Particle Physics School Munich Colloqium

The GALATEA Test Facility

Analysis of Surface Effects for coaxial n-type Germanium Detectors

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Outline

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6. The experimental Implementation
7. First Spectra

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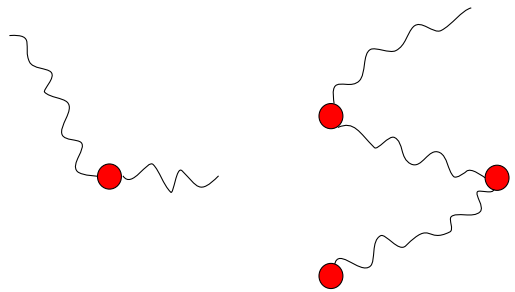
Characterisation of HPGe Detectors

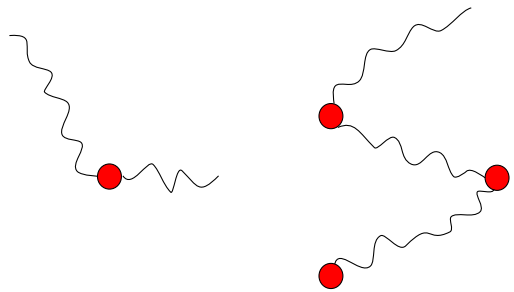


signal event: **localized**

background event: **multiside**

Characterisation of HPGe Detectors

- Background reduction through event recognition in low-background experiments
  - $0\nu\beta\beta$: localized event
  - γ: multiside events



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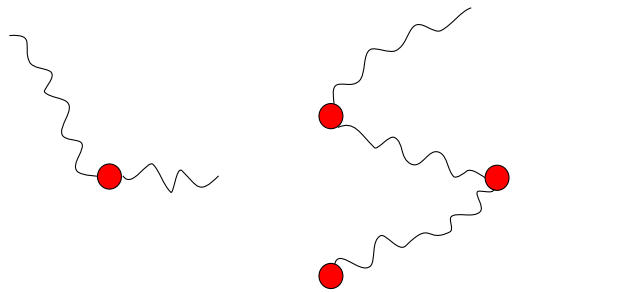

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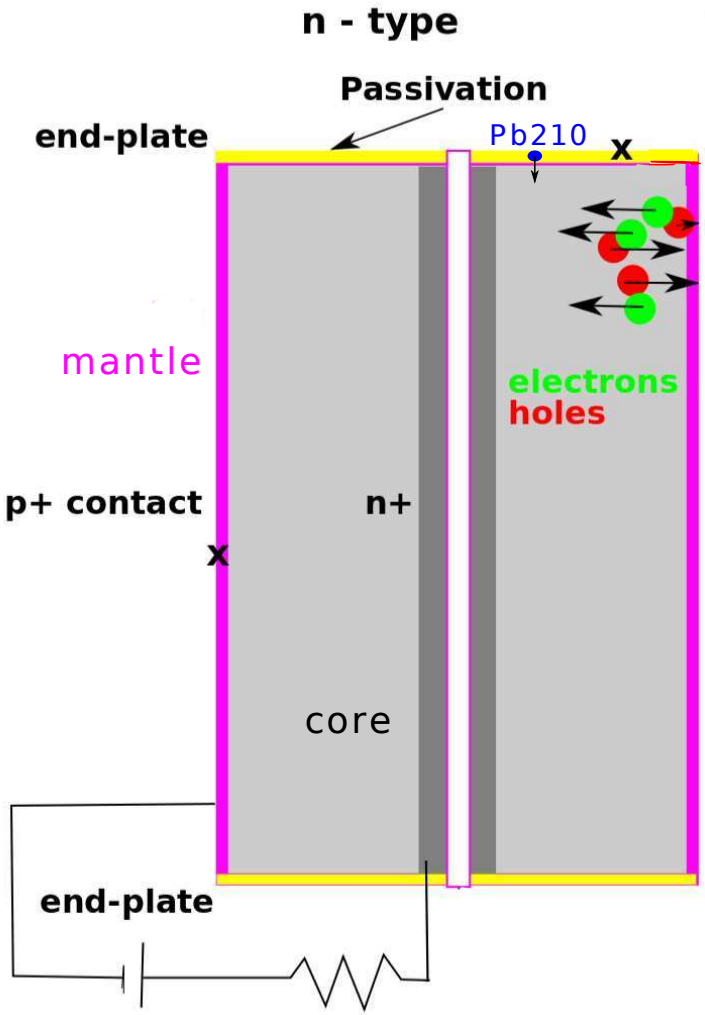
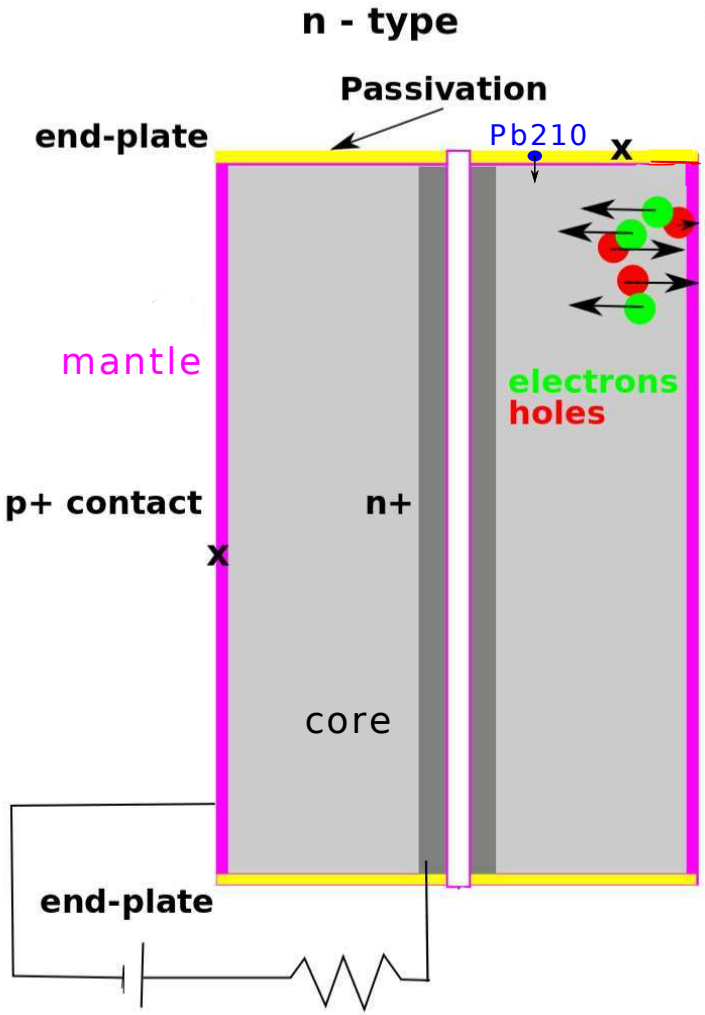
- Germanium detector properties are important for further analysis, like
  - Charge trapping
  - Surface effects

