LZ Dark Matter Searches: Neutron Analysis and OCS

Alice Baxter
Supervisors: Sergey Burdin and Carl Gwilliam
19/12/19
HEP Christmas Meeting

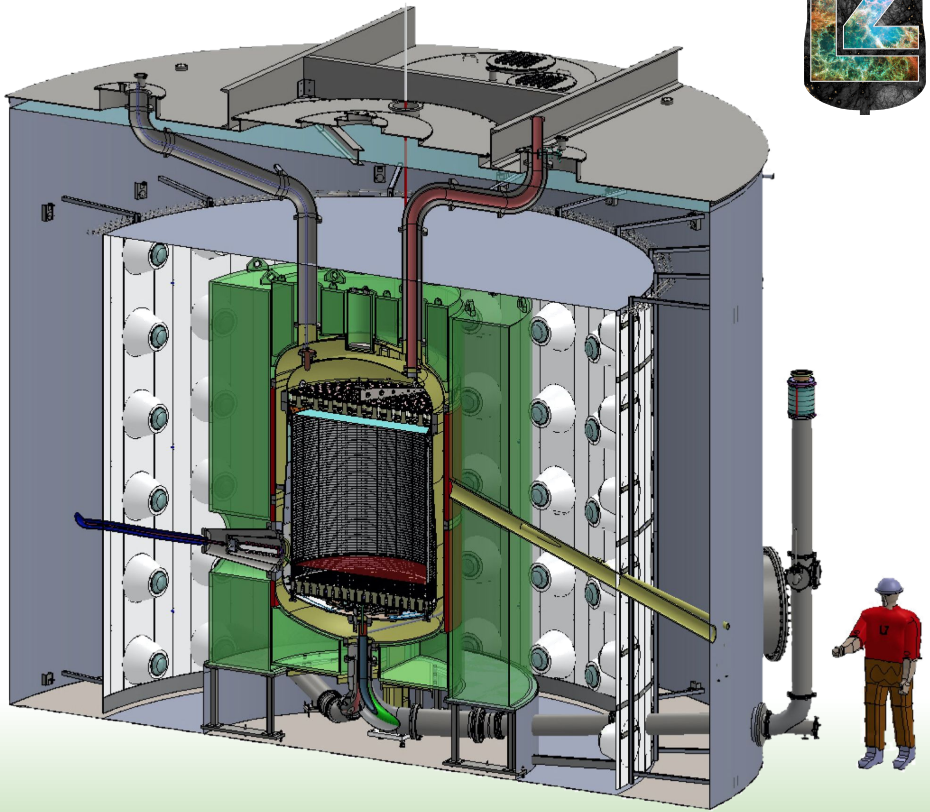
Overview

- What is LZ?
- Detecting dark matter.
- Understanding the neutron background.
- Optical Calibration System.

Me working in the clean room at SURF.

