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Machine learning models for single-particle classification with Timepix 3 detectors

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Semiconductor hybrid pixel detectors with Timepix3 chips developed by Medipix collaboration at CERN can simultaneously measure deposited energy and time of arrival of individual particle hits in all 256 x 256 pixels with 55 µm pitch size. Leveraging the single-particle detection sensitivity of Timepix3 chips, there is a potential to develop algorithms for classifying detected single particles into distinct categories corresponding to different particle types.
In this study, we introduce various machine learning models, such as recurrent neural networks or gradient-boosted decision trees, designed to facilitate the classification of single particle detections. These models are trained and tested on an extensive database of experimental data obtained from controlled radiation source experiments, allowing for robust performance across various scenarios. Finally, we apply these machine learning models on mixed radiation fields emanating from radioactive sources, as well as from out-of-field measurements in a radiotherapeutic proton beam environment.

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