Noble Liquid Capabilities at Lawrence Livermore National Laboratory (USA)

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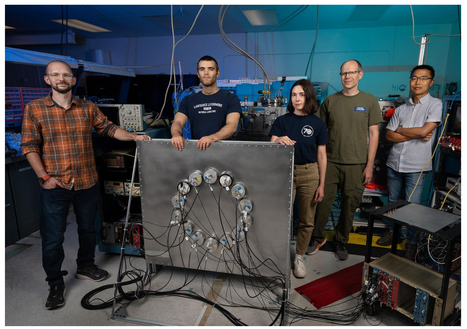
Introduction

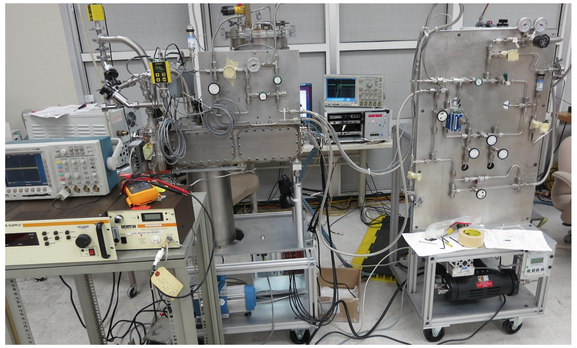
- LLNL is a founder of XENON10, LUX, LZ and XLZD with ~20 years of noble liquid dark matter search experience
- Two noble liquid TPCs with unique capabilities led to several world-leading R&D results
- Group has extensive experience in detector development, calibration, simulation and data analysis



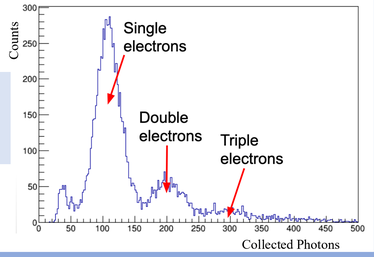
Compact, High-performance Xe TPC

We developed a portable, compact and high performance Xe TPC

- ~1"x1" target volume, ideal for external calibrations
- Up to 30 kV HV capability, ~100% electron extraction
- PMT and/or SiPM readout



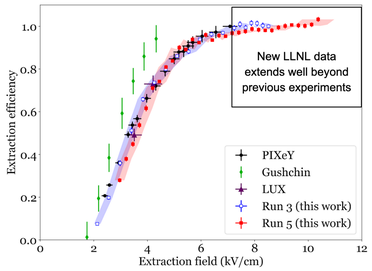
>100 photoelectrons /electron S2 gain, electron counting capability

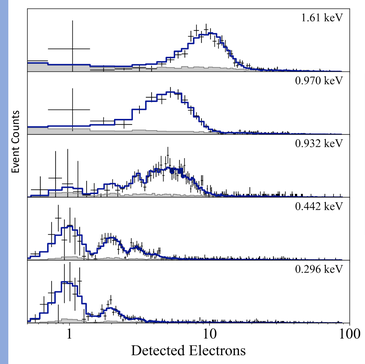


Recent Work on Xe R&D

Liquid-> gas electron extraction efficiency measurement up to 10.4kV/cm (liquid) with clear saturation feature

PRD 99, 103024



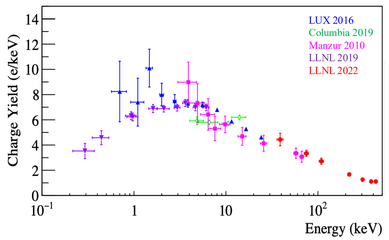


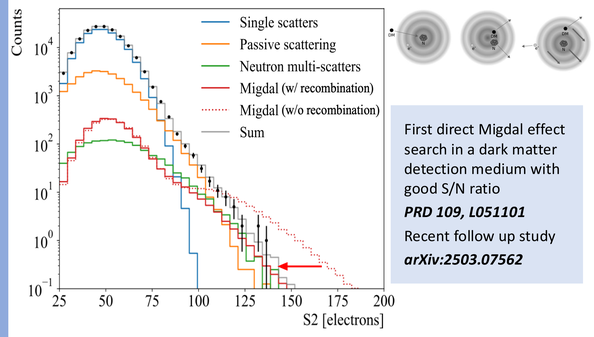
LXe response to NR signals down to 0.3keV with electron counting resolution, covering field range of 220 - 6240 V/cm

