

LEGEND-1000 Progress and Status

Justin Warren on behalf of the LEGEND Collaboration
University of North Carolina at Chapel Hill/TUNL



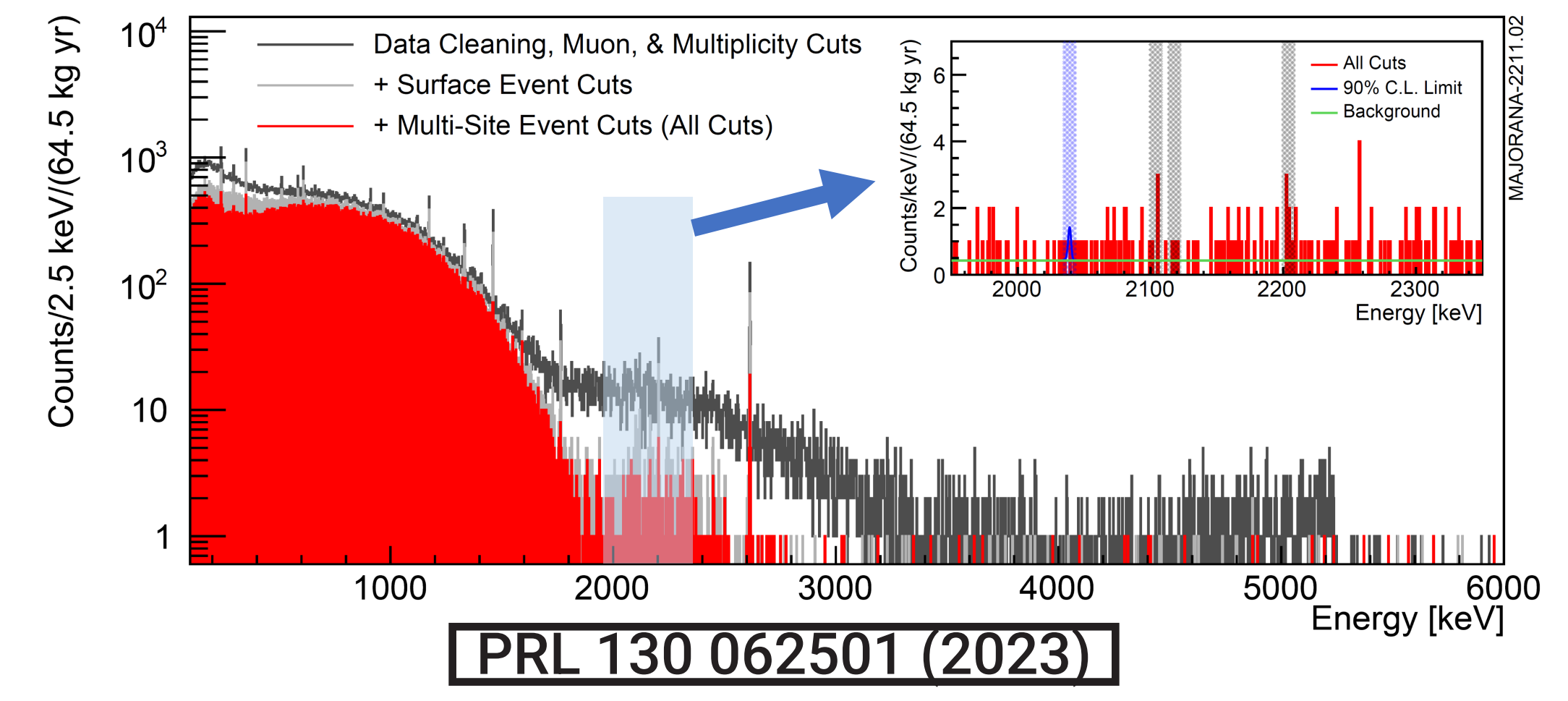
NEUTRINO '26
International Conference on Neutrino Physics and Astrophysics
June 22nd - 26th, 2026
UCI Department of Physics & Astronomy

Prior Experience & Innovation

MAJORANA DEMONSTRATOR

Vacuum cryostats in a passive graded shield with ultra-clean materials

Best resolution in ROI of all $0\nu\beta\beta$ Experiments
 $T_{1/2} > 0.83 \times 10^{26}$ yr (90% C.I.)

