AGATA Performance II: Efficiency and P/T

R.M. Pérez Vidal[1,2], F. Angelini[1,3], A. Ertoprak[1], B. Gongora Servín[1,4], J. Pellumaj[1,4], P. Aguilera[3,5], W. Raniero[1], H. Hess[6], A. Goasduff[1], J.J. Valiente Dobón[1], F. Crespi[7], S. Bottoni[7]

[1] *INFN Laboratori Nazionali di Legnaro, Legnaro, Italy.*
[2] *Instituto de Física Corpuscular, CSIC-Universidad de Valencia, Valencia, Spain.*
[3] *Università degli Studi di Padova, Dipartimento di Fisica e Astronomia, Padova, Italy.*
[4] *Università di Ferrara, Dipartimento di Fisica e Scienze della Terra, Ferrara, Italy.*
[5] *INFN, Sezione di Padova, Padova, Italy.*
[6] *Institut für Kernphysik, Universität zu Köln, Köln, Germany.*
[7] *Dipartimento di Fisica dell'Università degli Studi di Milano and INFN, Milano, Italy.*

INTRODUCTION

The Advanced GAmma Tracking Array (AGATA) [1, 2], recently installed at Legnaro National Laboratories (LNL), is a new generation γ-ray detector array that allows the reconstruction of the trajectories of the γ rays inside the whole array and the crystals thanks to its highly segmented structure [3, 4]. The analysis of the in-beam data and the preparation of incoming experiments require knowing the response of the spectrometer. The present contribution reports on the performance figures, efficiency and peak-to-total ratio (P/T), of AGATA phase II at LNL during the first campaigns. The AGATA performance on the energy resolution can be found in Ref. [5].

SOURCE MEASUREMENTS

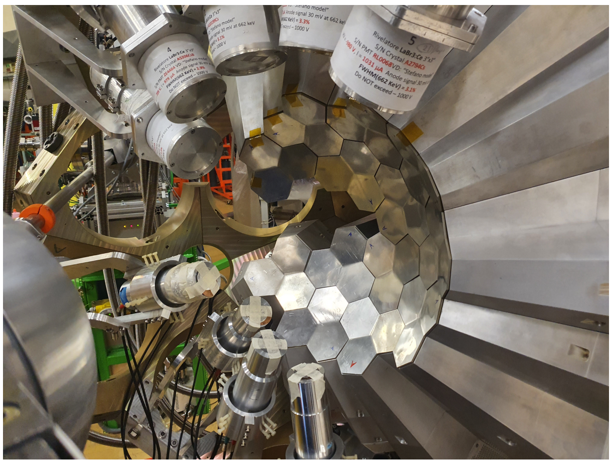

Fig. 1. The AGATA array with the absorbers installed at LNL.

A series of measurements were performed with calibration sources ^{60}Co, ^{152}Eu and ^{226}Ra was placed at the target position. During the measurements, AGATA was composed of 34 operational detectors (12 ATC) grouped at backward angles with respect to the target position (Fig. 1). AGATA was at the nominal position (AGATA crystals' front face is placed at 23.5 cm from the target position) for the measurement, although it can work also at closer configurations, (AGATA crystals' front face is placed at 18 cm from the target position). Several layers of absorbers (1 layer of 0.25 mm of brass and two layers of 1.25 mm of tin) were placed in the front face of the detector, the reaction chamber was closed, and the trapezoidal-filter risetime was 6 μs to evaluate the performance as in the actual experimental conditions.

EFFICIENCY AND P/T

The efficiency, using the ^{60}Co calibration source, was obtained by comparing the detected peak areas to the expected intensities given the source activity, the time of measurement, and the electronics dead time. The core efficiency at 1.3 MeV relative to a 3 in×3 in NaI detector (1.2×10^{-3} at 25cm) is reported for each detector in Fig. 2. The difference in the distance from the detector to the source position and the effect on the absorbers was corrected in the efficiency.

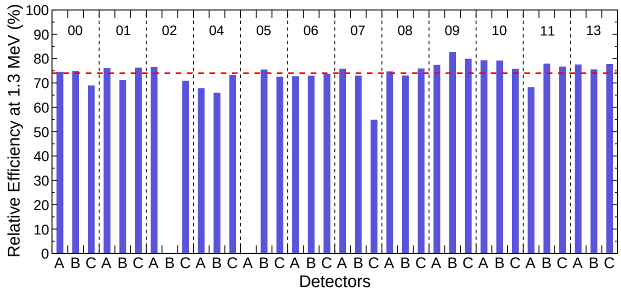

Fig. 2. Relative core efficiency at 1.3MeV (^{60}Co) for 34 capsules individually named with its position label. The red line is the average relative core efficiency (74%). 02B and 05A were excluded from the acquisition in this measurement. The correspondence of the detector position with the ATC and crystal number can be seen in the Table 1 in Ref. [5].

