

ProtoDUNE-SP Beam Instrumentation & TPC Track Matching

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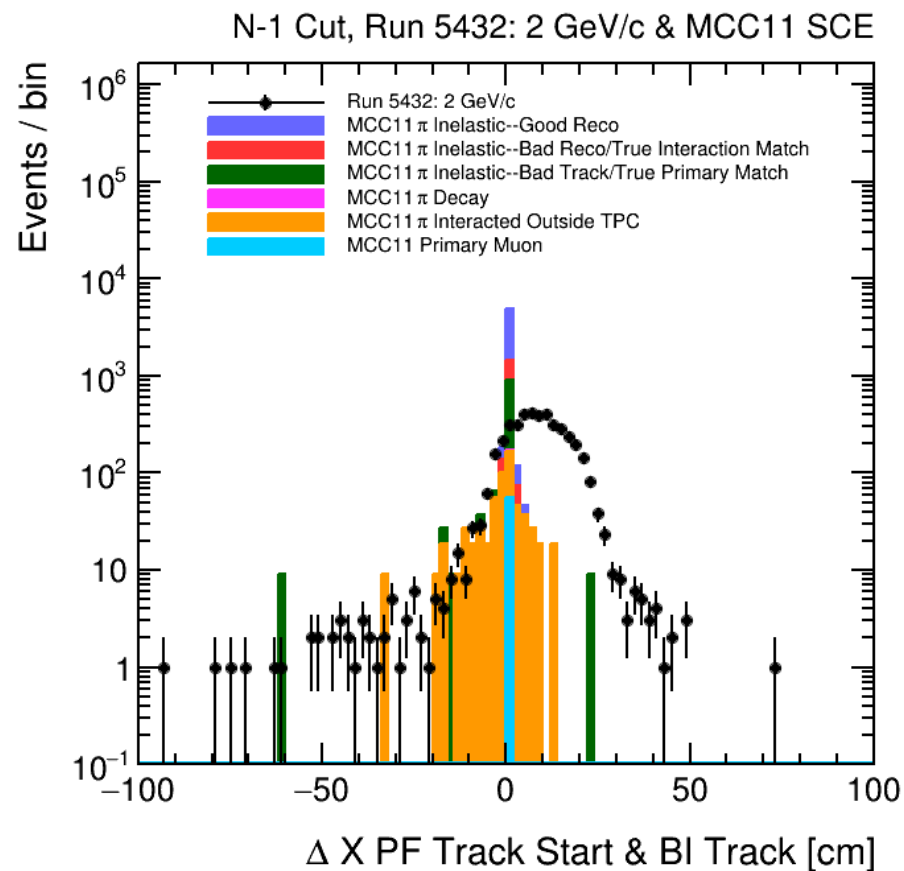
ProtoDUNE Analysis Meeting

2019-04-04



Introduction

- Last week, presented beam pion track selection
- Matching between TPC tracks and beam instrumentation tracks very different in data w.r.t. MC
- Investigate underlying distributions today



Check out ProtoDUNE-SP analysis task list:

https://wiki.dunescience.org/wiki/ProtoDUNE-SP_Analysis

Volunteer for a task or put your study on there! (& communicate with Stefania)

Diagram of Positions

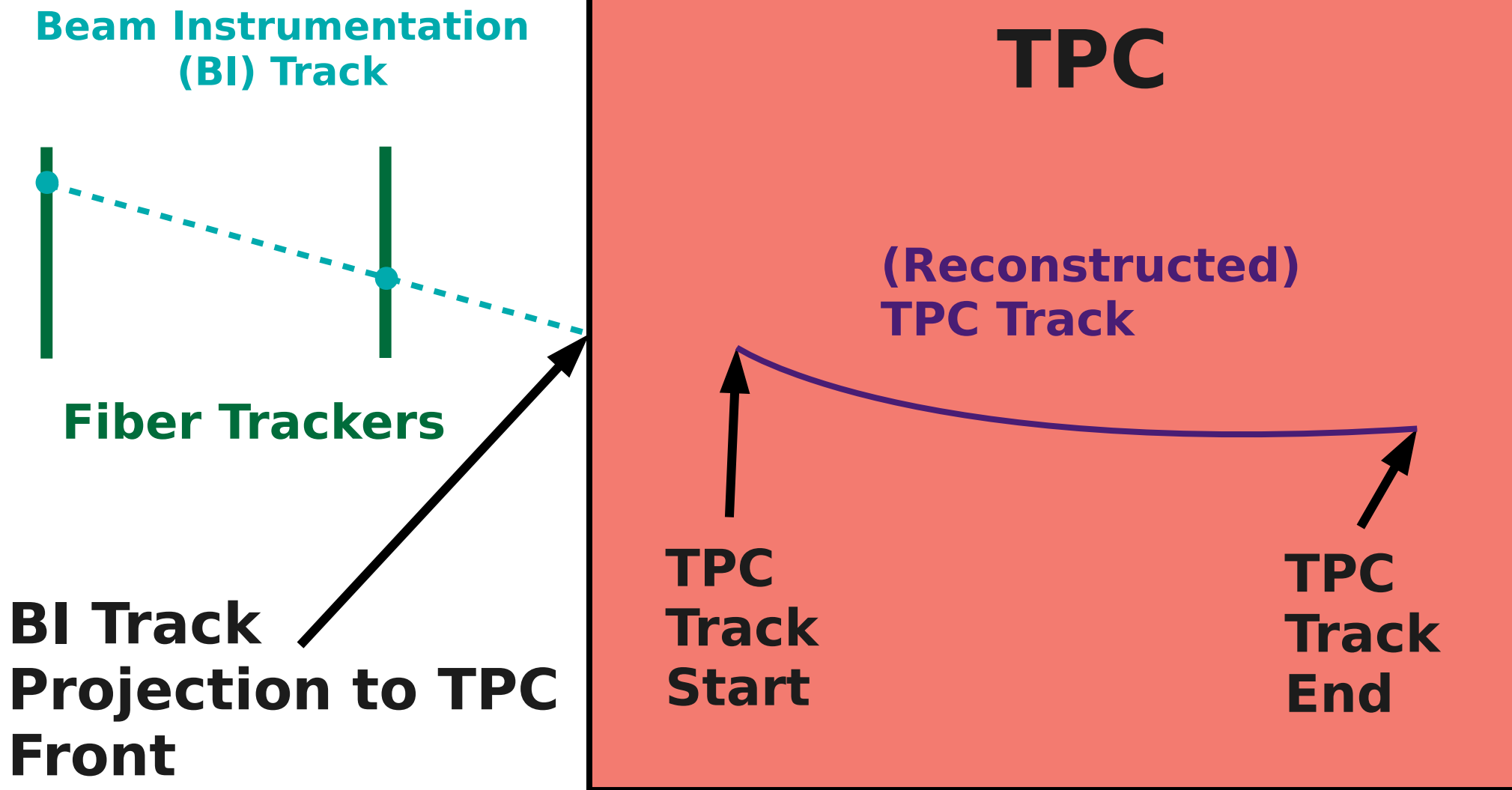
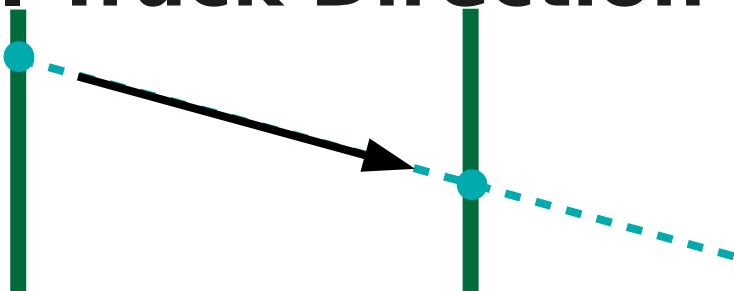
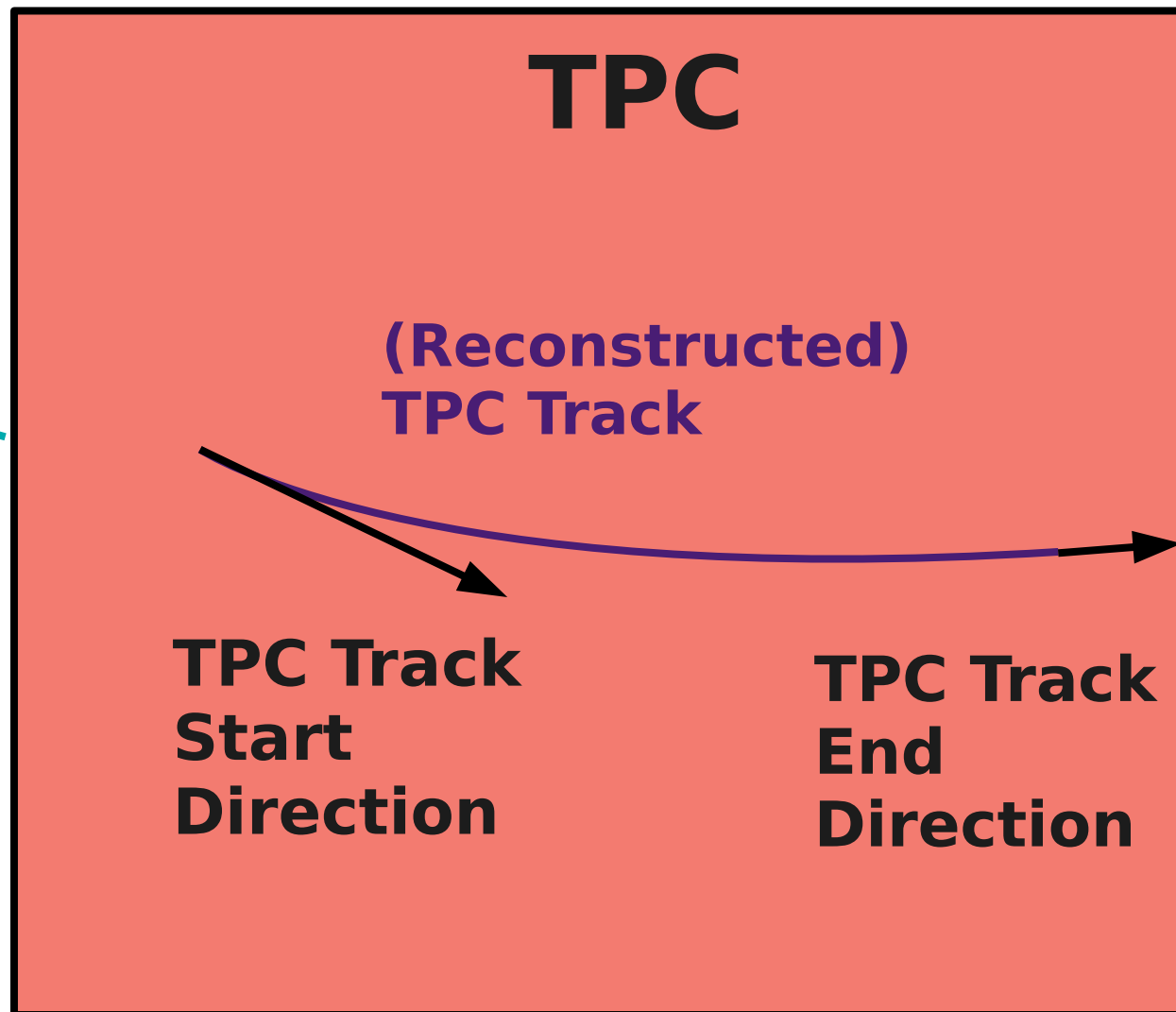


