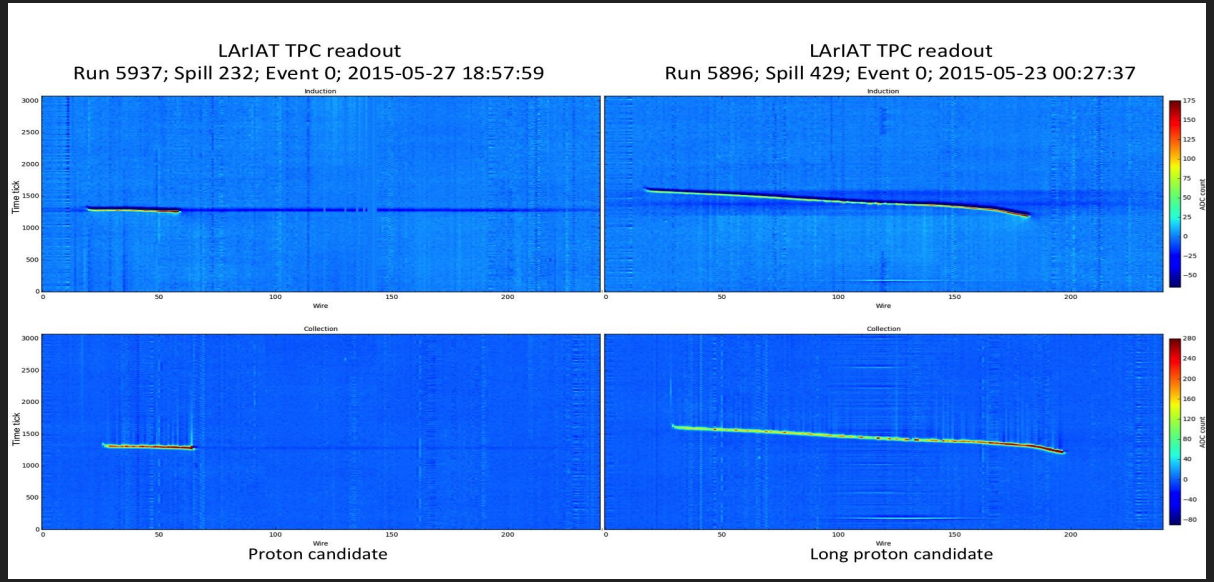
Proton XS Study

rb - LArIAT - UChicago

Proton Update Overview

- Broader picture of the analysis
- What I've been up to so far
- Short-term, mid-term, and long-term goals



Another cross section study!

- The overall strategy of this analysis aims to build off the Pion study underway while tuning for the specific nuances of the Protons
- Protons have a very clear signal so they are an extremely good candidate for not only such a study in general, but for evaluating of our techniques
    - e.g. playing with reconstruction parameters like tolerance of “kinks” in tracks

More top level perspective

- Phase I: Sample selection
  - Cuts applied in data
  - Studying these cuts in MC
  - Going back and optimizing for Protons
- Phase II: The cross section study
  - Defining our signal
  - Identifying our sensitivities
  - MC Truth study
  - MC Reco study
  - Opening the box
- Phase III: Studying backgrounds

Phase I and my work so far

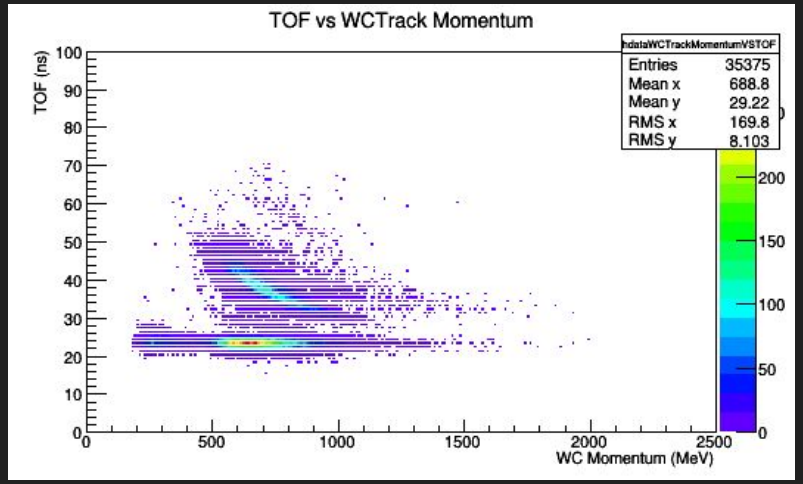
- This talk will focus on Phase I and the work I’ve done so far here
- I’ll cover the first look over on data
  - Mainly studying TPC matching inefficiencies
  - Applying cuts
  - Playing with some TPC variables
- There’s some early look at MC
  - Trying to understand some of the TPC parameters I saw in data
  - For now just Protons, but I’d like to also study the impurities of my sample (lighter particles)

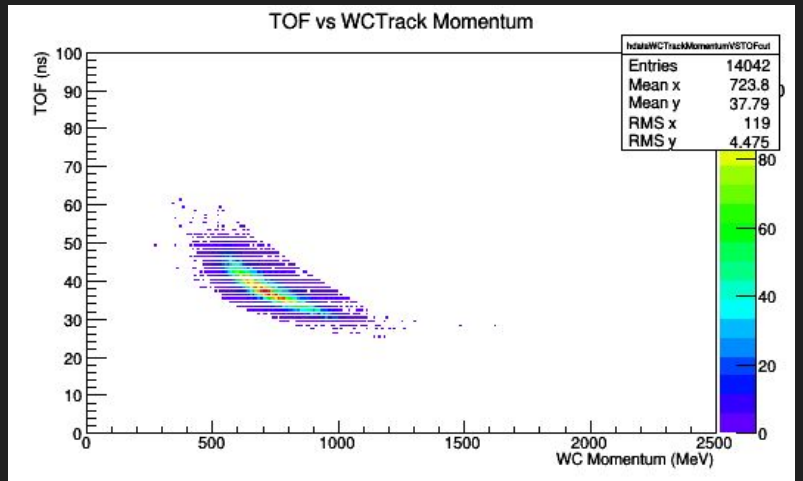
The workflow for Phase I

- I swear there are plots! Bear with me...
- Ideally the way this phase is carried out is by studying our selection and matching in beamline MC and then opening the box on data
- Since I can only play with data for now, I have attempted to establish a set of TPC only criteria that can be used to study the efficiencies of our selection
- After a first go on data, I then go to MC to check certain parameters for Protons to confirm the behavior we see in data
- Finally I'll go back to data and finish tweaking

Event Numbers Run I

Total Events	499,009
Events w/ >0 WC tracks	58,017
Events w/ reasonable TOF (0, 90)	39,741
Events w/ TPC hits	35,375
PID consistent w/ Proton (polynomial cuts)	14,042
> 1 Track w/ Start point < 2 cm	11,383
< 4 Tracks in First Z < 14 cm	9,680
Unique WC-TPC match && shower veto	5,628