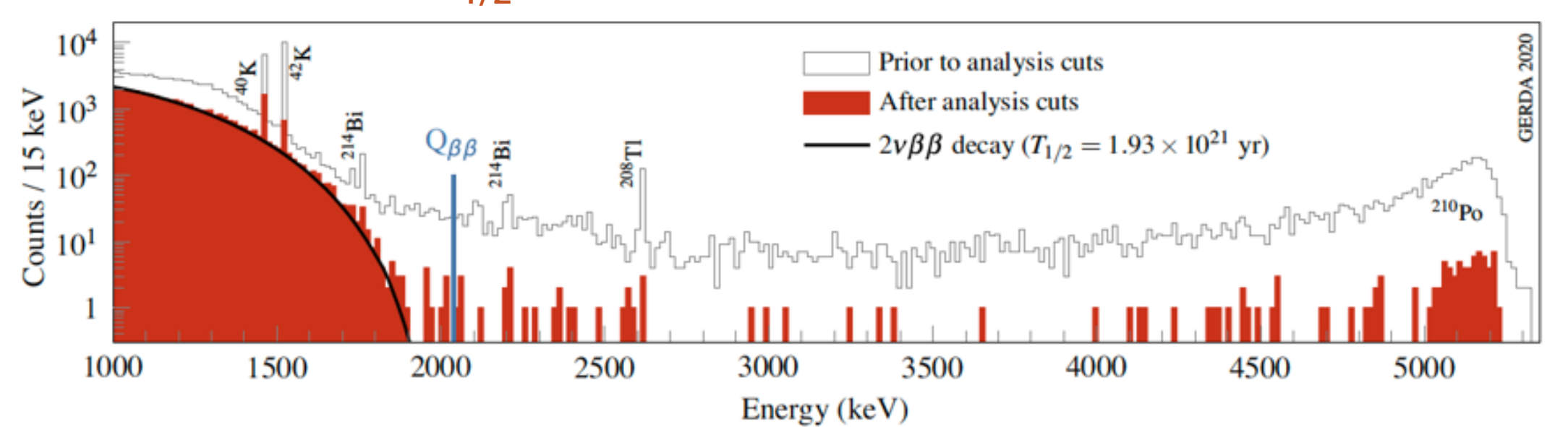


PRL 130 062501 (2023)

GERDA

Direct immersion in active LAr shield with outer water shield

Lowest background in ROI of all $0\nu\beta\beta$ Experiments.
 $T_{1/2} > 1.8 \times 10^{26}$ yr (90% C.I.)

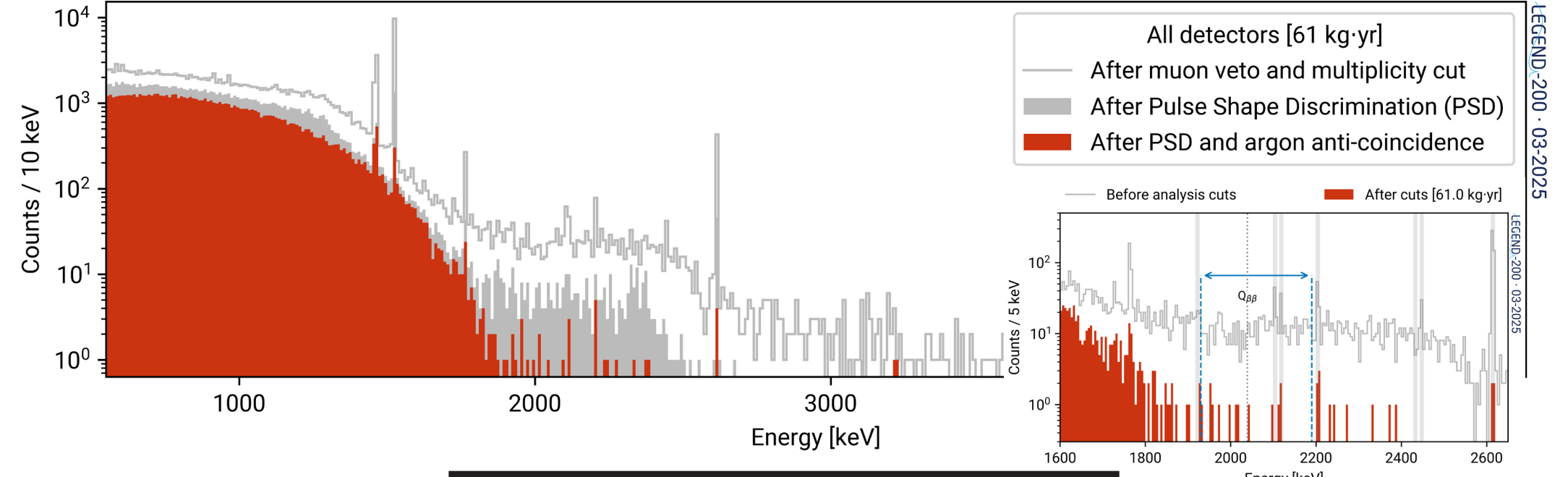


PRL 125 252502 (2020)

