Segmented Broad Energy Germanium Detector

Outline:

- Motivation
- [segmented] BEGe detector
- First measurements on segmented BEGe detector
- Pulse shape simulation
- Summary & outlook

Heng-Ye Liao

for the GEDET collaboration

Max-Planck-Institut für Physik

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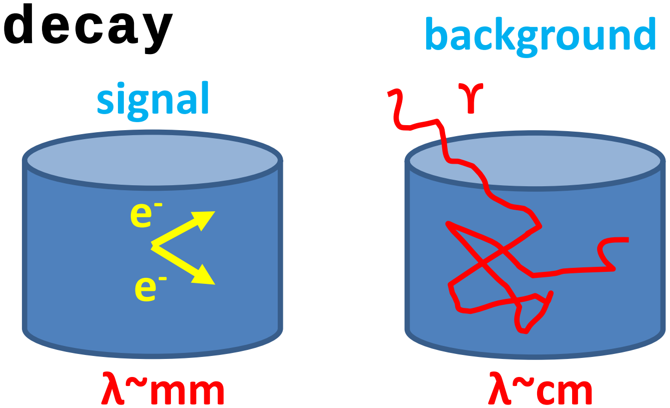
Motivation & Mission Statement

Germanium detector development:

Detector R&D for future application in fundamental physics

- ✓ **Neutrinoless double beta decay**
- ✓ **Dark matter searches**



Signal / background discrimination:

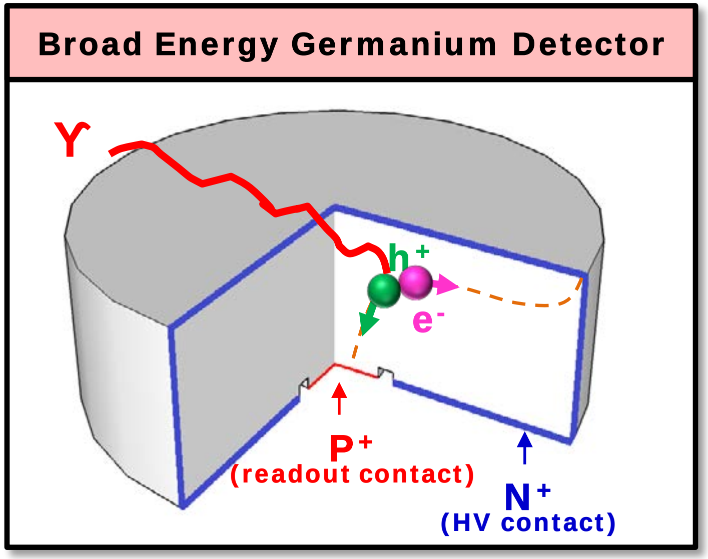
- ➢ **Establish techniques to distinguish signal topology from background topology**

→ Use <u>intelligent detectors</u>

Important issue:

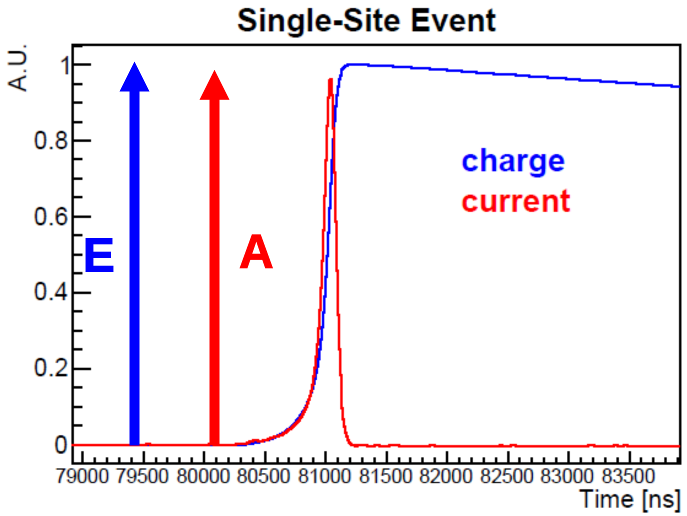
Good understanding of the detector response to minimize systematic uncertainties

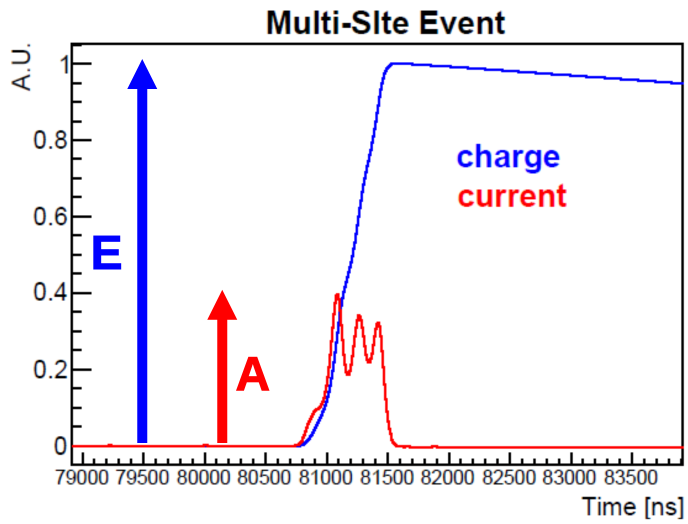
Broad Energy Germanium Detector



- **High Purity Germanium detector in general:**
  - ✓ Excellent energy resolution
  - ✓ Intrinsically clean
- **Broad Energy Germanium Detector**
- **Widely used for many experiments: GERDA / MAJORANA, CDEX, CoGeNT,...**
- **Advantages for BEGe detector:**
  - ✓ smaller p^+ contact ➡ less noise
  - ✓ Well pronounced weighting field:
    ➡ Powerful PSD
    PSD: Pulse Shape Discrimination

