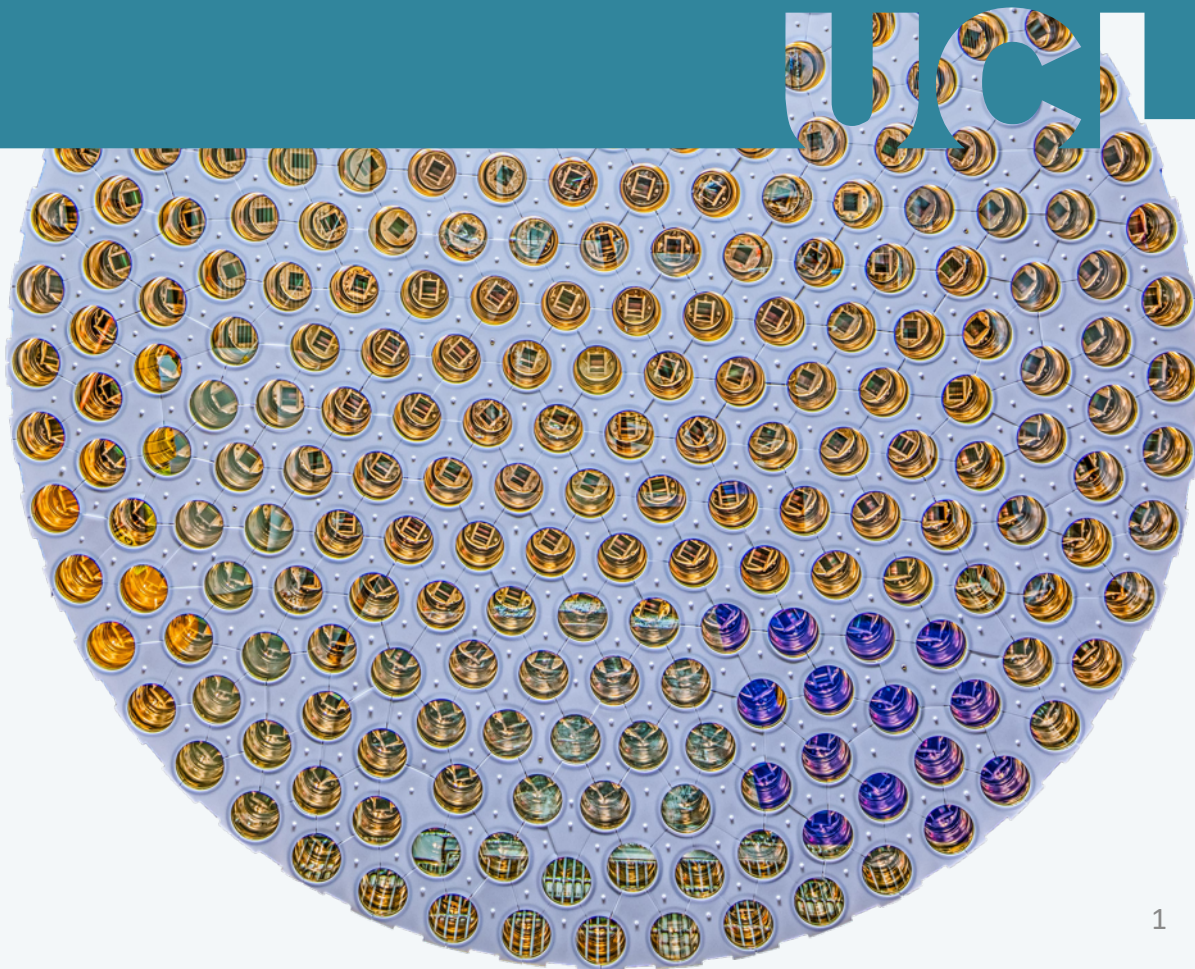


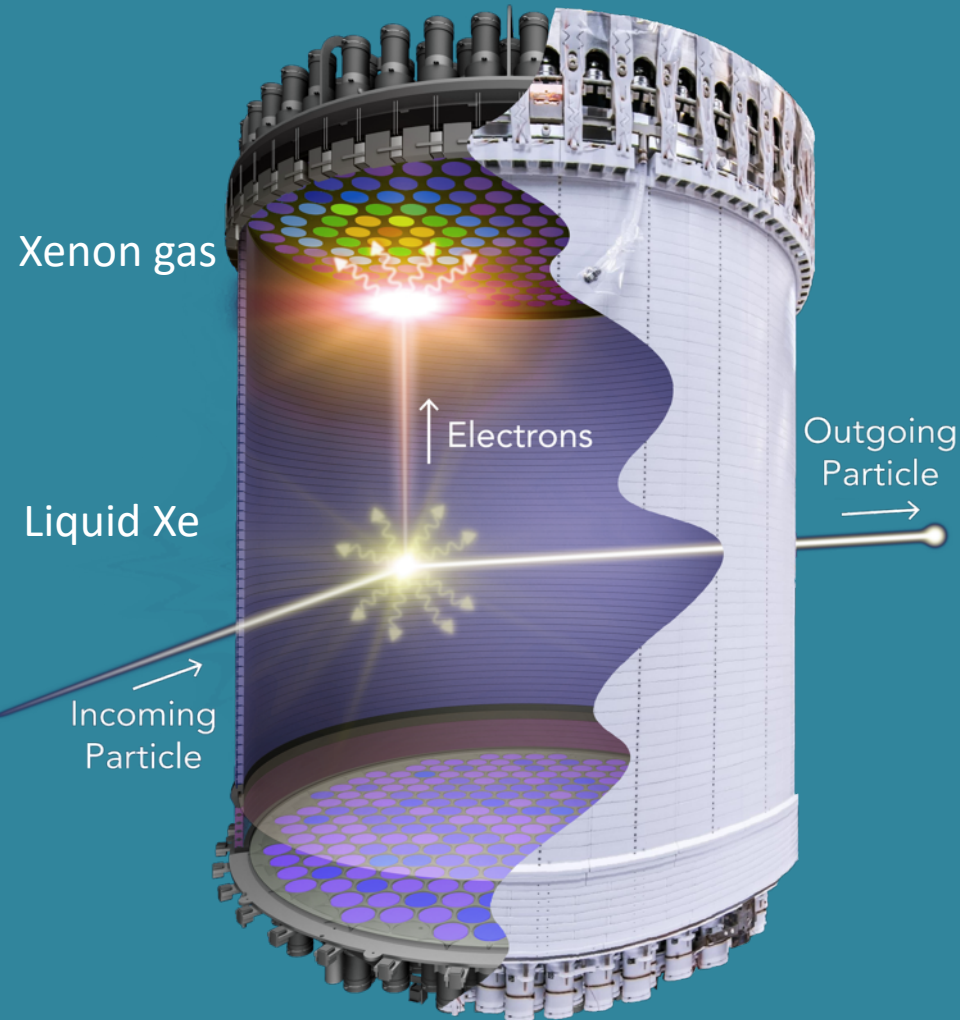


# Status of the LZ experiment

Theresa Fruth (UCL)