PRL 123, 231106

LXe response (light and charge) to NR signals between 39 and 426 keV, 200-2000 V/cm field range

PRD 106, 052013





First direct Migdal effect search in a dark matter detection medium with good S/N ratio

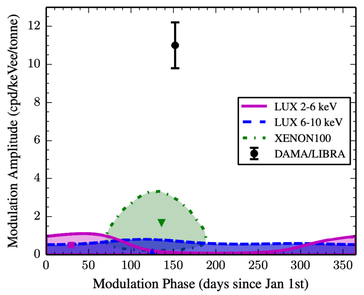
PRD 109, L051101

Recent follow up study

arXiv:2503.07562

LUX and LZ Contributions

LLNL delivered LUX PMT holder/shielding structure



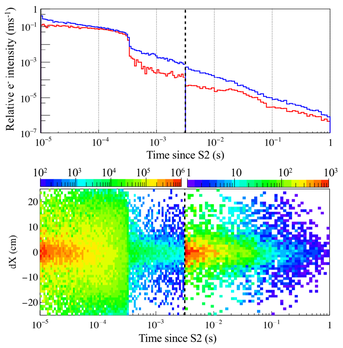
LLNL led LUX modulation signal search

PRD 98, 062005

LLNL carried out comprehensive low-energy electron background study with both LUX and LZ

PRD 102, 092004

LZ result to be published

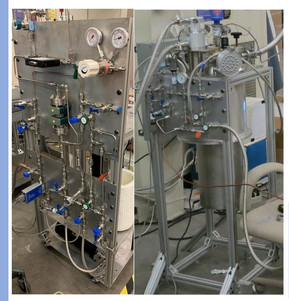


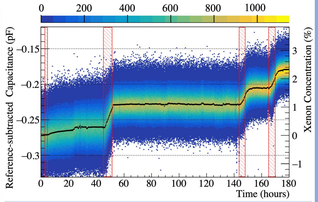
- Xu oversaw LUX analyses as Analysis Coordinator
- Mannino oversees LZ calibrations as Run Manager
- Kazkaz developed and maintained BACCARAT simulation
- Bernard developed LZ high voltage feedthrough (while at LBL)

Synergistic Activities

LLNL developed a liquid argon TPC with VUV SiPM readout and heavy xenon doping capability

Goal: *combine benefits of Ar and Xe in a single TPC detector*





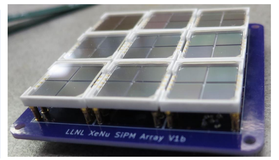
LLNL achieved stable operation with 5% Xe doped in LAr (2.3% in plot)

PRC 108, 045503

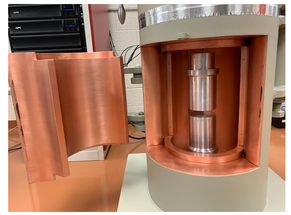
XLZD Research Interest

1. Investigate possible use of SiPM for the skin detector

- Low radioactivity
- Low profile
- Easy to tile
- Skin has higher tolerance to after-pulsing and crosstalk



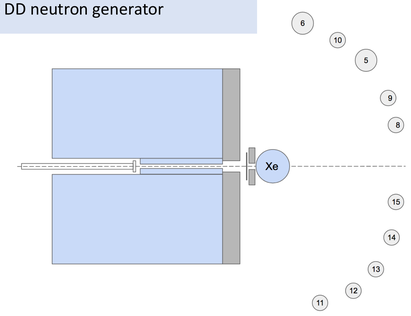
2. Radioactivity assay



- Many HPGe detectors at LLNL
- 2 Large, low-background HPGE detectors at SURF

3. *in-situ* and *ex-situ* xenon response calibration

- Extensive experience in calibrations
- Dedicated LXe TPC for calibration
- P383 DD neutron generator



Conclusion

- LLNL group has unique capabilities in LXe detectors
- 20 years of institution knowledge in LXe dark matter searches
- Two dual-phase TPCs developed in house, with each optimized for specific capabilities
- We have made significant contributions to the noble liquid field
- We would like to leverage our expertise to help XLZD succeed

Acknowledgement

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