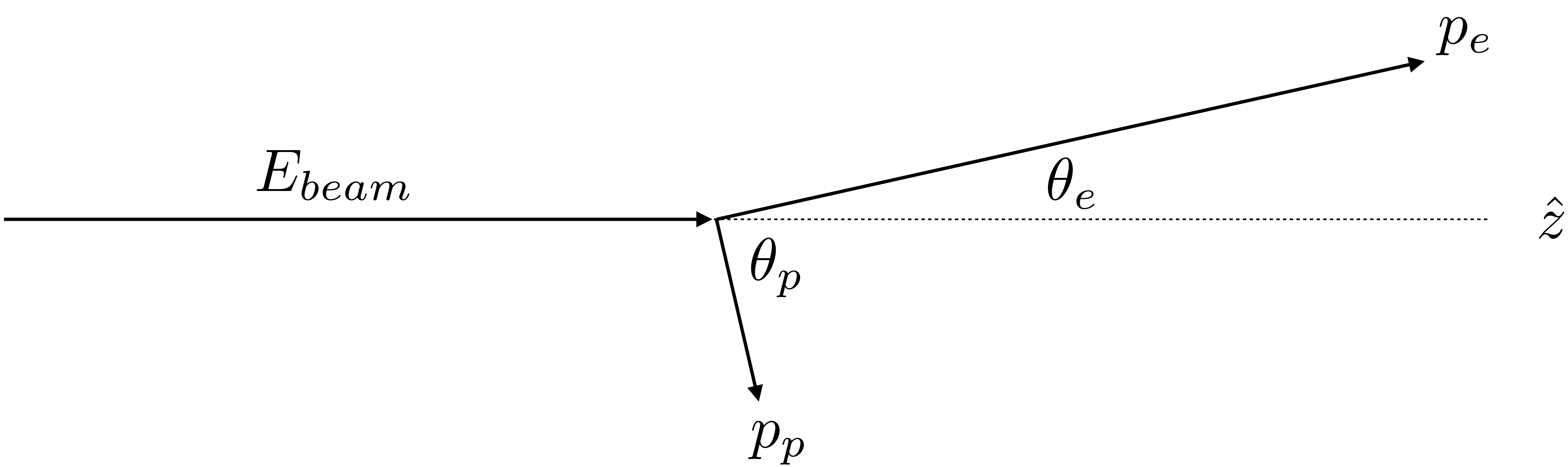
Analysis of Elastic Scattering with CLAS12

David Riser, UConn

Elastic scattering is a good calibration reaction.

$$ep \to e'p'$$

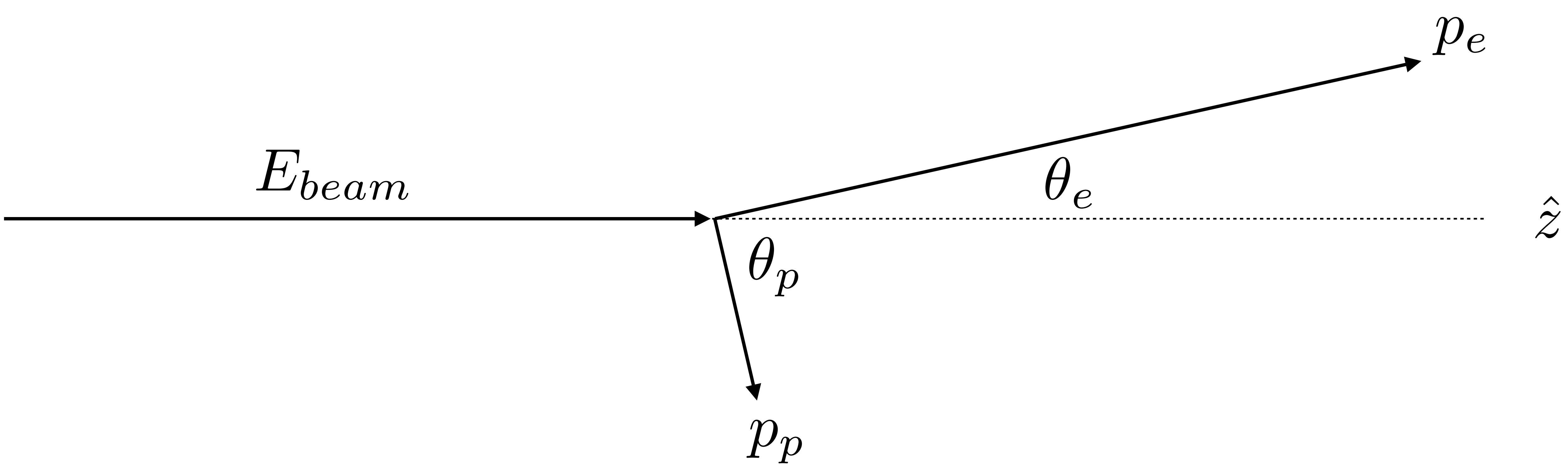


$$(E_{beam}, p_e, p_p, \theta_e, \theta_p)$$

If you know two of these, you can calculate the other three.

Elastic scattering is a good calibration reaction.

$$ep \rightarrow e'p'$$



$$(E_{beam}, p_e, p_p, \theta_e, \theta_p)$$

If you know two of these, you can calculate the other three.

Today we will use the electron angle and beam energy to predict the other three variables.

The data used for these studies comes from RG-A.

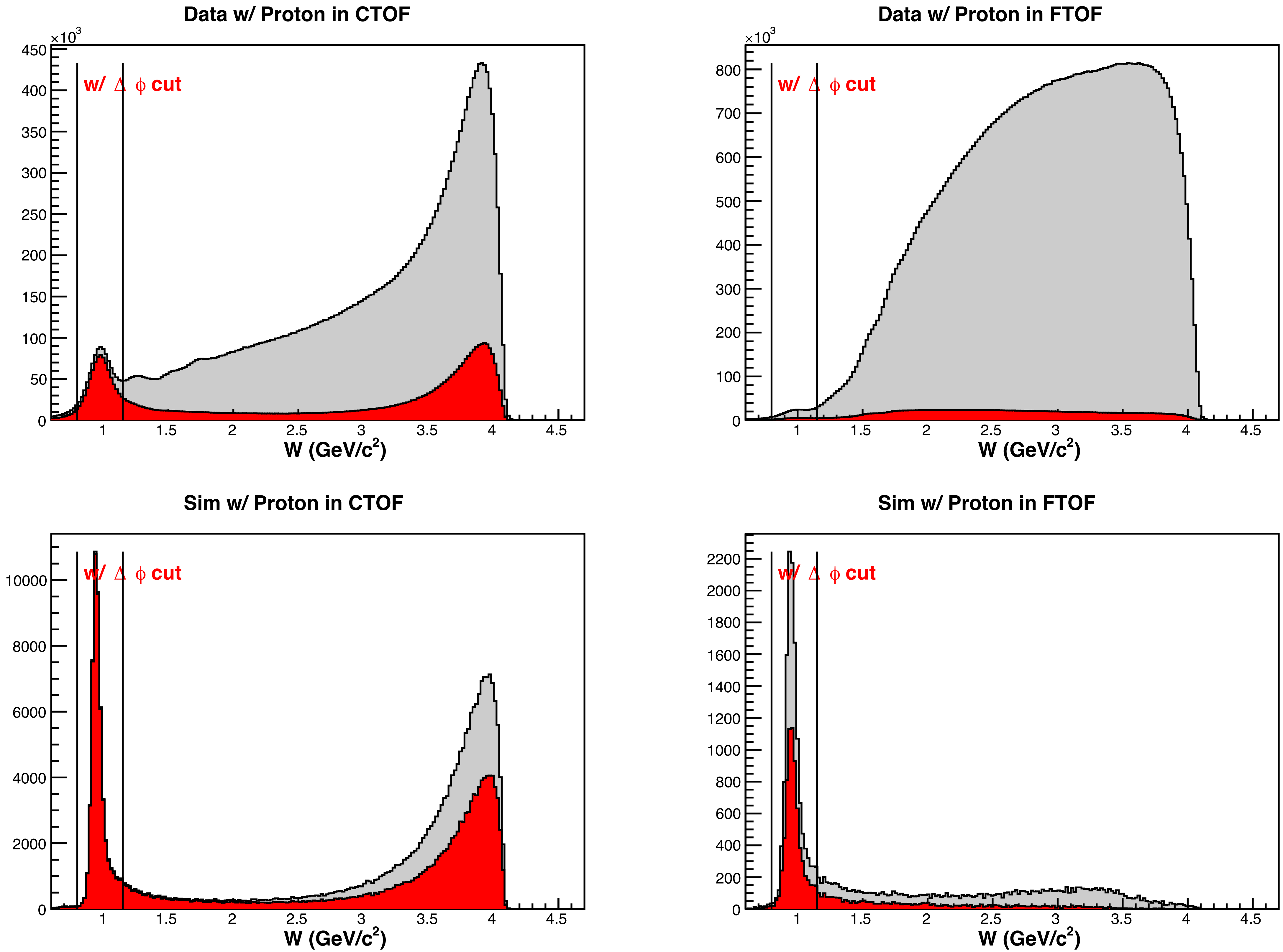
Data Run Period	RG-A F18
Total Runs	64
Torus Field	Electron Inbending (full strength)
Location	/work/clas12/rg-a/trains/v16_v2/skim4_inclusive/

Event Generator	Elastic + Radiative Effects (ESEPP)
Total Events Gen	5M
Torus Field	Electron Inbending (full strength)
Location	Unknown

* coatjava 6.3.1

Elastic event selection uses two simple cuts.

