SLAC

# Status of the LZ Experiment

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For the LZ Collaboration
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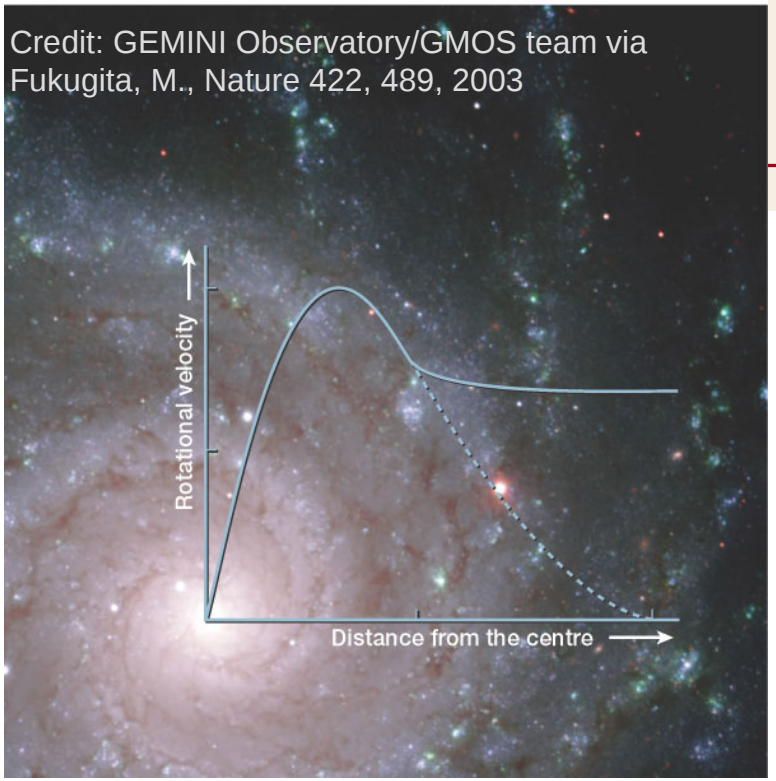
LLWI 2018


SLAC NATIONAL ACCELERATOR LABORATORY

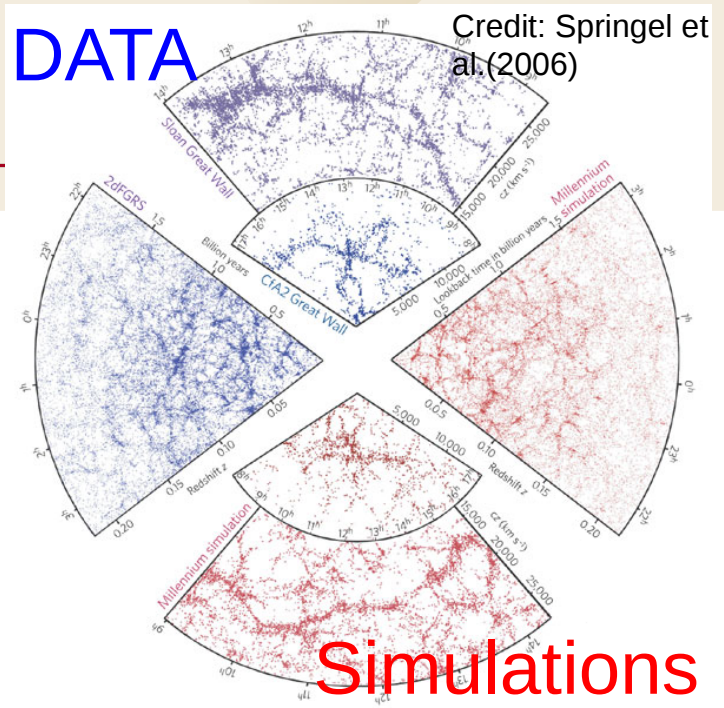
# LZ Collaboration


1. Center for Underground Physics (South Korea)
2. LIP Coimbra (Portugal)
3. MEPhI (Russia)
4. Imperial College London (UK)
5. Royal Holloway University of London (UK)
6. STFC Rutherford Appleton Lab (UK)
7. University College London (UK)
8. University of Bristol (UK)
9. University of Edinburgh (UK)
10. University of Liverpool (UK)
11. University of Oxford (UK)
12. University of Sheffield (UK)
13. Black Hill State University (US)
14. Brandeis University (US)
15. Brookhaven National Lab (US)
16. Brown University (US)
17. Fermi National Accelerator Lab (US)
18. Lawrence Berkeley National Lab (US)
19. Lawrence Livermore National Lab (US)
20. Northwestern University (US)
21. Pennsylvania State University (US)
22. SLAC National Accelerator Lab (US)
23. South Dakota School of Mines and Technology (US)
24. South Dakota Science and Technology Authority (US)
25. Texas A&M University (US)
26. University at Albany (US)
27. University of Alabama (US)
28. University of California, Berkeley (US)
29. University of California, Davis (US)
30. University of California, Santa Barbara (US)
31. University of Maryland (US)
32. University of Massachusetts (US)
33. University of Michigan (US)
34. University of Rochester (US)
35. University of South Dakota (US)
36. University of Wisconsin – Madison (US)
37. Washington University in St. Louis (US)
38. Yale University (US)

