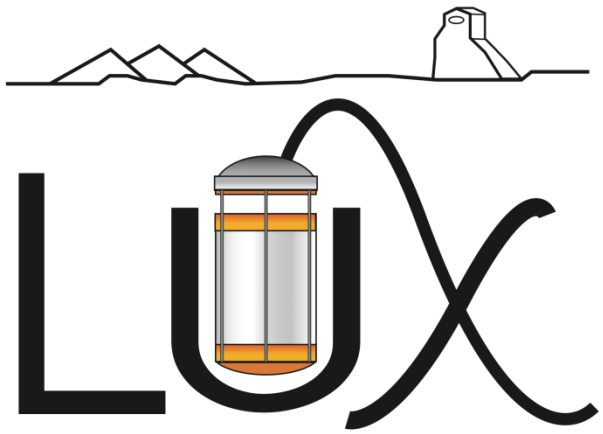
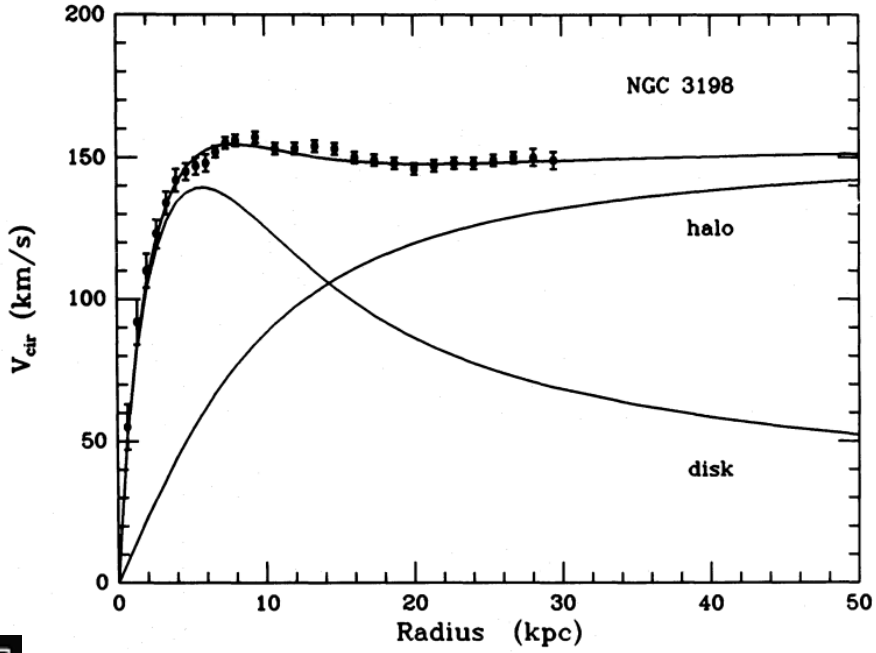
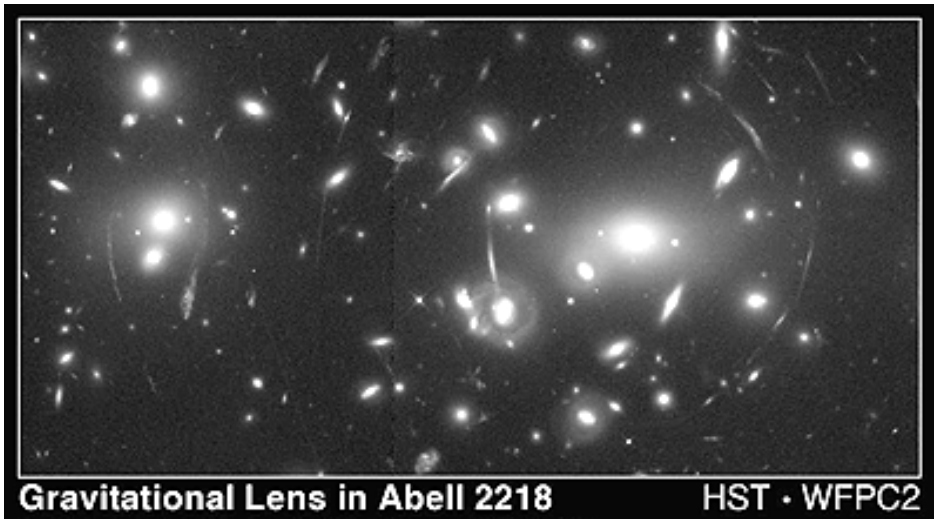
Dark Matter Searches with Dual-Phase Noble Liquid Detectors



- Evidence and Motivation
- Dual-phase Noble Liquid Detectors
- Initial Work

- Astronomical Evidence
  - Galaxy Cluster masses
  - Galaxy rotation curves
  - Gravitational lensing
- Cosmological Evidence
  - Cosmic Microwave Background (CMB)

