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In-Situ Range Verification for Particle Therapy Based on Secondary Charged Particles

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Radiation therapy using protons or heavier ions is sensitive to range errors caused by misalignment of the patient, changes in patient anatomy, and uncertainties in treatment planning. It is therefore of the utmost importance to ensure treatment quality through range verification. Determining the position of the Bragg peak inside the patient can be done through various means such as prompt gamma detection. When using heavier ions, charged secondary particles can also be used for range verification. Protons on the other hand do not produce charged secondaries of high enough energy to be detectable outside the patient. However, the unique properties of the Bergen pCT detector enable proton range verification through secondary charged particles without the need of an additional device in the treatment room. Preliminary results on Monte Carlo data for water phantoms and a pediatric head phantom suggest feasibility for this approach. The detected tertiary charged particles in the digital tracking calorimeter form a point cloud, from which features can be extracted and fed into machine learning models for predicting the range of the initial proton beam.

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