

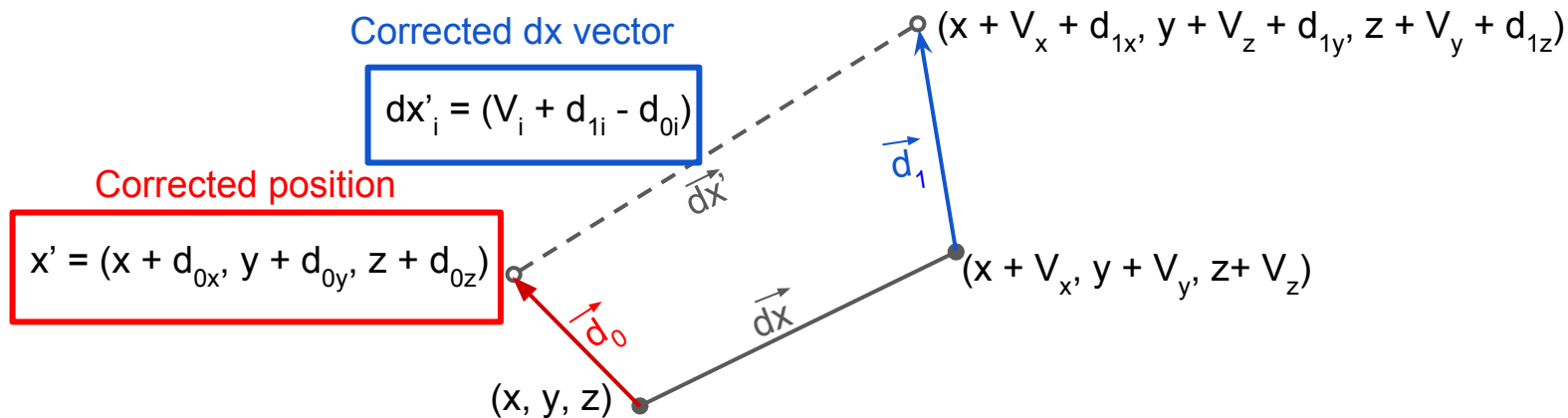


# Space Charge Calibration Update

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*ProtoDUNE Sim/Reco Meeting*  
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# Calibration Corrections

- Spatial corrections for  $dE/dx$  or  $dQ/dx$  applied in `larreco/Calorimetry/Calorimetry_module.cc`
  - Both **position** and **dx vector** must be corrected

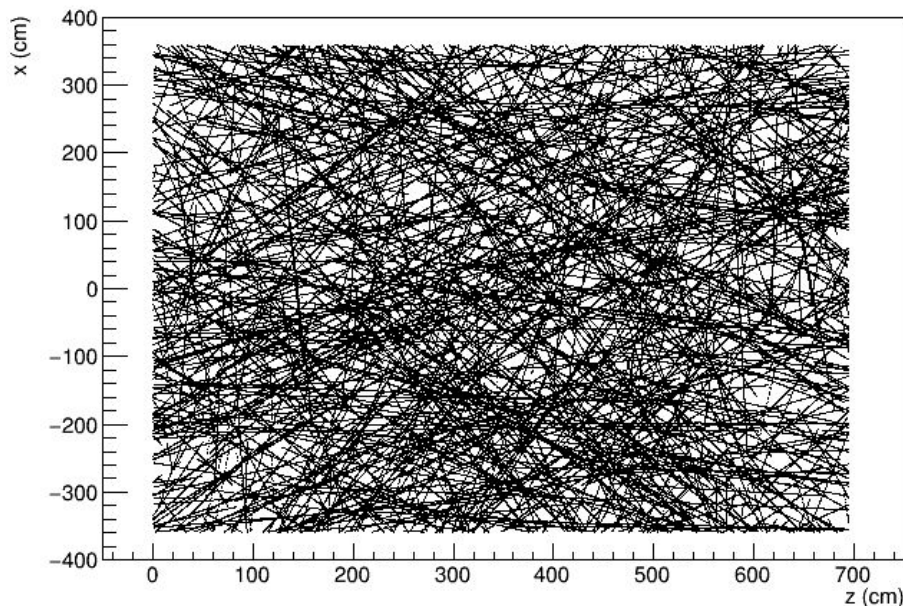


- Electric field corrections for  $dE/dx$  applied in `dunetpc/Protodune/singlephase/dEdxcalibration/CalibrationdEdxPDSP_module.cc`
  - Already spatially corrected (from `Calorimetry_module.cc`)
  - Corrected electric field used to calculate new recombination parameters from modified box model

