

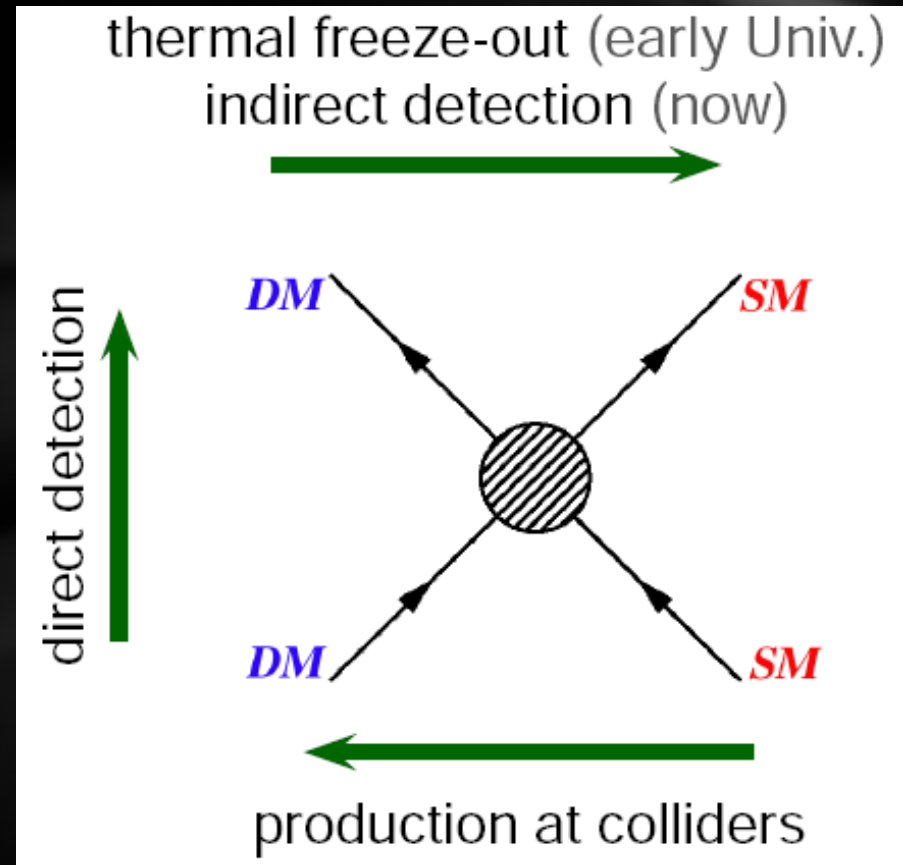
A top-down view of a circular detector component, likely a PMT array, featuring a dense grid of copper-colored cylindrical tubes. The tubes are arranged in a hexagonal pattern. The surrounding area is a light-colored, possibly aluminum, plate with various wiring and connectors visible around the perimeter. The text "The Large Underground Xenon (LUX) Experiment" is overlaid in large white font, and "An Overview" is overlaid in a smaller, italicized white font below it.

The Large Underground Xenon (LUX) Experiment

An Overview

The Goal: Directly Detect Dark Matter

- We theorize the existence of dark matter based on its gravitational effects. We currently have no other evidence of its existence, or its nature.
- Through direct detection we hope to verify its existence (as opposed to modified gravity theories) as well as learn about its properties (mass, interaction strength, etc).
- Direct detection is when a DM particle scatters off of a normal particle.



The candidate: WIMPs

- The leading candidate for dark matter is a particle called the WIMP.
- WIMP stands for Weakly Interacting Massive Particle, so called because it interacts only via the weak force and via gravity.
- This is because in order to get the correct amount of dark matter out of the big bang in the simplest models requires a particle with a self interaction cross section at the weak scale.
- WIMPS are expected to have mass in the 100GeV range. This makes Xenon an ideal detection medium, having mass $\sim 120\text{GeV}$.

