Status Report ADL and PSA Optimization

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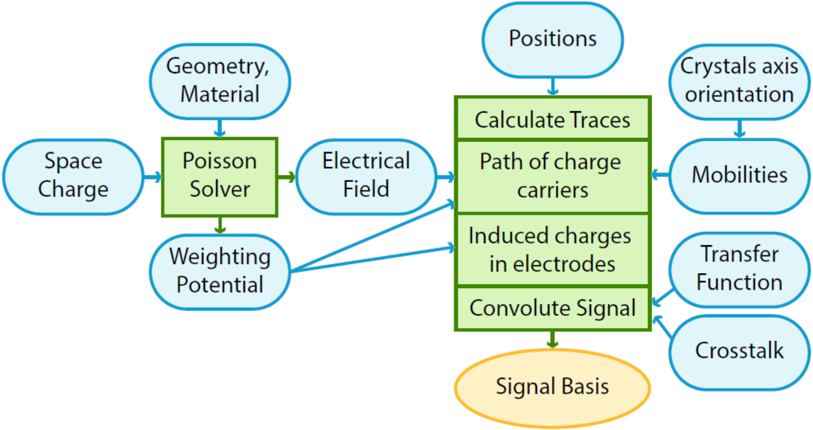
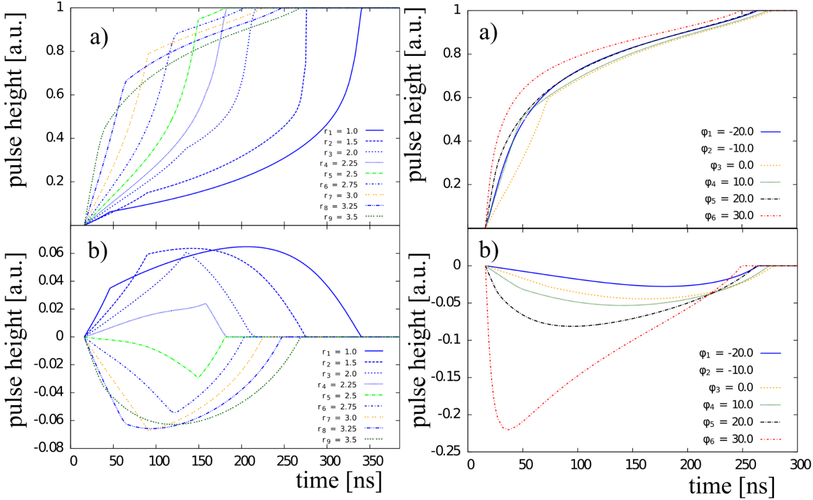
Content

- ADL: Reminder & status
- Time dependence of difference of measured and simulated traces & hole mobility

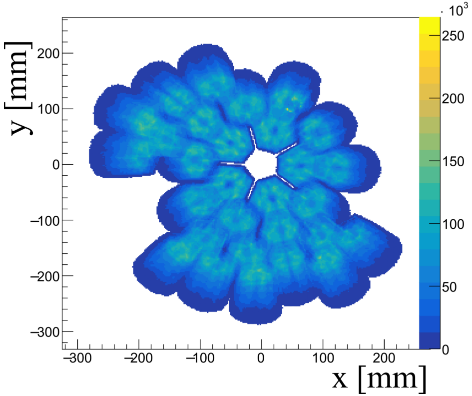
ADL Working Principle



Simulated Signals

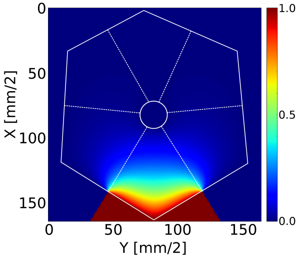


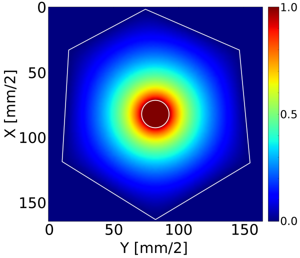
ADL Data Bases



- Data library for each individual crystal
- New ADL bases for new crystals are continuously being provided
- New bases since last AGATA week: A013, B015, B016, C015
- Available at `https://www.ikp.uni-koeln.de/research/agata/index.php?show=download`
- Different approaches (e.g. in-situ base). But as of now ADL still best solution available

