Study of PD Calibration with Pulsed Neutron Source

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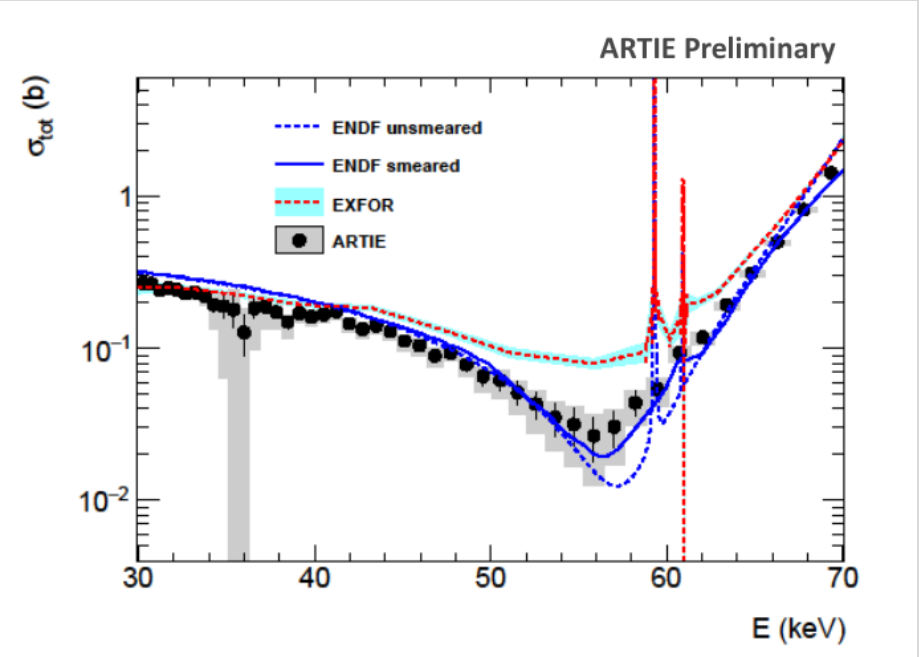
Overview

- Neutrons for Calibration
- Pulsed Neutron Source
- PNS for Photo-Detector Calibration

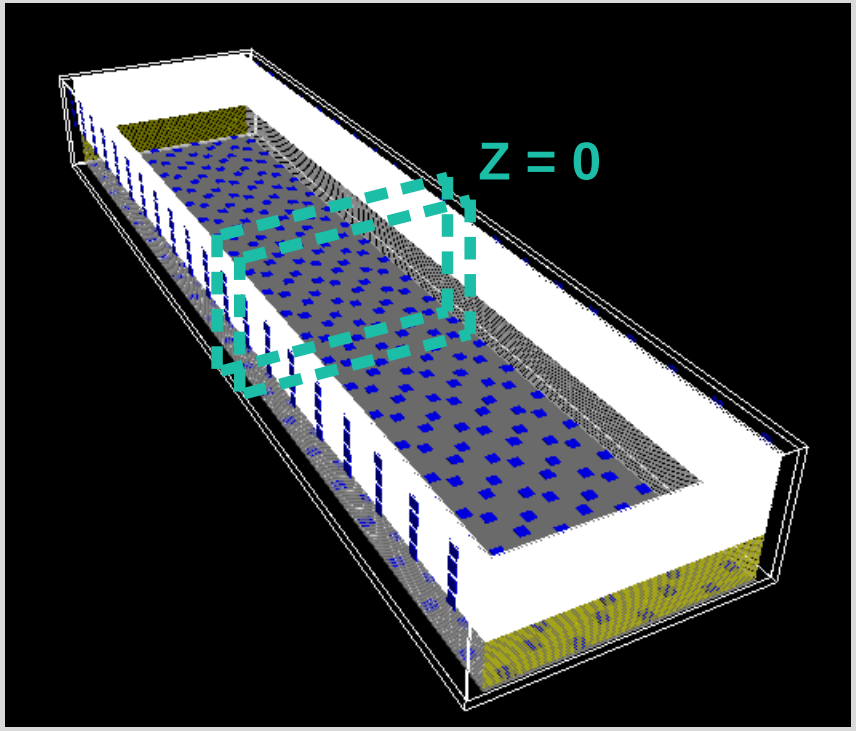
Neutrons for LArTPC Calibration

- Neutron capture on Ar-40 produces a 6.1 MeV gamma cascade
  - This well defined energy deposition can be used as a standard candle for calibration
- Neutrons can travel far distances in liquid Argon
  - A dip in the elastic scattering cross-section at 57 keV → ~30m attenuation length
  - Neutrons above this energy are likely to fall into the dip
- The total neutron capture cross section was measured in the ARTIE experiment to confirm this dip