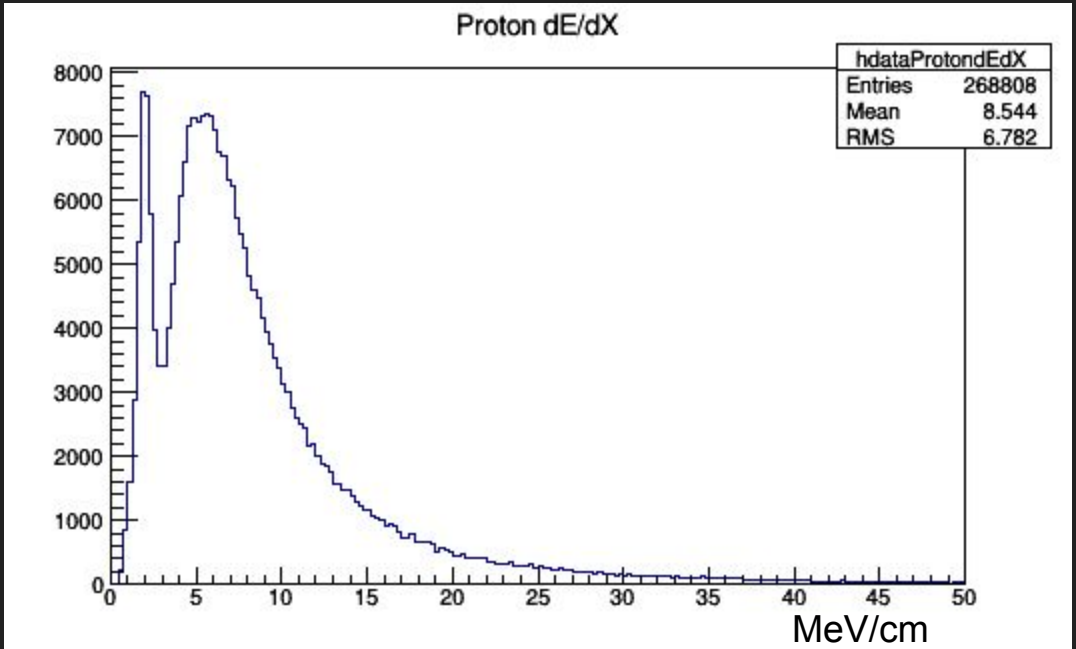




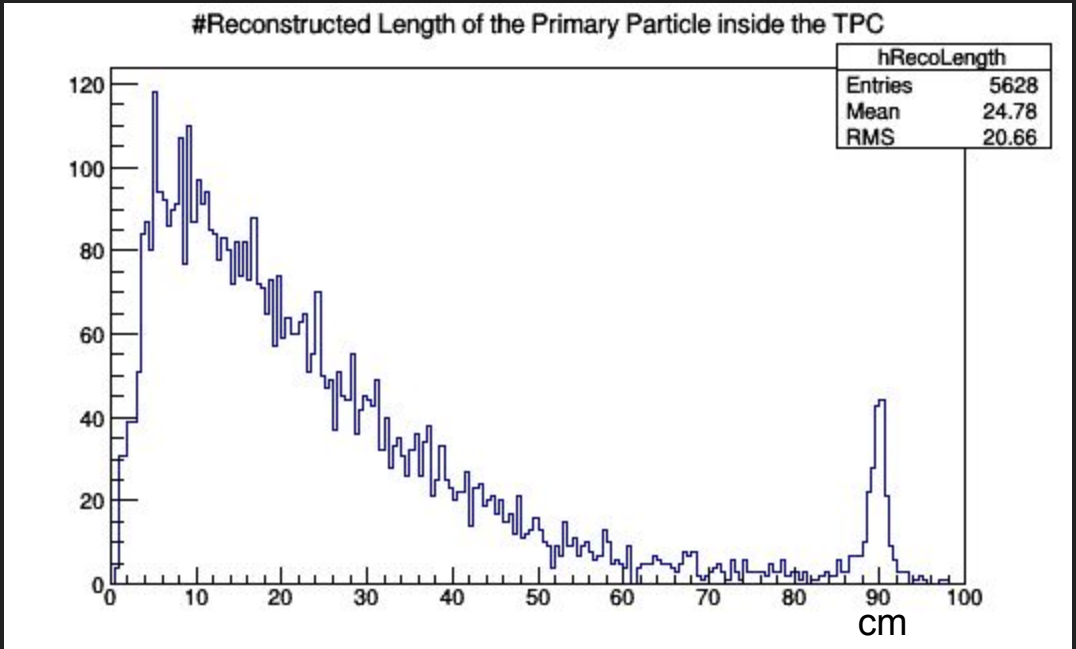
Polynomial TOF cut methodology

- Plotted TOF in bins of WC track momentum
- Made cuts on the gaussians in each binned plot
- Fit each set of points second order polynomial (in a limited region)

Signs of impurity in the sample



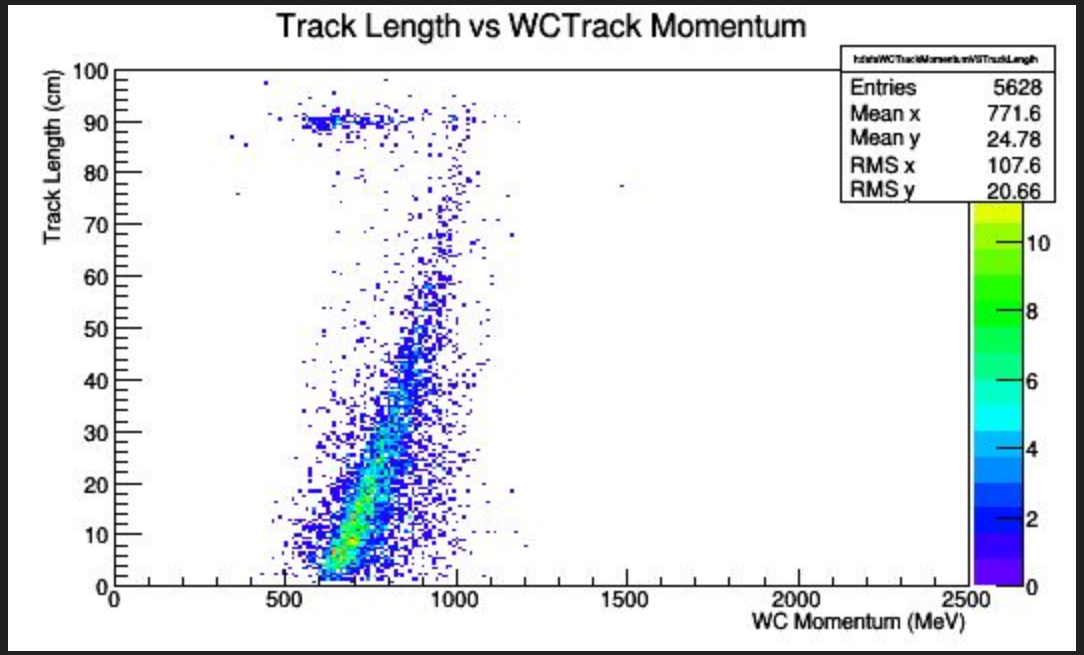
And again


#Reconstructed Length of the Primary Particle inside the TPC
hRecoLength
Entries 5628
Mean 24.78
RMS 20.66
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
cm

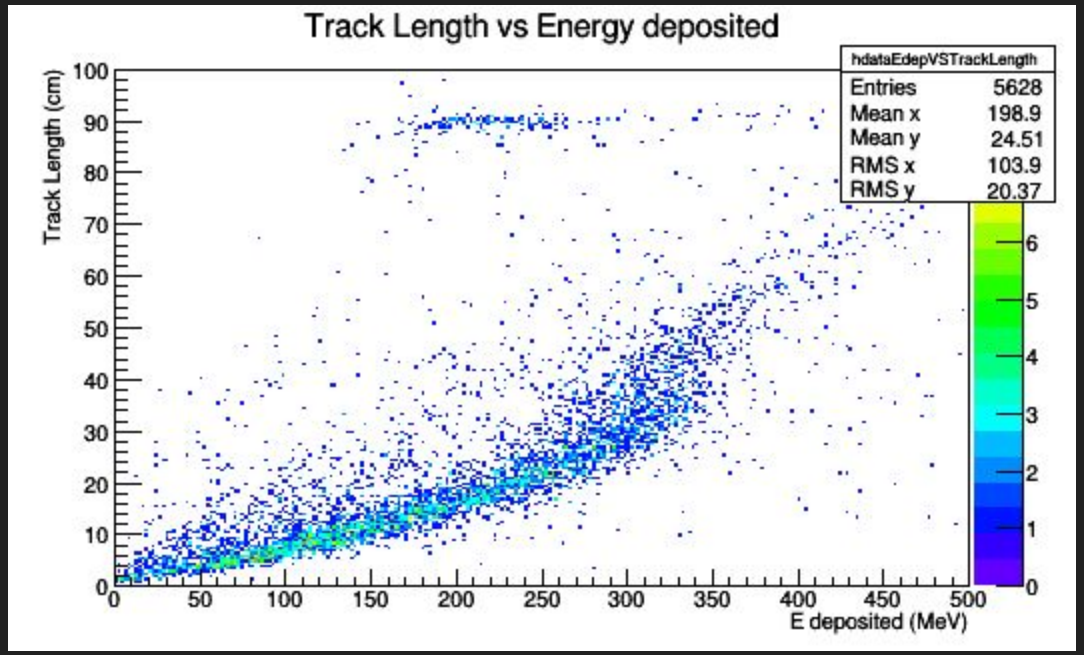
Understanding the Contamination

- The hypothesis is that among our proton sample we have some m.i.p particles. This is substantiated by the high population bin around 90cm and double de/dx peaks
- There are a couple theories for how this could happen (protons stopping in the cryostat and through going particles being picked up by the TPC for example). But without beamline simulation it is very difficult to understand the behavior of the matching algorithm
- What we can try is playing with data parameters and seeing how they respond to fiducial cuts