* Cut on W around the proton mass
* Cut on the coplanar angle between e-p



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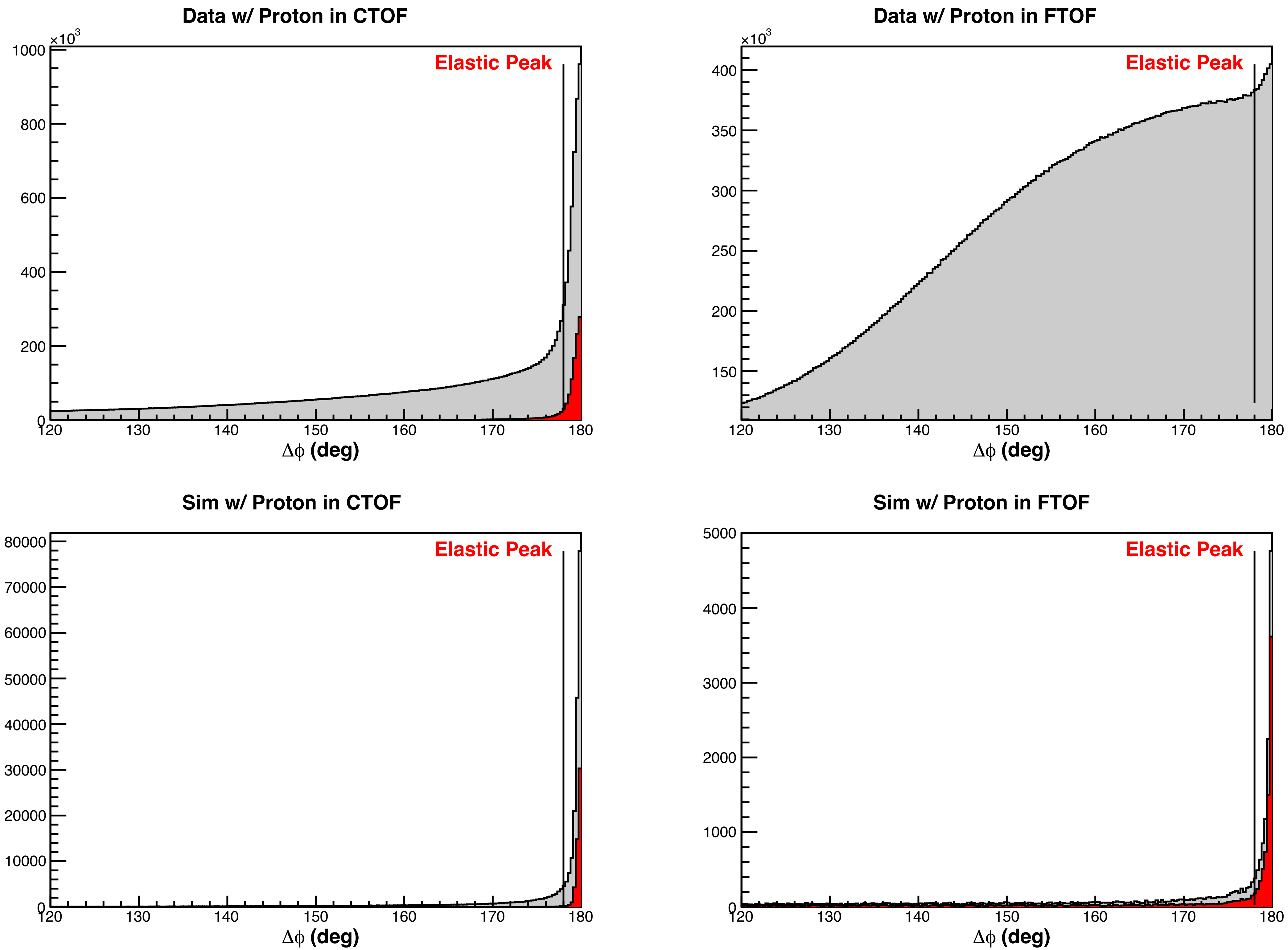
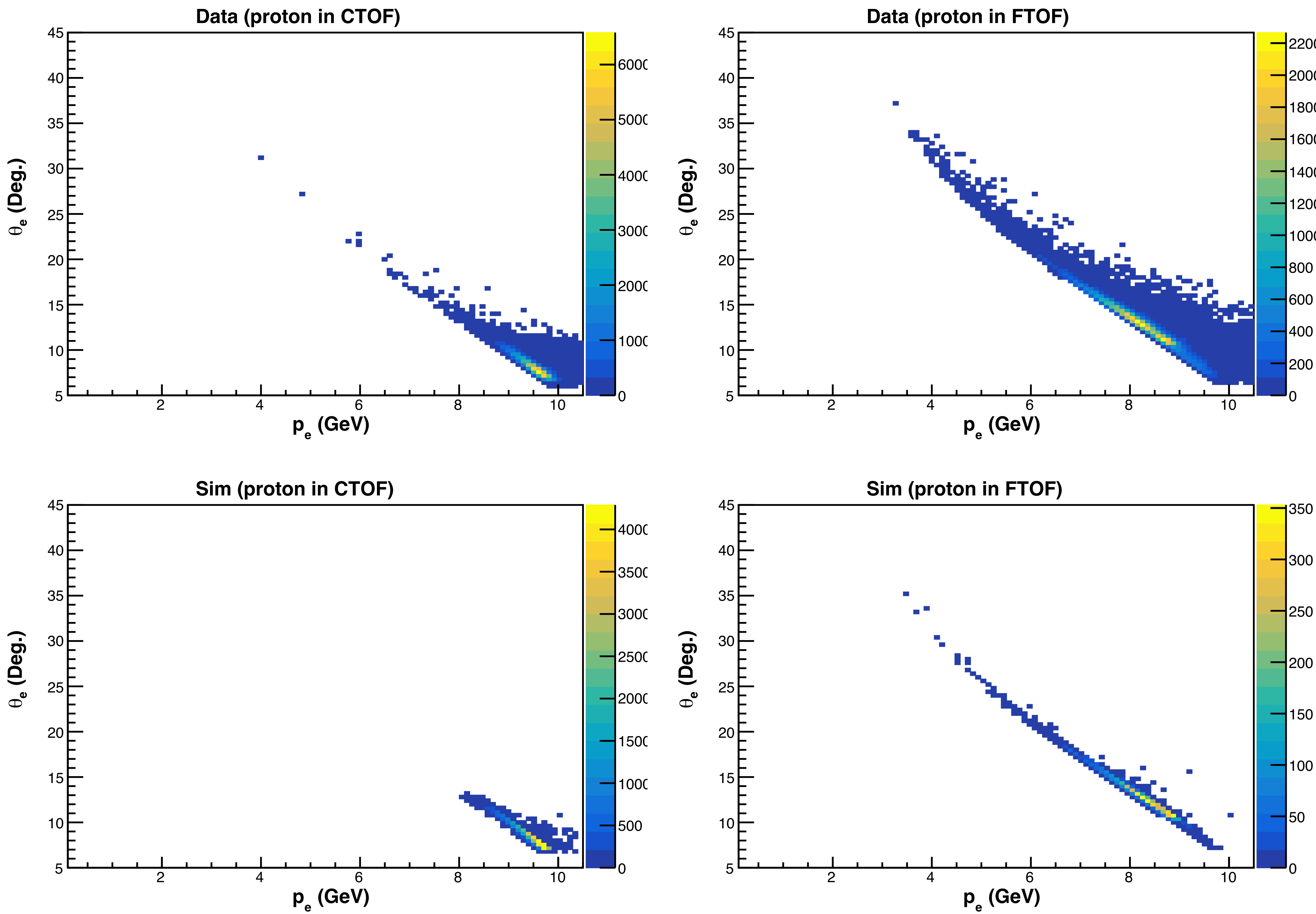


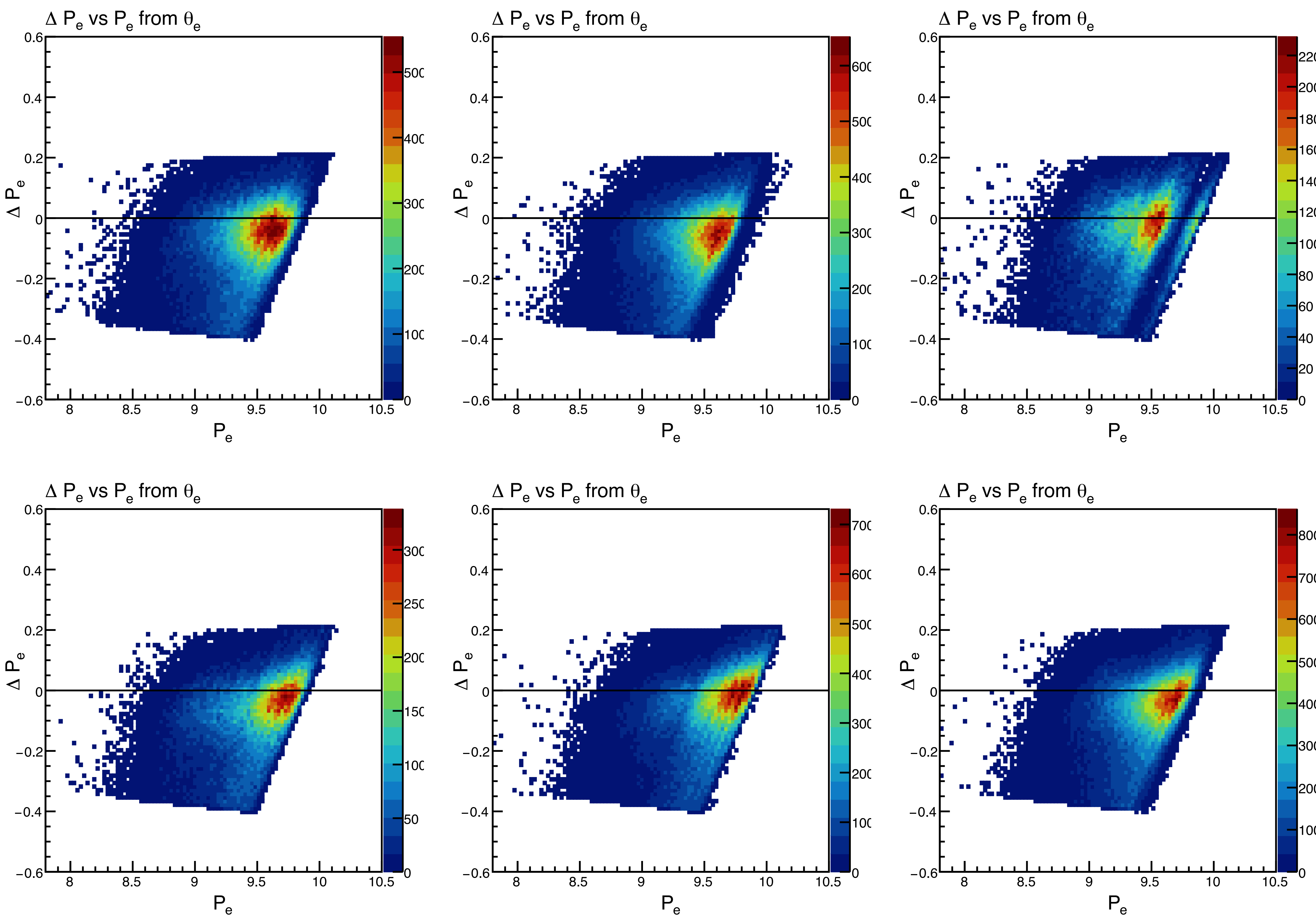
After event selection, we can look at the (small) phase space of elastic events.



We can pause at this point and draw some basic conclusions.

* The phase space is very small; consisting of high energy (low angle) electrons.
* Elastic events are mostly split between forward (electron) and central (proton), but there are some forward/forward events.

Momentum and theta resolutions have been measured for central.



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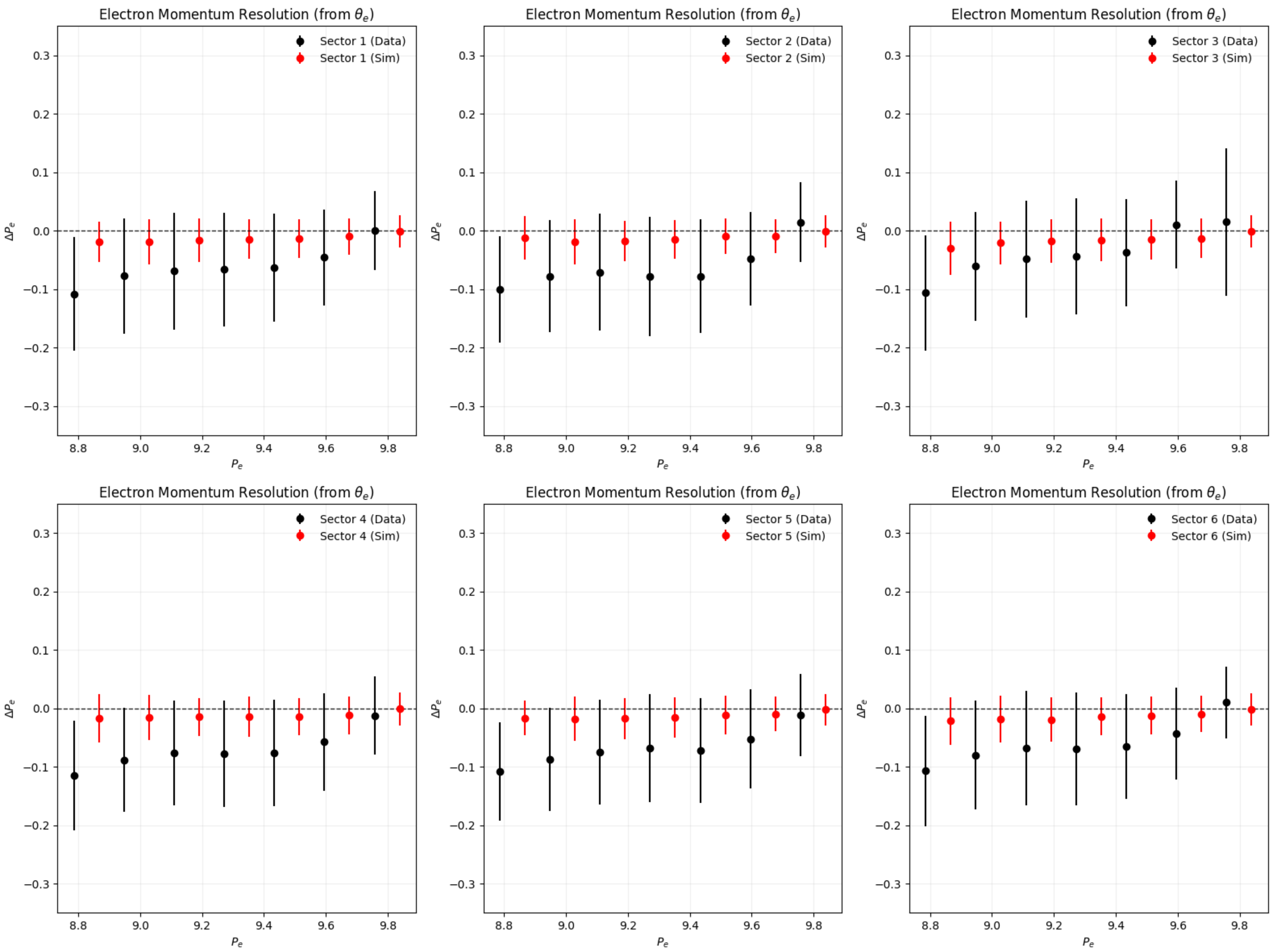

