LEGEND: The Large Enriched Germanium Detector for Neutrinoless Double-Beta Decay

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LEGEND
Large Enriched Germanium Experiment for Neutrinoless ββ Decay

University of Zurich[UZH]

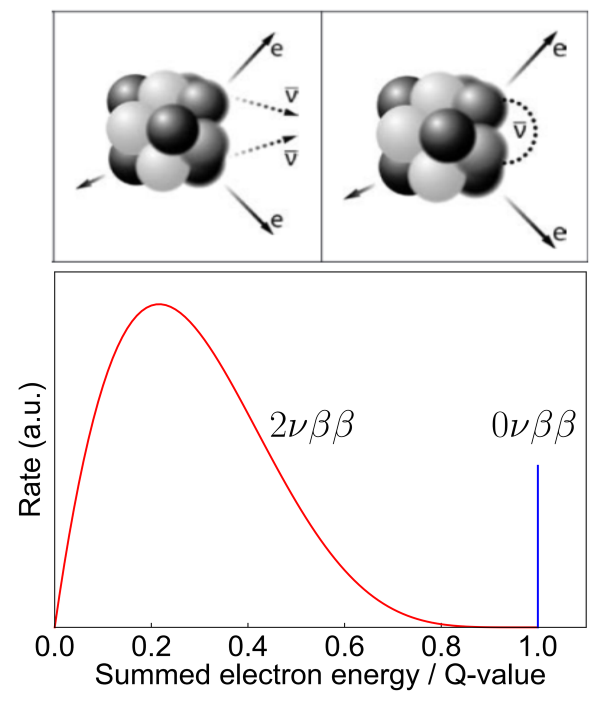
2νββ and 0νββ decay

Two-neutrino double-beta decay (2νββ):

- $^{76}Ge \rightarrow {}^{76}Se + 2e^- + 2\bar{\nu}_e$
- continuous decay spectrum

Neutrinoless double-beta decay (0νββ):

- $^{76}Ge \rightarrow {}^{76}Se + 2e^-$
- single peak at Q-value of the decay requiring good energy resolution ➞ Ge detectors

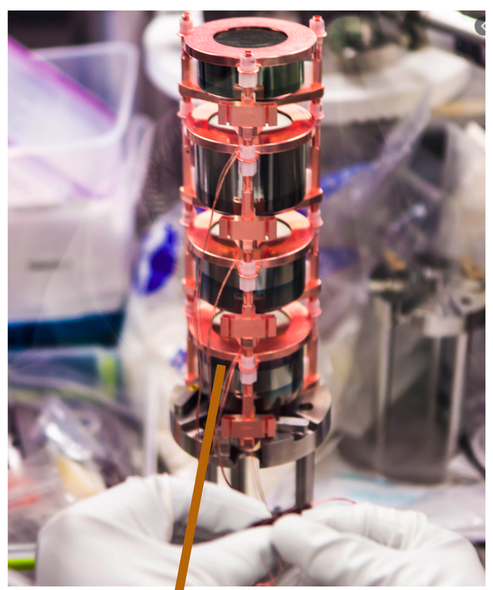


Observation of 0νββ would have relevant physics implications:

- Majorana-nature of neutrinos
- Asymmetry between matter and antimatter
- Violation of lepton number conservation
- Neutrino absolute mass scale and ordering (normal/inverted)

From MAJORANA + GERDA towards LEGEND

Majorana and GERDA use enriched ^{76}Ge detectors to search for neutrinoless double-beta decays. LEGEND-200 will combine the state-of-the-art techniques of both experiments:

