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Machine Learning Algorithms for the Gamma Conversion Reconstruction in the ClearMind Project

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ClearMind project aims to develop the TOF PET detection module providing a high detection efficiency, coincidence resolving time < 100 ps (FWHM), and spatial resolution in a few mm (FWHM). ClearMind project uses a large monolithic $PbWO_4$ crystal for the position-sensitive detector, microchannel-plate photomultiplier (MCP-PMT), and the bialkali photoelectric layer deposited on the crystal. The 511 keV gamma conversion produces both scintillating and Cherenkov photons, allowing the detector to have a good timing performance. We develop machine learning algorithms to reconstruct the 3D gamma conversion position in the crystal and compare them with a statistical method. To train the algorithms, we simulate the ClearMind detector in detail, including the gamma interaction in the medium, optical photon propagation, realistic simulation of the photocathode and the MCP-PMT, and the signal formation to generate the samples. In this study, the input variables are the parameters extracted from the readout signals, such as the charge, signal time, etc. We obtain the 2D spatial resolution of < 5 mm (FWHM) and show a potential to reconstruct the depth-of-interaction (DOI) using machine learning algorithms. ClearMind collaboration is also developing the reconstruction algorithms using a full signal shape as the input, which is expected to perform better in DOI reconstruction and time resolution.

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