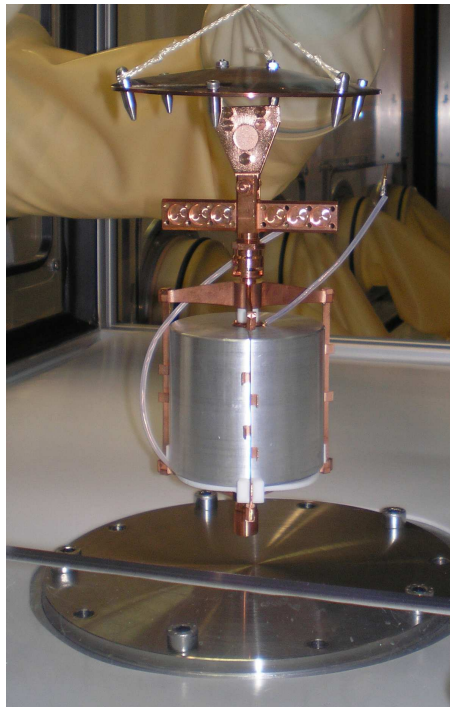




MAX-PLANCK-GESELLSCHAFT

Operation of a **GERDA Phase I** prototype detector in liquid argon and nitrogen



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K.Gusev, M.Hult, I.Kirpichnikov, V.Lebedev, G.Marissens, P.Peiffer,
S.Schönert, M.Shirchenko, A.Smolnikov, A.Vasenko, S.Vasiliev, S.Zhukov

Particles and Cosmology School, Baksan Valley, April 16-21 2007

GERDA Collaboration

- Dipartimento di Fisica dell'Università di Padova e INFN Padova, Padova, Italy
- INFN Laboratori Nazionali del Gran Sasso, Assergi, Italy
- Institute for Nuclear Research of the Russian Academy of Sciences, Moscow, Russia
- Institute for Reference Materials and Measurements, Geel, Belgium
- Institute for Theoretical and Experimental Physics, Moscow, Russia
- Jagiellonian University, Krakow, Poland
- Joint Institute for Nuclear Research, Dubna, Russia
- Max-Planck-Institut für Kernphysik, Heidelberg, Germany
- Max-Planck-Institut für Physik, München, Germany
- Physikalisches Institut, Universität Tübingen, Germany
- Russian Research Center Kurchatov Institute, Moscow, Russia
- Università di Milano Bicocca e INFN Milano, Milano, Italy

