Ge detectors developments

### G. Duchêne and J. Gerl

G. Duchêne

Summary

❑Introduction

❑ The GSI and IPHC scanning tables

❑ Ge detector characterisation

❑ Imaging

❑ Ge detector R&D

❑ The LEGEND-200 case

❑ Our project in the frame of DMLab

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ϒ-ray tracking

❑ **AGATA**

(Advanced GAmma Tracking Array)

➤ Encapsulated, electrically segmented, hyper pur Ge (HPGe) detectors

➤ Digital electronics

➤ Pulse-shape analysis (PSA)

➤ Gamma-ray tracking

➤ 4π array = 180 capsules

➤ Presently = 57 capsules

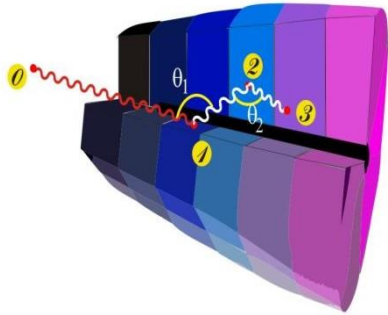➤ Phase 2 (2030) = 135 capsules
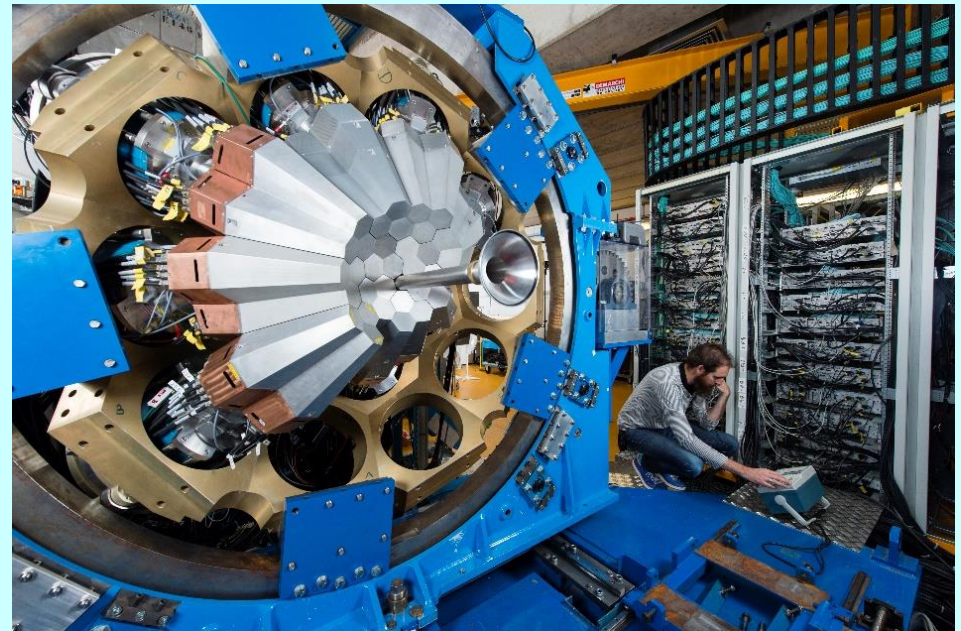
AGATA paper   *S. Akkoyun et al., NIM A668, 26 (2012)*
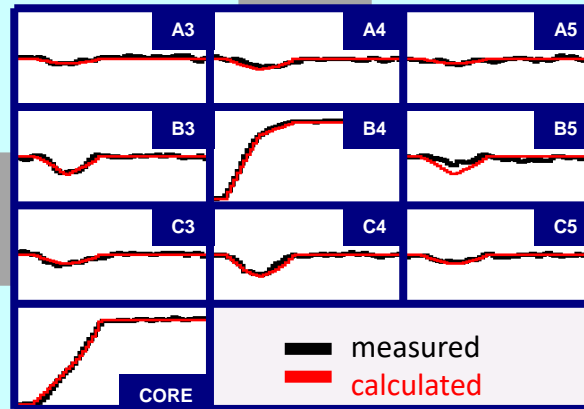*AGATA Phase 2 white book*   *W. Korten et al., EPJ A56, 137 (2020)*

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Ingredients of gamma-ray tracking
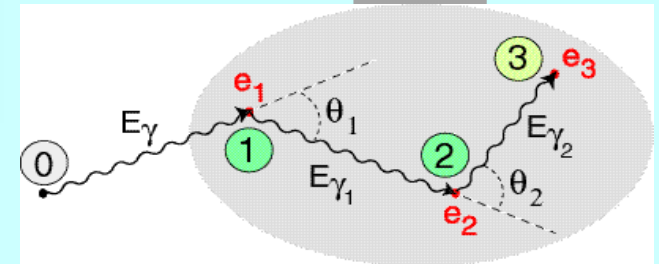
Reconstruction accuracy
Pulse-shape analysis (PSA) + ϒ tracking

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The GSI and IPHC scanning tables

Chi2 technique for pulse-shape selection

Pulse Shape Comparison Scan (PSCS)   IPHC

Database of ~48500 points

VERTICAL CONF.

HORIZONTAL CONF.

Scan pitch

X or Y axis

X or Y axis
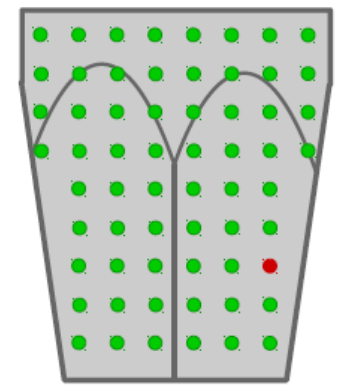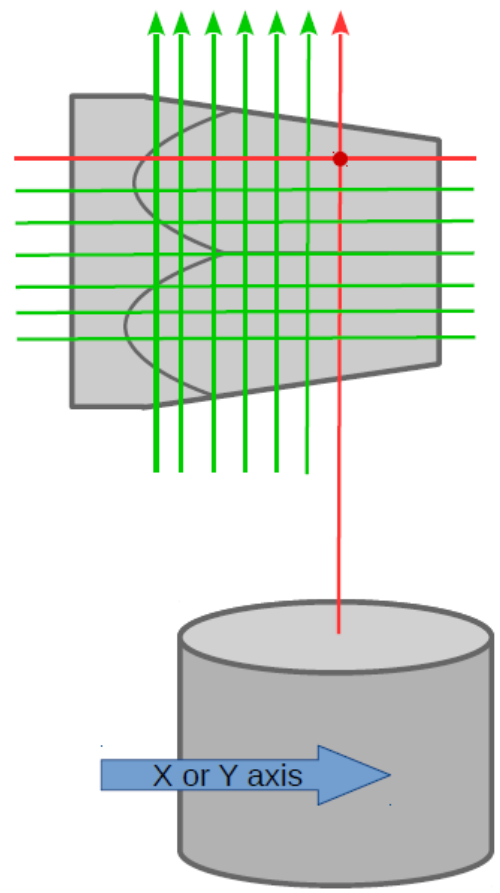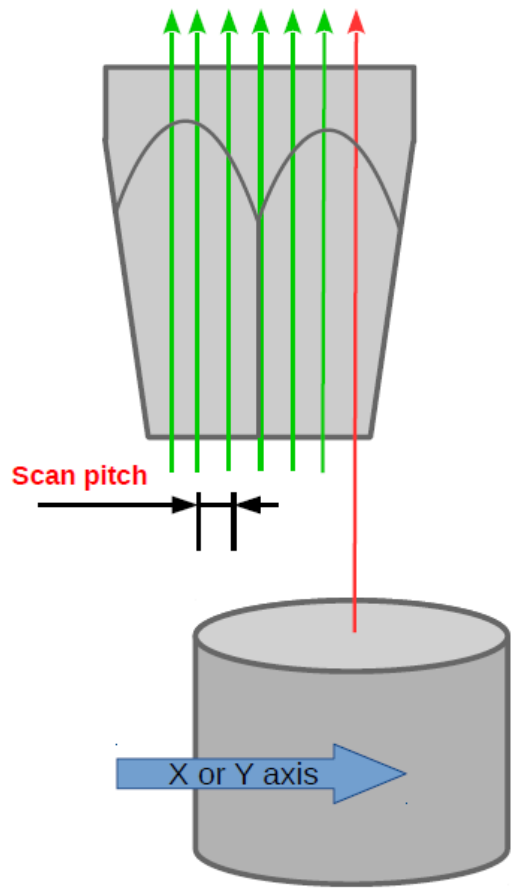
- Quite fast (full volume in 2 weeks)
- Several sources: ^{241}Am (60 keV), ^{137}Cs (662 keV), ^{152}Eu (122 - 1408 keV)
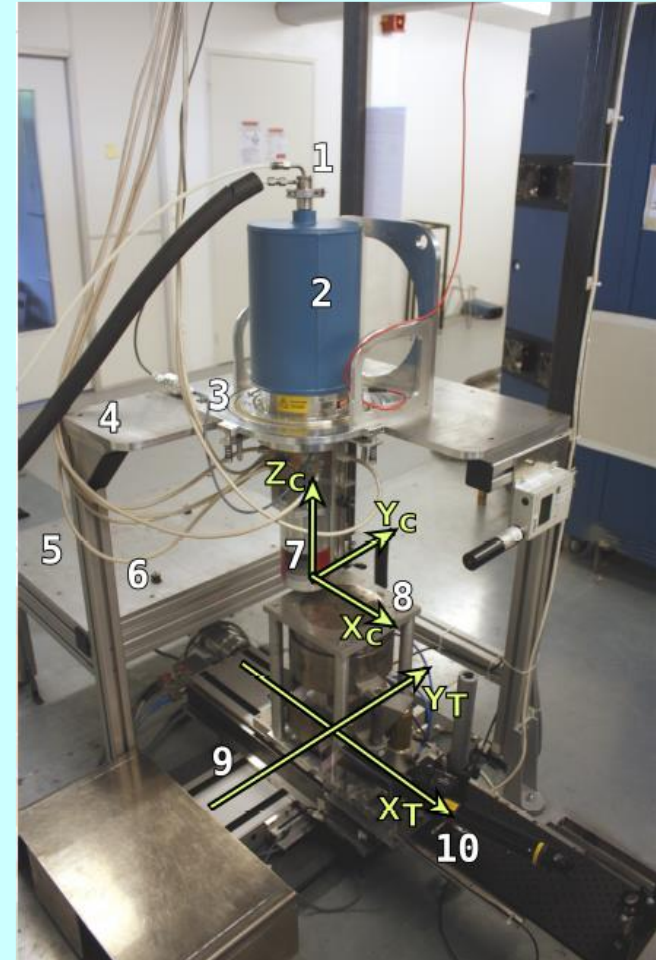- Single and multiple interactions selected

