Pi+ cross-section studies using geant4 reweighting tool

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DEEP UNDERGROUND NEUTRINO EXPERIMENT

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Geant4 Reweighting:

Thanks to **Jake Calcutt** for developing the g4reweighting tools and helping with its implementation.

Here is a link to Jake's recent talk where he discusses the details about the framework and how to use it.

Geant4_reweighting_tutorial_by_Jake_Calcutt

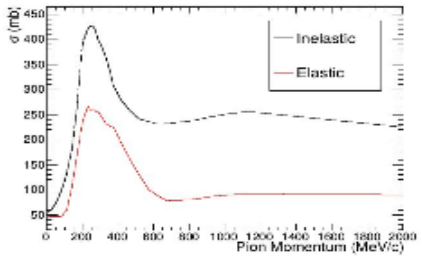
My talk will focus on some observables that can be reweighted.

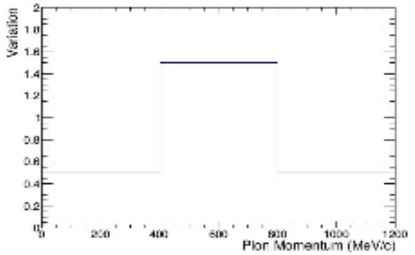
Very brief introduction to Geant4Reweight

Jake Calcutt

What is Geant4Reweight?

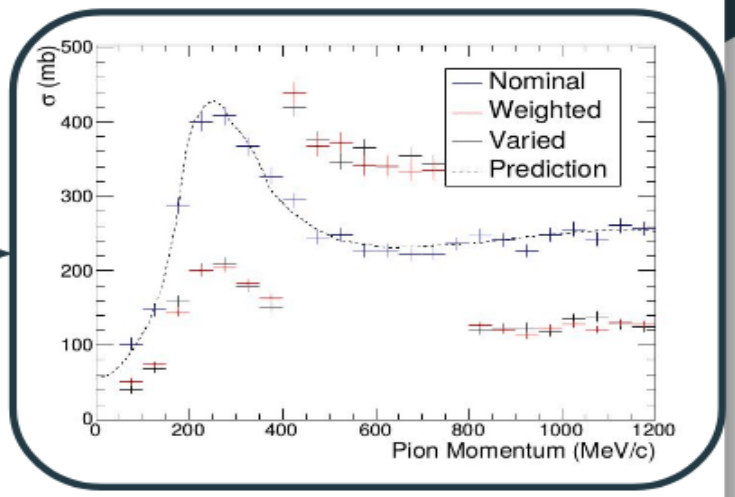
Software that produces weights for simulated particle tracks from Geant4





Geant4Reweight

Simulated Tracks



Weighted observables

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Let us look at the sample we are using [MC official production3]:

Total #of events :137800

#of events after beam-primary postion and angle cuts :118382

Total beam (pions+muons) = 27856

Selection cuts used:

- **Beam-primary particle position and angle cuts [mainly removes cosmics reconstructed by Pandora as primary particle**]**
- **dE/dx cuts [mainly removes daughter protons reconstructed as primary particle]**
- **removing tracks with recoEndZ>210cm [removes tracks broken at APA boundary]**

Numbers after selection cuts:

primary particles recons 12684

*Beam matched pi+ 11271 [88.86% of primary particles]

Non-beam mathced pi+ 455 [3.587% of primary particles]

Total primary protons 366 [2.88553% of primary particles]

Total primary muon 500 [3.94197% of primary particles]

