

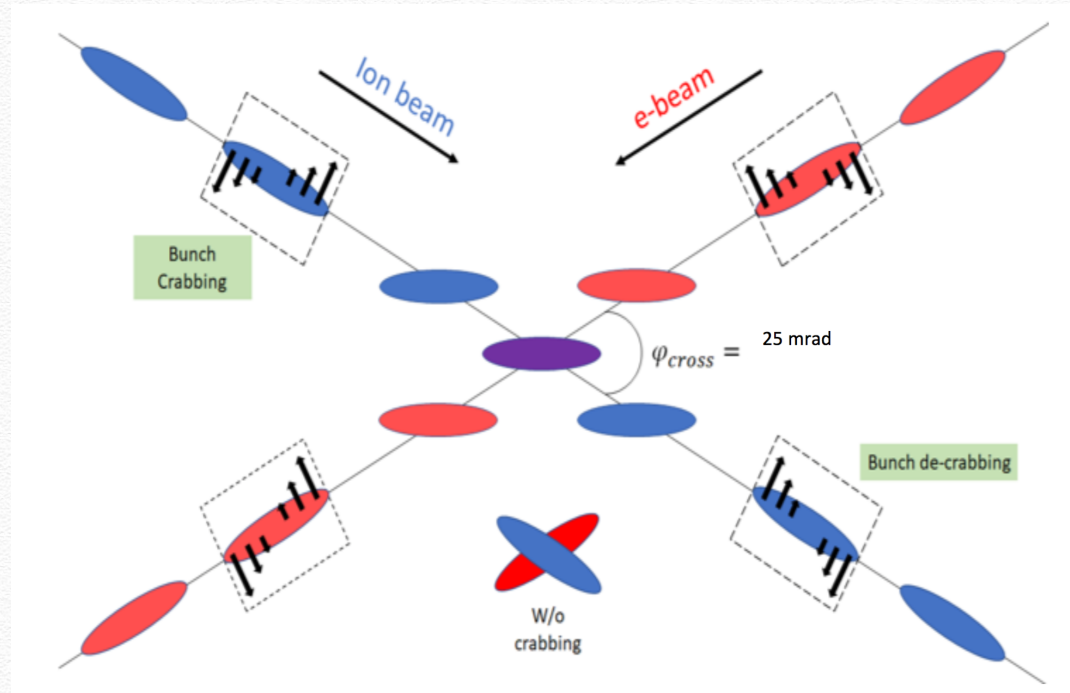
Crossing angle study at EIC (IP6)

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with lots of help & inputs from Jin Huang (BNL) and
Barak Schmookler (SBU)

Crossing angle @ EIC

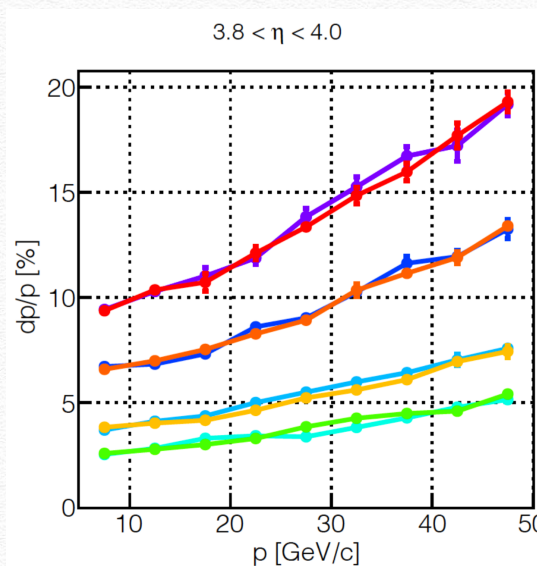
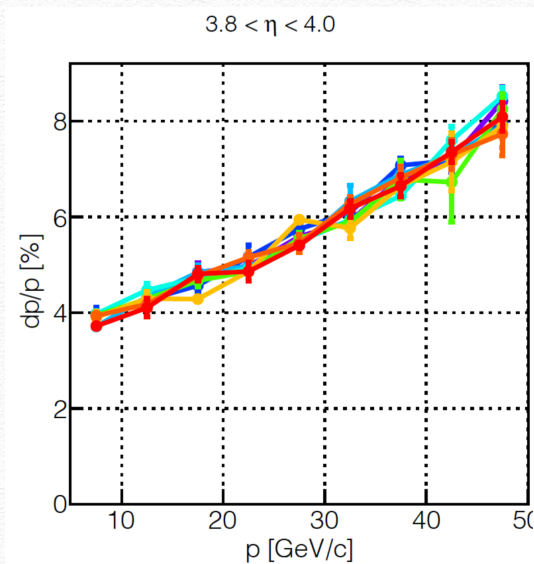
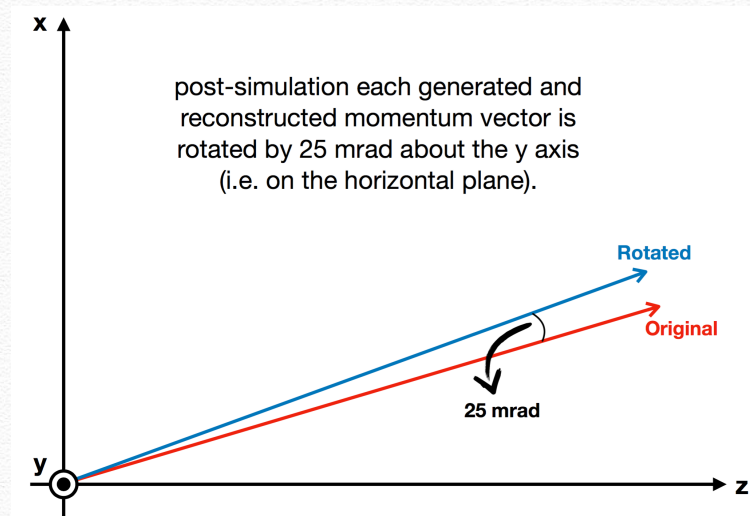
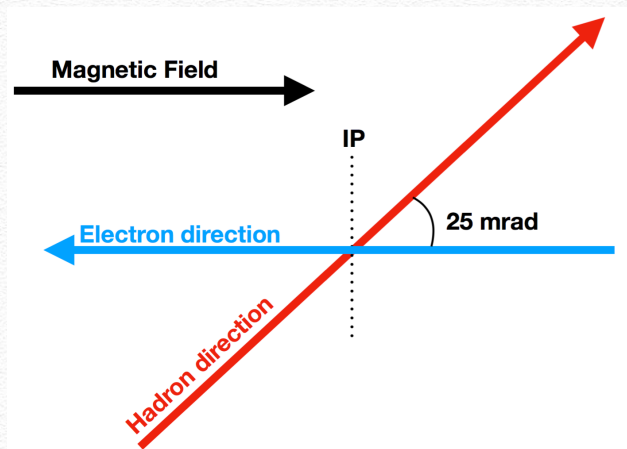
- ❖ At EIC IP6, the electron-hadron beam is not head-on along z axis like in HERA



