GeDET Project Review 2011

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- Motivation.
- Temperature dependence and axis determination for germanium detectors.
- GALATEA test stand.
- BEGe simulations.
- REGe background measurements.
- Aluminum as a background source.

GeDET Group

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Engineering: Sven Vogt

Many thanks to the Walter Kosmale, Reinhard Hoffmann, Stefan Mayer, Alex Wimmer, Martin Burrack and the colleagues from electronic and mechanic departments.

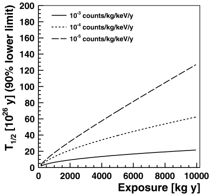
Development of segmented n-type Germanium detectors for future applications.

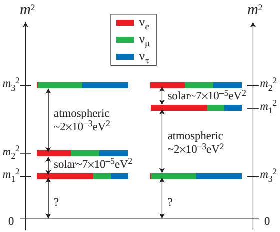
1 Ton initiative:

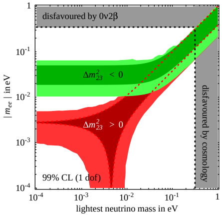
- Push further down sensitivity
- Normal or inverted hierarchy?
- 1 Ton of enriched Ge
- Background index of 10^{-5} counts/(kg y keV)

Study of properties of Ge detectors:

- Surface events induced by α and β
- Pulse shapes to extract position information and event topologies
- New germanium detector geometries $\rightarrow$ Segmented BEGe detectors



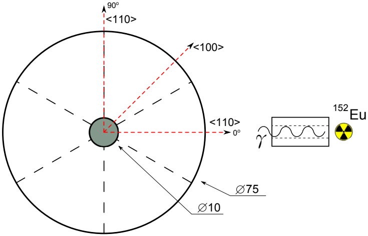


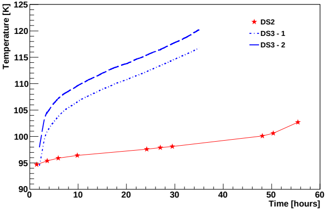


Temperature dependence of pulse lengths

Experimental Setup:

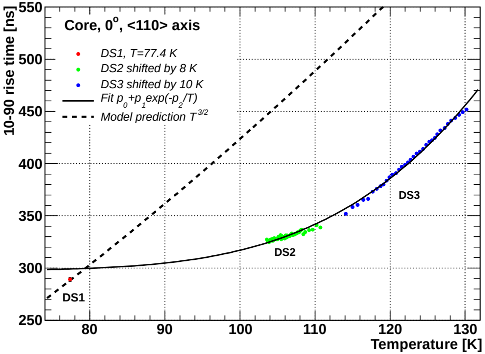
- A cylindrical true-coaxial 18-fold segmented n-type detector.
- The detector mounted either inside a vacuum cryostat (changing T), K1, or submerged in a liquid nitrogen volume (fixed T), GII.
- The detector was operated temperatures at 77 K and between 95 K to 130 K.





Ref."Measurement of the temperature dependence of pulse lengths in an n-type germanium detector", I. Abt et al., Eur. Phys. J. Appl. Phys. 56 (2011) 10104.

Temperature dependence of pulse lengths



Expectation:

- If $E \sim$ const. $\rightarrow$ $t_{rise} \propto \mu_{eff}^{-1}$.
- $\mu_{eff} \propto T^{-3/2}$.

Measurement:

- Boltzmann-like law: $t_{rise} \propto e^{-k/T}$.
- Is something else T-dependent?

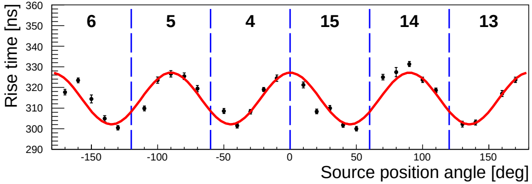
- Temperature dependence of the rise time should be taken into account when pulses are simulated.
- The detector was stable up to temperatures of 130 K!

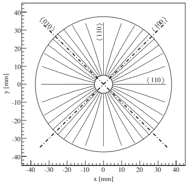
Ref. "Measurement of the temperature dependence of pulse lengths in an n-type germanium detector", I. Abt et al., Eur. Phys. J. Appl. Phys. 56 (2011) 10104.

Axes determination - Measurement

- The orientation of the axes of a detector is important for any analysis where pulse shapes are used.
- The difference of the mobility of charge carriers along the ”slow” and ”fast’ axes is significant, **longitudinal anisotropy**.
- Also, the path of charge carriers not drifting parrallel to the crystal axes are bent, **transverse anisotropy**.

Azimuthal scan of the detector:

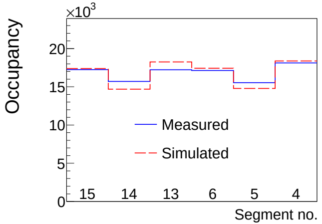


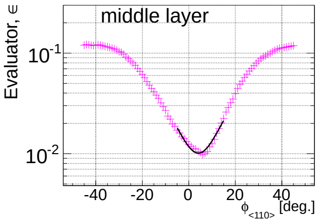


$$\phi_{\langle 110\rangle} = 0.2^\circ \pm 0.4^\circ\text{(stat.)} \pm 0.7^\circ\text{(syst.)}.$$

Ref. “Axes determination for segmented true-coaxial HPGe detectors”, I. Abt et al., to be submitted.