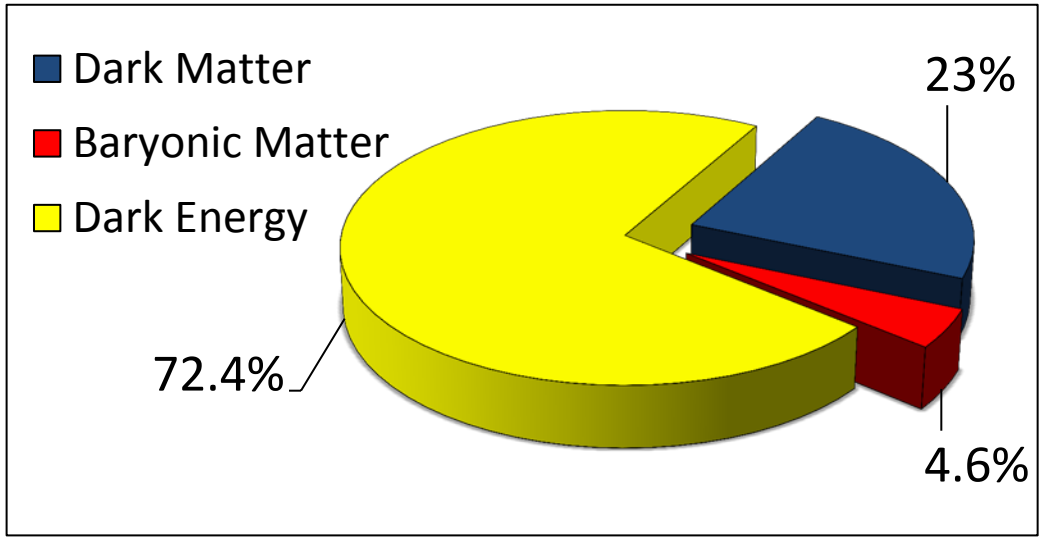




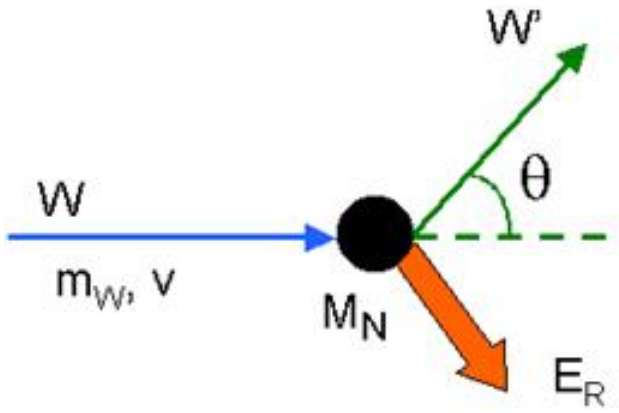
- Want to find direct evidence, measure local dark matter in the Galaxy

- Main properties:
  - Interact “weakly” with ordinary matter
  - Electromagnetically neutral
  - Massive
  - Stable

- Candidates:
- MACHOs
  - Massive Compact Halo Objects
- WIMPs
  - Weakly Interacting Massive Particles
- Other Particles

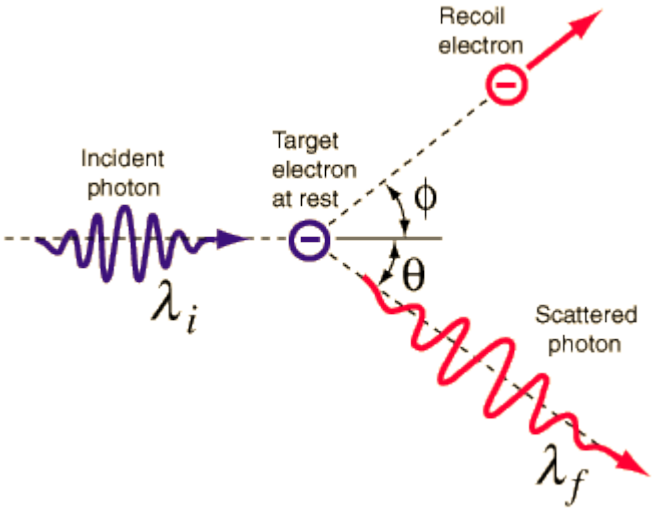


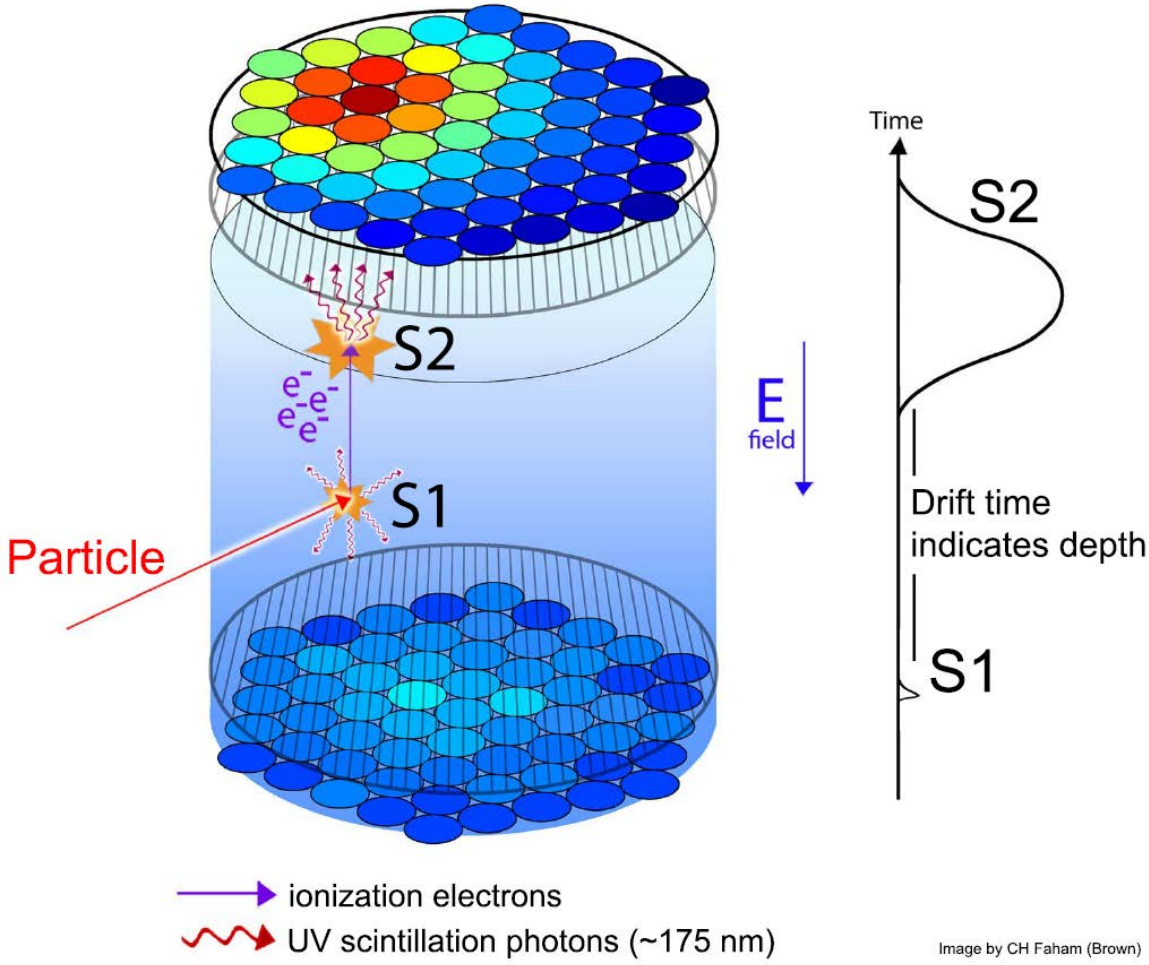
- Look for interaction in detector material



