Study of Longitudinal diffusion in the ProtoDUNE-SP

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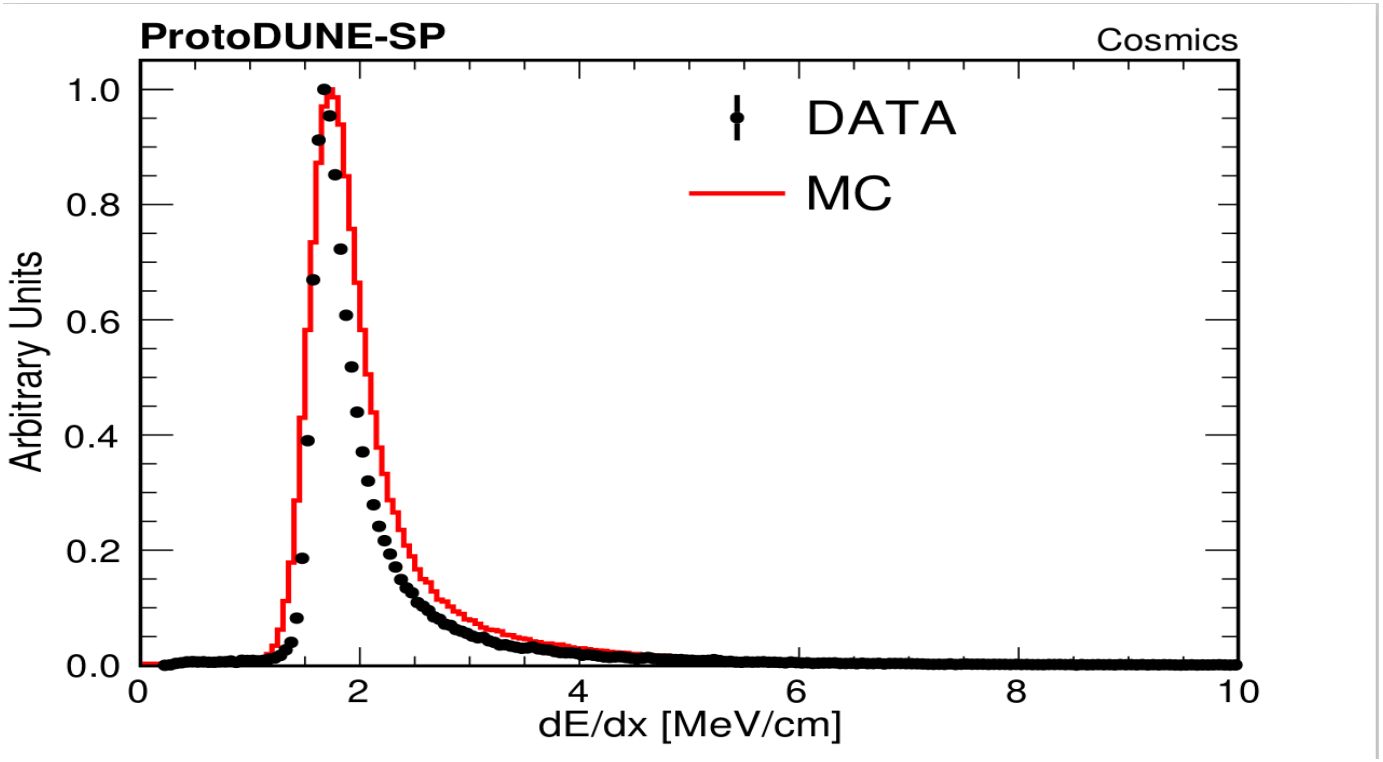
Motivation:

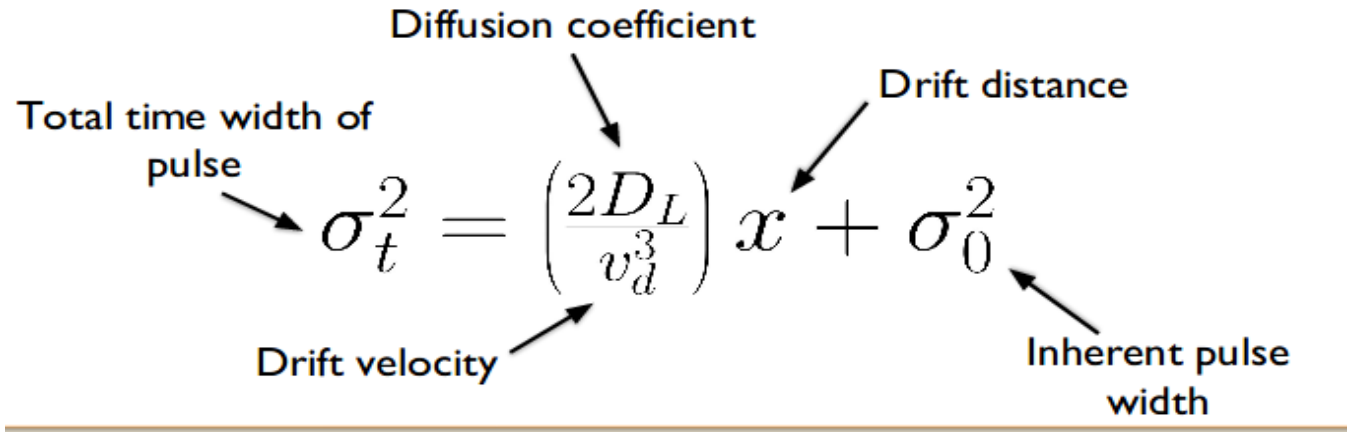
- To have a better understanding of the difference in width of dE/dx distribution for protoDUNE data and MC. In addition, a better understanding of diffusion in protoDUNE LArTPC will improve the simulation.



- Diffusion is the smearing out of ionization electrons as they traverse through a medium. It could be longitudinal (smearing along the drift direction) and transverse (smearing along the direction transverse to the drift direction).

- **In this talk I will be discussing the logitudinal diffusion in protoDUNE.**

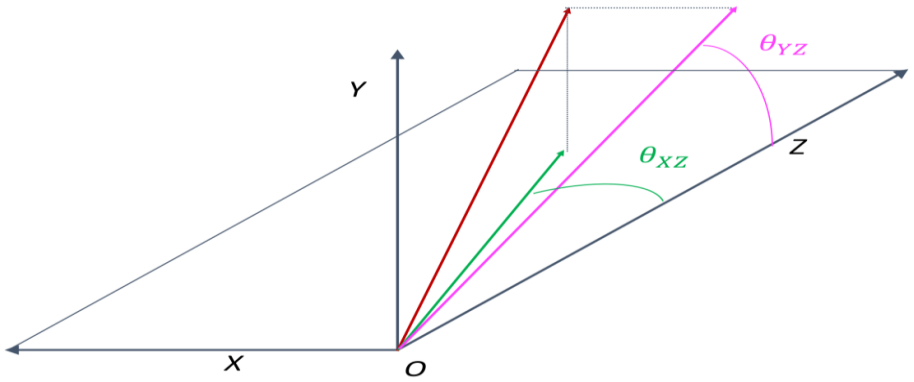
- **Longitudinal diffusion widens the signal pulse in time which can be extracted using σ_t square vs X fit**



MicroBooNE Study

Tracks and hit Selection:

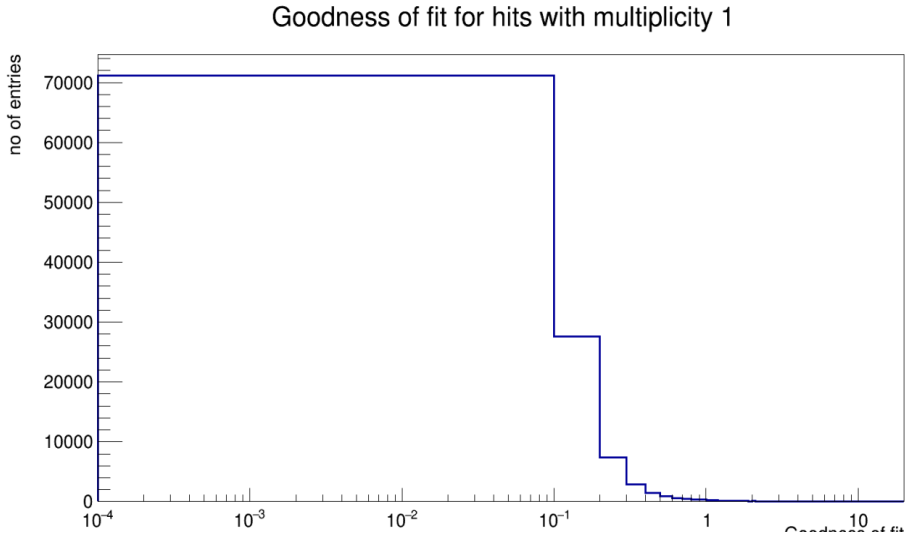
- We select T0 tagged tracks as they have known X position of the hits.
- Use tracks within a small angular range



For the current analysis we require:
30 deg<Abs(theta_YZ)< 40 deg
30 deg<Abs(theta_XZ)< 35 deg

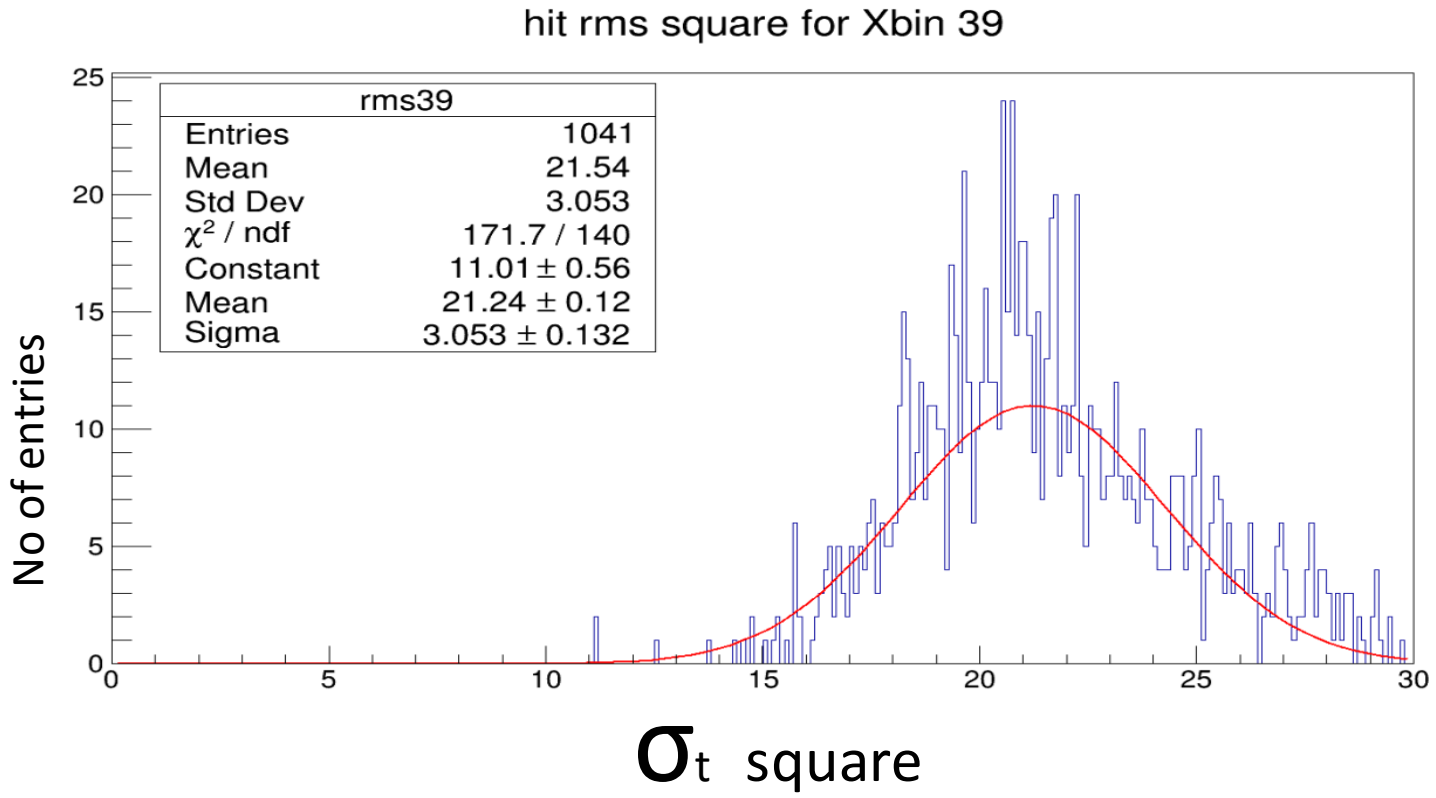
- We require hits to have multiplicity of 1 (Hit::Multiplicity()==1) .

