LEGEND

Large Enriched Germanium Experiment for Neutrinoless ββ Decay

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LEGEND Overview

As of November 2018, the experiment is in the design stage, with plans to begin operation of the first phase at Laboratori Nazionali del Gran Sasso (LNGS) in Italy in 2021

Mission Statement

The Large Enriched Germanium Experiment for Neutrinoless Double-Beta Decay (LEGEND) aims to develop a phased, ^{76}Ge-based double-beta decay experimental program with discovery potential at a half-life significantly longer than 10^{27} years, using existing resources as appropriate to expedite physics results.

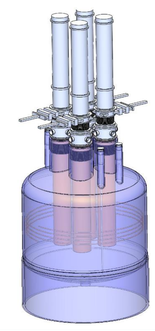
Physics Case

The matter/anti-matter asymmetry of the universe can be explained by leptogenesis, which requires lepton number violation. Neutrinoless double-beta decay would likely be the first LNV process discovered.

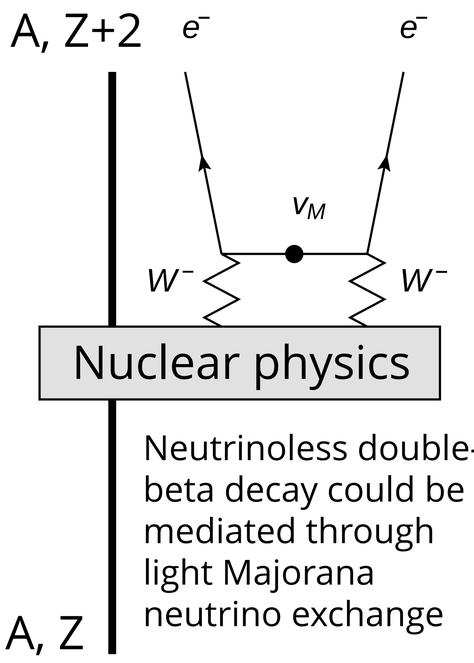
Two-phase approach

Phase 1
- 200 kg of enriched Ge
- Operate in GERDA cryostat at LNGS by 2021
- Combine MAJORANA and GERDA technologies
- Background goal of 0.6 c/(t-y-FWHM) at 2039 keV

Phase 2
- 1000 kg of enriched Ge
- Location TBD
  - Required depth under study
- Background goal of 0.1 c/(t-y-FWHM) at 2039 keV



The Physics

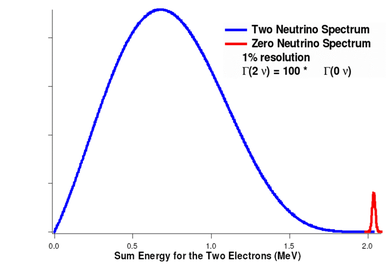


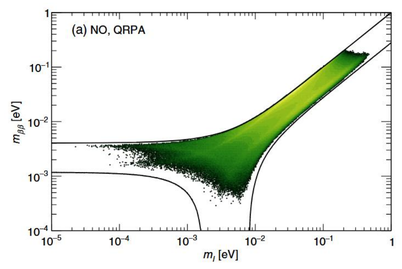
Neutrinoless double-beta decay could be mediated through light Majorana neutrino exchange

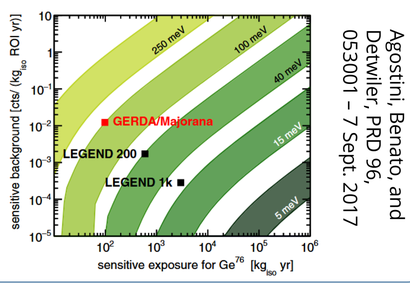
Signal is small peak at end of spectrum from 2νββ decay

Low background and superb energy resolution critical to discovery

Assuming log-flat priors, probability of discovery is concentrated above 10 meV in $m_{\beta\beta}$ for both normal and inverted hierarchies







