yr) is required. A Water-Cherenkov-Veto operates for this purpose for the current experimental phase LEGEND-200. It uses photomultiplier tubes (PMTs) as light detectors in a water-tank lined with a reflective foil to increase the light yield within the system. This contribution provides the working principle as well as the ongoing data analysis and simulations of the Muon Veto of LEGEND-200.

This work is supported by the U.S. DOE and the NSF, the LANL, ORNL and LBNL LDRD programs; the European ERC and Horizon programs; the German DFG, BMBF, and MPG; the Italian INFN; the Polish NCN and MNiSW; the Czech MEYS; the Slovak RDA; the Swiss SNF; the UK STFC; the Canadian NSERC and CFI; the LNGS and SURF facilities.

T 16.3 Mon 17:15 VG 3.103

Search for Neutrinoless Double Beta Plus Decays with NuDoubt^{++} — •Cloé Girard-Carillo for the NuDoubt-Collaboration — Johannes Gutenberg-Universität Mainz

The discovery of neutrino oscillations revealed the possibility of neutrinos having masses, which could originate from Majorana particles and result in lepton number violation. One way to observe this violation is through neutrinoless double beta decay, where neutrinos are exchanged internally without appearing as external particles.

Most experiments so far have focused on double electron emission. However, advancements in new scintillator technologies, offering enhanced particle identification, now make it feasible to investigate double positron emission processes as well.

This presentation introduces the NuDoubt++ experiment, which uses a hybrid opaque scintillator with isotope loading to search for such a process. This combination makes it possible to separate signal from background using event topology and the ratio of Cherenkov to scintillation light. We will also explain how we plan to load $\beta\beta$ isotopes into the scintillator and describe a new proposal for collecting light more efficiently. We present the latest progress on the project, including recent developments in detector design and performance.

T 16.4 Mon 17:30 VG 3.103

Event Classification for the Hybrid Opaque Scintillator Experiment NuDoubt^{++} — •Kyra Mossel for the NuDoubt-Collaboration — Johannes Gutenberg-Universität Mainz, Institut für Physik, 55128 Mainz, Germany

Neutrinoless double beta decay is a hypothetical nuclear process assuming that could occur if the neutrino is its own antiparticle. In this process, two neutrons (protons) decay into two protons (neutrons), emitting two electrons (positrons) but no neutrinos, thereby violating lepton number conservation and demonstrating the Majorana nature of the neutrino. Detecting this extremely rare decay requires exceptionally low background levels and reliable particle identification mechanisms.

The NuDoubt^{++} experiment, designed to study double beta plus decays, addresses this challenge using a novel hybrid and opaque scintillator which is permeated by a fine grid of optical fibers. This setup utilizes both the topology of energy deposits and the ratio of Cherenkov to scintillation light to enhance background discrimination and particle identification.

This presentation focuses on the Cherenkov-to-scintillation light ratio as a tool for background discrimination. The expected photon arrival time distributions

for different background event types are shown as well as the experiment's anticipated performance to distinguish them from signal events.

T 16.5 Mon 17:45 VG 3.103

Studies on general neutrino interactions with the KATRIN experiment — •Hanna Henke and Caroline Fengler for the KATRIN-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany

The KATRIN Experiment aims to determine the neutrino mass using precision spectroscopy of electrons from tritium β-decay. Recently, KATRIN published an improved upper bound of 0.45 eV at 90% C.L. [1] on the effective electron-neutrino mass; the latest step in an ongoing effort to reach a target sensitivity of below 0.3 eV. Supplementary to the neutrino mass measurement the high-precision spectroscopy allows to probe beyond standard model physics, for instance general neutrino interactions (GNI), which can be examined through shape deformations in the integral β-energy spectrum. For the GNI a model-independent approach combines each theoretically allowed interaction term into one effective field theory to describe the impact of energy-dependent spectrum contributions as an indicator for novel weak processes. Recently, first constraints on general neutrino interactions based on KATRIN data were released [2]. This talk will give an overview of the GNI framework and analysis, and present further GNI studies.

This work is supported by the Helmholtz Association, through the Helmholtz Initiative and Networking Fund (grant no. W2/W3-118), and by BMBF (grant no. 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6)

[1] arXiv:2406.13516, [2] arXiv:2410.13895

T 16.6 Mon 18:00 VG 3.103

Adiabatic characteristics of the KATRIN beamline in the TRISTAN phase — •Justus Beisenkötter for the KATRIN-Collaboration — Intitut für Kernphysik, Universität Münster

After the end of the neutrino mass search with KATRIN, the current focal plane detector will be replaced by the new TRISTAN detector with significantly better energy resolution and higher granularity, to enable a search deep into the tritium beta-decay spectrum for keV sterile neutrinos. In this new measurement phase, the retarding potential of the KATRIN main spectrometer will be reduced from the current level near the spectral end point to a few kV. This will lead to much higher surplus energies in the spectrometer, so that the magnetic moment $\mu = E_\perp/B$ of the beta electrons is no longer constant and the adiabatic approximation for electron tranport is no longer valid. Simulations have shown that by changing the field configuration, moving the highest magnetic field from the detector side of the main spectrometer to the source side, the non-adiabatic effects can be suppressed. The talk will present the results of measurements of this new magnetic field setup and a comparison with simulation results. This work is supported by BMBF ErUM-Pro 05A23PMA.

T 17: Neutrino Physics II

Time: Monday 16:45–18:15 Location: VG 3.104

T 17.1 Mon 16:45 VG 3.104

Novel constraints on neutrino physics beyond the standard model of elementary particles from the CONUS and CONUS+ experiments — •Dario Piani, Nicola Ackermann, Hannes Bonet, Christian Buck, Janina Hakenmüller, Janine Hempfling, Gerd Heusser, Manfred Lindner, Werner Maneschg, Kaixiang Ni, Thomas Rink, Edgar Sánchez García, and Herbert Strecker — MPIK, Heidelberg, Germany

The detection of coherent elastic neutrino-nucleus scattering (CEνNS) opens up new opportunities for neutrino physics within and beyond the standard model of elementary particles. Constantly refining the setup, the experiments CONUS (until 2022) and CONUS+ (since 2023) provide valuable data towards the detection of such events from reactor (anti)neutrinos emitted by the powerful (3.9 GW and 3.6 GW) reactors of the nuclear power plants in Brokdorf (Germany) and Leibstadt (Switzerland). The acquired and future CONUS/CONUS+ data sets enable further investigations on neutrino physics beyond the standard model, such as yet undetected neutrino channels and electromagnetic properties. This talk will explore constraints on beyond the standard model neutrino phenomenology from not yet analyzed data. Bounds on non-standard neutrino-quark interactions of vector and tensor type from CEνNS are presented. Furthermore, the parameter space of simplified scalar and vector mediators probed by CEνNS and elastic neutrino-electron scattering is discussed. Finally, limits on an effective neutrino magnetic moment and effective neutrino millicharge are given.

T 17.2 Mon 17:00 VG 3.104

First result of the CONUS+ experiment — •Nicola Ackermann for the CONUS-Collaboration — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

With the CONUS+ reactor antineutrino experiment, the coherent elastic neutrino nucleus scattering (CEνNS) on germanium nuclei is currently studied at the nuclear power plant in Leibstadt, Switzerland. Very low energy thresholds down to 160 eV were achieved in four 1 kg point contact germanium detectors equipped with electric cryocooling. The setup is positioned at a distance of about 20 m from the center of the reactor core. The detector performances and first CONUS+ results after few months of data taking will be presented. In November 2024 three detectors were replaced by newer models with higher Ge crystal masses of 2.4 kg each to further improve the sensitivity of the experiment.

T 17.3 Mon 17:15 VG 3.104

Precise Determination of the Background in Electronic Recoil Channel from XENONnT — •Ying-Ting Lin for the XENON-Collaboration — Saupfercheckweg 1, 69117 Heidelberg, Germany

The XENONnT experiment, utilizing a 5.9-tonne liquid xenon dual-phase time projection chamber (TPC), is searching for dark matter and other rare physical phenomena. Having achieved an unprecedentedly low background level in the electron-recoil (ER) channel, the detector will be capable of detecting proton-proton (pp) chain solar neutrinos via elastic neutrino-electron scattering, while at the same time setting new limits to search of Beyond the Standard Model (BSM) physics such as solar axions, neutrino magnetic moments, axion-like particles (ALPs), and dark photons. To achieve such sensitivity, it is critical to determine the precise levels of the two major background sources, ^{222}Rn and ^{85}Kr. For ^{222}Rn, a dedicated ^{222}Rn calibration was performed. Together with an analysis framework that tracks the ^{222}Rn alpha decay, this background contribution can be constrained to an order of 10% precision. For krypton, the Rare Gas Mass Spectrometer (RGMS) at the Max Planck Institute for Nuclear Physics (MPIK) has demonstrated the world-leading detection limit of 8 parts per quadrillion (ppq) to the krypton concentration in our xenon TPC, providing a stringent constraint to ^{85}Kr. The highlight will cover the analysis results for both background estimates.

T 17.4 Mon 17:30 VG 3.104

Prospects of Solar Neutrino Detection via Delayed Coincidence Signatures in ^{136}Xe Charged Current Interactions with XENONnT — •Henning Schulze Eissing for the XENON-Collaboration — Institut für Kernphysik, Universität Münster

The XENONnT experiment, located at the INFN Laboratori Nazionali del Gran Sasso, is a dual-phase time projection chamber containing a target mass of 5.9 tonnes of liquid xenon designed for direct dark matter detection. Its unprecedented low background level in the electronic recoil channel enable searches for rare processes beyond its primary science goal.

A search strategy for solar neutrino charged current interactions with ^{136}Xe into an excited state of ^{136}Cs is being developed, exploiting the unique de-excitation signature of ^{136}Cs* caused by low-lying isomeric states with lifetimes on the order of 100 nanoseconds. This characteristic delayed coincidence signature provides powerful background discrimination in XENONnT's already low-background environment. The analysis methodology employs two complementary machine learning approaches: a classifier trained to identify the characteristic multi-peak events in the scintillation waveforms, and a reconstruction algorithm capable of resolving individual scintillation signals within merged waveforms. The development of these ML models, their validation, and initial studies of the detection efficiency are presented along with a overview of the search strategy, demonstrating the potential of this approach for solar neutrino measurements with XENONnT.

This work is supported by BMBF ErUM-Pro 05A23PM1.

T 17.5 Mon 17:45 VG 3.104

Neutron Detection with SANDI II in ANNIE — •Amala Augusthy, Noah Goehlke, Philipp Kern, David Maksimovic, Johann Martyn, Daniel Schmid, Michael Wurm, and Dorina Zundel for the ANNIE-Collaboration — Institut für Physik and EC PRISMA+, JGU Mainz, Mainz 55128, Germany

ANNIE is an accelerator neutrino experiment at the Booster Neutrino Beam at Fermilab. It is a 26-ton Gadolinium-loaded water Cherenkov detector designed to measure CC interaction cross-sections and neutron multiplicity. In addition, ANNIE serves as a testbed for novel detector technologies amongst which is Water-based Liquid Scintillator (WbLS). WbLS is a novel detection medium that allows the simultaneous detection of scintillation and Cherenkov light. To test the detection capabilities with WbLS, a 366 L cylindrical vessel, filled with Gadolinium (Gd) loaded WbLS, dubbed SANDI II was deployed in ANNIE, in

fall 2024. Neutrons are a major source of systematic uncertainty in long baseline neutrino oscillation experiments, hence it is very important to tag neutrons efficiently. To investigate the enhanced neutron detection capabilities of Gd loaded WbLS, an AmBe neutron calibration source was deployed in ANNIE. This talk gives an overview of the preliminary results of the analysis of AmBe data with Gd loaded WbLS. This project is supported by DFG ANNIE and DFG Graduate School GRK 2796: Particle Detectors.

T 17.6 Mon 18:00 VG 3.104

First Water-based Liquid Scintillator (WbLS) measurement with DISCO — •Noah Goehlke[1], Amala Augusthy[1], Manuel Böhles[1], Daniele Guffanti[3], Benedict Kaiser[4], Tobias Lachenmaier[4], Hans Steiger[2], and Michael Wurm[1] — [1]Johannes Gutenberg-Universität Mainz — [2]Technical University of Munich — [3]University of Milano-Bicocca — [4]Eberhard Karls Universität Tübingen

Water based liquid scintillator (WbLS) is a novel detection medium, consisting of liquid scintillator dissolved in water with the help of a surfactant. It allows for the simultaneous measurement of Cherenkov and scintillation light. This hybrid event topology can be used for event reconstruction including sub-Cherenkov particles but also enhanced background rejection, for example for measuring the DSNB. Thus, WbLS is being considered as detection medium for future neutrino detectors like Theia. DISCO is a lab-scale experiment, designed to investigate the Cherenkov-scintillation separation and to characterize WbLS, using cosmic muons. The detector has a cylindrical 15 l test-cell which can be filled with water, WbLS or liquid scintillator. The light is detected by 16 fast 1" PMTs with the option to install in addition an LAPPD (Large Area Picosecond PhotoDetector). The fast photon detectors allow DISCO to investigate a time-based separation of the fast Cherenkov and slower scintillation light. Above the test-cell is a muon tracker, used as a trigger and to reconstruct the muon tracks. This talk presents results of the first WbLS run with DISCO. This work is supported by the Research Training Group "Particle Detectors".

T 18: Methods in Particle Physics I (Calo, Jets, Tagging)

Time: Monday 16:45–18:30 Location: VG 4.101

T 18.1 Mon 16:45 VG 4.101

Calibration of calorimeter signals in theATLAS experiment using an uncertainty-awareneural network — •Isabel Sainz Saenz-Diez — Kirchhoff Institute for Physics, Heidelberg University

Measuring energy deposits in the calorimeters are a key aspect of particle reconstruction. In the case of the ATLAS experiment at the Large Hadron Collider (LHC), the calorimeter signals are reconstructed as clusters of topologically connected cells (topo-clusters). These are calibrated in such way that they correctly measure the energy deposited by electromagnetic showers, but they do not compensate for the fraction of energy that does not contribute to the signal, which is part of the hadronic showers. In order to account for this energy, a local hadronic calibration of topo-clusters is applied. Machine Learning (ML) methods have been proposed as an alternative to the current hadronic calibration in ATLAS. Both a Deep Neural Net (DNN) and a Bayesian Neural Net (BNN) yield continuous unbinned calibration functions with an improved performance with respect to the standard calibration. Additionally, the BNN provide an estimation on the uncertainties of the calibration output. The talk will present the current status of the implementation and performance of the proposed models.

T 18.2 Mon 17:00 VG 4.101

Understanding punch-through effects on jet calibration using Run 2 and Run 3 data with the ATLAS detector — •Chiara Deponte and Chris Malena Delitzsch — Technische Universität Dortmund, Deutschland

At high energies, jets can penetrate beyond the calorimeter and deposit energy in the muon spectrometer, a phenomenon known as the punch-through. Since energy depositions in the muon spectrometer are not accounted for during jet reconstruction, the resulting jet energy tends to be smaller. To address this, corrections are applied during the jet energy calibration process to improve the jet energy resolution. In the ATLAS experiment, the Global Sequential Calibration mitigates punch-through effects by utilizing the number of muon segments associated with small-radius (R = 0.4) jets. The performance of this correction was studied using Monte Carlo simulation for Run 2 and 3, comparing both fast and full simulation.

T 18.3 Mon 17:15 VG 4.101

In-Situ Calibration of Small-Radius Jets Using the MPF Method with γ+jets Events in ATLAS — •Simone Ruscelli and Chris M. Delitzsch — Technische Universität Dortmund (Germany)

The V+jets calibration is a pivotal component of the in-situ jet calibration in ATLAS to correct for differences in the jet energy scale between data and Monte Carlo simulation due to the imperfect simulation of e.g. the detector materials, pile-up and jet formation. This presentation focuses on the γ+jets calibration of small-radius (R=0.4) jets, reconstructed from particle flow objects, using data collected with the ATLAS detector during Run 2. The Missing-E_{T} Projection Fraction (MPF) technique is used, which takes into account the full hadronic recoil in an event as opposed to the Direct Balance (DB) method, which only considers the balancing jet. The MPF method has numerous advantages, e.g. it is not strongly affected by the jet definition and is also robust to both pile-up and the underlying event.

T 18.4 Mon 17:30 VG 4.101

Run 3 performance and advancement of Heavy-Flavor Jet Identification in CMS — SVENJA DIEKMANN[1], MING-YAN LEE[1], SPANDAN MONDAL[2], •UTTIYA SARKAR[1], ALEXANDAR SCHMIDT[1], and SEBASTIAN WUCHTERL[3] — [1]III. Physikalisches Institut A, RWTH Aachen University, Germany — [2]Brown University, Providence, USA — [3]European Organization for Nuclear Research (CERN), Geneva, Switzerland

The identification of heavy-flavor jets is essential for many high-energy physics analyses, including studies of the top quark, Higgs boson, and new physics searches. Recent advances in machine learning, including graph networks, and transformers namely UParT (Unified Particle Transformer) algorithm, have significantly improved tagging performance for heavy-flavor (b, c) and hadronic tau jets. This talk presents the latest development of flavor taggers, their deployment in the CMS High Level Trigger (HLT) system and offline performances in proton-proton collision with the Run 3 data.

T 18.5 Mon 17:45 VG 4.101

Optimizing charm-jet tagging in ATLAS — Diptaparna Biswas[1], Beatrice Cervato[1], Markus Cristinziani[1], Carmen Diez Pardos[1], Ivor Fleck[1], Arpan Ghosal[1], Gabriel Gomes[1], Jan Joachim Hahn[1], Vadim Kostyukhin[1], Nils Krengel[1], Buddhadeb Mondal[1], Stefanie Müller[1], Sebastian Rentschler[1], Elisabeth Schopf[1], Katharina Voss[1], Wolfgang Walkowiak[1], •Adam Warnerbring[1], and Tongbin Zhao[1,2] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Shandong University, China

Classifying jets based on the flavour of the parton that initiates the jet is a crucial task in analyses involving final states with b- or c-quarks. In recent years, jet flavour taggers in ATLAS have seen significant improvements, largely thanks to the adoption of end-to-end transformer models that directly use track-level inputs to predict the jet class. While b-jet identification remains the strongest feature of these models due to the distinct characteristics of b-jets, they can also be used for c-jet tagging. This talk will focus on charm tagging using GN2, the latest flavour tagging model developed by ATLAS. The presentation will cover the challenges of simultaneous b- and c-tagging, the trade-offs in parameter choices, and the performance of the model in terms of efficiencies and rejection rates for benchmark samples.

T 18.6 Mon 18:00 VG 4.101

Material interactions in ATLAS jet flavour tagging — Diptaparna Biswas[1], Beatrice Cervato[1], Markus Cristinziani[1], Carmen Diez Pardos[1], Ivor Fleck[1], Arpan Ghosal[1], Gabriel Gomes[1], Jan Joachim Hahn[1], Vadim Kostyukhin[1], •Nils Krengel[1], Buddhadeb Mondal[1], Stefanie Müller[1], Sebastian Rentschler[1], Elisabeth Schopf[1], Katharina Voss[1], Wolfgang Walkowiak[1], Adam Warnerbring[1], and Tongbin Zhao[1,2] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Shandong University, China

Jet flavour tagging plays a crucial role in understanding particle physics processes. In the continuous effort to enhance flavour tagging performance the ATLAS Collaboration is currently deploying deep learning transformer models.

Jets originating from a b-quark are easy to tag because of the characteristic bottom hadron decays. Due to long lifetimes, B-hadrons decay far from the primary event vertex, producing a significant number of tracks with big impact parameters. However, this feature can be mimicked by interactions of particles with the detector material, also producing displaced tracks.

This presentation will demonstrate how material interactions may lead to the misidentification of jets originating from quarks of lighter flavour as b-jets, and

it will discuss first results of an attempt to mitigate the influence of material interactions. This attempt consists of adding an auxiliary task, which identifies these interactions, to the flavour tagging machine learning model.

T 18.7 Mon 18:15 VG 4.101

Flavour Tagging with ParticleNet at ILD — •Ulrich Einhaus[1] and Bryan Bliewert[2,3] — [1]Karlsruhe Institut für Technologie KIT — [2]Deutsches Elektronen-Synchrotron DESY — [3]Universität Hamburg

With the exploitation of the LHC in full swing, the particle physics community is turning its focus on the next flagship collider, an e^+e^- Higgs factory. Many studies are ongoing studying physics prospects and optimising detector designs. In recent years, machine learning approaches to reconstruction algorithms have moved to neural network architectures, showing the performance advantages of their optimised exploitation of detector-level information. One area of application are flavour taggers, where several neural network approaches are actively under development.

This talk presents an implementation of the ParticleNet flavour tagger for the ILD detector concept, with data in full simulation. It covers the structure and performance, in particular the new strange tag, and highlights the dependence on specific observables and their impact on selected physics channels, informing further detector development.

T 19: Search for Dark Matter I

Time: Monday 16:45–18:45 Location: VG 4.102

T 19.1 Mon 16:45 VG 4.102

The Direct search Experiment for Light Dark Matter (DELight): Overview and Perspectives — •Eleanor Fascione for the DELight-Collaboration — Heidelberg University

There is vast unexplored parameter space for dark matter masses below a few GeV, and the field of direct dark matter detection is constantly expanding to new frontiers. In particular, low mass dark matter candidates necessitate novel detector designs with lower thresholds and alternative target materials compared to e.g. the xenon-based experiments currently providing the strongest overall constraints on many dark matter models.

The Direct search Experiment for Light dark matter (DELight) will deploy a target of superfluid ^{4}He instrumented with large area microcalorimeters (LAMCALs) based on magnetic microcalorimeter (MMC) technology in a setup optimized for low mass dark matter searches. In this talk an overview of this novel upcoming experiment will be presented, including preliminary background models and sensitivity projections.

T 19.2 Mon 17:00 VG 4.102

Signal partitioning in superfluid ^{4}He: A Monte Carlo approach — •Francesco Toschi for the DELight-Collaboration — Karlsruhe Institute of Technology, Institute for Astroparticle Physics — Heidelberg University, Kirchhoff-Institute for Physics

Superfluid ^{4}He presents a compelling target for direct detection of light dark matter (LDM), offering both a low nuclear mass and a low energy detection threshold through quasiparticle generation. This talk will discuss the physical processes involved in the deposition of energy in superfluid ^{4}He, focusing on the response to nuclear and electronic recoils, which are crucial for the detection of LDM. A Monte Carlo simulation framework has been developed to model the distribution of deposited energy across distinct signal channels for various recoil types. This work is essential for optimizing the design and performance of next-generation detectors such as the DELight experiment.

T 19.3 Mon 17:15 VG 4.102

Simulation of Particle Induced Damage Tracks in Crystal Detectors — •Lukas Scherne and Alexey Elykov — Karlsruhe Institute of Technology, Institute for Astroparticle Physics

A new approach to detecting Dark Matter (DM) involves so-called "Paleo Detectors" (PD)-minerals that may have accumulated DM-induced damage tracks over billions of years. These damage tracks could potentially form when a DM interaction leads to a nuclear recoil in the mineral's lattice. Modern microscopy techniques could have the potential to image these nanometer-sized features. Additionally, PDs could be used as a new way for the detection and study of neutrinos.

However, there are many research and development challenges to face, before PDs can be realized. A pilot project at the KIT's Institute for Astroparticle Physics, in collaboration with geologists from Heidelberg University and microscopy experts from KIT's Laboratory for Electron Microscopy and Institute of Nanotechnology, aims to address several key challenges. In the scope of this project, we aim to perform a series of calibration studies, irradiating a range of mineral samples with ions and neutrons of known energy. These samples will then be imaged and analyzed for the presence of particle-induced damage tracks. To support these studies, we perform a series of simulations to study track formation and morphology in specific minerals. Ultimately, we seek to establish a clear correlation between the deposited energy and the resulting track morphology.

In this talk, I will report on the current state of these simulation studies and their implications for PDs.

T 19.4 Mon 17:30 VG 4.102

INCIDENCE - Impact of Crystal Effects on Cryogenic Detectors for Dark Matter Searches — •Holger Kluck[1], Jens Burkhart[1], Miroslav Macko[2], and Veronika Palušová[2,3] — [1]Institut für Hochenergiephysik der Österreichischen Akademie der Wissenschaften, 1050 Wien, Österreich — [2]Institute of Experimental and Applied Physics, Czech Technical University in Prague, 110 00 Prague 1, Czech Republic — [3]Johannes Gutenberg-Universität Mainz, Institut für Physik, 55128 Mainz, Germany

Nuclear recoils in cryogenic detectors are used to search for Dark Matter (DM) and for the prospective measurement of Coherent Elastic Neutrino-Nucleus Scattering (CEνNS). Experiments like CRESST or NUCLEUS reached detection thresholds for nuclear recoils in $CaWO_4$ and Al_2O_3 at the 20 eV-scale.

At this scale, solid-state effects can no longer be neglect, as they affect the observable energy. Once a DM particle or a neutrino induced a Primary Knock-On Atom in the detector crystal, the resulting displacement cascade can produce crystal defects that reduce the observable energy. Together with the ELOISE project, INCIDENCE aims to use Molecular Dynamics simulation to study this effect in $CaWO_4$ and Al_2O_3 at energies which are relevant for DM and CEνNS experiments.

In this contribution we will motivate the impact on the field, summarize the physics of the displacement cascade, present first results of defect creation in Al_2O_3 and give an outlook on the ongoing work for $CaWO_4$.

T 19.5 Mon 17:45 VG 4.102

New results from the SuperCDMS-HVeV program — •Emanuele Michielin for the SuperCDMS-Collaboration — Karlsruher Institut für Technologie, Institut für Astroteilchenphysik, 76344, Eggenstein-Leopoldshafen, Germany

SuperCDMS SNOLAB is a direct detection dark matter (DM) experiment currently under construction two kilometers underground at the SNOLAB laboratory near Sudbury, Canada. Its goal is to achieve world-leading sensitivity to DM-nucleus scattering within a mass range of 0.5 to 5 GeV. In parallel, gram-scale prototype detectors, known as HVeV devices, have been developed. These detectors achieve energy resolutions at the eV scale, enabling the detection of single electron-hole pairs when operated under high-voltage bias. HVeV devices present a unique opportunity to probe low-mass dark matter, study charge propagation, and refine calibration techniques that will also be implemented in SuperCDMS SNOLAB operations.

In this talk the latest results from the fourth data taking campaign with HVeV detectors in the NEXUS underground facility at Fermilab will be presented. A recent search for electron recoil DM candidates will be highlighted, which takes advantage of a new detector holder designed to eliminate luminescence-induced background from printed circuit boards. Additionally, a novel calibration method using Compton step spectral features in the low-energy region will be discussed. Finally, updates from the latest HVeV data-taking campaign at the SNOLAB laboratory will be introduced.

T 19.6 Mon 18:00 VG 4.102

The SuperCDMS HVeV run at CUTE — •Julius Viol for the SuperCDMS-Collaboration — Kirchhoff-Institut für Physik, Uni Heidelberg

The SuperCDMS HVeV detectors are gram-scale cryogenic semiconductor devices used for the direct search of dark matter. They have achieved eV-scale energy resolution through the application of an electric field, enabling the amplification of the phonon signal of ionizing particle interactions via the Neganov-Trofimov-Luke effect, resulting in great sensitivity to low-mass dark matter candidates. The energy resolution of these detectors also allows the investigation of the excess of low-energy events that has been systematically observed by cryogenic low-threshold experiments. In this talk I will present details of a recent run of HVeV detectors that was conducted at CUTE (Cryogenic Underground TEst facility), a test facility at the SNOLAB underground laboratory near Sudbury, Canada. This was the first time in which such sensitive detectors were operated deep underground in a low-background environment. I will describe the goals

of this run, the payload, as well as provide a first peek into the results of the ongoing data analysis.

T 19.7 Mon 18:15 VG 4.102

Study of Low Energy Excess in the CRESST experiment — •Eleonora Rebecca Cipelli — Max Planck Institute für Physik

The CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) experiment operates Transition Edge Sensors (TESs) at millikelvin temperatures to directly search for dark matter, with a focus on the sub-GeV mass range. Located in the ultra-low-background environment of the Laboratori Nazionali del Gran Sasso (LNGS) in Italy, CRESST is one of the leading experiments in the field thanks to its extremely low energy threshold. However, its sensitivity is affected by an increasing event rate at low energies (below ~200eV), known as the Low Energy Excess, whose origin remains unclear. While several potential causes have been ruled out, ongoing measurements and efforts to develop new detector designs aim to provide deeper insights into these observations. In this talk, the studies and latest results of Low Energy Excess performed by CRESST are presented.

T 19.8 Mon 18:30 VG 4.102

Results of the double-TES in the CRESST experiment — •Felix Dominsky — Max-Planck-Institut für Physik

CRESST is a leading direct dark matter search experiment that employs transition edge sensors (TES) to detect energy depositions in cryogenic target crystals. Like many experiments in this field, CRESST observes an excess of events near the detector threshold, commonly referred to as the low-energy excess (LEE). This phenomenon poses a significant challenge to the sensitivity of the experiment, particularly for light dark matter detection. To investigate the origin of the LEE, CRESST has developed the double-TES module, featuring two identical TESs on a single target crystal. A particle interaction in the bulk of the crystal is sensed in both TES, whereas events detected in only one TES can be excluded as valid particle interactions. This presentation will detail the operating principle of the double-TES and highlight new insights into the LEE derived from this technology.

T 20: Invited Topical Talks I

Time: Tuesday 13:45–15:45 Location: ZHG011

Invited Topical Talk T 20.1 Tue 13:45 ZHG011

An introduction to gas electron multipliers and their time to shine during the CMS phase 2 upgrade — •Shawn Zaleski — III. Physikalisches Institut A, RWTH Aachen University

Gas electron multipliers (GEMs) are a sub-class of micro-pattern gaseous detectors in which passing charged particles ionize the gas inside to create an electronic avalanche through multiple stages of amplification. Each GEM foil is copper-cladded Kapton with a chemically etched micro-pattern of holes allowing electrons to pass through and be amplified. Each amplification stage allows a moderate amplification gain per GEM foil to be achieved, yielding an overall gain of $\mathcal{O}(10^5)$.

The CMS GEM project makes use of the largest area GEM chambers up to now. GEMs were first installed in the first muon station of the CMS end caps during the last long shutdown (LS2) in 2021 and 2022. These chambers compliment the existing cathode strip chamber system improving the transverse momentum measurement of muons traversing the CMS end caps. A new addition to the GEM system, so-called ME0, will be installed adjacent to the planned high-granularity hadron calorimeter (HGCAL) in the nose of the CMS end caps. This will extend the pseudorapidity reach of the muon system from 2.4 to 2.8. The ME0 stacks, sets of six triple GEM chambers are planned to be installed during the next LHC long shutdown (LS3). Production of the ME0 stacks is currently underway and the first stacks are already undergoing quality control (QC) checks to test detector readiness. The production status and initial QC results will be presented.

Invited Topical Talk T 20.2 Tue 14:15 ZHG011

Searches for rare Higgs boson decays — •Martina Laura Ojeda — CERN, Geneva, Switzerland

Throughout the decade that has elapsed since the discovery of the Higgs boson, a considerable amount of effort has been put into precise measurements of its properties. Higgs boson couplings to vector bosons, τ leptons, bottom/top quarks, and (via loop processes) photons and gluons have now been established. As all current measurements point to the Higgs boson being Standard Model (SM)-like, rare and unobserved Higgs boson decay modes are an important contribution to further test the SM. This is particularly true for decay modes mediated by loops, which can be especially sensitive to physics beyond the SM.

This talk will focus on challenges and opportunities associated with rare decay searches, and highlight one such ATLAS search: the yet-unobserved $H \to Z/\gamma^* + \gamma$ decay. While not sensitive enough to claim observation of this decay process, current results hint at a slight tension with the SM expectation, with a $H \to Z\gamma$ decay rate of $(2.2 \pm 0.7)\times$ the SM prediction.

Invited Topical Talk T 20.3 Tue 14:45 ZHG011

Novel opportunities with the LHCb Software Trigger — •Titus Mombächer — CERN, Geneva, Switzerland

The LHCb experiment at the LHC has a unique acceptance and a highly flexible trigger system which enables a rich physics program, while keeping the processed and stored data sizes at a manageable level. Since the beginning of the current data taking period its flexibility got further enhanced by relying fully on a software-only trigger. This talk will describe the LHCb trigger system and illustrate its potential far beyond the design goals with examples from past, present and future, focusing on rare strange decays and particles with exotic signatures.

Invited Topical Talk T 20.4 Tue 15:15 ZHG011

Dark sector searches with invisible and displaced signatures at Belle II — •Giacomo De Pietro — Institut für Experimentelle Teilchenphysik, Karlsruher Institut für Technologie, 76131 Karlsruhe, Germany

Experimental evidence points to the existence of so-called dark matter, which makes up 85The Belle II experiment is collecting samples of e^+e^- collision data at center-of-mass energies near the $\Upsilon(4S)$ resonance. These data have constrained kinematics and low multiplicity, allowing searches for dark sector particles in the mass range from a few MeV to O(10) GeV. In this talk I will review some of the recent dark sector searches at Belle II, focusing on the results with invisible and displaced signatures.

T 21: Invited Topical Talks II

Time: Tuesday 13:45–15:45 Location: ZHG010

Invited Topical Talk T 21.1 Tue 13:45 ZHG010

The KM3NeT Ultra-High Energy Neutrino and its Possible Astrophysical Origins — •Massimiliano Lincetto — Lehrstuhl für Astronomie, Julius-Maximilians-Universität Würzburg, Würzburg, Germany — Deutsches Elektronen-Synchrotron (DESY), Zeuthen, Germany

High-energy astrophysical neutrinos, first discovered by the IceCube Neutrino Observatory, are key messengers for the understanding of hadronic acceleration processes in the Universe, with the potential to unveil the sources of ultra-high energy cosmic rays. The KM3NeT Collaboration is building two neutrino detectors in the Mediterranean Sea by instrumenting large volumes of seawater with photomultiplier tubes, sensitive to the Cherenkov light induced by secondary particles produced in neutrino interactions. KM3NeT has recently reported the observation of an ultra-high energy neutrino in the tens of PeV range, possibly the most energetic neutrino observed to date. The particle's incoming direction points slightly below the horizon, where atmospheric backgrounds are negligible, indicating a most likely cosmic origin. This talk will report on the KM3NeT detection of this exceptional event and its implications for our knowledge of astrophysical neutrinos. The talk will explore the neutrino's potential origins, including the search and characterisation of candidate extragalactic astrophysical counterparts.

Invited Topical Talk T 21.2 Tue 14:15 ZHG010

Multimessenger astronomy with ultra-high-energy cosmic rays and high-energy neutrinos — •Foteini Oikonomou — Norwegian University of Science and Technology

Multi-messenger astrophysics has advanced rapidly in the last decade, owing, primarily, to the newly discovered and growing body of observations of high-energy neutrinos and gravitational waves. Meanwhile, ultra-high energy cosmic ray experiments have made groundbreaking observations during this time, such as the discovery of dipole anisotropy in the UHECR arrival directions, which have revitalised the field of ultra-high energy cosmic ray astronomy. In

this talk, I will review recent results in the search for the origin of high-energy neutrinos and ultra-high-energy cosmic rays. I will also summarise our current understanding of the role of active galactic nuclei, gamma-ray bursts, and tidal-disruption events as high-energy-cosmic-ray accelerators based on the latest multimessenger observations.

Invited Topical Talk T 21.3 Tue 14:45 ZHG010

Peering into the Cosmos from Deep Underground – Astroparticle Physics with Xenon Detectors — •Christian Wittweg for the XENON-Collaboration — Physik-Institut, University of Zürich, 8057 Zürich, Switzerland

What is the dark matter in the Universe? Astronomical observations at all scales provide indirect evidence of weakly interacting and non-baryonic particles with possible masses spanning many orders of magnitude. However, a direct detection in an experiment is still pending. Xenon time projection chambers located deep underground lead the worldwide searches for dark matter in the form of weakly interacting massive particles (WIMPs) with masses of few GeV to hundreds of TeV. WIMPs are well-motivated dark matter candidates, but the expected signals are feeble and interaction rates would be on the order of few events per tonne of xenon and year. Therefore, detectors such as XENONnT need multi-tonne targets, ultra-low backgrounds and energy thresholds of few keV. Incidentally, this makes them ideal observatories for many astroparticle physics signals beyond WIMPs: neutrinos from various sources, alternative dark matter candidates and rare nuclear decays. The talk will present recent results from XENONnT and provide an outlook on the future XLZD/DARWIN observatory as the Swiss army knife of low-energy astroparticle physics.

Invited Topical Talk T 21.4 Tue 15:15 ZHG010

Feebly Interacting Particles in the Early Universe — •Mathias Becker — University of Padova

Feebly interacting particles (FIPs) have gained attention as a compelling alternative to WIMP dark matter. In this talk, I will present recent advancements in the precise determination of FIP production rates from a thermal plasma, emphasizing the role of finite-temperature effects. I will also discuss how experimental searches, including long-lived particle and direct detection experiments, can probe FIPs and potentially reveal insights into early universe phenomena such as inflationary reheating.

T 22: Annual Meeting of Young Scientists in High Energy Physics

Time: Tuesday 12:35–13:45 Location: ZHG011

T 22.1 Tue 12:35 ZHG011

Annual Meeting of Young Scientists in High Energy Physics (yHEP) — •Michael Lupberger — University of Bonn — yHEP Management Board

In our report, we will present our last year's activities. This includes the work with the committees and the organisation of events, e.g. for the Update of the European Strategy for Particle Physics. We give updates of the Know-your-Footprint campaign and our statement on the reform of the law for fixed-term contracts (WissZeitVG) and other topics. There is also some room for a discussion. However, the currently most relevant topics in our work on issues with residence permits and the WissZeitVG will be discussed in a separate session organised with the jDPG on Wednesday evening.

All students, doctoral candidates, post-docs and scientists on temporary contracts are cordially invited.

Please register to our mailing list which can be found from yhep.desy.de to receive details on the meeting.

T 23: Searches/BSM II (Non-collider)

Time: Tuesday 16:15–18:00 Location: ZHG010

T 23.1 Tue 16:15 ZHG010

Stringent Constraints on Pseudoscalar Couplings from Precision Hyperfine Splitting Measurements — •Cedric Quint[1], Zoltán Harman[1], Joerg Jaeckel[2], Fabian Heisse[1], Lutz Leimenstoll[2], and Christoph H. Keitel[1] — [1]Max Planck Insitute for Nuclear Physics, Heidelberg, Germany — [2]Institute for Theoretical Physics, Heidelberg, Germany

Axion-like particles and similar new pseudoscalar bosons coupled to nucleons and electrons are known to lead to spin-dependent forces in atoms and ions. Hyperfine structure measurements are a sensitive probe to this effect. Specific differences, which are meant to reduce uncertainties due to nuclear effects in hyperfine structure calculations and measurements, yield stringent bounds on these couplings. We show that existing measurements on Be provide competitive limits in the region $m_\phi \gtrsim 100\,\mathrm{keV}$. We find that measurements on Cs and B have discovery potential. We also discuss various other candidate elements and evaluate their prospects.

T 23.2 Tue 16:30 ZHG010

Nonlinear calcium King plot constrains new bosons and nuclear properties — •Agnese Mariotti[1], Alexander Wilzewski[2], Lukas J. Spiess[2], Malte Wehrheim[2], Shuying Chen[2], Steven A. King[2], Peter Micke[2], Melina Filzinger[2], Martin R. Steinel[2], Nils Huntemann[2], Erik Benkler[2], Piet O. Schmidt[2,7], Luca I. Huber[3], Jeremy Flannery[3], Roland Matt[3], Martin Stadler[3], Robin Oswald[3], Fabian Schmid[3], Daniel Kienzle[3], Jonathan Home[3], Diana Prado Lopez Aude Craik[3], Menno Door[4], Sergey Eliseev[4], Pavel Filianin[4], Jost Herkenhof[4], Kathrin Kromer[4], Klaus Blaum[4], Vladimir A. Yerokhin[4], Igor A. Valuev[4], Natalia S. Oreshkina[4], Chunhai Lyu[4], Sreya Banerjee[4], Christoph H. Keitel[4], Zoltan Harman[4], Julian C. Berengut[6], Anna Viatkina[2,5], Jan Gilles[2,5], Andrey Surzhykov[2,5], Michael K. Rosner[4], Jose R. Crespo Lopez-Urrutia[4], Jan Richter[1,2], and Elina Fuchs[1,2] — [1]LUH-ITP — [2]PTB — [3]LUH-IQE — [4]MPI — [5]TUB-IMP — [6]UNSW — [7]LUH-IQ

The SM predicts isotope shifts (IS), i.e. differential measurements of the same electronic transition in different isotopes of an element, to follow a linear relation: the King plot (KP). Nonlinearities in KP set constraints on the existence of new interactions. We measure IS in Ca14+ and in Ca+, as well as isotope masses of calcium, observing for the first time a nonlinearity in this system. Combining these with the calculation of the next-to-leading SM term, we are able to improve the bounds on the existence of a new light boson coupling electrons and neutrons.

T 23.3 Tue 16:45 ZHG010

BDF/SHiP @CERN (NA67): Search for Hidden Particles at a Future Beam Dump Facility — •Annika Hollnagel for the SHiP-Collaboration — JGU Mainz (DE)

The Search for Hidden Particles (SHiP) experiment has been selected as the new flagship project of the CERN Physics Beyond Colliders intensity frontier, featuring a dedicated Beam Dump Facility (BDF) at CERN's North Area ECN3 to exploit the full potential of the 400GeV SPS proton beam.

The experiment will be realised by a two-fold detector setup enabling a diverse physics program: While the Hidden Sector (HS) detector is going to study the decay of Heavy Neutral Leptons (HNL), Axion-Like Particles (ALPs), and other Feebly-Interacting Particles (FIPs) in a broad range of masses and coupling inaccessible to colliders, the upstream Scattering and Neutrino Detector (SND) will enable a direct search for Light Dark Matter (LDM), as well as measurements in neutrino physics with unprecedented precision. With the detector located closely downstream of the dense proton target, a major challenge will be the reduction of beam-related backgrounds. Following the hadron stopper, a magnetic muon shield will deflect most of these particles from the detector acceptance, and the 50m-long HS decay volume will be enveloped by a Surrounding Background Tagger (SBT). This talk will give an overview of the detector technologies and physics capabilities of the proposed experiment.

Having recently been approved by the CERN Research Board, this is the ideal time for new groups to join the project.

T 23.4 Tue 17:00 ZHG010

Background suppression in the SHiP experiment with the Surround Background Tagger — •Katharina Albrecht for the SHiP-SBT-Collaboration — Institut für Physik, Humboldt-Universität zu Berlin, Berlin, Germany

SHiP (Search for Hidden Particles) is an experiment that will be installed in a dedicated beam-dump facility in the ECN3 cavern, located in the CERN north area. SHiP will search for feebly interacting particles (FIPs) produced by 400 GeV/c protons from the SPS impinging on a heavy-metal target. Over a 15-year span, the objective is to accumulate 6×10^{20} protons on target with a detector setup that allows suppression of possible background to a negligible level. The experiment focuses on optimizing the sensitivity for models featuring long-lived FIPs below 10 GeV/c^2 by minimizing backgrounds induced by the huge flux of neutrinos and muons emerging from the beam-dump target. The Surround Background Tagger (SBT) is a critical component surrounding the 50 m long helium-filled decay volume. The SBT is instrumental to detect charged par-

ticles entering the decay volume from the sides as well as inelastic interactions of neutrinos and muons taking place inside the helium-filled decay volume, but also in the SBT itself. The presentation will discuss simulation studies on the background suppression strategies with focusing on role of the SBT.

T 23.5 Tue 17:15 ZHG010

Search for Sub-Relativistic Magnetic Monopoles with the IceCube Neutrino Observatory — •Jonas Häussler, Jakob Böttcher, Christopher Wiebusch, and Peter-John Cusack — RWTH Aachen University, Aachen, Germany

Magnetic monopoles are Beyond-Standard-Model particles, predicted by Grand Unified Theories (GUTs) to be created during their freeze-out in the early universe. At typical masses of the GUT-scale - above 10^{14} GeV - these particles would move at sub-relativistic speeds. The Rubakov-Callan effect predicts that magnetic monopoles can catalyze proton decays. This results in a unique signature of small particle cascades along the trajectory of the slow-moving particle. Since 2012, a dedicated Slow-Particle Filter has been implemented in the IceCube Neutrino Observatory for the detection of magnetic monopoles. The low, if existent, flux of the monopoles requires exceptional background rejection and signal efficiency. This is accomplished using machine learning methods. For this analysis we use a multi-level Boosted-Decision-Tree classifier. We present the strategy behind the background and signal simulation, the classification efficiency, and the projected sensitivity of IceCube for the detection of sub-relativistic magnetic monopoles.

T 23.6 Tue 17:30 ZHG010

Faint non-standard model particles in IceCube — •Nick Jannis Schmeisser, Timo Stürwald, and Christian Locatelli for the IceCube-Collaboration — Bergische Universität Wuppertal

Fractionally Charged Particles (FCPs) are particles that carry a fraction of the elementary charge e, which are predicted by multiple extensions of the standard model of particle physics. Relativistic FCPs produce Cherenkov light in the IceCube Neutrino Observatory. Due to the charge dependence of the Cherenkov light yield, the particles produce faint tracks in the detector. To increase the sensitivity for these faint signatures, the Faint Particle Trigger (FPT) was developed and deployed in 2023.

This presentation shows simulation studies optimizing the reconstruction of events triggered by the FPT. Different timing-based reconstruction techniques are compared based on their performance in reconstructing simulated FCP events. The reconstruction performance especially depends on the reduction of noise hits in the detector, which are dominant in comparison to the number of signal hits produced by FCPs. First efforts towards a Machine-Learning based analysis searching for FCPs using events triggered by the FPT are shown. A first reduction of background events includes the Faint Particle Filter utilizing results from the optimized event reconstruction.

T 23.7 Tue 17:45 ZHG010

Exploring beta decay with light boson emission in the KATRIN experiment — •Joscha Lauer for the KATRIN-Collaboration — Karlsruhe Institute of Technology (KIT)

The Karlsruhe Tritium Neutrino (KATRIN) experiment is designed to measure the effective electron antineutrino mass with a sensitivity better than $m_\nu c^2 = 0.3$ eV (90% C.L.) in a kinematic approach by applying precision electron spectroscopy to the beta decay of molecular tritium. The measurement focuses on the spectral endpoint (E_0) region, extending up to tens of eV below $E_0 \approx 18.6$ keV.

Light neutral pseudoscalars and vector bosons are predicted in many theories beyond the Standard Model (BSM). Constraints on the couplings of such particles to neutrinos or electrons can be derived from cosmological, astrophysical and laboratory observations. With high-statistics beta spectroscopy, KATRIN complements these approaches, as the emission of an additional light state in tritium beta decay introduces characteristic modifications to the observed electron spectrum. We present the computation of these spectra, based on JHEP 01 (2019) 206. Preliminary analysis of the second KATRIN measurement campaign explores the parameter space of boson couplings, offering perspectives for BSM physics.

This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2, and 05A23WO6).

T 24: Higgs Physics III (boson final states)

Time: Tuesday 16:15–17:45 Location: ZHG104

T 24.1 Tue 16:15 ZHG104

Measurement of $H \to \gamma\gamma$ fiducial cross sections with 13.6 TeV CMS data — Caio Daumann, Johannes Erdmann, Florian Mausolf, •Jan Lukas Späh, and Maximilian Wrabetz — III. Physikalisches Institut A, RWTH Aachen University

The Higgs boson is of fundamental importance for the understanding of particle physics. Since its discovery in 2012, it has been studied extensively by the ATLAS and CMS collaborations. The measurement of Higgs boson production cross sections is crucial to study deviations from the standard model in the scalar sector.

In this presentation, the measurement of Higgs boson production cross sections in the diphoton decay channel with the CMS experiment is presented. The data used in this analysis were collected in proton-proton collisions at $\sqrt{s}$ = 13.6 TeV in 2022 and correspond to an integrated luminosity of 34.7 fb^{-1}. To reduce extrapolation uncertainties and improve the model independence of the measurement, the cross sections are measured in a fiducial phase space at particle level. Special emphasis is placed on the statistical analysis in this talk. This includes the simulation-based signal modelling, the data-driven background modelling, and the treatment of uncertainties.

This analysis lays the foundation for further measurements of Higgs boson processes in the diphoton decay channel by the CMS collaboration in Run 3 of the LHC and beyond. A brief outlook for future measurements and the potential of such analyses to constrain Higgs boson couplings to light quarks is given.

T 24.2 Tue 16:30 ZHG104

Studies for H → $\gamma\gamma$ cross-section measurements with 13.6 TeV CMS data — Caio Daumann, Johannes Erdmann, Florian Mausolf, Jan Lukas Späh, and •Maximilian Wrabetz — III. Physikalisches Institut A, RWTH Aachen University

Precise measurements of Higgs boson production cross-sections are crucial for testing the Standard Model. In this presentation, studies for cross-section measurements of Higgs boson production in the diphoton decay channel, based on proton-proton collision data collected at $\sqrt{s}$ = 13.6 TeV by the CMS experiment in 2022 and 2023, are shown. They are performed in a fiducial phase space to reduce extrapolation uncertainties and enhance model independence.

The latest studies for a cross-section measurement of LHC Run 3 data are presented. These include the optimization of the categories for the analysis that are based on the estimated diphoton mass resolution and the decorrelation of that estimate with respect to the invariant diphoton mass.

T 24.3 Tue 16:45 ZHG104

Measurement of differential cross-sections in the $H \to ZZ^* \to 4\ell$ decay channel with the ATLAS Run 3 data — •Elena Cuppini, Alice Reed, Sandra Kortner, Oliver Kortner, and Tae Hyoun Park — Max-Planck-Institut für Physik

The decay of the Higgs boson into two Z bosons, which subsequently decay to four leptons ($H \to ZZ^* \to 4\ell$), offers a clean signature and high signal-to-background ratio for studying the properties of the Higgs boson. The measurement of differential fiducial cross-sections in this decay channel is performed for the first time with the Run 3 proton-proton collision data at a previously unexplored centre-of-mass energy $\sqrt{s}$ = 13.6 TeV. The data collected with the ATLAS detector during 2022 and 2023 corresponds to an integrated luminosity of 56 fb^{-1}.

The analysis minimises model dependence by employing fiducial phase-space selections that closely match the experimental acceptance, along with corrections for detector effects. Results will be compared to Standard Model predictions, with an emphasis on key differential observables.

Strategies for upcoming differential fiducial cross-section measurements with about three times more Run 3 data from the ATLAS detector collected by the end of 2024 will be discussed.

T 24.4 Tue 17:00 ZHG104

Optimization of machine learning-based measurements of Higgs production processes in the $H \to 4\ell$ decay channel with ATLAS Run 3 data — •Luca Spitzauer, Sandra Kortner, Hubert Kroha, Alice Reed, Elena Cuppini, and Tae Hyoun Park — Max-Planck-Institut für Physik

Cross-section measurements for various Higgs boson production and decay processes are crucial for exploring Higgs boson properties and have high sensitivity to potential physics beyond the Standard Model. The decay of a Higgs boson into a pair of Z bosons, each subsequently decaying into two leptons ($H \to ZZ^* \to 4\ell$), is particularly important for these measurements due to its exceptionally clear signal.

Within the framework of Simplified Template Cross Sections (STXS), exclusive regions of phase space are defined for each Higgs boson production mode. Optimized classification of reconstructed events according to the STXS produc-

tion regions is essential to enhance signal sensitivity and reduce uncertainties. The previous round of STXS measurements in the $H \to 4\ell$ channel using the Run 2 ATLAS dataset employed a Neural Network classification approach. With the new Run 3 dataset at a center-of-mass energy of 13.6 TeV, we are exploring potential optimizations of this classification using a new Deep Set machine-learning approach.

T 24.5 Tue 17:15 ZHG104

Measurement of gluon fusion and vector-boson fusion Higgs-boson production cross sections in $H \to WW^* \to l\nu l\nu$ decays with the ATLAS detector — •Ahmed Markhoos, Karl Jakobs, and Benedict Winter — University of Freiburg, Freiburg im Breisgau, Germany

As the Higgs boson decay with the second largest branching fraction, the decay to two W bosons ($H \to WW^*$) is not only advantageous due to its sizable signal yield. It also has a relatively clean signature with moderate backgrounds. This allows for accurate measurements of the total and differential cross-sections for Higgs boson production through the gluon-gluon fusion (ggF), vector boson fusion (VBF) and Higgs strahlung modes. Throughout the past decade, this decay channel has been analyzed with improving accuracy, directly testing the Standard Model predictions and measuring the Higgs boson's couplings. In this talk, an overview of the ongoing $H \to WW^* \to l\nu l\nu$ ggF and VBF Simplified Template Cross-Section (STXS) measurement of the full Run 2 ATLAS dataset is presented. The analysis greatly improves on the previously published Run 2 analysis by extending the use of multivariate techniques and considering Higgs-boson decays to light leptons of the same flavor ($e\nu\ e\nu/\mu\nu\ \mu\nu$), which had been disregarded, in addition to different flavor decays ($e\nu\ \mu\nu$). This enables a more granular and precise STXS measurement with a considerably higher sensitivity.

T 24.6 Tue 17:30 ZHG104

Quantum tomography using machine learning to infer incomplete information in $H \to WW \to \ell\nu\ell\nu$ — Carsten Burgard[1], Vince Croft[2], Andre Sopczak[3], •Andrii Vak[3], and Lennart Völz[1] — [1]TU Dortmund University — [2]Leiden University — [3]Czech Technical University in Prague

Potential entanglement originating from the scalar nature of the Higgs boson can translate to variables that could be accessible at collider experiments such as ATLAS at the LHC. The entanglement is mediated through the parity violation from weak decay vertices, affecting for example the angular properties of the dilepton system in $H \to WW \to \ell\nu\ell\nu$ decays. Thus, the analysis of multiple neutrinos in the final state is interesting for quantum tomography measurements. This study uses advanced machine learning methods for regression and inference of missing kinematic information.

T 25: Higgs Physics IV (BSM Higgs)

Time: Tuesday 16:15–17:45 Location: ZHG105

T 25.1 Tue 16:15 ZHG105

Search for heavy neutral Higgs bosons in the $t\bar{t}Z$ channel at CMS — •Yannick Fischer, Matteo Bonanomi, Lukas Ebeling, Johannes Haller, Daniel Hundhausen, Matthias Schröder, and Bianca Weidner — Institut für Experimentalphysik, Universität Hamburg

All measurements of the Higgs boson at 125 GeV so far agree with the standard model (SM) prediction, however the observed resonance could still be part of an extended Higgs sector. Such an extended Higgs sector is predicted by many theories of physics beyond the SM. Two Higgs Doublet Models (2HDM) assume the existence of a second Higgs doublet, giving rise to a total of five physical Higgs bosons. This talk will present a search for a hypothetical CP-odd Higgs boson A decaying into a hypothetical CP-even heavy Higgs boson H and a Z boson, with the H decaying into a top anti-top quark pair. This channel has been dubbed the smoking gun channel for various 2HDMs in the context of electroweak baryogenesis. We will focus on the fully hadronic decay of the $t\bar{t}$ pair, presenting improvements of the analysis strategy and first results with data measured by CMS at 13.6 TeV.

T 25.2 Tue 16:30 ZHG105

Improving the search for heavy neutral Higgs bosons in the $t\bar{t}Z$ channel at CMS using parameterized neural networks — •Bianca Weidner, Matteo Bonanomi, Lukas Ebeling, Yannick Fischer, Johannes Haller, Daniel Hundhausen, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

Many theories of physics beyond the Standard Model, such as Two Higgs Doublet Models (2HDM), suggest that the Higgs boson measured at 125 GeV might be part of an extended Higgs sector with five physical Higgs bosons. In this talk, we will explore a promising decay channel involving a hypothetical CP-odd heavy Higgs boson (A), which decays into a CP-even heavy Higgs boson (H) and a Z boson. The H boson then decays into a top quark-antiquark pair. Current analyses exclude signals of up to approximately 1.2 TeV for these hypothetical particles. We will focus on optimizing the analysis by investigating the impact of a parameterized neural network to separate signal events from the background. This approach improves the sensitivity to a potential signal and thus allows probing a larger region of the 2HDM parameter space.

T 25.3 Tue 16:45 ZHG105

Search for a light CP-odd Higgs boson decaying into a pair of τ-leptons in proton–proton collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector — •Manuel Gutsche, Asma Hadef, Tom Kresse, Christian Schmidt, and Arno Straessner — Technische Universität Dresden

The two-Higgs-doublet model (2HDM) continues to be one of the most well-motivated extensions of the Standard Model. The theory postulates a second Higgs doublet, thus predicting the existence of in total five Higgs bosons h, H, $H^{\pm}$, A, of which the latter A boson is electrically neutral and CP-odd. A certain choice of the model's parameters leads to the flavour-aligned 2HDM, which is able to explain discrepancies in the anomalous magnetic moment of the muon for an A boson mass of less than m_Z as well as large couplings to leptons and up-type quarks.

This talk presents a search for a CP-odd Higgs boson which is produced via gluon fusion and decays into two τ-leptons in the mass range of 20 GeV to 90 GeV. For this, the analysis uses 140 fb^{-1} of data recorded by the ATLAS detector at $\sqrt{s}$ = 13 TeV, focusing on the leptonic decays of the τ-leptons to exactly one electron and one muon.

After explaining the analysis strategy and event selection, an overview of fake-lepton estimation and most impactful systematic uncertainties is given. The expected and observed exclusion limits for the model-independent production cross-section, as well as for the coupling parameter to up-type quarks interpreted in the flavour-aligned 2HDM, are presented.

T 25.4 Tue 17:00 ZHG105

Updates on the Yukawa Type I for 2HDMS with a 95 GeV Higgs boson — •Dominik Heintz[1], Sven Heinemeyer[3], Cheng Li[4], and Gudrid Moortgat-Pick[1,2] — [1]II. Institut für Theoretische Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]DESY, Notkestraße 85, 22607 Hamburg, Germany — [3]Instituto de Física Teórica UAM-CSIC, Cantoblanco, 28049, Madrid, Spain — [4]School of Science, Sun Yat-Sen University, Gongchang Road 66, 518107 Shenzhen, China

The **2HDM** (Two-Higgs-Doublet Model) can be extended by a real singlet, **N2HDM**, or a complex singlet, **2HDMS**. Both models are promising candidates to describe the excess at ~ 95 GeV observed both at **CMS** and at **ATLAS** in the $\gamma\gamma$ channel with ~ 2.9σ and ~ 1.7σ, respectively, as well as in the $b\bar{b}$ decay channel at **LEP** with ~ 2.3σ. The lightest Higgs boson in the models, h_1 was interpreted as a new particle at ~ 95 GeV. Studies so far focused on the Yukawa types II and IV. However, the signal strength in the $\gamma\gamma$ channel went down substantially over the last years. This allows a greater freedom for $\frac{c_{h_1 bb}}{c_{h_1 tt}}$, the ratio of the coupling modifiers of the light Higgs to bottom and top quarks, respectively. This motivates the phenomenological study of the **2HDMS** in the Yukawa type I. The study includes current theoretical and experimental constraints using **HiggsTools** (**HiggsBounds** and **HiggsSignals**) and incorporates the most recent signal rates from **ATLAS**.

T 25.5 Tue 17:15 ZHG105

Searches for charged Higgs bosons in $H^{\pm} \to W^{\pm}h$ decays with the ATLAS detector — Dominik Duda[2], •Simon Grewe[1], Sandra Kortner[1], and Hubert Kroha[1] — [1]Max Planck Institut für Physik — [2]University of Edinburg

Many theories beyond the Standard Model predict the existence of charged Higgs bosons. The main production mode of these new particles depends on their mass. For large $H^{\pm}$ masses, the dominant mode of production is in association with a top quark and a bottom quark ($tbH^{\pm}$). In the alignment limit of the Two-Higgs-Doublet Model, heavy charged Higgs bosons decay almost exclusively via $H^{\pm} \to tb$. In other models such as the Georgi-Machacek model, however, significant branching ratios for $H^{\pm} \to W^{\pm}h$ are possible.

A search for charged Higgs bosons in $H^{\pm} \to W^{\pm}h$ (m_h=125 GeV) decays produced in association with a top and bottom quark is presented, based on the full Run-2 dataset of the ATLAS experiment. This is the first search for this decay at the LHC.

Two analysis strategies are employed to ensure high sensitivity for both low and high $H^{\pm}$ masses. For low $H^{\pm}$ masses the decay products have a relatively low Lorentz-boost and the $h \to b\bar{b}$ can be resolved by two small-radius jets. For high $H^{\pm}$ masses the final state particles acquire a lot of Lorentz-boost and the neutral Higgs boson decay has to be reconstructed via a single large-radius jet.

The invariant mass of the charged Higgs boson is reconstructed and used as the discriminating variable. No significant deviation from the SM expectation is observed and upper limits are set on $\sigma(pp \to tbH^{\pm}) \times BR(H^{\pm} \to W^{\pm}h)$.

T 25.6 Tue 17:30 ZHG105

tbH$^+$ Analysis with Multileptons Using Run-2 ATLAS Data — •Azad Afandizada and Andre Sopczak — Czech Technical University in Prague

The latest results with Run-2 ATLAS data are presented for the search tbH$^+$ in the multilepton channel.

T 26: Axions/ALPs I

Time: Tuesday 16:15–17:45 Location: VG 0.110

T 26.1 Tue 16:15 VG 0.110

Towards a low background SDD for IAXO — Joanna Bilicki[1], Patrick Bongratz[1,2], Frank Edzards[1], Susanne Mertens[1,2], •Lucinda Schönfeld[1,2], Juan Pablo Ulloa Beteta[1], Christoph Wiesinger[1,2], and Michael Willers[1,2] for the IAXO-Collaboration — [1]Technische Universität München, Garching, DE — [2]Max Planck Institut für Kernphysik, Heidelberg, DE

Axions are hypothetical particles that solve the strong CP problem and are candidates for dark matter. The International Axion Observatory (IAXO) is aiming to find these elusive particles by converting solar axions to X-rays. Detecting this rare signal requires highly efficient ultra-low background X-ray detectors, for which Silicon Drift Detectors (SDDs) are well suited. I will present the current status of the TRISTAN SDD for IAXO (TAXO) project, which is developing such an SDD. A particular focus will be the latest results of background measurements above ground at TUM and deep underground at the Canfranc underground laboratory.

This project has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and innovation programme (grant agreement No. 852845). It has also been supported by the DFG through the Excellence Cluster ORIGINS.

T 26.2 Tue 16:30 VG 0.110

X-ray focus on axions: optics for the International AXion Observatory (IAXO) — •Julia K. Vogel for the IAXO-Collaboration — Fakultät für Physik, TU Dortmund, Otto-Hahn-Str. 4, Dortmund D-44221, Germany

Axions are one of the leading candidates for the hypothetical, non-baryonic dark matter expected to account for about 27% of the energy density of the Universe. Axion helioscopes are experiments searching for axions and axion-like particles (ALPs) produced in the core of the Sun via the Primakoff effect by utilizing strong magnetic fields, x-ray optics and ultralow-background detectors. The International Axion Observatory (IAXO) is a next generation axion helioscope aiming at a sensitivity to the axion-photon coupling of 1 – 1.5 orders of magnitude beyond the current most sensitive axion helioscope, the CERN Axion Solar Telescope (CAST). BabyIAXO (BIAXO) is an intermediate scale helioscope with sensitivities to axion-photon couplings down to a few 10^{-11} GeV^{-1} reducing risks for IAXO while delivering first significant physics results. The optics for (B)IAXO are a key part of the experiment and consist of multilayer-coated Wolter-I approximations. Two pathfinder optics have been successfully tested at CAST and at the Panter x-ray test facility of MPE. Here we briefly introduce (B)IAXO and detail the optics and coating design along with the pathfinder performances.

T 26.3 Tue 16:45 VG 0.110

Development of a GridPix Detector for the International AXion Observatory — •Johanna von Oy, Klaus Desch, Jochen Kaminski, Tobias Schiffer, Sebastian Schmidt, and Markus Gruber for the IAXO-Collaboration — Physikalisches Institut der Universität Bonn

Axion searches with helioscope experiments like the International AXion Observatory (IAXO) focus mainly on the solar axion production. With its dense and high temperature environment, the sun's core can produce a high flux of axions through the Primakoff effect and ABC processes. To detect these solar axions, IAXO and also its intermediate stage BabyIAXO, will consist of a magnet that follows the sun for twelve hours a day. In the magnetic field the axions couple to X-rays which can then be focused onto dedicated detectors.

One of these detectors will be built in Bonn. Thanks to the solar axions' small coupling strengths and energies of about ~1 keV the two main requirements for a detector are an ultra low background and the ability to detect low energy X-rays.

A GridPix based gas-filled detector made out of very radiopure materials is therefore a good fit for a helioscope experiment. The ultra-thin vacuum-tight window will allow for low energy X-rays to enter the gas volume and produce electrons. The aluminium grid on top of a pixelated readout chip, the Timepix3, makes the detection of single electrons and therefore low energy X-rays possible.

This talk will focus on the development and challenges of a GridPix based detector for axion searches with IAXO and BabyIAXO.

T 26.4 Tue 17:00 VG 0.110

Optimization of a dielectric haloscope for axion dark matter detection, MADMAX — •Dominik Bergermann for the MADMAX-Collaboration — III. Physikalisches Institut A, RWTH Aachen University

Axions are promising candidates for cold dark matter and the absence of CP violation in strong interaction. The **MA**gnetized **D**isc and **M**irror **A**xion e**X**periment is a dielectric haloscope experiment targeting axion dark matter in a mass range of 40 to 400 μeV. It consists of multiple, consecutive and movable dielectric discs to amplify the weak microwave signal of axion photon conversion in a strong magnetic field.

Covering this range with a single experimental setup, while simultaneously being able to finetune the resonance on potential signals, necessitates repositioning the hardware continuously and automatically. The disc positions as parameter-space can be optimized to produce desired signal shapes. Multiple different optimization algorithms have been tested.

This talk discusses the strategies for optimizing a physical MADMAX-like setup in-place based on it's electrical microwave responses. Challenges are the sparse set of information, the time requirement of repositioning and the reliability of the algorithms.

T 26.5 Tue 17:15 VG 0.110

Probing electric fields insida a test setup for the dielectric axion haloscope MADMAX — •Max Zimmermann for the MADMAX-Collaboration — III. Physikalisches Institut A, RWTH Aachen University

Axions are promising candidates for cold dark matter and the absence of CP violation in strong interaction. The **MA**gnetized **D**isc and **M**irror **A**xion e**X**periment is a dielectric haloscope experiment targeting axion dark matter in a mass range of 40 to 400 μeV. It consists of multiple, consecutive and movable dielectric discs to amplify the weak microwave signal of axion photon conversion in a strong magnetic field.

Without measuring an axion signal, the problem of calibrating the amplification of the microwave signal occurs. The Bead-pull method and the Gradient method will be presented and their results will be compared. The two methods can both be used to calibrate the setup.

The methods rely on the perturbation of the electric field and the measurement of the reflection. The Bead-pull method uses a bead to perturb the fields in the booster, allowing to probe them in three dimensions from the systems reflectivity. But this will not be possible in the final design of the MADMAX experiment. Instead, with the Gradient method the dielectric disks are moved to perturb the field. This yields less information of the electric field, but may be realized in the final setup.

T 26.6 Tue 17:30 VG 0.110

Development of a Cosmic Muon and Neutron Veto System for BabyIAXO — •Dhruv Chouhan[1], Elisa Ruiz Choliz[2], and Matthias Schott[1] for the IAXO-Collaboration — [1]Rhenish Friedrich Wilhelm University of Bonn, Germany — [2]Johannes Gutenberg University of Mainz, Germany

The International Axion Observatory (IAXO) experiment is a cutting-edge helioscope designed to search for axions and axion-like particles (ALPs) produced in the Sun. As a preliminary step, the BabyIAXO project has been proposed as a smaller-scale version of the helioscope, with the capability to achieve a sensitivity to the axion-photon coupling of $1.5 \cdot 10^{-11}$ GeV^{-1} for axion masses up to 0.25 eV. This region of parameter space is particularly intriguing for axion physics.

A key challenge of the experiment lies in the design of a cosmic muon and neutron veto system, which will ensure an ultra-low-background environment for the x-ray detection system. This talk highlights the simulation and hardware advancements in developing the BabyIAXO cosmic-ray veto system, which leverages light-guided organic plastic scintillators coupled with Silicon Photomultiplier (SiPM) sensors.

To further optimize the veto system, Geant4 simulation studies have been conducted to replicate the performance of scintillators integrated with embedded wavelength-shifting fibers, accurately modeling energy deposition by various interacting particles.

T 27: Silicon Detectors III (ATLAS + CMS production)

Time: Tuesday 16:15–18:15 Location: VG 0.111

T 27.1 Tue 16:15 VG 0.111

Production of Outer Barrel Pixel Detector Modules for the ATLAS ITk Pixel Detector – From Wafer Probing to Assembly — Yannick Dieter, Wolfgang Dietsche, Walter Honerbach, Fabian Hügging, Hans Krüger, •Maximilian Mucha, Matthias Schüssler, and Jochen Dingfelder — University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany

The High-Luminosity upgrade of the Large Hadron Collider (LHC) aims to enhance its performance by increasing luminosity by a factor of 5. This upgrade introduces unprecedented challenges for the ATLAS detector, driven by elevated hit rates and radiation levels far exceeding current operational conditions. To address these challenges, the ATLAS Inner Detector will be replaced with the new all-silicon Inner Tracking Detector (ITk).

The ITk production phase involves the assembly of approximately 10,000 hybrid pixel detector modules, each of which must meet strict quality requirements to ensure reliable performance. The process begins with functionality testing at wafer level, where roughly 700 wafers containing 131 readout chips each are characterized to ensure chip functionality. External vendors then hybridize the readout chips with silicon sensor dies to construct bare modules. Subsequently, these bare modules are assembled into fully operational ITkPix modules at dedicated institutes worldwide.

This talk provides an overview of the complete ITkPix module production chain, with a focus on wafer probing and assembly.

T 27.2 Tue 16:30 VG 0.111

Production of Outer Barrel pixel detector modules for the ATLAS ITk pixel detector - Quality control during electrical testing — Yannick Dieter, Jochen Dingfelder, Matthias Hamer, Florian Hinterkeuser, Fabian Hügging, Hans Krüger, Maximilian Mucha, •Matthias Schüssler, and Alexandra Wald — University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany

With the upgrade of the Large Hadron Collider (LHC) to the High-Luminosity LHC (HL-LHC), the instantaneous luminosity will increase by a factor of 5 with respect to its design value from 2029 onward. This results in unprecedented hit rates and radiation levels which require major upgrades of the detectors at the HL-LHC to meet these challenging requirements.

For the upgrade of the ATLAS detector, a new all-silicon inner tracking detector (ITk detector) consisting of silicon strip and pixel modules will be installed to replace the currently operated Inner Detector. In total, approximately 10.000 new pixel detector modules have to be built and carefully tested to ensure that only functional detector modules are installed. During the 2-year production of the ATLAS ITk pixel detector, approximately 1200 pixel detector modules will be built and tested at the Forschungs- und Technologiezentrum Detektorphysik (FTD) in Bonn. This large-scale production requires a dedicated quality control (QC) effort to assure the functionality of the final detector. This talk provides an overview of the electrical testing procedures for assembled modules that will be performed at the FTD in Bonn.

T 27.3 Tue 16:45 VG 0.111

Production and Quality Control of CMS Phase-2 Inner Tracker Pixel Modules — •Chin-Chia Kuo, Massimiliano Antonello, Erika Garutti, Bianca Raciti, Jörn Schwandt, and Georg Steinbrück — University of Hamburg, 22761, Luruper Chaussee 149, Hamburg, Germany

A quad module for the Phase-2 upgrade of the CMS Inner Tracker is a hybrid detector consisting of four (2 × 2) CMS readout chips manufactured in 65 nm CMOS technology (RD53B_CMS) and a silicon pixel sensor. The sensor with 100×25 μm^2 pixel size and 150 μm thickness is coupled to the chips via fine-pitch flip-chip bump bonding. Module production and quality control procedures are presented in this talk, including threshold tuning and data transmission tests of the readout chip, IV measurements for sensors, open bump bond identification, and thermal stress tests. In addition, the performance of pre-production modules is included in this presentation.

T 27.4 Tue 17:00 VG 0.111

From Kick-Off to Production - Aachen as an Assembly Center for the CMS Phase-2 Outer Tracker Upgrade — Max Beckers[1], Clara Ebisch[2], Lutz Feld[2], Nina Höflich[1], Katja Klein[2], Martin Lipinski[2], Daniel Louis[2], •Vanessa Oppenländer[2], Alexander Pauls[2], Oliver Pooth[1], Nicolas Röwert[2], Jan Terörde[2], Lennart Wilde[1], Michael Wlochal[2], and Wioletta Wyszkowska[1] — [1]3. Physikalisches Institut B, RWTH Aachen — [2]1. Physikalisches Institut B, RWTH Aachen

The new operating conditions of the future HL-LHC require a replacement of the complete silicon tracking system of the CMS experiment as part of the CMS Phase-2 Upgrade. For the Phase-2 Outer Tracker new so-called 2S modules have been developed that consist of two silicon sensors stacked on top of each other. By correlating the measured hits of both sensors, this module design enables the inclusion of tracking information in the Level-1 trigger at CMS for the first time. The production of 2S modules requires a careful and precise assembly. Within the CMS Collaboration the 2S module assembly is distributed over several institutes across the US, Europe and Asia. The RWTH Aachen University represents one of those assembly centers with a contribution of around 1000 2S modules. In the last two years the project went through several stages which include a so-called kick-off batch, a pre-series and is now ramping up from pre-production to production. In this talk important results from the different stages will be presented as well as the qualification steps that have been carried out showing that the Assembly Center in Aachen is well prepared for production.

T 27.5 Tue 17:15 VG 0.111

Glue dispensing and assembly of CMS 2S modules at RWTH Aachen — •Lennart Wilde[1], Max Beckers[1], Nina Höflich[1], Oliver Pooth[1], Wioletta Wyszkowska[1], Lutz Feld[2], Katja Klein[2], Clara Ebisch[2], Michael Wlochal[2], Daniel Louis[2], Vanessa Oppenländer[2], Nicolas Röwert[2], Martin Lipinski[2], and Alexander Pauls[2] — [1]III. Physikalisches Institut B, RWTH Aachen University, Aachen — [2]I. Physikalisches Institut B, RWTH Aachen University, Aachen

For the Phase 2 Upgrade of the Compact Muon Solenoid (CMS) experiment, a full reconstruction of the Outer Tracker is planned, involving novel silicon detector modules. These modules, referred to as 2S modules, utilize two silicon strip sensors to facilitate both tracking and Level-1 trigger functionalities. To minimize the material budget associated with these modules, all components will be bonded using adhesive methods.

Among the numerous 2S modules produced in module production centers worldwide, RWTH Aachen University has taken the task of assembling approx. 1,000 2S modules. This introduces significant challenges related to maintaining high-quality standards throughout the assembly process while achieving peak production rates of up to four modules per day.

This presentation will introduce a new custom made glue dispensing device that enhances existing volumetric dispensing technologies. The proposed device employs readily available components and demonstrates superior repeatability compared to previously utilized systems.

T 27.6 Tue 17:30 VG 0.111

ATLAS ITk Strips sensor cracking mitigation efforts — Jan-Hendrik Ahrling, Sergio Diez, •Konstantin Mauer, and Ingrid Gregor — Deutsches Elektronen-Synchrotron DESY, Hamburg

The upcoming High-Luminosity upgrade of the Large Hadron Collider (HL-LHC) will significantly increase its instantaneous luminosity. This will lead to a higher track density, a higher hit rate and thus an increased amount of radiation damage in the experiments. For this reason, the ATLAS experiment will be upgraded and a new all-silicon inner tracking (ITk) detector has been designed, consisting of strip and pixel detector modules.

The strip modules are glued onto local support structures. During the preproduction for the detector such fully loaded structures where thermal cycled below operational temperatures. A coefficient of thermal expansion (CTE) mismatch in the layers of a module in combination with the gluing method creates localized stress points at low temperatures. This results at fracturing of the sensor accompanied by an early sensor breakdown. To prevent the loss off several detector modules in certain cooling scenarios, a mitigation strategy was sought.

In this talk, alternative methods of loading modules onto the local support are presented which are reducing the amount of stress in the sensor. The measurements comparing these methods and their impact on sensor cracking are discussed.

T 27.7 Tue 17:45 VG 0.111

Module assembly for the ATLAS High Granularity timing detector — •Hendrik Smitmanns[1], Jessica Höfner[1], Annika Stein[1], Frederic Maximilian Matthias Silvan Fischer[1], Lucia Masetti[1], Theodorus Manoussos[1], Jan Ehrecke[1], Andrea Brogna[2], Atila Kurt[2], Fabian Piermaier[2], Antonin Zeman[2], Quirin Weitzel[2], and Steffen Schoenfelder[2] — [1]University Mainz, Insitut for Physics — [2]University Mainz, PRISMA+ Detector Lab

To meet the challenges of the High Luminosity Large Hadron Collider (HL-LHC), especially the increase of pile-up interactions, the ATLAS detector will need to be upgraded. One of the foreseen upgrades is the installation of the High-Granularity Timing Detector (HGTD). The HGTD will mitigate the effects of pile-up in the ATLAS forward region, providing a time resolution of about 30-50 ps per track. The active area consists of 2 double-sided disks per end-cap. Two 2x2 cm^2 Low Gain Avalanche Detectors (LGAD) bump-bonded to two ASICs and glued to a flexible PCB form the HGTD basic unit, the so-called module. Multiple modules are glued onto a support unit to form a detector unit, which will be built into the final detector at CERN. Pre-production started at the

beginning of 2025 and over the next two years around 1000 modules, 10% of the total detector, will be assembled at Johannes Gutenberg University Mainz, as one of the six production sites. The full module assembly procedure with focus on wire bonding, metrology and the initial testing of the assembled modules is presented.

T 27.8 Tue 18:00 VG 0.111

Development of the Production Database of the High-Granularity Timing Detector for the ATLAS Phase-II Upgrade — •Annika Stein[1], Luca Cadamuro[2], Jan Ehrecke[1], Frederic Fischer[1], Jessica Höfner[1], Muhammad Imran[3], Yun-Ju Lu[4], Lucia Masetti[1], Muhammad Atif Shad Rao[3], Hendrik Smitmanns[1], and Song-Ming Wang[4] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz — [2]IJCLab, Orsay Cedex — [3]Experimental Physics Dep., CERN — [4]Academia Sinica, Taipei

During the production of components for the new High-Granularity Timing Detector, to be installed during the ATLAS Phase-II upgrade, assembly and testing sites need to keep track of the individual parts. The properties and measurement results, along with the relations between parts, need to be documented and readily accessible at different sites. There are metrology data, electrical measurements and binary files like images of parts to be recorded and retrieved in an efficient manner. Besides the work that is required on the backend-side of the application, i.e. the database with its tables and views, a special focus is laid on the visualization of results with the frontend application. Web tools like Grafana querying the database information through API requests, and customized webpages aiding the users in selecting the correct parts based on predefined labeling schemes are used to enter new information and display existing data.

In this presentation, the current status of implemented components, their attributes and relations, as well as the graphical interface will be explained.

T 28: Silicon Detectors IV (SiPMs, HG timing)

Time: Tuesday 16:15–17:45 Location: VG 1.101

T 28.1 Tue 16:15 VG 1.101

Electrical and mechanical tests of Flexible Printed Circuit cables for the ATLAS High Granularity Timing Detector — •Frederic Fischer[1], Lucia Masetti[1], Hendrik Smitmanns[1], Jessica Höfner[1], Annika Stein[1], Jan Ehrecke[1], Theodoros Manoussos[1], Andrea Brogna[2], Atila Kurt[2], Fabian Piermaier[2], Steffen Schönfelder[2], Antonin Zeman[2], and Quirin Weitzel[2] — [1]Johannes Gutenberg-Universität Mainz, Institut für Physik — [2]Johannes Gutenberg-Universität Mainz, PRISMA+ Detector Lab

The High Granularity Timing Detector (HGTD) for the ATLAS upgrade is under construction to meet the challenges of the HL-LHC. The silicon detectors along with the electronics are installed in two double-sided disks per end-cap and consist of modules connected to the peripheral electronics by flexible printed circuit cables (flex tails), which serve as interconnections for power, communication signals and HV bias. Their final version has been designed and several prototypes have been produced with mechanical as well as electrical tests offering promising results so far. The results of the latest tests both in the lab and at a demonstrator with the full readout chain will be presented. Mechanical aspects towards integration in the final detector are also considered.

T 28.2 Tue 16:30 VG 1.101

Gluing proceedings for the module assembly and the DU loading for the ATLAS High-Granularity timing detector — •Jessica Höfner[1], Annika Stein[1], Frederic Fischer[1], Lucia Masetti[1], Hendrik Smitmanns[1], Steffen Schönfelder[2], Jan Ehrecke[1], Theodorus Manoussos[1], Andrea Brogna[2], Atila Kurt[2], Fabian Piermaier[2], Antonin Zeman[2], and Quirin Weitzel[2] — [1]University Mainz, Insitute for physics — [2]University Mainz, PRISMA+ Detector Lab

One of the challenges of the high luminosity upgrade for the LHC (HL-LHC) is the increase of pileup interactions. The way to address this challenge is to exploit the time spread of the interactions to distinguish between collisions occurring very close in space but well separated in time. For this the ATLAS detector needs to be upgraded. One of the updates will be the installation of the High-Granularity Timing Detector (HGTD). The device will provide a timing resolution of 30-50 ps for minimum ionizing particles and therefore will improve significantly the performance in the forward region of the detector. The active area consists of 2 double sided disks per end-cap filled with modules made of two 2x2 cm^2 Low Gain Avalanche detectors dump-bounded to two ASICs and glued to a flexible PCB. Several modules will be glued onto a support unit to form a detector unit. The Mainz ATLAS group contributes to the assembly of modules and their loading onto DU's. Therefore, the gluing procedure needs to be set up. The current setup for the gluing and the loading procedure itself will be presented in this talk.

T 28.3 Tue 16:45 VG 1.101

The ATLAS High Granularity Timing Detector: Test-Beam and Test-Bench Results — •Theodoros Manoussos[1,2], Xiao Yang[1], Giulia Di Gregorio[1], Stefano Manzoni[1], Dominik Dannheim[1], Stefan Guindon[1], and Lucia Masetti[2] — [1]CERN — [2]Johannes Gutenberg-Universität Mainz, Germany

The increase of the instantaneous luminosity at the HL-LHC will be a challenge for the ATLAS detector. The pile-up is expected to increase up to 200 interactions per bunch crossing, resulting in poorer performance of the currently used reconstruction algorithms, in particular in the forward region. To mitigate these effects, a High Granularity Timing Detector (HGTD) will be integrated in the end-cap regions of ATLAS, covering a pseudo-rapidity range of $2.4 < |\eta| < 4.0$. HGTD, which also serves as a luminosity monitor, aims for a single-track time resolution for MIPs of 30 ps at the beginning of the lifetime, up to 50 ps after a maximum fluence of $2.5 \times 10^{15}\ \frac{\text{neq}}{\text{cm}^2}$. The high-precision timing information improves the correct assignment of tracks to vertices. HGTD sensors are based on the novel Low Gain Avalanche Detector (LGAD) technology. They provide a moderate gain, resulting in fast rise time and large signal-to-noise ratio, required for excellent time resolution. Each sensor is a 15×15 array of 1.3×1.3 mm^2 LGAD pads. A dedicated read-out ASIC, ALTIROC, was developed. ASICs are bump-bonded to sensors forming hybrids. Sensors and hybrids have been extensively tested in test-beam campaigns and with radioactive sources. The recent test-beam and test-bench results for sensors and hybrids before and after irradiation are presented in this talk.

T 28.4 Tue 17:00 VG 1.101

Optimizing Silicon Photomultiplier Readout for Particle Physics Detectors — •Johannes Wenk — ALU Freiburg, Physikalisches Institut,79104 Freiburg (DE)

To optimize the performance of silicon photomultiplier (SiPM) detectors and their readout electronics, we have developed a robust, light-tight calibration and test setup providing a reproducible environment for precise SiPM measurements. This system features a pulsed laser with adjustable intensity to simulate a wide range of experimental light conditions, critical for evaluating the linearity and dynamic range of SiPMs. The setup also enables measurements of SiPM response at variable bias voltages, intrinsic noise characteristics through dark count analysis, and temperature stability during operation. Its modular design accommodates diverse SiPM geometries and configurations, facilitating systematic comparisons of different types and designs. By providing a controlled, versatile testing environment, this calibration setup supports the optimization of detectors for high-energy physics experiments such as AMBER and SHiP at CERN, where SiPM performance is critical for achieving precise measurements. * Gefördert durch das BMBF

T 28.5 Tue 17:15 VG 1.101

MIP detection on a plastic scintillator and SiPM system in very noisy environments — •Katjana Neumann, Massimiliano Antonello, Erika Garutti, and Jörn Schwandt — Universität Hamburg, Hamburg, Germany

A system consisting of a plastic scintillator tile directly couple to a SiPM is used to detect minimum ionizing particles (MIP) from a Sr90 source. The design of the single channel in inspired by the tiles for the CMS HGCAL calorimeter upgrade.

The signal to noise (S/N) separation provided by the system is well above 10 at the beginning of the detector lifetime. Radiation damage of the SiPM, as that experienced during the lifetime of the HGCAL detector, increase the dark current and degrade the S/N separation and by that the MIP detection efficiency.

We investigate the degradation as a function of the dark current increase. The increase of dark current after irradiation can be mitigated by cooling the SiPM or lowering its operation voltage. The systematic dependence of S/N separation on these parameters will be discussed in the presentation.

T 28.6 Tue 17:30 VG 1.101

Correction of Non-Linear Response of Silicon Photomultipliers — •Lukas Brinkmann, Massimiliano Antonello, Erika Garutti, and Jörn Schwandt — Universität Hamburg, Hamburg, Germany

The finite number of pixels in a silicon photomultiplier (SiPM) limits its dynamic range. The SiPM response deviates from linear by more than 5% already for signals comparable to 50-60% of the total number of pixels. Correcting the non-linear response is essential to extend the SiPMs dynamic range. One challenge in determining the non-linear response correction is providing a reference linear light source. Instead, the single-step method used to calibrate PMTs is applied, based on the difference in responses to two light sources. With this method, the response of various SiPMs with different pixel geometries was measured and corrected. The study shows that the response function does not depend on the operation voltage in the range $2 - 4$ V overvoltage and it is only mildly dependent on temperature over a range of 40 K. Linearity within 1% can be restored by applying a single correction function in a range of ±5 K and ±2 V around the original conditions of the measurement.

T 29: Detectors III (Scintillators)

Time: Tuesday 16:15–17:30 Location: VG 1.102

T 29.1 Tue 16:15 VG 1.102

Status of cosmogenic studies in the JUNO pre-detector OSIRIS — •Marcel Büchner[1,2], Arshak Jafar[1,2], George Parker[1,2], Michael Wurm[1,2], Oliver Pilarczyk[1,2], Tim Charisse[1,2], and Manuel Böhles[1,2] — [1]Johannes Gutenberg-University, Mainz, Germany — [2]EC PRISMA+

OSIRIS as the pre-detector of the JUNO reactor neutrino measurement, is meant to monitor the radio-purity of the scintillator used. The monitoring of the scintillators radio-purity relies on an in situ measurement of radioactive decays in the 20-ton scintillator volume. Therefore, the scintillator volume is surrounded by 500 tons of water for external shielding and all detector materials have been carefully selected for radiopurity. To ensure that the background is as low as possible, OSIRIS is located approximately 700m under ground. Even at that depth, a relevant level of background events originates from cosmic muons, which not only cause a signal themselves but they can interact with the detector material and cause the creation of radioactive isotopes. This talk presents the ongoing work of the implementation of a muon tracking for OSIRIS. Utilizing the charge information of 64 PMTs inside OSIRIS, an estimate of the muon path will be calculated. This estimate will later be used as an input of a chi-squared-minimazation, to further improve the accuracy of the muon tracking. Based on the tracking of these muons and using spatial and tem poral correlations, cosmogenic neutrons and radioactive isotopes (e.g. C-11) can be identified. This Project is funded by the DFG Research Unit FOR 5519.

T 29.2 Tue 16:30 VG 1.102

Large Area MMC-based Photon detector - LAMP — •Christian Ritter, Christian Enss, Andreas Fleishmann, Daniel Hengstler, Ashish Jadhav, Cagla Mahanoglu, Ioana-Alexandra Nitu, Andreas Reifenberger, Daniel Unger, and Loredana Gastaldo — Kirchhoff Institute for Physics, Heidelberg University

Using scintillating crystals coupled to temperature sensors and a photon sensor to detect the scintillation light emitted upon a particle interaction plays a very important role in experiments for rare event searches. Comparing the amplitude of the signal from the temperature sensor and the one of the photon sensor allows for discriminating light particles from heavy particles. We present the development and first characterization of a large area (metallic magnetic calorimeters) MMC-based photon detector (LAMP). This detector features an MMC sensor with stripline geometry fabricated onto a silicon substrate that is used as a photon absorber. The LAMP detector has been conceived to be used as a photon detector in the AMoRE experiment for the search of neutrinoless double beta decay in Mo-100 using calcium molybdate scintillating crystals. We discuss the achieved performance in relation to the requirement of the AMoRE experiment and the suitability of the LAMP detector design to be part of a combined photon and phonon detector sharing the same Si substrate.

T 29.3 Tue 16:45 VG 1.102

Construction and operation of a scintillation detector with full waveform analysis for spatial resolution enhancement. — •Erik Ehlert, Dmitry Eliseev, Markus Merschmeyer, Thomas Hebbeker, and Alexander Schmidt — III. Physikalisches Institut A, RWTH Aachen University

Increasing the resolution in large area scintillation detectors usually demands a higher number of readout channels. In order to study ways of increasing spatial resolution for fewer readout channels, a setup of two detectors, a reference and large scintillaton tile, was developed. In addition, to demonstrate the plausibility of the concept, a Geant4 simulation of the entire detector setup was performed.

The reference detector consists of two layers of arrays of scintillator strips coupled to pairs of silicon photomultipliers (SiPMs). This detector is used to provide reference measurements for the single scintillator tile. The tile is read out by only four SiPMs. The signals from the reference and tile detector are digitized by an FPGA-based setup developed in-house. With the information about the exact hit position and the full SiPM-waveform data, an analysis for enhancing the spatial resolution was set up.

The talk provides an overview of the entire detector setup, simulation, analysis, and will showcase the achieved enhancement in spatial resolution.

T 29.4 Tue 17:00 VG 1.102

Osiris DAQ and Single Event Analysis — •Arshak Jafar, Michael Wurm, Oliver Pilarczyk, Tim Charisse, Marcel Buchner, and George Parker — JGU Mainz, Institute of Physics and EC PRISMA+

The Jiangmen Underground Neutrino Observatory (JUNO), under construction in southern China, will determine the neutrino mass hierarchy (MH) by observing neutrinos from nuclear reactors at a distance of 53 km. To reach the desired sensitivity ($> 3\sigma$) for MH, the radiopurity of the different detector components plays a crucial role. To ensure the purity of the 20 kt liquid scintillator (LS) target of JUNO, the Online Scintillator Internal Radioactivity Investigation System (OSIRIS) is being constructed. The 20-ton pre-detector will monitor the radiopurity of the LS during its production and the filling phase of the central detector of JUNO. This talk will focus on the design principles and working of the data acquisition system (DAQ) of the OSIRIS pre-detector as well as the single event analysis of the data to estimate the rate of radioactive contaminants in the liquid scintillator.

This work is supported by DFG, Research Unit FOR 5519.

T 29.5 Tue 17:15 VG 1.102

Quenching Studies to Increase JUNO's Sensitivity to Proton Decay — •Ulrike Fahrendholz, Lothar Oberauer, Matthias Raphael Stock, Selina Rudolph, and Hans Steiger — TUM School of Natural Sciences, Physics Department, James-Franck-Str. 1, 85748 Garching

The hypothetical proton decay $p \to K^+ + \bar{\nu}$ generates a distinctive threefold coincidence signal in the Jiangmen Underground Neutrino Observatory (JUNO). JUNO features 20 kton of liquid scintillator, which requires precise characterization of its scintillation response to achieve the high sensitivity necessary for proton decay searches.

This talk presents the results of quenching studies on protons at kinetic energies of the order of 100 MeV. Additionally, measurements of ^{12}C will be discussed, offering insights also relevant for the interpretation of supernova neutrino events.

From the proton quenching, the light emission behavior of kaons is extrapolated. These results can be used to increase the event selection efficiency for $p \to K^+ \bar{\nu}$ in JUNO.

This work is supported by the Clusters of Excellence Origins and PRISMA$^+$ and the DFG Collaborative Research Center "NDM" (SFB1258).

T 30: Top Physics II (Properties)

Time: Tuesday 16:15–17:45 Location: VG 1.103

T 30.1 Tue 16:15 VG 1.103

Towards Top Quark Mass Measurements in the Fully Hadronic $t\bar{t}$ Decay Channel using the Full Run 2 Dataset — •Tom Davids, Johannes Lange, Peter Schleper, and Hartmut Stadie — Institute of Experimental Physics, University Hamburg, Germany

Precision measurements of the mass of the top quark are an important test of Standard Model predictions. In this talk, the current progress towards a top quark mass measurement in the fully hadronic top quark pair ($t\bar{t}$) decay channel is presented. The fully hadronic decay channel of $t\bar{t}$-pairs has the largest branching ratio of the three dominant decay channels and has no undetectable neutrino in its final state. However, it has a large multijet background. The aim of this analysis is to evaluate data taken by the CMS detector at the LHC during Run 2 at $\sqrt{s} = 13\,\text{TeV}$ from 2016 to 2018. This dataset corresponds to an integrated luminosity of $115.13\,\text{fb}^{-1}$ considering only data recorded with the selected triggers for this final state. This talk presents studies of these triggers and discusses the background prediction for the multijet background by making use of Columnflow, a highly parallelized Python-based analysis framework.

T 30.2 Tue 16:30 VG 1.103

Optimizing Jet-Parton Assignments in Fully Hadronic Top-Quark Decays: A Comparison of SPANet and Traditional Methods — •Nico Rehberg, Johannes Lange, Hartmut Stadie, and Peter Schleper — Institute of Experimental Physics, Hamburg University, Germany

Accurate jet-parton assignments in fully hadronic top-quark decays are crucial for the precise reconstruction of the top-quark mass. Traditional approaches, such as applying a kinematic fit, provide reliable results but are limited by the rapid increase in possible permutations as the number of jets grows. These methods become less efficient due to combinatorics in case of high jet multiplicities, and they do not make use of dynamical properties of tt processes. The Symmetry Preserving Attention Network (SPANet), a machine learning-based approach, addresses these challenges by exploiting the inherent symmetries of the assignment problem, resulting in improved scaling during inference. This talk provides a brief overview of the network's structure and presents a comparison of assignment results between SPANet and traditional approaches, including the χ^2-method and kinematic fit.

T 30.3 Tue 16:45 VG 1.103

Measurement of the top-quark mass using singly produced top-quarks in the t-channel — •Lukas Kretschmann, Dominic Hirschbühl, and Wolfgang Wagner — Bergische UniversitätWuppertal, Wuppertal, Germany

Almost all measurements of the top-quark mass have been performed using top-quark-antiquark pair-production events, measurements in other channels can be important inputs for a global combination. First studies for a measurement of the top-quark mass using t-channel single top-quark events are shown. This channel is statistically independent to the top-quark-antiquark pair-production measurements and has different systematic uncertainties associated to it, e.g. modelling uncertainties from Monte Carlo event generators. The high rate of background-events is a major challenge in this channel, for this a Graph Neural Network (GNN) is trained to enrich the selection in single top-quark t-channel events. For the determination of the top-quark mass the invariant mass of the charged lepton and the b-quark jet is used as a sensitive observable employing a maximum likelihood fit.

T 30.4 Tue 17:00 VG 1.103

Using improved $bb4\ell$ predictions for the simultaneous extraction of the top-quark mass and decay width — Diptaparna Biswas[1], Beatrice Cervato[1], Markus Cristinziani[1], Carmen Diez Pardos[1], Ivor Fleck[1], Arpan Ghosal[1], Gabriel Gomes[1], Jan Joachim Hahn[1], Vadim Kostyukhin[1], Nils Krengel[1], Buddhadeb Mondal[1], Stefanie Müller[1], Sebastian Rentschler[1], Elisabeth Schopf[1], •Katharina Voss[1], Wolfgang Walkowiak[1], Adam Warnerbring[1], and Tongbin Zhao[1,2] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Shandong University, China

The sensitivity of the simultaneous measurement of the top-quark mass and decay width using the full Run-2 $\sqrt{s} = 13$ TeV ATLAS dataset depends critically on the accurate modeling of the $WWbb$ final state in Monte Carlo simulations. In particular, a precise description of the $t\bar{t}/tW$ interference and of the off-shell effects of the top-quark is essential. These effects are modelled at next-to-leading-order accuracy by the $bb4\ell$ POWHEG generator. We present the nominal $bb4\ell$ signal sample used in ATLAS, which is generated with a new, improved $bb4\ell$ process version, as well as a prescription to evaluate modelling uncertainties associated with this sample.

Finally, the influence of the updated $bb4\ell$ signal sample on the top-quark mass and width analysis, which targets the $WWbb$ final state in dileptonic $e\mu$ decay, is discussed.

T 30.5 Tue 17:15 VG 1.103

Measurement of top quark CKM elements at FCC-ee — Sarah Alshamaily, Sofia Giappichini, Simon Keilbach, Jan Kieseler, Markus Klute, Matteo Presilla, and •Xunwu Zuo — KIT, Karlsruhe, Germany

The CKM matrix is a central piece for the understanding of electroweak physics. Particularly, the CKM element |Vts| is not directly measurable at tree level in current experiments in a precise manner. The current most precise value, indirectly determined via Bs meson mixing, is highly model-dependent and dominated by theory uncertainties. The FCC-ee experiment expects to produce 2M $t\bar{t}$ events with a very clean environment, providing an excellent opportunity to probe the |Vts| through $t \to Ws$ decay directly and in a model-independent way. This contribution summarizes the recent study on the |Vts| measurement at FCC-ee and discuss its theory impacts.

T 30.6 Tue 17:30 VG 1.103

Searching for CPT violation with top quarks — •Nathaniel Sherrill — Leibniz University Hannover

We present the first model-independent sensitivity to CPT violation in the top sector of the Standard Model. ATLAS and CMS measurements of the top-antitop kinematical mass difference constrain the temporal component of a CPT-violating background field to the interval [-0.13, 0.29] GeV at 95% confidence level.

T 31: Flavour physics II

Time: Tuesday 16:15–18:15 Location: VG 1.104

T 31.1 Tue 16:15 VG 1.104

Search for Quantum Disentanglement in the $B^0\overline{B}^0$ system at Belle II — •Max Kei Hattenbach, Hans-Günther Moser, and Sagar Hazra — Max-Planck-Institute for Physics, Munich, Germany

$B^0\overline{B}^0$ pairs produced at the $\Upsilon(4S)$ resonance are expected to be maximally entangled - an assumption crucial for measurements of time-dependent CP violation in experiments such as Belle, BaBar, and Belle II. If a fraction of these $B^0\overline{B}^0$ pairs becomes disentangled, regardless of the underlying mechanism, it could introduce systematic uncertainties into analyses, which are currently not accounted for. In this study, we search for possible disentanglement effects by analysing the hadronic decay mode $B^0 \to D^{(*)-}\pi^+$ using Belle II data. A signature of disentanglement would be observed as a damping and/or phase shift in the measured time-dependent asymmetry, compared to the behaviour under maximally entanglement. By examining decay time difference (Δt) of the two B mesons, we aim to test the sensitivity for time-dependent CP violation measurements using Monte Carlo studies.

