SCE Map Update: Data-Driven Spatial and E Field Maps

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ProtoDUNE π^0 Analysis Meeting

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Overview

- Brief presentation on data-driven SCE maps, which we finally have in hand (and validated with "by eye" inspection)
  - Includes both spatial distortion maps and E field maps
- Planning on putting these maps into ProtoDUNE simulation
  - Spatial maps → properly simulate charge migration
  - E field maps → properly simulate impact on recombination
- Also planning on including in ProtoDUNE calibration chain
  - Spatial maps → correct dx in dE/dx
    - In principle can correct location of all t_0-tagged charge, but this may not be included in calibration chain (differing opinions on this)
  - E field maps → correct dE in dE/dx
- For corrections (calibration), easy for π^0 team to make them in separate framework → easily extracted from LArSoft

Methodology

- 1) Find spatial offset maps at boundaries in data, MC
- 2) Use spatial offset maps at boundaries, calculated for both data and MC, and form "scale factor map" for each face from data/MC offset ratio
- 3) Interpolate scale factors across entire detector to get data/MC scale factor for each 3D voxel
- 4) Obtain forward displacement map by applying 3D scale factors to MC map (no fluid flow for now, but can do both with and without flow and compare)
- 5) Use tetrahedral interpolation to obtain backward transportation map on grid
- 6) Use backward displacement map to obtain E field everywhere (see slide 8 for more details)

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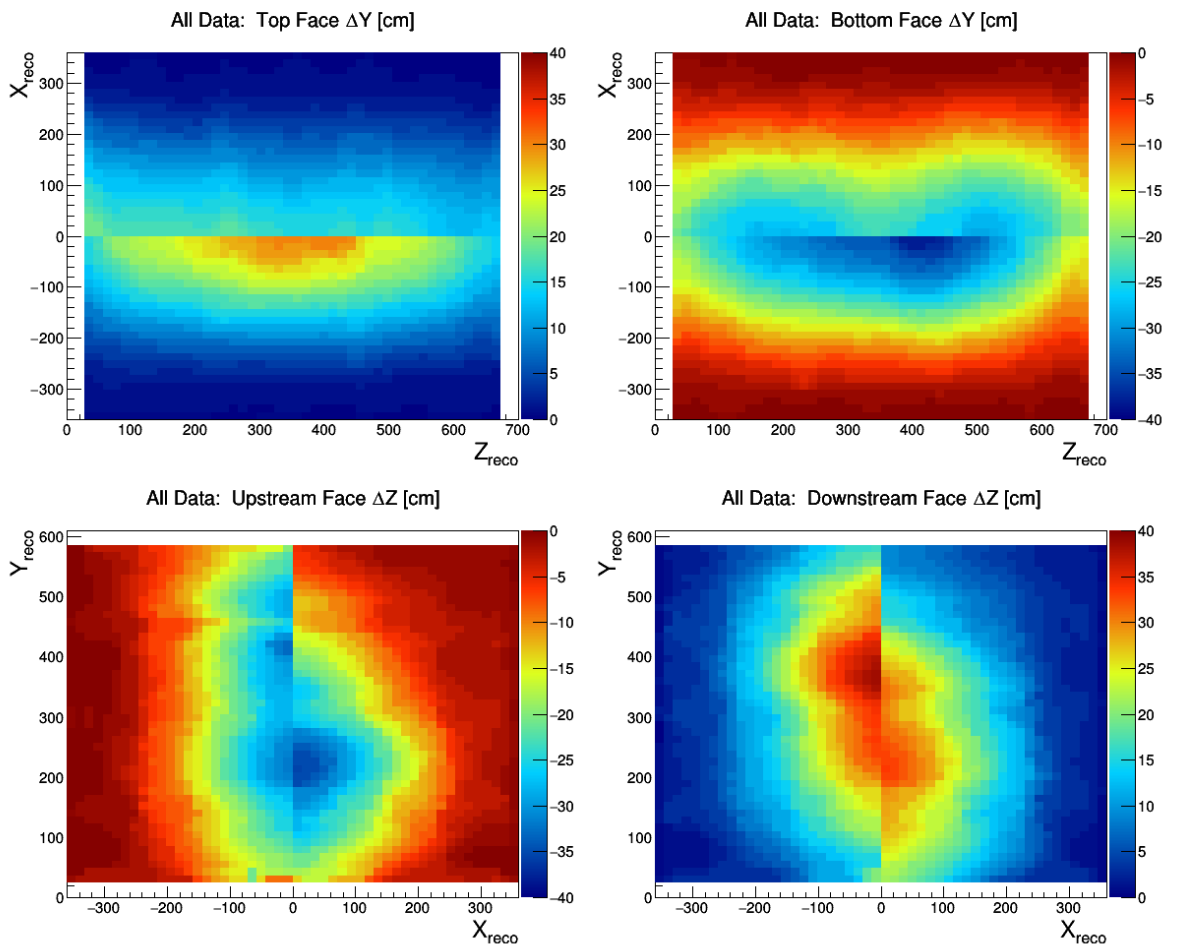
- 4) Obta 3D scale factors to do both with and withou
- 5) Use tetrahedral backward transportation map on grid
- 6) Use backward displacement map to obtain E field everywhere (see slide 8 for more details)

Method is new! Technique at MicroBooNE uses crossing t_0-tagged tracks. We want to do this eventually as well once we have better track coverage from including multiple methods of t_0-tagging at ProtoDUNE-SP. But this should get us close (close enough even?)

