

Data Driven Beam MC

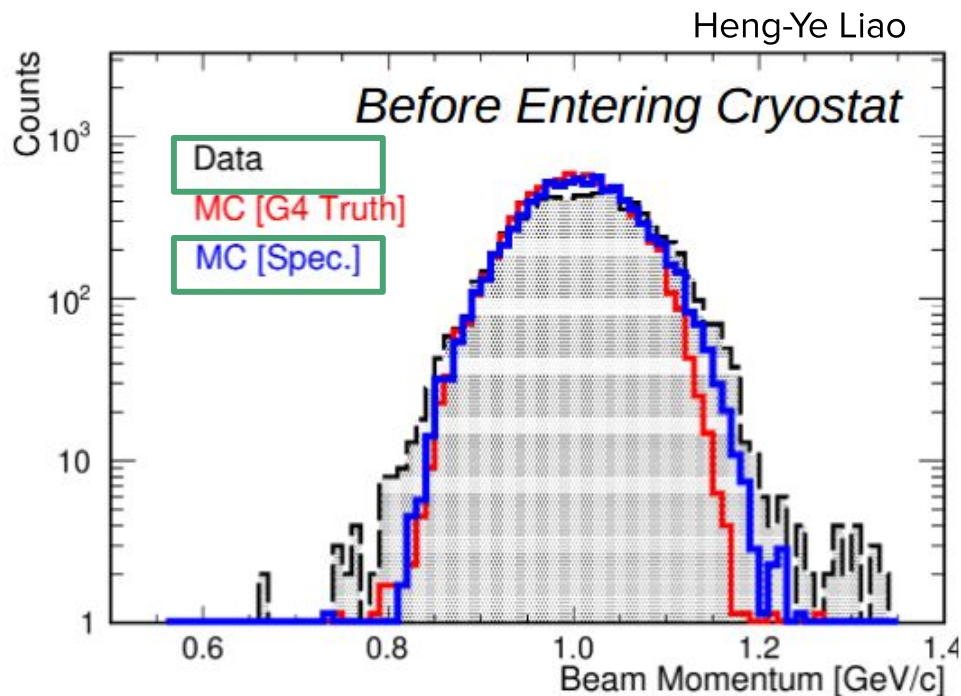
Jake Calcutt

Introduction

Recently, Heng-Ye showed an attempt at treating Data-MC discrepancies via reweighting beam line momentum

Motivated a discussion on the right approach to this and (offline) a different attempt at doing this

