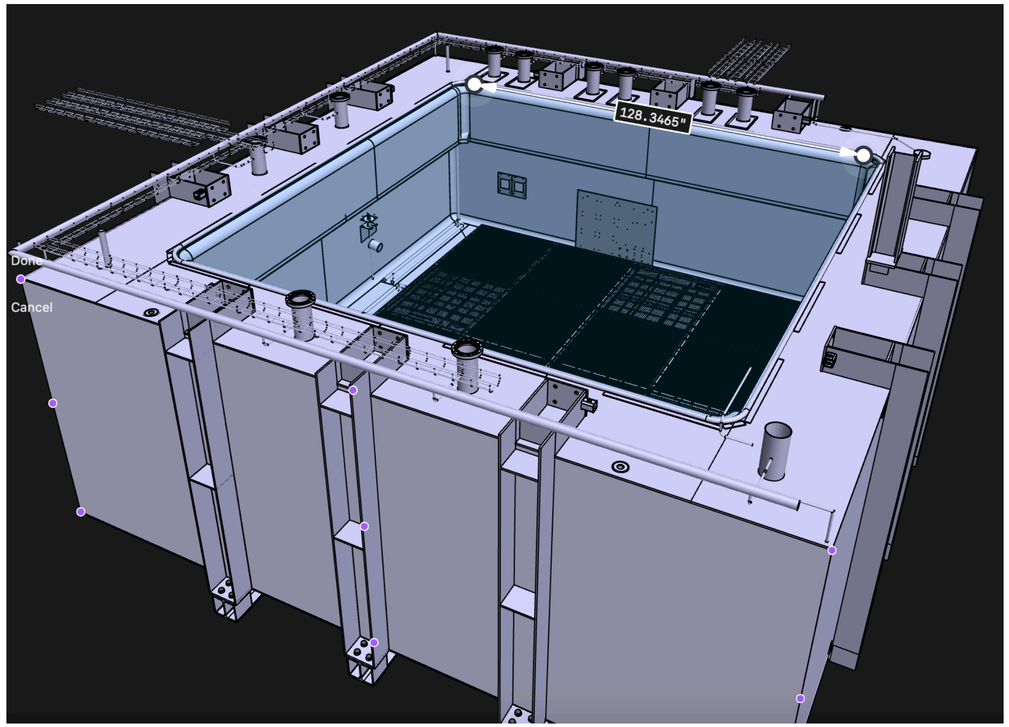
Status of Light Simulation in VD ColdBox

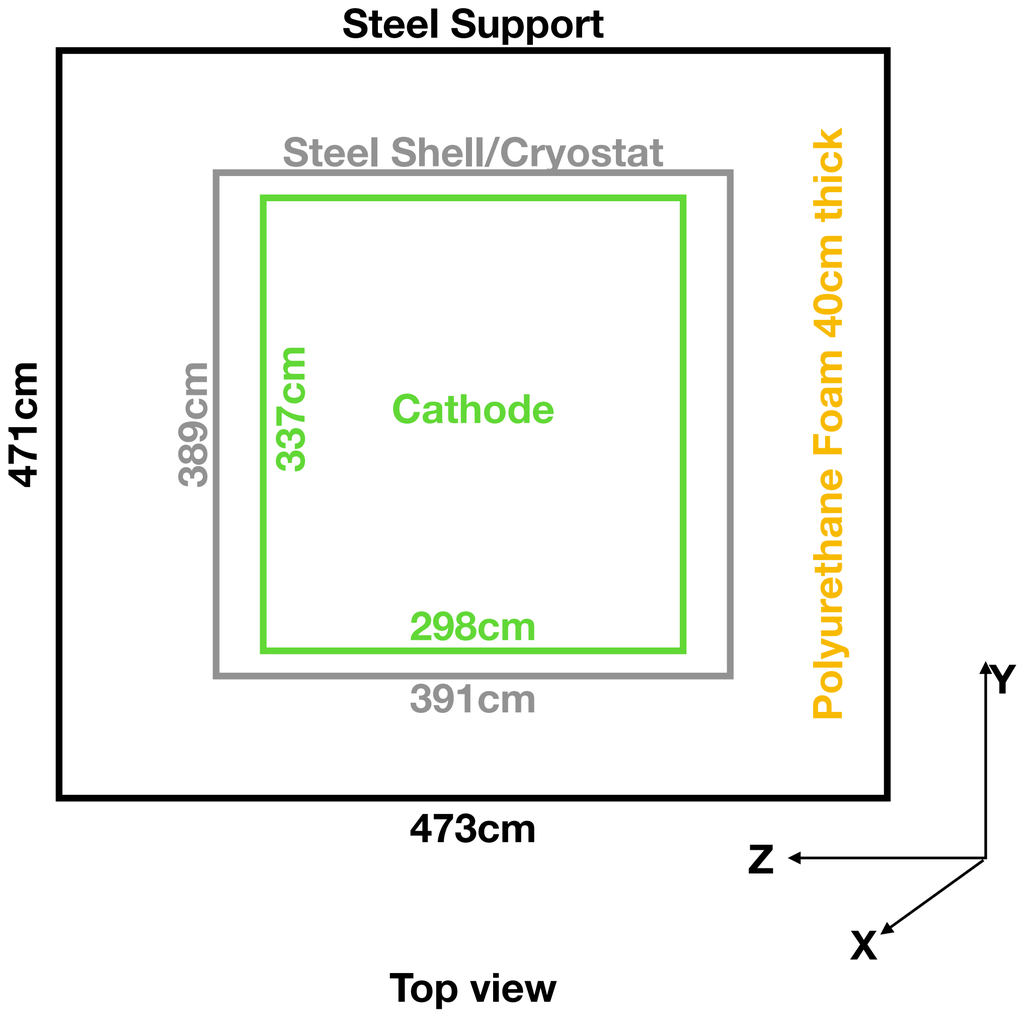
Wei
On behalf of the neutron capture for PDS calibration team



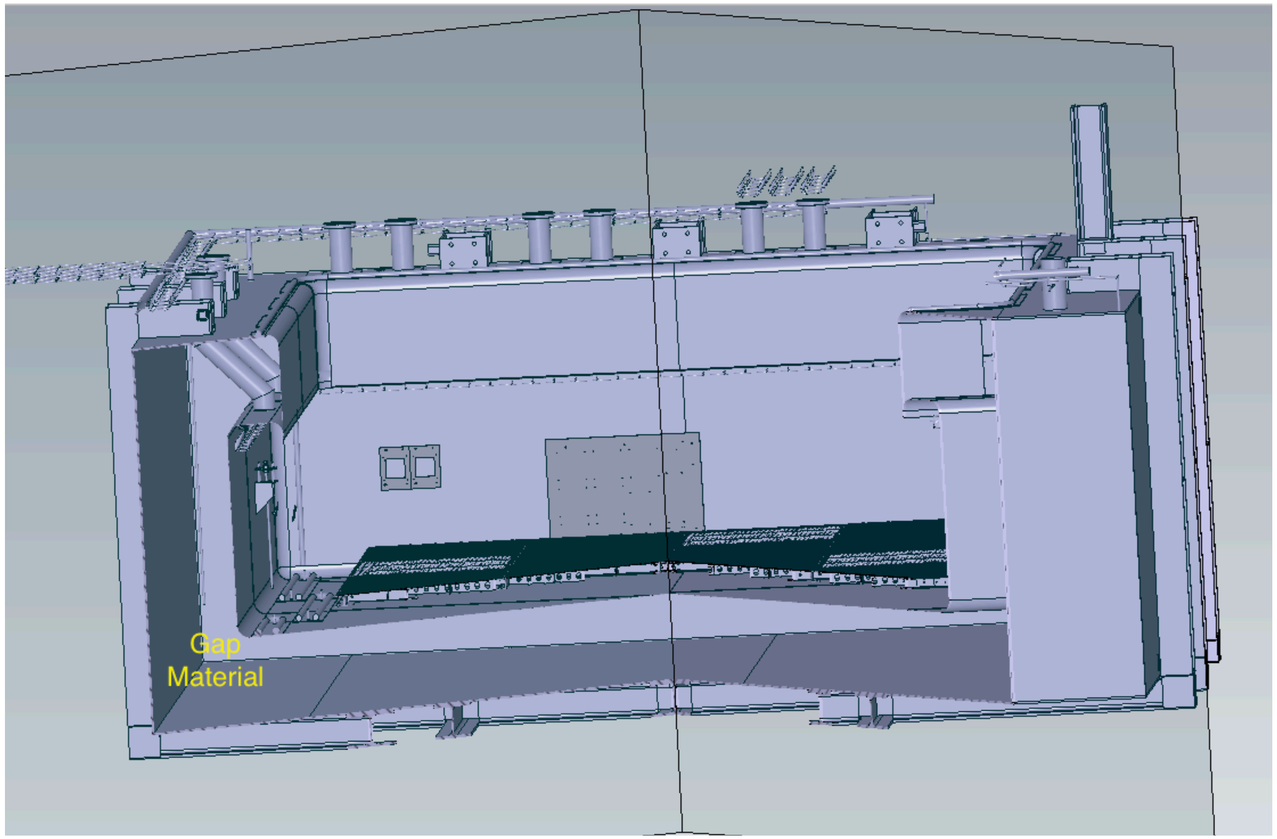
DEEP UNDERGROUND NEUTRINO EXPERIMENT

Stony Brook University

VD ColdBox Geometry



Top view