Spatial Offsets at TPC Faces

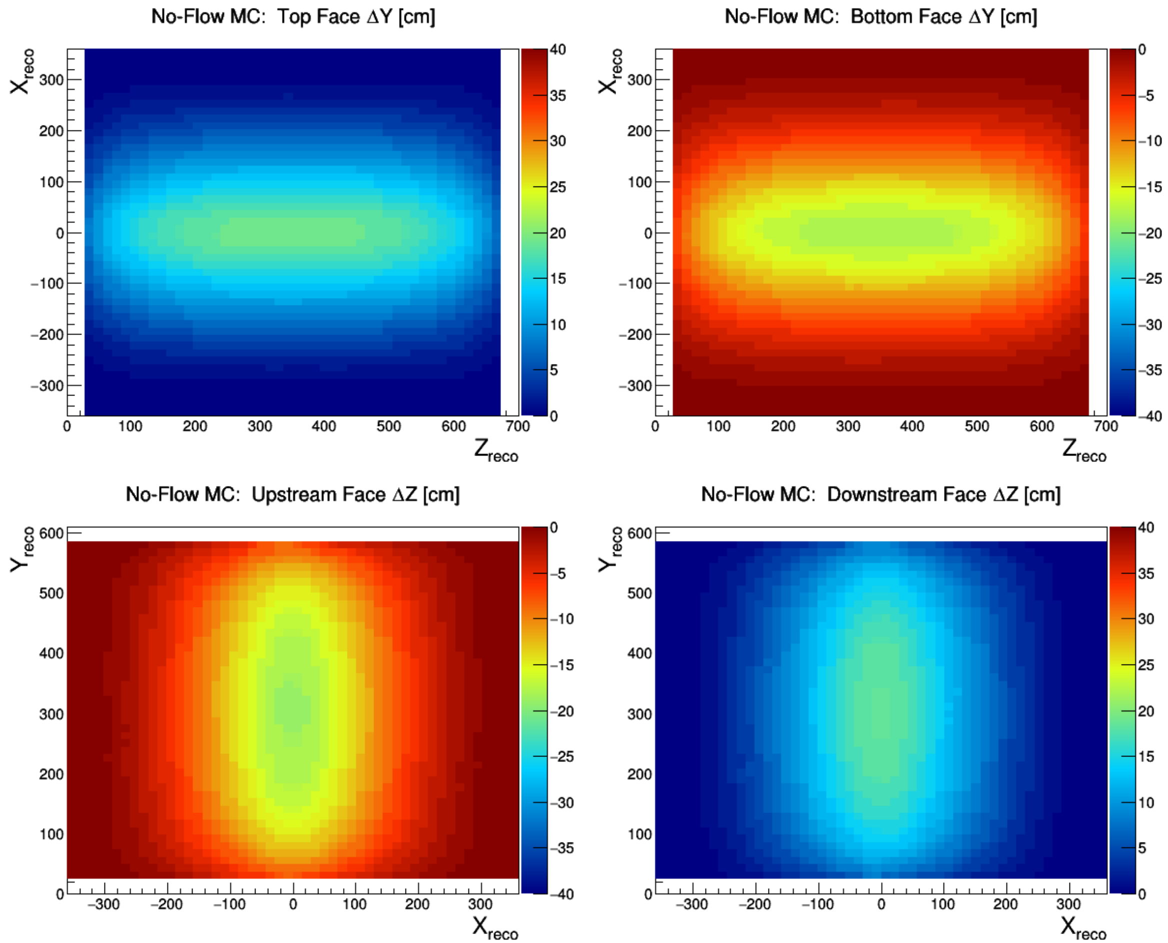
Data



♦ Reminder: we have long had our spatial displacement maps at TPC faces (in direction orthogonal to face)

Spatial Offsets at TPC Faces

MC
(No Flow)



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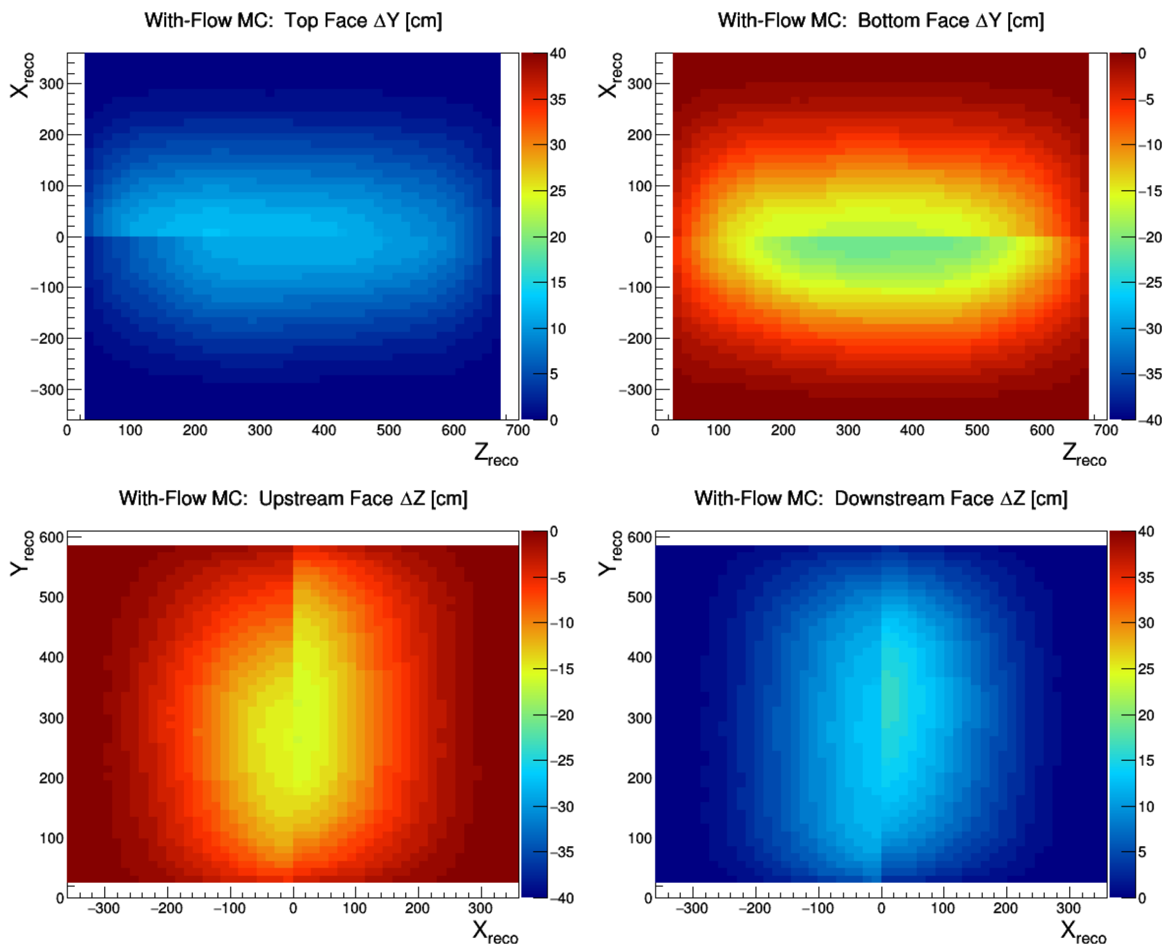
Spatial Offsets at TPC Faces

MC
(With Flow)



