ST 1: Radiation Therapy

Time: Monday 16:00–17:45 Location: STa

ST 1.1 Mon 16:00 STa

MC study of prompt gamma production in water by protons of 100-250 MeV energy — •Mariam Abuladze[1], Jonas Kasper[2], Ronja Hetzel[2], Revaz Shanidze[1,3], and Achim Stahl[2] — [1]Kutaisi International University, Kutaisi, Georgia — [2]RWTH Aachen University, Aachen, Germany — [3]Tbilisi State University, Tbilisi, Georgia

Proton therapy is a relatively new and advanced method of radiation treatment of cancerous tumors. The characteristic feature of this treatment modality is a high localization of energy deposit (Bragg peak) in a tumor, which requires a precise monitoring of the proton beam position in the patient. Prompt gamma radiation, which is produced during the ionization losses of the protons in a matter (patient) could be used for imaging of the beam position and hence for the proton therapy treatment control.

We used Geant4 toolkit for the MC study of the characteristics of the prompt gamma radiation produced by protons in the energy range of 100-250 MeV. Energy spectra, production vertices and directions of prompt gammas produced with the protons in the water phantom were studied, as well as the correlations with the Bragg location. This information is necessary for the development of prompt gamma imaging (PGI) devices. Several PGI-detectors are currently under consideration by different research groups, involved in the proton/ion therapy worldwide

ST 1.2 Mon 16:15 STa

Challenges of SiPM Applications for Prompt Gamma Range Verification in Proton Therapy — •Tobias Teichmann, Martin Serfling, Hannah Jacobi, and Arno Straessner — IKTP TU Dresden, Dresden, Germany

With an increasing role of proton therapy in cancer treatment there is a growing demand on reliable, non-invasive methods for in-vivo proton range verification to be able to adapt to changes of the irradiation conditions during a treatment session and to ensure best possible protection of organs at risk. The measurement of prompt gamma radiation which is emitted along the beam track due to the interaction of the incident protons with the nuclei of the patients body has been shown to provide both temporal and spectral information which can be used to determine the proton range and have the potential to meet all desired requirements. The present work studies the application of SiPMs coupled to scintillation detectors and read out with the PETsys TOF ASIC evaluation kit as a detector for prompt gamma radiation. The combination of SiPMs with high photon detection efficiency, excellent timing resolution, low bias voltage operation and immunity to magnetic fields and the cost effective, fast and scalable PETsys read out electronics present an interesting alternative to existing approaches in prompt gamma range verification. The presentation gives an overview over the most important challenges of prompt gamma detection such as detector efficiency, data throughput, load tolerance and timing resolution and will present the status of the work at the Dresden Institute of Nuclear and Particle Physics.

ST 1.3 Mon 16:30 STa

Characterization of pixelated silicon detectors for the measurement of small radiation fields in proton therapy — •Isabelle Schilling[1], Claus Maximilian Bäcker[1,3,4,5], Christian Bäumer[2,3,4,5], Carina Behrends[2,3,4,5], Kevin Kröninger[1], Beate Timmermann[3,4,5,6], and Jens Weingarten[1] — [1]TU Dortmund, Experimentelle Physik IV, 44221 — [2]TU Dortmund, Fakultät Physik, 44221 — [3]Westdeutsches Protonentherapiezentrum Essen, 45122 Essen — [4]Westdeutsches Tumorzentrum, 45122 Essen — [5]Universitätsklinikum Essen, 45122 Essen — [6]Universitätsklinikum Essen, Klinik für Partikeltherapie, 45122 Essen

In order to achieve a high-dose irradiation while sparing normal tissue, small fields generated by pencil beam scanning or beam shaping apertures are increasingly used in proton therapy. These irradiation methods require the development of small field dosimetry systems for quality assurance. Applying the knowledge from high energy physics it becomes apparent that 2D pixelated silicon detectors with a good spatial resolution, a high rate capability and an electronic readout enabling the counting of single protons could meet these requirements. To assess their applicability in proton therapy ATLAS pixelated silicon detectors are used to measure lateral beam profiles of different irradiation modes at the WPE Essen. The measured beam profiles of a single pencil beam spot matches the expectations within $\pm 4\,\%$. Further measurements underline the possibility to investigate the dose gradient at the field edges with high resolution. Analysis strategies to determine the residual proton energy are currently being worked on.

ST 1.4 Mon 16:45 STa

Consolidation and absolute measurement of the ^{12}C(p,pn)^{11}C-cross section for particle therapy — •Claus Maximilian Bäcker[1,2,3,4], Wihan Adi[5], Christian Bäumer[2,3,4,6], Marcel Gerhardt[1], Felix Horst[7,8], Kevin Kröninger[1], Christoph Schuy[8], Beate Timmermann[2,3,4,9], Nico Verbeek[2,3,4], Jens Weingarten[1], and Jörg Wulff[2,3,4,7] — [1]TU Dortmund, Experimentelle Physik IV, 44227 Dortmund — [2]Westdeutsches Protonentherapiezentrum Essen, 45122 Essen — [3]Westdeutsches Tumorzentrum, 45122 Essen — [4]Universitätsklinikum Essen, 45122 Essen — [5]II. Physikalisches Institut, Justus-Liebig-Universität, 35392 Giessen — [6]TU Dortmund, Fakultät Physik, 44227 Dortmund — [7]Institut für Medizinische Physik und Strahlenschutz, Technische Hochschule Mittelhessen, 35390 Gießen — [8]GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt — [9]Universitätsklinikum Essen, Klinik für Partikeltherapie, 45122 Essen

For PET imaging as a range verification method in proton therapy, an accurate knowledge of the activation cross sections is required to determine the expected β^+ activity distribution.

