Investigation of the Pulse Shape Analysis for the position sensitive γ-ray spectrometer AGATA

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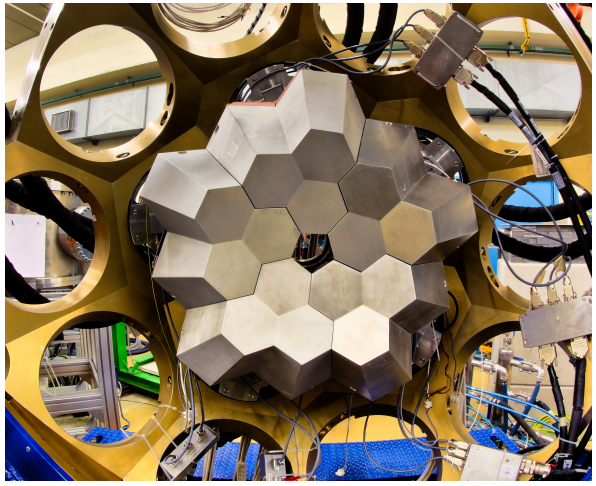
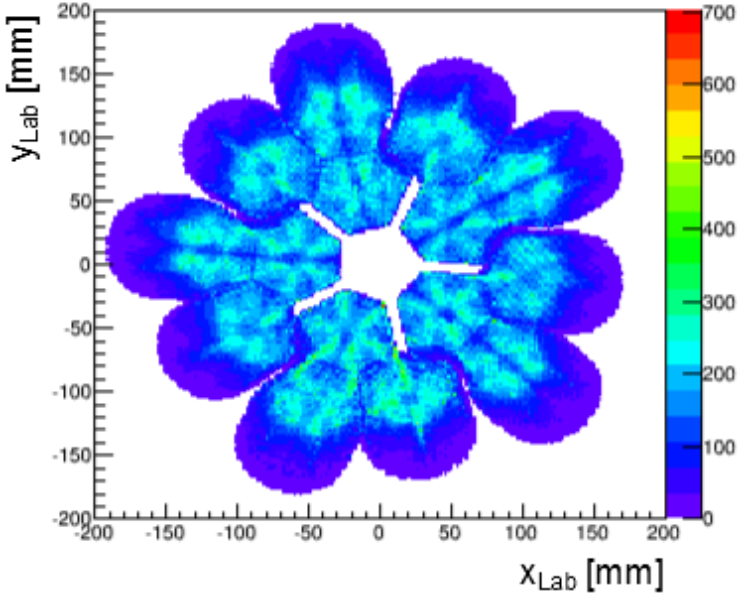
Content

