DARWIN

and the Future of Liquid Xenon Dark Matter Detectors

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UCLA Dark Matter

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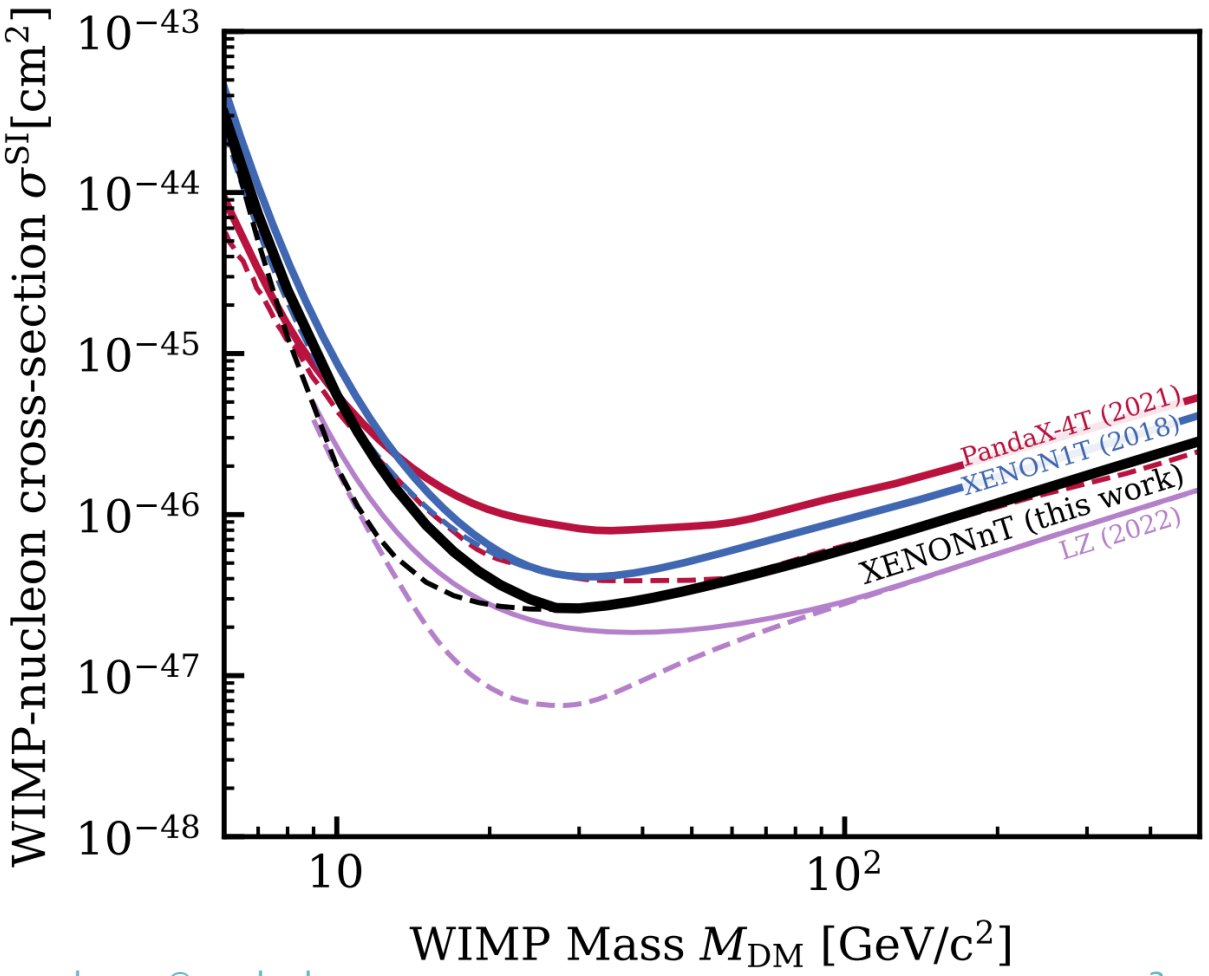
The DARWIN Collaboration

A World-Leading Technology

Liquid Xenon Time Projection Chambers have set the best limits on Spin-Independent Elastic Scattering Weakly Interacting Massive Particles.