Broad Energy Germanium Detector





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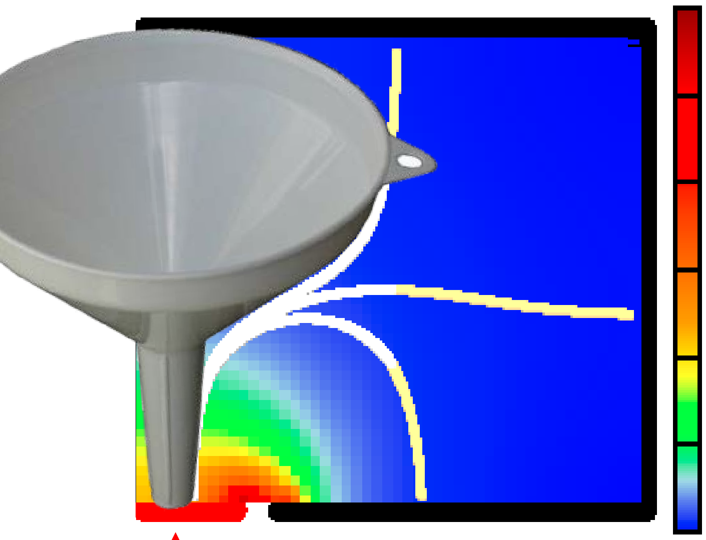

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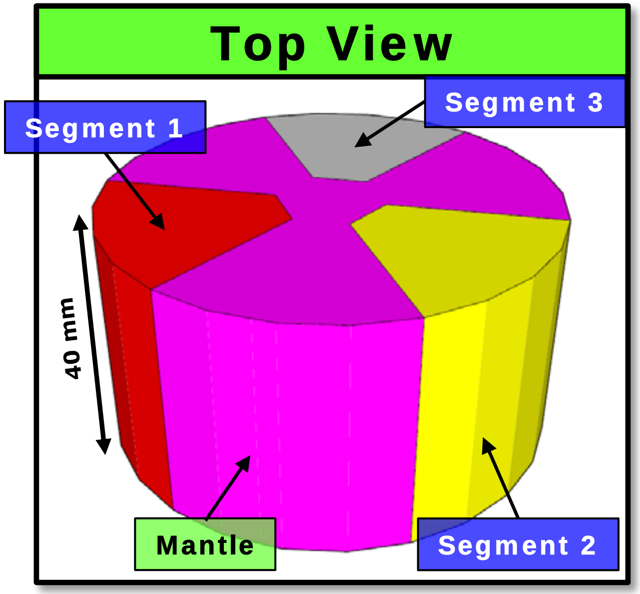
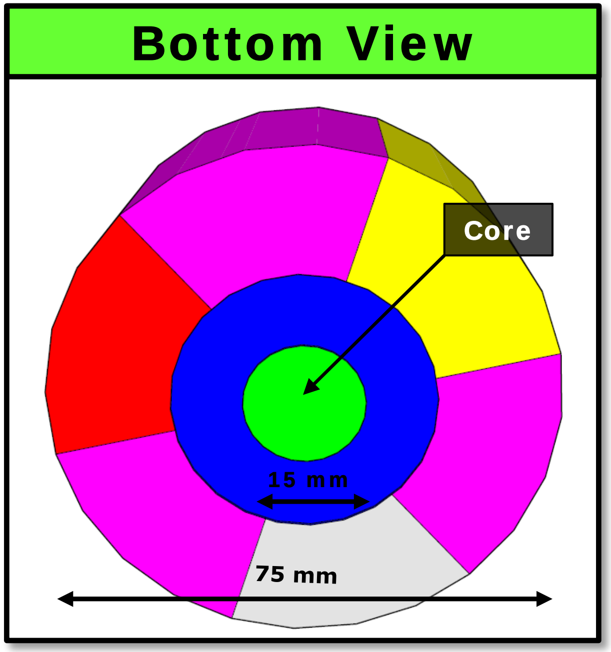
- **Disadvantages for BEGes:**

<u>1D degeneracy in (ϕ, z)</u>

➡ extra segmentations to reconstruct event position

Segmented Broad Energy Germanium Detector





- **Designed by the GEDET group, made by Canberra France**
- **n-type BEGe detector**
- **Point contact with 4-fold segmentation**
- **3D event reconstruction:**
  - ✓ **Break degeneracies on ϕ and pulse drift time**
- **Segmentation design:**
  - ✓ **Minimizing amount of contacts**
  - ✓ **Maximizing retrieval of information**
- **Configurations:**