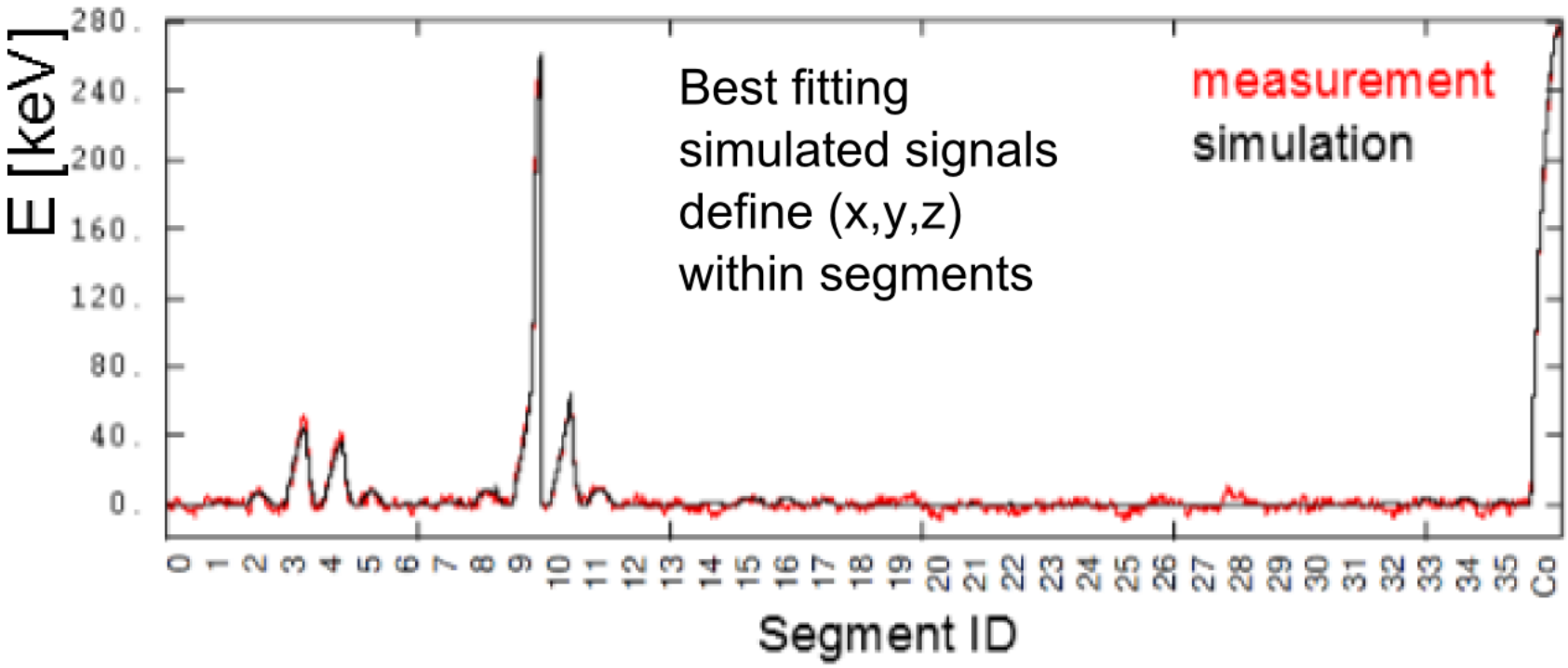
The AGATA Array





- 36 times segmented HPGe detectors
- Interaction position within segment with PSA
- γ-ray tracking $\Rightarrow$ Doppler correction, polarization measurements and improved P/T using properties of Compton scattering

Pulse Shape Analysis



- For every interaction position: set of simulated signals (ADL)
- Compare with measured signal $\Rightarrow$ Best fit $\Rightarrow$ Interaction position

PSA input parameters

Detector properties or setup of algorithm

- Distance metric ✓
- Time alignment ✓
- Crosstalk & differential Crosstalk ✓
- Transfer function of preamplifier ✓
- Space charge
- Energy alignment
- Crystal axis orientation
- ...

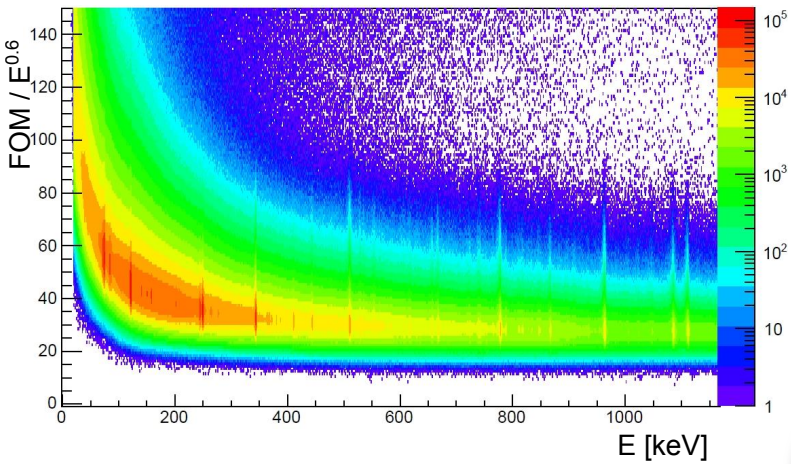
Comparison of Measurement and Simulation

Figure of Merit

$$\chi^2 = \sum_{t_i,j} |A_j^m[t_i] - A_j^s[t_i]|^p$$

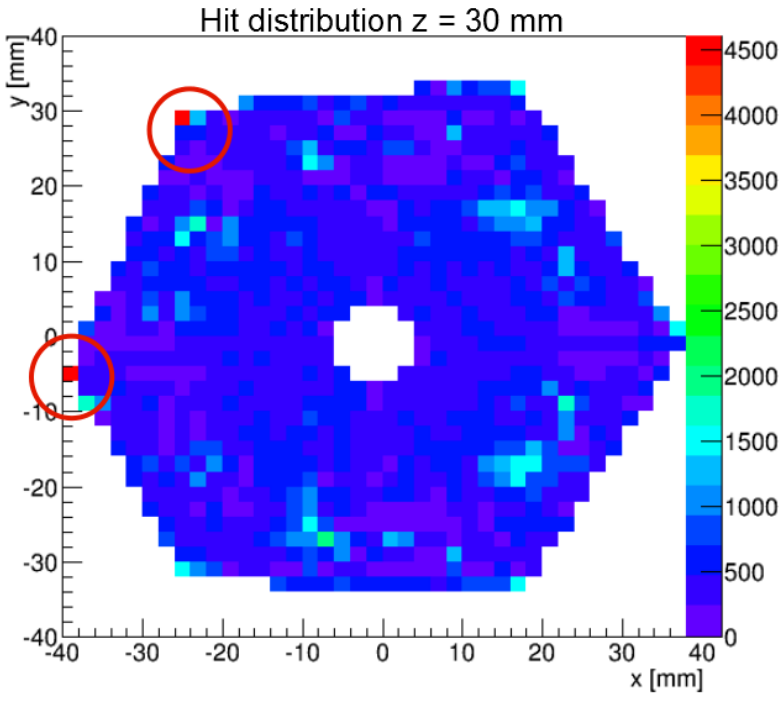
Measured A^m and simulated signal A^s of segment id j and time t_i