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The GSI scanning table
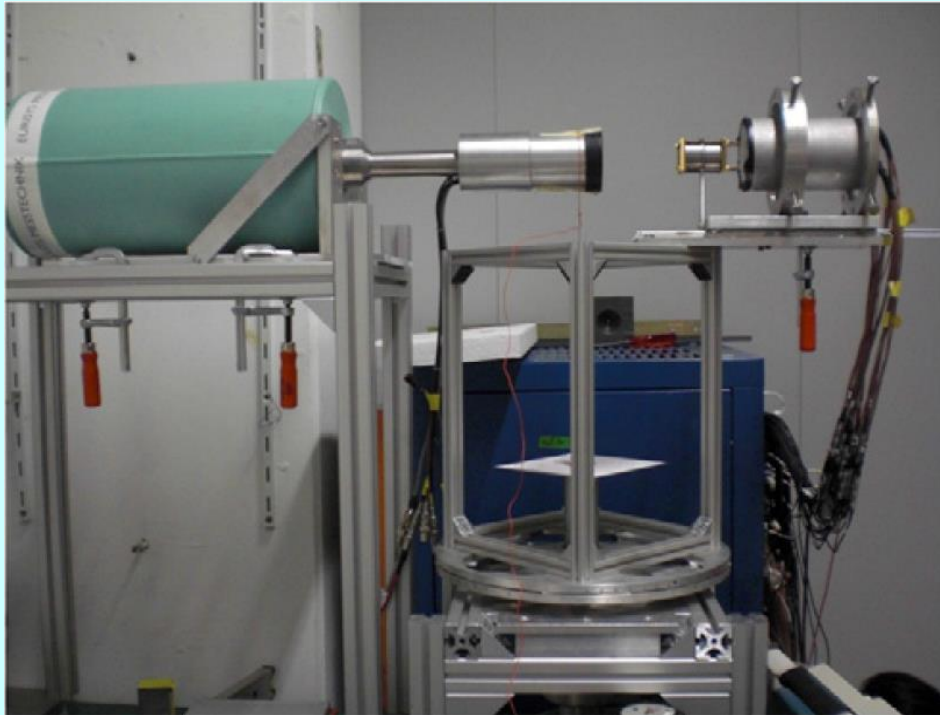
N. Goel et al., NIM A652, 591 (2011)

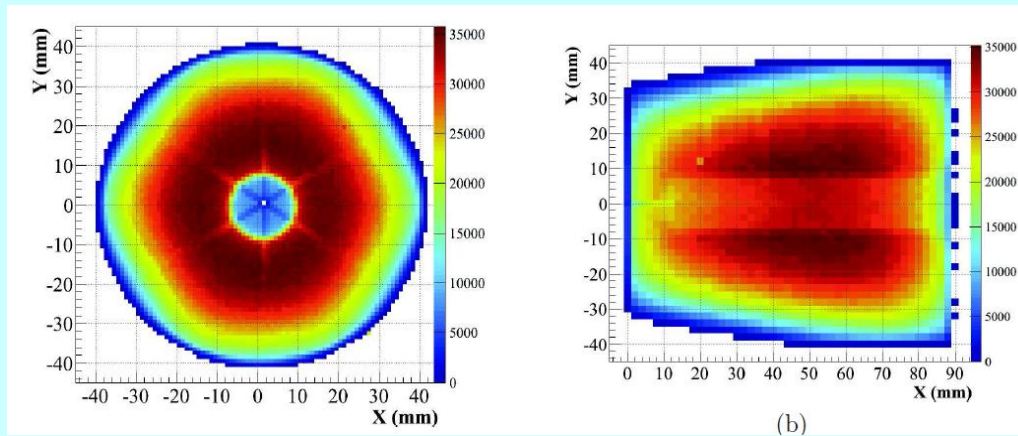B. De Canditiis et al., EPJ A56, 276 (2020), EPJ A57, 223 (2021)

The IPHC scanning table

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09/12/2021

Université de Strasbourg

DMLab kickoff meeting

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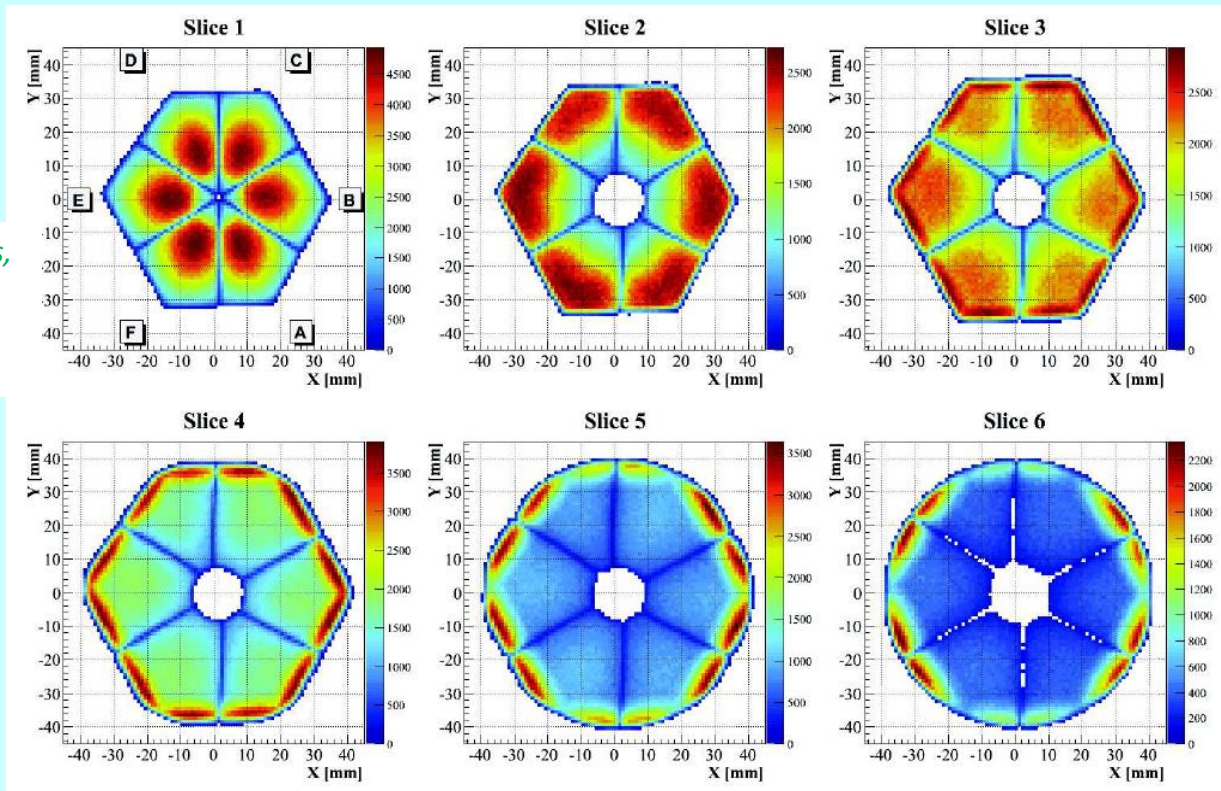
Ge detector characterisation