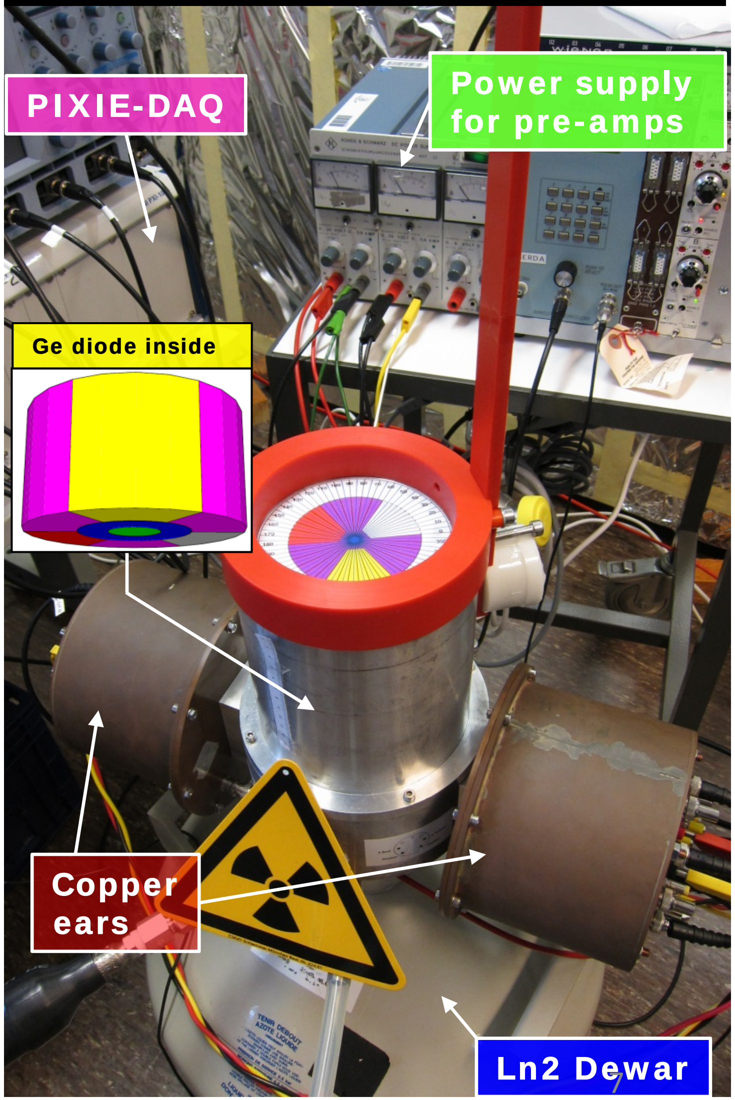
  Dimension: ϕ 75mm x 40mm

  Mass: 940 g

  HV: +4500 Volt (on N^+ contact)

