New results from the GERDA neutrinoless double-beta decay search

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Horizon 2020

Searching for 0νββ

Matter/anti-matter asymmetry could be explained by possible Majorana nature of the neutrino

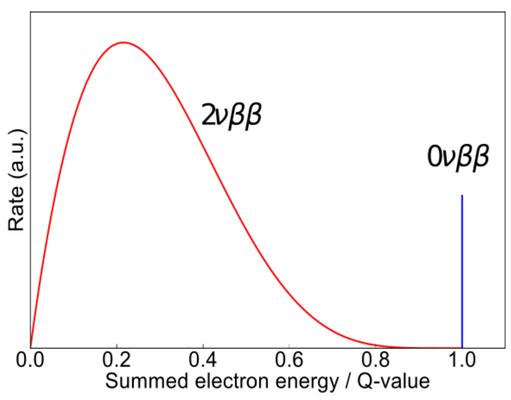
Neutrinoless double-beta decay (0νββ): hypothetical lepton-number violating process, e.g. $^{76}Ge \rightarrow {}^{76}Se + 2e^-$

Process probes nature of neutrino (Dirac/Majorana) and absolute mass scale

Very rare process $T^{0\nu}_{1/2} > 10^{25}$ yr [1] requires utmost background suppression

Signature in calorimeters looks like peak at $Q_{\beta\beta}$ above continuum of 2νββ

Signature of decay

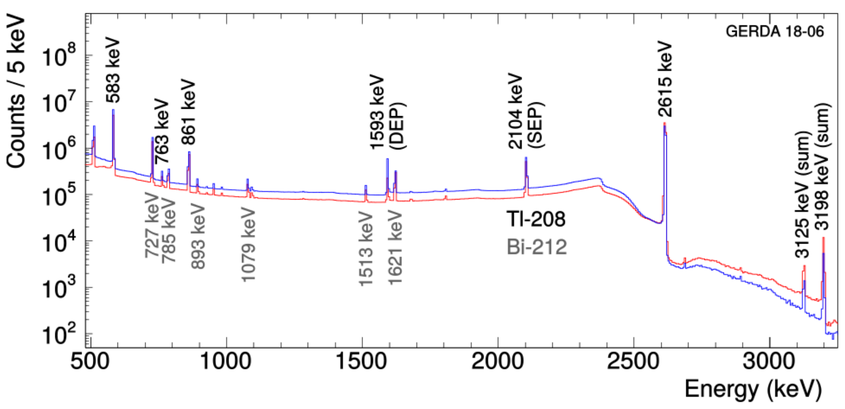


Energy scale and resolution

Energy scale calibrated by exposure to low-neutron ^{228}Th sources each 7-10 days

Stability monitored via 2.6 MeV ^{208}Tl line between calibrations

Combined calibration spectrum of Phase II



Resulting resolution at $Q_{\beta\beta}$ (FWHM):

Coaxial: $3.6(1)\,\mathrm{keV}$ **BEGe:** $3.0(1)\,\mathrm{keV}$

The GERDA experiment

GERDA (GERmanium Detector Array) searches for 0νββ decay of ^{76}Ge [2] at LNGS

35 kg germanium diodes isotopically enriched in ^{76}Ge act as both source and detector of 0νββ

Multiple layers of active and passive shielding reduce background

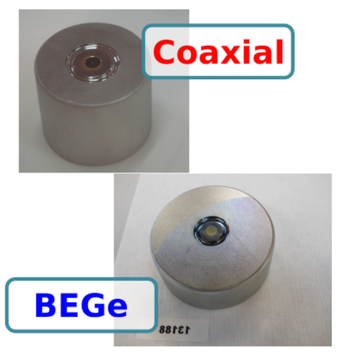
Detectors are operated bare in liquid argon (LAr)