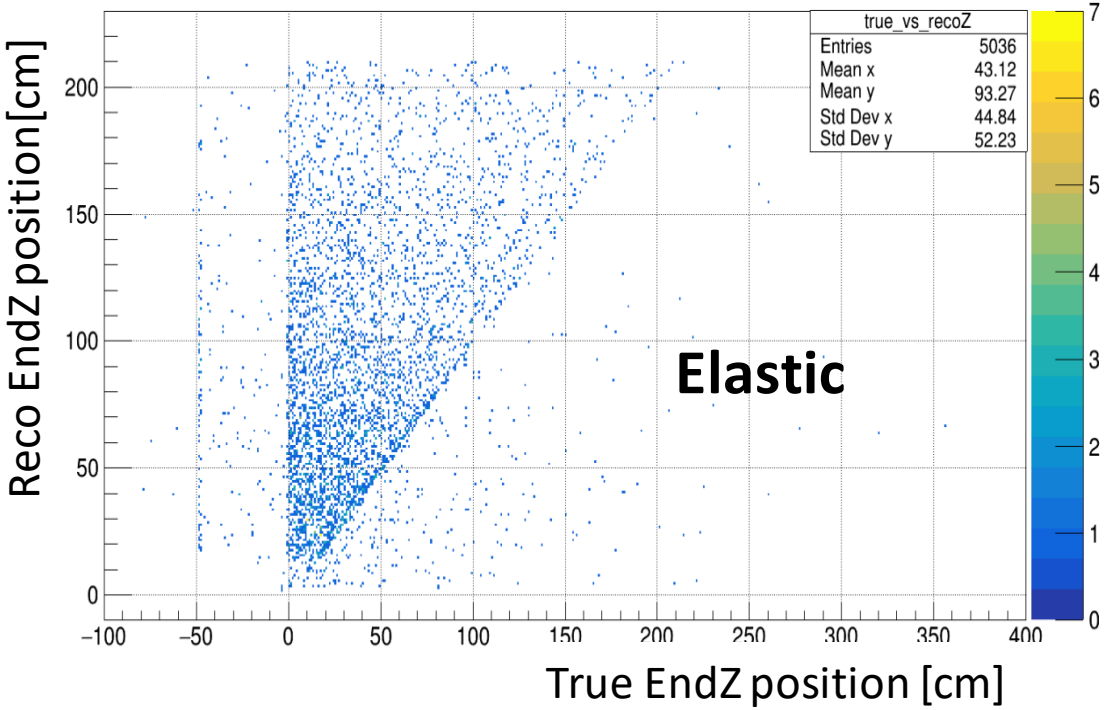
Other background [pi-, e+, e-, d etc] 92[0.72%]

*Beam matched==> True trackID of beam particle=True trackID of primary particle

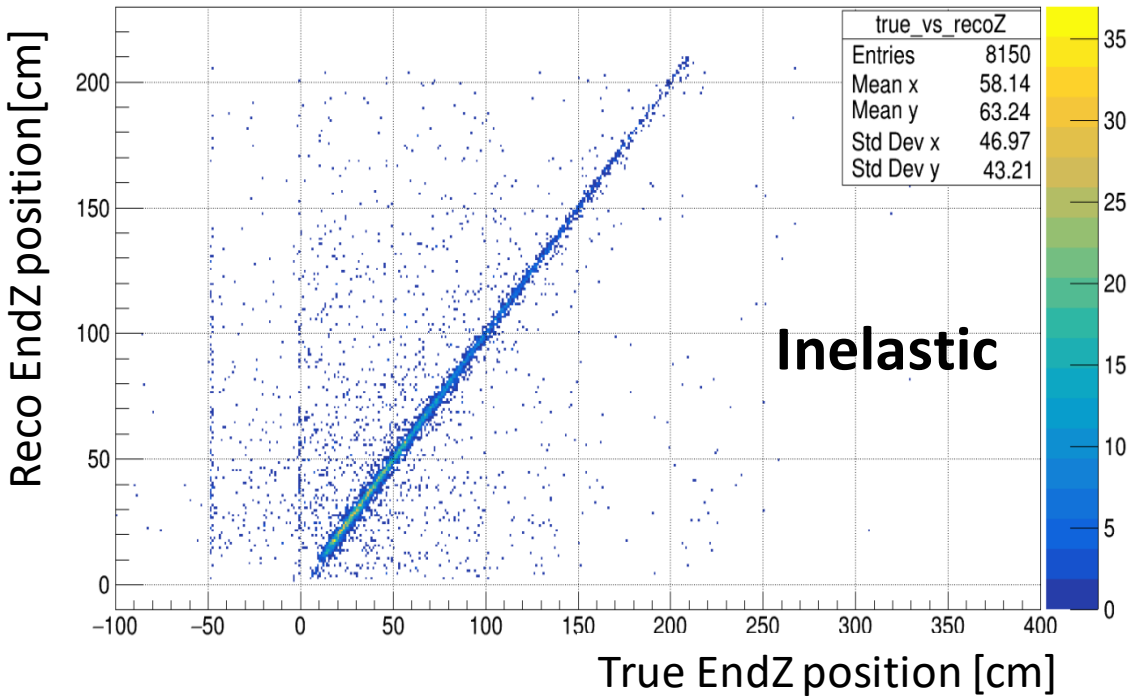
**primary particle==> Particle reconstructed by Pandora in the beam slice

Quick look at vertex reconstruction (Production 3, 1GeV sample):

Pi+ tracks with first interaction = hadElastic



Pi+ tracks with first interaction = pi+Inelastic



- Elastic vertex reconstruction has been difficult.
- Different techniques have already been tried to improve the vertex finding capability. Some more studies undergoing.
- Thin slice method requires good vertex reconstruction.
- Exploring Geant4reweighting as an alternative method for cross-section measurement.