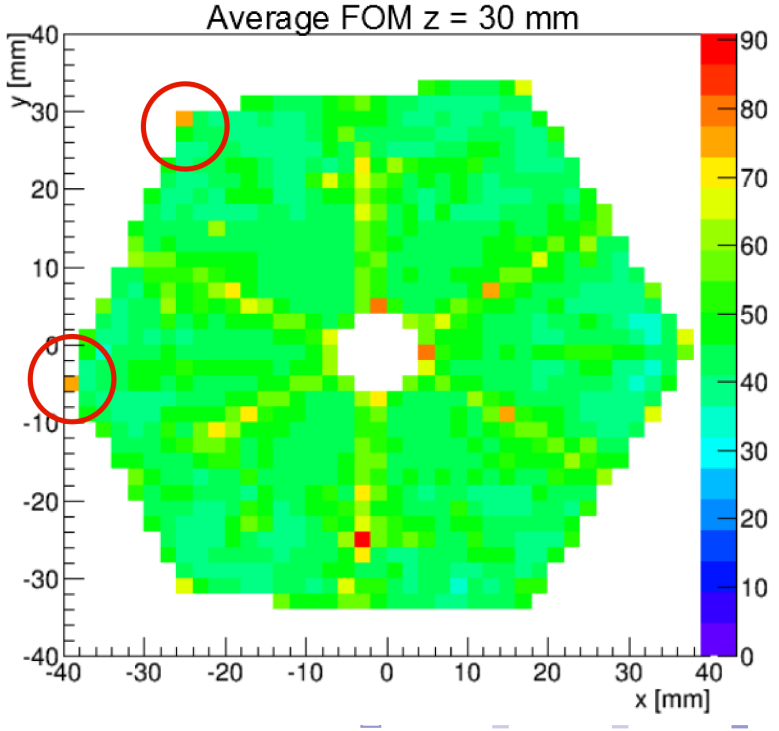
- χ^2 of best fit contains information on matching of measurement and simulation
- Measure for quality of detector response



χ^2-distribution

- Mean χ^2 for every grid point
- Compare with hit distribution (^{152}Eu)
- Six fold segment structure (only in χ^2 distr.)
- Both distributions non-homogeneous

