

# The LEGEND experiment

## Probing neutrinos without neutrinos

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### Double-beta decay ( $2\nu\beta\beta$ )

A weak nuclear process **allowed by the Standard Model** where lepton number is conserved ( $\Delta L=0$ ), observed in isotopes such as  $^{48}\text{Ca}$ ,  $^{76}\text{Ge}$ ,  $^{82}\text{Se}$ ,  $^{96}\text{Zr}$ ,  $^{100}\text{Mo}$ ,  $^{116}\text{Cd}$ ,  $^{130}\text{Te}$ ,  $^{136}\text{Xe}$ ,  $^{150}\text{Nd}$

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

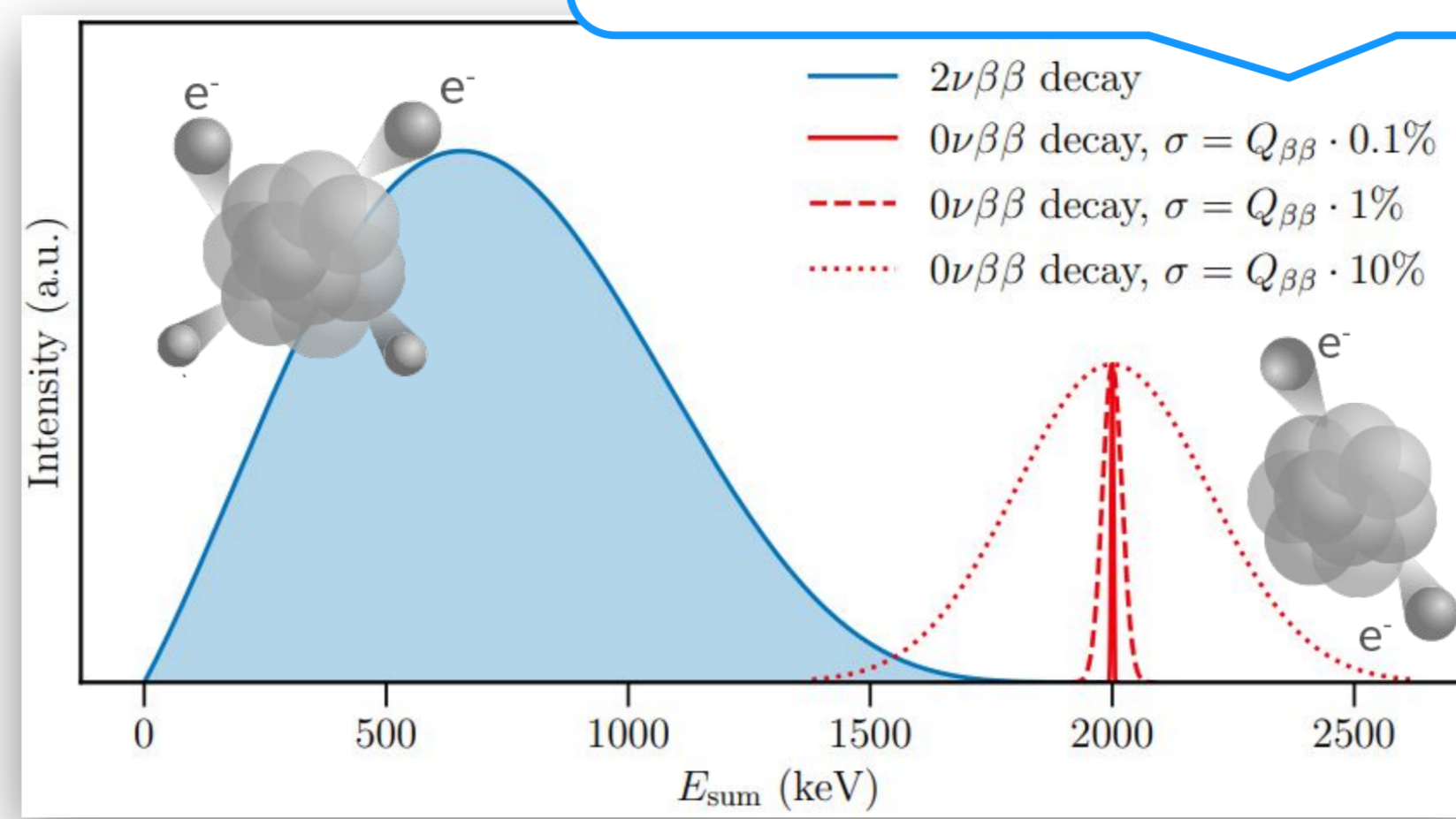
A hypothetical process with no neutrinos in the final state that **violates lepton number ( $\Delta L=+2$ )** and is forbidden in the Standard Model. If observed, it would

