

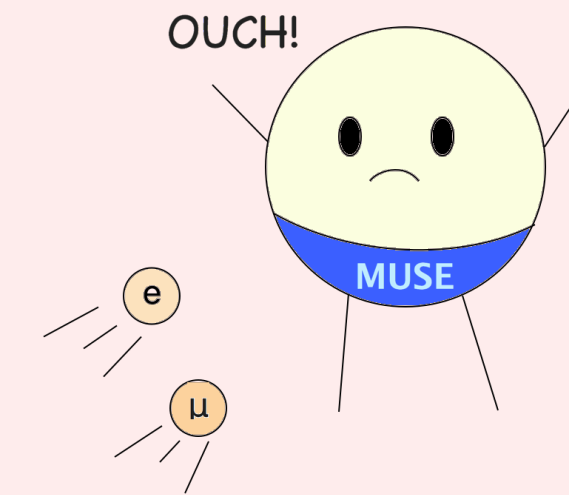
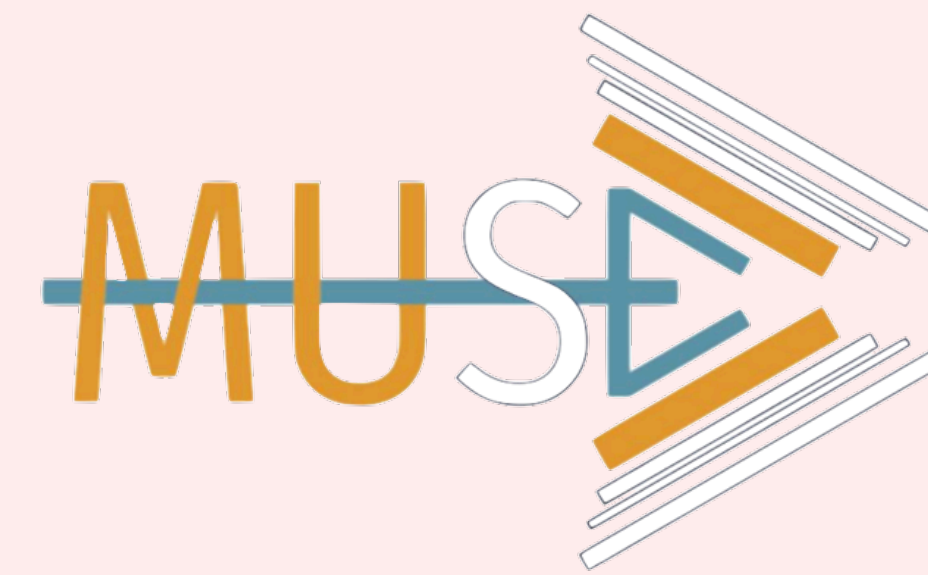
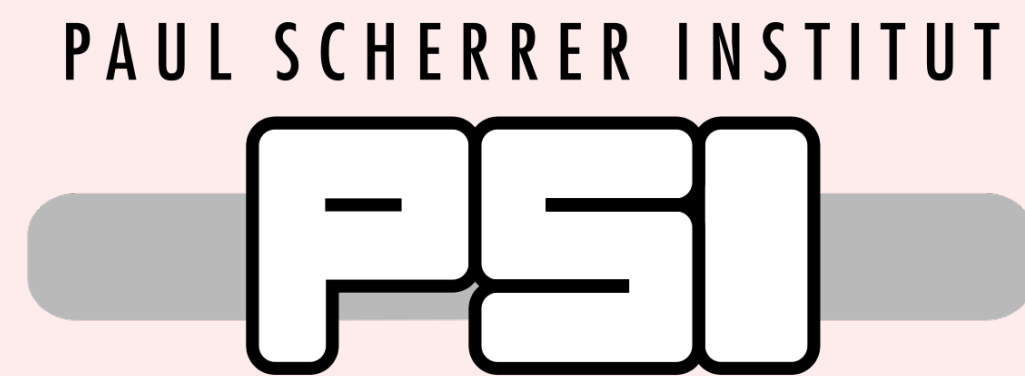
MUSE Experiment 2022 Update - Analysis Part I

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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

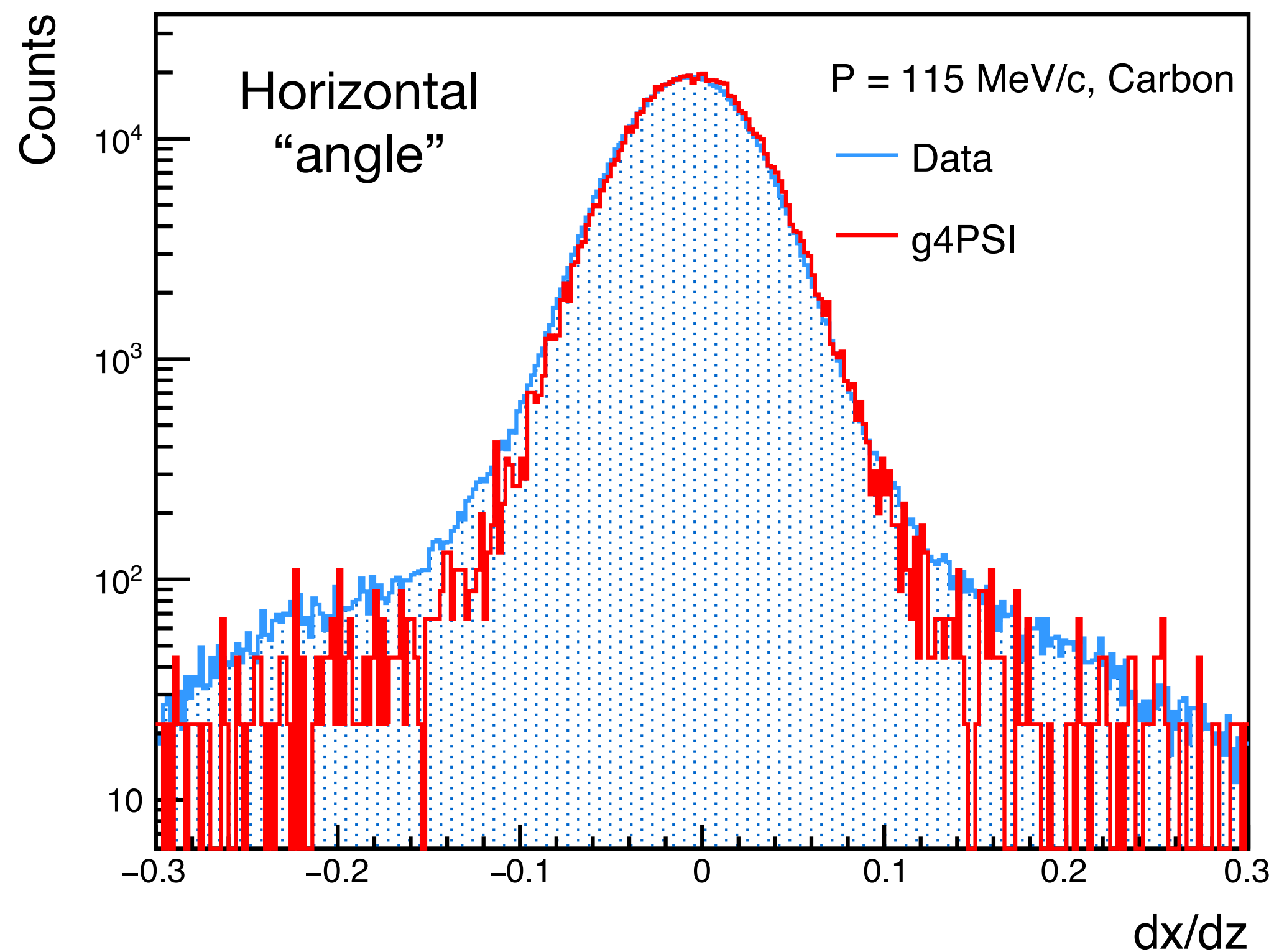
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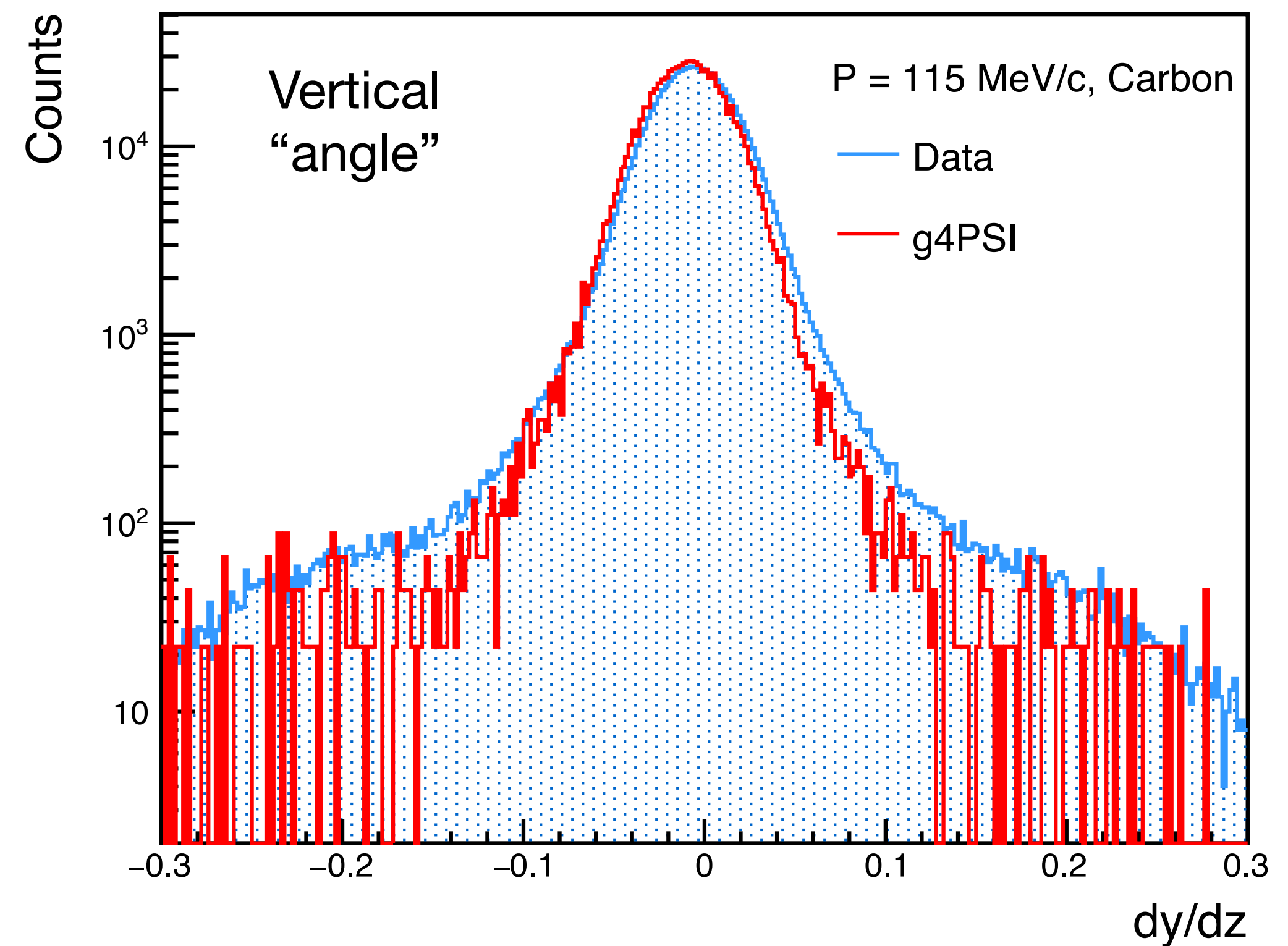
Good agreement between data and simulation

- 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 μ r, removed by target fiducial cuts