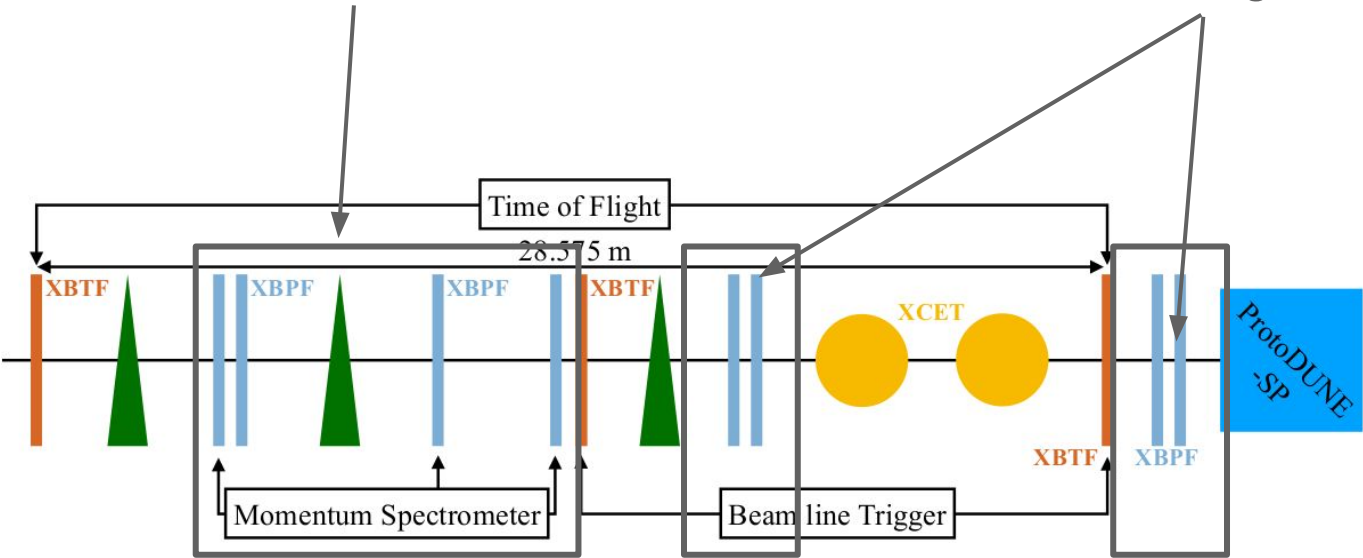
→ Data Driven MC



Data Driven MC

Idea: rather than generate MC based solely on beam line simulation (position & momentum), use the distributions in data as the starting point

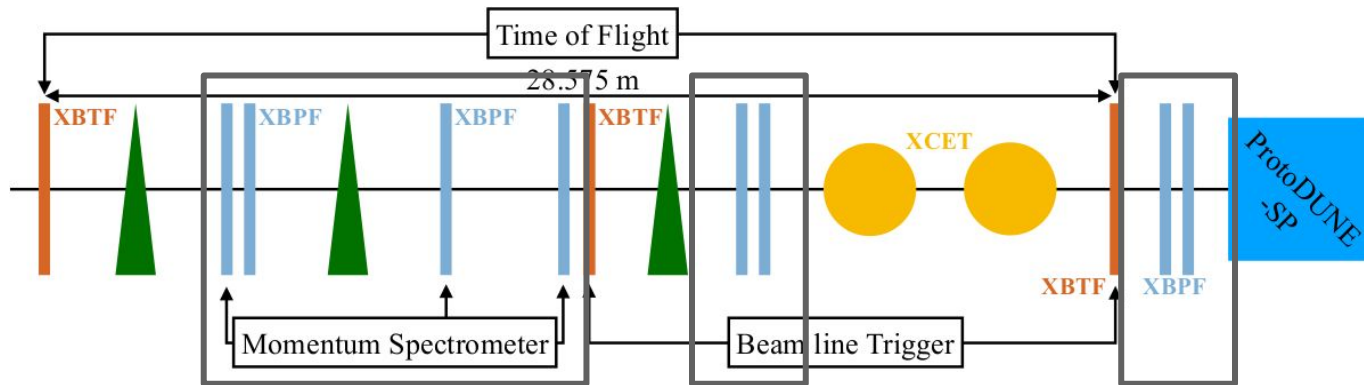
Sample the reconstructed momentum and struck fibers in the tracking monitors



Data Driven MC

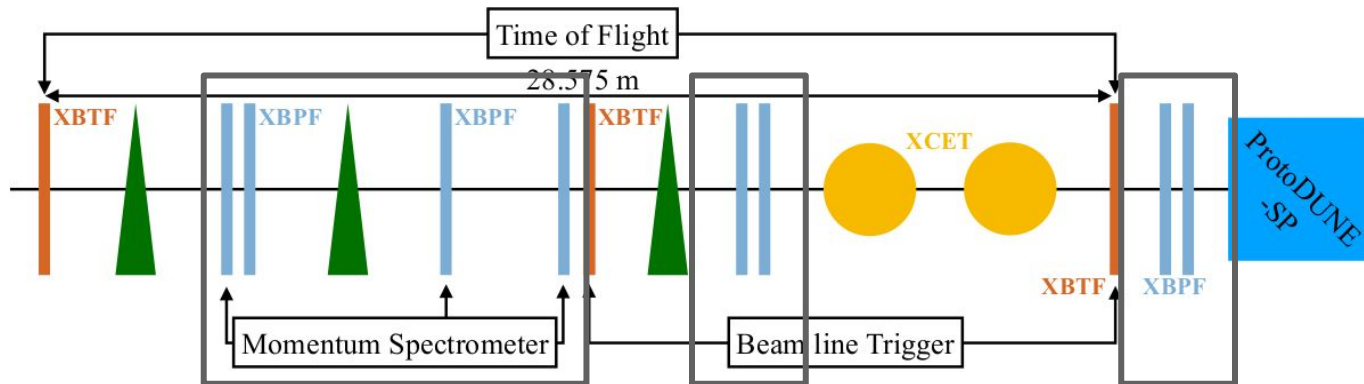
The positions in the tracking monitors will give us the direction & starting point of the generated beam particle (after projecting to some **generator point** -- $z \approx -196$ cm)

