Two Changes to SCE Simulation/Corrections

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ProtoDUNE Sim/Reco Meeting

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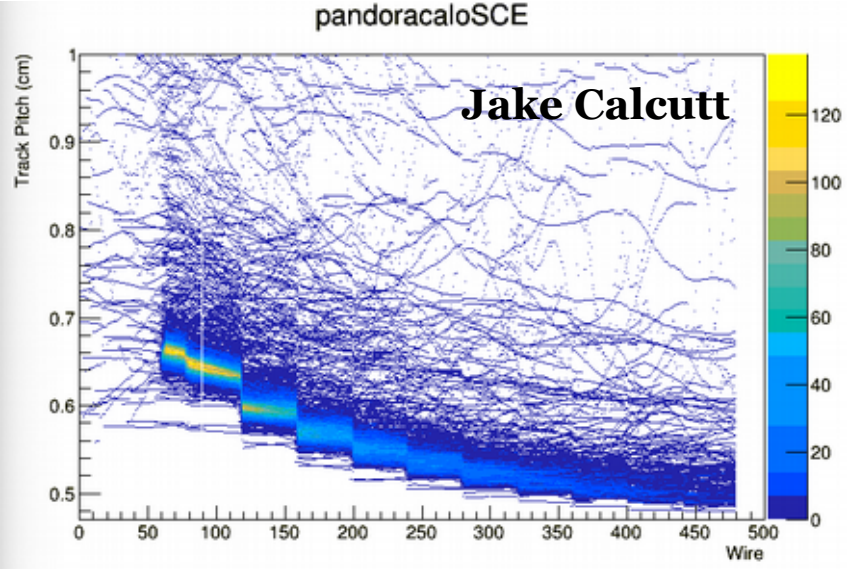
Introduction

- Previously several people working on ProtoDUNE-SP have noticed issue with SCE corrections in dE/dx reconstruction
  - Main observation has been discontinuities in “pitch” or dx
  - Impact seems to be both in simulation (dE/dx w/ SCE) and reconstruction (dE/dx corrections in Calorimetry module)
- This has been understood using toy MC – more info **here**



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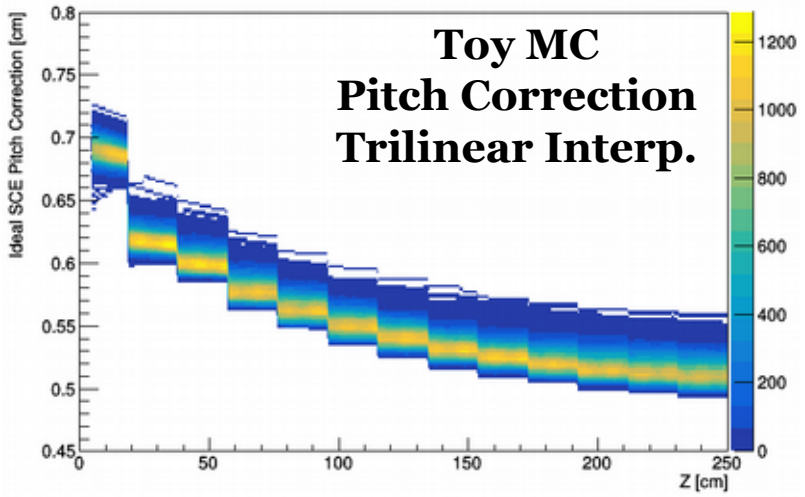
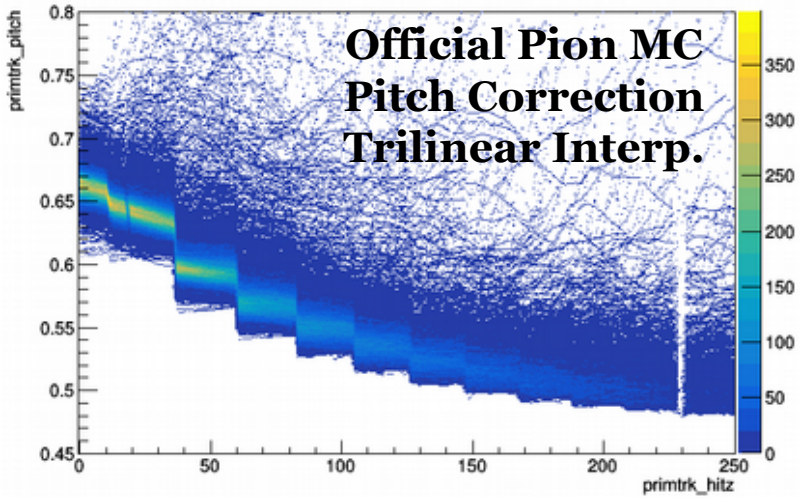
  - Main observation has been discontinuities in "pitch" or dx
  - Impact seems to be both in simulation (dE/dx w/ SCE) and reconstruction (dE/dx corrections in Calorimetry module)
- This has been understood using toy MC – more info **here**
  - **This has now been fixed w/ changes to dunetpc!**
- Additionally, issue with "v3" maps from preliminary SCE calibration that impacts offsets and E field near cathode
  - Bug in map-making code leads to error for **-20 cm < X < 20 cm**
  - Will impact Ajib's study of offsets at cathode using CPA boundaries, and also track stitching across cathode in data only
  - **This has also now been fixed w/ new "v4" map**

