Searching for $0\nu\beta\beta$ decay with LEGEND

Large Enriched
Germanium Experiment
for Neutrinoless ββ Decay

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On behalf of the LEGEND collaboration

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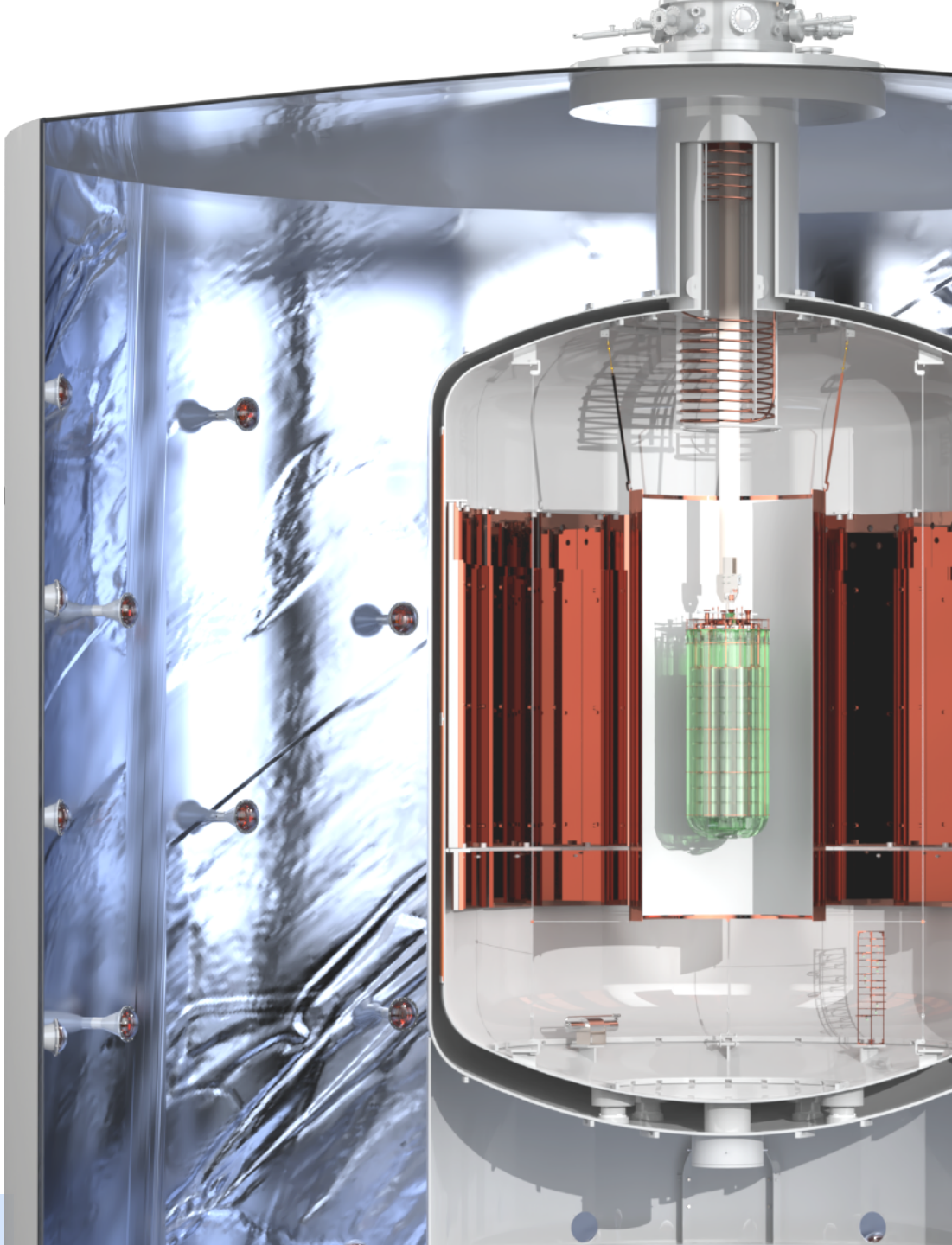
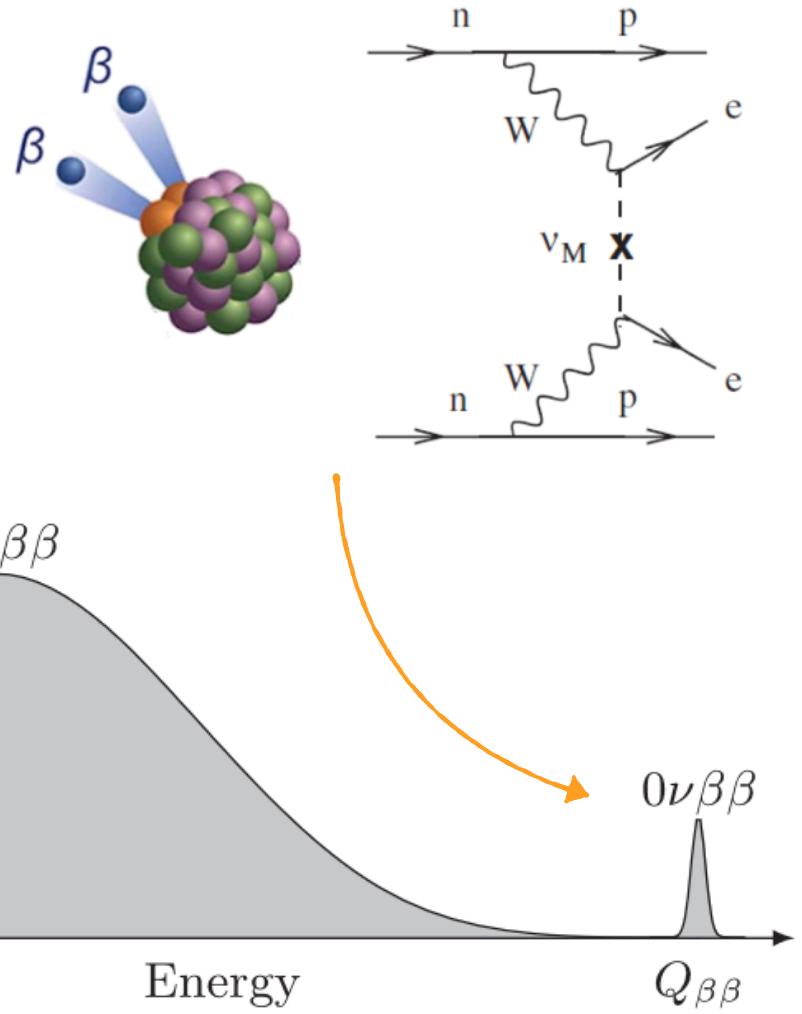