- reveal that neutrinos are Majorana particles
- shed light on the origin of the matter-antimatter asymmetry (via leptogenesis scenarios)
- give information about the absolute neutrino mass scale and their mass hierarchy

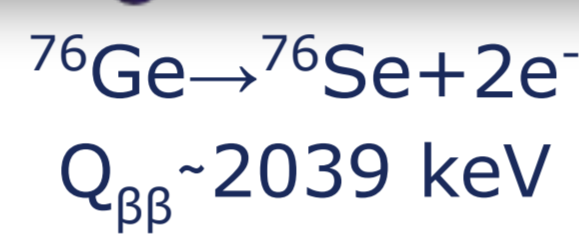
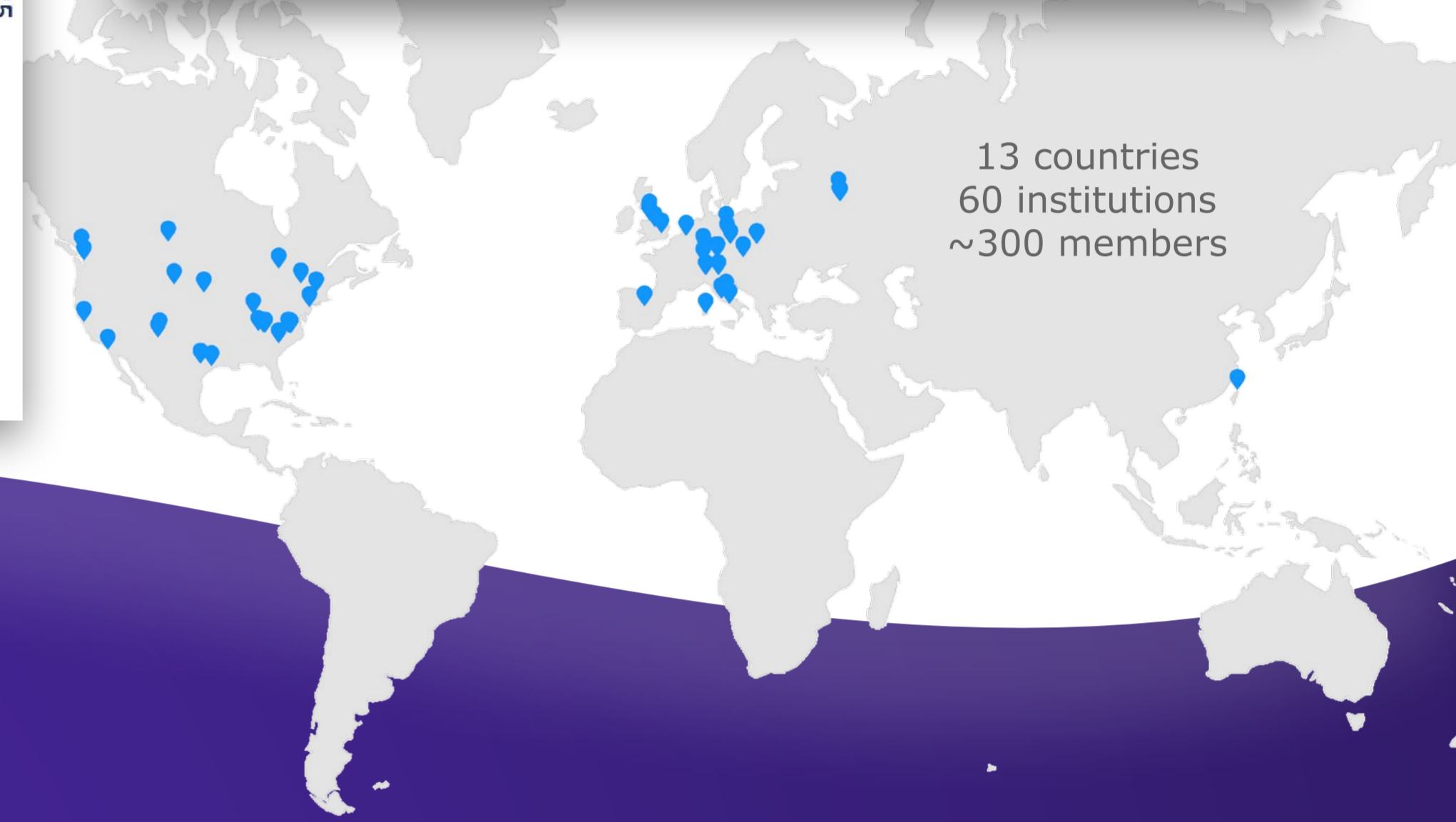
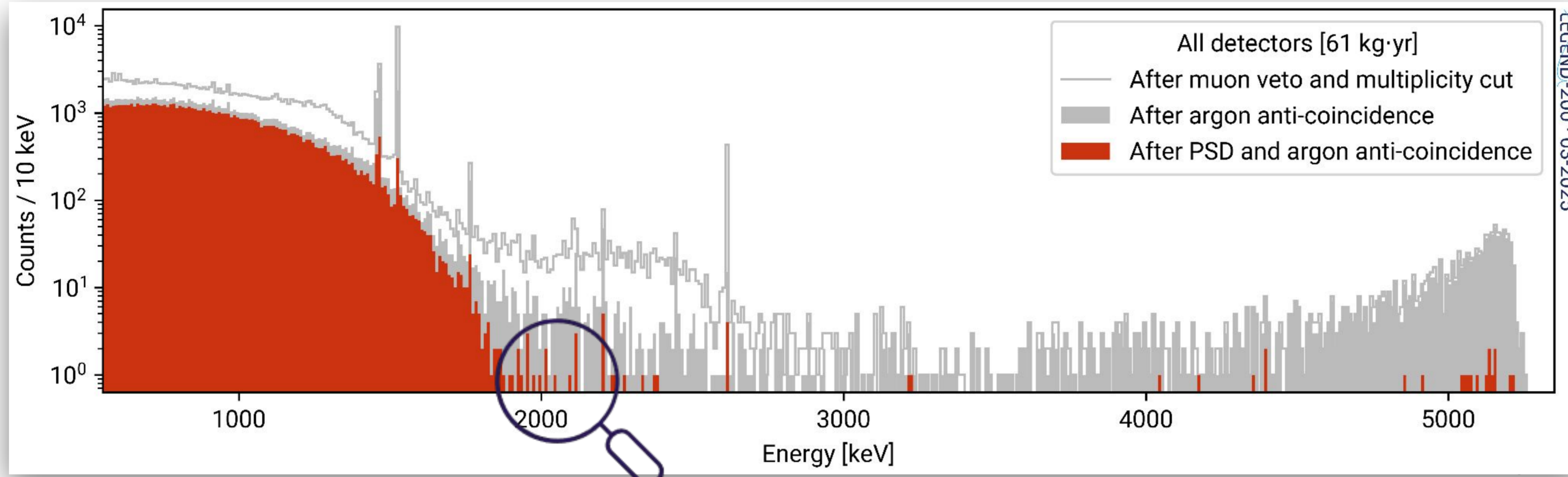
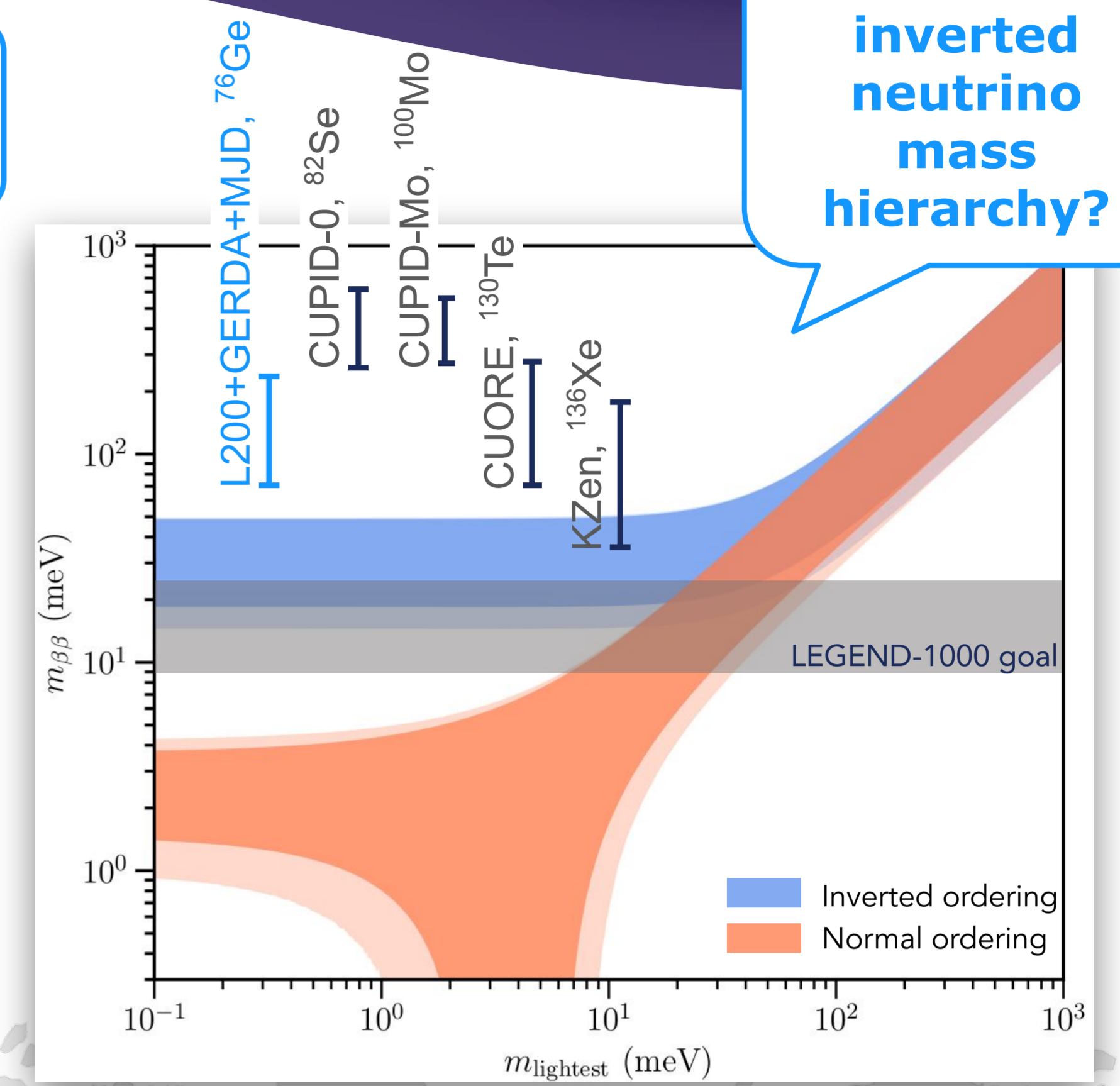
### $0\nu\beta\beta$ decay is a very rare process!