Total energy

Local detection efficiency

B. De Canditiis PhD thesis, Strasbourg university http://www.theses.fr/ 2020STRAE008

Segment slices

Slice 1 Slice 2 Slice 3
Slice 4 Slice 5 Slice 6

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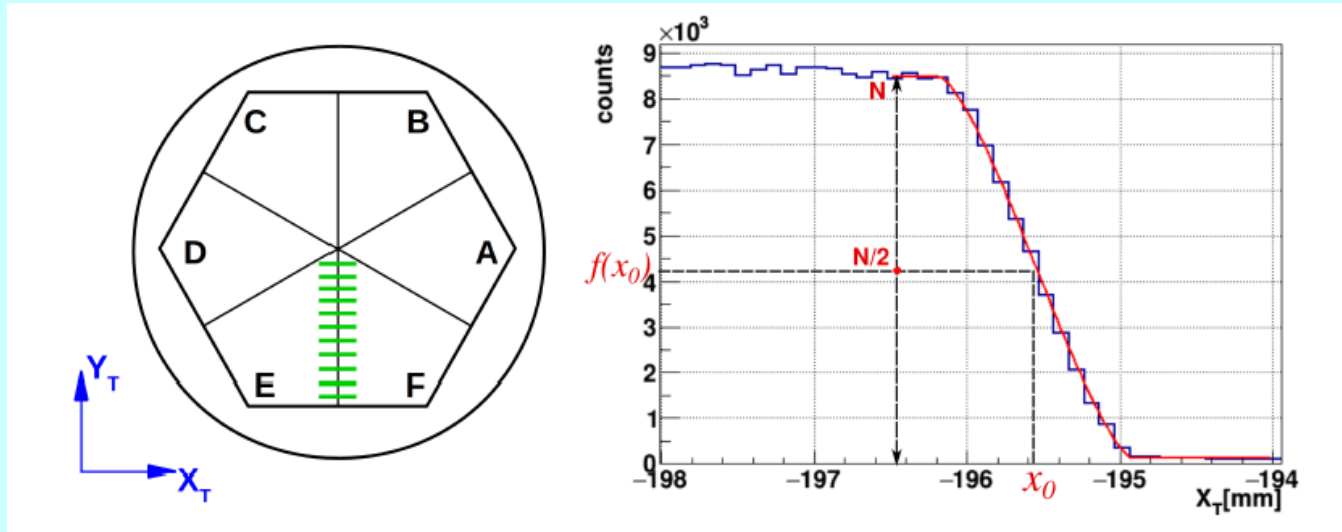
Width of the segmentation line determined within +/- 6 μm
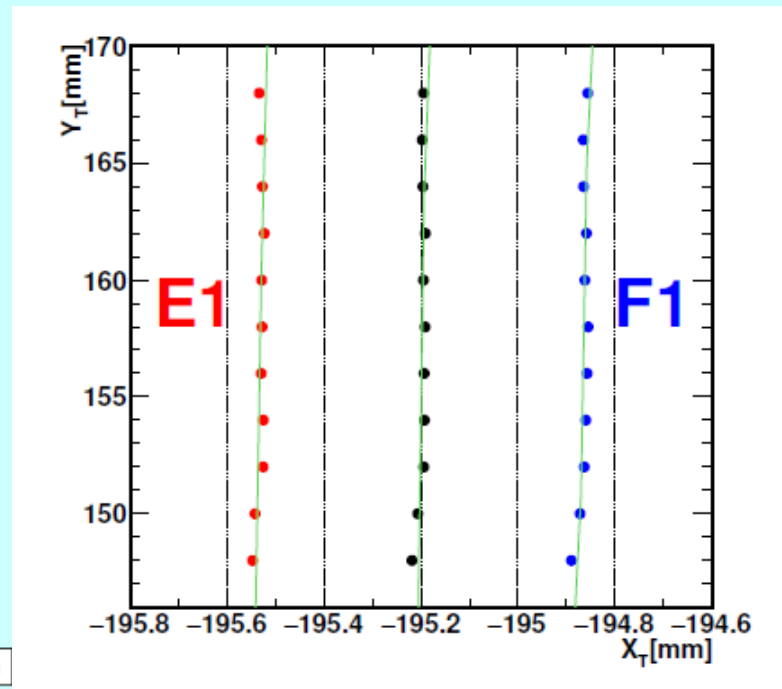
B. De Canditiis PhD thesis,

Ge detector characterisation

Risetime determination within +/- 1 ns

B. De Canditiis PhD thesis,

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Ge detector characterisation
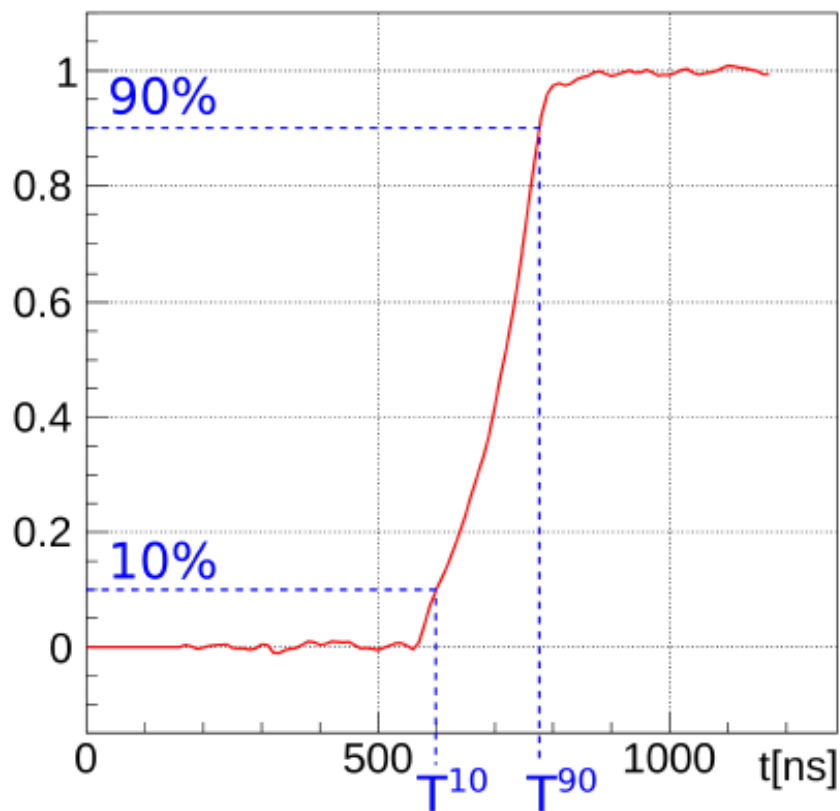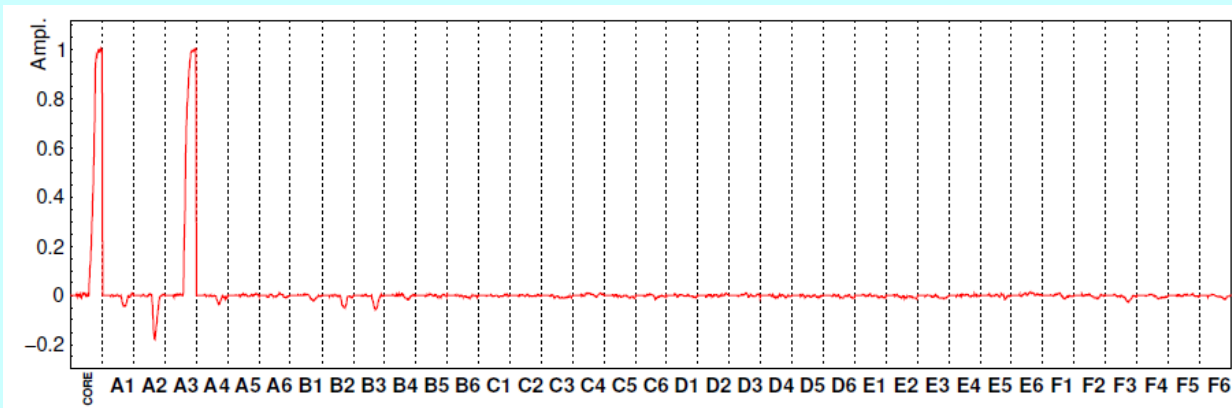

