

# Pulsed neutron source coldbox data analysis

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# DUNE VD coldbox from April 2024 runs

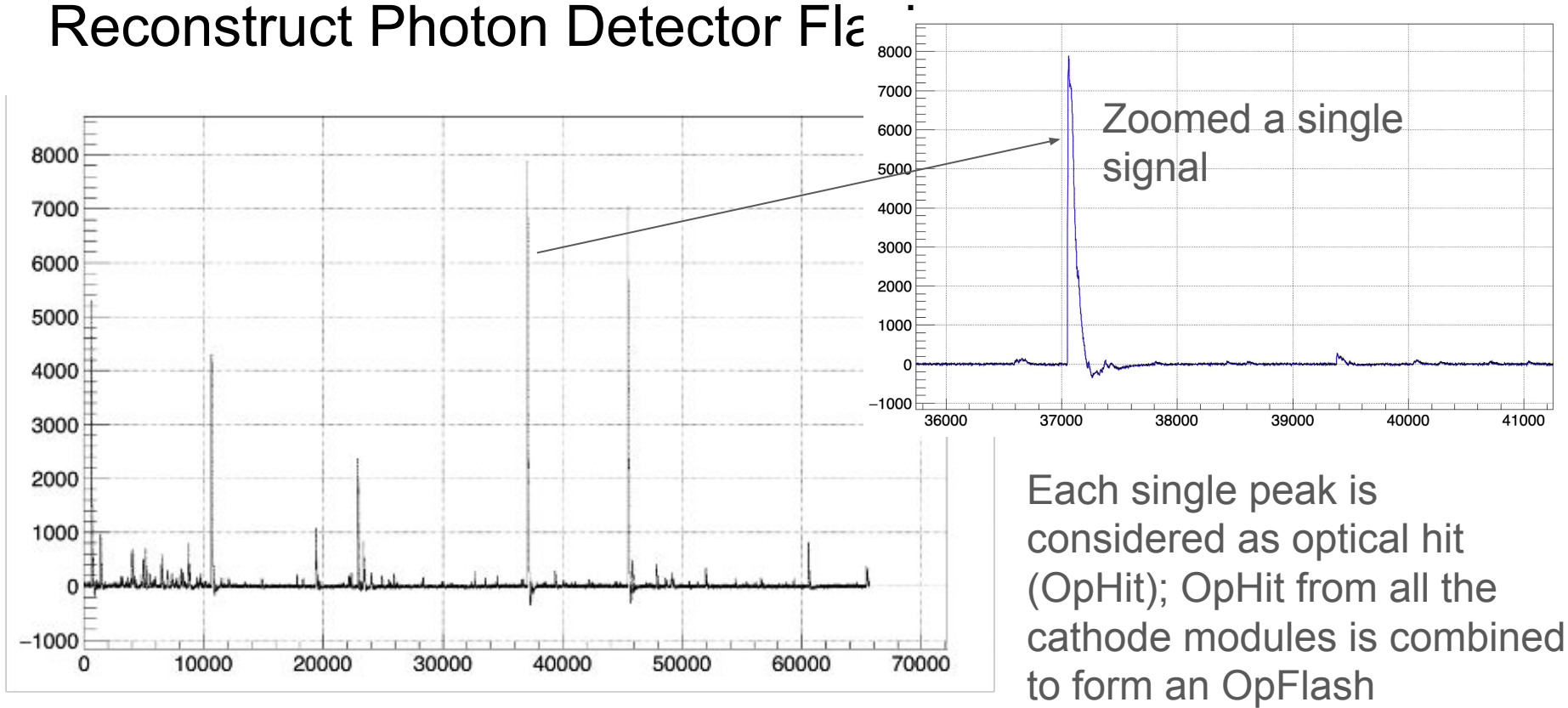


↑ Neutron beam direction

