The GALATEA Test Facility

Analysis of Surface Effects for coaxial n-type Germanium Detectors

Sabine Dinter
for the GeDet Group

Max-Planck-Institut für Physik

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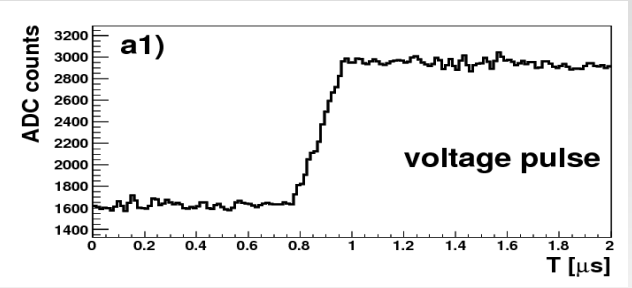
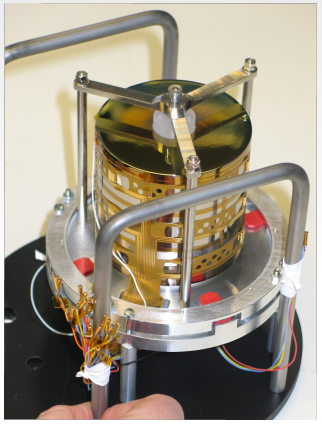
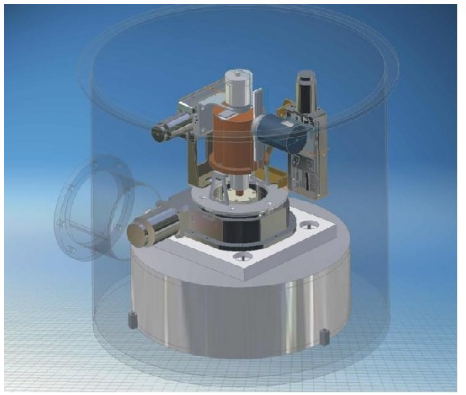
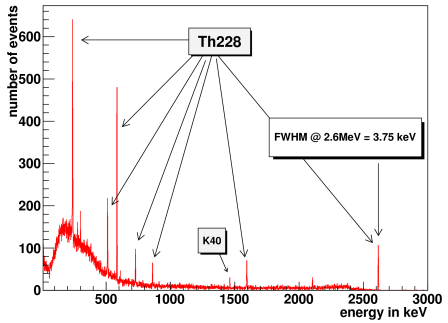
- The „SuSie“ Detector
- The experimental Implementation
- First Spectra









Characterisation of HPGe Detectors

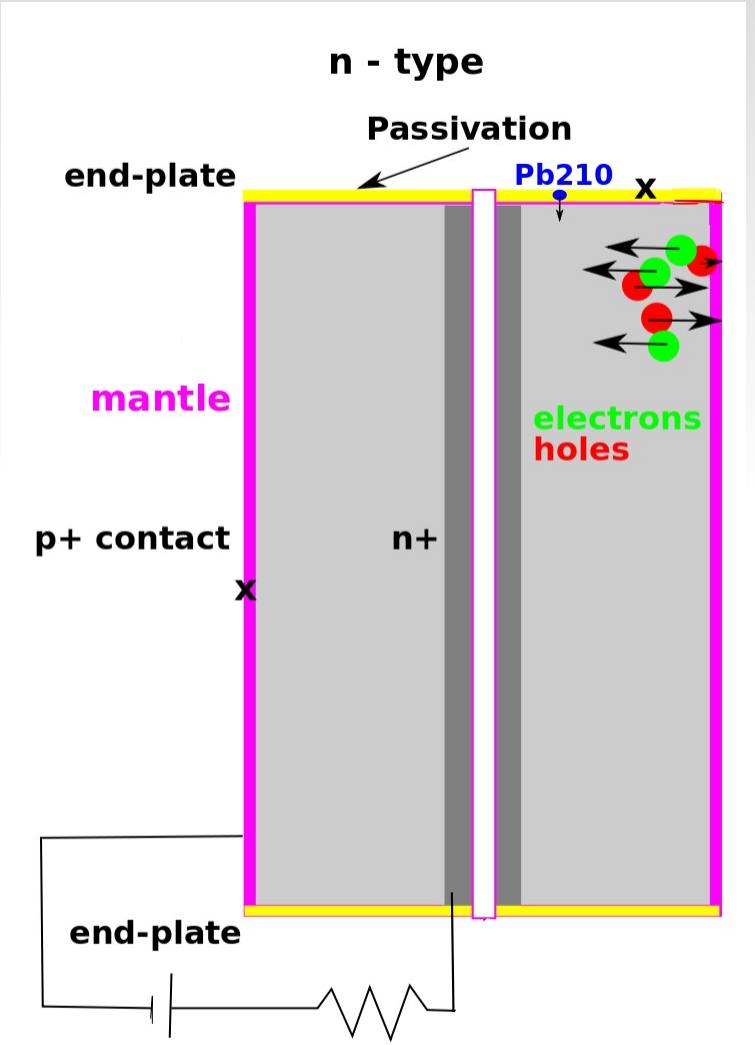
Motivation

Background reduction through event recognition in low-background experiments

- **Germanium detector properties are important for futher analysis**
  - **Charge trapping**
  - **Surface effects**

