European Commission

Characterization of BEGe detectors in the HADES underground laboratory

Development of a test facility for the fast screening of BEGe detectors assuring minimal exposure to cosmic radiation

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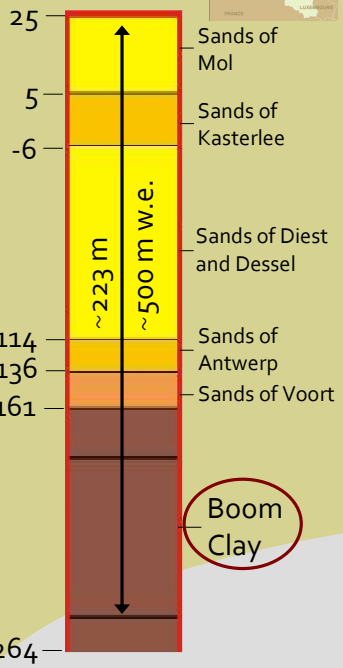
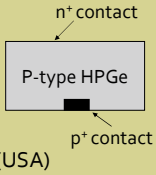


Broad Energy Germanium detectors (BEGe)

BEGe detectors are p-type **HPGe's** with a n^+ contact covering the whole outer surface and a small p^+ contact located on the bottom. Main properties:

-enhanced **Pulse Shape Discrimination properties,** which can be exploited for **background reduction** purposes [1].

-**excellent energy resolution (~0 . 1%)**.



The GERDA BEGe's are being produced from 35 kg of enriched germanium by **Canberra**:

-crystal pulling in Canberra **Oak Ridge** (USA)

-diode production in Canberra **Olen** (Belgium)

A **complete characterization** of the BEGe's is carried out in the **HADES** underground laboratory prior to their installation in the GERDA experimental set-up at Laboratori Nazionali del Gran Sasso (LNGS), Assergi (Italy).

GERDA

The **GERDA** experiment is searching for the ***0νββ* decay of ^{76}Ge** ($Q_{\beta\beta}$ = 2039 keV) using enriched (86%) High Purity Germanium detectors (**HPGe**) [2].

-**phase I**: currently running at Laboratori Nazionali del Gran Sasso (LNGS), located at a depth of ~3800 m w.e. using co-axial HPGe's.

-**phase II**: Broad Energy Germanium (**BEGe**) detectors will be used for additional active background reduction from Pulse Shape Discrimination properties.

Goal of phase II:

-**background index reduced to 10^{-3} cts/keV·kg·yr**

-Majorana m_ν range **~100 meV**

Radiopurity

Strategy to **minimize exposure to cosmic radiation**:

1. Diodes always **stored in underground locations** in the vicinity of the plants during production and characterization phases.

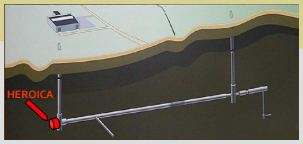
2. **Transport** from USA to Belgium by sea in a **container equipped with shielding layers of steel and water.**

HADES

Located **223 m** underground (**~500 m w.e.**) in a Boom Clay layer [3].

Muon flux reduced by ~10^4.

In Mol at ~ **30 km from Olen**.



HEROICA

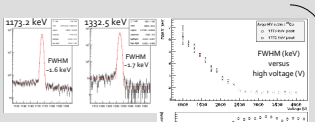
Hades **E**xperimental **R**esearch **O**f **I**ntrinsic **C**rystal **A**ppliances

Dedicated area of ~ 14 m²

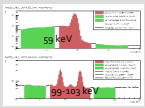
January 2012 - first batch of **7 BEGe's** deployed: Argo, Andromeda, Achilles, Agamennone, Archimedes, Aristoteles, Anubis. FWHM by Canberra: 1.64-1.79 keV @ 1.3 MeV.

The test protocol

-Energy resolution and high voltage scan up to the operational value (≤4kV) with ^{60}Co.



-Average top surface dead layer determination using ^{241}Am and ^{133}Ba:

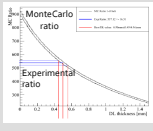


$$r_{Am241} = \frac{\varepsilon_{59.5keV}}{\varepsilon_{99keV} + \varepsilon_{103keV}}$$

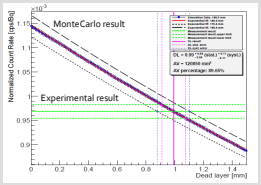
$$r_{Ba133} = \frac{\varepsilon_{81keV}}{\varepsilon_{356keV}}$$

ε = Experimental count rate under peak

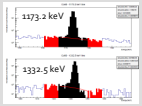
Comparison with Monte Carlo simulated ratio



-Active volume determination using ^{60}Co: count rate under the peaks @ 1173.2 keV and 1332.5 keV is compared to the simulated one.

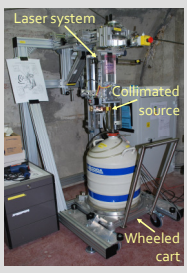


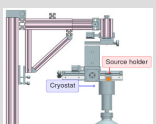
-Pulse Shape Discrimination performance [1].



Test stand 1

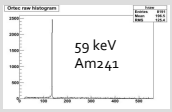
Test stand 2





Charge collection efficiency using a **collimated ^{241}Am** source of 5 MBq to study **dead layer uniformity**.

Movable, **motor controlled arm,** remotely operated. **Laser** system for the **alignment**.



Automated data acquisition systems using PYTHON scripts.

Data analysis:

-ROOT CERN package based scripts

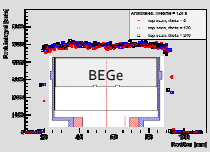
-Geant4 Monte Carlo simulations

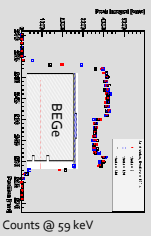
Automated surface scan of detector:

-count rate and FWHM @ 59 keV

-precision ~ 2 mm

Top and lateral scan at 3 different rotation angles.





References:

[1] D. Budjáš, et al., JNIST 4 (2009) P10007.

[2] I. Abt, et al., Proposal to the LNGS (2004), http://www.mpi-hd.mpg.de/gerda/proposal.pdf and http://www.mpi-hd.mpg.de/gerda/home.html.

[3] E. Andreotti, et al., Proceedings of the 3rd International Conference on Current Problems in Nuclear Physics and Atomic Energy, Kyev, 2011, P601.

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