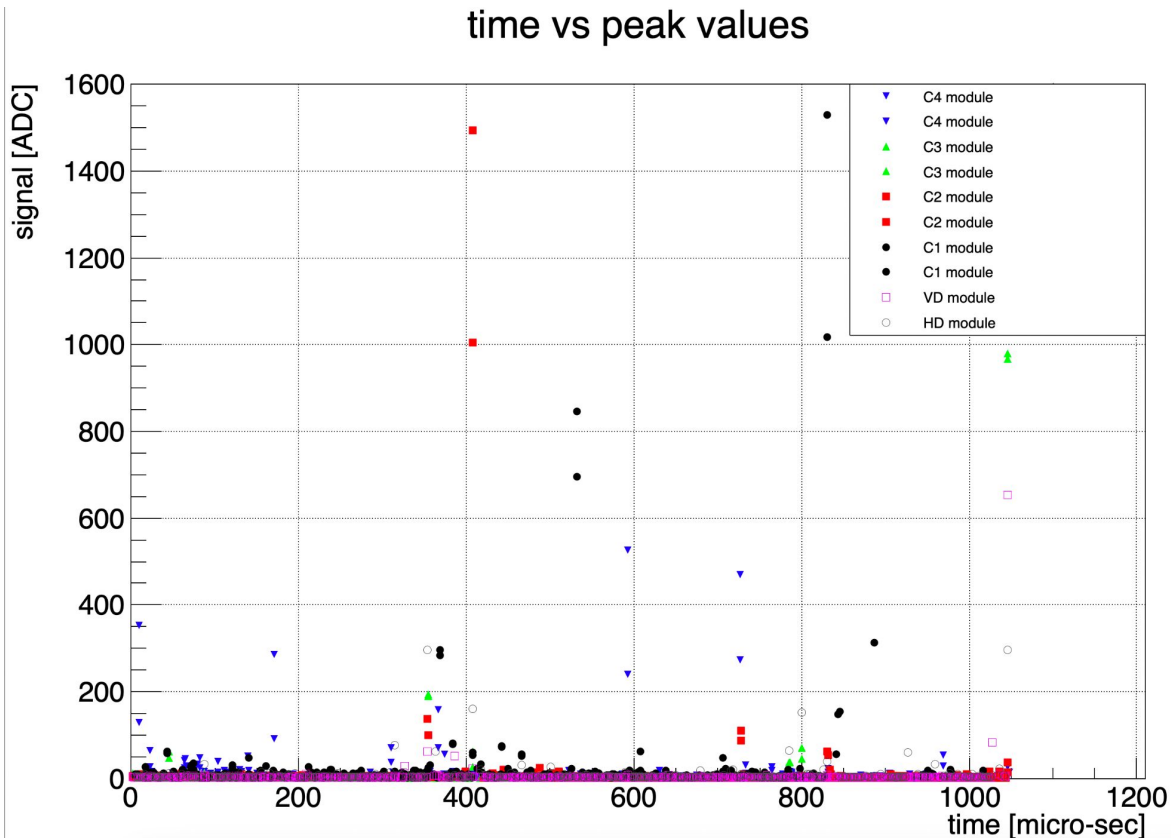
DUNE VD coldbox:  
4 PDS modules on the cathode and 2 PDS modules on the wall

All (except one run) the PNS runs are taken with both CRP and PNS readout active.

