Pion Absorption+Charge Exchange Analysis Update

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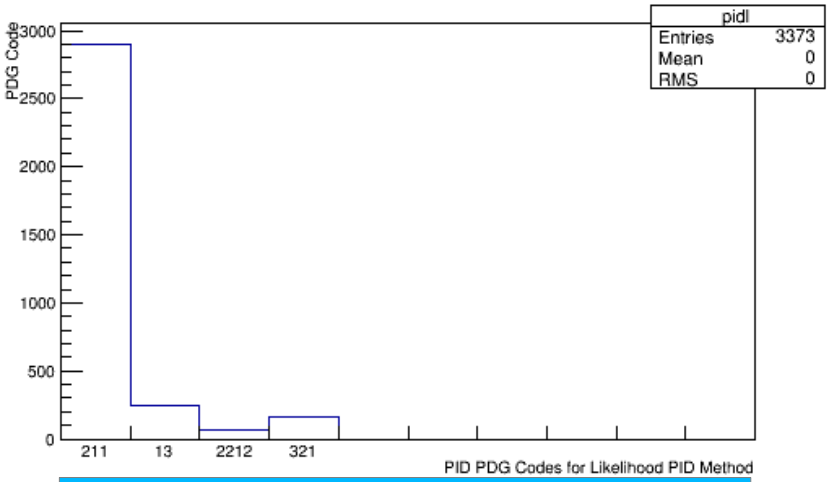
LArIAT meeting on 2/19/2016

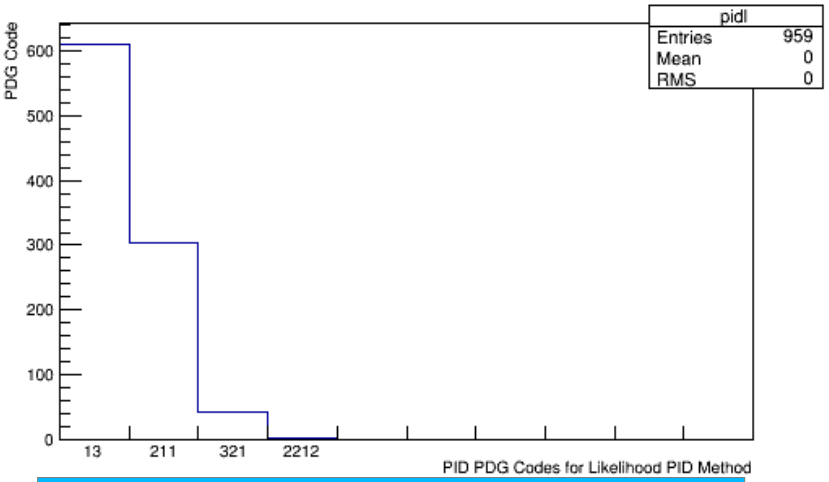
Goals After Last Presentation

- Find out how well Likelihood PID works on tracks entering TPC at different angles
- Implement pion absorption+charge exchange event selector
- Implement Likelihood PID in a LArSoft producer module

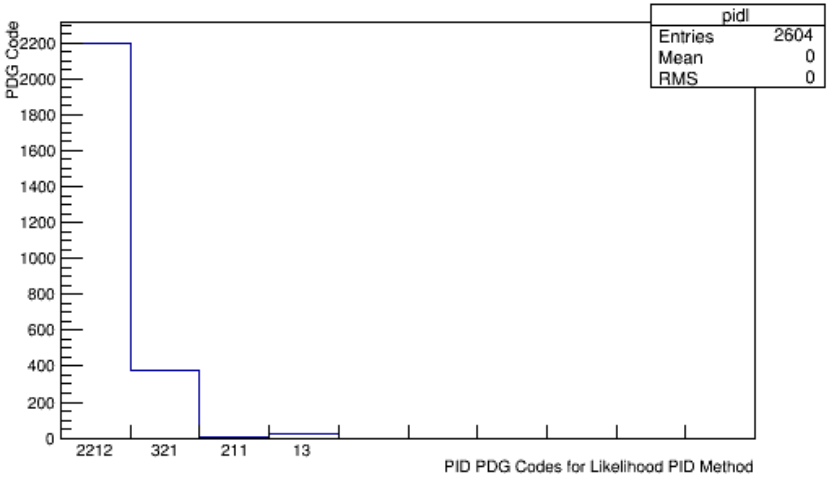
Last Likelihood PID Presentation Summary



