SIDIS Simulation – Update

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Introduction

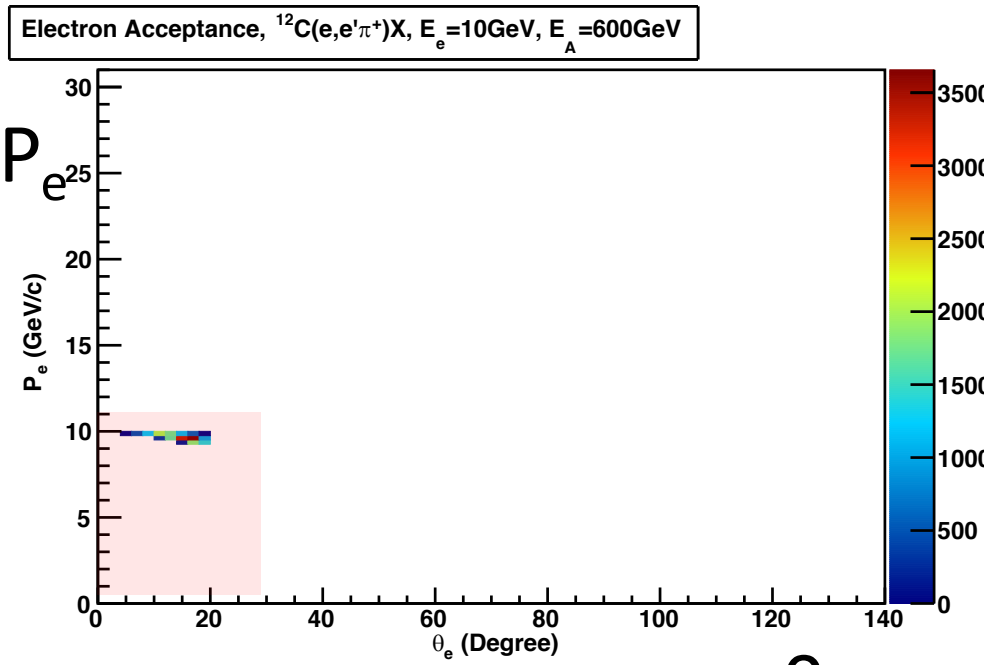
- Project: Nuclear modification of quarks from ratio

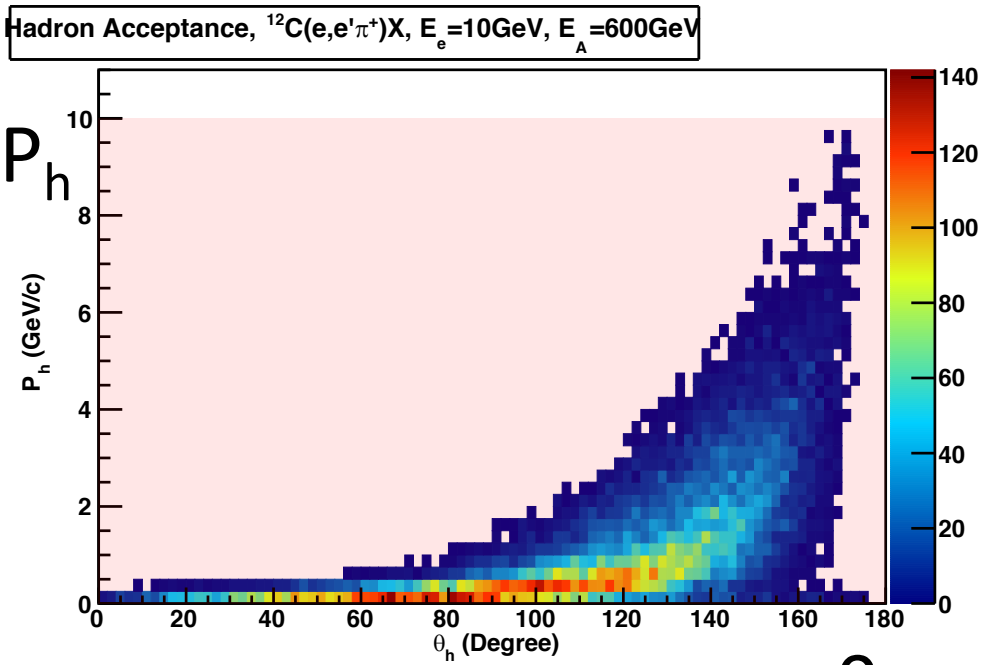
$$R(Q^2, z, x) = \frac{N_C(\pi^+) - N_C(\pi^-)}{N_d(\pi^+) - N_d(\pi^-)}$$

- Wanted: Error of the ratio = 1%
- Study with SIDIS simulation necessary statistics and systematic effects
- First step: MC sampling / integration error

Simulation parameter

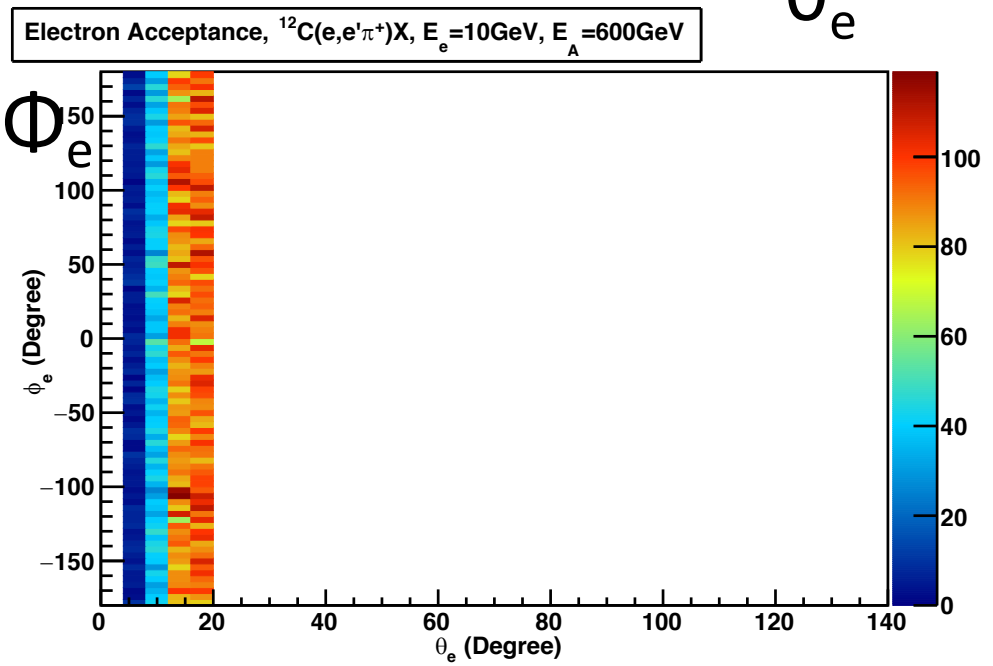
- ^{12}C with E_e = 10 GeV and E_A = 600 GeV, d with E_A = 100 GeV
- 500 Million events (already generated) for CTEQ ^{12}C and d
- LO PDF set and s-, sbar-, gluon-pdf = 0
- Event generation within:
  - 8.5 GeV/c < p_e' < 10.5 GeV/c
  - 0 GeV/c < p_h < 10 GeV/c
  - $0^\circ < \theta_e < 25^\circ$ but generation itself in cos(θ)
  - $0^\circ < \theta_h < 180^\circ$ but generation itself in cos(θ)
  - $0^\circ < \phi_{e/h} < 360^\circ$
- Cuts in event generation:
  - 0.03 < x < 0.15 (0.05 < x < 0.1 cut applied later)
  - $Q^2 > 1$
  - W > 2