$$n + {}^{40}Ar \rightarrow {}^{41}Ar + 6.1\ MeV$$



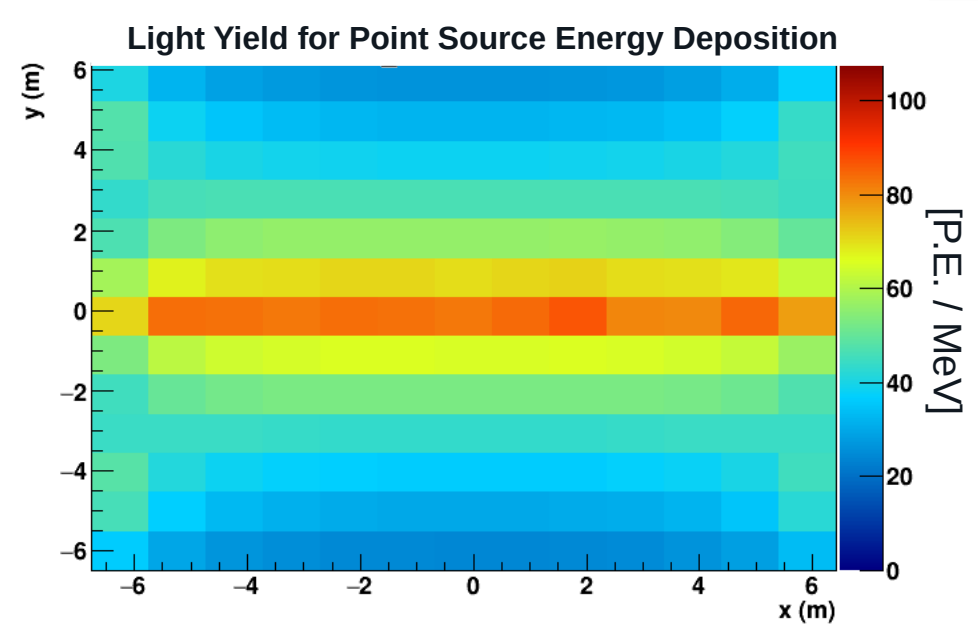
Simulation

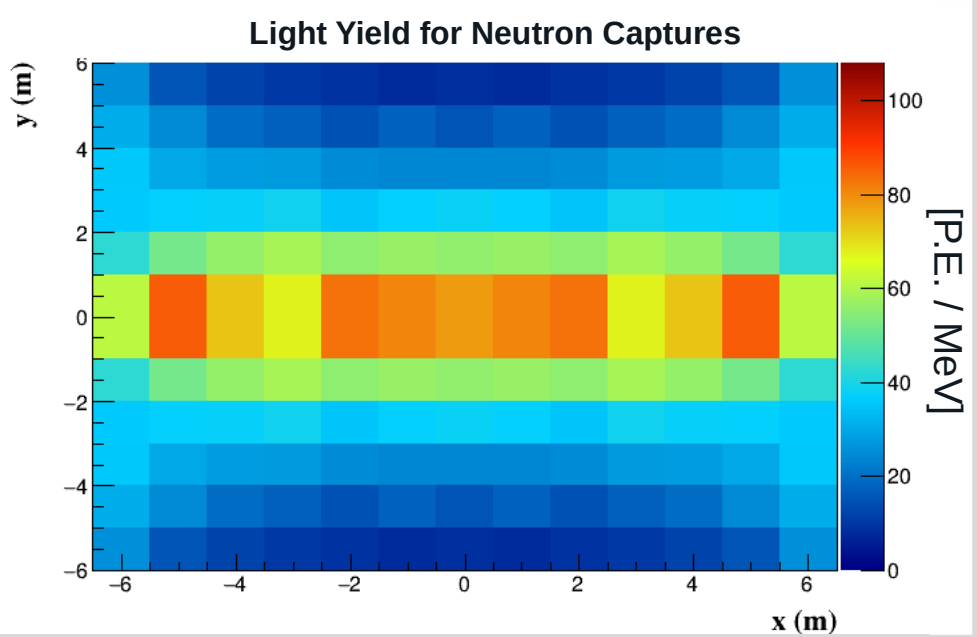


- Uses Geant4 Vertical Drift geometry from Franciole Marinho and Laura Paulucci
- Generate neutron captures in a 1m slice of the detector with uniform distribution
- Each $1m^3$ voxel contains 15 neutron captures
- Count the photons hitting the photo-detectors, and convert to photoelectrons using the total efficiency
  - Do this for the neutron captures in each voxel
  - Generate a map of LY/MeV as a function of voxel position

Results

- Compared to the point-source map we see similar overall behavior
- The light yield is lower near the edges of the detector
  - Likely due to the relatively wide (~50cm radius) distribution of the gammas from neutron captures.





