

ProtoDUNE-SP Pion Selection Update

Justin Hugon

Louisiana State University

ProtoDUNE Analysis Meeting

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Tasks Common to Pion (& other) Cross-Sections

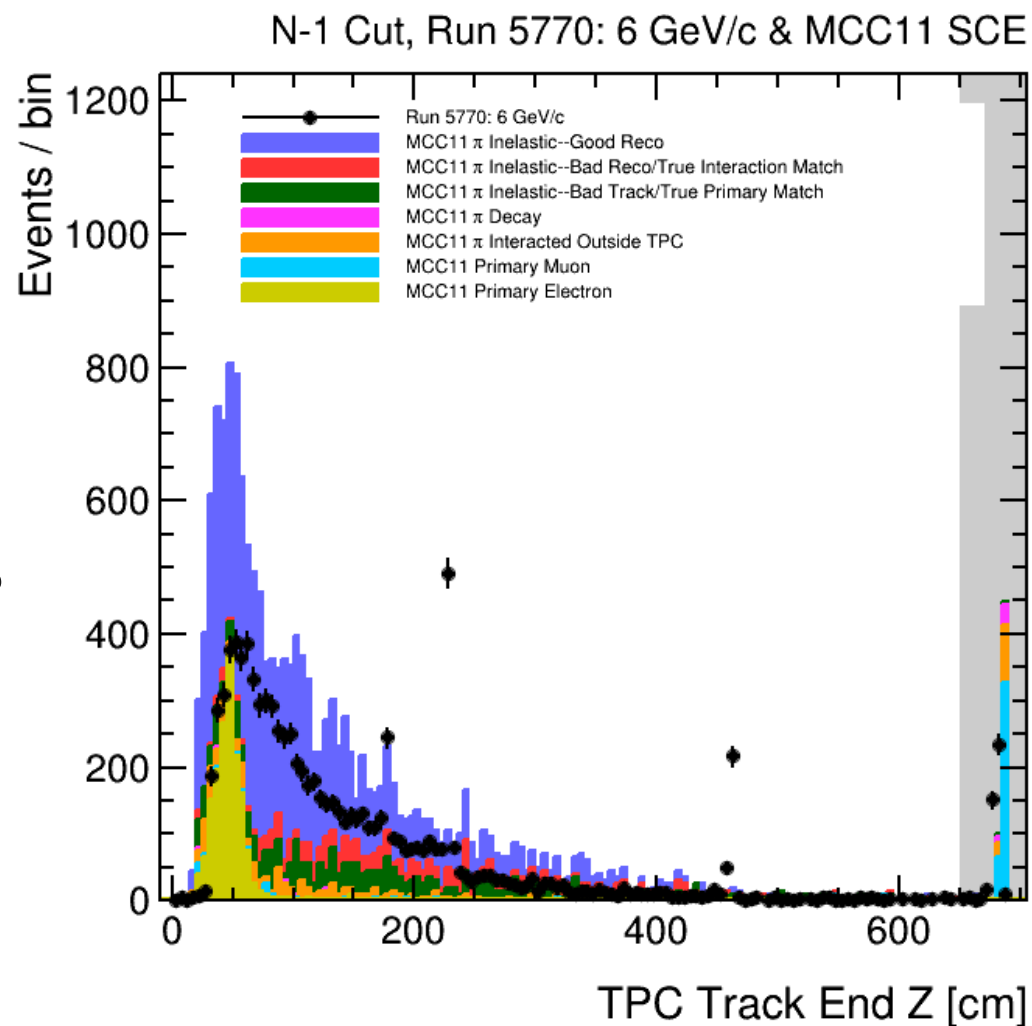
- **Primary Pion Selection**
- **Beam backgrounds: proton/electron/muon with uncertainty**
- **Beam instrumentation momentum uncertainty (not distribution of momentum)**
- **Energy loss between beam instrumentation and instrumented liquid argon (“material budget”)**
- **Primary track calorimetry uncertainty (“energy scale” and “energy resolution”)**
- **Machinery for thin slice method:**
 - **How to deal with SCE & electric field effects? (changing slice width, missed wires)**
 - **How to deal with misconstruction?**
- **Also position, charge, SCE calibration & corrections**

Tasks Specific to Analyses (Some may be Common)

- **Define signal at truth level**
- **Define acceptance cuts (minimum kink angle, hit & interaction fiducial region)**
- **Exclusive or inclusive event selection**
- **Interaction point selection**
- **Efficiency & uncertainty**
- **Beam-pion induced backgrounds (pion decay, unwanted channels)**
- **Need to have a list of common and specific tasks and volunteers so we don't duplicate work!**