ADL Source Code

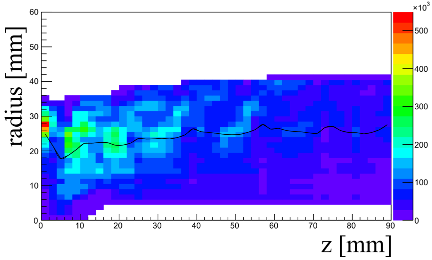


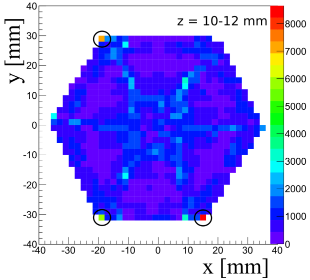


- Source code available at `https://www.ikp.uni-koeln.de/research/agata/index.php?show=download`
- Universal generalizable code, not restricted to AGATA crystals
- Different applications: GERDA signal discrimination, planar detectors, well detectors, GRETINA, ...
- Documentation available
- Bruyneel et al. EPJ A 2016, DOI 10.1140/epja/i2016-16070-9

PSA Results

- Position resolution about 4-5 mm (Söderström et al., Recchia et al.)
- Distribution of interactions: Non-physical allocation of hits
- Tracking efficiency: Simulation vs measurement
- Improve PSA performance





Time evolution of difference of measurement simulation

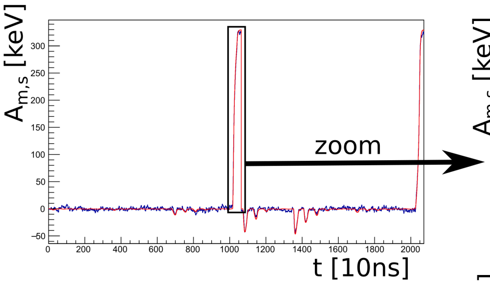
Figure of Merit for grid search

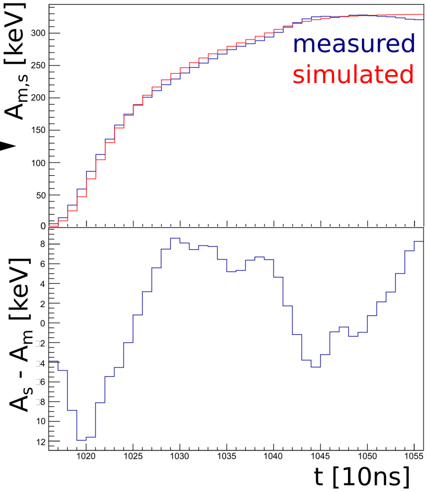
$$\mathrm{FOM} = \sum_{\mathrm{segments}\ i} \sum_{t_j} |A_{i,\mathrm{sim}}(t_j) - A_{i,\mathrm{meas}}(t_j)|^p$$

$A_i(t_j)$ pulse height of segment i at time step t_j

- Loss of information due to abs. value and summing
- Consider time evolution of $A_{i,\mathrm{sim}}(t_j) - A_{i,\mathrm{meas}}(t_j)$
- Search for systematic deviations

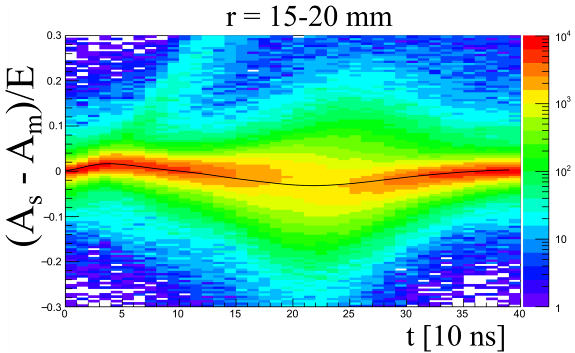
Difference of Measured and Simulated Signals





