Overview

Introduction

MonteCarlo and Data comparisons

Multiplicity extraction

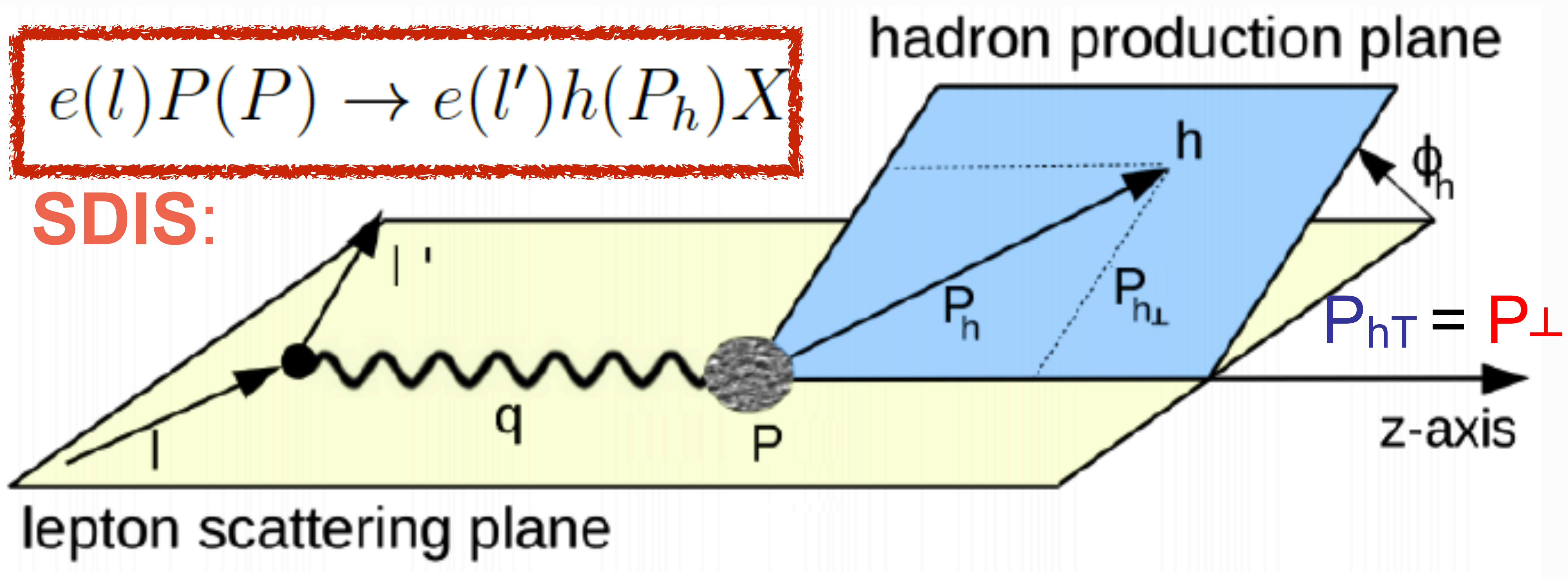
Phase space effects for transverse momentum extractions

Only π+ is shown but the analysis is done also on π-

Introduction

$$e(l)P(P) \rightarrow e(l')h(P_h)X$$

SDIS:



$P_{hT} = P_\perp + z\, k_\perp$

$Q^2 = -(l-l')^2$	Transfer momentum
$W^2 = (P+q)^2$	Squared Invariant mass of the final state
$x = \frac{Q^2}{2P\cdot q}$	Quark longitudinal momentum fraction
$y = \frac{P\cdot q}{P\cdot l}$	Fractional energy of the virtual photon
$z = \frac{P\cdot P_h}{P\cdot q}$	Final state hadron momentum fraction
P_{hT}	Transverse Momentum of the hadron

Multplicity definition:

$$\frac{d^2M^h(x,Q^2,z,P_{hT}^2)}{dz\,dP_{hT}^2} = \left(\frac{d^4\sigma^h}{dx\,dQ^2\,dz\,dP_{hT}^2}\right) \Big/ \left(\frac{d^2\sigma^{DIS}}{dx\,dQ^2}\right).$$

- Accessing quark and hadron transverse momentum

Rewriting the cross sections in terms of structure functions:

$$m_N^h(x,z,P_{hT}^2,Q^2) = \frac{\pi F_{UU,T}(x,z,P_{hT}^2,Q^2) + \pi\, \varepsilon F_{UU,L}(x,z,P_{hT}^2,Q^2)}{F_T(x,Q^2) + \varepsilon F_L(x,Q^2)}$$

- Accessing fragmentation function

Structure Function: $F \propto DF \otimes FF$

Partonic Distribution Function. Fragmentation Function

Fragmentation Function

$$D_i^H(z) \approx \int dx^- e^{-iP_H^+ x^-/z}\, \mathrm{Tr}\left[\gamma^+ \underbrace{\langle 0|\Psi(0)\mathcal{P}|H(P_H^+)X\rangle\langle H(P_H^+)X|\mathcal{P}'\bar{\Psi}(x)|0\rangle}_{\text{Bi-Local Operator}}\right],$$

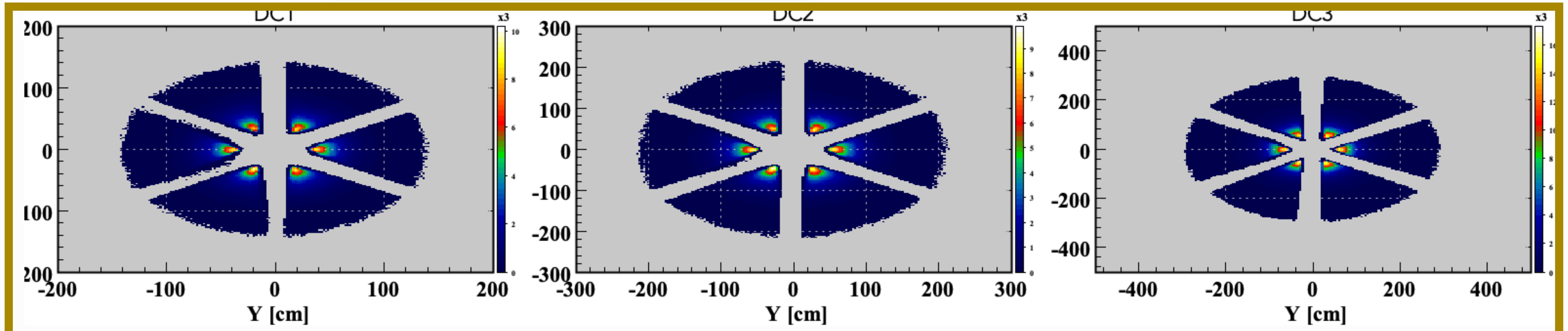
Non perturbative. Needs to be extracted from data.

Event Selection

$Q^2 > 1$ GeV^2 | W > 2GeV | y < 0.75

Pion momenta between 1.25 GeV/c - 5 GeV/c

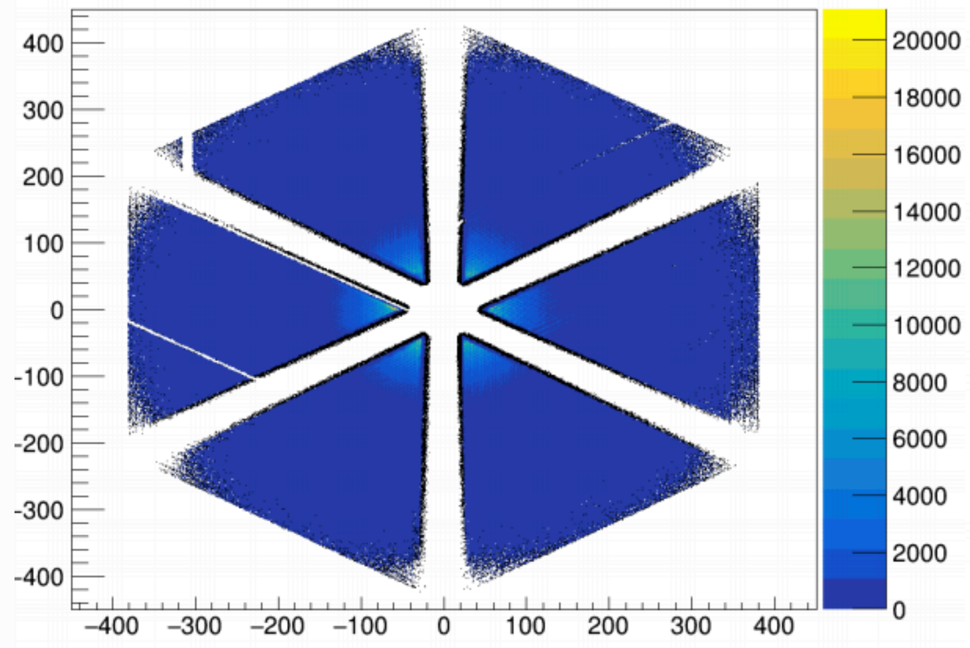
Standard RG-A common cuts for π+



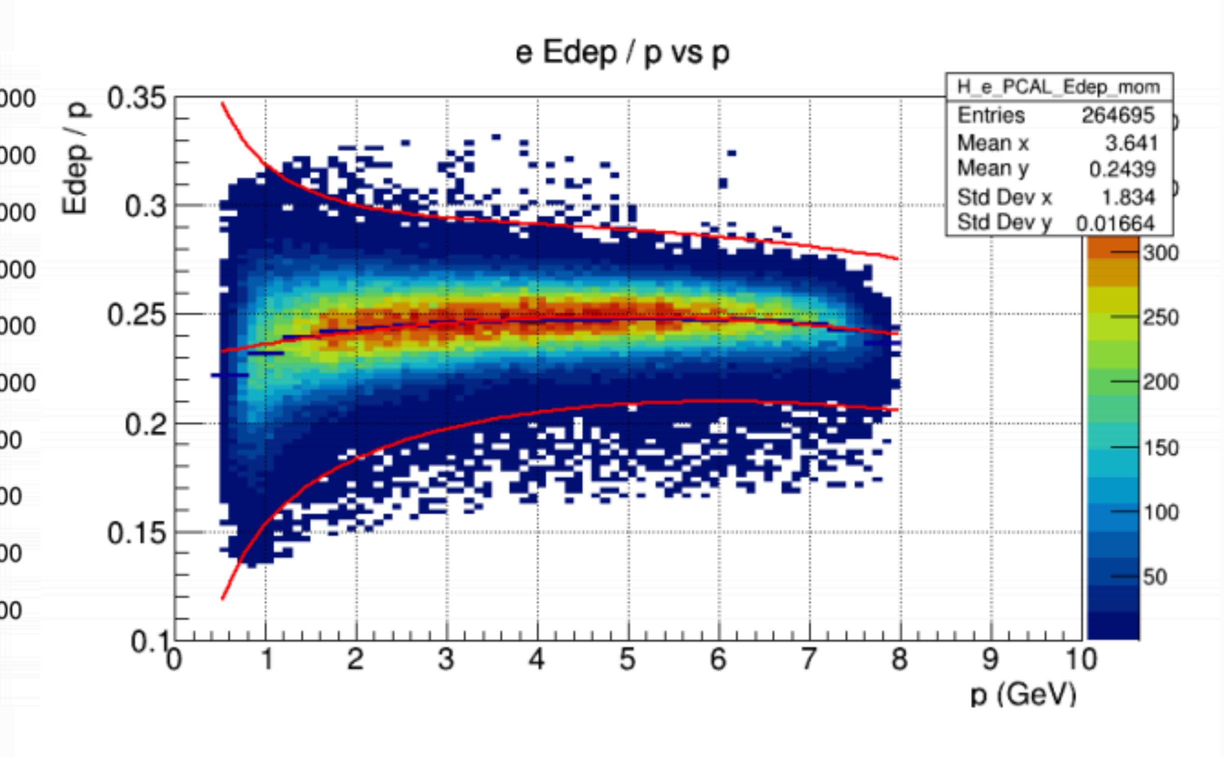
Electrons Hits on the 3 DC regions, after fiducial cuts

- **Minimum energy cut PCAL**
- **Electron Vertex -12 cm to 13 cm**
- **Pion Vertex Cut:**
  |El Vertex - Pion Vertex | <20 cm
- **Chi2PID: following the momentum parametrization of RG-A Common Analysis**
- Missing Mass> 1.5 GeV/c

PCAL:



Sampling Fraction: 3.5 sigmas



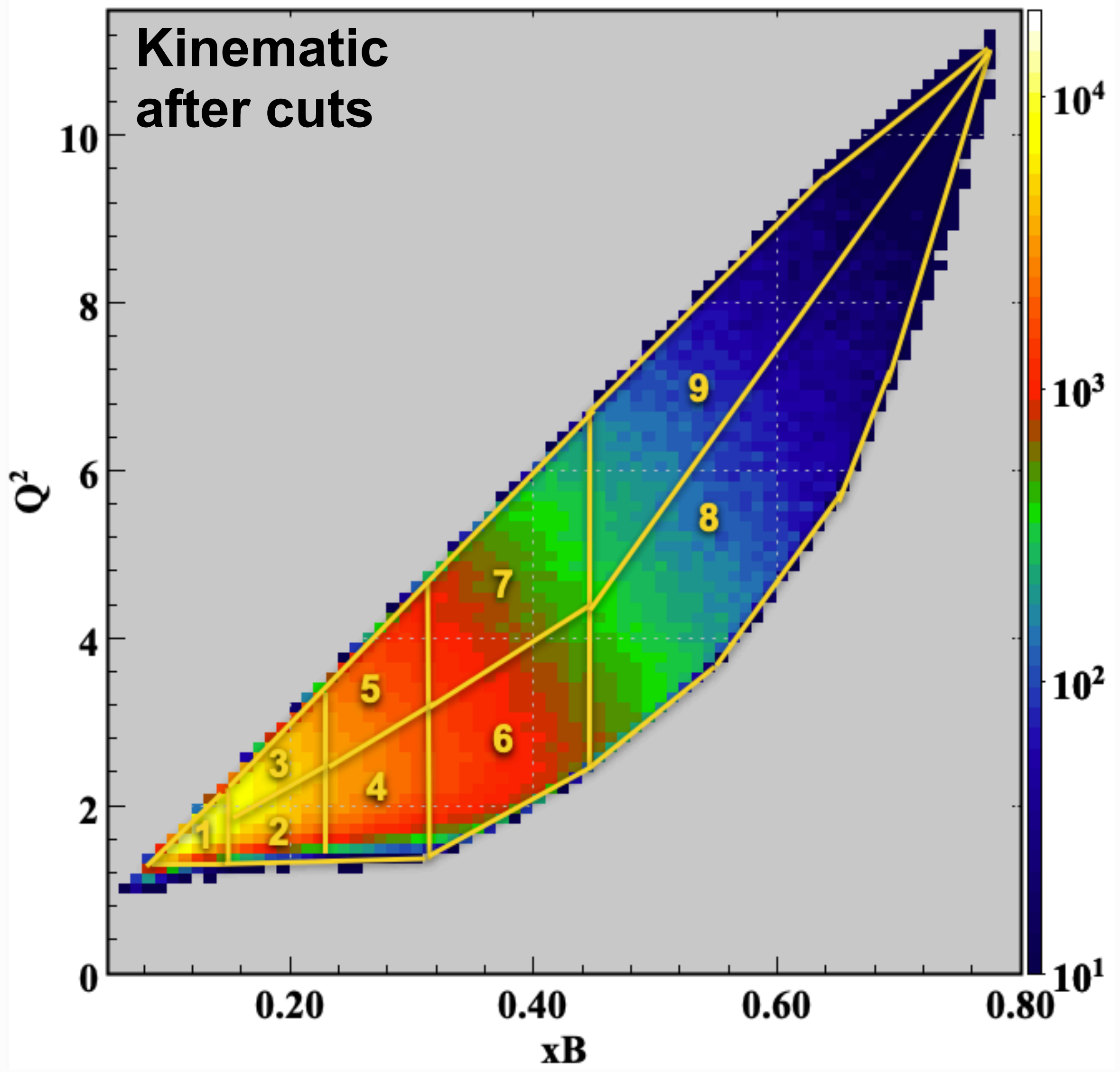
Projection of the final multiplicity analysis