n-type coaxial Detectors



n-type coaxial Detectors

- electron-hole pair creation



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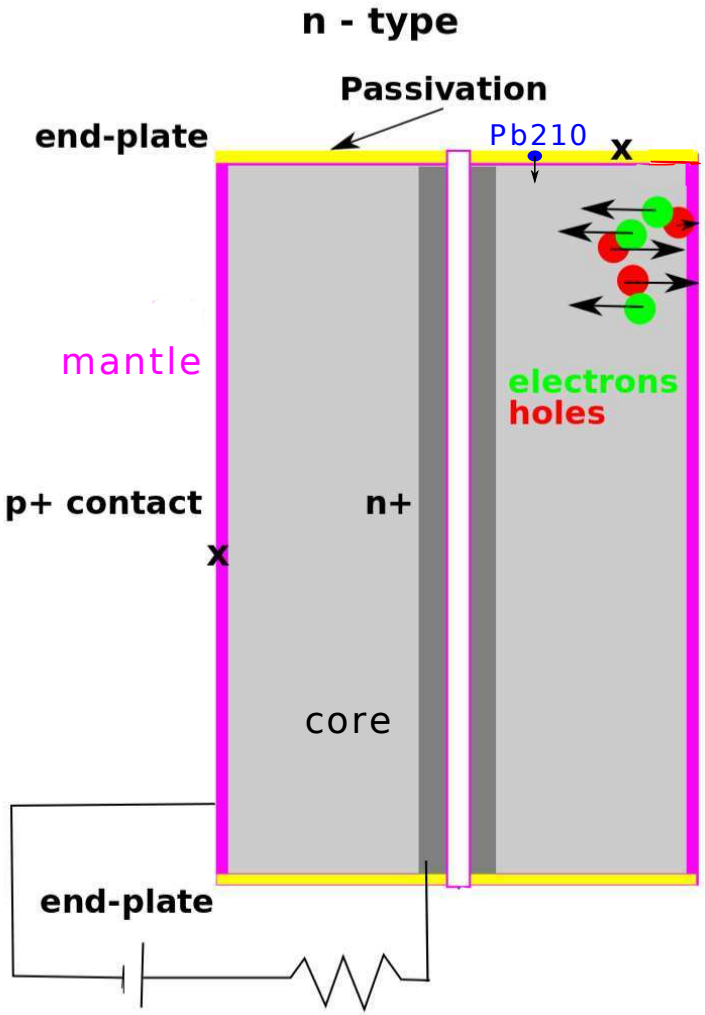

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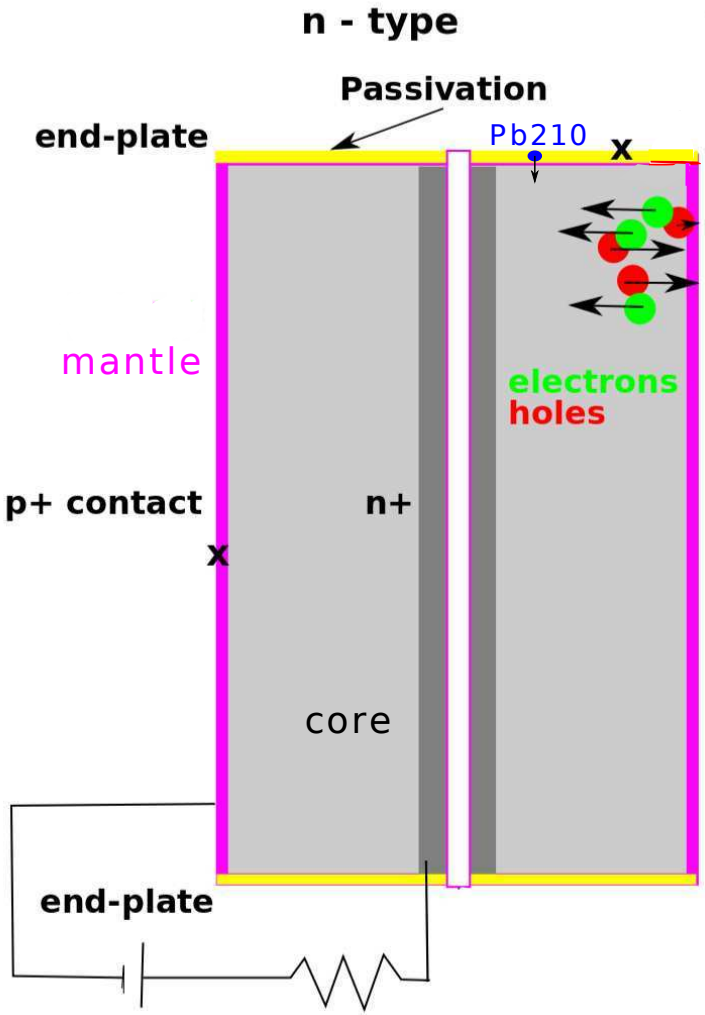

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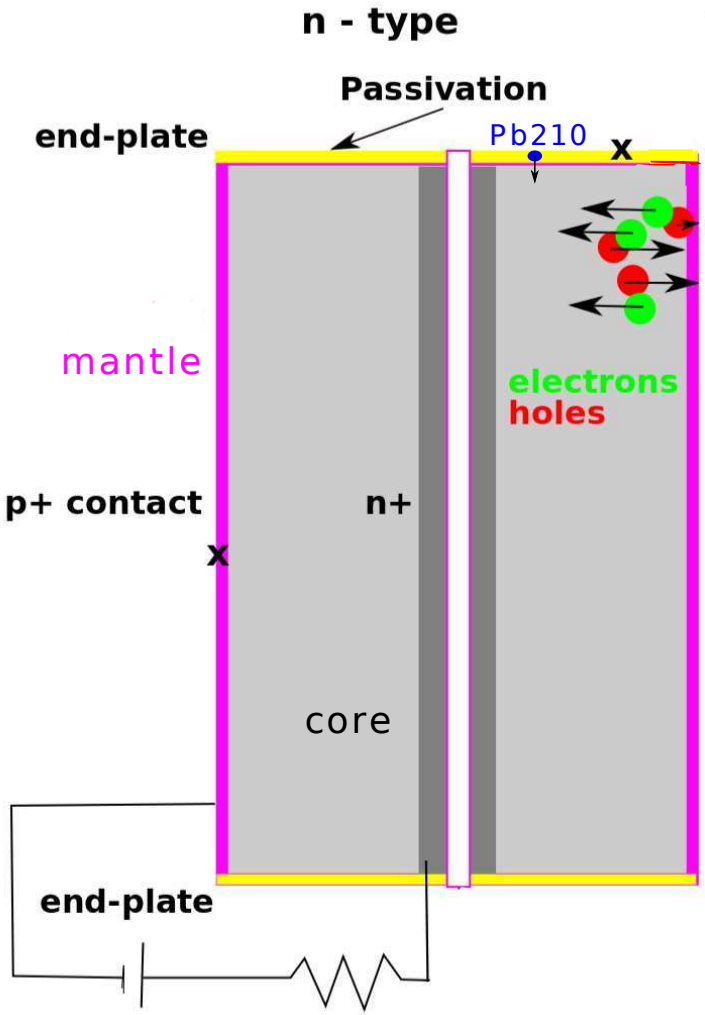