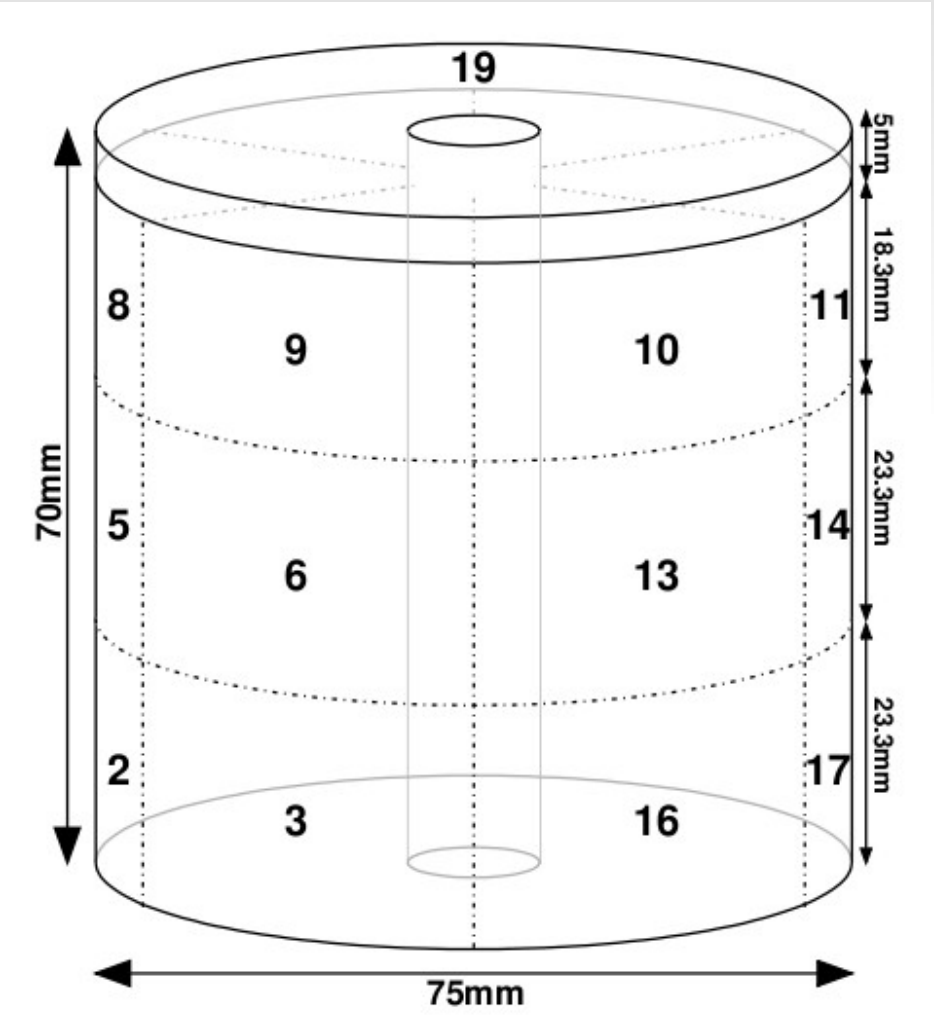
n-type coaxial Detectors

- Electron – hole pair production
- n-type: the electric field pulls the electrons to the core and the holes to the mantle
- Resulting pulses are sampled and digititized at a given frequency

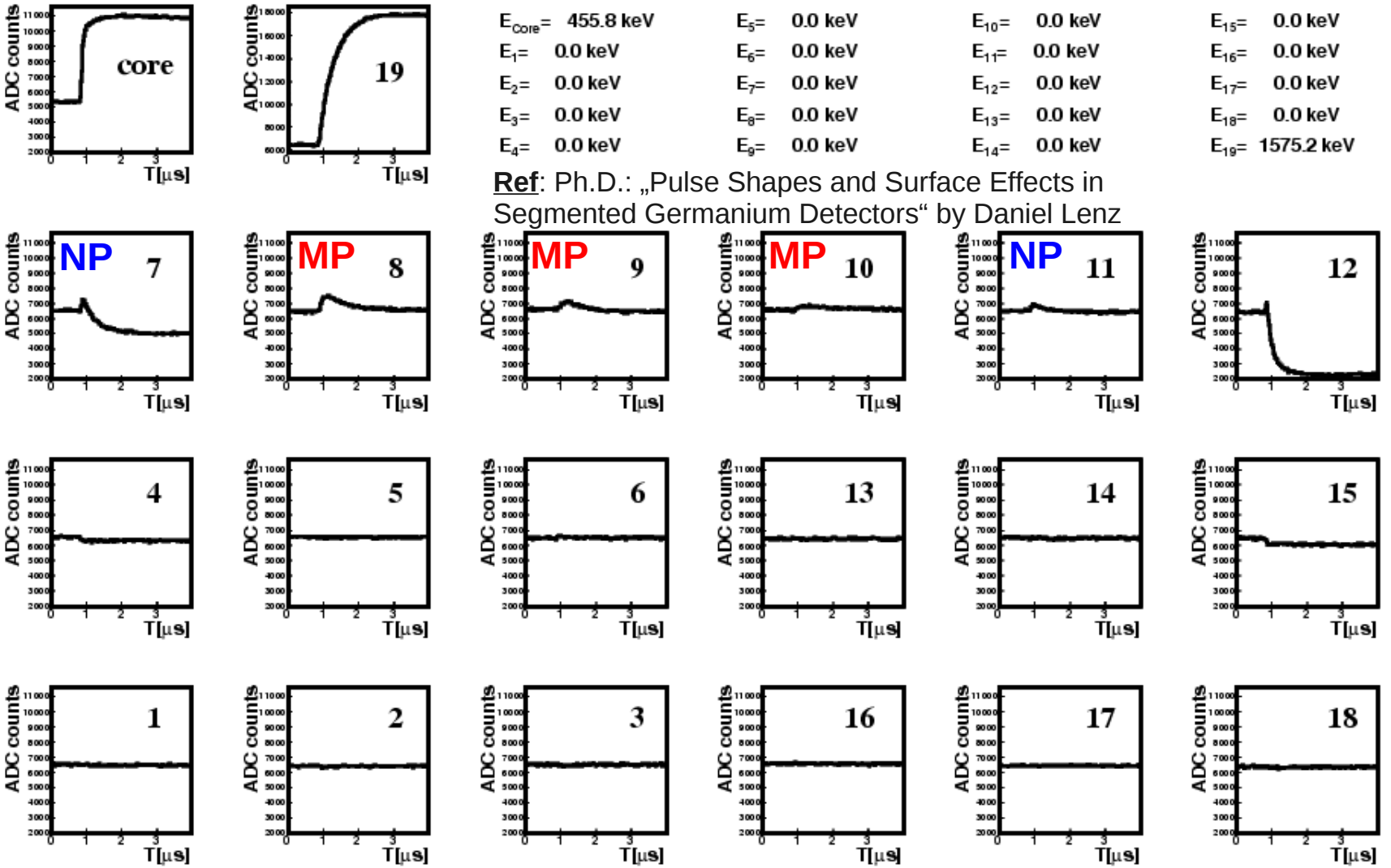


The Detector
Supersiegfried

- 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 & 6ϕ)
- Single segment on one side of the detector



Example pulse seen by the segmented Detector – One Event



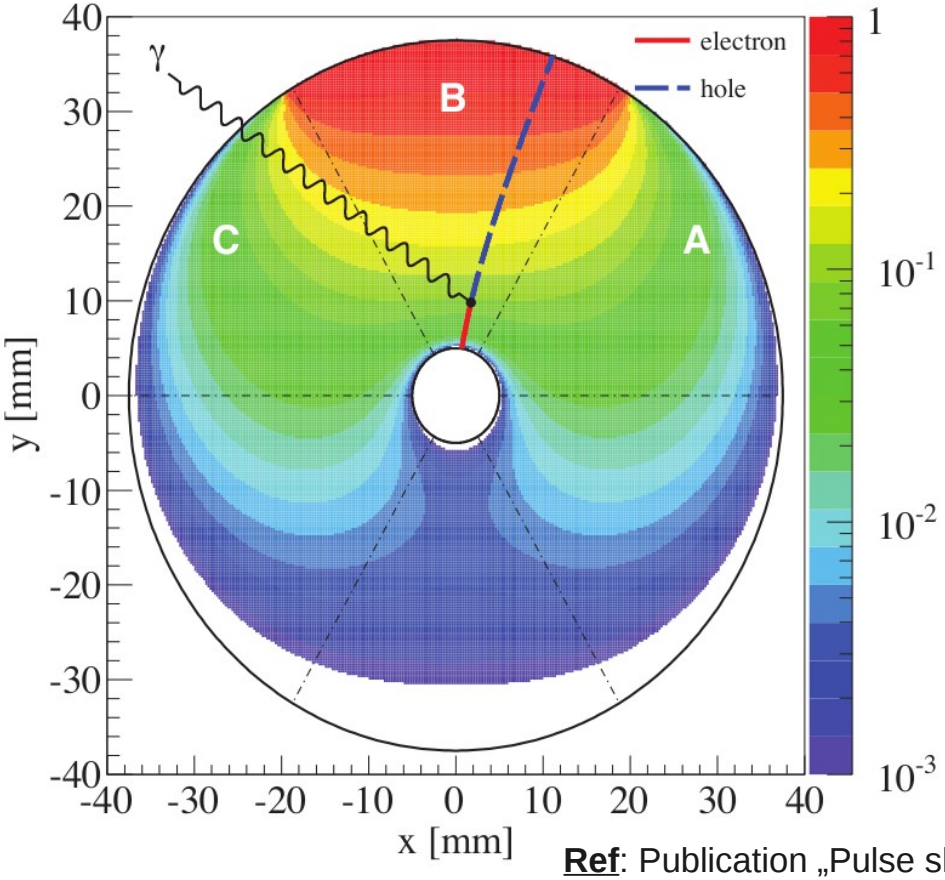
E_{Core}= 455.8 keV
E_1= 0.0 keV
E_2= 0.0 keV
E_3= 0.0 keV
E_4= 0.0 keV
E_5= 0.0 keV
E_6= 0.0 keV
E_7= 0.0 keV
E_8= 0.0 keV
E_9= 0.0 keV
E_{10}= 0.0 keV
E_{11}= 0.0 keV
E_{12}= 0.0 keV
E_{13}= 0.0 keV
E_{14}= 0.0 keV
E_{15}= 0.0 keV
E_{16}= 0.0 keV
E_{17}= 0.0 keV
E_{18}= 0.0 keV
E_{19}= 1575.2 keV