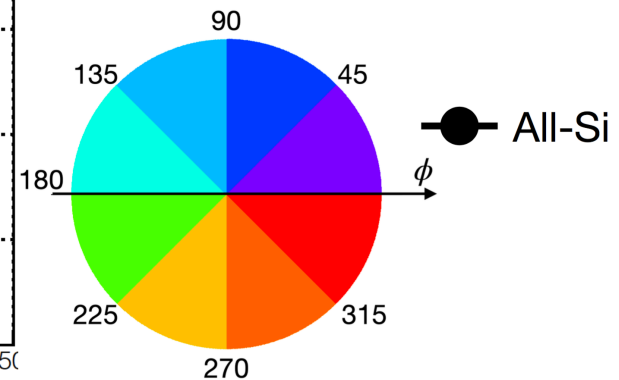
- ❖ Already some studies done
 - ❖ Crossing angle and its implications for the central detector design: <https://indico.bnl.gov/event/9887/timetable/>
 - ❖ Including a nice study from Rey

Rey's study

- Rey looked at the tracker performance if rotating tracks by 25 mrad

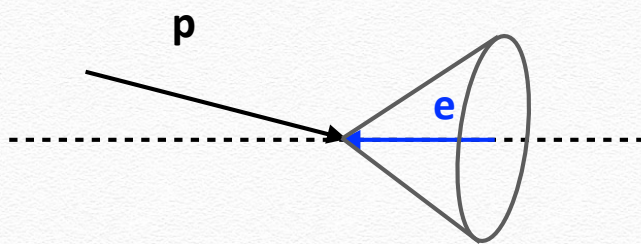


After rotating momentum vectors by 25 mrad about y axis



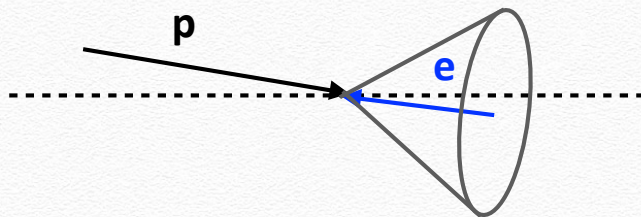
Steps to implement Xing angle

- ❖ Scenario: hadron beam has 25 mrad angle from z axis and electron beam along z
- ❖ Detectors' centroid aligned with z (magnetic field along aligned with z)

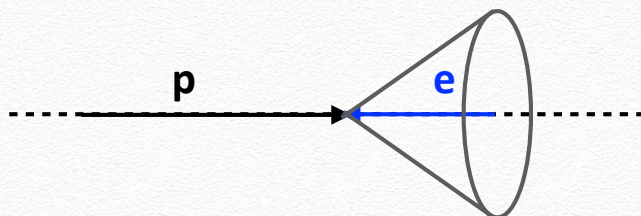


Real collision geometry

boost



rotation



Pythia head-on e+p event

Boost and rotation worked out by Jin and Barak

minimal boost vector: $(\sin\theta/2, 0, (\cos\theta-1)/2)$

Crossing angle study in Fun4All

- ❖ The crossing angle now implemented in Fun4All by Jin

- ❖ Xing angle + beam divergence: <https://github.com/sPHENIX-Collaboration/coresoftware/pull/1087>

- ❖ Crab cavity kick: <https://github.com/sPHENIX-Collaboration/coresoftware/pull/1113>

- ❖ PythiaRHIC

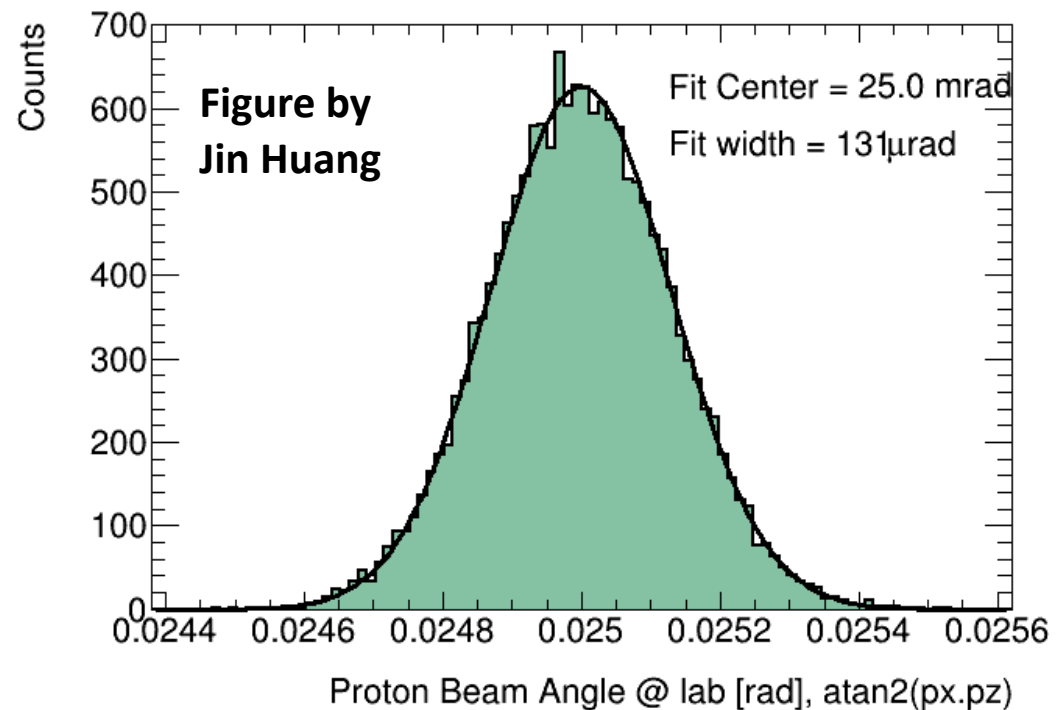
- ❖ Peel out $D^0 \rightarrow K\pi$

- ❖ Feed to Fun4All

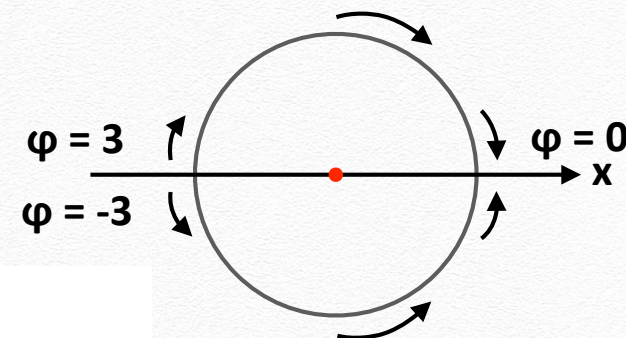
- ❖ Apply beam parameters

- ❖ Only turn on trackers (using Hybrid for this study)