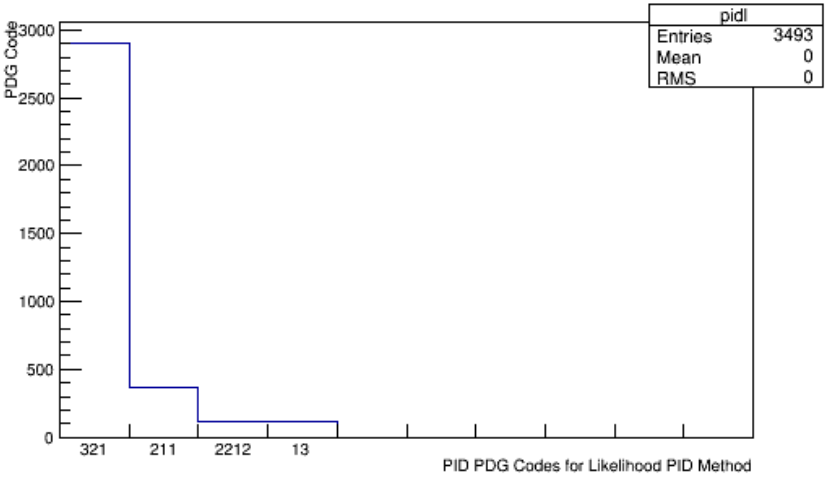
Pi Plus



Mu Minus



Proton

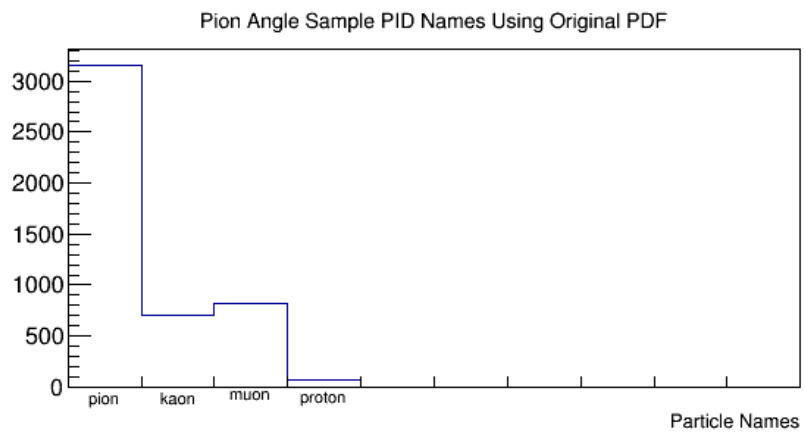


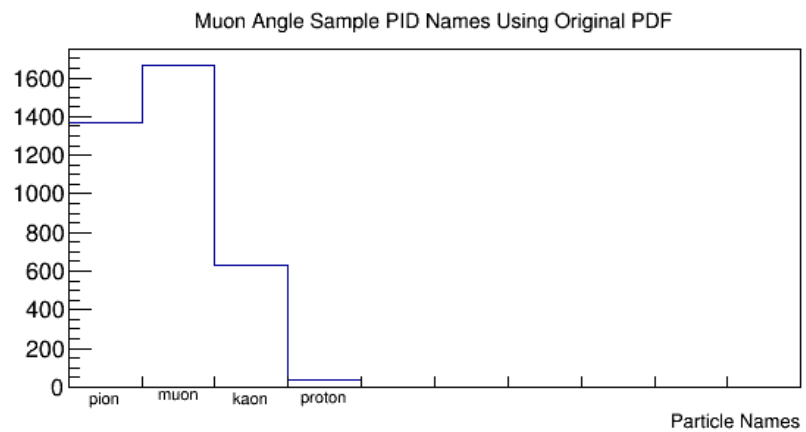
Ka Plus

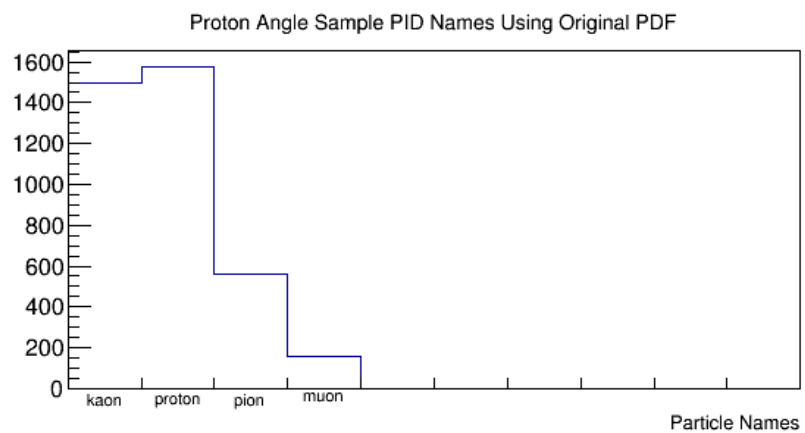
Likelihood PID with Angled Primaries

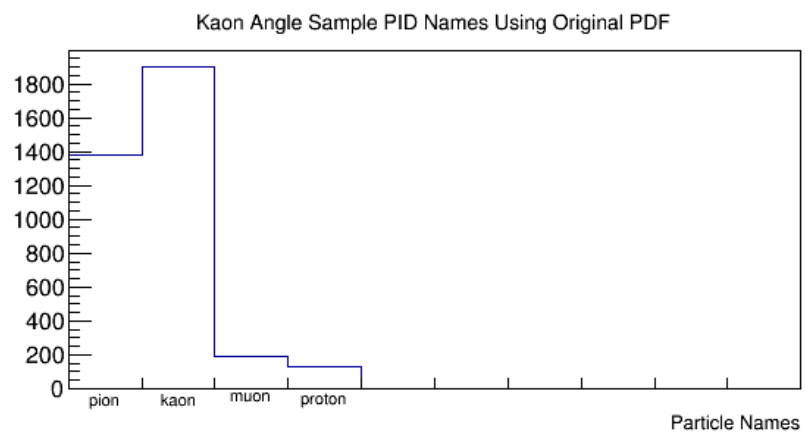
- Angle samples have primaries thrown in a cone with angles w.r.t. the z-axis uniformly distributed such that $0° < \theta < 60°$
- 1e4 pions, protons, and kaons with momenta uniformly distributed between 0 and 1.2 GeV/c
- 1e4 muons with momenta uniformly distributed between 0 and 0.3 GeV/c
- Particles start at z=5cm inside the TPC
- Cut exiting particles