In general, all the relative efficiencies are in agreement within the mean value (see Fig. 3), thereby ensuring no losses in the global efficiency. Regarding the global efficiency, although AGATA is a tracking array, it can be also used as the conventional arrays utilizing the signals from the core contacts. According to that the efficiency was evaluated

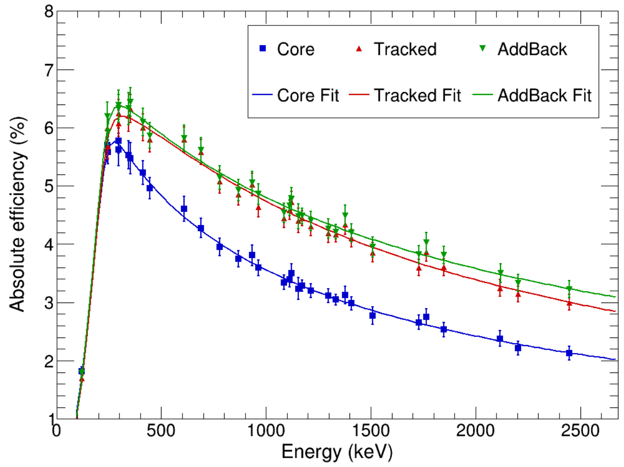

Fig. 3. Efficiency curves for 34 encapsulated AGATA detectors with the absorbers. AGATA was placed at nominal position (23.5 cm). The OFT parameters used for the tracking analysis are $\sigma_\theta = 1.5$, $P_{track} = 0.01$ and $Cl_{AngRed} = 3$.

through the following modes of analysis:

- Core: sum of the individual energy histograms for the core contacts
- Tracked: reconstructed energy by the tracking algorithm which uses the information given by the Pulse Shape Analysis (PSA).
- Addback: sum of all hits of neighboring crystals in an event.

In this work, the OFT tracking algorithm was employed [4]. The OFT parameters were optimized for the 1.3 MeV peak, being $\sigma_\theta = 1.5$, $P_{track} = 0.01$ and $Cl_{AngRed} = 3$. More details on the optimization and parameters description can be found in Ref. [6].

The absolute photo-peak efficiency for the whole AGATA array, composed of 34 operational detectors, is presented in Fig.3 for the nominal position of AGATA using the absorbers. The efficiency curves have been obtained with the spectra collected with ^{152}Eu and ^{226}Ra normalized to the absolute efficiency determined at 1.3 MeV. The general drop at energies below 300 keV is due to the presence of the absorbers in front of AGATA. The tracked and added back data points agree within the error.

The efficiency curves were fitted with the RadWare function [7]. The parameters of the fit for each method of analysis are summarized in Table 1. The parameter C was fixed to 0 and G was fixed to 10. From the fitted curves we can appreciate that the addback treatment (green curve) is slightly higher than the tracked (red curve), however, this is due to the fact that the former sums up all the hits of neighboring crystals in an event, while the tracking will discharge the wrong ones. The addback analysis mode is shown as a reference of the ideal efficiency that could be reached with the system.

Finally, the Tab. 2 shows the results for the absolute photo-peak efficiency at 1.3 MeV and the P/T for a configuration of 34 encapsulated detectors. Using AGATA as a conventional detector, core analysis treatment, gives rise to the lower values in efficiency and P/T (as already illustrated in Fig. 3. The use of AGATA in the addback mode produces an increment in both quantities efficiency and P/T. Lastly, the tracked analysis increases the P/T ratio while it preserves the addback efficiency.

Table 1. Fit parameters of the efficiency curves obtained for different analyses.

Analysis mode	A	B	D	E	F
Core	0.23(6)	1.87(17)	1.270(10)	-0.497(18)	-0.08(3)
Tracked	0.14(6)	2.02(16)	1.556(10)	-0.391(16)	-0.13(2)
Addback	0.19(6)	2.01(15)	1.569(10)	-0.359(16)	-0.09(2)

Table 2. Efficiency at 1.3MeV and P/T obtained for different analyses.

Analysis mode	Efficiency	P/T
Core	3.05(9) %	16.8(6) %
Tracked	4.16(12) %	32.9(9) %
Addback	4.21(13) %	28.6(8) %

SUMMARY AND FUTURE WORK

The performance of AGATA at LNL during the first campaigns has been presented in terms of efficiency and P/T measured at nominal position. Different methods of data treatment were used in this report, showing that the efficiencies of the tracked and addback analysis are comparable, while advanced capabilities of the AGATA tracking array are clearly seen regarding the P/T. It should be noticed that the optimal treatment of the in-beam data and the tracking optimization should be done for each experiment individually.

[1] S., Akkoyun et al., NIM A 668 (2012) 26–58.
[2] J.J. Valiente Dobón et al., NIM A 1049 (2023) 168040.
[3] Recchia et al., Nucl. Instr. Meth. A, 604 (2009) 555-562.
[4] A. Lopez-Martens et al., Nucl. Instr. Meth. A, 533 (2004) 454-466.
[5] R. M. Perez-Vidal et al., AGATA Performance I: Resolution, LNL Report 2022.
[6] F. Angelini, Master thesis, Università di Padova (2022).
[7] D. C. Radford. Nucl. Instr. Meth. A, 361(1-2):297–305, 1995.