Revisiting Pion Selection

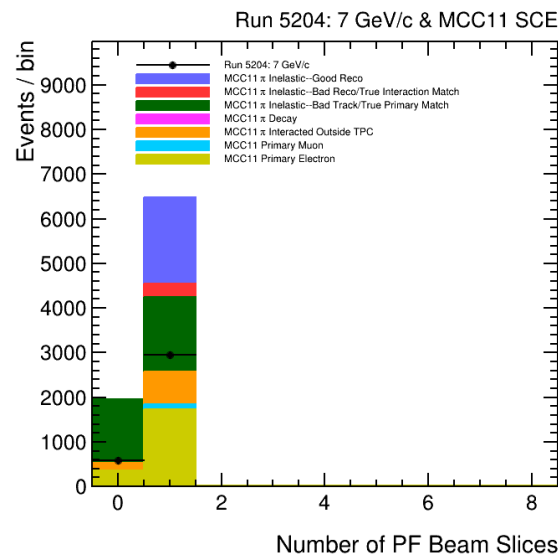
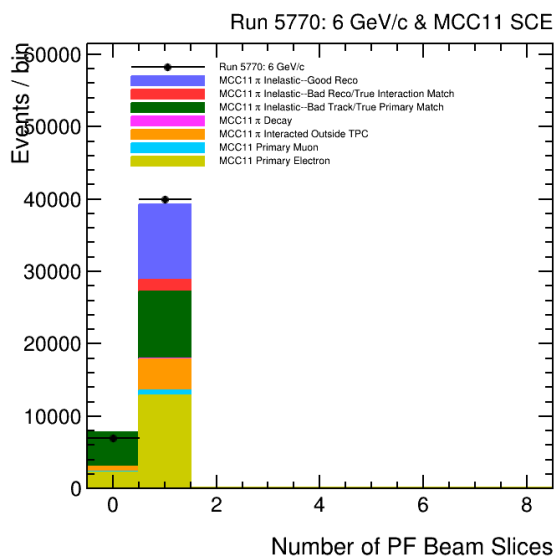
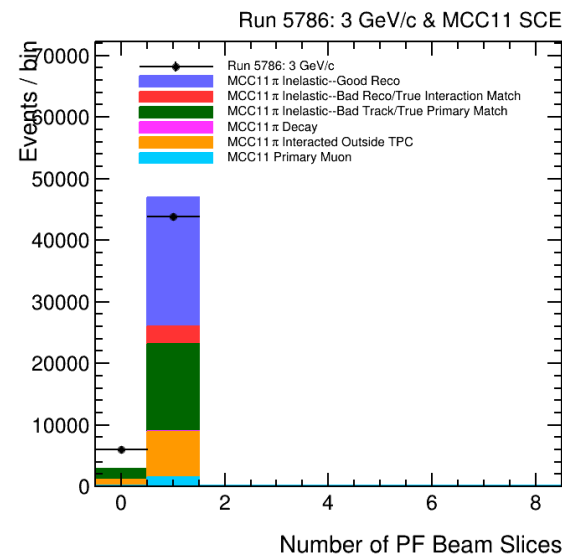
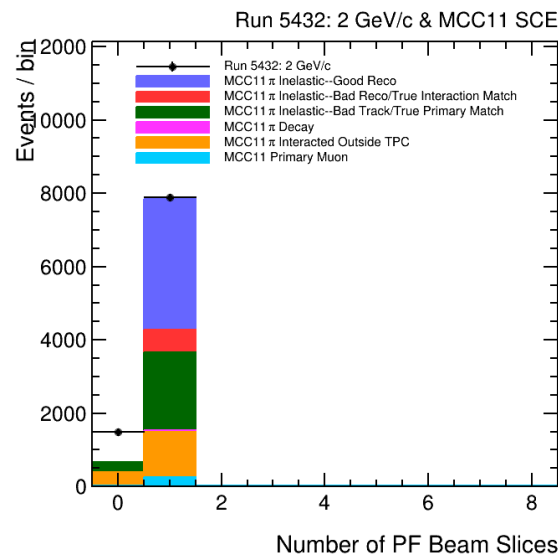
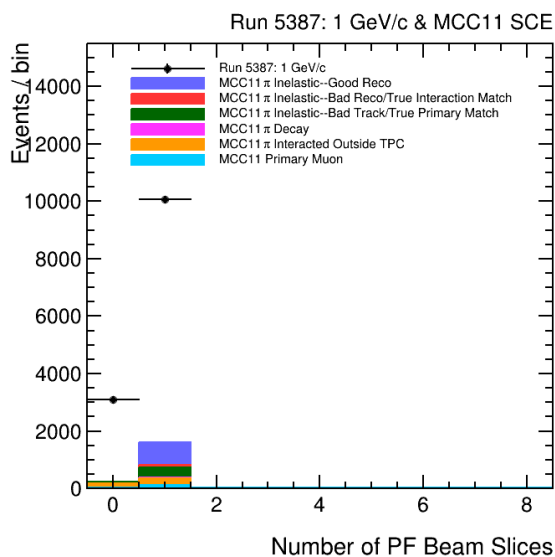
- Haven't looked at it for all beam momenta
- Starting from beam instrumentation pions as shown before (filter in dunetpc)
- Also investigate some interesting features like lots of tracks ending at APA boundaries:



Beam Pion Selection

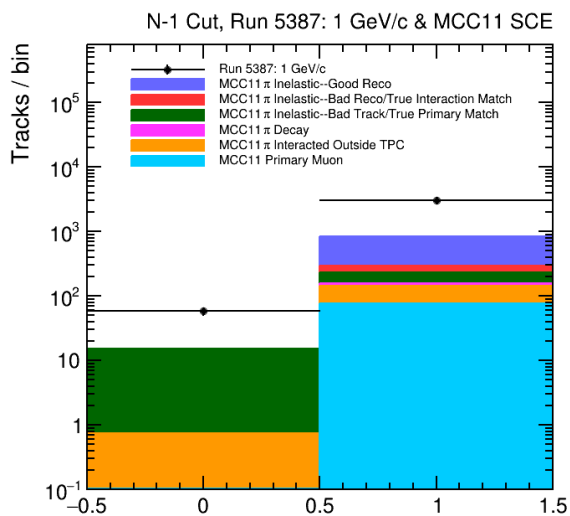
- **For data:**
 - **Require good beam instrumentation (BI) event with 1 track and 1 momentum passing pion selection**
 - **Require all beam-side (RaS) FEMBs to be properly readout**
- **For MC:**
 - **Beam primary true particle (starts at $t=0$) PDG = 211 or -13, or -11 for 6 & 7 GeV to match BI**
 - **Require exactly 1 Pandora beam slice**
 - **Require Pandora beam primary particle to be track-like**
 - **Require Pandora beam primary track start $z < 25$ cm**
 - **Require Pandora beam primary track end $z < 650$ cm**
 - **Require Δx and Δy of start of primary track - end of BI track (at $z=0$) to be:**
 - **For data: Δx : [0,20] cm Δy : [10,30] cm**
 - **For MC: Δx : [-5,5] cm, Δy : [0,10] cm**

Pandora Beam Slices

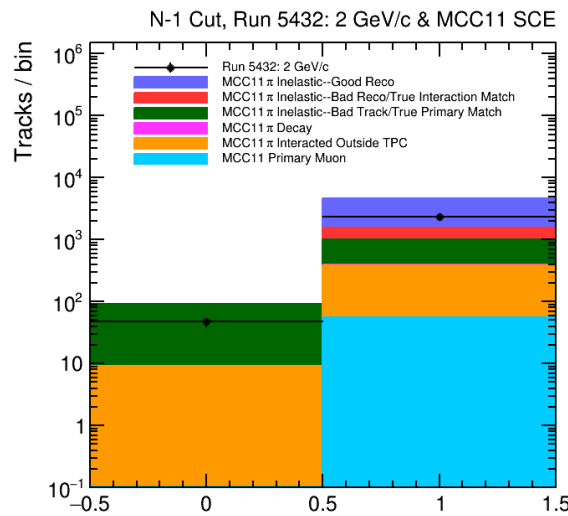


- MC normalized to number of events passing BI cuts
- Problem with 1 GeV MC normalization
- Only see 0 or 1 beam slices