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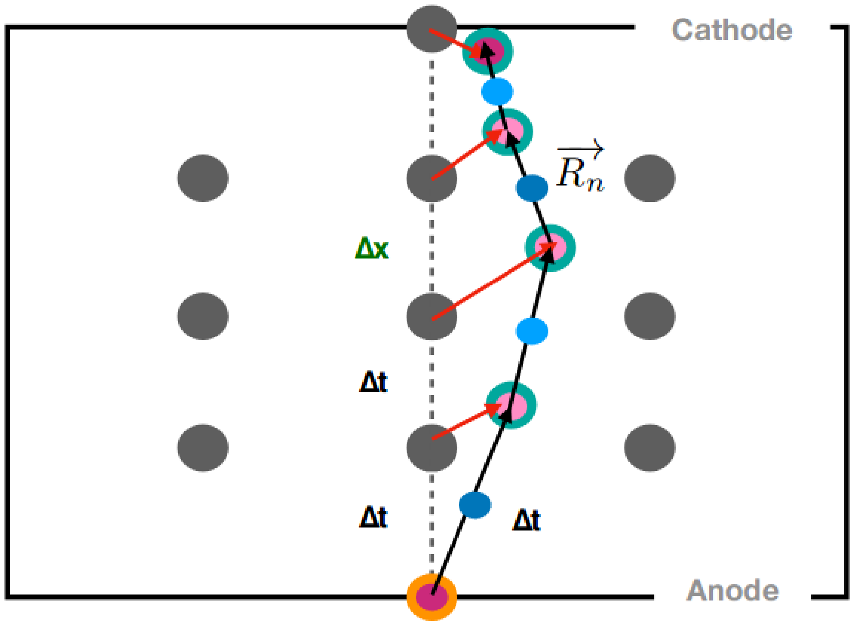
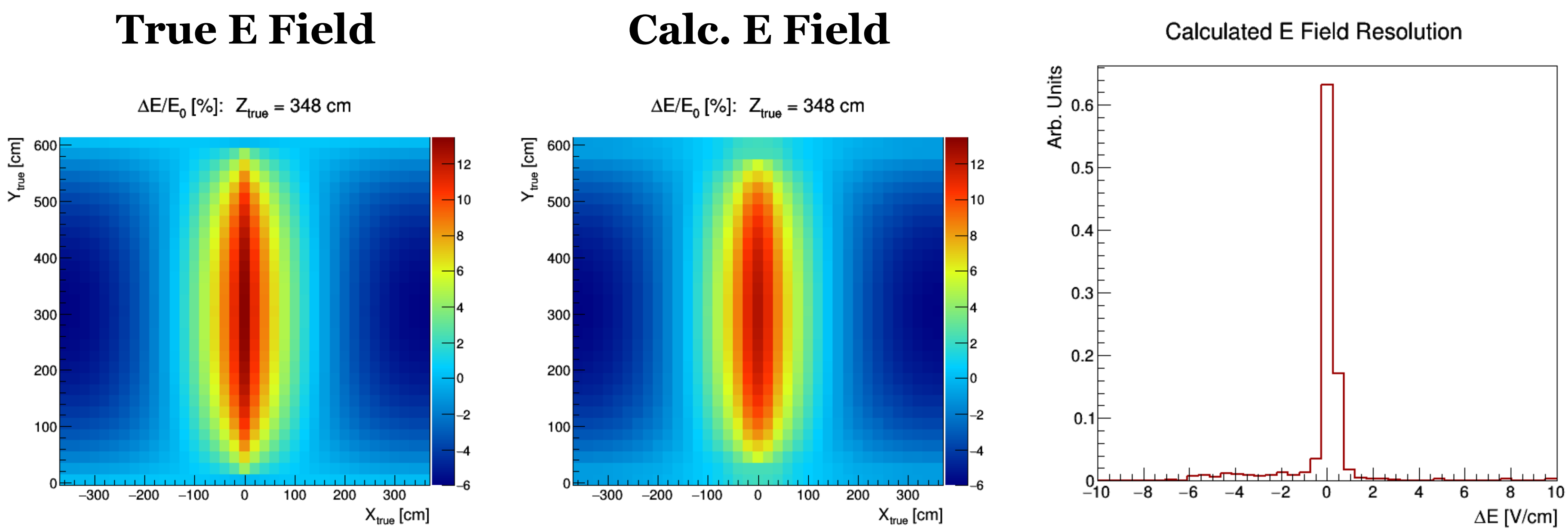
E Field Calculation



$$|\vec{v}_n| = \frac{|\vec{R}_n|}{\Delta X}|\vec{v}_0|$$

- E field calculation methodology developed by University of Bern – Mike M. made own implementation
- Above figure from forthcoming public note on laser-based SCE analysis at MicroBooNE
- Calculate drift velocity → use v(E) curve to get local E field

