

1 GeV beam studies - MCC12 Samples

DRA Meeting 06/12/2019
Owen Goodwin



- Look at a 1 GeV beam pion + muon selection in both MC and data for new MCC12 samples.

Datasets V08_21_00;

- 1GeV MC (1611 events):
/pnfs/dune/scratch/users/tjyang/v08_21_00/reco/mcc12_protodune_beam_p1GeV_cosmics_12ms_test/files.list
- Run 5387 (8632 events) (1 GeV Hadron trigger)
/pnfs/dune/scratch/users/tjyang/mcc12test/r5387/v1/r5387.v1.txt

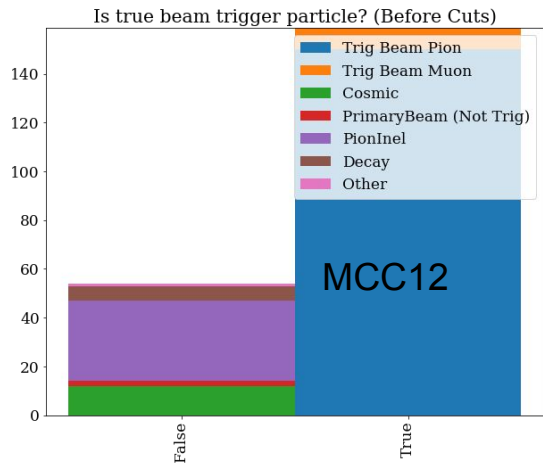
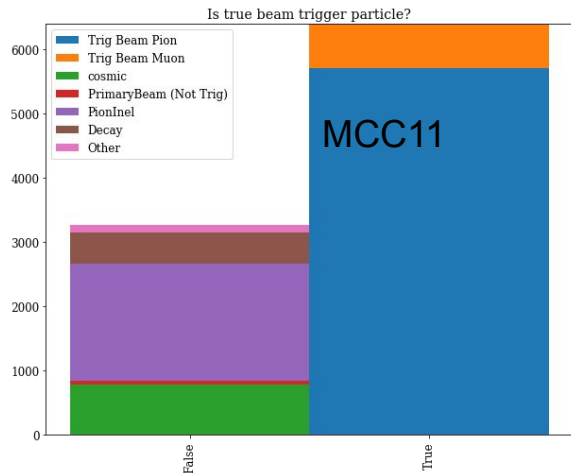
- Data filters.
 - Beamline 1 GeV Pion filter (ToF <170 ns and no hits in the low pressure Cherenkov counter)
 - Unstable HV filter
 - Inactive FEMB filter (Beamside APAs)
- MC selection;
 - events where the true beam particle is pion or muon.

Data Run 5387	# Events after filters with Pion trig	# events with Pandora reco beam track
Pions/Muons	2135	1908

Monte Carlo	# true beam events	# events with Pandora reco beam track
Muons	10	10
Pions	222	203

Beam Backgrounds in MC.

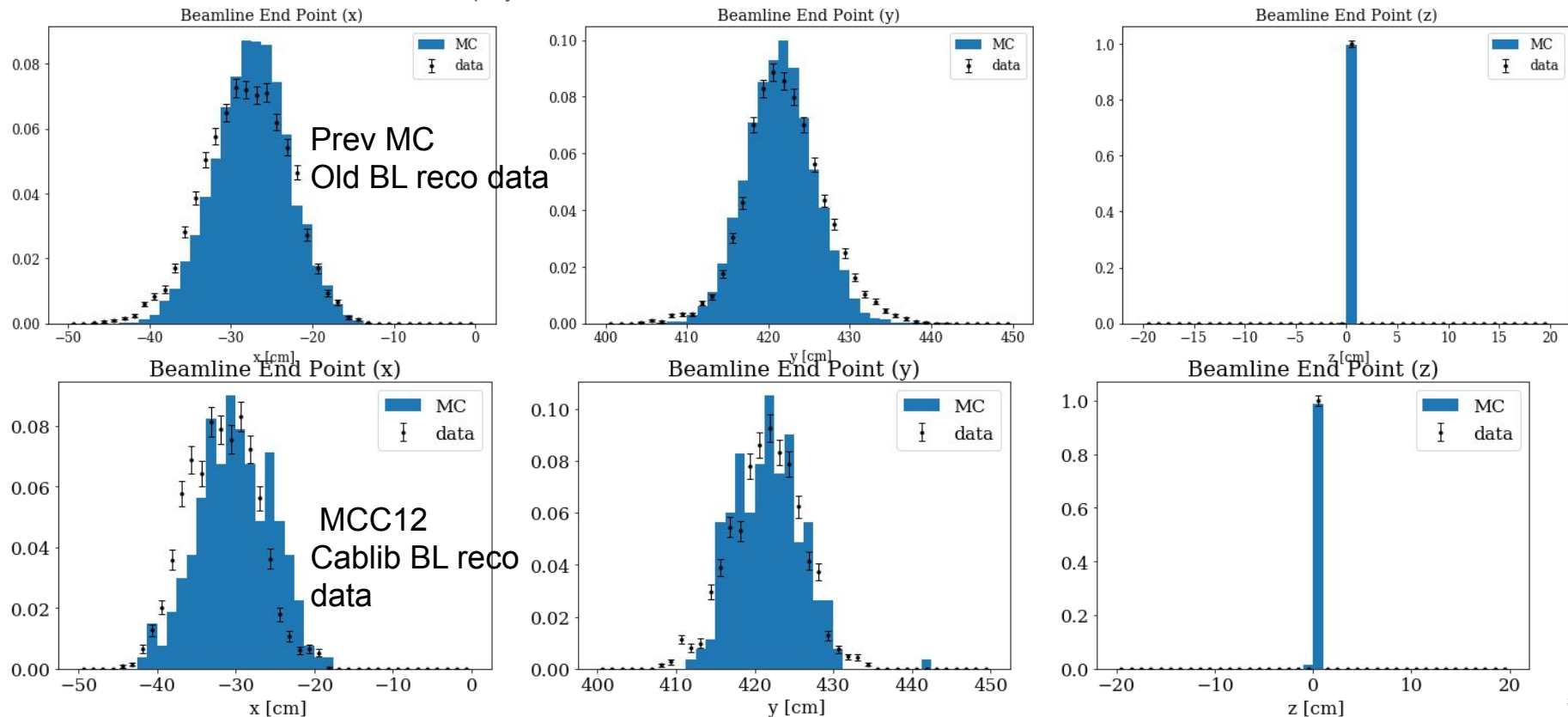
- Take the **reco** track Pandora assigns as beam particle and backtrack to find the MC particle that created the track.
- Can check if the backtracked MC particle matches the true beam particle.

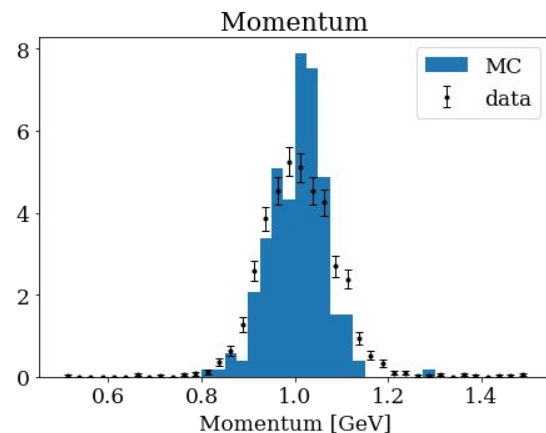
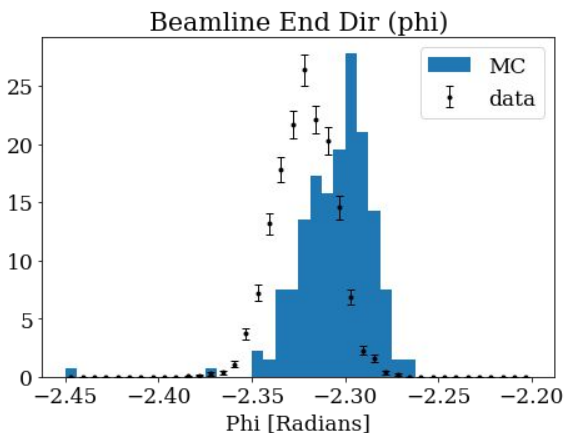
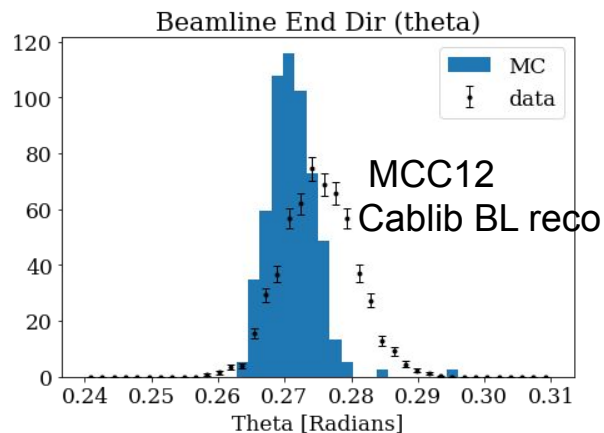
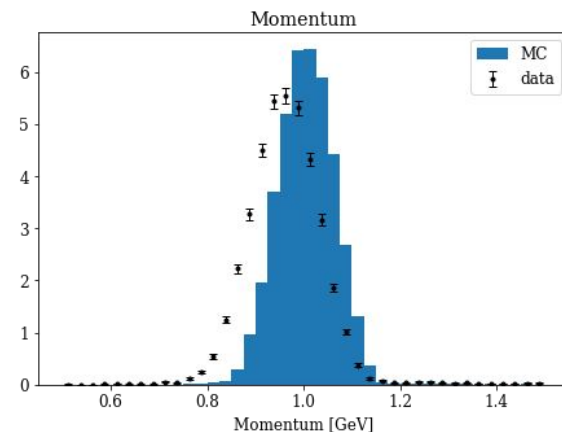
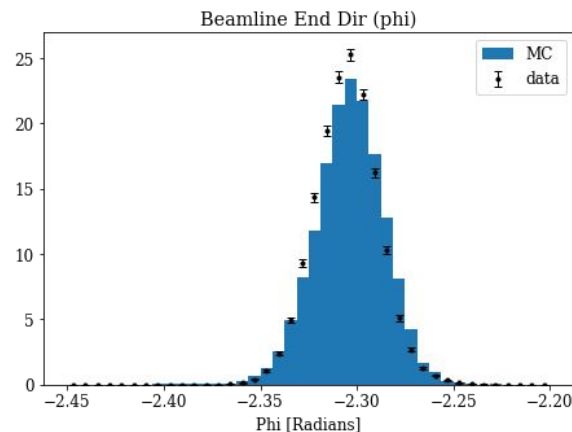
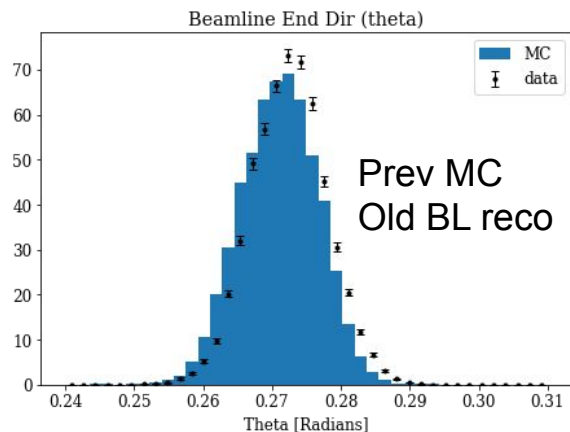


Beamline Position

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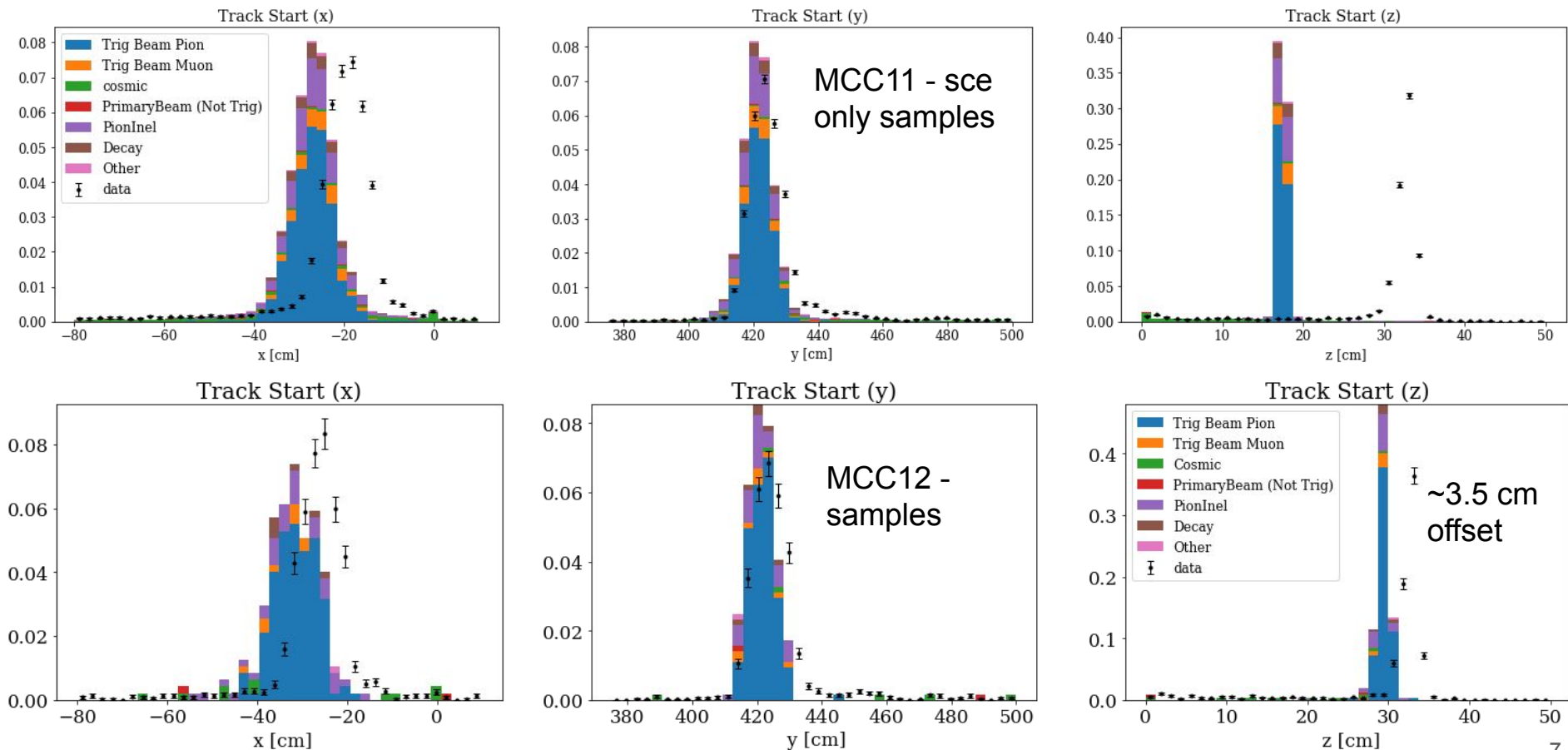
Replicate Beamline instrumentation position measurement in MC by projecting the beam MC particle direction onto the plane $z=0$. Data is from beamline reconstruction also which is also projected to $z=0$





Reco Track Start Position.

