Update on Proton Analysis

- Outline
  - New parameter in Prod. 3
  - Investigation on Data/MC Discrepancy

Heng-Ye Liao,
ProtoDUNE sim/reco Meeting
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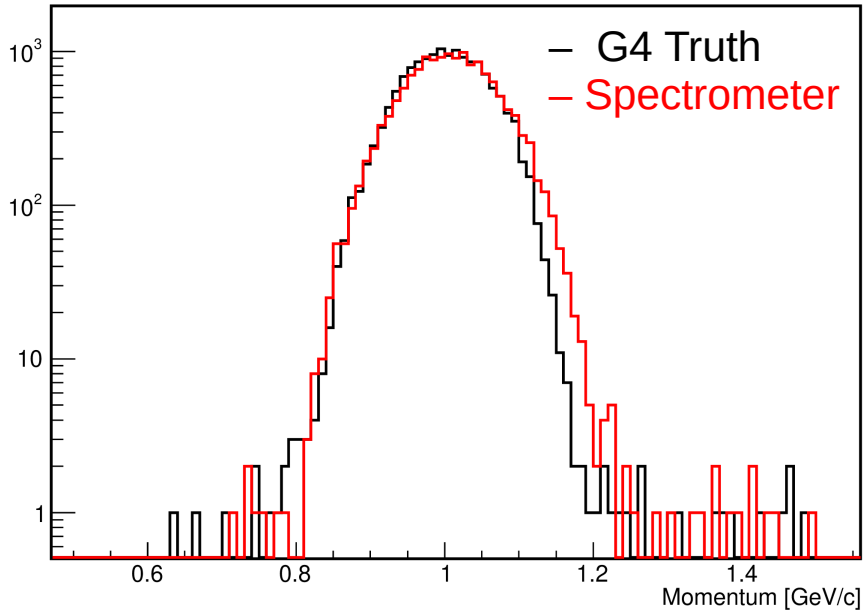
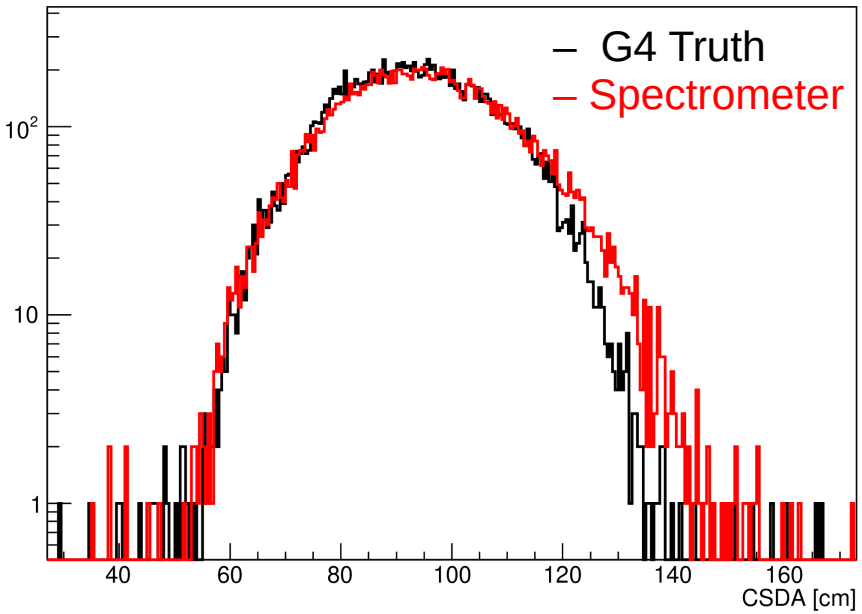
Data Sample

- New prod.3 MC sample (RITM0986948)
  - 1 GeV beam + cosmic MC samples
  + SCE ON, SCE correction, and electron lifetime correction (pandoracali)