E Field Calculation



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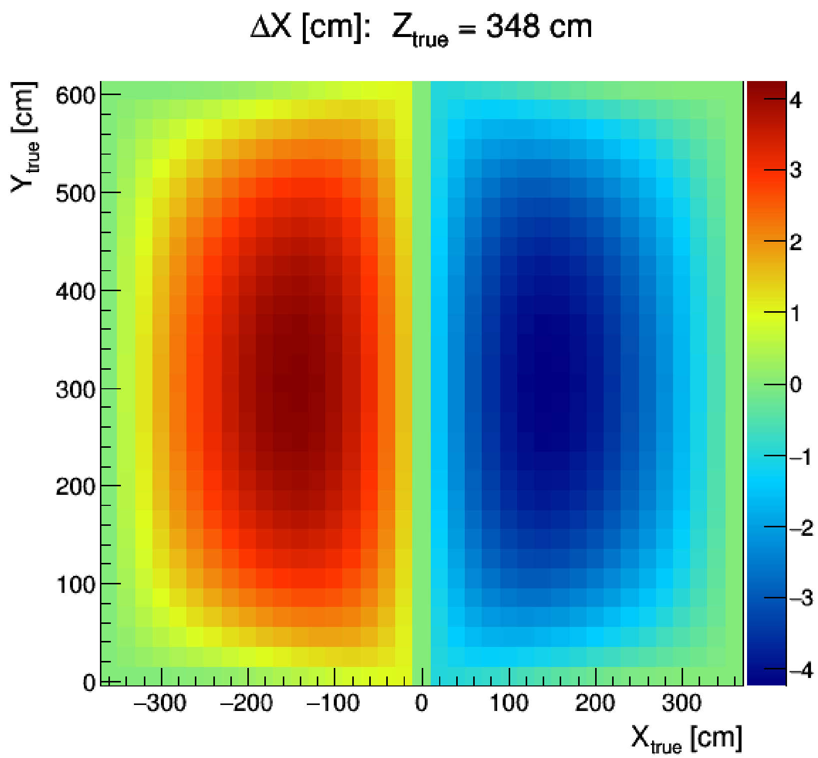
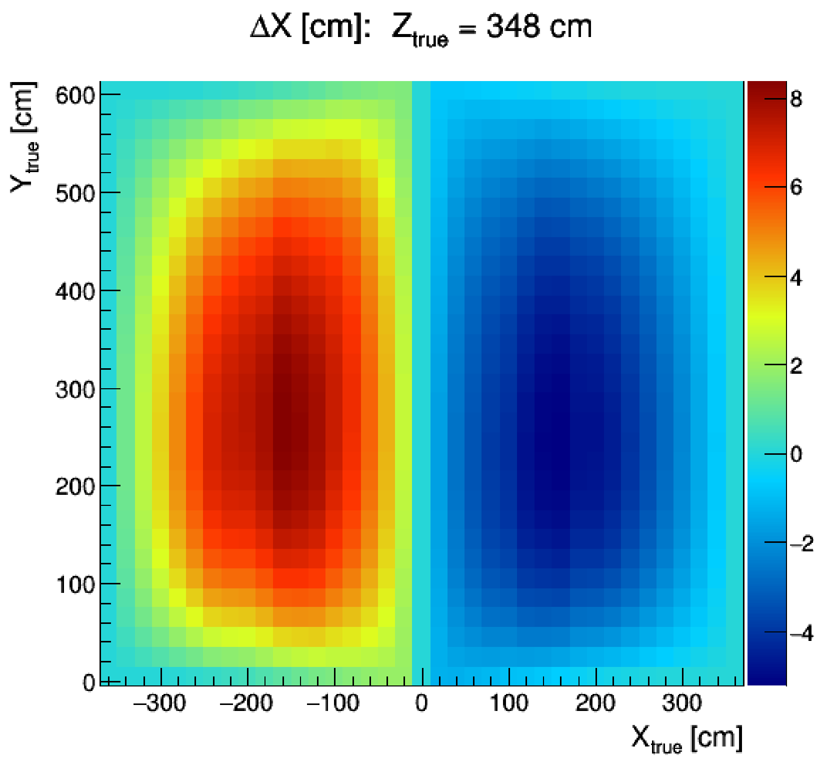
Forward Displacement Maps

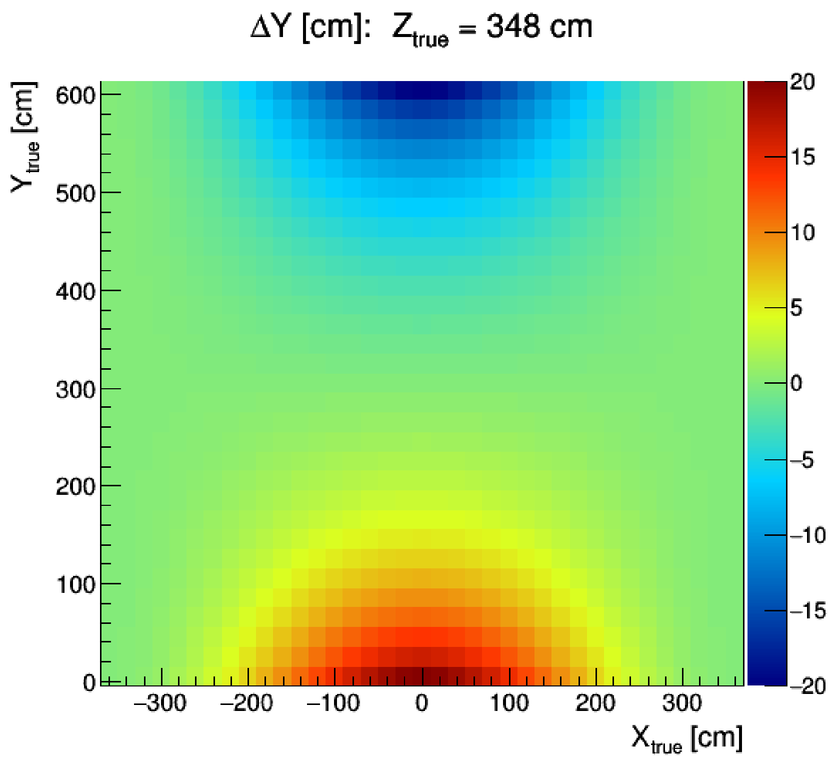


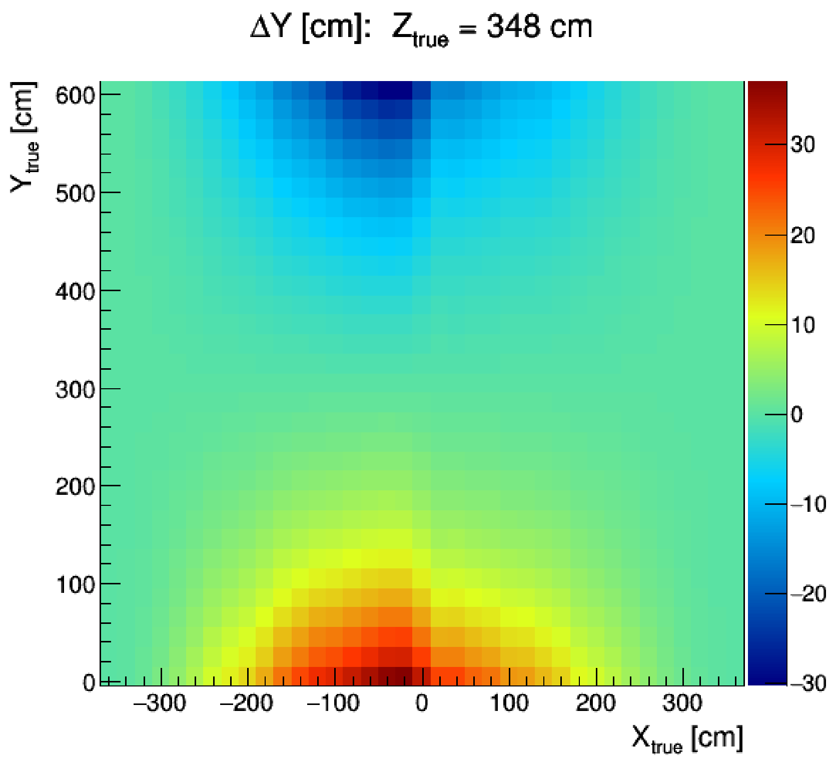
MC (No Flow)