T 31.2 Tue 16:30 VG 1.104

Study of Entanglement and Coherence at Belle II — •Simeon Hamurcu, Hans-Günther Moser, Sagar Hazra, and Maximilian Kei Hattenbach — MPI for Physics, Munich

Belle II is a next generation B-factory that aims to precisely measure Standard Model (SM) parameters and conduct searches for New Physics (NP) beyond the Standard Model. Electrons and positrons are asymmetrically collided at center of mass energies around the $\Upsilon(4S)$-resonance. This resonance mainly decays into a pair of B^0-mesons. In time dependent measurements it is assumed that these pairs are produced in a coherent and entangled state. This assumption however has not yet been tested at Belle II and tests at the predecessor experiment Belle still do not exclude a partial disentanglement. It is therefore necessary to conduct further studies to exclude or quantify disentanglement.

We implement models of disentanglement by adapting software from the B^0-lifetime and mixing frequency analysis. For that we compute and implement a new convolution to a resolution function of the Belle II detector and add additional disentanglement parameters to the software.

A validation is finally performed on signal Monte Carlo.

T 31.3 Tue 16:45 VG 1.104

$B_c \to \eta_c$ form factors at large recoil: Interplay of soft-quark and soft-gluon double logarithms — Guido Bell[1], Philipp Böer[2], Thorsten Feldmann[1], •Dennis Horstmann[1], and Vladyslav Shtabovenko[1] — [1]Theoretische Physik 1, Center for Particle Physics Siegen, Universität Siegen — [2]CERN, Theoretical Physics Department

Soft-Collinear Effective Theory is an important tool used for setting up factorisation theorems and achieving resummations to all orders in perturbation theory. While most conceptual problems appearing in calculations at leading power have been understood, at subleading power endpoint divergent convolution integrals appear in the factorisation theorems preventing the use of renormalization group equations for resummations. While this problem has been solved in a few collider processes, it persists in exclusive B-decays. We therefore resort to diagrammatic resummation techniques to derive the double-logarithmic series of the soft-overlap contribution to $B_c \to \eta_c$ transition form factors, assuming the scale hierarchy $m_b \gg m_c \gg \Lambda_{\rm QCD}$. We find that the leading double logarithms arise from a peculiar interplay of soft-quark endpoint logarithms from ladder diagrams with energy-ordered spectator-quark propagators, as well as standard Sudakov-type soft-gluon corrections. We elucidate the all-order systematics, and show that their resummation proceeds via a novel type of integral equations.

T 31.4 Tue 17:00 VG 1.104

Heavy-to-light form factors to three loops — Matteo Fael[1], Tobias Huber[2], Fabian Lange[3,4], •Jakob Müller[2], Kay Schönwald[3], and Matthias Steinhauser[5] — [1]Theoretical Physics Department, CERN — [2]Theoretische Physik 1, CPPS, Universität Siegen — [3]Physik-Institut, Universität Zürich — [4]Paul Scherrer Institut, Villingen — [5]Institut für Theoretische Teilchenphysik, Karlsruhe Institute of Technology

In this talk, we discuss the computation of form factors for decays of heavy into light quarks at third order in QCD for various currents. We describe the different steps of the calculation and use the results to compute the hard matching coefficients in Soft-Collinear Effective Theory for all currents. Further, we extract the hard function in $\bar{B} \to X_s\gamma$ to three loops using the tensor coefficients at light-like momentum transfer and study the impact of three-loop QCD corrections on partial decay rates in charged-current semi-leptonic $\bar{B} \to X_u l \bar{\nu}$ decays, where the newly computed corrections to the vector and axialvector coefficients constitute an essential ingredient to carry out this analysis.

T 31.5 Tue 17:15 VG 1.104

Modelling Quark-Hadron Duality Violation in Inclusive $B \to X_c \ell \bar{\nu}$ — •Ilija S. Milutin[1], Thomas Mannel[1], Rens Verkade[2,3], and K. Keri Vos[2,3] — [1]TP1, CPPS, University of Siegen, Germany — [2]GWFP, Maastricht University, The Netherlands — [3]NIKHEF, Amsterdam, The Netherlands

The Heavy Quark Expansion (HQE) is the main tool for calculating decay rates and kinematic moments of inclusive semi-leptonic B meson decays. The HQE

manifests as an Operator Product Expansion (OPE) in terms of powers of the inverse heavy bottom quark mass ($1/m_b$). Using the HQE, the CKM matrix element V_{cb} has been extracted at percent-level precision from moments of inclusive $B \to X_c \ell \bar{\nu}$ decays. The calculations upon which the theoretical estimates rely are done in terms of quarks and gluons, which are not accessible for experiments. Quark Hadron Duality (QHD) allows for a translation of theoretical predictions at the quark-level to experimental observables at the hadron-level. Since the increased accuracy in HQE predictions up to $O(1/m_b^5)$, violation of the QHD may start to become a relevant limit to the achievable precision. When QHD is violated, the OPE stops being a valid expansion. In my talk, I will show how we can derive a model for the Quark Hadron Duality Violation and how it can enter different kinematic moments of the $B \to X_c \ell \bar{\nu}$ decays.

T 31.6 Tue 17:30 VG 1.104

Measurement of kinematic moments of semileptonic B-meson decays with the Run 1 data set of Belle II — Florian Bernlochner, •Munira Khan, Markus Prim, and Slavomira Stefkova — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

The determination of the Cabibbo-Kobayashi-Maskawa matrix element $|V_{cb}|$ relies on $b \to c\ell^- nu_\ell$ transitions. The inclusive semileptonic process can be described with the Heavy Quark Expansion (HQE). Using the operator product expansion the total decay rate can be parameterized with a small number of non-perturbative parameters. These parameters cannot be determined from first principles, but their values are encoded into kinematic moments of the decay rate. We present the current status of measuring the full set of kinematic moments (q^2, M_X, E_ℓ) within a single analysis, which characterize the semileptonic $b \to c\ell^- nu_\ell$ and $b \to q\ell^- nu_\ell$ transitions using the Run 1 data of the Belle II experiment. This allows for the first time to properly correlate experimental uncertainties between the different moments. In addition, we present preliminary fits for $|V_{cb}|$ to simulated samples to illustrate the increase in sensitivity of this approach.

T 31.7 Tue 17:45 VG 1.104

Search for New Physics with $B^0 \to D^* \mu \nu$ angular analysis and LHCb — •Tobias Knospe[1], Johannes Albrecht[1], Biljana Mitreska[1], Hasret Nur[3], Lucia Grillo[3], Greg Ciezarek[4], Marco Gersabeck[5], Derek Yeung[2], and Manuel Schiller[3] — [1]TU Dortmund University, Dortmund, Germany — [2]The University of Manchester, Manchester, UK — [3]University of Glasgow, Glasgow, UK — [4]CERN, Geneva, Switzerland — [5]Albert-Ludwigs-Universitaet-Freiburg, Freiburg, Germany

Studying the angular structure of $b \to c\ell\nu$ using effiective field theory allows to probe potential New Physics (NP) effects. An angular analysis of the $B^0 \to D^* \mu \nu$ decay is presented, based on proton-proton collision data collected by the LHCb experiment, corresponding to an integrated luminosity of 3 fb^{-1}. The signal decays are extracted through a multidimensional fit to the data, using templated distributions derived from both simulation and control samples in the proton-proton collision data. The real and imaginary parts of NP Wilson coefficients are measured in single-coefficient scenarios and a combined multi-parameter fit. Additionally, hadronic form factors are measured in a Standard Model scenario using CLN, BGL and BLPR parameterizations.

T 31.8 Tue 18:00 VG 1.104

Joint measurement of the $b \to c\tau\nu$ Wilson Coefficients with LHCb and Belle II. — Johannes Albrecht[1], Florian Bernlochner[2], Biljana Mitreska[1], and •Marco Colonna[1] — [1]TU Dortmund University, Dortmund, Germany — [2]University of Bonn, Germany

Semileptonic $b \to c\ell\nu$ decays are excellent probe for testing Lepton Flavour Universality and New Physics (NP) effects. A combined measurement of NP Wilson coefficients is performed using of $B \to D^* \tau \nu$ decays in proton-proton collision data collected by LHCb and electron-positron collision data from Belle II. The signal is extracted using a multidimensional fit to data using templated distributions derived from simulation and from control samples. New Physics contributions are measured via their corresponding Wilson coefficients and in several fit configurations that allow for different New Physics operators.

T 32: Neutrino Astronomy II

Time: Tuesday 16:15–18:00 Location: VG 1.105

T 32.1 Tue 16:15 VG 1.105

Design and Production of the first P-ONE detector line — •Ben Nührenbörger for the P-ONE-Collaboration — Department of Physics, Technical University of Munich, Germany

Astrophysical neutrinos at the TeV scale would open a new observational window into currently obscured and inaccessible extreme environments. Detecting them poses significant challenges due to their low rate and weak interactions with matter. The Pacific Ocean Neutrino Experiment (P-ONE) addresses this problem by instrumenting a large volume of water at a depth of 2.6 km in the Northeast Pacific Ocean, piggybacking on a large oceanographic infrastructure maintained by Ocean Networks Canada. The ocean water will be used as a detection medium for the Cherenkov light emitted by the charged secondary particles produced by a neutrino interaction at TeV and above. This is done using an array of photomultiplier tubes encapsulated in glass hemispheres. A total of 20 hemispheres are mounted on a kilometer-high mooring line and read out by a newly designed data acquisition system that ensures sub-nanosecond timing, which is critical for correlating and reconstructing signals across the detector array. This talk will provide an overview of the design and integration of the first mooring line, focusing on the construction and operation of the optical modules, the measures taken to achieve precise timing, and the data acquisition processes.

T 32.2 Tue 16:30 VG 1.105

Status and results of the KM3NeT neutrino telescope — •Thomas Eberl for the KM3NET-ERLANGEN-Collaboration — Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg, Nikolaus-Fiebiger-Str. 2, 91058 Erlangen, Germany

KM3NeT is the next-generation underwater Cherenkov neutrino detector operational and under construction in the Mediterranean Sea at two different locations. The ORCA detector, close to Toulon, features a dense configuration of optical modules, optimised for the study of interactions of neutrinos with energies down to a few GeV. The same technology, albeit in a sparser configuration, is used for high-energy (TeV-PeV) neutrino astronomy with the ARCA neutrino telescope off the coast of Sicily. Both instruments are operational, take data since several years, and have been completed to more than 20% of their expected final volume. In this talk the construction plans and status will be reviewed and an overview of recent results on particle physics and neutrino astronomy will be given. The recent discovery of an extreme-energy neutrino will be discussed.

T 32.3 Tue 16:45 VG 1.105

Neutrino Event Generator Studies with NEUT — •Frederik Andersen, Thomas Eberl, and Rodrigo Gracia Ruiz for the KM3NET-ERLANGEN-Collaboration — Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg, Nikolaus-Fiebiger-Str. 2, 91058 Erlangen, Germany

The KM3NeT/ORCA neutrino telescope is currently under construction in the Mediterranean Sea. It is optimized to detect atmospheric neutrinos with energies up to 100 GeV. To this end a three dimensional grid of photomultiplier tubes detects Cherenkov radiation induced by particles that result from neutrino interactions with seawater. The data recorded by the experiment is analysed by comparing to detailed Monte-Carlo simulations which implement state-of-the-art knowledge on secondary particle production and detection processes. As a first step, so-called neutrino event generator codes employ different approximations to simulate the distribution of final-state particles produced in neutrino interactions. Differences in neutrino generators can introduce biases in the interpretation of the experimental data, and lead to tensions in measurements performed by different experiments. In this talk we will present our strategy to study how using different neutrino event generators impacts KM3NeT/ORCA's scientific results. We implement an alternative simulation pipeline using NEUT, the neutrino event generator developed by Super-Kamiokande, and compare its results to the default KM3NeT pipeline employing GENIE as event generator.

T 32.4 Tue 17:00 VG 1.105

Prospects for a combined measurement of the galactic neutrino flux with KM3NeT and IceCube — •Anke Mosbrugger and Oliver Janik — Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg

Observing the Galactic Plane with muon neutrinos relies on precise muon track reconstruction for accurate pointing and high detection efficiency. To suppress the dominant background from atmospheric muons, the Earth itself is used as a natural filter. This effectively yields a pure neutrino data set on the Hemisphere below the local horizon. Hence, combining data from a neutrino telescope in the Southern Hemisphere (IceCube) and the Northern Hemisphere (KM3NeT) increases the sensitivity to the astrophysical neutrino flux, especially for observations of the Galactic plane. The diffuse astrophysical neutrino flux is analyzed using a binned forward-folding likelihood approach. All statistical modeling in this work is handled by the framework NNMFit. This talk will outline the imple-

mentation of KM3NeT data in this framework and the prospects of combining data of the KM3NeT and IceCube neutrino telescopes for a measurement of the galactic neutrino flux.

T 32.5 Tue 17:15 VG 1.105

The Galactic Diffuse Neutrino Emission in a combined fit of Muon Tracks and Cascades with IceCube* — •Jonas Hellrung[1,2], Niclas Krieger[1,2], and Julia Tjus[1,2,3] for the IceCube-Collaboration — [1]Theoretical Physics IV, Plasma Astroparticle Physics, Faculty for Physics and Astronomy, Ruhr University Bochum, 44780 Bochum, Germany — [2]Ruhr Astroparticle and Plasma Physics Center (RAPP Center), Germany — [3]Department of Space, Earth and Environment, Chalmers University of Technology, 412 96 Gothenburg, Sweden

Although cosmic rays (CRs) were discovered more than a hundred years ago, their origin is not yet understood. One problem is that the cosmic-ray spectrum can only be measured close to Earth. However, there is a way to indirectly study the distribution of CRs in the Galaxy: When CRs interact with the interstellar medium, they produce gamma rays and neutrinos. The first observation of this neutrino flux was published in 2023 by IceCube. Here I present plans for a new analysis combining different event topologies. IceCube measures events in two main topologies: Tracks, originating in charged current ν_μ interactions, provide a better angular resolution. In contrast cascades, from most other possible interactions, provide a better energy resolution and are able to observe the Southern sky (and therefore the Galactic Center) despite the huge background of atmospheric muons. Combining both event topologies in one analysis exploits all these advantages. Sensitivities and model discrimination power of such a measurement are discussed here. *Supported by BMBF and SFB 1491

T 32.6 Tue 17:30 VG 1.105

Unfolding the Electron Neutrino Diffuse Spectrum — •Lene van Rootselaar, Lucas Witthaus, and Pascal Gutjahr for the IceCube-Collaboration — Technische Universität Dortmund

The IceCube Neutrino Observatory, located at the geographic South Pole, is a cubic-kilometre detector designed to identify neutrinos across a wide energy range. It distinguishes between two main types of neutrino signatures: track events, caused by muons traversing the detector, and cascade events, primarily produced by Charged-Current (CC) interactions of electron neutrinos and Neutral-Current (NC) interactions of all neutrino flavours. By analysing cascade events, it becomes possible to assess a diffuse electron neutrino spectrum, provided the background from Neutral-Current tau and muon neutrino interactions is properly accounted for.

Current progress on the production of this electron neutrino spectrum will be presented. The method used for this analysis is unfolding. The analysis is based on a Monte Carlo cascade sample. Preliminary flux results will be shown and compared to theoretical models, alongside an overview of the preparatory steps leading to this approach.

T 32.7 Tue 17:45 VG 1.105

Sensitivity of IceCube Upgrade to neutrinos from the Galactic Plane — •Berit Schlüter and Alexander Kappes for the IceCube-Collaboration — Universität Münster, Institut für Kernphysik

As part of the IceCube Upgrade, the IceCube neutrino observatory will be instrumented with seven additional strings during the Antarctic summer of 2025/26 to improve sensitivity in the low-energy range from 10 GeV to 1 GeV and to achieve a significant improvement in the detector's calibration. New optical modules and calibration devices have been developed for this purpose. To evaluate the impact of the IceCube Upgrade on low-energy sensitivity, analyses are being performed on two IceCube data sets and one MC data set for the IceCube Upgrade, focusing on neutrinos from the Galactic plane. In this talk, the procedure for this analysis will be presented, and preliminary results will be shown.

T 33: Data, AI, Computing, Electronics III (ML in Jet Tagging, Misc.)

Time: Tuesday 16:15–17:45 Location: VG 2.101

T 33.1 Tue 16:15 VG 2.101

Representation Learning — •Niklas Meier — TUM, Munich, Germany

Large neutrino telescopes, such as IceCube or KM3NeT, are experiments that try to measure incident neutrinos in order to learn about their properties and origins. For the detection, these experiments employ large volumes of transparent media, along with photo-sensors, to measure the light produced by secondary processes of neutrino events.

In the pursuit of analyzing data from these large neutrino telescopes, one often runs into the problem of a high memory footprint, due to the length of representations of neutrino events. Approaches that try to circumvent this issue, e.g. by subsampling, were in the past shown to perform poorly on these long representations. Hence it is worth putting in the effort to develop a method to generate low memory representations of neutrino events.

The approach, that is presented here, regards each event as a graph, where each node corresponds to a detector response, and aims to learn assignments that map the graphs to ones with fewer nodes. Such an encoding network can be trained, e.g. in the context of an autoencoder, where a similar second network decodes back to the original graph size. Alternatively, in so called contrastive methods, the encoding network is applied twice, but with different augmentations to the data, and the learned representations are compared. In this presentation, I will show the principles of dense pooling methods in encoding networks and their performance in both frameworks.

T 33.2 Tue 16:30 VG 2.101

Aspen Open Jets: Unlocking LHC Data for Foundation Models in Particle Physics — Oz Amram[1], Luca Anzalone[2], •Joschka Birk[3], Darius A. Faroughy[4], Anna Hallin[3], Gregor Kasieczka[3], Michael Krämer[5], Ian Pang[4], Humberto Reyes-Gonzalez[5], and David Shih[4] — [1]Fermi National Accelerator Laboratory — [2]University of Bologna — [3]University of Hamburg — [4]Rutgers University — [5]RWTH Aachen University

A foundation model is a type of deep learning model that is pre-trained on a large dataset, enabling it to serve as a versatile base for being fine-tuned to various downstream tasks or other datasets. This study illustrates the utility of data gathered from the CMS experiment at the Large Hadron Collider in pre-training foundation models for High Energy Physics (HEP). We present the AspenOpenJets dataset, which comprises approximately 180 million high-p_T jets extracted from the CMS 2016 Open Data. Our findings include new studies conducted with the OmniJet-α foundation model, highlighting how pre-training on AspenOpenJets enhances performance on generative tasks that involve significant domain shifts, such as generating boosted top and QCD jets from the simulated JetClass dataset. Beyond showcasing the effectiveness of pre-training a jet-based foundation model using actual proton-proton collision data, we also offer the ML-ready AspenOpenJets dataset for public access and further research.

T 33.3 Tue 16:45 VG 2.101

LHCb's neural network-based beauty trigger: Insights from Run 3 — •Nicole Schulte[1], Johannes Albrecht[1], Gregory Max Ciezarek[2], Blaise Delaney[3], and Niklas Nolte[4] — [1]TU Dortmund University, Dortmund, Germany — [2]CERN, Geneva, Switzerland — [3]Massachusetts Institute of Technology, Cambridge, USA — [4]META AI (FAIR)

The quality of the LHCb beauty physics programme relies upon b-hadron selection algorithms, particularly topological b-hadron triggers. These triggers are optimized to identify b-hadron candidates by exploiting the distinctive decay topologies of b-hadrons and their characteristic kinematic properties. As the dominant contributor to the trigger selection bandwidth, topological triggers are essential for enabling a wide range of physics analyses at LHCb.

In Run 3, LHCb introduced a novel inclusive beauty trigger which incorporates Lipschitz monotonic neural networks to enhance robustness against fluctuating detector conditions and improve sensitivity to long-lived particle candidates.

This contribution presents the performance of the inclusive topological beauty trigger across diverse conditions during the 2024 data-taking period. We demonstrate the effectiveness of these topological triggers in maintaining stable performance under varying conditions and discuss the selection efficiency using well-understood decay modes. Additionally, we examine the advantages provided by the monotonicity constraints in the trigger design.

T 33.4 Tue 17:00 VG 2.101

Domain adaptation in the context of flavour tagging at the LHCb experiment — Johannes Albrecht[1,2], Mirko Bunse[2], and •Quentin Führing[1,2] — [1]TU Dortmund University, Dortmund, Germany — [2]Lamarr Institute for Machine Learning and Artificial Intelligence, Dortmund, Germany

Decay-time-dependent measurements of oscillating neutral B mesons at LHCb require information of the B-meson flavour at the time of its production. This information cannot be inferred from the decay products used for the reconstruction of signal candidates. Instead, multivariate algorithms are used to estimate the production flavour of B mesons, which exploit a variety of particles produced in association with the signal in the proton-proton interaction.

Simulation is often used to provide a labelled data sample for the training of these algorithms. However, known differences between simulation and recorded data are present, particularly in quantities significantly impacting the flavour tagging performance, such as the track multiplicity in fragmentation processes. As

a consequence, the algorithms do not reach the same level of performance in data as in simulation.

We approach this mismatch between data and simulation with machine-learning techniques from the realm of domain adaptation. These methods prevent the multivariate algorithms from learning an implicit and undesired distinction between data and simulations. As a result, we expect improved performance on data. In this presentation, the idea and the status of the ongoing project is presented.

T 33.5 Tue 17:15 VG 2.101

Adversarial Studies on Jet-Flavor Tagging Machine Learning Algorithms using PAIReD Jets within the CMS Experiment — Alexander Jung[1], Spandan Mondal[2], Alexander Schmidt[1], Jan Schulz[1], and •Ulrich Willemsen[1] — [1]III. Physikalisches Institut A, RWTH Aachen — [2]Brown University

The PAIReD tagger is a novel jet flavor tagging algorithm in CMS that employs unconventional large-radius jets to identify Higgs boson decays to pairs of heavy-flavor quarks. In this talk, the vulnerability of machine learning-based jet flavor taggers to adversarial attacks is investigated, with a focus on the ParticleTransformer architecture used in the PAIReD tagger. It is shown that this architecture is more susceptible to adversarial perturbations than other established models. To mitigate this vulnerability, adversarial training is applied, incorporating adversarial examples into the training process. It is demonstrated that adversarial training enhances the robustness of the PAIReD tagger, recovering almost the nominal performance on both undisturbed and attacked inputs. These findings provide valuable insights into the behavior of the PAIReD tagger and the ParticleTransformer architecture for future applications in the CMS experiment.

T 33.6 Tue 17:30 VG 2.101

Gravity Gradient Noise Mitigation using Deep Learning at the Einstein Telescope — Markus Bachlechner[1], David Bertram[1], Johannes Erdmann[2], •Jan Kelleter[2], Patrick Schillings[2], and Achim Stahl[1] — [1]III. Physikalisches Institut B, RWTH Aachen — [2]III. Physikalisches Institut A, RWTH Aachen

The Einstein Telescope is a proposed gravitational wave detector of the third generation. It aims to improve sensitivity by at least an order of magnitude compared to current detectors. The dominant noise source in the region of 1 to 10 Hz is expected to be gravity gradient noise (GGN) from seismic activity in the surrounding rock. In order to reach the desired sensitivity, GGN must be actively mitigated. Seismometers will be installed in boreholes around the mirrors to measure the seismic activity. The current gold standard to predict the mirror response from seismometer measurements is the application of linear filters. In this talk, we present an approach to using neural networks in order to predict the mirror response to GGN from simulated seismometer measurements.

T 34: Data, AI, Computing, Electronics IV (DAQ, Detector Electronics)

Time: Tuesday 16:15–18:15 Location: VG 2.102

T 34.1 Tue 16:15 VG 2.102

FPGA-Based Solution Beyond High-Speed ADCs for Particle Detectors — •Dmitry Eliseev, Erik Ehlert, Carsten Presser, Markus Merschmeyer, Alexander Schmidt, and Thomas Hebbeker — III. Physikalisches Institut A, RWTH Aachen University

Modern particle detector electronics often handle a big number of channels. Field Programmable Gate Arrays (FPGAs) often serve as the core engine of multi-channel acquisition systems. However, the standard approach for acquiring energy or amplitude information for specific events often relies on high-speed multi-channel ADCs. Using such ADCs can increase complexity and raise the cost of signal acquisition electronics. The Multi-Voltage-Thresholding (MVT) method utilizes the internal digital comparators of FPGAs, partially replacing the functionality of ADCs with FPGA-internal resources. This approach enables a fast multi-channel acquisition, which is solely FPGA-based. By eliminating the need for external high-speed multi-channel ADCs, the resulting schematics are simplified, and the cost of the detector electronics is reduced.

This talk explains the MVT methodology and demonstrates its practical application using a 16x16 pixel muon detector with 64 Silicon Photo-Multipliers (SiPMs). The developed system is based on commercially available modules with System-on-Chip (Zynq MPSoC). With compact additional circuitry and developed soft- and firmware, the system features up to 16 high-speed ADC channels, each sampling at 1 GSPS and delivering the sampled data directly to module's RAM.

T 34.2 Tue 16:30 VG 2.102

The ATLAS Tile Calorimeter Trigger and Data Acquisition Interface — •Thomas Junkermann and Tigran Mkrtchyan — Kirchhoff-Institut für Physik Heidelberg

The Phase-II Upgrade of the ATLAS Tile Calorimeter (TileCal) is a replacement of the entire on- and off-detector electronics to cope with the higher amount of simultaneous proton-proton collisions of future LHC runs. New back-end electronics are designed to provide high-bandwidth data to the new Phase-II Trigger and Data Acquisition (TDAQ) system. The Tile Calorimeter Trigger and Data Acquisition Interface (TDAQi) is an ATCA rear transition module and as part of the new TileCal PreProcessor serves as the connection between the off-detector calorimeter electronics and the TDAQ system of ATLAS. After the calorimeter cell signals are received and energies reconstructed by the Compact Processor Modules, the TDAQi prepares the data for further use. Cell energies are converted to transverse energy, cells are sorted or added to larger sums for the trigger and various threshold comparisons for muon candidate identification are provided. Additionally, the TDAQi forwards these intermediate results to the DAQ system for monitoring. The TDAQi as part of the ATLAS Phase-II upgrade will be presented. Together with latest hardware validation and integration tests, the general TDAQi status is featured.

T 34.3 Tue 16:45 VG 2.102

Towards Data Transfer and Monitoring Interfaces for the future Signal Processor of the ATLAS Liquid Argon Calorimeters — •Markus Helbig, Rainer Hentges, Arno Straessner, Johann Christoph Voigt, and Philipp Welle — Institut für Kern- und Teilchenphysik, TU Dresden

During the Phase-II Upgrade of the ATLAS Liquid Argon Calorimeter System, the new LAr Signal Processor (LASP) system will be installed. With the HL-LHC starting operation in 2030, this off-detector processing system will enable the use of novel, more powerful algorithms for energy reconstruction implemented on Intel Agilex 7 FPGAs.

Beside the main readout path, the LASP will provide fine granular and presummed energies and energy threshold values to two new ATLAS trigger systems – the Global Event Processor (GEP) and the Forward Feature Extractor (fFEX). For both interfaces, the preferred protocol candidate is the Interlaken-based *core1990*, operating at a speed of 25.78125 Gbps. Its functionality and properties are currently being verified on the Agilex 7 FPGA.

Additionally, the LASP firmware will also contain several registers for control and monitoring purposes. The implementation is based on the *IPbus* protocol embedded in a custom framework. The physical connections are realized using a Gigabit Ethernet interface.

The presentation will summarize the challenges, recent progress and results of the LASP interface projects.

T 34.4 Tue 17:00 VG 2.102

Firmware development for temperature monitoring of electro-optical transceivers for the ATLAS Liquid Argon Signal Processor system — •Peter Maximilian Fischer, Markus Helbig, Rainer Hentges, and Arno Straessner — Institut für Kern- und Teilchenphysik, TU Dresden

As part of the Phase-II upgrade of the ATLAS detector, its Liquid Argon (LAr) calorimeters will be equipped with a new Signal Processor (LASP) system following the high luminosity upgrades to the LHC. The data transfer coming from the Front End Board (FEB2) to the LASP and going from the LASP to the ATLAS trigger system will be handled by electro-optical transceivers of type SAMTEC Firefly, which will have to be monitored with regards to their temperature by an FPGA. For this purpose, an I^2C master has been interfaced in VHDL. A simulation in QuestaSim as well as hardware testing with a Stratix-10 FPGA on a Firefly test card and a LASP testboard were performed in order to verify the desired behaviour, with a test on an Agilex-7 based LASP testboard pending. The results and conclusions from these tests will be presented, as well as an outlook towards the implementation of a Serial Peripheral Interface (SPI) for the communication between the Agilex-7 and MAX-10 FPGAs.

T 34.5 Tue 17:15 VG 2.102

DAQ software for QC-tests of ATLAS ITk-Pixel loaded local supports — Jörn Grosse-Knetter, •Paolo Malatesta, Arnulf Quadt, and Ali Skaf — II. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

The increase of luminosity at the ATLAS Large Hadron Collider (LHC), previewed in the phase 2 upgrade, will require an update of the ATLAS inner detector. A new all-silicon Inner Tracker (ITk) will be deployed resulting in an increased data rate. The 5 billion pixels comprise over 9,000 Quad Modules (QMs), which are managed by the DAQ system via FELIX hardware/software. In the ITk outer barrel, QMs send 1.28 Gb/s electrical signals to the Optoboard for conversion to optical signals, which are then transmitted off-detector to FELIX PCs and the DAQ software. The reverse path is used for QM Front-End (FE) configuration and control. To validate the DAQ system's readiness for the upgrade, a lab setup reproducing the FELIX/optoboard readout chain was tested with prepro-

duction QMs using serial powering. Simultaneous readout enabled analysis of system behaviour under load, identifying key parameters for signal quality and reliability. DAQ performance, including configuration time, was measured as a function of enabled FEs, providing insights crucial for scaling the DAQ chain to large systems like the local supports loaded with few 10 modules and the full ITk-pixel DAQ.

T 34.6 Tue 17:30 VG 2.102

ATLAS ITk-Pixel read-out stress tests — •Matthias Drescher, Jörn Grosse-Knetter, Arnulf Quadt, and Ali Skaf — II. Physikalisches Institut, Georg-August-Universität Göttingen

The current ATLAS Inner Detector will be upgraded to an all-silicon Inner Tracker (ITk) for the Phase 2 upgrade of the experiment. The ATLAS ITk read-out system is based on the FELIX hardware/software used to interface the on-detector components from the higher-level DAQ infrastructure. One FELIX card has 24 optical fibre links, which are fanned out to multiple Pixel modules by the lpGBT aggregator chip. To ensure stable operation under full load before moving to the final large-scale readout system, a stress test is being prepared populating all 24 FELIX fibres.

The data generation for the stress test takes place on several AMD FPGA boards, each containing multiple instances of lpGBT and front-end chip emulators. For this project, multiple front-end emulator flavours are developed to generate data streams according to the ITkPix production chip or the RD53A prototype chip data format. The front-end emulators use a hybrid design, where the test data is partially encoded off-FPGA and then stored in the FPGA's memory, to be fully encoded by the FPGA logic. As such, the project consists of both the FPGA design and the external software written in Python, which prepares the test data and automates the tests. Tests have been performed with both types of emulator flavours.

T 34.7 Tue 17:45 VG 2.102

Integration of SiPM-on-Tile Detectors with the Serenity Phase-2 DAQ Hardware for the CMS High Granularity Calorimeter — •Fabian Hummer[1], Luis Ardila-Perez[1], Matthias Balzer[1], Marvin Fuchs[1], Olivier Jacquemoth[1], Matthias Komm[2], Hendrik Krause[1], Katja Krüger[2], Jia-Hao Li[2], Torben Mehner[1], Mathias Reinecke[2], Frank Simon[1], Felix Sefkow[2], and Raghunandan Shukla[3] — [1]Institute for Data Processing and Electronics, Karlsruhe Institute of Technology, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany — [3]Department of Physics, Imperial College London, Exhibition Road, London, SW7 2BW, United Kingdom

For the upcoming high-luminosity LHC, the endcap calorimeters of the CMS experiment will be replaced by the high-granularity calorimeter (HGCAL), a sampling calorimeter using both silicon and scintillator as active materials in different regions depending on the radiation dose. This contribution describes the integration details of the scintillator-based front-end into the DAQ readout chain of HGCAL utilizing a Serenity FPGA card. Initial results from a beam test at CERN showcase stable operation of the SiPM-on-tile front-end in a 3 T magnetic field, synchronization of multiple tile modules, as well as a good understanding of the relation between trigger and DAQ data with properly calibrated modules.

T 34.8 Tue 18:00 VG 2.102

Development of a standalone drift-tube-based muon trigger for the ATLAS and CRESST experiments — D Cieri, •S Eder, O Kortner, S Kortner, A Langenkämper, M Mancuso, and F Petricca — Max Planck Institut für Physik, Garching, Germany

To operate the ATLAS experiment in the high-rate environment of the High-Luminosity Large Hadron Collider (HL-LHC), significantly improved selectivity of the first-level muon trigger is required. To achieve this, novel FPGA-based Monitored Drift Tube (MDT) trigger processor boards have been developed. These boards incorporate muon tracking information from precision MDT chambers into the first-level trigger processing chain for the first time. The new MDT chamber read-out and trigger processors must be commissioned using cosmic ray muons, necessitating the development of a dedicated muon track-finding algorithm that utilizes only information from drift-tube detectors.

This algorithm could potentially also be used to build a muon veto trigger for the CRESST experiment at Gran Sasso. The proposed experimental setup involves placing several spare MDT chambers from the ATLAS experiment around the cryogenic crystals of the CRESST detector. Events with cosmic muon tracks can then be vetoed if the signal in the crystals matches the signal from the MDT chambers, significantly reducing the experiment's output bandwidth.

In this talk, a dedicated standalone drift-tube-based muon trigger algorithm will be presented, along with its implementation in the FPGA firmware.

T 35: Electroweak Physics I (Weak Mixing Angle, Tau Production)

Time: Tuesday 16:15–17:45 Location: VG 2.103

T 35.1 Tue 16:15 VG 2.103

How to Extract the Weak Mixing Angle using Full Run2 ATLAS Experiment Data — •Lukas Bayer[1], Wells Craig[2], and Ludovica Aperio Bella[3] — [1]DESY, Hamburg, Germany — [2]DESY, Hamburg, Germany — [3]DESY, Hamburg, Germany

The full Run 2 data set from the ATLAS experiment provides sufficient statistics to measure the Drell-Yan cross-section four-fold differential in invariant mass, Z-boson rapidity and decay angles. It can be determined in the full solid angle by making use of an analytical decomposition of the final-state lepton's angular distribution. This does not only allow to probe the underlying quantum chromodynamics of Z-boson production, but also to extract the electroweak sector weak mixing angle from the forward-backward asymmetry, induced by parity violation in the neutral weak current. Sensitivity to the forward-background asymmetry is enhanced in events featuring one lepton in the forward part of the detector and correspondingly high Z-boson rapidity. Therefore, this talk will showcase recent work on forward electron performance at ATLAS, with focus on the determination of identification efficiency. Furthermore, it will present projections of the resulting sensitivity to the weak mixing angle.

T 35.2 Tue 16:30 VG 2.103

The weak mixing angle at the Belle II experiment — •Lukas Grussbach[1,2], Stephan Paul[1], and Daniel Greenwald[1] — [1]Technical University Munich — [2]Max Planck Institute for Physics

The weak mixing angle is known precisely only at high energies around the Z^0 mass. At much lower energies, NuTeV measured a value deviating from the standard-model prediction. At Belle II, we want to measure the weak mixing angle at a similar energy using the process $e^+e^- \to \mu^+\mu^-$.
I present concepts of such a measurement at Belle II.
*Funded by the DFG under Germany's Excellence Strategy - EXC2094 - 390783311 and BMBF Verbundforschung (05H21WOKBA BELLE2).

T 35.3 Tue 16:45 VG 2.103

Determination of the tau polarization in fully leptonic $Z \to \tau^+\tau^-$ decays from pp collisions at the ATLAS detector — •Florian Harz, Adrián Álvarez Fernández, and Stefan Tapprogge — Institut für Physik, Johannes Gutenberg-Universität, Mainz, Germany

The Z boson arises from the unification of the electromagnetism and weak forces, coupling differently to left- and right-handed particles as indicated by the effective weak mixing angle. Precisely measuring the tau polarization in $Z \to \tau^+\tau^-$ decays provides a mean to extract the weak mixing angle. The study considers the fully leptonic final state of the $Z \to \tau^+\tau^-$ decay channel and assesses its sensitivity to the tau polarization. This is accomplished by fitting templates to the visible mass derived from decays of purely left-handed or right-handed taus. This method can be verified using simulated samples. The status of these studies is presented, highlighting their potential application to real data, particularly focusing on proton-proton data collected at the ATLAS detector.

T 35.4 Tue 17:00 VG 2.103

Prospects of measuring quantum entanglement in $\tau\tau$ final states at the LHC and future colliders — •Cedric Breuning, Philip Bechtle, Klaus Desch, and Christian Grefe — Physikalisches Institut, Rheinische Friedrich-Wilhelms Universität Bonn, Nussallee 12, 53115 Bonn, Germany

We introduce a method to test quantum entanglement at colliders in the $\tau\tau$ final state. The prospects to perform these measurements in e^+e^- collisions at future colliders like the FCC-ee are evaluated using simulated events with a fast detector simulation. We will present two dedicated analyses using either $Z \to \tau\tau$ or $H \to \tau\tau$ at e^+e^- at centre of mass energies of $\sqrt{s} = 91.2$ GeV and $\sqrt{s} = 240$ GeV, respectively. Prospects and limitations of doing similar measurements at the LHC will be shown. Finally, we will discuss loopholes and collider specific problematics, which influence the interpretation of the result.

T 35.5 Tue 17:15 VG 2.103

Theoretical predictions for tau-pair production in ultraperipheral hadron collisions — Stefan Dittmaier, Tim Engel, •Jose Luis Hernando Ariza, and Mathieu Pellen — University of Freiburg

The anomalous magnetic moments of the electron and the muon have been measured with remarkable precision. On the other hand, there is no precise measurement for the magnetic moment of the tau-lepton. A promising approach is to measure it via the tau-pair production in ultraperipheral collisions of lead ions at the LHC. In this talk, I will present state-of-the-art theoretical predictions for photonic tau-pair production including leptonic tau-decays. In particular, the impact of spin correlations between the tau-leptons and next-to-leading-order electroweak corrections will be discussed.

T 35.6 Tue 17:30 VG 2.103

Differential measurements of $\gamma\gamma \to \tau\tau$ and constraints on τ-lepton electromagnetic moments in ultra-peripheral Pb+Pb collisions with ATLAS — •Weronika Stanek-Maslouska — Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

At the Large Hadron Collider (LHC), relativistic heavy-ion collisions produce a significant flux of equivalent photons, enabling photon-induced interactions. By studying the production of tau lepton pairs in these processes, constraints can be placed on the anomalous magnetic dipole moment (g-2) and electric dipole moment (EDM) of the tau lepton. Building on the observation of this process with ATLAS, which analyzed muonic decays of tau leptons in conjunction with electrons and particle tracks, we perform first unfolded differential cross section measurements. Additionally, new measurements of the tau lepton electromagnetic moments are performed. These results represent a substantial advancement in measuring photon-induced tau lepton pairs and probing the electromagnetic properties of the tau lepton using heavy-ion collisions.

T 36: Methods in Astroparticle Physics II

Time: Tuesday 16:15–17:45 Location: VG 3.101

T 36.1 Tue 16:15 VG 3.101

Characterisation of a SiPM Array in Liquid Xenon — •Vera H. S. Wu[1], Kaixuan Ni[2], Jianyang Qi[2], Haiwen Xu[2], and Yue Ma[2] — [1]Karlsruhe Institute of Technology, Institute for Astroparticle Physics — [2]University of California San Diego

Silicon-photomultipliers (SiPMs) have grown in attention and application among direct dark matter search and neutrino physics experiments due to some advantages compared to the traditional photomultipliers (PMTs). Using the liquid xenon detector R&D setup at the University of California San Diego, we installed 96 Hamamatsu VUV4 SiPMs surrounding a sensitive volume of about one litre, intending to detect sub-keV recoils in liquid xenon for the NUXE experiment. The number of the VUV4 SiPMs used is unprecedented for low-energy liquid xenon experiments. For a few months, we monitored the readout noise level and the gain of individual SiPM in either gaseous or liquid xenon. The gain-to-overvoltage ratio has been stable within months of measurement. We also tested the light collection efficiency (LCE) of the device in liquid xenon, as will be reported in this talk.

We acknowledge the financial support from Karlsruhe House of Young Scientists through a Research Travel Grant to visit and work at UCSD.

T 36.2 Tue 16:30 VG 3.101

Construction and commissioning of a Novel Krypton Concentrator for Next-Generation Dark Matter Experiments — •David Koke, Lutz Althüser, Volker Hannen, Christian Huhmann, Philipp Schulte, Patrick Alexander Unkhoff, Daniel Wenz, and Christian Weinheimer — Universität Münster, Germany

Future large scale dark matter experiments, such as DARWIN and XLZD, require high radiopurity in their liquid xenon detectors to probe WIMPs down to the neutrino fog. Due to the presence of the radioactive man-made isotope Kr-85, maintaining a low krypton concentration is a critical requirement. The LowRad project aims at developing a compact all-in-one xenon purification system for krypton, radon and electronegative impurities in xenon. The system's key components include a distillation column for continuous online removal, requiring a secondary distillation column as a concentrator for the krypton-enriched off-gas to avoid losses of xenon and enable monitoring of the krypton concentration. This novel krypton concentrator has been successfully constructed and commissioned, and underwent initial functionality tests. This talk will present the design and construction of the concentrator, along with the results of the first performance tests, demonstrating its capabilities. These advancements pave the way for achieving the ultra-low backgrounds necessary for future dark matter searches with next generation experiments. This work is supported by the ERC AdG project "LowRad" of C. Weinheimer (No. 101055063).

T 36.3 Tue 16:45 VG 3.101

Local coincidences in the Multi-PMT Digital Optical Module for IceCube Upgrade — •Anna-Sophia Tenbruck and Alexander Kappes for the IceCube-Collaboration — Universität Münster, Institut für Kernphysik

The IceCube Neutrino Observatory will undergo an upgrade during the Antarctic summer of 2025/26 that will significantly improve its sensitivity. Among the newly introduced components is the Multi-PMT Digital Optical Module (mDOM), a detector module equipped with multiple photomultipliers (PMTs) that enables the detection of local coincidences. This capability is particularly useful for applications such as noise suppression. In a comprehensive study conducted as part of a master's thesis, the multiplicity rate of an mDOM was measured in both air and water and compared to a Geant4 toolkit simulation. This presentation will discuss the results, focusing on the comparison between measurements and simulations.

T 36.4 Tue 17:00 VG 3.101

Determination of scintillation properties using alpha spectroscopy for IceCube's optical module — •Ines Bahloul and Alexander Kappes for the IceCube-Collaboration — Universität Münster, Institut für Kernphysik

The main optical background in IceCube's Digital Optical Modules (DOMs) arises from scintillation caused by trace amounts of radioactive isotopes in the glass of the pressure vessel. The current simulation of this background relies, among other factors, on a gamma spectroscopy measurement of the glass. However, this measurement cannot directly quantify radon and radium content. As part of my master's thesis, I aim to enhance this simulation by measuring these quantities with an alpha spectrometer. In this talk, experimental setup, calibration process, and the current progress of this study will be presented.

T 36.5 Tue 17:15 VG 3.101

Broadband Lightning Interferometry at the Pierre Auger Observatory — Markus Cristinziani[1], •Eric-Teunis de Boone[1], Qader Dorosti[1], Stefan Heidbrink[2], Noah Siegemund[1], Waldemar Stroh[2], Jens Winter[2], and Michael Ziolkowski[2] — [1]Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Elektronikentwicklungslabor der Physik, Universität Siegen

Lightning-related phenomena are known to interact with and influence all detector systems of the Pierre Auger Observatory in Argentina. Notably, the Surface Detector has recorded signals linked to Terrestrial Gamma Flashes (TGFs) which are rare phenomena linked to the initial processes of lightning. Interpreting these signals remains challenging due to the absence of a system capable of providing detailed 3D imaging of lightning propagation. To address this gap, we are developing a state-of-the-art interferometric lightning detection system that enhances the Observatory's unique capabilities for precision research on TGFs. It will consist of radio detectors that have been previously developed for the Auger Engineering Radio Array (AERA), located at strategic positions within the Auger field. This contribution highlights recent hardware developments and the initial large-scale data readouts from the first field installation, demonstrating the system's potential for advancing TGF and lightning research.

T 36.6 Tue 17:30 VG 3.101

Absolute energy calibration of the Fluorescence Telescopes at the Pierre Auger Observatory with a roving laser system* — •Rukije Uzeiroska-Geyik for the Pierre-Auger-Collaboration — ergische Universität Wuppertal, Wuppertal, Germany

The Fluorescence Detector (FD) of the Pierre Auger Observatory provides energy measurements of primary cosmic rays that are largely independent of specific interaction models. The FD energy measurement is crucial for calibrating the energy reconstruction of the Surface Detector. Consequently, the accuracy of the FD energy calibration plays a significant role in the systematic uncertainties associated with nearly all scientific results of the Observatory. To achieve high accuracy in calibration, a laser with a well-defined energy output is going to be fired in front of the FD telescopes. This method has the advantage that the response of the telescope to the laser closely simulates its reaction to an actual cosmic ray air shower, something that is not achievable with other calibration methods.

The system was designed with special attention given to the depolarization of the laser beam to ensure a consistent relationship between energy output and directional light yield. This contribution covers the ongoing development of the mobile laser system and the calibration measurements performed in the laboratory to ensure the highest precision of the in field measurements.

Supported by BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A23PX1)

T 37: Cosmic Rays II

Time: Tuesday 16:15–17:45 Location: VG 3.102

T 37.1 Tue 16:15 VG 3.102

Measuring the Cosmic Ray Sun Shadow with IceCube* — •Niclas Krieger[1,2], Jonas Hellrung[1,2], Lukas Merten[1,2], Julia Becker Tjus[1,2,3], and Paolo Desiati[4] for the IceCube-Collaboration — [1]Ruhr-Universität Bochum, Fakultät für Physik und Astronomie, Institut für Theoretische Physik IV, Universitätsstraße 150, 44780 Bochum, Germany — [2]Ruhr Astroparticle and Plasma Physics Center (RAPP Center), Bochum, Germany — [3]Chalmers University of Technology, Department of Space, Earth and Environment, 412 96 Gothenburg, Sweden — [4]Department of Physics and Wisconsin IceCube Particle Astrophysics Center, University of Wisconsin-Madison, Madison, Wisconsin 53706, USA

With the IceCube Neutrino Observatory atmospheric muons are detected that are produced when cosmic rays interact with the Earth's atmosphere. On their way to Earth, cosmic rays are blocked by the Sun and the Moon. While the Moon shadow serves as an absolute pointing calibration, the Sun shadow enables an indirect observation of the Solar magnetic field since this deflects cosmic rays on their way and thus leaves its footprint in the temporal variation of the cosmic-ray shadow with the 11-year solar cycle. In this talk the methods of measuring the shadows of these celestial objects will be reviewed. Furthermore, it will be shown how these observations help to understand the Solar magnetic field better.

*Supported by DFG (SFB 1491) and BMBF

T 37.2 Tue 16:30 VG 3.102

Towards a Directional Search for Ultra-High-Energy Photons Using the Surface Detector of the Pierre Auger Observatory — •Tim Fehler, Marcus Niechciol, and Markus Risse for the Pierre-Auger-Collaboration — Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen

In addition to its capabilities for precise measurement of ultra-high-energy (UHE, $E \gtrsim 10^{17}$ eV) cosmic rays through the observation of extensive air showers, the Pierre Auger Observatory also offers the potential to effectively detect UHE photons. Their connection to UHE cosmic rays is manifold; constraints on their flux provide valuable hints on the elusive nature of the UHE cosmic rays. Contrary to charged cosmic rays, which are deflected by magnetic fields, UHE photons carry the inherent advantage that their origin can be traced back directly, which promotes the search for directional excesses of photon-like events in the sky. This contribution details the developments for a new direction-dependent search for UHE photons, based on the paradigm of air-shower universality. With this approach, data from the Surface Detector (SD) array of the Pierre Auger Observatory can be used to reconstruct key quantities such as the primary energy and the atmospheric depth of the shower maximum X_{max}, which are essential for primary particle classification, with significantly improved precision. Furthermore, with sole dependence on the SD, one is able to take advantage of its ~ 100% duty cycle.

Supported by the BMBF Verbundforschung Astroteilchenphysik under project No. 05A23PS1.

T 37.3 Tue 16:45 VG 3.102

Inferring the Ultra-High-Energy Cosmic Ray Flux Prior to Deflections in the Galactic Magnetic Field Using Information Field Theory — Martin Erdmann, •Frederik Krieger, Josina Schulte, Michael Smolka, and Maximilian Straub — III. Physikalisches Institut A, RWTH Aachen University

Ultra-high-energy cosmic rays (UHECRs) are assumed to be charged nuclei with energies exceeding 10^{18} eV, whose origins and acceleration mechanisms are still not discovered. Upon entering the Earth's atmosphere, UHECRs interact with air molecules, initiating extensive particle showers that can be observed by cosmic ray observatories. However, as UHECRs traverse the Galactic magnetic field (GMF), they are deflected, changing their trajectories and causing the measured arrival directions to no longer point back to their sources. To address this challenge, we present a novel approach combining forward modeling and information field theory to reconstruct the UHECR flux before deflection in the GMF. We apply this method to an astrophysical model, demonstrating its potential to improve the estimation of the UHECR source distribution.

T 37.4 Tue 17:00 VG 3.102

A novel approach for air shower profile reconstruction using radio measurements with Information Field Theory — •Keito Watanabe[1], Tim Huege[1,2], Mitja Desmet[2], Stijn Buitnik[2], and Torsten Ensslin[3,4] for the LOFAR-Cosmic ray key science project-Collaboration — [1]Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Germany — [2]Vrije Universiteit Brussel, Astrophysical Institute, Brussels, Belgium — [3]Max Planck Institute for Astrophysics, Garching, Germany — [4]Ludwig-Maximilians-Universität, Munich, Germany

Reconstructing the profile of extensive air showers, generated from the interaction of cosmic rays in the Earth's atmosphere, is crucial to understanding their mass composition, which in turn provides valuable insight on their possible source of origin. However, current frameworks can only recover shower parameters that provide limited information on the composition and relies on computationally expensive simulations. In this work, we develop a novel framework to reconstruct the longitudinal profile of air showers using measurements from radio detectors with Information Field Theory, a state-of-the-art reconstruction framework based on Bayesian inference. We utilise prior knowledge about the physical process of radio emission to generate a fast-forward model based on template synthesis and incorporate realistic response and noise models to produce voltage traces at each antenna. We apply our framework with simulated datasets based on the LOFAR detector layout and analyse the reconstruction efficiency to highlight the performance of our framework.

T 37.5 Tue 17:15 VG 3.102

Identifying Ultra-High-Energy Photons with a Convolutional Neural Network on the Basis of Surface Detector Measurements at the Pierre Auger Observatory — •Tim Fehler, Eleonora Guido, Marcus Niechciol, Markus Risse, and Daniel Steiniger for the Pierre-Auger-Collaboration — Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen

Towards ultra-high energies (UHE, $E \gtrsim 10^{17}$ eV), the expected flux of cosmic photons becomes so small that only the indirect detection via extensive air showers remains feasible. The quest to identify ultra-high-energy photons then fundamentally boils down to a classification problem, in which photon-induced air showers must be distinguished from the vast background of hadron-induced showers, utilizing only the limited data provided by detector sampling on an individual event basis. This work explores the application of a convolutional neural network (CNN) to this task, considering the full temporal evolution of the signal in surface-detector stations of the Pierre Auger Observatory as input. We show that with this approach, high levels of accuracy in classifying simulated shower events can be reached, providing a promising tool for future searches for UHE photons.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 945422. It is also partially supported by BMBF Verbundforschung Astroteilchenphysik under project No. 05A23PS1.

T 37.6 Tue 17:30 VG 3.102

Investigating the Expected Flux of GZK Photons — •Chiara Papior, Marcus Niechciol, and Markus Risse — Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen

It is expected that charged cosmic rays produce ultra-high-energy (UHE, here beyond 10 PeV) photons during their propagation over extragalactic distances via photo-pion production with the cosmic microwave background. This effect is also known as the Greisen-Zatsepin-Kuzmin (GZK) effect and the photons produced via this interaction are termed GZK photons. The flux of GZK photons depends on the parameters of the emitted cosmic-ray spectrum such as the spectral index or a potential cutoff, as well as other parameters depending on the sources, including their distances, and the composition of the cosmic rays themselves. Simulations based on different input parameters have been performed, and the expected GZK photon flux will be presented. The goal is to update the allowed range of the expected GZK photon flux based on current measurements of cosmic-ray observatories at ultra-high-energy.

This work is supported by the German Research Foundation (DFG, Project No. 508269468).

T 38: Neutrino Physics III

Time: Tuesday 16:15–18:00 Location: VG 3.103

T 38.1 Tue 16:15 VG 3.103

ESS Neutrino Super Beam Plus (ESSνSB+) Target Test Facility(ETTF) - R&D Setup — •Rishabh Moolya and Tamer Tolba — Institut für Experimentalphysik, Universität Hamburg

The ESSνSB+ Target Station will consist of a target-horn system operating under an intense 1.25 MW proton beam power, derived from the nominal 5 MW proton beam with a 14 Hz frequency provided by the European Spallation Source (ESS) Linac. An ESSνSB+ Target Test Facility (ETTF) is planned to be located at the Mechanical Measurements Lab (MML) in ESS, building upon the successful ESS Target Helium Experiments at LTH (ETHEL).

The ESSνSB+ target features a packed bed of titanium (Ti) spheres cooled with pressurized helium gas to withstand the substantial power deposition expected in the target bulk. Due to the granular structure of the target bulk, numerical CFD modeling of the thermodynamic behavior of the cooling system and target pellets is highly complex and necessitates experimental validation. The primary objective of this R&D setup is to address the challenges in simulating the mechanical and thermodynamic behavior of the target cooling system.

The proposed setup will include: a booster compressor, an electric heater, a test vessel, and a cooling heat exchanger with water on the secondary side. Current status of the commissioning of the prototype target system and the results of the aforementioned studies will be presented.

T 38.2 Tue 16:30 VG 3.103

Neutrino oscillations parameters estimation with NOvA and T2K public data — •Sofia Lonardi — Ludwig-Maximilians-Universität (LMU), Theresienstraße 37, 80333 Munich, Germany — Technical University Munich (TUM), James-Franck-Strasse 1, 85748 Garching, Germany

Neutrino flavour oscillations are a promising open window into physics beyond the standard model. Numerous experiments provide a way to estimate the angles of the mixing matrix and the mass differences. Most parameters have been determined with increasing precision and agreement between different experiments, nevertheless, some questions still need to be addressed regarding the mixing angle Θ_{23} and the CP phase δ_{CP} dependence on the neutrino mass ordering. Notably, T2K and NOvA experiments show contrasting tendencies depending on the measurement channel. This study focuses on NOvA and T2K: new independent analyses are performed using publicly accessible data, and the official results are reproduced to demonstrate their validity. The parameters are estimated through likelihood maximization, and agreements and tensions between the two datasets are evaluated in a joint fit. This talk will explain the individual data analysis chains and the global fitting setup, discussing the obtained results in the broader context of the global neutrino oscillations landscape.

T 38.3 Tue 16:45 VG 3.103

Detection of neutrons produced in neutrino-nucleus interactions — •Asit Srivastava — Johannes Gutenberg - Universität Mainz

T2K is a long-baseline experiment which measures parameters of neutrino oscillations. This can be done by analysing the interaction of neutrinos closer to the point of beam production and 295 km downstream. The detector located near the source of beam production, called ND280, primarily includes the interactions of neutrinos with carbon nuclei. The particles produced as a result of the interactions deposit energy in ND280 which is used to characterise the incoming neutrino flux and neutrino cross-sections before oscillations occur.

Out of all the particles produced in typical neutrino interactions, neutrons are by far the most challenging to detect since they are electrically neutral and do not leave a visible track in the detector. As a result, they provide uncertainties in identifying the interactions happening in the detector and measuring cross-sections. ND280 has a newly installed Super Fine-Grained Detector (SFGD) made of plastic scintillator cubes. The upgraded detector capable of better position resolution and 3D reconstruction opens up the possibilities of improving the efficiency of neutron detection. Presence of a neutron is established using cuts on energy deposits and hence, possible neutron candidates, such as based on time of flight, kinetic energy of the candidate and the separation of energy deposit from the interaction vertex. This talk will go through neutron selection and how neutrons can help in understanding nuclear effects better.

T 38.4 Tue 17:00 VG 3.103

Exploring CEvNS with the NUCLEUS Experiment — •Raimund Strauss for the NUCLEUS-Collaboration — Technische Universität München, München, Deutschland

The NUCLEUS experiment aims to the first detection of coherent elastic neutrino nucleus scattering (CEvNS) at a nuclear reactor, exploiting an innovative detection system that consists of a 10g cryogenic detector setup made of CaWO4 and Al2O3 crystals. These target detectors are capable of reaching O(10 eV) energy thresholds, making it possible to measure nuclear recoils induced by CEvNS. The detectors will be surrounded by a twofold system of instrumented cryogenic vetoes, an external passive shielding and a muon veto to improve the identification and discrimination of backgrounds. NUCLEUS has recently demonstrated the successful operation of the neutrinos target detectors in coincidence with the other sub detectors of the experiment in the so called Long Background Run, performed in the shallow underground laboratory UGL located at TUM university in Munich. The experiment is now ready for the relocation to the Chooz-B nuclear power plant in the French Ardennes. This talk will provide an overview of the experiment's current status, focusing on the latest developments and milestones achieved.

T 38.5 Tue 17:15 VG 3.103

Exploring coherent elastic neutrino-nucleus scattering: status of the NUCLEUS experiment — •Chloé Goupy for the NUCLEUS-Collaboration — Max Planck Institute for Nuclear Physics (MPIK), Heidelberg, Germany

The first detection of coherent elastic neutrino nucleus scattering (CEvNS) at a nuclear reactor remains to be achieved, especially because the corresponding nuclear recoils lie in the O(100 eV) energy regime which is difficult to measure with conventional detection technologies, and also because of the unfavorable background conditions nuclear power plant environments generally offer.

To overcome these obstacles, the NUCLEUS experiment aims to develop an innovative detection system using cryogenic detectors made of CaWO4 and Al2O3 crystals capable of reaching O(10 eV) energy thresholds. These target detectors will be surrounded by a twofold system of instrumented cryogenic vetoes, an external passive shielding and a muon veto to improve the identification and discrimination of backgrounds.

At present, the experiment is under commissioning in the shallow underground laboratory at the Technical University of Munich (TUM), and the relocation to the Chooz-B nuclear power plant in the French Ardennes in underway. In this talk, I will provide an overview of the experiment's current status, focusing on the latest developments and milestones achieved.

T 38.6 Tue 17:30 VG 3.103

Investigation of rear wall candidates for keV sterile neutrino search at KATRIN — •Kerstin Trost, Dominic Batzler, James Braun, Robin Grössle, Philipp Haag, Elizabeth Paine, Marco Röllig, Marius Schaufelberger, Marie Schäfer, and Michael Sturm — KIT

The search for keV sterile neutrinos at the KArlsruhe TRItium Neutrino (KATRIN) experiment is set to start in 2026, measuring the full energy range of the tritium beta-decay spectrum. This novel approach introduces additional systematic uncertainties that must be addressed to ensure reliable results. A key challenge is mitigating the major systematics associated with electron backscattering and radioactive contamination of the rear wall. This talk introduces current concepts for rear wall optimization and discusses experimental efforts to validate these designs. Specifically, the (de)contamination behavior of potential rear wall materials such as beryllium and micro-structured silicon tested with the TRACE experiment is presented. This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6)

T 38.7 Tue 17:45 VG 3.103

Rear Wall concepts for keV sterile neutrino search at KATRIN — •Rudolf Sack for the KATRIN-Collaboration — Karlsruhe Institute of Technology - KIT

From 2026 on KATRIN will search for keV sterile Neutrinos with a differential electron energy measurement of the Tritium beta decay. The unwanted effects of the Rear Wall, such as electron backscattering, are thought to be the leading systematic effect. This talk will explain the requirements for new rear wall materials and design concepts. Further the talk will highlight our most promising concepts and present our performed characterization measurements.

T 39: Neutrino Physics IV

Time: Tuesday 16:15–17:45 Location: VG 3.104

T 39.1 Tue 16:15 VG 3.104

Insight into the Analysis of the KATRIN Neutrino Mass Data — Christoph Köhler[1,2], Susanne Mertens[1,2], •Jan Plössner[1,2], Richard Salomon[3], Alessandro Schwemmer[1,2], Jaroslav Štorek[4], Xaver Stribl[1,2], and Christoph Wiesinger[1,2] for the KATRIN-Collaboration — [1]Max Planck Institute for Nuclear Physics — [2]Technical University of Munich — [3]University of Münster — [4]Karlsruhe Institute of Technology

The KArlsruhe TRItium Neutrino (KATRIN) experiment probes the effective electron anti-neutrino mass by a precision measurement of the tritium beta-decay spectrum near the endpoint. A world-leading upper limit of 0.45 eV c^{-2} (90 % C.L.) has been set, including the data of the first five measurement campaigns, corresponding to approximately 15 % of the final statistics. Since then, the collected data has increased by a factor of five.

In this presentation, I will provide an update on the current status of the KATRIN neutrino mass analysis beyond the fifth measurement campaign and discuss the neural network approach utilized for this analysis.

This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2, and 05A23WO6).

T 39.2 Tue 16:30 VG 3.104

Unbinned analysis of ^{163}Ho-spectrum endpoint region — •Frederic Böhm — Kirchhoff Institute for Physics, Heidelberg University — ECHo Collaboration

The aim of the Electron Capture in ^{163}Ho (ECHo) collaboration is to determine the effective electron neutrino mass by analysing the endpoint region of the ^{163}Ho electron capture spectrum. The spectrum is measured using metallic magnetic calorimeters (MMC) enclosing ^{163}Ho and subsequently the data is reduced to avoid the presence of artifacts before further analysis can take place. Previously, a histogram-based approach already proved to be a suitable choice for the analysis of the spectrum and, in particular, of the endpoint region. To further improve the sensitivity of the fitting algorithms to quantify the effect of tiny neutrino masses, we are testing methods of unbinned analysis like a Kernel Density Estimation (KDE) to mitigate potential artifacts of binning the continuous event energies of the low-intensity endpoint region close to the Q-value of the ^{163}Ho decay. We present the implementation of these algorithms in the analysis of the ^{163}Ho spectrum acquired within the ECHo-1k experiment and compare the results with the ones obtained with binned spectra.

T 39.3 Tue 16:45 VG 3.104

Integrated magnetic field design for next-generation neutrino mass experiment with CRES — •René Reimann and Martin Fertl for the Project 8-Collaboration — Institute of Physics and Excellence Cluster PRISMA+, Johannes Gutenberg University Mainz, 55099 Mainz, Germany

The Project 8 experiment aims to probe the absolute neutrino mass through direct kinematic measurements of the tritium beta decay spectrum using cyclotron radiation emission spectroscopy (CRES). The low-frequency apparatus (LFA) should demonstrate the coexistence of CRES electron detection and an atomic trap while increasing the effective volume and lowering the background magnetic field compared to previous CRES experiments. To achieve the required energy resolution, the magnetic field experienced by the electrons must be known to very high precision. The magnetic field consists of a carefully tuned uniform background field with a super-imposed magnetic bottle trap to confine the CRES electrons within the detection region. In addition, a high-order multipole magnet adds a strong field only near the wall to confine the cold tritium atoms whose decay provides the electrons for CRES. This contribution describes how, individually and in concert, the three elements of Project 8's magnetic field impact key performance parameters of the detector.

T 39.4 Tue 17:00 VG 3.104

Simulating the atomic beam source for Project 8 experiment : from dissociation to cooling — •Aya El Boustani[1] and Sebastian Böser[2] for the Project 8-Collaboration — [1]Institute of Physics, Johannes Gutenberg University of Mainz, Germany — [2]Institute of Physics, Johannes Gutenberg University of Mainz, Germany

The Project 8 experiment aims to determine the absolute neutrino mass using Cyclotron Radiation Emission Spectroscopy (CRES) to measure the radiation emitted by tritium beta-decay electrons near the spectrum's endpoint, where the neutrino mass effect is most significant. Achieving the desired sensitivity requires an atomic tritium source with well-characterized beam properties. In the test setup at JGU Mainz, molecular hydrogen serves as a non-radioactive tritium analog and is dissociated using a tungsten capillary heated to approximately 2300 K. The dissociated gas undergoes a multi-stage cooling process to bring the atomic beam's temperature down to 8 K. This process is critical to allow the trapping of atoms at later stages of the experiment while minimizing recombination. For this study, simulations were carried out to investigate the atomic source and the accommodator, which serves as the first cooling stage. Using the SPARTA framework, gas flow within the heated tungsten capillary was modeled to characterize atomic beam formation, quantify dissociation efficiency, and evaluate the resulting beam properties. Additional analyses of the accommodator are conducted to assess the effects of surface geometry and gas-surface dynamics on cooling efficiency and overall beam characteristics.

T 39.5 Tue 17:15 VG 3.104

MMC Design and Microfabrication for the ECHo Experiment — •Lorenzo Calza — Kirchhoff Institute for Physics, Heidelberg University, Heidelberg, Germany — ECHo Collaboration

The ECHo experiment is conceived to determine the electron neutrino mass through the analysis of the endpoint region of a high statistics and high energy resolution ^{163}Ho spectrum. During the ECHo-100k phase more than 10^{12} ^{163}Ho decays will be detected by large metallic magnetic calorimeter arrays in which single pixels contain up to 10 Bq of ^{163}Ho. To achieve this goal, about 10^4 MMC pixels will be operated simultaneously. A dedicated chip composed of 60 pixels and 2 temperature channels for gain correction has been designed. 40 chips are microfabricated on a 3" silicon wafer. The design and fabrication steps have been optimised for ^{163}Ho implantation on wafer-scale. We describe the single pixel optimisation for minimal heat capacity and close to 100% quantum efficiency for all decay products besides the electron neutrino, as well as the final chip design. We also present the lithographic microfabrication process and the quality control procedures. We discuss the fabrication yield and the reproducibility of detector parameters. To meet the required pixel count for ECHo-100k, 6 wafers are currently being produced.

T 39.6 Tue 17:30 VG 3.104

ECHo-100k Chip characterization — •Neltje Sophie Buermann — Kirchhoff Institute for Physics, Heidelberg University, Germany — ECHo Collaboration

The ECHo experiment is designed to search for the signature of the finite neutrino mass in the endpoint region of the ^{163}Ho electron capture spectrum. The first stage of the experiment ECHo-1k has been completed, and now the second stage ECHo-100k is under construction. This stage includes a new metallic magnetic calorimeter array with improved pixel design and thermalization. The foreseen resolution of 4 eV FWHM will be more than a factor two better than the one achieved with the ECHo-1k arrays. In this contribution, we present the results for the newly developed chips and discuss their performance in terms of the ECHo-100k requirements.

T 40: Methods in Particle Physics II (Misc.)

Time: Tuesday 16:15–18:00 Location: VG 4.101

T 40.1 Tue 16:15 VG 4.101

ATLAS Forward Proton (AFP) detector operation challenges and ToF Run-3 performance — •Viktoriia Lysenko and Andre Sopczak — Czech Technical University in Prague

Operational and data quality challenges for the ATLAS Forward Proton (AFP) detector in 2024 are presented together with performance studies of the Time-of-Flight (ToF) detector during LHC Run-3 data-taking.

T 40.2 Tue 16:30 VG 4.101

Luminosity measurements using the ATLAS Forward Proton (AFP) detector — Jan Broulim, Petr Fiedler, •Daniil Khmelnytskyi, and Andre Sopczak — Czech Technical University in Prague

The latest results of luminosity measurements using the AFP detector are presented.

T 40.3 Tue 16:45 VG 4.101

Characterization of Losses in LHCb — Johannes Albrecht[1], Federico Alessio[2], Elena Dall'Occo[2], and •David Rolf[1] — [1]TU Dortmund University, Dortmund, Germany — [2]CERN, Geneva, Switzerland

The LHCb experiment is one of the four large particle detectors at the LHC. One important aspect of the experiment is to perform very precise measurements of rare b and c quark decays.

A very clean signal is required during nominal collisions. Operating the LHC comes with different sources of background particles induced from machine operation (MIB). These particles can collide with the collimators shielding the experiment causing secondary showers onto the detector.

In this talk the sources of such losses are explained. The losses are characterized by performing dedicated loss runs. The potential effect on the detector and the physics impact is studied.

T 40.4 Tue 17:00 VG 4.101

Study of the intrinsic detection asymmetry at Belle II for a generic search for matter-antimatter asymmetries — •Beatrice Locatelli, Thomas Lück, Nikolai Krug, and Thomas Kuhr — Ludwig-Maximilians-Universität München Germany

To explain the abundance of matter over antimatter observed in the universe, the CP symmetry must be broken. The Standard Model accounts for some CP violation, but that is not sufficient to explain the magnitude of the observed baryon asymmetry. Therefore, it is crucial to search for new manifestation of CP violation that might have been overlooked so far.

The main source of background in the measurement of CP asymmetries is the intrinsic detector asymmetry. For this reason, it is essential to have a precise knowledge of the asymmetry in particle detection, which can be done by studying the different reconstruction efficiencies between particles and antiparticles. The final goal is to formulate a model-independent analysis strategy that can be applied to detect asymmetries in B-decays at Belle II.

T 40.5 Tue 17:15 VG 4.101

Background Studies for the ILD Detector Concept at the FCC-ee — •Victor Schwan[1], Jenny List[2], and Daniel Jeans[3] — [1]DESY, Universität Hamburg — [2]DESY — [3]KEK, Japan

The ILD detector concept has originally been developed for the International Linear Collider (ILC). Detailed simulations gauged against the performance of prototype components have shown that ILD in its ILC incarnation is ideally suited to pursue the physics program of a linear Higgs factory as well as of a higher energy e^+e^- collider. Recently, the ILD collaboration has started to investigate how the detector concept would need to be modified in order to operate successfully in the experimental environment of a circular Higgs factory like for instance FCCee. In particular, the interaction region, or machine-detector interface (MDI), requires substantial changes to make room for accelerator elements and to withstand backgrounds. This contribution presents the assessment of the occupancy caused by machine backgrounds in the modified detector design, especially in the tracking subdetector systems.

T 40.6 Tue 17:30 VG 4.101

Optimization of module orientation for the DUNE TMS detector — •Asa Nehm for the DUNE-Collaboration — Johannes-Gutenberg University Mainz

The Deep Underground Neutrino Experiment (DUNE), currently under construction, will use a high-intensity neutrino beam from Fermilab and observe the neutrinos in the near detector based at Fermilab and the far detector complex located at SURF. The DUNE near detector complex will host a suite of detectors that are currently in development. The experiment will make precision measurements of the neutrino oscillation parameters including the CP violation phase and the mass ordering. It is also sensitive to neutrinos from galactic supernovas.

One of the near detectors is The Muon Spectrometer (TMS) that is tasked with determining the charge and measuring the momentum by range of the muons resulting from neutrino interactions exiting the preceding near detector. TMS will consist of alternating layers of plastic scintillators, in the form of bars, and steel. The scintillator bars will be read out by WLS fibers and SiPMs and detect the scintillation light created by through-going charged particles.

The original design featured a stereo orientation plan with the bars being tilted by $\pm 3^\circ$ alternatingly by layer. This introduces a large uncertainty in the dimension along the bars and can lead to problems in determining the momentum. In this talk different orientation plans including also orthogonal modules that could solve these problems will be discussed.

T 40.7 Tue 17:45 VG 4.101

Polarized Positron Production for HALHF concept — •Malte Trautwein, Manuel Formela, and Gudrid Moortgat-Pick — University of Hamburg

The HALHF concept represents an energy-efficient and cost-effective alternative to Higgs production using plasma-accelerated electrons and SRF accelerated positrons. The energy asymmetry of electrons (500 GeV) and positrons (31.3 GeV) reduces the overall effort of the acceleration process. An optimised positron source is required for eventful collision processes and for providing polarized beams to optimze the physics potential. Therefore, CAIN simulations are used to generate photon distributions originating from a helical undulator setup. The photon spectra are influenced by parameters such as the undulator strength parameter K, the spatial period of undulator λ_u or the drive beam energy E. The aim is to optimize a set of suitable parameters to generate a matching (polarized) positron spectrum and simultaneously maximise positron yield.

T 41: Search for Dark Matter II

Time: Tuesday 16:15–18:00 Location: VG 4.102

T 41.1 Tue 16:15 VG 4.102

Indirect Searches for Dark Matter with COSI — •Haoyu Xie[1,2], Savitri Gallego[1,2], Jan Lommler[1,2], and Uwe Oberlack[1,2] — [1]Johannes Gutenberg-Universität Mainz, Institut für Physik & ETAP - Experimentelle Teilchen- und Astroteilchen Physik — [2]On behalf of the COSI Collaboration

The NASA MeV mission COSI (Compton Spectrometer and Imager), to be launched in 2027, offers significantly improved sensitivity at high energy resolution and for diffuse emission due to a large field-of-view in the 0.2-5 MeV energy range. This energy range is particularly intriguing for indirect searches of dark matter, as sub-GeV DM candidates are still little constraint by direct searches, but could be detected indirectly as they either annihilate or decay into detectable gamma rays. In this work, we study the sensitivity of COSI to DM in the framework of a dark photon portal, exploring scenarios where sub-GeV dark matter annihilates into leptons, producing continuum gamma-ray signals. We also discuss opportunities to search for primordial black holes (PBHs) and sterile neutrino decays.

T 41.2 Tue 16:30 VG 4.102

The Status of the COSINUS Experiment — •Maximilian Hughes for the COSINUS-Collaboration — Max-Planck-Institut für Physik

COSINUS (Cryogenic Observatory for SIgnatures seen in Next generation Underground Searches) is a dark matter direct detection experiment using cryogenic sodium iodide (NaI) modules. The goal is a model independent test of the DAMA/LIBRA dark matter claim. Prototype modules using the remoTES to read out heat signals from NaI have been measured and the results will be presented. The underground facility construction is complete and the dry dilution refrigerator to provide the milli-kelvin temperatures required has been commissioned. The water Cherenkov muon veto surrounding the cryostat has been installed and filled with water. The next steps include installing cabling and superconducting quantum interference devices (SQUIDs) to read out the modules. The first data taking is planned to start in 2025 with eight 30 gram NaI modules.

T 41.3 Tue 16:45 VG 4.102

The first measurement of coherent elastic nucleus scattering of solar 8B neutrinos in the XENONnT experiment. — •Daniel Wenz for the XENON-Collaboration — University of Muenster

Liquid xenon (LXe) dual-phase time projection chambers (TPC) are thanks to their low energy threshold of sub-keV level and excellent background discrimination, the leading technology in the search for WIMP dark matter. They are also well suited to study other rare and faint phenomena like the coherent elastic neutrino-nucleus scattering (CEvNS) of solar neutrinos, opening a window towards solar and neutrino physics at lowest energies.

On of the leading experiment in this field is the XENONnT experiment, a highly sensitive, low background, dual-phase TPC with a LXe target volume of 5.9 t located at the Laboratori Nazionali del Gran Sasso (LNGS). In this talk the first measurement of solar ^{8}B neutrinos through CEvNS are presented by performing a dedicated low energy blind analysis, using an exposure of 3.51 t · yr. The background only hypothesis was rejected with 2.73 sigma, resulting in a measured ^{8}B flux of $(4.7^{+3.6}_{-2.3}) \cdot 10^{-6}\mathrm{cm}^{-2}\mathrm{s}^{-1}$. This result not only represents the very first measurement of CEvNS in LXe, but also CEvNS from solar neutrinos in general. It is therefore an important milestone towards a future liquid xenon observatory, not only for dark matter, but also for neutrino and solar physics.

This work is supported by BMBF ErUM-Pro 05A23PM1.

T 41.4 Tue 17:00 VG 4.102

Modeling the nuclear recoil response in XENONnT — •Johanna Jakob for the XENON-Collaboration — Institut für Kernphysik, Universität Münster

XENONnT, the latest stage of the XENON Dark Matter Project, is currently running with the science goals of detecting WIMP-nucleus scattering and searching

for other rare events. The detector is a dual-phase time projection chamber filled with 5.9 tonnes of liquid xenon in the active volume. In the detector, neutral particles are most likely to interact with the nucleus, resulting in nuclear recoil (NR). Potential WIMP interactions as well as the rare Standard Model process of coherent elastic neutrino-nucleus scattering (CEνNS) both produce NR interactions. Consequently, characterizing the detector response to NR is essential for such investigations. Neutrons serve as an excellent calibration source for studying this response, as their NR interactions are indistinguishable from those of WIMPs or CEνNS. This talk discusses how neutrons tagged with coincident 4.4 MeV gammas from an $^{241}Am^{9}Be$ source are used to constrain the light and charge yield parameters of the NEST model (Noble Element Simulation Technique). This work is supported by BMBF ErUM-Pro 05A23PM1.

T 41.5 Tue 17:15 VG 4.102

Simulation and design optimization of the DARWIN observatory — •Antoine Chauvin, Maike Doerenkamp, and Stephanie Hansmann-Menzemer — Im Neuenheimer Feld 226, 69120 Heidelberg

The DARWIN observatory is a proposed future direct dark matter detection experiment. Its main science target is the detection of WIMP-like particles through WIMP-nucleus interactions, in a multi-ton liquid xenon TPC. Designing the experiment and optimizing its layout requires good modeling of the detection processes and the signal and background sources. In this talk, we report on the simulation of the detector responses to signal and background events in the DARWIN TPC. We present the sensitivity of the DARWIN baseline design to WIMP-nucleus scattering infered from these simulations and the impact of detector design choices on the DARWIN sensitivity.

T 41.6 Tue 17:30 VG 4.102

Electrode Design & Characterisation for the XLZD Observatory — •Alexey Elykov for the XLZD-Collaboration — Karlsruher Institut für Technologie, Institut für Astroteilchenphysik

The XLZD (XENON, LZ, DARWIN) collaboration aims to construct and operate the ultimate multi-tonne xenon-based direct detection astroparticle observatory. Hosting a time projection chamber (TPC) with more than 60 tonnes of liquid xenon, with a keV-range threshold and an ultra-low radioactive background it will aim to probe the entire parameter space for WIMP dark matter down to the so-called neutrino fog. XLZD scientific research program also includes searches for solar axions, axion-like particles, measurements of the solar neutrino flux and a probe of the Majorana nature of neutrinos.

High-voltage electrodes, spanning 3 m in diameter, will lie at the heart of the XLZD TPC, playing multiple key roles in signal generation and reconstruction. The electrodes need to be feasible to produce, mechanically robust, sufficiently transparent to light propagation and have minimal spurious electron and light emission from their surface.

An R&D program at KIT aims to tackle these challenges. We've developed several test setups aimed at studying emission from electrode samples and ways of mitigating it, as well as a high-voltage scanning system for electrodes. Here, we will present our recent work on electrode R&D towards XLZD-scale electrodes. This work is supported in part through the Helmholtz Initiative and Networking Fund (grant agreement no. W2/W3-118) and by BMBF (ErUM-Pro, grant no. 05A23VK3).

T 41.7 Tue 17:45 VG 4.102

Next-to-Leading-Order QCD Corrections to Dark Matter Annihilation into Wqq' in the CxSM — •Pavao Brica — Karlsruher Institut für Technologie, Karlsruhe, Deutschland

I will present the results for our computation of the next-to-leading-order QCD corrections to the annihilation process of two dark matter particles into a W boson, a massless quark and a massless antiquark. This process contributes to the computation of the dark matter relic density. The calculation has been performed within the framework of the complex singlet extension of the Standard Model which extends the Standard Model scalar sector by a complex singlet and yields an appropriate dark matter candidate. The treatment of the UV and IR divergences that arise in the calculation is briefly addressed. The cross section as well as the relic density are presented at next-to-leading order. The impact of these corrections is analyzed.

T 42: Invited Overview Talks I

Time: Wednesday 11:00–12:30 Location: ZHG011

Invited Overview Talk T 42.1 Wed 11:00 ZHG011

Direct neutrino-mass measurements - current and next generations — •Magnus Schlösser — Karlsruhe Institute of Technology, Tritium Laboratory Karlsruhe, Karlsruhe, Germany

The precise measurement of neutrino masses represents a critical frontier in particle physics, with implications that extend beyond the Standard Model and into cosmology. Direct neutrino mass measurements are uniquely model-independent and critical for cross-validating of other approaches. The Karlsruhe Tritium Neutrino (KATRIN) experiment, employing beta-decay spectroscopy to measure the incoherent sum of neutrino masses, is in its final year of data taking. KATRIN has progressively improved the upper limit on neutrino mass, achieving $m < 0.45$ eV at 90% C.L. and aims to reach a final sensitivity of $m < 0.3$ eV. This limit represents the reach of the current state-of-the-art technology. Next-generation experiments, targeting sensitivities below the inverted ordering range ($m < 0.05$ eV), require novel technologies, such as atomic tritium sources and differential detection methods, as explored by KATRIN++, Project8, and QTNM.

Another approach is to calorimetrically measure the energy released from electron capture reactions, e.g. from Ho-163 atoms implanted into cryogenic micro-calorimeters. This technology is currently employed by the ECHo and HOLMES collaborations with sensitivities in the order of O(10 eV). Next, their statistics will be improved by increasing the number of channels and measurement time.

This talk will present the latest results and plans for next-generation neutrino mass experiments.

Invited Overview Talk T 42.2 Wed 11:30 ZHG011

Mapping out the Higgs Boson: Highlights from the LHC Experiments — •Elisabeth Schopf — Universität Siegen

The Higgs boson holds a unique position within the Standard Model of Particle Physics; it is the only known fundamental spin-0 particle and it has intrinsic links to the mass-generation mechanisms of fundamental particles and to the evolution of the Universe. It could hold a crucial key to unlocking access to yet unknown physics.

This talk will present the latest results of Higgs-boson research at the ATLAS and CMS experiments using proton-proton collision data from the Large Hadron Collider. The unprecedented precision reached in probes of Higgs boson couplings to fundamental fermions, leptons and quarks, hone in on the question if these couplings are proportional to the fermion masses as expected in the Standard Model or reveal the existence of additional unknown sources of mass generation. More extensive measurements of differential cross-sections probe for new physics affecting Higgs-boson production. Pushing the limits on studies of the Higgs-boson self-coupling further maps out the shape of the Higgs-field potential, which is connected to the long-term stability of the Universe. New and improved searches for other Higgs-boson-like particles and exotic Higgs-boson decays are cornering theories of additional phase transitions in the early universe and theories on the nature of dark matter. This presentation will also discuss the challenges of Higgs-boson research at the Large Hadron Collider and feature recent advancements in measurement techniques.

Invited Overview Talk T 42.3 Wed 12:00 ZHG011

Computing at the LHC and its transformation towards the HL-LHC — •Sebastian Wozniewski — II. Institute of Physics, Georg-August-University, Göttingen, Germany

Together with the data taken at the LHC and the increasing number of physics analyses performed on this data, the capacity of the WLCG has grown continuously in the past. We look back on a time when the market offered data storage and computing power at a lower price year after year and thus the growing demand for resources could be covered even with a flat budget. This trend has weakened or at least requires more technological adjustments on the user side. At the same time, we are facing major challenges with regard to the large resource requirements of the HL-LHC and the necessity to provide these resources in a sustainable and environmentally friendly way. In many places, developments are being driven forward in terms of resource provision and utilisation to meet these challenges.

This presentation will provide a broad overview, with a particular focus on developments and related projects in Germany, and show a selection of highlights on the way to the future LHC Computing.

T 43: Invited Overview Talks II

Time: Wednesday 13:45–15:45 Location: ZHG011

Invited Overview Talk T 43.1 Wed 13:45 ZHG011

Advances in Silicon Detectors — •Matthias Hamer — Physikalisches Institut, Universität Bonn

Silicon detectors play a crucial role in modern particle physics experiments, highly performing in demanding environments. Many planned experiments put ever higher requirements on these detectors in terms of radiation dose, hit, data and trigger rates, timing, radiation length and more.

In my presentation I will talk about recent advances in the design of silicon detectors and detail how these advances enable upcoming experiments to meet these requirements. I will cover developments for hybrid and monolithic silicon tracking detectors and silicon calorimeters. I will highlight novel features that have been successfully implemented already, as well as the path ahead towards the realisation of some of the most challenging experiments yet.

Invited Overview Talk T 43.2 Wed 14:15 ZHG011

Exploring the dark universe: the experimental quest for axions and ALPs — •Julia K. Vogel — Fakultät für Physik, TU Dortmund, Otto-Hahn-Str. 4A, D-44227 Dortmund, Germany

Axions and axion-like particles (ALPs) are hypothetical particles predicted in extensions of the Standard Model (SM) of particle physics. Originally proposed as a solution to the strong CP problem in strong interactions, axions have since gained prominence due to their potential role as dark matter candidates. ALPs, more broadly, arise in various beyond-the-SM theories, such as string theory. Both are characterized by extremely low masses and weak couplings to ordinary matter, making them elusive yet fundamental to understanding the universe's hidden structure.

Experimental searches for axions and ALPs span a diverse range of techniques. Haloscopes, helioscopes, and laboratory-based experiments use cutting-edge technologies to detect faint axion signals, while astrophysical and cosmological observations provide indirect constraints. These efforts leverage advances in resonant cavities, magnet technology, and high-intensity lasers to probe unexplored parameter space. The ongoing quest for axions and ALPs is not only a test of theoretical models but a potential gateway to groundbreaking discoveries in physics.

In this talk we will review the landscape of axion and ALP searches introducing the various types of experimental setups employed to look for these hypothetical particles. We will also discuss current results and outline future prospects.

Invited Overview Talk T 43.3 Wed 14:45 ZHG011

Overview on coherent elastic neutrino nucleus scattering and successful first detections — •Janina Hakenmüller — Duke University, Durham, USA

Coherent elastic neutrino nucleus scattering (CEvNS) refers to the standard model process when the neutrino interacts with the nucleus as a whole. The cross section is enhanced by the neutron number squared of the target nucleus, which is ideal for a precision test of the standard model and to look for physics beyond the standard model. Neutrino energies below 50 MeV are required for a coherent interaction. The observable is the tiny recoil of the nucleus hit by the neutrino, which poses a huge challenge on the noise threshold of the detectors. A multitude of experiments with different technologies at different neutrino energies is desirable. The COHERENT collaboration was the first to observe CEvNS at the spallation neutron source at the Oak Ridge national laboratory, USA, with a CsI scintillating crystal in 2017. This was followed by two more successful observations, the most recent one in 2023 with high-purity germanium (HPGe) spectrometers. At lower neutrino energies, the CONUS collaboration also employs HPGe detectors at the Leibstadt power plant, Switzerland, to observe CEvNS for the first time at reactor site with the first data taking run concluded in 2024. The NUCLEUS experiment located at the Chooz reactor, France, and currently under commissioning aims at achieving the lowest energy threshold of these experiments with their cryogenic calorimeters. In my talk, I will present the current status of these experiments and achieved results followed by an outlook on the future.

Invited Overview Talk T 43.4 Wed 15:15 ZHG011

Shifting paradigms in Gravitational-wave Astrophysics — •Imre Bartos — University of Florida

The decade since the first detection of gravitational waves brought about several transformational discoveries. The LIGO and Virgo observatories detected more and heavier black holes than anticipated; the first detection of a neutron star merger through gravitational waves and across the electromagnetic spectrum provided invaluable insights on the production of the heaviest elements in the universe; and a particularly heavy black hole was discovered that could have not come from stellar core collapse. With the exponentially increasing rate of discoveries over the next decade and a half, gravitational waves are all but guaranteed to further shift our astrophysical paradigms. The talk will primarily focus on one of these shifting paradigms: the merger of black holes that was historically considered to be "dark" events producing only gravitational waves, but new observations point towards a brighter, more impactful, multimessenger picture.

T 44: Searches/BSM III (Long-lived, Misc.)

Time: Wednesday 16:15–18:15 Location: ZHG010

T 44.1 Wed 16:15 ZHG010

Probing Delayed Jets with Dedicated Long-Lived-Particle Triggers at ATLAS — •Tobias Stephan Heintz[1,2], Gareth Bird[2], Oleg Brandt[2], and Christopher Lester[2] — [1]Kirchhoff Insitute for Physics, Heidelberg, Germany — [2]Cavendish Laboratory, Cambridge, United Kingdom

Delayed energy deposits are a compelling signature in searches for long-lived particles (LLPs) at the LHC. This talk will present an analysis strategy to search jets that arrive at the ATLAS calorimeter with a significant time delay of up to 35 ns.

These delayed signals can serve as benchmarks for exploring a hidden sector beyond the Standard Model. For instance, long-lived dark matter particles may travel slowly due to a mass hierarchy in the production mechanism $pp \rightarrow$ scalar particle $\rightarrow$ LLPs, leading to delayed signals in the ATLAS detector. In extreme cases, LLPs with velocities below $\beta \sim 0.1$ could reach the calorimeter even in the subsequent bunch crossing (BC).

Conventional triggers are inefficient for such events, but ATLAS has implemented a dedicated LLP trigger at the hardware level. This trigger specifically examines two consecutive BCs for signatures of missing transverse energy in BC $N-1$ followed by a delayed jet in BC N. This talk will discuss the motivation, implementation, and potential of this trigger in uncovering new physics at the LHC in Run-3.

T 44.2 Wed 16:30 ZHG010

Search for long-lived supersymmetric decays in CMS — •Soumyaa Vashishtha[1,2] and Isabelle Melzer-Pellmann[1] — [1]Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, D-22607 Hamburg — [2]Universität zu Köln, Albertus-Magnus-Platz, 50923 Köln

The standard model is an effective theory but a low-energy approximation to a more complete theory. Supersymmetry (SUSY) extends the Standard Model but is expected to be broken and mediated to the visible sector via mechanisms like gravity or gauge mediation. In the search for beyond the standard model processes, we present an ongoing analysis based on simplified models to study the pair production and semileptonic decay of the hypothetical SUSY partner of the tau lepton, known as the stau ($\widetilde{\tau}$) within the CMS experiment at the CERN Large Hadron Collider (LHC). In gauge-mediated SUSY-breaking scenarios, the stau has macroscopic lifetime, and decays via $\widetilde{\tau} \rightarrow \tau \widetilde{\chi}_0^1$. This study focuses on events where one tau lepton decays to a muon, and the other decays hadronically, forming a jet. Using a dedicated machine learning algorithm for displaced tau tagging, we reconstruct the stau.

T 44.3 Wed 16:45 ZHG010

Search for long-lived axion-like particles produced in Higgs boson decays at the ATLAS Experiment — •Lukas Bauckhage[1,2] and Federico Meloni[1] — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [2]Physikalisches Institut, Universität Bonn, Bonn, Germany

Exotic Higgs decays to long-lived particles are featured in theories beyond the standard model related to hidden sectors, while (long-lived) axion-like particles are not only a prime candidate to dark matter but also part of hidden and dark sector theories. Preliminary results of an ATLAS Run 3 search for long-lived axion-like particles produced in a Higgs decay in association with a Z boson and decaying into a pair of photons are presented. The ALP decay's displacement challenges the standard photon reconstruction and calls for new techniques, such as machine learning and a new tagger utilising shower shape information. Detailed studies of the performance of these algorithms will be presented.

T 44.4 Wed 17:00 ZHG010

Search for Semivisible Jets with CMS Run 2 Scouting Data — •Marcel Gaisdörfer[1], Benedikt Maier[3], Brendan Regnery[1], Markus Klute[1], Jonas Janik[1], Kevin Pedro[4], Roberto Seidita[2], Cesare Tiziano Cazzaniga[2], Annapaola De Cosa[2], Aimar Aguado Berasaluce[2], Rebecca Natalia Hampp[2], and Celeste Holm[2] — [1]Karlsruher Institut für Technologie (KIT) — [2]ETH Zürich — [3]Imperial College London — [4]Fermilab (FNAL)

Semivisible jets are large area jets containing missing transverse momentum. These jets could be caused by a QCD-like dark sector, coupled to the SM via an additional Z' boson. The dark sector contains dark quarks, which while hadronizing form both stable and unstable dark hadrons. This hadronization process leads to large jets containing both SM particles and invisible DM particles.

This search uses data scouting, a technique that utilizes HLT reconstruction to access otherwise lost events below the typical trigger thresholds, to expand the parameter space of the existing s-channel search for a resonant Z' decaying into two semivisible jets.

This talk will present the search strategy, status and expected limits for the search for semivisible jets using scouting data collected by the CMS experiment during Run 2 of the LHC.

T 44.5 Wed 17:15 ZHG010

Search for high-mass resonances in dilepton final states with associated b-jets at the ATLAS experiment — Frank Ellinghaus and •Anna Bingham — Bergische Universität Wuppertal

An overview of a search for a Z' boson in high-mass dilepton (ee,$\mu\mu$) final states with associated b-jets is presented. The considered Z' model is a candidate explanation for potential anomalies in B hadron decays and couples to b and s quarks in the production. The search is carried out using the dataset collected by the ATLAS detector in Run-2 of the LHC corresponding to an integrated luminosity of 140 fb^{-1}. Backgrounds are estimated from MC and also by data-driven methods. Control, signal and validation regions are defined, and these regions are fitted in a profile-likelihood fit. Exclusion limits on the Z' mass are obtained based on the results of the fit.

T 44.6 Wed 17:30 ZHG010

Impact of polarized beams for Higgs, Electroweak and Dark Matter Physics — •Gudrid Moortgat-Pick — University of Hamburg, Hamburg, Germany — Wackerweg 1

Future Electron-Positron Linear Collider Designs (ILC, CLIC, HALHF) offer high-energy, polarized beams and high-precision measurements. In the talk we discuss the impact of polarized beams for the detection of the Higgs couplings, CP-violation effects and Dark Matter candidates with respect to the model distinction in different Beyond the Standard Models (MSSM, 2HDMS, inflation models). The current experimental bounds have been taken into account and involved parameter scans have been performed.

T 44.7 Wed 17:45 ZHG010

The Principle of Global Relativity — •Jochum van der Bij — Albert-Ludwigs Universitaet Freiburg, Deutschland

I present a new principle of relativity in physics. It is an alternative away from naturalness towards a new paradigm. It allows for an a priori derivation of the gauge structure of nature. In particular it can explain why there are precisely three generations of fermions. A specific form of dark matter is preferred. The standard model can only be extended in a minimalistic way.

T 44.8 Wed 18:00 ZHG010

Einstein's Basement: A new sector for hypothetical particles — •Fritz Riehle and Sebastian Ulbricht — Physikalisch-Technische Bundesanstalt Braunschweig

The extremely fruitful concept of an avoided crossing in mechanical, optical, electrical science and in quantum mechanics of molecules, quantum chemistry and others rises the question for a supplement of the relativistic physics of particles. In this new sector - dubbed as Einstein*s basement - new quasi particles with novel kinematic properties occur [1]. The new particles cannot be treated as a sector of the standard model of particles. We calculate the kinematics between the new particles and regular particles under Newtonian gravity which under special conditions can lead to repulsion of the basement particles and a modified interaction with regular matter.

[1] Fritz Riehle and Sebastian Ulbricht arXiv:2402.13679 [gr-qc]

T 45: Higgs Physics V (HH and Trilinear Coupling)

Time: Wednesday 16:15–18:15 Location: ZHG104

T 45.1 Wed 16:15 ZHG104

Estimation of the Background from $t\bar{t}$ Events with Misidentified Tau Leptons in the Search for Di-Higgs Production in the $HH \to bb\tau_{\mathrm{had}}\tau_{\mathrm{had}}$ Channel with the ATLAS Detector — •Baktash Amini, Christian Weiser, Benedict Tobias Winter, Yingjie Wei, and Karl Jakobs — Albert-Ludwigs-Universität Freiburg

Interactions involving multiple Higgs bosons in the final state are yet to be observed. The di-Higgs production via gluon-gluon fusion and vector-boson fusion processes at the LHC provides a unique opportunity to study those properties and test the predictions of the Standard Model for the Higgs boson self-couplings. Thanks to a good balance of signal yield and signal purity, di-Higgs boson production with one Higgs boson decaying into two b-quarks and one into two tau leptons is one of the best channels to measure the Higgs boson self-couplings. In the $HH \to bb\tau\tau$ analysis, the second largest background is the $t\bar{t}$ fake-$\tau_{\text{had-vis}}$ process, where at least one quark- or gluon-initiated jet is misidentified as a visible tau lepton, $\tau_{\text{had-vis}}$. This background is estimated via a data-driven scale-factor method in the search for non-resonant $HH \to bb\tau_{\mathrm{had}}\tau_{\mathrm{had}}$ decays at the ATLAS experiment. In the talk, I will present the scale factor method for the analysis of the Run 2 and partial Run 3 datasets.

T 45.2 Wed 16:30 ZHG104

Fake-τ background estimation for the ATLAS $HH \to bb\tau\tau$ analysis — •Philipp Rincke[1,2], Stan Lai[1], and Arnaud Ferrari[2] — [1]II. Physikalisches Institut, Georg-August-Universität Göttingen, Deutschland — [2]Department of Physics and Astronomy, Uppsala University, Sweden

The $HH \to bb\tau\tau$ analysis has the highest expected sensitivity to the Standard Model (SM) Higgs boson pair production signal based on the legacy Run 2 results. Several SM processes contribute to this final state as backgrounds. One of the most important backgrounds consists of processes where quark- and gluon-initiated jets are mis-identified as hadronically decaying τ leptons (fake-τ leptons), which are difficult to model precisely with simulations. A better description of these backgrounds can be achieved using data-driven methods, such as the Fake Factor method.

This talk will present the Fake Factor method which is under development for the Run 2 + Run 3 analysis to model the QCD multijet background in the $bb\tau\tau$ channel. The method relies on creating a fake-τ enriched template of events by inverting the τ lepton identification criteria. This template is then re-weighted using Fake Factors derived in control regions to model the QCD multijet background in the signal region, for which the current fake-τ background and uncertainty estimates will be shown.

T 45.3 Wed 16:45 ZHG104

Background estimation for the di-Higgs process $HH \to \bar{b}b\tau^-\tau^+$ with Run3 data from the CMS experiment — •Ana Andrade, Nathan Prouvost, Bogdan Wiederspan, Marcel Rieger, Philip Keicher, Anas Haddad, Tobias Kramer, and Peter Schleper — University of Hamburg, Hamburg, Germany

The shape of the Higgs potential plays a crucial role in our understanding of vacuum stability. The potential is directly dependent on the Higgs boson self-coupling which, despite continuous efforts, has yet to be experimentally observed. One way to probe its existence is through double Higgs boson production, where one Higgs boson directly couples to two final state Higgs bosons. The predicted cross-section of such a decay depends on the self-coupling strength and can therefore be probed with experimental data.

