THE LUX-ZEPLIN DARK MATTER EXPERIMENT

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IWARA From Quarks to Cosmos
Sept 6 - 12, 2020

UNIVERSITY AT ALBANY
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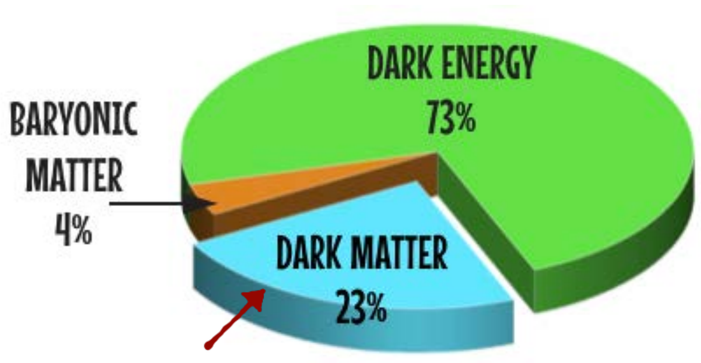
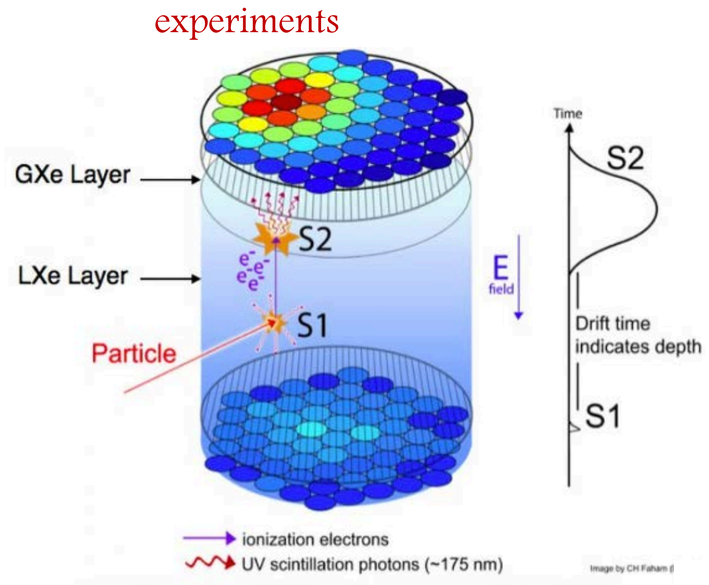
COMPONENTS OF OUR UNIVERSE



one of the GREATEST UNSOLVED MYSTERIES of the UNIVERSE !!!

WHAT IS DARK MATTER ???

- ✓ Matter that we cannot see but infer its presence from its gravitational effects
- ✓ One of the most promising dark matter candidate: Weakly Interacting Massive Particles (WIMPs)
- ✓ WIMPs are detected through nuclear recoil interactions in low-background experiments



LUX-ZEPLIN (LZ) EXPERIMENT:

- ✓ 'G2' (Generation 2) dark matter experiment merging LUX (Large Underground Xenon) and ZEPLIN (ZonEd Proportional scintillation in LIquid Noble gases) experiments
- ✓ Located 4,850 ft underground in Sanford Underground Research Facility (SURF), Lead, South Dakota
- ✓ LZ Collaboration ~250 scientists in 37 institutions in US, UK, Portugal, Russia, and Korea

THE LZ DETECTOR:

- ✓ Time Projection Chamber (TPC): contains 7 tonnes of ultra-pure cryogenic liquid Xe. WIMPs scatter with target Xe nuclei producing primary "S1" and secondary "S2" signals
- ✓ Photomultiplier tubes (PMTs): very sensitive photon detectors; detects S1 and S2 signals
- ✓ Skin and Outer detector: operates as an integrated veto system – rejecting gammas and neutrons; Gd - loaded liquid scintillator is held in large acrylic vessels
- ✓ Water Tank: mitigates cosmogenic backgrounds

