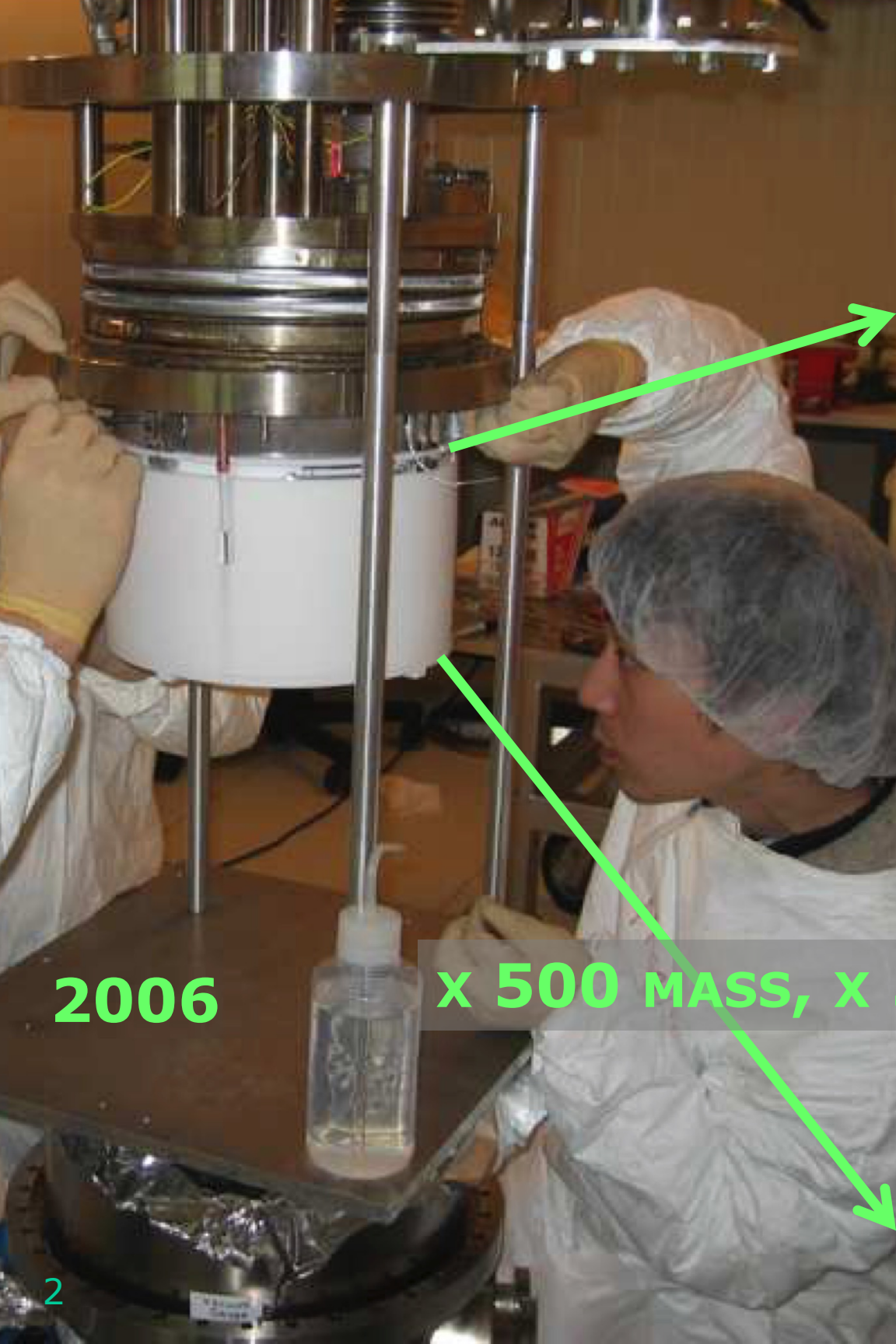


DARK MATTER SEARCH RESULTS FROM THE LUX-ZEPLIN (LZ) EXPERIMENT



**MARIA ELENA MONZANI (SLAC/STANFORD), ON BEHALF OF THE
LZ COLLABORATION - UCLA DARK MATTER, MARCH 31ST 2023**

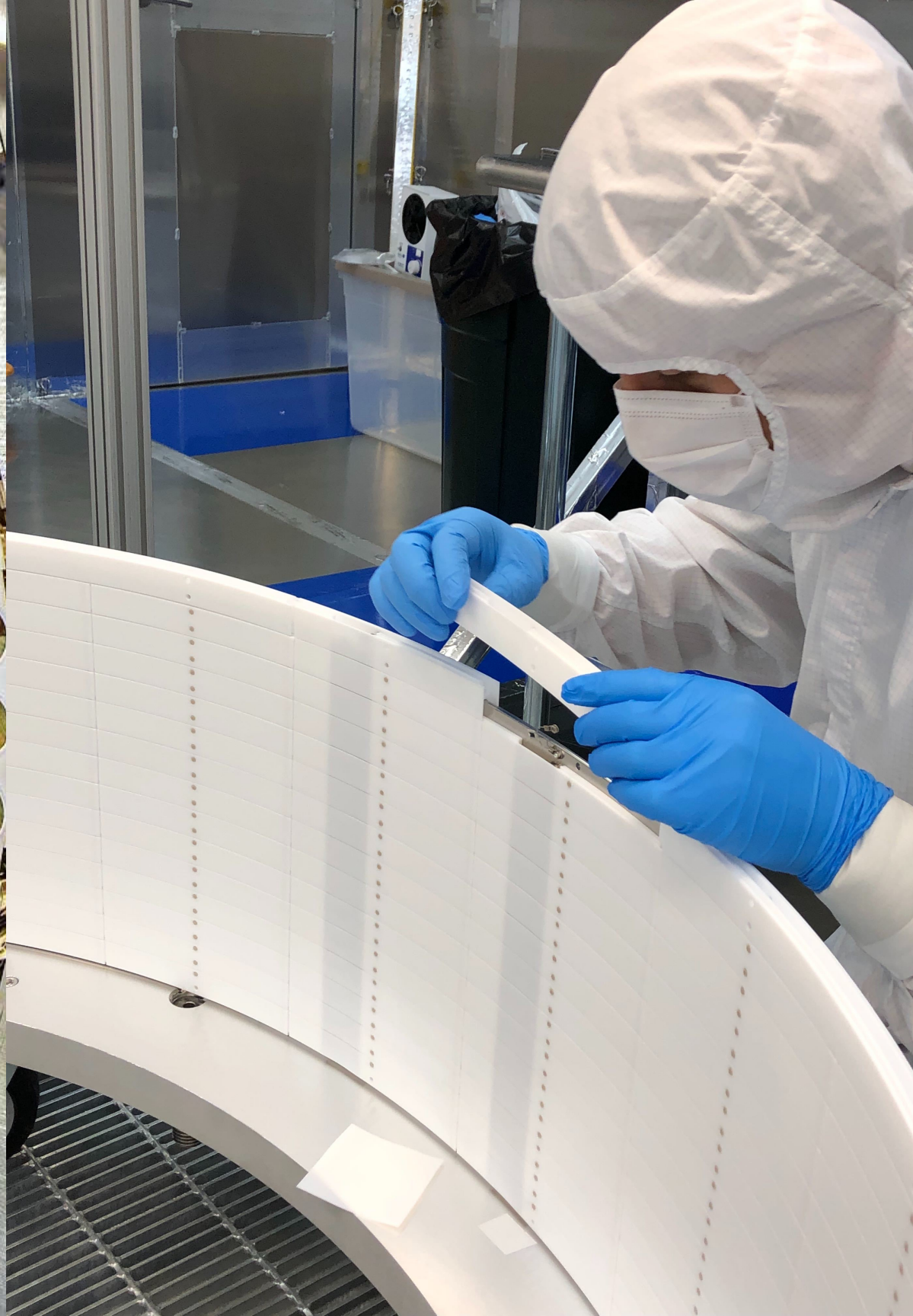
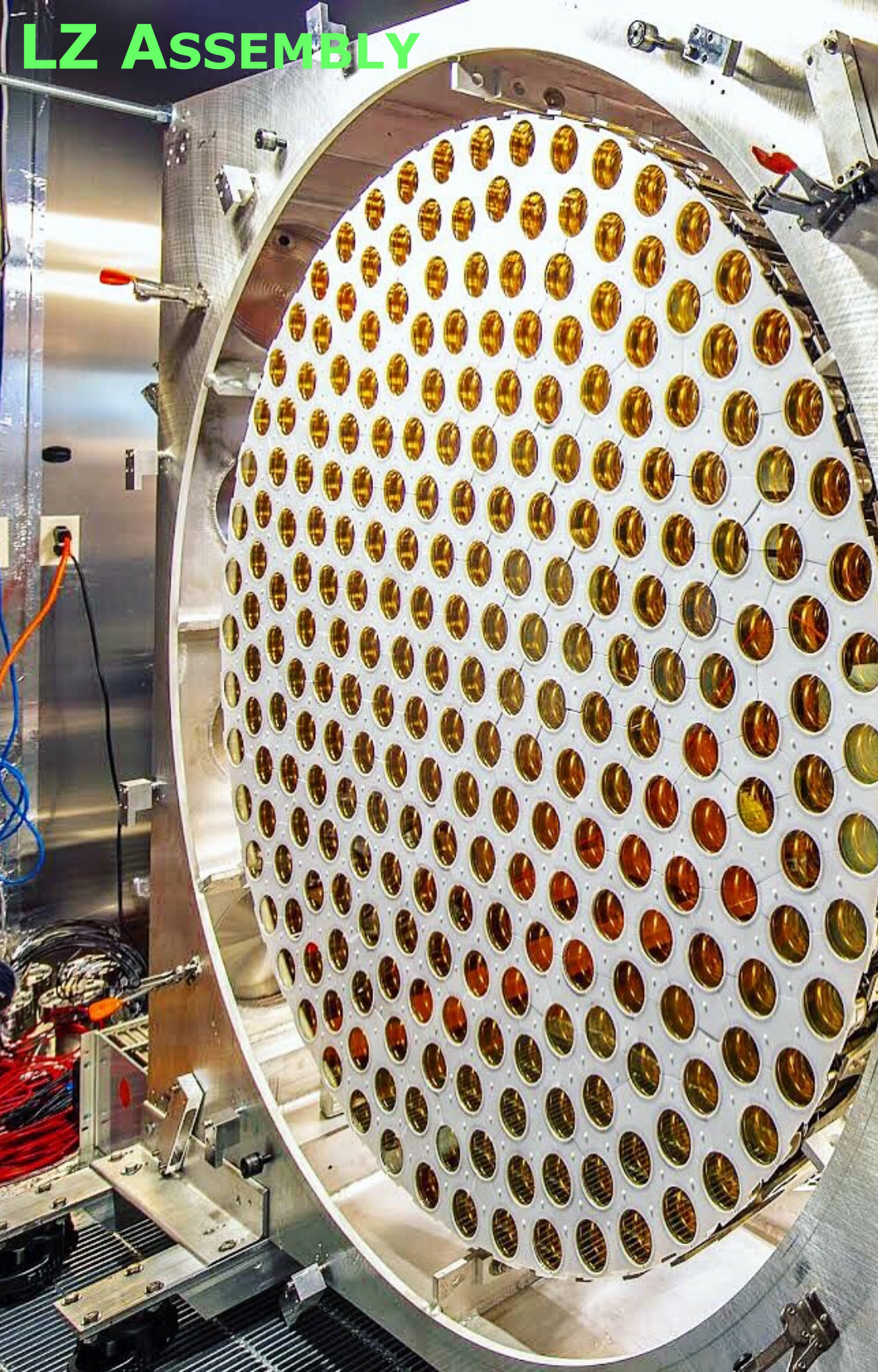


