STATUS OF THE LZ EXPERIMENT
Dual Phase Noble Liquid TPC

- Excellent 3D imaging capability
  - Z position from S1 - S2 timing
  - XY positions from S2 light pattern

- Charge / light ratio
  => Signal vs Background discrimination

Charge/Light
\[ \log_{10}(S2/S1) \]

S1 (phd)

LUX

Gamma calibration (ER)

Neutron calibration (NR)

(absolute values)
LZ Detector Overview

- LZ experiment at SURF, in Lead SD (~1 mile underground)
- **Xenon TPC**
  - Total mass: 10 T
  - Active mass: 7 T
  - Fiducial: 5.6 T

- **3-component veto system:**
  - Water tank
  - Gd-loaded scintillator
  - Instrumented LXe Skin

Xenon TPC

- 1.5 m diameter x 1.5 m height
- 7T active LXe (5.6T fiducial)
- 50 kV cathode HV
  - See talk by J. Watson! (April 19, H14, at 11:21am)
- 494x 3” PMTs
- Gas circulation @ 500 slpm (turnover full mass in 2.5 days)
- Instrumented Xe skin region, outside the field cage

TPC walls are made of PTFE with field rings

Top PMT array

GAS PHASE AND ELECTROLUMINESCENCE REGION

LXe surface

Skin PMT

Anode

Gate

Cathode grid

Reverse-field region

Bottom PMT array

Side Skin PMTs

TPC field cage
PMT arrays

Hamamatsu R11410 (3”)
- Top array: 252 PMTs
- Bottom array: 241 PMTs
Assembled TPC

Full TPC - August 2019

Insertion into inner cryostat vessel

October 2019

APS April 2020

Carmen Carmona - Penn State
Transport of TPC Underground

October 2019
Expected backgrounds for 5.6 T fiducial - 1000 days

<table>
<thead>
<tr>
<th>Background Source</th>
<th>ER (cts)</th>
<th>NR (cts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detector Components</td>
<td>9</td>
<td>0.07</td>
</tr>
<tr>
<td>Surface Contamination</td>
<td>40</td>
<td>0.39</td>
</tr>
<tr>
<td>Laboratory and Cosmogenics</td>
<td>5</td>
<td>0.06</td>
</tr>
<tr>
<td>Xenon Contaminants</td>
<td>819</td>
<td>0</td>
</tr>
<tr>
<td>Radon is the dominant background!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radon</td>
<td>222Rn</td>
<td>681</td>
</tr>
<tr>
<td>Radon</td>
<td>220Rn</td>
<td>111</td>
</tr>
<tr>
<td>natKr (0.015 ppt g/g)</td>
<td>24.5</td>
<td>0</td>
</tr>
<tr>
<td>natAr (0.45 pub g/g)</td>
<td>2.5</td>
<td>0</td>
</tr>
<tr>
<td>Physics</td>
<td>258</td>
<td>0.51</td>
</tr>
<tr>
<td>136Xe 2νββ</td>
<td>67</td>
<td>0</td>
</tr>
<tr>
<td>Solar neutrinos (pp+7Be+13N)</td>
<td>191</td>
<td>0*</td>
</tr>
<tr>
<td>Diffuse supernova neutrinos</td>
<td>0</td>
<td>0.05</td>
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<tr>
<td>Atmospheric neutrinos</td>
<td>0</td>
<td>0.46</td>
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<tr>
<td>Total</td>
<td>1131</td>
<td>1.03</td>
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<tr>
<td>with 99.5% ER discrim., 50% NR eff.</td>
<td>5.66</td>
<td>0.52</td>
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</table>

* 6 keV NR threshold used


Radon is the dominant background!

TPC + Xe skin + Gd-scint.

TPC only

~10 events/5.6 tonne Fiducial Volume

r² [cm²] z [cm]

≈1 events/5.6 tonne Fiducial Volume

r² [cm²] z [cm]
Xe Procurement and Kr Removal

- 10 tonnes of Xe in hand
- Chromatography to separate Kr from Xe.
  - Demonstration of 0.06 ppt (g/g) in R&D at SLAC
  - Designed for 0.015 ppt (g/g)
- Production in progress
  - See talk from A. Ames! (April 20, R13, at 2:54pm)

![Kr removal system at SLAC](image)
Xenon “Skin” veto

• Detection of scattered gamma rays
• Optically segregated from TPC
• TPC top skin: 93 1” PMTs
• TPC bottom skin and lower dome: 38 2” PMTs

Bottom side skin assembly & PTFE tiling in ICV
Outer Detector

- Suppression of neutron-induced nuclear recoil rate $\Rightarrow$ maximize fiducial volume.
  - Segmented acrylic tanks
  - 120 8” PMTs
  - Liquid scintillator: Gd-loaded (0.1%) LAB (linear alkyl benzene)
  - Total LAB mass: $\sim$17 tonnes

See talk by B. Penning! (April 20, R13, at 3:06 pm)

All Tanks in! 12/1/2018
Xe Circulation System & Cryogenics

- Xe tower
- Water tank
- Water tank flange
- Transfer Lines
- Test cryostat
- Cryocooler LN Tank
- Thermosyphon panel
- Xe Circulation Compressors
Current Status

- We have made significant progress in the assembly of the TPC and associated systems.
  - TPC complete, moved underground and currently at vacuum
  - HV cathode connection installed

- Out of concern for the health of our scientists and staff members and to slow the spread of the SARS-CoV-2 virus:
  - We are following DOE, Berkeley Lab, and Sanford Lab protocols and guidelines in response to this situation
  - We have secured the experiment in a safe and stable configuration
  - We await the reduction of risks associated with the virus and updated guidance from the DOE and the Laboratories to complete our assembly and advance to commissioning.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>2015</td>
<td>CDR Sep 2015</td>
</tr>
<tr>
<td>2016</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>TDR Mar 2017</td>
</tr>
<tr>
<td>2017</td>
<td>Titanium paper Feb 2017</td>
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<tr>
<td>2018</td>
<td>TPC assembled Aug 2019</td>
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<tr>
<td>2018</td>
<td>TPC moves underground</td>
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<tr>
<td>2019</td>
<td>WIMP sensitivity paper Feb 2018</td>
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<tr>
<td>2020</td>
<td>Experiment in safe configuration</td>
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<tr>
<td>2021</td>
<td></td>
</tr>
</tbody>
</table>

TPC moves underground

COVID-19 Experiment in safe configuration
Projected Sensitivity (5.6 T exposure, 1000 live days)

Approaches coherent neutrino scattering background!

LZ Collaboration:
36 Institutions: 250 scientists, engineers, and technical staff

- Black Hills State University
- Brandeis University
- Brookhaven National Laboratory
- Brown University
- Center for Underground Physics, Korea
- Fermi National Accelerator Laboratory
- Imperial College London
- LIP Coimbra, Portugal
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Northwestern University
- Pennsylvania State University
- Royal Holloway, University of London
- SLAC National Accelerator Laboratory
- South Dakota School of Mines and Technology
- South Dakota Science and Technology Authority
- STFC Rutherford Appleton Laboratory
- Texas A&M University
- University at Albany, SUNY
- University College London
- University of Alabama
- University of Bristol
- University of California, Berkeley
- University of California, Davis
- University of California, Santa Barbara
- University of Edinburgh
- University of Liverpool
- University of Maryland
- University of Massachusetts, Amherst
- University of Michigan
- University of Oxford
- University of Rochester
- University of Sheffield
- University of South Dakota
- University of Wisconsin – Madison
- Yale University