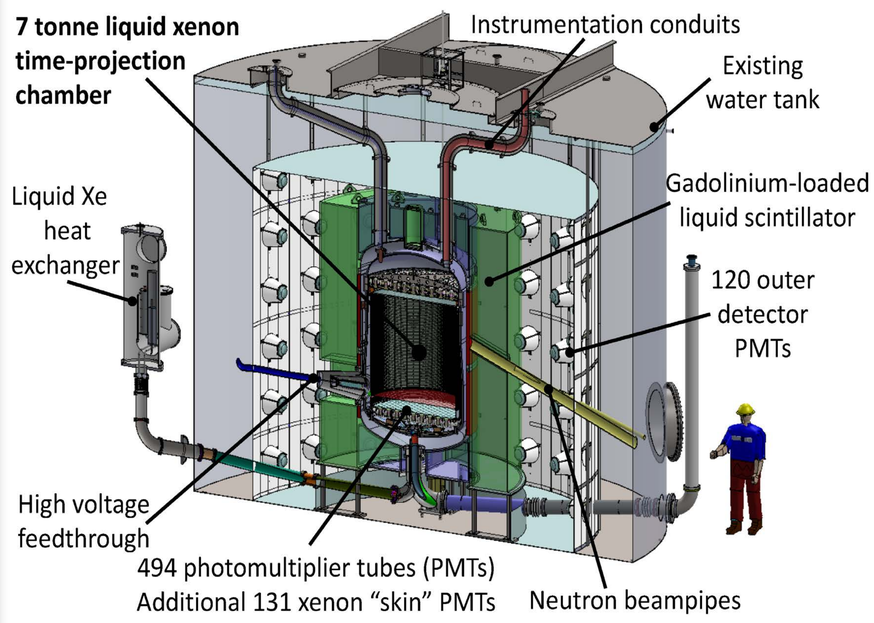
Working in Rn-reduced cleanroom

Assembled TPC

Moving TPC to the cavern

Dome Skin PMTs

The LZ Detector



BACKGROUNDS:

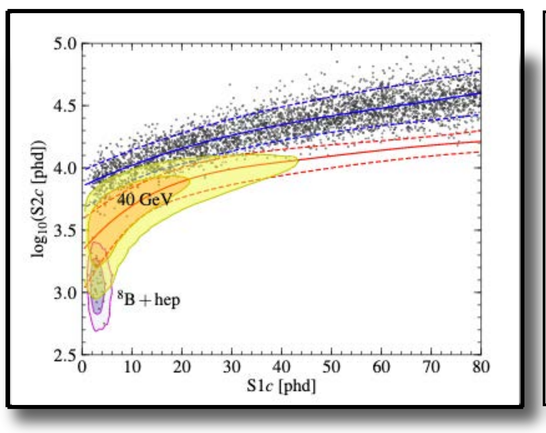
WIMPs, neutrons – Nuclear recoils
Gammas, betas – Electron recoils

External Sources

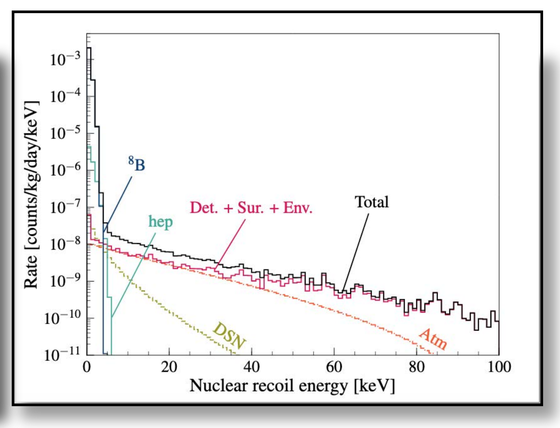
Mitigation:
- ✓ Will operate underground at SURF in Lead, SD
- ✓ Measure rock backgrounds
- ✓ Instrumented Xe skin region
- ✓ Gd- LS outer detector
- ✓ High purity water shield

Internal Sources

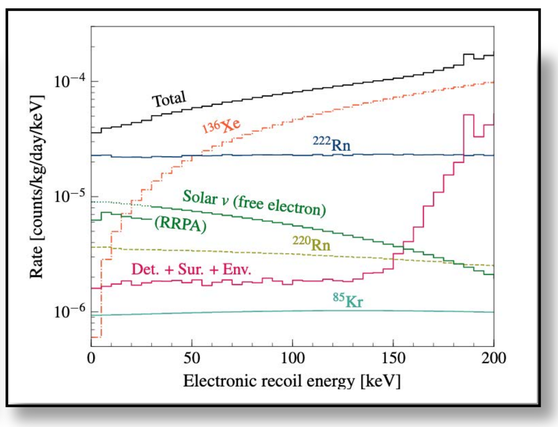
Mitigation:
- ✓ Radio-assay campaign
- ✓ Gamma- screening, ICPMS, NAA
- ✓ TPC assembly in Rn-reduced cleanroom
- ✓ Dust < 500 ng/cm^3 on all LXe wetted surfaces
- ✓ Rn-daughter plate-out on TPC walls < 0.5 mBq/m^2
- ✓ Charcoal chromatography at SLAC



LZ Simulation for a background only 1000 liveday run and a 5.6 tonne fiducial mass [2]



