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

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## Overview of Invited Talks and Sessions

(Lecture hall KH 01.013; Poster Redoutensaal)

### Plenary Talk

See plenary section for details.

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| PV XII | Thu | 9:00– 9:45 | AudiMax | **AI in the context of medical images** — •Stefan Wesarg |

### Invited Talks

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|---|---|---|---|---|
| ST 4.1 | Wed | 16:15–16:45 | KH 01.013 | **Introduction to modern nuclear medicine: almost one century of interdisciplinary innovations** — •Stephan Nekolla |
| ST 4.2 | Wed | 16:45–17:15 | KH 01.013 | **Personendosimetrie in der Nuklearmedizin** — •Felix Bärenfänger |
| ST 4.3 | Wed | 17:15–17:45 | KH 01.013 | **Dosimetry in Targeted Radionuclide Therapy: Challenges, Concepts, and Perspectives** — •Johannes Tran-Gia |
| ST 5.1 | Thu | 11:00–11:30 | KH 01.013 | **Prompt-Gamma-Based Range Verification** — •Beatrice Foglia |
| ST 5.2 | Thu | 11:30–12:00 | KH 01.013 | **Carbon-ion radiotherapy monitoring with charged nuclear fragments** — •Maria Martisikova, Laurent Kelleter, Rebekka Kirschgässner, Pamela Ochoa, Semi Harrabi, Jan Jakubek, Oliver Jäkel, Jürgen Debus |
| ST 5.3 | Thu | 12:00–12:30 | KH 01.013 | **Radioactive ion beams for real-time PET-guided adaptive particle therapy** — •Daria Boscolo for the BARB Collaboration |
| ST 5.4 | Thu | 12:30–13:00 | KH 01.013 | **Helium as a Range Probe in Carbon-Ion Therapy: From Concept to Mixed-Beam Experiments** — •Lennart Volz for the PROMISE collaboration |
| ST 8.1 | Thu | 16:45–17:15 | KH 01.013 | **Healing Patients, Heating the Planet: Why Circularity Matters in Healthcare** — •Katharina Hesels |

### Sessions

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|---|---|---|---|---|
| ST 1.1–1.5 | Tue | 11:00–12:15 | KH 01.013 | **Medical Imaging** |
| ST 2.1–2.4 | Tue | 16:15–17:15 | KH 01.013 | **Detectors for Treatment Monitoring** |
| ST 3.1–3.7 | Wed | 13:45–15:30 | KH 01.013 | **Detectors for Medical Applications** |
| ST 4.1–4.3 | Wed | 16:15–17:45 | KH 01.013 | **DPG meets DGMP: Dosimetry in Nuclear Medicine** |
| ST 5.1–5.4 | Thu | 11:00–13:00 | KH 01.013 | **Focus Session: Range Verification in Particle Therapy** |
| ST 6.1–6.5 | Thu | 14:15–15:45 | Redoutensaal | **Poster Session** |
| ST 7.1–7.2 | Thu | 16:15–16:45 | KH 01.013 | **Radiation Therapy** |
| ST 8.1–8.1 | Thu | 16:45–17:15 | KH 01.013 | **Keynote Session** |
| ST 9 | Thu | 17:15–17:45 | KH 01.013 | **Prize Ceremony and Closing Session** |
| ST 10 | Thu | 17:45–18:45 | KH 01.013 | **Members' Assembly** |

### Members' Assembly of the Radiation and Medical Physics Division

Thursday 17:45–18:45 KH 01.013

# ST 1: Medical Imaging

Time: Tuesday 11:00–12:15 Location: KH 01.013

ST 1.1 Tue 11:00 KH 01.013

**Investigation of a Simulation Framework for the Two-Plane Imaging System** — Patricia Borrego Jiménez, Kevin Kröninger, Hendrik Speiser, Annsofie Tappe, •Helen Thews, Jens Weingarten, and Sophia Wortmann — TU Dortmund, department of physics, Dortmund, Germany

In radiotherapy for cancer treatment, proton therapy is an important treatment due to the steep dose gradient, which leads to a high conformal dose distribution while sparing healthy tissue. However, anatomical changes of the patient have a high impact on the range of the protons; this uncertainty leads to larger safety margins. One opportunity to minimize this uncertainty is to use proton imaging in adaptive proton therapy.

A Two-Plane Proton Imaging System (TPIS) consisting of two ATLAS IBL pixel detector planes offers the opportunity to take water-equivalent-thickness (WET) images of the patient. These WET images can be used to identify anatomical changes in the patient's body. To take a look at the reachable WET resolution and the full-body dose, a simulation framework is being developed, which is validated using RayStation. The simulation framework mainly consists of TOPAS to simulate the dose in the patient's body and the deposited energy in the sensor. The detector readout is afterward simulated in Allpix Squared.

This talk will introduce the TPIS and its current status. Then the simulation framework is discussed. Finally, the first results of simulation studies using this simulation framework are shown.

ST 1.2 Tue 11:15 KH 01.013

**Clinical studies on the proton radiography system** — •Sophia Wortmann, Patricia Borrego Jiménez, Kevin Kröninger, Hendrik Speiser, Helen Thews, and Jens Weingarten — TU Dortmund Department of Physics, Dortmund, Germany

In proton radiography the water-equivalent thickness (WET) is determined to characterize material and density distributions with high precision. In adaptive proton therapy this information can be used to detect range changes that arise from anatomical variations between treatment fractions. A two-plane imaging system (TPIS) was developed for this purpose and a corresponding simulation framework was created. The goal of this project is to validate the framework by comparing its results with calculations from the RayStation treatment-planning system and to prepare it for use in preclinical studies.

