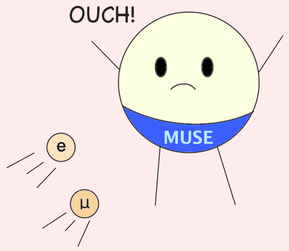

MUSE Experiment 2022 Update - Analysis Part I

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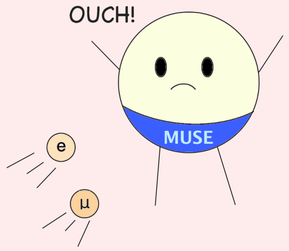
This work is supported by the National Science Foundation, grants NSF PHY-1913653 and 2209348.
The MUSE experiment is supported by the U.S. Department of Energy, the U.S. National Science Foundation, the Paul Scherrer Institute, and the US-Israel Binational Science Foundation.



MUSE Experiment 2022 Update
- Analysis Part I

- GEM Tracking and Comparison to Simulation
- STT Tracking and Comparison to Simulation
- Calorimeter Detector Response and Comparison to Simulation

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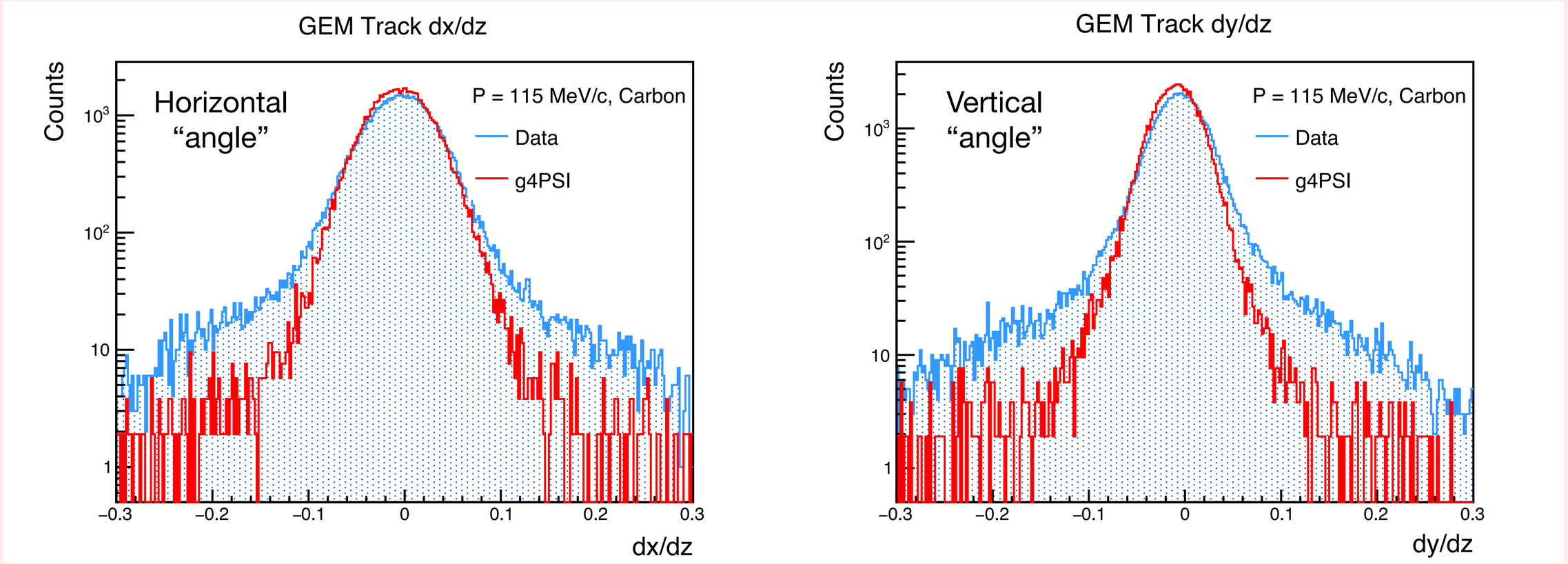
the Paul Scherrer Institute, and the US-Israel Binational Science Foundation.