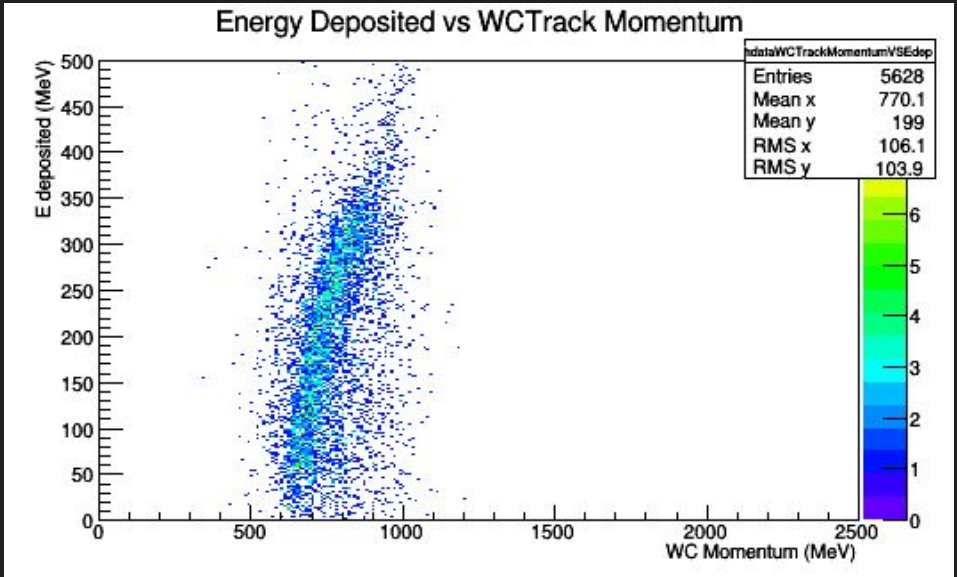
Some attempts at catching the impurity



A couple more ways to see the mips



Got unlucky with is one



- Had hoped for enough resolution to isolate features
- I don’t think there’s a meaningful separation to make here

Some cut ideas

- The simplest thing to do is some fiducial cut, which is what we'll see now
- Looking at these plot it may be nice to later only apply this cut at certain momentum ranges, but exactly where we will continue to study in MC

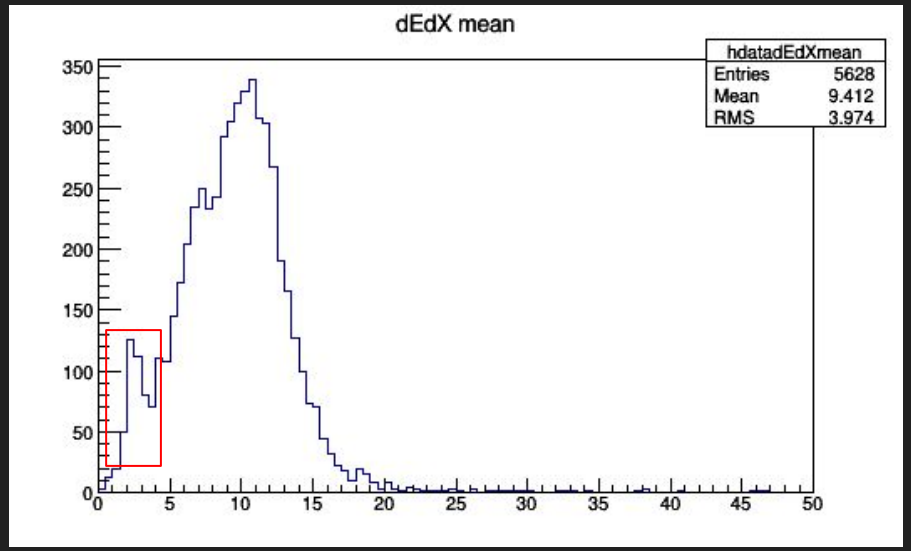
(after the track cut)

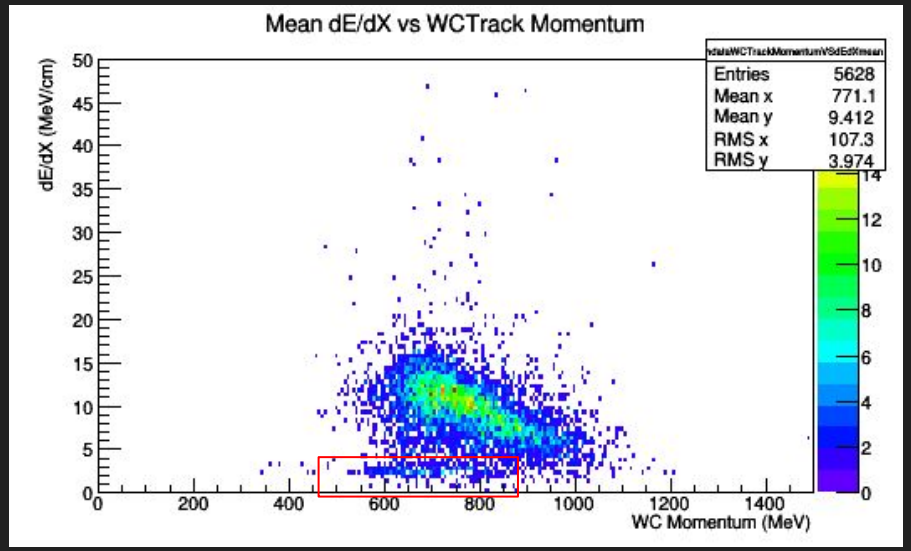
No luck here, but we'll see the impact of a fiducial cut on the next set of plots...