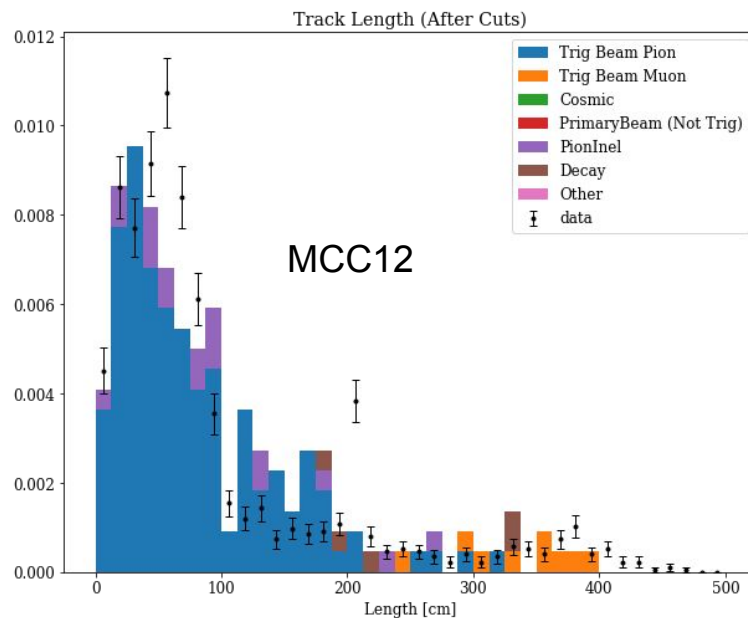
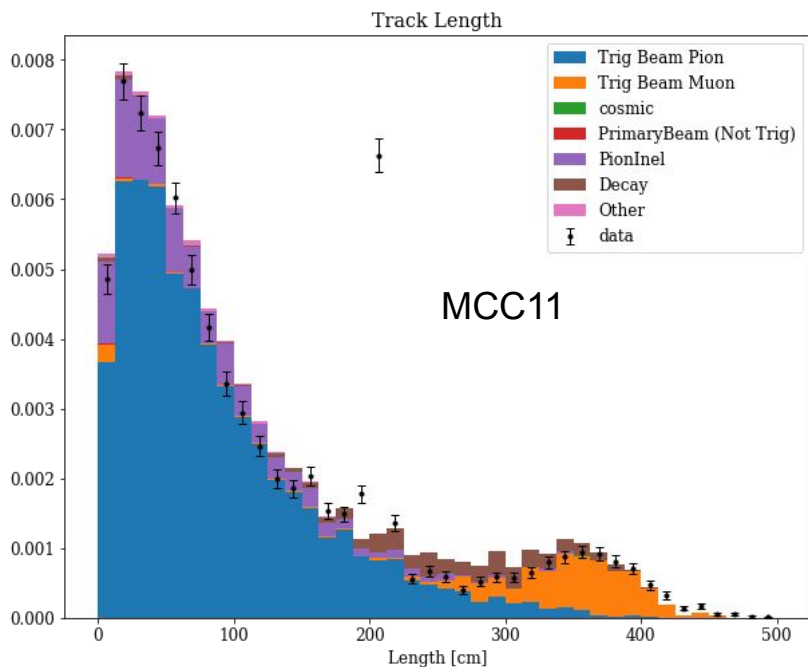
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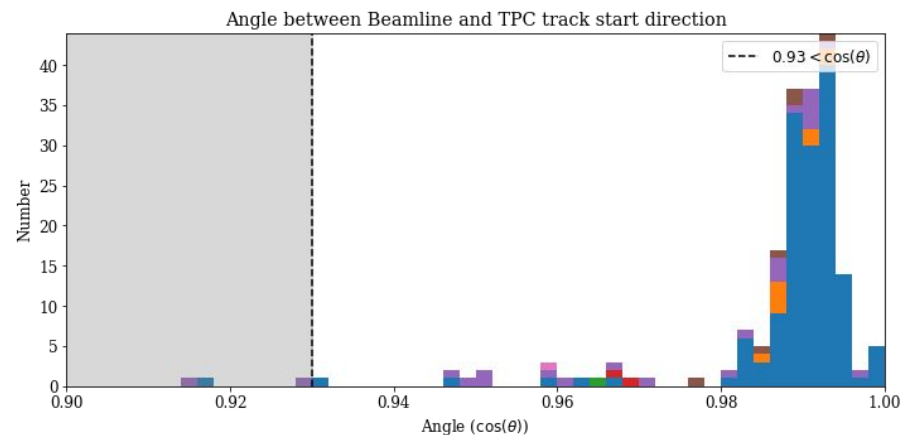
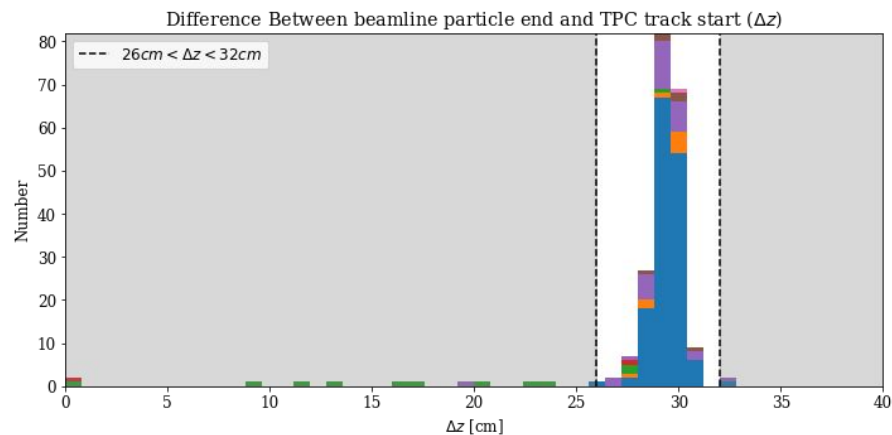
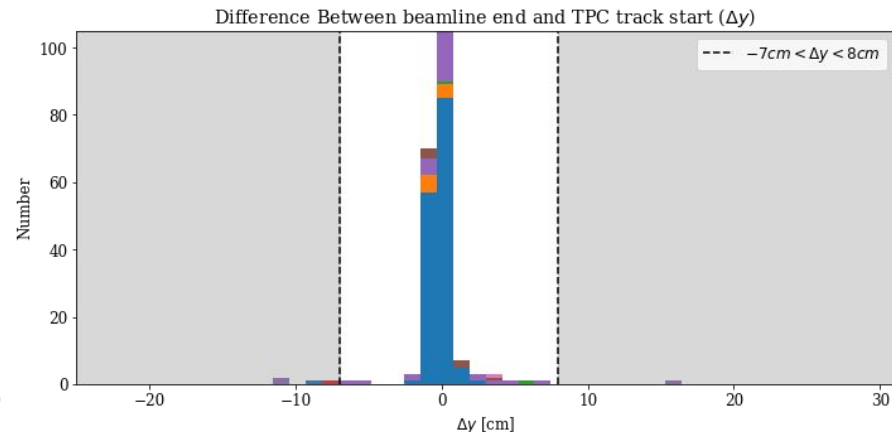
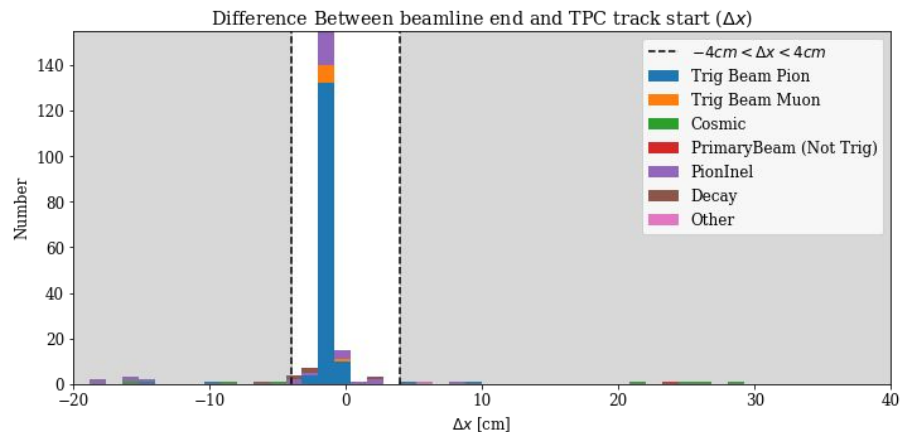
Reco Track Length (After cuts)

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- After new shifted beam quality cuts
on for MC in MCC12 start position
offsets



Back up



Back up (previous talk)

- Look at a 1 GeV beam pion + muon selection in both MC and data.
- Beam quality cut comparison using beam instrumentation information.
- Identify backgrounds to a beam selection and study the effect of quality cuts on background
- Selection and calorimetry of stopping beam muons in data.

Datasets;

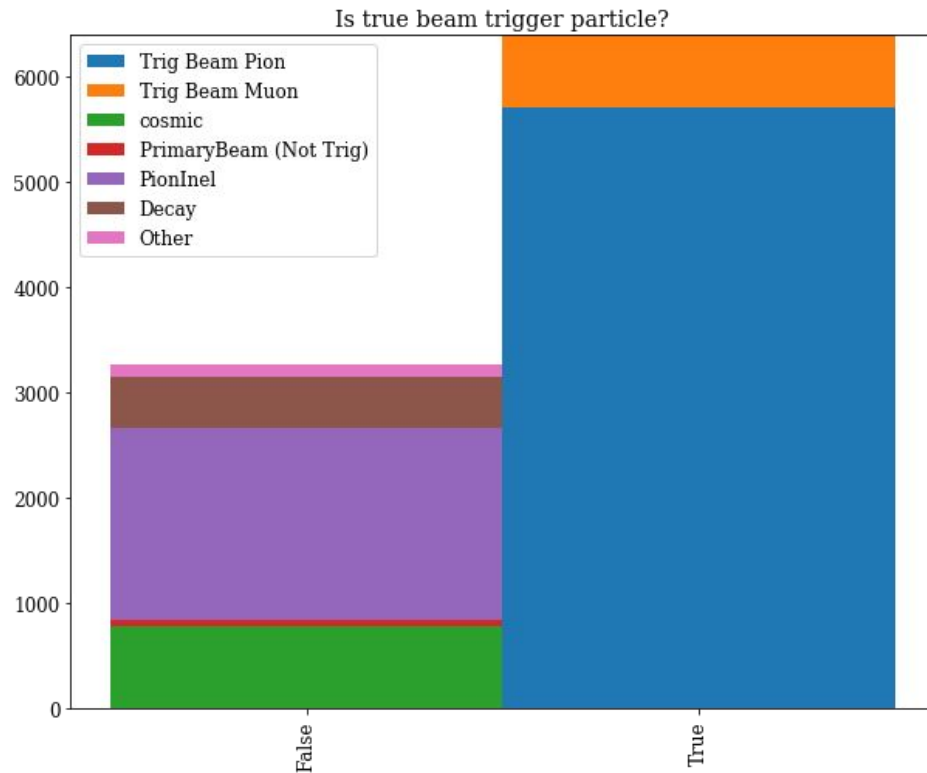
- 1 GeV high stats MC (SCE, no fluid flow sample - 74529 total events)
- Run 5387 (1 GeV Hadron trigger - 47190 total triggers, reco v07_08_00_03/4)

- Data filters.
 - Beamline 1 GeV Pion filter (ToF <170 ns and no hits in the low pressure Cherenkov counter)
 - Unstable HV filter
 - Inactive FEMB filter (Beamside APAs)
- MC selection;
 - events where the true beam particle is pion or muon.