Axes determination - Simulation



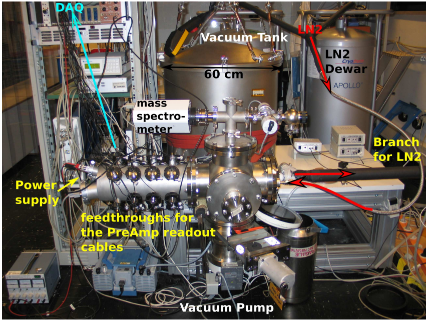


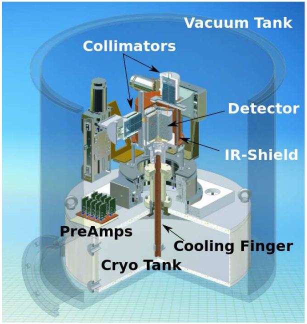
- Measured and expected occupancies for the 1.33 MeV (^{60}Co) line in the middle layer for the irradiation from the top.
- The resulting occupancies were evaluated by computing the quantity ϵ, $\epsilon = \sum_i \frac{(D_i - S_i)^2}{D_i^2}$.
- $\phi_{\langle 110 \rangle} = -1.8^\circ \pm 1.0^\circ$(stat.) $\pm 6.0^\circ$(syst.), from all layers.

Ref. "Axes determination for segmented true-coaxial HPGe detectors", I. Abt et al., to be submitted.

GALATEA test stand

Scanning of detector surfaces with low energy γ, β, α and laser
$\rightarrow$ understanding of surface events
$\rightarrow$ investigation of dead layer properties





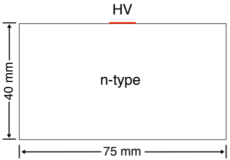
- First calibration data is collected in 2010 with 19-segment true-coaxial detector, SuSie.
- We are currently working on improving vacuum, electronics and grounding of the setup.

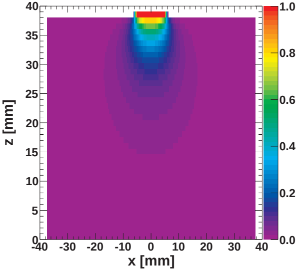
Non-segmented BEGe detectors

Non-segmented BEGe detectors are implemented in MaGe framework based on GEANT4.

BEGe detectors have special field distributions due to their contact geometry.

$\rightarrow$ Improved PSA capabilities.

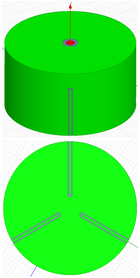


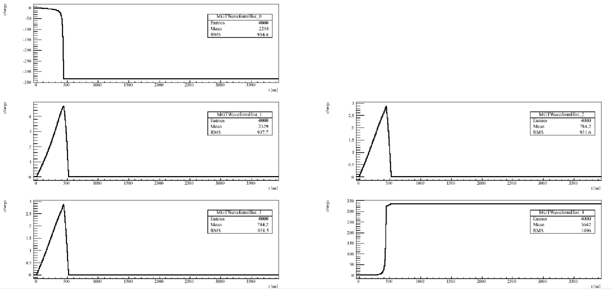


We will receive first BEGe detectors for GERDA Phase II in 2012.

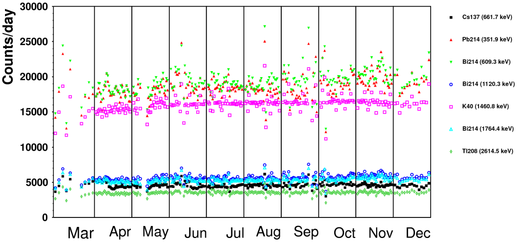
Segmented BEGe detectors - In progress

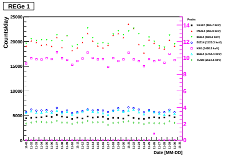
- Segmented BEGe detectors are modelled in Maxwell. $\rightarrow$ Field results are imported to MaGe for pulse shape analysis.
- Improve PSA capabilities and understand systematics of segmentation.
- Use mirror charges induced on segments to extract event topologies.
- Find optimum configuration for segments.





Monitoring natural background with two REGe detectors since the Fukushima incident.





Background from the decays of Aluminum

- Aluminum is commonly used to metalize (HPGe) detector surfaces.
- Great care is taken when selecting aluminum. $\rightarrow$ Cosmogenically produced ^{26}Al is not removed during the refinement process.
- The ^{22}Na, ^{26}Al, ^{226}Ra and ^{228}Th contaminations were simulated on the metallized surfaces.
- It is shown that with a single segment cut background levels from aluminum is low enough to keep background level 10^{-6} counts/(kg y keV).

Be careful when selecting aluminum, but it is not a show stopper!

Ref. “Aluminum as a source of background in low background experiments”, B. Majorovits et al., NIMA 647 (2011) 39-45.