Determination of the Ge crystal lattice orientation
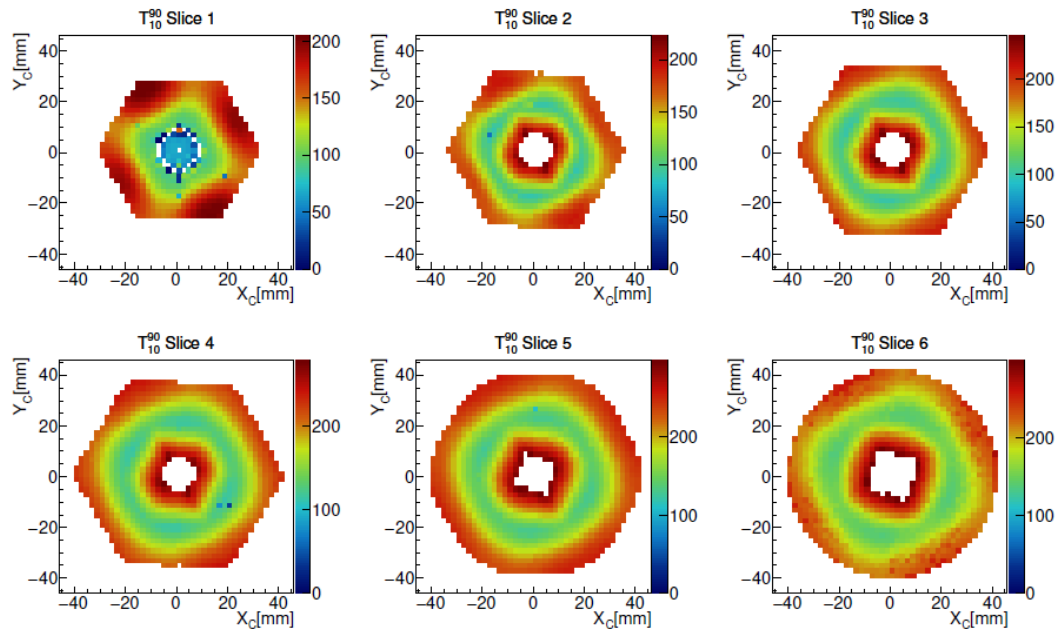
B. De Canditiis PhD thesis,