Data Run 5387	# Events after filters with Pion trig	# events with Pandora reco beam track
Pions/Muons	20991	13122

Monte Carlo	# true beam events	# events with Pandora reco beam track
Muons	734	719
Pions	9860	8936

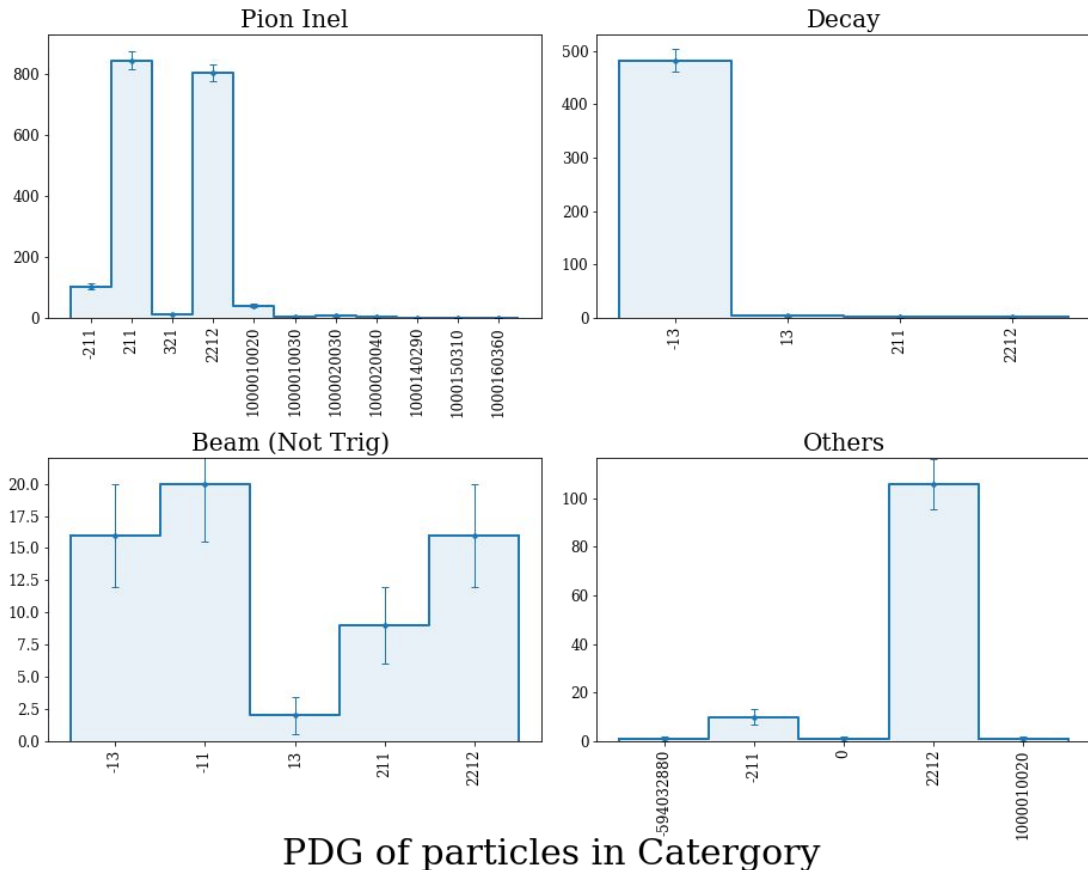
- Take the **reco** track Pandora assigns as beam particle and backtrack to find the MC particle that created the track.
- Can check if the backtracked MC particle matches the true beam particle.
- Split by the origin of the MC particle which contributed most to the **reco** beam track

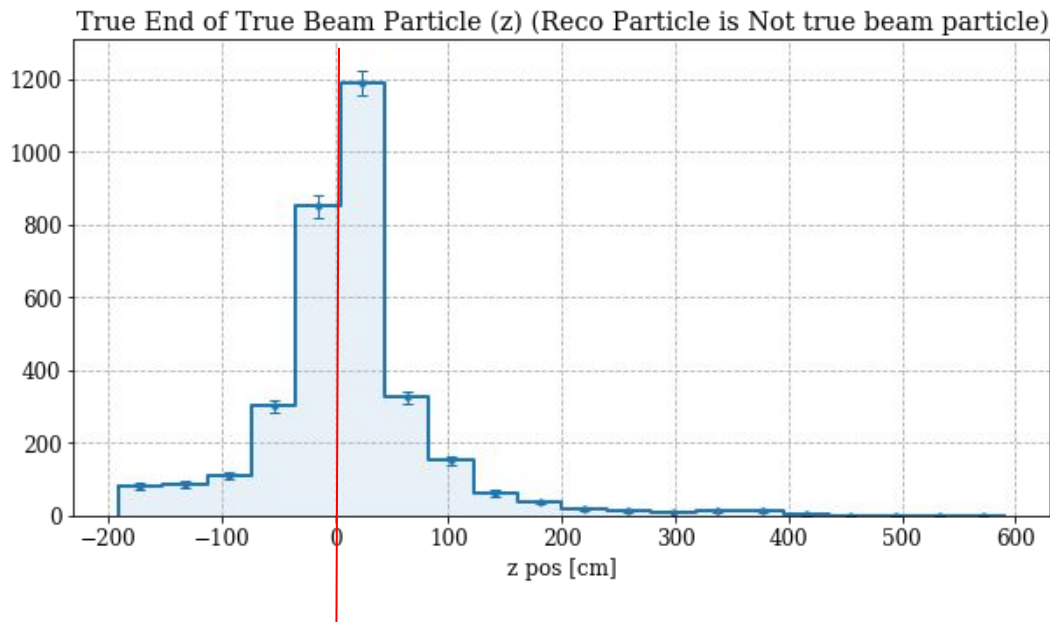


Background categories

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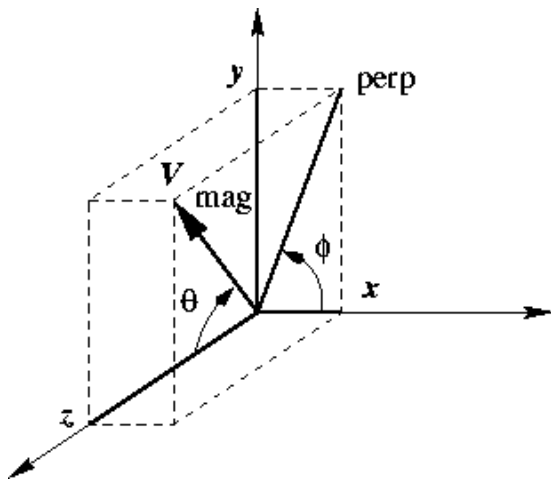
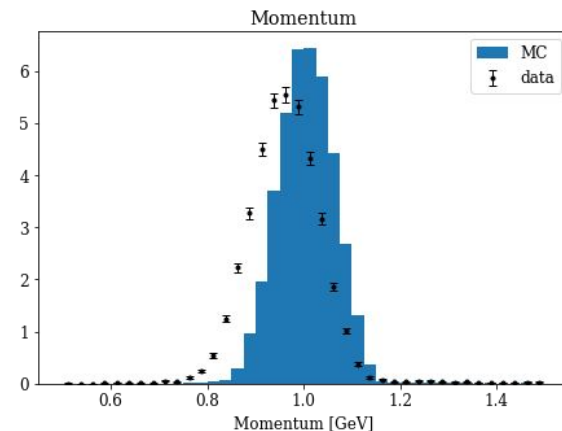
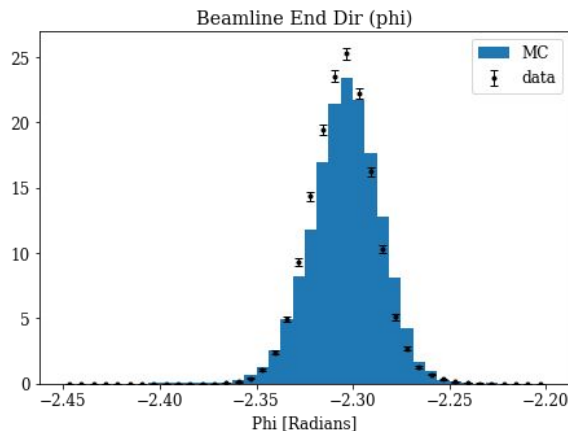
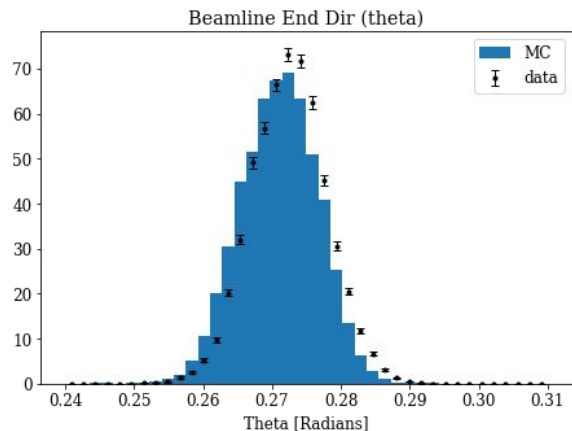
- **Pion Inel**; Pions and Protons produced from the beam pion interacting.
- **Decay**; Mainly muons from beam pion decay.
- **Primary Beam (Not trig)**; particles coming from beamline but not the one that triggered the event.
- **Others**; predominantly protons produced from secondary interactions (proton/neutron/pi- inelastic)





In around half of cases where reconstructed beam particle is background, the true beam pion did not reach the TPC (either interacted or decayed before $z=0$)

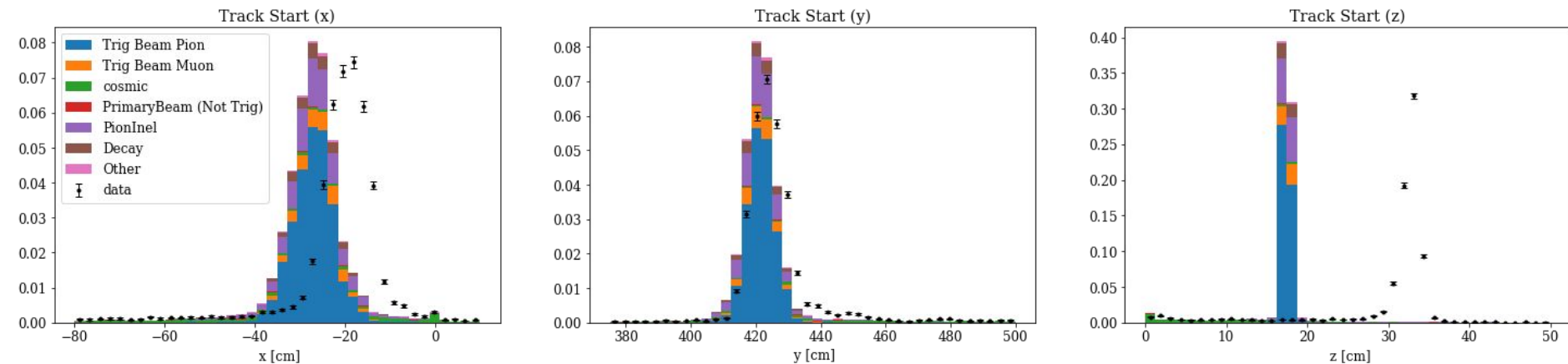
So could not have been reco'd



- Haven't updated to the new beamline reconstruction. Expect new data momentum to be shifted up by ~5%
- Neither Data or MC Mom has energy loss before TPC

Reco Track Start Position.

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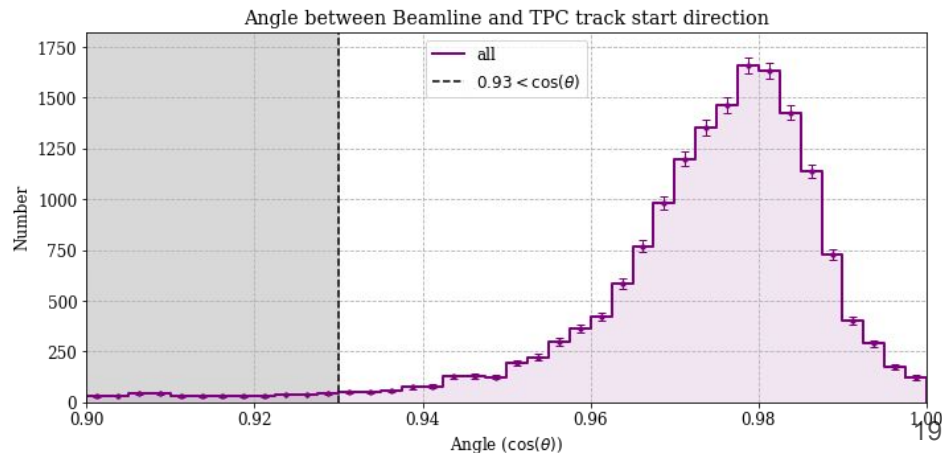
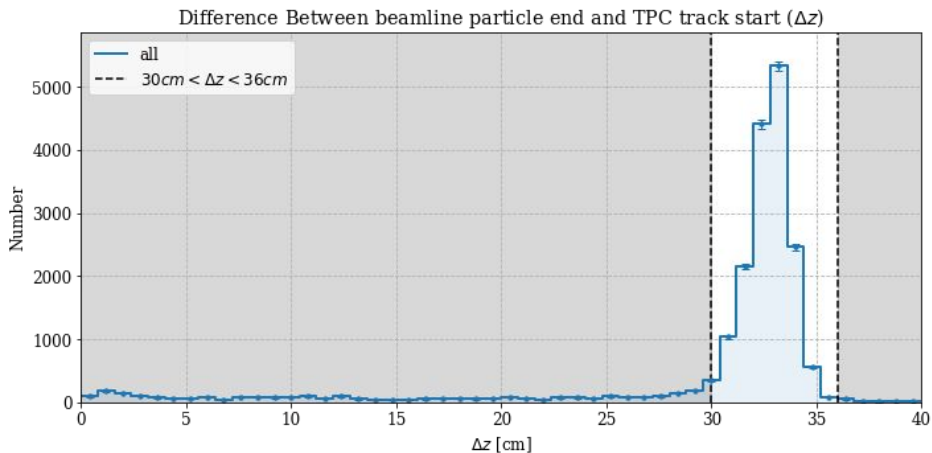
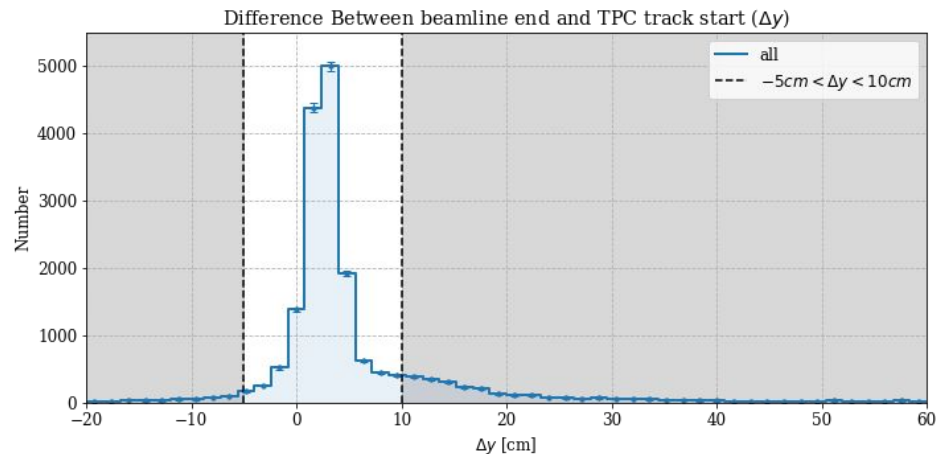
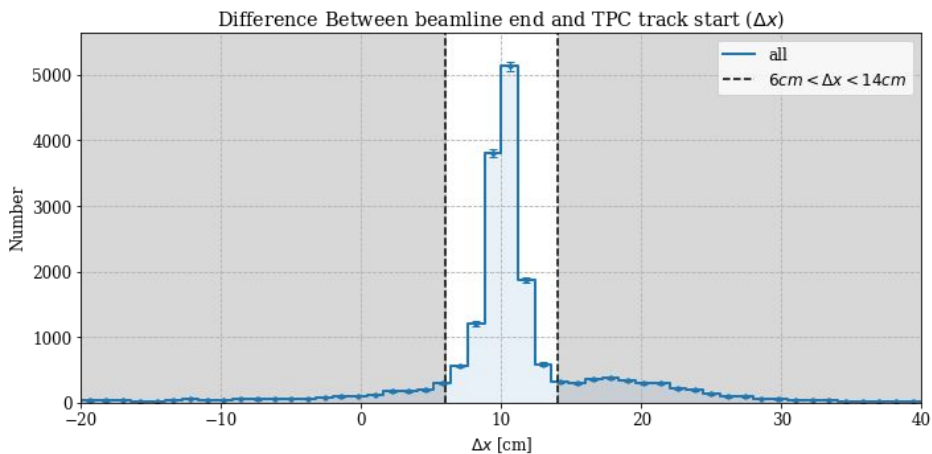
Start position of **reco** beam track.