Note: using the locations of the fiber monitors & the direction of the beam from surveys \rightarrow Could lead to systematic effects in positions/directions



Data Driven MC

The momentum is a bit trickier: sampling in reco space, but need to generate in true
→ Idea: Unfold from reco momentum in spectrometer to true momentum at the front of the detector



Implementation in dunetpc

Branch in dunetpc: **feature/calcuttj_PDSP_DataDriven_Beam**

Module: **dunetpc/dune/EventGenerator/PDSPDataDrivenBeam_module.cc**

Script to make inputs: **dunetpc/dune/EventGenerator/make_THn_beam_input.py**

Note: needs some preprocessing of data events as an input to this

PDSPDataDrivenBeam_module

Get distributions of momentum & struck fibers from data for

various

number

→

Sample

popula

Sample

Throw

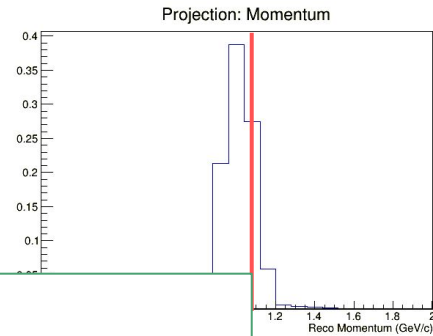
→ Accept/reject accordingly

Notes:

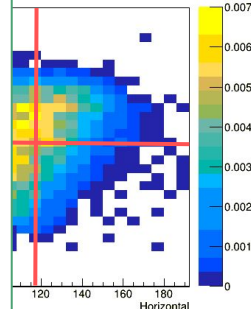
Also fills the ProtoDUNEBeamEvent object

Uses only data events with single fibers struck in momentum spec. & tracking monitors → Most accurate reconstruction

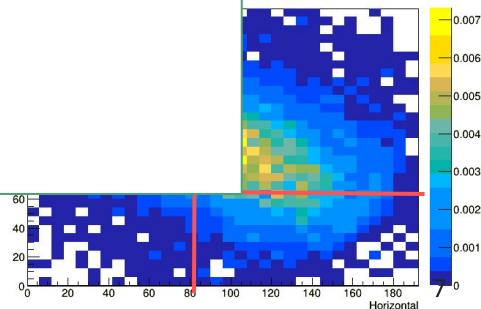
Not creating background particles associated with beam



stream Fibers



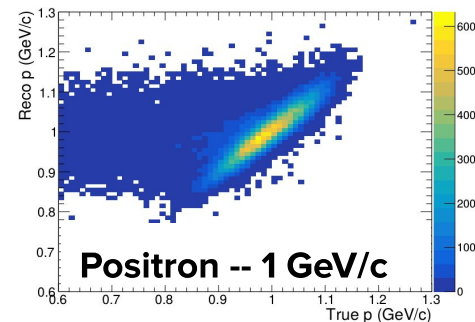
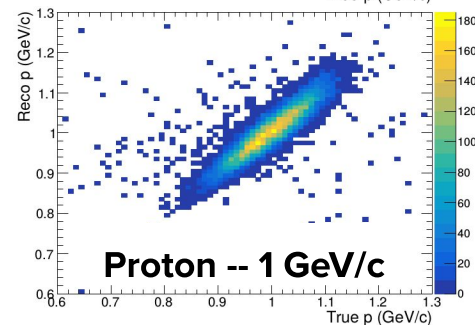
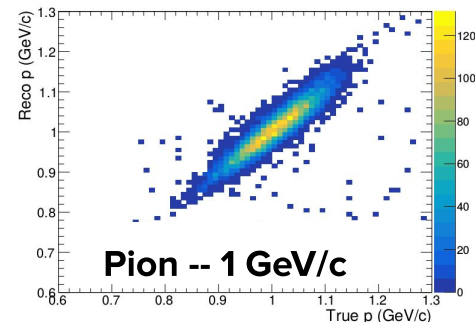
stream Fibers



Reco-to-True momentum

For this: sampling in reconstructed space, but need true momentum at the point at which we generate the particles

