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Development of self-calibration techniques for γ-ray energy-tracking arrays

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The development of γ-ray energy-tracking arrays using highly segmented High Purity Germanium (HPGe) detectors is currently the technological frontier of high-resolution gamma-ray spectroscopy for modern nuclear physics investigations[1]. The tracking capability of such arrays strongly depends on the performance of the Pulse Shape Analysis (PSA), which uses the position-dependent response of the detector signals to determine the γ-ray interaction positions within the detector volume. The PSA algorithm is performed by comparing the measured signal pulse shape to expected pulse shapes associated with different interaction positions from the signal basis. Therefore, producing a reliable signal basis is one of the key points for PSA.

A novel method to generate a reliable signal basis in a notably simple experimental way was proposed in reference[2]. In this method, a γ-ray source illuminates the full array and the Compton scattering data is obtained. Starting with the assumption of a segment-sized position resolution for every interaction point and using an iterative minimization procedure based on the tracking of Compton scattering events, it is possible to converge to the real positions after several iterations, which is so-called self-calibration. The self-calibration method was demonstrated in reference[2] with the simulation of a simplified geometry for the array and without considering electronic pulses.

This report presents the development of the self-calibration technique with a realistic geometry for the AGATA array with pulse shape signals. To demonstrate the performance of this technique, it is first applied to a simulation data obtained using the interaction points produced by the AGATA Geant4 simulation package combined with a pulse shape signal basis generated by the AGATA Detector Library (ADL)[3]. The signal basis produced by self-calibration method is compared with the initial ADL basis to show the validity of the method. This method is then applied to signals from a real gamma source calibration data to generate an experimental signal basis. The experimental signal basis is compared with the currently used ADL basis. PSA with both signal bases are attempted and observe reasonable results. Further development of the self-calibration technique is discussed. A more reliable experimental basis generated by the self-calibration technique is foreseen in the near future.

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