Similar differences in track start position between Data and MC as seen by others.

This is the SCE only sample, distributions for no SCE and SCE+FLF samples are in backup.

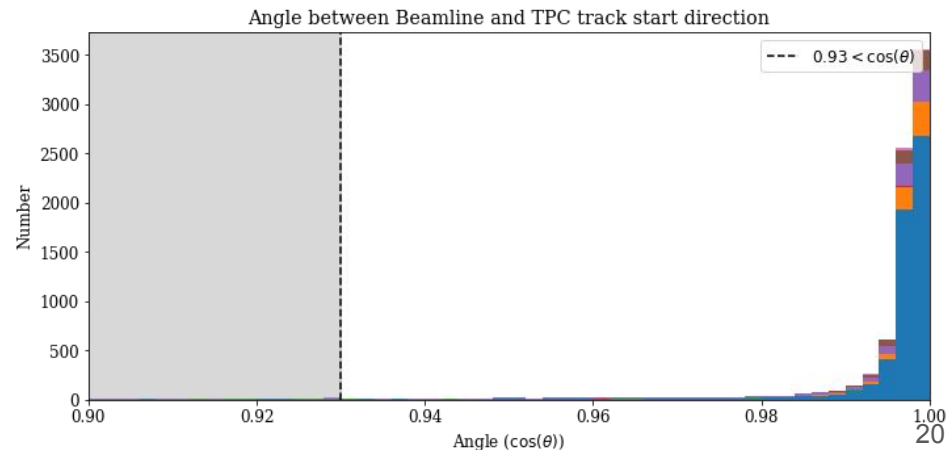
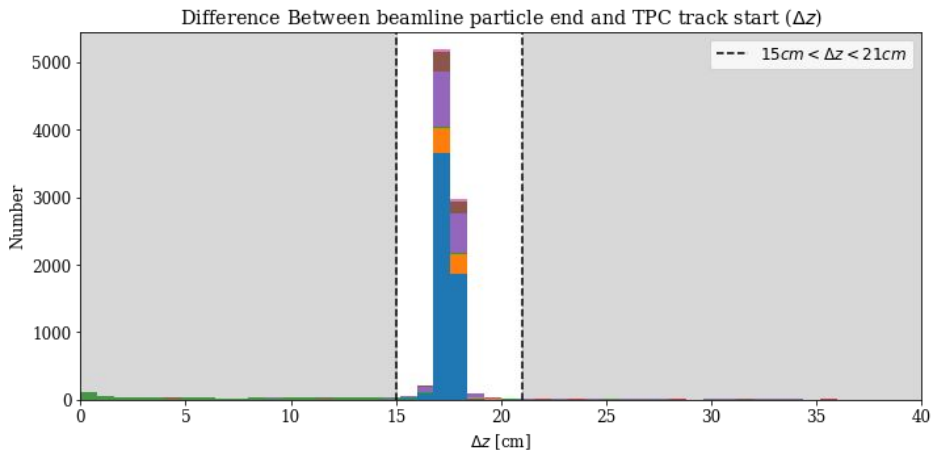
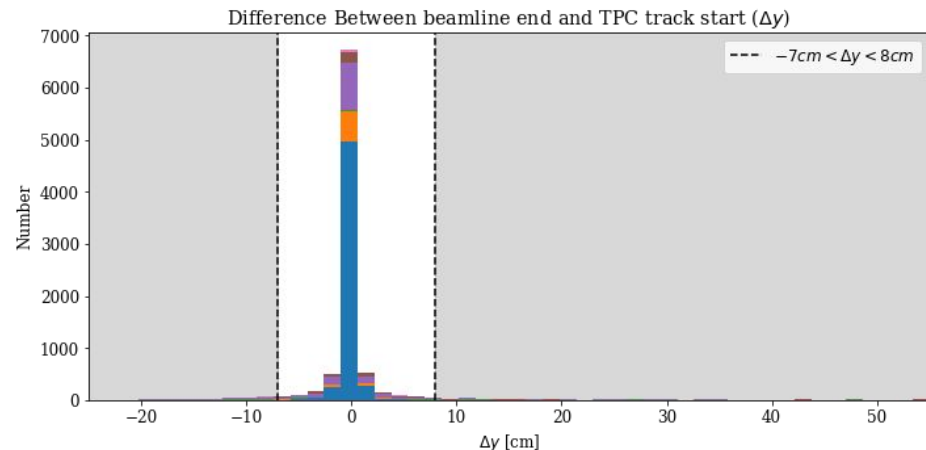
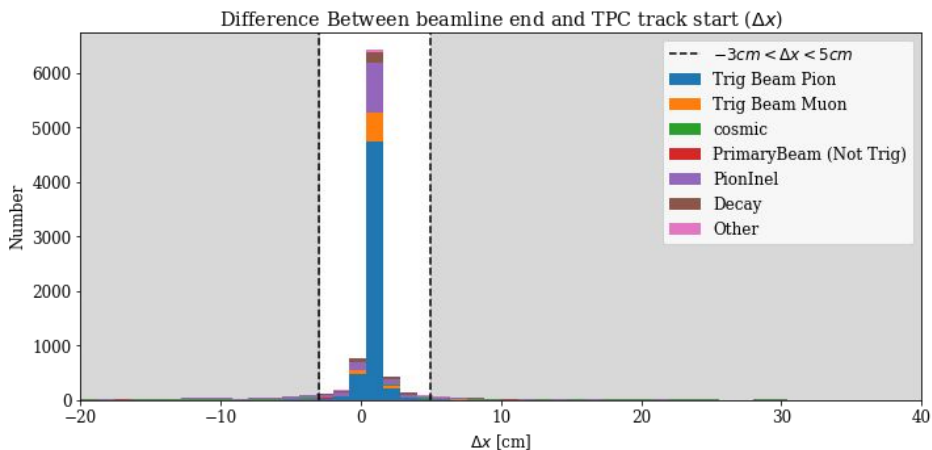
Data Quality Cuts

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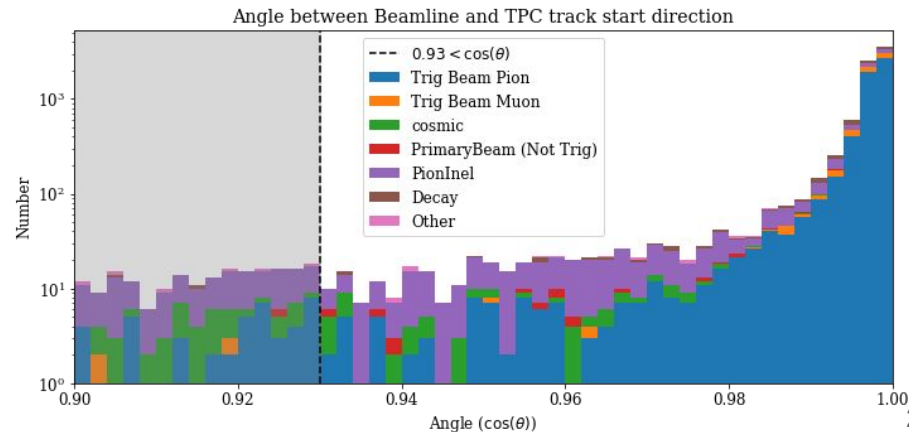
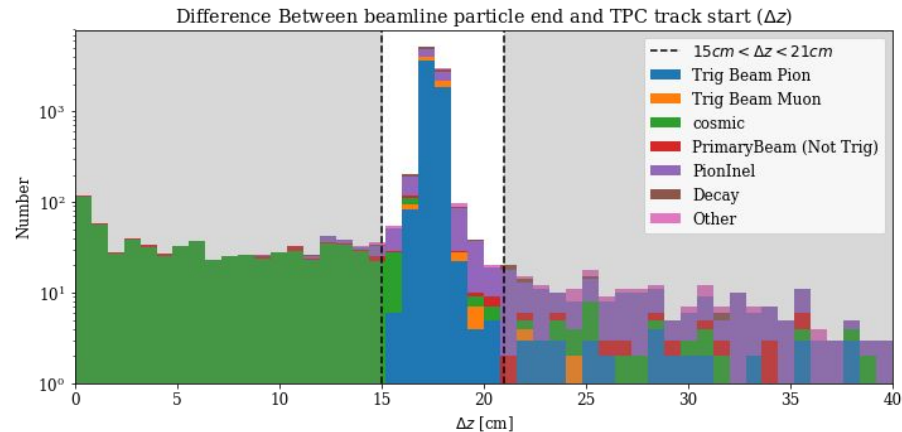
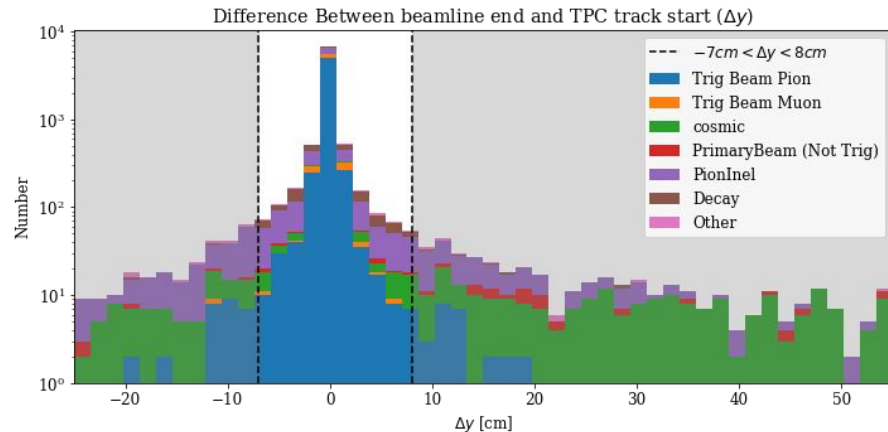
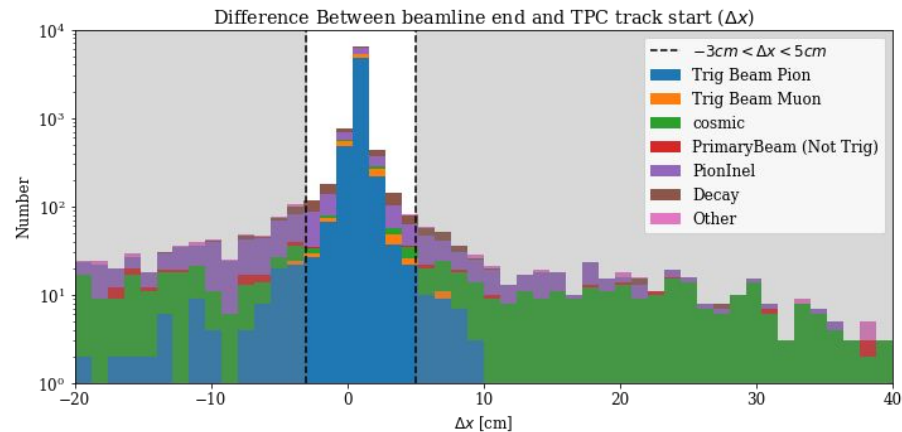
MC Quality Cuts

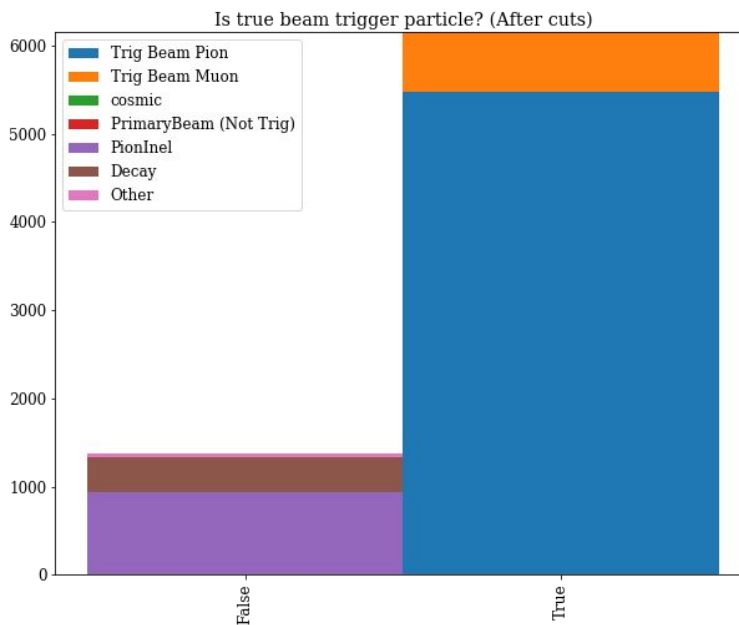
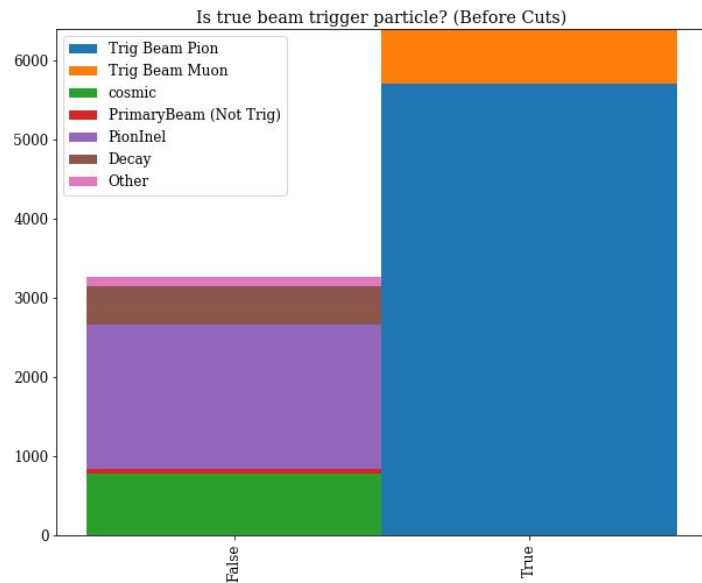
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MC Quality cuts (log)

