dE/dx Impact of SCE Map Interpolation

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ProtoDUNE Sim/Reco Meeting

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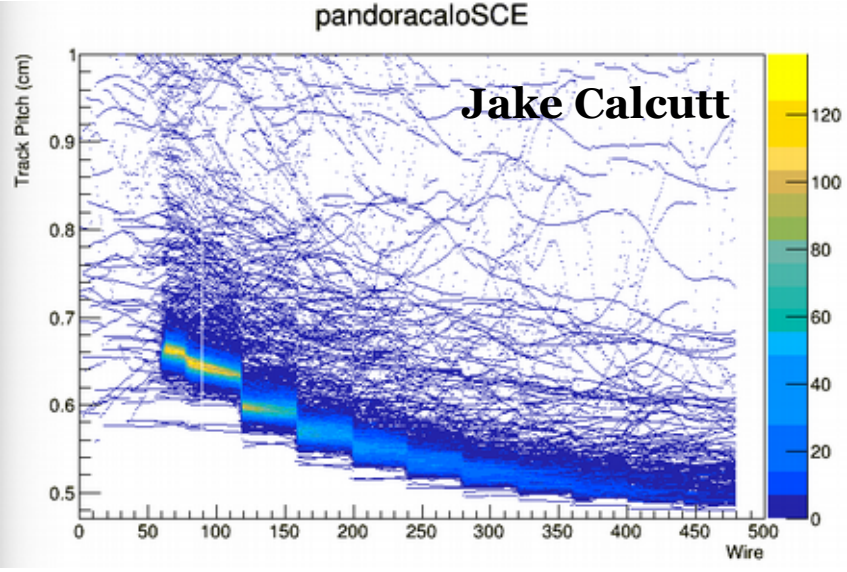
Introduction

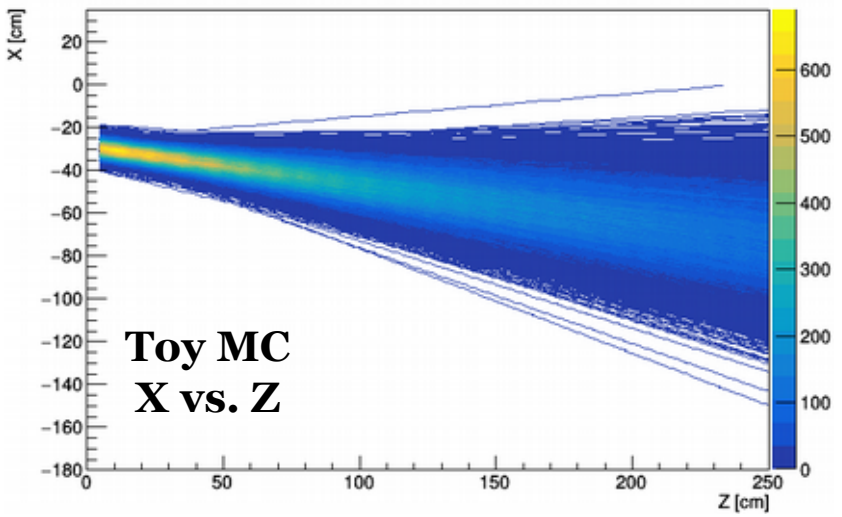
- Previously several people working on ProtoDUNE-SP have noticed issue with SCE corrections in dE/dx reconstruction
  - Main observation has been discontinuities in “pitch” or dx
  - Impact seems to be both in simulation (dE/dx w/ SCE) and reconstruction (dE/dx corrections in Calorimetry module)
- This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