GEM Track dx/dz



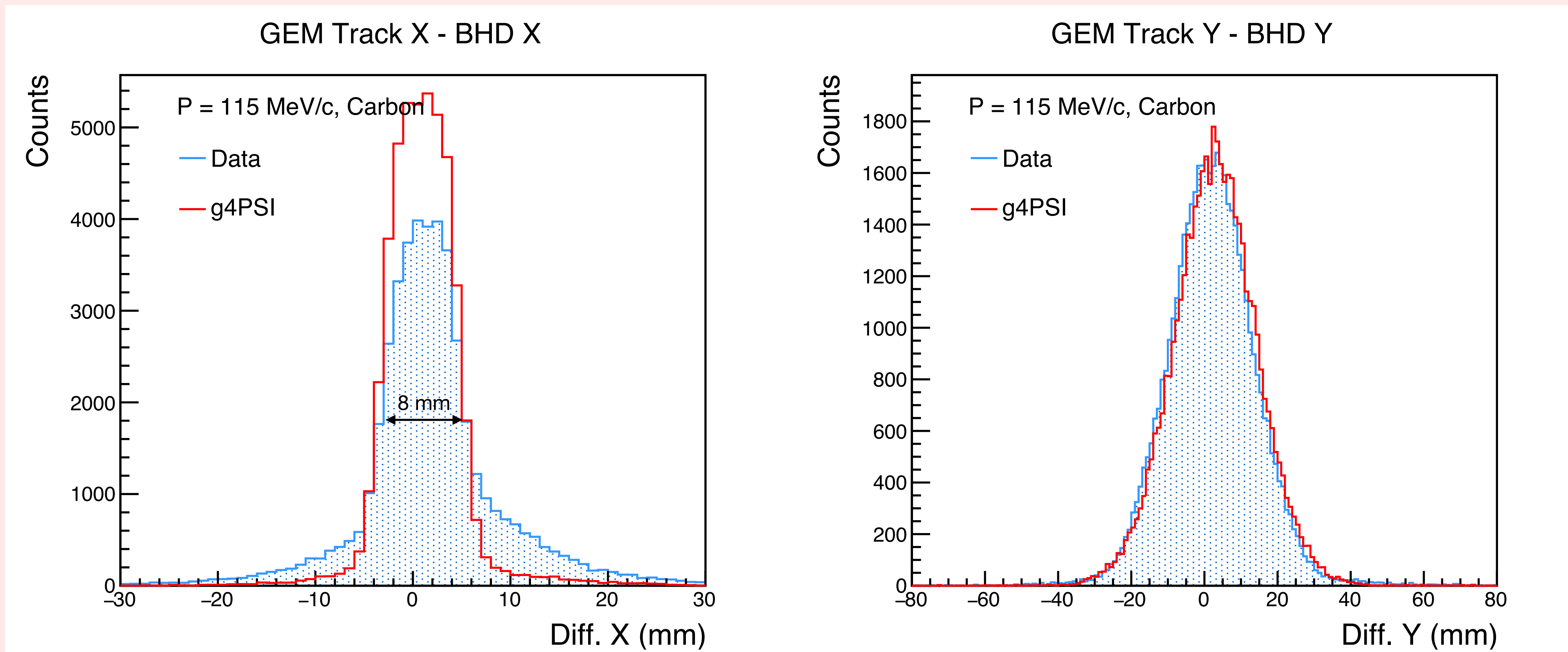
GEM Track dy/dz



GEM Tracking - Correlation with BH

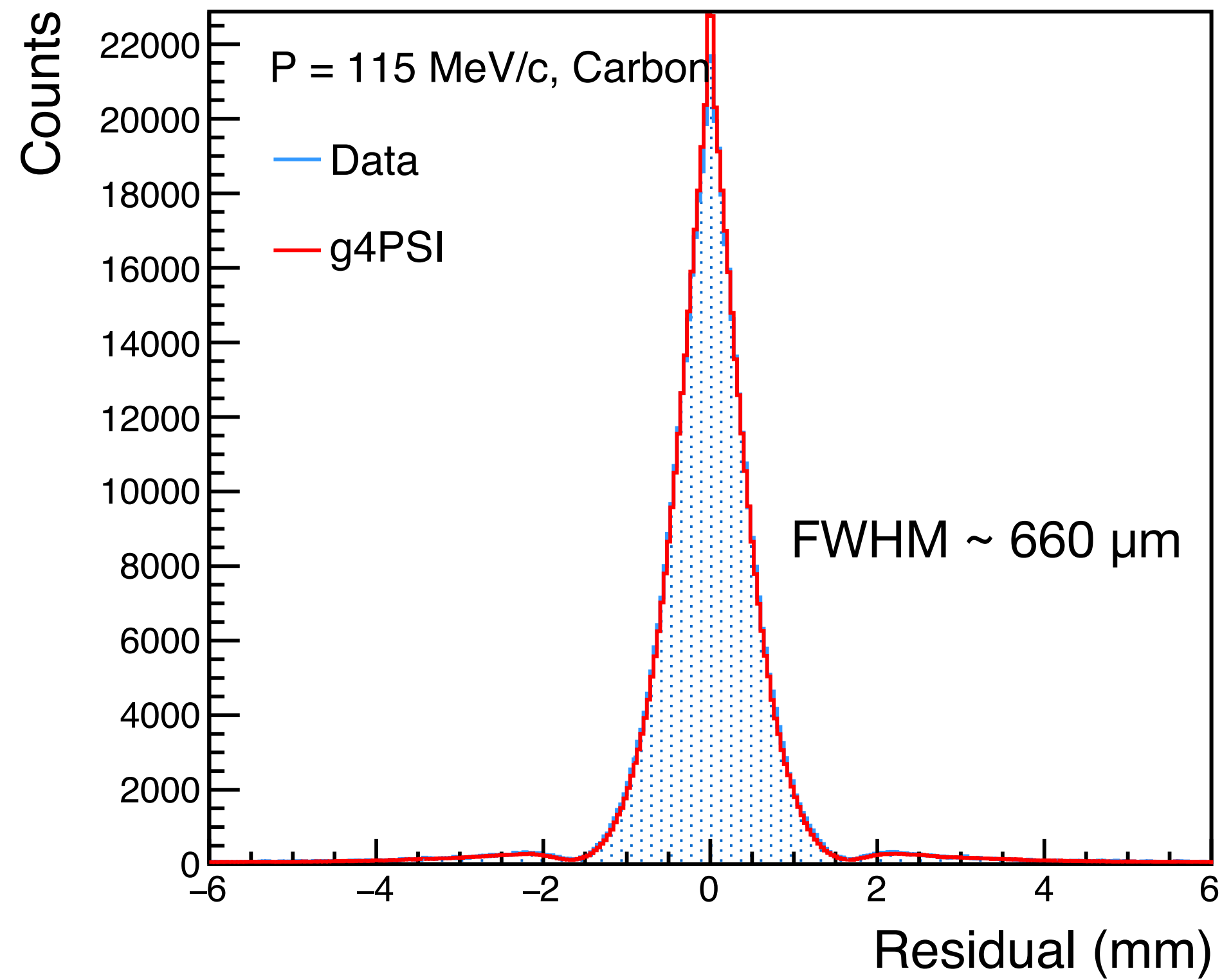
Good correlation with BH, for data and for simulation

- BH X: center of the hit paddle; BH Y: time difference between two SiPMs of the paddle
- Width of X: \sim 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

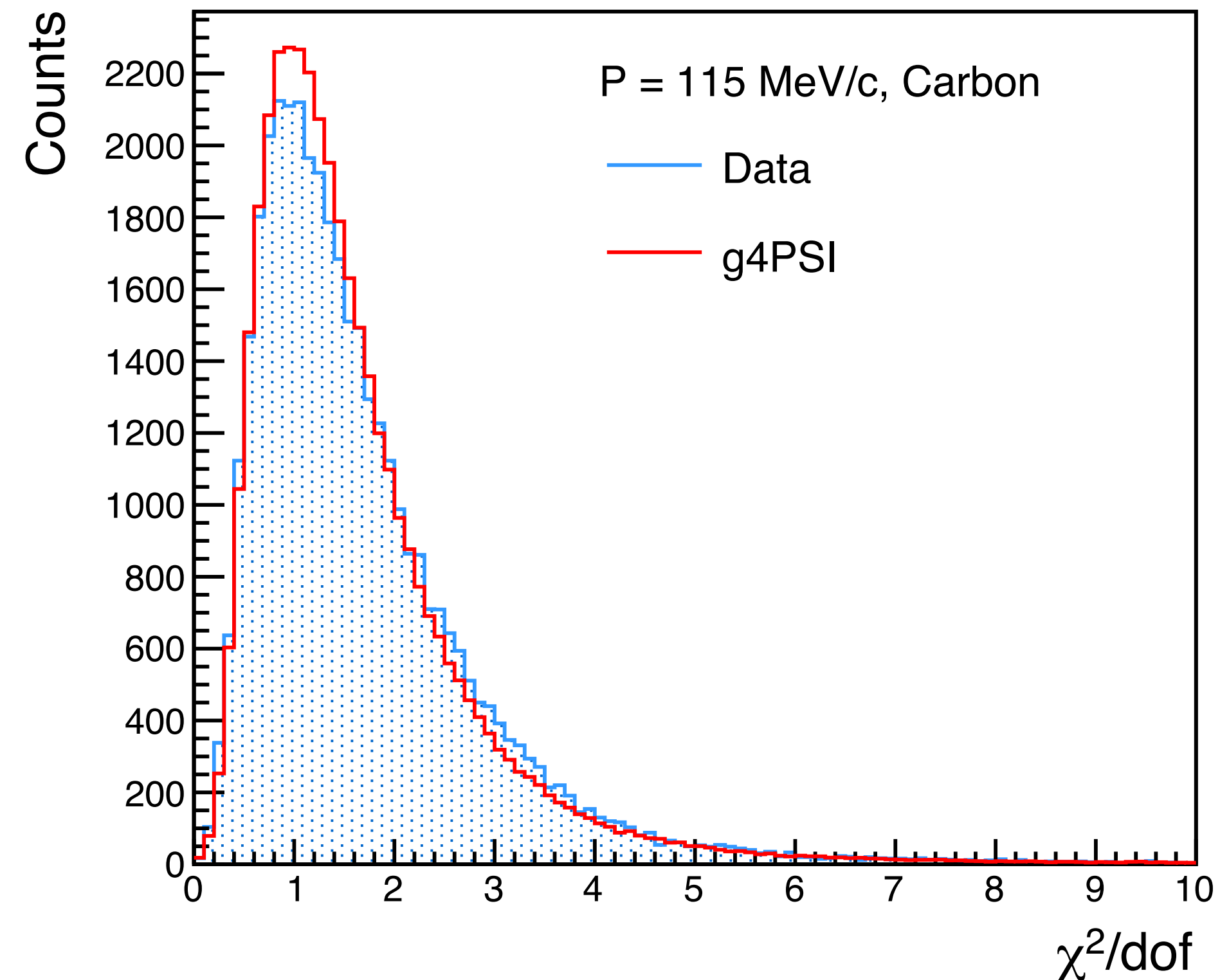


- Tracking using “GenFit”
- Require hits in at least 3 x-planes and at least 3 y-planes on the same side
- Simulation assumes all working straws have 90% efficiency (depends on threshold, analysis algorithm)