New Parameter in Prod. 3

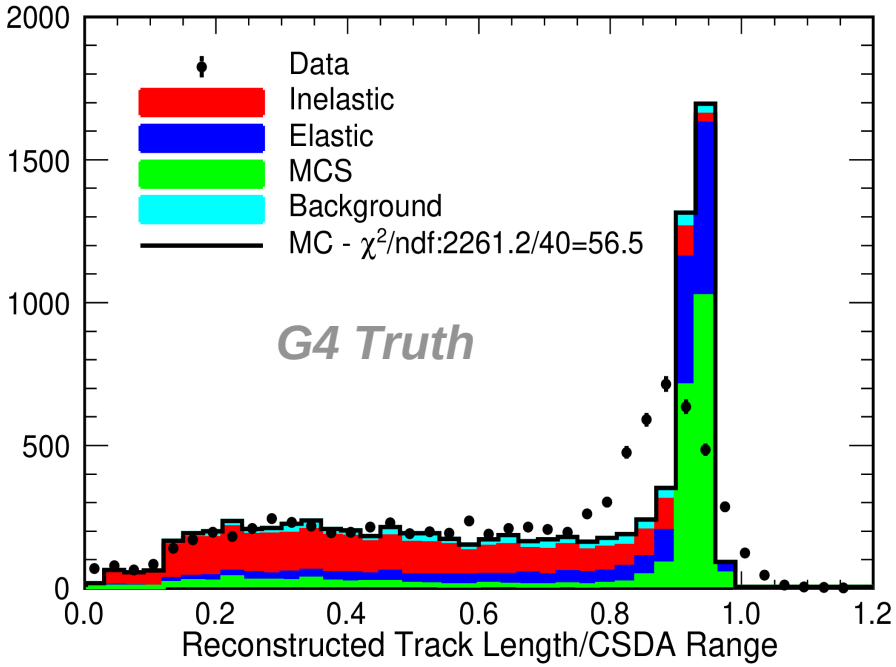


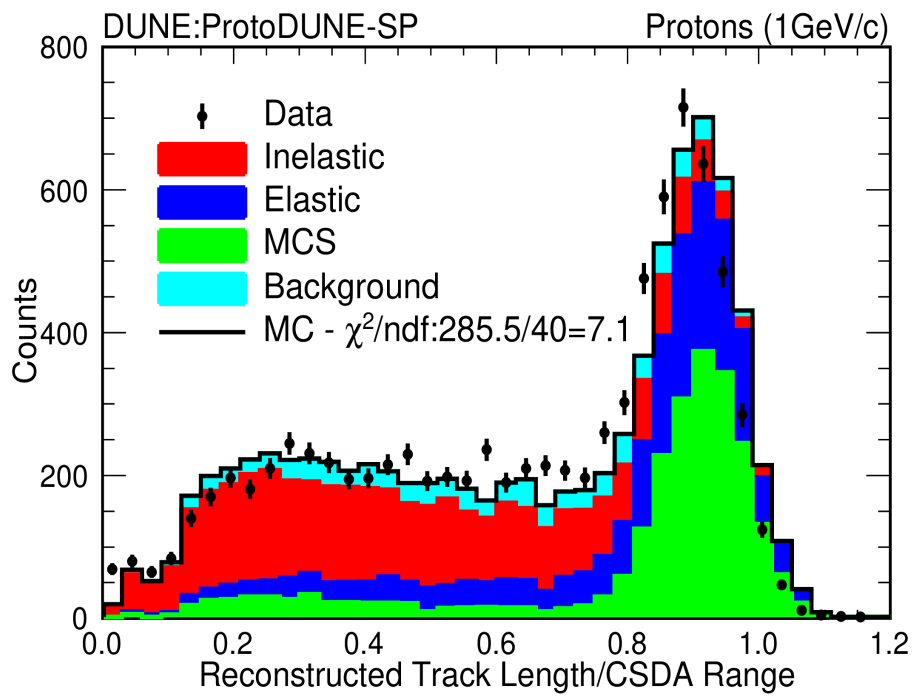


- Beam momentum from spectrometer implemented by Jake
- G4 truth & spectrometer

	Mean [MeV/c]	Sigma [MeV/c]
Prod. 3 [G4 Truth]	1002.2	61.5
Prod.3 [Spec]	1007.1	61.8

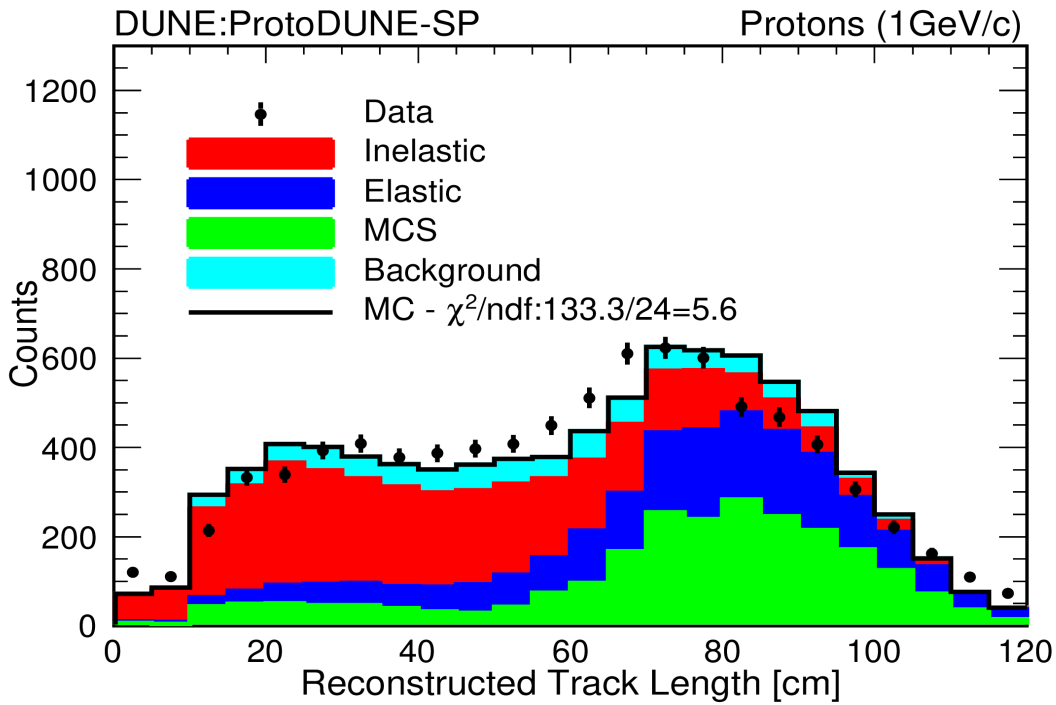
Normalized Track Length Distribution





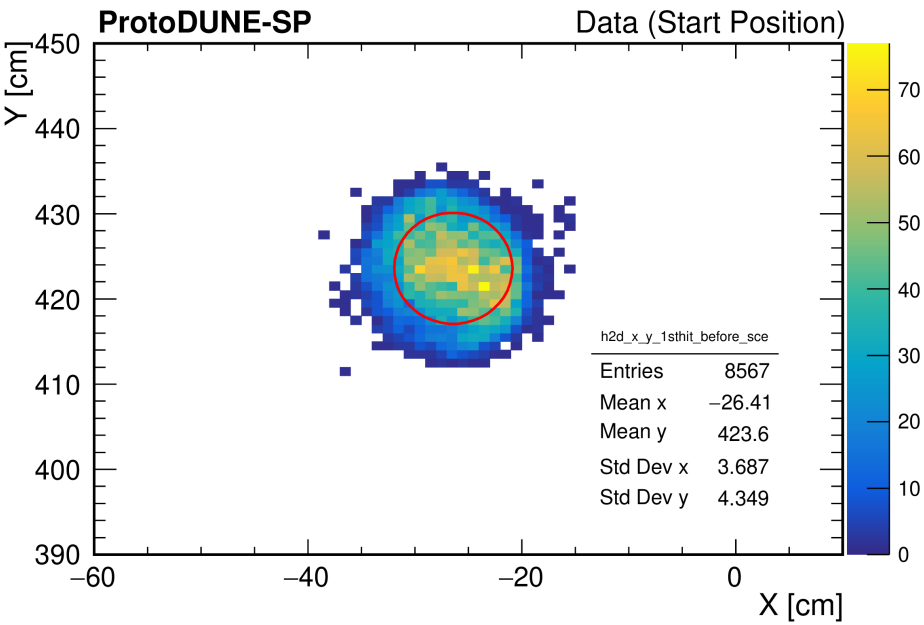
- CSDA range from G4 truth & spectrometer
- Improvement clearly seen using spectrometer output (Encouraging!)

