DEEP UNDERGROUND NEUTRINO EXPERIMENT

The University Of Sheffield.

Comparison of Muon and Proton dEdx

Karl Warburton with guidance from Tingjun Yang

08/07/2015

Importance of dEdx

- dEdx is the main identifier for particle identification in liquid Argon.
  - When used with residual range can clearly see difference between muons, pions, kaon, protons.
  - Will be useful to show this in the 35 ton.
- Was the driving force behind my calorimetry tuning and tracking efficiency studies.

Changes to simulation and method

- Until now simulation services has used Birks Model, however a Modified Box Model will probably work better so I have changed this locally and will push it to the newest version of lbnecode.

- Using MCC 3 for my sample. As use new simulation model I have re-ran them in my pnfs area.

  /pnfs/lbne/scratch/users/php13tkw/

- Remodelled the module I was using for Tracking Efficiency as this did track matching etc.

Particle Identification A (PIDA)

- This is a very clever ‘trick’ /‘tool’ noticed by Bruce Baller to identify particles in LAr.
- See this paper for details;
- http://arxiv.org/abs/1306.1712
- If you google ‘PIDA Bruce Baller’ and look at the top link (is a powerpoint) there is a detailed talk explaining the method.
- The following 3 are slides taken from this presentation.

Stopping Particle Stopping Power

Bethe-Bloch eqn has power law dependence with residual range (R) near the stopping point

$$(dE/dx)_{hyp} = A\,R^{b}$$

$$T_{range} = \frac{A}{b+1}\,R^{b+1}$$

Particle	A MeV/cm^{1-b}	b
pion	8	-0.37
kaon	14	-0.41
proton	17	-0.42
deuteron	25	-0.43

T_{range} (MeV), R (cm)