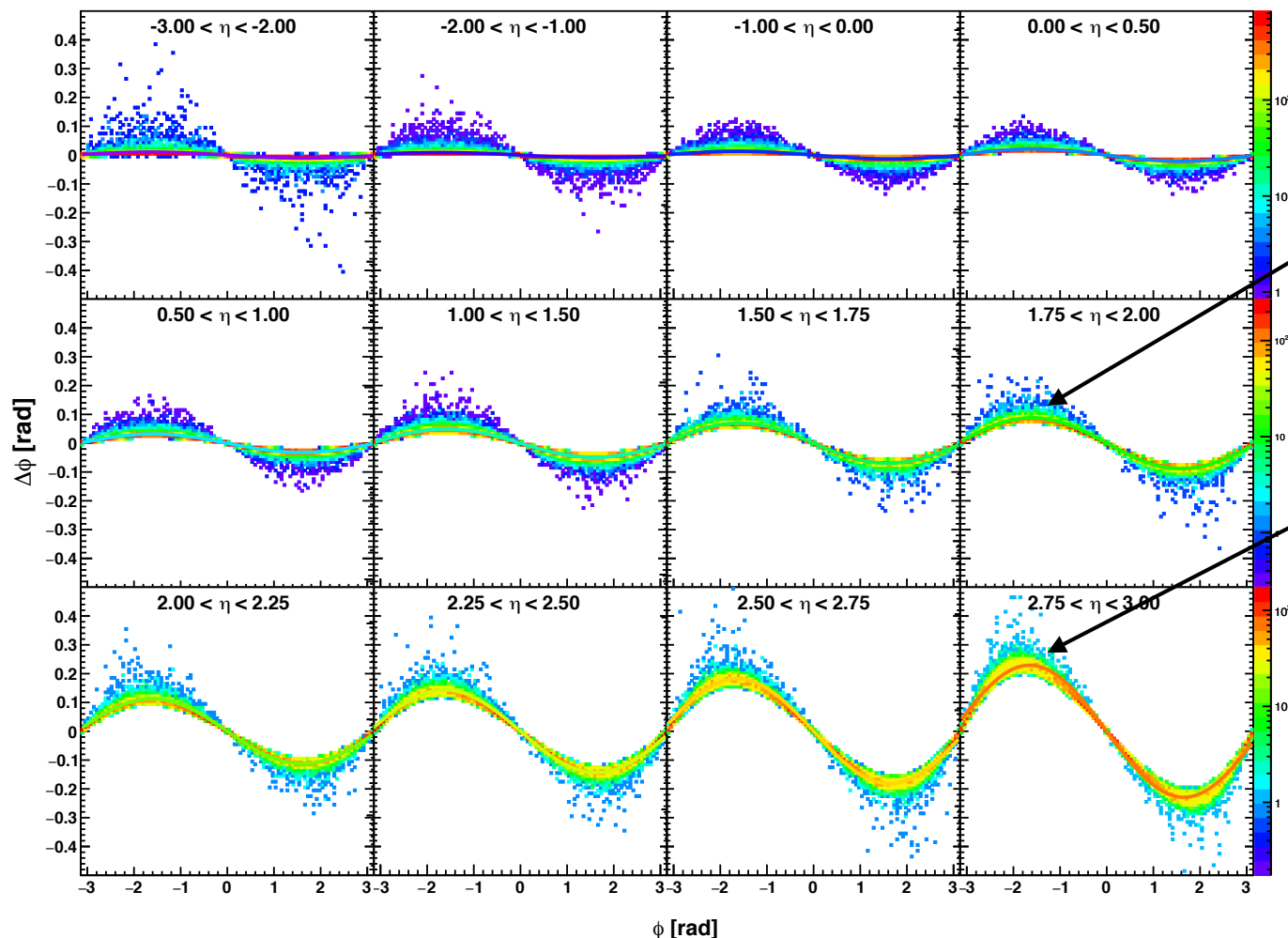
- ❖ Look at the new $D^0 \rightarrow K\pi$ (both reco and true) from track evaluator



