Dark matter and neutrino search with the LZ experiment

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on behalf of the LZ collaboration
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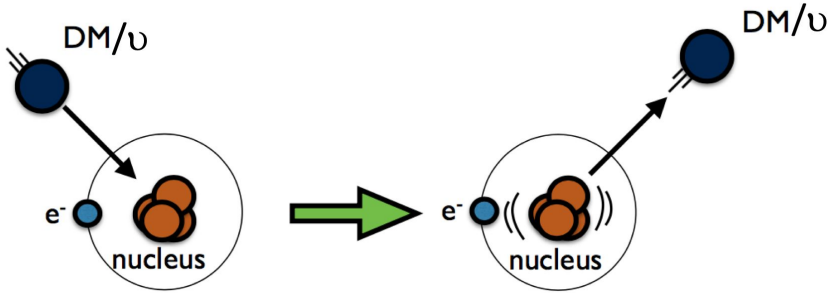
Two searches for low-energy, rare interactions

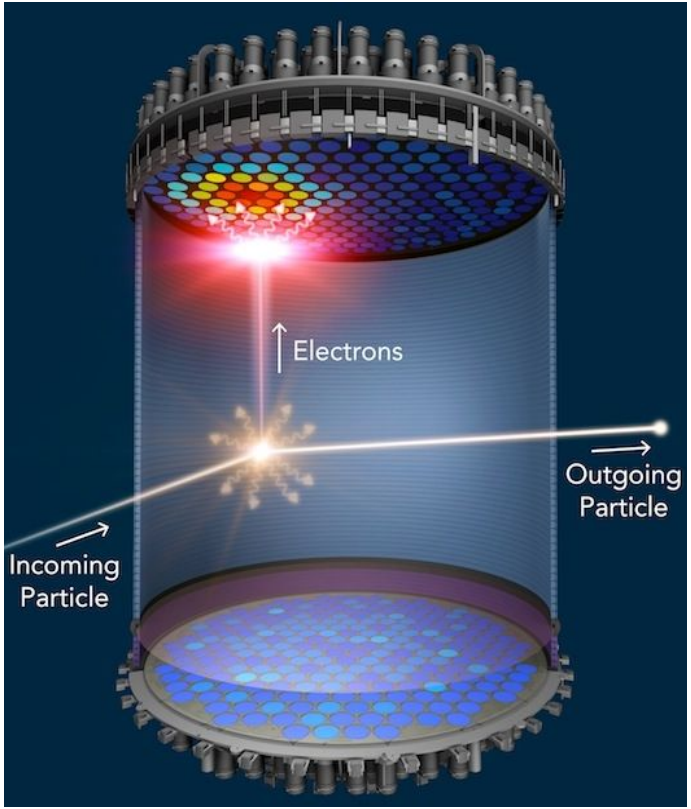
Anticipated WIMP dark matter interactions share many commonalities with CEvNS:

- Nuclear recoil signals
  - Potential discrimination from gamma background
  - Subject to quenching effects
- Signals in the very low energy region
  - keV to tens of keV
  - Near the threshold of particle detectors
- Low interaction rates
  - Weak scale mediator
  - Clean and sizeable detectors required



An introduction to Xe TPCs

- Dual-phase xenon Time Projection Chambers (Xe TPCs) collect both scintillation and (amplified) ionization signals
- Xe TPCs demonstrated
  - reasonable energy estimation
  - 3D position reconstruction
  - adequate particle identification
- Xe TPCs have achieved one of the lowest background rate in the keV energy region: <0.5 cpd/keVee/ton
- Xe TPCs are one of the few particle detectors with single electron sensitivities



The LZ collaboration (36 institutions, ~250 scientists, engineers, and technicians)

IBS-CUP (Korea)
LIP Coimbra (Portugal)
MEPhI (Russia)
Imperial College London (UK)
Royal Holloway University of London (UK)
STFC Rutherford Appleton Lab (UK)
University College London (UK)
University of Bristol (UK)
University of Edinburgh (UK)
University of Liverpool (UK)
University of Oxford (UK)
University of Sheffield (UK)