- Finite resolution on spectrometer measurement
- Energy loss throughout beamline (most important for positrons)



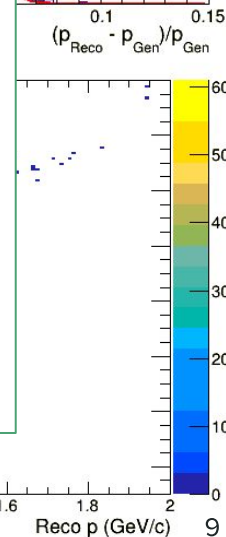
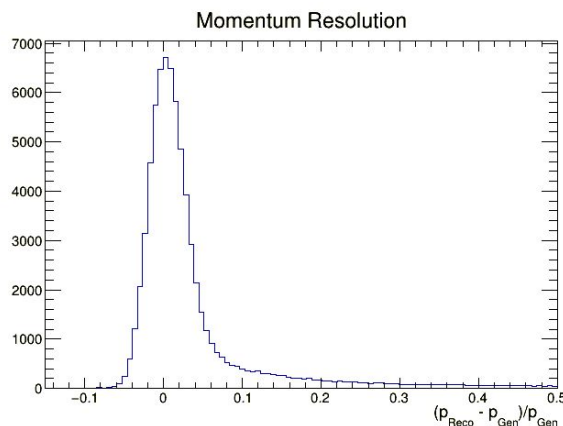
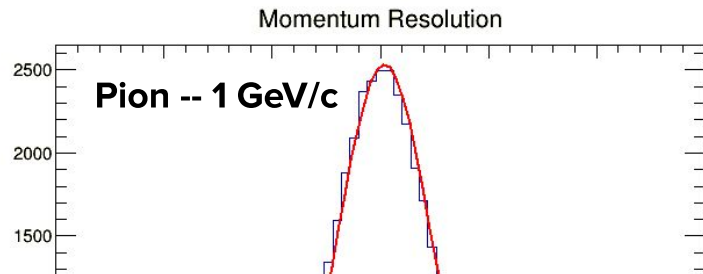
Reco-to-True momentum

Current implementation:

- Fi
- [(r
- T
- Tr
- p

Note:

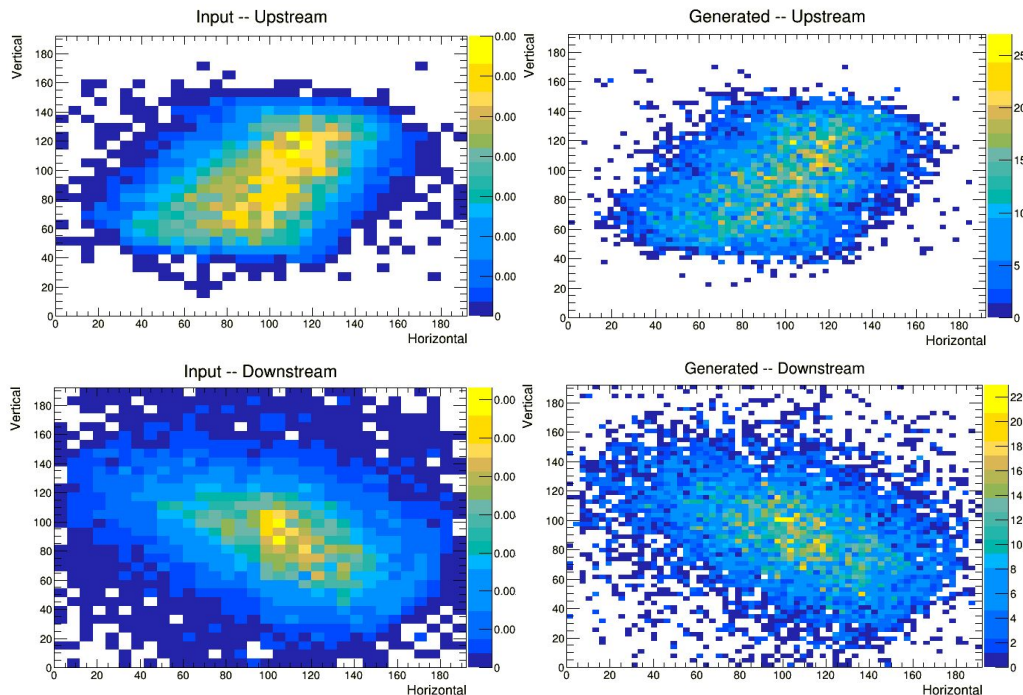
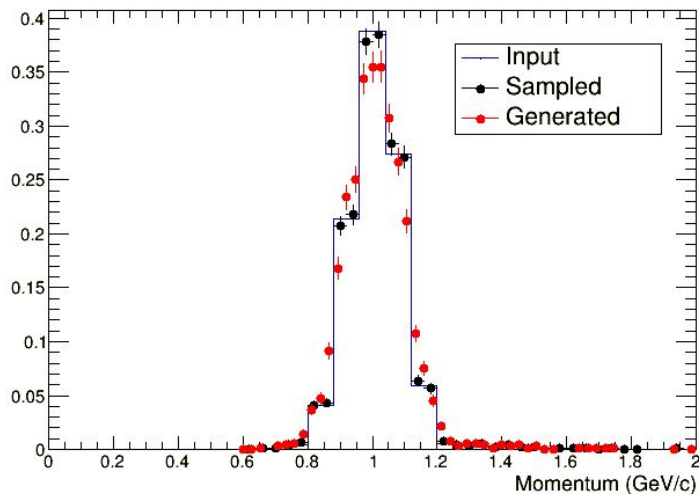
For positrons, this will be slightly different because they lose more energy throughout the beamline



