Neutrinoless double beta decay search with the GERDA experiment

ββ

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on the behalf of the GERDA collaboration

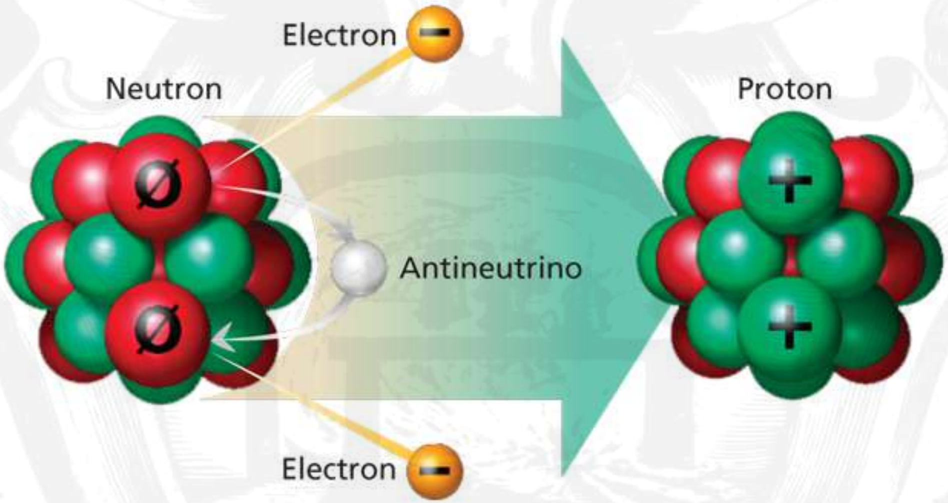
SIF 14-18 September 2020

GERDA

INFN LNGS
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali del Gran Sasso

Società Italiana di Fisica

Neutrinoless Double Beta Decay



See L. Pandola presentation (17/09)

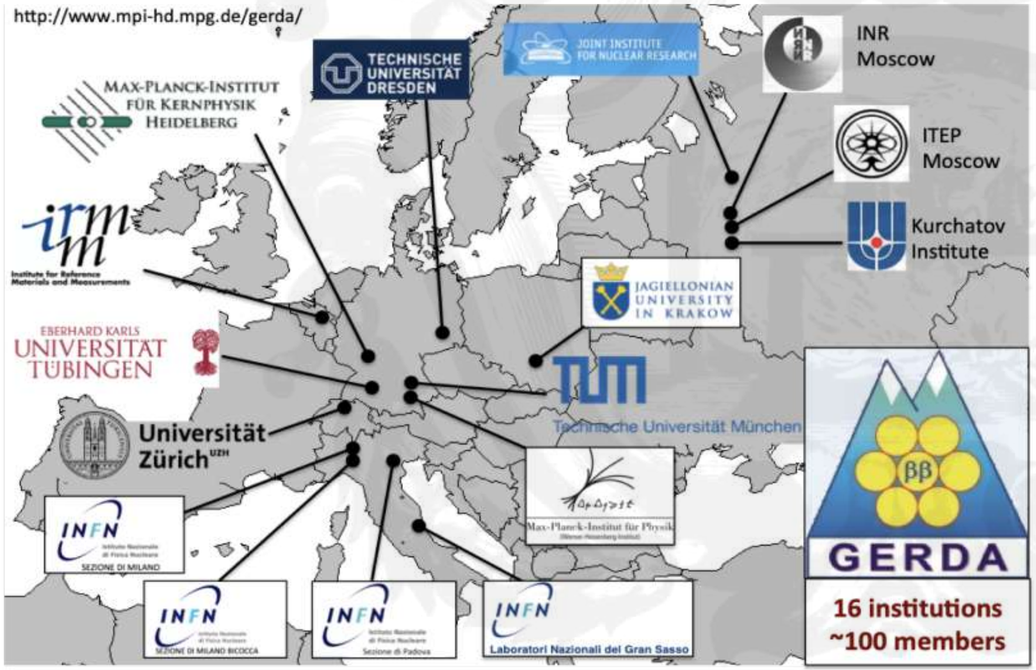
Neutrinoless double beta decay is one of the most sensitive probes for physics beyond the Standard Model, providing unique information on the nature of neutrinos

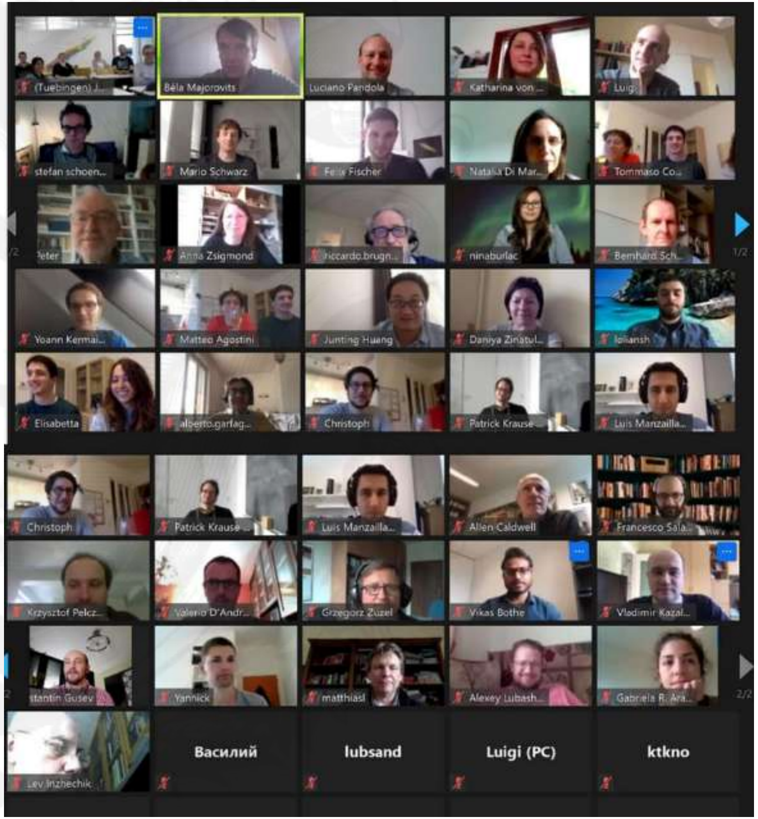
Nucl. Part. Physics Procs. 273 - 275 (2016) 1876
Science 365 (2019) 1445