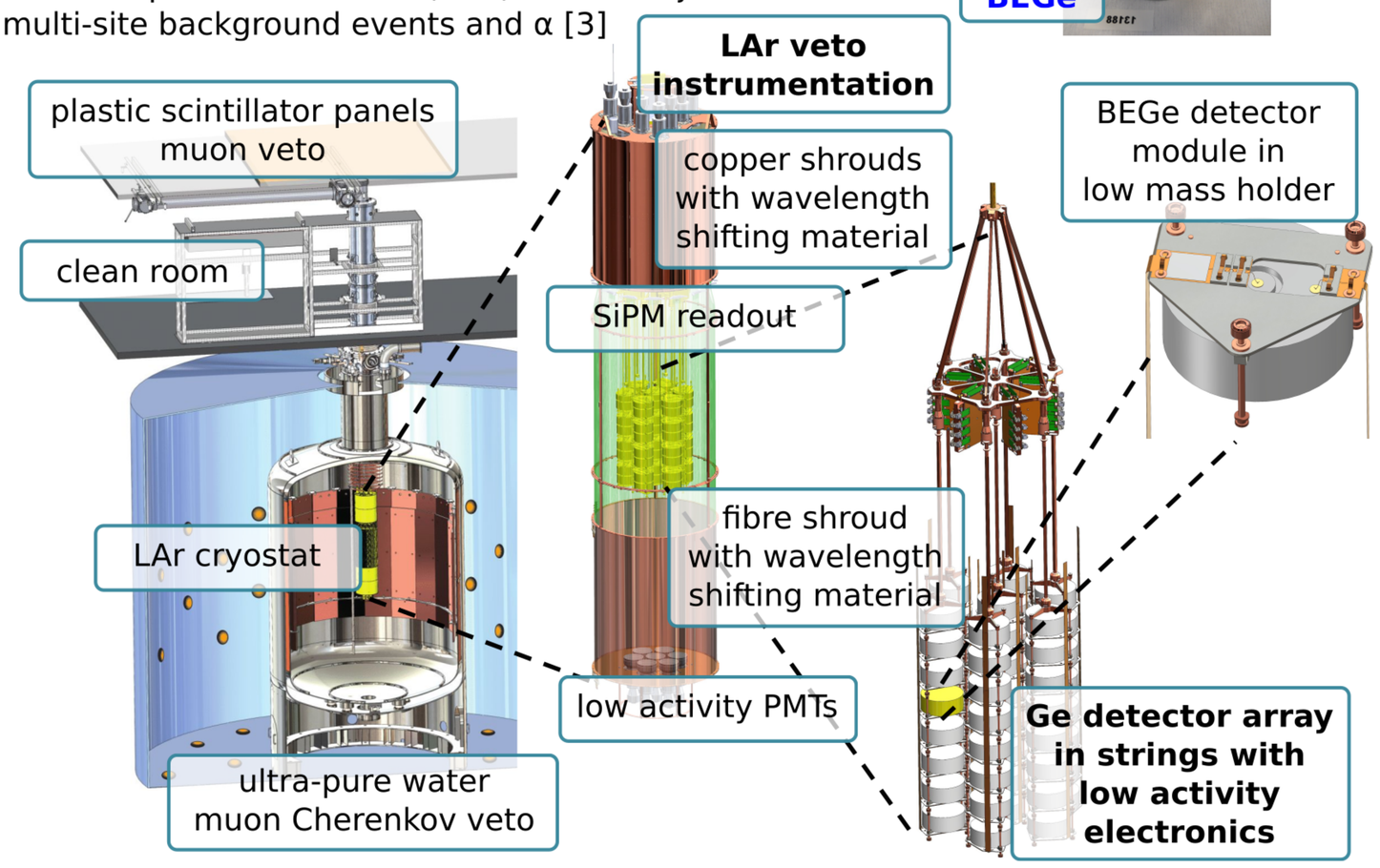
LAr veto is intrumented for light-readout to veto background events that cause scintillation

Pulse shape discrimination (PSD) used to reject multi-site background events and α [3]

Two detector types: **BEGe** and **Coaxial**

BEGe detectors offer improved energy resolution and pulse shape discrimination power compared to Coaxials