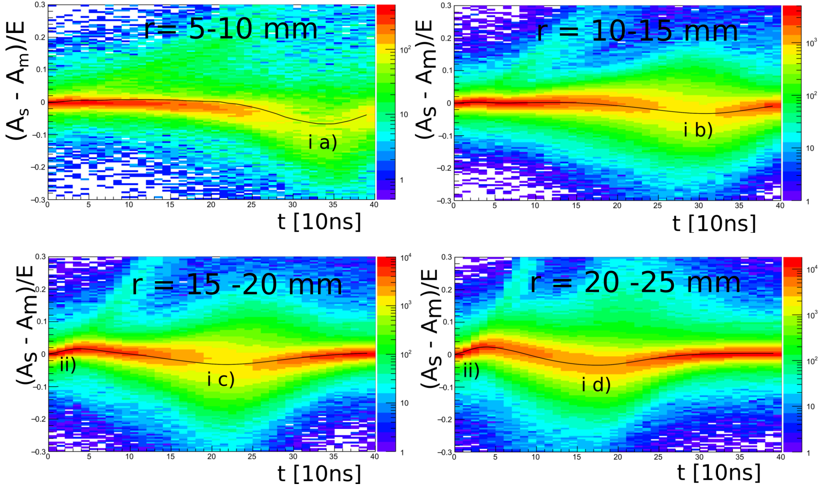
- Zoom on pulse of hit segment
- Difference of measurement and simulation
- Main contribution by noise
- Consider multiple events

Time dependent difference of measurement and simulation

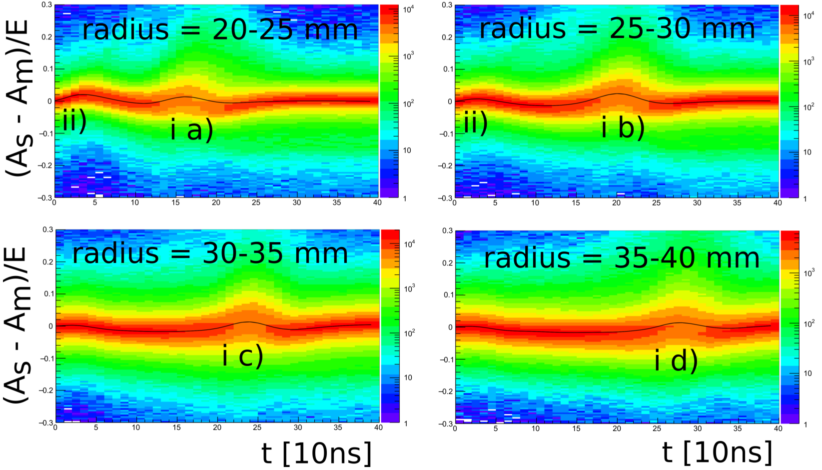


- Normalize traces to energy
- Restrict interaction position to ring three $\Rightarrow$ radial electr. field
- Gate on radius = gate on drift length
- Black line: Mean difference
- Differences very small ✓ but systematic deviations in time present