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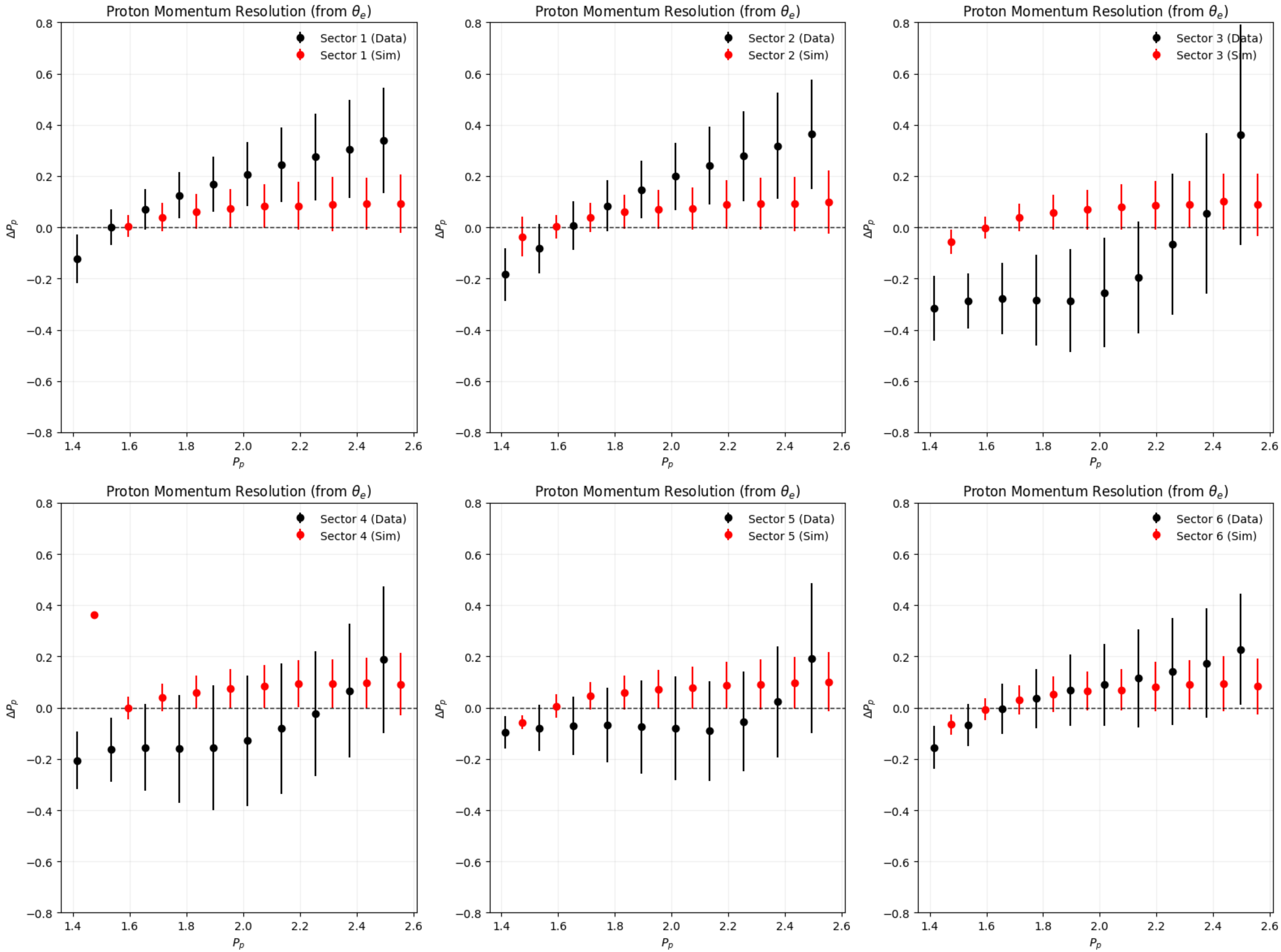


Some takeaways from this analysis:

- Most protons are incident on the central detector, which is largely ignored by analysts at this stage of analysis.
- By trusting the electron angle, the (fractional) momentum resolutions (forward/central split) are roughly given by:

$$\delta p_e / p_e \approx 1\%$$
$$\delta p_p / p_p \approx 10\%$$

Some directions forward include:

- Analyzing the smaller sample of forward/forward elastic events.
- Understanding shifts away from zero in data (magnetic field or geometry or something else).
- Measuring events that have a real photon emitted before/after collision, this should provide us a bigger phase space and (maybe) a larger forward/forward sample.
- Elastic with radiative effects can also be used for radiative corrections (closer to the kinematics used for DVCS/DVMP analyses).

$$ep \to e'p'\gamma$$

- Initial state radiation (ISR) along the beam line and final state radiation along the outgoing electron.
- Neither of these changes the electron/proton angles, so we can keep our coplanarity cut.

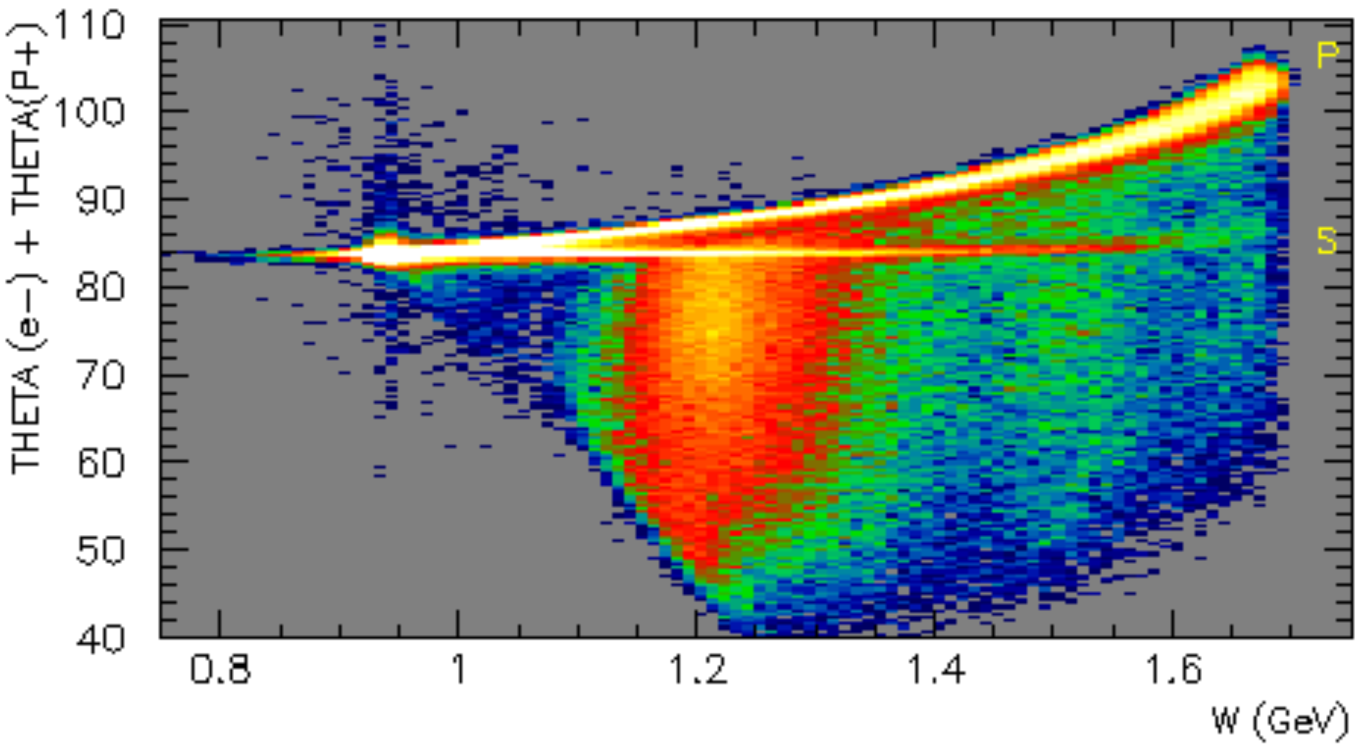
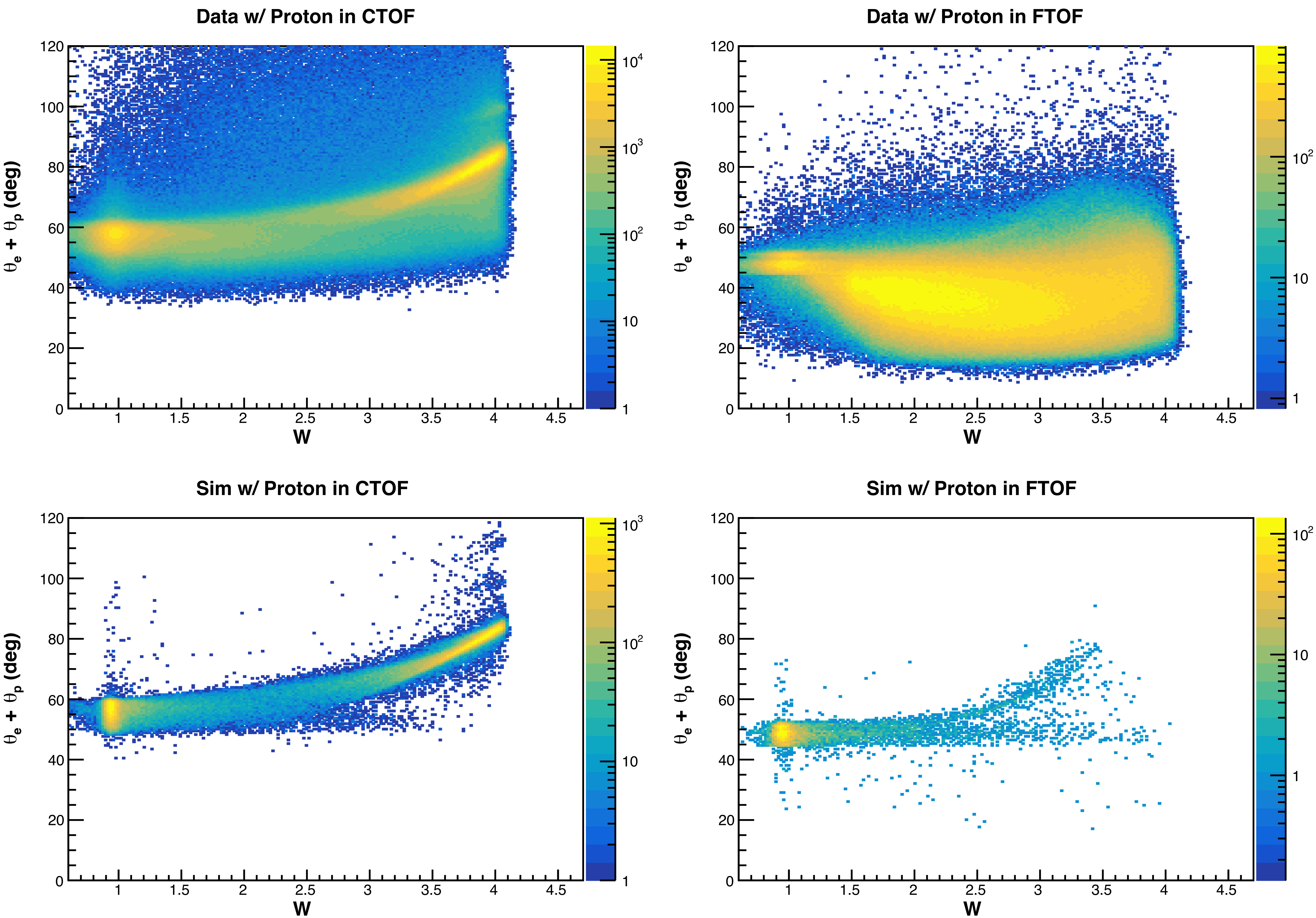


Figure from CLAS (e1e)