In this work the experimental measurements with the TPIS are reproduced in TOPAS and WET reconstructions that allow quantitative comparison are generated. The validation starts with simple PLA plate phantoms and is later extended to a more complex skull phantom. For all phantoms the achievable spatial resolution, the WET accuracy and the deposited dose are evaluated. These results provide an initial evaluation of the imaging performance of the system and are intended to support its use in future preclinical proton radiography studies.

ST 1.3 Tue 11:30 KH 01.013

**From Compton Kinematics to Physics-Informed Neural Network Reconstruction for High-Energy Gamma Imaging** — •Yazeed Balasmeh, Atharva Bahekar, Ivor Fleck, Mara Fries, Lars Maczey, and Devanshi Mehta — Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen

Compton cameras enable collimator-free imaging of high-energy gamma rays and are attractive for medical imaging, online range verification in cancer therapy, and targeted alpha therapy. This work presents a physics-informed neural network for Compton-camera image reconstruction that converts measured interaction positions and energies into a 2D source probability map. The objective is a general-purpose model that is computationally efficient, accurate, and stable across operating conditions, including incident energies from about 500 keV to 2 MeV and sources with varying sizes, shapes, and spatial distributions. Physical consistency is encouraged through physics-inspired inputs (e.g., reconstructed scatter angle, interaction-ordering cues, and detector-geometry features) and loss terms that penalize violations of Compton kinematics and constrain predictions to physically feasible Compton cones. A major focus is performance in low-statistics regimes relevant to Ac-225 targeted alpha therapy, where only a small number of detectable 1.57 MeV photons is available. We train and evaluate on Geant4-based simulations spanning count levels, energy spectra, and source configurations, and report energy- and statistics-dependent SSIM and peak-distance error.

ST 1.4 Tue 11:45 KH 01.013

**Dark-field imaging of cancerous breast tissue** — •Markus Kraft, Markus Schneider, Gisela Anton, Martin Rongen, Veronika Ludwig, Constantin Rauch, and Stefan Funk — ECAP FAU, Erlangen, Deutschland

Talbot-Lau X-ray phase-contrast imaging provides, next to the attenuation of X-rays, additional information about the phase shift in the object.This yields two additional image modalities, the differential phase image and the dark-field image, which results from small-angle scattering.

For breast-cancer detection, the dark-field signal is particularly valuable, as it yields a higher sensitivity to fine structures like microcalcifications. Those can be an indicator for ductal carcinoma in situ (DCIS), which accounts for 20-30% of breast cancer cases.

Currently, in at about 30% of DCIS operations, the cancer is not completely removed and a second operation is necessary. The goal of our project is to investigate the edges of the freshly removed cancer tissue for microcalcifications, via a dark-field CT. Ideally, this will enable us to provide immediate feedback to the surgeon if an increase of the surgical margin is necessary and, thereby preventing a second surgery.

Currently, we are optimizing the dark-field CT setup and are investigating sealed cancer-tissue samples provided by the "Pathologie Uniklinikum Erlangen" to verify the feasibility of the localization of microcalcifications.

ST 1.5 Tue 12:00 KH 01.013

**Reconfigurable Metamaterials in MRI** — •Dennis Philipp[1,2], Johannes Mueller[1,2], and Matthias Guenther[1,2] — [1]Fraunhofer MEVIS, Bremen, Germany — [2]University of Bremen, Bremen, Germany

Reconfigurable metamaterials (MTMs), operated in Tx and/or Rx during an MRI scan are an exciting new technology to leverage the full potential of MRI towards new imaging paradigms and potentially overcome existing limitations in terms of, e.g., SNR and imaging speed. They allow for on-demand RF field shaping during and/or between acquisitions and, thus, introduce new degrees of freedom into MRI. The potential advantages are, e.g., tailored local and spatio-temporal SNR enhancement for manifold applications.

Reconfigurable MTM prototypes are studied in simulations to infer a suitable geometry and parameter range of lumped elements for use in a 3T scanner. Prototypes are manufactured on rigid/flexible substrates and validated.

## ST 2: Detectors for Treatment Monitoring

Time: Tuesday 16:15–17:15 Location: KH 01.013

ST 2.1 Tue 16:15 KH 01.013

**Online 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], Stephan Brons[3], and Dennis Muecher[1] — [1]University of Cologne, Cologne, Germany — [2]GSI, Darmstadt, Germany — [3]HIT, Heidelberg, Germany

Interaction Vertex Imaging (IVI) is a proposed method for online range verification during heavy-ion therapy to determine relative range shifts in Bragg peak position (BP) with a sub-mm precision as previous experiments at HIT in Heidelberg have shown. This allows to add a safety interlock during treatment, which pauses irradiation if an incorrect BP position is detected. IVI tracks the secondary ions produced by beam-patient reactions with a purpose-built tracking system that uses the sensors developed by GSI for the Compressed Baryonic Matter experiment. These highly segmented, double sided silicon strip detectors have a 58 $\mu$m pitch, and cover a large sensitive area of up to 72 $cm^2$. In combination with the readout electronics count rates of up to 250 kHz per segment are capable. While the system has already shown its tracking performance at 2.35 MHz event rate with less than 0.002% pileup, there was so far no real online analysis. The technical aspects of IVI and online analysis, as well as tests using Muons and a $^{12}C$ beam at clinical intensities will be discussed in this contribution.