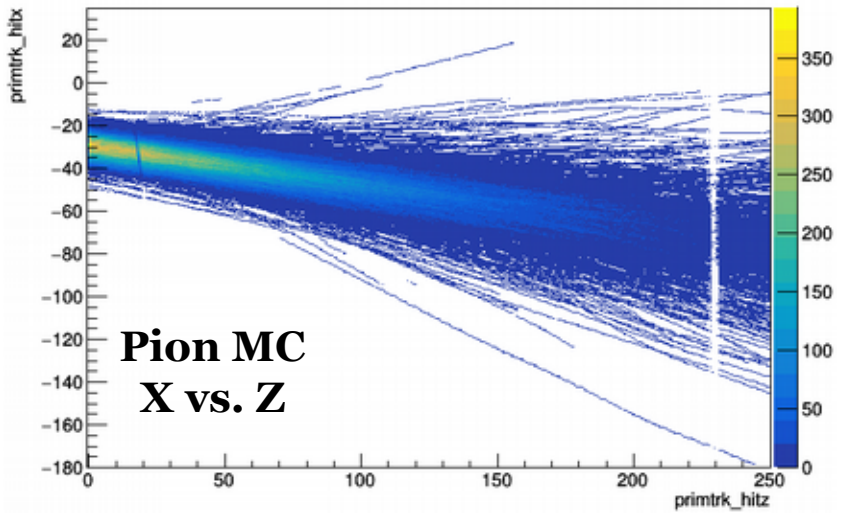


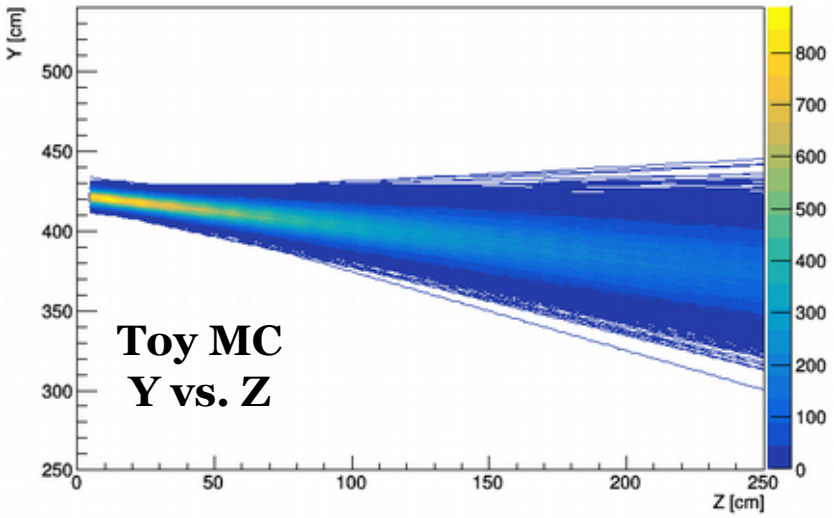
Toy MC

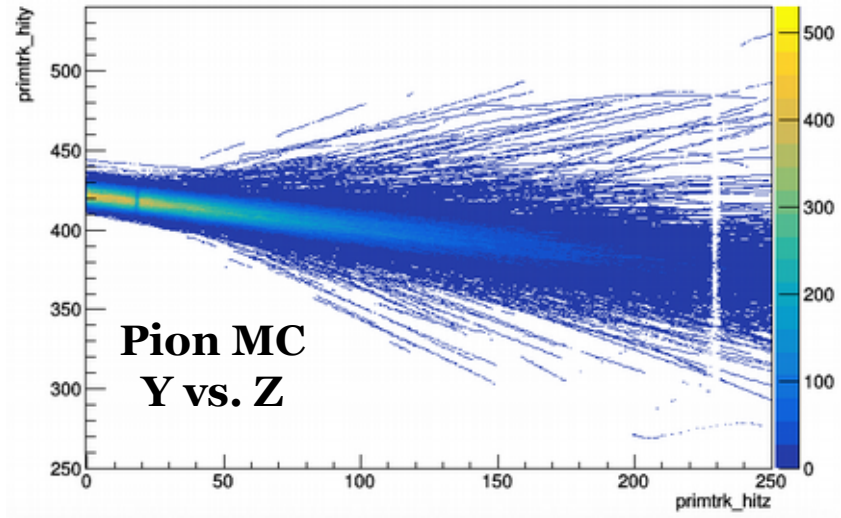
- Toy MC developed to recreate the trajectories of beam particles and compare to official ProtoDUNE-SP pion MC
  - Sandbox to recreate issue, develop solution method
- 10k tracks generated at beam spot with realistic spread in start point and direction
  - Perfectly straight with infinite range (infinite energy, no MCS)
- Sample location every 4.79 mm (wire-to-wire distance for collection plane), see how wire "pitch" changes w/ SCE simulation/correction offsets
- Try three map interpolations for SCE simulation+corrections
  - Trilinear interpolation – **current method** (TH3::Interpolate())
  - Splines – 1D splines (e.g. Z for dZ) + bilinear interp. (X/Y for dZ)
  - Hybrid – splines for sim., trilinear for corr. (currently data-like)