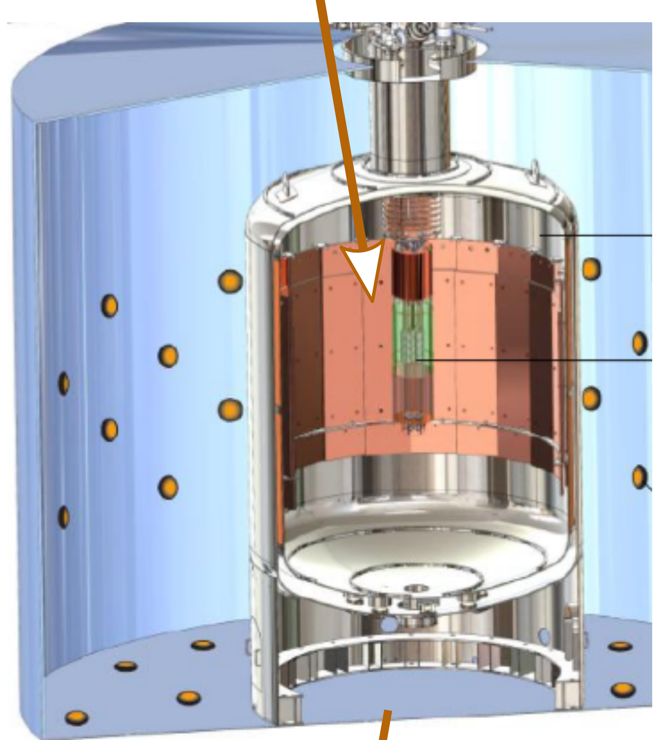


- Ge detectors from both MAJORANA and GERDA
- Additional 150kg of recycled or newly developed Ge detectors
- Low radioactive near-detector parts and low-noise electronics from MAJORANA

i Detector modules are surrounded by a curtain of fibers, which are part of the light detection system used to veto background events close to the detectors.

- Fiber veto system similar to GERDA's, but re-designed to improve light collection
- Increase of veto efficiency
- Background reduction

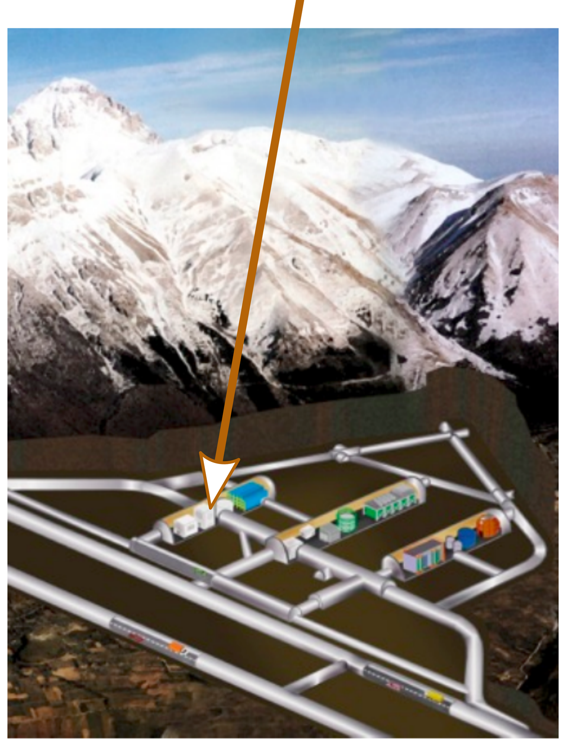
i Detectors and fibers are inside a cryostat filled with liquid argon, which cools down the detectors to their working temperature (87K), shields them from radioactive decays, and acts as a scintillation medium for the veto system.



- Upgrade of existing GERDA cryostat to allow for more germanium detector modules

i The cryostat is inside a water tank equipped with photomultiplier tubes, which detect the Cherenkov light produced by cosmic muons going through it. These muons can then be tagged and vetoed.

- Use of the water tank (muon veto) from GERDA
- Located at Laboratori Nazionali del Gran Sasso, under 1400 m of rock