Track Residual

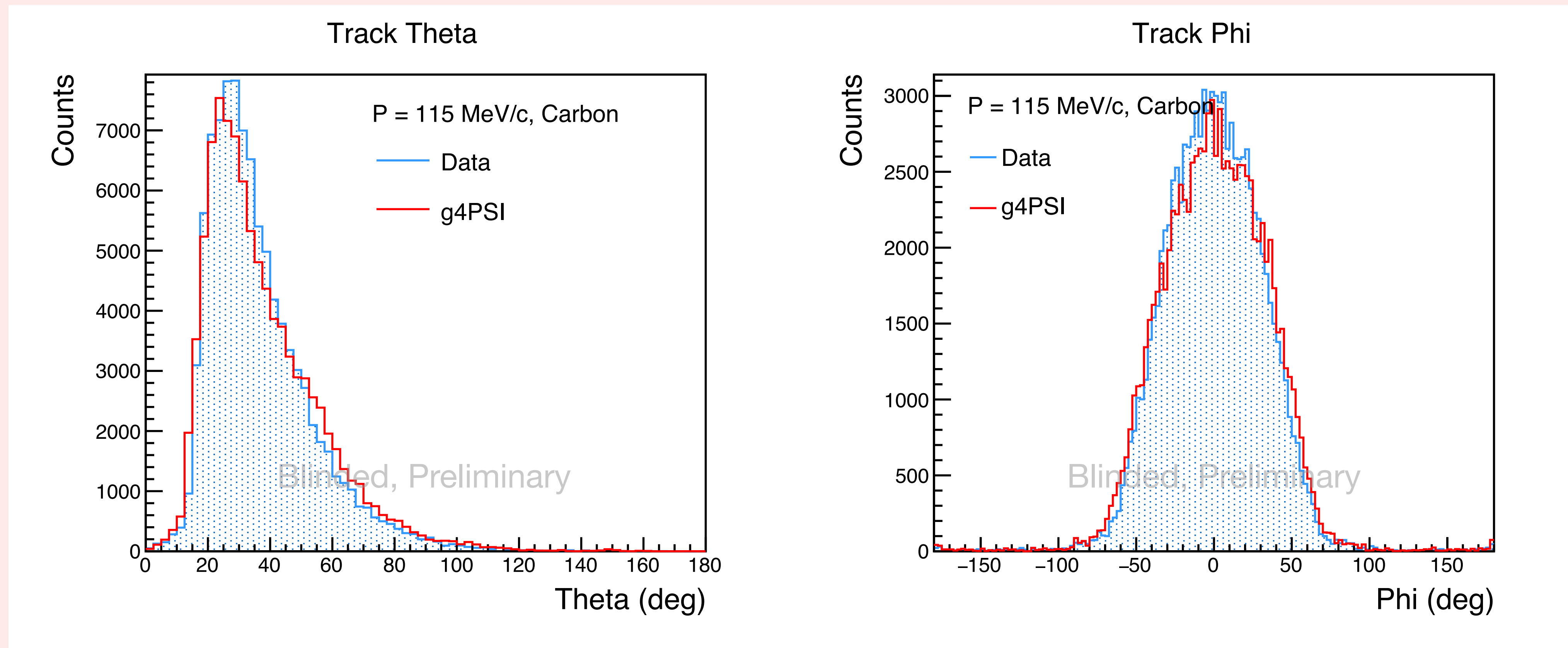


Track χ^2/dof



Good agreement between data and simulation for angles

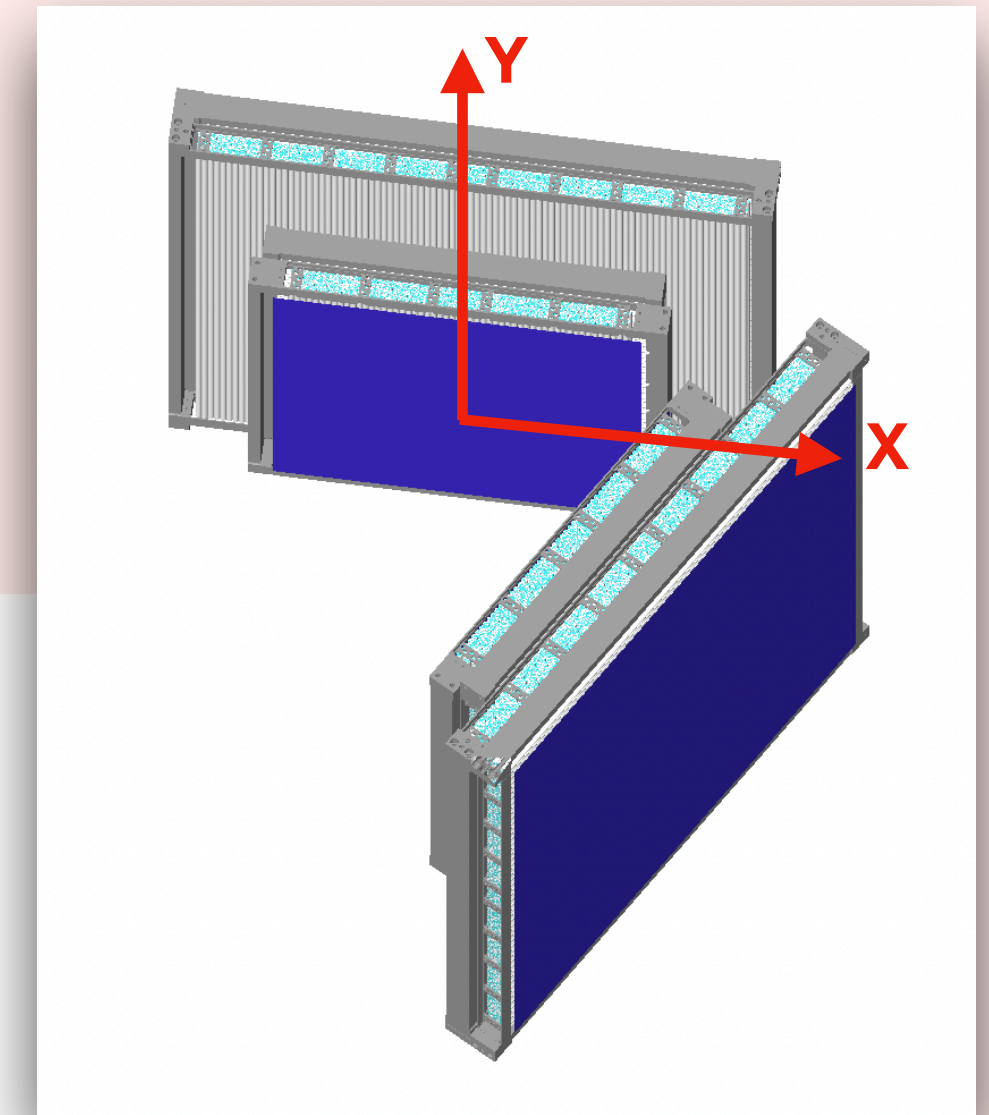
- Plots are polar angles in MUSE spherical coordinates, not scattering angles
- Nominal acceptance: 20 – 100 for theta; -45 – 45 degrees for phi
- Blinding prevents exact agreement



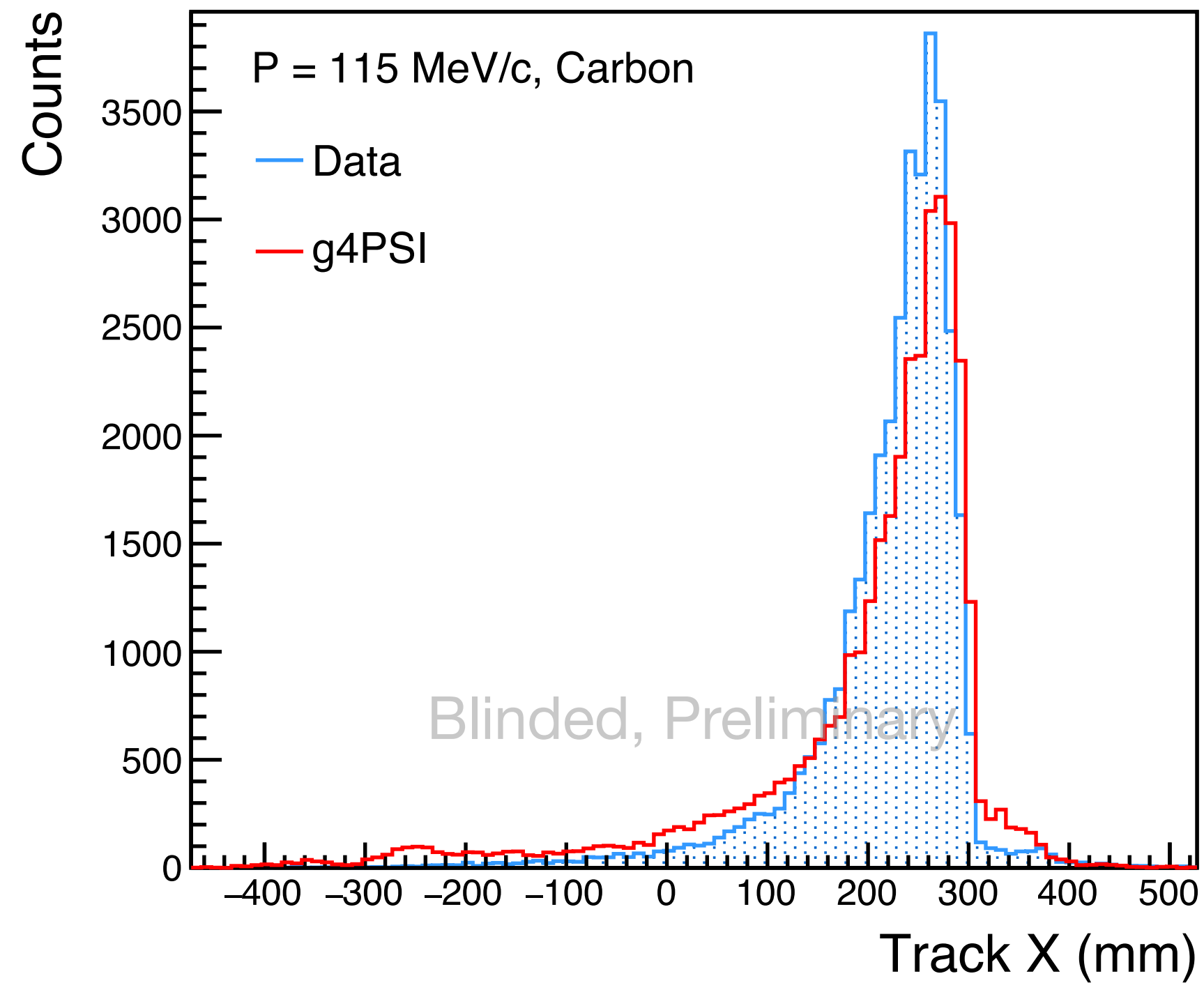
STT Tracking

Good agreement between data and simulation for the track position on STT

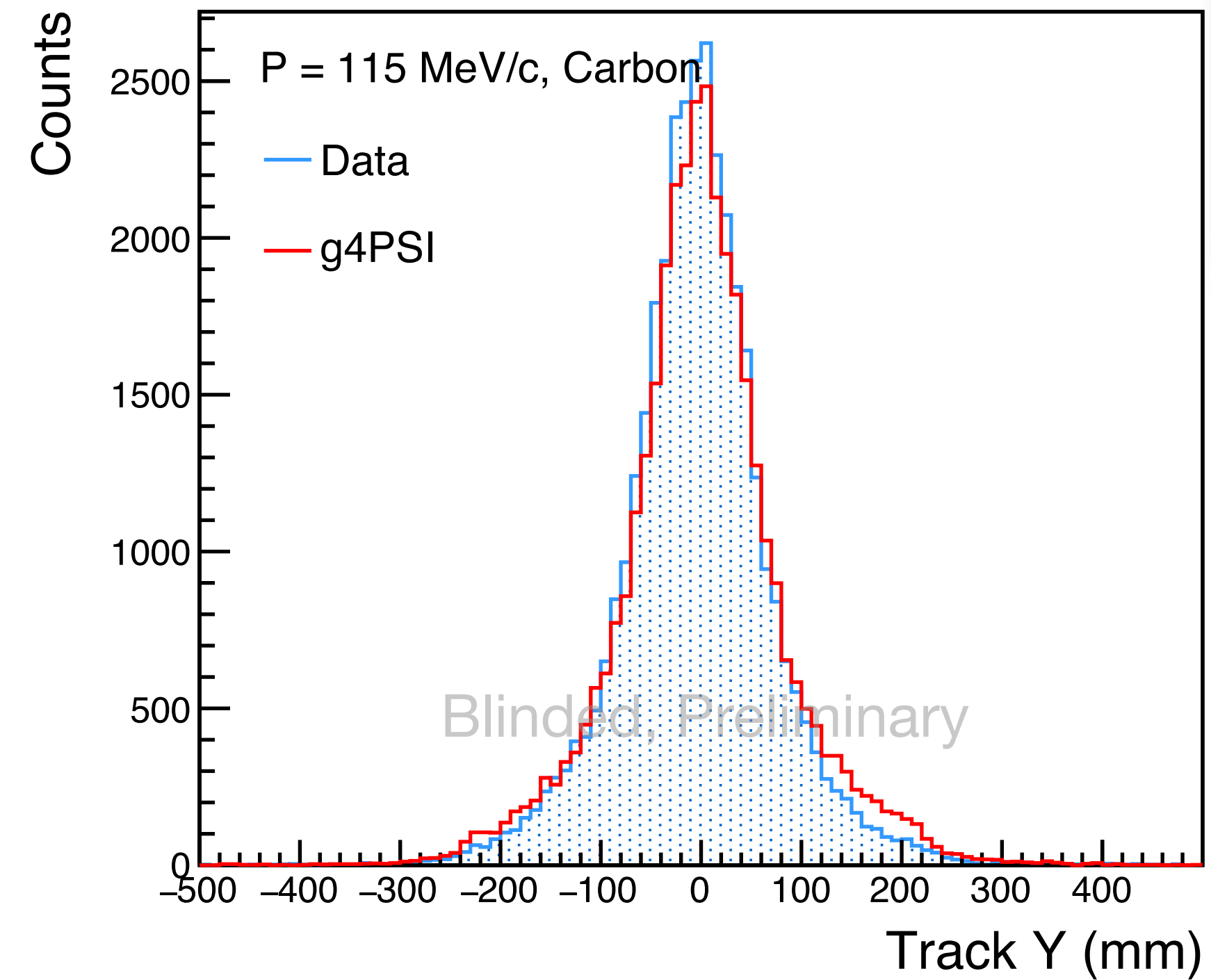
- Plots are in STT local coordinates; beam is expected to center at about $Y = 0$ and positive X
- STT front plane dimension: $\sim 600 \text{ mm} \times 600 \text{ mm}$



