Radiation and Medical Physics Division
Fachverband Strahlen- und Medizinphysik (ST)

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Overview of Invited Talks and Sessions

(Lecture hall ST-H4; Poster P)

Plenary Talk of ST

See plenary section for details.

PV I	Mon	11:40–12:25	Audimax	**Making uncertainty certain?: Proton therapy, range and in-vivo verification.** — •Tony Lomax

Invited Talks

ST 4.1	Tue	14:00–14:40	ST-H4	**Present status and future challenges of magnetic resonance-guided radiotherapy** — •Christian P. Karger
ST 10.1	Thu	16:15–16:55	ST-H4	**Artificial intelligence in PET image reconstruction and quantitative analysis** — •Zhaoheng Xie

Invited Talks of the joint symposium SMuK Dissertation Prize 2022 (SYMD)

See SYMD for the full program of the symposium.

SYMD 1.1	Mon	14:00–14:25	Audimax	**Timeless Quantum Mechanics and the Early Universe** — •Leonardo Chataigner
SYMD 1.2	Mon	14:25–14:50	Audimax	**First tritium β-decay spectrum recorded with Cyclotron Radiation Emission Spectroscopy (CRES)** — •Christine Claessens
SYMD 1.3	Mon	14:50–15:15	Audimax	**Watching the top quark mass run - for the first time!** — •Matteo M. Defranchis, Katerina Lipka, Sven-Olaf Moch
SYMD 1.4	Mon	15:15–15:40	Audimax	**Towards beam-quality-preserving plasma accelerators: On the precision tuning of the wakefield** — •Sarah Schröder

Prize Talks of the joint Awards Symposium (SYAW)

See SYAW for the full program of the symposium.

SYAW 1.1	Wed	14:10–14:40	Audimax	**Wie überprüft man die Ziele der Lehramtsausbildung Physik?** — •Horst Schecker
SYAW 1.2	Wed	14:40–15:10	Audimax	**Astronomy at Highest Angular Resolution - Adaptive Optics, Interferometry and Black Holes** — •Frank Eisenhauer
SYAW 1.3	Wed	15:10–15:40	Audimax	**Turbulence in one dimension** — •Alexander M. Polyakov

Sessions

ST 1.1–1.6	Mon	14:00–15:30	ST-H4	**Radiation therapy I**
ST 2.1–2.4	Mon	16:15–17:30	P	**Poster Session**
ST 3.1–3.5	Tue	11:00–12:15	ST-H4	**Artificial Intelligence in Medicine**
ST 4.1–4.5	Tue	14:00–15:40	ST-H4	**Radiation monitoring and dosimetry I**

ST 5	Tue	16:15–17:30	ST-MV	**Annual General Meeting**
ST 6.1–6.5	Wed	11:00–12:15	ST-H4	**Detectors and Applications I**
ST 7.1–7.5	Wed	16:15–17:30	ST-H4	**Radiation monitoring and dosimetry II**
ST 8.1–8.4	Thu	11:00–12:00	ST-H4	**Radiation therapy II**
ST 9.1–9.6	Thu	14:00–15:30	ST-H4	**Detectors and Applications II**
ST 10.1–10.1	Thu	16:15–16:55	ST-H4	**Total-Body PET**
ST 11	Thu	16:55–17:10	ST-H4	**Prize Ceremony and Closing Session**

Annual General Meeting of the Radiation and Medical Physics Division

Tuesday 16:15–17:30 ST-H4

Networking and Coffee Breaks

Everybody is kindly invited to join the meeting area during the coffee breaks. Continue the discussion with the speakers of the previous session, meet your colleagues and get to know new people. Please feel free to bring a cup of coffee and enjoy the networking!

ST 1: Radiation therapy I

Time: Monday 14:00–15:30 Location: ST-H4

ST 1.1 Mon 14:00 ST-H4

Usage of the track reconstruction framework Corryvreckan in proton therapy — •Christopher Krause, Valerie Hohm, Kevin Kröninger, Jens Weingarten, and Florian Mentzel — TU Dortmund, Dortmund, Germany

The Inner Tracker of the ATLAS experiment requires the optimal performance of its pixel sensors. To test their efficiency, a reliable track reconstruction and analysis for testbeam data is necessary to ensure the precise detection of particles. In the last years, track reconstruction was mostly done with the EUTelescope software, a generic and versatile framework.
In 2017, the new track reconstruction software Corryvreckan was published with the intention to reduce external dependencies without reducing the quality and versatility of track reconstruction in complex environments.
Efforts are made in TU Dortmund to use pixel sensors and track reconstruction software for proton computed tomography. The usage of Corryvreckan for low energy high density proton beams is investigated. This talk presents the performance tests of Corryvreckan with simulated data. The simulated data is generated with Allpix^2 and serves to test the usability of Corryvreckan with beam properties used in proton therapy. Results are further improved through the use of machine learning algorithms to separate true and false reconstructed tracks.

ST 1.2 Mon 14:15 ST-H4

Simulationen zur Ortsauflösung in der Protonenradiographie unter Verwendung eines ATLAS Pixeldetektors — •Jacqueline Schlingmann, Marius Hötting, Kevin Kröninger und Jens Weingarten — TU Dortmund, Lehrstuhl für Experimentelle Physik IV

Bei der Protonentherapie muss eine Sicherheitsspanne um den zu bestrahlenden Bereich eingehalten werden um sicherzustellen, dass das gesamte zu bestrahlende Gewebe behandelt wird. Unsicherheiten durch Lagerungsveränderungen und durch die Bildgebung mit Elektronen sind ausschlaggebend für die Sicherheitsspanne.

Um die Protonentherapie zu optimieren, soll zur Verifizierung der Position des zu bestrahlenden Bereiches eine Bildgebung mit Protonen am Ort der Bestrahlung stattfinden. Desweiteren kann der Patient vor und während der Bestrahlung überwacht werden. Für die Bildgebung wird zunächst die Auflösung über ein edge Phantom mit Hilfe der Modulation transfer function (MTF) untersucht. Außerdem werden Methoden zur Bildverarbeitung und Objektextraktion getestet.

In diesem Vortrag werden die Ergebnisse und die Methode zur Auflösungsbestimmung präsentiert. Desweiteren werden Bildverarbeitungsmethoden mit den verwendeten Filtern in Hinblick auf die Möglichkeit zur Positionsfindung von Objekten im Phantom diskutiert.

ST 1.3 Mon 14:30 ST-H4

Study of prompt gamma emission in c^{12}(p, p*γ)c^{12} nuclear reactions close to a bragg peak — •Mariam Abuladze[1,2], Ronja Hetzel[3], Jonas Kasper[3], Revaz Shanidze[1,2], and Achim Stahl[3] — [1]Tbilisi State Univerity, Tbilisi, Georgia — [2]Kutaisi International University, Kutaisi, Georgia — [3]RWTH Aachen University, Aachen, Germany

Proton therapy is a high-quality radiation therapy which uses a proton beam to irradiate human tissue. The advantage of this type of treatment is a highly conformal dose deposition due to the presence of the Bragg peak. Though it is often required to irradiate the tumor volume with a precision better than 1 - 2 mm, which means that proton therapy needs not only precise treatment planning but also monitoring and proton range verification during the treatment. One of the ways to monitor the proton range is Prompt Gamma Imaging (PGI) which means to detect gamma rays produced by the excitation of the target nuclei by incident protons.

