Range Verification in Hadron Therapy – Prompt Gamma Imaging

Overview In modern cancer treatment hadron therapy, i.e irradiating tumor cells with particles like protons, offers several advantages compared to conventional radiation therapy with photons. However, it sets many challenges to a treatment system, in order to benefit from all the advantages. One of the most essential questions in hadron therapy is the exact position of the so called Bragg peak inside the patient during the treatment. The Bragg peak is a direct consequence of the interaction of hadrons with matter resulting in the highest radiation dose deposit by hadrons at the very end of their path through matter, right before they are fully stopped. Hadron therapy exploits that property to target the cancer cells with a high dose, while keeping the radiation exposure of the surrounding tissue to a minimum.

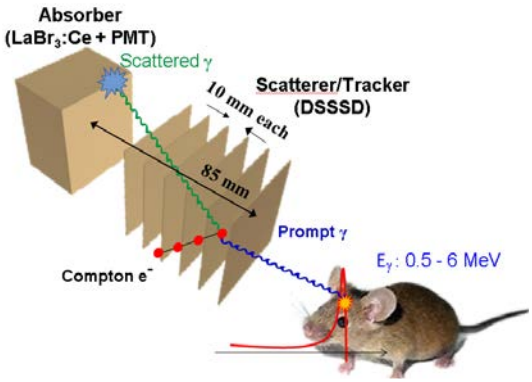

Figure 1: Schematics of our Compton camera prototype consisting of a monolithic scintillator as absorber and 6 layers of double-sided silicon strip detectors as scatterer.

Context of the thesis During the irradiation with hadrons, nuclei contained in the tissue target (e.g. ^{16}O, ^{12}C) are excited due to energy deposit and de-excite promptly under emission of a photon. These so called prompt gamma rays can be used to visualize the Bragg peak, as there is a direct correlation between the amount of emitted prompt photons and the energy deposit in the tissue.

In our group, we develop a Compton camera which is optimised for the requirements in applications. This Compton camera is a double-stage device, consisting of a scatter detector and an absorber (see figure 1) and allows for the reconstruction of the origin of photons by exploiting the kinematics of Compton scattering.

Our setup Our current prototype consists of a $LaBr_3$:Ce scintillator read out by a 256-fold segmented photomultiplier tube (PMT) as absorber detector. The multi-layer scatterer is composed of 6 layers of double-sided silicon strip detectors, allowing not just for the detection of photons, but also electrons. Furthermore, we are currently investigating an alternative scintillation crystal ($CeBr_3$) as absorber, silicon photomultipliers (SiPM) as alternative photosensors with corresponding highly integrated readout electronics and a scintillator-based scatterer.

Content of the Bachelor thesis Precise detection of the Compton-scattering kinematics requires a precise relative positioning and alignment of the scatter and absorber components of the Compton camera to an accuracy of better than 0.5 mm. In order to achieve this, an optical alignment system with a (partially) motorized and remote-controlled positioning system is needed. It will be the task of this Bachelor Thesis project to set up and commission this system in our labs at the Chair of Medical Physics in Garching.
Experience in laboratory work is advantageous but not mandatory.

If you are highly motivated and like practical, technical-oriented work, you are the right candidate for this thesis project and should contact us:

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For further information please refer to:
https://www.med.physik.uni-muenchen.de/research/range-verification/promptgamma/index.html