



Surface Characterization of Germanium Detectors with α Particles

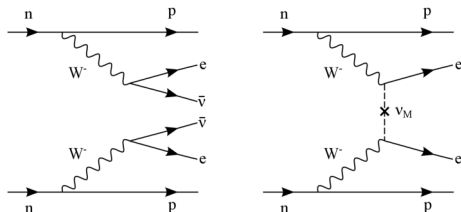
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- 1 Physics Motivation
- 2 Germanium Detector: Siegfried III
- 3 Experimental Setup - GALATEA
- 4 Analysis of Surface Events
- 5 Summary and Outlook

Neutrinoless double beta decay ($0\nu\beta\beta$): ${}^A_ZX \rightarrow {}^A_{Z+2}X + 2e^-$



- Lepton number violating
- Majorana/Dirac particle?
- Effective neutrino mass m_{ee} ?
- Neutrino mass hierarchy?

→ The GERmanium Detector Array (GERDA) Experiment

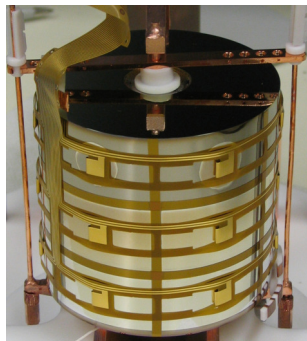
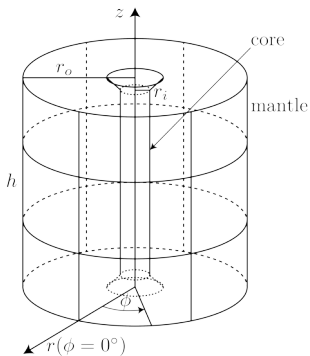
- ${}^{76}\text{Ge}$ is a possible candidate for $0\nu\beta\beta$
- ${}^{76}\text{Ge}$ enriched germanium is used as source and detector
- $T_{1/2} > 8.0 \times 10^{25}$ yr (90 % C.L.) [GERDA talk T92.1]

New Collaboration: LEGEND

(Large Enriched Germanium Experiment for Neutrinoless $\beta\beta$ Decay)

- Increase detector mass to ≈ 1 t of Germanium
- Biggest challenge: Further reduction of background

- Sources of background:
- α contaminations on the detector surface
 - inefficient charge collection (close to the surface)
 - How does the background look like? → veto
 - How does the metallization and passivation influence the charge collection?
 - How to improve detectors?