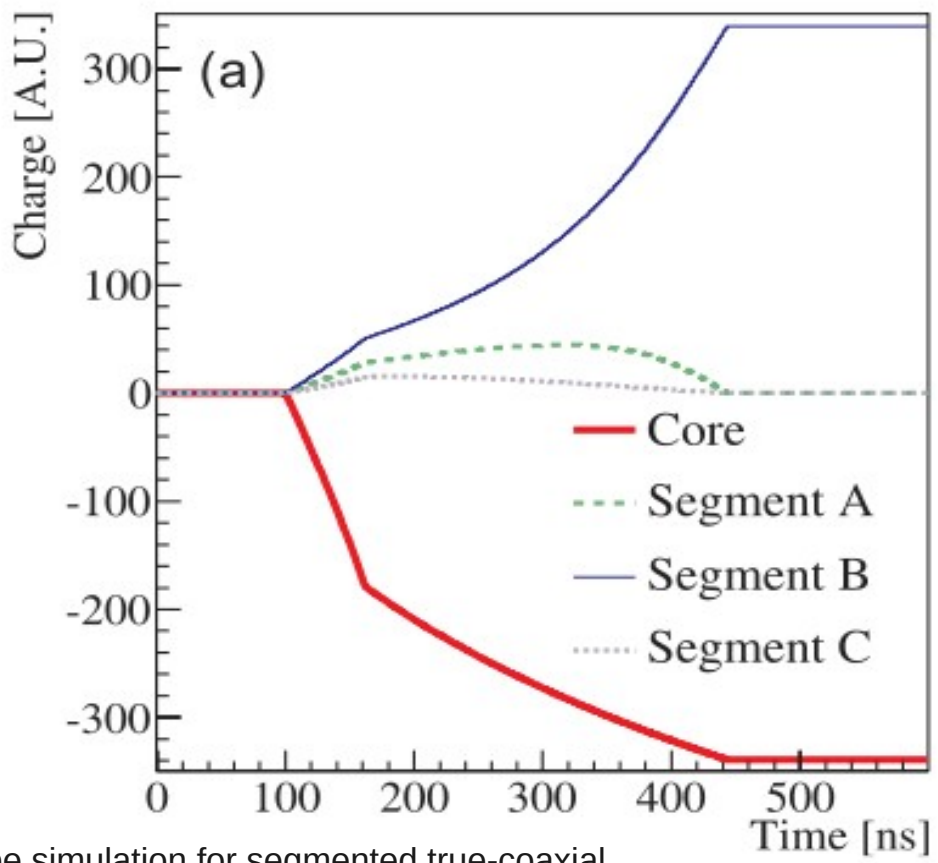
Ref: Ph.D.: „Pulse Shapes and Surface Effects in Segmented Germanium Detectors“ by Daniel Lenz