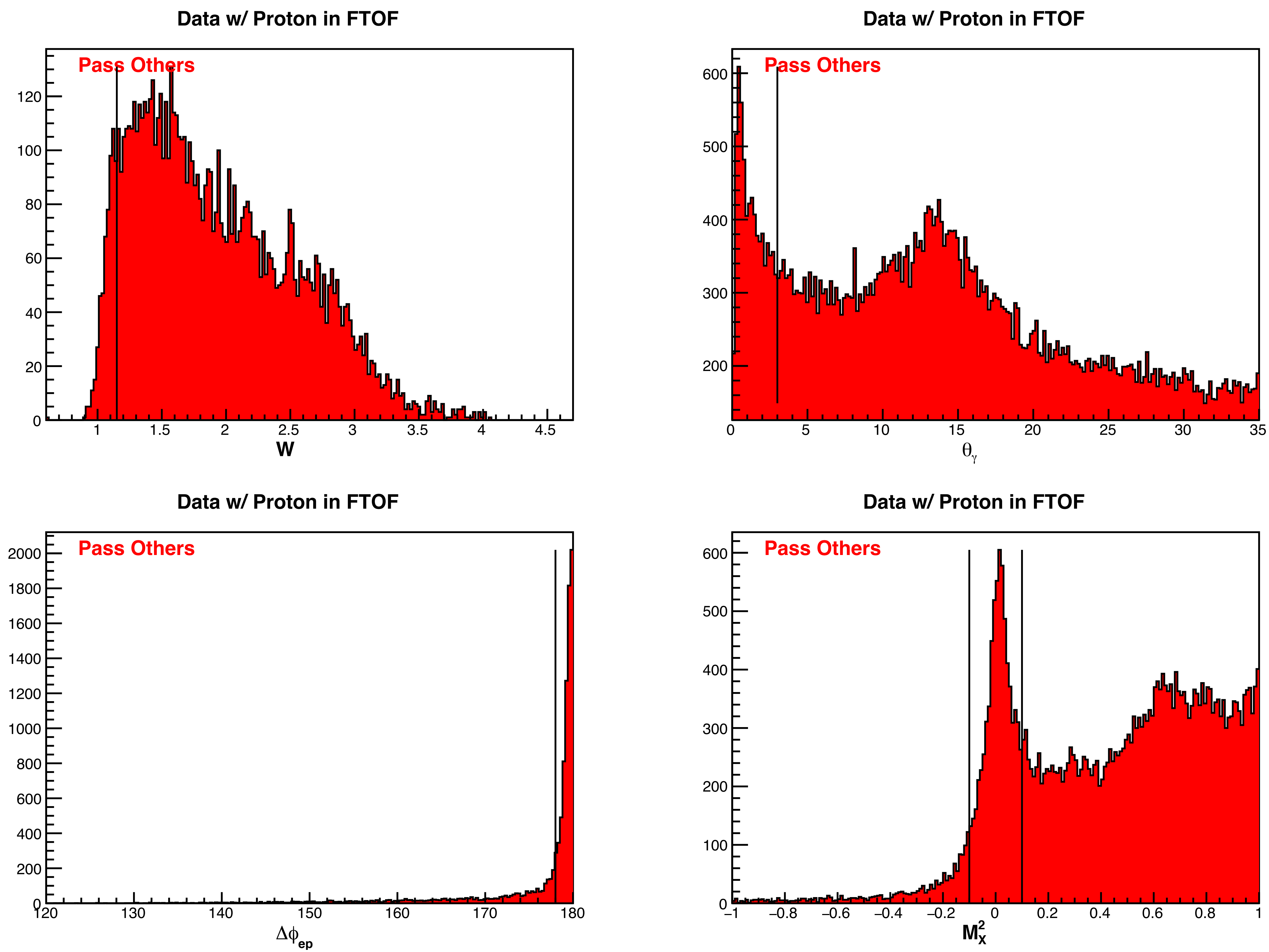


Data w/ Proton in CTOF
Data w/ Proton in FTOF
Sim w/ Proton in CTOF
Sim w/ Proton in FTOF
$\theta_e + \theta_p$ (deg)
W

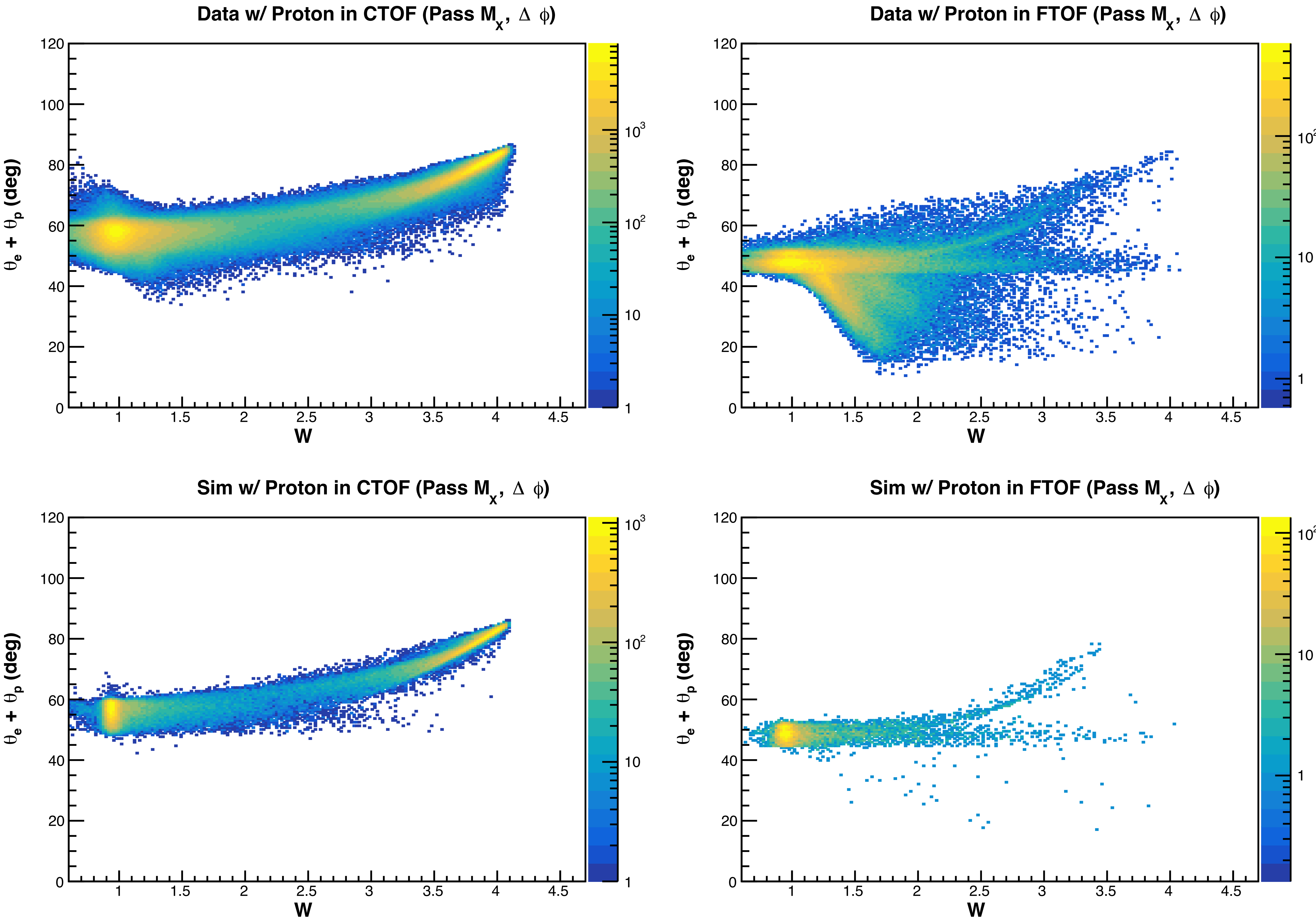
Let’s focus on events with both particles forward (closest to other analyses).

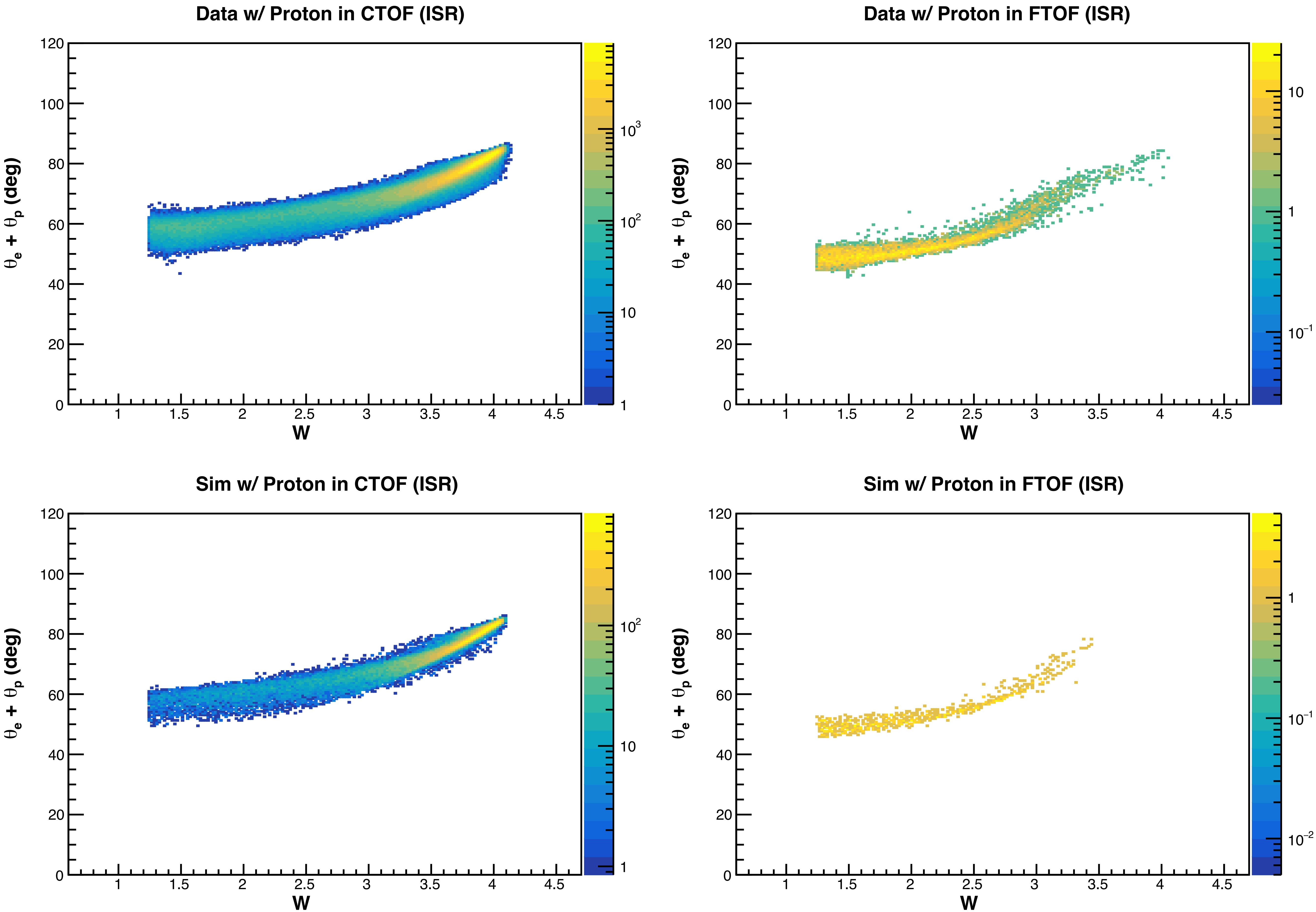
To identify events with initial state radiation we use four cuts.