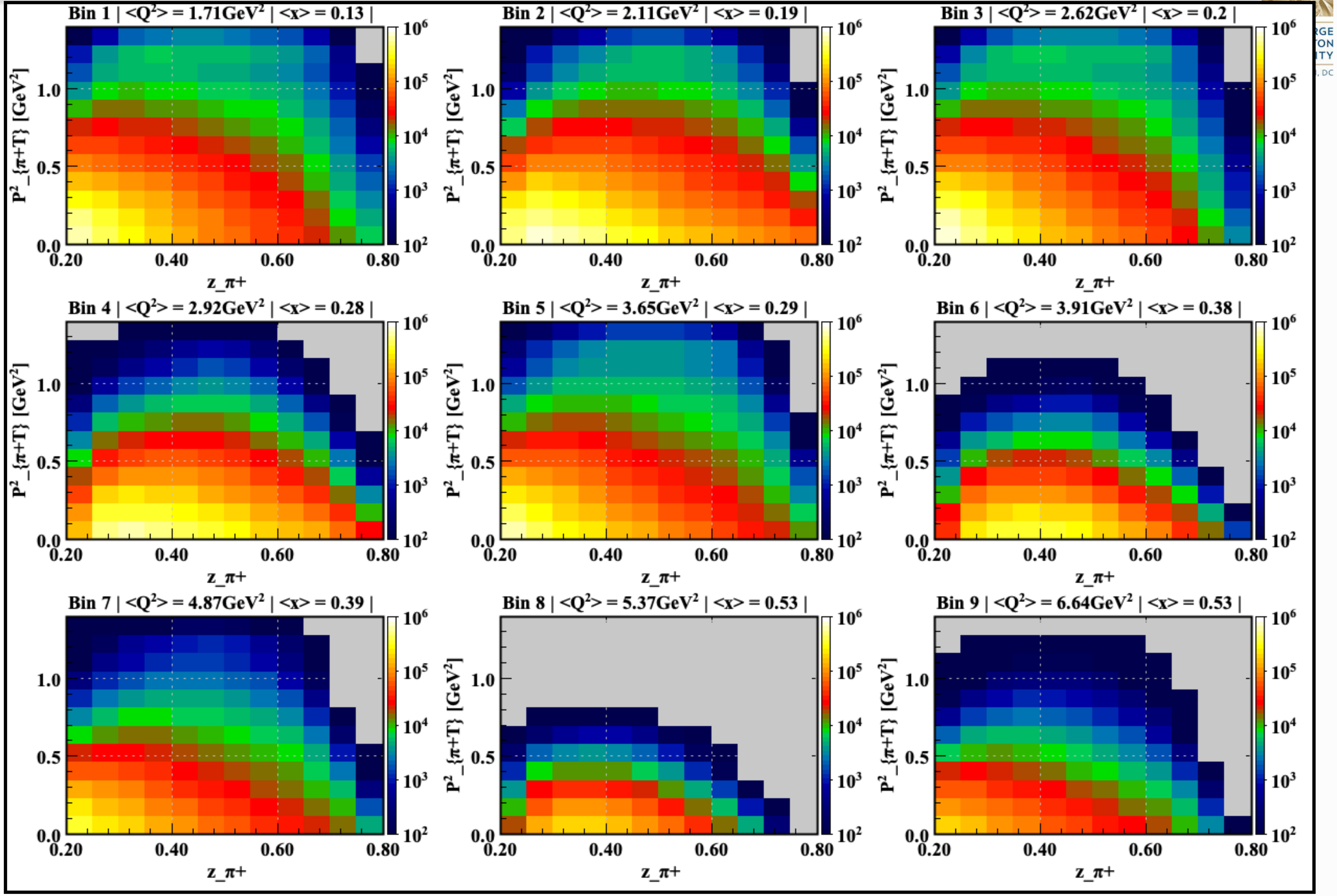
$Q^2 > 1\ GeV^2$ | W > 2GeV | y < 0.75

+PID Cuts
+ Missing Mass> 1.5 GeV/c
+ Fiducial cuts
+x_F >0

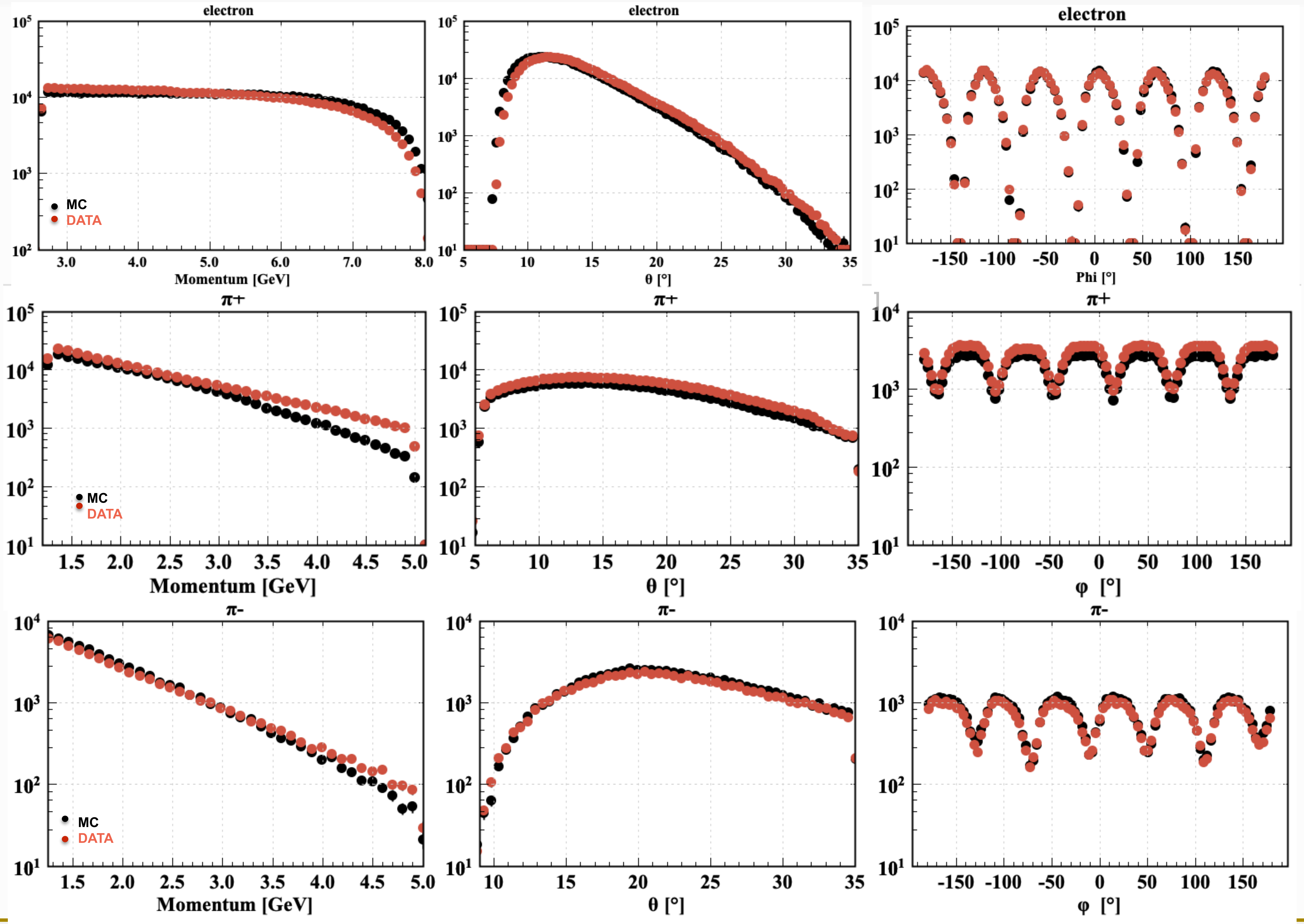
9 x 14 x 14 = 1764 bins

(Q^2, x) Z PT_2





MC vs Data: Overview



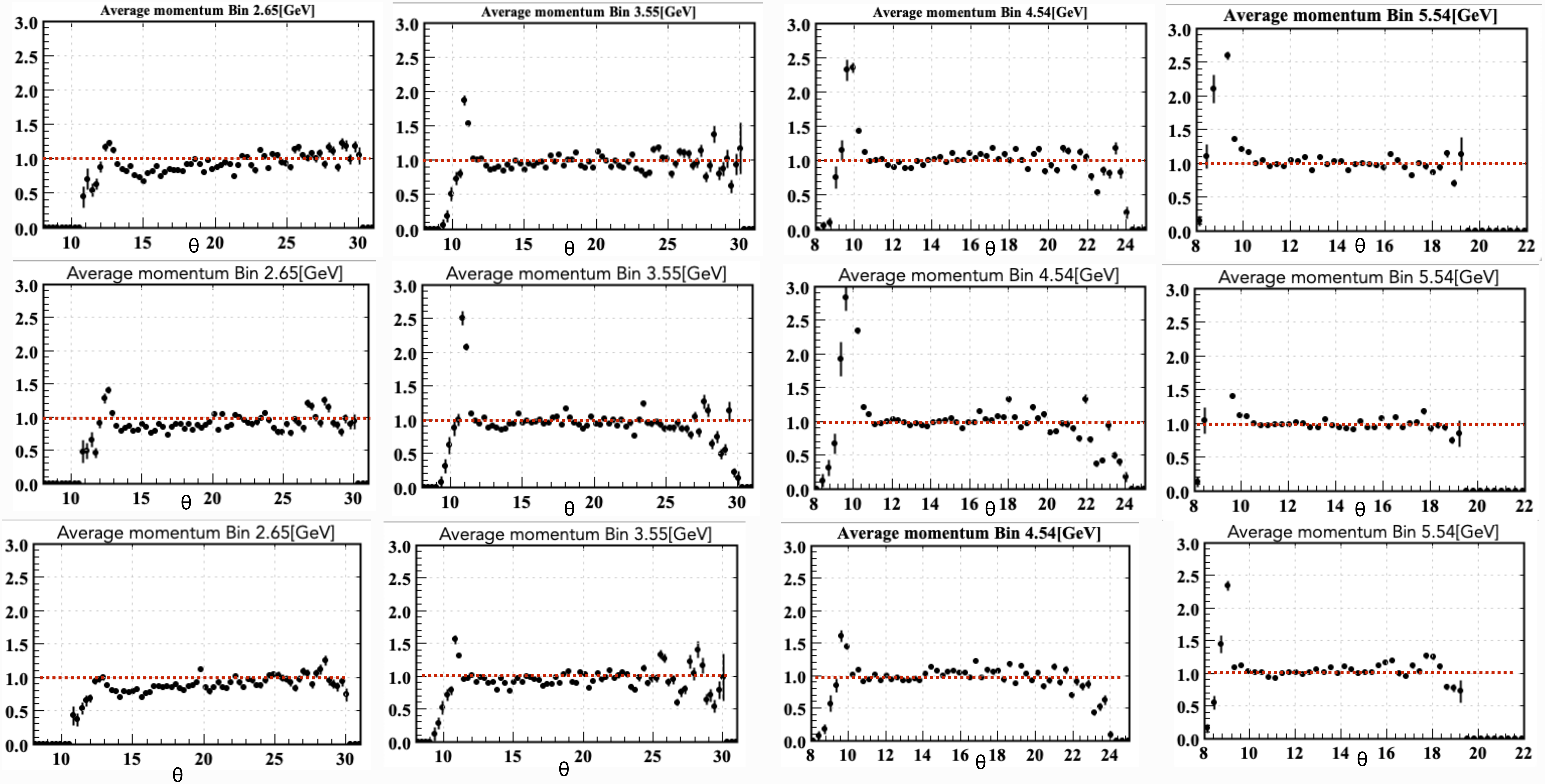
DATA vs MC: Theta Distributions

Ratio: MC/DATA Normalized to the same reconstructed electrons

S1

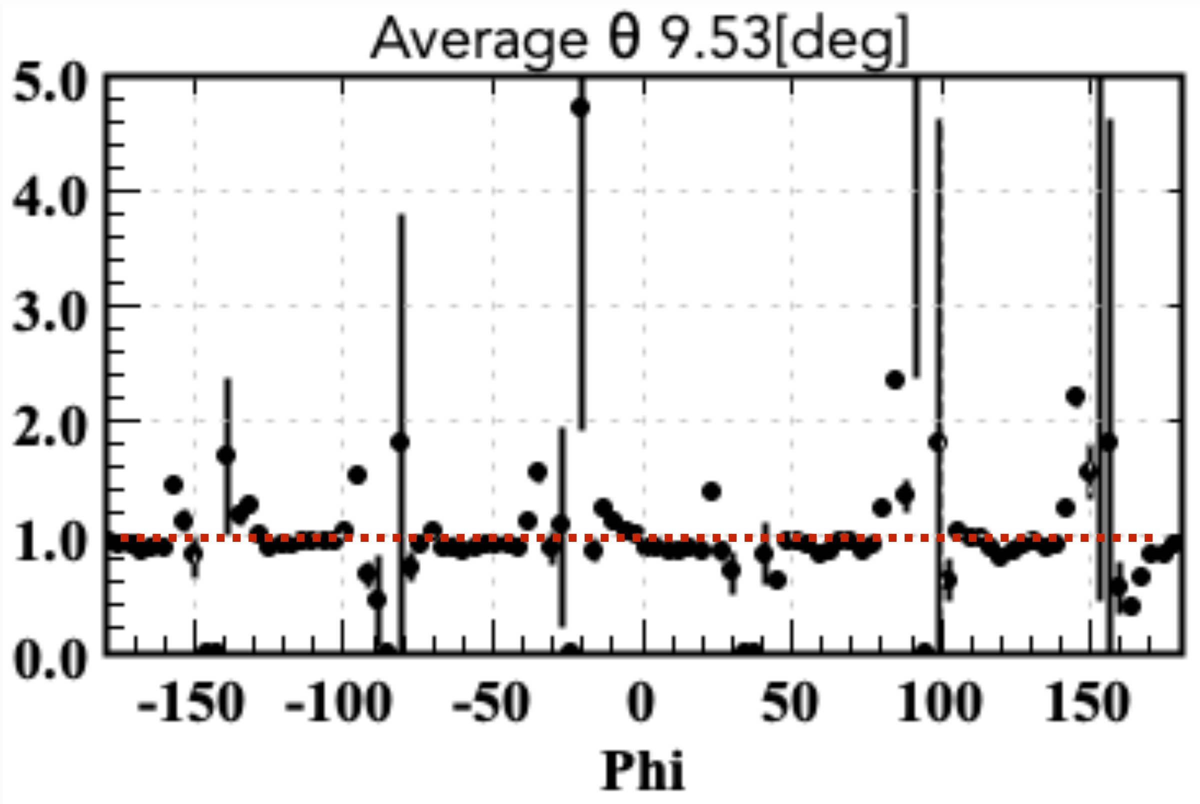
S3

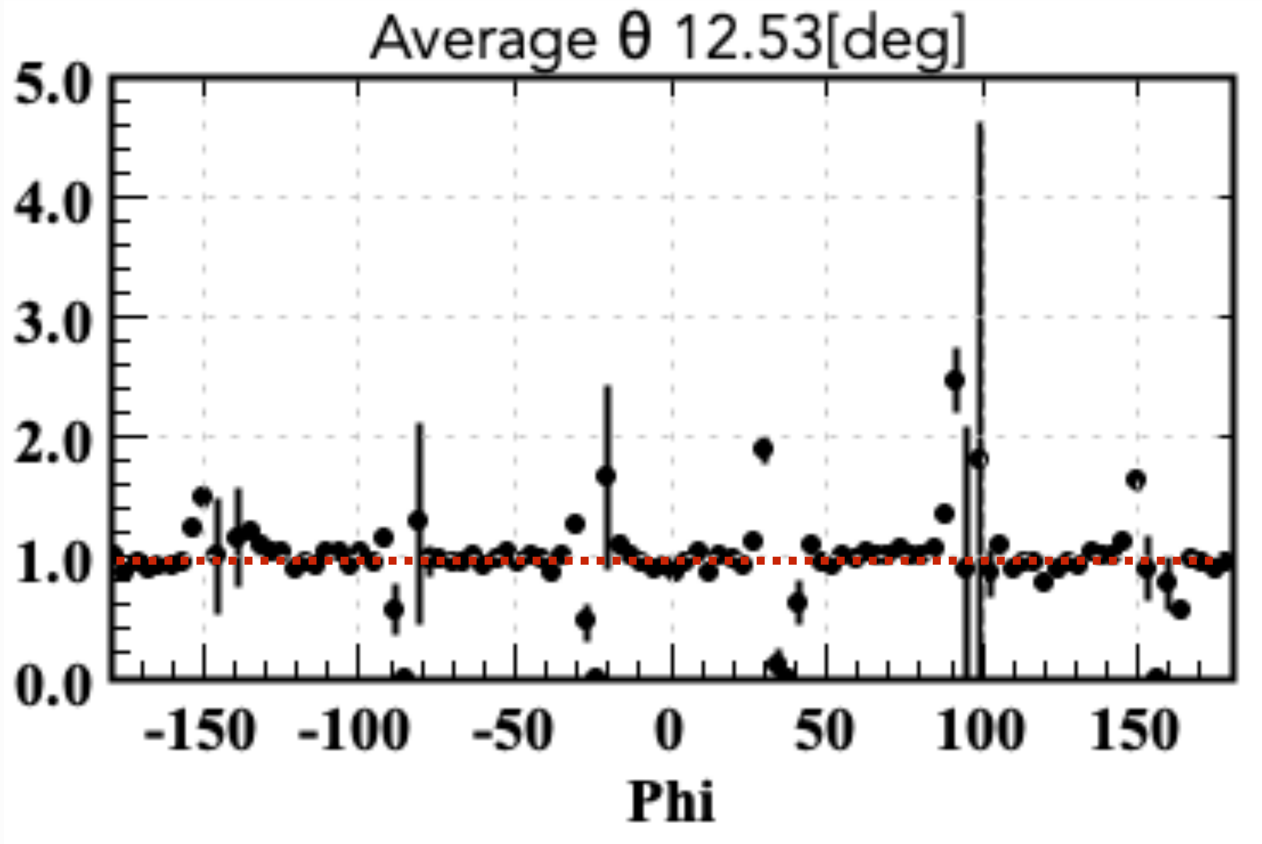
S5

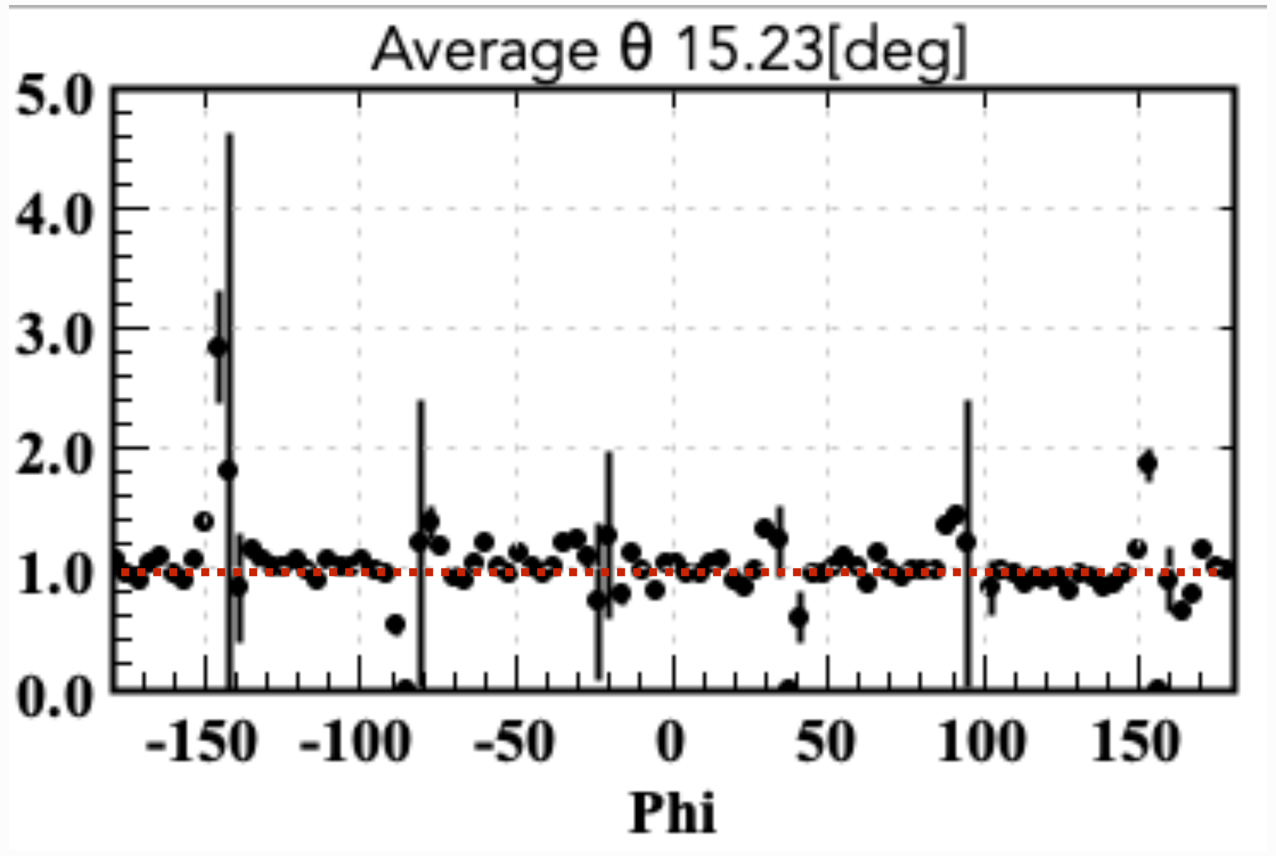


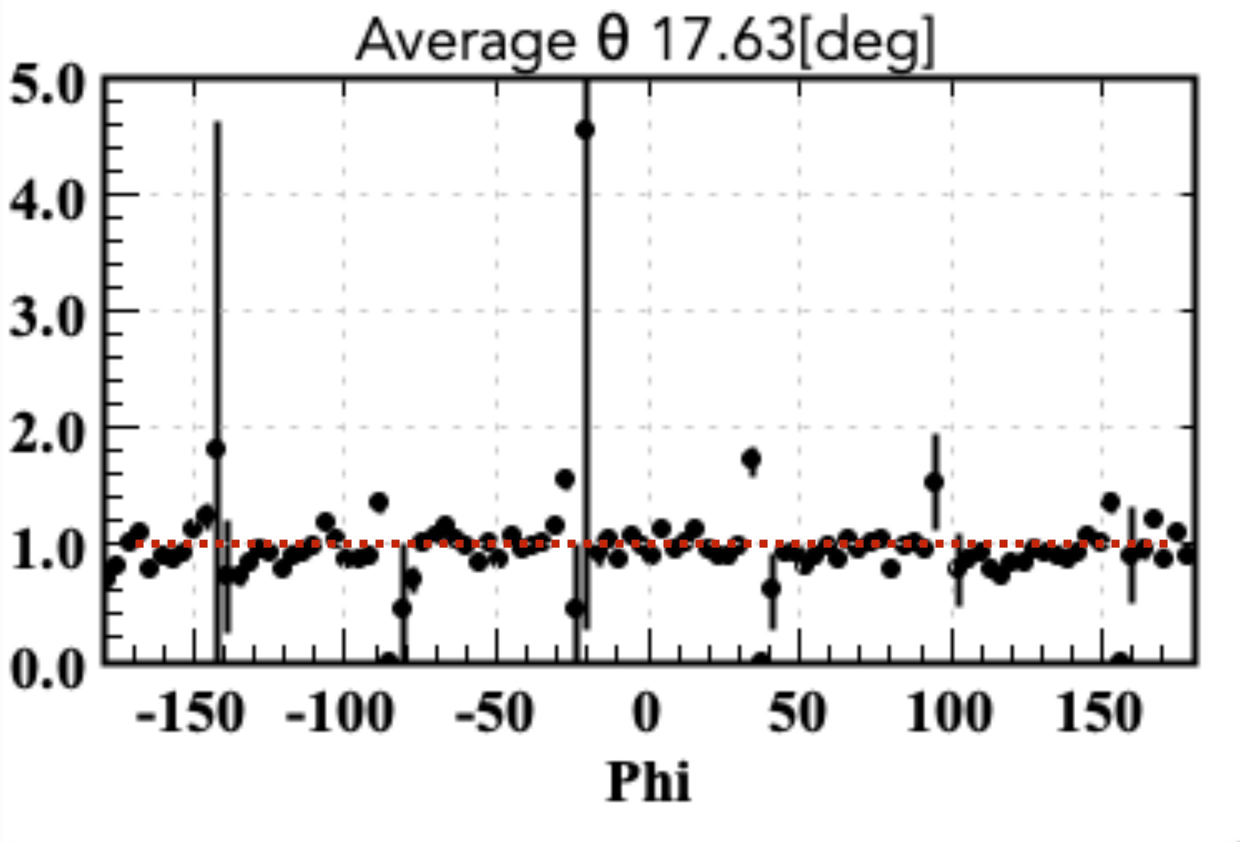
DATA vs MC: Phi distributions

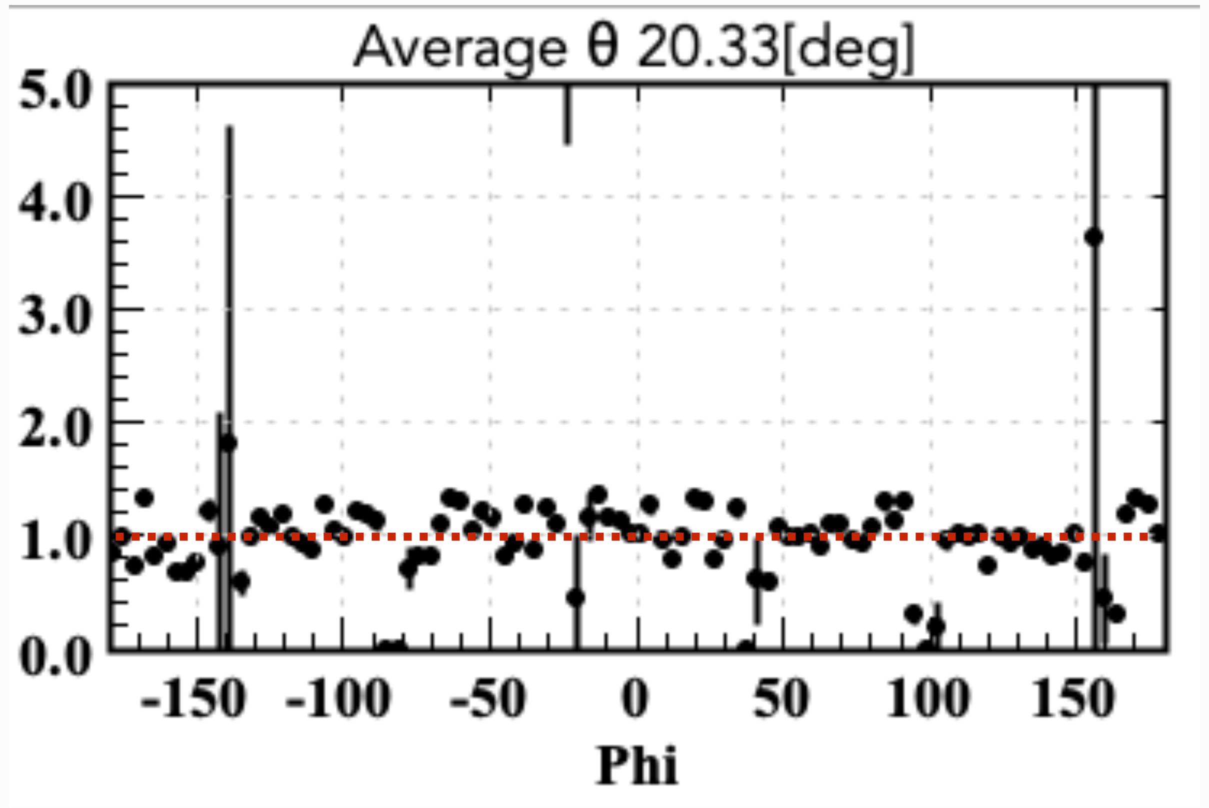
Ratio: MC/DATA   Normalized to the same reconstructed electrons