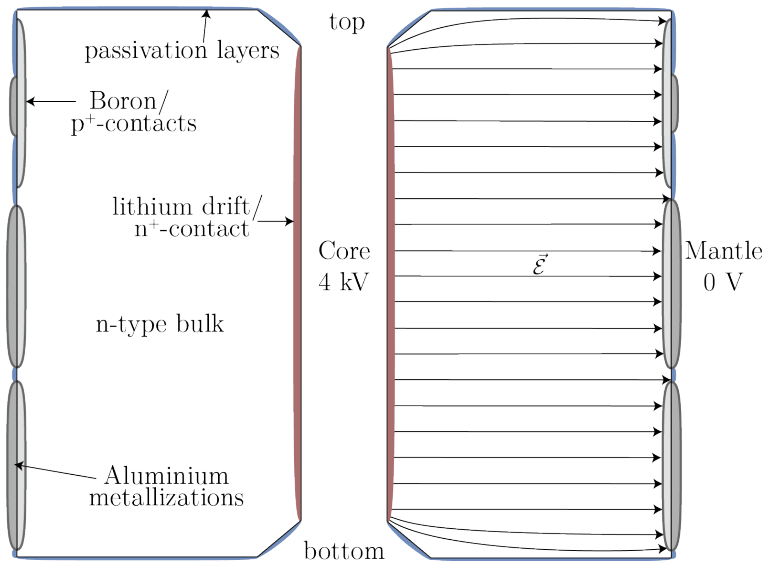


$h = 70.1 \text{ mm}$
 $m_D = 1662 \text{ g}$

$r_o = 37.5 \text{ mm}$
 $r_i = 5.0 \text{ mm}$

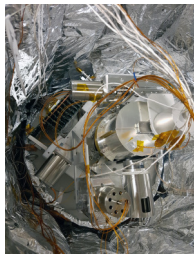
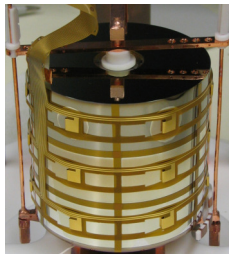
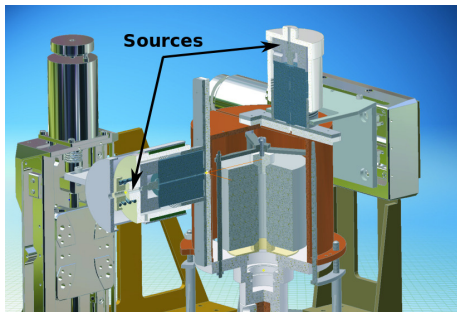
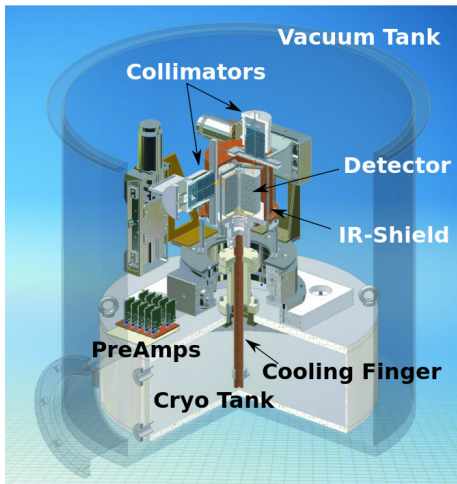
Germanium Detector: Siegfried III