Black Hill State University (US)
Brandeis University (US)
Brookhaven National Lab (US)
Brown University (US)
Fermi National Accelerator Lab (US)
Lawrence Berkeley National Lab (US)
Lawrence Livermore National Lab (US)
Northwestern University (US)
Pennsylvania State University (US)
SLAC National Accelerator Lab (US)
South Dakota School of Mines and Technology (US)
South Dakota Science and Technology Authority (US)

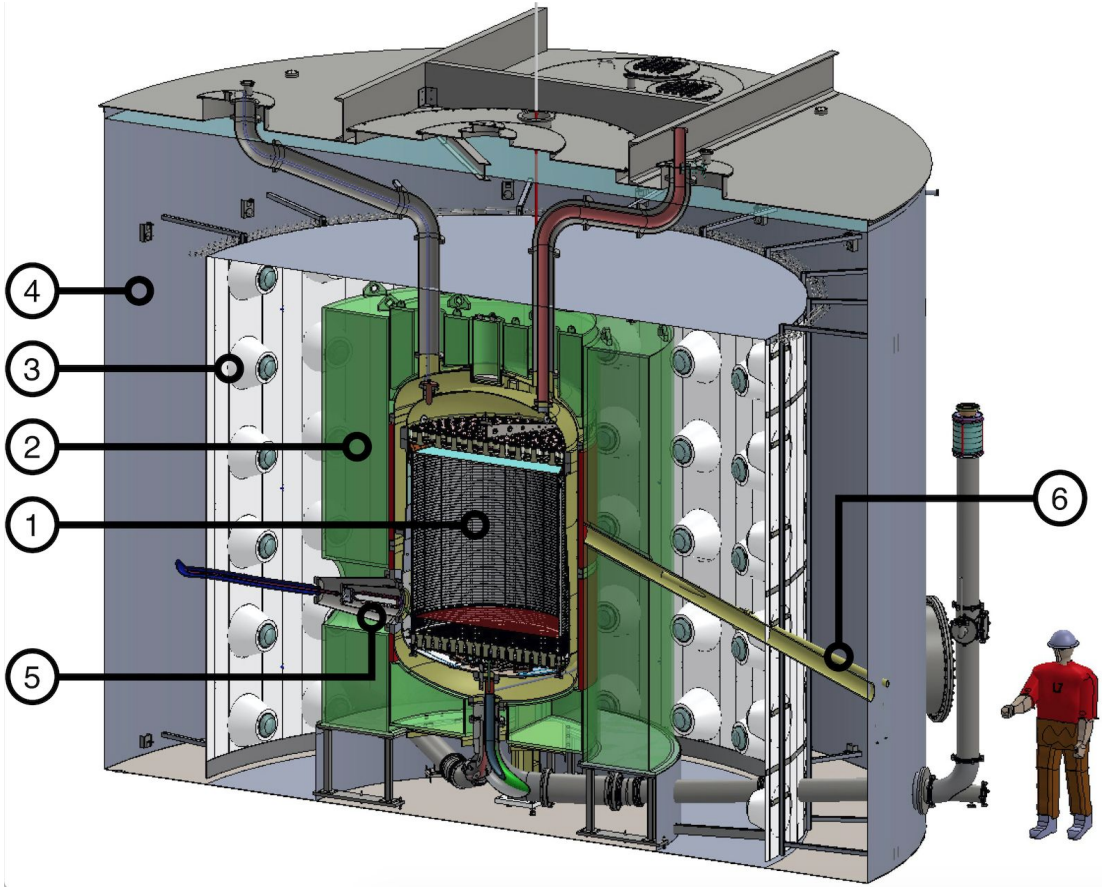
Texas A&M University (US)
University at Albany (US)
University of Alabama (US)
University of California, Berkeley (US)
University of California, Davis (US)
University of California, Santa Barbara (US)
University of Maryland (US)
University of Massachusetts (US)
University of Michigan (US)
University of Rochester (US)
University of South Dakota (US)
University of Wisconsin – Madison (US)