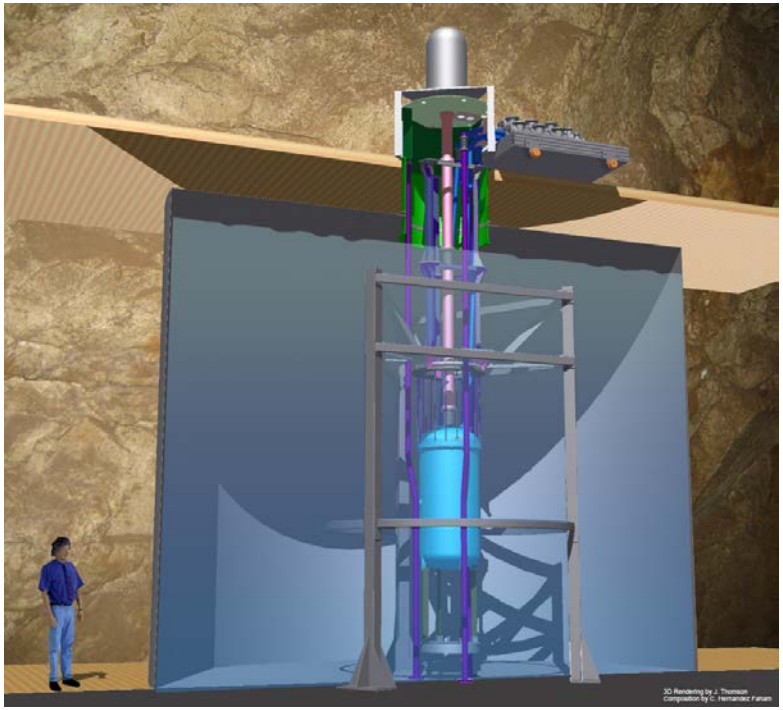
- Signal
  - Nuclear recoil from WIMP collision
  - Gives ionisation, scintillation and phonons.

- Background
  - Other nuclear recoils
  - Electron recoils

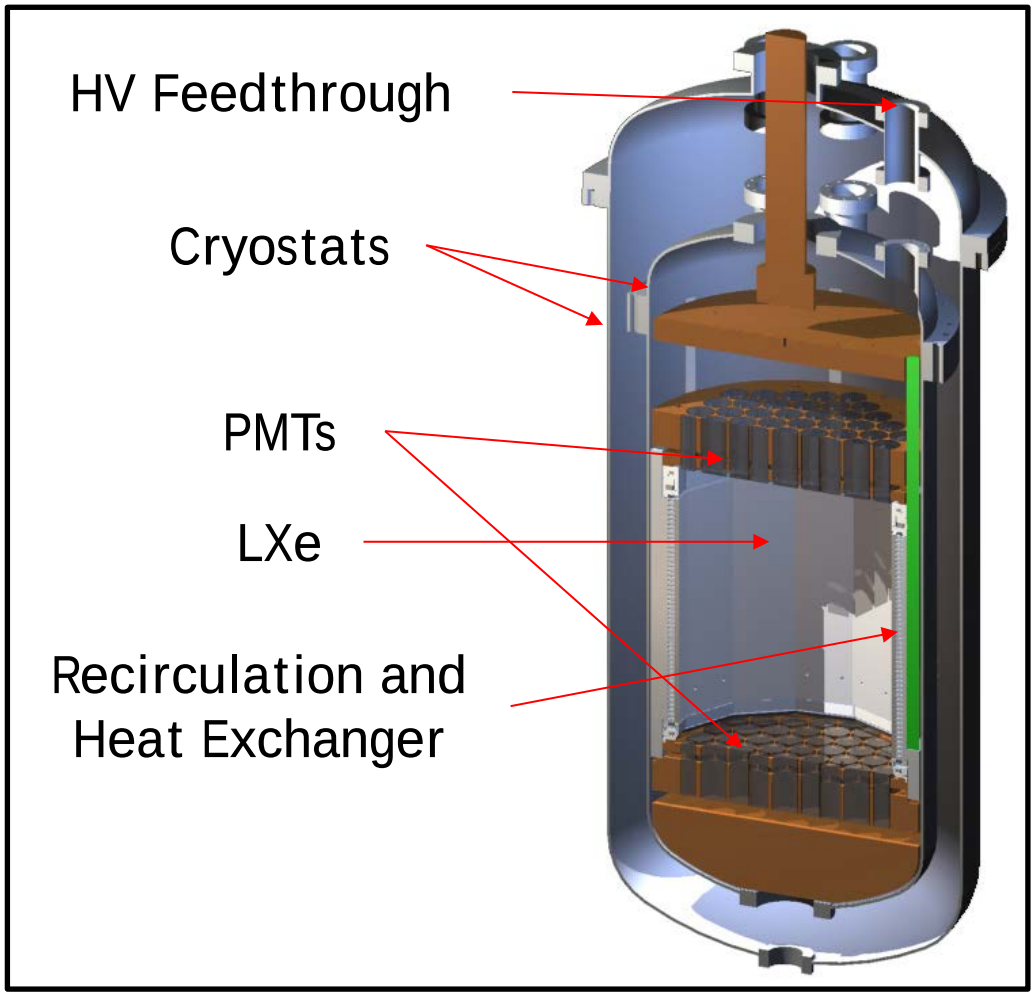




- Discriminate electron recoils
  - Different amounts of ionisation and scintillation
- Other recoils look like signal
  - Need to minimise radioactivity



