Energy reconstruction technique for very high energy muons with DUNE-FD LArTPC.

Jaydip Singh

University of Lucknow, India
Working With
Dr. Thomas R. Junk
FNAL, Batavia, USA
Dr. Jyotsna Singh
University of Lucknow, Lucknow, India.

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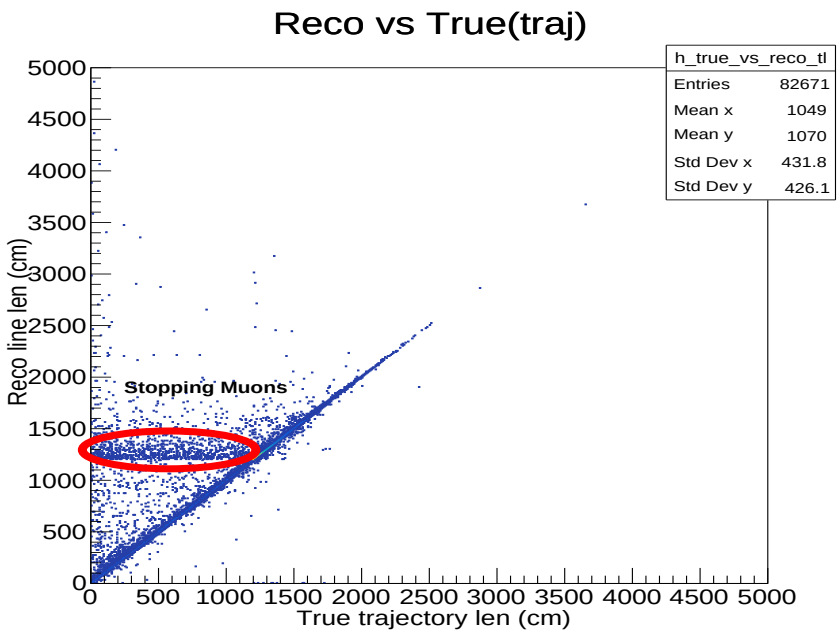
FD Simulation and Reconstruction Bi-Weekly

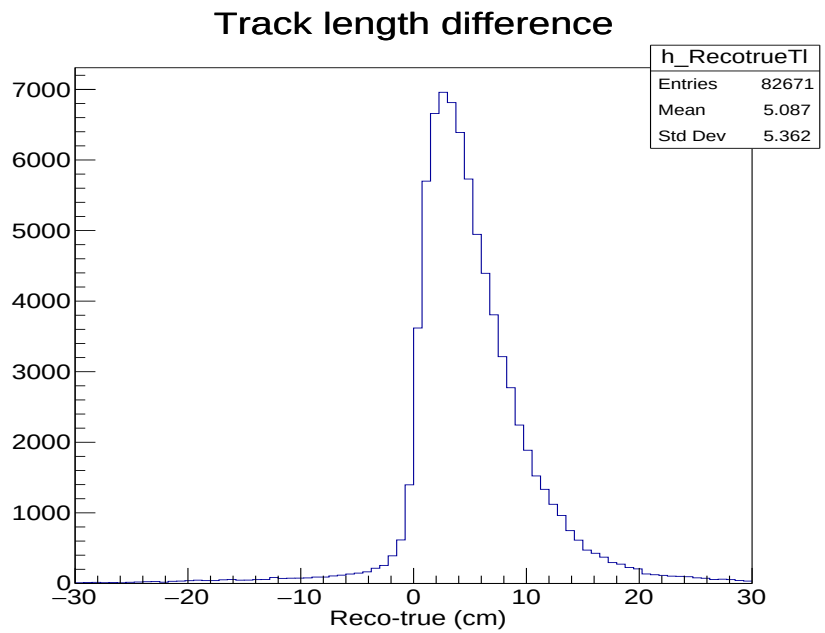
Outline

- Stopping muon events selection issue with MUSUN sample.
- dQ/dl analysis with short/small(5 m) reco tracklength.
- Reconstructed muon momentum resolution plot with dQ/dl.
- Future work.
- It will be a follow-up talk from my previous presentation[1].

