Pion cross-section studies using reweighting techniques

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Thanks to Tingjun for suggestions and feedback.

Outline:

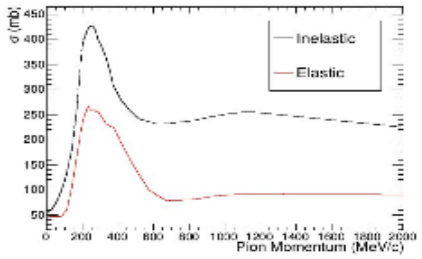
- We are comparing a few data-Monte-Carlo observables, eventually to calculate the pion cross-section in Argon.
- Geant4 reweighting framework
- Removing muons from pion sample
- Removing daughter protons reconstructed as primary particles
- Summary

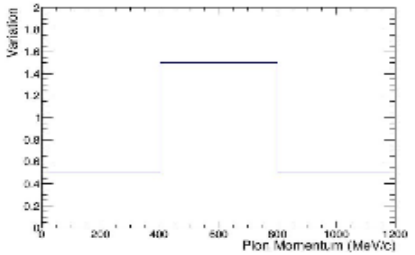
Very brief introduction to Geant4Reweight

Jake Calcutt

What is Geant4Reweight?

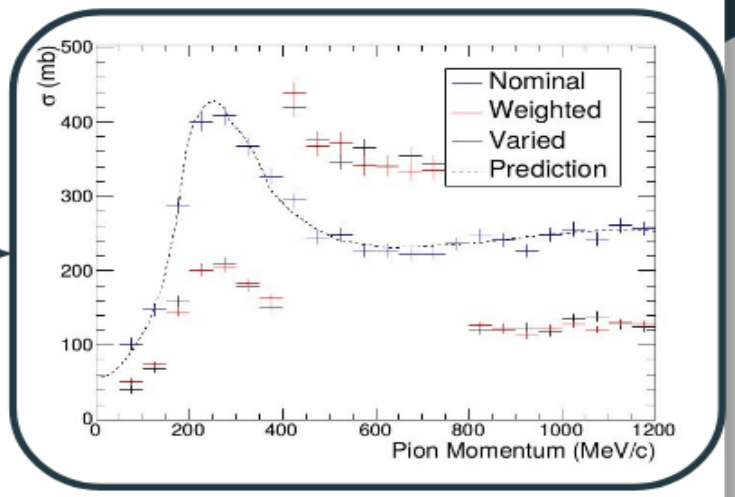
Software that produces weights for simulated particle tracks from Geant4





Geant4Reweight

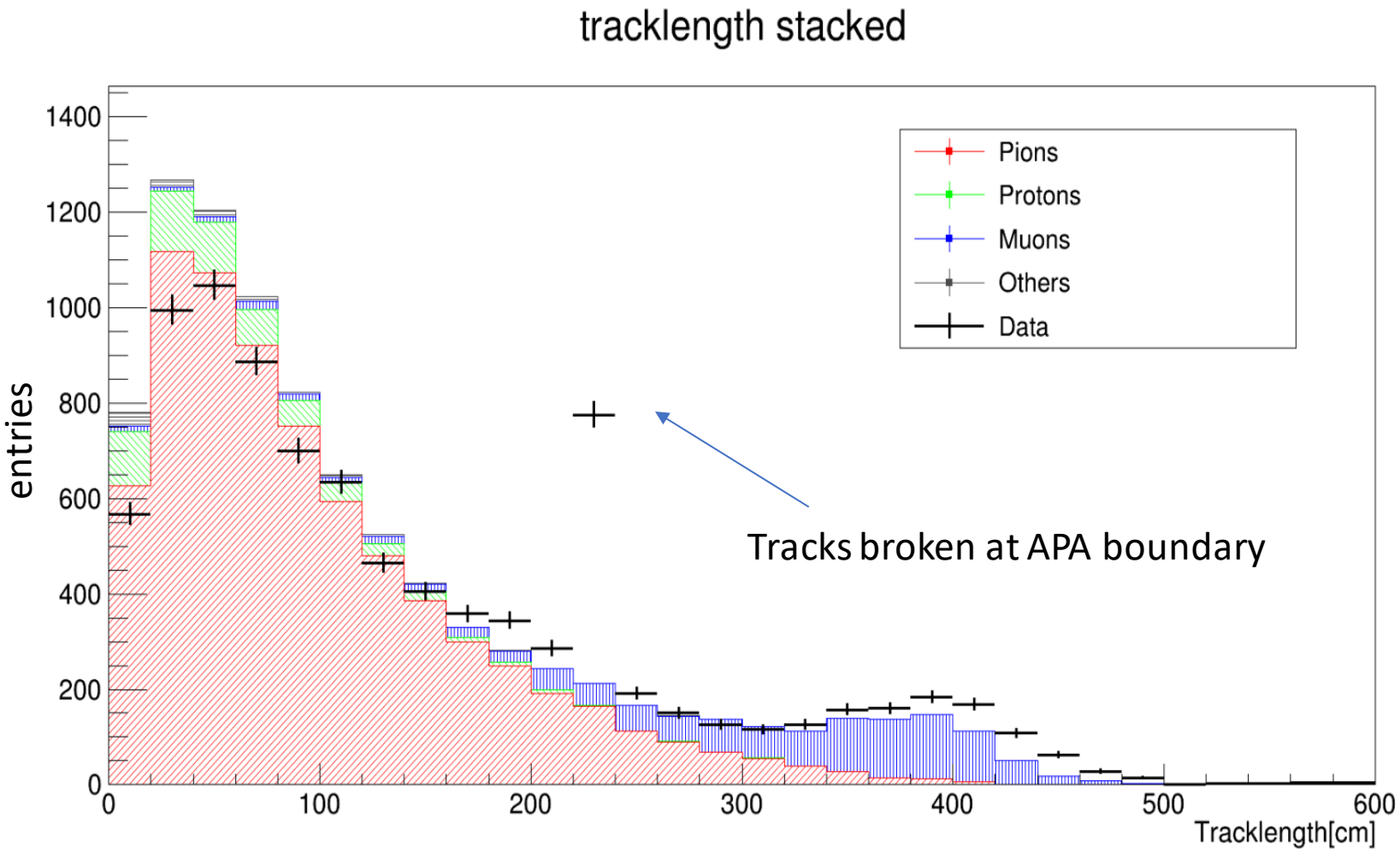
Simulated Tracks



Weighted observables

7

Data MC tracklength comparison

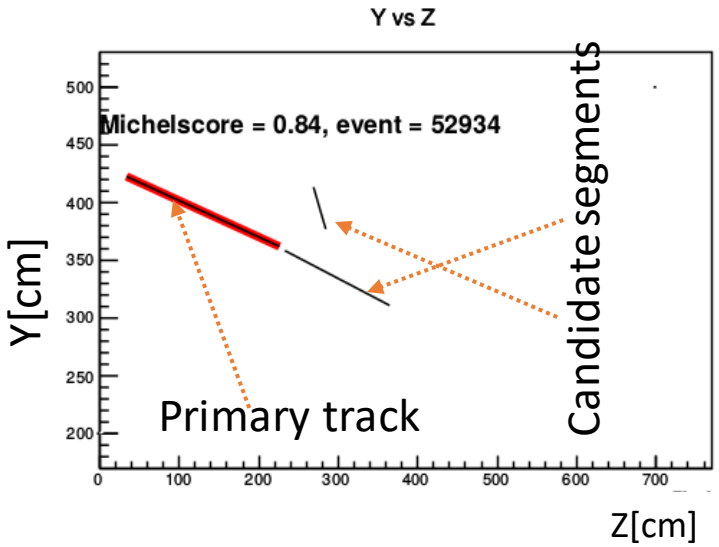


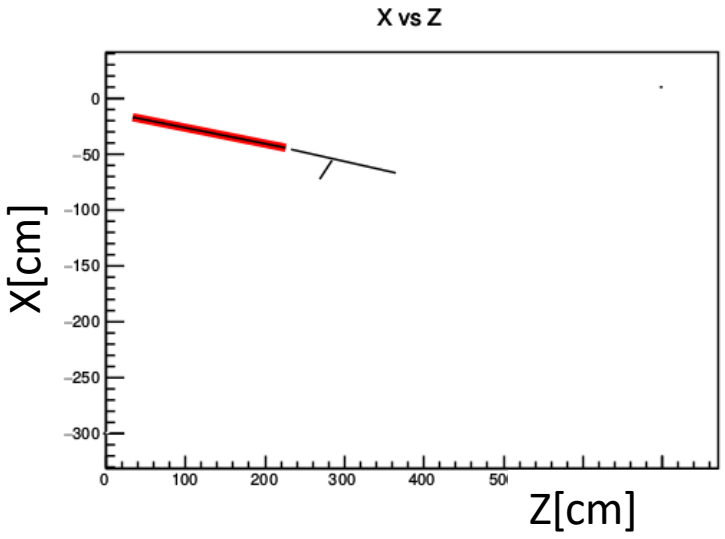
MC entries normalized to match DATA entries