DMUK Meeting, RAL  
16<sup>th</sup> November 2021





## LUX-ZEPLIN Overview

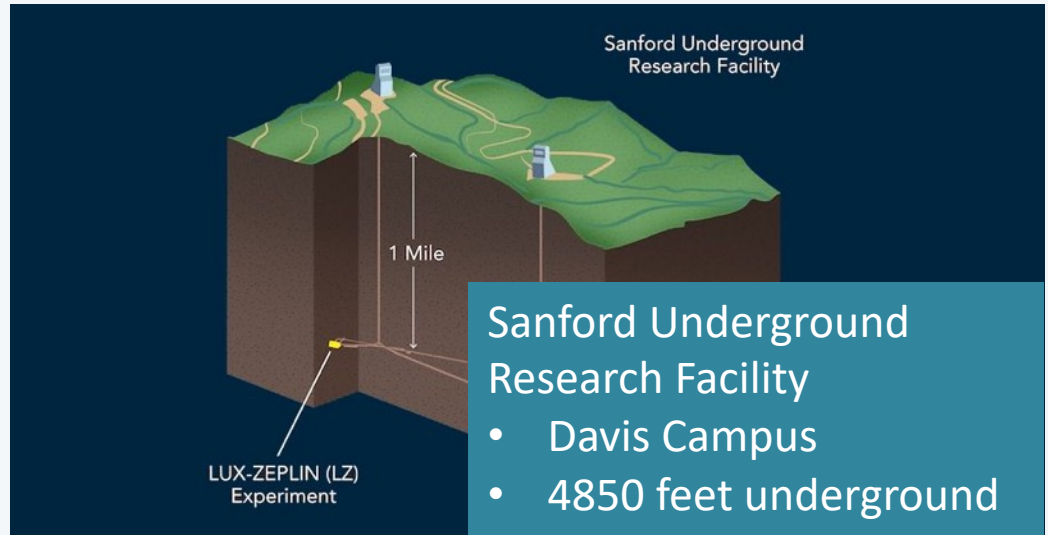
- Direct detection dark matter search via nuclear recoils
- Interaction leads to prompt scintillation and free electrons
- Electric field to extract electrons into gas leading to electroluminescence light
- 3D reconstruction with S2 (XY) and S1-S2 delay (Z) allows fiducialisation



## South Dakota



## Ray Davis Experiment



# Detector Overview

Outer Cryostat Vessel

Inner Cryostat Vessel

TPC

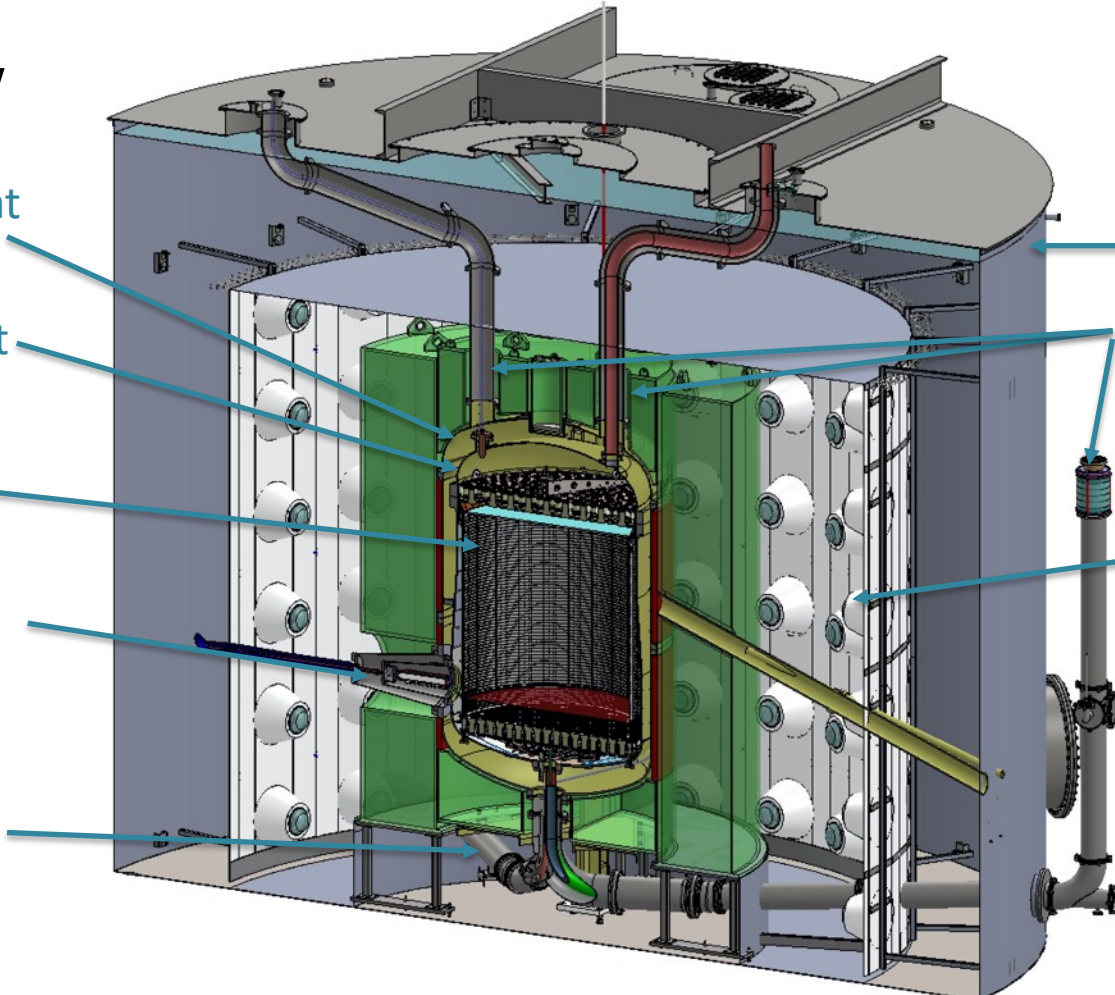
Cathode HV

Xenon lines

Water tank

Cable conduits

Outer Detector





## |Detector

# Xenon detector

- TPC:
  - 494 TPC PMTs
    - Hamamatsu R11410-22
  - PTFE field cage
    - 7 tonnes of xenon
    - 5.6 tonnes fiducial
  - 4 high-voltage grids for
    - drift field
    - extraction region
- Xenon Skin:
  - 2 tonnes of Xe between TPC and cryostat
  - Instrumented with PMTs on top and bottom
  - Cryostat lined with PTFE