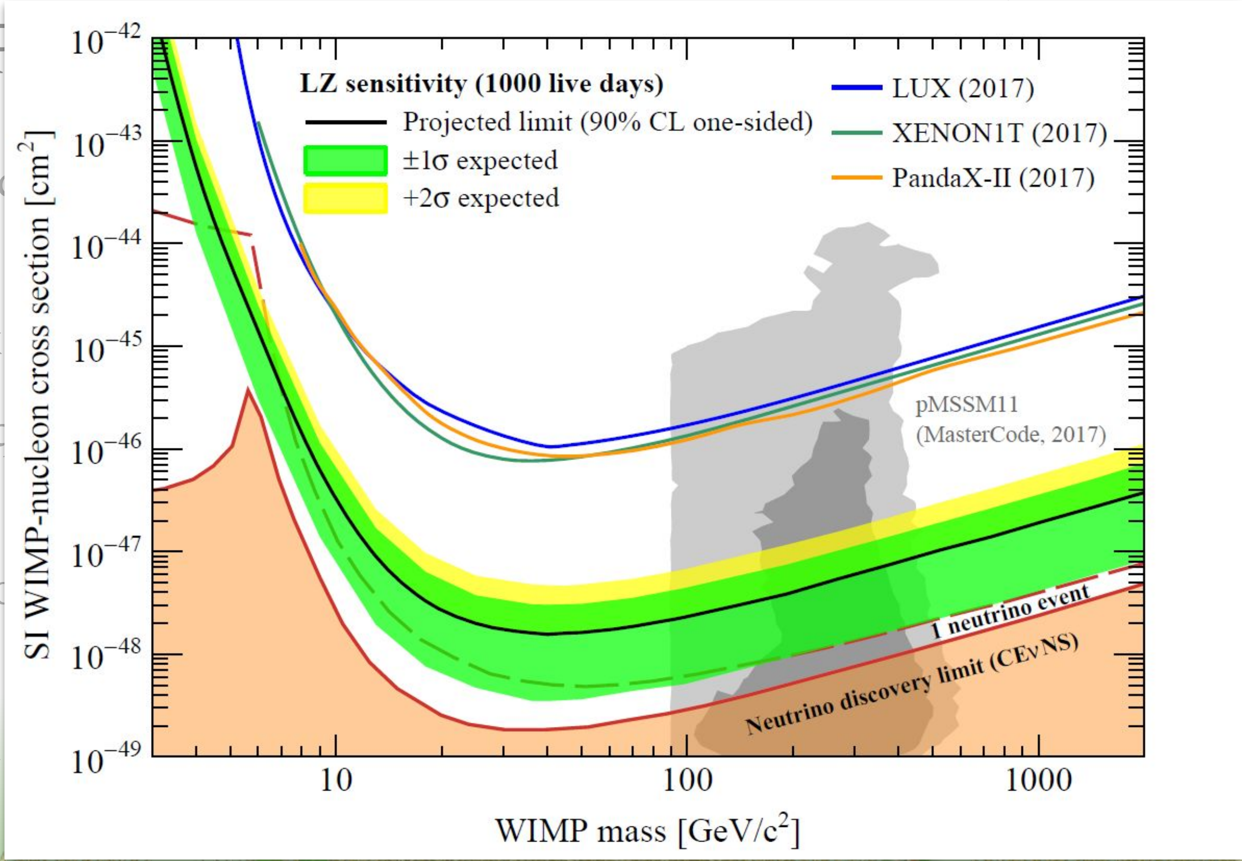
LUX-ZEPLIN

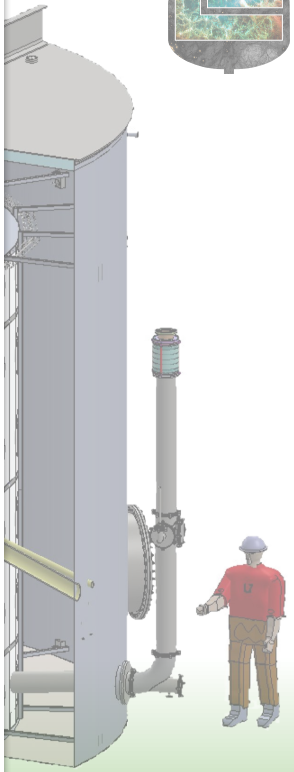
- Dark matter direct detection experiment.
- Dual-phase xenon TPC.
- Gd-loaded liquid scintillator outer detector.
- Situated almost a mile underground at SURF, SD.
- Aims to start taking data summer 2020.