LEGEND-200

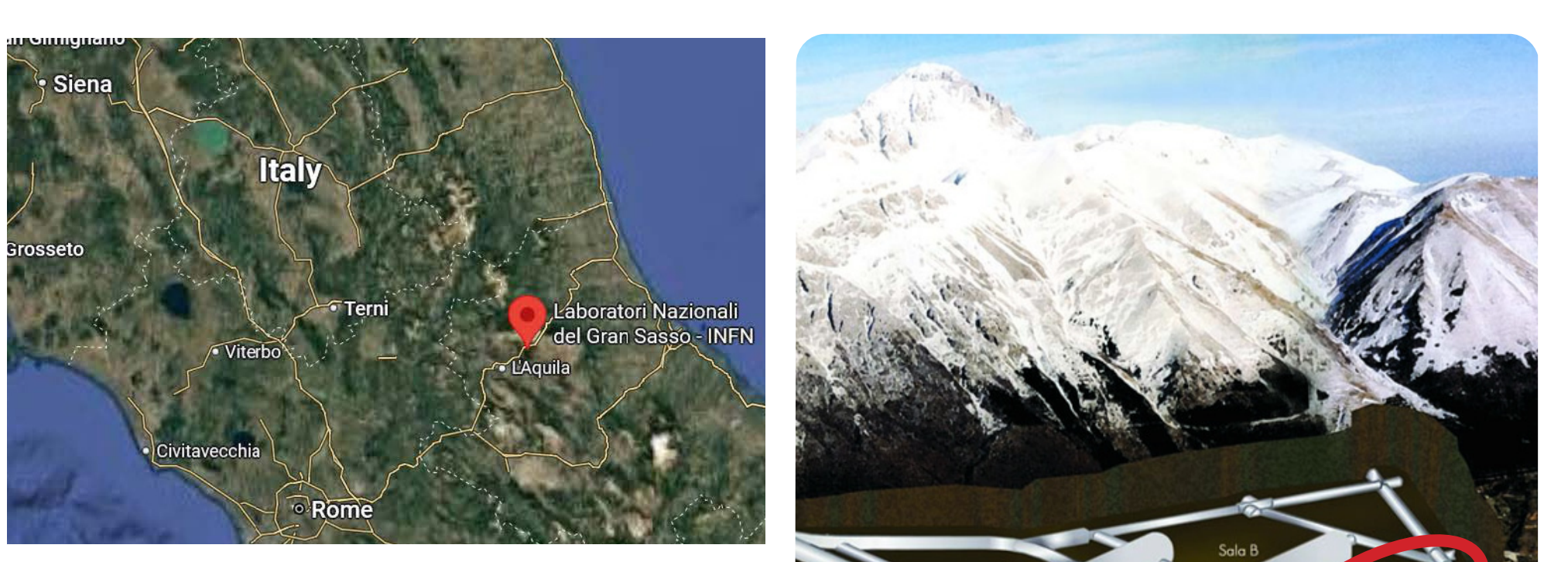
Direct immersion in active LAr shield with outer water shield

Excellent resolution, initial background comparable to GERDA
 $T_{1/2} > 0.5 \times 10^{26}$ yr (90% C.I.)