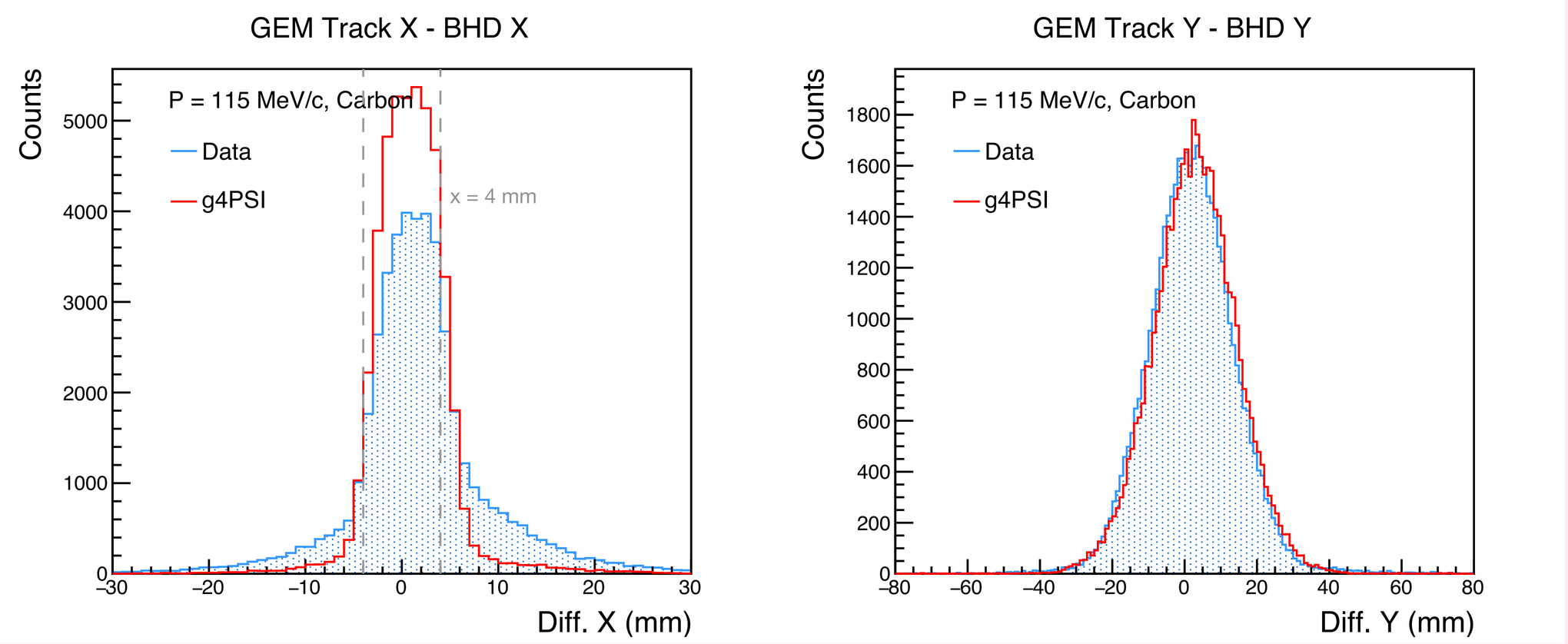
GEM Tracking

- Tracking using “GenFit”; Require at least two GEM planes are hit
- Simulations and data reasonably agree for central peak of the track angle distributions
- Data shows larger tails of the beam at angle > 100 mr
- Larger angle events offset by several cm when projected to target, removed by target fiducial cuts
- Tail differences likely from the difference in beam distribution and/or secondary particle production



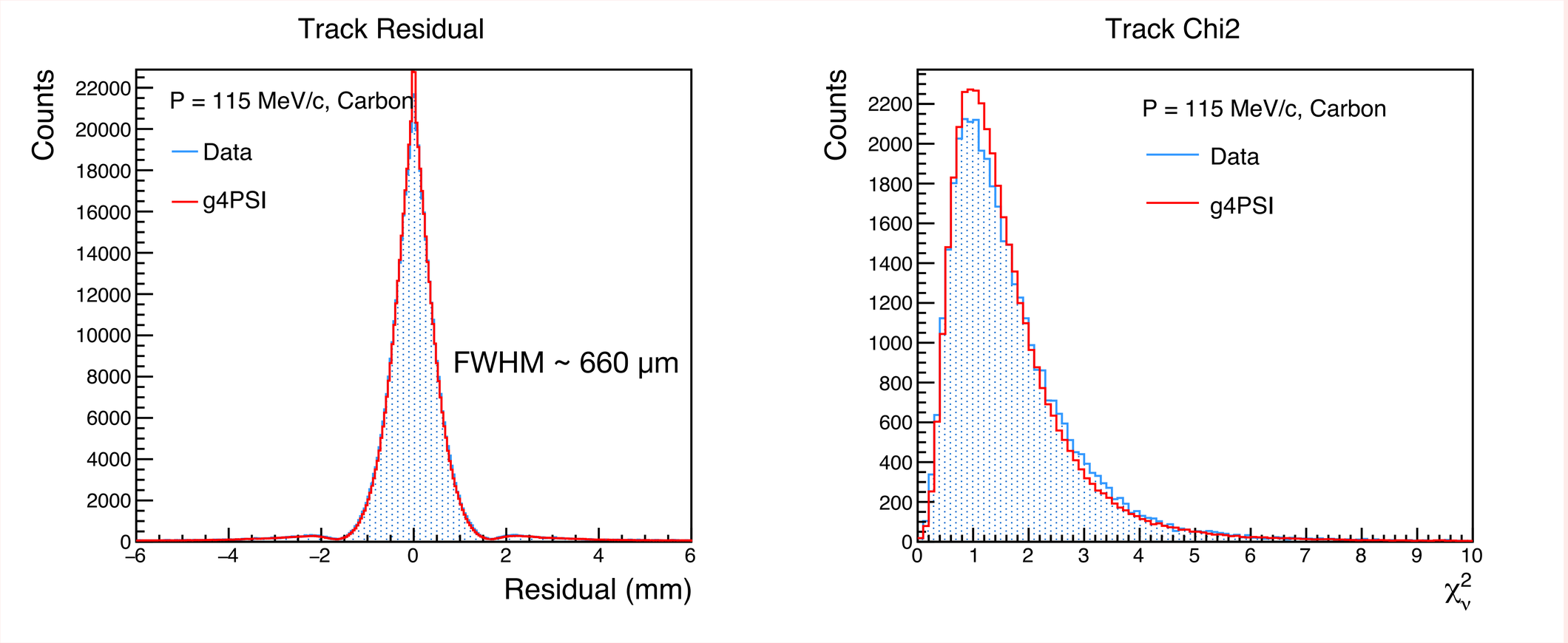
GEM Tracking - Correlation with BH

- BH X: center of the hit paddle; BH Y: time difference between two SiPMs of the paddle
- Width of X: ~ width of paddle (8 mm). Tail when track points to neighboring bar, more often in data
- Width of Y: dominated by BH timing resolution (~100 ps) corresponding to position resolution of ~ 2 cm