ST 2.2 Tue 16:30 KH 01.013

**A PWO Scintillator Range-Telescope for Real-Time Depth-Dose Measurement in Low-Dose Environments for Proton Therapy** — •Niclas Fiedler[1,2], Dzmitry Kazlou[1], Hans-Georg Zaunick[1], Kai-Thomas Brinkmann[1], and Kilian-Simon Baumann[2,3] — [1]2nd Physics Institute, Justus Liebig University Giessen — [2]University of Applied Sciences Giessen — [3]Marburg Ion-Beam Therapy Center

Proton therapy provides highly localized dose delivery to tumors while sparing surrounding healthy tissue. Heterogeneous media along the beam path, such as lung tissue, introduce range uncertainties that broaden the Bragg peak and obscure the distal fall-off, an effect quantified by the modulation power. A direct measurement will reduce these uncertainties. However, currently available detectors are designed for high-dose, high-flux environments making them unfit for imaging.

The work presents a novel PbWO4-based detector system developed to measure the depth-dose distribution of protons for low-dose environments in real-time. First beam tests with high-energy, low-flux proton beams were conducted using homogeneous and heterogeneous phantoms. Unfolding techniques are applied to extract accurate depth-dose curves, determining the modulation power. These initial results demonstrate the detector's suitability for precise characterization of Bragg-peak degradation in heterogeneous media.

ST 2.3 Tue 16:45 KH 01.013

**Measurement and Geant4 simulation of Cherenkov radiation with an electron monochromator** — •Atharva Bahekar, Yazeed Balasmeh, Ivor Fleck, Mara Fries, Lars Maczey, and Devanshi Mehta — Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen

High-energy electron detection techniques require monoenergetic electrons for detector response validation and optical simulations. This work characterizes a custom-built magnetic electron monochromator developed in the Compton Camera group at Universität Siegen, benchmarked by a detailed Geant4 simulation.

Electrons from a $^{90}Sr$ /$^{90}Y$ source are propagated into a fixed magnetic field and a collimator. A motorized linear and rotational stage positions the source for precise selection of electron energies. These selected electrons are then detected by a calibrated system of a ($Gd_3Al_2Ga_3O_{12}$ : Ce : Ce) (GAGG) scintillation crystal coupled to a photomultiplier tube (PMT). A corresponding Geant4 setup reproduces the source, magnetic optics and detector geometry. A direct comparison of the mean energies of simulated electrons to the experimentally obtained mean electron energies for various source configurations provides a quantitative validation of the Geant4 setup, subject to agreement between simulation and measurement.

This validated framework will be used to measure Cherenkov photon production in a PMMA radiator for fixed electron energies. This will provide credible data for neural network-based image reconstruction algorithms in our Compton Camera project.

ST 2.4 Tue 17:00 KH 01.013

**Absorption Point Reconstruction and Energy Measurement in Scintillation Material for Medical Imaging** — Atharva Bahekar, Yazeed Balasmeh, Ivor Fleck, Mara Fries, •Lars Maczey, and Devanshi Mehta — Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen

Scintillators are central to many imaging technologies that rely on gamma detection, where accurately reconstructing both the photon's absorption point and deposited energy is essential. The work presented here is motivated by the Compton camera project at the University of Siegen but is applicable to other imaging modalities in medicine.

This talk summarises results from measurements using inorganic scintillation crystals such as GAGG and LGSO coupled to SiPMs from Broadcom and Hamamatsu, with signal acquisition performed via the TOFPET v2c ASIC from PETsys Electronics. Several methods for reconstructing the absorption point are compared, including the centroid method, maximum-likelihood fitting and a machine-learning approach. Challenges encountered in achieving a reliable energy calibration are discussed as well as measurements of the depth of interaction (DOI) using a double-sided SiPM readout. Finally, I present and discuss different design strategies for the scintillator layer, ranging from a segmented crystal array to a monolithic crystal approach, and for the SiPM layer, ranging from small-sized analogue SiPM arrays to large-area position-sensitive SiPMs.

# ST 3: Detectors for Medical Applications

Time: Wednesday 13:45–15:30 Location: KH 01.013

ST 3.1 Wed 13:45 KH 01.013

**electronCT - A Candidate for Image Guidance in VHEE Radiotherapy** — •Aenne Abel[1,2], Leticia Braga da Rosa[1,2], Paul Schütze[1], Malinda de Silva[1], and Simon Spannagel[1] — [1]Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, D-22607 Hamburg — [2]University of Hamburg, Hamburg, Germany

electronCT (eCT) is an imaging method, which uses multiple scattering of electrons to acquire images of unknown objects. This imaging method is a candidate for image guided radiotherapy with very high energy electrons (100-250 MeV). For eCT, a low emittance pencil beam is propagated through an object and the scattering of the beam is quantified. The widening of the beam is dependent on the radiation length of the materials traversed by the beam. A measurement of the opening angle then allows for a reconstruction of the material properties of the sample. In this contribution eCT is introduced as a method, proof of concept studies are shown and the performance is discussed with respect to the obtained tomographic reconstructions.

ST 3.2 Wed 14:00 KH 01.013

**Evaluation of the KLauS Chip for Measurement of Scintillation and Cherenkov Light** — Atharva Bahekar, Yazeed Balasmeh, Ivor Fleck, •Mara Fries, Lars Maczey, and Devanshi Mehta — Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen

Detecting and imaging ionising radiation is essential in fields ranging from fundamental physics to medical diagnostics, where precise reconstruction of high-energy $\gamma$-ray interactions remains a key challenge. Conventional Compton Cameras show promising results but are typically optimised for $\gamma$-rays below 1 MeV, limiting their applicability in high-energy imaging scenarios. The Cherenkov Compton Camera concept uses a novel approach by introducing a thicker scattering layer in order to use Cherenkov light to track the Compton electron. This enables a determination of the direction of the recoil electron, thereby extending the energy range of Compton Cameras beyond 1 MeV.