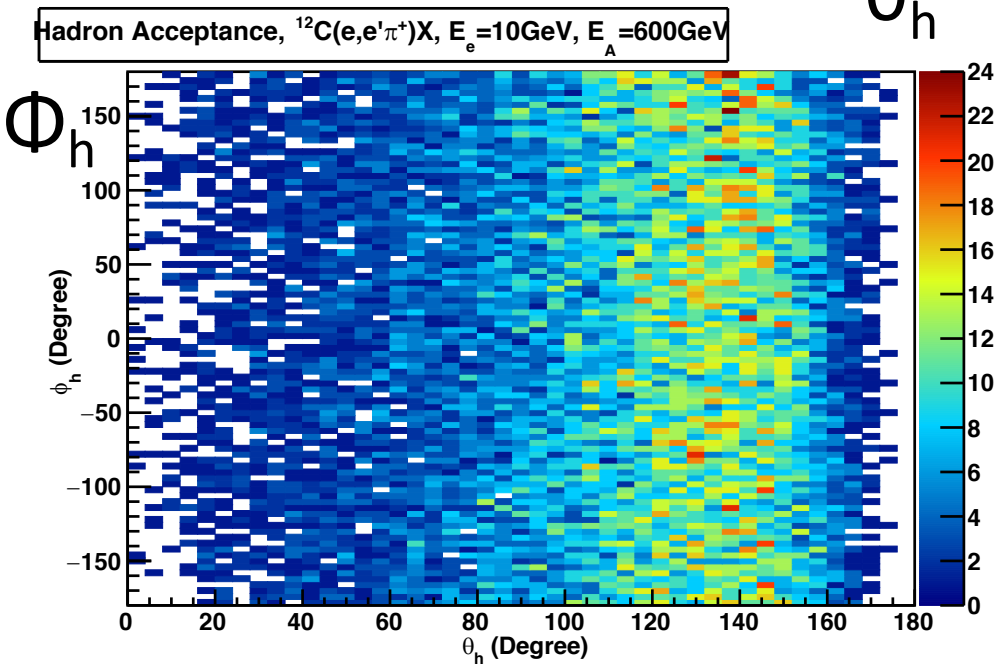




θ_e

θ_h



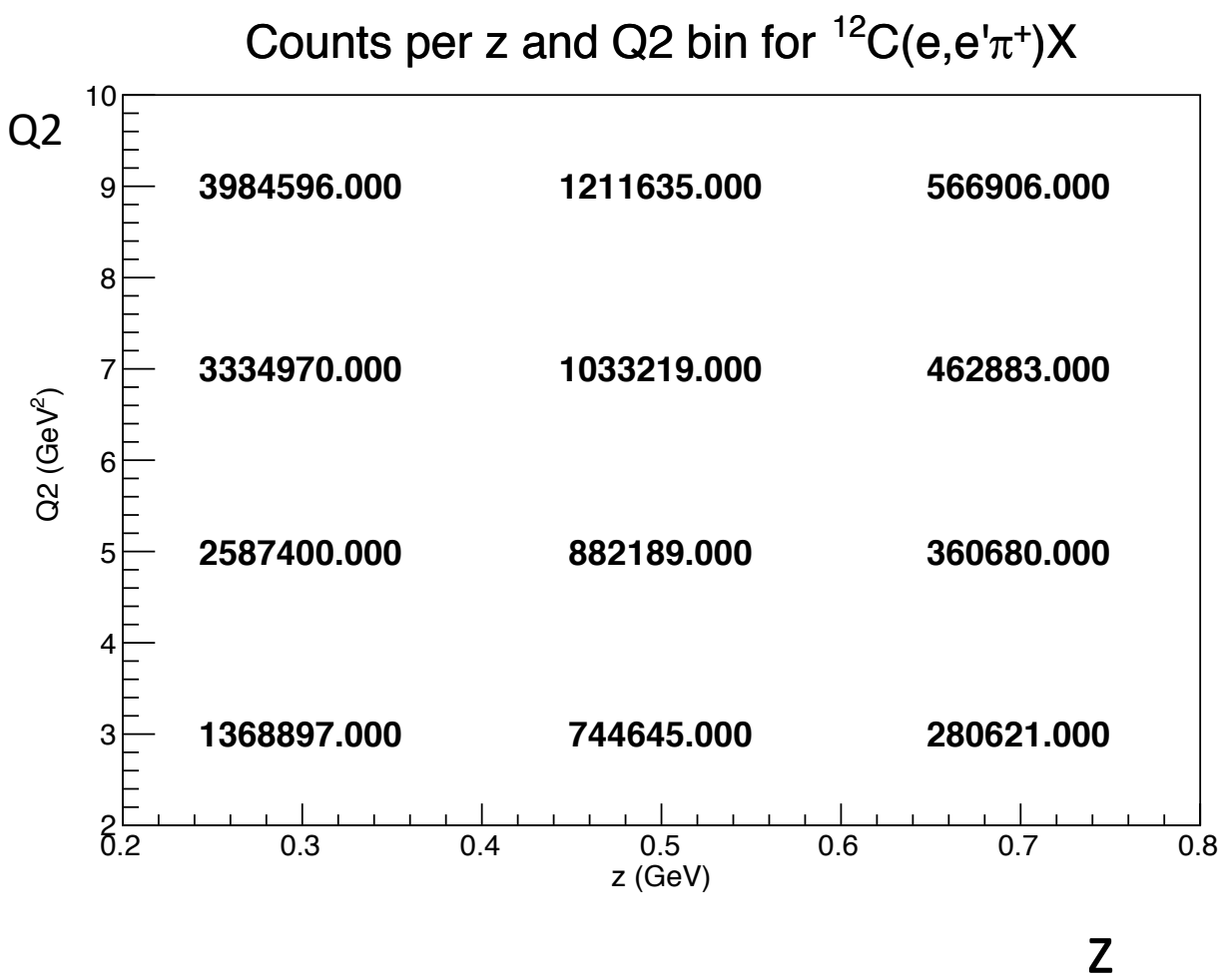


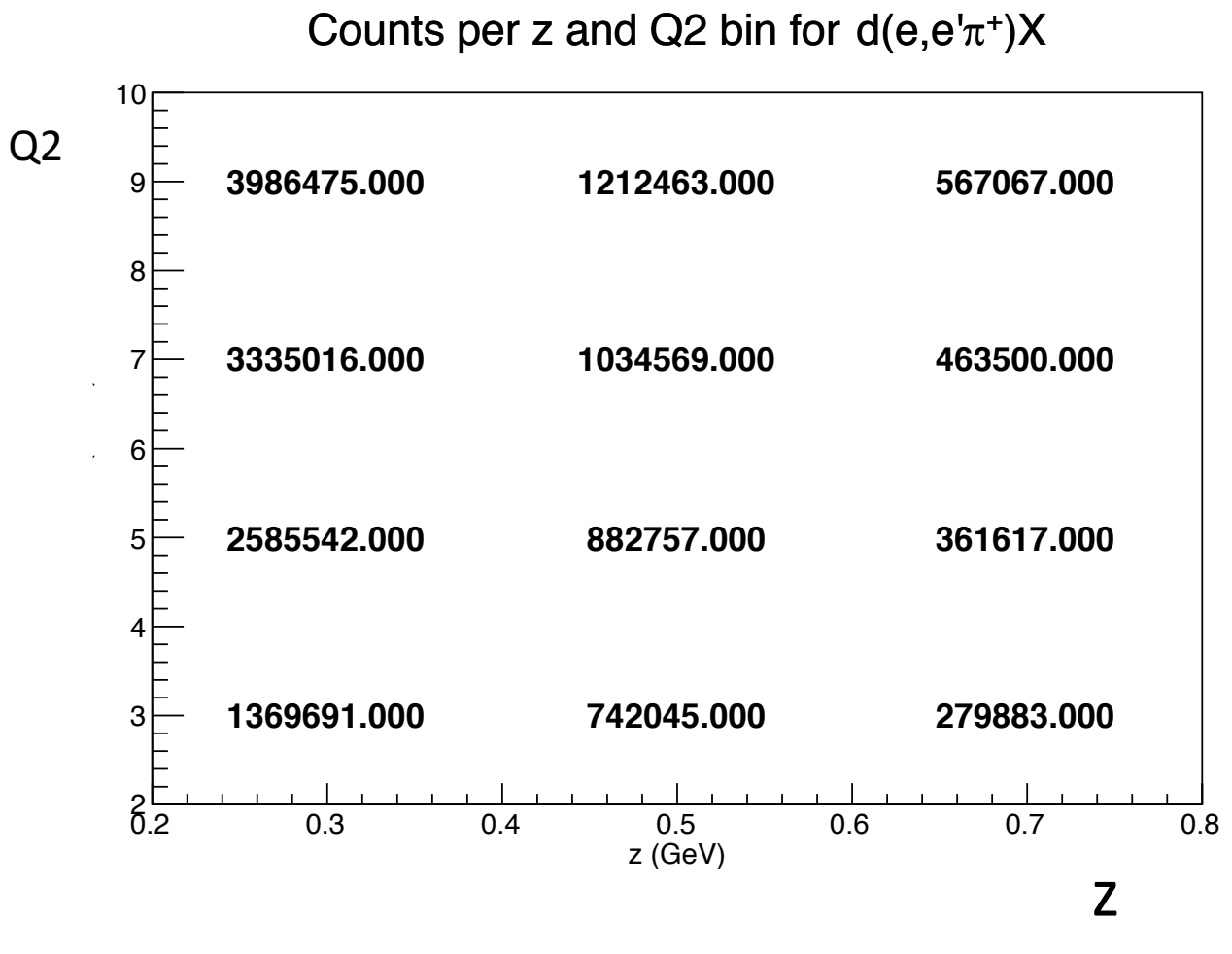
- $Q^2 < 10$
- $p_t < 1$ GeV/c
- $0.05 < x_B < 0.1$
- xs weighted
- 1M events

