



Characterization of HPGe Segmented Detectors Position Response Using Pulse Shape Comparison Techniques

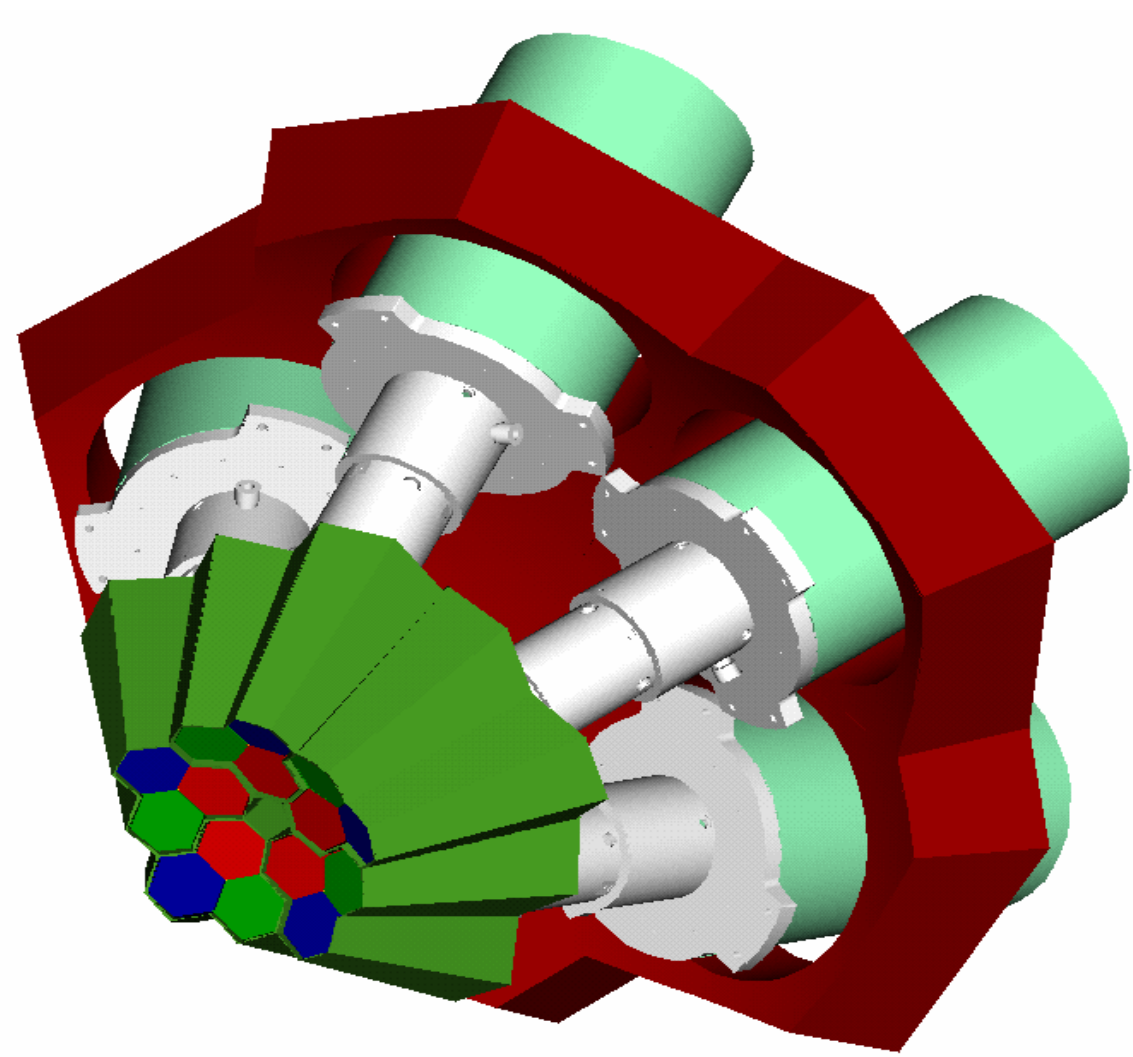


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