Track X on STT Front Plane

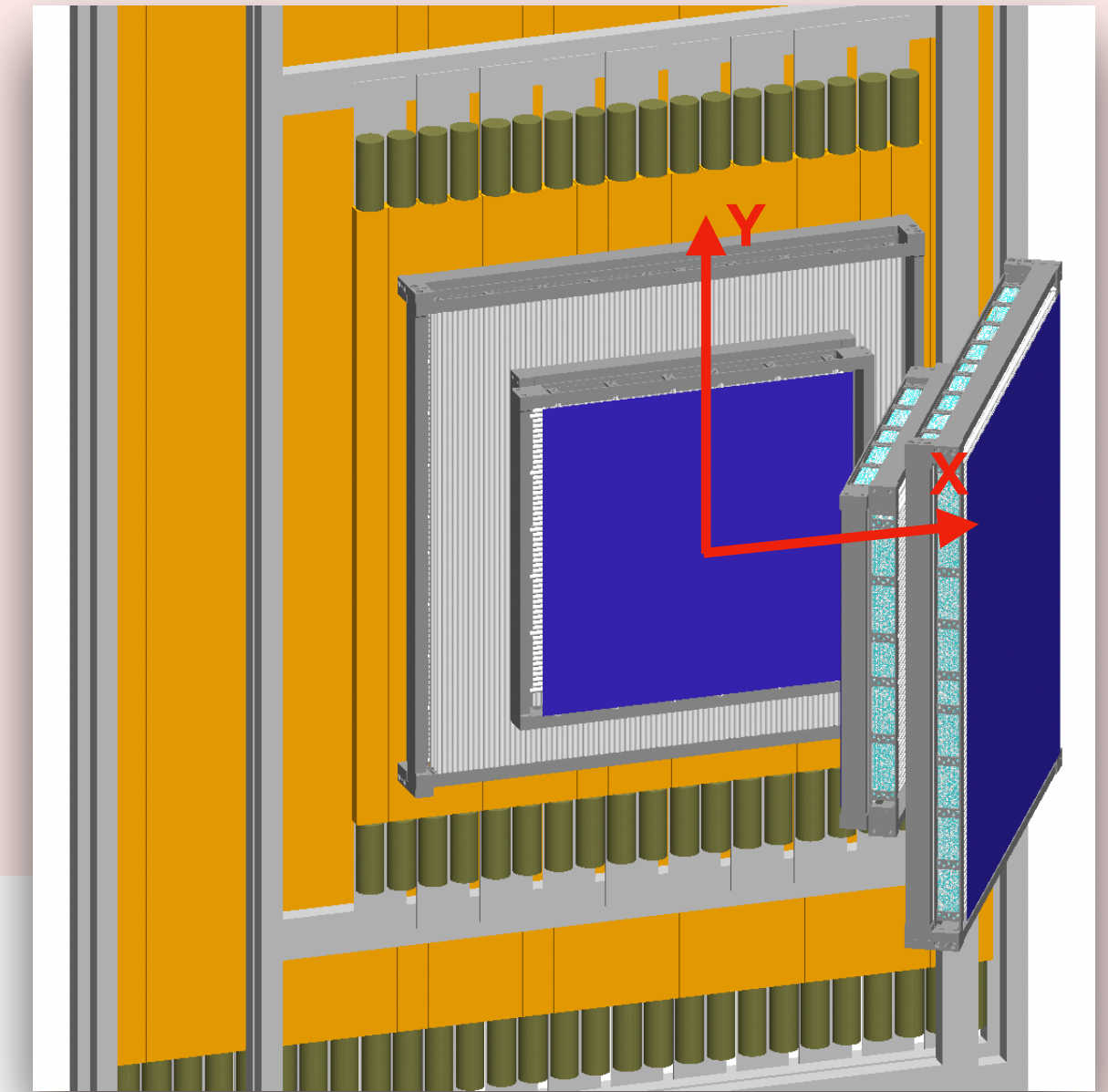


Track Y on STT Front Plane

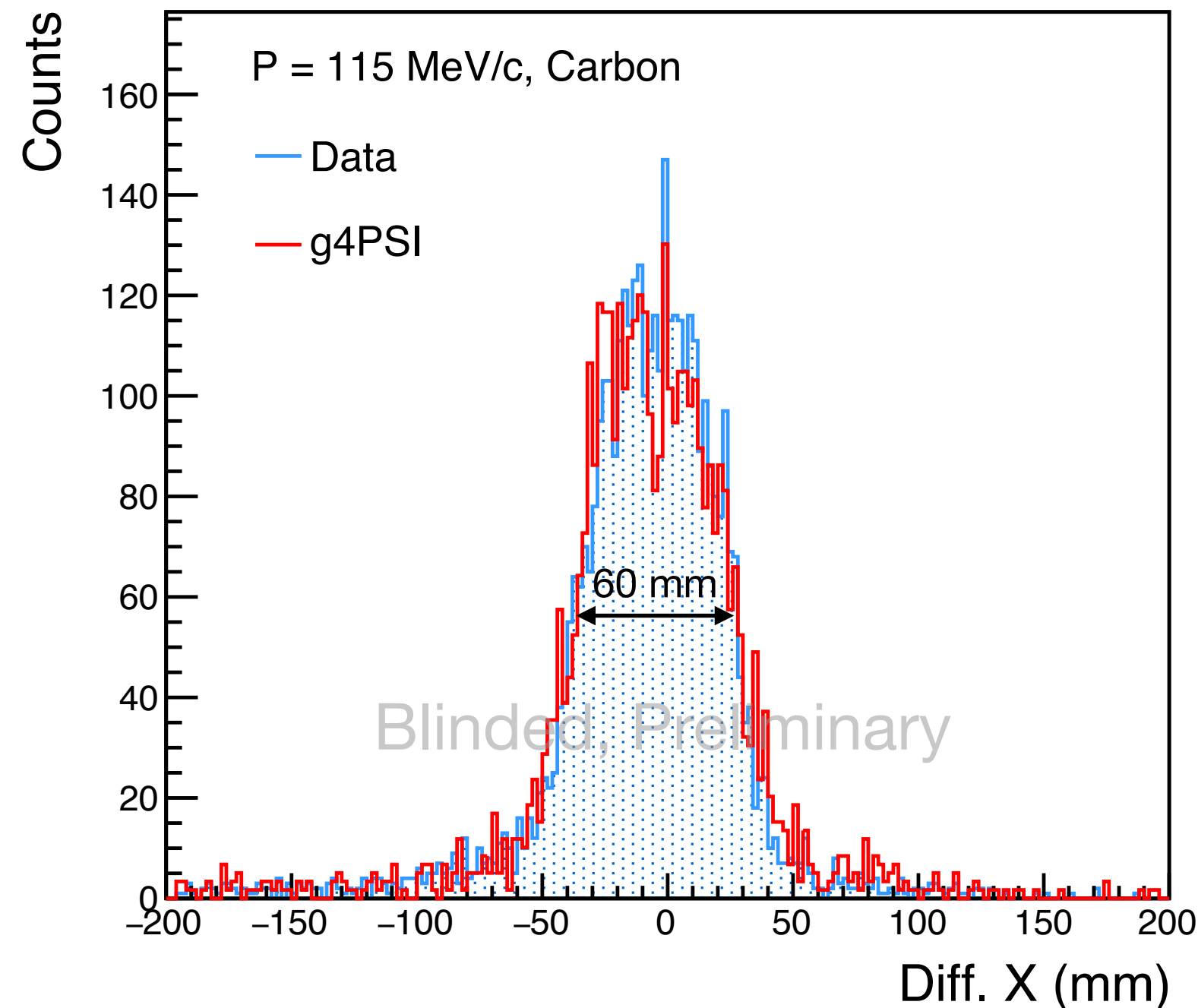


STT Tracking - Correlation with SPS

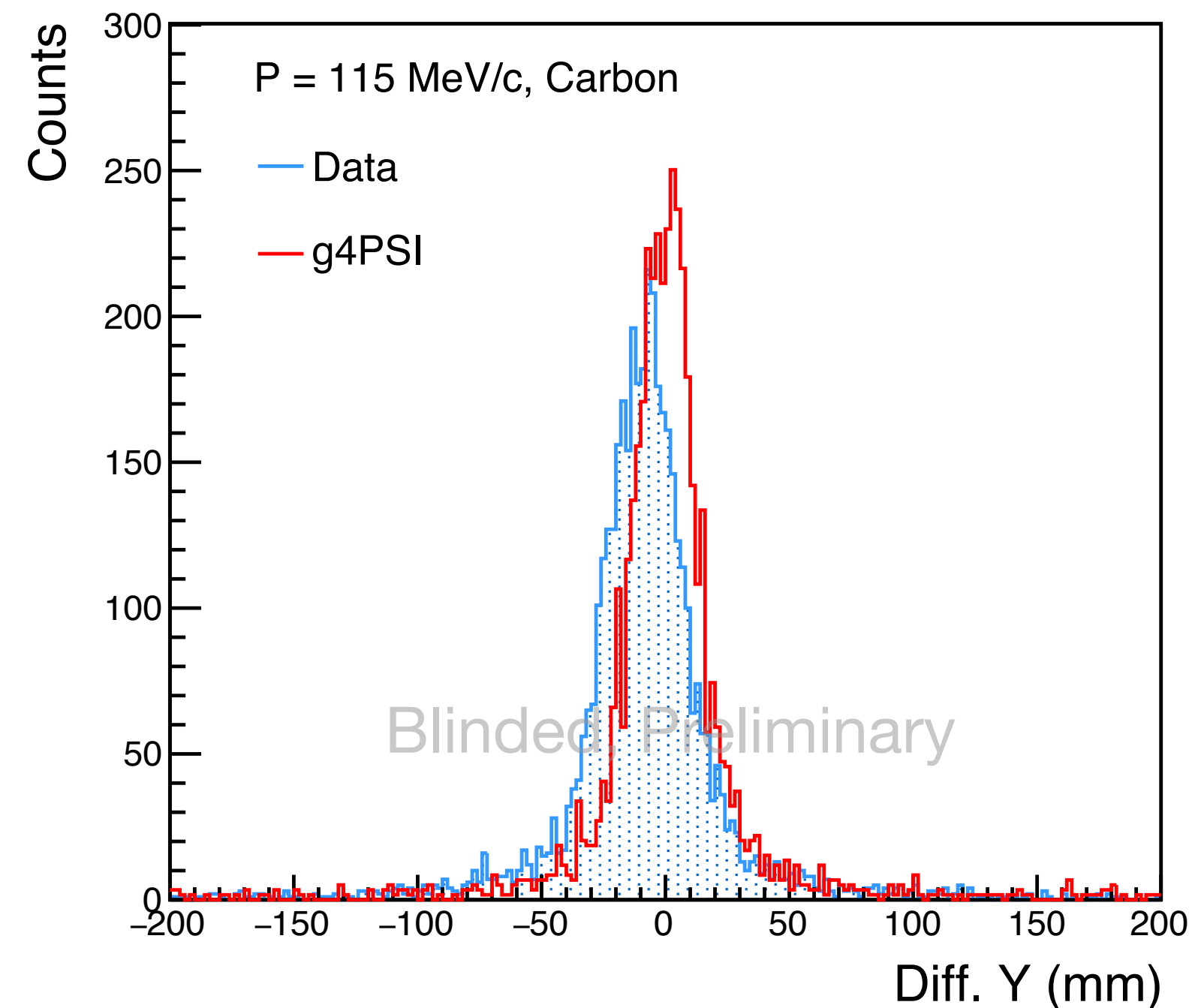
- Plots are in SPS local coordinates
- SPS X: center of the hit paddle
 - width: 60 mm wide bar
- SPS Y: time difference between two PMTs of the paddle
 - Width: position resolution of PMT time difference