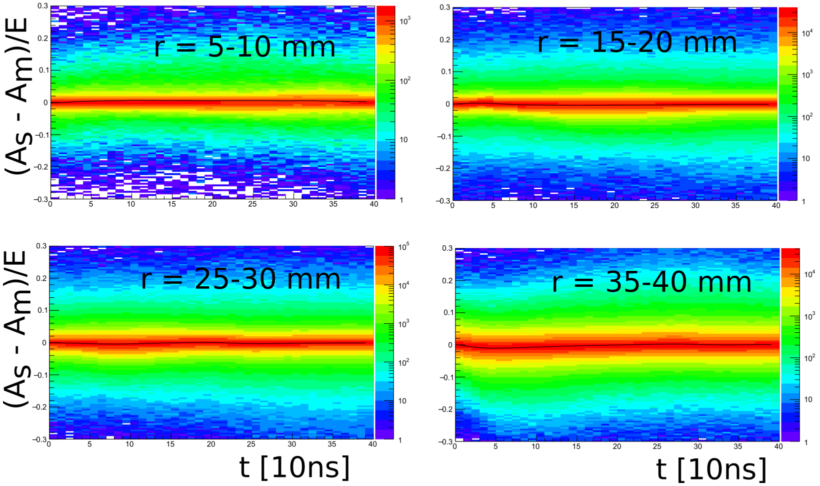
Difference for Segment Signals



Difference for Core Signals



Difference for Transient Signals

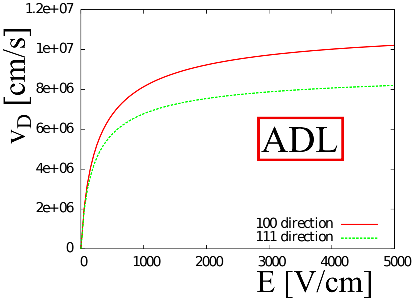


Drift velocities of charge carriers

Empirical model for hole drift velocity

$$v_D = \frac{\mu E}{(1 + (\frac{E}{E_0})^{\beta})^{\frac{1}{\beta}}}$$

v_D drift velocity, μ hole mobility, E electrical field, E_0, β empirical parameters



- Contradicting results/values for hole mobility
- Adjusted mobility $\Rightarrow$ increased PSA performance?

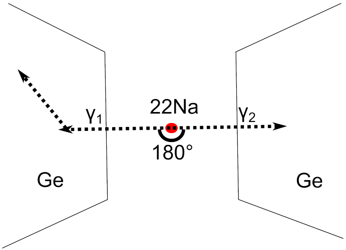
Results for hole mobility

source	$\mu_{<100>}$ $[\frac{\mathrm{cm}^2}{\mathrm{Vs}}]$	$\mu_{<111>}$ $[\frac{\mathrm{cm}^2}{\mathrm{Vs}}]$	remark
Reggiani et al. '77	66333	107270	T=78 K, from fit of $v_D(E)$ data (Bruyneel)
Omar and Reggiani '87	44675	-	T=80 K temperature dependent model $\mu = A/T^p$
Omar and Reggiani '87	33675	-	T=90 K GRETINA (?)
Bruyneel et al. '06	61824	61215	measured with MINIBALL
Bruyneel	62934	62383	measured with symmetric AGATA triple

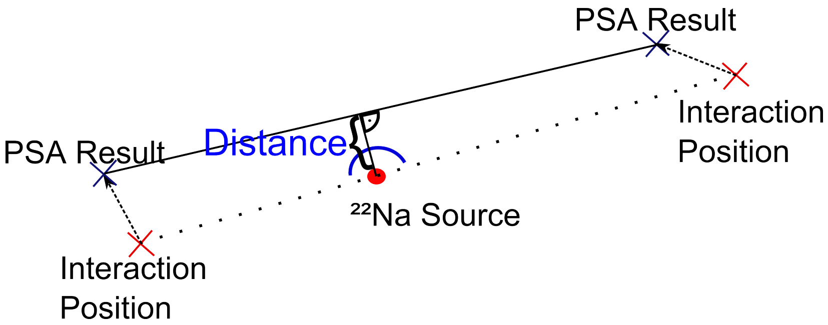
- Contradicting values

Determination of hole mobility

- For given empirical model - which mobility yields best results?
- ^{22}Na measurement for assessment of PSA performance

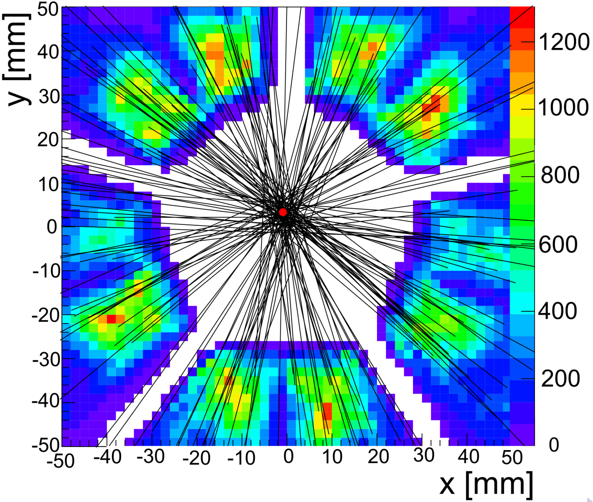


Principle

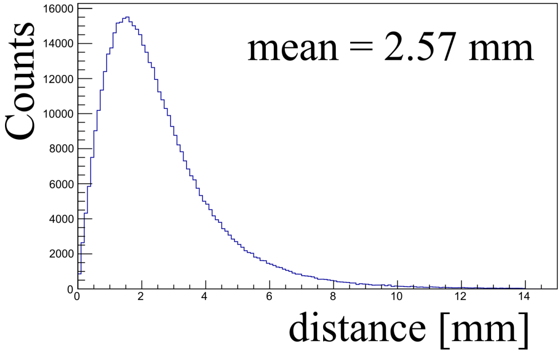


- β^+-decay of ^{22}Na
- Coincident detection
- Difference PSA result and physical interaction position
- Distance describes PSA performance