MP = Mirror Pulse
NP = Negative Pulse

Pulses and Mirror Pulses

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



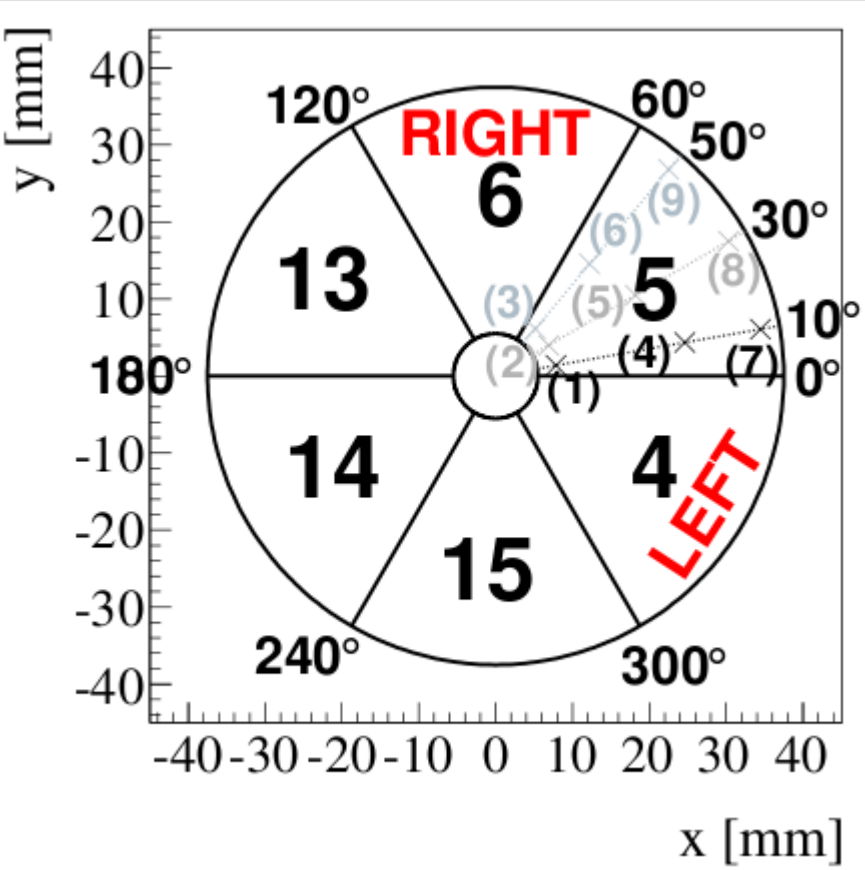


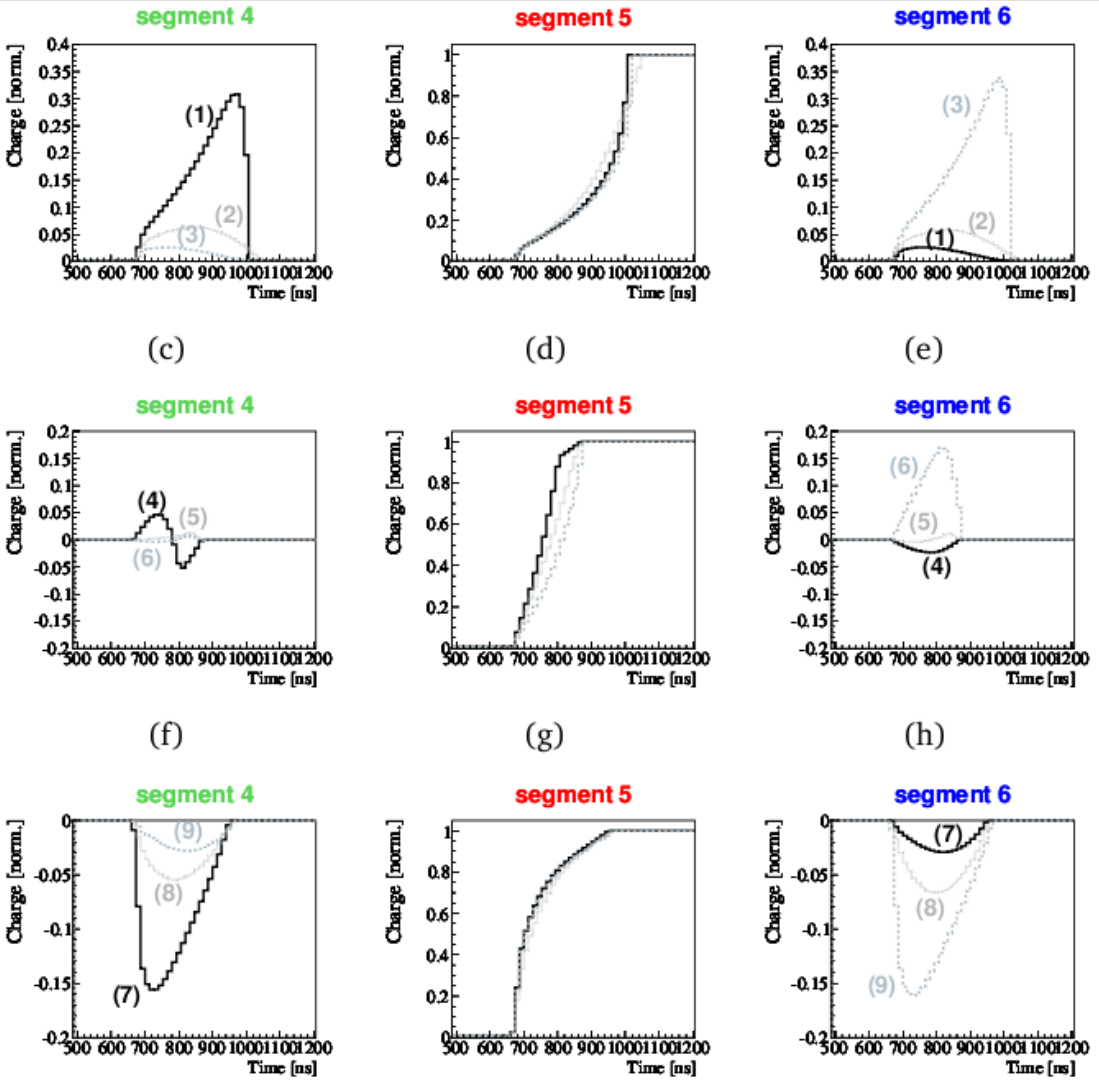
Ref: Publication „Pulse shape simulation for segmented true-coaxial HPGe detectors“ by I.Abt, A.Caldwell, D.Lenz, J.Liu, B.Majorovits

Real Pulse: **charge „trajectory“ ends at considered segment electrode**

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

Characteristics of Mirror Pulses





Ref: Diploma Thesis:
„Mirror pulses and position reconstruction in segmented HPGe Detectors“ by S. Hemmer

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Pulse Shapes including Mirror Pulses

Information about

+ the energy deposited

+ the position of an event

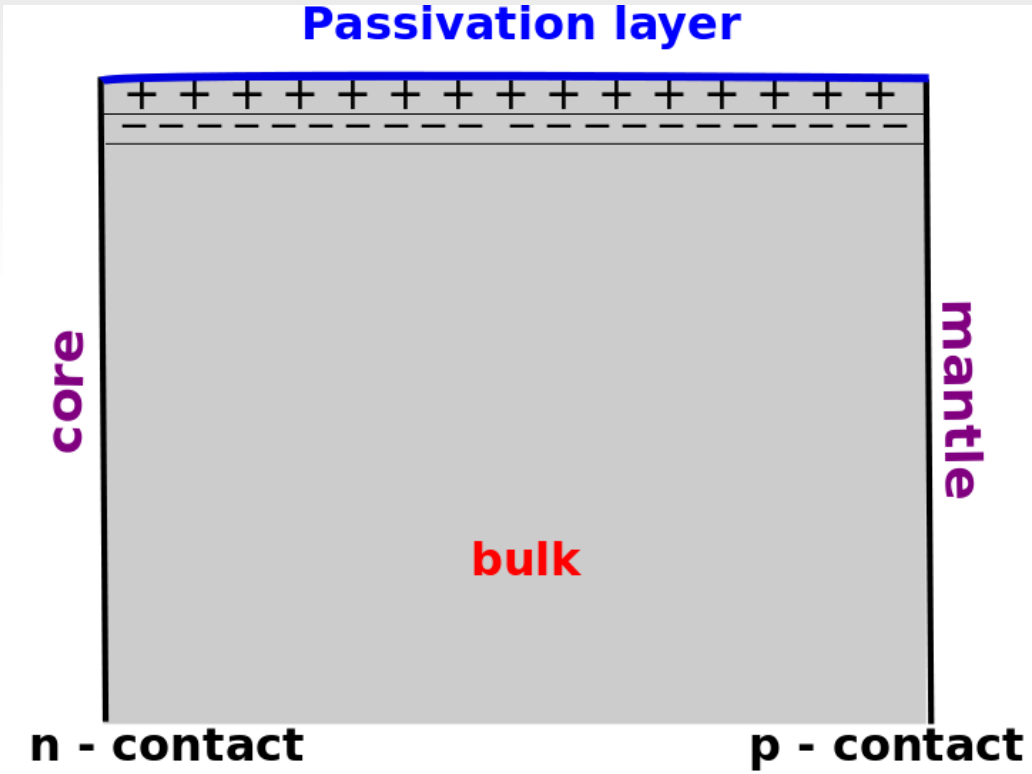
- **position in r → rise time plus polarity of mirror pulses**
- **position in phi → relative strength or mirror pulses**

Proximity to end plates → long and strange pulses

What is going on?