Since double Higgs boson production has a cross-section several orders of magnitude smaller than that of background processes, the efforts to observe the self-coupling are heavily limited by statistics. The channel $HH \to \bar{b}b\tau^-\tau^+$ is a promising target for such analyses as it offers a good compromise between sufficient statistics and reasonable background contamination. A major challenge in background estimation stems from multi-jet events, as these are notoriously difficult to simulate. In this talk, I will present techniques to model background processes in such analyses, with Run 3 data.

T 45.4 Wed 17:00 ZHG104

Morphing Di-Higgs processes — Ana Andrade, Anas Haddad, Philip Keicher, Tobias Kramer, •Nathan Prouvost, Marcel Rieger, Peter Schleper, and Bogdan Wiederspan — Universität Hamburg

The Standard Model of particle physics is currently the most successful theory describing our understanding of elementary particles and their interactions.

Currently, the investigation of the parameters of the Higgs mechanism is of utmost interest for tests of the predictions of the Standard Model. The trilinear higgs coupling is one such parameter. One of the challenges in the statistical interpretations of these measurements is the correct parametrisation of the distributions of the discriminating observable as a function of the coupling coefficients.

This talk summarizes a study on this topic based on a search for Di-Higgs production in the $bb\tau\tau$ final state at the CMS experiment.

T 45.5 Wed 17:15 ZHG104

Streamlined Optimization Studies in the Search for Di-Higgs Boson Production in the bb$\tau^+\tau^-$ channel at the ATLAS experiment — •Steffen Ludwig, Benedict Winter, Yingjie Wei, Christian Weiser, and Karl Jakobs — University of Freiburg, Institute of Physics, Freiburg im Breisgau, Germany

The Higgs boson has been studied at the Large Hadron Collider at CERN over the last decade with ever-increasing precision. However, one key quantity of electroweak symmetry breaking, the strength of the trilinear Higgs boson coupling, has not yet been observed due to the small Higgs pair production cross-section. A deviation of the coupling strength from the value predicted by the Standard Model would constitute an observation of new physics.

I will discuss prospects for improving the sensitivity of searches for the non-resonant production of Higgs boson pairs in the HH → bb$\tau^+\tau^-$ channel by using Graph Neural Networks. The study is based on the latest measurement with the Run 2 dataset using 140 fb^{-1} of proton-proton collisions at a center-of-mass energy of 13 TeV, recorded by the ATLAS detector at CERN.

To study the benefits of Graph Neural Networks and transformer models on parts of the analysis, I developed an automatization and orchestration tool, called grid-pipeline, to conduct the existing analysis and its derivatives. The tool's versatility enables the elementarization of complex computing workflows and the combination of resources from multiple computing sites. This allows for a significantly improved analysis optimization workflow and reduces the turn-around time.

T 45.6 Wed 17:30 ZHG104

Analysis for Run3 in the $HHH \to b\bar{b}b\bar{b}\tau\bar{\tau}$ channel with the CMS Experiment — •Thanh Tan Nguyen, Philip Keicher, Marcel Rieger, Nathan Prouvost, Ana Andrade, Bogdan Widerspan, Tobias Kramer, and Peter Schleper — University Hamburg, Hamburg, Germany

Understanding the Higgs mechanism is currently one of the largest fields of research at the LHC. One factor in this endeavor is the measurement of the Higgs self-coupling, which defines the shape of its potential. The sensitivity to this parameter of the standard model increases with the multiplicity of Higgs bosons. This analysis focuses on the triple Higgs production at LHC, which is sensitive to both the triple and quartic self-coupling. Here, the final state of four bottom quarks and two tau leptons is chosen; it*s a compromise between high branching ratio and clearer distinction of the decay products. The current status of this analysis is presented in this talk, with a particular focus on studies on the analysis phase space definition and the derivation of discriminating observables

T 45.7 Wed 17:45 ZHG104

Search for Higgs Boson Pair Production in Multi-Lepton Final States with the ATLAS Detector — Anamika Aggarwal, Volker Büscher, Christian Schmitt, •Niklas Schmitt, and Duc Bao Ta — Johannes Gutenberg-University, Mainz

After the discovery of the Higgs boson in 2012 at the LHC, many of its properties have already been determined precisely using 139 fb^{-1} of proton-proton collisions at $\sqrt{s}$ = 13 TeV. However, one of the biggest challenges in this field remains the measurement of the coupling of the Higgs boson to itself. It allows for a deep insight into the real shape of the Higgs potential and hence has a big impact on the understanding of fundamental interactions not only at the electroweak scale. In order to constrain the trilinear self-coupling, the Di-Higgs production cross section is measured. While decay modes including b-quarks typically have larger branching fractions, leptonic final states are generally much cleaner and have less SM background. Accordingly, probing this channel as a complement to $b\bar{b}$ analyses will be very promising.

This talk will give an overview about the analysis strategy, which relies on neural networks to distinguish the signal processes from the sum of all SM backgrounds. In addition, preparations for the Run 2 + partial Run 3 analysis, based on a combined dataset of about 300 fb^{-1}, will be presented, as well as a first look at Run 3 data and comparisons to Monte Carlo.

T 45.8 Wed 18:00 ZHG104

HH Analysis with Multileptons Using Run-2 ATLAS Data — •Elizaveta Denisova and Andre Sopczak — Czech Technical University in Prague

The latest results with Run-2 ATLAS data are presented for the search HH in the multilepton channel.

T 46: Higgs Physics VI (top-Higgs Coupling)

Time: Wednesday 16:15–18:15 Location: ZHG105

T 46.1 Wed 16:15 ZHG105

Significance Studies in the Dileptonic ttH(bb) Channel Using Run 3 CMS Simulation — •Philipp Nattland[1], Danyer Perez Adan[1], Kai Adamowicz[1], Lutz Feld[1], Valeria Botta[1], Kilian Krasenbrink[1], Matin Torkian[2], and Maria Aldaya Martin[2] — [1]RWTH Aachen University — [2]DESY, Hamburg

The associated production of a top-quark pair with a Higgs boson (ttH) directly probes the top-Higgs Yukawa coupling, a key parameter in the Standard Model. This study focuses on the ttH(bb) channel with dileptonic top decays, using Run 3 CMS simulation. Building on previous measurements with Run 2 data, we optimize event selection and background suppression to enhance signal significance. A binned maximum likelihood fit is employed to extract the expected signal significance, serving as a figure of merit for the optimization.

T 46.2 Wed 16:30 ZHG105

Preliminary Studies of the ttH(bb) Process in the Dileptonic Channel with SPANet, using CMS Run3 data — •Matin Torkian[1], Maria Aldaya martin[2], Dina Leyva Pernia[2], and Henriette Petersen[2] — [1]DESY, Hamburg University, Germany — [2]DESY, Hamburg, Germany

The Standard Model (SM) of particle physics predicts that the Higgs boson couples to fermions via a Yukawa-type interaction, with a strength proportional to the fermion mass. This makes the associated production of a Higgs boson with a top-quark pair ($t\bar{t}H$) a crucial process to directly probe the top-Higgs Yukawa coupling, an essential parameter for confirming the SM nature of the Higgs boson. Among Higgs boson decays, the channel into a $b\bar{b}$ quark pair has the largest branching fraction, offering an experimentally promising final state. However, ttH(bb) process faces significant challenges regarding backgrounds, especially $t\bar{t}$+jets production, with the $t\bar{t}b\bar{b}$ background being irreducible with respect to the $t\bar{t}H, H \to b\bar{b}$ signal. Advance Machine Learning techniques are essential to improve the sensitivity to the signal process.

This work focuses on the analysis of the $t\bar{t}H, H \to b\bar{b}$ process in events with two leptons, using proton-proton collision data collected by the CMS experiment at the LHC during Run3 at $\sqrt{s}$ = 13.6 TeV. ML methods are explored to significantly enhance the sensitivity to the $t\bar{t}H$ signal. For the first time in this final state we are exploring the potential of SPANet for jet-parton assignment and neutrino kinematic regressions and finally signal and background classification.

T 46.3 Wed 16:45 ZHG105

Kinematic reconstruction of t$\bar{t}$H (H → b$\bar{b}$) events in semileptonic t$\bar{t}$ final states using Run 2 CMS Simulation — •Kai Adamowicz, Lutz Feld, Danyer Perez Adan, Valeria Botta, and Philipp Nattland — RWTH Aachen

The $t\bar{t}H$ process provides a direct probe of the top-Higgs Yukawa coupling, an important parameter of the Standard Model. Due to a large and difficult to accurately model $t\bar{t}b\bar{b}$ background, its measurement in the $H \to b\bar{b}$ channel proved complicated. Using the transformer-based neural network architecture "SPANet", the prospect of a kinematic reconstruction of the final states is studied on Run 2 CMS simulation. This technique may form the basis of a signal extraction via the standard "bump hunt" approach using the invariant mass of the Higgs candidate, which has been proven succesful in many searches and cross section measurements of the SM Higgs boson in various decay modes.

T 46.4 Wed 17:00 ZHG105

Analysis of tH(bb) production with ATLAS Run-2 data — Andre Sopczak and •Roman Tomchik — Czech Technical University in Prague

The latest results of the analysis tH(bb) are presented with focus on machine learning using ATLAS Run-2 data.

T 46.5 Wed 17:15 ZHG105

ttH analysis with two light leptons and one hadronically decaying tau lepton with Run-2 ATLAS data — •Alina Haitota and Andre Sopczak — Czech Technical University in Prague

The latest results of the analysis ttH in the 2lSS1tau channel are presented with focus on machine learning using ATLAS Run-2 data.

T 46.6 Wed 17:30 ZHG105

Associated production of a Higgs boson and a single top quark from t-channel production (tHq) in channels with hadronically decaying tau leptons at ATLAS — •Florian Kirfel and Ian C. Brock — Physikalisches Institut der Universtiät Bonn, Deutschland

A measurement of single top-quark production in association with a Higgs boson and a spectator light-quark (tHq) gives insight into the properties of not only the top quark but also the Higgs boson. The associated production is uniquely sensitive to the relative sign of the top quark-Higgs boson Yukawa coupling.

The decay of the Higgs boson into two tau leptons is covered by the presented analysis. Both cases in which one or two taus decay hadronically are considered

and analysed based on the Run 2 LHC dataset from ATLAS.

The complete analysis workflow is covered, ranging from the treatment of light lepton and tau lepton misidentification, over the application of a categorical neural network for signal isolation with a k-fold training approach to a binned maximum likelihood estimation for the purpose of cross section estimation.

T 46.7 Wed 17:45 ZHG105

Higgs boson mass reconstruction in the analysis of tH($\tau\tau$) production with ATLAS Run-2 data — •Jiri Javora and Andre Sopczak — Czech Technical University in Prague

The latest results on the mass reconstruction in the analysis tH($\tau\tau$) are presented with focus on machine learning using ATLAS Run-2 data.

T 46.8 Wed 18:00 ZHG105

Application of the JAX-based Statistical Tool Evermore to a CMS Higgs Analysis — Peter Fackeldey[2], •Felix Zinn[1], Benjamin Fischer[1], and Martin Erdmann[1] — [1]RWTH Aachen University — [2]Princeton University

For precise measurements of the Higgs boson cross sections and coupling strengths, a likelihood based approach is typically needed for statistical inference. We introduce the python software package `evermore` which allows to define corresponding likelihood functions.

It is purely based on JAX and thus enables novel computing concepts such as automatic differentation and vectorization in the context of likelihood fitting.

We show how to build and evaluate a likelihood function in evermore with the example of an analysis of the tH and ttH production channel.

Furthermore we present how to set an upper limit on a parameter of interest. This procedure often requires the generation of pseudo data. We show how vectorized computation in `evermore` can be used for a toy-based approach.

T 47: Axions/ALPs II

Time: Wednesday 16:15–18:15 Location: VG 0.110

T 47.1 Wed 16:15 VG 0.110

Long-lived axion-like particles at the FCC-ee — Freya Blekman[1,2], Juliette Alimena[2], Lovisa Rygaard[1,2], and •Elnura Bakhishova[1] — [1]University of Hamburg, Germany — [2]Deutsche Elektronen-Synchrotron DESY, Hamburg, Germany

We study the sensitivity to long-lived particles (LLPs) of a proposed circular electron-positron collider, the FCC-ee. The very low background environments in electron-positron collisions provide exciting opportunities to search for several types of LLPs. This talk will focus on one example of a physics case resulting in a long-lived signature, namely, axion-like particles (ALPs), and it will show the sensitivity of the FCC-ee to a long-lived ALP signature.

T 47.2 Wed 16:30 VG 0.110

Searching for ALPs through Photon Fusion at the Belle II experiment — •Frederik Schmitt, Giacomo De Pietro, Torben Ferber, and Alexander Heidelbach — Institute of Experimental Particle, Karlsruhe Institute of Technology, Karlsruhe, Germany

Axion-Like Particles (ALPs) represent an extension of the standard model and may serve as a portal to a dark sector. At the high-intensity e^+e^- collider SuperKEKB, ALPs could be produced in direct e^+e^- interactions. For low masses, ALPs are predominantly produced via vector-boson fusion. Focusing on primarily electroweak couplings, specifically to photons, an interesting decay arises with $e^+e^- \to e^+e^-a$, $a \to \gamma\gamma$. This analysis investigates the sensitivity of Belle II for the given decay and its challenges which lie in the kinematic distribution of the final state particles - closely resembling radiative Bhabha-scattering. Considering the expectance of low lepton angles, the analysis considers 4 tag cases where either no, one positive/negative or both leptons are fully reconstructed. This talk will present the current status of the search and the complexities and advantages of each tag.

T 47.3 Wed 16:45 VG 0.110

Search for ALPs in $e^+e^- \to \gamma a, a \to \gamma\gamma$ at Belle II — •Alexander Heidelbach, Giacomo De Pietro, and Torben Ferber — Institute of Experimental Particle, Karlsruhe Institute of Technology, Karlsruhe, Germany

Axion-Like Particles (ALPs), predicted by theoretical extensions of the Standard Model, represent potential Dark Matter mediators. We are searching for the $e^+e^- \to \gamma a$ channel, with subsequent ALP decay into a photon pair, at the Belle II experiment. This study utilizes the Belle II detector's precision, the SuperKEKB collider's high luminosity, and a unique understanding of the initial state to explore a diverse range of ALP masses and couplings in this fully neutral three-photon final state.

Compared to the predecessor analysis based on the 2018 dataset, this analysis targets an around 1000 times larger dataset, an improved understanding of the photon reconstruction resolution, kinematic fits to the initial state, and an MVA-based candidate selection. This talk will discuss the current state of the new analysis.

T 47.4 Wed 17:00 VG 0.110

Search for the $K^+ \to \pi^+\pi^0 A$ decay — •Marco Ceoletta — Johannes Gutenberg Universitat, Mainz, Germany

This analysis aims to search for the hypothetical decay $K^+ \to \pi^+\pi^0 A$, where A is Feebly-Interacting Particle (FIP) like an Axion-like particle (ALP) or a Dark Photon, at the NA62 experiment (CERN). Obtaining a stringent upper limit on BR($K^+ \to \pi^+\pi^0 A$) is important for the verification of BSM theories. In particular the decay is sensitive to an axial-vector coupling of hypothetical pseudo-scalar particles to quarks. A search on $K^+ \to \pi^+\pi^0 A$ therefore complements the extensive work already performed on the associated two-body decay $K^+ \to \pi^+ A$, that is sensitive only to the polar-vector coupling current. A preliminary upper limit of the branching ratio to ALPs, as part of a feasibility study done in 2022, already outperformed the best previous limit using less than 20% of the available data. The presentation describes the analysis and gives an outlook on the selection and expected upper limits.

T 47.5 Wed 17:15 VG 0.110

Optimization of Background Determination Using Machine Learning with ATLAS Forward Proton Detector Data — •Andrei Aiurov, Viktoriia Lysenko, and Andre Sopczak — Czech Technical University in Prague

The neutral Standard Model Higgs boson was discovered in 2012 at CERN with a two-photon signature, and the search for further particles of extended models continues, in particular, the search for an Axion-Like-Particle (ALP). An ALP can be produced with a signature of two photons. The separation of ALP production from unwanted background reactions is crucial. In this analysis, the recorded data is used to determine the background expectation with machine learning algorithms to optimize the search for ALPs.

T 47.6 Wed 17:30 VG 0.110

Determination of the absolute X-ray detection efficiency of the TAXO SDD for IAXO — •Patrick Bongratz[1], Susanne Mertens[1,2], Lucinda Schönfeld[1], Daniel Siegmann[2], Juan Pablo Ulloa Beteta[2], and Christoph Wiesinger[2] for the IAXO-Collaboration — [1]Max Planck Institut für Kernphysik, Heidelberg, DE — [2]Physik-Department, Technische Universität München, Garching, DE

The International Axion Observatory (IAXO) aims to improve the search for solar axions by at least one order of magnitude with respect to previous helioscope experiments. In a helioscope experiment solar axions are back-converted to X-rays in a strong magnet pointed at the sun. Silicon drift detectors (SDDs) are particularly suited to detect this signal. Good noise performance allows for sub-keV thresholds, while a thin entrance window ensures high detection efficiency. In this talk, I will report on the TRISTAN SDD for IAXO (TAXO) project and the measurement of the absolute X-ray detection efficiency at the SOLEIL synchrotron facility. This project has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and innovation programme (grant agreement No. 852845).

T 47.7 Wed 17:45 VG 0.110

Development for an all semiconductor active-shield Detectors for IAXO — •Juan Pablo Ulloa Beteta[1], Susanne Mertens[2], Lucinda Schönfeld[2], Christoph Wiesinger[1], Michael Willers[1], and Patrick Bongratz[2] for the IAXO-Collaboration — [1]Physik- Department, Technische Universität München, Garching, DE — [2]Max Planck Institut für Kernphysik, Heidelberg, DE

The search for axions - a solution to the strong CP problem and a promising candidate for cold dark matter - is at the heart of the International Axion Observatory (IAXO). This next-generation helioscope experiment seeks to detect solar axions by converting them into X-ray photons. A critical challenge in achieving the required sensitivity for IAXO is the suppression of background caused by radioactivity and cosmic radiation. To address this, we are developing a novel all-semiconductor active-shield detector system. The system consists of a single-pixel Silicon Drift Detector (SDD) embedded within a High-Purity Germanium (HPGe) well-type detector, which serves as an active shielding to suppress background events. I will discuss the design progress and characterization studies of both the SDD and the HPGe detector, focusing on their energy resolution and noise performance. This project has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and

innovation programme (grant agreement No. 852845). It has also been supported by the DFG through the Excellence Cluster ORIGINS.

T 47.8 Wed 18:00 VG 0.110

Searching for New Physics with Nuclear Lineshape Data — •Fiona Kirk — PTB Braunschweig Germany — Leibniz University Hannover

Because of its potential as a nuclear clock state, the exceptionally low-lying isomer thorium-229m has been the subject of intense research for several decades. Recently, this state was laser-excited for the first time, bringing us an important step closer to the realisation of nuclear clocks, but also opening up new possibilities to search for new physics that couples to the quantum chromodynamics (QCD) sector.

In this talk I will describe how new physics might affect the shape of the nuclear resonance, and explain how nuclear lineshape data can already today set competitive bounds on ultra-light dark matter coupling to the QCD sector, or more generally, on the time variation of the QCD scale.

T 48: Silicon Detectors V (R&D, Simulation)

Time: Wednesday 16:15–18:45 Location: VG 0.111

T 48.1 Wed 16:15 VG 0.111

Design and Production of Pixel Strip Modules for the P2 Tracking Detector — •Lucas Sebastian Binn for the P2-Collaboration — Institute of Nuclear Physics, Johannes Gutenberg-University Mainz

The P2 Experiment at the new Mainz Energy-Recovering Superconducting Accelerator (MESA), which is currently under construction in Mainz, will measure the weak mixing angle in electron-proton scattering at low momentum transfer with unprecedented precision.

A key parameter for the analysis, the momentum transfer Q^2, is measured by a tracking detector consisting of 4 identical modules arranged in two layers. Each module consists of two sensor planes, with pixel sensors glued and wire-bonded on rigid-flex strips.

The mechanical, electrical, and cooling design have been developed and are currently undergoing testing. For this purpose, a scaled-down protoype has been constructed.

With a total production of 260 strips, processes are semi-automated, with dedicated glue and bonding machines.

This talk gives an overview of the P2 experiment with focus on the tracking detector, as well as the current state of the development of the strip modules and readout.

T 48.2 Wed 16:30 VG 0.111

Validation of TCAD simulations of the edge of planar silicon sensors to understand breakdown — •Christian Scharf[1], Peilin Li[1], Heiko Lacker[1], Ingo Bloch[2], Ilona Stefana Ninca[2], and Ben Brüers[2] — [1]Humboldt-Universität zu Berlin — [2]Deutsches Elektronen-Synchrotron (DESY)

Silicon sensors are widely used in high-energy physics due to their low material budget and radiation hardness. However, they are susceptible to surface breakdown, particularly under humid conditions. This study aims to improve the understanding of the underlying mechanisms by identifying the relevant defects contributing to electrical breakdown, and developing new methods to probe the electric field at the sensor's edge. Avalanche breakdown primarily occurs near the Si-SiO_2-interface, where localized electric field peaks can form between the guard ring and the edge. The local electric field is influenced by defects near the oxide surface and interface as well as the geometry of the sensor. Therefore, accurate simulations are challenging and it is essential to validate simulation parameters by comparing the simulation results to measurements.

The edge region of planar silicon diodes was simulated using Synopsis TCAD. Current, capacitance, and Transient Current Technique (TCT) simulations were performed and compared to measurements. Additionally, Allpix Squared simulations were used to determine whether the surface electric field near the edge can be extracted from top TCT measurements with 660 nm laser pulses using the prompt current method, similar to edge TCT.

T 48.3 Wed 16:45 VG 0.111

Open-Source Simulation of Semiconductor Detectors using SolidStateDetectors.jl — •Felix Hagemann, Julian Henzler, Benedikt Nagler, Ariana Pearson, and Oliver Schulz — Max Planck Institut für Physik, Garching, Deutschland

`SolidStateDetectors.jl` is a novel open-source software solution used to simulate the behavior of solid state detectors, e.g. germanium and silicon detectors. The package calculates the electric fields and weighting potentials, as well as the charge drift in the detectors and detector output signals.

Users can define arbitrary detector geometries via simple configuration files using constructive solid geometry. Detectors may also be segmented/pixelized and have more than two electrical contacts. The environment of the detector can be included in the geometry and the field calculation to simulate the effect of nearby objects on the field in detectors with large passivated surfaces.

`SolidStateDetectors.jl` features fully multi-threaded high-performance 3D field calculation in both cylindrical and Cartesian coordinates. Recent feature additions include simulation of the charge-cloud self-interactions, automatic detector capacitance calculation, GPU-support for accelerated field calculations, a simple charge trapping model and an extension to the Julia wrapper `Geant4.jl`, which allows for the simulation of realistic event distributions.

T 48.4 Wed 17:00 VG 0.111

Resistive Silicon Detector R&D for Future Detectors — •Ling Leander Grimm, Alexander Dierlamm, Umut Elicabuk, Ulrich Husemann, Markus Klute, and Brendan Regnery — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

The HL-LHC and future colliders present new challenges for the next generation of detectors, including improving pileup mitigation in high luminosity environments and particle identification. Resistive Silicon Detectors (RSDs/AC-LGADs) provide a promising solution by allowing "4D" tracking while minimizing power consumption, number of readout channels, and material budget.

RSDs combine Low Gain Avalanche Diode (LGAD) technology with a resistive cathode layer. Thanks to internal gain, the detector can be kept thin and therefore reduce material budget, while the resistive layer enables charge sharing among readout electrodes. As a result, the electrodes can be spaced further apart, which decreases the total number of required readout channels.

TCAD simulations aid in optimizing detector parameters and understanding internal functionality. Especially important is the determination of pad size and electrode shape.

This talk presents recent progress in Sentaurus TCAD simulations and experimental advances for RSD development at KIT and INFN/University of Torino.

T 48.5 Wed 17:15 VG 0.111

Measurements on the bPOL48V DC-DC Converter for a Future Particle Collider — Lutz Feld, Katja Klein, Martin Lipinski, Alexander Pauls, and •Joëlle Savelberg — 1. Physikalisches Institut B, RWTH Aachen

The bPOL48V is a DC-DC Point-Of-Load (POL) converter characterized in collaboration with CERN under the DRD7 program, a new Detector R&D initiative to develop future electronic systems and technologies for particle physics detectors. The bPOL48V enables power distribution by converting a 48V input to a 12V (adjustable) output voltage. This enables distribution at higher voltage and reduced current in supply cables, enhancing overall system efficiency by minimizing the power loss.

The bPOL48V consists of a rad-hard controller designed at CERN (GaN Controller), which is capable of continuous operation up to a high radiation limit of 50 Mrad and in magnetic fields exceeding 4 T. The GaN controller operates in conjunction with a power stage featuring a GaN chipset from EPC (EPC2152). This combination provides performance in harsh radiation and magnetic field environments, making it a potential solution for power distribution in high energy physics experiments.

This talk focuses on the tests conducted with the bPOL48V in various setups and the resulting performance. Key aspects include the converter's efficiency, temperature dependency, noise characteristics, and its ability to maintain a stable output voltage despite variations in input voltage and current.

T 48.6 Wed 17:30 VG 0.111

Characterisation and Simulation of stitched CMOS Strip Sensors — •Naomi Davis for the CMOS Strips Collaboration-Collaboration — Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

In high-energy physics, there is a need to investigate silicon sensor concepts that offer large- area coverage and cost-efficiency for particle tracking detectors. Sensors based on CMOS imaging technology present a promising alternative silicon sensor concept. As this technology follows a standardised industry process, it can provide lower sensor production costs and enable fast and large-scale production from various vendors.

The CMOS Strips project is investigating passive CMOS strip sensors fabricated by LFoundry in a 150 nm technology. The stitching technique was employed to develop two different strip sensor formats. The strip implant layout varies in doping concentration and width, allowing to study various depletion concepts and electric field configurations.

The performance of unirradiated samples is evaluated based on several test beam campaigns conducted at the DESY II test beam facility. Additionally, the detector response is simulated using Monte Carlo methods combined with TCAD Device simulations.

This contribution presents studies on the test beam performance of the sensors concerning their hit detection efficiency and resolution. In particular, the simulated detector response is presented and compared to test beam data.

T 48.7 Wed 17:45 VG 0.111

A novel Low Gain Avalanche Diode design: MARTHA — •Constanze Wais[1], Alexander Bähr[2], J. Damore[2], Erika Garutti[1], Christian Koffmane[2], Jelena Ninkovic[2], Rainer Richter[2], Gerhard Schaller[2], Florian Schopper[2], Jörn Schwandt[1], Johannes Treis[2], and Annika Vauth[1] — [1]University of Hamburg — [2]Semiconductor Laboratory of the Max Planck Society

The MARTHA - 'Monolithic Array of Reach THrough Avalanche photo diodes' design aims to tackle the collapse of the electric field at the gaps of LGAD (low gain avalanche diode) pixel arrays while also preventing the pixel edges from becoming blind. By adding an additional n-doped field drop layer (FDL) between the multiplication layer and the n^+-pixel contacts, the electric field at the n^+-edges is reduced, thereby preventing them from breaking down. Since this FDL does not interrupt the multiplication layer, particle detection is also possible in the interpixel regions. A first prototype batch with test structures, such as diodes with and without a gain layer, and strip sensors based on the MARTHA principle has already been fabricated. The sensors are optimised for photon science and are expected to have a fill factor of 100%. In this talk the MARTHA concept as well as initial characterisation measurements, utilising I-V, C-V and TCT techniques, will be presented.

T 48.8 Wed 18:00 VG 0.111

Exploring the potential of 4H-SiC diodes: Electrical properties and electron-hole pair creation energy — •Silas Müller[1], Pascal Wolf[1], Patrick Ahlburg[1], Grégory Grosset[2], Tomasz Hemperek[1], and Jochen Dingfelder[1] — [1]University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany — [2]Ion Beam Services IBS, Rue Gaston Imbert prolongée, ZI Peynier Rousset, 13790 Peynier, France

Silicon detectors are often used as tracking detectors in high-energy physics experiments as they can be designed for high radiation tolerance, high granularity and fast readout needed in such experiments. Furthermore, silicon is well understood and widely available. Silicon carbide (SiC) exhibits promising characteristics for the use in high-energy physics as well. Its wide band gap of 3.23 eV results in low leakage current, allowing for operation at high temperatures. The high displacement energy of 30-40 eV compared to 13-15 eV in silicon results in potentially better radiation hardness.

This talk presents an investigation of the properties of a p-in-n 4H-SiC diode. Details regarding the electrical characteristics of the diode as well as measurements determining the energy needed to create electron-hole pairs in 4H-SiC are discussed.

T 48.9 Wed 18:15 VG 0.111

Wafer-to-wafer bonded hybrid pixel detectors for high energy physics and medical applications — Fabian Hügging[1], Kevin Kröninger[2], Maximilian Mucha[1], •Janna Vischer[2], and Jens Weingarten[2] — [1]Universität Bonn, Bonn, Germany — [2]Technische Universität Dortmund, Dortmund, Germany

Semiconductor pixel detectors allow for precisely tracking ionizing particles in high-energy physics experiments and medical applications. Previously, during the manufacturing of hybrid pixel detectors, a common practice to combine the separately manufactured sensor and its readout chip is to bump-bond two single dies together. Wafer-to-wafer bonding is a method in development for manufacturing hybrid pixel detectors, where whole detector wafers and chip wafers are bonded before being diced to their definite size. This promises detectors to have larger sensitive areas and a reduced thickness through thinning of the wafers after bonding. Currently, silicon sensor wafers have been developed for a combination with Timepix3 read-out chip wafers.

This talk will give an introduction to the first wafer-to-wafer semiconductor pixel detectors with a focus on the investigations of the still unbounded sensor wafer and a prospect of upcoming bonded wafer measurements.

T 48.10 Wed 18:30 VG 0.111

Test beam analysis of irradiated, passive CMOS strip sensors — •Fabian Lex for the CMOS Strips Collaboration-Collaboration — Albert-Ludwigs-Universität Freiburg, Freiburg, Germany

Nearly all envisioned future high-energy particle detectors will employ silicon sensors as their main tracking devices. Due to the increased demand in performance, large areas of the detectors will have to be covered with radiation hard silicon, facilitating the need for silicon sensors produced in large quantities, reliably and cost-efficiently. A possible solution to these challenges has been found in the utilization of the CMOS process, which is an industrial standard, offering the advantage of a large choice of vendors and reduced production costs. To create the larger sensor structures typical for silicon strip trackers, the stitching process has to be used. Three variations of passive CMOS strip sensors have been designed by the University of Bonn and produced by LFoundry in a 150 nm process. Sensor samples have been irradiated up to a fluence of $1 \cdot 10^{16} n_{eq}/cm^2$ with reactor neutrons and up to $1 \cdot 10^{15} n_{eq}/cm^2$ with 23 GeV protons. In order to investigate the general performance of the designs, they were simulated with Sentaurus TCAD software and investigated in several test beam campaigns at the DESY-II facility. This talk will summarise the most important results of the simulation as well as the measurements of the irradiated samples.

T 49: Detectors IV (Scintillators)

Time: Wednesday 16:15–17:45 Location: VG 1.101

T 49.1 Wed 16:15 VG 1.101

Performance of Large Area Liquid Scintillator Detectors with Wavelength-shifting Optical Modules — •Andrés Krolla for the SHiP-SBT-Collaboration — ALU Freiburg, Physikalisches Institut, 79104 Freiburg (DE)

For the mitigation of background events caused by deep inelastic scattering of muons and neutrinos, a large volume tagger system is being developed. Main requirements are accurate timing information and positional reconstruction. The detector design is organic liquid scintillator based and uses immersed Wavelength-shifting Optical Modules for light collection. Of special interest is the efficiency and quality of the light collection depending on the choice of inner lining materials, which can be diffusely or specularly reflecting. Light yield heavily influences the positional reconstruction and requirements on data acquisition. Light yield measurements from detectors with barium-sulfate paint, PTFE or aluminum reflector foil coatings as well as untreated metal surfaces will be compared.

T 49.2 Wed 16:30 VG 1.101

Testbeam Performance and Signal Yields of Prototypes for the SHiP SBT — •Fairhurst Lyons for the SHiP-SBT-Collaboration — University of Freiburg, Freiburg, Germany

We present R&D towards the surrounding background tagger (SBT) of the Search for Hidden Particles (SHiP) experiment, a general-purpose detector housed at the CERN SPS accelerator to search for light, feebly interacting particles. This is a large-area detector for energy reconstruction and tracking, which consists of many individual cells filled with liquid scintillator. Each cell is equipped with two wavelength-shifting optical modules (WOMs) that capture scintillation light and transfer it to silicon photomultipliers. Multiple such cells with different detector materials were tested at a CERN SPS μ^- testbeam; analysis of performance and comparison with simulation will be presented here.

T 49.3 Wed 16:45 VG 1.101

Testbeam measurements with prototypes of the Surround- ing Background Tagger of the SHiP experiment — •Alessia Brignoli for the SHiP-SBT-Collaboration — Humboldt Universität zu Berlin

The Surrounding Background Tagger (SBT) is a crucial part of the SHiP experiment to suppress background from muons entering the decay vessel of the experiment or from muon/neutrino inelastic inter- actions inside the decay volume and its surroundings. The SBT is based on liquid scintillator (LAB+PPO) filled cells. Light collection is performed through PMMA Wavelength-Shifting Optical Modules (WOMs), optically coupled to an array of 40 SiPMs. We present results obtained with different prototypes. The first four-cells prototype, improving of a one-cell prototype that was tested with positrons in Oc- tober 2022 at DESY, was tested in spring 2024 with muons at CERN's PS. Three one-cell prototypes that were tested with muons in CERN's PS in November 2024. The different prototyes differ in the cell con- struction material, steel or aluminium, as well as the material used for increasing the inner walls reflectivity, crucial for the light collec- tion. For all the prototypes, each cell was equipped with two WOM tubes. The timing performance of the detector, which is important for the background rejection capabilities of the final SBT detector, was studied. In parallel, the comparison of data with Geant4-based photon transportation simulations results allows us to gather further information about the detector response and the quality of the built prototypes.

T 49.4 Wed 17:00 VG 1.101

On Calibration and Timing of the Mu3e Tile Detector — •Erik Steinkamp for the Mu3e-Collaboration — Kirchhoff-Institut für Physik, Heidelberg, Deutschland

The Mu3e experiment has been designed with the objective of detecting the charged lepton flavour violating decay $\mu \rightarrow eee$ with a branching ratio sensitivity of 10^{-16}, which represents the final goal for the second phase of the ex-

periment. This would represent a four-order-of-magnitude improvement on the current limit. The primary challenge associated with the Mu3e detector is excellent background suppression. This necessitates, in addition to precise vertexing and tracking using monolithic pixel sensors, the acquisition of highly precise timing data.

The Mu3e tile detector is a scintillator-based timing detector with SiPM readout that aims at a timing resolution of less than 100 ps. In order to guarantee this level of performance, it is essential to conduct a precise calibration of the detector. This presentation will focus on the calibration process, which is primarily concerned with the configuration of the readout electronics, particularly the MuTRiG ASICs, which are responsible for SiPM readout and digitization. Furthermore, the time-walk effect, which is caused by the non-linear response of the scintillator material, in addition to the time synchronisation must be realized between the various channels within and between the ASICs. In order to evaluate the timing resolution of the detector, calibration and time walk correction methods are applied to test beam data taken at DESY. The resulting performance studies and the evaluation of the detector's timing resolution will be presented.

T 49.5 Wed 17:15 VG 1.101

Timing characterization for T2K ND280Upgrade detector — •Gioele Reina — Johannes Gutenberg- Universität Mainz

The T2K experiment is a long baseline neutrino experiment, located in Japan. It studies neutrino oscillations by detecting accelerator neutrinos with a complex of near detectors and a far detector. ND280, one of the near detectors, provides a reduction of the neutrino flux and cross section uncertainties.

The new features of the upgraded ND280 detector allow to improve these capabilities. In particular, the newly installed target, the Super Fine-Grained Detector, consists of small plastic scintillator cubes read out by three WLS fibers in the three orthogonal directions. This new detector design offers high granularity and 3D reconstruction, unlocking the sensitivity to neutron detection and reconstruction by measuring its time of flight in the detector.

In such a context, the timing characterization of this detector is crucial. Here, a new methodology to perform time calibration for any high granular detector is described. By exploiting the granularity of the detector, it is possible to evaluate offsets and time walk contributions, along with the time resolution of the detector. The application and the results of this method are presented, allowing the upgraded ND280 to detect neutrons.

T 49.6 Wed 17:30 VG 1.101

Characterisation of hybrid-opaque scintillators for the *NuDoubt*$^{++}$ experiment — •Miriam Weigand for the NuDoubt-Collaboration — Johannes Gutenberg-Universität Mainz, Institut für Physik, 55128 Mainz, Germany

The *NuDoubt*$^{++}$ experiment is dedicated to the advanced search for double beta plus decay ($2\beta^+$), a rare nuclear disintegration process with an extremely long half-life of 10^{18} to 10^{24} years. In the Standard Model (SM), each double beta decay ($2\nu2\beta^+$) produces two neutrinos, but there is also the possibility of non-SM neutrino-less double beta decays ($0\nu2\beta^+$), which would suggest the Majorana nature of the neutrino.

Central to the *NuDoubt*$^{++}$ effort is the development of an innovative detector concept based on a hybrid, slow and opaque liquid scintillator loaded with the $2\beta^+$-decaying isotope. The hybrid scintillator uses slow light emission to enhance the detection of the Cherenkov and scintillation light, which allows the distinction of particle types. Wax is added to create an opaque scintillator that locally confines the produced photons. A grid of Optimised WaveLength-shifting (OWL) fibres is distributed throughout the detector to collect the light and allow detailed energy deposition patterns to be reconstructed.

This talk will discuss the demonstrator setup designed to test the new detector concept and to improve the composition and interplay of the components used.

T 50: Detectors V (Misc.)

Time: Wednesday 16:15–17:15 Location: VG 1.102

T 50.1 Wed 16:15 VG 1.102

Progress and Results of the AMoRE: Exploring Neutrinoless Double-Beta Decay with Molybdate Scintillators — •Cagla Mahanoglu, Christian Enss, Andreas Fleischmann, Daniel Hengstler, Ashish Jadhav, Ioana-Alexandra Nitu, Christian Ritter, Andreas Reifenberger, Daniel Unger, and Loredana Gastaldo — Kirchhoff Institute for Physics, Heidelberg University

The Advanced Molybdenum-based Rare process Experiment (AMoRE) aims to search for neutrinoless double-beta ($0\nu\beta\beta$) decay of the ^{100}Mo isotope using molybdate scintillating crystals. This rare nuclear process, if observed, would confirm the Majorana nature of neutrinos, provide insight into the absolute neutrino mass scale, and reveal new physics beyond the Standard Model. The experiment makes use of metallic magnetic calorimeter (MMC) sensors to achieve high energy resolution and efficient particle discrimination. AMoRE operates in three phases: AMoRE-Pilot (1.887 kg detector, 0.886 kg of ^{100}Mo), AMoRE-I (6 kg array of ^{100}Mo-enriched crystals), and AMoRE-II (large-scale 200 kg array at the Yemilab underground facility). Results from AMoRE-Pilot set a limit on the half-life of $T_{1/2} > 9.5 \times 10^{22}$ years. In AMoRE-I, a new lower limit of $T_{1/2} > 3.0 \times 10^{24}$ years (at the 90 percent confidence level) was achieved. The aim of AMoRE-II is to reach a sensitivity of $T_{1/2} > 6 \times 10^{26}$ years, which would cover the entire inverted Majorana neutrino mass hierarchy range of (15-46) meV. This talk will highlight the current status of the AMoRE, innovative advancements in detector design and optimization of analysis techniques.

T 50.2 Wed 16:30 VG 1.102

Strong-field QED measurement tests at FACET-II using new electron detector concept — •Luke Hendriks[1,3], Antonios Athanassiadis[1,2], Louis Helary[1], Ruth Magdalena Jacobs[1], Jenny List[1], Gudrid Moortgat-Pick[2], Evan Ranken[1], Ivo Schulthess[1], Matthew Wing[1,3], and E320 Collaboration[4] — [1]Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany — [2]Universität Hamburg, Hamburg, Germany — [3]University College London (UCL), London, United Kingdom — [4]SLAC National Accelerator Laboratory, Menlo Park, California, United States

Strong-Field Quantum Electrodynamics (SFQED) is an emergent field of physics, where conventional quantum electrodynamics calculations become non-perturbative due to a strong electromagnetic background field. This gives rise to non-linear Compton scattering and non-linear Breit-Wheeler pair production. Advances in laser technology have made it possible to explore this field, by colliding photons from a high-intensity laser with a high-energy electron beam. One of the experiments that will measure SFQED phenomena is LUXE, an experiment planned at DESY. Part of LUXE is its electron detection system (EDS), which will measure high rates of electrons coming from electron-laser interactions. It consists of a segmented straw Cherenkov detector, and a scintillator screen and camera set-up. A prototype of the EDS has recently made measurements with E320, an SFQED experiment at the FACET-II facility at SLAC, where it measured non-linear Compton scattering. This talk will discuss the prototype of the EDS and the first results obtained from the measurements at E320.

T 50.3 Wed 16:45 VG 1.102

Current status of the Mu2e experiment at Fermilab — •Stefan E. Müller, Anna Ferrari, Oliver Knodel, and Reuven Rachamin for the Mu2e-Collaboration — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

The Mu2e experiment, which is currently under construction at the Fermi National Accelerator Laboratory near Chicago, will search for the neutrinoless direct conversion of a muon to an electron in the field of an aluminum nucleus, aiming at a sensitivity four orders of magnitude better than previous experiments. The observation of a signal would imply the violation of charged lepton flavor, and hint at physics beyond the standard model.

The design and status of the Mu2e experiment and its detector subsystems will be presented. With the large superconducting solenoid magnets guiding the muons finally arriving on site at Fermilab, the experiment enters an exciting phase of its construction towards data taking.

T 50.4 Wed 17:00 VG 1.102

On the Production and QA of the Mu3e Tile Detector — •Küpperbusch Jan for the Mu3e-Collaboration — Kirchhoff-Institut für Physik, Heidelberg, Deutschland

The Mu3e experiment aims to find or exclude the occurrence of the decay $\mu^+ \to e^+e^-e^+$ with a sensitivity of $\mathcal{O}(10^{-15})$ in phase I and $\mathcal{O}(10^{-16})$ in phase II. In order to achieve this, the Mu3e experiment will be conducted at the Paul-Scherrer-Institute (PSI) utilizing the high rate muon beam (10^8 Hz in Phase I).

The Scintillating Tile Detector is one of the timing detector systems aiming to perform with a resolution of < 100 ps and is located at the two outer stations. It consists of organic scintillators precisely milled into tiles with a surface profile of roughly $5 \times 5\,\mathrm{mm}^2$. The tiles are wrapped in highly-reflective foil, glued to a Silicon Photomultiplier (SiPM) and read out by the MuTRiG, an application-specific integrated circuit (ASIC) which was developed for the Mu3e timing systems. Individual Channels are geometrically grouped onto separate PCB matrices hosting 4×4 channels, which simplifies production, calibration and quality assurance.

The talk will report on the quality assurance measurements of around 3200 individual channels including bare characterization of the SiPMs, as well as measurements of the finite assembled matrices with scintillator tiles.

T 51: Top Physics III (Cross Sections, Entanglement)

Time: Wednesday 16:15–18:15 Location: VG 1.103

T 51.1 Wed 16:15 VG 1.103

Measurement of the $t\bar{t}$ cross-section in the lepton+jets channel using pp collision data at $\sqrt{s}$ = 13.6 TeV with the ATLAS experiment — •Noah Scheugenpflug and Andrea Knue — TU Dortmund

In this contribution, the measurement of the top-quark pair production cross-section in the lepton+jets channel for proton-proton collision data at $\sqrt{s}$ = 13.6 TeV is studied. The data was recorded with the ATLAS detector at the LHC in 2022 and corresponds to an integrated luminosity of 29 fb-1. The cross-section is extracted using a profile likelihood fit. The configuration of the fit is validated by performing an Asimov fit. Events with exactly one electron or muon, at least four jets, with one or two of the jets being b-tagged, and missing transverse momentum are selected and divided into three signal regions according to their jet and b-tagged jet multiplicities. For each region, the signal-to-background separation power of a multitude of kinematic variables is studied. A selection of these variables is analyzed with respect to systematic uncertainties. The uncertainty is dominated by the luminosity and the $t\bar{t}$ signal modelling uncertainty.

T 51.2 Wed 16:30 VG 1.103

Observation of top-quark pair production in lead-lead collisions in the ATLAS experiment at the LHC — Anthony Badea[1], Weronika Bulanowska[2], Iwona Grabowska-Bołd[2], Santu Mondal[3], •Patrycja Potepa[2,4], and Matthias Schott[4] — [1]Harvard University, United States — [2]AGH University of Krakow, Poland — [3]Czech Technical University in Prague, Czech Republic — [4]Johannes Gutenberg University Mainz, Germany

In relativistic heavy-ion collisions, top quarks are expected to be attractive candidates for probing the quark-gluon plasma as well as to bring unique information about the time evolution of strongly interacting matter. We report the first observation of top-quark pair production in lead-lead collisions at the centre-of-mass energy of 5.02 TeV in the ATLAS experiment at the LHC. The dataset was recorded in 2015 and 2018, amounting to an integrated luminosity of 1.9 nb^{-1}. Top-quark pair production is measured in the $e\mu$ channel, with a significance of 5.0 standard deviations. The result is compared to theory predictions based on different nuclear PDF sets.

T 51.3 Wed 16:45 VG 1.103

Studies of top quark pair production with the CMS experiment in the dilepton decay channel including the boosted region — •Iakov Andreev and Olaf Behnke — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

We present an ongoing analysis of differential cross section measurements for top-pair ($t\bar{t}$) production in proton-proton collisions at a center-of-mass energy of 13 TeV, using events containing two oppositely charged leptons. The data were recorded with the CMS detector at the CERN LHC. We study kinematic distributions of the $t\bar{t}$ system, the top quark and antiquark and their decay products. For the first time in differential cross section measurements in the dilepton channel, the phase space includes events with highly boosted top quarks (with momenta above several hundred GeV). This phase space is characterised by small angular separations between the leptons and the b jets originating from the top quark decays. This necessitates the inclusion of non-isolated prompt muons and electrons in both the online trigger and the offline analysis. The talk presents the basic event selection and the adaptations made to include the region of boosted top quarks. Initial kinematic distributions are presented alongside estimates of signal and background processes.

T 51.4 Wed 17:00 VG 1.103

Towards the measurement of $t\bar{t}$ spin correlations using dilepton final states in pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector — Diptaparna Biswas[1], Beatrice Cervato[1], Markus Cristinziani[1], Carmen Diez Pardos[1], Ivor Fleck[1], Arpan Ghosal[1], Gabriel Gomes[1], Jan Joachim Hahn[1], Vadim Kostyukhin[1], Nils Krengel[1], Buddhadeb Mondal[1], Stefanie Müller[1], •Sebastian Rentschler[1], Elisabeth Schopf[1], Katharina Voss[1], Wolfgang Walkowiak[1], Adam Warnerbring[1], and Tongbin Zhao[1,2] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Shandong University, China

The top quark is the heaviest known elementary particle and it decays before hadronizing. Consequently, measurements of the angular distributions of top quark decay products give access to the spin of the top quark, allowing the precise testing of perturbative QCD in the top quark- antiquark pair ($t\bar{t}$) production process. In this contributions first studies towards the measurement of the $t\bar{t}$ spin correlations are presented using the data collected using proton-protons collisions at a centre-of-mass energy of 13 TeV. The data correspond to an integrated luminosity of 140 fb^{-1} collected with the ATLAS detector. The measurements are performed using events with two oppositely charged leptons (electrons or muons) and two or more jets, where at least one of the jets is identified as originating from a bottom quark. The spin correlations are measured from the angular distributions of the two selected leptons.

T 51.5 Wed 17:15 VG 1.103

Measurement of $t\bar{t}$ spin entanglement in the lepton+jets channel in ATLAS — Katharina Behr, Eleanor Jones, and •Fiona Ann Jolly — DESY, Hamburg, Germany

The top quark, one of the heaviest known elementary particles, is mostly produced in pairs ($t\bar{t}$) at the LHC. These $t\bar{t}$ final states are sensitive to characteristic quantum effects such as quantum entanglement of $t\bar{t}$ spins. One of the kinematic regions most sensitive to entanglement is characterised by low values of the invariant mass of the $t\bar{t}$ system, just above the kinematic 'turn-on' for $t\bar{t}$ production ($m_{t\bar{t}} \geq 2m_t$) The presence of entanglement is probed via a high-precision measurement of an angular variable sensitive to the $t\bar{t}$ spin correlation in this region.

In this talk, sensitivity studies for using the lepton+jets $t\bar{t}$ decay channel for quantum entanglement measurements in the $m_{t\bar{t}}$ threshold region are presented. The calculation of the relevant angular variable relies on the identification of the down-type quark jet coming from the W boson decay, which has the highest spin-analysing power among the hadronic top quark decay products. Furthermore, the potential effects of a possible $t\bar{t}$ quasi-bound state in the turn-on region, known as "toponium", are discussed.

T 51.6 Wed 17:30 VG 1.103

Quantum Entanglement in Top Quark Pairs in the Lepton + Jets Channel Using Boosted Topologies — •Jannis Vornholt and Andrea Knue — TU Dortmund

Quantum entanglement, a fundamental prediction of quantum mechanics, had been experimentally observed with electrons and photons, earning recognition through the 2022 Nobel Prize in Physics. At the LHC, this phenomenon had been observed in top quark pairs at production threshold in 2023, providing a high-energy test of quantum mechanics. A test of quantum entanglement of top quark pairs is also possible at high $m_{t\bar{t}}$ at the LHC and is the topic of this talk. The lepton + jets channel is considered, whereby the hadronically decaying top quark is reconstructed as a large radius jet.

The angle between the decay products of the top quarks can be used as indicator for quantum entanglement. First reconstructed properties are discussed.

The presented studies are performed with ATLAS Monte Carlo simulations under Run 2 conditions.

T 51.7 Wed 17:45 VG 1.103

Measurement of the differential t-channel production cross-section of single top quarks and top antiquarks in proton-proton collisions at 13 TeV using the full Run 2 dataset recorded with the ATLAS detector — Dominic Hirschbühl, Lukas Kretschmann, •Maren Stratmann, and Wolfgang Wagner — Bergische Universität Wuppertal, Wuppertal, Deutschland

The t-channel production is the dominant process for single top quark and single top antiquark production at the LHC. The measurement of the differential cross section can contribute to constraining proton PDFs and has not been measured with the full Run 2 dataset up to date. This measurement uses the full Run 2 dataset recorded with the ATLAS detector in the years 2015-2018. The differential production cross-sections of the top-quark and top-antiquark as well as their ratio are measured on parton level as a function of the transverse momentum p_{T} and rapidity $|y|$ of the top quark.

T 51.8 Wed 18:00 VG 1.103

Measurement of differential cross sections in the process $pp \rightarrow W^+W^-bb$ — Daniel Britzger[1], •Johannes Hessler[1,2], and Stefan Kluth[1] — [1]Max Planck Institute for Physics, Garching, Germany — [2]Technical University Munich, Garching, Germany

Precise measurements of differential cross sections in the process $pp \rightarrow W^+W^-bb$ offer an outstandingly rich physics potential at highest precision. Although the process is theoretically and experimentally well defined, dedicated measurements of W^+W^-bb production cross sections were not (extensively) performed in the past at the LHC. We will report on ongoing measurements in the single-lepton channel with Run-II data taken by the ATLAS experiment. The analysis comprises three signal regions, focusing on the interference between $t\bar{t}$ and tW processes, the explicit reconstruction of the kinematics of the $WbWb$ system and on phase spaces motivated by BSM searches.

T 52: Flavour Physics III

Time: Wednesday 16:15–18:15 Location: VG 1.104

T 52.1 Wed 16:15 VG 1.104

Measurement of the $\pi^0 \to e^+e^-\gamma$ decay at NA62 — •Célia Polivka — Johannes Gutenberg-Universität Mainz

The current value for the $\pi^0_D \to e^+e^-\gamma$ Dalitz decay is $\mathscr{B}r(\pi^0_D) = (1.174\pm0.035)\cdot 10^{-2}$ and has a large uncertainty. This is a limiting factor for other measurements that use the Dalitz decay as normalisation channel. This analysis aims to improve the precision on this measurement using data from the NA62 experiment at CERN. The π^0 mesons are tagged by $K^+ \to \pi^+\pi^0$ decays. The π^0_D is then identified by reconstruction of the three track vertex of e^+, e^- and π^+. Presented are the status of the analysis and an outlook on the precision of the measurement.

T 52.2 Wed 16:30 VG 1.104

Semileptonic Kaon decays in NA62 — •Atakan Akmete — Mainz University

The semileptonic charged kaon decays $K^+ \to \pi^0\ell^+\nu(\gamma)$ ($K_{\ell 3}$) provide a clean way to test the e-μ lepton universality and probe the first row unitarity $|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 1$ of the CKM matrix. Current results indicate a tension, known as the Cabibbo angle anomaly.

This work aims to update the branching fractions of $K_{\ell 3}$ decays, along with the other main K^+ decay channels using a minimum bias low-intensity dataset collected by the NA62 experiment (CERN) in 2024. This dataset offers high statistics in a clean environment. The measurement is performed by analyzing single positively charged tracks, allowing all six main decay modes to be measured simultaneously.

In this talk, I will present the current status of the analysis, including the expected precision on the branching fractions.

T 52.3 Wed 16:45 VG 1.104

The Anatomy of $K^+ \to \pi^+\nu\nu$ distributions — •Kai Henryk Sieja[1], Emmanuel Stamou[1], Mustafa Tabet[1], Martin Gorbahn[1,2], and Ulserik Moldanazarova[2,3] — [1]TU Dortmund University, Germany — [2]University of Liverpool, United Kingdom — [3]Karaganda Buketov University, Kazakhstan

The rare decays $K^+ \to \pi^+\nu\nu$ and $K_L \to \pi^0\nu\nu$ are among the strongest probes of Beyond-the-Standard-Model dynamics with new sources of quark-flavour violation. These decays are thus the main target for the dedicated experiments NA62 and KOTO, with new data published in 2024 by NA62. Different New Physics scenarios can have an distinctive effect on the NA62 distributions. We analyze the impact of lepton-number violating or conserving dimension-six operators on the experimentally accessible distributions within the LEFT framework. Concrete New Physics models can induce operators with different chirality, i.e., vector-, scalar, tensor-type operators, and different neutrino flavour structure. Using all published data from NA62, we assess the impact of a combined binned likelihood analysis in constraining the New Physics parameter space and how this varies for different operator types, as well as the competitiveness of correlated constraints within SMEFT.

T 52.4 Wed 17:00 VG 1.104

Charm-Quark Mass in the Heavy Quark Expansion — •Anastasia Boushmelev[1], Thomas Mannel[1], and K. Keri Vos[2] — [1]Theoretische Physik 1, Center for Particle Physics Siegen Universität Siegen, D-57068 Siegen, Germany — [2]Gravitational Waves and Fundamental Physics (GWFP), Maastricht University, Duboisdomein 30, NL-6229 GT Maastricht, the Netherlands and Nikhef, Science Park 105, NL-1098 XG Amsterdam, the Netherlands

The Heavy Quark Expansion is a powerful framework for making predictions for inclusive heavy hadron decays. It provides a method to calculate decay rates and spectra as a double expansion in powers of $\Lambda_{\rm QCD}/m_Q$ and $\alpha_s(m_Q)$ and is well established for b-decays enabling precise predictions for various observables. In this context, the quark mass in an appropriate scheme is determined with sub-percent precision, and $\alpha_s(m_Q)$ is as low as 0.1.

Though, considering the charm sector, the treatment of the quark mass has to be further investigated as these mass schemes are not suitable in this case. Here we suggest to replace the charm mass, as well as further non-perturbative quantities, directly by q^2 moments based on a similar strategy applied on b-decays using e^+e^- inverse moments studied in [1]. Following this strategy we study the impact on the perturbative series of q^2 moments, as well as the total rate.

[1] A. Boushmelev, T. Mannel and K. K. Vos, JHEP 07 (2023), 175 doi:10.1007/JHEP07(2023)175 [arXiv:2301.05607 [hep-ph]].

T 52.5 Wed 17:15 VG 1.104

Measurements of mixing parameters and search for CP violation in mixing using multibody charm hadron decays at LHCb — •Florian Reiss and Marco Gersabeck — Albert-Ludwigs-Universität Freiburg, Freiburg, Germany

The large samples of charm hadrons collected by the LHCb experiment facilitates the measurement of the charm mixing parameters and the search for charge and parity symmetry violating (CPV) effects with high precision. Multi-body charm hadron decays are of particular interest, as the interference of intermediate resonances can enhance CPV effects in certain regions of the phase space of the decay.

We present studies performed with model-dependent approaches to describe the contribution of the intermediate resonances to the overall decay amplitude as a function of phase space and decay time to extract the parameters of interest. The acceleration of these analyses using Graphics Processing Units is demonstrated and the expected sensitivity of ongoing measurements is shown.

T 52.6 Wed 17:30 VG 1.104

Early measurement of charm mesons production asymmetries at LHCb in Run 3 — •Luca Balzani[1], Laurent Dufour[2], Paula Herrero Gascon[3], Serena Maccolini[1], Dominik Stefan Mitzel[1], Sascha Stahl[2], Giulia Tuci[3], and Francesco Zenesini[4] — [1]TU Dortmund University, Dortmund, Germany — [2]CERN, Geneva, Switzerland — [3]Heidelberg University, Heidelberg, Germany — [4]University of Bologna, Bologna, Italy

Ahead of Run 3 of the LHC, the LHCb detector was profoundly upgraded to leverage the programmed increase in luminosity. Studying the features of the upgraded detector is of paramount importance in order to reliably perform measurements.

Production asymmetries are observables which depend on the colliding system characteristics but shall not be influenced by experimental effects. Having these latter contributions under control is essential to perform a consistent measurement. This makes production asymmetries ideal candidates to investigate the characteristics of the new LHCb detector. Being one of the first measurements done with the new data, it will also provide useful insights for their validation. Precise measurements of production asymmetries also allow for a better understanding of QCD models used in Monte Carlo generators, especially in the high-rapidity region. Finally, this analysis will lead to the first measurement of neutral charm meson production asymmetry for proton-proton collisions at the LHC energies. This contribution will discuss the general strategy and the techniques used for the measurement.

T 52.7 Wed 17:45 VG 1.104

Studies of CP violation in $D^0 \to \pi^+\pi^-\pi^0$ decays with the energy test method using LHCb Run 3 data — •Todor Todorov, Marco Gersabeck, Evelina Gersabeck, Florian Reiss, and Jan Karch — Albert-Ludwigs-Universität Freiburg, Freiburg im Breisgau, Germany

The standard model prediction for CP violation in the charm sector is relatively small and has a magnitude of the order of $\mathcal{O}(10^{-3}-10^{-4})$. An observation of such violation has been made by the LHCb collaboration in $D^0 \to hh$ decays, but this remains the only significant experimental evidence. $D^0 \to \pi^+\pi^-\pi^0$ decays offer a promising candidate for studies of CP asymmetries, because they proceed via the same electroweak decay mode as the observation channel. Multibody decays also provide a 2 dimensional phase-space where different local contributions to CP violation can be observed even in the case of global CP symmetry. The energy test statistical method is chosen to search for local CP asymmetries due to its independence of model and choice of binning. An early study of the application of this statistical test to LHCb Run 3 data is presented, which is projected to benefit from a four-fold increase in data sample size in comparison to previous LHCb analyses.

T 52.8 Wed 18:00 VG 1.104

Studies of angular and CP asymmetries in $D^+_{(s)} \to h^+\mu^+\mu^-$ decays at LHCb — •Luca Toscano, Dominik Mitzel, and Serena Maccolini — TU Dortmund

The LHCb experiment has recorded the world's largest sample of charm hadron decays and takes a leading role in measurements of rare decays and searches for CP violation.

Rare semi-leptonic charm decays such as $D^+ \to \pi^+\mu^+\mu^-$ and $D^+_s \to K^+\mu^+\mu^-$ are sensitive to beyond-standard-model effects in flavour-changing neutral current $c \to u\mu^+\mu^-$ transitions. Observables such as angular and CP asymmetries, can be defined to test the Standard Model. Null tests on these observables are performed in the vicinity of intermediate hadronic resonances, where new physics signals can be enhanced.

In this talk, the first study of angular distributions and CP asymmetries in $D^+_{(s)} \to h^+\mu^+\mu^-$ decays is presented. The analysis uses data collected by the LHCb detector from 2015 to 2018 at a centre-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 6fb^{-1}. The preliminary results are showed.

T 53: Neutrino Astronomy III

Time: Wednesday 16:15–18:15 Location: VG 1.105

T 53.1 Wed 16:15 VG 1.105

A bayesian approach to study the multimessenger emission from AGN-starburst galaxies* — •Silvia Salvatore[1,2], Bjoern Eichmann[1,2], and Julia Becker-Tjus[1,2] — [1]Theoretische Physik IV, Ruhr Universität Bochum, Bochum, Germany — [2]RAPP-Center at Ruhr Universität Bochum, Bochum, Germany

Active Galactic Nuclei (AGN) and starburst galaxies are multimessenger sources in the Universe, emitting from radio/infrared energies to gamma-ray and neutrino energies. NGC 1068 is a Seyfert II galaxy with a starburst ring that has been proven to emit the neutrinos detected by Icecube through hadronic processes most likely happening in the AGN corona. Two high-energy neutrinos with high probability of being of astrophysical origin have recently been reported by IceCube from the direction of NGC7469 as well. In this presentation, we model the different environments of these AGN-starburst composite sources and constrain the main parameters for the AGN and starburst environments using a Monte Carlo bayesian approach, where we include the data from radio to TeV energies*Supported by DFG (SFB 1491).

T 53.2 Wed 16:30 VG 1.105

Constraining the contribution of Seyfert galaxies to the astrophysical neutrino flux using NGC 1068 as a benchmark — •Lena Saurenhaus[1], Francesca Capel[1], and Foteini Oikonomou[2] — [1]Max-Planck-Institut für Physik, 85748 Garching b. München, Germany — [2]Norwegian University of Science and Technology (NTNU), Institutt for fysikk, 7491 Trondheim, Norway

Recently, the IceCube Collaboration reported evidence for TeV neutrino emission from several nearby Seyfert galaxies, with the highest significance found for NGC 1068. The lack of observable gamma rays at TeV energies associated with NGC 1068 suggests that these neutrinos are likely produced in the AGN corona, which is opaque to high-energy gamma rays. Based on this assumption, we simulate the neutrino emission of Seyfert galaxies with different X-ray properties and fit the resulting neutrino spectrum for NGC 1068 to public IceCube data. Using the result of this fit as a benchmark, we extrapolate our model to an entire population of sources simulated based on the X-ray luminosity function of AGNs and estimate the resulting diffuse neutrino flux. By comparing our results with observations, we derive constraints on the neutrino emission properties of the source population and find that NGC 1068 has to be a particularly powerful Seyfert galaxy. In addition, we use our model to evaluate the detection prospects of other nearby Seyfert galaxies besides NGC 1068 in order to obtain a coherent picture of the contribution of these sources to astrophysical neutrino observations.

T 53.3 Wed 16:45 VG 1.105

IFT on ice: Utilizing numerical information field theory to reconstruct glacial ice parameters — •Matthias Hübl, Laurin Söding, and Philipp Mertsch — Institute for Theoretical Particle Physics and Cosmology (RWTH Aachen University)

Due to their small interaction cross-sections, the detection of high-energy neutrinos requires the use of large, natural detection volumes, like glacial ice in the case of the IceCube Neutrino Observatory. In order to extract precise information from the light that is produced by high energy neutrinos, it has to be calibrated as accurately as possible. This means in particular that the ice properties such as scattering and absorption lengths for propagating photons should be known with high accuracy and spatial resolution. Information Field Theory (IFT) adopts a Bayesian approach, building on methods from different fields of physics, especially field theory and statistical physics. The python package NIFTy (Numerical Information Field Theory) uses the concepts of IFT and implements a variational inference approach in order to reconstruct parameter fields. This is both more robust than maximum-likelihood methods and allows determining the uncertainties of the inferred fields at the same time. Here, we present two approaches for modelling the light propagation in ice that can be interfaced with NIFTy: a differentiable Monte Carlo simulation and a finite-difference code. We compare the performance of both methods and characterise the reconstruction of a mock ice model.

T 53.4 Wed 17:00 VG 1.105

Search for Ultra-High Energy Neutrinos from Gamma-Ray Bursts with the Pierre Auger Observatory — •Therese Paulsen for the Pierre-Auger-Collaboration — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal, Germany

Primarily designed to detect ultra-high energy (UHE) cosmic rays, the Pierre Auger Observatory also possesses excellent sensitivity to UHE neutrinos. The Surface Detector array is used to search for highly inclined neutrino-induced air showers, which, though not observed yet, have clear characteristic signatures. Due to the null observation of UHE neutrinos, we can construct upper luminosity limits on each gamma-ray burst within the Observatory's field of view.

As the neutrino luminosity from these sources strongly depends on the modeled emission mechanisms and dissipative processes, we construct these upper limits using different neutrino spectra corresponding to distinct scenarios, for example, the one-zone fireball model. The spectra is constructed using the source code *Cosmic Ray Stochastic Interactions for Propagation* (CRISP), to compute quantities related to the propagation of heavier primaries within the source environment.

T 53.5 Wed 17:15 VG 1.105

Ultra-high-energy neutrino detection with radio antennas in the ground based observatory — •Baobiao Yue — Bergische Universität Wuppertal, Wuppertal. Germany

The detection of Ultra-High-Energy (UHE) neutrinos offers a unique opportunity to unravel the mysteries surrounding the astrophysical origins of the universe's most energetic cosmic rays. Radio detection provides significant advantages for detecting highly inclined air showers induced by UHE neutrinos, including a larger exposure range compared to particle detectors and a precise reconstruction. Furthermore, this technique improves the air shower longitudinal reconstruction, which can be used to identify neutrinos with their first interaction far below the top of the atmosphere.

The Pierre Auger Observatory is the largest instrument with radio antennas for measuring air showers produced by UHE cosmic rays and neutrinos. In this work, we use it as an example of a ground-based observatory to study UHE neutrino detection. We demonstrate how the integration of radio antennas enhances UHE neutrino detection capabilities and facilitates classification. Since shower reconstruction using radio emissions is central for neutrino identification in this work, we will emphasize the method developed for detecting inclined air showers induced by neutrinos. Finally, we present the expected neutrino detection sensitivity achievable with the radio antennas alone.

T 53.6 Wed 17:30 VG 1.105

Enhancing Sensitivity for Ultra-High Energy Down-Going Neutrino Detection with the Pierre Auger Observatory* — •Srijan Sehgal for the Pierre-Auger-Collaboration — Bergische Universität Wuppertal, Wuppertal, Germany

The Pierre Auger Observatory, originally conceived to study the properties of cosmic rays, also has the capability to identify neutrino-induced extensive air showers above 10^{17} eV by using its large Surface Detector (SD) array. Two new SD triggers, Time-over-Threshold-deconvolved (ToTd) and Multiplicity-of-Positive Steps (MoPS), installed in 2014, were shown to vastly increase the detection capability for the neutrino-induced air showers in the lower energy ($E < 10^{19}$ eV) regime.

This talk explores the role of newly implemented triggers in enhancing neutrino detection for zenith angles within the range $60^\circ < \theta < 75^\circ$. A novel neutrino identification method, which integrates MoPS and ToTd triggers, is developed and rigorously tested on simulated neutrino-induced air showers. The method is then applied to observational data to look for neutrino-like events using a *blind* search strategy. On the basis of the null observation new constraints to point-like sources of ultra-high-energy neutrinos will be presented for the angular range explored.

**Supported by BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A23PX1)*

T 53.7 Wed 17:45 VG 1.105

ML discrimination of atmospheric neutrinos for DSNB detection in JUNO — •David Maksimovic[1], Daniel Tobias Schmid[1], Dhaval J. Ajana[2], Michael Wurm[1], Marcel Büchner[1], Arshak Jafar[1], George Parker[1], Oliver Pilarczyk[1], and Tim Charisse[1] — [1]Johannes Gutenberg-University Mainz, Institute of Physics — [2]Department of Physics, Florida State University, Tallahassee, FL 32306, USA

The detection and analysis of the Diffuse Supernova Neutrino Background (DSNB) pose a significant challenge in neutrino astronomy, primarily due to backgrounds mimicking the Inverse Beta Decay (IBD) signature events. The Jiangmen Underground Neutrino Observatory (JUNO) uses a liquid scintillator to detect these neutrinos, especially challenged by Neutral-Current (NC) interactions of atmospheric neutrinos in the 12 to 30 MeV range. In this talk, we introduce novel methods employing 3D Convolutional Neural Networks (3D CNNs) and Convolutional LSTMs (ConvLSTMS) for better discrimination of DSNB events from these backgrounds. These techniques analyses time-sequenced data from photomultiplier tube (PMT) hit patterns, arranged in frames like a movie, capturing the spatial-temporal dynamics of particle interactions. Simulation studies within the JUNO detector environment show promising background reduction capabilities.

T 53.8 Wed 18:00 VG 1.105

Detecting Distant Supernovae Using Log-Likelihood Ratios — •Kashish Gupta, Thilo Birkenfeld, and Achim Stahl — Lehrstuhl für Experimentalphysik III B

The Jiangmen Underground Neutrino Observatory (JUNO) offers a robust platform for observing Core-Collapse Supernovae through neutrino emissions. In this study, the inverse beta decay (IBD) is used for Supernova search, where an electron antineutrino interacts with a proton, producing a positron and a neutron signal. The IBD channel's high cross-section and distinct event signature are particularly beneficial for detecting distant supernovae. A likelihood ratio test is applied to identify IBD events caused by a Supernova from background events dominated by reactor antineutrinos. In the first method, events are considered only within a time window corresponding to the CC-SNe duration, achieving a false alert rate (FAR) of 0.4/year for 2 IBD events and near-zero FAR for 3 IBD events.

A second method that treats arbitrary numbers of events on an equal footing is presented to improve sensitivity further.

T 54: Data, AI, Computing, Electronics V (Anomaly Detection, Event Selection)

Time: Wednesday 16:15–18:15 Location: VG 2.101

T 54.1 Wed 16:15 VG 2.101

Latest developments of CATHODE — •Tore von Schwartz, Gregor Kasieczka, Louis Moureaux, Chitrakshee Yede, and Manuel Sommerhalder — Institut für Experimentalphysik, Universität Hamburg

Despite an extensive search program at the LHC, no hints for new physics have been found so far. Anomaly detection has been introduced as a bridge between generic searches and searches targeting a specific signal. CATHODE as a model-agnostic anomaly detection method is designed to enhance resonant signals in the smoothly falling dijet invariant mass spectrum. It has been applied in the latest CMS anomaly search. We present the most recent developments to CATHODE improving its reliability and versatility in uncovering potential new physics signals.

T 54.2 Wed 16:30 VG 2.101

Anomaly Detection Using Machine Learning at Belle II — •David Giesegh, Nikolai Krug, and Thomas Kuhr — LMU Munich, Germany

In modern High Energy Physics, searches for New Physics are often inspired by specific theoretical models suggesting extensions to the Standard Model. Since, as of yet, none of these could be experimentally verified, the question arises if we are looking in the wrong places. For this reason recent years have seen increasing interest in model-agnostic alternatives to classical analyses, among them Machine Learning assisted methods such as Anomaly Detection. In this project we explored the application of two specific Anomaly Detection procedures based on autoencoders and density estimation at the Belle II Experiment. It could be shown on simulated data scenarios that both methods have the potential to increase the visibility of an unknown small signal on realistic backgrounds, providing a proof of concept for further development of such methods at Belle II.

T 54.3 Wed 16:45 VG 2.101

BGNet: A neural network for real-time background prediction and decomposition for Belle II — •Yannik Buch, Ariane Frey, Benjamin Schwenker, and Lukas Herzberg — Georg-August-Universität Göttingen, Göttingen, Deutschland

The Belle II detector investigates the b-sector by measuring the decays of the $\Upsilon(4S)$ resonance. These resonances are produced by the SuperKEKB accelerator at KEK in Tsukuba, Japan. The goal of SuperKEKB is to achieve an instantaneous luminosity of 6.5×10^{35} cm^{-2}s^{-1}. Currently, a luminosity of 5×10^{34} cm^{-2}s^{-1} is reached, showing that considerable improvements to the beam focusing and increases of the ring currents are still necessary. At the same time, however, the Belle II detector must not be damaged or its performance compromised by extensive radiation and hit rates. The beam backgrounds at Belle II are mostly composed of storage backgrounds, luminosity-based backgrounds and injection backgrounds of both rings due to continuous top-up injections. BGNet is trained to predict the overall hit rates and their decomposition in terms of background source for various Belle II sub-detectors.

The input data for BGNet are 1 Hz time series of diagnostic variables describing the state of the SuperKEKB collider subsystems. Using real-time data from the EPICS slow control system BGNet can be used to obtain a real-time beam background decomposition, enabling diagnostic background monitoring for all beam background components simultaneously.

T 54.4 Wed 17:00 VG 2.101

Using End-to-End Optimized Summary Statistics in IceCube — •Oliver Janik and Christian Haack — Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg

The characterization of the astrophysical neutrino flux with the IceCube Neutrino Observatory traditionally relies on a binned forward-folding likelihood approach. However, this method is constrained by the need for sufficient Monte Carlo (MC) statistics in each bin, which limits both the granularity and dimensionality of the binning scheme. By employing a neural network to learn a one-dimensional summary statistic, it becomes possible to optimize the binning scheme for the analysis while maintaining adequate MC statistics per bin. This, for example, allows the use of a larger number of observables in order to improve the analysis performance. The talk will go into detail on the application of end-to-end optimized summary statistics in the context of analyzing and characterizing the galactic neutrino flux.

T 54.5 Wed 17:15 VG 2.101

Novel Event Selection Techniques to Discriminate between Proton Decay and Atmospheric Neutrino Backgrounds in JUNO — •Korbinian Stangler, Ulrike Fahrendholz, Lothar Oberauer, and Carsten Dittrich — TUM School of Natural Sciences, Physics Department, James-Franck-Str. 1, 85748 Garching

The Jiangmen Underground Neutrino Observatory (JUNO) is a large liquid scintillator detector, capable of searching for the hypothetical proton decay $p \to \bar{\nu}K^+$, which is predicted by supersymmetric Grand Unified Theories. As the momentum of the daughter kaon is below the Cherenkov threshold in water, JUNO will be able to provide competitive results in comparison to the current partial lifetime limit of $\tau > 5.9 \cdot 10^{33}$ years, established by the Super-Kamiokande collaboration.

This talk presents a new machine-learning based strategy to discriminate proton decay events from atmospheric neutrino interactions in JUNO. From the resulting estimated sensitivity on $p \to \bar{\nu}K^+$, an improvement of the vertex reconstruction algorithm is suggested.

T 54.6 Wed 17:30 VG 2.101

Sterile Neutrino Search with Neural Networks at KATRIN — •Luca Fallböhmer for the KATRIN-Collaboration — Technical University Munich

The KATRIN experiment aims to search for keV sterile neutrinos in the full beta decay spectrum of tritium using the TRISTAN detector and DAQ system after the end of the neutrino mass measurement. Thanks to the high source activity of KATRIN, a sterile neutrino signature can be probed down to the parts per million level. Because the modelling of the deep differential tritium spectrum is very complex and the involved Monte Carlo simulations require long computing times to reach the necessary statistics, a fit of the sterile parameters is very challenging with the current model. Thus, neural networks are used to search directly for the sterile neutrino signature. In this talk, we demonstrate the sensitivity of the neural network method to the sterile neutrino signature. Additionally, we discuss the robustness of the neural network approach in the presence of experimental effects, their uncertainties, and modelling inaccuracies.

T 54.7 Wed 17:45 VG 2.101

Enhancing the identification of $HH \to b\bar{b}b\bar{b}$ by Triplet Learning — •Bao Tai Le, Lars Linden, Otmar Biebel, Stephanie Götz, Celine Stauch, Valerio D'Amico, and Tim Rexrodt — Ludwig-Maximilians-Universität, München, Deutschland

In recent years various machine learning techniques have proven to be quite successful in particle physics replacing old methodology and introducing new ways of thinking. One of those ways is Triplet Training. Its appeal comes from its resilience against noisy data by forming a more salient feature space leading to better categorization performances across many different categorization architectures.The production of a pair of Higgs bosons is possible due to the Higgs self interaction. However, the cross section of this process is tiny and the largest branching ratio of the Higgs decay involves bottom quarks which are also abundantly produced by strong interaction in proton-proton collisions. Even though bottom quark jets can be identified e.g. by secondary decay vertices, it is an experimental challenge to maintain a high efficiency to identify the four b-quark jets from a $HH \to 4b$ event. Due to the resilience of Triplet Learning against noisy data its application seems promising for enhancing the identification efficiency of $HH \to 4b$ events.

T 54.8 Wed 18:00 VG 2.101

MVA Based Selection for $B \to K_S(\pi^+\pi^-)\, l^+\, l^-$ — Ariane Frey[1], Thibaud Humair[1,2], •Dennis Rodermund[1], and Benjamin Schwenker[1] — [1]II. Physikalisches Institut, Georg-August-Universität Göttingen, 37073 Göttingen, Germany — [2]Deutsches Elektronen Synchrotron (DESY), 22607 Hamburg, Germany

Decays of B mesons mediated by a $b \to s\,l\,l$ transition are of high interest to search for physics beyond the Standard Model. The CP-violation content of such transitions has however been explored very little to date. The $B \to K_s\,l\,l$ transitions allow for measuring the CP-violation in the interference with mixing. This decay has a very small branching fraction and hence a good selection is needed in order to isolate signal events.

This talk focuses on the selection based on a BDT. The BDT takes event- and particle based variables like Fox-Wolfram moments or angular distributions as input and tries to predict if the considered event is either signal or background. A sophisticated BDT model thus provides a way to separate signal and background processes based on the BDT output, making further analyses possible.

T 55: Data, AI, Computing, Electronics VI (DAQ and Trigger)

Time: Wednesday 16:15–18:30 Location: VG 2.102

T 55.1 Wed 16:15 VG 2.102

Development of an FPGA-based DAQ system for the OBELIX sensor for the Belle II VTX upgrade — •Tobias Blesgen[1], Maximilian Babeluk[2], Christian Bespin[1], Jochen Dingfelder[1], Hans Krüger[1], and Alexander Walsemann[1] — [1]University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany — [2]Austrian Academy of Sciences, Institute of High Energy Physics, Nikolsdorfer G. 18, Vienna, Austria

To address the demands of higher luminosities at the Belle II experiment, a new vertex detector system featuring the monolithic OBELIX pixel sensor is currently under development. The large (3 cm x 2 cm) sensor area consists of over 400,000 pixels utilizing DMAPS technology. Alongside the OBELIX chip, a dedicated readout system for laboratory and beam tests is being designed and verified. The FPGA-based DAQ system builds upon the existing TJ-Monopix2 DAQ framework and has been adapted to include new features required to work with the OBELIX chip.

The FPGA is placed on the multi-purpose BDAQ board, originally developed for the RD53 readout for the upgrade of the ATLAS and CMS pixel detectors. TJ-Monopix2 and OBELIX exhibit the same command protocol as the RD53B chip while implementing a different hit data receiver logic to match the updated hit structure.

This talk presents the development process, key features and verification process of the data acquisition system.

T 55.2 Wed 16:30 VG 2.102

The XENONnT Data Acquisition System — •Robin Glade-Beucke for the XENON-Collaboration — Albert-Ludwigs Universität, Freiburg, Germany

The XENONnT experiment is an ultra-low background liquid xenon TPC for direct dark matter detection. Its trigger-less Data Acquisition System aims at achieving maximal total uptime and the lowest possible energy threshold. Live processing of the data allows timely insight in current data taking, even in high-rate scenarios such as during calibration. Later reprocessing with improved processing parameters is possible. The high data rates during calibration can be mitigated on-line with FPGA-based veto decision-making.

T 55.3 Wed 16:45 VG 2.102

On-Board Data Processing for a Mission to Study the Antiproton Content in Earth's Radiation Belts — •Peter Hinderberger, Martin J. Losekamm, Luise Meyer-Hetling, and Stephan Paul — School of Natural Sciences, Technical University of Munich, Garching, Germany

The Earth's magnetic field traps charged particles in the Van Allen radiation belts. We intend to precisely measure the flux of trapped antiprotons with energies of tens to hundreds of MeV using a tracking calorimeter made from scintillating plastic fibers and silicon photomultipliers. The instrument will fit on a compact satellite that will, however, restrict the power, volume, computing capacity, and transmission bandwidth available to our experiment. In addition, a low signal-to-background ratio and high event rates make data acquisition and processing challenging. To address these challenges, we are developing a hardware and software framework based on a field-programmable gate array (FPGA) that can acquire, filter, and compress data efficiently in orbit, exploiting its advantages in low-power parallel computing. Our pipelined multi-stage processing approach is designed to reliably identify, count, and partly reject clearly identifiable background events, and to compress the remaining signal candidates without losses. This minimizes the amount of data that must be transmitted to the ground without impacting our measurement. I present the motivation, current status, and short-term plans of our work. It is funded by the German Research Foundation (DFG, project number 414049180) and under Germany's Excellence Strategy-EXC2094-390783311.

T 55.4 Wed 17:00 VG 2.102

Constellation - a flexible DAQ and control system for test beam environments — •Stephan Lachnit and Simon Spannagel — Deutsches Elektronen-Synchrotron DESY

The qualification of new detectors in test beam environments presents a challenging setting that requires stable operation of diverse devices, often employing multiple Data Acquisition (DAQ). Changes to these setups are frequent, such as using different reference detectors depending on the facility. Managing this complexity necessitates a system capable of controlling the data taking, monitoring the experimental setup, facilitating seamless configuration, and easy integration of new devices.

Due to limitations in existing frameworks, collaborative efforts between DESY, DVel, Lund University, and the University of Hamburg have led to the development of Constellation - a new, flexible framework tailored towards laboratory and test beam environments. Constellation streamlines setup integration through network discovery, enhances system stability by operating autonomously, and simplifies onboarding with comprehensive documentation.

This contribution will provide a brief overview of the Constellation and insights from the first test beams with Constellation.

T 55.5 Wed 17:15 VG 2.102

Development and Tests of Python-based Control Software for a EUDET-type Beam Telescope at the ELSA Test Beam Area — •Rasmus Partzsch, Christian Bespin, Yannick Dieter, Jochen Dingfelder, Fabian Hügging, and Lars Schall — Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany

Test-beam telescopes are reference tracking devices used to investigate the performance of detector prototypes. The EUDET-type beam telescope consists of six MIMOSA26 pixel detector planes. These feature a small pixel pitch (18.4 um) to enable a high spatial resolution for particle tracks. A time-reference plane is added to the ANEMONE beam telescope to provide precise timing information for individual particle tracks. The detectors are synchronized with a trigger logic unit (AIDA-TLU). One of the main requirements of the test-beam infrastructure is flexibility to accommodate different types of devices under test and different experimental setups. This flexibility applies not only to the hardware setup but also to the control software, detector readout, and analysis tools. A new Python-based control software has been developed for the control of the AIDA-TLU, implementing various trigger logic configurations and communication modes for different devices.

In this talk, the Python-based control software for a EUDET-type beam telescope setup is presented. Additionally, test results using an ATLAS ITkPix chip, designed for the ATLAS inner tracker upgrade, as the time reference plane, along with the AIDA-TLU control software at trigger rates of up to 100 kHz at the ELSA test-beam area, will be discussed.

T 55.6 Wed 17:30 VG 2.102

Compact converters for fast frame rate detectors — •Kennedy Caisley[1], Hans Krüger[1], Bart Dierickx[2], and Jochen Dingfelder[1] — [1]University of Bonn, Bonn, Germany — [2]Caeleste, Mechelen, Belgium

Frame-based radiation detectors with integrating front-ends are especially well-suited for applications like electron microscopy and X-ray imaging where hit-rates are high, spatial resolution should be maximized with simple pixels, and energy resolution is needed, but particles need not be individually discriminated in time, space, or spectrum. In an experimental setting, fast frame rates allow for real time in-situ observations. Potential subjects include rapid chemical processes, molecular dynamics of proteins, crystal nucleation and growth, material phase transitions, thermal conductivity, charge transfer, and mechanical strain.

Our work pursues the possibility of a single-reticle array larger than 1 Mpixel with a continuous frame-rate surpassing 100,000 fps. For the conjunction of these two specifications to be met, we will discuss initial investigations into a compact and power efficient bank of column-parallel data converters, which at 10-12 bit resolution churn out data at a rate in excess of 1000 Gbps. To fit within the constraints of a chip bottom, the converter fabric must respect a restricted metric of 1 W/cm^2 while exceeding a 5 ksps/μm^2 sampling rate density. Successive-approximation ADCs are identified as the optimal choice, and various topologies and techniques will be analyzed to meet our goals.

T 55.7 Wed 17:45 VG 2.102

A parametrised Kalman filter for the GPU-based first level trigger of the upgraded LHCb experiment — Michel De Cian[1,2], Stephanie Hansmann-Menzemer[1], and •Lennart Uecker[1] — [1]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Germany — [2]Department of Physics and Astronomy, University of Manchester, United Kingdom

The LHCb Upgrade I detector implements a fully software-based trigger to select a wide range of physics signatures. The first-level trigger employs 500 GPU cards

to perform partial event reconstruction at the complete LHCb collision rate of 30 MHz. This includes finding charged tracks, reconstructing proton-proton collisions, particle identification and finding displaced vertices. The implementation enables an increased trigger performance, especially for hadronic channels, thus elevating signal yields above the increase in luminosity.

Kalman filters are commonly used in High Energy Physics to process pattern recognition tracks and extract optimal track parameters. However, these filters' sequential nature and substantial memory requirements make them suboptimal for GPU implementation. We developed a method that replaces computationally demanding operations with parametrized approximations, specifically material scattering calculations and state extrapolation in the magnetic field. This approach achieves high-throughput track fitting while maintaining track information quality, making it suitable for GPU-based processing in high-rate environments. In this talk we present the implementation and performance of the GPU based Kalman filter for LHCb Run 3.

T 55.8 Wed 18:00 VG 2.102

Reconstruction of photon conversion in rare decays — •Bernd Mumme — Physikalisches Institut, Heidelberg, Germany

Flavour changing decays involving the emission of an energetic photon are of great interest to study the peculiar flavour structure of the Standard Model and search for indirect signs of new dynamics at very high energy. Some of the most sensitive probes are the rare or forbidden flavour-changing neutral current decays of heavy fermions: $b \to s\gamma$, $c \to u\gamma$ and $\tau \to \mu\gamma$. Rare decays involving a photon in the decay products are reconstructed through the dielectron pair they convert to. To efficiently detect these dielectron pairs significant upgrades are being implemented in LHCb's trigger system to enhance efficiency. The trigger consists of a GPU-driven first high level trigger (HLT1) and a CPU-run second level trigger (HLT2). Improvements include the development of a new trigger line in HLT1 capable of reconstructing significantly displaced electrons from photon conversions in real time as well as incorporating these electron tracks in HLT2, both driven by modern machine learning techniques. These upgrades aim to maximize event selection efficiency and keep data throughput for rare decays manageable. This talk will outline the physics motivation for searches for flavour-changing neutral current decays and detail the technical developments in optimizing the LHCb trigger for these and similar rare decays.

T 55.9 Wed 18:15 VG 2.102

Development of an automated pixel monitoring website — Arnulf Quadt, Marcello Bindi, and •Tim Schlömer — II. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

The ATLAS Pixel detector registers charged particles by the charges generated in the detector by the incoming particles. A specific number of electrons, defined by the threshold, is required to register a hit. Additionally, the time-over-threshold (TOT) is measured. The charge threshold and TOT of the Pixel Detector are regularly tuned to maintain target values as they detune with integrated luminosity, as a result of radiation damage effects. Monitoring key parameters including but not limited to charge threshold, TOT, digital-to-analogue converters, the number of masked pixels, and the number of disabled columns is crucial. Tracking these parameters over time and across integrated luminosity is essential for maintaining optimal detector performance and contributes to studies on radiation damage.

The detector operation parameters are presented via a web framework which displays relevant plots and values. A pipeline for automatic updates after each detector tuning ensures the plots are up-to-date, while older versions remain accessible for reference. The framework also allows the user to visualise the evolution of critical parameters over time and compare specific tunings belonging to different period of the detector lifetime.

T 56: Electroweak Physics II (Multi-boson Processes)

Time: Wednesday 16:15–18:00 Location: VG 2.103

T 56.1 Wed 16:15 VG 2.103

Sensitivity study of VBS WZjj semi-leptonic final states to vector boson polarisation observables — •Aryan Borkar, Thomas Trefzger, Raimund Ströhmer, and Gia Khoriauli — Julius-Maximilians-Universität Würzburg

The electroweak symmetry breaking mechanism can be experimentally tested in the electroweak vector boson scattering (VBS) processes that occur in proton-proton collisions at the LHC. The unitarity of VBS cross sections of longitudinally polarised bosons $V_{1,L}V_{2,L} \to V_{3,L}V_{4,L}$, where ($V = W^{\pm}, Z$), in the Standard Model are preserved by including the Feynman diagrams with the Higgs boson propagator in calculations. Thus, precise measurements of VBS processes of longitudinally polarised vector bosons are important experimental tests of the validity of the Brout-Englert-Higgs mechanism. We present the preliminary study of the potential of measurements of WZ VBS polarisation observables in the Run-2 data sets collected by the ATLAS detector. VBS processes with semi-leptonic final states are considered in the study.

T 56.2 Wed 16:30 VG 2.103

Polarization Measurement in Same-Charged WW Scattering with the ATLAS Experiment — •Erik Bachmann, Frank Siegert, Max Stange, Tim Herrmann, and Mareen Hoppe — TU Dresden, Dresden, Germany

In 2023, the ATLAS experiment published the first differential cross-section measurement of same-charged W-boson scattering – an essential process for understanding electroweak symmetry breaking. Since W-bosons gain their mass and, consequently, their longitudinal polarization through the Higgs mechanism, studying the scattering of longitudinally polarized W-bosons offers a promising way to probe this mechanism and search for new physics beyond the Standard Model.

However, since W-bosons decay into a charged lepton and a neutrino, directly reconstructing their original polarization is not possible. To overcome this, the analysis presented in this talk employs neural networks to separate the longitudinal component of the same-charged W-boson scattering signal from other polarization states and background processes. This talk aims to give an overview of the analysis strategy and to discuss state of the art techniques used to include higher-order QCD and EW effects in the polarized signal prediction.

T 56.3 Wed 16:45 VG 2.103

Measurement of the differential di-boson cross-section in semileptonic final states at $\sqrt{s}$ = 13 TeV in 140 fb^{-1} of pp collisions with the ATLAS detector — •Anubhav Gupta, Chris Malena Delitzsch, and Amartya Rej — Otto-Hahn-Str. 4A 44227 Dortmund

The measurement of electroweak vector boson pair (VV) production cross-sections is a critical test of the Standard Model (SM), probing electroweak boson self-interactions and the electroweak theory. While VV production has been well-studied in fully leptonic decay channels at $\sqrt{s}$ = 13 TeV, semileptonic channels have only been measured at $\sqrt{s}$ = 8 TeV.

This analysis presents the first measurement of di-boson production in the semileptonic channel (leptons and a large radius jet) at $\sqrt{s}$ = 13 TeV, taking advantage of its higher branching fraction compared to fully leptonic decays and a cleaner signature than fully hadronic decays. The semileptonic channel is particularly sensitive at high energies, offering strong potential for detecting new physics beyond the SM in the tails of kinematic distributions.

The study includes particle-level inclusive and differential cross-section measurements, along with constraints on dimension-6 Effective Field Theory (EFT) operators in the Warsaw basis, affecting electroweak triple gauge couplings, at the folded level.

T 56.4 Wed 17:00 VG 2.103

Measurement of the electroweak production of a W boson accompanied by two jets at $\sqrt{s}$ = 13 TeV with the ATLAS experiment — •Lisa Marie Baltes — Kirchhoff-Institute for Physics, University Heidelberg, Germany

The observation and measurement of self-interactions of weak gauge bosons provide an indirect search for physics beyond the Standard Model. The electroweak production of a W boson in association with two jets includes the vector-boson-fusion (VBF) production of a W boson and is thus sensitive to the triple gauge boson vertices WWγ and WWZ. In proton-proton collisions, the characteristic signature of VBF includes two high-momentum jets at small angles with respect to the incoming beams and a centrally produced lepton-neutrino pair originating from the W boson decay. This unique signature provides kinematic discrimination from backgrounds such as strongly produced jets associated with a W boson, $t\bar{t}$ and dijet. In this talk, the current status of the electroweak Wjj analysis including event selection and background estimation is presented.

T 56.5 Wed 17:15 VG 2.103

Computation of the parity-odd part of the three-vector vertex function without DimReg — •Nils Kreher and Wolfgang Kilian — University of Siegen, Siegen, Germany

I present the computation of the parity-odd part of the three-vector vertex function with a closed fermion loop in a generic model. The vertex function is evaluated in analytic form in manifest four-dimensional Euclidean space, retaining full dependence on masses and external momenta without making use of dimensional regularization and hence avoiding ambiguities arising from γ_5. I demonstrate that this vertex function is unambiguously determined by the parameters of the model and its symmetry structure, provided it is understood as part of the universal effective action. If the model is interpreted as a gauge theory, the divergence of this vertex function in the asymptotic limit corresponds to the well-known gauge anomaly of the model. The implications for electroweak interactions and beyond are discussed.

T 56.6 Wed 17:30 VG 2.103

Constraining Triple Gauge Boson Couplings at Future Higgs Factories — •Leonhard Reichenbach[1,2], Andre Silva[3,4], André Sailer[1], Christian Grefe[2], Philip Bechtle[2], Jenny List[3], and Klaus Desch[2] — [1]CERN, Geneva, Switzerland — [2]Universität Bonn, Germany — [3]DESY, Hamburg, Germany — [4]Universidade de Coimbra, Portugal

We provide projections on the precision of (anomalous) $ZWW/\gamma WW$ triple gauge couplings (aTGC) using an optimal observable analysis of the process $e^+e^- \to \ell\nu q\bar{q}$ at center of mass energies of 240–250 GeV. The measurements of aTGC provide crucial input to global fits of Higgs couplings and SMEFT-based searches for new physics and offer a unique test of the gauge symmetry of the electroweak interaction. The current aTGC projections for future Higgs factories are either theory-only studies, neglecting experimental effects or extrapolations of older full-simulation studies for energies of 500–1000 GeV. We perform this analysis using the Key4hep framework, which enables us to perform the same analysis using several different detector models at different Higgs factories. This way, we will for the first time present consistently obtained results for the ILD detector for the International Linear Collider (ILC) and the CLD detector for the Future Circular Collider (FCC-ee).

T 56.7 Wed 17:45 VG 2.103

Measurement of $ZZ\gamma$ final states with the ATLAS detector at the LHC — •Anke Ackermann — Kirchhoff-Institute for Physics, Heidelberg University

The Standard Model of Particle Physics (SM) predicts the rare production of triboson final states. Although suffering from small cross sections and hence a limited amount of signal events, such triboson states can be studied with the vast amount of data collected by the ATLAS detector in Run 2. In addition to validating the predictions of the SM for rare processes, sensitivity to New Physics is given via anomalous quartic couplings of e.g. four neutral gauge bosons. This talk will focus on the analysis of the simultaneous production of $ZZ\gamma$. In order to determine the cross sections of this process, it is crucial to separate signal events from events arising through background processes mimicking the signal topology. The most dominant background process contains fake photons, which are non-prompt photons within jets. Due to the limited statistics a new approach with jet ratios is applied to estimate the amount of fake photons in the signal region. Additionally, processes with misidentified leptons contribute to the background. Their contribution is estimated with the matrix method. After giving a general introduction about the triboson production of the $ZZ\gamma$ process, a summary of the analysis, including the event selection and the background estimation, is presented.

T 57: Gamma Astronomy I

Time: Wednesday 16:15–18:15 Location: VG 3.101

T 57.1 Wed 16:15 VG 3.101

MAGIC Moments from more than 20 Years of Operation — •Daniela Dorner[1] and MAGIC Collaboration[2] — [1]Universität Würzburg, Deutschland — [2]www.magic.mpp.mpg.de

The Major Atmospheric Gamma-ray Imaging Cherenkov Telescope (MAGIC) started its operation more than 20 years ago. Driven by innovative spirit and an international group of inspired scientists, the two 17-m telescopes located at the Canary Island of La Palma deliver cutting-edge science at energies above 50 GeV. Not only a variety of compelling gamma-ray physics cases are prominent in the science program, but also new fields like intensity interferometry are explored, and a collaboration with the large-size-telescope (LST) of the Cherenkov Telescope Array Observatory (CTAO) has been started. The presentation summarizes highlights from the past two decades, recent results and future prospects.

T 57.2 Wed 16:30 VG 3.101

Longterm Variability Study of the Crab Nebula with the MAGIC Telescopes — Felix Wersig and •Cyrus Walther — TU Dortmund, Germany

As the brightest steady source in the sky at very high energies, the Crab Nebula is often used for the calibration of instruments in gamma astronomy. Since 2011 multiple flares at energies > 100 MeV have been observed by AGILE and Fermi-LAT. We investigate variability at very high energies using data spanning a time period of 10 years from the MAGIC telescopes. Non-periodic variability can manifests in three ways: flares, flux increase/decrease on long-timescales or as an additional fluctuation on top of the statistical fluctuations expected in the flux. To investigate those types of variability, different tests are implemented.The presence of flares is investigated with a Bayesian Blocks algorithm, changes of the flux on long time-scales are investigated with a likelihood ratio test and the fractional variation is introduced as test statistic for a model independent test for fluctuations in the data.

T 57.3 Wed 16:45 VG 3.101

Consistent long-term analysis of VHE blazars using autoMAGIC — •Cyrus Walther and Felix Wersig — TU Dortmund University

Through the Cherenkov light emitted by particles originating from primary gamma rays interacting with the atmosphere, Imaging Atmospheric Cherenkov Telescopes (IACTs) such as MAGIC observe TeV-emitting astrophysical sources since 2003. After 20 years, this allows now for long-term analyses. While the development of consistent multi-year analysis requires a significant time commitment and is prone to bias if performed manually period by period, a database-driven software could fix those issues. An automatic analysis dubbed autoMAGIC has been developed to automatize the analysis of data from the MAGIC telescopes. In this approach, we aim to utilize autoMAGIC to perform long-term analyses of gamma-ray emitting blazars and aim to develop long-term light curves for selected blazars

T 57.4 Wed 17:00 VG 3.101

Revealing FACTs about the Harder-when-Brighter Behaviour of Mrk 421 in an Unbiased Long-Term Study — •Daniela Dorner[1], Bernd Schleicher[2], and FACT Collaboration[3] — [1]Universität Würzburg, Deutschland — [2]ETH Zürich — [3]www.fact-project.org

Featuring two peaks in their spectral energy distribution, blazars exhibit a strong variability both in X-rays and very-high-energy gamma rays. Many studies find a harder-when-brighter behaviour of the spectral index in correlation with the flux.

Within the FACT monitoring program, the blazar Mrk 421 has been observed for more than 3200 hours at TeV energies. Thanks to the unbiased observing strategy, the data sample is ideally suited for systematic long-term studies. Owing to the stable photosensors that allow for observations during bright moon and the automatic and remote operation, the 10-year data sample covers more than 1100 nights.