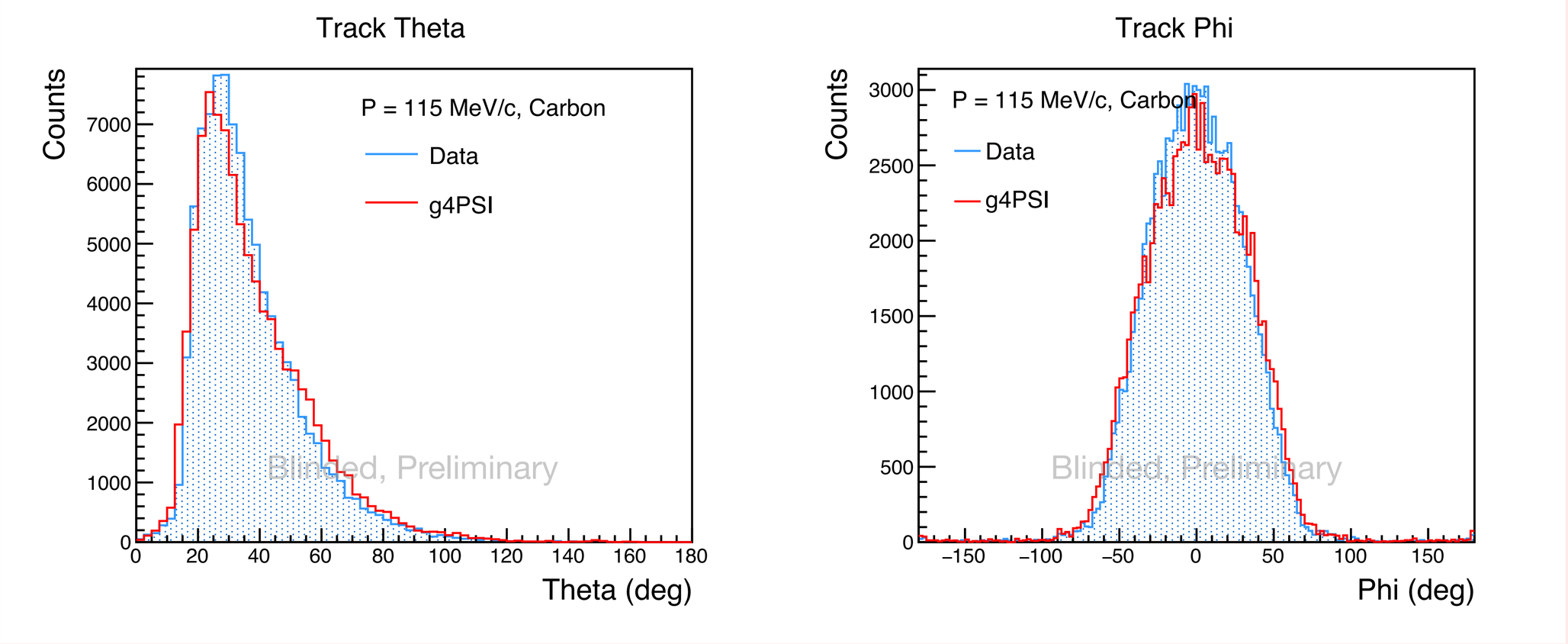
STT Tracking

- Tracking using “GenFit”; assume one track per event
- Require hits in at least 3 x-planes and at least 3 y-planes on the same side
- Simulation assumes all working straws have 90% efficiency (depends on threshold, analysis algorithm)
- Tracks are blinded, residual and Chi2 are not



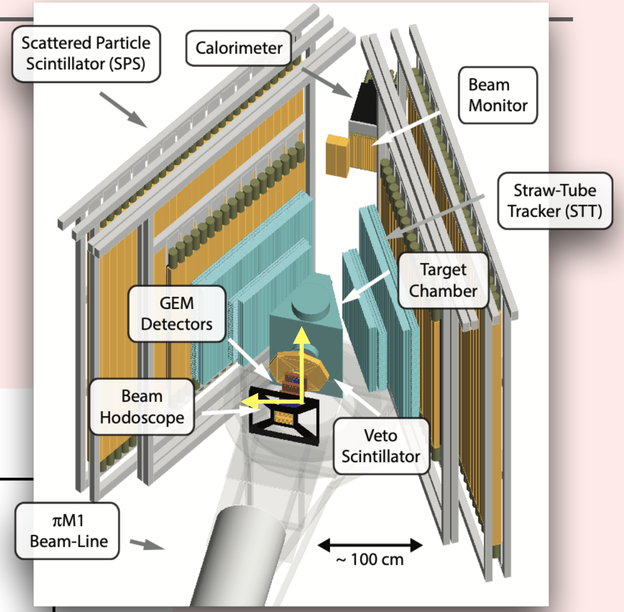
STT Tracking

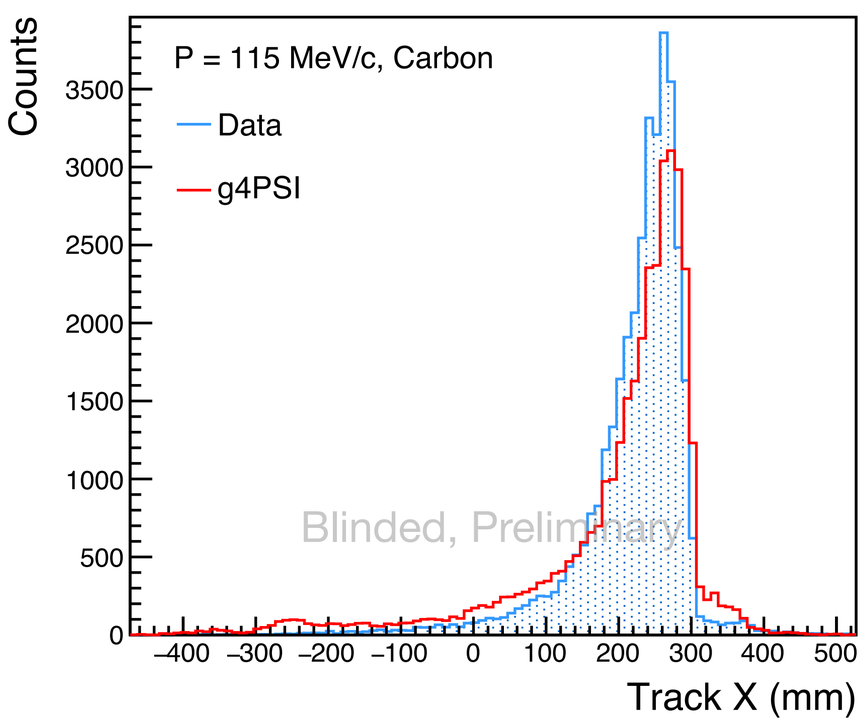
- Plots are polar angles in MUSE spherical coordinates, not scattering angles
- Theta range for target scattering: 20 – 100 degrees; Phi range: ~ -45 – 45 degrees
- Theta: particle decays and scattering from up/downstream materials can extend range
- Phi: vertical size of beam and scattering from near side of beam can extend range
- Data and simulation should not agree exactly because of blinding