- **Possibly more muons in DATA than in MC.**
- **Unequal fraction of muons in data-MC will impact the normalisation. We are trying to remove the muons before normalising data-MC distributions.**
- **Lots of broken tracks in data around APA boundary. Tried to stitch broken tracks before removing muons.**

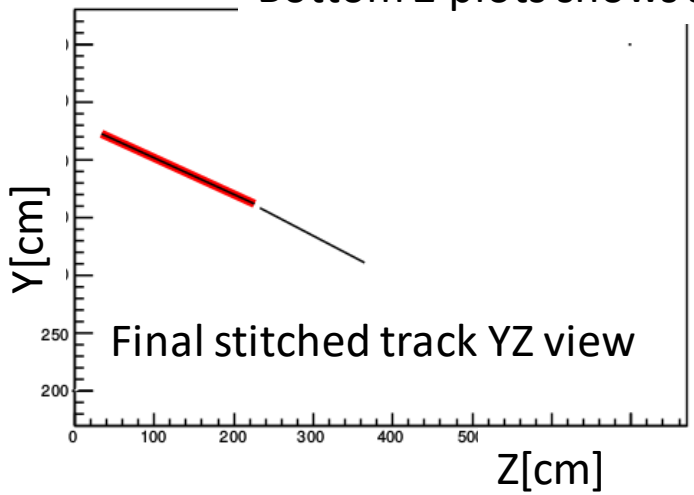
Stitching broken tracks:

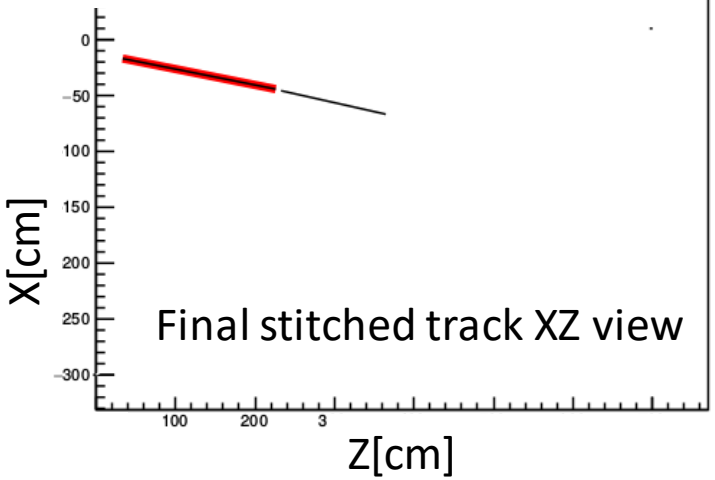
Top 2 Plots shows selected track segments before stitching





Bottom 2 plots shows selected track segments after stitching



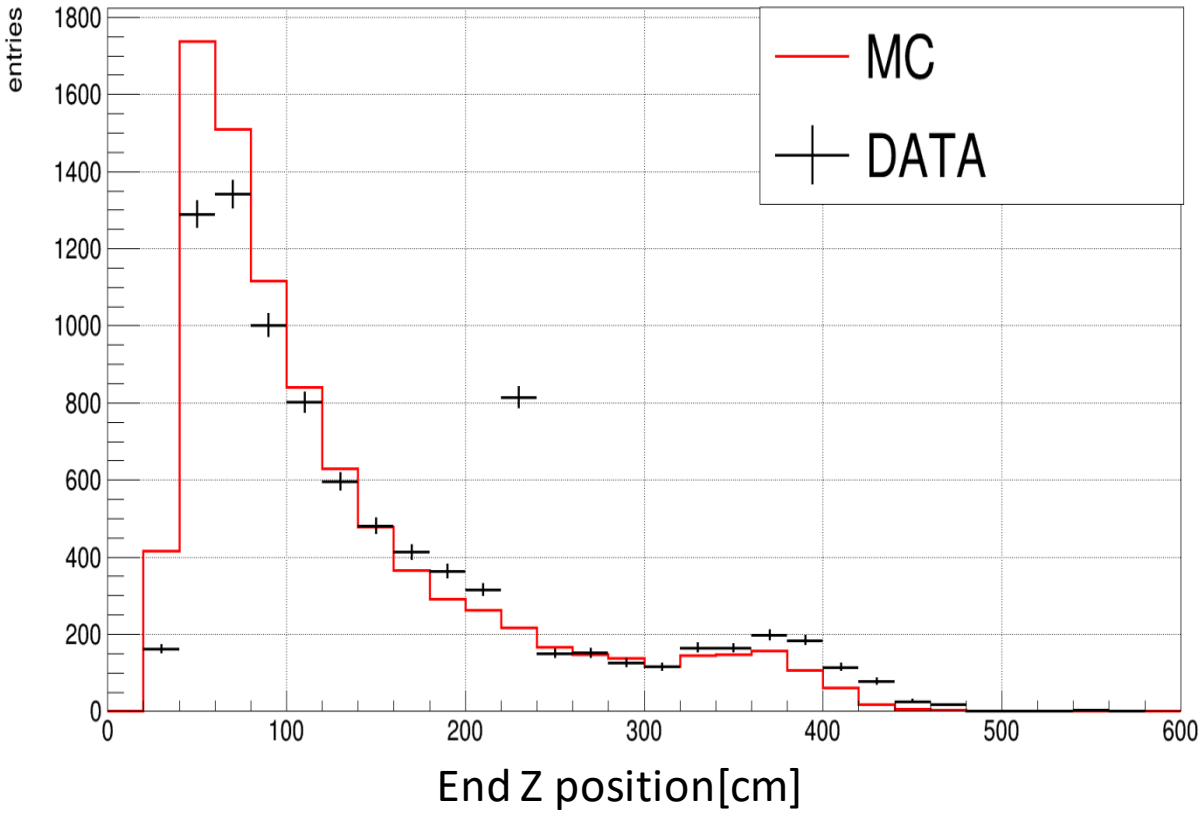


Select track segments in an event with -200<StartX (EndX)<0 and 200<StartY(EndY)<500 and tracklength>10cm.

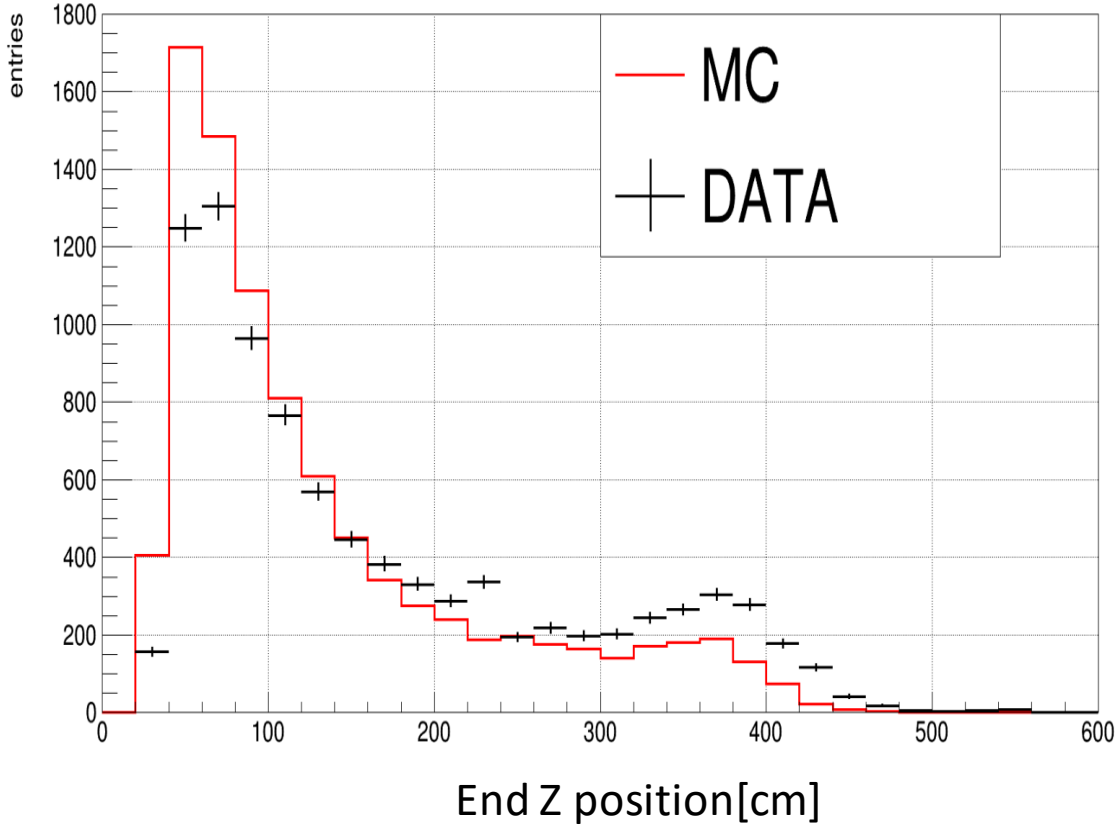
Look for track segment close to the end of the primary track (within 15cm) and making a small angle (less than 30deg) with the primary track.