STT Track X - SPSLF X



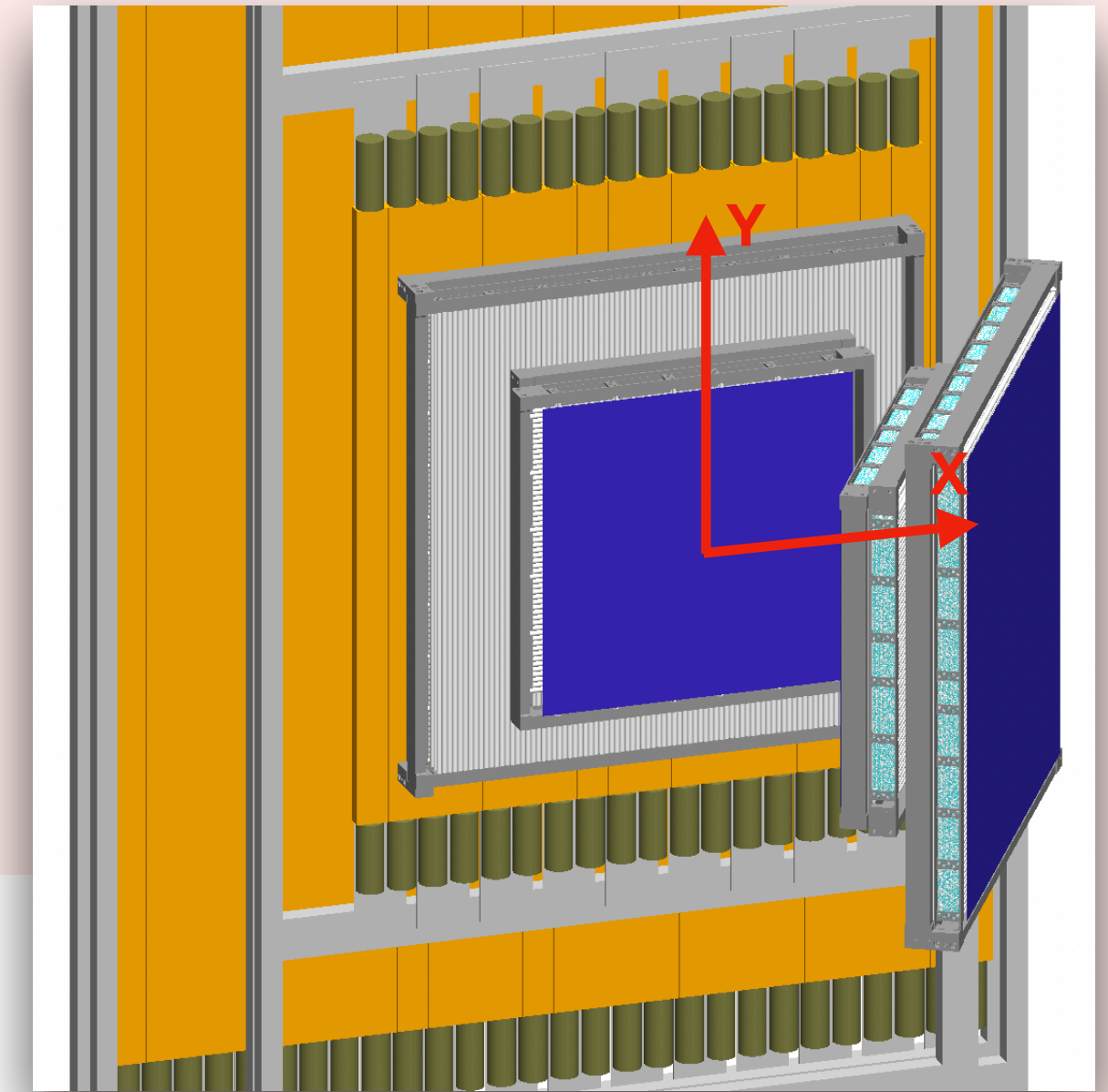
STT Track Y - SPSLF Y



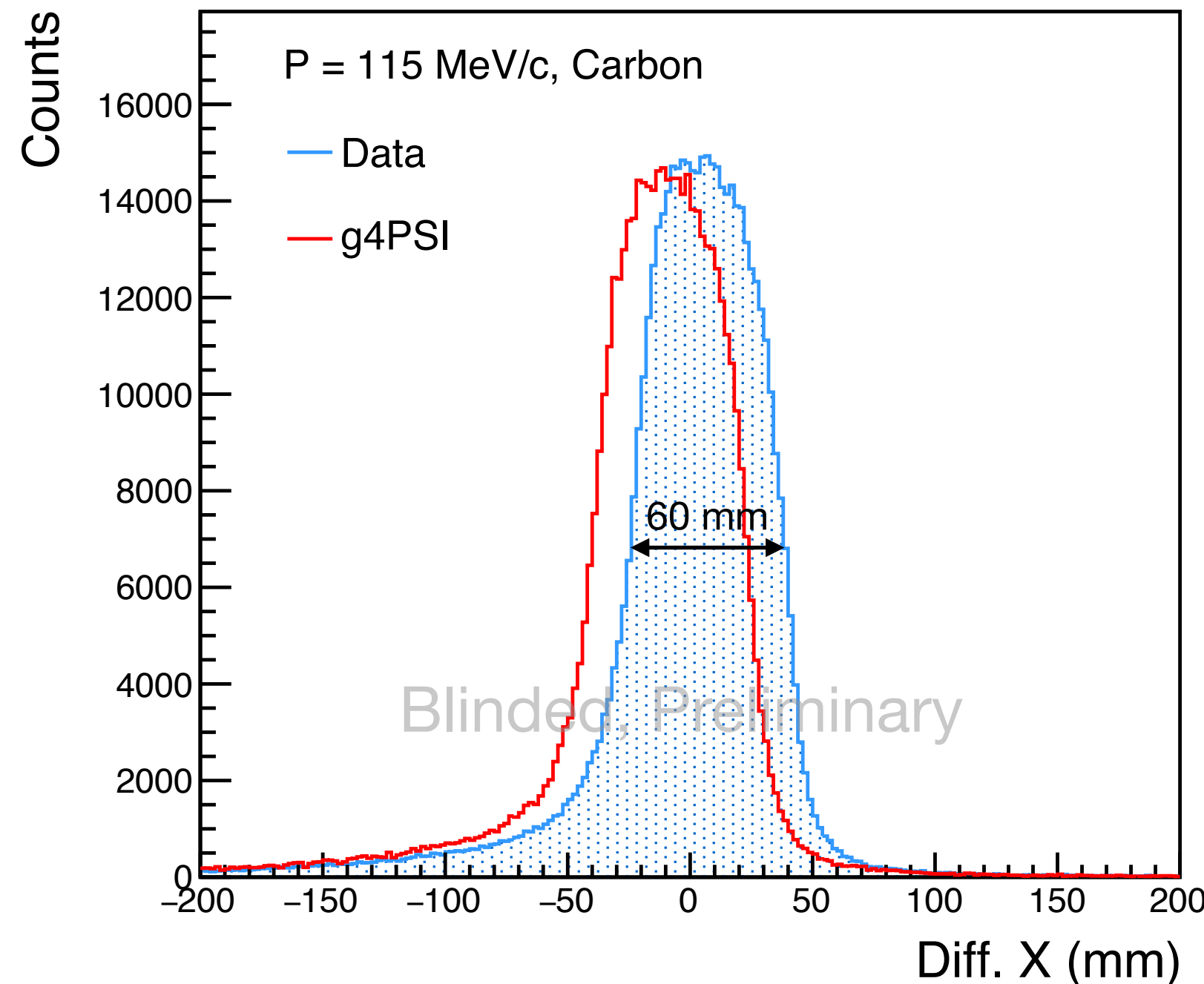
For SPSLF09 (central paddle)

STT Tracking - Correlation with SPS

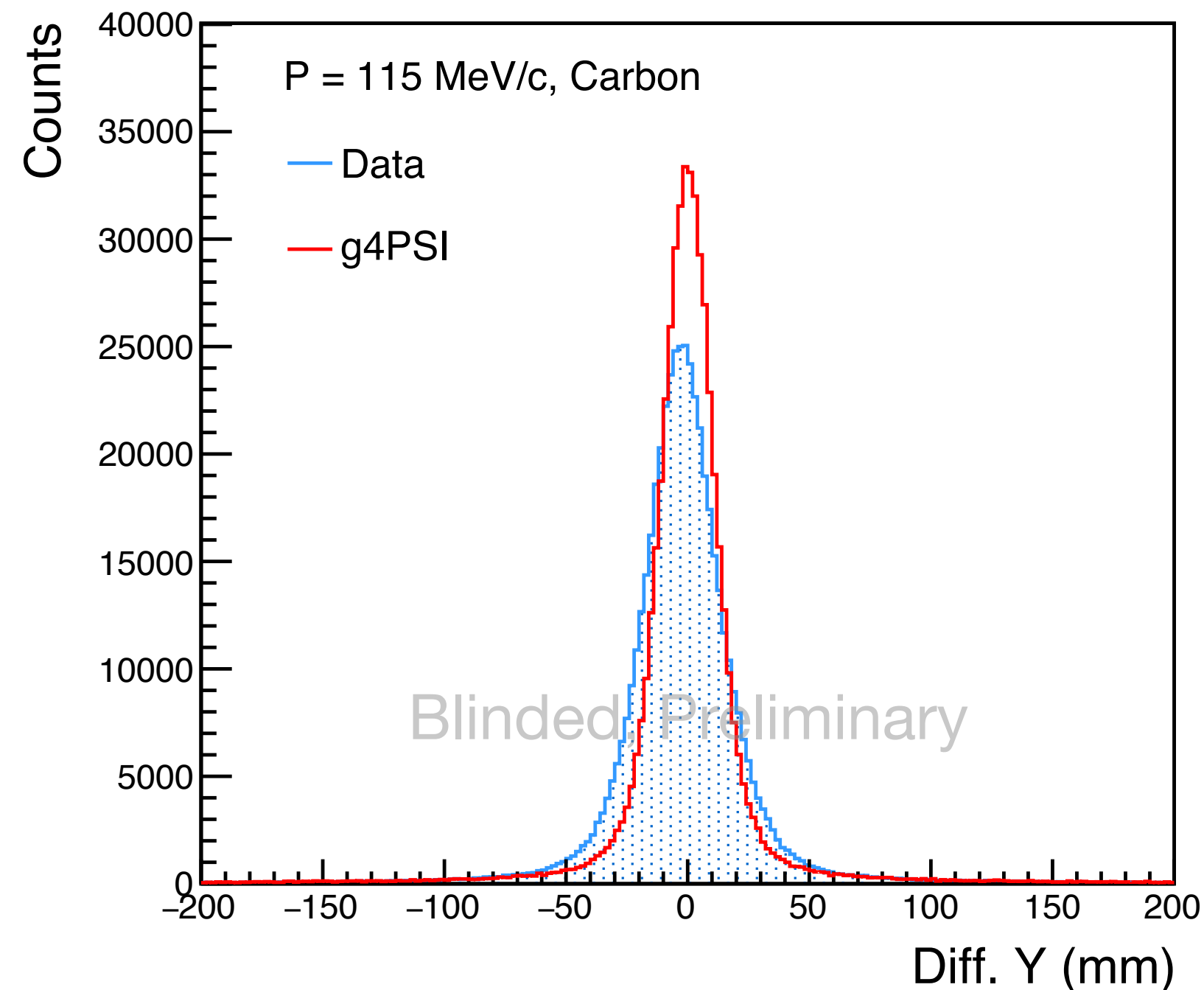
- Plots are in SPS local coordinates
- SPS X: center of the hit paddle
 - width: 60 mm wide bar
- SPS Y: time difference between two PMTs of the paddle
 - Width: position resolution of PMT time difference
- Further work needed