[1] Jaydip, FD Simulation and Reconstruction Bi-Weekly : ▸ Dec 14, 2020

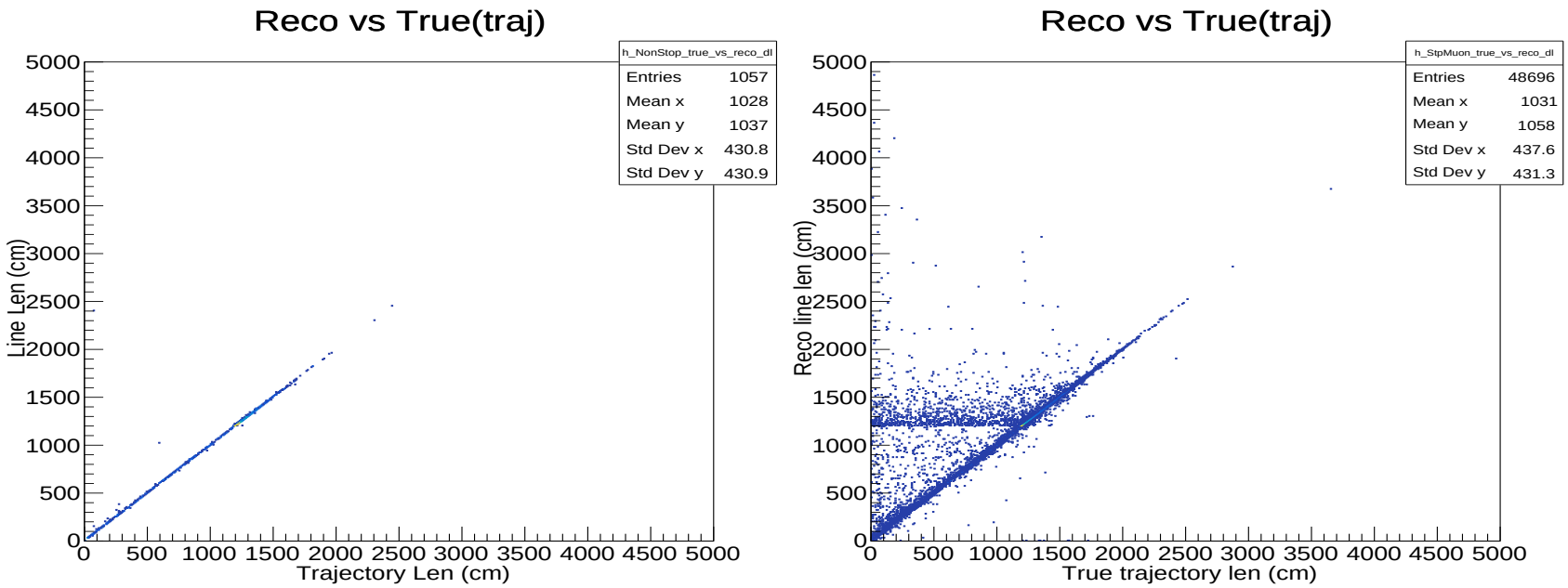
True and reconstructed track length





- Here true tracks length are estimated by adding up the trajectory point distances inside the LArTPC.
- For removing the stopping muon events, we consider only those events that have no space points inside spheres of radius 5 cm, centered at estimated exit points.
- Exit points are estimated with respect to the active volume.