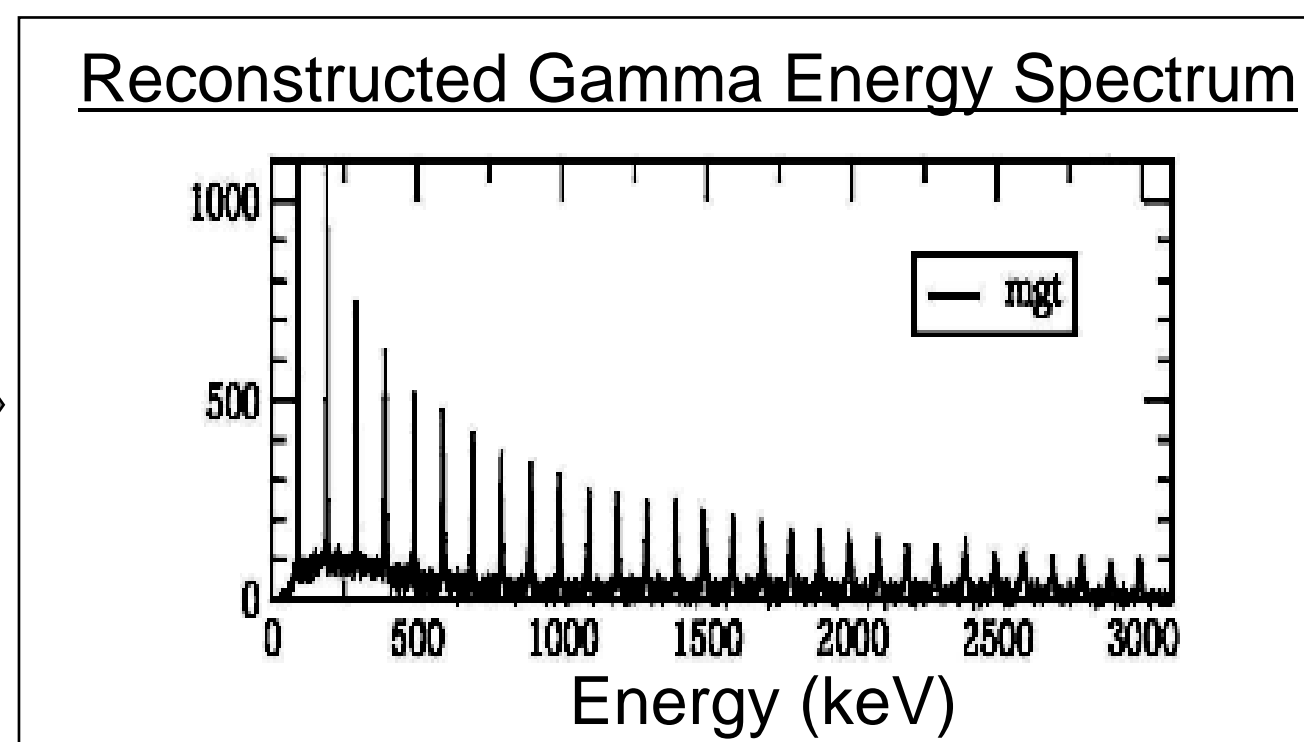
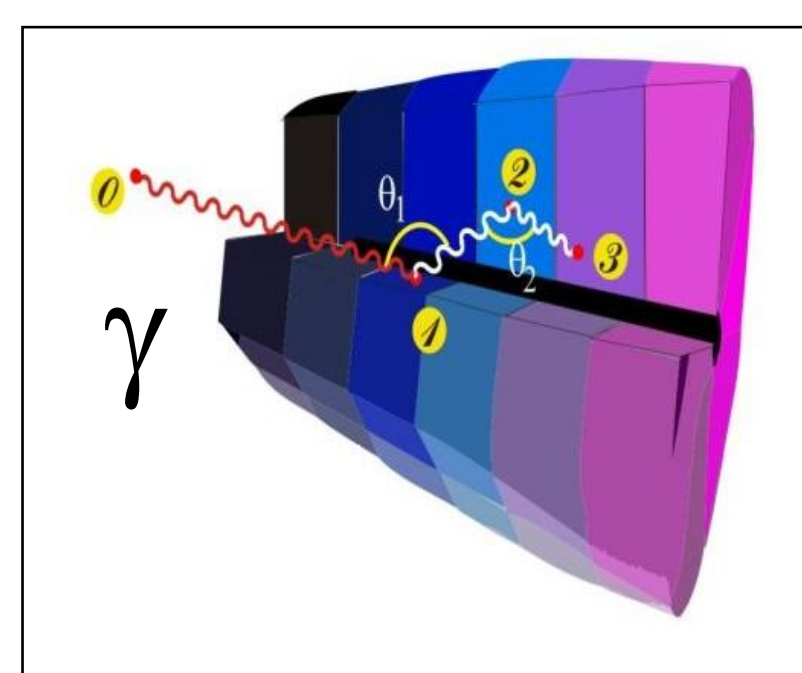
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γ -ray Tracking Detectors

