Study of SFGD Prototype's Response to Cosmic Rays

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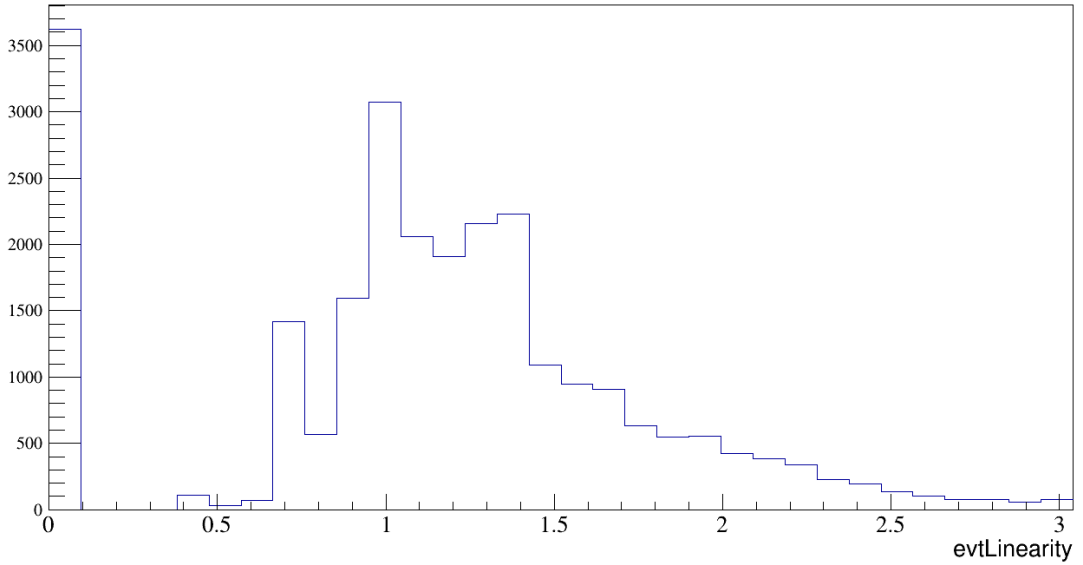
Introduction

- Study of cosmic tracks passing through detector from the SFGD prototype LANL 2020 data
- Cosmic data taking runs used a scintillator pad (22 cm x 18 cm) on the top surface of the detector to trigger a time window of 200 ns
- Looking at channels along X (24cm) and Z (48cm) axes; both use Type I MPPCs
- Looking at hit PE by channel
- Analysis performed using tools in neutronselection repository develop branch

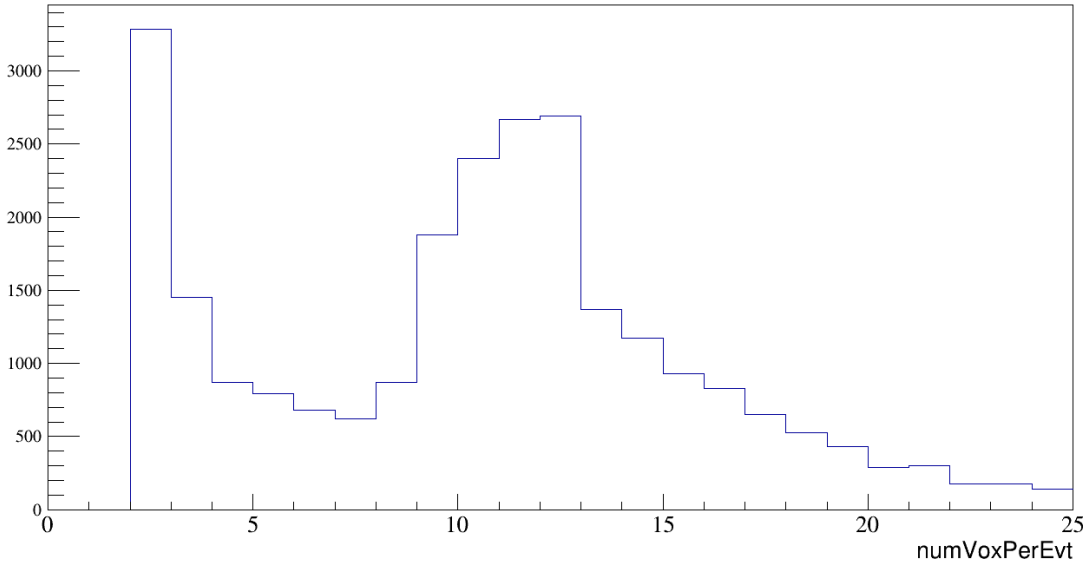
Event Selection

- Single time cluster within 20 ns
- 3D voxelization of hits
- Single spatial cluster
- Number of voxels between 6-12
- Voxels in top and bottom layers of detector
- PCA linearity > 0.9
- All plots following this slide include these cuts