The LZ experiment

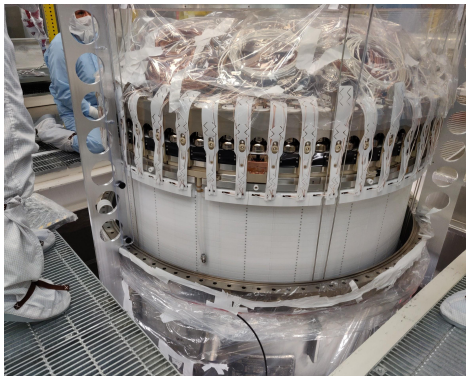
Major LZ detector components:

1. 7 tonne active Xe TPC
2. 17 tonne Gd-load liquid scintillator neutron veto
3. Light detection system (120 8” PMTs) for GdLS detector
4. 228 tonne water tank shielding
5. ~50kV cathode high voltage delivery system
6. Neutron calibration conduit

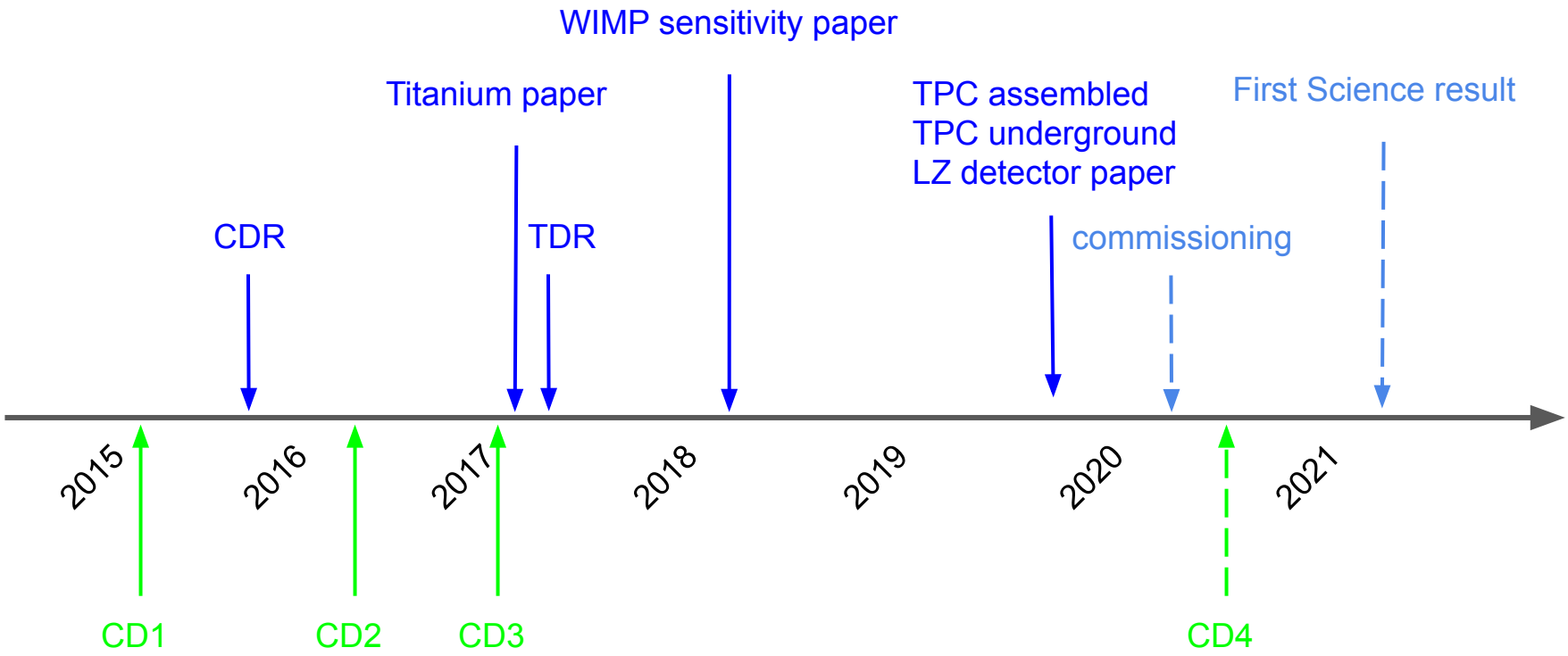
For more information about the LZ detector, visit arXiv:1910.09124