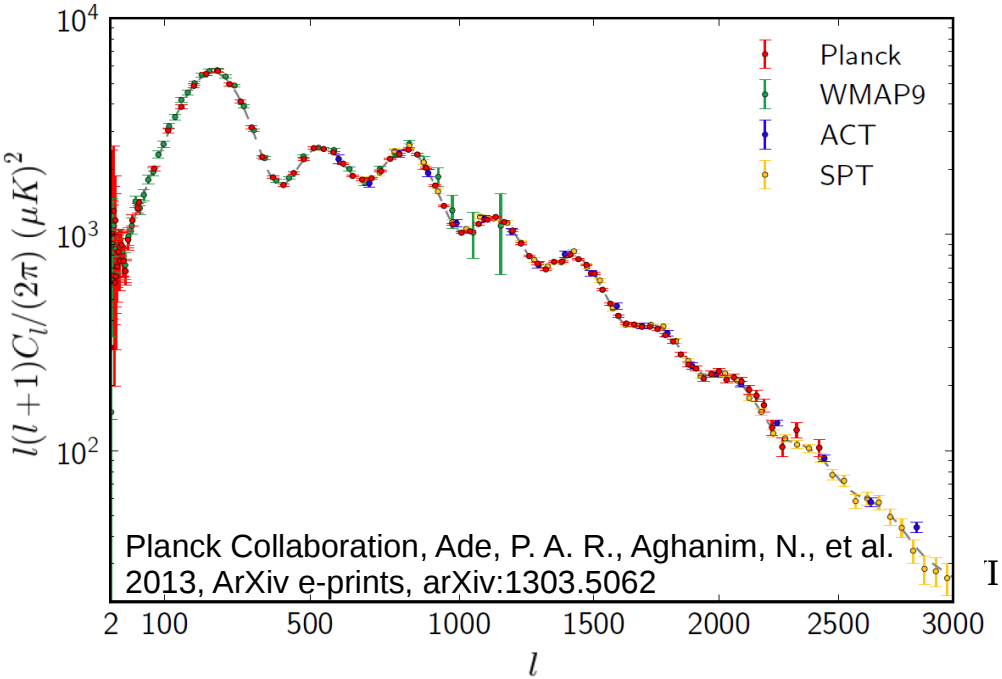



# Evidence For Dark Matter

DATA




Simulations




Planck Collaboration, Ade, P. A. R., Aghanim, N., et al. 2013, ArXiv e-prints, arXiv:1303.5062

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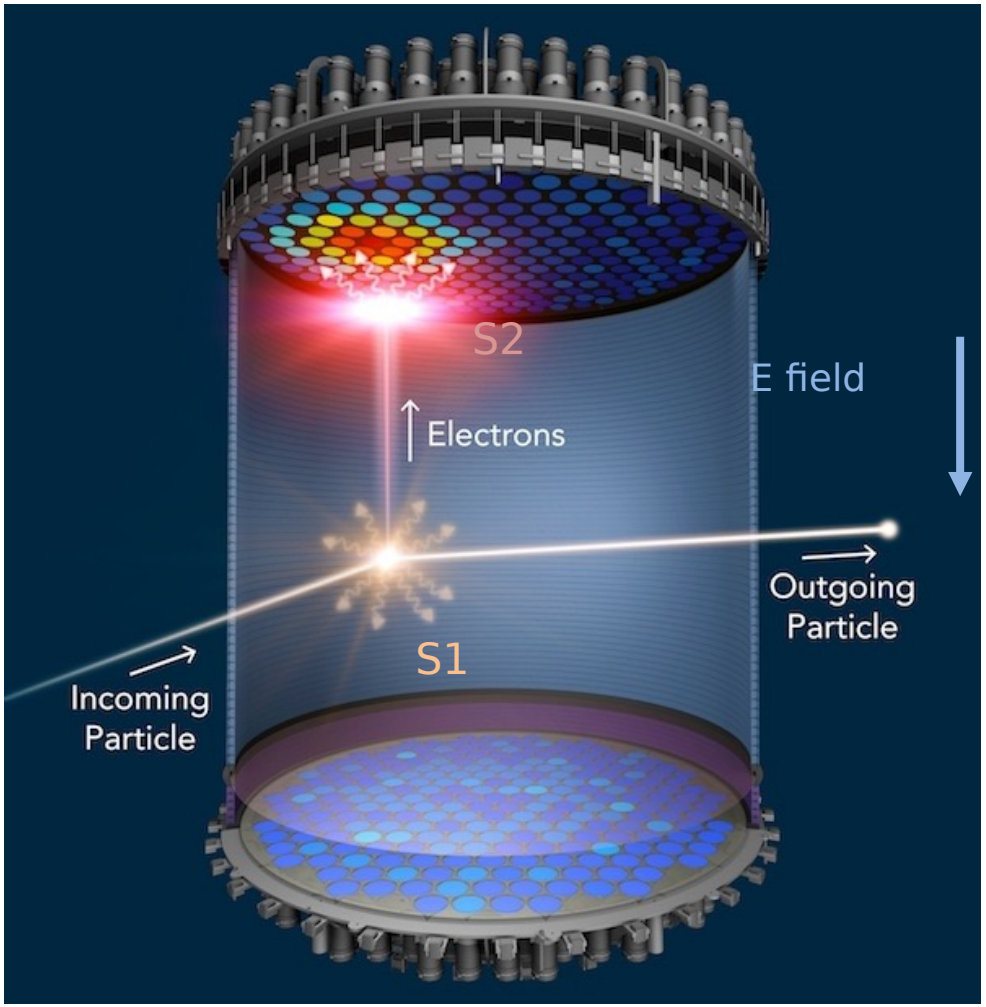
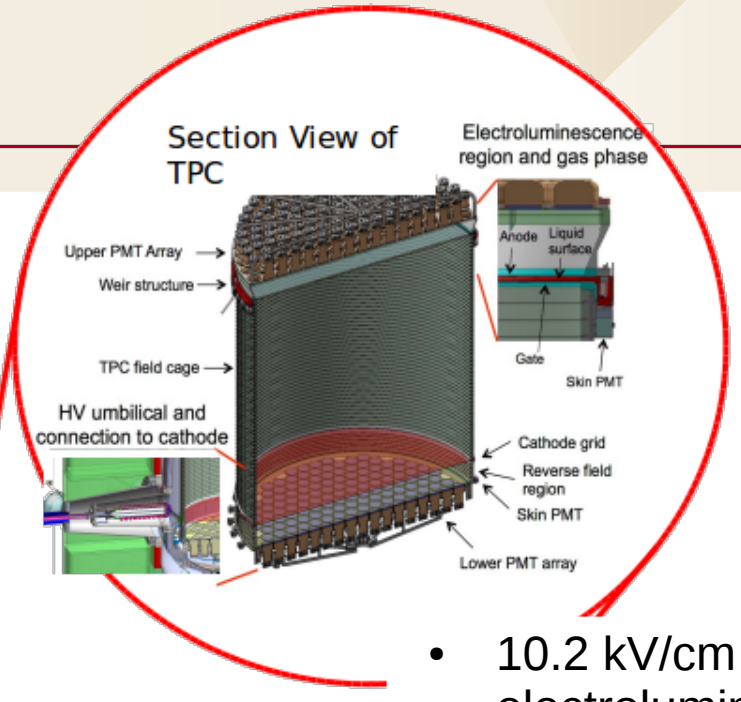
# Time Projection Chamber