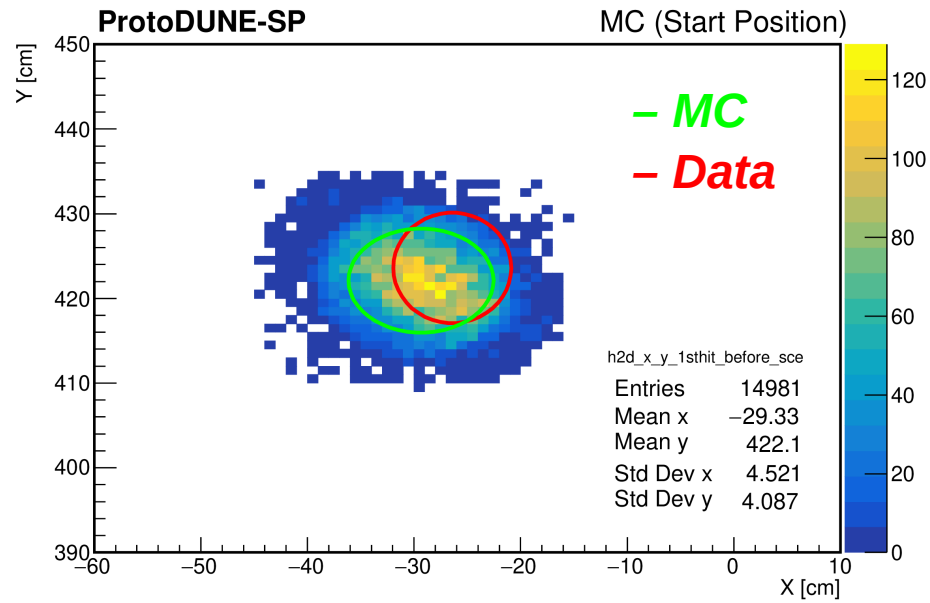
Data/MC Comparison



- Discrepancy between Data & MC observable needs to be understood before model-dependent XS reweighting
- Possible reasons of Data/MC discrepancy:
  - SCE correction
  - Beam angle difference between data & MC
  - Beam energy loss difference between data & MC

