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Study Secondary Particle Production in Carbon Ion Beam Radiotherapy

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Abstract : Ensuring accurate radiotherapy with carbon therapy requires precise monitoring of radiation dose distribution within the patient's body. This monitoring is essential for targeted tumor treatment, minimizing harm to healthy tissues, and improving treatment effectiveness while lowering side effects. In our investigation, we employed a methodological approach to monitor secondary proton doses in carbon therapy using Monte Carlo simulations. Initially, Geant4 simulations were utilized to extract the initial positions of secondary particles formed during interactions between carbon ions and water. These particles included protons, gamma rays, alpha particles, neutrons, and tritons. Subsequently, we studied the relationship between the carbon ion beam and these secondary particles. Interaction Vertex Imaging (IVI) is valuable for monitoring dose distribution in carbon therapy. It provides details about the positions and amounts of secondary particles, particularly protons. The IVI method depends on charged particles produced during ion fragmentation to gather information about the range by reconstructing particle trajectories back to their point of origin, referred to as the vertex. In our simulations regarding carbon ion therapy, we observed a strong correlation between some secondary particles and the range of carbon ions. However, challenges arose due to the target's unique elongated geometry, which hindered the straightforward transmission of forward-generated protons. Consequently, the limited protons that emerged mostly originated from points close to the target entrance. The trajectories of fragments (protons) were approximated as straight lines, and a beam back-projection algorithm, using recorded interaction positions in Si detectors, was developed to reconstruct vertices. The analysis revealed a correlation between the reconstructed and actual positions.

Keywords : radiotherapy, carbon therapy, monitoring of radiation dose, interaction vertex imaging
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