AGATA Demonstrator



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



Detector Position Response Determination

PSA algorithms developed for highly segmented HPGe detectors make use of a **signal data base** which contains the detector pulse shapes for **all the possible interaction positions inside the detector volume**. Such kind of information is usually **extracted by calculating the induced current pulses** and solving the appropriate electrostatic equations. In principle it is also possible to **extract the detector position response experimentally** but the standard techniques based on coincidence measurements require a prohibitive time consumption for a full volume detector scan. Nevertheless measurements for the characterization of AGATA HPGe detectors are presently performed in many laboratories since experimental data are strictly **needed to validate the calculated signals**.

Calculations

□ Electrostatic equations are solved

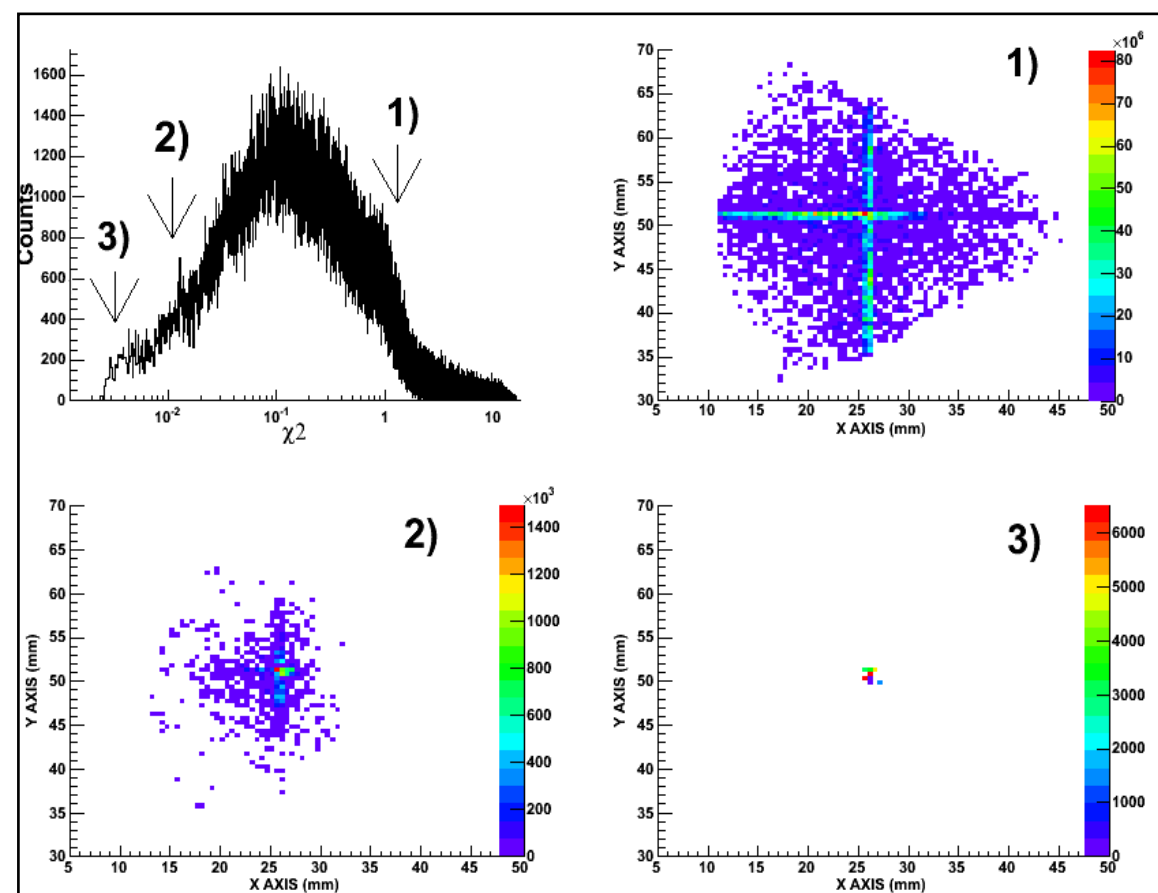
$$i_{ind}(t) = \frac{dQ_{ind}}{dt} = -q \frac{dV_w(P)}{dt} = q \vec{E}_w(P) \cdot \vec{v}(P(t))$$