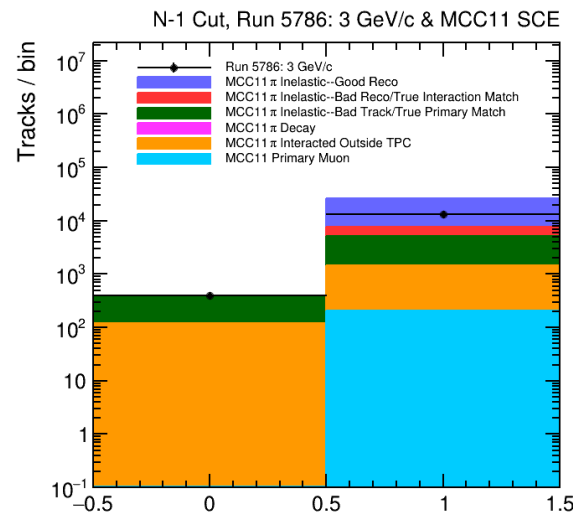
Pandora Beam Primary Track/Shower



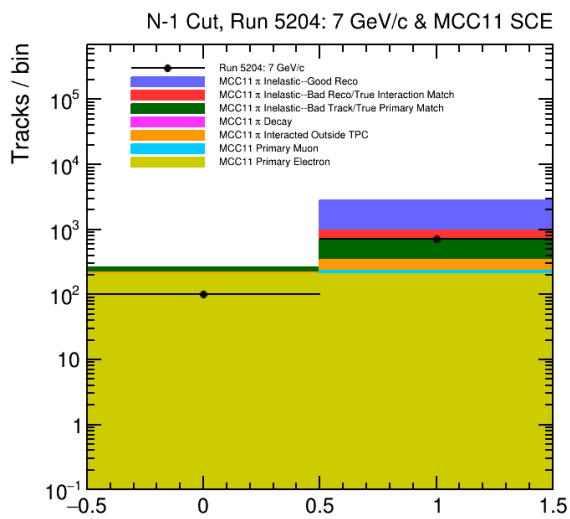
PF Beam Primary is Track-like



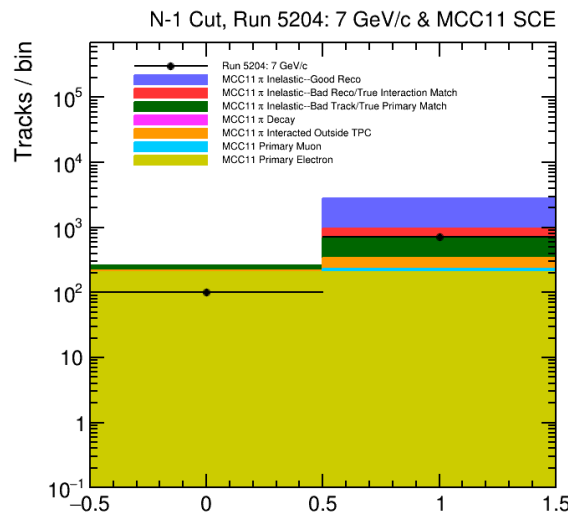
PF Beam Primary is Track-like



PF Beam Primary is Track-like



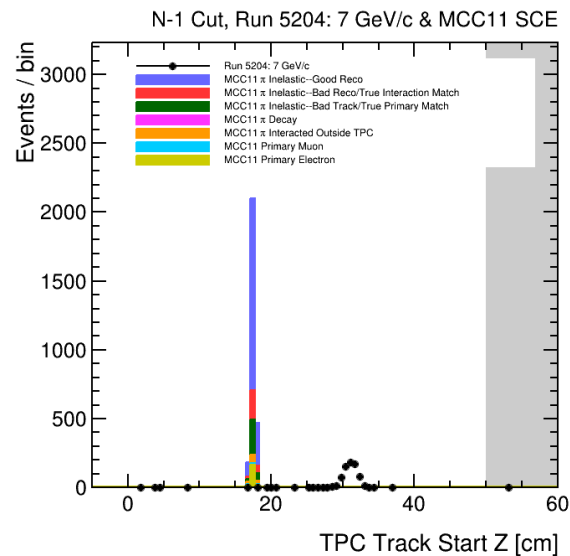
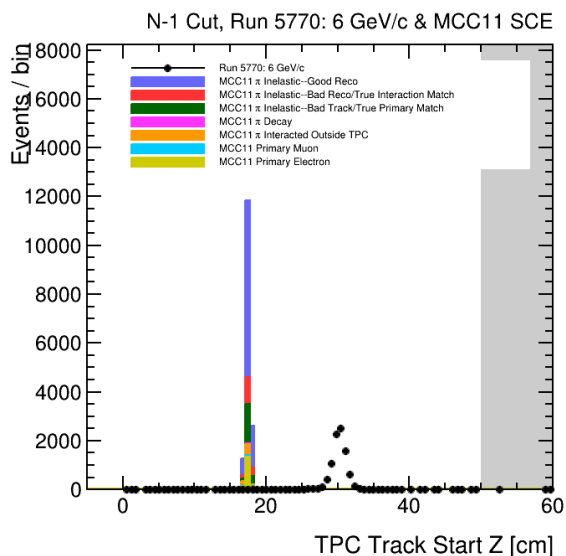
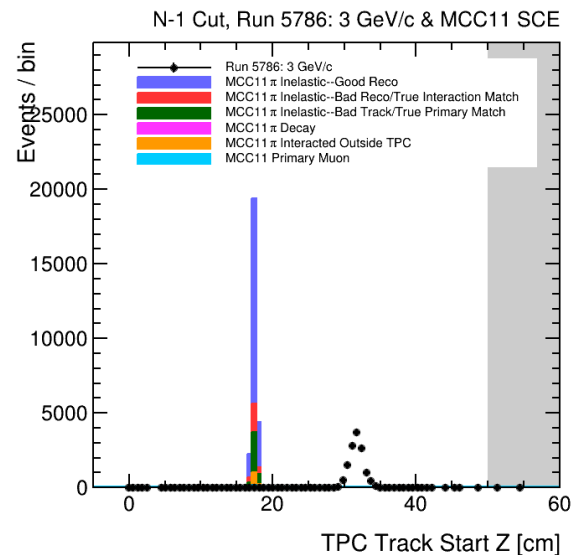