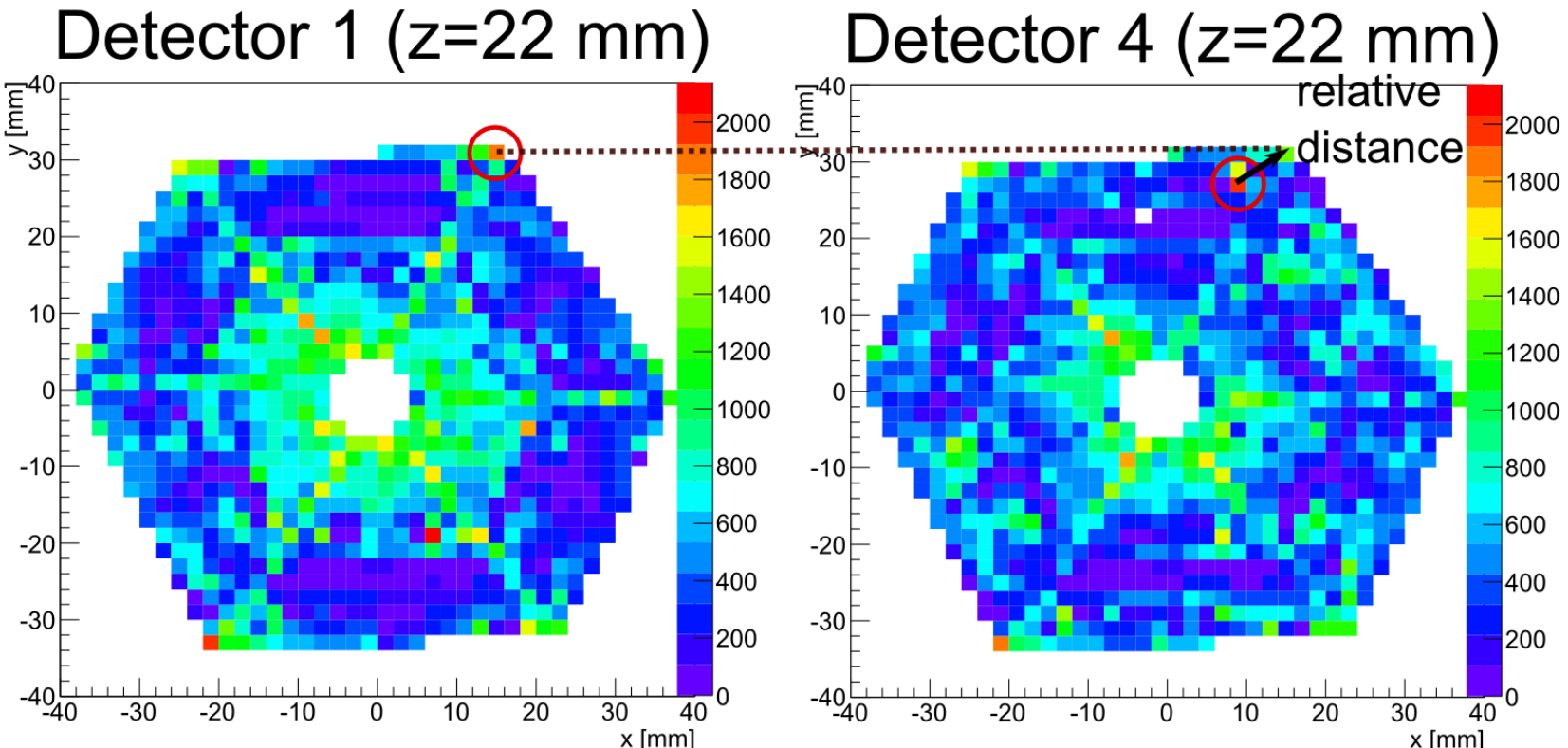




Segment and detector performance

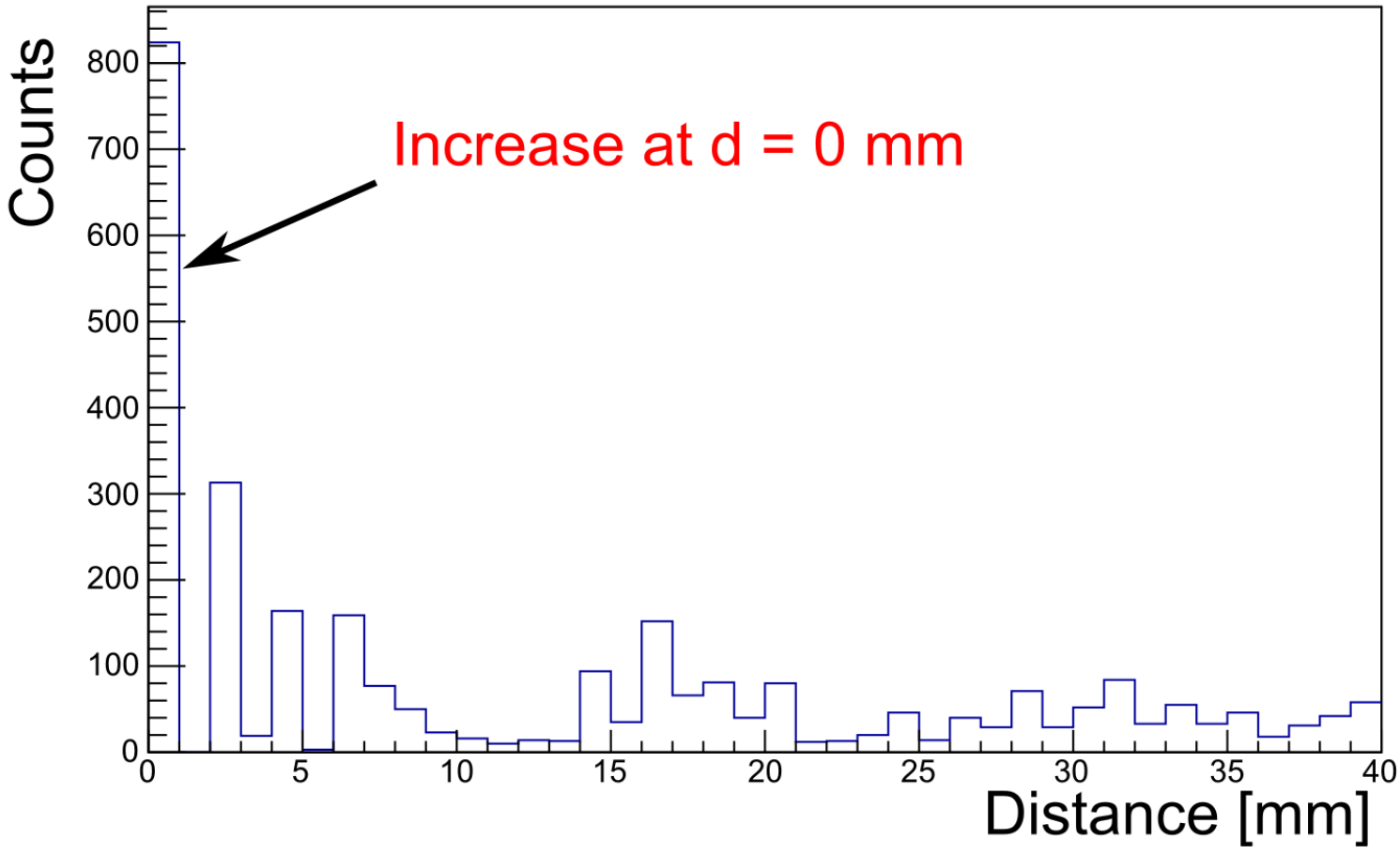
Distance of High Statistic Grid Points (HSGP)

- Investigate relative position of HSGPs
- Same or similar spot in all detectors?