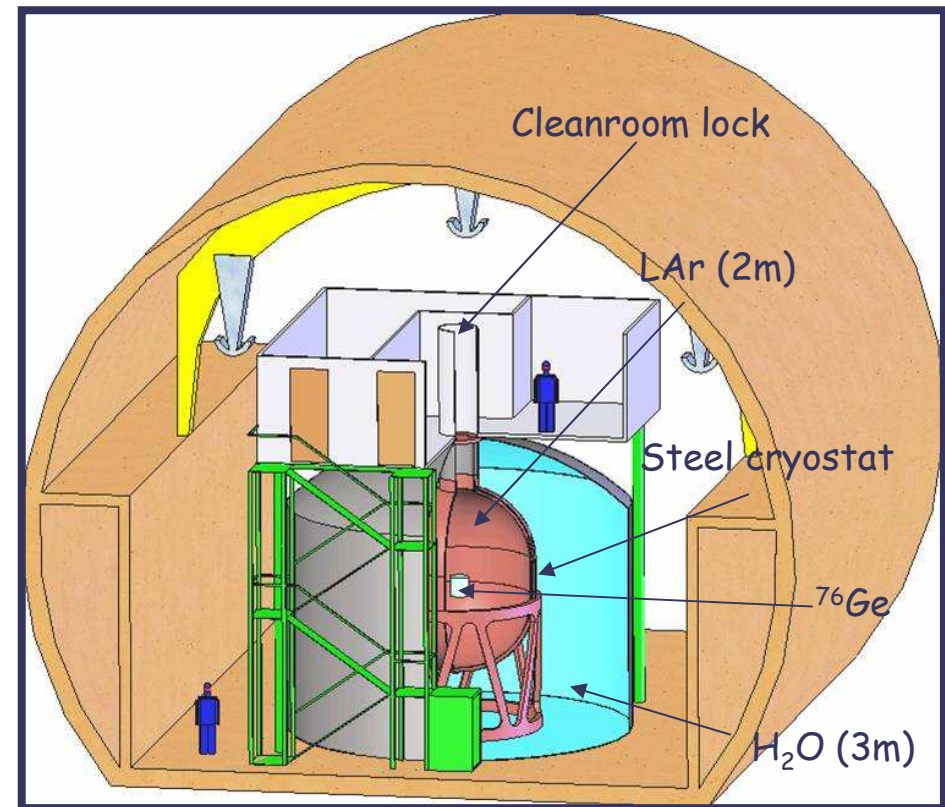
Outline

- Status of GERDA Phase I enriched diodes
- Summary of 1 year testing with Phase I detector prototype in GERDA Detector Laboratory, LNGS

GERmanium Detector Array for the search of neutrinoless $\beta\beta$ decays of ^{76}Ge at LNGS

Operation of bare
enriched HPGe
detectors in LAr

- Extremely low background
- Excellent energy resolution



GERDA

• Phase I

- Enriched ^{76}Ge (86 %)
 - HEIDELBERG-MOSCOW (5) and IGEX (3) detectors: 17.9 kg
- Non enriched Ge
 - Genius detectors (6): 15 kg
- Bkgd $< 10^{-2}$ cts/(keV·kg·y)
- 1 year data taking
- $T_{1/2} > 3.0 \cdot 10^{25}$ y, $m_{ee} < 0.24-0.77$ eV
- Check on Klapdor-Kleingrothaus group result

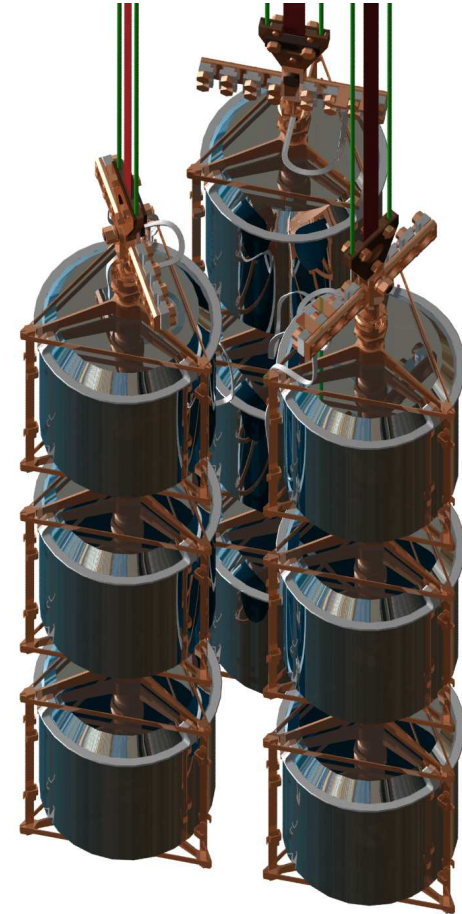
• Phase II

- New segmented enriched crystals: 35 kg
- Bkgd $< 10^{-3}$ cts/(keV·kg·y)
- 3 years data taking



• Phase III

- 500 kg - world wide collaboration

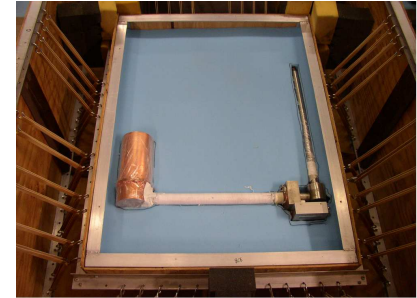
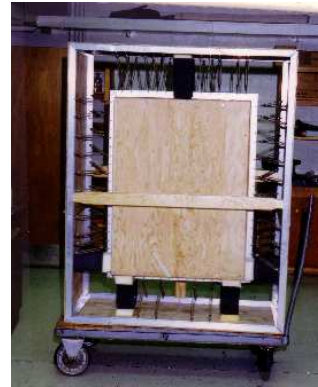


GERDA Phase I detectors mounted vertically into strings in low-mass Cu support and operated in LAr.