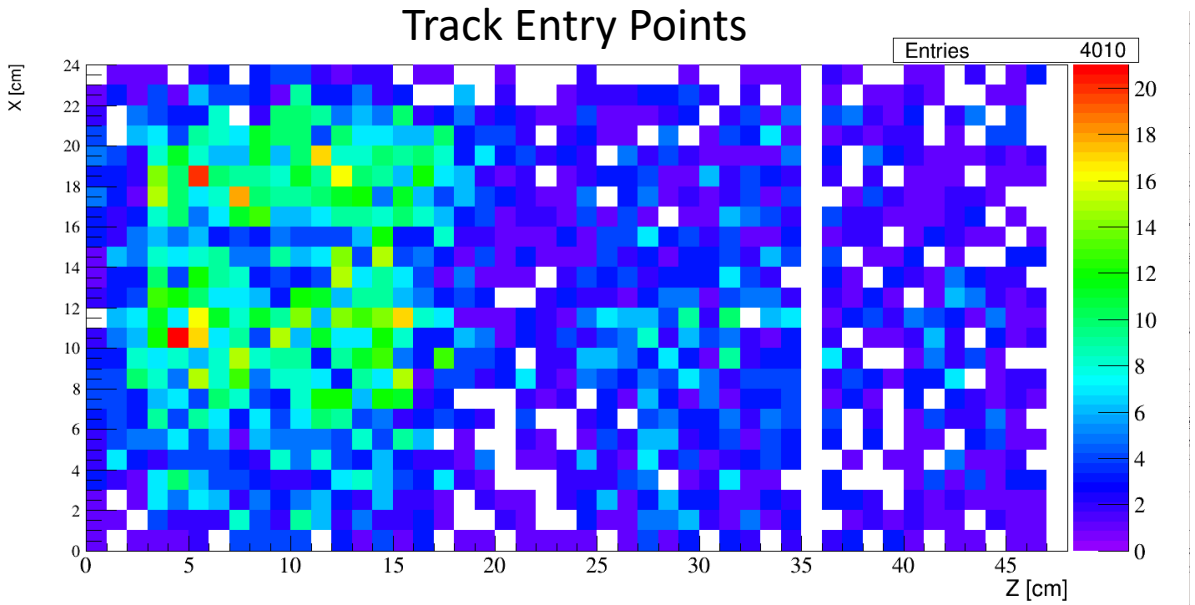
Linearity of All Events

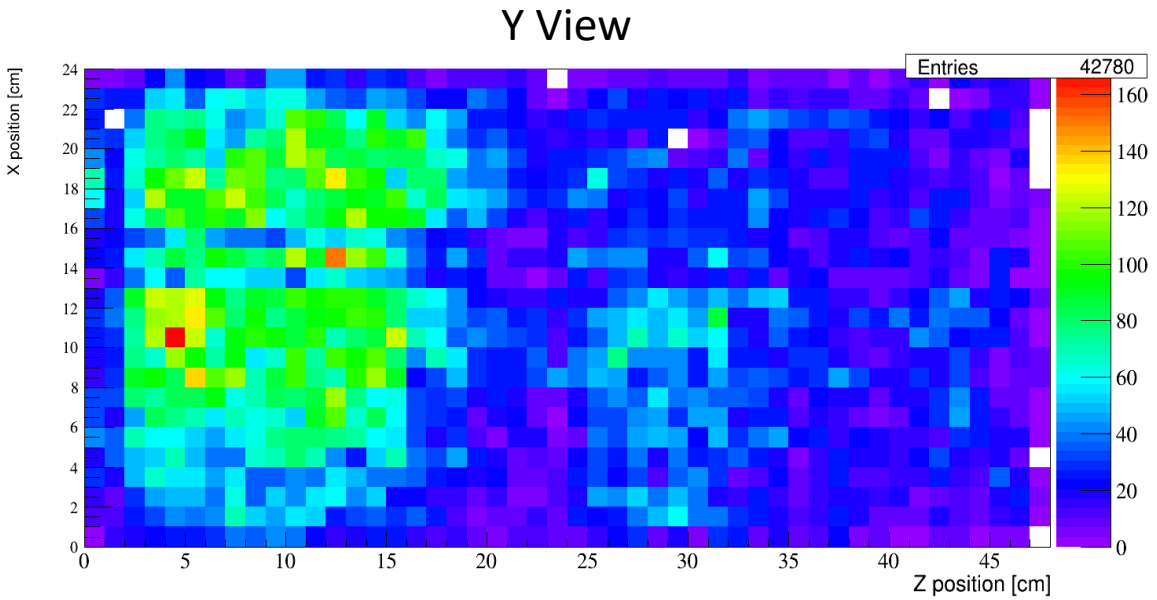


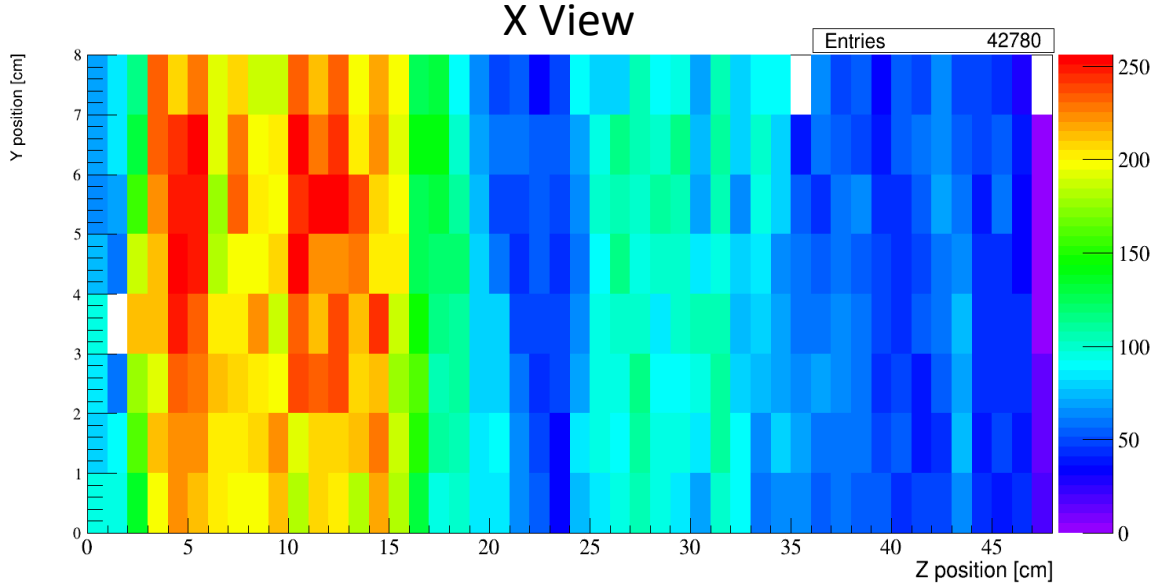
Voxels per Event

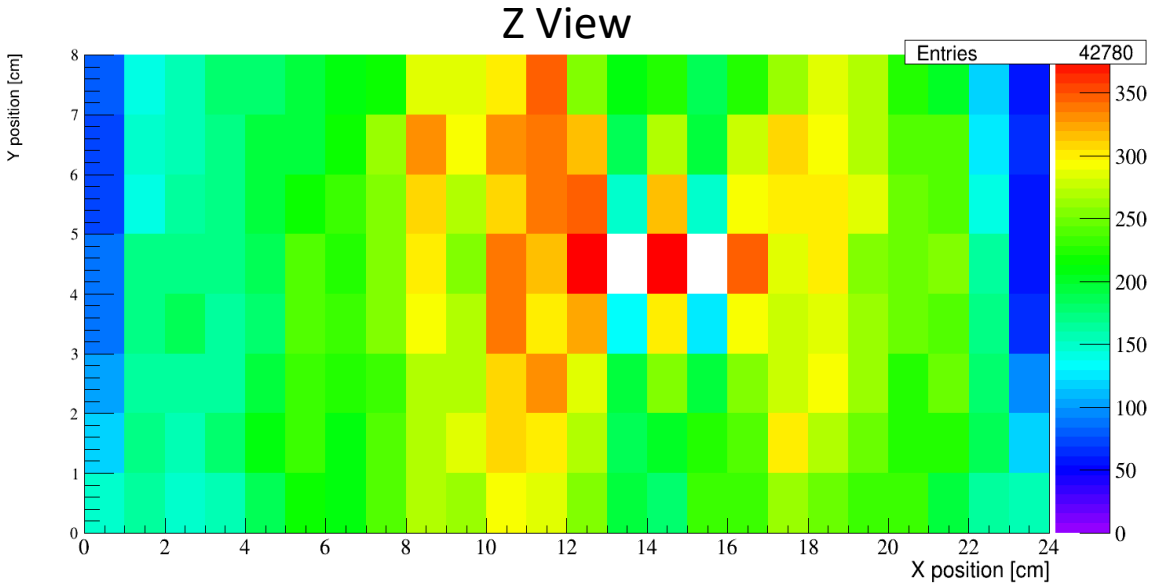


Hit Locations of All Events





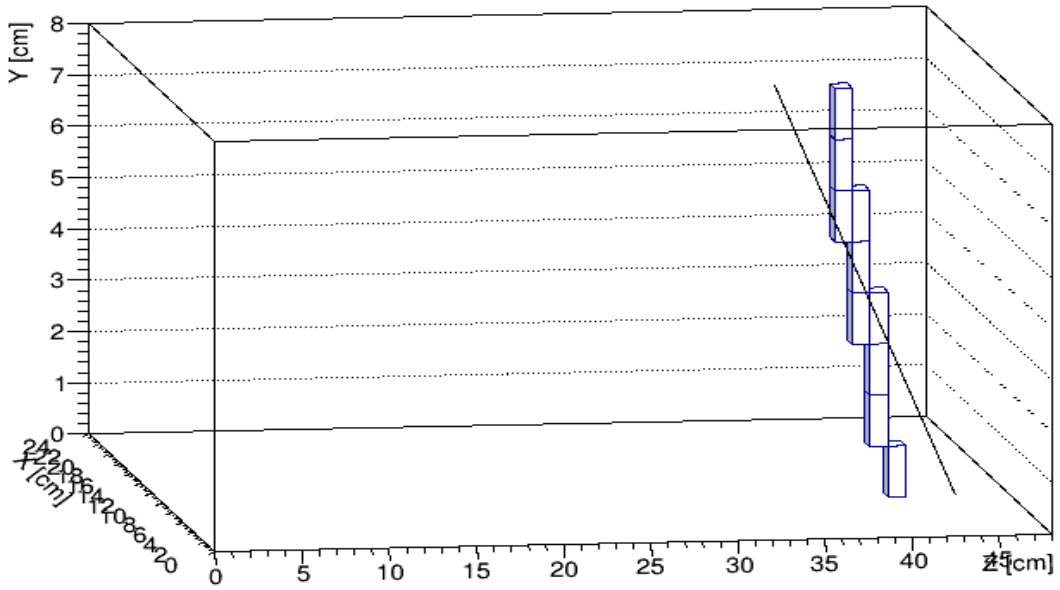




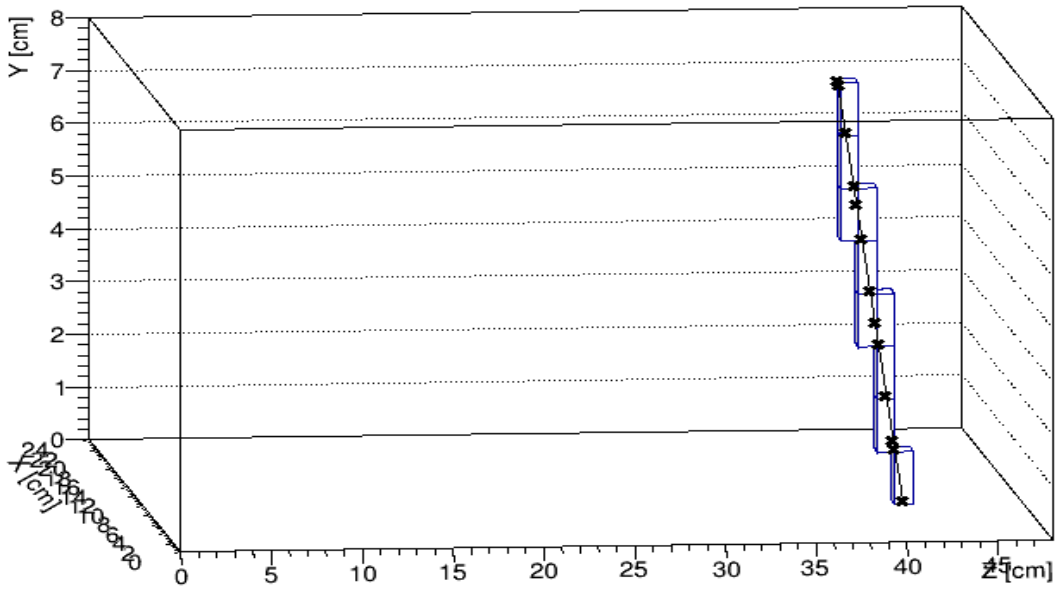
Track Fitting

- Default track fitting failed in some cases
- Fitting track with a straight line
- Function being minimized is the distance from the charge weighted voxel location
- Starting parameters are the charge weighted centroid and principal eigenvector of track geometry's charge weighted covariance matrix
- Result of fit is a point on the track and a vector along the track's direction
- Track fitting results then used to calculate the track lengths within each cube
- Selecting hits corresponding to track lengths between 0.8-1.2 cm within cubes