Surface Channel Effect

Not Depleted



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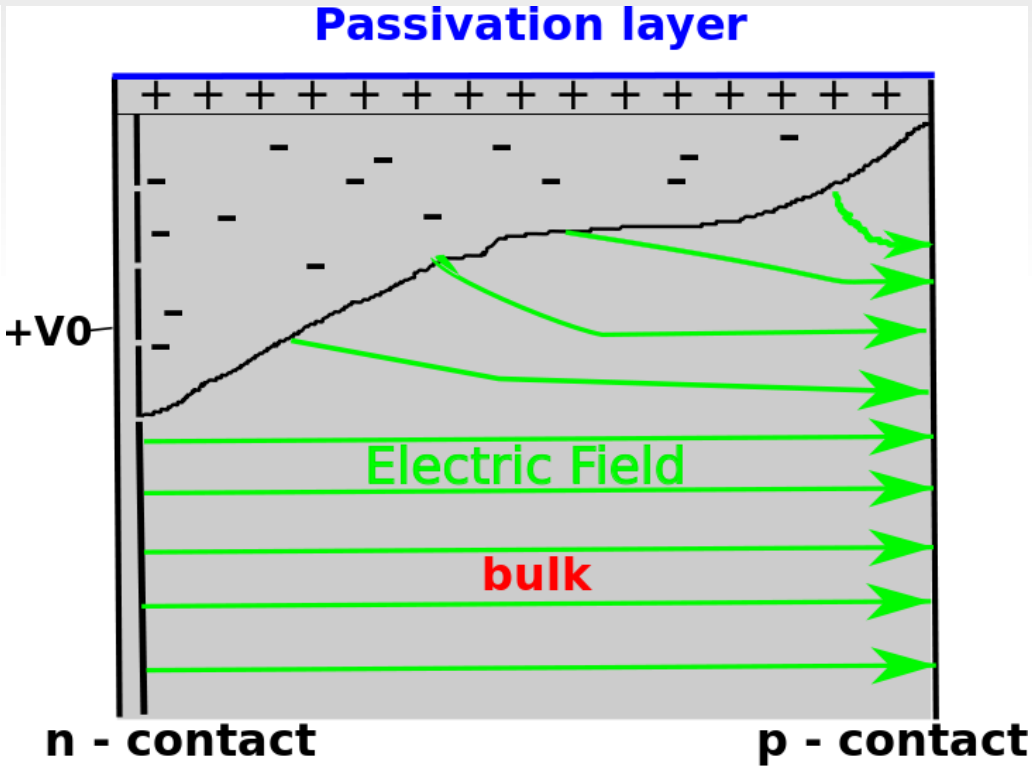


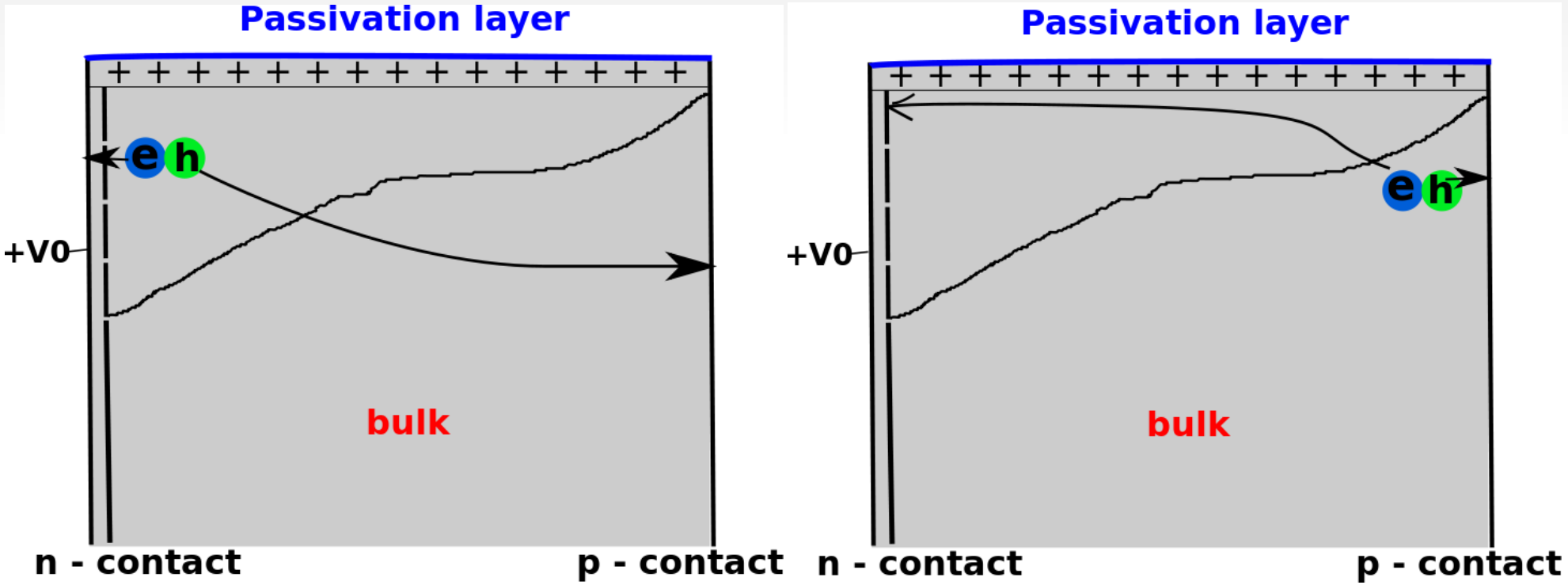
(Not to scale)

Surface Channel Effect

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

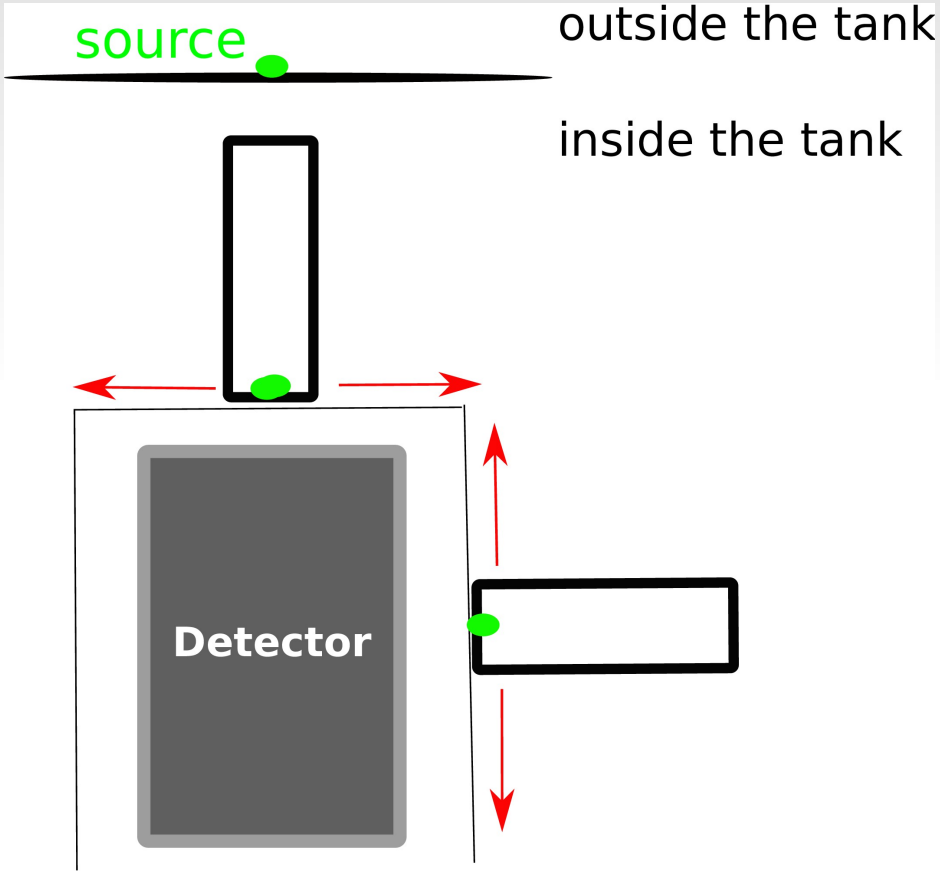
Electron-hole pairs created in the surface channel region