In this talk, I will present results from the ongoing development of the Cherenkov Compton Camera, focusing on the KLauS ASIC designed by the University of Heidelberg and its possible use in both the scattering and absorption layers. The KLauS ASIC has been tested with large scintillation signals from GAGG and LGSO crystals, as well as fast Cherenkov signals in UV-transparent PMMA. Characterization using UV-sensitive Broadcom SiPMs allows us to assess the suitability and operating performance of the KLauS readout for a high-energy Cherenkov Compton Camera.

ST 3.3 Wed 14:15 KH 01.013

**SiPM Characterisation for the Construction of a Compton Camera Prototype** — Atharva Bahekar, Yazeed Balasmeh, Ivor Fleck, Mara Fries, Lars Maczey, and •Devanshi Mehta — Experimentelle Teilchenphysik, Center for Particle Physics Siegen, Universität Siegen

The development of a next-generation Compton camera capable of operating beyond the current energy limitations of conventional nuclear medical imaging requires highly efficient and low-noise gamma detectors. As part of the ongoing Compton camera project at the University of Siegen, this work focuses on the characterization of UV-sensitive Silicon Photomultipliers (SiPMs), which will form a key component of the detector system. In this work, I will present the characterization of Hamamatsu SiPMs compared to Broadcom, focusing on noise behaviour, breakdown characteristics and photon detection efficiency. Staircase measurements were performed to study breakdown behaviour and noise characteristics. Furthermore, I will present the dependence of noise on bias voltage and temperature, including the integration of a cooling system to improve stability. Alongside UV tests, we are checking how the SiPMs perform with scintillators such as GAGG and LGSO, focusing on PDE in the visible range.

ST 3.4 Wed 14:30 KH 01.013

**Diamond detector for proton therapy based on the readout system of the LHCb Beam Conditions Monitor** — Johannes Albrecht, •Nicholas Oldman, Dirk Wiedner, and Lukas Witola — TU Dortmund University, Dortmund, Germany

Due to their exceptional radiation hardness and approximate tissue equivalence, synthetic diamonds make a promising candidate as detector material for the beam analysis in quality assurance at clinical proton therapy centers. At CERN, such diamonds are already in use as detectors at the so-called Beam Conditions Monitor (BCM) at the LHCb experiment.

The BCM features fast readout electronics that process the signal current from the detector diamonds with a time resolution of $40\,\mu$s. Based on the operating principle of the BCM, a novel detector system is being developed that aims to implement the use of diamond detectors into the clinical setting. Synthetic polycrystalline diamonds grown by chemical vapor deposition are used for this detector system. They are coated with metallic electrodes to obtain position-sensitive detectors with sub-millimeter spatial resolution. The readout electronics of the BCM are utilized to achieve a fast signal sampling rate.

The progress made in the development of this novel detector system will be presented. Using a simple readout chain, a first test setup is constructed to prepare future measurements of the beam at a proton therapy center.

ST 3.5 Wed 14:45 KH 01.013

**Fast beam monitoring for ion beam therapy with an HV-CMOS detector system** — •Thomas Renkhoff[1], Alexander Dierlamm[1,2], Ulrich Husemann[1], Markus Klute[1], Ivan Perić[2], and Bogdan Topko[1] — [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 is a well-established cancer treatment available at more than one hundred centers worldwide. Compared to more common photon-based radiation therapy, ion beam therapy allows for more precise dose deposition into the tumor volume. A conformal dose deposition to the tumor volume requires a beam monitor that needs to be fast, radiation tolerant and should have a low material budget to reduce the beam particle scattering.
To meet these requirements we are developing a beam monitor based on HitPix sensors. The HitPix sensors are monolithic active pixel sensors produced in high-voltage CMOS technology. HV-CMOS technology comes with several advantages, including high radiation tolerance, thin sensors and better affordability compared to hybrid pixel detectors. HitPix sensors feature hit-counting pixels with on-sensor hit projection-calculation, radiation tolerance and frame-based readout.
The talk evaluates readout speed and performance after irradiation of the HitPix sensors. In order to test beam parameters, a quasi-online reconstruction, the estimator block, is integrated into the existing FPGA-firmware and tested.

ST 3.6 Wed 15:00 KH 01.013

**Dosimetry of high intensity electron beams for FLASH radiotherapy using Dosepix detectors and nitrogen fluorescence** — •Florian Beisser for the NitroFLASH-Collaboration — ECAP, FAU Erlangen-Nürnberg, Erlangen, Germany

FLASH radiation therapy with high-intensity electrons, where the full dose is delivered in a very short time frame, has been proven to be a very promising evolution of radiation therapy. Yet there currently exist no established methods for online dosimetry and position determination as the established detector concepts, such as monitor chambers, saturate in the high intensity beams. We here explore two possible technologies: the detection of stray electrons using Dosepix solid-state detectors and nitrogen fluorescence in air. The response of the Dosepix detectors showed clear monotonous trends with respect to distance and bunch charge, enabling the determination of the beam position and intensity from that data. Additionally, a UV camera was mounted perpendicular to the beam axis to detect the emitted nitrogen fluorescence photons as the beam traverses air, thus imaging the electron beam and reconstructing its full position and width. Although a fluorescence signal of the beam could be detected with the UV-camera, the observed intensity was too low to meaningfully reconstruct beam parameters for ARES. However, much higher intensities are expected for the FLASHlab at PITZ.

