



HEROICA: a fast screening facility for the characterization of germanium detectors



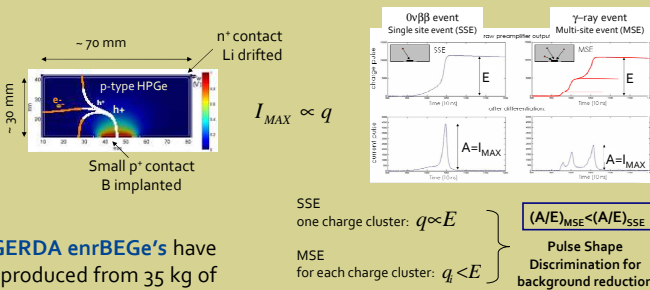
Development of a test facility for the fast screening of BEGe detectors assuring minimal exposure to cosmic radiation

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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:

- excellent energy resolution (~0.1%);
- enhanced Pulse Shape Discrimination properties, which can be exploited for background reduction purposes [1]:



The GERDA enrBEGe's have been produced from 35 kg of enriched germanium by Canberra:

- crystal pulling in Canberra Oak Ridge (USA)
- diode production in Canberra Olen (Belgium)

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: enriched Broad Energy Germanium (enrBEGe) 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:

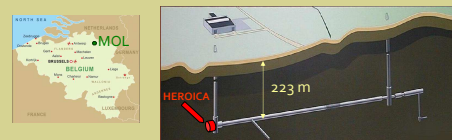
1. Diodes always stored in underground locations in the vicinity of the plants during production and characterization phases.
2. Transport from USA to Belgium by sea in a container equipped with shielding layers of steel and water.



A complete characterization of the enrBEGe's has been 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).

HADES

Located 223 m underground (~500 m w.e.) in a Boom Clay layer [3]. Muon flux reduced by ~10⁴. In Mol at ~30 km from Olen.



HEROICA
Hades Experimental Research
Of Intrinsic Crystal Appliances

Dedicated area of ~14 m²

January 2012 - first batch of 7 enrBEGe's arrival at HADES:

Argo, Andromeda, Achilles, Agamennone, Archimedes, Aristoteles, Anubis. FWHM by Canberra: 1.64-1.79 keV @ 1.3 MeV.

Daily transports HADES-Canberra during diode production: 4 weeks, with actual exposure time ~5 days for each BEGe.



August 2012: arrival of the second batch of 23 enrBEGes at HADES.

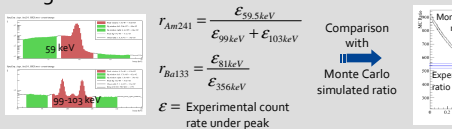
January 2013: 30 operating enrBEGe's fully tested.

The HEROICA test protocol

GOAL: full set of tests with 2 detectors per week

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

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



-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].

References:

- [1] D. Budjaš, et al., JNIST 4 (2009) P10007.
- [2] K.-H. Ackermann, et al., Eur. Phys. J. C (2013) 73-2330.
- [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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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



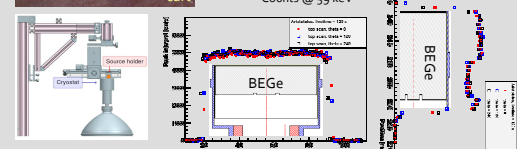
Automated surface scan of detector:

- count rate and FWHM @ 59 keV
- precision ~1 mm
- Top and lateral scan at various rotation angles.

Test stand 1



Automated data acquisition systems. Data analysis: -ROOT CERN package based scripts -Geant4 Monte Carlo simulations



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