(A) close to the n-contact **(B) close to the p-contact**



(Not to scale)

Experimental Scanning of the Detector



Sources inside the tank: looking for events which relate to α and ß => surface effects

→ **Using α and ß particles to study the surface because they do not penetrate deeply: penetration depth of an electron: ~1 mm at 1 MeV in Ge**

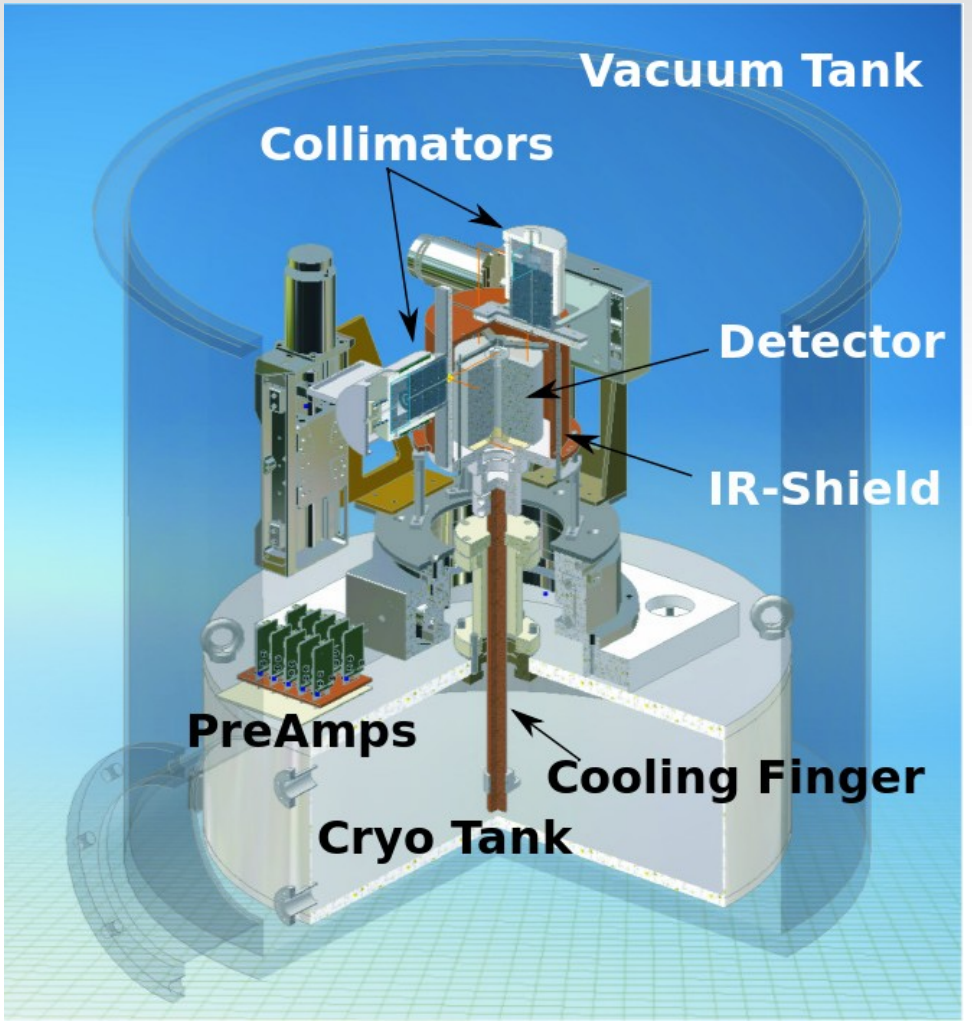
→ **Effective inactive layers can be measured very precisely**

Experimental Setup

The Test Stand "Galatea"

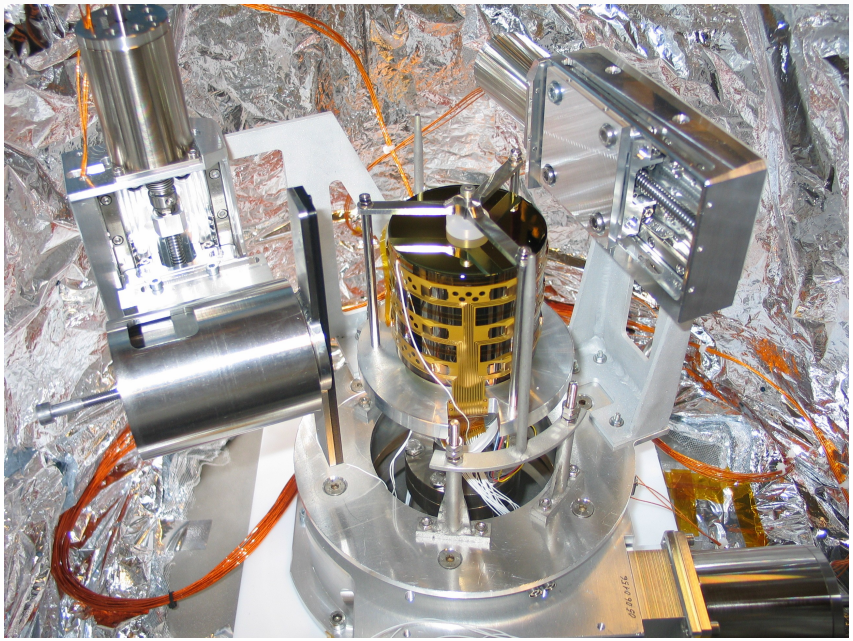
Technical Requirements

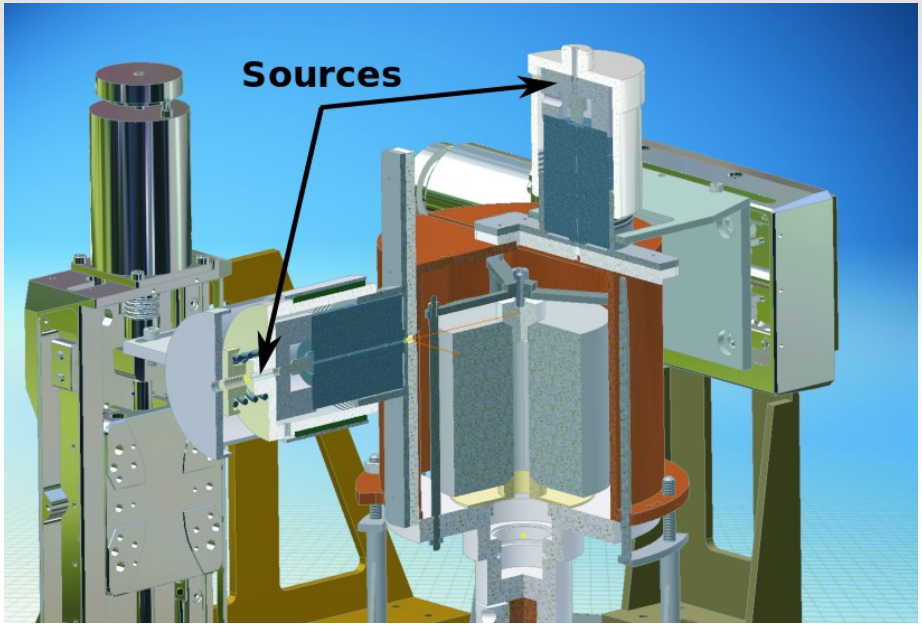
- Cooling System
- Vacuum
- Adjustable Sources
- Readout Electronics