GERDA Phase I enriched diodes

- IGEX diodes
 - November 2005 : transport from Canfranc to LNGS (18 hours above ground)
- Heidelberg-Moscow diodes
 - Underground at LNGS since HdM experiment

➔ 8 enriched diodes in GERDA Detector Lab, LNGS



Super-box for transport of IGEX diodes



Testing of the enriched detectors in their cryostats

May 2005	Ang 1	Ang 2	Ang 3	Ang 4	Ang 5
Full mass, kG	0.98	2.906	2.446	2.4	2.781
Energy resolution at 1332 keV (FWHM)	2.88	2.5	3.0	2.76	3.05

Dec 2005	RG 1	RG 2	RG 3
Full mass, kG	2.15	2.194	2.121
Energy resolution at 1332 keV (FWHM)	2.21	2.31	2.26

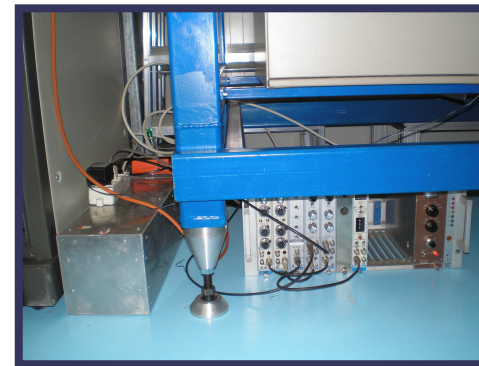
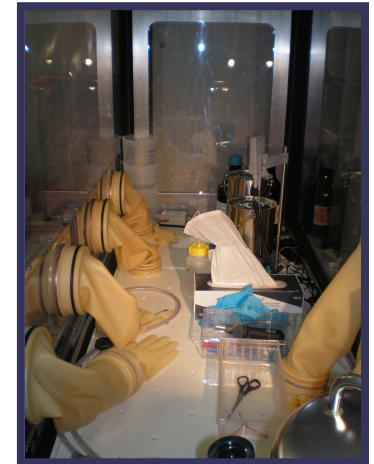
 All detectors in working conditions

GERDA Detector underground Laboratory, LNGS



Detector test bench, 'Rn free' bench and clean bench. Rn is monitored by Lucas cell, Ar level by weighting cells and humidity is kept low (30%).

- To test Phase I detectors
 - Clean room level 10 000
 - Clean bench and 'Rn free' bench level 10



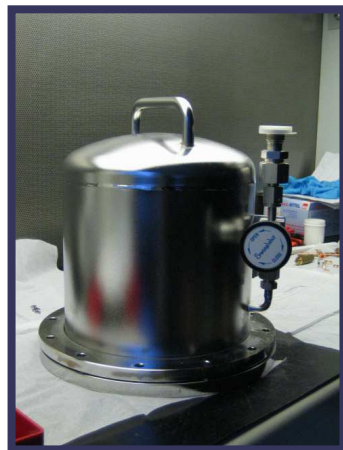
Enriched diodes

- In GERDA Detector Laboratory, LNGS, 2006 ...

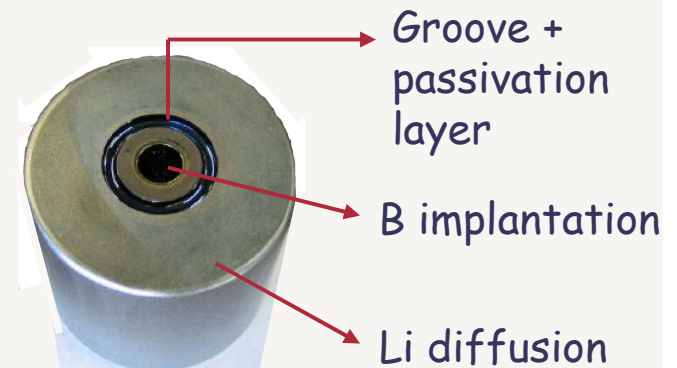


Opening and dimensions measurement

Keep under vacuum in electro-polished steel transportation container



Refurbishment at Canberra Semiconductor, Olen, Belgium



GERDA Phase I prototype diode

- Non-enriched HP p-type Ge diode to test
 - GERDA Phase I low mass support
 - Cooling/warming cycles
 - Test bench facility of the GERDA Detector Lab
 - Detector stability in LAr/LN₂
 - Refurbishment procedure