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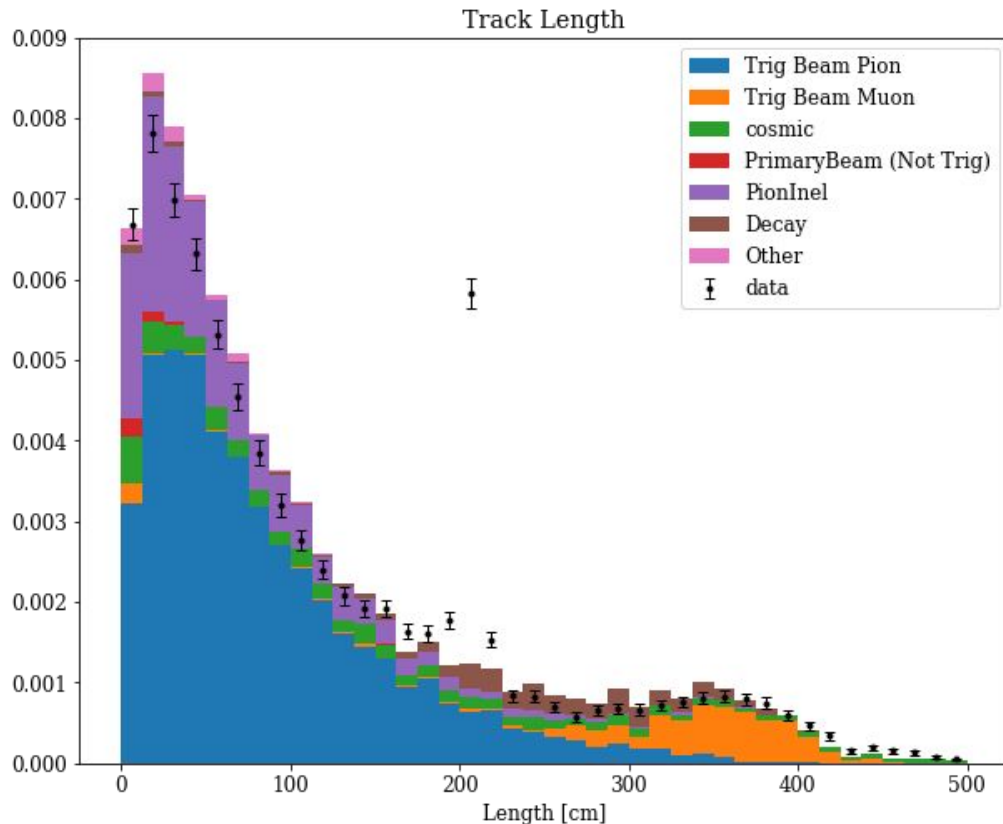




	# events before cuts	# after cuts
MC	9655	7521
Data	13311	9171

Track Length (Before cuts)

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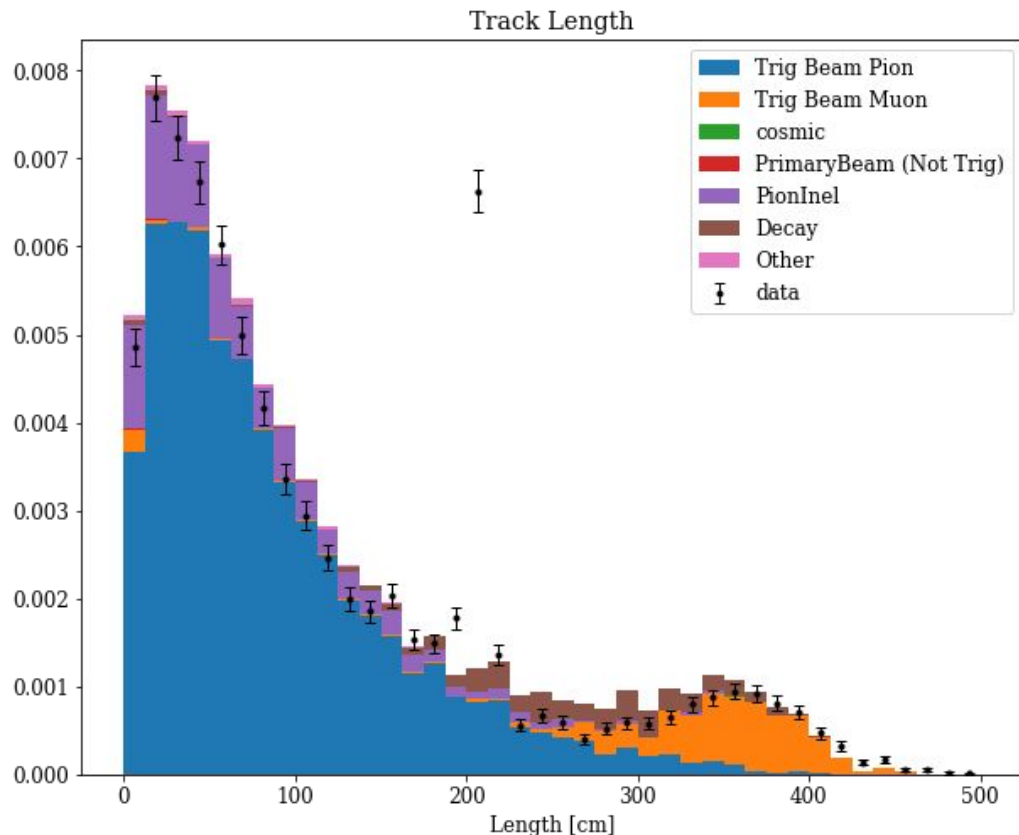
Length of **reco** beam tracks
in MC and data before quality
cuts.

Distribution normalised by
number of entries

Broken tracks at edge of first
APA (230 cm).

Reco Track Length (After cuts)

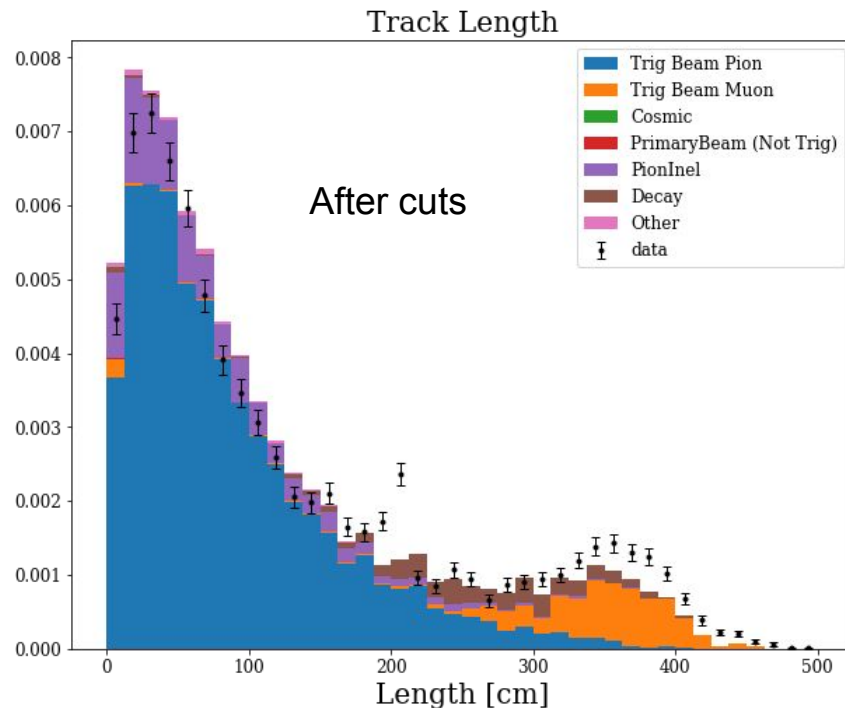
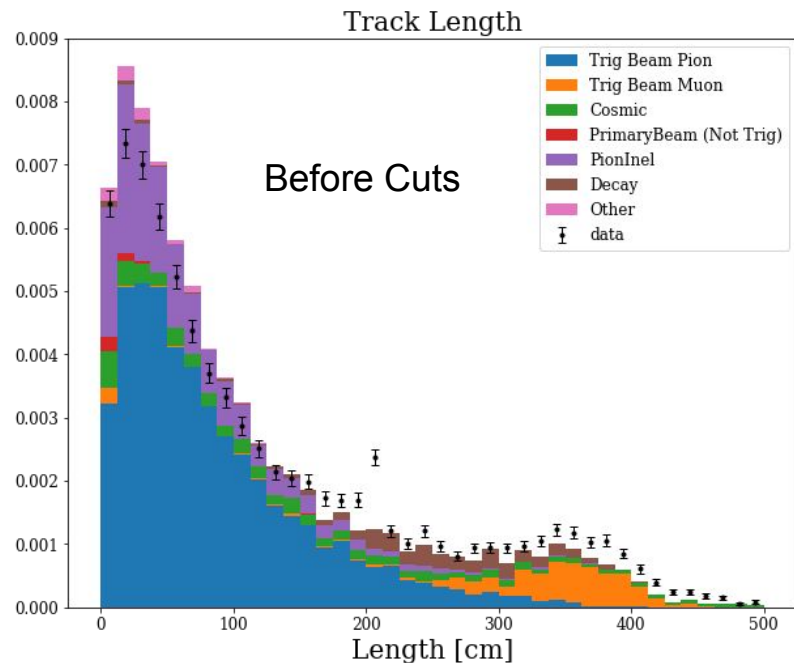
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- After beam quality cuts.
- Distribution normalised by number of entries
- Beam muons well separated from pions
- Particles from Pion Inelastic scatters are main background to beam
 - ~Half of these are protons. Possibility to remove with dE/dx cuts

Stitching Broken Tracks

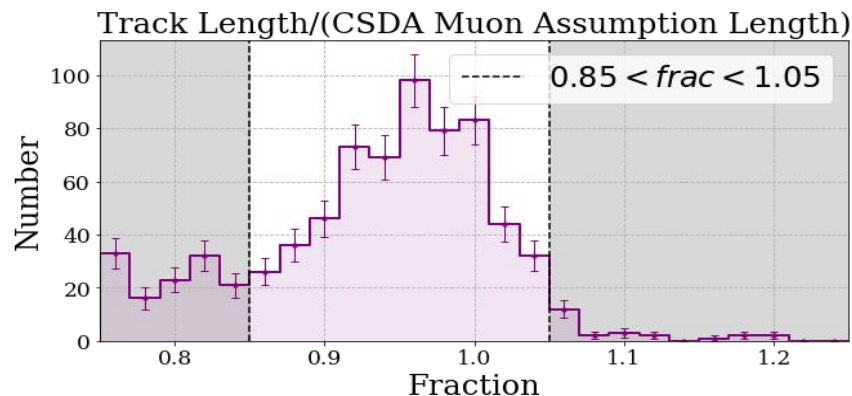
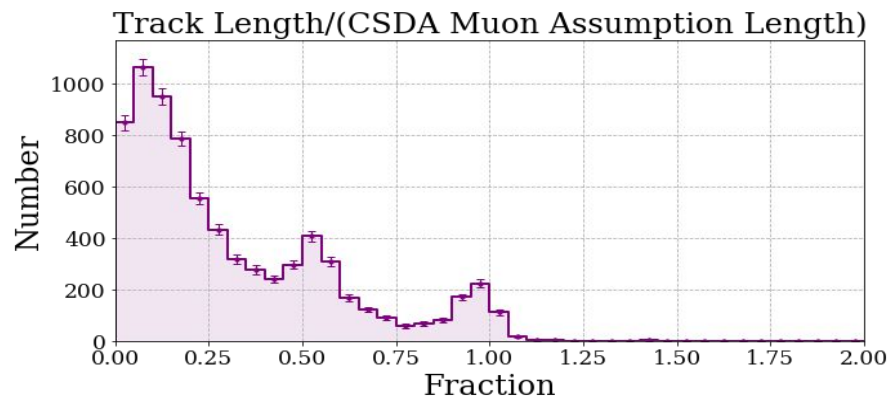
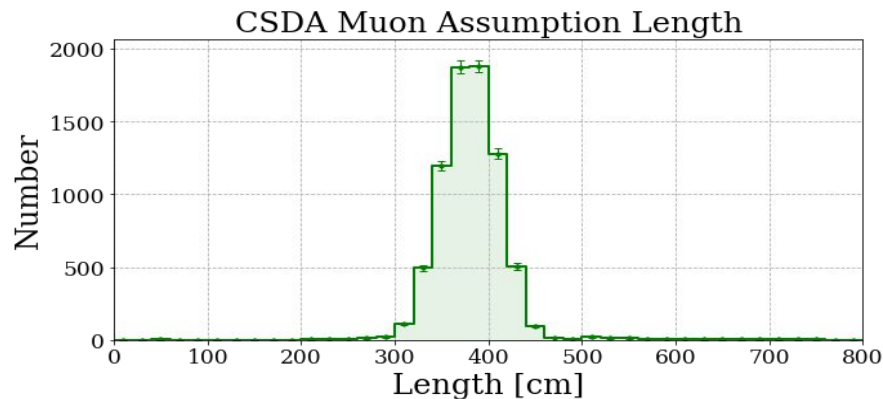
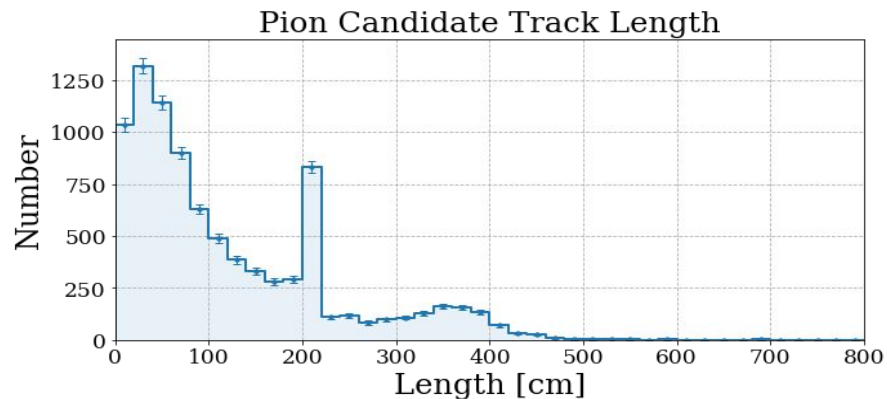
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Jake Calcutt wrote a tool which finds broken track candidates at APA boundary and stitches them together (<https://indico.fnal.gov/event/19739/contribution/4/material/slides/0.pdf>)