The Detector: LXe TPC

- Teflon Vessel containing liquid and gaseous Xenon
- PMT arrays at the top and bottom
- Biased wire grids provide electric field

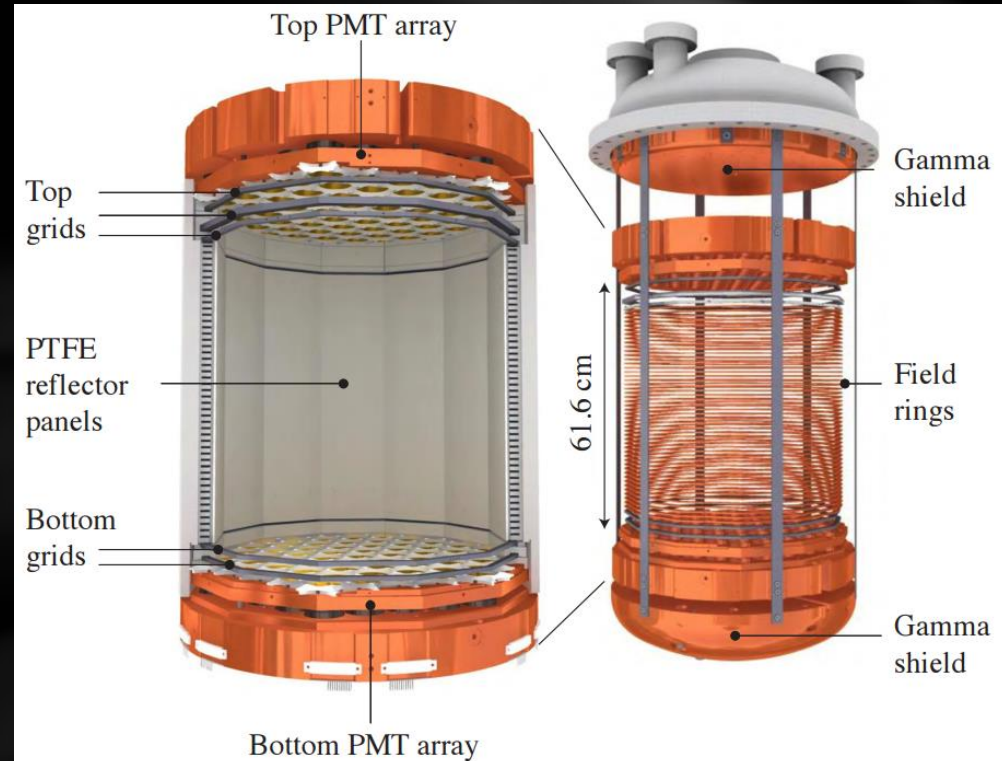
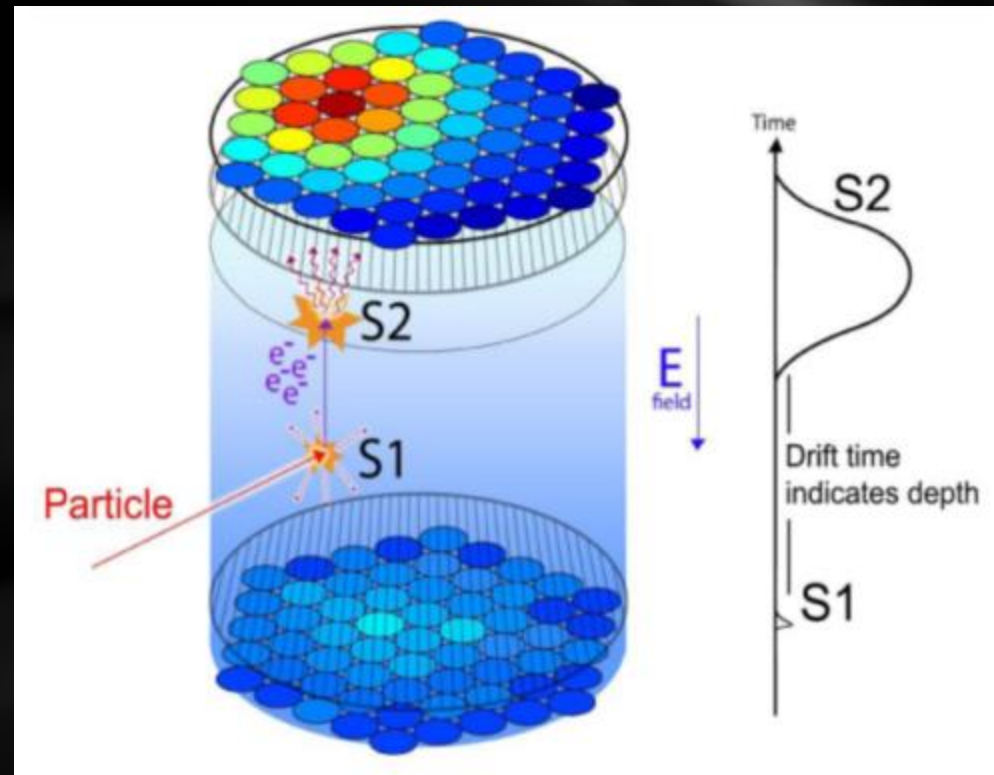


Figure 7: Rendering of the LUX TPC, supported from the top flange of the inner cryostat.