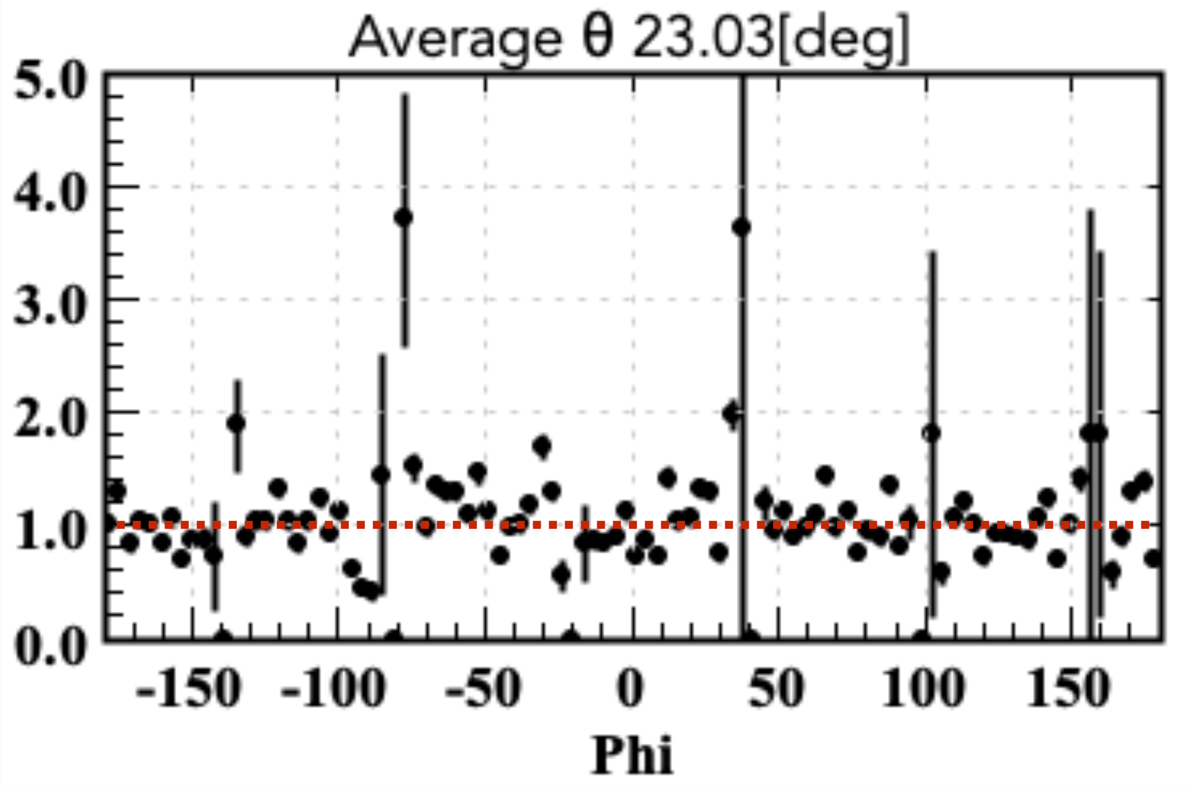












DATA vs MC: Missing Mass eπ+X

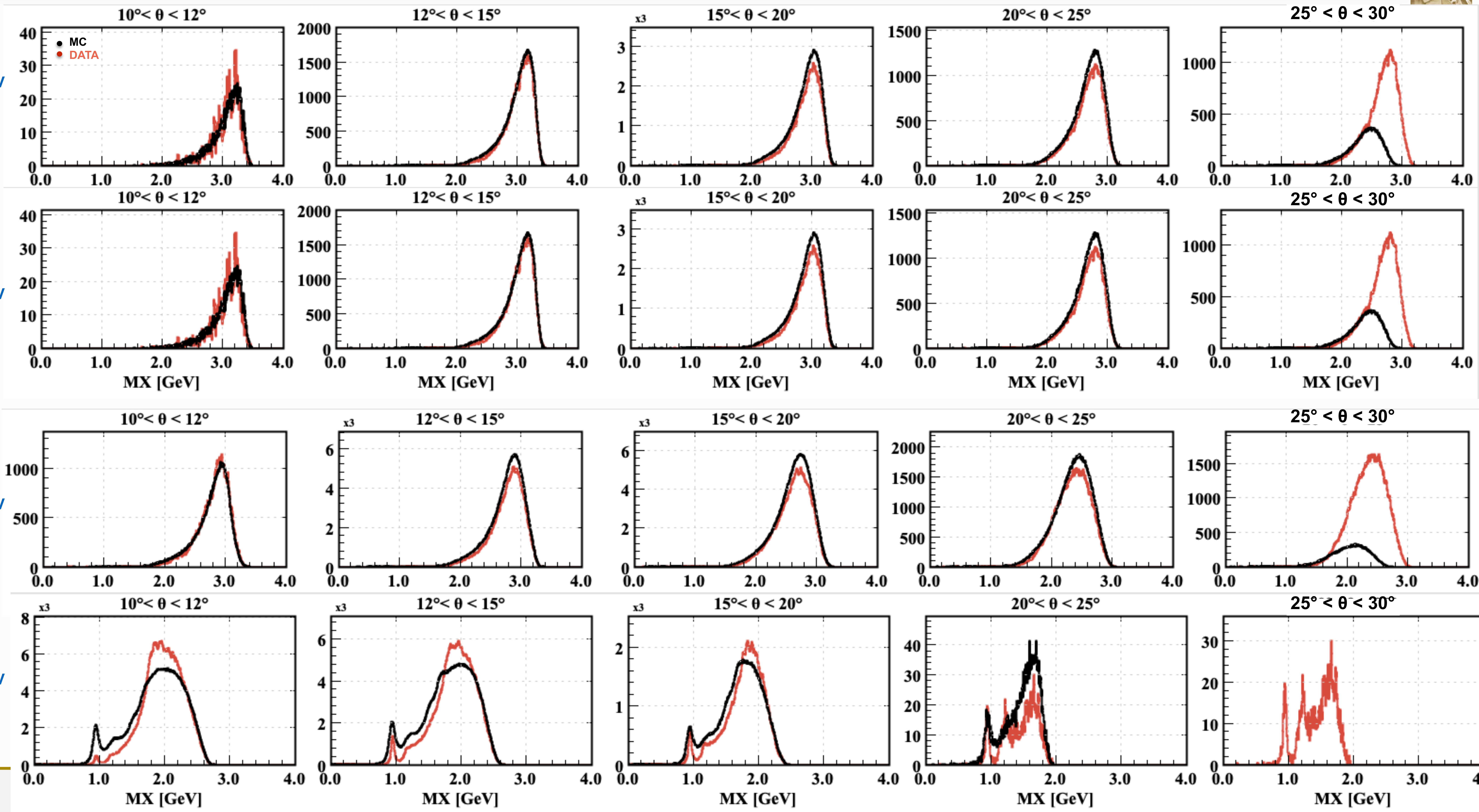
S1

2GeV<p<3GeV

3GeV<p<4GeV

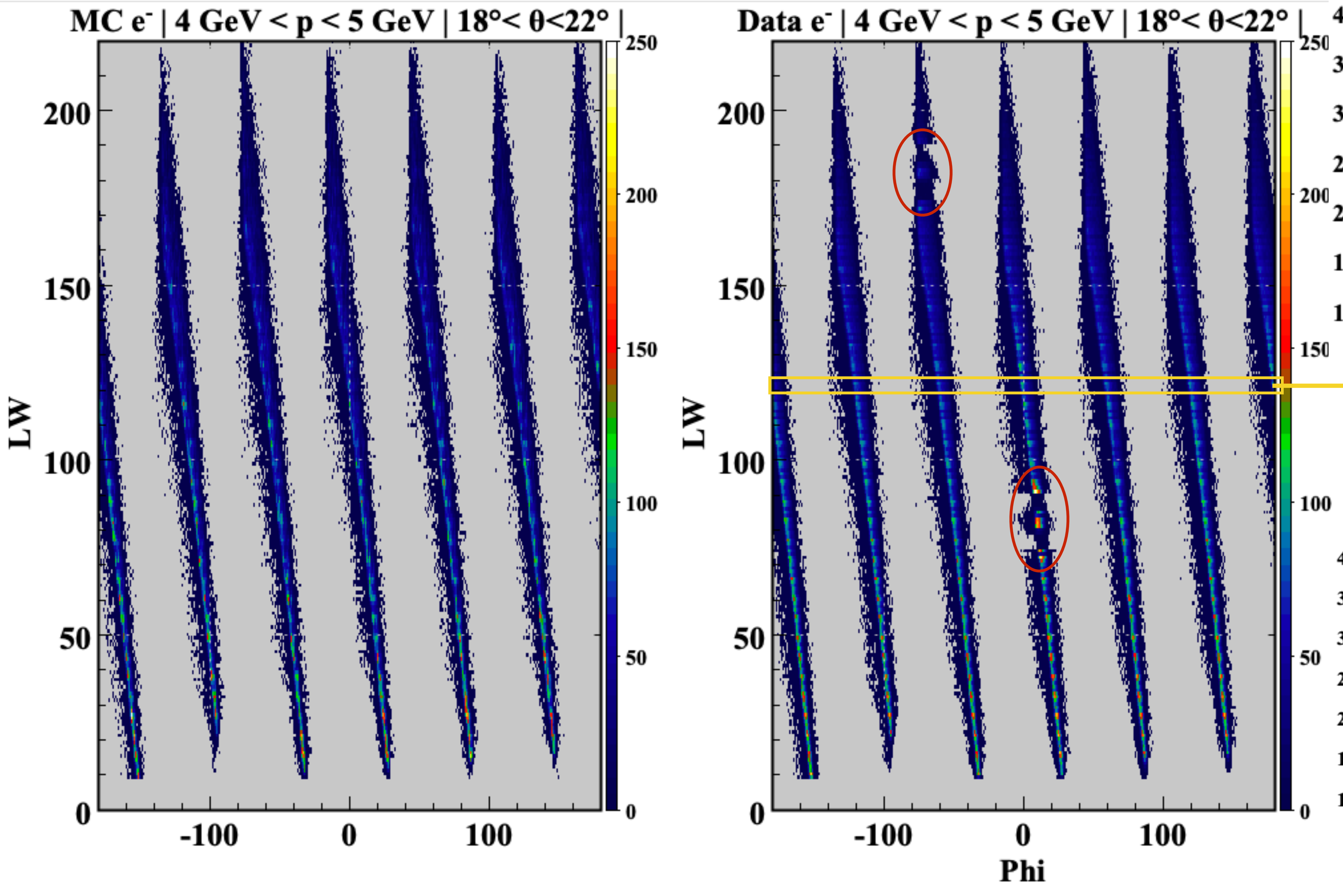
4GeV<p<5GeV

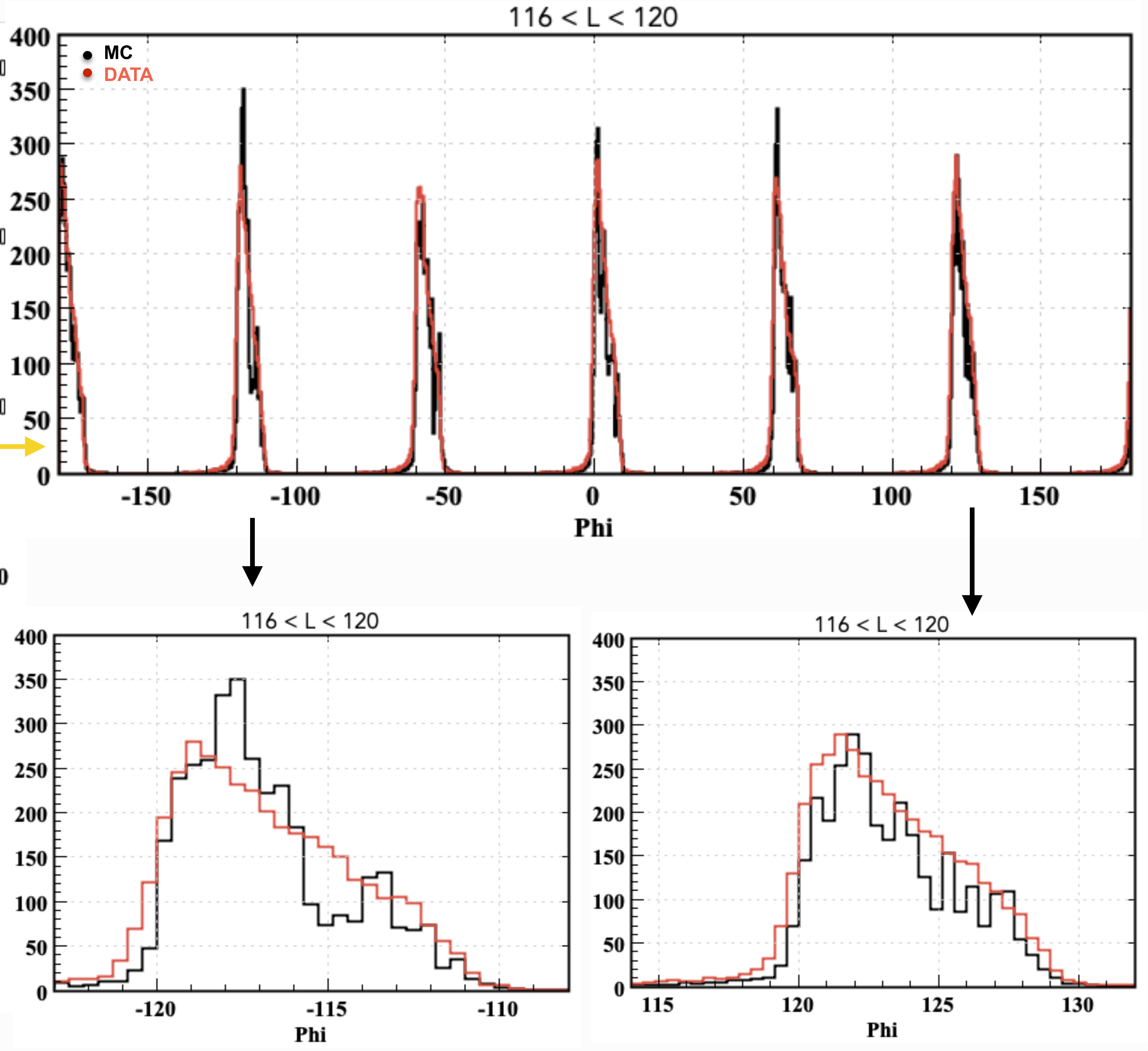
5GeV<p<7GeV



MC VS DATA : PCAL

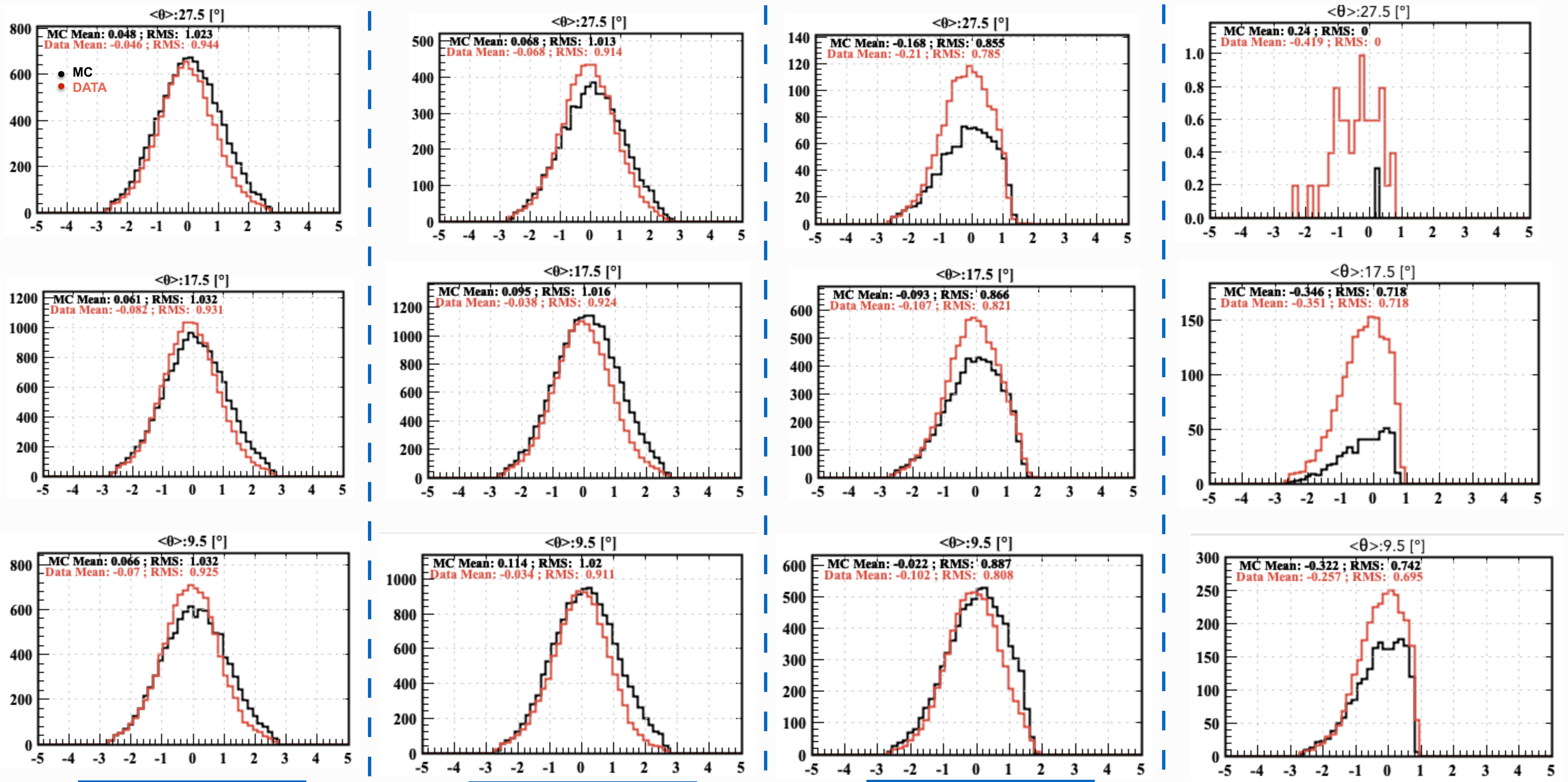
The plot are normalized for the same number of DIS electron reconstructed (in a trustable interval of momentum and angle)