- Coplanarity cut (same as elastic)
- W above elastic
- Missing mass cut
- Missing particle angular cut (along beamline)



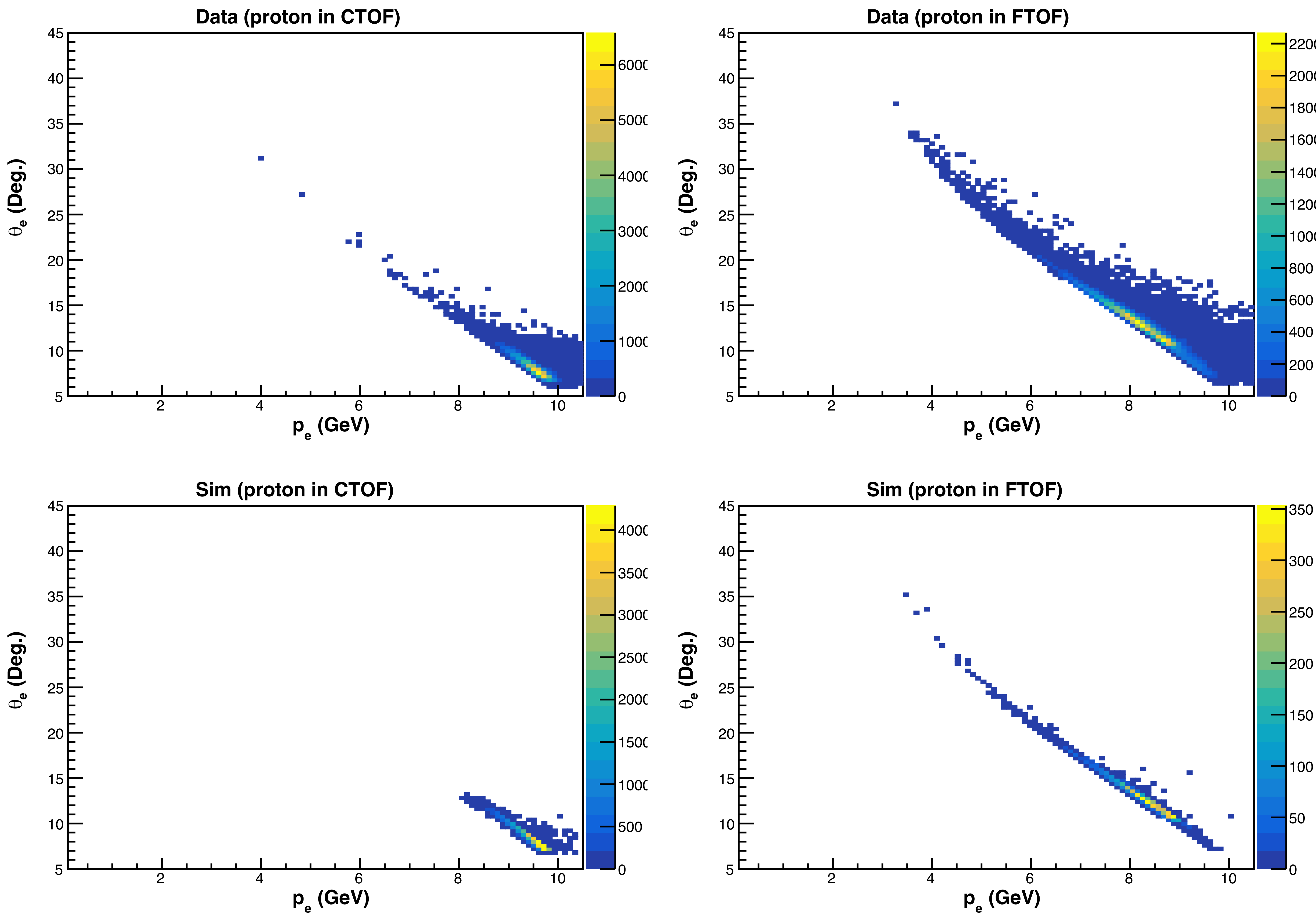
Data w/ Proton in FTOF
Pass Others
W
Data w/ Proton in FTOF
Pass Others
θ_γ
Data w/ Proton in FTOF
Pass Others
$\Delta\phi_{ep}$
Data w/ Proton in FTOF
Pass Others
M_X^2


Data w/ Proton in CTOF (Pass M_x, Δ ϕ)
Data w/ Proton in FTOF (Pass M_x, Δ ϕ)
Sim w/ Proton in CTOF (Pass M_x, Δ ϕ)
Sim w/ Proton in FTOF (Pass M_x, Δ ϕ)
$\theta_e + \theta_p$ (deg)
W



Data w/ Proton in CTOF (ISR)
Data w/ Proton in FTOF (ISR)
Sim w/ Proton in CTOF (ISR)
Sim w/ Proton in FTOF (ISR)
$\theta_e + \theta_p$ (deg)
W

Compare the phase space of elastic to ISR.



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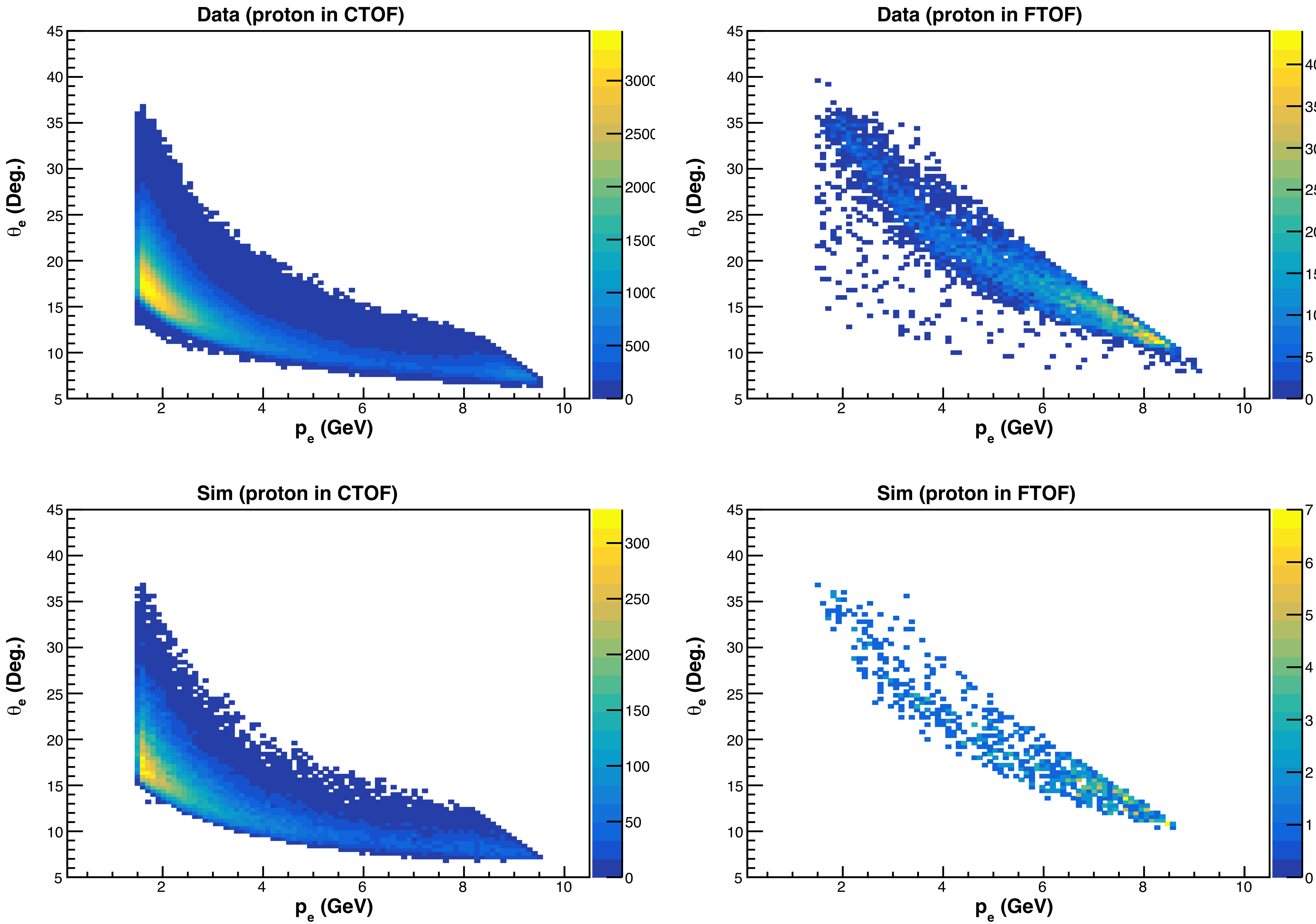