Track stitching results (SCE correction is not applied)

End Z position before stitching



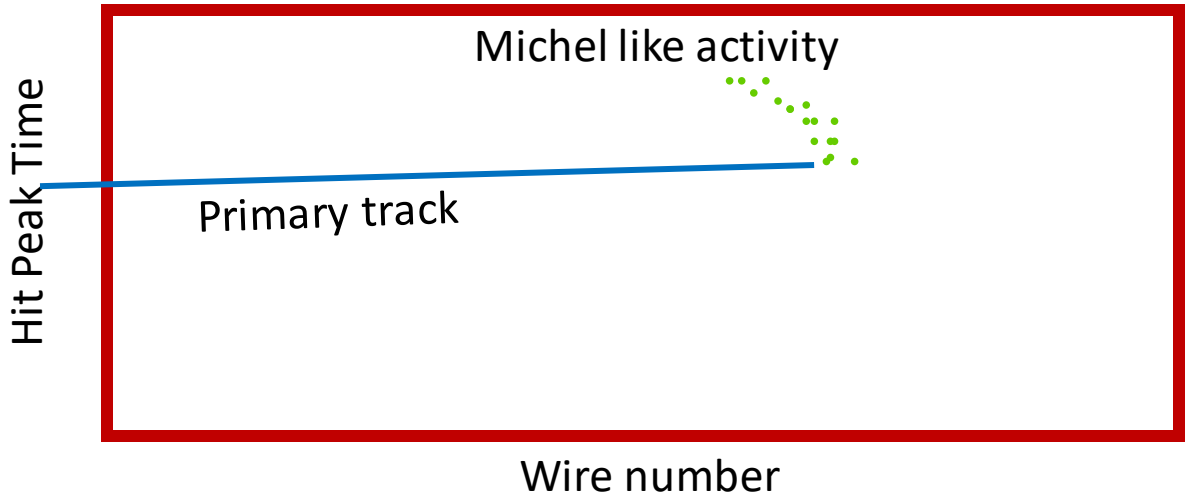
End Z position after stitching



Common mode of failure for stitching:

- If the second segment across the APA is <10 cm.
- In some cases there was no track segment in the second TPC, however there are hits that looks like part of the track.

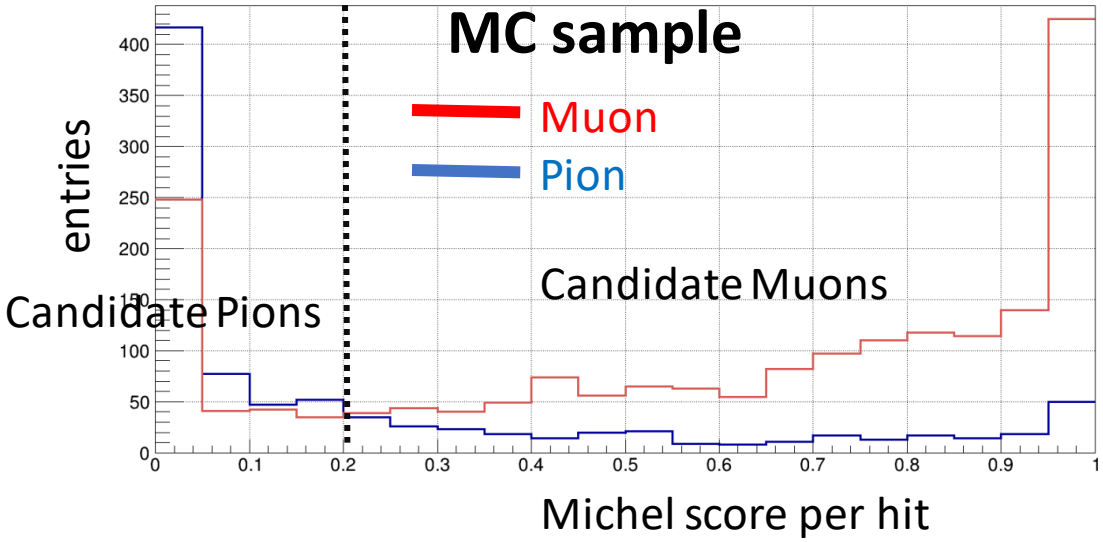
Muon tagging (We are using CNN based **Michel score** for the hits to identify muons, which was developed by Aidan):



Muon decay into Michel electron

$$\mu^+ \longrightarrow e^+ + \nu_e + \bar{\nu}_\mu$$

- Look for hits close to end of the track (within +/-20 wires and +/-50 micro-sec) and not belonging to the primary track or any other long track.
- Calculate the average Michel score for those hits.



I considered tracks with (Michelscore per hit>0.2 and endZ>240) as muon candidates, and removed them.

For Z>240cm:

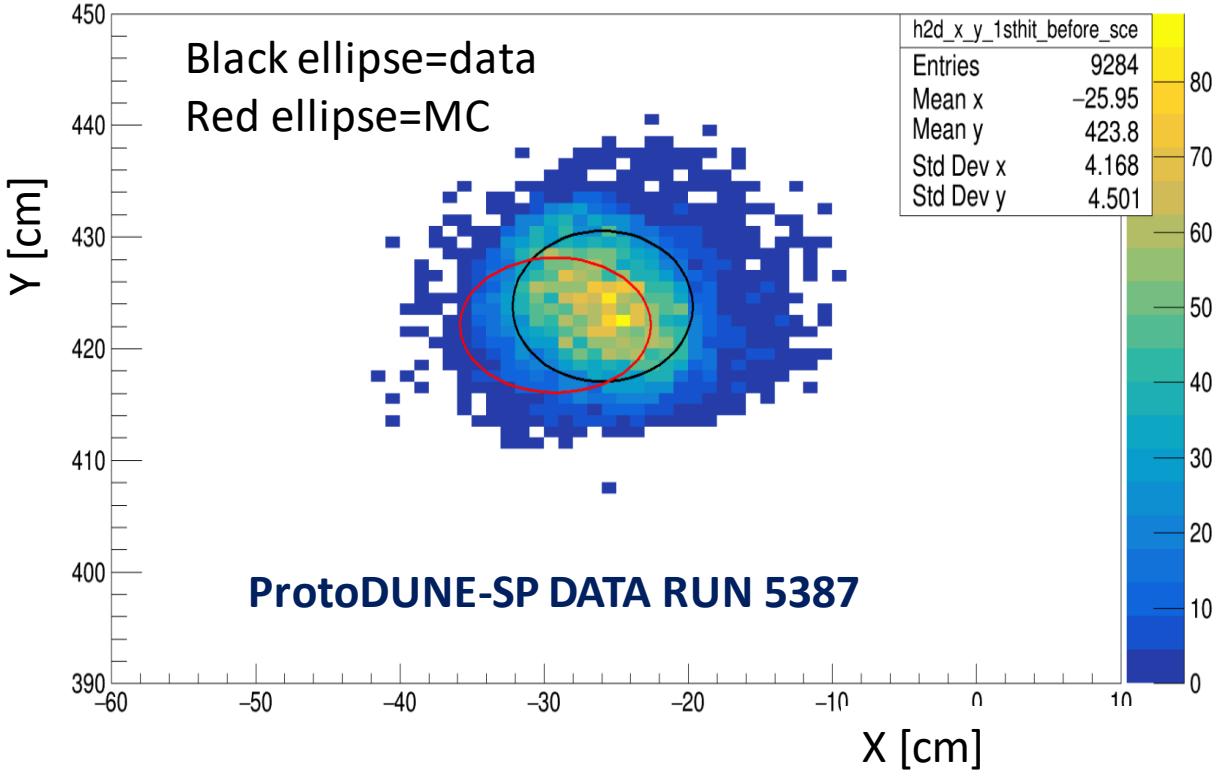
Before removing candidate muons: Pion=893 and Muon=1583