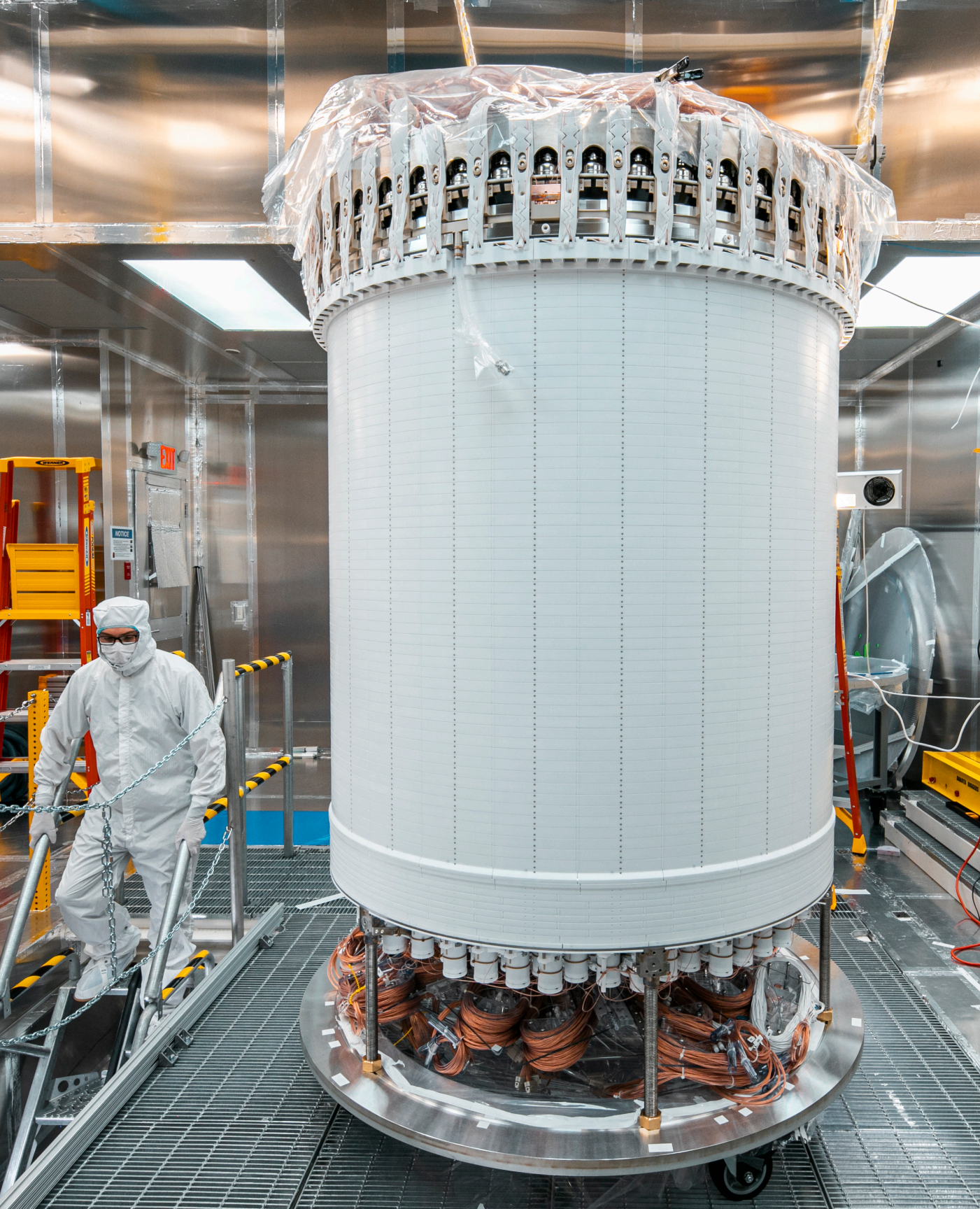
2006

x 500 MASS, x 5000 SENSITIVITY



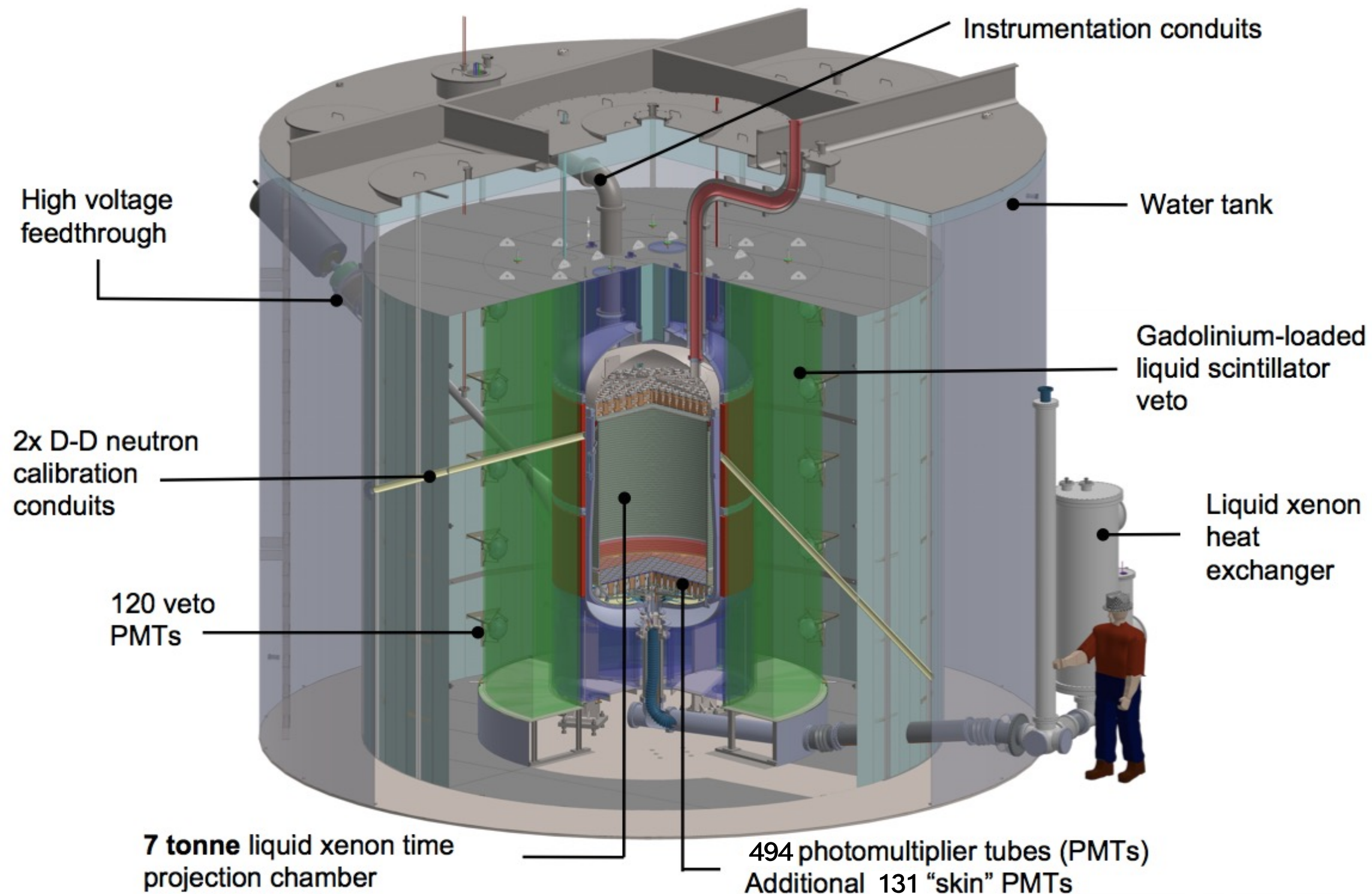
2019

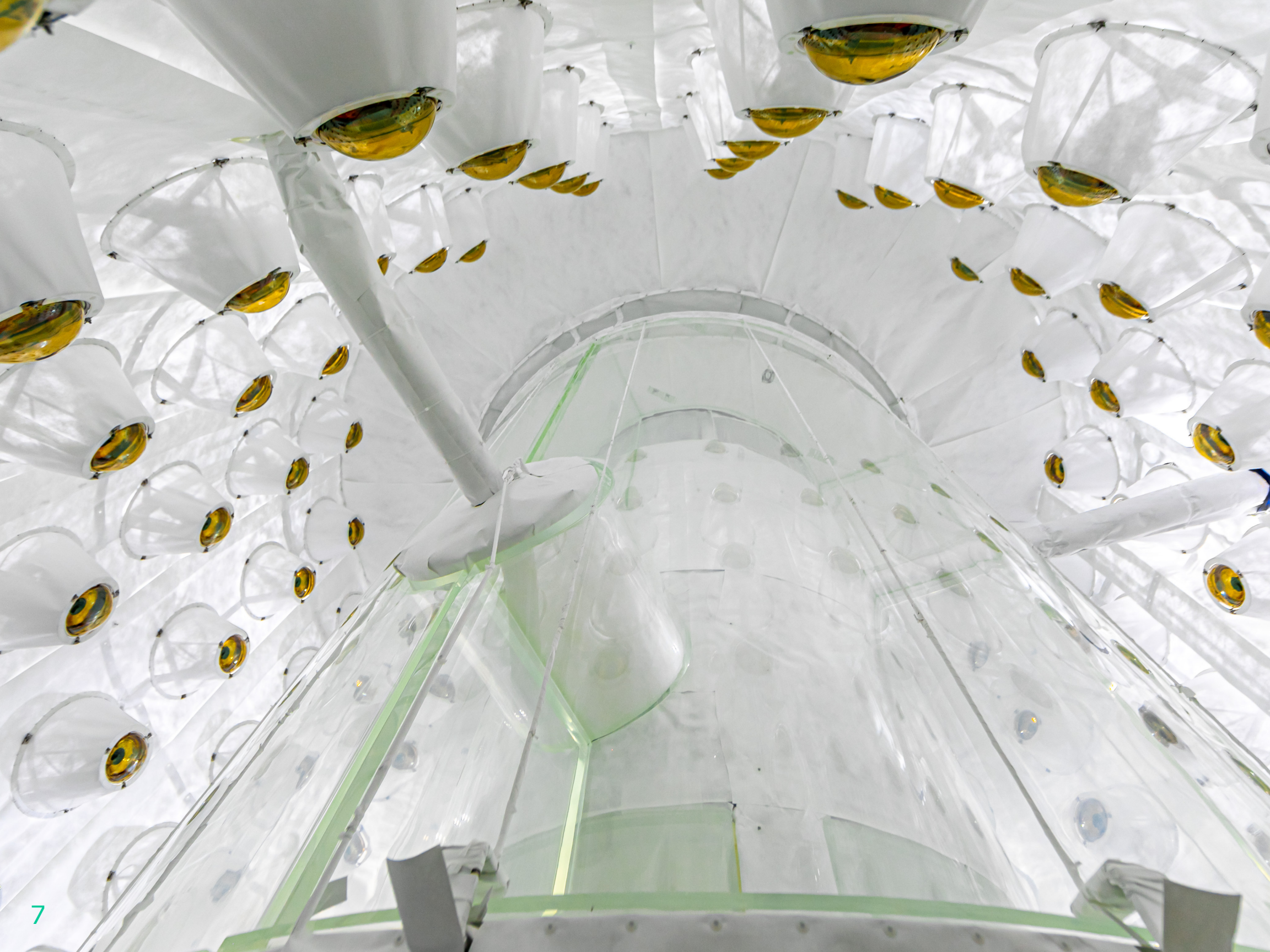






LZ TPC WITHIN ITS SHIELDING DETECTORS





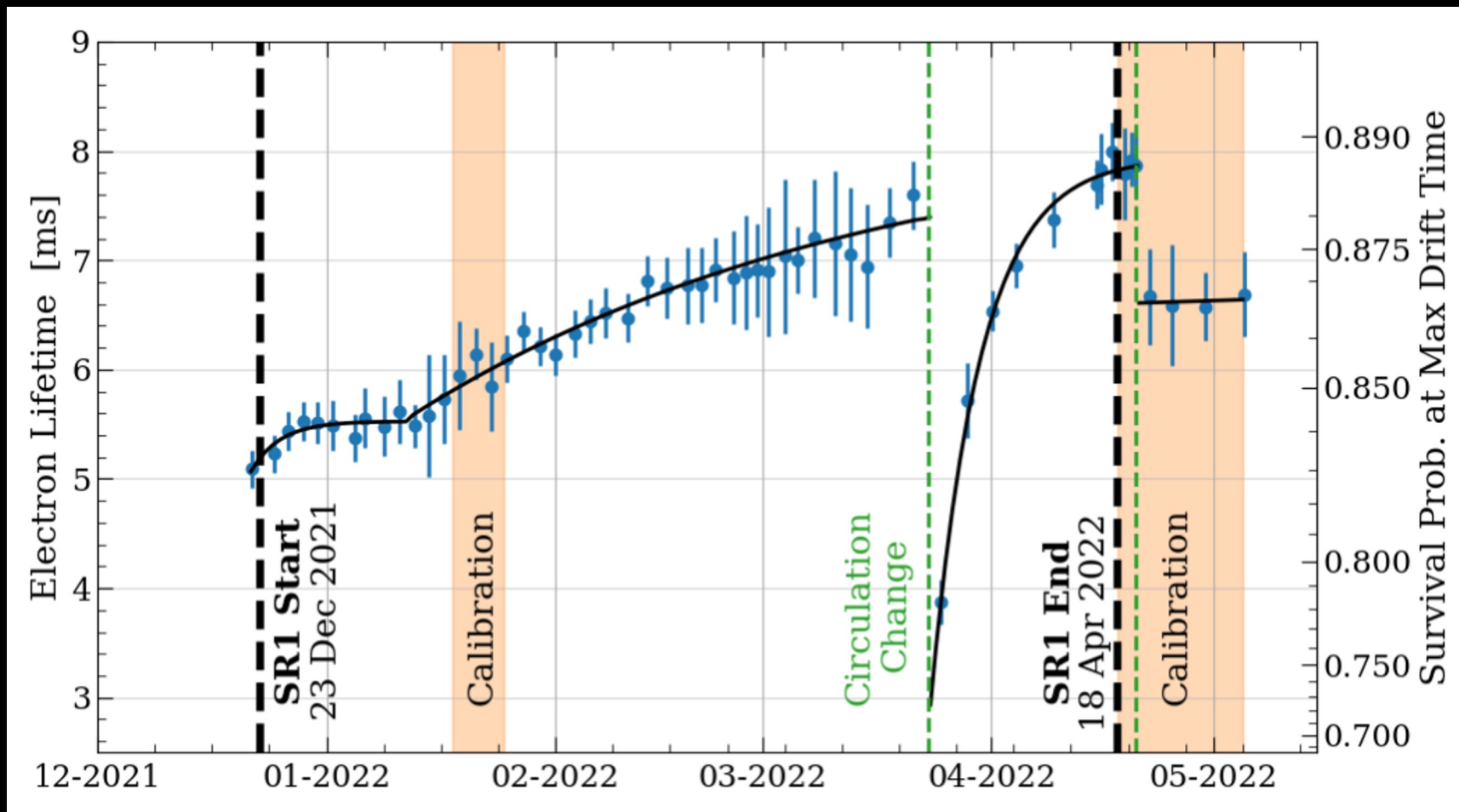
FIRST SCIENCE/ENGINEERING RUN