ST 3.7 Wed 15:15 KH 01.013

**Active Eye Lens Dosimetry with Dosepix: Influence of Measurement Position and Lead Glass Shielding** —

•Leonie Ullmann[1], Florian Beisser[1], Rolf Behrens[2], Stefan Funk[1], Gerhard Hilgers[2], Oliver Hupe[2], Jürgen Roth[2], Tom Tröltzsch[3], Hayo Zutz[2], and Thilo Michel[1] — [1]Erlangen Centre for Astroparticle Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany — [2]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [3]Karlsruher Institut für Technologie, Karlsruhe, Germany

Due to its sensitivity to radiation, the eye lens is subject to strict dose limits. Since exceeding these limits can lead to cataracts, precise monitoring of the dose in the eye is necessary. For this purpose, an active personal dosemeter for the eye lens has been developed for use by medical personnel. Previous investigations have shown that the prototype of this dosemeter delivers reliable results. Since the eye lens dosemeter is intended to be worn on the side of the head, follow-up studies now examined the effects of the measurement position for frontal and lateral positioning.

Furthermore, it is common practice for medical personnel to wear radiation protection glasses. As an approach to reproduce the absorption of such glasses, the attachment of lead glass pieces to the dosemeter was investigated. The resulting dose values were compared to those of thermoluminescent dosemeters (TLDs) behind radiation protection glasses.

## ST 4: DPG meets DGMP: Dosimetry in Nuclear Medicine

Time: Wednesday 16:15–17:45 Location: KH 01.013

**Invited Talk** ST 4.1 Wed 16:15 KH 01.013
**Introduction to modern nuclear medicine: almost one century of interdisciplinary innovations** — •Stephan Nekolla — TUM Klinikum, München, Germany

Nuclear medicine began in the 1940s with the clinical use of radioisotopes for diagnosis and therapy, evolving through gamma cameras and SPECT to PET. Early progress depended on advances in radiochemistry, detector physics, and instrumentation, which translated laboratory approaches into clinical applications. Nuclear medicine is inherently interdisciplinary: physicists are involved in tasks ranging from design detectors to reconstruction algorithms; radiochemists synthesize tracers; biologists identify molecular targets; and clinicians apply findings to patients. Current advances include digital PET and SPECT with improved detector materials, and integrated theranostic approaches that combine imaging with targeted therapy. Especially the latter resulted in an unprecedented interest and investments of the pharmaceutical industry. Where is this going to ? The emphasis is most likely a precision nuclear medicine with personalized radiopharmaceuticals, AI-enhanced image reconstruction and interpretation, and harmonized hybrid modalities that integrate molecular imaging with other data. Nuclear medicine's trajectory is defined by the open dialogue between interdisciplinary partners: in this particular context, physics supplies tools, models, and quantification; medicine supplies biological context and clinical questions. Sustained progress will require an open mindset, collaborative research infrastructures , cross-disciplinary training, and predictable regulatory pathways.

**Invited Talk** ST 4.2 Wed 16:45 KH 01.013
**Personendosimetrie in der Nuklearmedizin** — •Felix Bärenfänger — Universität Witten/Herdecke, Alfred-Herrhausen-Str. 50, 58453 Witten

Im Vergleich zu anderen *strahlenden* Disziplinen ist das Personal in der Nuklearmedizin häufiger messbaren Strahlenexpositionen ausgesetzt. Ursache hierfür sind der routinemäßige Umgang mit offenen radioaktiven Stoffen, nicht ortsfeste Strahlenquellen in Form der Patienten sowie komplexe, zeitlich und räumlich variable Strahlenfelder unterschiedlicher Nuklide. Diese Besonderheiten stellen sowohl die amtliche Personendosimetrie als auch den praktischen Strahlenschutz vor Herausforderungen. Neben der externen Exposition müssen häufig auch Kontaminationen und mögliche Inkorporationen als relevante Expositionspfade berücksichtigt werden. Die Auswertung des SSR-Registers für das Jahr 2024 zeigt, dass Grenzwertüberschreitungen in der Nuklearmedizin im Rahmen der amtlichen Personendosimetrie selten auftreten. Dennoch liefert die systematische Analyse der Personendosis bei der Anwendung von Dosisrichtwerten wertvolle Hinweise auf strukturelle, organisatorische oder arbeitsplatzbezogene Optimierungspotenziale. Personendosimetrie wird damit nicht nur zum Instrument der Grenzwertüberwachung, sondern zu einem aktiven Werkzeug der Qualitätssicherung im Strahlenschutz. Der Vortrag gibt einen Überblick über Möglichkeiten, Herausforderungen und Limitationen der Personendosimetrie in der Nuklearmedizin. Darauf aufbauend werden sinnvolle ergänzende Dosimetriekonzepte sowie praxisnahe Maßnahmen zur Reduktion der Personendosis diskutiert.

**Invited Talk** ST 4.3 Wed 17:15 KH 01.013
**Dosimetry in Targeted Radionuclide Therapy: Challenges, Concepts, and Perspectives** — •Johannes Tran-Gia — Universitätsklinikum Würzburg

Targeted radionuclide therapy (TRT) has emerged as a rapidly expanding modality in nuclear medicine, driven by highly effective $\beta$- and $\alpha$-emitting radiopharmaceuticals. Unlike external beam radiation therapy (EBRT), where radiation dose delivery can be planned and verified with high spatial and temporal precision, TRT involves internally distributed, time-dependent radiation exposure from radiopharmaceuticals whose biodistribution and kinetics vary substantially between patients. Consequently, dosimetry in TRT poses distinct physical and methodological challenges, including limited imaging sensitivity and spatial resolution, complex decay schemes, and the need for quantitative SPECT or PET imaging over multiple time points.

This talk introduces the principles of dosimetry in TRT and highlights key differences compared to EBRT from a physics perspective. Current clinical practice, which largely relies on fixed administered activities, is discussed in the context of historical and technical constraints. At the same time, growing evidence for absorbed dose*effect relationships for tumor response and normal-tissue toxicity motivates a shift toward dosimetry-guided treatment planning and verification. Recent advances in quantitative imaging, standardization, and computational methods offer promising pathways toward routine patient-specific dosimetry. The talk concludes with an outlook on how these developments may enable individualized and optimized TRT.