Visualization

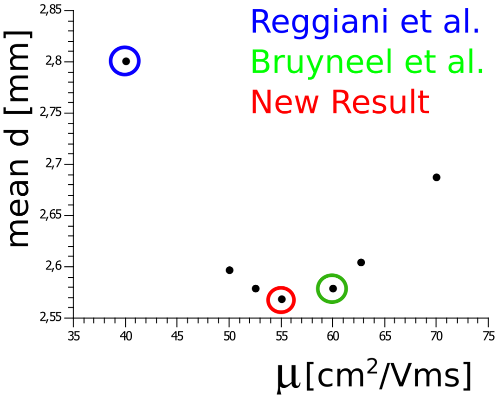


Distance to Source



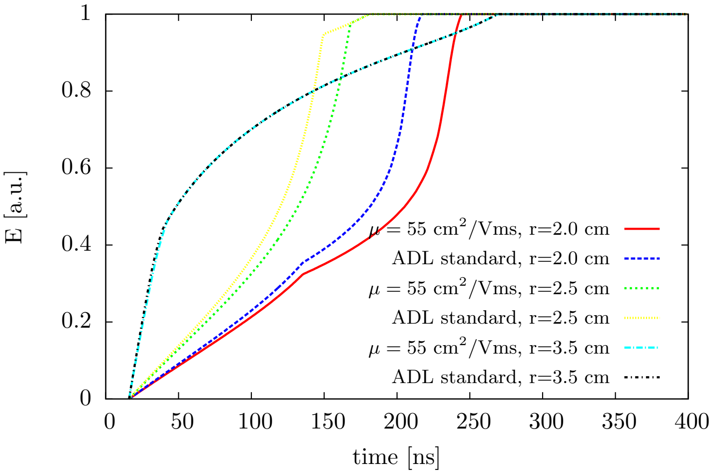
- Distance source position to line calculated event-by-event
- Mean distance used to optimize PSA

Variation of Hole Mobility



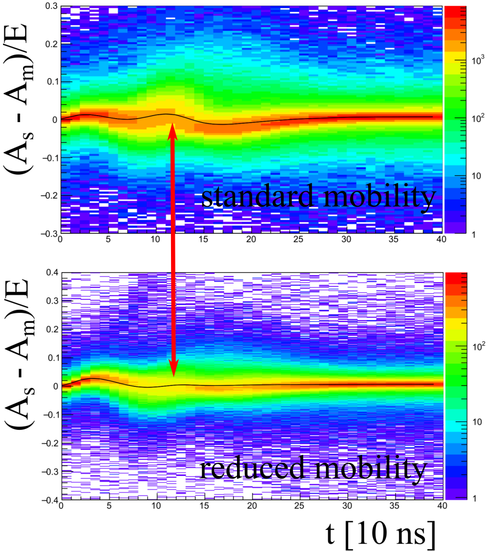
- Each variation step: New ADL for all crystals, repeat PSA, repeat ^{22}Na analysis. Time consuming
- Optimal mobility at 55 $\frac{\mathrm{cm}^2}{\mathrm{Vms}}$ very close to ADL value

Impact on Simulated Traces



- Notable impact for small radii
- (Nearly) no difference for larger radii (holes collected quickly)

Impact on Difference of Measurement and Simulation



- Core signal at radius r = 15-20 mm
- Slightly improved agreement
- Systematic deviations still present
- (Less statistics in 2nd picture)