Ge detector characterisation

Ge crystal lattice orientation
within +/- 0.4°

B. De Canditiis PhD thesis,

G. Duchêne

09/12/2021
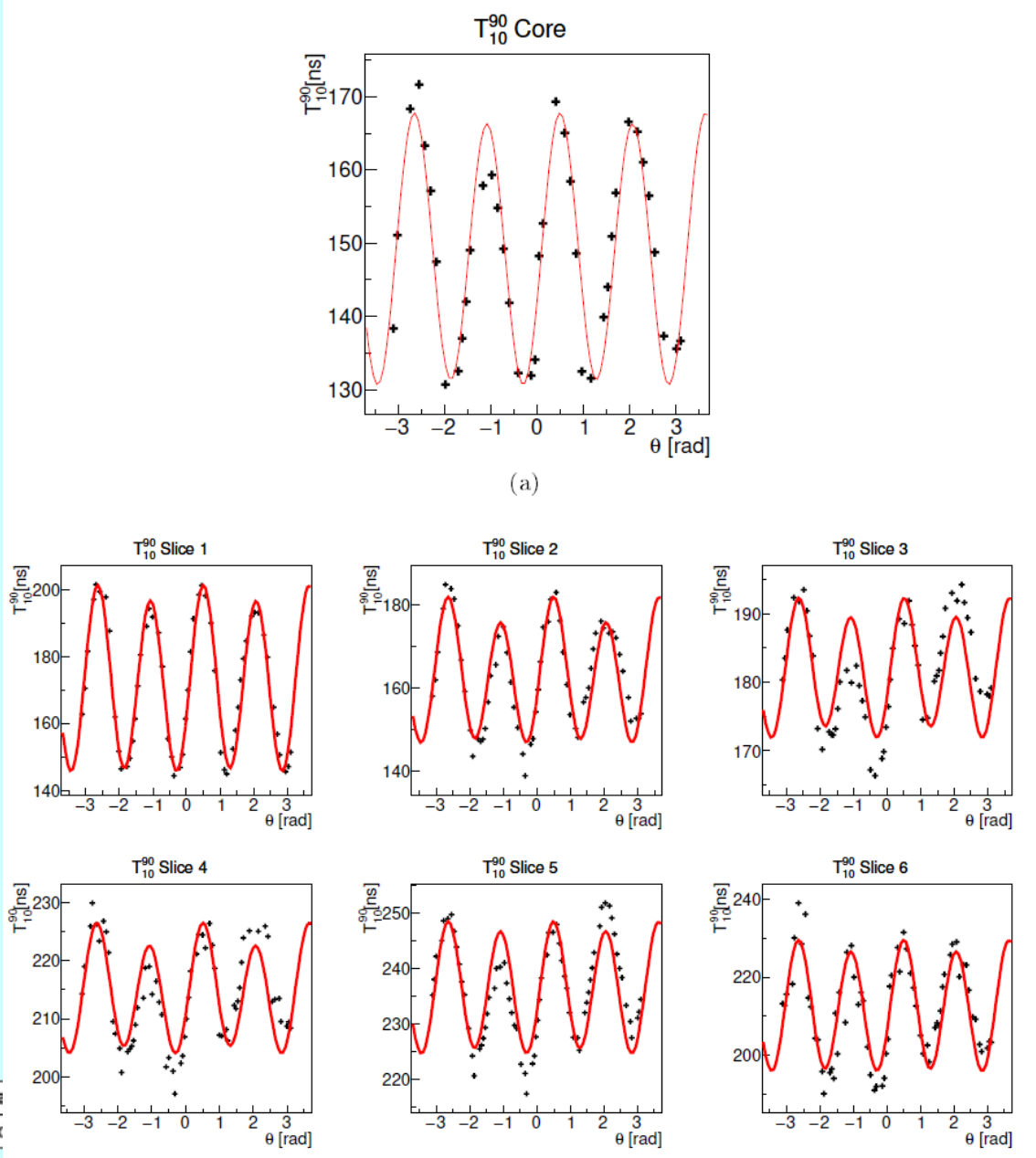
13

Ge detector characterisation

Charged carrier trapping

B. De Canditiis PhD thesis,

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Charged carrier trapping

B. De Canditiis PhD thesis,

G. Duchêne

Ge detector characterisation

Charged carrier trapping

B. De Canditiis PhD thesis,

DMLab kickoff meeting

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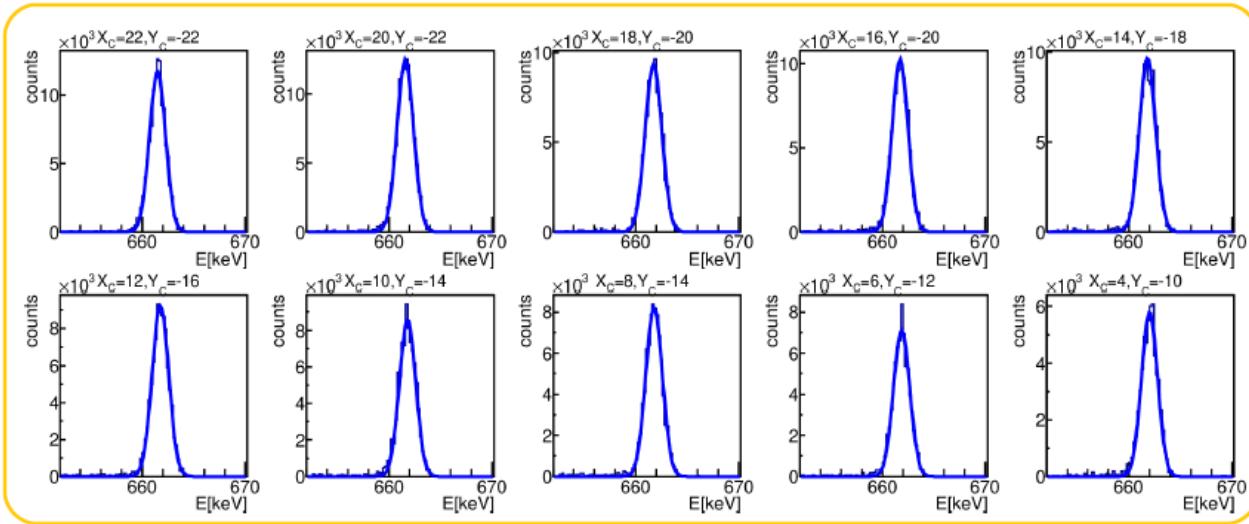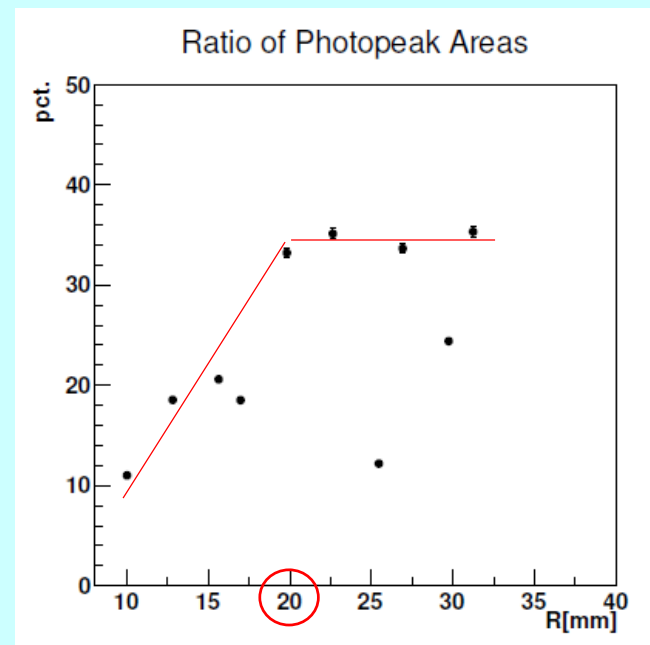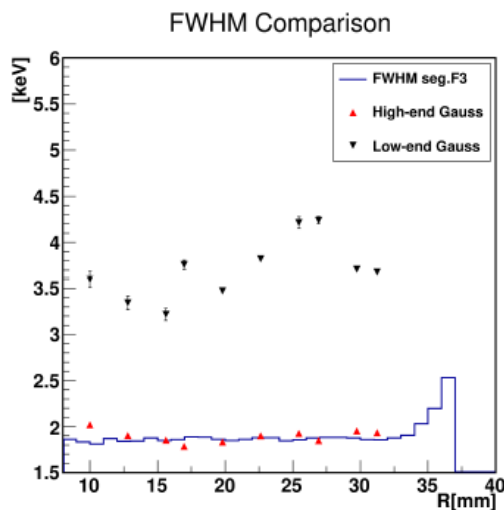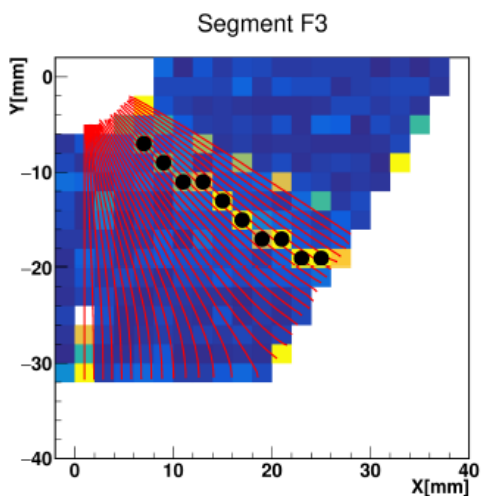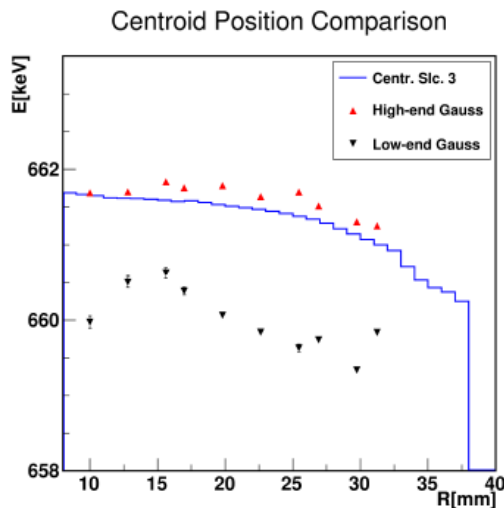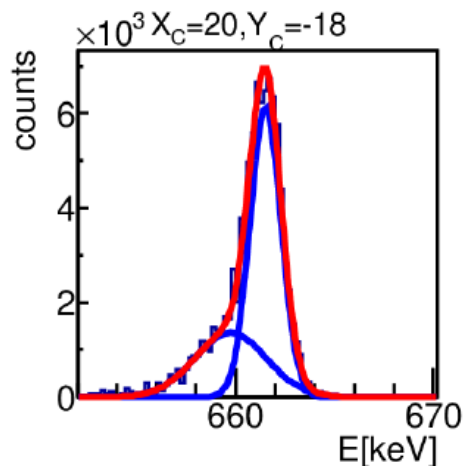
Ge detector R&D

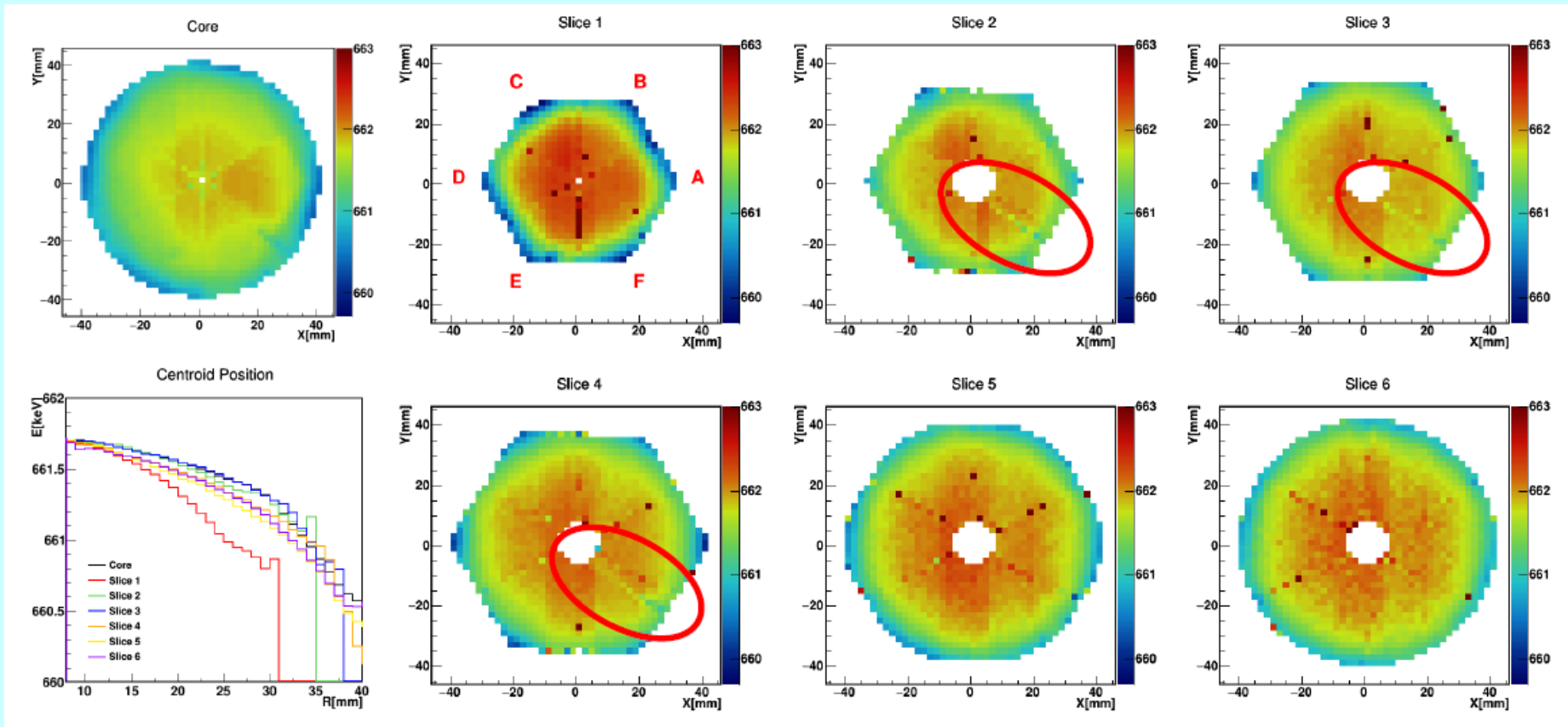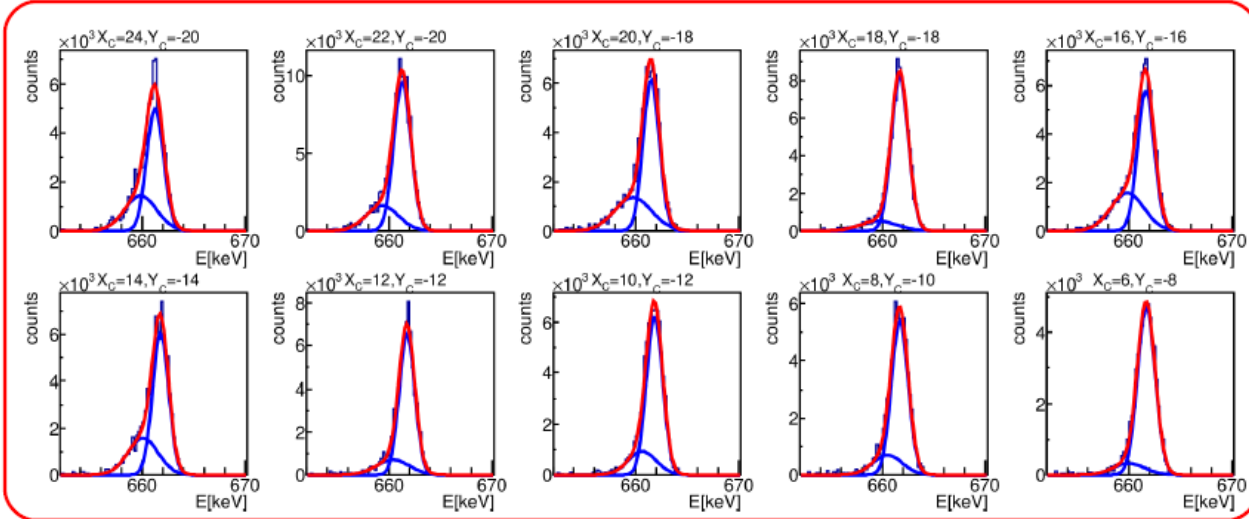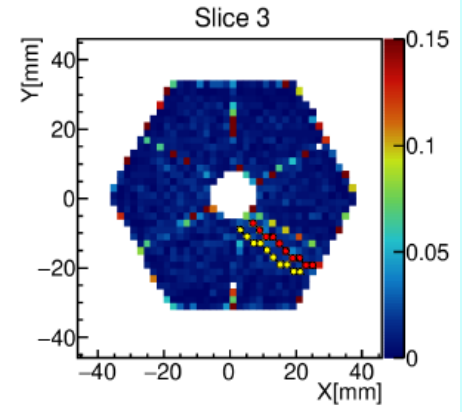❑ Improve detector spatial sensitivity