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- **n-type**: the electric field pulls the **electrons to the core** and the **holes to the mantle**
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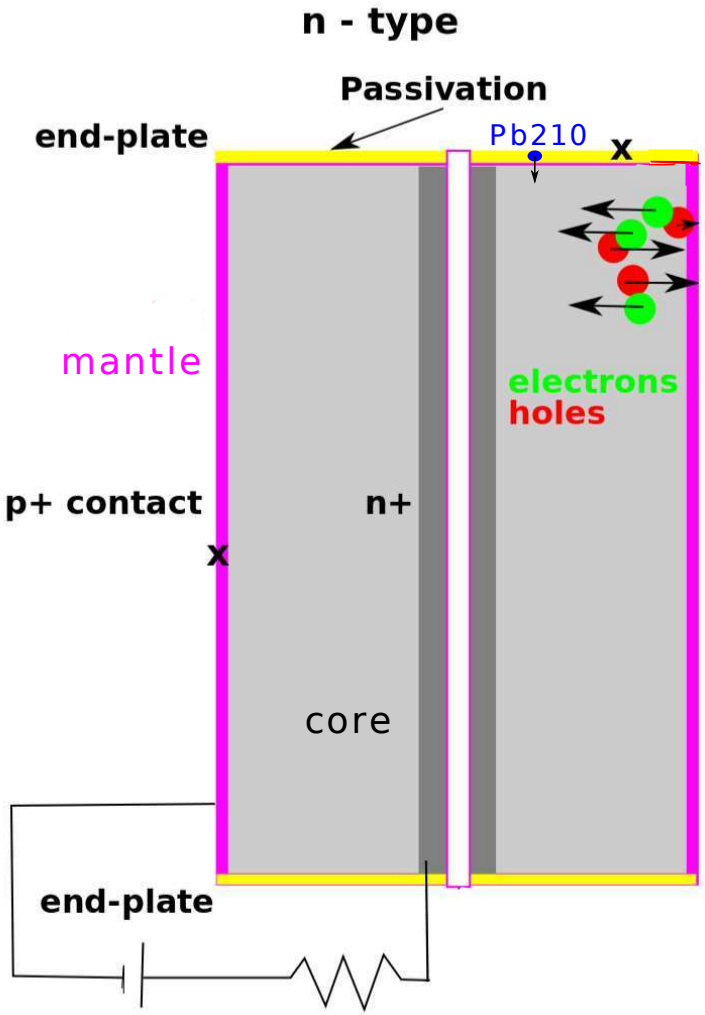
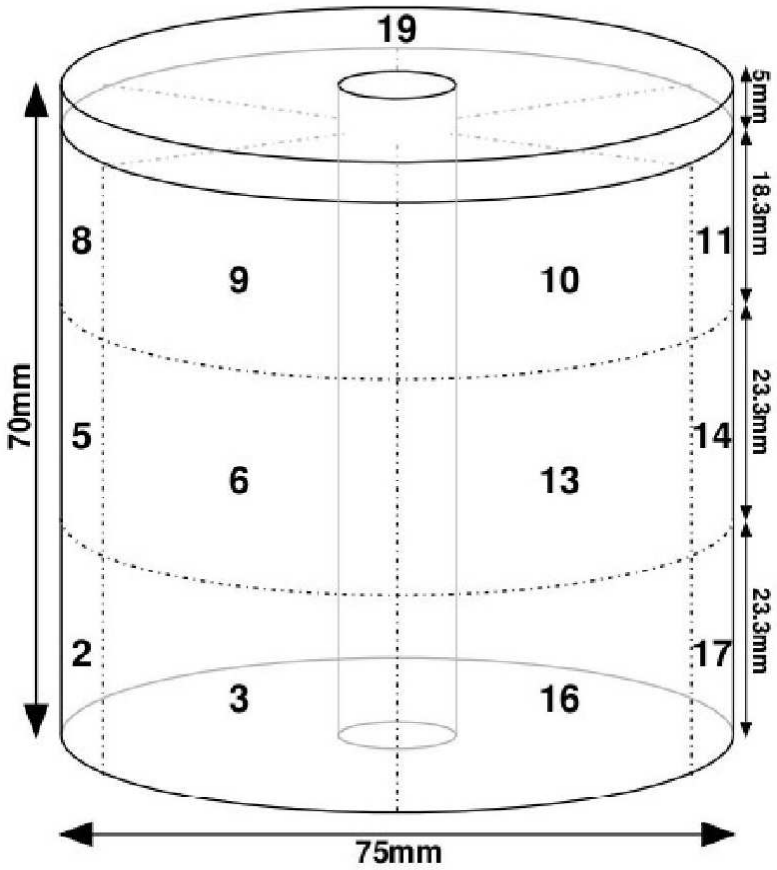
- passivation layers
- end plates → **contamination** → creates BG if part of energy is seen

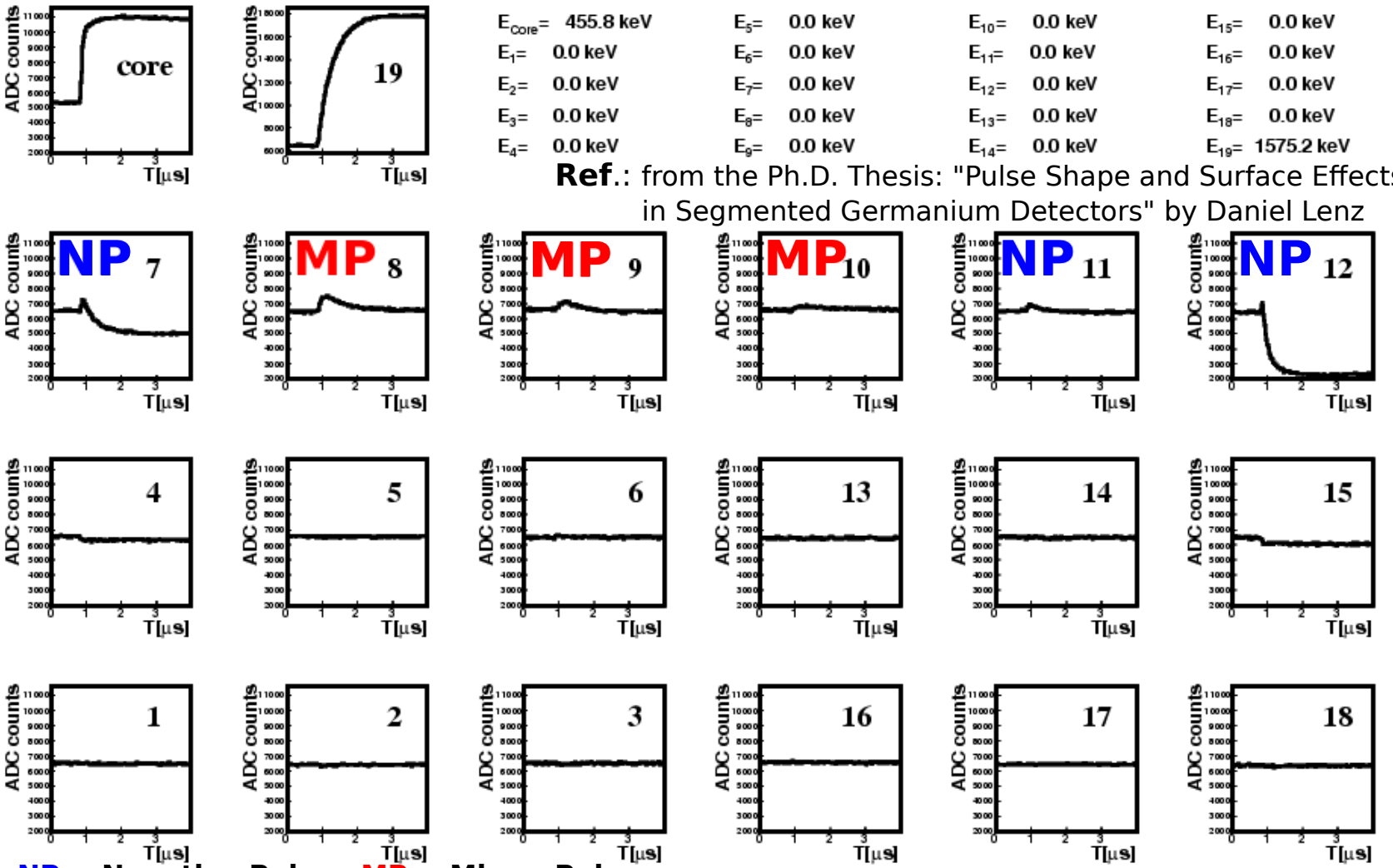


"Supersiegfried"