Explanation of Interp. Issue

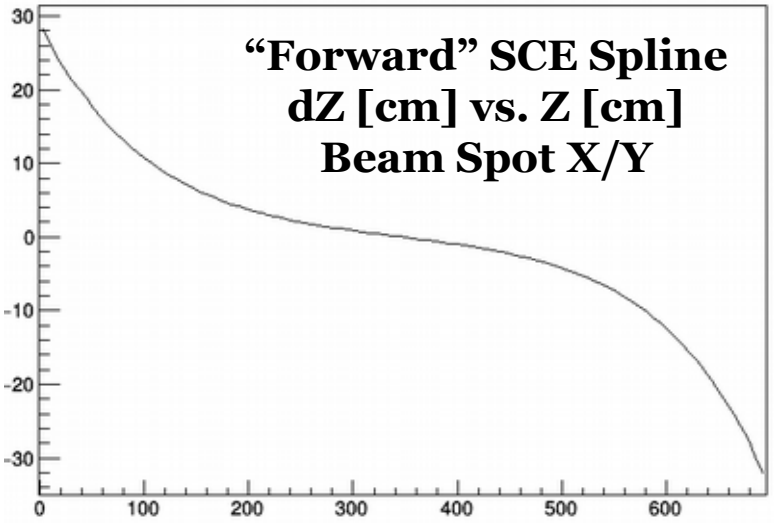


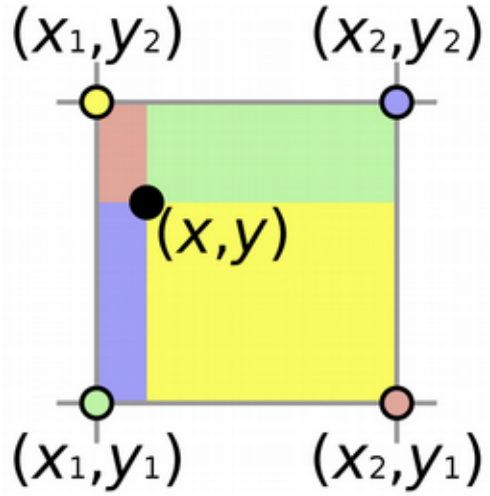


Trilinear Interpolation: $f(x,y,z) \approx a_0 + a_1 x + a_2 y + a_3 z + a_4 xy + a_5 xz + a_6 yz + a_7 xyz$

- Toy MC w/ trilinear interpolation recreates issue in pion MC
- Trilinear interpolation is linear in each direction (of course!)
- Pitch (dx) correction sensitive to **derivative** of interpolated map – linear interpolation implies constant derivative
  - Each bin sees constant dx correction → bin-to-bin jumps