GERDA Experiment

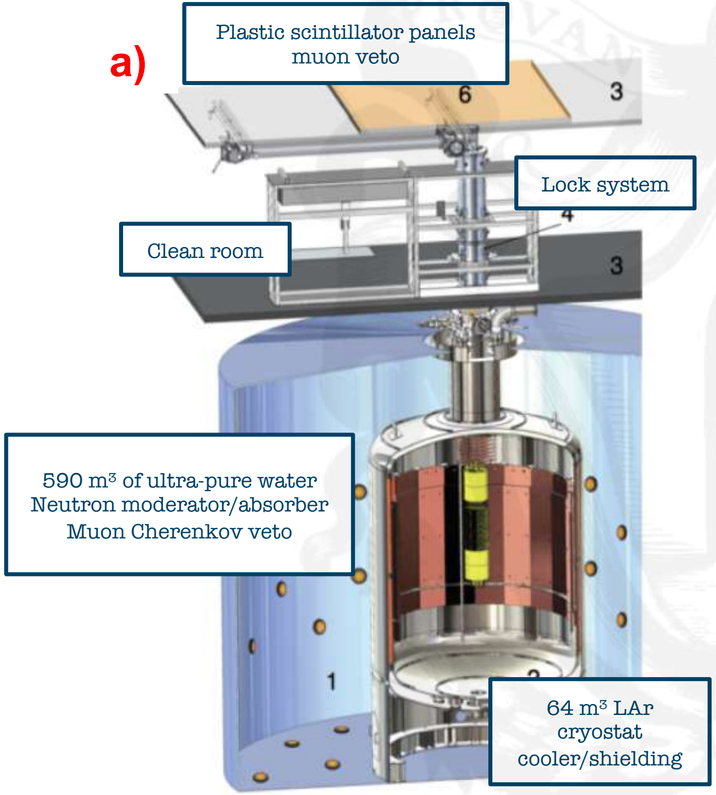
16 institutions from Europe

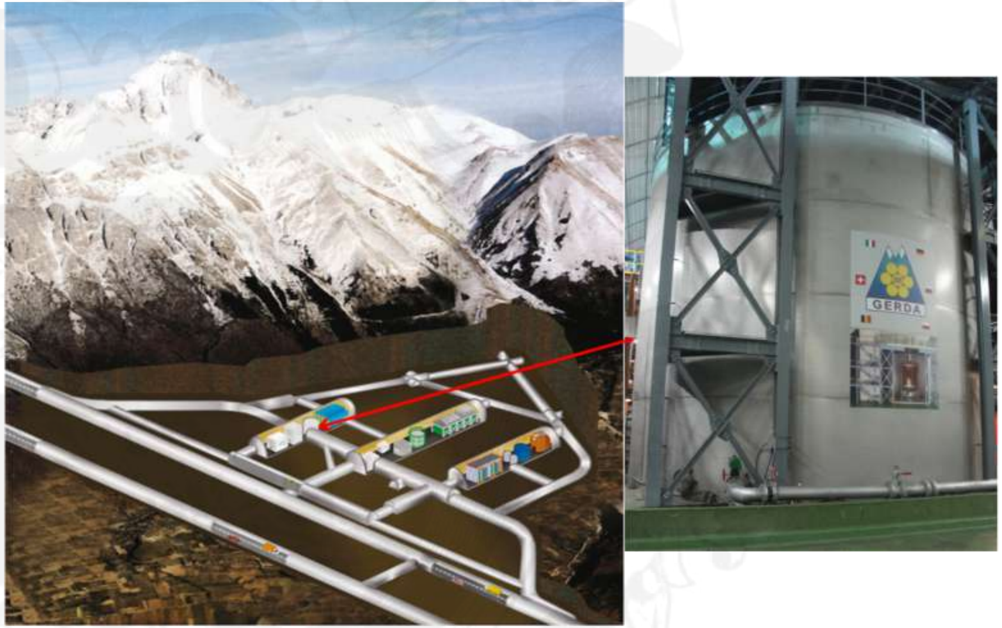
GERDA started data taking in 2011 and stopped in 2019