The State-of-the-Art:

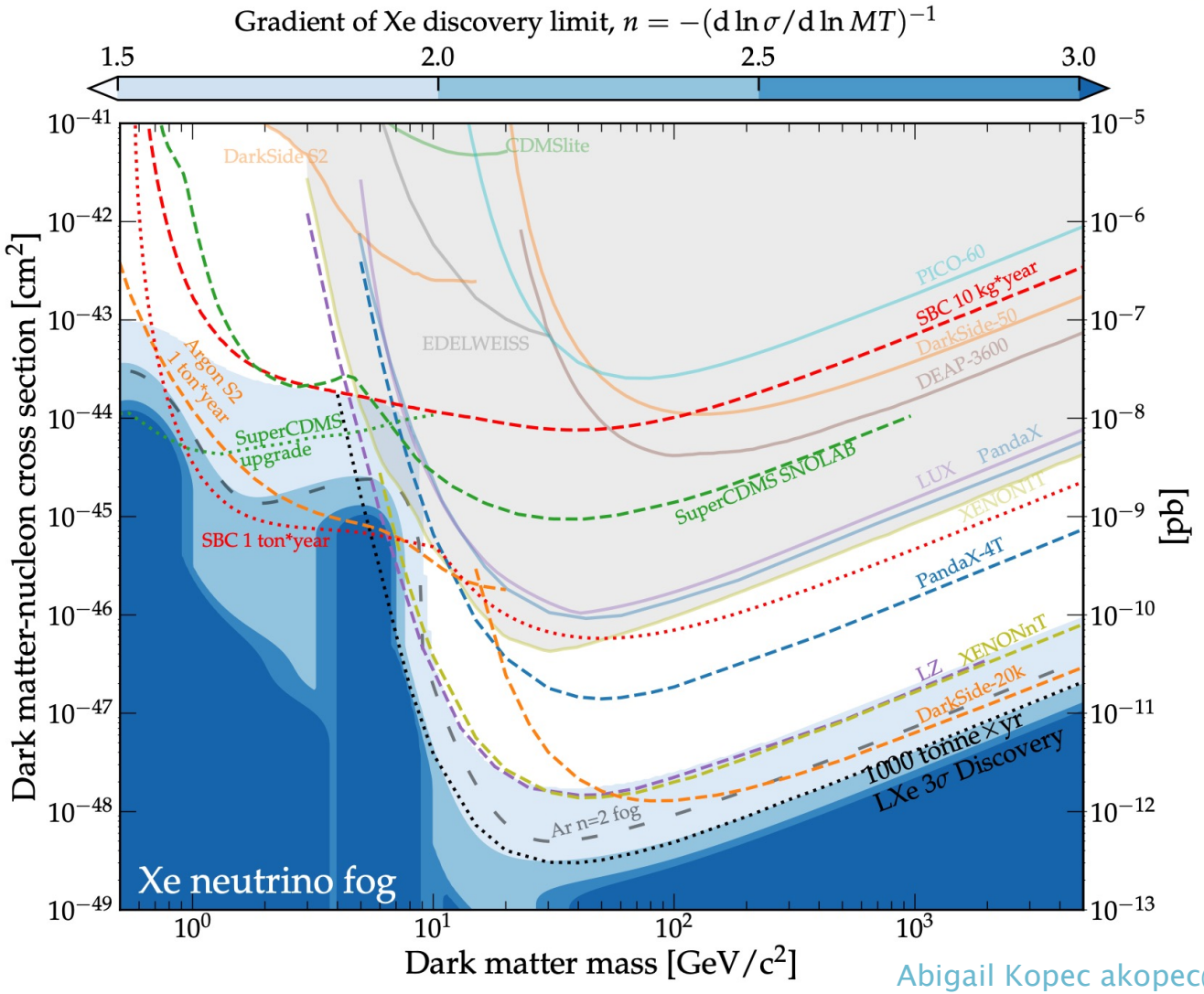
- LUX-ZEPLIN
- PANDAX-4T
- XENONnT



XENON Collaboration arXiv: 2303.14729

Envisioning an Ultimate Detector

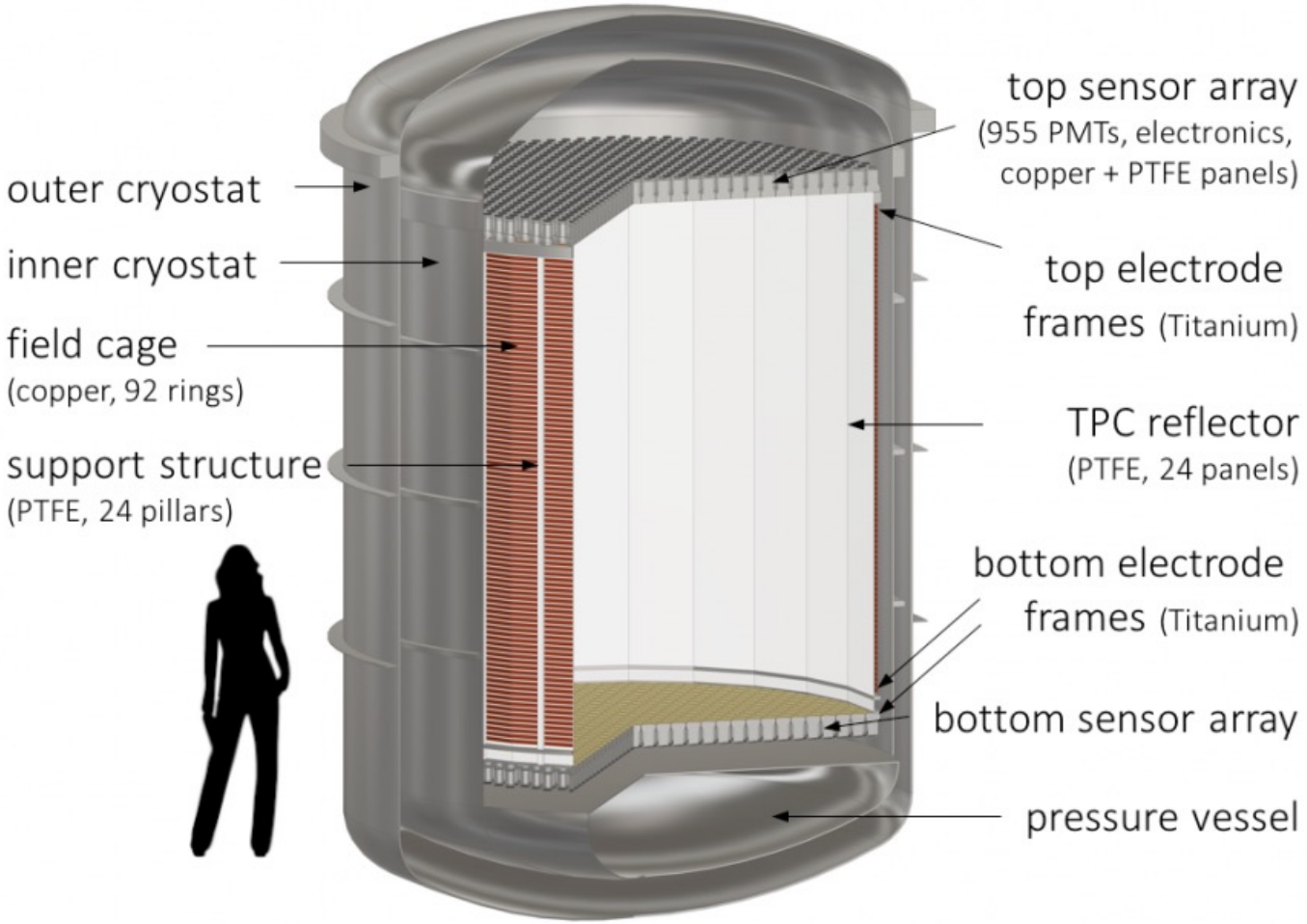
Snowmass 2021 Whitepaper arXiv: 2203.08084



There is a lot of parameter space left to look for WIMPs before reaching irreducible Neutrino backgrounds.