Neutrinoless double-beta decay ($0\nu\beta\beta$)

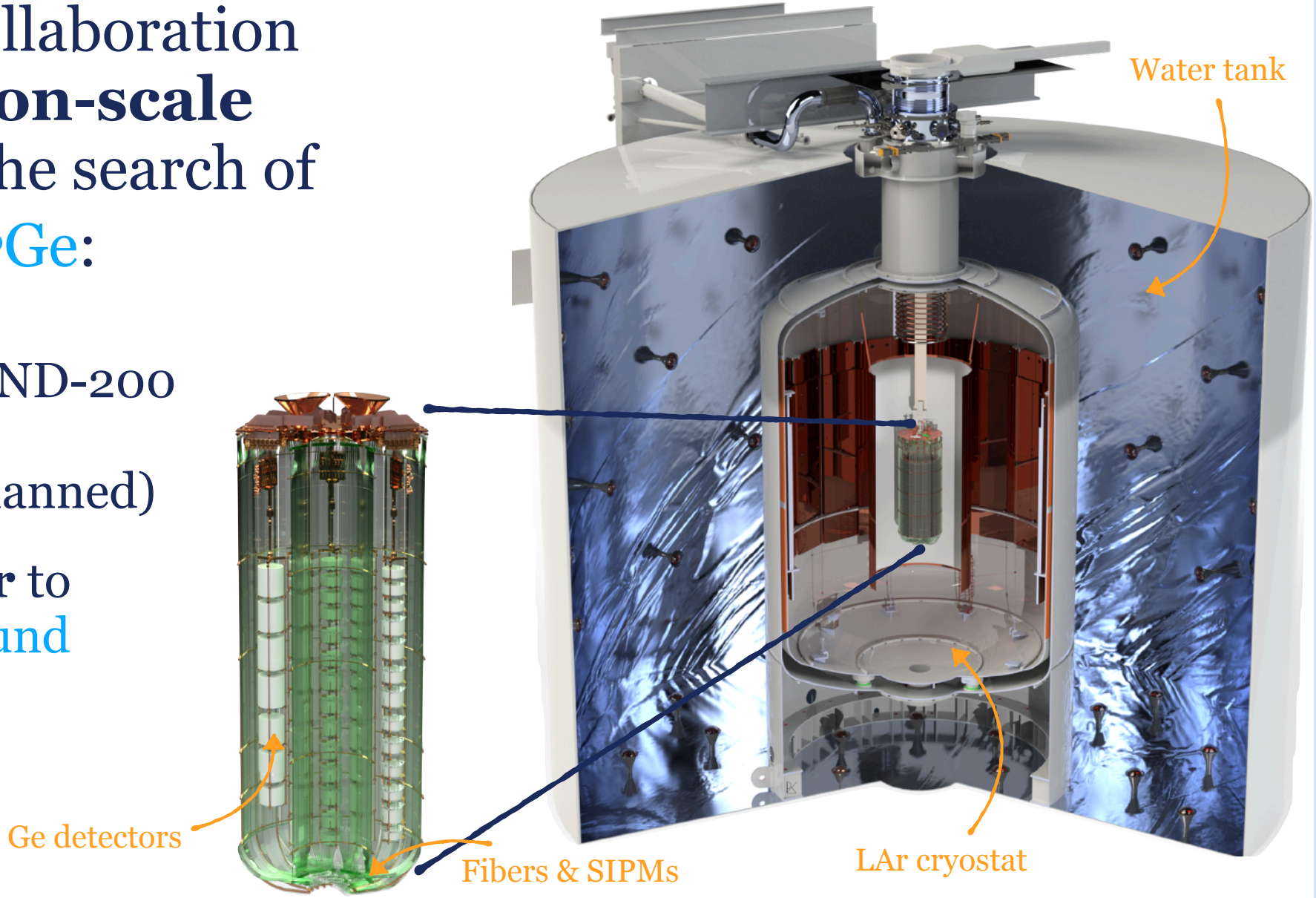
- Process not predicted by the Standard Model
- Neutrino: Majorana or Dirac particle?
- Is Leptonic number a fundamental symmetry?
- Can measure the effective mass of neutrinos
- Experimental signal: peak at the Q-value of the double beta decay ($Q_{\beta\beta} = 2039$ keV in ^{76}Ge)



The project

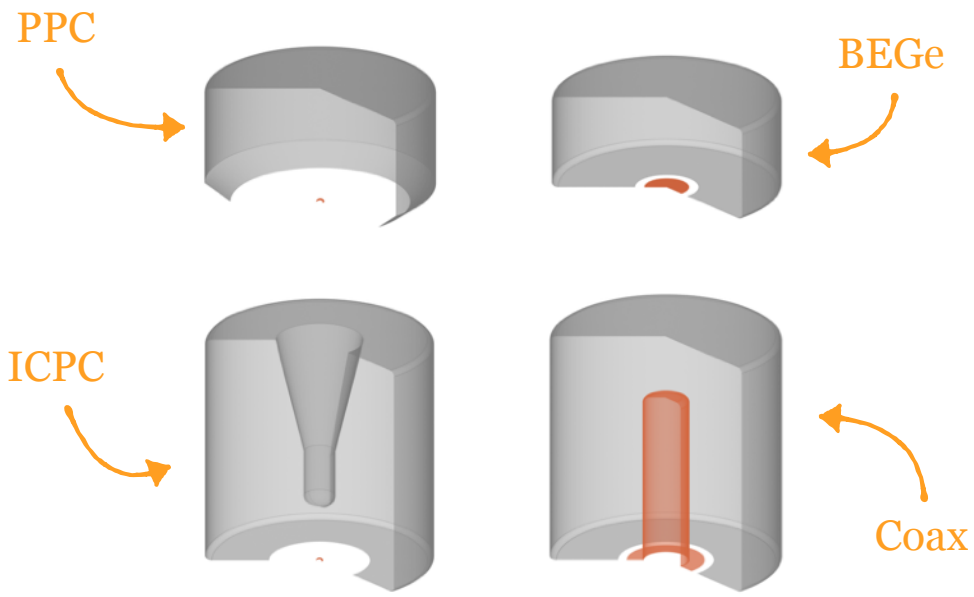
The LEGEND collaboration aims to build a **ton-scale** experiment for the search of $0\nu\beta\beta$ based on ^{76}Ge:

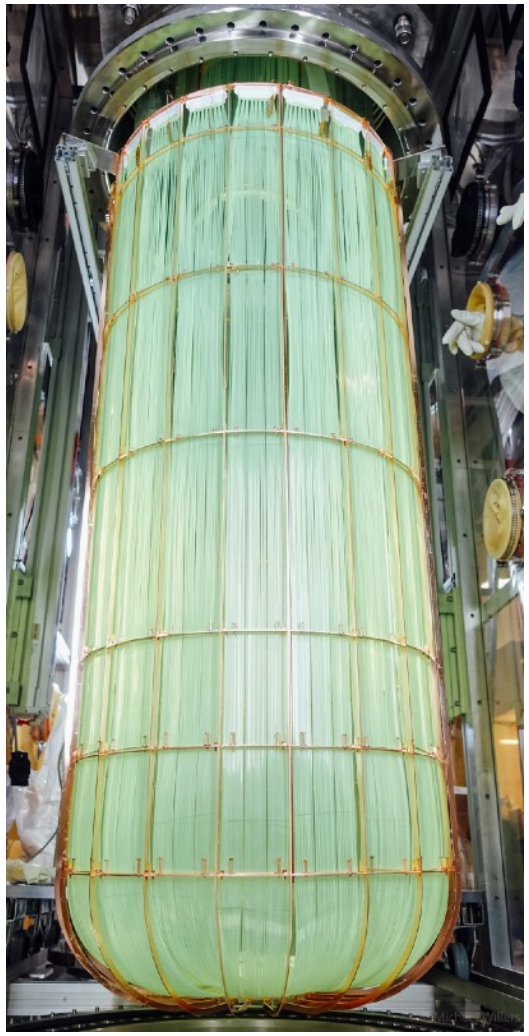
- Dual phase: LEGEND-200 (taking data) & LEGEND-1000 (planned)
- **Muon veto** + **LAr** to minimize background
- HPGe + LAr instrumentation



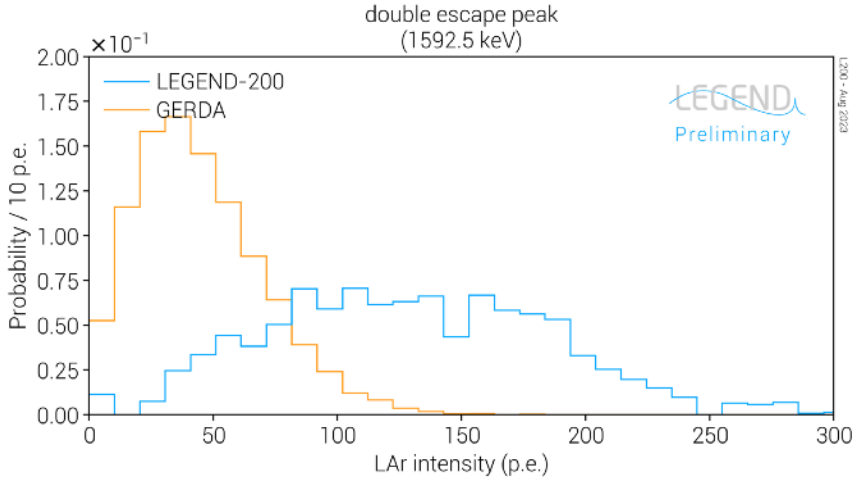
HPGe + LAr instrumentation

- ~ 200 kg of HPGe (High Purity Germanium) enriched in ^{76}Ge up to 92%
- High detection efficiency (**detector = $\beta\beta$ source**)
- Great energy resolution (FWHM @ $Q_{\beta\beta}$ ~ 0.13%)





