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3D particle distribution in Water Phantom in Therapy Beam

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Hadron therapy uses ion beams for irradiation of tumorous tissue. Ions have highly localized dose deposition in contrast to photon radiation. A main advantage of ions is that they deposit the most of energy at the end of their range according to the Bragg curve. Unfortunately the ion beams often generate a substantial amount of secondary particles with longer range. Thus certain fraction of dose is deposited by other than primary ions outside of the planned volume.

The observation of all ionizing particles accompanying the ion beam as well as the direct measurement of particle energy loss, trajectory, local energy deposition and lateral straggling can be directly provided by the semiconductor detector Timepix (256 × 256 pixels with 55 μm pitch). This device operates as an active nuclear emulsion providing visualization of particle traces. Analysing shapes of the characteristic particle traces we can distinguish primary ions from secondary particles.

Measurements were performed at the Heidelberg Ion Beam Therapy Center (HIT) with using medical carbon ion and proton beams. Narrow beams to size 3mm were directed onto a water tank phantom of size 355 x 355 x 420 mm³. The pixel detector was immersed in water inside the phantom and its location was controlled by a remote positioning system allowing 3D scanning of radiation field. Full scans were performed with two different beams: carbon 270 MeV/u and protons 143 MeV. The radiation field was evaluated in 24 detector positions. We tested both detector plane orientations: parallel and perpendicular with respect to the beam axis.

In each point the shapes of recorded tracks were evaluated and distributions of appropriate particles were created. The results show the different ranges of different types of secondary radiation. This work is carried out in frame of me the Medipix collaboration.

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