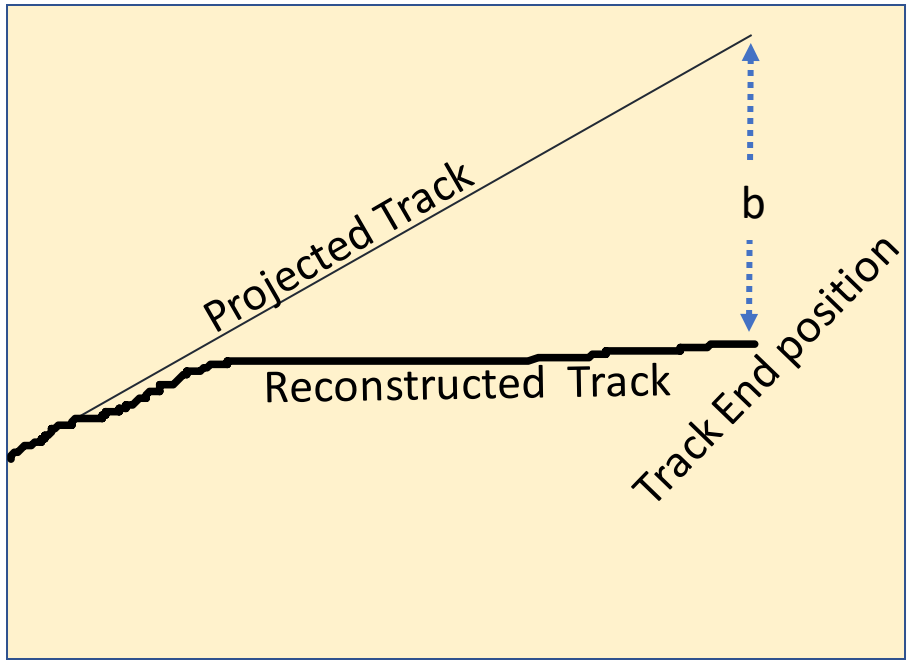
An alternative approach at measuring cross-section:

Let us look at some observables that can be compared between data and MC:

1)Reco Track end Z position (z2)

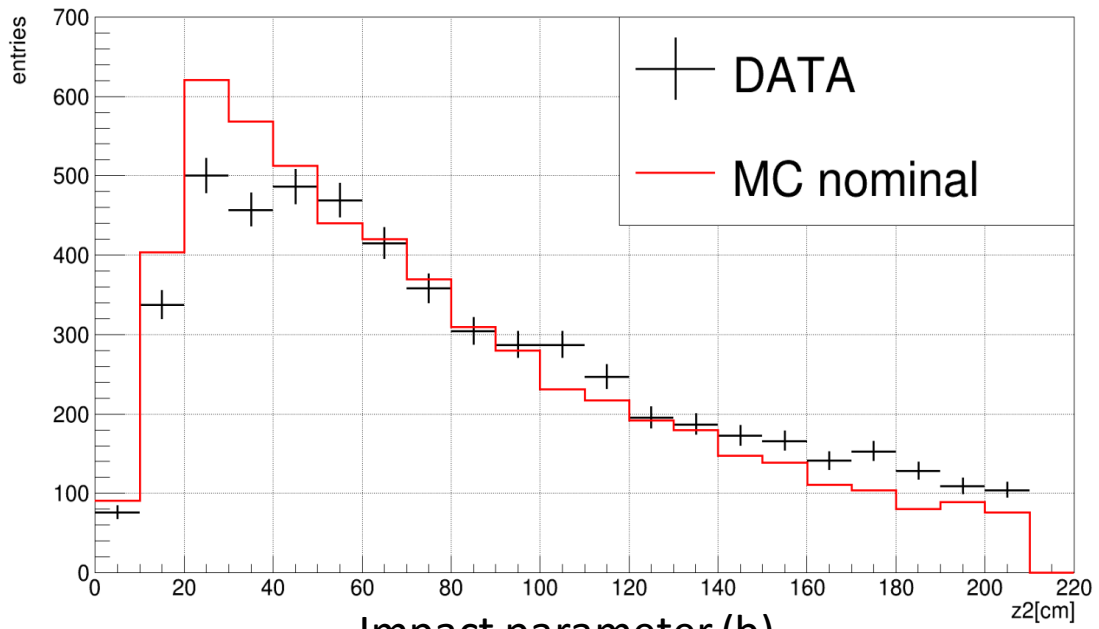
2)Reco Tracklength (tracklength)

3)Impact parameter (b), which is the 3D distance between track reco End point and projected point on the track (considering first few hits on the track) at z equal to reco trackendZ.