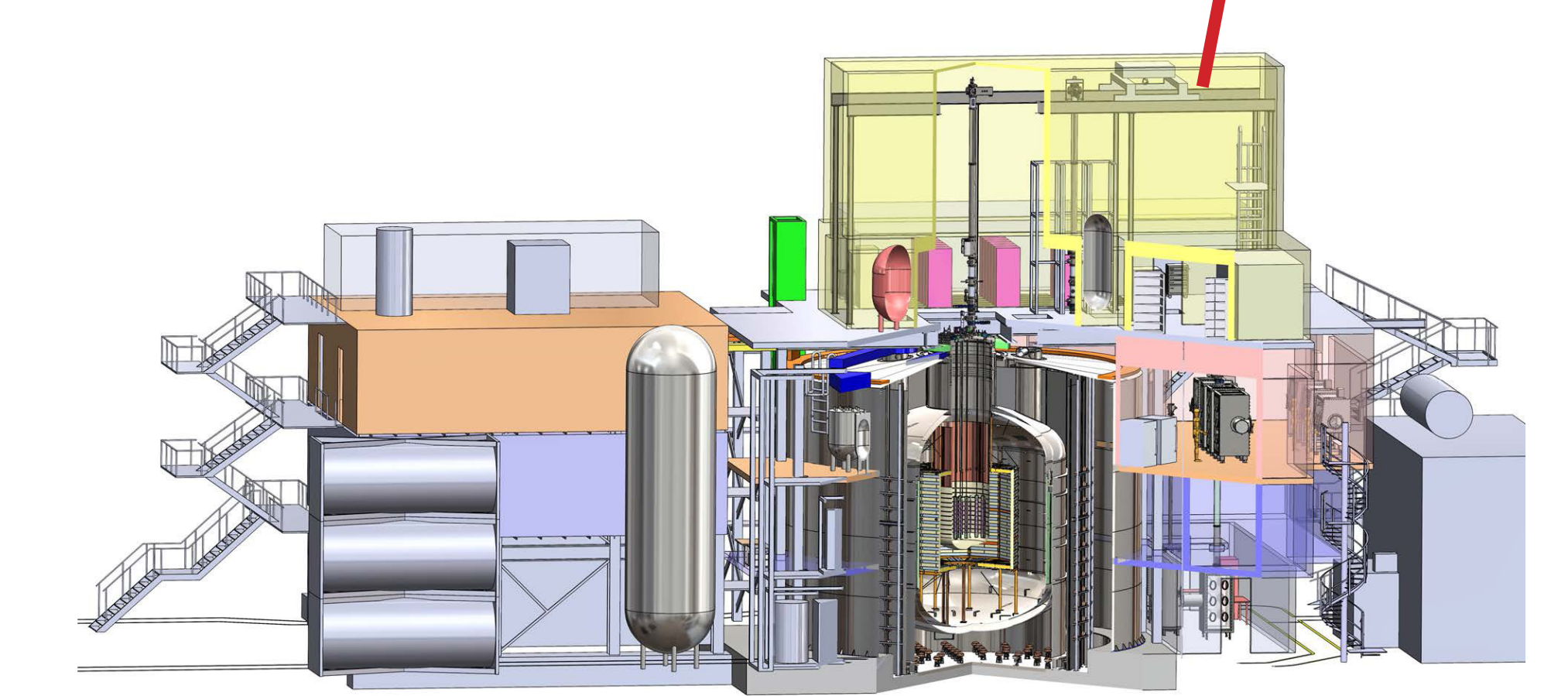


PRL 136 022701 (2025)

Combined MAJORANA, GERDA, and LEGEND-200:
 $T_{1/2} > 1.9 \times 10^{26}$ yr (90% C.I.)