Test Facility

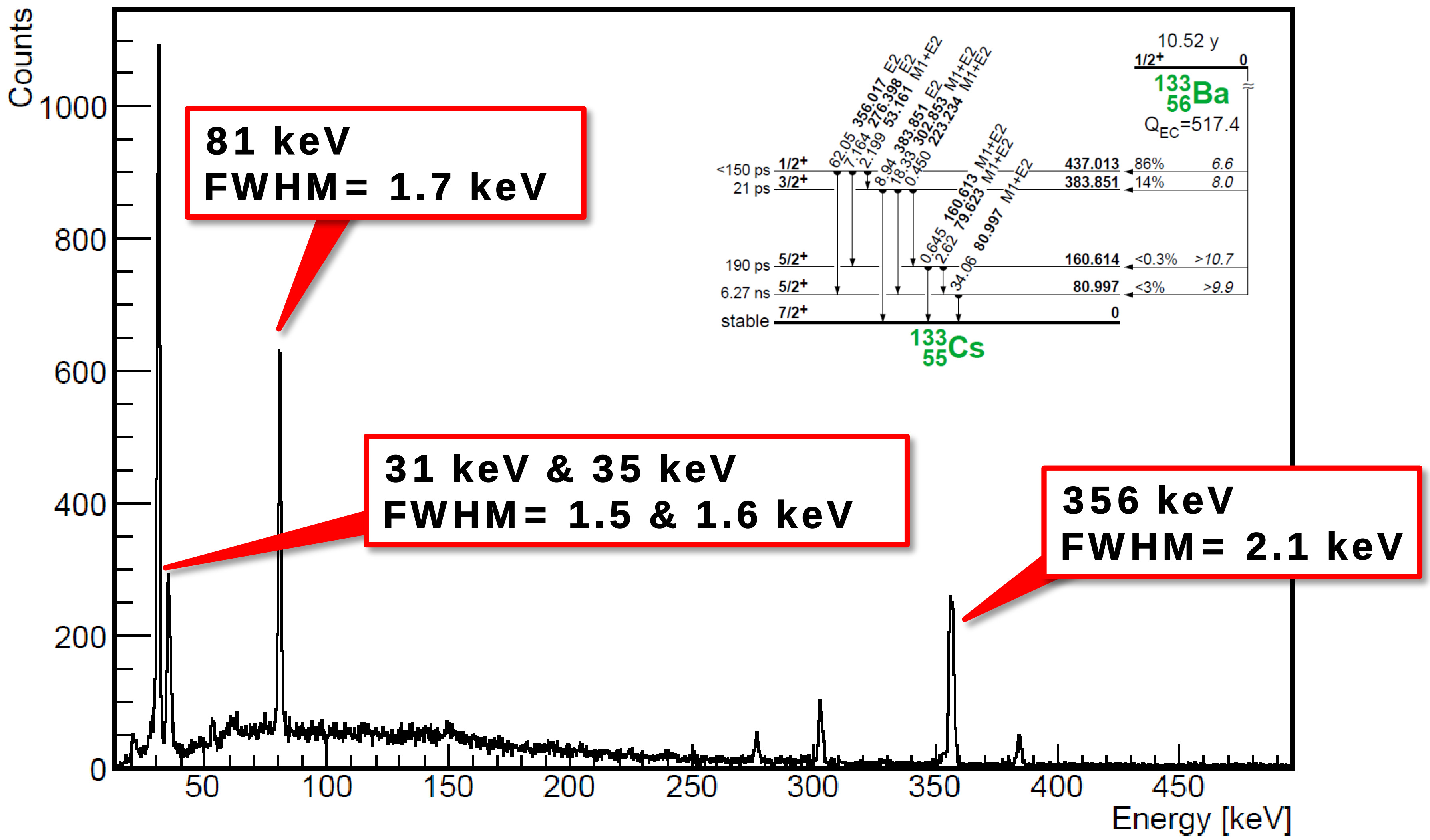
K1 Test Stand



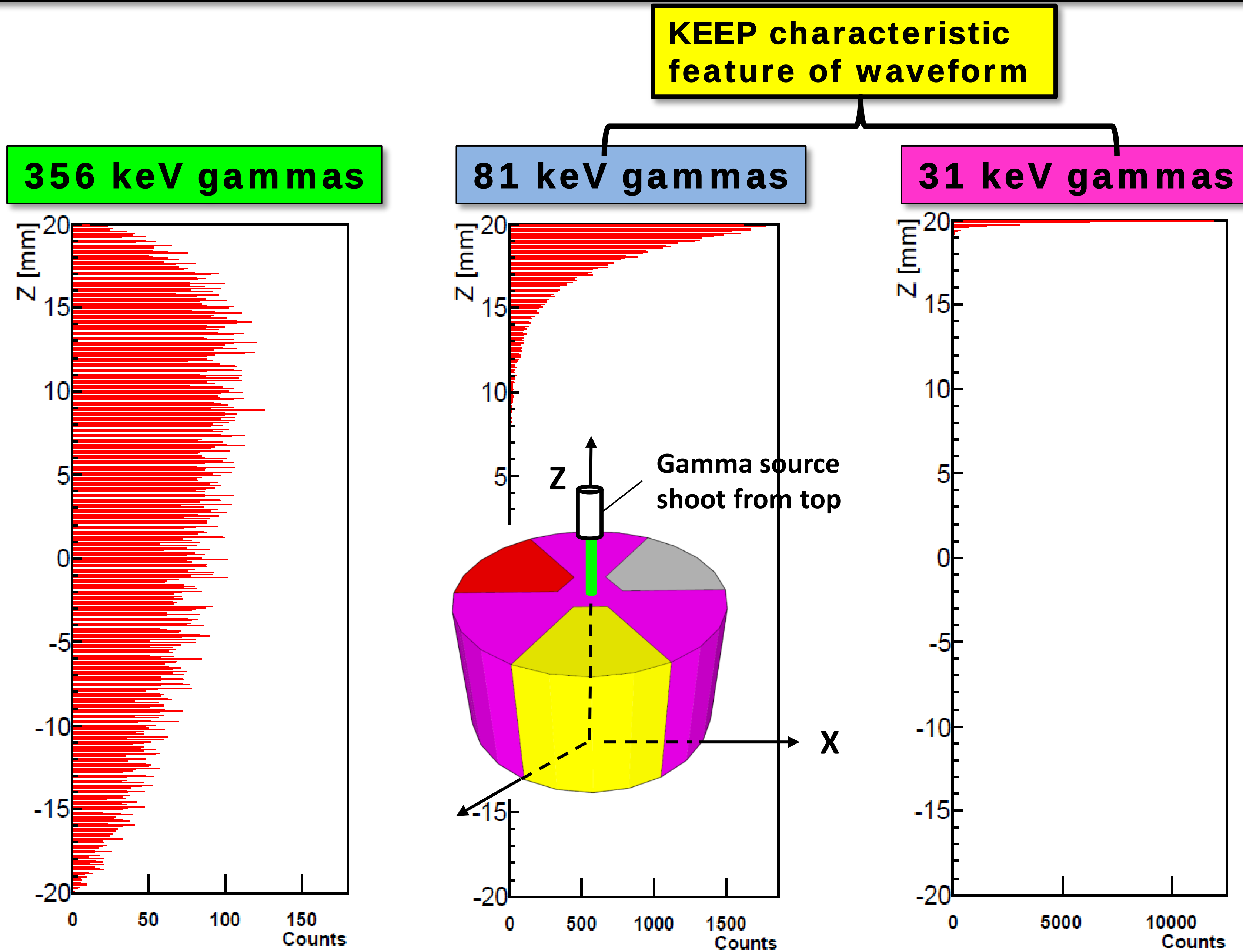
- **Canberra test stand:**
  - ➢ **Conventional vacuum cryostat**
  - ➢ **Single detector:**
    cooling finger submerged in LN2
  - ➢ **2 copper ears to house electronics**
    - **stand alone preamp for core**
    - **single preamp / segment**