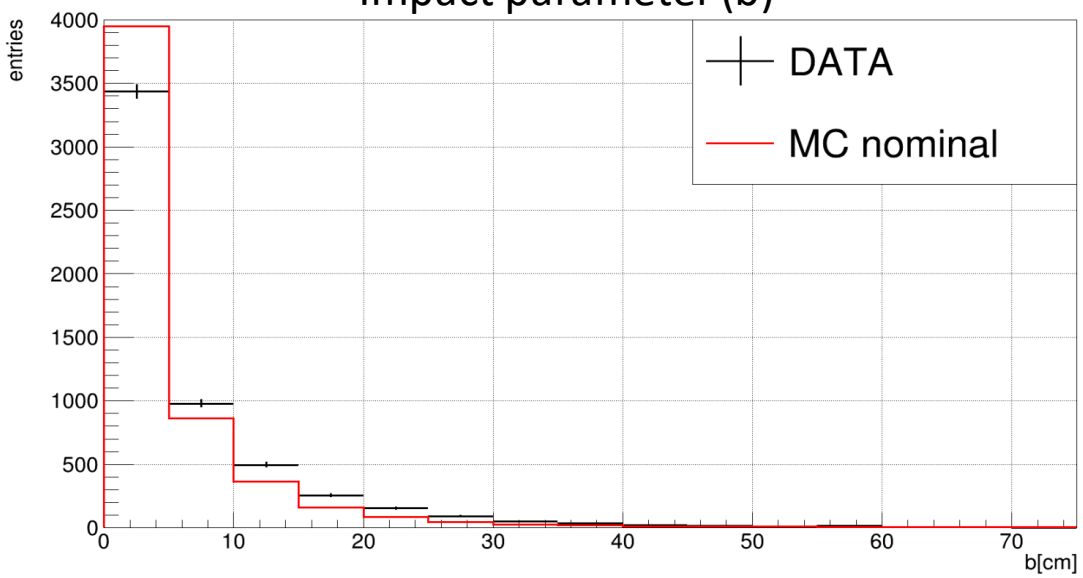


Data MC comparison:

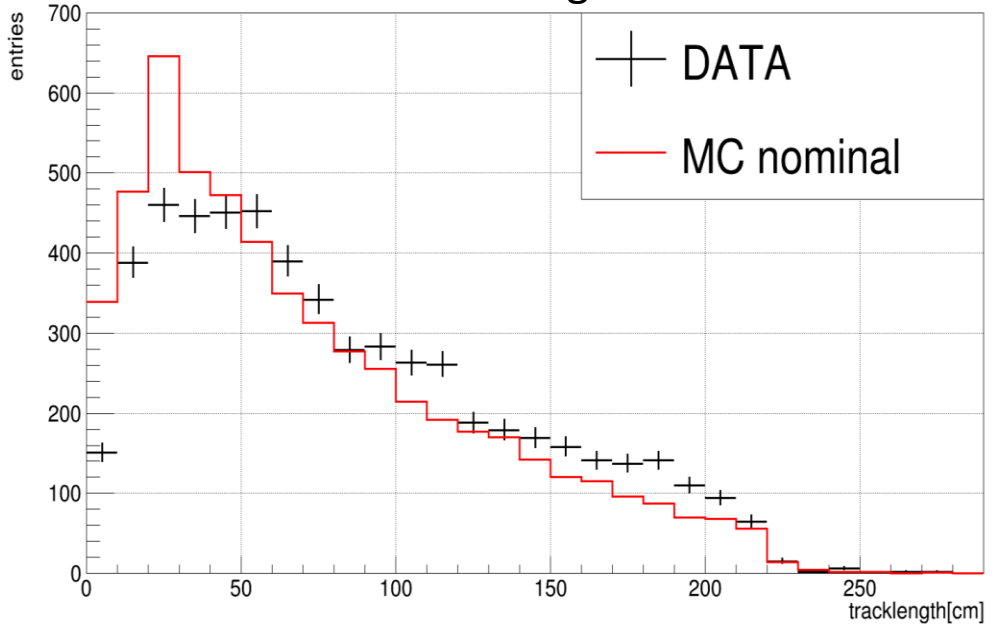
Reco EndZ position(z2)



Impact parameter (b)



