University of Zurich[UZH]

The Large Enriched Germanium Experiment for Neutrinoless Double Beta Decay

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Physics goal: Search for **neutrinoless double beta decay** ($0\nu\beta\beta$) with enriched high purity germanium detectors (^{76}Ge).

Two neutrinos emitted ($2\nu\beta\beta$): observed SM process

$^{76}Ge \rightarrow {}^{76}Se + 2e^- + 2\bar{\nu}_e$ ($\Delta L=0$)

Continuous broad energy spectrum

No neutrino emitted ($0\nu\beta\beta$): physics beyond the SM

$^{76}Ge \rightarrow {}^{76}Se + 2e^-$ ($\Delta L=+2$)

Energy peak at $Q_{\beta\beta}$= 2039 keV

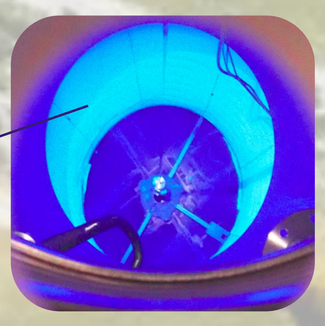
Ge detectors achieve excellent energy resolutions, needed to resolve the $0\nu\beta\beta$ peak.

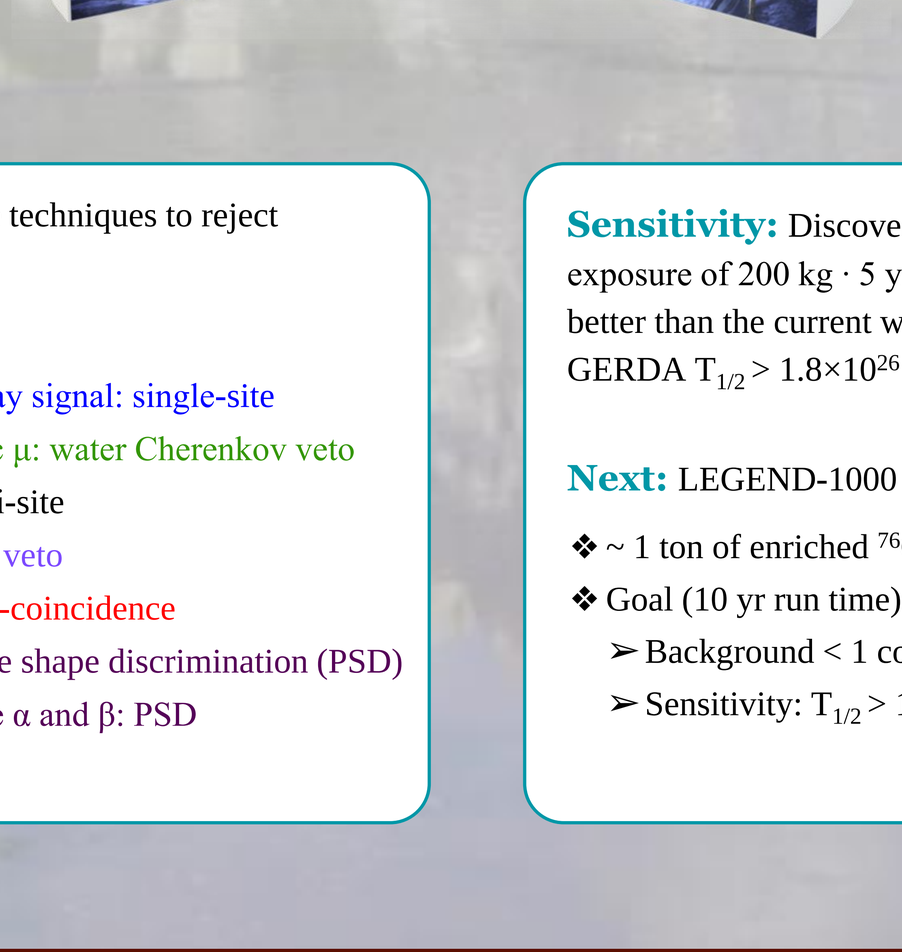
Physics motivation: An observation of **$0\nu\beta\beta$** would have important implications for particle physics & cosmology:

- ❖ Majorana nature of neutrinos (particle = antiparticle)
- ❖ Absolute neutrino mass scale and ordering (normal vs. inverted)
- ❖ Lepton number violation
- ❖ Hint on matter-antimatter asymmetry of the Universe

The LEGEND-200 experiment is located underground at Laboratori Nazionali del Gran Sasso (LNGS). A 1.4 km thick layer of rock reduces cosmic muons by $\mathcal{O}(10^6)$. LEGEND-200 is currently under commissioning with ~ 140 kg of ^{76}Ge detectors and will start physics data taking by the end of 2022. The final array will comprise ~ 200 kg of ^{76}Ge detectors to be ready by the end of 2023.