Results from an unprecedented study of Mrk 421 are presented, focussing on the correlation of the spectral index with the flux at very high energies and probing the often observed hard-when-brighter behaviour.

T 57.5 Wed 17:15 VG 3.101

Towards Searching for Photons with Energies beyond the PeV Range from Galactic PeVatrons — •Chiara Papior, Marcus Niechciol, and Markus Risse — Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen

Recently, photons of cosmic origin with energies in the PeV range have been measured by several gamma-ray observatories. Such energetic photons are potentially produced during the acceleration of charged particles in so-called PeVatrons which are widely assumed to be the sources of a large part of galactic cosmic rays. The LHAASO and HAWC observatories published catalogs of gamma-ray sources including sources with energy spectra without visible cutoffs up to the PeV range. Several of those sources have been selected and their spectra have been extrapolated up to the ultra-high-energy (UHE, here beyond 10 PeV) regime. It has been evaluated if (and under which conditions) giant air-shower observatories, for example the Pierre Auger Observatory, could contribute to testing the UHE luminosity of such PeV γ-sources. The expected fluxes and the required discrimination power to distinguish between photon- and hadron-initiated air showers will be presented. The impact of possible propagation effects is investigated as well.

This work is supported by the German Research Foundation (DFG, Project No. 508269468).

T 57.6 Wed 17:30 VG 3.101

Enabling ground-based one giga electronvolt gamma ray astronomy — •Sebastian Achim Mueller — Max Planck Institute for Nuclear Physics, Heidelberg, Germany

Timing the variable gamma ray emission from mergers, bursts, recurring novas, flaring jets, clocking pulsars, and many more is key to constrain physical models. For good timing on account of high rates, we would ideally collect the abundant low energetic 1GeV gamma rays, for which the universe is still transparent up to high red shifts, in large areas. Satellites collect low energetic gamma rays but only in desk sized areas. Cherenkov telescopes have multi soccer field sized collecting areas but only detect the rare high energetic gamma rays above several 10GeV. We propose a ground-based instrument that detects 1GeV gamma rays in a large area and hence achieves huge gamma ray detection rates: the Cherenkov plenoscope. With a groundbreaking optics, the plenoscope enables for the first time the high-resolution imaging of low energy gamma ray air showers using a huge (71m) mirror. The plenoscope can tolerate deformations and misalignments of its mirror and camera, what reduces its cost compared to a telescope. We will introduce the plenoscope's optics and demonstrate its capabilities. By simulating a

possible design we will briefly discuss the consequences for future ground based gamma ray astronomy.

T 57.7 Wed 17:45 VG 3.101

Bayesian approach to signal estimation in gamma-ray astronomy with Gammapy — •Matheus Genaro Dantas Xavier, Rodrigo Guedes Lang, Tim Unbehaun, and Stefan Funk — Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg

Gamma-ray observations from Imaging Atmospheric Cherenkov Telescopes, such as H.E.S.S., are overwhelmingly dominated by a background of cosmic rays. To properly estimate the strength of the observed signal, gamma-hadron separation methods are used in conjunction to background estimation techniques, where selection cuts remove the majority of background events (inevitably loosing a fraction of the unknown signal). We are interested in applying and extending a Bayesian method to perform signal estimation - the BASiL method from D'Amico et al. (2021) - to H.E.S.S. data, in both 1-dimensional (data binned in energy) and 3-dimensional (data binned in energy and spatial coordinates) analyses. This approach utilizes all available information after event reconstruction and the probability distributions associated to gamma- and hadron-like events without selection cuts. In the Bayesian framework, the posterior probability of the signal is obtained, from which credible intervals can be computed and the probability of two competing hypotheses (source or non-source) can be assessed through the Bayes factor. From simulated data, improved precision in signal reconstruction is achieved, while flux points are obtained from a modified version of Gammapy, revealing that fluxes can be measured even in highly background-dominated datasets.

T 57.8 Wed 18:00 VG 3.101

Impact of the three-dimensional Galactic gas distribution on the modeling of the diffuse gamma-ray flux* — •Yannick Schmidt[1,2], Julien Dörner[1,2], Jonas Hellrung[1,2], and Julia Becker Tjus[1,2,3] — [1]Theoretical Physics IV, Plasma Astroparticle Physics, Faculty of Physics and Astronomy, Ruhr-University Bochum, 44780 Bochum, Germany — [2]Ruhr Astroparticle and Plasma Physics Center (RAPP Center), Germany — [3]Department of Space, Earth and Environment, Chalmers University of Technology, 412 96 Gothenburg, Sweden

The high-energy γ-ray sky is predominantly shaped by diffuse emissions arising from non-thermal processes, such as inverse Compton scattering, Bremsstrahlung, and the decay of neutral pions. Simulations of these emissions serve as valuable tools to constrain models of the Galactic cosmic-ray population, providing insights into their origin and propagation through the interstellar medium (ISM). The accuracy of these simulations is highly dependent on the spatial distribution of the interstellar gas. To date, many models rely on a 2D cylindrically symmetric geometry, which imposes significant limitations in terms of physical realism. In this work, we investigate the impact of explicit three-dimensional distributions for the neutral gas components of the ISM on π^0-production. This is achieved by integrating the local emissivity along the line of sight, as implemented in the HERMES software framework. The resulting γ-ray emissions are subsequently analysed and compared with those obtained using traditional two-dimensional ring models for the gas distribution. * supported by SFB1491

T 58: Cosmic Rays III

Time: Wednesday 16:15–18:00 Location: VG 3.102

T 58.1 Wed 16:15 VG 3.102

CORSIKA 8: A modern and universal framework for particle cascade simulations — •Marvin Gottowik for the CORSIKA8-Collaboration — Karlsruher Institut für Technologie, Institut für Astroteilchenphysik, Karlsruhe, Germany

CORSIKA 8 represents a major advancement in the simulation of particle showers, building on the well-established foundation of CORSIK 7. It has been entirely rewritten as a modular and modern C++ framework, addressing the limitations of its predecessor to provide a flexible platform designed to satisfy current and novel use cases. This includes applications beyond traditional air-shower scenarios, such as cross-media particle cascades and enhanced radio emission calculations. For the first time, both the endpoint formalism and ZHS algorithm can be applied to the same simulation, demonstrating convergence to within 2 % on the radiation energy for high-precision simulations. A first official "physics-complete" version has been released, supporting hadronic interactions with current-generation models and the electromagnetic cascade with PROPOSAL 7.6.2. In this presentation, we will discuss the design principles, current capabilities, and validation efforts of CORSIKA 8, highlighting its potential applications for future experiments.

T 58.2 Wed 16:30 VG 3.102

Inclined Air Showers with Corsika 8 and Pythia 8: Cracking the Muon Puzzle One Shower at a Time — •Chloé Gaudu for the CORSIKA8-Collaboration — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal, Germany

The field of air shower physics seeks to understand the development of cosmic-ray interactions with the Earth's atmosphere. A key challenge in this field is the discrepancy in the muon content of extensive air showers observed by cosmic-ray experiments, such as the Pierre Auger Observatory, compared to predictions from state-of-the-art hadronic interaction models. This discrepancy, commonly referred to as the *Muon Puzzle*, stems from limitations in modeling high-energy hadronic interactions. The Pythia 8 interaction model emerges as a promising candidate for shedding light on the Muon Puzzle, owing to its user-friendly tunability and recent advancements in the Angantyr module, which enhances its handling of nuclear interactions. With Pythia 8 now partially integrated into the Corsika 8 particle-shower simulation code, preliminary analyses of the muon content in air showers are feasible.

This work is a comparative analysis of inclined air showers induced by proton primaries at 10^{19} eV, using Corsika 8 with Pythia 8 and current state-of-the-art alternatives, focusing on how differences in hadronic interaction models are reflected in shower observables. The preliminary results offer valuable insights into how Pythia 8 can advance our understanding of the Muon Puzzle and point to directions for future developments. **Supported by DFG (SFB 1491)*

T 58.3 Wed 16:45 VG 3.102

Simulating radio emission of extensive air shower with real noise for deep learning reconstruction at the Pierre Auger Observatory* — •Sven Querchfeld and Julian Rautenberg for the Pierre-Auger-Collaboration — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal

The ErUM-Wave project aims to develop an AI model to reconstruct 3-dimensional wave fields with the goal to predict the propagation of seismic waves based on only a few measurements. To test the transferability of the developed method to other fields, it will be applied to the propagation of radio waves in the atmosphere. These waves are produced by cosmic ray-induced air showers measured with the Pierre Auger Observatory. As part of the AugerPrime upgrade, each Water Cherenkov Detector (WCD) has been equipped with an additional radio antenna, enlarging the radio detection (RD) technique to the entire array, covering 3000 km^2. Realistic simulations of detector signals require realistic noise. With its unpredictable characteristics this needs to be extracted from real measured data. For vertical shower the particle footprint that triggers the station read-out is much larger than the radio footprint on the ground. We select noise data from outer stations which are not expected to have any radio-signal. The set of simulated events using the CoREAS extension of CORSIKA with this extracted realistic noise added will be used for first test of AI models to reconstruct the 3-dimensional wave propagation.

T 58.4 Wed 17:00 VG 3.102

Studies on Monte Carlo generator tuning for cosmic-ray induced air shower simulations — •Michael Windau and Kevin Kröninger — TU Dortmund, Fakultät Physik

Monte Carlo (MC) generators are a fundamental tool in particle and astroparticle physics. To achieve a high-quality simulation of physical processes, the hadronic interaction model of the generator must be tuned efficiently. The free parameters of MC generators are optimized with the help of experimental data and Bayesian methods. One area of application for MC generators is the simulation of cosmic-ray induced air showers in the Earth's atmosphere. Since hadronic interactions have a direct influence on the composition of secondary particles in shower formations, tuning the parameters of these hadronic models has an impact on crucial observables such as the muon number.

In this talk, studies on the tuning of the Monte Carlo generator PYTHIA for cosmic-ray induced air showers, using data from air shower experiments, are presented.

T 58.5 Wed 17:15 VG 3.102

Uncertainties in Atmospheric Interactions — •Alicia Fattorini for the IceCube-Collaboration — TU Dortmund, Dortmund, Germany

Many astrophysical measurements rely on assumptions about the absolute atmospheric flux of cosmic rays and their interaction in our atmosphere. While cosmic ray detectors such as Pierre AUGER measure cosmic rays via their secondary emissions in the atmosphere, neutrino detectors such as IceCube, and

IACTs such as MAGIC are subject to a background consisting of particles from the same interactions. For all these experiments, it is particularly important to understand the processes in the atmosphere and to be able to determine the flux of the emitted secondary particles. This work focuses on uncertainties in the processes occurring in the atmosphere where secondary particles are produced in cosmic ray-induced air showers, and in the cosmic ray flux itself. The aim is to estimate the normalization of the measured spectra and to determine the origin of the systematic uncertainties.

T 58.6 Wed 17:30 VG 3.102

comparing hadronic interaction models with air shower parameters at the IceCube Neutrino Observatory — •Fahim Varsi[1], Mark Weyrauch[2], Dennis Soldin[3], and Timo Peter Lemmer[1] for the IceCube-Collaboration — [1]Karlsruhe Institute of Technology, Institute of Experimental Particle Physics, Karlsruhe, Germany — [2]Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Karlsruhe, Germany — [3]Department of Physics and Astronomy, University of Utah, Salt Lake City, USA

The IceCube Neutrino Observatory studies cosmic-ray extensive air showers (EASs) using a surface array of ice-Cherenkov detectors, known as IceTop, by detecting the electromagnetic component and low-energy (~GeV) muons of EASs. A new reconstruction method, utilizing different lateral distribution functions (LDFs) for the electromagnetic and muonic components of the detector signals, is applied to estimate the shower size and low-energy muon content of EASs on an event-by-event basis. However, due to systematic uncertainties in high-energy hadronic interaction models, the simulated predictions of these EAS parameters show a significant dependence on the high-energy interaction models. Consequently, a detailed study of these systematic uncertainties in the reconstructed parameters provides insights into model-dependent variations in cosmic-ray air shower studies. In this work, we compare the EAS parameters reconstructed using three hadronic interaction models: Sibyll 2.1, QGSJet-II.04, and EPOS-LHC, and the results will be presented at the conference.

T 58.7 Wed 17:45 VG 3.102

Impact of adding simulations of ultra-heavy cosmic rays on neural network-based estimators using surface detector data of the Pierre Auger Observatory — •Steffen Hahn for the Pierre-Auger-Collaboration — Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Germany

To understand the physics of ultra-high-energy cosmic rays (UHECRs), an accurate estimate of the masses of UHECR is crucial. Direct detection of UHECRs is not feasible and requires the study of air showers induced by the interaction of UHECRs with the atmosphere. The surface detector stations of the Pierre Auger Observatory (Auger) measure the front of such cascades, called the shower footprint. Analyzing the spatio- temporal information of these shower footprints is highly non-trivial. Neural networks (NNs) offer a convenient way to exploit the correlations in the footprints and improve the reconstruction of high-level shower observables. However, simulations of UHECRs face limitations due to incomplete understanding of the high-energy hadronic interactions. The most prominent discrepancy is the muon puzzle – a systematic deficit of muons in simulations which complicates the application of simulation-trained NNs to Auger data. Typically, training data sets for Auger consist of a mix of proton, iron, and intermediate-mass nuclei. Since the number of muons produced in an air shower correlates with the mass of the UHECR, varying the mass composition in the training dataset could impact the transition to measurements. In this contribution, we show how the inclusion of heavier UHECRs affects NN-based estimators in simulations and measurements.

T 59: Neutrino Physics V

Time: Wednesday 16:15–18:30 Location: VG 3.103

T 59.1 Wed 16:15 VG 3.103

The Taishan Antineutrino Observatory — •Hans Theodor Josef Steiger — Physik-Department, Technische Universität München, James-Franck-Str. 1, 85748 Garching, Germany

The Taishan Antineutrino Observatory (TAO or JUNO-TAO) is a satellite detector for the Jiangmen Underground Neutrino Observatory (JUNO). JUNO will use reactor antineutrinos at a baseline of about 53 km to probe the interference effects between the two atmospheric mass-squared differences, which are sensitive to the sign of the mass ordering. Located near the Taishan-1 reactor, TAO independently measures the antineutrino energy spectrum of the reactor with unprecedented energy resolution and by that uncovering its fine structure for the first time. Beyond that, TAO is expected to make world-leading time-resolved measurements of the yield and energy spectra of the main isotopes involved in the antineutrino emission of nuclear reactors. By that TAO will provide a unique reference for other experiments and nuclear databases. In order to achieve its goals, TAO is relying on cutting-edge technology, both in photosensor and liquid scintillator (LS) development which is expected to have an impact on future neutrino and Dark Matter detectors. In this talk, the design of the TAO detector with special focus on its new detection technologies will be introduced. In addition, an overview of the progress currently being made in the R&D for photosensor and LS technology in the frame of the TAO project will be presented.

T 59.2 Wed 16:30 VG 3.103

JUNOs sensitivity to the annihilation of sub-GeV dark matter in the galactic halo — •Jessica Eck, Dhanushka Bandara, Lukas Bieger, Silvia Cengia, Adrian Keiderling, Florian Kirsch, Tobias Lachenmaier, Anurag Sharma, and Tobias Sterr — Eberhard Karls Universität Tübingen, Physikalisches Institut

The Jiangmen Underground Neutrino Observatory (JUNO) is in the final construction stage in southern China with the main goal to determine the neutrino mass hierarchy with reactor antineutrinos. Due to the large volume of 20 kt, indirect search for self-annihilating light dark matter (DM) in the mass range from 10 MeV to 1 GeV is an additional physics goal of JUNO. In this talk, the expected signal from a monoenergetic neutrino flux on Earth, originating from direct annihilation of DM particles into neutrinos, will be discussed. Furthermore, different methods to suppress background contributions in the respective energy range are presented to estimate the expected sensitivity of JUNO to DM self-annihilation in the Milky Way.

T 59.3 Wed 16:45 VG 3.103

Particle identification in JUNO with a Graph Convolutional Network — Thilo Birkenfeld, •Elisabeth Neuerburg, Philipp Soldin, and Achim Stahl — RWTH Aachen

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kton liquid scintillator-based neutrino observatory. Identifying the secondary particles gives a handle on the primary neutrino type. In this talk, a method of particle identification using a Graph Convolutional Network (GCN) is presented. A fixed Graph is fed into the network, which uses partition pooling for dimensionality reduction. This method is applied to the discrimination of electrons and positrons. Their discrimination aids in distinguishing atmospheric neutrinos and antineutrinos, as well as backgrounds from the IBD signal of reactor antineutrinos.

T 59.4 Wed 17:00 VG 3.103

A novel view at using the topological track reconstruction in JUNO — •Mikhail Smirnov, Daniel Bick, Milo Charavet, Caren Hagner, and Rosmarie Wirth — Institute of Experimental Physics, University of Hamburg, Hamburg, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) represents a new generation of kiloton-scale neutrino detectors based on liquid scintillator (LSc). With a target mass of 20 kilotons, it will be the largest LSc detector in the world. Utilizing the antineutrino flux from two nuclear power plants at a baseline of approximately 53 km, JUNO aims to determine the neutrino mass ordering with at least 3σ significance and to make precise measurements of oscillation parameters. Initially, the topological track reconstruction (TTR) was developed to reconstruct muon events in unsegmented LSc detectors for particles with energies up to 10 GeV. This reconstruction algorithm uses time and spatial information from PMT hits to iteratively determine the origin and trajectory of particles inside the detection medium. This talk reviews the TTR method and its potential applications in the JUNO experiment and is supported by the DFG.

T 59.5 Wed 17:15 VG 3.103

Application of the Topological Track Reconstruction to ANNIE — Daniel Bick, Caren Hagner, and •Malte Stender for the ANNIE-Collaboration — Universität Hamburg, Institut für Experimentalphysik

The Topological Track Reconstruction (TTR) is an algorithm originally developed for reconstructing the energy depostion of muons in liquid scintillator detectors like LENA for improving veto strategies. In its development history, the TTR was successfully used for electron/positron discrimination in JUNO and for separating Cherenkov and scintillation photons in an simulated idealised Water-based liquid scintillator (WbLS) detector. The latter application can be tested on real data in the near future with the help of the Accelerator Neutrino Neutron Interaction Experiment (ANNIE).

ANNIE is a 26-ton water-Cherenkov beam-neutrino detector that - besides neutrino-nucleus cross section and neutron multiplicity measurements - aims to be a test-bed for new detector technologies like WbLS and Large Area Picosecond Photodetectors (LAPPDs). For that, the ANNIE collaboration deployed an acrylic vessel filled with WbLS for several months and intends to use a greater volume of the liquid in the future.

A necessary step for the Cherenkov/scintillation light separation algorithm is the modification and application of the TTR to ANNIE data. This is the focus of

this talk together with an introduction to the ANNIE experiment and the TTR algorithm. The presented work is supported by the DFG.

T 59.6 Wed 17:30 VG 3.103

Topological reconstruction of neutrino interactions with the SHiP detector — •James Webb, Christian Weiser, and Karl Jakobs — Albert-Ludwigs-Universität Freiburg, Physikalisches Institut, 79104 Freiburg, Germany

The SHiP (Search for Hidden Particles) experiment, to be installed within ECN3 at CERN, aims to utilise a 400 GeV/c proton beam on target to probe a broad physics regime. The high energy, high intensity proton beam dump will produce a high flux of all neutrino flavours, making this environment ideally suited for performing neutrino physics studies.

A proposed detector to exploit the neutrino flux comprises a passive tungsten plane, followed by pairs of rotated silicon strip detectors; many such layers are envisioned to be stacked up along the beam axis.

This talk will discuss the potential of such a detector in terms of track and vertex reconstruction, with an emphasis on studying tau neutrino interactions.

T 59.7 Wed 17:45 VG 3.103

Tau-neutrino signal in AdvSND@LHC — Heiko Lacker and •Eduard Ursov — Humboldt University of Berlin, Berlin, Germany

The SND@LHC (Scattering and Neutrino Detector at the LHC) is a compact, stand-alone, emulsion-based experiment designed to measure neutrinos produced in proton-proton collisions at the LHC. It operates in the previously unexplored pseudo-rapidity range of $7.2 < \eta < 8.4$. In July 2023, the SND@LHC collaboration reported the observation of eight muon neutrino charged-current candidates with a significance of 6.8σ. AdvSND@LHC, a proposed fully electronic upgrade of SND@LHC, is planned to collect data during the High-Luminosity LHC era. The upgraded detector will feature two primary subsystems: a tungsten target and a hadronic calorimeter with magnetized iron as passive material. Both subsystems will be interleaved by sensitive planes composed of silicon strips. This work presents the development of a full simulation pipeline for neutrino studies at AdvSND@LHC. The pipeline encompasses the generation of proton-proton collisions at the interaction point, production of the neutrino flux, propagation of neutrinos to the detector vicinity, neutrino interactions within the detector, and digitization of the resulting signals. To study the tau-neutrino signal, a machine learning classifier based on the Boosted Decision Trees (BDT) algorithm has been developed. This classifier achieves effective separation between charged-current muon neutrino events and charged-current tau-neutrino events with subsequent leptonic decays of the tau-leptons.

T 59.8 Wed 18:00 VG 3.103

Simulation Studies on Muon Neutrino DIS Analysis at the SND@LHC Detector — Andrew Conaboy, Heiko Lacker, •Tilly Smith, and Eduard Ursov — Humboldt University Berlin

The SND@LHC experiment, located 480m downstream from the ATLAS interaction point at the LHC, aims to detect high-energy neutrinos originating from proton-proton collisions at the LHC. This standalone experiment targets the otherwise inaccessible pseudo-rapidity region of $7.2 < \eta < 8.4$ and with the data taken during the first year of running in 2022 has successfully identified 8 $\nu\mu$ CC candidates with a significance of seven standard deviations. An in-depth simulation of the detector environment as well as the muon neutrino deep inelastic scattering (DIS) interaction is being developed to further enhance this significance level.

This talk gives an overview of the developed simulation as well as its performance on MC simulated data for both signal and background processes. Details on the applied selection cuts, tracking algorithm and analysis methods are given as well as a comparison to previous performance studies. To improve the background rejection, we study the distributions of the interaction point, shower width and position, and muon angle after interaction for simulated signal and background samples.

T 59.9 Wed 18:15 VG 3.103

Detecting Collider Neutrinos at the LHC: the FASER Experiment — •Wissal Filali, Florian Bernlochner, Tobias Boeckh, and Markus Prim — Physikalisches Institut der Universität Bonn

The neutrinos produced at the Large Hadron Collider (LHC) proton-proton collision provide an opportunity to explore the TeV regime which has remained largely uncharted. The FASER experiment, located 480 meters downstream from the ATLAS interaction point and aligned with the beam collision axis, aims to measure the interaction cross section and flux of neutrinos ν_{mu} in the energy range from 400GeV to 6TeV. Using FASER's active electronic detector, charged current interactions of muon neutrinos and anti-neutrinos are identified, the neutrino flux is measured in six momentum bins and five pseudorapidity bins, with correlations between these measurements providing improved precision in the flux determination. In this presentation, we present the current status of the analysis.

T 60: Gravitational Waves

Time: Wednesday 16:15–18:00 Location: VG 3.104

T 60.1 Wed 16:15 VG 3.104

Archival search for sub-TeV neutrino counterparts to sub-threshold Gravitational Wave events with IceCube — •Tista Mukherjee for the IceCube-Collaboration — Institute for Astroparticle Physics (IAP), Karlsruhe Institute of Technology (KIT), Hermann-von-Helmholtz Platz 1, 76344 Eggenstein-Leopoldshafen, Germany

The IceCube Neutrino Observatory actively participates in multi-messenger follow-ups of gravitational wave (GW) events. With the release of the Gravitational Wave Transient Catalogue (GWTC)-2.1 and -3, sub-threshold GW event information from the third observation run of the LIGO-Virgo-KAGRA (LVK) collaboration is publicly available. This offers an opportunity to search for their corresponding neutrino counterparts. For these sub-threshold GWs, identified via template-based and minimally-modelled search pipelines, archival searches for neutrinos can enhance their astrophysical significance, and improve localization.

In this contribution, we perform a catalogue-based search for sub-TeV neutrino counterparts to some shortlisted sub-threshold GWs. This study uses archival data from IceCube's dense-infill array, DeepCore. By correlating IceCube data with sub-threshold GWs, we aim to contribute to the ongoing efforts to identify common astrophysical sources of neutrino and GW. We present the current status of this search and its role in advancing multi-messenger astronomy, paving the way for deeper exploration of transient astrophysical events.

T 60.2 Wed 16:30 VG 3.104

Seaching for high frequency gravitational waves using an external magnetic field — •Jasper Jödicke, Dieter Horns, and Marios Marouder — Institut für Experimentalphysik, Universität Hamburg

Gravitational waves interacting with external electric and magnetic fields can induce electromagnetic effects, such as displacement currents. A novel approach to detecting gravitational waves in the high-frequency regime benefits from existing axion haloscopes. In this talk the GravLC experiment is introduced, which leverages the 14 T solenoidal magnetic field of the WISPLC axion haloscope at DESY in Hamburg. By employing a suitably designed pickup loop, the experiment enables searches for transient and broadband signals, such as those expected from primordial black holes and the stochastic gravitational wave background, across the frequency range of 10 kHz - 10 MHz. This technique provides a complementary method to existing gravitational wave detection approaches.

T 60.3 Wed 16:45 VG 3.104

Quantum enhanced high frequency gravitational wave searches — •Tom Krokotsch[1], Lars Fischer[1], and Gudrid Moortgat-Pick[1,2] — [1]Universität Hamburg, Hamburg, Germany — [2]Deutsches Elektronen Synchrotron DESY, Hamburg, Germany

A promising way to probe physics beyond the Standard Model is to search for gravitational wave (GW) signals at high frequencies where known astrophysical sources can not obscure the signal. Similar to the search for dark matter, microwave cavity resonators can be used to detect faint effects from GWs. This talk will focus on the possibility to apply quantum enhancement techniques like vacuum squeezing to operate such detectors beyond the standard quantum limit. In particular, we will highlight the unique benefit this would bring to transient GW sensitivities such as those for primordial black hole mergers.

T 60.4 Wed 17:00 VG 3.104

Estimating the Detection Horizon of Gravitational Waves from Core-Collapse Supernovae for the Einstein Telescope — Markus Bachlechner, Thilo Birkenfeld, •Timo Butz, and Achim Stahl — III. Physikalisches Institut B, RWTH Aachen

Core-collapse supernovae are one of the most anticipated sources for gravitational wave detectors. A detection of such an event can provide crucial information on the processes occurring during the final stages of massive stars and open perspectives in multi-messenger astronomy. The proposed Einstein Telescope (ET), as the first of the third-generation of gravitational wave detectors, is predicted to be an order of magnitude more sensitive in the whole frequency band compared to the previous generation. Therefore, an increased event rate due to the enlarged observable volume and the ability to study details of the underlying mechanism are expected. This talk presents an analysis of ET's detection

horizon for core-collapse supernovae obtained with the unmodelled search algorithm *Coherent WaveBurst* and compares it to the upper limit given by optimal matched filtering.

T 60.5 Wed 17:15 VG 3.104

Characterizing the Seismic Impact of Steel- and Wood-Based Wind Turbines on the Einstein Telescope — Marc Boxberg[2], Tom Niggemann[1], •Niklas Nippe[1], Achim Stahl[1], and Florian Wagner[2] — [1]III. Physikalisches Institut B, RWTH Aachen — [2]Geophysical Imaging and Monitoring, RWTH Aachen

Knowing the seismic impact of nearby wind turbines is crucial for future gravitational wave detectors like the Einstein Telescope. In the low frequency regime, seismic and gravity gradient noise are the dominant effects impacting the sensitivity. Vibrations of nearby wind turbines (WTs) are expected to be significant contributions. Wood as an alternative tower material is known to decrease the transfer of vibrations into the ground for existing WTs. This talk will present measurements of seismic noise and simulations of the tower vibrations of a conventional steel-based WT and compare these to measurements and simulations of a wooden tower WT.

T 60.6 Wed 17:30 VG 3.104

Cavern Geometry Effects in Newtonian Noise at the Einstein Telescope — •Valentin Tempel, Markus Bachlechner, David Bertram, and Achim Stahl — III. Physikalisches Institut B, RWTH Aachen University

The Einstein Telescope (ET) is a proposed third-generation gravitational wave detector designed to surpass the sensitivity of current interferometers like LIGO and Virgo by at least an order of magnitude. This enhanced sensitivity will enable the detection of fainter gravitational waves and provide new insights into astrophysical phenomena. One of the major challenges in achieving the desired sensitivity is Newtonian Noise (NN), which dominates the expected noise budget of ET in the frequency range of 1 Hz to 5 Hz. NN arises from density fluctuations in the rock surrounding the cavern walls, leading to fluctuating gravitational forces on the mirrors. This talk presents the impact of cavern geometry on the coupling of seismic waves to the ET mirrors. Analytical and numerical approaches are applied to demonstrate how the size and shape of the cavern influence the coupling transfer functions.

T 60.7 Wed 17:45 VG 3.104

Testing noise mitigation techniques for future gravitational wave detectors — Markus Bachlechner, •Tim Johannes Kuhlbusch, and Achim Stahl — III. Physikalisches Institut B, RWTH Aachen

Future gravitational wave (GW) detectors like the Einstein Telescope aim to decrease the detector noise to measure weaker signals and to increase the precision of measurements. To measure the minuscule length changes induced by GWs, extremely low vibration levels for the test masses are required. New noise sources become relevant in reducing the residual vibrations of the detector test masses. Gravitational couplings from surrounding vibrating material, called gravity gradient noise, can not be shielded. Therefore, predicting the coupled noise from inertial sensors is essential to reduce the impact in the 1 to 10 Hertz range.

Wiener filters are a simple and robust approach to predicting coupled noise. However, the classic Wiener filter can not adapt to variations in the amplitude of the coupled noise. As variations in the amplitude over time are expected for the ambient noise sources in GW detectors, an adaptive filter is required for optimal performance. This talk will discuss adaptive filtering options including modifications to Wiener filters and neural networks. An evaluation on data from a small-scale interferometer will be presented.

T 61: Methods in Particle Physics III (Tracking)

Time: Wednesday 16:15–18:15 Location: VG 4.101

T 61.1 Wed 16:15 VG 4.101

Performance of the SciFi tracker alignment in 2024 — •Nils Breer, Biljana Mitreska, and Johannes Albrecht — TU Dortmund University, Germany

Alignment and calibration form a crucial part of the LHCb trigger system and are responsible for ensuring the best possible physics performance. The positions of the SciFi tracker need to be monitored over time using the track-based alignment software in order to find potential biases and disentangle effects coming from other tracking systems.

In 2024 the global alignment is performed utilising all of LHCb's tracking detectors. The SciFi alignment constants are analysed on a set of runs for multiple configurations as well as the stability over time of the SciFi tracker in order to validate the performance on 2024 data.

In this talk, studies on the alignment of the outermost modules of the SciFi will be presented alongside results on the performance achieved by the global alignment.

T 61.2 Wed 16:30 VG 4.101

SciFi Threshold Calibration — •Dhruvanshu Parmar[1], Xiaoxue Han[2], and Mikhail Mikhasenko[1] — [1]Ruhr-Universität Bochum, Bochum, Germany — [2]Ruprecht-Karls-Universität, Heidelberg, Germany

The Scintillating Fiber tracker (SciFi) at LHCb, operational since 2022, is the main tracker positioned downstream of the dipole magnet. Aided by upstream trackers, SciFi detects charged particles and precisely measures their momentum and trajectory with high accuracy. It consists of three stations, each composed of 5-meter high modules containing scintillating fiber mats. The ends of the tracker modules include readout boxes equipped with silicon photomultiplier sensors (SiPMs) that collect photons generated by particle interactions with the scintillating fibers. Analog signals from SiPM channels are processed by comparing them to a set of three "comparator" thresholds to discriminate signals from dark noise. Adjusting these thresholds is critical for a high hit efficiency, a low fake track rate and sustainable bandwidth. This talk summarizes the utilization of the Light Injection System (LIS) for calibrating the comparator thresholds for the full system of 524k SiPM channels and 1.5M comparators. Accurate time alignment for optimizing LIS performance and full calibration procedure of fitting SiPM spectra will be discussed. Finally, challenges faced with LIS calibration and strategies to address them will be highlighted.

T 61.3 Wed 16:45 VG 4.101

Studies of alignment systems for the LHCb Upgrade II downstream tracker — •Todor Todorov, Ksenia Solovieva, and Marco Gersabeck — Albert-Ludwigs-Universität Freiburg, Freiburg im Breisgau, Germany

For the LHCb Upgrade II in Long Shutdown 4 the instantaneous luminosity is planned to increase by at least a factor of 5 with respect to current operation. The increase in detector occupancy and pileup will be beyond the capabilities of the current scintillating fibers (SciFi) sensors utilised in the downstream tracker of the LHCb detector. A new hybrid tracker will be installed, the Mighty Tracker, which will consist of six layers of silicon pixel sensors in the most occupied regions near the beam pipe and of an improved SciFi in the remaining areas. An active hardware alignment system will be beneficial for the physics performance of LHCb but it will have to adhere to strict space and material budget constraints. A study of alignment requirements and of early prototype systems capable of fulfilling those within the above-mentioned constraints is presented.

T 61.4 Wed 17:00 VG 4.101

Track Based Software Alignment using the General Triplet Track Fit — •David Fritz, Tamasi Kar, Abhirikshma Nandi, and André Schöning — Physikalisches Institut, Universität Heidelberg, Germany

Modern particle physics experiments require very high precision and the accurate alignment of tracking detectors. While optical surveillance systems provide an initial reference, track-based software alignment is essential for achieving optimal physics performance.

A new alignment procedure based on the General Triplet Track Fit (GTTF) [1] is introduced, enabling the simultaneous determination of track and alignment parameters. The GTTF is a novel, non-iterative, triplet-based track fit that accounts for both hit uncertainties and multiple scattering effects. Its high parallelizability and scalability make it particularly well-suited for online alignment using hardware accelerators such as FPGAs or GPUs.

This talk will provide an overview of the GTTF-based alignment in the context of standard track based alignment procedures. Additionally, results from the GTTF-based alignment for a use case - the Mu3e Pixel Detector - will also be presented.

[1] A. Schöning, 2024, A General Track Fit based on Triplets, arXiv:2406.05240

T 61.5 Wed 17:15 VG 4.101

Studies of a New Track Fitting Algorithm for the ATLAS Event Filter — Abhirikshma Nandi[1], •André Schöning[1], Sebastian Dittmeier[1], and Christof Sauer[2] — [1]Physikalisches Institut, Universität Heidelberg, Heidelberg, Germany — [2]CERN, Geneva, Switzerland

The ATLAS experiment is going through a comprehensive set of upgrades in preparation for data taking at the High-Luminosity Large Hadron Collider. The Trigger and Data Acquisition (TDAQ) systems are being upgraded to handle an increased trigger rate and run more sophisticated algorithms online to retain performance in the face of increased event complexity.

The ATLAS Event Filter (EF) - running on commercial, potentially heterogeneous computing hardware - has to provide the second level of filtering, reducing the Level-0 trigger rate of 1 MHz to 10 KHz for storage. To this end, it is required to perform track reconstruction (EF Tracking) for the entire Inner Tracker (ITk) at a maximum rate of 150 kHz.

A new, parallelizable track fit, based on triplets of hits, is being studied for EF Tracking - with the aim to gain from parallel hardware, like GPUs. The General Triplet Track Fit (GTTF) is a generalization of the Multiple Scattering-only triplet fit, developed originally for the Mu3e experiment, by including hit uncertainties. The results from the studies of the GTTF will be summarized along with an overview of the work in the broader context of the EF Tracking project.

T 61.6 Wed 17:30 VG 4.101

Online Track Reconstruction for the Mu3e Experiment — •Haris Avudaiyappan Murugan — Institute of Nuclear Physics, Johannes Gutenberg University of Mainz, Germany

The Mu3e experiment aims to find or exclude the lepton flavour violating decay of a positive muon to two positrons and an electron with a branching fraction sensitivity of 10^{-16}. To observe such a rare event, we require a tracking detector from custom-designed High-Voltage Monolithic Active Pixel Sensors (HV-MAPS) together with timing detectors made from scintillating fibre and tiles for the experiment. The detector will be streaming up to 1 TBit/s of data to the filter farm composed of graphics processing units (GPUs), in which the data rate is reduced to less than 100 MB/s and this filtered data is stored for later analysis. This reduction can be achieved by selecting potential signal events with two positrons and one electron originating from a single vertex through online track and vertex reconstruction on the GPU. The misalignment of the thin pixel tracking detectors can affect the precision of track reconstruction. Track-based alignment algorithm requires constraints from global parameters of the actual position of the pixels which can be measured using a camera alignment system. By calibrating the track reconstruction and histogramming the momentum of tracks on the GPU, the searches can be extended to observe potential two-body decays of the muon.

T 61.7 Wed 17:45 VG 4.101

Tracking efficiency studies for LHCb in Run 3 — •Rowina Caspary[1], Michel de Cian[1], Peilian Li[2], and Maurice Morgenthaler[1] — [1]Physikalisches Institut, Heidelberg University — [2]University of Chinese Academy of Sciences (UCAS)

The LHCb experiment is dedicated but not limited to the precision measurement of particles containing b- and c-quarks. It has been collecting data with an upgraded detector and a novel software-only trigger framework since 2022 at an instantaneous luminosity up to $2 \times 10^{33} \mathrm{cm}^{-1}\mathrm{s}^{-1}$ at $\sqrt{s} = 13.6$ TeV.

The correct evaluation of the track reconstruction efficiency is essential for many high-precision measurements. A tag-and-probe method is developed to estimate the track reconstruction efficiency of each tracker using muonic tracks from $J/\psi \to \mu\mu$ decays, where hits from other detector systems are used to reconstruct the probe tracks. Discrepancies of the measured track reconstruction efficiency between simulation and data are evaluated, examined and corrected deliberately, taking into account various effects due to misalignment and inefficiency of the sub-detectors. An agreement between simulation and data at the sub-percent level is achieved over almost the entire phase space and for all tracking sub detectors, which illustrates the excellent understanding of the upgraded LHCb detector and its reconstruction sequences. This talk presents the results of the tracking efficiency methods in 2024 data and according systematic uncertainties.

T 61.8 Wed 18:00 VG 4.101

The Resolution Study of the New Scintillating Fiber Tracker of the LHCb Detector — •Ya Zhao — Physics Institute, Heidelberg University, Germany

The LHCb experiment started data-taking in 2022 with the upgraded tracking system including Vertex Locator(Velo), Upstream Tracker(UT) and Scintillating Fiber Tracker(SciFi). The hit resolution of SciFi is an essential part of its performance. An analysis of SciFi hit resolution was performed using 2024 dataset with latest alignment condition. The strategy to calculate hit resolution and the relationships between hit resolution and SciFi layers, track momentum, track slopes will be presented. The results of hit resolution measurement will provide SciFi hit errors for Kalman Filter to improve tracking performance. The long track momentum resolution is a key metric to evaluate the performance of the tracking system of LHCb. It can be estimated from the mass resolution of reconstructed Jpsi2mumu candidates. The approach and result of long track momentum resolution using 2024 dataset will be presented.

T 62: Search for Dark Matter III

Time: Wednesday 16:15–18:30 Location: VG 4.102

T 62.1 Wed 16:15 VG 4.102

Primordial Black Hole: from very early universe to Dark Matter — •Maël Gonin[1,2], Günther Hasinger[1,2], and David Blaschke[3,4,5] — [1]Deutsches Zentrum für Astrophysik, Görlitz 02826, Germany — [2]IKTP TU Dresden, Zellescher Weg 19, 01069 Dresden, Germany — [3]Institute of Theoretical Physics, University of Wroclaw, Wroclaw, Poland — [4]Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — [5]Center for Advanced Systems Understanding, 02826 Görlitz, Germany

Dark Matter (DM), comprising 30% of the universe's energy, remains one of cosmology*s greatest mysteries. Primordial Black Holes (PBHs), theorized by Hawking and Carr (1971), are compelling DM candidates as purely gravitational, non-baryonic objects. Though unproven, PBHs offer a unique alternative to particle DM (pDM) and insights into the early universe. We develop a novel PBH mass spectrum based on the equation of state (EoS) of the early universe, where phase transitions enhance PBH formation probabilities. Using advanced quark matter simulations, we also explore lepton flavor asymmetry and the possibility of a 17 MeV boson observed in electron-positron pair production. Additionally, N-body simulations using PeTar examine PBH detectability, focusing on globular cluster dynamics and PBH-star binaries, such as those observed by the Gaia collaboration. This presentation will discuss these approaches and their implications for identifying PBHs as DM candidates.

T 62.2 Wed 16:30 VG 4.102

SNAX: Supernova Neutrino Analysis in XENONnT — •Melih Kara for the XENON-Collaboration — Karlsruhe Institute of Technology, Institute for Astroparticle Physics

Core-collapse supernovae emit 99% of their energy as neutrinos, preceding any optical signals, offering a unique opportunity to study the physics of these explosive events. While traditional neutrino detectors are optimized for specific flavors, dark matter experiments like XENONnT leverage coherent elastic neutrino-nucleus scattering (CEνNS), enabling detection of neutrinos across all flavors at low energies.

This presentation focuses on the methods developed within the XENONnT framework to identify supernova neutrino signals promptly. We discuss the simulation of neutrino interactions, strategies for detecting CEνNS signals in real-time, and the integration of an active software trigger to communicate with the Supernova Early Warning System (SNEWS). These techniques ensure efficient and timely detection, allowing dark matter detectors to complement traditional neutrino observatories.

This work is supported in part through the Helmholtz Initiative and Networking Fund (grant no. W2/W3-118). Support by the graduate school KSETA at KIT is gratefully acknowledged.

T 62.3 Wed 16:45 VG 4.102

Novel Peak(let) Classification for the XENONnT Experiment — •Johannes Merz for the XENON-Collaboration — Johannes Gutenberg-Universität Mainz, Institut für Physik & Exzellenzcluster PRISMA+

The XENONnT Experiment is a dual phase time projection chamber searching for nuclear recoil signals generated by WIMP dark matter. Interactions with the liquid xenon in the bulk of the detector result in a prompt light signal (S1) and a secondary scintillation signal (S2), due to ionization electrons drifted in a moderate electric field to the liquid surface, where they are extracted to the gas phase in a strong field between two wire electrodes, called gate and anode.

These electrons lead to proportional scintillation in the gas phase and hence to an amplified S2 signal. XENONnT features a substantial background rate of single electrons, largely due to photoionization of neutral impurities, leading to numerous small S2 signals. These can be confused with S1 signals of similar size.

This presentation will show new machine learning classification methods used in XENONnT which will help to improve the discrimination between the two signal types and identify interesting signal populations in our data.

T 62.4 Wed 17:00 VG 4.102

DARWIN forecasted sensitivities — •Maike Doerenkamp — Physikalisches Institut, Universität Heidelberg

DARWIN, as a proposed next generation xenon based direct detection experiment, aims to explore new parameter-space of WIMP-nucleon interactions through nuclear recoil, all the way to neutrino dominated regimes. This requires extensive simulation of detector parameters and their impact on detection efficiencies, as well as a good understanding of relevant backgrounds and their mitigation strategies. This talk gives an overview of the used methods and obtained sensitivity estimates for the DARWIN observatory.

T 62.5 Wed 17:15 VG 4.102

Coating-based radon barriers for future liquid xenon detectors — •Sophie Armbruster[1], Giovanni Volta[1], Hardy Simgen[1], and Florian Jörg[2] — [1]Max Planck Institut für Kernphysik, Heidelberg — [2]Universität Zürich

Despite overwhelming evidence for dark matter in our universe, its true nature remains a mystery. In the search for dark matter, detectors using liquid xenon

are currently leading in sensitivity. However, these experiments are increasingly limited by self-induced backgrounds, particularly the emanation of radon from detector materials. To address this challenge, a novel radon mitigation technique using surface coatings as radon barrier has been investigated. Systematic studies at the Max Planck Institut für Kernphysik have demonstrated that electrochemical plating with a 5 μm copper layer can reduce radon emanation by up to three orders of magnitude. This technique is currently scaled up for vessel-like geometries with a new setup.

T 62.6 Wed 17:30 VG 4.102

Exploring Sub-GeV Dark Matter with CRESST: Advances, Challenges, and Prospects — •Marco Maria Zanirato — Max Planck Institut für Physik, München, Deutschland

The Cryogenic Rare Event Search with Superconducting Thermometers (CRESST) is a forefront experiment in the direct detection of dark matter, operating at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy. Utilising cryogenic calorimeters based on (mainly) scintillating crystals equipped with Transition Edge Sensors (TESs), CRESST achieves exceptional energy thresholds on the order of 30eV and operates at temperatures in the millikelvin range. These capabilities make CRESST uniquely suited to probe dark matter particles with sub-GeV masses. This talk will provide a comprehensive overview of CRESST, highlighting the working principles of its detectors, the latest results in dark matter searches, and the challenges inherent to such a cutting-edge experiment. The discussion will also include insights into ongoing efforts to refine detector designs and enhance the experiment's sensitivity, paving the way for future explorations in the quest to discover the nature of dark matter.

T 62.7 Wed 17:45 VG 4.102

Enhancing Simulation Statistics through Importance Biasing for the CRESST Experiment — •Praveen Murali for the CRESST-Collaboration — Heidelberg University

The CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) experiment is a pioneering project in the search for dark matter, employing ultra-sensitive cryogenic detectors to capture rare particle interactions. These rare events demand highly efficient and accurate simulations to optimize detector performance and data analysis. Importance biasing is a technique that boosts statistical accuracy without requiring extensive repetitions, offering a solution to this challenge. In this work, we apply GEANT4's Importance Biasing to CRESST simulations, demonstrating its successful implementation and impact on improving statistical outcomes. This presentation will detail the methodology and the results of this approach for CRESST.

T 62.8 Wed 18:00 VG 4.102

Development of a Detector Module with Optimized Scintillation Light Sensitivity for the COSINUS Experiment — •Lutz Ziegele for the COSINUS-Collaboration — Max-Planck-Institut für Physik, 85748 Garching, Germany

The Cryogenic Observatory for SIgnatures seen in Next generation Underground Searches (COSINUS) is a direct dark matter search located at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy. The experiment operates sodium iodide (NaI) as cryogenic calorimeters. Particle interactions within the crystal generate phonon signals, detected by a remote Transition Edge Sensor (remoTES). Combined with the scintillation signal detected by TES on a surrounding silicon beaker-shaped light absorber, a dual channel readout is achieved, enabling particle discrimination. This contribution focuses on the development of a detector module optimized in terms of scintillation light sensitivity. This is achieved by segmenting the light-collecting silicon beaker into multiple separated wafers surrounding the NaI crystal. The reduced size of these individual light absorbers minimizes heat capacity, thereby increasing sensitivity. The primary objective is the precise characterization of the scintillation light output of the ultrapure NaI crystals, which is vital for the data analysis of the upcoming COSINUS runs. Furthermore, this development represents a foundational step toward creating a detector module with single-photon resolution - a critical advancement for future investigations of dark matter interactions with electrons proposed within the LUCE/OνDES project funded by the Klaus Tschira foundation.

T 62.9 Wed 18:15 VG 4.102

Evaporated Gold Thin-Films on NaI Crystals for remoTES based cryogenic Detectors — •Kilian Heim for the COSINUS-Collaboration — Max-Planck-Institut für Physik, Garching, Deutschland

The COSINUS (Cryogenic Observatory for SIgnatures seen in Next generation Underground Searches) experiment plans a model-independent cross-check of the DAMA/LIBRA dark matter result. Starting its first operational phase in 2025, it will use the same target material NaI, but operated at cryogenic temperatures, enabling a dual-channel readout of both a scintillation and a phonon signal. The phonon signal is read out with a TES (transition edge sensor), but due to the low melting point and hygroscopicity of the NaI crystal, the TES cannot be deposited directly on the crystal. Therefore, the so-called remoTES setup is applied, in which the TES is located on a separate wafer and only a gold pad is required on the crystal. In the latest detector prototypes, the gold pad is deposited by an evaporation process. The first tests of this design have shown promising results. To further investigate and improve the performance and behavior of the detector design, the subsequent prototypes will be tested with different crystal masses and gold pad sizes. In this contribution, I would like to highlight the upgrades taken on the absorber part of the detector over the last year and present results of the latest detector prototype tests.

T 63: Invited Overview Talks III

Time: Thursday 11:00–12:30 Location: ZHG011

Invited Overview Talk T 63.1 Thu 11:00 ZHG011

Neutrino properties from the laboratory and the cosmos — •Thomas Schwetz-Mangold — Karlsruhe Institute of Technology, Karlsruhe, Germany

This talk reviews the present knowledge about neutrino properties, focusing on the determination of neutrino masses and PMNS mixing angles. I will review the implications of global data on neutrino oscillations and discuss the results of latest global fits, and I comment on expected near-term developements. For the determination of the absolute neutrino mass, complementary inforamtion is needed. In particular, recent results from cosmology lead to stringent upper limits on the sum of neutrino masses which start to be in slight tension with the lower bound implied by oscillation data. I will review the present status of this emerging tension and possible near future scenarios in light of upcoming data from DESI and EUKLID. A corroborated neutrino tension may be a sign of new physics in the cosmological model and/or in neutrino physics.

Invited Overview Talk T 63.2 Thu 11:30 ZHG011

Highlights from Standard Model physics at the LHC in the precision era — •Daniel Savoiu — Universität Hamburg

With the first two runs of the Large Hadron Collider (LHC) successfully completed, and Run 3 currently underway at an unprecedented center-of-mass energy of 13.6 TeV, the experiments at the LHC continue to collect a wealth of data for physics analysis. Following the discovery of the final component of the Standard Model (SM)—the Higgs boson—in 2012, the LHC physics program has entered an era of precision, aiming to measure the fundamental parameters of the SM and the properties of its constituent particles to the most precise extent possible. The quest for precision is complemented by a vast array of searches for phenomena beyond the SM (BSM), which directly benefit from the improved knowledge of the SM. In this contribution, I will present a selection of recent results from the ATLAS and CMS collaborations, focusing on SM electroweak and QCD physics, and touching upon searches for BSM phenomena.

Invited Overview Talk T 63.3 Thu 12:00 ZHG011

Cosmological results from the Dark Energy Spectroscopic Instrument — •Daniel Gruen — University Observatory, Faculty of Physics, Ludwig-Maximilians-Universität, Scheinerstr. 1, 81679 München

The Dark Energy Spectroscopic Instrument (DESI) is conducting by far the most comprehensive survey of galaxy distances to date. Its primary goal is a precision measurement of the expansion of the Universe over the past 10 billion years. This expansion may reveal more about the nature of one of the biggest mysteries of modern physics, the late-time accelerating effect called Dark Energy.

I will review the results of Baryonic Acoustic Oscillation measurements, which provide a 'standard ruler' of fixed physical scale that can be observed to track expansion from the embryonic to the adult universe. The first year of DESI data, together with cosmic microwave background and supernova observations, has provided tantalising evidence that Dark Energy indeed is not a constant vacuum energy density. The analysis of three years of DESI galaxy observations, potentially concluded by Göttingen25, will again sharpen what we know about the recent past and the future of our cosmos.

T 64: Invited Topical Talks III

Time: Thursday 13:45–15:45 Location: ZHG011

Invited Topical Talk T 64.1 Thu 13:45 ZHG011

Performance of the ATLAS New Small Wheels — •Fabian Vogel — LMU München

As the Large Hadron Collider (LHC) transitions into the High-Luminosity era (after 2029), all experiments are undergoing significant upgrades to cope with the more intense collision environment and to select the most interesting – and often rarest – events. For the ATLAS experiment, these upgrades are carried out in multiple steps. The first upgrade (Phase 1) was completed in 2022, while the second phase (Phase 2) is currently being prepared for 2026.

A major upgrade during Phase 1 was the replacement of the inner forward muon spectrometer (Small Wheels) with the New Small Wheels (NSWs) to handle the increased particle fluxes with excellent spatial and temporal resolution, effectively reducing fake triggers and pile-up. The NSWs consist of two gaseous detector technologies: small-strip Thin-Gap Chambers (sTGCs) and Micro-Mesh Gaseous Structure (Micromegas) detectors.

This talk will highlight the performance of these new detector technologies in the ATLAS muon spectrometer and assess their success in reducing pile-up while maintaining excellent spatial and temporal resolution with high efficiency and longevity during HL-LHC operation.

Further, studies on Micromegas position reconstruction will be presented, focusing on algorithms optimized for inclined particle trajectories.

Invited Topical Talk T 64.2 Thu 14:15 ZHG011

Top quark and friends — •Jan van der Linden — Gent University, Belgium

With the conclusion of Run 2 at the LHC, and a successful ongoing Run 3, the amount of data collected at the CMS experiment allows for precision measurements of rare top quark-associated processes and measurements of interesting top quark properties which have previously not been accessible.

In this talk I will highlight some of the recent CMS measurements in top quark physics, including (but not limited to) top quark-antiquark pair production in association with bosons or jets. I will discuss the improvements that have been made in recent years and what still remains unanswered.

Invited Topical Talk T 64.3 Thu 14:45 ZHG011

Searching for New Physics in Soft Unclustered Energy Patterns — •Alexander Lory — Ludwig-Maximilians-Universität Munich

Most collider-based searches for new physics focus on final states with a small number of high-momentum particles. In contrast, a Soft Unclustered Energy Pattern (SUEP) represents a distinct signature characterized by a high multiplicity of spherically distributed, low-momentum particles. Such a signature can arise from strongly coupled, quasi-conformal Hidden Valley models.

Although it may seem very exotic, such an extension of the Standard Model is well-motivated, as quantum chromodynamics exhibits similar behavior in its non-perturbative regime. However, identifying SUEPs at the LHC poses unique challenges, as their diffuse, low-momentum nature closely resembles the ubiquitous background from pile-up interactions. Furthermore, detecting them often requires pushing detector performance beyond its original design specifications.

Despite these challenges, the signature offers promising opportunities to explore new physics in uncharted regions of the kinematic phase space. This presentation reviews existing experimental searches for SUEPs and explores potential new strategies.

Invited Topical Talk T 64.4 Thu 15:15 ZHG011

Alignment and calibration at the LHCb experiment — •Biljana Mitreska — TU Dortmund University, Dortmund, Germany

The LHCb software trigger allows splitting the triggering of events in two stages, allowing to perform the detector alignment and calibration in real time. The real-time alignment and calibration procedure is a fully automatic procedure at LHCb that is executed at the beginning of each fill of the LHC. The alignment estimates the position of detector elements and is essential to achieve the best data quality. The procedure is implemented for the full tracking system at LHCb with the event reconstruction run as a multithreaded process ensuring consistency between triggered and offline selected events. The operational and technical aspects of this procedure during data-taking is discussed with the focus on the performance in the 2024 data-taking period where the first global tracker alignment was obtained.

T 65: Invited Topical Talks IV

Time: Thursday 13:45–15:45 Location: ZHG010

Invited Topical Talk T 65.1 Thu 13:45 ZHG010

Searching for Axions and other Light Bosons at DESY — •Jacob Egge — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

Light bosons, including the axion and axion-like particles (ALPs) inspired by string theory, are compelling candidates for new physics. These particles are of interest not only for their potential to address the strong CP problem but also as promising dark matter candidates and mediators of novel interactions. Experimental searches for light bosons span three main approaches: haloscopes probe signals from the galactic dark matter halo; helioscopes explore particles produced in the sun; and laboratory-based experiments aim to produce and detect these particles in controlled settings.

DESY is uniquely positioned to potentially host cutting-edge experiments in all three categories, including the haloscope MADMAX, the helioscope IAXO, and the light-shining-through-wall experiment ALPSII. In this talk, I will provide an update on DESY's efforts to search for axion-like particles, highlighting the results of the initial data-taking campaigns for MADMAX and ALPSII.

Invited Topical Talk T 65.2 Thu 14:15 ZHG010

14 years of coordinated outreach for particle physics: methods, impact and prospects — •Saskia Plura[1], Uta Bilow[2], Michael Kobel[2], Achim Denig[1], Heike Vormstein[1], and Mirco Christmann[1] for the Netzwerk Teilchenwelt-Collaboration — [1]Johannes Gutenberg-Universität, Mainz — [2]TU Dresden, Dresden

The outreach program "Netzwerk Teilchenwelt" was created in 2010 as a means of opening the LHC and its data for public engagement with science, ranging from analysis of original data to research participation in high school theses. Now, 14 years later, the network has expanded to more than 30 institutions with more than 200 scientists participating and includes now also hadron, nuclear and astroparticle physics.

The impact of a coordinated, large scale outreach program is profound: by focusing mostly on high school students and teachers, "Netzwerk Teilchenwelt" has managed to bridge the gap between scientists and schools. A three step program for students provides guidance and fosters interest, while the consecutive "Fellows" program allows for direct connection between researchers and university students. Alongside these programmes, a multitude of events for the general public help push particle physics into view.

The efforts of the community have shown to have long-term effects. This talk provides insights into the methods and the achievements of "Netzwerk Teilchenwelt" as a coordinated outreach program and its future prospects.

Invited Topical Talk T 65.3 Thu 14:45 ZHG010

The Emerging Population of Seyfert Galaxies as Neutrino Sources in IceCube — •Chiara Bellenghi, Tomas Kontrimas, and Elena Manao for the IceCube-Collaboration — Technical University of Munich

The IceCube detection of neutrinos from the X-ray-bright Seyfert galaxy NGC 1068, combined with the lack of a gamma-ray counterpart, suggests that gamma-ray hidden cores of Active Galactic Nuclei (AGN) could be powerful cosmic-ray accelerators. The X-ray-bright corona, near the AGN supermassive black hole, provides a suitable environment for neutrino production and gamma-ray absorption at the same time. This talk will review recent IceCube results from searches for extragalactic neutrino sources, adding to the growing evidence that X-ray-bright, non-blazar AGN could be the first emerging population of neutrino sources.

Invited Topical Talk T 65.4 Thu 15:15 ZHG010

First detection of neutrinos in water-based liquid scintillator at ANNIE — •Johann Martyn for the ANNIE-Collaboration — Johannes Gutenberg-University Mainz

Water-based liquid scintillator (WbLS) is a novel detector medium that allows for the separation of the scintillation and Cherenkov components of a signal. As such, it is of great interest for the development of future hybrid neutrino detectors, allowing for a low energy-threshold, directional event reconstruction, reconstruction of hadronic recoils, and enhanced particle identification.

The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) is a 26-ton gadolinium-loaded water Cherenkov neutrino detector installed on the Booster Neutrino Beam (BNB) at Fermilab. As its main physics goals the experiment aims to investigate neutrino-nucleus interactions and cross sections. Additionally, ANNIE has an equally important focus on the research and devel-

opment of new detector technologies, such as WbLS and Large Area Picosecond Photodetectors (LAPPDs).

This talk presents the deployment of a 70cm x 90cm WbLS vessel in ANNIE and the subsequent first detection of neutrinos in WbLS. The successful observation of both scintillation and Cherenkov light in ANNIE corresponds to a proof-of-concept for the hybrid event detection. This allows for the development of reconstruction and particle identification algorithms, as well as dedicated analyses in ANNIE, that make use of both the Cherenkov and scintillation component.

This work is supported by the DFG (490717455).

T 66: Searches/BSM IV (BSM with Tops, LQs)

Time: Thursday 16:15–18:00 Location: ZHG010

T 66.1 Thu 16:15 ZHG010

Search for new physics in all-hadronic $t\bar{t}t\bar{t}$ using ML with the CMS experiment — •Shahzad Sanjrani[1,2], Freya Blekman[1,3], and Joel Goldstein[2] — [1]Deutsches ElektronenSynchrotron DESY, Hamburg, Germany — [2]University of Bristol, Bristol, United Kingdom — [3]University of Hamburg, Hamburg, Germany

There is current interest in searching for beyond the standard model particles produced in association with a top quark pair, $t\bar{t} + X(X \to t\bar{t})$. This project focuses on a top-philic $Z*$ resonance model that may significantly enhance the $t\bar{t}t\bar{t}$ cross section. The all-hadronic channel is explored in the resolved regime using a novel machine learning algorithm, SPA-Net, which performs permutation-invariant jet-parton assignment to reconstruct events. This talk presents initial limits using this network to discriminate signal against large QCD multijet- and $t\bar{t}$-dominated backgrounds. Studies shown use Monte Carlo simulations of proton-proton collision data gathered by the CMS detector at the LHC.

T 66.2 Thu 16:30 ZHG010

Search for 3 top BSM resonances in boosted all hadronic final state with the CMS experiment — •Lucia Ximena Coll Saravia[1], Freya Blekman[1,2], Andreas Hinzmann[1], Kuan-Yu Lin[1], and Matthias Komm[1] — [1]DESY, Hamburg, Germany — [2]University of Hamburg, Hamburg, Germany

The production of three top quarks (3-top) has been identified as a promising signal for probing new physics beyond the Standard Model (BSM). Various BSM models propose a hypothetical Z' boson that preferentially couples to top quarks, which could manifest as an enhanced 3-top signal, a scenario yet unexplored by the CMS experiment. Recent analyses by ATLAS and CMS indicate that the observed four and three top cross section fits are consistent with predictions of a three top production cross section exceeding that of the Standard Model (SM). This study explores two channels in the fully hadronic final state: tZ' and tWZ'. Studies of three boosted top quark jets for Z' masses in the TeV range and the search sensitivity of Run 2 and Run 3 will be reported.

T 66.3 Thu 16:45 ZHG010

Search for Leptoquark pair production in $b\tau b\tau$ final states with the ATLAS experiment — •Johannes Klas, Tatjana Lenz, and Jochen Dingfelder — Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn

Leptoquarks are hypothetical particles that carry lepton and baryon quantum numbers and can thus decay into a quark and a lepton, which is forbidden in the Standard Model (SM). They are predicted in various theories beyond the SM, like theories of quark-lepton unification or Grand Unified Theories. Leptoquarks may offer an explanation of some of the open questions in the SM like the anomalous magnetic moment of the muon or the anomalies observed in the decay of B-Mesons into D-Mesons. The search for pair production of leptoquarks in the $b\tau b\tau$ final state using Run 2 ATLAS pp collision data will be presented in this talk. New methods to reconstruct leptoquark events are explored and the limits on the cross section are compared to the previous ATLAS Run 2 results.

T 66.4 Thu 17:00 ZHG010

Search for resonant Leptoquark production using Run 2 pp collision data of the ATLAS experiment — •Christopher Engel, Adrian Alvarez, and Stefan Tapprogge — Institute for Physics, Johannes Gutenberg University, Mainz, Germany

A Leptoquark is a hypothetical particle that couples to both leptons and quarks and carries both lepton and quark quantum numbers. Leptoquarks are are predicted by many extensions of the Standard Model, including Grand Unified Theories, and might explain similarities between the lepton and the quark generations. One way of searching for such a particle would be to look for the production of a single Leptoquark in proton-proton collisions caused by the interaction of a lepton and a quark coming from the inner structure of protons.

This talk focuses on this resonant production of a single Leptoquark decaying into an electron and a b-quark, which results in an electron+b-jet signal in the detector. This resonant structure in the invariant mass distribution of the electron and b-jet system could be identified on top of a smoothly falling background. One of the main goals of this contribution is the presentation of the background processes, the required cut optimization and the expected exclusion limits based on the Run 2 ATLAS data with 140 fb^{-1}.

T 66.5 Thu 17:15 ZHG010

Search for dark matter production in association with a single top quark at the CMS experiment — •Moritz Molch[1], Doug Berry[2], Ulrich Husemann[1], Michael Wassmer[1], and Sebastian Wieland[1] — [1]Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT) — [2]Fermi National Accelerator Laboratory (FNAL), Batavia, IL

This talk presents results of a search for the production of dark matter (DM) candidates in association with a single top quark in proton-proton collisions at a center-of-mass energy of $\sqrt{s}$ = 13 TeV with the CMS experiment, with a data set corresponding to an integrated luminosity of 138 fb^{-1}.

Since DM candidates are expected to interact only very weakly, they are not directly detectable with the CMS detector. Therefore the final state consists of a single top quark and missing transverse momentum.

The presented analysis targets the final state in which the top quark decays hadronically. A key feature of this analysis is the use of large-radius jets in combination with multivariate techniques to separate jets which originate from a top quark decay from purely QCD-initiated jets. The major backgrounds are estimated in the maximum likelihood fit for signal extraction using data from multiple control regions. Finally, the results are interpreted in the context of a simplified model introducing a flavor-changing neutral current at tree-level by a spin-1 mediator and spin-1/2 DM candidates.

T 66.6 Thu 17:30 ZHG010

Exploring boosted top quark decays using Run 3 data collected by the CMS experiment — •Johanna Matthiesen[1], Johannes Haller[1], Roman Kogler[2], and Daniel Savoiu[1] — [1]Institut für Experimentalphysik, Universität Hamburg — [2]DESY, Hamburg

Highly energetic top quarks produced in proton-proton collisions at the LHC can result in decay products that are highly collimated, appearing as a single large-radius jet in the CMS detector. These jets exhibit a distinctive internal substructure, enabling discrimination between top quark jets and those arising from other QCD processes. However, discrepancies between distributions in recorded data and simulations require corrections to the simulations. The boosted topology offers a unique opportunity to probe for new heavy particles decaying into top-antitop quark pairs. This presentation provides first insights from the ongoing LHC Run 3, focusing on the top-antitop quark mass spectrum as a potential window to new physics phenomena.

T 66.7 Thu 17:45 ZHG010

Search for Leptoquarks in the multilepton channel with ATLAS Run-2 data — •Ondrej Matousek and Andre Sopczak — Czech Technical University in Prague

The latest results in the search for leptoquarks in the multilepton chan- nel are presented using ATLAS Run-2 data.

T 67: Higgs Physics VII (HH and Trilinear Coupling)

Time: Thursday 16:15–18:45 Location: ZHG104

T 67.1 Thu 16:15 ZHG104

Search for non-resonant Higgs boson pair production in dilepton final states of the bbWW decay mode at CMS — •Lara Markus, Matteo Bonanomi, Mathis Frahm, Johannes Haller, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

The trilinear coupling of the Higgs boson is related to the shape of the Higgs potential, which makes it a crucial parameter of the Standard Model. The shape can be directly probed by measuring the cross section of Higgs boson pair production in pp collisions at the LHC.

This talk presents a search for non-resonant pair production of Higgs bosons decaying into a b quark anti-quark pair and two W bosons, with subsequent decays of the W bosons into leptons and neutrinos. The analysis strategy is developed using Run 3 data of the CMS experiment, with a corresponding center-of-mass energy of at 13.6 TeV. The analysis is implemented in a columnar-based framework 'columnflow'.

T 67.2 Thu 16:30 ZHG104

Search for Boosted Higgs Pair Production From Vector Boson Fusion in the Single Lepton $b\bar{b}W^+W^-$ Final State Using the ATLAS Detector — •Lars Linden, Valerio d'Amico, Celine Stauch, Stefanie Götz, Bao Tai Le, Tim Rexrodt, and Otmar Biebel — LMU Munich

The discovery of the Higgs boson solved one of the biggest problems in the standard model, the generation of particle masses. However, even more than 10 years after its discovery, not all of its properties are well know. One of these is the quartic coupling of a Higgs boson pair to a pair of electroweak gauge bosons. A process suited to constrain this coupling is given by Di-Higgs production via vector boson fusion (VBF), the second most common production mode at LHC. This talk will present some early results of a search for VBF Di-Higgs production in the $b\bar{b}W^+W^-$ final state with a single lepton, using the ATLAS run 2 and 3 datasets.

T 67.3 Thu 16:45 ZHG104

Efficiency measurements of di-lepton triggers in a search for di-Higgs production in CMS data — •Balduin Letzer, Lukas Ebeling, Mathis Frahm, Johannes Haller, Karla Kleinbölting, Finn Labe, Artur Lobanov, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

With a collision rate too large to store all events at the CMS experiment, a fast online selection (trigger selection) of interesting events is performed. The knowledge of the efficiency of this trigger selection is crucial in many physics analyses. A common method to measure the trigger efficiency in data uses a dataset selected with an orthogonal trigger selection. The method is used to measure the efficiency of different trigger selections in a search for di-Higgs production in the bbWW final state with two leptons, using data from the LHC Run-3. The results are used to derive correction factors that are applied to the simulated signal and background events in the analysis, in order to improve their modelling of the data.

T 67.4 Thu 17:00 ZHG104

Higgs self-coupling measurement at the ILC — •Bryan Bliewert[1,2], Julie Munch Torndal[1,2], and Jenny List[1] — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [2]Universität Hamburg, Hamburg, Germany

Measuring the Higgs self-coupling represents a cornerstone of the physics program of future colliders because it gives important insights into the shape of the Higgs potential. This contribution summarizes the updated projections for the determination of the Higgs self-coupling from di-Higgs production at future e^+e^- colliders. In particular, we will present an update of the analysis of di-Higgs production at 500 GeV using full simulation of the ILD detector concept, incorporating advancements through state-of-the-art particle ID and flavor tagging as well as covering the $HH \to b\bar{b}b\bar{b}$ and $Z \to q\bar{q}/e^+e^-/\mu^+\mu^-/\bar{\nu}\nu$ channels. Based on the experience of previous analyzes, we extrapolate these to cover some of the remaining decay modes, e.g. $HH \to \bar{b}bWW$ or $Z \to \tau^+\tau^-$, as well as the contribution from the W W fusion production mode. We study the dependency of the results on the center-of-mass energy as well as on the value of the trilinear coupling realized in nature.

T 67.5 Thu 17:15 ZHG104

Top-Yukawa-induced corrections to Higgs pair production — Arunima Bhattacharya[1], Francisco Campanario[1], •Sauro Carlotti[2], Jamie Chang[3], Javier Mazzitelli[3], Milada Margarete Mühlleitner[2], Jonathan Ronca[4], and Michael Spira[3] — [1]University of Valencia-CSIC, Spain — [2]Karlsruher Institut für Technologie, Germany — [3]Paul Scherrer Institut, Switzerland — [4]University of Padua, Italy

After the discovery of the Higgs boson in 2012, the measurements of the Higgs self coupling is still a challenge for current and future experiments in particle physics. Higgs-boson pair production via gluon fusion is a loop-induced process. In order to increase the accuracy of the theoretical predictions for this process, higher-order corrections are necessary to reduce theoretical uncertainties and to describe differential distributions reliably. The next-to-leading order (NLO) corrections involve the evaluation of two-loop Feynman diagrams. In particular, for electroweak (EW) corrections, many different mass scales appear in the calculation, such as the gauge boson, bottom, top quark, and Higgs boson masses. Further complications include numerical instabilities due to virtual thresholds which require careful treatment.

In my talk, I will present results for the EW corrections induced by the top Yukawa coupling with contributions from light-quark loops without using any reduction techniques to master integrals. The calculations is done by keeping the masses as fully symbolic parameters, allowing, in the future, for a study of parametric and mass scheme/scale uncertainties.

T 67.6 Thu 17:30 ZHG104

Quark-initiated Double Higgs Production at one loop — •Philipp Rendler — Karlsruhe Institute of Technology

We present the analytic amplitude for double Higgs production in the quark-initiated channel at one loop, with full dependence on all mass scales. The calculation is performed using the method of differential equations employing a large mass expansion to fix the integration constants. The results are written in terms of iterated integrals, with integrals from simpler topologies being expressed in terms of Generalized PolyLogarithms. This amplitude forms a part of the electroweak corrections to Higgs boson pair production.

T 67.7 Thu 17:45 ZHG104

Double Higgs production in vector boson fusion at NLO QCD with anomalous couplings — •Jens Braun[1], Pia Bredt[2], Gudrun Heinrich[1], and Marius Höfer[1] — [1]Institute for Theoretical Physics, Karlsruhe Institute of Technology (KIT), Wolfgang-Gaede-Str. 1, 76131 Karlsruhe, Germany — [2]Department of Physics, University of Siegen, Walter-Flex-Straße 3, 57068 Siegen, Germany

We present a calculation of the NLO QCD corrections to Higgs boson pair production in vector boson fusion, combined with the leading operators parametrising anomalous interactions in non-linear Effective Field Theory (HEFT). Based on our Monte Carlo implementation using GoSam+Whizard, we investigate the effects of anomalous Higgs couplings on various observables.

T 67.8 Thu 18:00 ZHG104

$\gamma\gamma b\bar{b}$ in a variable flavor number scheme — •Orcun Kolay[1], Stefan Höche[2], and Frank Siegert[1] — [1]Technische Universität Dresden, Germany — [2]Fermi National Accelerator Laboratory, Batavia, USA

Measuring Higgs boson pair production is crucial for directly probing the Higgs trilinear coupling, with $HH \to \gamma\gamma b\bar{b}$ emerging as one of the most sensitive final states at the HL-LHC. Given the significant continuum diphoton background, precise background modeling is essential to improve search sensitivity. This talk will present a novel approach that combines $\gamma\gamma b\bar{b}$ (4-flavor scheme, 4FS) and $\gamma\gamma$+jets processes (5-flavor scheme, 5FS) within the Sherpa framework. By incorporating b-quark mass effects and employing a variable flavor number scheme, this improved methodology enables more accurate predictions for scenarios involving fake heavy-flavor jets and aligns seamlessly with $\gamma\gamma$+jet simulations. These advancements provide a more comprehensive and precise description of the background for the $HH \to \gamma\gamma b\bar{b}$ analysis.

T 67.9 Thu 18:15 ZHG104

Comparison between off-shell and on-shell sensitivity to trilinear Higgs couplings at future colliders based on EFTs and models with an extended Higgs sector — Henning Bahl[1], Philip Bechtle[2], Johannes Braathen[3], Klaus Desch[2], Christian Grefe[2], Sven Heinemeyer[4], Jenny List[3], •Murillo Vellasco[2], and Georg Weiglein[3,5] — [1]Institute for Theoretical Physics (ITP), Universität Heidelberg, Germany — [2]Physikalisches Institut, Universität Bonn, Germany — [3]Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany — [4]Instituto de Física Teórica (UAM/CSIC), Universidad Autónoma de Madrid, Spain — [5]Institut für Theoretische Physik, Universität Hamburg, Germany

Measuring the Higgs potential is one of the main goals of the next generation of high-energy particle colliders. Studies of the future sensitivity to trilinear Higgs coupling, λ_{hhh}, have been mainly performed within the framework of EFTs, which offer some degree of model-independence. However, not only is the EFT approach not valid if BSM degrees of freedom are not fully decoupled, but one must often make a selection of relevant operators to consider out of larger set thereof.

In this work, we have investigated the sensitivity to λ_{hhh} at future colliders based on UV-complete models with extended Higgs sectors, while also comparing with results from EFT analyses. In particular, we considered cases where on-shell measurements sensitive to λ_{hhh} would show considerable deviations from the SM value, all the while avoiding large deviations in off-shell observables. The results highlight the need to go beyond EFT frameworks.

T 67.10 Thu 18:30 ZHG104

Renormalisation scheme dependence of the trilinear Higgs coupling in extended scalar sectors — •Marc Hannig[1], Marco Menen[1,2], Elina Fuchs[1,2,3], Henning Bahl[4], Georg Weiglein[3,5], and Johannes Braathen[3] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover — [2]Physikalisch-Technische Bundesanstalt (PTB), Braunschweig — [3]Deutsches Elektronen- Synchrotron DESY, Hamburg — [4]Institut für Theoretische Physik, Universität Heidelberg — [5]II. Institut für Theoretische Physik, Universität Hamburg

The trilinear Higgs coupling λ_{hhh} of the detected Higgs boson is a critical observable for understanding of the Higgs potential. With improving experimental bounds in the future, the theoretical predictions of this coupling for constraining BSM parameters become increasingly significant. Using the public code `anyH3`, this study investigates the numerical stability of different renormalization schemes for λ_{hhh} at one-loop level in extended scalar sectors. By comparing predictions of the coupling for various schemes, this study develops algorithmic criteria for switching between renormalisation schemes depending on the parameter region of the BSM model. This approach ensures numerically stable and reliable predictions for the trilinear Higgs coupling.

T 68: Higgs Physics VIII (CP)

Time: Thursday 16:15–18:30 Location: ZHG105

T 68.1 Thu 16:15 ZHG105

Measurement of CP-properties of the top Yukawa coupling via $t\bar{t}H$ and tH production in the $H \to \gamma\gamma$ decay channel at CMS — Johannes Erdmann and •Florian Mausolf — III. Physikalisches Institut A, RWTH Aachen University

After the observation of the Higgs boson at the LHC and with continuing accumulation of data, its properties can be determined with increasing precision. Among these properties, the strength of the couplings to fermions and the CP-properties of its interactions are of particular importance. The top-quark Yukawa coupling, the Higgs boson's strongest interaction with fermions, plays a central role in theory and experiment. While a purely CP-odd structure has been experimentally excluded, the possibility of a significant CP-odd admixture remains consistent with current LHC constraints. A CP-odd component would influence both the cross-sections and kinematics of top-quark-associated Higgs production processes, $t\bar{t}H$ and tH. For example, the tH cross-section would increase significantly with the inclusion of a sizeable CP-odd component.

This talk presents the strategy and ongoing developments for a measurement of $t\bar{t}H$ and tH production cross sections and the CP-properties using events where the Higgs boson decays into two photons. A particular emphasis is placed on a novel approach to separate $t\bar{t}H$ and tH production processes, enabling individual $t\bar{t}H$ and tH cross-section measurements without relying on strong assumptions about CP-even and CP-odd coupling modifiers.

T 68.2 Thu 16:30 ZHG105

Machine Learning for Top-Associated Higgs Production: Probing CP Structure with Neural Simulation-Based Inference — •Stefan Katsarov, Stephen Jiggins, and Judith Katzy — Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

The Standard Model (SM) predicts that the CP structure of the fermionic Higgs couplings is CP even. However, experimentally, a CP odd component is not yet fully excluded. Detecting an additional CP odd coupling would provide direct evidence of physics beyond the SM, with significant implications, such as explaining the baryon asymmetry in the universe. The CP structure can be directly measured in top-associated Higgs production processes (ttH and tH). However, this measurement is very challenging due to the extreme rarity of these production modes and the presence of irreducible backgrounds. I will demonstrate how Neural Simulation-Based Inference (NSBI), a novel machine-learning technique, can aid this measurement, presenting the first results of research in this direction.

T 68.3 Thu 16:45 ZHG105

Test of CP invariance in Higgs boson production via vector boson fusion exploiting the $H \to \tau_{\text{had}}\tau_{\text{had}}$ decay mode — •Daniel Bahner, Lorenzo Rossini, and Markus Schumacher — Albert-Ludwigs-Universität, Freiburg, Deutschland

The observed baryon asymmetry in the universe can be explained if the three Sakharov conditions are fulfilled. The violation of the CP invariance is one of them. The magnitude of CP violation encoded in the Standard Model is not enough to explain the observed asymmetry via electroweak baryogenesis. Through precision measurements of the properties of the Higgs boson, additional sources of CP violation might be found. One candidate is the vector-boson fusion (VBF) production mode of the Higgs boson. In the VBF production process, it is possible to probe CP-violating contributions to the HVV coupling vertex.

This talk is focused on the VBF Higgs boson production mode with a subsequent decay into two hadronically decaying tau leptons. The CP-odd optimal observable is used in a profile-likelihood fit to perform a test of CP invariance and to constrain the strength of new CP-violating interactions. The talk will discuss the analysis strategy, CP-odd observables, and preliminary results based on $\sqrt{s}$ = 13 TeV proton-proton collision data collected by the ATLAS detector with $\mathcal{L}_{\text{int}}$ = 140.1 fb^{-1}.

T 68.4 Thu 17:00 ZHG105

Search for CP violation in the tau Yukawa coupling with CMS Run 3 data — •Mathilde Witt[1,2], Andrea Cardini[3], Elisabetta Gallo[2], Anne-Catherine Le Bihan[1], Océane Poncet[1], Alexei Raspereza[2], Gourab Saha[1], and Stepan Zakharov[2] — [1]Institut pluridisciplinaire Hubert Curien, Strasbourg, France — [2]Deutsches Elektronen-Synchrotron, Hamburg. Germany — [3]Universidad de Oviedo, Oviedo, Spain

Following the discovery of the Higgs boson in 2012 by the ATLAS and CMS Collaborations, studies are required to investigate its Charge-Parity (CP) properties in the Yukawa interaction with tau leptons. This talk presents an ongoing master's thesis in the μa_1 decay channel. Different reconstruction techniques are implemented in the μa_1 channel to enhance the sensitivity to the CP properties of the Higgs boson to investigate whether its properties are CP-even, CP-odd, or CP-mixed. The a_1 channel denotes the decay $\tau \to \nu_\tau \pi\pi\pi$. The data were collected with the CMS detector during 2022-2023 at $\sqrt{s}$ = 13.6 TeV, corresponding to an integrated luminosity of 63 fb^{-1}

T 68.5 Thu 17:15 ZHG105

Construction and investigation of optimal observables for testing $\mathscr{C}\mathscr{P}$ invariance in the decay $H \to \tau^+\tau^-$ at the LHC — •Yann Stoll, Heidi Rzehak, and Markus Schumacher — Albert-Ludwigs-Universität, Freiburg

Since the discovery of the Higgs boson, one of the most important tasks in particle physics is to measure all of its properties as precisely as possible. The Higgs boson does not only play a crucial role in understanding electroweak symmetry breaking but might also be connected to, and thus hint towards, physics beyond the Standard Model. One desirable feature of a more complete model of particle physics is additional $\mathscr{C}\mathscr{P}$ violation in order to allow for electroweak baryogenesis.

A possibility to introduce additional $\mathscr{C}\mathscr{P}$ violation is that the physical Higgs boson is not a $\mathscr{C}\mathscr{P}$-eigenstate but an admixture. In this work it is investigated whether the sensitivity of $\mathscr{C}\mathscr{P}$-tests in the decay $H \to \tau^+\tau^-$ at the LHC can be improved by using the method of optimal observables. An outline of the construction of said observables, as well as studies of their sensitivity using simulated signal events only, will be presented.

T 68.6 Thu 17:30 ZHG105

Measurements of $H \to \tau\tau$ properties at FCC-ee — •Sofia Giappichini, Jan Kieseler, Markus Klute, Matteo Presilla, Aaron Wiedl, and Xunwu Zuo — KIT, Karlsruhe

The Future Circular Collider (FCC) stands at the forefront of the European Strategy for Particle Physics as the future Higgs factory. The $H \to \tau\tau$ decay, featuring a large branching ratio, clean identification at FCC-ee environment, and the possibility to reconstruct polarization information, is an excellent channel to measure Higgs properties. The CP nature of the Htautau coupling is of particular interest because the CP-odd component only appears in Higgs gauge couplings through loop effects, while it is allowed to be sizable in the Higgs couplings to fermions. This contribution shows recent progress in the experimental setup for the $H \to \tau\tau$ analysis and reports prospective results in both the ZH, $H \to \tau\tau$ cross section measurement and CP measurement, as well as the interpretation framework based on SM effective field theory.

T 68.7 Thu 17:45 ZHG105

Probing $\mathscr{C}\mathscr{P}$ violation in the top-Yukawa coupling at future colliders — •Vincent Riechers[1], Marco Menen[1,2], Elina Fuchs[1,2,3], and Henning Bahl[4] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover — [2]Physikalisch-Technische Bundesanstalt (PTB), Braunschweig — [3]Deutsches Elektronen-Synchrotron DESY, Hamburg — [4]Institut für Theoretische Physik, Universität Heidelberg

The $\mathscr{C}\mathscr{P}$-violating effects within the Standard Model (SM) are not sufficient to explain the observed baryon asymmetry of the Universe. Additional CP violation beyond the SM could be present in the Higgs boson couplings to other SM particles. The top-Yukawa coupling is of particular interest, as it is both

the largest and most accessible Higgs-fermion interaction at the LHC and is expected to show the largest $\mathscr{C}\mathscr{P}$-violating effects in many BSM models. The goal of this study is to evaluate the constraints that future colliders could impose on the $\mathscr{C}\mathscr{P}$ structure of the Higgs-top coupling. While a future e^+e^- collider benefits from a very clean background, which allows precise measurements of final states with many quarks, a proton-proton collider like the FCC-hh offers a high luminosity and center-of-mass energy. We use a machine learning approach to distinguish between $\mathscr{C}\mathscr{P}$-even and $\mathscr{C}\mathscr{P}$-odd events, enhancing sensitivity to potential deviations from the SM.

T 68.8 Thu 18:00 ZHG105

Symbolic Regression for Higgs CP analyses — •Marco Menen[1,2], Henning Bahl[3], Elina Fuchs[1,2], and Tilman Plehn[3] — [1]Institut für Theoretische Physik, Universität Hannover, Germany — [2]Physikalisch-Technische Bundesanstalt Braunschweig, Germany — [3]Institut für Theoretische Physik, Universität Heidelberg, Germany

Additional sources of CP violation beyond those in the Standard Model are needed to produce a sufficient baryon asymmetry of the Universe during baryogenesis. The Higgs sector is an intriguing candidate for such sources and could provide CP violation in the Higgs couplings to fermions and gauge bosons. Recently, much work has been put into optimizing probes of CP violation with machine learning techniques. While such analysis usually outperform analyses of individual observables, the techniques used can be potentially hard to interpret accurately. We demonstrate how different approaches of Symbolic Regression can be used to obtain analytical formula. We then apply our approaches to various steps of a CP analysis, such as the signal-background classification, the classification of the CP state, or the reconstruction of a parton-level observable.

T 68.9 Thu 18:15 ZHG105

CP violation in Standard Model extensions with a Higgs singlet — Greta Bösinger[1], •Lana Dambacher[1], and Heidi Rzehak[2] — [1]Institut für Theoretische Physik, Universität Tübingen — [2]Physikalisches Institut, Universität Freiburg

In order to explain the asymmetry of matter and antimatter in our universe, a particle-physics model must contain sources of CP violation. Since the amount of CP violation provided by the Standard Model (SM) is not sufficient for this explanation, we are looking for extensions of the SM that include further sources of CP violation.

One of the simplest extensions of the SM is an extension with a complex Higgs $SU(2)_L$ singlet. The singlet leads to a more involved Higgs potential, but otherwise does not couple to any other field. This results in some freedom in the definition of its CP transformation and therefore to no new CP violation. This freedom is reduced by coupling the singlet to a vector fermion, which creates the possibility of spontaneous or explicit CP violation.

In this talk the complex Higgs singlet extension with its possible CP properties is discussed.

T 69: Strong Interaction / QCD

Time: Thursday 16:15–18:15 Location: VG 0.110

T 69.1 Thu 16:15 VG 0.110

Measurement of the Z boson production cross-section in association with c-jets at $\sqrt{s}$ = 13 TeV with the ATLAS detector — •Stefanie Götz[1], Otmar Biebel[1], Valerio D'Amico[1], Bao Tai Le[1], Lars Linden[1], Tim Rexrodt[1], Celine Stauch[1], and Camilla Vittori[2] — [1]LMU München — [2]CERN

Z boson production cross-section measurements in association with heavy flavour jets are important tests for perturbative quantum chromodynamics (pQCD) and the proton internal structure. This talk intends to show preliminary studies on a new cross-section measurement of the Z boson production using the full proton-proton collision data of Run-2 ($\sqrt{s}$ = 13 TeV) taken by the ATLAS detector at the Large Hadron Collider (LHC). The focus will be on events containing at least one jet originating from a c quark, which may be sensitive to test the hypothesis of the intrinsic charm component of the proton, and a first glance at data-to-Monte Carlo comparison distributions will be provided.

T 69.2 Thu 16:30 VG 0.110

Non-perturbative effects in multidimensional dijet and Z+jet production at the LHC — Stefan Gieseke[1], Maximilian Horzela[2], Manjit Kaur[3], Dari Leonardi[1], Klaus Rabbertz[4], Aayushi Singla[3], and •Cedric Verstege[4] — [1]Institute of Theoretical Physics, Karlsruhe Institute of Technology — [2]II. Institute of Physics, Georg-August Universität Göttingen — [3]Department of Physics, Panjab University, Chandigarh, India — [4]Institute of Experimental Particle Physics, Karlsruhe Institute of Technology,

Comparison of precision LHC data at stable-particle level to the most accurate fixed-order calculations in perturbative QCD requires the latter to be corrected for non-perturbative effects. These effects are studied using Monte-Carlo simulation combining fixed-order predictions with parton showers and non-perturbative models for Underlying Event and hadronization.

The impact of the non-perturbative effects is studied for two well established processes, dijet and Z+jet production. Corresponding measurements may be used for precision determinations of parameters of the SM like the strong coupling constant or the proton structure. Surprising differences of the non-perturbative corrections for both processes in similar 3-dimensional phase spaces are observed. These differences also show a dependence on additional perturbative radiations, showcasing that the naive assumption of a clear differentiation between perturbative calculations and non-perturbative effects does not always hold.

T 69.3 Thu 16:45 VG 0.110

Elastic scattering with the ATLAS-ALFA detector at the LHC — •Per-Oleg Puhl, Hasko Stenzel, and Marko Milovanovic — II. Physikalisches Institut, Justus-Liebig Universität Gießen, D-35392 Gießen

The Absolute Luminosity For ATLAS (ALFA) detector is designed to detect elastic scattering protons under very small scattering angles. Elastic scattering in the very forward direction can be used for the measurement of the total pp cross section and a calibration of the luminosity.

The ALFA detector participated in several special runs of the LHC at high β^*. In this talk the ALFA detector will be presented and results from Run 1 and Run 2 will be discussed. Special emphasis in this talk will be placed on the special runs from 2018 with β^* = 90 m at $\sqrt{s}$ = 13 TeV, corresponding to an integrated luminosity of 500 nb^{-1}. In these runs the focus is on elastic scattering at large momentum transfer t and in particular on the dip-bump structure of the differential cross section. The precision of the measurement depends crucially on the alignment of the Roman Pot detectors, for which the preliminary results will be presented.

T 69.4 Thu 17:00 VG 0.110

QCD cross-section measurements for astroparticle physics with the LHCb experiment — Johannes Albrecht[1], Hans Dembinski[1], •Lars Kolk[1], Felix Riehn[1], and Michael Schmelling[2] — [1]TU Dortmund University, Dortmund, Germany — [2]Max Planck Institut Heidelberg, Heidelberg, Germany

A long-standing issue in the field of cosmic-ray research is the discrepancy between the observed and simulated numbers of muons in cosmic-ray-induced hadronic showers in the Earth's atmosphere, which are called air showers. This discrepancy is referred to as the Muon Puzzle, as the required changes to existing models in simulation would either violate data constraints or the consistency between air shower simulations and other air shower features.

One explanation for this inconsistency lies in universal strangeness enhancement, which measurements from the ALICE and LHCb experiments show first evidence off. To further study the impact on forward-produced hadrons and to test this universality, proton-ion data from the LHCb fixed target mode are analysed. Of particular interest are proton-oxygen collisions, as they are a good proxy for air showers. Since proton-oxygen data are not yet available, the first step is to bracket oxygen with helium and neon. The current status of this analysis is presented.

Supported by DFG (SFB 1491)

T 69.5 Thu 17:15 VG 0.110

Angular analysis of J/ψ pair central exclusive production with the LHCb experiment — •Ilya Segal and Mikhail Mikhasenko — Ruhr University Bochum, Bochum, Germany

The analysis of the central exclusive production (CEP) provides possibilities to study quantum chromodynamics (QCD). Since the CEP of the double J/ψ system is dominantly carried out through the double pomeron exchange (DPE) mechanism, it can provide an understanding of the role of the pomeron in QCD. The comparison of inclusive and exclusive double J/ψ production mass spectra offers a probe into double parton scattering (DPS) effects, which are absent in exclusive processes. Previously, several intermediate states were observed in the double J/ψ spectrum, such as $T_{c\bar{c}c\bar{c}}$ tetraquark. The angular analysis can shed light on their quantum numbers. In this talk, the first results of the angular analysis based on the data sample of pp collisions collected by the LHCb experiment during Run 1 and Run 2 data-taking periods are presented.

In addition to this, work is done to improve the performance of the general-purpose Monte-Carlo generators such as Pythia, Herwig, etc. for the cases of the DPS and DPE. This can be done using the tuning procedures that involve the Rivet analysis preservation tool. The Rivet plugin is developed for the inclusive double J/ψ production previously measured by LHCb. The performance of this plugin for the test data is also presented in the talk.

T 69.6 Thu 17:30 VG 0.110

$\bar{\Lambda}^0/K_S^0$ production cross-section ratio at LHCb in Run 3 — Johannes Albrecht[1], •Noah Behling[1], Lukas Calefice[2], Biljana Mitreska[1], and Titus Mombächer[3] — [1]TU Dortmund University, Dortmund, Germany — [2]Universitat de Barcelona, Barcelona, Spain — [3]CERN

Hadron production ratios are a useful probe to test and improve hadronisation models. In this work, the production ratio of K_S^0 and $\bar{\Lambda}^0$ is studied with Run 3 proton-proton collision data from the upgraded LHCb experiment. These studies are also essential to calibrate and validate the performance of the upgraded detector. The proper operation of all subsystems must be ensured step-by-step to carry out precise measurements with data recorded recently and in the future. The performance of the tracking system can be evaluated with the measured ratio.

Meson-to-baryon ratios and strangeness production also contribute to the understanding of hadronic processes in cosmic-ray-induced extensive air showers, which are dominated by soft-QCD effects in the forward region. In air-shower data, an excess of muons produced with respect to Monte Carlo event generators has been observed, which could originate from mismodelling of the hadronisation process. The LHCb experiment offers a unique environment to test hadronic models in the forward region.

The current status of the analysis and recent studies on detector performance will be presented. Additionally, the connection of collider experiments to air-shower measurements will be discussed.

T 69.7 Thu 17:45 VG 0.110

Partial-Wave Analysis of $\tau^- \to \pi^-\pi^-\pi^+\nu_\tau$ at Belle II — •Claudia Perez-Orive[1], Stefan Wallner[1], Hans-Günther Moser[1], Stephan Paul[1,2], Daniel Greenwald[2], and Andrei Rabusov[2] — [1]Max Planck Institute for Physics — [2]Technical University of Munich

$\tau^- \to \pi^-\pi^-\pi^+\nu_\tau$ decays measured at the Belle II experiment at the SuperKEKB e^+e^- collider offer a clean environment to investigate light mesons. We perform a detailed partial-wave analysis to precisely study the meson resonances appearing in the 3π system, including the $a_1(1260)$ and the $a_1(1420)$ signal observed by COMPASS.

We will present input-output studies using simulated data where we investigate resolution effects and effects caused by the unmeasured direction of the τ lepton on the partial-wave analysis. Additionally, we study how the fit depends on its initialization.

T 69.8 Thu 18:00 VG 0.110

Lattice determination of the higher-order hadronic vacuum polarization contributions to the muon g-2. — •Arnau Beltran Martínez[1] and Hartmut Wittig[1,2] — [1]PRISMA+ Cluster of Excellence and Institut für Kernphysik, Johannes Gutenberg-Universität, Mainz, Germany — [2]Helmholtz-Institut Mainz, Johannes Gutenberg-Universität, Mainz, Germany

We present initial results from a lattice QCD computation for the next-to-leading order (NLO) contribution to the hadronic vacuum polarization (HVP) of the muon $g-2$. Our approach is based on the time-momentum representation (TMR) involving three kernels needed to compute the different NLO HVP diagrams, following the framework developed by Balzani, Laporta and Passera.

For the NLO corrections involving extra photon or lepton lines, we present analytical series expansions for small values of the Euclidean time and numerical series expansions for the large time values. The NLO diagram with two QCD insertions is solved analytically and expanded across different regions of the two-dimensional Euclidean time plane.

These results are then combined with lattice QCD calculations of the vector correlator performed on more than 30 gauge ensembles using $O(a)$-improved Wilson quarks. To control the continuum limit, we implement two improvement schemes, each combining two discretizations. After correcting for finite-volume effects, we perform a combined chiral and continuum extrapolation to the physical point, yielding a final estimate for a_μ^{hvp}[NLO].

T 70: Silicon Detectors VI (MAPS, Mighty Tracker)

Time: Thursday 16:15–18:30 Location: VG 0.111

T 70.1 Thu 16:15 VG 0.111

Characterization of H2M: a MAPS produced in a 65 nm CMOS imaging process — •Sara Ruiz Daza[1,3], Rafael Ballabriga[2], Eric Buschmann[2], Michael Campbell[2], Raimon Casanova Moh[2], Dominik Dannheim[2], Ana Dorda[2], Finn King[2], Philipp Gadow[2], Ingrid-Maria Gregor[1,3], Karsten Hansen[1], Yajun He[1], Lennart Huth[1], Iraklis Kremastiotis[2], Corentin Lemoine[2], Stefano Maffessanti[1], Larissa Mendes[1,3], Younes Otarid[1], Christian Reckleben[1], Sebastien Rettie[2], Manuel Alejandro del Rio Viera[1,3], Judith Schlaadt[1], Adriana Simancas[1,3], Walter Snoeys[2], Simon Spannagel[1], Tomas Vanat[1], Anastasiia Velyka[1], Gianpiero Vignola[1,3], Håkan Wennlöf[1], and Ono Feyens[1] — [1]DESY, Hamburg, Germany — [2]CERN, Geneva, Switzerland — [3]University of Bonn, Bonn, Germany

The high energy physics community recently gained access to a 65 nm CMOS imaging process, which enables a higher density of in-pixel logic in MAPS. To explore this novel technology, the H2M (Hybrid-to-Monolithic) test chip has been designed and manufactured. The design followed a digital-on-top design workflow and ports a hybrid pixel-detector architecture into a monolithic chip.

This contribution will introduce the H2M chip and cover its characterization in the lab and test beam. A hit-detection efficiency above 99% has been measured, unaffected by thinning samples down to 21 um. Additionally, a measured non-uniformity of the in-pixel response related to the size and location of the n-wells in the analog circuitry will be discussed, as well as its impact on time resolution.

T 70.2 Thu 16:30 VG 0.111

Time and position resolved charge collection studies on a monolithic active pixel sensor — •Jona Dilg[1,3], Ono Feyens[1,4], Ingrid-Maria Gregor[1,3], Karsten Hansen[1], Yajun He[1], Lennart Huth[1], Finn King[1], Stefano Maffessanti[1], Larissa Mendes[1,3], Christian Reckleben[1], Sara Ruiz Daza[1,3], Manuel Alejandro del Rio Viera[1,3], Judith Schlaadt[1,3], Adriana Simancas[1,3], Simon Spannagel[1], Tomas Vanat[1], Anastasiia Velyka[1], Gianpiero Vignola[1,3], and Haakan Wennlöf[2] — [1]Deutsches Elektronen-Synchrotron DESY, Germany — [2]National Institute for Subatomic Physics Nikhef, Netherlands — [3]Universität Bonn, Germany — [4]Vrije Universiteit Brussel, Belgium

Monolithic Active Pixel Sensors (MAPS) are used in vertex detectors for high-energy particle colliders. They integrate sensors and readout electronics on a single chip, reducing material use compared to hybrid pixel detectors. The recent adoption of a 65 nm Complementary Metal-Oxide-Semiconductor (CMOS) imaging process enables a smaller pixel pitch with enhanced in-pixel electronics.

The DESY ER1 test chip consists of a single pixel and a 2×2 matrix with 35×25 μm pitch, with in-pixel amplification and digitization. In contrast to complementary test structures with fully digital readouts, it allows direct measurement of amplifier output, aiding in understanding effects obscured in purely digital schemes.

This contribution presents the chip's design and the insights gained through its characterization and pulse shape analysis of laboratory and test beam measurements.