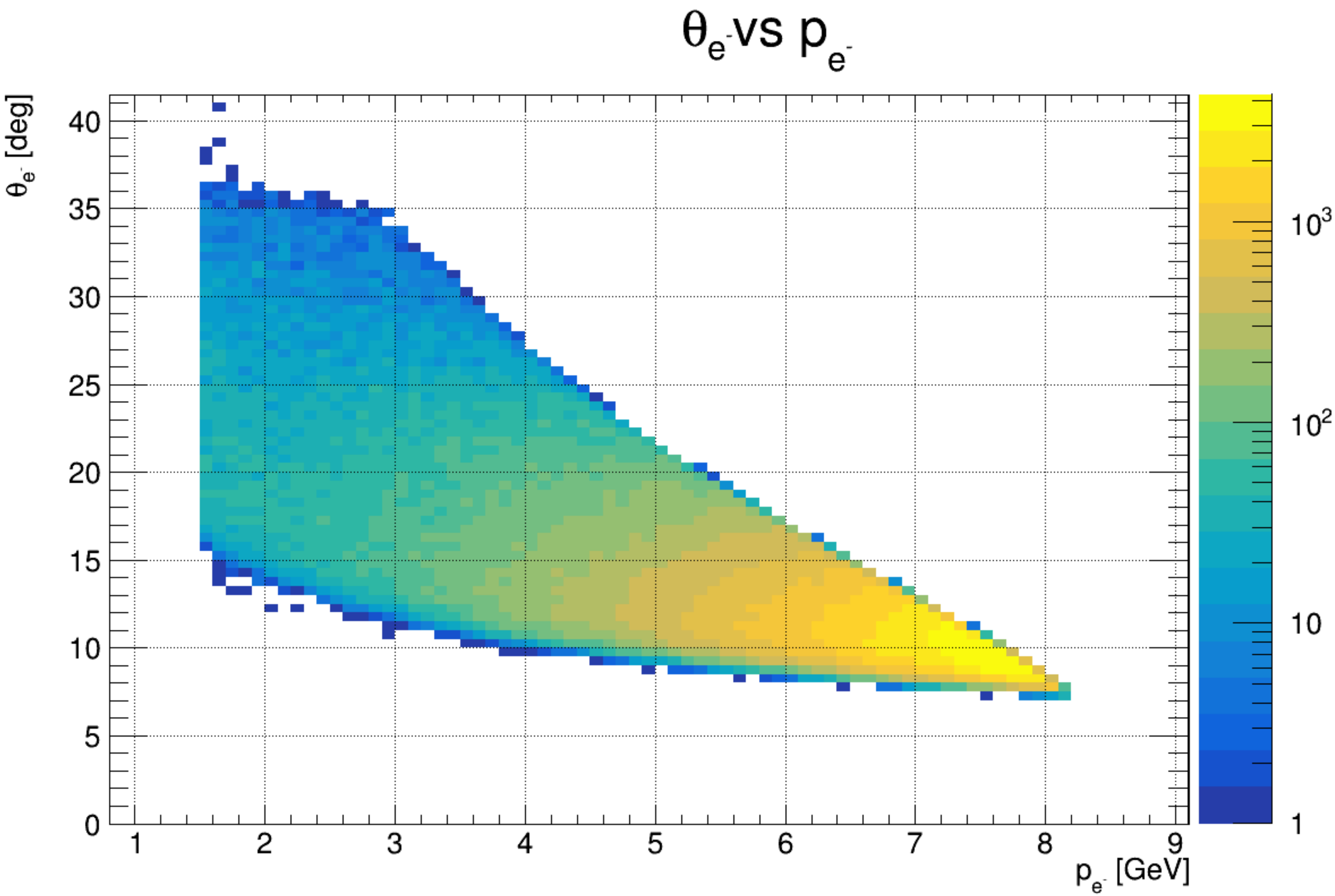


Figure provided by S. Diehl

$$ep \to e'p'\phi$$

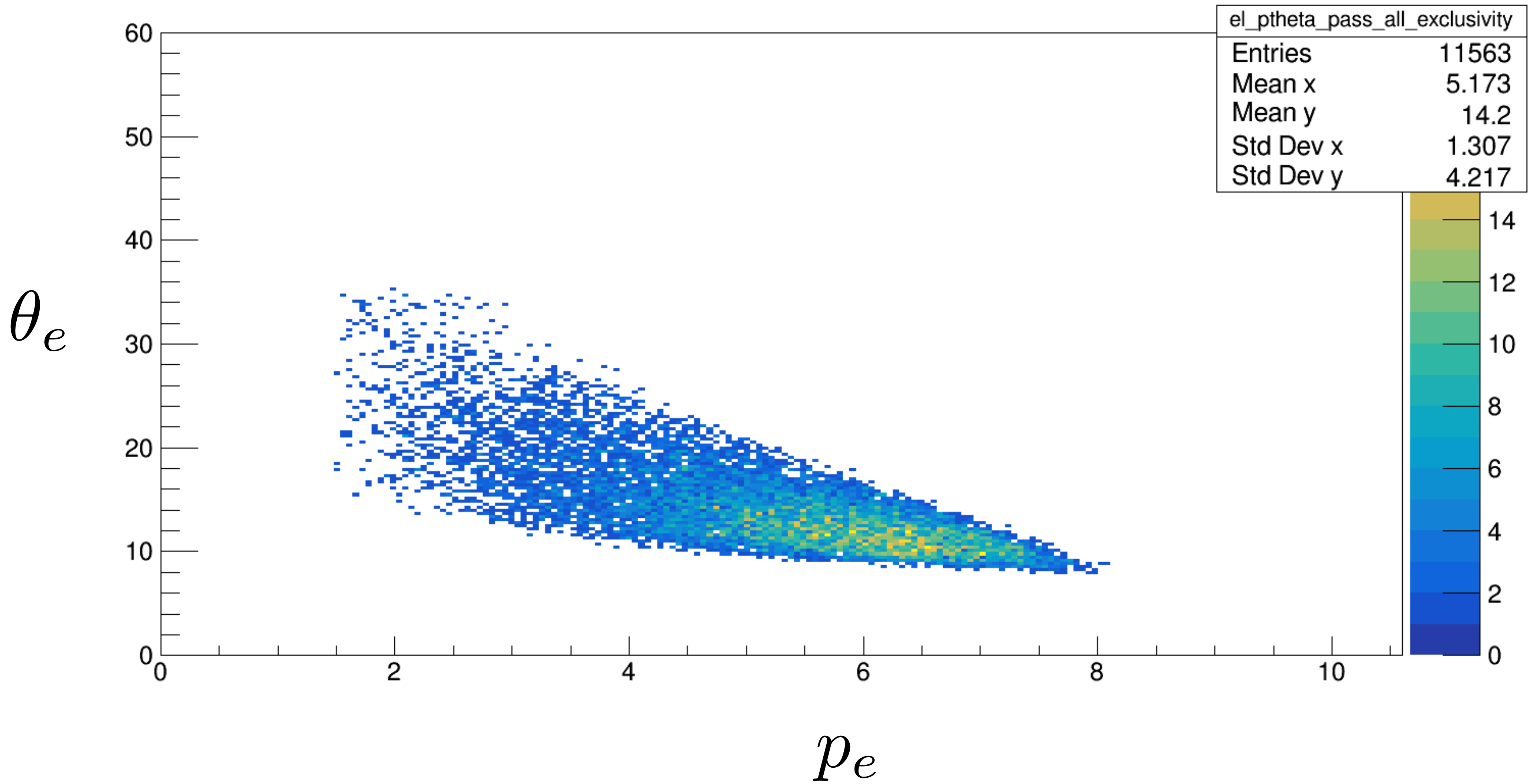


Figure provided by B. Clary

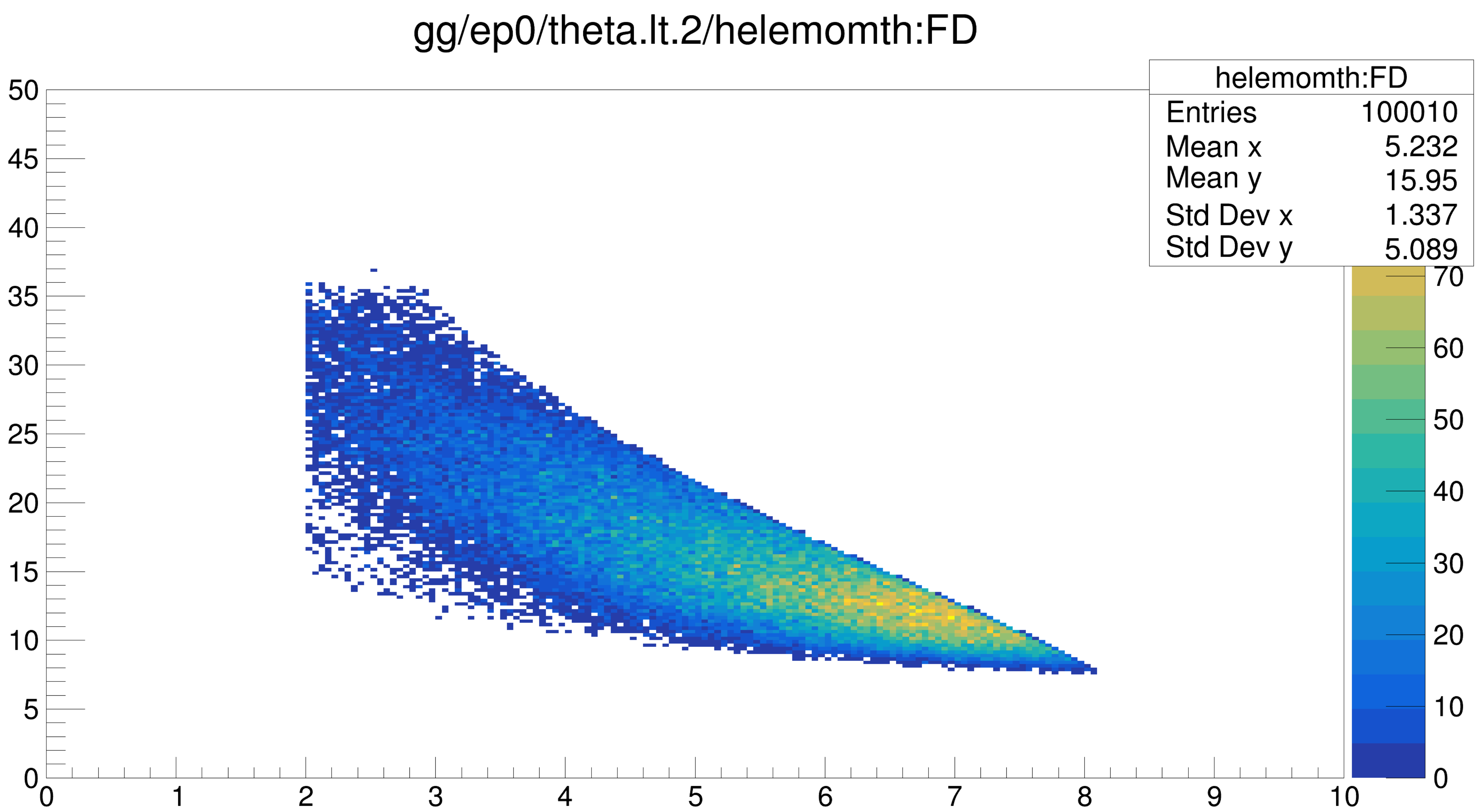
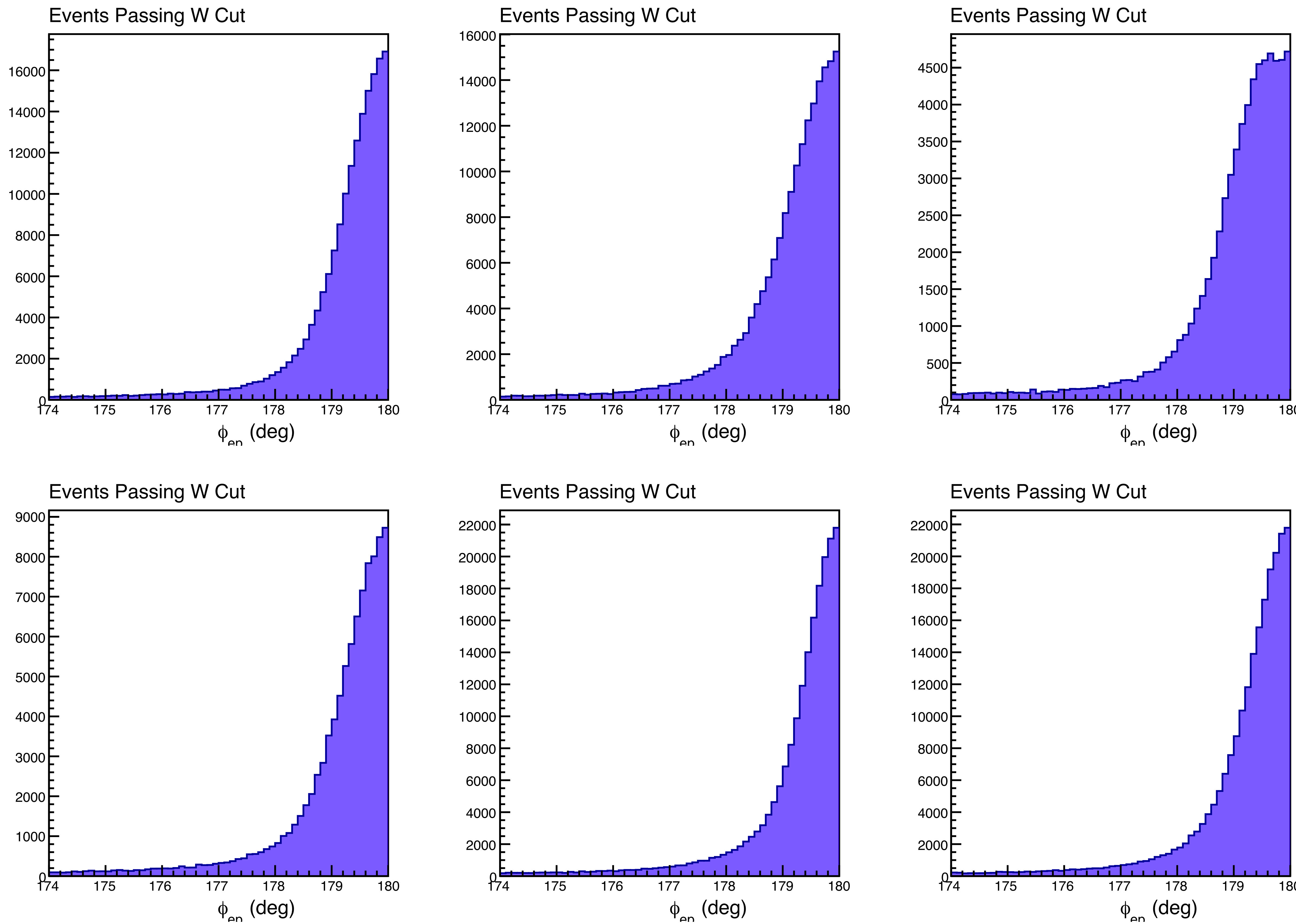
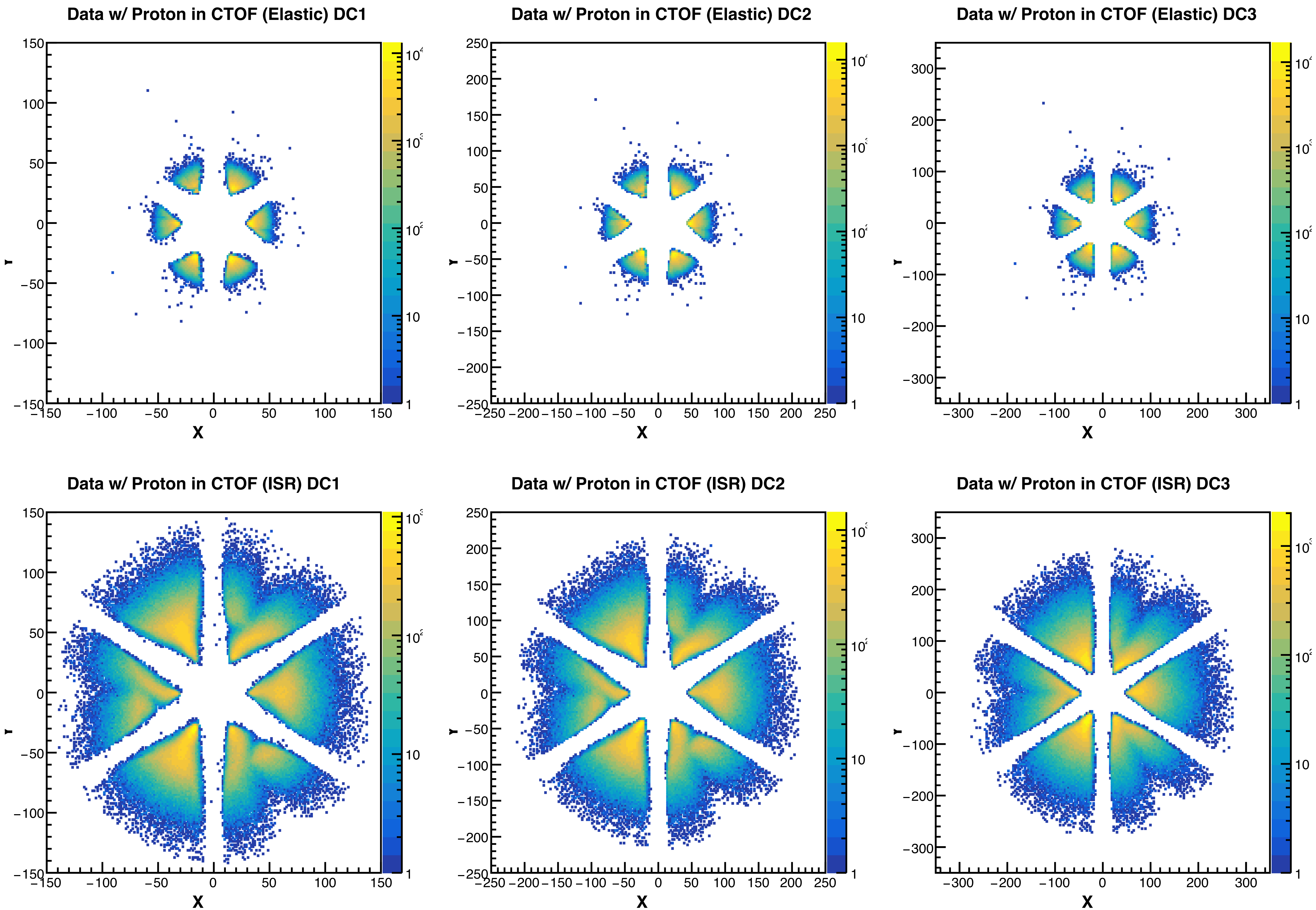


