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Proton therapy treatment verification: a spatio-temporal emission reconstruction with experimental data

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Abstract

Many efforts have been made to fully exploit charged particles' specific features in terms of dose delivered to the target and sparing of healthy tissues. Although the dose maximum, defined by the Bragg peak, can be well characterized for materials of known composition and physical properties, uncertainties in its determination are encountered in the clinical practice. To mitigate these uncertainties, treatment verification techniques based on the detection of secondaries have gained importance, but a clinical device integrated in the patient routine is yet to be available. We present here the first experimental results of the spatio-temporal emission reconstruction for treatment verification in proton therapy. With a multi-detector prompt-gamma timing system, we are able to simultaneously reconstruct the spatial and temporal distribution of the emitted prompt photons. This distribution is correlated to both the primary particle range and their motion inside the target. A detector prototype comprising two LaBr3:Ce-based detectors and an Ultra Fast Silicon detector was developed within the MERLINO (Measurement of the EneRgy Loss for IN-vivo Optimization in particle therapy) project for the technique proof-of-concept. Experimental measurements of a 227 MeV proton beam impinging on an homogeneous phantom were taken at the National Center for Oncological Hadrontherapy in Italy. First comparisons between data and simulation show excellent agreement, with a 98% average correlation of the prompt gamma timing distributions. A preliminary reconstruction of the prompt photons spatio-temporal emission is here reported for the first time for experimental data. The corresponding simulation was carried out with the FLUKA Monte Carlo tool. The results shown here represent the first step towards the experimental validation of the technique.

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