Toy MC Validation



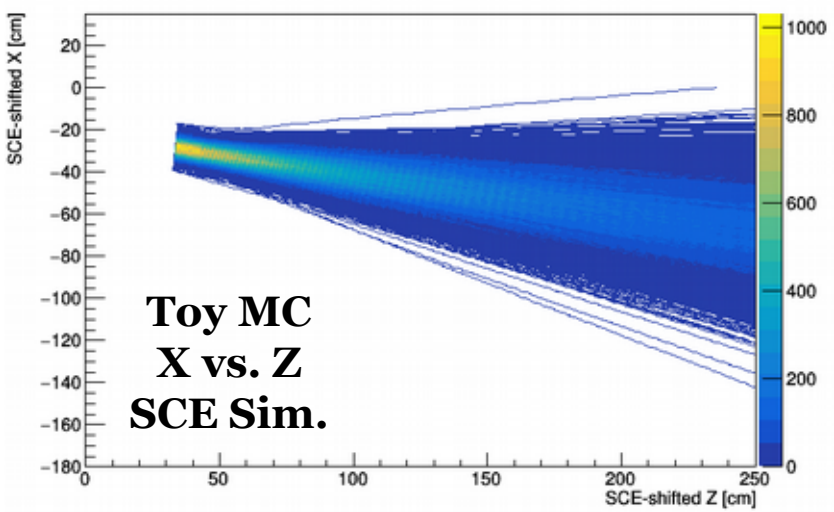


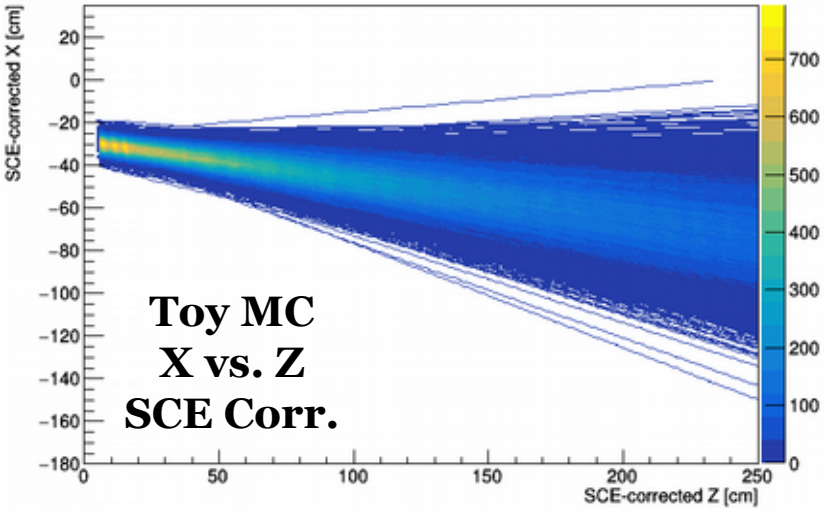


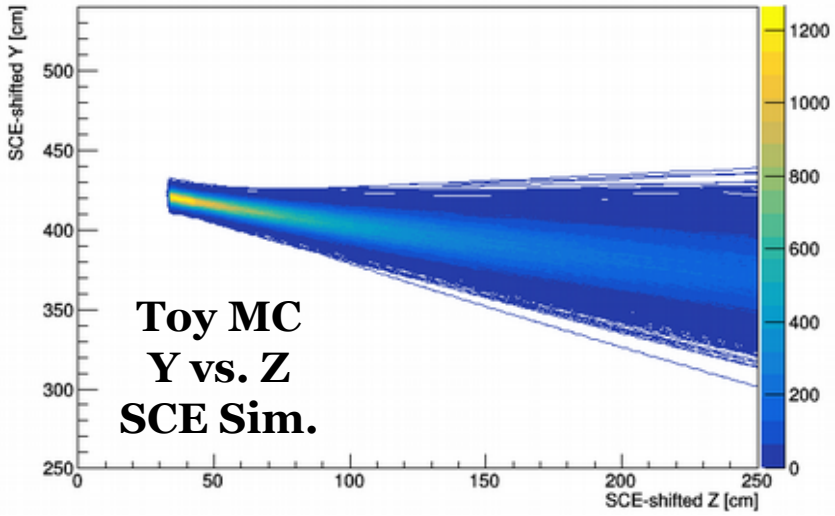