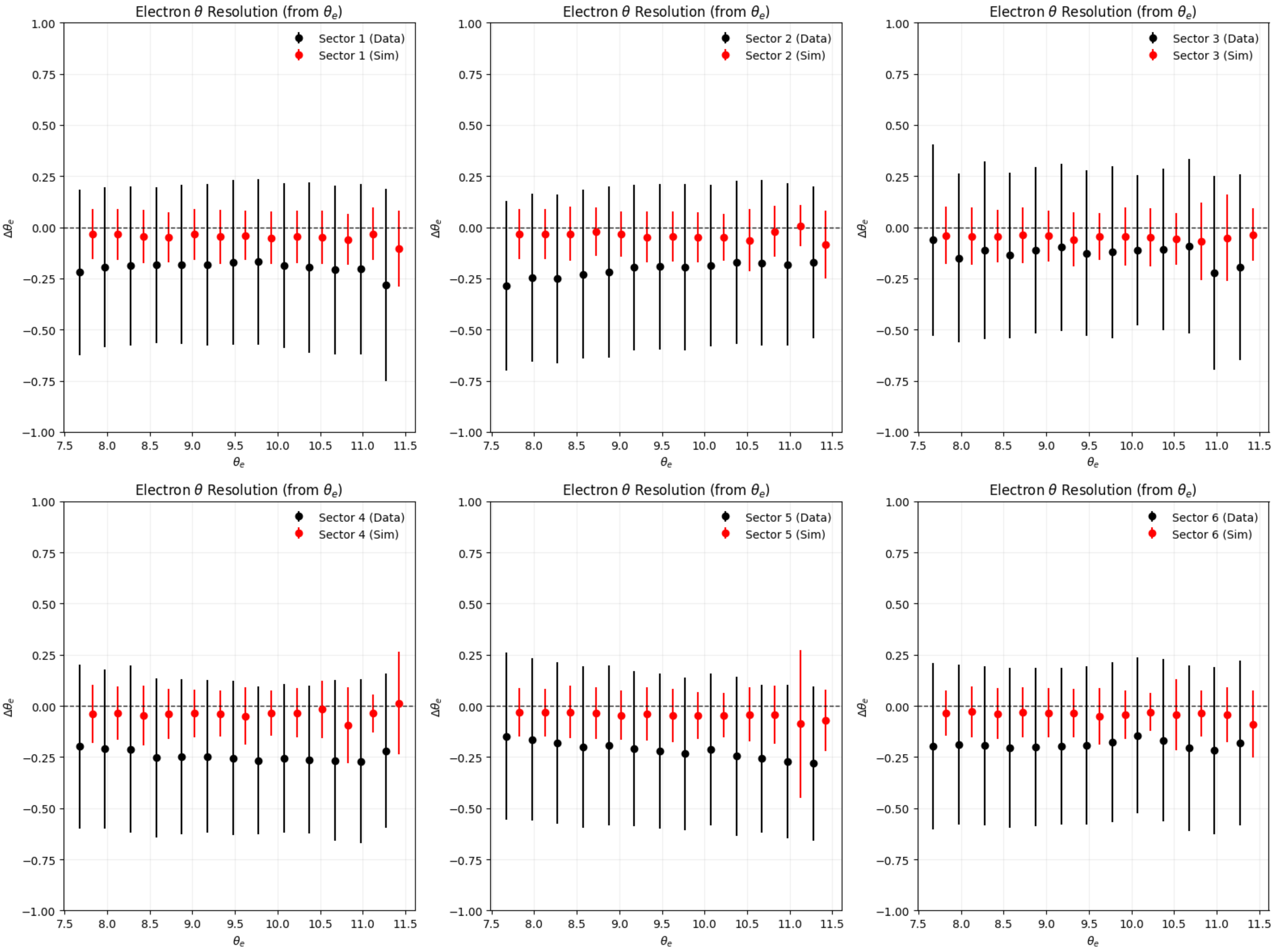
Figure provided by A. Kim

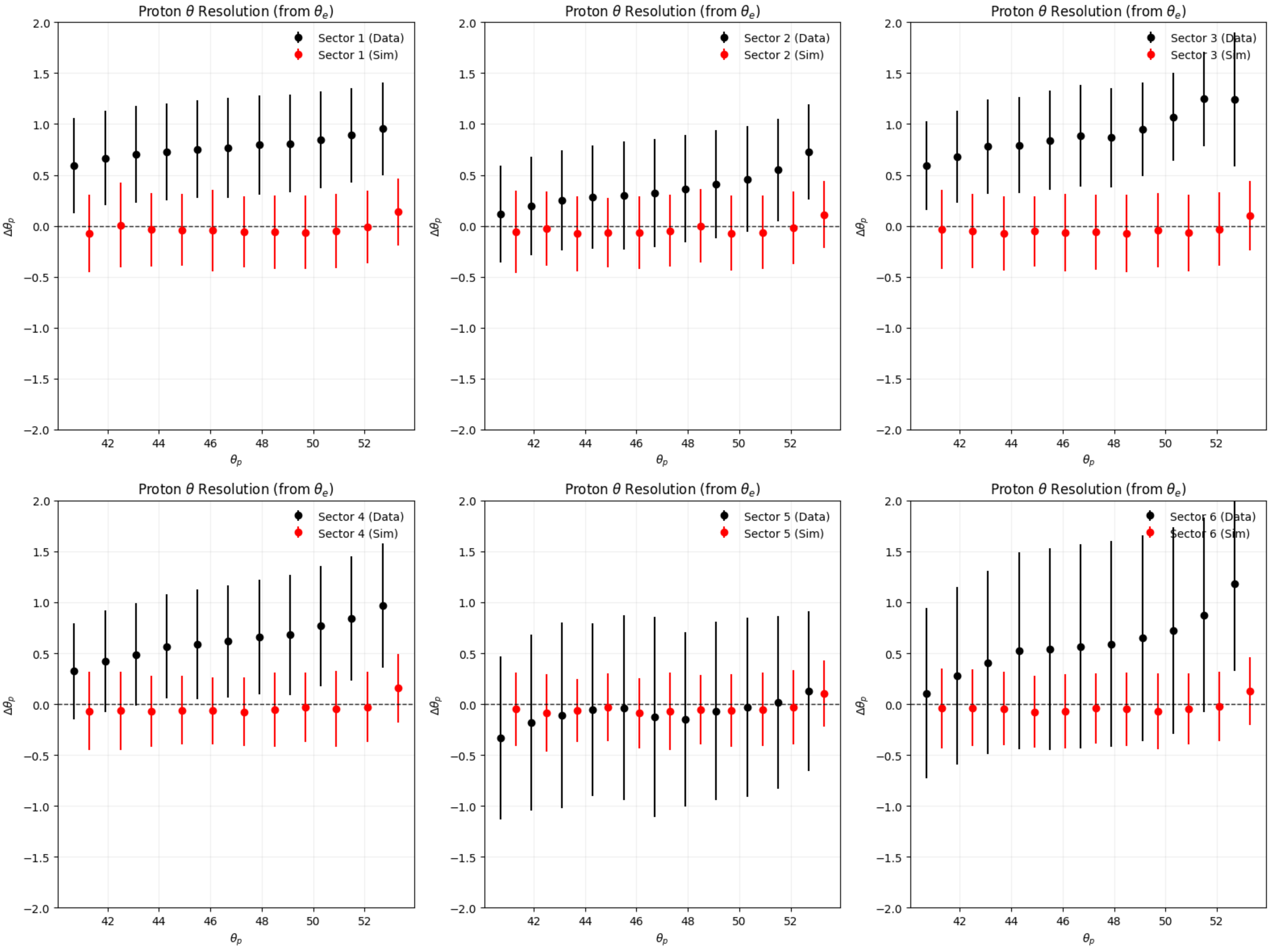
Concluding Remarks

- The ISR events overlap significantly with the phase space of exclusive resonance channels events from DVMP/DVCS.
- Momentum corrections can be developed based on these events. Those corrections should also apply for electron/proton in other channels with similar kinematics.
- Additional sample cleaning and validation is needed…