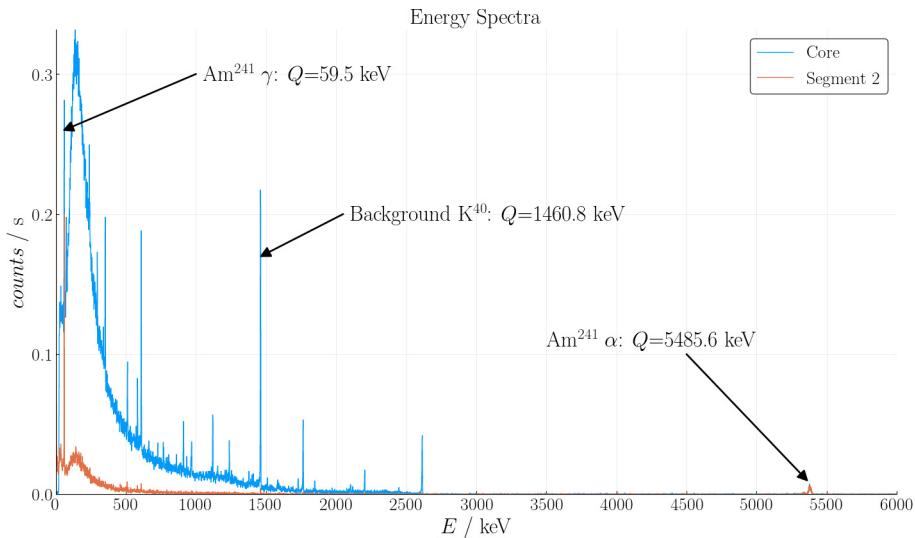
Siegfried III - Cross-Section

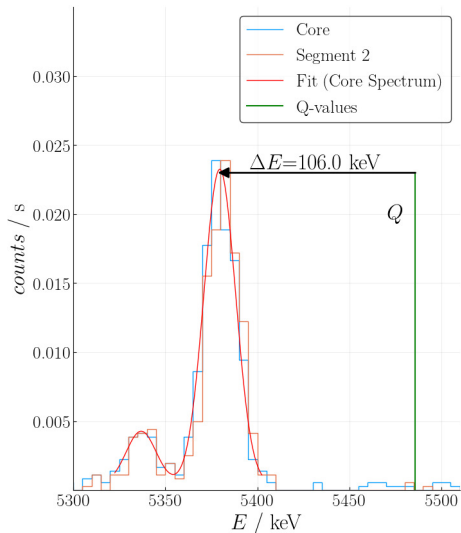


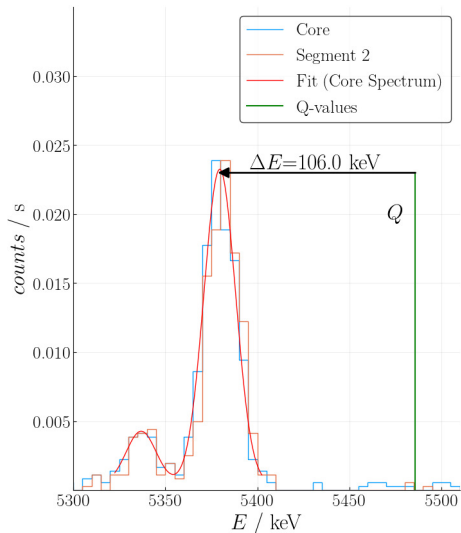
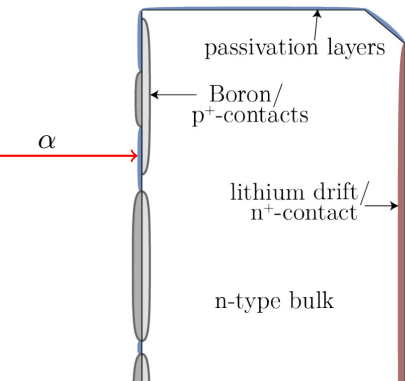
Experimental Setup

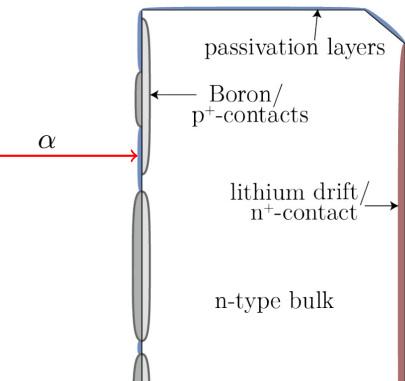
GALATEA







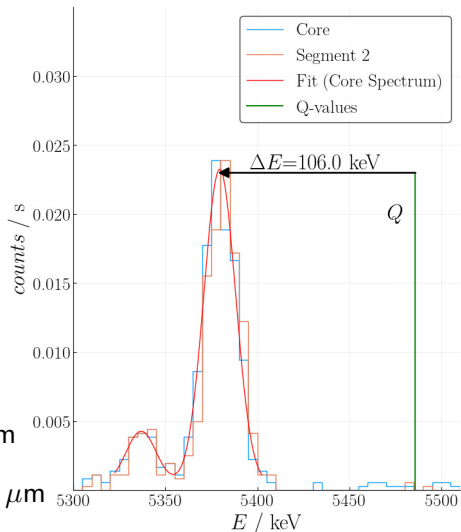




$$S_{\text{Ge}}^{\alpha}(E \approx 5.45 \text{ MeV}) \approx 206 \text{ keV}/\mu\text{m}$$

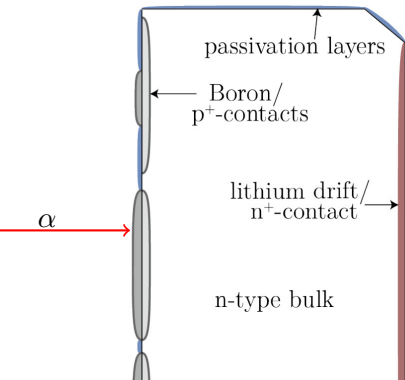
→ Boron implantation depth $\approx 0.5 \mu\text{m}$