GERDA Setup

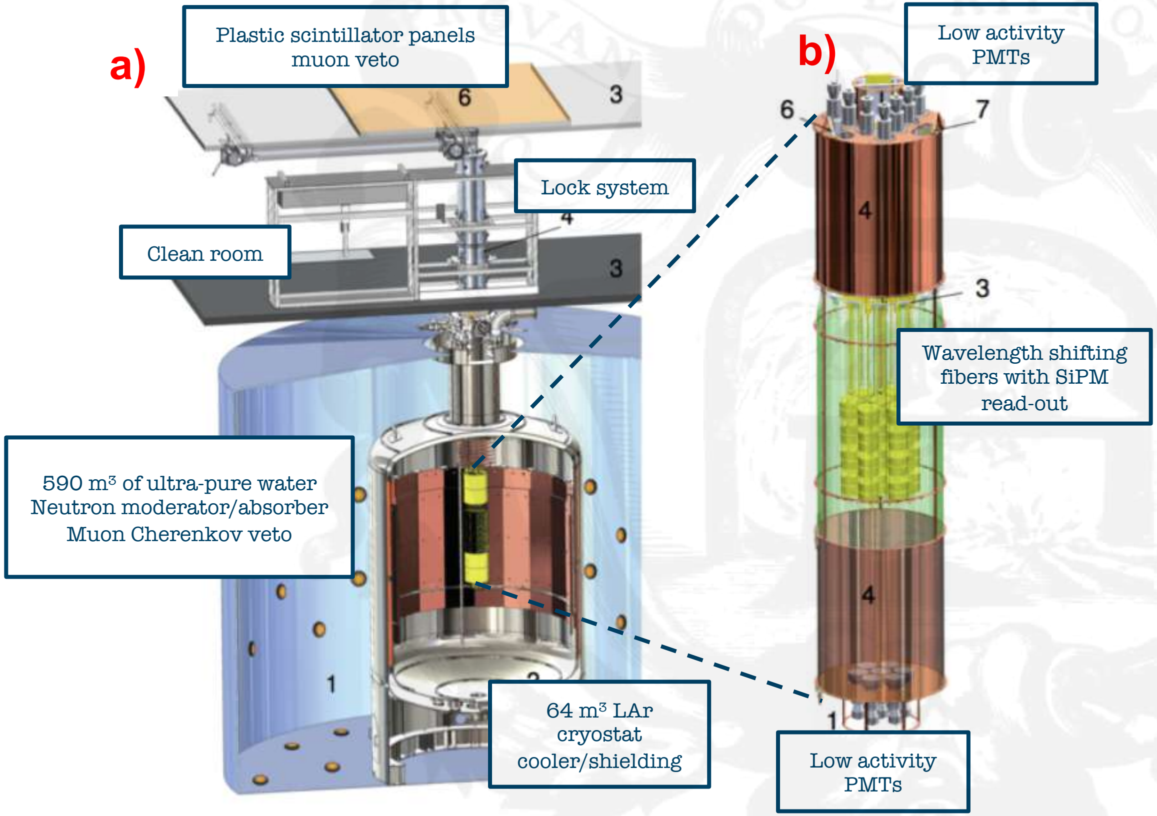




a) Overview

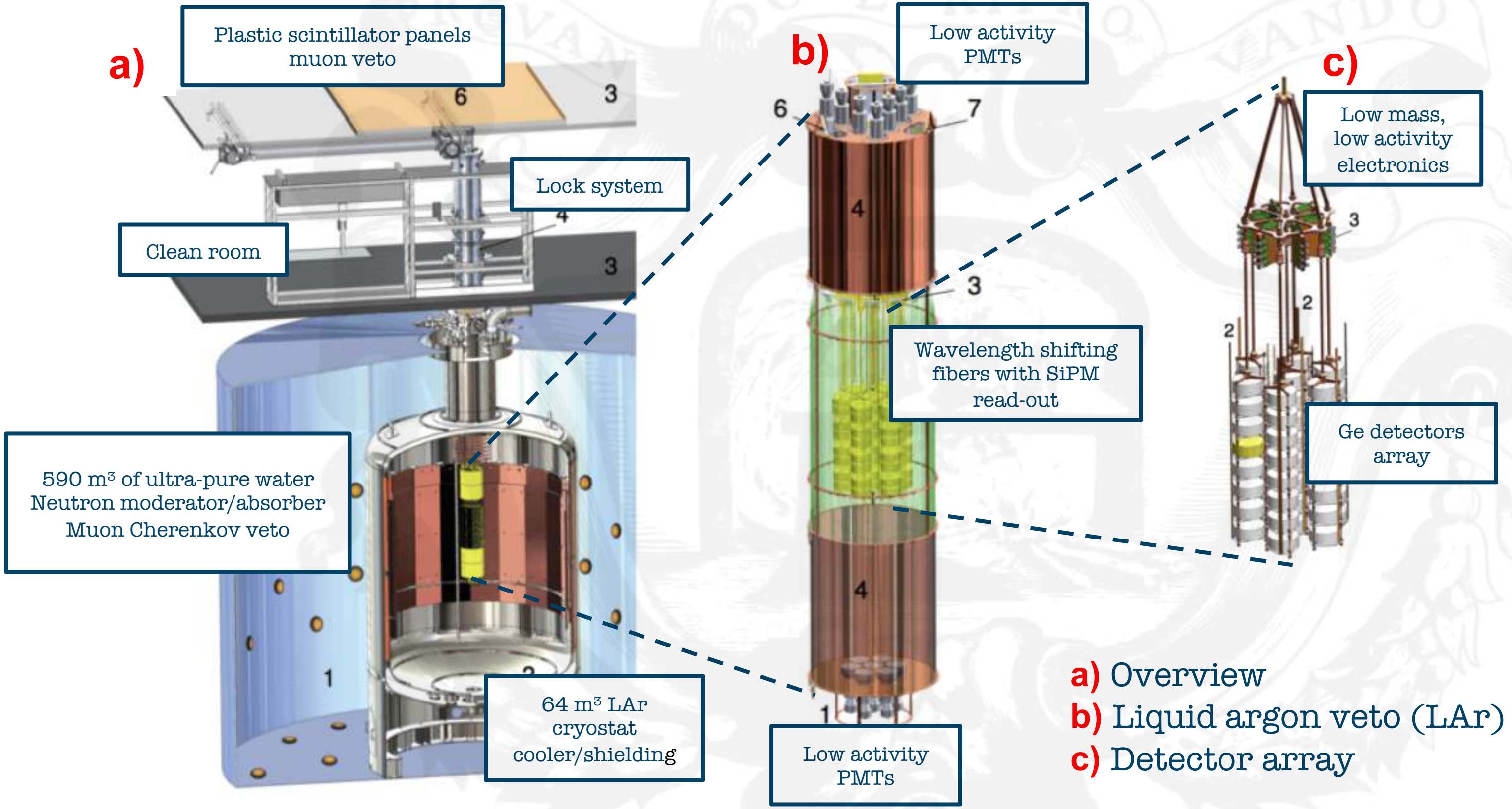
Eur. Phys. J. C 73 (2013) 2330
Eur. Phys. J. C 78 (2018) 388
Nature 544 (2017) 47

