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$4\pi\beta-\gamma$ Coincidence Detection with Machine Learning for Optimized Absolute Radionuclide Activity Measurement

This study presents a $4\pi\beta$ (plastic scintillator)$-\gamma$ coincidence detection system developed with the integration of machine learning to optimize the absolute activity measurement of radionuclides. A hardware setup utilizing a CAEN N5751 digitizer employed a pulse shape discrimination procedure to process signals from the detectors and generate binary list-mode files representing the measurement data. The detection system digitally acquired data by recording key features such as timing correlations, energy levels, and signal shapes for each signal from the $4\pi\beta-\gamma$ detectors. Several analysis parameter adjustments can be applied to the recorded data without requiring additional data collection experiments. In the machine learning implementation, the extracted data was used to train supervised machine learning models with a labelled dataset containing examples of true events and noise, enabling the system to classify each detected event as either true or noise. The system also performed corrections for background and decay. To determine the source activity, β efficiency was varied using computerized discrimination methods and extrapolated to 100% efficiency. The results of our study showed excellent agreement with reference values. This research can provide valuable insights into radionuclide measurement techniques, offering a robust system for fast and accurate absolute radioactivity measurement.

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