Kaons and Other 6+ GeV Particles Beam Update

Richie Diurba

diurb001@umn.edu

Introduction

Progress of 6 GeV sample:

- Conducted truth studies to ensure Geant4 cross section met simulation
- Used dE/dx calibrations Jake put in protoduneana to recalibrate my samples and test dE/dx distribution.
- Made miniature particle gun Prod. 3 sample to validate the new refactored simulation.

Special Thanks:

- Heng-Ye for writing the truth studies module to measure the inelastic and elastic cross section using MCTruth in MC samples.
- Hans Wenzel for developing the G4HadStudies package to obtain Geant4 cross section inputs and test on small LAr targets.
- Jake Calcutt for instituting ProtoDUNE dE/dx calibration code into protoduneana and Ajib Paudel for creating dQ/dx calibrations as a function of XYZ.

Truth Studies

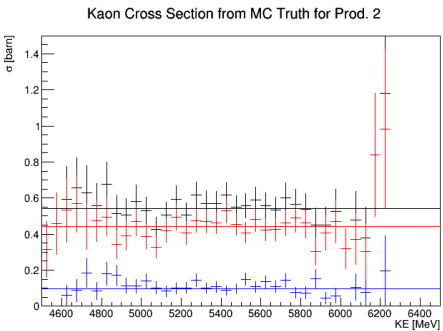
- Take thin slices of the track and bin in interacting and incident histograms based on the kinetic energy.
- Divide the histograms and propagate errors.
- Test for inelastic and elastic cross sections and compare to the Geant4 input.

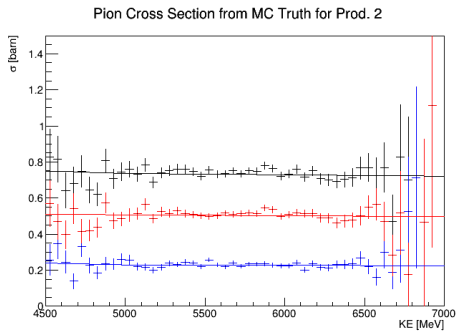
Tested with 6 GeV particles using Prod. 2 samples:

- 1,571 kaons
- 1,400 pions
- 1,989 protons

Prod. 2 Truth Cross Sections

Black=Total σ, Red=Inelastic σ, Blue=Elastic σ

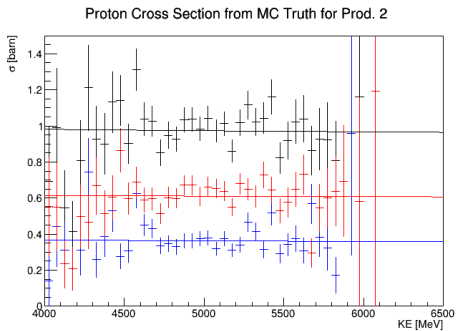




G4 inputs are the solid lines.

Prod. 2 Truth Cross Sections

Black=Total σ, Red=Inelastic σ, Blue=Elastic σ



G4 inputs are the solid lines.

Testing 6 GeV Beam Selection in Simulation

Compared GEANT4 particle determined as the beam candidate in simulation to the Pandora particle reconstructed as beam to measure purity of reco.

Candidates	$\pi+$	π-	K	μ	e	p	γ	other (nuclei)
$\pi+$	80.5%	3.1%	0.44%	6.7%	negl.	7.7%	1.27%	0.5%
p+	4.8%	2.5%	negl.	5.1%	negl.	85.9%.	0.8%	0.6%
K+	3.7%	2.7%	72.3%	12.1%	negl.	7.7%	1.0%	0.3%.

Beam particle from MCTruth separated as a percentage of Geant Good Particle candidates, the equivalent of beam inst. for MCC, in Prod. 2 at p6GeV.

New Beam Composition after Cuts

All cosmics were cut.

Candidates	N_{tot}	N_{cuts}	π	μ	p	K	other
$\pi+$	41466	17963	95.2%	2.6%	1.2%	0.1%	0.9%
p+	7039	2777	2.1%	0.1%	97.6%	0%	0.2%
K+	2421	1073	1.2%	7.7%	1.8%	89%	1.3%