LUX-ZEF

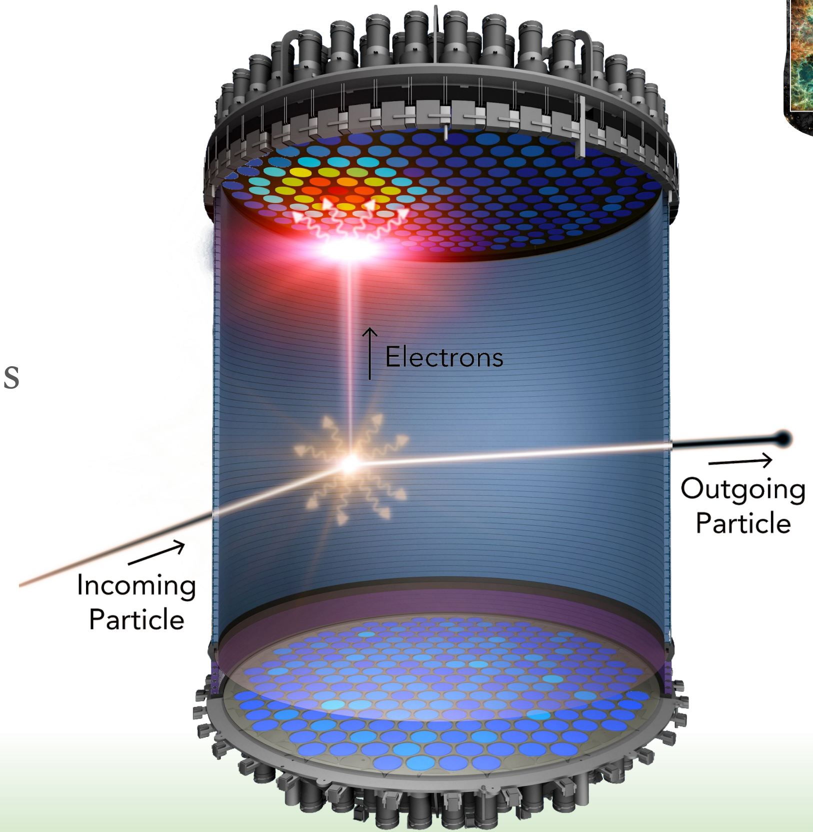
- Dark matter e
  experiment.
- Dual-phase x
- Gd-loaded lic
  detector.
- Situated almo
  SURF, SD.
- Aims to start





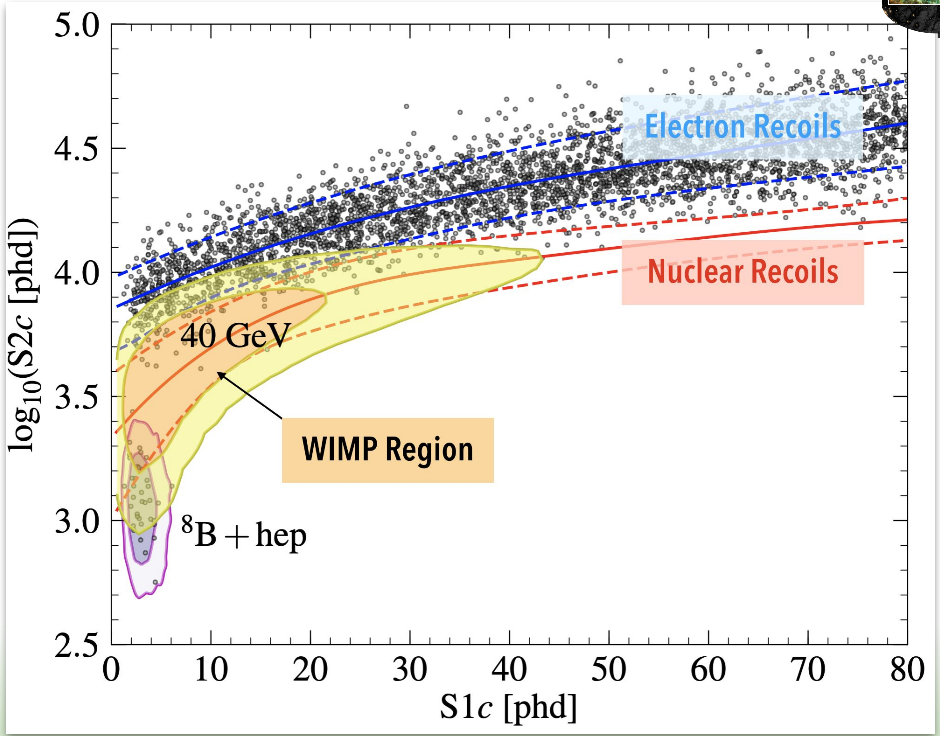
Dark Matter Detection

- A WIMP entering the TPC may interact with a Xe nucleus causing a recoil.
- This releases energy in the form of photons (S1) and electrons.
- The electrons are drifted to the top of the detector where they emit a secondary photon signal (S2).



