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Towards ion spectroscopy for hadron beam therapy – finding optimal settings of the Timepix detector

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In radiation therapy with ions heavier than protons nuclear fragmentation processes occur. Interactions of the projectile ions with tissue result in a spectrum of lighter ions which have a linear energy transfer and thus a radiobiological effectiveness different from the primary particle type. In order to correctly calculate the biological effect of ion beams it is important to know the complex radiation spectra resulting from the primary beam in different tissue depths and their spatial distribution.

Up to now ion spectroscopic measurements have employed large experimental apparatus and could thus obtain data only outside of targets. We however aim for performing spectroscopic measurements directly within phantoms to study fragments evolving from the primary particle beams in therapy-like situations.

For this purpose, we use the position-sensitive semiconductor pixel detector TimePix which allows the detection of single particles with per pixel energy-sensitivity. The device can thus directly determine the energy loss along particle trajectories in silicon. Data are collected via an integrated USB-based readout interface and can be visualized online with the Pixelman software.

The charge distribution created in the detector by an individual ion extends to several pixel forming a cluster. The spatial distribution of the irradiation pattern can be analyzed. Different cluster parameters like size and energy per pixel do not depend only on the incoming particle type but also on the detector settings, especially the applied bias voltage. To allow for good discrimination between different particle types we looked into optimal detector settings.

Measurements were performed at the Heidelberg Ion Beam Therapy Center. The detector was placed perpendicular to the beam without any material in front of it and irradiated with mono-energetic proton and carbon ion beams of energies between 48 and 410 MeV/u. Different detector parameters (bias voltage, ikrum value, acquisition time) were applied. The obtained cluster size, cluster energy and the ratio of both strongly depend on the applied sensor bias voltage. When using optimized detector settings, differences found in the cluster size and the energy per pixel distributions show the possibility to differentiate between carbon ion and proton induced events.

This work has been carried out in frame of the Medipix Collaboration.

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