The Large Enriched Germanium Experiment for  $\beta\beta$  Decay (LEGEND) aims to develop a  **$^{76}\text{Ge}$ -phased program with a discovery potential half-life of  $T > 10^{28}$  yr**

### Are neutrinos Dirac or Majorana particles?



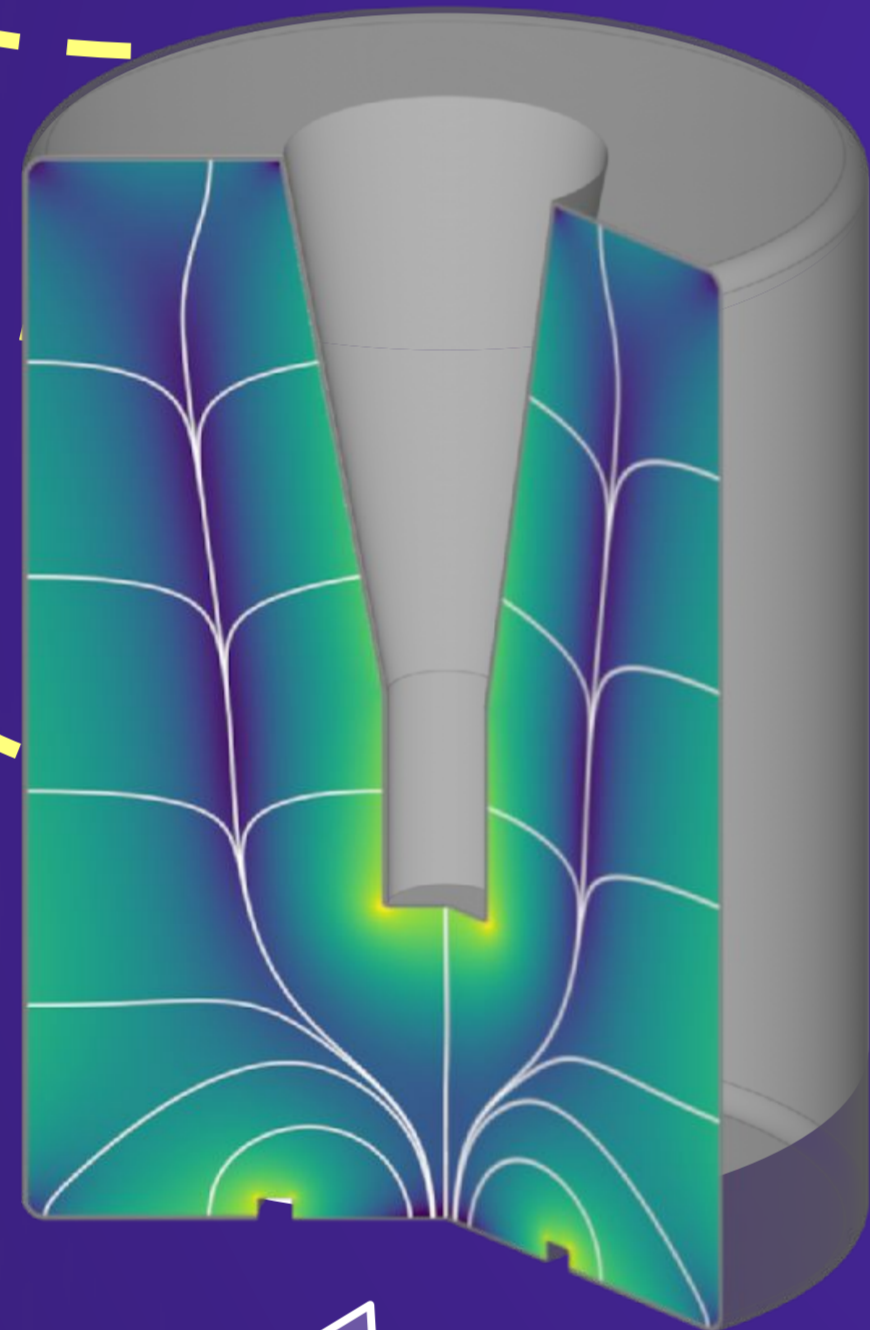
### Normal or inverted neutrino mass hierarchy?