- **Flexible device capable to scan through different (r, ϕ, z)**

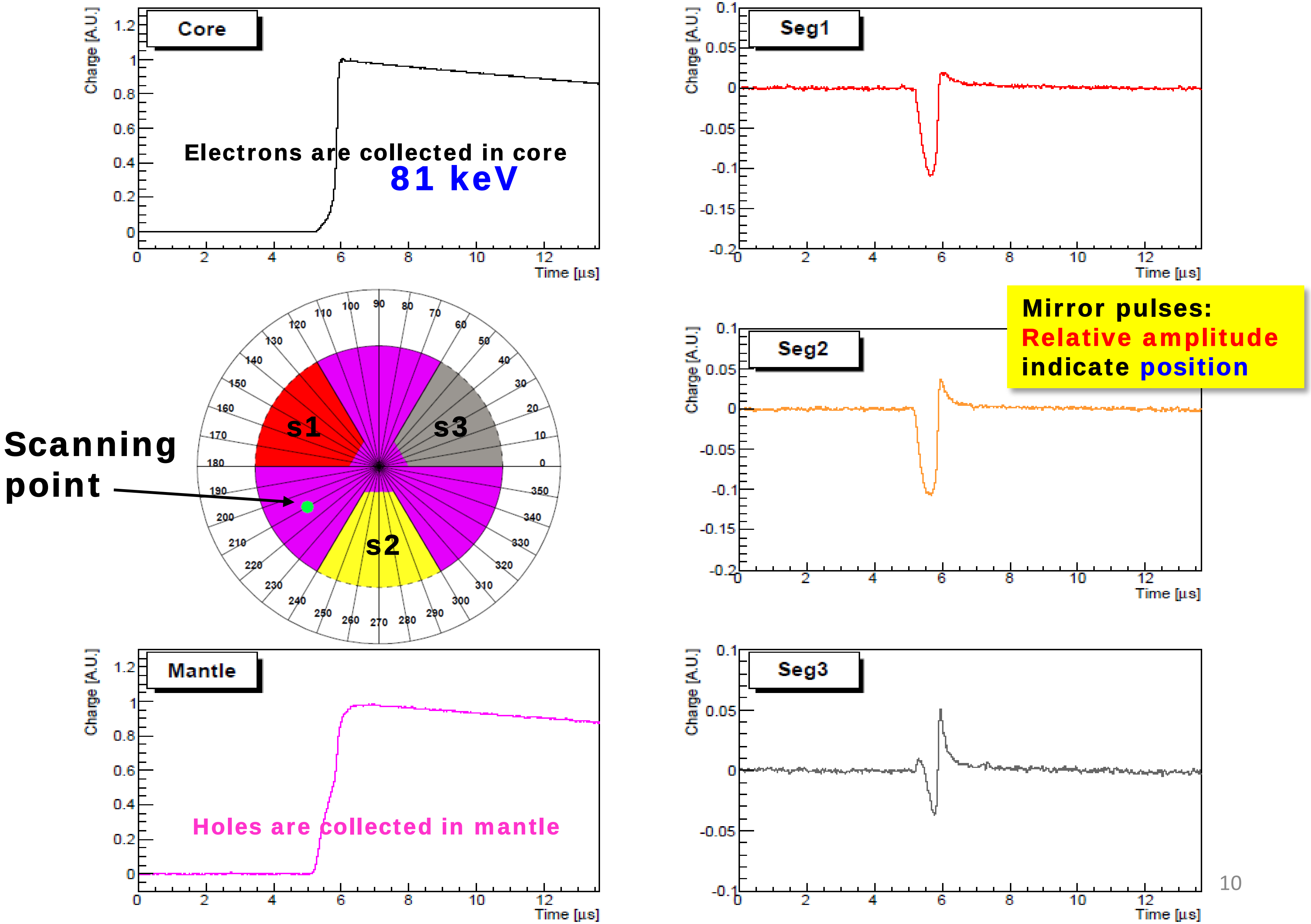
Characterization using ^{133}Barium source



Hit Positions at X-Z plane from simulation



Mirror Pulse: sensitive to event topologies



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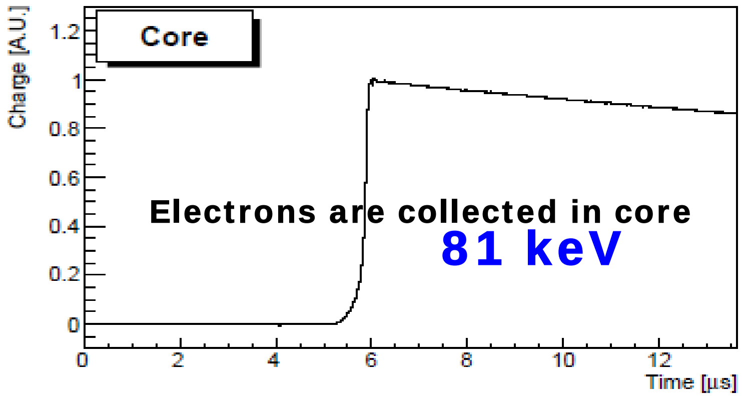
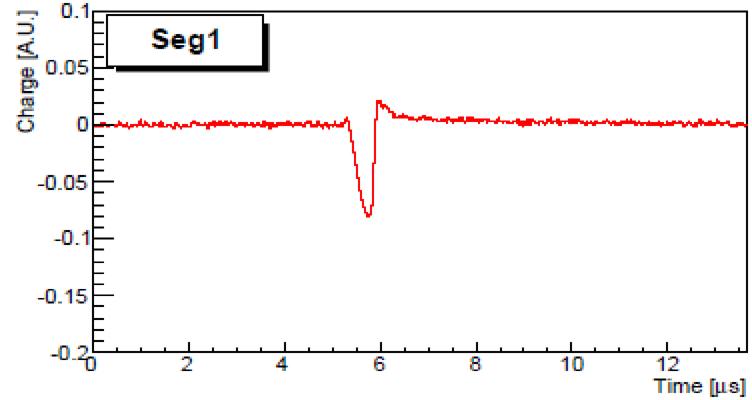
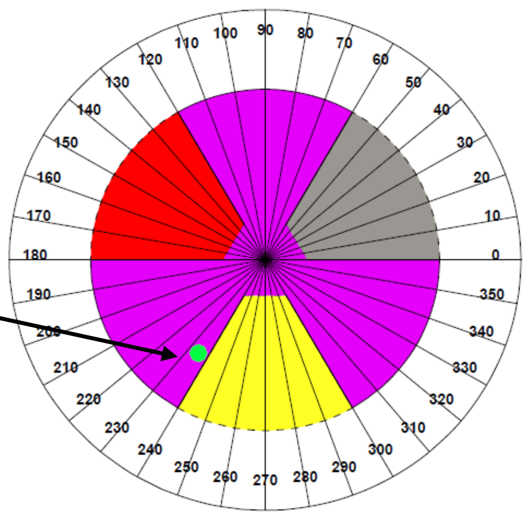
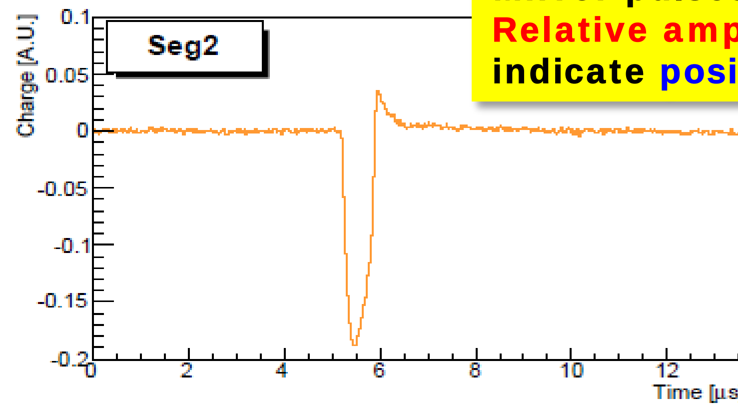