Standard Experimental Approach

□ Single site events are isolated imposing a coincidence between the HPGe detector and an ancillary one.

Pulse Shape Comparison Scan (PSCS) – Basic Idea –

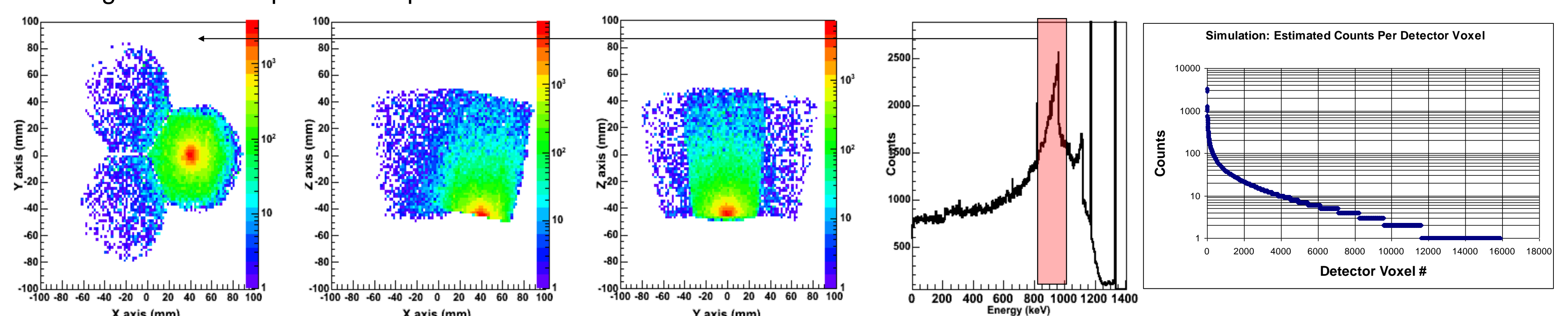
The technique is based on a **specific pulse shape comparison procedure** (therefore we named it Pulse Shape Comparison Scan, PSCS). The main difference between the PSCS and standard techniques is that PSCS **does not require any 'coincidence' between events**: this approach allows to enormously decrease the time duration of the measurements. In highly segmented HPGe detectors (e.g. AGATA), two different single-interaction gamma events give rise to clearly distinguishable signal shapes. To identify the **gamma ray interaction point position** 2 data sets are used: each one corresponding to a specific measurement characterized by a defined collimation of the gamma ray source. In fact, the only case in which a signal of one set is identical to a signal of the other is when the two signals originate at the position corresponding to the **crossing point of the two lines defined by the source collimation**.



New Technique Exploits Association Between Statistics, Signal Shape and Gamma Interaction Position

This variant of the PSCS method requires **no collimators**, thus reducing further the time duration of the measurements. Specifically, **Geant4 simulations of an AGATA triple cluster with a ⁶⁰Co source** placed in different positions have been performed. The spatial distributions of single interaction events, obtained by imposing a gate on the Compton edge of the 1172 keV gamma line, is calculated.

The technique relies on the fact that **the combination of the number of counts in each detector voxel is in principle unique, provided that a sufficient number of measurements with a source illuminating the detector from different directions (3 at least) is available**. In this way the calculated number of counts per voxel can be compared with the number of events with a specific line-shape acquired in the 3 measurements. It will be therefore possible to associate each line-shape with a position, thus measuring the detector position response.