In this work, a results of the Geant4 simulation (version 10.6.3.) of interactions of 17.56 MeV protons with a carbon target are shown. This includes the study of 4.4 MeV and 9.6 MeV line properties, as multiple differences were observed between simulation and experiment, one of which is a double peak for the C^{12}(p, p*γ)C^{12} spectral line. The shortcomings of the current physical models in Geant4 in describing the shape and intensity of the 4.4 MeV and 9.6 MeV gamma lines will be discussed.

ST 1.4 Mon 14:45 ST-H4

Granularity and Photomultiplier studies for Prompt Gamma Spectra in Proton Therapy — •Olga Novgorodova and Arno Straessner — IKTP TU Dresden, Dresden, Germany

Prompt gammas (PG) in proton therapy are one of the promising techniques for non-invasive measurements of in-vivo proton range and it is already in implementation in clinical research. It can be based on time or spectral measurements. We concentrate on the spectral properties by developing systems measuring PG in the range 2-8 MeV, which already were shown to provide a time resolution of about 100 ns. A big problem in the recording prompt gammas during the irradiation of patients is the data load due to the size of the crystal. By decreasing the size of the crystals and forming them into the matrices the load to each channel can be reduced and more PGs can be detected. We are investigating different sizes and types of crystals to find an optimum. Availability on the market and the choice of photomultipliers also plays an important role for the granularity of crystals. Three different types of photomultipliers were used: a regular PMT, MAPMT and several SiPMs, which have high photon detection efficiency, good time resolution, low bias voltage and can operate in magnetic fields. For the SiPMs, PETsys readout electronics was used. In the presentation we present effects due to crystal types and sizes, and compare different photomultipliers and read out systems.

ST 1.5 Mon 15:00 ST-H4

Use of PET Readout Electronics for a Scintillating Fiber-Based Compton Camera — •Sara Müller[1,3], Ronja Hetzel[1,3], Mareike Profe[1], Achim Stahl[1], Aleksandra Wronska[2], Ming Liang Wong[2], Magdalena Kołodziej[2], Katarzyna Rusiecka[2], David Schug[3], Björn Weissler[3], and Volkmar Schulz[1,3] — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]M. Smoluchowski Institute of Physics, Jagiellonian University Kraków, Poland — [3]RWTH Aachen University, Physics of Molecular Imaging Systems, Aachen, Germany

A powerful tool in cancer treatment is hadron therapy. Its precision can be optimised by online-monitoring the Bragg peak position by using prompt gamma radiation emitted in the process. A Compton camera is a promising setup for this task as it provides the possibility to reconstruct the shape and the location of the deposited dose.

The SiFi-CC (SiPM and scintillating Fiber-based Compton Camera) is developed by researchers of the RWTH Aachen University, the Jagiellonian University in Kraków and the University of Lübeck. The two parts of the SiFi-CC, the scatterer and the absorber, both consist of closely packed LYSO:Ce fibres and are read out by digital SiPMs. The SiPMs are arranged in a sensor tile which was originally developed for PET systems and which consists of 36 Digital Photon Counters containing four readout channels each. Thus, the light produced in the scintillating fibers is spread over several SiPMs. A small-scale prototype of the camera has been assembled and was tested under laboratory conditions. First results of these measurements will be presented.

ST 1.6 Mon 15:15 ST-H4

Proton field verification by implant activation — •Claus Maximilian Bäcker[1,2,3], Christian Bäumer[1,2,3], Walter Jentzen[5], Sandra Laura Kazek[5], Kevin Kröninger[1], Fleur Spiecker[1], Nico Verbeek[2,3], Jens Weingarten[1], Jörg Wulff[2,3], and Beate Timmermann[2,3,4,6] — [1]TU Dortmund University, Department of Physics, D-44221 Dortmund — [2]West German Proton Therapy Centre Essen, D-45122 Essen — [3]University Hospital Essen, West German Cancer Center, D-45122 Essen — [4]University Hospital Essen, Department for Particle Therapy, D-45122 Essen — [5]University Hospital Essen, Clinic for Nuclear Medicine, D-45122 Essen — [6]University Duisburg/Essen, Faculty of Medicine, D-45147 Essen

The delivered dose in particle therapy is sensitive to the correctly predicted range. Uncertainties arise e.g. from estimation of tissue stopping powers. In order to identify range uncertainties of the treatment fields, multiple techniques have been developed in the past. However, these techniques come with several limitations for the clinical applicability. In this study, the potential use of implant activation for field verification is investigated. Therefore, a method validation is performed focusing on the activation of titanium implants during proton therapy treatments and subsequent PET imaging. The parameters delivered dose and variations in the beam range are investigated to estimate the detectability of these changes during fractional treatment. While first pre-clinical studies demonstrated the general potential of implant activation for range verification, the current limitations and necessary developments in PET imaging will be presented in this talk.

ST 2: Poster Session

Time: Monday 16:15–17:30 Location: P

ST 2.1 Mon 16:15 P

Characterization of a multi-arm Compton-camera setup — •Henning Geesmann[1], Giullio Lovatti[1], Tim Fitzpatrick[1,2], Jennifer Zhou[1], Mohammad Safari[1], Florian Schneider[2], Vassia Anagnostatou[1], Katia Parodi[1], and Peter G. Thirolf[1] — [1]Ludwig-Maximilians-Universität, Munich, Germany — [2]KETEK GmbH, Munich, Germany

PET, γ-PET and prompt-γ imaging are all γ-ray based imaging techniques that can be used for beam range verification in particle therapy. They can all be realised by a multi-arm Compton camera (CC) setup.

We characterized a system where a single CC arm of the setup comprises a 16×16 pixelated GAGG crystal array as scatterer (26×26×6 mm^3, read out by one 25μm microcell SiPM array) and a monolithic absorber ($LaBr_3$:Ce or $CeBr_3$ crystal, 51×51×30 mm^3), read out by four 50μm microcell SiPM arrays). The characterization of the setup in terms of spatial resolution and efficiency is based on the use of different γ-ray point sources (511, 662 and 1274 keV) and several spatial arrangements of up to four CC arms. Further, the angular dependence of the Compton scattering kinematics can be exploited to identify spatial arrangements (scatterer/absorber) in a single CC arm that allow to select a certain regime of energies being deposited in the scatterer and, thus, allow for enhancing the performance of the setup. A summary of the latest status of the ongoing studies will be given.

This work was supported by the Bayerische Forschungsstiftung, by the ERC grant No. 725538 (SIRMIO) and by Sklodowska-Curie Individual Fellowship project HIPPOCRATE.