Diagram of Positions

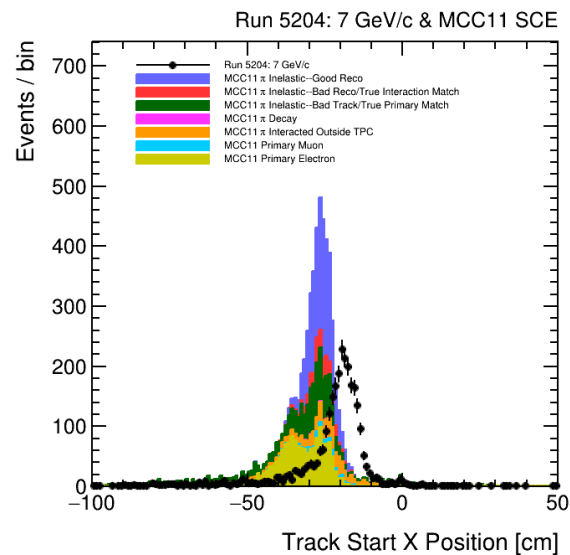
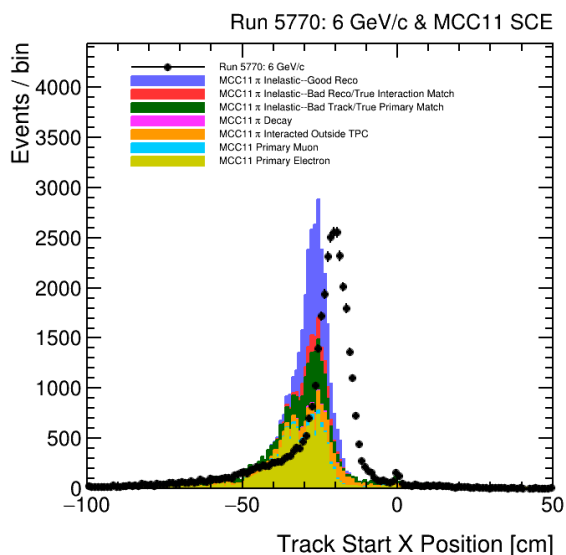
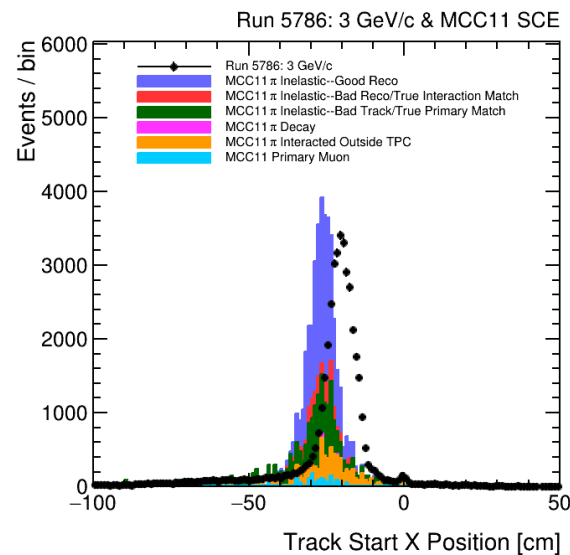
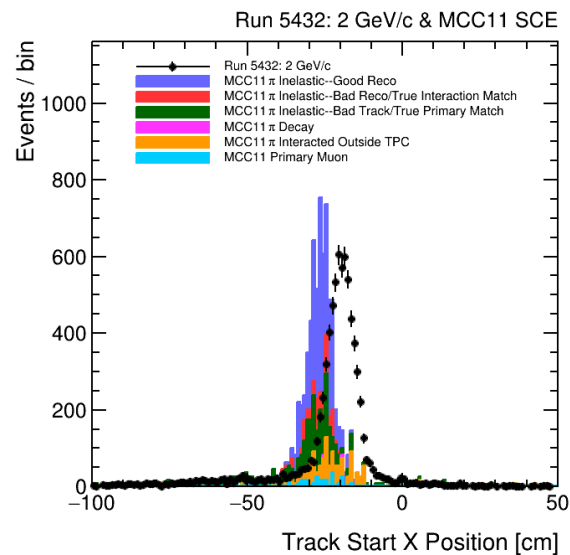
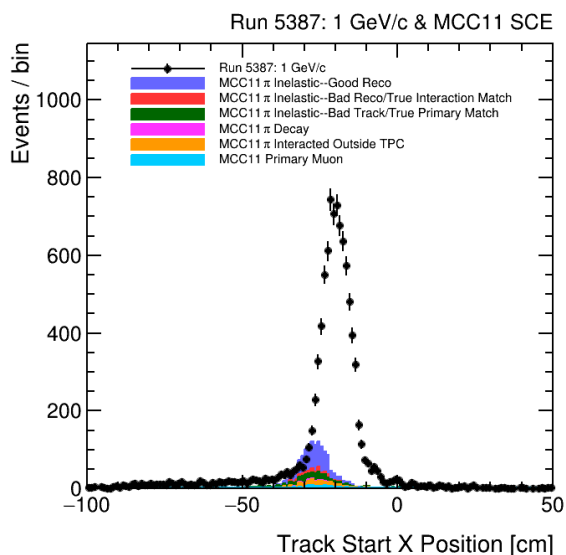
BI Track Direction



- θ_{xz} : the angle in x-z plane; $\theta_{xz} = 0$ at +z axis
- θ_{yz} : the angle in y-z plane; $\theta_{yz} = 0$ at +z axis

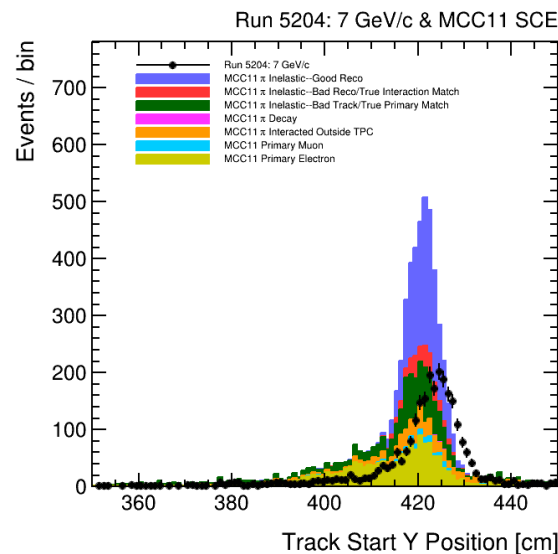
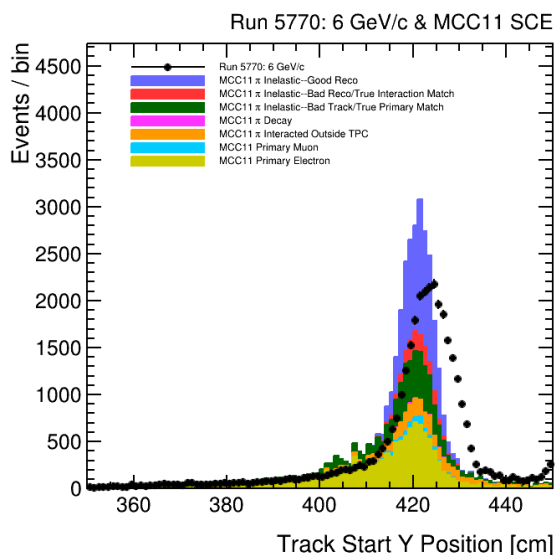
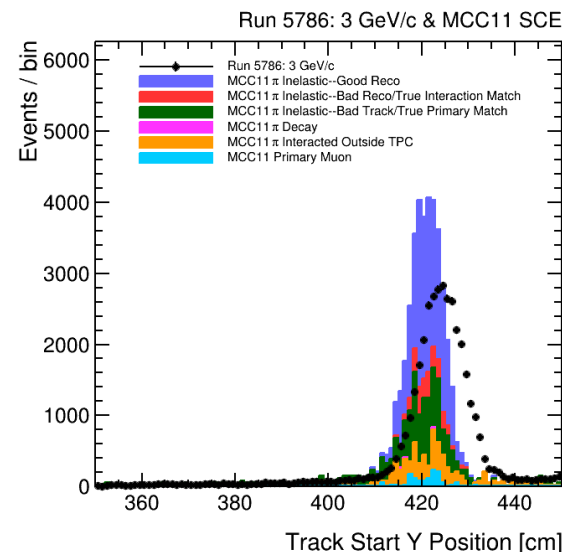
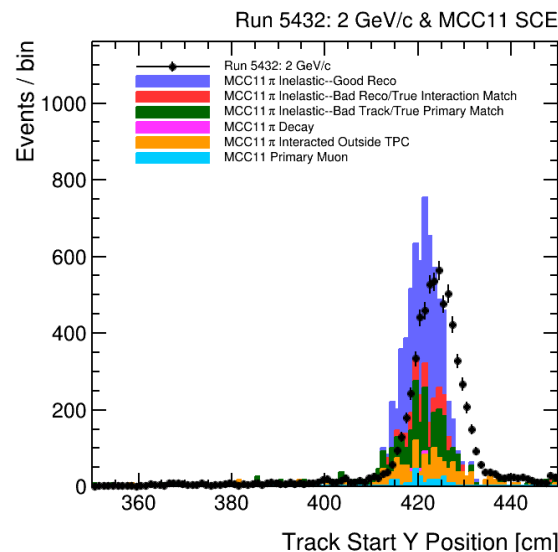
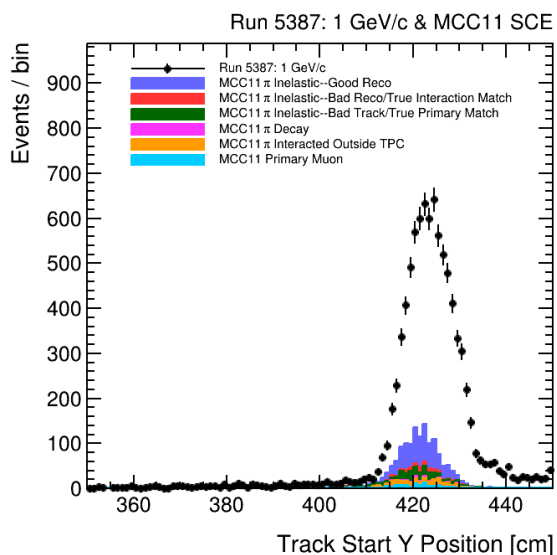


Pandora Track Start X Position



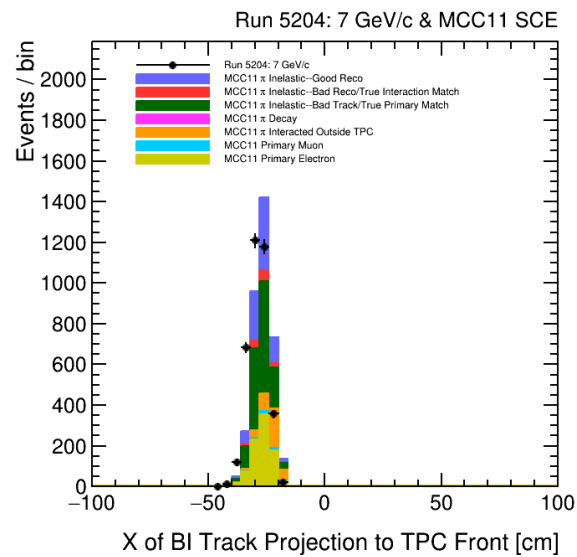
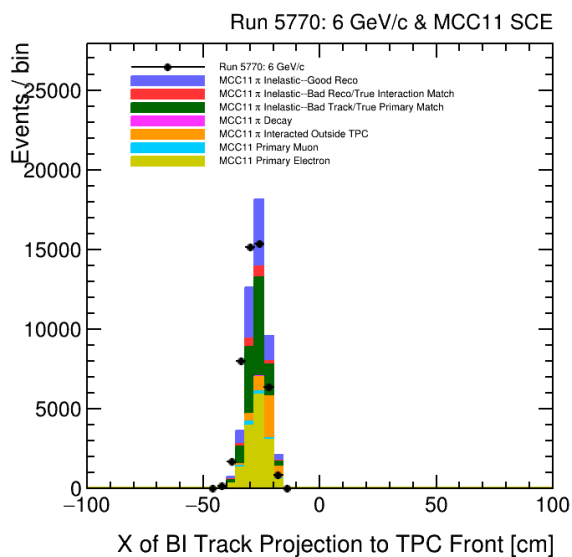
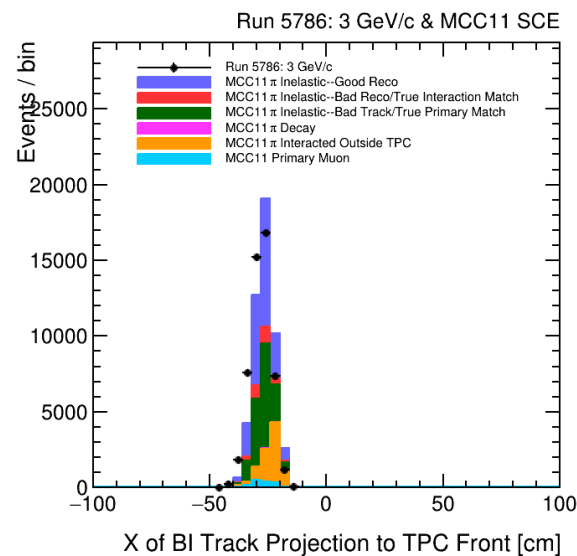
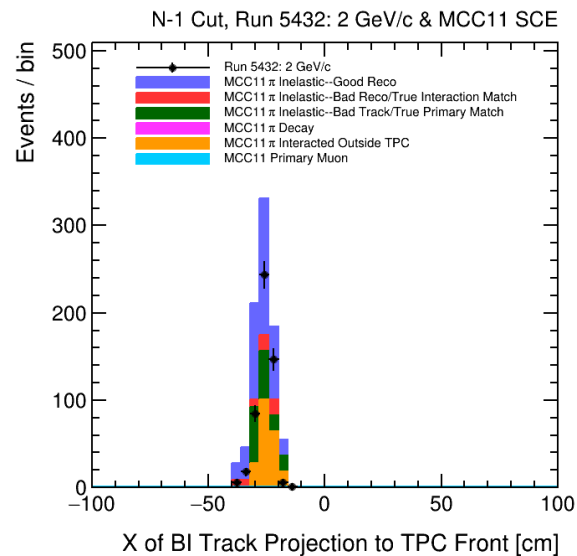
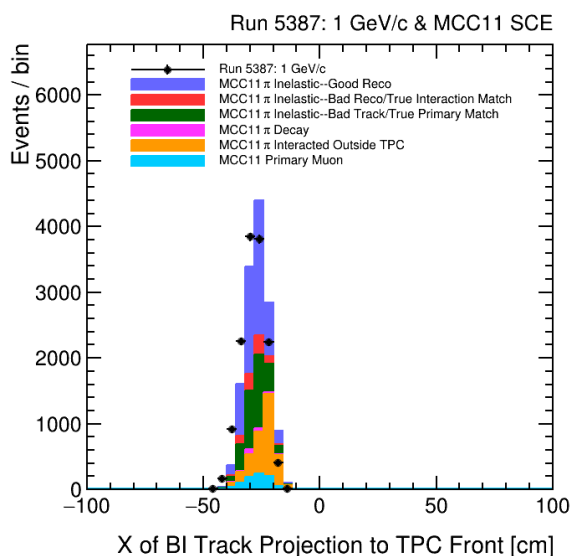
- **Width of distribution similar in data & MC**
- **Shift ~ 10-15 cm seems consistent with SCE**