T 70.3 Thu 16:45 VG 0.111

Simulation of Hexagonal Pixels in Monolithic Active Pixel Sensors — •Larissa Mendes — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

Monolithic active pixel sensors (MAPS) produced using 65 nm CMOS imaging technology are being investigated for particle physics applications, particularly in tracking detectors to meet the demands of future lepton colliders. The complex silicon doping and non-linear electric fields require precise simulations for sensor performance optimization. This study utilizes a combination of electrostatic field simulations and Monte Carlo techniques to predict the performance of different sensor designs.

A hexagonal pixel grid is explored as an alternative to traditional square or rectangular layouts, and the performance is assessed for various pixel sizes. Hexagonal pixels are particularly interesting because they can reduce electric field edge effects seen in square designs, provide a more homogeneous response over the pixel cell, and allow for a shorter drift path while maintaining adequate area for circuitry in the p-well, as well as reducing the number of neighboring pixels. While results for a thin epitaxial layer of 10 um show limited improvements in quantities like efficiency, cluster size, and spatial resolution, further investigations address design limitations and potential advantages, such as enhanced timing performance.

T 70.4 Thu 17:00 VG 0.111

Development and simulation of the LHCb Upgrade 2 tracker — Johannes Albrecht, Dominik Mitzel, •Donata Osthues, and Dirk Wiedner — TU Dortmund University, Dortmund, Germany

During the High-Luminosity LHC period, the LHCb collaboration aims to operate its detector at significantly higher instantaneous luminosities than in Run 3 data taking.

To adapt to higher radiation levels and hit occupancies, the LHCb detector will undergo a second upgrade. This includes a replacement of the SciFi-Tracker by the Mighty-Tracker, a combination of silicon-fiber modules in the outer region

and MightyPix modules in the space closest to the beam pipe. The MightyPix module development includes overall module design choices, serial powering and cooling solutions as well as the MightyPix chip development.

This talk presents quantities such as overall tracking efficiencies and material budget scans that are calculated to test and verify the hardware development by using a detailed detector geometry simulation as baseline. The results help to make justified decisions during the development process.

T 70.5 Thu 17:15 VG 0.111

Timing studies of an HV-MAPS for LHCb Mighty Tracker — •Benedict Maisano, Lucas Dittmann, Ruben Kolb, Ulrich Uwer, and Sebastian Bachmann — Physikalisches Institut, Heidelberg, Germany

For the LHC Run 5 the LHCb experiment plans to increase the instantaneous luminosity significantly. As a consequence an upgrade of the experiments detectors is pursuit. A part of this proposed LHCb Upgrade II is to replace the inner regions of the scintillating fibre tracking system with pixel detectors, tackling the increased occupancies and radiation. For this Mighty Tracker, the high-voltage monolithic active pixel sensor MightyPix is currently developed and characterised. The MightyPix utilizes an amplifier and a comparator inside every pixel.

As future MightyPix designs are likely to utilize an NMOS comparator instead of the currently used CMOS versions, it is necessary to ensure that performance is uneffected by this change. For this purpose the performance of a MightyPix predecessor with NMOS comparator, the Run2020v1, is studied. The presentation will feature results of the timing measurements performed in both the lab and testbeam setup and compare them to the timing requirement of the Mighty Tracker.

T 70.6 Thu 17:30 VG 0.111

Studies of the Depletion Region in irradiated HV-CMOS MAPS towards the LHCb Mighty-Tracker using TCT — •Niclas Sommerfeld, Klaas Padeken, Hannah Schmitz, and Sebastian Neubert — University of Bonn

With the high luminosity upgrade to the LHC during LS3 the instantaneous luminosity at the LHCb experiment will be eventually increased by more than a factor of 6 to $1.3 \times 10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ for Run 5. As a part of Upgrade II the downsteam tracker (Mighty-Tracker) is foreseen to be instrumented with $13\mathrm{m}^2$ of HV-CMOS MAPS arround the beam pipe. This is intended to meet the increased requirements in terms of granularity and radiation tolerance imposed by the higher luminosity.

As a part of the ongoing efforts to develop the HV-CMOS MAPS foreseen for the Mighty-Tracker, the change of the depletion region in irradiated HV-CMOS MAPS is studied. The non trivial behavior – evolving from a large size monolithic senor – is investigated in several measurements with a focus on the transient-current-technique(TCT), using a TCT setup at CERN.

T 70.7 Thu 17:45 VG 0.111

Studies on the Radiation Tolerance of HV-CMOS MAPS for the LHCb Mighty-Tracker — •Hannah Schmitz, Klaas Padeken, Niclas Sommerfeld, and Sebastian Neubert — University of Bonn

By the start of Run 5 of the LHC the instantaneous luminosity at LHCb will increase from $2 \cdot 10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ to $1.3 \cdot 10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$. Therefore, the overall tracking system has to be upgraded. The upgraded downstream tracker (Mighty-Tracker) is foreseen as a hybrid detector consisting of six layers of HV-CMOS MAPS with a total size of $13\mathrm{m}^2$, covering the central part of the acceptance close to the beampipe, and scintillating fibers in the outer part.

HV-CMOS MAPS are chosen to fulfill the upcoming requirements: High granularity, power consumption $\leq$ $150\mathrm{mWcm}^{-2}$, time resolution $\leq$ 3ns - required to operate the trigger-less 40MHz DAQ - and a high radiation level of $3 \cdot 10^{14}$1-MeV$\mathrm{n}_{\mathrm{eq}}\mathrm{cm}^{-2}$ (NIEL) and 25MRad (TID).

Performance studies of 180nm processed HV-CMOS MAPS with focus on the radiation tolerance, have been performed. Using a 14MeV proton beam at the Bonn cyclotron as well as an irradiation with x-rays, the impact of different types of radiation damages on the sensor have been investigated.

Both campaigns and the consequences induced by the radiation damage on the sensor operation with emphasis on the performance goals will be covered by this presentation.

T 70.8 Thu 18:00 VG 0.111

Support Structure Investigations for the LHCb Mighty Tracker in Upgrade II — •Ksenia Solovieva, Todor Todorov, and Marco Gersabeck — Albert-Ludwigs-University,Freiburg

In preparation for the challenging environment of the High Luminosity LHC, the LHCb detector will undergo major improvements. The Upgrade II is scheduled to be installed during Long Shutdown 4 and includes a replacement of the downstream tracker. The current scintillating fibre tracker detector will be replaced with a hybrid system, the Mighty Tracker, comprising layers of improved scintillating fibres and 6 layers of silicon pixel detectors. The latter requires optimisation in the detector design, service routing and support structures to adhere to a strict material budget of below 1% X/X0 per layer. In this presentation, early considerations and studies of potential support structure solutions are discussed.

T 70.9 Thu 18:15 VG 0.111

Irradiation Studies related to the Bias Behaviour of the MightyPix — Johannes Albrecht[1], •Jonas Rönsch[1], Sebastian Rüssmann[1], Klaas Padeken[2], Hannah Schmitz[2], Niclas Sommerfeld[2], Dirk Wiedner[1], and Lukas Witola[1] — [1]TU Dortmund University, Dortmund, Germany — [2]Helmholtz Institute for Radiation and Nuclear Physics, Bonn, Germany

To exploit the full flavour physics potential of the HL-LHC, the LHCb detector will be operated at an unprecedented instantaneous luminosity after long shutdown 4. Due to the new conditions, an upgrade of the tracking system is unavoidable. The Mighty Tracker will be the downstream LHCb Upgrade 2 tracking system. It combines scintillating fibres and high voltage monolithic active pixel sensors (HVMAPS) called MightyPix.

The MightyPix will be placed in the inner part of the detector. Therefore, they encounter irradiation levels up to 3×10^{14}1-MeV$\mathrm{n}_{\mathrm{eq}}\mathrm{cm}^{-2}$.

As part of the radiation tolerance studies, several MightyPix were irradiated at the Isochronous Cyclotron of the Helmholtz Institute for Radiation and Nuclear Physics in Bonn up to a fluence of 3×10^{15}1-MeV$\mathrm{n}_{\mathrm{eq}}\mathrm{cm}^{-2}$. The effect of the irradiation on the complex system of the monolithic sensor will be presented.

T 71: Detectors VI (Gaseous Detectors)

Time: Thursday 16:15–18:15 Location: VG 1.101

T 71.1 Thu 16:15 VG 1.101

Results of an aging study for the graphite coating of thin-gap RPCs for the ATLAS phase 2 upgrade. — •Davide Costa[1,2], Francesco Fallavolita[2], Oliver Kortner[2], Hubert Kroha[2], and Giorgia Proto[2] — [1]Department of Physics, Technical University of Munich, Munich — [2]Max Planck Institute for Physics, Garching bei Munchen

The increase of total electrode resistance is a well-established cause of decrease in Resistive Plate Chamber (RPC) rate capability over time, as it leads to a lower effective voltage being applied across the gas gap. Additionally, a degradation of the graphite electrode might lead to non-uniformities in the field, which could become more significant over the large area of the RPC, worsening detector performance. While previous works have associated this increase in electrode resistance mostly to the degradation of the graphite coating, it is not clear that this is the case. This contribution presents preliminary results of a long-term study performed at the Max Planck Institute for Physics in Munich, which induces aging at varying rates by simulating the expected charge accumulation from 10 years of operation at the event rates predicted for the High-Luminosity LHC (HL-LHC). This study aims to confirm the expected performance of the graphite coating, and to disentangle effects due to degradation of the coating from potential contributions from the high-pressure phenolic laminate (HPL) electrode plates themselves. Further tests will investigate the potential mechanisms behind the aging phenomena.

T 71.2 Thu 16:30 VG 1.101

Quality assurance and quality control of the production of thin-gap RPCs for the ATLAS phase 2 upgrade. — •Davide Costa[1,2], Francesco Fallavolita[2], Oliver Kortner[2], Hubert Kroha[2], Giorgia Proto[2], Pavel Maly[2], and Daniel Soyk[2] — [1]Department of Physics, Technical University of Munich, Munich — [2]Max Planck Institute for Physics, Garching bei Munchen

The planned upgrades to the ATLAS muon spectrometer for the phase 2 upgrade of the LHC have increased the demand for better-performing Resistive Plate Chambers (RPCs). The upgrade requires gas gaps reduced thickness, both of the electrode plates and the gas volume itself, which lead to improved rate-capability and longevity, as well as allowing for the installation of additional triplets of thin-gap RPCs, with the aim to improve acceptance and efficiency of the ATLAS muon trigger. In order to improve production rate and assure redundancy, facilities for the production and certification of RPCs have been set up at the Max Planck Institute for Physics (MPP) in Munich, in collaboration with German industrial partners. This contribution illustrates the role the MPP has played in setting up the infrastructure, developing quality assurance as quality control (QA/QC) standards, in order to ensure that efficient production be accompanied by high performance standards, as well as the Institute*s ongoing participation in the development of innovative solutions for detector construction that allow to more reliably reach the required performance goals.

T 71.3 Thu 16:45 VG 1.101

Effect of Different O_2 and H_2O Concentrations on MicroMegas Detector Performance in Ar-CO_2 Gas Mixtures at Various Drift Volumes — •Burkhard Böhm and Raimund Ströhmer — Universität Würzburg, Germany

In particle physics the MicroMegas detectors (MM), a prominent type of Micro-Pattern Gaseous Detectors (MPGDs), are used in several experiments. They are valued for their simple single-stage amplification and high and stable gain. However, their performance can be significantly affected by the composition of the gas mixture, including the contamination from ambient air. Since processes in multi-component gas mixtures can be highly complex, experimentally investigating the signal behavior at different levels of O_2, H_2O and their combination in an argon-based atmosphere is crucial.

To evaluate the effect of impurities in drift volume and amplification region separately, we performed studies with maximum drift distances from 5 mm to 2.5 mm. The aim is to determine the magnitude of electron attachment, a major factor in signal degradation, in the amplification stage and whether it can be mitigated by using a smaller drift volume.

Precise control of oxygen and water levels was achieved by introducing O_2 and humidified Ar-CO_2 into a resistive MM chamber. The resulting effects on gas gain, primarily due to electron attachment in the drift region, and the amplification of primary electrons were systematically studied. This research provides valuable insights into optimizing MPGDs performance in environments with varying gas impurities.

T 71.4 Thu 17:00 VG 1.101

Investigation of micro-pixel charge sharing Micromegas detectors — •Nirmal Mathew, Otmar Biebel, Valerio D'Amico, Stefanie Götz, Ralf Hertenberger, Eshita Kumar, Daniel Grewe, Nick Schneider, Chrysostomos Valderanis, and Fabian Vogel — LMU München

Micro-MEsh GAseous Structure (Micromegas) detectors are Micro Pattern Gaseous Detectors (MPGD's) used for their high-rate capability and excellent spatial resolution achieved through narrow amplification gap and fine strip pitch readouts. However, this performance comes at the expense of requiring a large number of readout channels for individual strips. The development and testing of Pixalated Avalanche Detectors (PAD's) are investigated, which leverage charge-sharing principles across multiple pixel layers, alternative to strip-based readouts in Micromegas, to reduce the number of readout channels strongly. Each successive layer is designed with larger pixels than the one below, culminating in a final layer that aggregates charge information to determine the particle hit position. This approach reduces the number of readout channels while maintaining comparable spatial resolution.

Two prototypes were tested: one with five pixel layers, and a hybrid PAD with three layers and novel strip-like readouts. The detectors were calibrated using an Fe-55 source and tested in a hodoscope setup to track cosmic muons. The performance and efficiency of these measurements will be presented, demonstrating the feasibility of PADs as a cost-effective alternative to traditional MPGDs.

T 71.5 Thu 17:15 VG 1.101

GridPix Production: Latest Developments in Bonn — •Sabine Hartung, Yevgen Bilevych, Jochen Kaminski, and Klaus Desch — Physikalisches Institut Universität Bonn

GridPix detectors are Micropattern Gaseous Detectors designed for high-resolution imaging and the detection of single primary electrons. They incorporate a highly pixelated readout ASIC chip, such as the Timepix or Timepix3, which feature 256 x 256 pixels with a pitch of 55 x 55 μm. To minimize the probability of chip damage by sparks an additional protective layer is applied to the surface of the chip. The Micromegas-like gas amplification stage is constructed on top of the chip by photolithographic postprocessing.

Until recently, this wafer-based production process was carried out at the Fraunhofer Institute IZM in Berlin. Now it is being transferred to the Forschungs- und Technologiezentrum Detektorphysik (FTD) in Bonn. The advancements of this technology at the FTD in Bonn enables not only the continuation of the established process but also the adoption of more flexible production techniques, such as new maskless methods, which allow for greater optimization possibilities.

This presentation will provide an overview of the general technological steps and outline the current status of production at the Bonn facility.

T 71.6 Thu 17:30 VG 1.101

GridPix-based X-ray Polarimeter — •Vladislavs Plesanovs, Markus Gruber, Klaus Desch, and Jochen Kaminski — Rheinische Friedrich-Wilhelms-Universität Bonn, Germany

X-rays are a powerful tool for probing the elemental composition and electromagnetic properties of matter. By measuring X-ray emission spectrum, scientists can characterize the chemical compositions of test targets, while in astrophysics, X-ray polarization unveils the intricate magnetic structures of distant galaxies and nebulae. Several testbeam campaigns with GridPix-based detectors have demonstrated impressive capabilities in reconstructing X-ray polarization.

To push the limits of performance, we are developing a novel GridPix-based polarimeter. This gaseous detector integrates a Timepix3 ASIC readout, offering a zero-suppressed 40 Mhits s^{-1} readout rate with a 55 μm pixel pitch. 1 μm thick aluminum grid mounted on 50 μm high pilars, both deposited using photolithographic methods, define the amplification gap and ensure near-perfect alignment of grid holes and pixels - allowing for precise detection of individual primary electrons.

This work presents an overview of X-ray polarimetry and the GridPix detector's production and operation. The main focus will be on the current status and development decisions of this project.

T 71.7 Thu 17:45 VG 1.101

Negative Ion Gridpix based High resolution TPC (NIGHT) detector — •Saime Gürbüz, Thomas Block, Can Cihan Çetinkaya, Klaus Desch, Jan Glowacz, Jochen Kaminski, and Michael Vogt — Physikalisches Institut, Bonn, Germany

The Negative Ion Time Projection Chamber (NITPC) equipped with a Gridpix pixelated readout represents a cutting-edge approach to high-precision particle detection, with significant potential for directional dark matter searches. The proof-of-concept detector, NIGHT, combines a Timepix ASIC with an InGrid amplification stage, offering an active area of 1.4 cm × 1.4 cm and a drift length of 3 cm.

Operating with a He:SF_6 gas mixture, the detector profits the electronegative properties of SF_6 to achieve negative ion drift, reducing diffusion and enhancing spatial resolution. As the carrier gas, Helium supports near-atmospheric operation and optimal ion transport properties. The Gridpix readout, featuring micromesh amplification, ensures high spatial and temporal resolution even for low-energy particle tracking.

The NIGHT detector's design, operational principles, and performance will be presented in this talk. Gain measurements are conducted with radioactive sources in the laboratory and further tested at the ELSA electron accelerator. These studies aim to validate the detector's capabilities and demonstrate the advantages of pixelated readouts combined with negative ion drift for precision particle detection and directional dark matter experiments.

T 71.8 Thu 18:00 VG 1.101

BODELAIRE: A Time-Projection-Chamber for Neutron Science — •Thomas Block[1], Klaus Desch[1], Saime Gürbüz[1], Jochen Kaminski[1], Markus Köhli[3,4], Michael Lupberger[1,2], and Jan Glowacz[1] — [1]Physikalisches Institut, Universität Bonn — [2]HISKP, Universität Bonn — [3]Physikalisches Institut, Universität Heidelberg — [4]StyX Neutronica GmbH, Mannheim

Due to the increase in demand and price of Helium-3 alternative approaches for developing detectors for various applications in neutron science are of utmost importance.

The Boron Detector with Light and Ionisation Reconstruction (BODELAIRE) combines the concept of a time projection chamber (TPC) with a boronated glass vessel as a neutron conversion stage. It deploys a GridPix-based readout with high granularity and high time resolution, which makes it a suitable candidate for imaging experiments. The naturally abundant isotope Boron-10 absorbs incoming neutrons and decays into an alpha particle and a Lithium ion. One ion enters the drift volume of the TPC and creates a trace of electron-ion pairs, which the readout detects. The other ion, which is emitted in the opposite direction, creates a light signal in the scintillator layer on the glass vessel, which is used to trigger the readout. The light is coupled to a FPGA-controlled silicon photomultiplier-based electronic board, which creates the trigger signal. Trigger signal thresholds can be set by the user.

In this work the detector concept of BODELAIRE and its current stage of development will be presented.

T 72: Detectors VII (Calorimeters)

Time: Thursday 16:15–18:30 Location: VG 1.102

T 72.1 Thu 16:15 VG 1.102

Results of the Megatile prototype for the CALICE AHCAL — Volker Büscher, Lucia Masetti, •Anna Rosmanitz, and Sebastian Ritter — Johannes Gutenberg-Universität Mainz

The CALICE collaboration has developped several highly granular calorimeter concepts for a future e^+e^- collider, that are designed for Particle Flow Algorithms.

The design used to produce a technological prototype of the Analog Hadronic Calorimeter (AHCAL) with more than 20k channels consists of 3x3 cm^2 scintillator tiles read out by silicon photomultipliers (SiPM). Each tile is individually wrapped in reflective foil and glued to the boards. The final AHCAL detector would countain 8 million channels.

To facilitate the assembly process, the Megatile design is developed at the University of Mainz. It is made from a large scintillator plate which houses 12x12 channels at once. The channels are separated by tilted trenches filled with a mixture of glue and TiO_2 for reflectivity and optical insulation. Optical tightness is achieved by gluing reflective foil on both faces and varnishing the edges. Until now, ten prototypes have successfully been built, continuously monitored in a cosmic test-stand in Mainz and tested in several test beam campaigns at DESY and CERN.

This talk presents the latest technical developments and preliminary results from electron beam measurements. We'll specifically focus on the Megatile's efficiency and optical cross talk.

T 72.2 Thu 16:30 VG 1.102

Fast Hadron Shower Simulation using the Discrete Cosine Transform with the CALICE AHCAL Prototype — •André Wilhahn, Zobeyer Ghafoor, and Stan Lai — II. Physikalisches Institut, Georg-August-Universität Göttingen, Deutschland

Extensive simulations of particle showers are crucial for high energy physics experiments, since they allow for a sensible interpretation of recorded calorimeter data. As many calorimeters are designed with increasing granularity, while having to cope with higher energy deposits and higher luminosity conditions, the accurate simulation of particle showers in a computationally efficient manner is of utmost importance. This talk describes preliminary investigations into a data-driven fast calorimeter simulation, based on compression algorithms, that is meant to describe particle showers accurately.

We start by investigating pion showers in the CALICE AHCAL (Analog Hadron Calorimeter) prototype, which is a highly granular hadronic calorimeter comprising a total of 38 active layers embedded in a stainless-steel absorber structure. Each active layer contains a grid of 24×24 scintillator tiles that are read out individually via silicon photomultipliers. The Discrete Cosine Transform is applied to hit energy distributions of test beam data, decomposing the distributions into distinctive cosine waves. By simulating the coefficients of these cosine waves, the goal is to develop a data-driven fast simulation with a reduced number of input values, but only limited information loss, and thus, being able to recreate energy distributions and preserving correlation factors between individual detector layers.

T 72.3 Thu 16:45 VG 1.102

CALO5D Calorimetry in five dimensions — Frank Simon[1], •Melike Akbiyik[1], Ulrich Einhaus[1], Lucia Masetti[2], Bohdan Dudar[2], Roman Pöschl[3], Xin XIA[3], Katja Krüger Krüger[4], and Vincent Boudry Boundry[5] — [1]Karlsruhe Institute of Technology, Karlsruhe , Germany — [2]Johannes Gutenberg University, Mainz, Germany — [3]IJCLab, Paris-Saclay, France — [4]DESY,Hamburg,Germany — [5]LLR, Palaiseau, France

This talk will present the collaborative research project CALO5D (Calorimetry in five dimensions) for future experiments in which a total of 4 universities (Hamburg (DESY), Karlsruhe (KIT), Mainz (JGU), Paris-Saclay (IJCLab), and Palaiseau(LLR) participate. The goal of the collaborative project is the further development of calorimeter concepts for future high-energy physics experiments, with an emphasis on meeting the requirements for future Higgs factory concepts.

CALO5D will combine detailed information on particle showers provided by imaging calorimeters (CALO) with precise time information at the cell level, in addition to space and local energy (5D). The exploitation of the information will be assisted by modern machine learning algorithm with the goal to improve the performance of energy reconstruction and particle flow algorithms. The capability of the tools will be demonstrated with performance studies on selected physics channels central to the physics case of future Higgs factories. The results of this project will have a fundamental impact on the design of the next generation high energy physics experiments.

T 72.4 Thu 17:00 VG 1.102

Kinematic reconstruction of deep-inelastic tau-neutrino interactions with SND@SHiP — Vasilisa Guliaeva[1], Heiko Lacker[2], and •Eduard Ursov[2] — [1]Constructor University, Bremen, Germany — [2]Humboldt University of Berlin, Berlin, Germany

SHiP (Search for Hidden Particles) is a general-purpose fixed-target experiment under development at CERN's SPS, aimed at exploring feebly interacting GeV-scale particles (FIPs), appearing in various extensions of the Standard Model and advancing neutrino physics studies. The experiment will feature two primary subdetectors: the Scattering and Neutrino Detector (SND@SHiP), designed to study neutrino signals and search for direct detection of FIPs, and the Hidden Sector Decay Search (HSDS) detector, dedicated to registering decay products of FIPs. This work focuses on the integration of SND into the SHiP experiment, addressing the search for the detector's optimal location and design optimization to maximize its physics potential. The SND will employ a sandwich-like structure composed of active scintillating fiber layers interleaved with magnetized iron as the passive material. To evaluate the detector's capability to identify tau-neutrino signals against a background of muon neutrino events, machine learning classifiers based on Boosted Decision Trees (BDT) and Graph Neural Networks (GNN) have been developed. The results of the classification will guide adjustments to the detector dimensions to maximize tau-neutrino signal and to improve the reconstruction of the neutrino properties.

T 72.5 Thu 17:15 VG 1.102

High Granularity Noble Liquid Calorimetry for FCC — •Martina Koppitz[1,2], Nikiforos Nikiforou[2], and Arno Straessner[1] — [1]TU Dresden — [2]CERN

Future high-energy collider experiments, such as the Future Circular Collider (FCC), demand advanced detector technologies to achieve their ambitious physics objectives. Spanning high-precision measurements around the Z-pole to direct Higgs production, the FCC's success relies on the performance of calorimeters, particularly highly-granular devices optimized for imaging and particle flow methods.

One of the proposed general-purpose detectors is Allegro (A Lepton coLlider Experiment with highly GRanular calorimetry Read-Out). Building on the proven advantages of noble liquid calorimetry, Allegro introduces a high-granularity ECAL design that incorporates multi-layer printed circuit boards (PCBs). This design features a sampling calorimeter comprising 1536 cylindrically stacked steel-clad lead or tungsten absorbers, with liquid argon or krypton serving as the active medium.

Simulations are underway to study and optimize the calorimeter's performance. Particular attention is being given to determining the optimal granularity for pi0 and photon identification, as well as developing methods to achieve the best pion rejection capabilities.

T 72.6 Thu 17:30 VG 1.102

Design of the SHiP Electromagnetic Calorimeter — •Claudia Caterina Delogu, Sebastian Ritter, and Matei Climescu — Johannes Gutenberg Universität Mainz

The SHiP (Search for Hidden Particles) experiment is designed to explore feebly interacting particles at the GeV scale at the CERN SPS beam dump facility. Central to the SHiP detector is its electromagnetic calorimeter, which is responsible for energy measurements, particle identification, and reconstruction of neutral particle directions (pointing capability).

This presentation will detail the design of the SHiP calorimeter: a modular sampling calorimeter made of iron and plastic scintillators, read out by Silicon Photomultipliers. The calorimeter is optimized to meet SHiP requirements for energy resolution and angular reconstruction. We will discuss the considerations that contribute to the design, particularly the geometric layout, and the construction of the first prototype.

T 72.7 Thu 17:45 VG 1.102

Pointing Studies with the SHiP Calorimeter Prototype — •Sebastian Ritter, Claudia Delogu, Rainer Wanke, Matei Climescu, and Volker Büscher — Johannes-Gutenberg Universität, Mainz

The SHiP experiment (Search for Hidden Particles) is an approved fixed-target experiment designed to explore the possible hidden sector of particle physics at the CERN SPS. An important component of SHiP is its electromagnetic calorimeter, which has to combine good energy resolution with the capability to reconstruct the direction of incoming neutral particles (pointing) as well as the identification of particles (PID). To validate the current design proposal, a conceptual prototype was tested at the DESY test beam facility in Hamburg. The prototype employs a modular sandwich structure with alternating layers of plastic scintillator readout by SiPMs and iron absorbers. During the test beam campaign, its performance was evaluated using electron beams with energies from

1 to 5.8 GeV and incident angles up to 7.5 degrees. Using precision tracking data, the spatial resolution, pointing accuracy, and angular reconstruction efficiency were characterized, correlating them with the prototype's design parameters. Furthermore, the impact of material alignment, layer staggering, and calibration strategies on the pointing performance were assessed. This talk presents an overview of the test beam setup, key findings, and implications for the detector design. The potential of the proposed concept to satisfy the SHiP requirements is demonstrated, paving the way for further optimization and a larger technological prototype.

T 72.8 Thu 18:00 VG 1.102

Control and safety systems for CMS high granularity calorimeter cassette assembly facility at CERN — •Maria Toms[1], Markus Klute[1], Ebru Simsek[2], Ziya Cihan Taysi[2], Bora Isildak[2], German Martinez[3], Andromachi Tsirou[4], and Piero Giorgio Verdini[5] — [1]Karlsruher Institut für Technologie, ETP, Germany — [2]Yildiz Technical University, Turkey — [3]Florida State University, US — [4]National and Kapodistrian University of Athens, Greece — [5]Universita & INFN Pisa, Italy

The CMS collaboration is building a new high-granularity calorimeter (HGCAL) as part of the CMS detector phase 2 upgrade. Silicon modules and SiPM-on-tile boards will be integrated into cassettes prior to their insertion into endcap structure. The cassette assembly will start in early 2025. After assembly, the cassettes will need to be tested in cold conditions with cosmic muons. The cold operation of cassettes inside cold boxes, specially built for this purpose, requires functional detector control (DCS) and subdetector environmental protection (SEP) systems. The purpose of those systems is to provide operators with a convenient way to control and monitor a significant amount of hardware inside and outside the cold box and to guarantee the safety of personnel and detector equipment. The experience obtained from the development and practical use of such systems for the operation of cassette assembly facility (CAF) at CERN can later be used to design control and protection systems for the final HGCAL detector at CMS. The design of control and protection systems for the HGCAL CAF at CERN and the progress on their development are presented.

T 72.9 Thu 18:15 VG 1.102

Study of effects of detector mis-calibration on energy resolution for the SiPM-on-tile section of the High Granularity Calorimeter for CMS. — •Daria Selivanova — Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany

High Luminosity era of the LHC is fast approaching and the upgrades of the detector systems are now in various stages of production. The CMS experiment will receive a High Granularity Calorimeter (HGCAL) to replace the existing endcaps. Active layers of the upcoming sampling calorimeter are being constructed, and, I bring into focus work performed in the Tile Assembly Center in DESY on Scintillator tile modules of the hadronic section. The modules are constructed using the SiPM-on-tile technology, named after it's two main components: scintillating tiles coupled to Silicon Photo-Multipliers. One such pair makes a single channel of the hadronic endcap and the complete detector will feature more than 280 000 of them. Due to detector's geometry and the difference in production technics, tiles are trapezoidal in shape, range in area from 5.3 to 30.4 cm^2 and have varying light yield depending on the size. These factors necessitate establishing the optimal strategy for monitoring of tile characteristics to assure longevity of good detector performance. Quality control (QC) procedures for tiles have been established following the successful pre-series campaign and are now being utilised. The acquired data are also used to add detail to the simulation of the detector to study the effects the precision of QC results has on energy resolution.

T 73: Flavour Physics IV

Time: Thursday 16:15–18:30 Location: VG 1.103

T 73.1 Thu 16:15 VG 1.103

Quantum Entanglement of neutral B-mesons at the Υ(5s) decay — •Adrian Liese — Max-Planck-Institut, Garching

We investigate the decay channel $\Upsilon(5s) \rightarrow B^0\bar{B}^{0*}$ and its subsequent decay into $B^0\bar{B}^0$. This B-meson pair is supposed to be produced in an $J^{PC} = 1^{-+}$ entangled state which is different from a neutral B-meson pair coming from the Υ(4s) where $J^{PC} = 1^{--}$. The different C-symmetry changes the entanglement and subsequently the probability density. The Belle I data for the Υ(5s) offers the unique ability to measure $\bar{t} = t_1 + t_2$ and $\Delta t = t_2 - t_1$ individually, which is not possible for Belle II data of the Υ(4s). The new probabilities were calculated as functions of $\bar{t}$ and Δt and compared to the C=-1 entanglement as well as the disentangled system.

T 73.2 Thu 16:30 VG 1.103

Event separation at the $\Upsilon(5s)$ for entanglement studies — •Kilian Brückner — Max Planck Institut for Physics Garching

Upcoming analyses aim to study the quantum coherence (entanglement) of the $B^0/\overline{B^0}$ system at the Υ(5s) resonance. Doing this effectively requires the knowledge of how the Υ(5s) decayed, since the different decay channels have different entanglement properties. In this analysis the $B^0/\overline{B^0}$ system is reconstructed and later separated into the $B^0/\overline{B^0}$, $B^{0*}/\overline{B^{0*}}$ and $B^{0*}/\overline{B^0}$ decay channels. The separation is done mainly using the variables ΔE, which describes the difference between the beam energy and B-Meson energy, as well as M_{bc}, which describes the beam-energy-constrained mass. Since the Belle II Experiment has thus far not collected any data exactly on resonance of the Υ(5s), Belle I data is used for this analysis.

T 73.3 Thu 16:45 VG 1.103

Entanglement studies with Belle Υ(5S) data — •Vanessa Geier — Max-Planck-Institute for Physics Garching

Compared to the Υ(4S) the Υ(5S) can decay in excited B^0 giving rise to $B^{0(*)}/B^{0(*)}$ states with different quantum numbers. Directly after the decay of the Υ(5S) the $B^{0(*)}/B^{0(*)}$ pairs are supposed to be in the $J^{PC} = 1^{--}$ state. After the transition of the excited state into the B^0/B^0 state via photon emission, the B^0/B^0 pairs are supposed to be in the states $J^{PC} = 1^{-+}$. Depending on the C parity the $B^{0(*)}/B^{0(*)}$ can be in a symmetric or antisymmetric wave function leading to different time evolutions of the entangled states. Possibly the gamma transition of the excited state can also disrupt the entanglement. We will study these effects using Υ(5S) data collected by the Belle experiment. The Analysis includes the reconstruction of the signal $B^{0(*)}$ mesons as well as the tag-side reconstruction through the decay chain $B^0 \rightarrow D^-(\rightarrow K^+\pi^-\pi^-)\pi^+$. In addition the resulting B^0/B^0 mesons need to be separated with the help of M_{bc} and ΔE variables. Reconstruction and selection efficiencies will be studied with MC events. Then the time evolution of the B-mesons will be investigated to study possible (dis)entanglement properties of the produced B^0/B^0 meson pairs.

T 73.4 Thu 17:00 VG 1.103

Analysis of Rare $B^0_{(s)} \rightarrow \mu^+\mu^-$ Decays using Run 3 LHCb Data — Johannes Albrecht[1], Lukas Bertsch[1], Claudiu Cotirlan[2], Joel Mainusch[1], Biljana Mitreska[1], and •Jan Peter Wagner[1] — [1]TU Dortmund University, Dortmund, Germany — [2]University of Manchester, Manchester, England

In 2024, the LHCb experiment recorded an integrated luminosity of more than 9 fb^{-1} of proton-proton collisions which is larger than the samples recorded during the combined LHC data-taking periods Run 1 and Run 2. A key measurement of the LHCb collaboration are the branching fraction measurements of the statistically limited rare $B^0_{(s)} \rightarrow \mu^+\mu^-$ decays. In this contribution studies on normalisation and control channels are presented using 2024 LHCb data and simulation. These include detector performance studies and studies comparing 2024 measurements with the already published Run 2 results.

T 73.5 Thu 17:15 VG 1.103

Studies of extended selection methods for the rare decays $B^0_{s,d} \rightarrow \mu^+\mu^-$ at the LHCb experiment — Johannes Albrecht, Maik Becker, Quentin Führing, and •Katharina Popp — TU Dortmund University, Dortmund, Germany

Studies of the rare decays $B^0_{s,d} \rightarrow \mu^+\mu^-$ are core to the physics programme of the LHCb experiment as they provide sensitivity to new physics. For effective suppression of combinatorial background and improvement of signal significance, extended selection strategies in the analysis of the rare decays $B^0_{s,d} \rightarrow \mu^+\mu^-$ at the LHCb experiment are investigated. Information from the existing Flavour Tagging algorithms, as well as from the underlying tracks of the event, is taken into account in the classification of signal and background candidates. MC-simulated signal samples as well as LHCb sideband data from 2018 are used, assuming that the data contains only combinatorial background. The data is recorded during LHC Run 2 at a centre-of-mass energy of 13 TeV in proton-proton collisions and corresponding to an integrated luminosity of 2.19 fb^{-1}. The multivariate selection method developed in previous analyses used as a baseline and mistag probabilities of the existing Flavour Tagging algorithms are included. A neural network is trained analogously to the previously used multivariate approach and shows an improvement in the classification. In addition, a DeepSet neural network is trained with the original variables and information about the underlying event. This contribution discusses the effect of the different classification algorithms and input information on the performance of the classification.

T 73.6 Thu 17:30 VG 1.103

Measurement of the branching ratio and q^2-spectrum of $B \to D^{**}\ell\nu$ decays at Belle II — •Eyluel Uenlue, Thomas Lueck, and Thomas Kuhr — Ludwig-Maximilians-Universitaet Muenchen

There is currently some tension between the measured value of $R(D^*) = \mathscr{B}(B \to D^*\tau\nu_\tau)/\mathscr{B}(B \to D^*\ell\nu_\ell)$ and the Standard Model prediction, hinting at lepton universality violation. Semileptonic B meson decays to D^{**} mesons are background to the $R(D^*)$ measurement, where D^{**} denotes the orbitally excited P-wave charm mesons: $D_1(2420)$, $D_2^*(2460)$, $D_0^*(2300)$, and $D_1^{'}(2430)$. These decays are not well understood, and there have been discrepancies between past measurements of their yields made by BaBar and Belle. Hence, improving understanding of these decays decreases an important systematic uncertainty on $R(D^*)$ measurements.

The aim of the present study is to use simulation and data from the Belle II experiment to study these decays, in particular to determine the q^2 spectrum, which is a key input for theory.

We reconstruct one of the B mesons from the $\Upsilon(4S) \to BB$ decay in the signal channel, $B \to D^{**}(D^*\pi)\ell\nu$. The other B meson is reconstructed in various hadronic modes using the Full Event Interpretation algorithm, which provides a tag B sample with well known kinematics. The signal yield is determined by a maximum likelihood fit to the mass difference $M(D^*\pi) - M(D^*)$. The resulting q^2 spectrum is fitted by a differential decay rate model after correcting for detector resolution effects. The current status of the analysis will be presented including results on simulation and some sources of systematic uncertainty.

T 73.7 Thu 17:45 VG 1.103

Measurement of angular coefficients of $\bar{B} \to D^*\ell\bar{\nu}_\ell$ using Belle II data — Florian Bernlochner[1], Markus Prim[1], Michael Hedges[2], and •Maximilian Hoverath[1] — [1]Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universiät Bonn — [2]Fermi National Accelerator Laboratory

A precise determination of the CKM matrix element V_{cb} is essential for understanding quark-flavor transitions within the Standard Model (SM). In addition to measuring V_{cb}, semileptonic decays provide a valuable opportunity to probe lepton-flavor universality (LFU), a fundamental feature of the SM that predicts universal gauge couplings for leptons. Any observed deviation from LFU would indicate the presence of physics beyond the SM. In this work, we analyze the exclusive semileptonic decay $\bar{B} \to D^*\ell\bar{\nu}_\ell$ using hadronic tagging and Belle II data to determine the angular coefficients. These coefficients allow for the determination of V_{cb} and the associated form factors, which parameterize the hadronic interaction in the decay. Additionally, we test LFU by measuring asymmetries between the electron and muon channels. Using helicity angles $\cos\theta_\ell$, $\cos\theta_V$, χ, and the hadronic recoil parameter w, we fully describe the kinematics of the decay product by reconstructing the angular coefficients in bins of w. We subtract the background in a model-independent way by fitting the missing mass squared and correct the measured distributions for migration and selection effects.

T 73.8 Thu 18:00 VG 1.103

Improving $R(D^{(*)})$ with hadronic FEI and leptonic tau decays with Belle II Run 1 data. — •Agrim Aggarwal, Florian Bernlochner, Markus Prim, Felix Metzner, and Ilias Ilias Tsaklidis — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn, Bonn, Germany

An important postulate of the Standard Model, which has been challenged by experimental measurements, is the assumption that all leptons couple identically to the electroweak gauge bosons. In this work, the expected precision of ratios $R(D^*) = \mathscr{B}(B \to D^{(*)}\tau\bar{\nu}_\tau)/\mathscr{B}(B \to D^{(*)}\ell\bar{\nu}_\ell)$ are studied, a crucial test of lepton flavour universality, at Belle II. The Long Shutdown Run 1 (LS1) data at Belle II which corresponds to the total integrated luminosity of 365 fb^{-1} is used. A technique known as hadronic tagging is employed to fully reconstruct one of the $\mathscr{B}$ mesons and furthermore the leptonic decays of τ lepton is considered. The ratios of interest are extracted using a two-dimensional binned maximum likelihood fit with a revised signal extraction strategy, implemented via pyhf, that enables a conceptually safer treatment of the systematic uncertainties handled using the package SysVar developed in Bonn.

T 73.9 Thu 18:15 VG 1.103

Measurement of the efficiency and the partial branching fraction in a B Meson to X_c inclusive semileptonic Decay for the different q^2 (squared momentum transfer) with Belle II data — •Rajeshwari Roy, Munira Khan, Florian Bernlochner, and Markus Prim — Physikalische Institut der Rheinische Friedrich-Wilhelms- Universität Bonn, Nussallee 12, 53115, Bonn

The study of B-meson decays into charmed hadronic states (X_c) accompanied by a lepton and neutrino ($B \to X_c\ell\nu$) provides crucial insights into the dynamics of weak interactions and the structure of the Standard Model. This project focuses on the measurement of the partial branching fraction for $B \to X_c\ell\nu$ for different kinematic regions defined by cuts on the squared momentum transfer, q^2. A detailed event selection strategy is employed, leveraging kinematic constraints (moments: q^2, M_X) The use of multivariate techniques distinguishes the signal events from the backgrounds, such as continuum events and non-charmed semileptonic decays. The plots and fit results are generated using pyhf, a robust framework for statistical modeling and systematic uncertainty evaluation.The efficiency of identifying these decays is determined using simulated datasets and is given by the ratio of the number of reconstructed events to the number of generated events. Further, the partial branching fractions are determined for different q^2 thresholds, providing a refined understanding of semileptonic decay dynamics.

T 74: Flavour Physics V

Time: Thursday 16:15–18:15 Location: VG 1.104

T 74.1 Thu 16:15 VG 1.104

Flavour Tagging for the LHCb Upgrade — •Micol Olocco[1], Quentin Führing[1,2], Sara Celani[3], and Johannes Albrecht[1,2] — [1]University of Dortmund, Dortmund, Germany — [2]Lamarr Institute for Machine Learning and Artificial Intelligence, Dortmund, Germany — [3]Heidelberg University, Heidelberg, Germany

One of the primary objectives of the LHCb experiment is to study charge-parity (CP) violation by analyzing the decays of a wide variety of beauty mesons produced in proton-proton collisions at the LHC. Such studies require the knowledge of the B-signal flavour at production time which cannot be directly inferred from its decay products.

Flavour-tagging algorithms exploit the correlations between the B-meson flavour at production and the charged particles associated with the signal production, allowing for the identification of the candidate as either a B-meson or an $\overline{B}$-meson. Along with the tagging decision, it is crucial to estimate the probability of a misidentification, which is done by applying Machine Learning algorithms.

Since the LHCb detector has been upgraded and operates at an increased instantaneous luminosity, Flavour-Tagging algorithms must be updated accordingly. This contribution will present the revised strategy and ongoing developments of the Flavour-Tagging algorithms for the upgraded LHCb.

T 74.2 Thu 16:30 VG 1.104

Transformer Model for Flavour Tagging at Belle II — Ariane Frey, Lukas Herzberg, Thibaud Humair, Benjamin Schwenker, and •Tilo Wettlaufer — II. Physikalisches Institut, Universität Göttingen

At the Belle II experiment, an entangled state of two B mesons is measured. In order to perform analyses on CP violation, one B meson is fully reconstructed (signal side). Due to entanglement, reconstructing the flavour of the other B meson (tag side) determines the flavour of the signal side. This process of flavour tagging uses the characteristics of flavour specific decay products and correlates them to the tag side flavour, without an exclusive full reconstruction. Currently, both a category based algorithm is used, which reports an effective tagging efficiency of: $Q_{\text{cat.}} = 30.0(13)$ %, as well as a graph neural network reporting: $Q_{\text{GNN}} = 37.4(6)$ %. An alternative deep neural network uses raw track attributes to construct numerical representations of tracks, giving: $Q_{\text{DNN}} = 29.3(16)$ % for neutral B mesons.

A new flavour tagging algorithm is presented based on the model of tabular transformers. This model uses contextual embeddings which are easier to interpret, as well as provide greater robustness against noisy or missing data compared to only using multi-layer perceptrons (MLP).

T 74.3 Thu 16:45 VG 1.104

Measurement of A_{fs}^s in $B_s^0 \to D_s^-\pi^+$ at the LHCb experiment in Run 2 — Johannes Albrecht[1], Jonathan Davies[2], Agnieszka Dziurda[3], Conor Fitzpatrick[2], •James Andrew Gooding[1], Jairus Patoc[4], and Nicole Skidmore[5] — [1]TU Dortmund University, Dortmund, Germany — [2]University of Manchester, Manchester, United Kingdom — [3]Institute of Nuclear Physics PAS, Kraków, Poland — [4]University of Oxford, Oxford, United Kingdom — [5]University of Warwick, Coventry, United Kingdom

$B_{(s)}^0 \to D_{(s)}^{(*)-}h^+$ decays are considered a standard candle of the SM and central to measurements of the CKM angle γ. Recently, tensions between the predicted and measured values of $B_{(s)}^0 \to D_{(s)}^{(*)-}h^+$ branching fractions have emerged of up to 7σ. These tensions leave a possibility for new physics contributions which may enhance time-integrated CP asymmetries by up to 1%. In the SM, CP violation in flavour-specific $B_s^0 \to D_s^-\pi^+$ decays arises only from $B_s^0 - \overline{B}_s^0$ mixing, measured previously in semi-leptonic B_s^0 decays as a_{sl}^s.

The high quality tracking and particle identification offered by the LHCb detector makes it well-equipped to reconstruct $B_s^0 \to D_s^-\pi^+$ decays in the $D_s^- \to$

$K^-K^+\pi^-$, $\pi^-\pi^+\pi^-$ decay modes, and thus to measure the time-integrated CP asymmetry $A^s_{\rm fs}$. This measurement is performed for the first time using 5.9 fb^{-1} of pp-collision data recorded at $\sqrt{s}$ = 13 TeV during Run 2 of the LHC.

In this contribution, the approach and current status of the analysis is presented. An overview of the sensitivity of this analysis and considerations of detection and production asymmetries is given.

T 74.4 Thu 17:00 VG 1.104

B-$\overline{\rm B}$ mixing to NNLO including penguin contributions — •Pascal Reeck[1], Matthias Steinhauser[1], Ulrich Nierste[1], and Vladyslav Shtabovenko[2] — [1]Karlsruher Institute für Technologie — [2]Universität Siegen

In this talk I will discuss recent advances made in the calculation of the NNLO QCD corrections to the width difference between B and $\overline{B}$ mesons. This work focuses on the perturbative high-energy part of the calculation, more specifically the matching coefficients between the $\Delta B = 1$ effective operators of the Weak Interaction and the $\Delta B = 2$ transition operator are calculated as a deep expansion in m_c/m_b.

This calculation yields novel results for the NNLO contributions with penguin operators which had not been considered previously at this order. Moreover, the NNLO contributions with two current-current operators, which were previously only known up to $\mathcal{O}(m_c^2/m_b^2)$ are calculated to a higher precision.

T 74.5 Thu 17:15 VG 1.104

Mixing Phases and Penguin Effects in B Meson Decays — Kristof De Bruyn[1,2], Robert Fleischer[1,3], and •Eleftheria Malami[4] — [1]Nikhef, Science Park 105, 1098 XG Amsterdam, Netherlands — [2]Van Swinderen Institute for Particle Physics and Gravity, University of Groningen, 9747 Groningen, Netherlands — [3]Faculty of Science, Vrije Universiteit Amsterdam, 1081 HV Amsterdam, Netherlands — [4]Center for Particle Physics Siegen (CPPS), Theoretische Physik 1, Universität Siegen, D-57068 Siegen, Germany

The phenomenon of B^0_q–$\bar{B}^0_q$ mixing ($q = d, s$) provides a sensitive probe for exploring physics beyond the Standard Model. Associated with this mixing are the phases ϕ_d and ϕ_s, which are crucial for studies of CP violation. The decays $B^0_d \to J/\psi K^0$, $B^0_s \to J/\psi\phi$, and $B^0_s \to D^+_s D^-_s$ play significant roles in determining these mixing phases. However, these decays are affected by contributions from penguin topologies, which limit the theoretical precision in the extraction of these quantities. To properly account for these penguin effects, we introduce a formalism that utilises the CP asymmetries of these decays. By applying this strategy to the most recent experimental data, we provide updated insights. Moving towards the high-precision era, with experimental data becoming more precise, this approach can provide a much sharper picture of the underlying dynamics.

T 74.6 Thu 17:30 VG 1.104

Λ_b baryon LCDAs in the short-distance expansion — Thorsten Feldmann and •Daniel Vladimirov — Theoretische Physik 1, Center for Particle Physics Siegen, Universität Siegen, 57068 Siegen, Germany

Light-cone distribution amplitudes (LCDAs) for the Λ_b baryon enter as universal hadronic matrix elements in QCD factorization approaches for energetic decays. Observables (e.g. form factors) can then be expressed as a convolution of the LCDA and a hard scattering kernel to the desired order in the strong coupling. The LCDAs are genuinely non-perturbative quantities that describe the low-energy dynamics of the hadronic bound state, which cannot directly be derived from first principles. In this work, we discuss the "radiative tail" of the 3-particle Λ_b LCDAs which can be computed in HQET perturbation theory by expanding in the light-cone separations between the light and heavy quarks in the baryonic bound state. Our results provide useful constraints on the modelling of Λ_b LCDAs in terms of a handful of HQET parameters.

T 74.7 Thu 17:45 VG 1.104

Search for radiative leptonic $B^+ \to \mu^+\nu_\mu\gamma$ decays at LHCb — Martino Borsato[1], •Fabian Glaser[2,3], and Marie-Hélène Schune[3] — [1]Milano-Bicocca University and INFN, Milano, Italy — [2]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany — [3]IJCLab, Orsay, France

The radiative leptonic decay $B^+ \to \mu^+\nu_\mu\gamma$ has never been observed but is of great interest as it is considered the golden mode to probe the B^+ meson substructure. In particular, a measurement of its branching fraction allows to probe the parameter λ_B, the first inverse moment of the B^+ meson light cone distribution amplitude (LCDA), which is a vital input for the calculation of non-leptonic B meson decays.

The reconstruction of this decay in proton-proton collisions at the LHCb experiment is extremely challenging. Selecting events in which the photon converts to an e^+e^- pair in the detector material allows to determine the displaced B decay vertex. With this approach, the background from photons produced in the proton collision is drastically reduced and the B flight direction can be used to correct for the missing neutrino momentum. This talk gives an overview of the current status of the ongoing analysis using data recorded in proton-proton collisions in Run 2.

T 74.8 Thu 18:00 VG 1.104

Search for the decays $\Xi_b^0 \to \Xi^0 J/\psi$ and $\Xi_b^0 \to \Xi^0\psi(2S)$ at the LHCb experiment — Johannes Albrecht[1], Vitalii Lisovskyi[2], •Leandra Moeser[1], and Janina Nicolini[3] — [1]TU Dortmund University, Dortmund, Germany — [2]Aix-Marseille Université, CNRS/IN2P3, CPPM, Marseille, France — [3]CERN

Weak decays of heavy-quark baryons provide an opportunity to probe for effects beyond the Standard Model, complementary to searches in meson decays. Given the high masses of b-baryons, they are primarily studied at hadron colliders. The LHCb experiment is ideally suited to investigate such weakly decaying b-baryons.

The current status of the search for the tree-level decays $\Xi_b^0 \to \Xi^0 J/\psi$ and $\Xi_b^0 \to \Xi^0\psi(2S)$ is presented. The used data was collected at the LHCb experiment from 2016 to 2018, corresponding to an integrated luminosity of 5.4 fb^{-1}. The challenges posed by the reconstruction of neutral decay chains are discussed and the calibration of the simulation is presented.

T 75: Neutrino Astronomy IV

Time: Thursday 16:15–18:30 Location: VG 1.105

T 75.1 Thu 16:15 VG 1.105

Recent Developments in RNO-G — •Zeynep Su Selcuk[1] and Anna Nelles[1,2] — [1]DESY, Platanenallee 6, 15738 Zeuthen — [2]ECAP, Friedrich-Alexander-University Erlangen-Nuremberg, 91058 Erlangen, Germany

Astrophysical neutrinos and their origins are the focus of the Radio Neutrino Observatory Greenland (RNO-G). Due to their electrically neutral nature and low cross-section, neutrinos from astronomical sources travel without being attenuated or deflected by electromagnetic fields. The observation of highly energetic neutrinos is particularly interesting since these can bring light to some of the most extreme objects in the Universe. Studying these neutrinos also provides the opportunity to test fundamental physics at energy scales far beyond those achievable by current particle accelerators. RNO-G is currently under construction and aims to become the world's most sensitive ultra-high energy (E > 10 PeV) neutrino detector. It searches for radio signals emitted through the Askaryan mechanism after neutrinos interact with the dense Greenlandic ice sheet, which provides a large effective volume to compensate for the low neutrino flux. The ice sheet is transparent to radio emission and thanks to the large attenuation length of the radio waves, a large volume can be observed with a relatively low number of stations. RNO-G plans to cover an area of approximately 50 km^2 with 35 stations and each station consists of 24 receiver antennas. 7 of these 35 stations are already operational. The data taken from these first 7 stations will help shape the future of the project. This talk gives an update on the latest developments in RNO-G.

T 75.2 Thu 16:30 VG 1.105

Updates on the optical module for IceCube-Gen2 — •Markus Dittmer and Alexander Kappes for the IceCube-Gen2-Collaboration — Universität Münster, Institut für Kernphysik

As part of the further development of IceCube, an innovative optical module (OM) was developed for IceCube-Gen2, which builds on the successful features of the mDOMs and D-Eggs of IceCube Upgrade, but also adapts to the limitations of the smaller borehole diameter. This new OM design, which will be tested in IceCube Upgrade, will serve as a prototype for the planned mass production of 10,000 OMs for IceCube Gen2. To simplify the assembly processes, important changes had to be made to the design, especially to integrate the gel pad concept. In this presentation, the design philosophy will be reviewed and various performance metrics will be presented.

T 75.3 Thu 16:45 VG 1.105

Discrimination of Muon Bundles from Single Muons in IceCube — •Alexandra Scholz and Cristina Lagunas Gualda for the IceCube-Collaboration — Technical University of Munich, Germany

The detection of neutrino events from astrophysical sources is one of the main goals of the IceCube Neutrino Observatory, which is located at the geographic South Pole. Atmospheric muons and neutrinos produced in the interaction of cosmic ray particles with the atmosphere build a large background for such events. Atmospheric neutrinos are irreducible background and cannot be di-

rectly filtered out. Nevertheless, for IceCube's northern sky the Earth serves as a shield for atmospheric muons, which often reach the detector in bundles. However, it also filters ultra-high energy (UHE) neutrino events. In order to detect UHE events, the whole sky has to be considered, leaving us with the problem of the enormous background of atmospheric muons. The strategy of this project is to discriminate muon bundles from single muons above 100 TeV, as single muons are the signature of astrophysical neutrino events in the detector. A graph neural network (GNN) will be used to classify the events based on CORSIKA simulations.

T 75.4 Thu 17:00 VG 1.105

Improving Track Reconstruction with Direct Muon Signals in IceCube Upgrade Modules — •Simon Pick — Ruhr-Universität Bochum — DESY, Zeuthen

One of the main constraining factors in IceCube's ability to detect neutrino point sources is angular resolution. Muon track reconstruction is limited by the knowledge of the optical properties of ice and detector responses. With the addition of multi-PMT optical modules in the upcoming upgrade of the existing detector, new calibration methods will be possible.

A promising approach for an improved track reconstruction is the measurement of a direct muon signal in multiple PMTs of separate modules. This may present a technique to confine the muon track with unprecedented accuracy treating the PMTs as anchor points and thus, by using those tracks as calibration sources, enabling a general improvement for all reconstructed tracks. This talk discusses the feasibility of the idea and presents the progress of its investigation through laboratory measurements.

T 75.5 Thu 17:15 VG 1.105

Advanced Northern Tracks Selection using a Graph Convolutional Neural Network for the IceCube Neutrino Observatory: Event classification — •Shuyang Deng, Philipp Behrens, Jakob Böttcher, Lasse Düse, Philipp Fürst, Leon Hamacher, Michael Handt, Lars Marten, Philipp Soldin, and Christopher Wiebusch for the IceCube-Collaboration — III. Physikalisches Institut B RWTH Aachen University, Aachen, Germany

The IceCube Neutrino Observatory is a large neutrino detector built deep in the Antarctic ice at the South Pole. The Advanced Northern Track Selection (ANTS) framework uses a graph convolutional neural network to select neutrino-induced muon tracks. These events have different topologies and signatures within the detector, such as through-going, starting, skimming tracks as well as remaining background from cosmic-ray induced muons and cascades e.g. related to electron neutrinos. In this work, we perform the classification of these event topologies using the ANTS framework, providing an event-wise probability for each topology. This classification enables dedicated handling of these topologies in further analyses.

T 75.6 Thu 17:30 VG 1.105

Advanced Northern Tracks Selection using a Graph Convolutional Neural Network for the IceCube Neutrino Observatory: Background Rejection — •Philipp Behrens, Jakob Böttcher, Shuyang Deng, Lasse Düser, Philipp Fürst, Leon Hamacher, Michael Handt, Lars Marten, Philipp Soldin, and Christopher Wiebusch for the IceCube-Collaboration — III. Physikalisches Institut, RWTH Aachen University, Aachen, Deutschland

The IceCube Neutrino Observatory is a large neutrino detector located in the ice at the geographic South Pole. It detects atmospheric and astrophysical neutrinos by Cherenkov radiation emitted by secondary particles with more than 5000 photomultipliers. A main challenge is the efficient distinction between neutrinos and air-shower-induced muons. The Advanced Northern Tracks Selection (ANTS) improves this classification using a deep graph convolutional neural network, capturing the node-like structure of the geometric arrangement of the photomultipliers inside the detector, as well as the raw sensor data. Using this architecture, both local and global features are learned. This work focuses on the evaluation and enhancement of the neural network architecture with respect to the background rejection of air-shower-induced muons.

T 75.7 Thu 17:45 VG 1.105

Advanced Northern Tracks Selection using a Graph Convolutional Neural Network for the IceCube Neutrino Observatory: Energy Reconstruction — •Lasse Düser, Philipp Behrens, Jakob Böttcher, Shuyang Deng, Philipp Fürst, Leon Hamacher, Michael Handt, Lars Marten, Philipp Soldin, and Christopher Wiebusch for the IceCube-Collaboration — III. Physikalisches Institut, RWTH Aachen University, D-52056 Aachen, Germany

The IceCube Neutrino Observatory is a detector located at the geographic South Pole, consisting of more than 5000 photomultipliers (PMTs). These PMTs detect Cherenkov radiation, produced by muons induced by charged current neutrino interactions, within the instrumented ice. The identification of neutrino-induced through-going muon tracks is performed by the newly developed Advanced Northern Tracks Selection (ANTS) using a graph convolutional neural network that encodes the spatial geometry of the PMTs. A significant advantage of this network architecture is utilizing the full event information, enabling an improved reconstruction of event features like neutrino energy. This talk discusses the network's performance and compares it to existing energy reconstruction methods. The reconstruction is evaluated with respect to resolution, direction, and computational efficiency across various event topologies.

T 75.8 Thu 18:00 VG 1.105

Using CRPropa to reconstruct the high energy neutrino emission of NGC 1068 [*] — •Alexander Kazatsky, Julia Becker Tjus, Björn Eichmann, and Julien Dörner — Theoretical Physics IV, Faculty of Physics and Astronomy, Ruhr-University Bochum, Universitätsstraße 150, 44801 Bochum

The Seyfert 2 galaxy NGC 1068 (also known as Messier 77) is one of the closest active galaxies for which a high energy neutrino flux has been detected by the IceCube Neutrino Observatory. Previous works have concluded that the neutrino emission is likely to originate from a region of the active galactic nucleus (AGN) called the AGN corona. In this work, this neutrino emission is calculated by developing a threedimensional model for the corona of NGC 1068 using a modified version of the publically available CRPropa propagation framework. The diffusive transport of the underlying cosmic rays is solved via stochastic differential equations in 3D space and different hadronic processes are taken into account for the generation of the overall non thermal emission. The resulting neutrino flux is compared to the available IceCube data to optimise the model of the AGN environment. [*] Supported by SFB 1491

T 75.9 Thu 18:15 VG 1.105

Hadronic Modelling of the TXS 0506+056 2017 Flare Using CRPropa[*] — •Vladimir Kiselev[1,2], Leander Schlegel[1,2], Julien Dörner[1,2], and Julia Becker Tjus[1,2] — [1]Theoretische Physk IV, Fakultät für Physik, Ruhr-Universität Bochum, Universitätsstraße 150, 44801 Bochum — [2]RAPP Center, Ruhr-Universität Bochum, Universitätsstraße 150, 44801 Bochum

TXS 0506+056 is a well-studied blazar that, in 2017, was associated with a high-energy neutrino detection by IceCube during a gamma-ray flare. This event marked the first indication of detection in multi-messenger astrophysics, highlighting the need for robust theoretical models. In response, several attempts have been made to model the multi-messenger emission from this flare. Here, we present our approach to modelling the 2017 neutrino and gamma-ray flares using a modified version of CRPropa. Compared to other models, we adopt a hadronic model to explain both the Very High-Energy gamma-rays and neutrinos, incorporating particle propagation in a fully three-dimensional environment with turbulent magnetic fields. Furthermore, we validate the result using both the SED and the lightcurve of the flare.

[*]Supported by DFG (SFB 1491)

T 76: Data, AI, Computing, Electronics VII (Generative AI, MC Generators)

Time: Thursday 16:15–18:45 Location: VG 2.101

T 76.1 Thu 16:15 VG 2.101

Correcting the mis-modeling of photon energy deposits in the calorimeter using normalizing flows and flow matching — Caio Daumann, Johannes Erdmann, and •Lars Schiffeler — III. Physikalisches Institut A, RWTH Aachen University

Simulated events are key ingredients for almost all high-energy physics analyses. However, imperfections in their configuration can result in mis-modelling and discrepancies between the data and simulations. Normalizing flows are used in CMS to correct the high-level inputs to the photon identification algorithms, which have a low dimensionality. Improved identification algorithms, on the other hand, use information with an increased dimensionality, such as individual energy deposits in a calorimeter. This poses a challenge to normalizing flows, as they are more effective in lower-dimensional spaces. We investigate the influence of this increase in dimensionality on normalizing flows and compare their effectiveness to flow matching. To study these effects, simulations of a CMS-inspired toy calorimeter are used.

T 76.2 Thu 16:30 VG 2.101

Belle II PXD background generation with diffusion models — •Fabio Novissimo, Nikolai Hartmann, and Thomas Kuhr — Ludwig-Maximilians-Universität München

The Pixel Vertex Detector (PXD) is the innermost detector of the Belle II experiment. Information from the PXD, together with data from other detectors, allows to have a very precise vertex reconstruction. The effect of beam background

on reconstruction is studied by adding measured or simulated background hit patterns to hits produced by simulated signal particles. This requires a huge sample of statistically independent PXD background noise hit patterns to avoid systematic biases, resulting in a huge amount of storage due to the high granularity of the PXD sensors. As an efficient way of producing background noise, we explore the idea of an on-demand PXD background generator realised using diffusion models. In order to evaluate the quality of generated background we measure physical quantities which are sensitive to the background in the PXD.

T 76.3 Thu 16:45 VG 2.101

Study of deep generative models for the enhancement of simulated ATLAS datasets — Boris Flach, Andre Sopczak, and •Lukas Vicenik — Czech Technical University in Prague

Numerous searches for new particles and precision measurements crucially depend on the amount of available simulated data, which has an impact on the resulting analysis uncertainties. For instance, machine learning algorithms for separating signal and background events could significantly profit from enlarged simulated datasets. We propose advanced generative models based on variational autoencoders, generative adversarial networks, and diffusion-based deep generative models to address the limitations of current simulated datasets. These models generate synthetic data that capture complex, non-homogeneous features observed in particle physics. Evaluation metrics from particle physics and machine learning are employed to assess the accuracy, diversity, and physical validity of the generated data. The augmented datasets are subsequently used to enhance signal and background separation, reduce uncertainties in analyses, and improve the overall reliability of the results.

T 76.4 Thu 17:00 VG 2.101

PointL2LFlows: How to generate Hadronic showers in ECal and HCal with CNFs — •Thorsten Buss — Institut für Experimentalphysik, Universität Hamburg, Germany

In collider experiments, Monte Carlo (MC) simulations are the essential tool for comparing experimental findings with theory predictions. However, they have a high computational demand, and future developments, such as higher event rates, are expected to increase this demand beyond availability.

Generative models provide a way of augmenting MC simulations, speeding them up, and overcoming this bottleneck. Recent works have successfully applied this approach to electromagnetic showers in electromagnetic calorimeters (ECal) and to pion showers in low-granular homogeneous calorimeters. However, applying it to pion showers developing in a highly granular ECal and continuing in a highly granular HCal remains a challenge due to their rich substructure.

This work shows how point-cloud-based continuous normalizing flows (CNF) can jointly generate pion showers in ECal and HCal. As in our L2LFlows model for EM showers, we generate one calorimeter layer at a time conditioned on the previous layers. This reduces the size of the point clouds reducing computational costs and making it easier for the model to focus on the most important structures in the showers.

T 76.5 Thu 17:15 VG 2.101

Point-Clouds based Diffusion Model on Hadronic Showers — •Martina Mozzanica — University of Hamburg

Simulating showers of particles in highly-granular detectors is a key frontier in the application of machine learning to particle physics. Achieving high accuracy and speed with generative machine learning models can enable them to augment traditional simulations and alleviate a major computing constraint. Recent developments have shown how diffusion based generative shower simulation approach that do not rely on a fixed structure, but instead generates geometry-independent point clouds, are very efficient.We present a novel attention mechanism based extension to the CaloClouds 2 architecture that was previously used for simulating electromagnetic showers in the highly granular electromagnetic calorimeter of ILD with high precision. This attention mechanism allows to generate complex hadronic showers from pions with more pronounced substructure in the electromagnetic and hadronic calorimeter together. This is the first time that ML methods are used to generate hadonic showers in highly granular imaging calorimeters.

T 76.6 Thu 17:30 VG 2.101

Generative transformers for learning point-cloud simulations — Joschka Birk[1], Frank Gaede[2], Anna Hallin[1], Gregor Kasieczka[1], Martina Mozzanica[1], and •Henning Rose[1] — [1]Institute for Experimental Physics, Universität Hamburg, Hamburg — [2]Deutsches Elektron-Synchrotron DESY, Hamburg

We successfully demonstrate the use of a generative transformer for learning point-cloud simulations of electromagnetic showers in the International Large Detector (ILD) calorimeter. By reusing the architecture and workflow of the OmniJet-α model, this transformer predicts sequences of tokens that represent energy deposits within the calorimeter. This autoregressive approach enables the model to learn the sequence length of the point cloud, supporting a variable-length and realistic shower development. Furthermore, the tokenized representation allows the model to learn the shower geometry without being restricted to a fixed voxel grid.

T 76.7 Thu 17:45 VG 2.101

AIDO - A Generalized Detector Optimization Framework using Surrogate Models — •Kylian Schmidt, Jan Kieseler, and Nikhil Krishna — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

The design of modern high-energy physics detectors is a highly intricate process, aiming to maximize their physics potential while balancing various manufacturing constraints. As detectors become larger and more sophisticated, it becomes increasingly difficult to maintain a comprehensive understanding of the entire system. To address this challenge, we aim to translate the design process into an optimization task suitable for Machine Learning by treating the parameters of the simulation as hyper-parameters of the model.

The AIDO framework is a generalized tool for the optimization of continuous and discrete detector parameters. We train a diffusion-based surrogate model on parallel Geant4 simulations with varying detector geometries, enabling the model to interpolate the expected performance across different configurations. This allows for gradient descent on the generated parameter space and identification of the optimal combination of parameters that maximizes a specific physics goal. As a demonstration, we show how this approach can be applied to generate an optimal sampling calorimeter by maximizing its energy resolution starting from a random initial composition.

T 76.8 Thu 18:00 VG 2.101

Navigating Phase Space for Event Generation: interfacing Sherpa with BAT.jl — Cornelius Grunwald[1], Timo Janssen[2], Kevin Kröninger[1], •Salvatore La Cagnina[1], and Steffen Schumann[2] — [1]TU Dortmund University, Dortmund, Germany — [2]Georg-August-Universität Göttingen, Germany

The generation of Monte Carlo events is a crucial step for all particle collider experiments. A major challenge in event generation is the efficient sampling of the phase spaces of hard scattering processes due to the potentially large number and complexity of Feynman diagrams and their interference and divergence structures. In this presentation, we address the challenges of efficient Monte Carlo event generation and demonstrate improvements that can be achieved through the application of advanced sampling techniques. We highlight that using the algorithms implemented in BAT.jl for sampling the phase spaces given by Sherpa offers great flexibility in the choice of sampling algorithms and has the potential to significantly enhance the efficiency of event generation. By interfacing BAT.jl, a package designed for Bayesian analyses that offers a collection of modern sampling algorithms, with the Sherpa event generator, we aim to improve the efficiency of phase space exploration and Monte Carlo event generation. We combine the physics-informed multi-channel sampling approach of Sherpa with advanced sampling techniques such as Markov Chain Monte Carlo (MCMC) and Nested Sampling.

T 76.9 Thu 18:15 VG 2.101

Geant4 Optimizations in ATLAS — •Mustafa Schmidt für die Mu2e-Kollaboration — Bergische Universität Wuppertal, Deutschland

The ATLAS experiment at the LHC heavily depends on simulated event samples produced by a full Geant4 detector simulations. These Monte Carlo simulations based on Geant4 were a major consumer of computing resources during the 2018 data-taking year and will remain one of the dominant resource users in the HL-LHC era. Consequently, ATLAS has continuously been working to improve the computational performance of this simulation for the Run 3 Monte Carlo campaign.

This report highlights the recent implementation of Woodcock tracking in the Electromagnetic Endcap Calorimeter and provides an overview of other implemented and upcoming optimizations that still have to be validated. These improvements include enhancements to the core Geant4 software, strategic choices in simulation configuration, simplifications in geometry and magnetic field descriptions, as well as technical refinements in the interface between ATLAS simulation code and Geant4.

Overall, a performance improvement of around 50% regarding CPU time was achieved compared to the baseline simulation configuration utilized during Run 2.

T 76.10 Thu 18:30 VG 2.101

Exploring tomorrow's Monte-Carlo generators: MC Validation in ATLAS with PAVER — •Johanna Kraus, Anna Bingham, Frank Ellinghaus, Dominic Hirschbühl, and Mustafa Schmidt — Bergische Universität Wuppertal

Monte-Carlo (MC) simulations play a key role in high energy physics, for example at the ATLAS experiment. MC generators evolve continuously, so a periodic validation is indispensable for obtaining reliable and reproducible physics simulations. For that purpose, an automated and central validation system was developed: PMG Architecture for Validating Evgen with Rivet (PAVER). It provides an MC event generator validation procedure that allows a regular evalua-

tion of new revisions and updates for commonly used MC generators in ATLAS as well as comparisons to measured data. The result is a robust, fast, and easily accessible MC validation setup that is constantly developed further. This way, issues in simulated samples can be detected before generating large samples for the collaboration, which is crucial for a sustainable and low-cost MC production procedure in ATLAS.

T 77: Data, AI, Computing, Electronics VIII (Fast ML, Triggers)

Time: Thursday 16:15–18:15 Location: VG 2.102

T 77.1 Thu 16:15 VG 2.102

Optimization of the muon momentum resolution in the ATLAS first-level trigger with machine learning techniques — •Francisco Resende, Davide Cieri, Oliver Kortner, and Sandra Kortner — Max-Planck-Institut für Physik, München

The ATLAS experiment is upgrading its muon trigger system for operation at the High-Luminosity LHC. The necessary significant improvement in the selectivity of muon tracks within the first-level trigger relies on, for the first time, muon tracking data from precision monitored drift-tube (MDT) chambers.

This research explores the feasibility and benefits of integrating machine learning into the challenging real-time environment of the ATLAS trigger system, aiming to enhance the experiment's discovery potential in the high-luminosity era. We investigate the use of machine learning algorithms to improve muon reconstruction for the ATLAS first-level trigger. Various neural network models were developed, with algorithms optimized for potential deployment on powerful FPGA devices. The performance of each model is evaluated and compared to that of the baseline analytic algorithm in terms of trigger efficiency and muon momentum resolution.

T 77.2 Thu 16:30 VG 2.102

Convolutional Neural Networks on FPGAs for Processing of ATLAS Liquid Argon Calorimeter Signals — Anna Franke, Manuel Gutsche, Markus Helbig, Rainer Hentges, Arno Straessner, •Johann Christoph Voigt, and Philipp Welle — Institut für Kern- und Teilchenphysik, TU Dresden

During the Phase-II upgrade of the ATLAS Liquid Argon Calorimeter, more than 500 high-performance FPGAs will be installed to allow for the energy reconstruction of all 182468 detector cells at the LHC bunch crossing frequency of 40 MHz. We trained 1-dimensional convolutional neural networks (CNNs) to improve the energy reconstruction under high-luminosity conditions with respect to the currently used Optimal Filter. The network architecture has been optimized with a hyperparameter search, where the network size is constrained to 400 parameters. This is motivated by resource estimates from the FPGA firmware prototype implementation. Quantization aware training using QKeras is used to adapt the CNNs to 18 bit fixed point numbers. A revised simulation pipeline is in development to produce training samples for clusters of similar cells. To better evaluate the physics impact of the CNN based readout, the networks are being integrated into the ATLAS common detector simulation and analysis framework, Athena. The inference code of these networks has been implemented in the hardware description language VHDL targeting an Intel Agilex FPGA. A test project targeting a Stratix-10 development kit is available to verify the behaviour of the implementation. Recent results of the CNN training and its firmware realisation will be presented.

T 77.3 Thu 16:45 VG 2.102

Using Transformer based Graph Neural Networks to Identify Hadronically Decaying Tau Leptons with the ATLAS trigger — •Athul Dev Sudhakar Ponnu and Stan Lai — II. Physikalisches Institut, Georg-August-Universitaet Goettingen.

The increased luminosity at the LHC poses challenges in efficiently selecting interesting events at the Atlas detector. Identifying events containing tau leptons is particularly difficult due to their predominantly hadronic decay, which often mimics light QCD jet signatures. Therefore, effectively discriminating against background jets during the identification of hadronically decaying tau leptons at the trigger level is crucial.

Building on the success of Transformer-based Graph Neural Networks used for offline Tau ID (GNTau) and b-tagging (GN2), this study explores their application to hadronic tau identification at the High Level Trigger (HLT). The online GNTau algorithm exhibits substantial improvements in background rejection compared to existing Deepset-based algorithms, across a wide phase space and variety of processes. After thorough evaluations, the GNTau is set to be deployed at the HLT for the 2025 data-taking period.

T 77.4 Thu 17:00 VG 2.102

Forward Electron Identification at the ATLAS First Level Trigger for the High Luminosity LHC — •Maximilian Linkert, Stefan Tapprogge, and Adrian Alvarez Fernandez — Institut für Physik, Johannes Gutenberg-Universität, Mainz

As part of the high luminosity LHC the challenge is to properly trigger events in the forward region of ATLAS covering a pseudo rapidity of $2.5 < |\eta| < 4.9$. New first level trigger modules (being under development) based on FPGAs will be used the first time to access the full (transversal and longitudinal) granularity of the calorimeters in this region to efficiently identify electrons and positrons. As a basis for reconstruction and identification a sliding window algorithm will be used. The aim is to use machine learning to gain efficiency compared to classical algorithms. The algorithms need to be optimized to run on the FPGAs, thus dealing with a simultaneous optimization of the signal efficiency, background rejection, resource consumption and latency. Moreover, the algorithm implementation needs to address non trivial changes in the geometrical calorimeter segmentation within the region under consideration. The present status of the investigations and next steps will be presented.

T 77.5 Thu 17:15 VG 2.102

First Level Trigger Algorithm for Electron Identification in ATLAS — •Julia Troppens, Maximilian Linkert, Dennis Layh, and Stefan Tapprogge — Institute for Physics, Johannes Gutenberg University, Mainz

The High Luminosity LHC upgrade aims to significantly increase the collision rate, presenting new challenges for data analysis within the detectors. Therefore, the ATLAS trigger system is being improved and expanded in the Phase II upgrade by incorporating additional information. This includes the planned implementation of a first level trigger algorithm in firmware for electron identification in the forward region (3.2<|eta|<4.9) of the ATLAS detector, based on the full granularity of calorimeters. The studies performed used simulated data to examine various approaches. The benefit of machine learning, as compared to cut-based algorithms, was investigated in terms of optimizing efficiency. Subsequently, studies were conducted to evaluate the feasibility of realising the algorithms in firmware. In conclusion, this contribution compares different algorithms in terms of their interplay between latency, resource usage, signal efficiency, and background rejection.

T 77.6 Thu 17:30 VG 2.102

Development of machine-learning based topological triggers for the CMS Level-1 trigger — •Karla Kleinbölting, Lukas Ebeling, Johannes Haller, Finn Jonathan Labe, Balduin Letzer, Artur Lobanov, Lara Markus, and Matthias Schröder — Institut für Experimentalphyisk, Universität Hamburg

At the CMS experiment, the Level-1 (L1) trigger system is pivotal in thereal-timeselectionofphysicseventsofinterest. Thistalkhighlights recent advancements in enhancing the L1 trigger performance through the integration of machine learning (ML) techniques. Using di-Higgs production as a benchmark process, the proposed ML-based trigger leverages full event topologies instead of individual object-based trig- gers. This approach allows the trigger system to identify and retain events in previously inaccessible low p_T regions while maintaining acceptable rates. The ML algorithms can be seamlessly integrated into the FPGA-based electronics of the trigger system using frameworks such as *hls4ml*.

T 77.7 Thu 17:45 VG 2.102

Implementation of a two-level AI-enhanced trigger on a single chip with AI cores for live reconstruction — •Patrick Schwäbig for the Lohengrin-Collaboration — Physikalisches Institut, Universität Bonn, Deutschland

For years, data rates generated by modern detectors and the corresponding readout electronics exceeded by far the limits of data storage space and bandwidth available in many experiments. The approach of using fast triggers to discard uninteresting and irrelevant data remains a solution used to this day: Using FPGAs, ASICs or directly the readout chip, a fixed set of rules based on low level parameters is applied as a pre-selection. In contrast to this stands live track reconstruction for triggering, which was rarely possible due to limited computation power in the past. With the emergence of highly parallelized processors for AI inference, attempts to sufficiently accelerate tracking algorithms become viable. The AMD Versal Adaptive Compute Acceleration Platform (ACAP) is one such technology and combines FPGA and CPU resources with dedicated AI cores. Our approach is to implement a two-level trigger on a single chip by utilizing the tightly integrated combination of FPGA and AI cores to profit from their individual strengths. In this talk our concept for a two-level trigger setup, implemented on an AMD VC1902, including quantized AI algorithms and Timepix3 readout, will be shown. They will be used in an envisioned mid-size ultra-high rate fixed-target dark matter experiment (Lohengrin) at the ELSA accelerator at the University of Bonn.

T 77.8 Thu 18:00 VG 2.102

Performance of a Quantized Neural Network on an FPGA for Next Generation Radio Array DAQ Systems — •Adam Rifaie for the IceCube-Gen2-Collaboration — Bergische Universität Wuppertal, Wuppertal, Deutschland

The IceCube neutrino observatory is a cubic kilometer neutrino detector built into the Antarctic ice at the geographical Southpole. As a result of its success, the next-generation detector for IceCube, IceCube-Gen2, is currently being planned. This will extend the optical array to approximately 10 cubic kilometers and will include a $\sim 500\,\mathrm{km}^2$ radio array, sensitive to Ultra High Energy neutrinos. The state-of-the-art, with respect to phased radio arrays, is the Radio Neutrino Observatory Greenland (RNO-G), where currently 7 of the planned 35 stations have been deployed. These stations enable hardware testing and optimization for the DAQ system of RNO-G. A novel idea for a DAQ system would consist of an FPGA with a trained and Quantized Neural Network implemented. The neural network will read the datastream and discriminate between background and signal in real-time. This will improve the effective volume of the detector by a factor of 3 compared to a standard threshold trigger at certain energies. The performance and comparison of a quantized neural network with a regular neural network will be discussed, followed by the next steps to an all-digital DAQ system for Radio arrays.

T 78: Gamma Astronomy II

Time: Thursday 16:15–18:15 Location: VG 2.103

T 78.1 Thu 16:15 VG 2.103

Constraining the intergalactic Magnetic field with Fermi-LAT observations — •Yosef Abed, Dieter Horns, and Matías Sotomayor — Institut für Experimentalphysik, Universität Hamburg

The intergalactic magnetic field (IGMF) represents a weak and omnipresent magnetic field permeating the intergalactic medium. Its origins are unclear and a detection of the IGMF has yet to be achieved. The most sensitive method to search indirectly for evidence of the existence of the IGMF are based upon γ-ray observations.This talk presents a conservative lower limit for the IGMF, calculated from *Fermi*-LAT data and ELMAG simulations. Extended source templates for several blazars were generated using ELMAG simulations with varying magnetic field strengths of the IGMF, where its coherence length was taken into account. In the *Fermi* binned likelihood analysis of these blazars, the extended templates were added as diffuse sources and from the loglikelihood profile, the normalization with 95% confidence level was calculated for each template. Then the spectral energy distributions of the normalized fitted template and the non-fitted simulation template were compared, from which the conservative lower limit for the IGMF was estimated.

T 78.2 Thu 16:30 VG 2.103

Adaptive Sampling in Simulations for the Cherenkov Telescope Array Observatory — •Tristan Gradetzke and Luca Di Bella — TU Dortmund University

Monte Carlo simulations of particle induced extensive air showers are of crucial importance to the analysis chain of data taken by Imaging Air Cherenkov Telescopes (IACTs). Besides for the training of particle classifiers and energy estimators, they are needed to compute a mathematical description of the measurement process required for the scientific analysis, the Instrument Response Functions (IRFs). There usage however, comes at the extensive cost of computational resources. Therefore much effort has been made to this day, to make these simulations more efficient. This work aims at investigating, among others, adaptive sampling based methods to sample only phase-space regions improving event statistics and to a limited extent uncertainties in e.g. IRFs. Thus reducing the extent of Monte Carlo productions. Phase space in this context refers to, among others, detector field of view and primary particle energy . The main challenges arise from the definition of a metric, that is optimized by any given algorithm. Here, the simple case of an event-per-bin based metric is presented and an outlook is given.

T 78.3 Thu 16:45 VG 2.103

Investigating the Effects of Symmetry Assumptions in the Instrument Response of the Cherenkov Telescope Array Observatory — •Luca Davide Di Bella and Tristan Franziskus Gradetzke — TU Dortmund University, Dortmund, Germany

The Cherenkov Telescope Array Observatory is the next generation of Imaging Air Cherenkov Telescope observatories, designed to operate in an energy range between 20 GeV to 300 TeV and achieve higher sensitivities and lower systematic uncertainties than previous experiments. An important data analysis step to achieving the systematic uncertainty targets is accurate modeling of the instrument response. This is done in discrete intervals of the relevant quantities using Monte Carlo simulated events to ensure accuracy.

In order to reduce the necessary amount of simulations, the Instrument Response Functions (IRFs) are assumed to be radially symmetric over the field of view of the telescopes. Due to for example atmospheric effects, this simplification is not necessarily accurate, especially at higher zenith distances. It is thus necessary to implement computation of non-radially symmetric Instrument Response Functions and evaluate their impact on the measurement.

More complex implementations, which allow asymmetry of the IRFs, have been implemented and will be compared against the existing radially symmetric implementations using simulated data sets.

T 78.4 Thu 17:00 VG 2.103

FlashCam development and verification — •Anne Timmermans for the FlashCam-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

FlashCam is a high-performance camera design for ground-based, imaging atmospheric Cherenkov telescopes. An advanced prototype has been installed in CT5 of the H.E.S.S. experiment, and has been successfully running since December 2019.

The next generation observatory for very high energy gamma-ray astronomy will be the Cherenkov Telescope Array Observatory (CTAO). The FlashCam team, is preparing another FlashCam camera for the MST pathfinder telescope on the Southern CTAO site. Before installation in Chile, the camera will be fully characterized in the lab. This talk will give an overview of the current status and presents results on the performance measurements.

T 78.5 Thu 17:15 VG 2.103

SWGO Array Trigger Performance Evaluation — •Johannes Bennemann — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

The Southern Wide-field Gamma-ray Observatory (SWGO) is a future gamma-ray instrument to be built in Chile. It will consist of more than 6000 water tanks with an almost 100% duty cycle. The amount of data produced by SWGO will be more than what can be handled by the available computing infrastructure. This makes a sophisticated trigger strategy necessary for the detector array. While data reduction is the key motivation for an array trigger, the scientific quality of the data is equally important. In this talk, the criteria for trigger performance studies will be presented. Additionally, the quality of different trigger strategies will be discussed.

T 78.6 Thu 17:30 VG 2.103

Modeling of dark matter prompt and secondary signatures in dwarf galaxies — •Athithya Aravinthan[1,2], Julia Becker Tjus[1,2,3], and Lukas Merten[1,2] — [1]Theoretische Physik IV, Ruhr-Universität Bochum, Bochum, Germany — [2]RAPP Center, Ruhr-Universität Bochum, Bochum, Germany — [3]Department of Space, Earth and Environment, Chalmers University of Technology, 412 96 Gothenburg, Sweden

Dwarf galaxies are a convenient testing ground in the indirect search for Dark Matter (DM), due to their low astrophysical background in radio and gamma ray frequencies. In addition to the much explored prompt emission of DM in dwarf galaxies, one must also consider the secondary multimessenger signatures of charged DM annihilation products via synchrotron radiation and inverse Compton scattering. The consistent modeling of this secondary emission with the astrophysical background is necessary for placing stringent constraints on the nature of DM.

In this work, the multi-wavelength secondary spectrum of DM annihilation for dwarf spheroidal galaxies is calculated using the open-source code CRPropa 3.2., which allows for the self-consistent treatment of the astrophysical background and secondary emissions. The code can also be extended to treat DM particles, which is currently not available in the public version. *Supported by DFG (SFB 1491).

T 78.7 Thu 17:45 VG 2.103

Analysis of the IC 443 Supernova Remnant with H.E.S.S. Data — •Lukas Grosspietsch, Alison Mitchell, and Tina Wach for the H.E.S.S.-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg

The Jellyfish Nebula or IC 443 is one of the few observed supernova remnants (SNRs) interacting with a molecular cloud. In this contribution, we present a first spectral and spatial analysis of gamma-ray emission from IC 443 observed with the H.E.S.S. telescope array using the open source analysis package gammapy. The data show some significant emission best modeled by an extended source. Further- more, we combine our analysis with some multi-wavelength data which can best be modeled by a parent proton population producing gamma rays via neutral pion decay, indicated by the characteristic pion-bump. This analysis of

the IC 443 gamma-ray emission observed by the H.E.S.S. telescope therefore again highlights IC 443 as a probe for cosmic ray acceleration in SNRs.

T 78.8 Thu 18:00 VG 2.103

Spatially coherent 3D distributions of HI and CO in the Milky Way — •Laurin Söding[1], Gordian Edenhofer[2,3], Torsten A. Ensslin[2,3,6], Philipp Frank[2], Ralf Kissmann[4], Vo Hong Minh Phan[5], Andrés Ramírez[4], Hanieh Zandinejad[2,3], and Philipp Mertsch[1] — [1]RWTH Aachen University, Aachen, Germany — [2]Max Planck Institute for Astrophysics, Garching, Germany — [3]Ludwig Maximilian University of Munich, Munich, Germany — [4]Universität Innsbruck, Innsbruck, Austria — [5]Sorbonne Université, Paris, France — [6]Excellence cluster ORIGINS, Garching, Germany

The spatial distribution of the gaseous components of the Milky Way is of great importance for a number of different fields, for example, Galactic structure, star formation, cosmic rays, and diffuse emission. We used three-dimensional (3D) Gaussian processes to model correlations in the interstellar medium, including correlations between different lines of sight, and enforce a spatially coherent structure in the prior. We inferred the spatial distributions of atomic hydrogen (HI), carbon monoxide (CO), their emission line widths, and the Galactic velocity field in a joint Bayesian inference from multiple datasets, mainly Doppler-shifted line emission. Our main result consists of a set of samples that implicitly contain statistical uncertainties. We confirm previous findings regarding the warping and flaring of the Galactic disc. A comparison with 3D dust maps reveals a good agreement on scales larger than approximately 400 pc. While our results are not free of artefacts, they present a big step forward in obtaining high-quality 3D maps of the interstellar medium.

T 79: Methods in Astroparticle Physics III

Time: Thursday 16:15–18:15 Location: VG 3.101

T 79.1 Thu 16:15 VG 3.101

Measuring Infrared Light Emission in Xenon — •Kai Böse for the XENON-Collaboration — Max-Planck-Institut für Kernphysik

Xenon is an ideal target for searching for rare events such as dark matter or neutrinoless double-beta decay. Several experiments utilize its ultraviolet scintillation to study interactions with nuclei and electrons. However, it is also known that xenon emits infrared light, which has been less extensively studied. Our group at MPIK Heidelberg has begun investigating the IR component in xenon interactions using infrared-sensitive photomultiplier tubes for future rare event search applications.

T 79.2 Thu 16:30 VG 3.101

Developing a cryogenic heat pump for liquid xenon radon removal systems — •Philipp Schulte, Lutz Althüser, Robert Braun, Hannah Ginkel, Volker Hannen, Christian Huhmann, David Koke, Patrick Unkhoff, Daniel Wenz, and Christian Weinheimer — Institute for Nuclear Physics, University of Münster

Future liquid xenon (LXe) dark matter detectors require a detector background 10 times smaller than the solar neutrino background. Achieving this requires reducing the 222Rn concentration in LXe to <0.1 μBq/kg - corresponding to less than one 222Rn atom in 160 mol xenon. The ERC project "LowRad" aims to develop the next generation of radon and krypton removal technology using cryogenic distillation. By exploiting the different vapour pressures of xenon and radon, radon is removed through repeated evaporation and condensation in a large surface area distillation column with partial reflux. To reach this low radon concentration, the throughput flow of the column must increase, as higher flow rates remove more radon per time, lowering its concentration in the detector. This requires scaling up from 65 kg/h (XENONnT) to ~750 kg/h, with O(20) kW of heating and cooling power for the evaporation and reliquification. Therefore, an additional heat pump circuit using xenon as the working medium is being developed to lower the cooling requirement to the thermodynamic input of the heat pump. This talk will explain the working principle of cryogenic distillation and the heat pump, as well as the results from its development. Acknowledging the support of the ERC AdG project "LowRad" (101055063).

T 79.3 Thu 16:45 VG 3.101

Commissioning of ALMOND, a mobile neutron detector for LNGS — •Felix Kratzmeier[1], Melih Solmaz[1,2], Klaus Eitel[1], Alfredo Davide Ferella[3,4], Francesco Pompa[1,3], Kathrin Valerius[1], and Denis Tcherniakhovski[5] — [1]Karlsruhe Institute of Technology, Institute for Astroparticle Physics — [2]Heidelberg University, Kirchhoff Institute for Physics — [3]University of L'Aquila, Department of Physics and Chemistry — [4]INFN-Laboratori Nazionali del Gran Sasso — [5]Karlsruhe Institute of Technology, Institute for Data Processing and Electronics

ALMOND is a mobile low-flux neutron spectrometer for the LNGS underground laboratory based on a plastic scintillator array surrounded by Gd foils. It has been designed and built at KIT as a stand-alone system. In this talk, we will present the commissioning of the detector system at KIT including MC simulations of its performance, as well as first data taken underground at LNGS.

T 79.4 Thu 17:00 VG 3.101

ALMOND: An LNGS Mobile Neutron Detector — •Melih Solmaz[1,2], Klaus Eitel[2], Alfredo Davide Ferella[3,4], Felix Kratzmeier[2], Francesco Pompa[2,3], and Kathrin Valerius[2] — [1]Heidelberg University, Kirchhoff Institute for Physics — [2]Karlsruhe Institute of Technology, Institute for Astroparticle Physics — [3]University of L'Aquila, Department of Physics and Chemistry — [4]INFN-Laboratori Nazionali del Gran Sasso

Environmental neutrons introduce a source of background to rare event searches, such as dark matter direct searches, neutrinoless double beta decay experiments and in cross section measurements for nuclear astrophysics, which take place in deep underground laboratories. The flux and spectrum of the ambient neutrons vary greatly with time and location. ALMOND is a mobile low-flux neutron spectrometer conceived for the LNGS underground laboratory. In this talk, we will present an overview of the design and construction of ALMOND as well as the calibration measurements performed at KIT and in Frascati, Italy. This project is supported by the German Federal Ministry of Education and Research (BMBF) under the grant number 05A21VK1. We acknowledge the support by S. Loreti and his colleagues from the Frascati Neutron Generator (FNG) facility.

T 79.5 Thu 17:15 VG 3.101

Status of the IceAct Telescopes above the IceCube Neutrino Observatory — •Lars Heuermann, Lars Marten, Andreas Nöll, Sönke Schwirn, and Christopher Wiebusch — RWTH Aachen - III. physikalisches Institut B, Aachen, Germany

IceAct is an array of Imaging Air Cherenkov Telescopes on the ice surface above the IceCube Neutrino Observatory. Each telescope features a SiPM-based 61-pixel camera and Fresnel lens-based optics, resulting in a 12-degree field of view. The design is optimized to be operated in harsh environments, particularly at the South Pole. The setup will consist of a station of seven telescopes in a so-called fly's eye configuration, increasing the field of view to 36°, and an additional telescope 200m apart for stereoscopic observations. Three of the eight telescopes are currently taking data. Another two have been shipped and are being prepared for data taking starting in 2025. In this talk we will review the status of the installation, recent analysis results, and report on the ongoing upgrade.

T 79.6 Thu 17:30 VG 3.101

Development of a Dataset for Hybrid Cosmic-Ray Measurements using IceAct, IceTop, and IceCube — •Sönke Schwirn, Shuyang Deng, Lasse Düser, Jonas Häussler, Lars Heuermann, Lars Marten, Philipp Soldin, Julian Vogt, and Christopher Wiebusch — RWTH Aachen - III. Physikalisches Institut B, Aachen, Germany

IceAct is an array of Imaging Air-Cherenkov Telescopes stationed at the South Pole as part of the IceCube Neutrino Observatory. One of its main goals is the hybrid detection of cosmic-ray induced air showers. We combine the shower development as measured with IceAct, the surface component as measured with IceTop, and TeV muons as measured deep in the ice with IceCube. For this, accurate and robust event synchronization and matching is required to combine these complementary measurements. Furthermore, it is necessary to precisely align the geometric orientation of the IceAct telescopes for an analysis of these events. In this talk, we will present a new data processing for a hybrid dataset including an improved event matching and its application to updated geometric alignment. Finally, we present a graph convolutional network for event reconstruction.

T 79.7 Thu 17:45 VG 3.101

Analysis of AERA measurements for optimizing the lightning interferometer at the Pierre Auger Observatory* — •Melanie Joan Weitz for the Pierre-Auger-Collaboration — Bergische Universität Wuppertal, Wuppertal, Germany

The Pierre Auger Observatory has detected downward terrestrial gamma-ray flashes with its water Cherenkov detectors. A key to understanding this high-energy radiation in thunderstorms is to combine such measurements with those of lightning processes in their earliest stages. The introduced lightning interferometer is a detector currently under construction for imaging lightning propagation in 3D based on radio interferometry. With eleven modified Auger Engineering Radio Array (AERA) stations and their bandwidth range from 30 – 80 MHz the necessary precision can be provided.

One step towards the lightning interferometer data acquisition is to investigate

the existing AERA measurements for lightning signal traces and to study their properties. We will present their signal characteristics measured with AERA stations using external lightning information. This allows the optimization of the signal dynamical range for the modified stations.
Supported by BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A23PX1)

T 79.8 Thu 18:00 VG 3.101

A test system for the AERA/RD beacon at the Pierre Auger Observatory — Markus Cristinziani[1], Eric-Teunis de Boone[1], Qader Dorosti[1], Stefan Heidbrink[2], •Noah Siegemund[1], Waldemar Stroh[2], Jens Winter[2], and Michael Ziolkowski[2] — [1]Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen — [2]Elektronikentwicklungslabor des Departments Physik, Universität Siegen

Precise timing is crucial in the radio detection of cosmic-ray-induced air showers, as it enables an accurate reconstruction of $X_{\max}$ through radio interferometry. GPS receivers such as those used for time synchronization in AERA/RD at the Pierre Auger Observatory cannot achieve sub-ns accuracy. To correct these inaccuracies, AERA exploits a beacon system that transmits sine waves to provide timing corrections. We are developing a test system based on the White Rabbit (WR) technology to evaluate the accuracy and scalability of the beacon. This system can tackle new challenges associated with the upgrade from AERA to RD. WR delivers precise timing in the sub-ns range over a distance up to several kilometers via fiber optic cables and serves as a reference signal for data acquisition at multiple radio stations. The recorded data is analyzed offline using interferometric signal processing techniques to assess the stability of the beacon signal. Sub-ns accuracy has been achieved in our initial tests on a short baseline. Future plans to scale the system are outlined in this contribution.

T 80: Cosmic Rays IV

Time: Thursday 16:15–18:00 Location: VG 3.102

T 80.1 Thu 16:15 VG 3.102

Investigation of the Diffusion Tensor for Different Turbulence Levels and Rigidities in the Resonant Scattering Regime — •Jan-Niklas Bohnensack[1], Julia Becker Tjus[1,2,3], and Leander Schlegel[1,2] — [1]Theoretical Physics IV: Plasma-Astroparticle Physics, Faculty for Physics & Astronomy, Ruhr-Universität Bochum, D-44780 Bochum, Germany; Supported by SFB1491 — [2]Ruhr Astroparticle And Plasma Physics Center (RAPP Center), Bochum, Germany — [3]Department of Space, Earth and Environment, Chalmers University of Technology, SE-412 96 Gothenburg, Sweden

The quasi-linear theory (QLT) describes the interactions between charged particles and astrophysical plasmas in the limit of $b/B \ll 1$. The goal of the underlying thesis was to verify the QLT's prediction that for small turbulence levels b/B, where b is turbulent magnetic field strength and B is the homogeneous magnetic field strength, the diffusion coefficient behaves like $\kappa \propto \rho^{\gamma}$ with $\gamma = 1/3$. This is currently only done with smaller statistics (number of propagated particles) due to technical restrictions. To overcome those restrictions a code was developed in the underlying thesis to utilize methods of parallelization that calculate the running diffusion coefficient from particles propagated with CRPropa faster. As part of this, an algorithm was created that can verify the convergence of the given running diffusion coefficient and can stop the simulations accordingly. With diffusion coefficients that were generated for a range of reduced rigidities and turbulence levels that lie in the Resonant Scattering Regime, the behavior of the index γ for smaller b/B according to the QLT was verified.