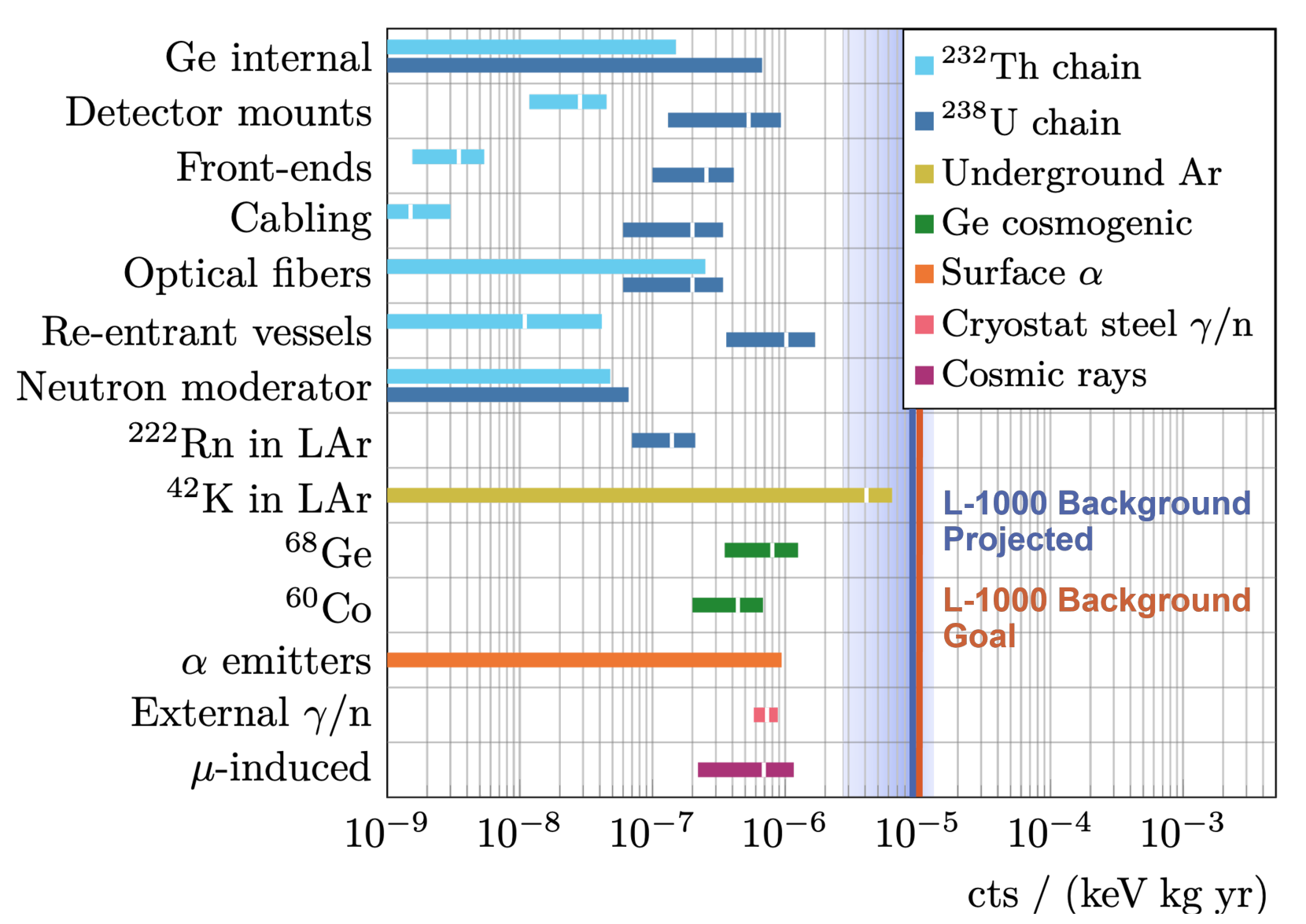


Location : Laboratori Nazionali del Gran Sasso, Italy



Mission
"Develop a phased, ^{76}Ge based double-beta decay experimental program with discovery potential at a half-life beyond 10^{28} years"

• Data taking projected to begin in 2033



LEGEND-1000

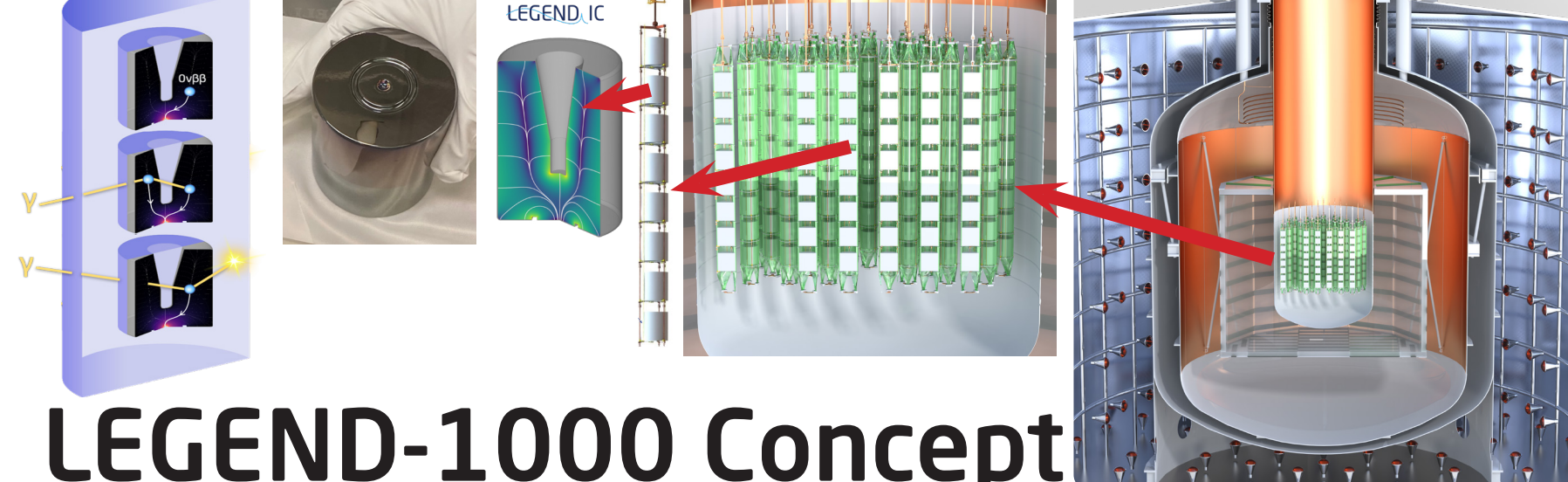
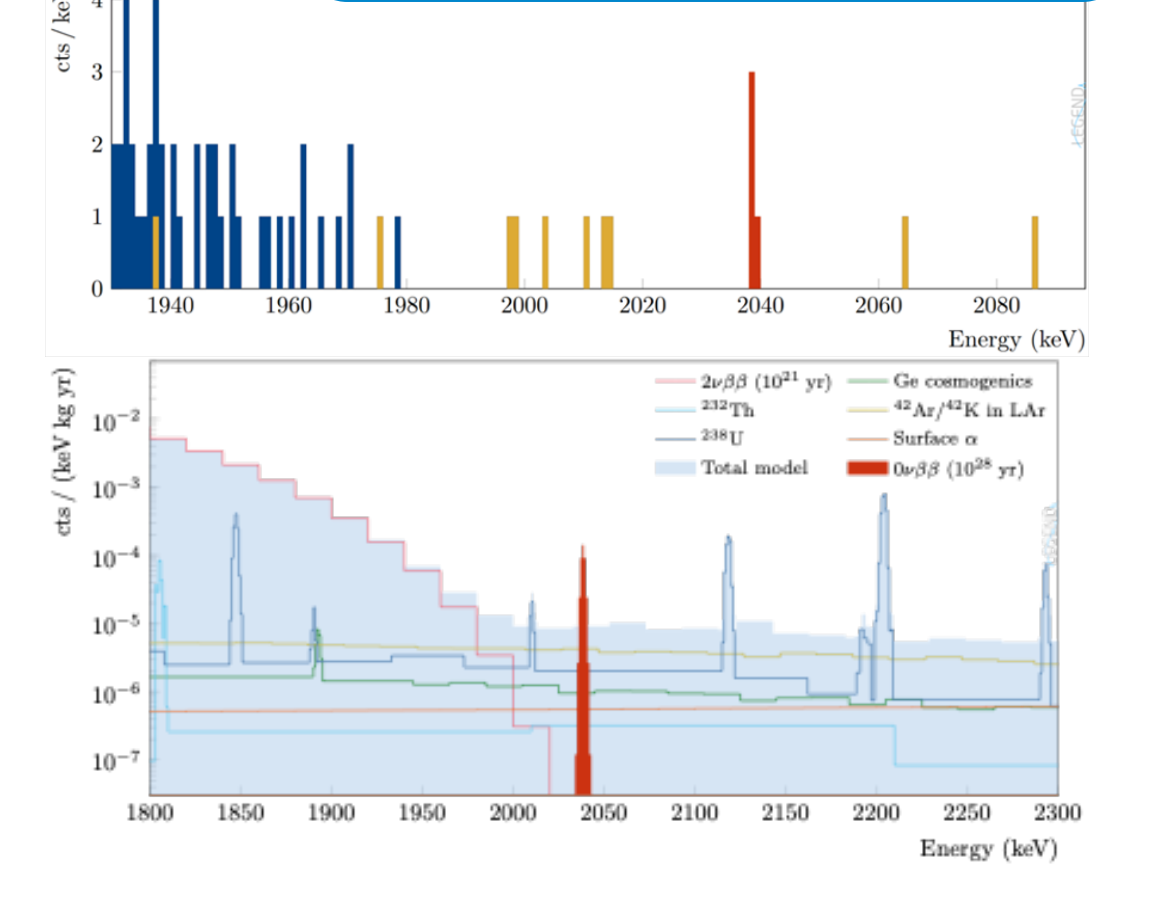
Discovery & Advantages of ^{76}Ge