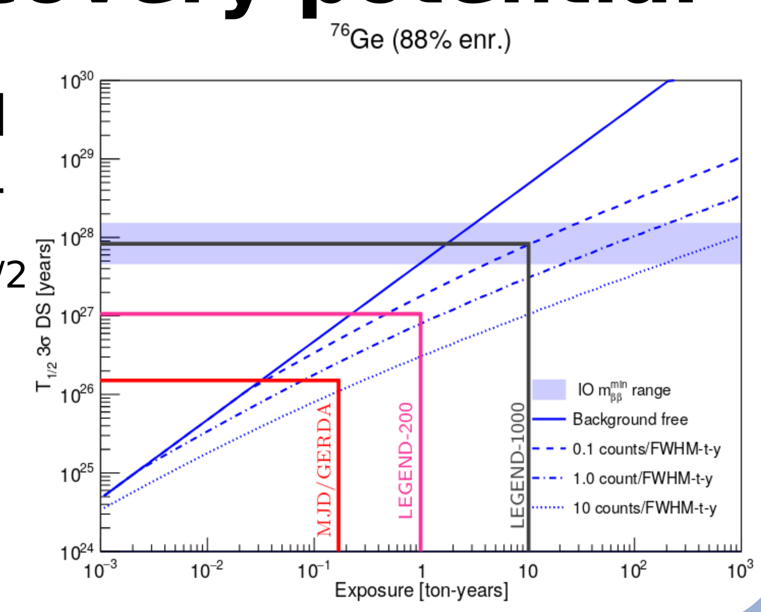


i The location deep underground shields the experiment from most of the cosmic muons (only 1 in 10^6 reach the detector).

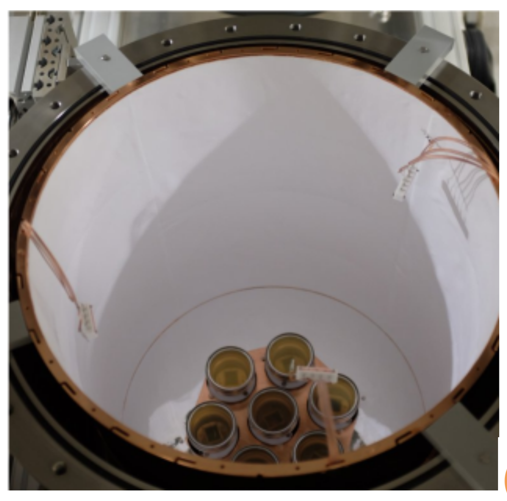
Projected discovery potential

Current and expected sensitivity to the half-life of 0νββ-decay, $T_{1/2}$

GERDA/MAJORANA: >1.1x10²⁶ yr
LEGEND-200: 10²⁷ yr
LEGEND-1000: 10²⁸ yr



Ongoing activities at UZH

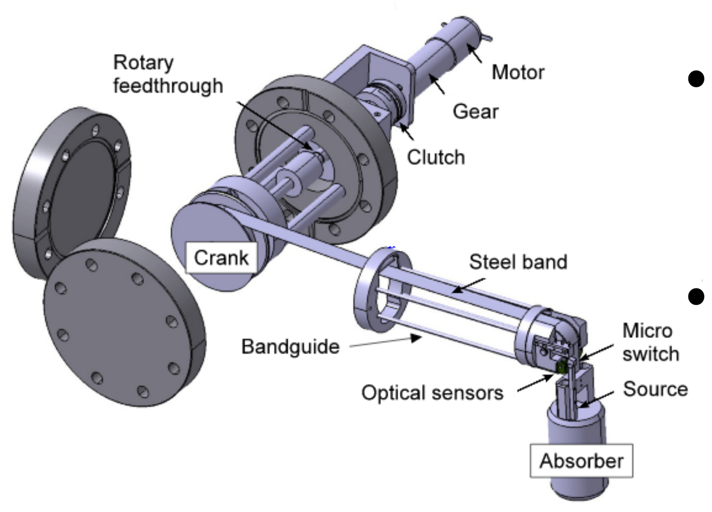


- Installation of wavelength-shifting Tetratex reflector foils

i Detection of scintillation light outside the detectors allows to discriminate signal from background events.

- Detector calibration with thorium source

i The multiple γ-lines from radioactive decays from the thorium source are used to determine the energy scale and the resolution.



- Modification of existing GERDA source insertion system (SIS)
- SIS stress tests under cryogenic temperatures

- Emanation rate measurements
- Material screening
- Analysis of background and calibration data
- Exotic physics searches (SuperWIMPs, ALPs, Majorons, Sterile Neutrinos)

Join our worldwide collaboration!

References:

[1] The Legend Collaboration: The large enriched germanium experiment for neutrinoless double beta decay (LEGEND), AIP Conference Proceedings (2017) 1894:020027

[2] European Astroparticle Physics Strategy 2017-2026, APPEC (2017)