# Reconstruct Photon Detector Flash



# Combining hits into flashes: For selecting OpHits I require the peak to be > 10 PE

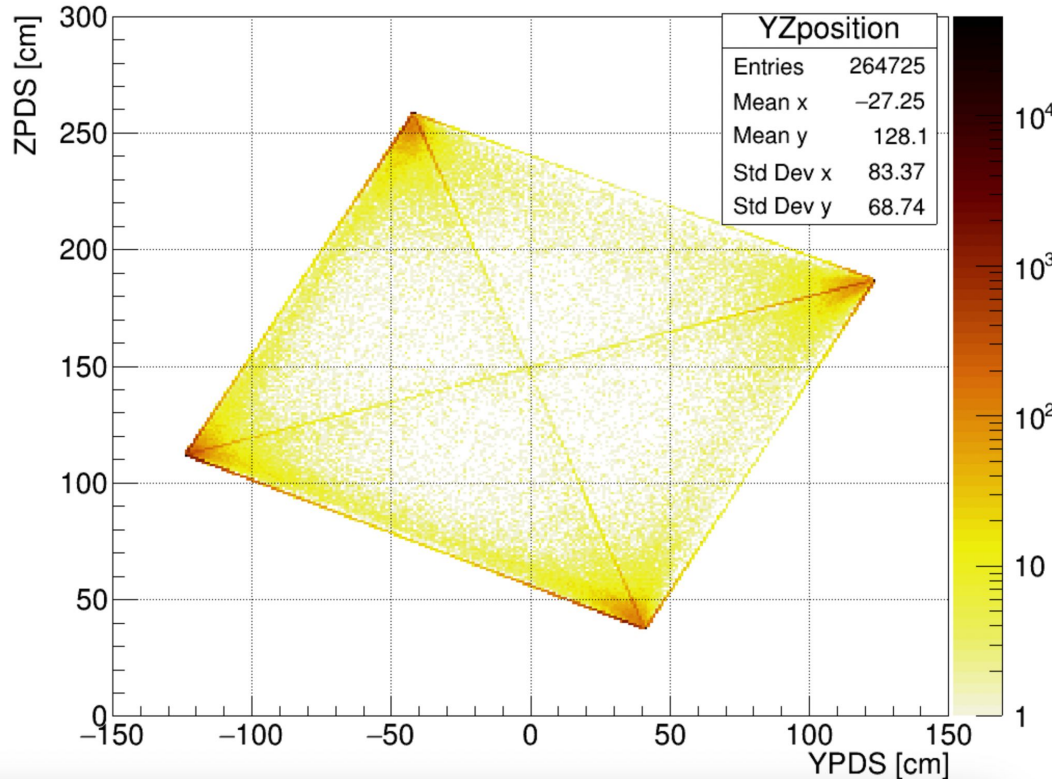


OpHits are scanned from the beginning of event window, once I find a hit > 100 PE; I look for collection of hits within -1 to +5 micro-sec of the hit > 100 PE.

Flash position is calculated considering weighted signal value on each detector

$$Y/Z_{\text{pos of flash}} = \frac{\text{Sum}(\text{PE}_{\text{det}}) * Y/Z_{\text{det}}}{\text{Sum}(\text{PE})}$$

# YZ position of all flashes



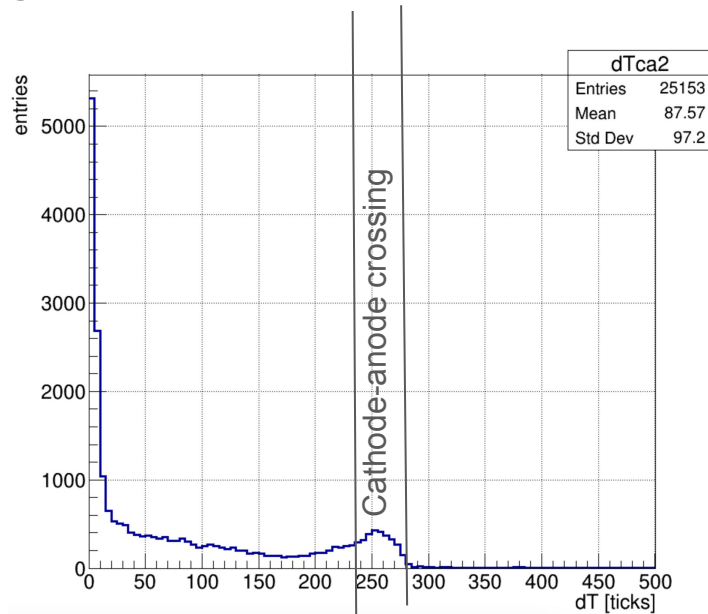
There are many limitations for reconstructing positions using Photon signals such as:

big tiles are big (60 cm x 60cm),

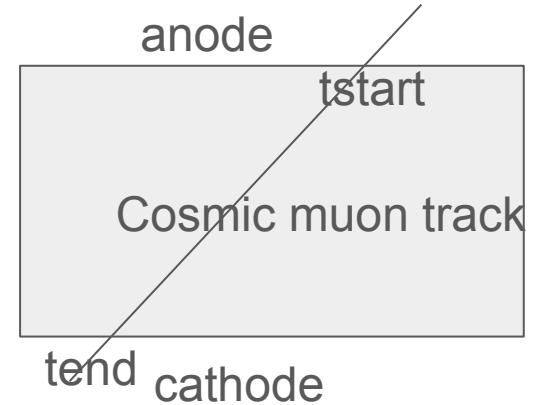
signals appear instantaneously in all the detectors irrespective of the location. Causing a big uncertainty in the estimated activity position.