D^0 ϕ shift with Xing angle



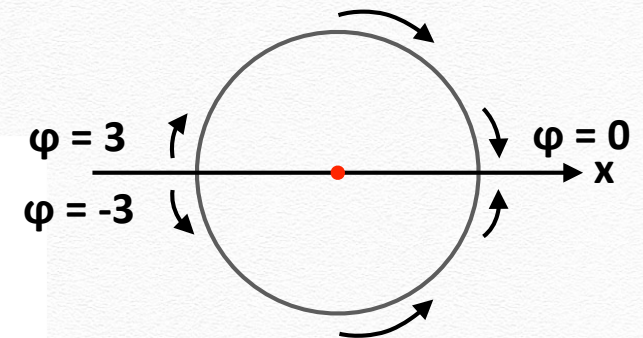
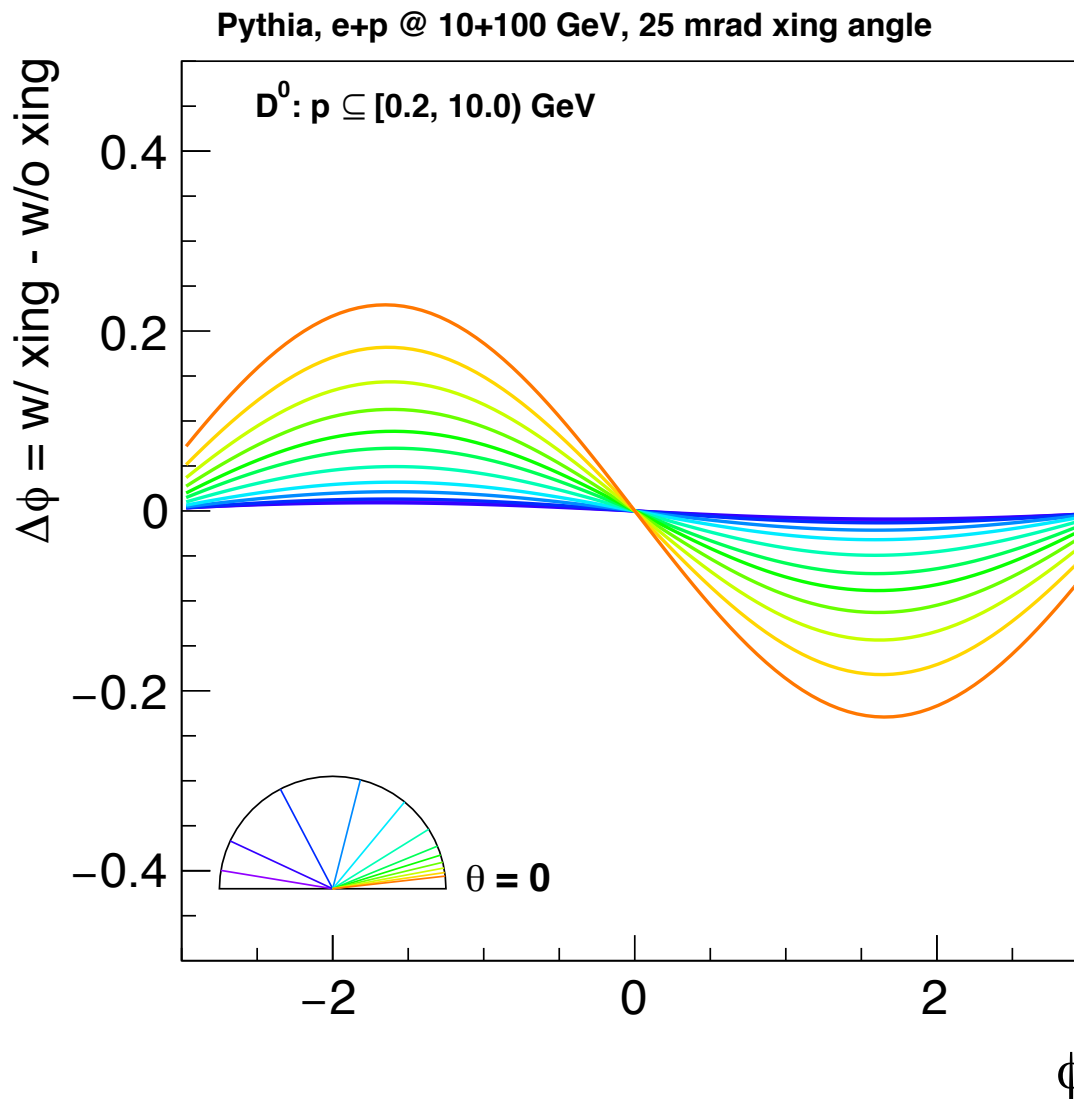
Pythia, e+p @ 10+100 GeV, Min Bias ($Q^2 > 10 \text{ GeV}^2$), 25 mrad Xing angle



Stronger $\Delta\phi$ shift
along y axis

Stronger $\Delta\phi$ shift
at forward rapidity
(around $\theta \sim 0$)

D^0 ϕ shift with Xing angle

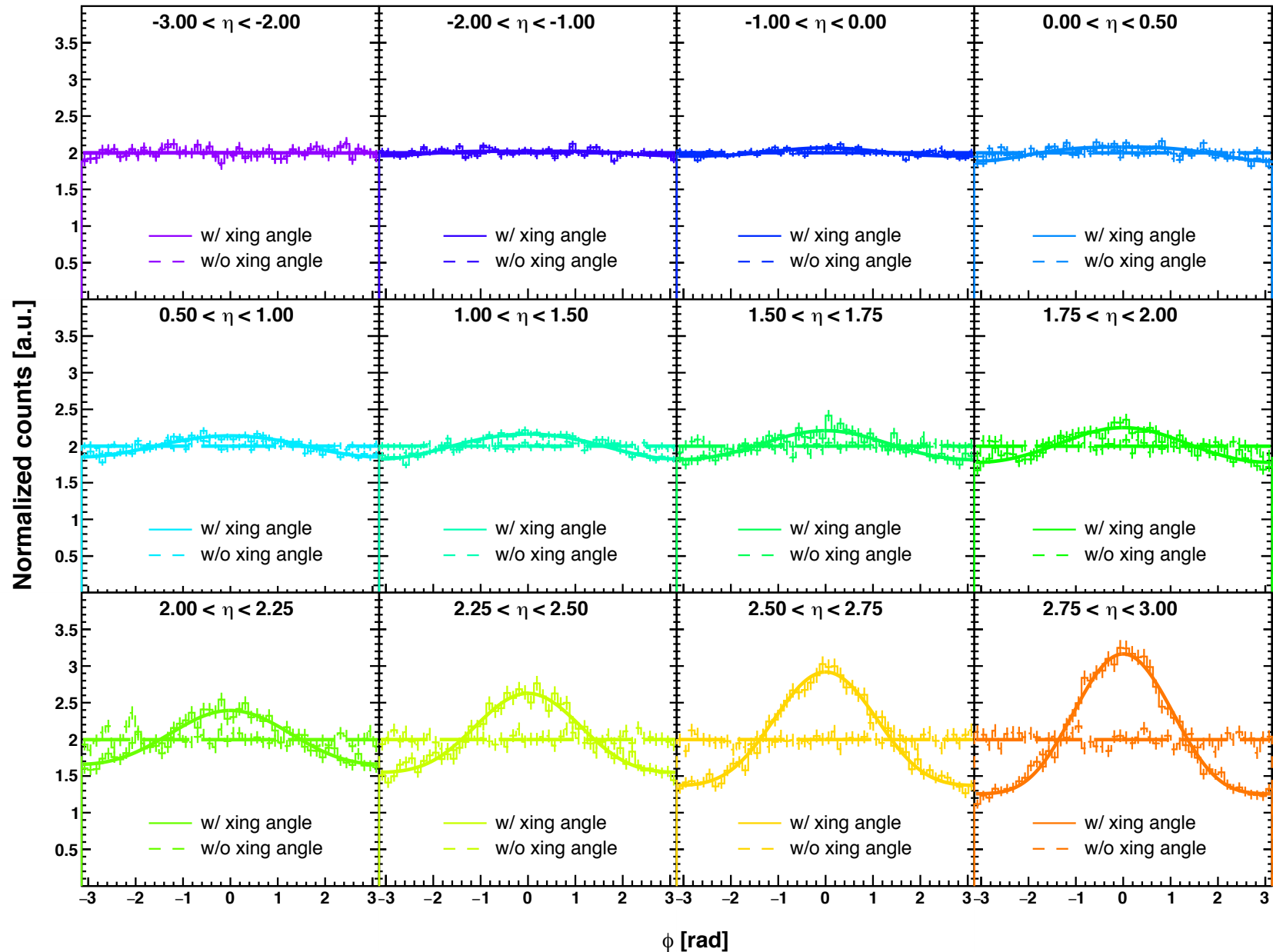


Such shift will create an “artificial” azimuthal anisotropy of the outgoing particles