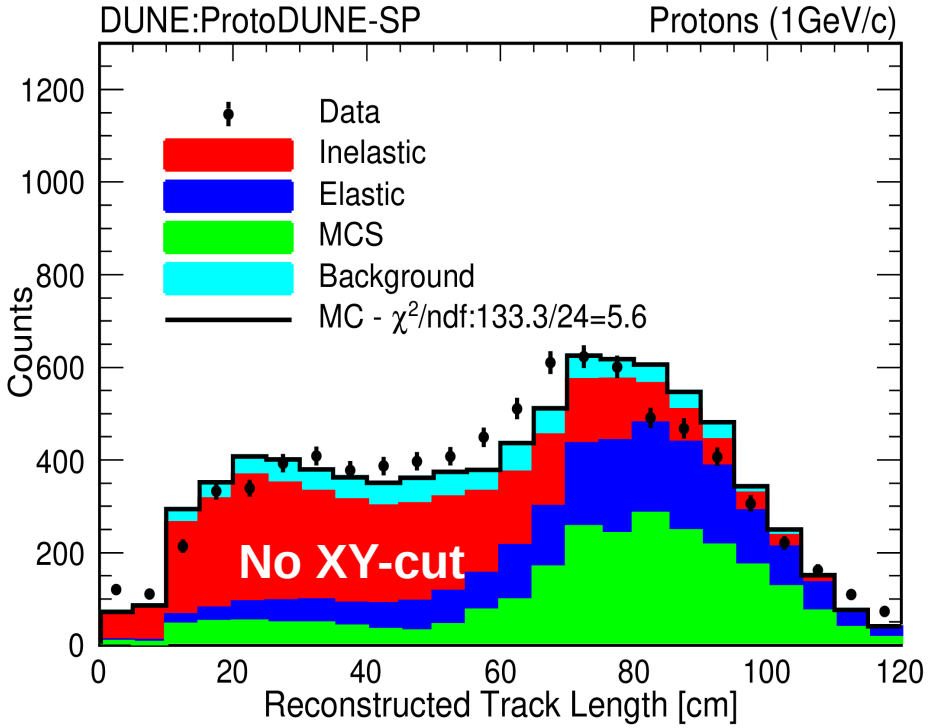
XY Cut

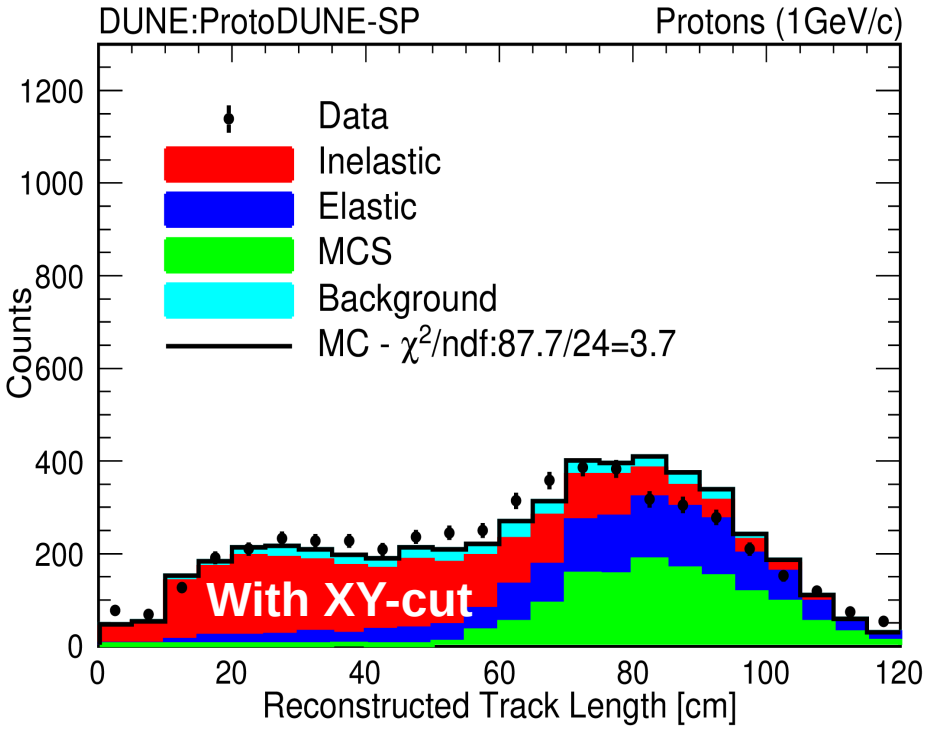




- XY-distribution of 1st hit in TPC [before SCE Corr.]
- Shape difference between data & MC
  - Hints that beam angle difference between data & MC
- Apply XY-cut on both data & MC to mitigate the discrepancy due to beam angle configuration (select tracks within an ellipse)

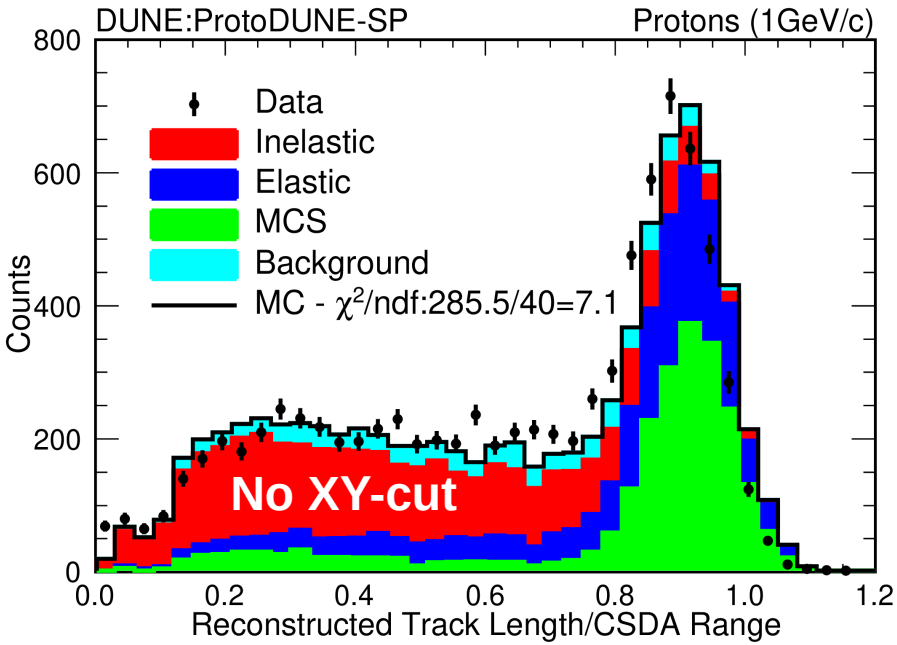
Track Length Distributions - Before & After XY-Cut