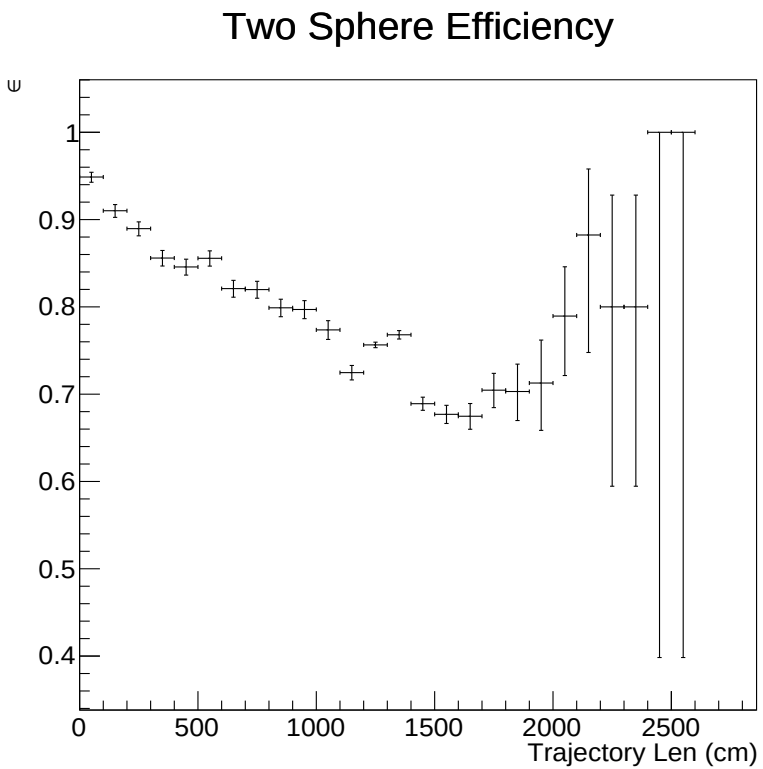
Stopping muons sample



- Left panel shows the track lengths by removing the stopping muons events from the sample.
- Right panel shows the candidate stopping muon tracks removed from whole sample.

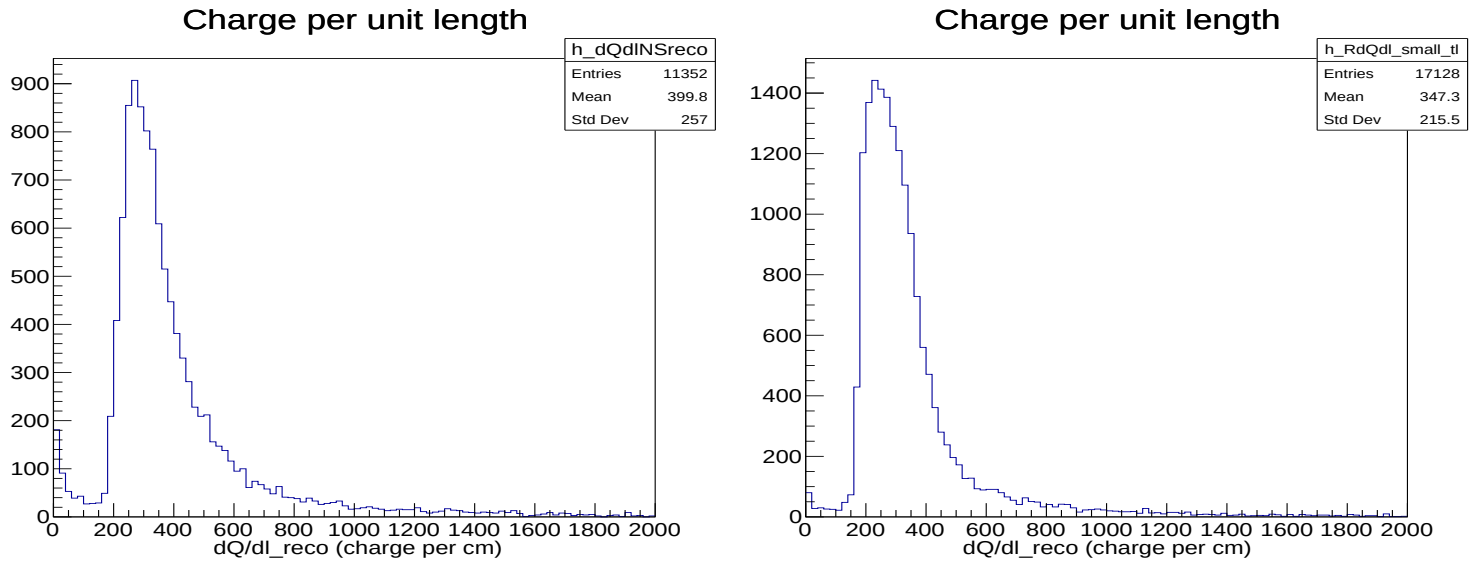
Two sphere cut algorithm efficiency

- This presented efficiency plot estimted by taking the ratio of true tracks with cuts, (abs($reco_{len}$ - $true_{len}$) < 10) and passes by applying the 5 cm sphere cut on reconstructed tracks.
- This is the efficiency of your two-spheres cut as a function of the true track length.
- Still working on to improve the two sphere algorithem for seleting the stopping muons events that will be used for calibration[2].