Distance of High Statistic Grid Points

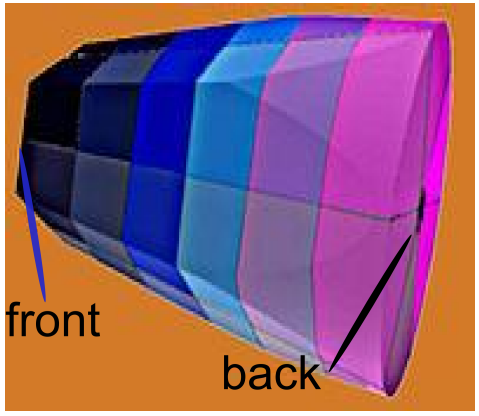
- Search for HSGP segment wise
- HSGP positions at characteristic spots
- *General* problem that exists for every detector

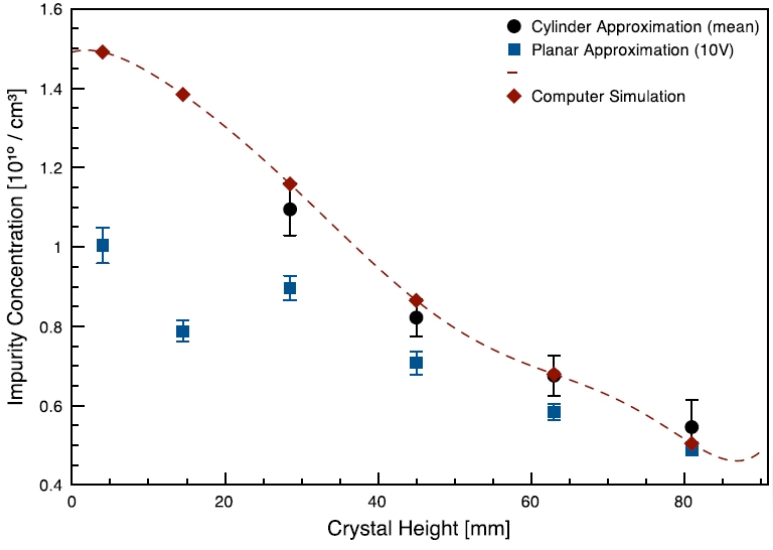


The AGATA Data Library

The AGATA Data Library (ADL) contains the signals for every possible interaction point

- Consider **impurity concentration of the crystal**
- Not constant over whole crystal
- Assumptions: cylindrical symmetry, no radial change, linear gradient from front to back
- Two dimensional optimization problem: Iterative method
- Impurity concentration in the order of $10^{10}/\mathrm{cm}^3$