# Matching PDS and TPC signals:

To validate the synchronisation of TPC and PDS readout, I compared the  $t_0$  measurement for cathode anode crossing comics muons.

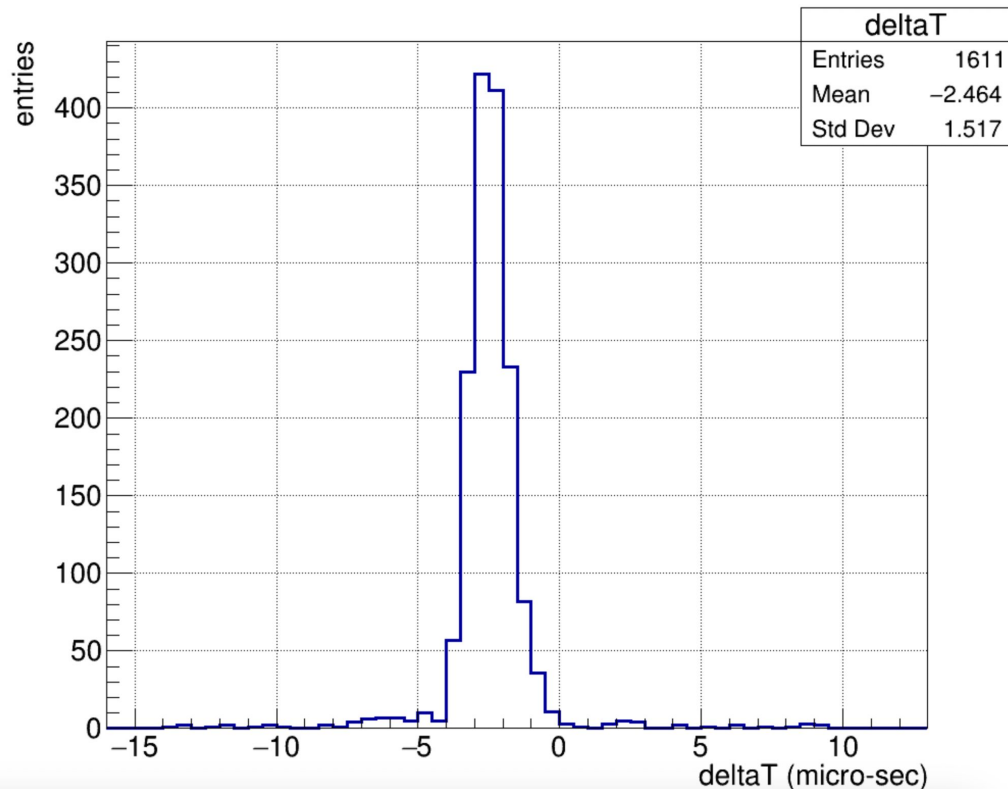


$$dt = t_{\text{start}} - t_{\text{end}}$$



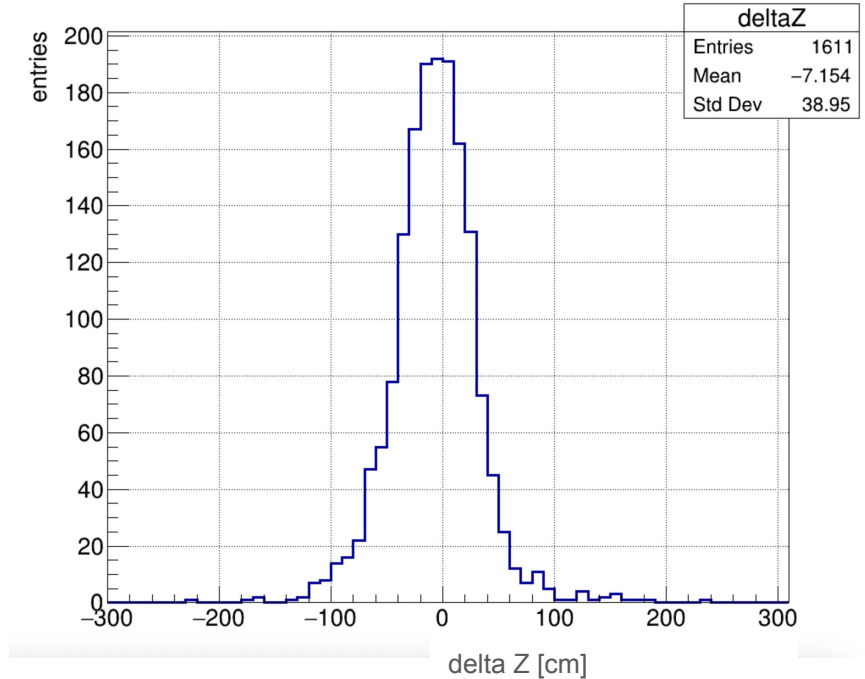
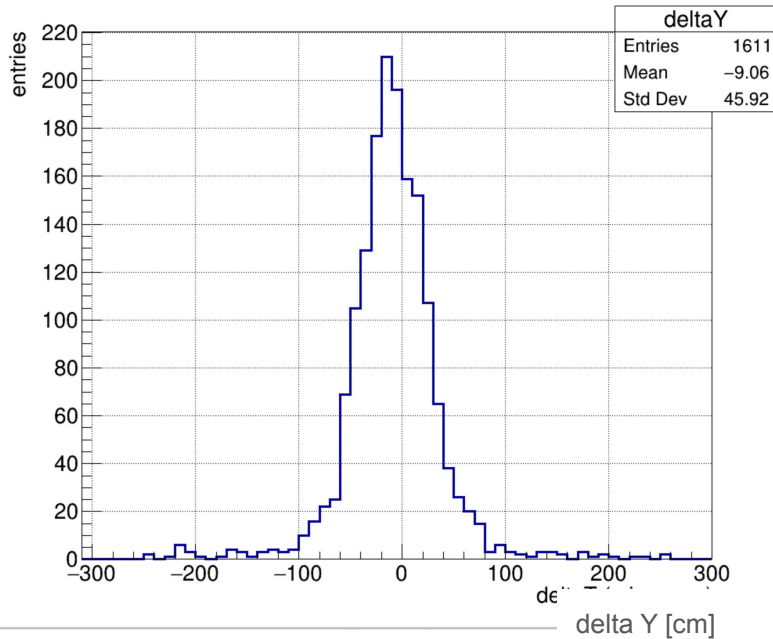
Event time ( $t_0$ ) for cathode-anode crossing track = tstart

Comparing t0 for cathode-anode crossing tracks using PDS and TPC data:



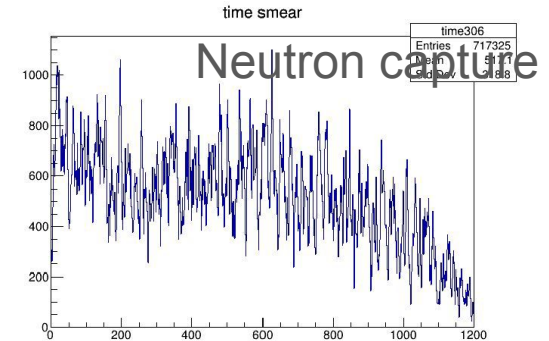
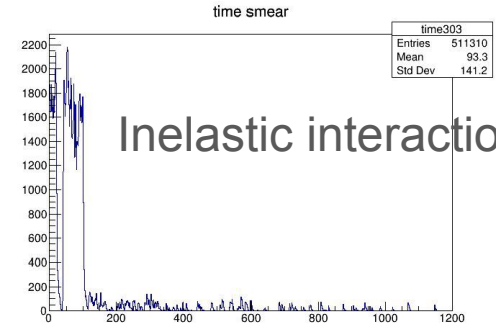
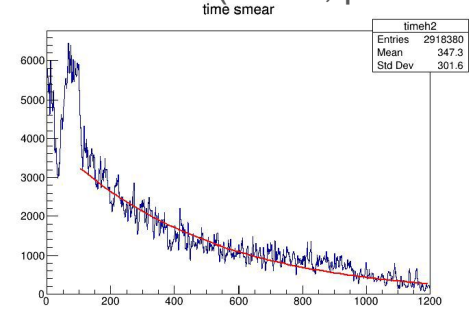
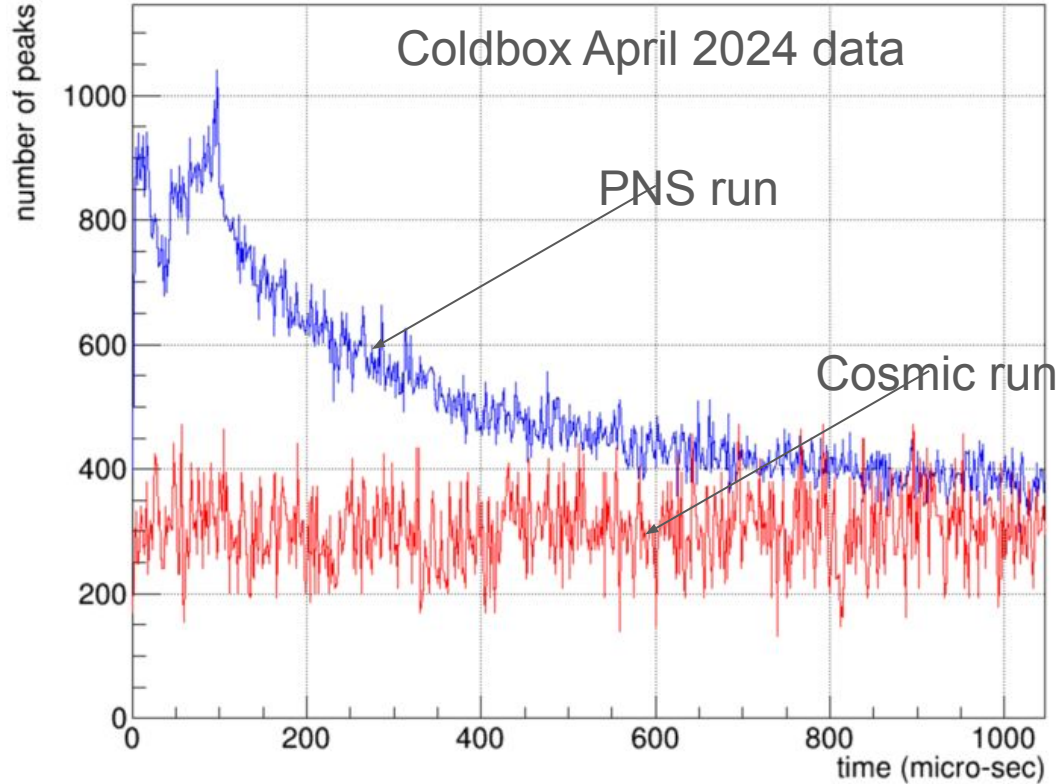
cathode-anode  
crossing track is  
selected; the PDS  
flash closest in time to  
the TPC t0 is found  