STT Track X - SPSLF X

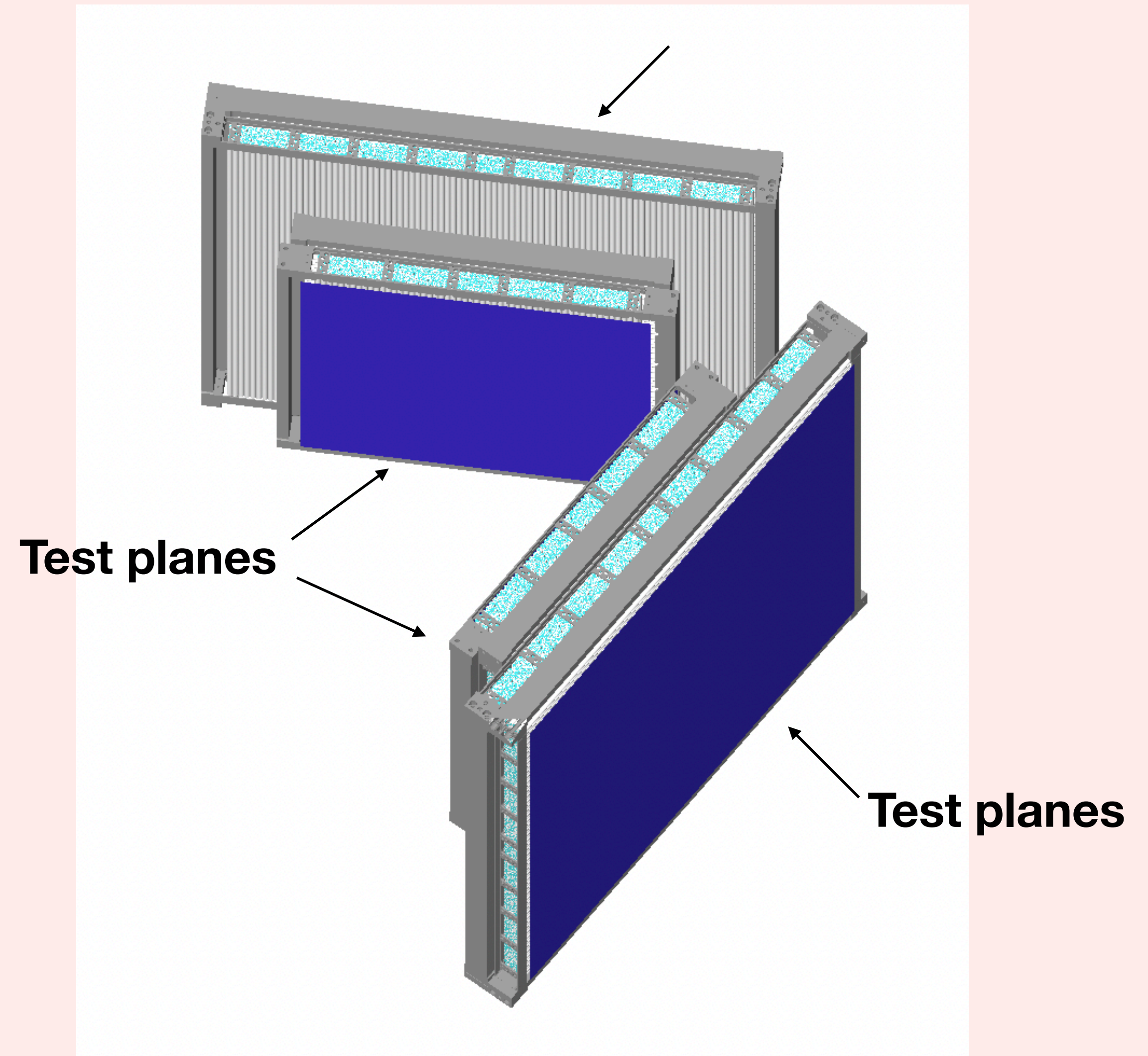


STT Track Y - SPSLF Y



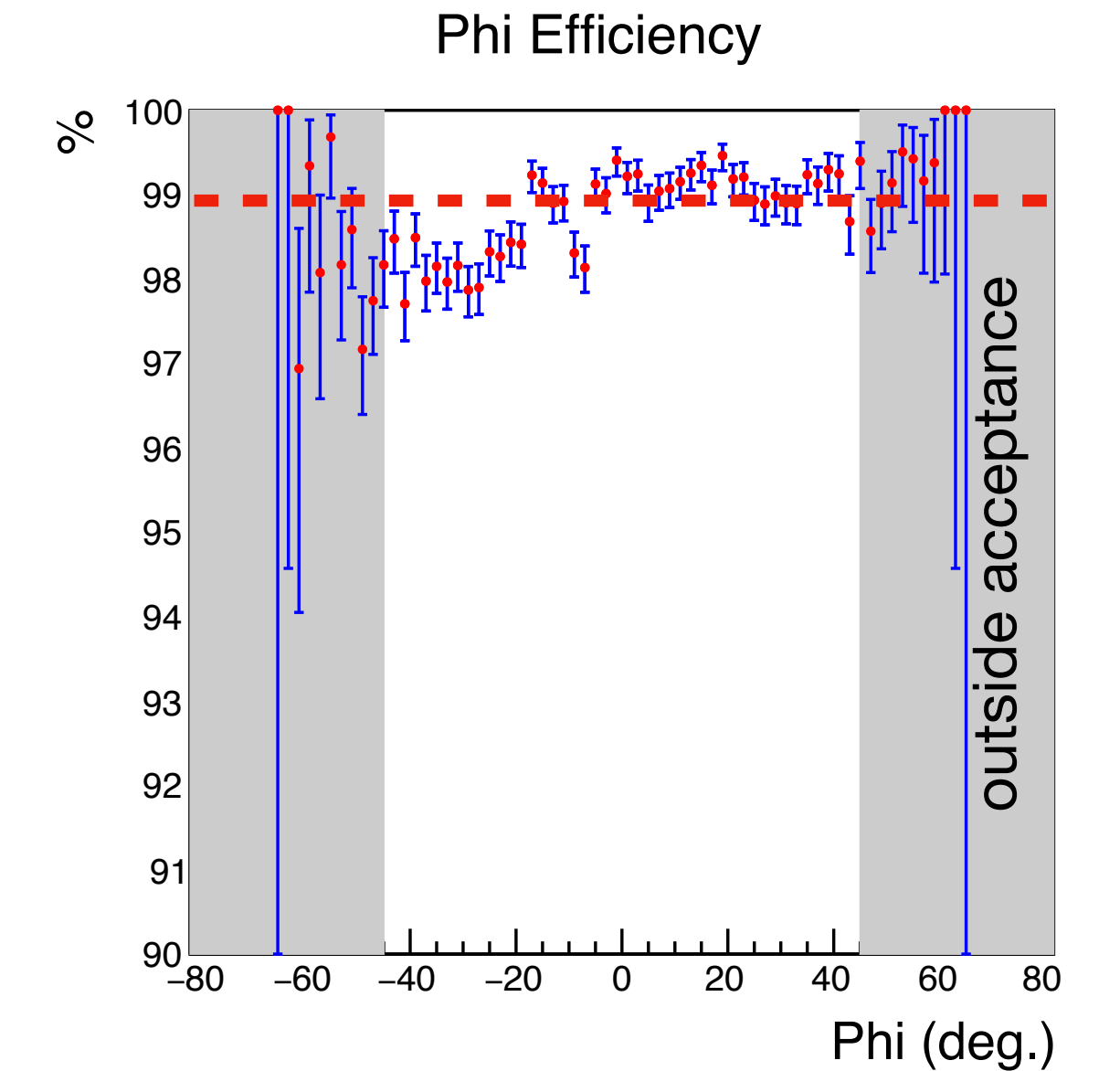
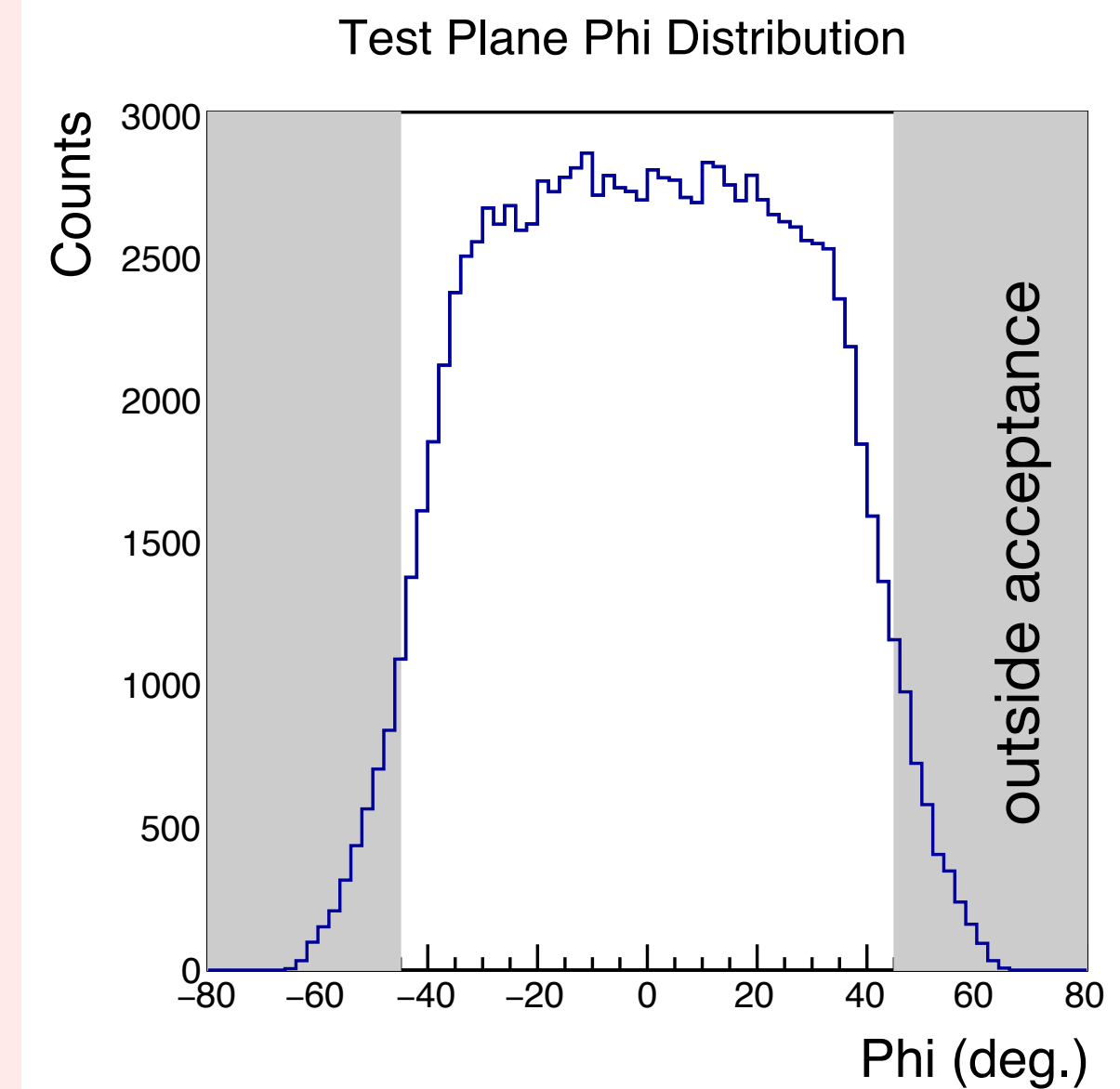
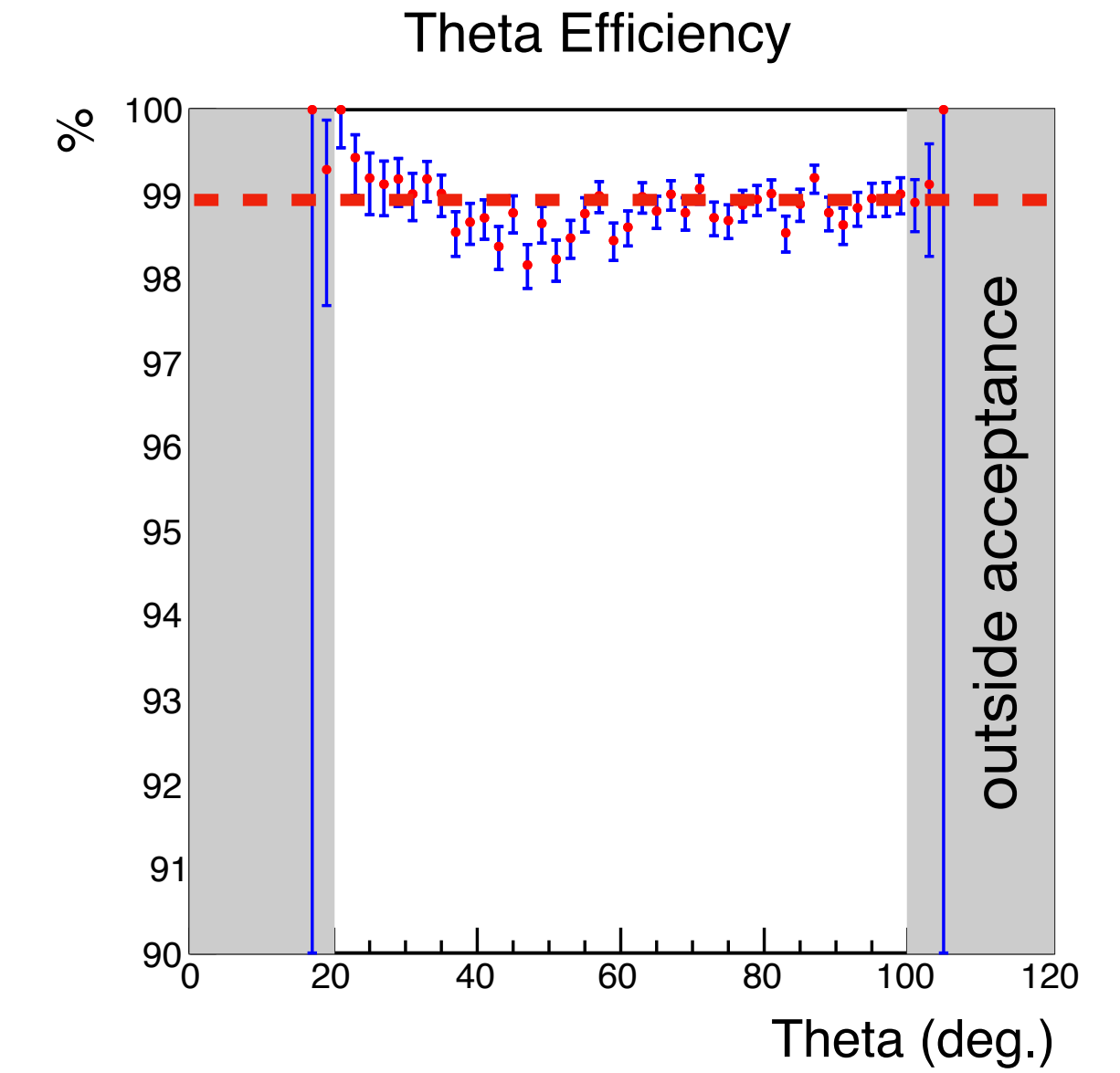
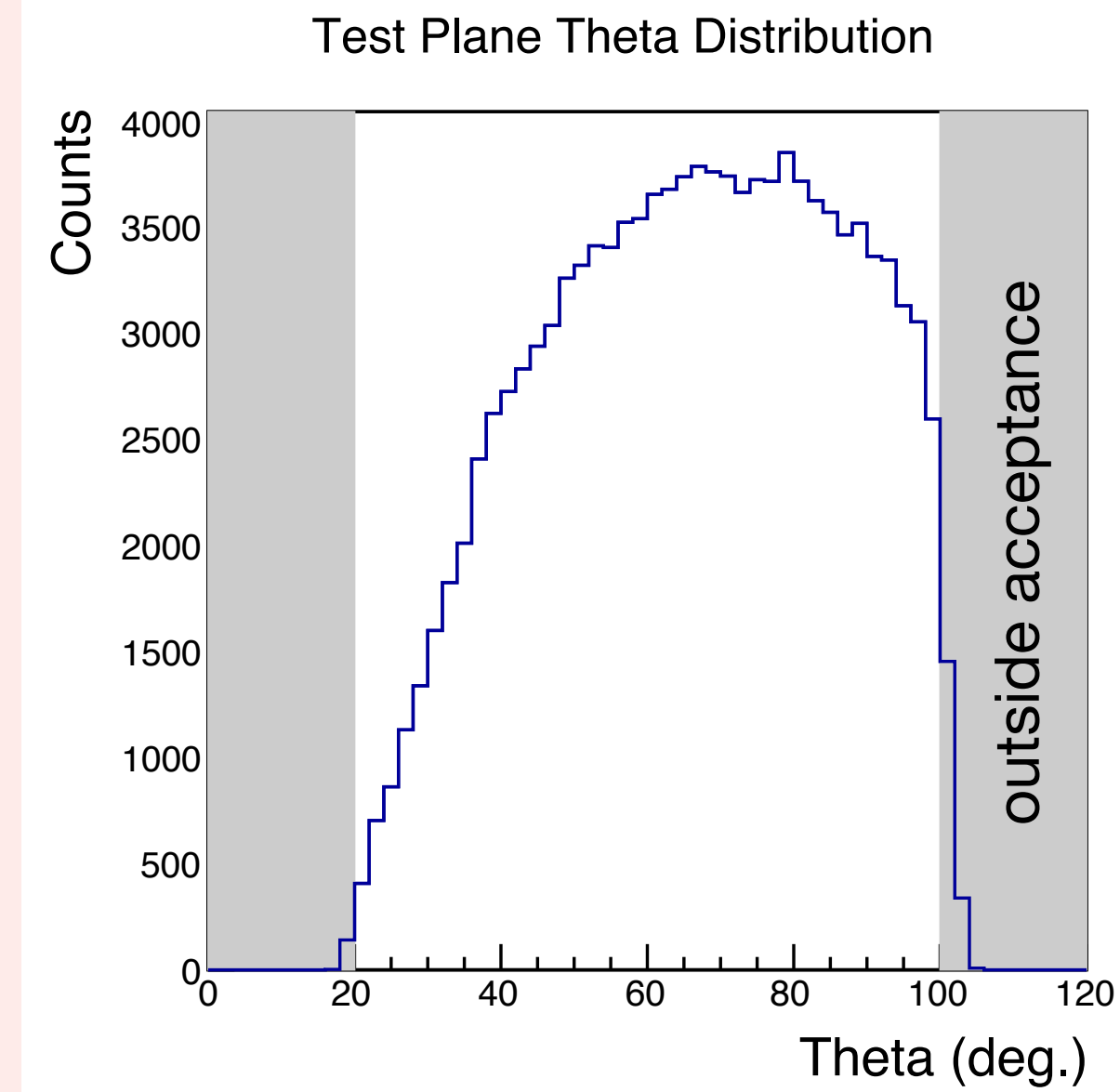
For SPSLF01 (forward paddle)