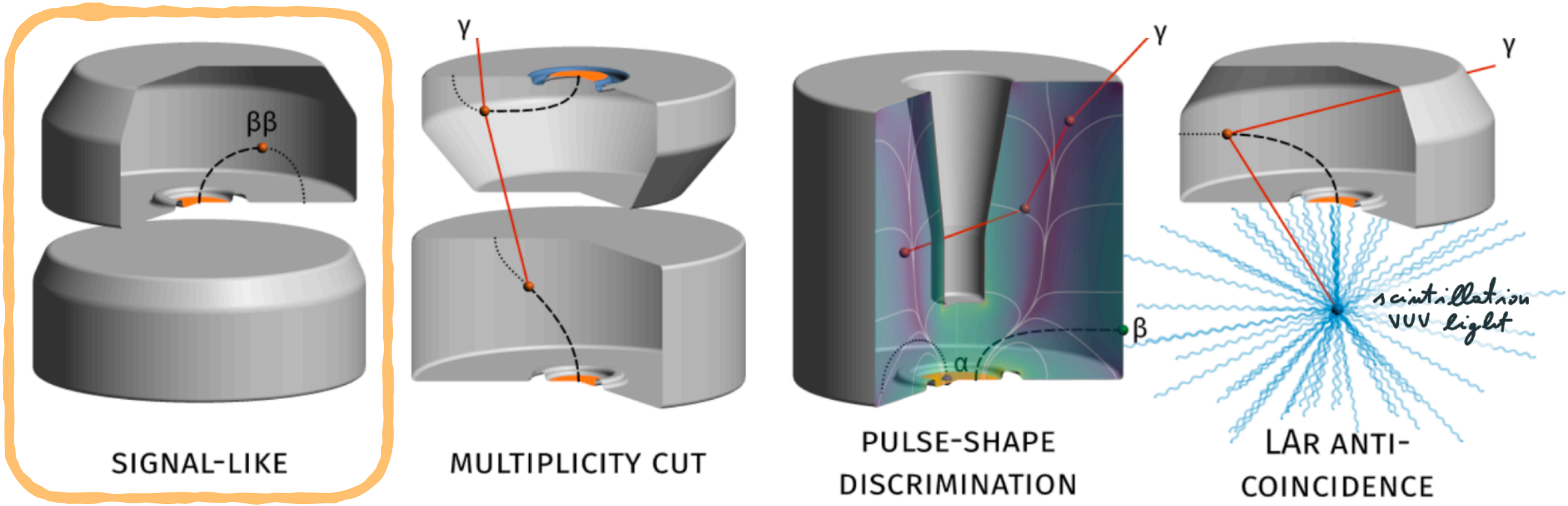
- Detects LAr scintillation
- **Actively suppress background**
- Used in GERDA and **improved** (increased photo-electron signal)