[2]David, DUNE Calibration WG : ▸ Feb 19, 2021

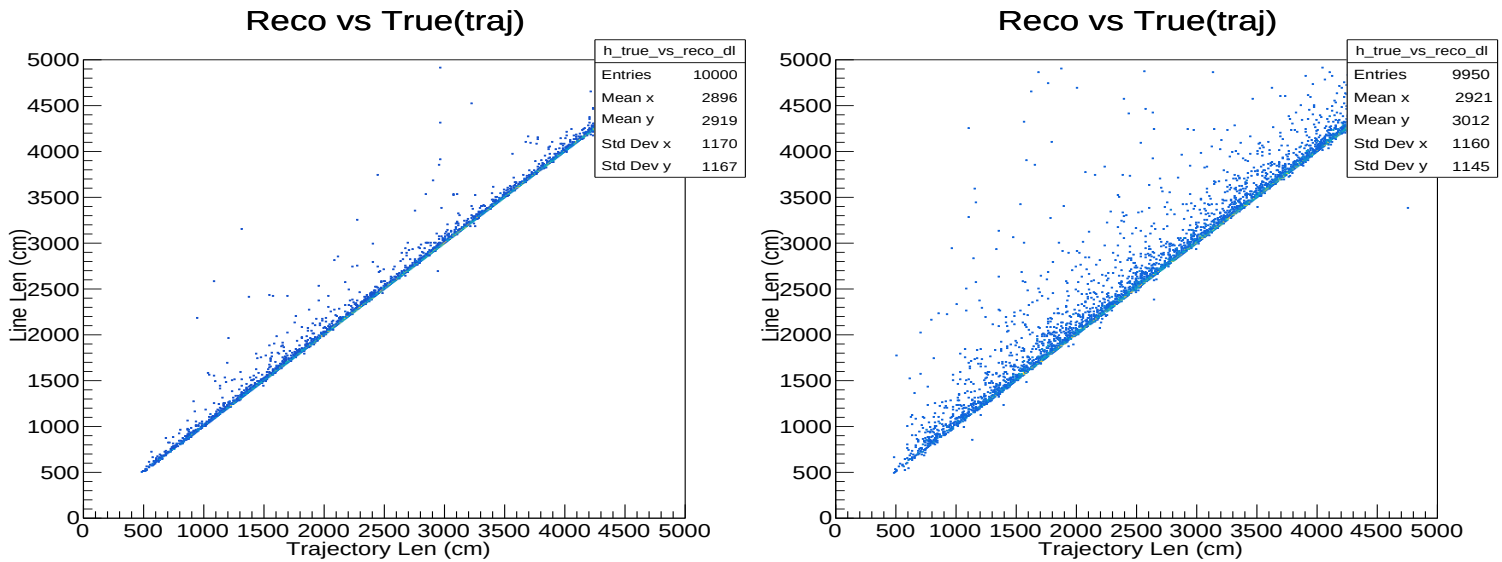
dQ/dl with non-stopping muons track segments.



