The Advanced Gamma Tracking Array detector characterisation

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http://www.gsi.de/agata/
Ingredients of $\gamma$-Tracking

1. Highly segmented HPGe detectors
2. Digital electronics to record and process segment signals
3. Pulse Shape Analysis to decompose recorded waves
4. Identified interaction points $(x,y,z,E,t)_i$
   - Reconstruction of tracks e.g. by evaluation of permutations of interaction points

Reconstructed $\gamma$-rays
Hexaconical Ge crystals
90 mm long
80 mm max diameter
36 segments
Al encapsulation
0.6 mm spacing
0.8 mm thickness
37 vacuum feedthroughs
Detector assembly
AGATA detector status

- Symmetric detectors
  - 3 delivered
- Asymmetric detectors
  - 19 ordered (9 accepted, 4 in test, 2 not accepted, 4 to be delivered)
- Preamplifiers available
  - Core (Cologne);
  - Segment (Ganil & Milano)
- Test cryostats for characterisation
  - 5 delivered
- Triple cryostats
  - 5 ordered
  - 1 complete, 2 being assembled, 2 ordered
Ingredients of $\gamma$-Tracking

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2. Reconstruction

3. Pulse Shape Analysis to decompose recorded waves

4. Identified interaction $(x,y,z,E,t)_i$

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- Reconstructed $\gamma$-rays
Detector Characterisation and PSA

- Calibrate detector response function
- Comparison of real and calculated pulse shapes
- Coincidence scan for 3D position determination
- Validate codes

“How well your basis fits your real data”
AGATA detector scanning

[Diagram showing the AGATA detector setup with labeled components such as Support structure, Dewar, LVDS cables, Detector cryostat, Scatter collimators, Scintillators, Steel plate, Pb collar, Injection collimator, Source housing, Parker scanning table, Scintillator pre-amp box, and Base frame.]
Azimuthal Position Information

* Image Charge Asymmetry (ICA)

\[
ICA = \left| A_{\text{anticlockwise}} \right| - \left| A_{\text{clockwise}} \right| + \left| A_{\text{anticlockwise}} \right|
\]
\[
ICA = \frac{|A_{\text{above}}| - |A_{\text{below}}|}{|A_{\text{above}}| + |A_{\text{below}}|}
\]

*Vertical Image Charge Asymmetry*

Sectors C and D

Depth Information

Back view
AGATA Coincidence scanning

Scatter collimator depth in crystal
- D1 & D7 = 6.4mm
- D2 & D8 = 17.9mm
- D3 = 33.4mm
- D4 = 51.0mm
- D5 = 67.2mm
- D6 = 85.9mm
- D9 = 33.1mm
- D10 = 51.8mm

Source
AGATA Coincidence scanning

- 16 radial scans + 4 azimuthal scans

- $\sqrt{r,\theta}$ grid adopted
- 1200 positions
Azimuthal detector sensitivity

$r = 24\text{mm}$
$z = 7.3\text{mm}$
$\theta = 171.9^\circ$

AGATA detector characterisation
Electric Field Simulations: MGS

- Electric field simulations have been performed and detailed comparisons have been made with experimental pulse shape data.
"Superpulse generation"

Zone 2, $x = 5.7 \pm 0.7 \text{mm}, y = -9.4 \pm 0.7 \text{mm}, z = 15.7 \pm 0.3 \text{mm}.$
Experiment vs Theory Performance

![Graph showing displacement vectors with coordinates and labels: A4, B4, C4, E4, F4.](image)

**a) Displacement vectors, \( z = 4.8 \pm 0.3\text{mm} \)**

**a) Displacement vectors, \( z = 48.8 \pm 0.9\text{mm} \)**

<table>
<thead>
<tr>
<th>Depth (mm)</th>
<th>Ring</th>
<th>Min Displacement (mm)</th>
<th>Max Displacement (mm)</th>
<th>(&lt;\text{Displacement (mm)}&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2±0.3</td>
<td>1</td>
<td>0.1±0.4</td>
<td>11.9±0.4</td>
<td>2.2±0.4</td>
</tr>
<tr>
<td>15.7±0.3</td>
<td>1</td>
<td>0.2±0.6</td>
<td>17.3±0.6</td>
<td>2.7±0.6</td>
</tr>
<tr>
<td>48.8±0.3</td>
<td>4</td>
<td>0.1±0.7</td>
<td>17.0±0.7</td>
<td>2.6±0.7</td>
</tr>
</tbody>
</table>
Status of the PSA

3 types of codes:

• Whole crystal with multi-hits per segment
  – Genetic algo. (Padova, Munich)
  – Swarm algo. (Munich)
  – Adaptative grid search (Padova)
  – Matrix method (Orsay)

• Single-hit in one segment
  – Binary search (Darmstadt)
  – Neural network (Munich, Orsay)

• Determination of the number of hits
  – Recursive subtraction (Milan)
  – Matrix method (Orsay)
Pulse-Shape Analysis: current status

Results from the analysis of an in-beam test with the first triple module, e.g. Doppler correction of gamma-rays using PSA results

\[ d^{(48}\text{Ti, }p)^{49}\text{Ti}, \nu/c \sim 6.5\% \]

Results obtained with Grid Search PSA algorithm (R. Venturelli et al.)

Position resolution \(\sim 4.4\) mm
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