Background rejection

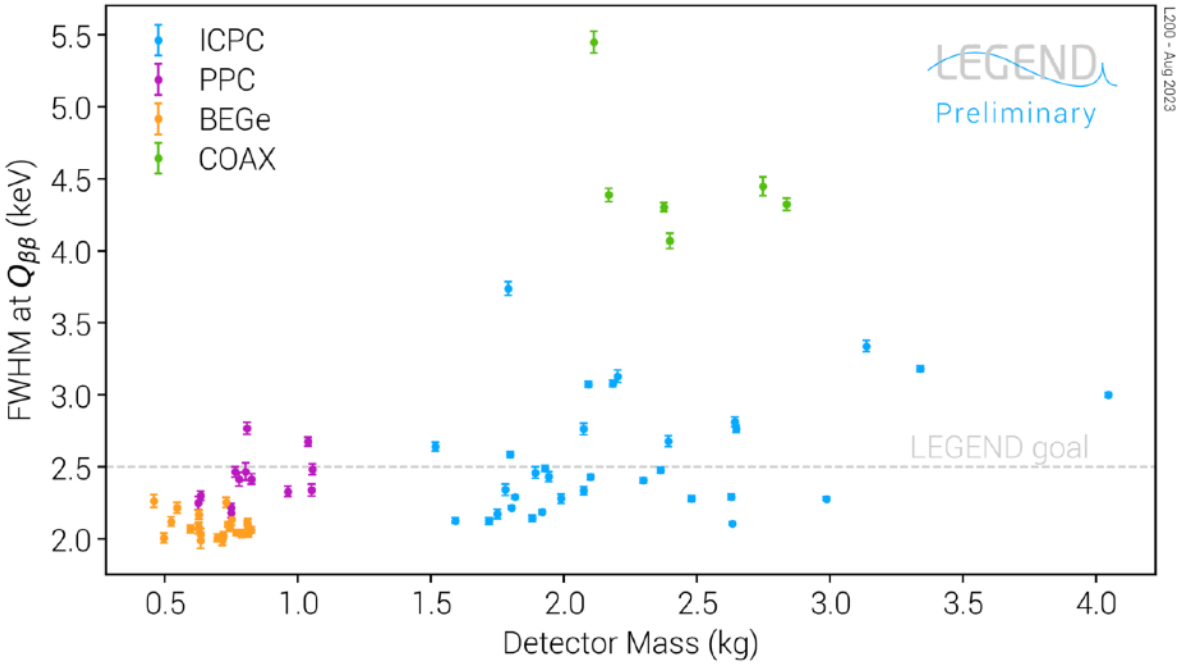
Multiple rejection techniques:

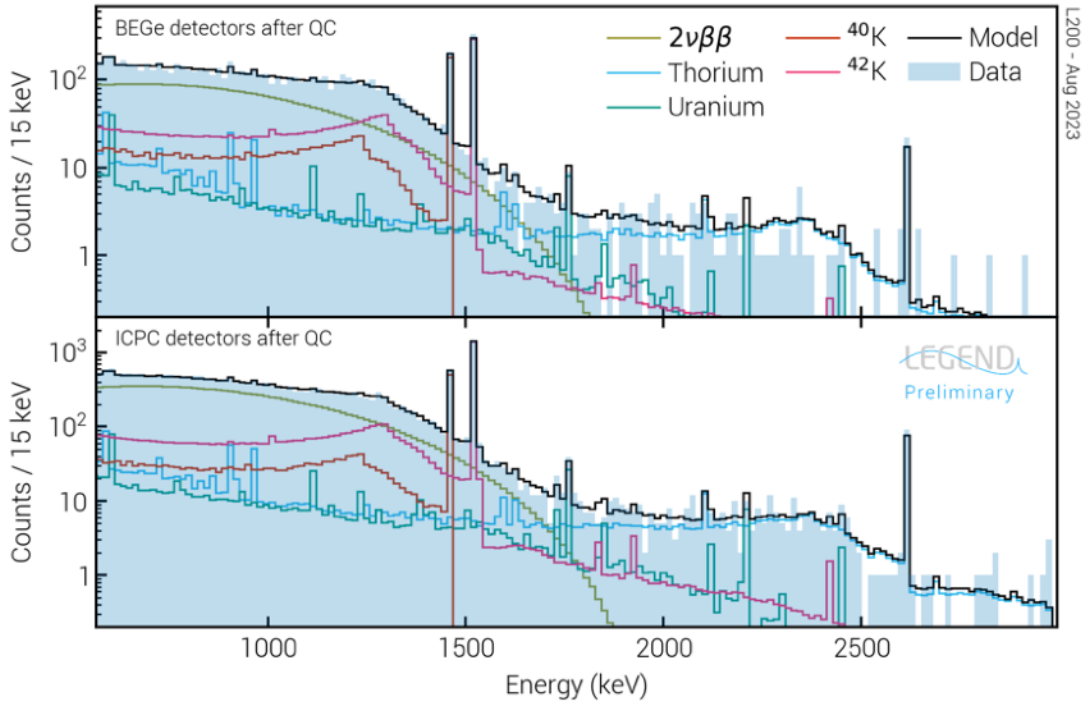
- Water Cherenkov
- Multiplicity cut (AC cut)
- Pulse Shape Discrimination (PSD cut)
- LAr anti coincidence (LAr cut)