Steel shell vertical height (X) ~100cm

VD ColdBox Geometry

```
Optical Channels positions:  4
0  -15.387  -38  257.901
1  -15.387  118  186.701
2  -15.387  -118  111.701
3  -15.387  37.2  40.9009
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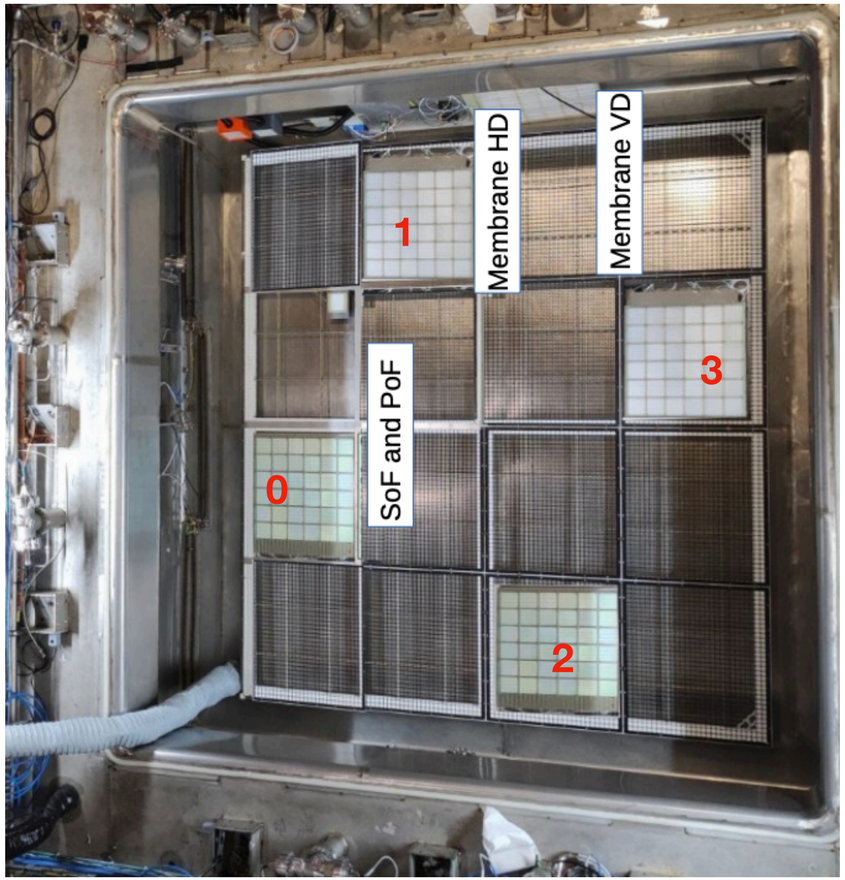
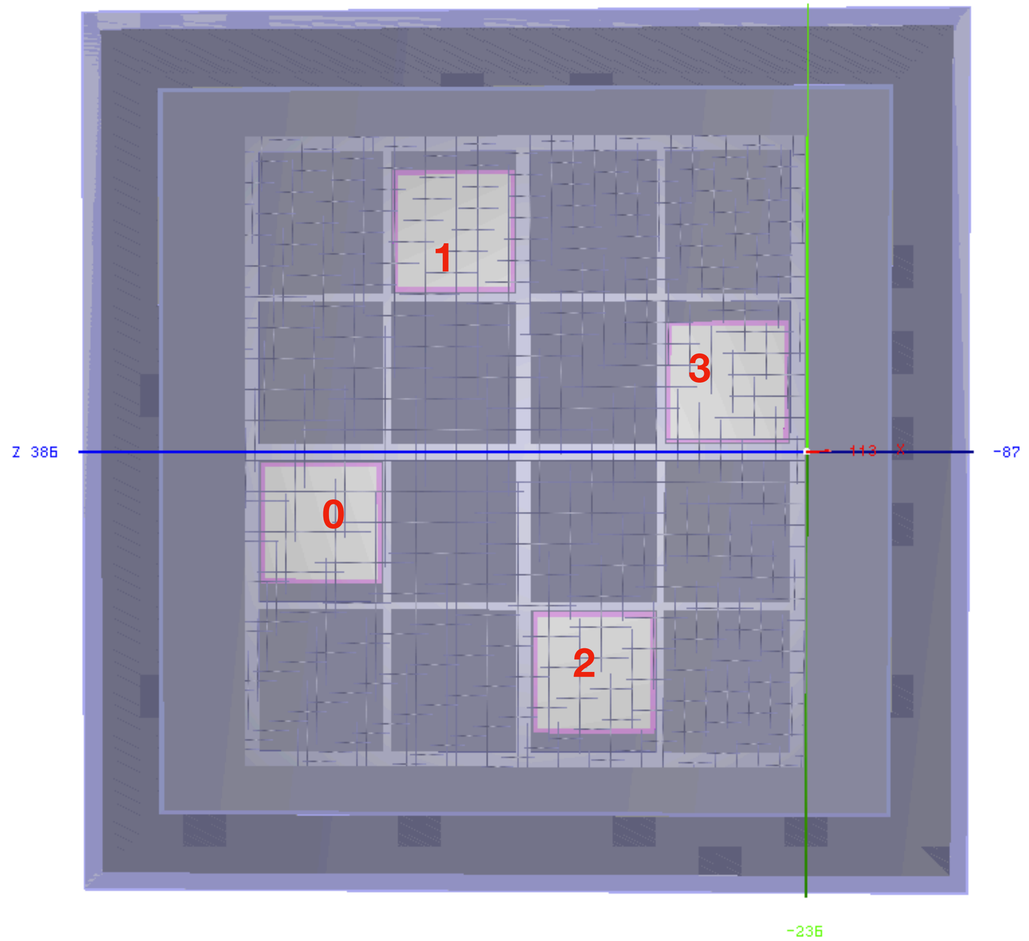
