Proton Identification

Libo Jiang (Virginia Tech)

MC Sample Used in This Analysis

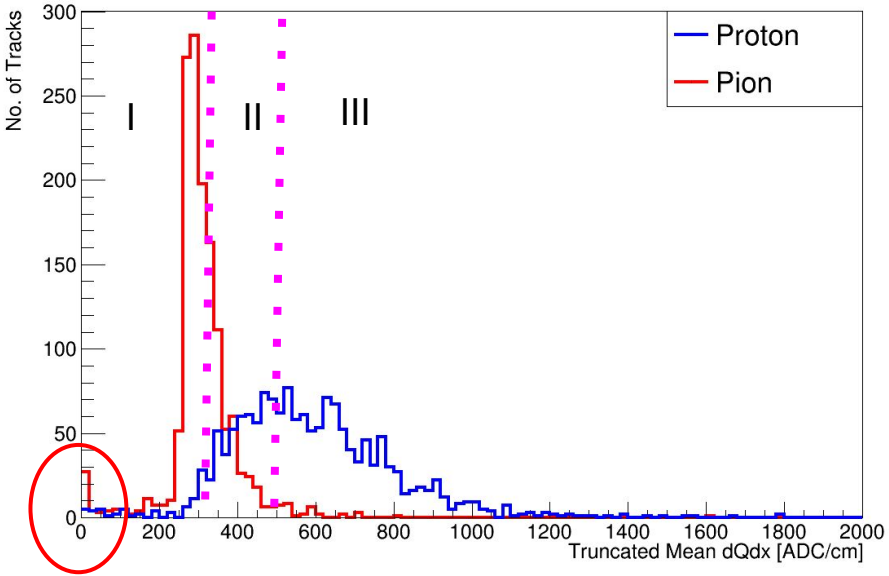
https://wiki.dunescience.org/wiki/Look_at_ProtoDUNE_SP_data

MC with SCE on

Momentum (GeV/c)	Definition Name	SAM Query Links
1	PDSPProd2_MC_1GeV_reco_sce_datadriven	describe, summary, files
2	PDSPProd2_MC_2GeV_reco_sce_datadriven	describe, summary, files
3	PDSPProd2_MC_3GeV_reco_sce_datadriven	describe, summary, files
6	PDSPProd2_MC_6GeV_reco_sce_datadriven	describe, summary, files
7	PDSPProd2_MC_7GeV_reco_sce_datadriven	describe, summary, files

Started the study of proton identification with the pion beam sample at 2.0 GeV

Truncated Mean dQdx



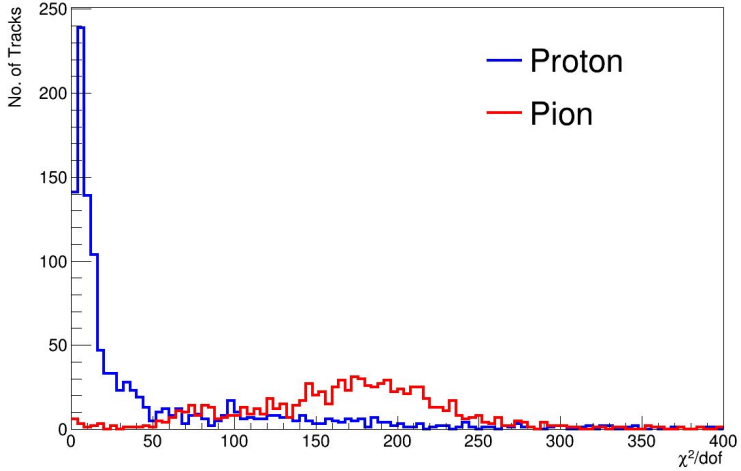
Tracks travel along wire direction?