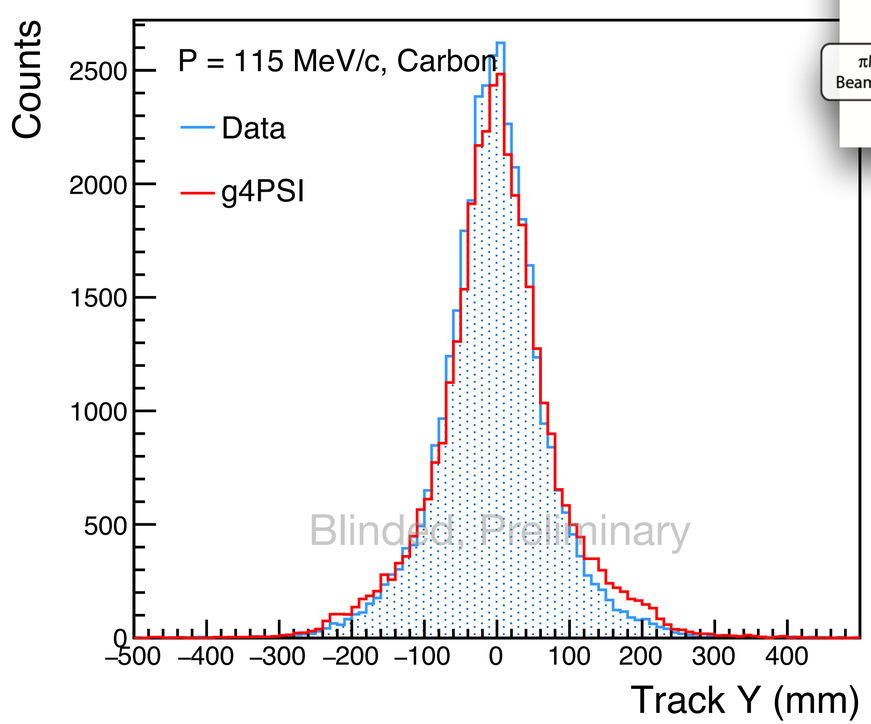


STT Tracking

- Plots are in STT local coordinates; beam is expected to center at about Y = 0 and positive X
- STT front plane dimension: ~ 600 mm x 600 mm
- X (horizontal): reflects scattering distribution
- Y (vertical): reflects beam height is Y = 0

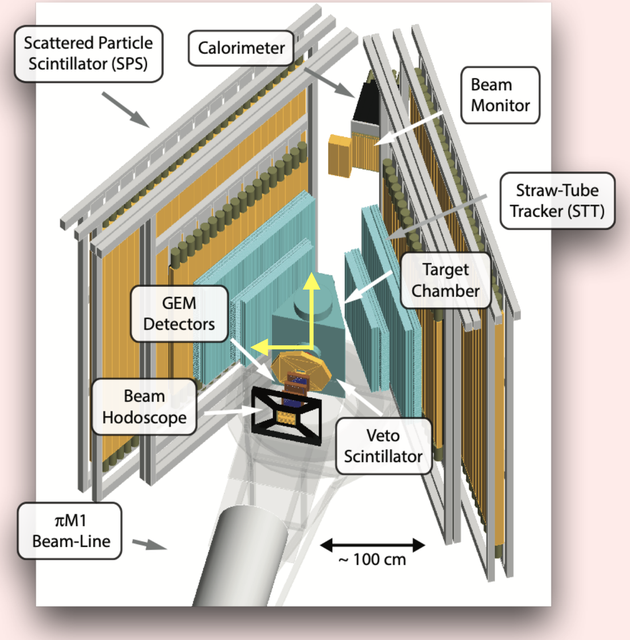


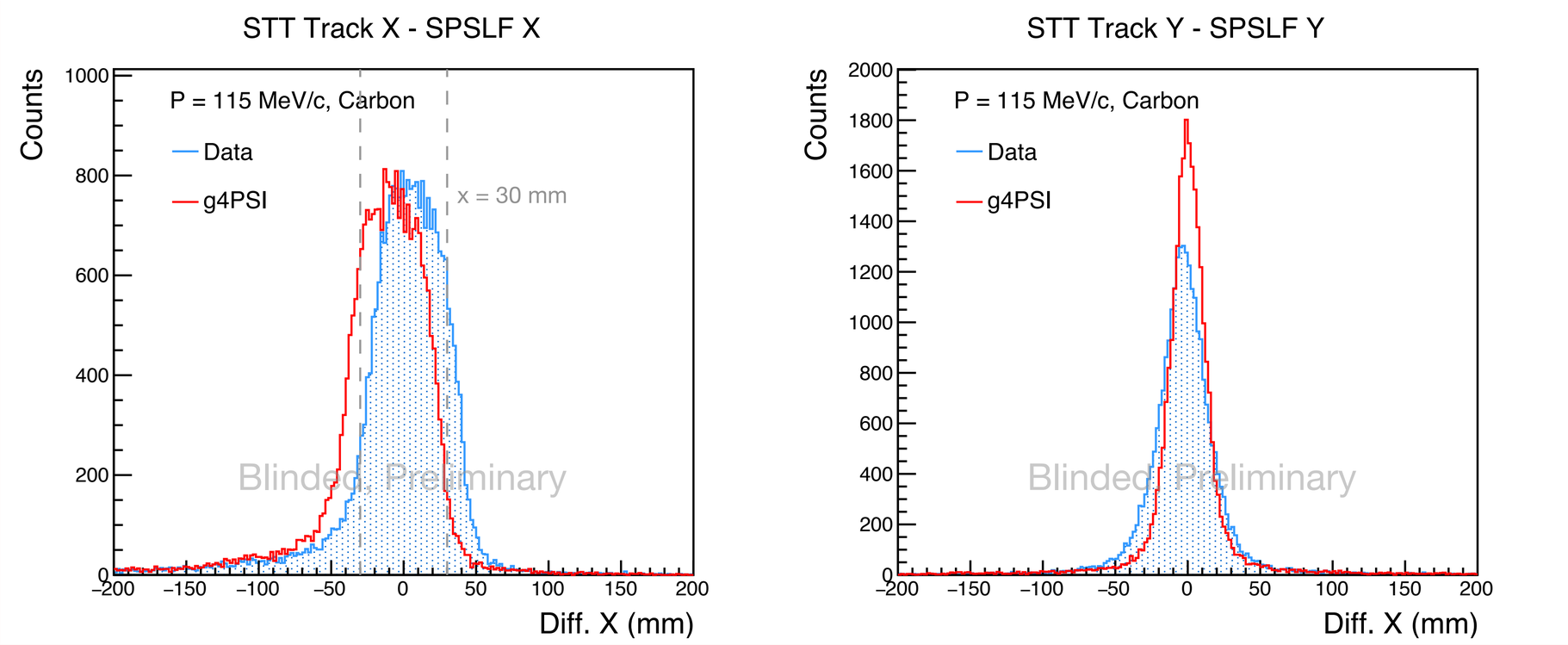




STT Tracking - Correlation with SPS

- Plots are in SPS local coordinates
- SPS X: center of the hit paddle
  - width: 60 mm wide bar + STT track resolution + event in the neighboring bar
- SPS Y: time difference between two PMTs of the paddle
  - Width: position resolution of PMT time difference