PIDA

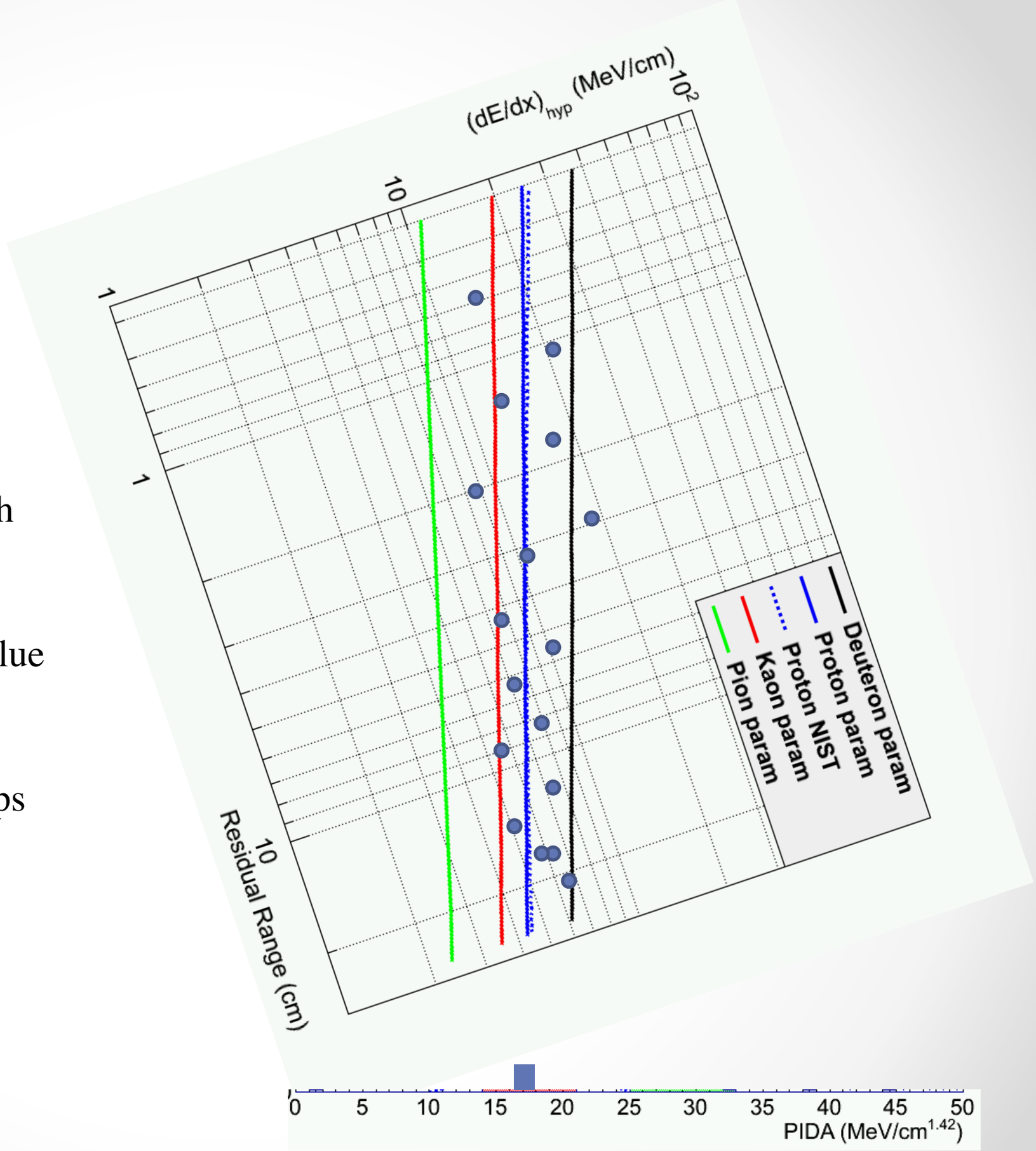
Algorithm

Set b = constant = 0.42