Splines for Interpolation



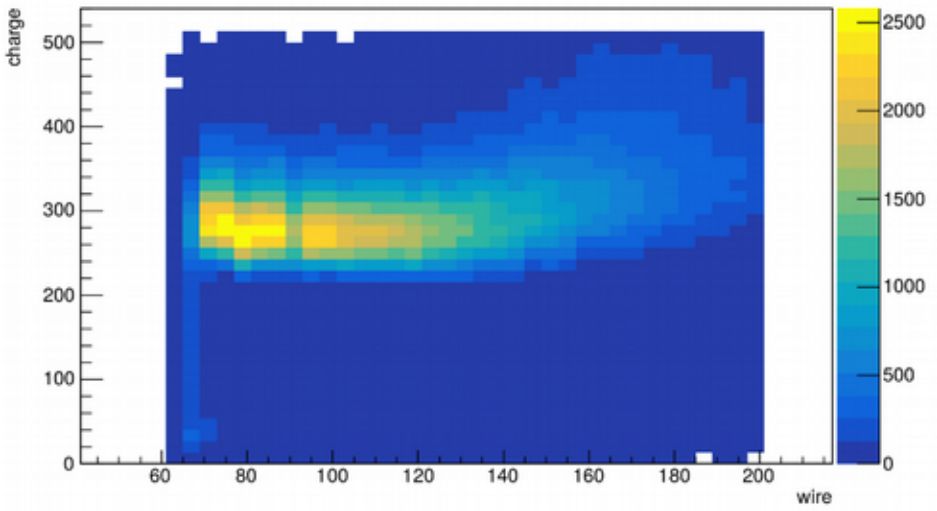


$$f(x,y) \approx a_0 + a_1 x + a_2 y + a_3 xy$$

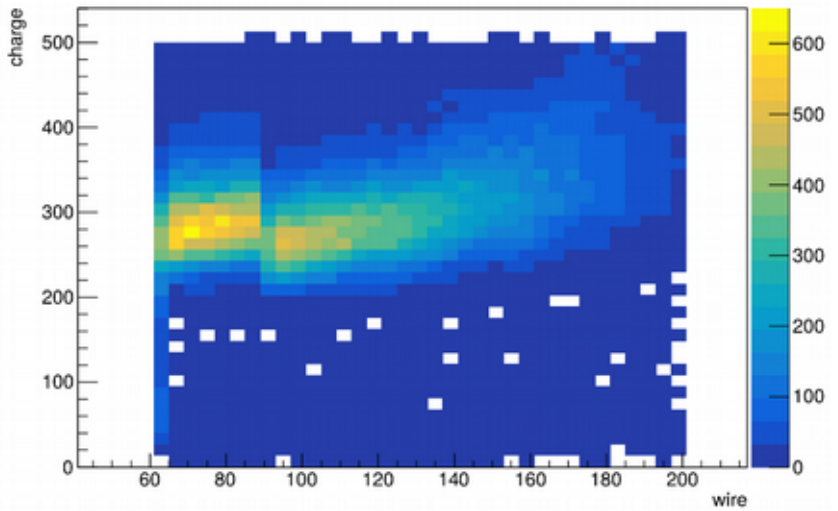
- 1D splines for SCE simluation/correction in same dimension as offset correction of interest: Z for dZ, Y for dY, X for dX
- Use bilinear interpolation for other two dimensions, to interpolate between splines – e.g. X/Y for dZ
- Should lead to more "smooth" spatial offset sim./corr.

Validation of Official Fix

dQ vs. Wire: Proton Data



dQ vs. Wire: Proton MC (Old)



- Added spline-based interpolation to SpaceCharge service in dunetpc
  - Enable by changing RepresentationType to “Splines_TH3”
  - See feature/mrmooney_SpaceChargeSplineInterp (v08_62_00)
- Heng-Ye validated by running proton MC w/ fix – looks good!
  - Similar validations by Ajib w/ pions show consistent results

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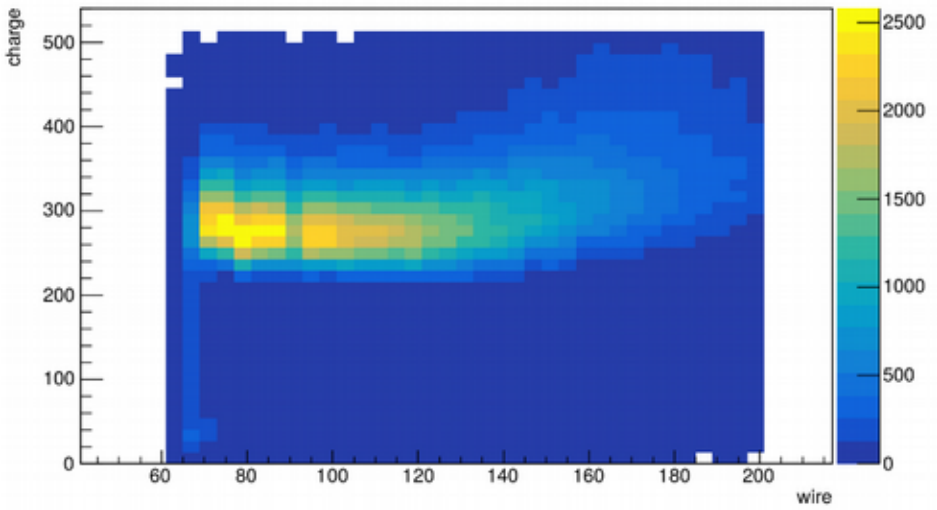