and the left plot  
shows;  
 $\text{deltaT} = T0\_PDS - T0\_TPC$

For all the t0 matched track and Flash shown below is the Y and Z position comparison:





# Neutron capture event selection:

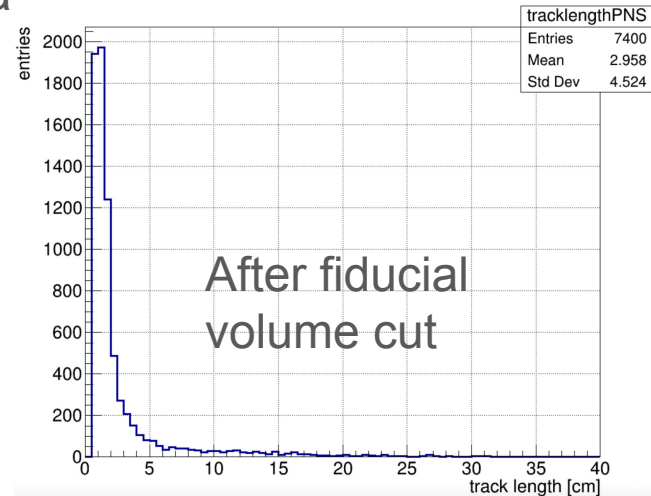
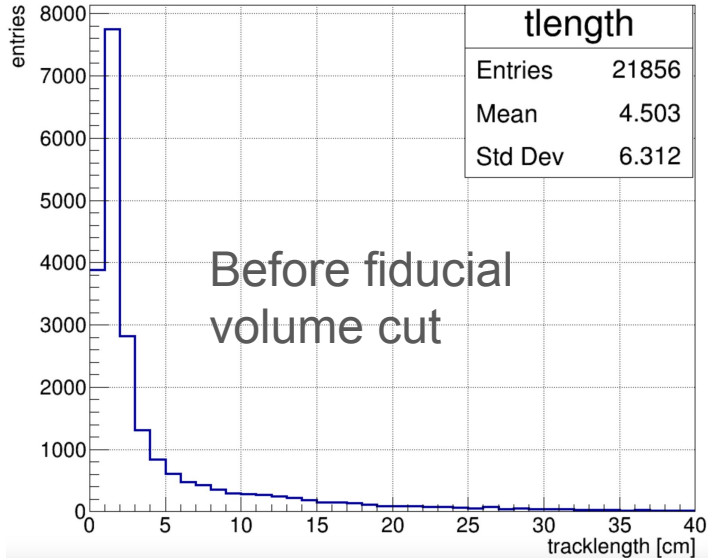