After removing candidate muons: Pion=631 and Muon =361

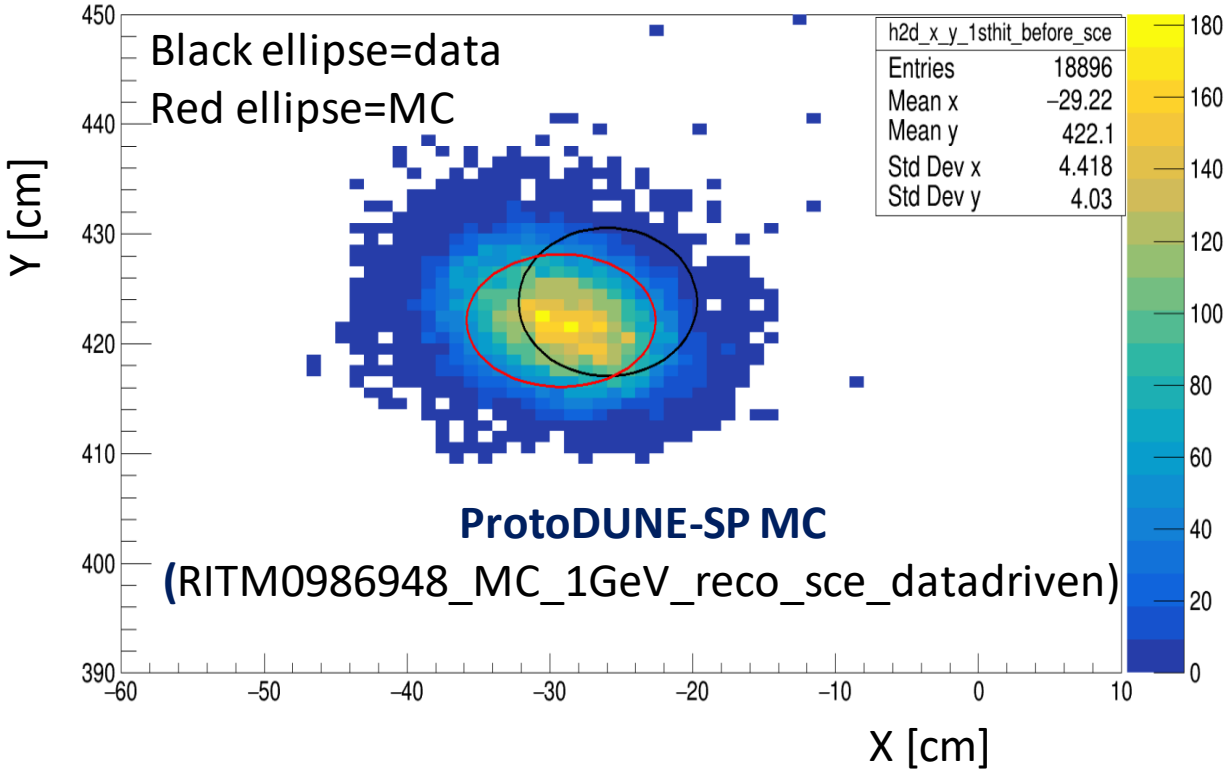
Michel score cut removes, 77.2 % of muons and 29.3% pions

Looking at Beam angles for data and MC

Incident X, Y position for 1st hit inside the TPC



Incident X, Y position for 1st hit inside the TPC



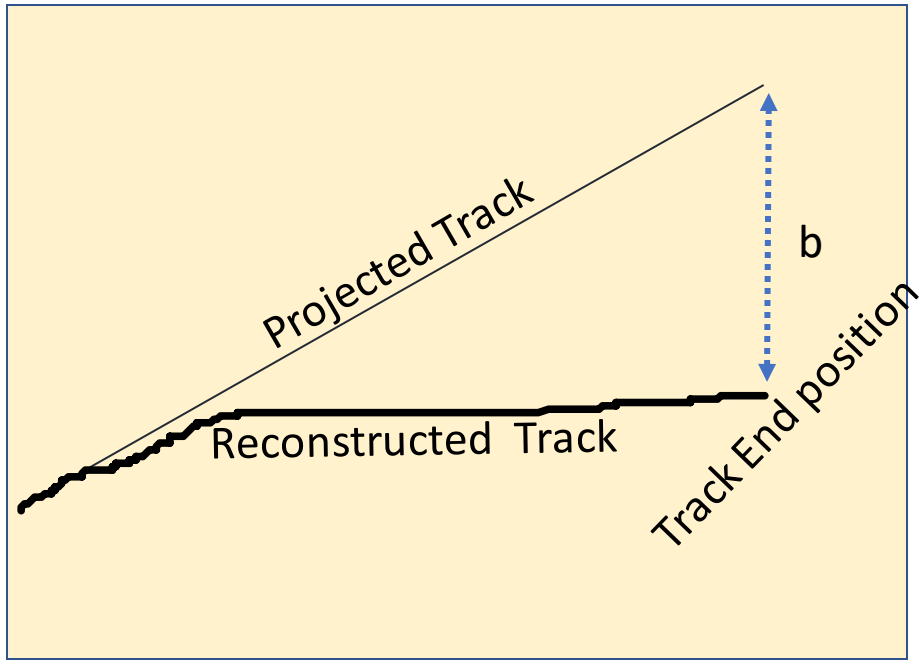
In all the subsequent studies I used only those tracks which lies inside both the ellipses.

Ellipses are centered at Mean X, Mean Y and radius =1.5 Std Dev X, 1.5 Std Dev Y

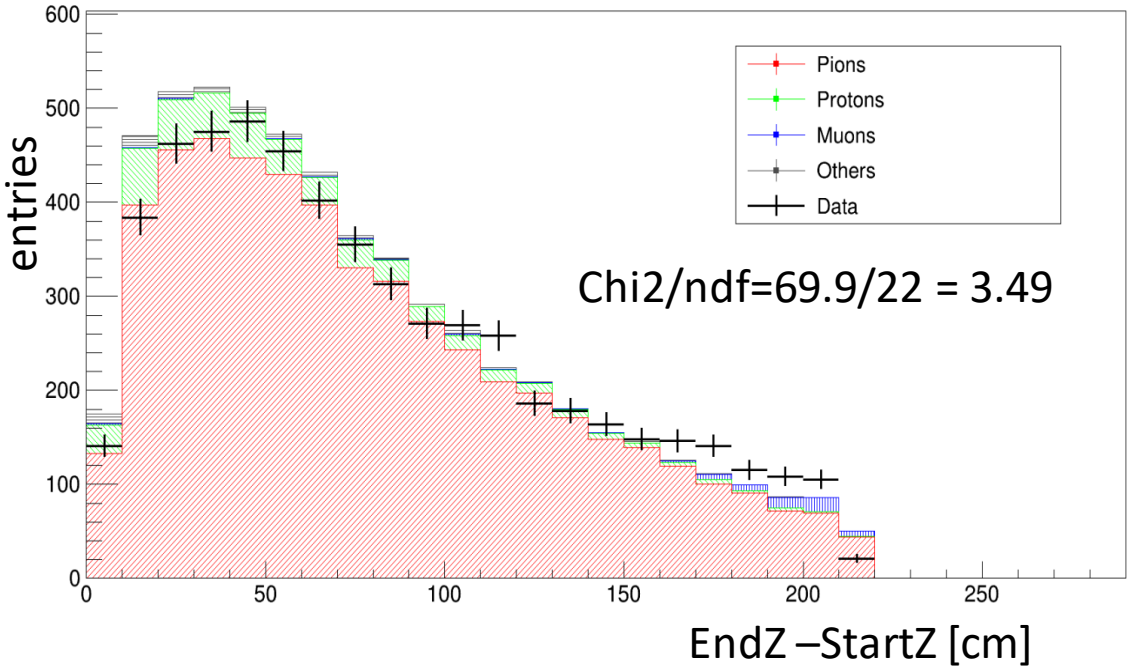
Here are some observables that are used for data-MC comparison:

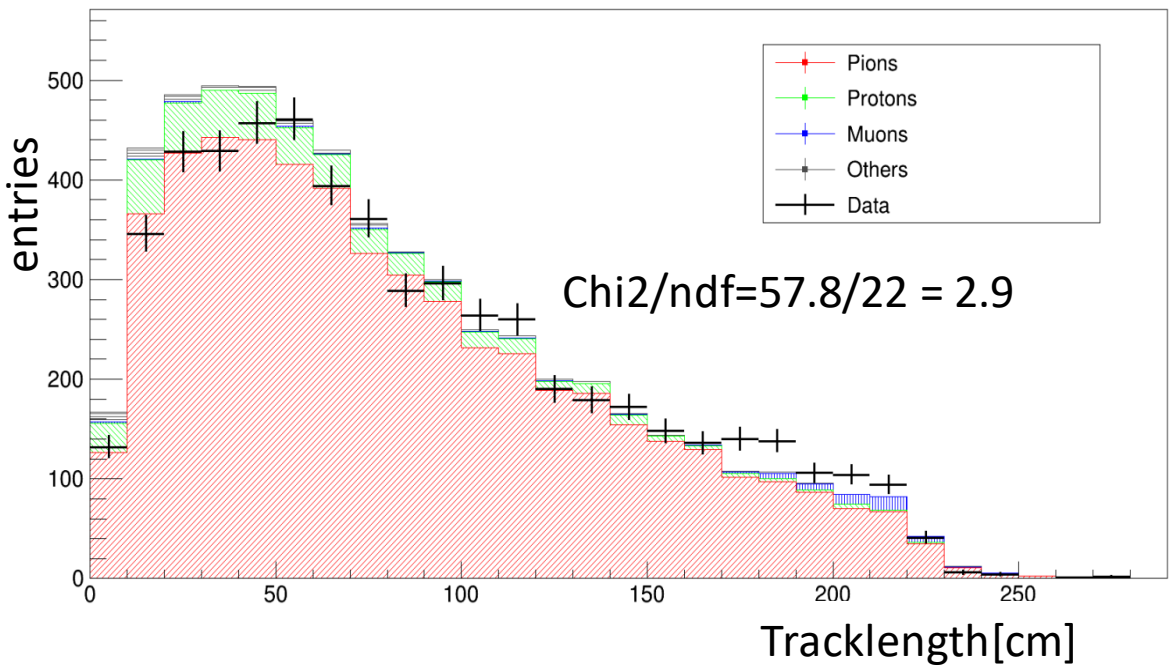
- Reconstructed track (EndZ –StartZ)
- Recostructed Tracklength
- Impact parameter (b), which is the 3D distance between track reco End point and projected point on the track (considering first few hits on the track) at z equal to reco trackendZ.
- dXYZ, which is the 3D distance between Start and end of the track

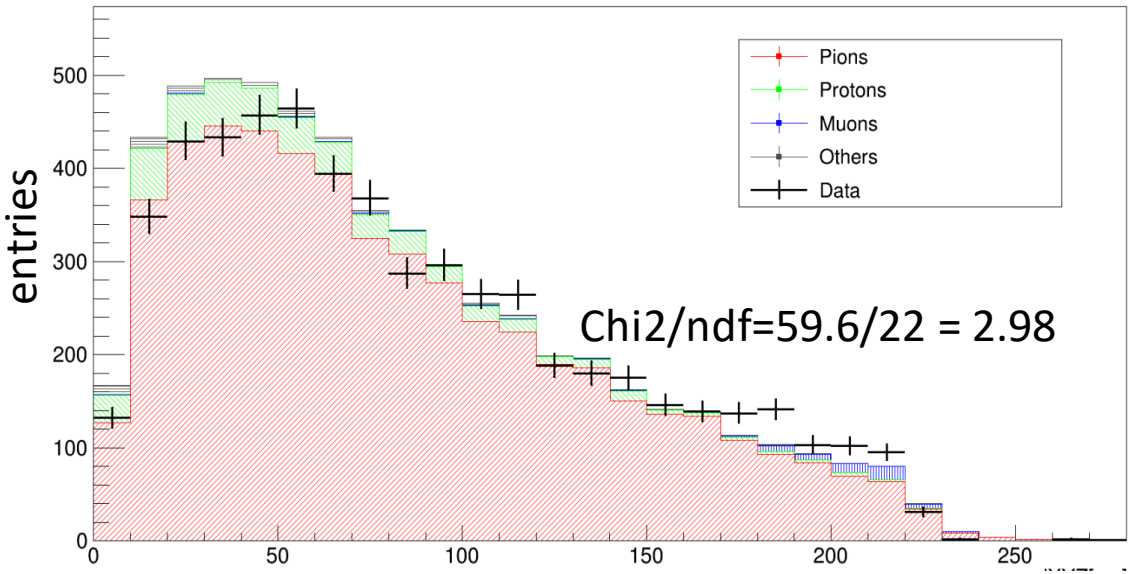
Impact parameter definition

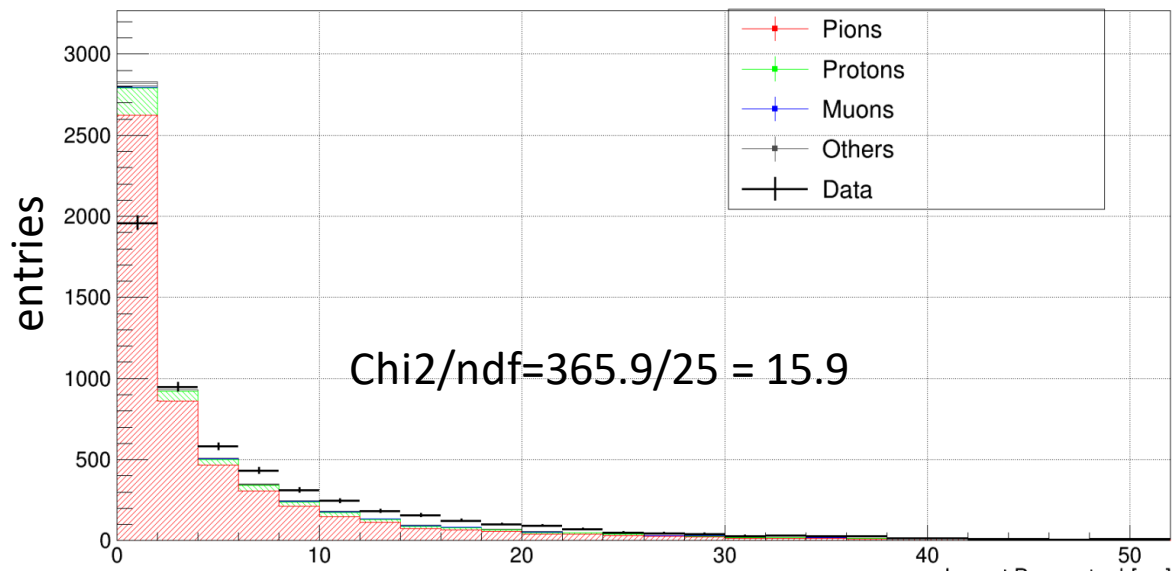


Comparing Observables for data run5387 and MC [after removing muons for Z>240]

