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 μm 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.