Too early to decide: Can we achieve it all at once, or should we continue to take a step approach?

The DARWIN TPC



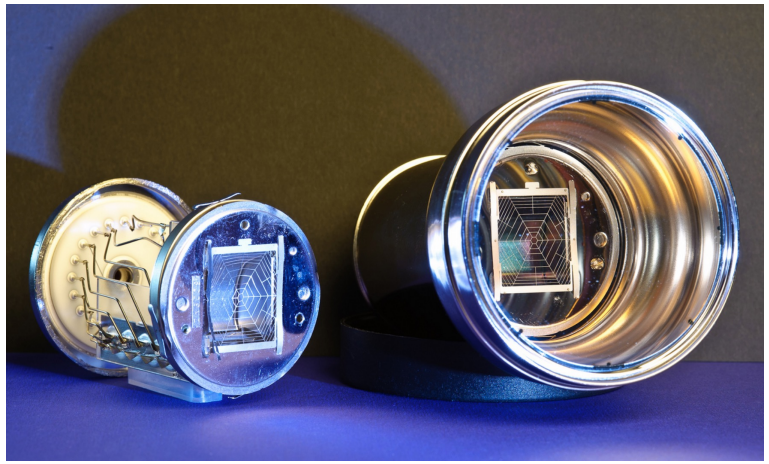
Benchmark Configuration:

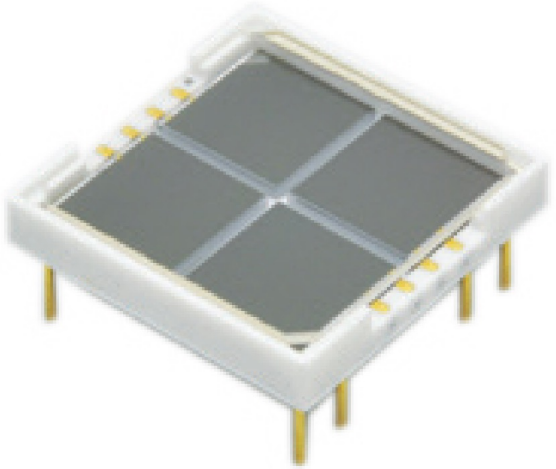
- 1,910 3” PMTs (955 Top and Bottom Arrays)
- 50t LXe detector volume
- 0.1 μBq/kg Rn-222
- Gran Sasso National Laboratory

