ST 6: Radiation Therapy

Time: Wednesday 15:00–17:00 Location: H48

ST 6.1 Wed 15:00 H48

Entwicklung eines SiPM-basierten Detektorsystems für die Reichweiteverifikation in der Protonentherapie unter Nutzung des Single Plane Compton Imagings — •Marc Iltzsche[1,3], Boyana Deneva[1,3], Wolfgang Enghardt[1,2,3,4], Benjamin Lutz[1], Guntram Pausch[1,2], Katja Roemer[1], David Weinberger[1], Andreas Wagner[1] und Toni Kögler[1,2,3] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Germany — [2]OncoRay - National Center for Radiation Research in Oncology, Germany — [3]Technische Universität Dresden, Germany — [4]German Cancer Consortium (DKTK)

Die sehr präzise Partikeltherapie ist aufgrund der charakteristischen Tiefendosisverteilung besonders anfällig für Reichweiteungenauigkeiten. Eine Verifikation der Strahlreichweite ist daher wünschenswert.

Neben klassischen Methoden, wie der PT-PET, wurden Methoden entwickelt, welche die bei der Bestrahlung prompt emittierten hochenergetischen Photonen nutzen. Eine Kombination dieser Methoden könnte die Genauigkeit der Reichweitebestimmung verbessern.

Die Verhältnisse an einem therapeutischen Protonenbeschleuniger stellen jedoch hohe Anforderungen an den Messbereich, die Energie- und Zeitauflösung sowie die Lastverträglichkeit eines Detektorsystems.

Im Rahmen dieser Arbeit wurde die Anwendbarkeit des SPCI-Prinzips für die Reichweiteverifikation untersucht. Erste Messungen am Elektronenlinearbeschleuniger ELBE, sowie am Universitäts-Protonentherapie Dresden, zeigten dabei eine deutliche Abhängigkeit der gemessenen Energiespektren vom Einfallswinkel der Photonen.

ST 6.2 Wed 15:15 H48

Quantifizierung des Effekts der Bragg-Peak-Verbreiterung durch heterogenes Lungengewebe in der Protonentherapie von thorakalen Tumoren — •Kilian-Simon Baumann[1,2], Veronika Flatten[1,2], Uli Weber[3], Rita Engenhart-Cabillic[1,4] und Klemens Zink[1,2] — [1]Universitätsklinikum Gießen und Marburg, Klinik für Strahlentherapie und Radioonkologie, Marburg, Deutschland — [2]Technische Hochschule Mittelhessen, Institut für Medizinische Physik und Strahlenschutz, Gießen, Deutschland — [3]GSI Helmholtzzentrum für Schwerionenforschung, Abteilung Biophysik, Darmstadt, Deutschland — [4]Marburger Ionenstrahl-Therapiezentrum (MIT), Marburg, Deutschland

Heterogene Strukturen im sub-millimeter Bereich wie Lungengewebe führen zu einer Verbreiterung des Bragg-Peaks. Wird diese Verbreiterung in der Bestrahlungsplanung von Lungenkarzinomen nicht berücksichtigt, kann dies die Dosisverteilung im Patienten signifikant beeinflussen. Jedoch kann die Verbreiterung auf Grundlage konventioneller CT-Bilder kaum berücksichtigt werden, da die Strukturen des Lungengewebes nicht ausreichend aufgelöst werden. Mithilfe einer Dichtemodulation der CT-Voxel, die mit der Lunge assoziiert sind, kann die Verbreiterung reproduziert und somit der Einfluss auf reale Patientenpläne analysiert werden. Anhand mehrerer Patientenpläne konnte gezeigt werden, dass es bei einer Nichtberücksichtigung der Bragg-Peak-Verbreiterung zu einer Unterdosierung des Tumors und einer Überdosierung distalen Normalgewebes kommen kann. Je kleiner ein Tumor ist und je tiefer er in der Lunge liegt, desto größer ist dieser Effekt.

ST 6.3 Wed 15:30 H48

Activation of Titanium Samples in Proton Therapy — •Claus Maximilian Bäcker[1,2,3,4], Aaron Bley[1], Christian Bäumer[2,3,4], Pedro Fragoso Costa[3,4,5], Marcel Gerhardt[1], Ken Herrmann[3,4,5], Samantha Kauer[1,2,3,4], Kevin Kröninger[1], Christian Nitsch[1], Hilda Milani Siregar[1], Beate Timmermann[2,3,4,6], Jens Weingarten[1], and Azad Yazgan[1,2,3,4] — [1]TU Dortmund, Lehrstuhl für Experimentelle Physik IV, 44227 Dortmund — [2]Westdeutsches Protonentherapiezentrum Essen, 45122 Essen — [3]Westdeutsches Tumorzentrum, 45122 Essen — [4]Universitätsklinikum Essen, 45122 Essen — [5]Universitätsklinikum Essen, Klinik für Nuklearmedizin, 45122 Essen — [6]Universitätsklinikum Essen, Klinik für Partikeltherapie, 45122 Essen

Titanium is one of the most commonly used materials for implants. These implants might be activated in nuclear interactions of protons during proton therapy. Different radionuclides can be produced during the irradiation of those implants. For this study, simplified titanium samples are irradiated with clinical proton beams at different energies.