Selecting Beam Stopping Muons

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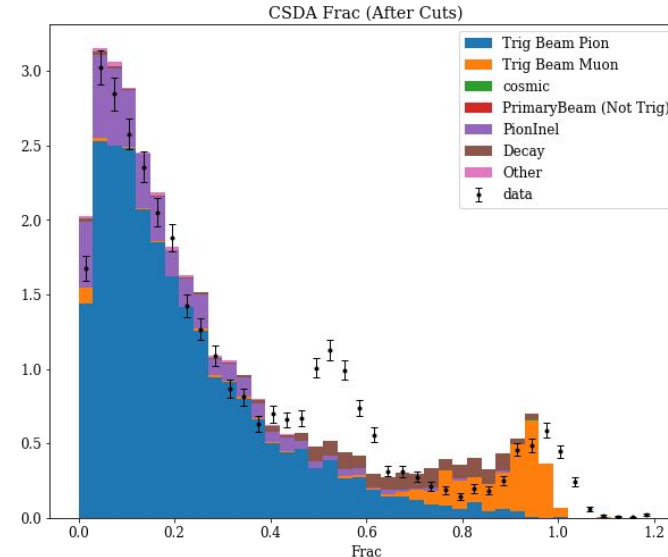
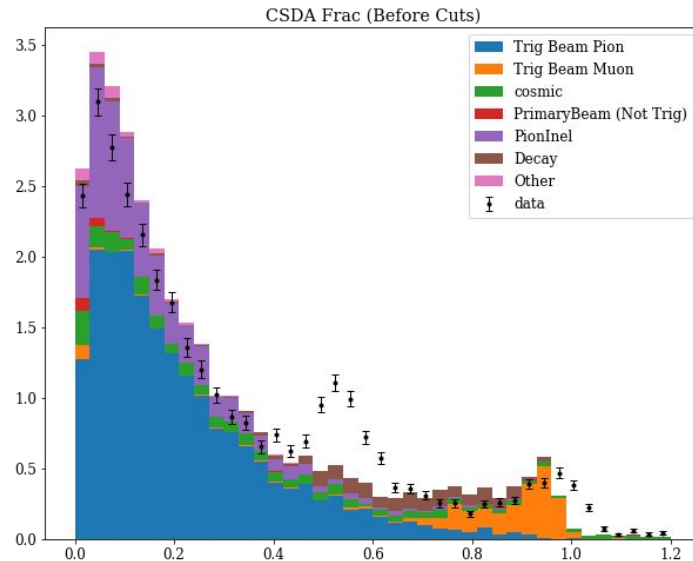


Use beamline momentum measurement to calculate the expected range of the beam particle under the assumption it is a stopping muon.

Back up

Use beamline momentum (or MC truth mom) to calculate range CSCA range under muon assumption.

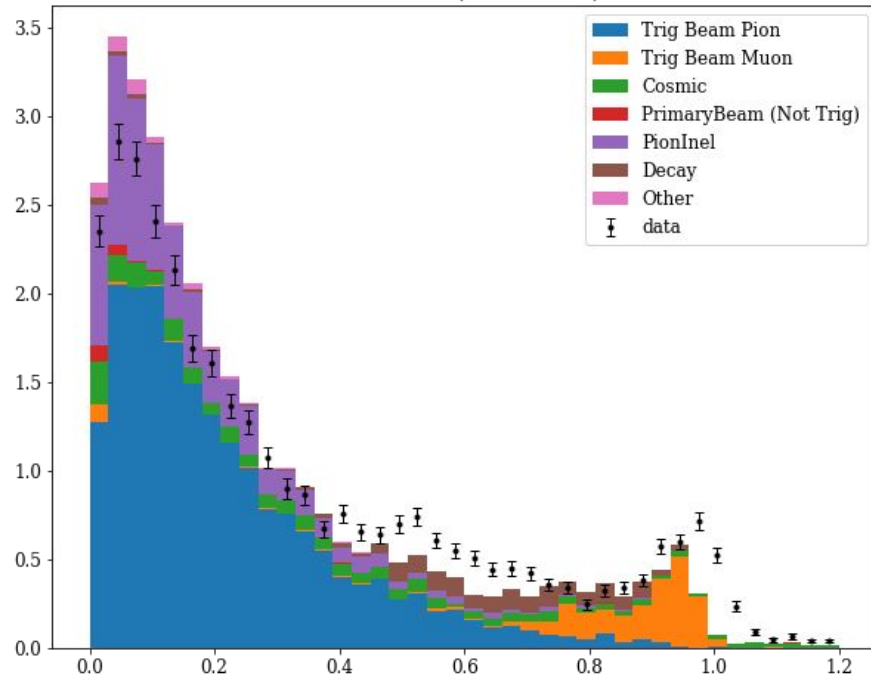
Divide track length by this. Peak around 1 from stopping muons.



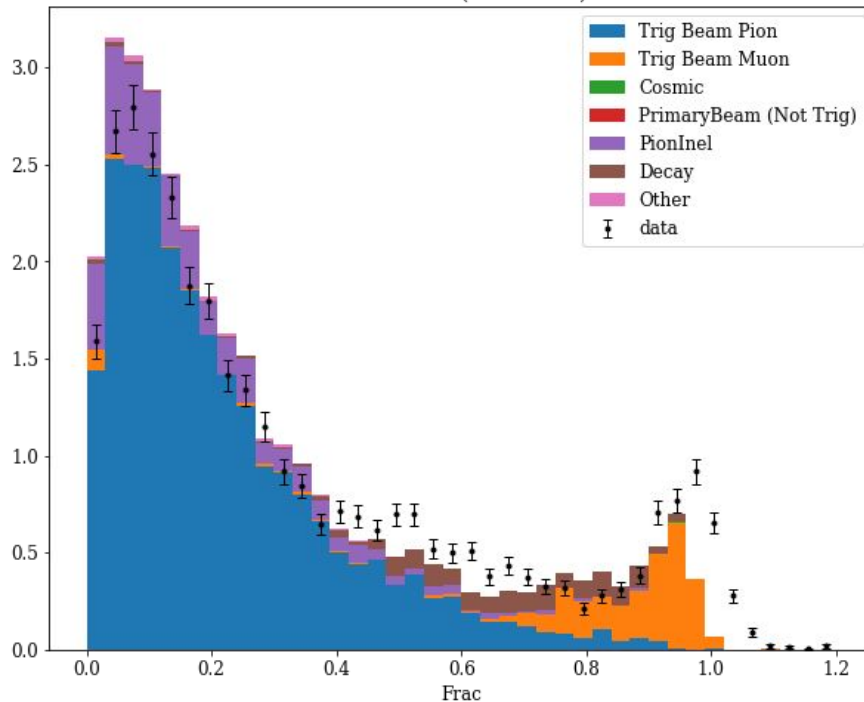
CSDA frags after stitching

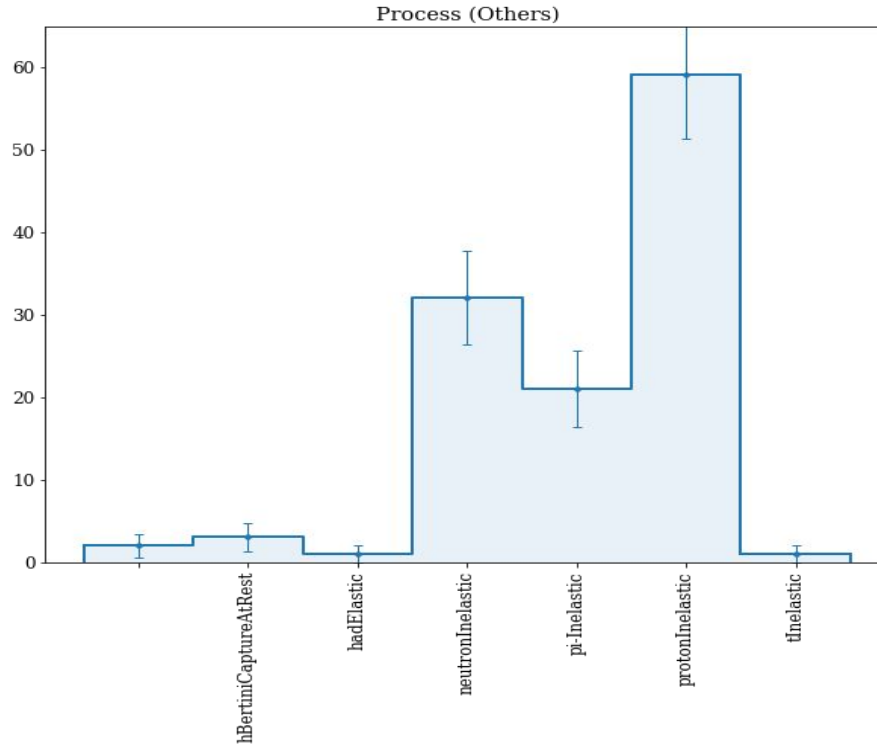
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CSDA Frac (Before Cuts)



CSDA Frac (After Cuts)

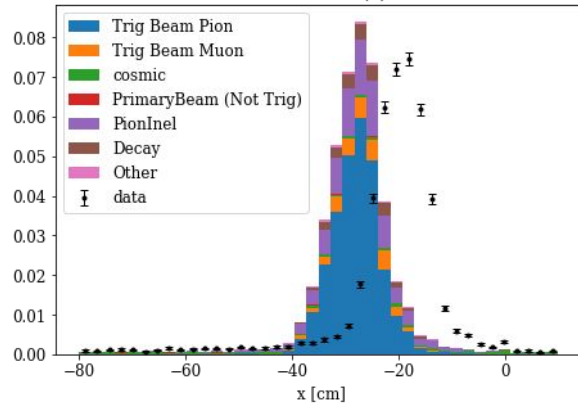




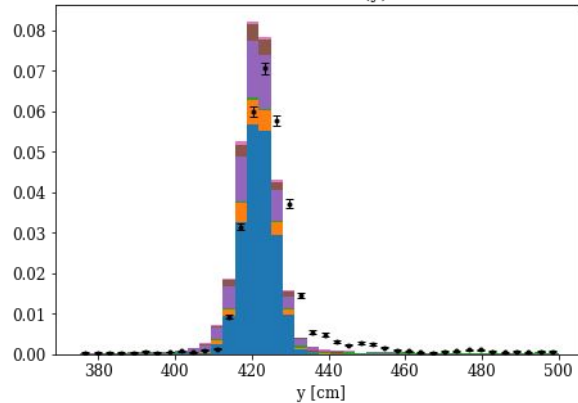
No SCE sample

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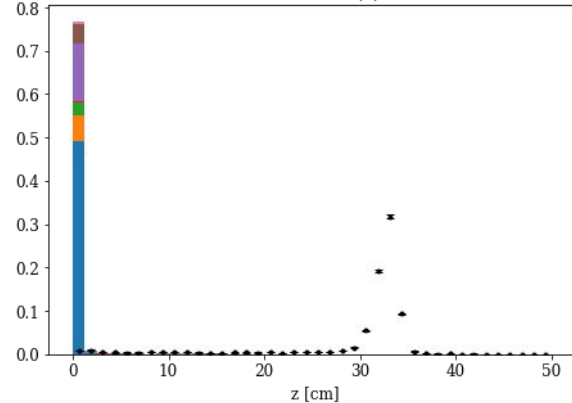
Track Start (x)



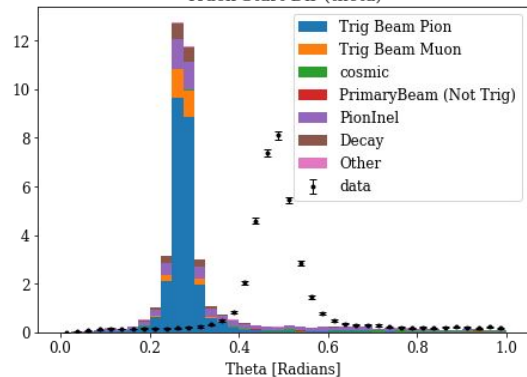
Track Start (y)



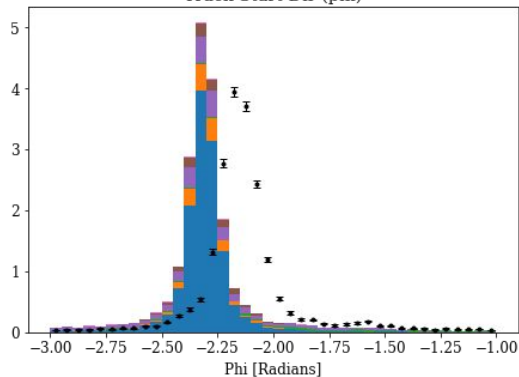
Track Start (z)