R&D: Photosensors

Optimization:

- Maximize photon collection and resolution
- Maximize position resolution
- Minimize dark count backgrounds





JINST 17 (2022) C01038

R&D: Scalability

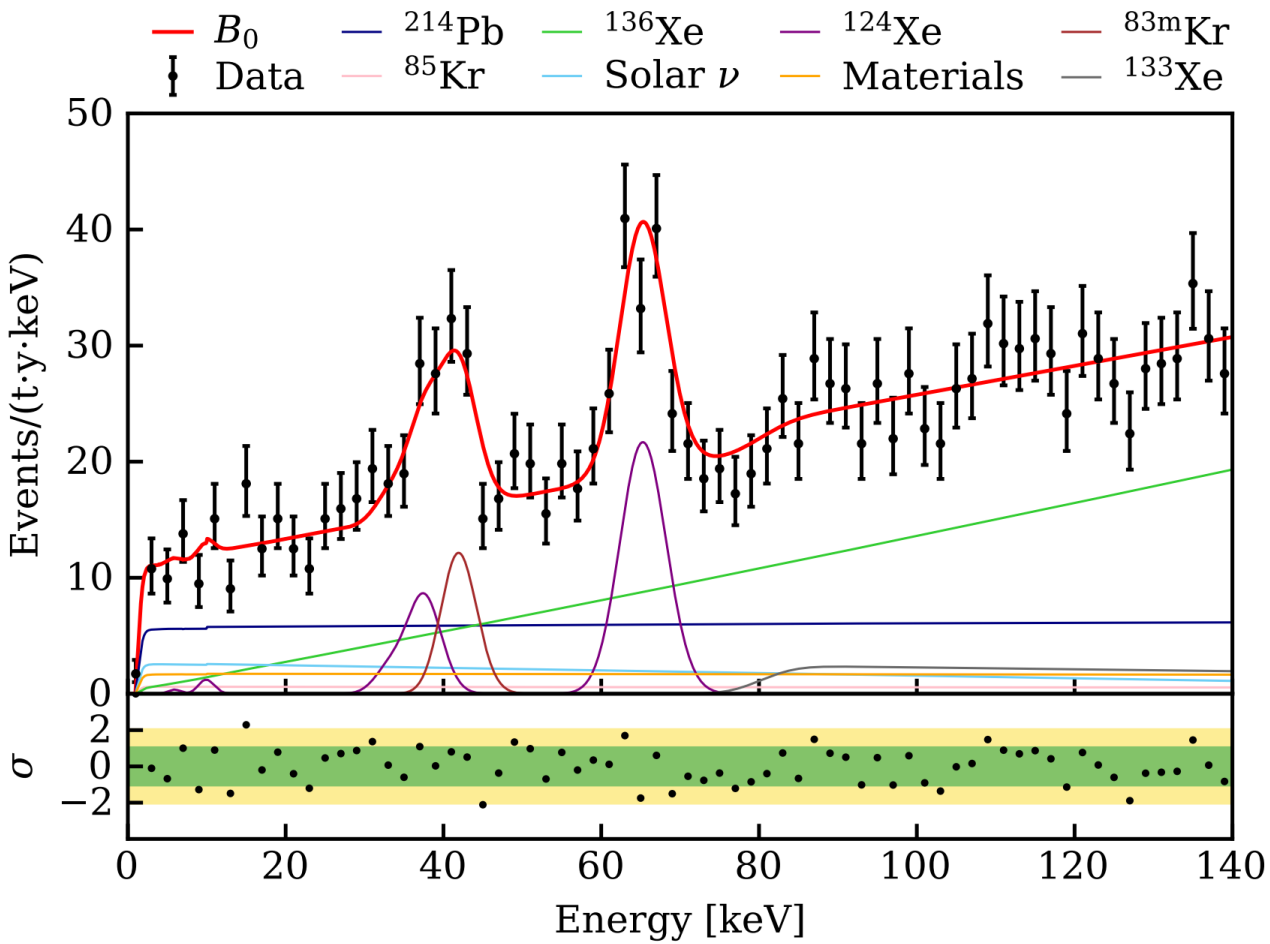
PANCAKE (Freiburg)

Full-Diameter (2.6m)
Electrode Testbed

Xenoscope (Zurich)

Full-Length (2.6m)
Drift Column Testbed

R&D: Cryogenics



Eliminating radiogenic backgrounds and electronegative impurities builds on:

XENONnT: developed Radon Distillation and Liquid Purification

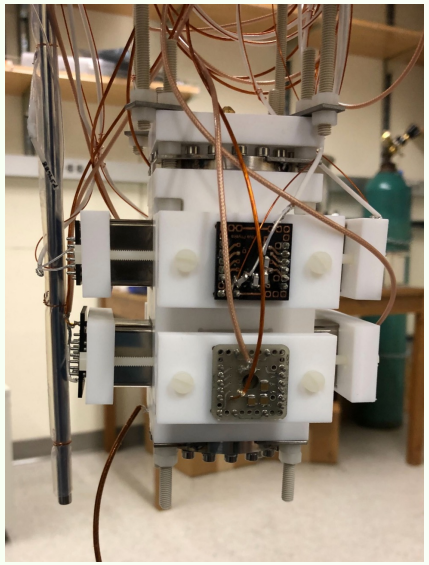
LUX-ZEPLIN: undertook monumental efforts to build a clean detector

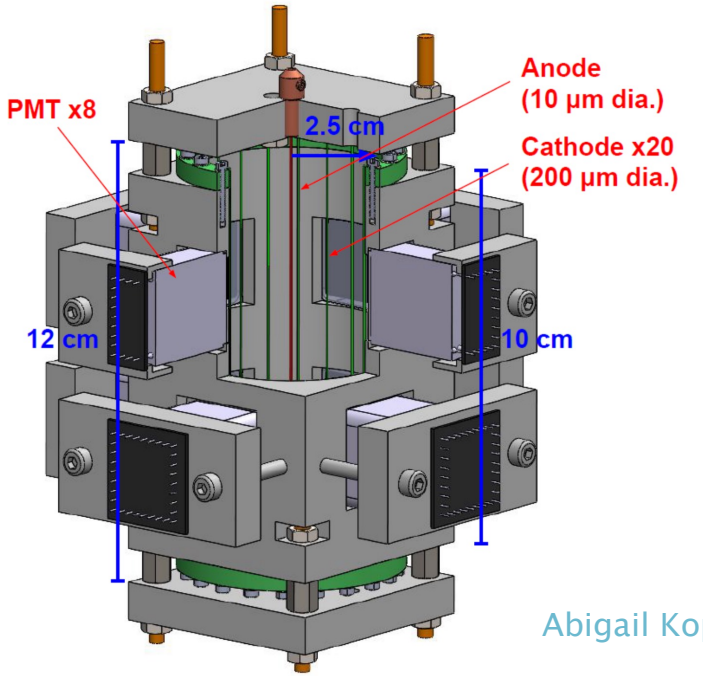
Phys. Rev. Lett. 129, 161805 (2022)