A major breakthrough for LEGEND has been the invention of **p-type inverted-coaxial detectors** with active mass up to 4 kg, world-leading resolution (2.5 keV @ 2 MeV), and excellent signal-background rejection via strong pulse-shape discrimination

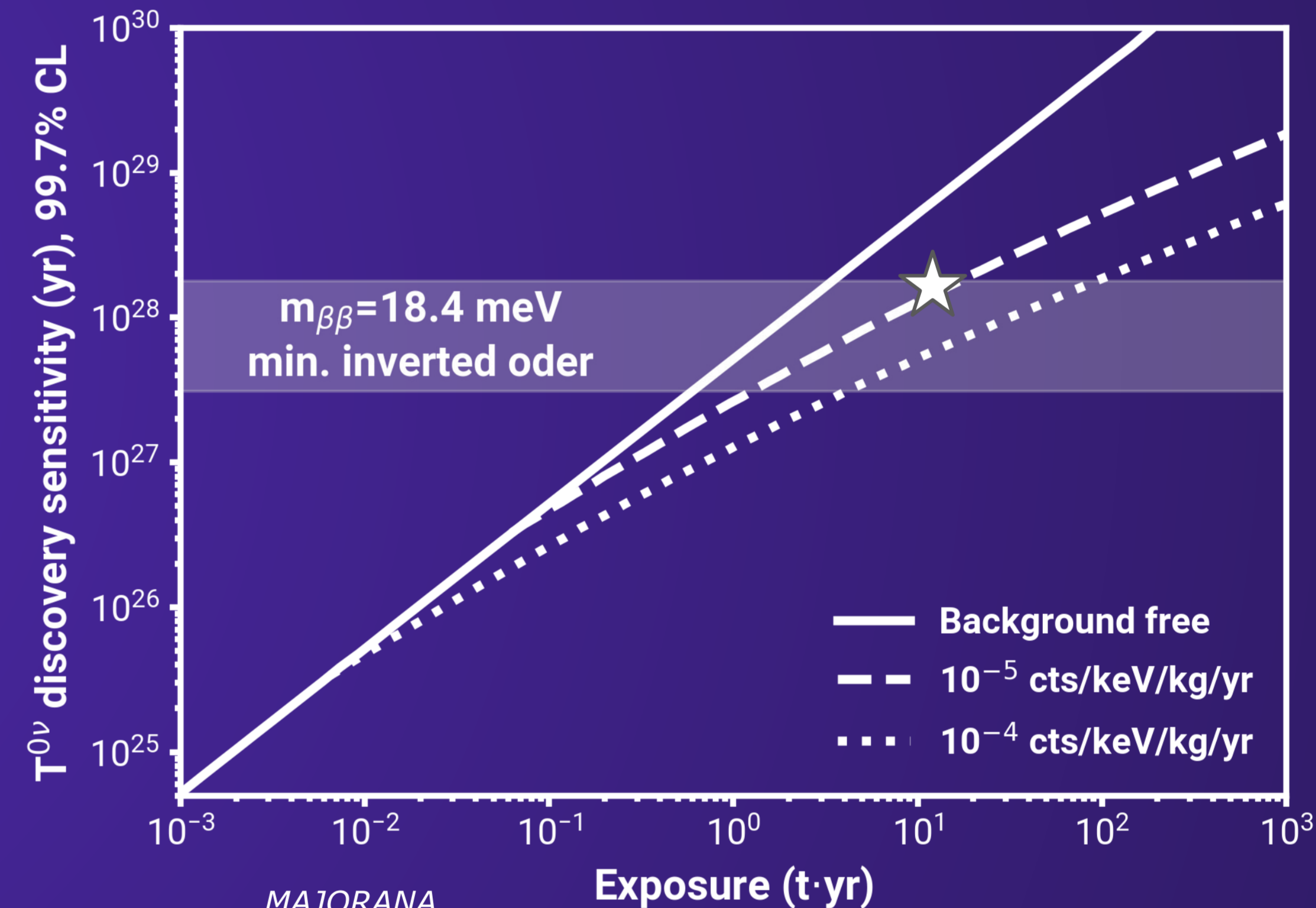