→ No passivation on the mantle



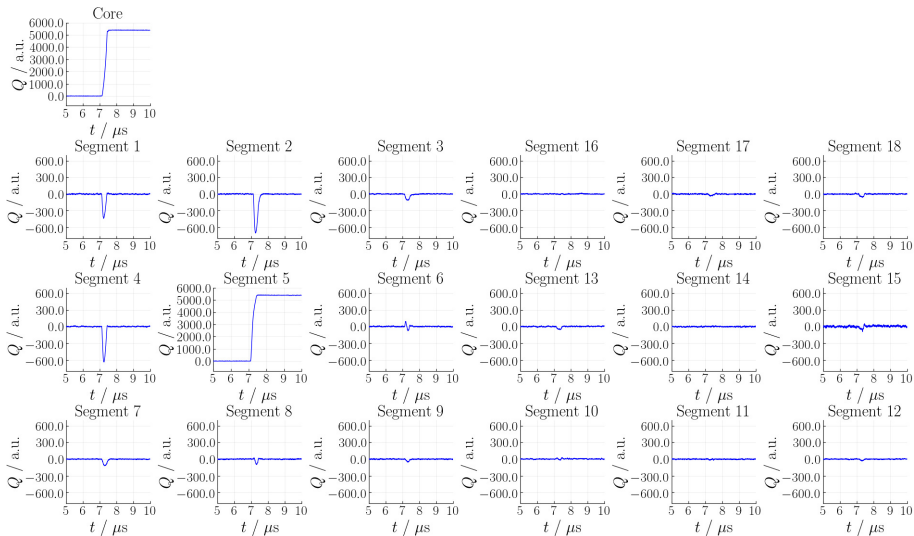
^{241}Am - Event Pulse Display

Mirror Pulse Amplitudes - Asymmetries



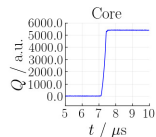
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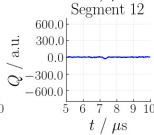
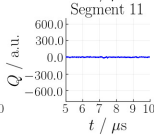
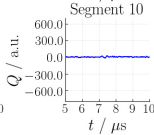
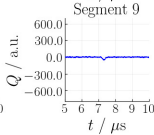
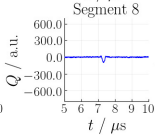
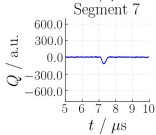
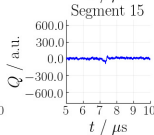
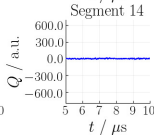
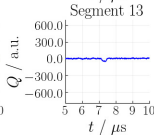
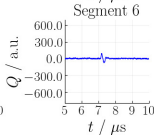
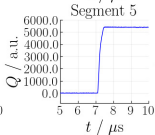
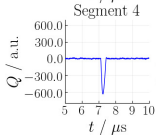
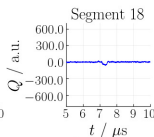
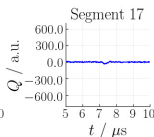
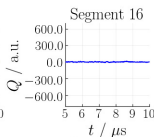
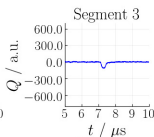
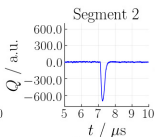
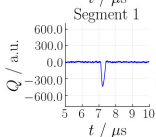
^{241}Am - Event Pulse Display

Mirror Pulse Amplitudes - Asymmetries



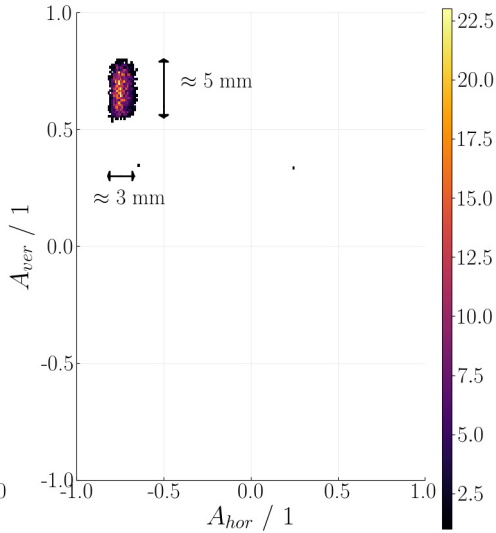
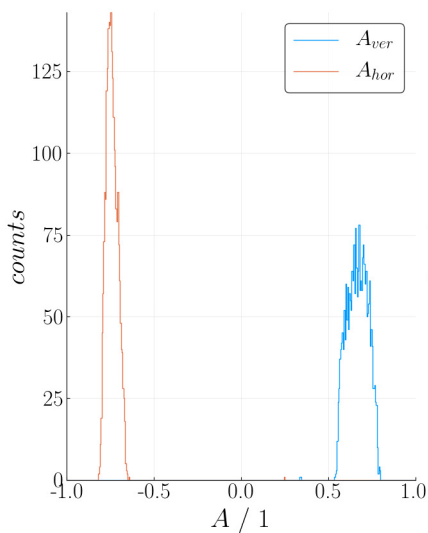
$$A_{hor} = \frac{MPA_{right} - MPA_{left}}{MPA_{right} + MPA_{left}}$$