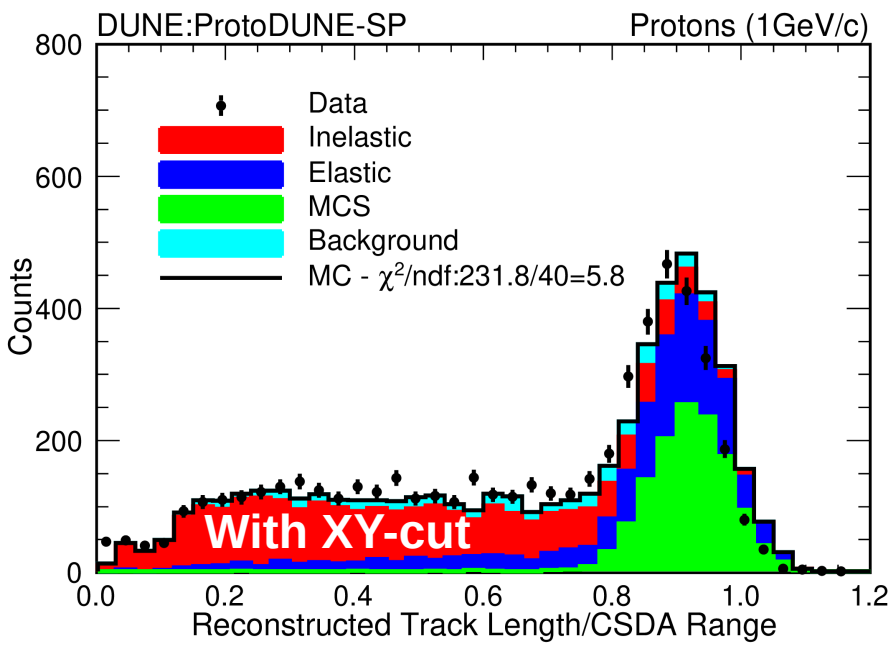




- XY-cut helps to improve agreement between data & MC

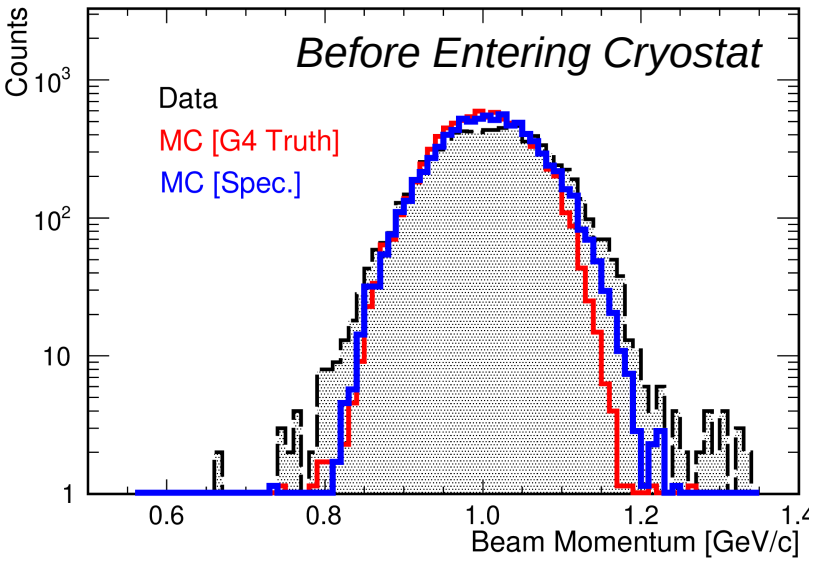
Normalized Track Length Distributions - Before & After XY-Cut