Some statistical variables

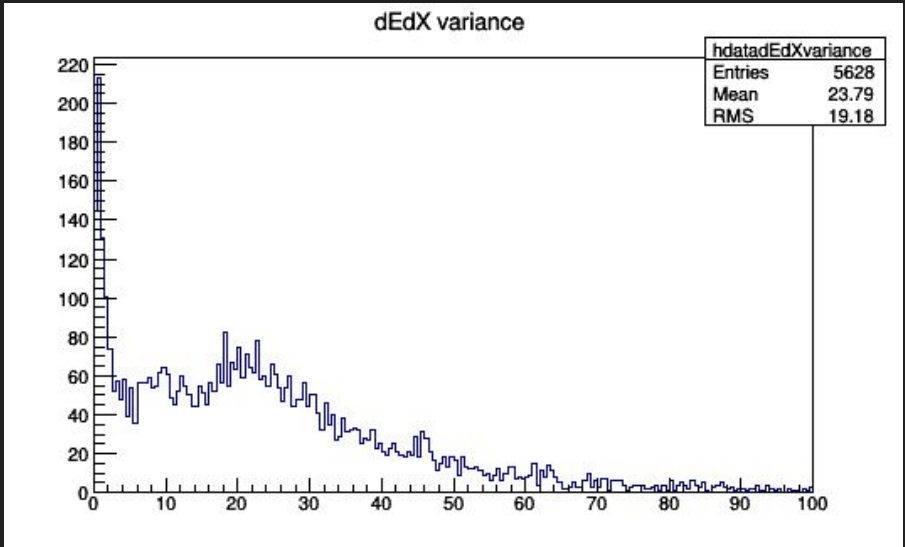
- Last thing I thought would be pretty helpful for catching the impurities was looking at statistical variables (mean and variance which are helpful fo PID)
- The idea is we should be able to isolate particles based off features in these plots, namely variance since the protons ought to have high variance (not a constant energy deposition)

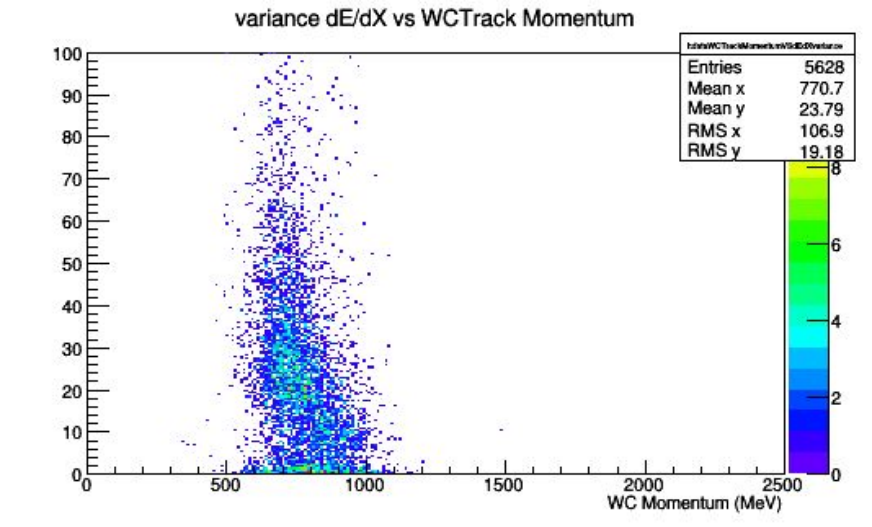
Mean


dEdX mean
hdatadEdXmean
Entries 5628
Mean 9.412
RMS 3.974

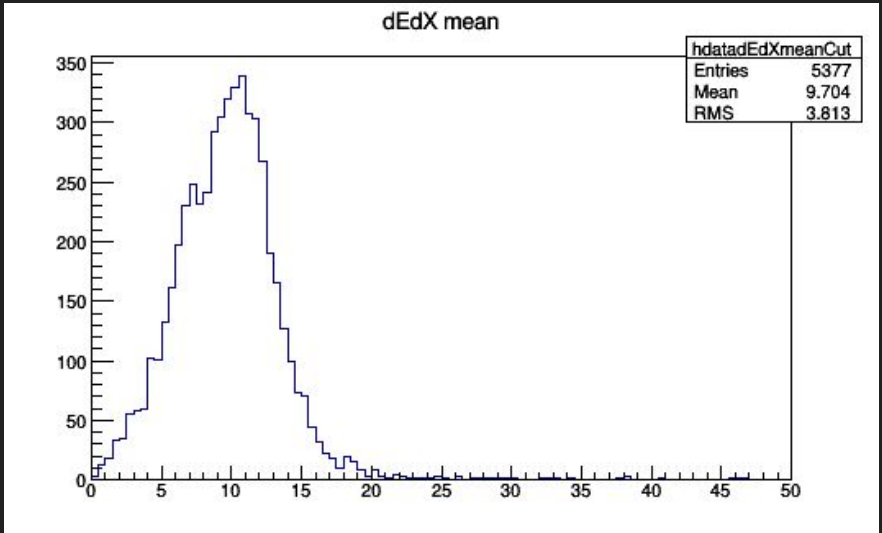

Mean dE/dX vs WCTrack Momentum
Entries 5628
Mean x 771.1
Mean y 9.412
RMS x 107.3
RMS y 3.974
dE/dX (MeV/cm)
WC Momentum (MeV)

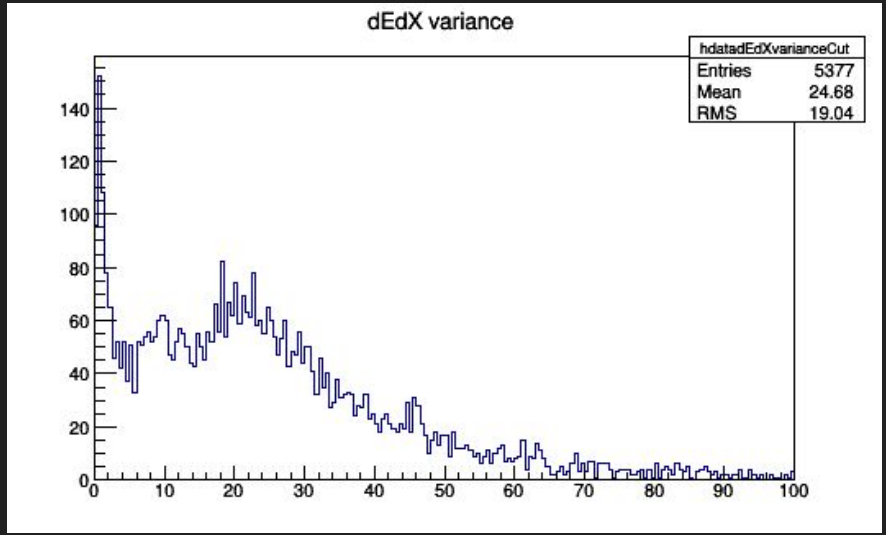
Variance


dEdX variance
hdatadEdXvariance
Entries 5628
Mean 23.79
RMS 19.18


variance dE/dX vs WCTrack Momentum
Entries 5628
Mean x 770.7
Mean y 23.79
RMS x 106.9
RMS y 19.18
WC Momentum (MeV)

After Cuts


dEdX mean
hdatadEdXmeanCut
Entries 5377
Mean 9.704
RMS 3.813
0 50 100 150 200 250 300 350
0 5 10 15 20 25 30 35 40 45 50


dEdX variance
hdatadEdXvarianceCut
Entries 5377
Mean 24.68
RMS 19.04
0 20 40 60 80 100 120 140
0 10 20 30 40 50 60 70 80 90 100

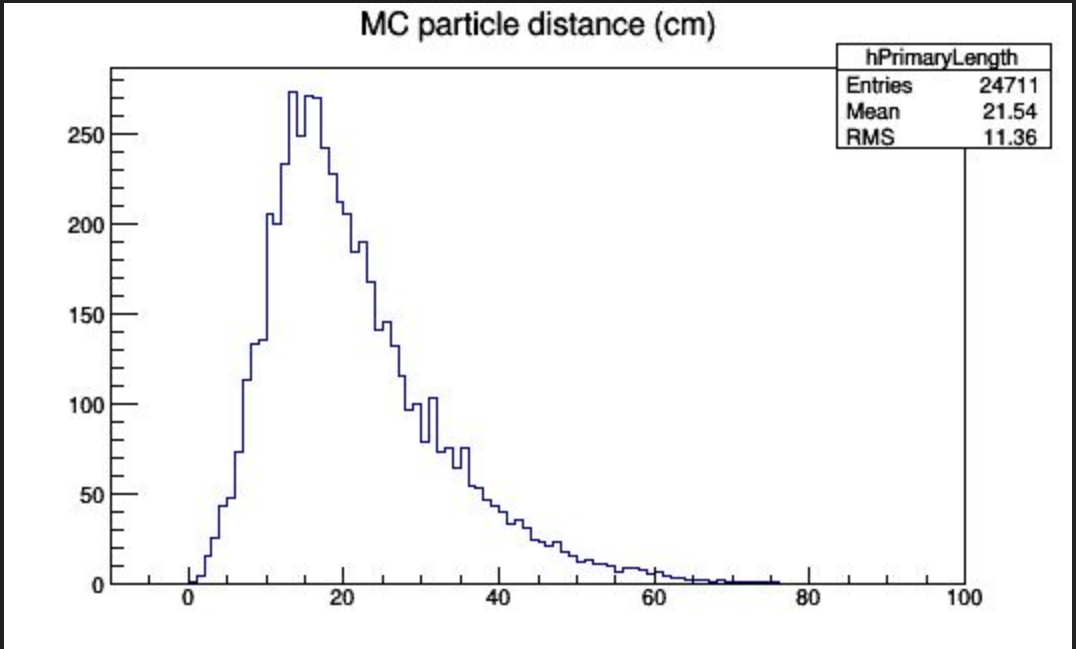
Some conclusions about data

- We can isolate these impurities in data after our beamline selection using TPC parameters and this is great because that means we can study these parameters in MC
- Expect a lot of this to get cleaned up from better TOF alone
- Once we can convince ourselves we have a very pure sample, we can start optimizing cut parameters for higher stats