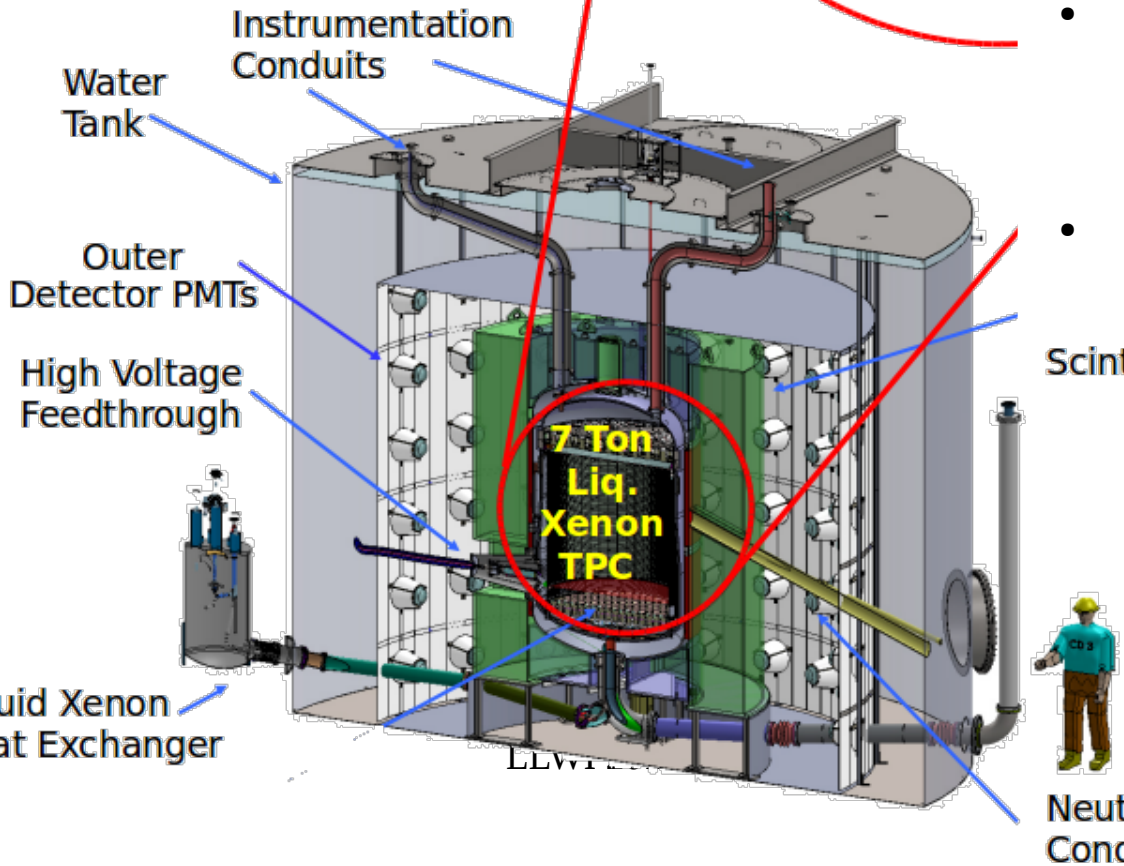
- LZ is a dual-phase time projection chamber (TPC)
- Particle collision → light (S1) + charge
- Charge is extracted → electroluminescence (S2)
- 3D position reconstruction
  - The S2 is localized in X-Y
  - Time difference between S1 and S2 gives depth
- Strengths of Xe TPCs
  - Self-shielding + position reconstruction → Fiducialization
  - S2/S1 ratio → BG discrimination




# LZ

- 10 tonnes total, 7 tonnes active, 5.6 tonnes fiducial
- 1.5 m diameter, 1.5 m height
- 2-component veto system: LXe skin and outer detector
- Gas circulation/purification system @ 500 slpm
- Internal an external calibration, ER and NR
- 494 3” PMTs in TPC




- 10.2 kV/cm electroluminescence field (11.5kV difference)
- 310 V/cm drift field (50kV Cathode)

# BG Controls

- Screening of ALL materials
  - About 50% done
    - See https://arxiv.org/abs/1702.02646 for example of the choice of Titanium
  - Includes radon assays
- On line radon removal system for most problematic components – warm cables
- Radon-reduced clean room for TPC assembly
- Exposure to dust tracked with witness plates
- Procedures and real-time quality controls