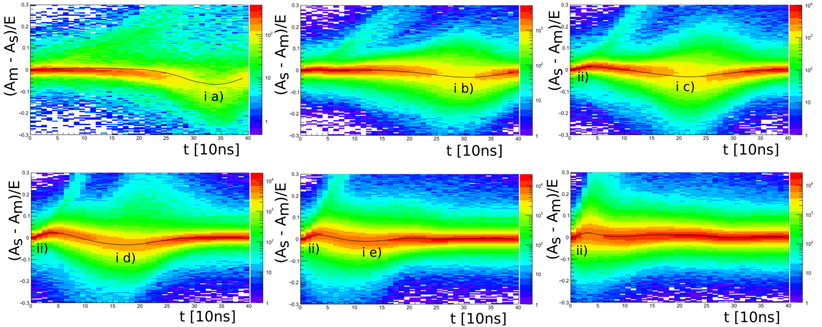
Summary

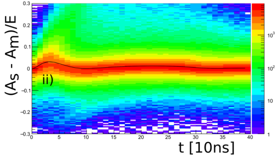
Summary

- Continuous supply of ADL bases for new crystals
- Data bases for all crystals in frame (+more) available for download
- (Small) systematic deviations of measurement and simulation
- Investigation of hole mobility and drift velocity
- Hole mobility reduced by $\sim$10% yields slightly improved results

Thank you for your attention

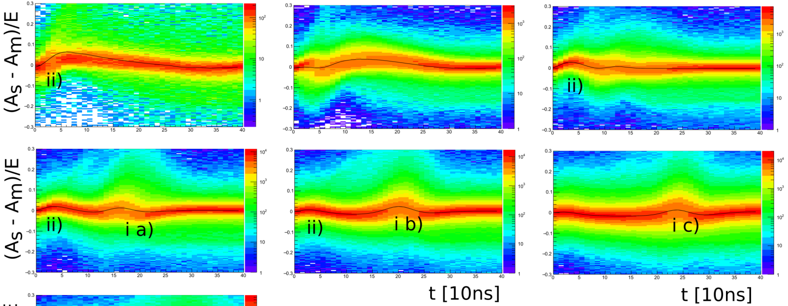
Segments

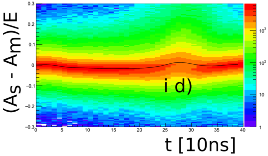




- Systematic deviation correlated with completed charge collection of holes i a-e)
- Overestimation of measurement in first few ticks ii)

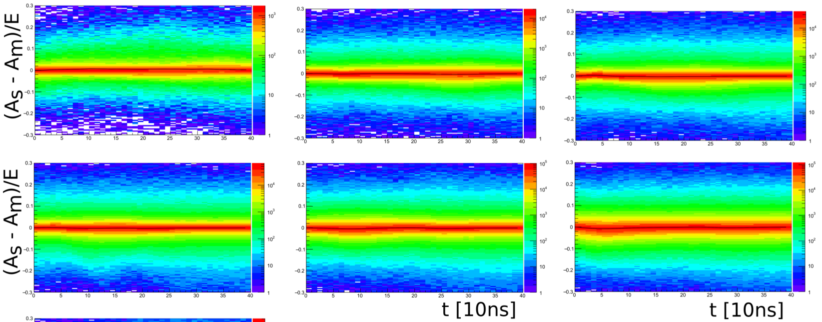
Segments

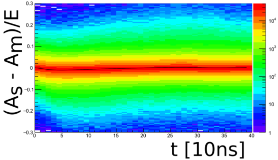




- Systematic deviation correlated with completed charge collection of electrons i a-e)
- Overestimation of measurement in first few ticks ii)

Transients





- Transient signals (neighboring segments)
- No systematic deviations in time

Drift Velocity parameters

Table 1
An overview of charge carrier mobility data in Ge at 78 K. The fit parameters to Eq. (1) for the electron and hole mobility along the ⟨1 0 0⟩ a
⟨1 1 1⟩ direction are presented. The parameters obtained from the data by Reggiani et al. [16] correspond to the fit shown in Fig. 6

Ref.	⟨1 0 0⟩ direction				⟨1 1 1⟩ direction			
	μ_0	β	E_0(V/cm)	μ_n	μ_0	β	E_0(V/cm)	μ_n
(A) *Electron mobility parameters* (μ in (cm^2/Vs))								
[14]	40180	0.72	493	589	42420	0.87	251	62
[10]	38609	0.805	511	−171	38536	0.641	538	510
(B) *Hole mobility parameters* (μ in (cm^2/Vs))								
[16]	66333	0.744	181	–	107270	0.580	100	–
[10]	61824	0.942	185	–	61215	0.662	182	–