New beam composition with beam cuts

Selecting ProtoDUNE Kaons in Real Life

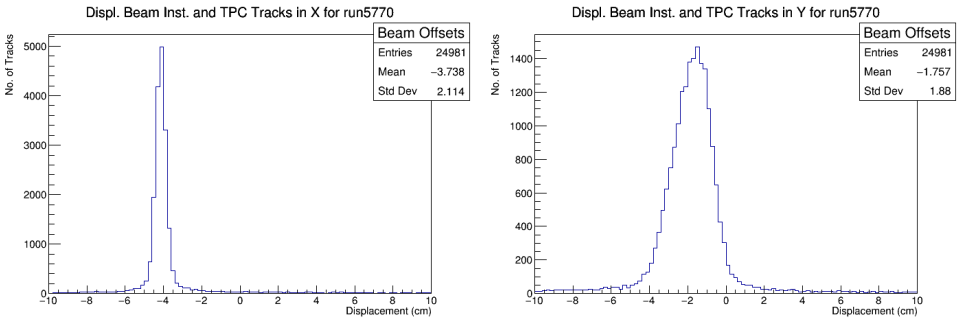
From Alex Booth and Jake Calcultt:

Candidates	High Pressure Cherenkov	Low Pressure Cherenkov
$\pi+$	1	1
p+	0	0
K+	1	0

Beam Instrumentation Tagging for 6-7 GeV

No need for TOF other than as a QA-check. Purely logical candidate selection.

Beam Tracking in Run 5770

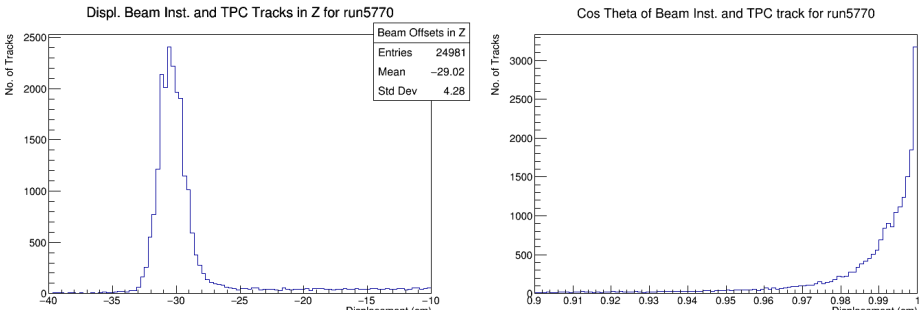


dX (left) and dY (right) for run5770.

Beam Tracking in Run 5770

Based on the plots I made the following, harsh, cuts:

- Data: -6<dx<-3, -5<dy<0, -33<dz<-25, cos>.996



dZ (left) and cosine between the track directions (right) for run5770.

Prod. 2 dE/dx Sample

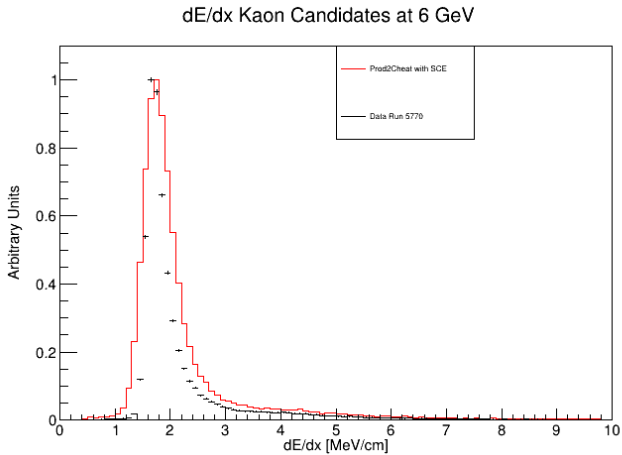
- MC Cheated to ensure G4 MC particle matched beam particle to bump up statistics with the new dE/dx calibration for protoduneana.
- Previous studies have shown that while having a data-like sample is preferred. The dE/dx contamination minimally impacts the distribution of the curve.
- dE/dx was plotted without regard for hit position in z.

Sample:

- 1,908 true proton tracks
- 10,223 true pion tracks
- 516 true kaon tracks

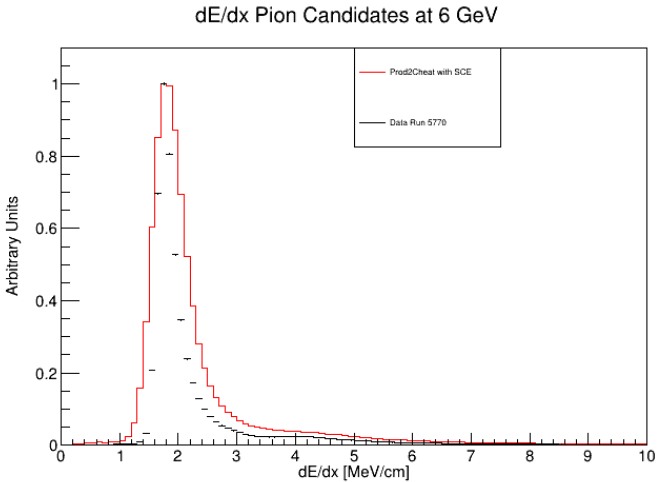
Kaon dE/dx

- Data MPV: 1.65 MeV/cm
- MC MPV 1.75 MeV/cm



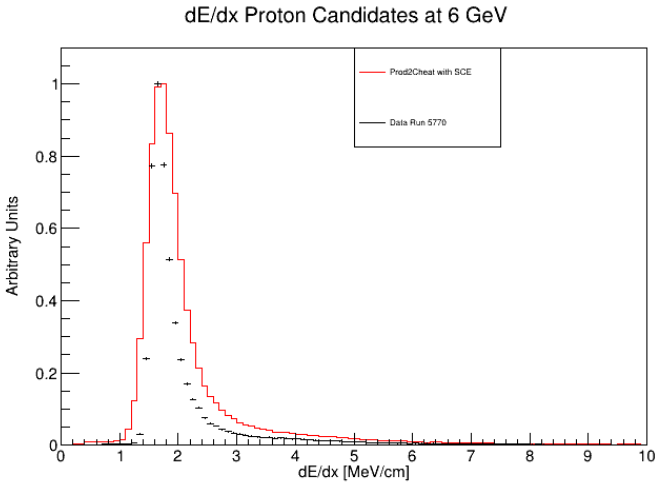
Pion dE/dx

- Data MPV: 1.65 MeV/cm
- MC MPV 1.65 MeV/cm



Proton dE/dx

- Data MPV: 1.65 MeV/cm
- MC MPV 1.75 MeV/cm

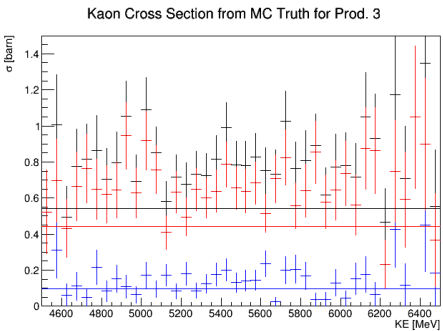


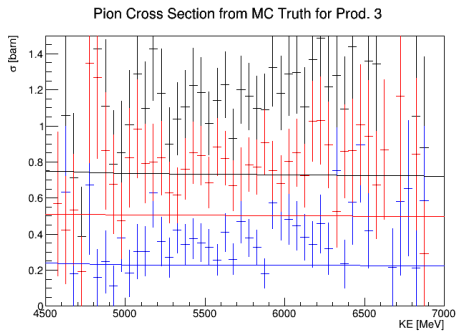
Testing Prod. 3 Simulation

- Took 6±0.5 GeV particles (spectrum from Prod. 2) and shot particles with SCE on but cosmics off using the refactored simulation. Shot 1k kaons, 1k pions, and 1k protons with the mean trajectory and position of the Prod. 2 beam particles.
- Only 500 kaons, 635 pions, and 730 protons survived and made reconstructed tracks, so statistics are limited.
- Measured dE/dx using Ajib's Prod. 3 corrections.
- Rerun all the same tests.

Prod. 3 Truth Cross Sections

Black=Total σ, Red=Inelastic σ, Blue=Elastic σ

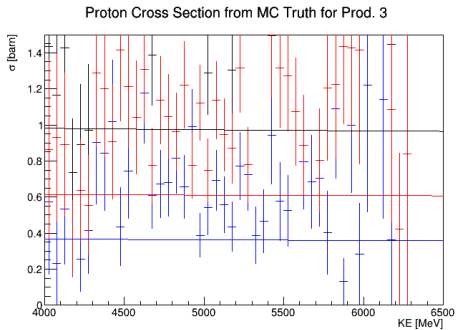




G4 inputs are the solid lines.

Prod. 3 Truth Cross Sections

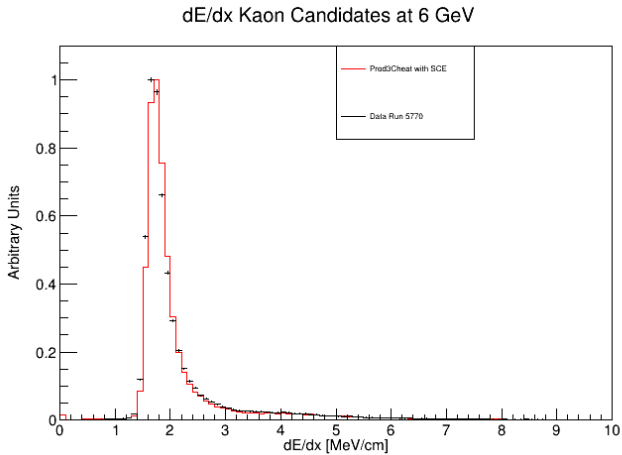
Black=Total σ, Red=Inelastic σ, Blue=Elastic σ



G4 inputs are the solid lines.

