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A Study of Secondary Particle Production from Carbon Ion Beam for Radiotherapy

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Abstract : Achieving precise radiotherapy through carbon therapy necessitates the accurate monitoring of radiation dose distribution within the patient's body. This process is pivotal for targeted tumor treatment, minimizing harm to healthy tissues, and enhancing overall treatment effectiveness while reducing the risk of side effects. In our investigation, we adopted a methodological approach to monitor secondary proton doses in carbon therapy using Monte Carlo (MC) simulations. Initially, Geant4 simulations were employed to extract the initial positions of secondary particles generated during interactions between carbon ions and water, including protons, gamma rays, alpha particles, neutrons, and tritons. Subsequently, we explored the relationship between the carbon ion beam and these secondary particles. Interaction vertex imaging (IVI) proves valuable for monitoring dose distribution during carbon therapy, providing information about secondary particle locations and abundances, particularly protons. The IVI method relies on charged particles produced during ion fragmentation to gather range information by reconstructing particle trajectories back to their point of origin, known as the vertex. In the context of carbon ion therapy, our simulation results indicated a strong correlation between some secondary particles and the range of carbon ions. However, challenges arose due to the unique elongated geometry of the target, hindering the straightforward transmission of forward-generated protons. Consequently, the limited protons that did emerge predominantly originated from points close to the target entrance. Fragment (protons) trajectories were approximated as straight lines, and a beam back-projection algorithm, utilizing interaction positions recorded in Si detectors, was developed to reconstruct vertices. The analysis revealed a correlation between the reconstructed and actual positions.

Keywords : radiotherapy, carbon therapy, monitor secondary proton doses, interaction vertex imaging
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