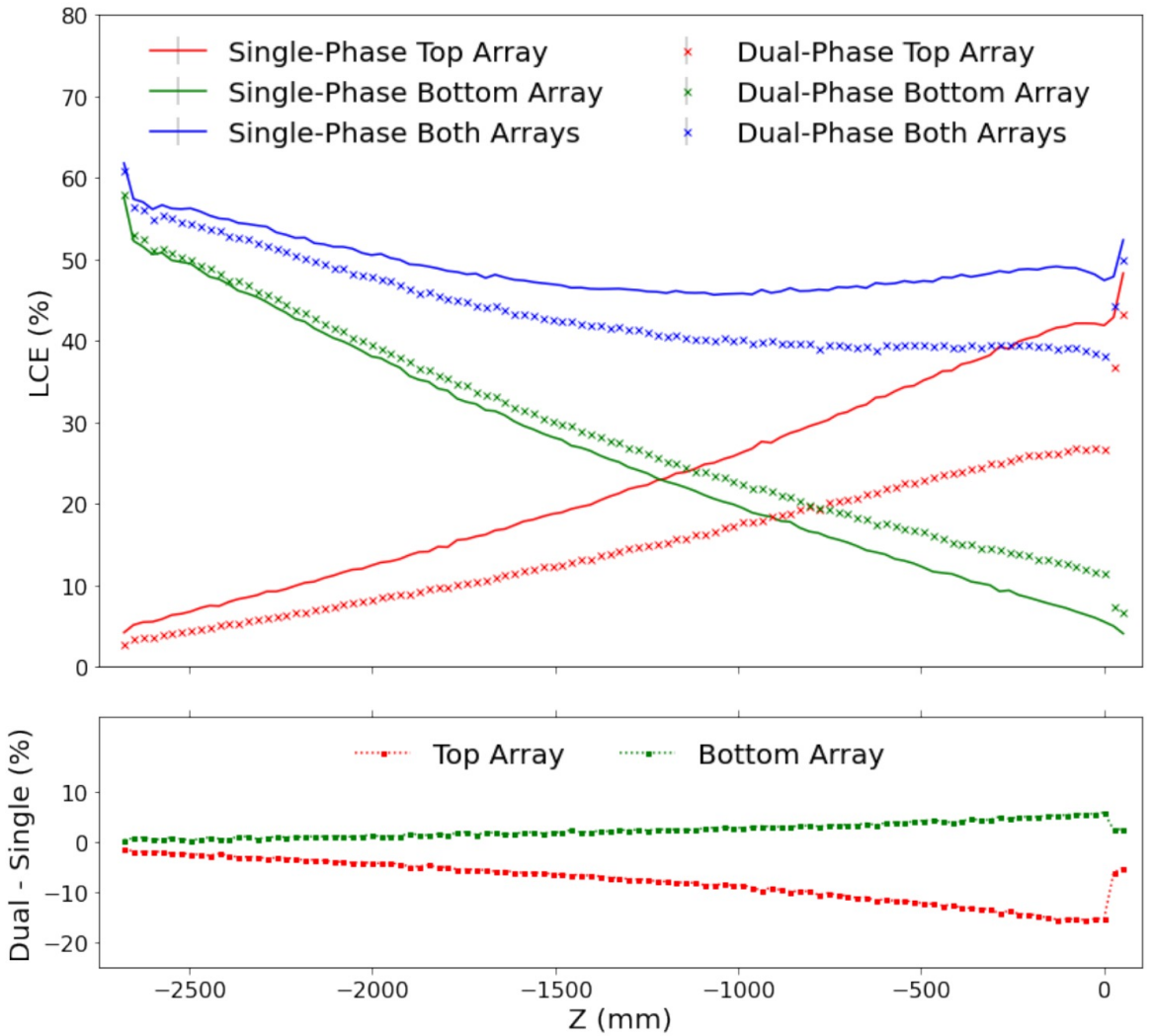
R&D: Single-Phase Detector

No detector has achieved perfect charge collection because of **purity** and **extraction efficiency**.

SanDiX (UC San Diego)