GERDA Setup



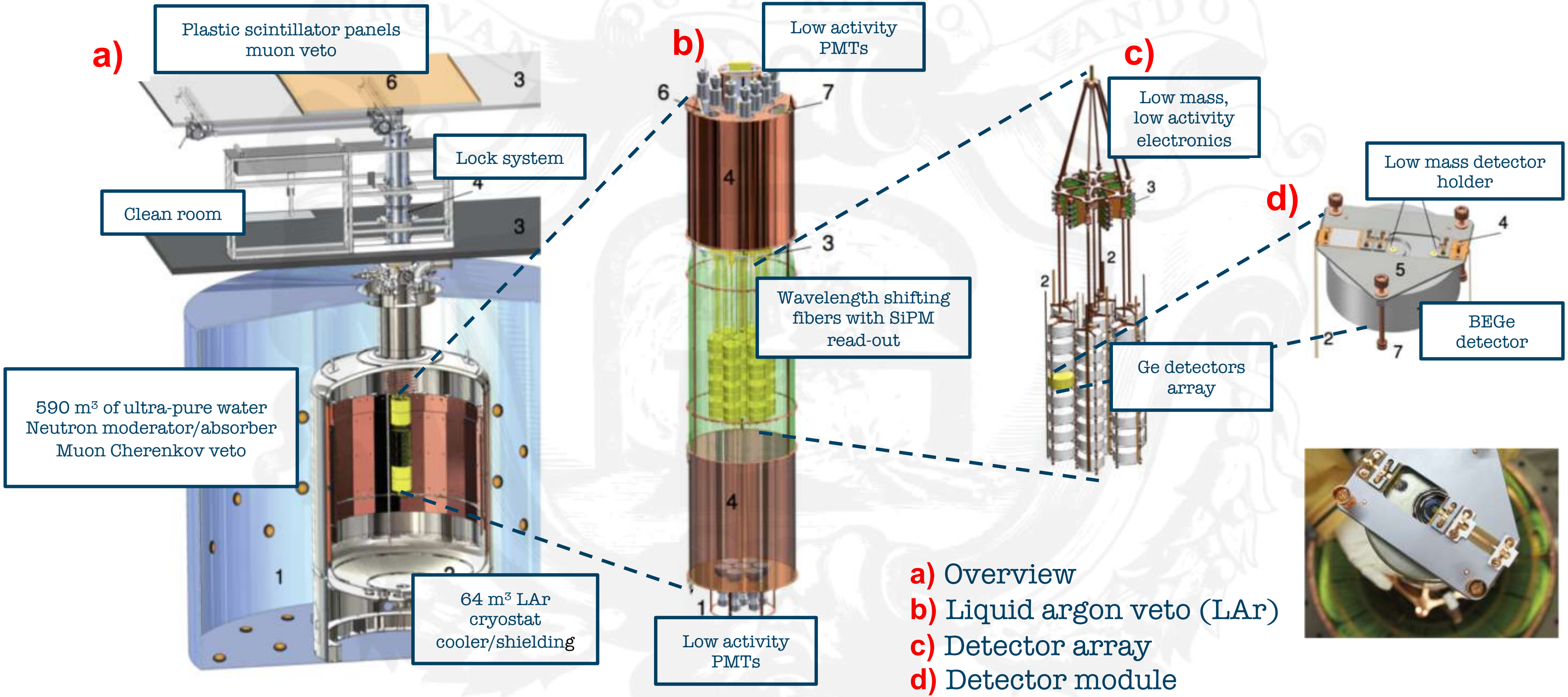
a) Overview
b) Liquid argon veto (LAr)

GERDA Setup



a) Overview
b) Liquid argon veto (LAr)
c) Detector array

GERDA Setup



a) Overview
b) Liquid argon veto (LAr)
c) Detector array
d) Detector module

Germanium Detectors

3 types of HPGe detectors enriched up to 87% in ^{76}Ge:

Semi-Coaxial

BEGe

Inverted-Coaxial

41.8 kg·yr + 53.3 kg·yr + 8.5 kg·yr

From previous experiments (HdM, IGEX)