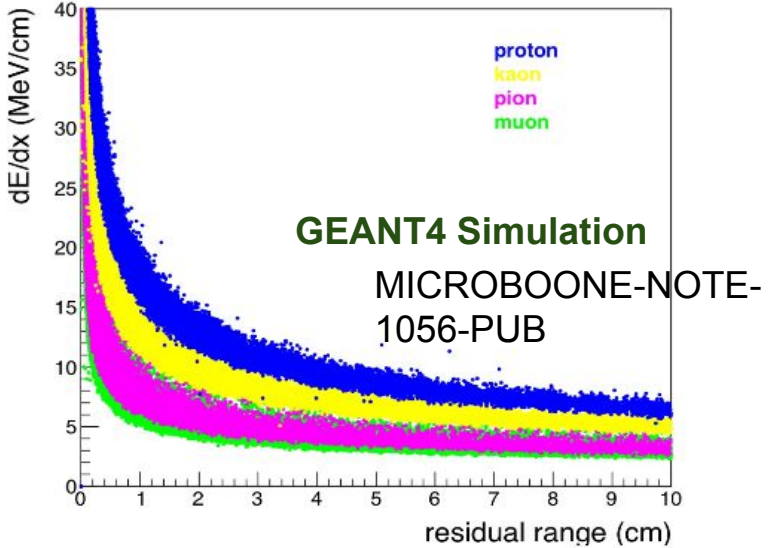
- Truncated Mean dQdx was calculated form collection plane with ADC/cm.
- Calculation
  - Take the dQdx of all the hits for a given track and save as a vector
  - Get the median value and the RMS of the vector elements
  - Select the hits with dQdx greater than median - n*RMS and less than median n*RMS; save all the hits in this range in a new vector (n=2)
  - Get the mean value of the new vector

Three Region

- I. Pion region (™ dQdx<300)
- II. Transition region (need further background subtraction)
- III. Proton region (™ dQdx>500)