For the ^{12}C(p,pn)^{11}C-reaction, the measured cross sections accumulate around two excitation functions, which are about 15% apart. This difference persists in the recent measurements from Essen / Dortmund and Giessen / Darmstadt. With comparative measurements, the reason for this systematic difference is investigated and the new reference cross section (68 ± 2) mbarn of the ^{12}C(p,pn)^{11}C-reaction is evaluated at 100 MeV proton beam energy. The results are presented in this talk.

ST 1.5 Mon 17:00 STa

Investigation of radio-activation of titanium implants in proton therapy — •Fleur Anna Spiecker[1], Claus Maximilian Bäcker[1,2,3,4], Christian Bäumer[2,3,4], Walter Jentzen[4], Sandra Kazek[4], Kevin Kröninger[1], Beate Timmermann[2,3,5], and Jens Weingarten[1] — [1]TU Dortmund, Experimentelle Physik IV, 44227 Dortmund — [2]Westdeutsches Protonentherapiezentrum Essen, 45122 Essen — [3]Westdeutsches Tumorzentrum, 45122 Essen — [4]Universitätsklinikum Essen, 45122 Essen, Klinik für Nuklearmedizin — [5]Universitätsklinikum Essen, Klinik für Partikeltherapie, 45122 Essen

In order to verify the calculated proton dose distribution after the proton irradiation of a patient, the β^+ activation of titanium implants can be used. For this purpose, the knowledge of the dependence between the dose, activity and proton energy is needed.

To examine this dependence, different PMMA phantom shapes with different titanium implants are irradiated with protons and measured over time with a PET scanner. The results are illustrated as depth activation curves and compared with the depth dose curve, which is calculated by the treatment planning system. To verify the dose, the expected activity is calculated as a function of depth by using the cross sections of the positron-emitting reaction products. The local proton energies are calculated by using the CSDA-ranges for water and titanium. With this method the distal fall-off of the activity distribution can be already predicted successfully for a simplified setup. In this talk the results of the project will be presented.

ST 1.6 Mon 17:15 STa

Monte-Carlo-Simulationen der verschiedenen Therapieformen für intraokulare Tumore — •Saskia Müller[1], Michelle Stroth[1], Henning Manke[1], Bernhard Spaan[1] und Dirk Flühs[2] — [1]Experimentelle Physik 5, TU Dortmund — [2]Strahlenklinik, Universitätsklinikum Essen

Bei der Behandlung von Augentumoren gibt es verschiedene Modalitäten wie zum Beispiel die Brachytherapie. Ziel der Arbeit ist es Dosis-Volumen-Histogramme der Brachytherapie anhand von echten Falldaten zu simulieren, da es weder in der Bestrahlungsplanung noch in der retrospektiven Analyse von Bestrahlungen Informationen über die Dosisverteilung in den Augenstrukturen gibt.

Ein generisches Augenmodell wird mithilfe des Konstruktionsprogramms "Autodesk Fusion 360" erstellt. Die einzelnen Kompartimente werden automatisiert in viele Teilvolumina zerlegt und anschließend in einer Monte-Carlo-Simulation in "Geant4" eingebunden. Die Implementierung wird mit "CADMesh" realisiert und die Teilvolumina einer gemeinsamen Risikostruktur erzeugen zusammen ein Dosis-Volumen-Histogramm. Die Simulation wird an ausgewählte reale Fälle angepasst, so dass Informationen für eine retrospektive Analyse erzeugt werden können. Hierfür wird eng mit dem Universitätsklinikum Essen zusammen gearbeitet, um eine möglichst realitätsnahe Simulation zu gewährleisten.

ST 1.7 Mon 17:30 STa

Evaluation of a New Inverse Planning Software and Implementation of Plan Verification for Gamma Knife Treatments — •Feline Heinzelmann[1], Moritz Budde[2], Kevin Kröninger[1], and Jan Boström[3] — [1]Technische Universität Dortmund, Experimentelle Physik 4, Dortmund, Germany — [2]Marien Hospital Herne, Universitätsklinikum der Ruhr-Universität Bochum, Klinik für Strahlentherapie und Radio-Onkologie, Herne, Germany — [3]Gamma Knife Zentrum, Bochum, Germany

Gamma Knife therapy uses ionizing radiation for stereotactic radiosurgery. This non-invasive treatment is suitable for brain diseases, such as malignant and benign brain tumors or vascular malformations. Usually, radiation treatment plans are created either manually or with the help of an optimization software of the Gamma Knife device manufacturer. This inverse planning software often converges to local minima of the objective function precluding the optimal solution.

The software IntuitivePlan uses a new global convex optimization algorithm. In a prospective user study, this algorithm was tested in clinical practice and was evaluated based on plan quality metrics.

In particular, the use of the plan optimization software shows a considerable improvement in the selectivity of the target volume and high target volume coverage. Significant differences are likewise apparent in the planning time and the sparing of organs at risk. Further advantages and disadvantages, especially concerning the disease, were identified. Preparations to implement a treatment plan verification for Gamma Knife radiosurgery by using film dosimetry have been made.