ST 2.2 Mon 16:15 P

Stabilization of magnetic fields in a low-field magnetic resonance tomograph for student learning — •Velda Azalia Abraham, Thomas Heinzel, and Mihai Cerchez — Condensed Matter Physics Laboratory (IPKM), Heinrich-Heine University Dusseldorf

EFNMR (Earth's Field Nuclear Magnetic Resonance) is a low-field NMR (Nuclear Magnetic Resonance) technique. Employing the Earth's magnetic field, this is an excellent tool for Medical Physics students learning as it is easy to operate and low-cost. However, EFNMR also has some downsides related to signal-to-noise ratio and magnetic field stability. Either natural fluctuations in the Earth's magnetic field or room-related changes may influence the long-time 3D imaging through changes in the Larmor frequency. Therefore a stabilization system, that would keep the magnetic field stable at all times is needed. We present here a two-directional Helmholtz correction coil system that compensates for changes of the homogeneous magnetic field in the room, leading to increased imaging quality.

ST 2.3 Mon 16:15 P

Image registration of CT and MRI scans using deep learning — •Alexander Ratke, Hannah Timm, Johannes Wintz, Göksu Ünlü, and Bernhard Spaan — TU Dortmund University, Dortmund, Germany

In radiation therapy, precise localisation of tumour and risk structures is important for therapy planning. Medical imaging methods, such as computed tomography (CT) and magnetic resonance imaging (MRI), offer different advantages due to the respective physical process, which can be combined by image fusion.

In this project, CT scans and T_1- and T_2-weighted MRI scans of different body regions are used. For their registration, two processing steps are performed. The preparatory part includes equalising the formats of the images, which is required for a neural-network-based registration. Deep learning is then used to filter structures of an image and to match them to a second image. The results of the registration of three-dimensional CT and MRI scans of the skull and the thorax will be presented as well as studies of quality and uncertainty, performed with a Shepp-Logan phantom.

ST 2.4 Mon 16:15 P

Design and validation of a Digital Twin for tumor stage prediction of prostate cancer patients — •Anna-Katharina Nitschke, Carlos Andres Brandl, and Matthias Weidemüller — Physikalisches Institut, Ruprecht-Karls Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

Digital Twins (DT) are virtual representations of physical assets. In healthcare, DT can help to personalize diagnosis and treatment for complex diseases like prostate cancer.

To be able to generate a DT which is supporting the complete clinical journey of a cancer patient, a conceptual development for combining several individual algorithms is needed. This approach also ensures best possible practices for patient data protection during collaborative work. As interpretability and uncertainty quantification are crucial in medical applications, on hast to find a solution that meets these requirements as well as clinical guidelines. Through using ensemble methods, we develop a concept of a DT, which is combining machine learning algorithms and expert systems with the medical doctor's opinion to improve decision-making. We exemplify the approach with tumor stage prediction (TNM) before treatment planning.

This work is part of the project CLINIC 5.1 and is supported by the BMWi.

ST 3: Artificial Intelligence in Medicine

Time: Tuesday 11:00–12:15 Location: ST-H4

ST 3.1 Tue 11:00 ST-H4

Optimierung und Evaluierung der Registrierung von CT- und MRT-Bildern mithilfe maschinellem Lernens — •Elena Darsht, Alexander Ratke und Bernhard Spaan — Experimentelle Physik 5, TU Dortmund

In der Strahlentherapie ist der Erfolg einer Bestrahlung abhängig von der Genauigkeit der Tumorlokalisierung. Diese erfolgt üblicherweise anhand der zur Bestrahlungsplanung verwendeten CT-Bildern. Im Vergleich dazu bieten MRT-Bilder eine bessere Darstellung von gesunden und kranken Weichteilstrukturen für eine präzisere Konturierung an. Durch die Bildregistrierung und -fusion von CT- und MRT-Bildern kann die Bestrahlungsplanung anhand von CT-Bildern erfolgen und zusätzlich können die Informationen der MRT-Bilder genutzt werden.

Eine Möglichkeit die Registrierung umzusetzen, ist die Verwendung eines neuronalen Faltungsnetzes, wodurch eine Rechenzeit von nur einigen Minuten pro Registrierung erreicht werden kann. Es wird der Aufbau und die Evaluierung des verwendeten neuronalen Netzes präsentiert. Dabei werden insbesondere die zur Optimierung für dreidimensionale Schädelaufnahmen genutzten Parameter vorgestellt. Zur Evaluierung der Registrierung wird der *Dice*-Koeffizient verwendet, bei dem die Überlappung von segmentierten Bildern ermittelt wird.

ST 3.2 Tue 11:15 ST-H4

Towards a Digital Twin for clinical decision support of a prostate cancer patient — •Carlos Andres Brandl, Anna-Katharina Nitschke, and Matthias Weidemüller — Physikalisches Institut, Ruprecht-Karls Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

We present concepts to realise a Digital Twin for decision support in medicine using the example of prostate cancer. The aim for a medical Digital Twin is to support clinical decision making by providing an intuitively interpretable way for the doctors' decisions. Inspired by concepts from engineering, we devise a combination of data-driven models with evidence-based knowledge which comprise a wide range of parameters and data types available. As a higher integrated approach, we discuss the implementation of latent representations of the patient. Compatibility with the clinical guidelines and physicians' decision-making processes must be ensured by finding appropriate and interpretable representations.

This work is part of the project CLINIC 5.1 and is supported by the BMWi.

ST 3.3 Tue 11:30 ST-H4

Using generative adversarial networks to predict proton beam dose distributions in mice — •Lara Bussmann, Kevin Kröninger, Armin Lühr, Florian Mentzel, Janine Salewski, and Jens Weingarten — TU Dortmund

The clinically used generic relative biological effectiveness (RBE) of 1.1 for protons compared to photons does not consider variations along the beams axis. For a better estimation of the varying RBE and to assess potential adverse effects, mouse brains are irradiated and excised to visualize DNA double-strand breaks.

In order to deduct conclusions about the RBE, the observed irradiation damage in the tissue is compared to the expected damage from Monte Carlo simulations of the dose distribution.

Using Monte Carlo simulations for dose distribution predictions can be very time-consuming. Machine learning models can be trained to predict dose distributions based on the phantom geometry.

In this talk, a deep learning dose prediction model for proton mouse irradiations based on generative adversial networks (GANs) is presented. GANs can be trained to generate data samples following a learnt distribution, which are indistinguishable from a ground truth distribution. In this study, MC simulation samples are used to train the GAN, using geometrical information about the target phantom as conditional input.

ST 3.4 Tue 11:45 ST-H4

A step towards treatment planning for microbeam radiation therapy: fast dose predictions with generative adversarial networks — •Florian Mentzel[1], Micah Barnes[2], Kevin Kröninger[1], Michael Lerch[2], Olaf Nackenhorst[1], Jason Paino[2], Anatoly Rosenfeld[2], Ayu Saraswati[3], Ah Chung Tsoi[3], Jens Weingarten[1], Markus Hagenbuchner[3], and Susanna Guatelli[2] — [1]TU Dortmund University, Department of Physics — [2]Centre for Medical Radiation Physics, University of Wollongong, Australia — [3]School of Computing and Information Technology, University of Wollongong, Australia

Microbeam radiation therapy is a novel and currently pre-clinical radiotherapy treatment based on planar arrays of high intensity submillimetre synchrotron gamma rays. Due to good healthy tissue sparing it is a promising candidate e. g. for the treatment of glioblastoma. The dose computations required to plan treatments are currently performed using time-consuming Monte Carlo (MC) simulations with Geant4. The dose computations are complex as steep dose gradients near the beams require very high spatial resolution while the need to take into account the effect of stray radiation over large distances makes small voxel sizes infeasible.

