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Measurement of secondary radiation with the pixel detector Timepix during ion beam therapy

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In ion beam therapy the finite range of the ion beams in tissue and the presence of the Bragg-peak are exploited. Unpredictable changes in the patients condition can alter the range of the ion beam in the body. Therefore it is desired to verify the actual ion range during the treatment, preferably in a non-invasive way. Positron emission tomography has been used successfully to monitor the precision of the applied dose distributions. This method however suffers from limited applicability and low detection efficiency. As an alternative to photons, in this study we investigate the possibility to measure secondary charged particles and to increase the detection efficiency.

An initial experimental study to register the outcoming radiation was performed at the Heidelberg Ion Beam Therapy Center (HIT) in Germany using medical carbon ion beams. A static pencil beam was dumped in a PMMA block and the emerging secondary radiation was measured with the position-sensitive Timepix detector outside of the phantom. The detector, developed by the Medipix Collaboration, consists of a silicon sensor connected to a pixelated readout chip (256×256 pixels with 55 μm pitch). Timepix can operate as an active nuclear emulsion registering single particles online with 2D-track visualization. The shape of the tracks together with the measurement of the deposited energy in each pixel allows drawing conclusions on the radiation type, energy and position. The direction of the particles are readily determined by using more-layered detectors.

Measurements were performed at different distances from the beam impact point on the block, corresponding to the plateau, Bragg-peak, tail and behind. Distributions of the registered tracks were analyzed as a function of quantities like the track shape and deposited energy. Due to the observed clear correlation with the depth, the Bragg peak position can be possibly determined from the measured data.

This work is carried out in frame of the Medipix Collaboration.

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