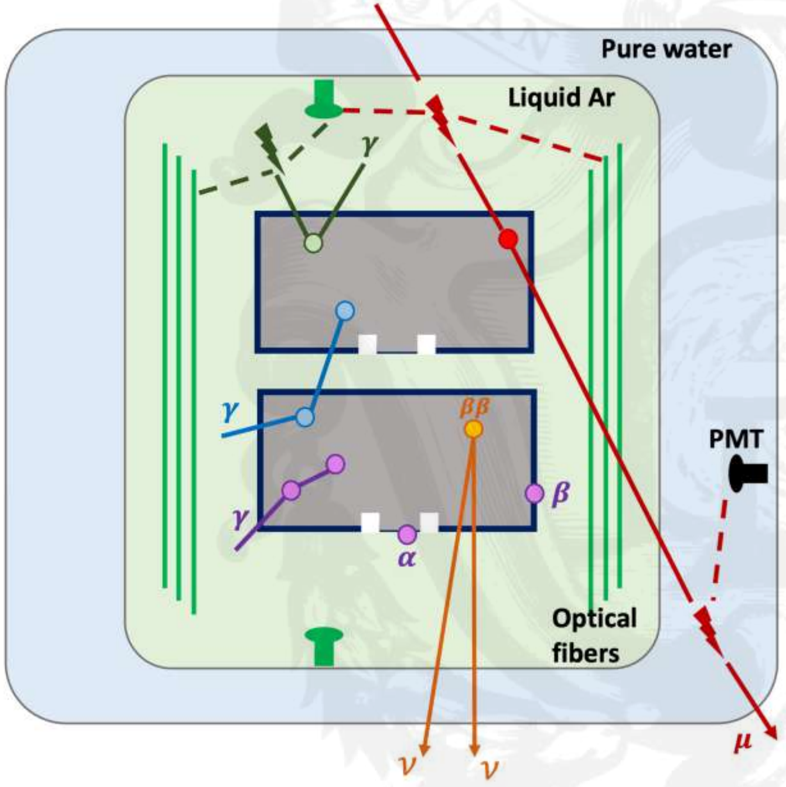
Produced for GERDA

Tested for next generation experiments (LEGEND-200, LEGEND-1000)

=

103.7 kg·yr

Active Background Reduction

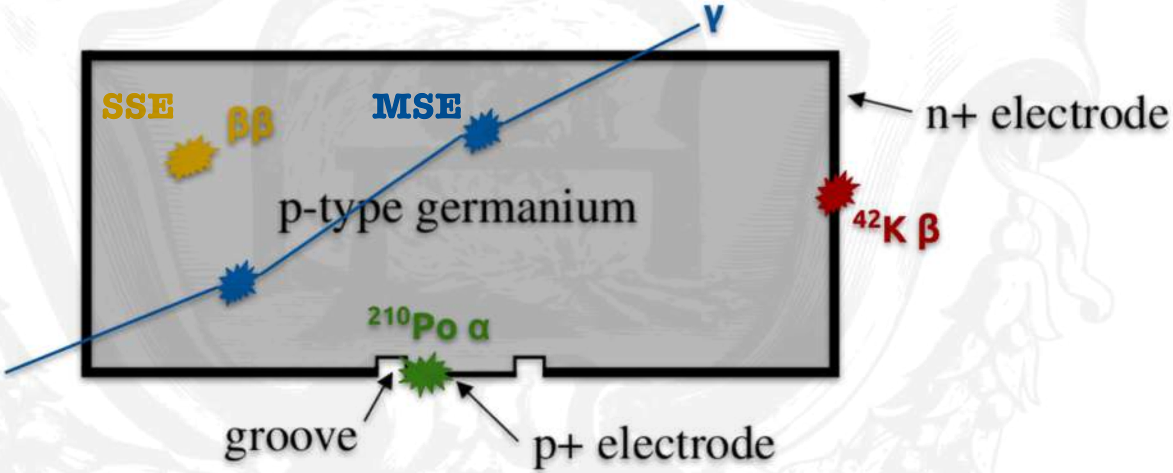


- Muon veto based on Cherenkov light and plastic scintillator
- LAr veto based on Ar scintillation light read by fibers and PMT
- Ge detector anti-coincidence
- Pulse shape discrimination (PSD) for multi-site and surface α events

Pulse Shape Discrimination (PSD)

$\beta\beta$ decay signal: single energy deposition ($Q_{\beta\beta}$ = 2039 keV) in a 1 mm^3 volume

PSD: reject multi-site and surface events based on detector signal shape

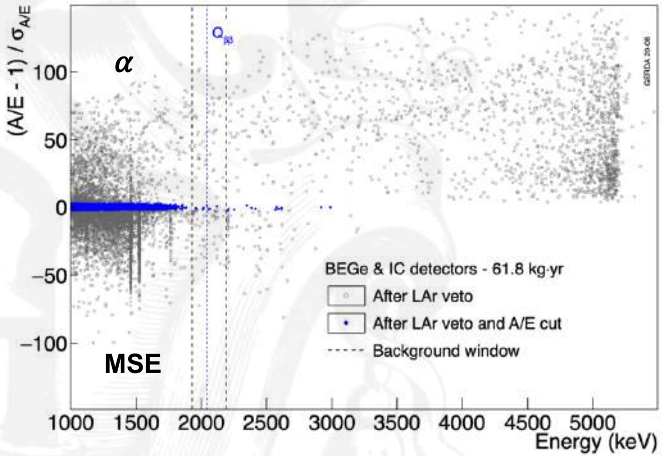


Eur. Phys. J. C 73 (2013) 2583
Nuclear Instruments and Methods in Physics Research A 891 (2018) 106

PSD for BEGe and IC detectors

Amplitude of Current/Energy (**A/E**)

- **A/E** ~ **1** for SSE;
- **A/E** < **1** for MSE and β;
- **A/E** > **1** for α.