The Measurement with an asymmetric AGATA triple cluster at LNL INFN

EXPERIMENTAL DATA

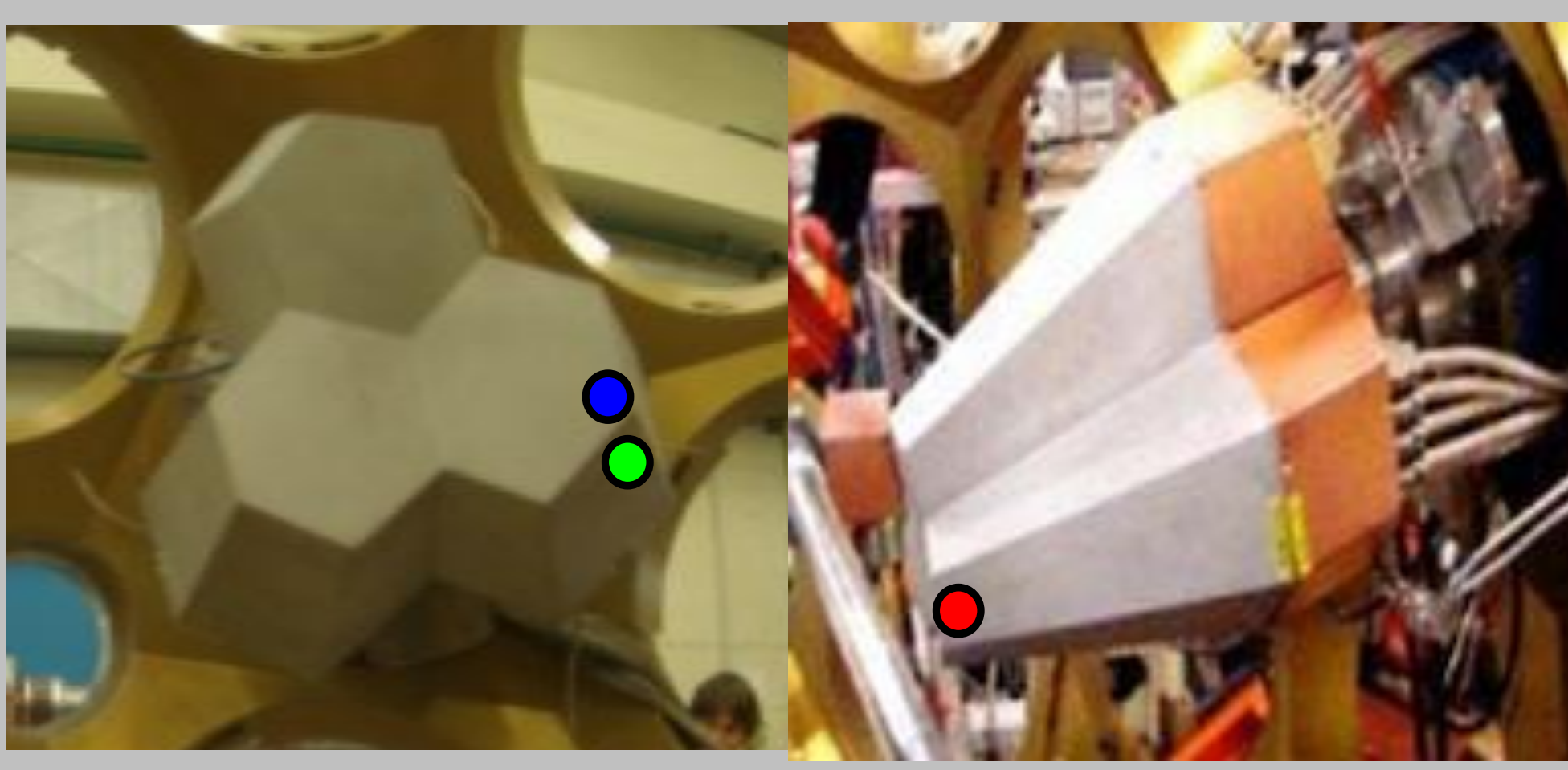
Signal Shape (parameters) → Counts for different source positions (3 at least)