Q^2 and z Bins for SIDIS Ratio

- Q^2 cut limits:
  - Q2_cut [5] = {2.0, 4.0, 6.0, 8.0, 10.}
- z cut limits:
  - z_cut[4] = {0.2, 0.4, 0.6, 0.8}
- x cut:
  - $0.05 <= x_B <= 0.1$
- $p_t < 1$ GeV/c (transversal to q)

Number of Events for 50M generated events





Calculation of MC Sampling / Integration Error

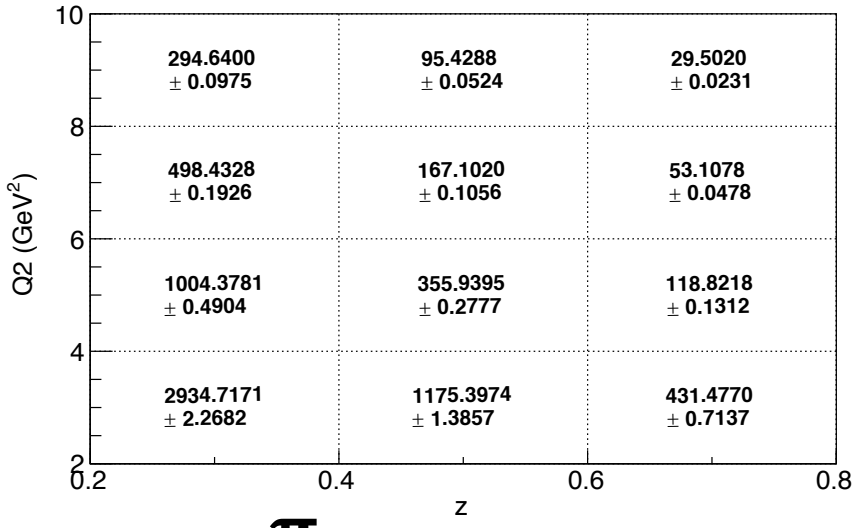
- Method 1 adapted from Numerical Recipes (Charles)
  - N events generated in phase space V with weights. Integral of function *f* (cross section) is
  - $\frac{V}{N}\sum_i f(x_i) \pm \frac{V}{\sqrt{N}}\sqrt{\left[\frac{1}{N}\sum_i f^2(x_i)\right] - \left[\frac{1}{N}\sum_i f(x_i)\right]^2}$

- Method 2 (adapted from Zhihongs Code):
  - Plot weighted Q2 distribution
  - Value = histo->GetSum() [ROOT]
  - Error = sqrt(sum (variance)) [done via ROOT]

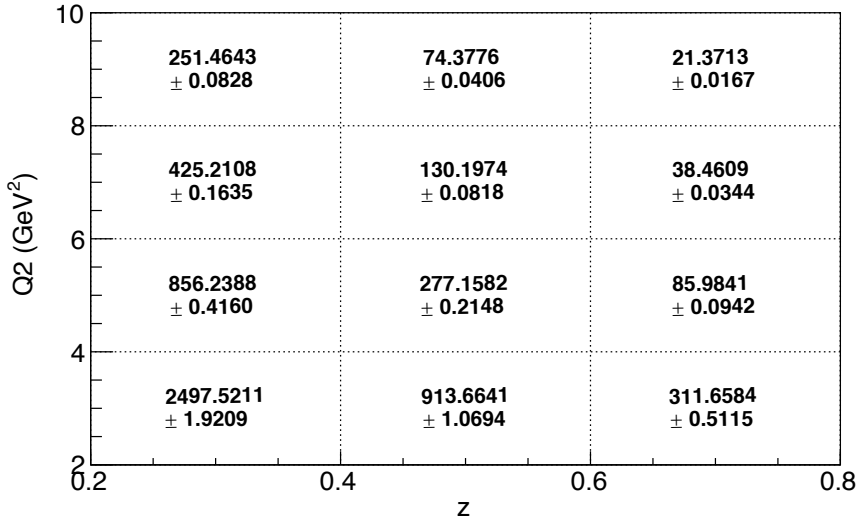
→ Both calculations gave the same error

Deuterium Results on Weighted Cross Section (Count Rates) from 500M Events

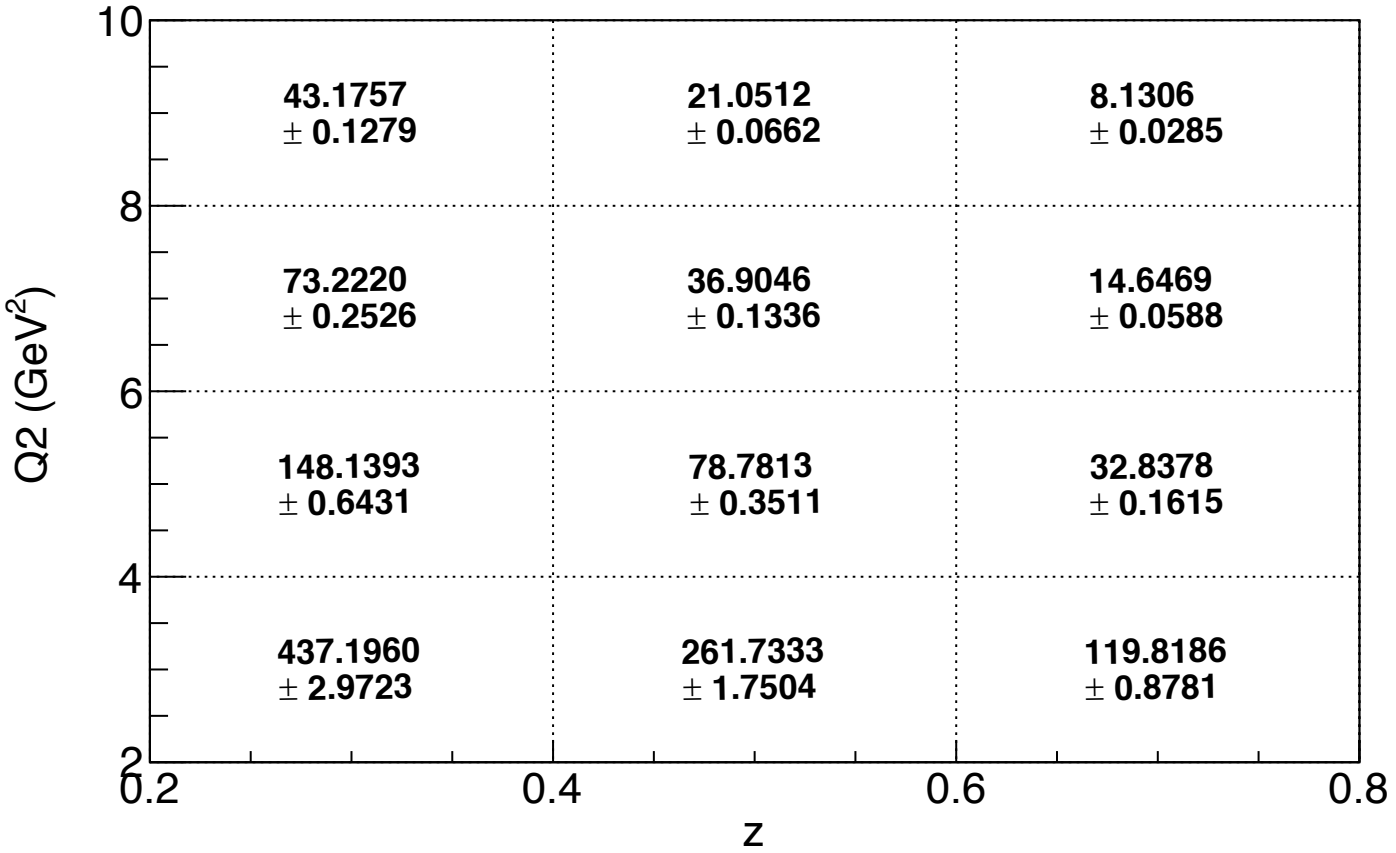
π+



π-

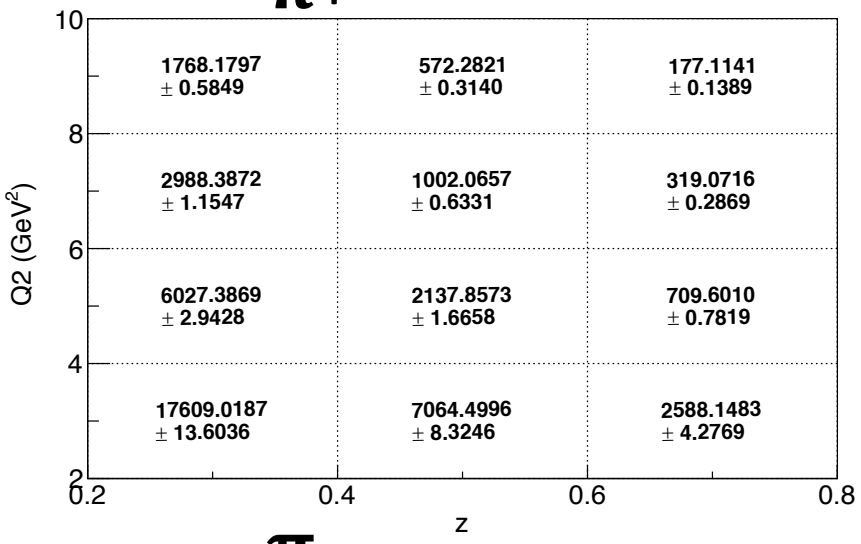


σ(π+) - σ (π-)

