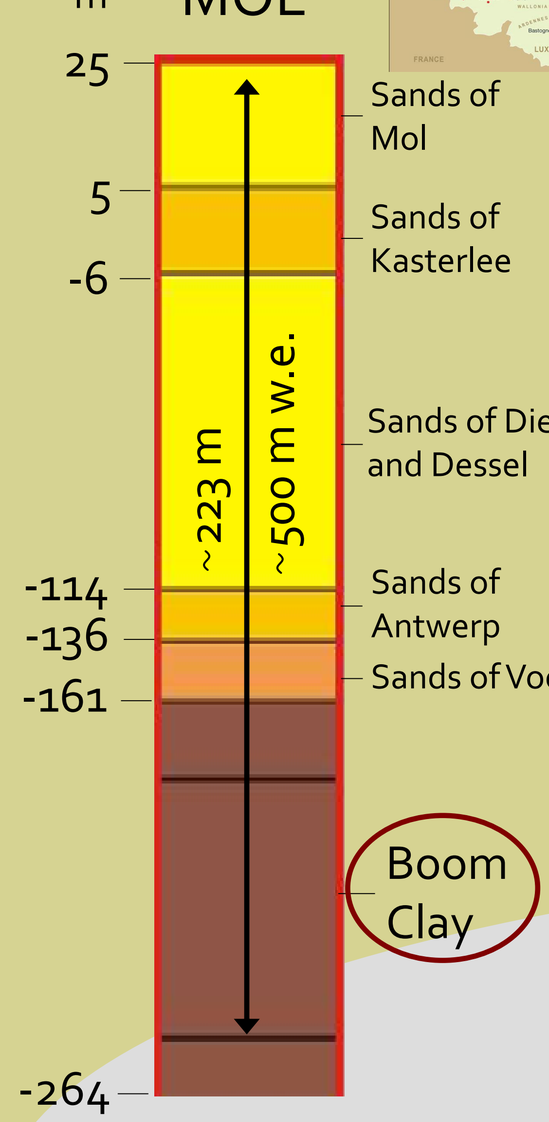
European Commission

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

Erica Andreotti, Matteo Agostini, Giovanni Benato, Riccardo Brugnera, Dusan Budjáš, Raphael Falkenstein, Nuno Fiuza de Barros, Alberto Garfagnini, Alexander Hegai, Sabine Hemmer, Mikael Hult, Björn Lehnert, Alexey Lubasheskiy, Bela Majorovits, Werner Maneschg, Gerd Marissens, Luciano Modenese, Christopher O'Shaughnessy, Christopher Schmitt, Stefan Schönert, Bernhard Schwingenheuer, Katharina von Sturm, Matteo Turcato, Victoria Wagner, for the GERDA collaboration

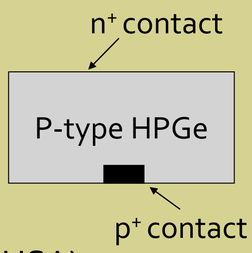


Broad Energy Germanium detectors (BEGe)

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 $0\nu\beta\beta$ **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.

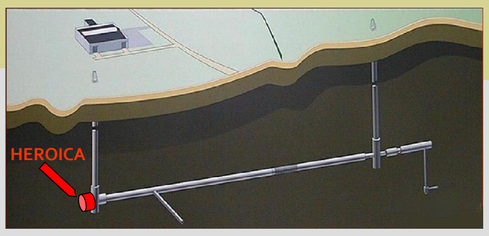
2. **Transport** from USA to Belgium by sea in a **container equipped with shielding layers of steel and water.**

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

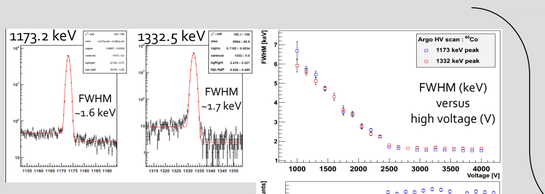
Hades **E**xperimental **R**esearch **O**f **I**ntrinsic **C**rystal **A**ppliances

