Status of the the GERDA neutrinoless double-beta decay experiment

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GERDA

Searching for 0νββ

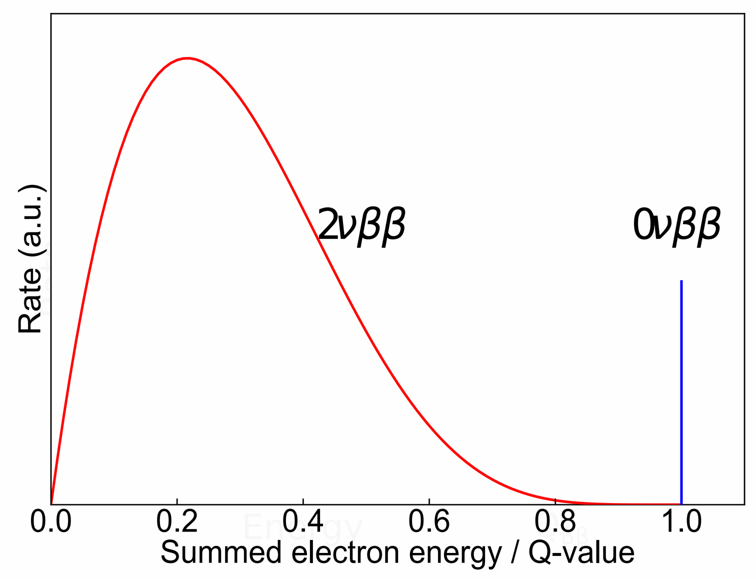
Neutrinoless double-beta decay (0νββ): hypothetical lepton-number violating process, e.g. $^{76}Ge \rightarrow {}^{76}Se + 2e^-$

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

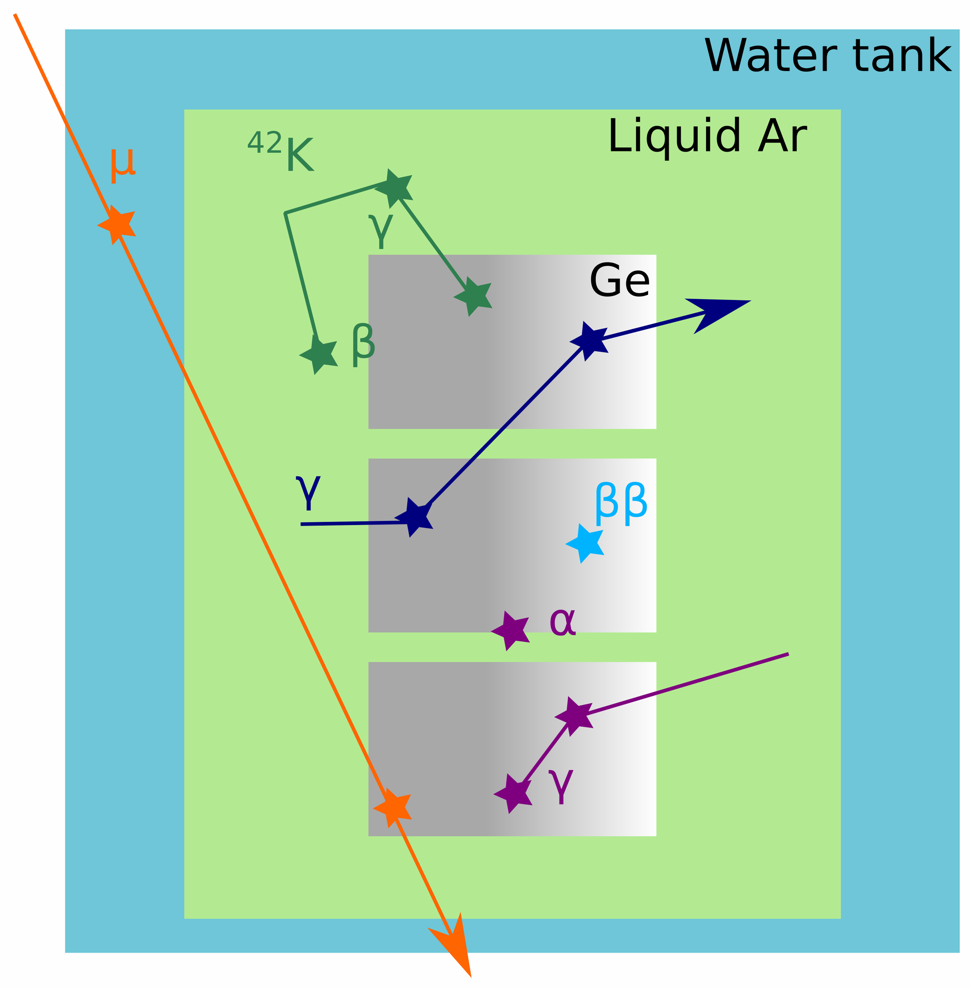
Signature of decay



Sensitivity to half-life of decay in "background-free" regime: $T^{0\nu}_{1/2} \propto \epsilon M t$
where ϵ: efficiency; Mt: exposure

Background reduction techniques

- Signal! Single-site event
- Cherenkov water veto for muons
- LAr scintillation veto for γ, β
- Detector anti-coincidence cut
- Pulse shape discrimination (PSD) for multi-site and surface α events [3]



Schematic showing various background reduction techniques of GERDA

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

Sensitivity scales as background-free!