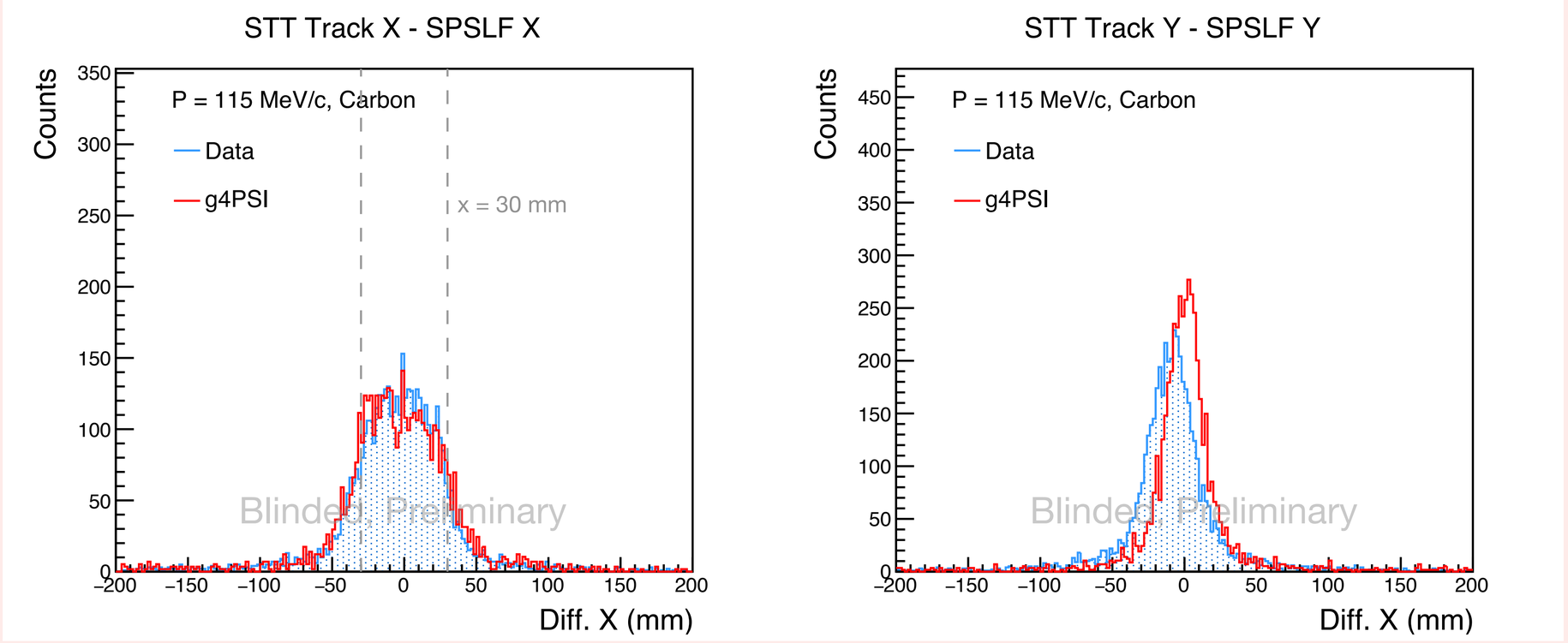


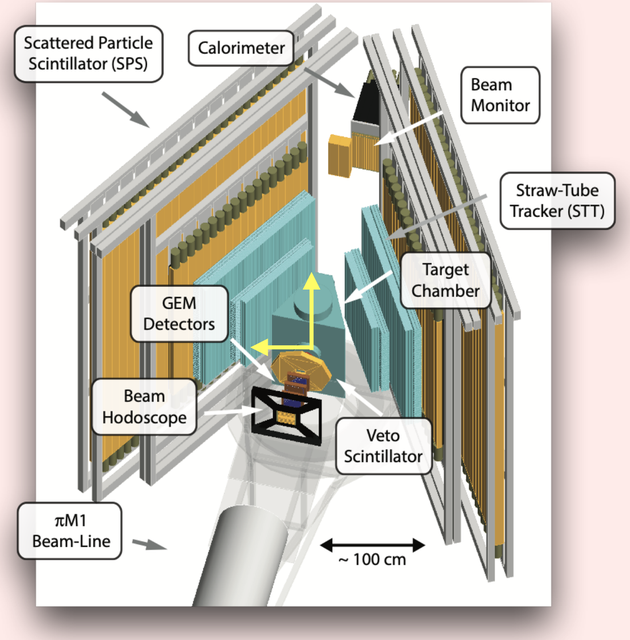


For entire SPS plane

STT Tracking - Correlation with SPS

- Plots are in SPS local coordinates
- SPS X: center of the hit paddle
  - width: 60 mm wide bar + STT track resolution + event in the neighboring bar
- SPS Y: time difference between two PMTs of the paddle
  - Width: position resolution of PMT time difference
- Further work needed for SPS digitization