Dedicated area of ~ 14 m²

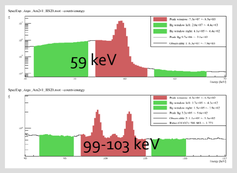
January 2012 - first batch of **7 BEGe's** deployed: Argo, Andromeda, Achilles, Agamennone, Archimedes, Aristoteles, Anubis. FWHM by Canberra: 1.64-1.79 keV @ 1.3 MeV.

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:

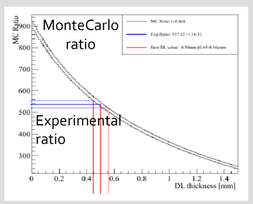


$$r_{Am241} = \frac{\varepsilon_{59.5keV}}{\varepsilon_{99keV} + \varepsilon_{103keV}}$$

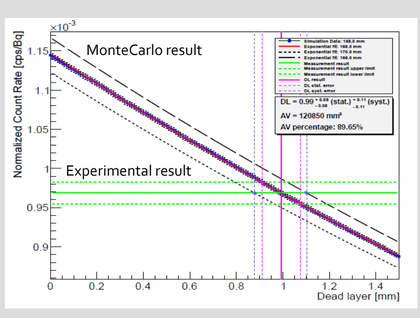
$$r_{Ba133} = \frac{\varepsilon_{81keV}}{\varepsilon_{356keV}}$$

ε = Experimental count rate under peak

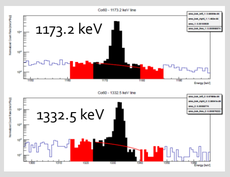
Comparison with Monte Carlo simulated ratio



-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

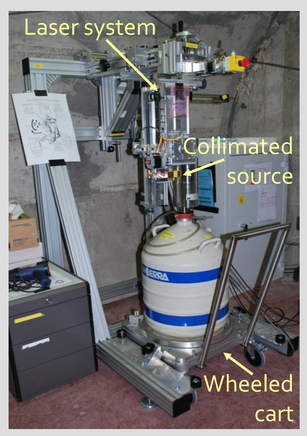
Automated data acquisition systems using PYTHON scripts.

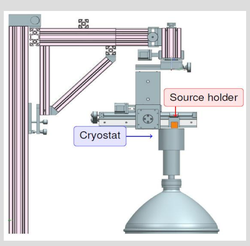
Data analysis:

-ROOT CERN package based scripts

-Geant4 Monte Carlo simulations

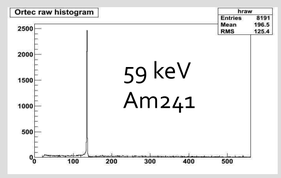
Test stand 2





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

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

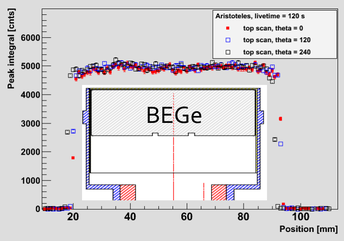


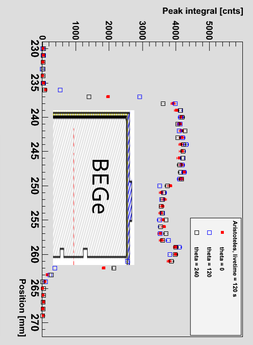
Automated surface scan of detector:

-count rate and FWHM @ 59 keV

-precision ~ 2 mm

Top and lateral scan at 3 different rotation angles.





Counts @ 59 keV

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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Joint Research Centre

Contact Erica Andreotti
European Commission • Joint Research Centre
Institute for Reference Materials and Measurements
Tel. ++32 14 571 776 • Fax ++32 14 584 273
E-mail: erica.andreotti@ec.europa.eu