- Cylindrical true coaxial n-type high purity germanium detector
- h = 70 mm
- Inner bore hole r = 5.05 mm
- Outer radius r = 37.5 mm
- 18 + 1 fold segmentation (3z and 6ϕ) $\rightarrow$ segmentation for inference of
  - Event topologies
  - Event positions
- Single segment on one side of the detector



Example pulse seen by "SuSie" - one Event



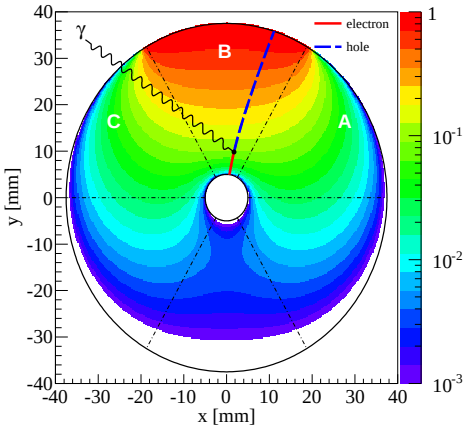
E_{Core}= 455.8 keV	E_5= 0.0 keV	E_{10}= 0.0 keV	E_{15}= 0.0 keV
E_1= 0.0 keV	E_6= 0.0 keV	E_{11}= 0.0 keV	E_{16}= 0.0 keV
E_2= 0.0 keV	E_7= 0.0 keV	E_{12}= 0.0 keV	E_{17}= 0.0 keV
E_3= 0.0 keV	E_8= 0.0 keV	E_{13}= 0.0 keV	E_{18}= 0.0 keV
E_4= 0.0 keV	E_9= 0.0 keV	E_{14}= 0.0 keV	E_{19}= 1575.2 keV

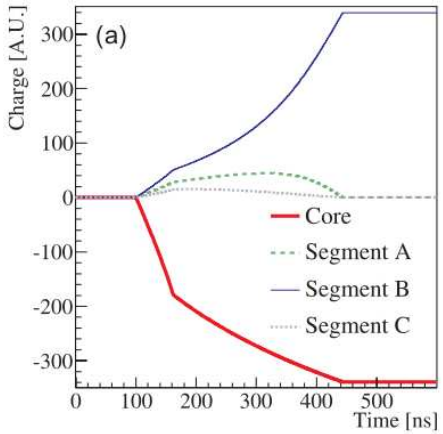
Ref.: from the Ph.D. Thesis: "Pulse Shape and Surface Effects in Segmented Germanium Detectors" by Daniel Lenz

NP = Negative Pulse **MP = Mirror Pulse**

Pulses and Mirror Pulses

Drift of charge carriers in a hitted segment induces mirror pulses in neighbouring segments



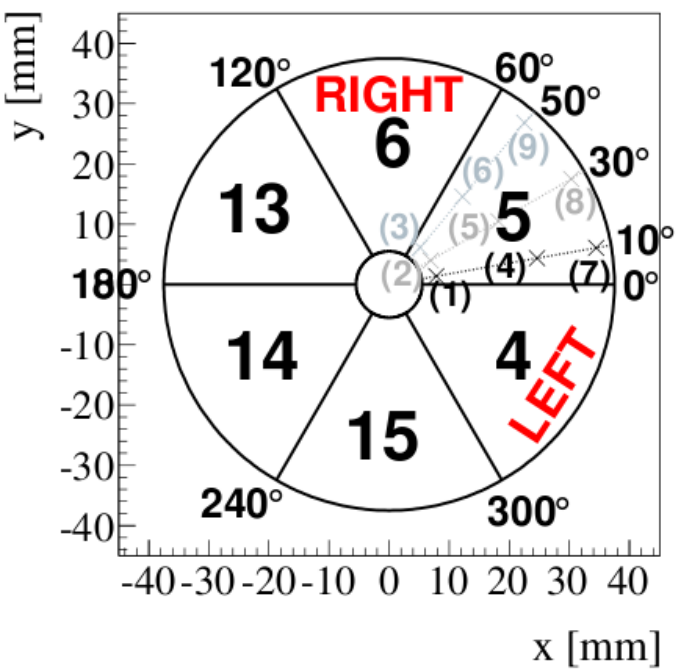


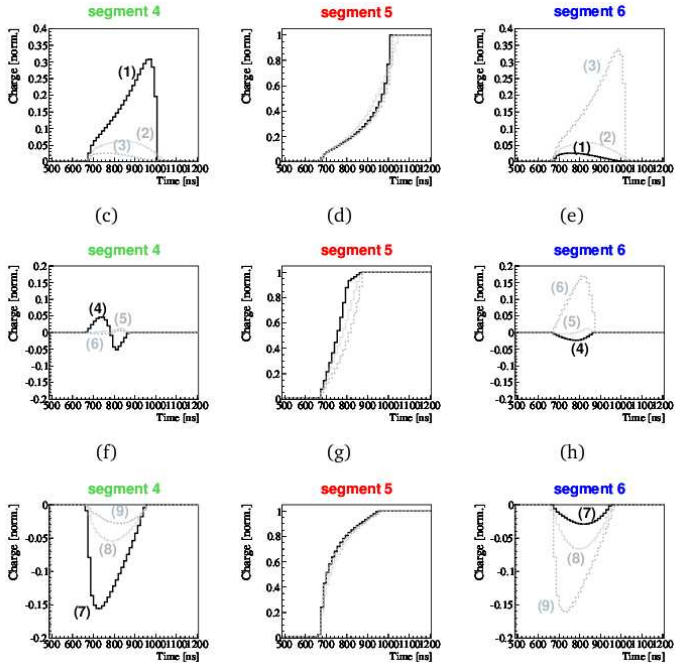
Real Pulse: charge "trajectory" ends at considered segment electrode

Mirror Pulse: charge "trajectory" does not end at considered segment electrode

Ref: Publication: "Pulse shape simulation for segmented true-coaxial HPGe detectors" by I. Abt, A. Caldwell, D. Lenz, J. Liu, B. Majorovits

Characteristics of Mirror Pulses





Ref: Diploma Thesis: "Mirror pulses and position reconstruction in segmented HPGe detectors" by S.Hemmer

Pulse Shapes including Mirror Pulses

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  1. The energy deposited

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- Information about
  1. The energy deposited
  2. The position of an event
     - Position in r $\rightarrow$ rise time plus polarity of mirror pulses
     - position in $\phi \rightarrow$ relative strength of mirror pulses
- Proximity to end plates $\rightarrow$ we see long and strange pulses

What is going on???

