Fast Pulse Shape Analysis for AGATA

T. Habermann[1,2]*, J. Gerl*[2]*, and J. Maruhn*[1]

[1]Goethe Universität Frankfurt, Germany; [2]GSI, Darmstadt, Germany

Introduction

The Advanced Gamma Tracking Array (AGATA) [1] will be used for nuclear structure experiments at the future FAIR facility as part of the NUSTAR program. Already in 2012 the PRESPEC-AGATA collaboration performed experiments with AGATA placed at the S4 area behind the FRS [2]. In its full configuration, the array consists of 60 high purity germanium crystals, each 36-fold electronically segmented to enable the identification of the gamma-interaction position inside the detector. For experiments with relativistic beam energies, it is a major issue to know the angle of the emitted gamma for calculating the energy in the rest frame and to produce a Doppler-corrected spectrum.

Pulse Shape Comparison

Pulse shape analysis (PSA) is applied to each of the recorded pulses of the detector to determine the interaction position. Due to a complicated geometrical shape of the AGATA crystals, there exists no simple algorithm to get the position from the pulse shape directly. However, it is possible to determine the position by comparing a recorded pulse with those from a database that contains pulse shapes for a huge number of interaction positions. As this procedure is rather time-consuming, the PSA is the rate-limiting part of the AGATA online analysis and requires optimization to make use of higher beam intensities. The algorithm that is currently used to find the best fit from the database is the Adaptive Grid Search Algorithm [3]. The basic ingredient for this algorithm is a χ^2-comparison of the recorded signal with the signals from the database. Without going into details, the next section will explain one feature of this algorithm, that is relevant for the present work.

Pulse Shape Comparison with threshold

A brute force algorithm would compare the full recorded signal with all signals from the database. Apart from selecting the part of the signal that is most sensitive to the interaction position, there is another way to make the search for the best fit more efficient. The comparison of two pulse shapes can be aborted, once the χ^2 value is higher than the best χ^2 value that has been calculated so far. On the other hand, if the χ^2 value is lower than any previous one, this one can be used as the new threshold. The top panel of Figure 1 shows the number of signals from the database that can be considered as candidates for the best fit depending on the number of samples that have been compared already (i.e. the number of database signals whose χ^2 value is below the threshold). The red curve shows the situation for the brute force algorithm without applying any threshold. The area under the curves can be considered as the required computing time to find the best fit, as it represents the total number of samples that have to be compared. It is obvious that the number of samples to be compared can be reduced by more than half by applying the threshold.

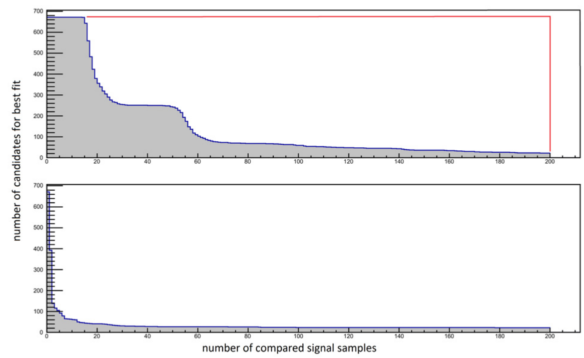

Figure 1: The red box corresponds to the computing time of a brute force algorithm. The grey area corresponds to the computing time when a threshold is applied (see text for details).

Fast Pulse Shape Comparison

The number of significant samples that have to be compared to find the best fit from the database can be reduced even further by applying a transformation to all the pulses before comparing them. By considering only orthogonal transformations it is ensured that the result of any comparison is unchanged. One can choose the transformation such that in the transformed signals, the relevant information is concentrated in only few signal components. The best result is achieved, when the signals are expanded in terms of their principal components. These are obtained by applying a singular value decomposition to the matrix whose columns are the pulse shapes from the signal database. The bottom panel of Figure 1 again shows the number of best fit candidates when the threshold is applied after each sample depending on the number of samples that have been compared. There is a clear advantage to the case when the signals are not transformed (cf. top panel of Figure 1). Compared to the brute force approach, the computation time can be reduced by a factor of roughly 20 (compared to ~6 for the original algorithm).

References

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[3] R. Venturelli, D. Bazzacco, LNL Annual Report 2004, INFN-LNL, Italy, 220