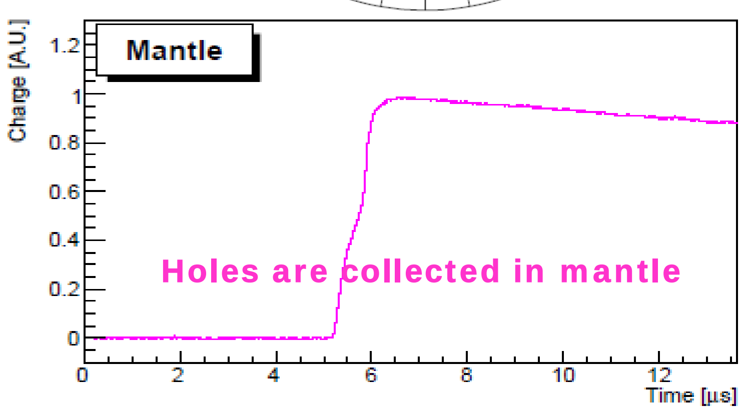


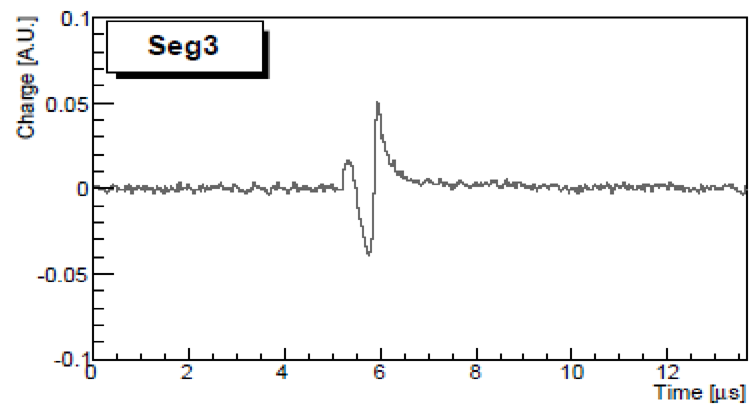
Mirror pulses:
Relative amplitude
indicate position

Scanning point









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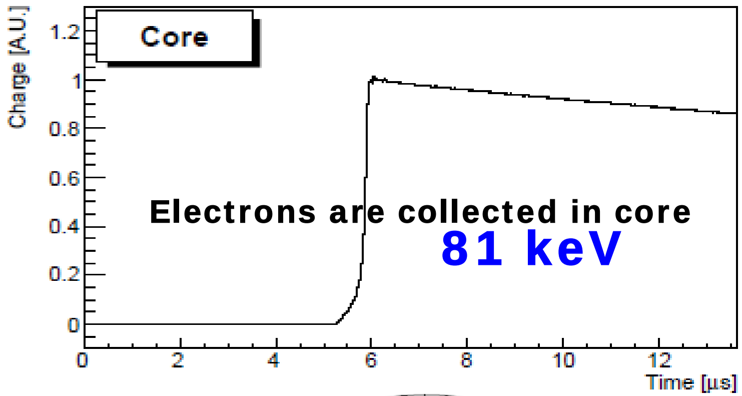

