LEGEND The ^{76}Ge Neutrinoless Double Beta Decay Program

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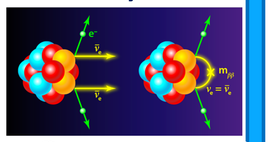
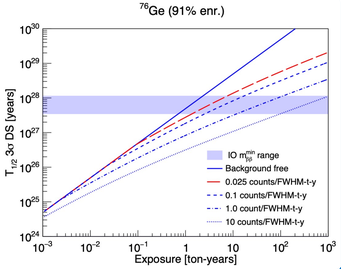
LEGEND is a collaboration of over 250 researchers from 48 institutions with mission, "To develop a phased, ^{76}Ge based double-beta decay experimental program with **discovery potential at a half-life beyond 10^{28} years,** using existing resources as appropriate to expedite physics results."

The Search for Neutrinoless Double Beta Decay

Observation of this phenomenon would be the **first evidence for lepton number violation in Nature** and provide insight into the **matter-antimatter asymmetry** in our Universe.



Advantages of ^{76}Ge:
- Large & reliable world supply
- Able to enrich from 8% to ≥ 92%
- Best E resolution: ~0.1%, 2039 keV
- Lowest background demonstrated of any 0νββ experiment
  - Excellent pulse shape discrimination
  - Negligible 2νββ background
  - No strong background lines near $Q_{\beta\beta}$



See also at PANIC

- Luigi Pertoldi, first talk tomorrow in Neutrino parallel session
- Małgorzata Harańczyk, Purification of Large Volume of LAr for L200 (poster)
- CJ Barton, In-situ Cosmogenic Background for LEGEND (poster)

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Learn more at **legend-exp.org**

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Realizing Ultra-Low Backgrounds

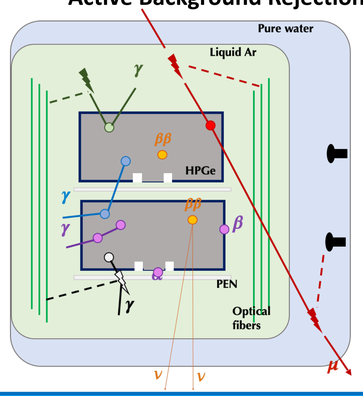
Strategy: Select best technologies based on what has been learned from GERDA and the MAJORANA DEMONSTRATOR, as well as contributions from other groups.

GERDA:
- LAr veto
- Low-A shield, no Pb

MAJORANA:
- Radiopurity of nearby parts
- Low noise, low-threshold electronics

Both:
- Lowest background and best resolution 0νββ experiments
- Clean fabrication techniques
- Controlling surface exposure time of components
- Development of large point-contact detectors

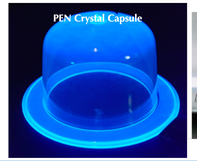
Active Background Rejection Baseline in LEGEND

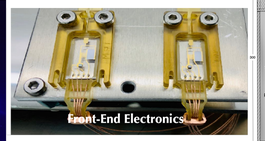


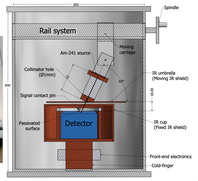
- Signal is single-site bulk events with no coincidence
- Pulse shape discrimination (PSD) for multi-site and surface events
- Ge detector anti-coincidence veto
- Scintillating PEN plate
- LAr veto: Ar scintillation light read by fibers + PMT's
- Muon veto: Cherenkov light & plastic scintillator

Select Ongoing Research and Development

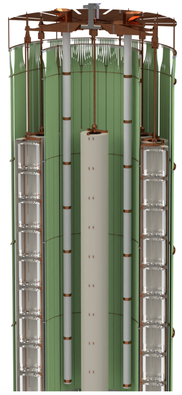
- Scintillating PEN as structural material
  - JINST 14 (2019) 07006
- Xe-doped liquid argon veto
  - NIM A 1011 (2021) 165575
- ASIC front-end electronics
  - JINST 15 (2020) 09022
- Surface scanning cryostats
  - arXiv:2105.14487, arXiv:2006.13179