PID for Angle Sample using Original PDF



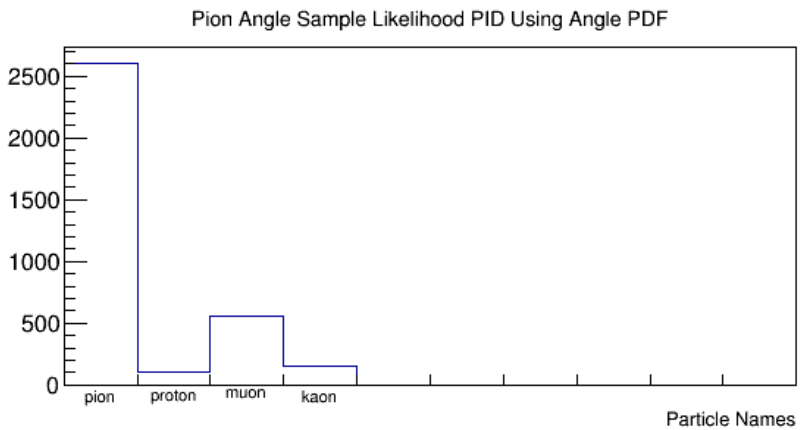


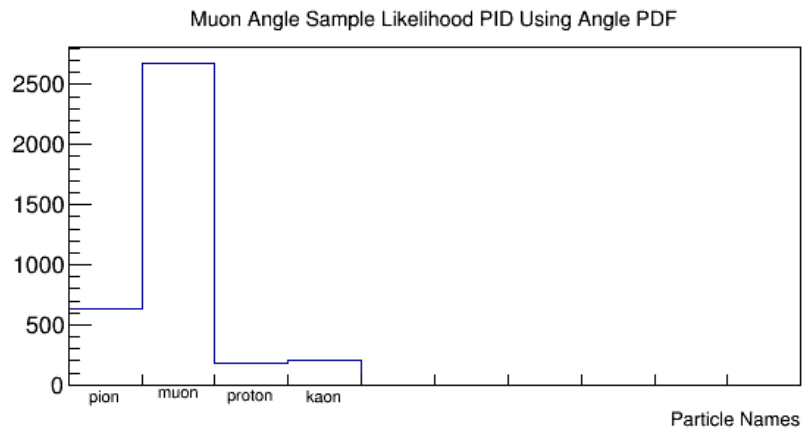


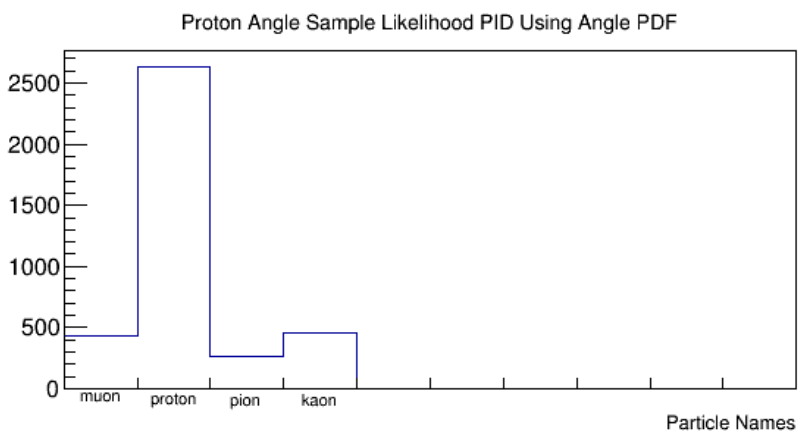


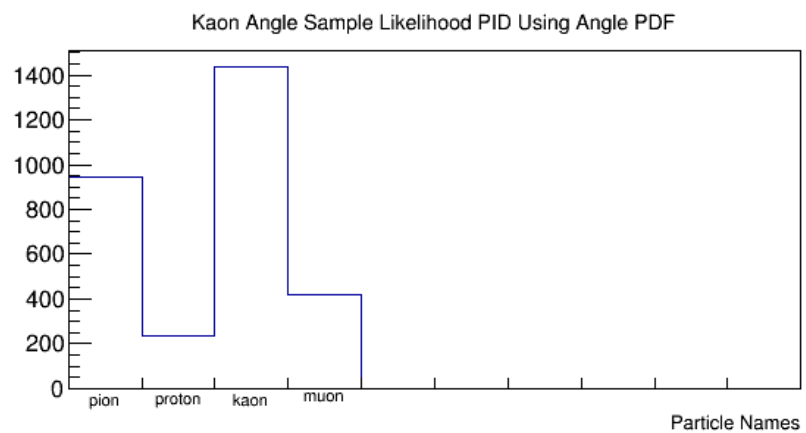
The original PDF does not work well on this sample thrown at various angles

PID Plots with Angles



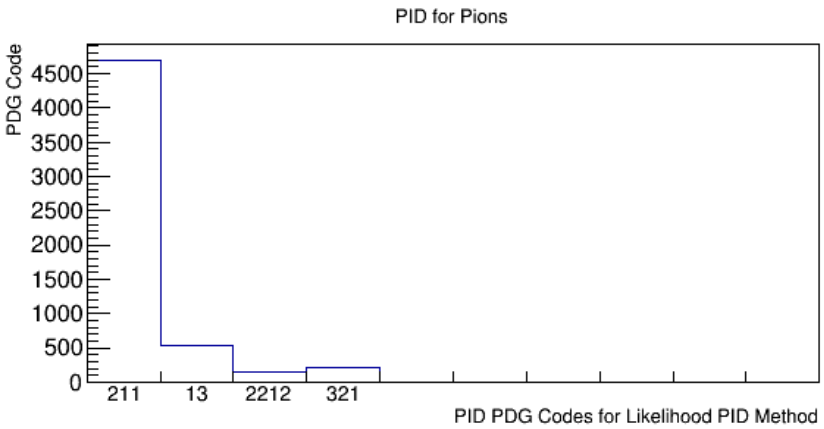


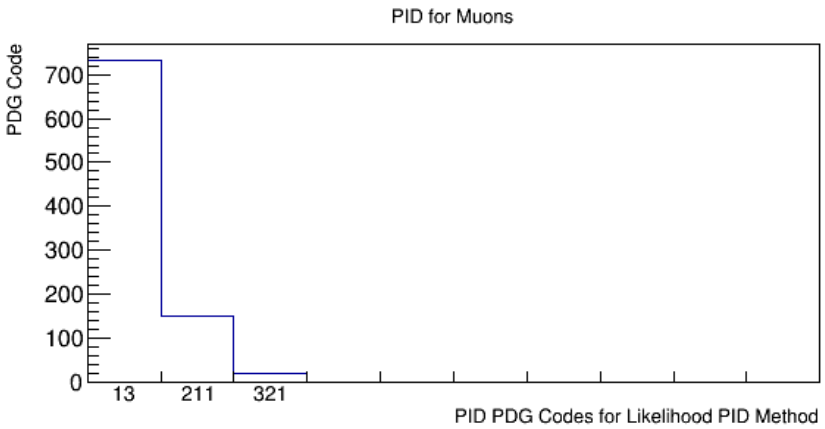


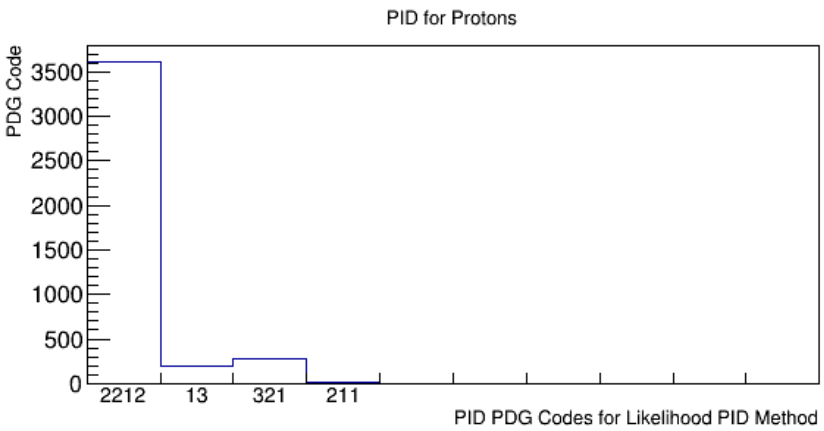


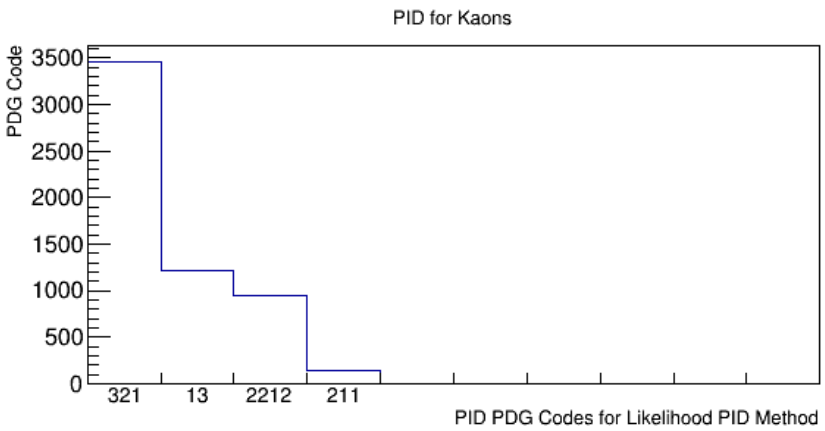
Pions, muons, and protons still identified relatively efficiently, but kaons are now identified as pions