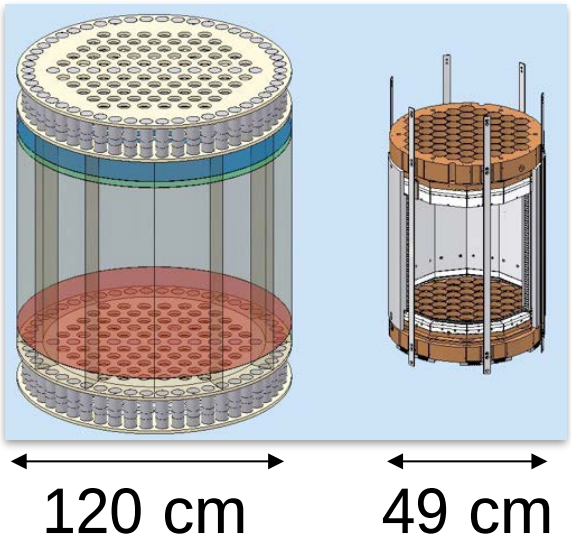
- Large Underground Xenon
- 370 kg with 100-150 kg fiducial mass (self-shielding)
- Two arrays of 61 PMTs



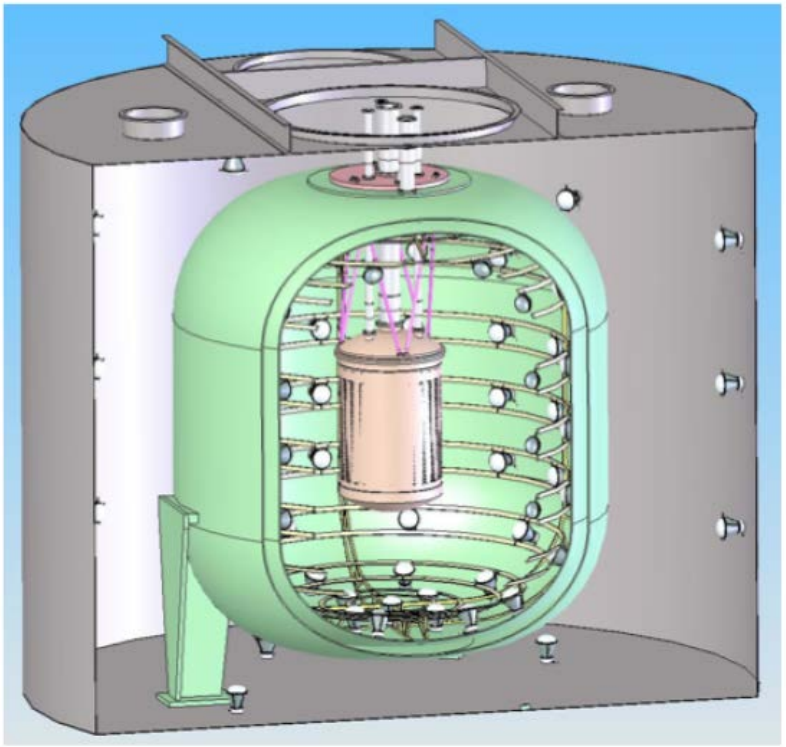
- My involvement
  - Data analysis
  - Simulation
  - Operations support

- LUX-ZEPLIN
  - Combination of LUX and ZEPLIN collaborations
- Builds on previous LUX and ZEPLIN technology
- Same site – use previous infrastructure

LZ



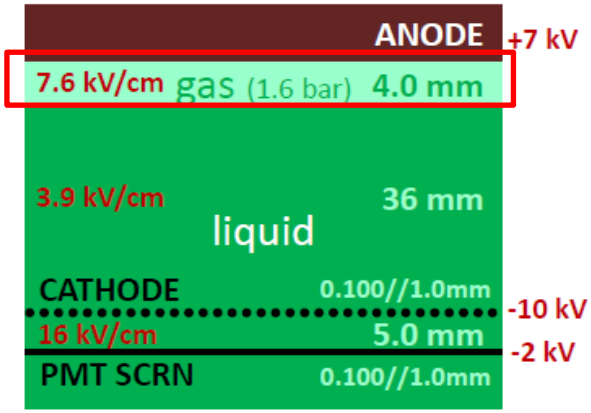
LUX



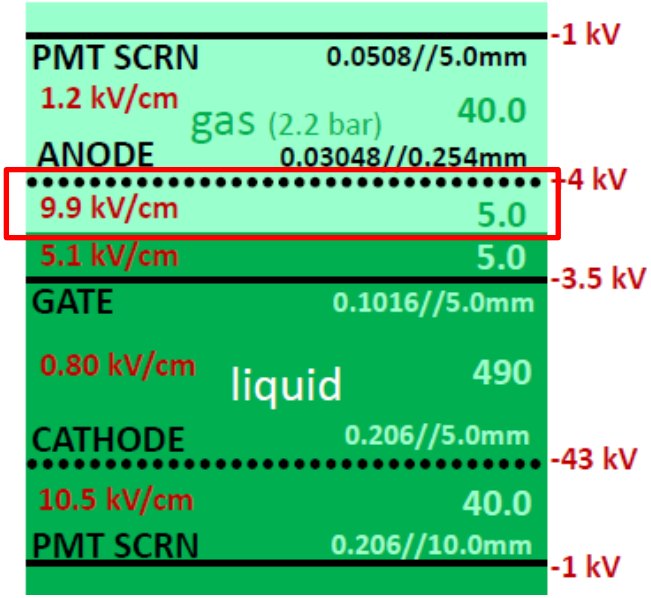
- Working on R & D
  - Use two-phase xenon chamber at Imperial