Data

Forward Displacement Maps

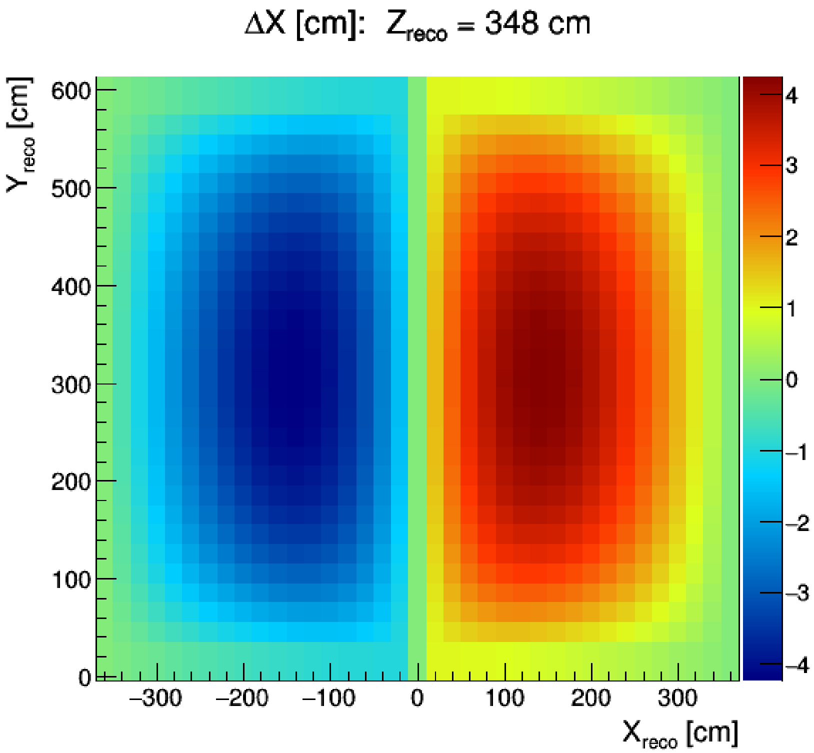


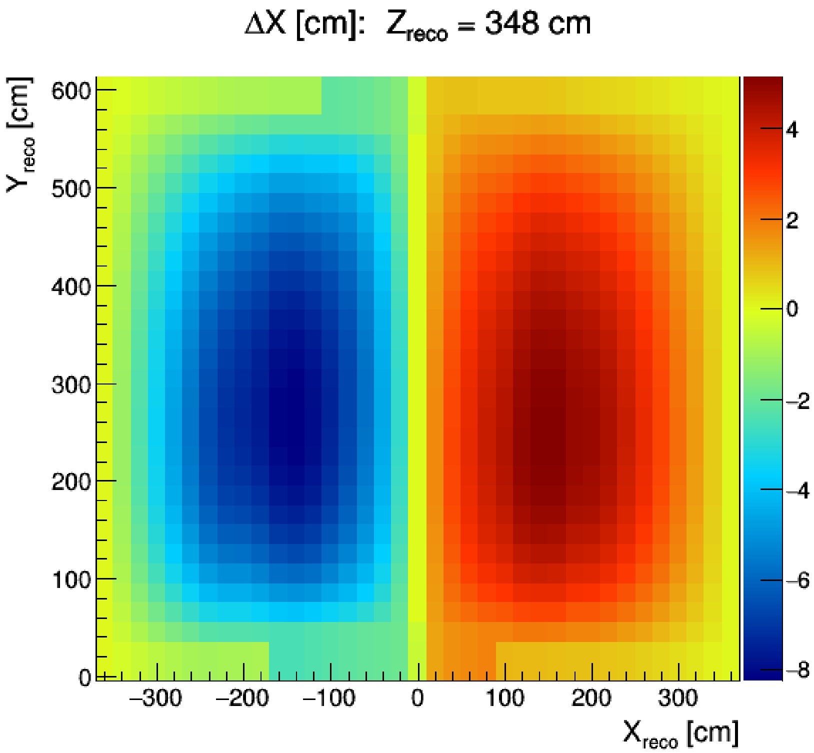


MC (No Flow)