Default Track Fit

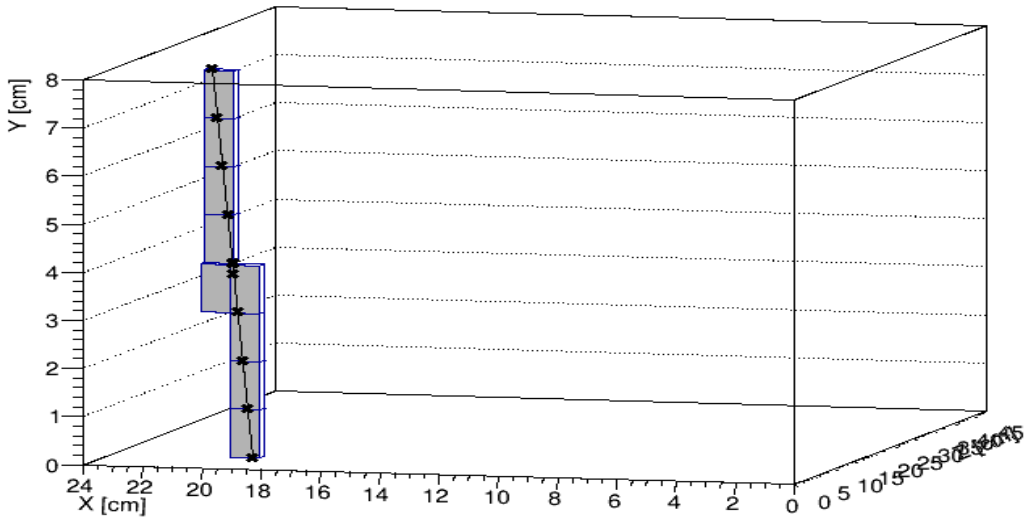


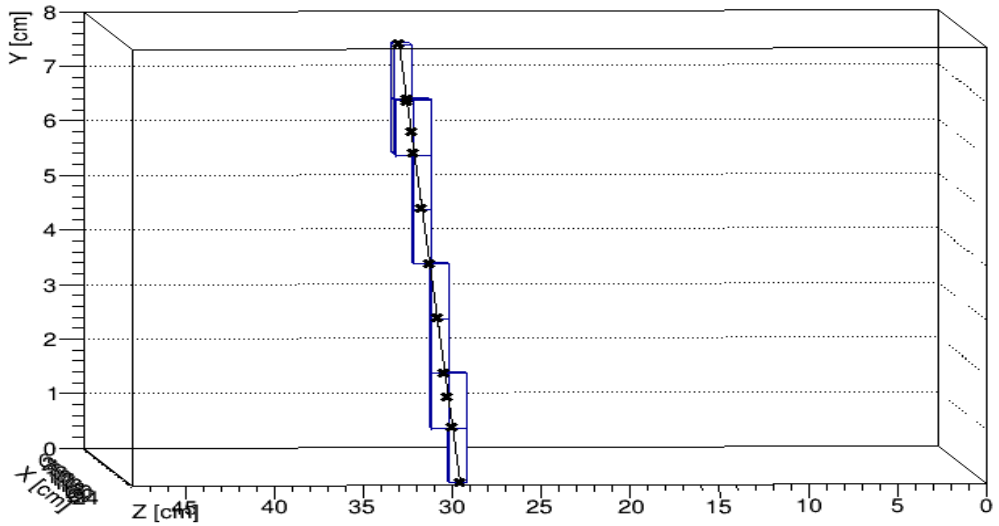
Charge Weighted Track Fit



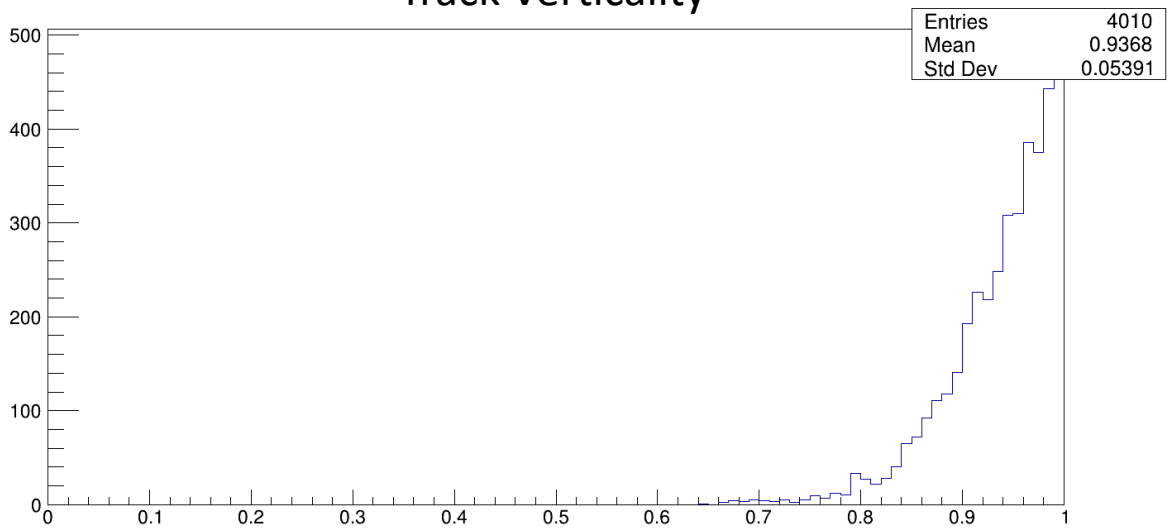
Rename this to track features

Track Fitting

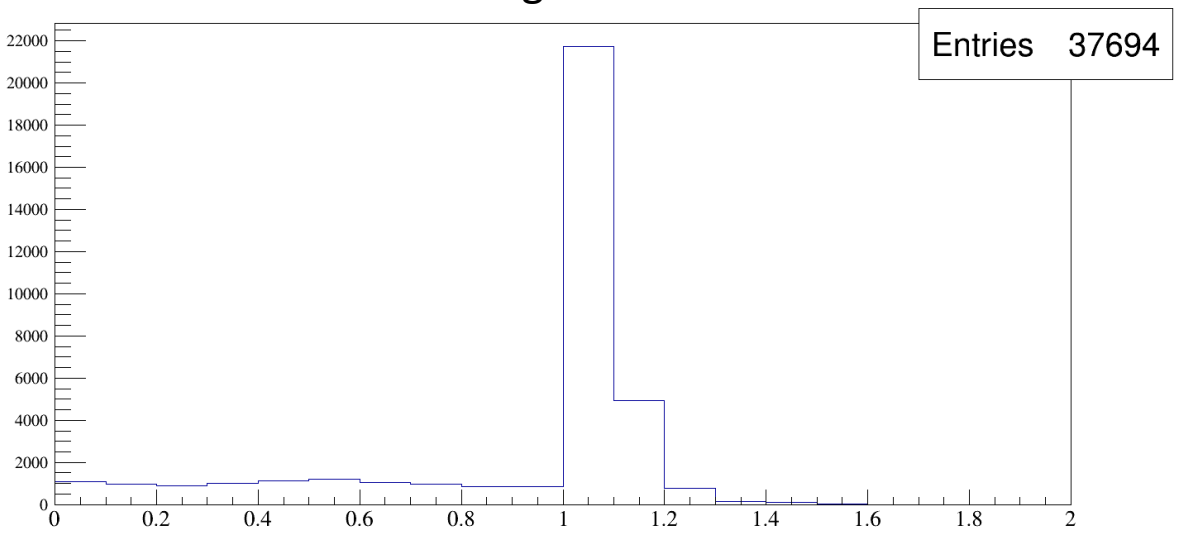




Track Verticality

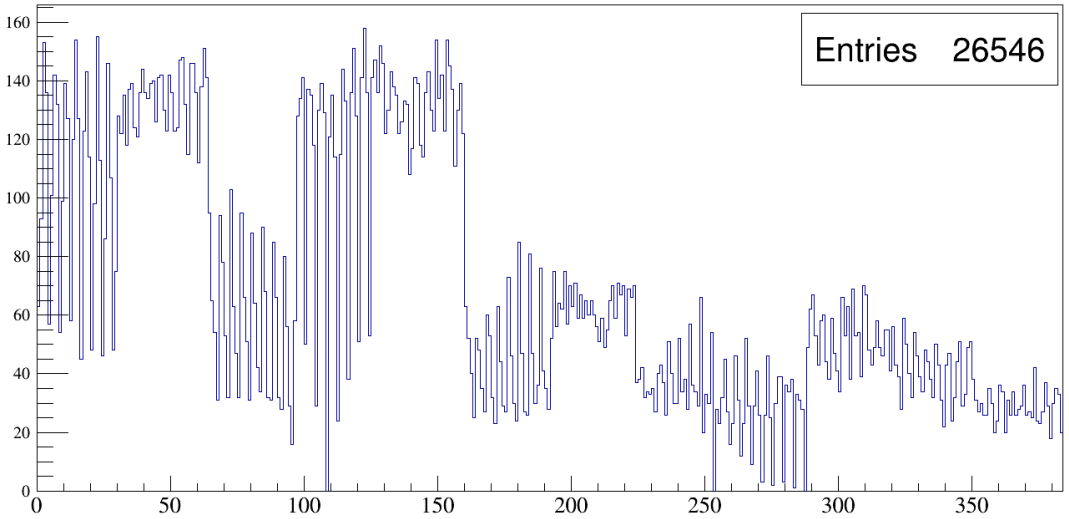


Track Lengths in Cubes

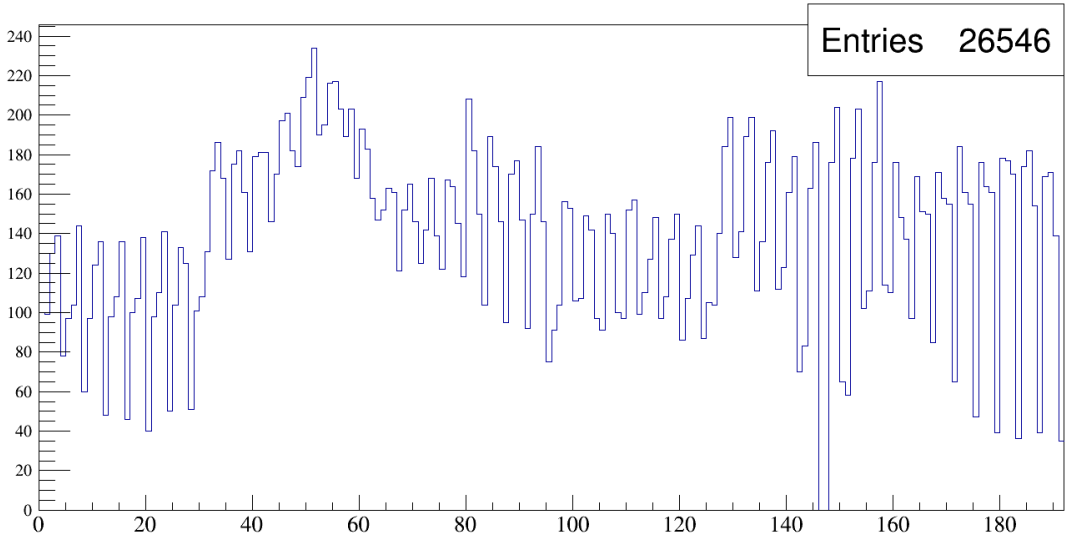


Sample Overview

Hits per X-Channel