MC VS DATA : π+ Chi2PID

S1

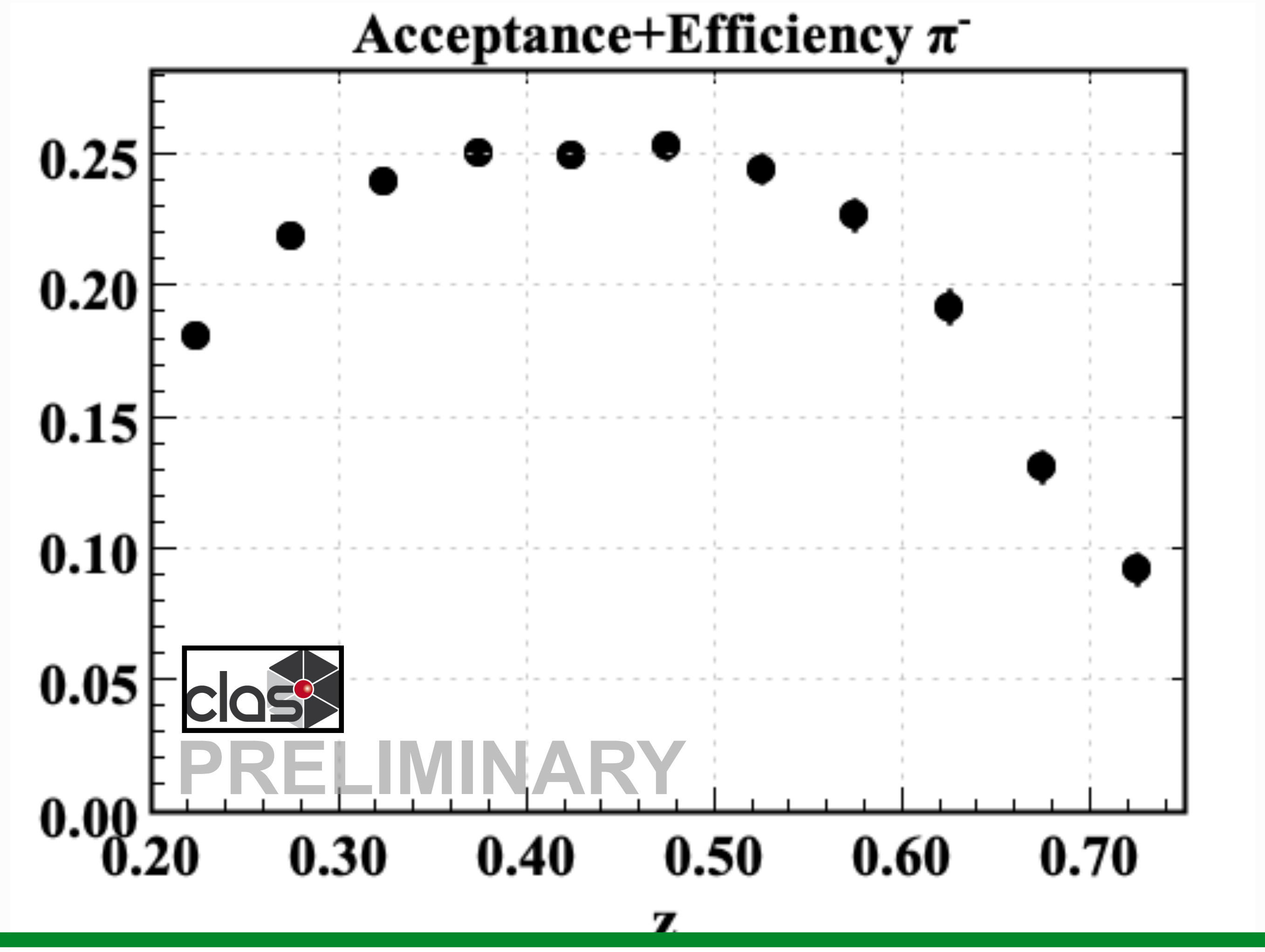


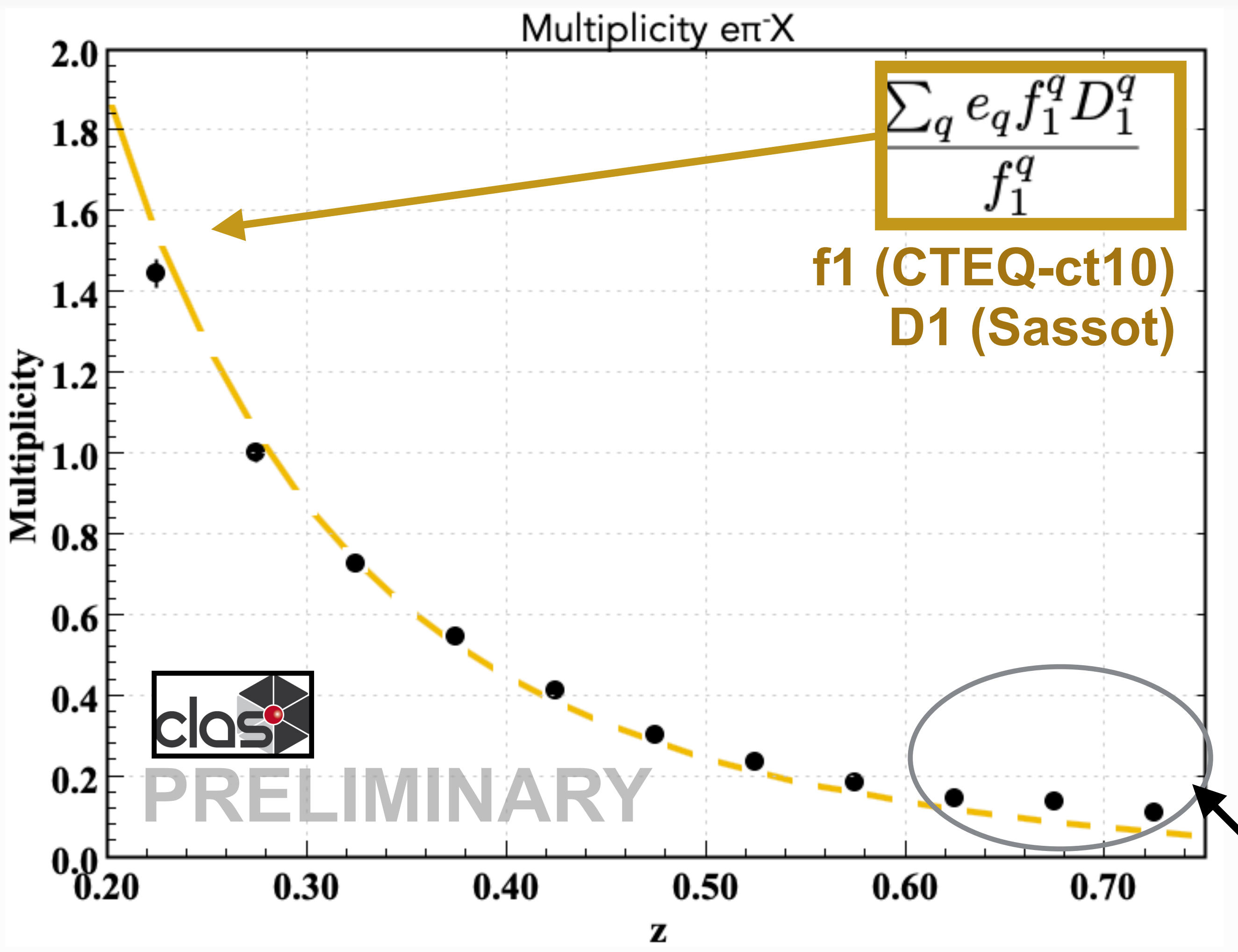
1.25GeV<p<1.5GeV | 2.0GeV<p<2.5GeV | 3.0GeV<p<3.5GeV | 4.5GeV<p<5.0GeV

Multiplicity vs z

From previous study with 1/10 of statistics

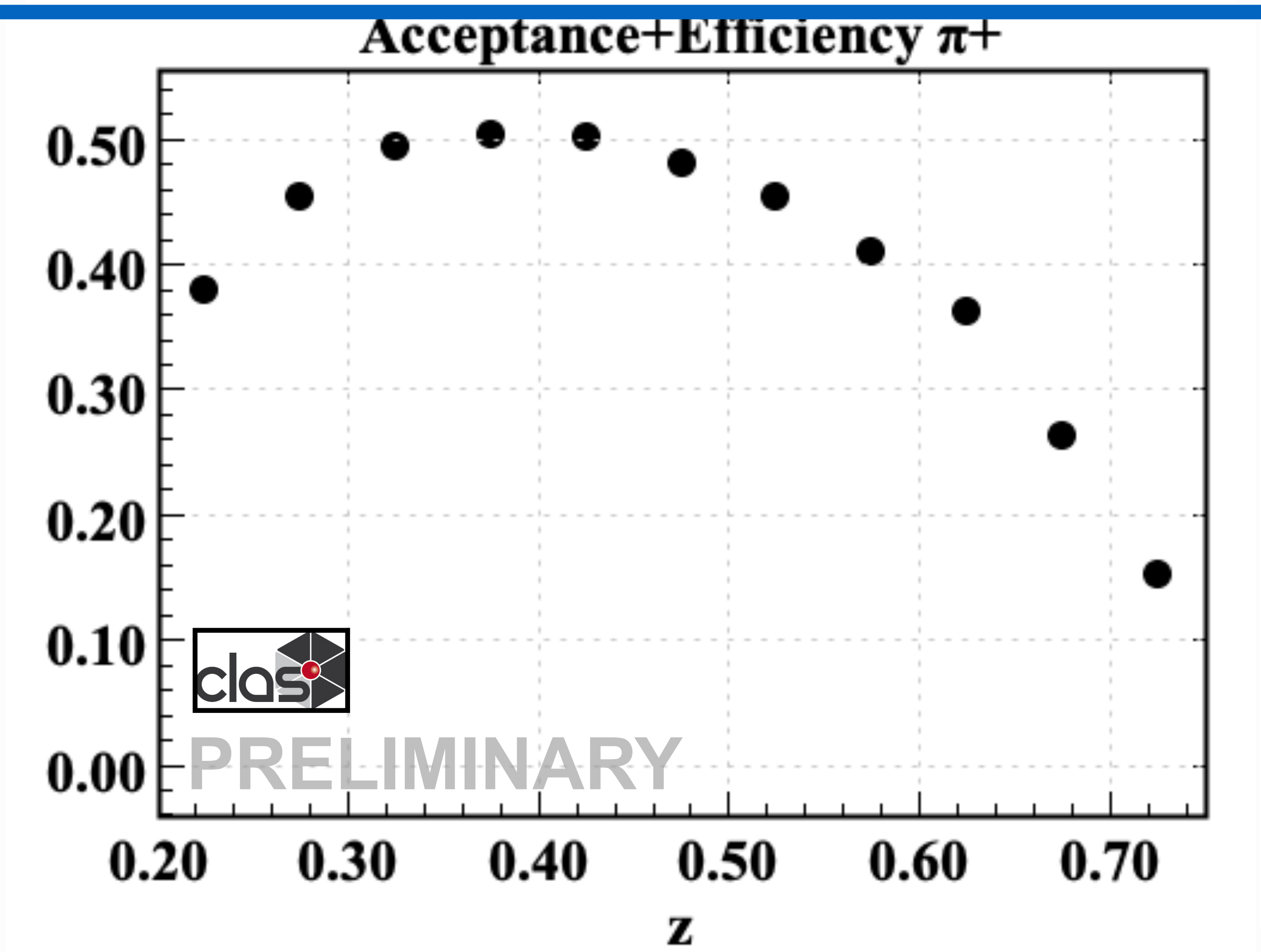
ep->eπ-X

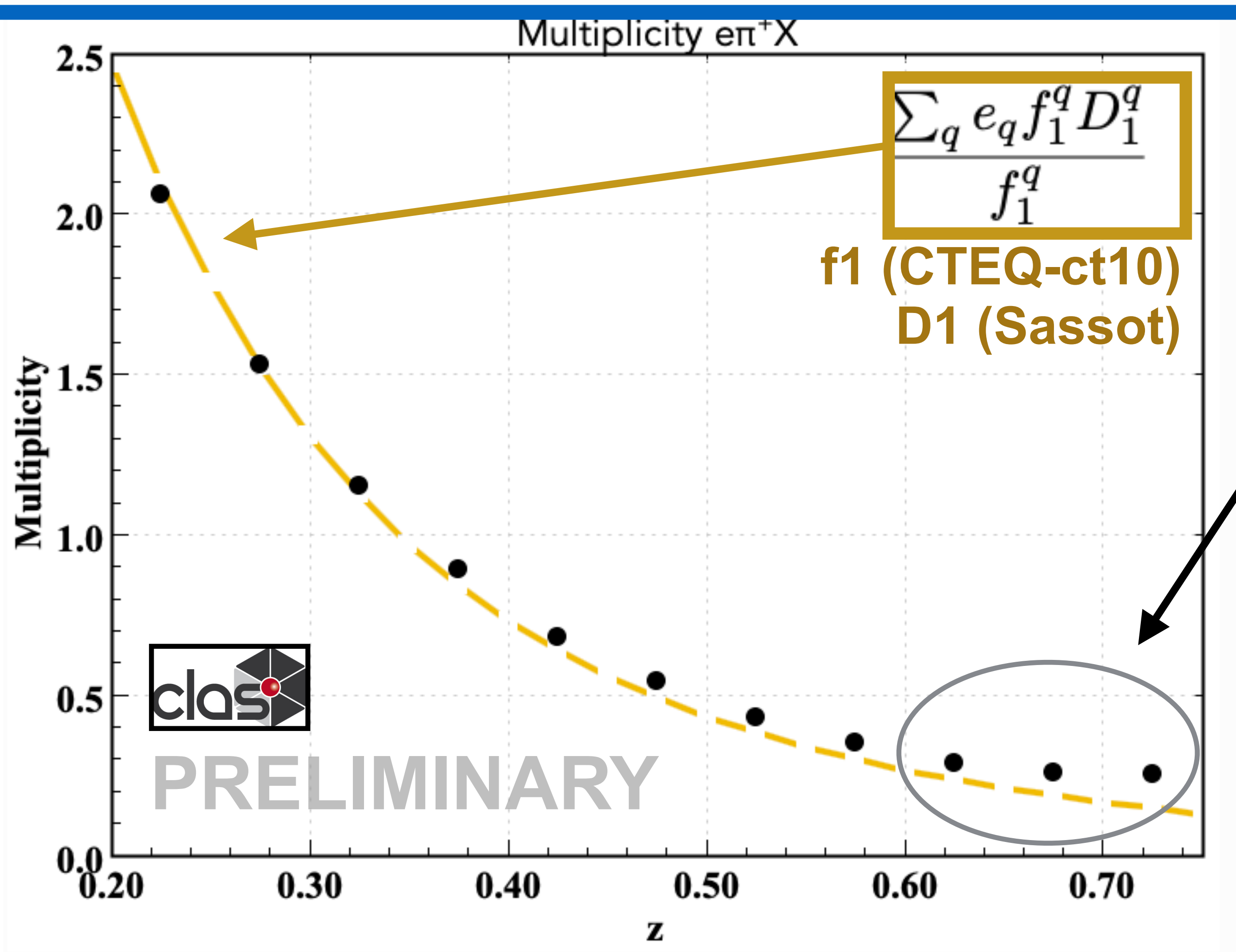




Under study,
Possible
higher twist effects

ep->eπ+X



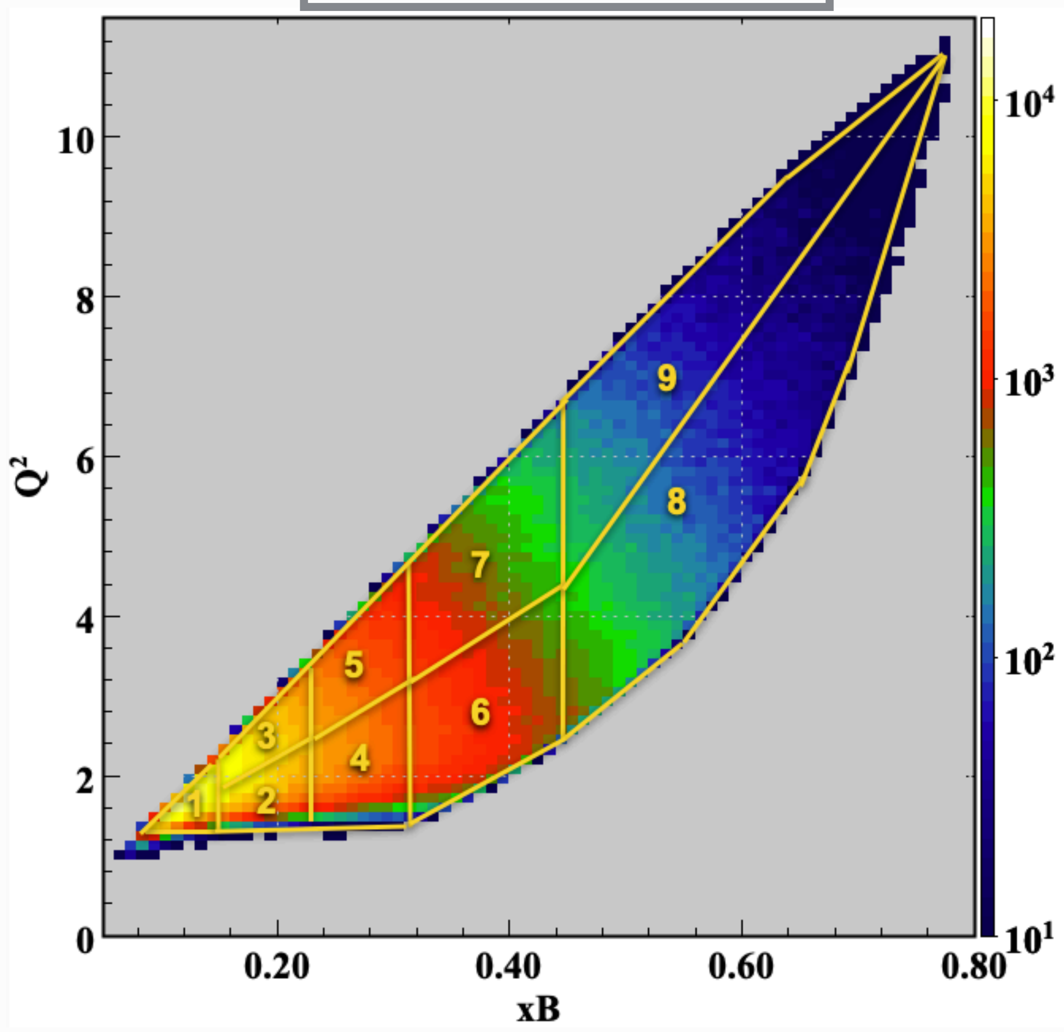


Multiplicity vs z and P_T^2 :Acceptances π^+

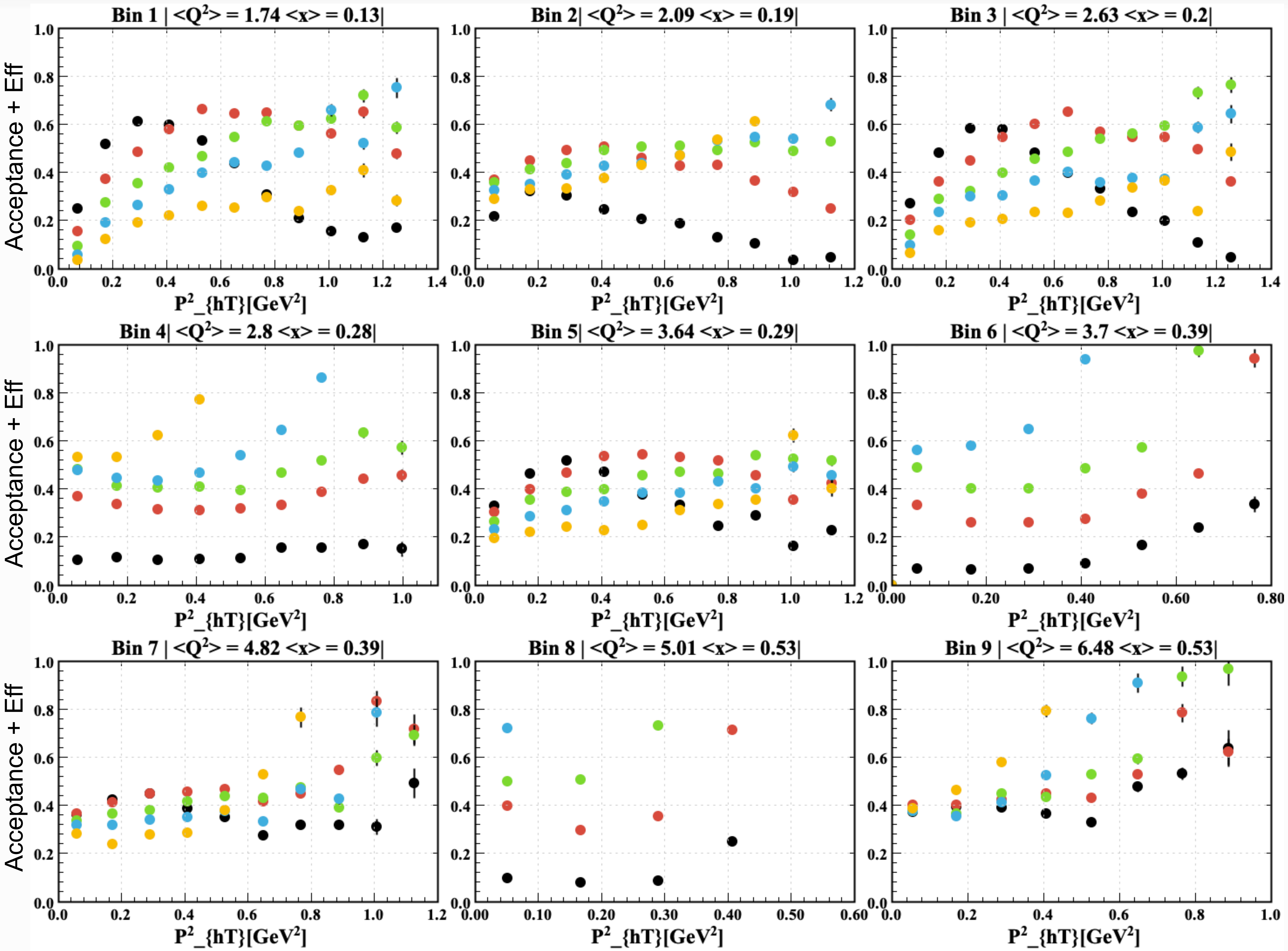
ep->eπ+X

Color legend

- 0.2<z<0.3
- 0.3<z<0.4
- 0.4<z<0.5
- 0.5<z<0.6
- 0.6<z<0.7



If we reconstructed < 10 events
&& If we generated <100 events
|| reconstructed>generated
The data point is removed