Chi2: shows agreement between theoretical prediction and measurements

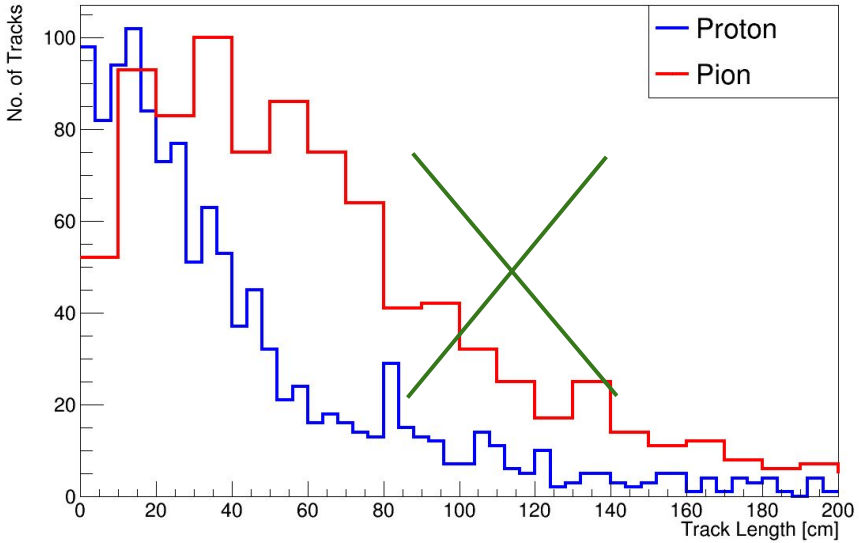




- *ndof*: number of hits in the collection plane

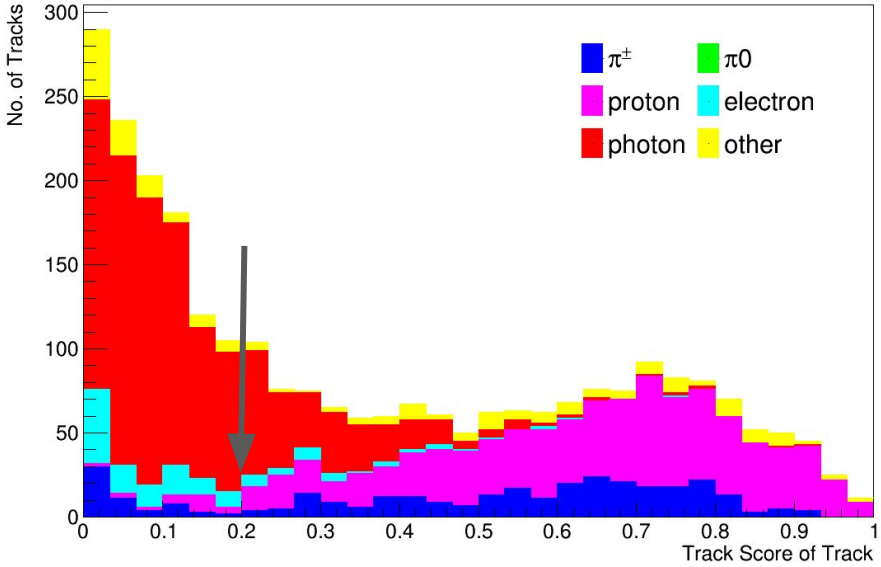
$$PID = \chi^2_{proton}/ndof = \sum_{hit}(\frac{(dE/dx_{measured} - dE/dx_{theory})}{\sigma_{dE/dx}})^2/ndof$$

Track Range of Proton vs Pion result



- No obvious separation in track range
- Even no obvious separation in the truncated mean dQdx vs residual range.

Track Score of Tracks



- Pure Background (non - proton tracks) Region with track Score < 0.2
- Further background subtraction can be done with the combination of the other variables

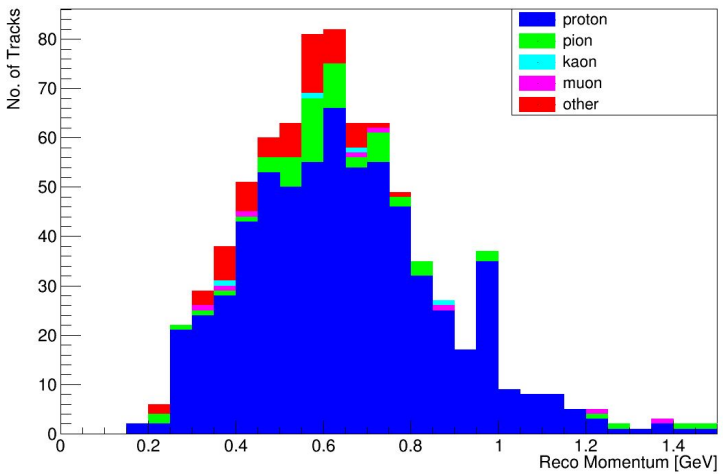
Proton Identification Strategy

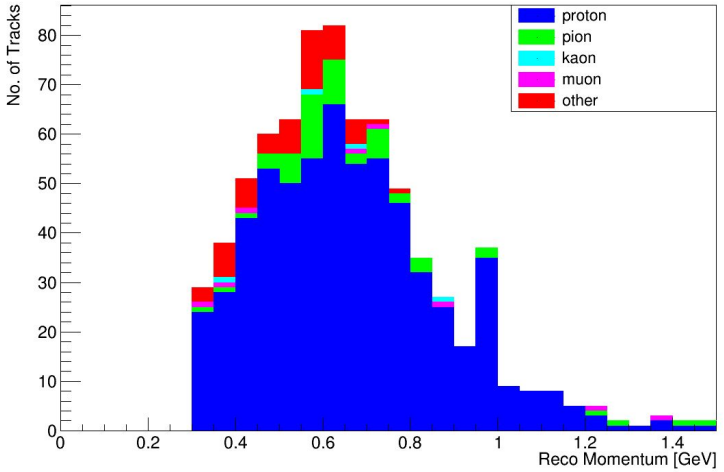
- A proton identification scheme is based on truncated mean dQdx, track(EM) score and chi2
- Background if:
  - Truncated mean dQdx < 300
  - 300<Truncated mean dQdx < 500 && chi2 with proton hypothesis > 200.
  - Track Score <0.2
- More sophisticated scheme can be developed.
  - But considering the efficiency and purity, the current result is pretty good.
  - Complexity will make systematic evaluation more complicated.

