

Status of the LZ experiment

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ILUX-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





Ray Davis Experiment







The LZ experiment, NIM A953 (2020)163047



Detector Xenon detector

- TPC:
 - 494 TPC PMTs
 - Hamamatsu R11410-22
 - PTFE field cage
 - 7 tonnes of Xe
 - 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



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





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 γ-rays and neutrons
- Observe γ-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 gammascreening and ICPMS
- Radon emanation:
 - 4 Rn emanation screening sites (including UCL)
 - Target Rn activity: 2 μBq/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 ng/cm² on all LXe wetted surfaces
- Rn-daughter plate-out on TPC walls
 <0.5 mBq/m²

Xenon purification:

 Charcoal chromatography @ SLAC to remove Xenon contaminants – ⁸⁵Kr and ³⁹Ar

Sensitivity Paper: Phys. Rev. D 101, 052002

Backgrounds Expected background events



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



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Sensitivity Projection WIMP search

90% CL minimum of 1.4 x 10^{-48} cm² at 40 GeV/c²



EDELWEISS

XENON1T (2020)

ALP Mass, m_{ALP}^{10} [keV/c²]

LZ Exclusion

LUX 201

Sensitivity Projection Other Physics Searches



Neutrinoless double-beta decay

Axion-like particles

CoGeNT

LZ 3 o Evidence

10⁻¹¹

 10^{-12}

 10^{-13}

 10^{-14}

 10^{-15}

CDMS

ON100

Axio-electron coupling, g_{Ae}

 10^{2}

|Detector construction TPC



PMT array cabling at SURF



Grid weaving at SLAC

Bottom array with grids and field cage





Detector construction TPC & Skin



Inner Cryostat Tiling and Skin PMTs



TPC insertion into cryostat

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





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**



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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

¹³⁶Xe $Q_{\beta\beta}$ = 2458 keV

 $T_{1/2}$ (90% C.L.) > 1.06 x 10²⁶ 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.