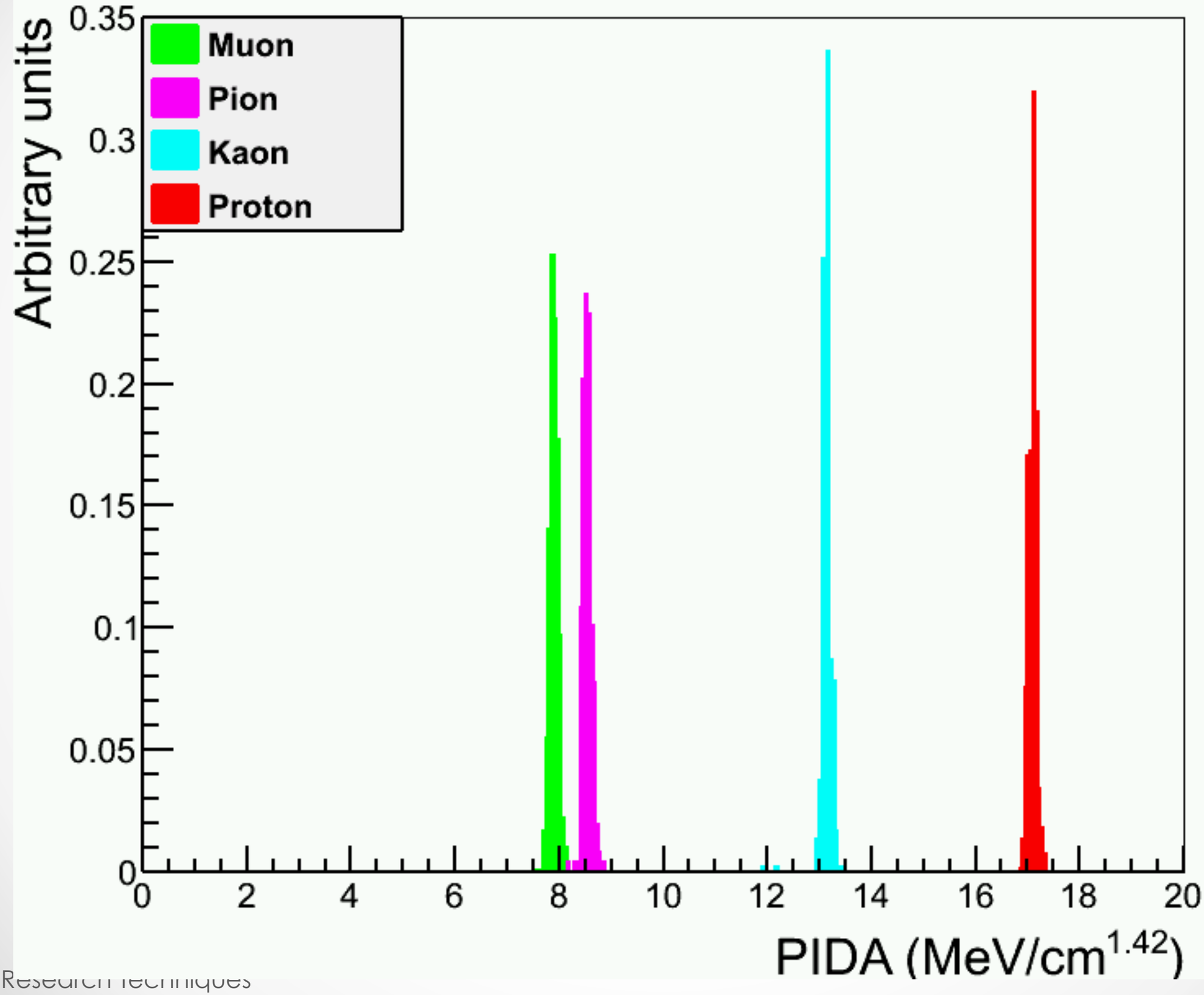
Find $A_i = (dE/dx)_{calo} \times R^{0.42}$ for each space point i on a track