We require goodness of fit to be <=0.1 (Hit::GoodnessOfFit()<0.1) based on the goodness of fit distribution on the plot aside.



Hit::RMS() function gives the width of the pulse in LArSoft.

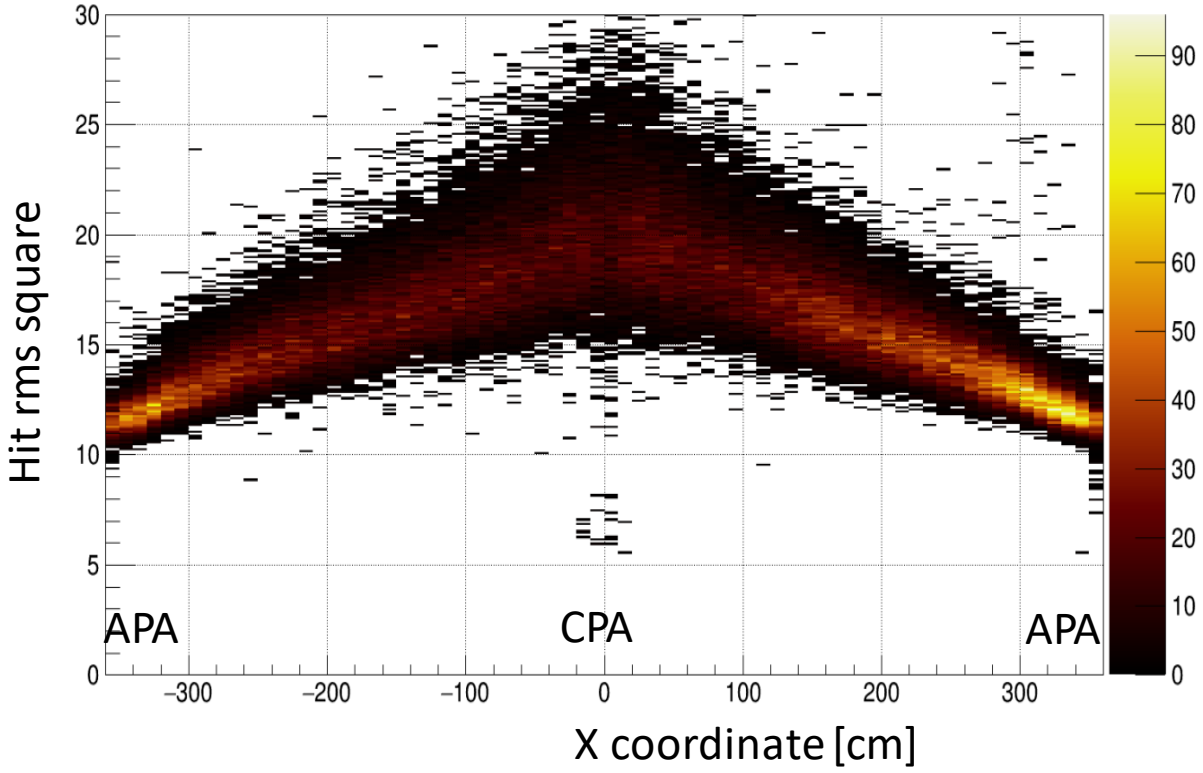
We divide the protoDUNE drift distance of 360 cm into 10 cm bins, then fit the distribution with a Gaussian function and determine the fitted mean.