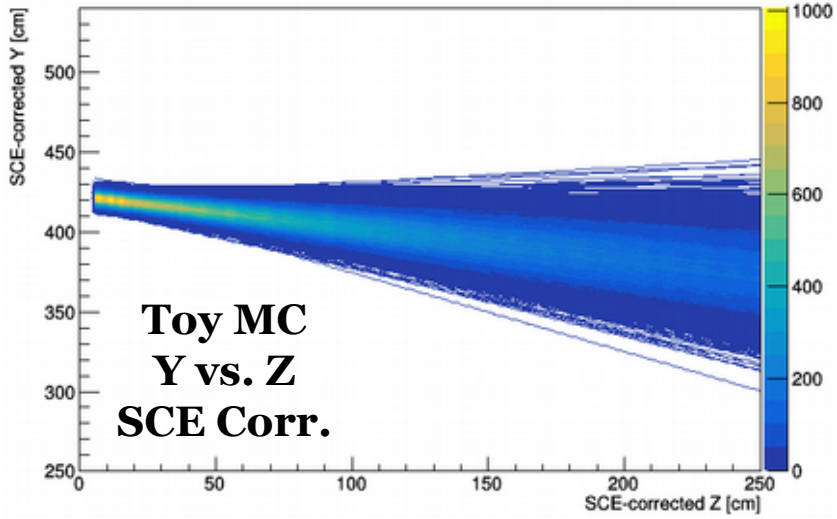
- Toy MC yields realistic trajectories compared to pion MC

Spatial SCE Sim./Corr.