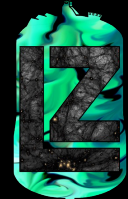
Goal: Demonstrate **physics capability** of the detector, with expectation of **competitive sensitivity**

Dec 2021 to May 2022: **60 live days** WIMP Search

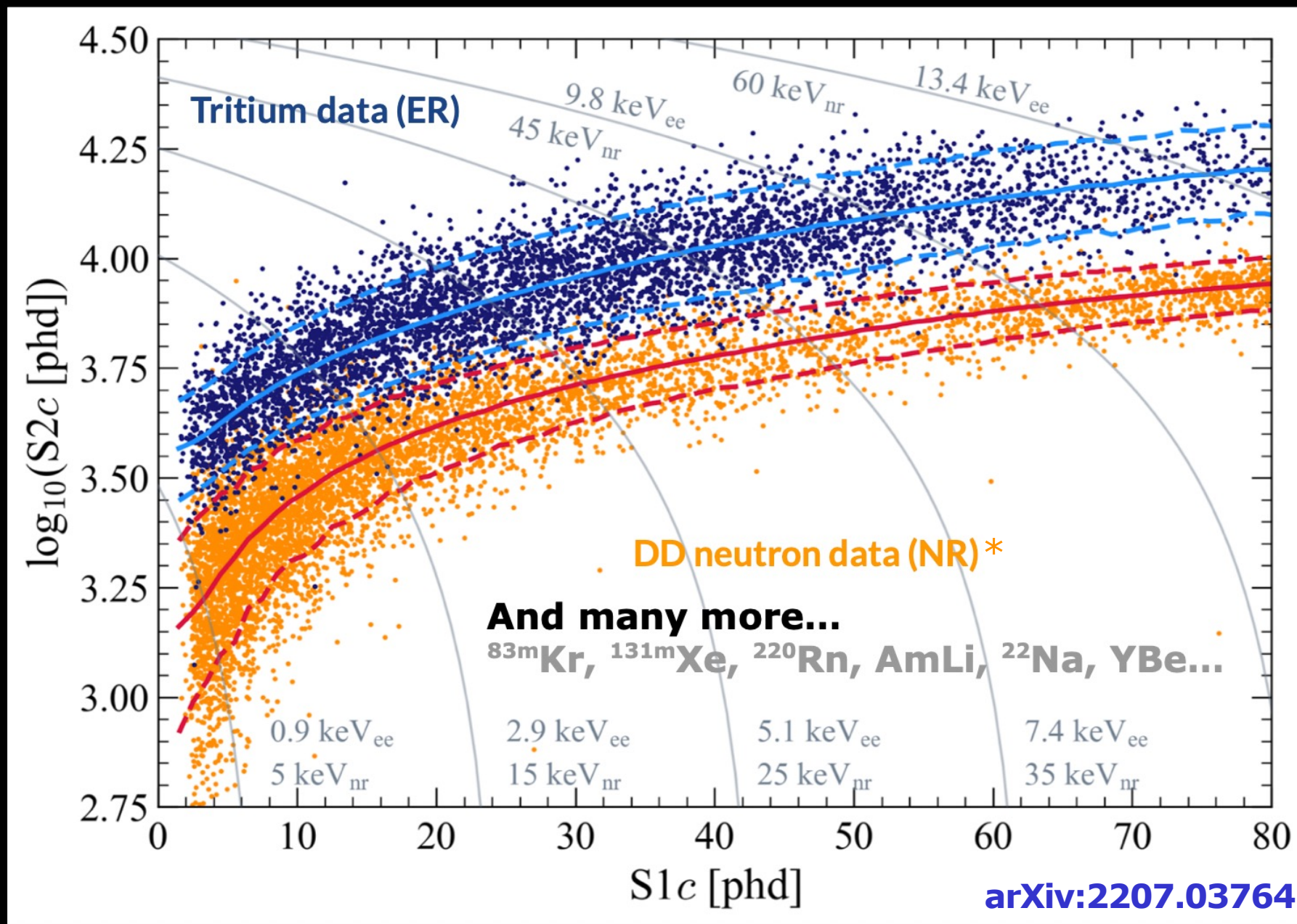
Combined science/engineering run: **no bias mitigation**