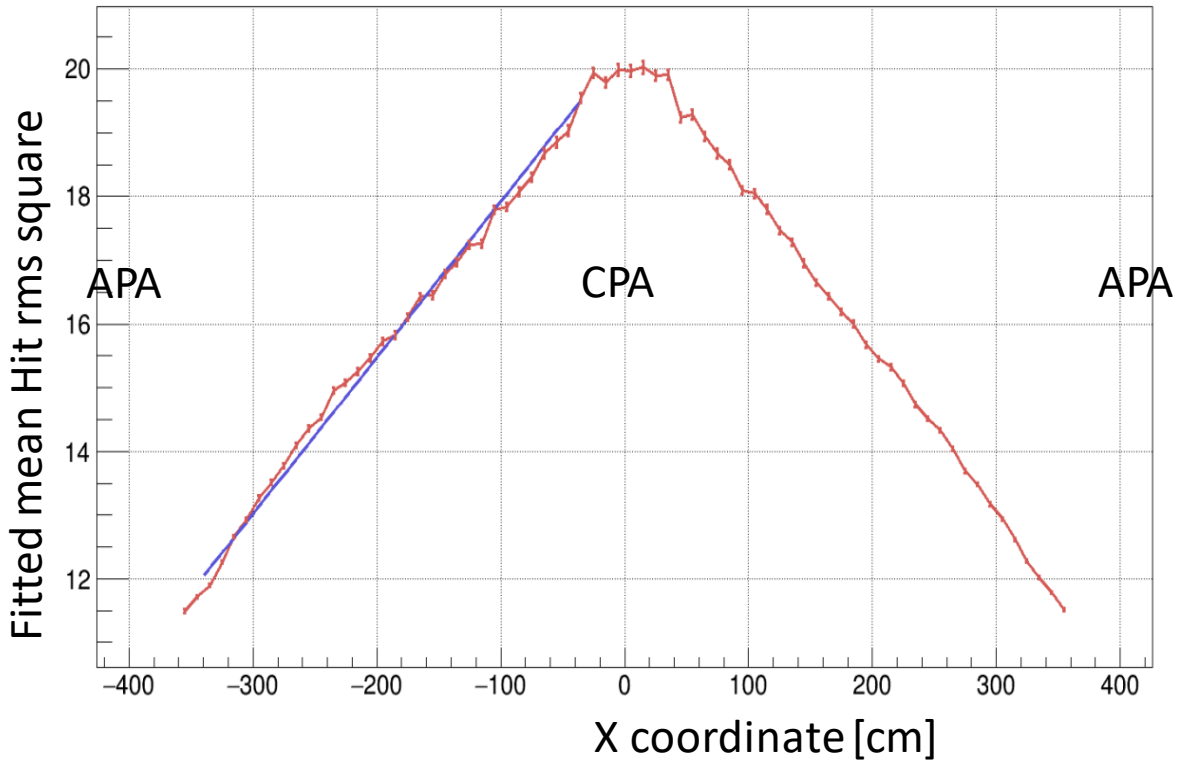
Plot on the right shows hit rms square distribution for an arbitrary X bin (30cm - 40cm) for SCE ON sample.