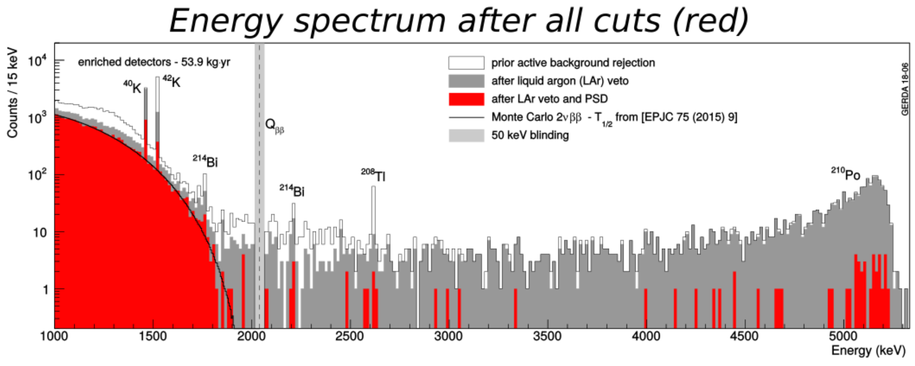
Energy spectrum

Backgrounds suppressed:
- PSD suppresses multi-site γs, surface events from β, degraded α events
- LAr veto suppresses γ, β

Remaining features: 2νββ, ^{40}K, ^{42}K, ^{208}Tl and ^{214}Bi γs, α

Background at $Q_{\beta\beta}$ even contributions of: α, ^{42}K β^-, γ from ^{232}Th and ^{238}U chains

Energy spectrum after all cuts (red)



Resulting background index at $Q_{\beta\beta}$:

Coaxial: $5.7^{+4.1}_{-2.6} \cdot 10^{-4}\,\mathrm{cts/(keV \cdot kg \cdot yr)}$

BEGe: $5.6^{+3.4}_{2.4} \cdot 10^{-4}\,\mathrm{cts/(keV \cdot kg \cdot yr)}$

Results of 0νββ search

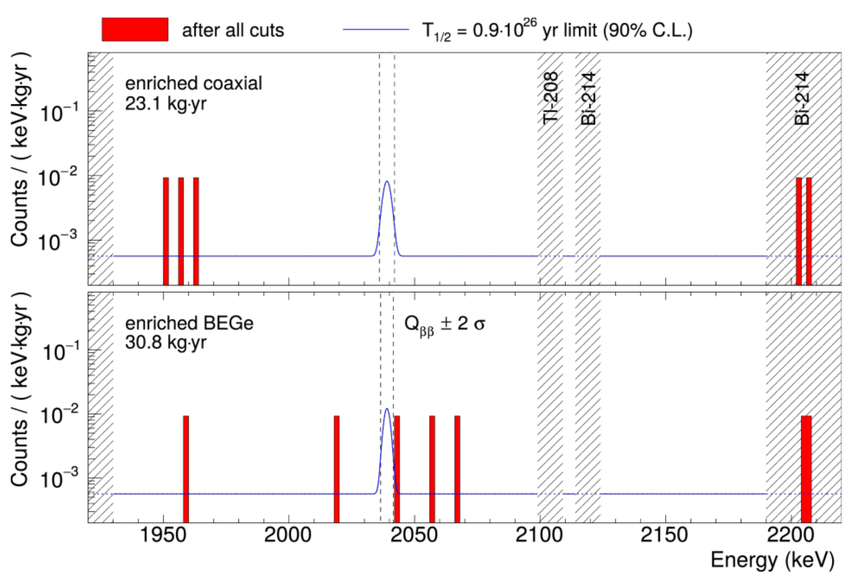
Events in 50 keV region around $Q_{\beta\beta}$ are unblinded after analysis fixed

Latest unblinding made in May 2018, with exposure of 58.9 kg yr (35.7 kg yr new)

Statistical analysis shows spectrum is best fitted by no signal

World's best sensitivity for limit-setting on half-life of 0νββ decay of ^{76}Ge:
$T^{0\nu}_{1/2} > 1.1 \cdot 10^{26}$ yr (90% C.L.)

Spectrum around $Q_{\beta\beta}$ after all cuts for two detector types



The future: LEGEND

Success of GERDA inspires global collaboration: Large Enriched Germanium Experiment for 0νββ decay (LEGEND)

LEGEND wil use Ge detectors of GERDA and MAJORANA and additional new detectors, currently tested in GERDA

Two stage approach with first 200kg, ultimately reaching 1t of enriched Ge

Aims for discovery potential with half-life significantly longer than 10^{27} years

[1] Phys. Rev. Lett. 120 (2018) 132503
[2] Phys. J. C 78 (2018) 388
[3] The European Physical Journal C 73.10 (2013): 2583

This project has received funding/support from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 674896.