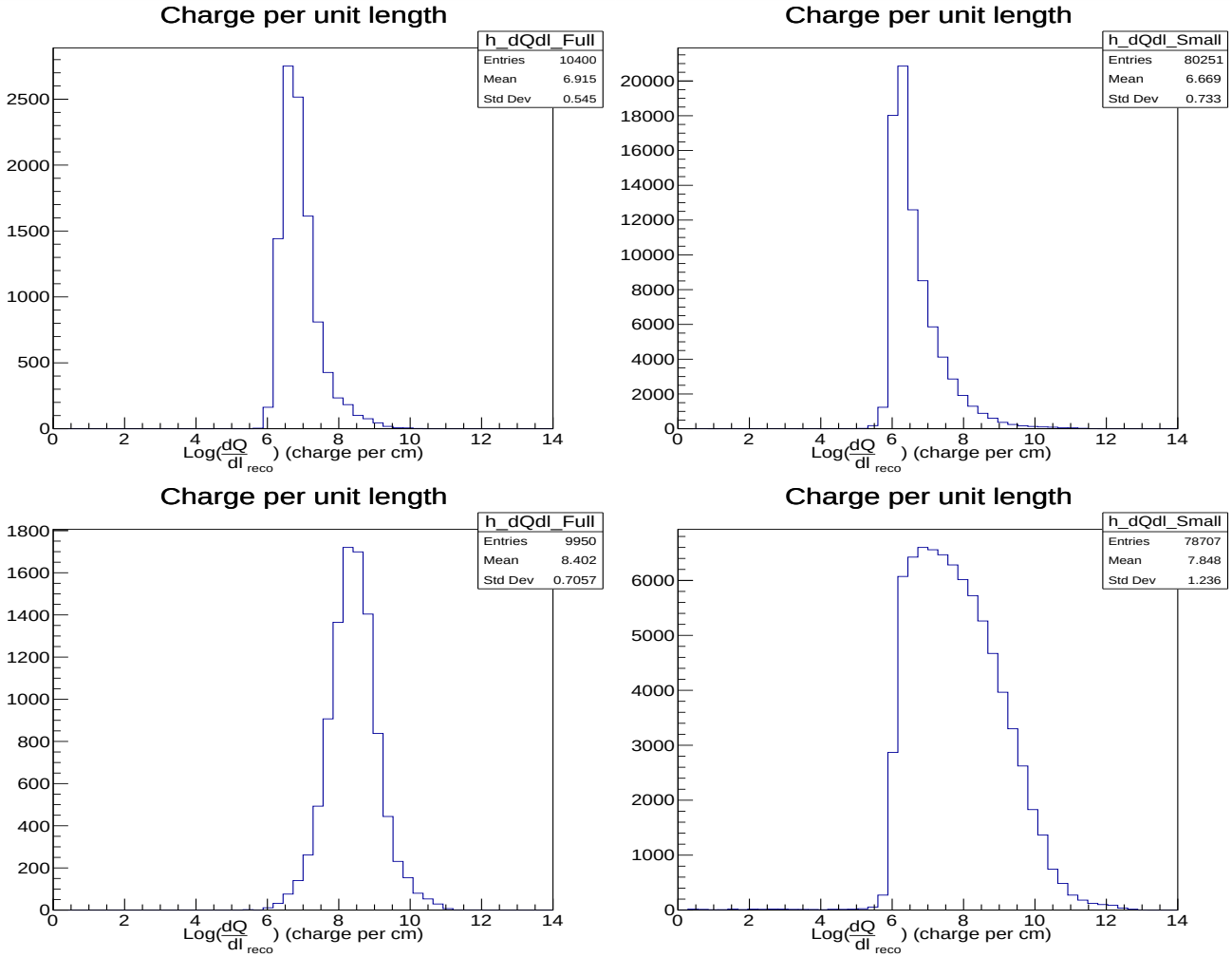
- Left panel shows the charges(recob::Hit::Integral()) per unit length for full track length and right panel shows for short track segments (L = 5m).

Analysis with monoenergetic MC sample

- Mono energitic events are generated with the particle gun and muons are propagated along the horizontal direction.
- Angle are uniformly varies randomly from 1 to 11° ($\theta_{xz\&yz}$=6 ± 5).
- X and Y coordinates are also uniformly varied randomly from -500 to 500 cm while Z is kept fixed at 0.0.
- Presented reconstructed tracks length with 1 and 10 TeV (left and right panel) muons events are shown in the figure.