Outer cryostat vessel

Inner cryostat vessel

Skin region

Skin PMTs

PMT array

Anode grid

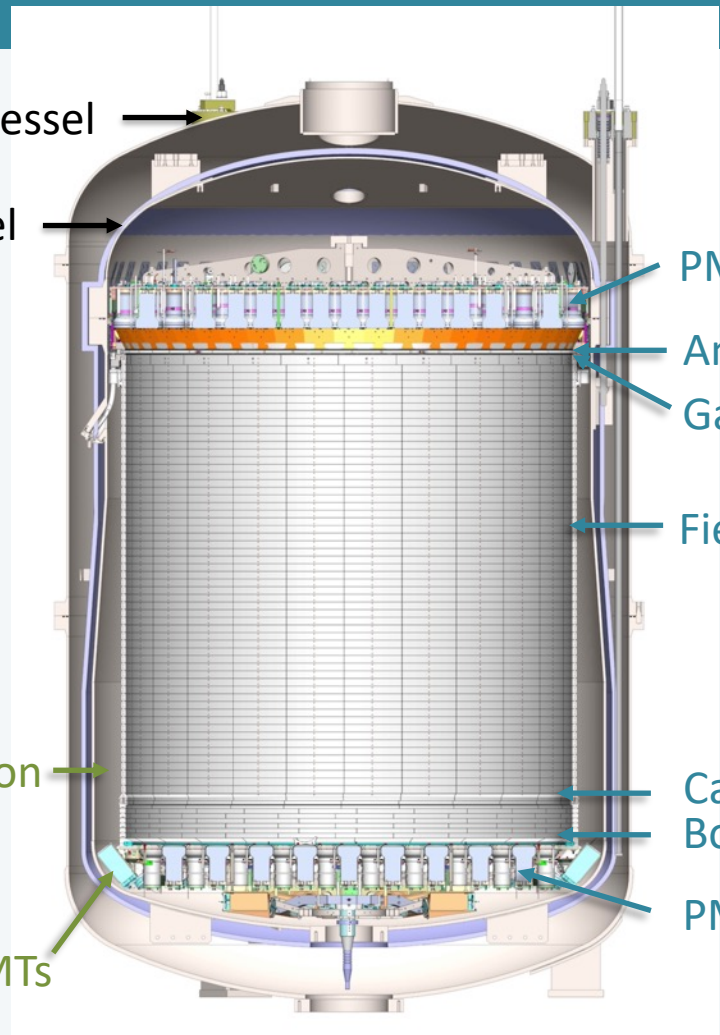
Gate grid

Field cage

Cathode grid

Bottom grid

PMT array



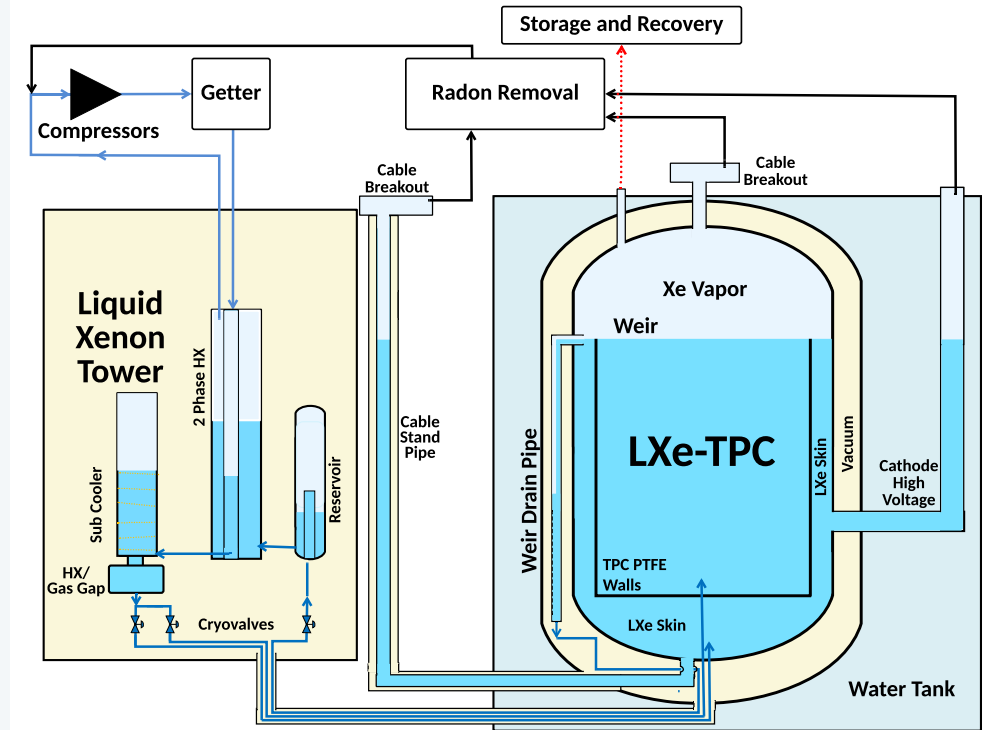
## Detector

# Xenon circulation

- 10 tonnes of xenon
- Krypton reduction to  $< 300$  ppq Kr/Xe using gas chromatography at SLAC
- LZ circulation with constant gas purification through hot-zirconium getter



Krypton removal system at SLAC

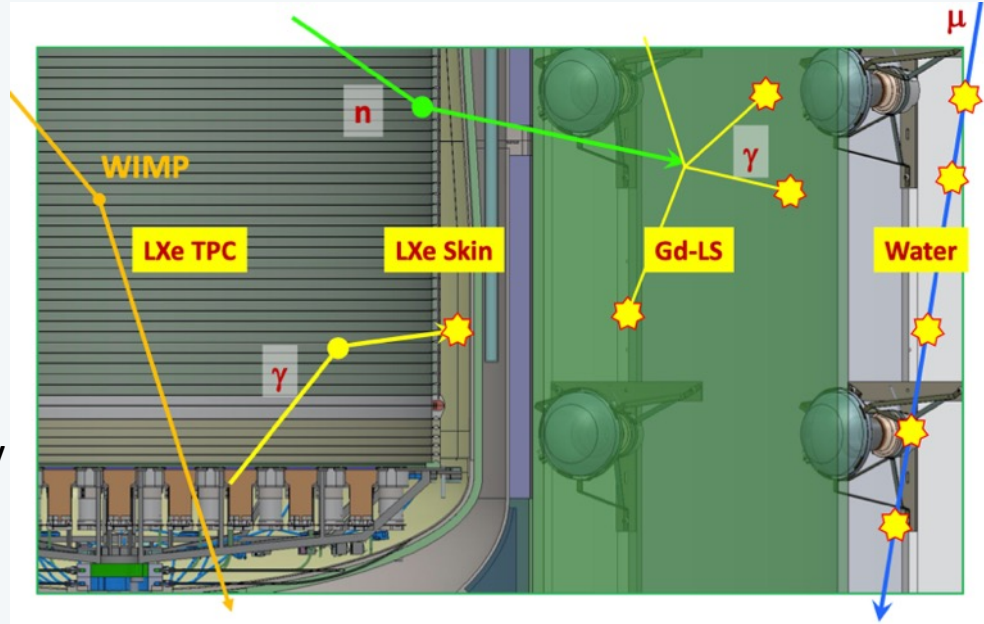


LZ circulation system

## |Detector

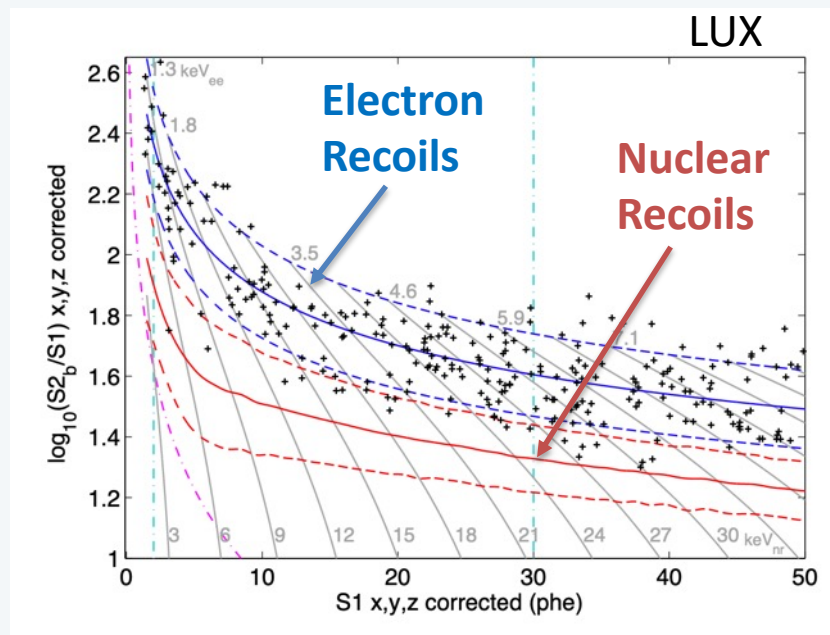
# Outer Detector

- 17 tonnes Gd-loaded liquid scintillator in acrylic vessels
- 120 8" PMTs mounted in the water tank
- Anti-coincidence detector for  $\gamma$ -rays and neutrons
- Observe  $\gamma$ -rays from thermal neutron capture with total energy of about 8 MeV