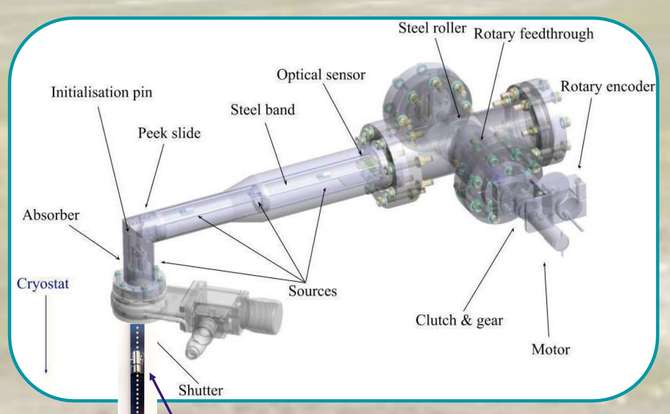
Wavelength-shifting **reflectors**





Water tank

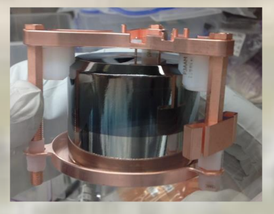
LAr cryostat

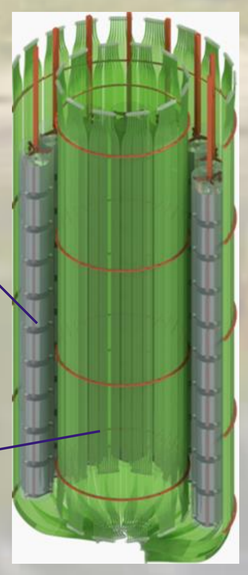


Calibration system

^{228}Th sources

^{76}Ge detector





Wavelength-shifting **fibers**

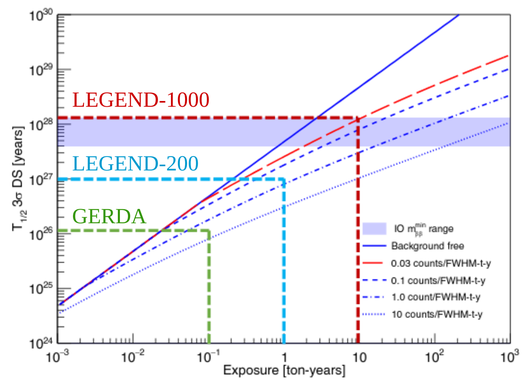
Background reduction: LEGEND uses multiple techniques to reject background events to clearly identify the $0\nu\beta\beta$ peak.

- ❖ $\beta\beta$ decay signal: single-site
- ❖ Cosmic μ: water Cherenkov veto
- ❖ γ: multi-site
  - ➢ LAr veto
  - ➢ Anti-coincidence
  - ➢ Pulse shape discrimination (PSD)
- ❖ Surface α and β: PSD

Sensitivity: Discovery sensitivity aim of $T_{1/2} > 10^{27}$ yr (with an exposure of 200 kg · 5 yr) of LEGEND-200 is an order of magnitude better than the current world-leading $T_{1/2}$ constraint in Ge from GERDA $T_{1/2} > 1.8\times10^{26}$ yr (90% C.L.).

Next: LEGEND-1000

- ❖ ~ 1 ton of enriched ^{76}Ge
- ❖ Goal (10 yr run time):
  - ➢ Background < 1 count
  - ➢ Sensitivity: $T_{1/2} > 10^{28}$ yr



Photos: Enrico Sacchetti and Michael Willers

LEGEND

11 countries,
~ 50 institutions,
> 250 members