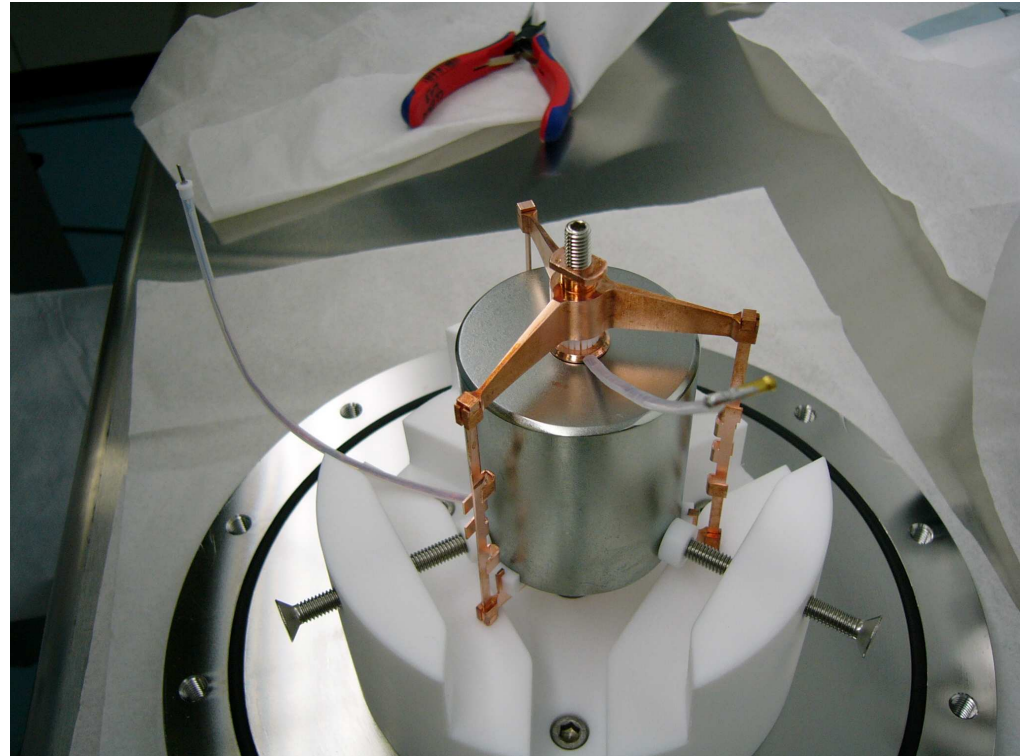
➔ **To be ready for the enriched diodes**



Prototype diode (1.6 kg) refurbished by CANBERRA using the same technology as for the enriched diodes. The FWHM in a test cryostat is 2.2 keV at 1.332 MeV.