SIMULATIONS

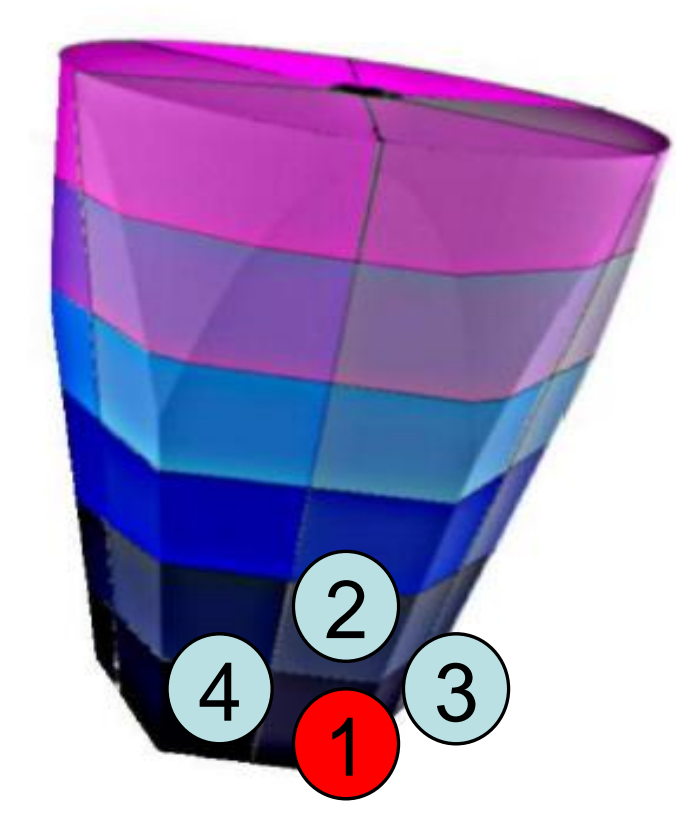
Counts for different source positions (3 at least) → Interaction Position (X,Y,Z)

3 Measures with Different position of the ⁶⁰Co source

- FRONTAL
- LATERAL 1
- LATERAL 2

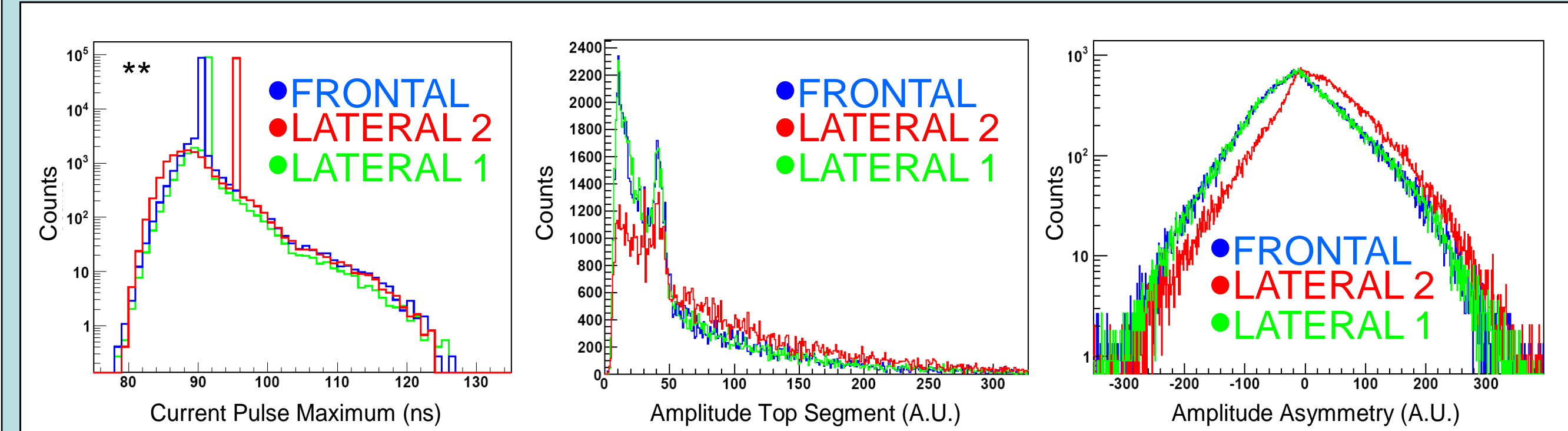


Position response of segment 1



The signal shape is described by 3 parameters (p0,p1,p2)