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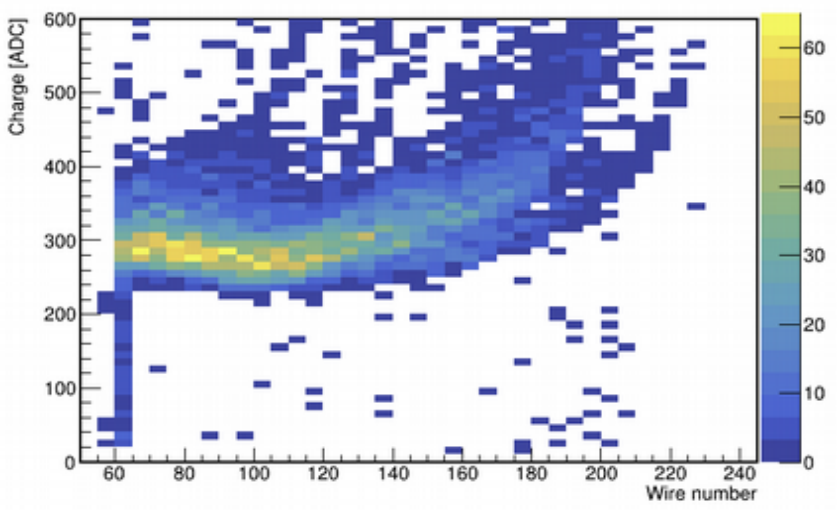

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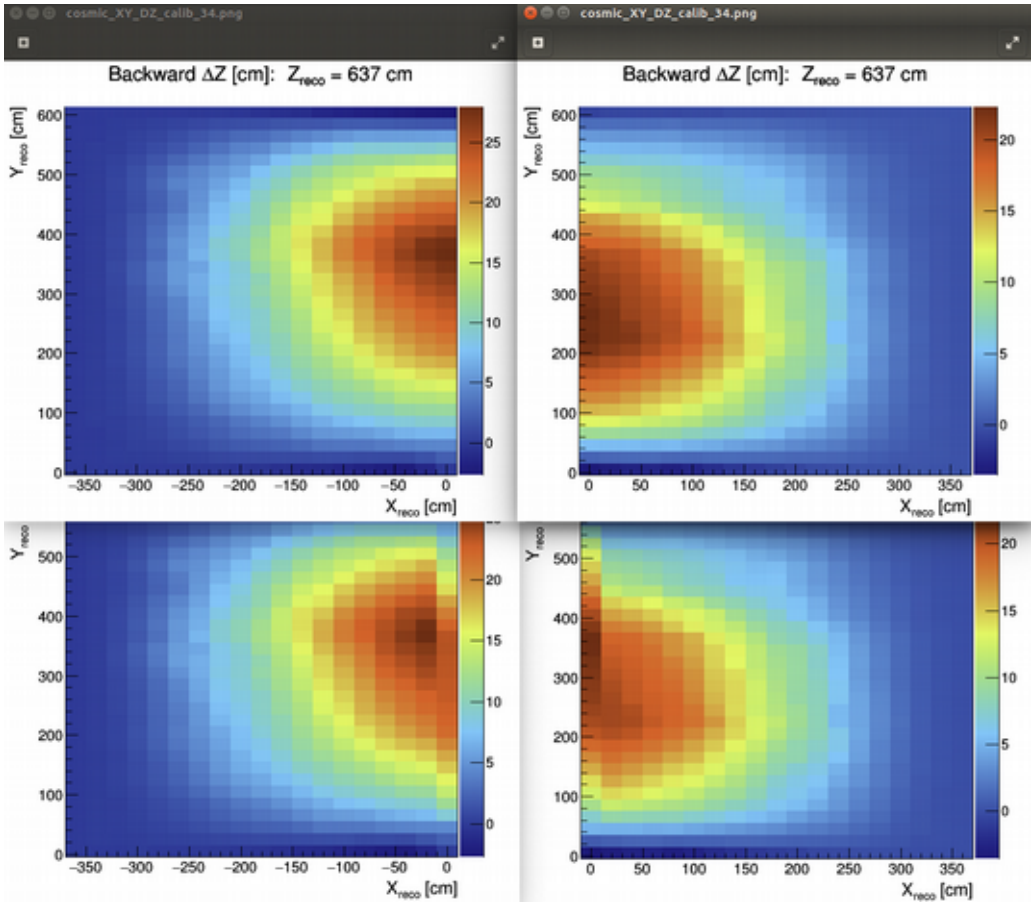
Bug in Maps Near Cathode

- Second problem impacts all three "v3" maps (forward spatial, backward spatial, E field) for **-20 cm < X < 20 cm**
  - Basically scale factors used to rescale simulation to match data are incorrect in this region – uses an average from two sides of cathode as opposed to the correct scale factors on each side
- Doesn't impact us greatly as beam particles generally stay in negative drift volume, in particular X < - 20 cm
  - But track stitching and other studies right at cathode impacted!
- This has also now been fixed in new "v4" map
  - Change InputFilename to "SCE_DataDriven_180kV_v4.root"
  - Must be done in both g4 and reco steps (same as for using new spline-based interpolation)

Example of Change in Maps

v4 Map Negative X

v4 Map Positive X



v3 Map Negative X

v3 Map Positive X

- To showcase change, look at ΔZ in Y-X plane for Z = 637 cm
- Top row is new v4 map, bottom old v3 map – improvement!

BACKUP SLIDES