Results: *MC SCE ON sample (Production 2)*

Hit rms square vs X coordinate



Fitted mean Hit rms square vs X coordinate

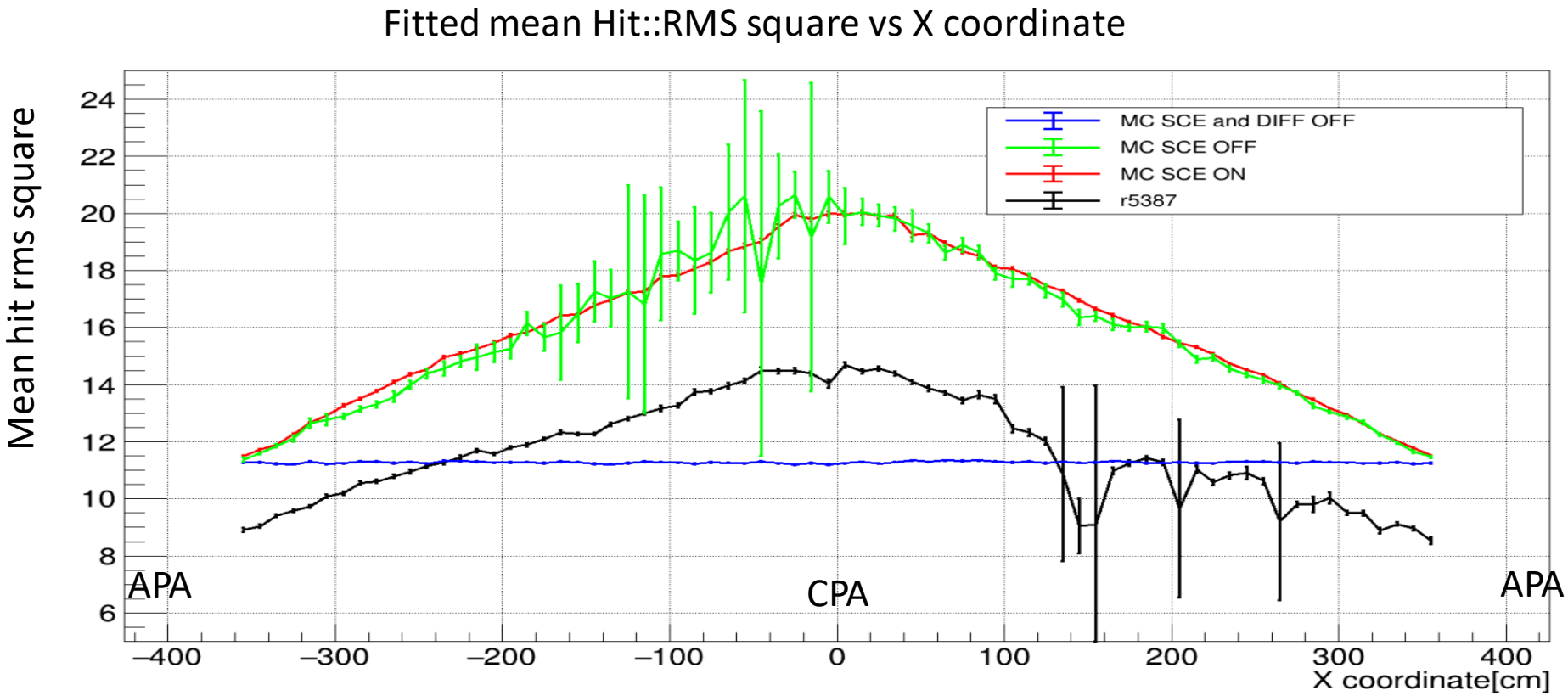


Using the slope of the fit on the plot on the right we found,
Diffusion constant = 12.2 cm^2/sec

While the input diffusion constant is 6.2 cm^2/sec, observed diffusion constant is about twice the input value which is puzzling.

Results:

Plot of mean hit rms square vs X position for different samples :