- Superb energy resolution: $\sigma/Q\beta\beta = 0.1\%$
- No background peaks near the energy of interest
- Flat background measured, no reliance on modeling

LEGEND-1000 (2107.11462)

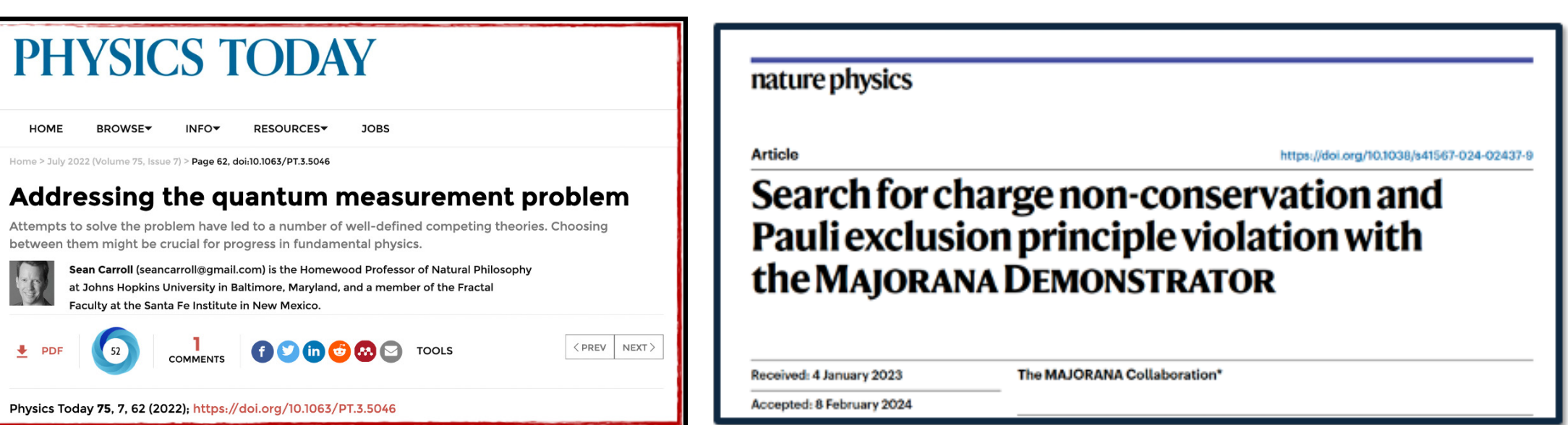
- Up to 1000 kg of ^{76}Ge (staged) enriched to $>90\%$
- BG goal : < 0.025 cts/(FWHM t yr)
- $< 1 \times 10^{-5}$ counts/(keV kg yr)