MSE cut: low A/E cut set to accept 90% of Tl DEP* from calibration

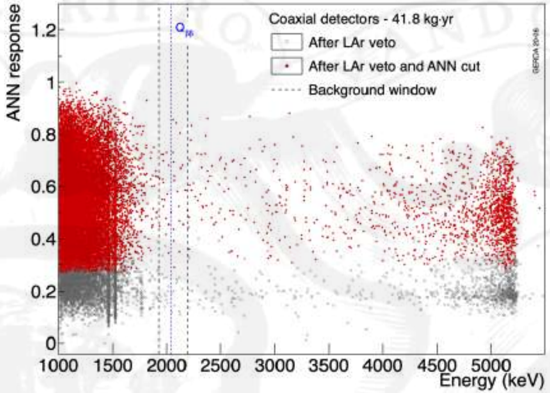
Alpha cut: high A/E cut set to 4σ of SSE A/E band

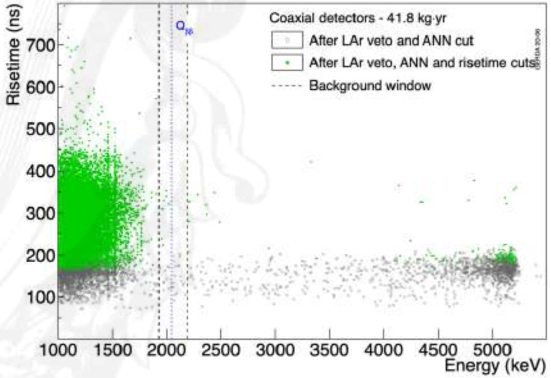
- $\epsilon_{PSD}^{BEGe} = (88.7 \pm 3.2)\%$
- $\epsilon_{PSD}^{IC} = (90.0 \pm 1.7)\%$

*DEP: Double Escape Peak

PSD for Semi-Coaxial detectors

Artificial Neural Network (**ANN**)
and **risetime**





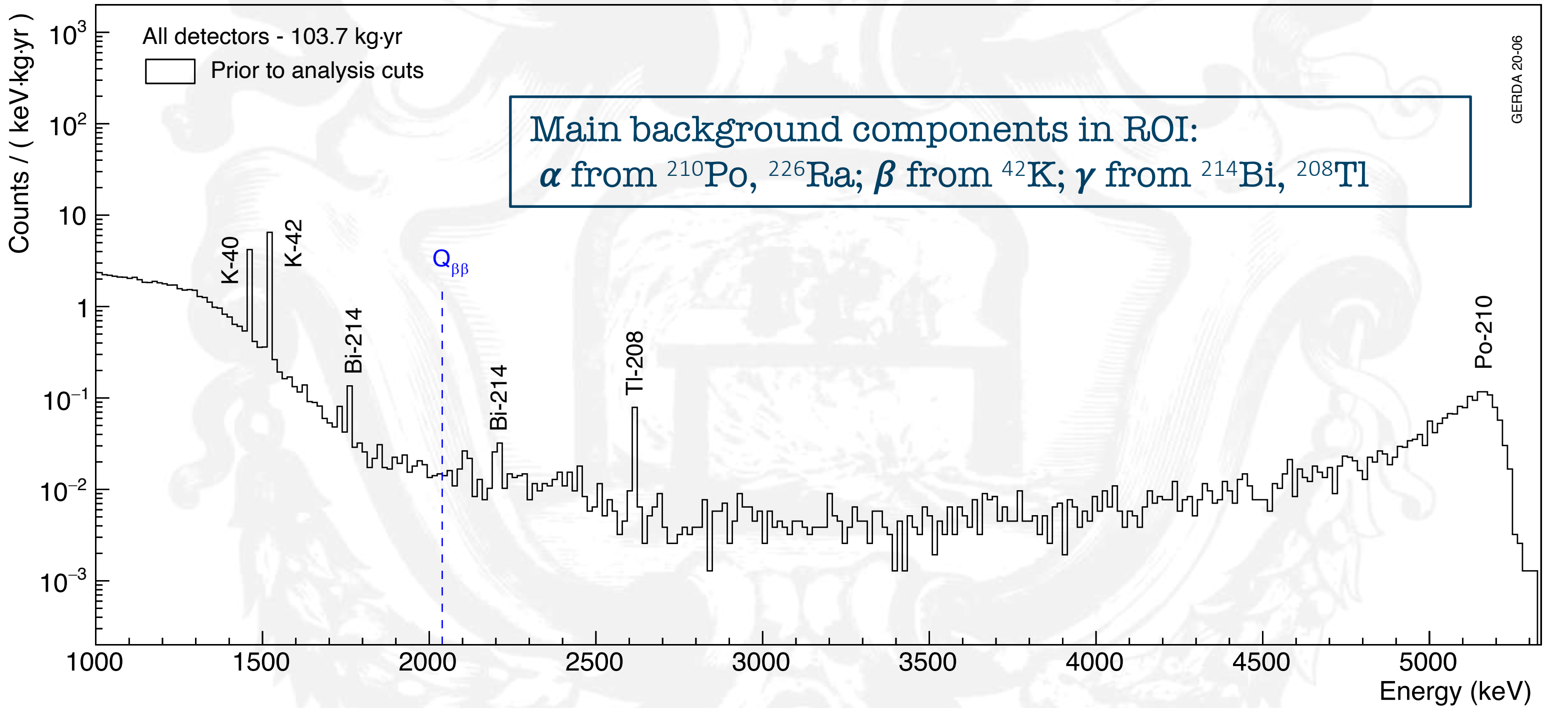
MSE cut: ANN fed with SSE and MSE proxies from calibration, cut set to accept 90% of Tl DEP events

Alpha cut: charge collection risetime (10% - 90%). Cut optimized from $2\nu\beta\beta$ and α samples: max[$\epsilon_{2\nu\beta\beta}$(1-$\epsilon_{\alpha}$)]