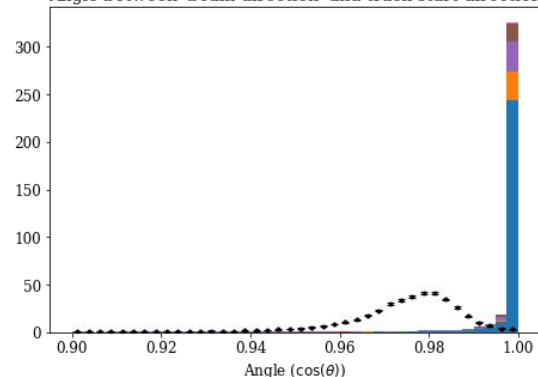
Track Start Dir (theta)



Track Start Dir (phi)

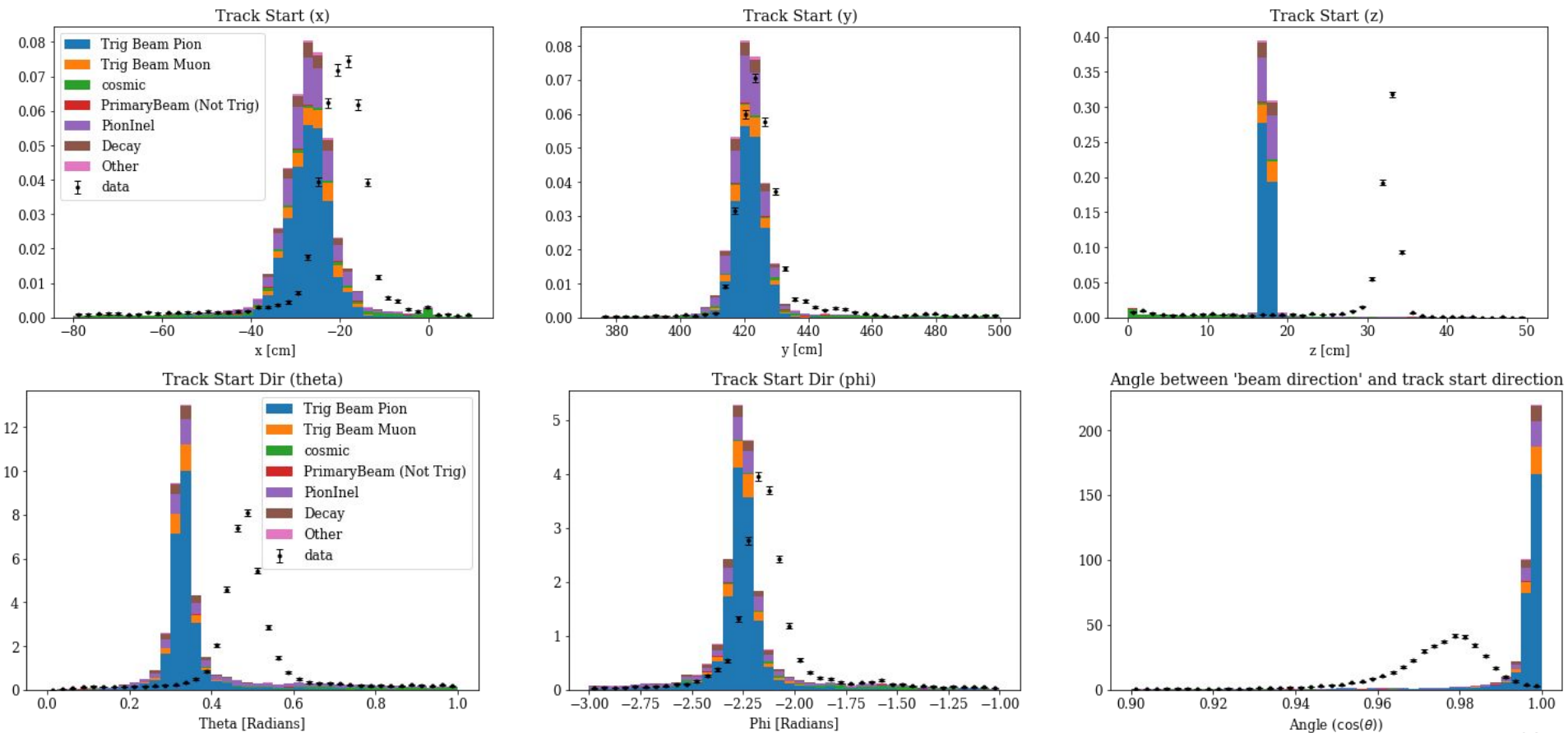


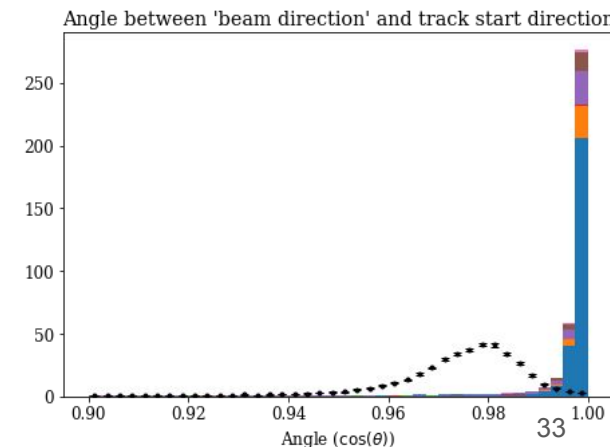
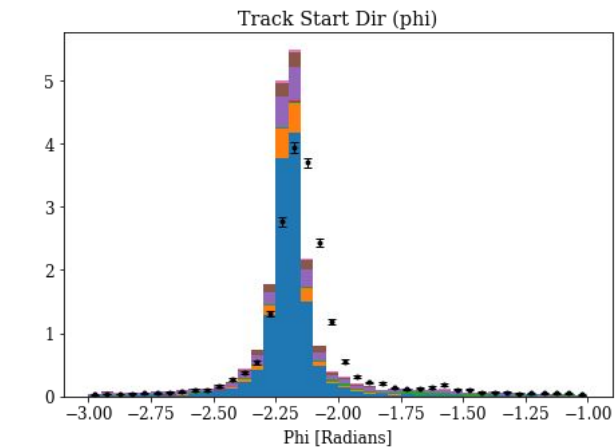
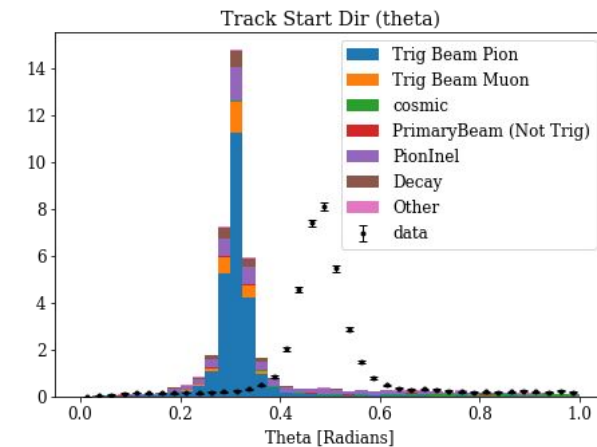
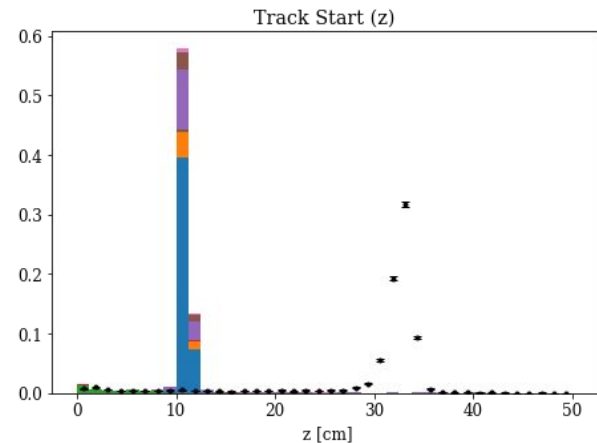
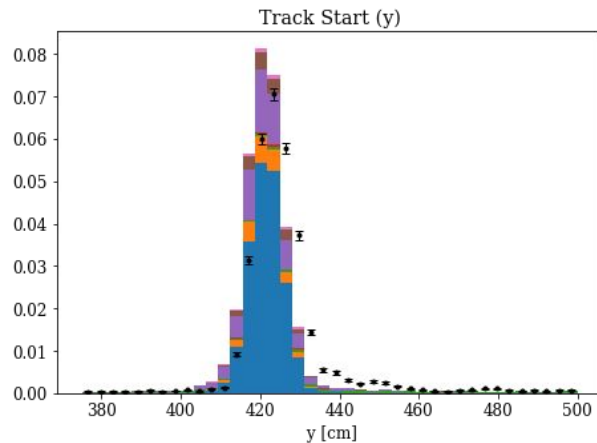
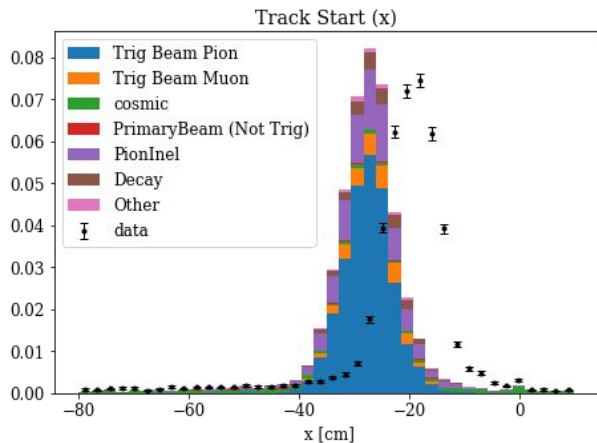
Angle between 'beam direction' and track start direction



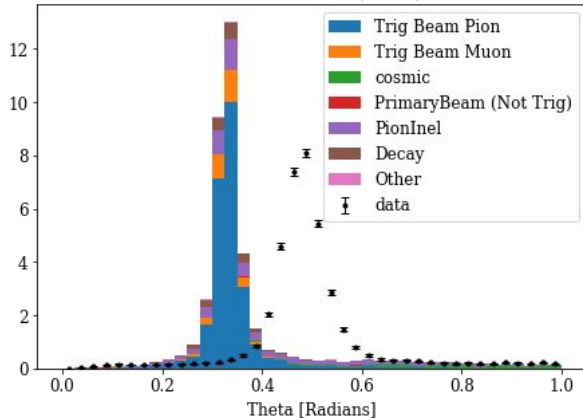
SCE sample.

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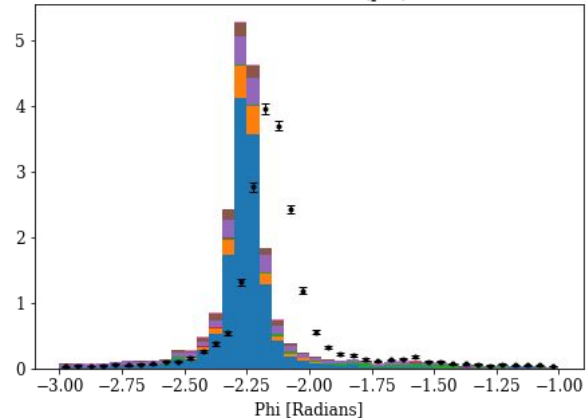




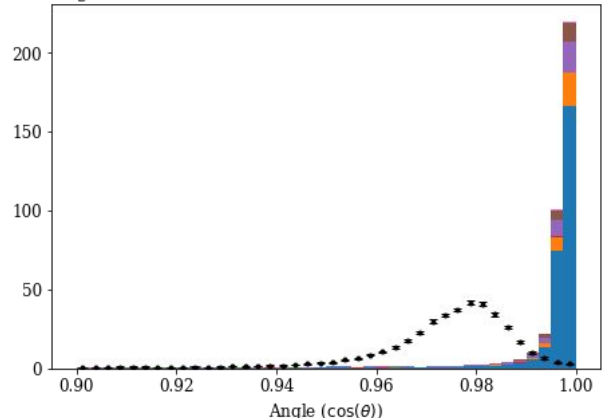
Track Start Dir (theta)



Track Start Dir (phi)



Angle between 'beam direction' and track start direction

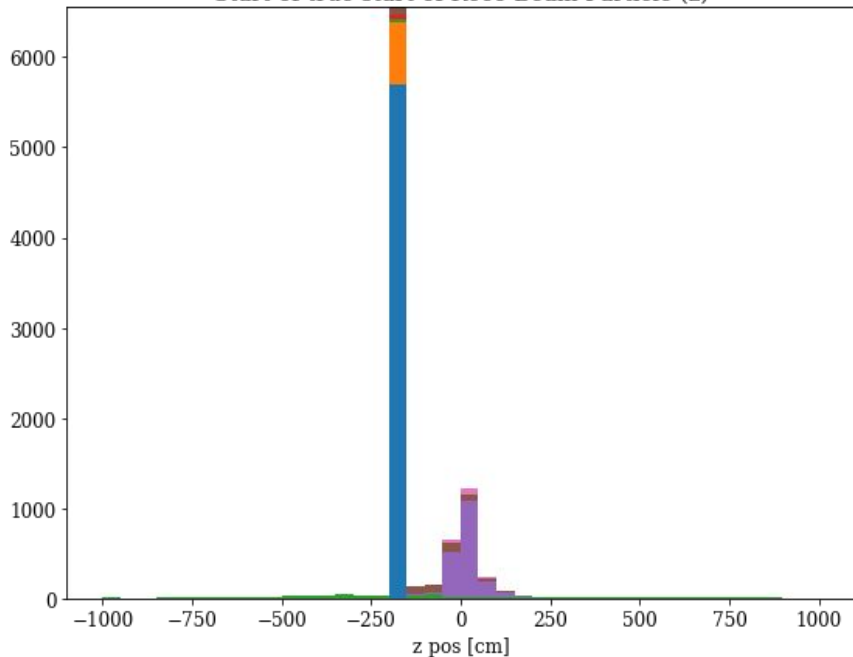


- Large difference in theta direction of track.
- Compare track direction with average beamline direction.