Preliminary Results

Used 1 GeV run 5387 to create PDFs
(selected only pions & protons)

Generated 10k events



Samweb def:

`calcutj_pdsp_datadriven_1GeV_v08_60_00_v3`

Testing

Sent the generated files through the Prod2 reco chain (without cosmics)

Samweb defs:

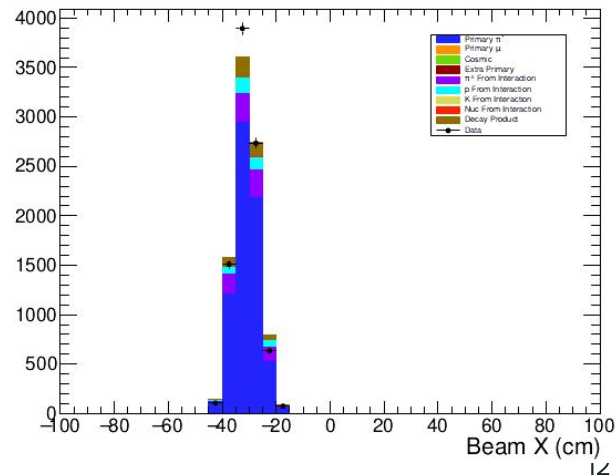
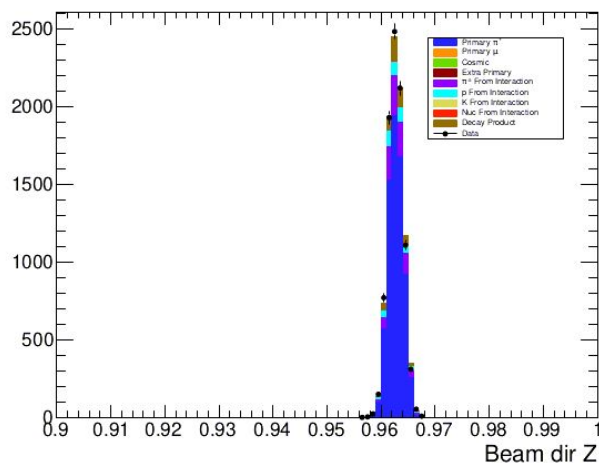
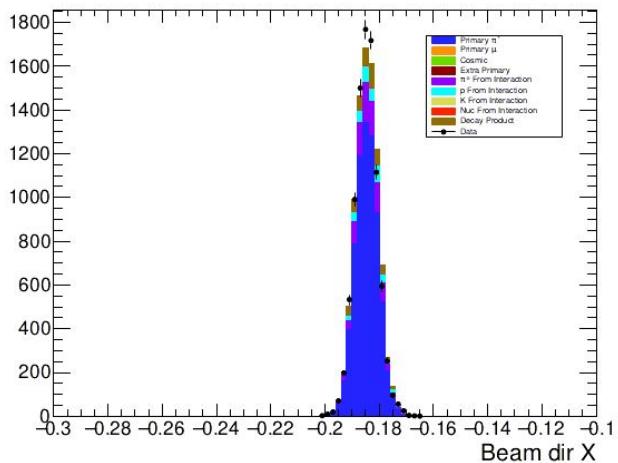
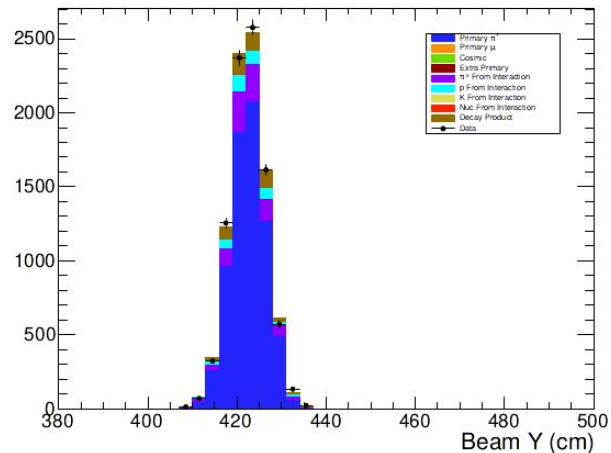
- Generated: **calcuttj_pdsp_datadriven_1GeV_v08_60_00_v3**
- w/ G4, Detsim, Reco: **calcuttj_pdsp_datadriven_reco_1GeV_v08_60_00**