$$A_{ver} = \frac{MPA_{top} - MPA_{bot}}{MPA_{top} + MPA_{bot}}$$



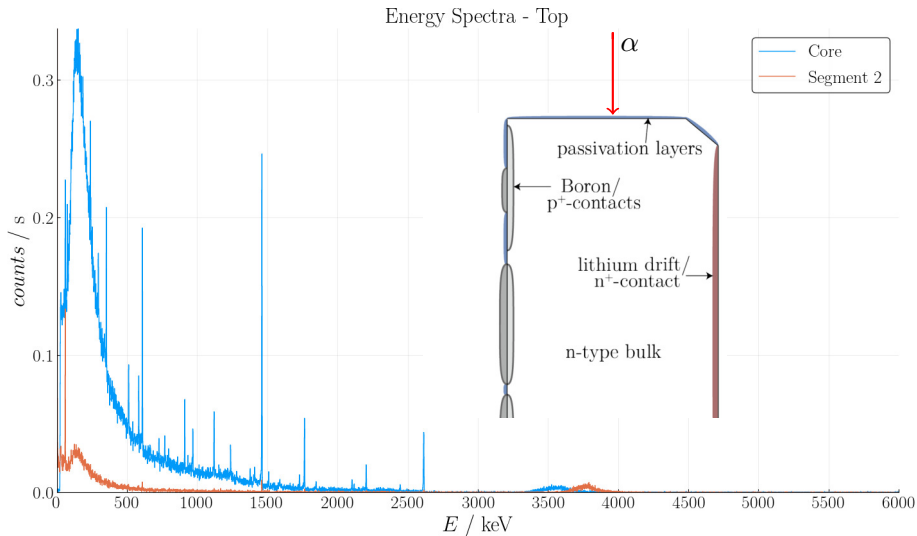
Event Localization

Mirror Pulses Amplitudes - Asymmetries



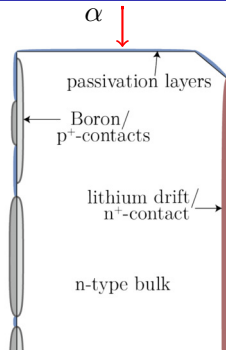
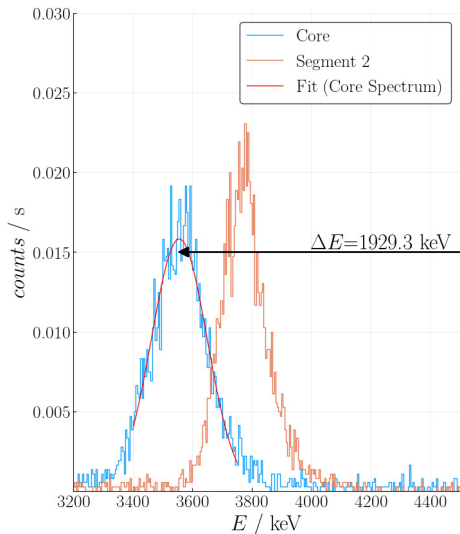
Inefficient Charge Collection

Energy Spectrum



Inefficient Charge Collection

Energy Spectrum

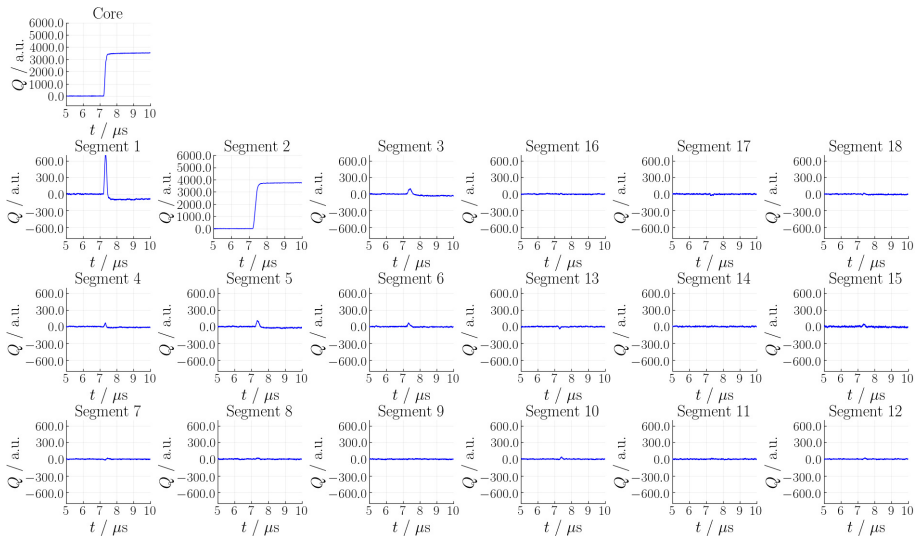


$2 \mu\text{m}$ Passivation $\hat{=}$ $\Delta E \approx 330 \text{ keV}$
equivalent dead layer of $\approx 9 \mu\text{m}$

Inefficient Charge Collection



Charge Trapping



Summary:

- Further background reduction is very important for LEGEND
- Segmentation is used to investigate events
- Alpha events are studied to gain information to veto events
- Alphas can also be used to characterize detector surfaces

Outlook:

- Investigate segment boundaries, metallization effects and passivation areas in detail
- Improve our simulations (add segmentation, metallization, passivation)
- Compare observations to simulation