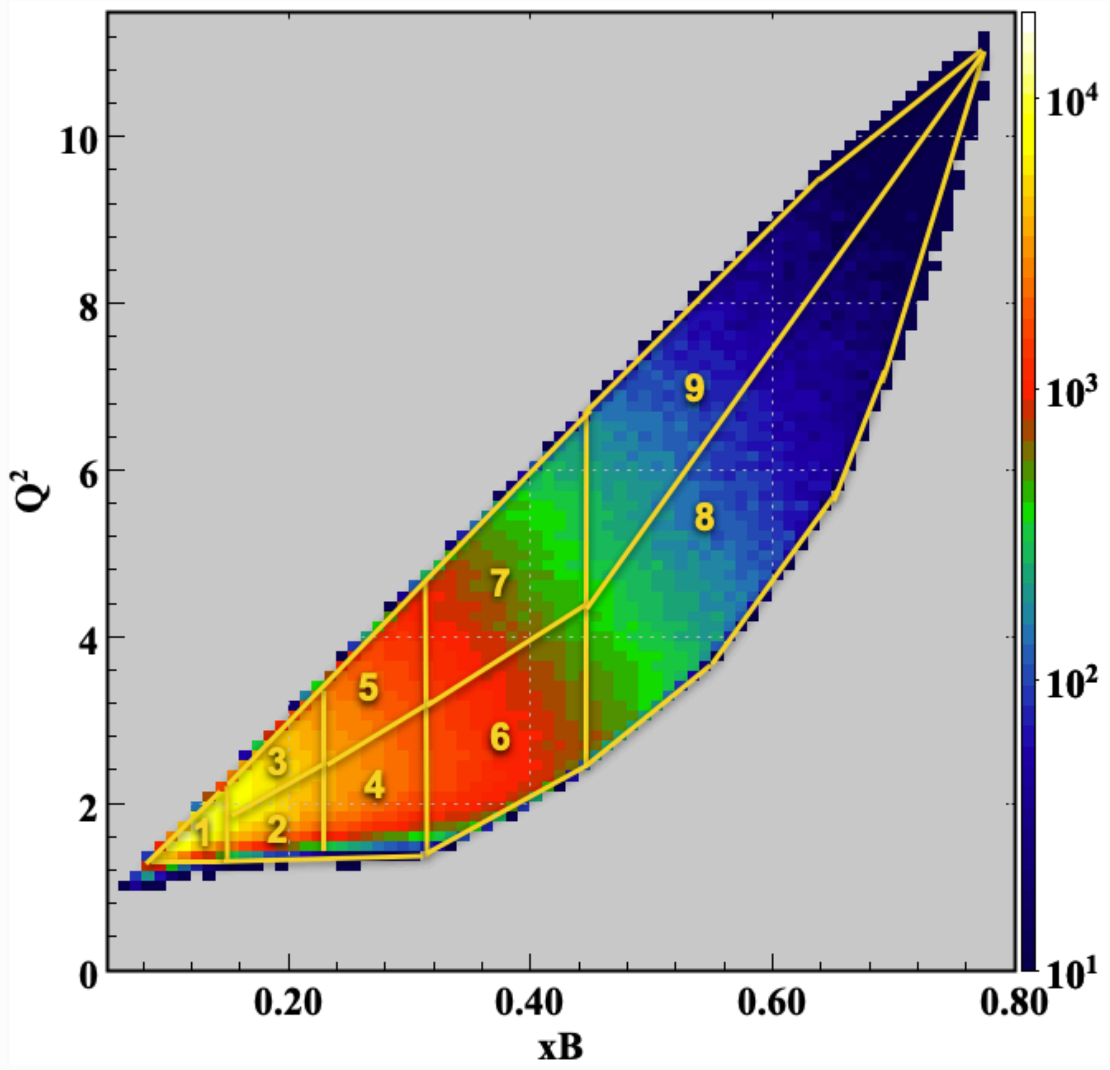


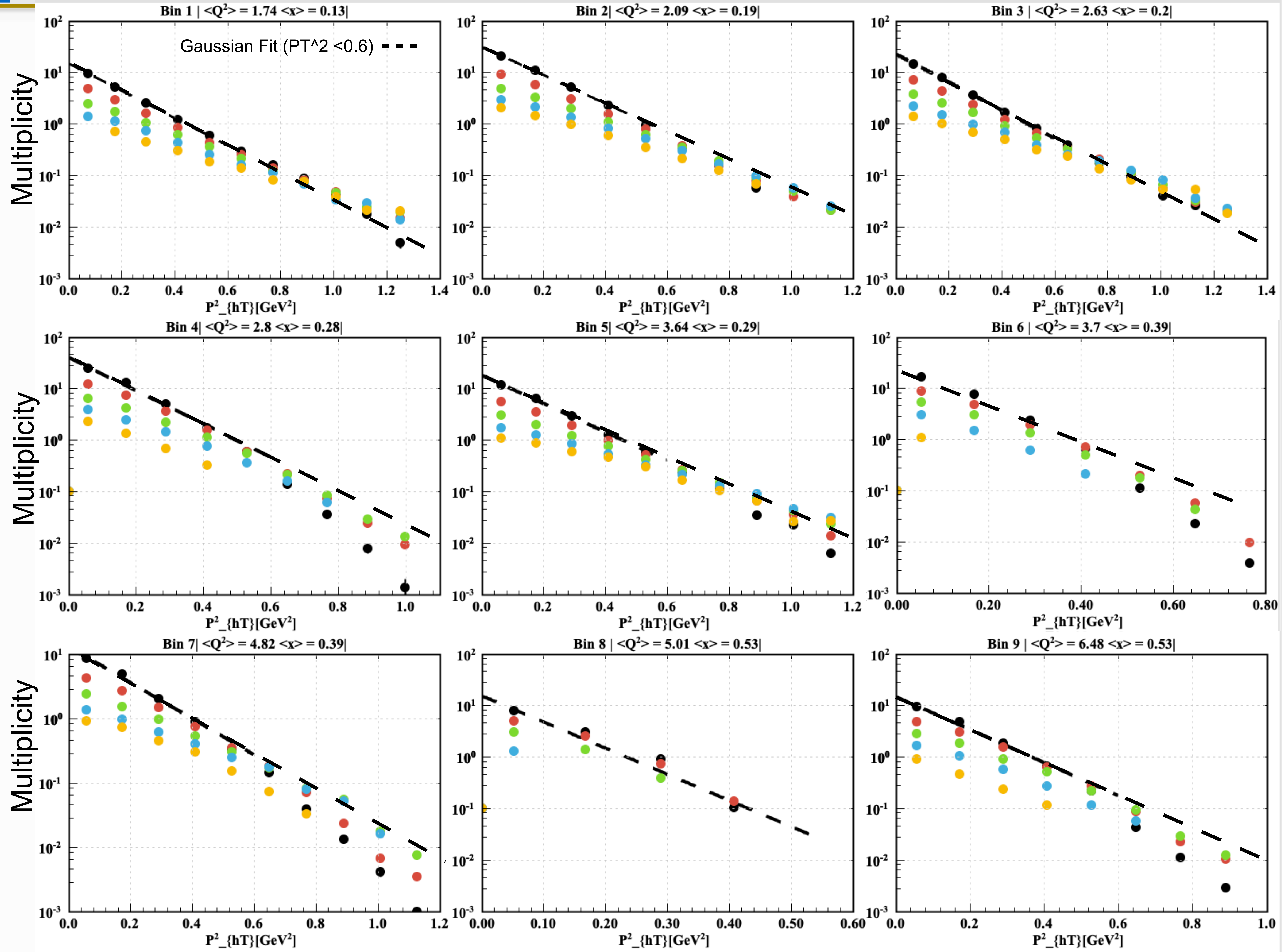
Multiplicity vs z and PT^2 : Multiplicity π^+

ep->eπ+X

Color legend

- 0.2<z<0.3
- 0.3<z<0.4
- 0.4<z<0.5
- 0.5<z<0.6
- 0.6<z<0.7



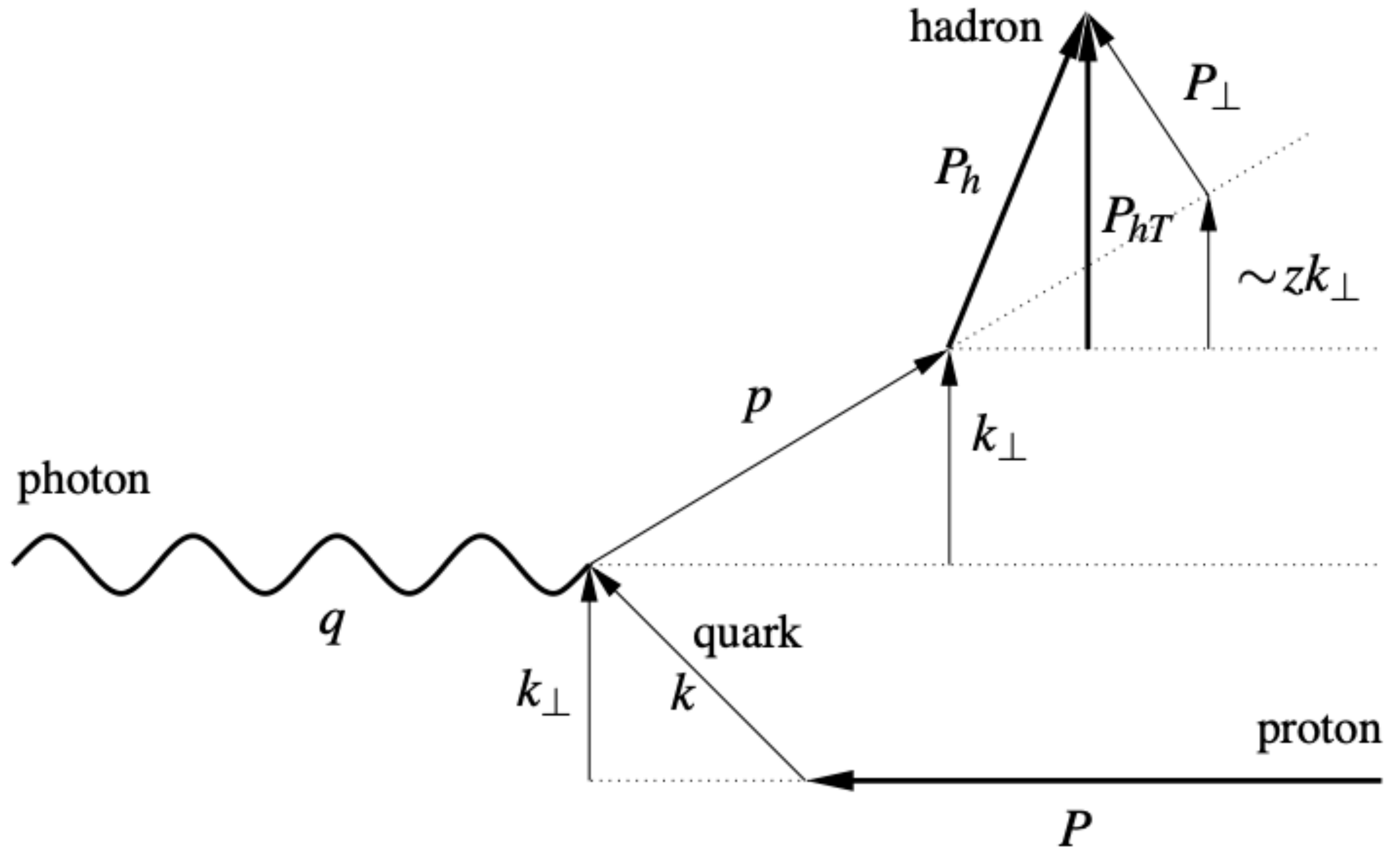


On the extraction on transverse momentum

$$f_1^q \otimes D_1^q = \int d^2k_\perp d^2p_\perp \delta^2\left(k_\perp - p_\perp - \frac{1}{z}P_{h\perp}\right) f_1^q(x,k_\perp) D_1^q(z,p_\perp)$$

We would like to extract average transverse momentum from our data

$$m_N^h(x,z,\boldsymbol{P}_{hT}^2) = \frac{\pi}{\sum_a e_a^2\, f_1^a(x)} \times \sum_a e_a^2\, f_1^a(x)\, D_1^{a\to h}(z)\, \frac{e^{-\boldsymbol{P}_{hT}^2/\left(z^2\langle \boldsymbol{k}_{\perp,a}^2\rangle + \langle \boldsymbol{P}_{\perp,a\to h}^2\rangle\right)}}{\pi\left(z^2\langle \boldsymbol{k}_{\perp,a}^2\rangle + \langle \boldsymbol{P}_{\perp,a\to h}^2\rangle\right)}$$



$$\langle \boldsymbol{P}_{hT,a}^2\rangle = z^2\langle \boldsymbol{k}_{\perp,a}^2\rangle + \langle \boldsymbol{P}_{\perp,a\to h}^2\rangle \,.$$

Momentum	Physical description
k	4-momentum of parton in distribution function
p	4-momentum of fragmenting parton
$\boldsymbol{k}_\perp$	light-cone transverse momentum of parton in distribution function
$\boldsymbol{P}_\perp$	light-cone transverse momentum of final hadron w.r.t. fragmenting parton
$\boldsymbol{P}_{hT}$	light-cone transverse momentum of final hadron w.r.t. virtual photon

From: Investigations into the flavor dependence of partonic transverse momentum

Signori et Al., https://arxiv.org/pdf/1309.3507.pdf

Extracting transverse momentum

In order to reconstruct the initial parton transverse momentum one should:

- Assume a functional dependency of Pion transverse momentum that link it to the parton transverse momentum

-Correct for effects due to detector and limit phase space:

1)Correction from detector using MC description of the detector (acceptance corrected data).
2) Correction from phase space.

This is an on going work.

Here I am going to show you the effects of phase space with pion produced from strings, omegas produced from strings, and pion decayed from those omegas by using a dedicated MC.

Extracting transverse momentum

This is an analysis on LUND Generated files.