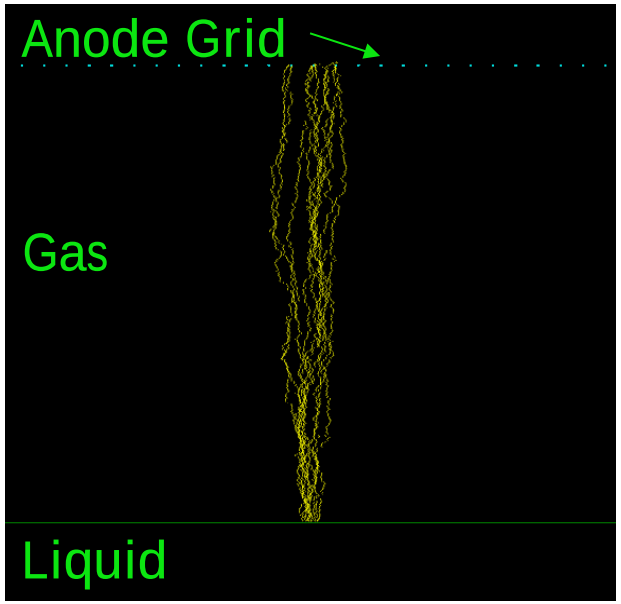
- Design work for LZ
  - ZEPLIN-III achieved a high signal discrimination
  - Was this due to the high field, or an effect of the geometry?
- Simulated scenarios