Data

Backward Displacement Maps

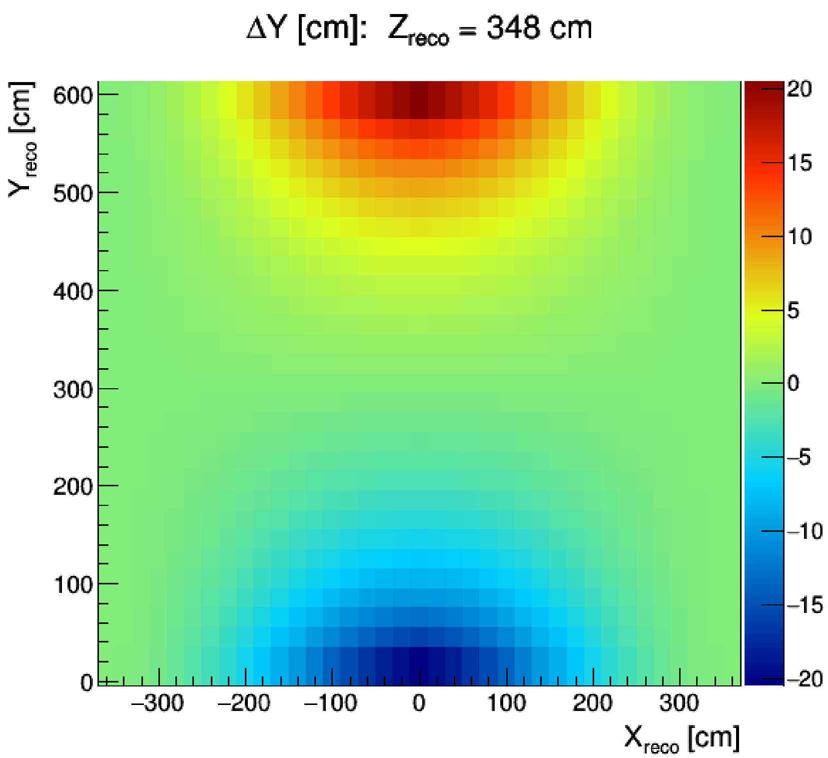




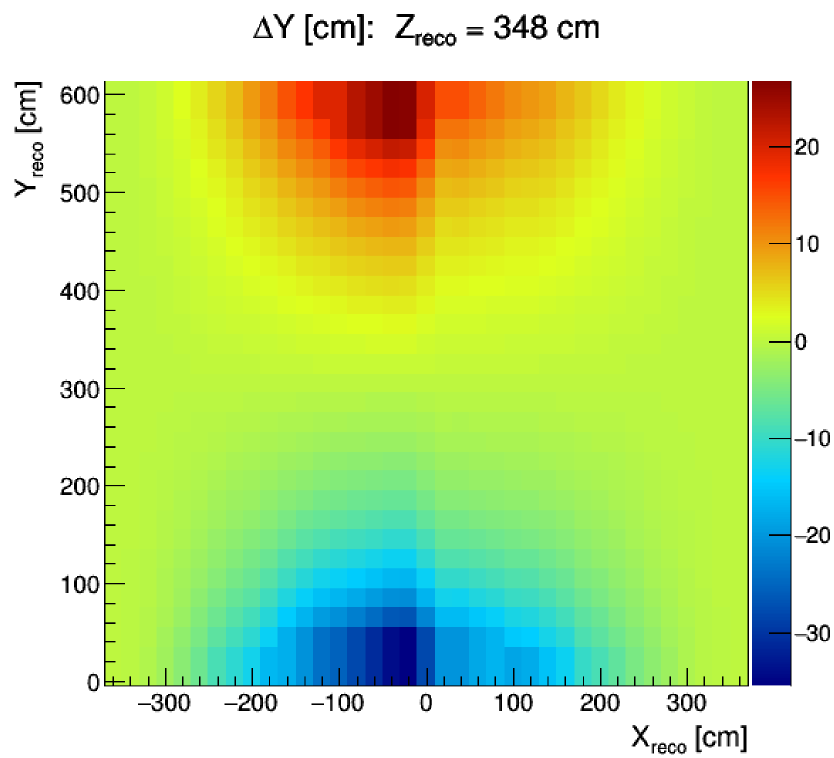
MC (No Flow)

Data

Backward Displacement Maps

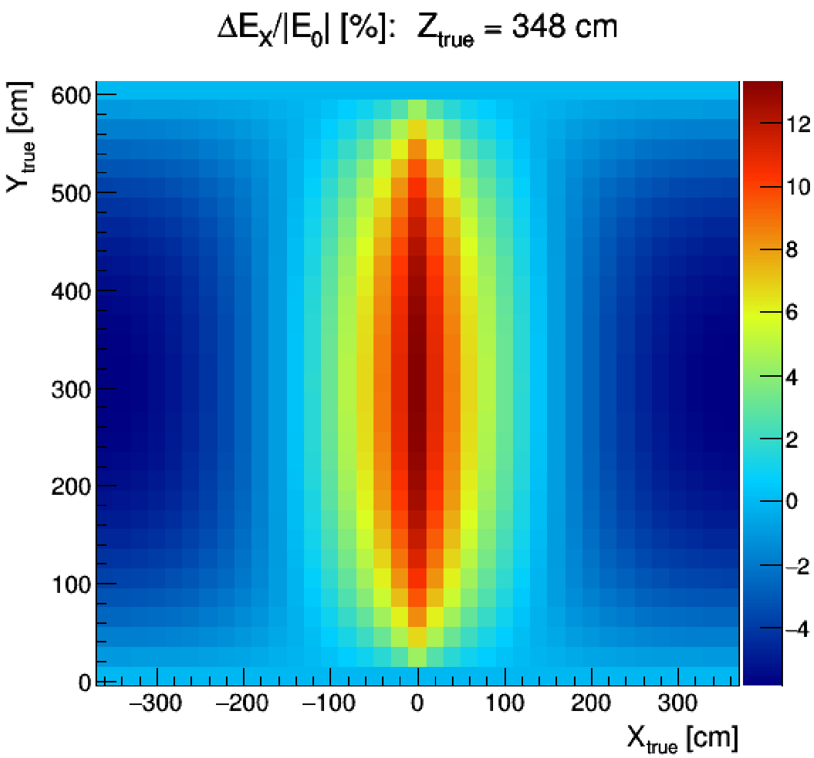


MC (No Flow)