Comparing to run 5387

Testing -- Beam Position & Direction

New generation & data match as expected for ProtoDUNE BeamEvent info

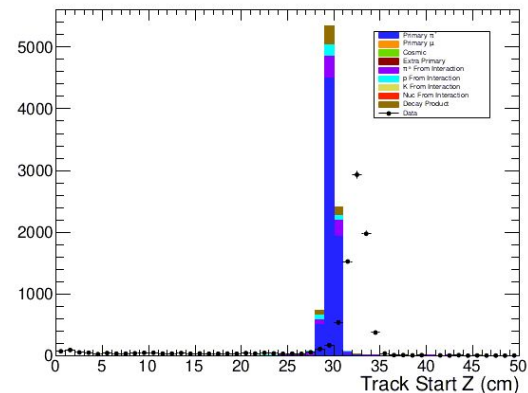
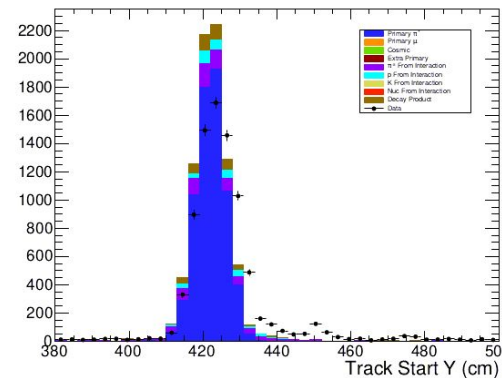
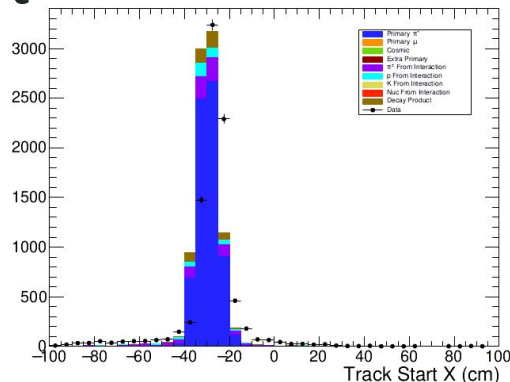
→ Data was used as an input to the generator