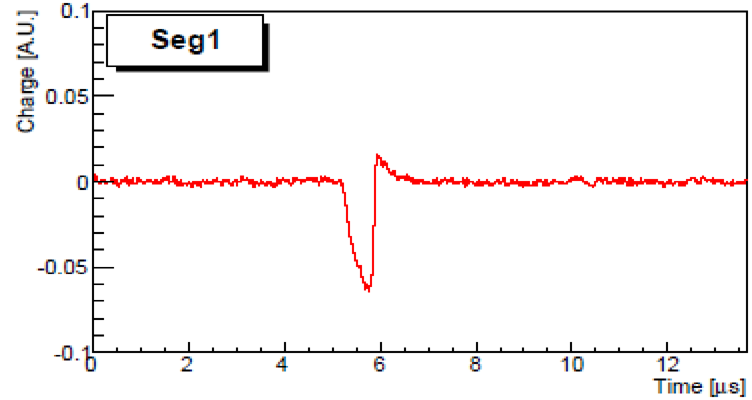

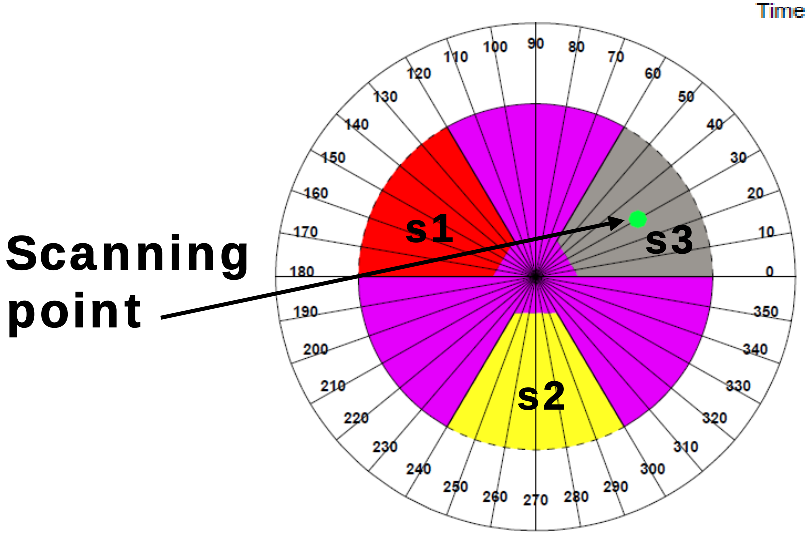

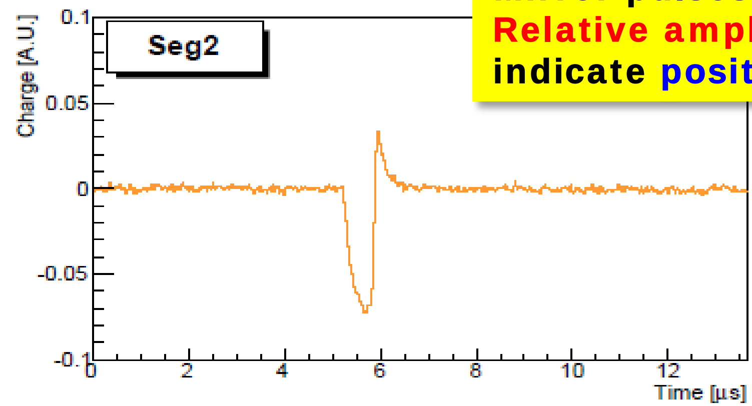

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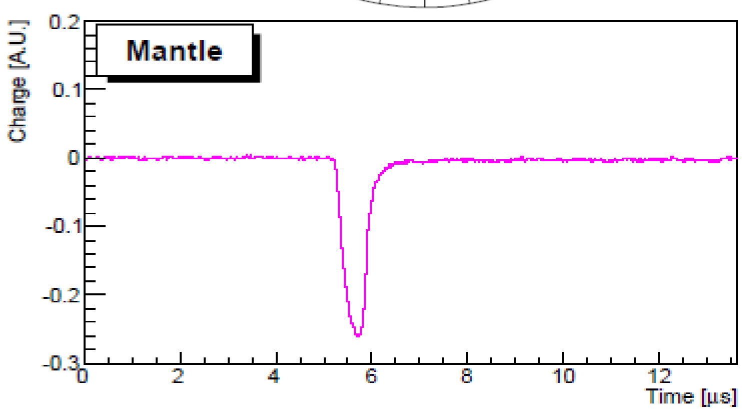