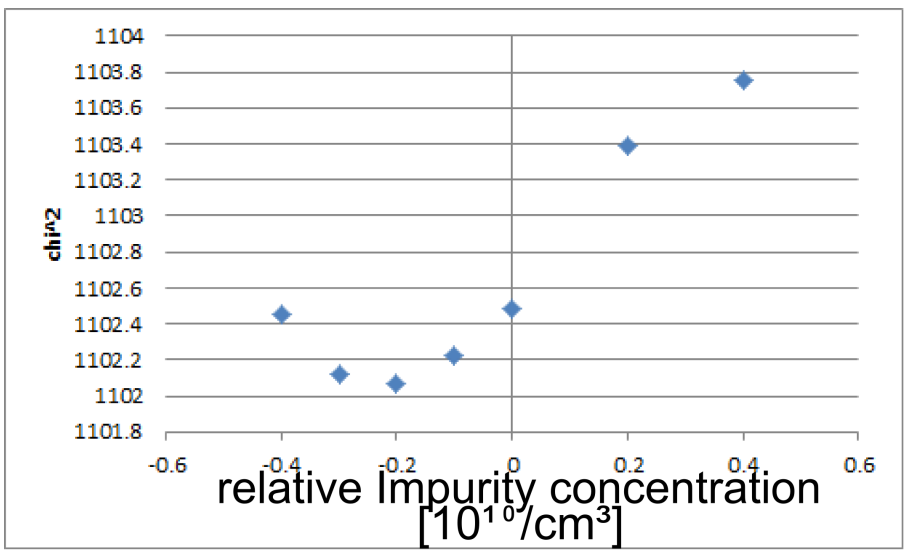


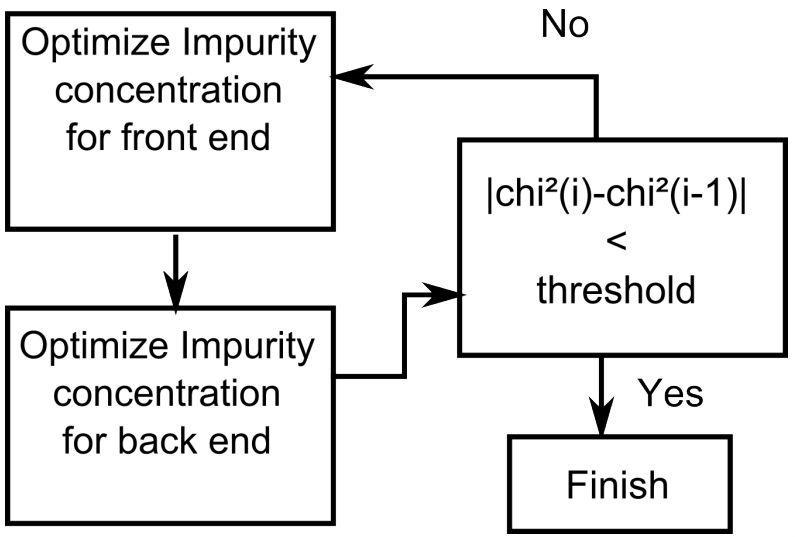


Optimization of the Impurity Concentration

- Use average χ^2 of best fit of all interactions of source run as minimization variable
- Imp. concentration is given relative to start value provided by manufacturer

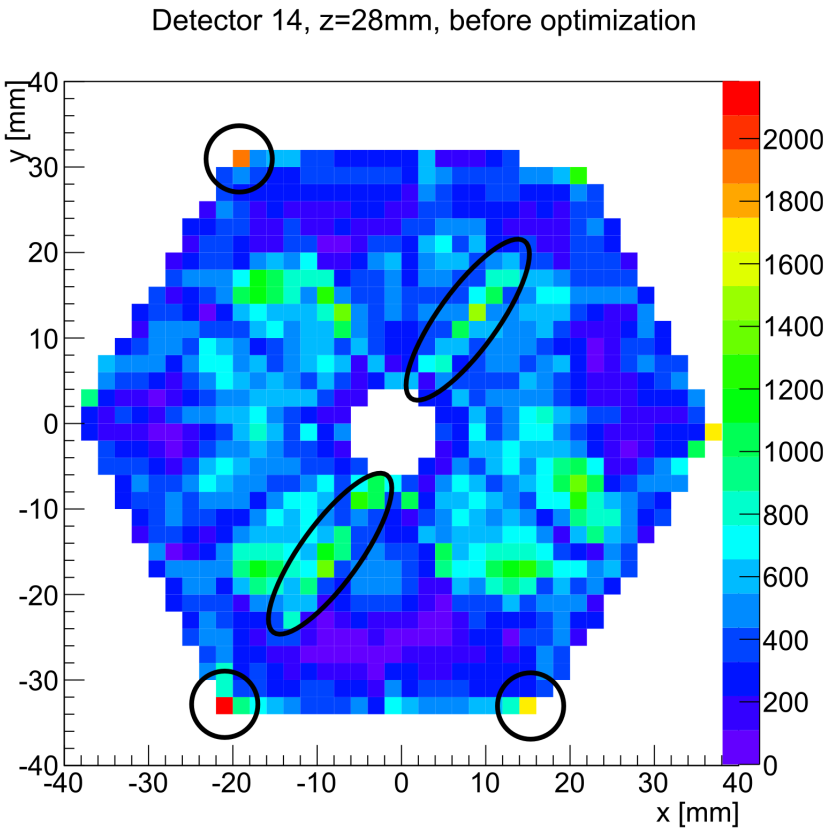
- Imp. Concentrations for back and front not independent and cannot be evaluated separately
- Iterative method uses output of previous step as input