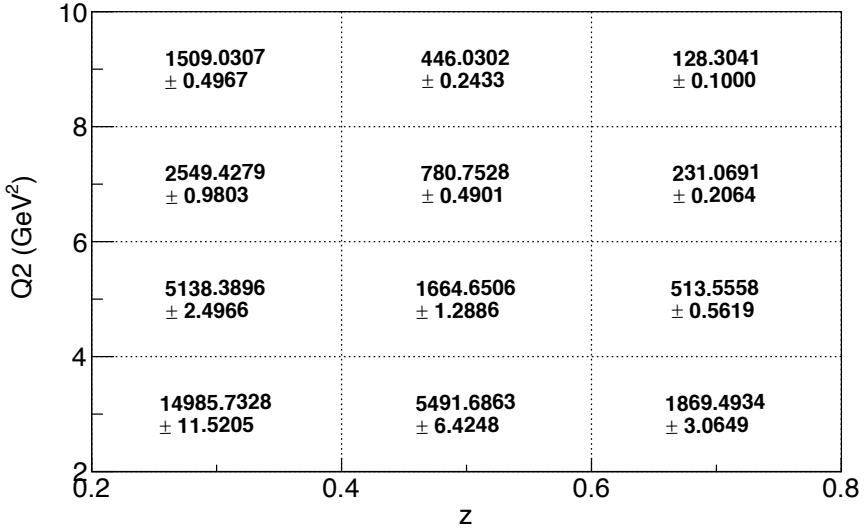


^{12}C Results on Weighted Cross Section (Count Rates) from 500M Events

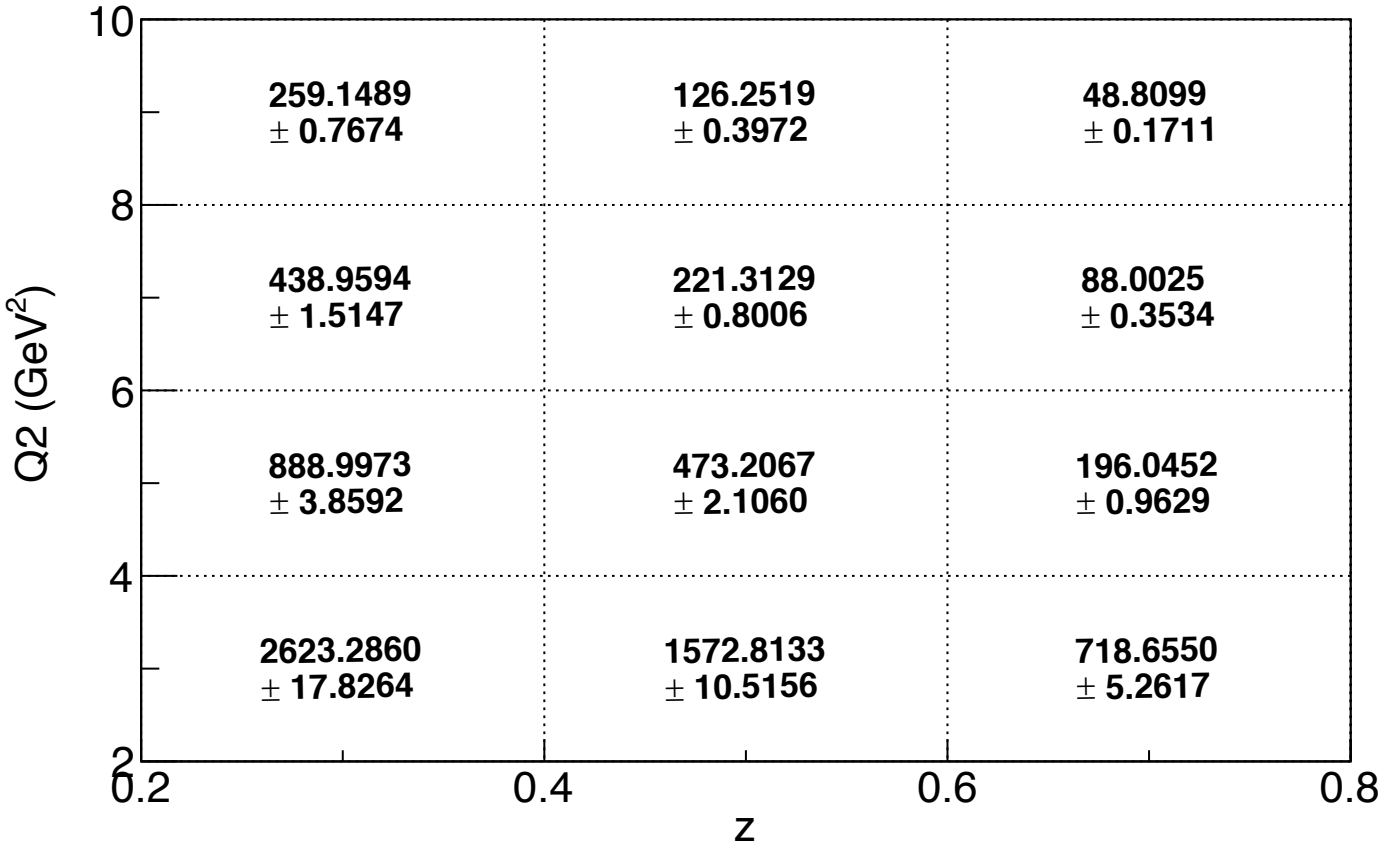
π+

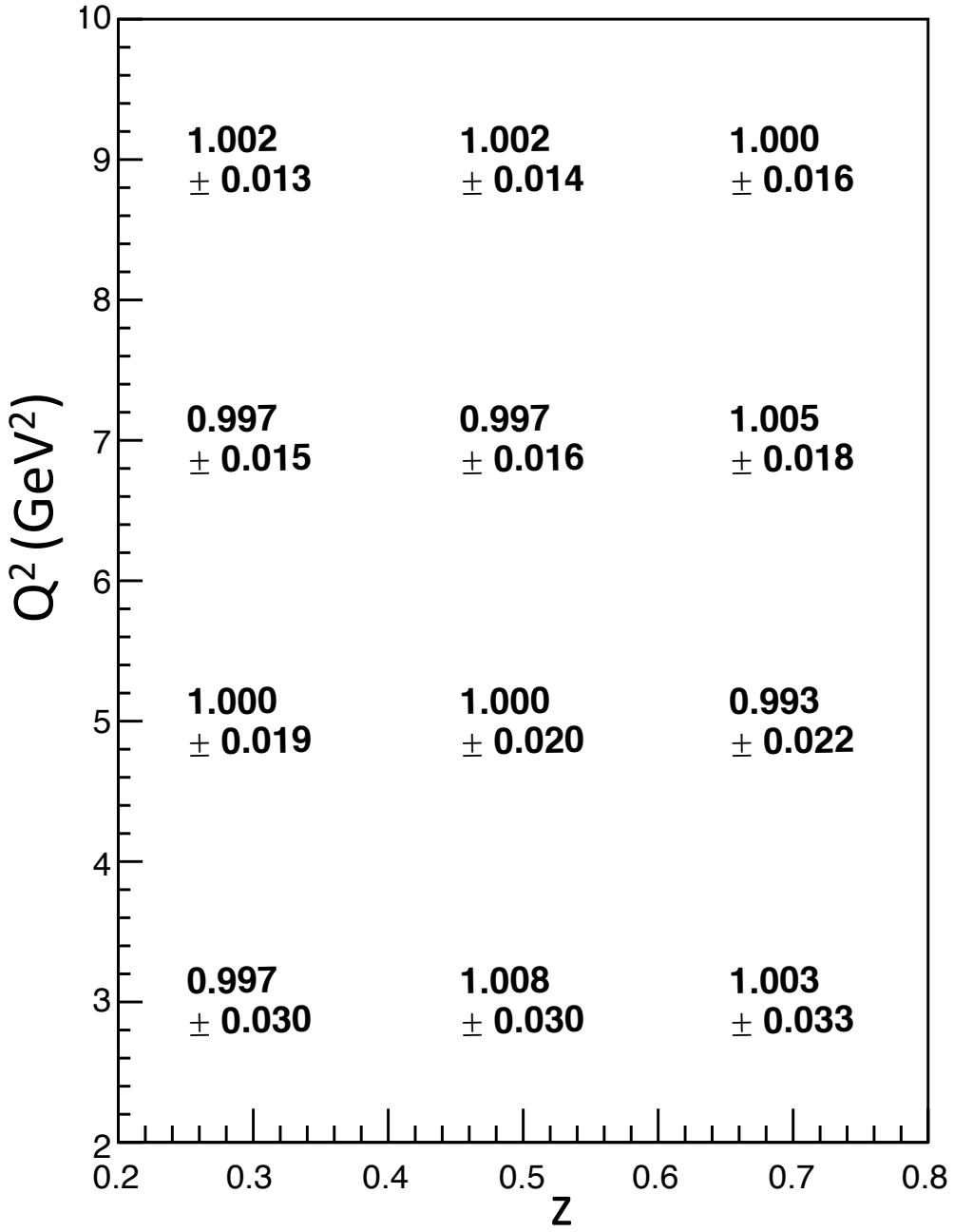


π-



σ(π+) - σ (π-)





