Application of a Simple PSA Algorithm for HPGe Segmented Detectors to in-Beam Data

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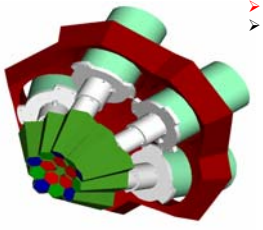
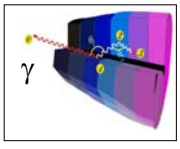
γ–ray Tracking Detectors

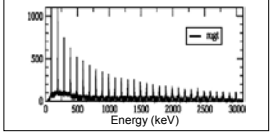
AGATA Demonstrator

- Large volume (240 cm³), Highly segmented HPGe detectors
- Digital electronics to record and process signals from segment
- Pulse Shape Analysis (PSA) to decompose recorded signals
- Reconstruction of tracks evaluating permutations of Interaction Points (IPs)





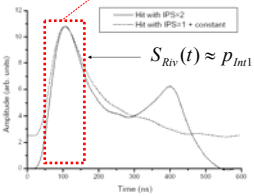
Reconstructed Gamma Energy Spectrum



PSA with Recursive Subtraction (RS) Algorithm

ISSUE: determination of the Number Of Interactions in a segment and their radial coordinate, processing the net-charge signal

➢ It exploits the fact that in small window around the Current Pulse maximum the shape of the signal is mainly determined by the characteristics (x,y,z,E) of the most energetic interaction



$$S_{Riv}(t) \approx p_{Int1} \cdot S_{Int1}(t) + c$$

RS Algorithm:

1) Compares the detector signal (Current Pulse) with a set of reference signals for single interaction gamma events. The shape of the signals is compared in a small window near the detector current pulse maximum.

2) The signal of the set that fits best is subtracted from the detector signal

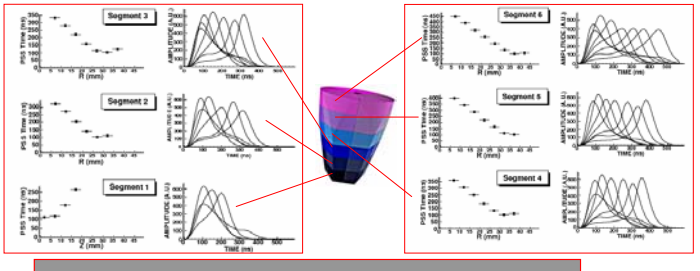
3) Step 1 and 2 are iterated until an energetic weight of 100% is reached, anyway no more than M* times

*M is the maximum number of interaction per segment that is expected to find.

A Direct Relation Exists Between The Current Pulse Maximum Position and The Gamma Interaction Position

❑ **Calculated* pulse shapes and their maxima, plotted as a function of the Radial (Z) coordinate of the interaction point (for the different detector segments)**

*Signals are calculated using MGS code. (P. Medina, et al., A simple method for the characterization of HPGe detectors, IMTC, Como, Italy, 2004)

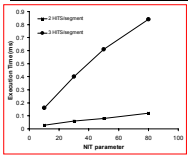


Execution Time Performances

RS algorithm execution time scales Linearly with the number of interactions To disentangle (not exponentially like in brute force algorithms)

The execution time can be tuned by changing NIT parameter (number of signals considered Eligible for representing the first decomposed Interaction

Execution time constraints for PSA: < 1 ms/event

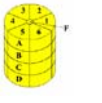


In-beam experiments

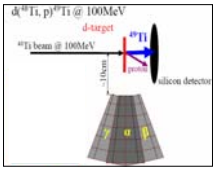
MARS detector in beam test (Legnaro, INFN Laboratories):

Coulex. of ^{56}Fe @ 240 MeV on ^{208}Pb
v = 0.08c

Studied the first 2⁺ state of ^{56}Fe → 846.77 keV transition



AGATA triple symmetric cluster in beam test (IKP Koeln):



RS algorithm application to the experimental signals

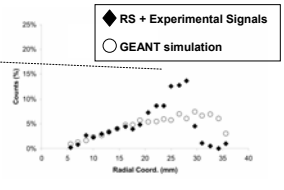
Radial Coordinate Determination

Comparing the **radial distribution of the events** reconstructed by PSA with that resulting from GEANT simulations

MARS detector in beam test:

This deviation is not introduced by the algorithm!

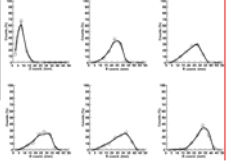
- *Same effect found with a different PSA method (Th. Kroell et al., NIMA 586 (2008) 421–431)*
- *Most probably due to miss correspondence between calculated and real detector position response*



AGATA cluster in beam test:

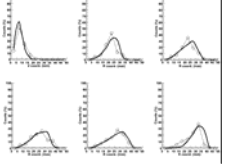
GEANT simulation VS RS algorithm applied to **simulated** signals

Very good agreement between the two Distributions!



GEANT simulation VS RS algorithm applied to **experimental** signals

Residual miss correspondence could be adduced to the presence of cross talk effects which have been observed but not yet included in the calculations (B. Bruyneel NIMA 569 (2006) 774–789)

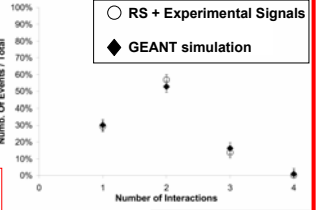


Number Of Interactions Determination

Comparing the **number of interactions per segment distribution** of the events reconstructed by PSA with that resulting from GEANT simulations

MARS detector in beam test:

Excellent agreement between the experimental and calculated Distribution!



AGATA cluster in beam test

Excellent agreement between the experimental and calculated Distributions!