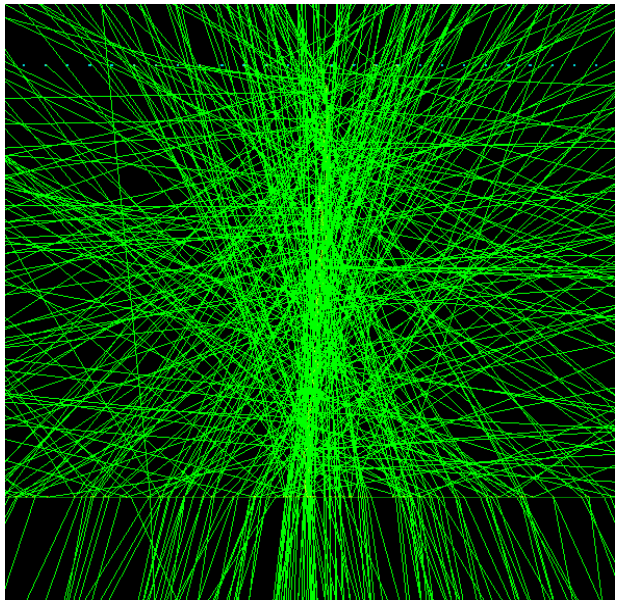
ZEPLIN-III

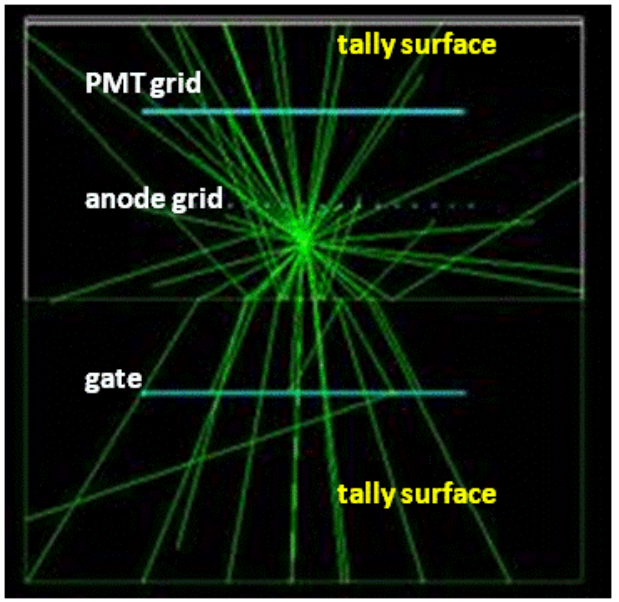


LUX Grid



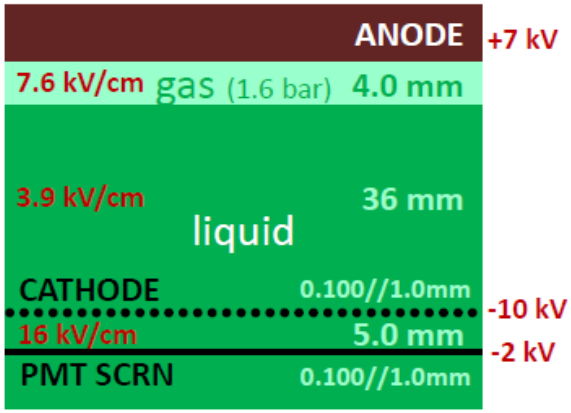




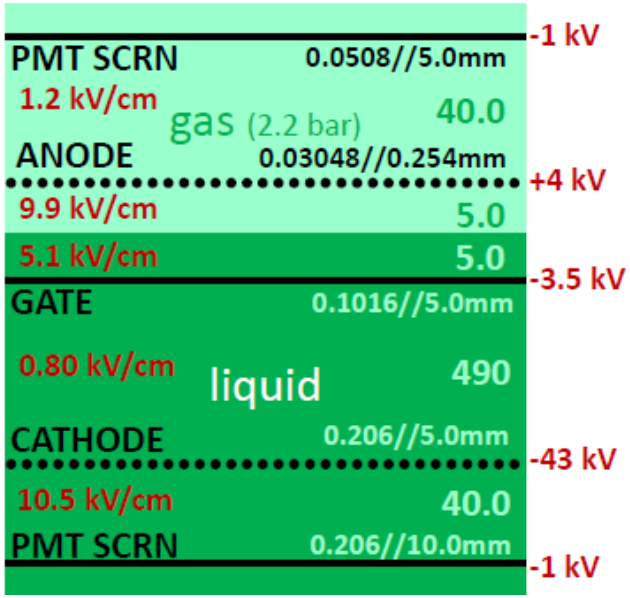


- Photon emissions
- Propagation
- Count photons and find variance

ZEPLIN-III



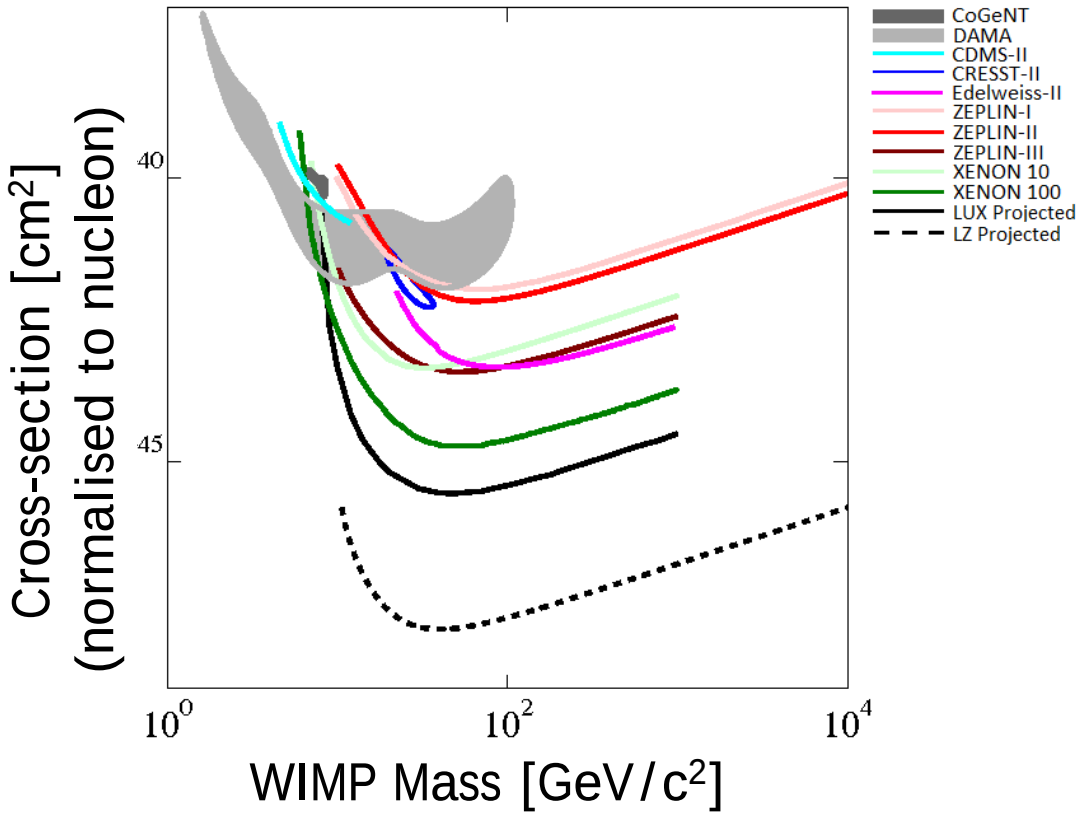
LUX Grid



- Total Variance = 5.72 %

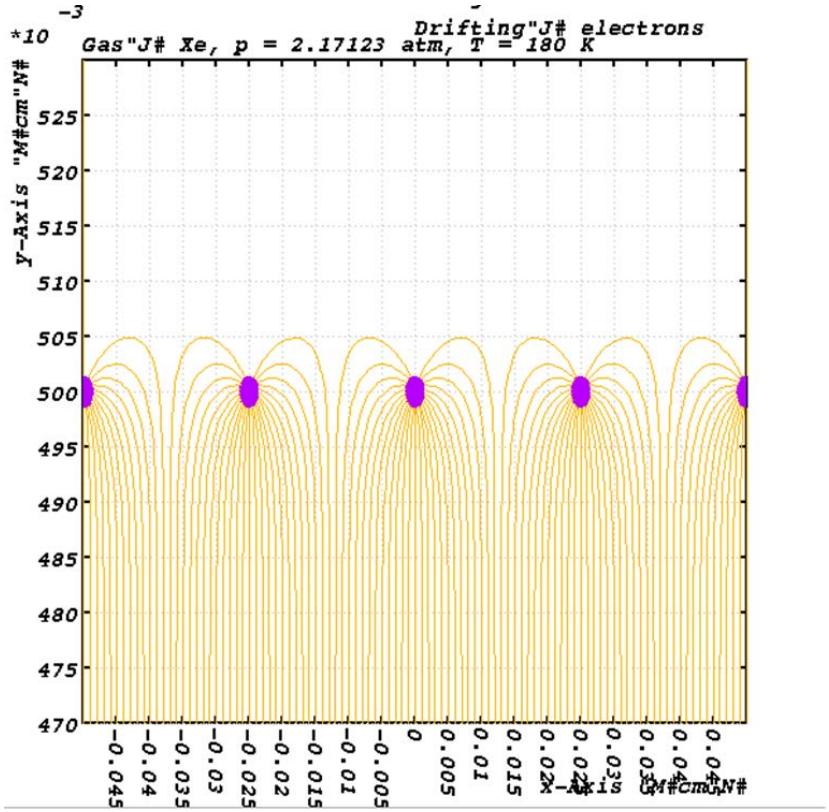
- Total Variance = 2.49%
  - Variance for each PMT array was similar to ZEPLIN-III
  - Two PMT arrays improved it