Hits per Z-Channel



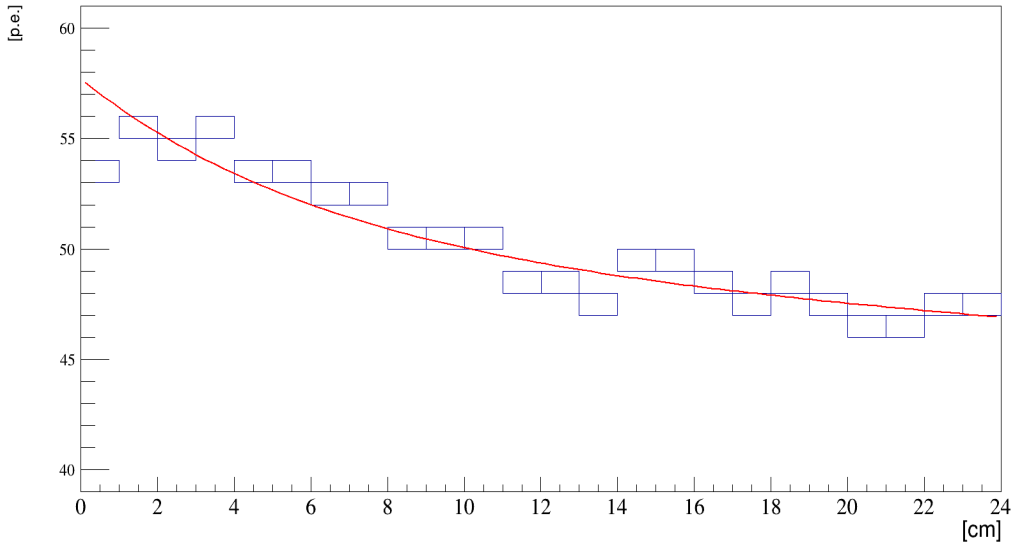
- After adding cut on track lengths in cubes

Fiber Attenuation

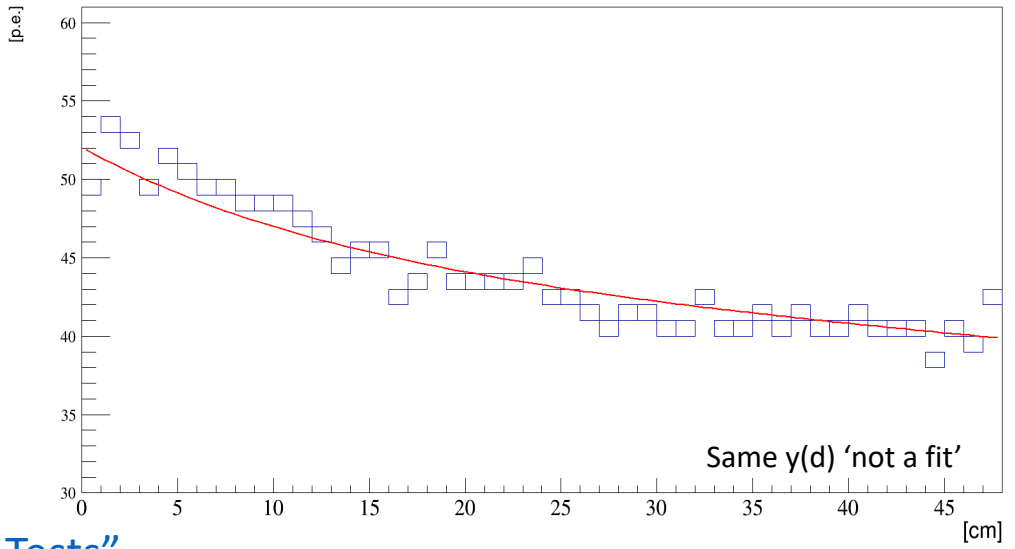
$$y(d) = LY_o(\alpha e^{-\frac{d}{L_S}} + (1-\alpha)e^{-\frac{d}{L_L}})$$

- Weighting factor $\alpha = 0.1399$
- Long attenuation constant:
  $L_L = 400$ cm, from manufacturer
- Short attenuation constant:
  $L_S = 6.306$ cm, for 24 cm fibers