Surface Channel Effect

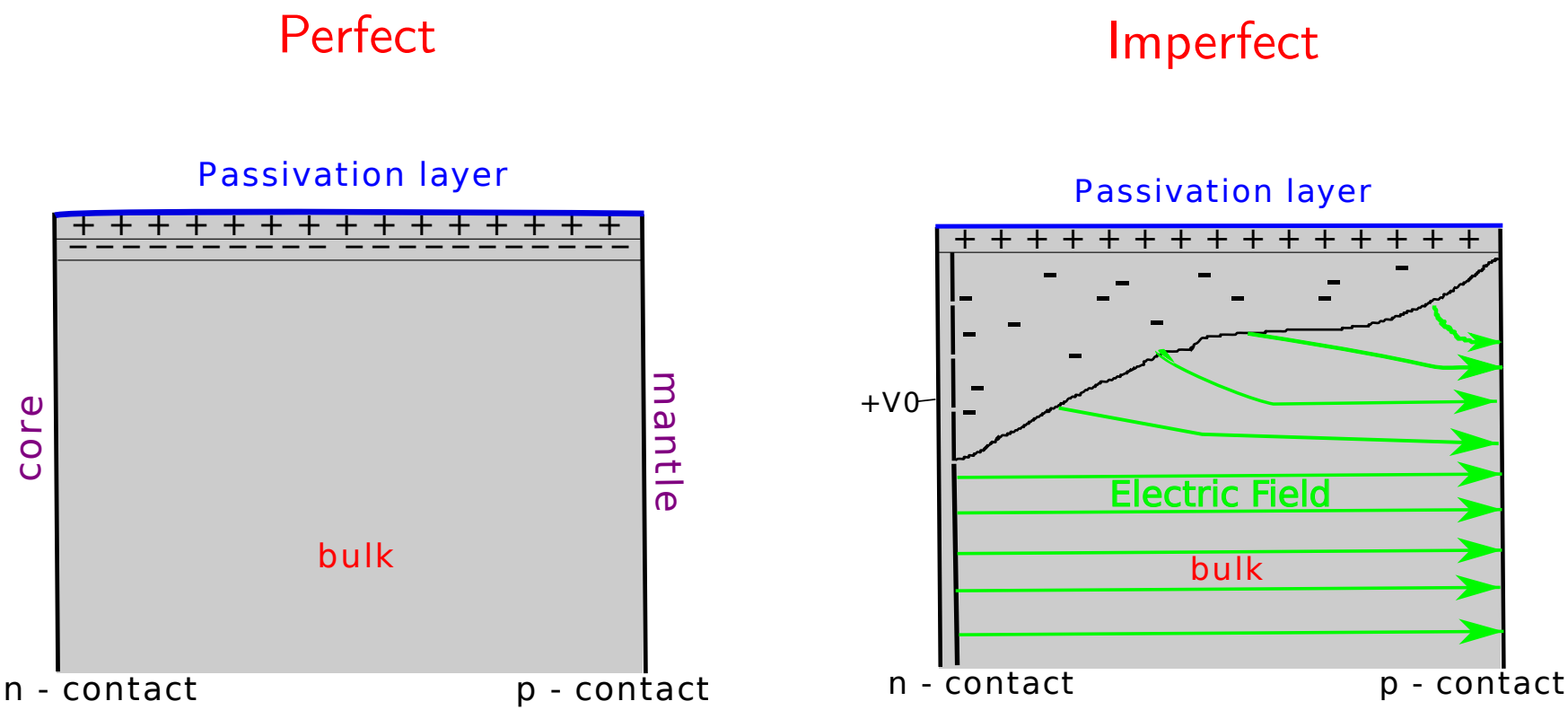
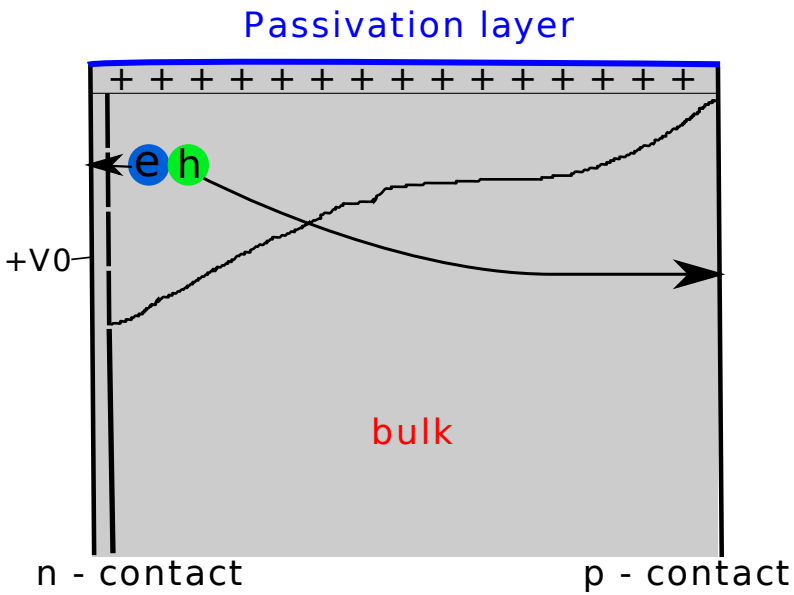


Figure adapted from: Ph.D. thesis by D. Lenz

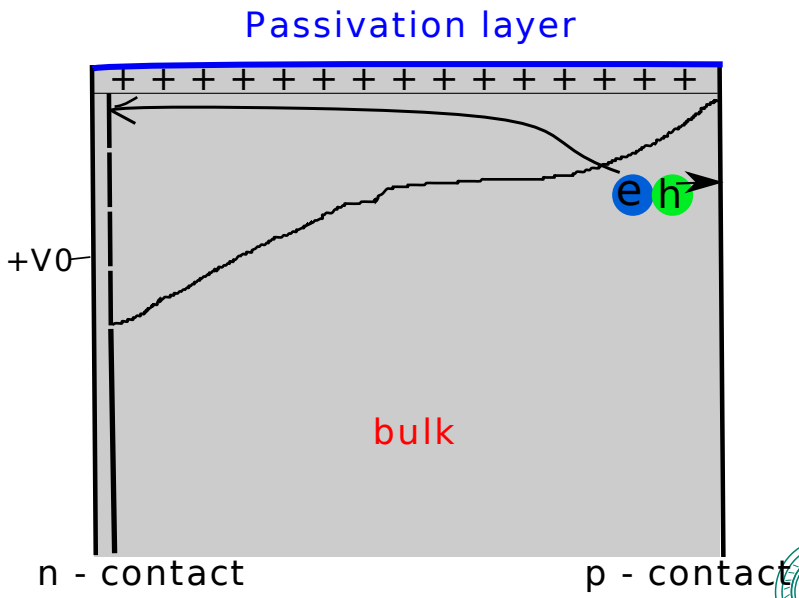
Path of electrons and holes in a detector with an n-type surface channel