- $\epsilon_{\mathbf{PSD}}^{\mathbf{Coax}} = (68.9 \pm 3.1)\%$

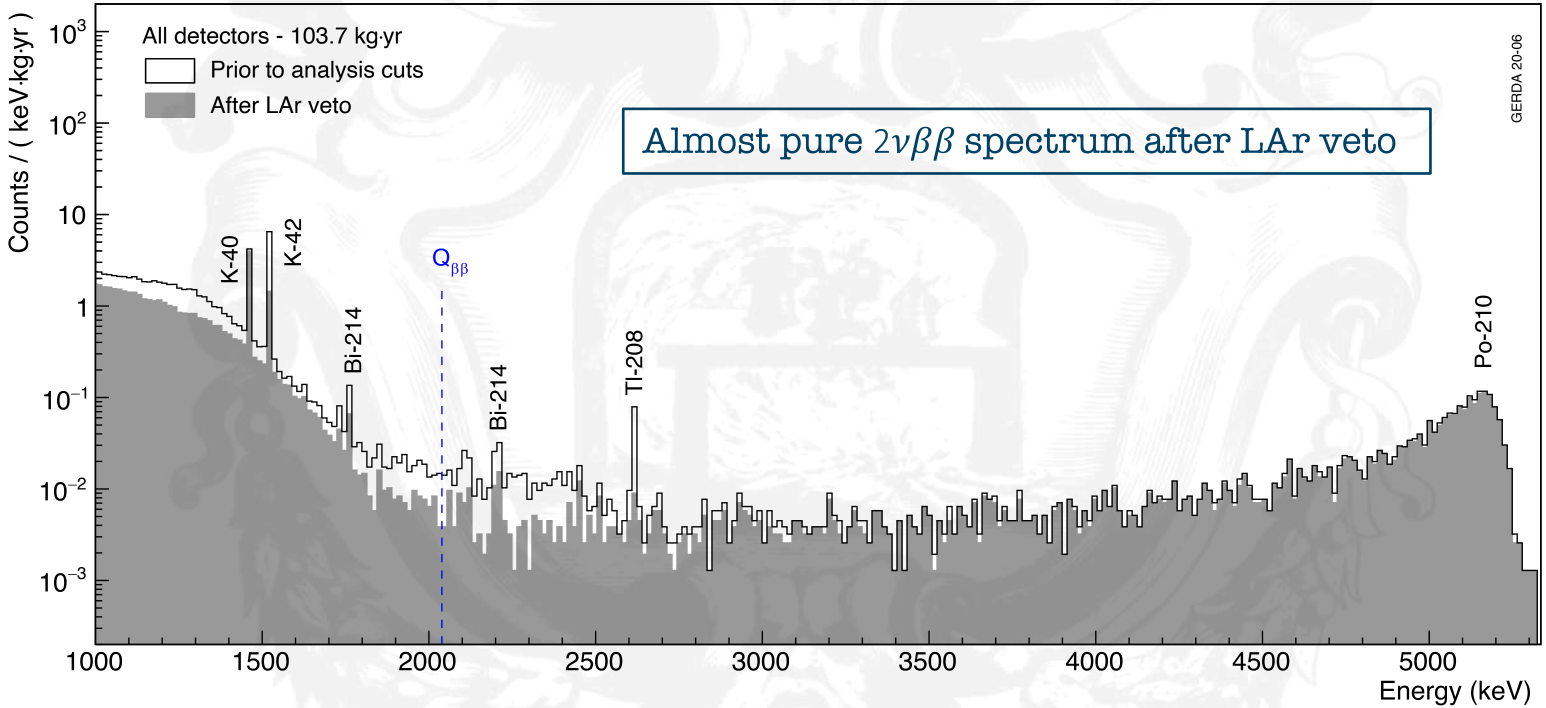
Physics spectra before cuts

See L. Pertoldi video



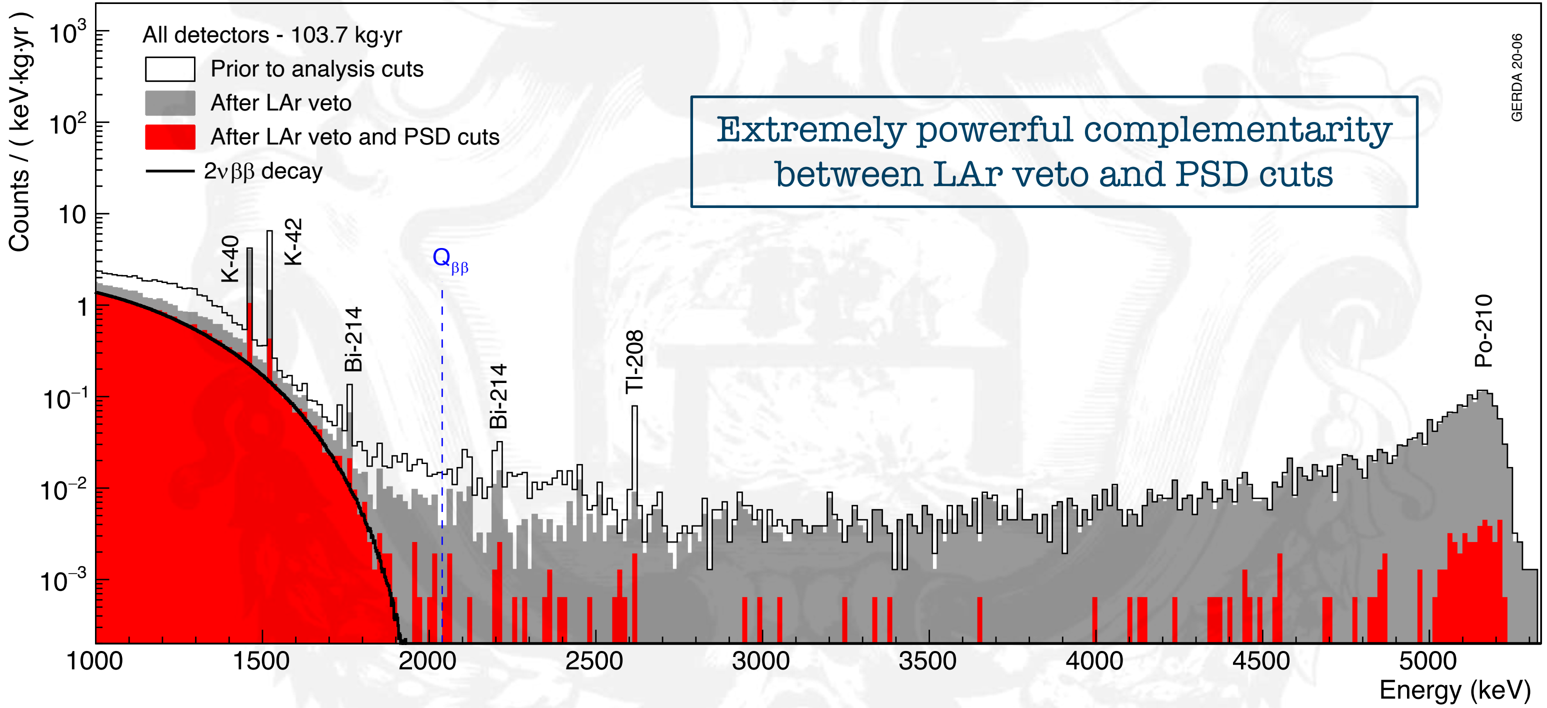
Main background components in ROI:
α from ^{210}Po, ^{226}Ra; β from ^{42}K; γ from ^{214}Bi, ^{208}Tl