T 80.2 Thu 16:30 VG 3.102

Anisotropy induced by a modulation of the ultra-high-energy cosmic ray flux — •Janning Meinert[1,2], Leonel Morejón[1], Veronika Vašíčková[1], and Karl-Heinz Kampert[1] — [1]Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal, Germany — [2]ITP Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany

We investigate the energy-dependent residence time of extragalactic cosmic rays due to the galactic magnetic field using CRPropa. We examine whether a sudden and substantially increased flux of homogeneously injected ultra-high-energy cosmic rays (UHECR) in the past about 10-100 kiloyears leads to a dipole, as observed by the latest Auger data for proton injection only. Another observable will be the energy dependent amplitude evolution. An agreement with anisotropy data while preserving a homogeneous injection of cosmic rays could strengthen the hypothesis of *one* predominant UHECR source, such as Centaurus A, which may be isotropised due to echoes in the council of giants. While currently mild tensions between the dipole amplitude between Auger data and the simulation are apparent for the highest energies (E ≥ 32 EeV), incorporating more realistic simulation scenarios might mitigate those tensions in the future.
Supported by DFG under SFB 1491

T 80.3 Thu 16:45 VG 3.102

Study on the transport behavior in blazars in anisotropic magnetic fields* — •Milena Brütting[1,2], Vladimir Kiselev[1,2], and Julia Becker Tjus[1,2] — [1]Theoretical Physics IV, Ruhr-University Bochum, Bochum, Germany — [2]RAPP-Center at Ruhr-University Bochum, Bochum, Germany

Active Galactic Nuclei (AGN) are currently considered a likely source of ultra-high-energy cosmic rays (UHECR). Blazars, in particular, represent highly interesting research objects from an astrophysical point of view due to a complex jet structure which will hopefully yield new information on particle transport behavior. Following this line of research we plan to investigate the effect of anisotropies of the magnetic field on cosmic-ray propagation in the jets of blazars. For this purpose, a modified version of the open-source code CRPropa 3.2 shall be used to allow for cosmic ray transport in blazar jets. Building on previous work, we will attempt to simulate the propagation of high-energy protons in a relativistic plasmoid and investigate their diffusive behavior in the presence of an anisotropic magnetic field.
* Supported by DFG (SFB 1491)

T 80.4 Thu 17:00 VG 3.102

Stochastic analytic expressions for efficient modeling of hadronic interactions — •Leonel Morejon — Bergische Universit\"{a}t Wuppertal, Gau{\ss}str. 20, 42119 Wuppertal

While sources of Ultra-High-Energy Cosmic Rays (UHECRs) are expected to be radiation dominated, subdominant hadronic interactions might, nevertheless, yield observable effects in the spectra of messengers like photons and neutrinos.

Hadronic interactions are usually modeled with suitable generators to create production tables that are convolved with the spectra of primary UHECRs to predict the spectra of secondary particles. This method works reasonably well when the number of interactions is sufficiently large, but does not apply when fluctuations are important, as is the case for UHECR sources.

This work shows that the stochastic behavior in optically thin scenarios can be described with analytic expressions. Such expressions are used to compute the spectra of secondaries like photons and neutrinos produced in the sources, for suitable examples.

T 80.5 Thu 17:15 VG 3.102

Cosmic-ray induced ionisation and spatio-temporal correlations between supernova remnants and molecular clouds — Hanno Jacobs[1], Vo Hong Minh Phan[2], •Mareike Berkner[1], and Philipp Mertsch[1] — [1]Institute for Theoretical Particle Physics and Cosmology, RWTH Aachen University — [2]Sorbonne Université, Observatoire de Paris, PSL Research University, LERMA, CNRS UMR 8112, 75005 Paris, France

MeV cosmic rays can penetrate dense molecular clouds and oftentimes dominate the ionisation, thus contributing to the physical and chemical dynamics of star forming regions. The effect of cosmic rays can be quantified by their ionisation rate. Interestingly, the ionisation rate predicted from the locally measured cosmic-ray fluxes is one to two orders of magnitude lower than the observed ionisation rates. This disagreement is known as the ionisation puzzle. Previously, it was shown that the point-like nature of cosmic-ray sources implies a stochastic scatter in the stochastic ionisation rates. Drawing distances between clouds and supernova remnants randomly, the discrepany between model and observations could be reduced. Here, we extend this model by considering spatial and temporal correlation between source and cloud positions. These are to be expected to a certain degree as supernova remnants are likely formed in the same cloud complexes. We will present the predictions for different assumptions on the correlations and compare to ionisation data.

T 80.6 Thu 17:30 VG 3.102

Observing the Prompt Component of the Atmospheric Muon Flux Using IceCube — •Leander Flottau — TU Dortmund University, Dortmund, Germany

Atmospheric muons are created by the decays of secondary particles generated in cosmic ray interactions with the upper atmosphere. Based on the muons' parent particles, they can be categorized into conventional muons, originating from pions and kaons, and prompt muons, generated by the decays of more short-lived particles. While the conventional component dominates at lower energies, prompt muons become dominant at high energies, around 1 PeV and above.

Measuring these muons using the IceCube neutrino telescope is useful for studying hadronic interactions at a combination of center-of-mass energies and rapidities that are difficult to replicate in any current collider experiment. Due to the low overall flux at the energies where the prompt component dominates, no analysis to date has been able to significantly measure it.

The talk will cover the process of investigating the normalization of the prompt muon flux using a forward fit. This involves testing the method's ability to identify the prompt component using simulations, as well as its intended subsequent application to actual IceCube data.

T 80.7 Thu 17:45 VG 3.102

An approach to classify the prompt neutrino component of cosmic ray showers with IceCube. — •Roman Peschin — TU Dortmund University, Dortmund, Germany

The earth's atmosphere is like a translucid veil. It is nearly transparent for the human eye, but not to high-energy cosmic particles. Our atmosphere allows these particles to interact with the air molecules, which then produce a cascade of secondary particles. Prompt neutrinos are one component of these cosmic ray showers and dominante in the energy regimes above roughly 20 TeV for electron neutrinos and above about 1 PeV for muon neutrinos. While conventional neutrinos are mainly produced by pions and kaons, prompt neutrinos originate from the decay of charmed mesons.

The IceCube Neutrino Observatory is a cubic kilometer neutrino detector located at the South Pole that is constantly gaining information about the outter space. Besides the intended detection of astrophysical neutrinos, IceCube is particularly sensitive to secondary particles, like muons, from cosmic ray showers. These muons behave like a background noise for neutrino detection and are the main challenge for the classification of the prompt neutrino component.

For that purpose we use a deep neural network as an attempt to seperate the prompt element from the muon background. One approach is to look for coincident events produced by the same cosmic ray shower. The final goal is to improve the classification of the prompt neutrinos, leading to a better understanding of the composition of cosmic rays and the mechanisms of neutrino production.

T 81: Neutrino Physics VI

Time: Thursday 16:15–18:15 Location: VG 3.103

T 81.1 Thu 16:15 VG 3.103

A full Monte Carlo simulation for keV-sterile neutrino searches with the KATRIN experiment — •Claudio Silva for the KATRIN-Collaboration — Karlsruhe Institute of Technology, IAP, Campus North, Geb. 401, 76344, Germany

Sterile neutrinos are predicted by several extensions to the Standard Model and, if their mass falls within the keV range, they present a compelling dark matter candidate. One potential searching method involves looking for a kink-like distortion in the β spectrum. The Karlsruhe Tritium Neutrino Experiment (KATRIN) uses a tritium source to measure the neutrino effective mass, focusing on the endpoint where the mass effect is the clearest

The next phase of the KATRIN experiment, known as TRISTAN, seeks to extend this search across the entire tritium spectrum. This phase requires the installation of a new multi-pixel silicon drift detector and a specialized readout system, as well as significant modifications to the KATRIN beamline to improve sensitivity.

In this phase, sensitivity to keV sterile neutrinos is strongly influenced by systematic effects, including electron scattering in the source, detector response, and other factors. Addressing these challenges requires a highly efficient Monte Carlo (MC) simulation of the entire KATRIN beamline, capable of generating high-statistics datasets.

In this presentation, we introduce the KATRIN full MC simulation developed using Geant4. We will outline its key components, assess its performance, and present preliminary studies of systematic uncertainties affecting the search for keV-scale sterile neutrinos.

T 81.2 Thu 16:30 VG 3.103

Monte Carlo Simulation for Electron Scattering in the KATRIN Tritium Source — •Leo Laschinger for the KATRIN-Collaboration — Technische Universität München — Max-Planck-Institut für Kernphysik, Heidelberg

The KATRIN experiment is designed and currently being operated to measure the effective electron antineutrino mass by studying the endpoint region of the tritium beta decay spectrum. It also provides an opportunity to search for keV-scale sterile neutrinos. To that end, an investigation of the full beta spectrum is planned after the completion of the neutrino mass campaign. Electron scattering on tritium molecules in the gaseous tritium source is an important systematic effect in the KATRIN experiment, both for the ongoing neutrino mass measurement and for the upcoming search for keV-scale sterile neutrinos. In order to model this effect and its impact on the measured beta spectrum, an event-by-event Monte Carlo simulation utilizing Markov Chains for efficient cross section sampling has been developed. In this talk, I will present the working principles of the simulation, highlight the key results obtained, and discuss their implications for the KATRIN analysis. This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6). This project has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and innovation programme (grant agreement No. 852845).

T 81.3 Thu 16:45 VG 3.103

The Monte Carlo Simulation of JUNO's pre-detector OSIRIS — •Lukas Bieger, Dhanushka Bandara, Silvia Cengia, Adrian Keiderling, Florian Kirsch, Tobias Lachenmaier, Anurag Sharma, and Tobias Sterr — Eberhard Karls Universität Tübingen, Physikalisches Institut

The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose neutrino experiment with a 20 kt liquid scintillator detector in the final phase of construction in southern China. Its primary objective is to determine the neutrino mass hierarchy by precisely measuring the oscillated energy spectrum of electron antineutrinos from nearby nuclear power plants. The Online Scintillator Internal Radioactivity Investigation System (OSIRIS) will monitor the radio-purity of the liquid scintillator during the filling of JUNO, to ensure that the required contamination levels are met. OSIRIS itself is a 18 t liquid scintillator detector, instrumented with 64 20-inch PMTs to collect the light produced by events in the detector's sensitive volume. A precise Monte Carlo simulation is essential for understanding the detector's performance and optimizing analysis methods. This talk will present the comprehensive simulation framework developed for OSIRIS and will discuss the agreement of the simulation output with respect to source calibration data. Furthermore, ongoing MC tuning using calibration data to improve the accuracy is reported. This work is supported by the Deutsche Forschungsgemeinschaft.

T 81.4 Thu 17:00 VG 3.103

LiquidO: Simulations for Cloud Detector — •Susanna Wakely for the CLOUD-Collaboration — Johannes Gutenberg University

LiquidO is an innovative technology that uses opaque liquid scintillators for particle detection. A LiquidO scintillator combines a short scattering length and a long absorption length to stochastically confine optical photons close to their creation point. A fine array of wavelength-shifting fibres collects and transports the scintillation light for readout by SiPMs. A LiquidO detector will have unprecedented position resolution compared to current transparent scintillators and be capable of particle identification via event topology. LiquidO prototypes have demonstrated proof of principle of stochastic light confinement.

The Cloud collaboration is designing a 5-10 ton LiquidO anti-neutrino detector. This will be an above-ground ultra-near reactor neutrino detector located in the Chooz nuclear power plant, in France.

This talk will discuss simulations of the inner detector, including particle identification via event topology and fibre array design. Two broad fibre array designs are considered: z-parallel and stereo. A z-parallel fibre array can achieve mm-scale resolution in x and y, with z-position obtained at lower resolution from signal timing differences. A stereo fibre array would produce the same x and y resolution while improving the z resolution but presents challenges for detector construction and signal reconstruction.

T 81.5 Thu 17:15 VG 3.103

Simulations regarding the water tank instrumentation for LEGEND-1000 — •Eric Esch — University Tübingen, Tübingen, Germany

In order to reach the challenging background goal of less than 10^{-5} cts/(keV·kg·yr) targeted by the next phase of the **L**arge **E**nriched **G**ermanium **E**xperiment for **N**eutrinoless $\beta\beta$ **D**ecay (LEGEND), new detector systems have to be planned and optimized. Previous Monte Carlo studies have revealed that the in-situ production and delayed decays of ^{77}Ge and its metastable state ^{77m}Ge constitute a significant cosmogenic background. This talk will present recent simulations exploring the instrumentation of the water tank, aimed at mitigating these contributions. Specifically, the instrumentation seeks to identify and veto events produced by neutron-showering muons, the key source of $^{77(m)}$Ge background.

T 81.6 Thu 17:30 VG 3.103

Current Status of ANNIE Monte Carlo — •Johann Martyn, Amala Augusthy, Noah Goehlke, Philipp Kern, David Maksimovic, Daniel Tobias Schmid, Michel Wurm, and Dorina Carolin Zundel for the ANNIE-Collaboration — Johannes Gutenberg-Universität, Institut für Physik, Mainz 55128, Germany

The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) is a 26-ton water Cherenkov neutrino detector installed on the Booster Neutrino Beam

(BNB) at Fermilab. Its main physics goals are to perform a measurement of the neutron yield from neutrino-nucleus interactions, as well as a measurement of the charged-current cross section of muon neutrinos. Additionally, ANNIE has strong focus on the research and development of new detector technologies and target media, such as Large Area Picosecond Photodetectors (LAPPDs) and Water-based Liquid Scintillator (WbLS). Ratpac is a simulation and analysis framework build with GEANT4, ROOT, and C++, which is currently used by multiple experiments in the investigation of WbLS. In ANNIE Ratpac simulates the full detector response, including the WbLS and LAPPDs. This talk presents the current status of the ANNIE implementation in Ratpac. his work is supported by the DFG.

T 81.7 Thu 17:45 VG 3.103

Status of the Super-SANDI deployment — •Philipp Kern, Amala Augusthy, Noah Goehlke, David Maksimociv, Johann Martyn, Daniel Schmid, Michael Wurm, and Dorina Zundel for the ANNIE-Collaboration — Johannes Gutenberg Universität Mainz

The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) is a Cherenkov neutrino detector at the Booster Neutrino Beam (BNB) at Fermilab. To also allow measurements with scintillation light a water based scintillator (WbLS) is installed inside the detector in a 366 litre large vessel (SANDI). The advantage of WbLS in the detector is that it is possible to extract the energy of the neutrinos with the scintillation light as well as the trajectory of it with the Cherenkov cone. To allow us to observe the full potential of the water based scintillator by a full reconstruction of extendet neutrino event vertices, a larger vessel made out of nylon holding 8000 litres of WbLS will be deployed in 2026. To be able to deploy this vessel, Super-SANDI into ANNIE it has to be inflatable to be able to fill out the whole volume of the detector. We will present you the current status of the development of this vessel, which has unique challenges because of its size and the properties of the WbLS.

I would like to thank the DFG and the Graduate School - Particle Detectors for their funding.

T 81.8 Thu 18:00 VG 3.103

DUNE-PRISM: An innovative technique for neutrino oscil- lation analysis — •Ioana Caracas for the DUNE-Collaboration — JGU Mainz

As long baseline neutrino experiments are entering the high-precision era, an increased sensitivity towards constraining the oscillation parameters space is expected. A classical approach for the oscillation predictions is prone to systematic uncertainties, due to the incompleteness of neutrinos interaction cross section modelling. This would in turn limit the capability to obtain the physics goals for modern long baseline experiments, such as the Deep Underground Neutrino Experiment (DUNE).

An innovative technique, the Precision Reaction-Independent Spectrum Measurement (PRISM) has been proposed and studied within the DUNE collaboration. This novel method is designed to measure and predict neutrino oscillated spectra on a data-driven approach, avoiding thus the most theoretical model uncertainties. In this regard, the Near Detector (ND) is designed to move off the neutrino beam axis at several locations up to a distance of 30 m. Different neutrino fluxes are thus sampled and these ND off-axis results are further used as basis to predict the neutrino oscillated spectrum at the DUNE Far Detector. The prediction obtained with the DUNE-PRISM analysis framework and preliminary results regarding the systematics impact on the oscillation parameters will be presented. Ongoing studies to improve the overall sensitivity to the oscillation parameters and reduce their dependence on the interaction model will also be discussed.

T 82: Neutrino Physics VII

Time: Thursday 16:15–18:15 Location: VG 3.104

T 82.1 Thu 16:15 VG 3.104

Cherenkov source for JUNO — •Manuel Böhles[1], Tim Charissé[1], Johann Martyn[1], Oliver Pilarcyzk[1], Hans Theodor Josef Steiger[2], and Michael Wurm[1] — [1]Johannes Gutenberg University Mainz, Institute of Physics, Staudingerweg 7, 55128 Mainz, Germany — [2]Technical University of Munich, Physics Department, James-Franck-Str. 1, 85748 Garching, Germany

For the calibration of hybrid analyses of the JUNO experiment, a Cherenkov source has been developed to gain a better understanding of the light yield and propagation of Cherenkov light in JUNO. With this knowledge, the CID method (Correlated and Integrated Directionality) for the detection of solar neutrinos, which has already been successfully applied in Borexino, can be refined. The improved resolution of the ratio of Cherenkov to scintillation light can effectively suppress background events and help in the search for the Diffuse Supernova Background (DSNB).

The fundamental idea is based on the use of a beta source with a few MeV electron energy whose electrons pass through a Cherenkov radiator. In order to improve the triggering of the detector, a coincidence source is to be used (e.g. Bi-Po), the second decay of which triggers a scintillation signal in a plastic scintillator.

The development is funded by the DFG Research Unit "JUNO" (FOR5519).

T 82.2 Thu 16:30 VG 3.104

Source Calibration of the OSIRIS Radiopurity Monitor for JUNO — •Rosmarie Wirth[1], Daniel Bick[1], Caren Hagner[1], Mikhail Smirnov[1], Milo Charavet[1], and Tobias Sterr[2] — [1]Universitaet Hamburg, Hamburg, Deutschland — [2]Eberhard Karls Universität Tübingen, Physikalisches Institut

The Jiangmen Underground Neutrino Observatory (JUNO) features a 20-kiloton liquid scintillator (LS) detector currently under construction in Jiangmen, China. Its primary scientific goal is to determine the neutrino mass ordering with a confidence level of 3 σ within the first six years of data taking. This will be achieved by observing the oscillation spectrum of reactor anti-neutrinos at a baseline of $\sim$ 53 km. To effectively distinguish between normal and inverted ordering, the detector requires an energy resolution of 3 % at 1 MeV, high optical coverage, and low background levels, demanding high purity liquid scintillator.

To monitor scintillator quality during the filling of JUNO, the Online Scintillator Internal Radioactivity Investigation System (OSIRIS) has been developed. OSIRIS is a 18-ton cylindrical LS detector that assesses the radio-purity of the provided scintillator through Bismuth-Polonium coincidence signals. For calibration, an Automatic Calibration Unit (ACU) from the Daya Bay experiment is implemented, allowing to submerge different sources in the scintillator, providing calibration points for energy and vertex reconstruction, as well as for the timing and charge calibration of the photomultiplier tubes (PMTs).

This presentation covers the current status of the calibration of OSIRIS using the ACU.

T 82.3 Thu 16:45 VG 3.104

Status of the Laser Calibration of the JUNO pre-detector OSIRIS — •Tobas Sterr[1], Dhanushka Bandara[1], Lukas Bieger[1], Silvia Cengia[1], Jessica Eck[1], Adrian Keiderling[1], Florian Kirsch[1], Tobias Lachenmaier[1], Anurag Sharma[1], and Rosmarie Wirth[2] — [1]Eberhard Karls Universität Tübingen, Physikalisches Institut — [2]Universität Hamburg

The 20 kt liquid scintillator (LS) detector of the Jiangmen Underground Neutrino Observatory (JUNO) experiment, currently under construction in southern China. To achieve its physics goals, stringent radiopurity requirements for the LS must be fulfilled. In order to ensure these limits, the Online Scintillator Internal Radioactivity Investigation System (OSIRIS) was designed as a predetector for JUNO. During the months-long filling period of JUNO, OSIRIS will assess the radiopurity of purified LS batches to allow fast countermeasures in case of contaminations. In OSIRIS, an array of 76 Photomultiplier Tubes (PMTs) instruments a water-shielded 18-ton LS target. A pico-second pulsed laser system is used for PMT timing and charge calibration. This presentation will summarize the current status of the laser calibration system, the calibration strategy of this system and first results of the calibration in the commissioning phase of OSIRIS. Furthermore, OSIRIS PMT performance parameters using the laser calibration system are presented and compared to the results of the JUNO PMT testing campaign.

This work is supported by the Deutsche Forschungsgemeinschaft.

T 82.4 Thu 17:00 VG 3.104

Charge Sensitive Amplifier R&D for the LEGEND-1000 Experiment — •Andreas Gieb, Florian Henkes, Susanne Mertens, and Michael Willers for the LEGEND-Collaboration — Technische Universität München, Deutschland

The Large Enriched Germanium Experiment for Neutrinoless Double-Beta Decay (LEGEND) uses ^{76}Ge to search for neutrinoless double-beta ($0\nu\beta\beta$) decay. The LEGEND-200 phase, currently operating at Gran Sasso, serves as a precursor to LEGEND-1000, a 1000-kg experiment designed to achieve discovery sensitivity at half-lives exceeding 10^{28} years, targeting the inverted-ordering neutrino mass scale. Reaching this sensitivity requires ultra-low background levels and exceptional energy resolution in the region of interest.

To meet these requirements, readout electronics near the detectors play a critical role. An application-specific integrated circuit (ASIC)-based front-end system has been developed to achieve low background while maintaining low noise and high energy resolution. This work presents the results of the first ASIC iteration and outlines changes for the second iteration.

We acknowledge support by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy - EXC 2094 - 390783311 and through the Sonderforschungsbereich (Collaborative Research Center) SFB1258 'Neutrinos and Dark Matter in Astro- and Particle Physics'.

T 82.5 Thu 17:15 VG 3.104

R&D efforts regarding the water tank instrumentation for LEGEND-1000 — •Lorenz Gessler — University Tübingen, Tübingen, Germany

In the pursuit of the stringent background target set by the next phase of the Large Enriched Germanium Experiment for Neutrinoless Double-Beta Decay (LEGEND), the integration and optimization of additional veto systems are essential. Among the most challenging backgrounds are those arising from muon-induced neutron showers, which can produce metastable isotopes such as ^{77m}Ge.

This talk will present ongoing R&D efforts dedicated to enhancing the LEGEND-1000 water tank instrumentation. We are investigating a range of neutron-tagging strategies, such as gadolinium-loaded plastics, alternative Gd-based compounds, and liquid scintillator solutions, using a dedicated 700 L water Cherenkov test detector in Tübingen. By comparing and refining these approaches, we aim to guide the ultimate design of the water-based veto system, thereby improving background suppression and advancing the experiment's sensitivity to the elusive $0\nu\beta\beta$ decay signal.

T 82.6 Thu 17:30 VG 3.104

Detection of Cherenkov and Scintillation light in hybrid scintillators — •Dorina C. Zundel[1], Michael Wurm[1], Manuel Böhles[1], and Hans Steiger[2] — [1]Johannes Gutenberg-Universität Mainz, Institute of Physics and Cluster of Excellence PRISMA+, Staudingerweg 7, 55128 Mainz — [2]Technische Universität München, James-Franck-Straße 1, 85748 Garching

Hybrid scintillator detectors aim at the simultaneous detection of Cherenkov and scintillation light. SCHLYP (**S**cintillation **CH**erenkov **L**ight **Y**ield **P**rism) is a newly developed laboratory setup, used to distinguish Scintillation and Cherenkov light in scintillator samples. The setup uses the geometrical advantages of a hollow prism filled with various scintillator samples as a detector, equipped with three ultra-fast photomultipliers, on each side. Photons from a close-by ^{137}Cs source create a signal by Compton scattering in the scintillator. Using a secondary inorganic scintillator detector, recoil photons are selected to be aligned with the prism geometry, so that two of the PMTs detect both Cherenkov and Scintillation light, while the third PMT is only able to detect scintillation light. The samples being investigated range from slow scintillators to water-based liquid scintillators. In this talk the improved setup and the analysis of the phase II data will be presented.

T 82.7 Thu 17:45 VG 3.104

Development of a High-Pressure Scintillator Test Cell for Double Beta Experiments — •Magdalena Eisenhuth for the NuDoubt-Collaboration — Johannes Gutenberg-Universität Mainz, Institut für Physik, 55128 Mainz, Germany

The investigation of two-neutrino and neutrino-less double beta decay is crucial for understanding the Dirac or Majorana nature of neutrinos.

In this context, the krypton isotope Kr-78 (Q=2.88 MeV) stands out as a promising candidate for a first detection of two-neutrino ECb+ and 2b+ decays.

Detectors like the proposed NuDoubt++ experiment featuring opaque scintillator or an upgrade of the OSIRIS detector with hybrid scintillator can profit from solving the krypton gas in the scintillator at high pressure to increase the loading factor.

This presentation explores the loading process in a small-scale scintillator test cell and the characterization techniques for determining the loading factor.

T 82.8 Thu 18:00 VG 3.104

Electron scattering in cryogenic scintillating calorimeters for rare event searches — •Elisa Gaido for the COSINUS-Collaboration — Max-Planck-Institut für Physik, Munich, Germany

Cryogenic scintillating calorimeters (CSCs) are an established technology for the direct detection of dark matter through nuclear scattering. Current CSC experiments like COSINUS are starting to explore the possibility of using CSCs for the direct detection of dark matter-electron and neutrino-electron scattering, e.g. in the OνDES project. The theoretical framework for these searches is still under development. This contribution explores the possibility of detecting neutrino-electron scattering with CSCs and constraining their properties beyond the standard model of particles. This research is part of the LUCE/OνDES project funded by the Klaus Tschira foundation.

T 83: Methods in Particle Physics IV (Lepton Reconstruction)

Time: Thursday 16:15–18:45 Location: VG 4.101

T 83.1 Thu 16:15 VG 4.101

Electron Reconstruction Efficiencies in Run 2 and Run 3 at ATLAS — •Marius Melcher, Asma Hadef, and Arno Straessner — Technische Universität Dresden

Before particles detected by the ATLAS experiment can be used in physics analyses, their measured signatures undergo several analysis steps, e.g. reconstruction and identification. It is crucial that these steps and their performances are well understood. This talk will focus on the electron reconstruction and the measurement of its efficiency.

For electron reconstruction, information from different parts of the detector needs to be connected: a track from the Inner Detector is matched to energy deposits in the EM calorimeter by reconstruction algorithms. To estimate how many real electrons successfully pass these algorithms the tag-and-probe method is used for $Z \to ee$ decays to measure efficiencies both for data and Monte Carlo simulation in dependence of p_{T} and η. These results are then used to derive scale factors which are applied to correct MC predictions in subsequent analyses with electrons in the final state. In addition to the scale factors also their uncertainty is passed to the analyses. Understanding and controlling the systematic uncertainties of the efficiency measurement is therefore crucial.

After introducing the method and its data-driven approach for background estimation, recent results for the full Run 2 and already available Run 3 datasets are discussed.

T 83.2 Thu 16:30 VG 4.101

Likelihood Tuning for LHC Run 3 — •Max Fusté Costa[1], Martina Laura Ojeda[2], and Sarah Heim[1] — [1]DESY, Hamburg, Germany — [2]CERN, Geneva, Switzerland

A likelihood-based identification (LH ID) is used to identify the reconstructed electrons in the ATLAS detector and to reject hadronic jets and electrons from heavy flavor decays. Due to differences between Run 2 and 3 at the LHC, the LH ID needs to be retuned. The transverse momentum range of the tuning will be extended as well. This is done using Run 3 Monte Carlo samples, with observables adjusted using the Shift and Stretch (S&S) method to match the data. The performance of the tuning and the fudging are evaluated through efficiency measurements.

T 83.3 Thu 16:45 VG 4.101

Photon identification at the CMS experiment using particle flow candidates and individual calorimeter energy deposits — •Caio Daumann and Johannes Erdmann — III. Physikalisches Institut A, RWTH Aachen University

Many physics processes under study at the Large Hadron Collider are characterized by the presence of photons in the final state. Consequently, the performance of photon identification algorithms is crucial for the physics reach of the CMS experiment. Currently, the photon identification algorithm is based on a Boosted Decision Tree that utilizes high-level variables as input, such as shower shapes and isolation variables. Instead of relying on high-level variables, we investigate the performance of a photon classifier trained on low-level quantities, such as individual energy deposits in the calorimeter and particle-flow candidates surrounding the photon, from which high-level information is typically derived. Modern machine learning architectures are well-known for their ability to extract informative features directly from raw training data, often outperforming classifiers based on high-level variables. In this study, we report the performance of a classifier trained using such low-level information.

T 83.4 Thu 17:00 VG 4.101

Measurement of photon identification efficiency with the inclusive photon method using 2022 CMS data — Johannes Erdmann, •Nitish Kumar, and Jan Lukas Späh — III. Physikalisches Institut A, RWTH Aachen University

The measurement of the photon identification efficiency is an essential component of all analyses using photons. Conventionally, the CMS collaboration uses the tag-and-probe technique to measure the photon identification efficiencies up to photon p_{T} of 500 GeV. This method is limited by small event yields in the high-p_{T} region and the extrapolation beyond 500 GeV is associated with additional uncertainties, which is relevant for analyses involving high-p_{T} photons.

The inclusive photon method, also known as the matrix method, allows a precise measurement of the photon identification efficiencies at high photon p_{T}. This method uses an inclusive photon sample selected with single photon triggers. It utilizes isolation criteria to obtain the fraction of prompt photons in the whole sample and the subsample meeting the identification criteria. This allows the extraction of the photon identification efficiency in a data-driven way. In this talk, we present the preliminary measurement results of photon identification efficiencies with the inclusive photon method using data collected by the CMS experiment in 2022, including the associated systematic uncertainties.

T 83.5 Thu 17:15 VG 4.101

Determination of Universal Tau Fake Factors for the Run 3 Data Taking Period of ATLAS — •Christian Schmidt, Arno Straessner, and Asma Hadef — Institut für Kern- und Teilchenphysik, Technische Universität Dresden

Tau leptons are an important product in collision events at the LHC; they primarily decay into a hadronic final state. Hadronic jets can easily produce similar signatures inside the ATLAS detector, i.e. fake taus, so it becomes necessary to estimate the fake tau background. The Fake Factor (FF) method estimates this background from data events with non-isolated tau candidates using a correction factor which depends on the transverse momentum of the tau candidate. In addition, the FF depends on the origin of the fake-producing jets, such as quark or gluon jets. Instead of measuring the FFs in a separate control region for each physics analysis, the Universal Fake Factor (UFF) method uses an estimate of the jet composition to linearly interpolate the FFs.

This talk will present the general principles of the UFF method, the process of calculating parameters to be used for determining the UFF parameters in ATLAS Run 3 data, and current results.

T 83.6 Thu 17:30 VG 4.101

Measurement of Tau Identification Scale Factors in the $W \to \tau\nu$ Channel Using LHC Run 3 Data — •Luka Vomberg, Christian Grefe, Philip Bechtle, and Klaus Desch — Physikalisches Institut Bonn

Scale factors are necessary to calibrate the selection efficiency for the identification of hadronic tau-lepton decays in simulation to the observed efficiencies in data. These factors are determined for all ATLAS analyses in dedicated tag-and-probe studies.

A measurement of tau identification (ID) scale factors using 2022 data from LHC Run 3 is presented, focusing on the $W \to \tau\nu$ channel. This channel offers a higher transverse momentum reach than $Z \to \tau\tau$ or $t\bar{t}$ due to the W-boson recoiling from a jet, and allows tight missing energy cuts because of the neutrino in the final state. The primary challenge is the large dijet QCD background, addressed using the data-driven ABCD method.

The entire measurement workflow is implemented with Snakemake, providing a novel and systematic solution to ensure easy reproducibility and interoperability - an essential but often overlooked aspect of such measurements. Additionally, new strategies for improving fake tau estimation are proposed to enhance the measurement's precision and reliability.

T 83.7 Thu 17:45 VG 4.101

Inference of the Neutral Four-Momentum of Hadronic τ-Leptons using Neural Networks in ATLAS — •Simon Thiele[1], Lukas Cieslik[1], Christian Grefe[1], Alessandra Betti[2], Philip Bechtle[1], and Klaus Desch[1] — [1]Rheinische Friedrich-Wilhelms Universität Bonn — [2]Sapienza Università di Roma

Reconstructing the four-momenta of neutral decay products of hadronically decaying τ-leptons, which are almost exclusively π^0's, allows to infer the spin of the τ. This allows for example to measure the CP of the Higgs boson. Therefore it is desirable to reconstruct this momentum as accurately as possible, which is challenging since the photons from the π^0 decays are only measured in the electromagnetic calorimeter.

Currently these neutral decay products are reconstructed in ATLAS using the Tau-Particle-Flow algorithm, which also performs a decay mode identification, classifying the tau jets by the number of charged and neutral hadrons they contain. In recent years a new neural network based decay mode classifier has been developed. This new classifier has a higher efficiency than the current algorithm. But since it is only a classifier without a reconstruction of the neutral four-momentum, this gain in efficiency is not accessible to these Higgs CP studies. Therefore we are currently working on developing a neural network based solution for that also provides inference of the neutral four-momentum.

In this talk I will first go over this motivation and the current state of the art algorithms and then discuss the performance of the new neural network solution.

T 83.8 Thu 18:00 VG 4.101

Muon Momentum Scale and Resolution Calibration for CMS — •Dorian Guthmann, Markus Klute, and Jost von den Driesch — Karlsruher Institut für Technologie, Karlsruhe, Deutschland

Many analyses conducted with the CMS experiment at the LHC rely on a precise description of muon momenta. However, deviations between data and simulation arise due to mismodeling of the detector, such as misalignment and limited magnetic field precision. To address this, scale and resolution corrections are applied to the transverse momentum of muons, mitigating biases and aligning the theoretical description of muons with their experimental counterpart. This presentation will provide an overview of the progress made over the past year in refining and enhancing these corrections.

T 83.9 Thu 18:15 VG 4.101

Reconstruction of Stand-Alone Muons in Run 3 of ATLAS — •Celine Stauch[1], Otmar Biebel[1], Valerio D'Amico[1], Stefanie Götz[1], Lars Linden[1], Bao Tai Le[1], Tim Rexrodt[1], and Giorgia Proto[2] — [1]LMU Munich — [2]MPI Munich

The identification and reconstruction of muons is an essential aspect for precise measurements of processes including muons in the final states of the ATLAS experiment at the LHC and HL-LHC. Various important physics processes produce muons which are detected by the Muon Spectrometer with almost 100 %-efficiency and good momentum resolution. Muons in the very forward region of the detector are called stand-alone muons. These muons are outside the reach of the Inner Track detector and are reconstructed solely using the Muon Spectrometer.

The measured efficiency in Monte Carlo (MC) samples is then compared with that obtained from dataset. The agreement between the efficiency measured in data and the corresponding efficiency in MC is called Scale Factor and is used to quantify the deviation of the simulation from the real detector behavior and is then used to correct the simulation in physics analyses.

T 83.10 Thu 18:30 VG 4.101

Estimation of Non-Prompt Lepton Backgrounds with Classical and Machine Learning Techniques — Korn Steffen, Quadt Arnulf, and •Schiel Nico — II. Physikalisches Institut, Georg- August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Non-prompt leptons are a significant background in many particle physics analyses, for example tt and HWW^* analyses. These processes depend on the modelling of parton showers and are therefore challenging to predict theoretically. Consequently, data-driven approaches are utilised to model backgrounds arising from non-prompt leptons. Often, classical methods such as the fake-factor method are used. However, machine learning based methods such as normalising flows also show promising results for modelling non-prompt leptons. In this talk, both approaches are compared with respect to their performance.

T 84: Search for Dark Matter IV

Time: Thursday 16:15–18:45 Location: VG 4.102

T 84.1 Thu 16:15 VG 4.102

Status of the DarkMESA Experiment — •Mirco Christmann for the MAGIX-Collaboration — Institute for Nuclear Physics, JGU Mainz, Germany

At the Institute for Nuclear Physics in Mainz the new electron accelerator MESA will be operational shortly. The high-power beam dump of the P2 experiment (150 MeV, 150 μA) is ideally suited for a parasitic dark sector experiment – DarkMESA.

The experiment is designed for the detection of Light Dark Matter (LDM) which in the simplest model couples to a massive vector particle, the dark photon γ. It can potentially be produced in the beam dump by a process analogous to photon Bremsstrahlung and may then decay into Dark Matter (DM) particle pairs $\chi\bar{\chi}$. A fraction of them scatter off electrons or nuclei in the DarkMESA detectors.

This contribution discusses the extension of the simulation framework through the integration of additional models and the current status of the Phase A setup. Beyond the use of a traditional calorimeter, the possibility of utilizing a liquid scintillator for Phase B is under investigation. Initial results obtained in co-operation with the NuDoubt^{++} collaboration are presented.

T 84.2 Thu 16:30 VG 4.102

Light Dark Matter Search with DarkMESA — •Christian Stoss for the MAGIX-Collaboration — Institute for Nuclear Physics, Johannes Gutenberg-University Mainz, Germany

The existence of Dark Matter remains one of the most significant open questions in particle physics. The DarkMESA experiment aims to search for Light Dark Matter (LDM) in an unexplored mass and coupling regime. This parasitic beam dump experiment will be located downstream of the P2 experiment at the new MESA accelerator in Mainz. It is planned to operate for 10,000 hours in extracted beam mode, using a $150\mu A$ electron beam with an energy of $150MeV$.

In the simplest model of LDM, the dark matter particle χ couples to a massive vector particle, the dark photon γ'. In this framework, electrons in the beam dump can produce γ' via a Bremsstrahlung-like process. If kinematically allowed, these dark photons then decay into $\chi\chi$ pairs. If LDM exists within the targeted parameter space, a fraction of the produced LDM will scatter off electrons or nuclei in the calorimeter's Cherenkov crystals, generating measurable signals.

This contribution will include a brief overview of the planned experimental stages of DarkMESA as well as a further study for possible improvement of the readout techniques with additional SiPMs at different operating temperatures.

T 84.3 Thu 16:45 VG 4.102

Investigation of hadronic Backgrounds for Lohengrin — •Laney Klipphahn for the Lohengrin-Collaboration — Universität Bonn

The search for dark matter has long been of interest to scientists around the world. Previous searches have so far been unsuccessful in finding proposed DM particles. A promising and not well explored family of DM models contains dark matter particles with masses below ≈ 1 GeV connected through a portal interaction to the standard model. The Lohengrin experiment at the ELSA electron accelerator in Bonn is a fixed target experiment designed to probe this mass range by searching for dark photons in a dark bremsstrahlung process in the target.

Lohengrin will probe the dark sector by analyzing events with a significant amount of missing momentum in the final state. Hadronic final states comprise a particularly challenging background to the dark photon search, as single nucleons or mesons can be ejected from the target at high angles, evading the detectors that are placed in forward direction. In this talk I will present the results of a MC driven background estimation for the Lohengrin experiment, and its impact on the design and layout of the detector.

T 84.4 Thu 17:00 VG 4.102

Active muon veto of the COSINUS experiment — •Kumrie Shera for the COSINUS-Collaboration — Max-Planck Institute for Physics, Munich, Germany

The Cryogenic Observatory for SIgnatures seen in Next Underground Searches (COSINUS) is a direct dark matter search experiment utilizing sodium iodide (NaI) crystals as cryogenic calorimeters. The cryogenic facility is located in hall B of the Laboratori Nazionali del Gran Sasso (LNGS) in Italy. The NaI cryogenic detectors will be housed in a dry dilution refrigerator positioned at the center of a water tank with a diameter and height of seven meters. The water serves as passive shielding against ambient radiation.

High-energy muons can penetrate the detector's surroundings, generating muon-induced neutrons that may cause nuclear recoils, potentially mimicking a dark matter signal. To actively identify and veto these events, the water tank is equipped with 30 photomultiplier tubes (PMTs), enabling the tank to operate as an active muon veto.

This contribution outlines the installation tests, PMT testing, and the commissioning of the full muon veto system at LNGS.

T 84.5 Thu 17:15 VG 4.102

Pulse Shape Studies on the COSINUS prototypes with BAT — •Sarah Braun for the COSINUS-Collaboration — MPP Munich

The Cryogenic Observatory for SIgnatures seen in Next generation Underground Searches (COSINUS) experiment, located at the Laboratori Nazionali del Gran Sasso (LNGS), Italy, will provide a model-independent cross-check of the DAMA/LIBRA experiment's findings of modulation signals consistent with the expected dark matter signal. It utilizes ultrapure NaI crystals operated at cryogenic temperatures, enabling a dual-channel readout of scintillation and phonon signals to discriminate different particle interactions.

This contribution focuses on fitting different pulse shape models to the COSINUS detector prototypes, using the Bayesian Analysis Toolkit (BAT) in Julia. Franz Pröbst's model for cryogenic detectors has proven effective when applied to the CRESST experiment detectors. This study explores whether similar success can be achieved with COSINUS prototypes using a remoTES. The overall objective is to understand the detector parameters and their effect on the performance, to guide and accelerate our detector R&D strategy.

T 84.6 Thu 17:30 VG 4.102

Dark matter direct detection with XENONnT experiment — •Giovanni Volta for the XENON-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Understanding the nature of Dark Matter (DM) is one of the open issues in modern physics. In this context, XENON project aims to lead the effort on DM direct detection using ton-scale xenon dual-phase time projection chamber technology, operating in a low background environment. The status of XENONnT experiment, operating at the underground LNGS (L'Aquila, Italy) laboratory, will be shown, along with the most recent DM search results.

T 84.7 Thu 17:45 VG 4.102

Study of spurious clustered electron emission signals in XENONnT — •Alexis Michel and Alexey Elykov — Karlsruhe Institute of Technology, Institute for Astroparticle Physics

In direct search of dark matter, dual-phase xenon time projection chambers (TPCs) like XENONnT are widely used. This kind of detector has a target of liquid xenon (LXe) with a layer of gaseous xenon (GXe) above. Alongside the prompt scintillation signal, interactions in the TPC produce ionization electrons. These are drifted upward as a cloud of electrons by an applied electric field and extracted into the GXe to produce a secondary scintillation signal.

The extraction into the gas is not always complete and electrons can stay behind. What then happens to those electrons is not exactly known yet. Previous experiments often observed a number of spurious signal types, which could be associated with delayed extraction of trapped electrons. One such signal type takes the form of significantly delayed localized bursts of electrons (e-burst).

Understanding the origin of this background is of key importance for low-energy searches that look for particle interaction products down to the single- and few-electron level. Moreover, characterization of the e-burst background could shed light on the microphysics processes at the liquid-gas xenon interface, informing the operation and design of the current and future generation of xenon TPCs.

In this talk I will present the recent results and progress on studies of such signals and their correlation with detector conditions.

T 84.8 Thu 18:00 VG 4.102

.MOTION, a liquid xenon time projection chamber platform for high voltage development in dark matter detectors — •Yanina Biondi, Alexander Jansen, Steffen Lichter, Michael Schrank, Karin Vogt, and Yanina Biondi — Institute For Astroparticle Physics, Karlsruhe Institute of Technology

MOTION is a time projection chamber with 80 kg of liquid xenon (LXe), serving as a testing platform for high-voltage (HV) delivery of around -200 kV and stability in LXe for next-generation dark matter detectors. The objective of this detector is to study the breakdown voltage of liquid xenon, which might depend on different factors such as surface area of the conductor and the purity of the liquid xenon, among others. The detector also serves as a platform to study spurious electron emission from electrodes, as well as the development of high voltage feedthroughs made out exclusively of radiopure materials. This project is supported by the Young Investigator Group Preparation Program of the Karlsruhe Institute of Technology.

T 84.9 Thu 18:15 VG 4.102

Design and Commissioning of the MainzTPC2 — •Constantin Szyszka, Alexander Deisting, Christopher Hils, Peter György, Kaveh Kooshkjalali, and Uwe Oberlack — Institut für Physik & Exzellenzcluster PRISMA$^+$, Johannes Gutenberg-Universität Mainz

The MainzTPC is an experimental dual-phase xenon time projection chamber (TPC) dedicated to studying scintillation and ionization processes in liquid xenon for low-energy electronic and nuclear recoils. Its design has been optimized for use as the primary target in Compton and neutron scattering experiments to measure recoil energies in liquid xenon down to 1 keV.

To address known instabilities in the liquid level of the MainzTPC, we observed the liquid-gas interface using commercially available cameras and aim to improve the level meters and level control based on these observations. Additionally, the MainzTPC is being redesigned to accommodate an array of silicon photomultipliers (SiPMs) instead of the top photomultiplier tube (PMT) and eight avalanche photodiodes (APDs) to improve position resolution in x and y. Both of these changes require a complete redesign of the TPC and its infrastructure. We report on the status of this work.

T 84.10 Thu 18:30 VG 4.102

Simulation and Prototyping of the MainzTPC2 — •Peter Gyorgy, Alexander Deisting, Christopher Hils, Kaveh Kooshkjalali, Uwe Oberlack, and Constantin Szyszka — Johannes Gutenberg-Universität Mainz, Institut für Physik & Exzellenzcluster PRISMA+

The MainzTPC, a small-scale dual-phase xenon time projection chamber, is being redesigned. This upgrade includes the replacement of the top photomultiplier tube (PMT) with a silicon photomultiplier (SiPM) array to gain significantly improved spatial resolution in event reconstruction.

The goal is to achieve a deeper understanding of xenon scintillation and ionization yields at low energies, and to attempt to observe the elusive Migdal effect — a hybrid nuclear- electron- recoil signal that could prove key to extend to lower dark matter masses the sensitivity of large dual-phase time projection chambers, such as XENONnT or XLZD.

The prototyping process requires extensive modeling and simulations in GEANT4, exploring various design configurations. It must consider optical physics, neutron and gamma scattering, and long-term radioactive exposure. This presentation will summarize results from this simulation process.

T 85: Members' Assembly

Time: Thursday 19:00–20:00 Location: ZHG104

All members of the Particle Physics Division are invited to participate. Pretzels and drinks will be provided.

T 86: Searches/BSM V (Misc.)

Time: Friday 9:00–10:30 Location: ZHG010

T 86.1 Fri 9:00 ZHG010

BSM Searches at a 12 GeV Gamma-Gamma collider based on the European XFEL — •Marten Berger[1], Gudrid Moorgat-Pick[1,2], and Monik Wüst[1] — [1]Universität Hamburg, Hamburg, Germany — [2]DESY, Hamburg, Germany

Photon-Photon colliders have been discussed before, offering so far unrealized complimentary possibilities to any current and future linear collider. Implementing one as extension to the Beam dump of the 17.5 GeV European XFEL as the first high energy collider of its sort. It would not just be to study the concept of photon colliders but would also be a collider without competition in the region of 5 – 12 GeV for photon-photon collision. In this range, bb and cc resonances, tetraquarks as well as mesonic molecules can be observed. Furthermore, some BSM processes can also be reached in this range making use of the polarization effects from compton backscattering. In this talk we want to discuss the possibility of observing ALPs at such a collider. We will use a simplified description of the compton backscattering process to get a first look at cross sections and extend this to the full beam dynamics included prediction.

T 86.2 Fri 9:15 ZHG010

Hunting coloured scalars with machine learning — Thomas Flacke[1], Jeong Han Kim[2], •Manuel Kunkel[3], Jun Seung Pi[2], and Werner Porod[3] — [1]Center for AI and Natural Sciences, KIAS, Seoul, Republic of Korea — [2]Department of Physics, Chungbuk National University, Republic of Korea — [3]Institut für Theoretische Physik und Astrophysik, Julius-Maximilians-Universität Würzburg, Germany

Composite Higgs models with an underlying fermionic description predict an extended scalar sector featuring also QCD coloured states. We study an electrically neutral colour octet and a colour sextet with charge 4/3. Both states couple to top quarks such that pair production leads to a four top quark signature. We train neural networks to separate these signal processes from their SM backgrounds and derive the discovery reach and expected exclusion limits at the HL-LHC. Since both states may be present simultaneously, we also assess how well the respective events can be separated by our networks.

T 86.3 Fri 9:30 ZHG010

Trigger-level search for dijet resonances at ATLAS — •Falk Bartels — Kirchhoff-Institut für Physik, Heidelberg

The search for sub-TeV dijet resonances at the LHC is statistically limited due to the reduced readout rate of lower p_T jet triggers. The ATLAS trigger-level analysis covers this part of the spectrum by recording a strongly reduced set of event-level information processed by the High Level Trigger for all events passing the seeding Level-1 trigger. This allows for lowering the minimal detectable dijet resonance mass from above 1 TeV to around 400 GeV.

With more than 1 billion events in the recorded dijet mass spectrum, an exceptional statistical precision can be achieved. Matching this level of precision poses unique challenges especially for the custom trigger-level jet calibration and the background estimate. A general overview of the well-advanced analysis is presented.

T 86.4 Fri 9:45 ZHG010

Searching for anomalous dijets in CMS data with CATHODE — •Chitrakshee Yede, Gregor Kasieczka, Louis Moureaux, Tore von Schwartz, and Manuel Sommerhalder — Institute for Experimental Physics, Universität Hamburg, Hamburg, Germany

In high-energy physics, numerous analyses conduct searches for new phenomena beyond the Standard Model. A new paradigm of model-agnostic searches has emerged based on anomaly detection which is aimed at automatically identifying deviations from the background expectation in the data using machine learning. We present the recently published analysis by the CMS Collaboration that employs such machine learning techniques. We discuss CATHODE, a method combining density estimation and weak supervision and its first-ever application on 13 TeV proton-proton collision data recorded by the CMS experiment at the LHC. This study focuses on heavy resonances decaying into two large-radius jets with anomalous substructure. This approach establishes a foundation for data-driven, model-agnostic searches, enabling the simultaneous investigation of multiple potential new physics signals within a single analysis.

T 86.5 Fri 10:00 ZHG010

Statistical analysis with anomaly detection — •Kristian Warnholz, Louis Moureaux, Gregor Kasieczka, and Manuel Sommerhalder — Universität Hamburg

Although extensive searches for new physics at the Large Hadron Collider have been conducted, no new particles beyond the Standard Model have been discovered. A key limitation may stem from the reliance on specific models to guide these searches, potentially overlooking more exotic phenomena. In response, recent years have seen the development of numerous machine learning-based, model-independent anomaly detection methods designed to uncover unexpected signals in the data. The first results using these methods have recently been published by the ATLAS and CMS Collaborations. We present a statistical analysis of the behavior of the p-values and exclusion limits derived using the anomaly detection process.

T 86.6 Fri 10:15 ZHG010

Exploring new physics at LHC with Model Unspecific Search in CMS — Alexander Schmidt, Arnd Meyer, •Chinmay Seth, Felipe Torres Da Silva De Araujo, and Thomas Hebbeker — III. Physikalisches Institut A, RWTH Aachen

The Standard Model of Particle Physics, while highly successful, has limitations and fails to provide a comprehensive description of fundamental particles. Beyond Standard Model theories explore alternative explanations for these shortcomings.

The Large Hadron Collider provides access to unprecedented energy for proton-proton collision experiments, generating data to explore theories beyond the Standard Model. Model Unspecific Search in CMS (MUSiC) is one such effort where a model-independent approach is used to look for regions of possible discrepancies between observations from the CMS detector and standard model predictions.

MUSiC classifies events into 'event classes' based on the multiplicity of specific reconstructed final state particles, such as a class with 2 muons and 1 jet. Kinematic distributions for these classes are generated using three key event variables. The algorithm calculates a p-value, considering systematic and statistical effects, and identifies regions in distributions that deviate from the statistical model. Applying further statistical corrections yields a final p-value, highlighting the most deviating event classes. If the p-value surpasses a set threshold, it signifies a potential window to new physics in that corresponding region. We discuss the concept of MUSiC, its scope, and challenges in this talk.

T 87: Higgs physics IX (Charm and Tau Final States)

Time: Friday 9:00–10:15 Location: ZHG104

T 87.1 Fri 9:00 ZHG104

NLO QCD Corrections to ZH Production via Gluon Fusion — •Dominik Grau[1], Matthias Steinhauser[1], Marco Vitti[1], Joshua Davies[2], and Kay Schönwald[3] — [1]Karlsruhe Institute of Technology , Karlsruhe, Germany — [2]The University of Liverpool, Liverpool, United Kingdom — [3]Universität Zürich, Zürich, Switzerland

The associated production of a Higgs boson with a vector boson is an important process investigated at the LHC. Formally the gluon fusion channel enters the process pp→ZH at NNLO. However, it gives sizeable contributions to the cross section and to the theoretical uncertainties which motivates the computation of NLO QCD corrections to gg→ZH. In this talk we describe an approach to obtain analytic results for the two-loop virtual corrections as an expansion around the forward limit. We show that the combination of these results with analytic high-energy expansions can cover the whole phase-space without the need of time-consuming numerical methods.

T 87.2 Fri 9:15 ZHG104

Current developments in the search for the Higgs boson decay to a charm-anticharm pair in vector boson associated production mode at CMS in Run 3 — •Valentyn Vaulin[1], Alexander Schmidt[1], Andrey Pozdnyakov[1], Jan Schulz[1], Gaetano Barone[2], Spandan Mondal[2], Trevor Russell[2], Ulrich Heintz[2], Licheng Zhang[3], Chris Palmer[3], and Braden Kronheim[3] — [1]RWTH Aachen University, Germany — [2]Brown University, USA — [3]University of Maryland, College Park, USA

During the recent years multiple analysis techniques to measure the Higgs boson coupling to charm quarks using the full Run-2 data of the CMS experiment have been established. The Higgs boson decay into a charm-anticharm pair, where the Higgs boson is produced in association with the W or Z boson, is expected to be the most sensitive channel. In this talk developments of the VH(cc) analysis, using Run-3 data at CMS, are presented. In particular, the analysis strategy and the first expected limits will be shown.

T 87.3 Fri 9:30 ZHG104

PAIReD jets in CMS: Recent developments of a novel jet tagging approach for H(cc) and H(bb) searches in the CMS experiment — Gaetano Barone[1], Alexander Jung[2], Ming-Yan Lee[2], Spandan Mondal[1], Trevor Russel[1], Uttiya Sarkar[2], Alexander Schmidt[2], •Jan Schulz[2], and Ulrich Willemsen[2] — [1]Brown University, Providence, USA — [2]III. Physikalisches Institut A, RWTH Aachen University, Germany

The identification of jet flavors based on machine learning is the most critical ingredient for the search for rare Higgs decays in two charm quarks. For the upcoming CMS analysis, a new jet tagging strategy has been developed that outperforms classical tagging approaches, especially for small Lorentz boosts of the Higgs boson. The central element of this new method is the so-called PAIReD jet, a new unconventional jet type which, in contrast to traditional AK4 jets, exploits correlations between the two charm jets. This talk will give an overview of the PAIReD approach and recent developments such as mass-decorrelated training and simultaneous jet-mass regression.

T 87.4 Fri 9:45 ZHG104

Search for the Higgs plus charm quark production mode in the $H \to WW \to e\nu\mu\nu$ channel — •Ming-Yan Lee, Alexander Schmidt, Andrey Pozdnyakov, Uttiya Sarkar, and Valentyn Vaulin — III. Physikalisches Institut A, RWTH Aachen University, Aachen, Germany

The Higgs plus charm production mode is another topology to probe the Higgs-charm Yukawa coupling complementary to H→cc channels. This topology provides the possibility to access the Higgs-charm coupling via cleaner final states. In this analysis, we aim to consider the Higgs decay into W boson to dileptonic final states with additional charm-tagged jets. The upper limit to extract H-c coupling is demonstrated using the data-taking period 2016 to 2018 of the CMS experiment at the LHC at $\sqrt{s}$ =13 TeV.

T 87.5 Fri 10:00 ZHG104

Performance of tau reconstruction with CMS — Markus Klute, Olha Lavoryk, Artur Monsch, •Jan Voss, and Roger Wolf — Institut für Experimentelle Teilchenphysik, Geb. 30.23 Wolfgang-Gaede- Str. 1 76131 Karlsruhe

The precise measurements of tau-leptons play an important part in many analyses, especially in Higgs physics. For higher precision, the use of scale factors is widespread to correct for mismodelings of the data with simulations or data driven techniques. This talk will cover the measurement of the DeepTau ID scale factors in different quantities like transverse momentum, decaymode and energy scale, as well as its technical intricacies.

T 88: Miscellaneous

Time: Friday 9:00–10:30 Location: ZHG105

T 88.1 Fri 9:00 ZHG105

A semi-classical particle model explains mass and other data quantitatively — •Albrecht Giese — Taxusweg 15, 22605 Hamburg

We present a particle model that is an evolution of Louis de Broglie's original approach. It is mostly classical, but has properties that are largely superior to QM calculations. At first, a classical model of inertial mass is explained which, unlike the Higgs model, gives precise results without the use of free parameters. It also allows, in contrast to the mere postulations of QM, the derivation of known rules/facts such as frequency-energy, the Bohr magneton, the fine structure constant. And it derives the structure of the strong field inside particles. This was previously in great conflict with quantum chromodynamics (QCD), but is now in agreement after a recent QCD modification.

Further info: ag-physics.org/rmass

T 88.2 Fri 9:15 ZHG105

Notational invariance of the standard model — •Lello Boscoverde — Istituto della Fava Pazza, Garching, Germany

I will present the concept of notational invariance, the history of its development, and example applications relevant to contemporary particle physics.

T 88.3 Fri 9:30 ZHG105

Comment on the Sommerfeld Fine Structure Constant tension — •Manfred Geilhaupt — University of applied Sciences HS Niederrhein

In todays physics, the fine-structure constant (alpha) is a fundamental physical constant which quantifies the strength of the electromagnetic interaction between elementary charged particles. The constant alpha was introduced in 1916 by Arnold Sommerfeld. However, alpha still is an unsolved theoretical and even experimental physical problem up to now! Alpha from atomic interferometric experiments shows a large difference compared to their high accuracy:

1. 2018 Parker et al. 1/137.035999046(27), atomic interferometer experiment

2. 2020 Morel et al. 1/137.035999206(11), atomic interferometer experiment

3. 2011 More et al. 1/137.035999084(15), quantum hall experiment. The 2011 last experimental von Klitzing constant RK=25812.807442(30)Ohm accuracy can be increased by an order of magnitude today. So the RK=e^2/h makes the difference.

4. 2019 form Codata given alphaC= 1/137.035999177

5. 2019 from Codata given alphaRKC=1/137.035999127 based on RKC= 25812.807450(00)Ohm (exact defined) does not match. The presentation contains two answers to the question about tension. Critics appreciated. (A. Einstein: Ein Problem kann man nicht mit der Denkweise lösen, durch die es entstanden ist.)

T 88.4 Fri 9:45 ZHG105

Uniqueness of unification — •Christoph Schiller — Motion Moutain Research, Munich

A unified description of motion that includes general relativity and the standard model of particle physics with massive neutrinos must be unique, without inequivalent alternative, and must agree with the observed invariant Planck limits for speed, action, entropy and force. It is first argued that the Planck limits imply

* that space, horizons, wave functions and fields are neither continuous nor discrete,

* that nature at the Planck scale cannot be described with equations,

* that all motion in nature – that of quantum particles, of black hole horizons, and of curved space – results from unobservable filiform, and tangled constituents of Planck radius that follow a simple *fundamental principle.*

For fermions, this closely resembles the description used by Dirac in his lectures. Step by step, it is found that other constituents, other descriptions of quantum effects and wave functions, other gauge groups, other elementary particles, other Feynman vertices, other values of the fundamental constants, other numbers of dimensions, other theories of gravitation, and other Lagrangians contradict the observed Planck limits. As a result, a unified description of motion must be based on the topology and statistics of tangled constituents. In total, only the fundamental principle implies general relativity and the standard model with massive neutrinos. Any measurable deviation is excluded.

Details and publications at https://motionmountain.net/research

T 88.5 Fri 10:00 ZHG105

Compositeness and spatial extension of fundamental particles in a circular extra space — •Hans-Dieter Herrmann — Berlin

A particle model is proposed living in space-time as well as in an extra space complementing space-time, called basic space. The models in basic space called 'birotons' consist of two 'rotons' with nearly equal masses. Birotons have a composited spin of 1/2 h_bar and show four spinor-like states. The rotons perform a circular motion with a 4π- resp. a 2π-cycle. This geometric difference causes a symmetry violation corresponding to the weak parity violation. The mass symmetry and the spin-asymmetry between the two rotons represent an internal super-symmetry.The charge of the biroton is attached to only one of the two rotons, this results in gyromagnetic factors of 1 and 0 for the rotons, however nearly 2 for the biroton. The biroton has two modes of translation: a local mode (corpuscle-picture) and a nonlocal mode (corresponding to a picture of two parallel probability waves). In the nonlocal mode the rotons including their partial masses have different positions in space-time that causes quantum nonlocality as well as a nonlocal gravity of the same origin. The dual space-concept applied for the model contruction has a philosophical foundation, see https://philarchive.org/archive/HERACQ.

T 88.6 Fri 10:15 ZHG105

Kaluza + spin — •Thomas Schindelbeck — IRAEPH Mainz

A modified Kaluza model plus Spin 1/2 as boundary condition provides the symmetry of the elementary fermion zoo, a converging energy series that covers the range from the electron to the Higgs, as well as other particle properties such as magnetic moment or coupling constants.

The calculations are ab initio and typically yield an accuracy in the range of QED corrections.

https://zenodo.org/record/3930485

T 89: Axions/ALPs III

Time: Friday 9:00–10:30 Location: VG 0.110

T 89.1 Fri 9:00 VG 0.110

Advancing Axion Detection: Cryogenic Calibration and Dark Matter Search with MADMAX — •Juan Maldonado for the MADMAX-Collaboration — maldonad@mpp.mpg.de

Discovery of the axion could solve both the strong CP problem, fundamental in particle physics, and the dark matter problem. The MAgnetized Disc and Mirror Axion eXperiment - MADMAX - is a project based on the novel dielectric haloscope concept to detect axion dark matter in the mass range around 100 ueV through enhancement of the inverse Primakoff process. The higher precision required to operate an axion haloscope at a mass range above 40*eV corresponding to a frequencies greater than 10 GHz poses additional challenges in the realm of microwave engineering and cryogenics, with potential applications to other fields of research. In this talk, I will present the cryogenic calibration of the experimental setup and discuss a first dark matter search using a MADMAX prototype at a temperature below 10 K, performed at CERN in 2024.

T 89.2 Fri 9:15 VG 0.110

Commissioning The RADES axion haloscope of MPP — Babette Döbrich, Cristian Cogollos, José María García Barceló, and •Ziheng Yang — Max-Planck-Institut für Physik, Munich

The Axion is a pseudoscalar particle to solve the problem of the non-observation of CP violation in strong interactions, in a simple and compelling fashion. In this framework axions will have a very small mass and interact with other particles very weakly which makes they are an idea candidate for dark matter. The inverse Primakoff effect is commonly employed as detection method. Axions will transform into photons under strong magnetic fields. We report on the status of the RADES experiment at MPP Munich. In this experiment, we place the cavity at a temperature of 7mK and a magnetic field of 12T. In this talk we will also elaborate on the injection of realistic synthetic axion signals to test that the setup is performing as foreseen.

T 89.3 Fri 9:30 VG 0.110

Study of Higgs decays into long lived Axion-Like Particles with the ATLAS Experiment — •Janek Both, Christian Schmitt, Kristof Schmieden, and Volker Büscher — Johannes Gutenberg-Universität Mainz

Axion-Like Particles (ALP) or more generally, pseudoscalars that are gauge singlets under the Standard Model gauge group, appear in many well-motivated extensions of the Standard Model. These particles are naturally assumed to be light compared to the electroweak scale and might for example provide insides into the nature of dark matter. In scenarios where the ALP couples to the Higgs boson, collider searches can provide sensitivity to ALPs in the GeV range and thus offer a complementary approach to other experiments that mainly focus on lighter ALPs. Depending on the coupling strengths of the ALP, it might decay displaced from the primary vertex inside the calorimeters of the ATLAS detector. Such a signature would be almost background free and hence can be reconstructed with high efficiency. In this talk, a study of long-lived ALP decays inside the ATLAS calorimeter is presented and projected exclusion limits in the ALP mass and photon-coupling plane for an integrated luminosity of 1000 fb^{-1} are shown. The future dataset will greatly improve upon the existing ATLAS run-2 and run-3 analyses, which focus on displaced ALP decays within the tracking system.

T 89.4 Fri 9:45 VG 0.110

Solar axion couplings from the Nuclear Spectroscopic Telescope Array — •Jaime Ruz and Julia Vogel — Fakultät für Physik. Technische Universität Dortmund. Dortmund, D-44221, Germany

Data from the Nuclear Spectroscopic Telescope Array (NuSTAR) collected during the 2020 solar minimum, along with advanced solar atmospheric magnetic field models, establish a new limit on the axion-photon coupling strength $g_{a\gamma} \lesssim 6.9 \times 10^{-12}$ GeV^{-1} at 95% C.L. for axion masses $m_a \lesssim 2 \times 10^{-7}$ eV. This constraint surpasses current ground-based experimental limits, studying previously unexplored regions of the axion-photon coupling parameter space up to masses of $m_a \lesssim 5 \times 10^{-4}$ eV. These findings mark a significant advancement in our ability to probe axion properties and strengthen indirect searches for dark matter candidates.

T 89.5 Fri 10:00 VG 0.110

First search for axion dark matter using a MADMAX prototype — •David Leppla-Weber for the MADMAX-Collaboration — Deutsches Elektronen-Synchrotron DESY, Germany

The nature of dark matter is one of the biggest open questions in physics today. One possible answer is the axion, which was originally predicted as a solution to the strong CP problem but also makes for an excellent cold dark matter candidate. The MAgnetized Disk and Mirror Axion eXperiment (MADMAX) aims at detecting axions from the galactic dark matter halo in the theoretically well motivated mass range around 100 μ eV using a dielectric haloscope. It utilizes a booster system consisting of a stack of dielectric disks and a mirror to resonantly enhance the axion-photon conversion in a magnetic field. Results of the first axion dark matter search using a MADMAX prototype are shown and the calibration procedure is explained. A system with three ø 200 mm sapphire disks in a < 1.6 T magnetic field was used. No dark matter signal was observed. The results demonstrate the feasibility of such systems and their capability to reach unexplored parameter space.

T 89.6 Fri 10:15 VG 0.110

First Results of the Any Light Particle Search II (ALPS II) — •Todd Kozlowski for the ALPS-Collaboration — Deutsches Elektronen-Synchrotron DESY

The Any Light Particle Search II (ALPS II) is an ongoing 'light-shining-through-a-wall' experiment located at DESY in Hamburg, designed to probe the existence of lightweight bosons through their coupling to photons in a background magnetic field. ALPS II leverages technology developed specifically for this task, including a record-breaking long-baseline optical cavity, an ultra-sensitive detector capable of measuring coherent powers as low as 10^{-24} W, and a sophisticated optical control system. Since beginning operation in May 2023, ALPS II has conducted several successful measurement campaigns. In this talk, I will discuss the initial results and outline planned upgrades to further enhance the experiment*s sensitivity.

T 90: Silicon Detectors VII (ATLAS + CMS phase-2)

Time: Friday 9:00–10:30 Location: VG 0.111

T 90.1 Fri 9:00 VG 0.111

The ATLAS ITk cell integration site in Bonn — •Alexandra Wald, Klaus Desch, Matthias Hamer, Florian Hinterkeuser, Nico Klein, and Dominik Hauner — PI, Uni Bonn, Germany

In conjunction with the high luminosity upgrade of the Large Hadron Collider at CERN, the current tracking system of the ATLAS experiment will be replaced by the Inner Tracker (ITk), an all-silicon detector consisting of 5 layers of pixel detectors and 4 layers of strip detectors. More than 8000 modules will be installed in the pixel layers, which together have an active area of approximately $13\mathrm{m}^2$ and cover a pseudorapidity of up to 4. In order to build such a large detector in time, the integration of the ITk Pixel modules on their local support structures (so-called longerons or inclined halfrings(IHR)), as well as the quality control of individual loaded local supports will be distributed over many institutes. One of the assembly lines will be setup at the University of Bonn, with technicians from other German locations also helping with cell integration. Due to the serial powering scheme of the ITk Pixel Detector, the quality control of a loaded local support is challenging in several aspects, as the simultaneous operation of multiple modules is necessary for any tests. A large number of different components must hence be integrated into the quality control setup, such as an optical readout system, an interlocks system, industrial power supplies and a scalable DCS.

In this talk, the current status of the LLS assembly line in Bonn is presented, and results from the integration of the first inclined half-ring are shown.

T 90.2 Fri 9:15 VG 0.111

Electrical testing of loaded cells for the ATLAS ITk Pixel loaded local support pre-production — •Nico Klein, Desch Klaus, Matthias Hamer, Florian Hinterkeuser, Alexandra Wald, and Dominik Hauner — Physikalisches Institut, Universität Bonn, Deutschland

The high luminosity upgrade for the Large Hadron Collider at CERN requires a complete redesign of the current tracking detector of the ATLAS experiment. The new Inner Tracker, the ITk Detector, will consist of a silicon pixel detector and a silicon strip detector. The ITk Pixel Detector is divided into three subsystems, the Outer Barrel (OB), Outer Endcaps and Inner System. In the OB, modules are loaded on thermally conducting cells (now called loaded cells) before they are mounted on the local supports (so-called longerons and half-rings). Before the loaded cells are mounted on the support structures, they are individually tested for basic functionality after shipment. In this talk I will present the results of the reception tests of the loaded cells for the first pre-production half-ring that has been assembled in Bonn.

T 90.3 Fri 9:30 VG 0.111

Assembly and test procedures of silicon detector modules for the Phase-2 Upgrade of the CMS Outer Tracker and the current status of production — •Stefan Maier, Tobias Barvich, Bernd Berger, Alexander Dierlamm, Ulrich Husemann, Markus Klute, Kai Kraemer, Waldemar Rehm, Hans Jürgen Simonis, and Lea Stockmeier — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

In preparation for the High Luminosity LHC, the entire tracker of the CMS experiment will be exchanged within the Phase-2 Upgrade until 2029. The new outer tracker will be made of approximately 13000 silicon sensor modules which come in two types: 2S modules (consisting of two parallel silicon strip sensors) and PS modules (one pixel and one strip sensor combined in a module). With these modules the tracker provides tracking information to the Level-1 trigger. By correlating the hit information of both sensor layers in the magnetic field of CMS and, thus, allowing to suppress charged particles with low transverse momentum (<2GeV/c), the corresponding hit data can be read out every 25 ns. To guarantee successful operation of the CMS detector at the HL-LHC, the production of the outer tracker modules has to fulfil strict requirements. The production is distributed among several institutes all around the world to achieve the required module assembly rates. The talk will shortly explain the assembly and test procedures of 2S modules at KIT and summarize the status of the production which started recently.

T 90.4 Fri 9:45 VG 0.111

Thermal Integration Test with 2S Module Prototypes for the Phase-2 Upgrade of the CMS Outer Tracker — •Lea Stockmeier[1], Alexander Dierlamm[1], Ulrich Husemann[1], Stefan Maier[1], and Cristiano Turrioni[2] — [1]Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT) — [2]National Institute for Nuclear Physics (INFN), Perugia Unit

To deal with the increased luminosity of the HL-LHC, the CMS experiment will be upgraded until 2029. During this Phase-2 Upgrade, the CMS Outer Tracker will be equipped with modules each assembled with two silicon sensors. Depending on the position in the tracker, these silicon sensors are pixel or strip sensors. The modules with two strip sensors are called 2S modules. In the barrel region, they are placed on mechanical structures called ladders. A fully equipped ladder contains twelve modules.

During the prototyping phase of the modules, integration tests are performed with the purpose of testing the integration procedure itself as well as the module functionality on the final detector structures. Investigations focus on the cooling performance as well as on electrical performance of the modules on the supporting structures.

This talk summarizes an integration test with twelve 2S modules on a ladder performed at CERN in cooperation with other CMS working groups. The test focuses on thermal aspects of the performance of a 2S module built with sensors irradiated with protons to the expected lifetime fluence.

T 90.5 Fri 10:00 VG 0.111

Thermal Cycling of Modules for the Upgrade of the CMS Outer Tracker — •Aenne Abel[1,2], Ana Ventura Barosso[1], Günther Eckerlin[1], and Andreas Mussgiller[1] — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg — [2]University of Hamburg, Hamburg, Germany

At the high-luminosity LHC the CMS Tracker will be faced with unprecedented instantaneous luminosity. To cope with this harsh environment, the existing tracker will be replaced with a completely new system that will operate at -35 degree C. As a final step of quality control each module has to undergo several thermal cycles between room and operation temperature, which is called burn-in. The presentation will introduce the burn-in setup at DESY and discuss the current status and foreseen testing procedures.

T 90.6 Fri 10:15 VG 0.111

In-Time Efficiency of ITk pixel modules using the ITkPixV1.1 front end — •Christopher Krause, Kevin Kröninger, Jens Weingarten, and Tobias Bisanz — TU Dortmund, Germany

The ATLAS Inner Tracker (ITk) will replace the Inner Detector of the ATLAS experiment for the High-Luminosity phase of the LHC. To ensure an excellent tracking performance of the silicon pixel and strip sensors of the ITk under the harsh HL-LHC environment, their performance has to be thoroughly tested and validated in testbeam facilities before installation. A crucial property of the pixel modules is their efficiency in regard to the phase of the 40 MHz clock of the LHC and the detector systems. As these modules can only record hits during the single 25 ns long readout time frame, evaluating their performance in dependence on the time is important to ensure a high tracking efficiency. To determine the in-time efficiency of an ITk pixel module, the clock of the DUT and the BDAQ system that is used to read out the data were synchronized. This talk presents the beam test results of In-Time efficiency measurements of an unirradiated 3D pixel module using the ITkPixV1.1 front end. The collected data was analysed with the track reconstruction framework Corryvreckan.

T 91: Silicon Detectors VIII (MAPS, misc.)

Time: Friday 9:00–10:30 Location: VG 1.101

T 91.1 Fri 9:00 VG 1.101

All-Silicon Modules — Hans Krüger, Marco Vogt, •Andreas Ulm, and Jochen Dingfelder — Universität Bonn

Silicon pixel detectors are an essential part of modern tracking systems for high energy physics experiments as they meet the requirements of high spatial and time resolution, and relatively low material budget. To cover large areas in the detector volume individual chips are combined to create modules. These modules are easier to assemble to full tracking systems. However gluing, additional flex PCBs, cooling and support structures, and also structural silicon can introduce significant amounts of material.

To reduce the material budget of tracking detectors as much as possible, a new concept of module building is investigated. By post-processing monolithic chip wafers, redistribution layers can be built on top of the chips for electrical connections to 4 chips in a row. By using low-power monolithic chips air cooling may be feasible and mechanical support is not necessary for thin ladder structures of up to 15 cm in length with thicknesses around 400 microns.

This talk will discuss concepts, ideas and first steps to prototyping such all-silicon modules.

T 91.2 Fri 9:15 VG 1.101

Performance of irradiated TJ-Monopix2 depleted monolithic active pixel sensors — •Lars Schall, Christian Bespin, Ivan Caicedo, Jochen Dingfelder, Fabian Hügging, Hans Krüger, Rasmus Partzsch, Norbert Wermes, and Sinuo Zhang — Physikalisches Institut der Universität Bonn, Bonn, Germany

Monolithic active pixel sensors with depleted substrates present a promising option for pixel detectors in high-radiation environments. Leveraging high-resistivity silicon substrates and high bias voltages in commercial CMOS technologies facilitates full depletion of the charge sensitive volume and enhances the radiation tolerance and charge collection performance. TJ-Monopix2 is the most recent large-scale chip in its respective development line, originally designed for the outer layers of the ATLAS Inner Tracker. TJ-Monopix2 is designed in 180 nm TowerJazz CMOS technology and features a small charge collection electrode, which requires the separation of the in-pixel electronics into p-wells. Process modifications in form of an additional n-type implant minimize regions with low electric field and improve the charge collection efficiency impaired by the long drift distances. The small pixel size of 33 x 33 μm^2 reduces the detector capacitance to approximately 3 fF enhancing noise and power performance. This contribution focuses on the performance of TJ-Monopix2 chips after irradiation to 5e14 neq/cm^2 NIEL fluence and 100 Mrad in total ionizing dose. Latest laboratory and beam test measurements are presented.

T 91.3 Fri 9:30 VG 1.101

Grazing Angle Test Beam Studies of the Hybrid-to-Monolithic MAPS Prototype — •Ono Feyens, Sara Ruiz Daza, Finn King, and Simon Spannagel — Deutsches Elektronen-Synchrotron DESY, Germany

The TANGERINE (Towards Next Generation Silicon Detectors) project at DESY investigates and develops fully integrated Monolithic Active Pixel Sensors (MAPS) using a novel 65 nm CMOS imaging technology. MAPS are an attractive technology for vertex detectors at future lepton colliders where a unique combination of high spatial resolution ($\lesssim 3$ μm), fast timing ($\sim$ ns) and low material budget ($\lesssim 50$ μm) are required. The 65 nm technology enables the production of MAPS with an increased density of in-pixel logic.

The H2M (Hybrid-to-Monolithic) prototype is the latest chip in a series of technology demonstrators. Its design ports a hybrid pixel-detector architecture into a monolithic chip with a pixel matrix of 64x16 square pixels of size 35x35 μm^2. To investigate the internal electric field and charge collection characteristics of H2M, grazing angle studies are performed at the DESY II Test Beam Facility. Here, particles impinge the sensor at very shallow angles, enabling the extraction of charge collection as a function of depth. This contribution will provide an overview of the experimental setup and will show first results of the grazing angle measurements.

T 91.4 Fri 9:45 VG 1.101

Charge calibration and reconstruction from binary hit data with MALTA2 a monolithic active pixel sensor — •Lucian Fasselt[1,2] and Steven Worm[1,2] — [1]DESY, Zeuthen, Germany — [2]Humboldt University, Berlin, Germany

MALTA2 is a depleted monolithic active pixel sensor (DMAPS) designed for tracking at high rates and is produced in the modified Tower Jazz 180nm CMOS technology. The sensing layer of the pixels with 36.4um pitch consists of either high resistivity epitaxial or Czochralski silicon. A small collection electrode features a small pixel capacitance and offers low noise. Typically, the detection threshold is around 200e-. A simple procedure is developed to calibrate the threshold to electrons making use of a dedicated charge injection circuit and an Fe-55 source with main charge deposition of 1600e-.

In this contribution, MALTA2 sensors are characterised in terms of hit detection efficiency inside the pixel and cluster size at fine threshold steps, for samples produced with different doping concentration of the internal n- layer, substrate voltage and irradiation dose. Test beam data was taken at CERN SPS in 2023 and 2024, using a MALTA beam telescope consisting of multiple sensor planes with 4um spatial and 2ns timing resolution. A reconstruction of the signal amplitude from binary hit data is performed. Through the charge calibration a two-dimensional map of the collected charge is obtained with sub-pixel resolution. The presented method provides an in-beam alternative to grazing angle studies or Edge-TCT for determining a charge collection profile.

T 91.5 Fri 10:00 VG 1.101

TelePix2: A HV-CMOS pixel sensor for Fast Timing and Region of Interest Triggering — •Arianna Wintle[1], Andre Schöning[2], David Immig[2], Felix Sefkow[1], Heiko Augustin[2], Ivan Peric[3], Lennart Huth[1], Lucas Dittmann[2], Marcel Stanitzki[1], and Ruben Kolb[2] — [1]Deutsches Elektronen-Synchrotron — [2]Heidelberg University — [3]The Karlsruhe Institute of Technology

The DESY II Test Beam Facility offers electrons with a user selectable momentum from 1-6 GeV primarily for detector characterisation. TelePix2, a HV-CMOS sensor, is the latest new user infrastructure at the test beam facility used as an arbitrary Region of Interest (ROI) trigger and a timing plane, for efficient small prototype testing and ambiguity suppression.

This contribution will highlight the importance of TelePix2 in the context of user operation at the test beam facility whilst providing an insight into test beam user infrastructure. The latest performance metrics of TelePix2 including an efficiency above 99 %, a timestamp resolution below 4 ns, and a ROI trigger time resolution below 2.5 ns will be presented.

T 91.6 Fri 10:15 VG 1.101

Investigation of the Belle II Pixel Detector Power Supply Network — •Paula Scholz[1], Florian Bernlochner[1], Jochen Dingfelder[1], Hans Krüger[1], Jannes Schmitz[1], and Botho Paschen[2] — [1]Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn — [2]Lawrence Berkeley National Laboratory

During beam loss events at the particle accelerator SuperKEKB in Japan, large amounts of radiation can severely damage the innermost layers of the Belle II detector, the Pixel Detector (PXD). Due to an increasing frequency of these events, the PXD has been shut down since May 2024 to prevent further harm.

The PXD consists of silicon pixel matrices based on the DEpleted P-channel Field Effect Transistor (DEPFET) technology. To control these matrices, Application-Specific Integrated Circuits (ASICs), the so-called „switchers“, are implemented on each module. During each readout cycle (50kHz), these switchers switch voltage levels of 20 V within a few nanoseconds. Since the PXD has been shown to be safe when the switchers are unpowered, a secure method to rapidly power down modules during beam loss events is needed. However, the powering network that involves 23 interdependent voltages, complicates this task.

To address this issue, a simulation of the PXD powering scheme, which includes more than 15 m long cables, has been developed. The transmission of emergency shutdown signals is studied by comparing simulation results with experimental data. The goal is to identify hardware modifications for safe PXD operation.

T 92: Detectors VIII (Gaseous Detectors)

Time: Friday 9:00–10:30 Location: VG 1.102

T 92.1 Fri 9:00 VG 1.102

Stability and Performance studies of upgraded Gas Monitoring Chambers for the T2K Near Detector — •Ziyan Cao, Stefan Roth, David Smyczek, Jochen Steinmann, and Nick Thamm — RWTH Aachen University - Physik Institute III B, Aachen, Germany

As part of the T2K ND280 near detector upgrade, Gas Monitoring Chambers (GMCs) are used to monitor key gas parameters such as drift velocity and gain, ensuring precise calibration of Time Projection Chambers(TPCs). This work focuses on evaluating the performance of upgraded GMCs with new features, including comparative analyses of drift velocity and gas gain with previous models and simulations. Observed discrepancies prompted systematic investigations into factors such as gas flow configuration, flow rate, and chamber stability. The results from testing the newly designed Micromegas will also be presented.

T 92.2 Fri 9:15 VG 1.102

Development of a novel GEM based neutron detector with VMM readout — •Jan Glowacz[1], Thomas Block[1], Klaus Desch[1], Saime Gürbuz[1], Jochen Kaminski[1], Markus Köhli[2], and Michael Lupberger[1] — [1]University of Bonn — [2]Heidelberg University

For the neutron science community the increase in price for Helium-3 has sparked the interest in detectors based upon solid neutron converters like Boron or Gadolinum. The boron based multi stage tracking detector (BASTARD) is a neutron detector, with a focus on high spatial resolution and high readout rates. It consists of a multi layer gaseous detector chamber with boron coated cathodes for neutron conversion. The boron captures the neutrons and decays into helium and lithium ions. The ions are detected with a high position resolution. The readout allows for rates of up to 10 Mhz and is realized with VMM3a hybrids via the RD51 Scalable Readout System. A prototype detector with an active area of 10cm x 10cm is being assembled. We plan to present our first experiences with it.

T 92.3 Fri 9:30 VG 1.102

A Straw Tracker Prototype for SHiP — •Wei-Chieh Lee, Caren Hagner, and Daniel Bick — Institut für Experimentalphysik, Universität Hamburg, Hamburg, Deutschland

SHiP (Search for Hidden Particles) is a general-purpose beam-dump experiment at the CERN SPS accelerator designed for the search of feebly interacting particles. In this experiment, the spectrometer straw tracker (SST) is located downstream of the hidden sector decay volume, and tracks the decay products of the hidden particles for the reconstruction of the decay vertex, the mass and the impact parameter of these particles. As the main component of the SST, straw tubes function as wire-based gaseous detectors that are robust and have little material budget for the purpose of minimizing multiple scatterings. The University of Hamburg is participating in the design and prototyping of the SST with the goal of optimization of the mechanical stability and the assembly strategy. In this presentation, a straw tracker prototype will be introduced with the plans of its future testing.

T 92.4 Fri 9:45 VG 1.102

Development of a straw-tube chamber prototype for the inner detector of a future e^+e^- collider experiment — •Julia Okfen, Davide Cieri, Francesco Fallavollita, Oliver Kortner, Sandra Kortner, Hubert Kroha, Giorgia Proto, Robert Richter, Elena Voevodina, and Jörg Zimmermann — Max Planck Institut für Physik

The future e^+e^- collider provides a unique opportunity for precision measurements of the Higgs boson and electroweak properties. The process $e^+ + e^- \rightarrow Z^* \rightarrow Z + H$ allows Higgs detection via the recoil momentum, independent of the Higgs decay modes. The precise momentum measurement of the Z-boson decay particles is crucial, requiring an accuracy at the level of 0.1% for $p_T \approx$

50 GeV/c, commensurate with the narrow spread of the center-of-mass energy. Such precision can only be attained using silicon sensors that offer position resolutions on the order of a few μm. However, gaseous-based technologies are essential for particle identification via dE/dx measurements along charged particle trajectories. To prevent a significant compromise of momentum resolution due to excessive multiple scattering, the detector material must be minimized. Straw tube chambers meet these requirements and add advantages: each unit operates independently, so a broken wire affects only one tube. They also offer flexibility in gas choice and volume instrumentation. This contribution will present a concept for an inner detector with straw tube and the design, production, and test of a straw-tube prototype chamber.

T 92.5 Fri 10:00 VG 1.102

Research and Development of an Inverted RICH Detector — •Daniel Grewe, Otmar Biebel, Valerio D'Amico, Stefanie Götz, Ralf Hertenberger, Eshita Kumar, Nirmal Mathew, Nick Schneider, Chrysostomos Valderanis, and Fabian Vogel — LMU München

In high-energy physics experiments, Ring Imaging Cherenkov Detectors (RICH) play an important role in identifying charged particles with known momenta. An inverted RICH detector takes a novel approach by reconstructing the momentum of a known particle through the measurement of its Cherenkov cone. A previous prototype employs a Lithium Fluoride (LiF) crystal to generate Cherenkov photons, which are converted to electrons via a Cesium Iodid (CsI) photocathode. The electrons are detected using a resistive strip Micromegas. While functional, this prototype requires further optimization. The CsI photocathode is highly sensitive to humidity, prompting the exploration of Diamond-Like Carbon (DLC) photocathodes as robust alternatives. To enhance the efficiency of detecting electrons generated in the photocathode, various counting gases are examined.

This talk will introduce the fundamental principles behind the inverted RICH Detector and highlight the latest developments in its prototype design, offering insights into the challenges and innovations shaping its evolution.

T 92.6 Fri 10:15 VG 1.102

Preparations for Upgrading the ND280 Gas Monitoring Chambers — Ziyan Cao, Stefan Roth, •David Smyczek, Jochen Steinmann, and Nick Thamm — RWTH Aachen University - Physics Institute III B, Aachen, Germany

A new pair of Time Projection Chambers for high angle measurements (HATs) have been installed during the upgrade of the T2K near detector ND280. To improve their calibration, the gas parameters will be continuously monitored using upgraded Gas Monitoring Chambers (GMCs). To upgrade the current Gas Monitoring Chambers several new features in hard and software have to be tested. These features include a new preamplifier, a new temperature controlled SiPM trigger and new readout software. These new features and results of their tests will be presented.

T 93: Top Physics IV (Misc.)

Time: Friday 9:00–10:00 Location: VG 1.103

T 93.1 Fri 9:00 VG 1.103

Studying Machine Learning Techniques to Improve Statistical Precision of Monte Carlo Samples in Top Quark Measurements — •Lennert Griesing, Hartmut Stadie, Peter Schleper, and Johannes Lange — Institute of Experimental Physics, Hamburg University, Germany

Precise measurements of top quark properties at the Large Hadron Collider (LHC) are crucial for testing the Standard Model and exploring new physics. In these measurements, Monte Carlo (MC) simulations are needed to compare theoretical predictions with experimental observables. To account for systematic uncertainties, MC samples are generated for different model parameters. Due to computational costs, these samples are produced with fewer events than the large default simulation sample. Thus, the smaller sample size limits their statistical precision and poses a challenge for nuisance parameter fits. A possible solution is to modify the large default simulation sample using machine learning techniques (ML) so that their distributions reflect the variations in the different model parameters. The aim is to evaluate the precision, accuracy, and potential biases introduced by applying these ML techniques to MC simulations of top quark pair production within the CMS experiment.

T 93.2 Fri 9:15 VG 1.103

Measurement perspectives of the top-antitop energy asymmetry in the production with an additional jet in the resolved topology with ATLAS — •Jessica Höfner, Annika Stein, Frederic Fischer, and Lucia Masetti — University Mainz, Insitute for physics

The top quark is the heaviest particle in the Standard Model (SM) of particle physics and the only quark which decays before hadronization can happen. The top quark is suitable for the search of physics beyond the SM of particle physics (BSM). There could be even heavier particles and they might become observable at higher center-of-mass energies, and the top quark could potentially interact with them. At the currently reachable center-of-mass energies, however, the impact of BSM physics might only be indirectly observable via the variation of properties of the production or decay of SM particles. In the production of a top-antitop pair with an additional jet at the LHC the energy asymmetry, complementary to the rapidity asymmetry, can be measured. The energy asymmetry is expected in the SM, but also sensitive to physics beyond the SM and therefore it is of high interest to measure this observable. After a first measurement of the energy asymmetry in the topology with a collimated hadronic top decay and a semileptonic decay with the ATLAS experiment, the future goal is to measure this observable in the full phase space. Therefore the event reconstruction in the resolved topology, in which the hadronic decaying top quark is reconstructed with several small-R jets, must be optimized. This presentation shows the current progress regarding this optimization.

T 93.3 Fri 9:30 VG 1.103

Optimal Observable Machine: The case of four top quark differential cross sections with SMEFT contributions. — •Alejandro Quiroga Trivino[1], Torben Mohr[1], Matteo Defranchis[2], Jan Kieseler[1], Ankita Mehta[2], Artur Monsch[1], and Markus Klute[1] — [1]Karlsruhe institute of technology — [2]CERN

Identifying optimal observables that are maximally sensitive to Standard Model Effective Field Theory (SMEFT) coefficients, while systematically accounting for uncertainties, is crucial for constraining new physics. This study focuses on developing strategies to determine such observables, with particular attention to minimizing total uncertainties and maximizing sensitivity to SMEFT effects. As a case study, we investigate four-top quark production in proton-proton collisions at a center-of-mass energy of 13.6 TeV. This rare process, characterized by an energetic final state and a tiny cross section, provides a unique testing ground for SMEFT contributions. Specifically, we analyze the effects of a heavy-quark operator with Wilson coefficient ctt1*, employing systematic-aware training to achieve precise constraints in ctt1. This talk will present our approach, highlight progress in identifying optimal variables, and discuss the implications for measuring SMEFT coefficients and uncovering potential new physics.

T 93.4 Fri 9:45 VG 1.103

Search for heavy right-handed Majorana neutrinos in the decay of top quarks produced in proton–proton collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector — •Diptaparna Biswas[1], Markus Cristinziani[1], Nikolina Ilic[2], Lianliang Ma[3], Oğul Öncel[4], Sebastien Roy-Garand[2], Mário José da Cunha Sargedas de Sousa[5,6], and Tongbin Zhao[1,3] — [1]Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen, Germany — [2]University of Toronto, Canada — [3]Shandong University, China — [4]Albert-Ludwigs-Universität Freiburg, Germany — [5]INFN Genova, Italy — [6]Università di Genova, Italy

A search for heavy right-handed Majorana neutrinos is performed with the ATLAS detector at the CERN Large Hadron Collider, using the Run-2 dataset. This search targets $t\bar{t}$ production, in which both top quarks decay into a bottom quark and a W boson, where one of the W bosons decays hadronically and the other decays into an electron or muon and a heavy neutral lepton. The heavy neutral lepton is identified through a decay into an electron or muon and another W boson, resulting in a pair of same-charge same-flavor leptons in the final state. This talk presents a search for heavy neutral leptons in the mass range of 15 – 75 GeV using $t\bar{t}$ events. No significant excess is observed over the background expectation, and upper limits are placed on the signal cross-sections. Assuming a benchmark scenario of the phenomenological type-I seesaw model, these cross-section limits are then translated into upper limits on the mixing parameters of the heavy Majorana neutrino with Standard Model neutrinos.

T 94: Flavour Physics VI

Time: Friday 9:00–10:30 Location: VG 1.104

T 94.1 Fri 9:00 VG 1.104

Test of Lepton Flavour Universality with $\Lambda_b^0 \to pK^-\ell^+\ell^-$ decays at LHCb — Johannes Albrecht[1], Vitalii Lisovskyi[2], and •Jannis Speer[1] — [1]TU Dortmund University, Dortmund, Germany — [2]CPPM, Marseille, France

Rare decays mediated by $b \to s\ell^+\ell^-$ transitions provide a diverse range of probes for the SM. These include null tests of fundamental principles of the SM, such as lepton flavour universality (LFU), which asserts that the gauge bosons couple equally to all three generations of leptons.

The LHCb experiment has performed several measurements of LFU in rare decays, most prominently the ratio of branching fractions between b-meson decays with electrons and muons in the final state. LFU can also be studied in rare b-baryon decays, which are affected by partly orthogonal experimental and theoretical uncertainties. The first measurement of the ratio of branching fractions of the decays $\Lambda_b^0 \to pK^-e^+e^-$ and $\Lambda_b^0 \to pK^-\mu^+\mu^-$, R_{pK}^{-1}, was performed by the LHCb collaboration using pp collision data corresponding to an integrated luminosity of 4.7 fb^{-1}. The ratio was measured to be $R_{pK}^{-1} = 1.17^{+0.18}_{-0.16} \pm 0.07$ in the dilepton mass-squared range $0.1 < q^2 < 6.0\,\mathrm{GeV}^2/\mathrm{c}^4$ and the pK mass range $m(pK) < 2600\,\mathrm{MeV/c}^2$. The updated measurement of R_{pK}^{-1} aims to minimize the uncertainties by using the full 9 fb^{-1} LHCb pp dataset and implementing enhanced analysis techniques.

This contribution provides an update on the current progress of the ongoing analysis.

T 94.2 Fri 9:15 VG 1.104

Search for $B^+ \to K^{*+}\tau^+\tau^-$ with Hadronic Tagging at the Belle II experiment — •Lennard Damer, Torben Ferber, and Pablo Goldenzweig — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

In recent years, intriguing hints for violation of lepton flavor universality have been accumulated in semileptonic B decays with the help of various experiments.

The flavor-changing neutral current process $b \to s\tau^+\tau^-$ is particularly sensitive to models which feature large couplings to third generation leptons or couplings proportional to the particle mass. Some theoretical models allow for an increase in the branching fraction of up to three orders of magnitude compared to the Standard Model prediction, which is within the observable range of the Belle II experiment.

In this analysis, hadronic tagging is employed where the corresponding B meson partner in $\Upsilon(4S)$ decays is reconstructed in a variety of hadronic decay chains to increase the selection purity.

This talk presents the status of the first search for $B^+ \to K^{*+}\tau^+\tau^-$ decays along with an estimate on the signal sensitivity.

T 94.3 Fri 9:30 VG 1.104

Fully inclusive analysis of untagged $B \to X\ell^+\ell^-$ decays at Belle II — •Arul Prakash, Sviatoslav Bilokin, Nikolai Krug, and Thomas Kuhr — Ludwig-Maximilians-Universität München

In recent years various deviations from the standard model expectation were observed in $b \to s\ell^+\ell^-$ measurements, dominated by exclusive studies. The combined deviations, while being large, are still not above the 5σ discovery threshold, partially owing to theoretical uncertainties. Precision measurements of inclusive $B \to X\ell^+\ell^-$ decays can provide invaluable complementary information to scrutinize anomalies observed in their exclusive decay counterparts. However, limited tagging efficiency, small Standard Model signal and very high background rate make these measurements extremely challenging, with no results being published so far.

In our work, we will evaluate the chances of a 5σ result with data from the Belle and Belle II experiments and estimate systematics with Monte Carlo simulations. We will apply machine learning algorithms to tackle background rejection. We will finally measure the branching fractions $B(B \to X\mu^+\mu^-)$ and $B(B \to Xe^+e^-)$ which will be key to constrain potential New Physics contributions.

T 94.4 Fri 9:45 VG 1.104

Early measurement of $r_{J/\psi}^{K,K^*}$ with 2024 data — Johannes Albrecht[1], Michele Atzeni[2], Lukas Calefice[3], Angel Fernando Campoverde Quezada[4], James Gooding[1], Carla Marin Benito[5,3], •Lorenzo Nisi[1], Renato Quaglani[5], Alessandro Scarabotto[1], Eluned Smith[2], and Pol Vidrier Villalba[3] — [1]TU Dortmund University, Dortmund, Germany — [2]Massachusetts Institute of Technology, Cambridge, United States — [3]Universitat de Barcelona, Barcelona, Spain — [4]University of Chinese Academy of Sciences, Beijing, China — [5]CERN, Geneva, Switzerland

During 2024, the LHCb experiment collected more than 9 fb^{-1} of integrated luminosity for pp collisions, recording approximately as many collisions as between 2011 and 2018. The performance of the upgraded LHCb detector in Run 3 of the LHC must be fully understood to perform precise measurements with this new dataset.

Measurements of ratios between B meson decays to final states containing different lepton pairs can be used to study lepton flavour universality, e.g., R_{K,K^*} between $B^{+(0)} \to K^{+(0*)}\mu^+\mu^-$ and $B^{+(0)} \to K^{+(0*)}e^+e^-$ decays. The $J/\psi \to \ell\ell$ resonant modes are commonly used as control channels and their ratio $r_{J/\psi}^{K,K^*}$ is well-understood to be consistent with unity. As such $r_{J/\psi}^{K,K^*}$ can be used to validate detector performance and data-MC corrections.

This contribution presents the progress towards a measurement of $r_{J/\psi}^{K,K^*}$ using 2024 data.

T 94.5 Fri 10:00 VG 1.104

Dalitz analysis on $B^+- > K_S^0\pi^+\pi^0$ — •Oskar Tittel, Stefan Wallner, Hans-Günther Moser, and Markus Reif — Max-Planck Institut für Physik, München

The Belle II experiment in Tsukuba, Japan, is working at the high-intensity frontier of the search for physics beyond the Standard Model (SM). A direct test of the SM is the verification of the so-called "isospin sum-rule" in the $B \to K^*\pi$ system, which depends on the branching fractions (BF's) and the direct CP asymmetries of all $B \to K^*\pi$ decay modes. These quantities can be extracted from Dalitz analyses on the decay channels $B^0 \to K^+\pi^-\pi^0$ and $B^+ \to K_S^0\pi^+\pi^0$.

I will present the Belle II experiment, introduce the isospin sum rule and show the current state of the analysis on $B^+ \to K_S^0\pi^+\pi^0$.

T 94.6 Fri 10:15 VG 1.104

Search for the $B^0 \to D^0\bar{D}^0$ decay with the LHCb experiment — Johannes Albrecht, •Jonah Blank, Quentin Führing, and Sophie Hollitt — TU Dortmund University, Dortmund, Germany

With precise measurements of B meson decays, the LHCb experiment can test the integrity of the Standard Model of particle physics. $B \to DD$ decays are particularly interesting probes of CP violation, further constraining the unitarity triangle. While decays to charged $D^\pm$ mesons have already been well measured, the $B^0 \to \bar{D}^0D^0$ decay channel has not yet been observed by any experiment. In this analysis, data collected in pp collisions by the LHCb experiment at $\sqrt{s} = 7, 8$ and 13 TeV corresponding to an integrated luminosity of 9 fb^{-1} is used to search for the $B^0 \to \bar{D}^0D^0$ decay channel. The topologically similar $B^0 \to \bar{D}^0\pi^+\pi^-$ decay channel is utilized as a normalisation mode to cancel systematic uncertainties.

An update on the current status of the analysis will be presented.

T 95: Outreach

Time: Friday 9:00–10:15 Location: VG 1.105

T 95.1 Fri 9:00 VG 1.105

Public Multi-Experiment Higgs Analysis Demonstrator — Achim Geiser and •Lucas Karwatzki — Deutsches Elektronen-Synchrotron (DESY)

Open data offers new possibilities for a wider audience to access, reproduce and complement active research. In high-energy particle physics many challenges arise, due to several different data formats and large data samples. Therefore, a transformation of the open data to a common data format is used. This enables analysis to be performed within a single workflow and reduces the amount of data and computation time by two orders of magnitude.