The activity of the produced radionuclides is measured using low-level gamma-ray spectrometry. With these results the nuclear activation cross sections can be calculated. Furthermore, activated titanium samples are scanned with preclinical PET/CT imaging. The PET/CT imaging method is used to estimate the β^+ activity in the samples. The delayed response of secondary radiation from titanium might be used for in-vivo dose verification with off-line PET.

ST 6.4 Wed 15:45 H48

Studies of target reconstruction in proton therapy with prompt gamma energy-time templates — •Marius Walther, Arno Straessner, and Olga Novgorodova — Institut für Kern- und Teilchenphysik, TU Dresden

Proton therapy is one of the most promising technologies to treat cancer cells inside the human body. A major problem of this therapy are range uncertainties that lead to large safety margins for the treatment. Prompt gamma rays that are created from the interaction between the proton and the material are a good tool for range verification in real time and are currently researched.

To tackle the statistical problem that clinical environments encounter when using e.g. a pencil-beam scanning mode, an unfiltered energy- and time-resolved detection of all generated prompt gamma rays is proposed. This leads to the loss of the spatial information that comes from using a slit in front of the detector. However, the energy-time spectra allow a reconstruction of the local material composition and thus of the dose profile. Based on simulations, a template method is developed and tested on a reduced set of target materials. A first statistical benchmark will be presented in this talk.

15 min. break

ST 6.5 Wed 16:15 H48

First test results with a PETSys-based setup for highly segmented Prompt Gamma detection. — •Oliver Köchel[1], Olga Novgorodova[1], Rainer Hentges[1], Andreas Glatte[1], Benjamin Lutz[2], Katja Römer[2], Guntram Pausch[2], and Arno Straessner[1] — [1]IKTP, TU Dresden — [2]HZDR, Dresden

Radiation therapy requires controlling range and dose during treatments. Therefore, in vivo dosimetry is very attractive and has seen many approaches and developments in recent years, with prompt gamma ray detection being one of them. Prompt gamma rays exhibit emission energies of 2-8 MeV. A small prototype for a prompt-gamma detector was developed based on a highly segmented 4x4 scintillator matrix with 6mmx6mm BGO crystals read out by a SiPM array. Based on the experience with BGO crystals, new detectors made of CeBr3 and GAGG(Ce) crystals were assembled with a SiPM array and tested with a TOFPET2 kit developed by PETSys electronics. The kit originally aims at PET applications and allows measurements of energy and arrival time of photons. We present first assembly experience, optimization procedures and laboratory tests based on measurements with radioactive sources.

ST 6.6 Wed 16:30 H48

Modelling the physical mechanism for thermal enhancement of radiation therapy — •Adriana De Mendoza, Jens Karschau, Sona Michlikova, and Damian McLeod — OncoRay - National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital C. G. Carus, TU Dresden, HZDR, Dresden, Germany.

Radiation therapy (RT) is one of the pillars in the fight against cancer. It is a potent killer of cancer cells, but at the cost of collateral damage to healthy tissue. Previous studies found that combination of RT with local hyperthermia (HT) can not only reduce whole tissue toxicity but also improve control of tumor growth. We here propose a consistent model to further understand the thermal enhancement of RT on the basis of theoretical as well as mechanistic explanations. We propose that the main driver of the thermal enhancement ratio is sub-lethal cellular damage caused by mild HT. Using a three-stage cell model [(A)<->(*)->(D): alive, activated, dead] we explain that cells are prepared to die through a reversible transition, and then die in a non-reversible process if the right amount of additional energy is

applied. Including the appropriate thermodynamic considerations, we show that TER is proportional to the energy deposited in the process (A)<->(*), finding the same exponential dependence on temperature that was found empirically by other authors. Our model reproduces to good precision different experimental data sets from in-vitro and in-vivo studies for simultaneous application of moderate HT and RT.

ST 6.7 Wed 16:45 H48

Physical dose enhancement of gold nanoparticles and their impact on water radiolysis in radiotherapy — •Benedikt Rudek[1,2], Aimee McNamara[2], Hilary Byrne[3], Zdenka Kuncic[3], and Jan Schuemann[2] — [1]Physikalisch-Technische Bundesanstalt — [2]Massachusetts General Hospital — [3]University of Sydney

Gold nanoparticle (GNP) radio-sensitization is a promising technique to increase the dose deposition in the tumor while sparing neighboring healthy tissue. The sensitization is most pronounced for keV x-rays, where the mass energy-absorption coefficient of gold is up to 150 times larger than that of soft tissue. Measurements in vitro and in vivo also showed an effect on cell survival and tumor control for other modalities such as MV photons and proton beams, where the physical dose enhancement by GNPs is expected to be negligible. Most simulation studies have, thus, focused on photon irradiation of isolated GNPs in water neglecting experimental evidence of GNP clustering within cells. In a systematic study, we use the Monte Carlo simulation tool TOPAS-nBio to model the GNP radio-sensitization within a cell as a function of GNP concentration, size and clustering for a wide range of energies for photons, protons and carbon ions. Moreover, we include water radiolysis and subsequent chemistry as implemented in Geant4-DNA. While the physical dose enhancement for 10MeV protons at 1% GNP concentration was only 0.07% compared to 62% for 50keV photons, we find the yield of reactive oxygen species change by up to 15% which could partly explain the experimental dose enhancement for protons.