Pandora Track Start Y Position



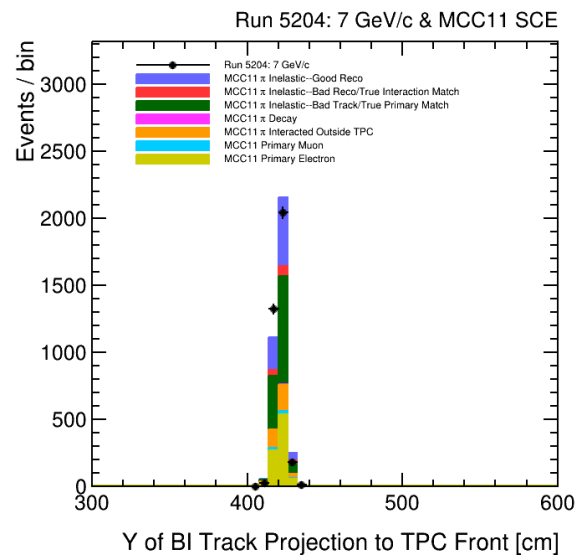
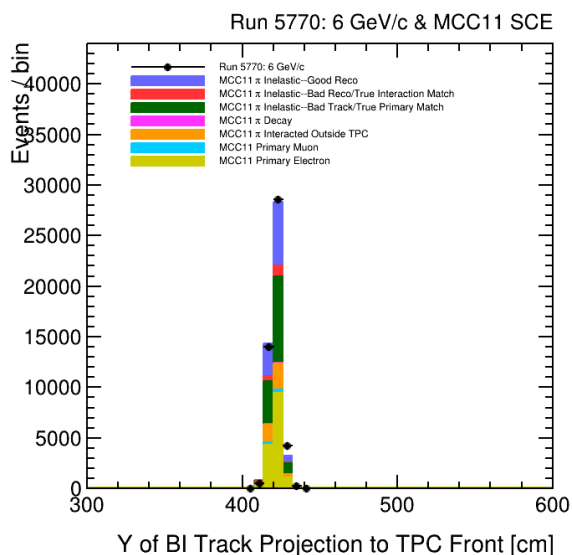
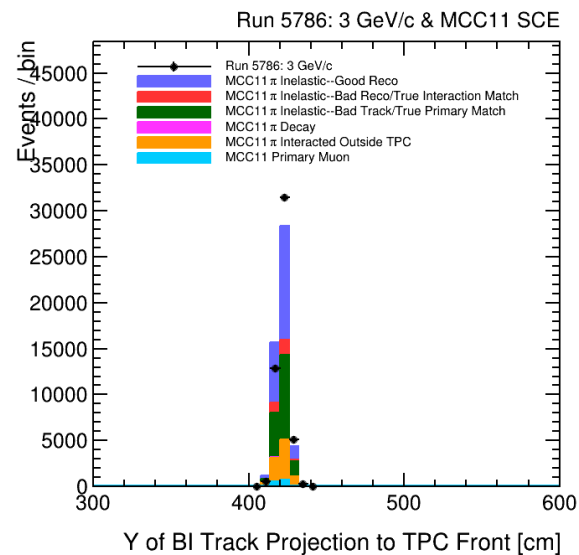
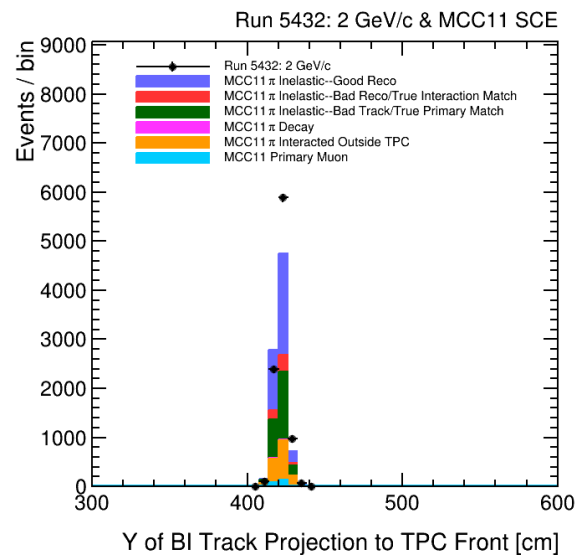
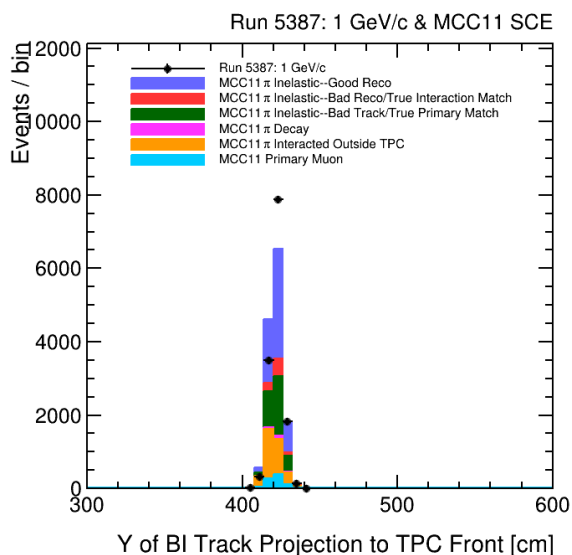
- Width of distribution similar in data & MC
- Shift ~ 5 cm seems consistent with SCE

Beam Instrumentation Track X Position



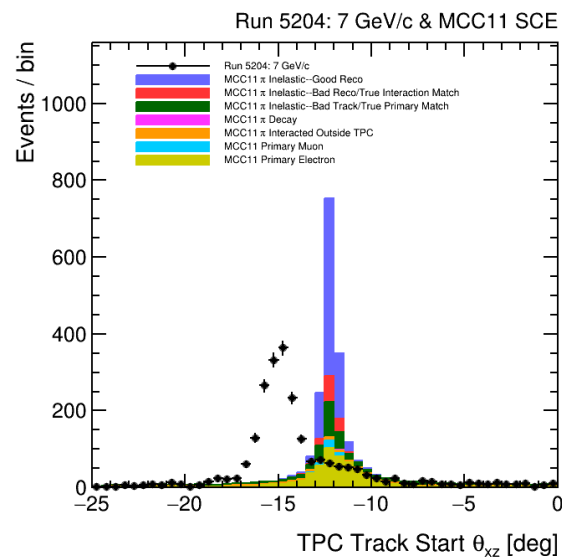
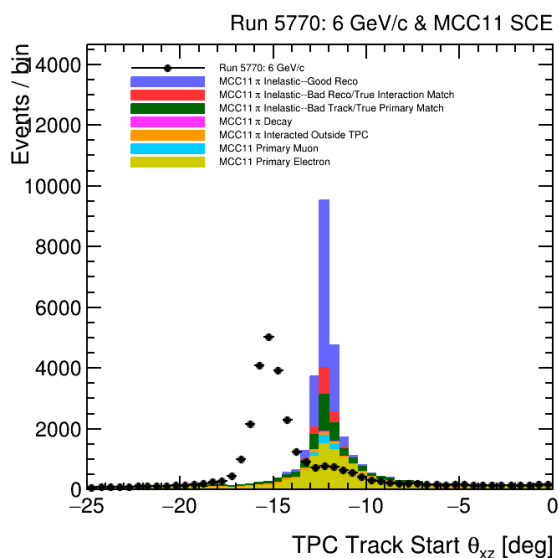
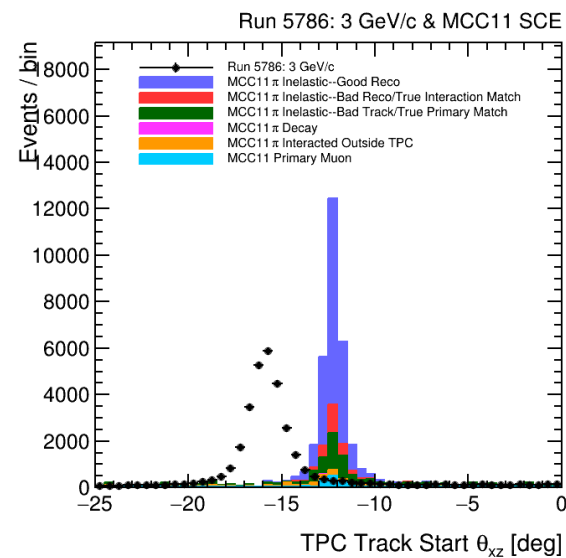
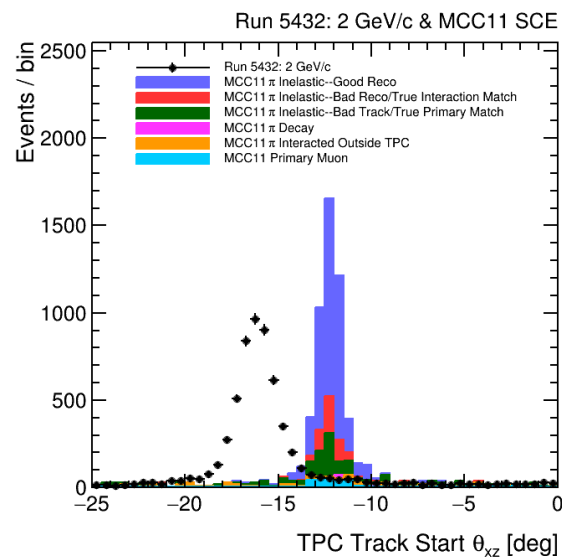
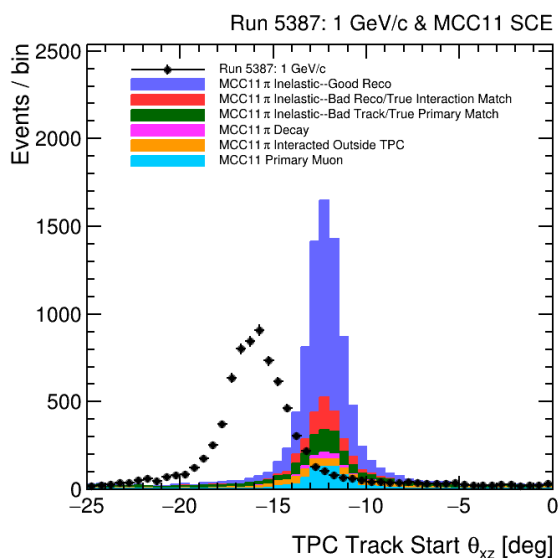
- **Width & position of distribution similar in data & MC**

Beam Instrumentation Track Y Position



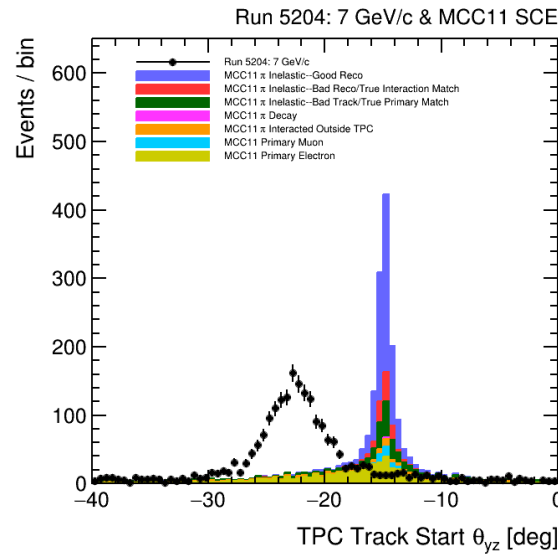
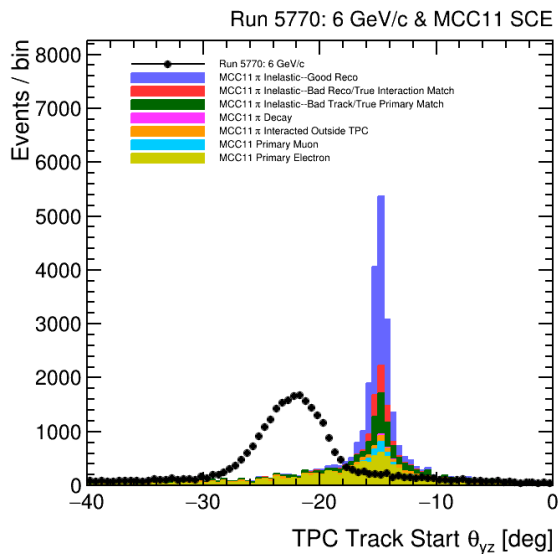
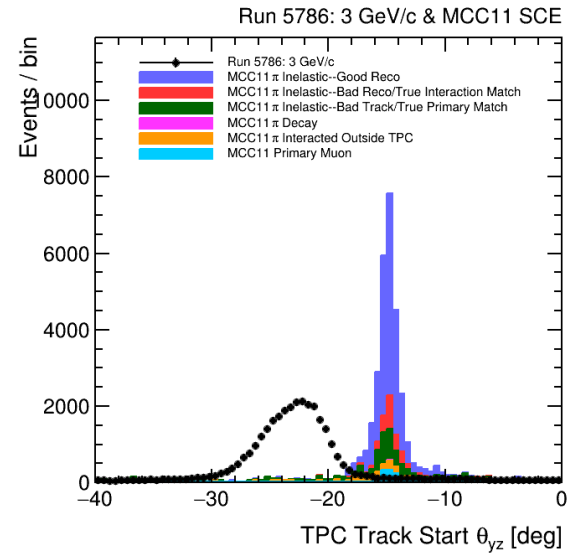
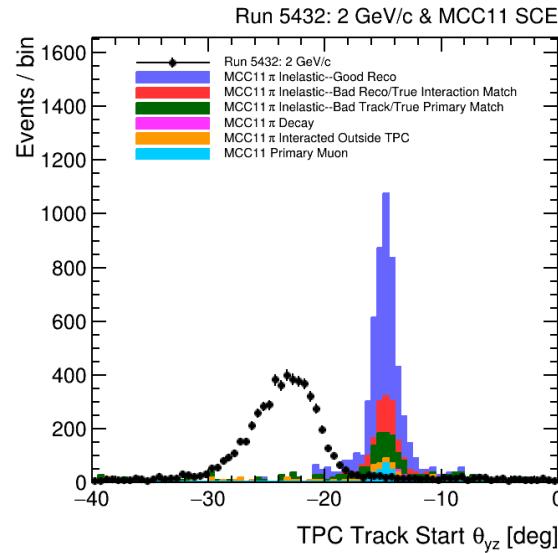
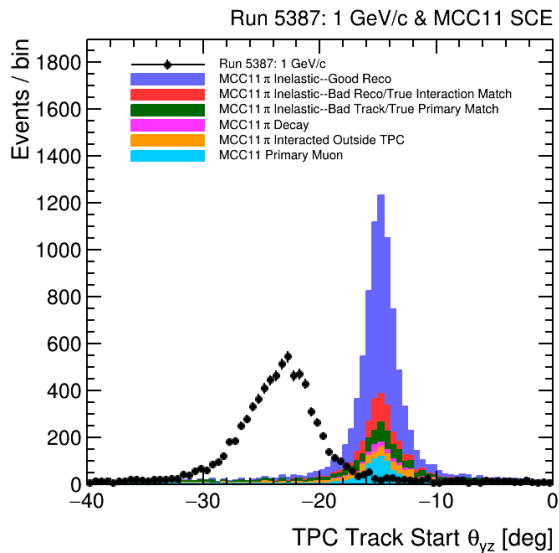
- **Width and position of distribution similar in data & MC**

