The LZ Dark Matter Detector

Bhawna Gomber, University Of Wisconsin
(On behalf of LZ Collaboration)
LZ = LUX + ZEPLIN

University of Alabama
University at Albany SUNY
Berkeley Lab (LBNL)
University of California, Berkeley
Brookhaven National Laboratory
Brown University
University of California, Davis
Fermi National Accelerator Laboratory
Kavli Institute for Particle Astrophysics & Cosmology
Lawrence Livermore National Laboratory
University of Maryland
University of Michigan
Northwestern University
University of Rochester
University of California, Santa Barbara
University of South Dakota
South Dakota School of Mines & Technology
South Dakota Science and Technology Authority
SLAC National Accelerator Laboratory
Texas A&M
Washington University
University of Wisconsin
Yale University

LiP Coimbra (Portugal)
MEPhI (Russia)
Edinburgh University (UK)
University of Liverpool (UK)
Imperial College London (UK)
University College London (UK)
University of Oxford (UK)
STFC Rutherford Appleton Laboratories (UK)
Shanghai Jiao Tong University (China)
University of Sheffield (UK)
Scale Up ~50x in fiducial mass

**LZ**
- Total mass - 10 T
- Active Mass - 7 T
- Fiducial Mass - 5.6 T

Gain ~400X in sensitivity
LZ Overview

Instrumentation Conduits

High Voltage Feedtrough

120 Outer Detector PMTs

488 Photomultiplier Tubes (PMTs)
Additional 200 `skin’ PMTs

Water Tank

Gadolinium Loaded Liquid Scintillator

Liquid Xenon Heat Exchanger

Neutron Calib. Conduit

12/16/15
How to maximize the WIMP target mass?

- Two-component outer detector:
  - 0.75 m thick Gd-loaded scintillator
  - instrumented Xenon “skin”
  - tag neutrons and gammas

\[
\text{Fiducial Mass: 3.3 T}
\]

\[
\text{Fiducial Mass: 4.2 T}
\]

\[
\text{Fiducial Mass: 5.6 T}
\]
Projected Sensitivity - Spin Independent
(LZ 5.6 Tonnes, 1000 live days)

2×10^{-48} \text{ cm}^2

\log_{10}(\sigma_s) [\text{pb}]

m_\chi [\text{GeV}/c^2]

LZ projected (baseline)
- 90% CL Median
- ± 1 \sigma expected
- ± 2 \sigma expected
- LZ 1keV cutoff
- LZ S2 only

Zeplin III (2011)
LUX (2013)
LUX 300d

\nu-N coherent scattering

1 event
\nu-N coherent, 3\sigma significance
1000 Tonne-years

Bhawna Gomber, 28th Texas Symposium on Relativistic Astrophysics
12/16/15
Summary

- LUX has provided the most stringent limit on the WIMP-nucleon spin-independent interaction cross-section, and pioneered techniques with internal calibration sources.

- LZ holds the promise to be the ultimate WIMP search experiment. Limited by neutrino-induced 'background'.

- LZ Project well underway. Procurement of Xe, PMTs and cryostat vessels started. Extensive prototyping program.

- Projected commissioning in 2019.
Backup
## Backgrounds

**Expected backgrounds for 5.6 T fiducial - 1,000 days**

<table>
<thead>
<tr>
<th>Item</th>
<th>Mass kg</th>
<th>U mBq/kg</th>
<th>Th mBq/kg</th>
<th>$^{60}\text{Co}$ mBq/kg</th>
<th>$^{40}\text{K}$ mBq/kg</th>
<th>n/yr</th>
<th>ER cts</th>
<th>NR cts</th>
</tr>
</thead>
<tbody>
<tr>
<td>R11410 PMTs</td>
<td>93.7</td>
<td>2.7</td>
<td>2.0</td>
<td>3.9</td>
<td>62.1</td>
<td>373</td>
<td>1.24</td>
<td>0.20</td>
</tr>
<tr>
<td>R11410 bases</td>
<td>2.7</td>
<td>74.6</td>
<td>29.1</td>
<td>3.6</td>
<td>109.2</td>
<td>77</td>
<td>0.17</td>
<td>0.03</td>
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<tr>
<td>Cryostat vessels</td>
<td>2,140</td>
<td>0.09</td>
<td>0.23</td>
<td>$\approx$0</td>
<td>0.54</td>
<td>213</td>
<td>0.86</td>
<td>0.02</td>
</tr>
<tr>
<td>OD PMTs</td>
<td>122</td>
<td>1,507</td>
<td>1,065</td>
<td>$\approx$0</td>
<td>3,900</td>
<td>20,850</td>
<td>0.08</td>
<td>0.02</td>
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<tr>
<td>Other components</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>602</td>
<td>9.5</td>
<td>0.05</td>
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<tr>
<td><strong>Total components</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>11.9</strong></td>
<td><strong>0.32</strong></td>
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<tr>
<td>Dispersed radionuclides (Rn, Kr, Ar)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>54.8</td>
<td>-</td>
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<tr>
<td>$^{136}\text{Xe} \ 2\nu\beta\beta$</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>53.8</td>
<td>-</td>
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<tr>
<td>Neutrinos (ν-e, ν-A)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>271</td>
<td>0.5</td>
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<tr>
<td><strong>Total events</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>391.5</td>
<td>0.82</td>
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<tr>
<td>WIMP background events</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.96</td>
<td>0.41</td>
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<tr>
<td>(99.5% ER discrimination, 50% NR acceptance)</td>
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<tr>
<td><strong>Total ER+NR background events</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td><strong>2.37</strong></td>
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