Operation of a prototype detector for GERDA P I

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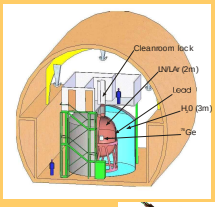
GERmanium Detector Array for the search of neutrinoless ββ decays of ^{76}Ge

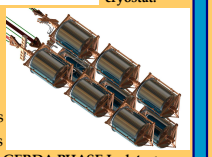
- Neutrino : Majorana particle?
- $(A,Z) \rightarrow (A,Z+2) + e_1^- + e_2^-$ (e^- spectrum measured)
- Sensitivity
  - Isotope mass (M)
  - Running time (T)
  - Background index (B)
    - Internal: ^{60}Co ($<10^{-2}$ cts/(keV·kg·y)
    - External 228Th ($<10^{-3}$ cts/keV·kg·y)



GERDA will be situated in Hall A of LNGS. The Ge crystals will be operated in LN/LAr, inside vacuum-insulated cryostat.

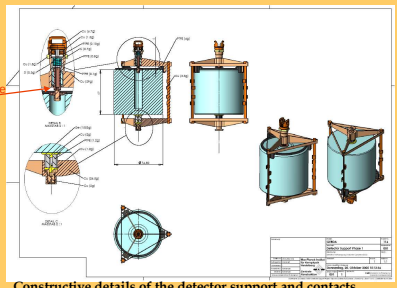
PHASE I

- Enriched 86% Ge (17.9kg)
  - HEIDELBERG-MOSCOW (5) and IGEX (3) detectors
- 1 year data taking (FWHM~3.6 keV, ε~95%) → 0.5 cts
  - No event : $T_{1/2} > 3.0 \cdot 10^{25}$ y, $m_{ee} < 0.24\text{-}0.77$ eV
  - 1 Event : $T_{1/2} > 2.21 \cdot 10^{25}$, $m_{ee} < 0.28\text{-}0.9$ eV



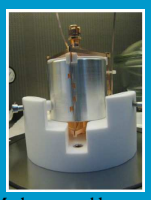
GERDA PHASE I : detectors mounted vertically into strings in low-mass Cu support.

Low-mass detector support and contacts (diodes refurbished from Ortec to Groove type)

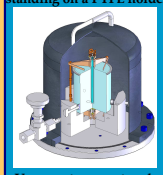


Constructive details of the detector support and contacts

- Bckg $<1.5 \cdot 10^{-3}$ cts/(keV·kg·y)
  - Copper and PTFE (screening with GEMPI), Silicon (NAA)
  - Copper cleaned by electro-polishing and quartz-distilled water
  - PTFE cleaned in diluted nitric acid
  - Minimal exposure to cosmic rays (^{60}Co)



Mock-up assembly standing on a PTFE holder.



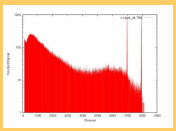
Vacuum transport and storage container in stainless steal, electro-polished surface and butyl O-ring.

See GERDA – a Search for Neutrinoless Double Beta Decay, *K. Kröninger* and Efficiency determination of Ge-detectors by using Monte Carlo Simulations, D.Budjas

Testing of the prototype detector assembly in liquid nitrogen

- Non enriched HP-Ge p-type diode refurbished at CANBERRA
  - Mechanical machining of a new groove
  - New lithium diffusion up to the groove
  - New boron inner contact implantation
  - Evaporation of a new passivation layer
  - 2.2 keV FWHM at 1.332 MeV (in a standard test cryostat)

The diode dimensions are 75 mm diameter, 69 mm height, bore hole: 12 mm diameter and 60 mm depth, 1.6 kg.



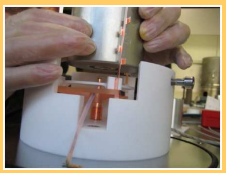
Spectroscopy measurement

Warming up in methanol bath

HV V	Test point V	Noise mV
0	-0.4	200
100	-0.7	100
200	-0.7	80
500	-0.8	50
1000	-0.9	40
2000	-1.0	30
3000	-1.1	20
4000	-1.2	20

Test point of the preamplifier and noise level recorded as the HV is increased

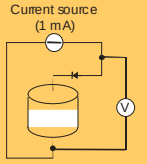
- Testing sequency



Crystal mounted in the detector holder with HV and signal contacts

HV to signal resistivity measurement at room temperature

Cooling down in LN. Up, in a standard cryostat at CANBERRA and right, in the cryogenic test stand of the LArGe facility, LNGS



Forward resistivity measurement : a source produces a current of 1 mA and the voltage drop is measured.

Action performed to improve the spectroscopic performance of the detector and/or the behavior of the electronic

Testing tool

- Signal to HV resistivity (30-50 Ω)
- Forward resistivity (few kΩ)
- Leakage current
- Noise
- Energy spectrum with ^{60}Co

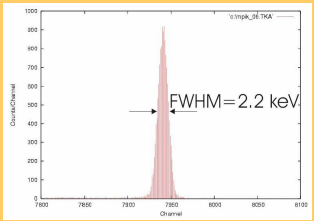
Testing at CANBERRA SEMICONDUCTOR, Olen, Belgium (in collaboration with technical staff)

- Goal : spectroscopic performance of the prototype detector assembly
- Operations
  - 8 thermal cycles with testing and modifications of the detector assembly and/or electronics
- Conclusion
  - Mounting of the prototype holder is straightforward
  - Signal and HV contacts are mechanically and electrically stable
  - Good quality signal and central HV contact is achieved
  - Groove etching and polishing procedure from CANBERRA is very efficient to reprocess a faulty passivation layer
  - Minor modification to the detector support envisaged
  - Detector assembly prototype test successful

Detector assembly with copper infrared shielding.

Crystal mounted in a leakage current test holder.

2.2 keV FWHM at 1.332 MeV
(same as measured inside a cryostat)



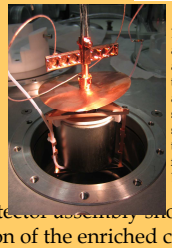
Testing in the radon-free test bench of the LArGe facility, LNGS

- Facility
  - Chemical fume hood
  - DI water supply
  - High purity chemicals
  - Clean bench
  - Cryogenic test stand (dewars flushed and filled with HP liquid nitrogen)
  - γ spectroscopy electronics
  - 14 bit/105MHz FADC

Radon-free clean bench with liquid nitrogen detector test stand in LARGE underground detector laboratory, LNGS.

- Goal
  - Spectroscopic performance of the detector assembly in the radon-free test bench
  - Test of upside-down configuration
- Operation
  - 11 thermal cycles with mechanical and electrical modifications performed
- Conclusion
  - The resistivity measurements at LN and room temperature give similar results for both configurations, indicating that GERDA PHASE I detectors can be mounted with HV contact on top
  - Resolution achieved : 2.7 keV FWHM at 1.332 MeV
- Summary : Testing of the prototype detector assembly showed that we are ready to start the modification of the enriched crystals

Upside down version for the low-mass detector support.



Detector assembly attached to the flange and suspension system in the radon-free clean bench

Summary

- **GERDA Phase I low-mass detector support and contact designs are very robust and give excellent spectroscopic performance**

On going activities with enriched crystals

- Opening of Heidelberg-Moscow and IGEX detectors
- Dimensions measurement, testing and refurbishment
- Background performance in the shielded liquid argon facility (LARGE)

Opening and dimensions measurement of ANG 1, April 2006.