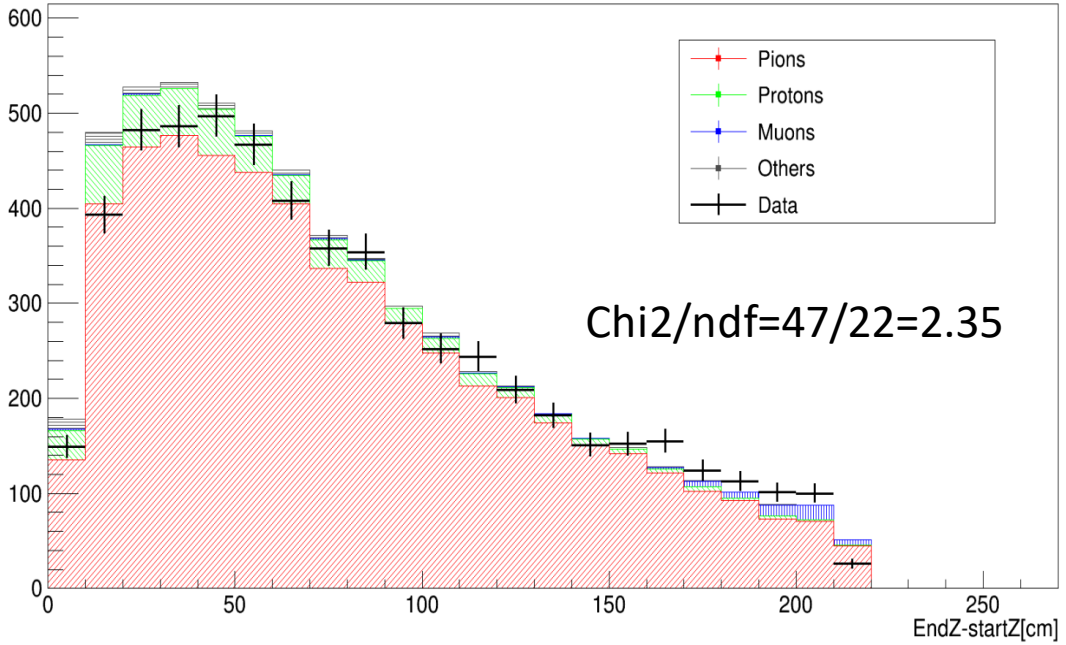


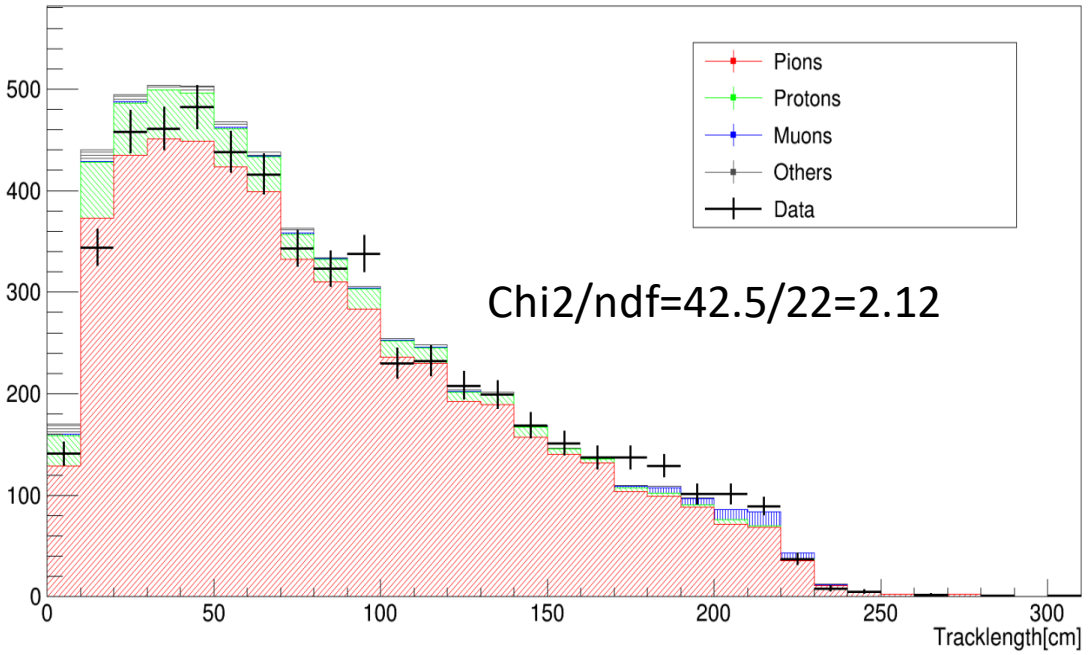


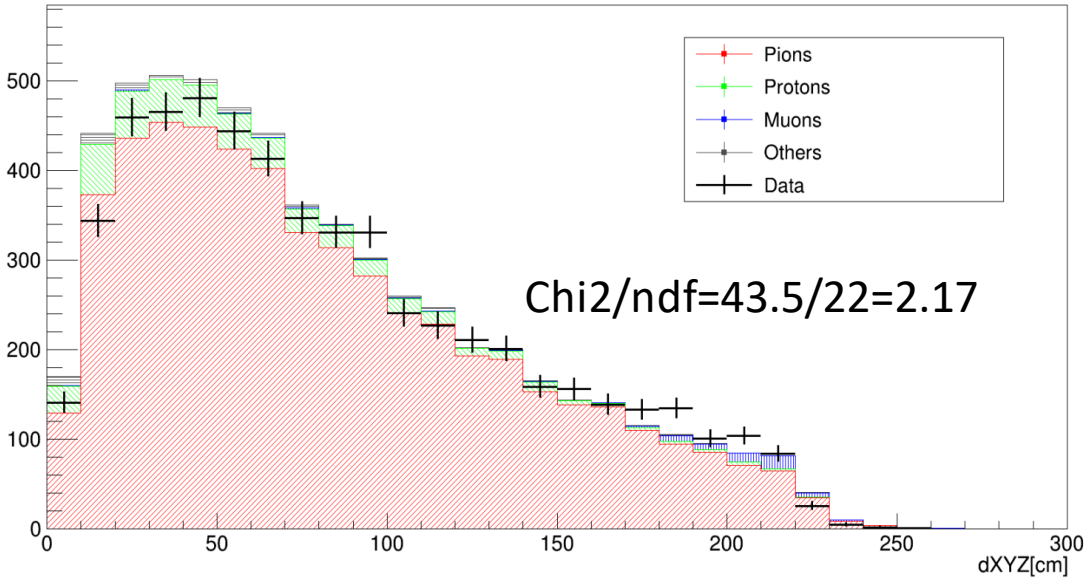


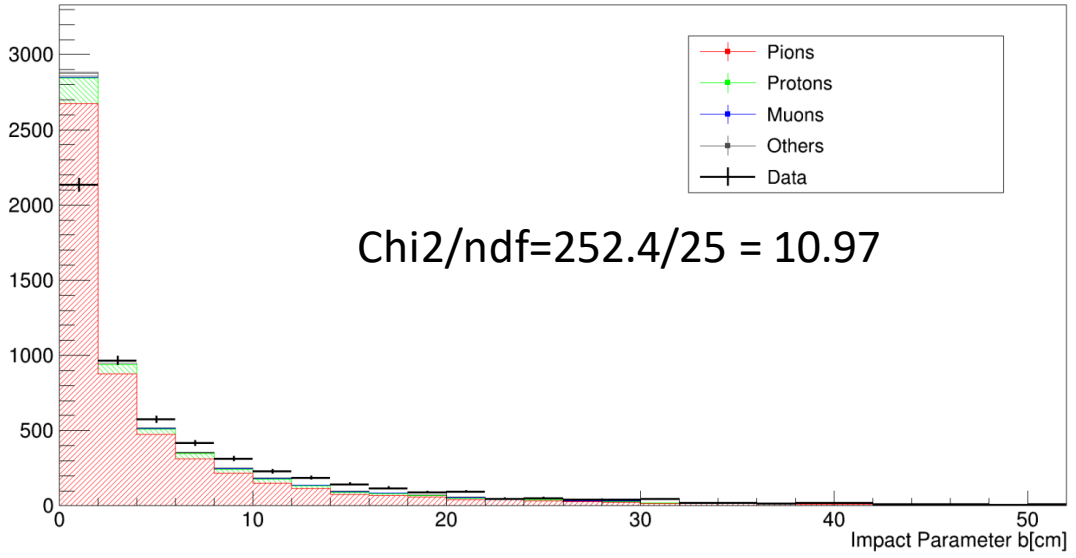


Looking at another 1GeV pion triggered run [5842, after removing muons for Z>240cm]:

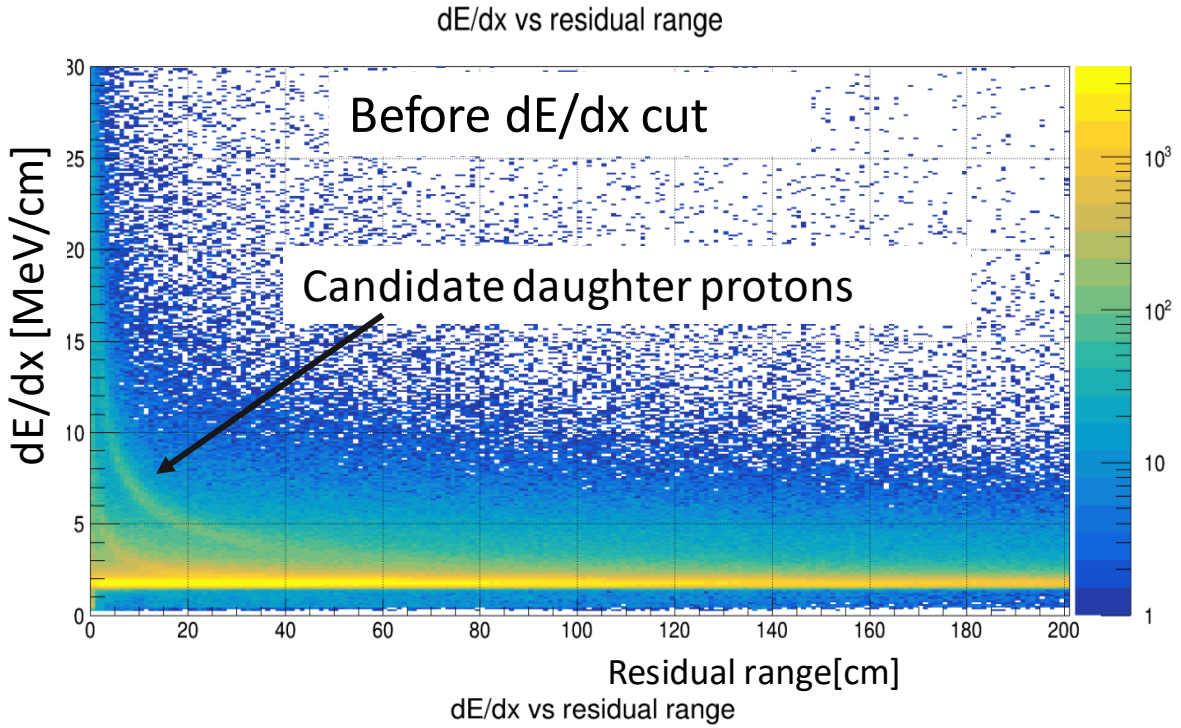


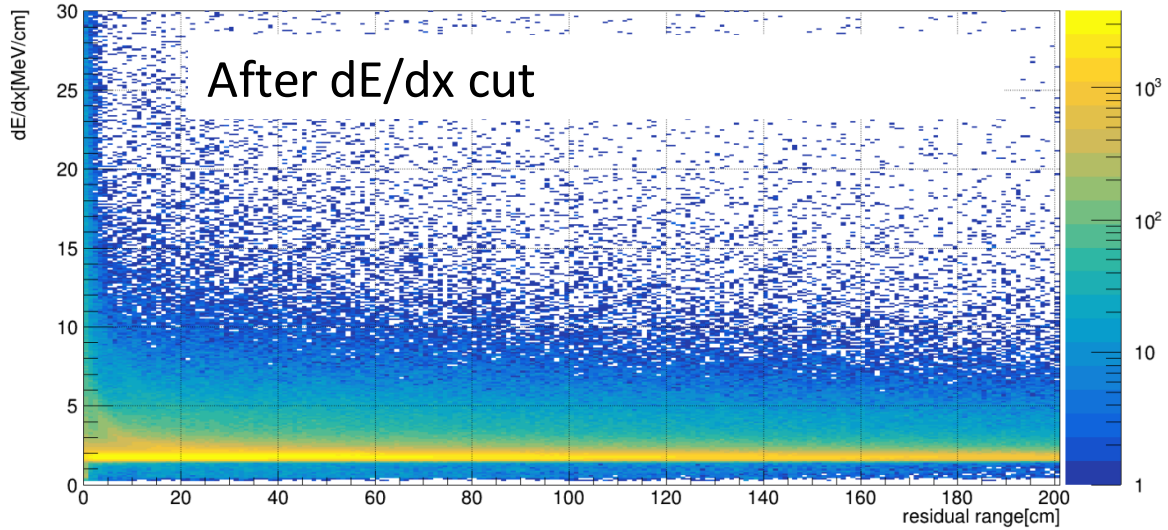


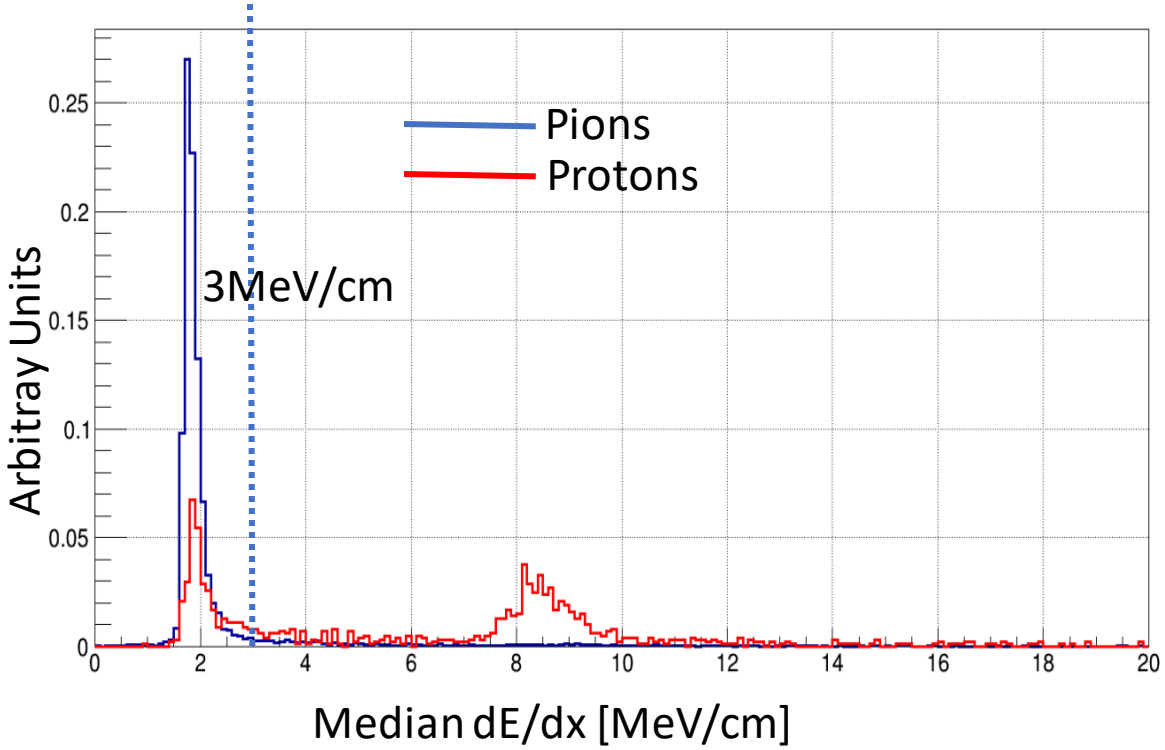




Removing secondary protons: MC plots

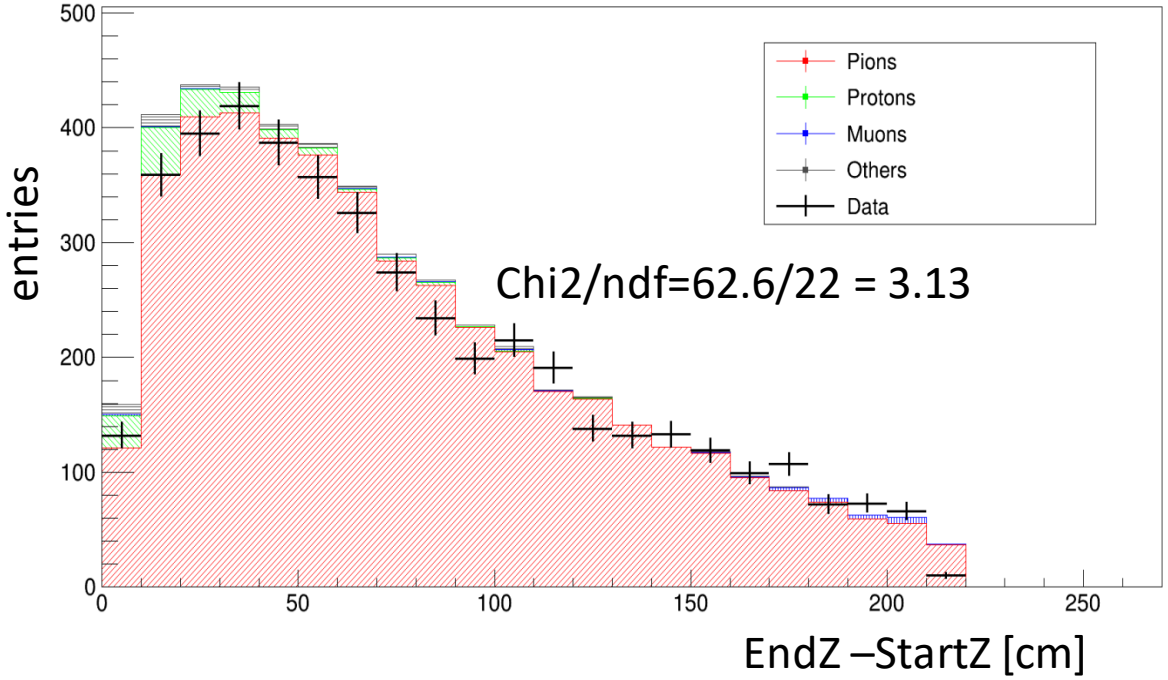


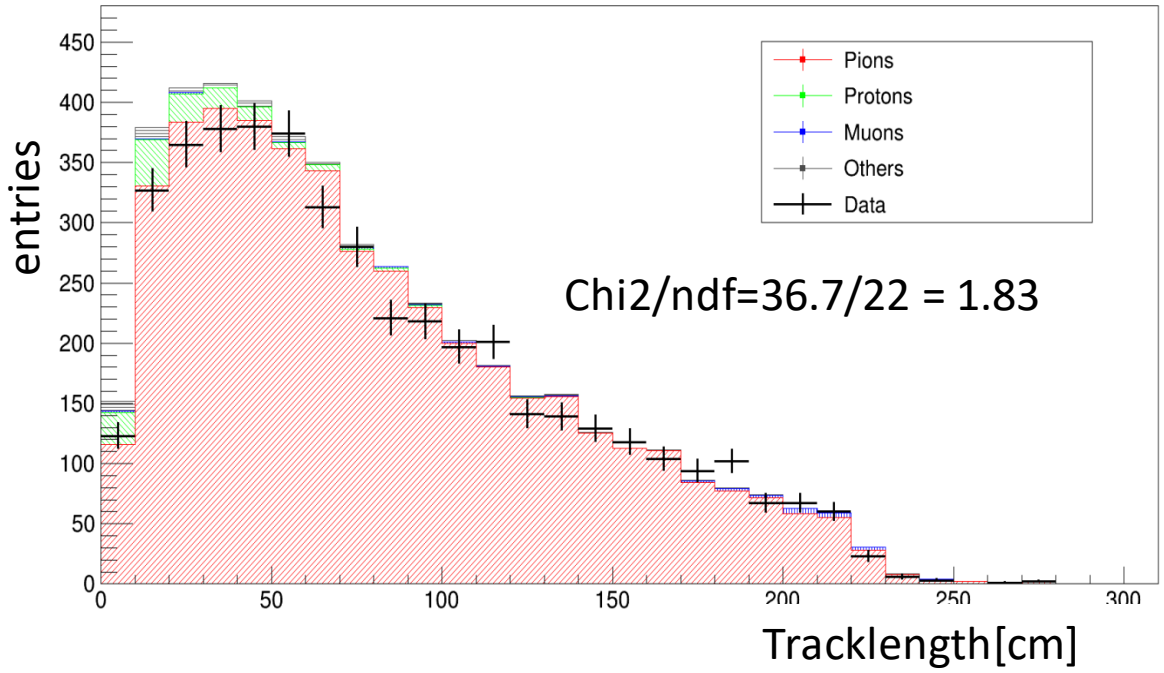


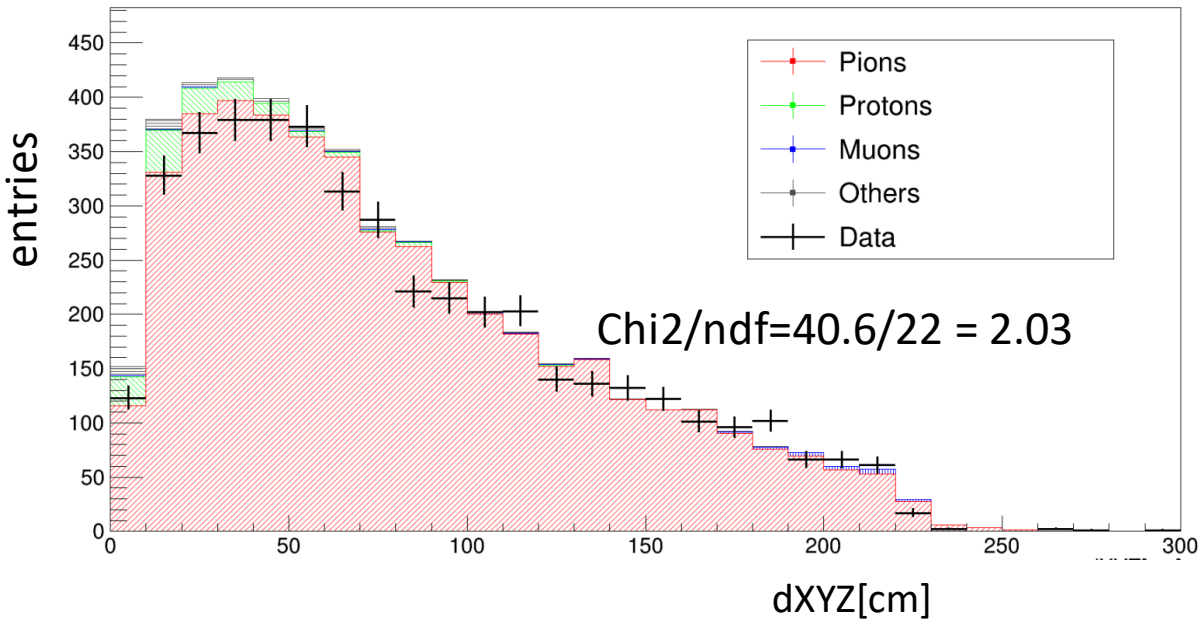


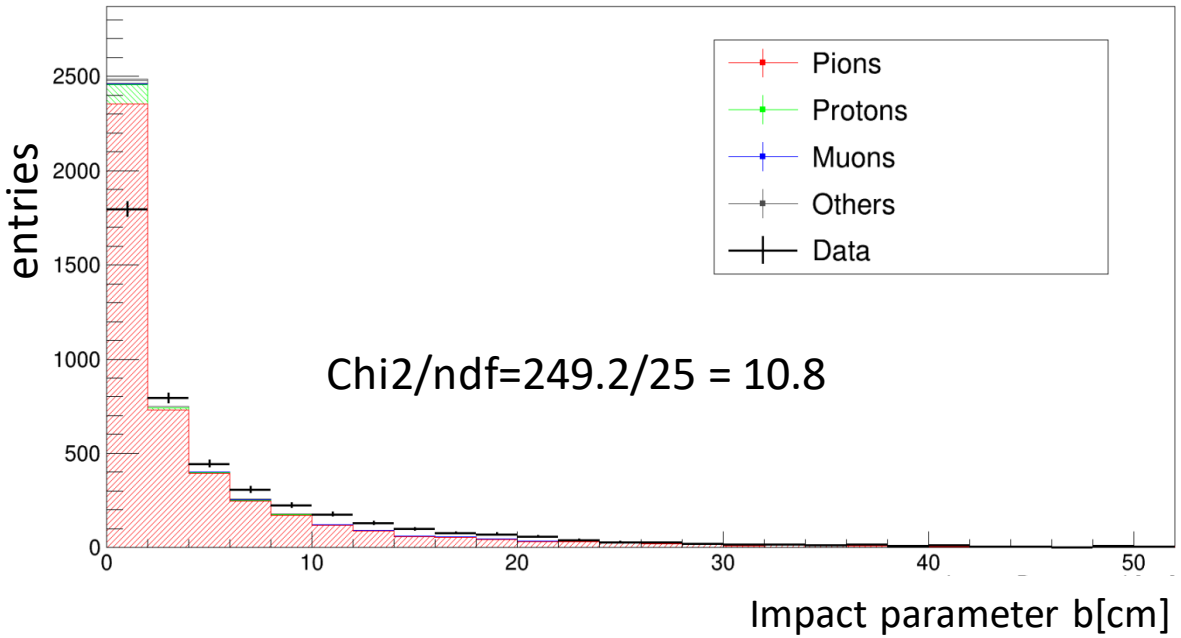
- If the daughter protons have been reconstructed as primary tracks, median dE/dx is higher than pion dE/dx.
- We remove tracks with median dedx>3MeV/cm.

Comparing Observables for data run5387 and MC [dE/dx cut to remove protons applied]









Summary:

Chi_square/ndf table

Observables	Run 5387 removing muons only	Run 5842 removing muons only	Rum 5387 after removing muons and protons
EndZ-startZ	69.9/22=3.49	47/22=2.35	62.6/22=3.13
Tracklength	57.8/22=2.9	42.5/22=2.12	36.7/22=1.83
dXYZ[3D distance between start and End]	59.6/22=2.98	43.5/22=2.17	40.6/22=2.03
Impact parameter[b]	365.9/25=15.9	252.4/25=10.97	249.2/25=10.8

Future plans:

- Studying data-MC momentum agreement/disagreement using muons.
- Varying cross-section using reweighting tool developed by Jake to extract cross-section.