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Analysis of the Response of AGATA Detectors at GSI

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Abstract. In 2012 and 2014 the γ-ray tracking spectrometer AGATA was operated at the SIS/FRS facility at GSI in Darmstadt, Germany. The performance of the array is discussed, outlining some important aspects of the offline data processing and analysis. Relying on the data obtained from measurements with standard γ-ray sources, a first estimate of the photopeak efficiency and peak-to-total (P/T) is presented.

1 Introduction

Accessing unique nuclear structure information in the field of γ-ray spectroscopy calls for an exclusive coupling of accelerator facilities for radioactive ion beams and sophisticated γ-ray spectrometers. The Advanced GAmma Tracking Array (AGATA) [1] is aiming at as exhaustive as possible spatial and energy information on γ rays. With the advance of algorithms treating the original signals of the segmented detectors, it is possible to extract the three-dimensional positions of interactions. Relying on this input, newly developed tracking algorithms can then reconstruct the path of a γ ray.

In the course of the PreSPEC-AGATA campaign at GSI [2], several source run measurements have been conducted. The setup comprised twenty-one 36-fold segmented AGATA crystals positioned at the nominal target-array distance of 23.5 cm. The calibration sources – ^{60}Co, ^{152}Eu, ^{133}Ba, ^{166}Ho and ^{56}Co – were placed at the target position. The data was acquired using an external non-segmented EUROBALL Ge detector as a reference. The output of the preamplifiers of each AGATA detector was digitized by a flash ADC. In this measurement the EUROBALL detector was connected to one of the AGATA digitizers. Therefore, it followed the same digitization procedure. The offline data treatment requires several corrections to provide reliable energy and position information for the final tracking stage. In the following, the main stages of the data processing are addressed.

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2 Data Processing

The AGATA data acquisition (DAQ) system is realized via a dedicated modular framework called Narval [3], with so-called "actors" that receive and process the data. Since the digital signal processing electronics implies parallelized treatment of the data flow, the AGATA DAQ is designed to work in a pipeline mode, such that all the detectors are handled individually. This is known as local-level processing, which is a necessary step prior to the global-level processing. At last, the previously independently handled detector events are all assembled and the actual events are built. It is also possible to perform these actions offline, replaying the raw data by means of a Narval emulator.

2.1 Overview of Data Processing Stages

At the local-level processing, the electronics is read-out and signals are saved in raw-data files. The original waveforms for all 36 segments and the central contact are decoded – at this stage, represented by the Narval actor *Producer*. The data is then formatted and passed to the actor *Preprocessing*. The amplitudes extracted previously have to be calibrated and stored. The waveform contains the time information, which is obtained using a software leading edge filter or the linear fit of the signals corresponding to segments and central contact. Additionally, *Preprocessing* addresses the cross-talk [4] between segments.

The actor *PSA* follows and is responsible for decomposing the waveforms. It aims at deriving the interaction position. A sophisticated PSA algorithm (see Ref. [5]) performs the comparison of the recorded waveforms of observed signals with a set of reference signals. Once refined by *PSA*, the data is passed to the actor *PostPSA*. All the information, such as energy and time of the central contact and energy of the segments is accessible. This is especially important if the sum of energy deposits recorded by the segments is not equal to the energy 'seen' by the central contact. Thus, recalibration can be performed here.

Finally, the global-level processing can take place, represented by the actor *Event Builder*. To characterize the response of AGATA, only those events that fulfilled the EUROBALL-detector coincidence trigger requirement were used. Then the actor *Tracking* is applied, executing the algorithm to first group those hits that are the best candidates for a γ-ray path and then filter only those that satisfy the restrictions posed by the physics of the interaction (see, e.g., Ref. [6]).

2.2 Improvements Along the Way

To access the energy information from the sampled detector signal, the moving-window deconvolution technique is used. It relies on the digital algorithm providing trapezoidal filtering suitable for Ge detectors. Knowing the features of the detector preamplifier, such as rise-time and shaping-time, the *Preprocessing* filter can readily perform the energy calibration. In an event involving several segments, the portions of energy deposited in all of them should be equal to the initial energy, but due to the cross-talk this is not always the case. Cross-talk can compromise the energy resolution and hinder the accuracy of the segment energy information, which tracking heavily depends on. Therefore, a linear combination of amplitudes recorded by all segments has to be applied sequentially to correct for the amplitude of the actual segment. Since this analysis treats prompt $\gamma\gamma$ coincidences, time information first needs to be acquired consistently on the local-level, within each detector (segments aligned to the central contact) by *Preprocessing*, and subsequently for all the detectors (all central contacts between each other) by *PSA*. Thereby, contributions of random coincidences are well reduced. In addition, at the global-level, different time latencies of the detectors have to be fixed, and the resulting corrections passed back to the local-level *PostPSA*.

3 First Results

The analysis was initially performed on the data from the run with ^{60}Co. First estimate of efficiency and P/T at 1.173 MeV refers to AGATA as a calorimeter, summing up energies recorded by the central contacts of all crystals. The second scenario measures efficiency on the basis of energy from the central contact of only a single crystal. Preliminary γ-ray spectra of ^{60}Co in these two cases are shown in Fig. 1. Furthermore, AGATA was treated as a tracking array, utilising the energy information from reconstructed γ-ray interactions. The calorimetric approach results in an efficiency of 3.3 % and P/T of 32 %, whereas the obtained tracking efficiency yields 2.5 % and P/T of 34 %. The latter results were obtained with standard values of tracking parameters, which still require optimization in the course of the further analysis. Additionally, Geant4 simulations have been performed and they suggest somewhat higher values, namely 3.9 % efficiency and a P/T of ~50 %.

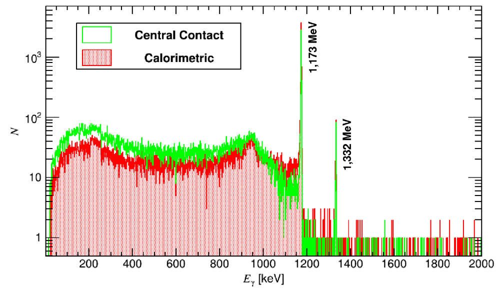

Figure 1. Pulse-height spectra measured by the AGATA array from the γ-ray spectrum issued by the ^{60}Co calibration source obtained as a sum from all central contacts (red) or scaled from a single central contact (green). The spectra were taken in prompt coincidence with the 1.332-MeV line. The weak presence of the 1.332-MeV line itself is due to random events.

4 Summary and Outlook

To optimize information from recorded signals of AGATA detectors, the complete complex framework for data processing is employed. Fine tuning is necessary to obtain a first estimate of the absolute efficiency and peak-to-total of the AGATA-at-GSI setup. The detailed analysis is still ongoing and should provide reliable performance figures of AGATA to be used for the analysis of the data taken within the PreSPEC-AGATA campaign.

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