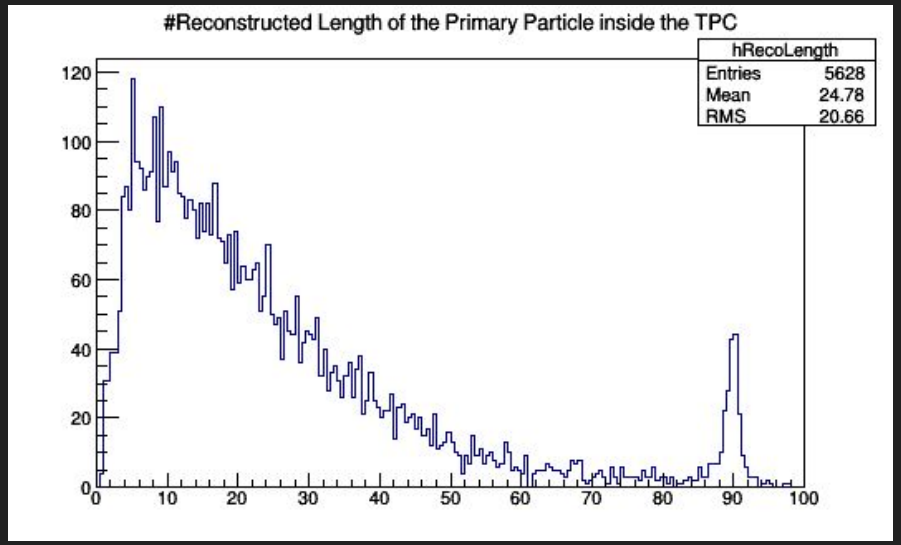
Very early MC look!

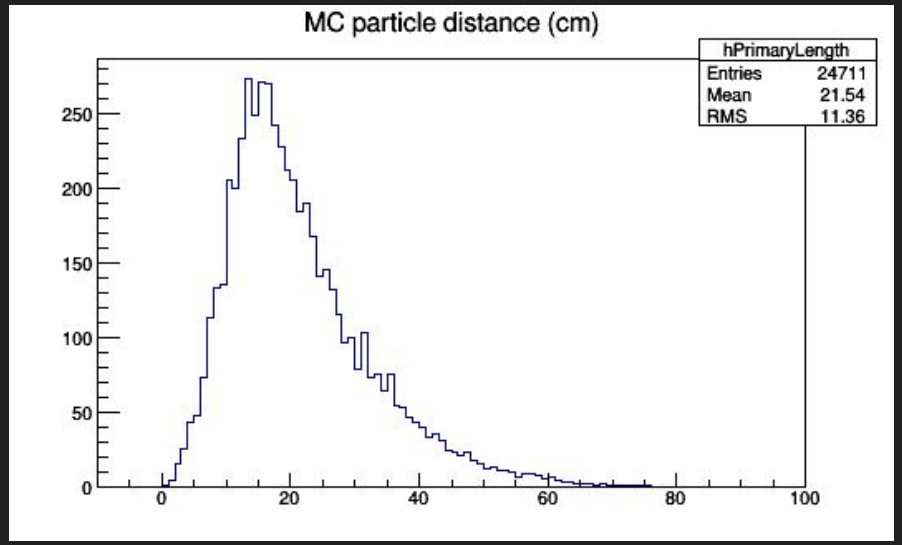
- The rest of the talk will be a look at MC Protons, and some TPC parameters to start studying the cuts in data
- What I was curious about:
  - How many protons are through going, what energies is this relevant at
  - What does reconstructed dE/dx look like in MC
- For now this is all I’ve thought of as a way to measure the efficiency of our in TPC PID cuts, more suggestions are welcome!

Truth level distance traveled (weighted by Pz)

