Investigation of a mixed helium/carbon beam for treatment monitoring in carbon therapy

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Abstract

Purpose: Recently, it has been proposed that a mixed helium carbon beam could be used for on-line monitoring of carbon ion therapy: Due to their approximately equal magnetic rigidity at the same energy per nucleon, helium and carbon ions could potentially be accelerated together in a synchrotron facility. At the same energy per nucleon, the helium ion have approximately 3 times the range of the carbon, enabling simultaneous treatment of the tumor volume and online range monitoring with helium ions. We present preliminary results of an experimental investigation of this promising modality performed at the HIT facility.
Methods: As of now, a real mixed beam cannot be generated at HIT facility. In first experiments, helium and carbon ions were therefore irradiate separately at the same energy and the runs were mixed in data processing to resemble a 10:1 ratio between carbon and helium primaries. To monitor the helium range, a novel range telescope prototype developed by the University College London was used. The detector consists of a stack of thin scintillation sheets read out by a flat panel CMOS sensor. We investigated simple PMMA and two anthropomorphic phantoms (a pelvis phantom and a simple lung geometry). Geant4 simulations of the setup were used to further exploit the modality.

Results: For the simple PMMA geometries, online range changes of down to 1mm seen by a fraction of the pencil beam could be detected with the device, despite the signal contamination with carbon fragments. For the pelvis phantom, the system enabled to observe changes in the gas filling of the rectum. Patient position changes during irradiation (translational and rotational) are currently being analyzed.

Discussion: A helium/carbon mixed beam could enable on-line motion monitoring as well as post-treatment verification. At the same time, this comes at almost no cost in terms of dose even if a 10% helium contamination of the primary beam is used (below 1% in biological dose to the tumor). Reconstructing the measured range data into a 2D image after the irradiation of each energy layer would further help in assessing the treatment accuracy.

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Future investigations will focus on identifying patient cases that would benefit most from such method.