Electron-hole pairs created in the surface channel region

(a) close to the n-contact

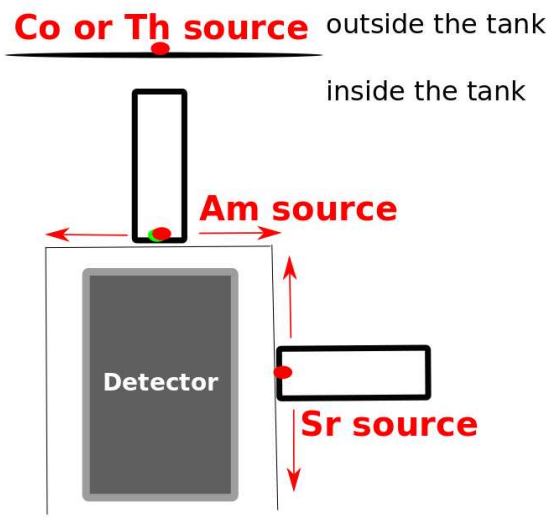


(b) close to the p-contact



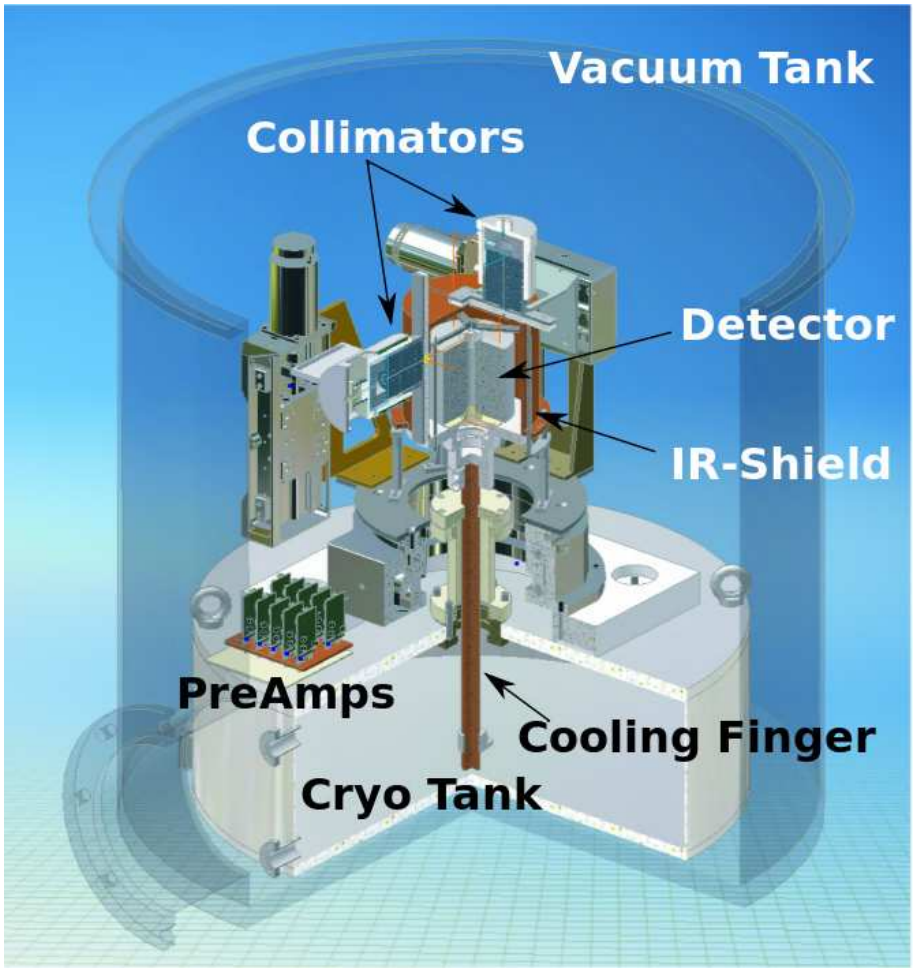
(not to scale) Figure adapted from: Ph.D. thesis by D. Lenz

Experimental Scanning of the Detector



- Sources inside the tank: looking for events which relate to α and $\beta \rightarrow$ surface effects
- Using α and β particles to study the suface $\rightarrow$ they do not penetrate deeply (penetration depth of an electron: $\approx$ 1mm at 1 MeV in Ge)
- Effective inactive layers can be measured very precisely

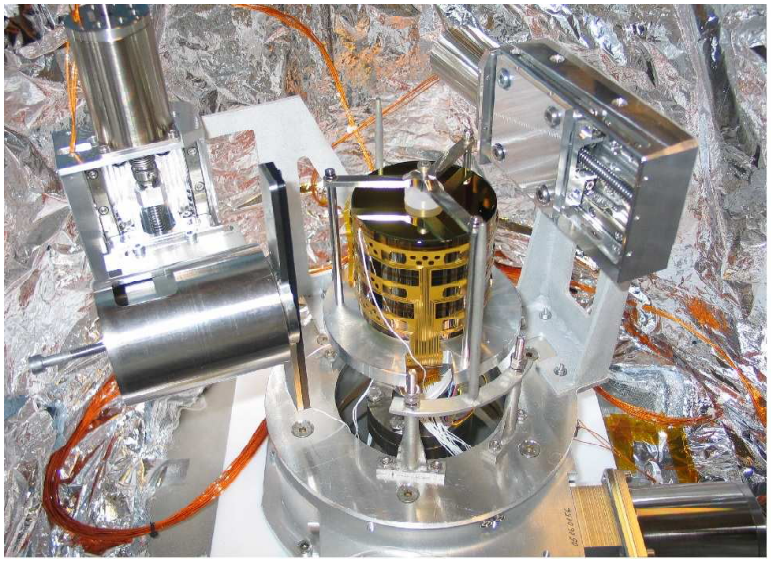
The Test Stand "Galatea"