TPC Track Start θ_{xz}



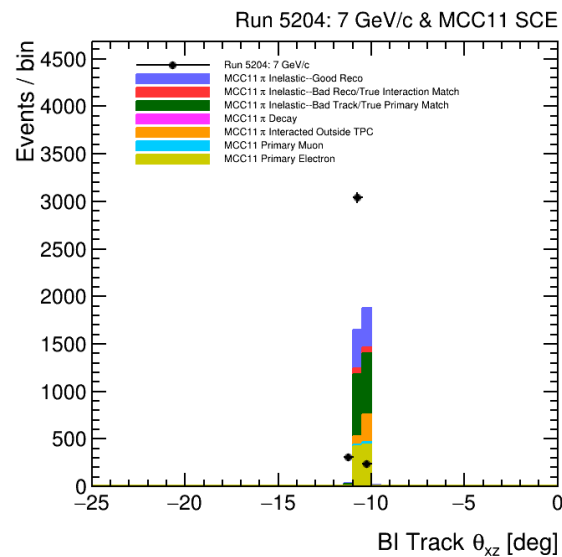
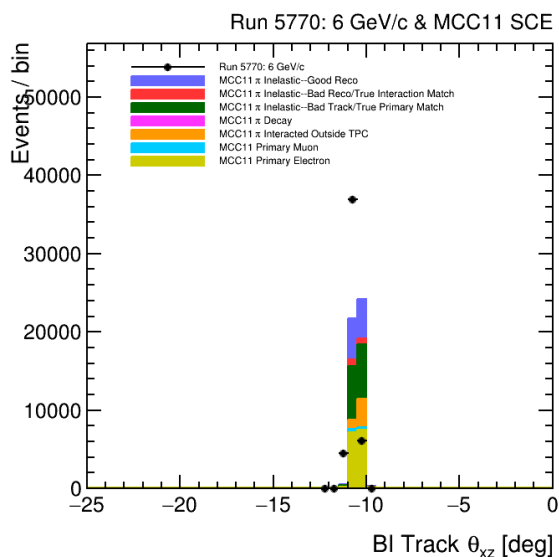
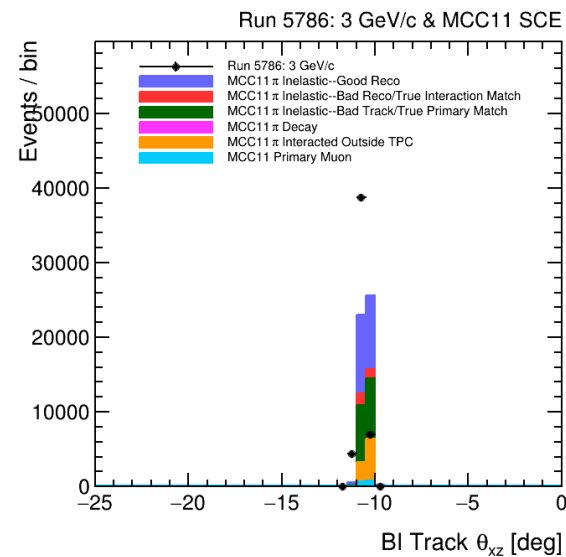
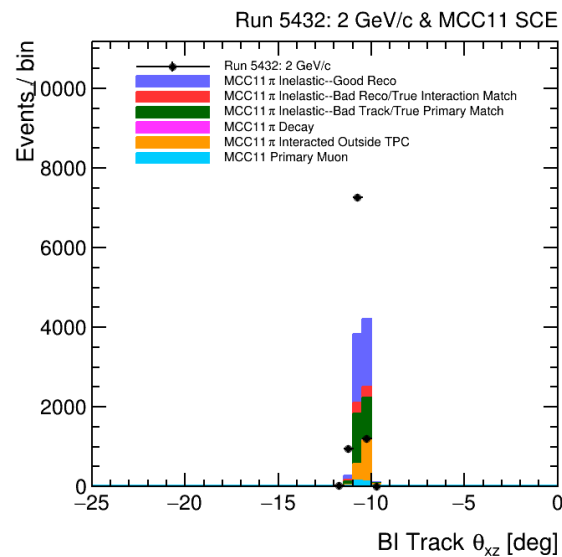
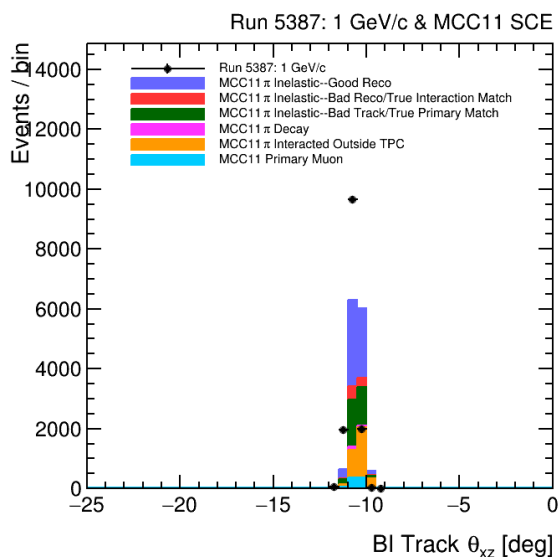
- Data a little wider than MC
- Data shifted more (to the right when looking in beam direction?)

TPC Track Start θ_{yz}



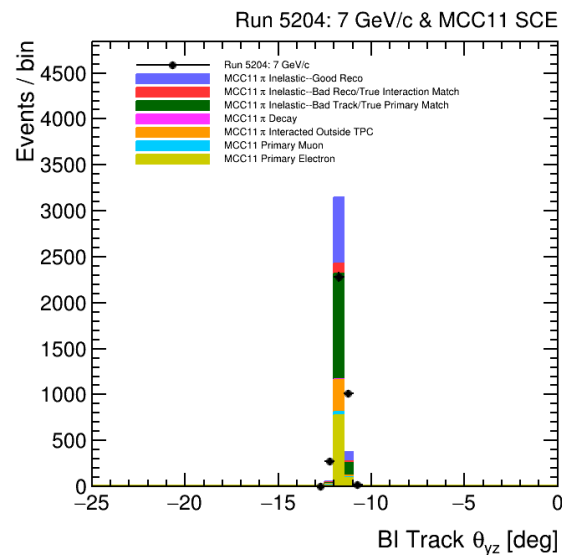
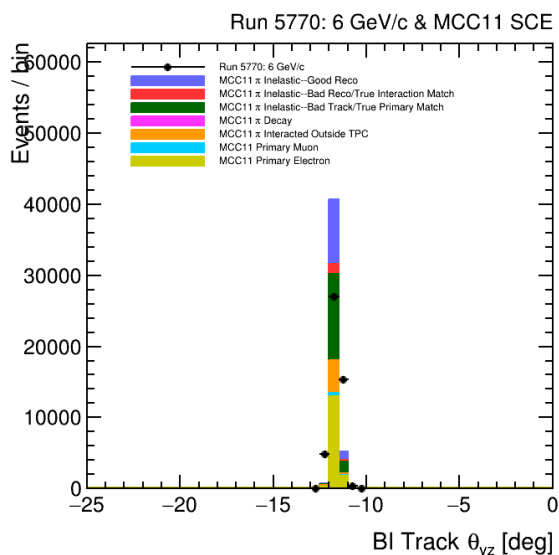
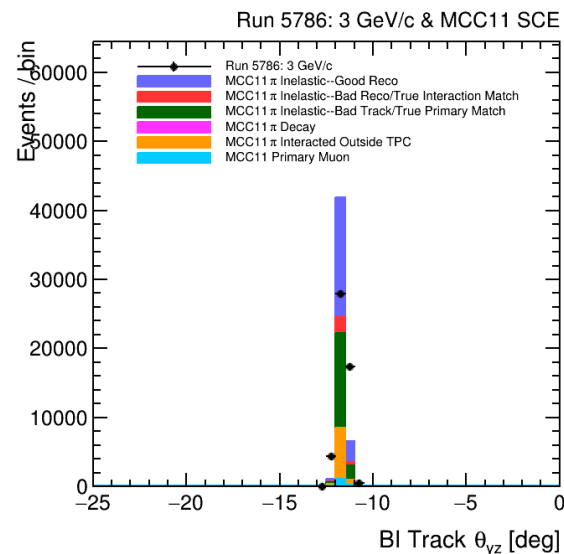
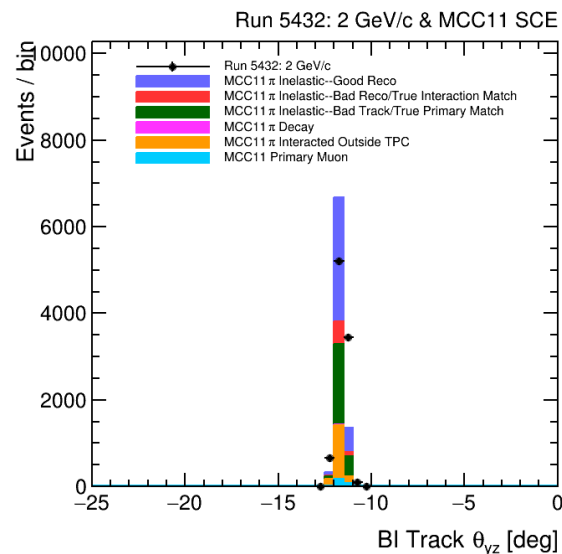
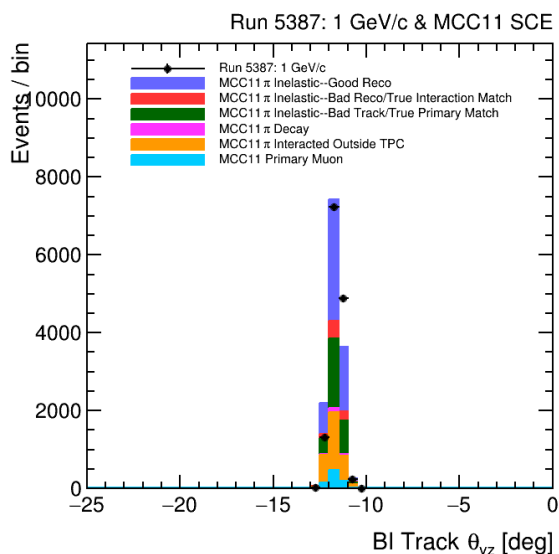
- Data significantly wider than MC
- Data pointing downward more than MC

Beam Instrumentation Track θ_{xz}



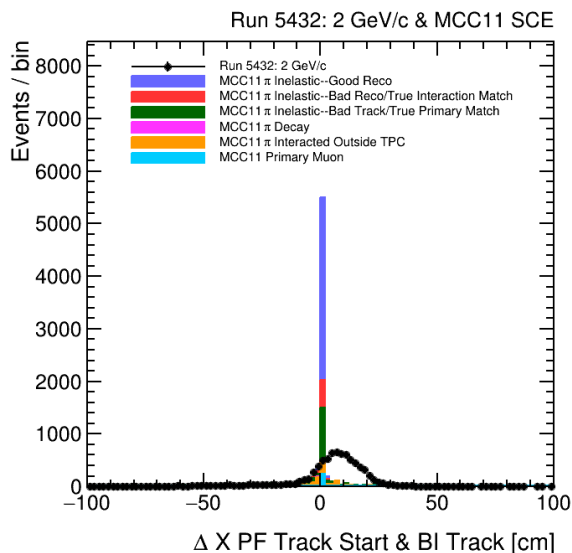
- Data narrower than MC?
- Data position similar to MC

Beam Instrumentation Track θ_{yz}

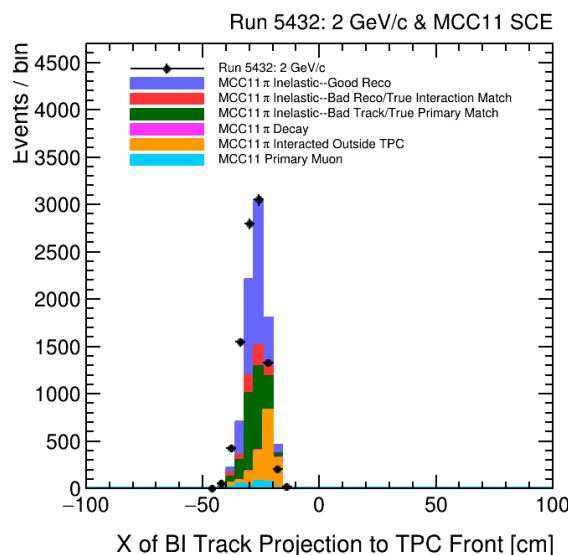
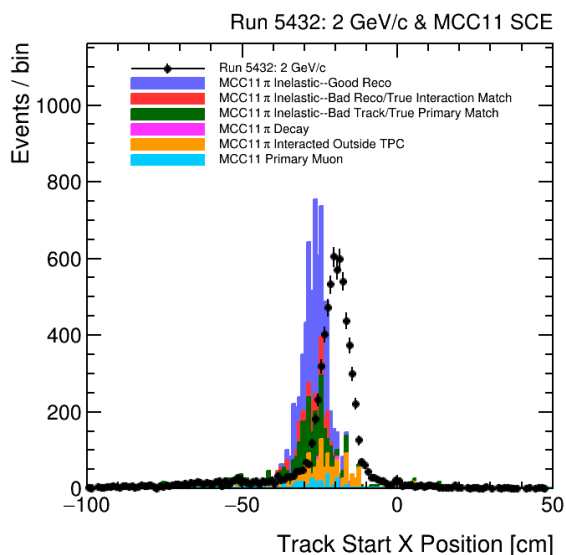