COMPREHENSIVE CALIBRATION CAMPAIGN

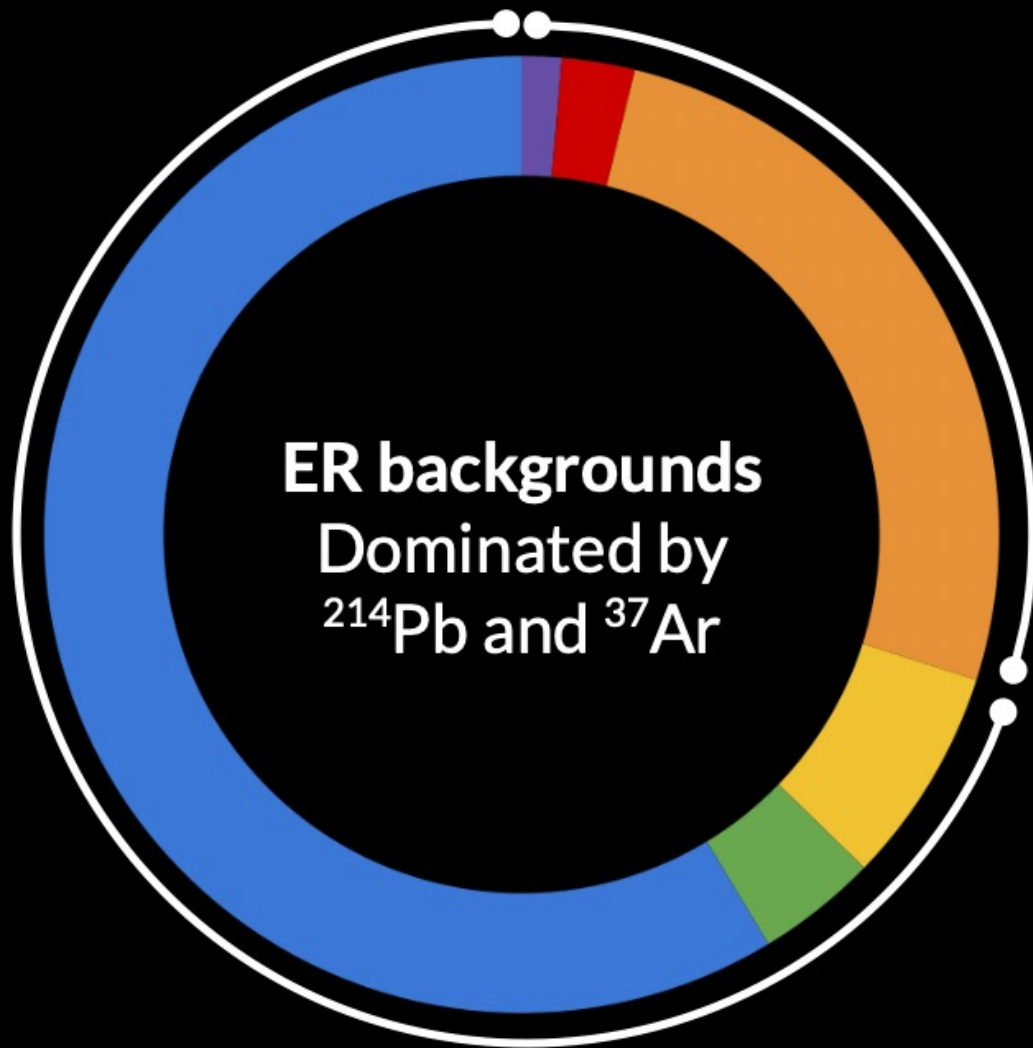


Dispersed and external radioactive sources, to calibrate detector response of TPC, skin, and OD

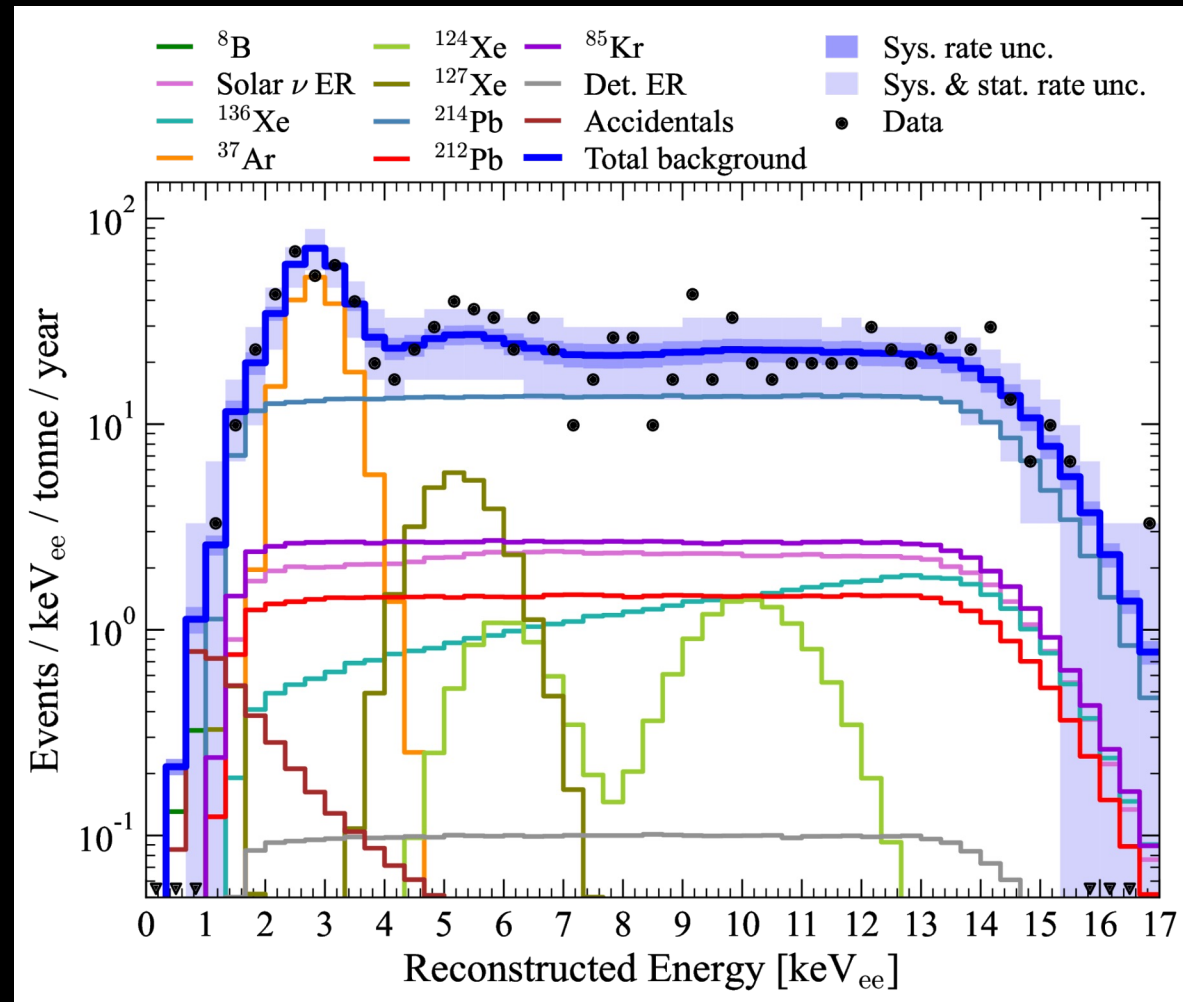


* More on DD sources today 5pm

DETAILED BACKGROUND MODEL



See Amy Cottle's talk
today at 3:30pm and
[arXiv:2211.17120v1](https://arxiv.org/abs/2211.17120v1)



WIMP DATASET: EVENT SELECTIONS



All triggers

Time hold-offs

high rates of spurious instrumental activity, dominated by post-S2 hold-off (70% live fraction)

Low energy single scatters

$3 < S1c < 80$ phd, $S2c > 600$ phd ($10e^-$)