  ➤ Shift the segments from a segment slice to the next

    ❖ Increase the number of neighbouring segments

  ➤ ANR project rejected (Univ. Lyon, IJCLab Orsay, GANIL Caen, IPHC Strasbourg)

  ➤ In the R&D plan of AGATA phase 2

Courtesy J. Dudouet Lyon Uni

G. Duchêne
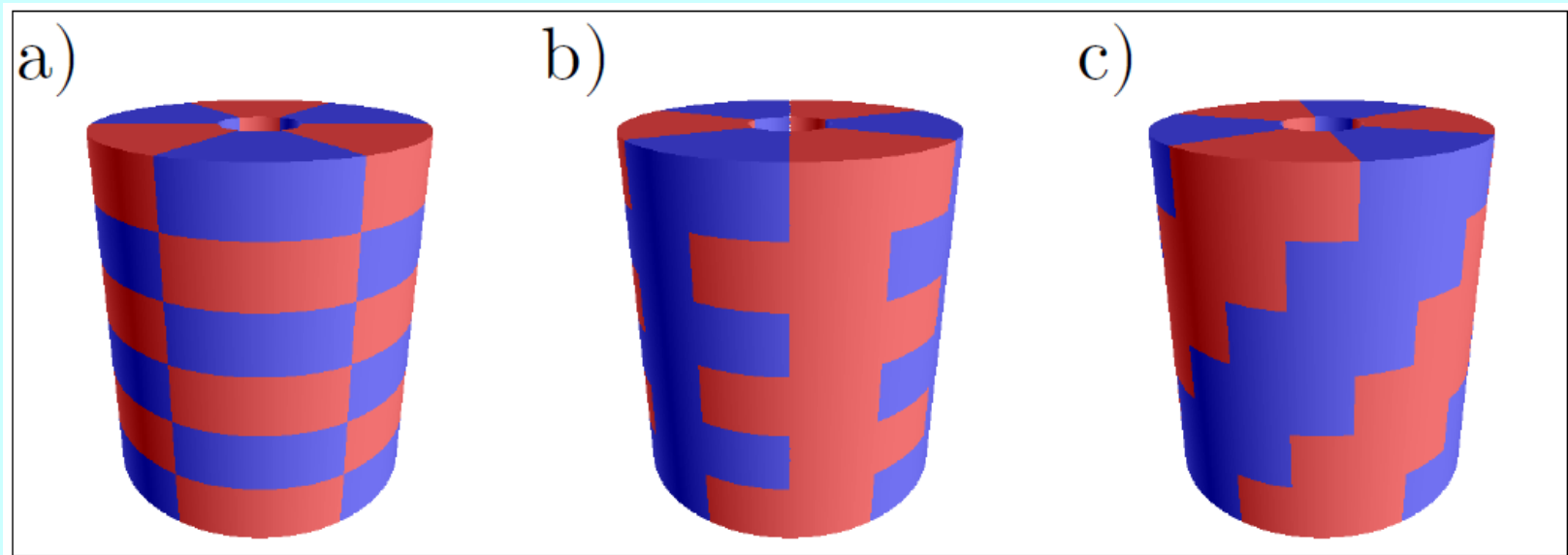
Ge detector developments

- Electric segmentation (Mirion)
- New encapsulation (IKP Köln)
- Point contact detectors (Mirion)
- Coaxial inverted detectors (Radford)

*Courtesy J. Wright
Liverpool Uni*

SIGMA detector

de Strasbourg

Ge detector R&D
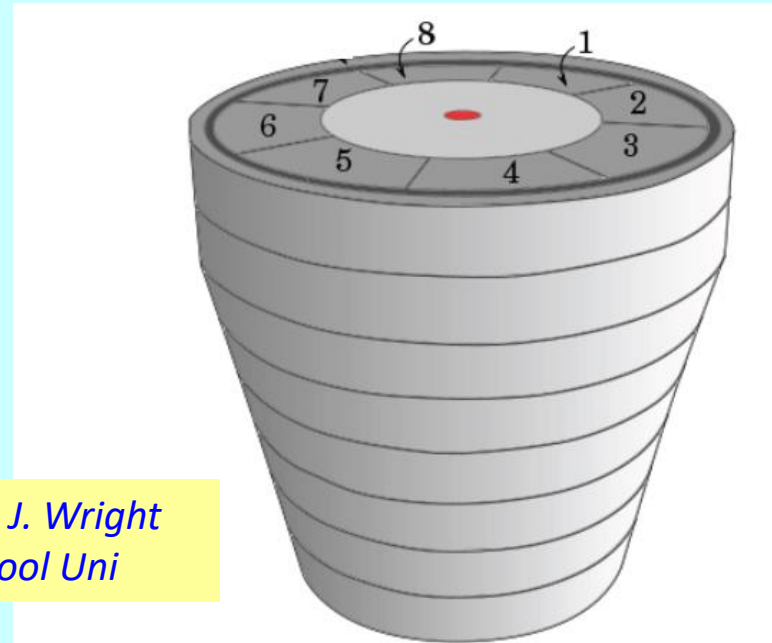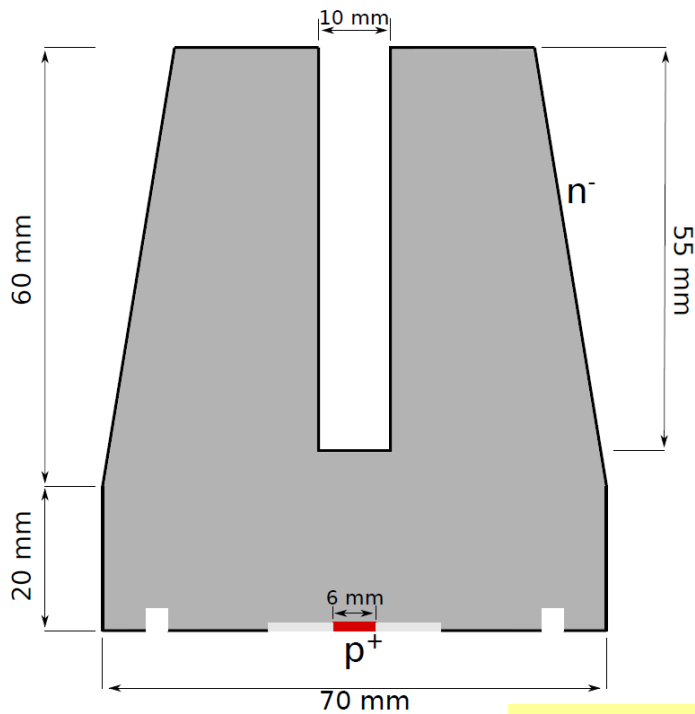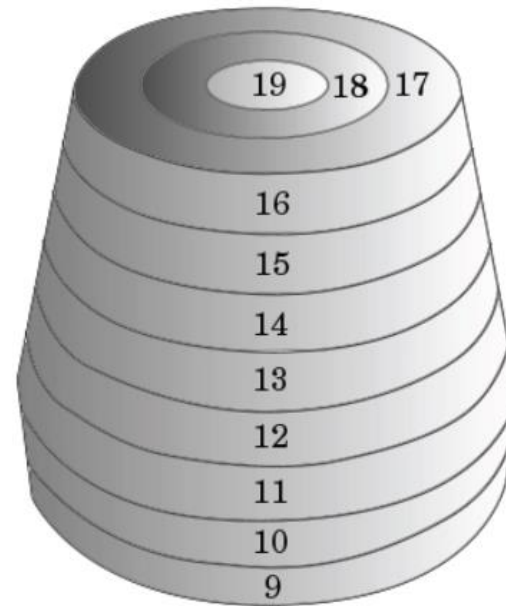
- ➢ Low electric field
- ➢ Long charge carrier drift
- ➢ Enables us to distinguish single from multiple interaction events