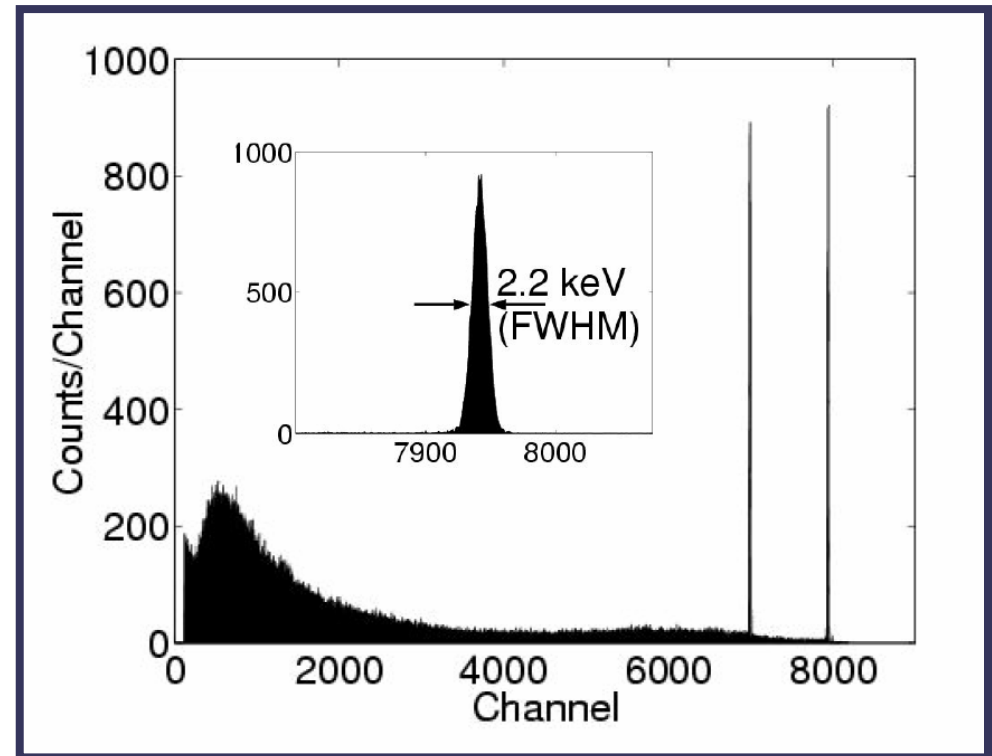
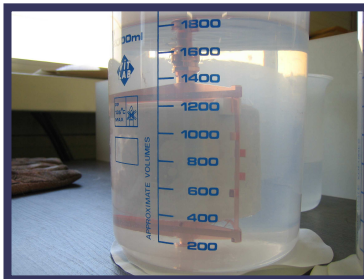
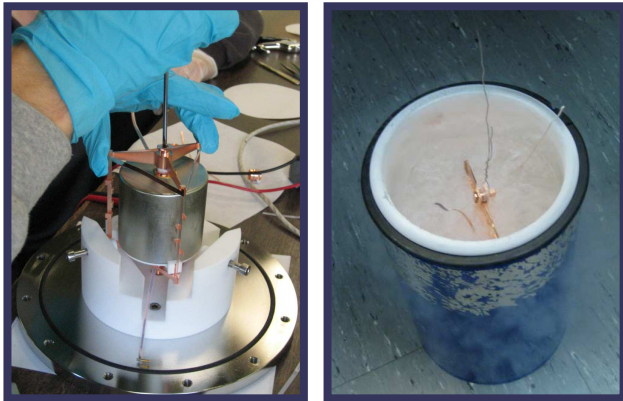
GERDA Phase I detector assembly

- Low mass Cu holder
(use only screened materials with known radioimpurities)
 - Low activity Cu (80 g)
 - PTFE
 - Silicon
- Monte Carlo simulations and screening limits →