Proton Identification Strategy

- Efficiency :
  - Denominator: Number of true protons with/o (true) momentum cut
  - Numerator: Number of true protons with/o (reco) momentum cut
  - Definition is different from the event reconstruction/selection efficiency
- Purity:
  - Signal / background after proton identification with/o momentum cut

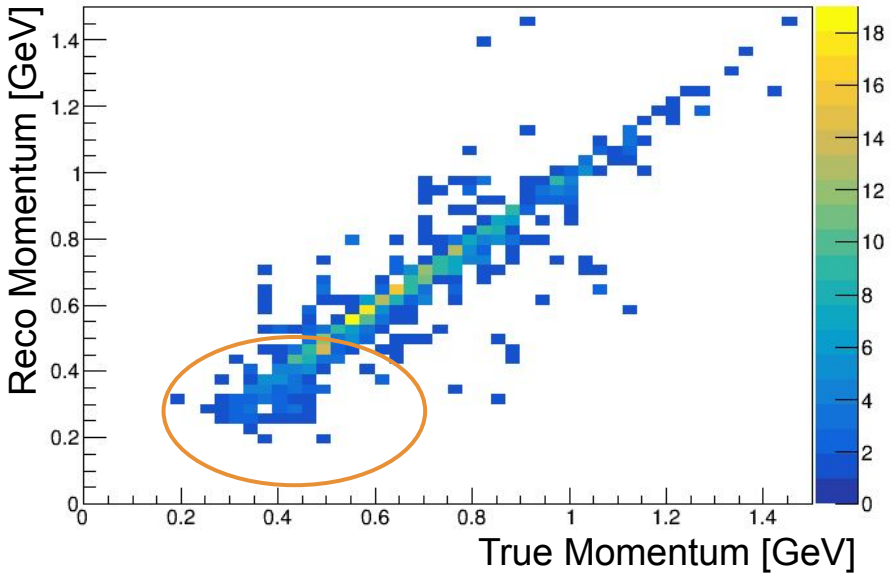
Final Efficiency and Purity





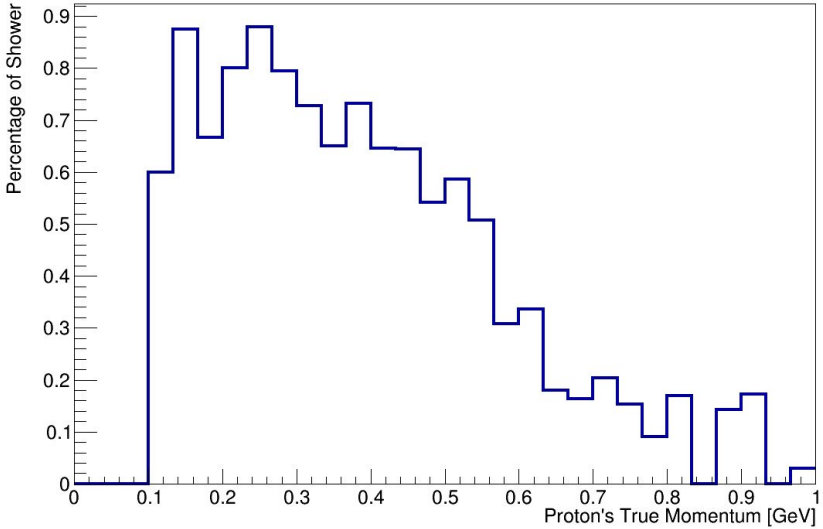
	No Threshold Cut	300MeV
Efficiency	53.7%	52.4%
Purity	83.7%	83.8%