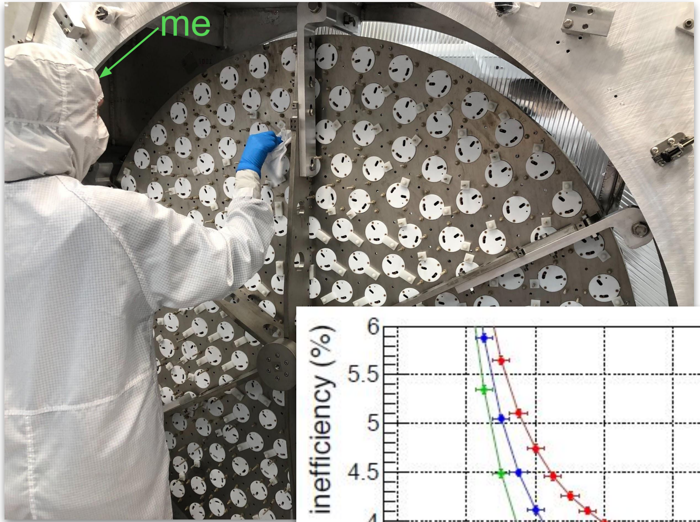
Particle Identification

- The ratio of the S1 and S2 signals is different for electron recoils and nuclear recoils.
- WIMPs interact via nuclear recoils and can therefore be separated from many backgrounds using this method.
- Neutrons also cause nuclear recoils.



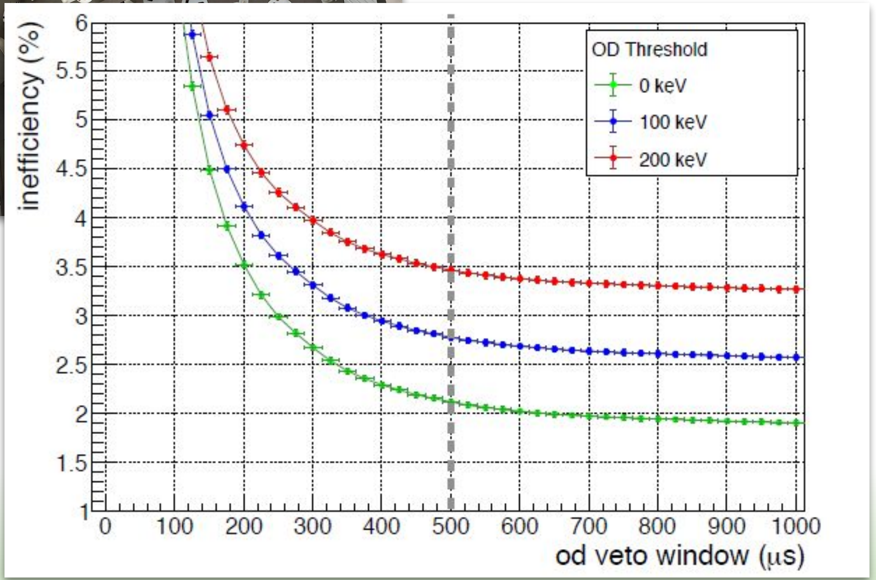
Backgrounds

- Backgrounds reduced by shielding and cleanliness.
- Veto detectors help to remove other background events.
- Gd in the OD has a high neutron capture cross-section resulting in most neutrons being captured.