- Electroluminescence studies:
  - Anode grid does not spoil resolution
  - Two PMT arrays improves resolution
- LUX is filled – now turning on
- LZ currently being designed

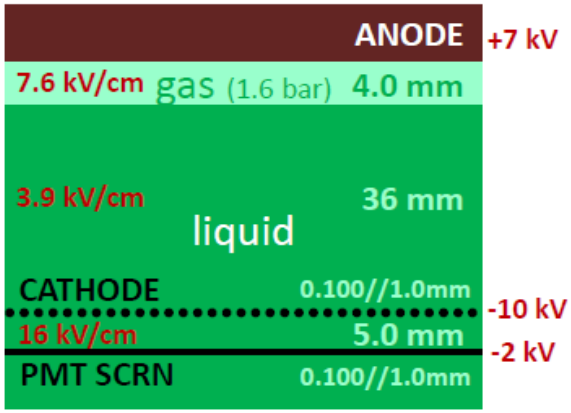


- Garfield++
  - Calculates electric fields
  - Magboltz for properties of the gas
  - Drifts electrons through the chamber

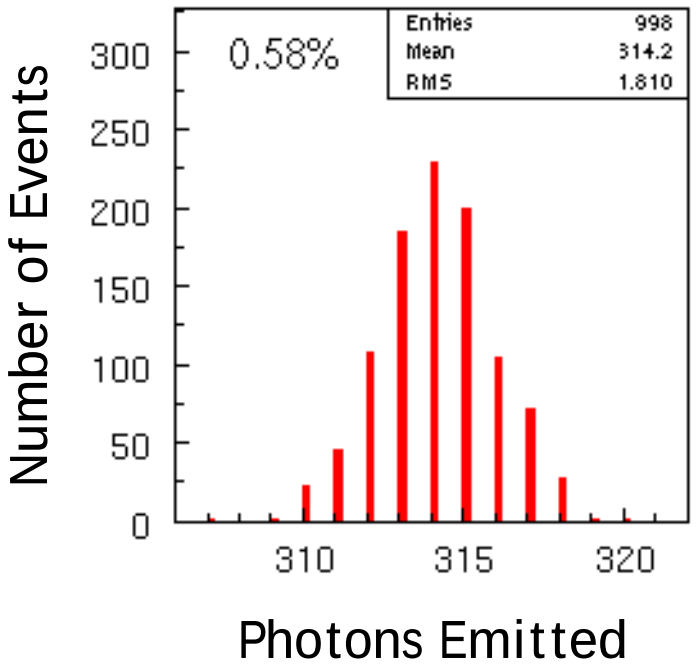
- Drift lines for wire grid



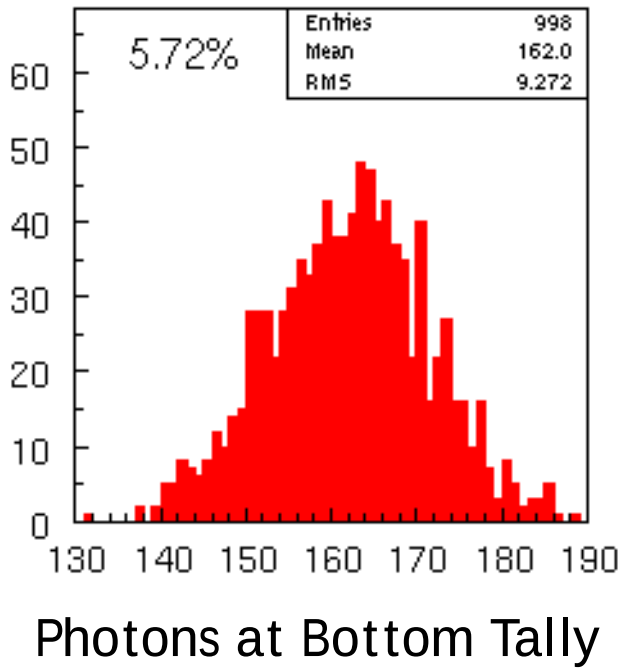
- ZEPLIN-III geometry
- 30% reflectivity from copper anode