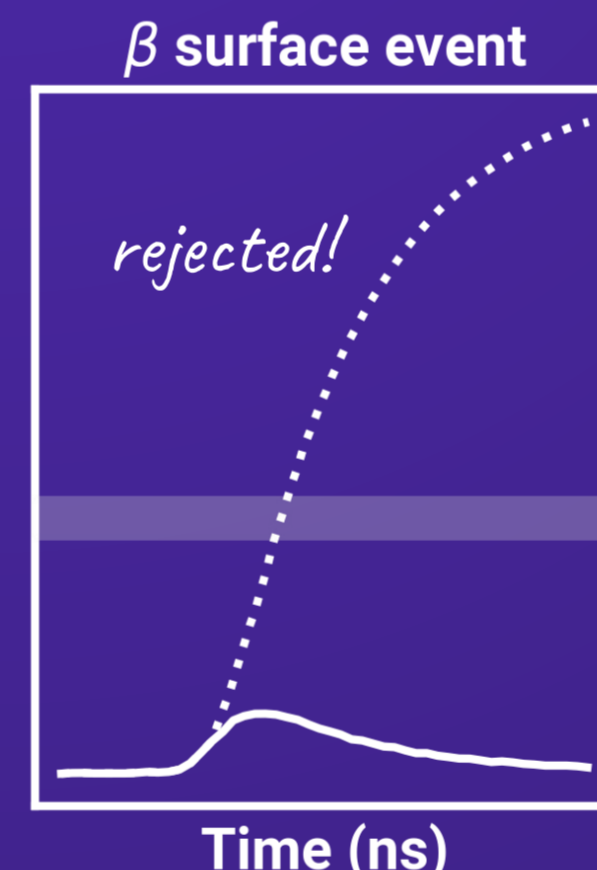
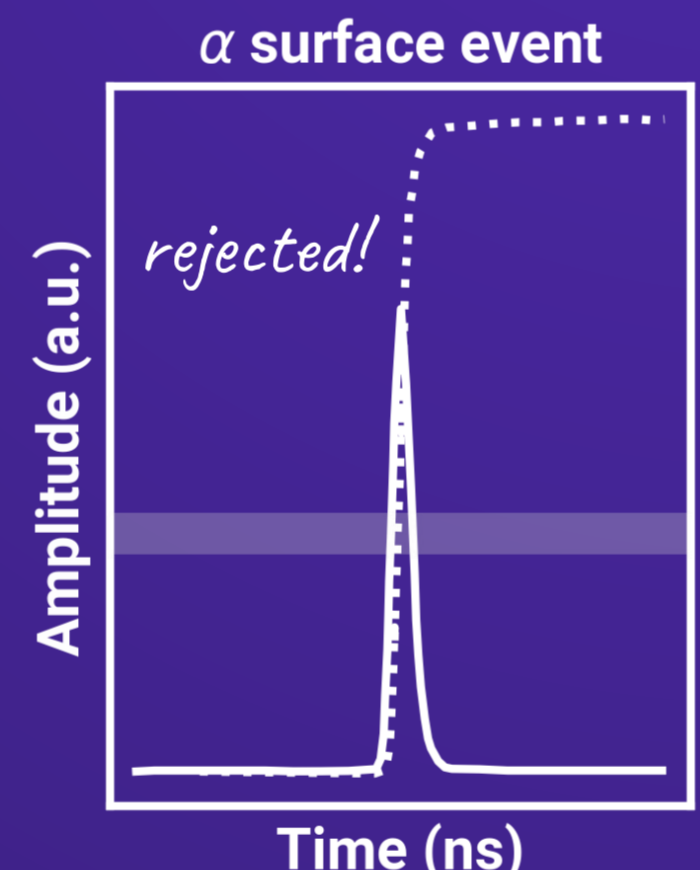
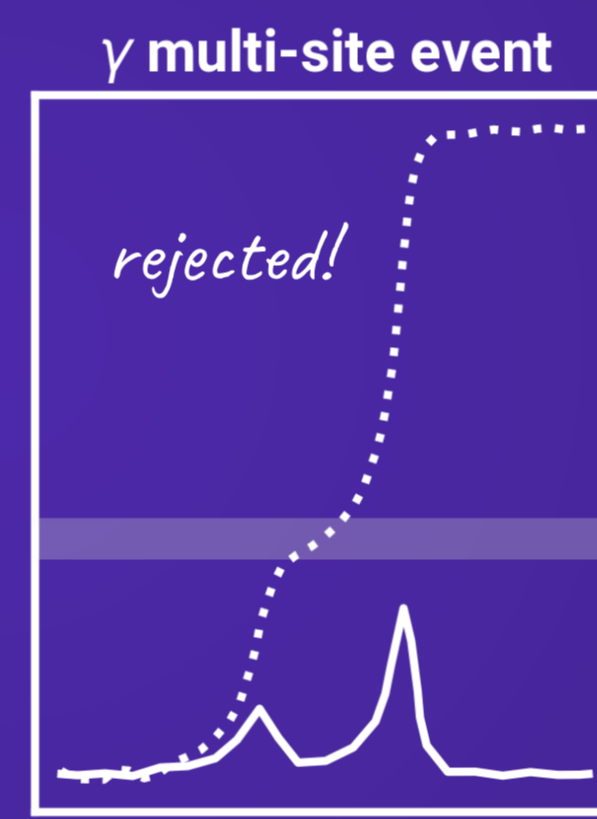
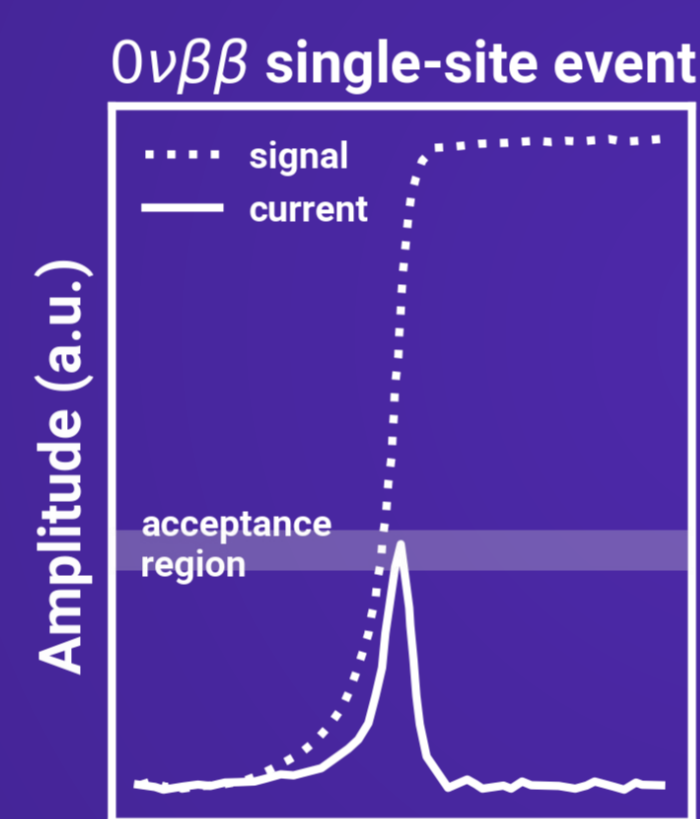
Ask us!