Momentum Resolution of Selected True Protons



- Reco Momentum is calculated based on Track Range
- At low momentum region, a lot of proton's momentum are underpredicted, which means cutting off the tracks with reco momentum < 0.3 GeV might cause the removal of the tracks with true momentum > 0.3 GeV
- Diagonal dist shows a good agreement and precision

Protons mis-identified as showers



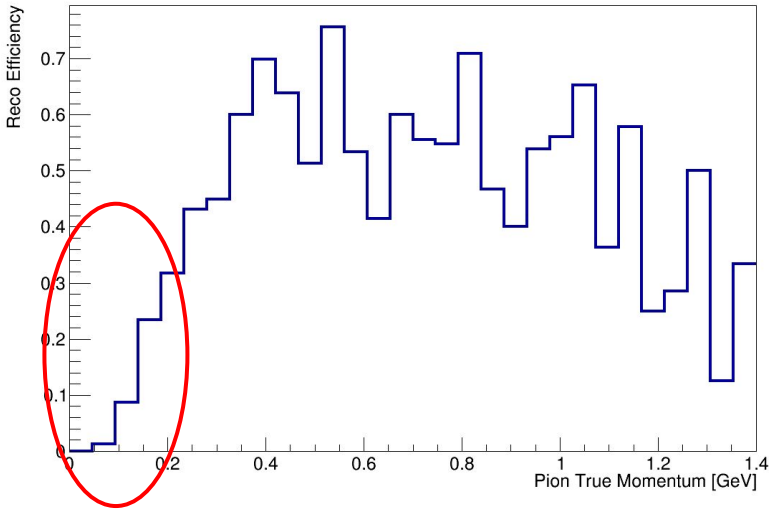
- The lower the momentum, the more protons reconstructed showers.
- When the momentum around 0.2-0.3 GeV, even ~80% of the protons reconstructed as showers.
- 0.3 GeV is reasonable as the momentum cut

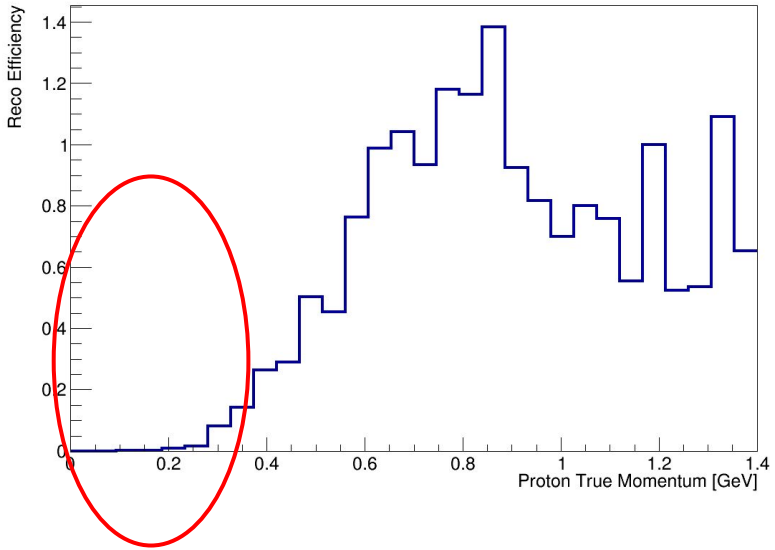
Summary & Plan

- Proton identification algorithm was developed based on the truncated mean dQdx, chi2 and track score of the track candidates
- Purity 84% and Efficiency 54% after the identification
- Still some space for improvements for the selections by varying the cut values
- The lower the momentum, the more protons are identified showers
- Next Step
  - Run more samples to confirm the proton identification scheme
  - Similar Scheme can be implemented in the pion identification
  - Select pion absorption sample based on this particle identification
  - Prepare a memo/internal note for the particle identification

Contact me if anyone is interested to join or collaborate (email: jiangl@vt.edu)

Efficiency of Pion and Proton Reconstruction





Lower momentum, Lower reconstruction efficiency