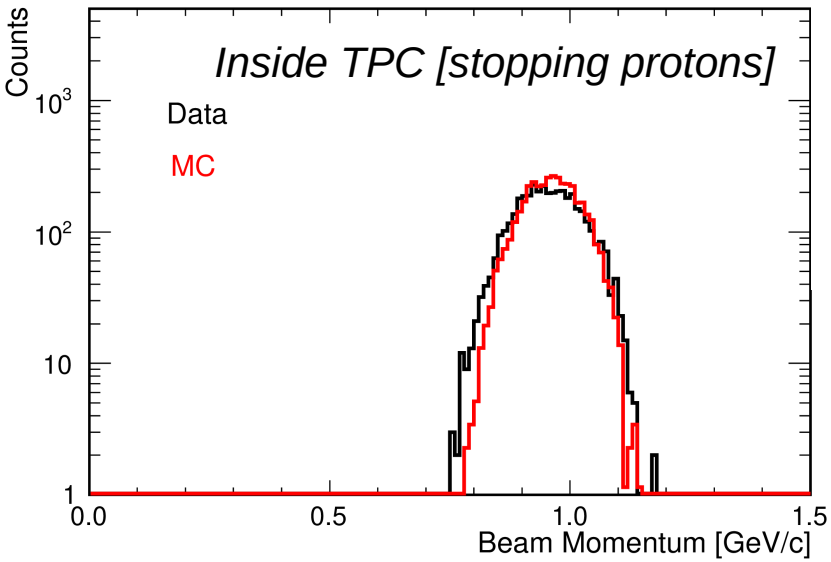


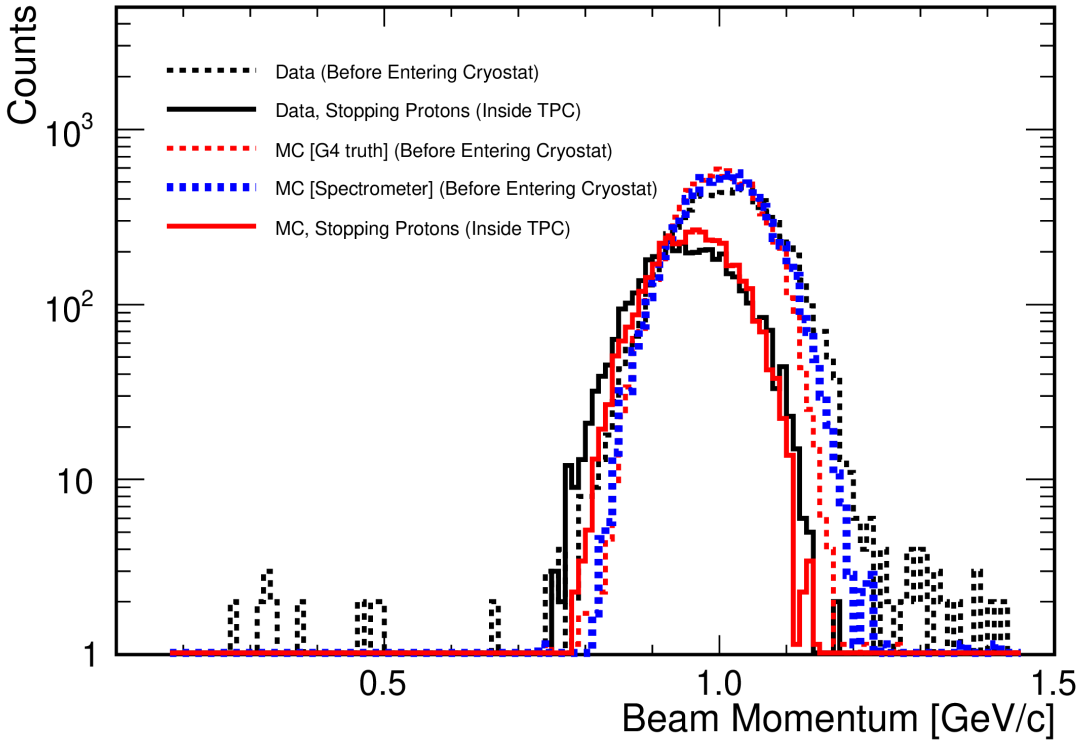


- XY-cut helps to improve agreement between data & MC

Beam Momentum – Before/After Entering TPC





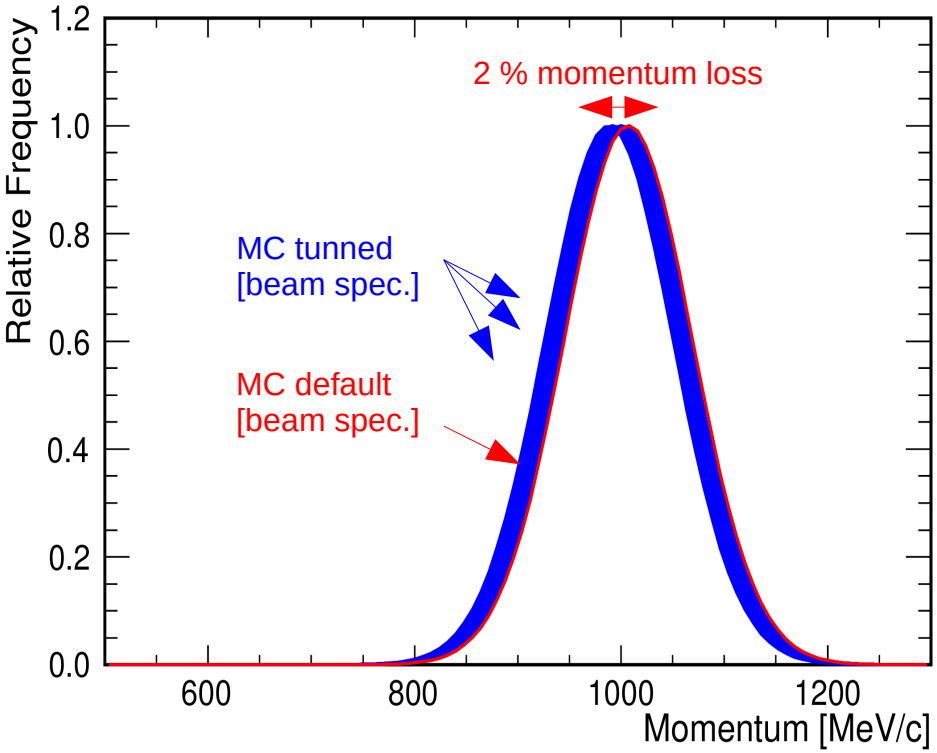


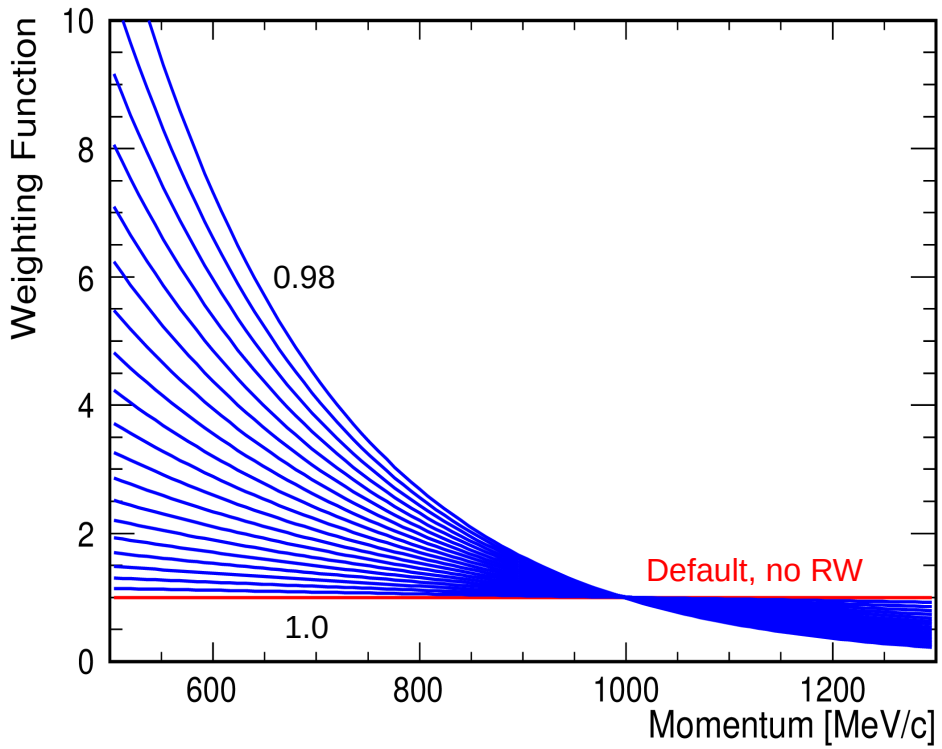
- Data has wider width than MC

Beam Momentum – Before/After Entering TPC

	Mean (sigma) of Peak [MeV/c]		
	Data	MC	
		Prod. 3	Prod. 3 [Spec]
Before entering cryostat	1013.2 (72.2)	1002.2 (61.5)	1007.1 (61.8)
Stopping protons inside TPC	955.4 (72.8)	963.0 (62.3)	
Momentum loss	57.8	39.2	44.1
Momentum loss fraction	5.7 %	3.9 %	4.4 %
Energy loss	41.9 MeV	28.4 MeV	31.9 MeV
Energy loss fraction	9.5 %	6.5 %	7.3 %