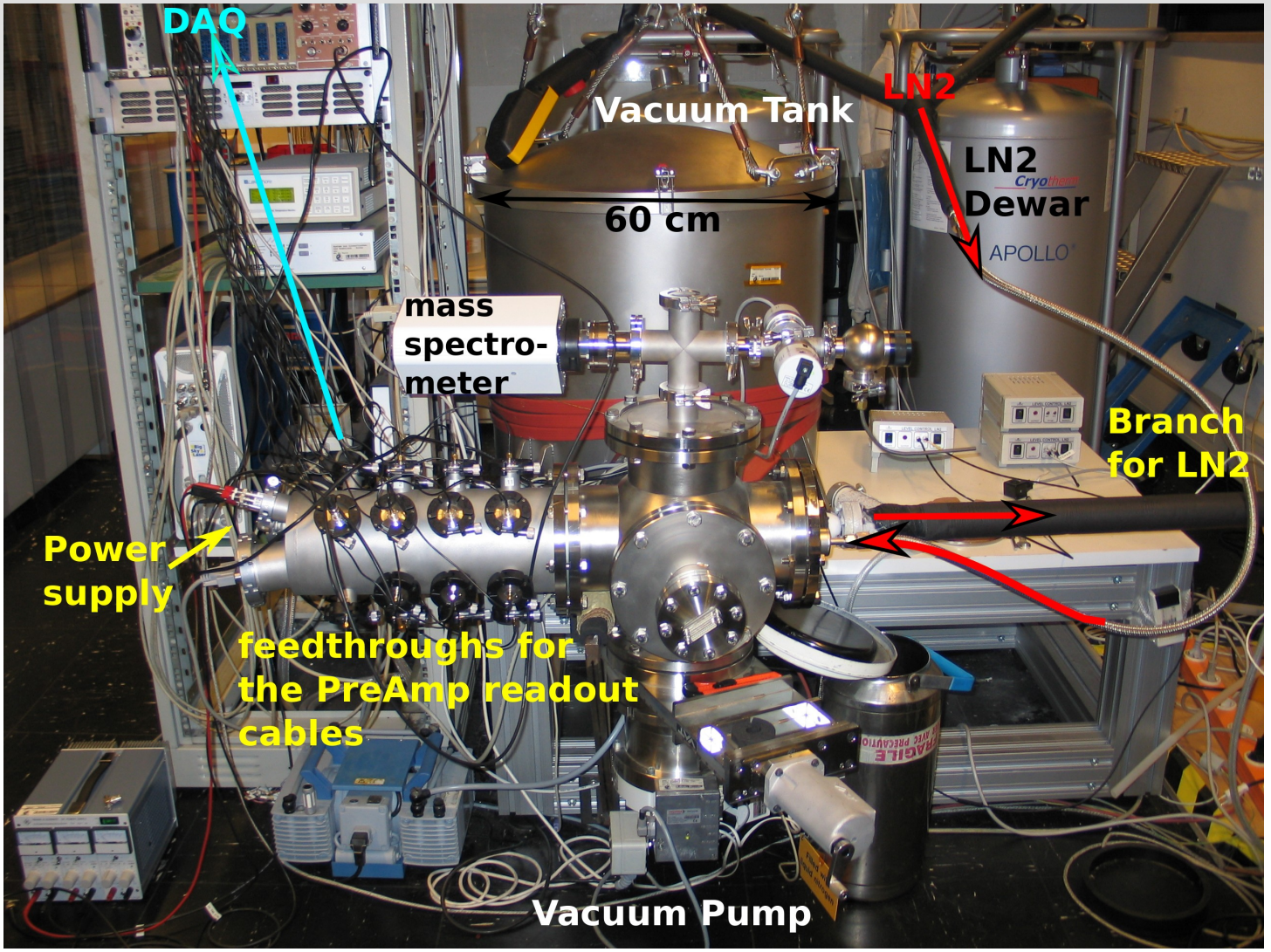
View into the Vacuum Tank

Detector in its holder surrounded by two movable stages





The entire GALATEA setup



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Commissioning

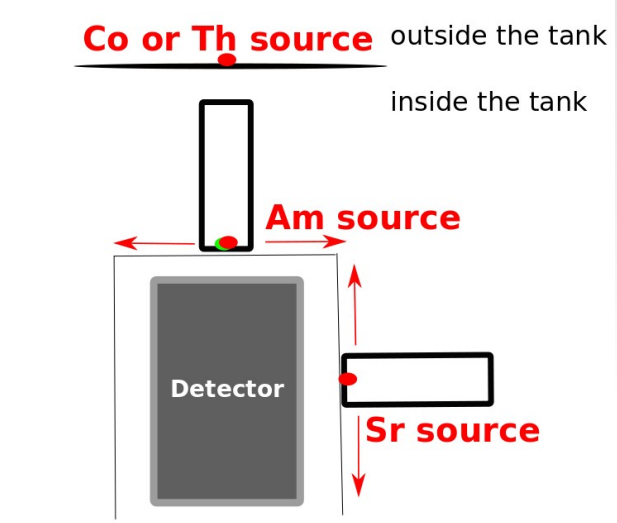
- ^{60}Co and ^{228}Th source on top of the tank