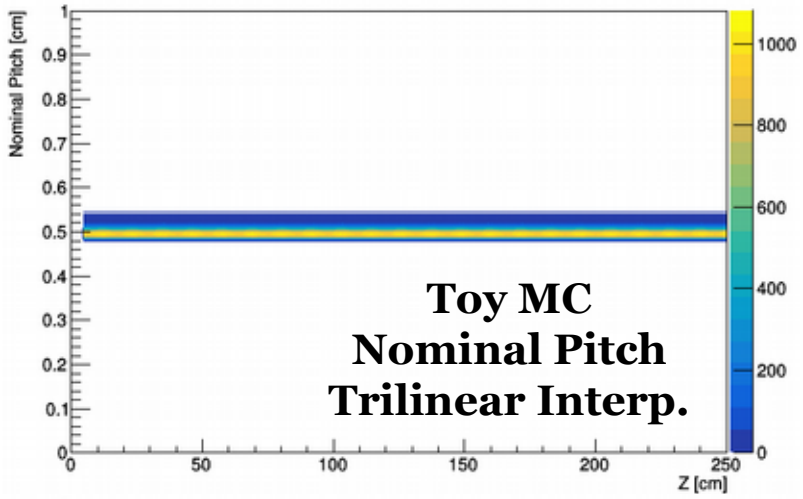


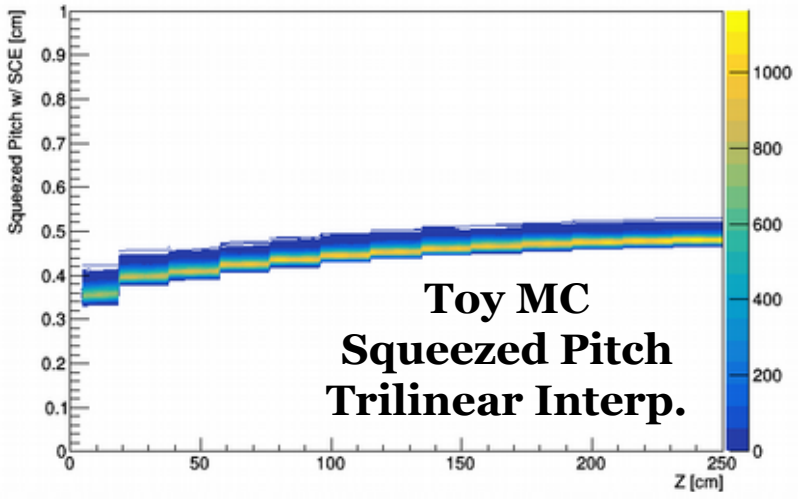


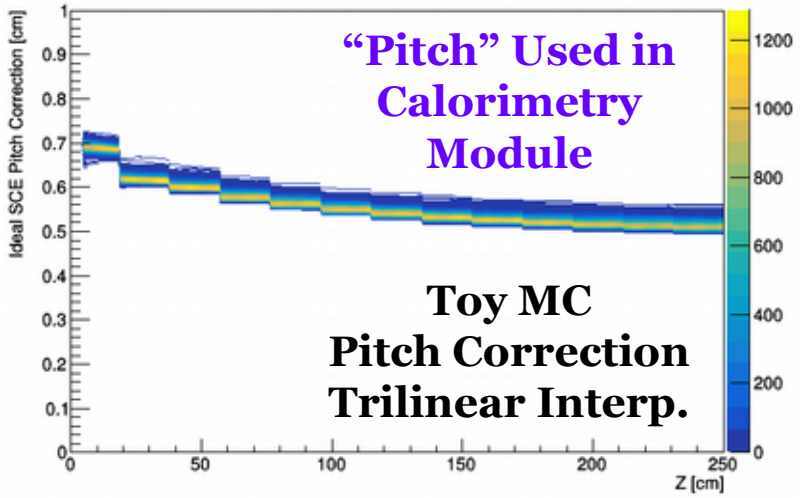


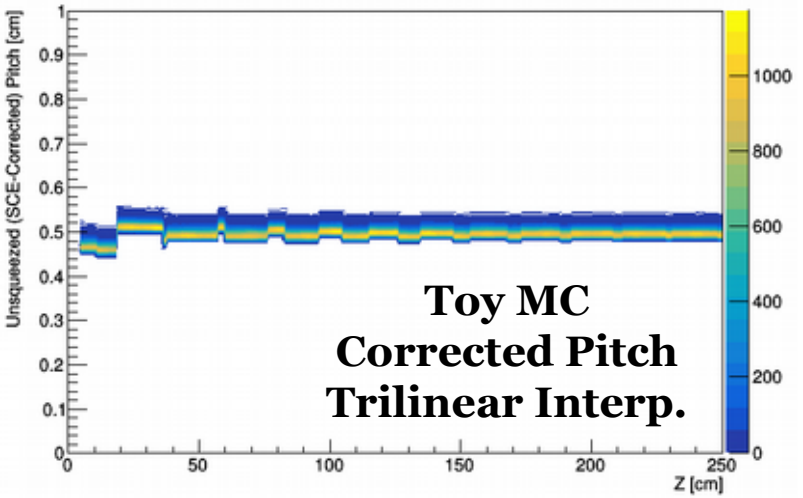
- Using nominal interpolation method (trilinear interp.), no discontinuities in spatial SCE simulation/corrections

Pitch w/ Trilinear Interp.