A two-fold approach to these problems is explored: first, a novel data taking method for MC simulations is presented. The method considers both high resolution and long-range effects of stray radiation. Second, a deep learning model based on 3D-UNet GANs is created to mimic dose simulations of Geant4, allowing for very short prediction times.

ST 3.5 Tue 12:00 ST-H4

A neural network for the event identification of a Compton camera — •Mareike Profe[1], Jonas Kasper[1], Awal Awal[2], Aleksandra Wrońska[3], and Achim Stahl[1] — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]Forschungszentrum Jülich - Institute for Nuclear Physics, IKP-4, Jülich, Germany — [3]Jagiellonian University - M. Smoluchowski Institute of Physics, Cracow, Poland

In proton therapy, a main approach to diminish the problem of range uncertainties is to verify the range of the proton beam on-line. By imaging prompt gamma photons originating from interactions of the proton beam within the body this challenge can be mastered. For the on-line range verification, the SiFi-CC project aims to develop a Compton camera based on scintillating fibers read out with silicon photomultipliers. The Compton events need to be discriminated from other event types: random coincidences and physical background. Subsequently, their features crucial for imaging need to be determined, i.e. the position of the Compton effect, the energy transferred to the electron, the position of the first interaction of the Compton-scattered gamma and its energy. Neural networks are an promising alternative to a classical selection algorithm to tackle this task. Here, a convolutional neural network is trained to predict the type and parameters of the events. The design of the neural network as well as the evaluation of the performance are presented.

ST 4: Radiation monitoring and dosimetry I

Time: Tuesday 14:00–15:40 Location: ST-H4

Invited Talk ST 4.1 Tue 14:00 ST-H4

Present status and future challenges of magnetic resonance-guided radiotherapy — •Christian P. Karger — German Cancer Research Center (DKFZ), Heidelberg, Germany

As a special realization of image-guided radiotherapy (IgRT), magnetic resonance (MR)-guided radiotherapy (MRgRT) has been implemented clinically by integrating linear accelerators (Linacs) into MR imaging devices. These so-called MR-Linacs allow for fast imaging with superior soft-tissue contrast without extra dose prior or even during radiation treatment. The acquired images may be used to adapt the treatment plan to the actual anatomical situation and to compensate for motion by beam gating or tracking. Besides technical challenges of integrating and shielding of the two devices, dose distributions and the detector responses are changed by the magnetic field requiring modified dose calculation techniques and dosimetry protocols. Clinically, the development and validation of new workflows is challenging as adaptive treatment planning while the patient is lying on the table (online adaptive radiotherapy) requires fast and robust planning techniques as well as new methods for validating the adapted treatment plan. In addition special end-to-end tests have to be developed to quantify the overall dosimetric and geometric accuracy. The presentation gives an overview on the present status and future developments in MR-guided radiotherapy.

ST 4.2 Tue 14:40 ST-H4

The performance of scintillating fibre based beam profile monitor for ion therapy in magnetic field — •Qian Yang, Liqing Qin, and Blake Leverington — Physikalisches Institut Universitaet Heidelberg

In the Heidelberg Ion-beam Therapy Center (HIT), proton, helium, carbon and oxygen ions are used for cancer therapy. The existing scanning technique, it is called Raster scanning. The beam is not switched off between spots but adjusted by the 2 dimensions fast deflection magnet. A tracking system is used to monitor the beam and feedback to adjust the scanning magnet currents online. The commercial MWPC (multiwire proportional chamber) currently used has several drawbacks. An MR magnetic is currently installed at the HIT facility for studying treatment with prompt MR imaging. The BMBF funded ARTEMIS project is focused on the establishment of a unique MR-guided ion-beam therapy prototype for clinical application. A scintillating fibre based detector is now studied as a possible monitor replacement for this system. The detector performance in the environment of MR magnetic fields is also be studied, to complement the ARTEMIS project at HIT. Recently, the performance of the detector was tested under the condition inside the Helmoltz coil by changing the magnetic field (from 0.1 mT ~ 99.9 mT) and it will also be tested inside the prompt MR imaging in the following days.

ST 4.3 Tue 14:55 ST-H4

First study on energy resolution in proton radiography — •Marius Hötting, Kevin Kröninger, Isabelle Schilling, Jacqueline Schlingmann, Hendrik Speiser, and Jens Weingarten — TU Dortmund, department of physics

Proton radiography offers the possibility of real-time patient positioning before or during the treatment. Typically, pixelated silicon sensors are used in the implementation, which makes it possible to contour various structures of phantoms or patients from the pure evaluation of the proton hit position.

With the additional information of the deposited charge of each particle per pixel, the initial proton energy, the residual range and finally the water equivalent thickness (WET) can be calculated. This allows conclusions about the material traversed without an additional external energy detector and gives the opportunity for cross-check with the treatment plan.

The challenge is to determine the proton energy with the limited resolution in deposited charge and a low number of detected protons per pixel. The measurement of the WET of a phantom is therefore done in two steps, one without and one with an additional homogeneous absorber of known width. The energy difference in both images allows minimization of the systematic uncertainties. Finally, the conversion to the WET is done with a simulated calibration curve.

In this talk, we describe the currently investigated method for WET calculation with pixel sensors and first simulations with Allpix^2 to determine depth-dependent uncertainties.

ST 4.4 Tue 15:10 ST-H4

New Optimisation Method for Proton Radiography Images — Marius Hötting, Kevin Kröninger, Florian Mentzel, •Hendrik Speiser, and Jens Weingarten — TU Dortmund, department of physics

For years, proton therapy for cancer treatment has been experiencing an increasing application, as it has known advantages such as the high dose conformity of protons. However, using this precision requires enhanced imaging techniques to ensure the accurate patient alignment. This results in a reduction of the safety margin around the target volume and in the protection of the surrounding healthy tissue.

As part of a master thesis, a new method is being developed to improve the quality of proton radiography images and thereby achieve greater therapeutic success as mentioned above. At present, the image quality and the resolution of structures in the patient are degraded by proton scattering. The goal of the project is to combine the projections of the widened proton trajectories onto the image plane with conventional proton hit maps to increase the resolution of object edges in radiography images.

This talk will include a brief description of the developed method and the evaluation of the image quality using Monte Carlo simulations. Subsequently, the application of the new approach will be compared with results of previous imaging methods.

ST 4.5 Tue 15:25 ST-H4

Monte Carlo feasibility study for neutron radiography in proton therapy — •Hannah Rotgeri, Marius Hötting, Kevin Kröninger, Alina Landmann, and Jens Weingarten — TU Dortmund University, Department of Physics

Due to their depth dose dose distribution, proton beams used in cancer treatment can reduce damage to healthy tissue when compared to irradiation with photons. Neutrons, and other secondary particles, are produced during proton therapy, causing dose deposition outside the treatment field. Being unavoidable, the feasibility for using these neutrons for imaging during the treatment is studied in the context of a master thesis.

The study is performed in the Monte Carlo framework Geant4. It is investigated whether different energy ranges of neutrons are suitable for radiography, due to the different ways they can be detected. This talk will present the recent results of this study. This includes the investigation of different angles of the detector with respect to the proton beam. Finally it will be shown whether the different materials found in a human body can be distinguished.