# ST 5: Focus Session: Range Verification in Particle Therapy

Time: Thursday 11:00–13:00 Location: KH 01.013

**Invited Talk** ST 5.1 Thu 11:00 KH 01.013

**Prompt-Gamma-Based Range Verification** — •Beatrice Foglia — Ludwig-Maximilians-Universität München, Department of Medical Physics, Garching b. Muenchen, Germany

Prompt gammas (PG) are high-energy (~MeV) photons emitted immediately after nuclear interactions of ions with matter along nearly the entire beam path. As such, PG emission can provide valuable information on the ion beam range, making it a promising tool for in vivo range verification. Their nanosecond-scale emission and detection enable real-time monitoring, which is particularly attractive for adaptive therapy and is driving strong interest in the radio- and hadrontherapy community. Since the first proposal by Stichelbaut and Jongen at the PTCOG meeting in 2003, PG-based range verification has become a topic of worldwide research interest. Several workflows have been developed, generally relying on comparisons between measured PG profiles and expected signals obtained from Monte Carlo simulations or analytical models. Various PG detection modalities have been proposed and optimized to address challenges such as low PG yields and the broad, high-energy PG spectrum. Moreover, although PG emission and dose deposition arise from different physical processes, recent studies have demonstrated the feasibility of reconstructing dose distributions from PG signals. This talk will provide an overview of widely used PG-based range verification workflow, PG detection modalities and analytical PG modeling, and recent advances extending PG applications beyond range verification toward dose reconstruction and adaptive treatment strategies will be discussed.

**Invited Talk** ST 5.2 Thu 11:30 KH 01.013

**Carbon-ion radiotherapy monitoring with charged nuclear fragments** — •Maria Martisikova[1,2,3], Laurent Kelleter[1,2,3], Rebekka Kirschgässner[1,2,4], Pamela Ochoa[1,2,4], Semi Harrabi[5,6], Jan Jakubek[7], Oliver Jäkel[1,2,3,5], and Jürgen Debus[2,3,5,6] — [1]Heidelberg Institute for Radiation Oncology HIRO, National Centre for Research in Radiation Oncology NCRO — [2]German Cancer Research Centre DKFZ, Department of Medical Physics in Radiation Oncology — [3]National Center for Tumor Diseases (NCT) Heidelberg — [4]Department of Physics and Astronomy, Heidelberg University — [5]Department of Radiation Oncology, Heidelberg University Hospital — [6]Heidelberg Ion-Beam Therapy Center (HIT) — [7]ADVACAM s.r.o., U pergamenky 12, Prague, Czech Republic

Our group has been investigating the potential of measured secondary ion emission profiles to assess delivered dose distributions. A secondary-ion tracking system has been developed and successfully implemented in the clinical environment of the Heidelberg Ion Beam Therapy Facility. Within the InViMo clinical trial, secondary ion emission profiles have been measured during at least two treatment fractions for 35 patients to date. While the measured profiles were consistent between fractions for the majority of patients, pronounced inter-fractional changes were observed in several cases. These differences correlate with plausible anatomical locations.

**Invited Talk** ST 5.3 Thu 12:00 KH 01.013

**Radioactive ion beams for real-time PET-guided adaptive particle therapy** — •Daria Boscolo for the BARB Collaboration — GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

Heavy ion particle therapy offers superior dose conformity compared to conventional radiotherapy, but its clinical potential is limited by high sensitivity to range uncertainties at the distal edge of the Bragg peak. To ensure tumor coverage, large safety margins are often applied, partially negating the benefits of particle therapy. Online range verification methods are therefore essential, particularly for adaptive treatment strategies. Positron emission tomography (PET) is among the most established techniques for in-beam range verification; however, in conventional 12C-ion therapy its accuracy is constrained by low signal-to-noise ratios, spatial mismatches between activity and dose peaks, and long acquisition times. The direct use of $\beta$*-emitting radioactive ion beams for both treatment and imaging offers a promising solution to these limitations. Within the BARB project, the feasibility of 11C-ion beams combined with real-time in-beam PET imaging has been extensively investigated. We report the first demonstration of real-time adaptive particle therapy using radioactive ion beams in a living mouse model, showing that dynamic beam repositioning produces spatially resolved PET signals correlated with distinct treatment outcomes. These results provide compelling evidence that 11C-beams-based imaging can enable precise range verification, adaptive treatment delivery, and improved tumor control with reduced toxicity.

**Invited Talk** ST 5.4 Thu 12:30 KH 01.013

**Helium as a Range Probe in Carbon-Ion Therapy: From Concept to Mixed-Beam Experiments** — •Lennart Volz for the PROMISE collaboration — GSI Helmholtz Zentrum für Schwerionenforschnung GmbH, Darmstadt, Germany

Carbon ion therapy offers superior dose conformity compared to conventional radiotherapy, but its full potential is limited by the lack of real-time, in-beam range verification. The PROMISE project (ERC Grant No. 101124273) investigates a novel approach based on mixed ion beams to enable simultaneous treatment delivery and particle-based imaging. Carbon and helium ions have nearly identical charge-to-mass ratios and can therefore be accelerated simultaneously to the same velocity in a synchrotron. At equal velocity, helium ions have a threefold larger range than carbon ions. While the carbon component delivers the therapeutic dose, the helium ions act as a low-dose imaging probe. This contribution reports on the first experimental realization of mixed beam range verification and imaging at GSI's SIS18 synchrotron. Experiments on a lung-cancer-mimicking setup reveal that a mixed beam enables tracking a spherical tumor at sub-millimeter accuracy, with high sensitivity to range changes down to $<0.1\%$ of the beam range using a particle imaging scintillator detector. Simulations on patient CT data are used to explore the clinical potential of this technique. This work represents an important step toward fully image-guided heavy-ion therapy.