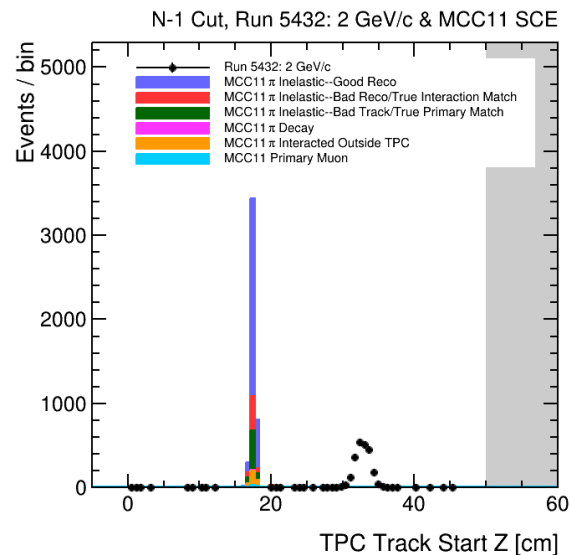
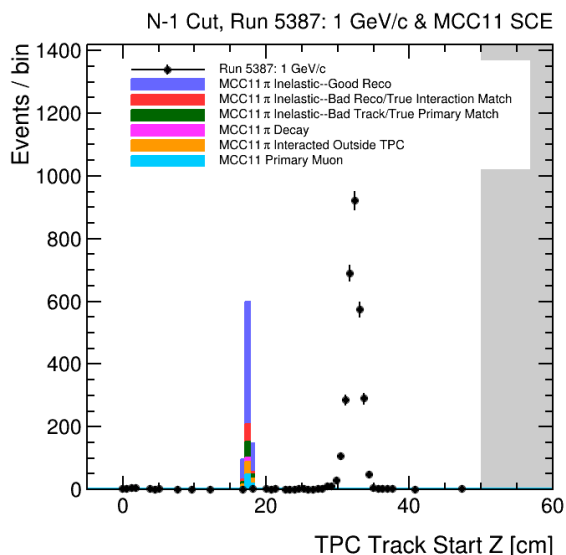
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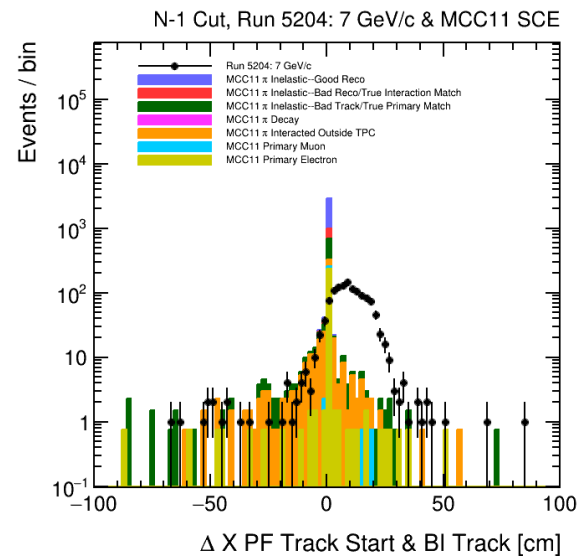
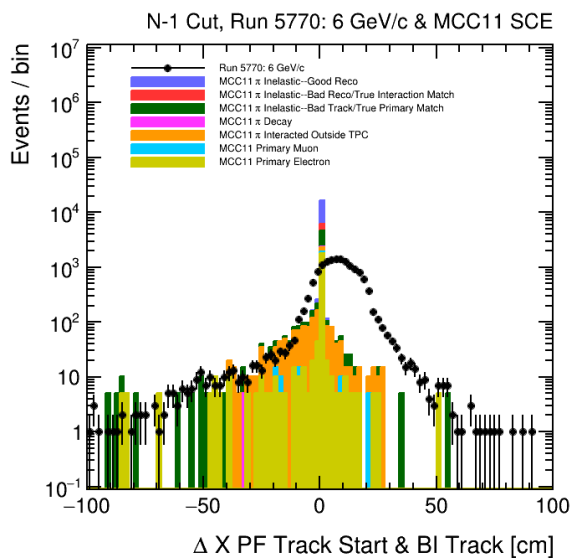
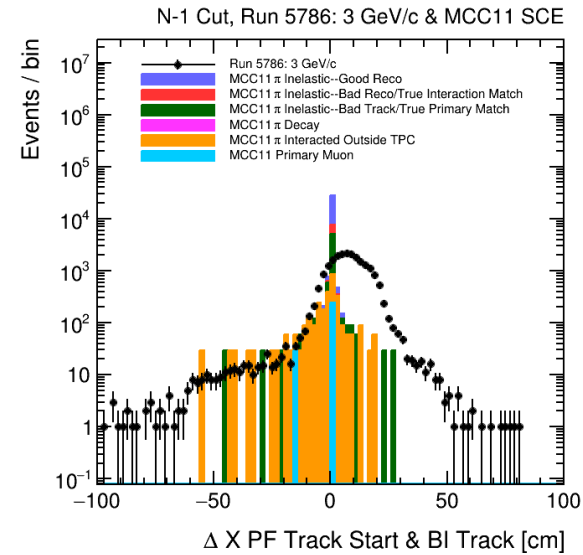
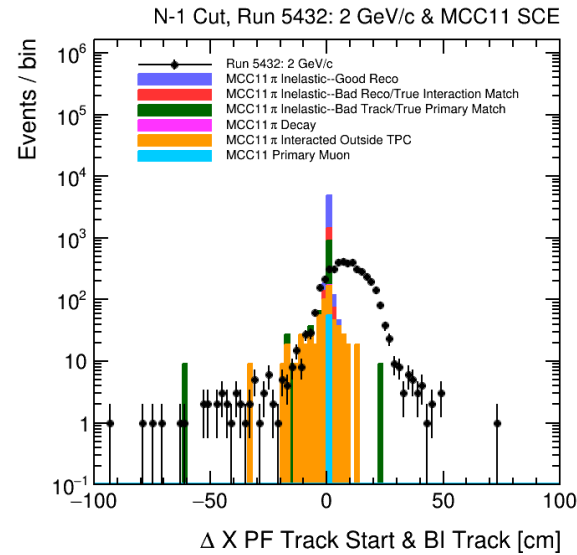
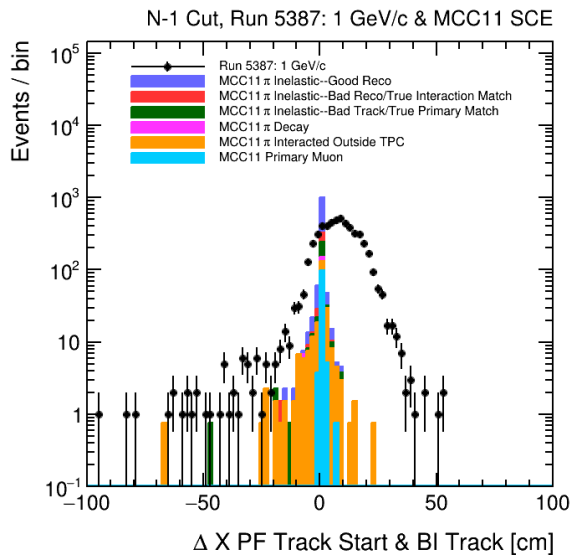
• **Need to tweak 6 & 7 GeV plots**