Simulated LEGEND-1000 example spectrum for $T_{1/2} = 10^{28}$ years and $\text{BI} < 10^{-5}$ cts/keV kg yr after 10 years of data

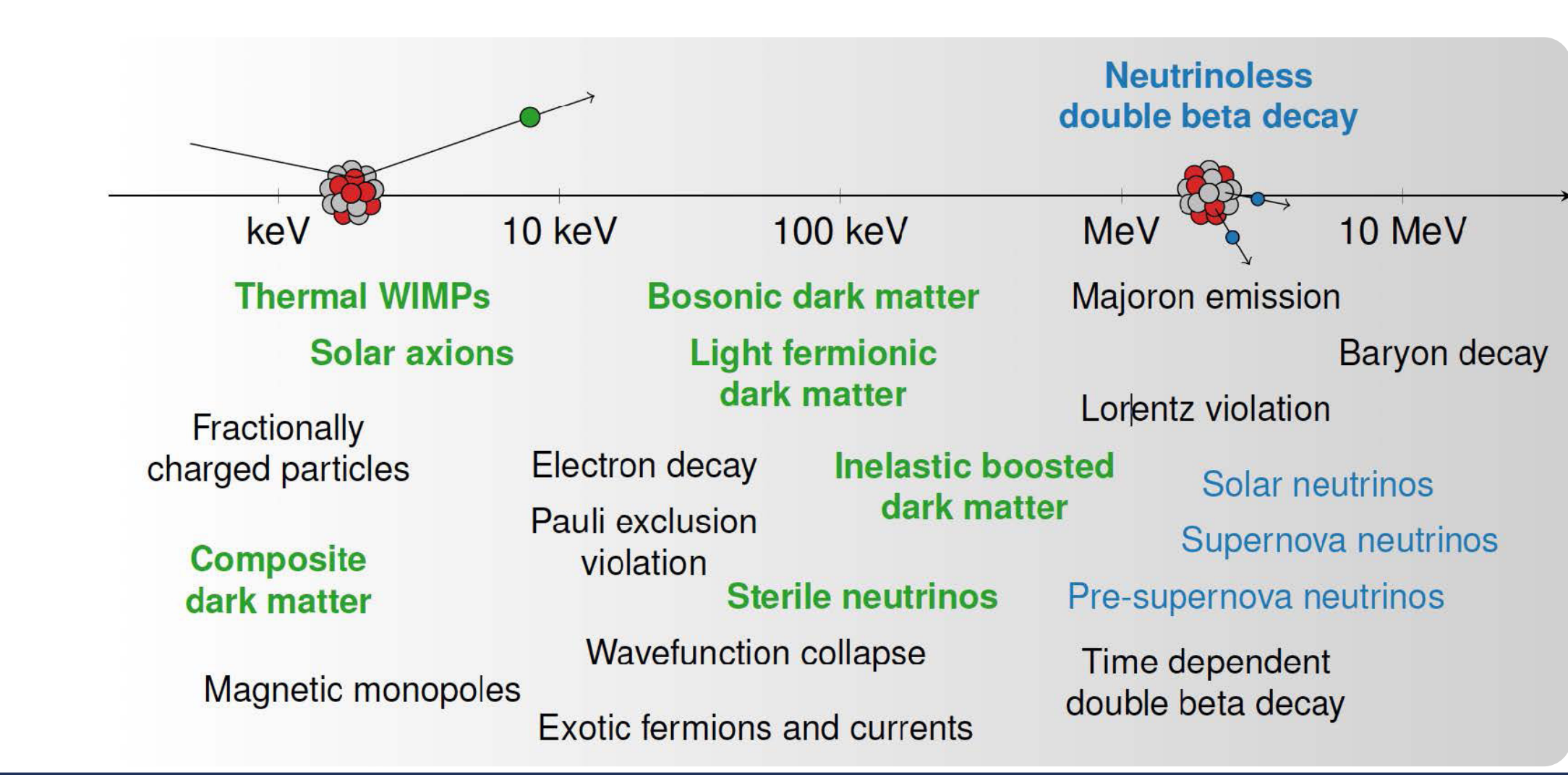


- ### LEGEND-1000 Concept
- Inverted-Coaxial Point Contact ^{76}Ge detectors
 - Made from Ge enriched to $>90\%$ in ^{76}Ge isotope
 - $\sim 3\text{kg}$ each
 - ICPC design developed and refined at ORNL
 - Immersed in 20 tons of underground LAr (low level of ^{42}Ar)
 - 42 strings of 8 detectors each, surrounded by light readout fibers
 - LAr is both active shield and cryogen