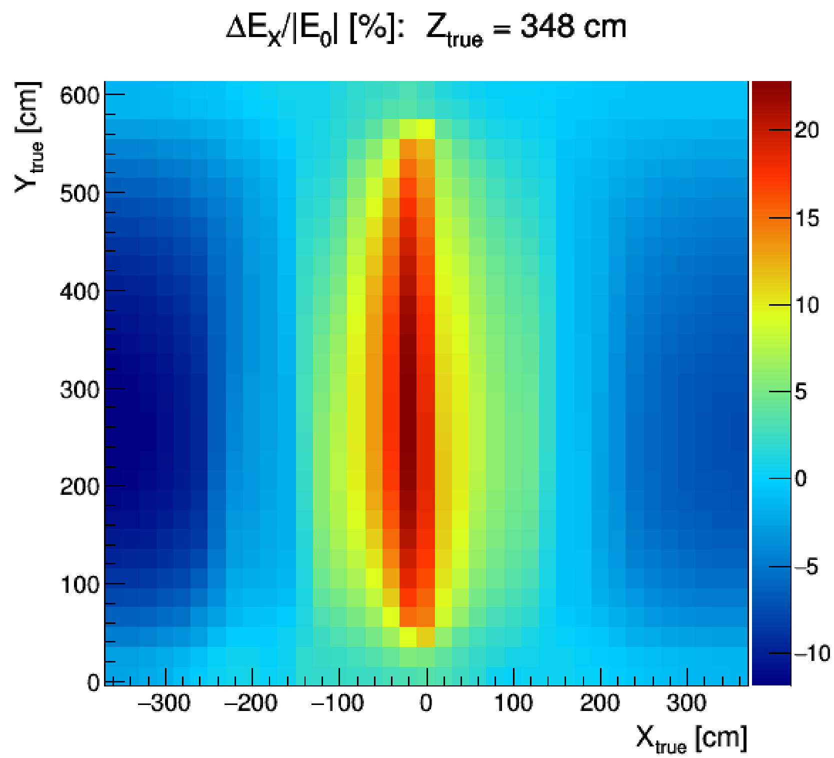


Data

E Field Maps

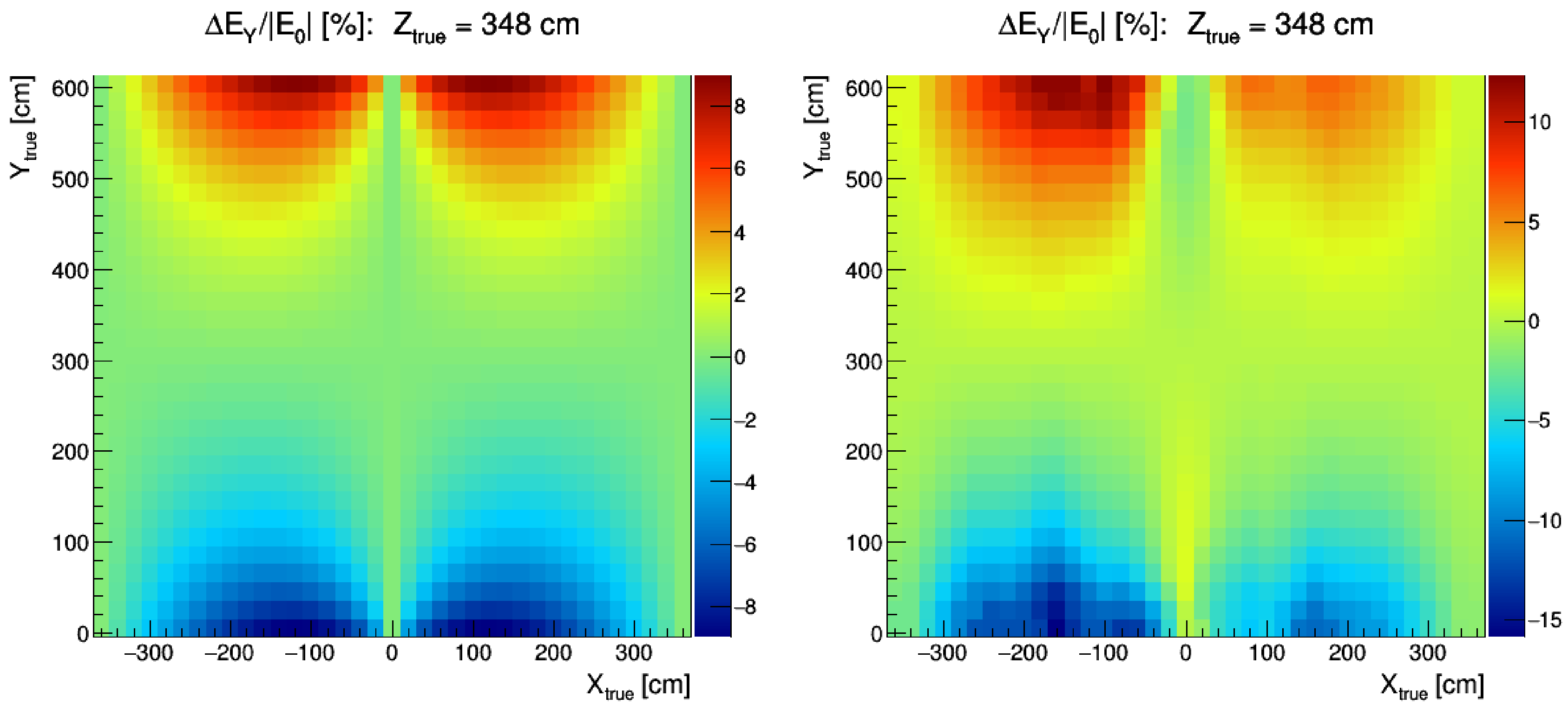


MC (No Flow)