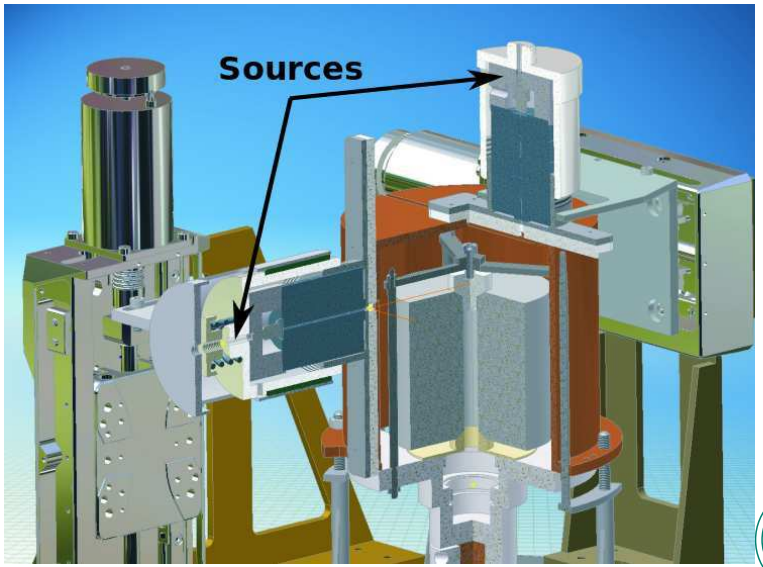
Technical Requirements

- Cooling System
- Vacuum
- Adjustable Sources
- Readout Electronics

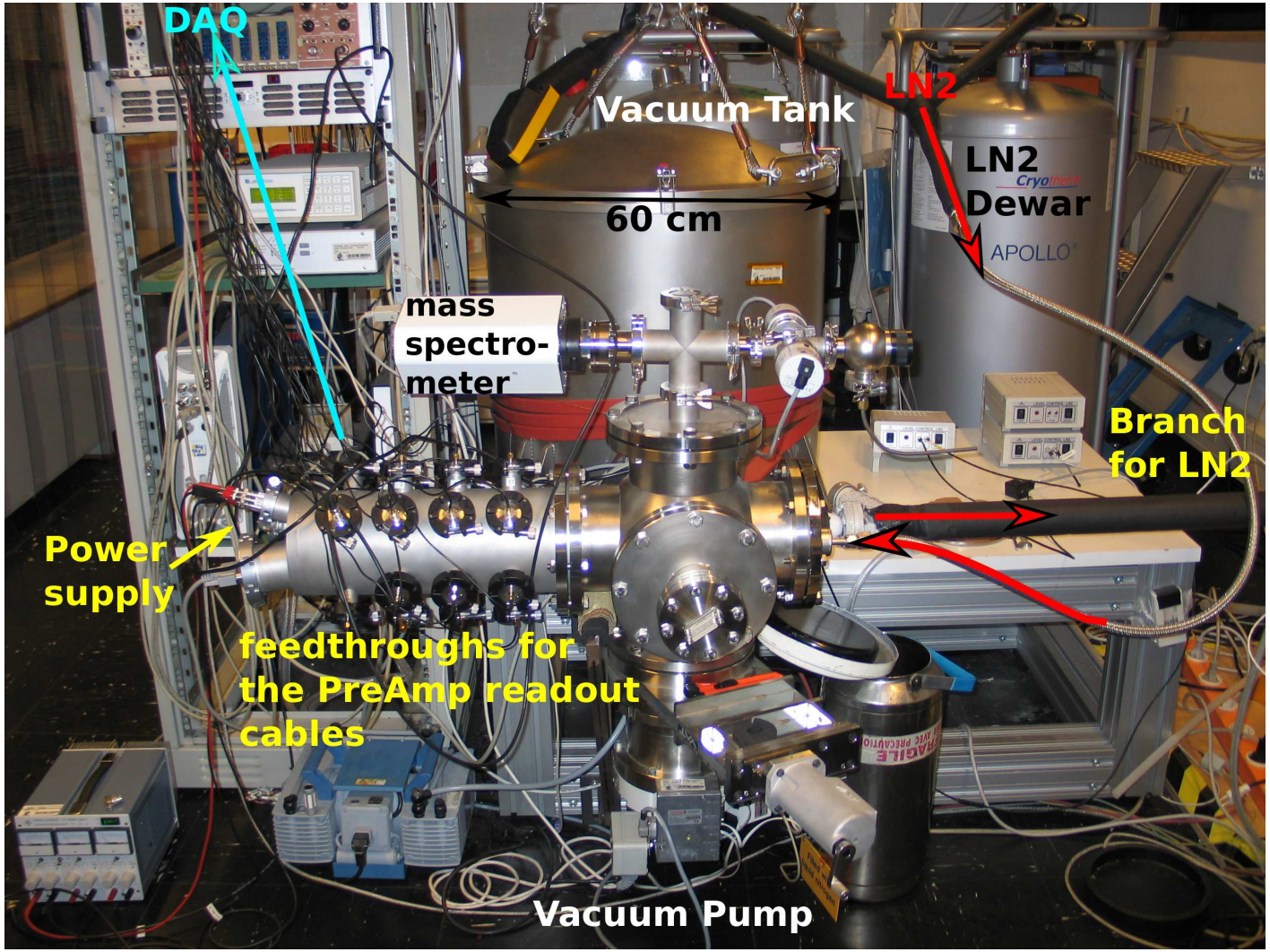
Inside view into the Vacuum Tank



Detector in its holder surrounded by two movable stages



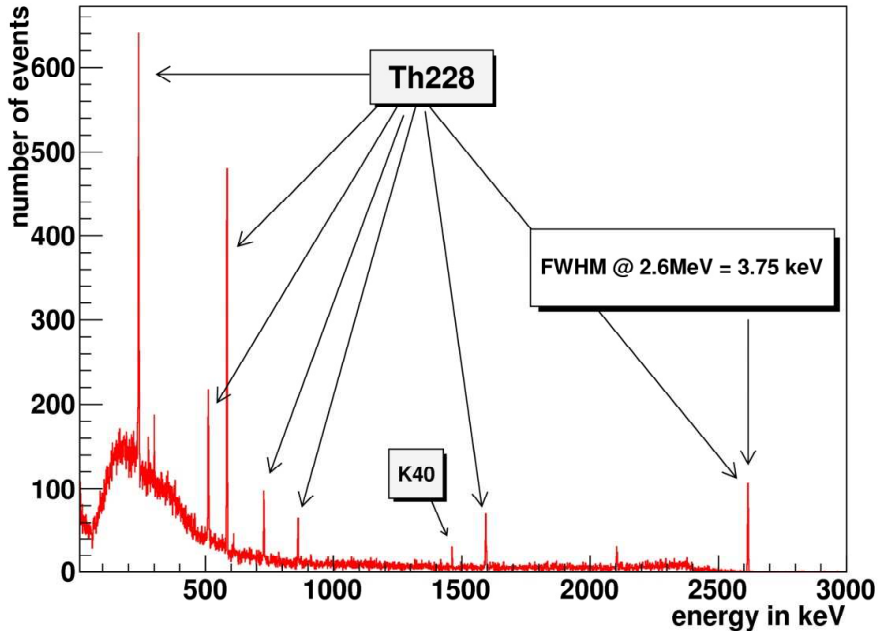
The GALATEA setup



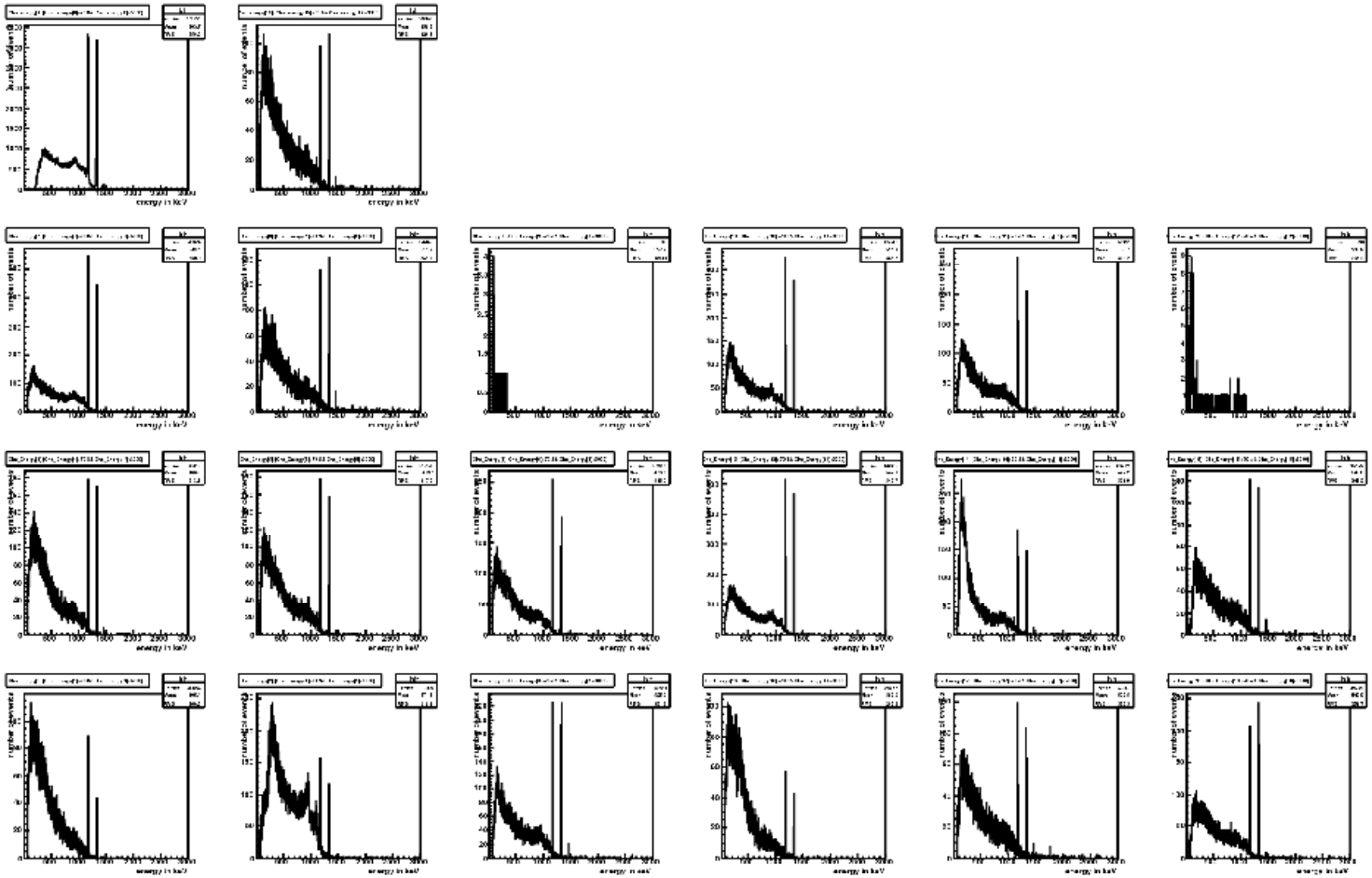
^{228}Th Spectrum seen by the "SuSie" Detector in one representive Segment