Correctable as long as one boost back to head on event by event

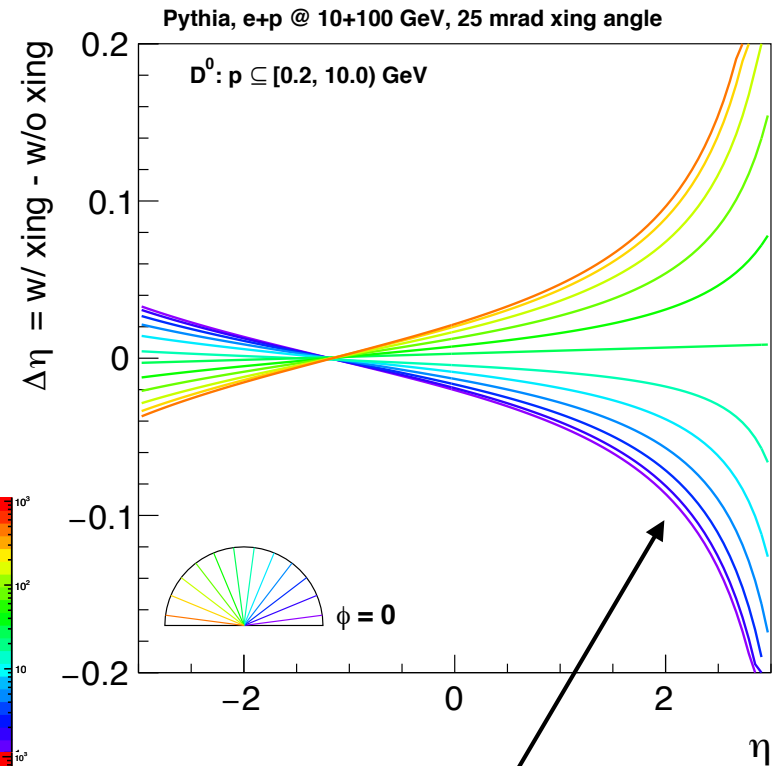
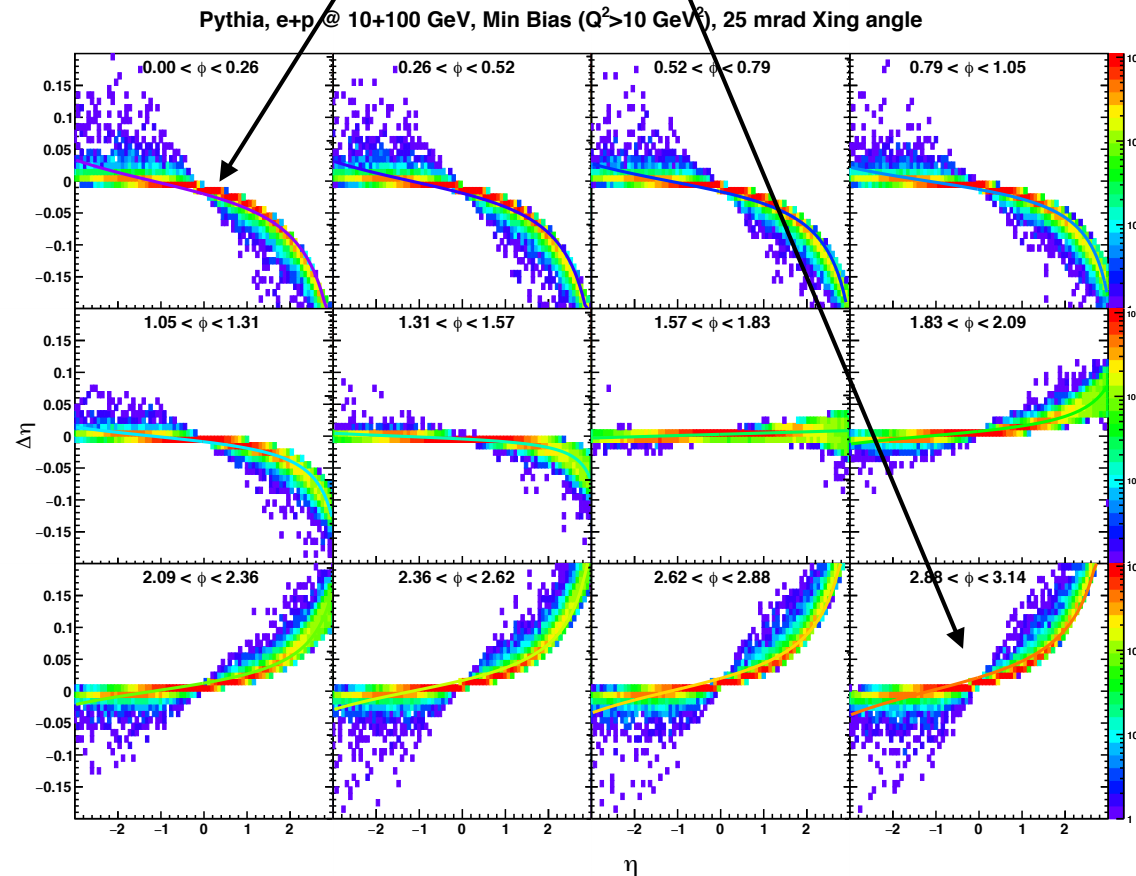
D^0 ϕ distribution w & w/o Xing angle

Pythia, e+p @ 10+100 GeV, Min Bias ($Q^2 > 10 \text{ GeV}^2$), 25 mrad Xing angle