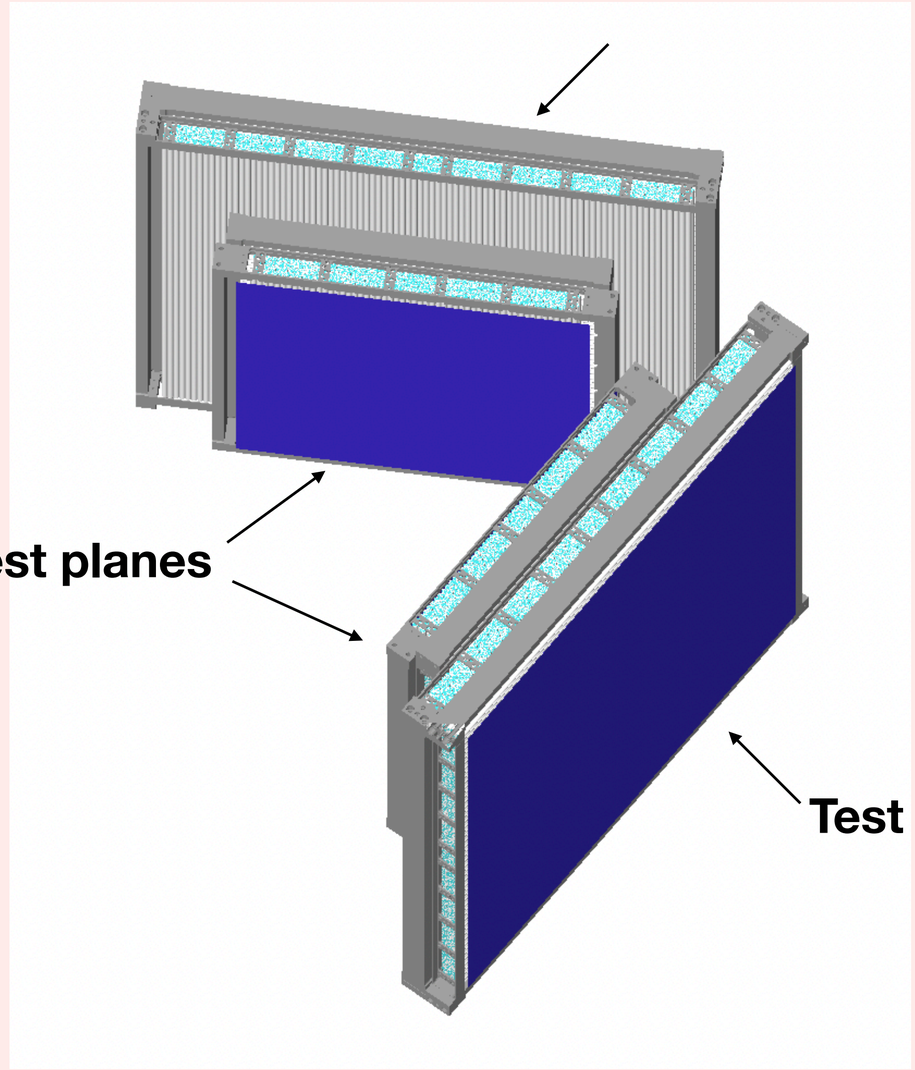


For 1 central SPS paddle

Larger data sample

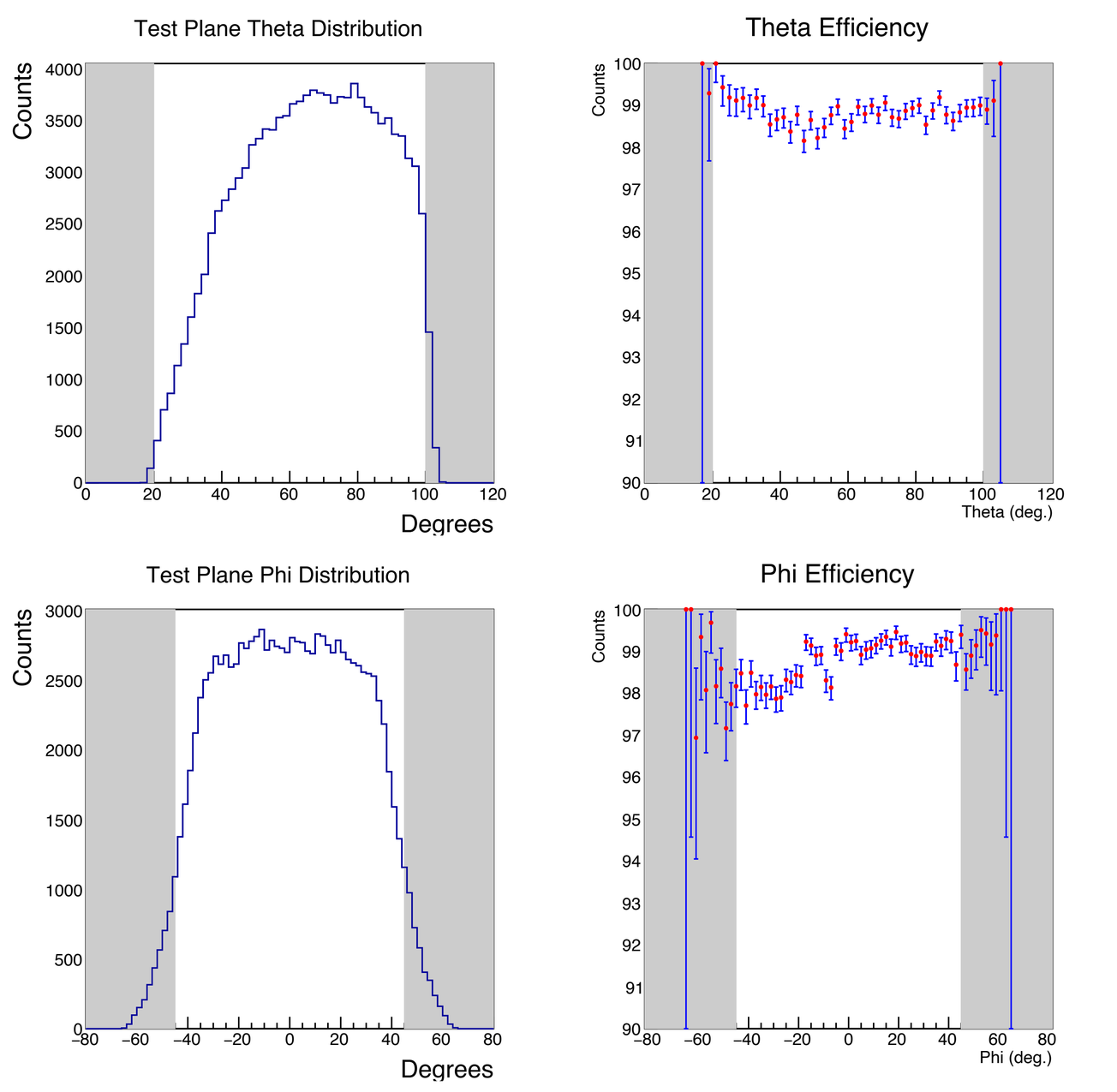
Tracking Efficiency from Simulation

- Calculated from simulation
- Place test planes before and after STTs
- Beam: 115 MeV/c e-, 4π from target
- Select clean single track in simulation
- Track found if hits in at least 3 x-planes and at least 3 y-planes on the same side