• Data similar to MC

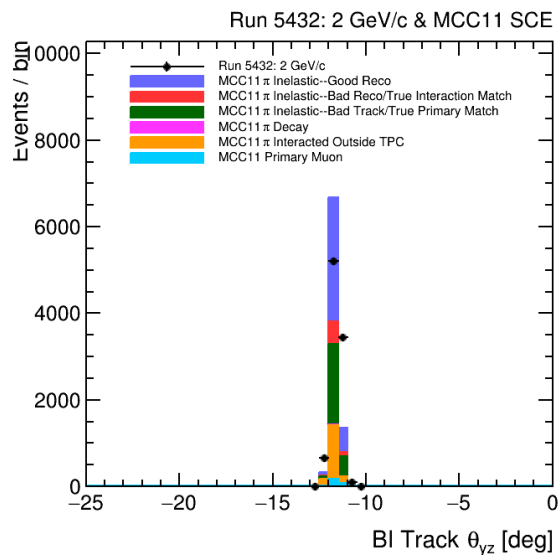
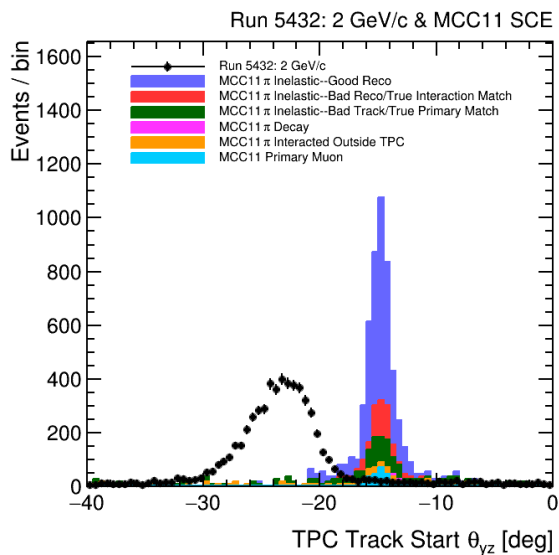
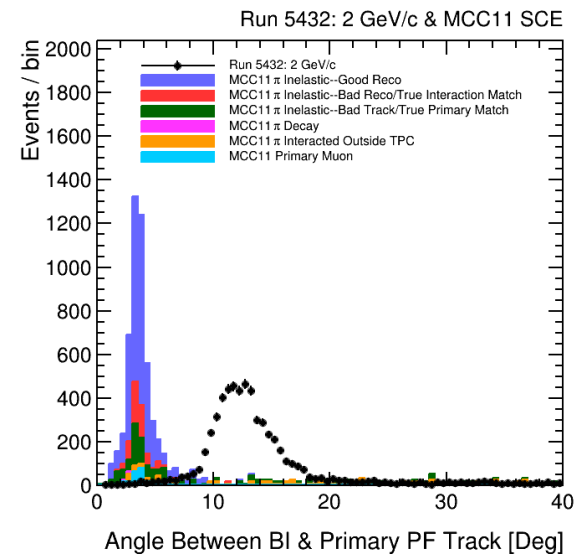
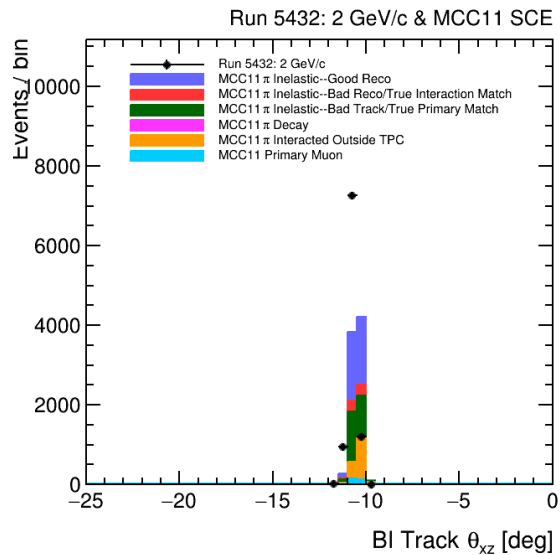
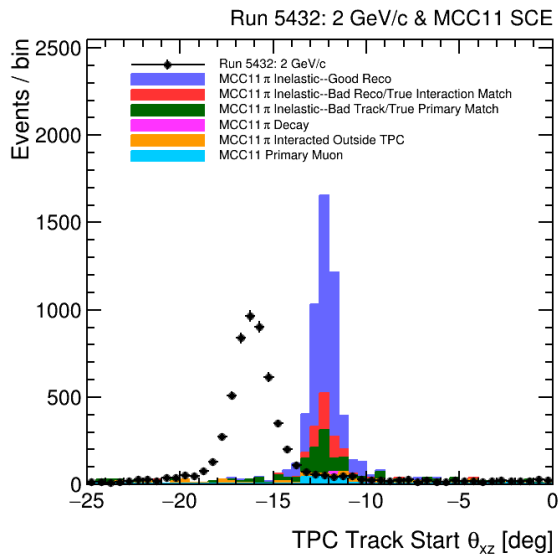
Comparing BI & TPC Positions for Run 5432



- **BI resolution is perfect in MC: I don't smear anything**
- **So MC TPC track resolution really good**
- **Data ΔX width similar to width of underlying distributions**
- **Resolution ~ width of distributions?**

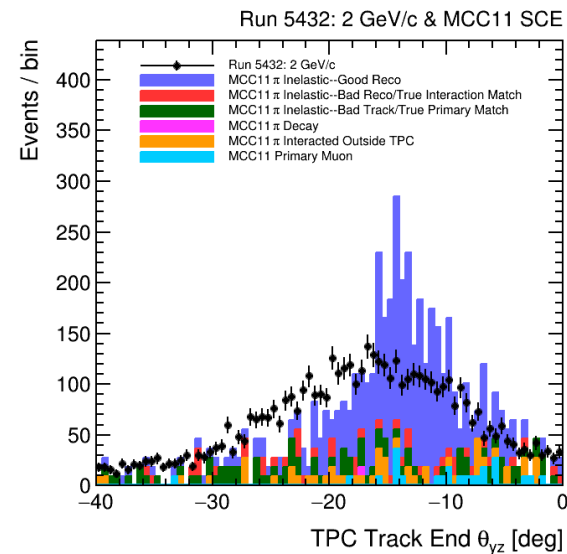
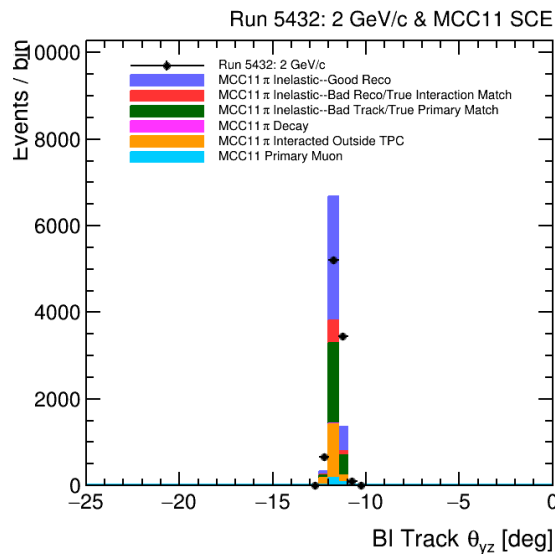
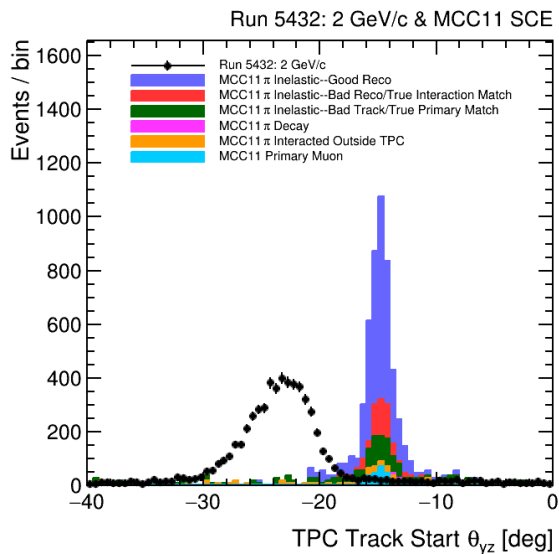
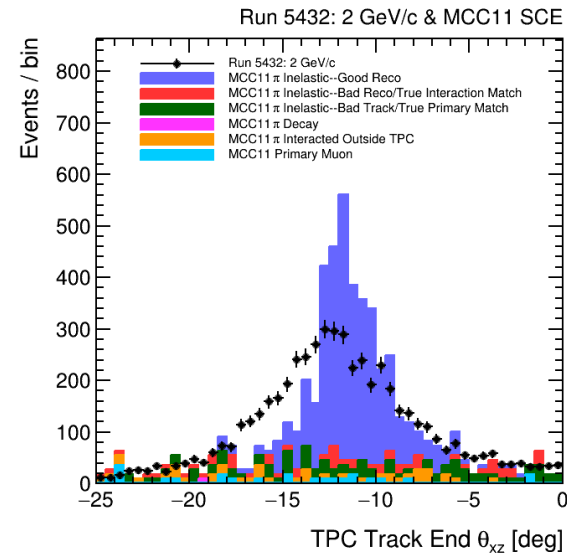
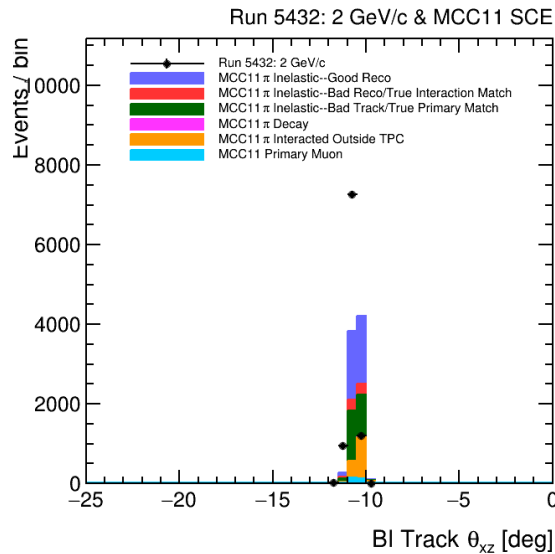
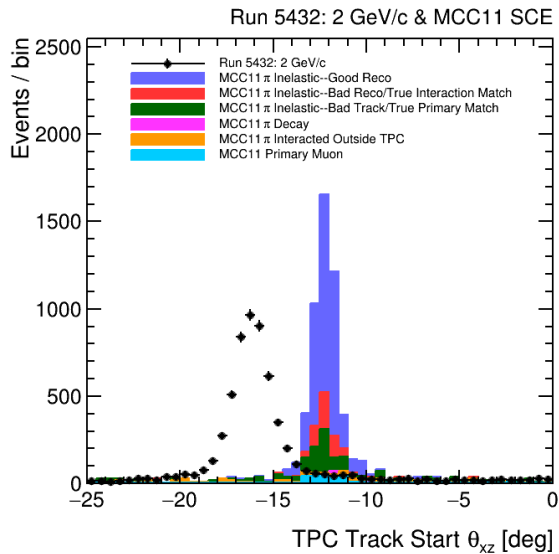


Comparing BI & TPC Angles for Run 5432



- **Wider and offset angle between tracks seems to be due to TPC track angles—E-field effects**

Comparing BI & TPC Angles for Run 5432: Track End Angle



Track end angle matches BI and MC better, but wider

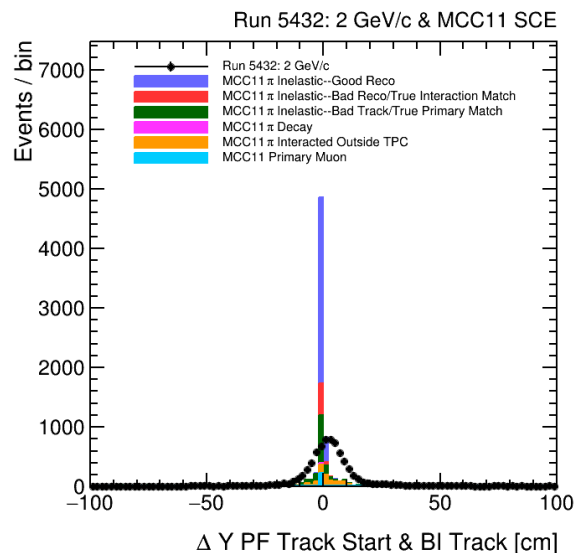
E-field variations smaller further into TPC

Conclusions

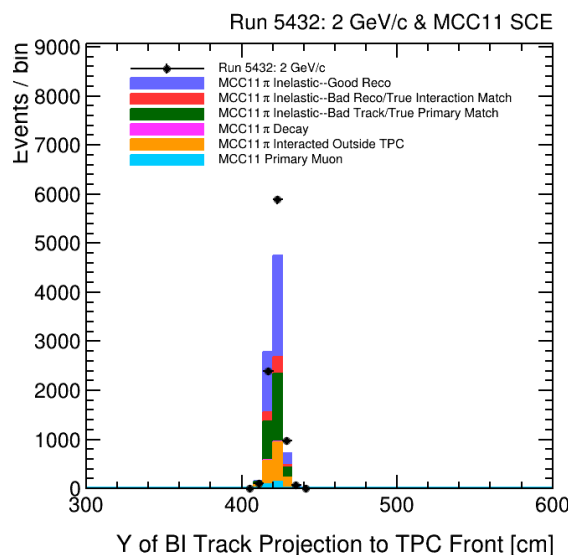
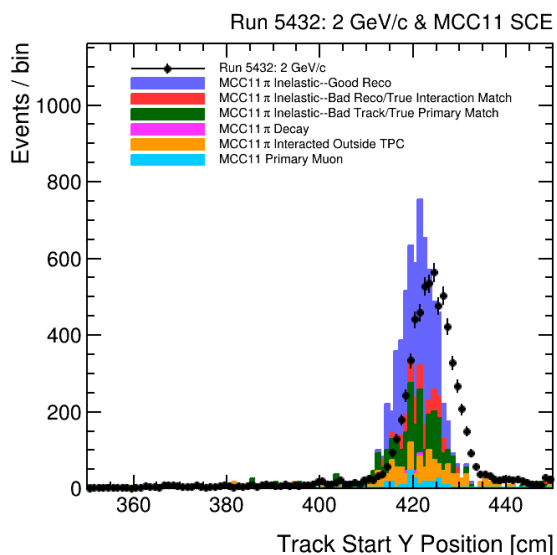
- **Poor matching between beam instrumentation & TPC tracks**
 - **Distributions wide**
 - **Data doesn't match MC**
- **Beam instrumentation distributions match MC well**
- **TPC distributions don't match MC as well, but don't explain poor matching**
- **Needs more investigation**