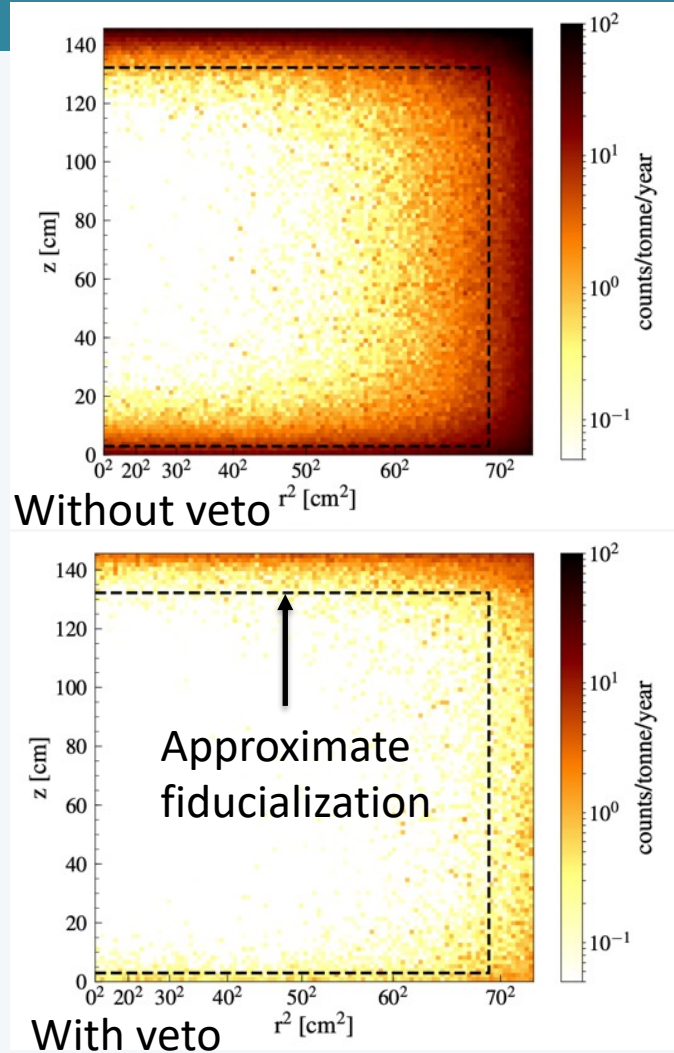




# Backgrounds Discrimination



<http://arxiv.org/abs/1310.8214v2>  
<https://arxiv.org/abs/1802.06039>



## |Backgrounds Mitigations

### Material Selection:

- Radio-assay campaign with gamma-screening and ICPMS
- Radon emanation:
  - 4 Rn emanation screening sites (including UCL)
  - Target Rn activity: 2  $\mu\text{Bq/kg}$

### Shielding:

- Deep underground
- High purity water shield
- Veto detectors

### Cleanliness during construction:

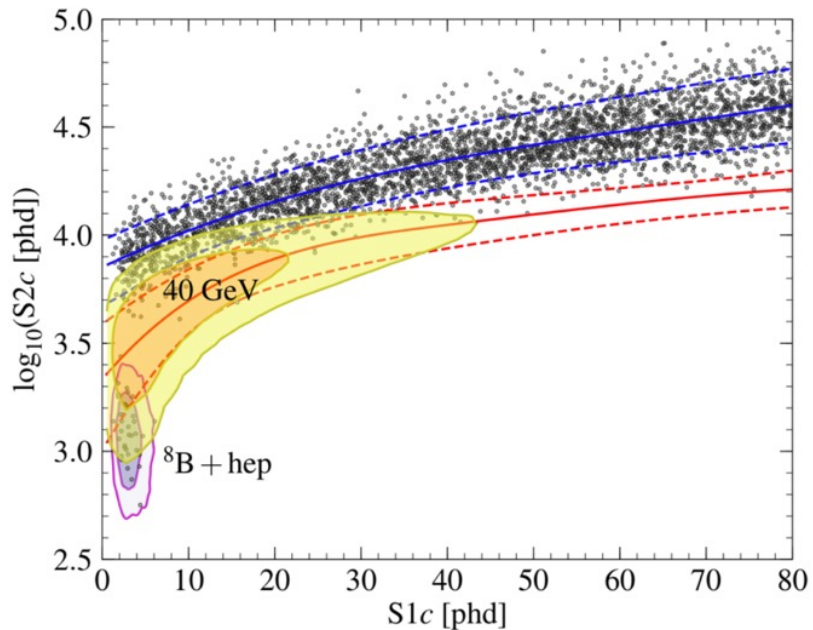
- Rn daughters and dust on surfaces
- TPC assembly in Rn-reduced cleanroom
- Dust  $<500 \text{ ng/cm}^2$  on all LXe wetted surfaces
- Rn-daughter plate-out on TPC walls  $<0.5 \text{ mBq/m}^2$

### Xenon purification:

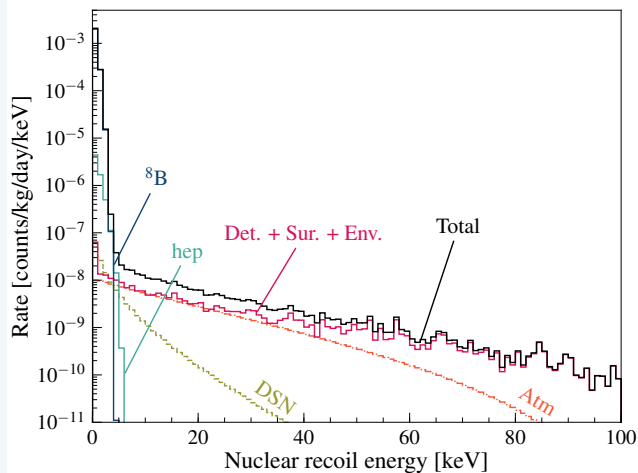
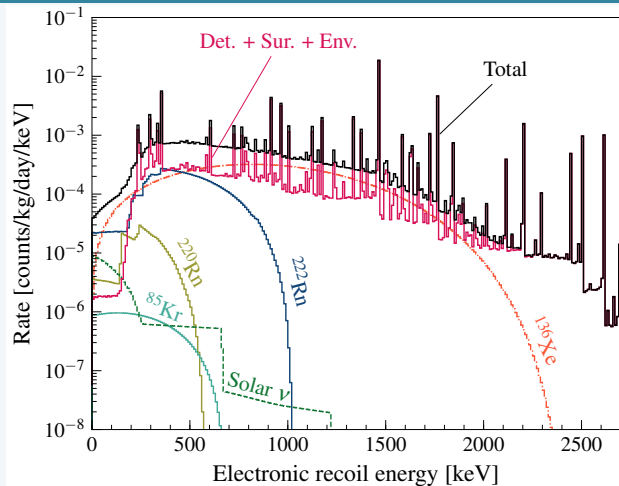
- Charcoal chromatography @ SLAC to remove xenon contaminants –  $^{85}\text{Kr}$  and  $^{39}\text{Ar}$