Define PIDA = $< A_i >$ = average value for the track

Histogram PIDA and look for bumps
→



PIDA – MC Truth



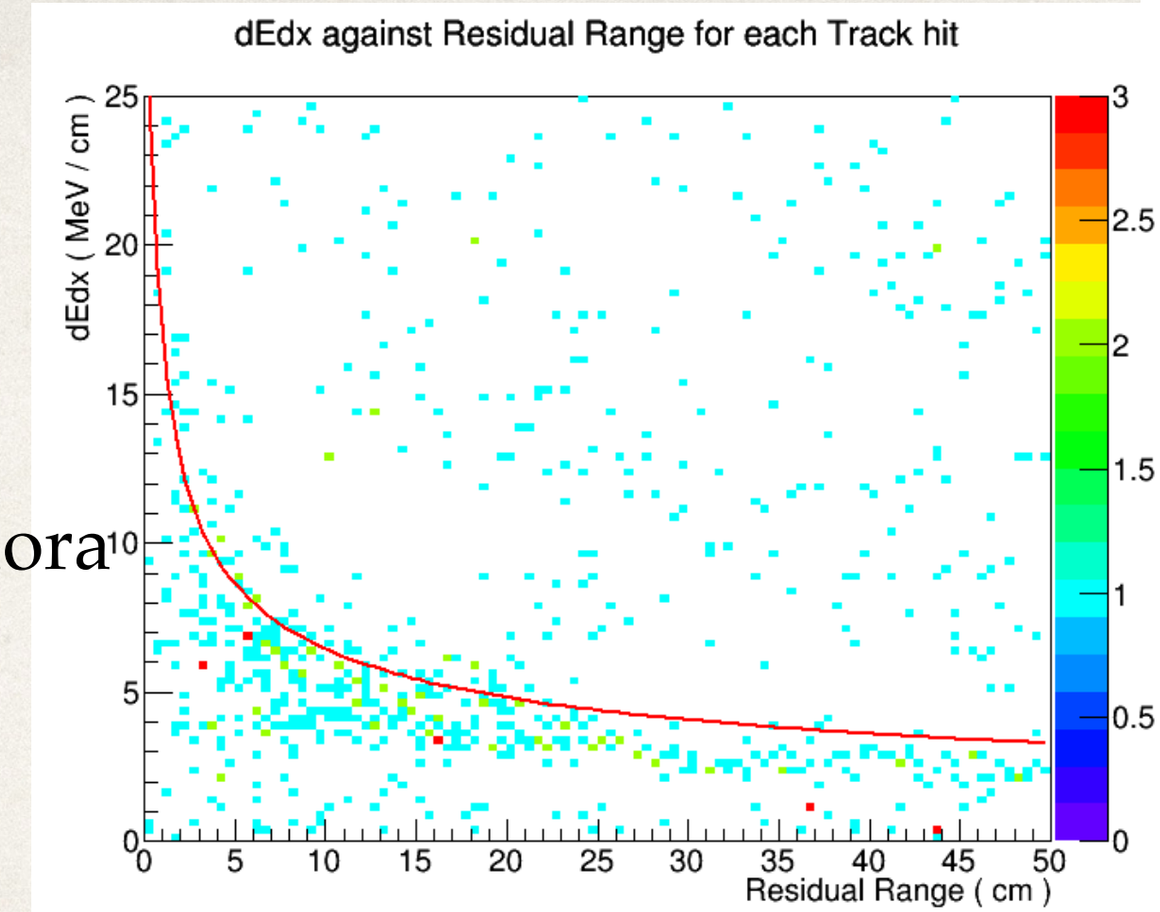
Fitting theoretical predictions

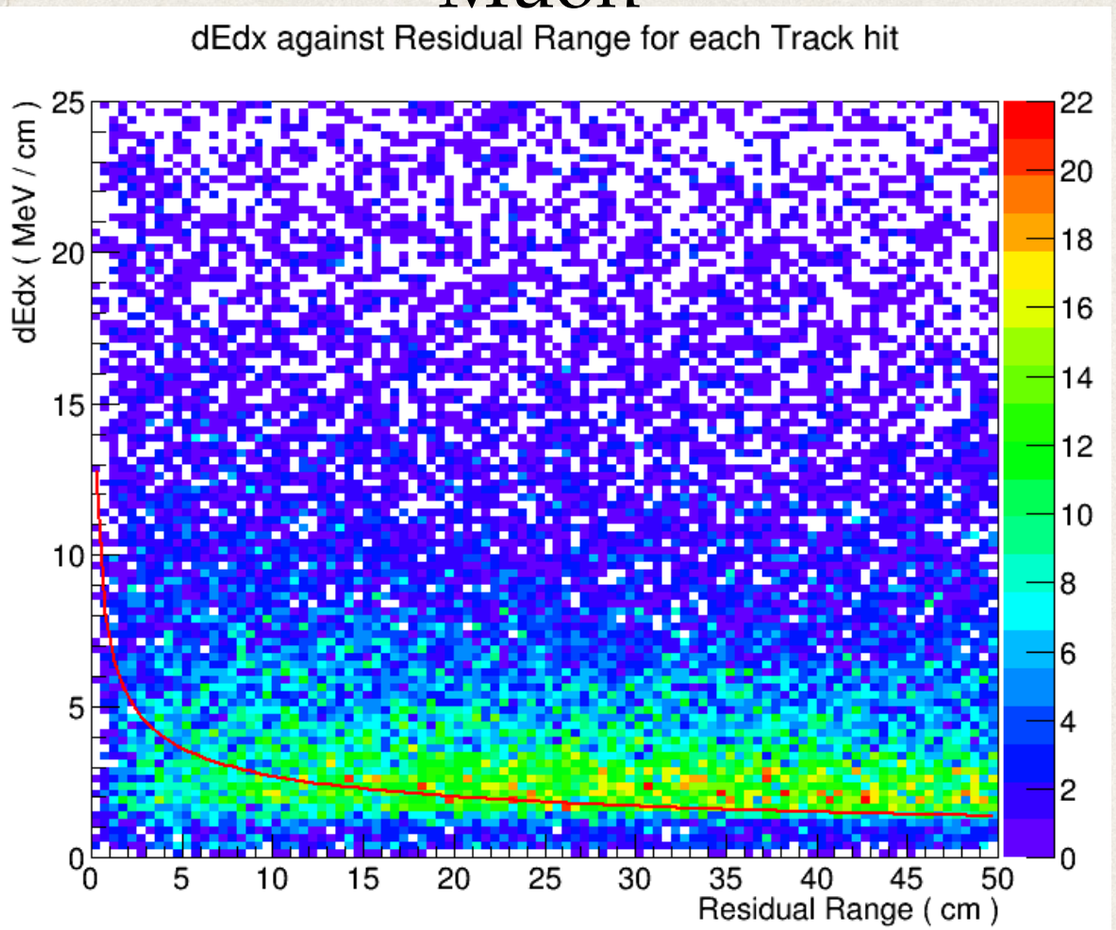
- In the following plots for muon and proton dEdx vs Residual Range there are fitted lines.
- Proton Fit
  - Comes from the best fit value found by Bruce Baller.
    A = 17, B = -0.42.
- Muon Fit
  - Comes from NIST tables on muons in LAr and fitted with the most probable value for PIDA found by Bruce Baller.

