Search for the neutrinoless ββ decay in 76Ge with the GERDA experiment
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The Gerda Ovββ experiment

Neutrinoless ββ decay: \((A,Z) \rightarrow (A,Z+2) + 2e^-\)

Forbidden in the Standard Model: violates two units of the lepton number conservation

Process signature:

- SM-allowed 2p process
- Sum of the electron kinetic energies

Experimental sensitivity:

\[ T_{1/2} = 4.3 \times 10^{33} \text{ yr} \]

90% CL

The GERMANium Detector Array experiment (GERDA) will look for Ovββ decay in \(^{76}\text{Ge}\) using HP-Ge detectors enriched in \(^{76}\text{Ge}\) at the Gran Sasso underground laboratory (Italy)

GERDA concept

- Idea to reduce the background down to \(10^{-3} \text{ counts/keV kg y}\)
- shield against external γ operating ike \(6\) crystals suspended in high radioactivity liquid nitrogen or argon (also cooling medium)
- same concept of Genius and GEM

Design: graced shielding. Inner liquid N/Ar shielding + external water buffer.

Water: additional γ shielding, neutron shielding, Cerenkov muon veto

No high-Z material surrounding the detectors

Background from external γ rays can be reduced below \(10^{-3} \text{ counts/keV kg y}\)

Additional background reduction from material selection (especially for parts close to detectors), detector anti-coincidence and segmentation, pulse shape analysis (Ovββ = localized energy deposition)

Phase I detectors

- Eight enriched detectors (< 18 kg) from the former HM and IGEX experiments have been underground for more than ten years
- Internal cosmogenic background reduced. A procedure for the removal of their current crystal, re-contacting and mounting inside LN bath while keeping their radiopurity quality has been developed

Phase I Detectors

- Array
- Using Ge-Ge coincidences to suppress bg signal
- Only 50 g of selected clean material around each detector (conventional Ge crystals = 3-4 kg)

Phase II detectors

Custom-made detectors: true-coaxial n-type prototype

- Already procured 37 kg of Ge enriched at 86% in \(^{76}\text{Ge}\) (Krasnaysk, Russia) for the production of the new crystals
- Material stored underground to prevent cosmonergic activation

- Designed a suspension system such that a minimum of material is used under test
- Crystals will be segmented (e.g. 18-fold, 6-fold in the azimuth angle \(\phi\), 3-fold in the height \(z\)) each segment read out separately
- Detectors placed in hexagonal pattern in strings of three detectors each

Cerenkov muon veto

- The water tank is operated as a Cerenkov muon veto, to reduce the background induced by cosmic ray muons
- The water tank is covered with VM2000™ light-reflecting foil
- 80-100 8” PMTs mounted on the walls of the water tank. The walls of the crystal and of the water tank are covered with VM2000™ light-reflecting foil

Front-end electronics

- To reduce background minimize mass of component close to detector, integration is ongoing
- Two ASIC CMOS circuits under development and test
- 0.8 μV 5V CMOS single or differential ended preamp with external input stage (CFET) or integrated input FET, external feedback components

ASIC CMOS preamplifier in LN bath

Tested circuit structure: external BR62 JFET + 0.8 μV 5V CMOS single-ended preamplifier

Digital DAQ system

- pulse shape analysis to reduce the background produced by multi-site events
- digital filters can improve detector response when signals are affected by microphonic or high ripple
- detector test and characterization
- building of pulse shape databases for the PFA algorithm

Results with a low-noise planar Ge detector

- HP-Ge detectors
- Eight enriched detectors (= 18 kg) from the former HDX and IGEX experiments have been reduced
- Results with a low-noise planar Ge detector
- Detectors placed in strings of \(i=1,2,3\) detectors
- F = 0.05 μV, FWHM = 2.7 keV
- FWHM@1332keV = 2.7 keV
- Total power consumption: ~ 25 mW
- The Gerda Ovββ decay: \((A,Z) \rightarrow (A,Z+2) + 2e^-\)
- Claim for the observation of Ovββ decay in \(^{76}\text{Ge}\) based on the detection of the Helidelberg-Moscow (HM) experiment at Gran Sasso

\[ T_{1/2} = 0.69 \times 10^{35} \text{ yr} \]

No positive indication from the IGEX experiment

- 8.8 kg y, \(B = 0.2 \text{ c/keV kg y}\)

GERDA background for GERDA: 10^{-2} counts/keV kg y

- 100 kg exposure background-free

Phased approach:

- Phase I: existing detectors from HM and IGEX, establish background reduction
- Phase II: new detectors