ST 5: Annual General Meeting

Time: Tuesday 16:15–17:30 Location: ST-MV

Annual General Meeting of the Radiation and Medical Physics Division

ST 6: Detectors and Applications I

Time: Wednesday 11:00–12:15 Location: ST-H4

ST 6.1 Wed 11:00 ST-H4

Upgraded Proton Irradiation Site at Bonn University — •Pascal Wolf[1], Dennis Sauerland[2], Jochen Dingfelder[1], David-Leon Pohl[1], and Norbert Wermes[1] — [1]Physikalisches Institut, Universität Bonn — [2]Helmholtz Institut für Strahlen- und Kernphysik, Universität Bonn

The Bonn Isochronous cyclotron delivers 14 MeV (≈ 12.5 MeV on-device) protons with typical beam currents of 1 μA and beam diameters of a few millimeters to the irradiation site. Enhanced beam diagnostics as well as R/O electronics allow for online monitoring across several orders of magnitude of beam currents with a relative uncertainty of ≈ 1%. Devices are irradiated by being scanned through the beam in a row-wise pattern while housed in a thermally-insulated cooling box kept at ≈ -20 °C to minimize annealing. Online monitoring of the beam current at extraction facilitates a measurement of the fluence per scanned row with an accuracy of a few %, ensuring homogeneous irradiation. The setup allows one to power and read out DUTs during irradiation as well as pause irradiations for in-between measurements. Latest irradiations of thin CMOS pixel test structures yield a proton hardness factor with reduced uncertainty, compatible with previous measurements and simulation, facilitating irradiations up to 10^{16} neq / cm^2 within a few hours. The setup, its reworked components, the irradiation procedure as well as the latest proton hardness factor measurements are presented in this talk.

ST 6.2 Wed 11:15 ST-H4

Comparison of different methods measuring the beam energy in proton therapy using pixelated silicon detectors — •Isabelle Schilling[1], Claus Maximilian Bäcker[1,2,3], Christian Bäumer[1,2,3], Carina Behrends[1,2,3], Marius Hötting[1], Kevin Kröninger[1], Beate Timmermann[2,3,4,5], and Jens Weingarten[1] — [1]TU Dortmund University, Department of Physics, 44221 Dortmund — [2]West German Proton Therapy Centre Essen, 45122 Essen — [3]West German Cancer Center, University Hospital Essen, 45122 Essen — [4]University Hospital Essen, Clinic for Particle Therapy, 45122 Essen — [5]Faculty of Medicine, University of Duisburg-Essen, 45147 Essen

The accurate measurement of beam range for quality assurance (QA) in proton therapy is important for optimal patient treatment. Conventionally used detectors mostly calculate the energy by detecting the depth dose distribution of the protons. In contrast to this, the ATLAS pixelated silicon detector measures the deposited energy in the sensor for single protons, allowing the determination of the stopping power. The restriction on the dynamic energy range of the measurement is given by the readout chip. Hence, there are different ways to use the detector whose applicability is being examined. For range consistency checks during the QA, an absorber with different thicknesses is used to investigate the variation of the charge production in the sensor. In comparison, this talk also presents results of energy calculations by measuring the stopping power in the silicon sensor directly, all performed at the West German Proton Therapy Centre Essen.

ST 6.3 Wed 11:30 ST-H4

Real-time analysis for a scintillating fiber-based beam profile monitor for charged particle beams — •Liqing Qin, Qian Yang, and Blake Leverington — Physikalisches Institut, Heidelberg, Germany

A lighter, faster and more precise real-time beam profile monitor

(BPM) is desired by the Heidelberg Ion-beam Therapy Center (HIT) to upgrade their original Multiwire chambers. A Scintillating Fibre based BPM will offer real-time information of the beam conditions, including position and width, with a readout rate of 10 kHz using photodiode arrays with a channel size of 0.8mm. Currently the data from the BPM is saved offline for processing and analysis, but the goal is to reconstruct the beam profile in real-time on board the device. A reconstruction algorithm has been designed and the goal is to implement this within the FPGA of the readout electrons. The calibration of the detector as well as the beam reconstruction steps will be presented, describing how radiation damage effects to the fibres will be managed.

ST 6.4 Wed 11:45 ST-H4

Evaluation of HV-CMOS Sensors in a Beam Monitoring System for Ion Therapy — •Martin Pittermann[1], Alexander Dierlamm[1], Ulrich Husemann[1], Stefan Maier[1], Hans Jürgen Simonis[1], Pia Steck[1], Matthias Balzer[2], Felix Ehrler[2], Ivan Perić[2], Rudolf Schimmasek[2], and Alena Weber[2] — [1]Institute of Experimental Particle Physics (ETP), Karlsruher Institute of Technology (KIT) — [2]Institute for Data Processing and Electronics (IPE), KIT

Ion therapy is an advanced tool for the treatment of cancer by means of irradiation. The characteristic Bragg peak of ionizing radiation creates a highly localized energy deposit. Additionally, very narrow beams (pencil beam) and raster scan techniques are used. This allows the dose distribution to conform to the tumor while minimizing damage to surrounding tissue. Fast and precise feedback of the beam parameters is required for closed-loop control of the beam optics.

We investigate the feasibility of using HV-CMOS pixels sensors to monitor the position, size and shape of such a medical ion beam in real-time. The high intensities encountered in a primary particle beam prohibit the use of traditional single-hit-readout sensors used in high energy particle physics. Instead, a dedicated counting pixel sensor is being developed at the IPE. The radiation hardness and high-rate capabilities of this sensor are tested at the therapeutic ion beam line. Further development steps towards a beam monitoring system replacing the current wire chambers are also discussed.

ST 6.5 Wed 12:00 ST-H4

Coincident Detection of Cherenkov Photons from Electrons for Medical Applications — •Kaveh Kooshk, Ivor Fleck, and Daniel Berker — Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen

The need for medical imaging devices capable of detecting high energy photons prompts research into new detection methods such as Compton camera in nuclear medicine. A new detection method for Compton electrons using Cherenkov radiation is proposed in this work as a proof of principle. Electrons from beta minus decay of Strontium 90/Yttrium 90 with energies up to 2.28 MeV are used. They are directed through a vacuum channel within which an EM field from an electromagnet allows only a specific energy to reach a collimator at the end of the path. After the collimator, the energy spread of the electrons is less than 6% around the nominal energy which can vary between 0.5 and 2.28 MeV. The electrons subsequently reach a radiator material (PMMA) and produce Cherenkov photons, which are detected via a 8x8 Silicon-Photomultiplier array with 64 readout channels. For each electron, the Cherenkov photons are collected within a time-window of 100 ns. The spatial distribution of the Cherenkov photons and their total number are recorded and will be investigated as a function of electron energy, and the results will be compared with theoretical data.