 $Bkgd_{ROI} < 1.5 \cdot 10^{-3} \text{cts}/(\text{keV} \cdot \text{kg} \cdot \text{y})$



GERDA Phase I detector assembly

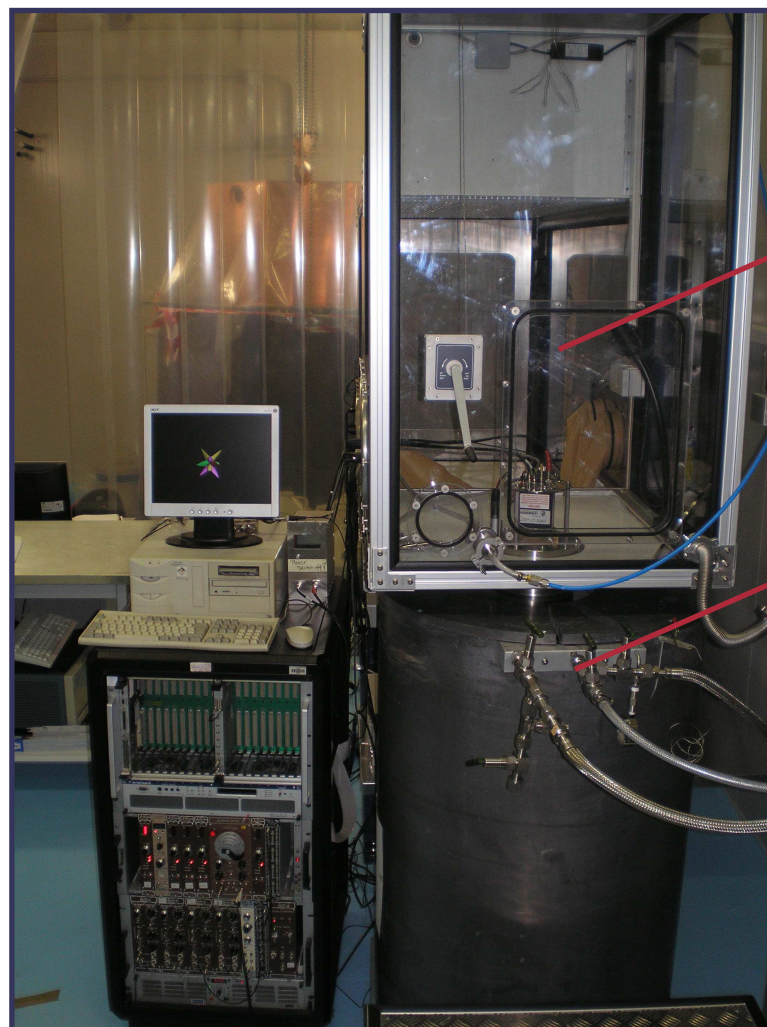
- Testing at Canberra
 - Mounting procedure
 - Signal and central HV contact quality
 - Mechanical stability
 - Spectroscopy performance