# Discrimination and Fiducialization

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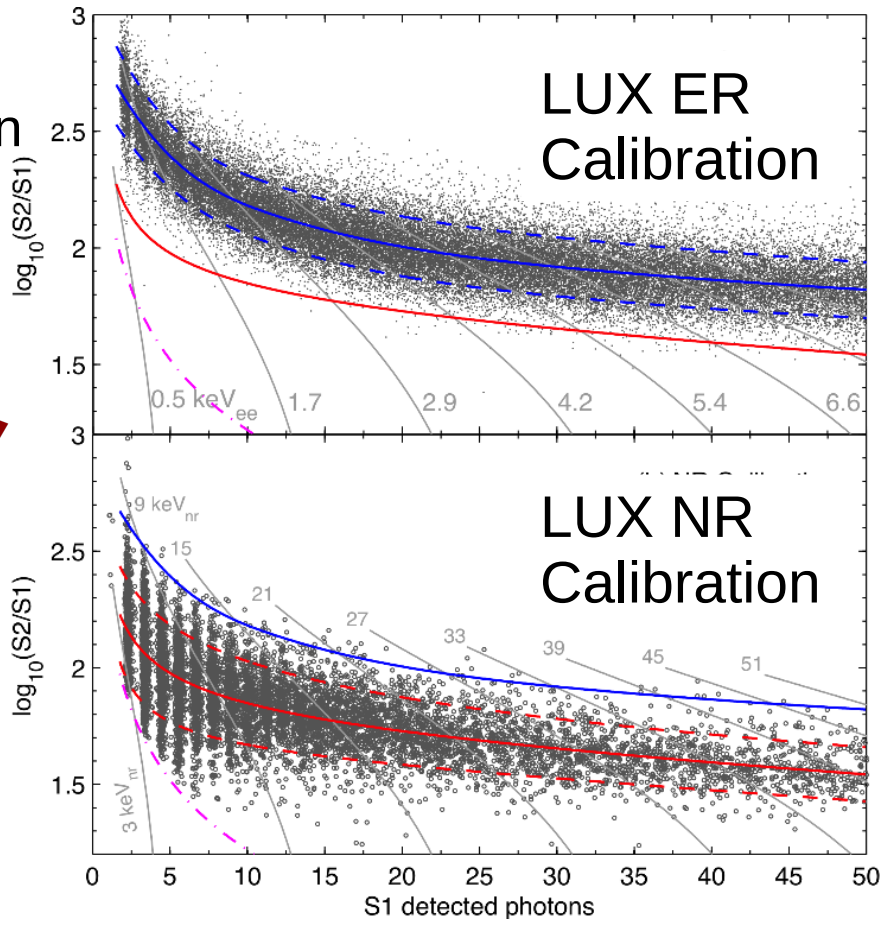
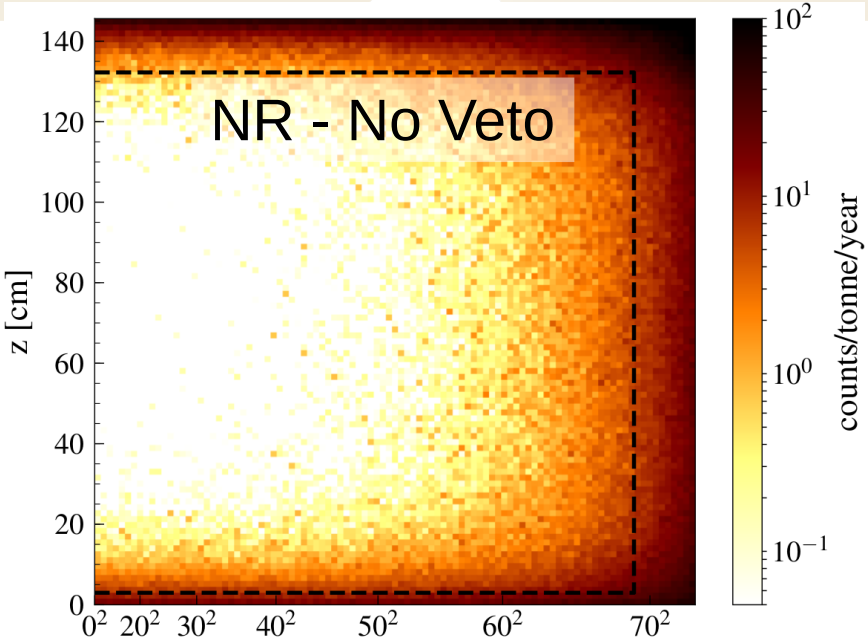
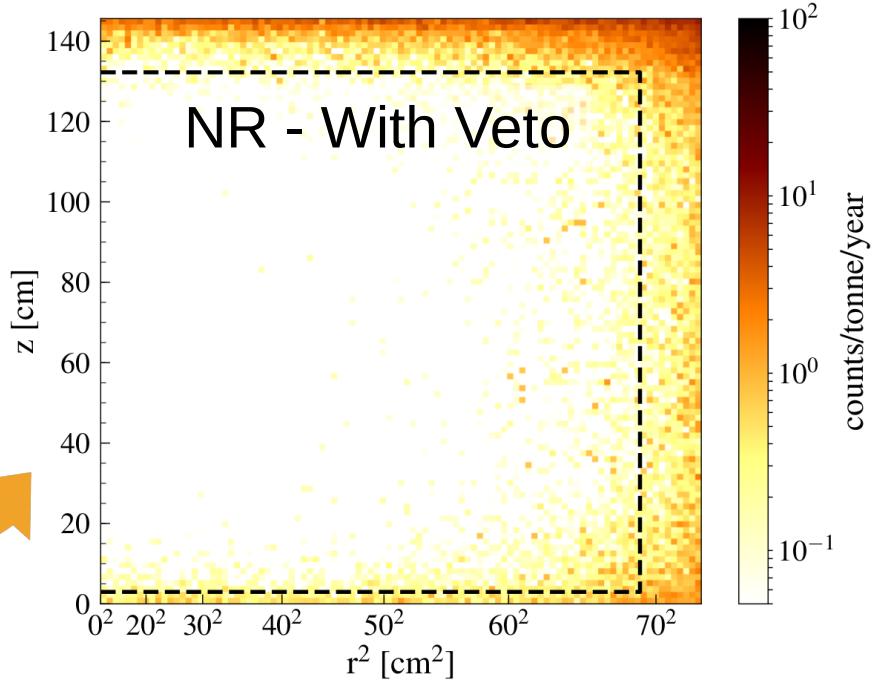
ER-NR discrimination thanks to S1 & S2




Xe skin and outer detector veto further reduce backgrounds (simulation shown)

# Backgrounds

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5.6 Tonne fiducial mass, 1000 live-days, ~1.5 - 6.5keV, single scatters and veto

| Background Source | ERs | NRs |
|---|---|---|
| Detector Components | 9 | 0.07 |
| Dispersed Radionuclides — Rn, Kr, Ar | 816 | — |
| Laboratory and Cosmogenics | 5 | 0.06 |
| Surface Contamination and Dust | 40 | 0.39 |
| Physics Backgrounds — 2β decay, neutrinos* | 322 | 0.51 |