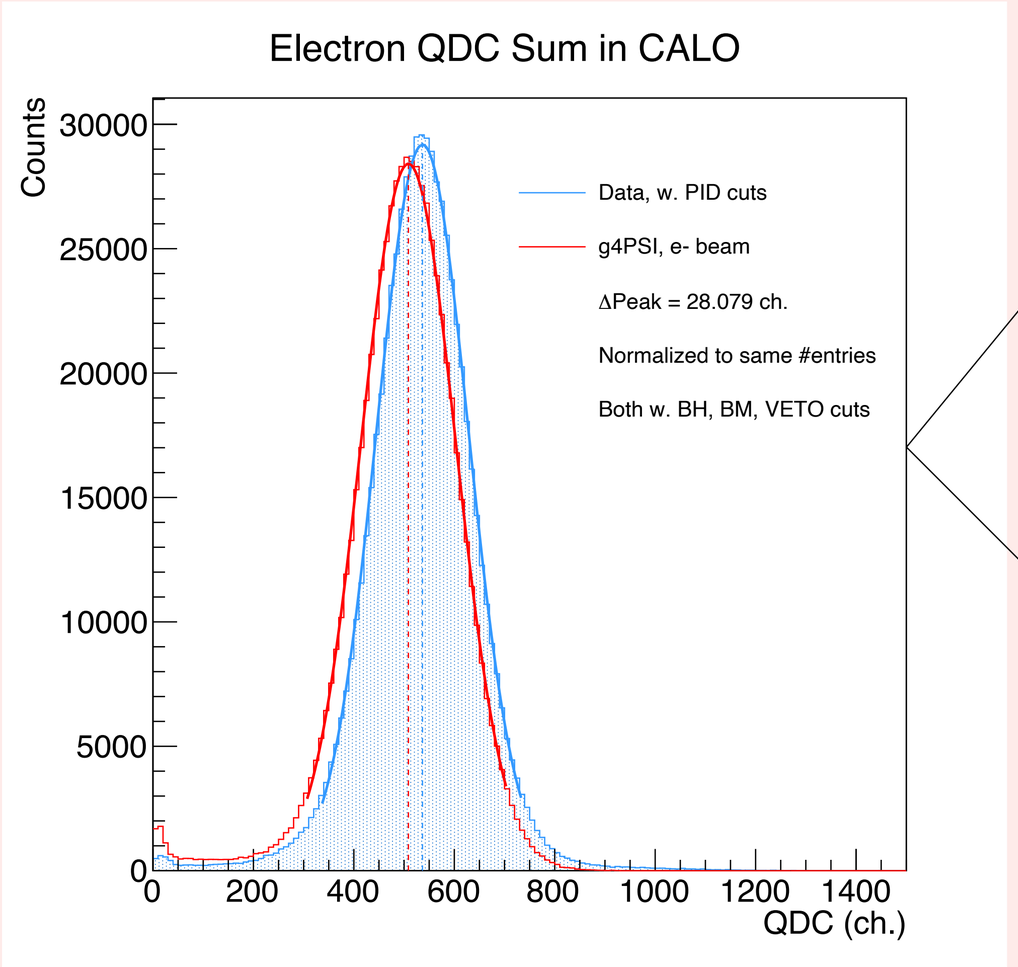
Tracking Efficiency

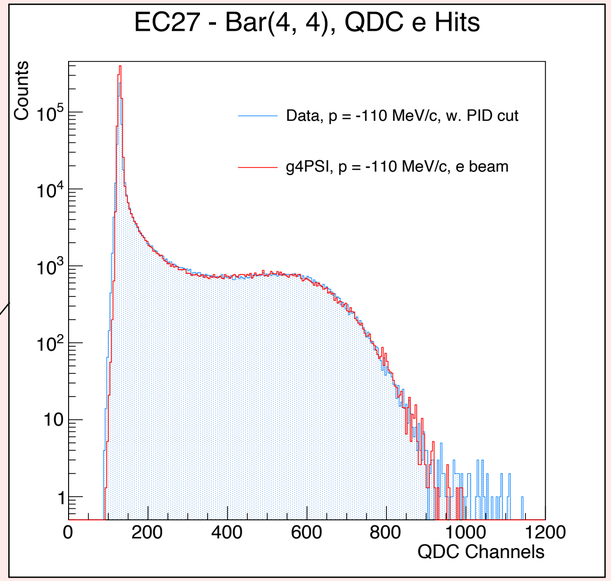
- Calculation shows the tracking efficiency is generally the same for all angles within acceptance
- Efficiency close to 99%
- The exact efficiency found depends on the tracking algorithm

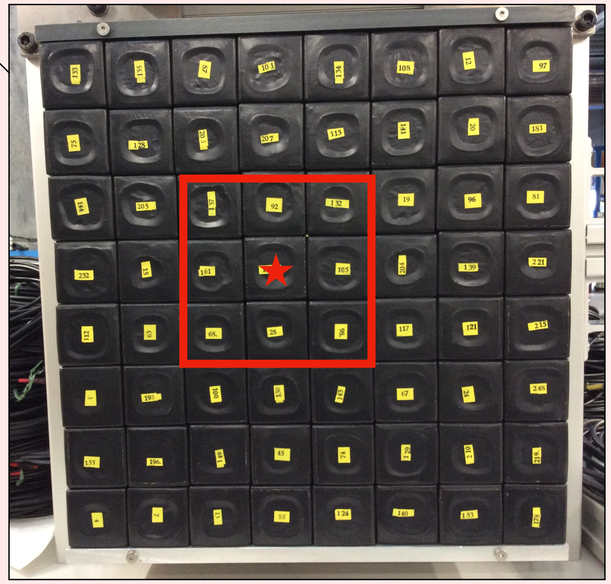


Calorimeter Energy

- Compared the detector response between data and simulation.
- Energy sum is calculated by highest energy deposited bar + 8 surrounding neighbors