Tracklength

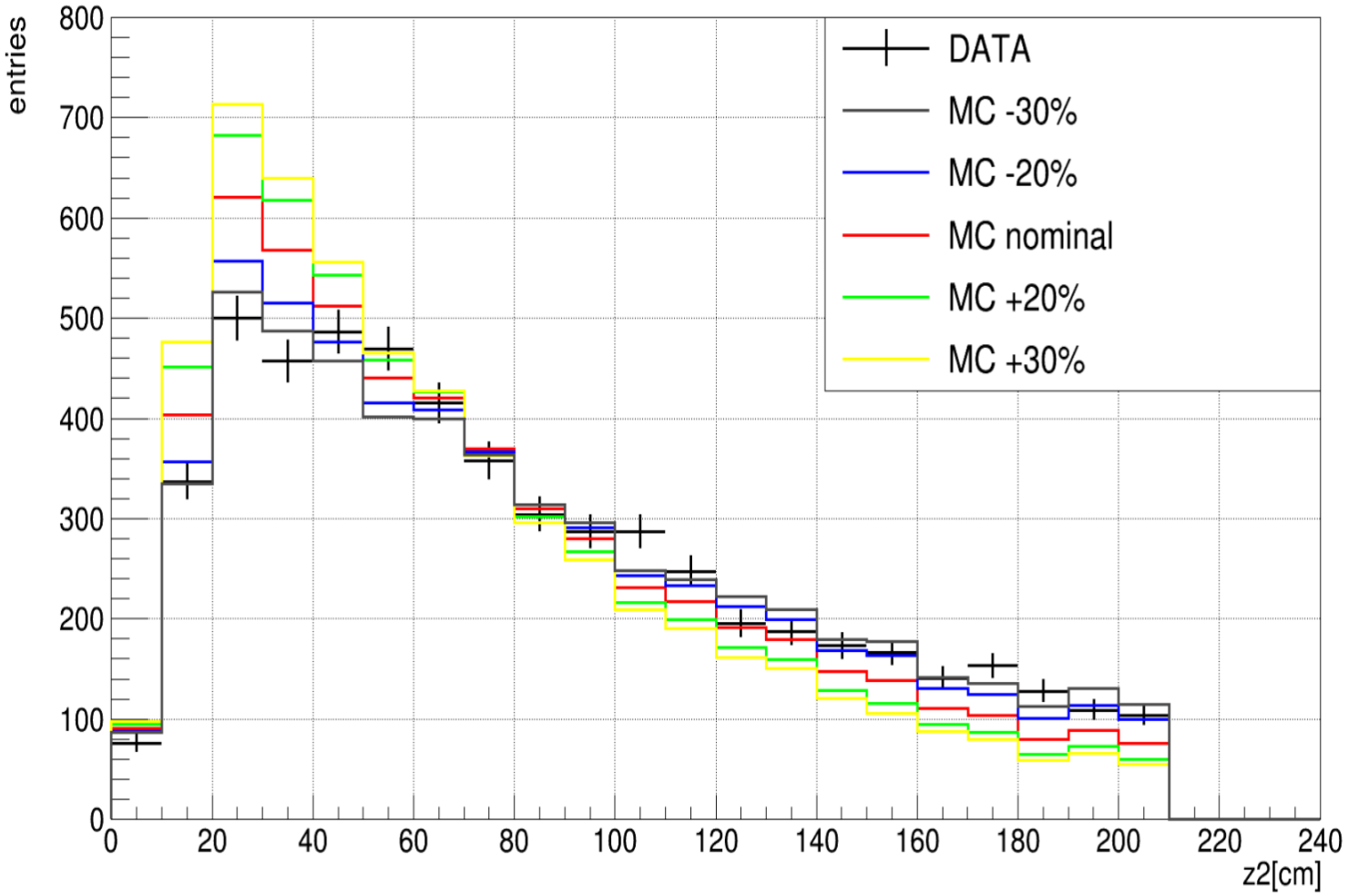


- Histograms show data (run5387) and MC production 3 comparison.
- These parameters will depend on cross-section besides other factors including SCE, reconstruction issues.
- Idea is to vary the cross-section to get best data-MC agreement. This way we can get best estimate of model dependent cross-section.

Varying the cross-section and looking at observables:

Only Inelastic cross-section are varied:

Looking at EndZposition (z2)