PID for Original Sample using Angle PDF



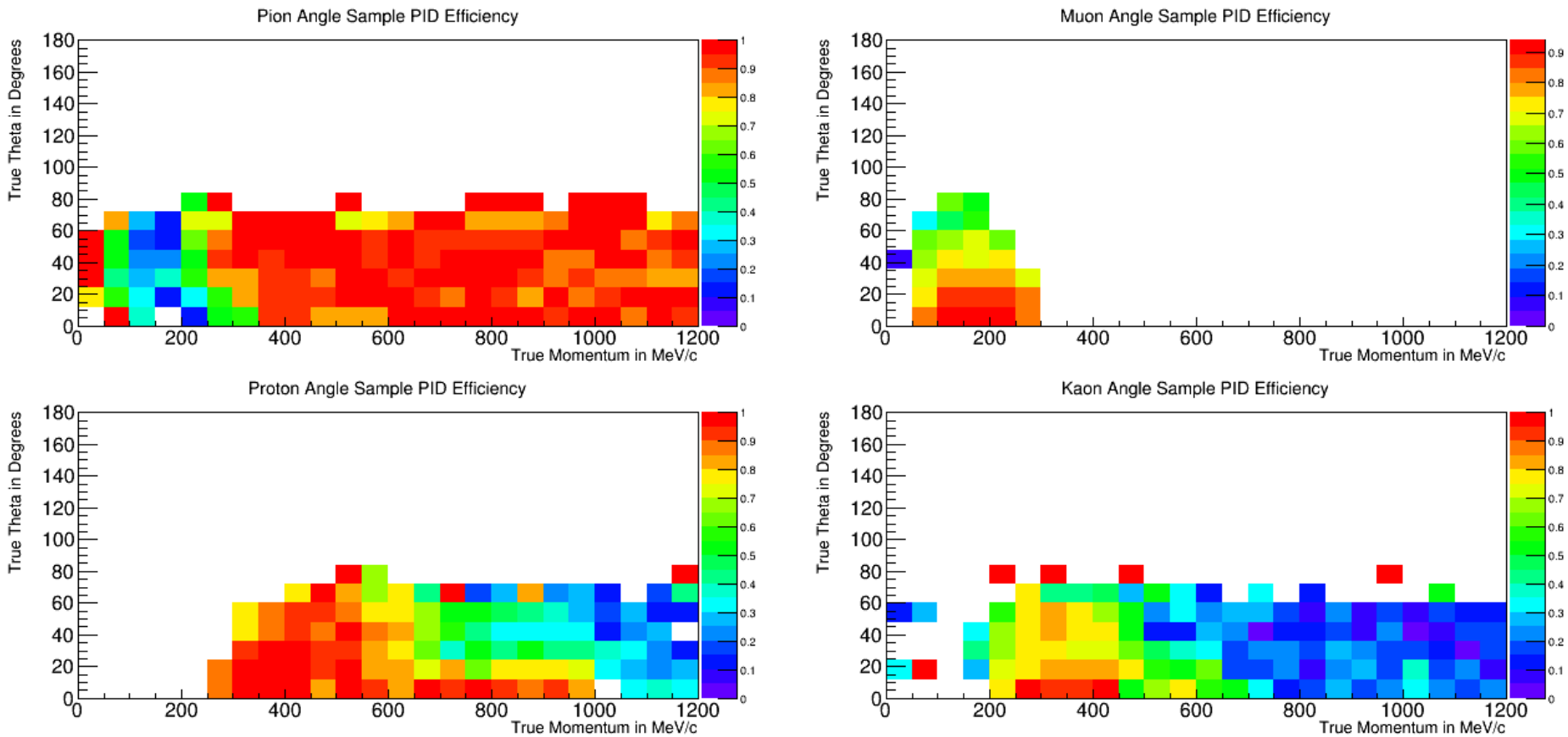






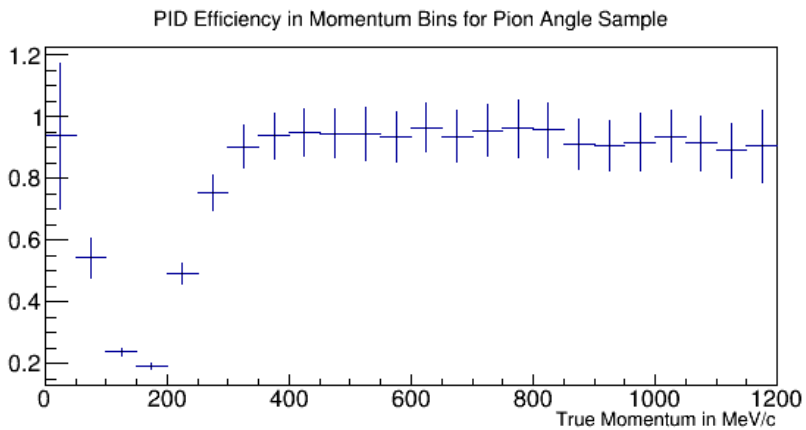
The angle PDF is still reasonably efficient with the original sample