# Test of Implementation

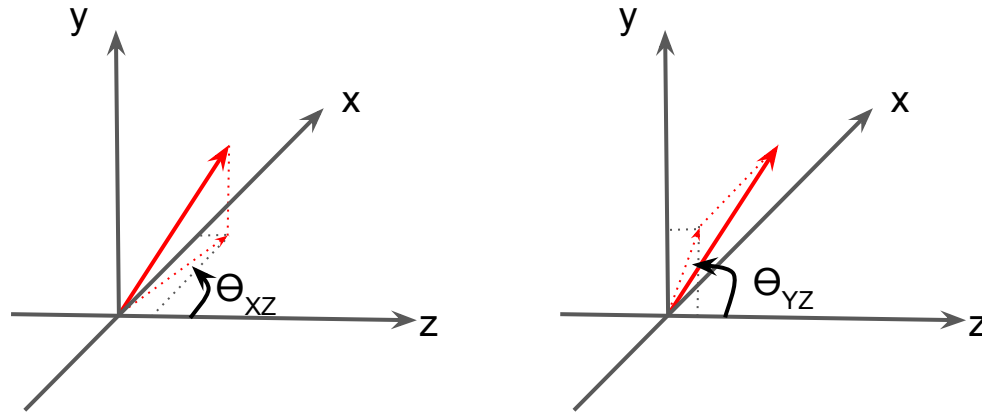
- Use 1000 isotropic, high-energy (1000 GeV), quiet muons to cover detector
  - Each trajectory point should have same deposited energy ( $dE/dx = 2 \text{ MeV/cm}$ )
  - Electron lifetime set to 30000  $\mu\text{s}$  (basically infinity)
- Compare 5 data sets:

Set	SCE in sim?	SCE in reco?
1	No	No
2	Yes	No
3	Yes	Spatial only
4	Yes	E-field only
5	Yes	Yes (both)



# Angle Cut Definition

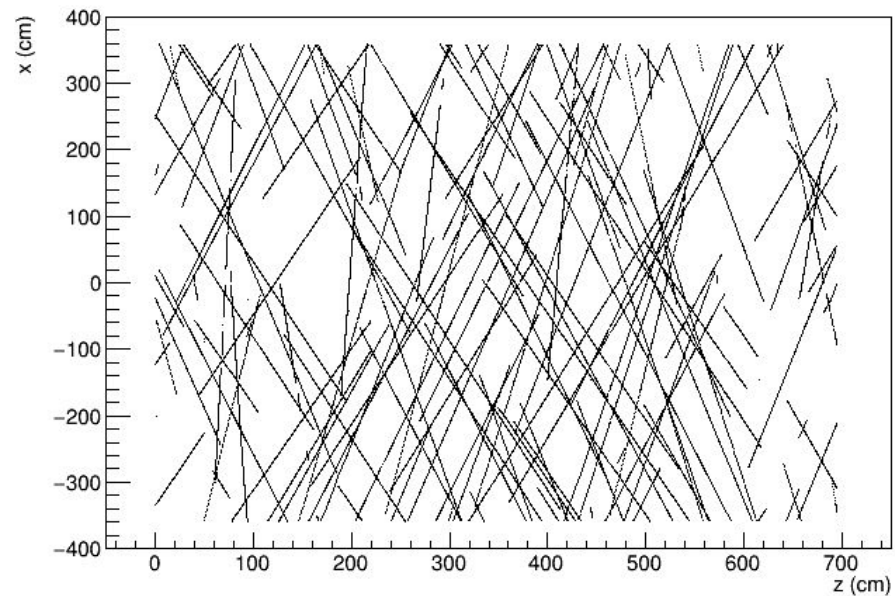
- Define  $\Theta_{XZ}$  and  $\Theta_{YZ}$ : Angle between Z-axis and projection onto XZ or YZ plane