Backup Slides

Comparing BI & TPC Positions for Run 5432



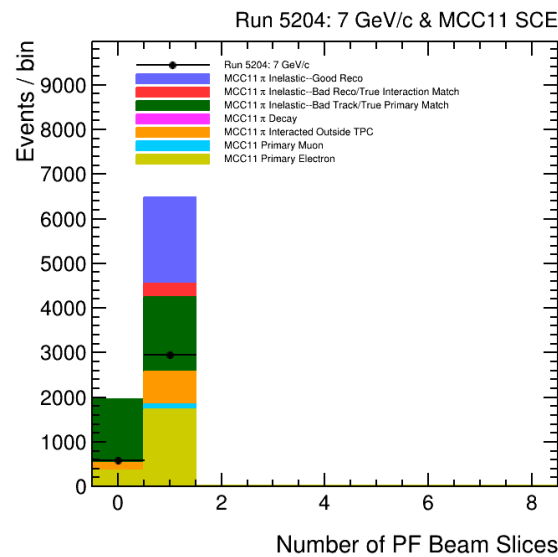
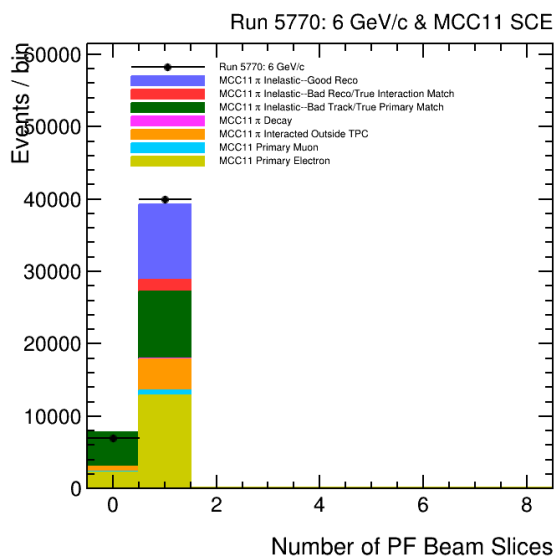
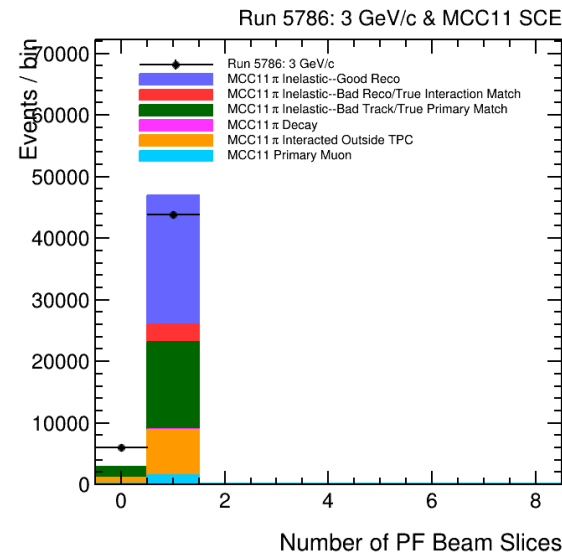
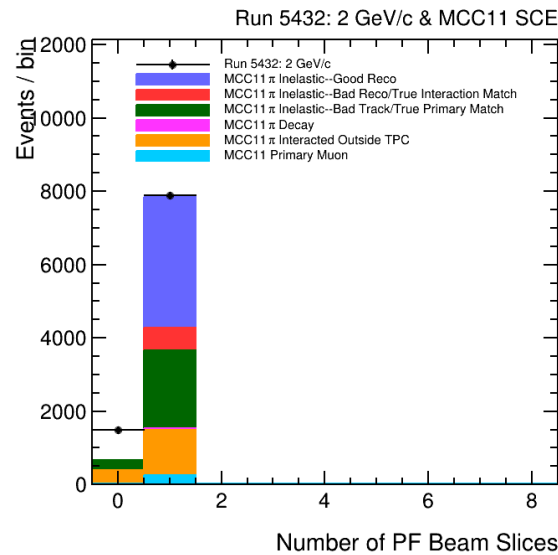
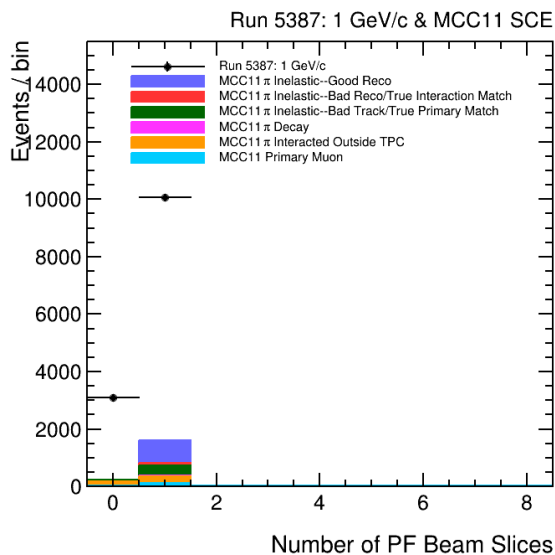
- **BI resolution is perfect in MC: I don't smear anything**
- **So MC TPC track resolution really good**
- **Data ΔX width similar to width of underlying distributions**
- **Resolution ~ width of distributions?**



Beam Pion Selection

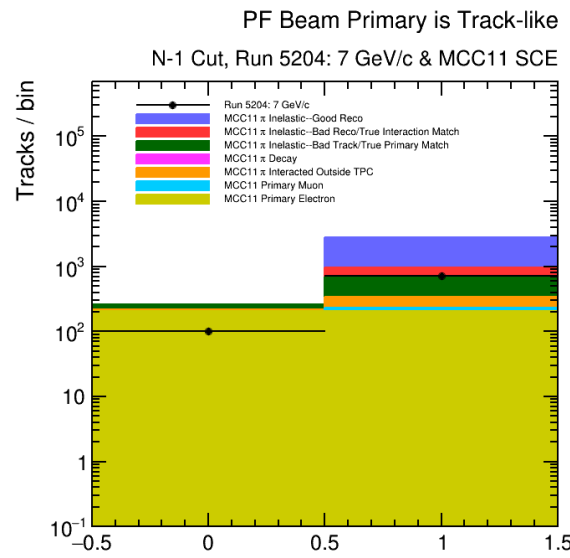
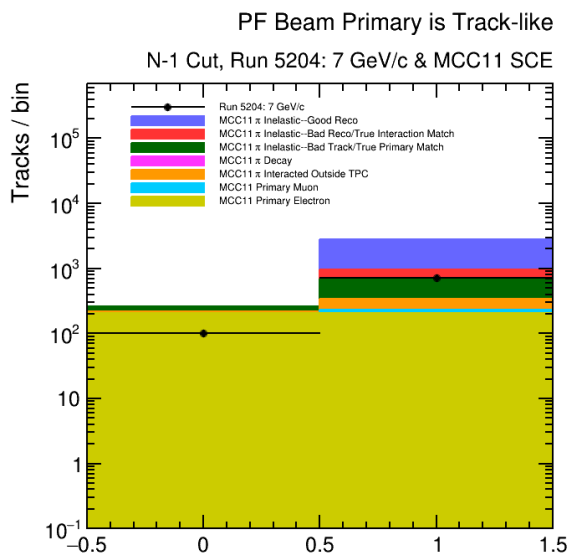
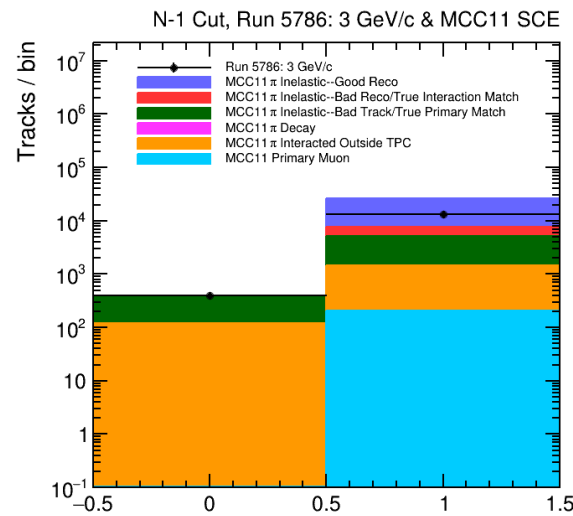
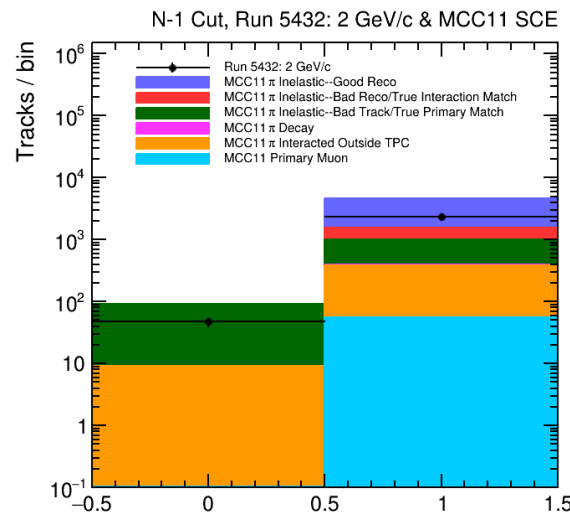
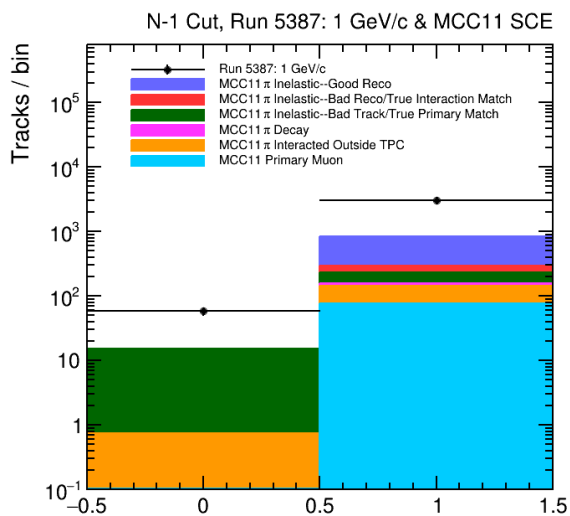
- **For data:**
 - **Require good beam instrumentation (BI) event with 1 track and 1 momentum passing pion selection**
 - **Require all beam-side (RaS) FEMBs to be properly readout**
- **For MC:**
 - **Beam primary true particle (starts at $t=0$) PDG = 211 or -13, or -11 for 6 & 7 GeV to match BI**
 - **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



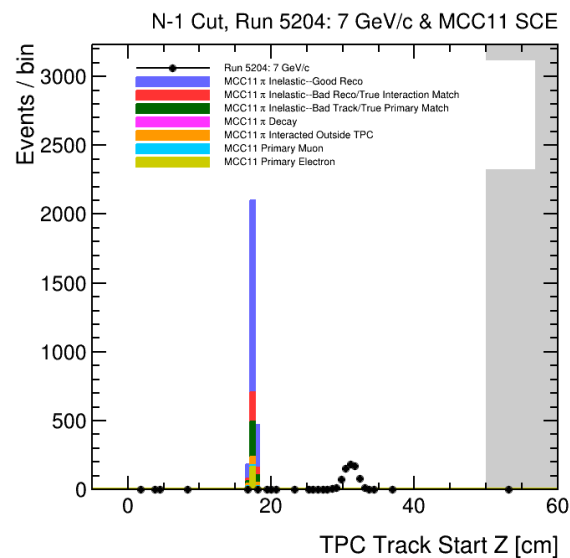
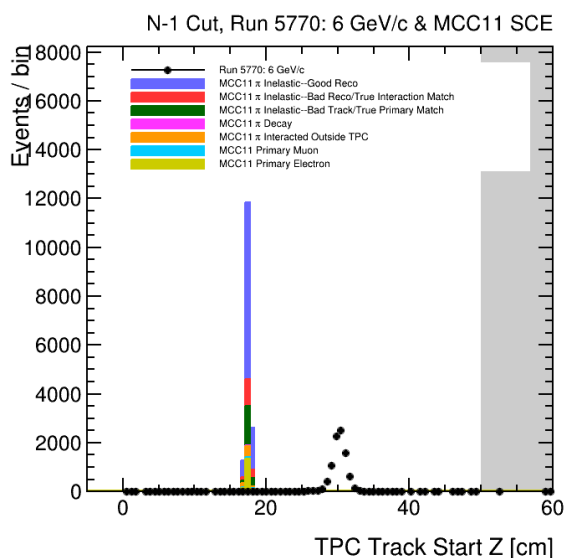
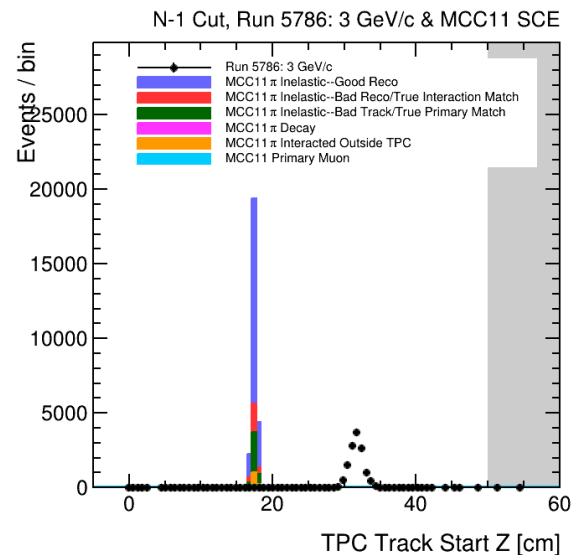
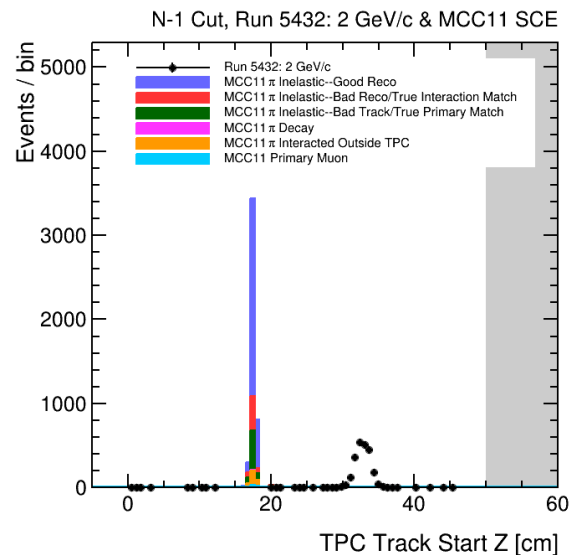
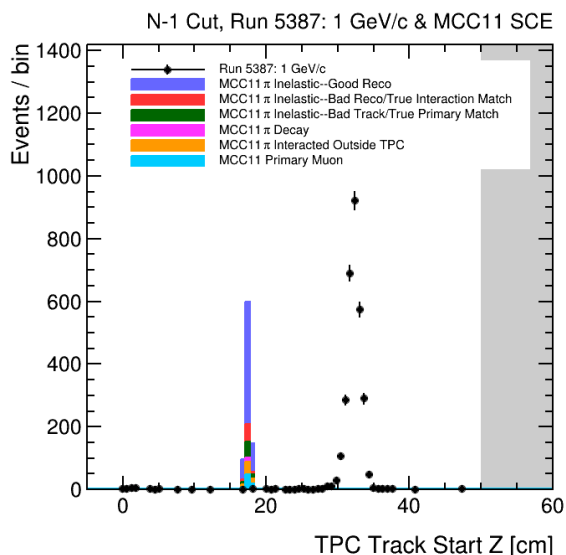
- MC normalized to number of events passing BI cuts
- Problem with 1 GeV MC normalization
- Only see 0 or 1 beam slices