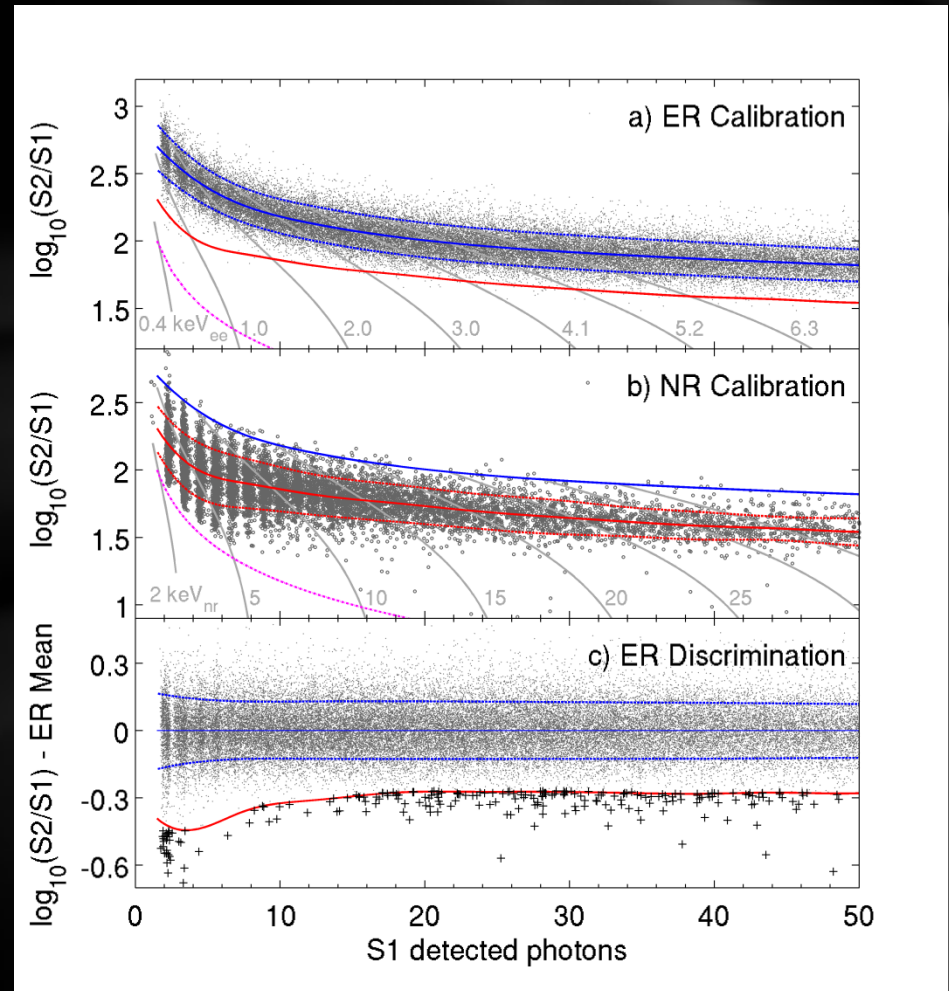
The Signal: Scintillation and Electroluminescence

- Interactions produce both excited Xe molecules (Xe_2^*), and Xe ions (Xe^+).
- Xe_2^* relaxes to produce scintillation (S1) (175 nm photons).
- e^- from ionization can do two things:
 - recombine to form Xe_2^* , then scintillate
 - or drift to the surface and cause electroluminescence (S2) in the gas (the e^- further excite Xe gas and that scintillates)
- The pattern of light on the PMT arrays along with the delay between the S1 and S2 signals tell us where the event took place.



Signal Types: Electron vs Nuclear recoils

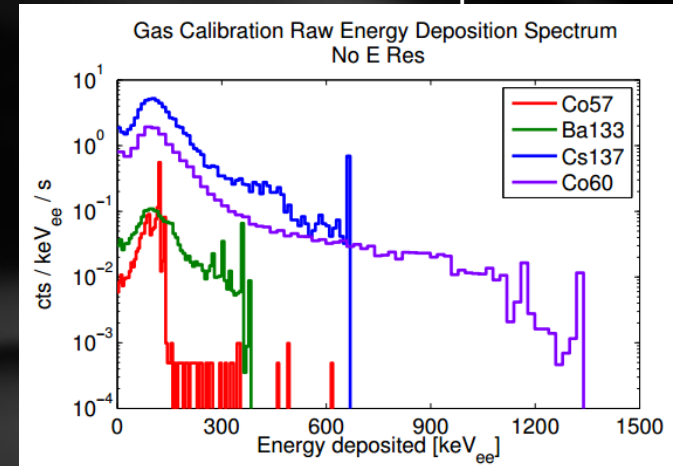
- Charged particles and photons produce electron recoils.
- Non-charged particles (like WIMPS and neutrons) produce nuclear recoils.
- Electron recoils result in more ionization than nuclear.
- Because of this, their S_2/S_1 ratio is higher which can be used to distinguish between them.