D^0 η shift with Xing angle

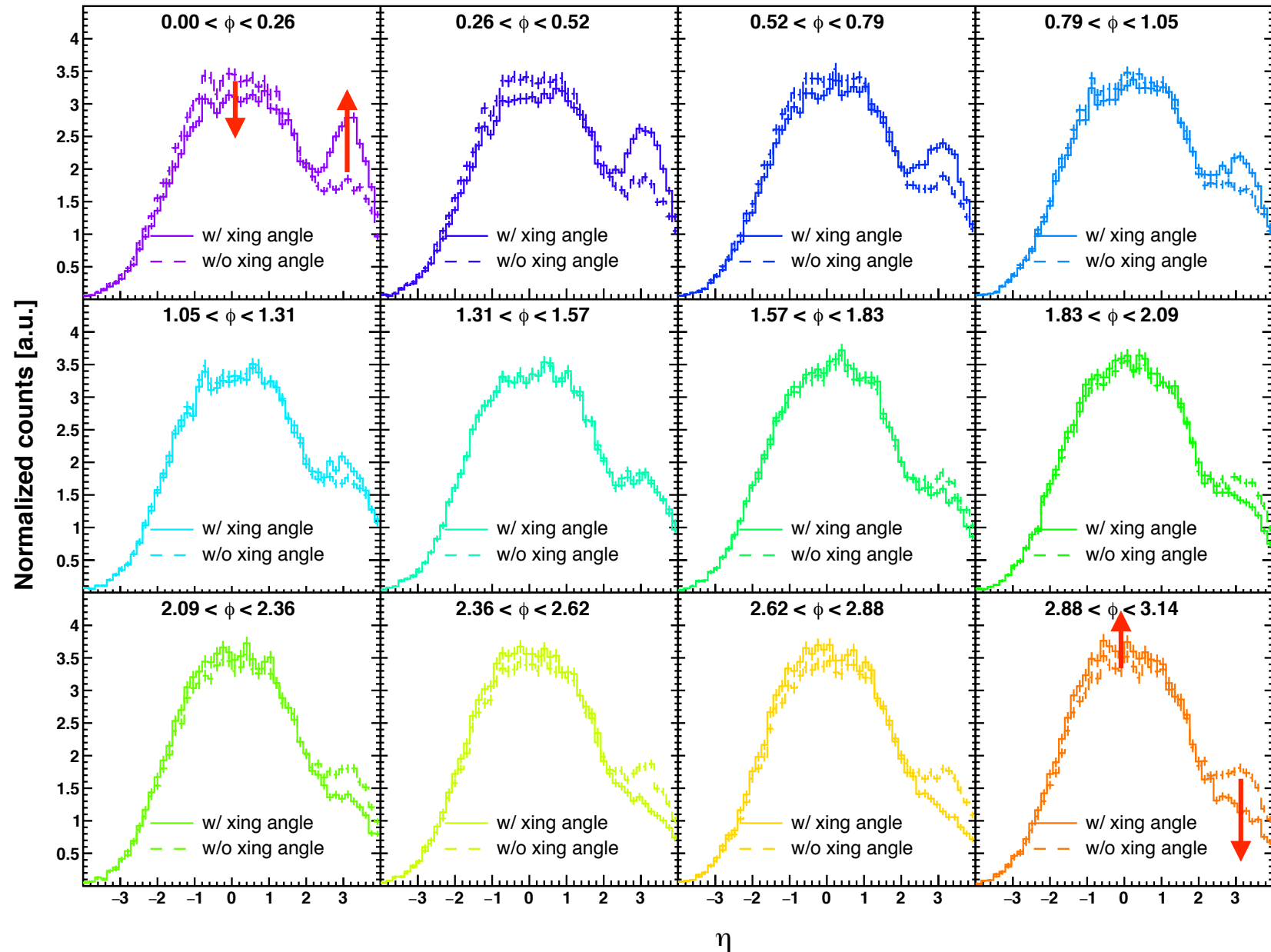
Larger effect along x axis



Larger effect at very forward rapidity

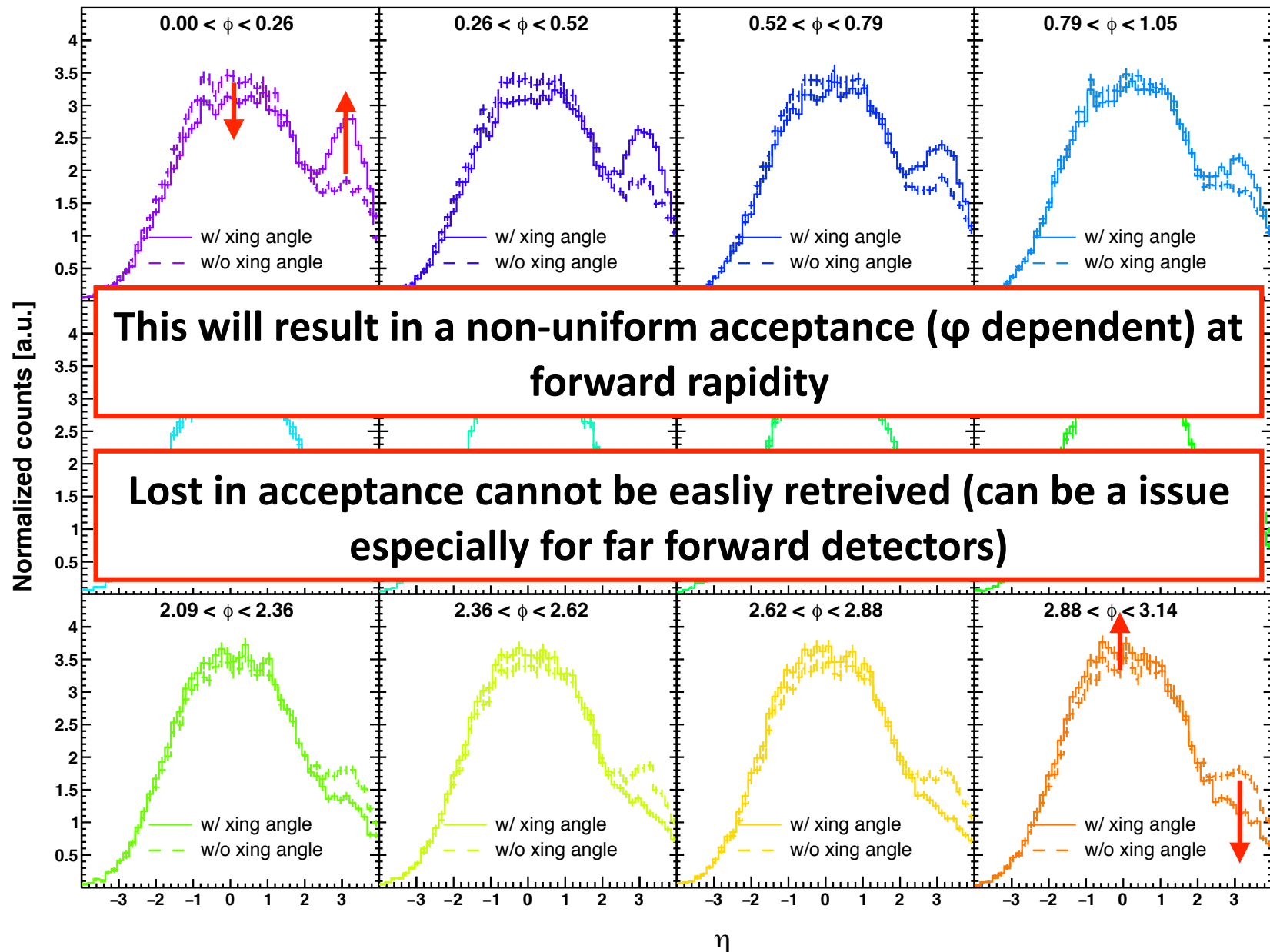
$D^0 \eta$ distribution w & w/o Xing angle

Pythia, e+p @ 10+100 GeV, Min Bias ($Q^2 > 10 \text{ GeV}^2$), 25 mrad Xing angle