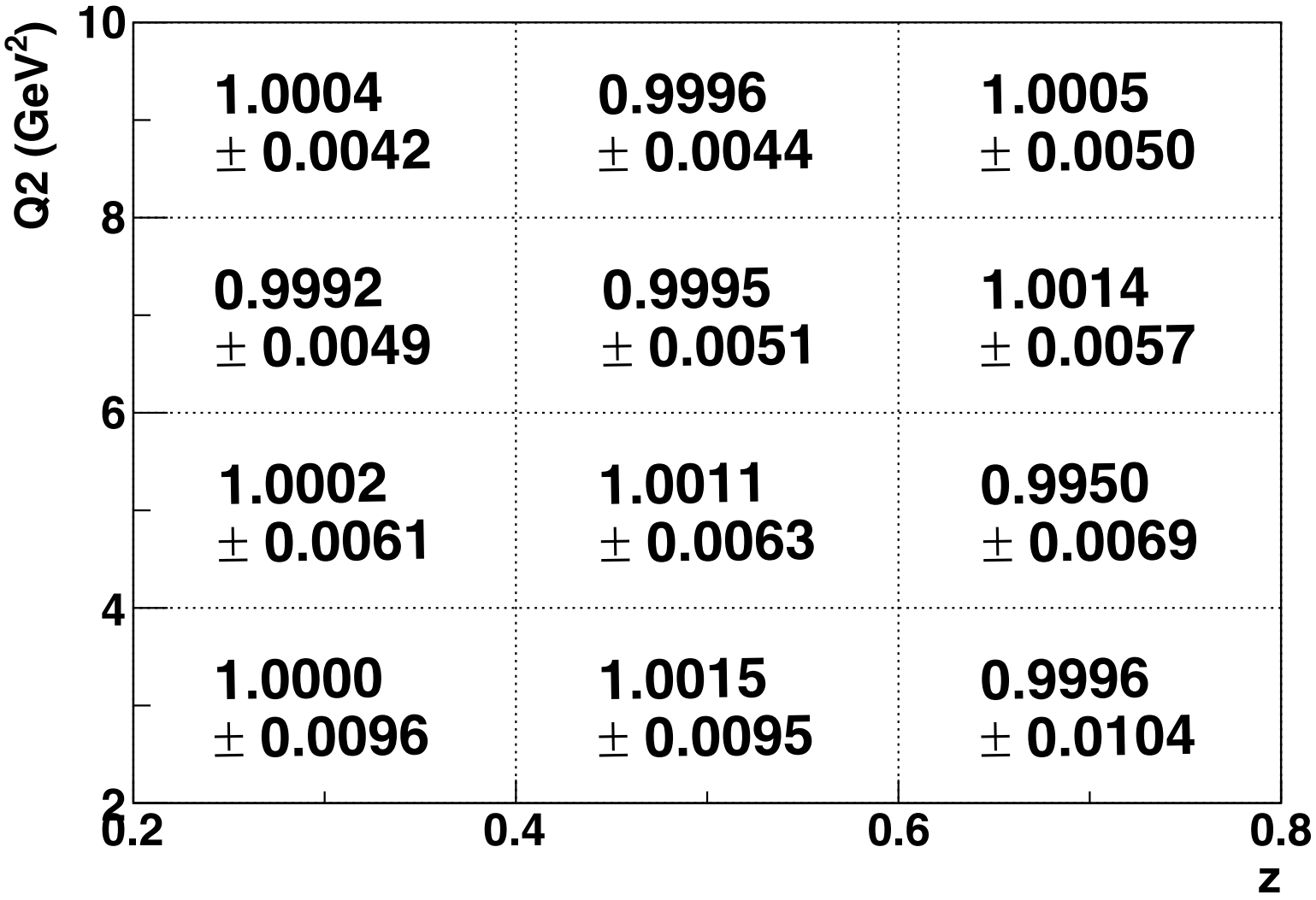
Previous Result for SIDIS Ratio - 50M Events

$$R(Q^2, z, x) = \frac{\boldsymbol{\sigma}_C(\pi^+) - \boldsymbol{\sigma}_C(\pi^-)}{6 * \boldsymbol{\sigma}_d(\pi^+) - \boldsymbol{\sigma}_d(\pi^-)}$$