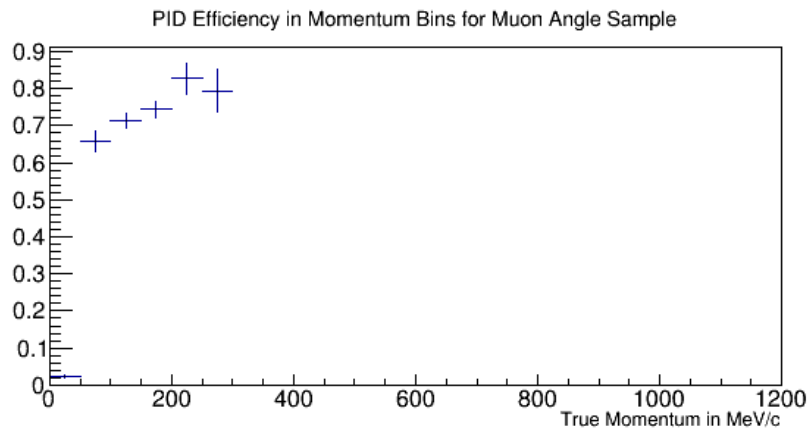
Efficiencies for Angles Sample

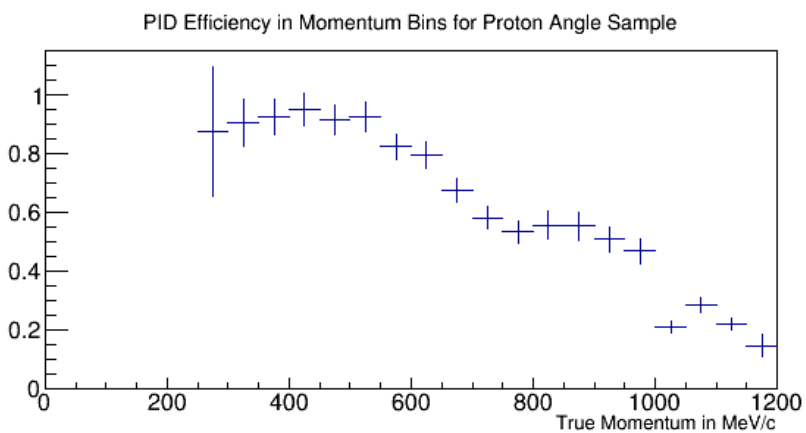


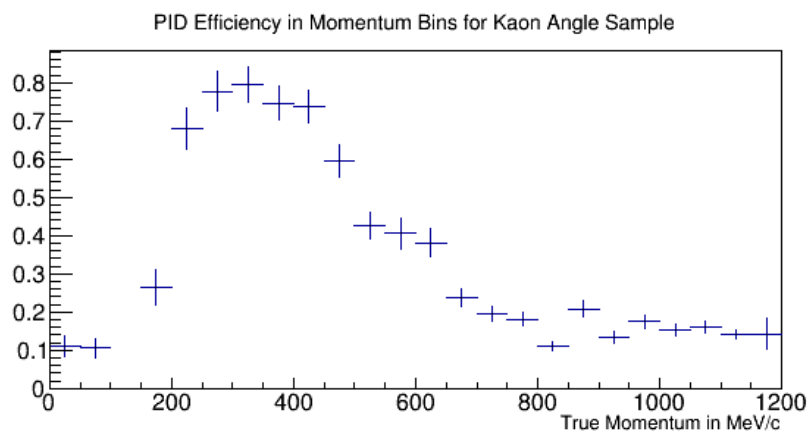
PID may be efficient for high energy pions and low energy particles of every other species

