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Utilizing machine learning for the Data Analysis of AGATA's PSA database.

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In-beam gamma-ray spectroscopy, particularly with high-velocity recoil nuclei, necessitates precise Doppler correction. The Advanced GAmma Tracking Array (AGATA) represents a groundbreaking development in gamma-ray spectrometers, boasting the ability to track gamma-rays within the detector. This capability leads to exceptional position resolution which ensures optimal Doppler corrections.

AGATA's design features high-purity germanium crystals, with each crystal divided electrically into 36 segments for enhanced detection accuracy. The core of AGATA's position resolution lies in the Pulse Shape Analysis (PSA) algorithm, responsible for pinpointing gamma-ray interaction locations. This algorithm functions by matching observed signals with a pre-established database of signals. However, the current model of relying solely on simulated signals for the PSA database presents limitations. In contrast, utilizing experimental data for building the PSA database promises significant improvements in accuracy and efficiency.

The experimental data is acquired by scanning the crystal using collimated gamma-ray sources. Utilizing what is known as the Strasbourg Scanning Table, the crystal is scanned both horizontally and vertically, the gathered signals are then matched using the Pulse Shape Coincidence Scan (PSCS) algorithm to be assigned to a unique 3D position. The PSCS is notably time-intensive, requiring approximately several days to analyse entire datasets.

In this work, we propose a new algorithm to replace the PSCS, based on machine learning techniques. Specifically, we employed Long Short-Term Memory (LSTM) networks, renowned for their robustness and their ability to decipher time series. The loss function has been adapted to incorporate Strasbourg's scanning table specificities. The processing time of the signals was brought down to only about an hour using this model. Different metrics were used to compare our new results to the PSCS reference, indicating a greater consistency and accuracy.

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