All X Channels mean Hit PE Dist. vs Dist to MPPC

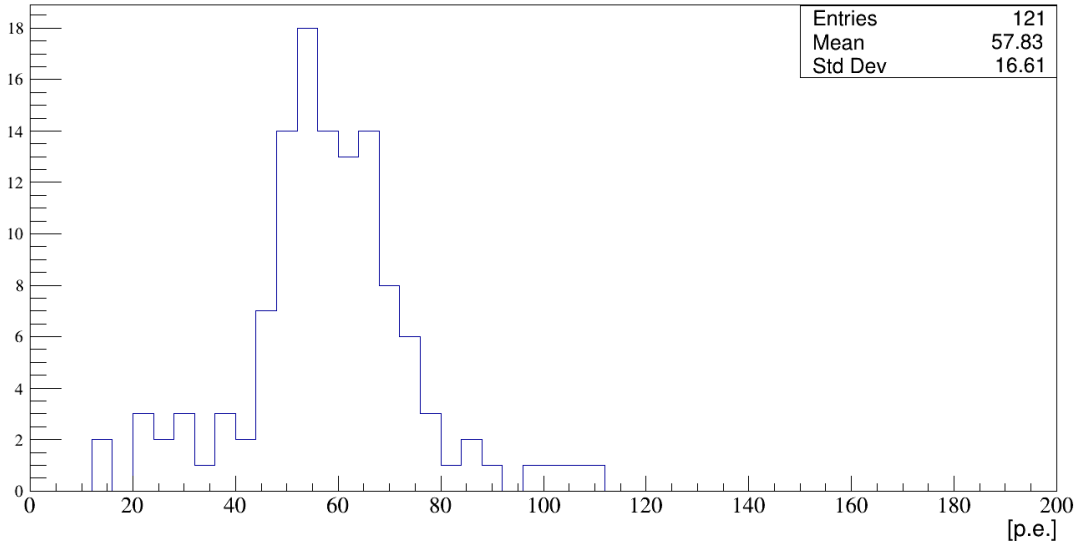


All Z Channels mean Hit PE vs Dist. to MPPC

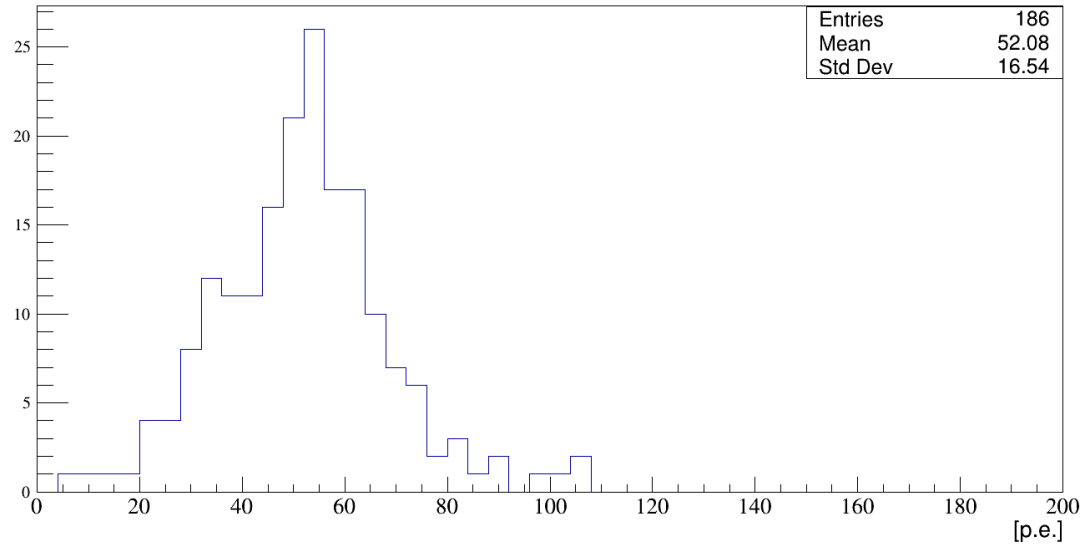


Attenuation constants quoted from:
A. Blondel et al. "The SuperFGD Prototype Charged Particle Beam Tests"

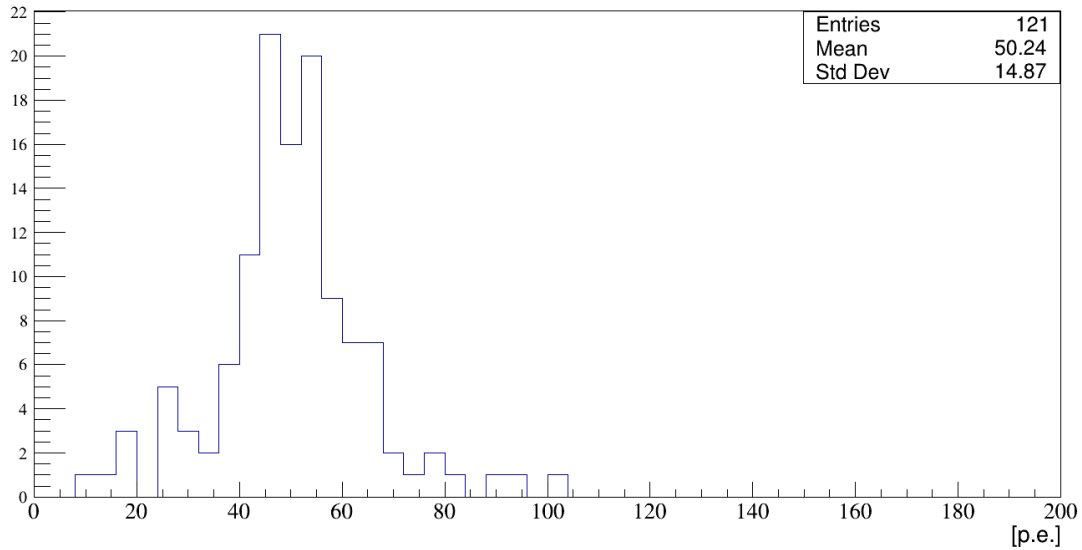
LYo after correction. X Channel along y=3, z=3



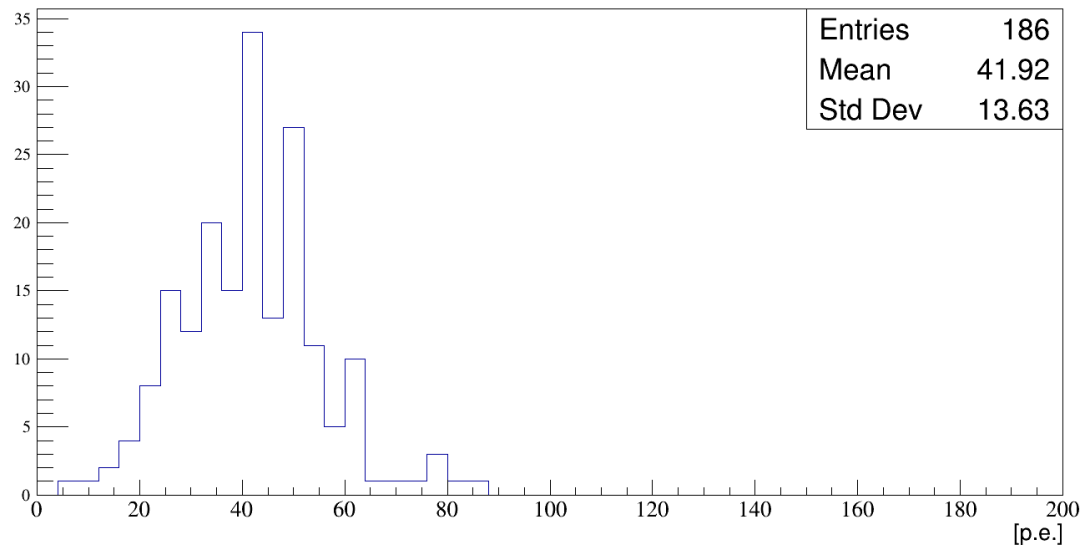
LYo after correction. Z Channel along y=4, x=11