Efficiencies with Momentum



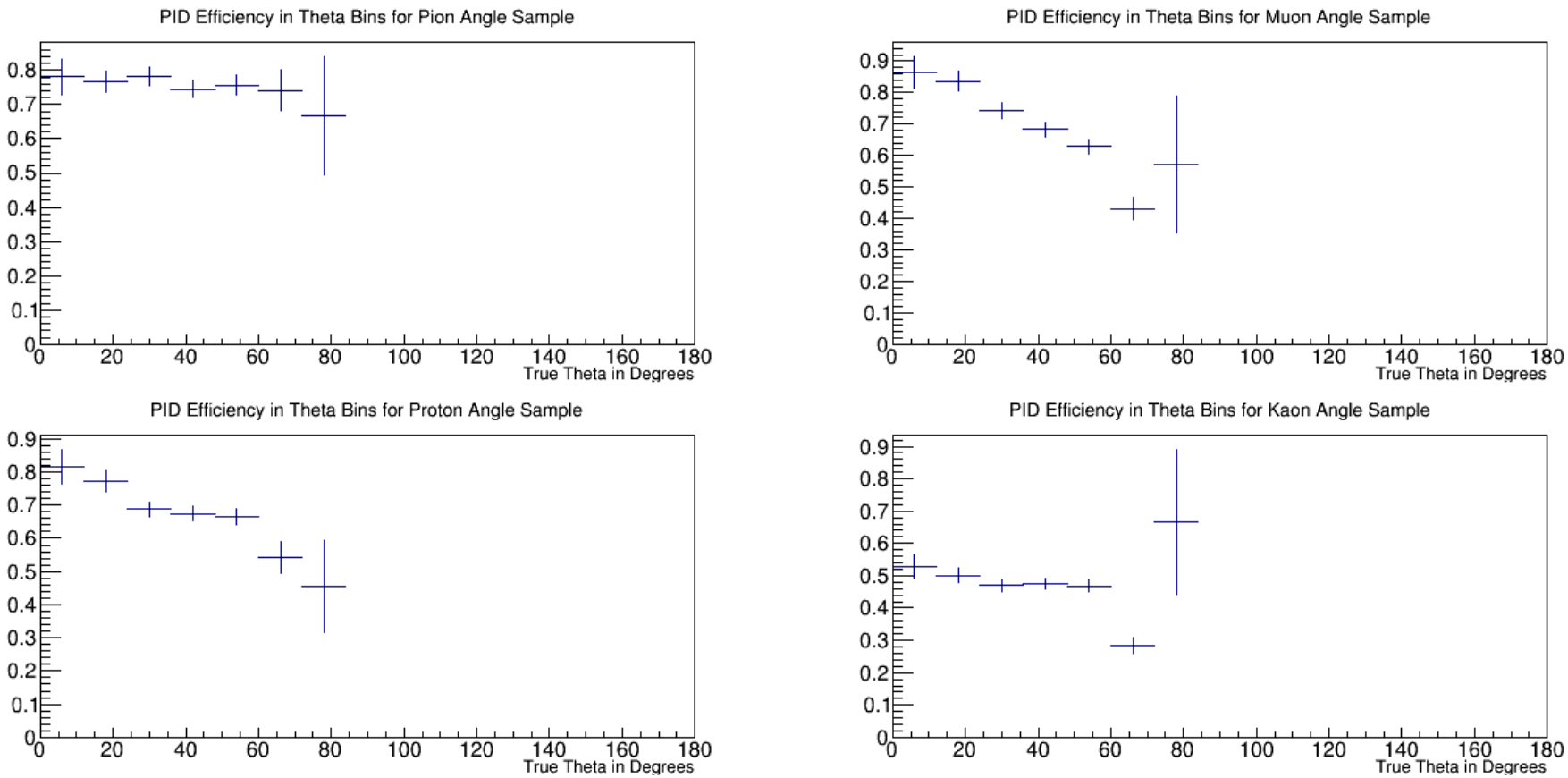






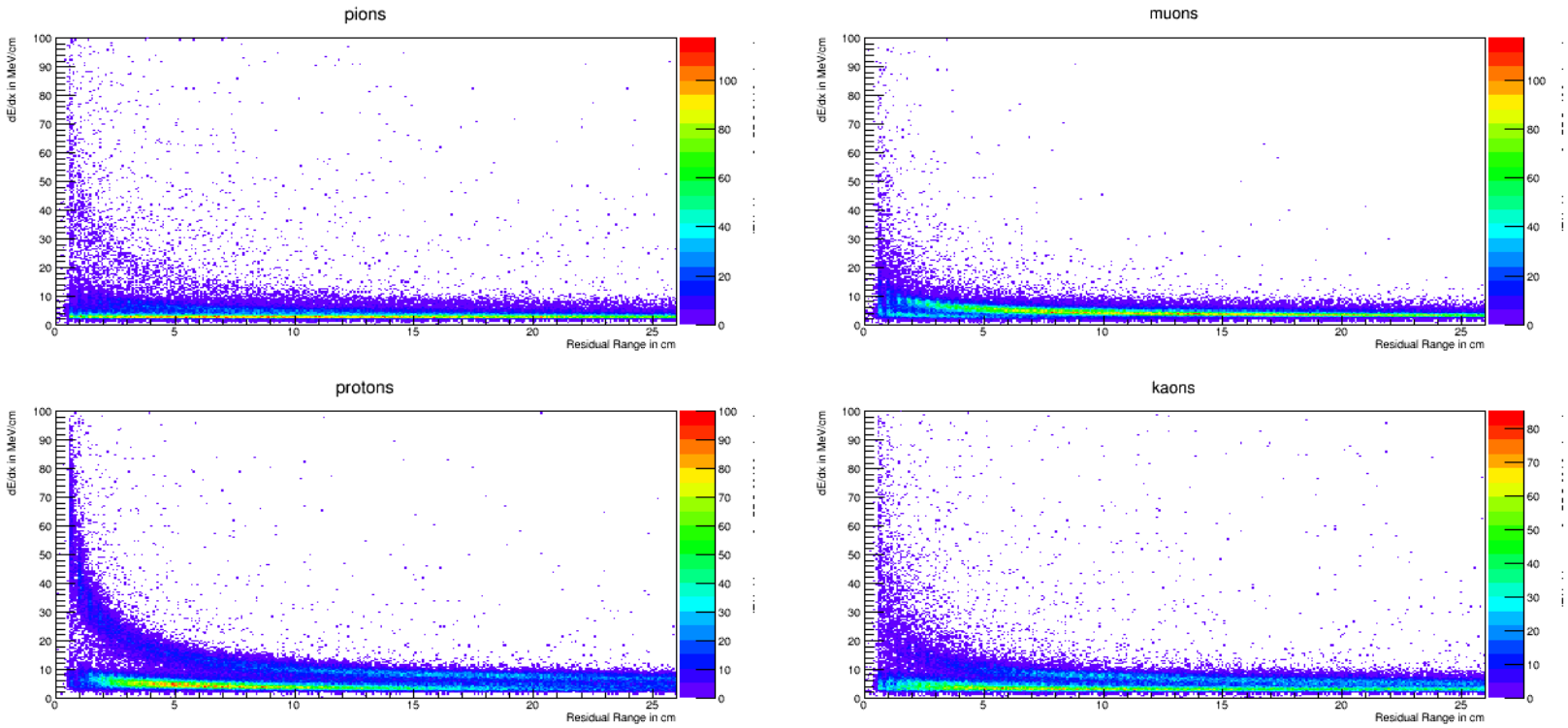
Better detail and error bars on efficiencies versus true starting momentum

Efficiencies with Theta



Better detail and error bars on efficiencies versus true starting angle with the z axis, theta

PDFs with Angles



- Few points in Bethe-Bloch region of PDFs may be cause of regions of poor efficiency

Conclusions and Next Steps

- LikelihoodPID
  - Likelihood PID efficiency seems to depend on angle and momentum
  - Running sample of particles at angles with lower momenta to improve Bethe-Bloch region of each PDF
  - Likelihood PID is ready to be used with higher energy samples for entering pion identification
  - Implement LArSoft LikelihoodPID module
- Pion Absorption+Charge Exchange Analysis
  - Study momentum ranges of typical pion absorption products
  - Make plots of the ratio of misidentified particles in angle and momentum bins
  - Use likelihood-based PID to check entering and leaving particles in pion absorption candidate events
  - Study pion absorption+charge exchange selection on beam sample

Backup Slides

- Begin Backup Slides Below

Backup: Likelihood Definition

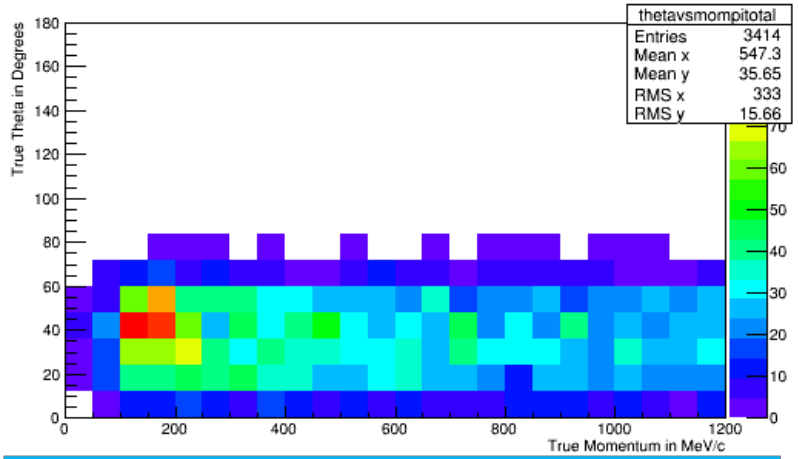
- Given some set of points $\{(x_i, y_i)\}$, (residual range, dE/dx) from an anab::Calorimetry object
- Given a probability density funciton

  f(x , y), a TH2D of dE/dx Versus Residual Range for the purposes of this presentation
- $\ln(L(x_1, x_2, \ldots, x_n, y_1, y_2, \ldots, y_n)) = \sum_i \ln\left(f\left(x_i, y_i\right)\right)$
- To make the best use of double precision values, ln(L) is calculated as a sum of natural logs rather than as a product
- $\ln(L_{pion}/L_{proton}) = \ln(L_{pion}) - \ln(L_{proton})$ is plotted in the likelihood ratio plots in this presentation

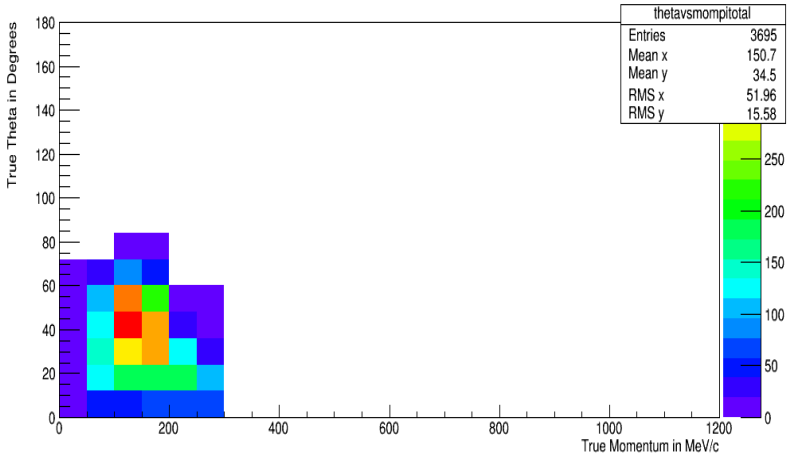
Backup: Technical Software Details

- lariatsoft v01_10_00 e9:debug
- Reco_MC.fcl
  - lariat_calroi
  - gaus_hitfinder
  - standard_clustercrawlerhit
  - standard_clustercrawler
  - standard_linecluster
  - standard_cosmictracker
  - standard_pmalgtrackmaker
  - standard_cctrackmaker
  - standard_calomc