Courtesy H. Crawford LBNL
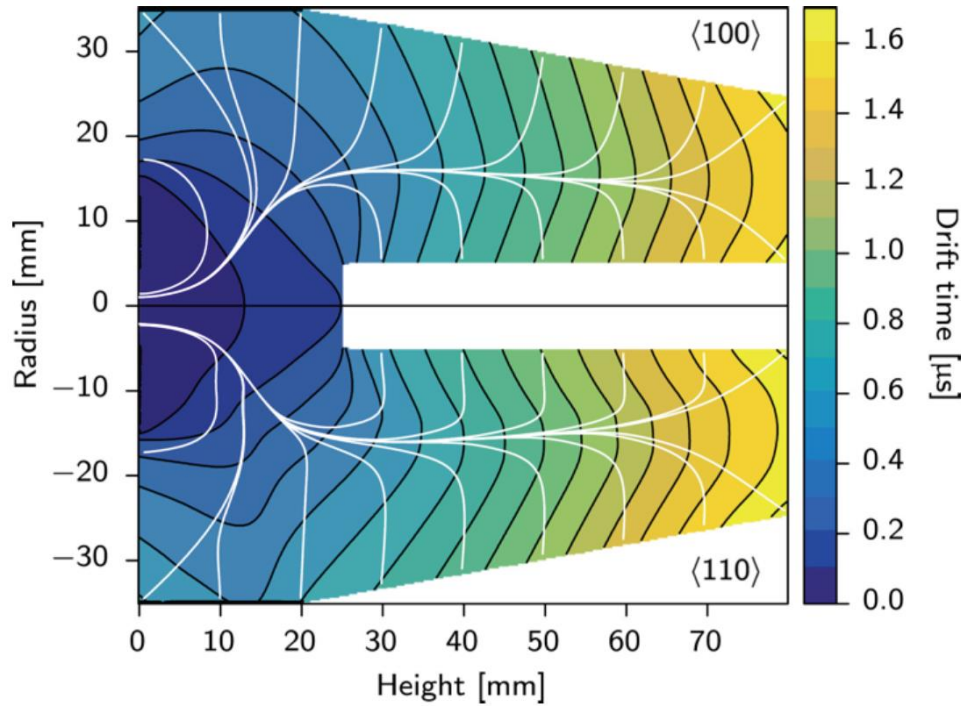
SIGMA detector

Courtesy J. Wright Liverpool Uni

Ge detector R&D

G. Duchêne
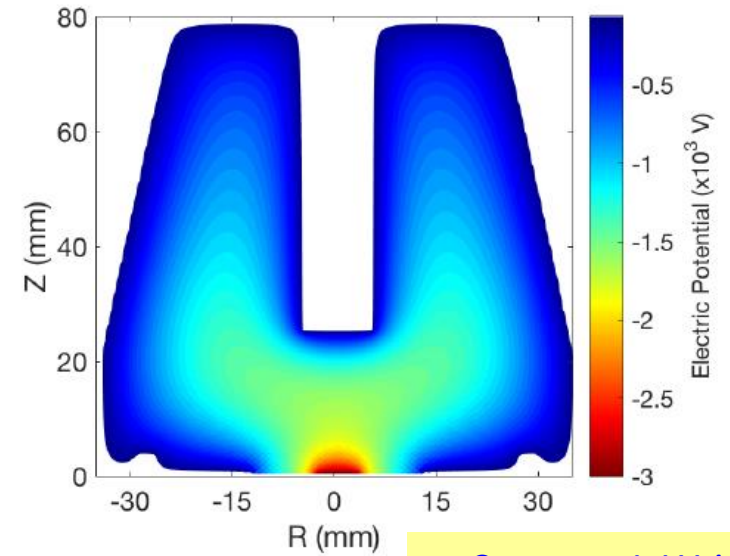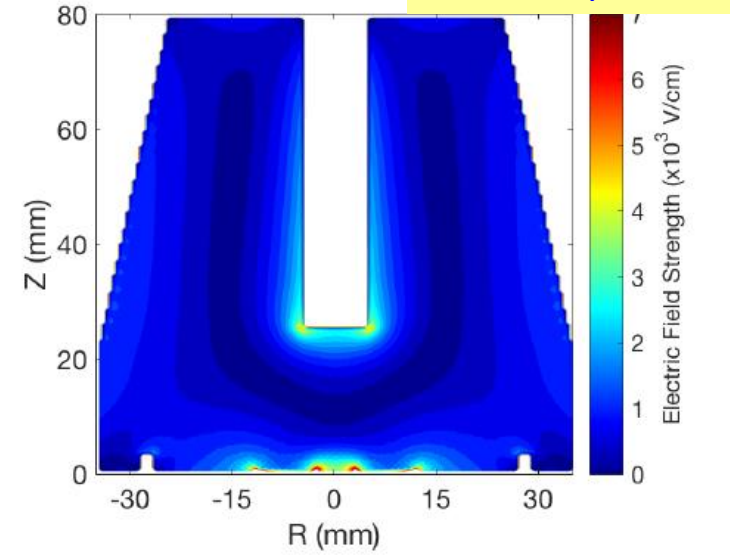
Courtesy J. Wright
Liverpool Uni
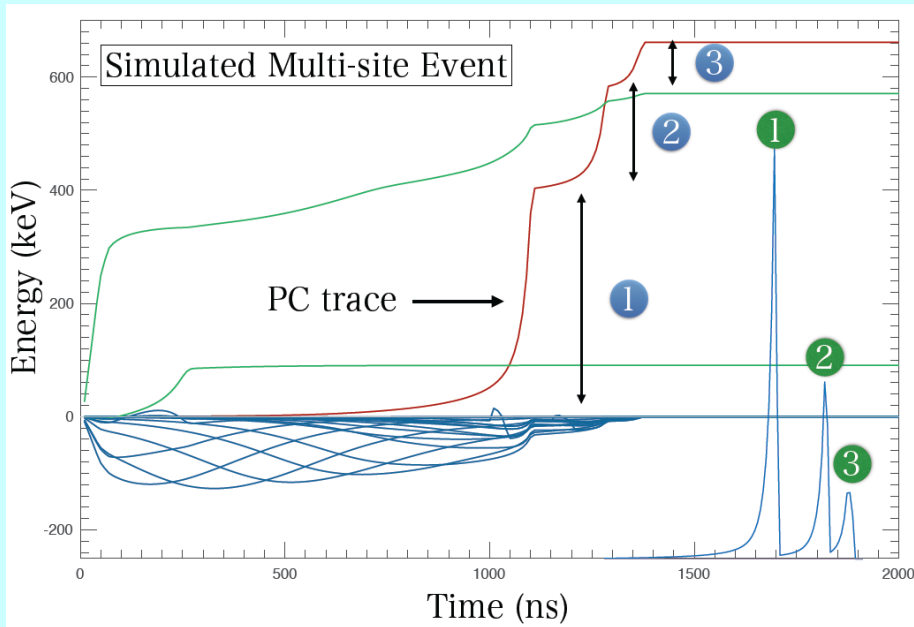
SIGMA detector
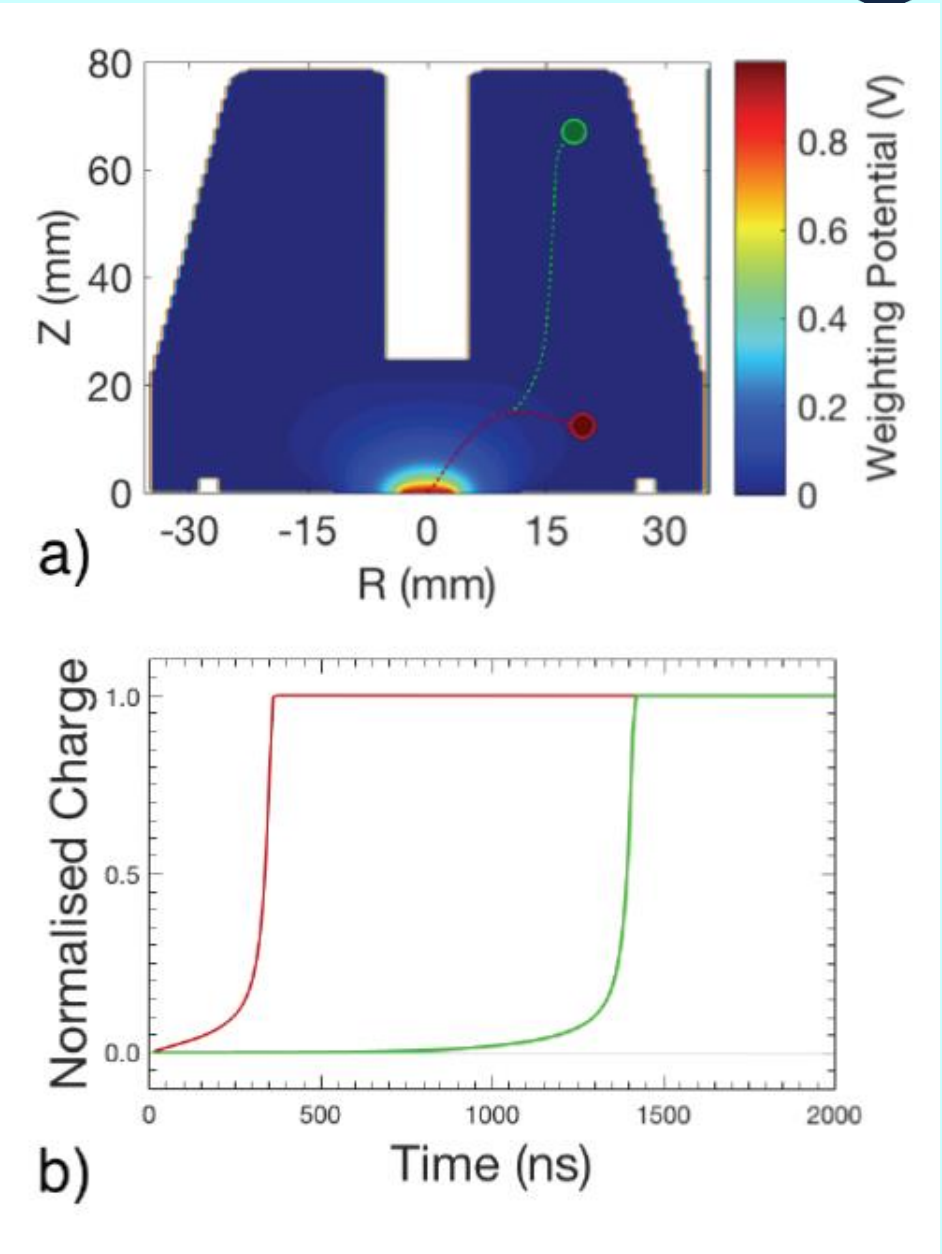
The LEGEND-200 case