Attenuated Hit PE . X Channel along y=3, z=3



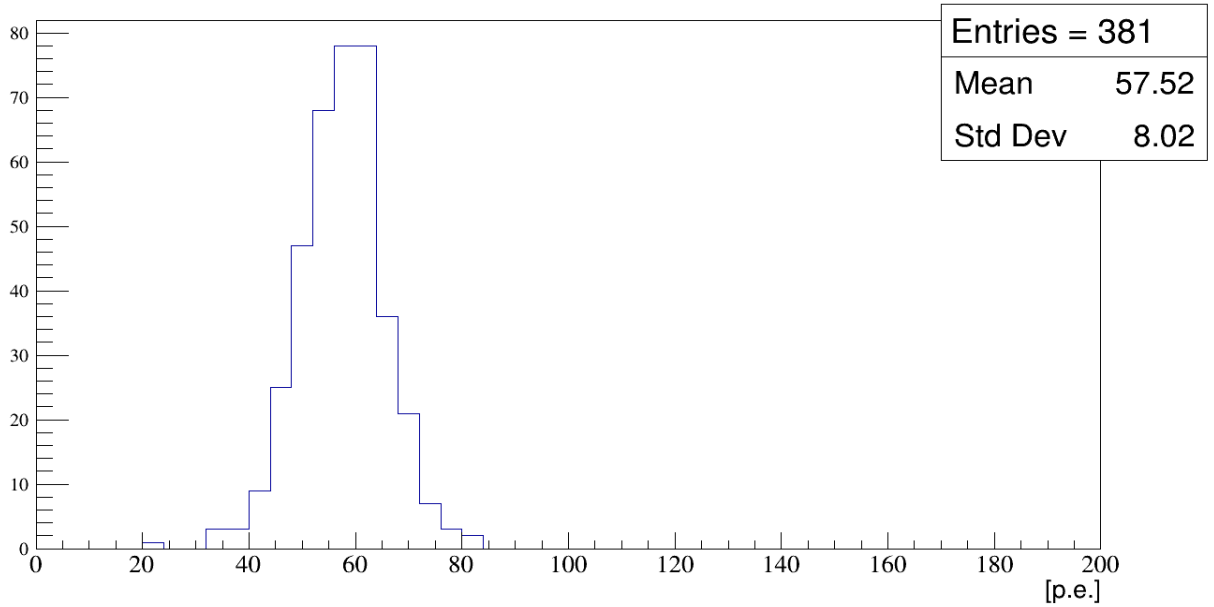
Attenuated Hit PE . Z Channel along y=4, x=11



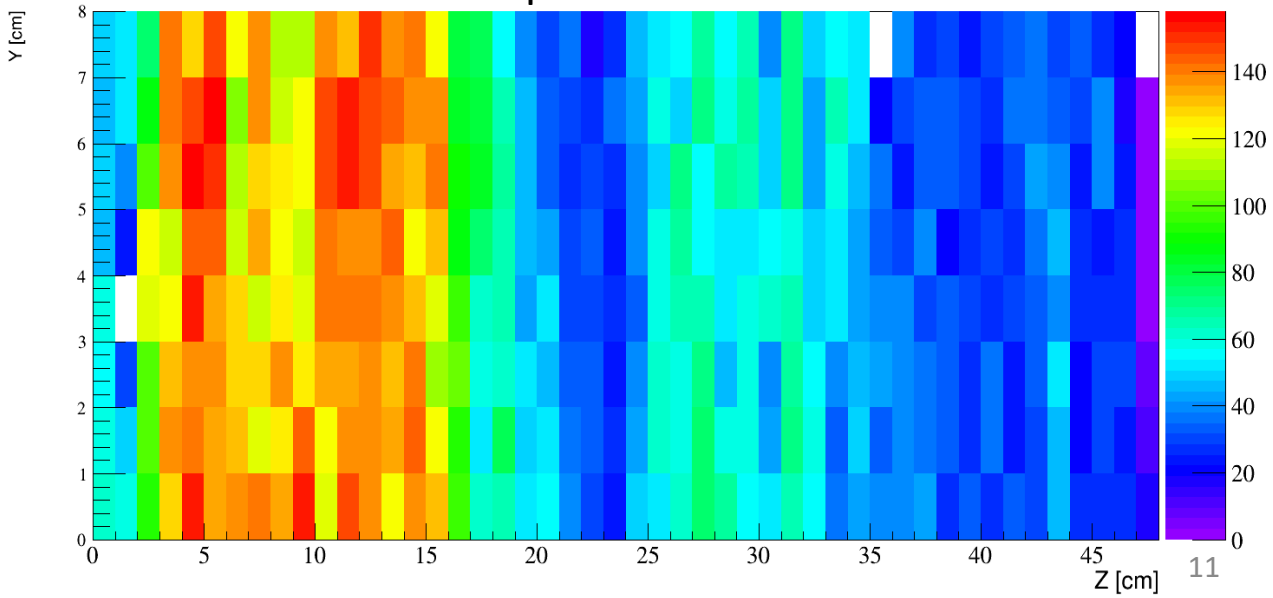
X Channels Mean Response

- Relatively even response in map
- bands in stats plot may be due to some overlap in scintillator pad location