- Calculated from simulation
- Place test planes before and after STTs
- Beam: 115 MeV/c e⁻, 4π from target
- Select clean single track in simulation
- $\epsilon = \text{\#tracks} / \text{\#events passing both test planes}$



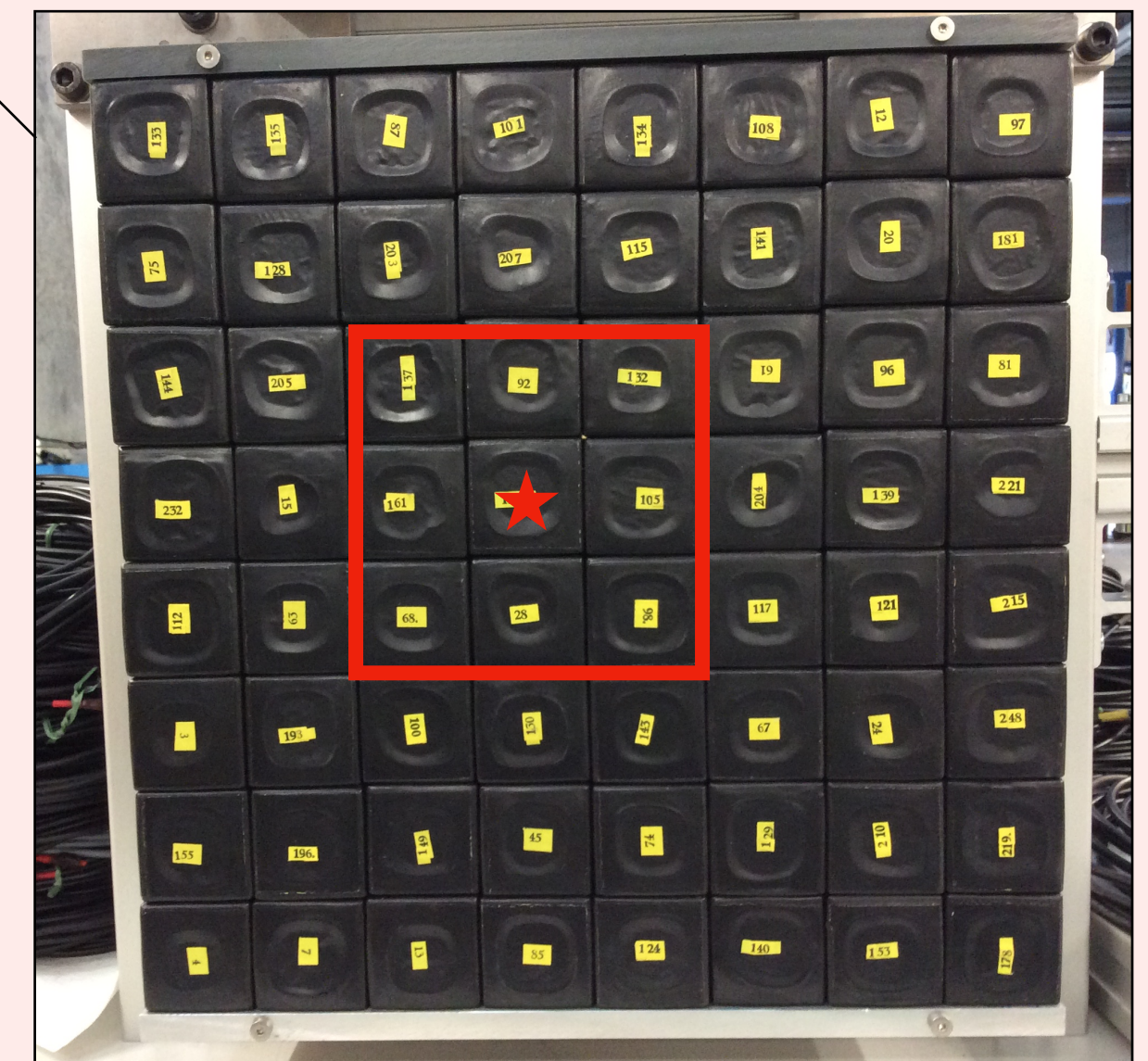
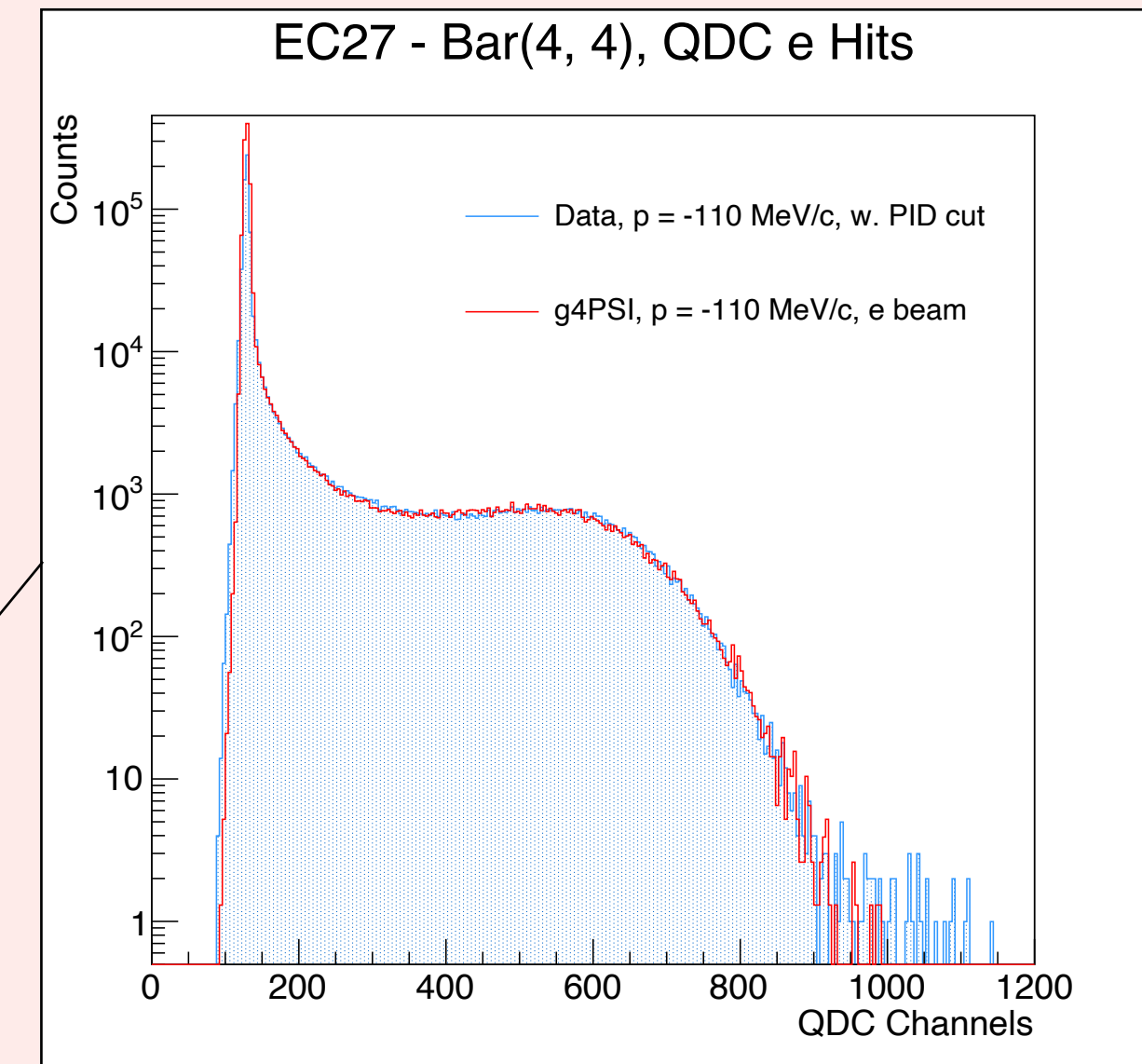
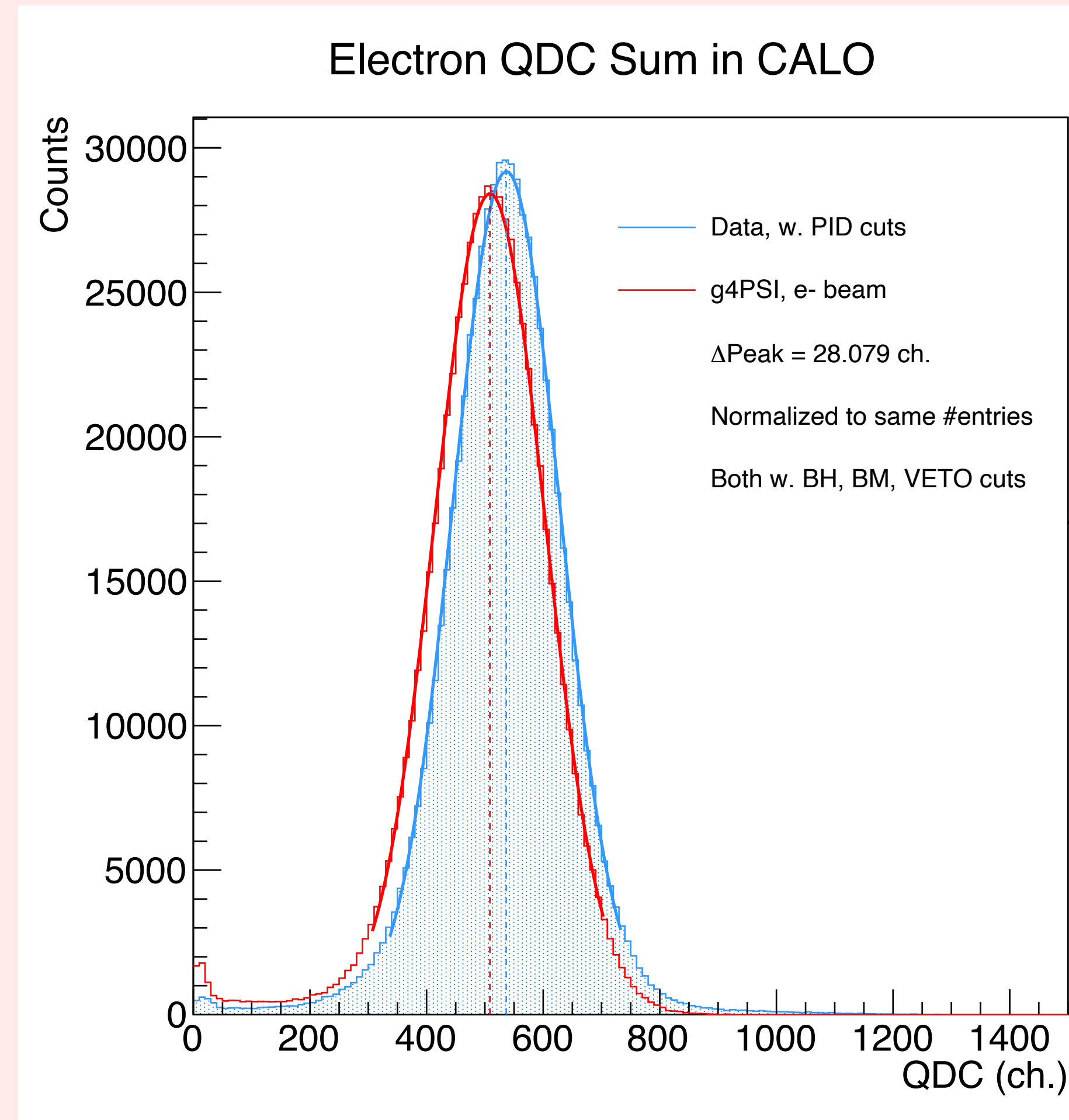
Tracking Efficiency