Me cleaning the top PMT array to remove dust

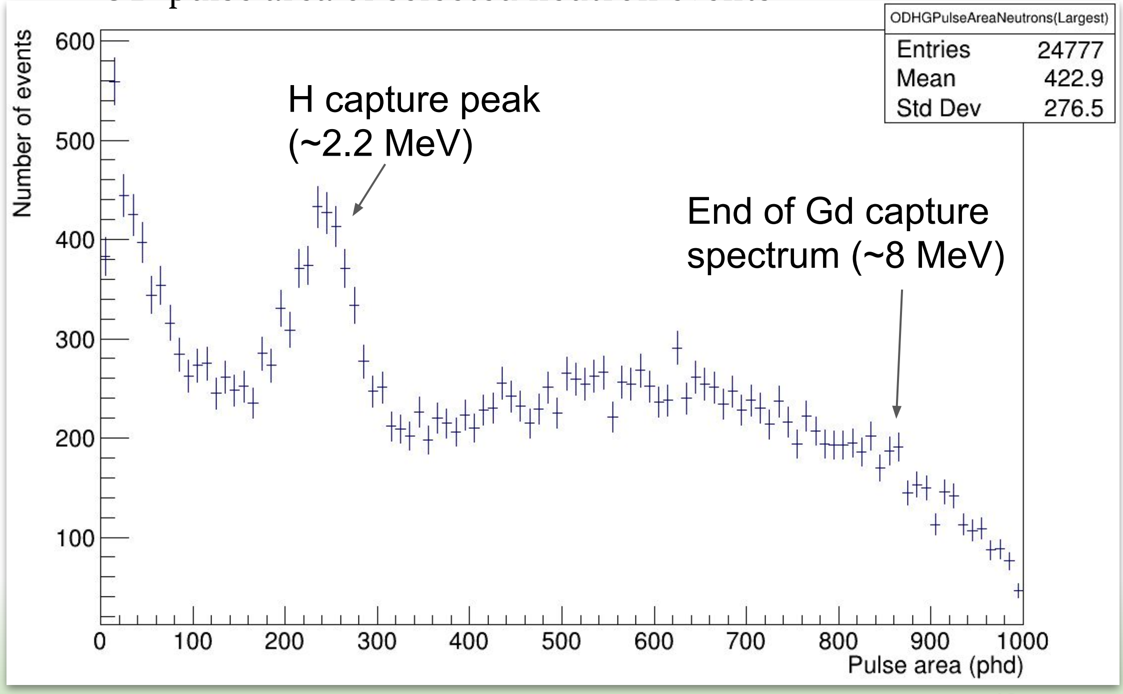
Neutron Veto Inefficiency



Selecting Neutrons

- Average time to capture is ~30 μs but can be 1 ms after the neutron enters the OD.
- Capture is often preceded by at least one scatter somewhere in the detector.
- Can select neutron events by looking for these two signals separated by a minimum time difference.

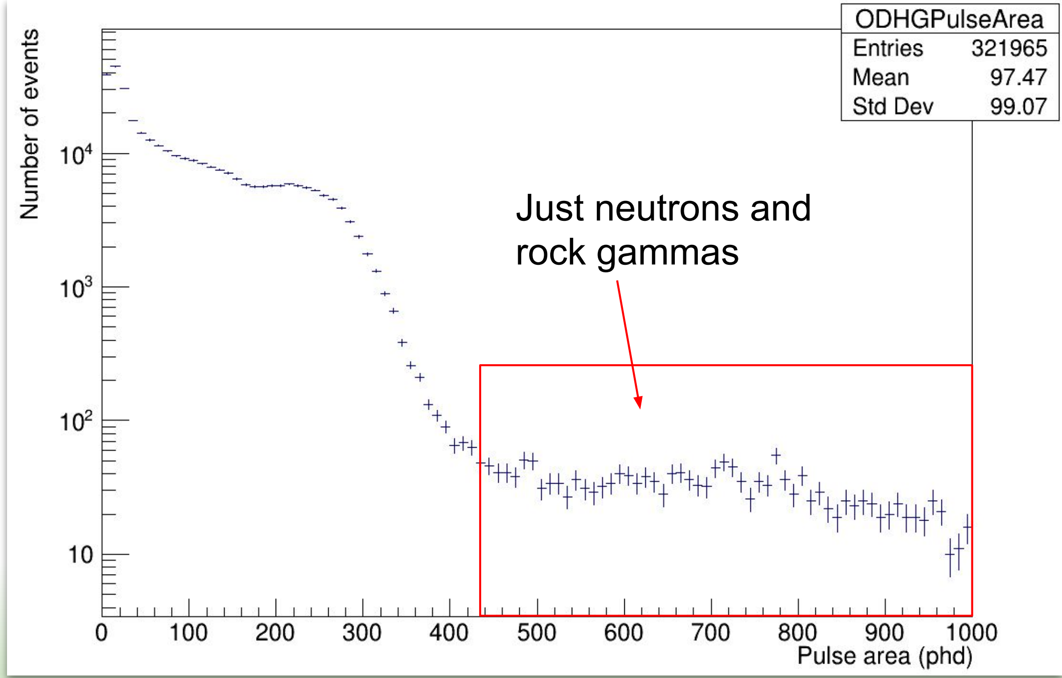
OD pulse area of selected neutron events