Pandora Beam Primary Track/Shower



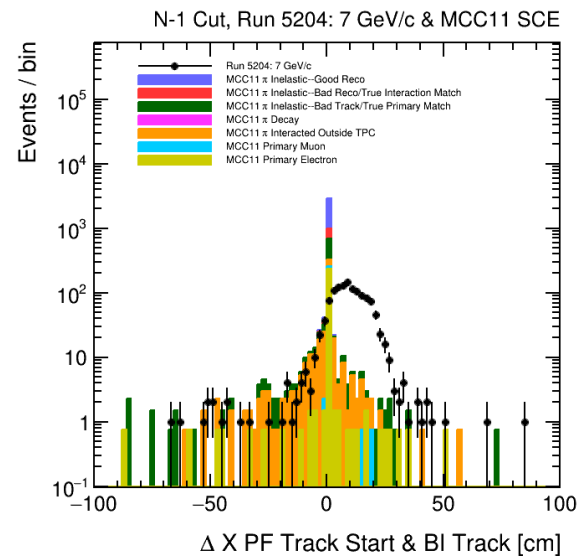
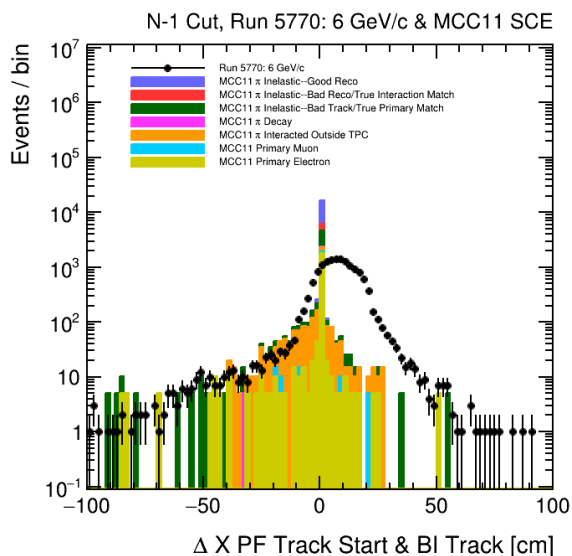
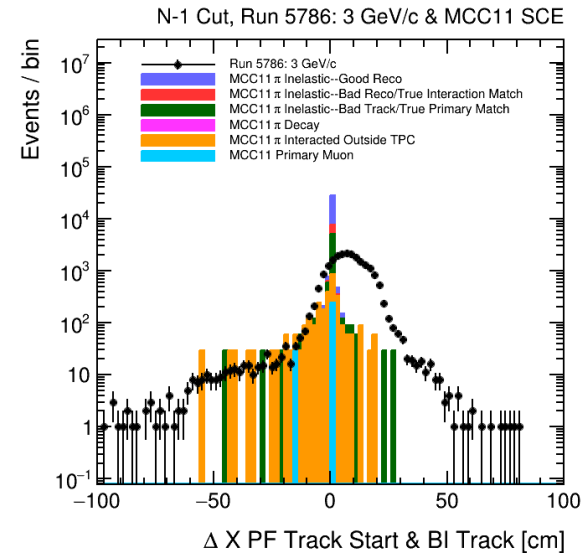
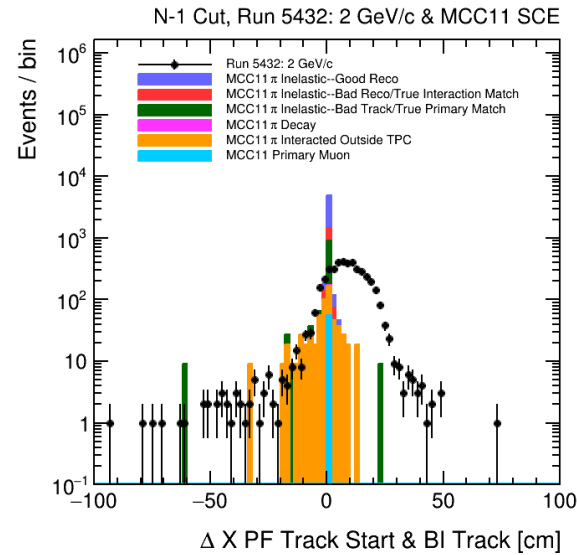
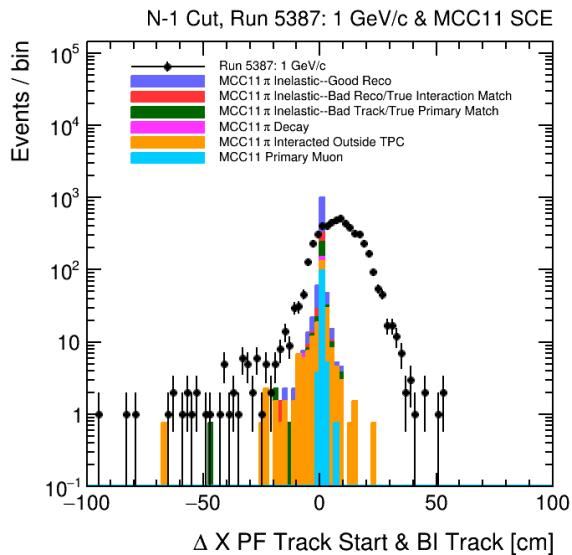
• Need to tweak 6 & 7 GeV plots

Pandora Beam Track Start Z



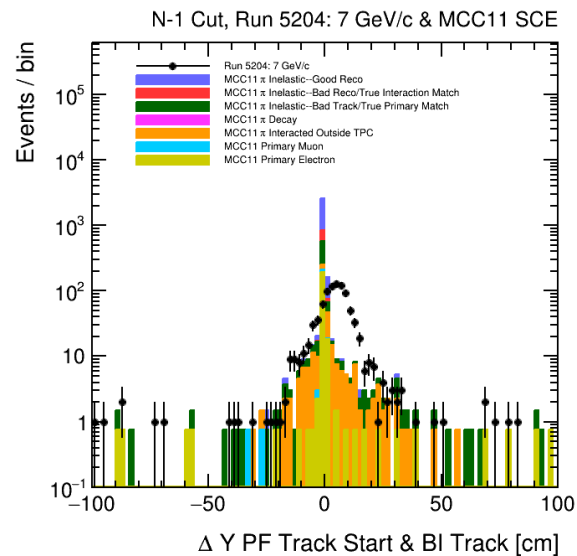
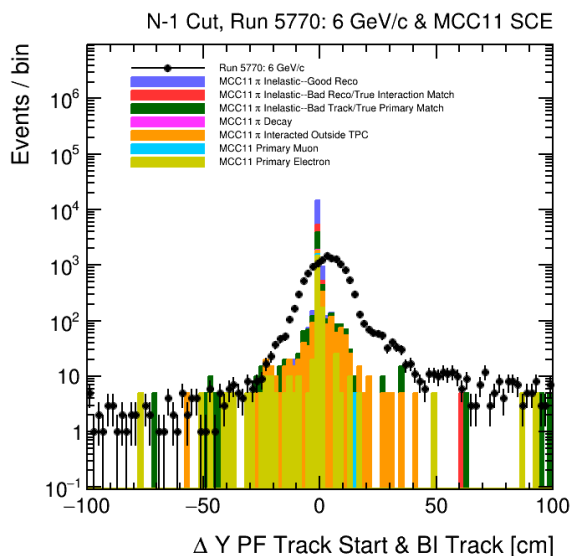
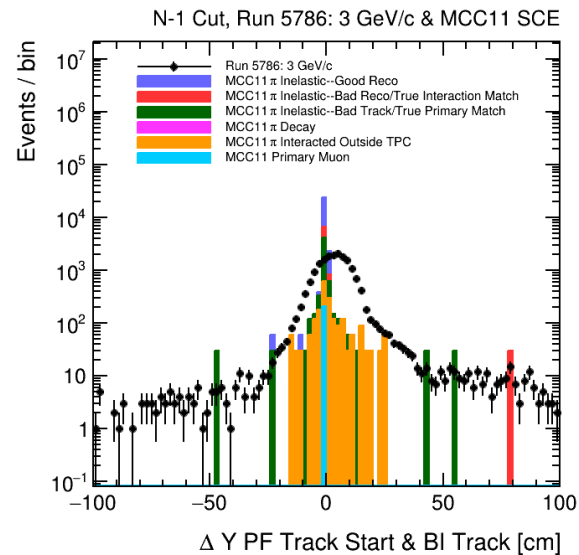
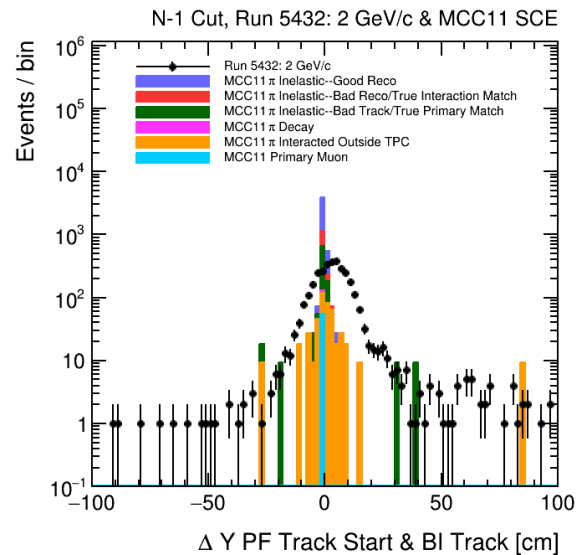
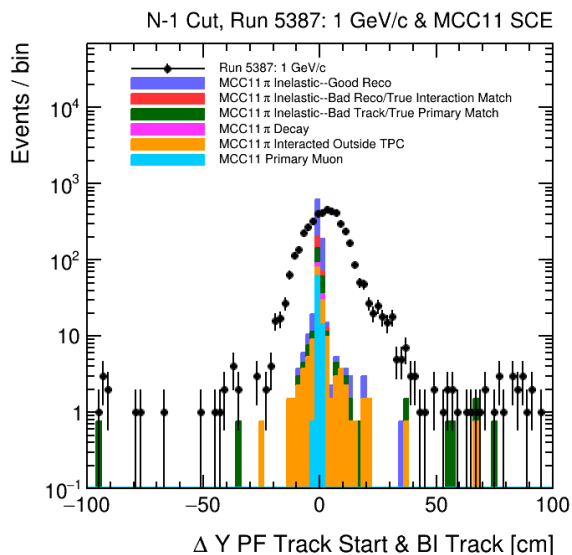
• All runs pretty similar

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)