* Not Including $^{8}$B and hep

Total (after 99.5% discrimination and 50% NR efficiency) 6.48

# Sensitivity

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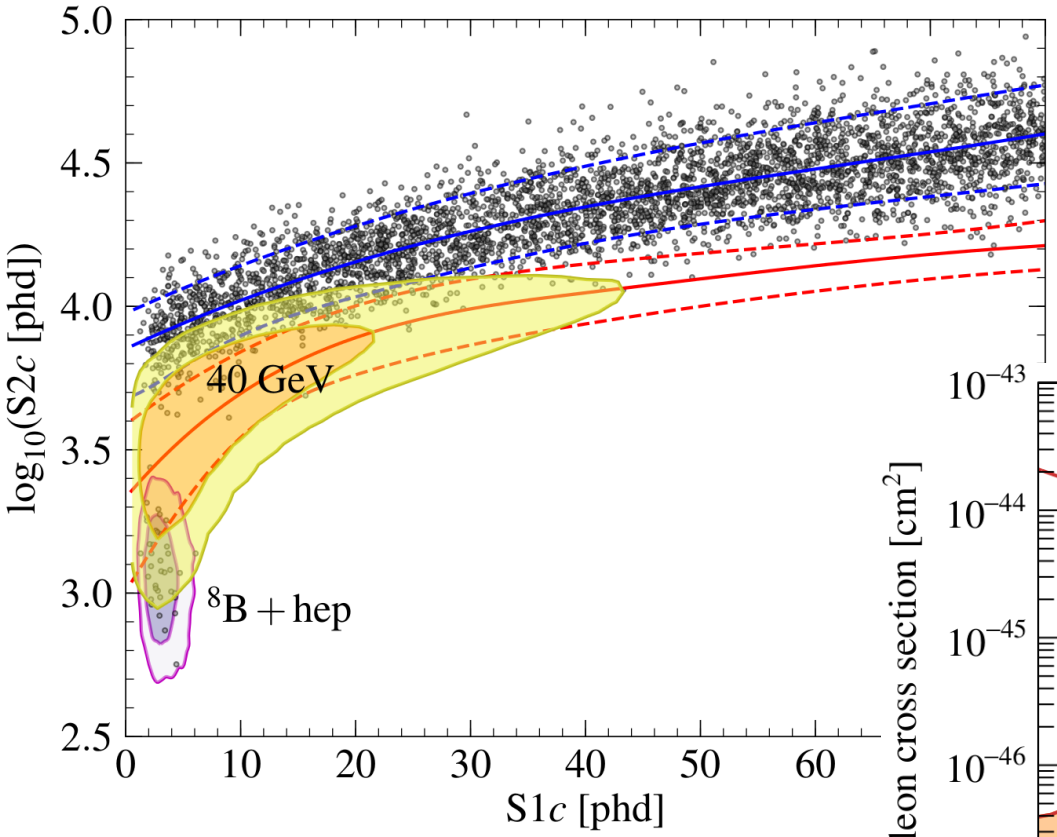
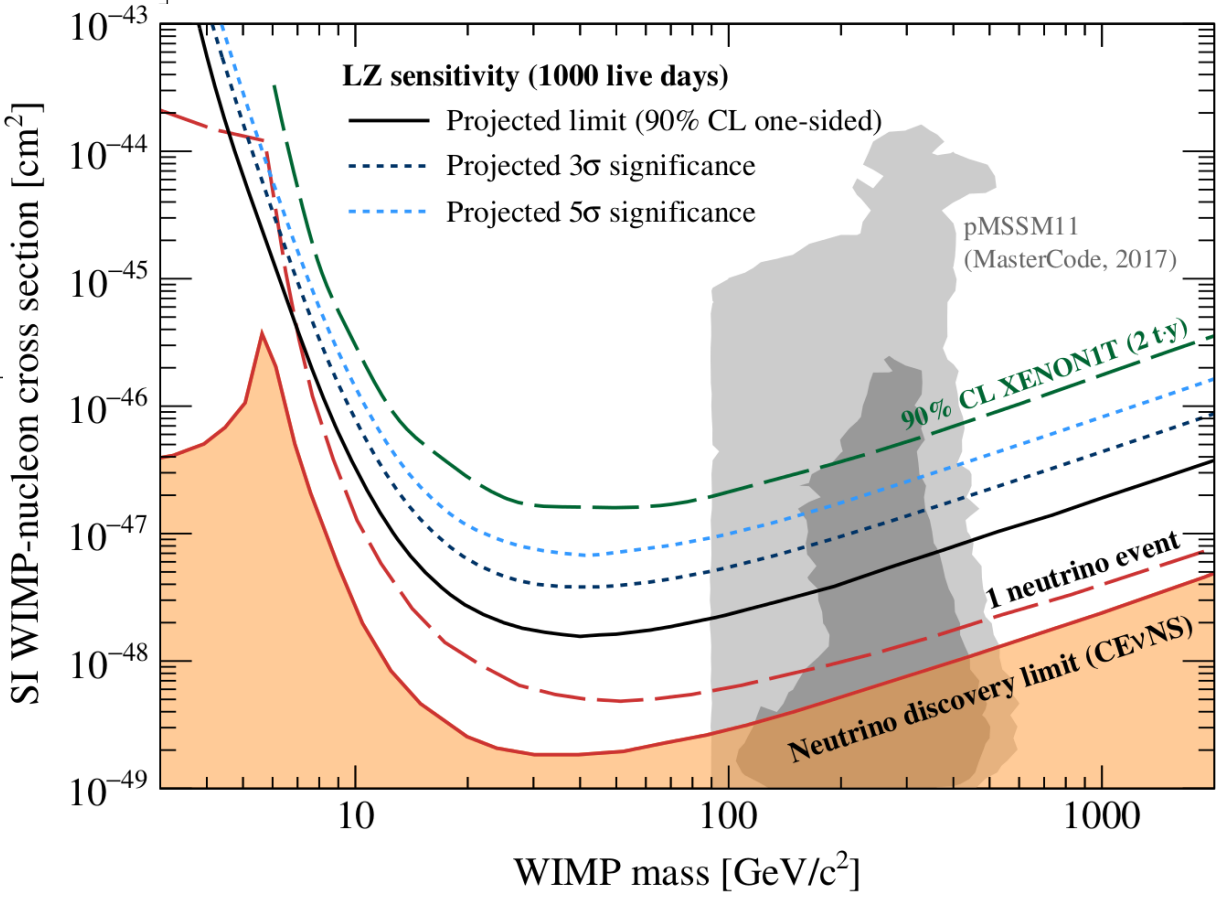