Current status of LZ



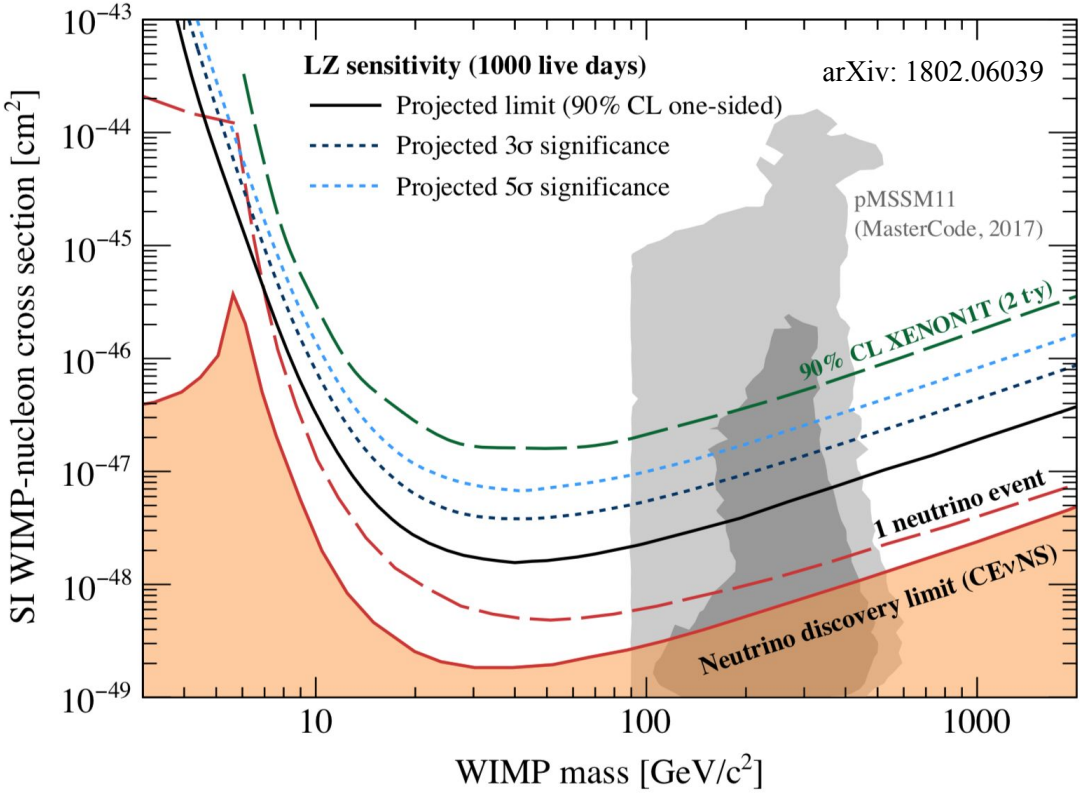
LZ timeline


WIMP sensitivity paper
Titanium paper
TPC assembled
TPC underground
LZ detector paper
First Science result
CDR
TDR
commissioning
2015
2016
2017
2018
2019
2020
2021
CD1
CD2
CD3
CD4

Projected LZ sensitivity

Assumption: 5.6 tonnes fiducial volume X 1000 live days

- SI WIMP-nucleon sensitivity: 1.6×10^{-48} cm^2 for 40 GeV WIMP mass
- SD WIMP-neutron (proton) sensitivity: 2.7×10^{-43} (8.1×10^{-42}) cm^2 for 40 GeV WIMP mass
- Effective Field Theory dark matter interactions, axion-like dark matter searches, and 0vbb searches…