Pandora Beam Track Start Z



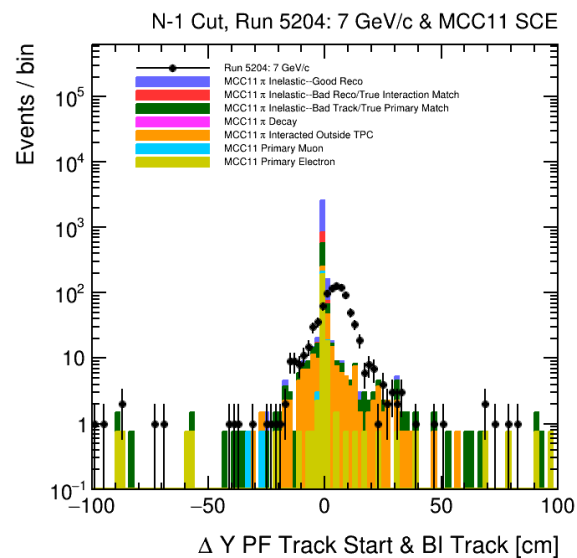
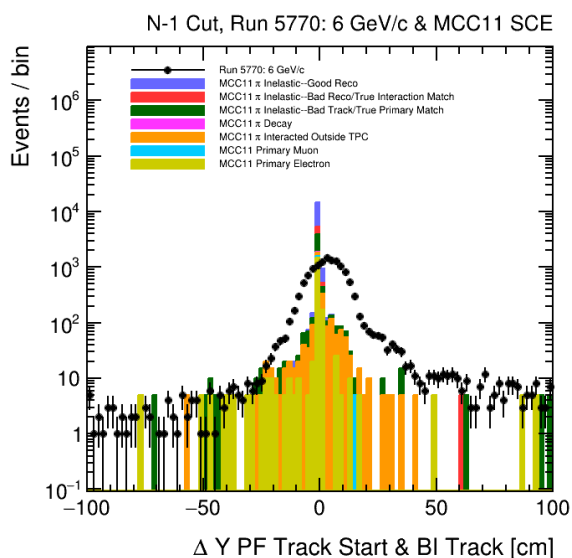
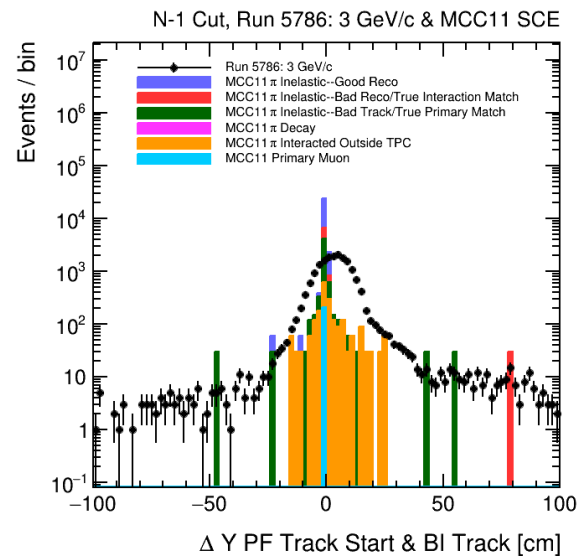
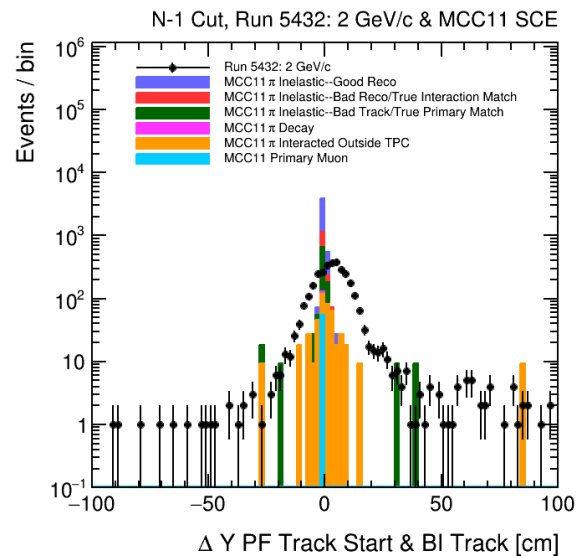
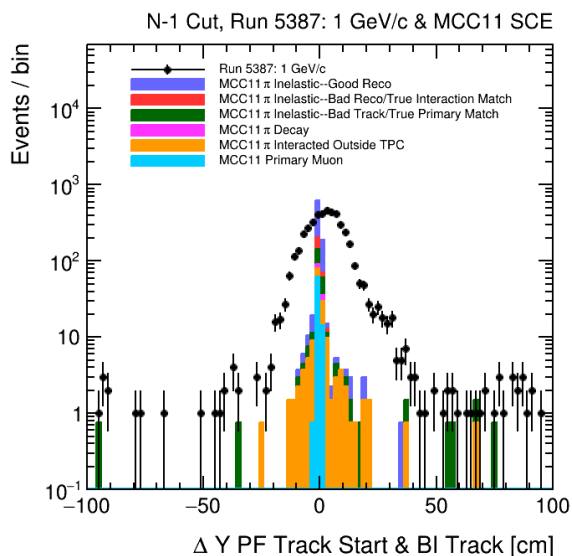
• All runs pretty similar

Delta X Pandora Track End & BI Track Start



- Data distributions seem really wide
- Key is that I make sure the Pandora track start $z < \text{end } z$ (if not flip)