Here we present an anlysis demonstrator developed in the context of the PUNCH4NFDI consortium showcasing the feasibility of analyzing Open Data from CMS and ATLAS at the same time. Further an example utilizing data from multiple CMS runs will be presented. The demonstrator uses the $H \to 4\ell$ channel and features various levels of complexity to cater to a wide range of users. This framework guides users from basic visualization of the four-lepton invariant mass spectra to producing the four-lepton invariant mass spectrum from transformed datasets within hours.

The talk will showcase the latest results of the analysis demonstrator, which may be used as an access point for future open data analysis.

T 95.2 Fri 9:15 VG 1.105

Von der Schulbank ins Studium - Nachwuchsförderung — •Heike Vormstein und Mia Smit für die Netzwerk Teilchenwelt-Kollaboration — Johannes Gutenberg-Universität, Mainz, Deutschland

Bekanntermaßen wünschen wir uns mehr Physikstudierende. Um dieses Ziel zu erreichen, ist es entscheidend, jungen Menschen zu zeigen, dass Physik spannend und modern ist. Dieser Vortrag beleuchtet, wie es gelingen kann, Interesse an Physik zu wecken und langfristig bis ins Studium zu begleiten.

Bereits in der Mittelstufe entwickeln viele Jugendliche Interesse an tiefergehenden Themen. Dies bietet eine hervorragende Gelegenheit, moderne Forschung näherzubringen und Begeisterung für Physik zu wecken. Da von der Mittelstufe bis zum Studium mehrere Jahre vergehen, ist es wichtig, das Interesse aufrechtzuerhalten.

Eine ehemalige Teilnehmerin verschiedener Angebote der Mainzer Physik berichtet, wie man junge Menschen dauerhaft für Physik begeistern und sie später im Studium wiedersehen kann. Der Beitrag richtet sich an Lehrkräfte, Wissenschaftler:innen und alle, die sich für eine nachhaltige Nachwuchsförderung in der Physik einsetzen möchten.

T 95.3 Fri 9:30 VG 1.105

CMS Masterclass 2: Discovering the Higgs Boson with Python Notebooks and CMS OpenData — •Christian Winter, Artur Monsch, Cedric Verstege, and Günter Quast — ETP, Karlsruhe Institute of Technology, Karlsruhe, Germany

The current CMS Masterclass focuses on the graphical analysis of event displays to teach how analyses work in high-energy physics. This Talk focuses on the experience on executing a new CMS Masterclass. In this CMS Masterclass the students use Python Notebooks and CMS OpenData to reconstruct the Higgs discovery channel $H \to ZZ \to 4\ell$ and measure the significance of their findings. This Masterclass was carried out for the second time as part of a week-long Science Camp for High School students, which focused on astro-/particle physics. Together with the experience gathered, improvements and the frame for such a Masterclass will be discussed. The possibility for other collaborations to have a simmilar Masterclass will be adressed, too.

T 95.4 Fri 9:45 VG 1.105

Build Your Own Particle Detector: Workshops for Schools and Universities — •Sebastian Laudage, Florian Bernlochner, and Maike Hansen for the Netzwerk Teilchenwelt-Collaboration — Physikalisches Institut, Universität Bonn, Nussalle 12, 53115 Bonn

In 2023 and 2024, we developed and tested interactive workshops at the University of Bonn under the motto "Build Your Own Particle Detector." These hands-on workshops enable participants, regardless of prior experience, to construct their own functional particle detector in just a few hours. Participants can then use these detectors to measure cosmic rays or natural background radiation, gaining direct insights into the invisible world of particle physics. Building on the lessons learned from these workshops, we are developing a next-generation detector concept designed to be versatile, user-friendly, and accessible to a broad audience, from school students to university-level participants. To ensure sustainability, we also create comprehensive educational materials that will empower other institutions to host similar workshops independently. This contribution highlights the insights gained from past workshops, outlines our plans for the upcoming year, and provides an update on the development of the new DIY detector system.

T 95.5 Fri 10:00 VG 1.105

Activities of the german LHC-Office for outreach and transfer — •Marius Hoffmann[1], Sophia Haves[2], Laura Fabietti[3], Stephanie Hansmann-Menzemer[4], Alexander Schmidt[2], and Wolfgang Wagner[5] — [1]Georg-August-Universität Göttingen} — [2]RWTH Aachen — [3]Technische Universität München — [4]Universität Heidelberg — [5]Bergische Universität Wuppertal

Communicating the scientific results to the public and fostering cooperation with partners in industry are key tasks of the german LHC research groups. For this reason in 2020, the research focuses ("Forschungsschwerpunkte" short ErUM-FSPs) of the four LHC experiments have initiated a joint "LHC-Office" which is funded by the Federal Ministry for Education and Research (BMBF). Since then, the LHC-office has established itself as a key stone of the outreach program of the german LHC-FSPs. The office has a multitude of tasks, which include organizing community events, soft skill workshops, industry fair stands and much more. This talk will give an overview of the LHC-office's work of the last years and present an outlook into future activities and possibilities to collaborate.

T 96: Detectors IX (Calorimeters)

Time: Friday 9:00–10:30 Location: VG 2.101

T 96.1 Fri 9:00 VG 2.101

Quality Control of the Tileboards for the High Granularity Calorime- ter upgrade of the CMS experiment — •Anurag Sritharan — Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany

The CMS experiment will be upgrading its detectors in lieu of higher luminosities and collision rates during the High-Luminosity era of the LHC (HL-LHC). One key upgrade of the CMS detector will be its end-cap calorimeters, which will be fitted with the new High Granularity Calorimeter (HGCAL). Since the HL-LHC will have 10 times more luminosity, the HGCAL will have improved radiation hardness and better background rejection that is caused due to much higher pile-up. It will consist of both the Electromagnetic and Hadronic calorimeters. Furthermore, the Hadronic calorimeter is split into two different technologies owing to the amount of radiation damage. The SiPM-on-Tile technology consists of small scintillator tiles that are linked to SiPMs (Silicon Photo-multiplier) on the PCB. The PCB without any scintillators on it is known as a tileboard. A tileboard will house 1 or 2 readout ASICs (called HGCROCs), and each HGCROC can read out 72 channels. The production tileboards have already started to be made. To test and certify the boards and the functionality of the HGCROCs, a robust quality control procedure is needed. The QC procedure, as well as some of the results, will be discussed in this presentation.

T 96.2 Fri 9:15 VG 2.101

Simulation of a cosmic muon test stand for the the CMS HGCAL upgrade — •Mohammed Adnan Ali, Andreas Hinzmann, and Freya Blekman — DESY, Notkestr. 85, 22607 Hamburg

The CMS High Granularity Calorimeter (HGCAL) upgrade requires thorough quality control during the production of its components. A cosmic muon test stand for fully assembled boards equipped with scintillator tiles, SiPMs and readout-electronics is setup to verify that all detector components operate as expected. In this talk we present a GEANT4-based simulation in CMSSW of this test stand allowing to study energy deposition patterns, reconstructed angle accuracy, and minimum ionizing particle light yields to help the design of the test stand and for comparison to the collected data.

T 96.3 Fri 9:30 VG 2.101

Multi-Tilemodule test system using cosmic rays for the CMS HGCAL upgrade — •Jia-Hao Li — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

The CMS experiment plans to upgrade its calorimeter endcap for the high luminosity phase of the LHC with the High Granularity Calorimeter (HGCAL). The Tilemodule is one of the basic elements in the hadronic calorimeter part of the HGCAL. It uses small scintillator tiles directly coupled to SiPMs (SiPM-on-tile technology) and it is the first step in the production sequence providing an object capable of detecting particles. The Tilemodule is equipped with one or two HGCROC ASICs for data readout. To test and calibrate the Tilemodules, a cosmic ray setup capable of testing up to 9 Tilemodules simultaneously is developed for quality control and a better understanding of the property of the Tilemodules. The presentation will discuss the idea and current status of the cosmic test setup at DESY.

T 96.4 Fri 9:45 VG 2.101

Fast Hadron Shower Simulation using a Distance Based Sor- ting for Calorimeter Tiles with the CALICE AHCAL Prototype — •Zobeyer Ghafoor, André Wilhahn, and Stan Lai — II. Physikalisches Institut, Georg-August Universität Göttingen

The simulation of particle showers in calorimeters plays a critical role in high-energy physics research. As calorimeter precision and resolution improve, the complexity and volume of data increase substantially. This growth presents significant challenges for computational resources, data storage, and analysis, underscoring the need for innovative simulation algorithms. This talk outlines a data-driven fast simulation approach. By optimising computational efficiency, this method aims to significantly reduce the total number of hits for the simulation, thereby optimising computational efficiency. However, the reduction must preserve critical calorimeter and shower information. This study uses data from a 2018 test beam with pion beams and the CALICE AHCAL. The calorimeter features 38 active layers, each comprising 24×24 tiles that are read out individually. For the fast simulation, a distance-sorting algorithm was employed, which orders the tiles in each layer based on their distance from the event's centre-of-gravity, sorted from smallest to largest. This helps avoid complications due

to necessary geometrical transformations when simulating energies based upon radial distances from the shower centre. To enhance efficiency, limitations were imposed on both the number of tiles and layers, effectively reducing the total number of readout channels while maintaining essential information for accurate event reconstruction.

T 96.5 Fri 10:00 VG 2.101

Integrated Cooling Solutions for a Highly Granular Scintillator-Based Hadronic Calorimeter and Advances in 3D-Printed Scintillators — •Andre Klotzbücher[1], Lucia Masetti[1], Bohdan Dudar[1], Quirin Weitzel[2], Steffen Schönfelder[2], Fabian Piermaier[2], and Konrad Briggl[3] — [1]Institut für Physik, Johannes Gutenberg Universität Mainz — [2]Prisma+ Detektorlabor, Johannes Gutenberg Universität Mainz — [3]Kirchhoff-Institut für Physik, Universität Heidelberg

This talk discusses the adaptation of the analogue hadronic calorimeter (AHCAL), originally developed by the CALICE collaboration for the International Linear Collider (ILC), to meet the demanding requirements of future circular colliders. For the linear collider environment, no integrated cooling system was necessary, as power consumption was effectively managed through power pulsing. However, this approach is no longer feasible due to the significantly higher interaction rate in circular colliders, requiring the electronics to remain continuously powered. To address this challenge, an integrated cooling system is being developed, and the latest progress will be presented.

Additionally, advances in 3D-printed scintillators are opening new possibilities for detector design. Following successful tests of basic printed tiles, efforts now focus on structured scintillators with optimized surface properties for improved light collection and performance. Preliminary results on performance and key characteristics will be discussed, highlighting the potential of these technologies for next-generation detectors.

T 96.6 Fri 10:15 VG 2.101

Calorimetry in searches for collider electron neutrinos at SND@LHC — •Matei Climescu and Rainer Wanke — Johannes Gutenberg Universität Mainz

SND@LHC is an experiment located in the TI18 tunnel at LHC which leverages its unique off-axis positioning to observe outgoing neutrinos of all flavours produced at the ATLAS interaction point with knowledge of the production mechanism. Electron neutrinos are of particular interest as their emerge primarily from charm decays and may be searched for in emulsion detectors which are utilized as very-high spatial resolution calorimeters, enabling unique reconstruction techniques. These searches are presented here with a focus on calorimetric reconstruction of charged and neutral current collider neutrino interactions.

T 97: Data, AI, Computing, Electronics IX (AI-based Object Reconstruction)

Time: Friday 9:00–10:30 Location: VG 2.102

T 97.1 Fri 9:00 VG 2.102

Hit-Filtering with Graph Neural Networks for Tracking at Belle II — •Greta Heine, Giacomo De Pietro, and Torben Ferber — Karlsruher Institut für Technologie (KIT), Karlsruhe, Deutschland

Over the next few years, the Belle II Experiment will increase its instantaneous luminosity, which will also lead to a significant increase in the beam background, affecting the efficiency of both online and offline tracking algorithms. To overcome this challenge and to facilitate the identification of displaced vertices for the discovery of new physics phenomena, Belle II needs more robust tracking algorithms.

Graph Neural Networks (GNNs) are a powerful class of machine learning models capable of adapting to irregular geometries and modeling complex relationships within detector hits. In this work, GNNs are used to filter background hits in the Belle II Central Drift Chamber based on edge classification using detector-level information. By filtering the background hits, both the track fitting performance as well as the computational efficiency can be improved at high background levels.

This talk will present the performance of this filtering approach for offline tracking algorithms on both simulated and real data, showing significant improvements in tracking efficiency and robustness under varying background conditions.

T 97.2 Fri 9:15 VG 2.102

End-to-End Multi-Track Reconstruction using Graph Neural Networks at Belle II — •Lea Reuter, Giacomo De Pietro, and Torben Ferber — Institute of Experimental Particle Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany

Displaced vertices are an important signature in Standard Model analyses involving K_S and many searches for New Physics. However, the current Belle II tracking algorithm falls short when dealing with particles that decay after a large distance, resulting in a decrease in tracking efficiency with increasing displacement.

In this work, we show a novel track finding algorithm that combines the Object Condensation algorithm with Graph Neural Networks. This approach simultaneously identifies all tracks in an event and determines their respective parameters. Additionally, we integrated the new track finding algorithm into the Belle II analysis software framework.

Our results show significant reconstruction improvements of more than 50% for a long-lived particle within the GeV mass range and a lifetime of 10 cm in comparison to the existing Belle II track finding algorithm. This improvement is achieved while maintaining a similar efficiency and fake rate for prompt tracks originating from the interaction point.

T 97.3 Fri 9:30 VG 2.102

Graph Neural Networks for Track Reconstruction at the ATLAS Event Filter — •Giulia Fazzino, Sebastian Dittmeier, and André Schöning — Physikalisches Institut, Universität Heidelberg, Germany

In its High-Luminosity phase, the LHC will collide particles at unprecedented luminosity scales, drastically increasing the number of interactions per bunch crossing and thus introducing the need for upgrades in the ATLAS Trigger System. In parallel, a new tracking detector, the Inner Tracker (ITk), will be installed. Its data will be used by the Event Filter in the last step of the trigger chain, for track reconstruction and, finally, event selection.

To minimize the computing resources needed by the Event Filter, the usage of hardware accelerators such as GPUs or FPGAs is studied, and significant effort is put into the development of a tracking algorithm based on Graph Neural Networks (GNNs). Such a method would first build a graph by connecting the hits in the ITk, and subsequently generate track candidates from it thanks to a GNN and a segmentation algorithm. The construction of the graph can be conducted in several ways, one of which is to use Metric Learning, a machine learning procedure connecting hits depending on their distances in a feature space.

This talk will provide an outline of GNN-based tracking for the ATLAS Event Filter, with a focus on Metric Learning, and present results on the realization and optimization of such a graph construction method for FPGA deployment.

T 97.4 Fri 9:45 VG 2.102

GCNN-based Hybrid Reconstruction of Cosmic Rays with IceAct and IceCube — •Lars Marten, Philipp Behrens, Shuyang Deng, Lasse Düser, Jonas Häussler, Lars Heuermann, Sönke Schwirn, Philipp Soldin, Julian Vogt, and Christopher Wiebusch — RWTH Aachen - III. physikalisches Institut B, Aachen, Germany

IceAct is an array of Imaging Air Cherenkov Telescopes stationed at the South Pole as part of the IceCube Neutrino Observatory. Among its goals is the combined measurement of air showers together with the in-ice detector IceCube and the IceTop surface detector. Such hybrid measurements grant the advantage of complementary information improving reconstruction capabilities. Our graph convolutional neural network has been developed using a simulation of the IceAct array with the purpose of reconstructing the direction of the primary particle of an air shower. In this talk we will present an updated version of this neural network with additional reconstruction capabilities such as primary particle energy and relative shower core position. Also, we will present our advances in including hybrid data into our network prediction.

T 97.5 Fri 10:00 VG 2.102

Advanced Northern Tracks Selection using a Graph Convolutional Neural Network for the IceCube Neutrino Observatory: Network Architecture — •Philipp Soldin, Philipp Behrens, Jakob Böttcher, Shuyang Deng, Lasse Düser, Philipp Fürst, Leon Hamacher, Michael Handt, and Christopher Wiebusch for the IceCube-Collaboration — RWTH Aachen University

The IceCube Neutrino Observatory is a large neutrino detector located in the ice at the geographic South Pole. It detects atmospheric and astrophysical neutrinos through the Cherenkov radiation emitted by secondary particles using over 5,000 photomultipliers (PMTs). One of the primary challenges is effectively distinguishing between muons induced by either neutrinos or air-showers. To address this, the Advanced Northern Tracks Selection (ANTS) employs a deep graph convolutional neural network (GCNN). This neural network takes advantage of the node-like structure of the PMT array's geometric arrangement and processes raw sensor data. By leveraging both local and global event features, the ANTS GCNN enhances classification performance. This presentation focuses on the architecture of the ANTS GCNN and evaluates its performance in rejecting background interference from air-shower-induced muons. We assess the accuracy and resolution of the reconstruction, and computational efficiency, showing

significant improvements over traditional methods across various muon track topologies.

T 97.6 Fri 10:15 VG 2.102

Exploring position reconstruction of HPGe detector events in LEGEND with a deep neural network — •Christoph Seibt[1] and Aobo Li[2] — [1]TU Dresden, Germany — [2]UCSD, USA

LEGEND is searching for neutrinoless double-beta ($0\nu\beta\beta$) decay, using High-Purity Germanium (HPGe) crystals enriched in ^{76}Ge as both source and detector. With its second phase, LEGEND-1000, the experiment uses 1 ton of germanium crystals to reach a discovery potential of half-lives greater than 10^{28} years. HPGe detectors measure pulse shapes of excellent quality, which are analyzed to reconstruct the events energy and reject background-induced events. These pulse shapes depend on the location of the events in the detector. This work leverages pulse shape topology to extract positional information, utilizing a recurrent-type neural network to overcome the limitations of classical methods. Simulated pulses from random event locations are used for training and testing. The current progress on a deep neural network for position reconstruction is displayed in this presentation. It shows the current reconstruction potential and first applications to specifying detector parameters.

This work is supported by the U.S. DOE and the NSF, the LANL, ORNL and LBNL LDRD programs; the European ERC and Horizon programs; the German DFG, BMBF, and MPG; the Italian INFN; the Polish NCN and MniSW; the Czech MEYS; the Slovak SRDA; the Swiss SNF; the UK STFC; the Canadian NSERC and CFI; the LNGS, SNOLAB, and SURF facilities.

T 98: Electroweak Physics III (W/Z Production and Properties)

Time: Friday 9:00–10:30 Location: VG 2.103

T 98.1 Fri 9:00 VG 2.103

Sensitivity to lepton-flavour-violating decays of the Z boson using a data-driven background estimate with the ATLAS Experiment — •Naman Kumar Bhalla, Valerie Lang, and Markus Schumacher — Albert-Ludwigs-Universität Freiburg

One of the primary goals of the Large Hadron Collider (Lhc) program is to look for phenomena beyond the Standard Model (SM) of particle physics. One such phenomenon is lepton flavour violation (LFV), which has already been observed in neutrino oscillations, but not in processes involving charged leptons. A search for LFV in decays of the Z boson with charged leptons in the final state, such as $Z \to e\tau_\mu$ and $Z \to \mu\tau_e$, is of high interest and well motivated by various beyond-SM theories. This search can be performed using a data-driven background estimate, which takes advantage of the idempotency of SM backgrounds under the exchange of an electron and a muon. The symmetry is broken only by the difference in branching ratios between LFV decays with $e\tau$ and $\mu\tau$ final states.

This talk discusses the achievable sensitivities for the search of LFV decays of the Z boson using this data-driven background estimate. The full Run-2 data set is used, which was collected by the Atlas detector in pp collisions at $\sqrt{s} = 13$ TeV, corresponding to an integrated luminosity of 140 fb^{-1}. The data-driven estimate, the neural network used to classify the LFV signal against other background processes along with the statistical model used for the analysis are presented.

T 98.2 Fri 9:15 VG 2.103

Measurement of the differential $W \to \ell\nu$ cross section at high transverse masses at $\sqrt{s} = 13$ TeV with the ATLAS detector — •Tim Frederik Beumker, Johanna Wanda Kraus, and Frank Ellinghaus — Bergische Universität Wuppertal

A measurement of the double-differential cross section of the process $W \to \ell\nu$ at high transverse masses is shown. The data set analyzed is based on data from pp-collisions at a center-of-mass energy of $\sqrt{s} = 13$ TeV, corresponding to an integrated luminosity of $\mathscr{L} = 140$ fb^{-1}. It is taken with the ATLAS detector during LHC Run-2. The measurement is done double-differentially in the transverse mass of the W boson and the pseudorapidity of the lepton. It focuses on the region of high transverse masses between 200 GeV and 5000 GeV. The results will allow for constraints on effective field theories and parton distribution functions of the proton. An overview of the complete analysis will be presented. The talk will focus on the interpretation of the final results.

T 98.3 Fri 9:30 VG 2.103

Production of hadronically-decaying boosted vector bosons in association with jets at the ATLAS experiment — •Donna Maria Mattern and Chris Malena Delitzsch — TU Dortmund, Fakultät Physik

Due to the unprecedented energy of the proton-proton collisions at the Large Hadron Collider (LHC), massive electroweak vector bosons (W and Z bosons) are frequently produced with energies much larger than their masses, thus receiving a Lorentz boost. When these particles decay hadronically, their decay products are collimated and can be reconstructed as single large-radius jets (R=1.0). These high-transverse momentum large-radius jets have distinctive properties like their mass, and jet-substructure, which describes the internal structure of the jet. Signal events have to be distinguished from large sources of background events produced from quantum-chromodynamic processes at the LHC, which have similar, multi-jet signatures. Studies of the large-radius-jet substructure are useful to discriminate between these signal and background processes to be able to measure the production of the boosted-vector bosons. Studies on the production of W and Z bosons in association with jets in LHC Run-2 data collected with the ATLAS detector, and Monte Carlo simulated samples are presented.

T 98.4 Fri 9:45 VG 2.103

Exploring the effects of a boosted vector boson's polarisation on the jet reconstructed from their hadronic decay products — •Maren Bühring[1], Max Lehmann[1], Frank Siegert[1], Karolos Potamianos[2], Amartya Rej[3], Donna Maria Mattern[3], and Chris Malena Delitzsch[3] — [1]IKTP, Technische Universität Dresden — [2]University of Warwick — [3]Technische Universität Dortmund, Fakultät Physik

The production of W or Z bosons in association with additional jets at the Large Hadron Collider (LHC) facilitates precision tests of the Standard Model, while also constituting an important background for other vector boson related processes and new physics searches. One of the challenges in the case of hadronically decaying vector bosons is to identify the bosons' decay products among all of the other hadronic activity at the LHC. If the transverse momentum of the boson is especially high, then its decay products are likely to be reconstructed as one large radius jet, which makes the substructure of that jet one of the most useful tools in identifying them. This study explores the impact of the boson's polarisation on the resulting jet's kinematics and substructure using events simulated with Sherpa 3.0.0, with the goal of applying the results in an ATLAS analysis aiming to measure the cross section of vector boson plus jets production in the LHC Run 2 data set.

T 98.5 Fri 10:00 VG 2.103

Validating the Hadronic Recoil Calibration in the ATLAS low-$\langle\mu\rangle$ W Mass Analysis — •Mathias Backes — Kirchhoff-Institut für Physik

The measurement of the mass of the W-boson is one of the fundamental tests of the Standard Model. ATLAS (2024) and CMS (2024) published measurements presenting results for the W-mass which are in agreement with the Standard Model. These measurements are in more than 5σ tension with the value obtained by the CDF collaboration (2022). In order to investigate this tension ATLAS is currently performing an additional measurement.

The W mass is most accurately measured using the leptonic decay channel $W \to l\nu_l$ with $l \in (e, \mu)$. The low-pileup dataset of ATLAS (taken in Run-2) is especially useful because a central aspect of this analysis is the precise estimation of the hadronic recoil to infer the energy and direction of the neutrino. Since the W mass cannot be measured directly it has to be inferred through comparisons with Monte Carlo simulations in a Profile Likelihood Fit. The success of such a fit strongly depends on the quality of the simulation. It is therefore necessary to explicitly calibrate the hadronic recoil estimation in the simulation to ensure it is modeled properly. The calibration can be validated by using Z-boson events, which can also be extracted from the low-pileup dataset.

T 98.6 Fri 10:15 VG 2.103

Heavy-meson reconstruction at the FCC-ee — Kevin Kröninger[1], Romain Madar[2], Stéphane Monteil[2], and •Willy Weber[1,2] — [1]TU Dortmund University, Department of Physics, Dortmund — [2]Université Clermont-Auvergne, Laboratoire de Physique de Clermont, Clermont-Ferrand

The Future Circular Collider (FCC-ee) is a proposed electron-positron collider designed to enable high-energy collisions at unmatched scales. It is expected to produce approximately $\mathcal{O}(10^{12})$ $Z \to \bar{q}q$ events, significantly enhancing our ability to perform precision measurements of electroweak observables.

This talk presents the first steps of a study focusing on decays of charmed D-mesons, which are produced as a result of the hadronization process. D-mesons have a short lifetime (up to 10^{-12} seconds) before they decay into other particles. In particular, $D^+ \to \pi^+\nu\bar{\nu}$ and $D^0 \to \pi^0\pi^0$ are considered. Challenges of this final states are the non-detectable neutrinos ν and the hard-to-detect neutral pions π^0. To identify the two photons coming from the π^0 decay, high energy and angular resolution are required, which makes the reconstruction and then the tagging of this final state difficult.

The results of this study may contribute to the study of CP violation in the charm sector. Additionally, the insights gained from this research can contribute to design decisions of the calorimeter to be developed for the FCC-ee.

T 99: Methods in Astroparticle Physics IV

Time: Friday 9:00–10:30 Location: VG 3.101

T 99.1 Fri 9:00 VG 3.101

Comissioning a first atomic tritium source — •Leonard Hasselmann, Daniel Kurz, and Caroline Rodenbeck for the Atomic Tritium at TLK-Collaboration — KIT-IAP, Karlsruhe, Germany

The Karlsruhe Tritium Neutrino mass (KATRIN) experiment will Research a sensitivity below 0.3 eV/c^2. In order to increase the sensitivity on the neutrino mass a new high resolution differential measurement method is required. The maximum effective resolution which can be achieved is not limited only by the detector, but also by molecular effects in the source gas constraining it to ~1 eV FWHM for T_2. Thus, future ultimate neutrino experiments need to use differential detectors combined with atomic tritium sources. Therefore, we move forward with the development of atomic tritium sources.

At the Tritium Laboratory Karlsruhe, a system to demonstrate the production of atomic tritium is currently being comissioned. A commercially available cracking system is used for hydrogen dissociation. For beam diagnostics, a quadrupole mass spectrometer equipped with a cross beam ion source is used.

In this talk, results from the comissioning of the system with non-radioactive gases like protium and deuterium are shown.

This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2, and 05A23WO6)

T 99.2 Fri 9:15 VG 3.101

Reduction of the molecular background in an atomic tritium setup using different shroud configurations — •Daniel Kurz, Leonard Hasselmann, and Caroline Rodenbeck for the Atomic Tritium at TLK-Collaboration — KIT-IAP, Karlsruhe, Germany

The investigation of the tritium β-decay spectrum at its endpoint is a direct way to measure the neutrino mass. Using molecular tritium reduces the achievable sensitivity by a broadening due to rotational and vibrational excitations of the $^3HeT^+$ daughter molecule. The use of atomic tritium overcomes this fundamental limitation.

After a commissioning phase with inactive hydrogen, the "Beam for an Atomic Tritium Experiment" setup at Tritium Laboratory Karls-ruhe is going to demonstrate the production of atomic tritium. To dissociate the hydrogen molecules, a commercially available dissociation device, the tectra H-flux atomic hydrogen source, is used. Investigating the beam composition is done by a HIDEN DLS10 quadrupole mass spectrometer (QMS) equipped with a cross-beam ion source.

Previous results show that recombination by wall contacts produces a major molecular background. To prevent recombined molecules from reaching the QMS beam shaping skimmers and a shroud are indispensable. The latter is an actively pumped tube around the QMS. In this, two opposite holes act as a skimmer trimming the beam to the size of the QMS entrance aperture. Molecules recombined inside the QMS are pumped away.

This talk presents the results investigating the reduction of the molecular background using different shroud configurations.

T 99.3 Fri 9:30 VG 3.101

Enhancing the energy resolution of MAC-E filters using a Transverse Energy Compensator (TEC) — •Richard Salomon, Kevin Gauda, Kyrill Blümer, Christian Gönner, Volker Hannen, and Christian Weinheimer — Universität Münster - Institut für Kernphysik, Münster, Deutschland

Precise electron spectroscopy with energy resolutions on the eV-scale is currently possible using magnetic adiabatic collimation with an electrostatic filter. Such a MAC-E filter is currently in use at the Karlsruhe Tritium Neutrino (KATRIN) experiment, where an energy resolution of 2.7 eV is achieved in the standard measurement configuration.

This talk focuses on a novel method to improve the energy resolution of MAC-E filters. It can be shown that accelerating electrons in a Wideröe-type drift tube with a polynomial voltage ramp in a high magnetic field creates an angular-dependent energy gain compensating the missing longitudinal energy component in the analyzing plane. In the KATRIN example, a Transverse Energy Compensator (TEC) can lead to an improvement by up to an order of magnitude, while other configurations might benefit even more. If combined with a time-of-flight measurement, it is possible to obtain a differential spectrum measurement with a sub-eV energy resolution, which is necessary to probe the inverted neutrino mass ordering.

This idea by Christian Weinheimer has been submitted as a provisional patent application under the number 10 2024 126 381 by the University of Münster.

This work is supported by BMBF ErUM-Pro 05A23PMA.

T 99.4 Fri 9:45 VG 3.101

Position Reconstruction in a Scintillating CeBr3 Crystal for the ComPol CubeSat Using Neural Networks — •Jonas Schlegel — TUM, Muenchen, Deutschland

Compact objects such as Black Hole Binaries represent extreme astrophysical environments with many unresolved questions. Their small size makes them unsuitable for imaging techniques. Precise X-ray spectra and polarization measurements are crucial for understanding their dynamics and geometry. The CubeSat mission ComPol targets the binary system Cygnus X-1, which includes a rotating black hole and a companion star. After In-Orbit Verification (IOV) on the ISS, it will operate in Low Earth Orbit (LEO), performing spectroscopy and polarimetry in the 20-200 keV hard X-ray range.

Polarimetry is based on Compton scattering kinematics in a two-layer detector system. The prototype uses Silicon Drift Detectors (SDD) to determine the recoiling electron's energy and position, while a CeBr3 scintillator records photon energy via a Silicon Photomultipliers (SiPM) matrix. The core objective is to reconstruct absorbed X-ray events in the calorimeter.

A barium source is used for detector calibration, with scans performed in the X-Y and Y-Z planes. Neural networks achieve position resolutions of 2.4-4.3 mm in the x and y plane and 2.8 mm for the z plane. Edge effects are corrected with position- and energy-dependent shifts. Data from the LARIX X-ray facility validate the expected ϕ-distribution for unpolarized X-rays, demonstrating the success of the position reconstruction methods.

T 99.5 Fri 10:00 VG 3.101

Reconstruction of atmospheric neutrino events in JUNO — •Milo Charavet, Rosmarie Wirth, Mikhail Smirnov, Caren Hagner, and Daniel Bick — Hamburg University, Hamburg, Germany

The ordering of the neutrino masses is one of the fundamental open questions in the field of neutrino physics. The Jiangmen Underground Neutrino Observatory (JUNO) is a multipurpose liquid scintillator-based experiment (LS) with a target mass of 20 kt. It aims to determine the neutrino mass ordering (NMO) with at least 3σ significance, through a measurement of the oscillation pattern of reactor neutrinos over 53 km baseline. While reactor neutrinos are the main source of sensitivity to NMO at JUNO, atmospheric neutrino oscillation can provide independent sensitivity, and enhance its overall sensitivity in the combined analysis. As one of the largest LS detectors, JUNO might be able to measure with high precision the atmospheric neutrino events and their oscillation parameters. However, accurately reconstructing atmospheric neutrinos in such a large liquid scintillator detector is a significant challenge. This talk presents reconstruction methods to analyze these atmospheric neutrino events.

T 99.6 Fri 10:15 VG 3.101

Development of a high temperature superconducting magnet for applications in space — •Christian von Byern[1], Laurenz Klein[1], Daniel Louis[1], Niklas Moldrickx[2], Irfan Özen[1], Dominik Pridöhl[1,2], Ben Rüsse[2], Stefan Schael[1], Thorsten Siedenburg[1], Myrto Theodorou[1], and Michael Wlochal[1] — [1]I. Physics Institute B, RWTH Aachen, Germany — [2]Institute of Structural Mechanics and Lightweight Design, RWTH Aachen, Germany

While AMS-02 is currently operated on board of the International Space Station, the next generation of cosmic particle detector is already planned. AMS-100 is designed for operation at Lagrange Point 2 and will feature a geometric acceptance of $100 m^2 sr$. With this large acceptance and improved momentum resolution a measurement of cosmic rays up to the PeV scale will be possible and an improvement of factor 1000 regarding the sensitivity of anti-matter measurements is expected. The magnetic field of the spectrometer will be generated by a High Temperature Superconducting (HTS) solenoid. This coil will include several layers of individual HTS tapes. During operation at 55K it will produce a field of 0.5T at 4.5kA current. To reduce the material budget in terms of mass and interaction length the HTS tapes will be stabilized using few millimetres of aluminium. As an intermediate step a small demonstrator coil is in preparation. In this R&D phase multiple samples, including straight cable samples, bent cable samples as well as coil samples with few windings are prepared and tested. In this talk measurement results of the different samples will be presented and interpreted.

T 100: Cosmic Rays V

Time: Friday 9:00–10:15 Location: VG 3.102

T 100.1 Fri 9:00 VG 3.102

Exploring High-Energy Atmospheric Muons with IceCube: Unfolding the Muon Flux — •Pascal Gutjahr — TU Dortmund University, Dortmund, Germany

Atmospheric muons, produced in cosmic ray air showers, can be divided into two components: conventional muons from pion and kaon decays, and prompt muons from heavy meson decays. While conventional muons dominate at TeV energies, the prompt component becomes increasingly relevant at PeV energies. Studying these muons is essential for understanding cosmic rays, refining hadronic interaction models, and reducing neutrino background in neutrino telescopes like IceCube.

This talk will present recent air shower simulations performed with CORSIKA, validated against numerical predictions from MCEq. A key focus will be on a method to unfold the atmospheric muon flux at the surface, leveraging machine learning for event reconstruction in IceCube.

T 100.2 Fri 9:15 VG 3.102

Unfolding the Atmospheric Muon Spectrum Using Stopping Muons in IceCube — •Lucas Witthaus for the IceCube-Collaboration — TU Dortmund University

The IceCube Neutrino Observatory is a neutrino detector embedded within the Antarctic ice sheet near the South Pole. Although its primary goal is the neutrino observation, the majority of detected events are attributed to atmospheric muons generated by cosmic-ray-induced air showers in the upper atmosphere. As muons enter the ice, they lose significant energy through interactions with the surrounding matter, which limits their propagation length depending on their initial energy. This talk presents the unfolding of the muon surface energy spectrum and the stopping muon depth intensity, providing information about the abundance of atmospheric muons in the South Pole ice. The study targets a specific subset of events comprising single muons that stop within the IceCube detector. The event classification as well as the reconstruction of the muon tracks are performed using deep neural networks.

T 100.3 Fri 9:30 VG 3.102

Studies of primary mass sensitivity of muons of the IceCube surface array IceTop — •Donghwa Kang for the IceCube-Collaboration — Karlsruhe Institute of Technology

The surface component of the IceCube Neutrino Observatory at the geographical South Pole, IceTop, is designed to measure the air showers of cosmic ray with energies from PeV to EeV. Based on the charge signal distribution only with IceTop, a mass-sensitive parameter was defined and estimated event by event, which is the sum of the charge signals divided by the effective area at a fixed distance from the shower core. In this contribution the estimated mass-sensitive parameter and its dependencies on the hadronic interaction models will be discussed.

T 100.4 Fri 9:45 VG 3.102

Detection of Ultra-High-Energy Cosmic Rays using the Next-Generation Prototypes of the Fluorescence-Detector Array of Single-Pixel Telescopes (FAST) — •Marcus Niechciol for the FAST-Collaboration — Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen

Understanding the nature and origin of ultra-high-energy cosmic rays (UHECRs) remains one of the key goals in astroparticle physics. The Fluorescence-detector Array of Single-pixel Telescopes (FAST) is a proposed next-generation cosmic-ray observatory, aimed at observing UHECRs with energies above 10^{19} eV with unprecedented statistics. To achieve this, FAST will employ cost-effective, easily deployable, autonomous fluorescence telescopes, each equipped with four photomultiplier tubes with a diameter of 200 mm positioned at the focal plane of a segmented mirror with a diameter of 1.6 m. Currently, there are three prototypes in operation at the Telescope Array Experiment in the Northern hemisphere (Utah, USA) and one in the Southern hemisphere at the Pierre Auger Observatory (Malargüe, Argentina). Together, they enable observations of UHECRs in both hemispheres using the same technology. In the contribution, the current status of observations of UHECRs using the FAST prototypes is summarized. Preliminary results from the data analysis are presented, as well as recent developments towards a mini array of FAST telescopes, to be installed at the Pierre Auger Observatory.

T 100.5 Fri 10:00 VG 3.102

Diffuse emissions with stochastic cosmic ray sources — •Anton Stall and Philipp Mertsch — Institute for Theoretical Particle Physics and Cosmology (TTK), RWTH Aachen University, Aachen, Germany

Diffuse emission in gamma-rays and neutrinos are produced by the interaction of cosmic rays with the interstellar medium. Below some hundreds of TeV, the sources of theses cosmic rays are most likely Galactic. Hence, observations of high-energy gamma-rays and neutrinos can be used to probe the flux of cosmic rays in other parts of the Galaxy. Supernova remnants are usually considered as the prime candidate for the acceleration of Galactic cosmic rays. They inject cosmic rays in a point-like and specific time-dependent manner. As the precise positions and ages of the sources are not known, predictions must be obtained in a stochastic model. At GeV energies, the distribution of sources can be approximated with a smoothly varying spatial and temporal source density. At hundreds of TeV, however, the point-like nature matters as less sources contribute effectively due to shorter escape times. We have modelled diffuse emissions at hundreds of TeV, relevant for measurements by LHAASO, Tibet AS-gamma, IceCube, and the upcoming SWGO. In general, we have found its morphology to be very different from those at GeV energies, as measured by Fermi-LAT. Those differences can potentially be used to constrain source models and locate cosmic ray sources.

T 101: Neutrino Physics VIII

Time: Friday 9:00–10:30 Location: VG 3.103

T 101.1 Fri 9:00 VG 3.103

Search for Light Sterile Neutrinos with the KATRIN Experiment — •Christoph Köhler[1,2], Xaver Stribl[1,2], and Susanne Mertens[1,2] for the KATRIN-Collaboration — [1]Technical University of Munich — [2]Max Plabck Institute for Nuclear Physics

Light sterile neutrinos with a mass at the eV-scale could explain several anomalies observed in short-baseline neutrino oscillation experiments. The Karlsruhe Tritium Neutrino (KATRIN) experiment is designed to determine the effective electron anti-neutrino mass via the kinematics of tritium β–decay. The precisely measured β-spectrum can also be used to search for the signature of light sterile neutrinos.

In this talk we present the status of the light sterile neutrino analysis of the KATRIN experiment. We describe the method used to study the first five measurement campaigns. The obtained results are compared to findings of complementary experiments and anomalies in the field of light sterile neutrinos.

This work is supported by the Technical University of Munich, the Max Planck Institute for Nuclear Physics, the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2, and 05A23WO6). This project has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and innovation programme (grant agreement No. 852845).

T 101.2 Fri 9:15 VG 3.103

The new detector section for KATRIN for the keV sterile neutrino search — •Simon Gentner — Karlsruhe Institut für Technologie (KIT)

At the Karlsruhe Institute of Technology (KIT) a full-scale replica of the KATRIN experiment's detector system was developed to pretest the innovative TRISTAN detectors. The replica system facilitates comprehensive testing and calibration of currently three TRISTAN detectors under controlled conditions, ensuring their optimal performance prior to integration into the KATRIN beamline in 2026 which will enhance KATRIN's sensitivity in the search for keV-scale sterile neutrinos. Critical operational parameters, including energy resolution, count rate capabilities, and data aquisition, are meticulously evaluated. Preliminary results indicate that the TRISTAN modules achieve exceptional high-resolution beta spectroscopy, essential for precise neutrino mass measurements and the exploration of potential new physics. This presentation will discuss the setup, detailed test procedures and initial results that emphasize the central role of the TRISTAN upgrade in advancing neutrino research.

T 101.3 Fri 9:30 VG 3.103

Bayesian analysis of KATRIN neutrino mass data using a neural network — Philipp Krönert[1], Susanne Mertens[2], Oliver Schulz[3], and •Alessandro Schwemmer[2] for the KATRIN-Collaboration — [1]Helmholtz-Institut für Strahlen- und Kernphysik, Bonn — [2]Physik Department, Technische Universität München, Garching — [3]Max-Planck-Institut für Physik, München

The Karlsruhe Tritium Neutrino (KATRIN) experiment probes the effective electron anti-neutrino mass by precisely measuring the tritium beta-decay spectrum near its endpoint. A world-leading upper limit of 0.45 eV c^{-2} (90 % CL) has been set with the first five measurement campaigns following a frequentist analysis procedure. A neural network has been developed in this context, enabling fast and precise model calculations. Utilizing this neural network, a new Bayesian framework has been built in the Julia programming language. It allows for efficient sampling of the posterior density using Hamiltonian Monte Carlo methods implemented by BAT.jl. In this talk, we will present the current development status of the Bayesian framework and its application to the analysis of the first five KATRIN measurement campaigns.

This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2, and 05A23WO6).

T 101.4 Fri 9:45 VG 3.103

Sensitivity studies for a next-generation neutrino-mass experiment using tritium β-decay — •Svenja Heyns for the KATRIN-Collaboration — Karlsruhe Institute of Technology, Germany

The Karlsruhe Tritium Neutrino (KATRIN) experiment probes the absolute neutrino mass scale by precision spectroscopy of tritium β-decay. With a total of 1000 days of measurement by the end of 2025, a final sensitivity better than 300 meV/c^2 (90% C.L.) is anticipated by the collaboration.

Taking next steps in enhancing the sensitivity, for instance towards the regime of inverted mass ordering, requires novel technological approaches to significantly improve statistics, energy resolution, and background suppression. We explore two key strategies: (1)implementing a differential detector with sub-eV energy resolution (quantum sensor detector array, time-of-flight measurement) to resolve each electron's energy individually while covering the entire energy interval of interest simultaneously and (2)exploring a large-volume atomic tritium source. In this presentation, we introduce the conceptual framework for simulations to investigate the requirements by technology and limits by physics to confine the achievable sensitivity on the neutrino mass with a differential measurement. *This work is supported by the Helmholtz Association, the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Initiative and Networking Fund (W2/W3-118).*

T 101.5 Fri 10:00 VG 3.103

Update on the ECHo Experiment — •Raghav Pandey — Kirchhoff Institute for Physics, Heidelberg University

In the ECHo experiment large arrays of low temperature metallic magnetic calorimeters (MMCs) enclosing Ho-163 are used for the high resolution measurement of the electron capture spectrum. The goal of the experiment is to achieve the sensitivity to detect an extremely small spectral shape distortion in the end point region due to a finite neutrino mass. The first phase, ECHo-1K was designed to test the properties and reproducibility of MMCs with implanted Ho-163 and the sensitivity to the effective electron neutrino mass. For 6 months between December 2019 and June 2020, Ho-163 events were acquired using about 50 MMC pixels enclosing about 1 Bq Ho-163 each. Data reduction methods were developed and applied on the acquired dataset. 'Quality Control' parameters have been defined to track and quantify the effect of the data processing algorithms devised and the selection criteria invented to eliminate unsuitable data. A Ho-163 electron capture spectrum was compiled containing more than 2×10^8 events and showing an energy resolution of 7.8 eV.

T 101.6 Fri 10:15 VG 3.103

Data reduction of the ECHo-1k-Au data — •Rasmus Jeske — Kirchhoff Institute for Physics, Heidelberg University — ECHo Collaboration

For the ECHo-1k experiment two metallic magnetic calorimeter arrays with Ho-163 implanted in the absorber have been used. They differ in the host materials in which Ho-163 was implanted, Au and Ag. Data reduction algorithms and quality control procedures have been developed and characterized for the analysis of the data acquired with detectors having Ho-163 implanted in silver. We present the application of the data reduction protocol to the data acquired with detector having Ho-163 implanted in gold, ECHo-1k-Au data. We discuss the criteria to identify and eliminate triggered noise and other possible spurious events along with the efficiency and stability of the filters. From the analysis of the obtained spectra we derive the properties of the detectors in term of energy resolution and energy calibration over the course of the experiment. In addition, we demonstrated that the probability of having spectral shape artifacts in the endpoint region due to misinterpreted bad events is smaller than the statistical error.

T 102: Neutrino Physics IX

Time: Friday 9:00–10:30 Location: VG 3.104

T 102.1 Fri 9:00 VG 3.104

Sensitivity determination for neutron flux measurements in the LEGEND experiment — •Loris Steinhart — University Tübingen, Tübingen Germany

The next phase of the Large Enriched Germanium Experiment for Neutrinoless Double-Beta Decay (LEGEND) aims to achieve unprecedented background suppression, making accurate neutron flux measurements within the detector array critical. This contribution focuses on sensitivity studies for determining the neutron flux using a Gadolinium-loaded polyethylene (GdPE) string integrated into the detector setup. This talk will present the methodology, simulation results, and initial experimental efforts, highlighting the impact of this measurement on understanding neutron-induced backgrounds and optimizing the LEGEND setup for maximum sensitivity to search for the $0\nu\beta\beta$ decay signal.

T 102.2 Fri 9:15 VG 3.104

Implementation of the Pulse Shape Discrimination Classifier within the JuLeAna Software Stack for LEGEND-200 — •Verena Aures[1], Florian Henkes[1], Felix Hagemann[2], and Susanne Mertens[1] — [1]Technische Universität München, Deutschland — [2]Max Planck Institut für Physik, Garching bei München, Deutschland

The Large Enriched Germanium Experiment for Neutrinoless $\beta\beta$ Decay (LEGEND) searches for neutrinoless double-beta decay using high-purity germanium detectors enriched in ^{76}Ge, which serve as both the source and detector. The project's final phase, LEGEND-1000, aims to set a new limit on the half-life of ^{76}Ge exceeding 10^{28} years. The first phase, LEGEND-200, is currently running at the Laboratori Nazionali del Gran Sasso in Italy with its first results presented in 2024. The experimental sensitivity is enhanced by using pulse shape discrimination (PSD) techniques to distinguish signal-like from background-like events. This work focuses on the development and optimization of the A/E classifier, a PSD tool to efficiently reject multi-site events. The implementation was performed within the Julia-based software stack JuLeAna (Julia LEGEND Analysis), focusing on the classifier's performance and the evaluation of a charge trapping correction.

T 102.3 Fri 9:30 VG 3.104

The Liquid Argon Instrumentation of LEGEND-200: Background Rejection Performance — •Rosanna Deckert for the LEGEND-Collaboration — Technical University of Munich, Garching, Germany

LEGEND-200 is an experiment designed to search for neutrinoless double beta decay of Ge-76. Located deep underground at LNGS, it operates up to 200 kg of enriched high-purity germanium detectors in a liquid argon (LAr) cryostat. To achieve ultra-low backgrounds, the LAr is instrumented as an active volume to detect scintillation light emitted upon interactions with ionizing radiation, thus tagging and rejecting backgrounds. To provide insight into the rejection capability at different origins of scintillation light generation, we require proper modeling of light propagation throughout the experimental setup, from any origin in the LAr volume to its eventual detection by the light read-out system. The optical model must be tuned on special calibration data to match the observed photo electron yield. In this contribution, I will present a first analysis of special calibration runs that were performed to benchmark the optical simulations. Additionally, I will discuss the rejection performance of the LAr instrumentation in physics data.

This research is supported by the BMBF through the Verbundforschung 05A20WO2 and by the DFG through the Excellence Cluster ORIGINS and the SFB1258.

T 102.4 Fri 9:45 VG 3.104

KATRIN++ - Development of New Detector Technologies for a Future Neutrino Mass Experiment with Tritium — •Neven Kovac[1], Fabienne Adam[1], Beate Bornschein[1], Woosik Gil[1], Ferenc Glück[1], Svenja Heyns[1], Sebastian Kempf[2,3], Andreas Kopmann[3], Michael Müller[2], Rudolf Sack[1], Magnus Schlösser[1], Frank Simon[3], Markus Steidl[1], and Kathrin Valerius[1] — [1]Institute for Astroparticle Physics (IAP), Karlsruhe Institute of Technology (KIT) — [2]Institute of Micro- and Nanoelectronic Systems (IMS), Karlsruhe Institute of Technology (KIT) — [3]Institute for Data Processing and Electronics (IPE), Karlsruhe Institute of Technology (KIT)

Currently, the tightest constraints on the absolute scale of neutrino mass from a direct, model-independent approach, are obtained by the KATRIN experiment, giving an upper limit on the mass of the electron anti-neutrino of 0.45

eV (https://doi.org/10.48550/arXiv.2406.13516), with final projected sensitivity below 0.3 eV. Going beyond this limit, and probing the inverted mass ordering (and beyond), will be the task for future neutrino mass experiments. In this regard, development of new detector technologies is of utmost importance, with quantum sensor arrays currently being the front runners due to their exceptional performance and excellent energy resolution. We report on our R&D efforts aiming to demonstrate the feasibility of developing and operating large quantum sensor arrays for detection of external electrons in a KATRIN-like setup, as a basis for the next generation neutrino mass experiments with tritium.

T 102.5 Fri 10:00 VG 3.104

Determination of the absolute nuclear transition energies of ^{83m}Kr using the gaseous krypton source of KATRIN — •Benedikt Bieringer and Matthias Böttcher for the KATRIN-Collaboration — Institut für Kernphysik, Universität Münster

The KATRIN experiment aims to measure the electron neutrino mass m_ν with 0.3 eV/c^2 (90% C.L.) sensitivity after 1000 measurement days in 2025, by measuring the T_2 β spectrum near its endpoint E_0 and performing a fit including parameters E_0 and m_ν^2. Since these are highly correlated, systematic effects influencing the obtained m_ν will also manifest in E_0 and the derived T_2 Q value. Comparing this with the T–^{3}He mass difference from Penning-trap measurements is therefore a valuable for cross checks of our experimental procedure. Determining the KATRIN Q value with high precision requires calibration of the experimental energy scale with ^{83m}Kr conversion electrons. This is limited by knowledge of ^{83m}Kr nuclear transition energies, being known to 0.3 eV precision in the literature. The excited nucleus of ^{83m}Kr decays via a two-step cascade of 32.2 keV and 9.4 keV highly converted γ transitions, and a weak direct transition. With a gaseous Kr source, a measurement of conversion electrons from all three transitions was performed in 2023 at KATRIN. Following the method described in ref. EPJ C 82 (2022) 700 the nuclear transition energies can be determined, which can allow for a reduction of the T_2 Q value uncertainty to 0.1 eV. In this talk, we present the analysis of the measurement.

This work is supported by the Helmholtz Association and BMBF (grant numbers ErUM-Pro 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6).

T 102.6 Fri 10:15 VG 3.104

^{83m}Kr N-line spectrum measurement at KATRIN — •Jaroslav Storek[1] and Matthias Böttcher[2] for the KATRIN-Collaboration — [1]Institute for Astroparticle Physics, Karlsruhe Institute of Technology — [2]Institute of Nuclear Physics, University of Münster

Conversion electrons from ^{83m}Kr are used as a versatile calibration tool in a range of different (astro-)particle physics experiments. Favourable properties are the short half-life and narrow line spectrum of 83m-Kr as a nuclear standard. In the KArlsruhe TRItium Neutrino experiment (KATRIN) which currently provides the best direct neutrino mass upper limit of 0.45 eV/c^2 (90% C. L.), several systematic uncertainties are studied by a shape distortion of the quasi monoenergetic ^{83m}Kr spectrum. This creates high demands on precise knowledge of the undistorted spectrum.

In KATRIN we use the 32 keV N-lines lying in the high energy region of the spectrum including the weaker N_1 line. Results of a dedicated measurement of the ^{83m}Kr electron N-spectrum with emphasis on N_1 line and adjacent shake lines will be presented in this talk.

This work is supported by the Helmholtz Association and by the Ministry for Education and Research BMBF (grant numbers 05A23PMA, 05A23PX2, 05A23VK2 and 05A23WO6) and the Doctoral School "Karlsruhe School of Elementary and Astroparticle Physics: Science and Technology (KSETA)" through the GSSP program of the German Academic Exchange Service (DAAD).

T 103: Methods in Particle Physics V (Event Reconstruction, PID)

Time: Friday 9:00–10:30 Location: VG 4.101

T 103.1 Fri 9:00 VG 4.101

Improving Reconstruction in the Belle II Electromagnetic Calorimeter Using Graph Neural Networks — •Jonas Eppelt and Torben Ferber — Karlsruher Institut of Technology

Belle II uses an Electromagnetic Calorimeter (ECL) built from Cesium-Iodide crystals to measure a particle's energy. The current clustering algorithm faces significant challenges from high background conditions, low momentum minimal ionizing particles, and hadronic particles creating multiple clusters. This affects energy resolutions, detection efficiencies for low energetic photons, and higher-level variables used in many analyses. Graph Neural Network(GNN) based methods can leverage more of the available information from the ECL and better represent the sparse and irregular geometry of the clusters. This talk will present ongoing efforts to reduce background, improve energy resolution, and analyze other variables.

T 103.2 Fri 9:15 VG 4.101

Event reconstruction for opaque liquid scintillator detectors. — •Kitzia Hernandez for the NuDoubt-Collaboration — Johannes Gutenberg-Universität Mainz

Opaque liquid scintillators represent a novel approach to particle detection. This technology uses Mie scattering to confine the scintillation light around its interaction point, conserving the topology of the event in comparison with classical transparent scintillators. However, the opacity of these detectors and their energy deposition topologies represent a new paradigm opening the way to new reconstruction methods.

Here, we explore the adaptation of the Cambridge-Aachen jet clustering algorithm, traditionally used in High-energy physics, for event reconstruction in opaque liquid scintillator detectors. By clustering optical photons in the x-y plane and incorporating timing information, this method can effectively reconstruct event position, energy, and particle type. Furthermore, it provides a robust framework for particle discrimination and is a reference point for comparing with more sophisticated approaches using Graphic Neural Networks.

T 103.3 Fri 9:30 VG 4.101

Machine Learning Assisted Reconstruction of Hadron-Collider Events using Mini-Jets — •Josef Murnauer[1], Stefan Kluth[1], Daniel Britzger[1], and Roman Kogler[2] — [1]Max-Planck-Institut für Physik, Garching — [2]DESY, Hamburg

Reconstructing impactful physical observables from hadron collider data represents challenges due to combinatorial ambiguities and experimental effects. We propose a novel approach using mini-jets (R=0.1) as the sole reconstructed objects, employing a deep neural network for observable determination. This method condenses full event information into a manageable size, demonstrating superior efficiency and generality compared to classical algorithms for future LHC analyses.

T 103.4 Fri 9:45 VG 4.101

The Heterogeneous HGCAL event reconstruction — •Wahid Redjeb[1,2], Alexander Schmidt[2], Felice Pantaleo[1], and Marco Rovere[1] — [1]CERN — [2]III. Physikalisches Institut A, RWTH Aachen

The High-Granularity Calorimeter (HGCAL) is a sampling calorimeter with both lateral and longitudinal fine granularity designed for the High-Luminosity LHC. The calorimeter will use silicon sensors in the high radiation regions, providing high pile-up mitigation, and scintillators in the low radiation regions. For the physics object reconstruction, a dedicated framework for HGCAL is currently under development: The Iterative Clustering (TICL), which utilizes the 5D (x,y,z,t,E) information from the reconstructed hits and returns particle properties and probabilities. Heterogeneous computing will play a fundamental role in the physics object reconstruction software to fully exploit the reach of the HL-LHC. We present an overview of the TICL framework, highlight the TICL Framework's capabilities to perform Particle Flow reconstruction in the challenging endcap region with dedicated algorithms for electromagnetic and hadronic objects. Additionally, we will describe how Performance Portability has been achieved through the Alpaka library, being able to run core parts of the Framework on GPU and on CPU with a single source code.

T 103.5 Fri 10:00 VG 4.101

Particle Identification at Belle II using Neural Networks — •Erik Gräter[1,2], Stefan Wallner[1], Hans-Günther Moser[1], and Martin Bartl[1] — [1]Max-Planck-Institut für Physik, München — [2]Technische Universität München

We will present advancements in the charged-particle identification at the Belle II experiment located at KEK, Japan. At Belle II we employ a neural network to combine the information from six subdetectors to identify the particle species. Improvements in the reconstruction of the subdetector information that enters the neural network were made. In the context of this we will deliver a new neural-network trained on the latest data including those improvements. With a detailed study of the performance on particle-identification Additionally, we will provide an in-depth analysis of the importance of individual neural-network input features on its classification decisions.

T 103.6 Fri 10:15 VG 4.101

Development and testing of a neutron identification algorithm for Belle II — Slavomira Stefkova, Florian Bernlochner, and •Georgios Alexandris — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

Among the various neutral Standard Model particles, neutrons and, to a lesser extent, antineutrons are considered invisible in the Belle II detector due to their weak interaction with the detector material. A better understanding of their interaction rates is therefore crucial for analyses in Belle II that involve significant missing energy. While neutrons can only interact with atomic nuclei in the electromagnetic calorimeter (ECL) and the K0L and muon detector (KLM) through inelastic and elastic scattering, antineutrons can also be identified by the products of their annihilation with matter. This project aims to investigate the interaction properties of these neutral hadrons and use their distinct characteristics to develop particle identification (PID) algorithms for identifying neutrons. Preliminary results from these studies will be presented.

T 104: Search for Dark Matter V

Time: Friday 9:00–10:30 Location: VG 4.102

T 104.1 Fri 9:00 VG 4.102

A digital SiPM in liquid xenon — •Tiffany Luce[1], Michael Keller[2], and Peter Fischer[2] — [1]Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany — [2]Institute for Computer Engineering, Heidelberg University, Germany

Silicon PhotoMultipliers (SiPMs) are photosensors commonly used in many experiments. However, achieving single-photon sensitivity in the experiments is limited by the high dark count rate (DCR) of these devices. Digital SiPMS, where the digitization happens directly on the chip, can show DCRs competitive to that of traditional photomultiplier tubes (PMTs) with the added benefit of not needing analog to digital converters and greatly reducing the data rate. This would open up to cheaper and thus larger systems. We present results of the first test of a digital SiPM in cryogenic liquid xenon, one of the most important detector target for dark matter searches.

T 104.2 Fri 9:15 VG 4.102

Development of assay techniques for the electrodes of a future xenon-filled dark matter obsevatory — •Alexander Deisting[1], Jan Lommler[1], Shumit Mitra[1], Uwe Oberlack[1,2], Fabian Piermaier[2], and Quirin Weitzel[2] — [1]Institut für Physik & Exzellenzcluster PRISMA$^+$, Johannes Gutenberg-Universität (JGU) Mainz — [2]PRISMA Detector Laboratory, JGU Mainz

Dual-phase xenon time projection chambers (TPCs) lead the search for WIMP dark matter. Current experiments (LZ, XENONnT, PandaX-4T) feature electrode diameters between 1 m and 1.5 m. The XLZD collaboration plans a next generation dual-phase TPC with 3 m height and diameter, representing an extraordinary scale for this technology.

Existing TPCs have struggled to achieve their design electric fields, making it ever more crucial for the XLZD TPC to ensure exceptional electrode quality. To address this challenge, a set-up has been developed in Mainz to evaluate electrode performance. It allows the measurement of electrostatic sagging, the analysis of wire quality with high resolution imaging and confocal microscopy, and the detection of small scale defects by measuring local currents associated with Townsend discharge in an electric field. For the latter, a custom tool was developed and mounted on a gantry together with other metrology components (camera, laser-distance sensors, and a confocal microscope). This talk benchmarks the sagging measurement capabilities and the performance of the discharge-based defect detection system. This work is part of ongoing efforts by XENONnT and DARWIN collaborators to develop improved electrodes for current and future experiments.

T 104.3 Fri 9:30 VG 4.102

Certification of 1.5m-TPC electrodes in a large liquid xenon R&D platform — •Julia Müller — University of Freiburg

Over the past decades dual-phase xenon time projection chambers (TPCs) for the direct search for dark matter continuously grew in size and became more sensitive. However, also the technical realization of these large TPCs got more and more challenging. Among the most crucial and also most complex detector components are the large-diameter TPC electrodes required to establish the electron drift field across the TPC. These electrodes need to feature a high optical transparency and high voltage resilience. The large-scale test platform PANCAKE in Freiburg allows testing such electrodes in a liquid xenon environment before they are installed into the final TPC. We will present results of a qualification campaign of three TPC electrodes of 1.5m diameter.

T 104.4 Fri 9:45 VG 4.102

RelExt: A new Tool to Search Dark Matter Relic Density Parameter Spaces — •Karim Elyaouti[1], Rodrigo Capucha[2], Johann Plotnikov[1], Milada Margarethe Mühlleitner[1], and Rui Santos[2] — [1]Karlsruher Institut für Technologie, ITP, Karlsruhe, Deutschland — [2]Centro de Física Teórica e Computacional, Lissabon, Portugal

We developed a tool which allows for efficient parameter space searches which obey the Dark Matter relic density constraint. Its goal is to find parameters for any model with a thermal Dark Matter candidate which is able to generate the full relic abundance observed by PLANCK. This is achieved by numerically solving the Boltzmann equation and providing different methods to automatically adjust the parameters such that the experimentally observed relic density is generated.

T 104.5 Fri 10:00 VG 4.102

In View of Large Detector Arrays: Automated Analysis Modules for COSINUS Direct Dark Matter Search — •Maximilian Gapp — Max Planck Institut für Physik, Garching, Deutschland

One unresolved issue is the explanation for the annual modulation in the rate of interactions in sodium iodide (NaI) crystals detected by DAMA/LIBRA, which is consistent with the expected dark matter signal. The COSINUS (Cryogenic Observatory for SIgnatures seen in Next generation Underground Searches) experiment has been designed to cross-check the long-standing results of the DAMA/LIBRA experiment. This will be achieved by employing cryogenic NaI calorimeters, which have low energy thresholds, and by introducing particle identification techniques through the use of an additional channel. In order to achieve this, it is necessary to test and characterize a significant number of detector prototypes. Furthermore, the COSINUS experiment plans to operate 16 channels initially and 48 subsequently. Given the substantial volume of data that will be generated, it is impractical to analyze the raw data manually. One solution is to automate the analysis chain wherever feasible. This contribution presents the analysis workflow for characterizing new prototypes and highlights potential avenues for automation.

T 104.6 Fri 10:15 VG 4.102

Characterization of a Spring-Based Passive Decoupling System with Capacitive Distance Measurements for the COSINUS Experiment — •Lutz Ziegele for the COSINUS-Collaboration — Max-Planck-Institut für Physik, 85748 Garching, Germany

The COSINUS experiment (Cryogenic Observatory for SIgnatures seen in Next generation Underground Searches) is a direct dark matter search, operating sodium iodide absorbers equipped with Transition Edge Sensors (TES) inside a dry dilution refrigerator. A spring-based passive decoupling system is used to reduce microphonics - one of the major non-particle background sources. To optimize the decoupling system, a profound understanding of its behavior is essential. However, a characterization of the decoupling system inside a closed cryostat at temperatures in the order of tens of milli-kelvin is not straightforward. This contribution discusses the capabilities and limitations of capacitive distance measurement sensors, which repurpose already existing refrigerator structures.

T 105: Invited Overview Talks IV

Time: Friday 11:00–13:00 Location: ZHG011

Invited Overview Talk T 105.1 Fri 11:00 ZHG011

Galactic Astrophysics with H.E.S.S. — •Lars Mohrmann for the H.E.S.S.-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

The High Energy Stereoscopic System (H.E.S.S.) is an array of imaging atmospheric Cherenkov telescopes that has been used to observe the sky in TeV γ rays since 2004. Thanks to its unique location in the Southern Hemisphere and several upgrades to the system, the experiment continues to enable cutting-edge astrophysics despite its age. In this contribution, I will review the latest H.E.S.S. results on Galactic γ-ray sources, including pulsar wind nebulae, young massive star clusters, microquasars, and the Galactic Centre region.

Invited Overview Talk T 105.2 Fri 11:30 ZHG011

Physics in the era of big data: AI in particle and astroparticle physics — •Jonas Glombitza — Erlangen Centre for Astroparticle Physics, FAU Erlangen-Nürnberg

Physics and artificial intelligence (AI) are interconnected. The recent Nobel Prize for Physics has once again revealed this productive connection. While physics concepts laid the foundation for today's neural networks, these algorithms, in turn, enable efficient physics analyses with exceptional precision. This emerging technology opens new perspectives for the data-intensive research field of particle and astroparticle physics. In this talk, I will give an overview of the versatile applications of AI in particle and astroparticle physics, review the breakthroughs that this new technology made possible, and discuss future directions and challenges.

Invited Overview Talk T 105.3 Fri 12:00 ZHG011

What the LHC tells us about the top quark, the heaviest particle in nature — •Matthias Komm — DESY, Hamburg

The unprecedented data collected during proton-proton collisions at 13 and 13.6 TeV by the CERN LHC have significantly advanced our understanding of the top quark, the heaviest known elementary particle. This talk will highlight recent results on top quarks from the ATLAS and CMS collaborations, including precise determinations of key properties such as its mass and the production rates of rare processes, including four-top quark production. Additionally, the top quark's unique role in the Standard Model, particularly its large Yukawa coupling, close to unity, establishes a strong connection with the Higgs boson and makes it therefore a compelling focus for exploring potential new particles. Investigating top quark interactions at the highest energy scales underscores the potential of the LHC experiments to uncover fundamental new aspects of our universe.

Invited Overview Talk T 105.4 Fri 12:30 ZHG011

The flavor intensity frontier: latest results from Belle II and LHCb — •Daniel Greenwald — Technische Universität München, Garching

The study of the different flavors of quarks and leptons may answer some of the most interesting questions of particle physics, including explaining why the visible universe is built only of matter, not antimatter, and discovering new particles and forces not yet known to us. The Belle II and LHCb experiments, located at KEK in Tsukuba, Japan and at CERN in Geneva, Switzerland, precisely measure flavor phenomena using their uniquely large data sets. I will present an accessible overview of both experiments, their measurement techniques, and some of their recent results.

Working Group on Accelerator Physics
Arbeitskreis Beschleunigerphysik (AKBP)

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Overview of Invited Talks and Sessions

(Lecture halls ZHG004; Poster ZHG Foyer 1. OG)

Invited Talks

AKBP 3.1	Tue	16:00–16:30	ZHG004	**SRF accelerating cavity design for the future circular collider** — •SHAHNAM GORGI ZADEH

Sessions

AKBP 1.1–1.3	Mon	16:45–18:15	ZHG004	**Electron Accelerators I**
AKBP 2.1–2.7	Tue	13:45–15:45	ZHG004	**Novel Accelerator Concepts I**
AKBP 3.1–3.1	Tue	16:00–16:30	ZHG004	**AKBP Accelerator Prize Talks**
AKBP 4.1–4.19	Tue	16:30–18:00	ZHG Foyer 1. OG	**AKBP Posters**
AKBP 5.1–5.6	Wed	11:00–12:30	ZHG004	**Particle Sources**
AKBP 6.1–6.7	Wed	13:45–15:45	ZHG009	**Accelerators for Medical Applications (joint session ST/AKBP)**
AKBP 7.1–7.8	Wed	16:15–18:15	ZHG004	**Novel Accelerator Concepts II and FELs**
AKBP 8.1–8.6	Thu	11:00–12:30	ZHG004	**Diagnostics**
AKBP 9.1–9.7	Thu	13:45–15:45	ZHG004	**Novel Accelerator Concepts III and Hadron Accelerators**
AKBP 10.1–10.8	Thu	16:15–18:15	ZHG004	**Novel Accelerator Concepts IV and Applications**
AKBP 11	Thu	18:20–19:00	ZHG004	**Members' Assembly**
AKBP 12.1–12.6	Fri	9:00–10:30	ZHG004	**Radiofrequency and Instrumentation I**
AKBP 13.1–13.4	Fri	11:00–12:00	ZHG004	**Radiofrequency and Instrumentation II**

Members' Assembly of the Working Group on Accelerator Physics

Thursday 18:20–19:00 ZHG004

Sessions

– Invited Talks, Group Reports, Contributed Talks, and Posters –

AKBP 1: Electron Accelerators I

Time: Monday 16:45–18:15 Location: ZHG004

Group Report AKBP 1.1 Mon 16:45 ZHG004

Exploring cutting-edge research and technology at KIT's advanced accelerator facilities — •Erik Bründermann for the IBPT accelerator team-Collaboration — KIT, Karlsruhe, Deutschland

The Institut für Beschleunigerphysik und Technologie at the Karlsruhe Institute of Technology operates the Karlsruhe Research Accelerator, KARA, with the 2.5 GeV electron storage ring, the 40 MeV to 90 MeV short-pulse linear accelerator FLUTE, and KITTEN, a test center for energy-responsible research infrastructures. Combined with additional ATP facilities of the accelerator technology platform like the Magnet and Cryogenics Facilities, this is a perfect environment for accelerator research at KIT and technology transfer. In the future, cSTART - a compact storage ring ideally suited to study novel operation scenarios - and compact laser-plasma accelerators including a 75 TW laser system will expand the short-pulse facilities. We will explore the existing and upcoming accelerator test facilities at KIT and highlight results for accelerator physics and technologies.

Group Report AKBP 1.2 Mon 17:15 ZHG004

Recent Developments at S-DALINAC* — •Michaela Arnold, Adrian Brauch, Lisa Dingeldein, Manuel Dutine, Joachim Enders, Ruben Grewe, Katharina E. Ide, Lars Jürgensen, Maximilian Meier, Fatemeh Sadat Moujani Ghomi, Clemens M. Nickel, Norbert Pietralla, Vincent Pruy, Lukas Reichel, Valentin Reichenbach, Felix Schliessmann, Dominic Schneider, Benjamin Thormann, and Tim Zimmermann — Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Germany

The superconducting Darmstadt linear accelerator S-DALINAC is a thrice-recirculating accelerator for electrons [1]. Besides the conventional acceleration scheme with corresponding nuclear physics experiments, the accelerator can also be operated as an energy recovery linac (ERL) [2]. Since its establishment in 1991, the S-DALINAC was mainly developed and operated by students. Multiple projects to improve the overall beam quality or the operational capabilities of the accelerator are currently in progress: A streak camera for investigating the bunch length, upgrades to the beamline and diagnostics system, support of beam tuning by machine learning techniques and more. A laser Compton backscattering setup is close to its commissioning. Lessons learned from the ERL operation are included in a design study for a future ERL. This contribution gives an overview.

[1] N. Pietralla, Nucl. Phys. News, Vol. 28, No. 2, 4 (2018).
[2] F. Schliessmann et al., Nat. Phys. 19, 597-602 (2023).

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Group Report AKBP 1.3 Mon 17:45 ZHG004

Current Developments at ELSA — •Michael Switka, Max Ammann, Klaus Desch, Frank Frommberger, Daniel Fry, Samuel Kronenberg, Thomas Perlitius, Dennis Proft, Paul Rolf, Yannick Schober, Susanne Speath, Axel Spreitzer, and Leonardo Thome — Physikalisches Institut, Universität Bonn

The electron stretcher accelerator facility (ELSA) at the University of Bonn utilizes a storage ring design to deliver a continuous 3.2 GeV beam of polarized and unpolarized electrons to external experimental stations. Alongside its main purpose to service the hadron physics community, additional modes of operation are developed to allow versatile usage for accelerator-, detector- and medical research. Current developments in beam polarization enhancement, beam diagnostics, electron source and permanent magnet design as well as modification of beam extraction schemes for medical research and a more economic usage for the detector testing community are presented.

AKBP 2: Novel Accelerator Concepts I

Time: Tuesday 13:45–15:45 Location: ZHG004

Group Report AKBP 2.1 Tue 13:45 ZHG004

Energy Compression of a Laser-Plasma Accelerator — •Paul Winkler[1], Max Trunk[1], Lars Hübner[1], Alberto Martinez de la Ossa[1], Sören Jalas[1], Manuel Kirchen[1], Ilya Agapov[1], Sergey A. Antipov[1], Reinhard Brinkmann[1], Timo Eichner[1], Angel Ferran Pousa[1], Thomas Hülsenbusch[1], Guido Palmer[1], Matthias Schnepp[2], Kaja Schubert[1], Maxence Thévenet[1], Paul A. Walker[1], Christian Werle[1], Wim P. Leemans[1,2], and Andreas R. Maier[1] — [1]Deutsches Elektronen Synchrotron, DESY — [2]Universität Hamburg

Laser-Plasma accelerators (LPAs) promise a compact alternative to modern RF-technology, and support orders of magnitude higher electric fields. GeV-energy LPA electron beams from cm-scale sources have been demonstrated. However, the central energy jitter and energy spread, both on the percent-level, have yet prevented LPAs to drive real-world applications.

Here, we present active energy compression of laser-plasma accelerated electron beams. At the LUX experiment at DESY, a dipole chicane stretches the beams in time and thereby imprints an energy-time correlation (a chirp), which is subsequently removed inside an RF cavity. Our setup reduces the fluctuation in central energy as well as the energy spread of the beams by more than an order of magnitude down to the permille-level. We demonstrate performance so far only attributed to modern RF based accelerators which opens the door for a variety of applications, such as compact plasma-based injectors for synchrotron storage rings.

AKBP 2.2 Tue 14:15 ZHG004

Ultrafast plasma wave shadowgraphy for laser wakefield acceleration — •Paula Sedlatschek, Marc Osenberg, Thomas Heinemann, Mirela Cerchez, Onur Bilen, Edgar Hartmann, and Bernhard Hidding — Institute for Laser- and Plasmaphysics, Heinrich Heine University Düsseldorf

Plasma Shadowgraphy via an ultrashort laser pulse can be utilized to probe the small and fast processes in laser wakefield accelerators (LWFAs). This high-resolution technique reveals the plasma dynamics in the sub-micrometer, femtosecond-regime and visualizes the accelerating plasma wave. We present our approach to implement such a probe laser, using a low-power split-off from the main laser driver which is subsequently and further spectrally broadened. The modulated spectrum of the probe laser enables the use of cut-off filters which block the fundamental spectrum from the accelerating main laser. This is leading to precise visualization of density gradients within the plasma. By integrating this method, we aim for a comprehensive characterization of critical LWFA parameters, such as plasma density evolution, wakefield stability, and laser-plasma coupling. This non-intrusive diagnostic intends to improve our laser wakefield accelerator.

AKBP 2.3 Tue 14:30 ZHG004

Optical Imaging as Synthetic Diagnostic in PIConGPU — •Finn-Ole Carstens[1,2], Richard Pausch[1], Klaus Steiniger[1], Fabia Dietrich[1,2], Jessica Tiebel[1,2], Nico Wrobel[1,2], Susanne Schöbel[1], Patrick Ufer[1,2], Arie Irman[1], Michael Bussmann[1], Ulrich Schramm[1,2], and Alexander Debus[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Dresden, Deutschland — [2]Technische Universität Dresden, Dresden, Deutschland

We present a synthetic shadowgraphy plugin for the particle-in-cell code PIConGPU. By time-integrating electric and magnetic fields and propagating them onto a screen in the far field with Fourier methods, shadowgram images equivalent to experimental measurements can be produced.

Our in-situ plugin enables recording few-cycle probe pulses after they propagate through plasma structures of e.g. laser-plasma accelerators. Propagation of the probe pulse takes place during the normal PIC cycle, meaning that all laser-plasma interactions are self-consistently taken into account. By analyzing these shadowgrams alongside the 3D, time-resolved density distribution from the simulation, one can trace the origin of specific features, such as cavity elongation and deformation and a variety of scattering signals that allow improving our understanding of the cavity formation and dynamics in experiments.

AKBP 2.4 Tue 14:45 ZHG004

Multidimensional sensitivity analysis of laser wakefield accelerated electrons in dependence on laser and plasma parameters — •Jessica Tiebel[1,2], Richard Pausch[1], Finn-Ole Carstens[1,2], Fabia Dietrich[1,2], Franziska Herrmann[1,2], Arie Irman[1], Susanne Schöbel[1,2], Klaus Steiniger[1,3], René Widera[1], and Ulrich Schramm[1] — [1]Helmholtz-Zentrum Dresden - Rossendorf — [2]Technische Universität Dresden — [3]CASUS, Görlitz

Laser-plasma accelerators (LPAs) are a promising tool for generating high-charge, low-emittance electron beams, with broad applications in science and research. LPAs are highly sensitive to variations in laser and plasma parameters, some of which are detectable and others of which are difficult or impossible to measure. In addition, many of these parameters are subject to significant fluctuations. The limited knowledge of the parameters and the non-linear nature of laser wakefield acceleration (LWFA) make experimental investigations of the dependencies between laser and plasma parameters and electron beam properties challenging. In this work, we present a simulation-based study to develop a multi-dimensional mapping of laser and plasma parameters to electron beam parameters for self-truncated ionization injection in LWFA. Using the multi-GPU particle-in-cell code PIConGPU and an automated Snakemake workflow, we performed a comprehensive exploration of the parameter space. This study reveals complex multidimensional dependencies and provides actionable insights for experimentalists to optimize input parameters and achieve high quality electron beams with greater efficiency.

AKBP 2.5 Tue 15:00 ZHG004

Metrology of gas targets designed for laser plasma wakefield accelerators — •Natascha Thomas, Thomas Heinemann, Constantin Aniculaesei, and Bernhard Hidding — Institute of Laser- and Plasmaphysics, Heinrich Heine University Düsseldorf

Laser Wakefield Acceleration (LWFA) relies on the precise formation of plasma waves (wakes) driven by intense laser pulses to accelerate charged particles. The dynamics of this process thereby depend on the generated plasma density profile, which is, in turn, determined by the underlying gas density of the utilized targets. For this reason, an accurate and reliable measurement of their characteristics is an essential prerequisite for optimizing LWFA experiments. We present the development and application of an optical diagnostic setup built for the characterization of such gas jets over a wide range of densities and profiles. The system's design offers high flexibility and rapid adaptation to a range of various targets. Additionally, first results and further ideas for improved data collection and analysis are discussed.

AKBP 2.6 Tue 15:15 ZHG004

Recent developments of the cSTART project — •Markus Schwarz, Erik Bründermann, Robert Ruprecht, Axel Bernhard, Bastian Härer, Dima El Khechen, Anton Malygin, Michael Johannes Nasse, Gudrun Niehues, Alexander Papash, Jens Schäfer, Marcel Schuh, Nigel Smale, Pawel Wesolowski, Christina Widmann, Thiemo Schmelzer, Nathan Ray, David Squires, Alexander Saw, Joseph Natal, Anke-Susanne Müller, and Matthias Fuchs — KIT, Karlsruhe, Germany

The combination of a compact storage ring and a laser-plasma accelerator (LPA) can serve as the basis for future compact light sources. One challenge is the large momentum spread (about 2%) of the electron beams delivered by the LPA. To overcome this challenge, a very large acceptance compact storage ring (VLA-cSR) was designed as part of the compact STorage ring for Accelerator Research and Technology (cSTART) project, which will be realized at the Karlsruhe Institute of Technology (KIT, Germany). Initially, the Ferninfrarot Linac- Und Test-Experiment (FLUTE), a versatile source of ultra-short bunches, will serve as an injector for the VLA-cSR to benchmark and emulate LPA-like beams. In a second stage, a laser-plasma accelerator will be used as an injector. The small facility footprint, the large-momentum spread bunches with charges from 1 pC to 1 nC and lengths from few fs to few ps pose challenges for the lattice design, RF system and beam diagnostics. Recently, the Technical Design Report was developed in cooperation with Research Instruments and subcontractors. This contribution summarizes the latest state of the project.

AKBP 2.7 Tue 15:30 ZHG004

Laser-plasma accelerator as injector for the cSTART storage ring — •David Squires, Alexander Saw, Nathan Ray, Joseph Natal, and Matthias Fuchs — IBPT, KIT, Karlsruhe, Germany

Laser-plasma accelerators (LPAs) are promising options for next-generation accelerator facilities. Accelerating structures on the millimeter scale and accelerating gradients several orders of magnitude higher than RF cavities suggest that LPAs can be used as compact accelerators that produce ultrashort pulses of high intensity electrons. We plan to develop an LPA-based injector for cSTART, a compact, high-acceptance storage ring to be built at the Karlsruhe Institute of Technology (KIT).

The LPA injector for our compact storage ring must produce electron beams with a comparatively low beam energy (50-90 MeV) for an LPA, have a narrow relative energy spread (4%), and a high shot-to-shot stability. Reaching these parameters is challenging and requires extensive simulation work before physical devices are built. In our study, we have used fbpic to simulate an ionization injection scheme in combination with tailored plasma density profiles to generate stable LPA beams. The density profile enables us to reach the desired beam energy and energy spread.

AKBP 3: AKBP Accelerator Prize Talks

Time: Tuesday 16:00–16:30 Location: ZHG004

Invited Talk AKBP 3.1 Tue 16:00 ZHG004

SRF accelerating cavity design for the future circular collider — •shahnam gorgi zadeh — CERN, Geneva, Switzerland

The Future Circular Collider (FCC-ee) is an ambitious project aimed at conducting high-precision studies of the Z, W, Higgs, and top quark particles. A critical component of this electron-positron collider is the superconducting radiofrequency (SRF) system, which must adapt to the collider's diverse operational modes. The RF system is required to deliver 50 MW per beam to compensate for synchrotron radiation losses in the 91 km ring while accommodating beam currents and RF voltages that can vary by up to two orders of magnitude across different operational modes. This presentation delves into the design and optimization of SRF accelerating cavities, higher-order mode (HOM) couplers, and power couplers tailored for the FCC-ee's main collider and booster. The engineering of the RF system to handle varying beam currents and RF voltages will be presented. Additionally, it highlights novel concepts, including the SWELL cavity, which offers potential advantages beyond FCC-ee.

AKBP 4: AKBP Posters

Time: Tuesday 16:30–18:00 Location: ZHG Foyer 1. OG

AKBP 4.1 Tue 16:30 ZHG Foyer 1. OG

A novel test cavity setup for surface conductivity measurements of additive manufacturing samples — •Julian Sonpar[1], Hendrik Hähnel[1], Guenther Dollinger[2], Michael Mayerhofer[2], and Ricardo Helm[2] — [1]Goethe University Frankfurt, 60438 Frankfurt am Main, Germany — [2]Bundeswehr University Munich, 85579 Neubiberg, Germany

Additive Manufacturing (AM) has the potential to increase the performance of radio frequency (rf) cavity resonators while cutting manufacturing costs. To investigate the surface conductivity of AM samples and postprocessing techniques, a compact rf cavity design has been introduced. The cylindrical cavity is made from Aluminum. The test body is held by a dielectric inside the cavity. A simulation assisted approach has been used to generate the dependence curve of surface conductivity to Quality factor. In order to calibrate this curve, to the rf cavity's experimentally measured Quality factor, an AOFC test body has been used which is assumed to have ideal conductivity. To further investigate the error that is made from said assumption and calibration, another method of generating the mentioned dependence curve is being investigated. This method uses simulations and Q-measurements to precisely evaluate the rf cavity's intrinsic (Aluminum) conductivity and loss tangent of the dielectric material. The aim is to generate the mentioned dependence curve without the need for AOFC test body calibration.

AKBP 4.2 Tue 16:30 ZHG Foyer 1. OG

Development of a 4:1 Guanella-type Impedance Transformer for the future SIS100 Broadband Cavity Systems — •Christoph Julien Wegmann[1] and Harald Klingbeil[1,2] — [1]Fachgebiet Beschleunigertechnik, Technische Universität Darmstadt, 64289 Darmstadt, Deutschland — [2]Abteilung Ring RF Systems, GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Deutschland

Most particle accelerator cavity systems like e.g. the acceleration cavities focus on generating a harmonic voltage of a given frequency. The SIS100 heavy ion synchrotron under construction at GSI/FAIR will also contain broadband cavity systems generating signals with significant spectral components in a range from 100 kHz to 20 MHz.

Previous analyses have shown that designing a suitable transmission path leads to multiple serious challenges. One of these is that the input capacitance of the tetrode amplifier limits the upper cutoff frequency. To counteract this effect, the load impedance at the input of the tetrode amplifier can be reduced from 50 Ω to 12.5 Ω at the expense of more driver amplifier power. However, to achieve an impedance matching to the driver amplifier necessitates the inclusion of a transformer generating a broadband 4:1 impedance transformation over the entire relevant frequency range.

A Guanella-type 4:1 ferrite transmission line transformer meeting these requirements was developed, built and verified. The core operating principles, approaches and measurement results are presented.

AKBP 4.3 Tue 16:30 ZHG Foyer 1. OG

Towards three-dimensional confinement of the electron beam inside dielectric laser accelerators — •Manuel Konrad[1], Julian Freier[1], Stefanie Kraus[1], Leon Brückner[1], Julian Litzel[1], Tomas Chlouba[1,2], Roy Shiloh[1,3], and Peter Hommelhoff[1,4] — [1]Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen — [2]Center for Nanophotonics, AMOLF, 1098 XG Amsterdam — [3]Institute of Applied Physics, Hebrew University of Jerusalem (HUJI), Jerusalem, Israel — [4]Department Physik, Ludwig-Maximilians-Universität München (LMU), 80799 München

Dielectric laser accelerators are the optical counterpart to classical RF-accelerators. Here, nanophotonic dielectric structures are illuminated by ultrashort laser pulses to create the accelerating modes. Alternating phase focusing (APF) is employed to confine the electron beam inside the acceleration channel [1]. After we successfully applied this concept to gain phase space control over the electrons in the longitudinal and one transverse direction [2], we have recently shown acceleration of electrons in combination with APF. By keeping the beam confined in a 500 μm long structure, we accelerated the electrons from 28.4 to 40.7 keV in a scanning electron microscope [3]. We will show how the APF scheme can be expanded to full 3D confinement and discuss how it is affected by illuminating the structure from the top.

[1] Niedermayer et al., PRL 121, 214801 (2018) [2] Shiloh et al., Nature 597, 498 (2021) [3] Chlouba et al., Nature, 622, 476 (2023)

AKBP 4.4 Tue 16:30 ZHG Foyer 1. OG

Optimisation of drift tube cooling and drift tube geometries of an additive manufacturing IH-type cavity — •Benjamin Dedic, Hendrik Hähnel, Adem Ateş, Jan Dominik Kaiser, and Ulrich Ratzinger — Institut für Angewandte Physik Goethe Universität Frankfurt am Main

Additive manufacturing is a now-powerful tool for the rapid prototyping and manufacturing of complex geometries. A proof-of-concept 433 MHz IH-DTL cavity was constructed for direct additive manufacturing of linear accelerator components. The CFD analysis of the initially designed cooling for the drift tube revealed a design with insufficient heat dissipation; this can lead to thermal deformations as well as problems in keeping the frequency stable during operation. In this respect, an optimization of the cooling system was done in detail with the help of advanced thermal simulation and iterative design improvements. Furthermore, the geometries of the drift tubes were refined to improve mechanical stability and thermal efficiency without compromising electromagnetic performance. The results illustrate that additive manufacturing can achieve significant design freedom, enabling new approaches toward the thermal management challenges faced by high-frequency linear accelerator components.

AKBP 4.5 Tue 16:30 ZHG Foyer 1. OG

Ultrafast electron diffraction at DELTA - commissioning and first results — •Linus Bölte[1], Xijie Wang[1,2], Arne Held[1], Peter Hartmann[1], Carsten Mai[1], Klaus Sokolowski-Tinten[2], and Marius Milnikel[2] — [1]Technische Universität Dortmund — [2]Universität Duisburg-Essen

Ultrafast electron diffraction (UED) enables the measurement of atomic-scale dynamics with femtosecond time resolution.

At DELTA, a new UED experiment has been commissioned, featuring a 100 kV direct current electron gun and a 3 GHz radiofrequency cavity. Here we present the commissioning process and initial results, demonstrating the potential for simultaneous bunch compression and acceleration.

AKBP 4.6 Tue 16:30 ZHG Foyer 1. OG

New aspects of laser polishing of niobium for the production of superconducting cavity resonators — •Florian Brockner and Dirk Lützenkirchen-Hecht — Bergische Universität Wuppertal, Germany

Superconducting cavity resonators require niobium surfaces with low roughness, high chemical purity and isotropic properties. Laser polishing is a more environmentally friendly alternative to established chemical and electrochemical polishing processes and avoids the formation of impurities through non-contact processing.

The melting of the surface during polishing not only smoothes the surface but also heats it. This allows niobium to be doped during the polishing process. Both polishing and doping are strongly influenced by process parameters such as laser power, nitrogen pressure and material parameters related to the crystal structure of the material.

The process parameters were varied to investigate the influence on nitrogen deposition and roughness. The surface properties were analysed using optical profilometry and electron microscopy. The changes in chemical composition and nitrogen incorporation were studied by electron microscopy combined with energy dispersive X-ray spectroscopy and extended X-ray absorption fine structure. X-ray diffraction was also carried out.

AKBP 4.7 Tue 16:30 ZHG Foyer 1. OG

Messung der dielektrischen Eigenschaften von 3D Druck Filamenten bei 500 MHz — •Philipp Müller und Hendrik Hähnel — Institut für Angewandte Physik, Goethe-Universität Frankfurt am Main, Frankfurt am Main, Deutschland

Zur Bestimmung der relativen Permittivität ϵ_r und des Verlustfaktors tan(δ) von 3D-Druck Filamenten bei einer Frequenz von 500 MHz wurde ein Testresonator gebaut. Durch Einlegen von Testkörpern des jeweiligen Materials (Dielektrikums) ändern sich die Resonanzfrequenz, sowie die Güte der Kavität. Durch Vergleich mit Simulationen lassen sich dann ϵ_r und tan(δ) bestimmen, was es ermöglicht 3D-Druck Filamente in HF Anwendungen, wie z.B. Kopplern einzusetzen. Die Ergebnisse der Untersuchung werden präsentiert.

AKBP 4.8 Tue 16:30 ZHG Foyer 1. OG

Utilizing Raspberry Pi Cameras for Multipacting Observations and Beam Characterization — •Leonie Bauer, Adem Ates, Hendrik Hähnel, and Ulrich Ratzinger — Institut für Angewandte Physik, Goethe Universität Frankfurt

Multipacting is a well-known phenomenon in accelerator cavities, typically appearing at lower RF power levels. To gain a better comprehension and characterization of these resonant discharges, the Institute for Applied Physics at Goethe University Frankfurt has implemented optical diagnostic techniques as part of the FRANZ project. By installing Raspberry Pi cameras both inside and outside the Radio Frequency Quadrupole (RFQ) cavity, we can directly visualize low power multipacting events and even observe the beam passing through the RFQ. As the conditioning power increases, additional optical phenomena become evident, starting at approximately 15 kW. Moreover, these camera systems enable the detection of beam-induced residual gas fluorescence, providing a direct method to determine the x-y position of the 700 keV proton beam at the RFQ exit.

AKBP 4.9 Tue 16:30 ZHG Foyer 1. OG

Generation of few-cycle laser pulses via HCF-based compression for pump probe experiments in plasma-based accelerators — •Onur Bilen, Marc Osenberg, Mirela Cerchez, Edgar Hartmann, Paula Sedlatschek, and Bernhard Hidding — Institute of laser- und plasmaphysics, Heinrich Heine University Düsseldorf

Generating ultrashort laser pulses is essential for resolving femtosecond-timescale dynamics in plasma-based particle accelerators. Here we present a hollow-core fiber setup designed to achieve sub-10 femtosecond pulses with a record-breaking pulse energy output of at least 2 millijoule. These ultrashort laser pulses will be utilized to visualize the acceleration process of electrons within a plasma wake via shadowgraphy. To create an ultrashort pulse, multiple light frequencies must overlap constructively, the more frequencies the shorter the pulse. To introduce more frequencies into a pulse, a nonlinearity known as self-phase modulation is employed. Self-phase modulation requires an intense, short laser pulse and a material with strong third-order nonlinearity. Noble gases such as neon and argon have shown sufficiently strong third-order nonlinear behaviour and are widely used for spectral broadening. The necessary intensity is achieved by focusing the light down to a smaller beam diameter. A hollow-core fiber is used to maintain a small beam diameter over a longer distance and to clean the spatial profile of the pulse. The spectrally broadened pulse can then be compressed to sub-10 femtoseconds using chirped mirrors and used for shadowgraphy.

AKBP 4.10 Tue 16:30 ZHG Foyer 1. OG

Extended phase space tomography for EOSD simulation considering crystal geometry effects — •Felipe Donoso, Stefan Funker, Erik Bründermann, Anke-Sussane Müller, and Martin Frank — KIT, Karlsruhe, Germany

This theoretical study presents an advanced method for longitudinal phase space tomography in electron storage rings, focusing on reconstructing phase space densities from electro-optical spectral decoding (EOSD) measurements that incorporate crystal geometry effects. The EOSD crystal geometry significantly impacts the measurement signal due to signal integration along its length and interference from wake fields and Cherenkov diffraction radiation (ChDR). These effects add challenges to reconstructing the original phase space density from experimental data.

To address these challenges, we integrate two theoretical frameworks. First, we employ the Vlasov-Fokker-Planck equation to model the turn-by-turn evolution of the charge density distribution. Second, CST simulations of the bunch profile characterize the electric field inside the crystal, enabling a tailored simulation for the EOSD system at the Karlsruhe Research Accelerator (KARA). By combining these approaches, we propose a refined tomography method that more accurately reconstructs the longitudinal phase space from sensor data, effectively capturing the interplay between bunch dynamics and the EOSD system configuration.

AKBP 4.11 Tue 16:30 ZHG Foyer 1. OG

Possibilities for performance enhancement of a compact TDS at FLUTE — •Sergei Glukhov[1], Matthias Nabinger[2], Michael Nasse[2], Anton Malygin[2], Erik Bründermann[2], Anke-Susanne Müller[2], and Oliver Boine-Frankenheim[1] — [1]Institute for Accelerator Science and Electromagnetic Fields (TEMF), Darmstadt, Germany — [2]Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

A compact transverse-deflecting system (TDS) is being commissioned at the test facility FLUTE (Ferninfrarot Linac- und Test-Experiment) located at the Karlsruhe Institute of Technology (KIT). It has been proposed for diagnostics of short electron bunches. The idea of the technique is to use terahertz (THz) radiation, produced by the tilted-pulse front method using a part of the photoinjector laser, amplified by a sub-mm scale resonator for streaking of the electron bunch. Two types of resonators and their arrays have been studied: inverse split-ring and tilted slit resonator.

Since the temporal resolution of this technique depends strongly on the electric field strength in the resonator gap, it would be desirable to increase this field strength. A horn-antenna-like device placed near the resonator has been proposed and simulated for this purpose. Simulations and geometrical parameter optimization have been performed using CST MICROWAVE STUDIO and will be presented in this contribution.

AKBP 4.12 Tue 16:30 ZHG Foyer 1. OG

Experimental strategy for diagnostic and parameters control of ARCTURUS high power laser system — •Kamill Naczynski, Mirela Cerchez, Koen Macken, Thomas Heinemann, Marius te Poel, and Bernhard Hidding — Institute of Laser- and Plasmaphysics, Heinrich-Heine-University Düsseldorf, Germany

Plasma-based Laser-Wakefield Accelerators (LWFAs) are a compact source of highly relativistic electron beams. However, fluctuations in the laser-plasma interaction affect the stability and reproducability compared to other acceleration methods. For this reason, the characterization and active control of laser parameters is vital to improve the LWFA performance.

Here, we present an integrated strategy to monitor, characterize and active control the ARCTURUS high power laser beam at the Heinrich Heine University Düsseldorf aiming towards the characterization of pulse duration, spatial and temporal intensity profile and spectrum. The beam pointing and wavefront are measured and actively corrected in a closed loop by an adaptive mirror, specifically including the possibility to employ this system at full-power operation. This setup aims for substantial improvements in reproducability and shot-to-shot stability, in turn enhancing the performance of future LFWA experiments.

AKBP 4.13 Tue 16:30 ZHG Foyer 1. OG

Advanced Diagnostic Setup Combining Few-Cycle Shadowgraphy, Schlieren Imaging, and Interferometry for Laser Wakefield Acceleration Experiments — •Marc Osenberg, Paula Sedlatschek, Onur Bilen, Edgar Hartmann, Georg Pretzler, and Bernhard Hidding — Institute of Laser- and Plasmaphysics, Heinrich Heine University Düsseldorf

We present a comprehensive diagnostic setup for laser wakefield acceleration (LWFA) experiments, combining few-cycle pulse shadowgraphy with quantitative Schlieren imaging and interferometric phase shift measurements. This integrated approach enables precise visualization and quantification of refractive index gradients induced by the electron distribution in plasma wakefields generated by high-power laser pulses. The quantitative Schlieren method provides detailed mapping of refractive index variations, while the interferometric capability allows for accurate phase shift measurements to reconstruct plasma density profiles and electric field distributions. By leveraging advanced optical setups and image processing algorithms, the system achieves high spatial and temporal resolution, facilitating in-depth analysis of wakefield dynamics, including amplitude, phase velocity, and electron distribution. The combined techniques provide significant insights into laser-plasma interactions, paving the way for enhanced performance in next-generation accelerator technologies.

AKBP 4.14 Tue 16:30 ZHG Foyer 1. OG

Self- and pre-ionized electron-driven wakefields in mixed gases at SLAC FACET-II — •Edgar Hartmann[1], Ahmad Fahim Habib[2,3], Mirela Cerchez[1], Marc Osenberg[1], Thomas Heinemann[1], Andrew Sutherland[1], Alexander Knetsch[4], and Bernhard Hidding[1,2,3] — [1]Institute for Laser- and Plasmaphysics, Heinrich Heine University, Düsseldorf — [2]University of Strathclyde, Glasgow, UK — [3]The Cockcroft Institute, Warrington, UK — [4]SLAC National Accelerator Laboratory, Menlo Park, California, USA

We present experimental results from the Facility for Advanced Accelerator Experimental Tests II (FACET-II) at SLAC National Accelerator Laboratory, marking the first exploratory experiments of the E310: Trojan Horse-II program. This work focuses on advancing a novel mechanism for generating high-brightness witness beams in electron beam-driven plasma wakefield accelerators. The mechanism, known as Trojan Horse injection, relies on selective ionization of a low-ionization-threshold (LIT) and high-ionization threshold (HIT) species, such as hydrogen and the first ionization level of helium. In this process, the LIT species provides the plasma sustaining the wakefield accelerator and is ionized either by the electron beam itself or by a pre-ionizing laser pulse. A secondary injector laser pulse ionizes the HIT species only within a small, defined region directly within the wakefield. The preliminary experiments investigated the ionization capabilities of the 10 GeV electron driver in a gas mixture. Selective ionization of only the LIT species is critical for enabling Trojan Horse injection.