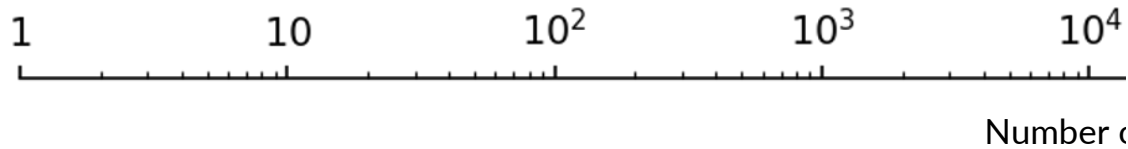
Pulse quality cuts

target accidental coincidence events

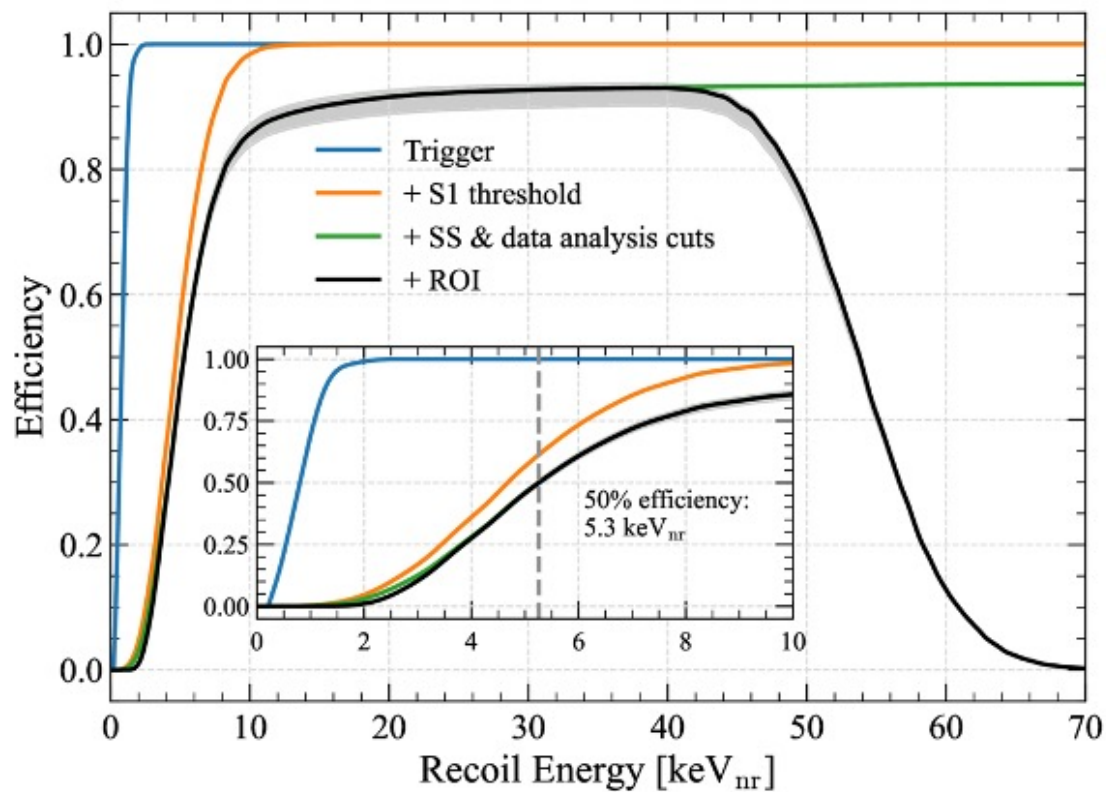
Fiducial volume

central 5.5 tonnes of LXe

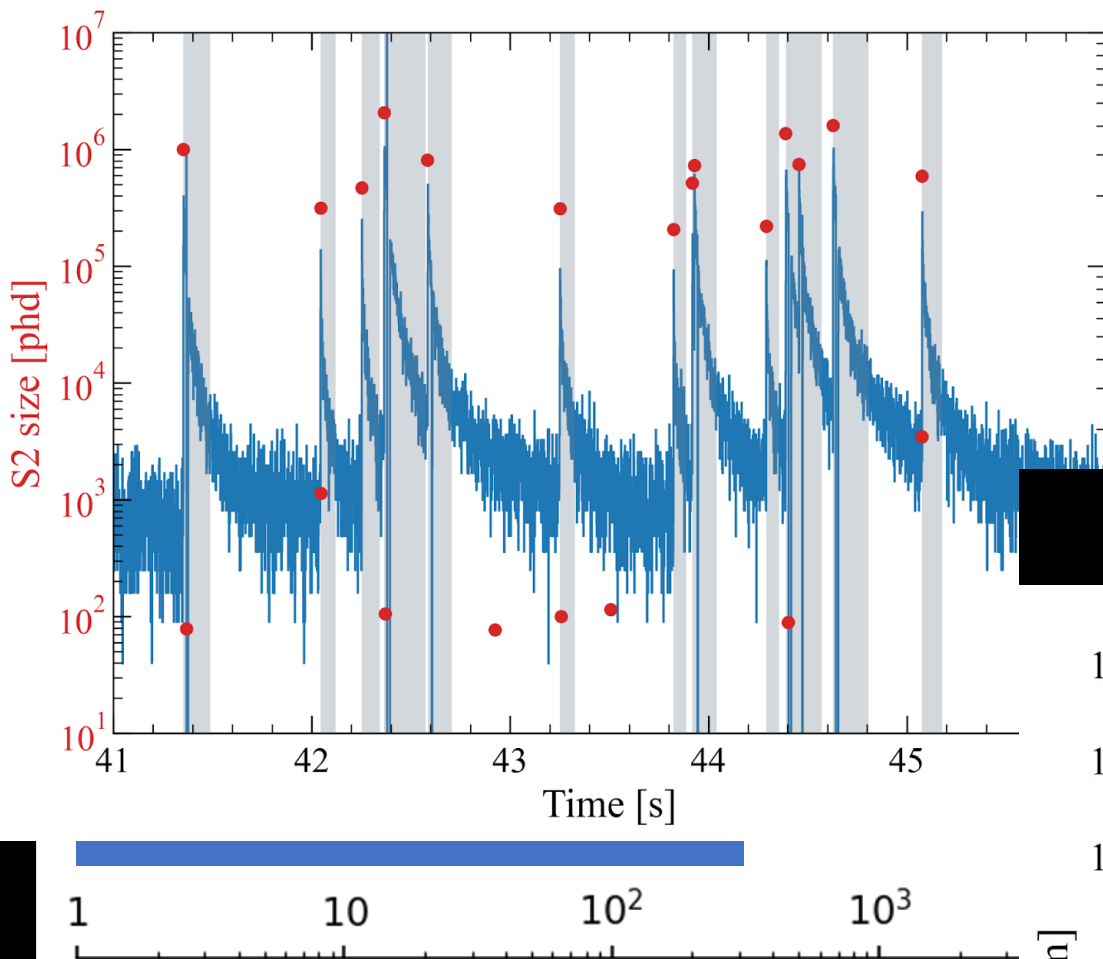
OD + Skin vetoes



Signal efficiency evaluated using tritium and AmLi calibration data



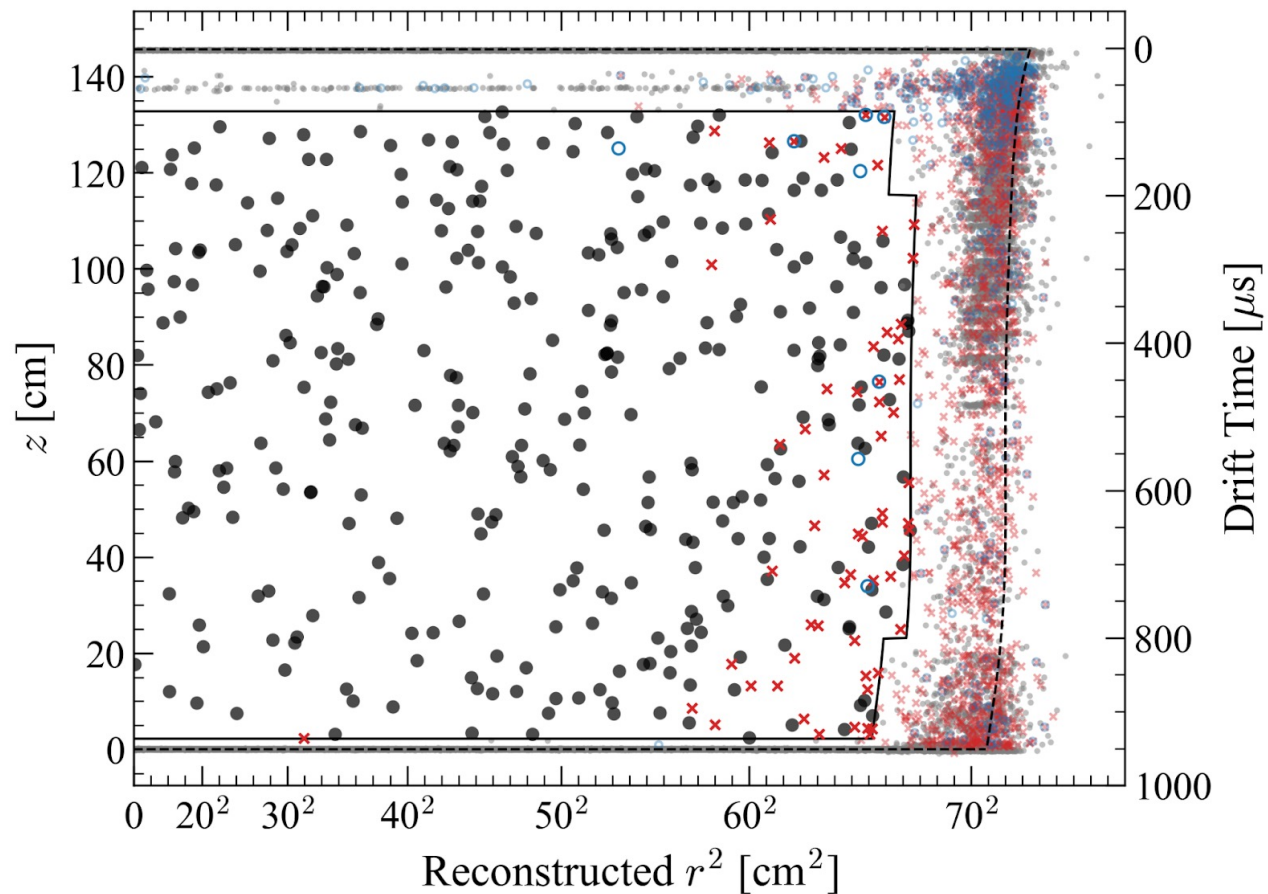
WIMP DATASET: EVENT SELECTIONS



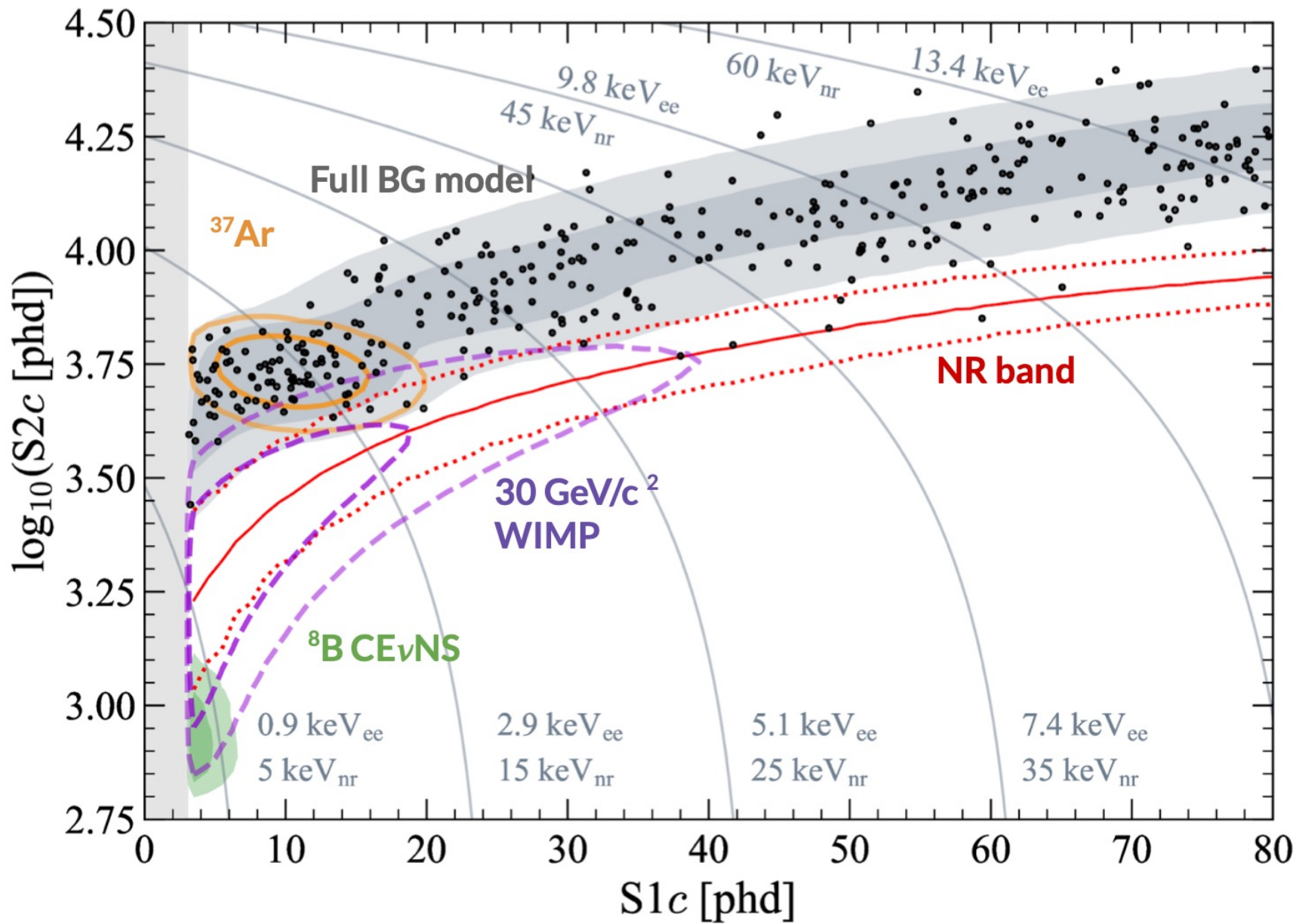
Post-S2 Holdoff
(30% livetime loss)