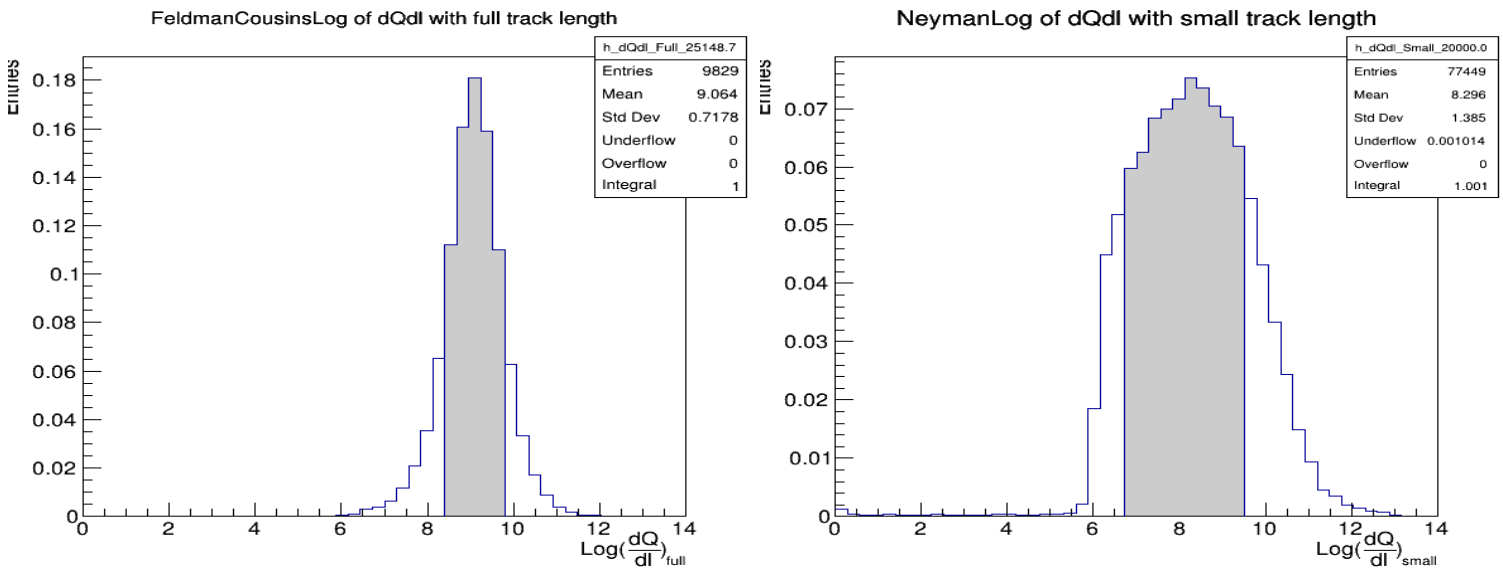


dQ/dl with 1 and 10 TeV muons track segments



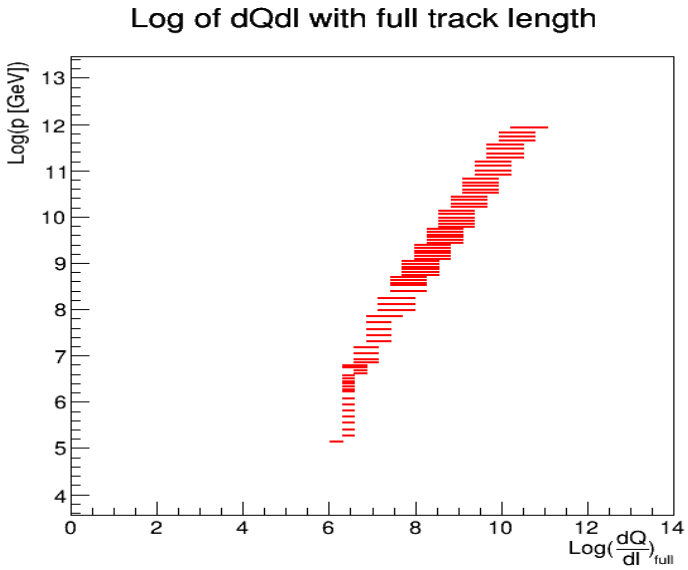
- Top left and right panel shows the dQ/dl distribution with full track and short track (L = 5m)respectively for 1 TeV muons and the bottom panel shows for 10 TeV muons events.

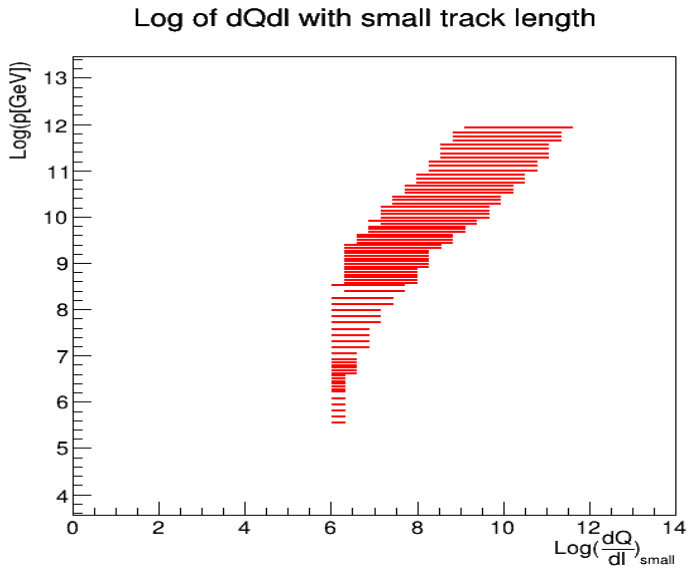
Confidence interval for dQ/dl



- Here left and right panel shows the dQ/dl distribution for 10 TeV muon events with confidence intervals (68.3%) for full track and short track (L = 5m) respectively.