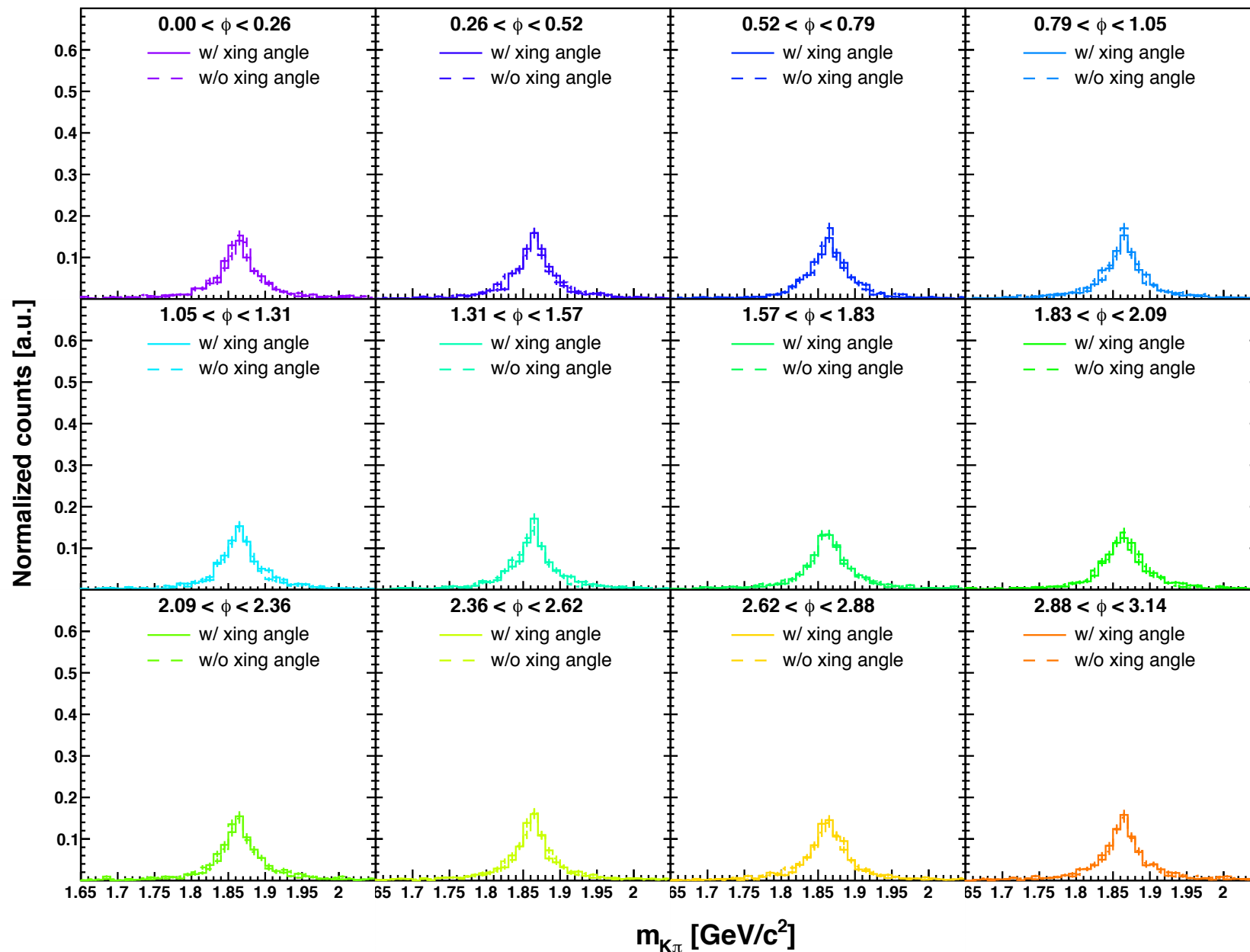
$D^0 \eta$ distribution w & w/o Xing angle

Pythia, e+p @ 10+100 GeV, Min Bias ($Q^2 > 10 \text{ GeV}^2$), 25 mrad Xing angle