Performances

- **10.1 kg·yr** of exposure
  (goal up to 1000 kg·yr)
- No unexpected background components
- Model reproduces data well
  (small exposure → high uncertainties)

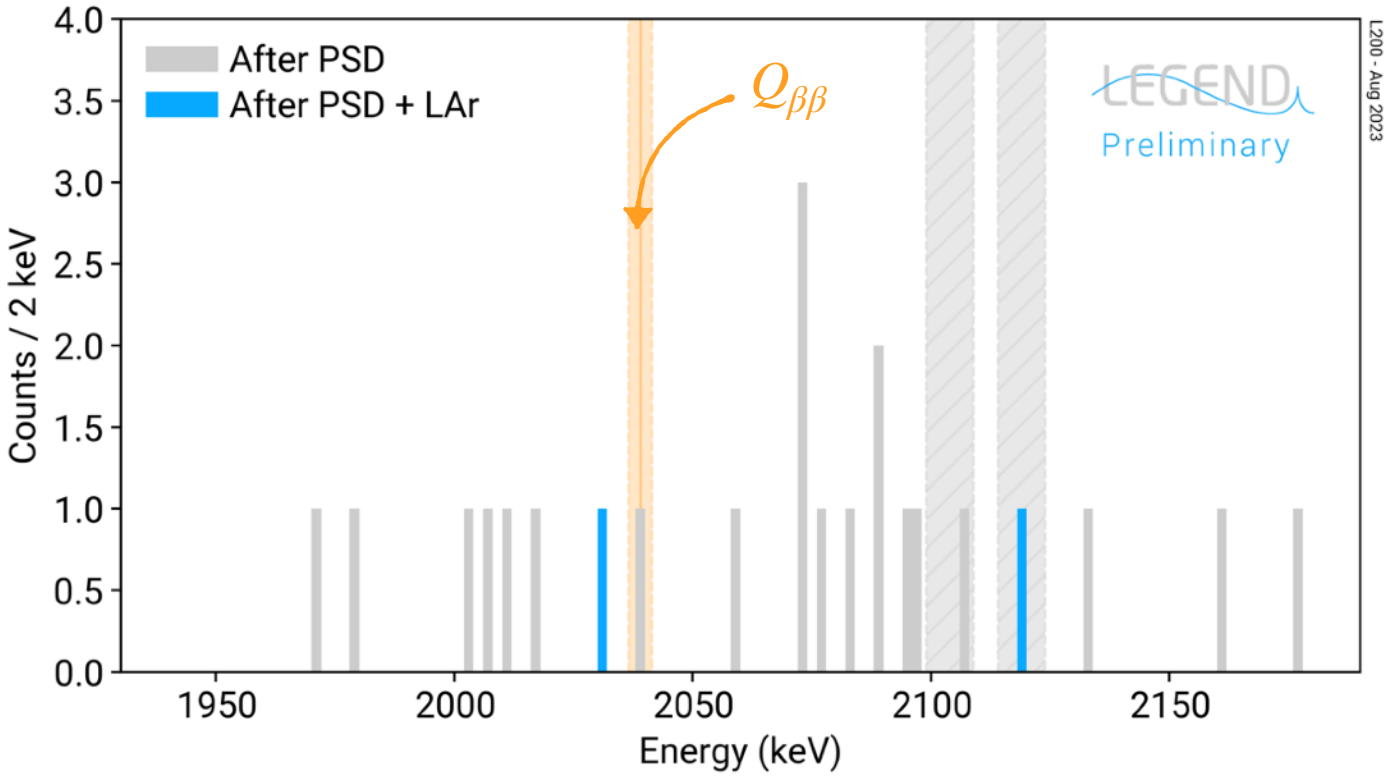




- 0.13% FWHM at $Q_{\beta\beta}$
- Stable energy observables

LEGEND-200 first background

First 10.1 kg·yr of LEGEND-200 physics data near $Q_{\beta\beta}$ (BEGe & ICPC)