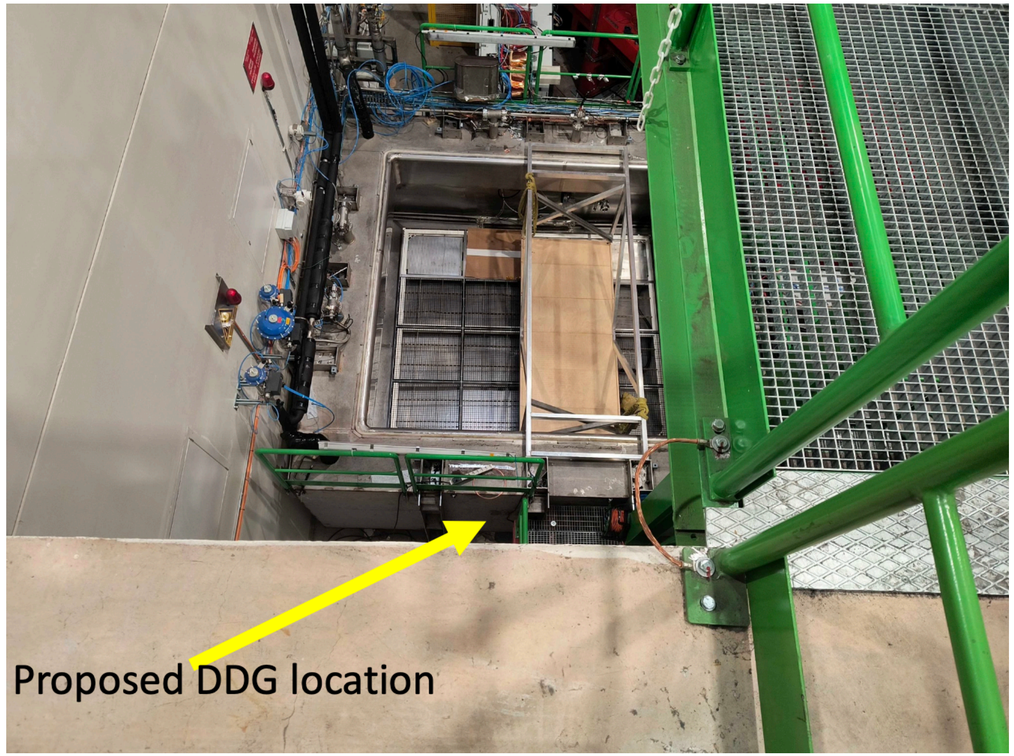


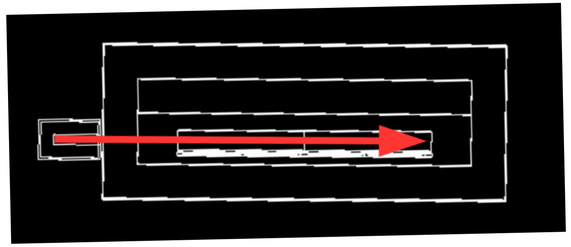


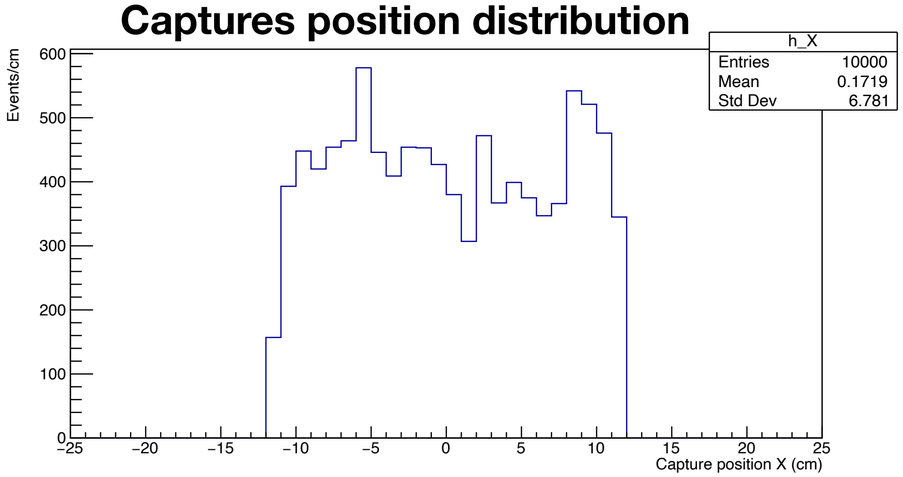
- Outstanding items:
  - Wall XAs: light collection area is half of nominal XA
  - CRP?
  - Foam between cryostat and outside steel support: used density 0.088g/cm^3, to be confirmed!