- Simulation of a 1000 day LZ run



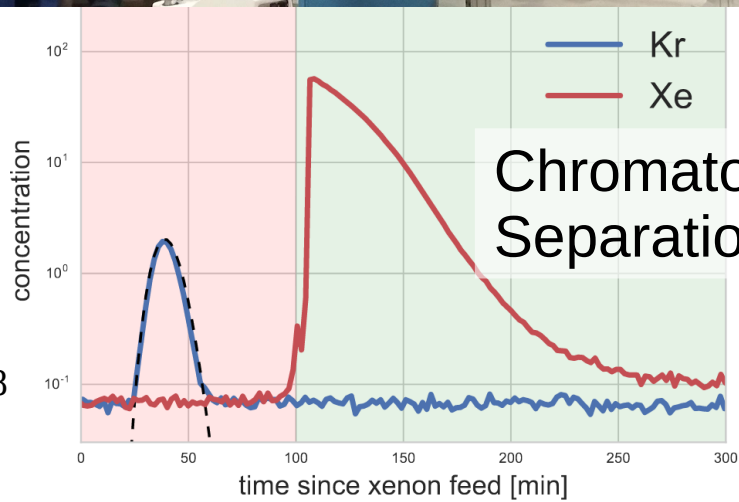

- Projected detection and exclusion curves for LZ

# Progress

# Xenon Procurement and Purification



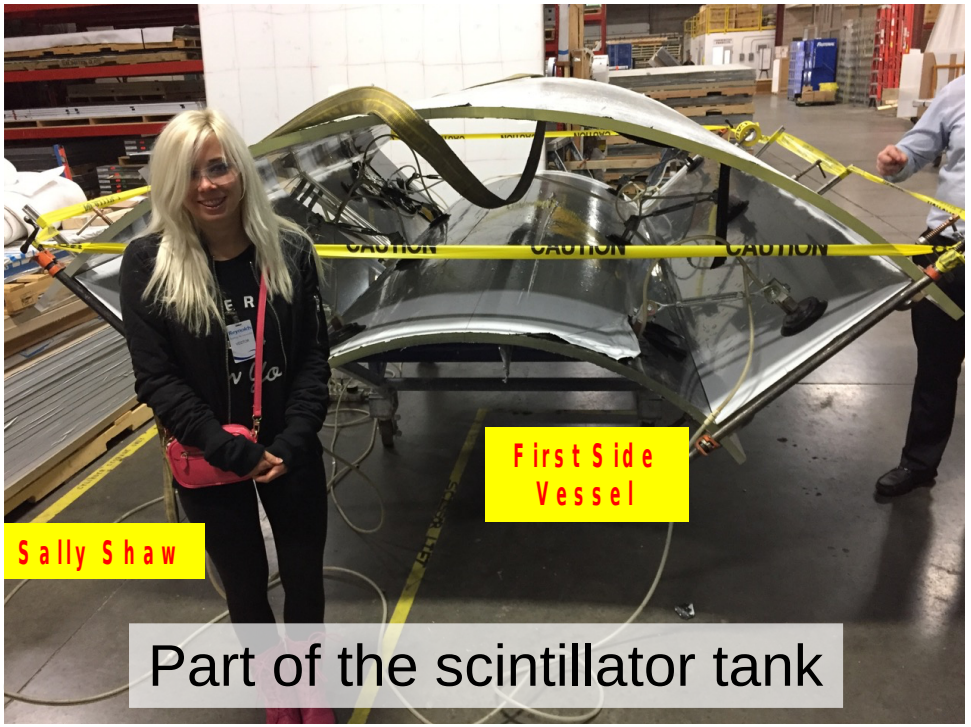
- 6.5 tonnes of Xe at SLAC
  - 4 tonnes to go
- Xenon purification via charcoal chromatography
  - https://arxiv.org/abs/1605.03844



# Xe & OD Vessels


Inner Vessel

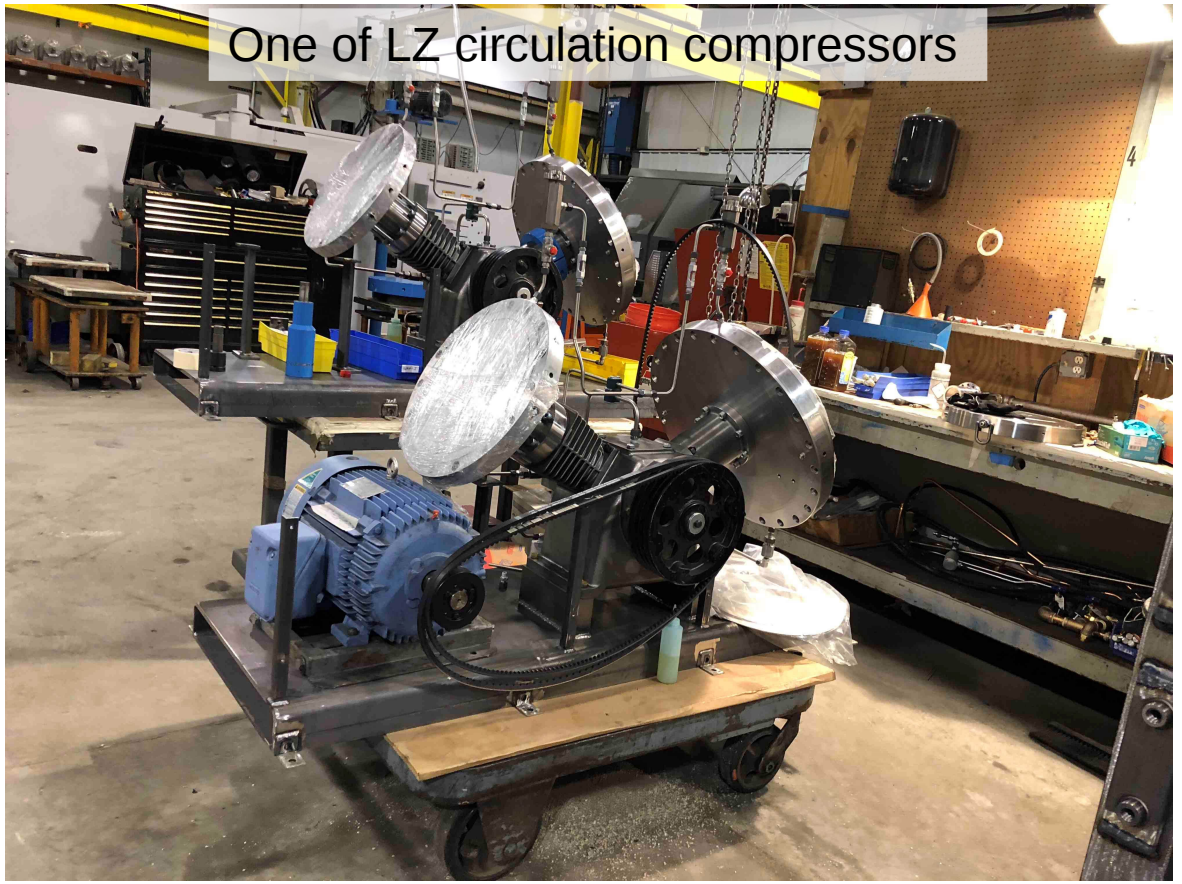
- Inner and outer vessels are finished, delivery soon
- Outer detector scintillator tanks finished this month