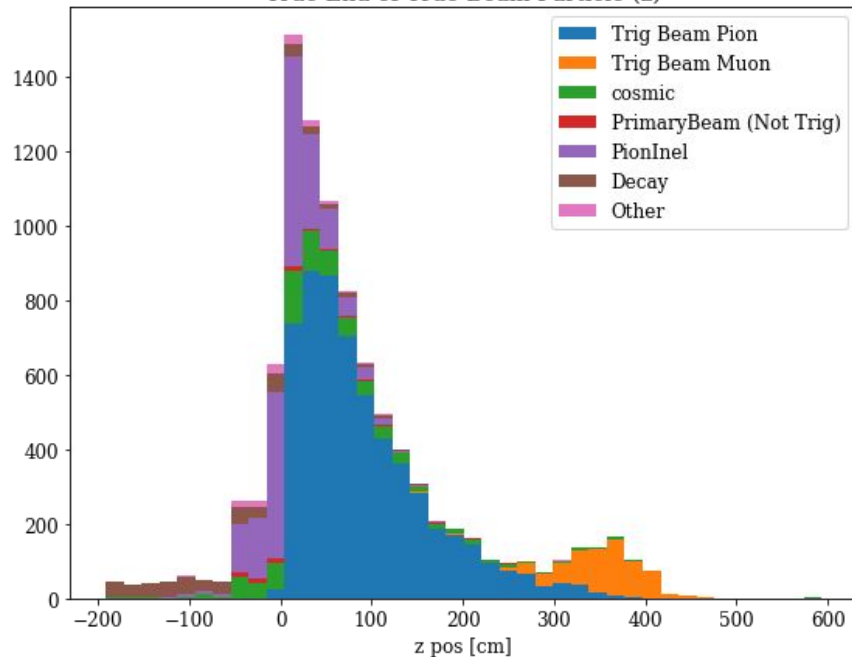
True Z start and End

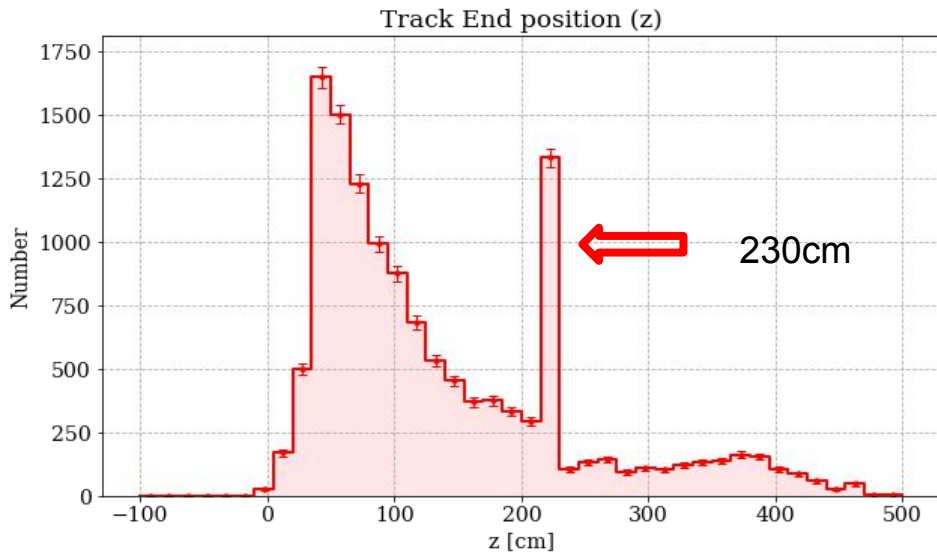
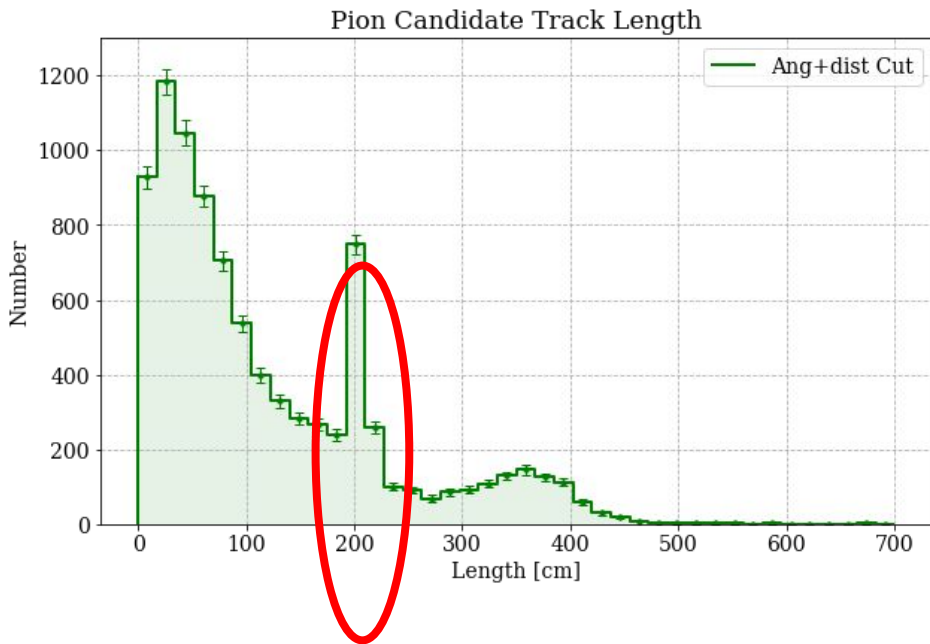
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Start of true start of Reco Beam Particle (z)

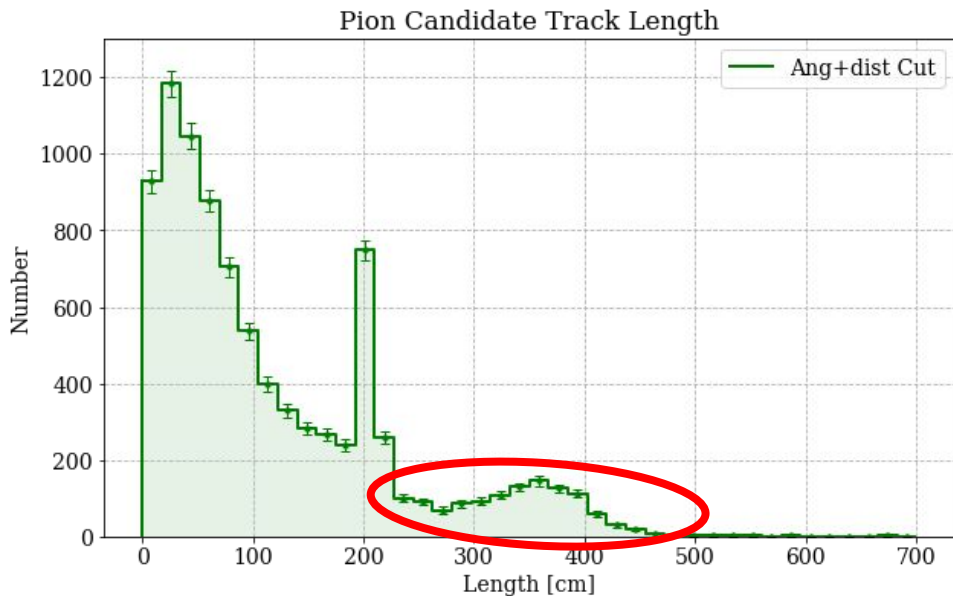


True End of True Beam Particle (z)





Spike at 200cm cause by broken tracks at end of first APA (230cm in Z direction)



Peak much beyond Pion-LAr
interaction length at 1 GeV ($<1\text{m}$)

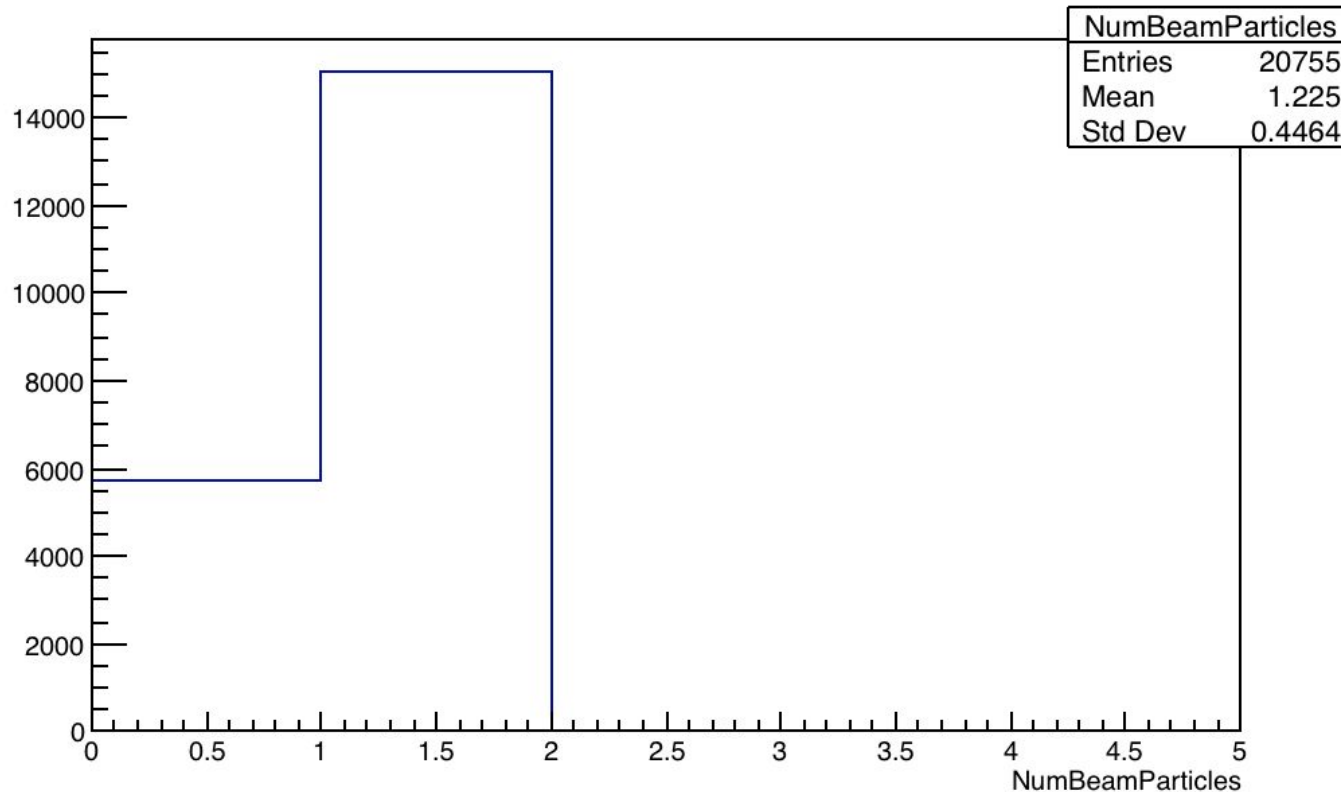
Muon Contamination

1GeV mom Stopping Muon
expected range using CSDA tables

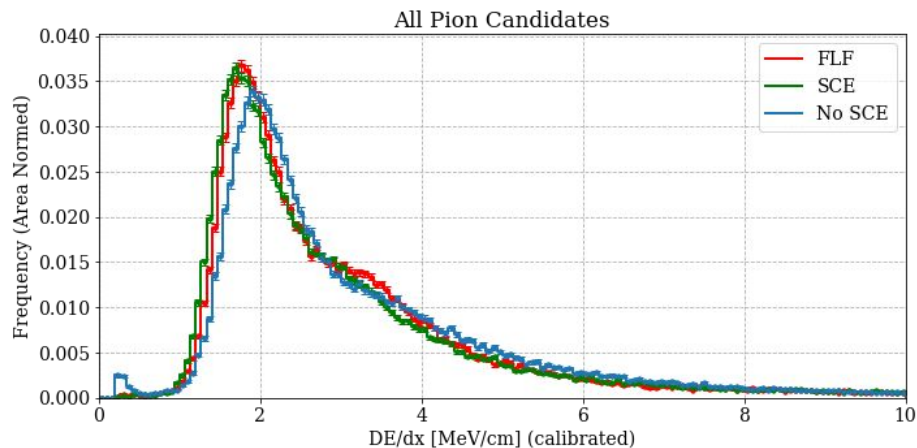
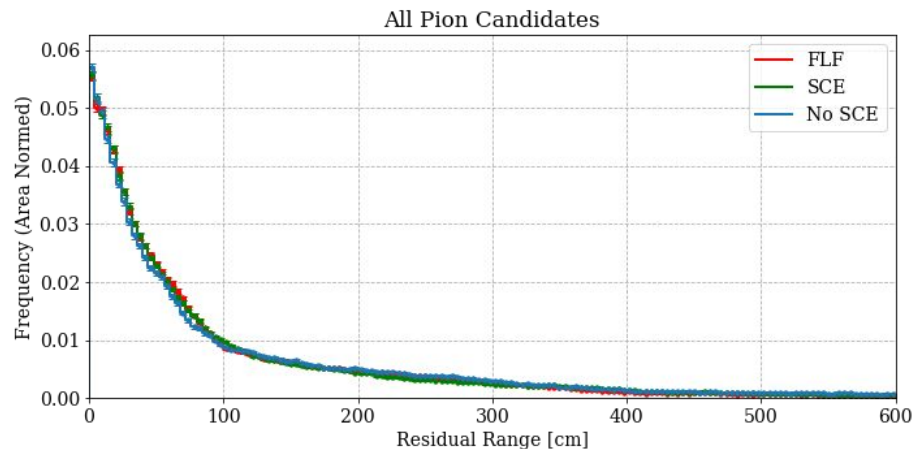
(http://pdg.lbl.gov/2012/AtomicNuclearProperties/MUON_ELOSS_TAB
[LES/muonloss_289.pdf](#)) is $\sim 395\text{cm}$

Number of beam particles

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- 1 GeV Beam MC.
- Select events where beam particle is true pion
- Use Ajib's calibration for each MCC11 sample (No SCE, SCE, SCE+FLF)



Parameters used in broken track stitching

```
BrokenTrackParameters: {  
  BrokenTrackZ_low: 220  
  BrokenTrackZ_high: 230
```

```
  StitchTrackZ_low: 232  
  StitchTrackZ_high: 240
```

```
  StitchXTol:    10  
  StitchYTol:    10  
}
```