AKBP 4.15 Tue 16:30 ZHG Foyer 1. OG

Extending aperture3d for Beam Dynamics Simulations of the High-Level Injector (HLI) at GSI — •Pascal Häckel[1,2], Winfried Barth[1,2], and Uwe Scheeler[1] — [1]GSI, Darmstadt — [2]Hi, Mainz

Beam dynamics simulations play a critical role in understanding and optimizing accelerator systems. In this work, we utilize and extend the capabilities of aperture3d, a versatile beam dynamics simulation framework, to model the High-Level Injector (HLI) at the GSI Helmholtzzentrum für Schwerionenforschung.

The study involves adapting aperture3d to accurately represent the unique components and operational parameters of the HLI, including the ion source, RFQ, and drift tube linac. Enhancements to the software were implemented to accommodate specific requirements, such as detailed beamline geometries, and custom diagnostics for analyzing transverse and longitudinal beam dynamics.

The extended functionality of aperture3d enabled precise simulations of the HLI's performance, highlighting emittance growth mechanisms, beam losses, and potential bottlenecks. These insights not only validate aperture3d as a robust tool for high-intensity accelerator studies but also pave the way for further software improvements tailored to complex accelerator systems.

This work underscores the value of extending modular simulation frameworks like aperture3d for advanced research in beam physics and accelerator optimization.

AKBP 4.16 Tue 16:30 ZHG Foyer 1. OG

Variation of the laser focus field geometry for direct electron acceleration — •Lars Torben Schwabe, Jan Riedlinger, Marc Osenberg, and Georg Pretzler — Institute of Laser- and Plasmaphysics, Heinrich Heine University Düsseldorf

The field geometry of a laser focus can be engineered by spatially resolved phase and polarization manipulations in the near field. In this work, focal structures with isolated longitudinal fields on axis, surrounded by a ring of transversal fields, are generated. Experimental results of these focal geometries, which match numerical simulations of the 3D field structures, are presented. Furthermore, PIC-simulations were performed to model the interaction of these fields with free electrons, for example in plasma. We discuss the possibilities and conditions for obtaining directed electron acceleration in the longitudinal fields of an ultrashort laser pulse and its properties.

AKBP 4.17 Tue 16:30 ZHG Foyer 1. OG

Thermal emittance measurements of photocathodes using single-shot techniques at the European XFEL — •Meng Cai — University of Hamburg, Mittelweg 177, 20148 Hamburg — DESY, Notkestraße 85, 22607 Hamburg

The operation of the European XFEL relies on the generation of high-quality electron beams at the photoinjector exit, with peak brightness limited by the photocathode's thermal emittance. Cathode characteristics evolve over time due to multiple cathode laser properties and actual gun conditions, making regular measurements essential for injector optimization. This work explores a single-shot measurement technique at the European XFEL to image and measure the transverse momentum distribution of photoemitted electrons. This method maps the momentum onto an observation screen, greatly enhancing time efficiency for thermal emittance measurements while preserving high spatial and momentum resolution.

AKBP 4.18 Tue 16:30 ZHG Foyer 1. OG

Adaptive automated activation of GaAs photocathodes at Photo-CATCH* — •Markus Engart, Joachim Enders, Maximilian Herbert, Maximilian Meier, Robin Petry, Julian Schulze, and Vincent Wende — Institut für Kernphysik - TU Darmstadt

Photocathodes based on the III-V seminconductor GaAs are used as photoelectron sources to supply spin-polarized electron beams for accelerator applications. In order to achieve a sufficient electron yield, a thin surface layer of cesium combined with an oxidant is applied onto the cathode surface. This process is called the cathode activation and is typically done manually by an experienced operator. This contribution presents the ongoing development and testing of an adaptive algorithm for automated activation at the Photo-CATCH test stand.

*Work supported by DFG (GRK 2128 AccelencE, project number 264883531)

AKBP 4.19 Tue 16:30 ZHG Foyer 1. OG

Optical Emission Spectroscopy for the Characterization of a 2.45 GHz ECRIS Plasma — •Maria Molodtsova, Alexandra Philipp, and Erik Ritter — DREEBIT GmbH, Southwallstr. 5, 01900

ECR ion sources are widely used at many research institutions to provide ions for various experimental setups. DREEBIT GmbH aims to industrialize this type of ion source technology for efficient and reliable use in, e. g., hadron cancer therapy as well as ion implantation of semiconductors. Our goal is to build table-top sized ion sources which can easily be handled as part of a larger machine such as a particle accelerator or target irradiation facility, thereby fulfilling high requirements on beam current, quality, stability as well as reproducibility in serial production. To achieve this, we have already optimized the microwave injection system and magnetic plasma confinement by introducing a simple method to allow for injection of circularly polarized waves and adjusted the magnetic field distribution which led to an 80 % increase of beam current. In the present work, we show how optical emission spectroscopy was used to gain deeper information about the plasma of this specific type of ion source, independent from its ion extraction system. The plasma characterization includes studies of the electron energy distribution and the density of atomic and molecular hydrogen showing that the previous design changes of introducing circularly polarized microwaves and optimizing the magnetic field distribution have led to a well-optimized ECR ion source concerning plasma heating and proton production inside the plasma.

AKBP 5: Particle Sources

Time: Wednesday 11:00–12:30 Location: ZHG004

AKBP 5.1 Wed 11:00 ZHG004

Current Developments in a Hybrid Thermionic and Photoemission Electron Gun for ELSA — •Samuel Kronenberg, Klaus Desch, Philipp Hänisch, Dennis Proft, Yannick Schober, and Michael Switka — Physikalisches Institut der Universität Bonn

A novel electron gun is currently under development for the S-band Linac injector for ELSA. The goal of this enhancement is to realise a new single bunch injection mode in addition to the standard long pulse (multi bunch) mode along with a potential increase in emission current. A dual-mode design is being developed that utilises a caesium dispenser cathode both as a thermionic and a photo-cathode using thermally assisted photoemission. Initial measurements on dispenser cathodes were performed to verify the properties in this mode of operation. The current progress regarding gun design, as well as the development of a dedicated gun test stand will be presented.

AKBP 5.2 Wed 11:15 ZHG004

Spin-Polarized Electron Beams at the ELSA Accelerator Facility — •Axel Spreitzer, Klaus Desch, Dennis Proft, and Michael Switka — Physikalisches Institut der Universität Bonn

At the Electron Stretcher Facility (ELSA) in Bonn a spin-polarized electron beam is generated by irradiating a Strained-Layer Superlattice GaAs photocathode. The electron beam converted into a circularly polarized photon beam allows for double polarization hadron physics experiments. After being hibernated for several years, the polarized source is to be characterized and optimized to re-establish regular operation. Current efforts focus on the optimization of the source's laser and its beamline, as well as the investigation of the quantum efficiency of different photocathode crystals. Furthermore, in prospect of improving the overall system performance, plans include the optimization of the electron beamline and enhancing the electron polarization transfer efficiency. The current state of the polarized electron source setup is presented and discussed.

AKBP 5.3 Wed 11:30 ZHG004

Photocathode Research at Photo-CATCH* — •Maximilian Herbert, Joachim Enders, Markus Engart, Jonas Imhof, Maximilian Meier, Robin Petry, Julian Schulze, Vincent Wende, and Victor Winter — Institut für Kernphysik, Fachbereich Physik, Technische Universität Darmstadt, Darmstadt, Germany

TU Darmstadt's test stand for Photo-Cathode Activation, Testing and Cleaning using atomic-Hydrogen Photo-CATCH faciliates dedicated research on GaAs photocathodes for electron-beam production at accelerators. This contribution will give an overview of recent, ongoing and planned projects at Photo-CATCH, e.g., on automatized activations [1] and Li-enhanced surface layers for increased photocathode lifetime [2,3].

[1] M. Herbert et al., PoS(PSTP2022), Vol. 433, p. 003 (2023).
[2] N. Kurichiyanil et al., J. Instrum. 14 (8), P08025 (2019).
[3] M. Herbert et al., Phys. Rev. Accel. Beams, in press.

*Work supported by DFG (GRK 2128 "AccelencE", project number 264883531)

AKBP 5.4 Wed 11:45 ZHG004

Studie zur Nutzung einer Lanthanhexaborid-Kathode als thermionische Elektronenquelle des S-DALINAC* — •Benjamin Thormann, Michaela Arnold, Lars Jürgensen und Norbert Pietralla — Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Deutschland

Der Elektronenbeschleuniger S-DALINAC verwendet aktuell ein Wolfram-Filament als thermionische Elektronenquelle. Hinsichtlich der ausgezeichneten Strahlqualität, die mittels LaB_6-Kathoden in Elektronenmikroskopen erreicht wird, wurde untersucht, ob die Elektronenquelle des S-DALINAC durch den Einsatz dieser Kathoden verbessert werden kann. Dazu wurde die Elektronenquelle mit LaB_6-Kathode in CST Studio simuliert und mit einer Simulation des aktuellen Aufbaus verglichen. Dieser Vortrag gibt einen Überblick über die Studie. Ihre Ergebnisse werden diskutiert.

*Unterstützt durch DFG (GRK 2128, IRTG 2891) und das Land Hessen (Research Cluster ELEMENTS (Project ID 500/10.006)).

AKBP 5.5 Wed 12:00 ZHG004

Positron Source at Future Linear Collider Designs (ILC, HALHF, CLIC) — •Gudrid Moortgat-Pick[1,2], Sabine Riemann[3], Peter Sievers[4], Gregor Loisch[2], Carmen Tenholt[2], Tim Lengler[5], Dieter Lott[5], Niclas Hamann[1,2], and Manuel Formela[1,2] — [1]University of Hamburg, Hamburg, Germany — [2]DESY, Hamburg, Germany — [3]DESY, Zeuthen, Germany — [4]CERN, Geneva, Switzerland — [5]Helmholtz Zentrum Hereon, Geesthacht

Positron Sources for high luminosity high-energy colliders with at least a cms of 500 GeV are a challenge for all future lepton colliders as, for instance, the International Linear Collider (ILC), Compact Linear Collider (CLIC) as well as new concepts as the HALHF collider design. In the talk new R&D developments for the undulator-based positron source are discussed. The talk includes physics requirements, target material tests, current prototypes for optic matching devices as pulsed solenoid as well as plasma lenses. The applicability of the undulator-based positron source in order to provide polarized positrons for all three collider designs is discussed.

AKBP 5.6 Wed 12:15 ZHG004

Results Of Longevity Measurements Of A Prototype Plasma Lens For Positron Matching — •Niclas Hamann[1], Manuel Formela[1], Gregor Loisch[2], Gudrid Moortgat-Pick[1,2], Kai Ludwig[2], Stephan Wesch[2], and Jonathan Wood[2] — [1]Uni Hamburg — [2]DESY Hamburg

The pursuit of novel technologies in the dynamic landscape of scientific exploration has driven the investigation of plasma lensing as a promising solution for optical matching at future positron sources. This research gains importance as emerging scientific objectives call for innovative approaches to advance experimental capabilities. Our initial experiments uncovered instabilities within the plasma and a significant level of copper sputtering at the electrodes. This presentation will explore these findings in detail and will also present the results of longevity tests conducted across various pressure regions and for two different materials.

AKBP 6: Accelerators for Medical Applications (joint session ST/AKBP)

Time: Wednesday 13:45–15:45 Location: ZHG009

Invited Talk AKBP 6.1 Wed 13:45 ZHG009

Mixed ion beams for treatment monitoring: recent developments and future prospects — •Elisabeth Renner[1], Hermann Fuchs[2], Matthias Kausel[3,1], and Claus Schmitzer[3] — [1]Atominstitut, TU Wien, Vienna, Austria — [2]MedUni Wien, Vienna, Austria — [3]MedAustron, Wiener Neustadt, Austria

In recent years, the use of mixed ion beams has been proposed as a method for treatment monitoring in ion beam therapy. A promising candidate in this context is a $^{12}C^{6+}$ beam with a small $^{4}He^{2+}$ contribution. The similar charge-to-mass ratios of these two ion species enable their simultaneous acceleration in medical synchrotrons. Being extracted at almost the same energy per mass, $^{4}He^{2+}$ features a range in matter approximately three times that of $^{12}C^{6+}$. This opens the possibility for tumor treatment with $^{12}C^{6+}$ while simultaneously performing $^{4}He^{2+}$ imaging downstream of the patient.

In 2024, the first successful delivery of a mixed $^{12}C^{6+}/^{4}He^{2+}$ beam in a clinical facility was achieved at MedAustron. Instead of being generated in a single ion source, as realized at GSI in late 2023, the two ion species were mixed during the injection into the synchrotron, before being simultaneously accelerated and extracted into the research irradiation room. There the ion mix was characterized using radiochromic films, low-gain avalanche diode detectors, and a configuration of two ionization chambers separated by multiple PTW RW3 slabs.

This talk provides a general overview of recent breakthroughs in mixed ion beam delivery, discusses technical challenges, and explores the future potential for treatment monitoring in ion beam therapy.

AKBP 6.2 Wed 14:15 ZHG009

Beam Dynamics and Energy Variation in H-Type Drift Tube Linac for Proton Eye Therapy — •Ali Almomani — Physics Department, Yarmouk University, 21163 Irbid, Jordan

In this study, we investigate the beam dynamics of a proposed H-type drift tube linac (DTL) designed for proton therapy in eye cancer treatment, utilizing the KONUS (Kombinierte Null Grad Struktur) beam dynamics approach and LORASR code. The linac design accelerates protons from 3 MeV to 70 MeV across six cavities with 140 accelerating gaps along a 20-meter structure, operating at a frequency of 325.244 MHz. To ensure transverse beam focusing and beam matching, 11 triplet quadrupole lenses are distributed along the linac. The beam dynamics analysis yielded optimized values for drift tube lengths and gap distances, and simulations showed 100% beam transmission efficiency. The design demonstrated low emittance growth, with less than 20% transversely and 90% longitudinally, ensuring a highly focused beam. The output beam emittances are smaller than what cyclotron can offer, facilitating the generation of a pencil beam capable of scanning the tumor volume from one point to another. Additionally, energy variation options allow flexible beam energy adjustment between 58 and 70 MeV, enabling customizable treatment depths. The energy variation may be realized by varying the gap of voltage levels. The simulation results indicate a stable structure even in the presence of machine errors, supporting further development for RF simulations and mechanical modeling. The overall outcomes are promising, confirming the feasibility of the design for proton therapy applications.

AKBP 6.3 Wed 14:30 ZHG009

Beam spot diagnostics of highly focused electron beams in therapeutic X-Ray generators via Optical Transition Radiation — •Thomas Beiser[1] and Kurt Aulenbacher[2] — [1]Helmholtz-Institute Mainz, (Germany), GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt (Germany) — [2]Helmholtz-Institute Mainz, (Germany), GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt (Germany), Johannes Gutenberg-University, Mainz (Germany)

Optical Transition Radiation (OTR), which is commonly used for beam diagnostics in accelerators at high energies (e.g. MeV to GeV electrons), allows for beam spot diagnostics of intense and highly focused electron beams in therapeutic X-Ray generators with energies as low as 100 keV, using off-the-shelf camera equipment.

AKBP 6.4 Wed 14:45 ZHG009

Development of a Fast Extraction Method to Extract High Intensity Short Pluses at ELSA — •Leonardo Thome, Klaus Desch, Dennis Proft, and Michael Switka — Physikalisches Institut der Universität Bonn

The electron accelerator facility ELSA delivers electron beams up to 3.2 GeV energy, extracted via slow resonance extraction from the stretcher ring in an extraction cycle of typically 10 s. Currently ongoing studies for radiation therapy, investigating the FLASH effect, require short beam pulses reaching from ns to ms. In a preliminary operation mode the booster synchrotron is already used to deliver electrons beam pulses of 1.2 GeV energy with fixed length of 250 ns to irradiate cell samples. To cover higher energies up to 3.2 GeV and different pulse lengths ranging from ns up to several ms, a fast extraction method from the stretcher ring is developed. The concept and realization by different techniques such as a repurposing of the existing injection kickers for extraction or utilizing a dispersive orbit to extract the beam is evaluated.

AKBP 6.5 Wed 15:00 ZHG009

First Results from Cell Irradiation Experiments with Ultrahigh-Energy Electrons (UHEE) at ELSA — •Susanne Spaeth[1], Manuela Denz[2], Klaus Desch[1], Stephan Garbe[2], Frank Giordano[3], Barbara Link[3], Carsten Herskind[3], Barbara Link[3], Dennis Proft[1], and Leonardo Thome[1] — [1]Physikalisches Insitut der Universität Bonn — [2]Klinik für Strahlentherapie und Radioonkologie, Universitätsklinikum Bonn — [3]Klinik für Strahlentherapie und Radioonkologie, Universitätsklinikum Mannheim

A new approach to improve radiotherapy is the use of the so-called FLASH effect, a phenomenon characterised by significantly reduced toxicity in healthy tissue at high dose rates (>40 Gy/s). This effect potentially broadens the therapeutic window, improving tumour control while minimising side effects. At the electron accelerator facility ELSA, the FLASH@ELSA project utilises ultra-high energy electrons (UHEE) to study their effect on tumour cells. Electrons with energies of 1.2 GeV are delivered in sub-microsecond pulses via the booster synchrotron, enabling dose rates up to 10 MGy/s due to the short pulse lengths of 250 ns. Cell samples are irradiated within a water phantom, with dosimetry performed using radiochromic films and luminous screens. Further the FLASH irradiation at ELSA is compared to conventional radiotherapy using a medical linear accelerator (Varian TrueBeam STx) at the University Hospital Bonn. This comparison provides the first survival curves contrasting FLASH and conventional irradiation.

AKBP 6.6 Wed 15:15 ZHG009

Dosimetry of broadband electrons from laser-plasma accelerators — •Antonio Tarzikhan[1], Arpad Lenart[2], Chuan Zheng[1], Thomas Heinemann[1], Constantin Aniculaesei[1], Mirela Cerchez[1], and Bernhard Hidding[1] — [1]Institute of Laser- and Plasmaphysics, Heinrich Heine University, Düsseldorf, Germany — [2]University of Strathclyde, Glasgow, Scottland

Laser-plasma accelerators (LPA) offers compact sources of highly relativistic electron beams for various applications. This study focuses on the dosimetry of broadband electron beams, which are accelerated using the Arcturus laser system at the University of Düsseldorf with laser pulse energies of several millijoules sufficient to accelerate electrons to kinetic energies in the mega-electronvolt range, resulting in an energy distribution characterized by a shallow penetration and high dose deposition at the surface. These electron beams are therefore ideally suited for the treatment of skin cancer. We present the design and calibration of various diagnostics components and report on first experimental results obtained in a recent measurement campaign, incorporated with simulations to optimize the parameters used for the characterization of the electron beam energy- and angular-distribution and the charge calibration to determine the dose. Additionally, accelerated electron beams from intrinsic ultra-short bunch durations, are excellent candidates for FLASH radiotherapy and thus, minimizing damage to surrounding healthy tissues. This highlights the potential of LPA as a new technology in medical physics.

AKBP 6.7 Wed 15:30 ZHG009

Acoustic tracing of dose deposition of laser accelerated ion-bunches by modulation of the depth-dose curve — •Jeannette Cadeggianini, Alexander Prasselsperger, Anna-Katharina Schmidt, and Jörg Schreiber — Ludwig-Maximilian-Universität, München, Germany

A high-repetition-rate online dose reconstruction method is crucial for accelerated particle applications. Ionoacoustic measurements determine monoenergetic ion energies by recording acoustic signals generated by localized thermal expansion in the Bragg region. These waveforms encode the ion beam's energy and spatial distribution.

However, this method depends on pronounced spatial energy density gradients, which are absent in laser-accelerated ion beams, which exhibit broad, exponential energy spectra. To address this, we introduce TIMBRE (Tracing Ionoacoustic Modulations of Broad Energy Distributions), which uses modulator foils to create steeper energy deposition gradients. These foils serve two functions: due to the materials the stopping power in the foils is higher than in the interspaces, generating an acoustic wave at each interface because of the steep pressure gradient. Simultaneously, each foil reduces the amplitude of the signals from shallower foils, compressing the dynamic range.

By unfolding the measured acoustic traces with the corresponding analytic model, TIMBRE reconstructs depth dose distributions of laser-accelerated ion bunches. It offers a real-time diagnostic, supporting modern accelerators operating at Hz-level repetition rates and beyond.

AKBP 7: Novel Accelerator Concepts II and FELs

Time: Wednesday 16:15–18:15 Location: ZHG004

AKBP 7.1 Wed 16:15 ZHG004

Considerations for high repetition rate plasma accelerator sources — •Juan Pablo Diaz, Stephan Wesch, and Jonathan Wood for the FLASHForward-Collaboration — Deutsches Elektronen-Synchrotron DESY

Electron-bunch-driven plasma-wakefield accelerators promise to revolutionize particle acceleration by providing compact and cost-effective energy boosters for electron linacs which could, for example, significantly enhance the photon energies produced by free-electron lasers. The FLASHForward facility at DESY has made substantial progress, demonstrating that accelerated electron bunches can maintain their charge, energy spread, and emittance during plasma acceleration. A major challenge remains in achieving high-repetition-rate operation, as is common in conventional radiofrequency accelerators.

To match the bunch patterns of superconducting RF linacs, identical plasma acceleration events must take place at MHz frequencies. This presents two challenges: how to maintain the same plasma density over these timescales, and how to deal with the high heat load in the plasma and its containment device. In this contribution we will first outline plans and recent results to measure the density evolution of discharge-initiated plasmas with high temporal and spatial resolution. Secondly, we will report on the long-term heating of the plasma cell from repeated plasma creation events with a view towards implementing mitigation strategies

AKBP 7.2 Wed 16:30 ZHG004

New radiation-based method for diagnosing driver dynamics in plasma wakefield accelerators — •Nico Wrobel[1], Alexander Debus[1], Arie Irman[1], Maxwell La Berge[1], Susanne Schöbel[1], Ulrich Schramm[1], Klaus Steiniger[2], Jessica Tiebel[1], Patrick Ufer[1], and Richard Pausch[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf: Dresden, Sachsen, DE — [2]Center for Advanced Systems Understanding: Görlitz, DE

Plasma Wakefield accelerators (PWFA) are a novel concept to build compact particle accelerators while improving beam quality compared to Laser Wakefield accelerators (LWFA). The precise dynamics of the driver in a PWFA are subject of interest, as they determine the created fields and therefore the capabilities to accelerate particles in the wake. One issue in improving PWFA is understanding these driver beam dynamics in the plasma, since it cannot be observed directly in experiments.

Here, we present a novel diagnostic method to overcome this problem by using the measurement of radiation emitted by the driver electrons. This method can reconstruct transversal and longitudinal dynamics of the driver. To develop this method, the many-GPU particle-in-cell code PIConGPU was used to model the ab-initio plasma dynamics. In addition, we computed the spectrally and directionally resolved far field radiation in-situ. We also developed an analytical description to explain the complex driver dynamics, such as the oscillation and degradation patterns observed in the plasma simulations, and directly related them to the infrared radiation signatures.

AKBP 7.3 Wed 16:45 ZHG004

Hydrodynamic simulations of plasma sources for wakefield acceleration — •Mathis Mewes[1], Gregory Boyle[2], Harry Jones[1], Rob Shalloo[1], and Maxence Thévenet[1] — [1]DESY, Hamburg, Germany — [2]James Cook University, Townsville, Australia

With the recent advancements in plasma wakefield acceleration (PWA), it becomes more important to fully understand the dynamics of plasma sources. Some of the critical questions surround discharge control, laser guiding and cooling. Numerical simulations can provide detailed insight into the relevant dynamics.

Particle in Cell simulations work well in the kinetic regime of a wakefield, which occurs on femtosecond time scale, but they are impractical for long term plasma evolution. Instead, (Magneto-)Hydrodynamic simulations can describe thermalized plasma at viable computational costs.

In this work, we propose a quasi-neutral single-fluid plasma model for plasma sources. It uses two temperatures and evolves the composition via collisional reactions and diffusion. The model is implemented in the COMSOL multiphysics software.

We will present and examine simulation results and benchmarks for laser ionized and discharge plasma sources utilized in plasma wakefield accelerators.

AKBP 7.4 Wed 17:00 ZHG004

A virtual spectral diagnostic for plasma accelerated bunches at FLASHForward — •Philipp Burghart[1,2], Lewis Boulton[1], and Jonathan Wood[1] for the FLASHForward-Collaboration — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [2]University of Hamburg, Germany

Plasma-wakefield acceleration (PWFA) promises to reduce the size of future machines significantly by providing multi-GeV/m acceleration gradients, orders of magnitude higher than conventional RF accelerators. However, PWFA is a process with many non-linear dependencies, making it difficult to understand the influence of input parameters. Moreover, measurements of e.g. energy spectra are destructive, preventing the output beam from being used for applications whilst only allowing for the diagnosis of one bunch in a bunch train simultaneously. Neural networks trained on non-destructive measurements can be used to predict the properties of accelerated bunches, which would provide more insight into sources of variability and potential shot-to-shot, non-destructive measurements for whole bunch trains. Using experimental data collected at FLASHForward - a beam-driven plasma acceleration experiment at DESY, Hamburg - a neural network-based virtual diagnostic predicting the spectral properties of plasma accelerated bunches is being investigated. In this contribution, we present first results from this project.

AKBP 7.5 Wed 17:15 ZHG004

Plasma Afterglow Metrology for Laser-Wakefield Accelerators — •Nils Hanold, Marc Osenberg, Paula Sedlatschek, Kamil Naczynski, Edgar Hartmann, Onur Bilen, Natascha Thomas, Jesko Wrobel, Andrew Sutherland, Mirela Cerchez, Constantin Aniculaesei, Thomas Heinemann, and Bernhard Hidding — Institute of Laser- and Plasmaphysics, Heinrich Heine University Düsseldorf

Characterizing the plasma light emitted upon the interaction of a high-power laser with a gas target aims for the development of a non-invasive metrology technique for the complex processes in laser-wakefield accelerators (LWFAs). While integrating the emitted afterglow temporally and spectrally allows obtaining top level information about the interaction, resolving it spectrally and temporally allows extracting further information such as involved ionization levels, laser-plasma interaction strength, dynamics and evolution, to identify and quantify ionization processes along the laser propagation axis, and markers of injection events.

AKBP 7.6 Wed 17:30 ZHG004

Status of THz FEL activities at PITZ — •Namra Aftab, Xiangkun Li, and Mikhail Krasilnikov — Deutsches Elektronen-Synchrotron DESY, Platanenallee 6, 15738 Zeuthen, Germany

A single-pass THz free-electron laser (FEL) at the Photo Injector Test facility at DESY in Zeuthen (PITZ) was designed and implemented for a proof-of-principle experiment on a tunable high-power THz source for pump-probe experiments at the European XFEL. THz pulses are generated at a radiation wavelength of 100 μm within a 3.5 m long, strongly focusing planar LCLS-I undulator. High gain is achieved by driving the FEL with high brightness beams from the PITZ photoinjector at 17 MeV and a bunch charge of up to several nC. Simulations have been carried out to understand the experimental results. THz diagnostics are focused in particular in order to accurately characterize the radiation pulse energy, spectrum and temporal profile.

AKBP 7.7 Wed 17:45 ZHG004

High-gain high-efficiency tapered FEL oscillator — •Margarit Asatrian[1], Eugenio Ferrari[2], Andrew Fisher[3], Georgia Paraskaki[2], Pietro Musumeci[3], and Wolfgang Hillert[1] — [1]University of Hamburg, Hamburg, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [3]University of California at Los Angeles, Los Angeles, California, USA

Free Electron Lasers (FELs) are unique light sources capable of producing intense, high-brightness radiation in the XUV and X-ray regimes. The growing demands of experimental science are pushing FELs to their performance limits in terms of radiation quality and output power. To meet these challenges, it is crucial to explore ways of improving the energy conversion efficiency between the electron beam and the FEL output. Enhanced efficiency could either expand the achievable power range of FELs or enable more compact infrastructures.

The TESSA (Tapering-Enhanced Stimulated Superradiant Amplification) scheme offers a promising solution, with efficiencies more than an order of magnitude higher than those of conventional FELs. This approach employs a strongly tapered undulator and a high-power seed to extract energy from a pre-bunched electron beam. At short wavelengths, however, the absence of suitable high-power seed laser sources calls for the use of cavity-based FELs to generate the required seed. Here, we present FEL simulations that illustrate the power buildup and steady-state regime of such a TESSA-based high-gain FEL oscillator in the XUV wavelength range.

AKBP 7.8 Wed 18:00 ZHG004

Beam-by-design pulse shaping for seeded Free-Electron Laser — •Andreas Thiel[1], Skirmantas Alisauskas[2], Margarit Asatrian[1], Giovanni Cirmi[2], Eugenio Ferrari[2], Ingmar Hartl[2], Wolfgang Hillert[1], Nhat-Phi Hoang[2], Tino Lang[2], Pardis Niknejadi[2], Lucas Schaper[2], and Jiaan Zheng[2] — [1]Universität Hamburg, Hamburg, Germany — [2]Deutsches Elektronen-Synchrotron, Hamburg, Germany

External seeding offers significant improvements in the pulse properties of Free-Electron Lasers (FELs) compared to Self-Amplified Spontaneous Emission (SASE) FELs. Seeding techniques such as High-Gain Harmonic Generation (HGHG) and Echo-Enabled Harmonic Generation (EEHG) utilize seed lasers and dispersive beamline elements to structure the longitudinal phase space of the electron beam. This process creates a density modulation that initiates the FEL process. The coherence properties of the seed are transferred to the FEL output, enabling the production of fully coherent, narrowband radiation with enhanced stability at shorter wavelengths. At the FEL facility FLASH (DESY), the ongoing FLASH2020+ upgrade project includes the integration of external seeding at high repetition rates. A key component of this upgrade is the development of an advanced laser system (SLASH) to act as the seed source. We explore the use of pulse shaping on the seed laser to control the characteristics of the seeded FEL output. Here, we present initial results from a test of the pulse shaper on our laser system, along with numerical simulations that investigate the potential and limitations of generating custom-tailored FEL pulses.

AKBP 8: Diagnostics

Time: Thursday 11:00–12:30 Location: ZHG004

AKBP 8.1 Thu 11:00 ZHG004

Terahertz Streaking Detection for Longitudinal Bunch Diagnostics at FLUTE — •Matthias Nabinger[1], Michael Nasse[1], Erik Bründermann[1], Matthias Fuchs[1], Anke-Susanne Müller[1], Marvin Noll[1], Johannes Steinmann[1], Jens Schäfer[1], Thiemo Schmelzer[1], Robert Ruprecht[1], Nigel Smale[1], Micha Dehler[3], Rasmus Ischebeck[3], Matthias Moser[3], Volker Schlott[3], Thomas Feurer[4], Zoltan Ollmann[4], Sergei Glukhov[2], Oliver Boine-Frankenheim[2], Mozghan Hayati[4], and Marcel Schuh[1] — [1]KIT, Karlsruhe, Deutschland — [2]TU Darmstadt, Darmstadt, Deutschland — [3]PSI, Villingen, Schweiz — [4]Universität Bern, Bern, Schweiz

The Karlsruhe Institute of Technology is currently exploring a compact method of longitudinal electron bunch diagnostics with femtosecond resolution that has recently been demonstrated for other parameter ranges. The experimental setup utilizes a THz-based streaking approach with resonator structures, achieving both high compactness and efficiency. In this contribution, we report on the experimental observation of streaking signals with our Compact Transverse Deflecting System, which has been successfully tested using two different resonators, an Inverse Split-Ring Resonator and a Tilted-Slit-Resonator.

AKBP 8.2 Thu 11:15 ZHG004

Time-resolved measurements of transverse beam excitation in an electron storage ring — •Marvin Noll, Johannes Steinmann, Erik Bründermann, Erhard Huttel, and Meghana Patil — KIT-IBPT

In the Karlsruhe Research Accelerator (KARA), electron beams of up to 200 mA are stored with an energy of 2.5 GeV, while injection is performed at 500 MeV. At the injection energy, the beam life time and the injection efficiency depend largely on Touschek and/or intra-beam scattering. As a counter measure, the beam size can be enlarged transversally by an exciting modulation, e.g., applied via a strip-line.

Here, we examine different excitation strategies and their effects on beam size and the beam orbit. The ultra-fast line camera KALYPSO is used to measure the transverse beam profile from the emitted synchrotron radiation on a turn-by-turn basis.

AKBP 8.3 Thu 11:30 ZHG004

Upgrade of the RF Readout Electronics of the Cavity Beam Position Monitors at the S-DALINAC* — •Valentin Reichenbach, Michaela Arnold, Uwe Bonnes, Manuel Dutine, Ruben Grewe, Lars Jürgensen, Norbert Pietralla, Dominic Schneider, and Felix Schliessmann — Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Germany

At the electron accelerator S-DALINAC, cavity BPMs are used for high-precision non-destructive beam parameter measurements. The preexisting RF readout boards have a limited dynamic range. Hence, the existing electronics cannot be used for both low beam current applications (e.g. tuning) and high current experiments without manual adjustments. A new generation of RF boards with a significantly improved dynamic range have been developed in-house, leading to an extensive upgrade of the RF electronics at the S-DALINAC. Within this contribution, the implementation of the new cavity BPM electronics including performance measurements will be presented.

*Work supported by the State of Hesse within the Research Cluster Project ELEMENTS (Project ID 500/10.006) and by DFG (GRK 2128 AccelencE).

AKBP 8.4 Thu 11:45 ZHG004

High-Resolution Longitudinal Beam Diagnostics with a Fast Faraday Cup at the UNILAC Accelerator — •Nimue Schmidt[1,2], Maksym Miski-Oglu[1], Rahul Singh[1], and Winfried Barth[1,3,4] — [1]GSI, Darmstadt, Deutschland — [2]TU, Darmstadt, Deutschland — [3]HIM, Mainz, Deutschland — [4]JGU, Mainz, Deutschland

At the heavy ion accelerator UNILAC at GSI Helmholtz Center for Heavy Ion Research in Darmstadt, measurements were carried out with a Fast Faraday Cup (FFC) in order to precisely measure the time structure of the particle beam. The FFC offers a highly accurate time-resolved recording of the charge distribution along the longitudinal beam profile. The data obtained in combination with a dipole magnet is used to determine the longitudinal phase space and emittance of the beam. After analyzing the measurement results, the method is integrated into the regular beam diagnostics to ensure continuous monitoring and control of the particle beam during operation. Measurement procedure and results are presented.

AKBP 8.5 Thu 12:00 ZHG004

Stabilization of Transverse Beam Parameters for Future Electron-Induced Fission Experiments at the S-DALINAC* — •Dominic Schneider, Michaela Arnold, Jonny Birkhan, Uwe Bonnes, Adrian Brauch, Manuel Dutine, Ruben Grewe, Bastian Hessbacher, Lars Jürgensen, Igor Jurosevic, Norbert Pietralla, Tim Ramaker, Maximilian Resch, Felix Schliessmann, and Gerhart Steinhilber — Institut für Kernphysik, TU Darmstadt

Research on electron-induced fission reactions of transuranium actinides is in preparation at the S-DALINAC. The intended small target sizes require a limitation of transverse displacement of the electron beam due to drifts and distortions to below 200 μm. Three systems have been developed, implemented and interconnected to monitor and improve the transverse beam stability: (i) A beam position monitoring system based on high-speed cameras provides transverse beam parameters with micrometer resolution at a kilohertz rate. (ii) A newly designed compensator device mitigates longitudinal and transversal perturbations from the mains frequency on the electron beam. (iii) Lastly, an active beam-stabilization system ensures high beam stability at the intended interaction point of the electron beam and the fission target. A brief overview of the design and implementation of these systems as well as performance measurements will be presented in this contribution. *Work supported by State of Hesse within the Research Cluster Project ELEMENTS (Project ID 500/10.006) and DFG (GRK 2128 AccelencE).

AKBP 8.6 Thu 12:15 ZHG004

Precise Beam Position Characterization for MESA using ALICE Stripline BPM. — •Robin Wolf — Johannes Gutenberg Universität Mainz

In order to ensure precise beam positioning and stability, the MESA accelerator relies on accurate and fast beam position measurements. This study focuses on adapting the ALICE stripline beam position monitor (BPM) for MESA's beam diagnostics. Originating from the ALICE accelerator, which operates at 1.3 GHz, this BPM aligns well with MESA*s frequency.

Initial laboratory testing demonstrated the functional reliability of the BPM, laying the foundation for practical applications. Subsequent deployment in the Mainz Microtron (MAMI) beamline allowed for further evaluation, despite MAMI*s higher operating frequency of 2.45 GHz. By employing a broadband stripline and fast oscilloscope, the ALICE BPM captured time-resolved images of MAMI bunches, providing the first successful diagnostics of this kind. However, observed non-linearities in position data highlighted the need for deeper analysis.

This talk will present the performance outcomes of the ALICE stripline BPM, addressing challenges such as non-linearities, while showcasing its potential for rapid and precise measurements under diverse operational conditions.

AKBP 9: Novel Accelerator Concepts III and Hadron Accelerators

Time: Thursday 13:45–15:45 Location: ZHG004

Group Report AKBP 9.1 Thu 13:45 ZHG004

Establishing a new class of High-Current Acceleratordriven Neutron Sources (HiCANS) with the HBS project — •Andreas Lehrach[1], Thomas Gutberlet[1], Paul Zakalek[1], and Holger Podlech[2] — [1]Forschungszentrum Jülich — [2]Johann Wolfgang Goethe-Universität Frankfurt

Accelerator-driven high brilliance neutron sources are an attractive alternative to the classical neutron sources of fission reactors and spallation sources to provide scientists with neutrons to study and analyze the structure and dynamics of matter. With the advent of high-current proton accelerator systems, a new class of such neutron facilities can be established referred to as High-Current Accelerator-driven Neutron Sources (HiCANS). The basic features of HiCANS are a medium-energy proton accelerator with of tens of MeV and up to 100 mA beam current, a compact neutron production and moderator unit and an optimized neutron transport system to provide a full suite of high performance, fast, epithermal, thermal and cold neutron instruments. The Jülich Centre for Neutron Science (JCNS) has established a project to develop, design and demonstrate such a novel acceleratordriven facility termed High Brilliance neutron Sources (HBS). The aim of the project is to build a versatile neutron source as a user facility with open access and service according to the diverse and changing demands of its communities.

Embedded in an international collaboration with partners from Germany, Europe and Japan, the Jülich HBS project offers the best flexible solutions for scientific and industrial users.

AKBP 9.2 Thu 14:15 ZHG004

Laser cooling of bunched relativistic ion beams at the FAIR SIS100 — •Danyal Winters[1], Michael Bussmann[2,3], Tamina Grunwitz[4], Jens Gumm[4], Volker Hannen[5], Thomas Kühl[1,6], Sebastian Klammes[1], Benedikt Langfeld[4], Ulrich Schramm[2,7], Denise Schwarz[4], Mathias Siebold[2], Peter Spiller[1], Thomas Stöhlker[1,6,8], Ken Ueberholz[5], and Thomas Walther[4,9] — [1]GSI Darmstadt — [2]HZDR Dresden — [3]CASUS Görlitz — [4]TU-Darmstadt — [5]Uni Münster — [6]HI-Jena — [7]TU-Dresden — [8]Uni-Jena — [9]HFHF Campus Darmstadt

The heavy-ion synchrotron SIS100 is (at) the heart of the Facility for Antiproton and Ion Research (FAIR) in Darmstadt, Germany. It is designed to accelerate intense beams of heavy highly charged ions up to relativistic velocities and to deliver them to unique physics experiments, such as those planned by the APPA/SPARC collaboration. In order to cool these extreme ion beams, bunched beam laser cooling will be applied using a dedicated facility at the SIS100. We will use a novel 3-beam concept, where laser beams from three complementary laser systems (cw and pulsed) will be overlapped in space, time and energy to interact simultaneously with a very broad ion velocity range in order to maximize the cooling efficiency. We will present this project and give an update of its current status. We will also give an overview of the laser and detector systems that will be used.

AKBP 9.3 Thu 14:30 ZHG004

BEETLE - High average power laser-plasma accelerator using a 1 kW Yb-based laser with nonlinear compression — •Tatiana Nechaeva, Timo Eichner, Sören Jalas, Christian Werle, Lutz Winkelmann, Guido Palmer, Manuel Kirchen, and Andreas Maier — DESY, Hamburg, Germany

Laser-plasma acceleration (LPA) is a promising technology for a future compact accelerator. However, current Ti:Sapphire laser technology typically supports few-hertz repetition rates, with scaling to higher rates being challenging. High energy, kHz-level Yb-based laser systems have longer, sub-picosecond pulses. After nonlinear spectral broadening in a multipass cell, these pulses can be compressed to tens of fs duration, becoming a promising LPA driver alternative. In this poster, we introduce the BEETLE project, recently initiated at DESY, that aims to demonstrate high-energy, high repetition rate electron acceleration. The driver laser pulses, provided by a 5 kHz Yb-based laser system (Trumpf Scientific Lasers), have an energy of 200 mJ and are compressible to 30 fs via spectral broadening. We present an overview, goals and the current status of the project.

AKBP 9.4 Thu 14:45 ZHG004

Modular, Automated Beam Stabilization of the ATLAS-3000 Laser at the Centre for Advanced Laser Applications (CALA) — •Florian Schweiger, Michael Bachhammer, Timo Pohle, Johannes Zirkelbach, Leonhard Doyle, Sonja Gerlach, and Jörg Schreiber — LMU Physik, Munich, Germany

Thermal effects in optical elements as well as subtle changes in the experimental environment (e.g. airflow, humidity, vibrations) are well-known challenges affecting laser alignment. For high-power lasers comprising a multitude of amplification stages, the resulting long-term drifts (occurring over minutes to hours) affect both beam and laser parameters. Monitoring these drifts at the Petawatt-class ATLAS laser at CALA prompted us to develop a modular solution for long-term beam stabilization. This stabilization system consists of separate diagnostic and control modules in between the individual amplification stages of the laser chain. Each module measures the laser near- and far-field and is capable of stabilizing both the position and angle of the beam using motorized mirror mounts. Currently, a total of three stabilization units are installed in the ATLAS frontend, and (supervised) stabilization on the minute timescale has been successfully implemented. Overall, the system improves the stability, precision, and reproducibility of the laser alignment and is therefore advantageous for high-class laser-plasma accelerators. This work was supported by the BMBF within project 01IS24028 and CALA.

AKBP 9.5 Thu 15:00 ZHG004

More realistic laser-plasma simulations by laser profiles measured via Insight — •Fabia Dietrich[1,2], Jessica Tiebel[1,2], Richard Pausch[1], Thomas Püschel[1], Ulrich Schramm[1], and Klaus Steiniger[3] — [1]Helmholtz-Zentrum Dresden-Rossendorf — [2]TU Dresden — [3]CASUS, Görlitz

Laser-plasma physics is an important field of research with wide-ranging applications such as particle acceleration for medical purposes or inertial confinement fusion. A fundamental challenge in this field is understanding and controlling the complex interaction between high-intensity laser pulses and the plasma, for which Particle-in-Cell (PIC) simulations have become indispensable tools.

A significant limitation in many simulation codes is the assumption of idealized laser conditions, such as perfectly Gaussian beams. This simplification arises from the difficulty in analytically modelling spatio-temporal couplings (STCs) that inevitably influence realistic laser pulses.

To address this discrepancy, we present a method for importing realistic laser field data from INSIGHT measurements into multiple-GPU PIC simulations with PIConGPU. INSIGHT measurements provide complete field information of the laser pulse at the focal position, and therefore allow to create a digital twin of experimental setups. This enables us to investigate in detail the impact of STCs on the performance of laser particle accelerators realized at HZDR. Moreover, this new capability permits the prediction of optimized operation points in upcoming experiments.

AKBP 9.6 Thu 15:15 ZHG004

Full Power Laser Diagnostic — •Luis Gwinner, Michael Bachhammer, Leonard Doyle, and Jörg Schreiber — Faculty of Physics, Ludwig-Maximilians-Universität München, Garching, Germany

In the field of particle acceleration, laser-driven ion acceleration has garnered significant research interest. Recent studies have identified several key parameters in the laser-target interaction that can be optimized to maximize particle acceleration efficiency. However, interpreting results when tuning these parameters is often challenging due to the high shot-to-shot variability inherent in laser systems, such as the PW-class Advanced Titanium Sapphire Laser (ATLAS) at the Centre for Advanced Laser Applications (CALA). If these variations stem from statistical fluctuations, one potential solution is to perform a large number of shots to average out the laser-induced variations. This approach necessitates a high-repetition-rate laser and target system, which is a major focus of current research. Another strategy is to directly monitor the key laser parameters just before the laser interacts with the target, without compromising the full laser power delivered to the target. This poses a significant challenge, as monitoring a laser capable of turning matter into plasma requires sophisticated optical systems. Such minimally invasive systems must split the laser beam, directing a small, predictable portion to diagnostic tools while ensuring that the remaining high-energy beam remains unperturbed and reaches the target. The presentation will include preliminary designs, concepts, and first results for this innovative diagnostic setup.

AKBP 9.7 Thu 15:30 ZHG004

100Hz repetition rate, high energy Ti:Sapphire amplifier for laser plasma acceleration — •Thomas Hülsenbusch, Timo Eichner, Man Jiang, Juan B. Gonzalez-Diaz, Adbullah Yousefi, Jelto Thesinga, Mikhail Pergament, Wim P. Leemans, Guido Palmer, and Andreas R. Maier — Deutsches Elektronen-Synchrotron DESY, Notkestrasse 81, 22607 Hamburg, Germany

To move Laser Plasma Acceleration (LPA) from a few-shot, proof-of-principle experiments to applications, it is necessary to increase the repetition rate of the driving laser to the kHz range. While it has been shown that Ti:Sapphire (Ti:Sa) lasers can deliver the high quality, high intensity pulses required for LPA, the high quantum defect of Ti:Sa poses a major challenge for high repetition rate operation. As a first step towards kHz operation, we here present experimental results on a 100Hz Ti:Sa amplifier that delivers pulses of >700 mJ energy, supporting a transform limited pulse duration of <30 fs. The thermal lens can be managed with cryogenic cooling of the laser crystal, allowing a high beam quality of $M^2 < 1.7$ at 100Hz to be maintained. This laser will enable high repetition rate LPA experiments in the near future.

AKBP 10: Novel Accelerator Concepts IV and Applications

Time: Thursday 16:15–18:15 Location: ZHG004

AKBP 10.1 Thu 16:15 ZHG004

Studies on laser driven fission at CALA — •Maximilian J. Weiser, Erin G. Fitzpatrick, Laura D. Geulig, Jinbao Hong, and Peter G. Thirolf — Ludwig-Maximilians-Universität München, Garching, Germany

The field of laser ion acceleration has attracted great interest in the recent years as an alternative to classical accelerators due to its unique features like a small footprint, short bunch duration and solid state like bunch densities. Especially the latter is crucial for studying the so-called *fission-fusion* nuclear reaction mechanism which could help exploring the r-process nucleosynthesis of heavy elements in the Universe. A necessary preliminary study for realising this mechanism experimentally is to gain a better understanding how fission induced by light particles impinging onto high-Z elements performs [1]. For this reason, we developed a gas-based transportation system which enables us to transport the fission products away from our EMP-contaminated experimental chamber to a shielded HPGe γ-detector. In our first experimental campaign conducted at the Centre of Advanced Laser Applications (CALA) we found that the expected fission products could not be measured due to a to small yield arriving at the detector. Therefore, we are currently focusing onto improving the amount of produced fission fragments and the transport efficiency of the setup. This work has been funded by the BMBF under Grant No. 05P24WM2. We acknowledge the GSI target lab (Dr. Bettina Lommel) for providing the U targets. [1] D. Habs et al., Appl. Phys. B 103, 471-484 (2011)

AKBP 10.2 Thu 16:30 ZHG004

Improved strong-field QED rates for collisions of particle-beams with high-power laser pulses — •Nikita Larin[1,2,3] and Daniel Seipt[1,2,3] — [1]Helmholtz Institute Jena, Jena, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany — [3]Institute of Optics and Quantum Electronics, Jena, Germany

In collisions of high-energy particle beams with intense laser pulses, dominate effects of strong field QED (SFQED), such as emission of high-energy gamma rays and pair production. Contemporary particle accelerators, combined with high-intensity lasers, make the observation of these effects feasible. And for successful experimental measurements, the reliable numerical simulations are of the great importance.

The key component of these simulations are the probability rates, which contain information about the quantum nonlinear processes that play a significant role in such extreme conditions. These rates can be readily implemented in Monte-Carlo modules amending laser-plasma and laser-beam simulation codes.

In this talk, I will present a new derivation of the so-called "locally monochromatic approximation" of SFQED processes. It is suited to simulate SFQED processes in beam-laser collisions in the transition regime from perturbative to non-perturbative QED, such as the LUXE project [1] aims to measure. Moreover, our new derivation allows us to remedy some technical issues of the previously known rates.

[1] H. Abramowicz et al., Eur. Phys. J. Spec. Top. **230** (2021) 2445-2560.

AKBP 10.3 Thu 16:45 ZHG004

Nonlinear Breit-Wheeler pair production using polarized photons from inverse Compton scattering — •Daniel Seipt[1], Mathias Samuelsson[2], and Tom Blackburn[2] — [1]Helmholtz Institute Jena, Fröbelstieg 3, 07743 Jena, Germany — [2]Department of Physics, University of Gothenburg, SE-41296 Gothenburg, Sweden

The production of electron-positron pairs from the collision of photons is one of the most elusive processes in QED. Observing multiphoton electron-positron pair production (the nonlinear Breit-Wheeler process) requires high-energy γ rays to interact with strong electromagnetic fields. In order for these observations to be as precise as possible, the γ rays would ideally be both mono-energetic and highly polarized. In this talk I will present Monte Carlo simulations of an experimental configuration that accomplishes this in two stages. First, a multi-GeV electron beam interacts with a moderately intense laser pulse to produce a bright, highly polarized beam of γ rays by inverse Compton scattering. Second, after removing the primary electrons, these γ rays collide with another, more intense, laser pulse in order to produce pairs. I will show that it is possible to measure the γ-ray polarization dependence of the nonlinear Breit-Wheeler process in near-term experiments, using a 100-TW class laser and currently available electron beams. Furthermore, it would also be possible to observe harmonic structure and the perturbative-to-nonperturbative transition if such a laser were colocated with a future linear collider.

AKBP 10.4 Thu 17:00 ZHG004

Real-time search for Dark Photons at the Upgraded LHCb experiment — •Carlos Eduardo Cocha Toapaxi — Heidelberg University, Heidelberg, Germany

Different theoretical model predicts the existence of dark matter mediators which interact minimally with standard model particles. Charm decays are an excellent place to search for dark photons, one kind of light dark matter mediators. The challenge to reconstruct dark photons consists in finding a peak on top of an irreducible non-resonant background of several kHz. Here the search profites enormously from the novel real-time analaysis strategy implement at the LHCb experiment in Run 3. LHCb can read out the entire detector in real time (at 30 MHz) and filter interesting events through a two-stage software trigger using farms of GPUs (first stage) and CPUs (second stage). Sophisticated online selections are employed at both trigger stages to select charm decays, identify the extremely soft electrons that dark photons decay into, and reduce the overwhelming combinatorial background, followed by a dedicated offline selection. In this talk we present the trigger selections and initial sensitivity estimates for dark photons in LHCb Run 3.

AKBP 10.5 Thu 17:15 ZHG004

Simulations of Beam Dynamics and Beam Lifetime for the Prototype EDM Ring — •Saad Siddique for the JEDI and CPEDM Collaborations-Collaboration — GSI Darmstadt Germany

The matter-antimatter asymmetry may be explained through CP-violation by observing a permanent electric dipole moment (EDM) of subatomic particles. An advanced approach to measure the EDM of charged particles is to apply a unique method of "Frozen spin" on a polarized beam in an accelerator. To increase the experimental precision step by step and to study systematic effects, the EDM experiment can be performed within three stages: the magnetic ring COSY (Cooler Synchrotron Juelich), a prototype EDM ring and finally all electric EDM ring. The intermediate ring will be a mock-up of the final ring, which will be used to study a variety of systematic effects and to implement the basic principle of the final ring. The simulations of beam dynamics of prototype EDM ring with different lattices were performed to optimize the beam lifetime and to minimize the systematic effects. After getting beam losses estimations by using analytical formulas for preliminary design of prototype EDM ring , beam-target interaction have been studied in detail which helped to find optimized position of target in storage ring for minimum beam losses. After finding dynamic aperture by using more sophisticated program Bmad, a long term tracking is being performed along with beam-target interactions. Further investigations to reduce systematic effects are also under process.

AKBP 10.6 Thu 17:30 ZHG004

Precision measurement of the beam polarisation for the P2 experiment — •Rakshya Thapa — Institut für Kernphysik, Johannes Gutenberg-Universität Mainz

A 5 MeV Mott polarimeter will be implemented at Mainz Energy-recovering Superconducting Accelerator (MESA) to precisely measure the polarisation of the polarised electron beam. The polarimeter is being fabricated and will soon undergo a pilot test at MAMI.

AKBP 10.7 Thu 17:45 ZHG004

Status of the Laser Compton Backscattering Source at the S-DALINAC* — •Lisa Dingeldein, Michaela Arnold, Adrian Brauch, Manuel Dutine, Ruben Grewe, Lars Jürgensen, Maximilian Meier, Norbert Pietralla, Felix Schliessmann, and Dominic Schneider — Institut für Kernpysik, Technische Universität Darmstadt, Darmstadt, Germany

The COmpton Backscattering at a Recirculating Accelerator (COBRA) project utilizes a high-power laser, which is well synchronized to the electron beam of the Superconducting DArmstadt LINear ACcelerator (S-DALINAC). The backscattering provides high-energy photons for diagnostic and nuclear-photonic applications. A stable and precise laser beam transport to the interaction point in an evacuated beamline is ensured before COBRA will be used during an upcoming operation of the Energy Recovery Linac (ERL). The installation of laser safety precautions, methods for centered alignment of both beams and the detector for the backscattered photons, along with recurring measurements of the laser parameters will be presented.

*Work supported by DFG (GRK 2128, IRTG 2891, Inst163/308-1 FUGG)

AKBP 10.8 Thu 18:00 ZHG004

Advanced bandwidth and energy control of an all-optical hard Compton X-ray source — •Martin Meisel[1], Simon Bohlen[1], Theresa Brümmer[1], Florian Grüner[2], Cristina Mariani[1,2], Theresa Staufer[2], Jonathan Wood[1], Jens Osterhoff[3], and Kristjan Poder[1] — [1]Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany — [2]Universität Hamburg and Center for Free-Electron Laser Science, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA

Compact, tunable X-ray sources with narrow bandwidths are essential for many applications. Laser-plasma accelerator-driven inverse Compton scattering sources show promise but are limited by broad bandwidths and low photon flux. Using an active plasma lens for electron beam tailoring, we demonstrated X-ray tunability from 34 keV to 81 keV without moving parts and reduced electron bunch-induced broadening, achieving a threefold improvement in total bandwidth. Ongoing work to shape the scattering laser aims to further narrow the bandwidth and boost photon production, paving the way for highly precise and efficient compact X-ray sources for future applications.

AKBP 11: Members' Assembly

Time: Thursday 18:20–19:00 Location: ZHG004

All members of the Working Group Accelerator Physics are invited to participate.

AKBP 12: Radiofrequency and Instrumentation I

Time: Friday 9:00–10:30 Location: ZHG004

AKBP 12.1 Fri 9:00 ZHG004

Refurbishment of TESLA Cavities for future ERL upgrades at MESA (*)(**) — •Paul Plattner, Florian Hug, and Timo Stengler — Institut für Kernphysik, Mainz, Deutschland

A future upgrade from 1 mA to 10 mA beam current is planned for the Mainz Energy-Recovering Superconducting Accelerator (MESA), an Energy-Recovering (ER) LINAC. Calculations show a potential limitation of the Higher Order Mode (HOM) antennas, which couple the stored power from HOM out. Through the upgrade of the beam current a quench at the HOM antenna would happen. This limit can be increased by using a superconducting material with a higher ctritical temperature than Niobium. For the studies are chosen NbTiN and Nb3Sn, which are applied as a thin film on substrates like Niobium and Copper. The modified antennes will be tested in an cryomodule from the decomissioned ALICE. This cryomodule need to be refurbished and modified for fulfill the requirements for MESA. (*)We would like to thank STFC Daresbury for their generous gift. (**)The work received funding by BMBF through 05H21UMRB1.

AKBP 12.2 Fri 9:15 ZHG004

Development of a new Chopper Cavity for the S-DALINAC* — •Vincent Pruy, Michaela Arnold, Adrian Brauch, Manuel Dutine, Ruben Grewe, Katharina E. Ide, Lars Jürgensen, Clemens M. Nickel, Norbert Pietralla, Felix Schliessmann, and Dominic Schneider — Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Germany

The operation of the superconducting radio-frequency cavities of the S-DALINAC relies on a bunched electron beam. Currently, the continuous beam generated by the thermionic gun is divided into bunches using a chopper system incorporating a single deflecting cavity. However, this system induces nonlinear curvatures to the beam trajectory. To mitigate this effect, a second, identically constructed deflecting cavity can be employed to re-bend the beam thus counteracting the nonlinear distortions. This work focuses on an excellent deflection behavior and quality factor of the cavity by performing electromagnetic and particle tracking simulations. In this contribution, we report on the progress in the simulation and design of such a double-cavity chopper system.

*Work supported by DFG (GRK 2128, IRTG 2891) and State of Hesse (Research Cluster ELEMENTS (Project ID 500/10.006)).

AKBP 12.3 Fri 9:30 ZHG004

Performanceverbesserung der 6-zelligen Einfangstruktur des S-DALINAC durch Anpassung der Kopplerlängen* — •Lukas Reichel, Michaela Arnold, Manuel Dutine, Ruben Grewe, Katharina E. Ide, Lars Jürgensen, Norbert Pietralla, Felix Schliessmann und Dominic Schneider — Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Germany

Der supraleitende Injektorbeschleuniger des S-DALINAC besteht aus einer 6-zelligen Einfangstruktur und zwei 20-zelligen Beschleunigungsstrukturen. Der 6-Zeller ist auf ein relativistisches Geschwindigkeitsverhältnis von $\beta = 0{,}86$ ausgelegt und beschleunigt die eintreffenden Elektronen so weit vor, dass sie von den auf $\beta = 1$ ausgelegten 20-Zellern angemessen weiterbeschleunigt werden können, weshalb er großen Einfluss auf die Strahlqualität hat. Bei der Inbetriebnahme des 6-Zellers wurde festgestellt, dass die Güte und die maximale Feldstärke deutlich unter den erwarteten Werten lagen. Des Weiteren waren die ausgekoppelte Leistung und der Wärmeeintrag in das Heliumbad problematisch hoch, sodass ein Betrieb nur mit einem reduzierten Energiegewinn durch die Einfangstruktur möglich war. Durch ein gezieltes Kürzen der Ein- und Auskopplerlänge konnte die maximale Feldstärke ungefähr um den Faktor 2,9 erhöht und die ausgekoppelte Leistung deutlich reduziert werden. In diesem Vortrag werden die Vergleichsmessungen, die vorgenommenen Änderungen und deren Ergebnisse vorgestellt und diskutiert.

*Work supported by DFG (GRK 2128, IRTG 2891) and State of Hesse (Research Cluster ELEMENTS (Project ID 500/10.006)).

AKBP 12.4 Fri 9:45 ZHG004

Helium Level Stabilization System of Cryomodule for HELIAC — •Szymon Kowina[1], Maksym Miski-Oglu[1], Thorsten Kuerzeder[1,2], and Viktor Gettmann[1] — [1]GSI, Darmstadt, Deutschland — [2]HIM, Mainz, Deutschland

The superconducting heavy-ion HELmholtz LInear ACcelerator (HELIAC) is designed to meet the needs of the Super Heavy Element (SHE) research and materials science user programs at GSI in Darmstadt. The beam energy can be varied smoothly between 3.5 and 7.3 MeV/u, with an average current of up to 1 emA and a duty cycle of 100 %. Recently, the first cryomodule, CM1, was fully commissioned and tested. CM1 comprises three Crossbar H-mode (CH)-type accelerator cavities, a CH-rebuncher, and two superconducting solenoid lenses. The focus of this contribution is on the details of the liquid helium stabilization system of CM1.

AKBP 12.5 Fri 10:00 ZHG004

Co-sputtering of Nb_3Sn thin films on copper for superconducting HOM antenna application — •Amir Farhood[1], Alexey Arzumanov[1], Márton Major[1], Paul Plattner[2], Florian Hug[2], Timo Stengler[2], and Lambert Alff[1] — [1]Institute of Materials Science, TU Darmstadt, 64287 Darmstadt, Germany — [2]Institut für Kernphysik, Johannes Gutenberg-Universität Mainz, D-55128 Mainz, Germany

For superconducting (SC) accelerators working in continuous wave (CW) mode the power coupled at the higher order mode (HOM) antennas is a power limiting factor. In particular, HOM antennas could quench in energy-recovery operation at high beam currents. Calculations showed that HOM antennas coated with a superconducting film can increase the possible maximal deposited power in HOMs. For this study a copper HOM antenna model was coated with SC Nb_3Sn thin film by co-sputtering. The sputtering system was modified to achieve homogeneous coating of the three-dimensional antenna. Since stoichiometry plays a significant role on the critical temperature of the coating, the Nb to Sn ratio was checked by energy dispersive spectroscopy (EDS) measurements on test samples attached to different areas of the model antenna. The temperature dependence of resistivity and magnetization was measured on the test samples. A minimum critical temperature (T_c) of 13 K at every part of model was shown and on the top part of the antenna, where the heat load is the largest (T_c) of 14.5 K and critical field (H_{c1}) of 150 mT (at 5K) were achieved.

AKBP 12.6 Fri 10:15 ZHG004

Nb_3Sn thin films grown by co-sputtering for SRF cavity application — •Márton Major[1], Alexey Arzumanov[1], Amir Farhood[1], Michaela Arnold[2], Norbert Pietralla[2], and Lambert Alff[1] — [1]Institute of Materials Science, Technical University of Darmstadt, Darmstadt, Germany — [2]Institute of Nuclear Physics, Technical University of Darmstadt, Darmstadt, Germany

Superconducting (SC) RF cavity technology is dominated by bulk Nb due to its proven physical performance and mature production technology. Needs for reducing the energy consumption of particle accelerators, however, call for alternative SC materials, such as Nb_3Sn, to allow their operation at higher temperatures at lower cryogenic costs. The Nb_3Sn coating of carrier structures has a huge potential to reach high acceleration gradients even at 4.2 K. Utilizing thin film technology enables to use copper, an excellent heat conductor, for the bulk of the cavity to which Nb_3Sn can be sputtered for high-quality SC coatings. However, several key technological and physical challenges must be mastered to coat the hollow body of a cavity from inside. At our group, based on a low-temperature magnetron co-sputtering process, the direct deposition of SC Nb_3Sn on Cu became possible. The grown films had high critical fields and critical temperatures. Presently we are scaling up the coating process from small substrates to larger structures, like HOM antennae and QPR cups.

This work was supported by the BMBF through grant 05H21RDRB1 and by the DFG via the Research Training Group GRK 2128 "AccelencE", project No. 264883531.

AKBP 13: Radiofrequency and Instrumentation II

Time: Friday 11:00–12:00 Location: ZHG004

AKBP 13.1 Fri 11:00 ZHG004

Design of a permanent magnet septum with variable field strength for ELSA — •Daniel Fry, Klaus Desch, Dennis Proft, and Michael Switka — Physikalisches Institut der Universität Bonn

As a way to greener accelerators and reduced power consumption permanent magnets have been a rising contender in the last years. For a first project in this field at the ELSA electron accelerator, a permanent magnet septum is designed and evaluated for its feasibility. Intended for a beam energy range of 0.5GeV−3.2GeV magnetic field stregths of 0.15T−0.97T need to be achieved. A mechanism with moveable Samarium-Cobalt (SmCo) magnets, which are chosen for their radiation hardness, is proposed. The magnets are moved from the iron yokes of the septum into a magnetic short circuit iron loop to cover the variable field strength. CST Studio simulations are used to evaluate possibilities to minimize the magnetic forces on this movement and the feasibility of the design. A simulation model is presented and further steps towards construction are discussed.

AKBP 13.2 Fri 11:15 ZHG004

Lattice Optimization for the MESA Injection and Recirculation Arcs Using ELEGANT. — •Esraa Khidr — Institut für Kernphysik, Mainz, Germany

The Mainz Energy-Recovering Superconducting Accelerator (MESA) is under construction at the Johannes Gutenberg University Mainz. MESA will enable a range of high-precision experiments in particle and nuclear physics through its dual-mode operation: External Beam Mode runs with 150 *A with polarized electrons at 155 MeV and Energy Recovery Linac (ERL) Mode with an unpolarized beam of 1 mA at 105 MeV. This work presents beam dynamics simulations for MESA's injection and recirculation arcs. We optimize the lattice design using the ELEGANT tracking code to achieve dispersion-free and small beta functions within the cryomodule. Additionally, the acceptance of the injection arc has been analyzed to ensure robust beam transport. These simulations are essential for ensuring MESA's successful operation in both modes.

AKBP 13.3 Fri 11:30 ZHG004

Beam-Dynamics Simulations for the ERL-Facility Concept DICE* — •Fatemeh Sadat Moujani Ghomi, Michaela Arnold, Norbert Pietralla, and Felix Schliessmann — Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Germany

The Darmstadt Individually recirculating Compact Energy recovery linac (DICE) is a multi-turn energy-recovery concept in a racetrack structure with two linacs and separate beam transport. This layout allows to tune each arc individually with respect to transverse beam focusing and longitudinal dispersion. The latter enables sophisticated manipulations of the longitudinal phase space. In this contribution, beam-dynamics simulations addressing the tracking through certain sections of DICE are presented. For the tracking, the software ELEGANT is used.

*Work supported by DFG (GRK 2128, IRTG 2891) and State of Hesse (Research Cluster ELEMENTS (Project ID 500/10.006))

AKBP 13.4 Fri 11:45 ZHG004

Developing an Ion Beam Analysis Setup in Bonn — •Henry Schumacher, Dennis Sauerland, and Sebastian Neubert — Helmholtz-Institut für Strahlen und Kernphysik, Universität Bonn

The Bonn Isochronous Cyclotron can accelerate protons, deuterons and ions up to $^{12}C^{4+}$ with nominal ion energies of 7 to 14 MeV/nucleon. At one of the five beam lines, a new measuring station for material analysis is in development.
Initially the site will be equipped with two detectors for Rutherford backscattering (RBS) and two additional ones for particle induced X-Ray emissions (PIXE). Employing these two methods together provides the possibility to detect, identify and distinguish most isotopes.
Utilizing this ion beam setup, it will be possible to analyze a wide variety of samples, such as biological, geological, archaeological and even pieces of art and items of historical value in a non-destructive manner.
In this talk, an overview over the planned ion beam analysis setup as well as estimations on the setup's count rates for RBS and PIXE at the Bonn Isochronous Cyclotron are presented.

Working Group on Equal Opportunities
Arbeitskreis Chancengleichheit (AKC)

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Overview of Invited Talks and Sessions

(Lecture hall ZHG009)

Invited Talks

AKC 1.1	Thu	11:00–11:30	ZHG009	**Lucy Mensing: Forgotten Pioneer of Quantum Mechanics** — •Gernot Münster
AKC 1.2	Thu	11:30–12:00	ZHG009	**The Spectrum of He^+ as a Proving Ground for Bohr's Model of the Atom: A Legacy of Williamina Fleming's Astrophysical Discovery** — •Bretislav Friedrich
AKC 1.3	Thu	12:00–12:45	ZHG009	**Unethical Behavior in Academia: Forms, Causes, and Countermeasures** — •Daniel Leising

Sessions

AKC 1.1–1.3	Thu	11:00–12:45	ZHG009	**AKC**
AKC 2	Thu	12:45–13:45	ZHG009	**Women in Physics Lunch**

Sessions

– Invited Talks –

AKC 1: AKC

Time: Thursday 11:00–12:45 Location: ZHG009

Invited Talk AKC 1.1 Thu 11:00 ZHG009

Lucy Mensing: Forgotten Pioneer of Quantum Mechanics — •Gernot Münster — Universität Münster

In 1925 a young postdoc, Lucy Mensing, came to Göttingen to do research with the new matrix mechanics, which had just been formulated. In the following years she did groundbreaking work. She successfully made the first application of the new theory to diatomic molecules. As a by-product of this work, she was the first who found that, even though in general both integer and half-integer values are allowed for angular momentum, orbital angular momentum always takes on integer values. Pauli, being impressed by her clear and masterful treatment of the problem, invited her to work with him on the polarizability of gases. After that, she worked in Tübingen. In my contribution I will sketch the pioneering work of Mensing and give a brief account of her life. I will also discuss why she gave up her career, which ended in 1930 after she married and started a family.

Invited Talk AKC 1.2 Thu 11:30 ZHG009

The Spectrum of He^+ as a Proving Ground for Bohr's Model of the Atom: A Legacy of Williamina Fleming's Astrophysical Discovery — •Bretislav Friedrich — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin

In 1896, Edward Charles Pickering (1846-1919), Director of the Harvard College Observatory (HCO), reported in a trio of publications the observation of "peculiar spectra" of the southern star zeta-Puppis, which he attributed to an "element not yet found in other stars or on earth." Supported by laboratory spectra obtained by Alfred Fowler (1868-1940), Niels Bohr (1885-1962) showed in 1913 that this "element" was in fact ionized helium, He^+. Its spectrum has become known as the Pickering Series, even though Pickering credited Williamina Fleming (1857-1911) for the discovery. Fleming was one of HCO's "computers" and the future Curator of Harvard's Astronomical Photographic Glass Plate Collection. The series of spectral lines associated with Pickering's name played a unique role on the path to quantum mechanics by serving as a proving ground for Bohr's model of the atom. Our examination of the discovery of the Pickering series relied on the records held at the Center for Astrophysics | Harvard & Smithsonian (the successor institution to HCO), especially the Notebooks and Diaries of Williamina Fleming and others as well as on the Center's Glass Plate Collection. Glimpses of the "peculiar sociology" of a research institution, half of whose staff were women employed on grossly unequal terms with men, are given in the course of the narrative.

Invited Talk AKC 1.3 Thu 12:00 ZHG009

Unethical Behavior in Academia: Forms, Causes, and Countermeasures — •Daniel Leising — Technische Universität Dresden

Recent years have seen a steady flow of media reports about cases of unethical behaviour in academia. Such behaviour seems surprisingly common, often causes great damage, and typically remains unsanctioned. In my talk, I will first introduce a number of concepts that are relevant to the discourse on this topic (e.g., power, abuse of power). Then I will discuss some key factors that may explain the emergence and the persistence of unethical behaviour in academia. Notably, some of these factors are properties of unethical actors themselves (e.g., psychopathic traits), some are properties of the people that surround unethical actors (e.g., fear), and some are properties of the organizational setup (e.g., incentives, hierarchies, lack of effective controls). Based on this analysis, I will present some recommendations for reforms of the academic system that may help reduce the frequency and severity of unethical behaviour in academia.

AKC 2: Women in Physics Lunch

Time: Thursday 12:45–13:45 Location: ZHG009

Female physicists of all career stages are cordially invited to join our meet-and-greet networking lunch or snack. Diverse and all kinds of interested colleagues are also welcome!

Working Group "Young DPG"
Arbeitskreis junge DPG (AKjDPG)

Simon Neuhaus
Bergische Universität Wuppertal
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Overview of Invited Talks and Sessions

(Lecture halls ZHG007, ZHG008, and ZHG Foyer EG)

Invited Talks

AKjDPG 1.1	Mon	13:00–13:50	ZHG007	**Introduction to direct dark matter searches** — •Daniel Wenz
AKjDPG 2.1	Tue	12:30–13:20	ZHG007	**Overview of selected medical physics topics for young scientists** — •Jens Weingarten
AKjDPG 3.1	Tue	19:00–19:25	ZHG008	**From a clean lab to dirty barns** — •Sonja Zeissner
AKjDPG 3.2	Tue	19:25–19:50	ZHG008	**From Academia to Actuarial: Bridging Science and Business** — •Reinke Sven Isermann
AKjDPG 3.3	Tue	19:50–20:15	ZHG008	**Enabling the future through light - Product Line Manager at Excelitas** — •Julia Granget
AKjDPG 3.4	Tue	20:15–21:30	ZHG008	**Podium discussion with the three speakers** — •Michael Lupberger

Sessions

AKjDPG 1.1–1.1	Mon	13:00–13:50	ZHG007	**jDPG Tutorium – Dark Matter**
AKjDPG 2.1–2.1	Tue	12:30–13:20	ZHG007	**jDPG Tutorium – Medical Physics**
AKjDPG 3.1–3.4	Tue	19:00–21:30	ZHG008	**yHEP Physicists Beyond Academia**
AKjDPG 4	Tue	21:30–22:30	ZHG Foyer EG	**Bier & Brezel**
AKjDPG 5.1–5.1	Wed	19:00–21:30	ZHG007	**jDPG/yHEP Discussion on current topics relevant to young researchers**

Sessions

– Invited and Contributed Talks –

AKjDPG 1: jDPG Tutorium – Dark Matter

Time: Monday 13:00–13:50 Location: ZHG007

Invited Talk AKjDPG 1.1 Mon 13:00 ZHG007

Introduction to direct dark matter searches — •Daniel Wenz — Unversity of Muenster

A large number of evidence from galactic to cosmic scales suggests the existence of a massive, non-luminous, and non-baryonic matter component which is five times more abundant than regular matter. This so-called dark matter (DM) represents an excellent window to the physics Beyond the Standard Model of particles. One well-motivated class of DM candidates are so called weakly interacting massive particles (WIMPs).

To directly search for WIMPs, highly sensitive experiments are required which utilize different techniques to discriminate environmental backgrounds from potential signals. Not only in the direct search for WIMPs, but also in other rare event searches like searches for the neutrinoless double beta decay, or solar neutrinos, similar techniques are used to measure these faint and rare signals.

In this tutorial we will discuss the fundamentals of the direct search of WIMP dark matter and use this as an example to illustrate how these challenging experiments in the field of rare event searches are designed. As an example, we will have a closer look at the XENONnT experiment which is one of the world leading experiments in the direct search of high mass WIMPs.

AKjDPG 2: jDPG Tutorium – Medical Physics

Time: Tuesday 12:30–13:20 Location: ZHG007

Invited Talk AKjDPG 2.1 Tue 12:30 ZHG007

Overview of selected medical physics topics for young scientists — •Jens Weingarten — Technische Universität Dortmund

"Medical Physics is the application of physics to healthcare; using physics for patient imaging, measurement and treatment." This definition by the European Federation of Organisations for Medical Physics, as well as similar statements all over the web, show the vastness of of this field.

In this tutorial, I will a give brief introduction and overview on selected topics in the field of medical physics. The overview is especially dedicated to young colleagues working on their MSc thesis or their PhD. We will focus on topics that are discussed in the specialized talks in various sessions at the DGP meeting. Thus the overview may serve to give some guidance for the meeting.

AKjDPG 3: yHEP Physicists Beyond Academia

Time: Tuesday 19:00–21:30 Location: ZHG008

Invited Talk AKjDPG 3.1 Tue 19:00 ZHG008

From a clean lab to dirty barns — •Sonja Zeissner — VetVise GmbH, Hannover, Germany

If you happen to love academia, but you also have a family and don't want to move every two years, what do you do? Right, you leave academia. I, however, found a job that is still fairly close to doing research.

We are going to take a look at what I do as a data scientist at VetVise GmbH, a start-up that is using data analysis and machine learning to improve yields and animal welfare in livestock farming. We are going to find out about the similarities and differences of working with elementary particles and chickens. And we are going see if getting a Ph.D. in HEP can actually prepare you for working with data from pig barns.

Invited Talk AKjDPG 3.2 Tue 19:25 ZHG008

From Academia to Actuarial: Bridging Science and Business — •Reinke Sven Isermann — Göttingen

In this talk, I'll share my journey from academia to the insurance industry, exploring how a background in theoretical high energy physics research led to a career as an actuary. I'll discuss the parallels between solving scientific problems and tackling actuarial challenges, as well as the hurdles and opportunities that come with transitioning between these fields.

Invited Talk AKjDPG 3.3 Tue 19:50 ZHG008

Enabling the future through light - Product Line Manager at Excelitas — •Julia Granget — Excelitas - Qioptiq Photonics GmbH & Co. KG

Excelitas provides innovative photonic components and subsystems to global OEMs who are seeking the highest-performance solutions from a market-driven partner.

My path from a PhD in detector physics to product line management in the business unit Semiconductor Equipment will be presented in this talk. In addition, a brief introduction of Excelitas and my work in the Semiconductor business will be given.

Invited Talk AKjDPG 3.4 Tue 20:15 ZHG008

Podium discussion with the three speakers — •Michael Lupberger — University of Bonn — yHEP

A podium discussion follows the presentations of the three speakers. They are all former particle physicists now working outside academia. The audience is welcome to ask questions, in particular regarding e.g. career path, skills learned in physics usable in the commercial sector, working atmosphere, decision-making for leaving academia and much more. I will moderate the discussion and co-chair the presentaions of the speakers.

AKjDPG 4: Bier & Brezel

Time: Tuesday 21:30–22:30 Location: ZHG Foyer EG

get together

AKjDPG 5: jDPG/yHEP Discussion on current topics relevant to young researchers

Time: Wednesday 19:00–21:30 Location: ZHG007

AKjDPG 5.1 Wed 19:00 ZHG007

Discussion – Future of Academic Work — Simon Neuhaus[1,3] and •Michael Lupberger[2,4] — [1]jDPG — [2]yHEP — [3]University of Bonn, Bonn, Germany — [4]Bergische Universität Wuppertal, Wuppertal, Germany

The jDPG and yHEP want to give in this session students, doctoral candidates and post-docs on temporary contracts the opportunity to discuss important topics for their future work condition in academia. This are especially the topic of the new "Wissenschaftszeitvertragsgesetz" and residence permits. In the begin of the session there will be a short presentation about the basics of the both topics and the opinion of the yHEP Management board.

Working Group on Physics, Modern IT and Artificial Intelligence Arbeitskreis Physik, moderne Informationstechnologie und Künstliche Intelligenz (AKPIK)

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Overview of Sessions

(Lecture hall Theo 0.134; Poster ZHG Foyer 1. OG)

Sessions

AKPIK 1.1–1.3	Wed	13:45–14:45	ZHG001	**Theory of Machine Learning (joint session MP/AKPIK)**
AKPIK 2.1–2.2	Wed	16:15–18:15	ZHG Foyer 1. OG	**AKPIK Poster Session**
AKPIK 3.1–3.5	Thu	16:15–17:30	Theo 0.134	**Machine Learning in Particle- and Astroparticle Physics**
AKPIK 4.1–4.6	Fri	9:00–10:30	Theo 0.134	**Simulation and Workflows**

Sessions

– Contributed Talks and Posters –

AKPIK 1: Theory of Machine Learning (joint session MP/AKPIK)

Time: Wednesday 13:45–14:45 Location: ZHG001

AKPIK 1.1 Wed 13:45 ZHG001

Time Series Analysis of machine learned Quantum Systems — •Kai-Hendrik Henk and Wolfgang Paul — Martin-Luther-Universität Halle-Wittenberg, Halle(Saale), Deutschland

The Rayleigh-Ritz variation principle is a proven way to find ground states and energies for bound quantum systems in the Schrödinger picture. Advances in machine learning and neural networks make it possible to extend it from an analytical search from a subspace of the complete Hilbert space to the a numerical search in the almost complete Hilbert space. Here, we extend the Rayleigh-Ritz principle to Nelson's stochastic mechanics formulation of non-relativistic quantum mechanics, and propose an algorithm to find the osmotic velocities $u(x)$, which contain the information of a quantum systems in this picture (*Phys. Rev. A 108, 062412*). Motivated by experiments by the Aspelmeyer group at the University of Vienna using quantum levitodynamics (see for example *Nature 595, 373-377 (2021)*), we apply the algorithm to the harmonic oscillator, the Gaussian and the Lorentzian potential and analyze them using methods from time series analysis and phase portraits.

References: *Henk, K.-H., and Paul, W. Machine learning quantum mechanical ground states based on stochastic mechanics. Phys. Rev. A 108 (Dec 2023), 062412*

AKPIK 1.2 Wed 14:05 ZHG001

Opening the Black Box: predicting the trainability of deep neural networks with reconstruction entropy — •Yanick Thurn[1], Ro Jefferson[2], and Johanna Erdmenger[1] — [1]Institute for Theoretical Physics and Astrophysics, Julius-Maximilians-University Wuerzburg — [2]Institute for Theoretical Physics, and Department of Information and Computing Sciences, Utrecht University

An important challenge in machine learning is to predict the initial conditions under which a given neural network will be trainable. We present a method for predicting the trainable regime in parameter space for deep feedforward neural networks (DNNs) based on reconstructing the input from subsequent activation layers via a cascade of single-layer auxiliary networks. We show that a single epoch of training of the shallow cascade networks is sufficient to predict the trainability of the deep feedforward network on a range of datasets (MNIST, CIFAR10, FashionMNIST, and white noise). Moreover, our approach illustrates the networks decision making process by displaying the changes performed on the input data at each layer, which we demonstrate for both a DNN trained on MNIST and the vgg16 CNN trained on the ImageNet dataset.

AKPIK 1.3 Wed 14:25 ZHG001

Analytic continuation of Greens functions with a neural network — •Martin Rackl, Yanick Thurn, Fakher Assaad, Anika Götz, René Meyer, and Johanna Erdmenger — Julius-Maximilians University Würzburg, Am Hubland, 97074 Würzburg, Germany

An important problem in many-body physics is to reconstruct the spectral density from the imaginary-time domain Greens function. Typically, this Greens function is generated by Monte Carlo methods. As the one-point fermionic kernel diverges for large frequencies, the numerical noise present generically causes instabilities. A standard method to tackle the reconstruction of the spectral density is the maximum entropy method (MaxEnt). In this paper, we follow a different approach and use a convolutional neural network for obtaining the spectral density for a given imaginary time Greens function. The network is very sensitive to the nature of the training data that we create using random Gaussians. Here we improve the training data set available by considering collision centres for Gaussians rather than uniformly distributed Gaussians. Our network is constructed in such a way that its output fulfils the positive semidefiniteness of the spectral density and is ppropriately normalized. We compare the results of this network with results of MaxEnt for the same problem. This com- parison is performed for different cases: artificial test data, spin-charge separation in the 1d Hubbard model. Using the Wasserstein distance as metric, we find that the network performs in the same order of magnitude of accuracy as MaxEnt.

AKPIK 2: AKPIK Poster Session

Time: Wednesday 16:15–18:15 Location: ZHG Foyer 1. OG

AKPIK 2.1 Wed 16:15 ZHG Foyer 1. OG

Exploring GNN-based trigger algorithms for underwater neutrino telescopes — •Avalon Rego[1,2], Francesca Capel[2], Christian Spannfellner[3], and Li Ruohan[3] — [1]Ludwig-Maximilians-Universität, München, Deutchland — [2]Max-Planck-Institut für Physik, Garching bei München, Deutchland — [3]Technical University of Munich , Munich, Germany

Neutrinos are a window into a deeper understanding of both beyond standard model physics and various high-energy astrophysical phenomena. This is because they can easily escape dense environments due to their weakly interacting nature and can pinpoint their sources since they are not deflected by magnetic fields. We detect these weakly interacting particles by embedding detectors into massive volumes of naturally available water or ice and then detecting the Cherenkov radiation produced by their interactions. These detectors are sensitive to complex backgrounds such as bioluminescence signals which are a challenge for standard trigger algorithms. In this work we investigate the use of Graphnet, a GNN-based python framework, for signal classification and improving discrimination for bioluminescence signals in particular comparing it to a standard coincidence trigger. We also explore the possibility of using this trigger to lower the energy threshold for neutrino detection.

AKPIK 2.2 Wed 16:15 ZHG Foyer 1. OG

Automated Metadata Verification and Experimental Validation Using Dual Neural Networks in Alignment with FAIR Principles — •Rebekka Murati[1], Johannes Marczinkowski[1], Cedric Kessler[1], Andrei Schliwa[2], Matthias Böhm[3], and Nina Owschimikow[1] — [1]IOAP, TU Berlin — [2]IFKP, TU Berlin — [3]Institut für Softwaretechnik und Theoretische Informatik, TU Berlin

The sustainable management of scientific data is guided by the principles of Findability, Accessibility, Interoperability, and Reusability (FAIR). In particular, the quality and accuracy of metadata, data that describes the measurement data, play a central role in ensuring the reproducibility and integrity of experimental results. We present an approach for the automated verification and validation of metadata and experimental results, using the example of an X-ray spectroscopy experiment. The approach is based on the use of an electronic lab notebook and two neural networks for detecting data quality issues of both meta data and experimental data. We synthetically generated metadata (aligned with the FAIR principles) and a wide variety of measurement data, as well as introduced a spectrum of realistic data corruptions (e.g. spelling errors) for training these models. By combining both outputs, it becomes possible to make precise judgments about whether the metadata for the experiment has been fully and correctly recorded and whether the experiment itself was conducted without errors and is consistent with the metadata. This approach enables improved quality assurance and provides real-time feedback to experimenters regarding the quality of their data and metadata.

AKPIK 3: Machine Learning in Particle- and Astroparticle Physics

Time: Thursday 16:15–17:30 Location: Theo 0.134

AKPIK 3.1 Thu 16:15 Theo 0.134

A Hybrid Approach for Optimizing Background Simulations in IceCube — •Simon Koch, Christian Haack, and Benedikt Mayer — Erlangen Centre for Astroparticle Physics - ECAP, FAU Erlangen-Nürnberg

The IceCube Neutrino Observatory detects high-energy cosmic neutrinos by observing Cherenkov radiation emitted from secondary particles, such as muons, produced in neutrino interactions. A key challenge in detecting cosmic neutrinos is the large background of cosmic-ray induced muons, which has to be reduced by a factor of $\sim 10^7$.

Thus a large sample of background events has to be simulated in order to accurately estimate the background reduction efficiency. The computationally most expensive part of the simulation chain is the propagation of Cherenkov photons, induced by the muon energy losses.

In this work we develop a hybrid simulation approach that combines traditional simulation methods with a surrogate model. Our surrogate model predicts the probability of cosmic ray induced muons surviving the background reduction process based on the muon energy loss information. This approach ensures that computational resources required for the photon propagation of the background events are better spent on statistically rare events, which have a high chance of surviving the background reduction. For a given sample size of background events, we are thus able to reduce the statistical uncertainty of the estimated background reduction efficiency.

AKPIK 3.2 Thu 16:30 Theo 0.134

Searching for Ultra-High Energy Photons applying Machine Learning Methods Using the Surface Detector of the Pierre Auger Observatory — •Fiona Ellwanger for the Pierre-Auger-Collaboration — KIT, Karlsruhe, Germany

Identifying sources of cosmic rays is challenging, as the charged particles are deflected by magnetic fields and do not point back to their sources. Neutral particles, such as ultra-high energy (UHE) γ's will point directly to their sources, unless they interact in the interstellar medium or are absorbed. Cosmic ray detectors such as the 3000 km^2 surface array of the Pierre Auger Observatory are capable of observing UHE γ's above 10^{18} eV. With increasing energy, their mean free path allows probing extragalactic sources up to a few Mpc. Unlike cosmic rays, photon-induced showers are almost purely electromagnetic. Different methods like BDTs and air-shower Universality have been previously applied to the search of γ's at different energy ranges. Although no UHE γ's have been found, the obtained bounds of the fluxes provide crucial constraints on cosmic-ray acceleration models.

Neural networks have the potential to improve discriminating variables, enhancing the sensitivity to even lower fluxes. In this work, we present a convolutional neural network designed to distinguish between simulated UHE photon and proton showers. We evaluate it on an independent test set, assessing its sensitivity and robustness to systematic uncertainties, including broken stations, detector aging, and noise. These steps aim to validate the network for application to the measured events.

AKPIK 3.3 Thu 16:45 Theo 0.134

Neural Network-Based Event-by-Event Reconstruction of Muon Number from Data of the SD-750 of the Pierre Auger Observatory — •Alina Klingel for the Pierre-Auger-Collaboration — KIT, Karlsruhe, Deutschland

Ultra-high-energy cosmic rays ($\sim$ 1 EeV) provide a unique opportunity to probe physics beyond the energies of human-made accelerators. At such extreme energies, direct detection is infeasible; instead, these cosmic rays are studied through the particle cascades, or air showers, they generate upon interacting with Earth's atmosphere. The SD-750 surface detector of the Pierre Auger Observatory records the shower footprint, the spatial distribution of particles and energy deposited on the ground, as time-resolved ground signals. The main advantage of the SD-750 lies in its proximity to the Underground Muon Detector (UMD), allowing for an independent measurement of the muon content of air showers. This setup forms an ideal testbed to develop and benchmark neural network-based estimators for the muon number, even when simulations contain discrepancies. In this contribution, we present a neural network architecture designed to predict the relative muon number in air showers. We aim to shed light on the muon puzzle by cross-calibrating with muon measurements from the UMD.

AKPIK 3.4 Thu 17:00 Theo 0.134

Advanced Northern Tracks Selection using a Graph Convolutional Neural Network for the IceCube Neutrino Observatory: Adversarial Training — •Leon Hamacher, Philipp Behrens, Jakob Böttcher, Shuyang Deng, Lasse Düser, Philipp Fürst, Philipp Soldin, and Christopher Wiebusch for the IceCube-Collaboration — RWTH Aachen

The IceCube Neutrino Observatory, located at the South Pole, detects atmospheric and astrophysical neutrinos. One important task is differentiating between these neutrinos and muons induced by air showers. The Advanced Northern Tracks Selection (ANTS) accomplishes this identification using a graph-convolutional neural network. However, neural networks can be sensitive to minor adversarial perturbations, which can significantly alter their outputs. Adversarial training is a method to include artificially perturbed data during the training process to enhance resistance to such perturbations. For this purpose, a dedicated algorithm, MiniFool, has been developed that takes experimental uncertainties into account. This talk presents the results of applying MiniFool to ANTS.

AKPIK 3.5 Thu 17:15 Theo 0.134

Adaptive Generative Modeling for Accelerated Calorimeter Simulations via Domain Transfer — •Lorenzo Valente[1], Fank Gaede[2], Gregor Kasieczka[1,3], and Anatolii Korol[2] — [1]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Deutsches ElektronenSynchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany — [3]Center for Data and Computing in Natural Sciences CDCS, Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany

Simulating particle collider detectors presents significant computational challenges, with current methods struggling to scale with increasingly complex experimental datasets. Deep generative models offer a promising solution for dramatically reducing computational overhead, especially as upcoming particle physics experiments are expected to produce unprecedented volumes of data.

We introduce a novel domain adaptation framework that utilises state-of-the-art deep generative models to generate high-fidelity 3D point-cloud representations of particle showers. Using transfer learning techniques, our approach adapts simulations across diverse electromagnetic calorimeter geometries with exceptional data efficiency, thereby reducing training requirements and eliminating the need for a fixed-grid structure.

Preliminary results demonstrate that our method can achieve high accuracy while significantly reducing data and computational demands, offering a scalable solution for next-generation particle physics simulations.

AKPIK 4: Simulation and Workflows

Time: Friday 9:00–10:30 Location: Theo 0.134

AKPIK 4.1 Fri 9:00 Theo 0.134

Integration of a data centre for high-energy astroparticle physics in PUNCH4NFDI infrastructure — •Victoria Tokareva — Karlsruhe Institute of Technology, Institute for Astroparticle Physics, 76021 Karlsruhe, Germany

The PUNCH4NFDI (Particle, Universe, NuClei and Hadrons for Nationale Forschungsdaten Infrastruktur) consortium brings together experts from astro-, nuclear, astroparticle and particle physics to develop an infrastructure and tools for data-intensive research. The PUNCH4NFDI Science Data Platform (SDP) aims to provide users with access to the data resources of the data providers participating in the consortium, while offering advanced features such as enhanced search capabilities for data objects, support for reproducible workflows, and online data analysis.

One such data provider is the KCDC (KASCADE Cosmic-ray Data Centre). Established in 2013, KCDC was the first online platform to provide full open access to data from the high-energy astroparticle physics experiment KASCADE and its successor KASCADE-Grande. Over time, its scope expanded to include data from other astroparticle physics experiments as well as a wider range of digital objects such as simulations, software codes, user manuals, tutorials, and cosmic-ray spectra. This contribution shows the status of the integration of KCDC's data objects into the PUNCH4NFDI SDP, addresses encountered challenges, and describes strategies and technical solutions chosen for this purpose. This work is partially supported by the DFG fund 'NFDI 39/1' for the PUNCH4NFDI consortium.

AKPIK 4.2 Fri 9:15 Theo 0.134

The Lecture Notes Makeover with AI — •Soraya Thiess, Ilya Segal, and Mikhail Mikhasenko — Ruhr University Bochum, Bochum, Germany

Artificial intelligence is rapidly advancing, offering powerful tools to automate and enhance various workflows. This research project aims to accelerate the cre-

ation of scientific scriptures with the use of Large Language Models (LLM). We use a programming interface (API) to an advanced LLM provided by OpenAI to transform raw lecture material, like audio transcriptions and handwritten notes, into well-phrased and organized formats. In a multi-step process, beginning with the segmentation of the input into distinct topics, the content gets rephrased to enhance readability while ensuring contextual accuracy by addressing any out-of-place terminology. The user can choose the desired output format, such as Markdown or LaTeX, and incorporate images afterwards. While designed for the input of audio transcriptions and notes of hadronphysics lectures, this model could be adapted for any field requiring the transformation of spoken or handwritten content into structured, publication-ready material.

AKPIK 4.3 Fri 9:30 Theo 0.134

Parametrizing workflows with ParaO and Luigi — Martin Erdmann and •Benjamin Fischer — III. Physikalisches Institut A, RWTH Aachen University

Workflow tools provide the means to codify complex multi-step processes, thus enabling reproducibility, preservation, and reinterpretation efforts. Their powerful bookkeeping also directly supports the research process, especially where intermediate results are produced, inspected, and iterated upon frequently.

In Luigi, such a complex workflow graph is composed of individual tasks that depend on one another, where every part can be customized at runtime through parametrization. However, Luigi falls short with regards to the steering of parameters, accounting for the consequences thereof, and the modification or reuse of task graphs.

This is where the parameter handling of ParaO shines: it has vastly extended key mechanics and value coercion while automatically propagating their effects throughout the task graph. Since the dependencies are described through parameters too, the same principles can be used to freely alter or transplant (parts of) the task graph, thereby empowering reuse. At the same time, ParaO remains largely compatible with plain Luigi and packages building upon it, such as Law.

AKPIK 4.4 Fri 9:45 Theo 0.134

Simulation of radio galaxies with 2D Gaussian distributions — •Christian Arauner, Anno Knierim, Tom Gross, and Kevin Schmitz — TU Dortmund University, Dortmund, Germany

Radio interferometry enables high-resolution observations of astronomical objects. Due to the incomplete coverage of the (u, v) space, these observations are very noisy. The state of the art cleaning algorithms are time-consuming and not scalable for the expected data volumes of the next gen telescopes As an alternative, neural networks can be used, which can automate and accelerate the cleaning of many measurements. However, training a neural network requires large amounts of training data that have the same properties as the observed objects.

Due to the fact that neural networks are a new approach, there are still very few simulations of training data. The observations from the MOJAVE archive are particularly suitable for the development of simulation software. The archive comprises a large data set of high-quality data that has been measured over a long period of time under similar conditions. The individual components of the galaxies can be generated with multidimensional Gaussian distributions, and a complete galaxy can be simulated from the sum of the components.

In this talk, I will present a novel approach to simulate radio galaxies with multidimensional Gaussian distributions.

AKPIK 4.5 Fri 10:00 Theo 0.134

Simulating Polarisation in Radio Interferometry Experiments Using pyvisgen — •Anno Knierim, Christian Arauner, and Kevin Schmitz — TU Dortmund University, Dortmund, Germany

Recent approaches in radio astronomy aim to improve image cleaning in radio interferometry measurements using machine learning techniques. Reconstructing sources using these novel techniques has the advantage of being agnostic to initial parameters used in traditional cleaning algorithms.

The radionets project is a deep-learning framework developed at TU Dortmund University. The goal is to reconstruct calibrated observations with convolutional neural networks to produce high-resolution images. Deep learning approaches such as radionets require large amounts of training and validation data. One approach to simulating the required datasets is provided by the simulation tool pyvisgen.

pyvisgen utilises the Radio Interferometer Measurement Equation (RIME) to represent the measurement process of a radio interferometer. It produces images suitable as input to train deep-learning-based cleaning approaches. This talk presents the recent implementation of polarisation effects on radio waves.

AKPIK 4.6 Fri 10:15 Theo 0.134

Binary Black Hole Parameter Estimation using a Conditioned Normalizing Flow — •Markus Bachlechner and Achim Stahl — III. Physikalisches Institut B, RWTH Aachen

The proposed Einstein Telescope is the first of the third-generation gravitational wave detectors. It is expected to reach a noise level at least an order of magnitude lower than current interferometers like LIGO and Virgo. The thus improved sensitivity increases the observable volume and extends the time window in which the inspiral phase of binary systems is measurable. To analyze the resulting vast amounts of data efficiently, Neural Networks (NNs) can be utilized. This talk presents a fast Binary Black Hole parameter reconstruction by applying a conventional convolutional NN which conditions a subsequent Normalizing Flow (NF). Using the NF, an approximated posterior parameter distribution on an event-by-event basis is obtained, and thus uncertainties can be estimated.

Index of Exhibitors Göttingen 2025

Exhibition venue

Universität Göttingen

Zentrales Hörsaalgebäude (ZHG)

Platz der Göttinger Sieben 5, 37073 Göttingen

Exhibition opening hours

Tuesday, April 1	10:00 - 18:00
Wednesday, April 2	10:00 - 18:00
Thursday, April 3	10:00 - 18:00

Stand-No.

Abacus Laser GmbH **10**

Hannah-Vogt-Straße 1, 37085 Göttingen

Laser- und Lidarsysteme

Forum Wissen, Georg-August-Universität Göttingen **12**

Wilhelmsplatz 1, 37073 Göttingen

Das Wissensmuseum der Universität Göttingen ist ein Ort der Begegnung, an dem Wissen vermittelt, reflektiert, diskutiert und geschaffen wird. 27. März bis 5. Oktober 2025 | Die Ausstellung zum Quantenjahr 2025.

Hamamatsu Photonics Deutschland GmbH **03**

Arzbergerstraße 10, 82211 Herrsching

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Institut für Luft- und Kältetechnik gemeinützige Gesellschaft mbH **06**

Bertolt-Brecht-Allee 20, 01309 Dresden

Präsentation Kryoflüssigkeitspumpe zzgl. Steuerungselektronik.

JUST VACUUM GmbH **01**

Daimlerstraße 17, 66849 Landstuhl

Vakuumtechnik

Kashiyama Europe GmbH **04**

Leopoldstraße 244, 80807 München

Trockenlaufende Vakuumpumpen NeoDry15E und 30E, Pumpenmodell.

LHC ErUM-FSP Office, Georg-August-Universität Göttingen **08**

Friedrich-Hund Platz 1, 37077 Göttingen

Das LHC ErUM-FSP-Büro ist das gemeinsame Projektbüro für Öffentlichkeitsarbeit, Transfer und Nachwuchsförderung der deutschen Community an den LHC Experimenten.

Netzwerk-Teilchenwelt **09**

TU Dresden, Institut für Kern- und Teilchenphysik, Zellescher Weg 19, 01069 Dresden

www.teilchenwelt.de

Peter Huber Kältemaschinenbau SE **11**

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SAES Getters S.p.A. **07**

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Als partnerschaftlich organisierte IT-Beratung arbeiten wir kundenorientiert an vielfältigen Projekten in den Bereichen Agile Softwareentwicklung, Künstliche Intelligenz und DevOps & Cloud.