# ST 6: Poster Session

Time: Thursday 14:15–15:45 Location: Redoutensaal

ST 6.1 Thu 14:15 Redoutensaal

**WO3-based polymer composites for radiation protection** — •Maria Stefanova[1], Stefani Bogoeva[1], Vladimira Videva[1], Strahil Georgiev[2], Dimitrina Petrova[1,3], Vera Marinova[1], and Dimitre Dimitrov[1,4] — [1]Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Sofia, Bulgaria — [2]Faculty of Physics, Sofia University,1164 Sofia, Bulgaria — [3]Faculty of Engineering, South-West University, 2700 Blagoevgrad, Bulgaria — [4]Institute of Solid State Physics, BAS, 1784 Sofia, Bulgaria

Lead-based radiation shielding materials, though effective, are limited by their toxicity, rigidity, and environmental hazards. This study explores a polymer composite incorporating tungsten trioxide (WO3) as a lead-free alternative for gamma and X-ray protection. WO3 was selected for its high atomic number, density and chemical stability, offering efficient attenuation with lower ecological impact. Composites with varying WO3 concentrations were synthesized and evaluated for mechanical properties, microstructural uniformity and radiation shielding efficiency. Preliminary results indicate that WO3*polymer composites achieve comparable attenuation to conventional lead materials while exhibiting superior flexibility, lower weight and non-toxicity. These findings demonstrate the potential of WO3-filled polymers as sustainable materials for radiation-protective equipment.

Acknowledgments The research was supported by the scientific infrastructure INFRAMAT, part of the National Roadmap of Bulgaria for scientific infrastructure, financially supported by the Ministry of Education and Science.

ST 6.2 Thu 14:15 Redoutensaal

**Tracking Polymeric Residues in Silicone Implants and Adjacent Tissue via Raman Spectroscopy and CNN-Based Classification** — •Hoang Thinh Nguyen[1], Susanne Gramsall[2], Rima Nuwayhid[3], and Paul-Tiberiu Miclea[1,2] — [1]Martin Luther University Halle-Wittenberg, Institute of Physics, MicroMD Group — [2]Fraunhofer Center for Silicon Photovoltaics, Halle (Saale), Germany — [3]University Hospital Leipzig, D-04103 Leipzig, Germany

Silicone breast implants are widely used in reconstructive and aesthetic surgery. While silicone is generally considered biologically inert, concerns remain regarding long-term biocompatibility and potential microplastic release. Six samples (2 explanted implants, 4 surrounding tissue specimens) were analyzed using Raman spectroscopy combined with CNN-based spectral classification. Implant surfaces were examined directly, while tissue samples underwent KOH digestion and filtration onto silicon membrane filters (1 micrometer pore size). A Mask R-CNN model trained on about 50 reference spectra with an 8:2 split outperformed SVM and KNN. Raman mapping detected PVC on implant surfaces. In tissue, polymeric residues were found (primarily silicone), but also non-silicone polymers such as PS and PVC, near 960 cm-1 and 1600 cm-1. These results suggest migration of polymer components into surrounding tissue and support links to implant-related inflammatory responses.

ST 6.3 Thu 14:15 Redoutensaal

**Comparison of Proton Beam Dose Profiles in matRad and Geant4 Simulations** — •Mariam Abuladze[1], Revaz Shanidze[2], Beka Bochorishvili[2], Nikoloz Tchikadze[3], and Achim Stahl[4] — [1]Kutaisi International University, Kutaisi, Georgia — [2]Tbilisi Stare University, Tbilisi, Georgia — [3]Todua Clinic, Tbilisi, Georgia — [4]RWTH Aachen University, Aachen, Germany

Cancer treatment is one of the most pressing issues in the modern world, and proton therapy is one of the main methods used to combat this disease. Protons Coulomb Interactions with electrons and nuclei there are well tested methods that describe these interactions very well. In contrast nuclear interactions are more complicated to describe so accurately as Coulomb interactions. In order to account for nuclear interactions in dose calculations, it is necessary to use higher-precision Monte Carlo modeling. In this work we compare doses calculated by two software tools, one uses Monte Carlo calculations the other not. In order to compare calculated doses by these two software tools we study simplest case: homogeneous water medium and monochromatic proton beams. The study investigates absorbed doses obtained using two software tools: matRad and Geant4 and obtained dose distributions and lateral profiles are compared. According to the results besides some differences in dose profiles dose distributions are closer enough according to clinical standards.

ST 6.4 Thu 14:15 Redoutensaal

**Thin Film Scintillators for $\alpha$-Particle Detection** — •Kim Tabea Giebenhain, Hans-Georg Zaunick, and Kai-Thomas Brinkmann — 2$^{nd}$ Physics Institute, Justus Liebig University, Giessen, Germany

Reliable detection of $\alpha$-particles is one of the core tasks in Radon detection, since relevant Radon isotopes decay by $\alpha$-emission.
For the development of an efficient and cheap Radon detector, multiple thin scintillator materials were tested to increase the effective area of an existing detector system, while still maintaining a low-cost photodetection setup and good background suppression.
This works present the findings on the light transport of 50 $\mu$m thick Polyethylene-Naphthalate foils and thin coatings of scintillating paint EJ-296 on acrylic glass, read out by a dual-SiPM system.