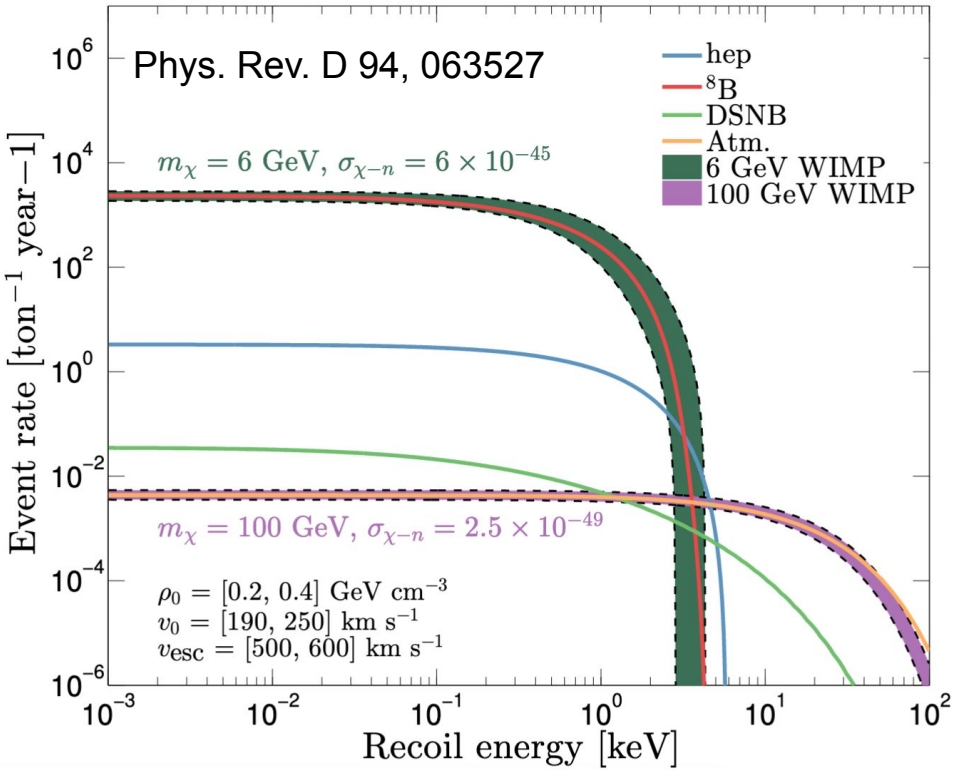


When neutrinos show up in a dark matter detector

CEvNS sets the dark matter discovery limits of any WIMP detectors without directionality capability

In particular, CEvNS from solar ^{8}B neutrinos produces signals that are almost identical to those by 6 GeV WIMPs

- An irreducible background in high-sensitivity WIMP search in the low-mass region
- An in-situ demonstration of claimed WIMP dark matter sensitivity