Other BSM Physics with LEGEND-1000



Search for tri-nucleon decays of ^{76}Ge in GERDA
Searches for new physics below twice the electron mass with GERDA



Low Background Materials

Underground electroformed copper used as structural material

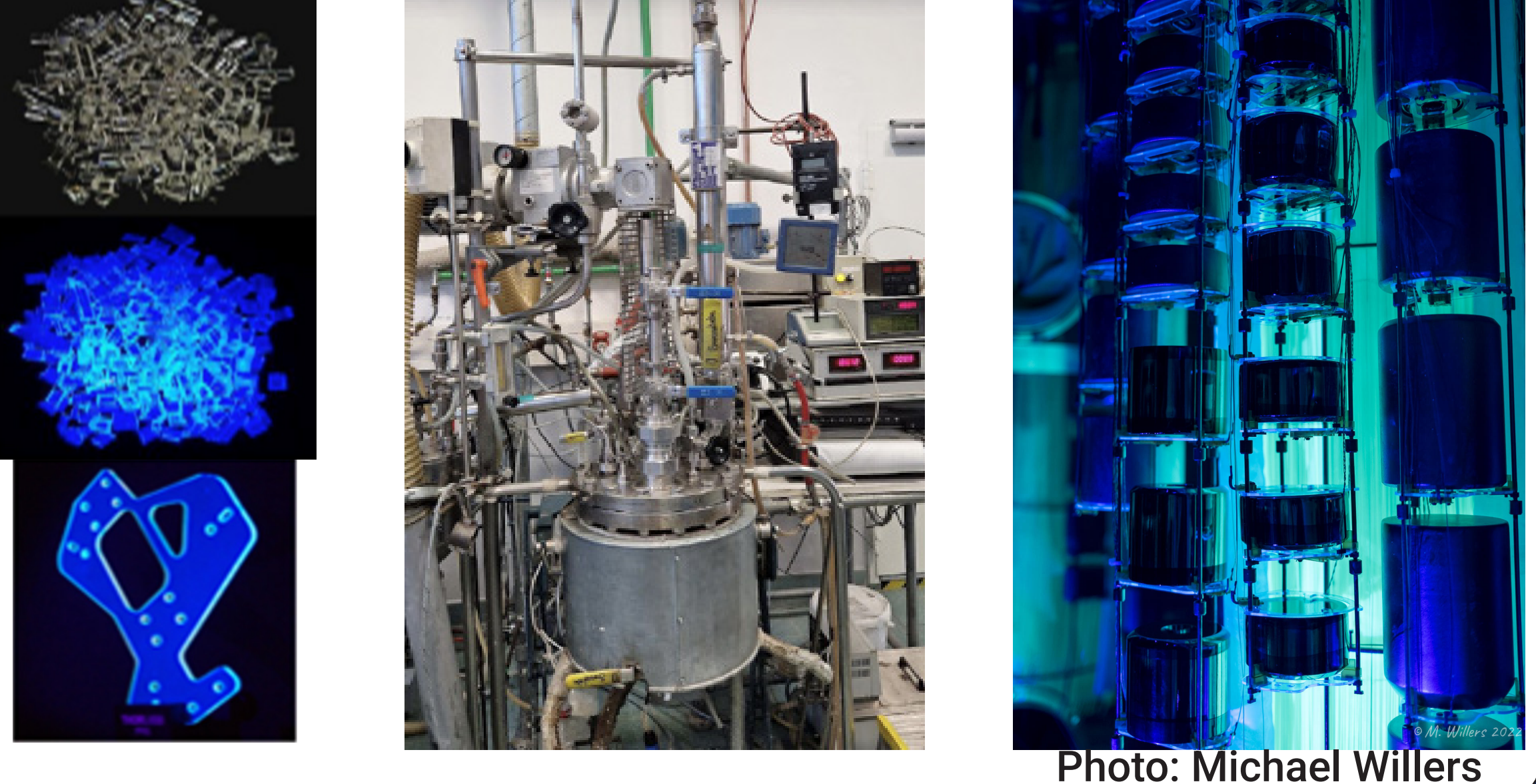


Underground sourced Ar reduces ^{39}Ar and ^{42}Ar
• $\sim 1400\text{x}$ reduction in LAr backgrounds from LEGEND-200



PEN as structural scintillating polymer

• PEN: scintillates with similar processing to PET



LEGEND Collaboration

- ~ 350 members
- ~ 60 member institutions

Acknowledgments

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Large Enriched Germanium Experiment for Neutrinoless $\beta\beta$ Decay