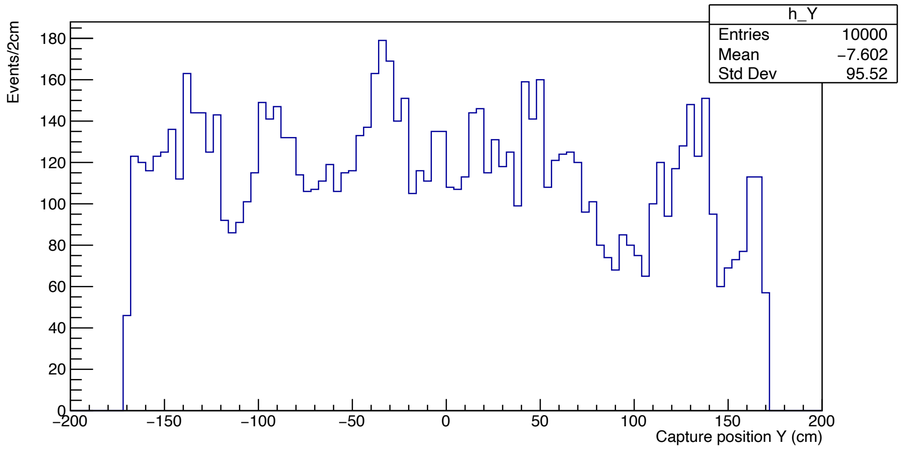
PNS Placed at the side of ColdBox

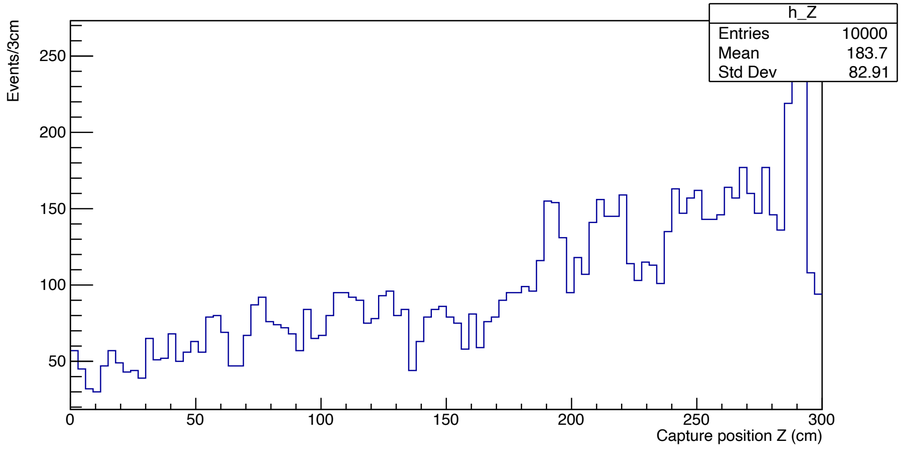
- Number of captures similar for positioning PNS on top or side
  - But side position is still favored over the top of ColdBox for the reason of using thicker CB wall to moderate gamma backgrounds from PNS



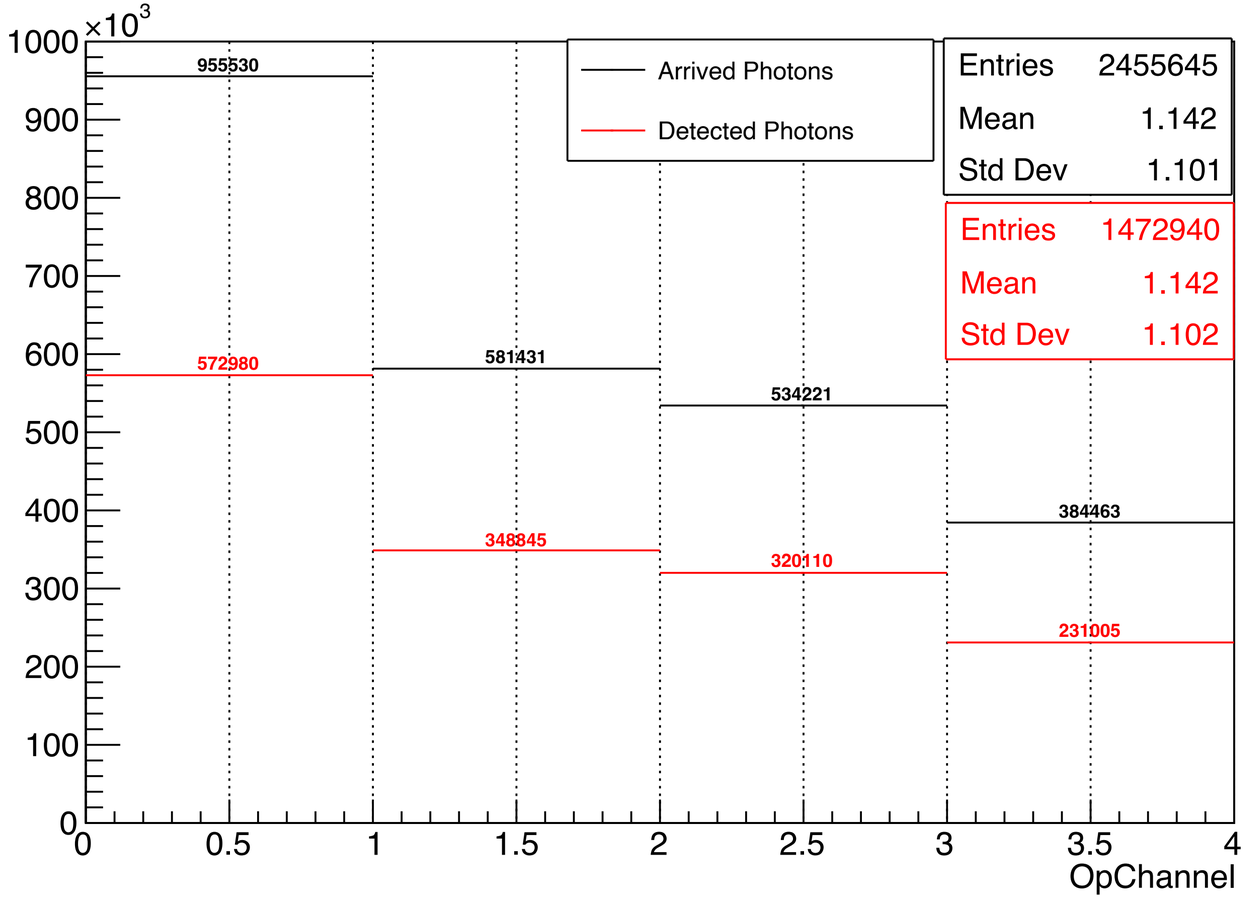








Photons from gamma cascades

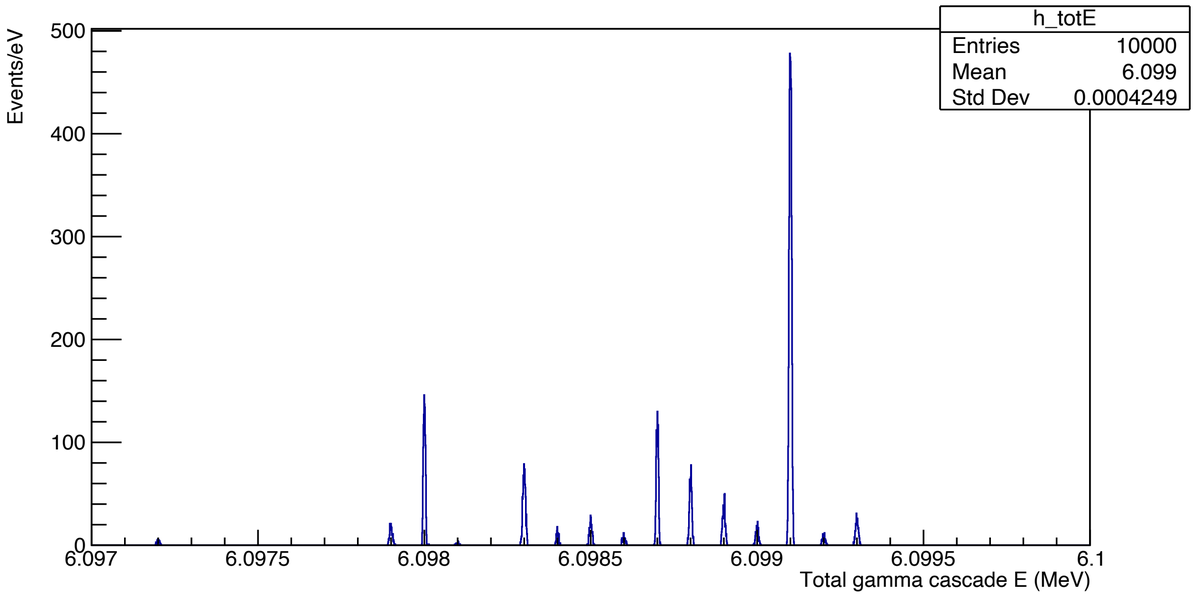


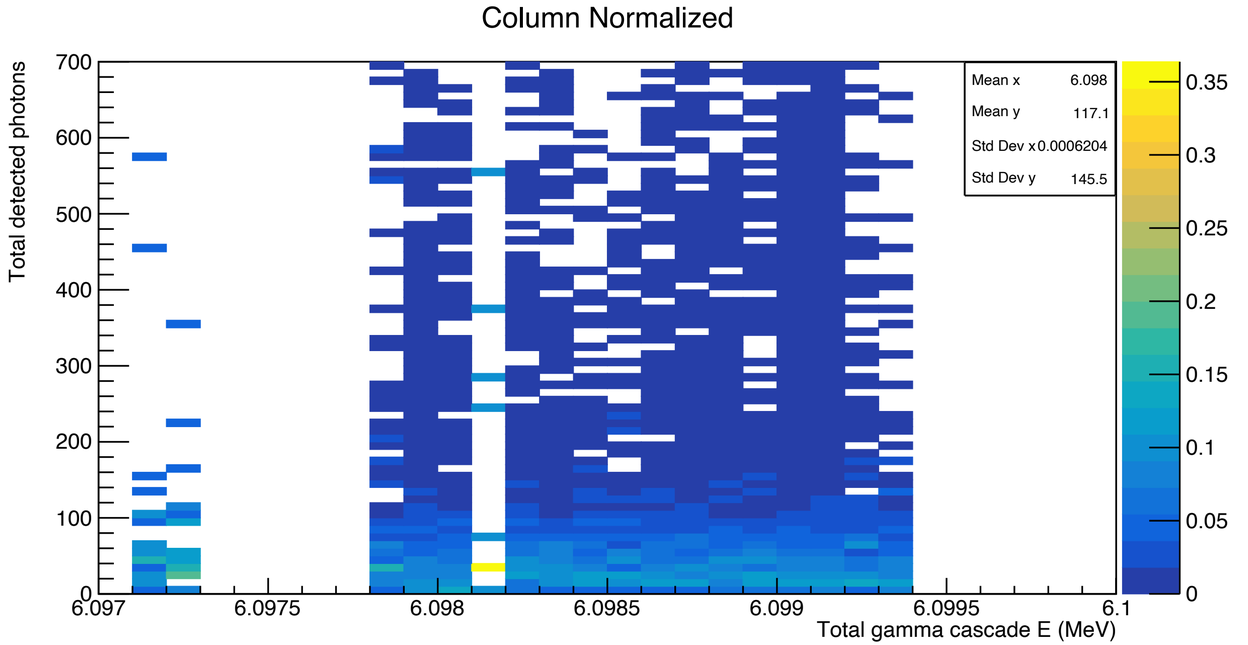
- All photons arriving at each XA surface from 10k events
  - Channel 0 XA higher: capture distribution skewed at high Z