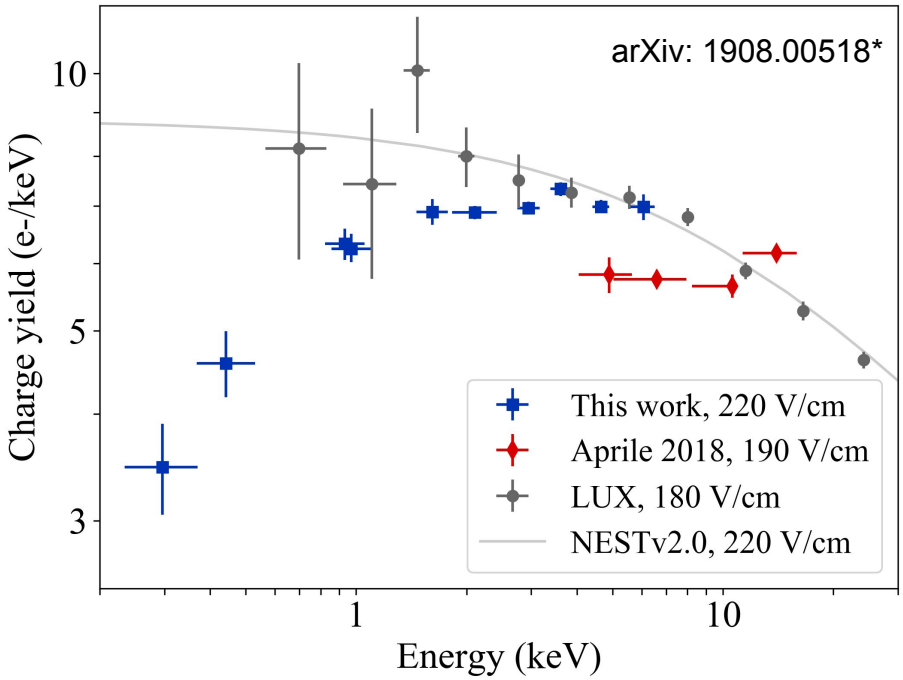


Uncertainties in CEvNS detection in LZ

CEvNS events from ^{8}B occupy the energy region close to the Xe TPC threshold

- Energy calibration is largely uncertain
- The LLNL noble liquid group recently calibrated the ionization yield of Xe recoils down to 0.3 keV (~1 e-)
- The light yield of Xe recoils in this energy regime remains uncalibrated

Where will CEvNS events show up in LZ?



Xenon recoil ionization yield as a function of nuclear recoil energy

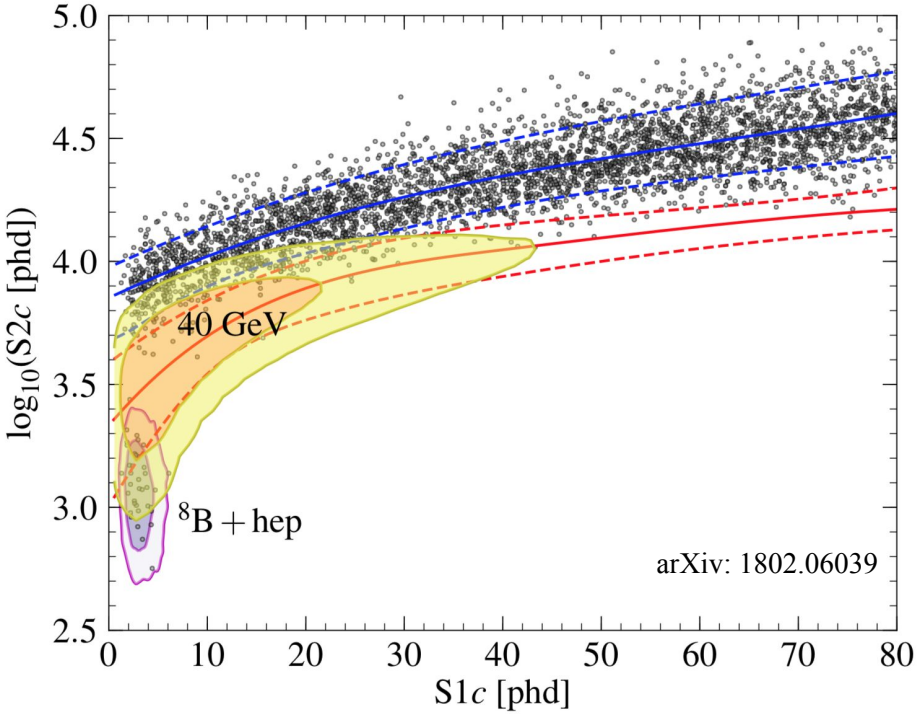
See Lenardo's talk on the measurement details

Expected CEvNS events in LZ

We expected ~35 CEvNS events in the whole LZ exposure

- The actual CEvNS rate will depend on the low-energy xenon recoil yield values and detector efficiencies
- The exact distribution of ^{8}B CEvNS events may shift if the yield values differ from current assumptions

The event rate will be much higher if we can lower the analysis threshold (reduced S1 coincidence threshold, or S2-only)



Anticipated distribution of CEvNS from 8B and hep neutrinos in the S2-S1 parameter space in LZ

Summary

- LZ is the most sensitive WIMP dark matter experiment that is currently planned & under construction
- LZ construction is on schedule, with an anticipated commissioning time of mid 2020
- LZ is expected to observe a few dozens of CEvNS events from solar ^{8}B neutrinos
- The observation of solar CEvNS events in LZ will be a direct confirmation of the experiment's low mass WIMP sensitivity
- Stay tuned on LZ progress!