Physics spectra after LAr veto



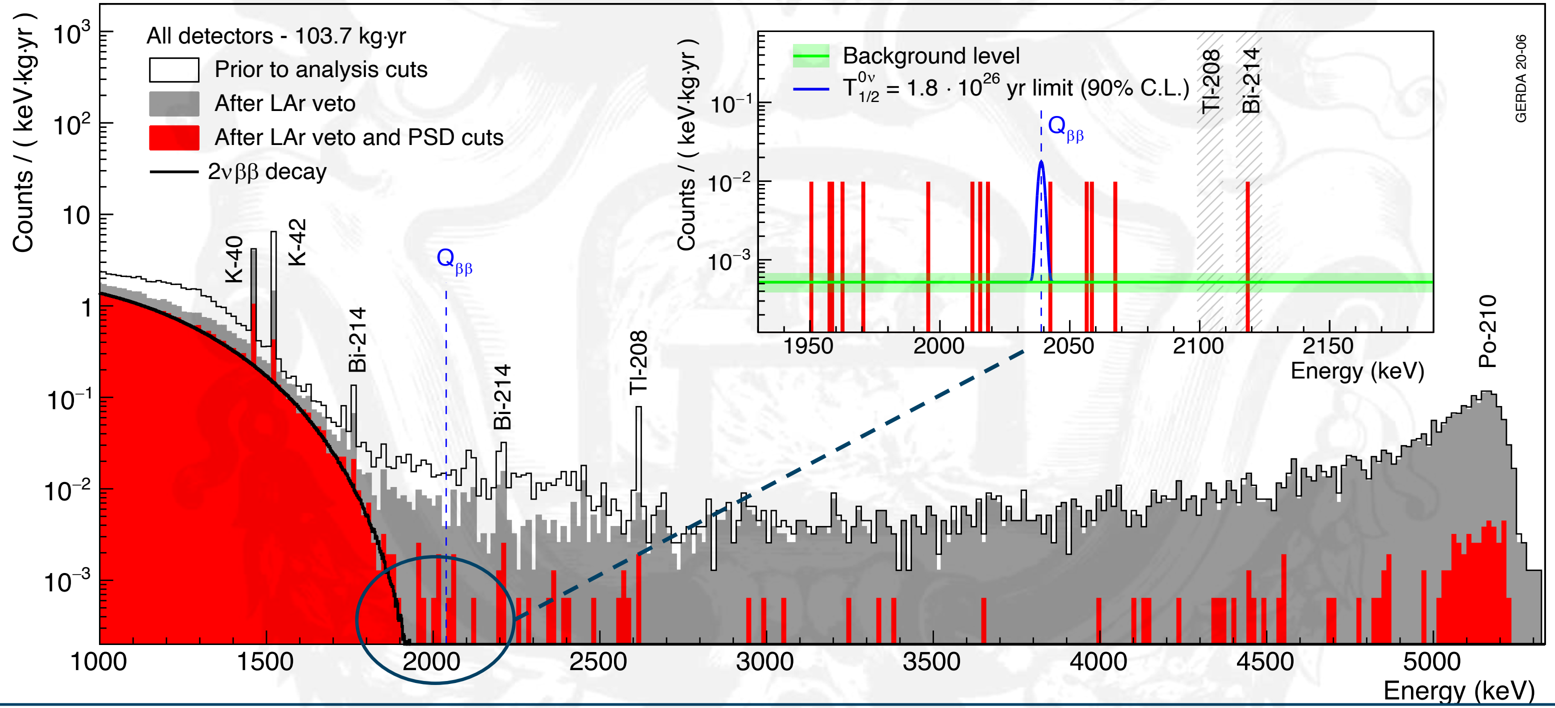
Almost pure $2\nu\beta\beta$ spectrum after LAr veto

Conclusions



Conclusions: Final Results

Background level = 5.2 · 10^{-4} cts / (keV kg yr)



These results confirm the high quality of the Gerda design and the effectiveness of background suppression techniques, consisting of the powerful Pulse Shape Discrimination and LAr veto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