(70% live fraction)

5.5 tonne inner volume



THE FINAL WIMP SEARCH DATASET



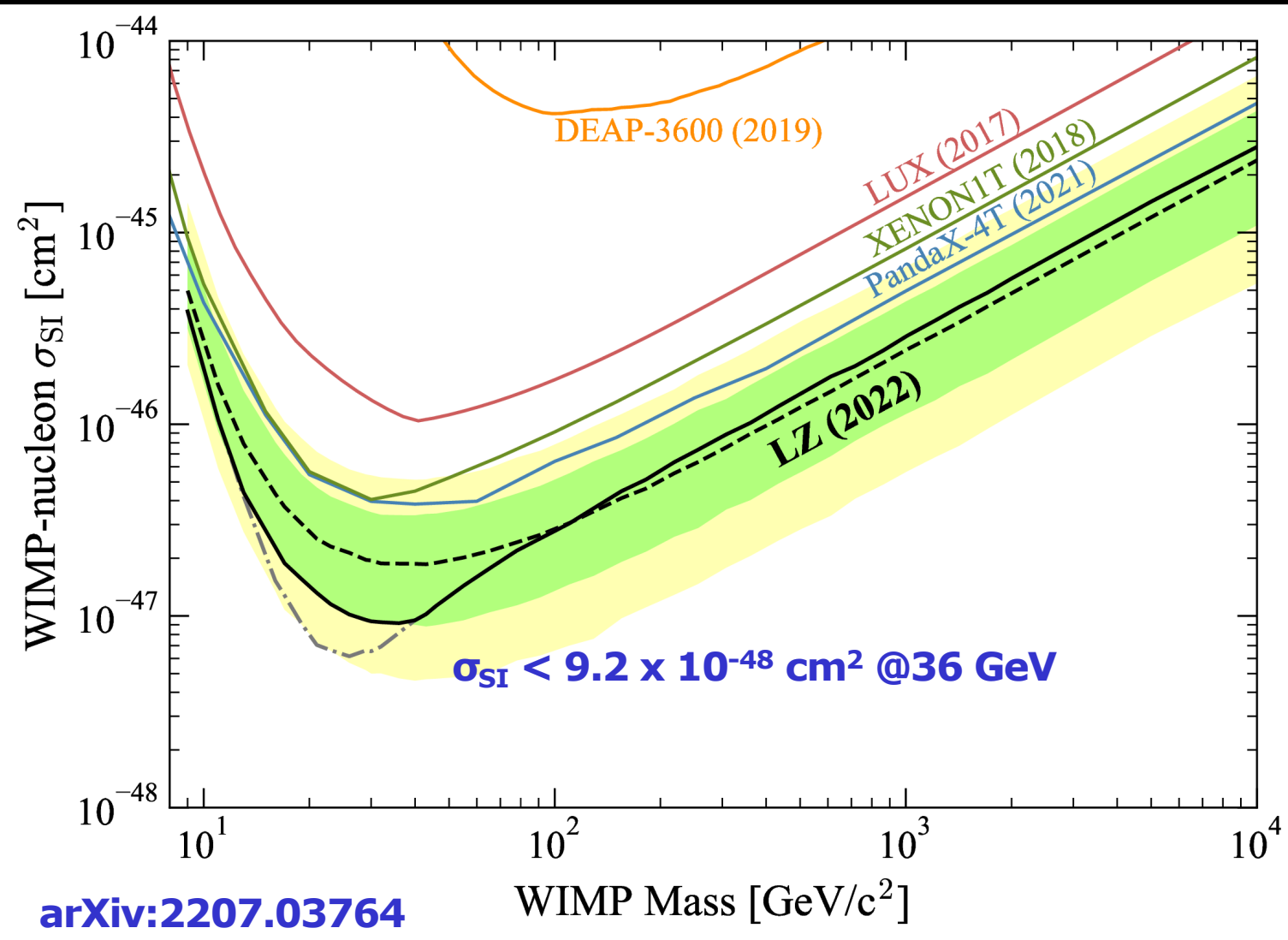
- **335 evts** surviving all cuts
- **60 ± 1** live days
- **5.5 ± 0.2** tonne FV

[More on ³⁷Ar today at 5pm]

Best fit with zero WIMP events at all masses 💔



WORLD-LEADING SENSITIVITY TO WIMPS



Power-Constrained Limit defined using "discovery power"

D. Baxter, et al.
Recommended conventions for reporting results from direct dark matter searches
European Physical Journal C, 81, 907 (2021)

Now updated to use "rejection power"

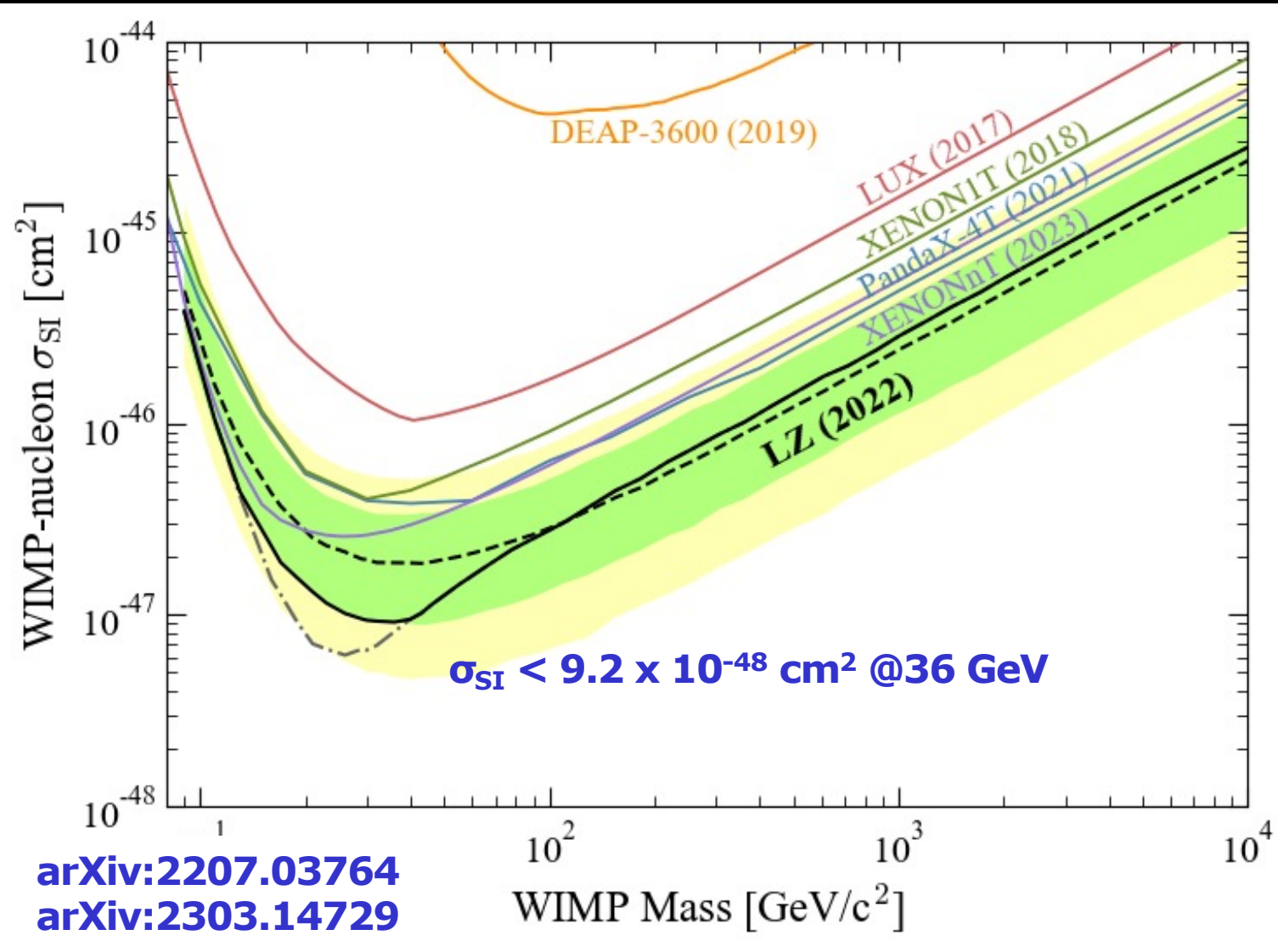
G. Cowan, K. Cranmer, E. Gross, O. Vitells,
Power-Constrained Limits
arxiv:1105.3166.

Critical threshold set to 0.16 (~ 1 sigma)

Eternal gratitude to "Reviewer B" who pointed out the issue!



WORLD-LEADING SENSITIVITY TO WIMPS



Power-Constrained Limit defined using "discovery power"

D. Baxter, et al.
Recommended conventions for reporting results from direct dark matter searches
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Now updated to use "rejection power"

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Power-Constrained Limits
arxiv:1105.3166.