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

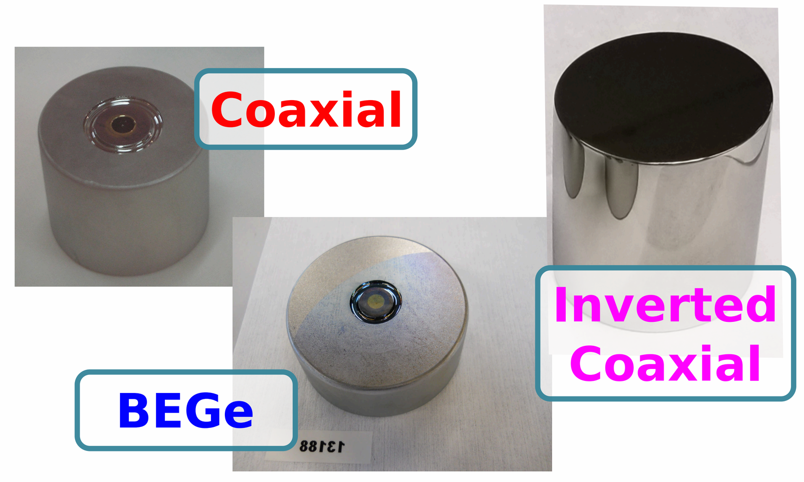
Detectors are operated bare in liquid argon (LAr)

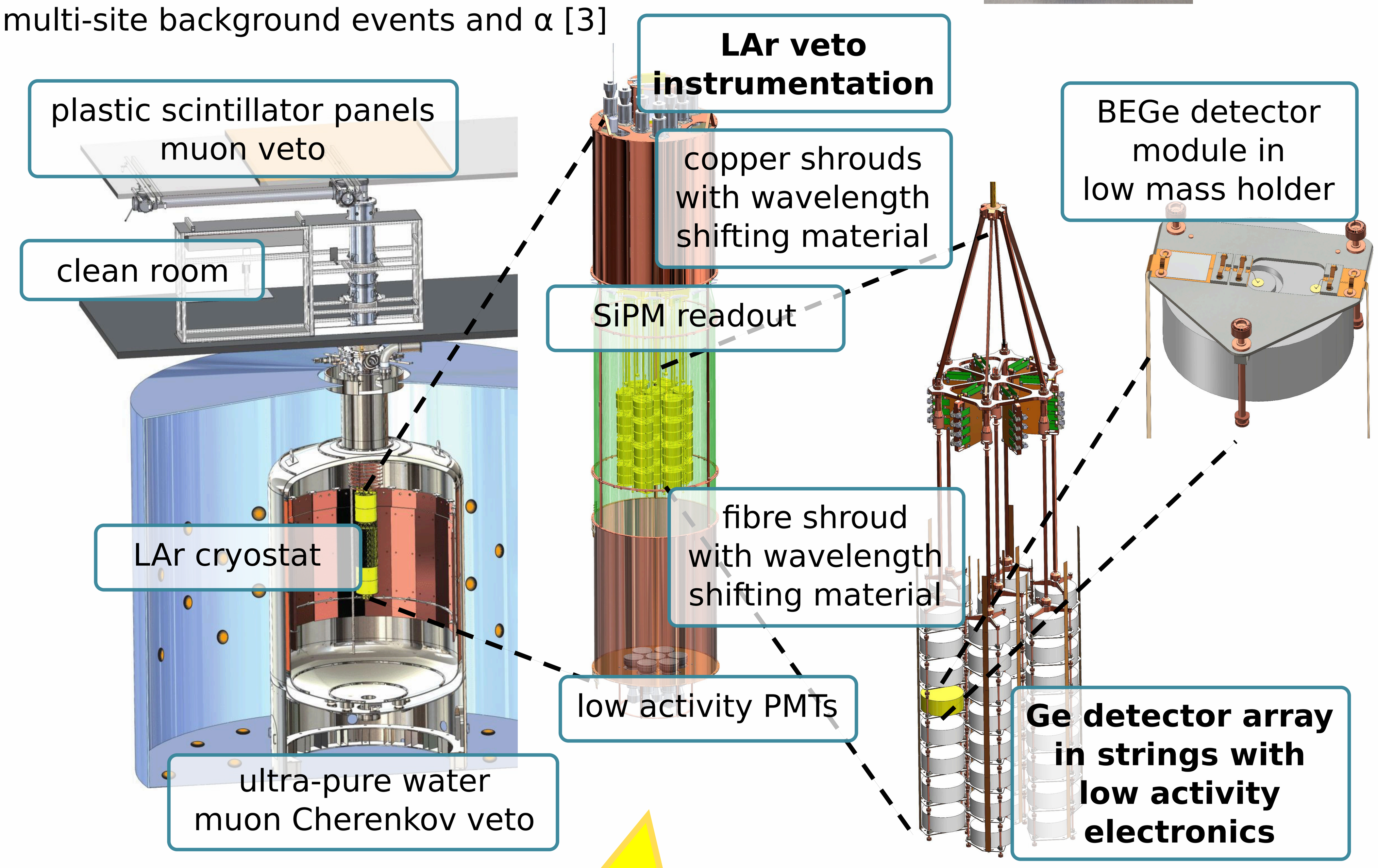
LAr veto is intrumented for light-readout to veto background events that cause scintillation