- 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

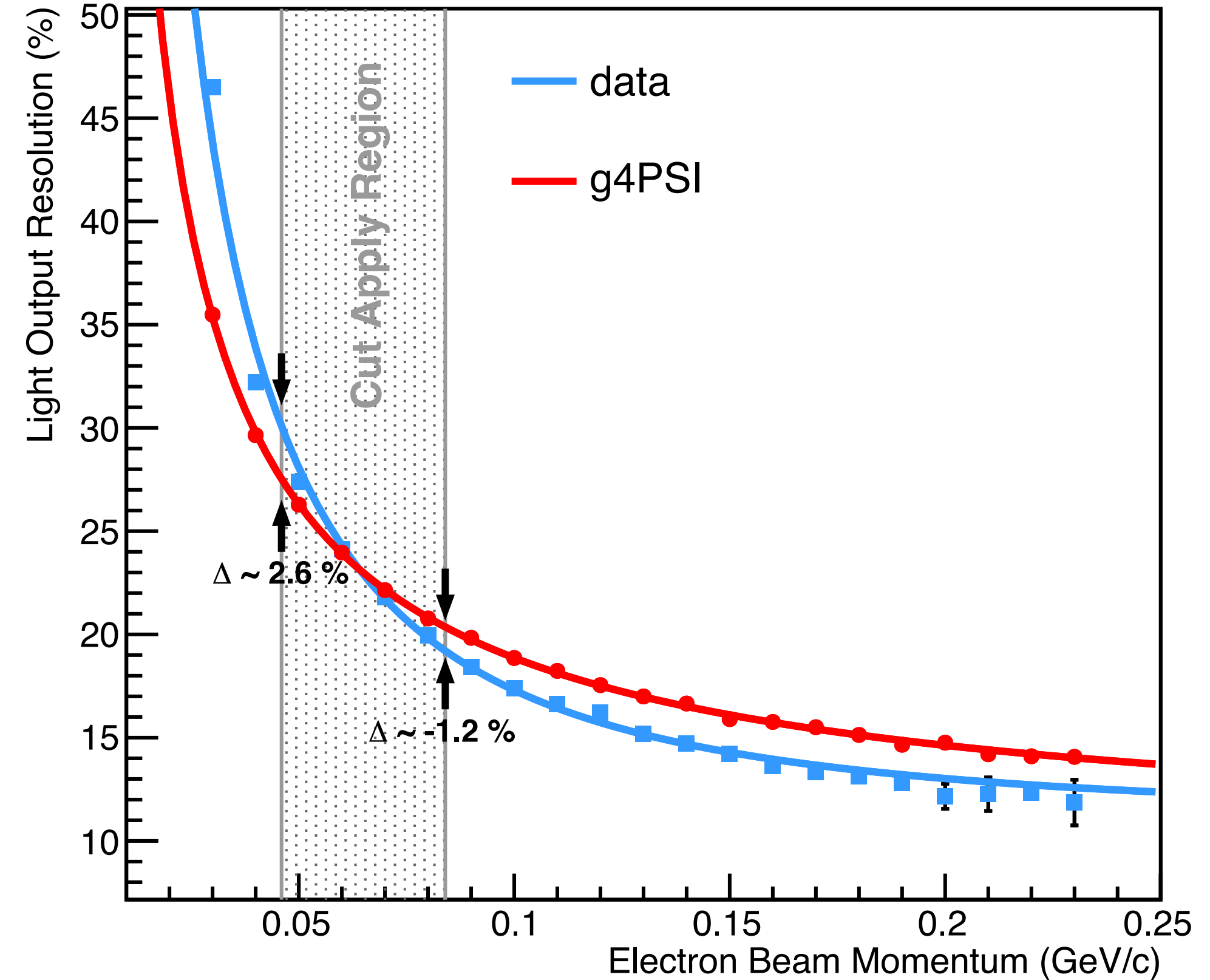
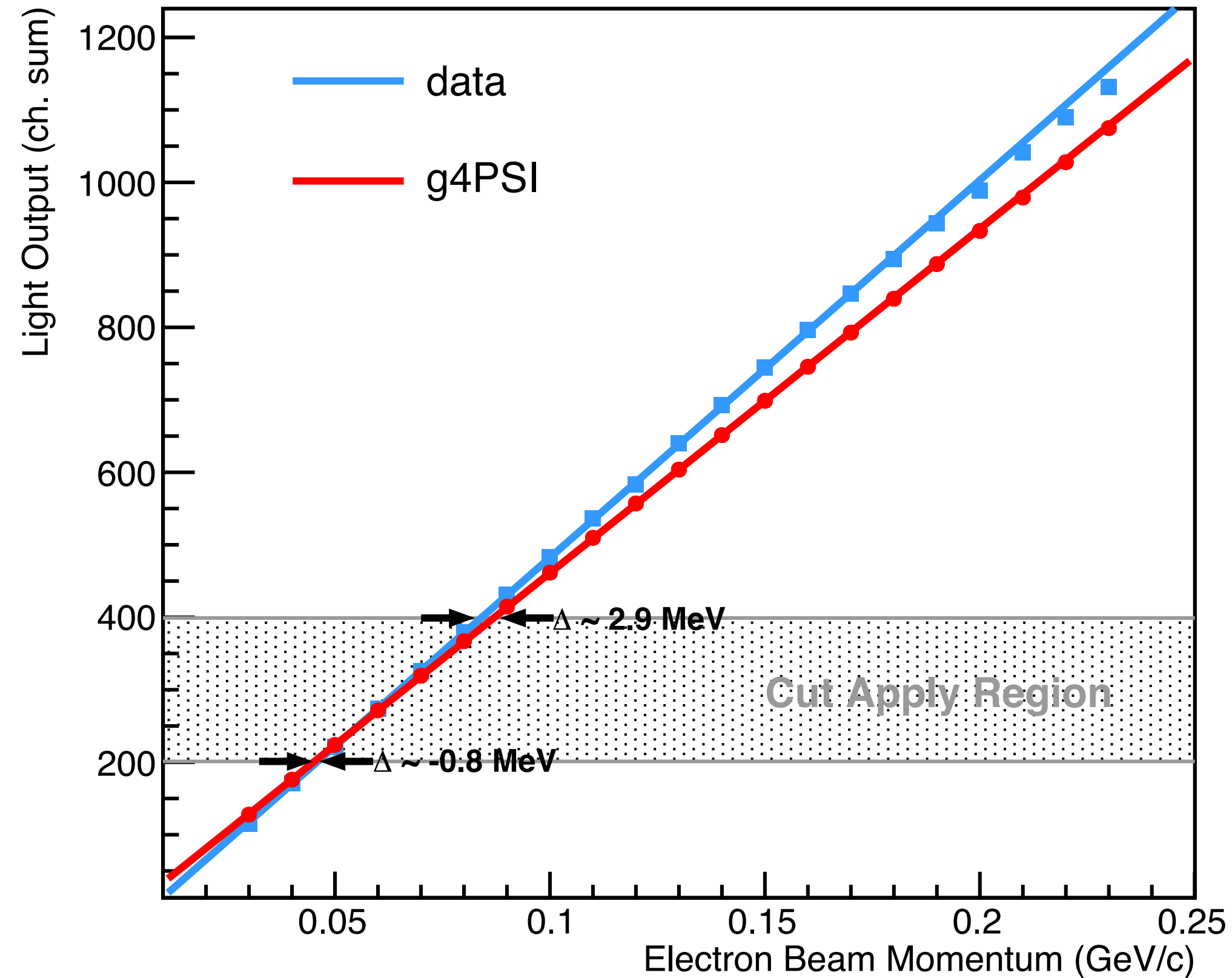


Calorimeter Energy

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



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



- GEM tracking: shows good agreement between data and simulation,
 - 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 close to 90% for all angles within the MUSE acceptance
- Calorimeter has good energy response and comparison with simulations is already at needed level