+ adding recent result from XENONnT

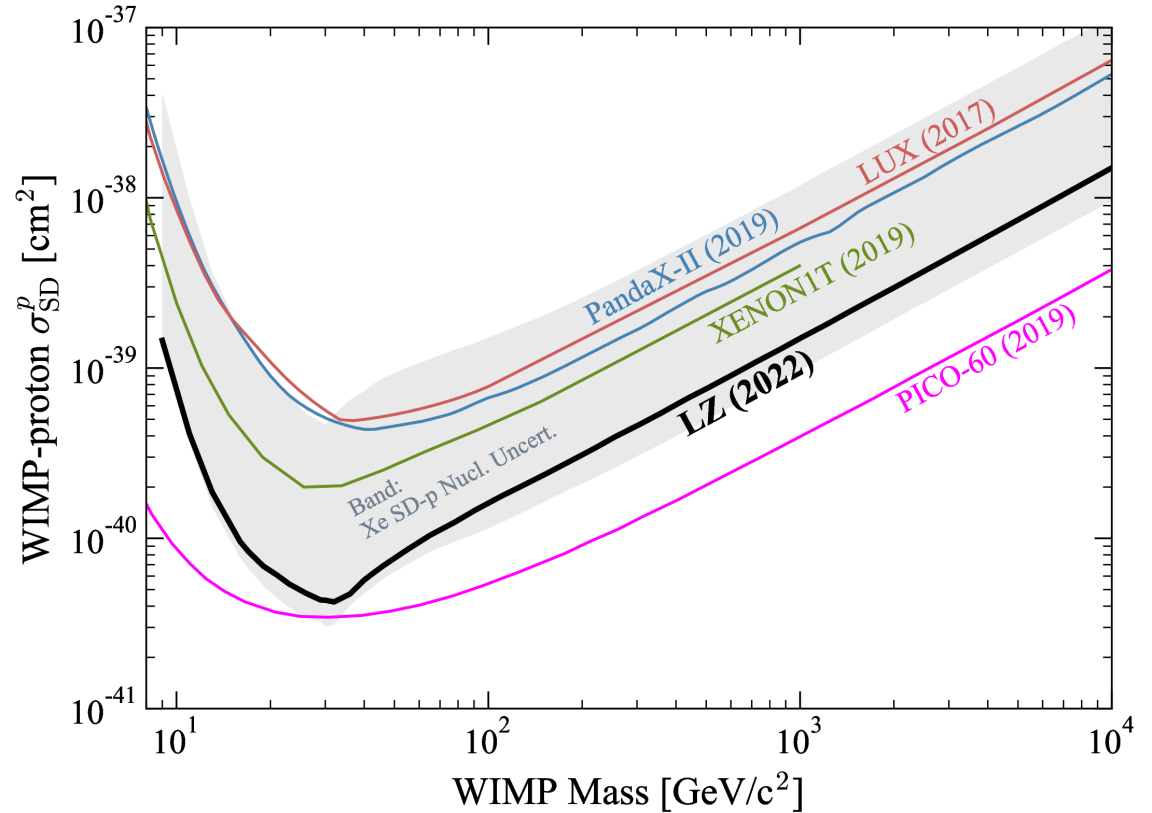
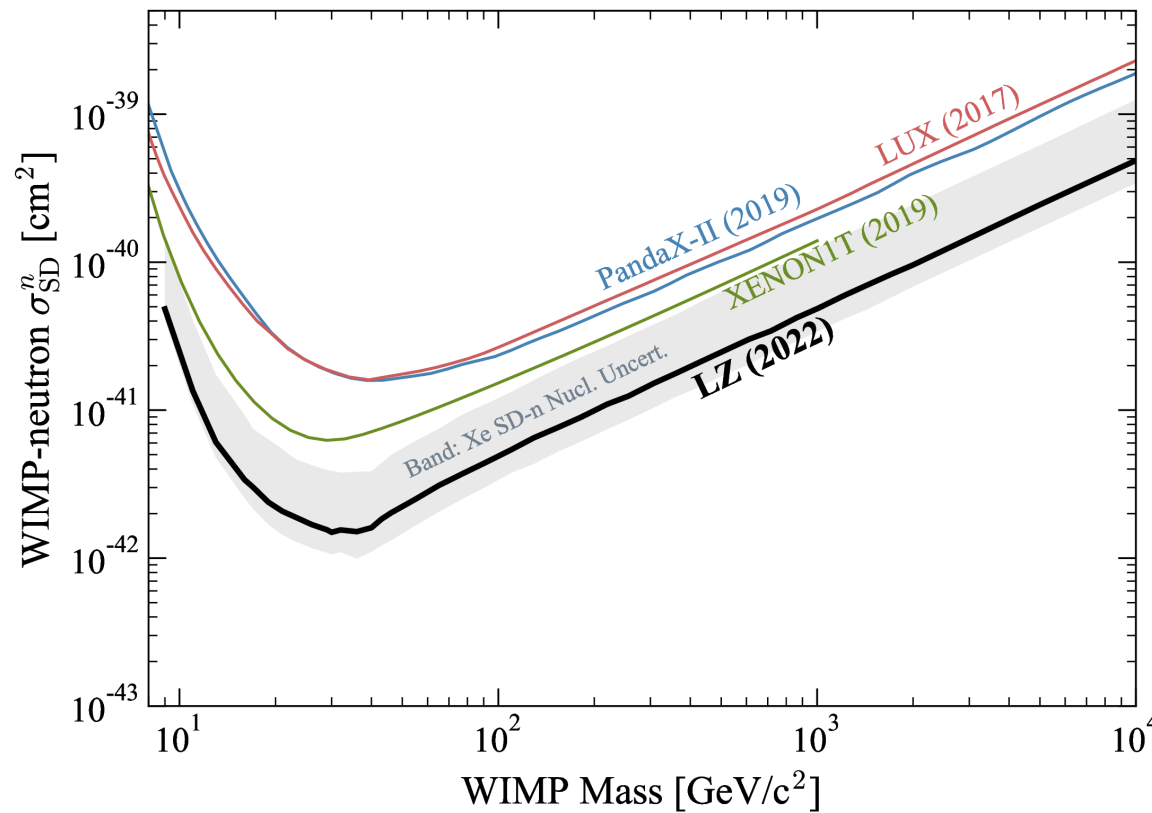
Both curves constrained here at ~ 1 sigma for comparison

New conventions needed for the direct detection community?

SPIN-DEPENDENT LIMITS



SD WIMP-neutron scattering SD WIMP-proton scattering



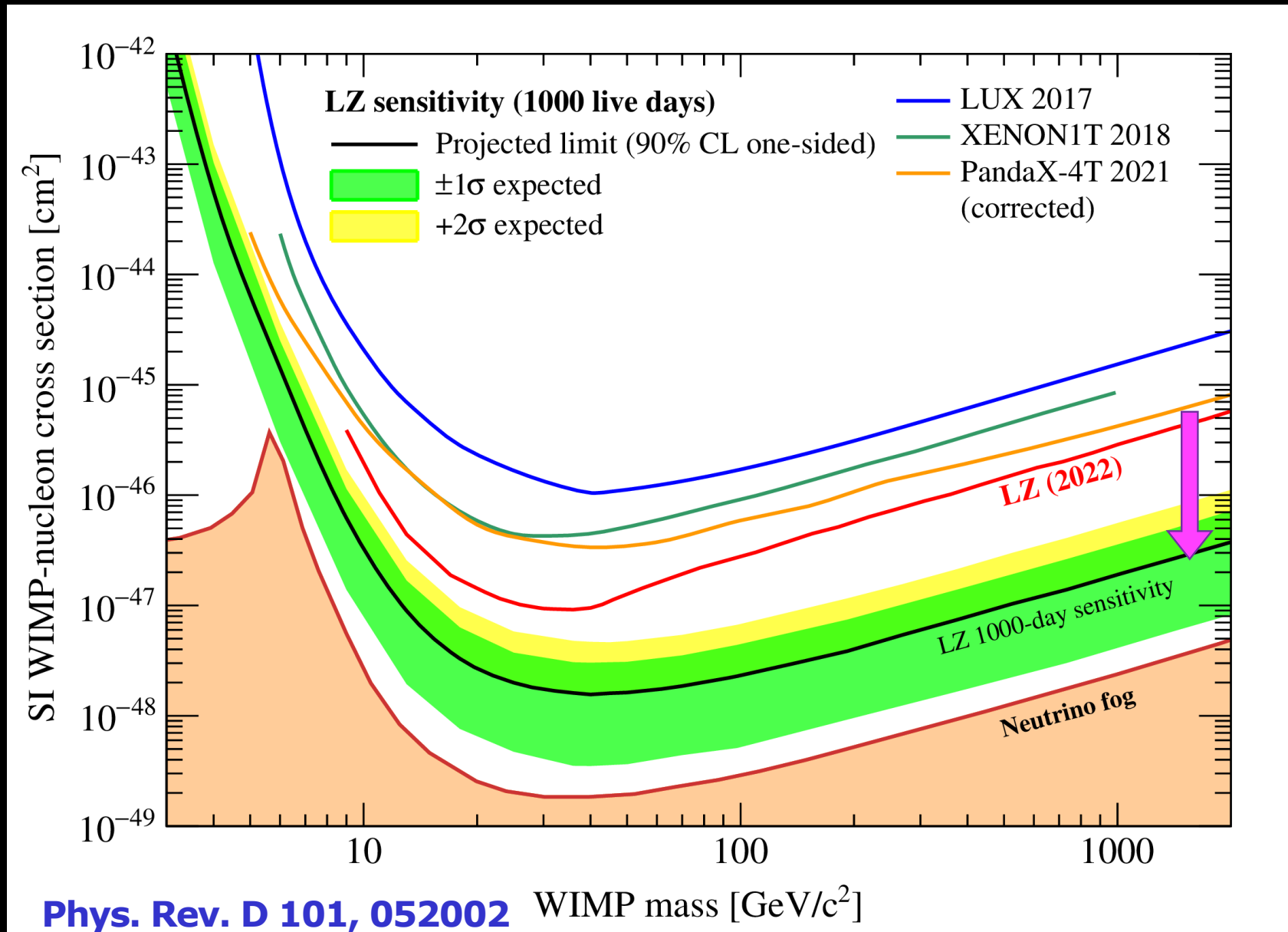
Uncertainty bands represent **theoretical uncertainty on nuclear form factor** for Xe - "Brazil" band omitted for clarity

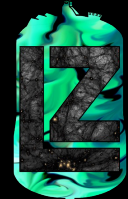


OK, WHAT'S NEXT FOR LZ?