  - LArSoft scaled down to 5% of actual phs, actual photons: 2455645/5% ~ 49112900
- Detected efficiency is about ~3%, in the ballpark of XA PDE measurement

Light Yield vs Energy

Plot is column normalized,
so each energy slice shows the PDF of detected photons

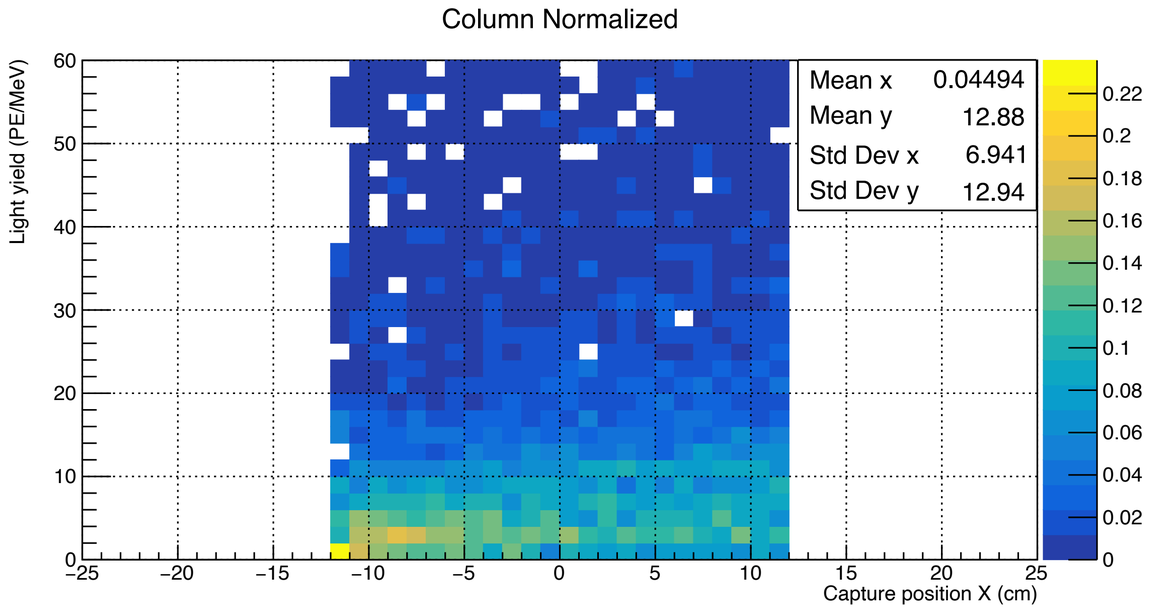
Cascade tot E difference is ~1keV, won't see energy dependence

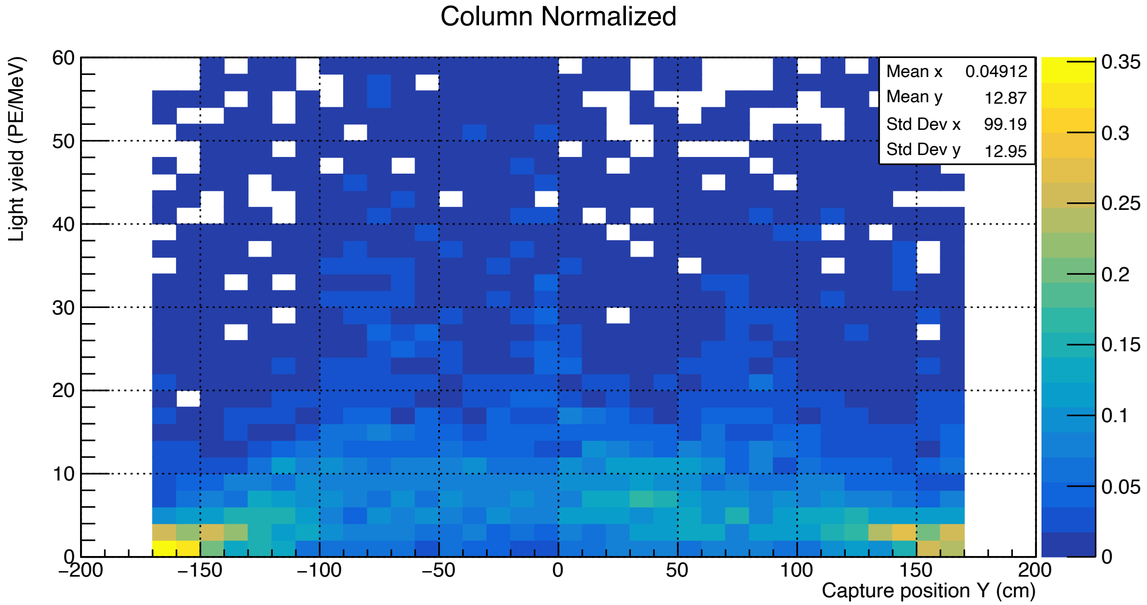




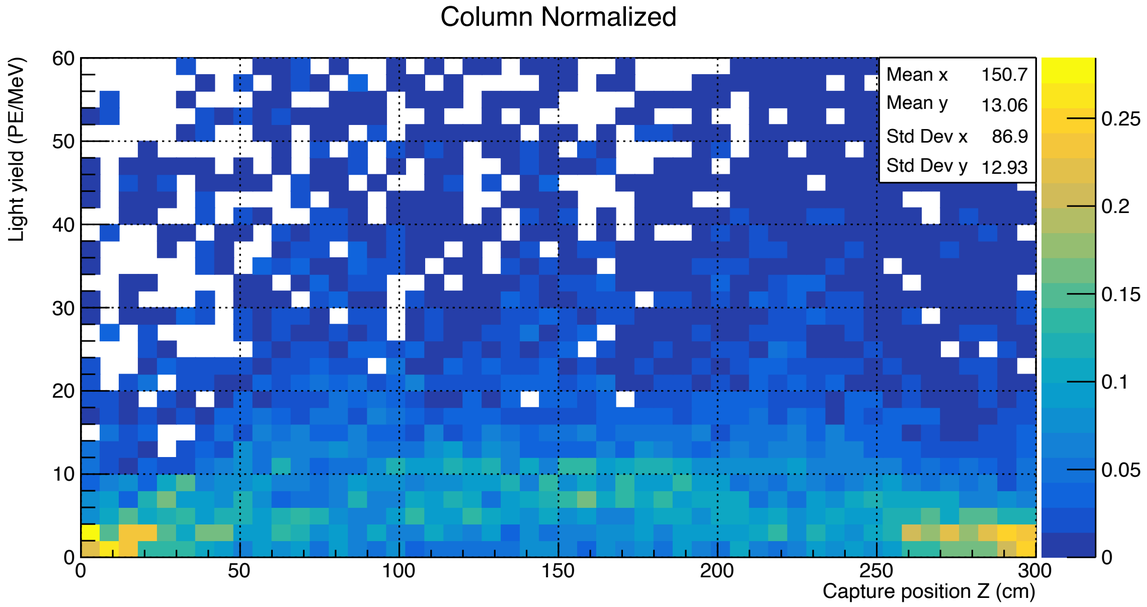
Light Yield vs Capture Position

Plot all column normalized,
so each position slice shows the PDF of detected photons





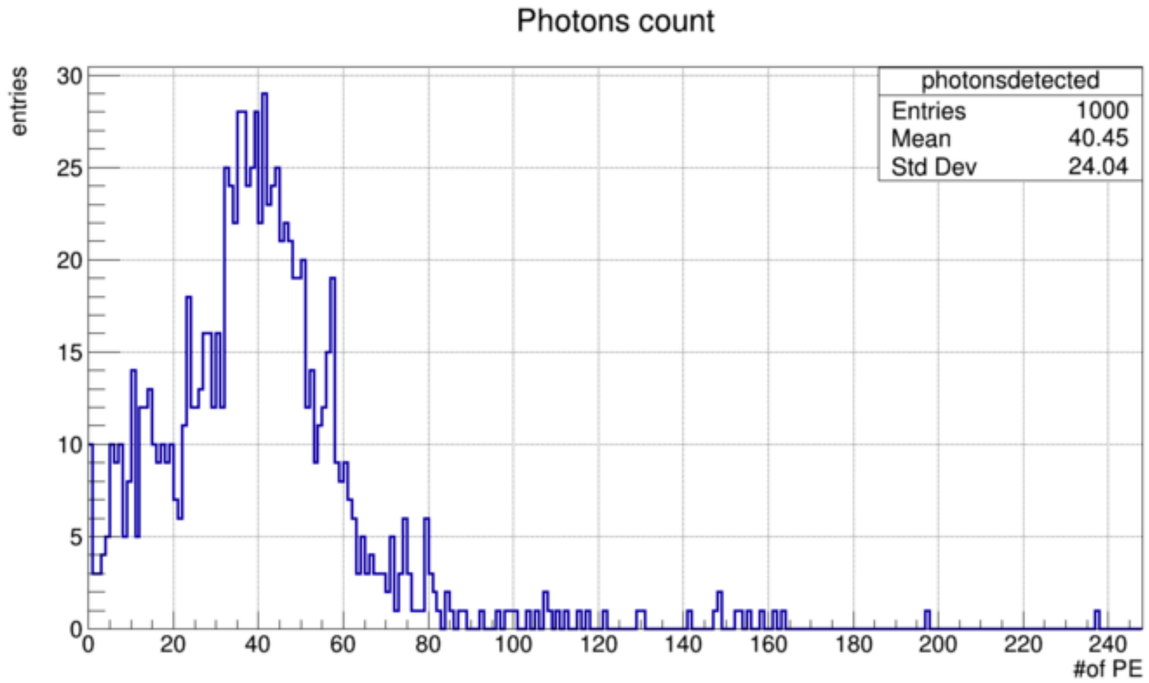
- Lower mean LY at the edges of Y & Z (Expected)