## |Backgrounds

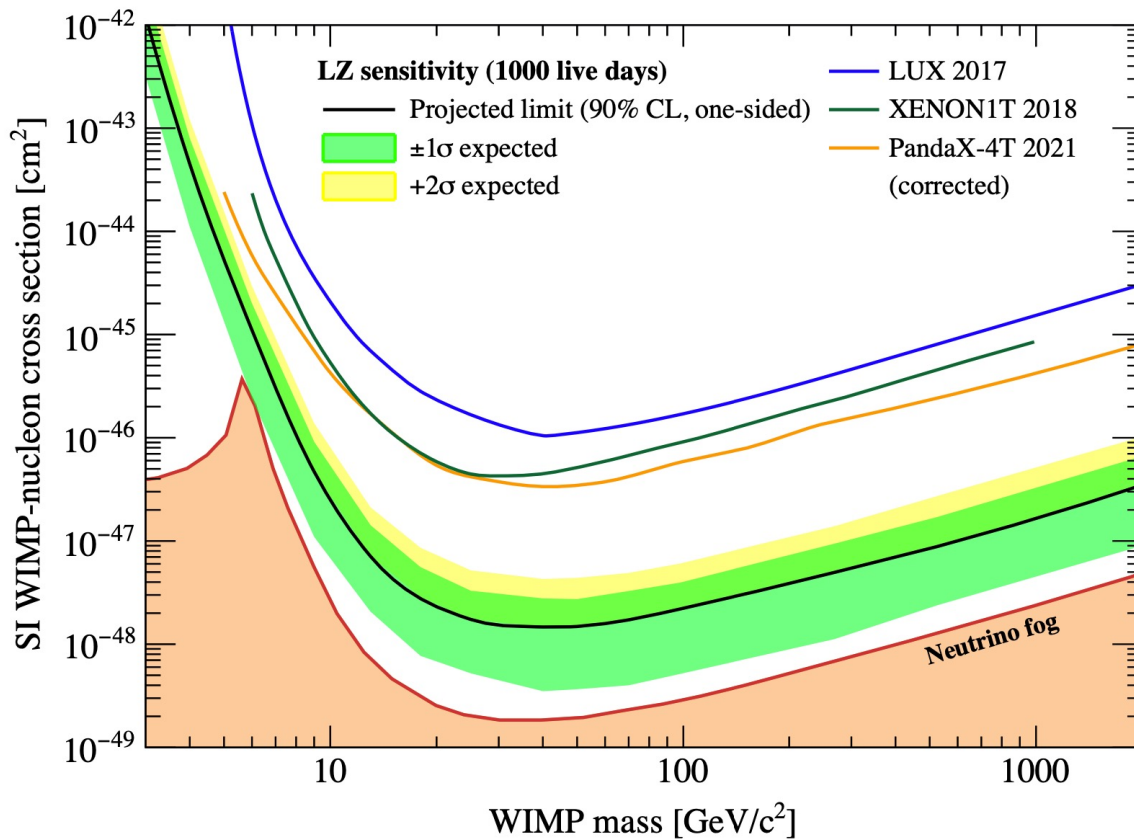
## Expected background events



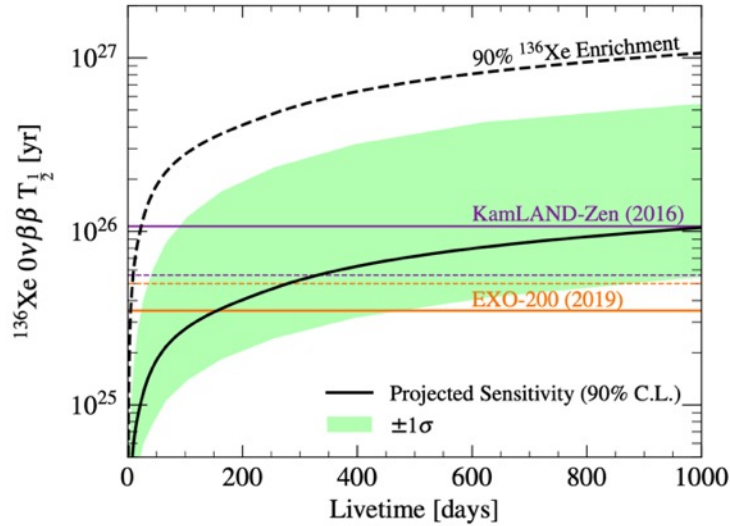
1000 day run - Powerful discrimination and well-calibrated background model for final PLR analysis



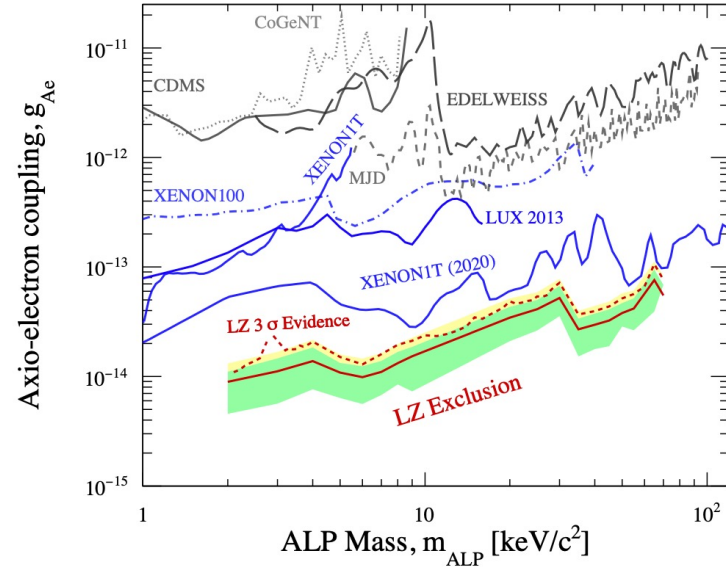


|Sensitivity Projection  
WIMP search90% CL minimum of  $1.4 \times 10^{-48} \text{ cm}^2$  at  $40 \text{ GeV}/c^2$ 