Same resolution as obtained
in a test cryostat!

GERDA Phase I detector assembly

- Testing in GERDA Detector Laboratory test bench



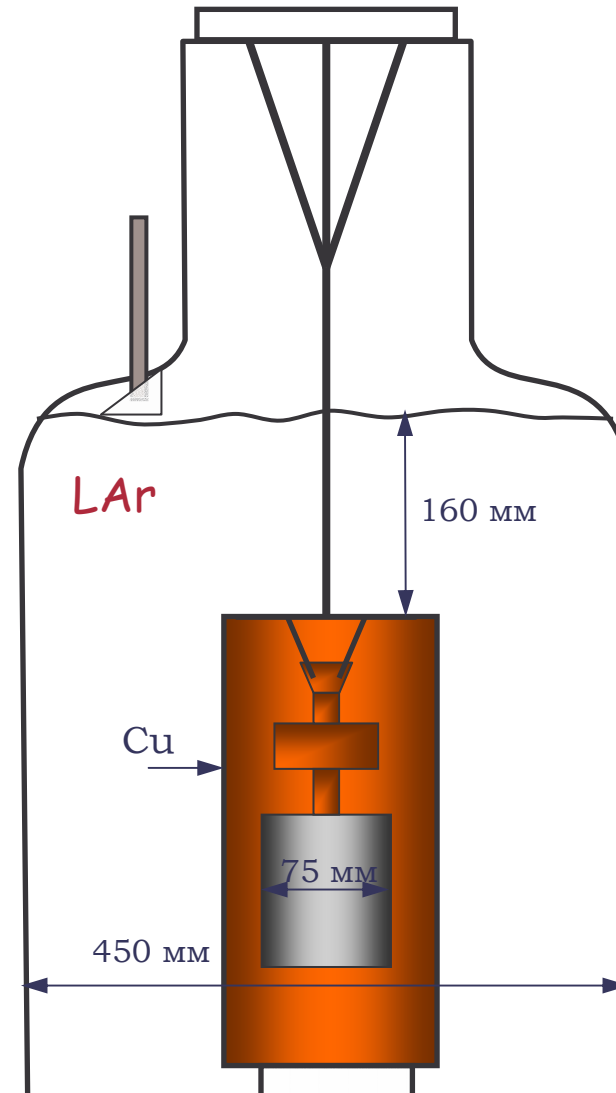
'Rn free' bench

Shielding

- 2.5 cm lead, 20 cm LAr
- 10 x suppression of external background

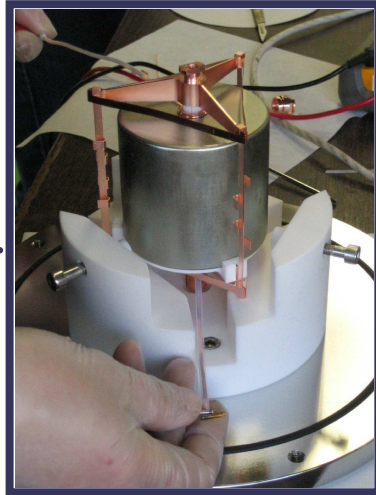
Detector test bench

- Infrared shield
- Warm FET
- 1 m cables
- LAr: 1 filling/week

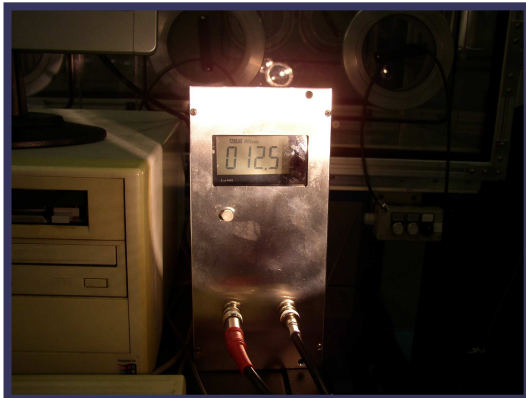


Detector 'health' monitoring

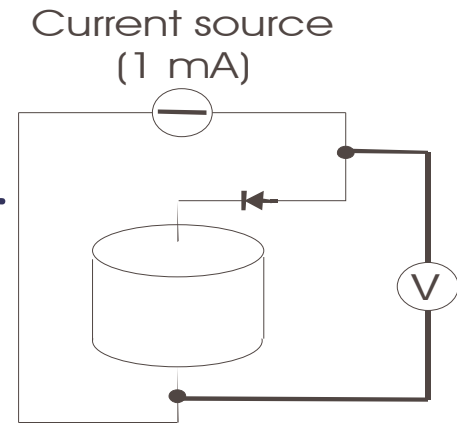
- Signal to HV resistivity measurement



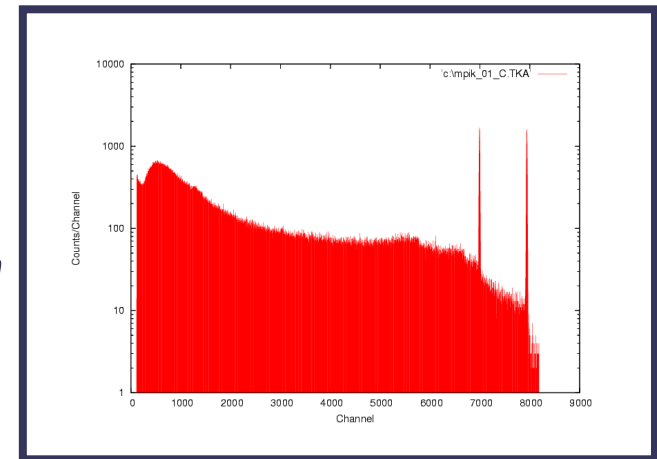
- Test point, picoammeter and noise level recorded