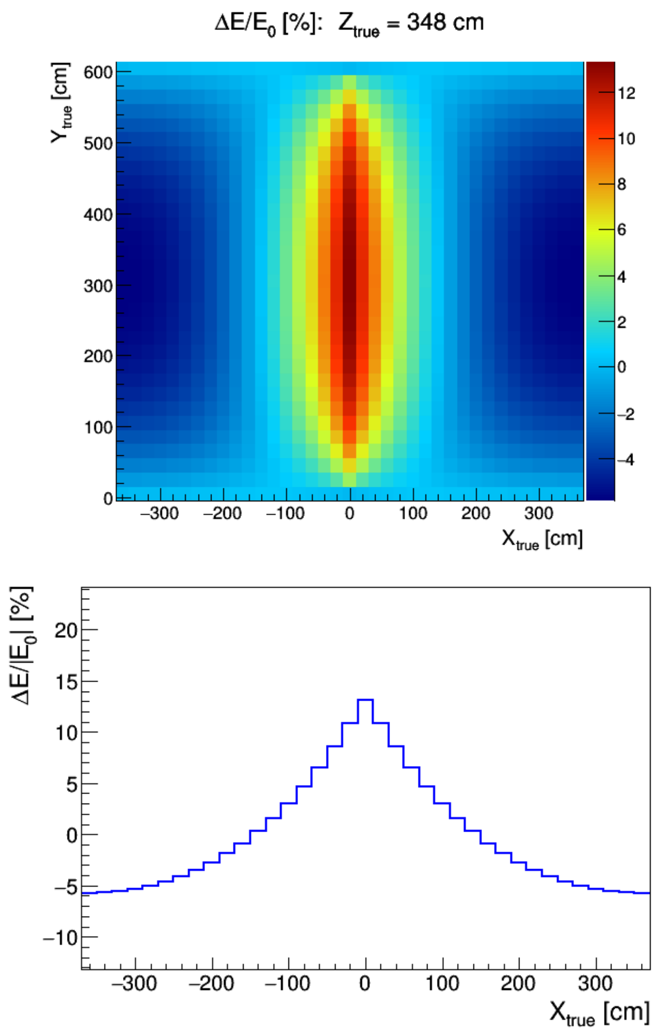
Data

E Field Maps

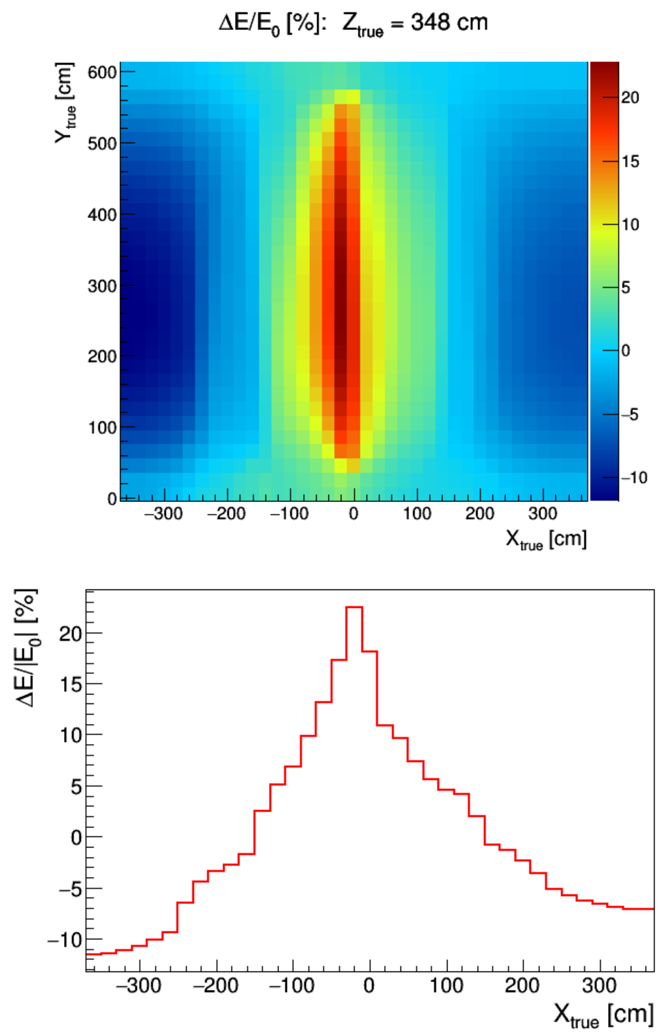


MC (No Flow) **Data**

E Field Maps



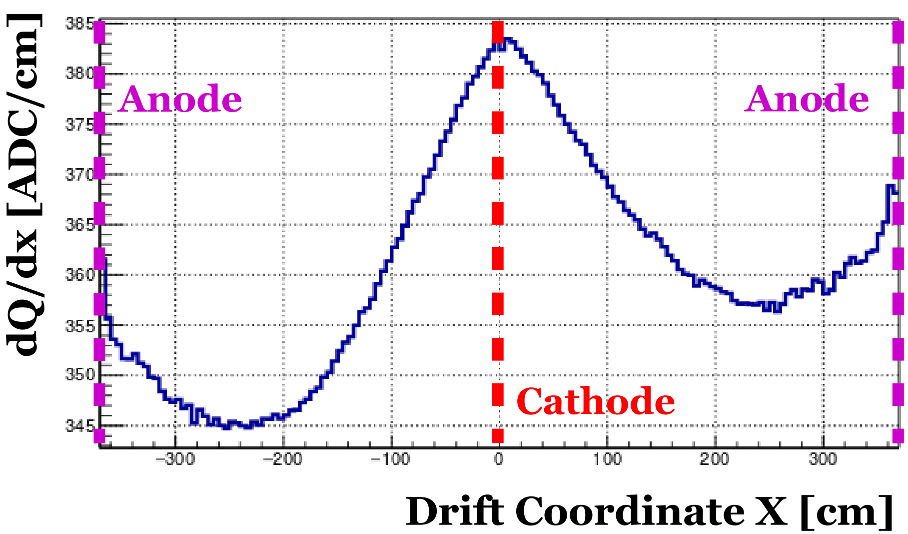
MC (No Flow)

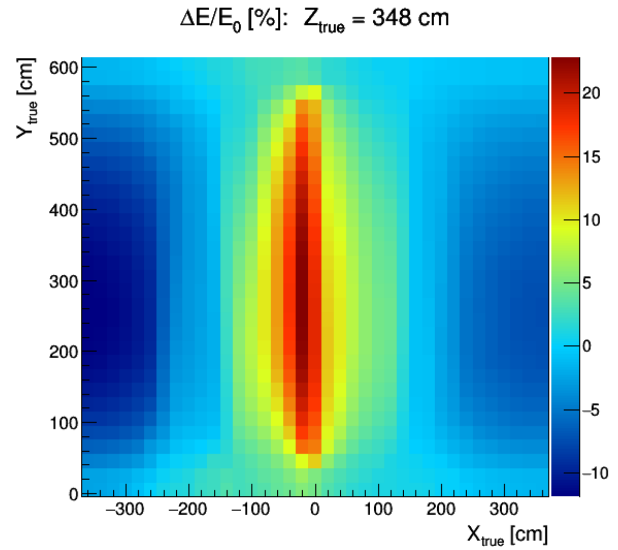


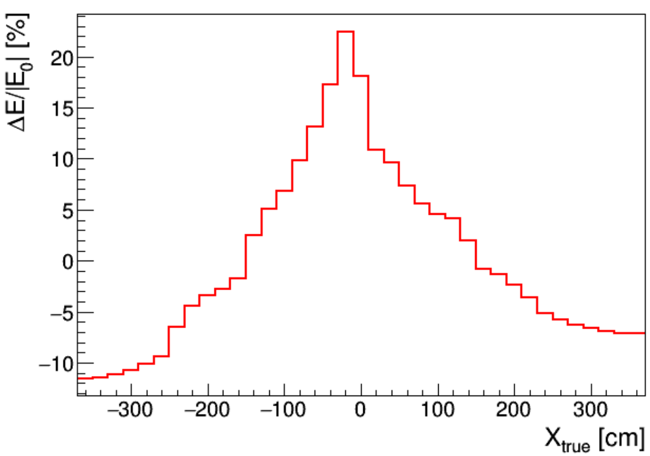
Data

E Field Maps

Matches observed dQ/dx biases! (e$^-$ lifetime also relevant)







Data

Forthcoming Improvement

- An additional improvement can be made: move "zero point" of ΔY and ΔZ offset maps by looking at cathode and seeing where offsets go to zero at cathode
- Current maps assume that $\Delta Y(Z) = 0$ at $Y = 0$, and $\Delta Z(Y) = 0$ at $Z = 0$ → incorrect if space charge "center of mass" not at center of detector
- Use anode-cathode-crossing tracks, project part of track near anode to cathode (using Principal Component Analysis, or PCA) to find "true" crossing point, before distortion
  - Find where $\Delta Y(Z) = 0$ and $\Delta Z(Y) = 0$ at cathode
  - Rescale maps throughout TPC by enforcing this condition
- Currently doing this work… have by tomorrow? Next week?

Summary

- First full data-driven SCE maps available, which includes:
  - Forward displacement maps (simulation)
  - Backward displacement maps (reconstruction)
  - Electric field maps (simulation/reconstruction)
- This was done by interpolating results at TPC boundaries
  - Will spend more time investigating method of using pairs of crossing tracks to do true 3D correction in bulk – does it help?
  - Data can tell us which is performing best (dE/dx resolution, data/MC comparison of track angles/lengths)
- Planning to produce new MC with new SCE simulation
  - Also include Hannah's SCE calibration in reconstruction chain, which targets dE/dx of t_0-tagged tracks (beam and cosmics)
  - Should begin talking about calibrations in our own framework

BACKUP SLIDES