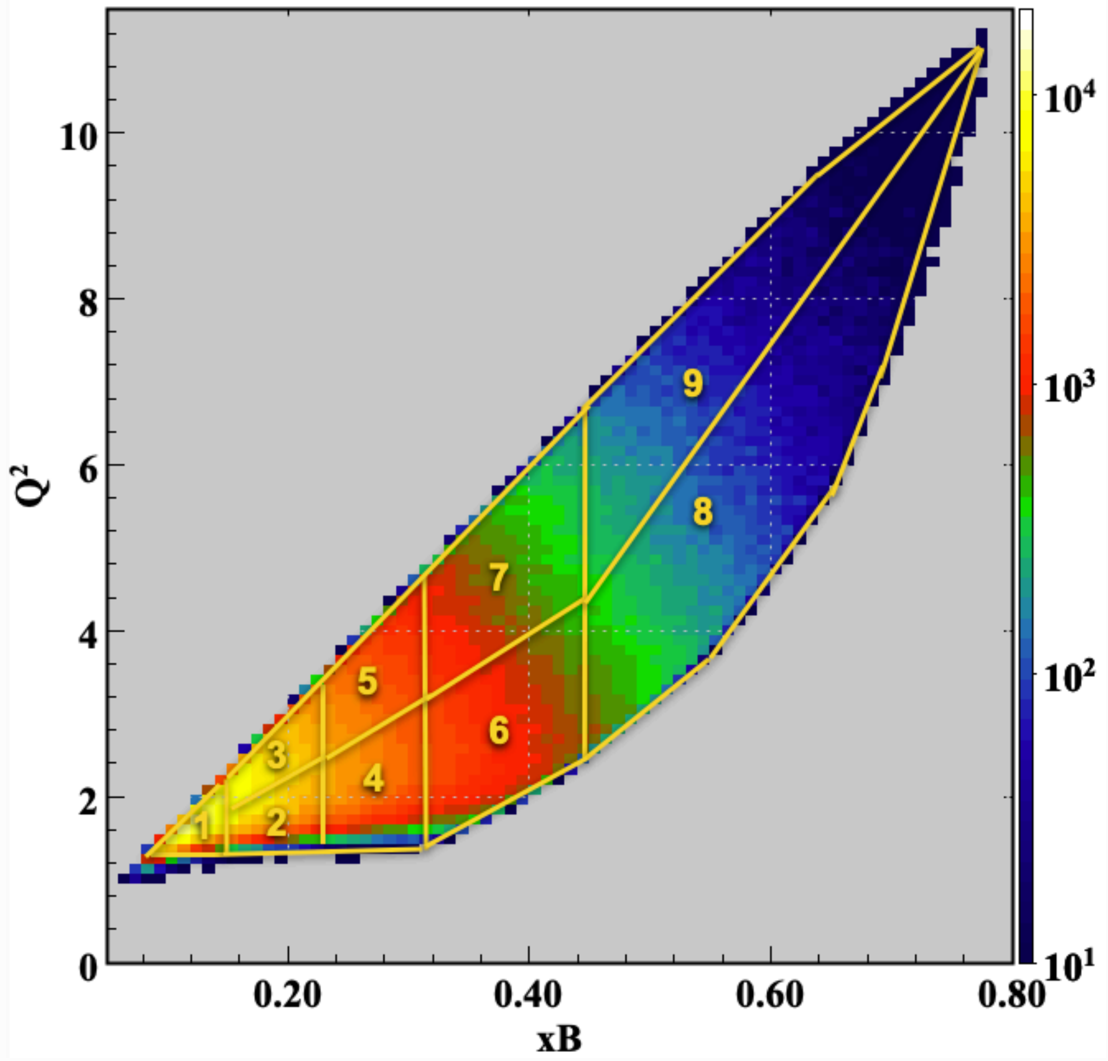
π^+
Directly produced from strings

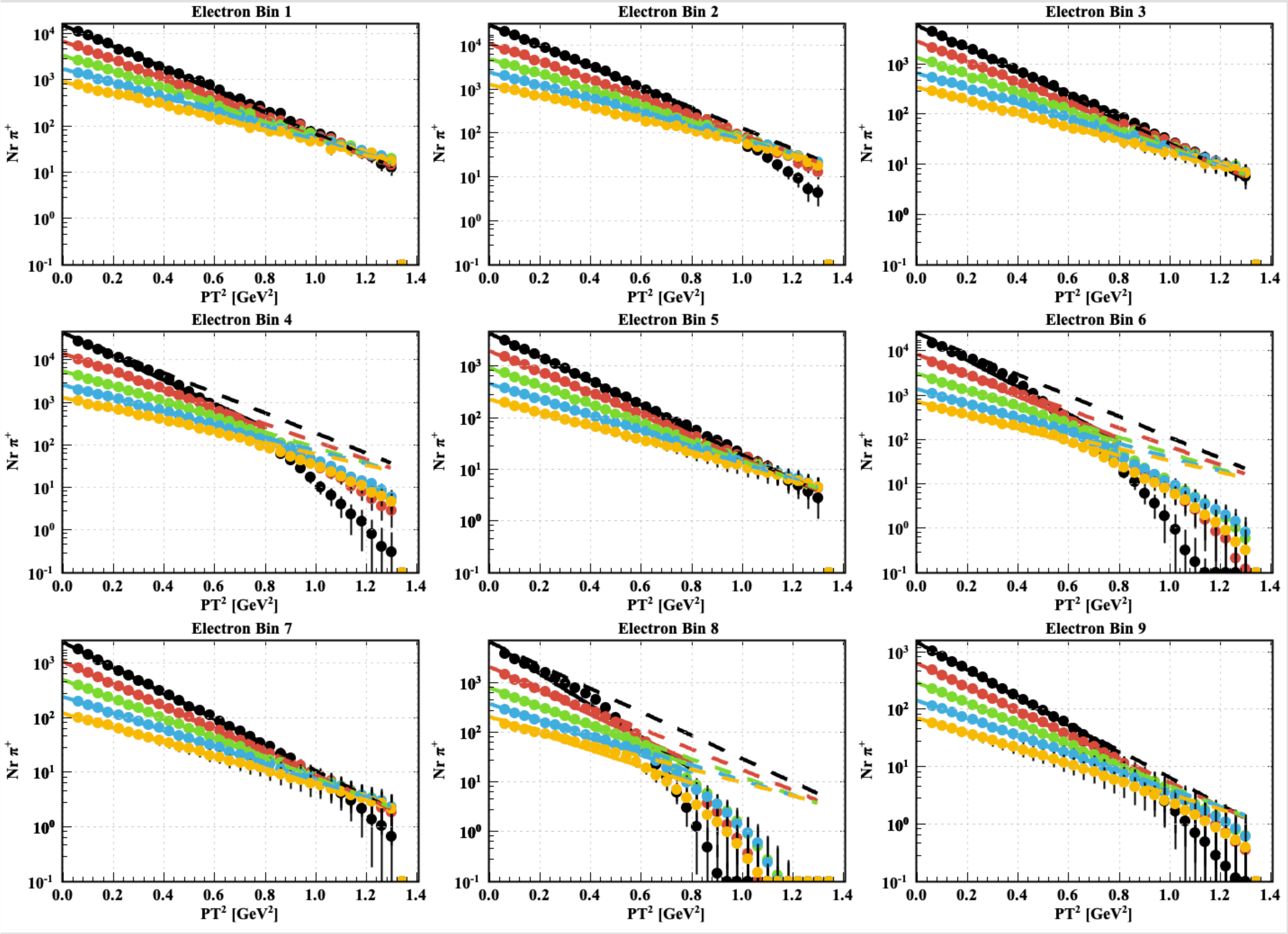
Color legend

- 0.2<z<0.3
- 0.3<z<0.4
- 0.4<z<0.5
- 0.5<z<0.6
- 0.6<z<0.7

------ Input Function

—— Fitted



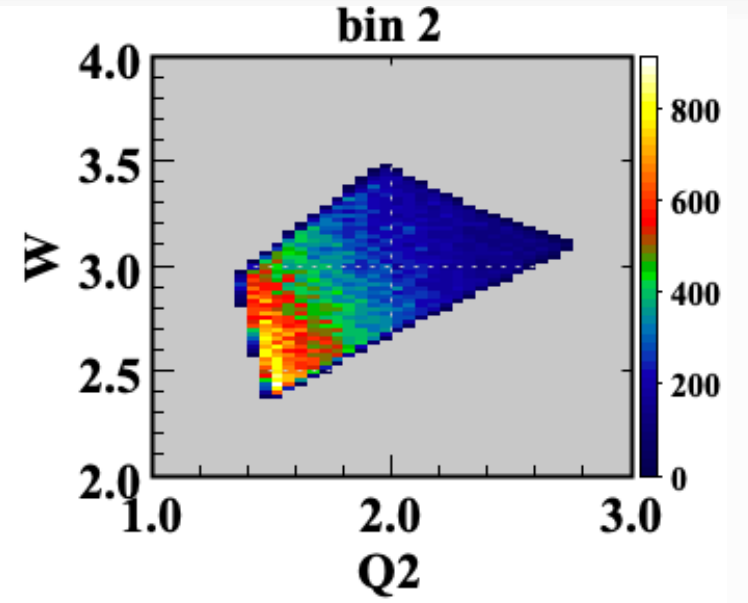


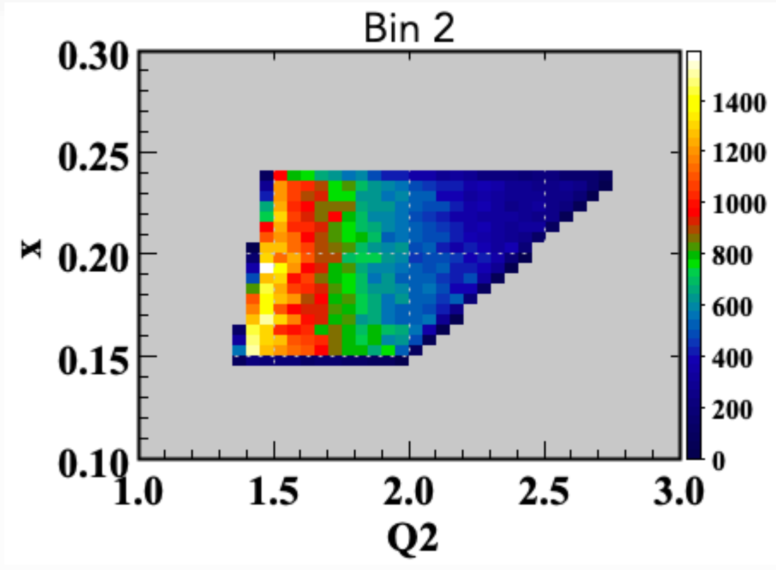
Extracting transverse momentum

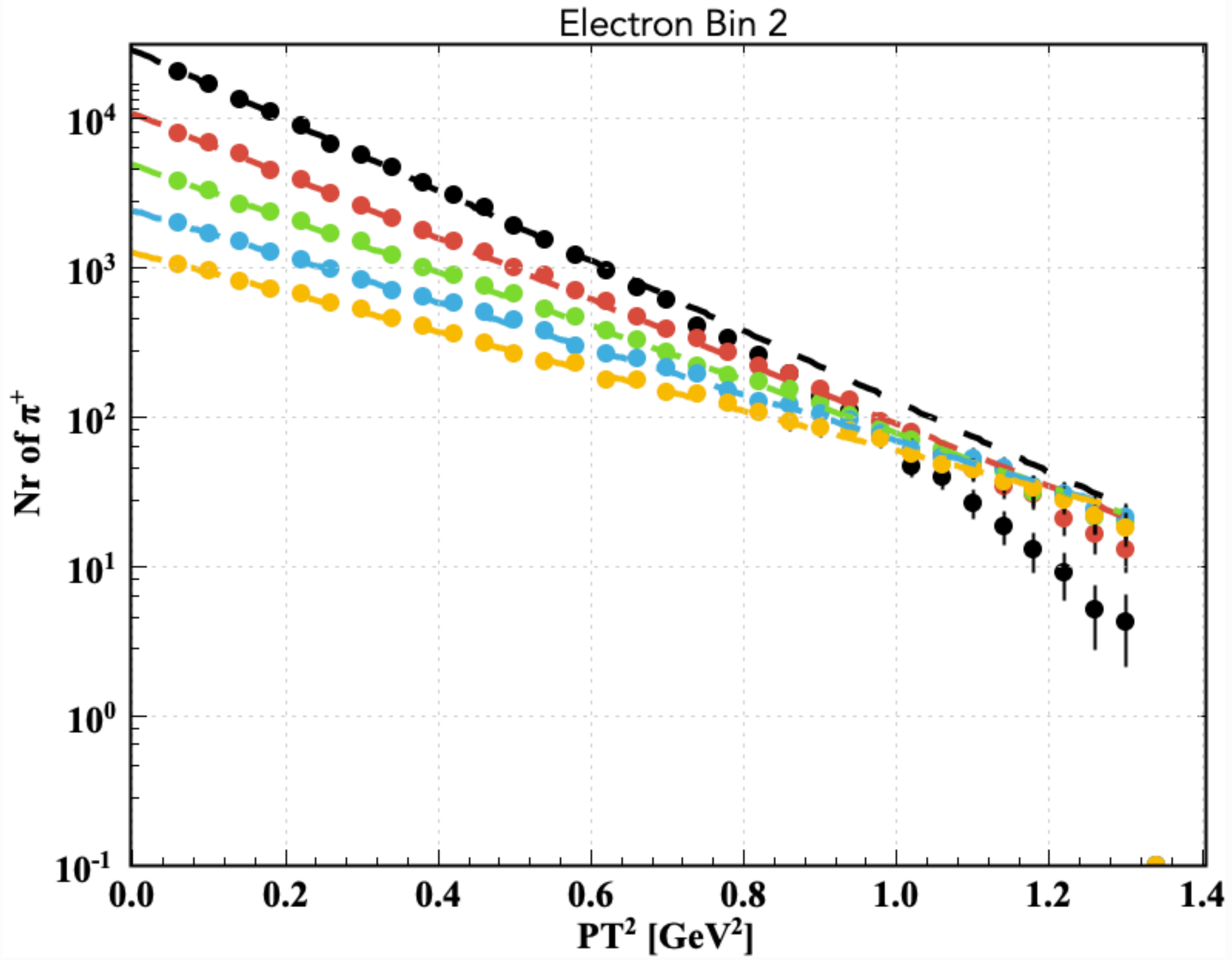
Color legend

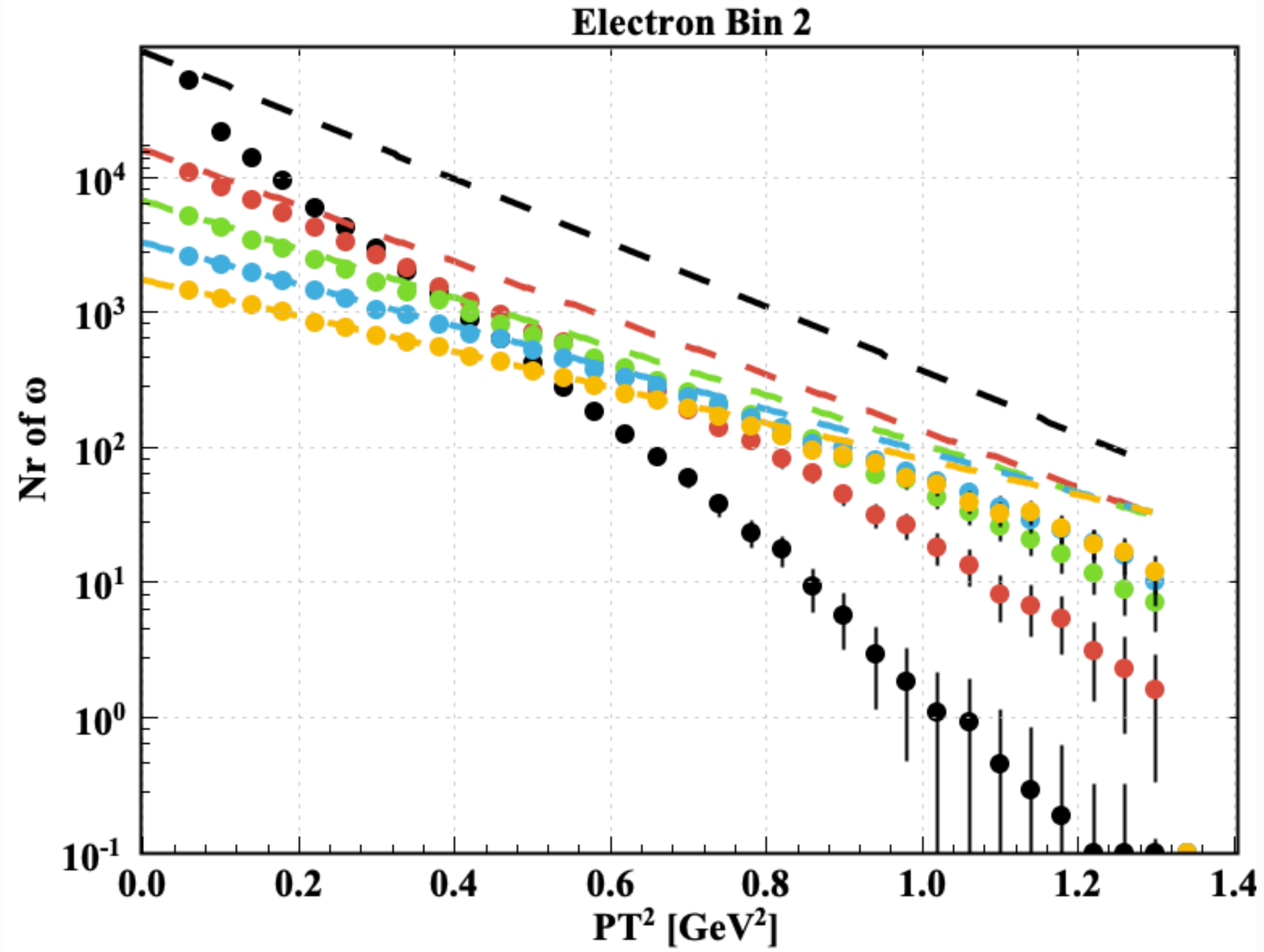
- 0.2<z<0.3
- 0.3<z<0.4
- 0.4<z<0.5
- 0.5<z<0.6
- 0.6<z<0.7

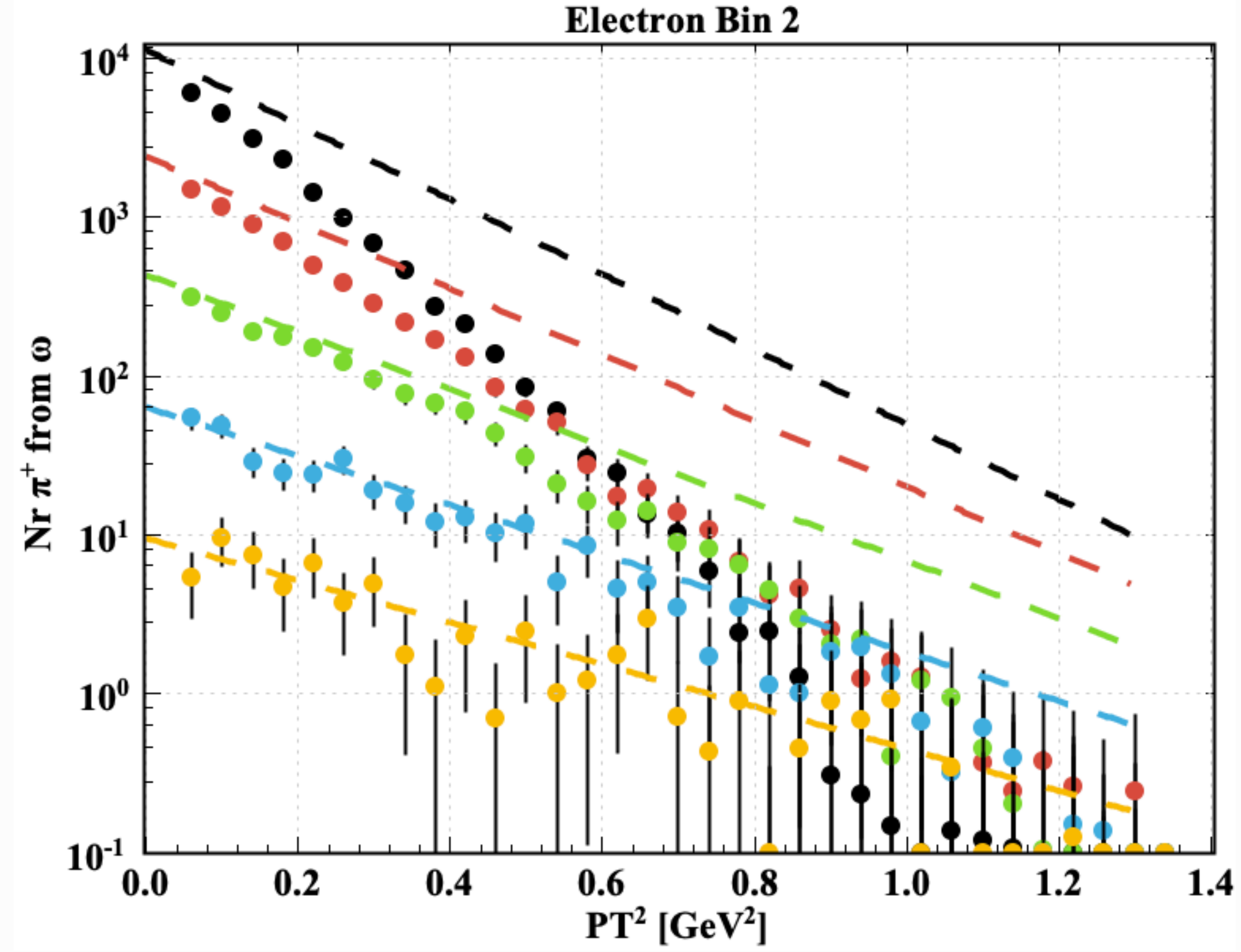
------ Input Function











Don't look at the y axis, the normalization is different but focus on the differences between the dotted line (generated function) to the points : what is generated within the phase space .

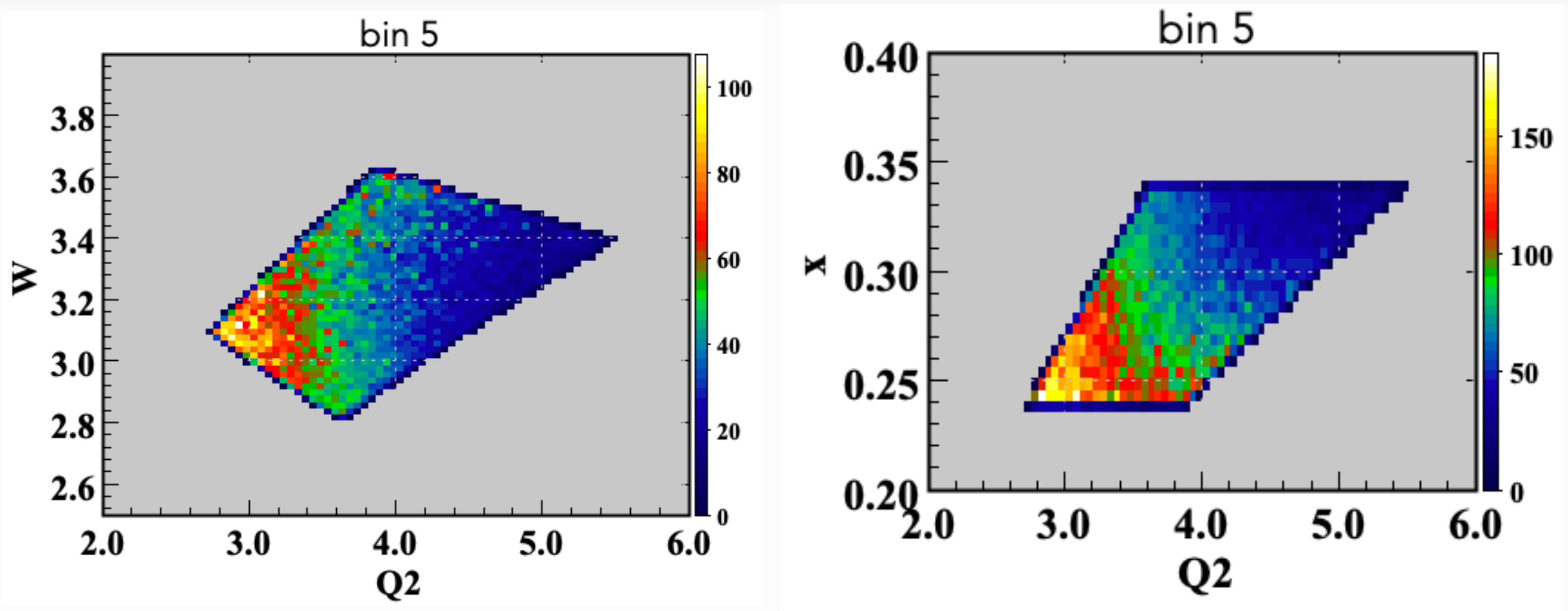
The phase space effects depends by the particle type. So the corrections will be model dependent .

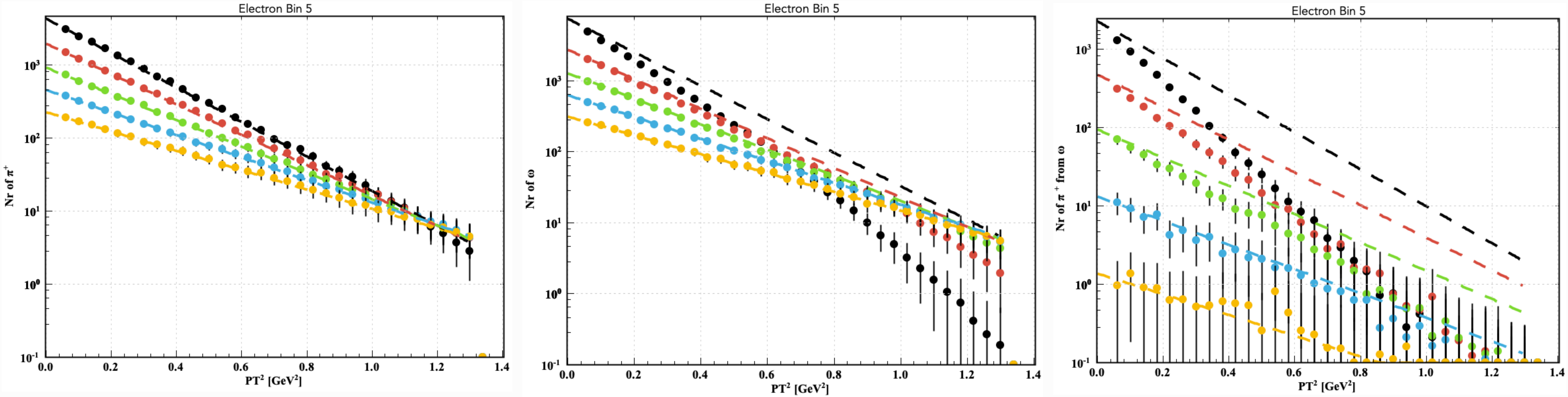
Extracting transverse momentum

Color legend

- 0.2<z<0.3
- 0.3<z<0.4
- 0.4<z<0.5
- 0.5<z<0.6
- 0.6<z<0.7

------ Input Function





We need to correct the data for the phase space effect, but since the correction depends on the VM, it will be dependent to the VM ratio used in our models.

Summary + future plans

MC in-bending completed (about 2x data) and available at:
/work/clas12/rg-a/montecarlo/fall2018/torus-1/clasdis/bg/

The measurement of charged pion multiplicity is being extracted using CLAS12.

We are working on improve our fiducial cuts.

Effect of phase spaces and VM production under study.

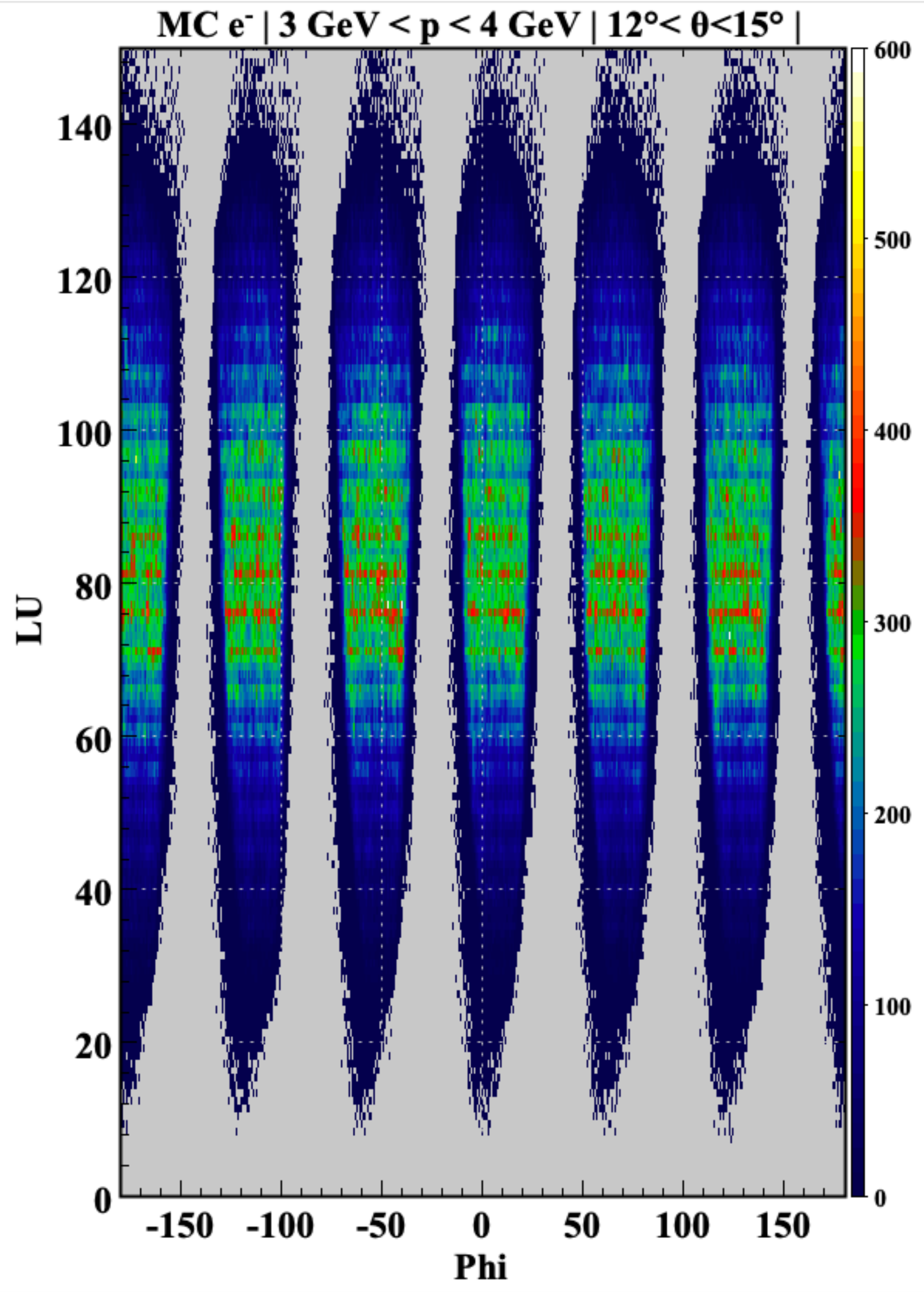
Study on systematics and radiative effects will be performed.