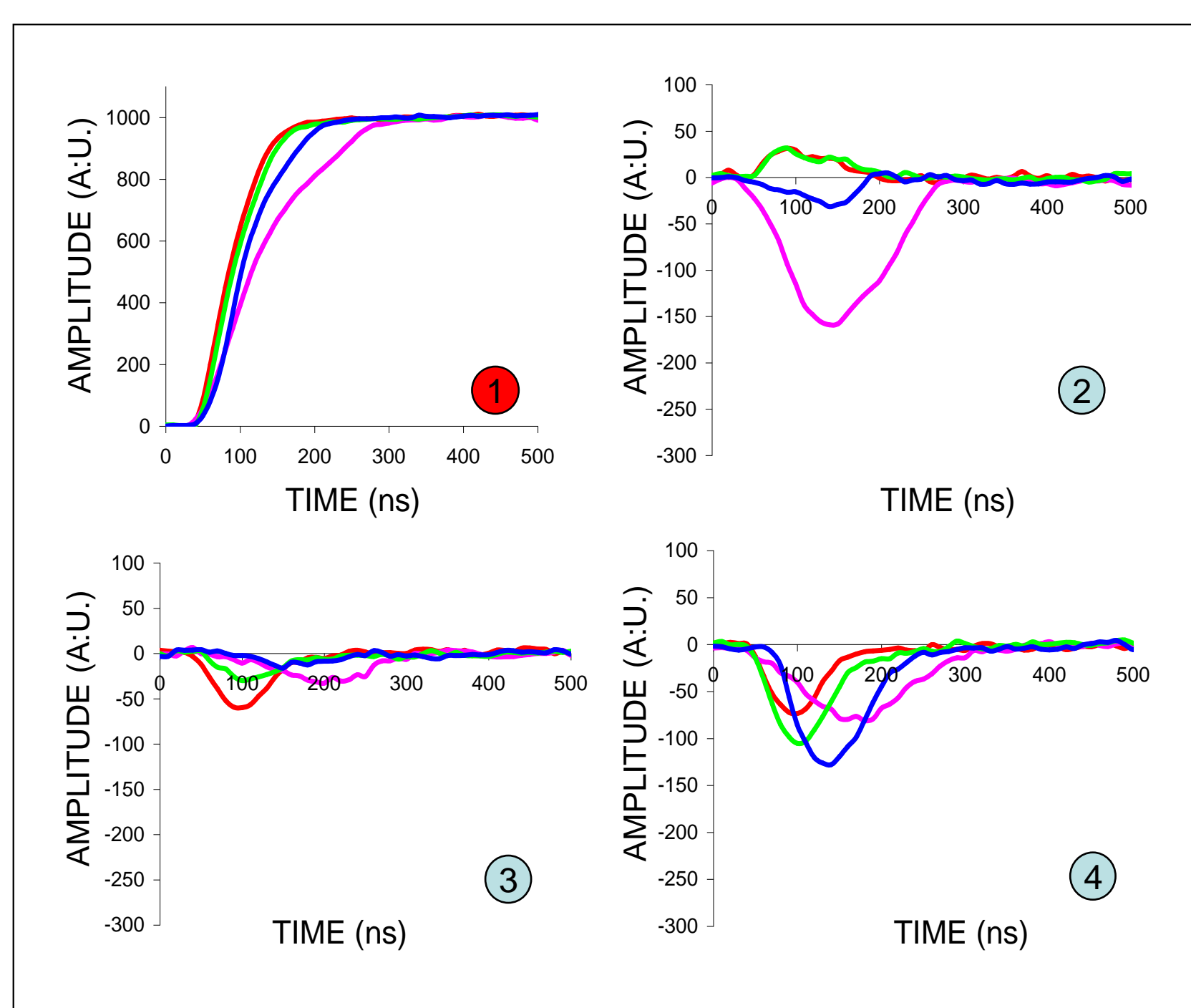
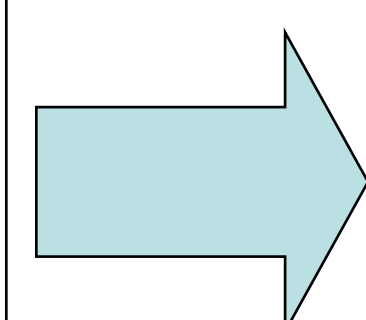
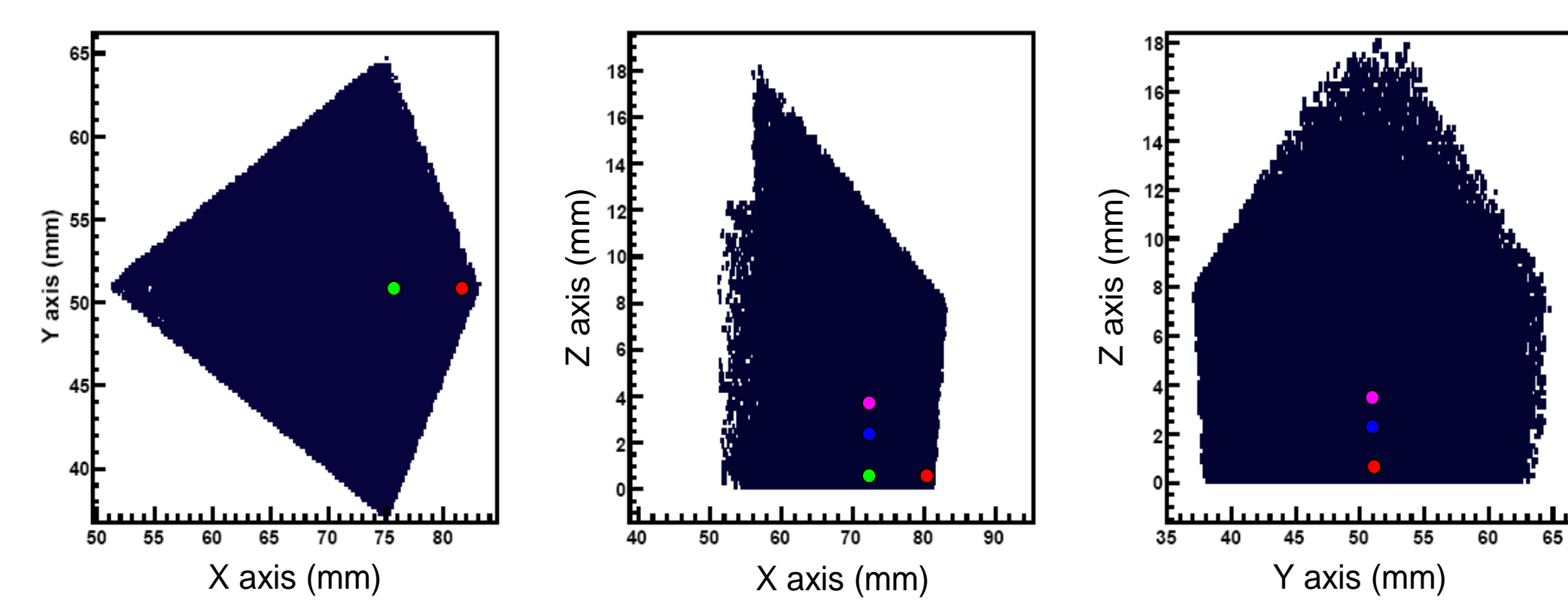
- Maximum of the current pulse in segment 1 (p0)
- Amplitude of the transient signal in segment 2 (p1)
- Amplitude difference of segments 3 and 4 (p2)



** The peak is associated to the current pulse maximum of the shapes generated in the proximity of the source position. The binning of the histogram is determined by the 10 ns sampling time

Segment 1

The signal shape in the positions indicated with the colored dots is extracted (the signal shape is associated to the color in the plots on the right →)



Conclusions

A variant of the Pulse Shape Comparison Scan (PSCS) has been experimentally tested on a 36-fold segmented HPGe AGATA crystal. This technique doesn't require collimators and high intensity sources. The position response of a detector segment has been extracted after performing 3 measures of about 2 hours each, with a ⁶⁰Co source placed in specific positions. A critical point is the consequence of the approximation used of a constant spatial sensitivity in the segment volume and this effect can be evaluated with additional measures and simulations. The obtained results have to be validated: this can be done, for example, exploiting the Doppler corrections or imaging capabilities of segmented HPGe detectors as suggested in [1,2,3].

[1] F. Recchia et al., Nucl. Instr. and Meth. A 604 (2009), p. 60
 [2] F. Recchia et al., Nucl. Instr. and Meth. A 604, (2009), p. 555
 [3] F. Recchia, Ph.D Thesis, University of Padova, Italy, 2008.