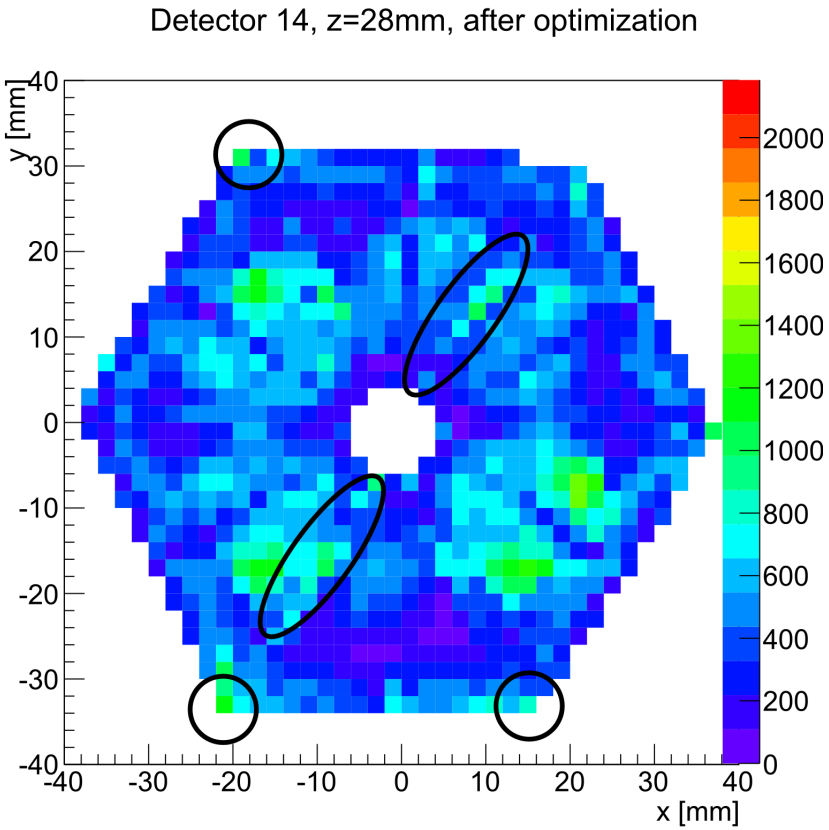




Optimization of the Impurity Concentration

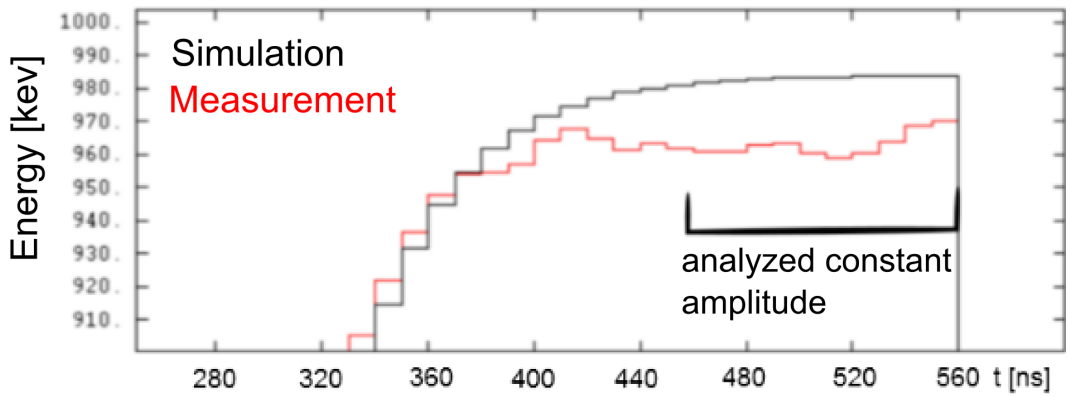
Results of the optimization





Comparison of Measurement and Simulation

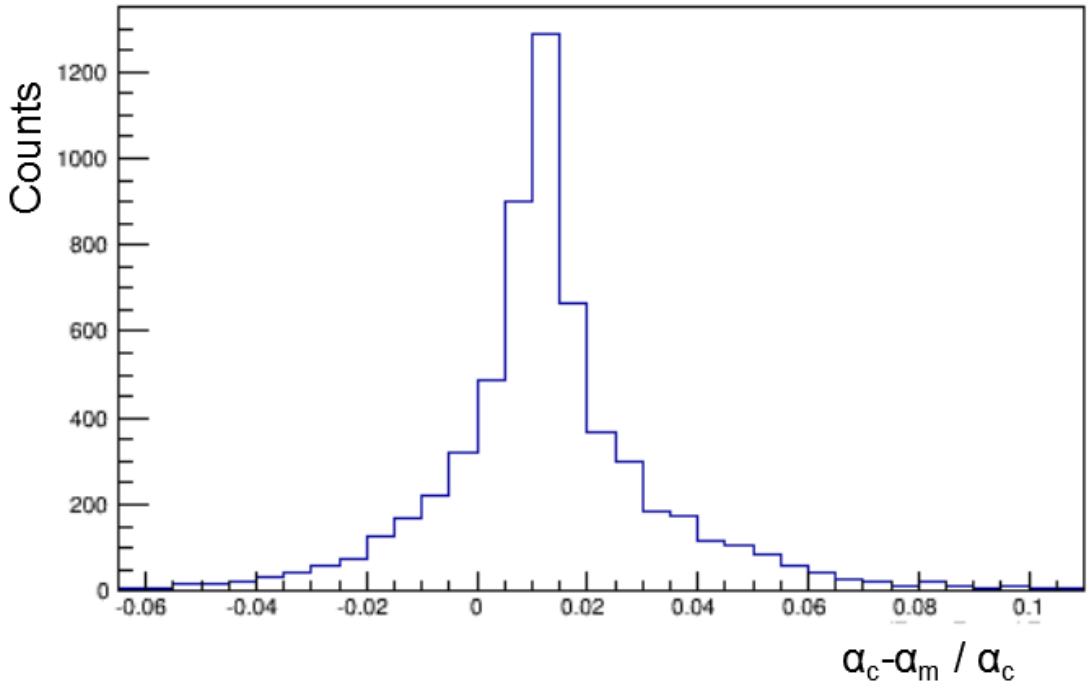
- Amplitudes of measurement and simulation do not coincide
- Systematic deviation