ST 7: Radiation monitoring and dosimetry II

Time: Wednesday 16:15–17:30 Location: ST-H4

ST 7.1 Wed 16:15 ST-H4

Augenlinsendosimetrie für den klinischen Expositionsalltag - Untersuchungen zur Dosisverteilung sowie Risikobewertung hinsichtlich der Kataraktentwicklung — •Jennifer Schlüss[1], Kevin Kröninger[1], Jörg Walbersloh[2] und Jens Weingarten[1] — [1]Technische Universität Dortmund, Dortmund, Deutschland — [2]Materialprüfungsamt NRW, Dortmund, Deutschland

Der Jahresgrenzwert für Augenlinsen bei beruflich strahlenexportierten Personen wurde auf Empfehlung der Internationalen Strahlenschutzkommission (ICRP) im Jahr 2017 auf 20 mSv/Jahr herabgesetzt. Dieser Grenzwert beruht nicht auf einer empirischen Absicherung hinsichtlich des immanenten schädigenden Potentials der Arbeitsumgebung. Entsprechend der Arbeitsschutzbestimmungen für das Klinikpersonal wird verhindert, dass sich die Personen im direkten Strahlengang aufhalten, stattdessen wirkt hier Streustrahlung. Zur Detektion der aufgenommenen Strahlendosis ist das Tragen eines Augenlinsendosimeter unabkömmlich. Vorgestellt wird eine Versuchsreihe zur Bestimmung einer optimalen Trageposition für ein Augenlinsendosimeter (TL-DOS-Dosimeter) vorgestellt. Zur Modellierung wird ein Wasserphantom, ein anthropomorphes Phantom und ein PhantomX verwendet, mithilfe derer zunächst Winkelmessungen an TL-DOS-Dosimetern mittels H_p(3)-Dosismessungen durchgeführt werden. Maßnahmen des persönlichen Strahlenschutzes am Auge wie das Tragen einer Brille oder eines Visiers werden hinsichtlich ihrer Wirkung analysiert, um daraus eine Trageempfehlung für das Klinikpersonal abzuleiten.

ST 7.2 Wed 16:30 ST-H4

Implementation and characterization of a virtual Cs-137 gamma irradiation facility — •Lena Olbrich[1], Evelin Derugin[1], Kevin Kröninger[1], Florian Mentzel[1], Jörg Walbersloh[2], and Jens Weingarten[1] — [1]TU Dortmund — [2]Materialprüfungsamt NRW

A Cs-137 gamma irradiation facility is operated at the *Materialprüfungsamt NRW* for research purposes in the field of thermoluminescence dosimetry and calibration of dosimeters, mainly for official personal dose monitoring. The facility is sufficiently characterized for routine dose monitoring. For the development of new dosimeters, a complete simulation of the irradiation facility is useful to perform virtual prototype tests before anything is built. To understand all the processes involved and their influence on the radiation field at different points, e.g. in the reference point for calibration, all relevant aspects of the entire irradiation facility are implemented and investigated successively using Geant4 simulations.

In this talk, the results of the implementation and characterization of a virtual Cs-137 irradiation facility will be presented.

ST 7.3 Wed 16:45 ST-H4

Automatisierte Vermessung des Feldes der Cs-Bestrahlungsanlage am MPA NRW — •Polina Stecher[1], Evelin Derugin[1], Kevin Kröninger[1], Jens Weingarten[1] und Jörg Walbersloh[2] — [1]TU Dortmund, Lehrstuhl für Experimentelle Physik IV — [2]Materialprüfungsamt NRW

Die Cäsium-137 Bestrahlungsanlage am Materialprüfungsamt NRW wird für die Kalibrierung der thermolumineszenz Personendosimeter und für Forschungsbestrahlungen genutzt. Mit einer bekannten Dosisrate, die vorher mit Hilfe einer Ionisationskammer an einem definierten Referenzpunkt bestimmt wurde, werden die Dosimeter an der gleichen Position bestrahlt und anschließend ausgelesen. Für die Kalibrierbestrahlung ist die Kenntnis der räumlichen Dosisverteilung der Bestrahlungsanlage sehr wichtig. Zum einen lässt sich überprüfen, wie groß und homogen das Bestrahlungsfeld tatsächlich ist und zum anderen feststellen, welche potenzielle Streuquellen im Bestrahlungsraum die Homogenität des Feldes beeinträchtigen. Informationen der räumlichen Dosisverteilung der Cs-Anlage lassen sich aktuell nur aus Simulationen gewinnen. Eine manuelle räumliche Dosismessung konnte erste valide Messergebnisse liefern. Wir präsentieren den Fortschritt einer automatisierten Feldvermessung. Mit Hilfe von Schrittmotoren wird eine Ionisationskammer an verschiedene Positionen innerhalb einer Ebene des Bestrahlungsfeldes platziert. Mit dem Messaufbau soll das gesamte Bestrahlungsfeld der Cäsium-Anlage abgetastet und die zugehörige Dosisverteilung aufgenommen werden.

ST 7.4 Wed 17:00 ST-H4

Thermoluminescence glow curve generation using generative adversarial networks (GANs) — •Evelin Derugin[1], Florian Mentzel[1], Kevin Kröninger[1], Jens Weingarten[1], and Jörg Walbersloh[2] — [1]Department of Physics, TU Dortmund University

— [2]Materialprüfungsamt NRW

Personal dose monitoring is essential for a successful radiation protection program for occupationally exposed persons. The Materialprüfungsamt NRW produces thermoluminescence detectors based on LiF:Mg,Ti. First studies on artificial neural network (ANN) analysis techniques have been successfully performed based on both measured data and artificial glow curves from empirical simulations using parameter interpolation. ANNs require large data sets to be trained before they can be used to predict parameters of new measurements. Therefore the Department of Physics at TU Dortmund is developing multivariate methods for the simulation of thermoluminescence glow curves using GANs in cooperation with the MPA NRW. These glow curves can be used to predict additional information about the irradiation scenario such as the irradiation date or the number of irradiation fractions. In this study, GANs are trained to simulate a glow curve model using a measured data set of 4200 glow curves. Due to a large number of different irradiation times in the data set, the stochastic properties can be used to improve the simulation process. In this talk, we present the comparison of the simulated glow curves with the measured ones and provide information about the performance and the optimization of the neural network.

ST 7.5 Wed 17:15 ST-H4

Neutron Detection using B4C-coated Silicon Detectors — Kevin Alexander Kröninger, •Alina Johanna Landmann, and Jens Weingarten — TU Dortmund, Fakultät Physik, Otto Hahn Str. 4, 44227 Dortmund

He(3) is a frequently used element in neutron detection. However, the world is suffering from an extreme He(3)-shortage increasing the need for alternative detection methods. Semiconductors, commonly known from high energy physics, coated with B(10) as neutron converters, represent a promising alternative. The coating process of the first prototype on-site of the TU Dortmund was performed. Geant4 simulations are used to investigate how specific parameter changes within the coating process can increase the detection efficiency. Results indicate that the detection efficiency is suitable for high neutron flux particle fields which can be found, for example, within the thermal column of a research reactor. Yet, the detection of lower neutron fluxes with coated semiconductors remains difficult. Promising candidates for that purpose are scintillation detectors enriched with neutron converters.

In this talk, we will present the results obtained from the Geant4 simulations regarding the increase in detection efficiency of coated silicon detectors; and discuss alternative neutron detector candidates, suitable for lower neutron flux.