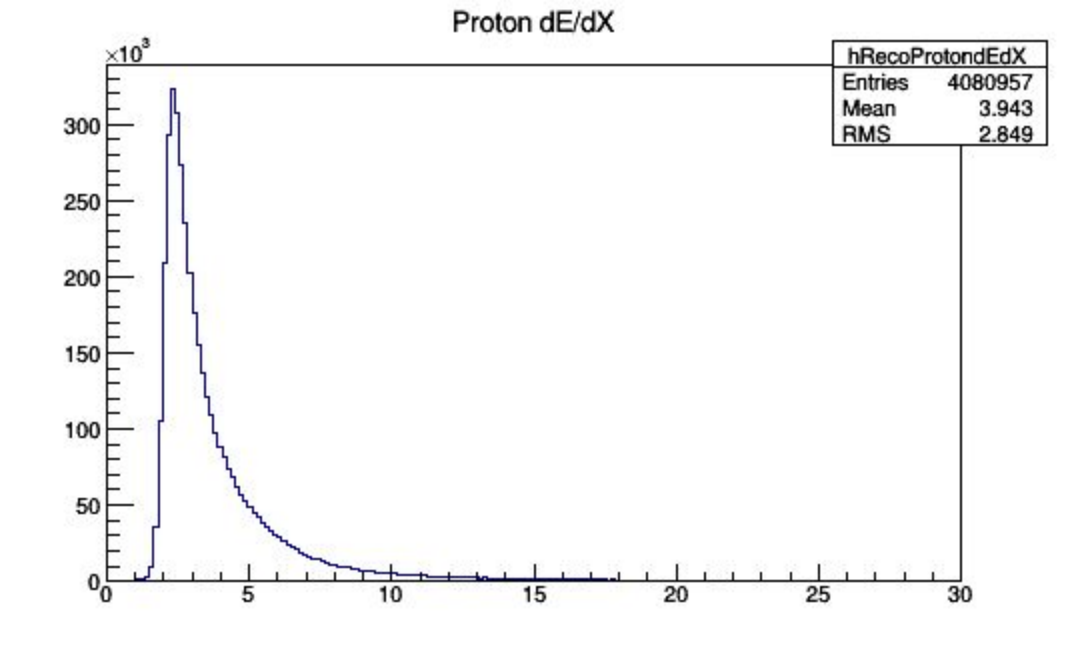


Side by side comparison

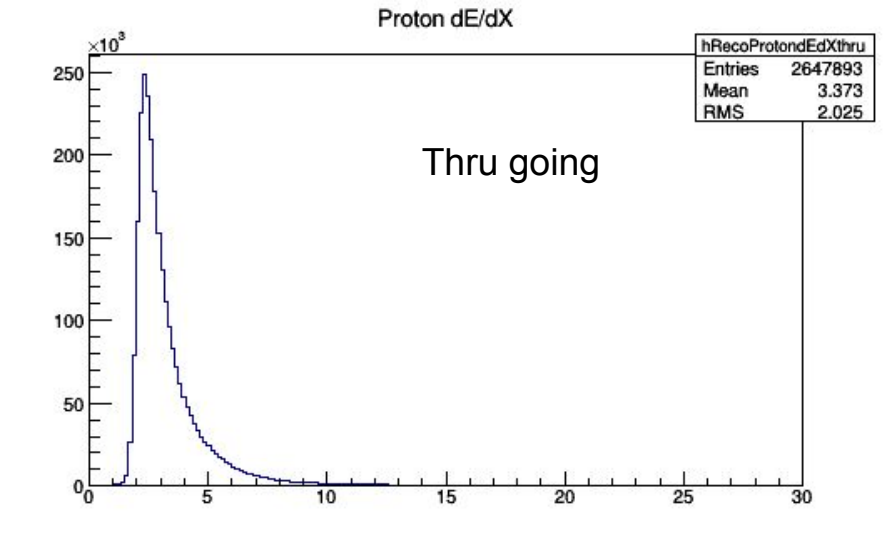


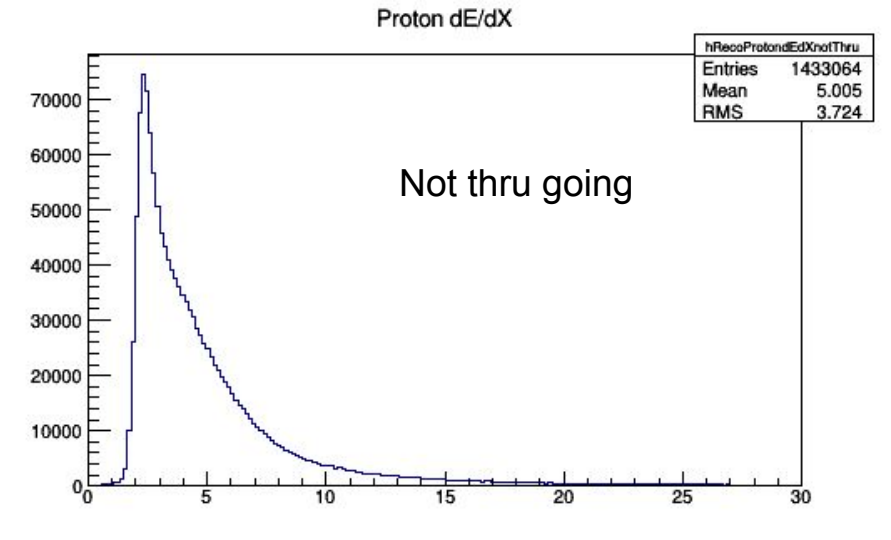


dE/dX

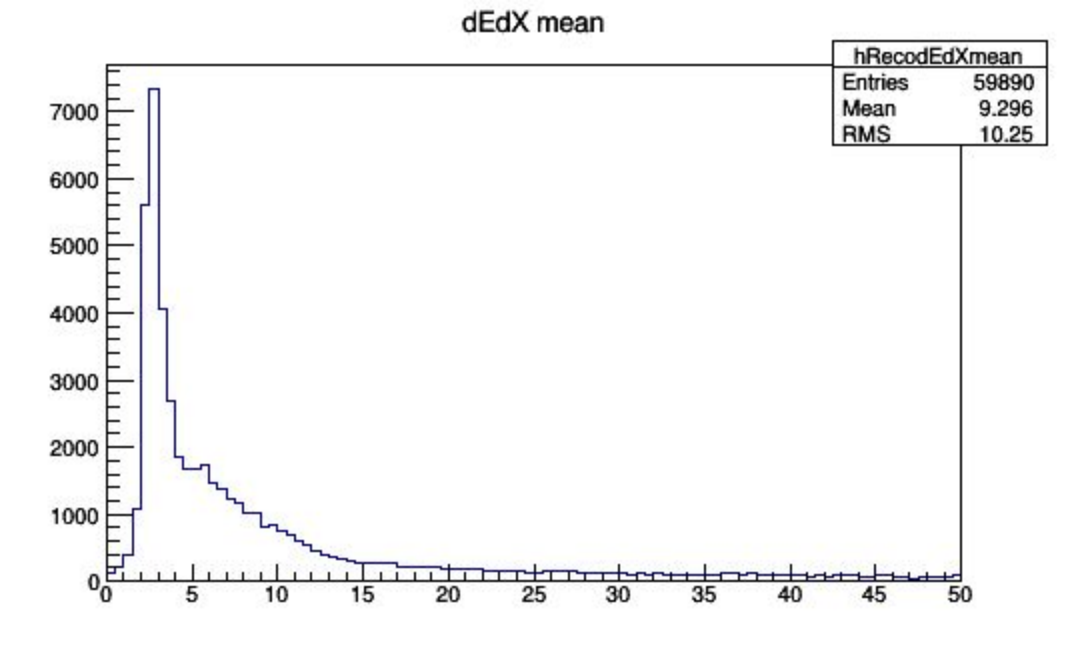

Proton dE/dX
hRecoProtondEdX
Entries 4080957
Mean 3.943
RMS 2.849
×10^3
300
250
200
150
100
50
0
0
5
10
15
20
25
30

dE/dX (exiting vs non-exiting)

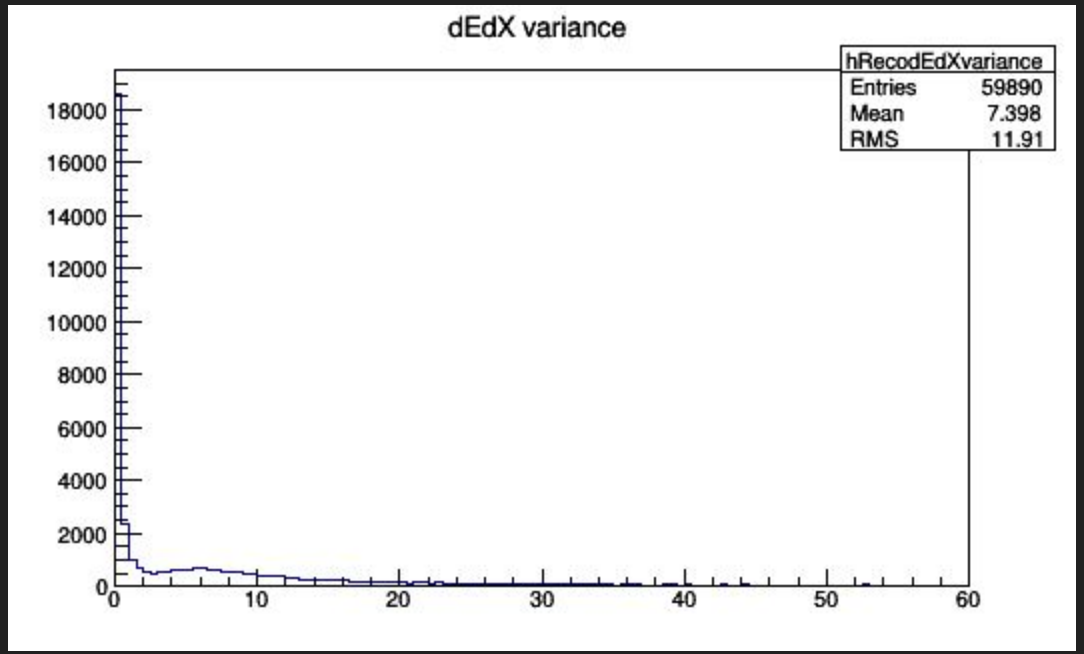




dE/dX mean


dEdX mean
hRecodEdXmean
Entries 59890
Mean 9.296
RMS 10.25
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
35
40
45
50

dE/dX variance



Closing remarks on MC

- The results from the distance traveled check are very helpful!
- This means any population in the 90 cm bin is an impurity
- I still want to study the feature present in dE/dX variance, try to isolate the first couple bins based on TPC parameters

Looking ahead (short-term)

- I want to re-run all of my cuts on data with improved TOF first and foremost and see how much of the impurities are lifted
- In the next week I want to continue looking at MC parameters to evaluate the impurity left in the data (looking at punch through, dE/dX statistics)