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

Three detector types: **BEGe**, **Coaxial** and **Inverted Coaxial**

BEGe and Inverted Coaxial detectors [4] offer improved energy resolution and pulse shape discrimination power compared to Coaxials





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Results of 0νββ search

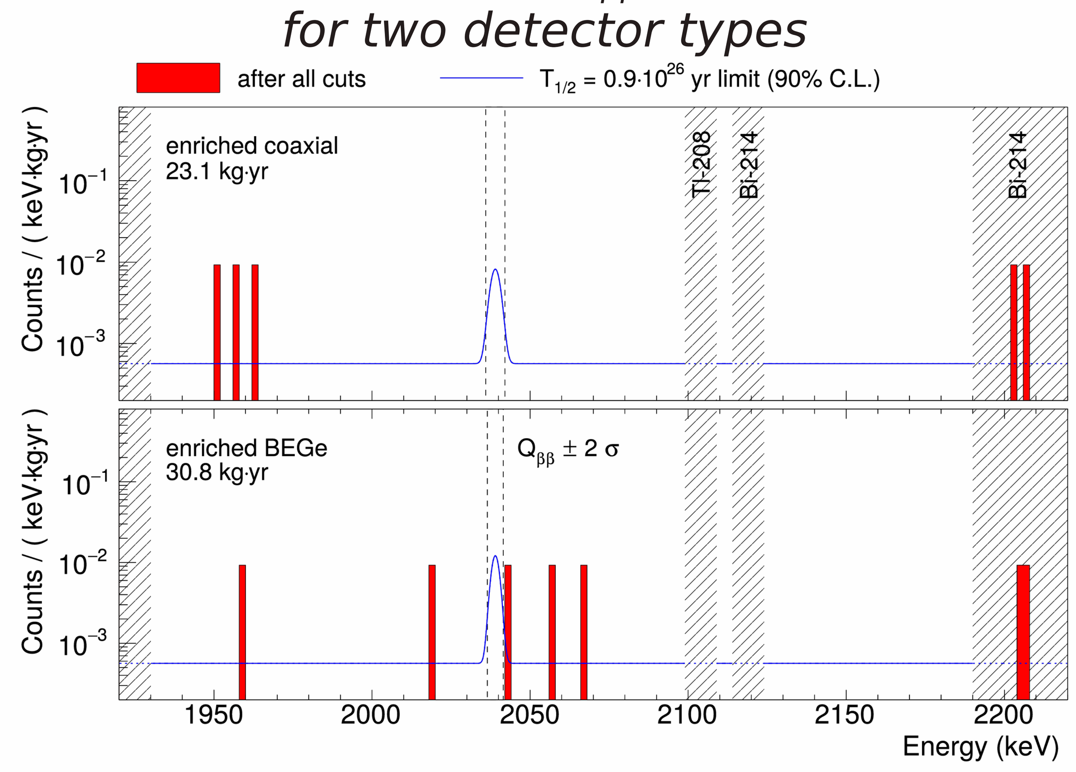
Events in 50 keV region around $Q_{\beta\beta}$ are unblinded after analysis fixed

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

One new event is seen at 2042 keV, 2.4σ from $Q_{\beta\beta}$

Statistical analysis shows spectrum is best fitted by no signal

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



New frequentist limit on half-life of 0νββ decay of ^{76}Ge:

$T^{0\nu}_{1/2} > 0.9 \cdot 10^{26}$ yr (90% C.L.)

Corresponding limit on Majorana mass of neutrino, $m_{\beta\beta}$:

$$m_{\beta\beta} < (104 - 228)\,\mathrm{meV}$$

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.)

When combined with other 0νββ experiments:

$$m_{\beta\beta} < (66 - 155)\,\mathrm{meV}$$

GERDA upgrade

Integration of 5 new **Inverted Coaxial** detectors, performing well

New fibre shroud for increased light collection efficiency (right)

Cables and electronics replaced for reduced noise and background contributions

New fibre shroud with central fibre module

[1] Phys. Rev. Lett. 120 (2018) 132503
[2] Phys. J. C 78 (2018) 388
[3] The European Physical Journal C 73.10 (2013): 2583
[4] The European Physical Journal C, in print arXiv:1901.06590
[5] Science 365.6460 (2019): 1445-1448