Part of the scintillator tank

# Xe Gas and Liquid Handling


- Circulation tests at ~70SLPM at SLAC
- LZ circulation system installed and tested underground at the end of 2018
  - Using a dummy cryostat

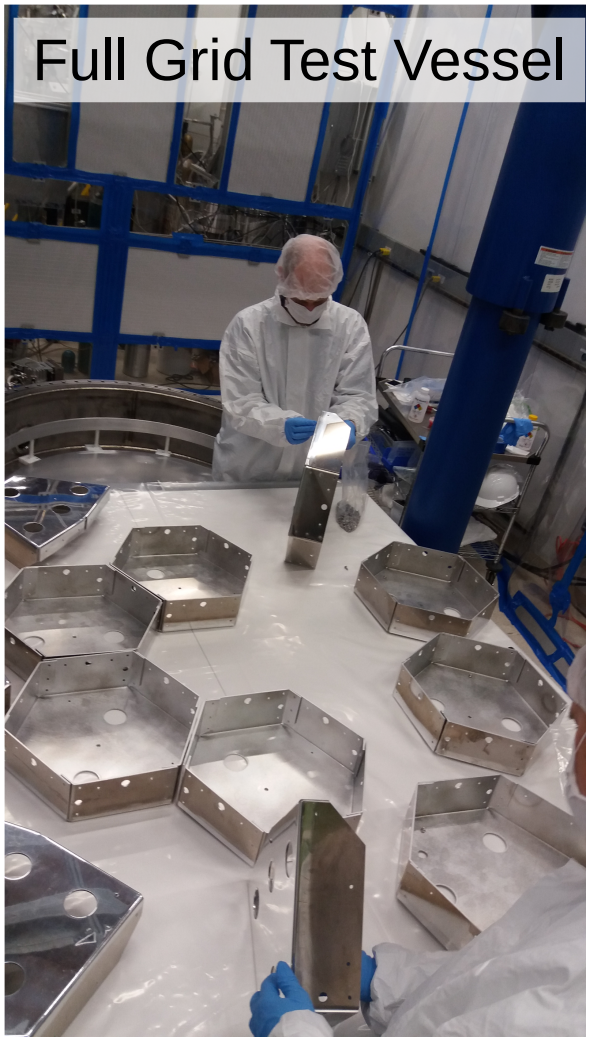


# HV Testing

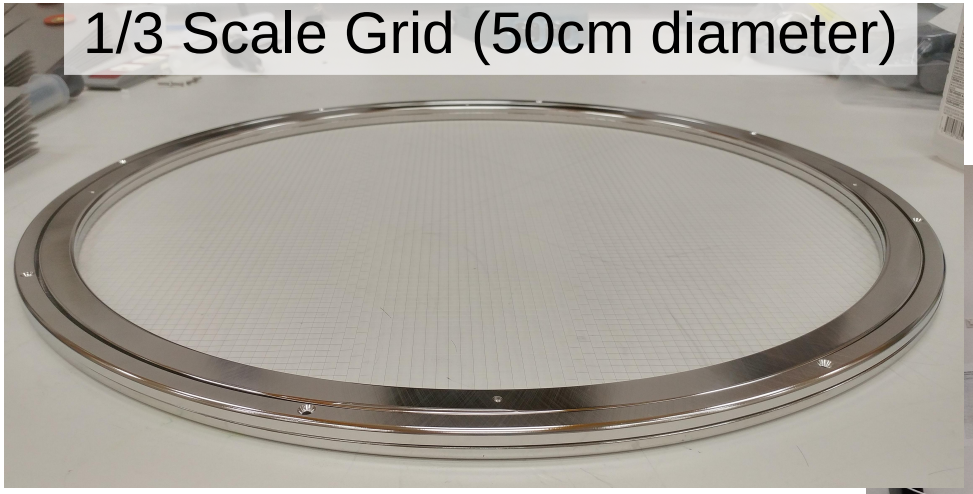

Cathode HV Test Structure

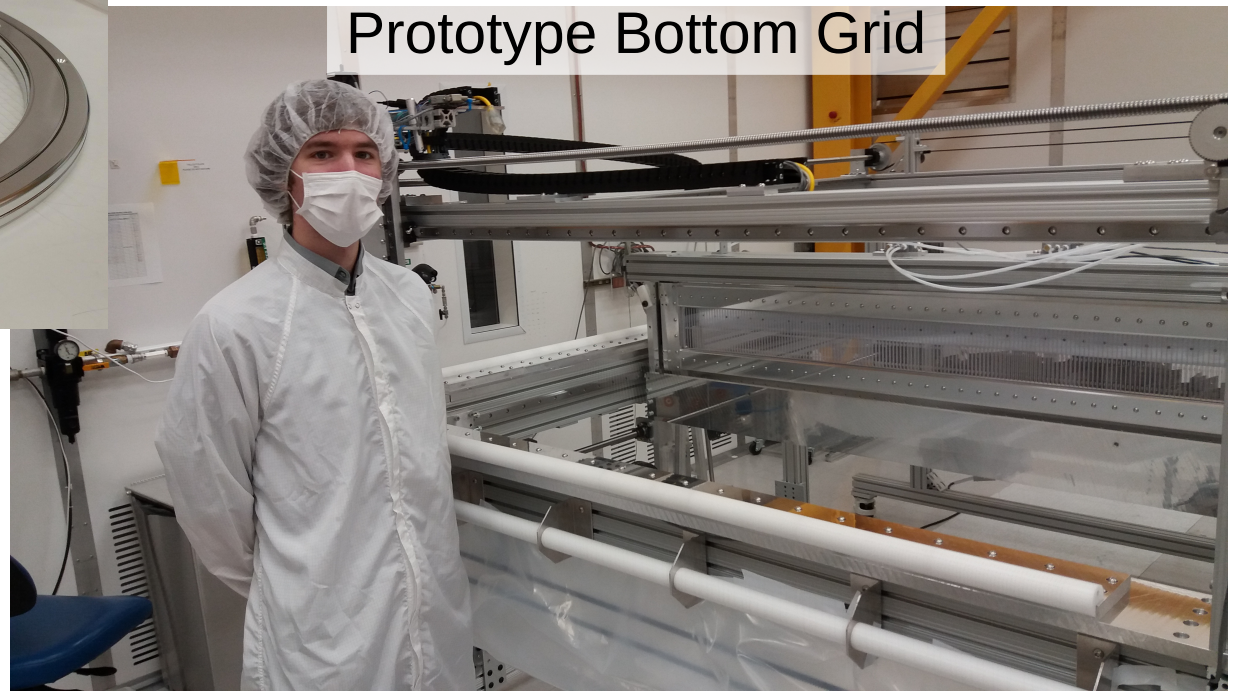
- Cathode cable tested to 120kV
  - Cathode feedthrough testing in LAr to same voltage
- Small versions of grids (and individual wires) tested in gas and liquid Xe
- Full scale testing coming


Small Test Extraction Region


Full Grid Test Vessel

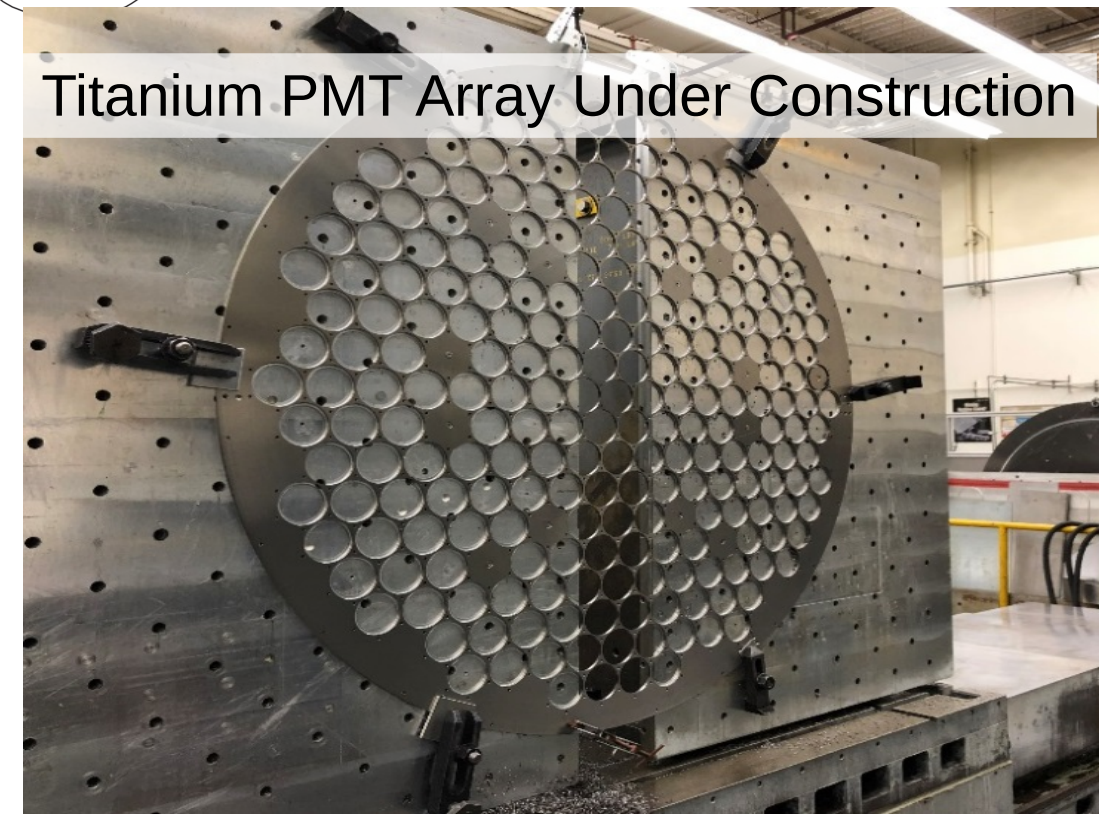
# HV: Full Scale Grids




- 50cm test grid woven and glued to test methods
- First full scale grid in production now

# PMT & DAQ




- All 3” PMTs in hand
- All cold tested
- DAQ chain test constructed
- Measured response to Xe scintillation light
  - https://arxiv.org/abs/1801.01597

# Schedule

- CD1 Review – March 2015
- CD2 Review – April 2016
- CD3 Review – February 2017 - construction can start in earnest
- Cryostat fabrication just completed
- PMT array assembly begins in March
- Xenon handling installation and commissioning starts Fall 2018
- TPC installation Spring-Summer 2019
- Cooldown starts Winter 2019-2020
- First physics data – Spring 2020

# Conclusions

- WIMP dark matter remains an attractive dark matter candidate
- LZ will exclude a large fraction of the available parameter space and has the potential to discover WIMPs even if previous experiments fail to see them
- Massive screening and R&D program has made LZ possible
- Construction is under way!
- Details in the technical design report https://arxiv.org/abs/1703.09144
- … and the sensitivity paper: https://arxiv.org/abs/1802.06039

Thank You