Testing -- Reco Track Start

Reconstructed track position (before SCE) correction

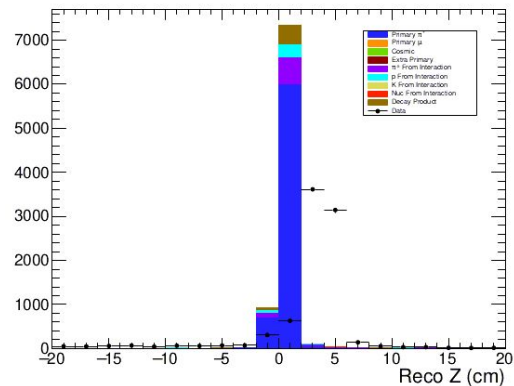
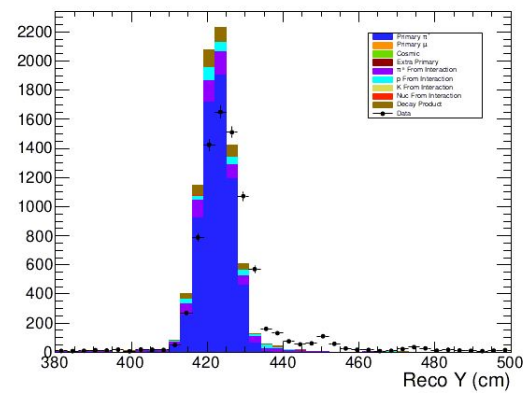
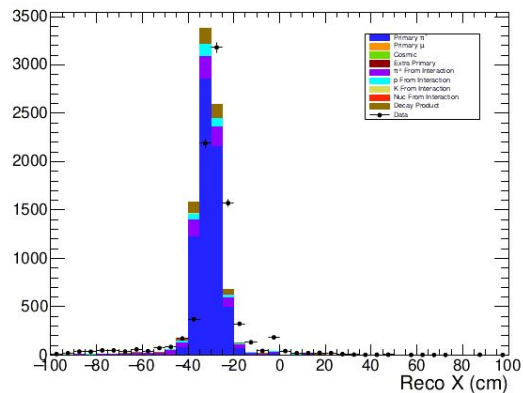
Difference in Z (bottom) suggests difference in SCE



Testing -- Reco Track Start

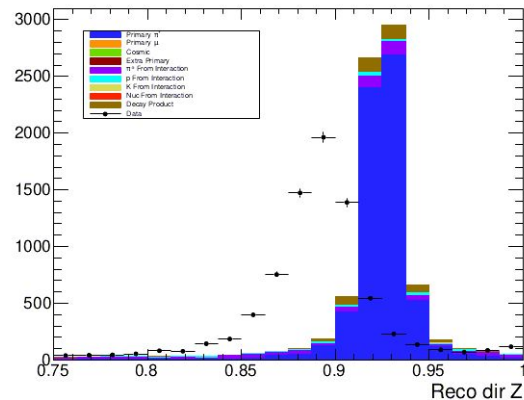
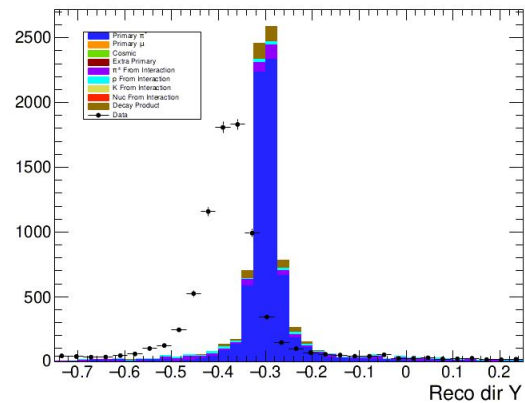
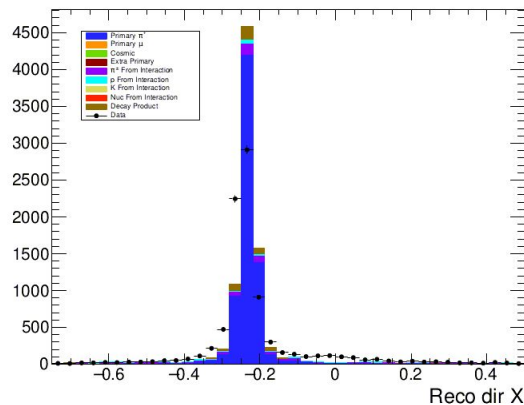
Reconstructed track position (after SCE) correction