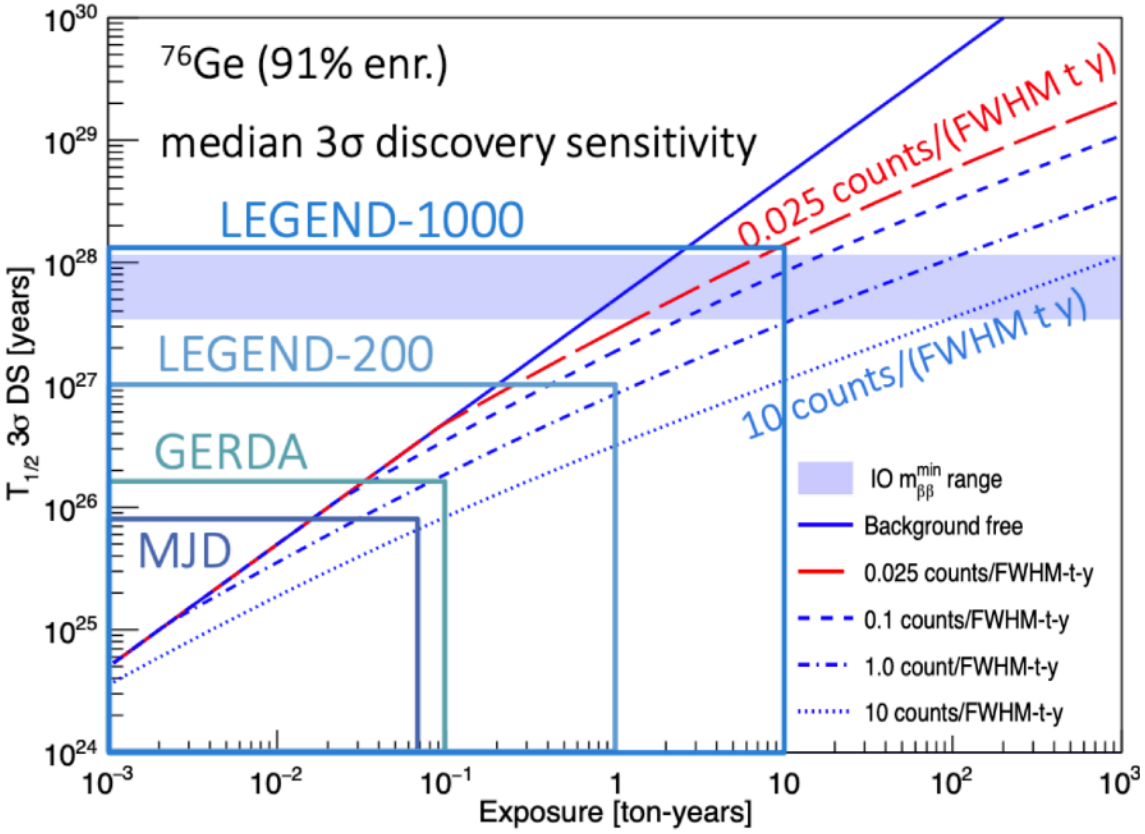
Background Index after PSD and LAr:

$4.11\ [1.5,11.4] \times 10^{-4}$ cts/(keV kg y)

Compatible with L-200 goal!!

Outlooks

	LEGEND-200	LEGEND-1000
Ge Mass	200 kg	1000 kg
Exposure goal	1000 kg y	10000 kg y
Background goal	$\leq 2 \times 10^{-4}$cts/(keV kg yr)	$\leq 1 \times 10^{-5}$cts/(keV kg yr)
Half-life sensitivity	1.5×10^{27} yr	1.3×10^{28} yr
Effective mass sensitivity	26 - 63 meV	9 - 21 meV



Conclusions

- LEGEND-200 currently operational, 142 of 200 kg of detector mass inside
- GERDA and MAJORANA DEMONSTRATOR analysis techniques are being modified and applied to LEGEND data, with new techniques in active development
- Able to test our PSD routines and model the background data
- We have already obtained the required energy resolution for most of the detectors, and the **BI** is compatible with LEGEND-200 goal
- The **latest major update was released on Tuesday** at Neutrino 2024

Thanks for your attention!!

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