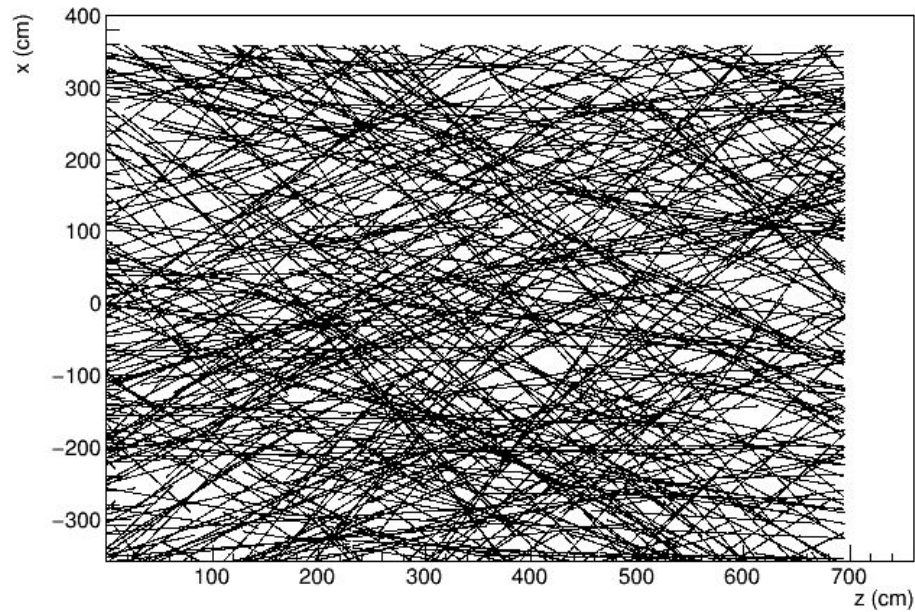
- Remove tracks with  $|\Theta_{XZ}| = (1.13, 2.0)$  OR  $|\Theta_{YZ}| = (1.22, 1.92)$

# Angle Cut

Removed tracks:



Kept Tracks:

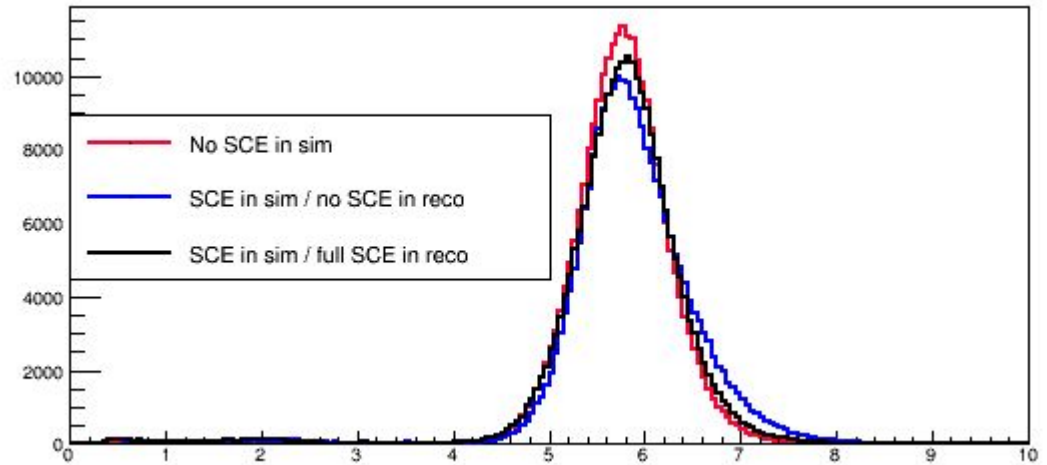


# dE/dx of Remaining Muons

Red = no SCE in sim

Blue = no SCE corrections

Black = full SCE corrections

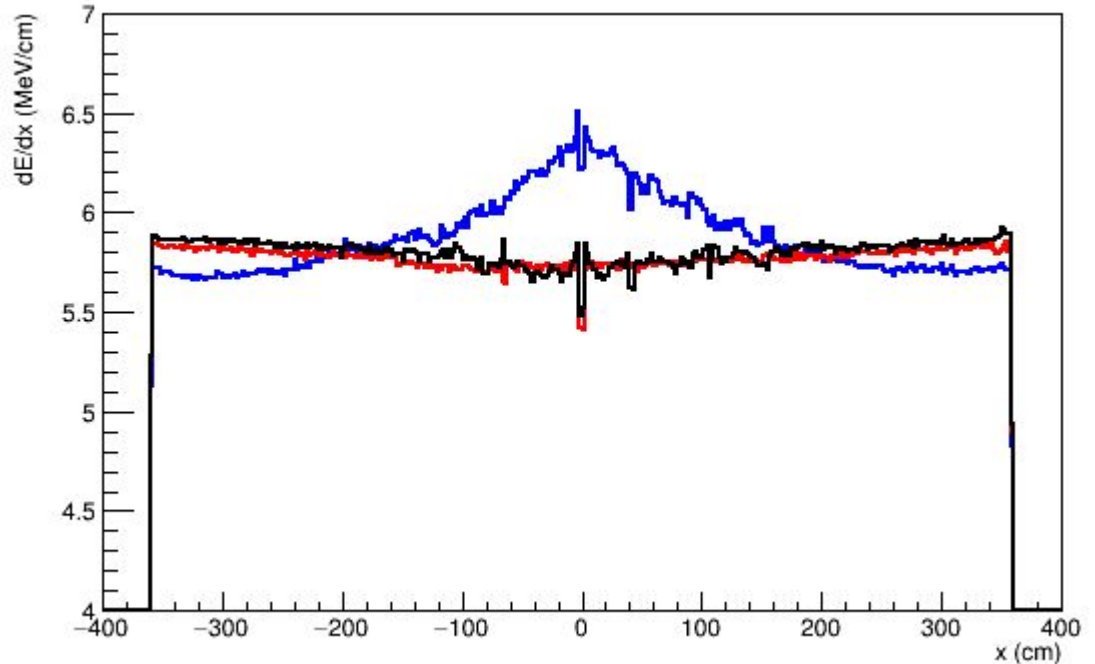


# $dE/dx$ vs $X$ of Remaining Muons

Red = no SCE in sim

Blue = no SCE corrections

Black = full SCE corrections



# dE/dx vs X of Remaining Muons

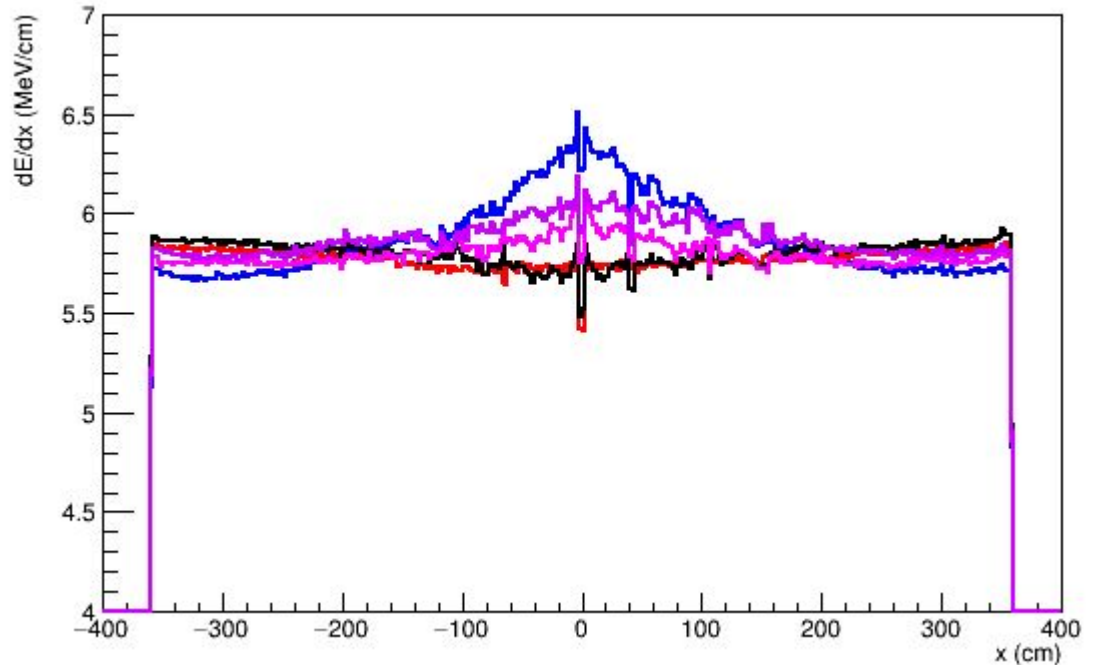
Red = no SCE in sim

Blue = no SCE corrections

Black = full SCE corrections

Pink = dx corrections only

Purple = dE correction only



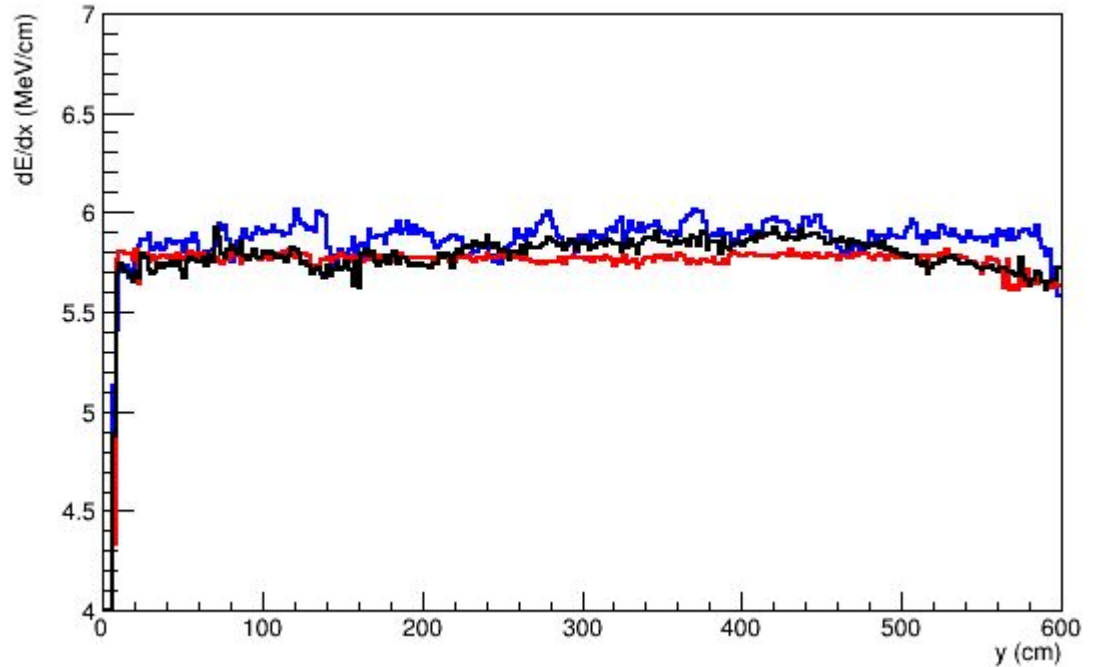