Results cover **6%** of planned **1000-day exposure**

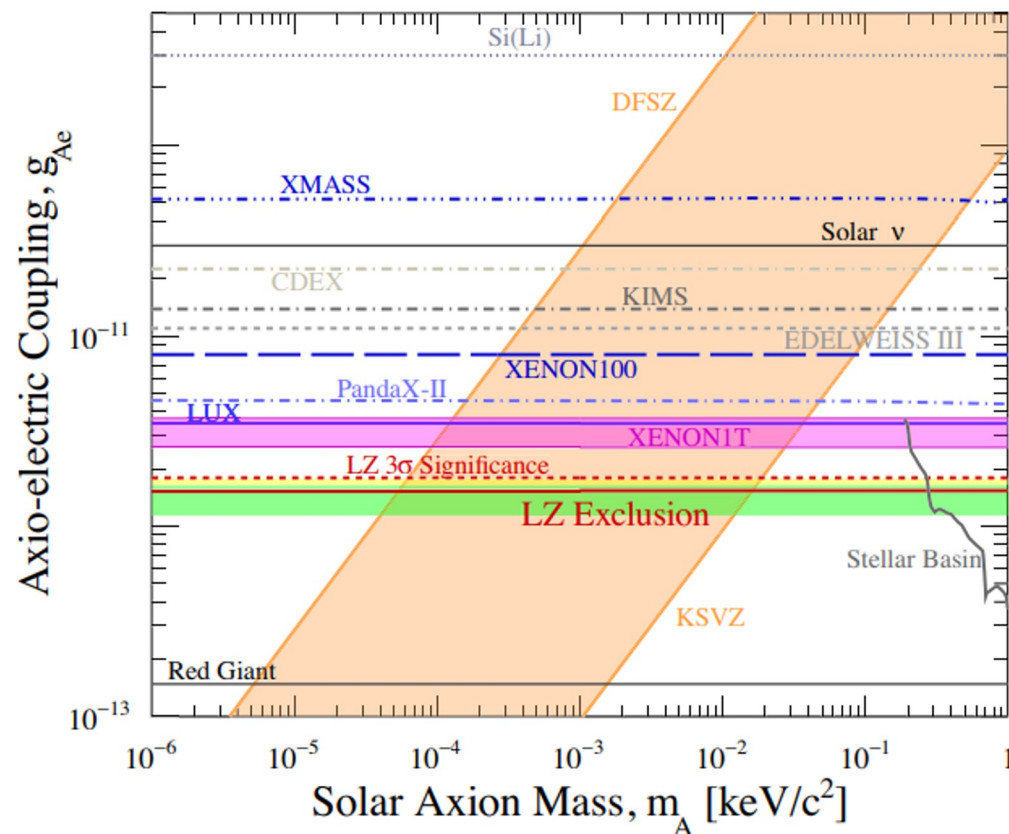
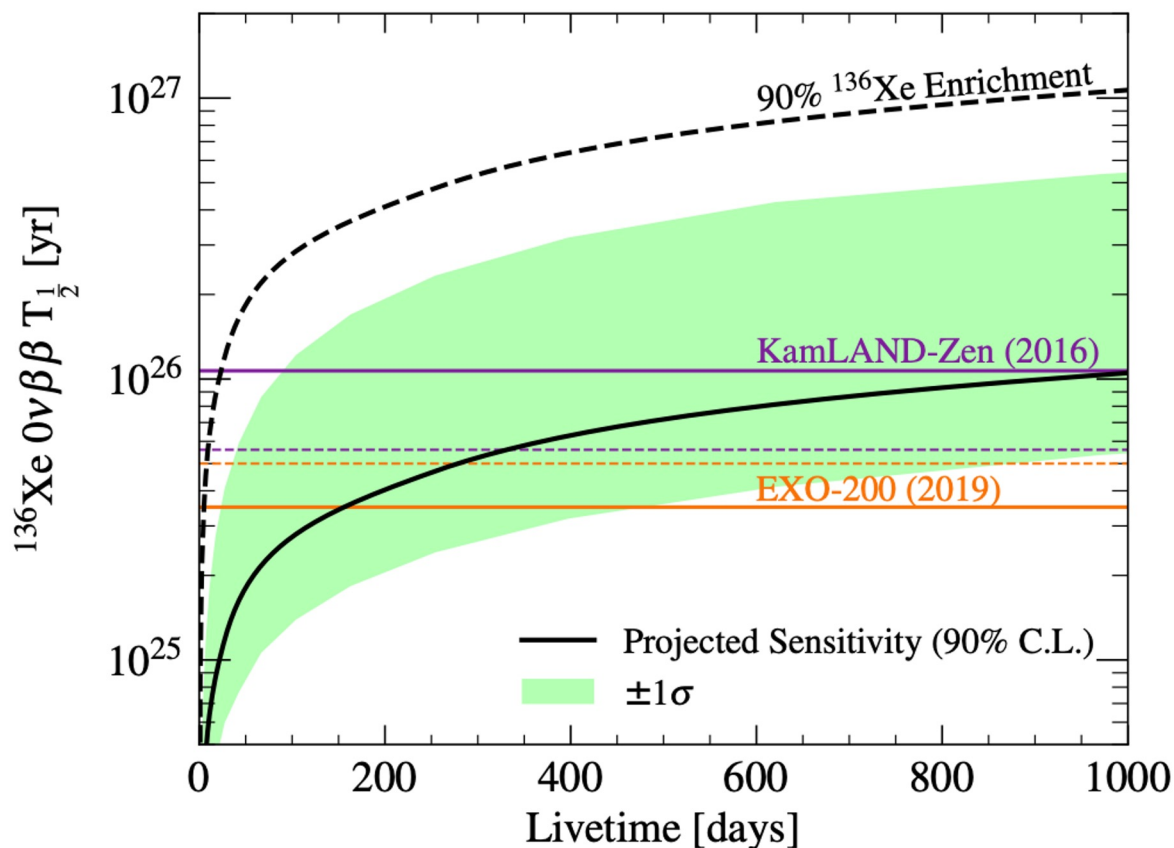
Second Science Run enters entirely unexplored EW parameter space: **Genuine discovery potential**





WHAT'S ELSE IS NEXT FOR LZ?

Broad science program including searches for non-WIMP dark matter, BSM physics & rare neutrino processes



Phys. Rev. C 102, 014602 (2020) Phys. Rev. D 104, 092009 (2021)
Phys. Rev. C 104, 065501 (2021) E-Print arXiv:2101.08753 (2021)

A TEAM EFFORT! THE LZ COLLABORATION (PRE-PANDEMIC PHOTO AT SURF)



Thanks to our
sponsors and
participating
institutions!



U.S. Department of Energy
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MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

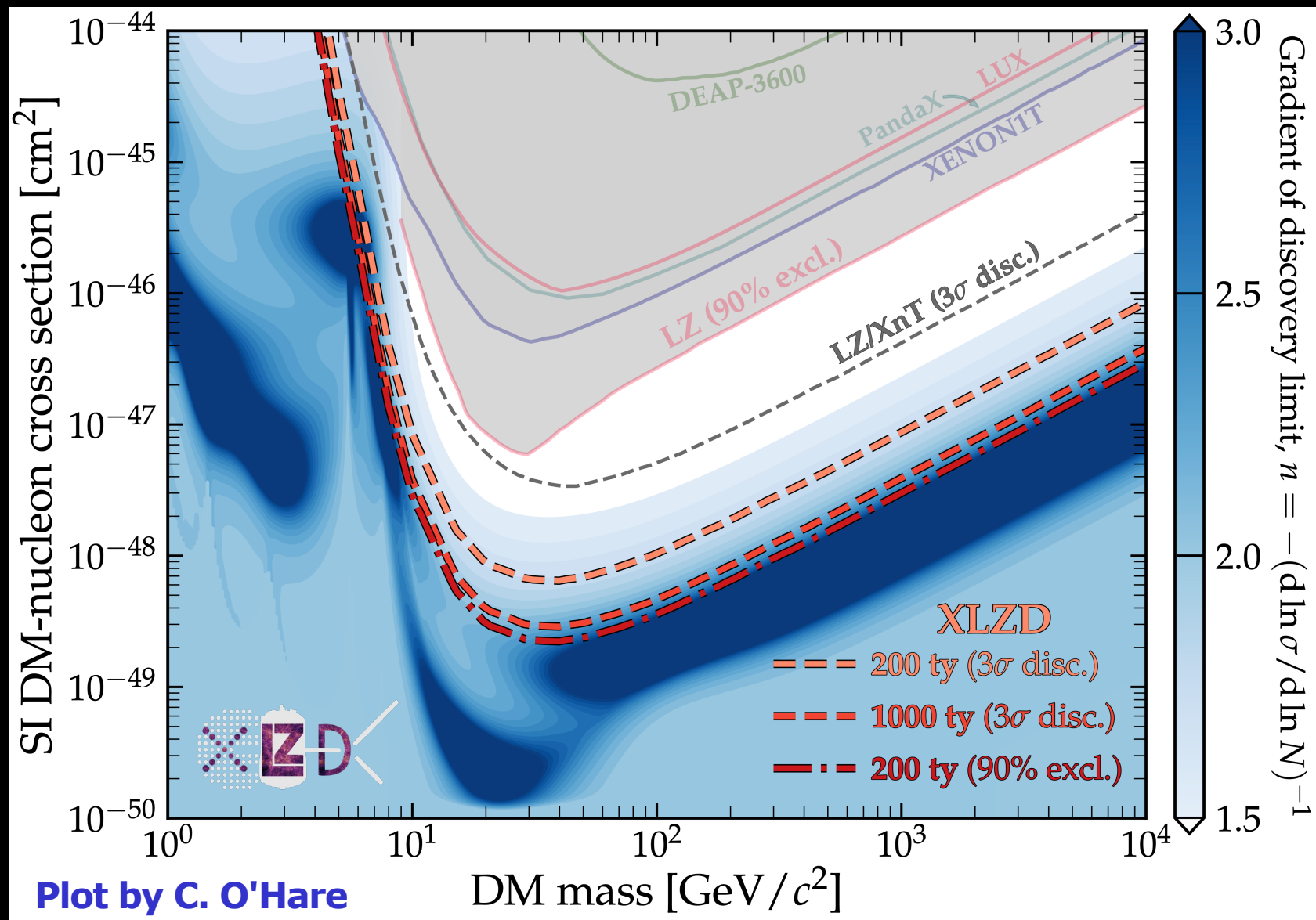


THE FUTURE-FUTURE PLAN: XLZD



LUX-ZEPLIN AND XENON-NT FORMED A CONSORTIUM TO BUILD THE ULTIMATE LXE DARK MATTER DETECTOR

100-TONNES
SCALE LXE
DETECTOR
OBSERVATORY
REACH DOWN
AND INTO THE
NEUTRINO FOG
2ND IN PERSON
MEETING NEXT
WEEK @ UCLA



SUMMARY & OUTLOOK

- **LXe TPC technology** leading direct detection since 2007
- LZ is probing the $10^{-48} \text{ cm}^2 \sigma_{\text{SI}}$ range for the first time, with only 6% of planned exposure.
- Vast discovery space ahead + **multiple physics channels**
- **XLZD consortium** will build the **ultimate** WIMP detector

Additional LZ talks scheduled for today:

- Ibles Olcina Samblas (9:30 am): New constraints on ultra heavy dark matter from the LUX-ZEPLIN (LZ) experiment
- Amy Cottle (3:30 pm): Background determination for the LUX--ZEPLIN experiment
- Jeanne Bang (5:00 pm): Migdal Search in LUX-ZEPLIN Dark Matter Experiment

Ideas on potential LZ upgrades (still today):

- Scott Haselschwardt (4:00 pm): First measurement of discrimination between helium and electron recoils in liquid xenon as a means for detecting sub-GeV dark matter (HydroX)
- Hao Chen (6:15 pm): A crystalline xenon TPC to reach the neutrino detection limit



IZ

BACKUPS

POWER CONSTRAINT: 1-SIGMA VS MEDIAN