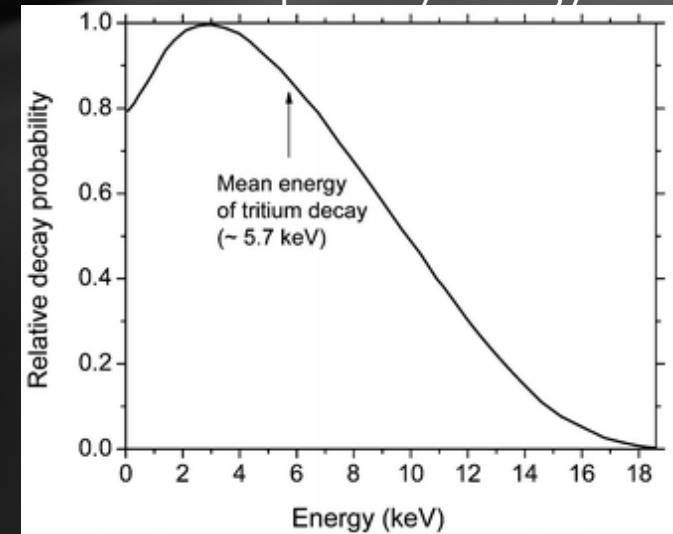
Calibration: Electron Recoil

- We use a range of γ -ray sources to determine the shape of the ER band. Most of these are deployed externally and only penetrate the outer edge of the detector.
- Two sources are injected directly:
 - Tritium (^3H) in the form of CH_3T - a β source at < 18.6 keV (mean e^- energy of 5.7 keV)
 - $^{83\text{m}}\text{Kr}$ - A metastable excited state of Krypton which emits two γ s at 41.6 keV and 9.4 keV.

