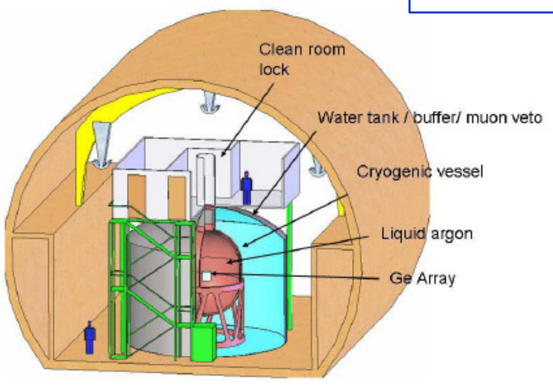
Development and installation of the GERDA experiment

The main goal of the GERDA experiment is searching for neutrinoless double beta decay of ^{76}Ge with considerable reduction of background and increasing sensitivity in comparison with predecessor experiments.

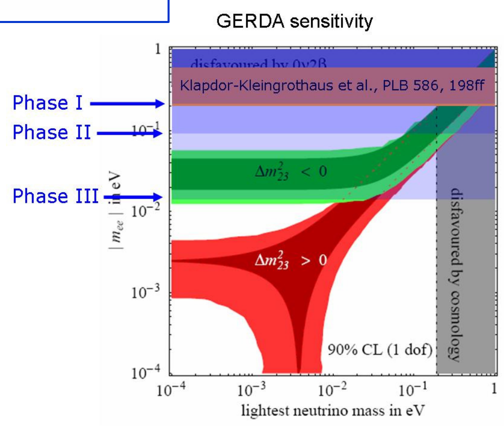
The GERDA project is based on using low background High-Purity-Germanium (HPGe) detectors. HPGe detector fabricated from germanium enriched in ^{76}Ge isotope (up to 86 %) is simultaneously the ββ decay source and the 4π detector.

Main GERDA experimental concepts

The main conceptual design of the GERDA experiment is to operate with "naked" HPGe detectors (enriched in Ge-76) submerged in high purity liquid argon supplemented by a water shield.
"Naked" detector means a bare Ge crystal without traditional cryostat.
Minimizing of the support material should provide considerable reduction of the inner background.
Using of ultra pure LAr (instead of LN) both as a cooling media and shielding material is the other idea of the GERDA.
In this case (Phase II) anti-coincidence with LAr scintillation should reduce both the inner and external background of HPGe detectors.



Expected GERDA sensitivity

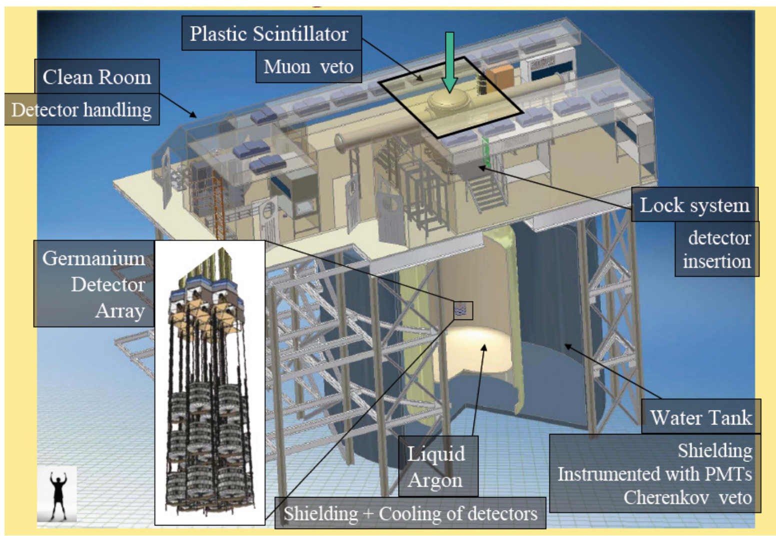


GERDA phase I :
background 0.01 cts / (kg · keV · y)
► to scrutinize KKDC result within 1 year

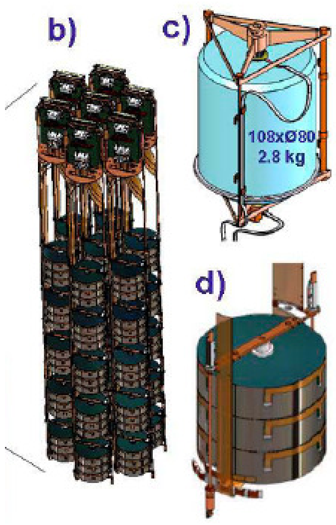
GERDA phase II :
background 1 cts / (ton ! · keV · y)
► to cover the degenerate neutrino mass hierarchy $<m_{ee}>$ < 0.08 – 0.29 eV

Phase III :
GERDA –MAJORANA collaboration
background 0.1 cts / (ton · keV · y)
► to cover the inverted neutrino mass hierarchy $<m_{ee}>$ ~10 meV