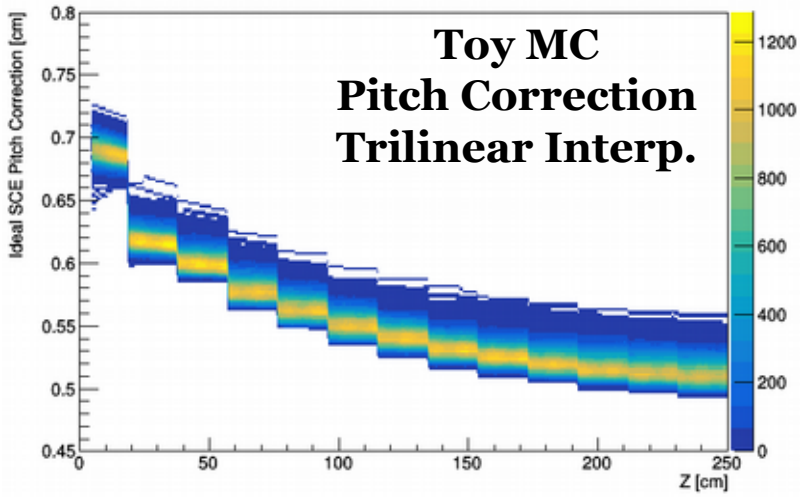


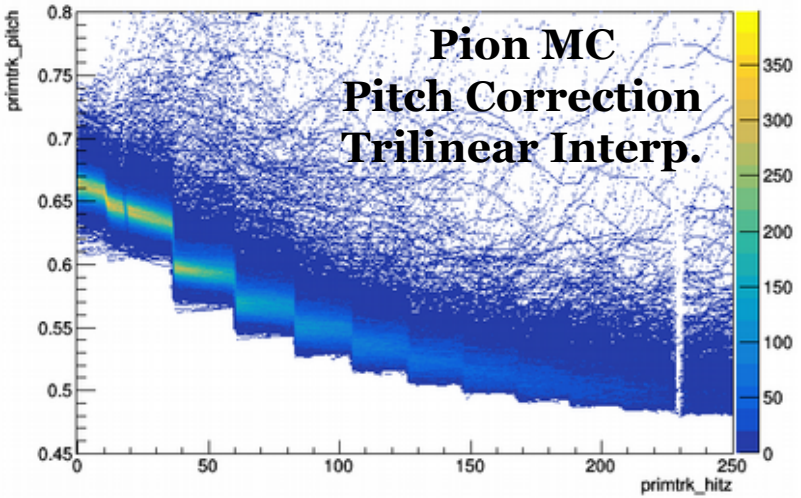




- Toy MC w/ trilinear interpolation recreates issue in pion MC
- Post-correction result still close to "perfect" despite issue

Explanation of Issue

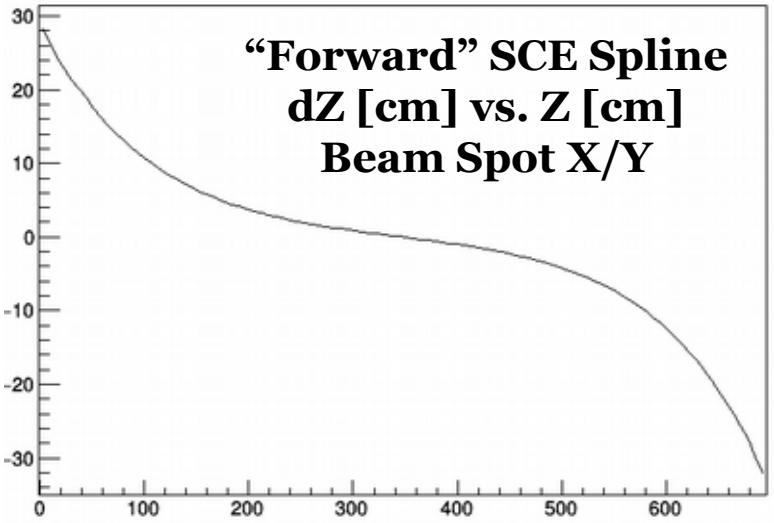


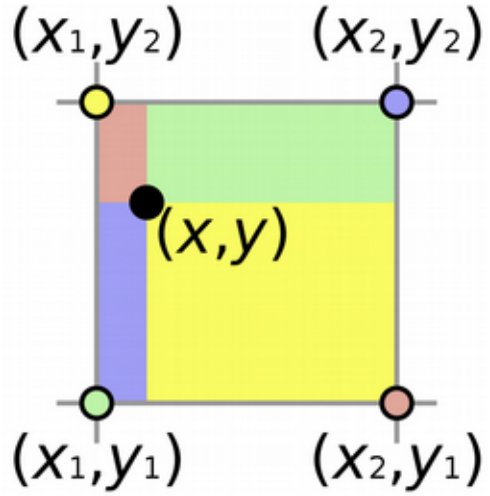


Trilinear Interpolation: $$f(x,y,z) \approx a_0 + a_1 x + a_2 y + a_3 z + a_4 xy + a_5 xz + a_6 yz + a_7 xyz$$