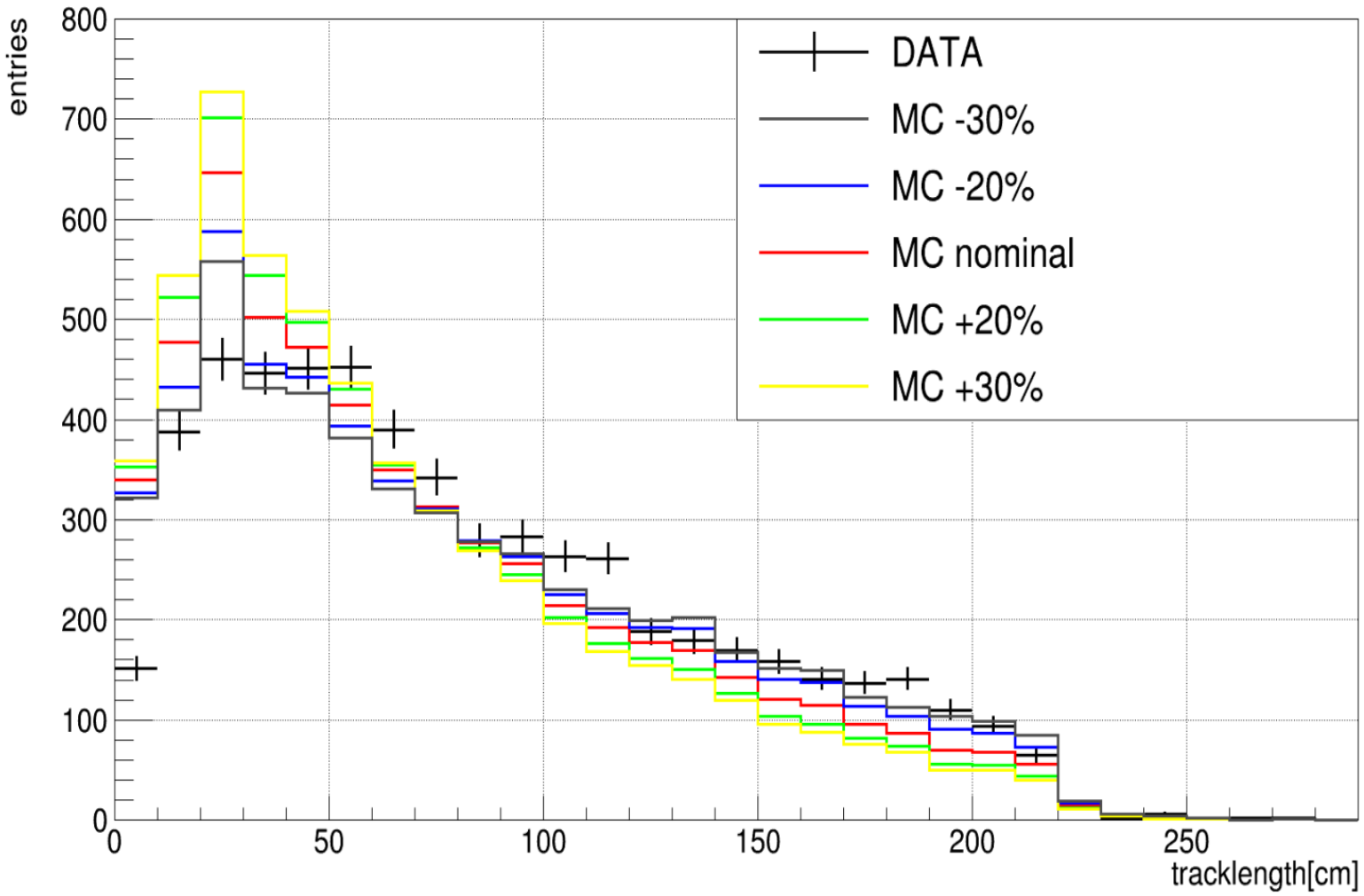


Sample	Chi^2/ndf
Nominal –30%	0.44
Nominal –20%	**0.60**
Nominal	2.43
Nominal +20%	6.66
Nominal +30%	9.61

Legends denotes the percentage increase or decrease in cross-section from nominal value.

