Contribution ID : **505** Type : **not specified**

Experimental tests of a scanner prototype for medical imaging with protons developed at IEM-CSIC

Tuesday, 22 March 2022 10:20 (20)

Abstract

Proton therapy requires precise knowledge of the patient's anatomy to guarantee an accurate dose delivery [1]. X-ray computed tomography (CT) images are currently used to calculate the relative stopping power (RSP) needed for proton therapy treatment planning [2]. Recent studies indicate that tomographic imaging using protons has the potential to provide directly more accurate measurement of RSP with significantly lower radiation dose than X-rays [3].
The proton CT (pCT) scanner prototype developed at IEM-CSIC is composed of a tracking system of two double-sided silicon strip detectors, and the CEPA4 detector as the residual energy detector. Our pCT scanner prototype was tested at the Cyclotron Centre Bronowice (CCB) facility in Krakow, Poland during the first week of June 2021. The planar imaging capabilities of our pCT scanner prototype were studied using three different planar phantoms of aluminum and PMMA: a uniform phantom of PMMA, a cross-shaped phantom of aluminum and PMMA, and a Derenzo-type phantom of aluminum and PMMA. Planar images were reconstructed from pixelated detectors, and they were converted into continuous images by uniformly distributing the statistics of each pixel over the pixel area. With the pCT scanner prototype, it was possible to differentiate and localize the different materials that composed the phantoms. The images displayed great fidelity with respect to the actual shapes. The dimensions of the cross-shaped and Derenzo-type phantom were obtained by getting the grey-level profiles of different regions of interest (ROI) and fitting them to a super-Gaussian function, reporting their values within the full width at half maximum (FWHM) and full width at tenth maximum (FWTM). The spatial resolution of this pCT scanner prototype was determined with the study of the Derenzo-type phantom. The scanner prototype was capable to resolve structures with sizes up to 2 mm and 3 mm while using proton beams of 100 MeV and 110 MeV, respectively. Likewise, volumetric phantoms composed of cylindrical matrices made of PMMA with air, alcohol, and water structures were imaged at different angular positions. Current work is being done to generate the tomographic reconstruction of the three-dimensional phantoms. The continuation of this work includes a new experiment that will be carried out during April 2022 at the CCB facility. This new experiment aims to study more complex phantoms with proton beams with energies around 200 MeV.
In this conference, I will present the planar imaging capabilities of our pCT scanner prototype we obtained, alongside the status of the tomographic reconstructions of the imaged volumetric phantoms.

References

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Session Classification : Investigación orientada, tecnología e innovación

Track Classification : Investigación orientada, tecnología e innovación