Difference in Z (bottom) suggests difference in SCE/correction



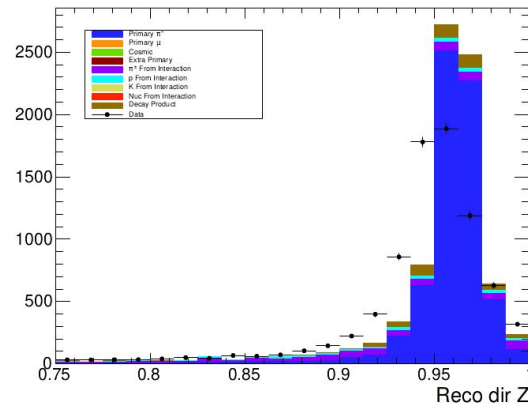
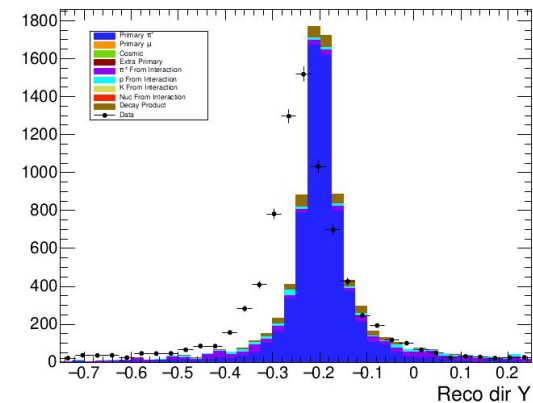
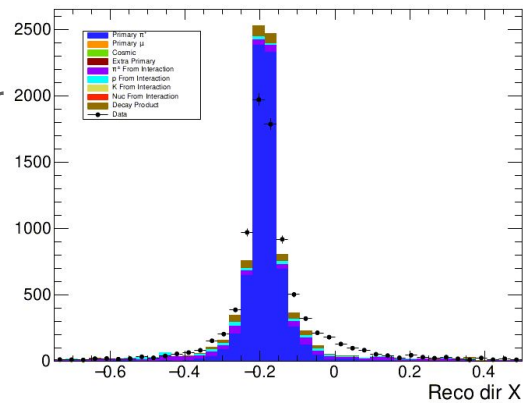
Testing -- Reco Track Direction

Reconstructed track direction
(before SCE) correction



Testing -- Reco Track Direction

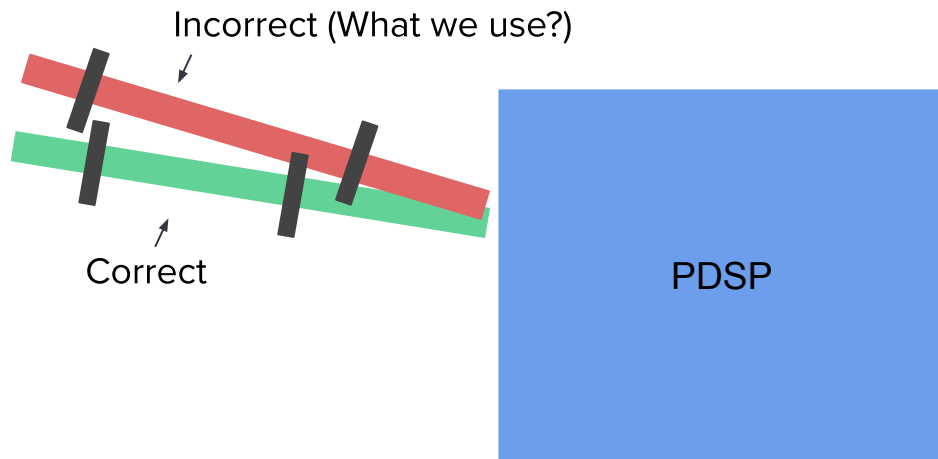
Reconstructed track direction (after SCE) correction



Considerations

The intent of the data-driven MC is to get the MC to match the data as best as possible

- But what if data is ‘wrong’? I.e. the surveyed positions of the monitors/direction of the beam are wrong → Will lead to errors in positioning/direction
 - How do we identify this?
 - How do we disentangle from SCE or detector deformation?
 - Does it matter?



To-do

Explore binning options for input (balance efficiency in sampling)

Consider better transformation of reco → true momentum (i.e. smearing matrix)

→ Also implement for positrons

Mix some muons into pion samples (can't tell difference in beam PID @ 1GeV)

Extend to other runs (need input PDFs & testing)

Add background particles to generator