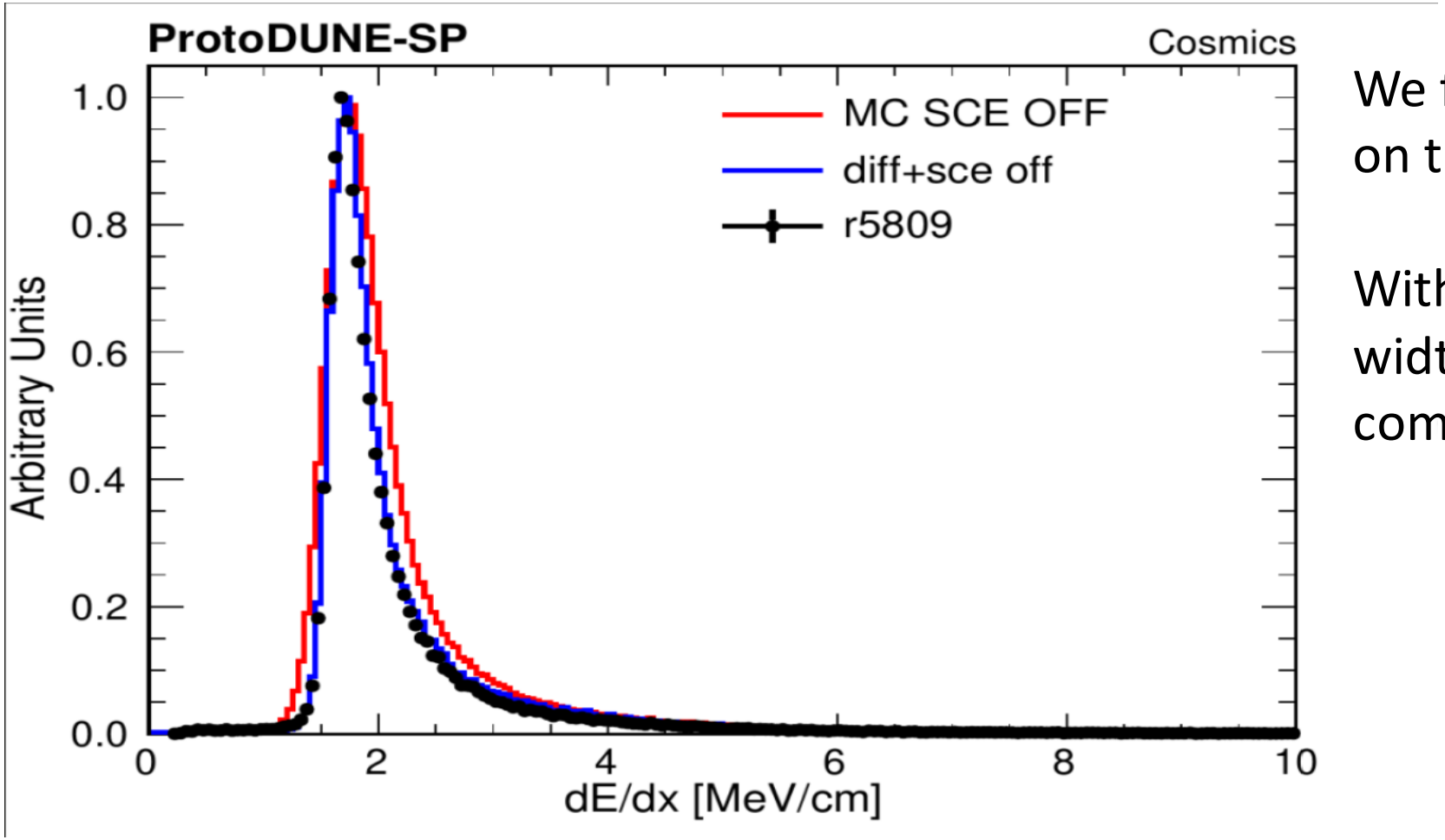


Sample Type or Date Run	Observed Longitudinal Diffusion constant
MC SCE ON	12.2 cm^2/sec
MC SCE OFF	12.9 cm^2/sec
Data RUN 5387	8.1 cm^2/sec

Note:Number of entries are different for different samples, fluctuations are statistical

Results:

Tingjun generated some (diffusion + SCE)-> OFF sample to see if dE/dx width depends on diffusion constant,



We found the width depends on the diffusion constant.

With diffusion turned off width of MC dE/dx becomes comparable to data dE/dx.

SUMMARY:

- dE/dx width is found to depend on diffusion constant.
- For Monte-Carlo measured diffusion constant is around twice the input diffusion constant, which is puzzling.
- Diffusion in data appears to be less than in simulation.
- In addition to diffusion there could be other factors which is leading to difference in width between data and MC.