**$^{228}\text{Th}$  sources activity measurement** for detectors calibrations + **source insertion system** design & development



Ask us!

**Detector characterization** at underground laboratory **HADES**, in Belgium



MAJORANA DEMONSTRATOR and GERDA set the strongest constraints for  $^{76}\text{Ge}$   $0\nu\beta\beta$  decay → GERDA:  $T > 1.8 \times 10^{26}$  yr @ 90% CL with an exposure (mass-time) of 127.2 kg-yr



LEGEND

### LEGEND-200

- Up to 200 kg of  $^{76}\text{Ge}$ -enriched diodes
- Upgraded GERDA infrastructure @ *Laboratori Nazionali del Gran Sasso* (LNGS), Italy
- now in data taking phase since 2023
  - $T > 10^{27}$  yr after 5 yr

### LEGEND-1000

- Up to 1000 kg of  $^{76}\text{Ge}$ -enriched diodes
  - Under construction @ LNGS
  - $T > 1.3 \times 10^{28}$  yr after 10 yr

Ask us!

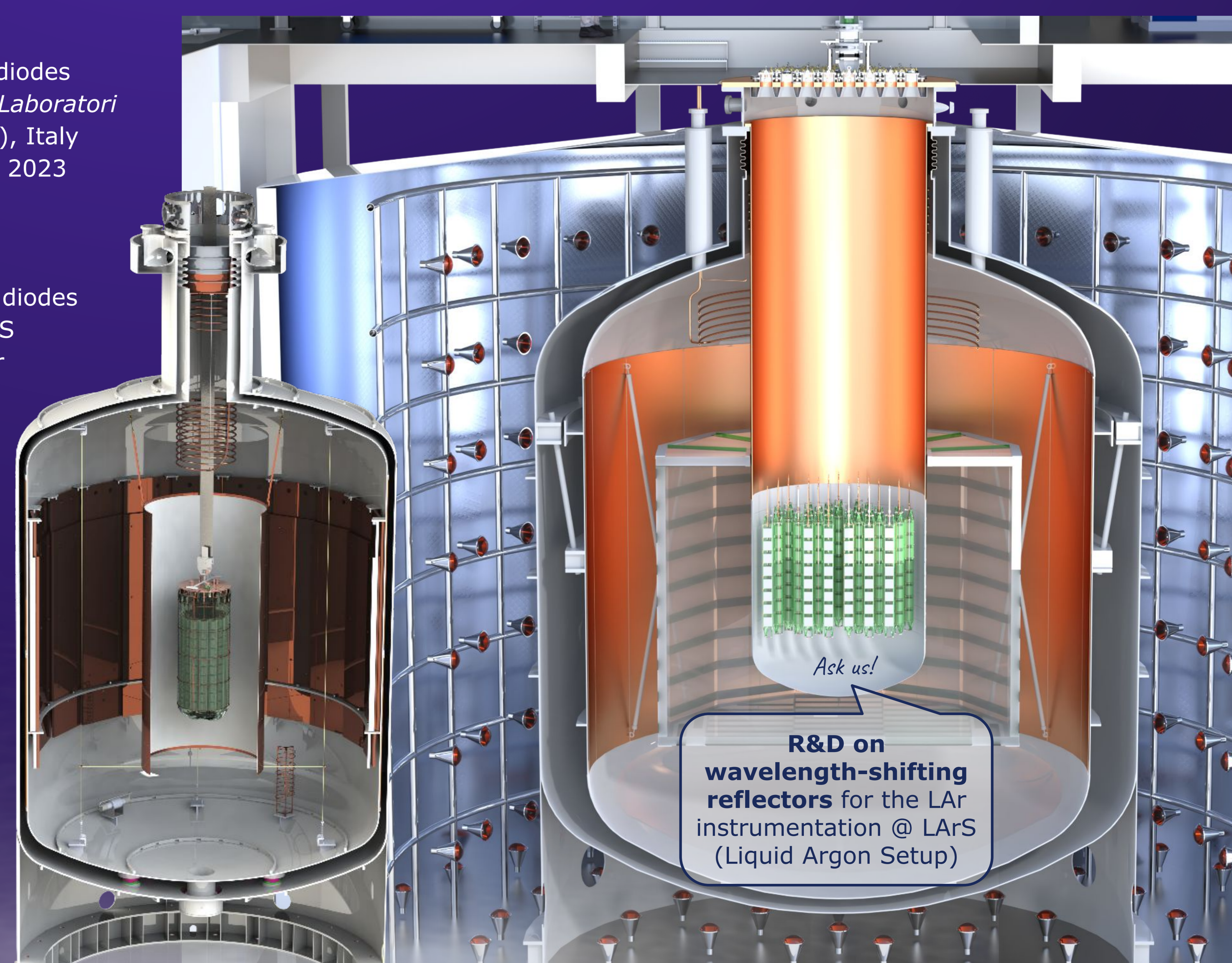
**Response monitoring, simulation and modeling via standard and machine learning techniques** of large mass high-purity germanium detectors enriched in  $^{76}\text{Ge}$



Baudis' group



LEGEND!



**R&D on wavelength-shifting reflectors** for the LAR instrumentation @ LARs (Liquid Argon Setup)

Ask us!

University of Zurich UZH

