nEXO Overview & Computing Challenges

DANCE Workshop 2019

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October 28, 2019

LLNL-PRES-XXXXXX

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

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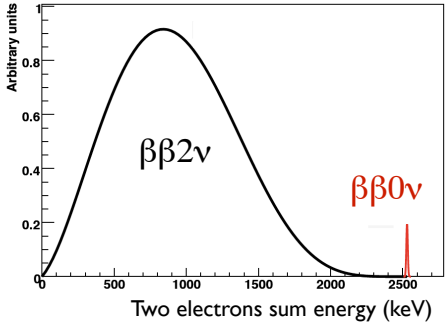
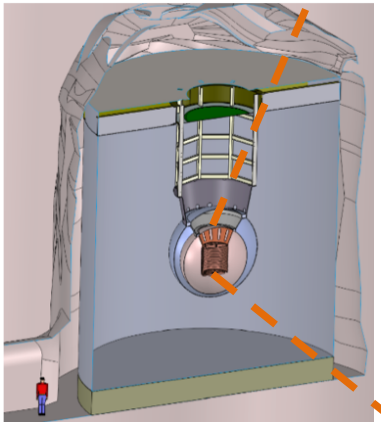
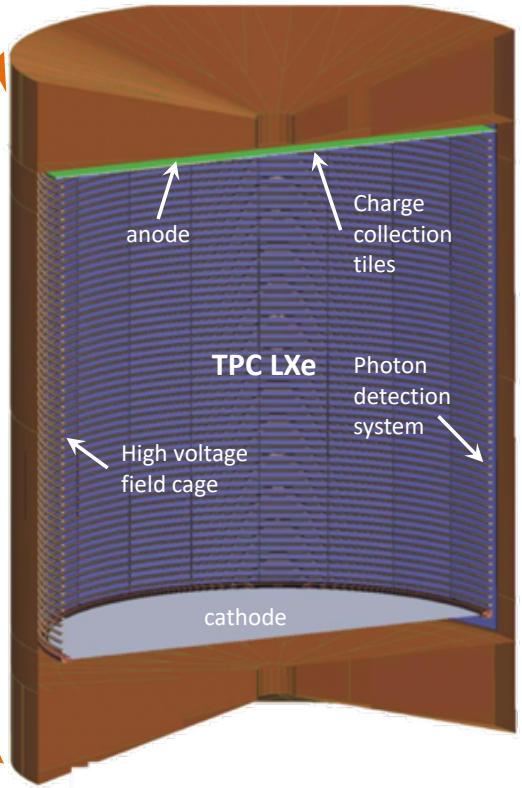
The nEXO Experiment

- 5000 kg of Xe at 90% enrichment i
  ^{136}Xe $0\nu\beta\beta$ candidate isotope
- Monolithic LXe Time Projection Chamber (TPC)
- Correlated measurement of ionization and scintillation signals
- Layered active and passive shielding
- Based on successful EXO-200 experiment



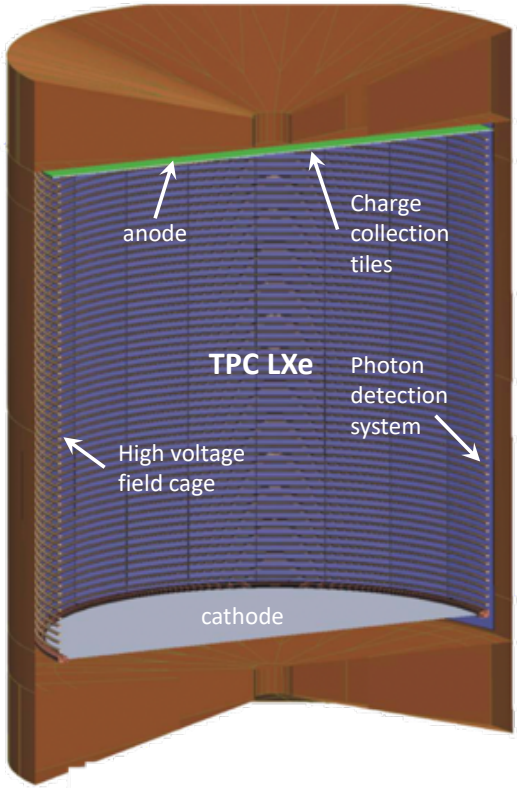




Ref:
"nEXO pre-conceptual Design Report", arXiv:1805.11142
"Sensitivity and discovery potential of the proposed nEXO experiment", PRC97, 065503 (2018)