Looking ahead (mid-term)

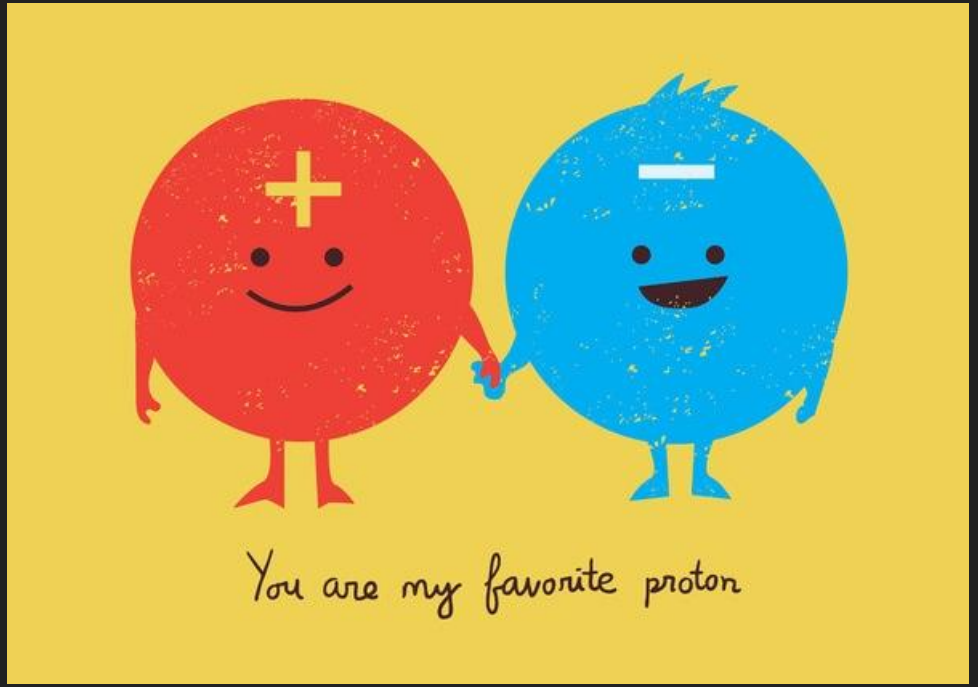
- I’d like to wrap up “Phase I” as soon as possible and start the cross section study
- This means go back and tune some of the parameters at the bottom of the event table from earlier in the talk
- Get a sense of our statistics for the study with run I and run II together
- Start defining our signal and moving forward...

Looking ahead (long-term)

- The goal is to have a preliminary cross section measurement by the end of my summer (end of september)
- This is a little ambitious, but with the clarity of the Proton signal and the guidance from everyone so far who has helped me I think this is very do-able!

Any insight is much appreciated!

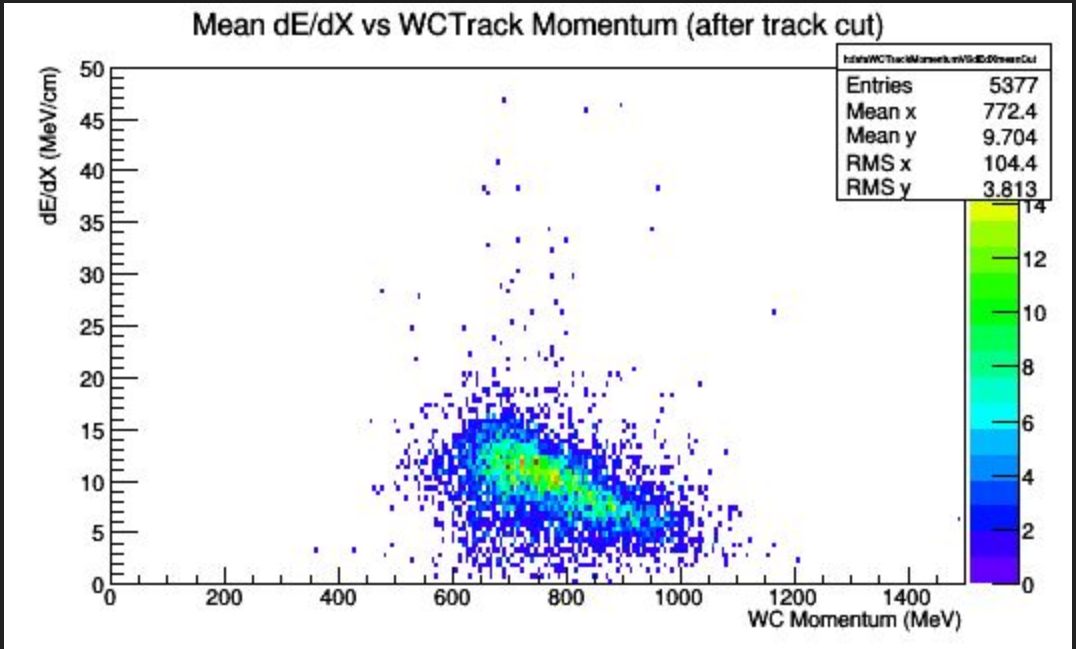
I’m looking for any range of specificity in advice. Please let me know what you think!



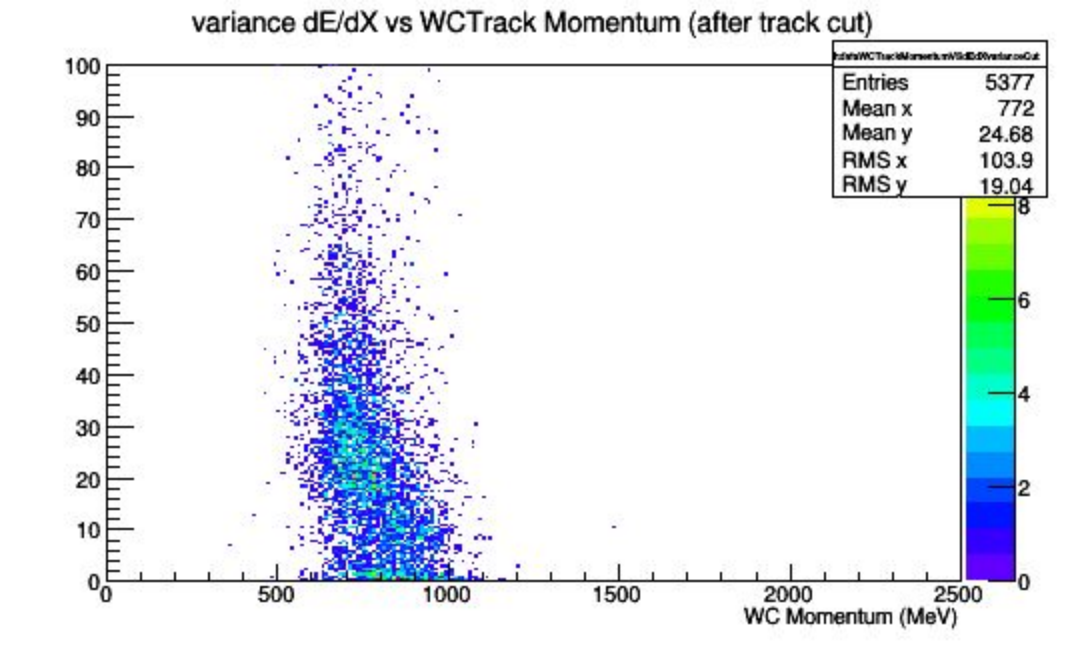
Thank you!