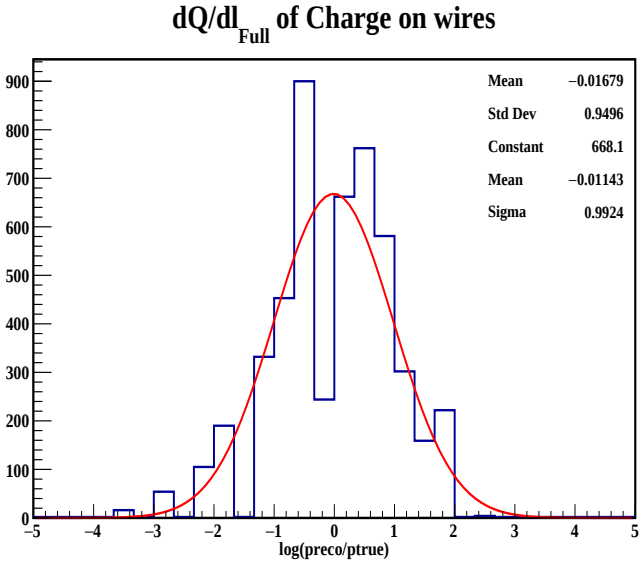
Neyman plot for dQ/dl with muons track segments

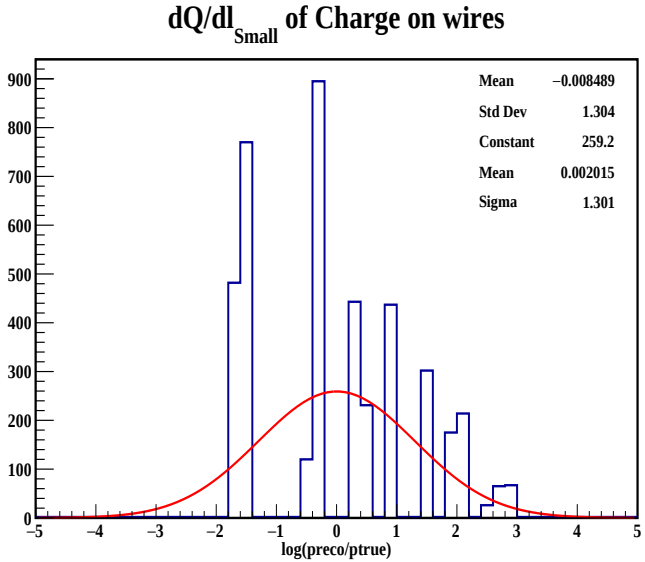




- Here left and right panel shows the Neyman plot for dQ/dl distribution for full track and short track (L = 5m) respectively.
- The confidence belt is constructed by combining all the confidence intervals of the histograms at all the energies (100GeV to 50000GeV).

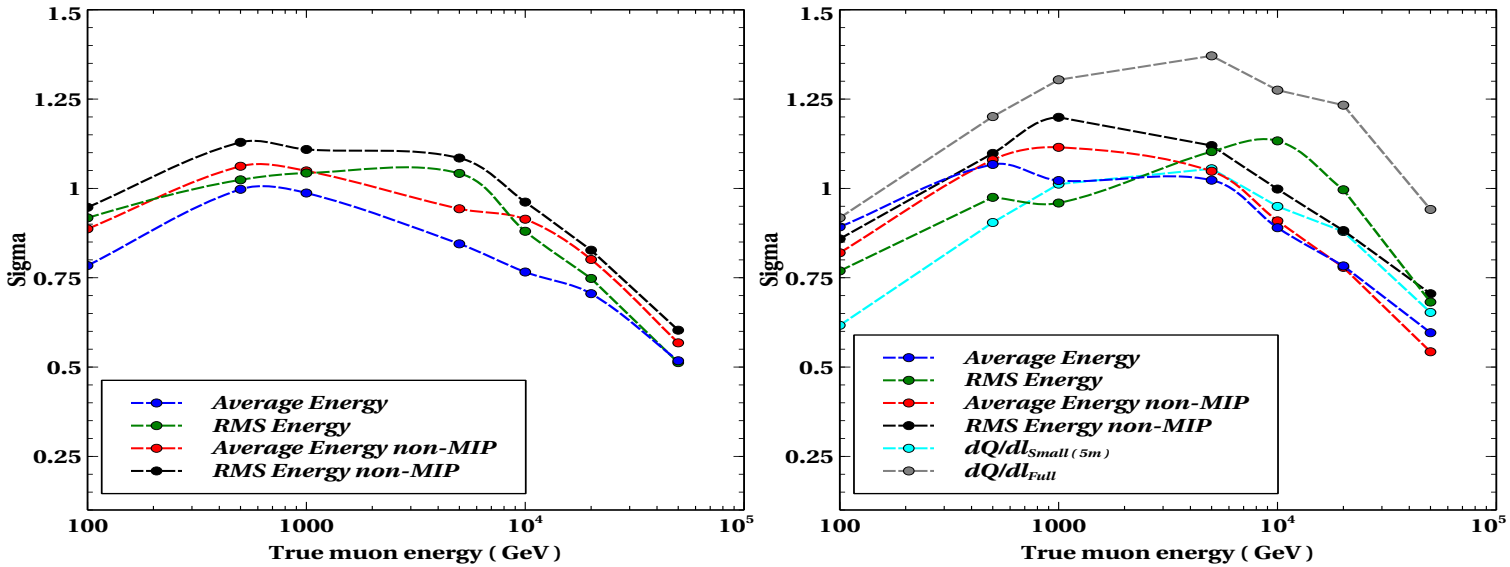
Reconstructed momentum resolution for with dQ/dl