❑ LEGEND-200

- ➢ Underground installation

- ➢ Point-contact Ge detectors enriched in ^{76}Ge for the search of $0\upsilon\beta\beta$ events

- ➢ Cooled at LAr temperature (88K, -186°C)

- ➢ Low electric-field detectors

https://legend-exp.org)

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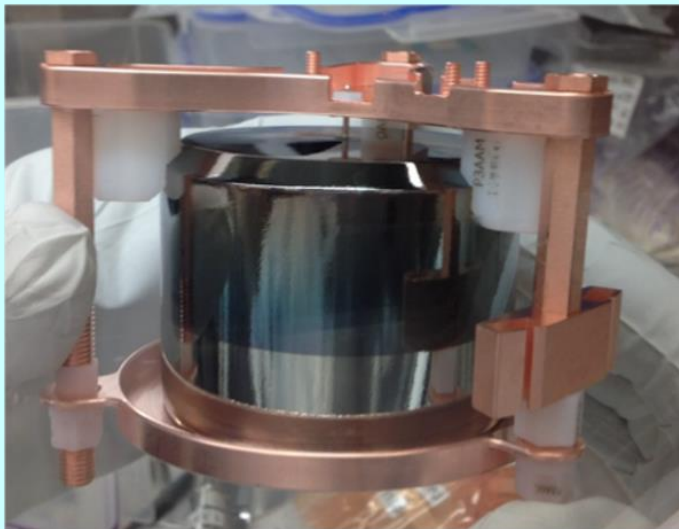
The LEGEND-200 case

❑LEGEND-200

➢ Noise rejection is critical

➢ Radon emitted α always present in underground facilities

➢ Pulse-shape analysis

➢ Low electric-field detectors

➢ Use of gamma-ray scanning tables such as the ones in GSI and IPHC for

❖ detector characterisation

❖ pulse-shape algorithms improvement

I.J. Arnquist et al., EPJ C, arXiv : 2006,13179v2

G. Duchêne

Our project in the frame of DMLab

- ❑ **Dark Matter projects**
  - ➢ Develop contacts with DM projects for making use of our tools and knowledge on Ge detector response
  - ➢ Propose Ge prototype scans
  - ➢ Contribute to any study on Ge detectors

- ❑ **Pulse-shape recognition**
  - ➢ Improving the reliability of our PSA algorithms based on experimental data
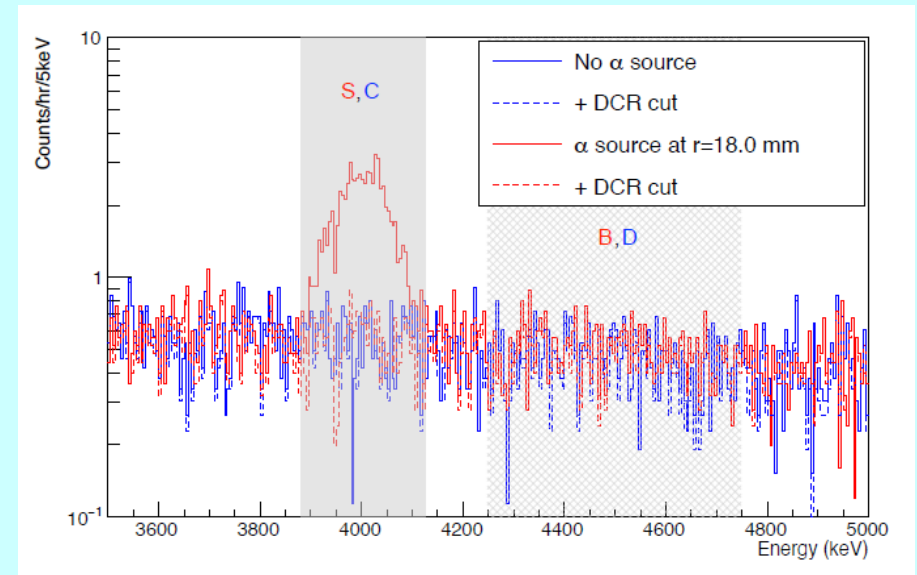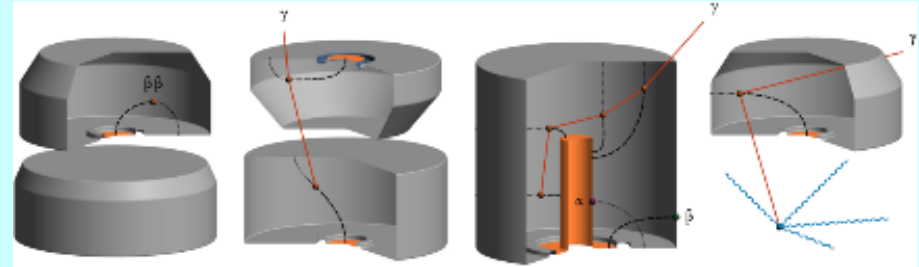   - ❖ Modify the Chi2 technique (change power value, different weights for fired and non-fired segments)
    - ❖ Use our available raw data to train Machine Learning algorithms looking for faster and better results

- ❑ **Scanning runs**
  - ➢ Scan Ge detectors of different geometries on both tables
    - ❖ GSI for fast results on volume response
    - ❖ IPHC for detailed volume and surface studies

- ❑ **Travels**
  - ➢ IPHC to GSI for scans and ML work
  - ➢ GSI to IPHC for scans

- ❑ **Exchanges**
  - ➢ Co-tutorial PhD on Machine Learning applied to scanning tables
  - ➢ Possible stays of several weeks at GSI and IPHC

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Our project in the frame of DMLab

GSI team (J. Gerl)

- Ge detectors:
  - I. Kojouharov, H. Schaffner
- Scanning table:
  - Post-doc/PhD
- Machine Learning:
  - H. Albers, A. Montalbano, N.N.

IPHC team (G. Duchêne)

- Ge detector and scanning table:
  - M.H. Sigward, M. Filliger
- Machine Learning:
  - M. Moukaddam, F. Didierjean

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Colloque GANIL 2021

Thank you for your attention

Any question ?

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