# Neutron capture event selection for TPC data and matching with PDS flashes:

Preliminary selection: Neutron capture seems to appear as small tracks?

Reconstruction needs to be improved and understood in more details.

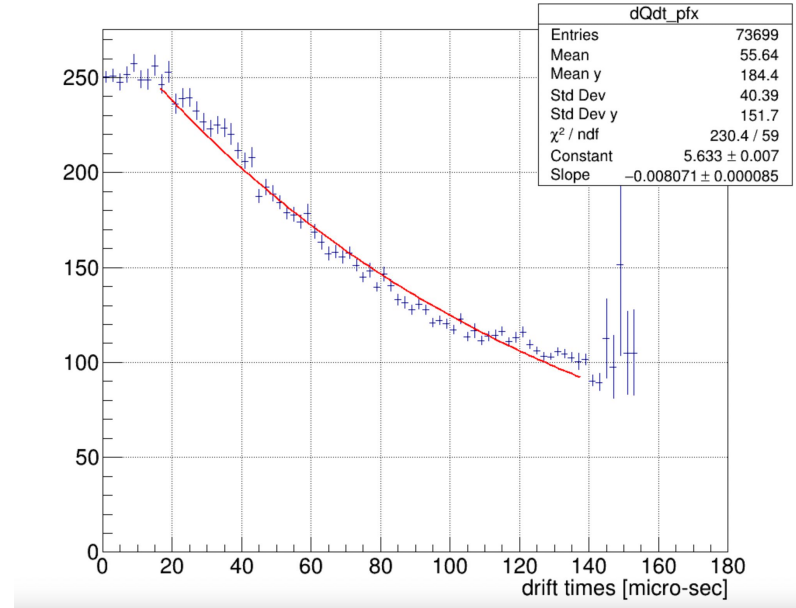
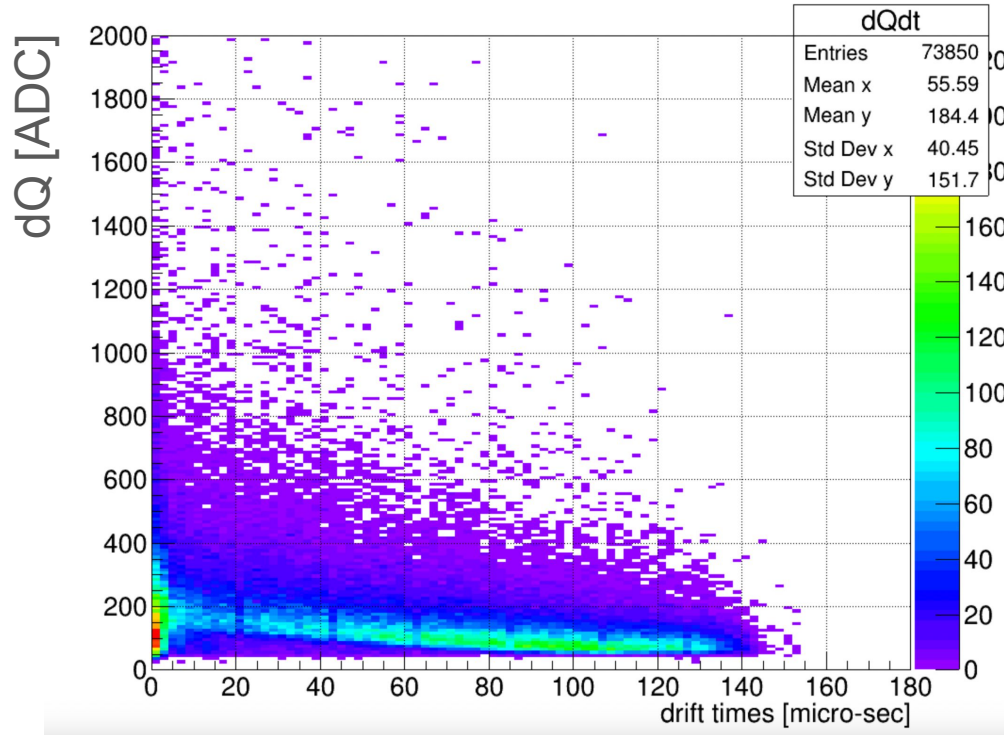
As a quick selection a fiducial volume cut is used; tracks entering the TPC from any of the boundary are removed.