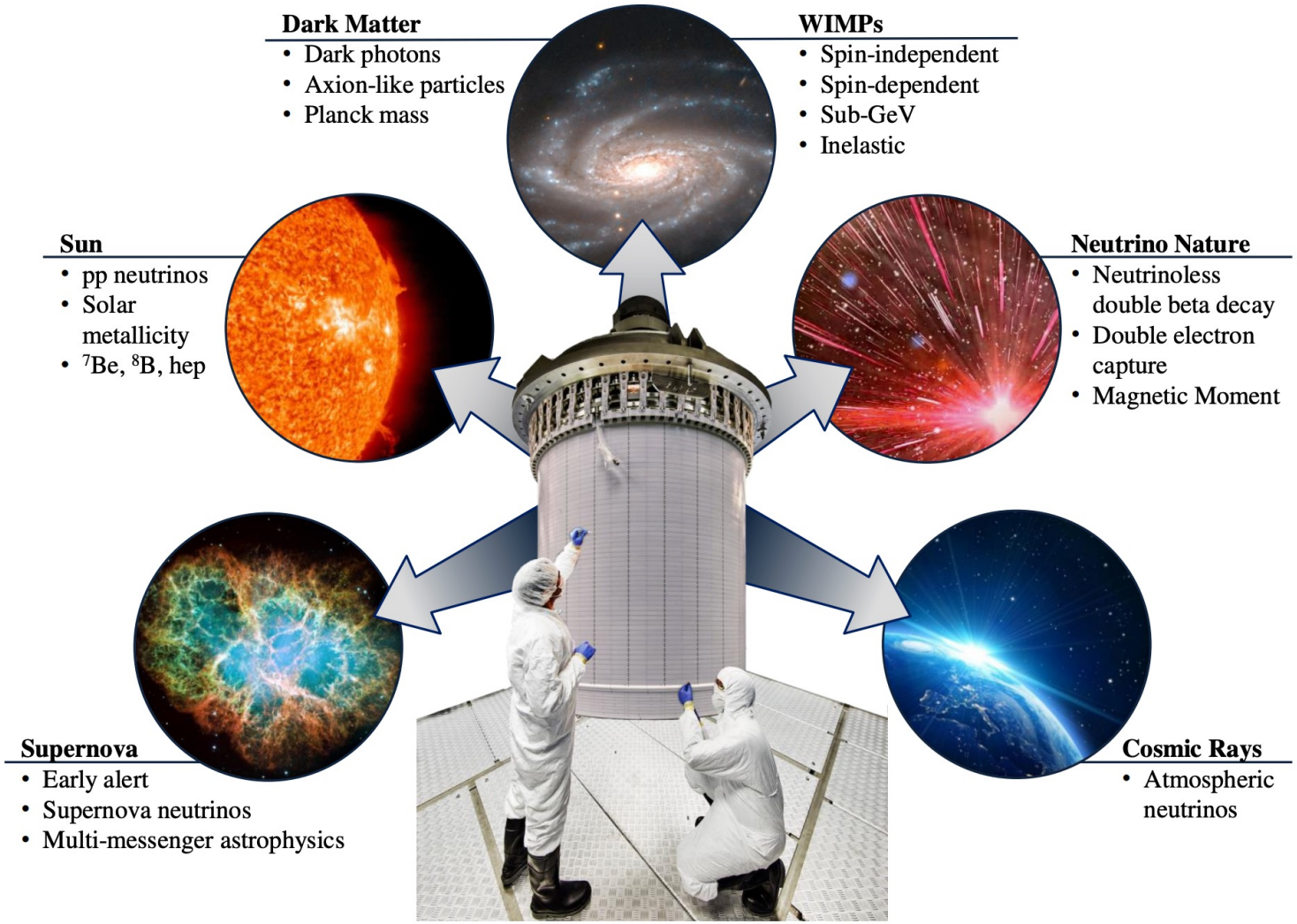
JINST 17 (2022) P07018

arXiv: 2301.12296

XLZD Consortium

Building the Ultimate Detector requires all Experts

Rich Science Program

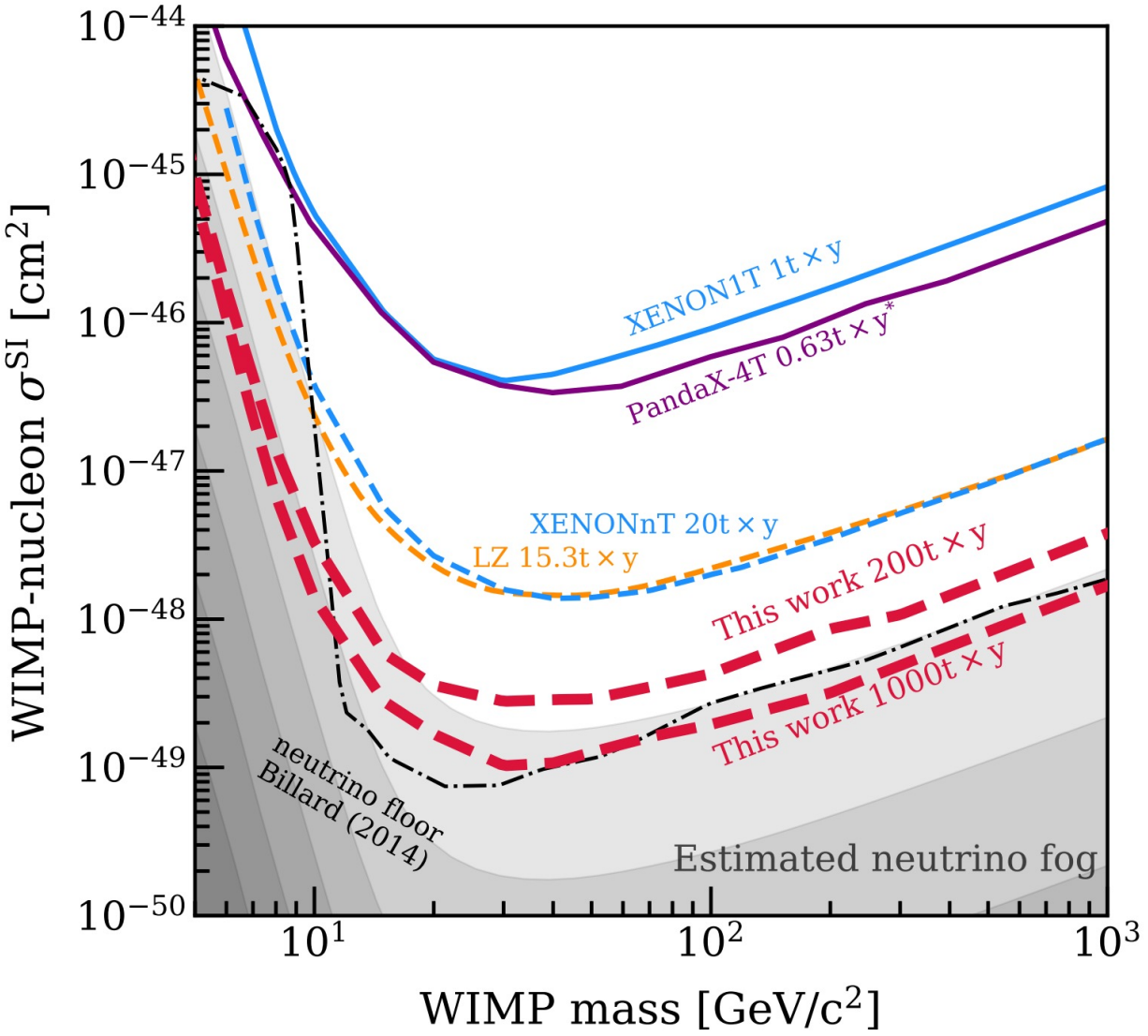


J. Phys. G: Nucl. Part. Phys. 50 (2023) 013001

WIMPs and CEvNS

A 200 t*y exposure probes cross-sections down to $3*10^{-49}$ cm^2 and is sensitive to solar neutrinos.