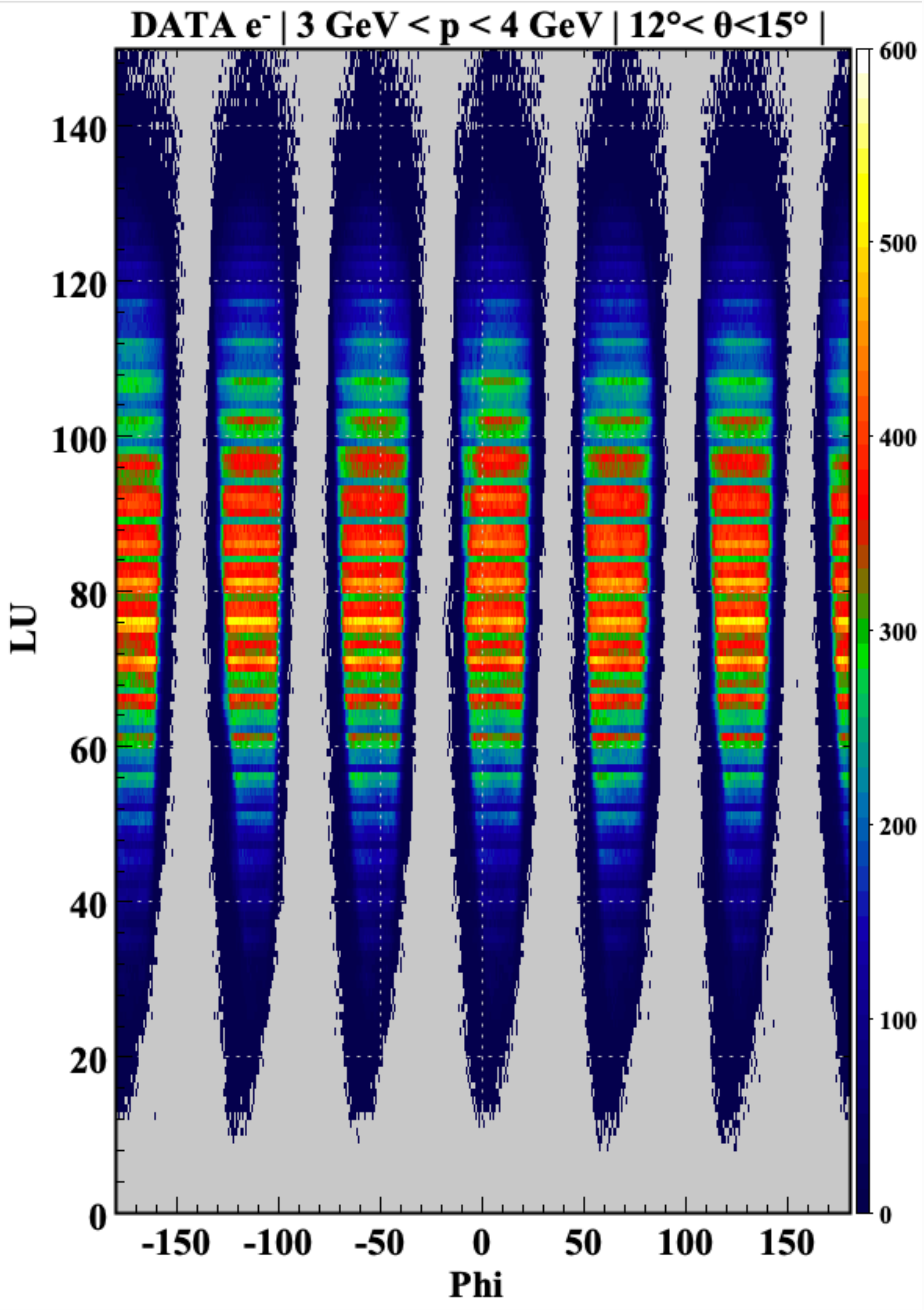
We expect to complete this analysis and submit an analysis note by this summer.

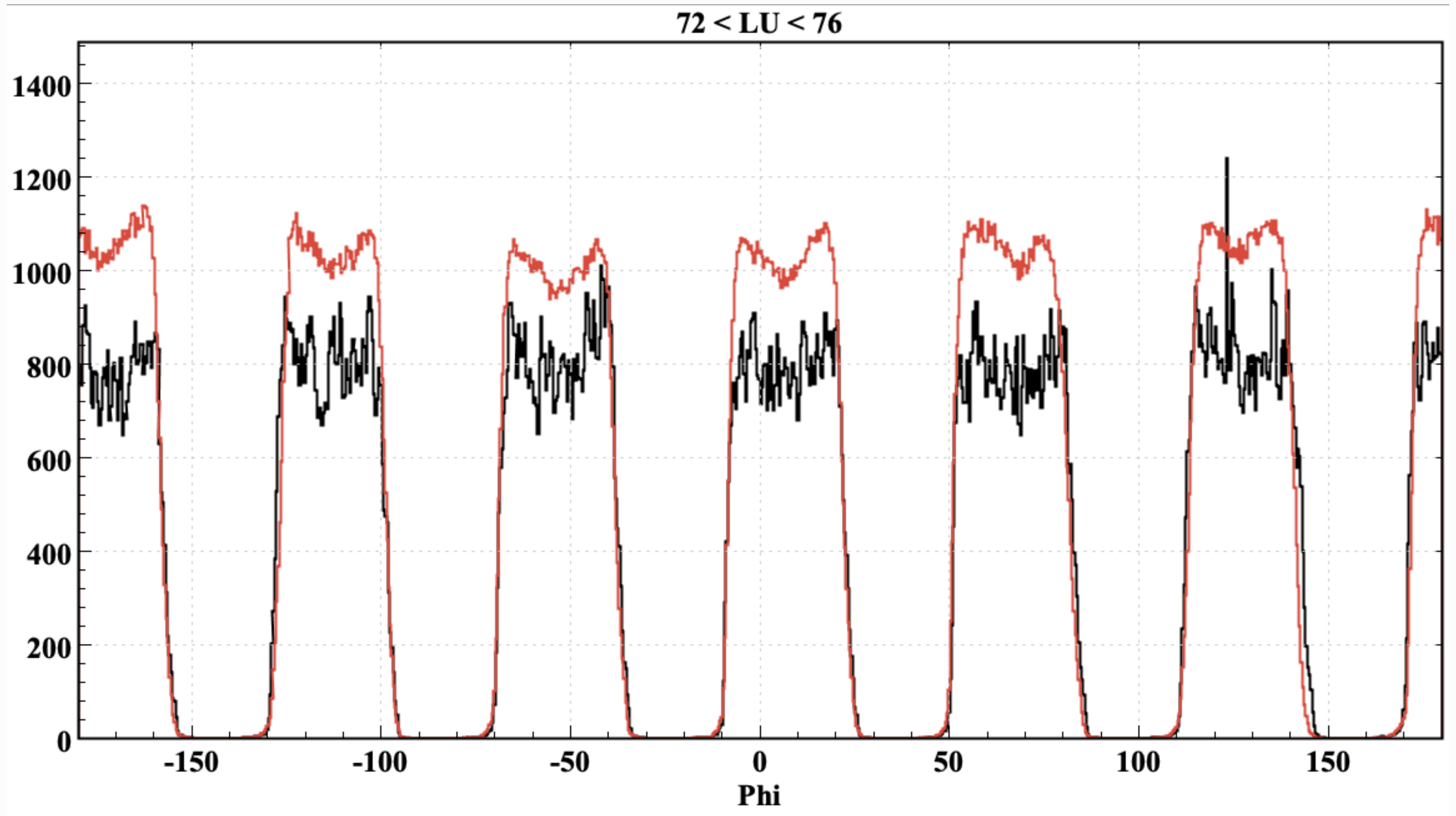
This work is supported by the DOE grant DE-SC0016583

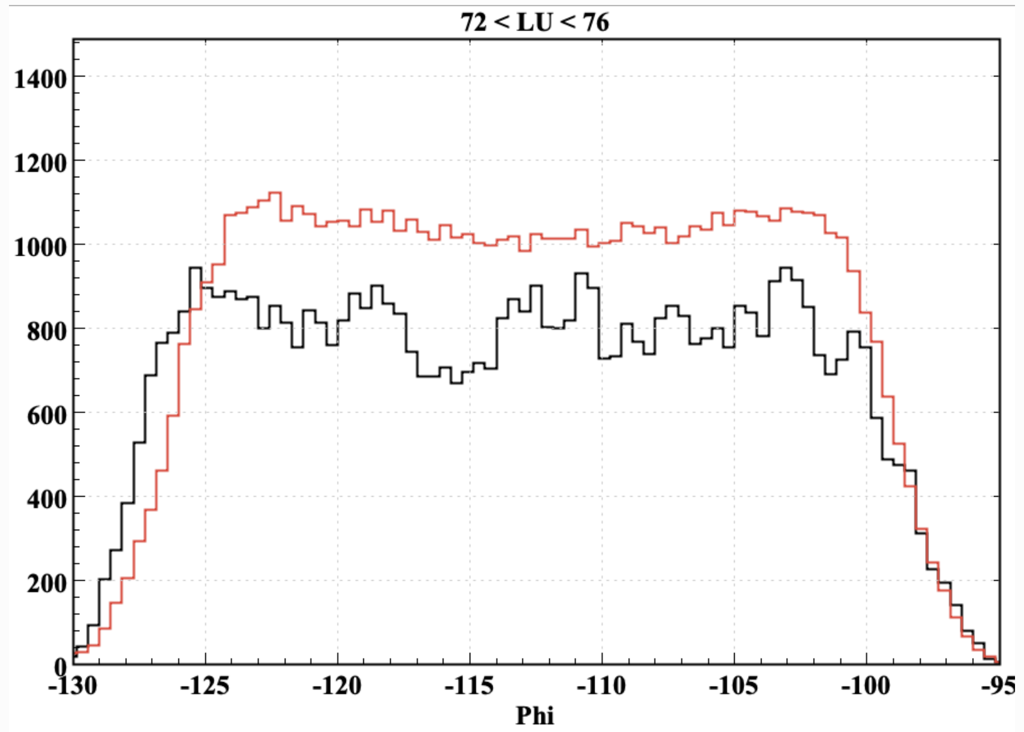
MC VS DATA : PCAL

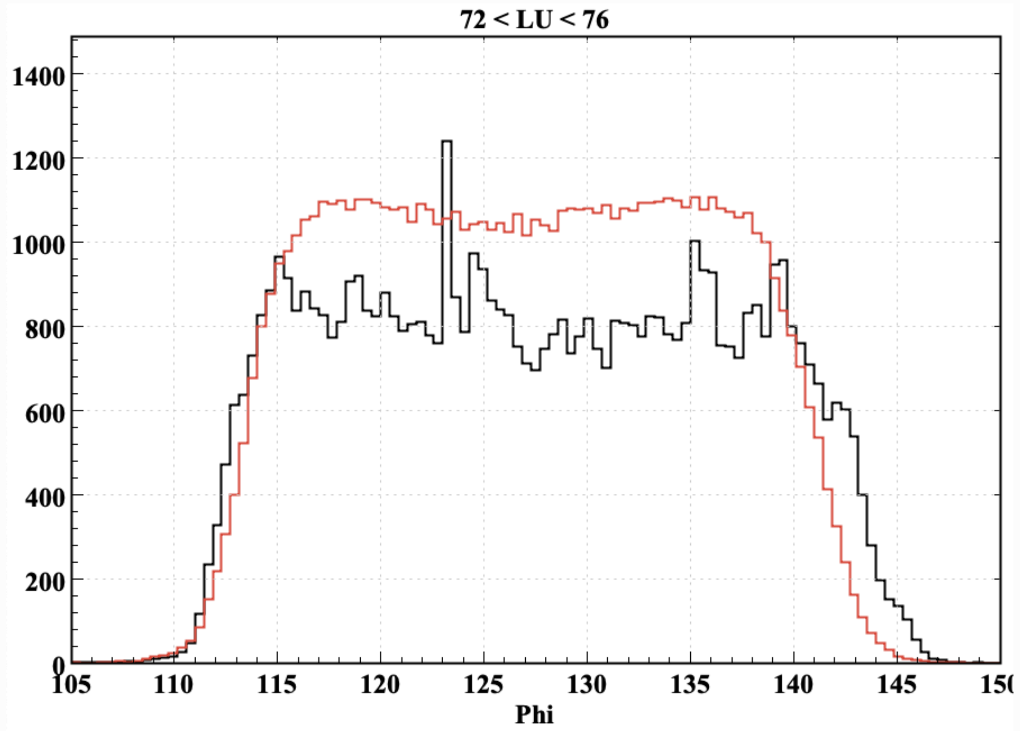
The plot are normalized for the same number of DIS electron reconstructed (in a trustable interval of momentum and angle)