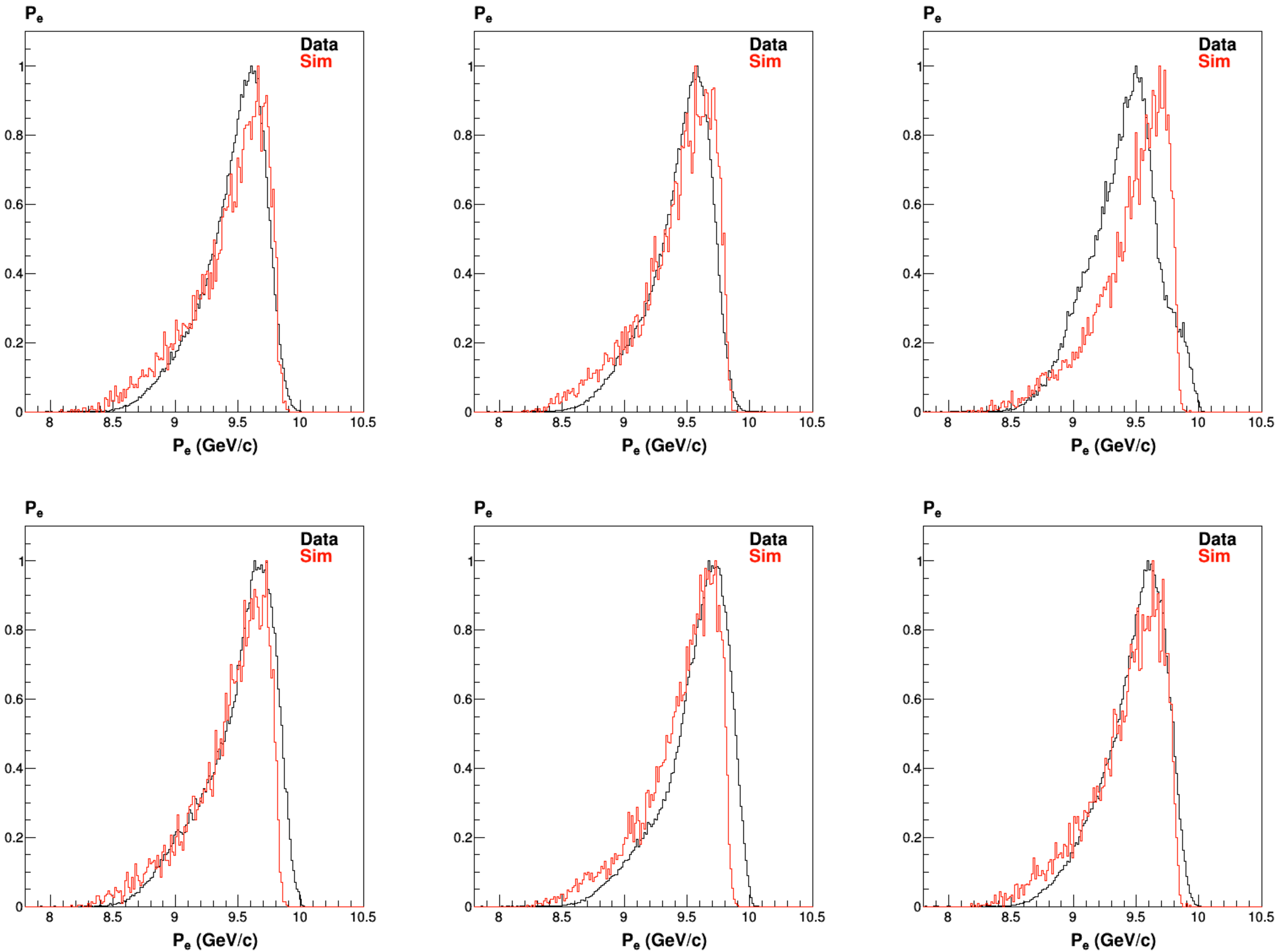

Events Passing W Cut
ϕ_{ep} (deg)
Events Passing W Cut
ϕ_{ep} (deg)
Events Passing W Cut
ϕ_{ep} (deg)
Events Passing W Cut
ϕ_{ep} (deg)
Events Passing W Cut
ϕ_{ep} (deg)
Events Passing W Cut
ϕ_{ep} (deg)


Data w/ Proton in CTOF (Elastic) DC1
Data w/ Proton in CTOF (Elastic) DC2
Data w/ Proton in CTOF (Elastic) DC3
Data w/ Proton in CTOF (ISR) DC1
Data w/ Proton in CTOF (ISR) DC2
Data w/ Proton in CTOF (ISR) DC3
X
Y

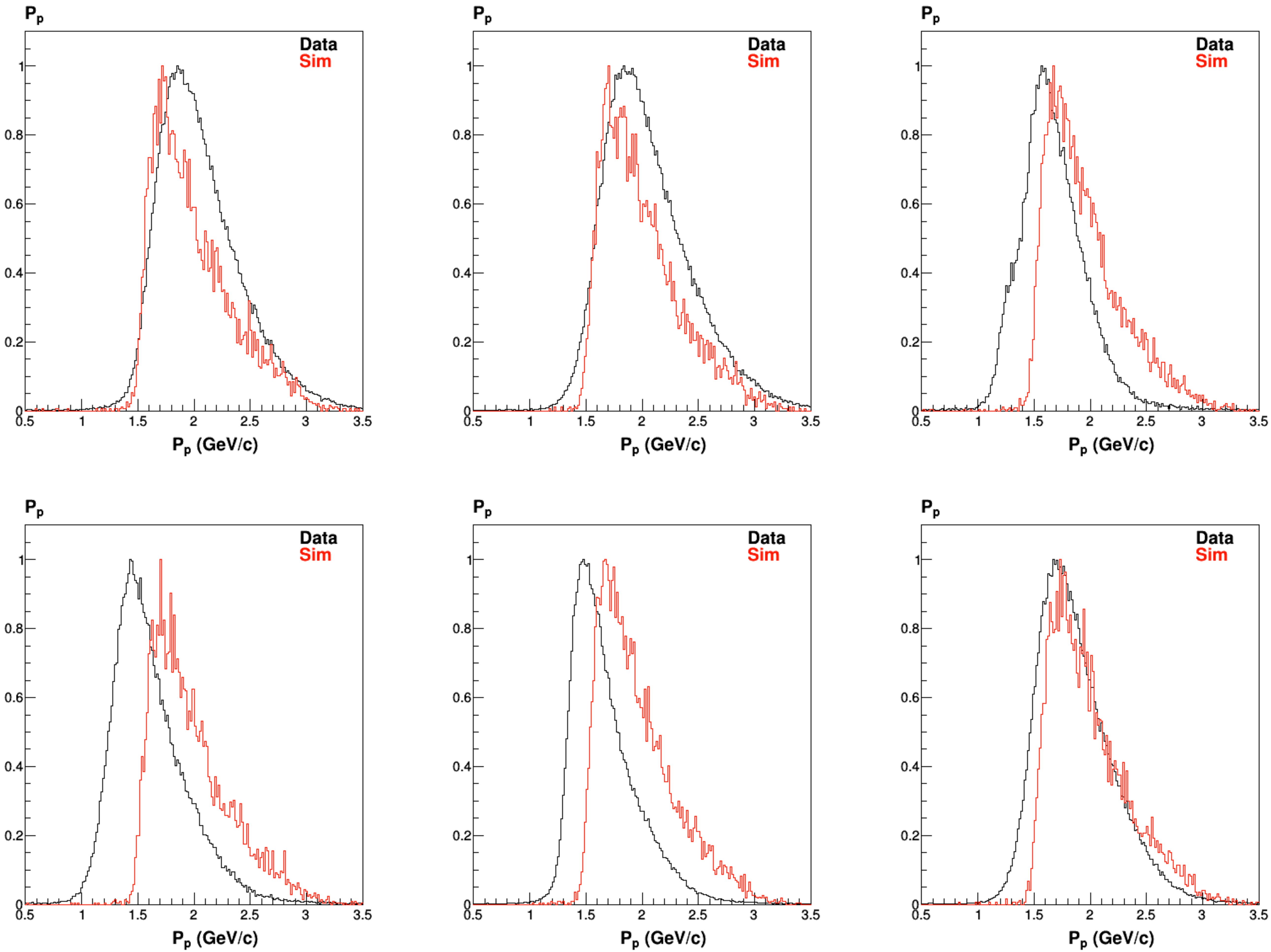

Electron θ Resolution (from θ_e)
Sector 1 (Data)
Sector 1 (Sim)
Sector 2 (Data)
Sector 2 (Sim)
Sector 3 (Data)
Sector 3 (Sim)
Sector 4 (Data)
Sector 4 (Sim)
Sector 5 (Data)
Sector 5 (Sim)
Sector 6 (Data)
Sector 6 (Sim)
$\Delta\theta_e$
θ_e



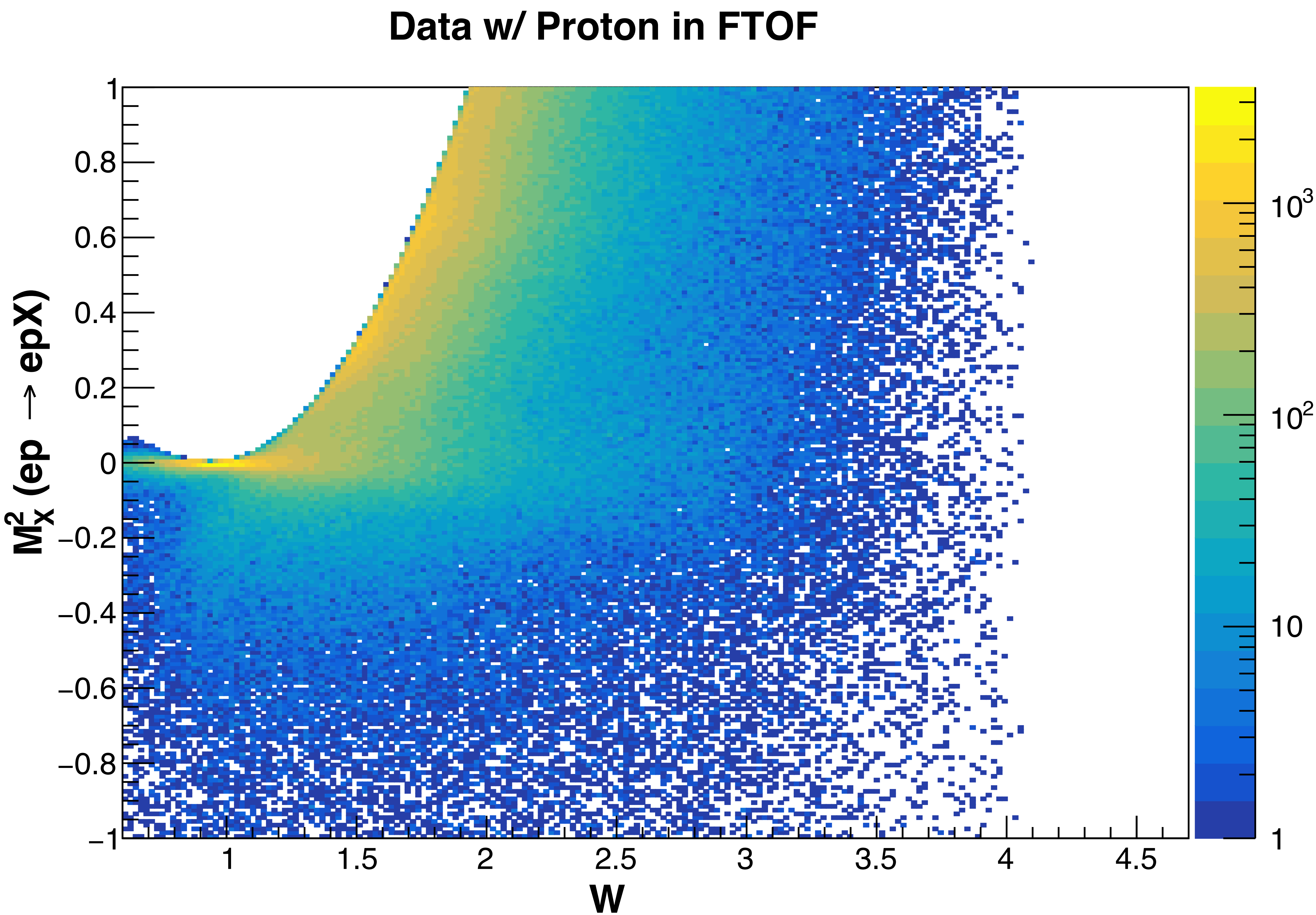
Proton θ Resolution (from θe)
Sector 1 (Data)
Sector 1 (Sim)
Sector 2 (Data)
Sector 2 (Sim)
Sector 3 (Data)
Sector 3 (Sim)
Sector 4 (Data)
Sector 4 (Sim)
Sector 5 (Data)
Sector 5 (Sim)
Sector 6 (Data)
Sector 6 (Sim)
Δθp
θp



P_e
Data
Sim
0
0.2
0.4
0.6
0.8
1
8
8.5
9
9.5
10
10.5
P_e (GeV/c)
P_e
Data
Sim
0
0.2
0.4
0.6
0.8
1
8
8.5
9
9.5
10
10.5
P_e (GeV/c)
P_e
Data
Sim
0
0.2
0.4
0.6
0.8
1
8
8.5
9
9.5
10
10.5
P_e (GeV/c)
P_e
Data
Sim
0
0.2
0.4
0.6
0.8
1
8
8.5
9
9.5
10
10.5
P_e (GeV/c)
P_e
Data
Sim
0
0.2
0.4
0.6
0.8
1
8
8.5
9
9.5
10
10.5
P_e (GeV/c)
P_e
Data
Sim
0
0.2
0.4
0.6
0.8
1
8
8.5
9
9.5
10
10.5
P_e (GeV/c)



Pp
Data
Sim
Pp (GeV/c)
Pp
Data
Sim
Pp (GeV/c)
Pp
Data
Sim
Pp (GeV/c)
Pp
Data
Sim
Pp (GeV/c)
Pp
Data
Sim
Pp (GeV/c)
Pp
Data
Sim
Pp (GeV/c)


Data w/ Proton in FTOF
M_X^2 (ep → epX)
W
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
1
1.5
2
2.5
3
3.5
4
4.5
10^3
10^2
10
1