Proton

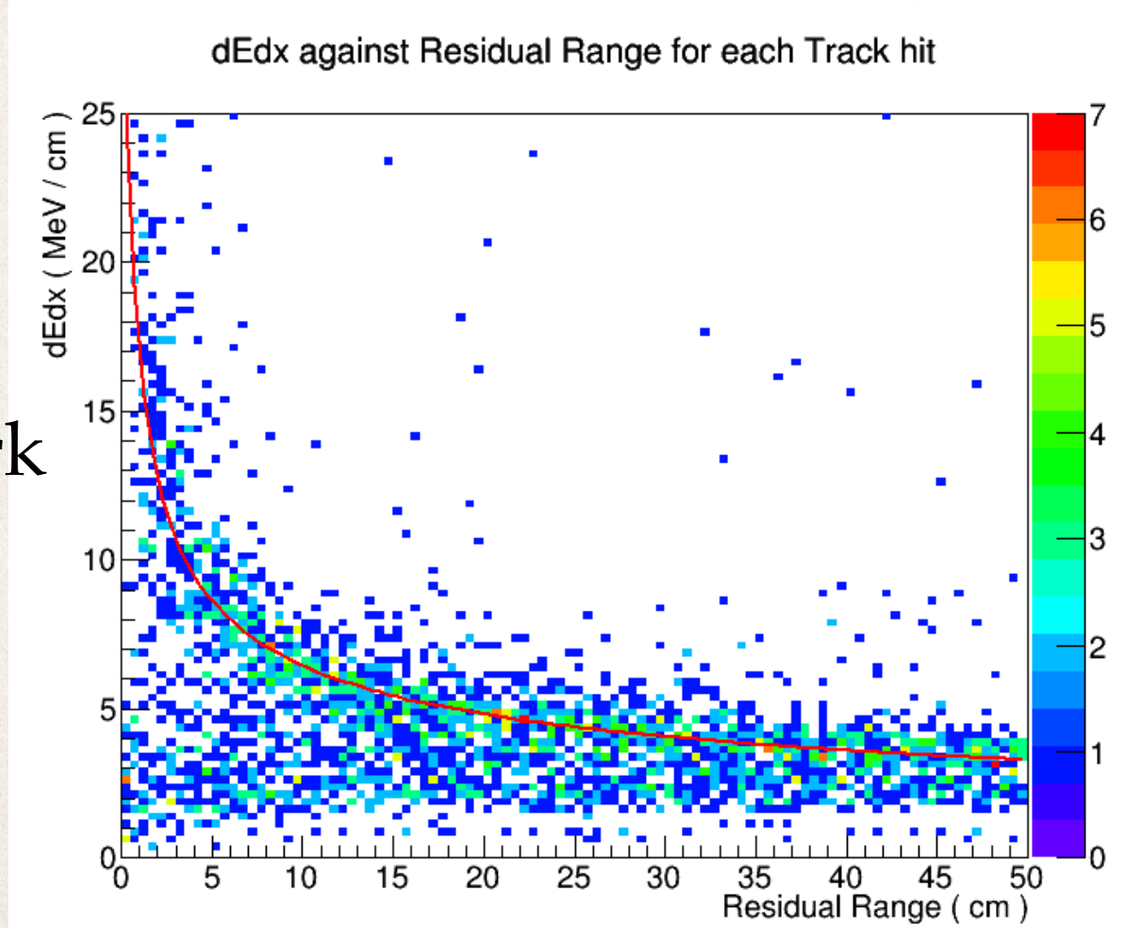
Muon

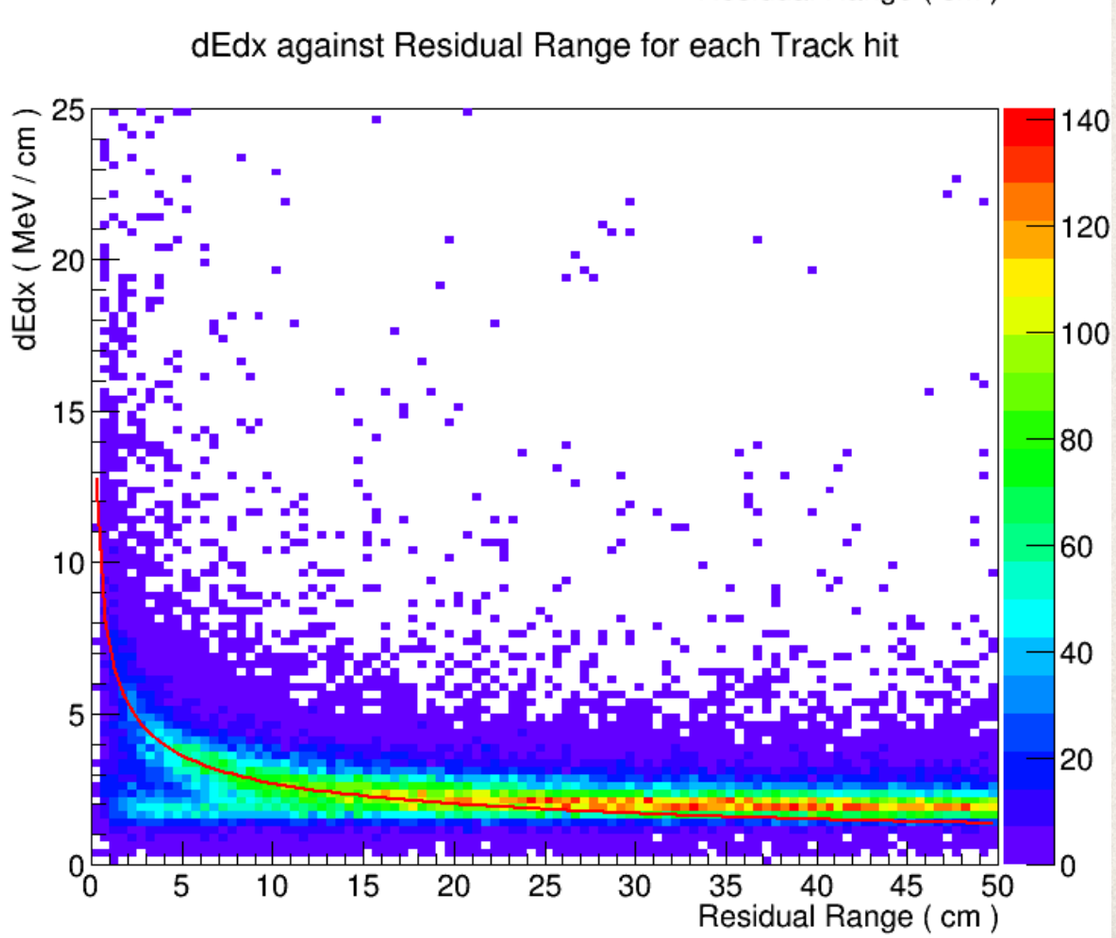
Pandora





CosTrk

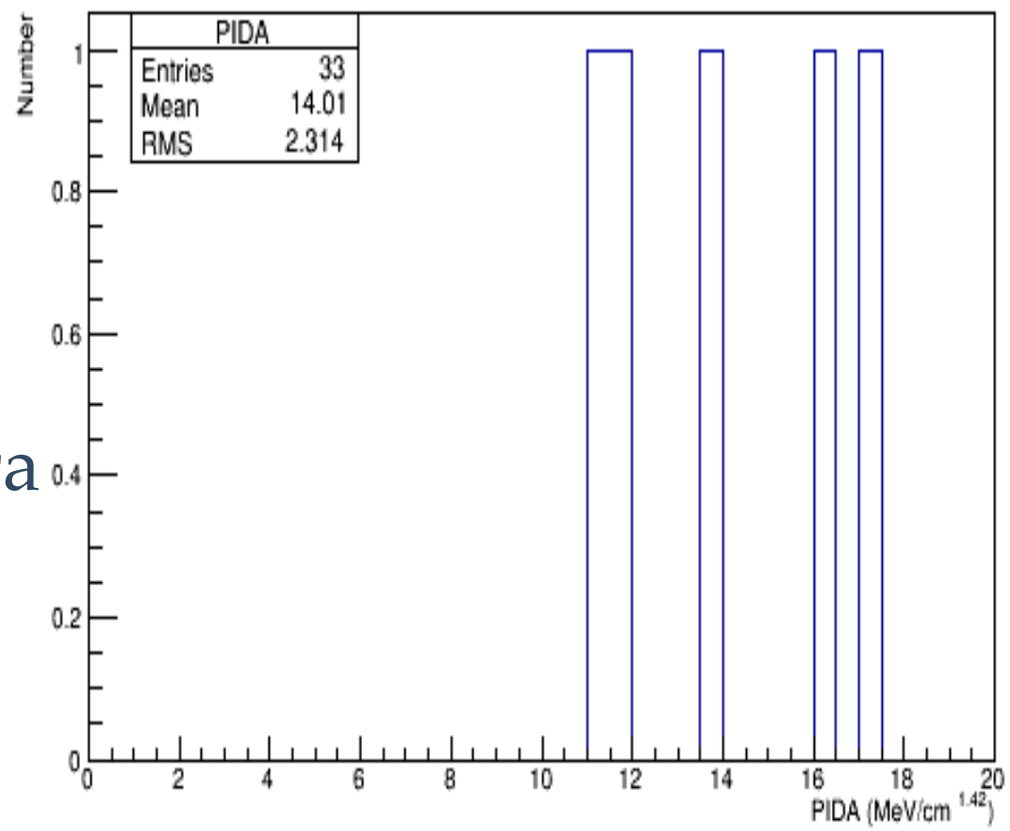


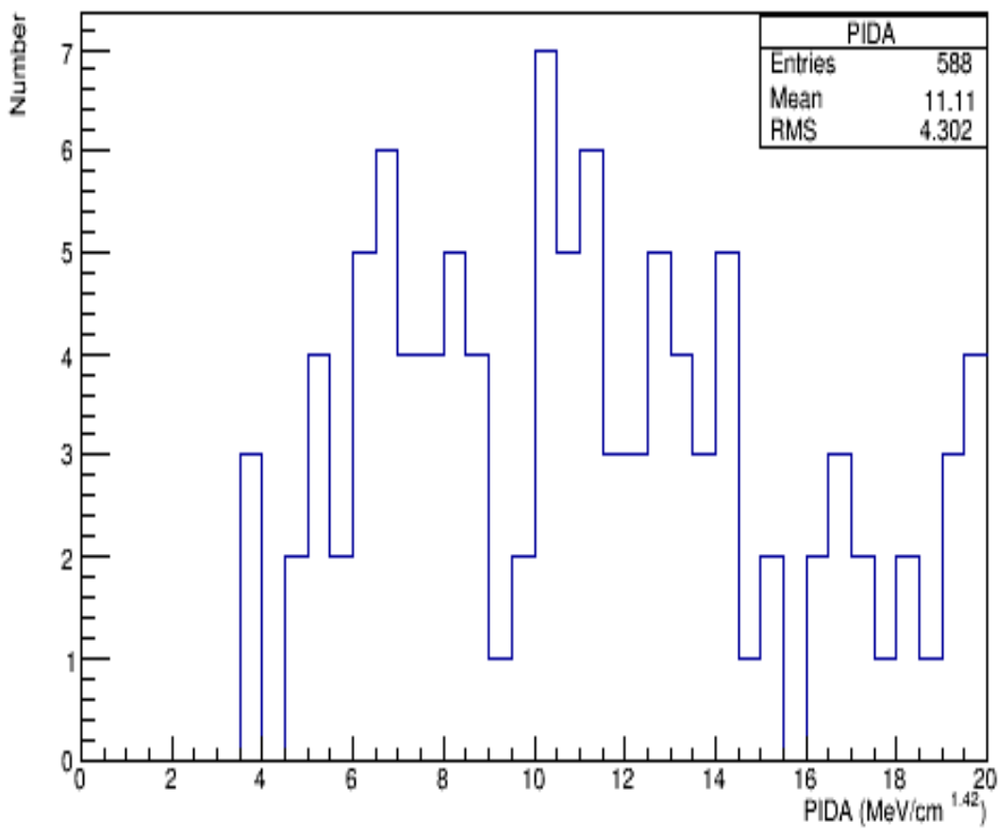


Proton

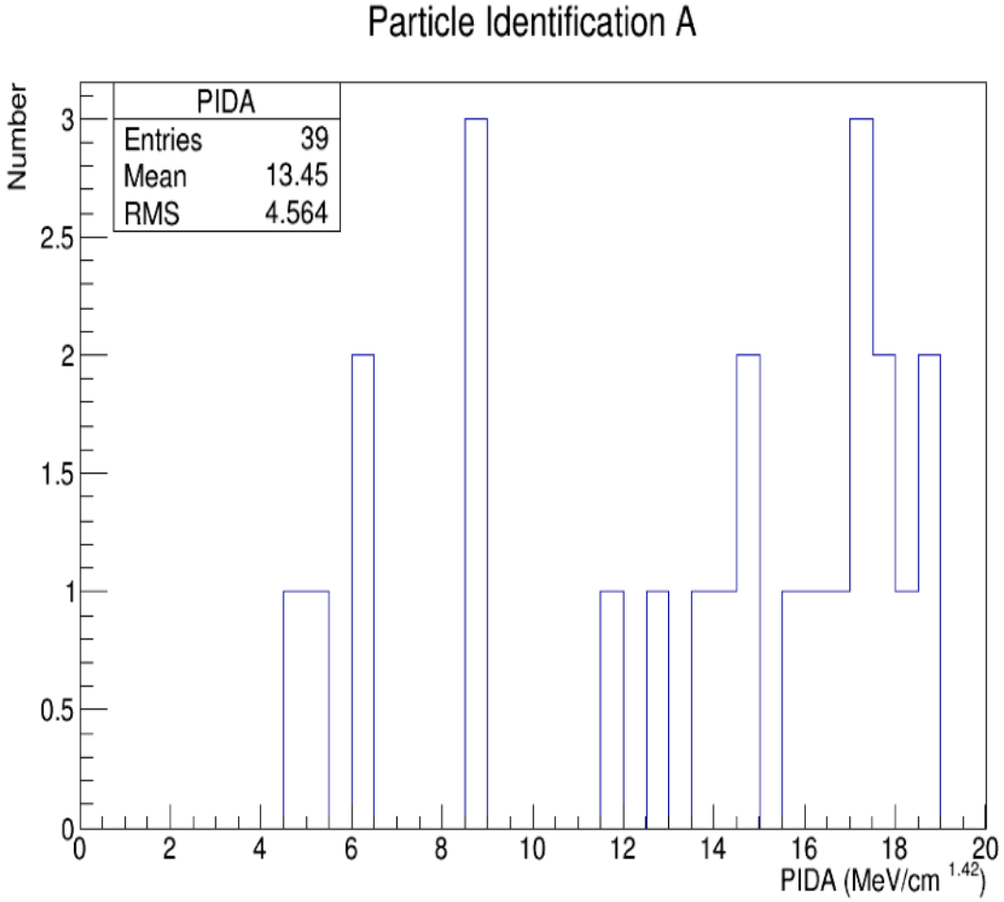
Muon

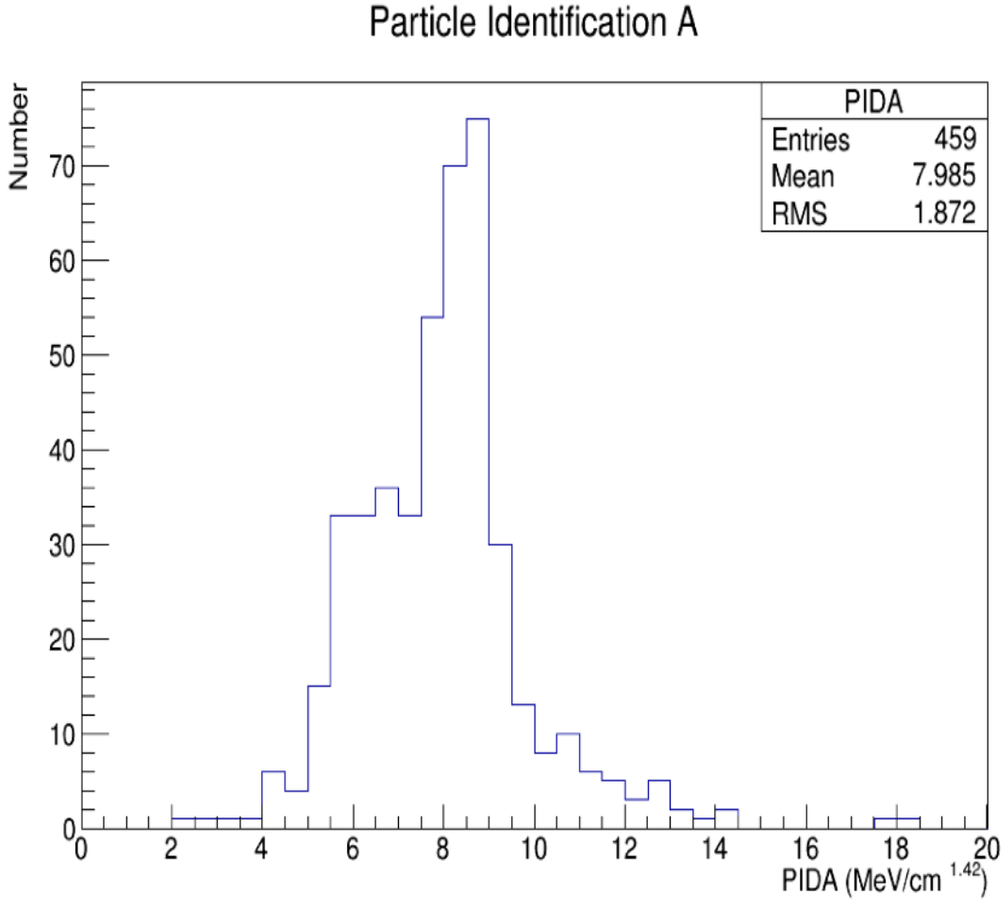
Pandora





CosTrk





Important things to note…

- T0 information
  - I use MCTruth to get T0. Obviously won't have this for data!
- Selecting stopping particles.
  - I use MCTruth to select stopping particles. Need to develop reconstructed event selection.
- I need much more statistics!
  - 39 matched proton tracks for CosTrk and 35 for Pandora is not conclusive. Even the ~500 muons for each isn't huge.

Simulation issues…

- Initial kinetic energy returned by calorimetry looks at energy deposited on each plane and sums them to get a total energy for each plane.
  - Take the plane with the most hits as most likely kinetic energy? Spread normally isn't huge, but it can be. If it is, then what?
    - Can only work for stopping particles, but no way around this.
    - Will want to use for some analyses.
- Big spread in Muon dEdx values from Pandora. Don't know why…
- Feature at dEdx of ~2 MeV/cm for Protons which shouldn't be there. Why I have some PIDA's at ~6 Mev/cm? Also present in others.
- Muon dEdx vs ResRange fit seems to go below peak values at high ResRange. Could this increase above the fit be due to the feature giving PIDA of 6 MeV/cm?

Conclusion

- First stage of particle identification looks solid.
- Managed to reproduce Bruce Ballers work using reconstructed events. It isn’t perfect and needs much more work, but isn’t terrible.
- Long list of things to try and improve.