# dE/dx vs Y of Remaining Muons

Red = no SCE in sim

Blue = no SCE corrections

Black = full SCE corrections

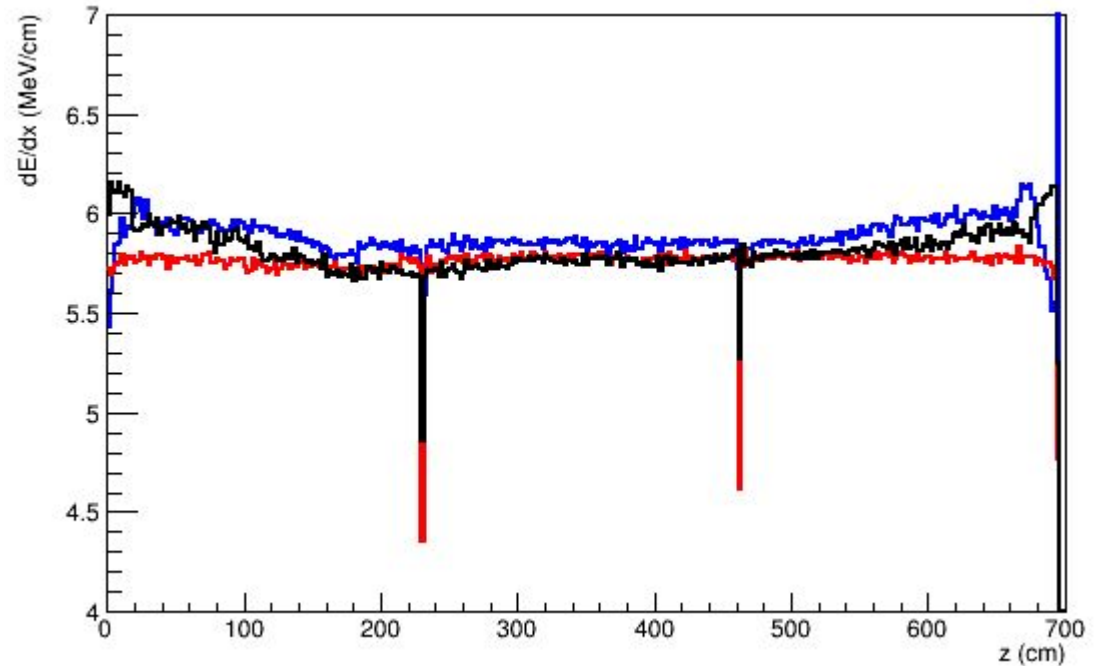


# dE/dx of vs Z Remaining Muons

Red = no SCE in sim

Blue = no SCE corrections

Black = full SCE corrections



# Conclusions

- Bug found in x spatial corrections (in space charge service)
  - Brings  $dE/dx$  after SCE corrections much closer to  $dE/dx$  with no SCE in simulation
- Looking into remaining differences
  - Building simulation outside of LArSoft to check the maps
  - Looking for other correction or variable dependent anomalies