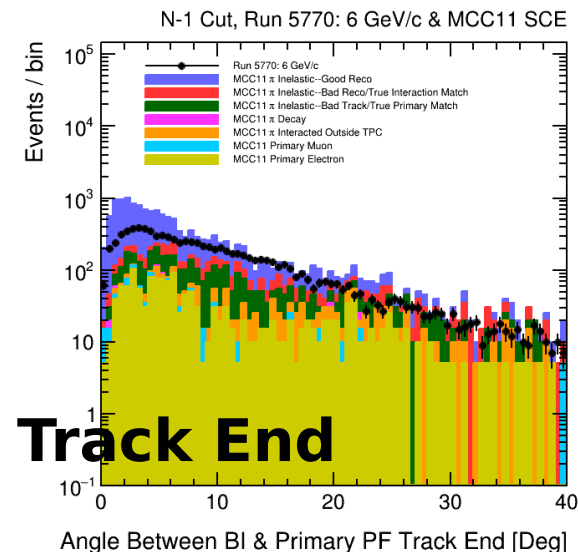
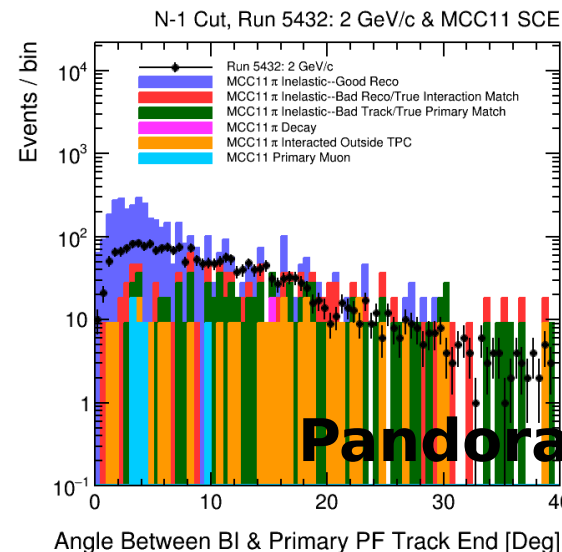
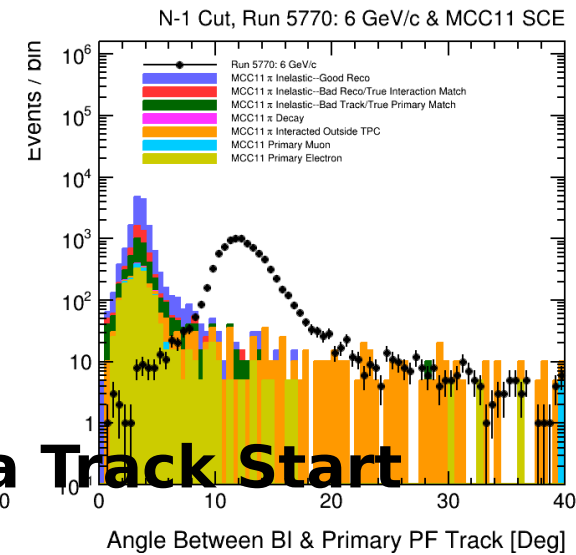
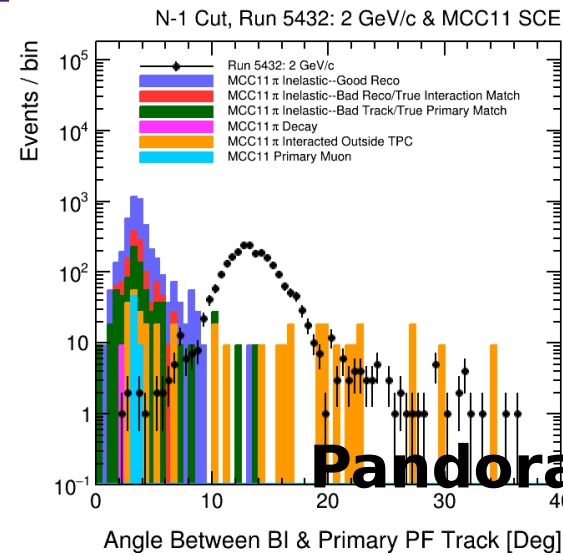
Delta Y Pandora Track End & BI Track Start



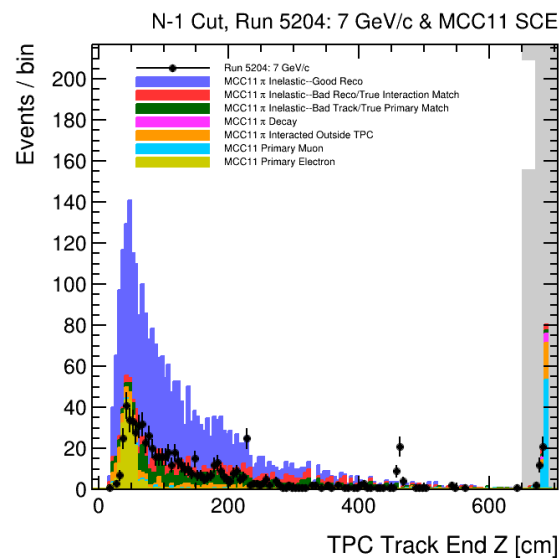
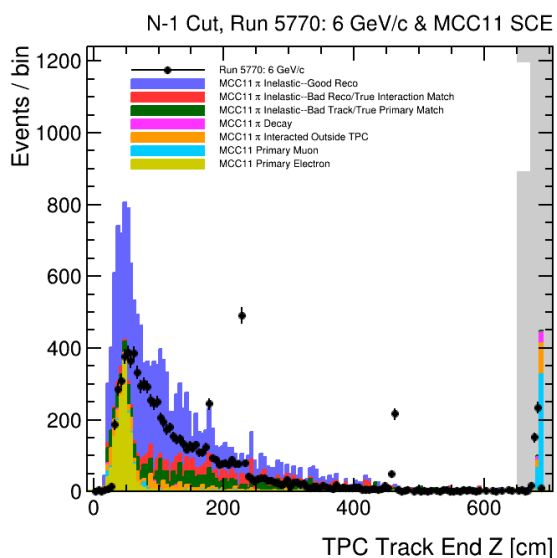
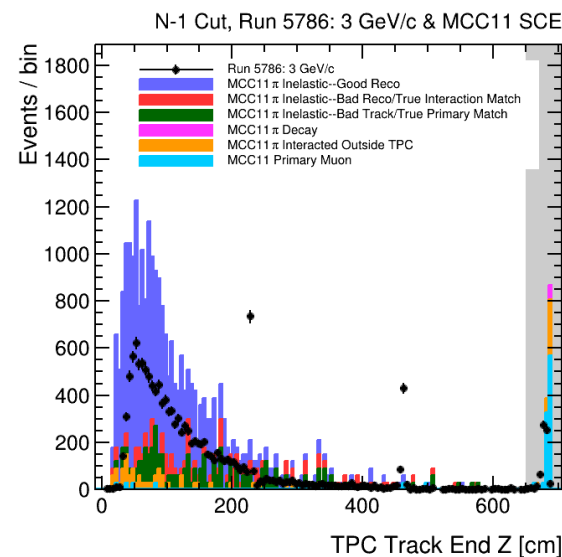
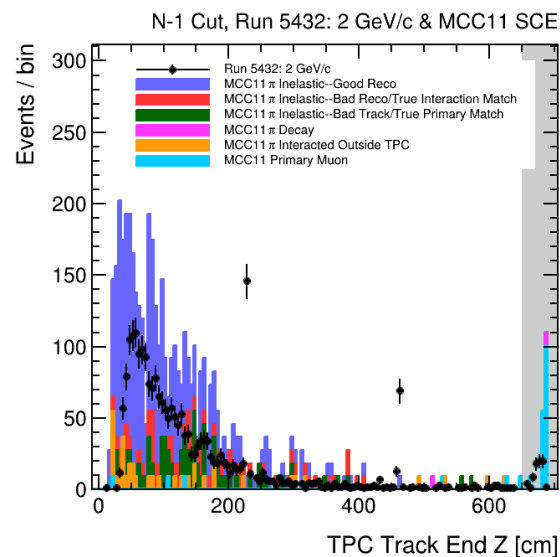
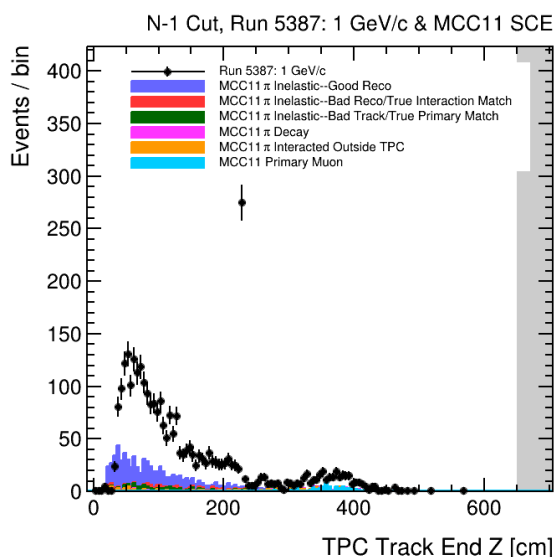
- Data distributions seem really wide
- Key is that I make sure the Pandora track start $z < \text{end } z$ (if not flip)