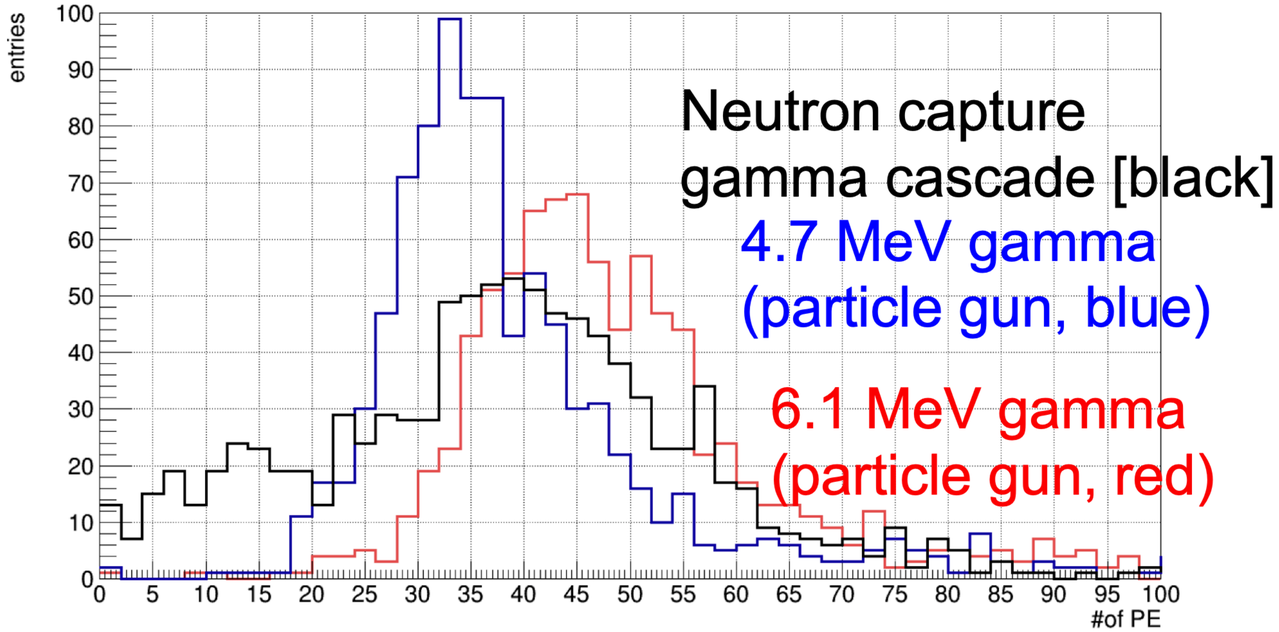
From Ajib

Captures at the center of CB

Generated at the center of CB
x=0, y=0, z=150cm



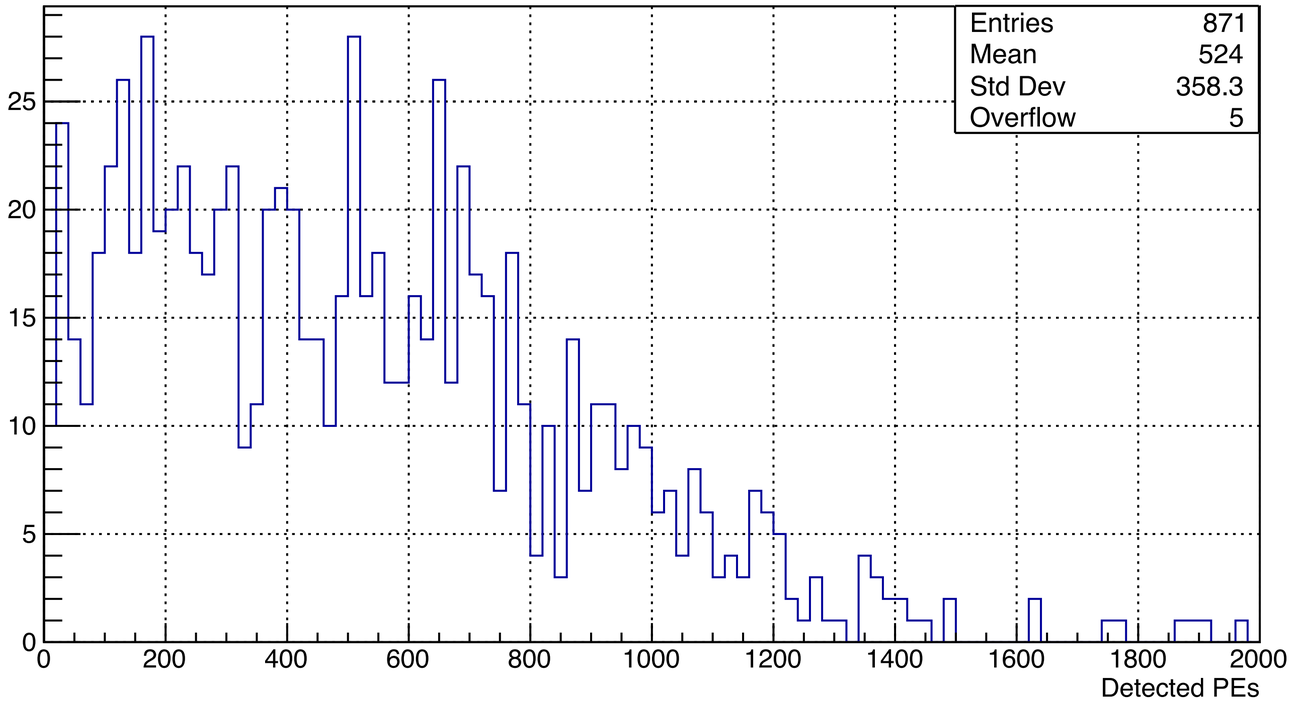
Each XA detects ~10PE



Captures right at the top of each XA

Captures right at the top of each XA give much higher light yield as expected (~10 times higher, mean 500 PE vs 40 PE)

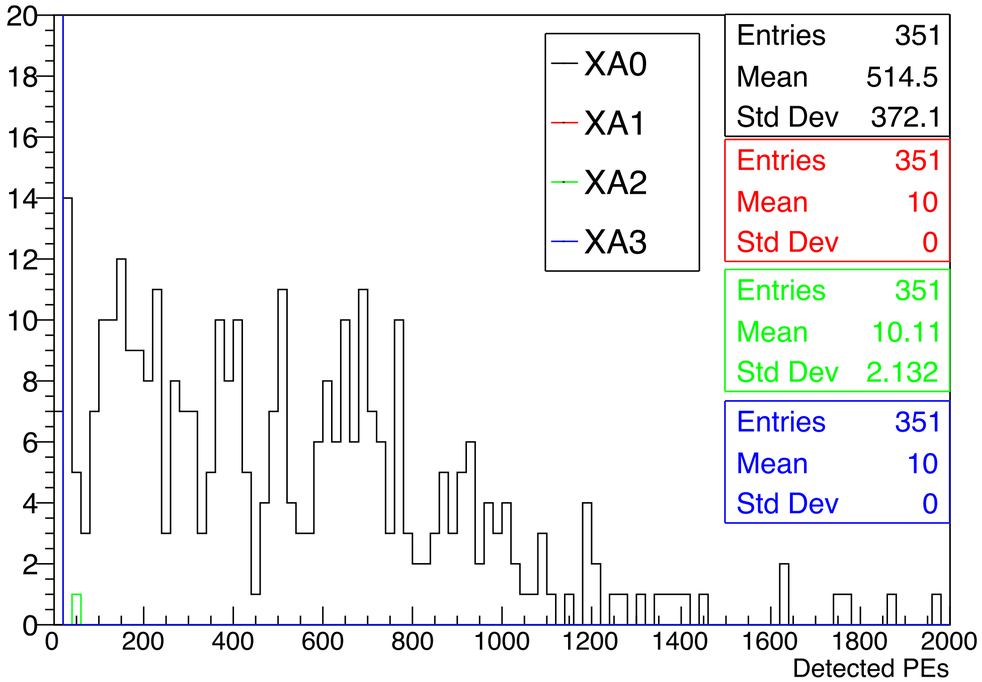
Plot shows detected PEs from all captures happen at +/-28cm around the center of each XA (y/z) in the ColdBox drift region (x= XA plane x + 20cm) for all 4 XAs on the cathode:



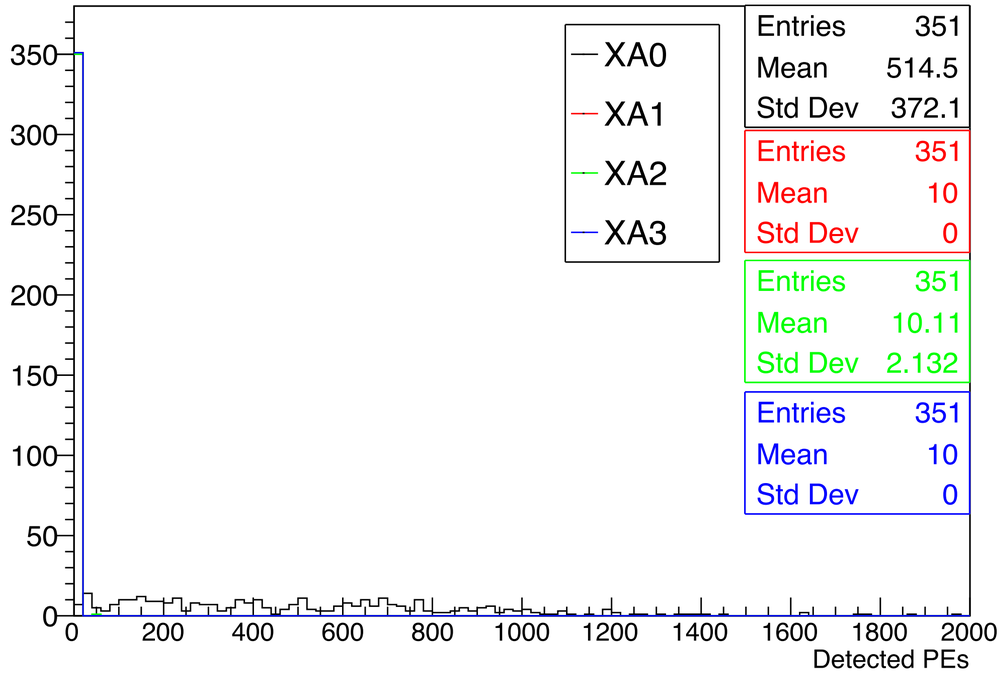
871 captures out of 10k: ~8.7% (PNS at side)