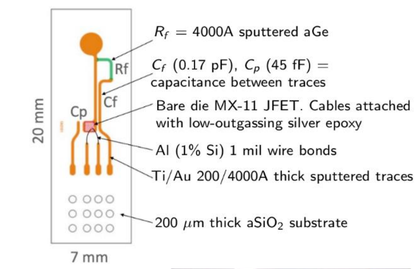
Agostini, Benato, and Detwiler, PRD 96, 053001 – 7 Sept. 2017

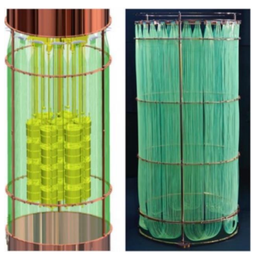
The Goal

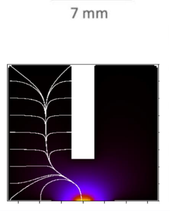
LEGEND 1T aims to achieve a sensitivity to 0νββ decay with a half-life longer than 10^{27} years

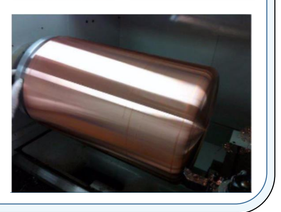
This goal can be achieved by increasing sensitive exposure by ~20x, and reducing the background rate by ~20x over GERDA/MAJORANA

Initial Improvements for LEGEND 200:
- Use MAJORANA electronics, electroformed copper, and other clean materials
- Use GERDA LAr veto
  - Improve light collection to veto ^{42}K decays
- More massive detectors









The Facility

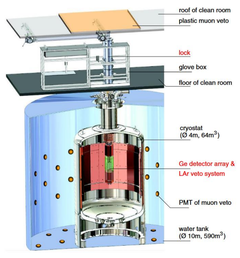
First 200 kg stage located in upgraded GERDA infrastructure at LNGS Hall A

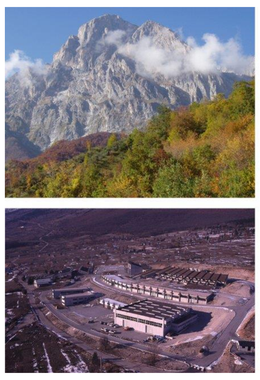
GERDA cryostat originally built to handle larger experiment

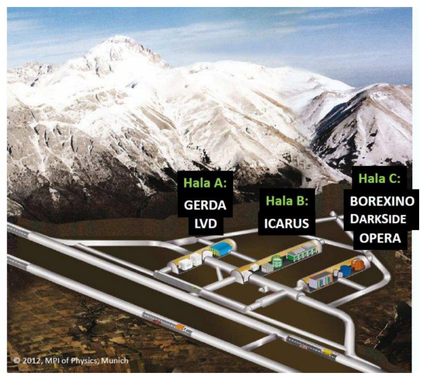
Second 1000 kg stage location TBD

Depth required for background goal under evaluation

INFN LNGS







The Collaboration

Academia Sinica
Argonne National Laboratory
Banaras Hindu University
Chalmers University of Technology
Comenius University
Czech Technical University in Prague / IEAP
Dokuz Eylül University
Gran Sasso Science Institute
Institute of Nuclear Research, RAS
Jagiellonian University
Joint Institute for Nuclear Research, Dubna
Joint Research Centre, Geel
Laboratory for Experimental Nuclear Physics, MEPhI
Laboratori Nazionali del Gran Sasso / INFN
Laboratori Nazionali del Sud / INFN
Lawrence Berkeley National Laboratory
Leibniz-Institut für Kristallzüchtung
Los Alamos National Laboratory
Lunds Universitet
Max Planck Institut für Kernphysik
Max Planck Institut für Physik
National Research Center Kurchatov Institute
North Carolina State University
Oak Ridge National Laboratory
Princeton University
Queen's University
Sichuan University
South Dakota School of Mines and Technology
Technische Universität Dortmund
Technische Universität Dresden
Technischen Universität München
Tsinghua University
University College London
Università dell'Aquila / INFN Aquila
University of Liverpool
Università di Milano / INFN Milano Bicocca
University of New Mexico
University of North Carolina at Chapel Hill
Università di Padova / INFN Padova
University of South Carolina
University of South Dakota
University of Tennessee, Knoxville
University of Texas at Austin
Universität Tübingen
University of Washington / CENPA
Universität Zürich