- 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

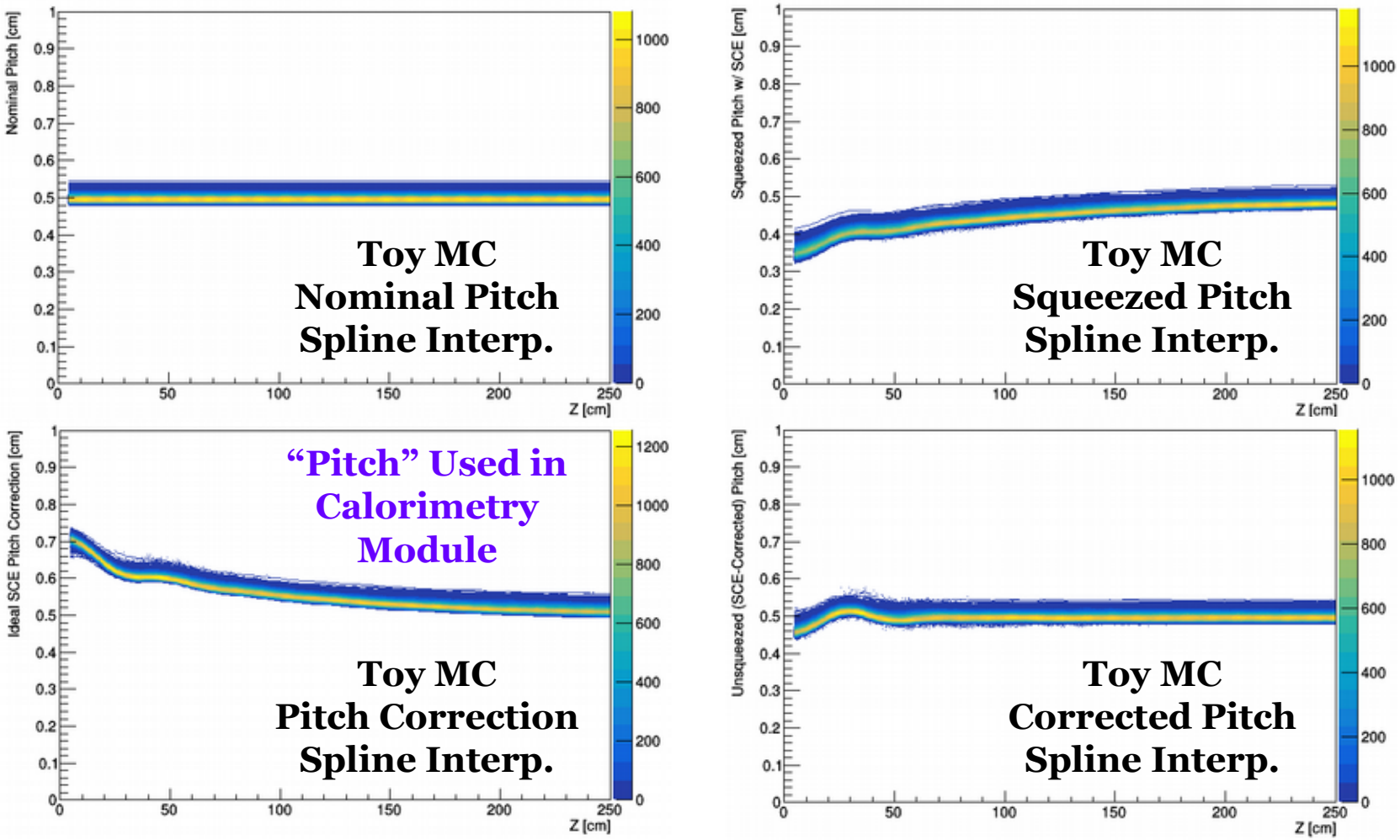




$$f(x,y) \approx a_0 + a_1 x + a_2 y + a_3 xy$$

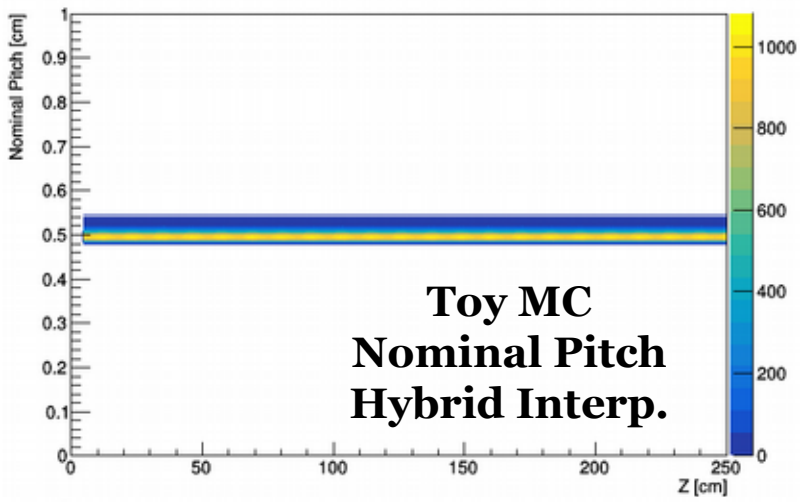
- 1D splines for SCE simluation/correction in same dimension as offset correction of interest: Z for dZ, Y for dY, X for dX
- Use bilinear interpolation for other two dimensions, to interpolate between splines – e.g. X/Y for dZ
- Should lead to more "smooth" spatial offset sim./corr.