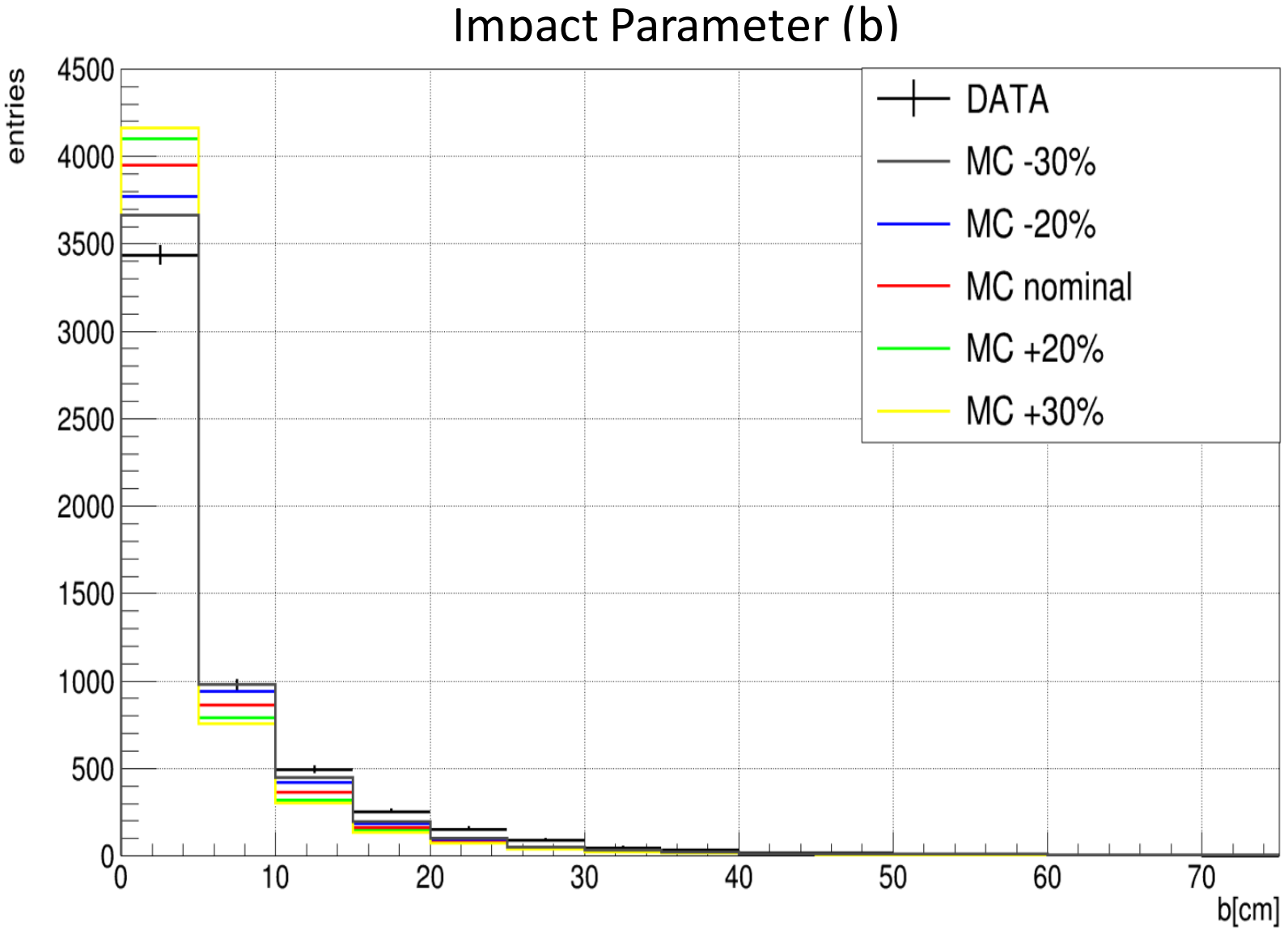
Only Inelastic cross-section are varied:

Looking at tracklength:



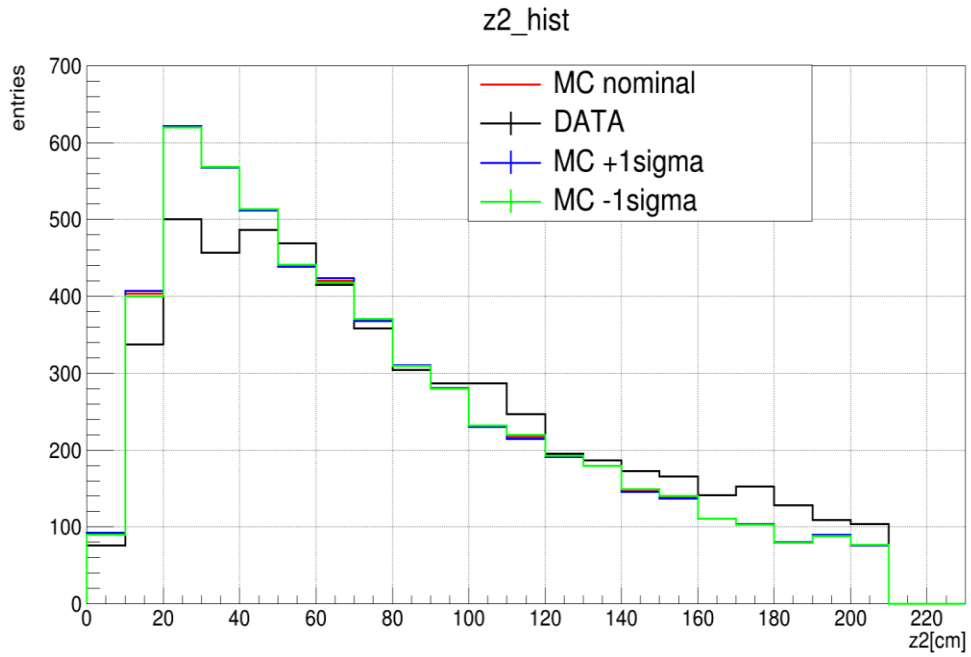
Sample	
Nominal –30%	1.57
Nominal –20%	1.95
Nominal	3.72
Nominal +20%	7.05
Nominal +30%	9.23