Background Neutron Rate

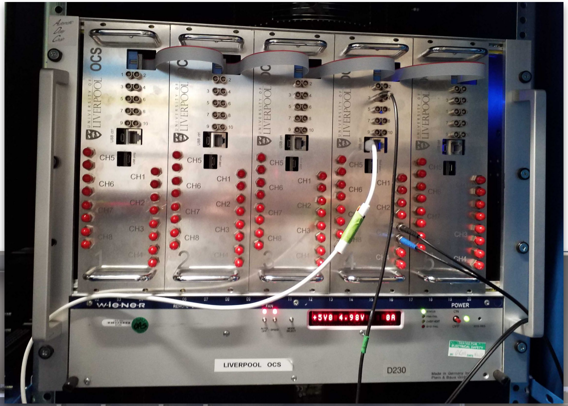
- The higher energy signals in the OD are neutrons or high energy gammas from the cavern rocks.
- Remove the rock gammas to estimate the number of high energy neutrons.
- The spectrum found using the neutron selections can be used to extrapolate to the lower energies.

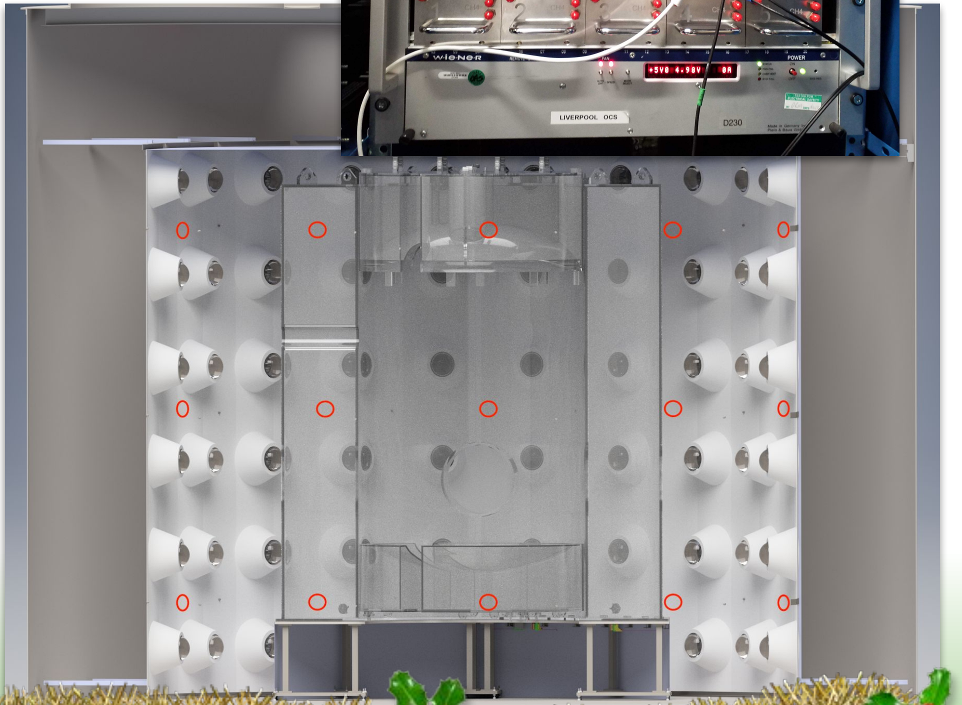
Background Spectrum in the OD



Optical Calibration System

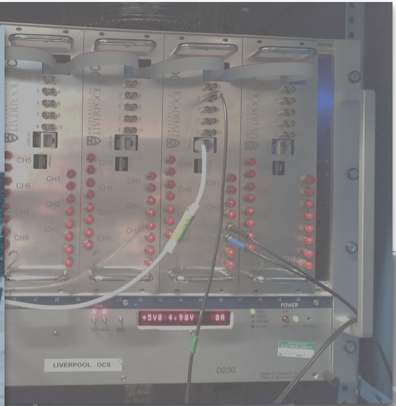
- System used to calibrate the OD.
- Injects pulses of light into the OD via optical fibres.
- Built at Liverpool.
- Will, Harvey and I installed and tested the electronics in SD.
- Fibres will be installed next year.





Optical Calibra

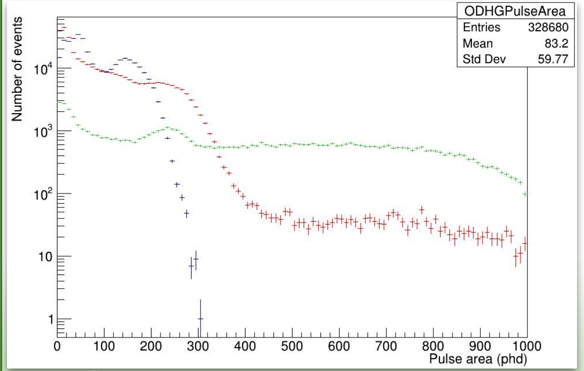
- System used to calibr
- Injects pulses of light
  via optical fibres.
- Built at Liverpool.
- Will, Harvey and I ins
  tested the electronics
- Fibres will be installe



Other work