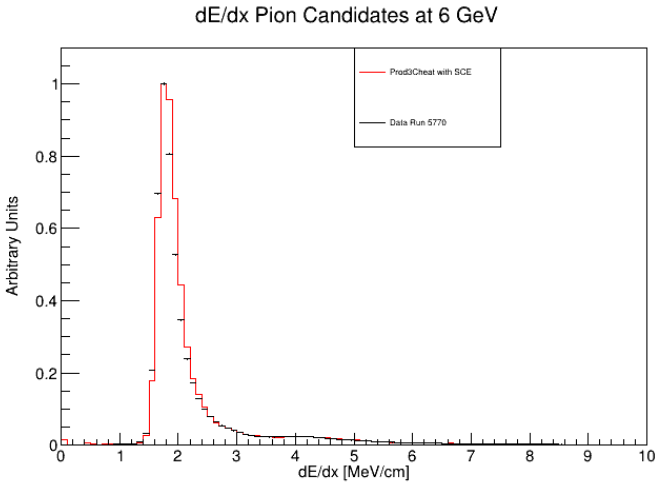
Prod. 3 Sim Kaon dE/dx

- Data MPV: 1.65 MeV/cm
- MC MPV 1.75 MeV/cm



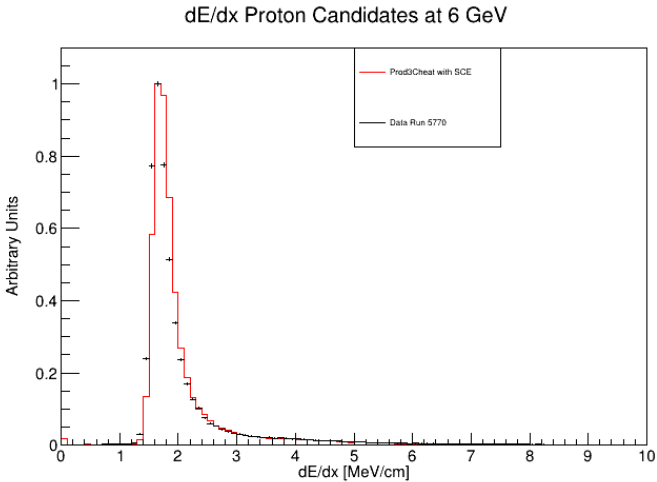
Prod. 3 Sim Pion dE/dx

- Data MPV: 1.65 MeV/cm
- MC MPV 1.65 MeV/cm



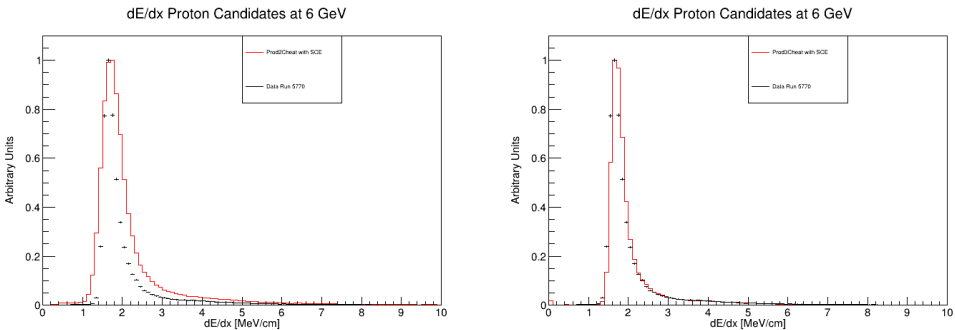
Prod. 3 Sim Proton dE/dx

- Data MPV: 1.65 MeV/cm
- MC MPV 1.65 MeV/cm



Prod. 3 vs. Prod. 2

Simulations have different diffusion parameters so they should look different. Prod. 3 simulation agrees much better with data.



Prod. 2 sim (left) and Prod. 3 sim (right)

Moving Forward

- Issues with 6 GeV beam dE/dx look resolved. Small discrepancies still exist, but nothing worse than the 1 GeV distributions.
- The truth cross sections for Prod. 3 seem a bit high. I will try and make larger samples and samples that avoid the scattering issue I'm seeing in my particle gun.
- Looking towards making a cross section plot with MC and data calorimetry information. I was going to do it this week, but got distracted this week making refactored simulation particle gun samples.