Captures right at the top of XA0

Captures happen at +/-28cm around the center of XA0 (y/z)
in the ColdBox drift region (x = XA plane + 20cm)



Zoom out



Trigger based on total detected PEs any time:
If only one XA > 100 PE && all other XAs < 20 PE

Same behavior for other XAs

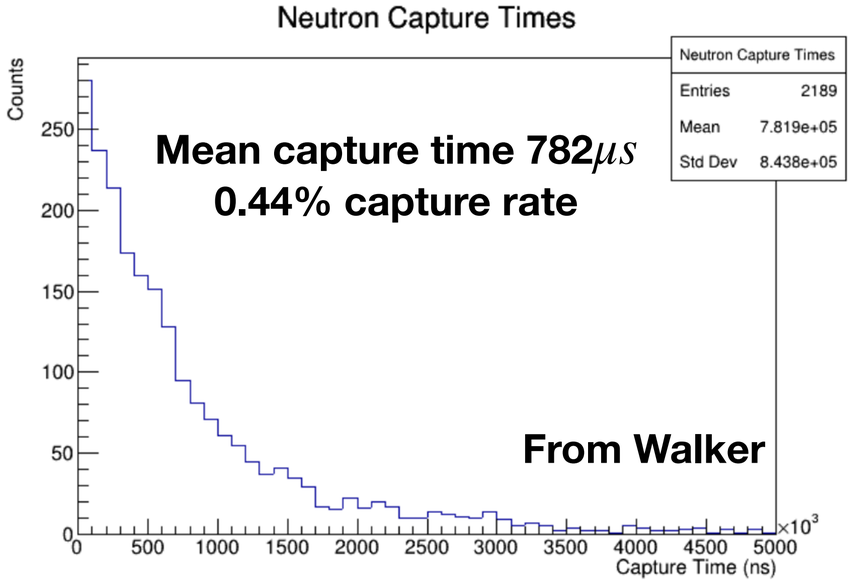
Trigger & DAQ strategy

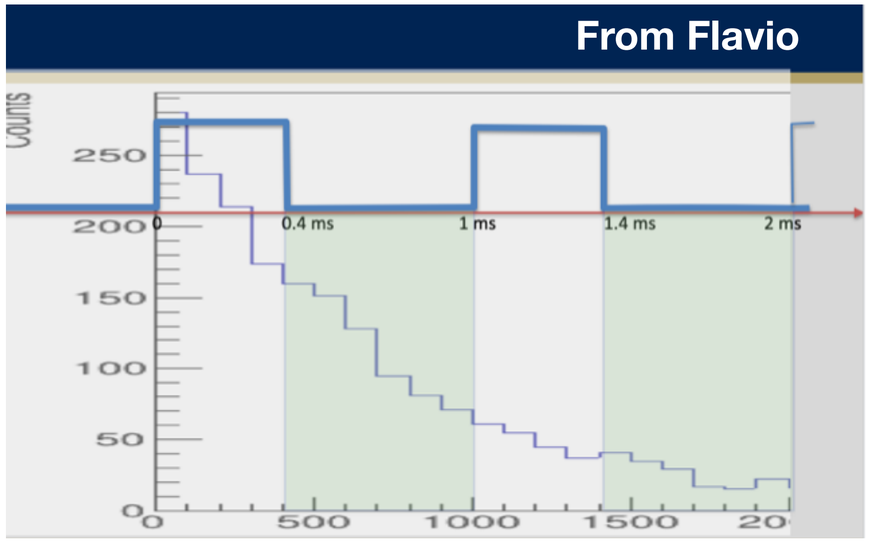
1. **A** OR **B (B is complementary to A)**
   A. **DDG time stamp based** trigger
      - Rep-rate 1kHz (**T**=1ms): set a fixed acquisition window of 0.6ms after DDG pulse width 0.4ms (TTL trigger)
      - ~1 n capture/pulse but also much fewer muon backgrounds (~1) - a good compromise

   B. **Amplitude based** trigger on captures right on top of XA
      - Require only one XA > 100 PE && all other XAs < 20 PE (any time)
      - May validate in data

2. Random trigger:
   - For extra trigger study, e.g., validate bullet point 1
   - Keep track of DDG time stamp

3. Trigger based on CRP data? (Too slow, offline?)
   - Select fiducial volume to cut captures on insulating material/reject cosmics
   - Identify gamma e+/e- pair productions





Next Steps in CB Simulation

- Improve simulation
  - Add wall XAs
  - Add CRP
  - Add background simulation: cosmics, captures in CB material: foam, steel