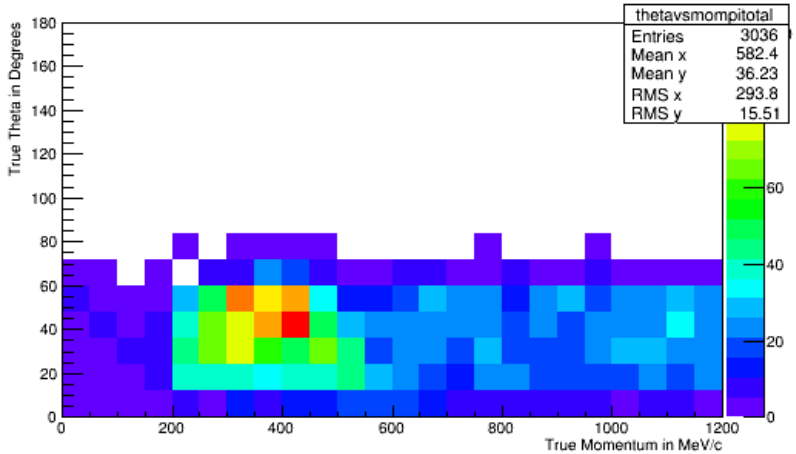
Backup: Number of Particles



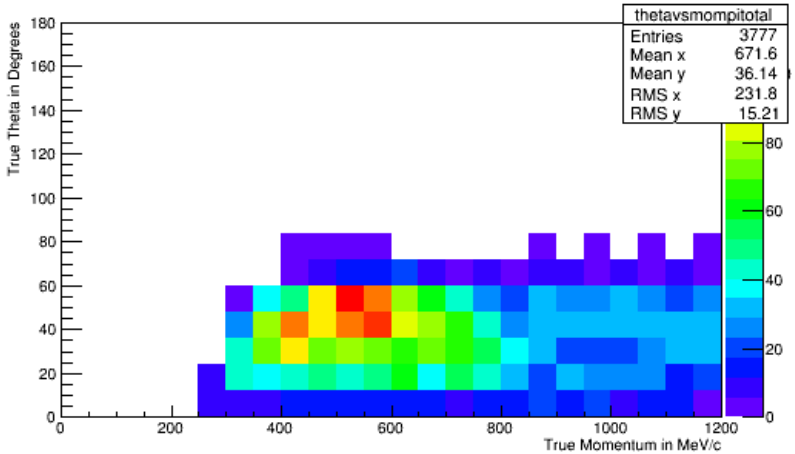
Pi Plus



Mu Plus

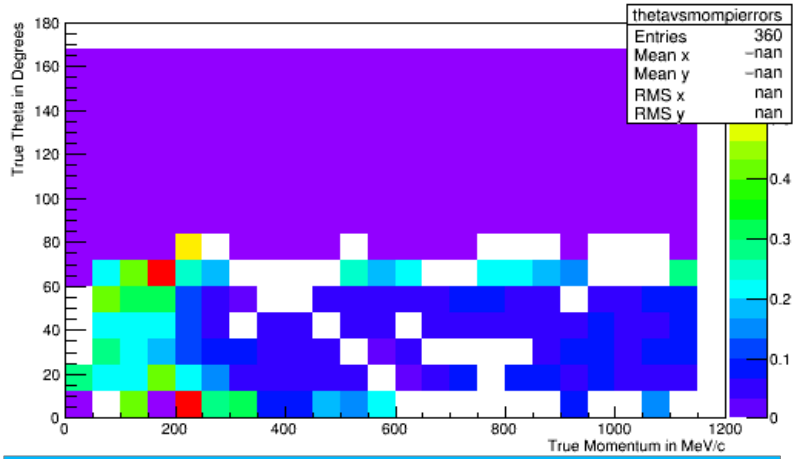


Ka Plus

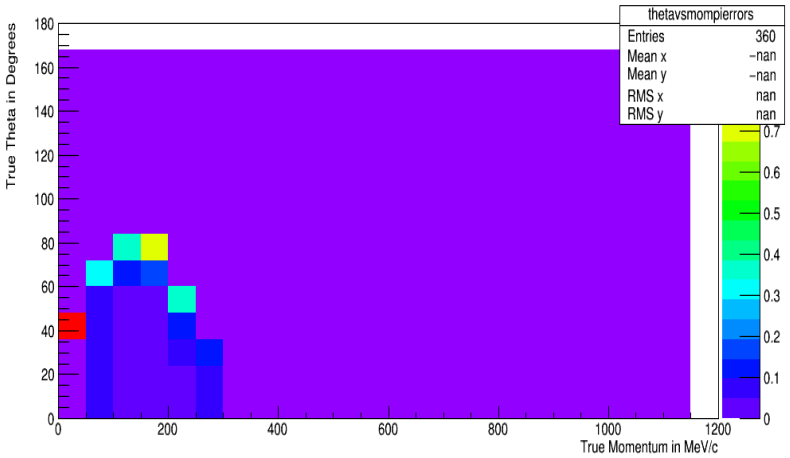


Proton

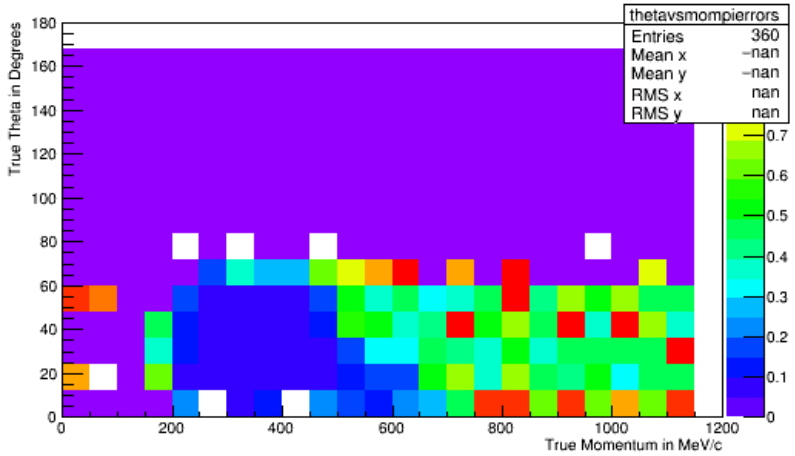
Backup: PID Uncertainties



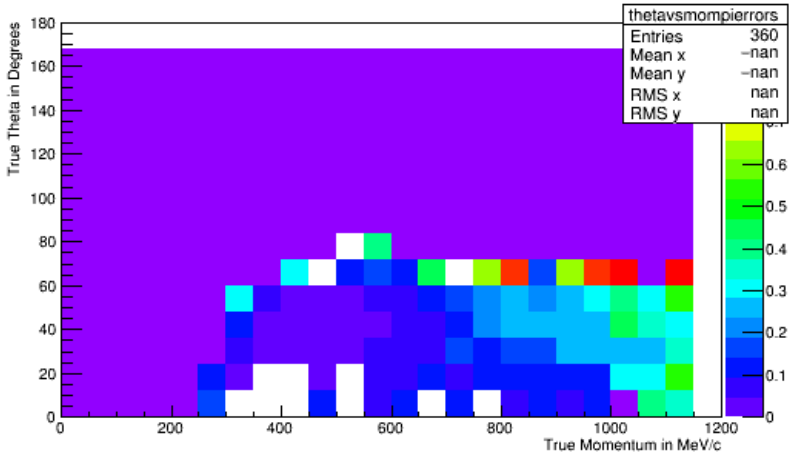
Pi Plus Uncertainty



Mu Plus Uncertainty

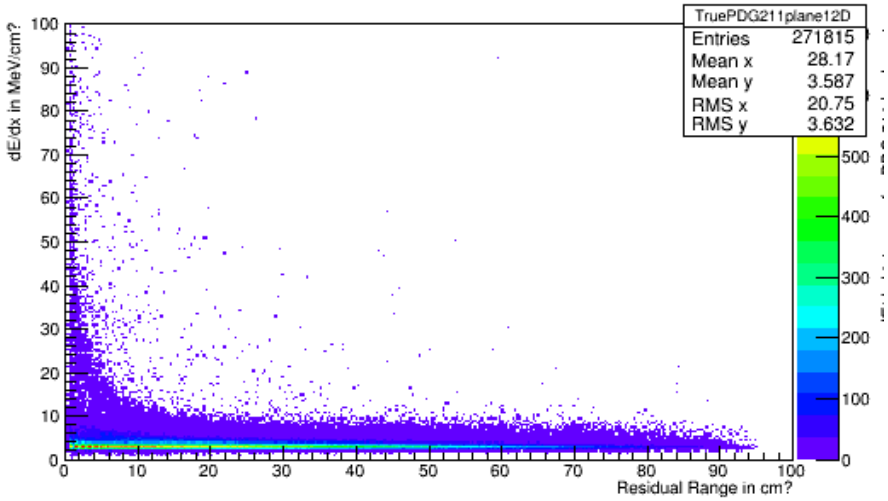
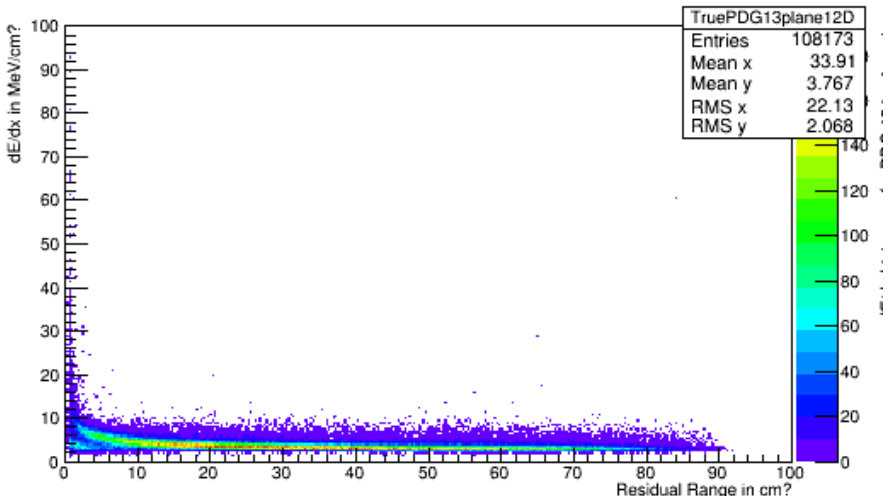
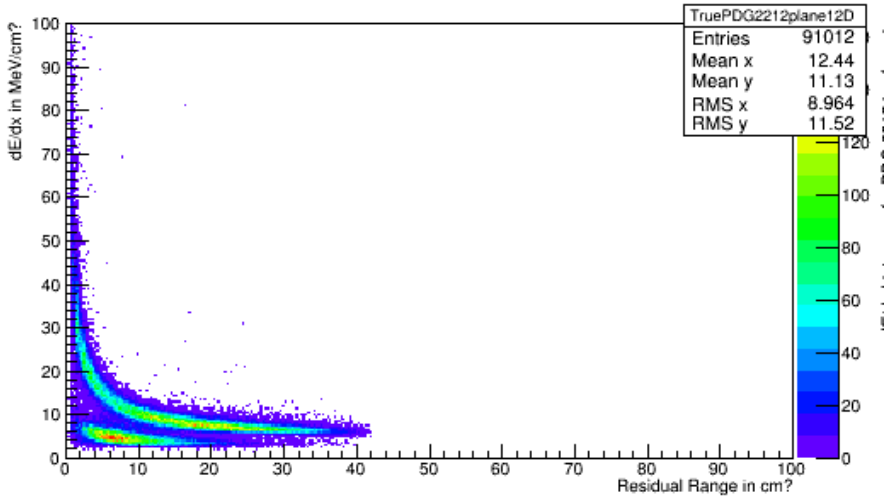
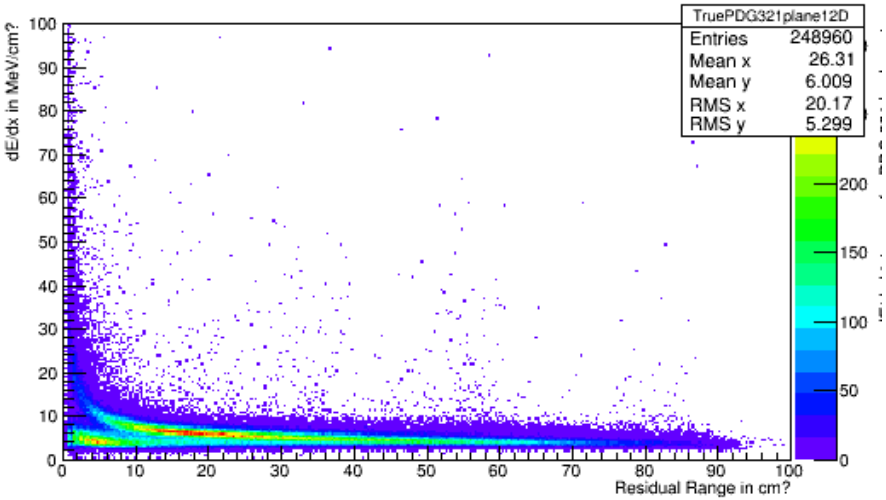


Ka Plus Uncertainty



Proton Uncertainty

Backup: Environment and Reconstruction Chain for Original Likelihood PID Study

- lariatsoft v01_07_00 e7:prof: future jobs ready to be run on develop branch
- Samples:
  - 10000 protons, ka+, mu-, pi+ with momenta uniform in [0.3, 0.90]
  - 2000 protons, ka+, mu-, pi+ with momenta uniform in [0.1, 0.5]
  - Z0 set to -39.5388 (front flange from gdml file)
- Reco_MC.fcl
  - lariat_calroi
  - gaus_hitfinder
  - standard_clustercrawlerhit
  - standard_clustercrawler
  - standard_linecluster
  - standard_cosmictracker
  - standard_pmalgtrackmaker
  - standard_cctrackmaker
  - standard_calomc
  - standard_chi2pid
  - lariat_primaryvertex

Backup: PDF from Sample Without Angles