Angle Between BI Track & Pandora Track

- I'm not sure if people have been showing the angle with the track start or end (since some are flipped in reco)
- Start distribution narrower than end: scattering
- End data & MC matches well: SCE induced curvature is worse at start of TPC

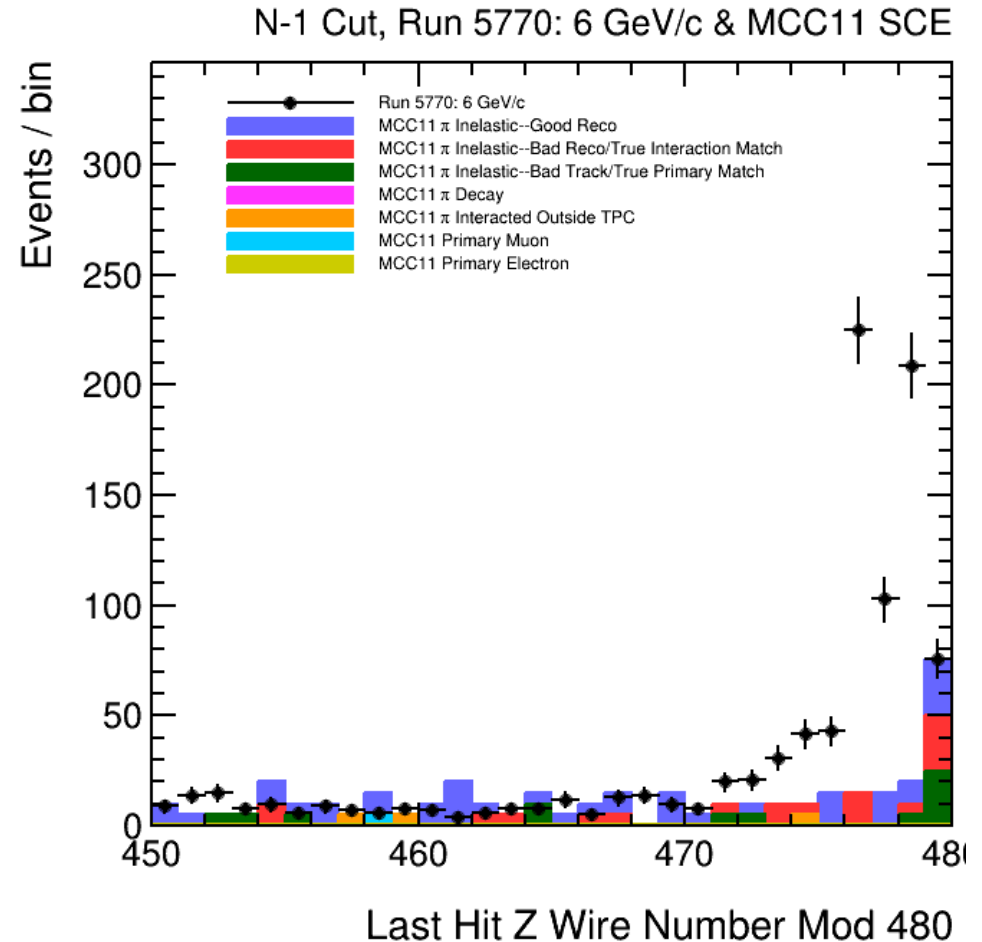
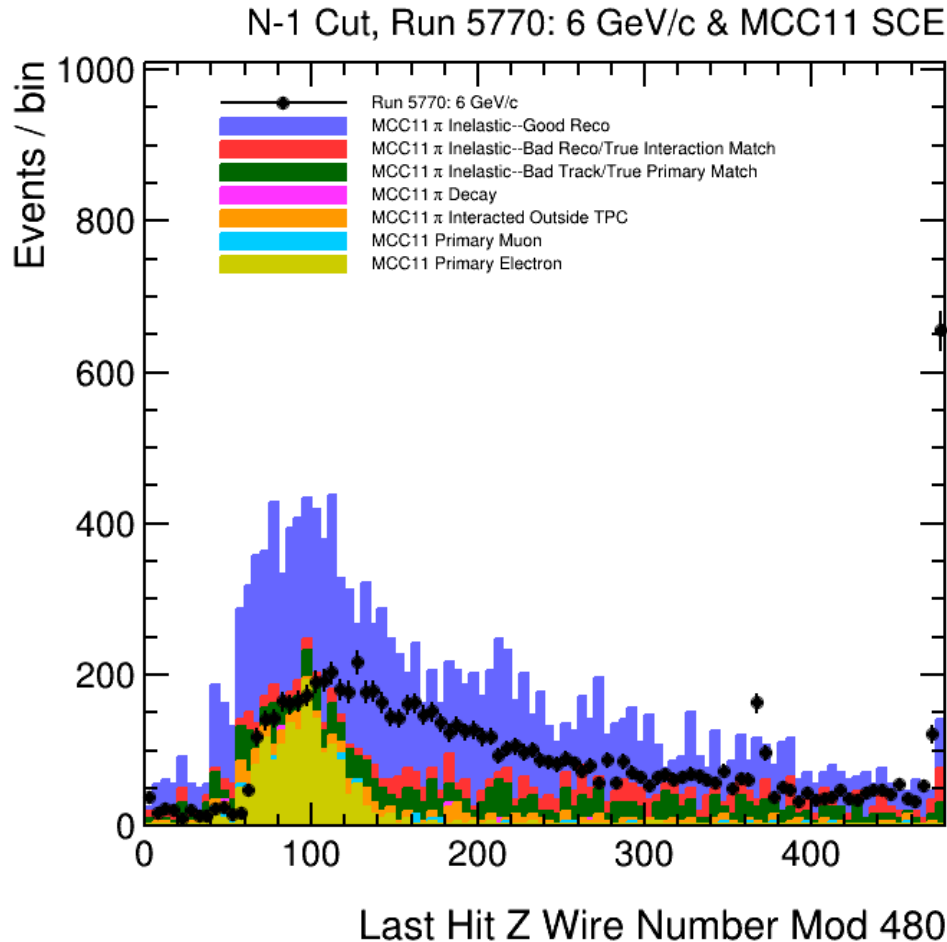