  ➔ calibration

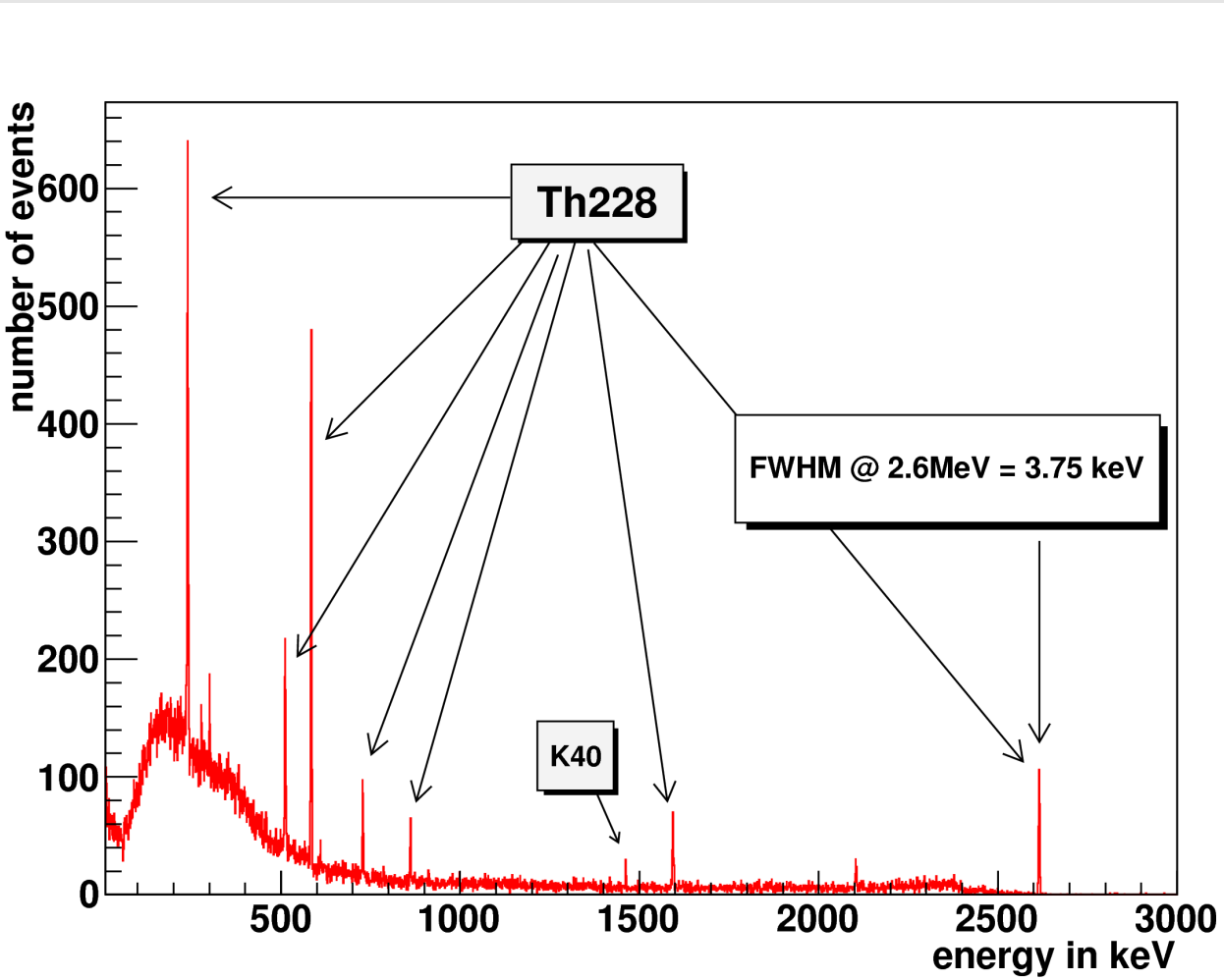
- α- and β- source inside the tank mounted

  ➔ ^{243}Am as an α-source from the top (horizontal stage)

  ➔ ^{90}Sr as a β-source from the side (vertical stage)



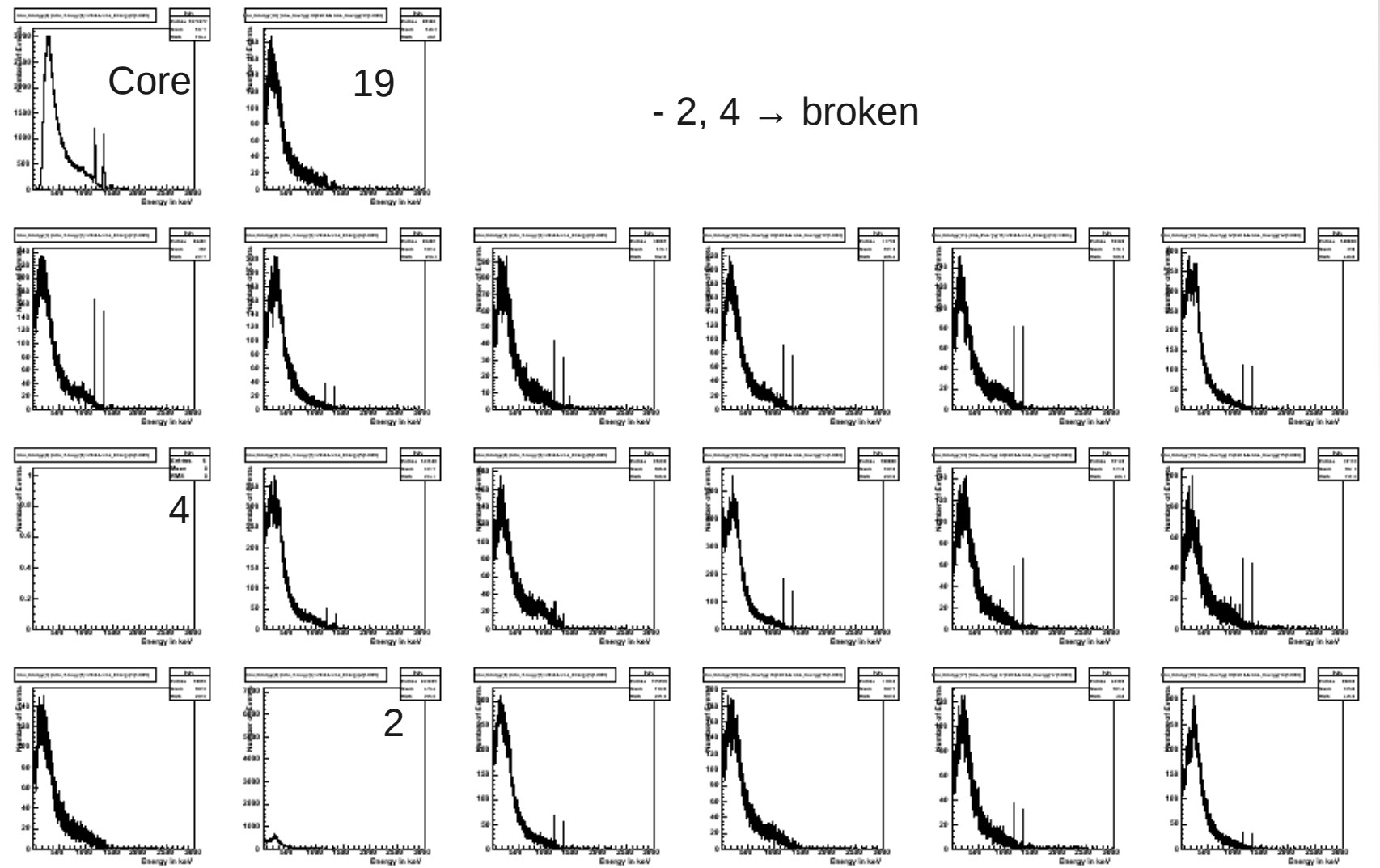
^{228} Th Spectrum in one representative Segment



Resolution
(in all measurements so far):

Segments: 3 - 4 keV
19th Segment: ~ 3 keV
Core: ~ 15 keV

^{60}Co Spectra



- 2, 4 → broken

Open Issues

- **Work in progress**
  - **Grounding, cable shielding... → improve core resolution**
  - **Improvement of the pumping and cooling procedure to allow permanently running measurements**
- **Goals**
  - **Full scan of the detector with different sources**
  - **Preparation of a laser system for further studies**

Summary & Outlook

Goal is to study surface effects in a segmented true-coaxial HPGe Detector

- **Scanning of the detector with α and ß particles**
  - **Characterize events to allow identification**
- **A new test stand is being commissioned**
  - **First calibration spectra have been shown!**

Looking forward to full detector scans!