Major background should be broken tracks; working on the broken tracks removal

# Energy reconstruction of selected tracks:

Lifetime correction: using cathode-anode crossing cosmic muons

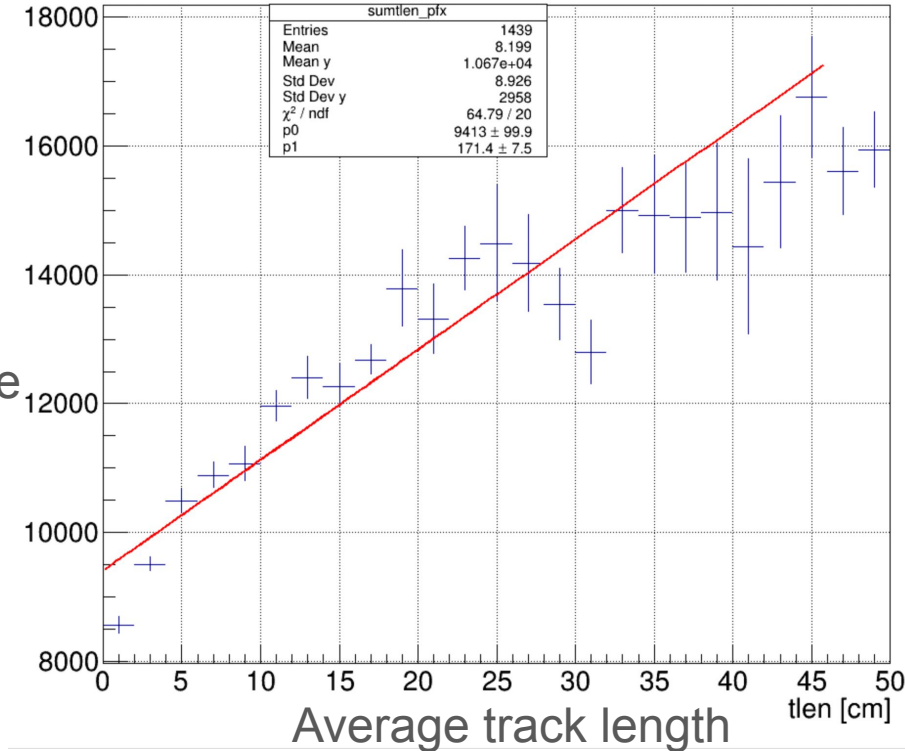


$$\text{Electron lifetime} = 1/(8.071\text{e-}3) \\ = 124 \text{ micro-sec}$$

# Calibration (discussing concept, ignore the result as reconstruction needs tuning)

$$\begin{aligned}dQ/dx &= \text{slope} \\ &= 171.4\end{aligned}$$

Average  
sum dQ  
After lifetime  
correction



Assuming all cosmic tracks deposit energy in the MIP region. Recombination factor will be a constant if we consider all energy deposit to be MIP.

$$\begin{aligned}\text{Cal\_const} * dQ/dx &= dE/dx \\ \text{Cal\_const} &= 2.1 \text{ MeV}/171.4\end{aligned}$$

Now knowing the dQ value  
 $dE = \text{Cal\_const} * dQ$



## Future plan:

1. Understanding the reconstruction scanning some events
2. Matching PDS and TPC hit for PNS:
  - Based on shortest distance and the  $t_0$  can be estimated, which can be used for lifetime correction and energy estimate. A comparison of the photons detected and charge deposited will be used to validate the selection.