Notable Experimental Considerations

- Searches for $\beta\beta0\nu$:
  - Focus on high-energy interactions ($Q_{\beta\beta}$ = 2458 keV)
  - Energy resolution is important (though not the only factor)
- Single-phase liquid xenon TPC
- Charge signal:
  - Read out via tiles on the anode
  - < ~ 8000 channels
  - No Frisch grid
- Light signal:
  - SiPMs on the barrel
  - < ~ 6400 channels
  - No reflectors
  - No separation between active and skin LXe (open-cage TPC design)
  - Dark Rate (< 50 Hz / mm^2)
- Calibration: high-rate calibration (~2 kHz) with external gamma sources



Example EXO-200 final data

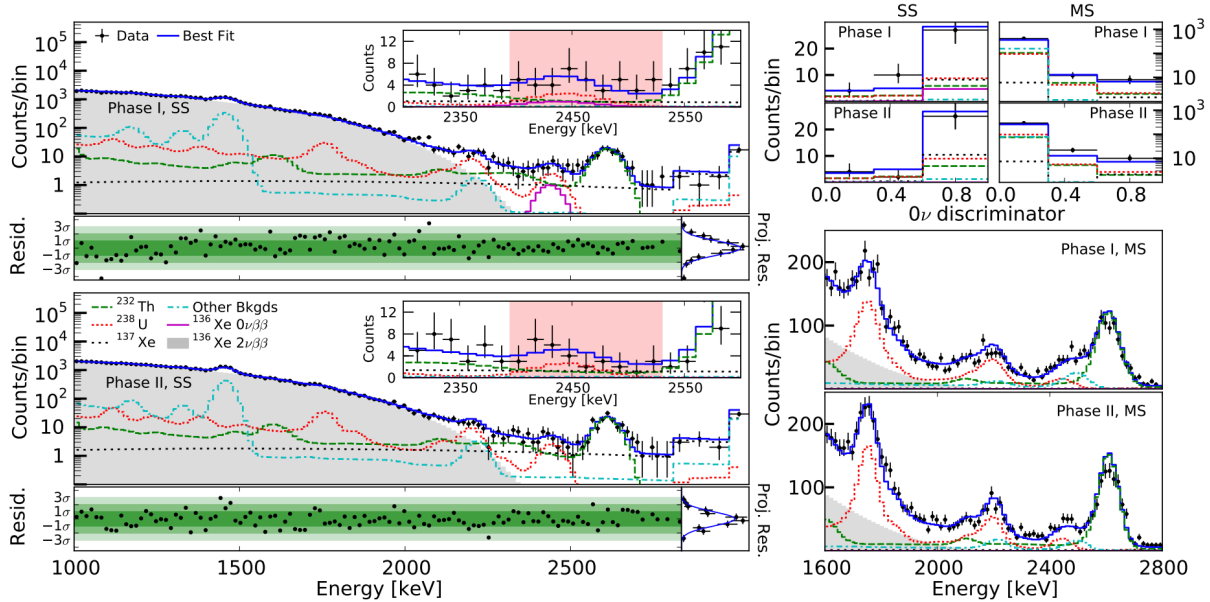


FIG. 5. Best fit to the low background data SS energy spectrum for Phase I (top left) and Phase II (bottom left). The energy bins are 15 keV and 30 keV below and above 2800 keV, respectively. The inset shows a zoomed in view around the best-fit value for $Q_{\beta\beta}$. (top right) Projection of events in the range 2395 keV to 2530 keV on the DNN fit dimension for SS and MS events. (bottom right) MS energy spectra. The best-fit residuals typically follow normal distributions, with small deviations taken into account in the spectral shape systematic errors.

- MLM fit
- Multiplicity SS/MS
- Energy
- DNN discriminator

Ref. Phys. Rev. Lett. 123, 161802 (2019)

Computational Challenges

- Large channel number and data rate (400 Gb/s)
- Significant simulations required
- Machine learning
- Optical simulations
- High-rate calibration (1.6 kHz)
  - Continuous occupancy in the detector
  - More complex event reconstruction
  - Match light to deep events charge signals
- Statistical rigor
- Long-term (~10y) software development and management
  - Long term support for tools
  - Dependency management (upgrades)
  - Onboarding and expertise retention

Current Status

- Development of the software pipeline
  - Need fast turn-around to support detector design and optimization
- Increase details and fidelity of the simulations
- Development of the analysis
- Development of the DAQ and computing infrastructure
- Establish our SW development ecosystem
  - Code dev, integration, release, deployment, distribution, etc…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