

Operation of bare HPGe detectors in LAr/LN₂ for the GERDA experiment



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GERmanium Detector Array at LNGS¹

GERDA will search for neutrinoless double beta decay in ⁷⁶Ge submerging high purity germanium detector (HPGe) directly in LAr. By operating bare HPGe detectors, GERDA aims at an extremely low background (10⁻³ cts/(kg·y·keV)) and an excellent energy resolution. GERDA will proceed in different phases:

Phase I

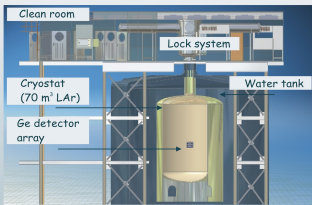
- Operation of reprocessed HDM² and IGEX³ enriched detectors (17.9 kg), Genius-TF⁴ detectors (15 kg)
- Exposure: 15 kg·y
- T_{1/2} = 3·10²⁵ y, m_{eff} = 0.3-0.9 eV

Phase II

- New segmented crystals (37.5 kg)
- Exposure: 100 kg·y
- T_{1/2} = 2·10²⁵ y, m_{eff} = 0.09-0.29 eV

Phase III

- Collaboration with Majorana (1 ton)
- m_{eff} ~ 10 meV



GERDA Phase I detectors

The GERDA Phase I enriched detectors have been tested in their cryostats in GERDA Detector Laboratory, LNGS, in 2005. All detectors were in good working condition. The cryostats were opened and the diode dimensions measured.

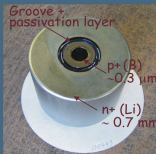


The enriched diodes are kept under vacuum in a transportation container. They are being refurbished at the detector manufacturer (stored underground).



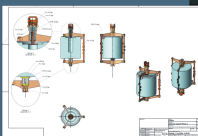
GERDA Phase I detector assembly

Non-enriched HPGe detectors are used to perform tests and measurements prior to operate the enriched detectors. The prototype detectors use the same technology as planned for the Phase I enriched detectors.

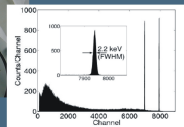


- Prototype detectors to test
- Phase I detector assembly
 - Detector handling
 - Refurbishment technology
 - Spectroscopy performance
 - Long-term stability in LAr/LN₂

Low mass holder

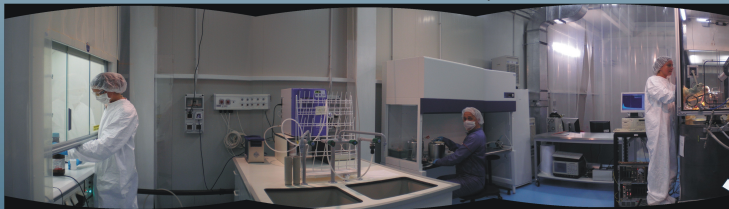


The low mass holder is made of ultrapure materials with known radioimpurities: low-activity Cu (80 g), PTFE, Silicon.



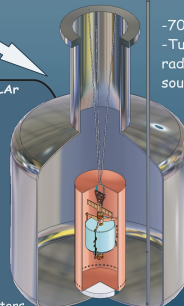
Detector assembly tested successfully
→ Same resolution as in a test cryostat

GERDA Detector Laboratory (GDL)



GDL is a clean room level 10 000 with clean benches level 10 in which the Phase I detectors will be tested prior to their operation in GERDA. GDL is equipped with 2 detector test benches. The detectors are manipulated in a closed, ultraclean environment under nitrogen atmosphere.

Detector test bench



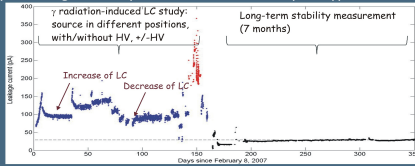
- 70 l Dewar
- Tube for radioactive source

- Infrared shield
- Resolution with warm FET and 1 m cables
- 3 keV FWHM at 1.332 MeV

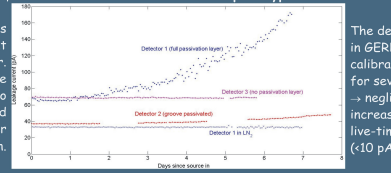
2 years of operation of bare HPGe detectors in LN₂/LAr

- 2 detector test benches
- 4 detectors tested (1 enriched, 3 prototypes)
- > 50 cooling/warming cycles performed
- 1 year study with a prototype detector continuously operated in LAr under varying γ irradiation conditions
- γ irradiation results in an increase of the leakage current (LC)
- radiation-induced LC is reversible
- reducing the size of the passivation layer strongly suppresses γ radiation-induced LC
- not a problem for GERDA
- Detector parameters not deteriorated after 1 year of continuous operation in LAr (10 pA → 10 pA)

1 year of high accuracy LC measurement with a prototype detector in LAr



γ radiation-induced LC in LAr for 3 prototypes detectors



The detectors have different passivation layer. The 1st prototype detector has also been operated in LN₂ under γ irradiation.

The detectors in GERDA will be calibrated - 1/week for several minutes → negligible LC increase during the live-time of GERDA (<10 pA)

The Phase I detectors will be mounted into strings in low-mass holders and operated in LAr