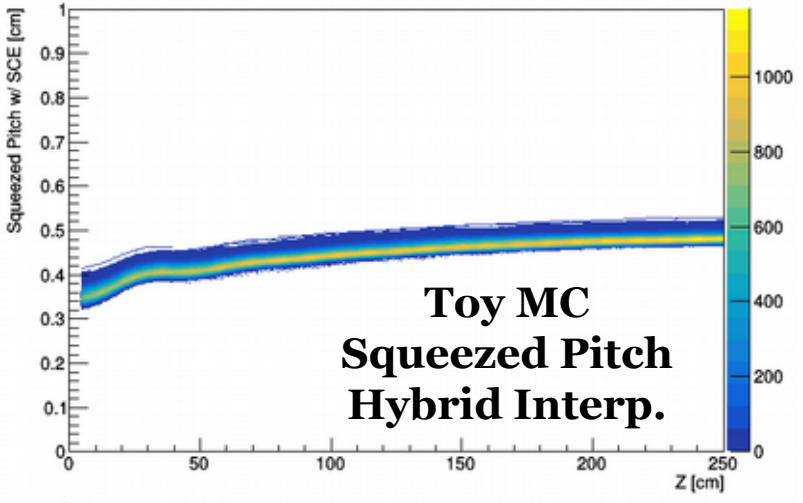
Pitch w/ Spline Interp.

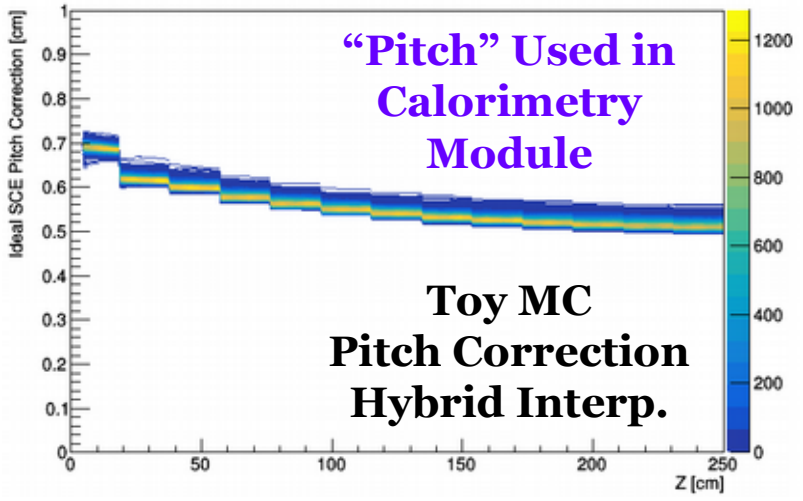


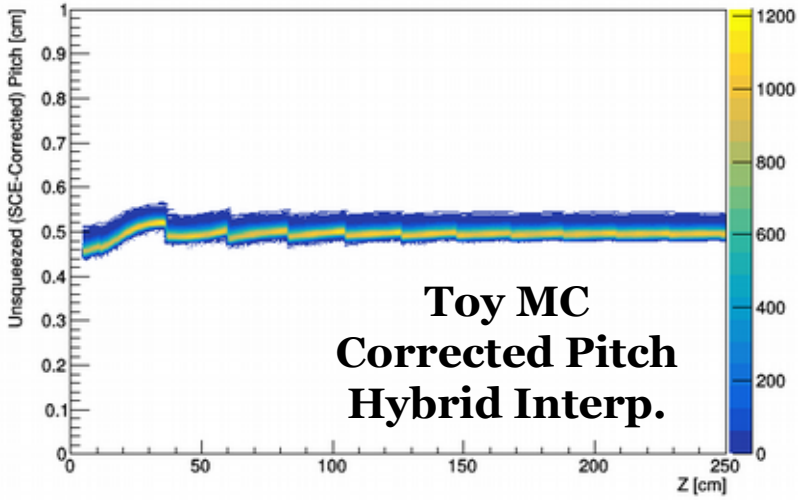
- Toy MC w/ spline interpolation resolves issue
- Post-correction result close to "perfect" – small residuals

Pitch w/ Hybrid Interp.









- Toy MC w/ hybrid interpolation showcases impact on data
- Post-correction bias is still very small, though different

BACKUP SLIDES