Position resolution estimation of Adaptive Grid search algorithm for multi-site interactions position determination in 'SIGMA' detector

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High Purity Germanium detectors are widely used in gamma-ray spectroscopy for nuclear structure studies due to their excellent energy resolution and efficiency. However, Doppler broadening and partial gamma-ray absorption can limit energy precision, motivating the use of Pulse Shape Analysis (PSA) to determine gamma-ray interaction positions for Doppler correction and gamma-ray tracking.

Segmented HPGe detectors enable accurate interaction localisation via PSA, and the Segmented Inverted-coaxial Germanium Array (SIGMA) detector is a novel 19-segment design developed for this purpose. In PSA, experimentally measured signals are compared with a validated simulated signal database, generated using the AGATA Detector Library where the expected signals are provided on a 1 mm spatial basis throughout the detector volume.

While single-interaction events are relatively straightforward to localise, determining the positions of multi-interaction events requires more advanced methods. In this work, an adaptive grid search approach using coarse and fine search regions has been developed and applied to determine multi-site interaction positions.

Validation is achieved by comparing experimental data with GEANT4 simulated data. The validation is based on the comparison of simple back-projected images using Compton kinematics. PSA position resolution is estimated to be 6.79 mm for 662 keV full-energy events from ^{137}Cs and 7.95 mm for full-energy 1173 and 1332 keV events from ^{60}Co.
PSA developed in this work has been applied to data collected with the SIGMA detector at the MARA focal plane at Jyväskylä, enabling the use of gamma tracking to correlate gamma rays with implantations in decay spectroscopy.