Ideally, a 1 kt*y exposure reaches 10^{-49} cm^2 and is sensitive to atmospheric neutrinos.



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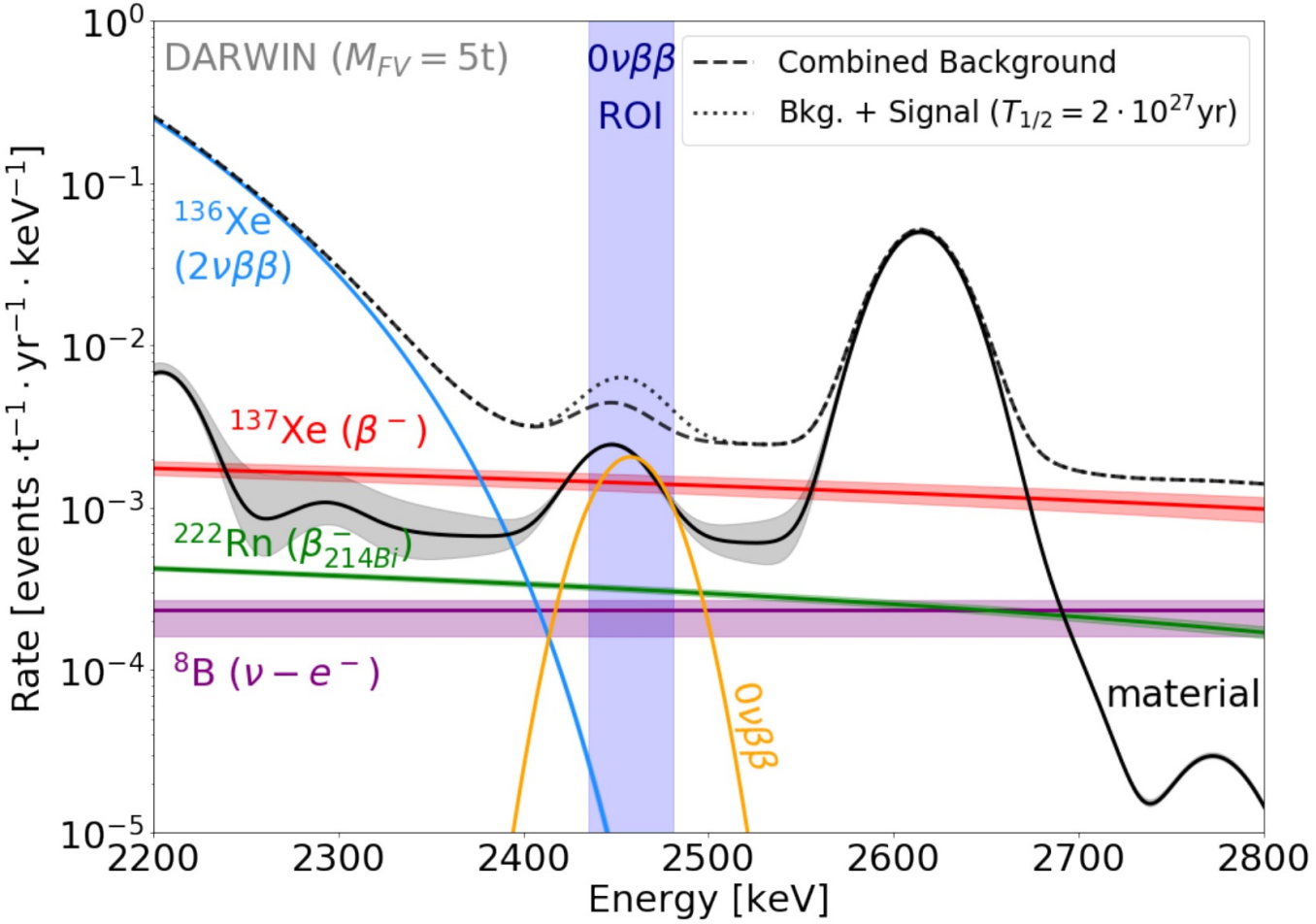
Neutrinoless Double-Beta Decay



With natural xenon abundances, the purest fiducial volume containing 5t would be sensitive to a half-life of $2*10^{27}$ years.

Eur. Phys. J. C 80, 808 (2020)

Summary

The DARWIN Collaboration and XLZD Consortium are pursuing the ultimate liquid xenon time projection chamber.

- The Ultimate Detector would reach a sensitivity limited solely by irreducible neutrino backgrounds, approaching 1kt*y exposure.
- A larger, monolithic target presents design challenges, and many R&D projects are underway to ensure reduced backgrounds and optimal detector performance.
- The XLZD Consortium is uniting to realize an Ultimate Detector.