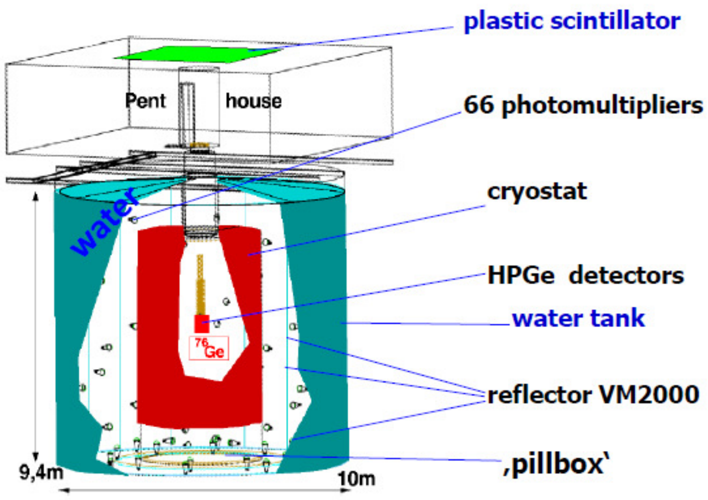
General Infrastructure of the GERDA set up



A stainless steel cryostat (25 t) with internal Cu shield (20 t) contains 90 t of liquid argon.
The cryostat is immersed in a water tank (565 t of water).
A cleanroom and radon tight lock on top of the assembly allow to insert and remove individual detector strings. without contaminating the cryogenic volume.

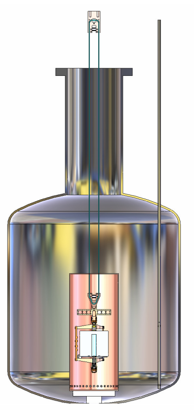


The Ge detector array is made up of individual detector strings and is situated in the central part of the cryostat.



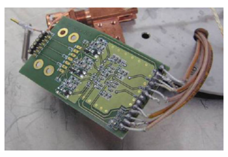
The ultra-pure water buffer serves as a gamma and neutron shield and as a Cherenkov detector for vetoing cosmic muons with the efficiency of more than 99 % .
Plastic scintillator panels (20 m², 20 x 2 = 40 modules) on top of the detector will tag muons which enter the cryostat through the neck with the vetoing efficiency of about 98 % .

Testing of detectors in LAr

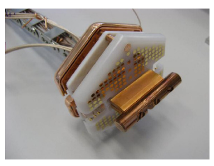


Long-term stability tests of naked HPGe detectors were performed in test banches filled with Liquid Argon.
The detector parameters (FWHM = 2.5 – 2.9 keV at 1332keV) do not deteriorate after one year of continuous operation in LAr even after irradiation with intensive gamma sources .
This shows the feasibility of the overall GERDA project.

Preamplifiers and cabling



Several versions of cryogenic low-noise ASIC charge sensitive preamplifiers were produced and investigated with the naked HPGe inside the LAr test bunches

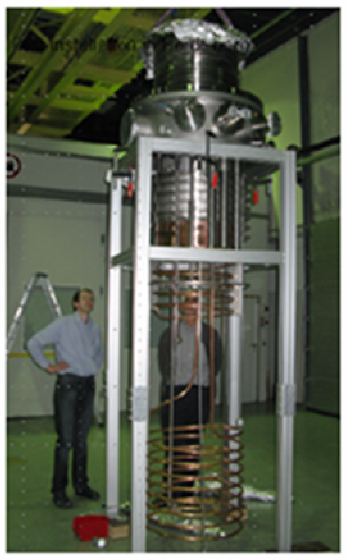


Connecting matrix installed inside the cable arm. The cabling is mounted.

Material screening

The radioactivity of all construction materials was measured by several low-background Ge gamma-spectrometers situated in different underground laboratories as well as by the high sensitive systems for Rn emanation measurements.

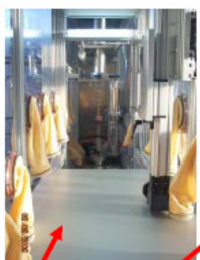
Active cooling system



The cryostat is equipped with an active cooling system using LN_2 which due to sub-cooling of LAr provides minimal losses of evaporated argon (< 0.1 m³ / 10 days)

Construction of the GERDA set up started in 2007 in the INFN Gran Sasso National Laboratory (LNGS), Italy.
The "nested type" assembly has already installed in the deep underground facility (Hall A) at 3500 m w.e.

Installation of the GERDA set up



Detector string
Glove box & lock
Clean room
Cryostat & μ-veto
Heat exchanger & pipes

In the Phase I all 8 reprocessed detectors made from ^{76}Ge (in total 18 kg) from the previous Heidelberg-Moscow and IGEX experiments, and 6 reprocessed HPGe detectors made from natural Ge (in total 15 kg) from Genius TF will be deployed in strings

In the Phase II new segmented or BeGe detectors (>20kg of ^{76}Ge) made from ^{76}Ge will be added.
In total: 40 kg of ^{76}Ge + 15 kg of ^{Nat}Ge.

Several detectors from depleted in 76Ge material will be incorporated too.