External Source Spectra

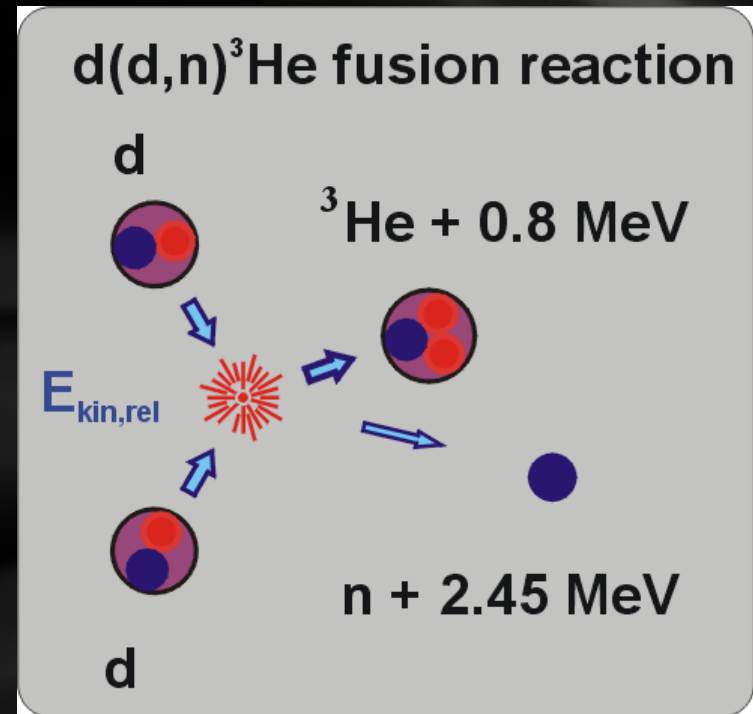


Tritium β Decay Energy



Calibration: Nuclear Recoil

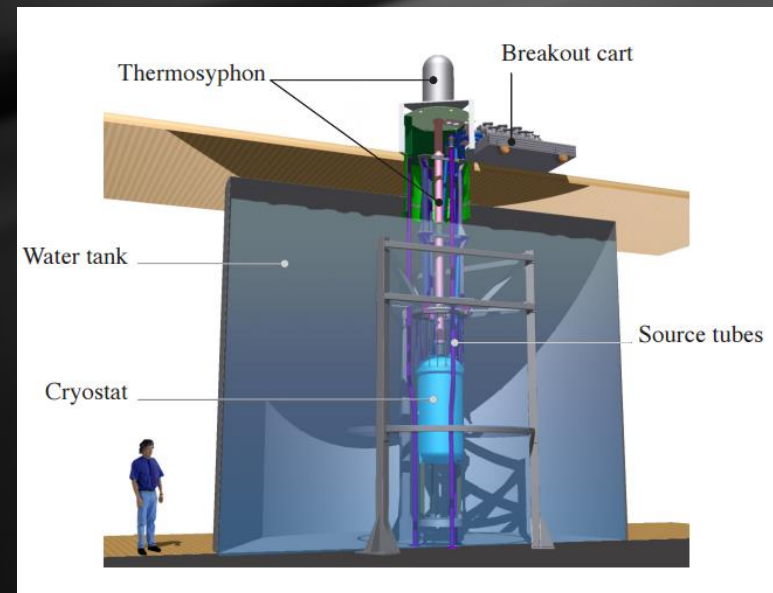
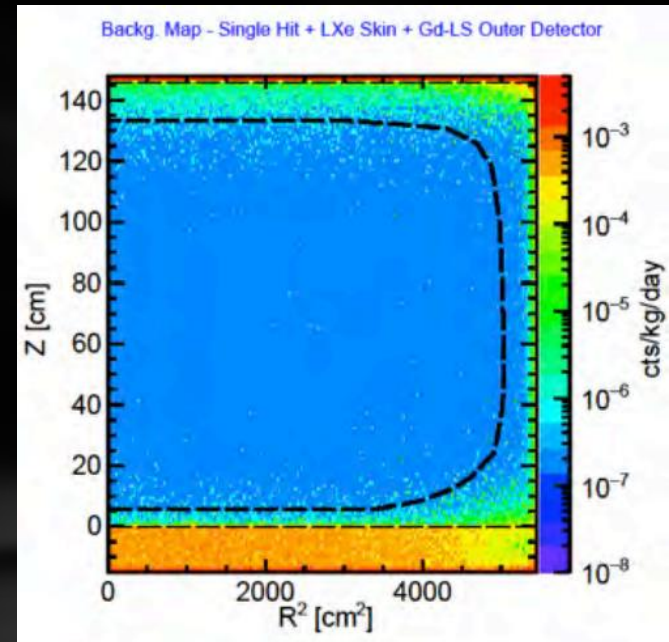
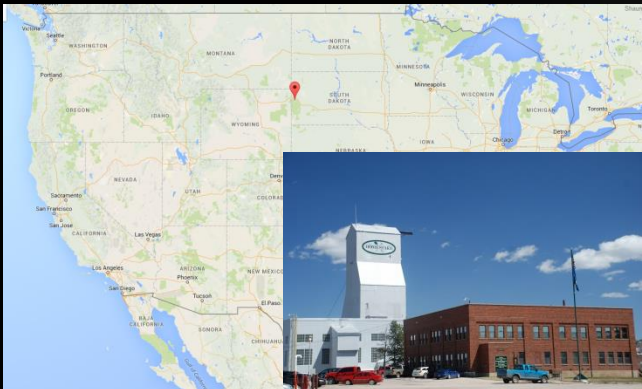
- We use a Deuterium-Deuterium (DD) neutron generator to map out the NR band.
- The neutrons are monoenergetic with 2.45 MeV kinetic energy.
- This creates an energy deposition spectrum out to ~74 keV, covering the expected WIMP region.



<http://www2.mpg.mpg.de/lpg/research/neutrons/neutrons.html>

Backgrounds:

- We mitigate the background from cosmic rays by retreating underground to the 4850' level at the Sanford Underground Research Facility in Lead, SD.
- The ground is also radioactive, however, so we need a water tank to shield against radiation from the cavern walls.
- The detector components themselves also emit radiation so we only use the innermost portion of the Xe to look for WIMPs.



Results & Progress

- Our first real search was a 90 day run (called runo3). Which produced the best spin independent limit at that time.
- After the fact, we refined calibrations and analysis techniques and produced a new limit with the same data from Runo3 which we call the “Runo3 Reanalysis” which is the current leading spin independent limit.
- Runo4 is an additional 210 live-day run that just finished earlier this month.
- We are in the process of final calibrations and analysis of this data.

