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#9-287 A proton computed tomography scanner prototype for relative stopping power mapping

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Proton therapy relies on accurate knowledge of patient anatomy to ensure precise dose delivery. Treatment planning systems in proton therapy centers rely on X-ray computed tomography (CT) as the primary imaging modality to calculate proton treatment doses for tumors and surrounding healthy tissues. However, the derivation of proton stopping powers from X-ray images introduces significant uncertainties in the proton range, which can affect dose accuracy. To reduce this uncertainty, proton computed tomography (pCT) has been proposed as an alternative imaging method, offering the potential for more direct and accurate proton relative stopping power (RSP) determination with reduced radiation exposure. This work evaluates the capabilities of a newly developed pCT scanner, designed with a system of double-sided silicon strip tracking detectors and a high-energy-resolution CEPA4 scintillator for measuring the residual energy of protons. This prototype was tested in a series of experimental campaigns conducted at the Cyclotron Centre Bronowice (CCB) proton therapy facility in Krakow, Poland. Custom-made volumetric phantoms, composed of polymethyl methacrylate matrices with inserts of air, ethanol, water, and aluminum, were positioned within the field of view of the scanner and irradiated with protons at energies up to 110 MeV. Proton radiographs were obtained from the proton trajectories from the pixelated tracking detectors and the energy lost in the sample was estimated by measuring the remaining energy in the CEPA4 scintillator. Sinograms were generated from proton radiographs taken at several rotation angles of the sample and were used to reconstruct tomographic images employing the Filtered Back-Projection algorithm. The reconstructed images were analyzed to assess the spatial resolution and RSP mapping capabilities of the scanner. Radiographic images exhibited high fidelity in reproducing the shapes of the studied samples, achieving a spatial resolution better than 2 mm in radiography mode and below 3 mm in tomography mode. The RSP values obtained were consistent with previously published data and comparable to those achieved by other state-of-the-art pCT systems. Preliminary findings indicate that the scanner can produce medium to high-quality images, making it a promising tool for reducing range uncertainties in proton therapy. Current efforts are focused on further data analysis using additional samples and materials, using proton beam energies up to 210 MeV, aiming to refine the imaging performance of the scanner and evaluate its applicability in real settings. These results demonstrate the potential of this pCT scanner for advancing proton therapy treatment planning, with significant implications for improving dose accuracy and minimizing radiation exposure, thereby enhancing both therapeutic efficacy and patient safety.

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