ST 8: Radiation therapy II

Time: Thursday 11:00–12:00 Location: ST-H4

ST 8.1 Thu 11:00 ST-H4

Development of an end-to-end verification method for Gamma Knife treatments — Irenäus Adamietz[2,3], Jan Boström[2,3], Moritz Budde[3], •Feline Heinzelmann[1], and Kevin Kröninger[1] — [1]TU Dortmund University, Department of Physics, Dortmund, Germany — [2]University Hospital at Ruhr-Universität Bochum, Gamma Knife Zentrum, Bochum, Germany — [3]Marien Hospital Herne, University Hospital at Ruhr-Universität Bochum, Clinic for Radiotherapy and Radiation Oncology, Herne, Germany

Gamma Knife is a stereotactic radiosurgery (SRS) instrument using Cobalt-60 radiation sources to treat malign and benign brain tumours and other skull base disorders. With the introduction of inverse radiation planning, which has recently been adopted in Gamma Knife treatment, dose verification is recommended for Gamma Knife radiosurgery. Such plan verification is already standard practice for other teletherapies. For plan verification in Gamma Knife therapy, a new SRS phantom based on film dosimetry and an end-to-end verification protocol has been developed and implemented. The gamma analysis is used to evaluate the conformance between the measured dose distribution and the dose distribution calculated by the radiation planning system. The focus of this lecture is on the adaptations of the standardized plan verification method to stereotaxy and the associated challenges such as the small target volumes and the high applied dose, which demand high accuracy.

ST 8.2 Thu 11:15 ST-H4

Simulations of silicone-tungsten shieldings for ruthenium eye applicators — •Justine Gemmecke[1], Henning Manke[1], Michelle Stroth[1], Saskia Müller[1], Dirk Flühs[2], and Bernhard Spaan[1] — [1]Experimental Physics 5, TU Dortmund — [2]Department of Radiotherapy, University hospital Essen

Brachytherapy with Ruthenium-106 eye plaques is a standard treatment modality for ocular tumours. A silver calotte with an integrated Ruthenium-106 layer is attached to the patient's eye for a calculated duration, applying the prescribed dose in order to destroy the tumour tissue. Surrounding healthy tissue and high-risk organs should be spared as much as possible.

To optimize the protection of healthy tissue, precision fit shieldings made of a silicone-tungsten mixture, fixed to the eye plaque surface, are currently being developed. Their dosimetric properties are investigated by means of both simulations in Geant4 and measurements in a water phantom. Simulations based on real patient data also allow retrospective estimation of the dose distribution to the tissue, measuring dose-volume histograms of the irradiated area and an evaluation of the effect of the shielding under clinical conditions.

When developing patient individual shieldings, two main aspects have to be considered. First, the highest possible tungsten fraction in the shieldings has to be determined in order to achieve the maximal protection of the healthy tissue. Second, an easy manufacturing process has to be developed to apply this technique to the clinical routine.

ST 8.3 Thu 11:30 ST-H4

A combination of Brachy- and X-ray-therapy as a novel concept for intraocular tumors — •Henning Manke[1], Dirk Flühs[2], Justine Gemmecke[1], Saskia Müller[1], Michelle Stroth[1], and Bernhard Spaan[1] — [1]Experimental Physics 5, TU Dortmund — [2]Department of Radiotherapy, Essen University Hospital

Eye plaque brachytherapy with the beta emitter Ruthenium-106 is applied to a large fraction of ocular tumors. Due to the emitted particles' steep dose gradient, there is a limitation to the clinically treatable tumor height. Depending on the indications, eyes affected by a tumor larger than the maximum height have to be enucleated in many cases, especially if located close to the posterior pole. As this massively impairs the patients' quality of life, a novel concept to treat such tumors is currently investigated.

External photon irradiation through insensitive parts of the eye can be used to enhance the applied dose at the tumor apex. A confocal irradiation concept results in a low exposure of healthy tissue while the tumor control dose can be reached in all parts of the target volume. The X-ray therapy can be performed while the Ruthenium-plaque is positioned on the eye. Therefore the plaque itself, which is mainly made of silver, can be used as a beam stopper. This leads to an additional significant reduction of dose in the healthy tissue behind the tumor.

This contribution presents the general concept of the combined therapy, our methods to examine the physical and radiobiological properties and first results.

ST 8.4 Thu 11:45 ST-H4

Monte Carlo simulations of a combination of brachytherapy and external X-ray irradiation for the treatment of intraocular tumors — •Michelle Stroth[1], Henning Manke[1], Justine Gemmecke[1], Saskia Müller[1], Dirk Flühs[2], and Bernhard Spaan[1] — [1]Experimental Physics 5, TU Dortmund — [2]Department of Radiotherapy, University hospital Essen

Brachytherapy with ruthenium-106 eye plaques is a standard modality for the treatment of intraocular tumors. In order to ensure a sufficient tumor apex dose even in larger tumors without exceeding dose limits at neighboring organs at risk, the concept of combining eye plaque brachytherapy with an external beam from a precisely positioned X-ray tube is currently being investigated.

For this purpose, a generic eye model is created using the CAD software Fusion 360 and adapted to the data of real patient cases. The area

of the exit window of the X-ray tube is created for various positions depending on the tumor apex, so that different directions of photon irradiation are simulated. A decomposition of the model into many sub-volumes and their implementation in a Monte Carlo simulation in Geant4 allows the analysis of local dose profiles and dose-volume-histograms in organs at risk and the tumor.
This presentation shows the setup of the simulation and first results of combining brachytherapy with external X-ray irradiation.

ST 9: Detectors and Applications II

Time: Thursday 14:00–15:30 Location: ST-H4

ST 9.1 Thu 14:00 ST-H4

Polyethylene naphthalate as alpha and heavy nucleus detection material — •Kim Tabea Giebenhain, Hans-Georg Zaunick, Roman Bergert, and Kai-Thomas Brinkmann — Justus-Liebig Universität, Gießen, Germany

Polyethylene naphthalate (PEN) is a material with intrinsic scintillation capabilities. Using a thin film of PEN read out by SiPM photo sensors has shown to be an excellent detector for alpha particles with potential applications for alpha spectroscopy. Measurements with alpha sources were conducted to determine the achievable energy resolution. Furthermore, optimization of the detector by means of optical surface coating was studied and results will be discussed.

ST 9.2 Thu 14:15 ST-H4

Technical aspects of simulation-based scatter correction in total-body Positron Emission Tomography (PET) imaging using the uEXPLORER PET scanner — •Reimund Bayerlein, Edwin K. Leung, Zhaoheng Xie, Eric Berg, Benjamin A. Spencer, Negar Omidvari, Qian Wang, Lorenzo Nardo, Simon R. Cherry, and Ramsey D. Badawi — University of California Davis

Positron Emission Tomography (PET) is a powerful tool for molecular imaging and has brought enhancements to biological research with widespread oncological and clinical adoption. The limited sensitivity of conventional PET scanners with a short axial field of view (AFOV) has been overcome by the uEXPLORER total-body PET scanner with a total AFOV of 194 cm. With a 15-68-fold increase in sensitivity and a spatial resolution of 3.0 mm the uEXPLORER can provide improved image quality, or reduced scan duration, or reduced radioactivity in the subject, or late time point imaging, or some combination of these. This state-of-the-art PET scanner constitutes a paradigm shift in nuclear medicine with the ability to address open questions in medicine and biology. However, the large number of detectors and the widened acceptance angle dramatically increase the data sizes, setting higher demands on the image reconstruction algorithms. Specifically, quantitative techniques for the correction of scattered events become more complex and computationally expensive. Due to the high number of lines of response (92 x 10^9) scatter correction by direct computation using the Klein-Nishina formula is challenging in total-body PET and Monte-Carlo (MC) methods are preferred. In the spirit of a technical note, this contribution will describe the procedure of scatter correction in total-body PET using MC simulations embedded in a framework using a list-mode ordered subset expectation maximization image reconstruction. The method was developed and validated using phantom studies conducted at the EXPLORER Molecular Imaging Center at UC Davis. In the presentation, mathematical, physical, and computational aspects will be highlighted.