# Sensitivity Projection Other Physics Searches



Neutrinoless double-beta decay

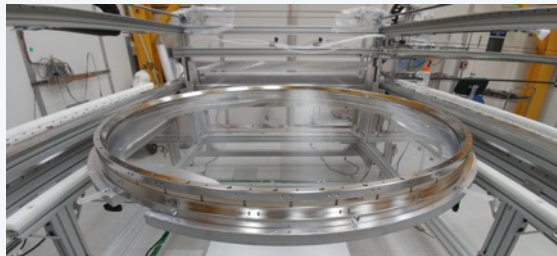


Axion-like particles

# |Detector construction TPC



PMT array cabling at SURF



Grid weaving at SLAC



Bottom array with grids and field cage



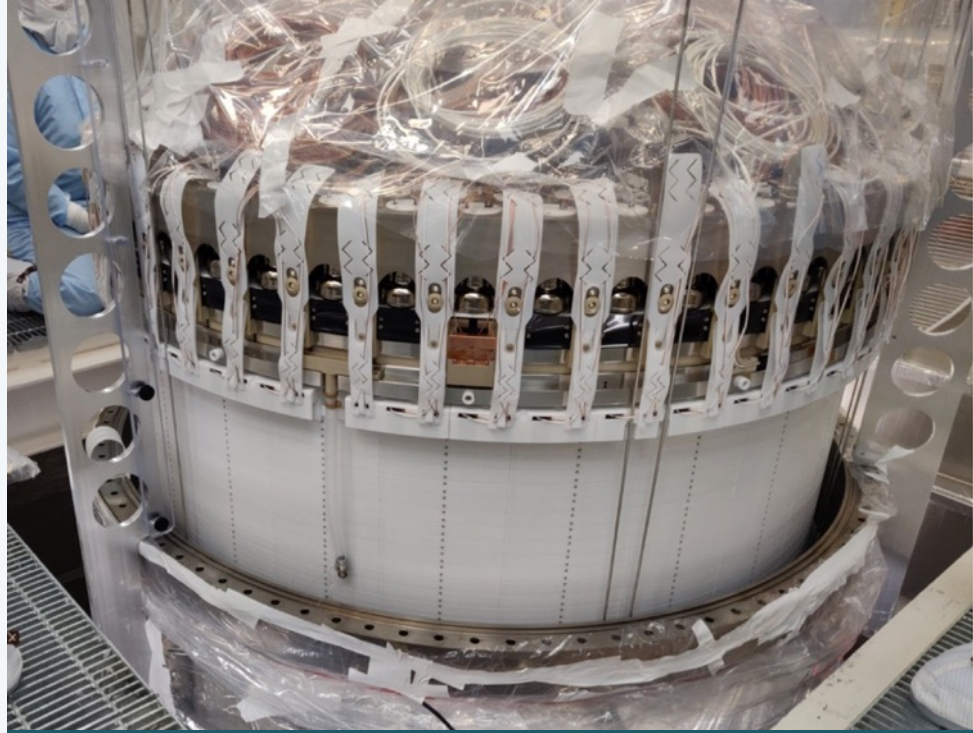
Assembled TPC



## |Detector construction TPC & Skin



Inner Cryostat Tiling and Skin PMTs



TPC insertion into cryostat

# Integration underground ICV transport & installation



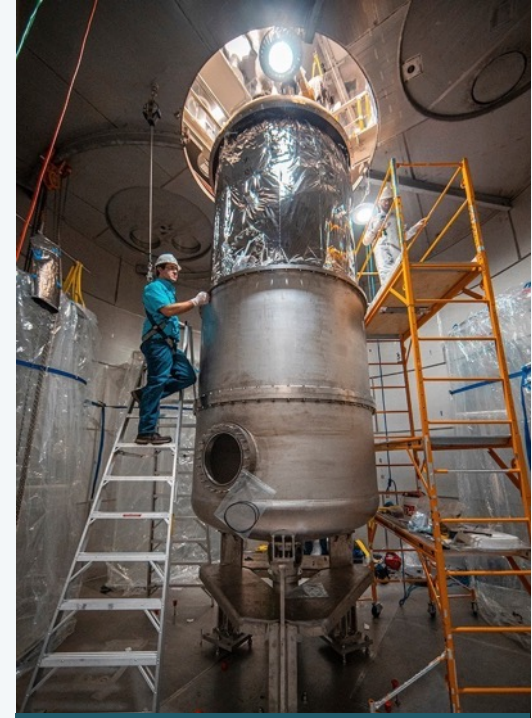
ICV transport underground



ICV instrumentation



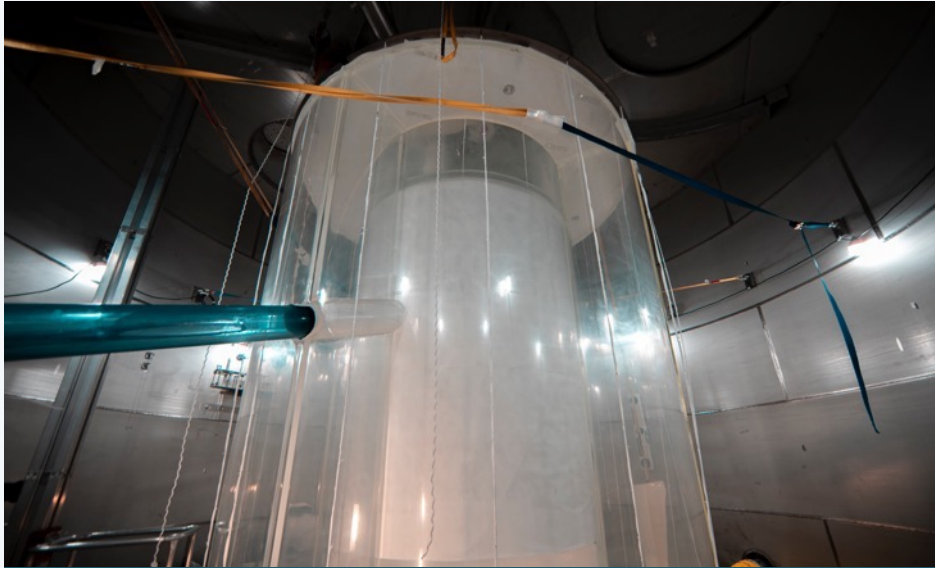
CHV feedthrough installation



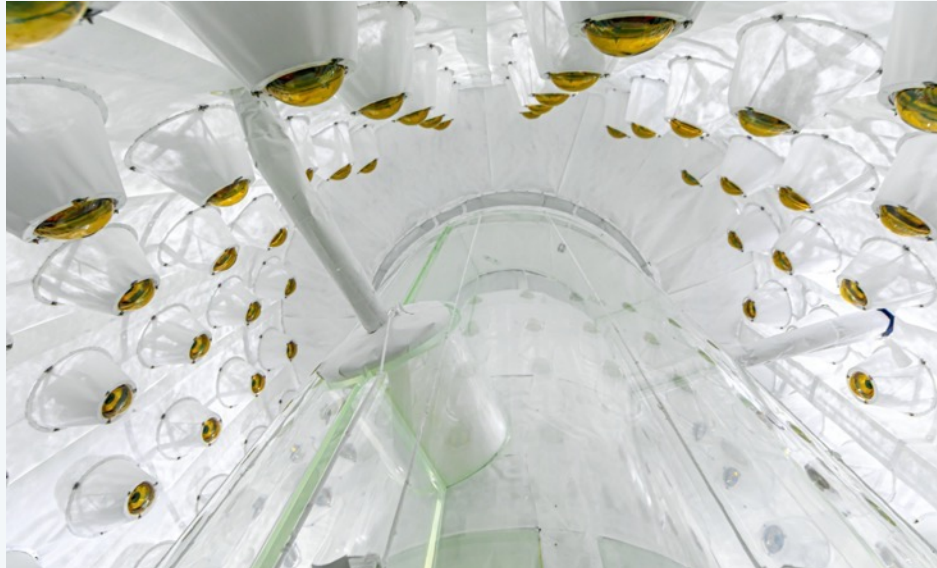
ICV installation in OCV



## Integration underground Outer Detector



Installation of OD tanks around Outer Cryostat Vessel



Completed Outer Detector

# Integration underground Xenon System



Xenon tower outside of water tank  
With heat-exchanger & thermosyphons



Xenon storage underground



Circulation compressors (gas)

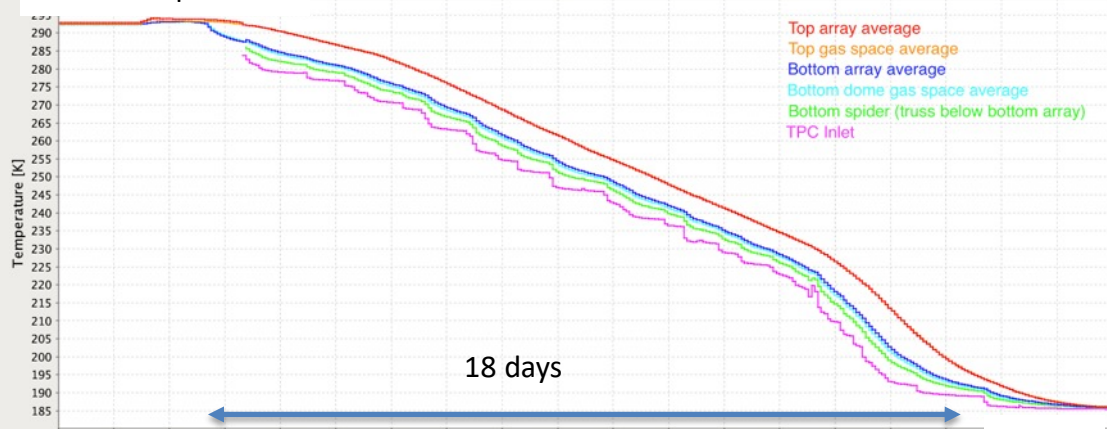


## Commissioning is underway!



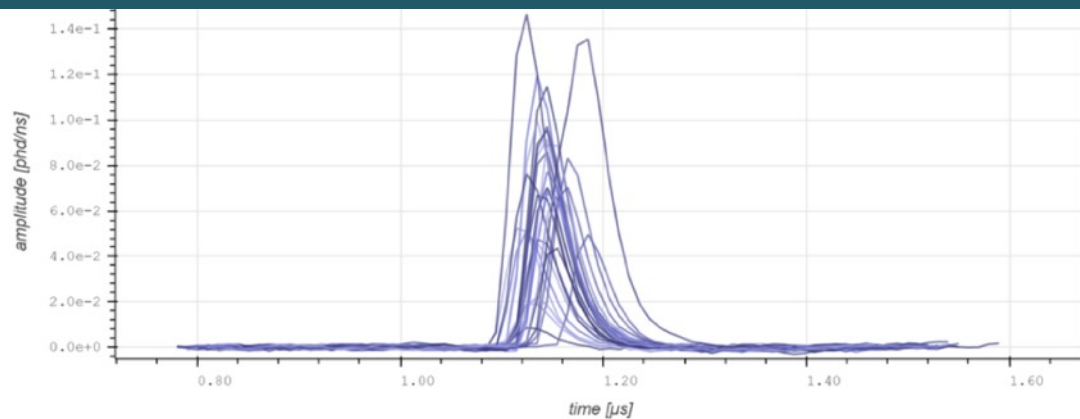
Test cryostat for circulation test  
Demonstrated flow rates up to 600 slpm