Error from standard error propagation of individual weighted count rates

-> not sufficient statistic in each bin for error < 1%

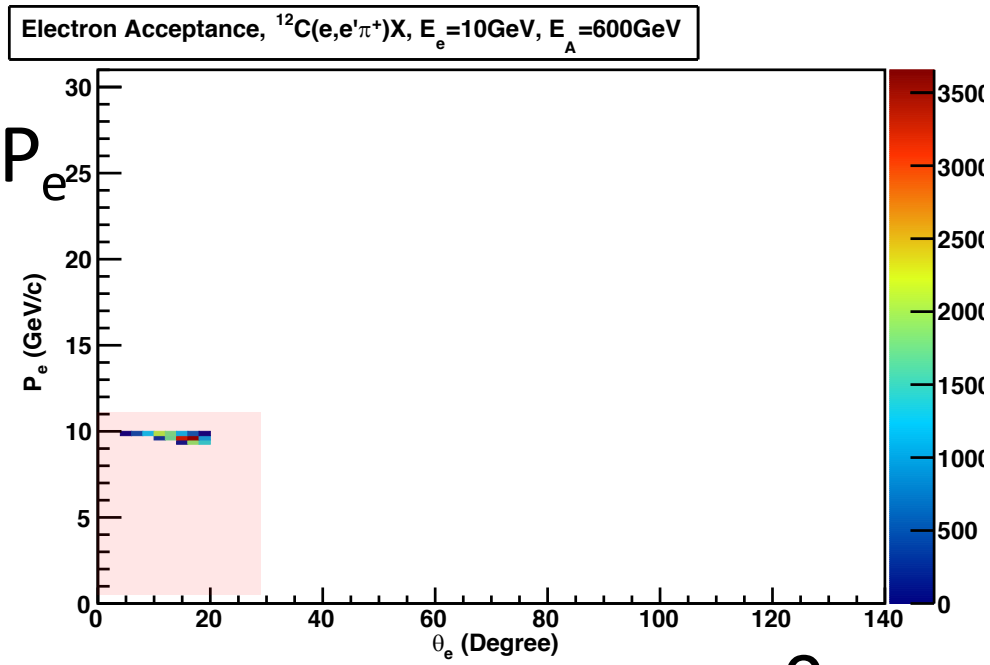
Result for SIDIS Ratio with 500M Events

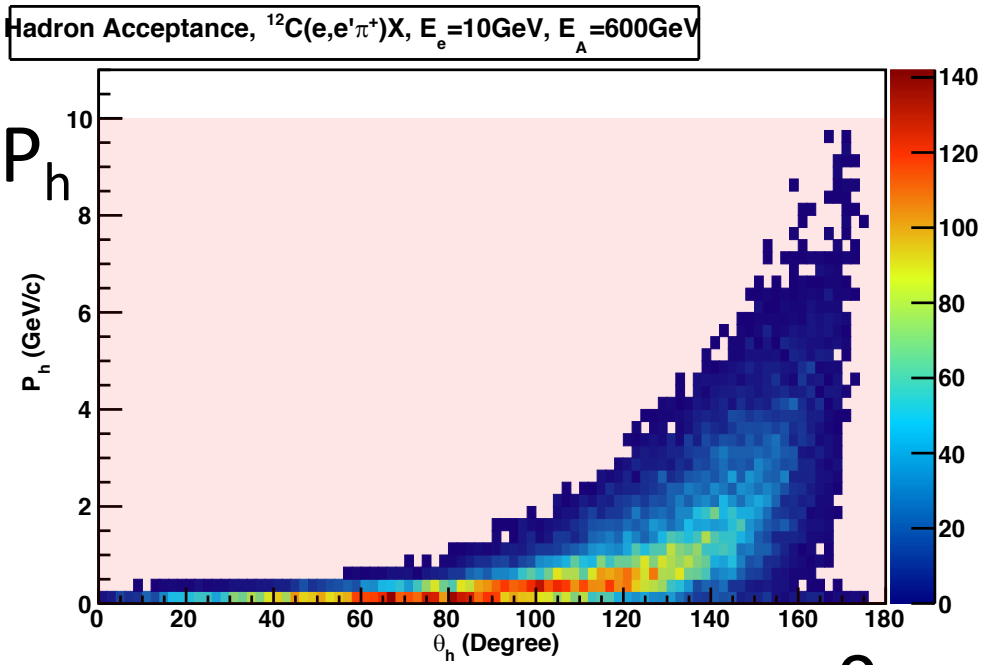


$$R(Q^2, z, x) = \frac{\boldsymbol{\sigma}_C(\pi^+) - \boldsymbol{\sigma}_C(\pi^-)}{6 * \boldsymbol{\sigma}_d(\pi^+) - \boldsymbol{\sigma}_d(\pi^-)}$$

-> sufficient statistic for all bins that MC sampling error is < 1%

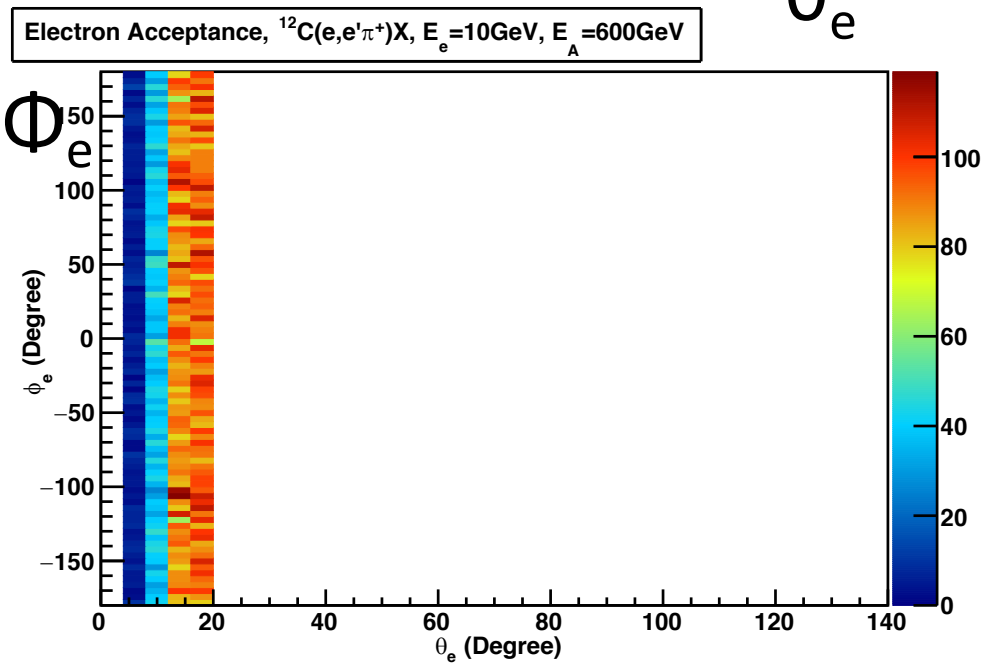
Resolution in Detector - Smearing of Momenta and Angle