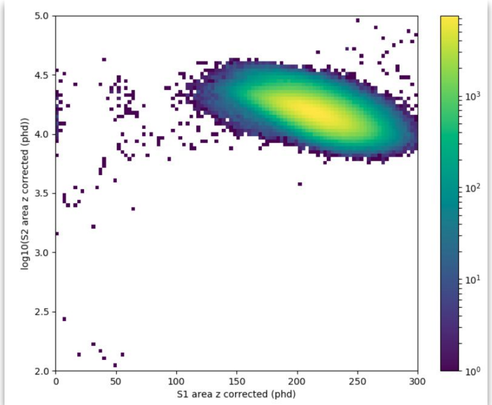
Data production

- No official calibration datasets have been produced recently so we have generated and quality checked our own at Liverpool for use in my analysis.



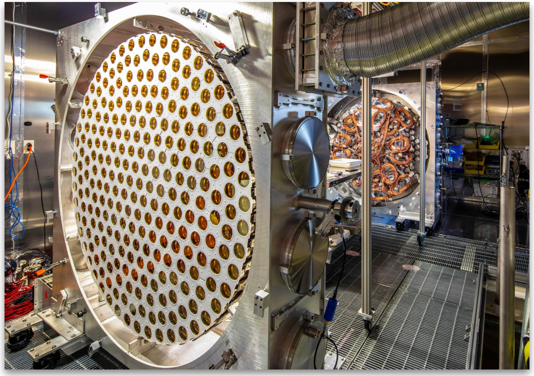
LUX EFT

- Created Kr83m PDF for use in the LUX EFT analysis.
- Hand-scanning selected events.



TPC assembly

- Cabling the top PMT array.



Developing LZ data processing package (LZap)

- Implemented OD specific RQs.
- Identified and investigated issues.

Developing analysis framework (ALPACA)

- Tested and modified ALPACA framework at various stages to make it accessible to the whole collaboration.

Next Steps

- Investigate rock gammas and use this info to help calculate neutron rates.
- Run neutron analysis on full month of simulated WIMP search data.
- Go on LTA in South Dakota in January.
- Install optical fibres for the OCS (March/April).
- Calibrate the detector and help to obtain the first data.