## Room temperature



Detector cool down

## PMT calibrations with LED light



# LZ collaboration - 34 Institutions: 250 scientists, engineers, and technical staff

- Black Hills State University
- Brandeis University
- Brookhaven National Laboratory
- Brown University
- Center for Underground Physics
- Edinburgh University
- Fermi National Accelerator Lab.
- Imperial College London
- Lawrence Berkeley National Lab.
- Lawrence Livermore National Lab.
- LIP Coimbra
- Northwestern University
- Pennsylvania State University
- Royal Holloway University of London
- SLAC National Accelerator Lab.
- South Dakota School of Mines & Tech
- South Dakota Science & Technology Authority
- STFC Rutherford Appleton Lab.
- Texas A&M University
- University of Albany, SUNY
- University of Alabama
- University of Bristol
- University College London
- University of California Berkeley
- University of California Davis
- University of California Santa Barbara



- University of Liverpool
  - University of Maryland
  - University of Massachusetts, Amherst
  - University of Michigan
  - University of Oxford
  - University of Rochester
  - University of Sheffield
  - University of Wisconsin, Madison
- US      UK      Portugal      Korea

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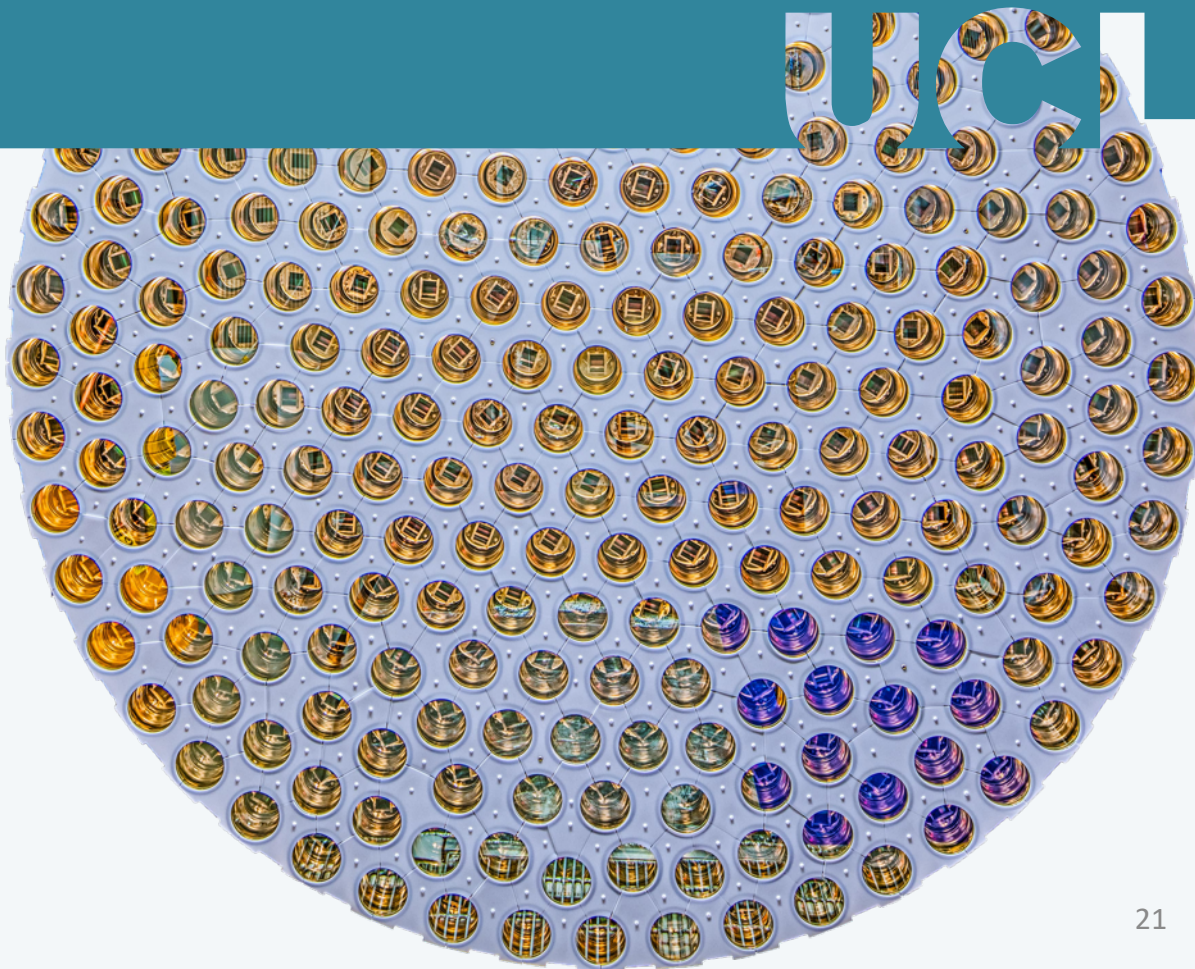
- LZ construction and underground circulation test complete
- Commissioning is underway! The detector has been cooled down and all PMTs have been tested with LEDs
- 2022 will be an exciting year for LZ