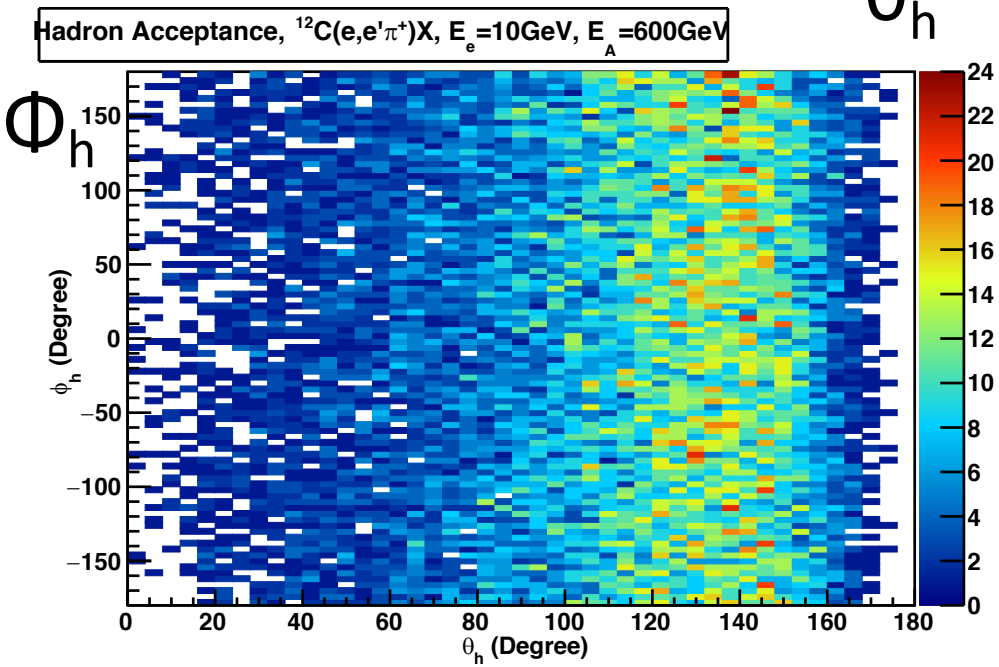




θ_e

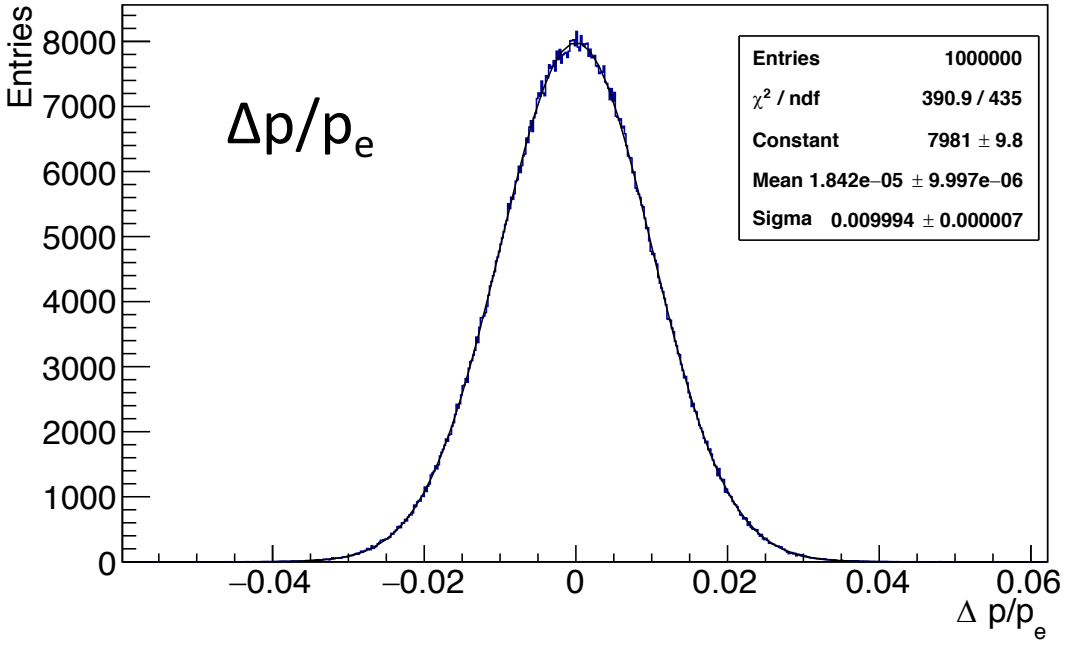
θ_h

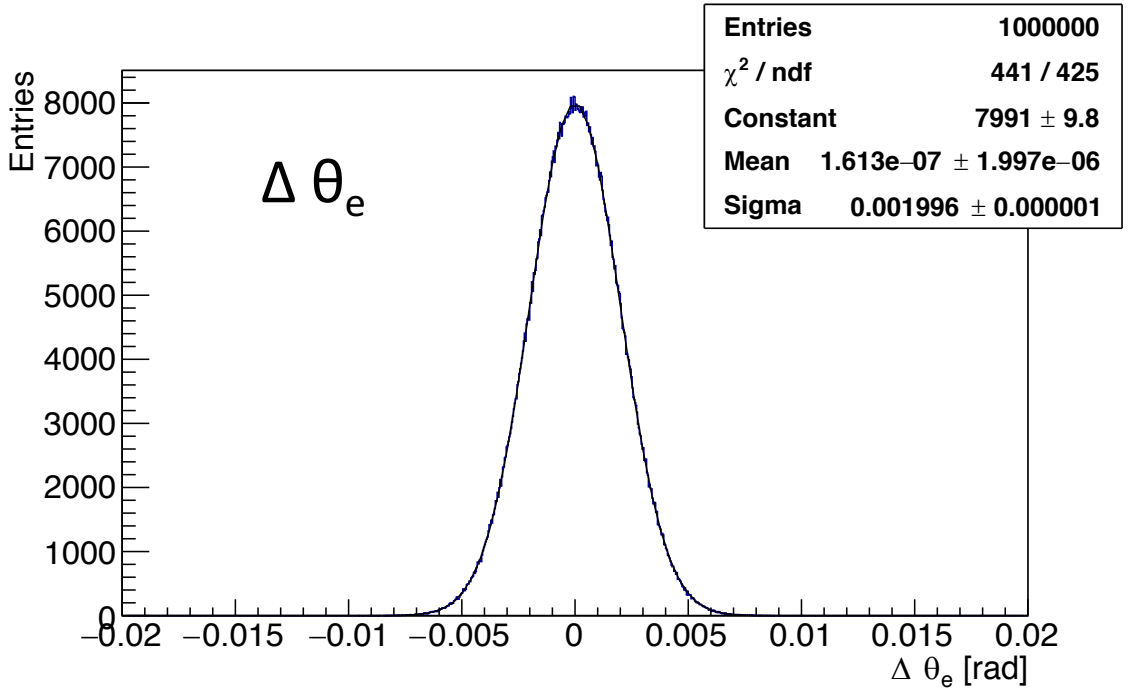




- $Q^2 < 10$
- $p_t < 1$ GeV/c
- $0.05 < x_B < 0.1$
- xs weighted
- 1M events

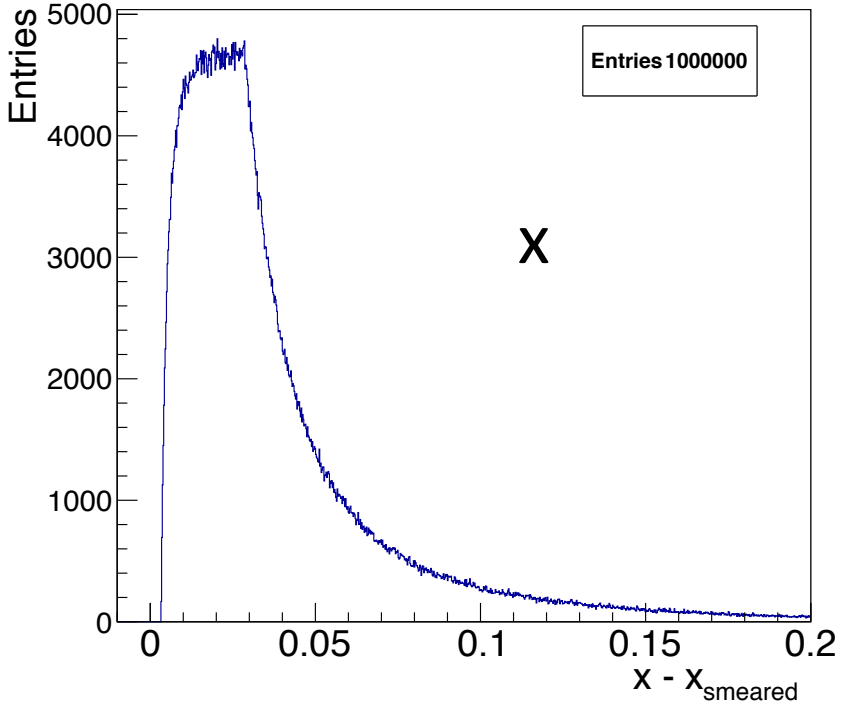
Smearing Plots for $\Delta p/p_e$ =1%, $\Delta p/p_h$ = 2%, $\Delta\theta_{e/h}$ = 2mrad)

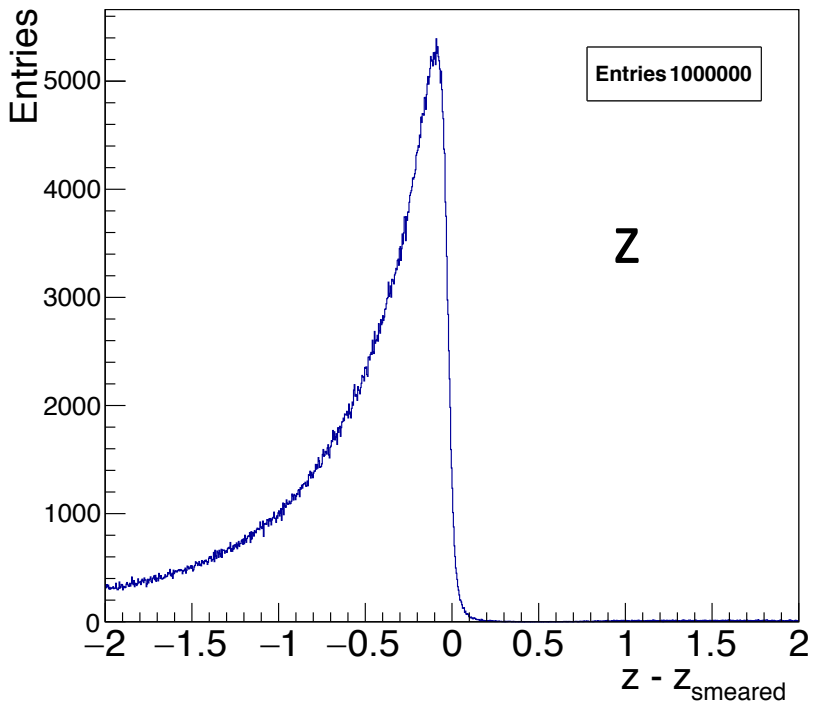


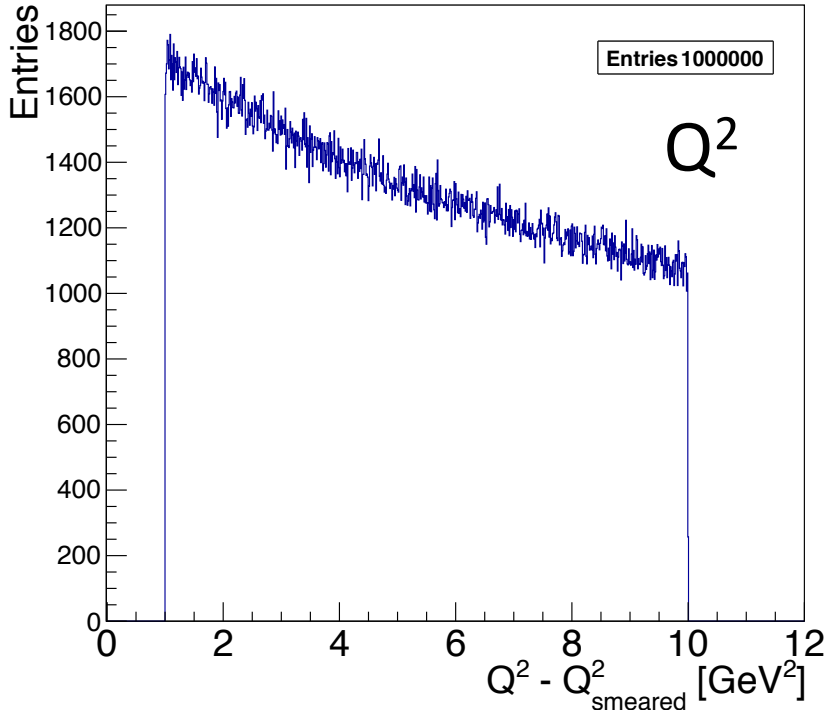


(similar for the pions)