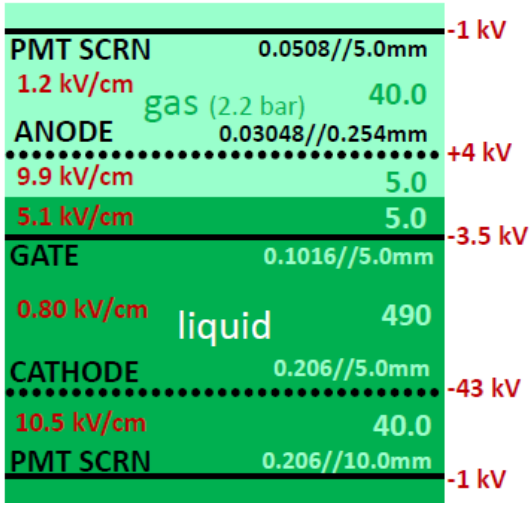
Variance at Production



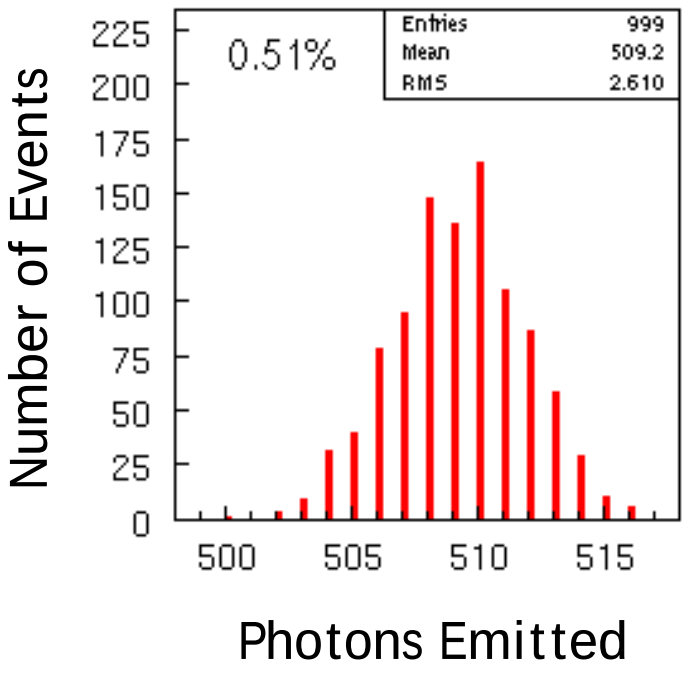
Variance after Propagation



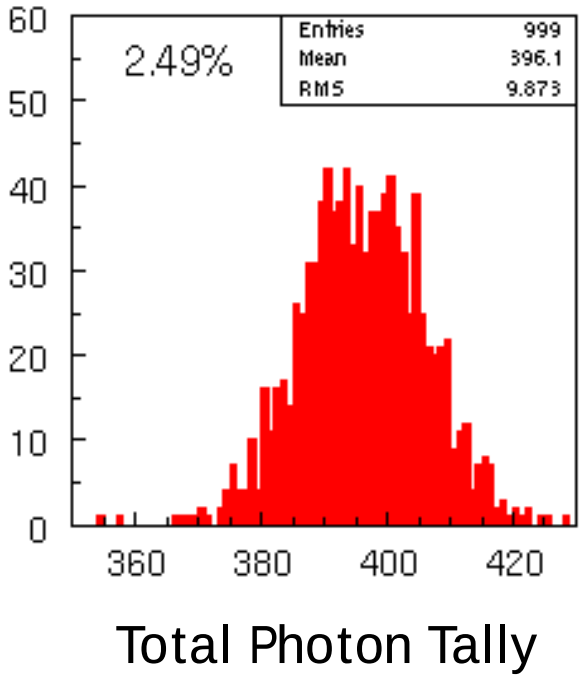
- LUX geometry with wire grid
- 25% reflectivity from the steel wires



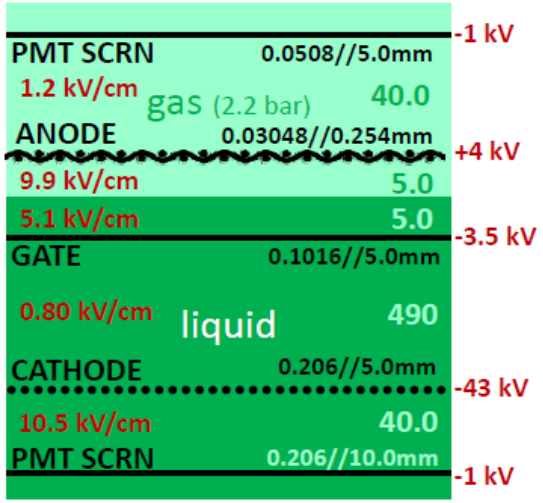
Variance at Production



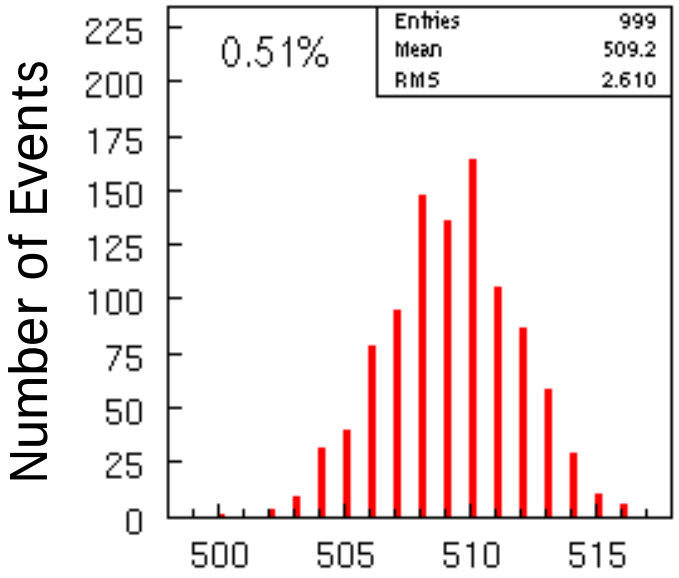
Variance after Propagation



- LUX geometry with wire mesh
- 25% reflectivity from the steel wires

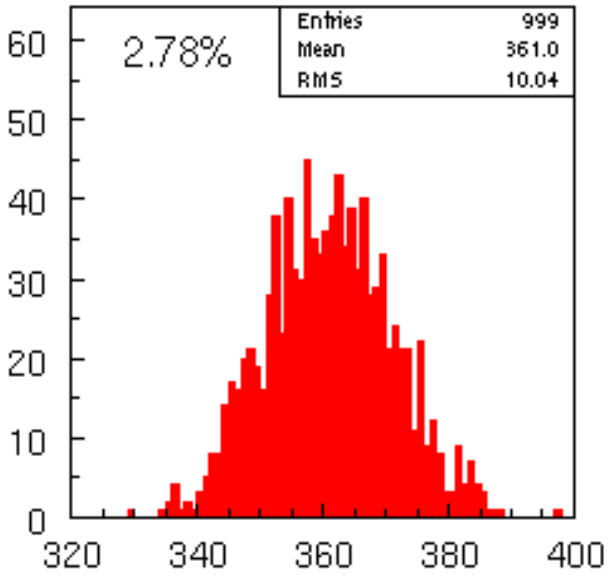


Variance at Production



Photons Emitted

Variance after Propagation



Total Photon Tally