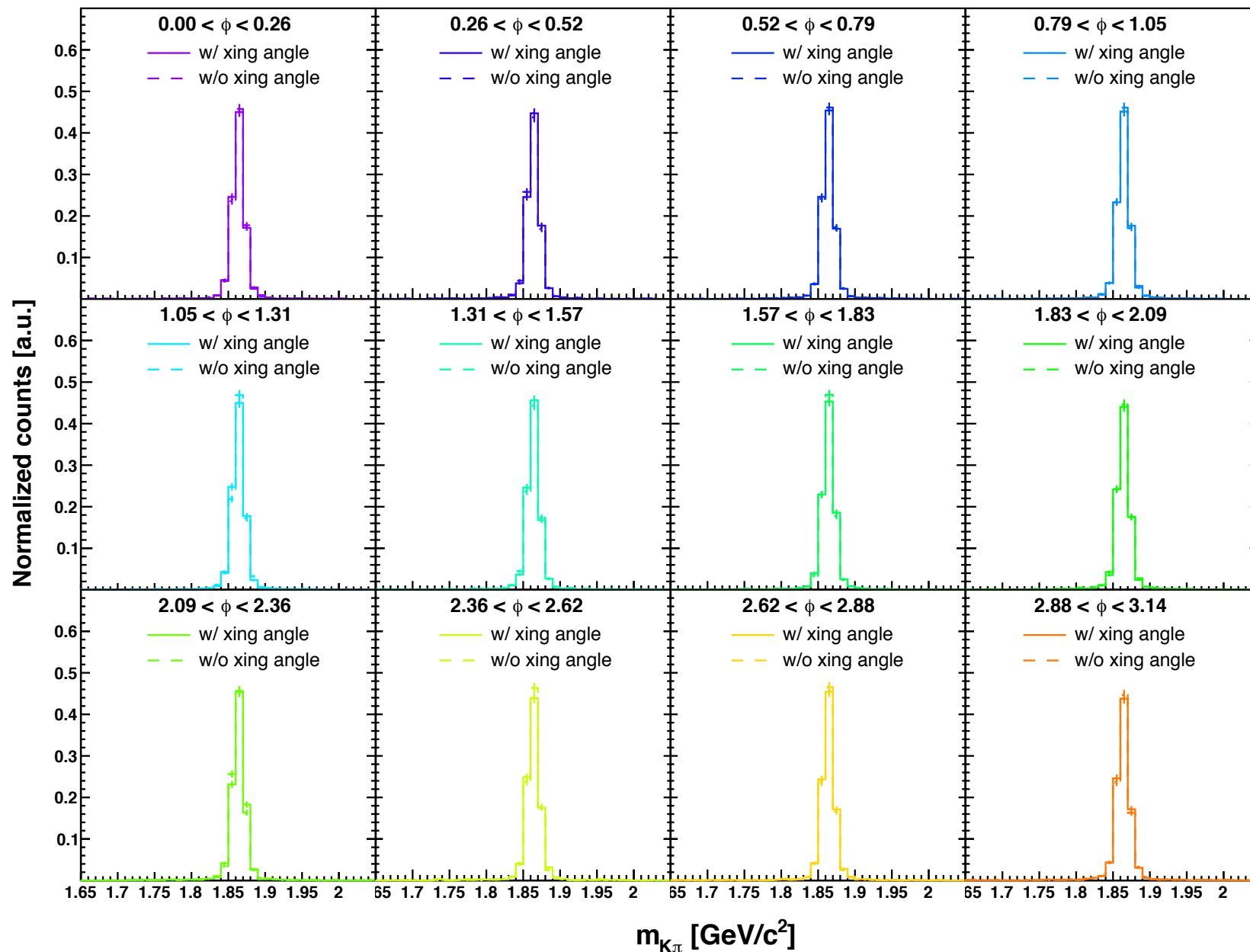
D^0 mass resolution w & w/o Xing angle

Pythia, e+p @ 10+100 GeV, Min Bias ($Q^2 > 10 \text{ GeV}^2$), 25 mrad Xing angle, $-3.00 < \eta < -2.00$



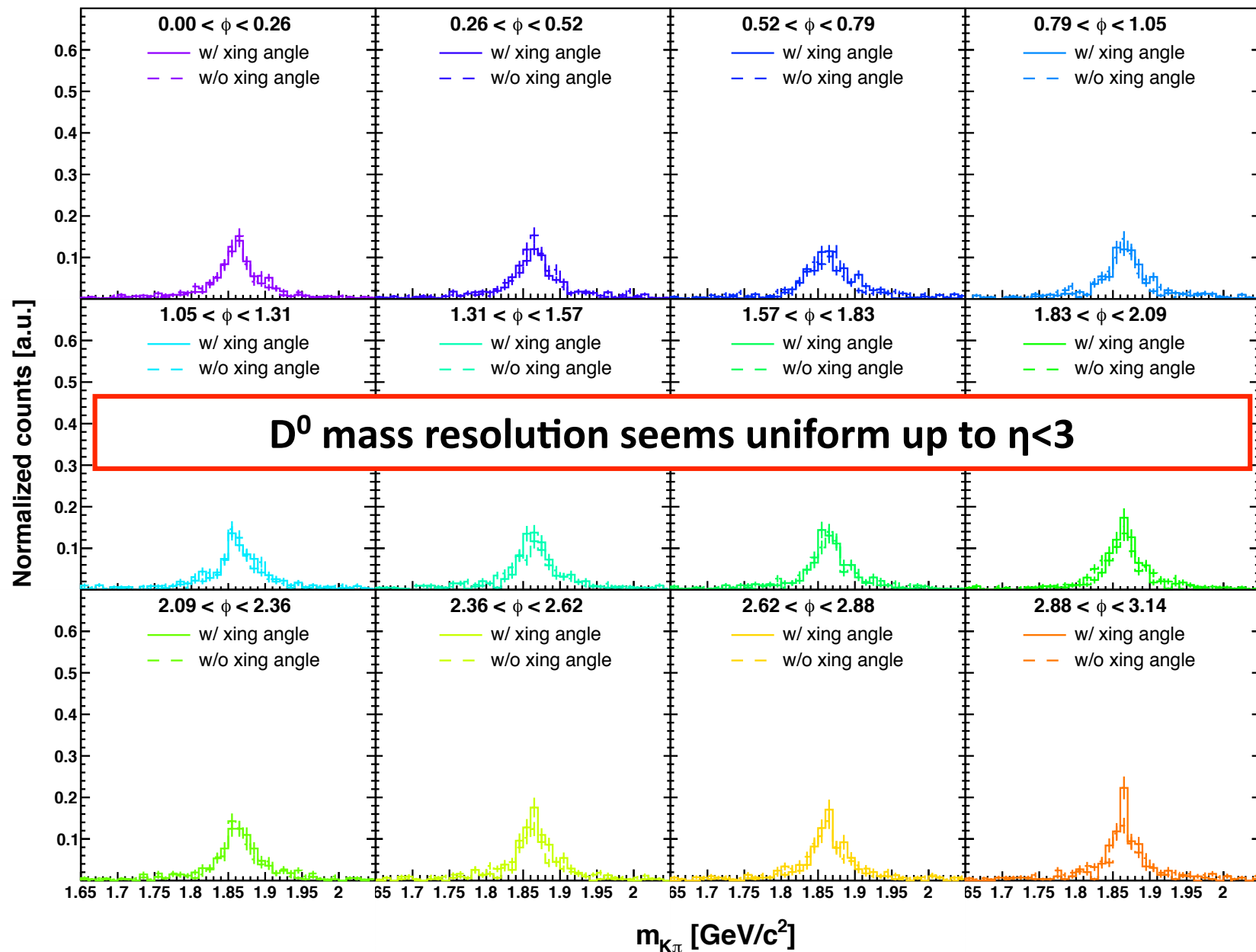
D^0 mass resolution w & w/o Xing angle

Pythia, e+p @ 10+100 GeV, Min Bias ($Q^2 > 10 \text{ GeV}^2$), 25 mrad Xing angle, $0.00 < \eta < 0.50$



D^0 mass resolution w & w/o Xing angle

Pythia, e+p @ 10+100 GeV, Min Bias ($Q^2 > 10 \text{ GeV}^2$), 25 mrad Xing angle, $2.75 < \eta < 3.00$



Summary

- ❖ After implementing Xing angle:
 - ❖ The particle production (σ) become ϕ dependent
 - ❖ Such effect can be corrected after boosting/rotating the event back to the head-on frame
 - ❖ However the particles out-of-acceptance in the lab-frame cannot be retrieved $\rightarrow$ a non-uniform acceptance in the head-on frame at forward rapidity along ϕ
- ❖ Effect on D^0 measurement:
 - ❖ No significant effect on the mass resolution
 - ❖ More particles around $\phi \sim 0$ (more combinatorial background for heavy flavor hadrons) $\rightarrow$ worse S/B ratio
 - ❖ Acceptance correction will be ϕ dependent

$$\sigma_r^{c\bar{c}}(x_B, Q^2) = \frac{dN(D^0 + \bar{D}^0)/2}{\mathcal{L} \cdot \epsilon \cdot \mathcal{B}(D^0 \rightarrow K\pi) \cdot f(c \rightarrow D^0) \cdot dx_B dQ^2} \times \frac{x_B Q^4}{2\pi\alpha^2[1 + (1 - y)^2]}$$