Recent results from the Monte Carlo simulations for the AGATA array

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In the past few years, two projects have been started with the goal of building an array of germanium detectors based on the novel concepts of pulse shape analysis and γ-ray tracking: AGATA in Europe [1] and GRETA in the USA [2]. In the initial phase of both projects, a reduced version of the array will be assembled, to prove that pulse shape analysis and γ-ray tracking are feasible on line and therefore that the full array can be operated.

Monte Carlo simulations play an essential role in a project like AGATA, since the detector arrangement must be carefully optimized and realistic datasets are needed to test the tracking and pulse shape analysis algorithms. For this reasons, we developed a Monte Carlo code, based on the C++ classes of the Geant4 package [3], which could meet the requirements of the AGATA collaboration.

An early version of the simulation code was used to address the most urgent question, namely the definition and the optimization of the geometry of the array. The final configuration for AGATA includes 180 irregular hexaconical encapsulated crystals of three different shapes, grouped in triple clusters within a single cryostat. The expected values of photopeak efficiency and P/T ratio, including the effect of the present tracking algorithm, are respectively 43% and 58% for single photons of 1 MeV and 28% and 49% for a cascade of multiplicity $M_\gamma = 30$.

The demonstrator and especially the full AGATA array will be most likely operated under quite harsh experimental conditions, which would be prohibitive for the present arrays. In particular, it is expected that the full AGATA array will be mainly used at the planned radioactive beam facilities, where in most cases the beam momentum will not be well defined, nor the beam spot size will be negligible. Since the γ-ray tracking algorithms rely on the knowledge of the source position and direction, extensive Monte Carlo simulations were carried out to evaluate to what extent the definition of the vector velocity of the nuclei emitting the photons affects the global performance of the array. These calculations prove that the quality of the spectra, namely the peak widths, is strongly affected by the uncertainty on the velocity of the recoiling nuclei, while on the other hand the photopeak efficiency and P/T ratio are rather insensitive to the same parameter. As a consequence, ancillary detectors helping to define the direction of the recoils will be of primary importance in the AGATA project, and therefore it is essential to find a reliable way to evaluate their impact on the overall performance of the array.

The simulation code was recently upgraded to include the possibility to decode generic events from formatted files, describing in a generic way the emission of light particles and photons from recoiling nuclei. This ensures high flexibility and the possibility to easily consider effects such as the angular distribution of the reaction products. Another essential addition to the code was the possibility to simulate generic ancillary devices, both as passive and as active objects.

According to the calculations, the impact of passive materials inside the array on the process of γ-ray tracking is comparable to the case of conventional detectors. Preliminary calculations were carried out considering active ancillary devices and physically meaningful events. The data was written out in list-mode after the tracking process and analyzed as if it were produced in a real experiment using the GASP data analysis package. The results obtained in this way confirm that ancillary devices defining the direction of the recoils will be of primary importance for a tracking array like AGATA or GRETA.

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[2] M.A. Delaplanque *et al.*, N. Inst. and Meth. A430, 292 (1999).
[3] S. Agostinelli *et al.*, N. Inst. and Meth. A506, 250 (2003).