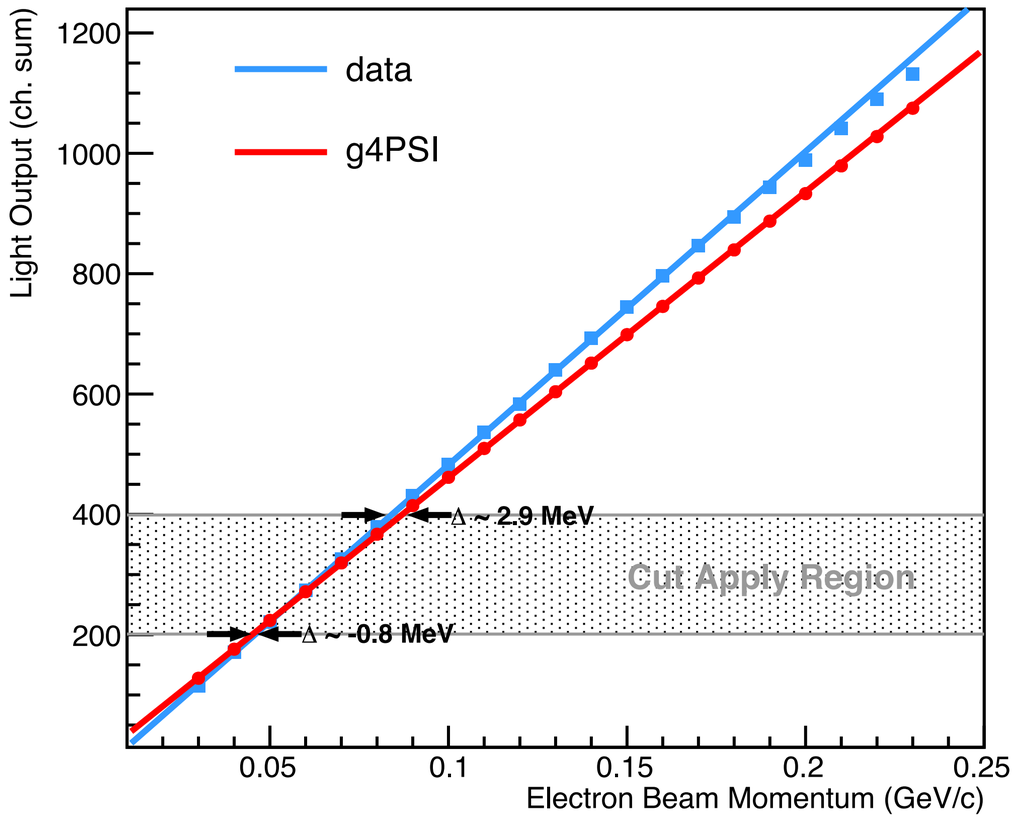


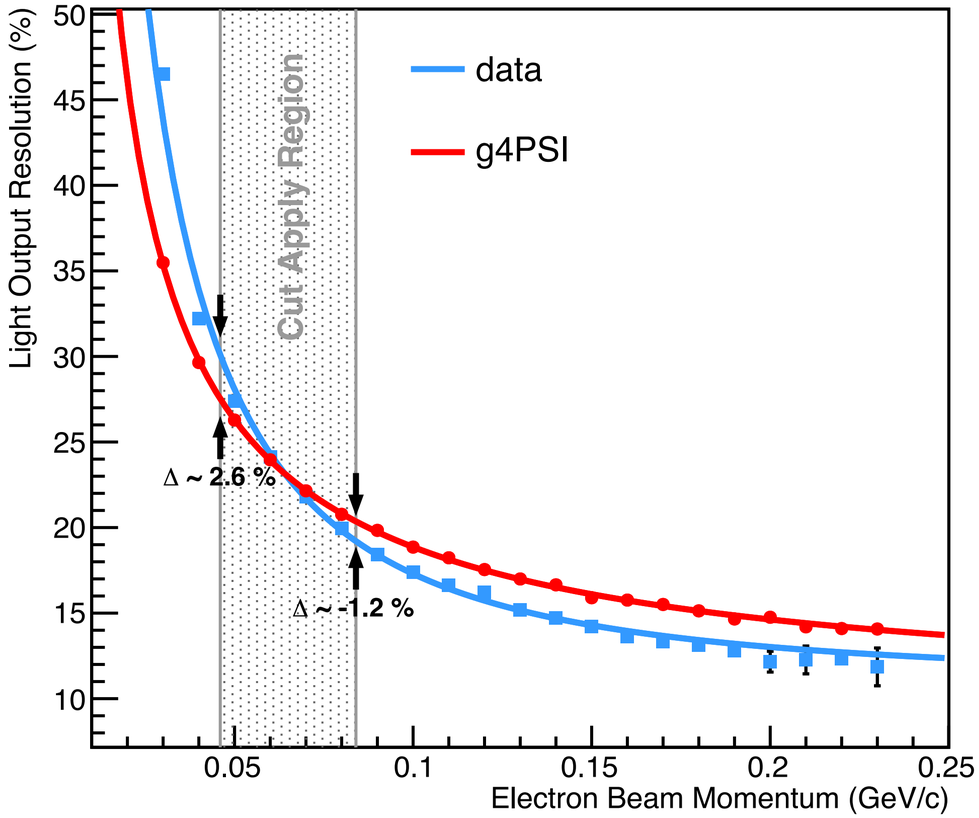




Calorimeter Energy

- Simulation shows similar response to different beam energy as data.
- Differences are greater at higher momentum.
- In the region (~40%p, 46 - 84 MeV/c) where cut will apply, data and simulation agree better than our requirement.





Summary

- GEM tracking: shows good agreement between data and simulation, with small differences in tails from beam distribution / secondaries, which will be cut away by analysis
- STT tracking: data and simulation agree well, SPS digitization needs more work
- Tracking efficiency shows good and smooth behavior for the MUSE acceptance
- Calorimeter has good energy response and comparison with simulations is already at an acceptable level