MC VS DATA : PCAL

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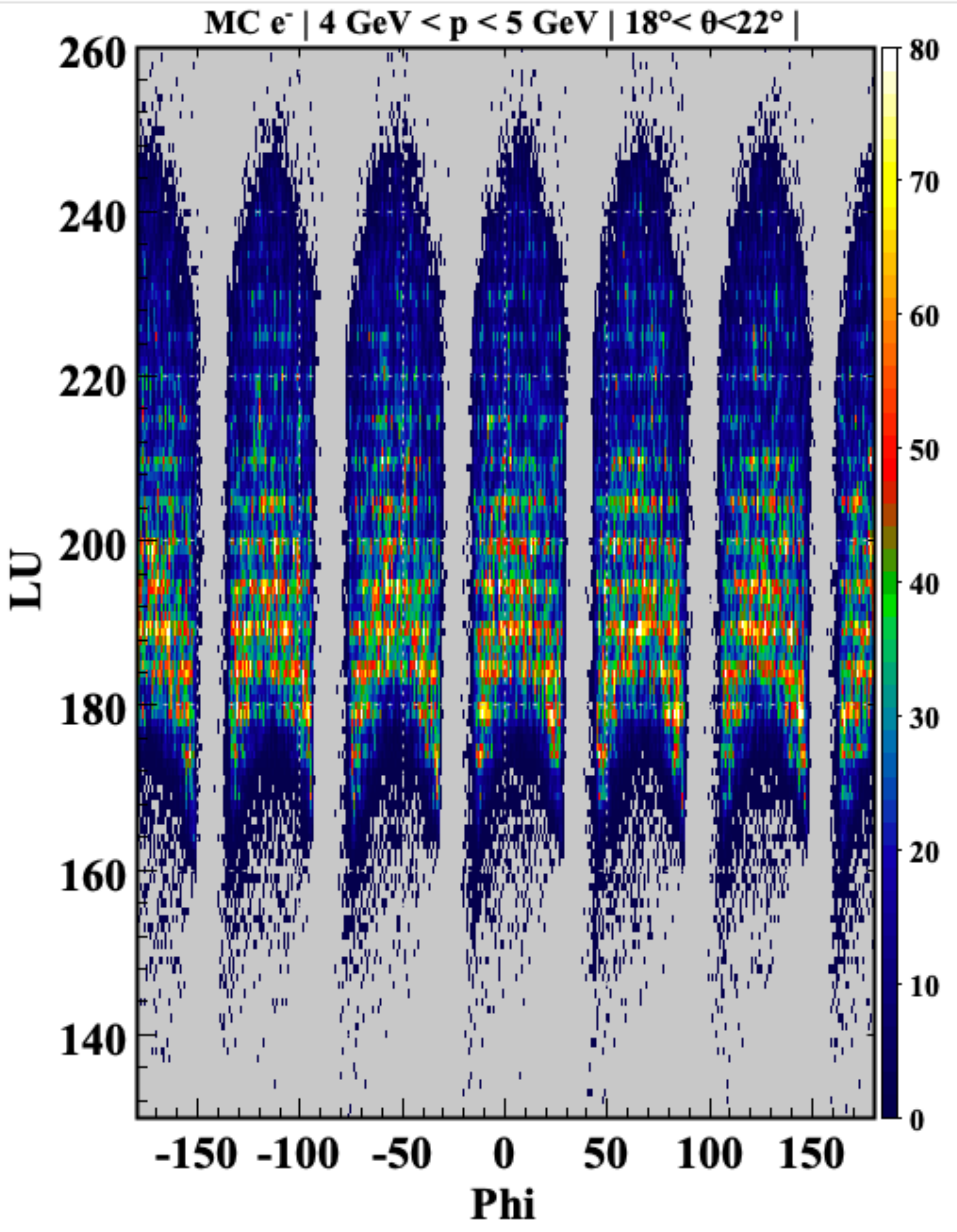
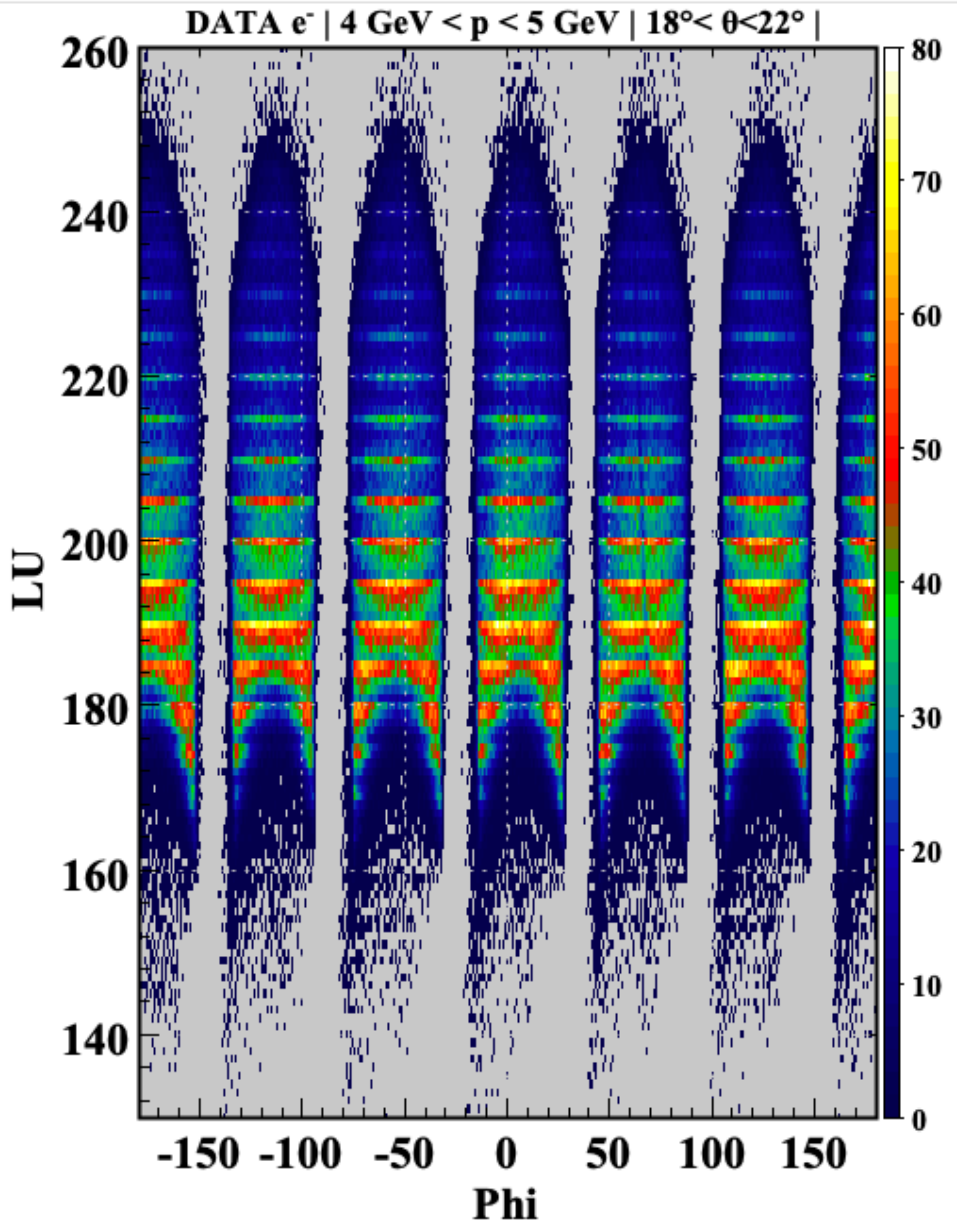
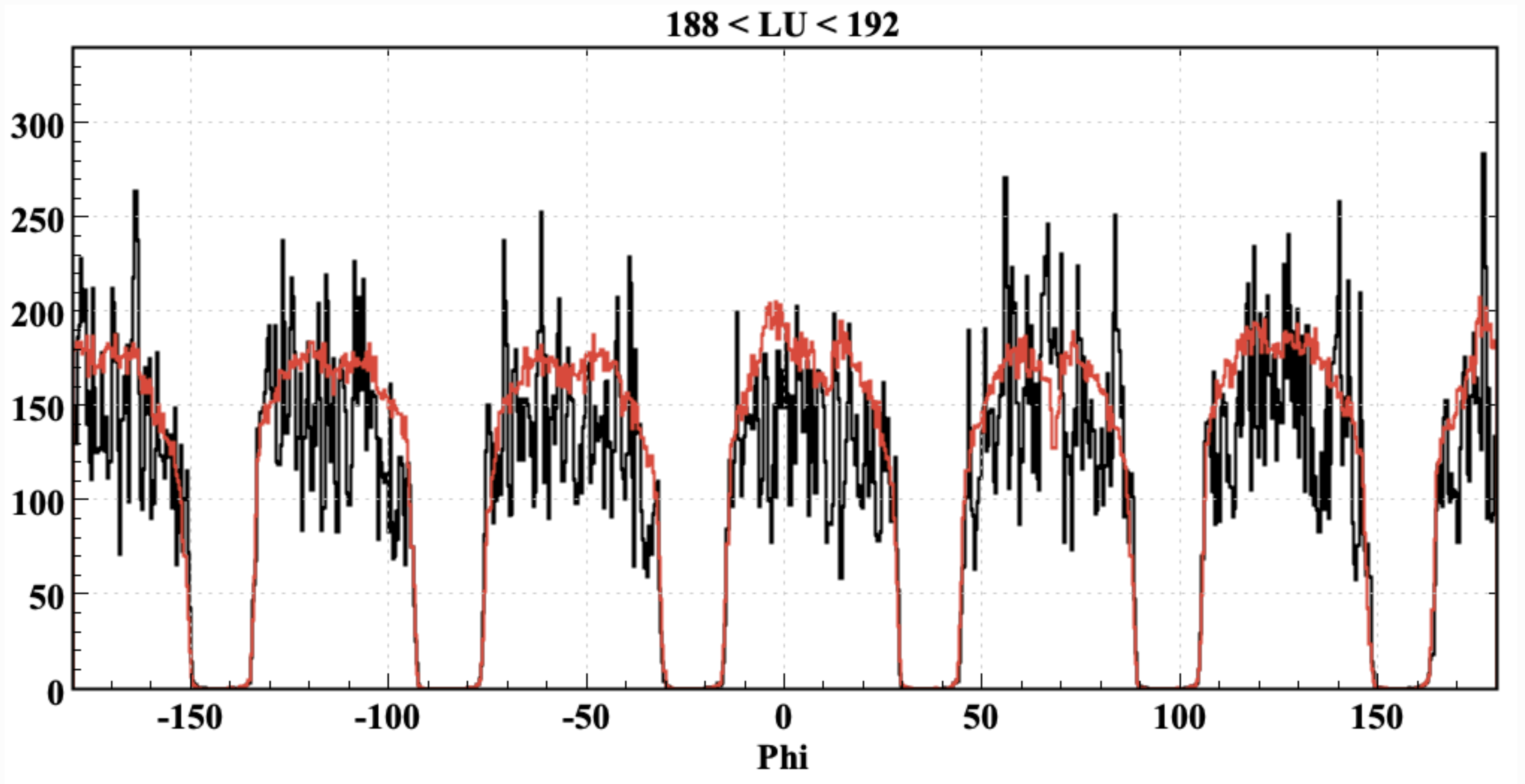
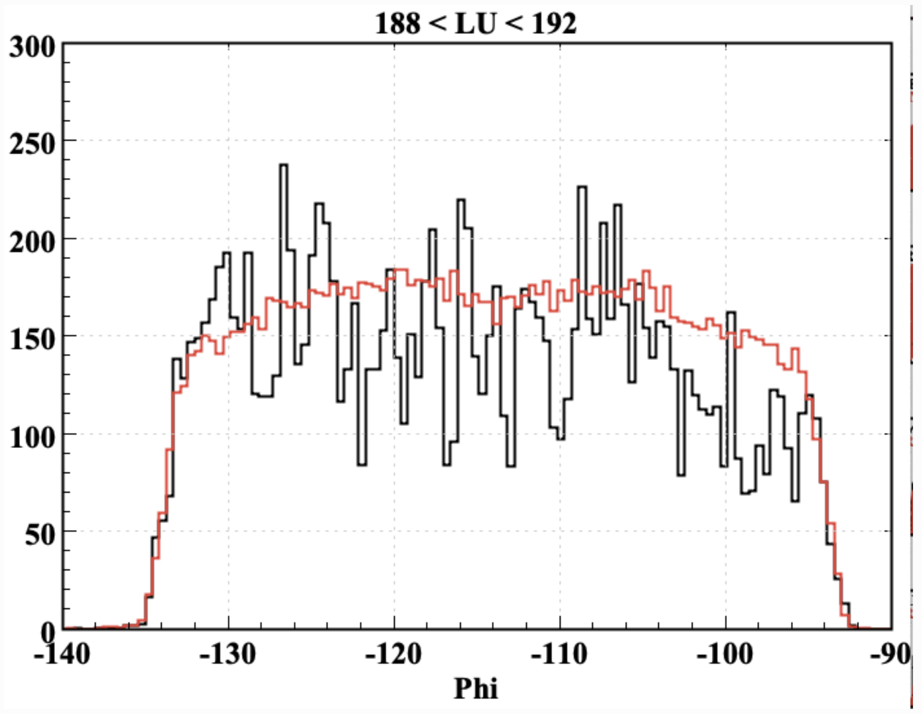
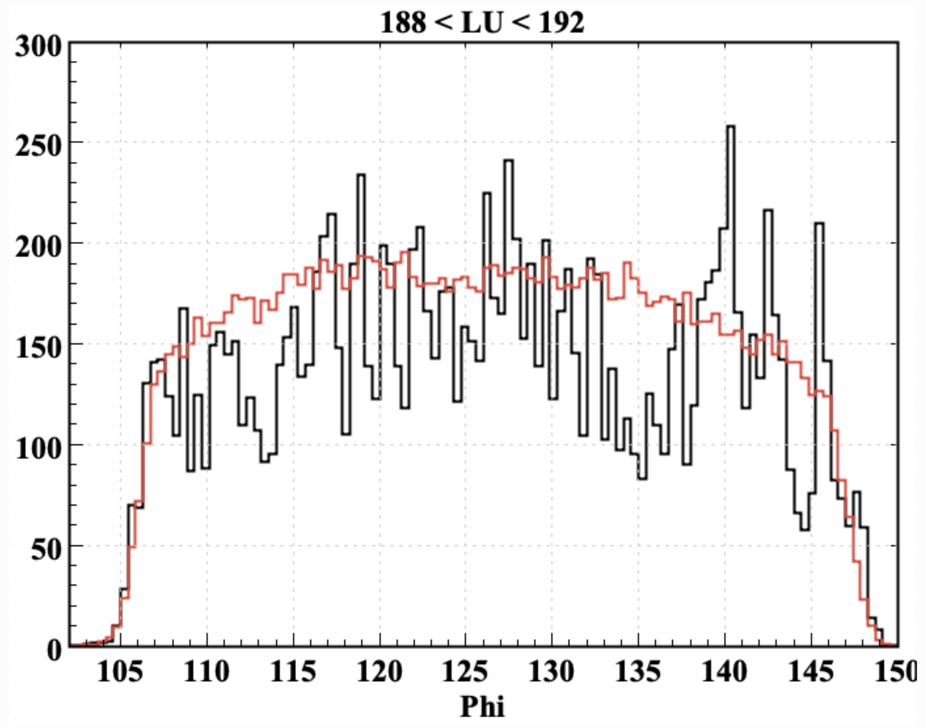










Study of acceptances (very preliminary)

In order to trust the acceptances and use them, we want to ensure that the reconstruction work similarly in data and MC.

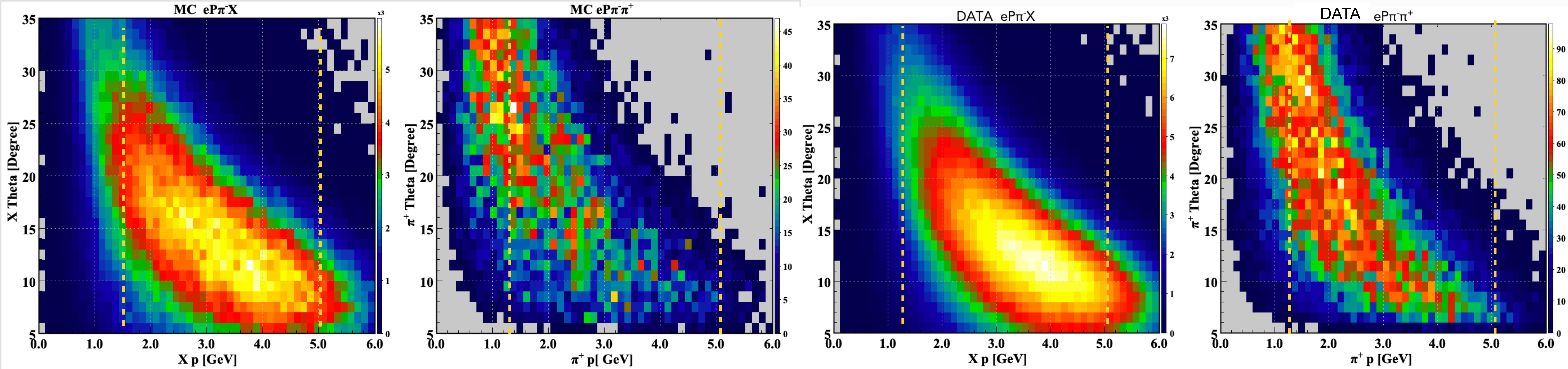
To do that I have looked at the reconstructed sample:

ePπ^- X

and look in how many of these samples there were reconstructed. as ePπ^-π^+ and nothing else.

Compared this ratio between data and MC can gives us a first idea if we can trust our acceptances.

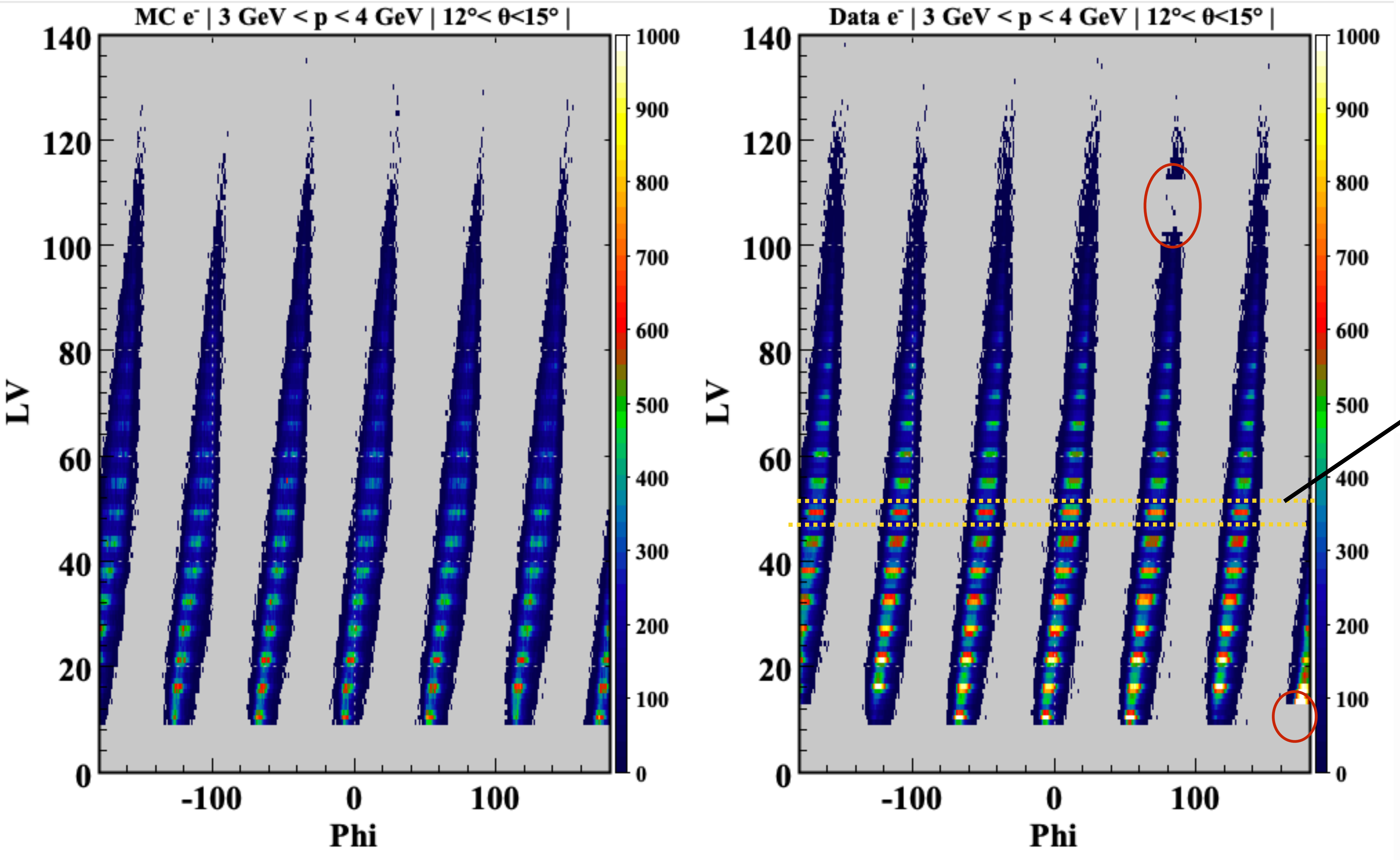
MC used is about 80% of DATA

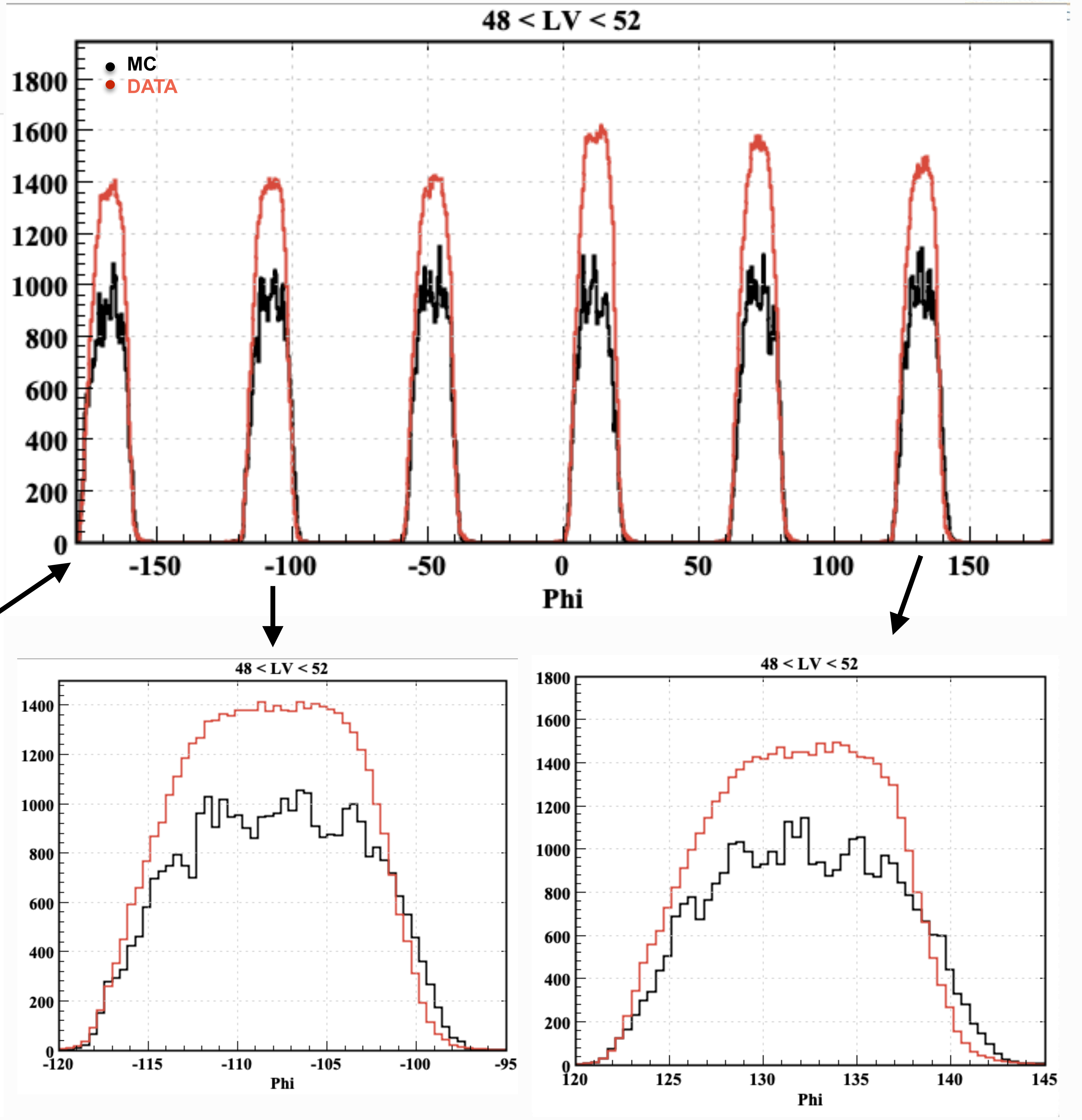


MC VS DATA : PCAL

The plot are normalized for the same number of DIS electron reconstructed (in a trustable interval of momentum and angle)

Same reconstructed overall electron, but each strips shows significant differences.

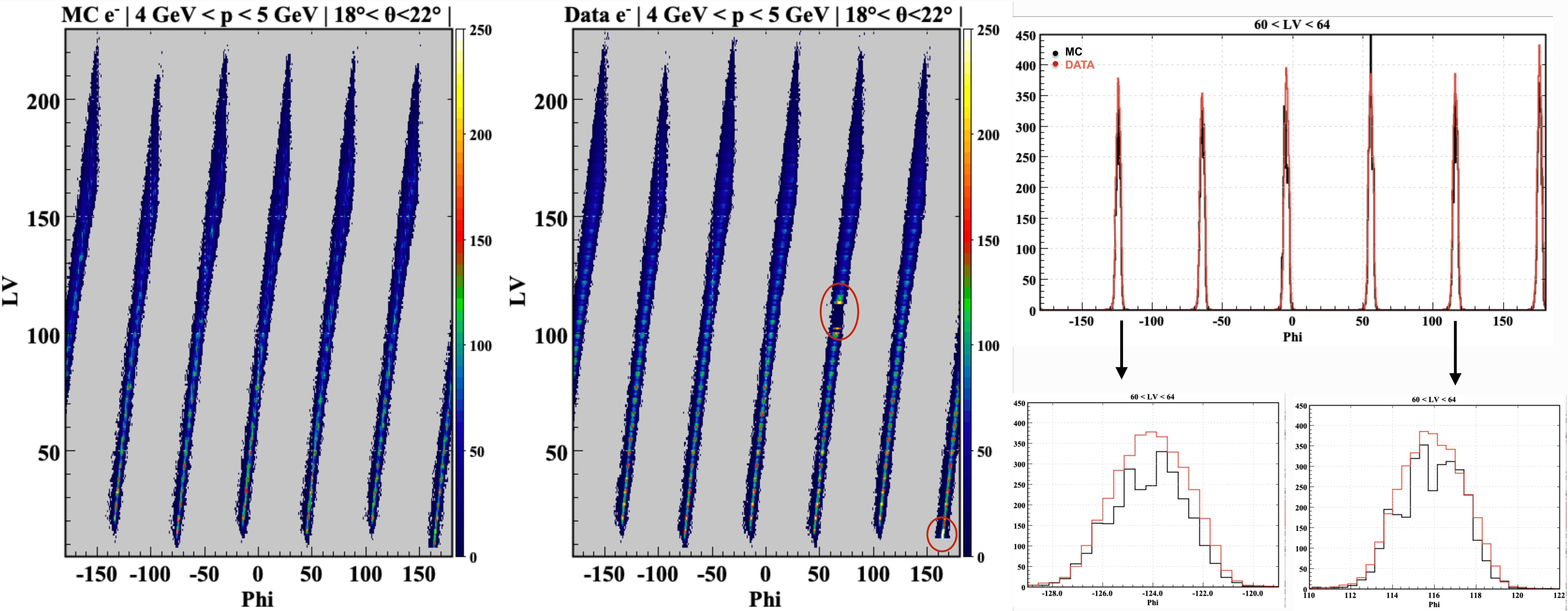




MC VS DATA : PCAL

The plot are normalized for the same number of DIS electron reconstructed (in a trustable interval of momentum and angle)

Less effects at higher



MC VS DATA : PCAL

The plot are normalized for the same number of DIS electron reconstructed (in a trustable interval of momentum and angle)