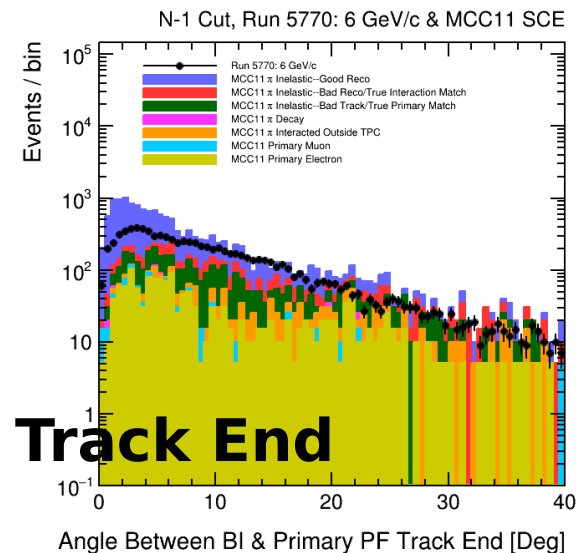
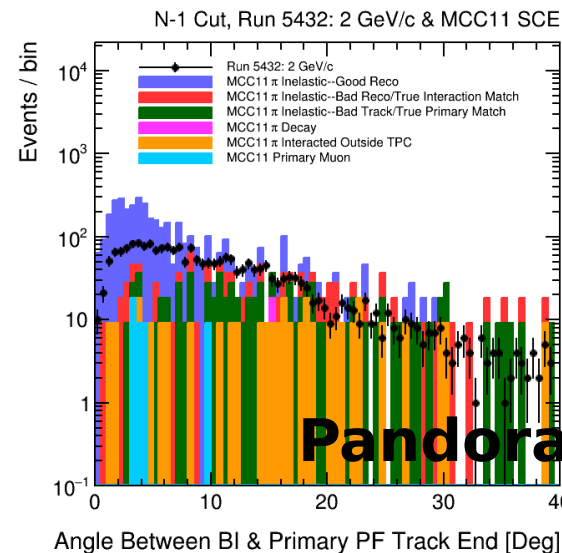
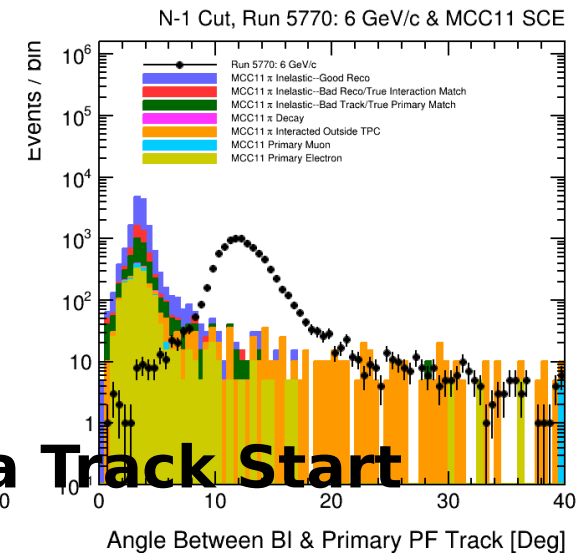
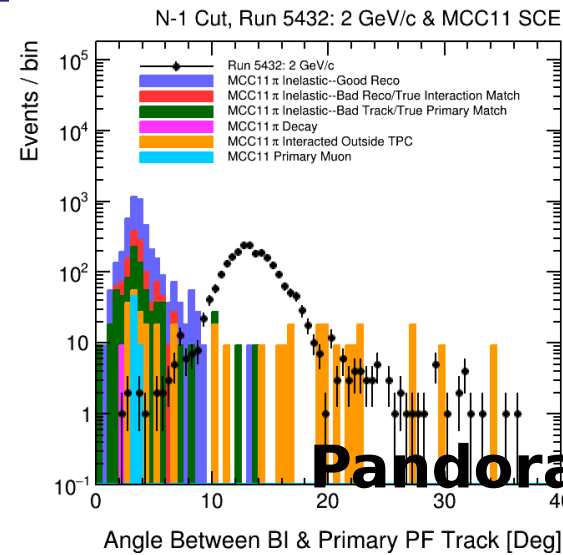
Delta Y Pandora Track End & BI Track Start



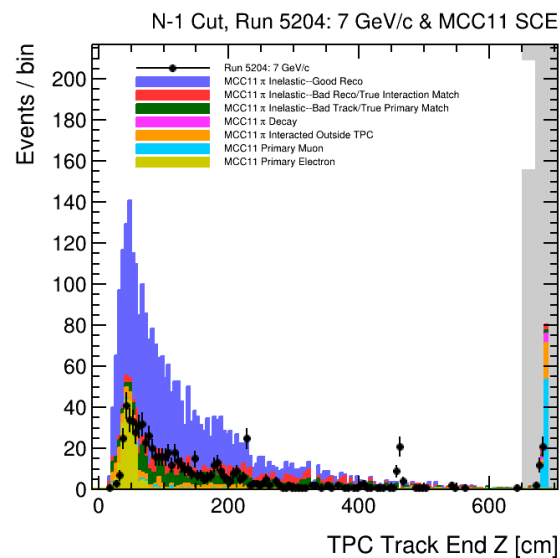
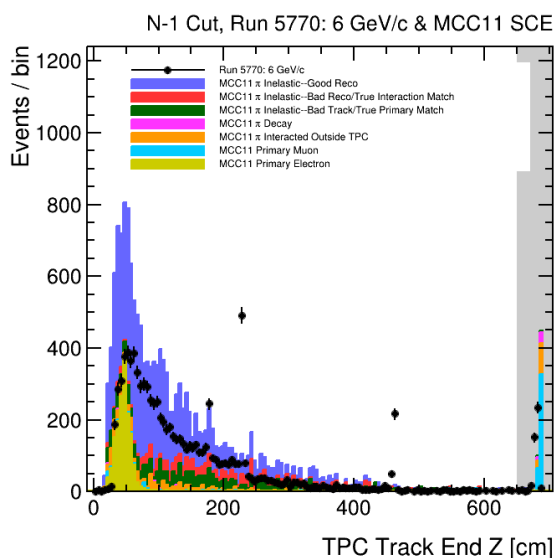
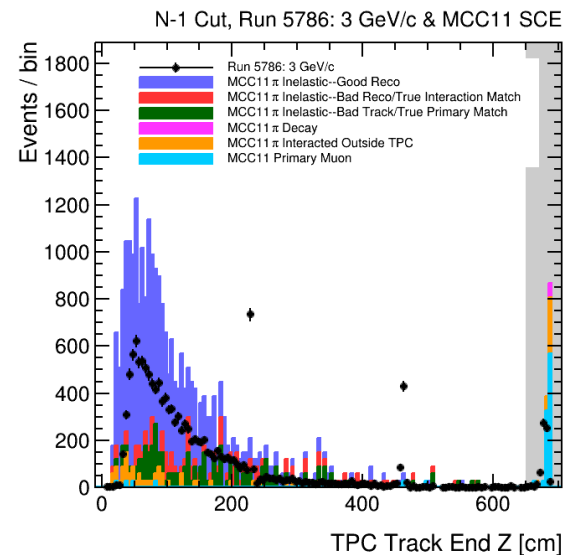
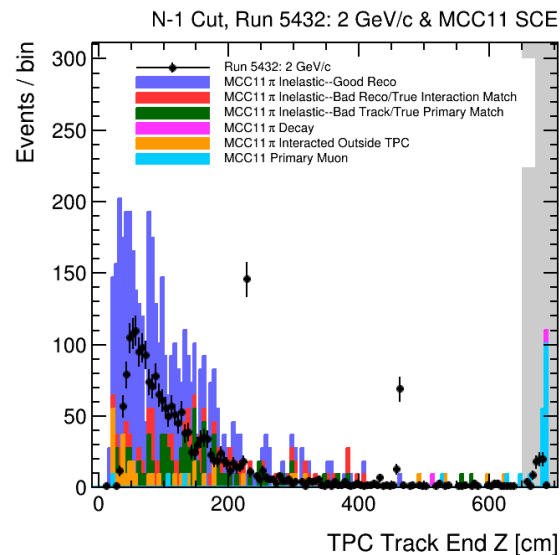
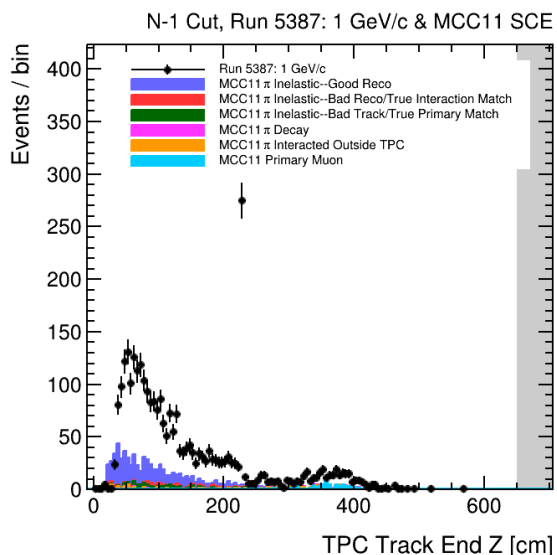
- Data distributions seem really wide
- Key is that I make sure the Pandora track start $z < \text{end } z$ (if not flip)

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

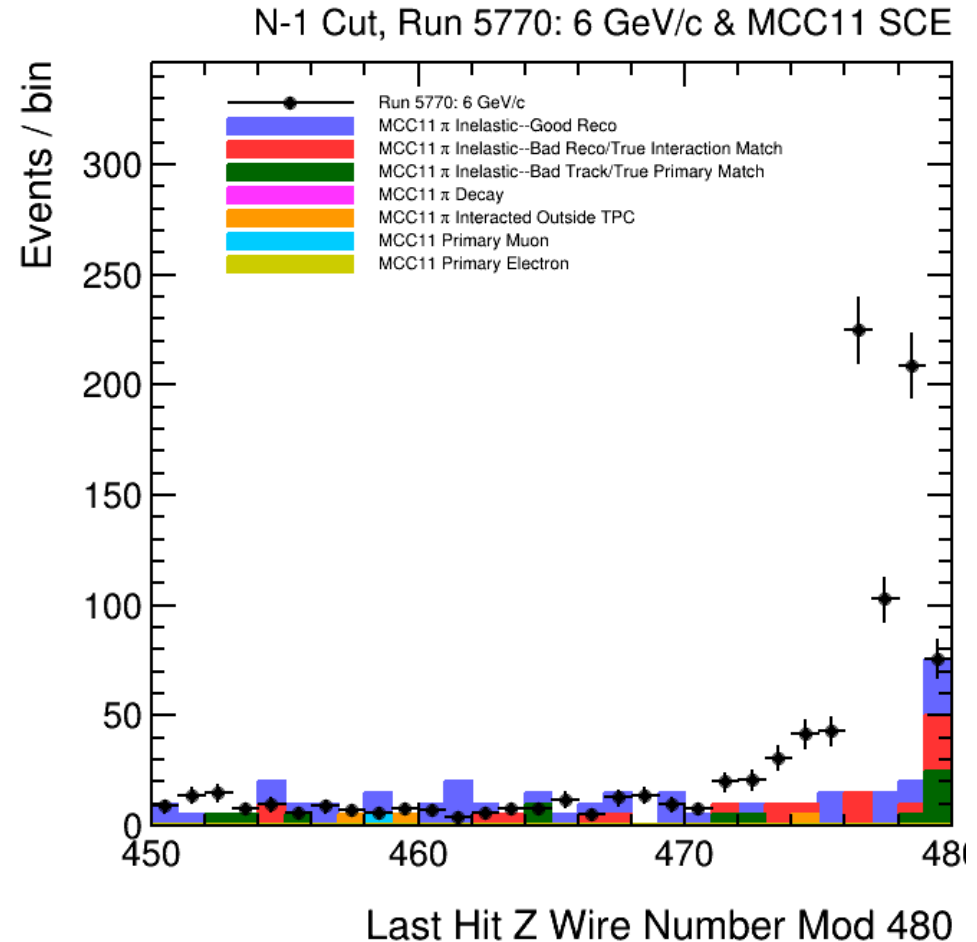
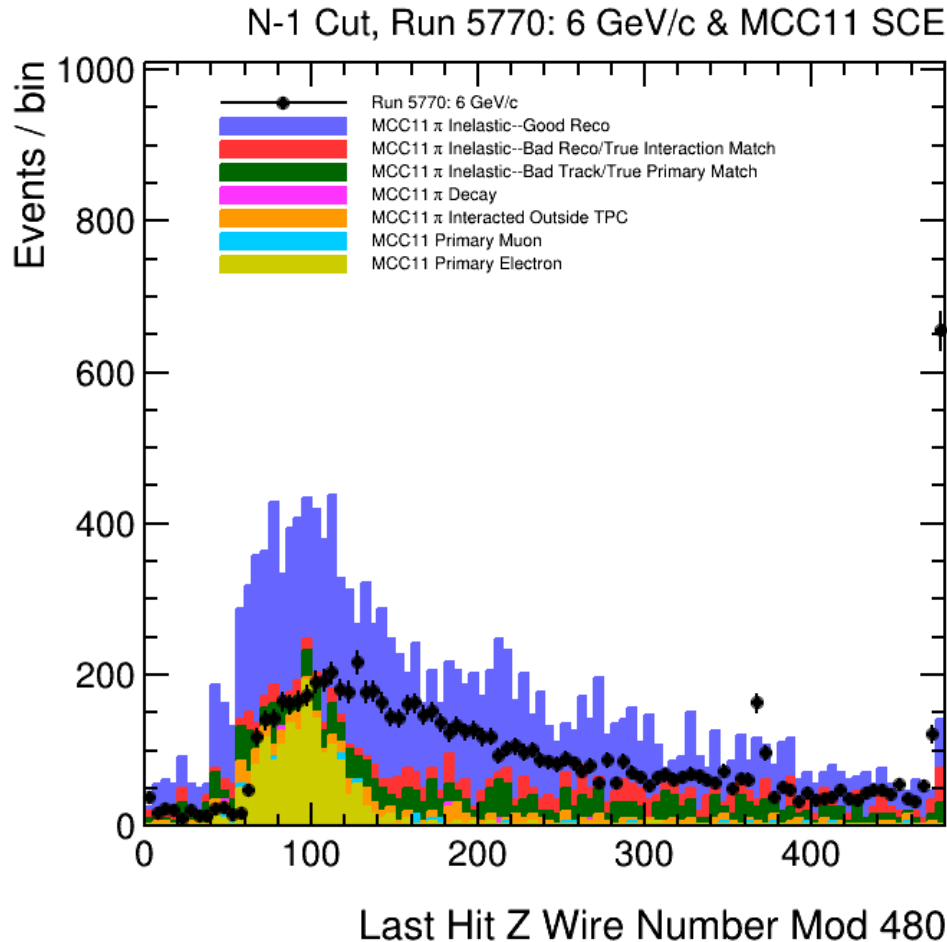


Pandora Beam Track End Z



- 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