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Event Identification in Compton Camera Imaging via Machine Learning for Proton Therapy Monitoring

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One of the most important challenges in hadron therapy is the development of online monitoring techniques. Monitoring systems based on the detection of secondary radiation such as prompt gamma (PG) emission produced during treatment are promising approaches for this purpose [1,2]. The SiFi-CC, a Compton camera based on stacks of heavy scintillating fibers and SiPMs, is being developed for PG imaging [3,4]. A machine learning approach based on TMVA [5] to recognize Compton events is proposed for the classification of pseudo-data generated by the Geant4 simulation for a 180 MeV spot-scanning proton beam impinging on a PMMA phantom. To reconstruct a Compton event, a minimum of two interactions is required. Therefore, the proposed method first builds a learning set of the events filtered with interactions that yielded at least one interaction in each of two modules of the SiFi-CC. The data set is used to train the boosted decision tree (BDT) model using nine features including the position and deposited energy of interactions in the scatterer and the absorber, and the cosine of internal scattering angles term. A 10-fold cross-validation of the BDT model shows a great increase in the signal to background ratio. A software based on the LM-MLEM algorithm [6,7] was applied for the reconstruction of the PG distribution. Very good agreement between the reconstructed distal edge position and that of simulated Compton events was obtained. Moreover, it was shown that the precision of a few millimeters in distal edge position determination is feasible.

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