- Forward resistivity measurement while cooling

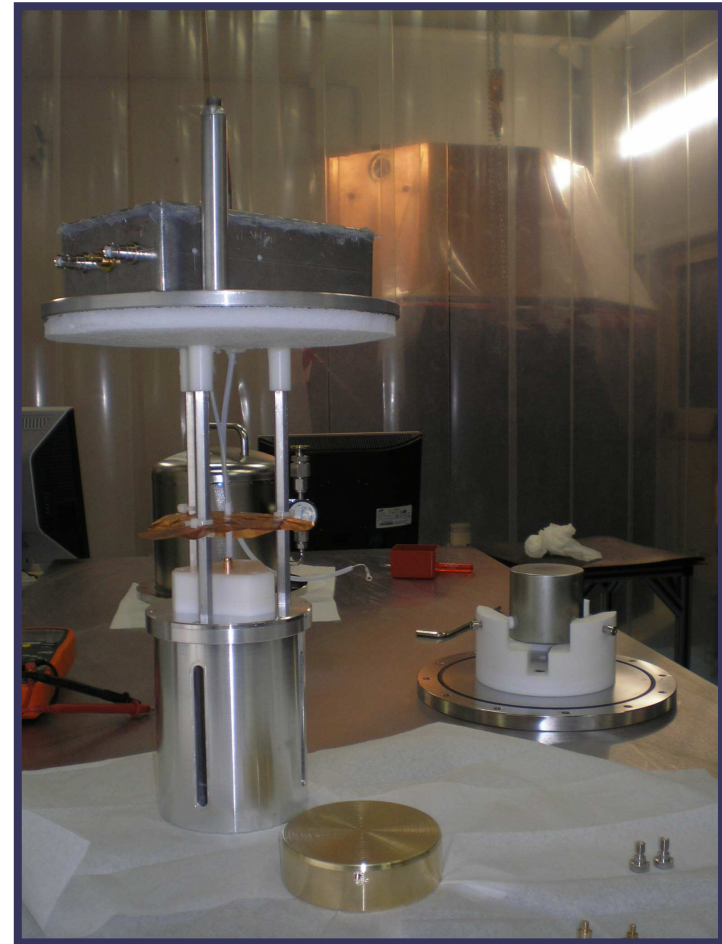
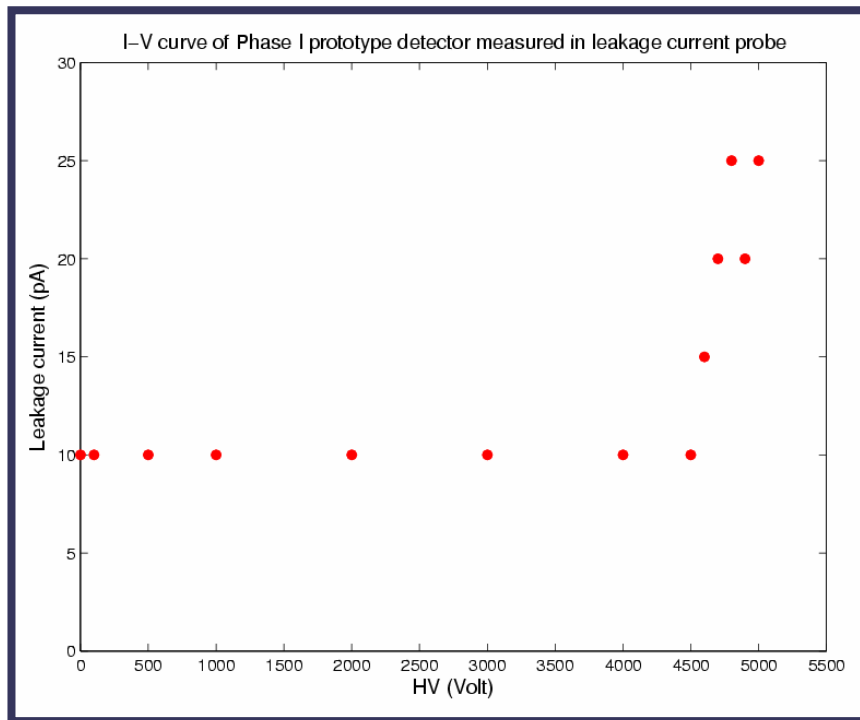


- Spectra collecting



Detector 'health' monitoring

- Leakage current probe
 - I-V curve of diodes



GERDA Phase I prototype detector ... 1 year testing

- LN₂ and LAr
- 43 cooling-warming cycles
 - To perform diode mounting and/or electronics modifications
- 2 refurbishments
 - New passivation layer evaporated
 - Refurbishment and transport procedure within 1 week
- Detector parameters stable over long term measurement
 - 2 months
 - Physics results: 1st limit on the radiative 0νECEC decay of ³⁶Ar
- Spectroscopy performance: 3.4 keV FWHM at 1.332 MeV

Enriched detectors status

- Refurbishment procedure is ongoing
 - **ANG 1** and **RG 3** are refurbished and ready to be tested in **GDL**
 - Total exposure to cosmic rays ~ 60 hours
 - ^{60}Co and ^{68}Ge production negligible
 - **ANG 2-5, RG 1-2, Genius 1-6** are being refurbished at Canberra Semiconductor, Olen, Belgium



During the refurbishment process, the diodes are stored underground, in Hades facility, Geel, Belgium

Conclusion

- GERDA Phase I: operation of bare IGEX and HdM detectors in LAr
 - Goal : extremely low background and excellent energy resolution to check Klapdor-Kleingrothaus claim on $0\nu\beta\beta$ of ^{76}Ge
- Enriched diodes are being refurbished at Canberra Semiconductor, Olen, Belgium
- 1 year testing with prototype detector in Gerda Detector Laboratory, LNGS
 - Low mass holder
 - Cooling/warming cycles
 - Operation in LAr and LN_2
 - Refurbishment procedure
 - Long term stability measurement