Resolution (in all measurements)

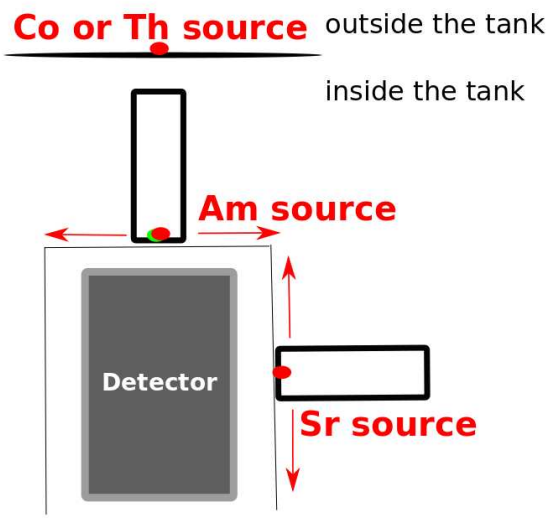
- Core: $\approx$ 15 keV
- Segments: 3-4 keV
- 19th segment: $\approx$ 3 keV



^{60} Co Spectra seen by the "SuSie" detector in all segments



Status Report



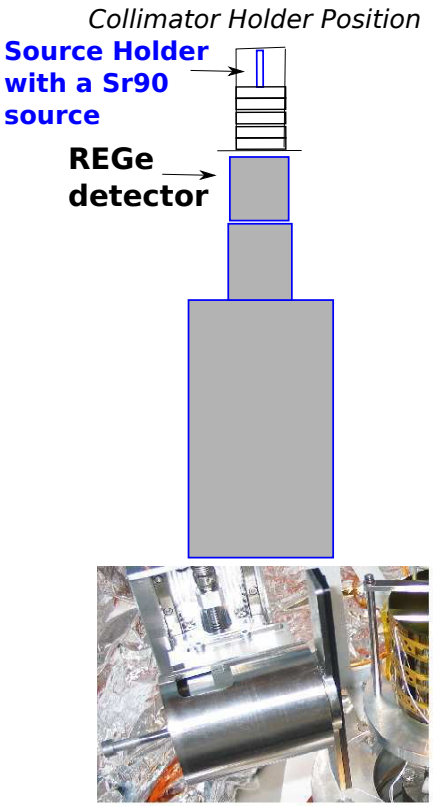
Commissioning phase of Galatea

- Calibration spectra with a ^{60}Co and a ^{228}Th source have been taken
- First test runs with an α (^{243}Am) and a β (^{90}Sr) source

Work in progress: grounding, cable shielding, vacuum, cooling, improvement of the core resolution...

^{90}Sr Spectrum seen by a ReGe detector

REGe = Reverse-Electrode Coaxial Ge Detector



Calibration Measurements

1. **The REGe Detector**
   - Geometry is related to cylindrical Ge detectors
   - mantle: p-contact, core: n-contact
   - 3 keV - 10 MeV
2. **Galatea Collimator holder**
   - W collimator segments
3. **β source: ^{90}Sr**
   - $^{90}\mathrm{Sr} \rightarrow {}^{90}\mathrm{Y} + \mathrm{e}^{-} + \bar{\nu}$

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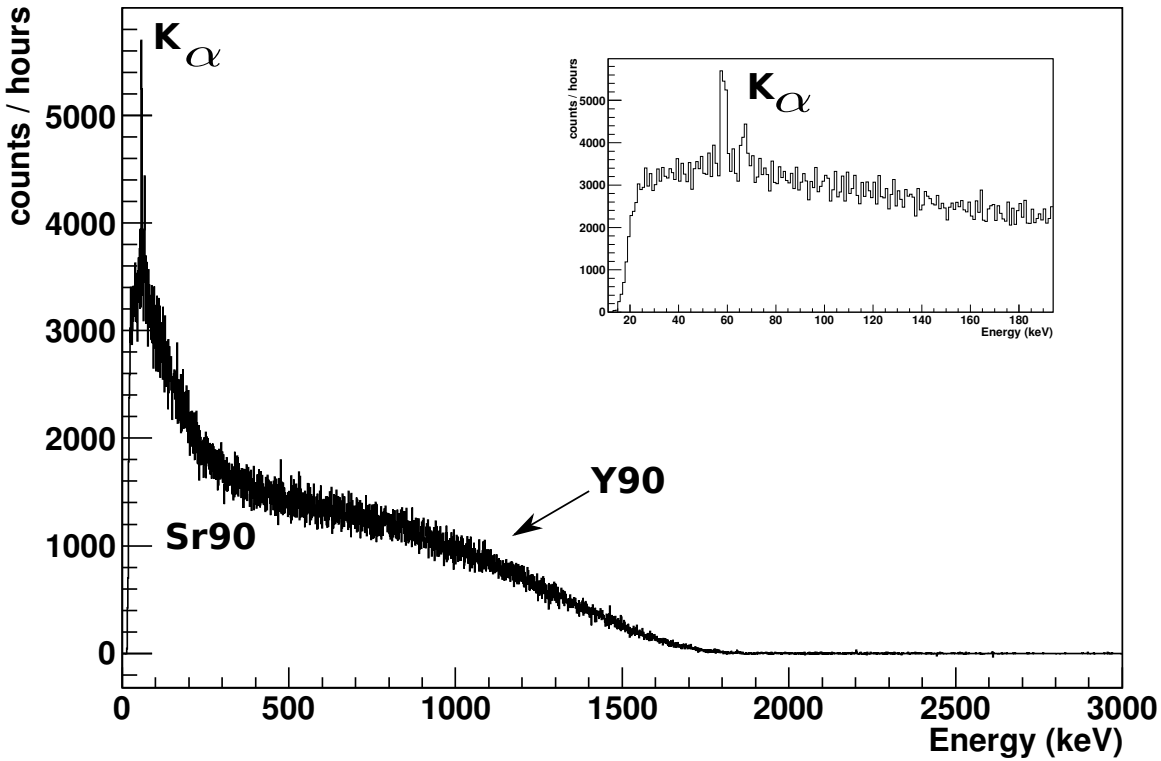

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4. **Looking forward to full detector scans!**