Calibration of calculated signals

- Amplitude of simulation depends on decay time τ of preamplifier

Energy shift of simulation

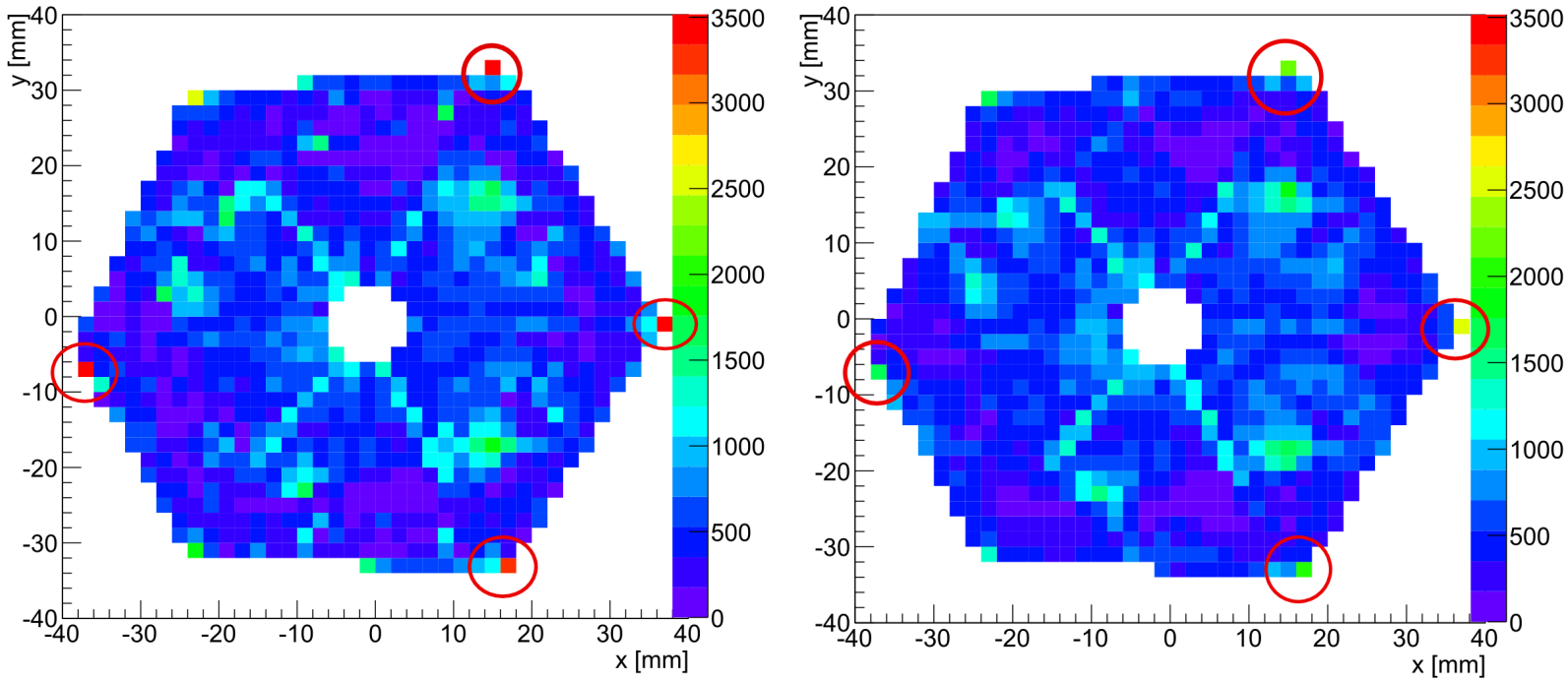


Variation of τ for every preamplifier: 555 parameters!

$$\tau_{\text{new}} = \tau(1 - m), \;\; m = \text{mean of distribution}$$

Impact on PSA

- Improvement of HSGP at highlighted spots



Summary and Outlook

- PSA performance investigated thoroughly (well functioning in general)
- Impurity concentrations have been optimized
- Energy alignment of simulation has been performed
- Improvements in PSA performance could be achieved

Previously optimized PSA parameters

- Distance metric
- Differential Crosstalk
- Preamplifier rise times
- Time alignment

Outlook

- Comparison with experimental data
- Use scanning table data
- Further PSA optimization (transfer function, crystal axis orientation, radial dependence of impurity concentration, ...)

Thank you

Thank you for your attention!

This project is supported by the German BMBF

AGATA Data Library