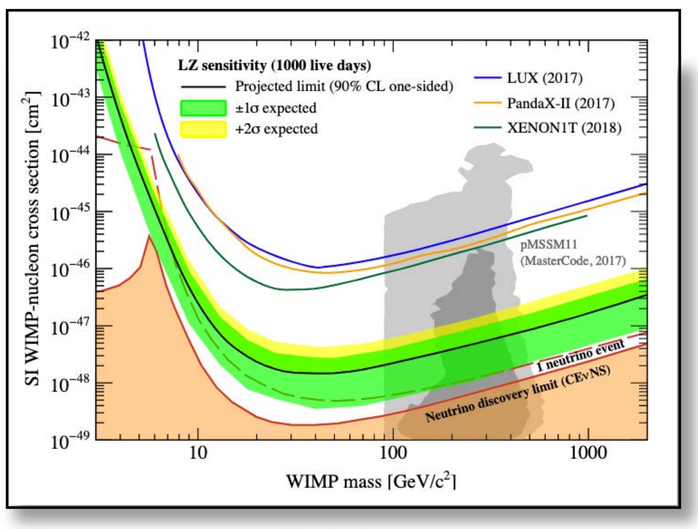
Expected NR background spectra in the 5.6-tonne fiducial volume for single scatter events without skin and OD veto signals [2]



Expected ER background spectra in the 5.6-tonne fiducial volume for single scatter events without skin and OD veto signals [2]

SENSITIVITY:

For a 1000 live day run, the projected spin-independent cross-section sensitivity of LZ is **1.6 x 10^{-48} cm^2** for a 40 GeV/c^2 mass WIMP

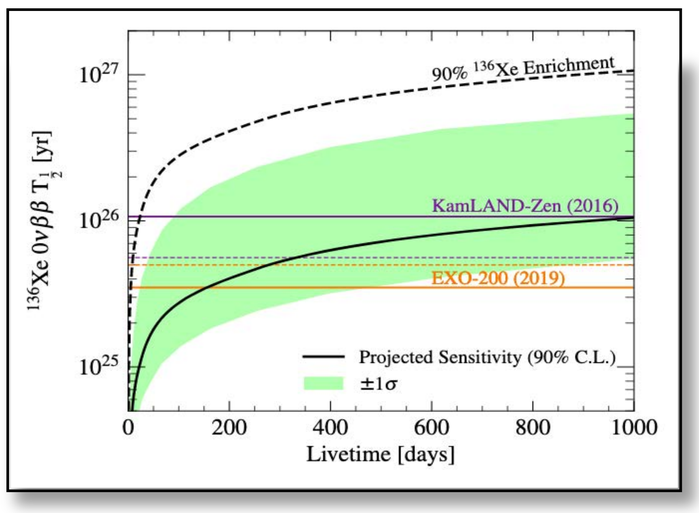


LZ projected sensitivity to SI WIMP-nucleon elastic scattering for 1000 live days and a 5.6 tonne fiducial mass [2]

Sensitivity to ^{136}Xe 0νββ :

- ✓ **High abundance of the decaying element:** LZ uses 7 tonnes of LXe, yielding 623 kg of ^{136}Xe at natural abundance
- ✓ **High energy resolution at the Q-value of the decay:** Predicted LZ energy resolution at $Q_{\beta\beta}$ is 0.88%

The median exclusion sensitivity to the half-life of ^{136}Xe is projected to be **1.06×10^{26} years** (90% CL) after 1000 live-days



LZ projected sensitivity to ^{136}Xe 0νββ decay as a function of detector live time [4]

LZ will be the most sensitive direct detection dark matter experiment.
LZ construction is near complete and it will start commissioning this year.

STAY TUNED!!!

References:
1) D.S. Akerib et al., The LUX-ZEPLIN (LZ) radioactivity and cleanliness control programs, arXiv: 2006.02506 (2020)
2) D.S. Akerib et al., Projected WIMP sensitivity of the LZ dark matter experiment, PRD 101, 052002 (2020)
3) D.S. Akerib et al., The LUX-ZEPLIN (LZ) experiment, NIM A, Vol. 953,163047 (2020)
4) D.S. Akerib et al., Projected sensitivity of the LUX-ZEPLIN experiment to the 0νββ decay of ^{136}Xe, Phys. Rev. C 102, 014602 (2020)
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6) D.S. Akerib et al., Measurement of the Gamma Ray Background in the Davis Cavern at the Sanford Underground Research Facility, Astropart. Phys, 116, 102391 (2019)
7) S.J.Haselschwardtet al., A Liquid Scintillation Detector for Radioassay of Gadolinium-Loaded Liquid Scintillator for the LZ Outer Detector, NIM A, Vol. 937, 148-163 (2019)