Light Yeild map created by **Hamza Amar** and **Michel Sorel** using point-source optical photons

Conclusions & Next Steps

- Further studies are needed to demonstrate the feasibility of using the Pulsed Neutron Source for Vertical Drift Photo-Detector calibration
- The first simulation results look promising

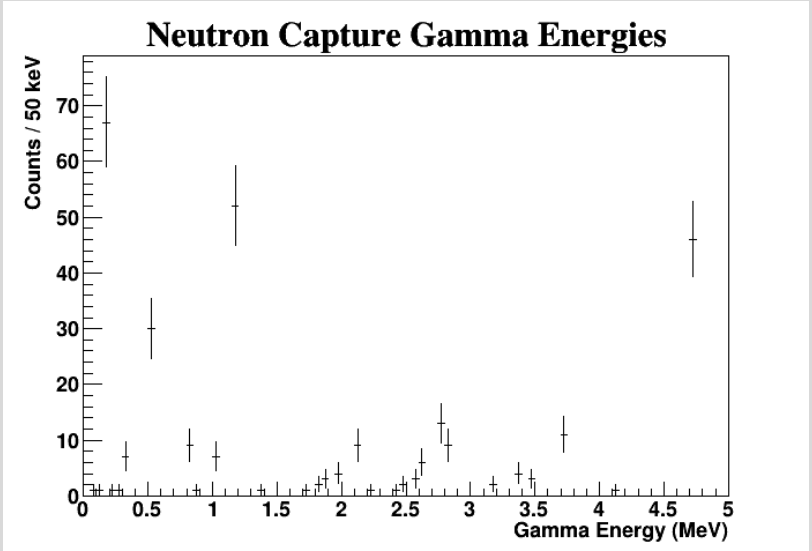
Next Steps

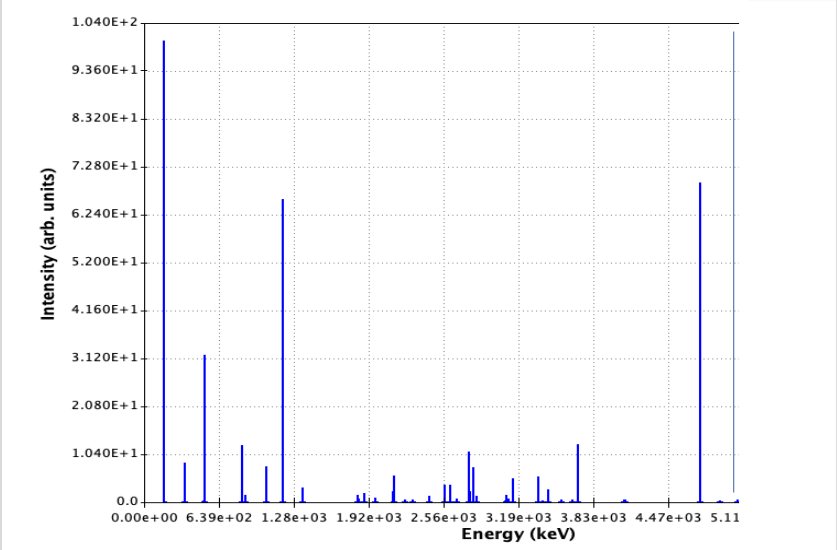
- Move to full LArSoft simulation and reconstruction
  - Ajib is currently working on this
- Possibly test the PNS at the ColdBox

Questions?

Physics List

- Using the EM Livermore model
- Added hadronic processes to the physics list
  - Elastic
  - Inelastic
  - Capture
  - Fission
- This includes a modified neutron capture process for Argon which produces the correct gamma cascades
  - Geant4's standard physics packages do not properly produce the gamma cascade





Pulsed Neutron Source (PNS) TDR Design

- Technical Design Report for the PNS:
  - Deuterium-deuterium neutron generator (DD generator): 2.5 MeV neutrons
  - Si moderator: 2.5MeV ⟶ <1MeV
  - Sulfer Energy Filter: Select 73 keV neutrons
  - Pb reflector: increase neutron yield
  - 6-Li absorber: supress thermal neutrons
  - Li-Polyethylene shield: radiation protection
- It may not be necessary to moderate and filter the neutrons to a low energy
  - PD-1 test uses a simplified design