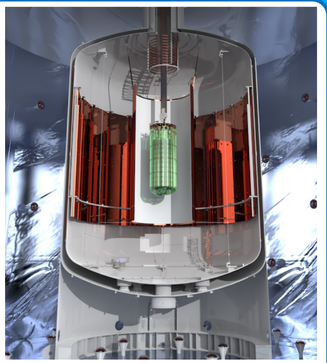




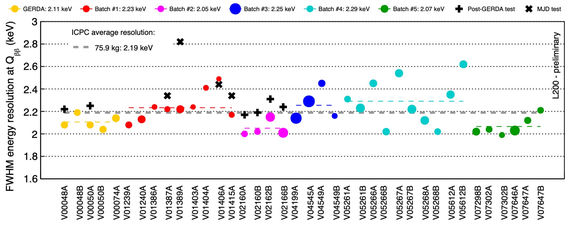
LEGEND-200: Current Status



- 200 kg ^{enr}Ge in upgrade of existing infrastructure at LNGS
- 1000 kg yr enriched exposure
  - x10 increase over GERDA
- Resolution: 2.5 keV FWHM
  - matching MAJORANA
- BG goal: < 0.6 cts/(FWHM t yr)
  - x2.5 decrease from GERDA
- Will use GERDA and MAJORANA DEMONSTRATOR enriched detectors
- Data start in late 2021



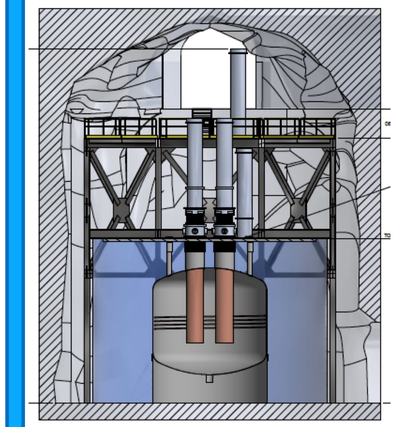
Commissioning activities ongoing through fall



New ICPC detector averages:
- Detector mass: 2.02 kg
- Energy resolution at $Q_{\beta\beta}$: 2.2 keV
- Continuum rejection at $Q_{\beta\beta}$: 65%

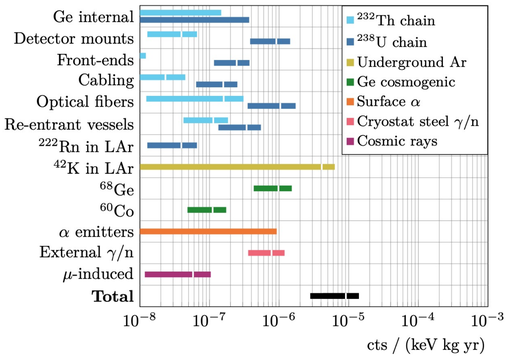
Over 80 kg of new ICPC detectors on hand, in addition to GERDA and MAJORANA enriched detectors

Towards LEGEND-1000



Robust background model based primarily on achieved levels in GERDA and the MAJORANA DEMONSTRATOR

Baseline Design:
- 1000 kg ^{enr}Ge (staged approach, multiple payloads)
- Resolution: **2.5 keV FWHM**
- Background goal: **< 0.025 cts/(FWHM t yr)**
  - < 0.01 cts/(keV t yr)
- Discovery sensitivity (3σ) of 1.3 x 10^{28} yr
  - $m_{\beta\beta}$ upper limit of 9-21 meV
- SNOLAB and LNGS underground locations under study
- Lab-specific infrastructure and cryostat design underway



Preconceptual Design Report online at arXiv:2107.11462