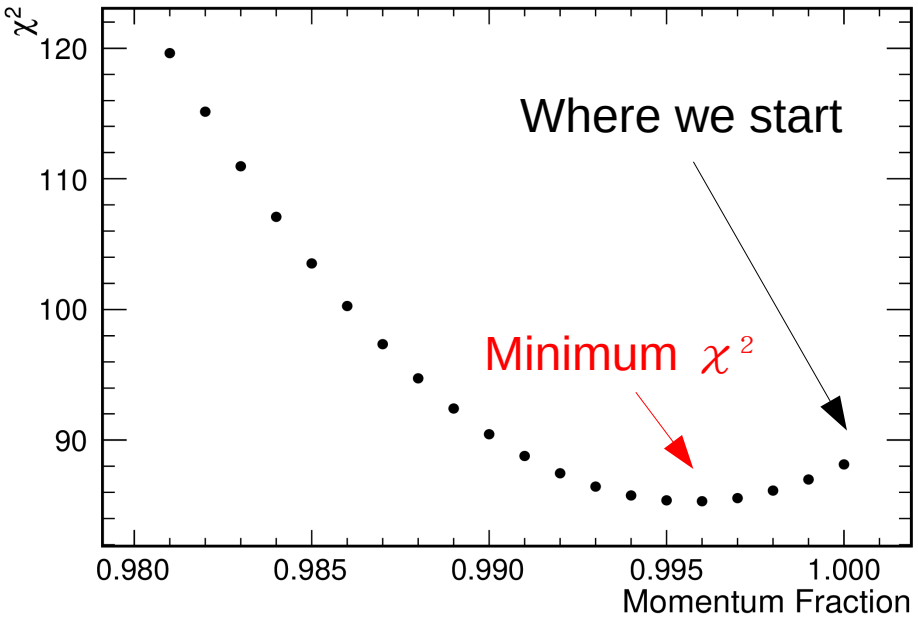
Beam Momentum Reweighting

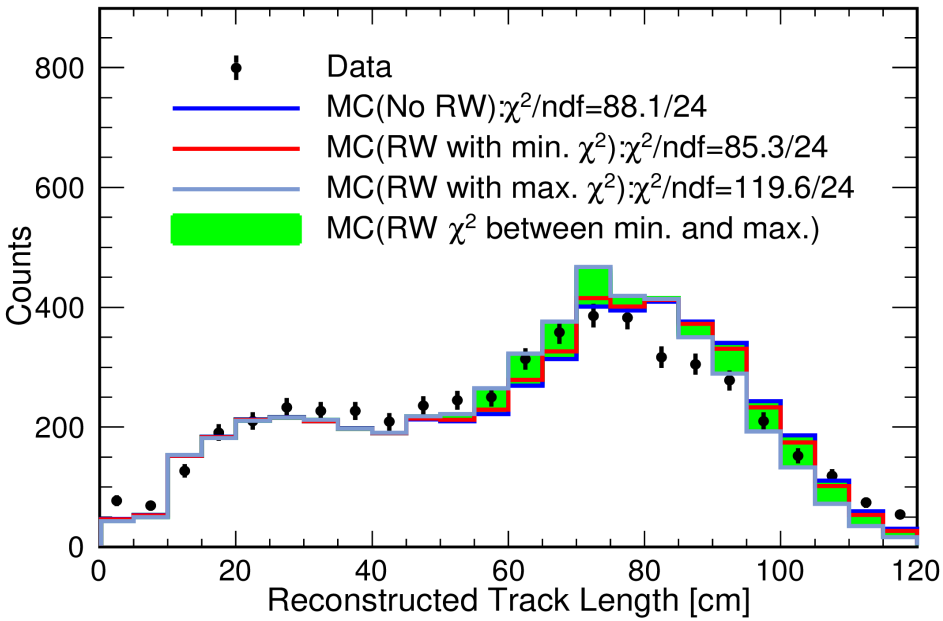




- Use the similar idea that we used for XS reweighting
- MC beam momentum before entering cryostat (Mean: 1008 MeV/c; σ: 62 MeV/c)
- Scan from no momentum loss to 2% momentum loss (100 divisions, 0.1% loss per division)
- RW function:=Gaussian(with momentum loss)/Original Gaussian

Track Length Distribution – B.M. Reweighting





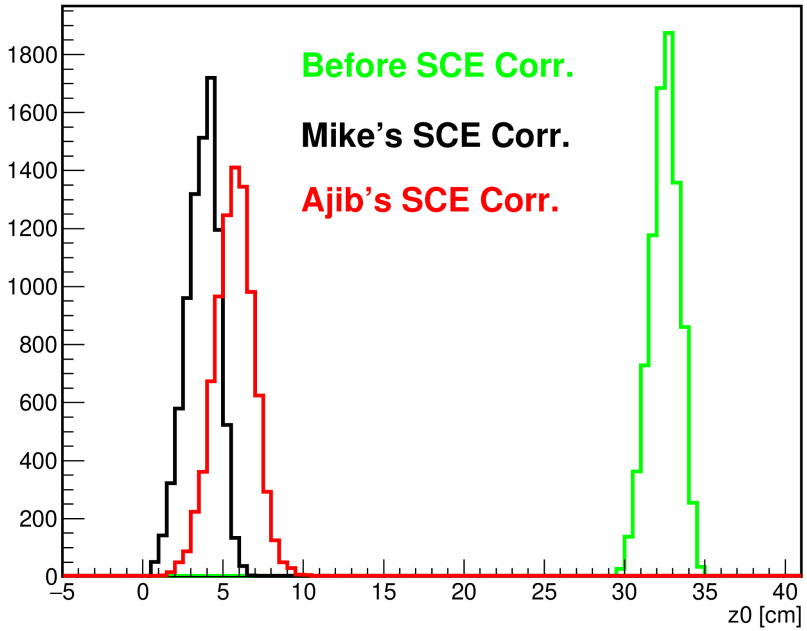
- Scan from 1.0 (no loss) to 0.98 (2 % momentum loss)
- MC peak shifts to the lower side as beam momentum reduces (expected)
- Minimum χ^2 close to MC default

