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Development of a novel self-calibration technique 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 in modern nuclear physics [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 – i.e. 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 [2], and this presentation reports on the testing and implementation of this method. 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 the so-called "self-calibration" approach. Heil *et al.* [2] demonstrated the feasibility of the approach using a simulation, applied a simplified geometry for a generic array and without considering electronic pulses.

This presentation reports the new development of the self-calibration technique with a realistic geometry for the AGATA array with pulse-shape signals, and the first implementation of the approach using experimental source data with AGATA at the Legnaro National Laboratory. 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 calculated pulse shape signal basis generated by the AGATA Detector Library (ADL)[3]. The signal basis produced by the self-calibration method is compared with the initial ADL basis to show the validity of the method. This method was then applied to signals from real γ-ray source calibration data to generate, for the first time, an experimental in-situ signal basis for AGATA. This experimental self-calibrated basis is compared with the currently-used calculated ADL basis. PSA using both signal bases have been attempted and the comparison looks very encouraging for the new approach. Further development of the self-calibration technique is proposed and improvements to the experimental basis generated by the self-calibration technique are foreseen in the near future.

[1] A. Korichi, T. Lauritsen, Eur. Phys. J. A 55, 121 (2019).
[2] S. Heil, S. Paschalis, M. Petri, Eur. Phys. J. A 54, 172 (2018).
[3] B. Bruyneel, B. Birkenbach, P. Reiter, Eur. Phys. J. A 52, 70 (2016).

Attendance Type

In-person

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