**Stay tuned!**



@lzdarkmatter

<https://lz.lbl.gov/>



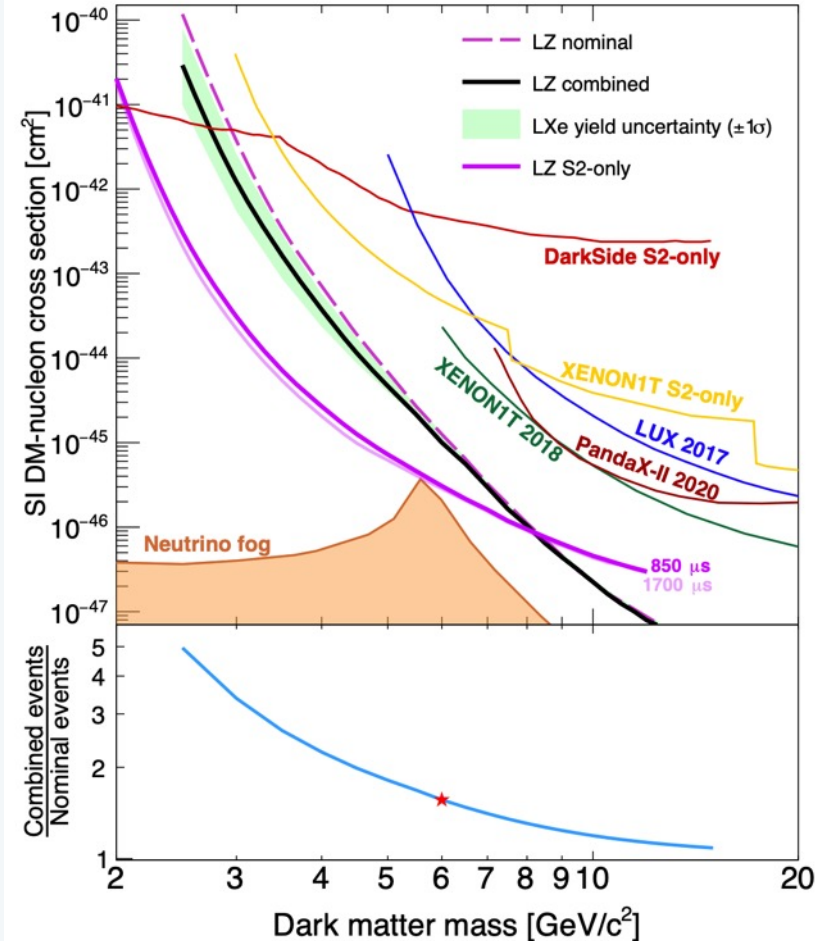
# BACKUP



## Sensitivity Projection GeV Dark Matter

Enhancing sensitivity in the low WIMP mass regime by lowering in the detector threshold.

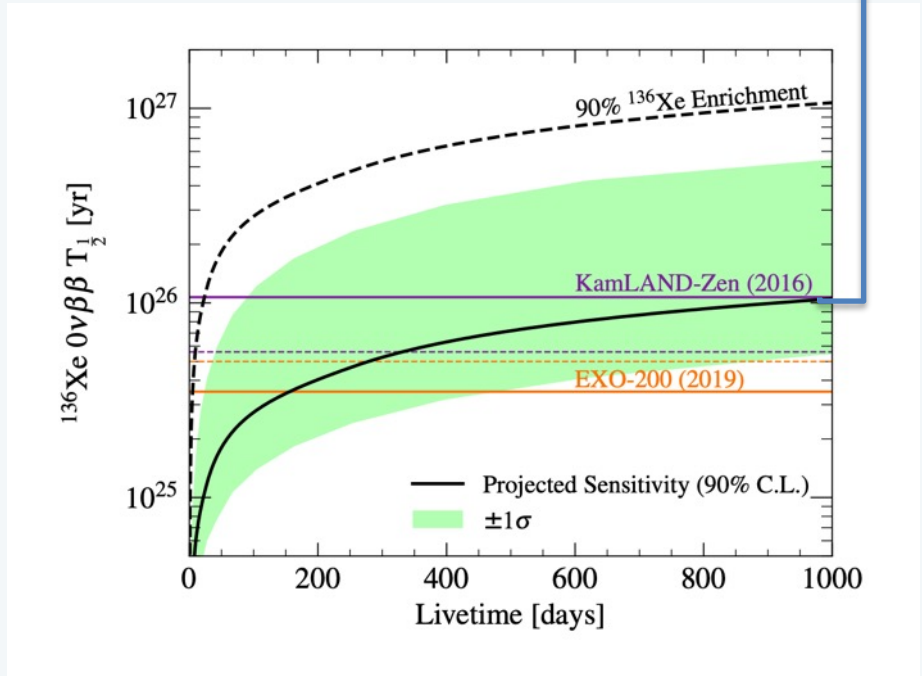
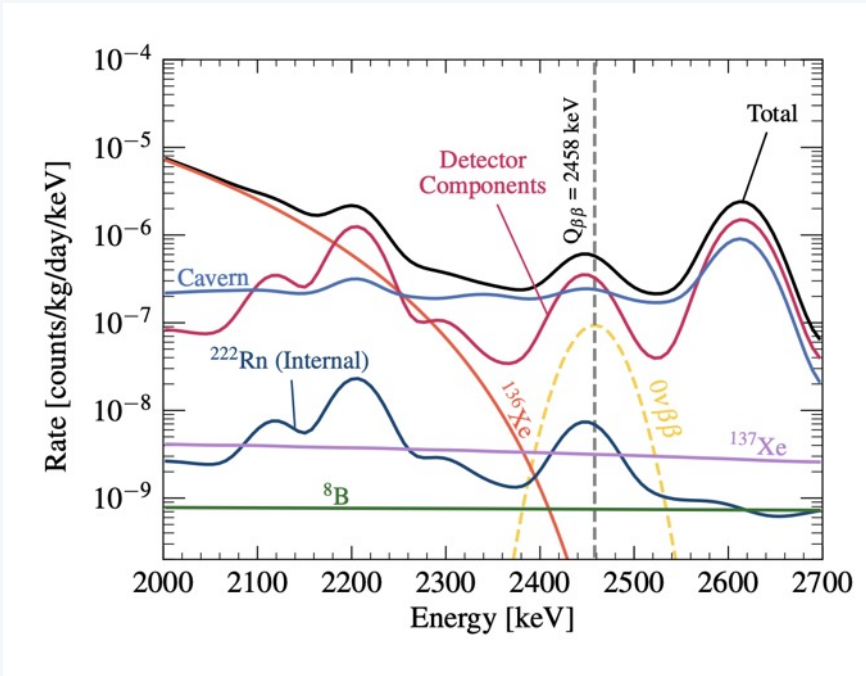
- Lower S1 coincidence requirements from 3 to 2 photons (making use of the DPE effect) -> LZ combined
- S2-only analysis -> LZ S2-only (for nominal and enhanced electron lifetime)



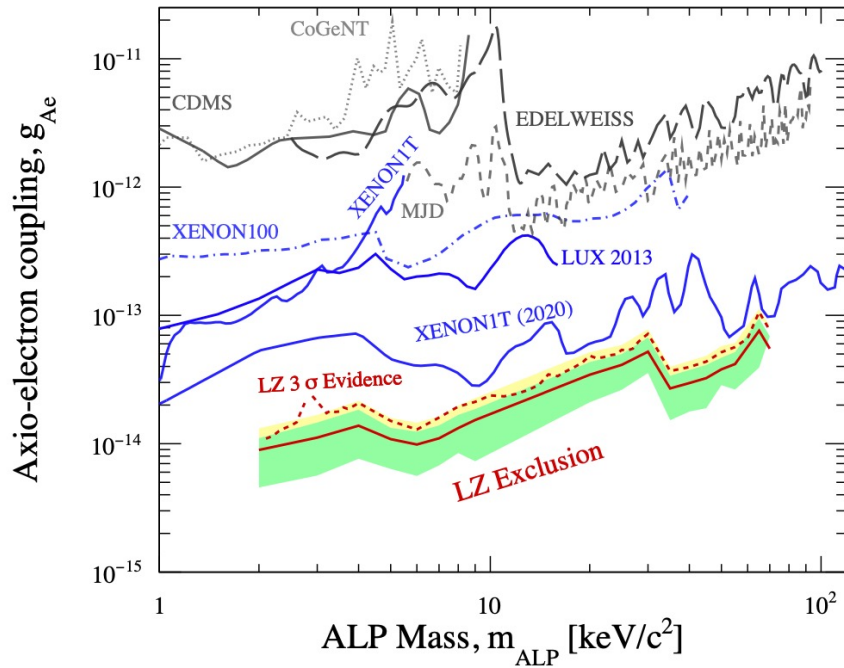
# Sensitivity Projection Neutrinoless double-beta decay

$^{136}\text{Xe } Q_{\beta\beta} = 2458 \text{ keV}$

$T_{1/2} (90\% \text{ C.L.}) > 1.06 \times 10^{26} \text{ years in 1000 live-days}$



# Sensitivity Projection Axion-like particles



- ER band searches for axions and ALPs assuming axio-electric interaction
- ALPs – monoenergetic feature in ER band
- Plot shows expected sensitivity for 1000 live-days and 5.6 tonne fiducial mass.