ST 9.3 Thu 14:30 ST-H4

Two Photon Absorption - TCT: Characterisation of LGAD and other silicon sensors with a newly developed table-top TPA-TCT system — •Sebastian Pape[1,5], Esteban Currás[1], Marcos Fernández[1,2], Michael Moll[1], Raúl Montero[3], F. Rogelio Palomo[4], Christian Quintana[2], Ivan Vila[2], and Moritz Wiehe[1,6] — [1]CERN — [2]Instituto de Física de Cantabria — [3]Universidad del Pais Vasco (UPV-EHU) — [4]Universidad de Sevilla — [5]TU Dortmund University — [6]Universität Freiburg

The Two Photon Absorption – Transient Current Technique (TPA-TCT) uses fs-pulsed infrared lasers, with photon energies below the silicon band gap to only generate excess charge carriers in a small volume (approximately 1μm × 1μm × 20μm) around the focal point of the laser beam. Therefore, a resolution in all three spatial directions is achieved to characterise silicon devices. Following the initial success of the method, a compact TPA-TCT setup was developed at CERN and first measurements were performed. The setup, measurements on non-irradiated and irradiated PIN diodes, and measurements on LGAD sensors with focus on the gain suppression mechanism will be presented.

ST 9.4 Thu 14:45 ST-H4

Studies towards a Time-of-Flight system equipped with LGADs — •Valerie Hohm[1], Kevin Kröninger[1], Sebastian Pape[1,2], and Jens Weingarten[1] — [1]TU Dortmund, Department of Physics — [2]CERN

Treatment planning is a crucial part in particle therapy of cancer in order to prevent healthy tissue from being irradiated falsely. One approach to improve the precision in proton therapy is the usage of proton computed tomography (pCT) for imaging. In such a system the paths of the protons as well as their energy loss in a phantom are measured to create an image of the phantom.

To measure the energy loss of protons, a Time-of-Flight (ToF) system can be used. The time an ionising particle needs to traverse two detectors in a given distance depends on its energy. For a precise energy measurement, the time resolution of the used detectors needs to be as small as possible.

In high-energy physics so called Low Gain Avalanche Detectors (LGADs) were developed for the ATLAS and CMS experiment upgrades. These n-in-p silicon sensors with an additional gain layer are designed for a typical charge amplification in the range of 10 to 30 for unirradiated LGADs which results in a time resolution up to 30 ps.

This talk focuses on the usage of LGADs in a ToF system. The feasibility of the system for the energy measurement in a proton tomography system will be presented as well as first measurements with a prototype.

ST 9.5 Thu 15:00 ST-H4

Single Photon Avalanche Diodes with an on-chip integrated preamplifier to improve single photon time resolution — •Jonathan Preitnacher[1], Wolfgang Schmailzl[1], Sergei Ageev[2], and Walter Hansch[1] — [1]Bundeswehr University Munich, Neubiberg, Germany — [2]The Moscow Engineering Physics Institute-Kashira Hwy, 31, Moscow, Russland, 115409

Silicon photomultiplier (SiPM) are solid-state detectors used for applications requiring high timing resolution and single photon sensitivity and play an important role in various measurement methods in high energy physics or in fields of medical imaging. To further improve the measurements in such applications, an enhanced single photon time resolution (SPTR) on the SiPM is required. For this we designed and implemented a small array of 4x4 single photon avalanche diodes (SPAD) in CMOS 350 nm technology and combined it with an on-chip integrated amplifier. The amplifier is a modified Regulated Common Gate (RCG) circuit and consists of an n-MOS based current follower with additional amplification stages that provides a stable signal and a fast slew rate, which are necessary conditions for a good SPTR. The standard characterization of the SiPM using parameters such as IV-curves, breakdown voltage, dark count rate, crosstalk, gain and afterpulsing shows acceptable results. Furthermore, first measurements of SPTR with a femtosecond laser and an oscilloscope with 10 GHz bandwidth show that it is possible to measure SPTR down to 42 ps FWHM. The results and different contributions to the SPTR are also discussed.

ST 9.6 Thu 15:15 ST-H4

Space applications - Measuring the effect of total ionization dose on field-effect transistors — •Erik Jozsef[1], Andreas Reeh[2], Hans-Georg Zaunick[2], Kai-Thomas Brinkmann[2], and Uwe Probst[1] — [1]Technische Hochschule Mittelhessen, Gießen, Germany — [2]Justus-Liebig University, Gießen, Germany

Compared to terrestrial applications the utilization of electronics in space environment meets several additional requirements to ensure functional reliability. One of the key requirements is the radiation hardness of the electronic components. Field-effect transistors are vital for modern electronics and are commonly used in power electronics. This presentation shows a method how radiation hardness of switching transistors can be investigated qualitatively. Parameters relevant to operation, such as threshold voltage, parasitic capacitances and leakage currents are to be measured. Measuring methods, process and equipment are presented. EU regional development funding via the EFRE scheme of the State of Hesse is gratefully acknowledged.

ST 10: Total-Body PET

Time: Thursday 16:15–16:55 Location: ST-H4

Invited Talk ST 10.1 Thu 16:15 ST-H4
Artificial intelligence in PET image reconstruction and quantitative analysis — •Zhaoheng Xie — University of California Davis

Positron emission tomography (PET) in vivo visualizes the molecular pathway and is the most sensitive molecular imaging modality routinely applied in clinic. Recent developments in PET technology dramatically increased the effective sensitivity by increasing the geometric coverage or improved time of flight (TOF) resolution. In this talk, I will discuss a few examples of deep learning-based solutions to address the specific challenges in ultra-low-dose or ultra-fast scanning, which enables more convenient and safer clinical practice, medical research and drug screening. The talk will start with an overview of the applications of AI in PET imaging. Then I will provide some frontline applications, which will cover the latest works we published including learning-based PET image reconstruction, scatter correction, motion correction, and kinetic modeling. A special emphasis is on deep-learning-based methods. We will discuss their potential benefits and limitations. The talk will conclude with a few challenging opportunities in various research and clinical applications.

ST 11: Prize Ceremony and Closing Session

Time: Thursday 16:55–17:10 Location: ST-H4

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 devision at the DPG Spring Meeting 2022*. We welcome everyone to celebrate a successful conference with us, to provide some final feedback and to take the chance to meet other participants one last time at this conference.