ST 6.5 Thu 14:15 Redoutensaal

**Design-Oriented Monte Carlo Evaluation of Tungsten Oxide-Loaded Flexible Polymer Shields for Diagnostic Photon Energies** — •Türkan Alkan[1] and Hakan Epik[2] — [1]Vocational School of Health Services, Izmir University of Economics, Balçova, Izmir 35330, Turkey — [2]Department of Physics, Faculty of Science, Dokuz Eylul University, Buca, Izmir 35160, Turkey

Flexible and lead-free radiation shielding materials have attracted significant attention as safer alternatives to conventional protective systems. This study aims to systematically evaluate the photon attenuation behavior of tungsten trioxide ($WO_3$)-reinforced PVA/PEG polymer composites within the diagnostic X-ray energy interval (20-150 keV) using a Monte Carlo-based modeling approach.

Composite structures containing 0-40% $WO_3$ by volume were computationally modeled using the GAMOS (GEANT4-based) simulation platform. Energy-dependent mass attenuation coefficients were obtained from transmitted photon fluence under narrow-beam conditions. Linear attenuation coefficients, half-value layer (HVL), tenth-value layer (TVL), and mean free path (MFP) were subsequently derived to quantify shielding efficiency across all compositions.

Increasing $WO_3$ loading produced a pronounced enhancement in attenuation performance, particularly at lower photon energies dominated by photoelectric interactions. The composite containing 40% $WO_3$ demonstrated the strongest shielding capability, exhibiting substantial reductions in HVL and MFP compared with the unfilled matrix. These findings indicate that tungsten oxide incorporation significantly improves photon interaction probability while enabling thinner shielding structures.

The simulation outcomes confirm that $WO_3$-reinforced PVA/PEG composites represent promising candidates for flexible, lead-free shielding applications in diagnostic radiology. The presented Monte Carlo framework provides a practical tool for guiding material selection and optimizing filler concentration prior to experimental fabrication.

## ST 7: Radiation Therapy

Time: Thursday 16:15–16:45 Location: KH 01.013

ST 7.1 Thu 16:15 KH 01.013

**Investigation of the surface dose distribution of Ru-106 eye plaques using an innovative setup** — •Johannes Wintz[1], Johannes Albrecht[2], and Dirk Flühs[1] — [1]Department of Radiotherapy, University Medicine Essen, Essen — [2]TU Dortmund University, Dortmund

Brachytherapy with ruthenium-106 applicators is an established method for treating eye tumours. Due to the manufacturing process, the surface dose distribution is not homogeneous and exhibits so-called hot and cold spots where the dose is higher or lower than at the centre of the eye plaque. According to the manufacturer's production specifications, relative dose deviations of up to ± 11% are permitted. For quality assurance, the dose profile is measured at 33 positions to ensure that this standard is met.

Within the project, measurements of the surface dose distribution are carried out using a bespoke measurement apparatus to determine the dose profile with higher resolution and analyse its influence on therapy. A new method using a plastic scintillator is employed, surrounded by air, which reduces the potential for Cherenkov radiation and thus provides more precise information about the activity on the eye plaque.

The structure of the new measurement system will be presented, along with initial results, which will be compared with the simulations and the manufacturer's specifications.

ST 7.2 Thu 16:30 KH 01.013

**Tabletop setup for in-vitro cell irradiation with low energy electron bunches** — •Julian Freier[1], Leon Brückner[1], Lukas Kuhlmann[2], Bastian Löhrl[1], Giulia Cramer[2], Christoph Bert[2], Luitpold Distel[2], and Peter Hommelhoff[1,3] — [1]Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen, Germany — [2]Department of Radiation Oncology, Universitätsklinikum Erlangen, Erlangen, Germany — [3]Department Physik, Ludwig-Maximilians-Universität München (LMU), Munich, Germany

Low-energy electrons (LEE) in the keV range are expected to have a high relative biological effectiveness (RBE) and, due to their limited penetration depth, may enable highly localized cancer therapy [1]. This work presents an ultrafast pulsed electron source based on photoemission from arrays of gold needle tips [2], capable of delivering electron energies up to 50 keV. Human fibroblasts and tumor cell lines were irradiated with LEE and compared to X-ray exposure. DNA double-strand breaks, visualized through $\gamma$H2AX staining, show a characteristic depth-dependent pattern under LEE irradiation. Colony formation assays are used to determine the RBE. The emerging results set the ground for further radiobiological assessments and for the development of future therapeutic strategies, particularly in combination with laser-accelerator-on-a-chip technology suitable for endoscopic applications [3]. Ref. [1] Tye, J., et al. R. Soc. Open Sci. 11.11 (2024): 240898. [2] Bruckner, Leon, et al. Nano Lett. 24.16 (2024): 5018-5023. [3] England, R. Joel, et al. Rev. Mod. Phys. 86.4 (2014): 1337-1389.

## ST 8: Keynote Session

Time: Thursday 16:45–17:15 Location: KH 01.013

**Invited Talk** ST 8.1 Thu 16:45 KH 01.013

**Healing Patients, Heating the Planet: Why Circularity Matters in Healthcare** — •Katharina Hesels — Siemens Healthineers

Healthcare exists to save lives, yet paradoxically, it is a significant contributor to global warming, a crisis that increases mortality rates as temperatures rise. In this keynote, I will address this dual responsibility and share how circular economy principles can help reconcile patient care with planetary health. Through examples of refurbishment programmes, eco-design initiatives, and responsible usage of AI, we will explore how MedTech can reduce its carbon footprint without compromising clinical outcomes.

## ST 9: Prize Ceremony and Closing Session

Time: Thursday 17:15–17:45 Location: KH 01.013

**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 2026". 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 10: Members' Assembly

Time: Thursday 17:45–18:45 Location: KH 01.013

**All members of the Radiation and Medical Physics Division Division are invited to participate.**