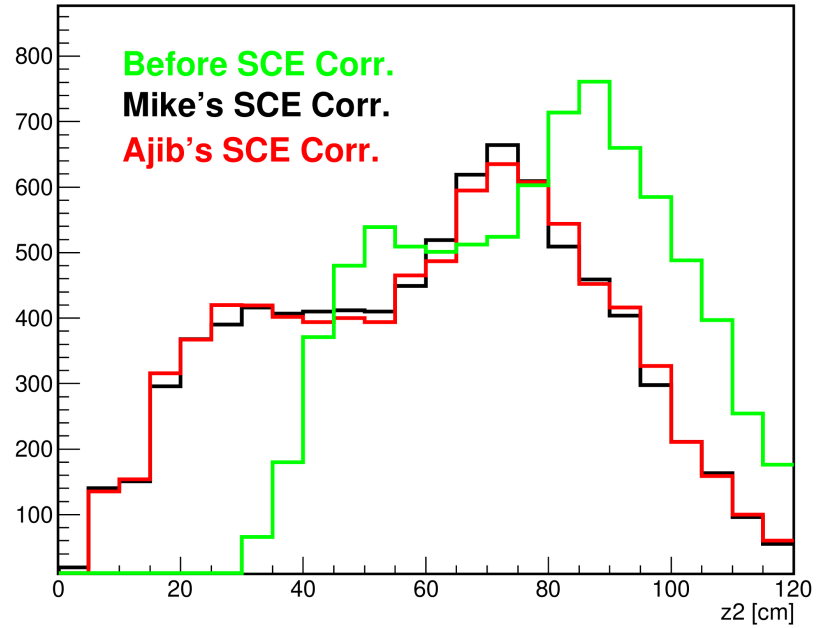
Summary & Outlook

- Beam momentum from spectrometer helps to improve MC normalized track length distribution.
- Improve data/MC agreement by using
  (1) xy-cut,
  (2) beam momentum reweighting.
- Remaining issue: MC track length is longer than data
- Plan to include the effect of beam momentum width in weighting function.

Backup

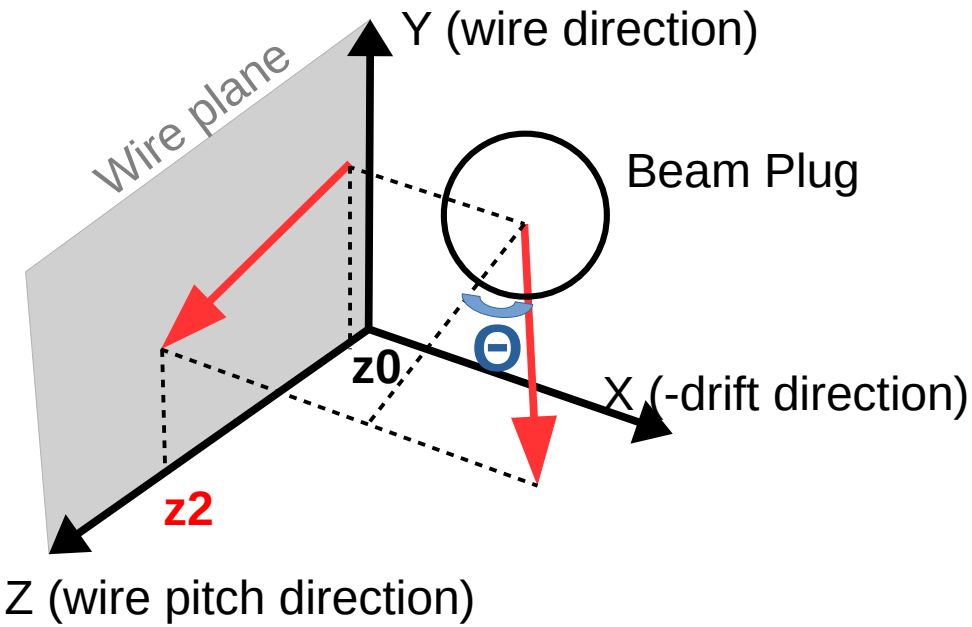
Investigation on SCE Correction

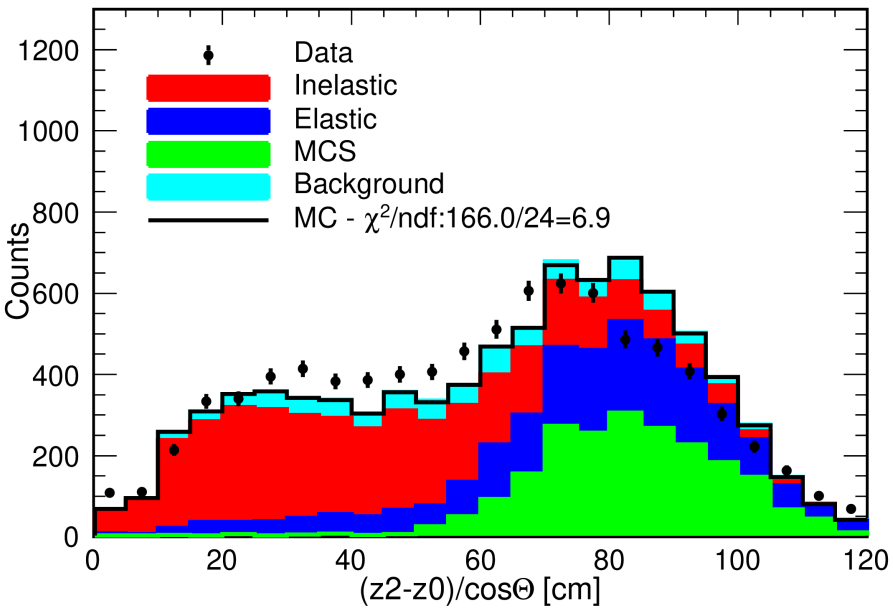




- Z2 distributions agree well between Mike's & Ajib's AA map
- Z0 offset: raw:~33 cm Mike's: ~4 cm ; Ajib's: ~6 cm
- Z2 is well-measured; Z0 may not be well-corrected
  - z0 should peak at 0 cm if SCE correction is done perfectly

(z2-z0)/cosΘ


Y (wire direction)
Wire plane
Beam Plug
Θ
z0
X (-drift direction)
z2
Z (wire pitch direction)


Data
Inelastic
Elastic
MCS
Background
MC - χ²/ndf:166.0/24=6.9
Counts
0
200
400
600
800
1000
1200
0
20
40
60
80
100
120
(z2-z0)/cosΘ [cm]