Pandora Beam Track End Z



- Muons end > 650 cm for ≥ 2 GeV/c
- Do we want a cut at ~ 300 cm for 1 GeV/c?
- Peaks at APA boundaries
- Funny peak ~ 180 cm at 6 GeV/c

Track End Z Wire in APAs



Tracks seem to be ending in the last few Z wires of an APA

Maybe Jake's stitching utility will help?

New Selection

	Run 5387	Run 5432	Run 5786	Run 5770	Run 5204	MCC 11 1	MCC 11	MCC 11	MCC 11 6	MCC 11 7
	1 GeV/c	2 GeV/c	3 GeV/c	6 GeV/c	7 GeV/c	GeV/c SCE	2 GeV/c SCE	3 GeV/c SCE	GeV/c SCE	GeV/c SCE
All	125682.0	21602.0	191451.0	160873.0	7490.0	81000.0	2430.0	2980.0	11000.0	13260.0
Timing Beam Trigger	46231.0	12488.0	119227.0	90640.0	6147.0	81000.0	2430.0	2980.0	11000.0	13260.0
Matched Beam Trigger to Timing Trigger	46231.0	12488.0	119227.0	90640.0	6147.0	81000.0	2430.0	2980.0	11000.0	13260.0
> 0 Beam Tracks	45552.0	12342.0	117955.0	89645.0	6082.0	81000.0	2430.0	2980.0	11000.0	13260.0
> 0 Beam Momenta	44914.0	12267.0	117291.0	89145.0	6032.0	81000.0	2430.0	2980.0	11000.0	13260.0
Exactly 1 Beam Tracks	30537.0	8996.0	84466.0	62347.0	4463.0	81000.0	2430.0	2980.0	11000.0	13260.0
Exactly 1 Beam Momenta	27785.0	8339.0	78017.0	57124.0	4283.0	81000.0	2430.0	2980.0	11000.0	13260.0
Official BI Pion/Muon	13676.0	5728.0	50244.0	47611.0	3586.0	81000.0	2430.0	2980.0	11000.0	13260.0
All Beam-side APAs Good	13152.0	5687.0	49818.0	46971.0	3544.0	81000.0	2430.0	2980.0	11000.0	13260.0
MC Truth Pion or Muon (or Electron)	13152.0	5687.0	49818.0	46971.0	3544.0	66447.0	1796.0	2306.0	9325.0	11189.0
1 Pandora Beam Slice	10064.0	4796.0	43777.0	39955.0	2954.0	58582.0	1632.0	2161.0	7788.0	8602.0
PF Primary is Tracklike	8919.0	4112.0	36391.0	26998.0	2047.0	23898.0	1002.0	1521.0	4895.0	5633.0
PF Primary Start Z < 50 cm	8821.0	4027.0	35687.0	26496.0	2019.0	23728.0	988.0	1511.0	4838.0	5578.0
PF Primary End Z < 650 cm	8791.0	3877.0	33853.0	25255.0	1906.0	23591.0	960.0	1451.0	4649.0	5347.0
Delta X PF Track & BI Track TPC Front	4461.0	1935.0	18043.0	13127.0	904.0	13772.0	666.0	1034.0	3344.0	3904.0
Delta Y PF Track & BI Track TPC Front	3039.0	1401.0	13196.0	9146.0	723.0	12212.0	619.0	971.0	3173.0	3709.0

New Selection

Cumulative Cuts Percentage of Previous Row

	Run 5387 1 GeV/c	Run 5432 2 GeV/c	Run 5786 3 GeV/c	Run 5770 6 GeV/c	Run 5204 7 GeV/c	MCC 11 1 GeV/c SCE	MCC 11 2 GeV/c SCE	MCC 11 3 GeV/c SCE	MCC 11 6 GeV/c SCE	MCC 11 7 GeV/c SCE
All	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Timing Beam Trigger	36.8	57.8	62.3	56.3	82.1	100.0	100.0	100.0	100.0	100.0
Matched Beam Trigger to Timing Trigger	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
> 0 Beam Tracks	98.5	98.8	98.9	98.9	98.9	100.0	100.0	100.0	100.0	100.0
> 0 Beam Momenta	98.6	99.4	99.4	99.4	99.2	100.0	100.0	100.0	100.0	100.0
Exactly 1 Beam Tracks	68.0	73.3	72.0	69.9	74.0	100.0	100.0	100.0	100.0	100.0
Exactly 1 Beam Momenta	91.0	92.7	92.4	91.6	96.0	100.0	100.0	100.0	100.0	100.0
Official BI Pion/Muon	49.2	68.7	64.4	83.3	83.7	100.0	100.0	100.0	100.0	100.0
All Beam-side APAs Good	96.2	99.3	99.2	98.7	98.8	100.0	100.0	100.0	100.0	100.0
MC Truth Pion or Muon (or Electron)	100.0	100.0	100.0	100.0	100.0	82.0	73.9	77.4	84.8	84.4
1 Pandora Beam Slice	76.5	84.3	87.9	85.1	83.4	88.2	90.9	93.7	83.5	76.9
PF Primary is Tracklike	88.6	85.7	83.1	67.6	69.3	40.8	61.4	70.4	62.9	65.5
PF Primary Start Z < 50 cm	98.9	97.9	98.1	98.1	98.6	99.3	98.6	99.3	98.8	99.0
PF Primary End Z < 650 cm	99.7	96.3	94.9	95.3	94.4	99.4	97.2	96.0	96.1	95.9
Delta X PF Track & BI Track TPC Front	50.7	49.9	53.3	52.0	47.4	58.4	69.4	71.3	71.9	73.0
Delta Y PF Track & BI Track TPC Front	68.1	72.4	73.1	69.7	80.0	88.7	92.9	93.9	94.9	95.0

Conclusions

- **Updated pion selection and review for all beam momenta**
- **Want to use Jake's track stitching utility to fix tracks stopping in-between APAs**
- **Could also investigate BI to TPC track matching**
 - **seem to lose a lot of events in data**
 - **Don't think I want to cut on angle right now**