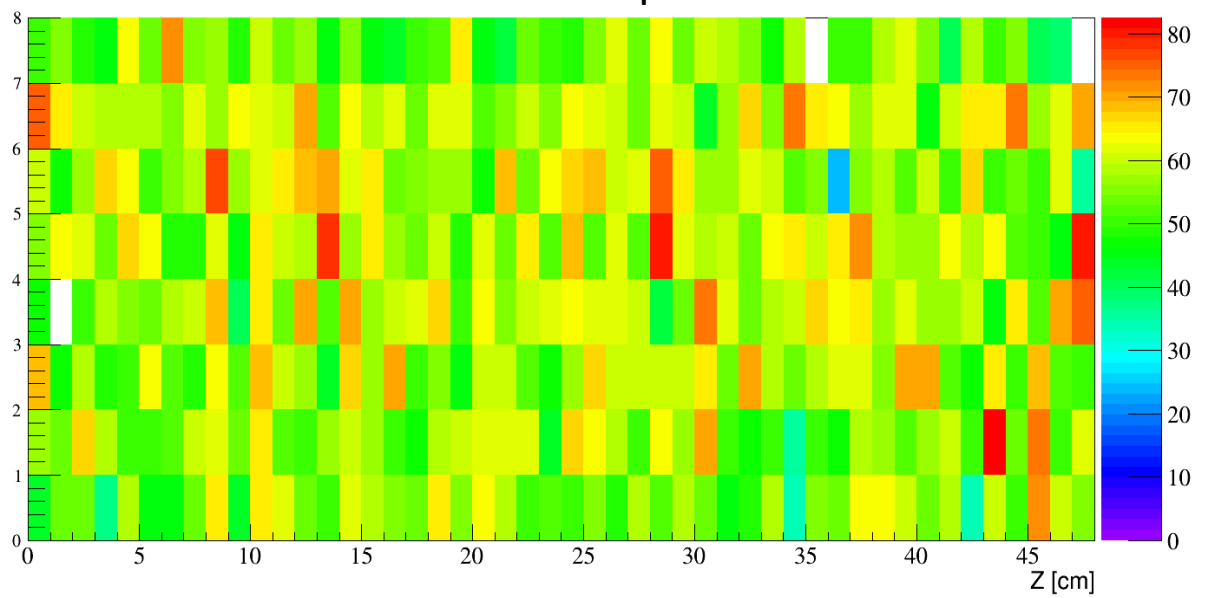
X Channels Mean LYo after corrections



Hits per X Channel



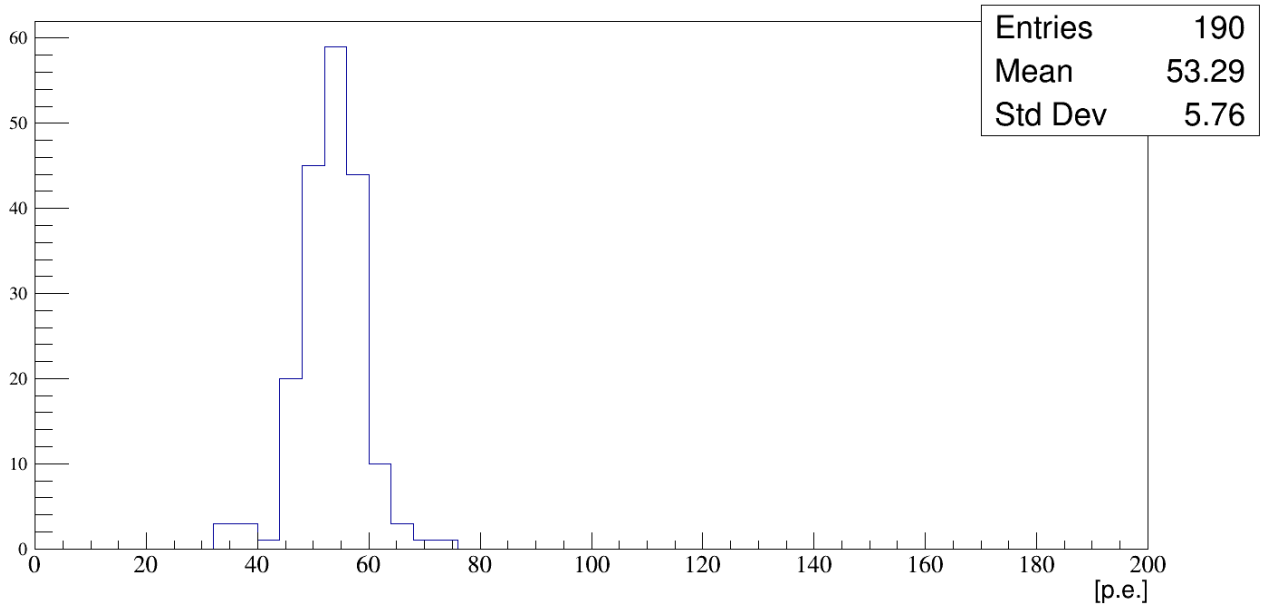
X Channels Mean LYo Map after corrections



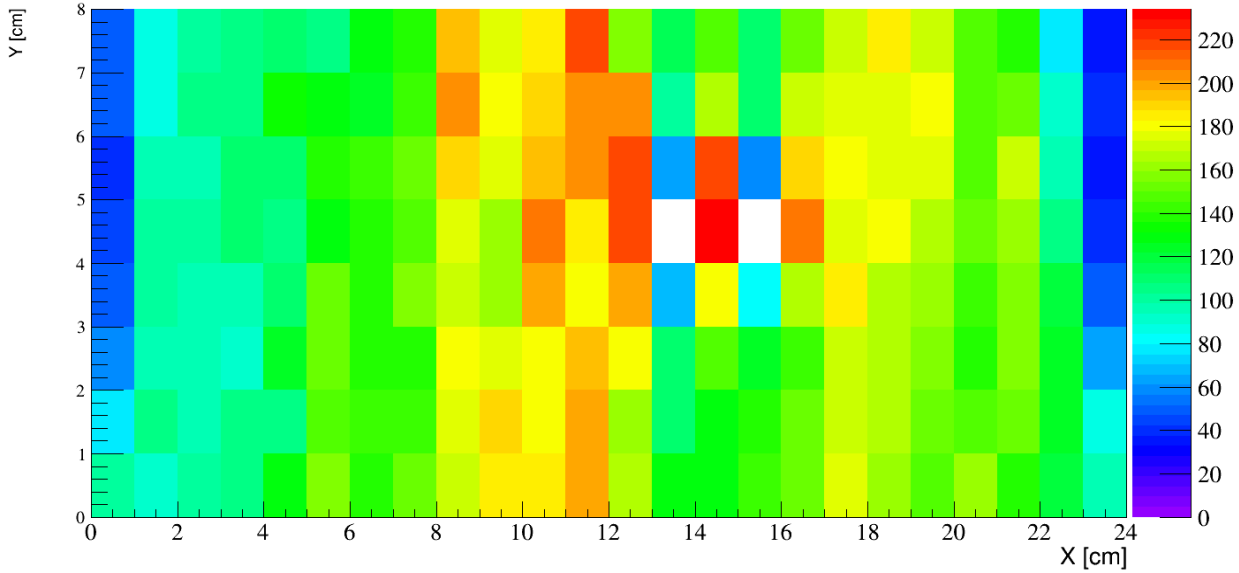
Z Channels Mean Response

- Relatively even response in map again.
- Same MPPC but different mean

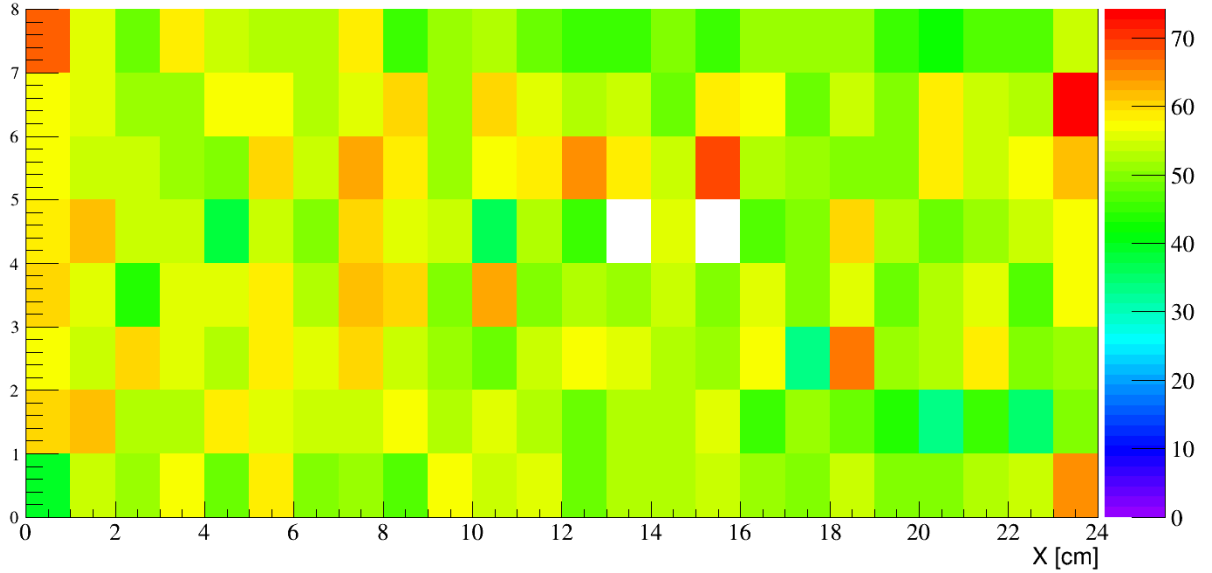
Z Channels Mean LYo after corrections



Hits per Z Channel



Z Channels Mean LYo Map after corrections



Summary and Next Steps

- We have performed data analysis on cosmics LANL
- We have calculated the means per channels for X and Z fibers
- Channels are relatively uniform in both X and Z
- Mean and spread similar to CERN charged beam tests
- Next steps. planning to look at the y channels with high angle or tilt data if enough statistics (24 x 48 channels)
- If available might want to see if any temperature corrections for the MPPC response can improve what we have seen