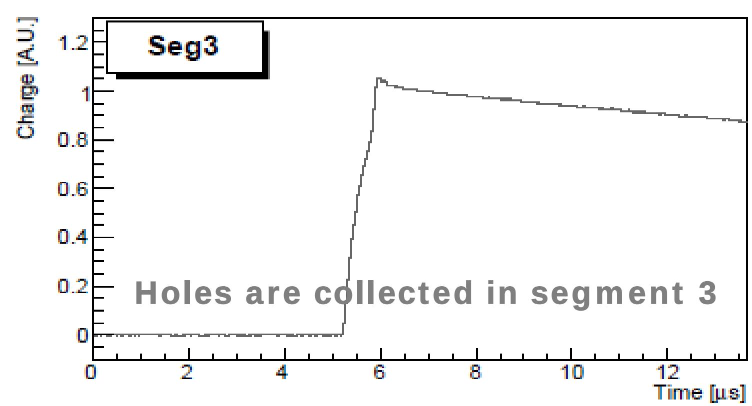

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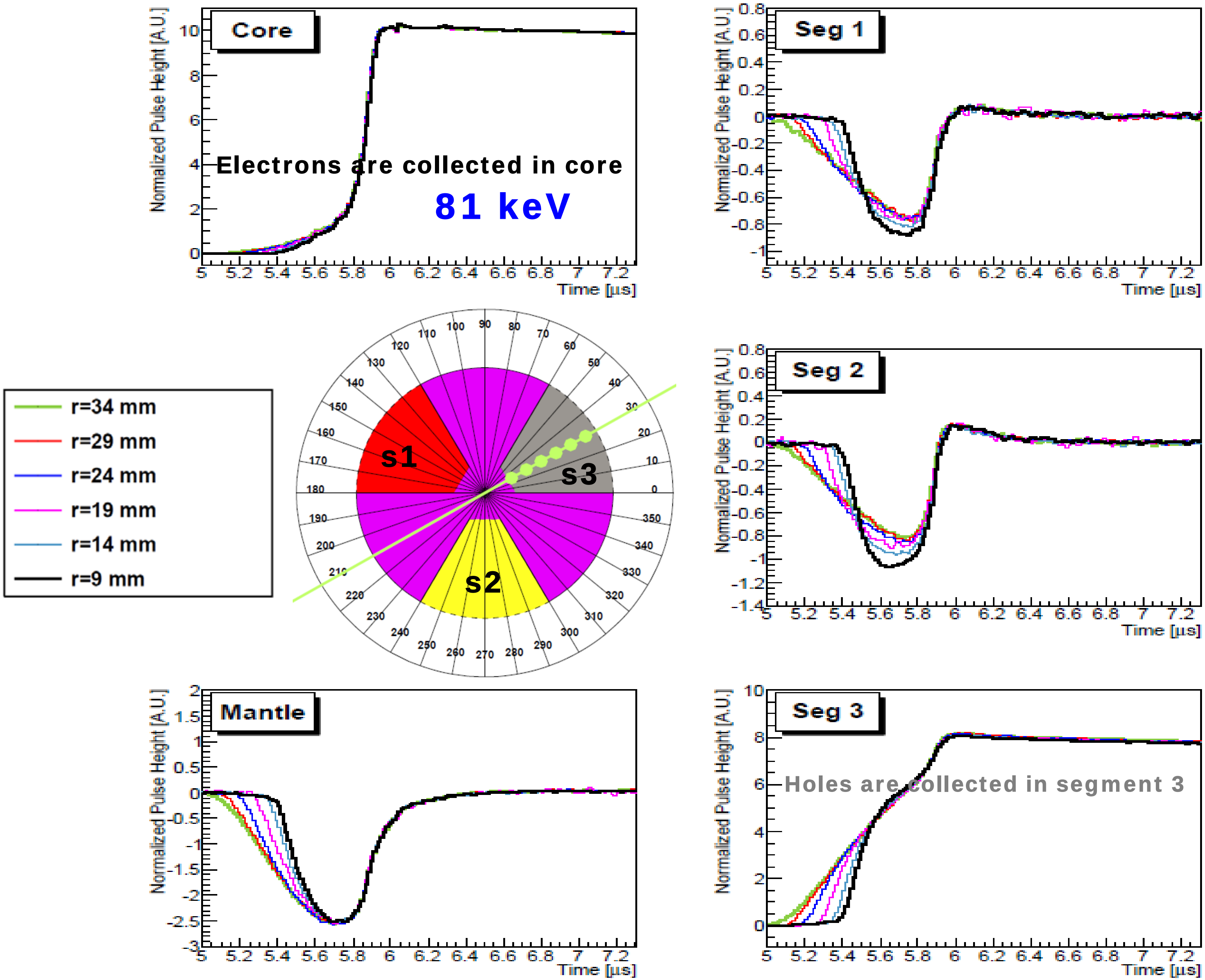


Pulse Shape Simulation

- **Why pulse shape simulation?**

  Improve the understanding of Germanium detector
  - impurity distribution
  - charge trapping
  - charge collection efficiency
  - Sensitivity of event position reconstruction

- **Simulation tools:**

✓ Geant4: physics process ➡ hit info

✓ MaGe: Pulse shape simulation

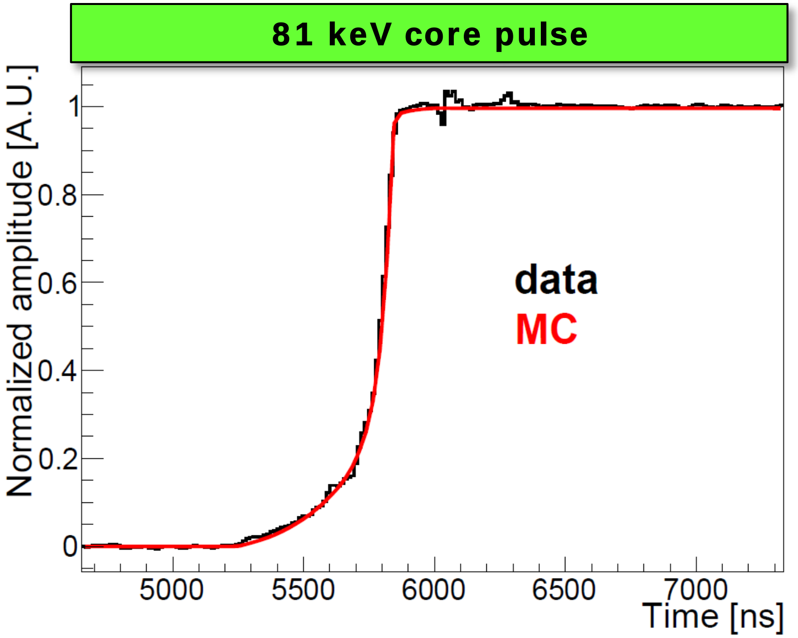
Field calculation

⇓

e / h drift in the bulk

⇓

induced charge on the electrode (waveform)



Summary & Outlook

Summary:

- **BEGe detector with extra segmentations useful to disentangle different event topologies**
- **The segmented BEGe detector is designed by GEDET group and built by Canberra France**
- **Characterization using ^{133}Ba source**

Outlook:

- **Validate Monte Carlo**
- **Determine algorithms for event position reconstruction**
- **Measure HPGe parameters like impurity concentration, e/h mobility**