The MAJORANA DEMONSTRATOR

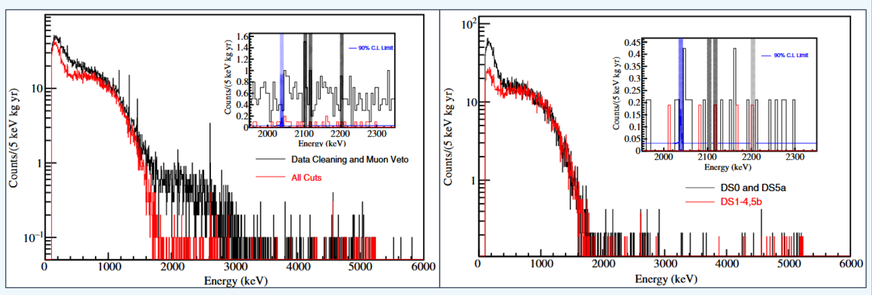
Results (7/2018)

Best bkg: 11.9 c/(t-y-FWHM)

Exposure: 26 kg-y

E res (FWHM): 2.5 keV (0.12%)

Limit on 0νββ HL: 2.7×10^{25} y

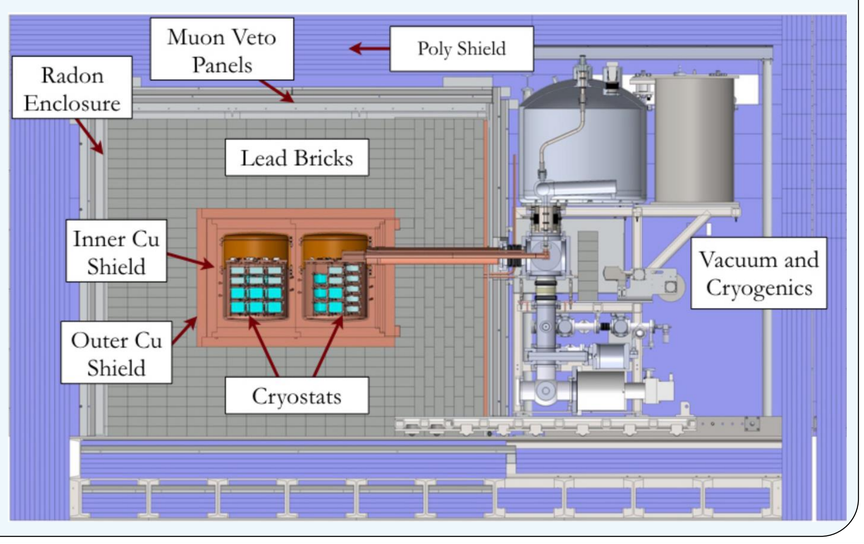


30 kg of ^{enr}Ge

Detectors shielded by compact n-arresting plastic, lead, and underground electroformed copper

All detectors P-type Point Contact

Located at the Sanford Underground Research Facility in Lead, SD, USA



GERDA Phase II

Results (7/2018)

Best bkg: 1.7 c/(t-y-FWHM)

Exposure: 82.4 kg-y

E res (FWHM): 2.9 keV (0.14%)

Limit on 0νββ HL: 9×10^{25} y

20 kg of ^{enr}Ge

Detectors directly immersed in active LAr scintillating veto

Detectors mix of coaxial and P-type Point Contact design