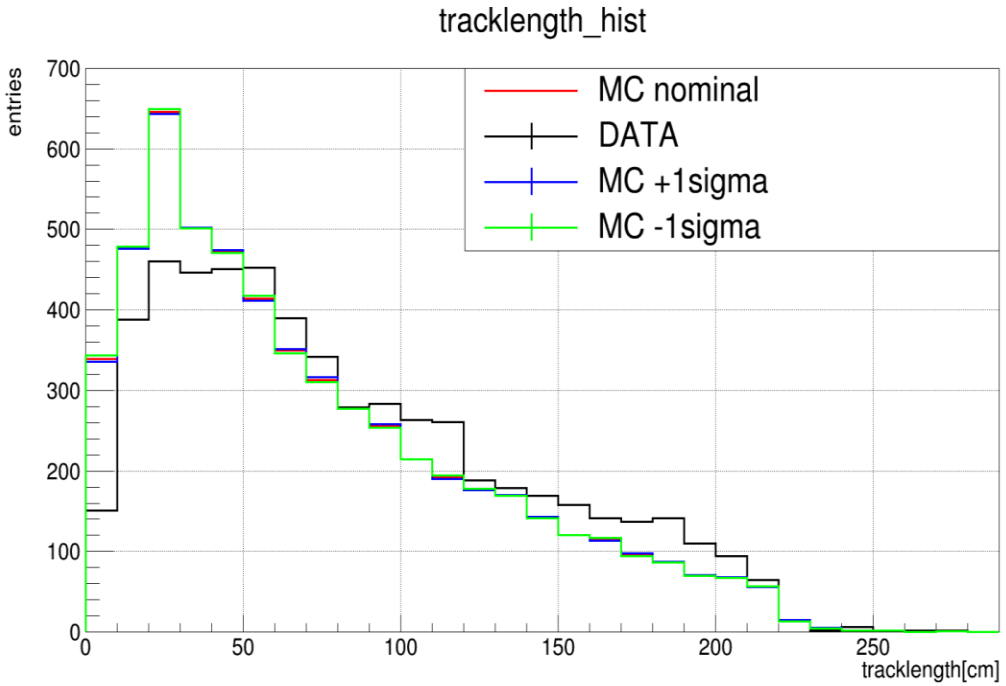
Only Inelastic cross-section are varied:

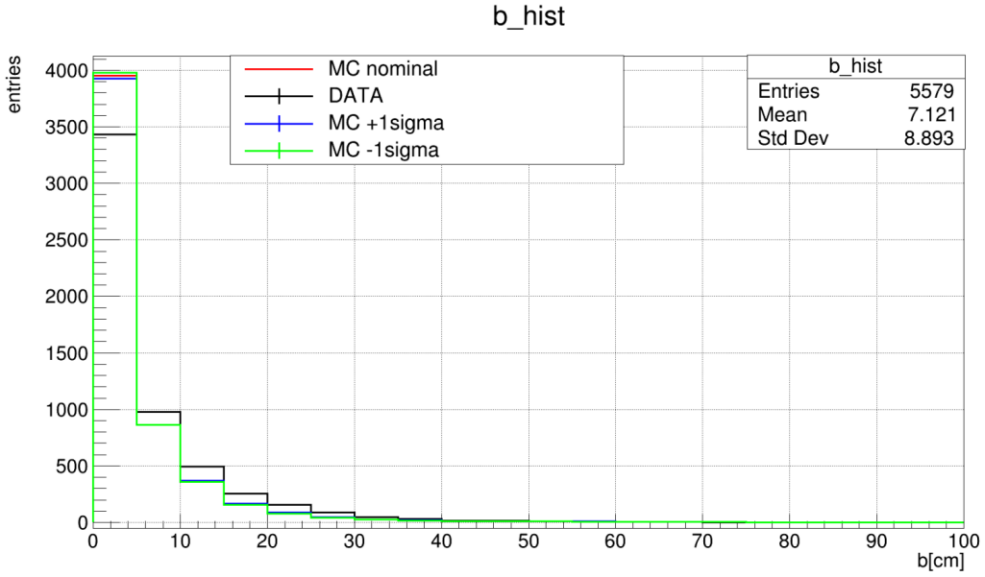


Sample	Chi^2/ndf
Nominal –30%	0.96
Nominal –20%	1.53
Nominal	3.3
Nominal +20%	5.9
Nominal +30%	7.39

Varying Elastic cross-sections







Sample	End Z position Chi^2/ndf	Tracklength Chi^2/ndf	b Chi^2/ndf
Nominal-20%	2.18	3.50	3.60
Nominal	2.43	3.72	3.34
Nominal+20%	2.61	3.86	3.02

20 % change in Elastic cross-section does not appear to affect any of the variables.

Summary and further study:

- Preliminary study on using geant4 reweighting tool for model dependent cross-section estimates looks encouraging.

- Some of the data-MC discrepancy could be due to non cross-section related issues such as reconstruction and residual SCE distortion, which needs to be handled carefully.

- Lowering the Inelastic cross-section makes data-MC agreement better.

- Elastic cross-section variation does not seem to affect the observables used, need to investigate more.

- Comments and/or suggestions are welcome.

Thank You