Results of Smearing on x, z and Q^2







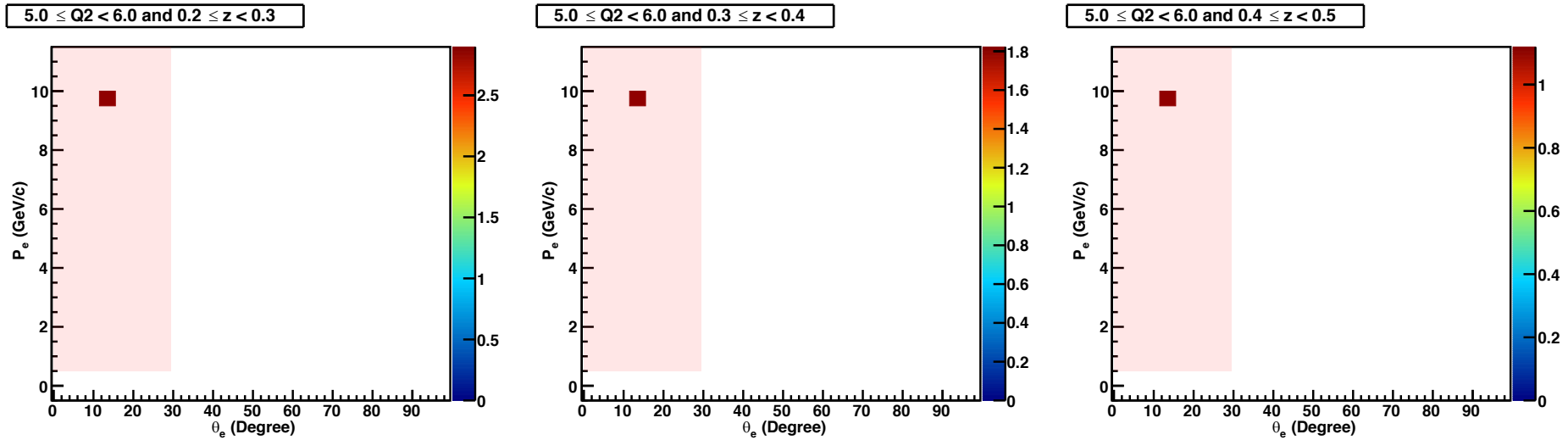
-> Further study of bin migration

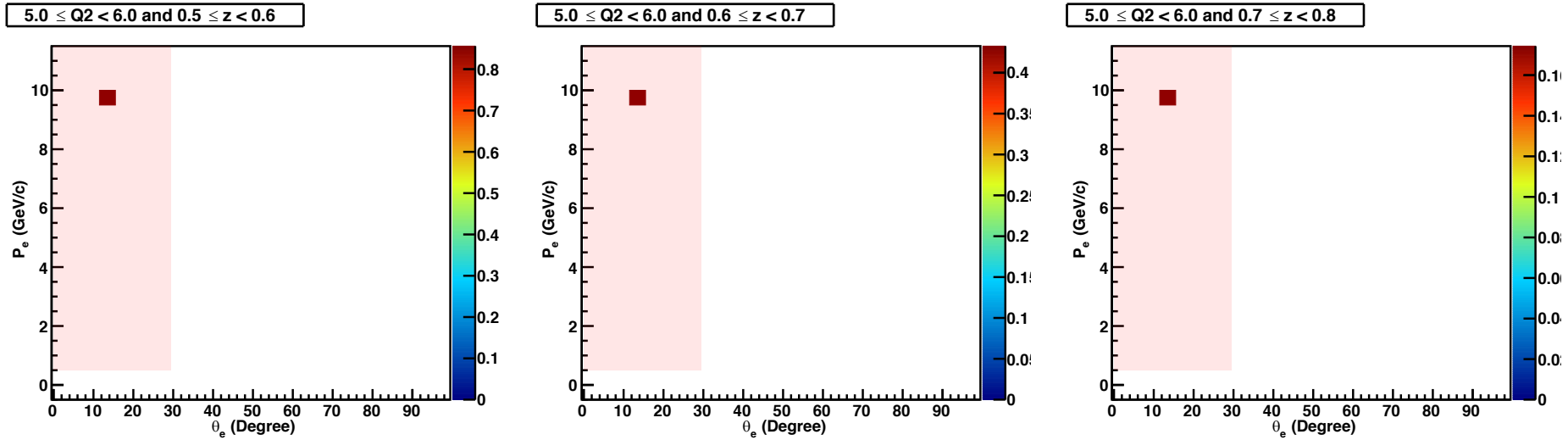
Next steps

- Smearing: Study systematics from bin migration
- More simulations with nuclear modification (EPS09) for C12
- Check results with half the events for π+ and the other half for π-
- Calculation of necessary events (taking into account luminosity and run time) for required statistical error

Extra Slides

Generated Values for fix Q^2 and variable z ($0.05 < x_B < 0.1$)



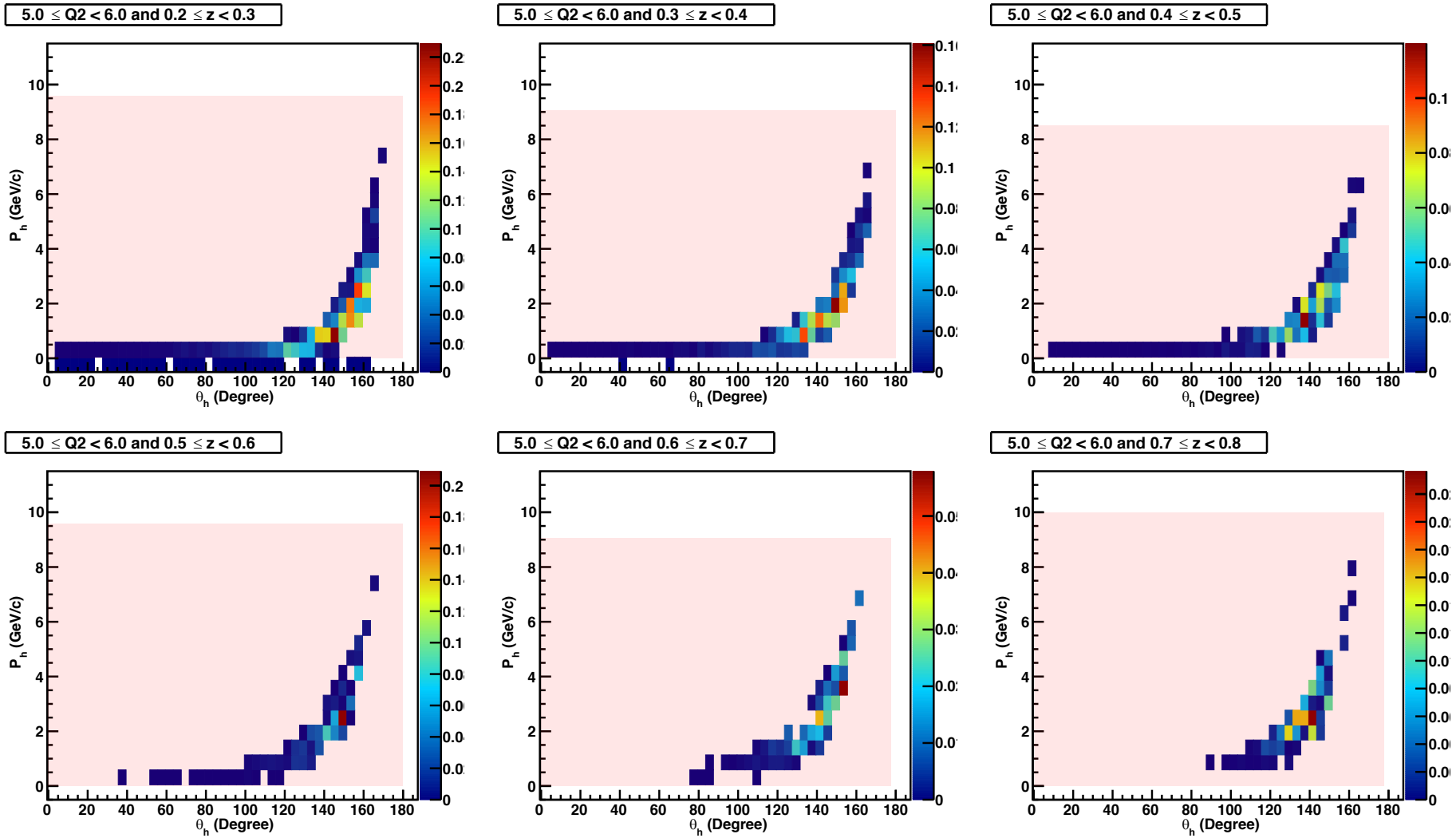


Electrons
weighting
only positive hadrons

$5.0 <= Q^2 < 6.0$

Very small
phase space
In generated
values

Generated Values for fix Q^2 and variable z ($0.05 < x_B < 0.1$)



Hadrons
weighting
only positive hadrons

$5.0 <= Q^2 < 6.0$