- LArIAT
- Dave
- Johnny
- Jonathan
- Dan
- Elena
- (the computing division for also giving me a job…)

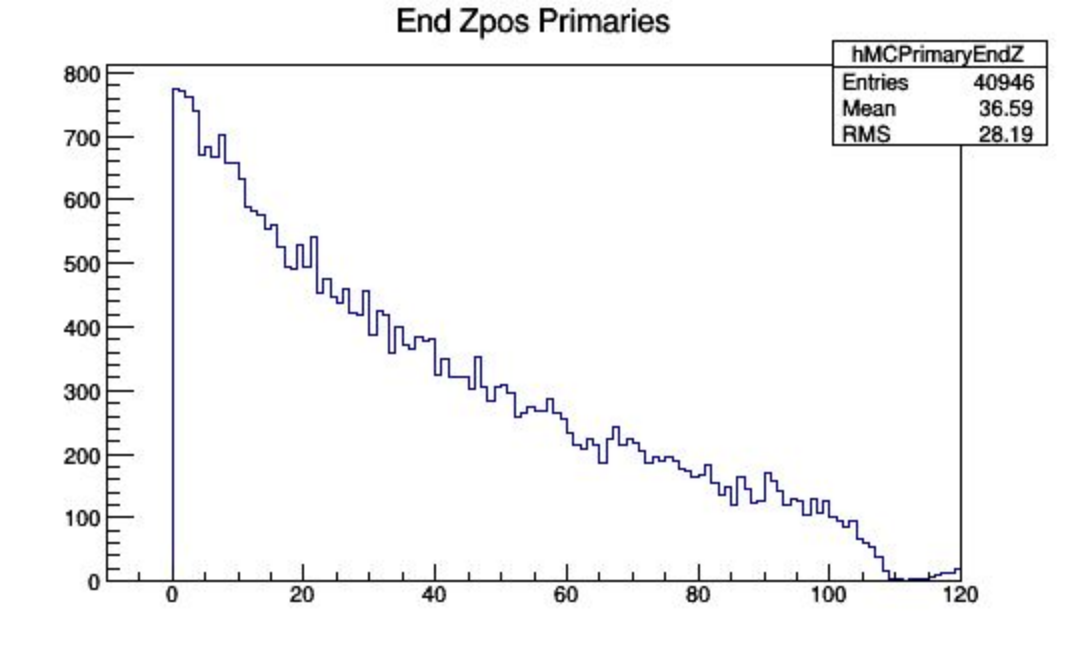
Backups


Mean dE/dX vs WCTrack Momentum (after track cut)
Entries 5377
Mean x 772.4
Mean y 9.704
RMS x 104.4
RMS y 3.813
dE/dX (MeV/cm)
WC Momentum (MeV)
0
5
10
15
20
25
30
35
40
45
50
0
200
400
600
800
1000
1200
1400
0
2
4
6
8
10
12
14

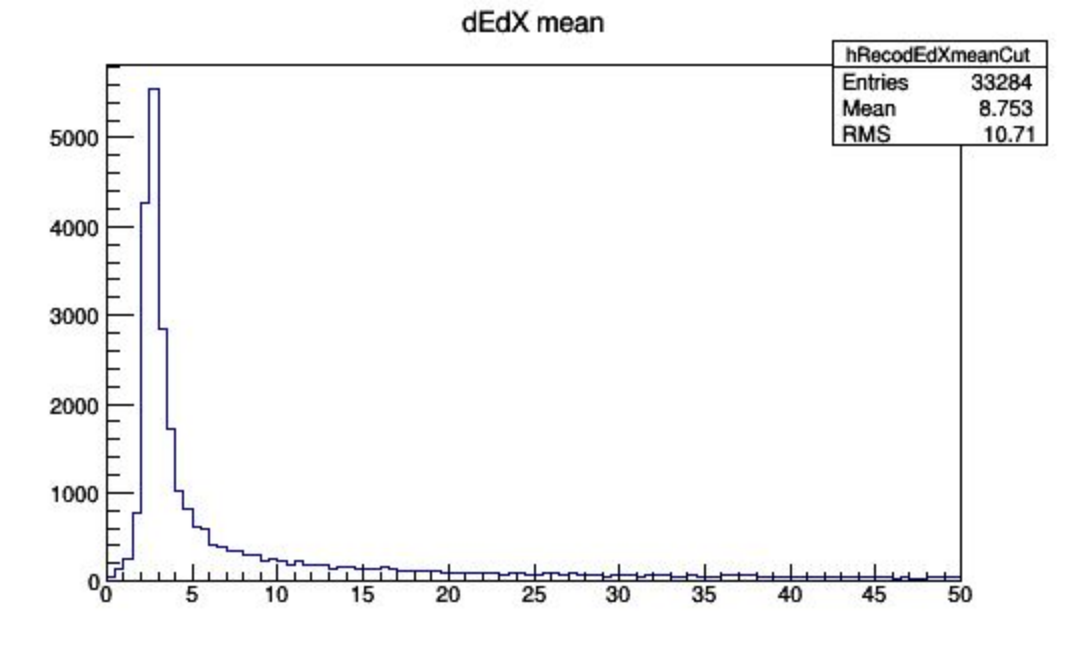
Backups


variance dE/dX vs WCTrack Momentum (after track cut)
Entries 5377
Mean x 772
Mean y 24.68
RMS x 103.9
RMS y 19.04
WC Momentum (MeV)
0
500
1000
1500
2000
2500
10
20
30
40
50
60
70
80
90
100
2
4
6
8

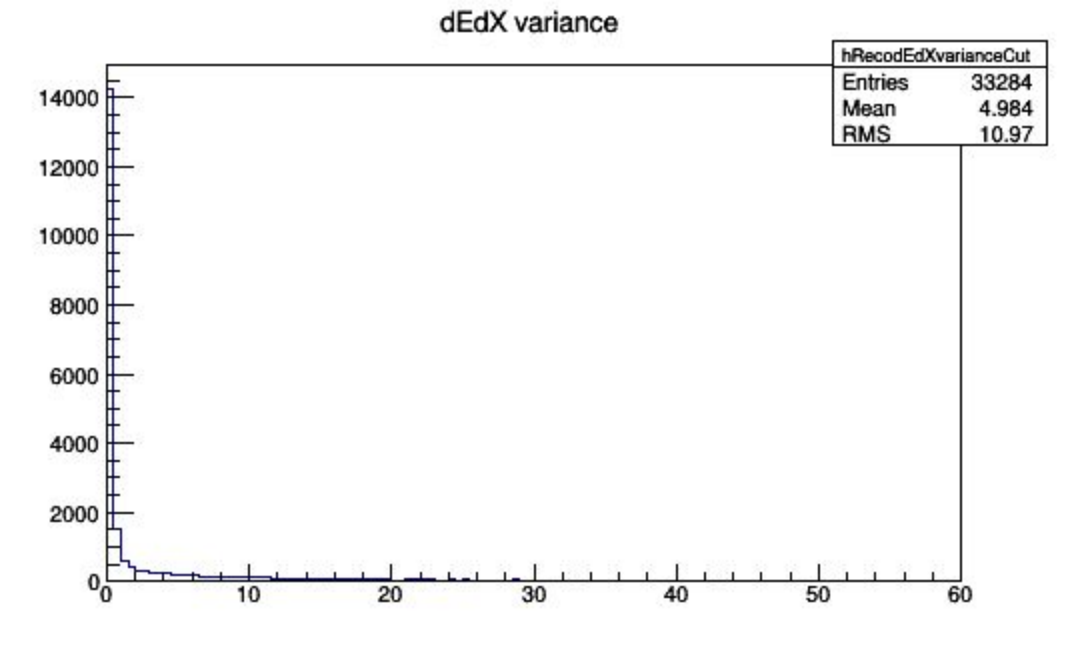
Backups


End Zpos Primaries
hMCPrimaryEndZ
Entries 40946
Mean 36.59
RMS 28.19
800
700
600
500
400
300
200
100
0
0
20
40
60
80
100
120

Backups


dEdX mean
hRecodEdXmeanCut
Entries 33284
Mean 8.753
RMS 10.71
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
35
40
45
50

Backups


dEdX variance
hRecodEdXvarianceCut
Entries 33284
Mean 4.984
RMS 10.97
14000
12000
10000
8000
6000
4000
2000
0
0
10
20
30
40
50
60