Spatial resolution improvements in helium-beam radiography

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Abstract

Helium ions undergo less multiple Coulomb scattering (MCS) in matter than protons with the same range. Therefore, helium-beam radiographies exhibit better spatial resolution (SR) than proton-beam radiographies, without any disadvantage in contrast-to-noise ratio (CNR) (abstract by T. Gehrke). Potentially, further improvements in SR can be obtained by increasing the initial energy of the beam in order to decrease the MCS inside the phantom. This hypothesis has been investigated in this work.

Measurements have been performed at the HIT facility in Heidelberg. An apparatus for single ion detection has been used to image an edge phantom. The apparatus consists of front and rear trackers and an E-loss detector located directly in front of the Bragg peak. All detectors are thin silicon pixelated detectors called Timepix. The phantom consists of 160mm of PMMA in the beam direction with a 2mm air edge placed at middle depth. Four increasing beam energies (from 675 MeV up to 882 MeV) have been used to image the edge phantom. For each energy a radiography has been reconstructed and SR, CNR and absorbed dose have been evaluated. In order to compensate for the longer range associated with more energetic ions, an energy degrader (copper slab) with variable thickness has been placed in front of the energy detector. For dose estimations, FLUKA simulations have been performed. A SR increase of 30% has been measured in the investigated beam energy interval, reaching a value of 0.72lp/mm (@10% MTF). A total CNR decrease of only the 24% has been measured for radiographies generated with the same amount of absorbed dose (350 μGy). In the worst case the CNR was above 6 for radiography with 1 mm pixel size.

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