- Left panel shows the resolution with full track length and right panel shows the resolution with short track segments (L = 5m) for 10 TeV muon events.

Reconstructed momentum resolution



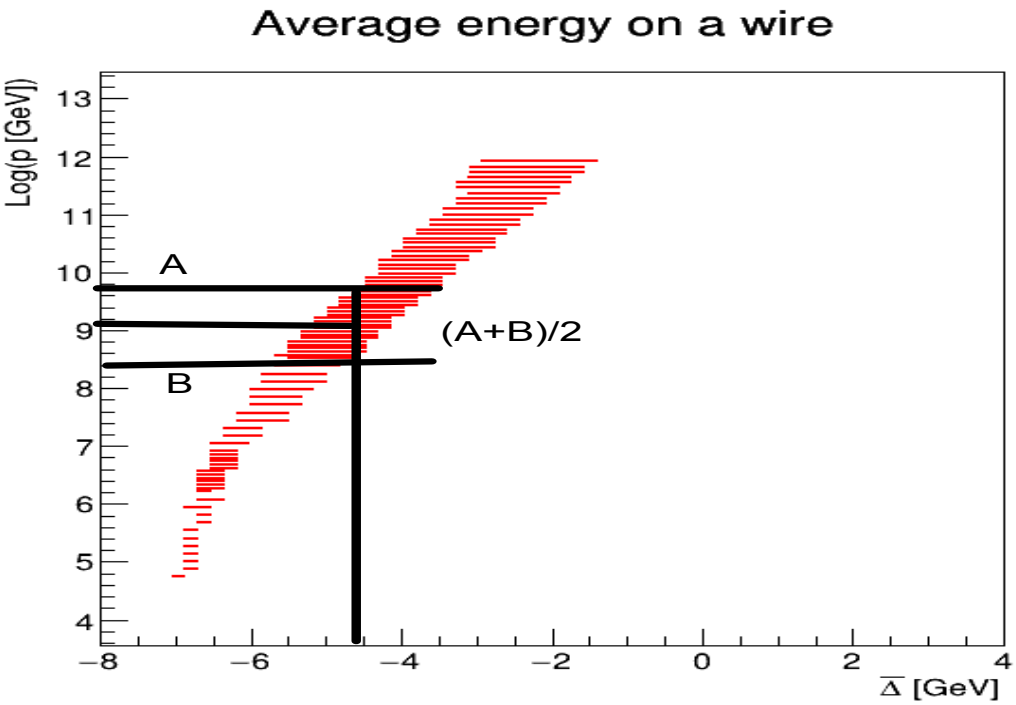
- Left panel shows the resolution plots as a function of true muon momentum for the list of parameters presented in previous meeting[3].
- Right panel shows the resolution plots with the previous list of parameters as well with the dQ/dl estimated with new MC sample.

[3] Jaydip, FD Simulation and Reconstruction Bi-Weekly : ▸ Dec 14, 2020

Future work

- Reconstructed muon momentum resolution analysis for unidirectional events with the reconstructed variables dQ/dl and truncated dQ/dl.
- Test the algorithm with the cosmic muons events available in protoDUNE data.
- Improve the stopping muons algorithm and perform the calibration work with the MUSUN sample.
- Differentiating upward-going muons from downward-going muons using shower shapes.
- Systematic uncertainty evaluation. (muon radiation modeling, electronics saturation, recombination modeling in dense showers and electron lifetime).

Backup



- preco = exp((A+B)/2).
- Where A is the top of the confidence region in log(p) for a particular muon, and B is the bottom of the confidence region in log(p) for the same muon.
- The suggested value is in the center of the interval.