Jet quenching and modification at RHIC and jet calorimeter (J-cal) for LHC-ALICE

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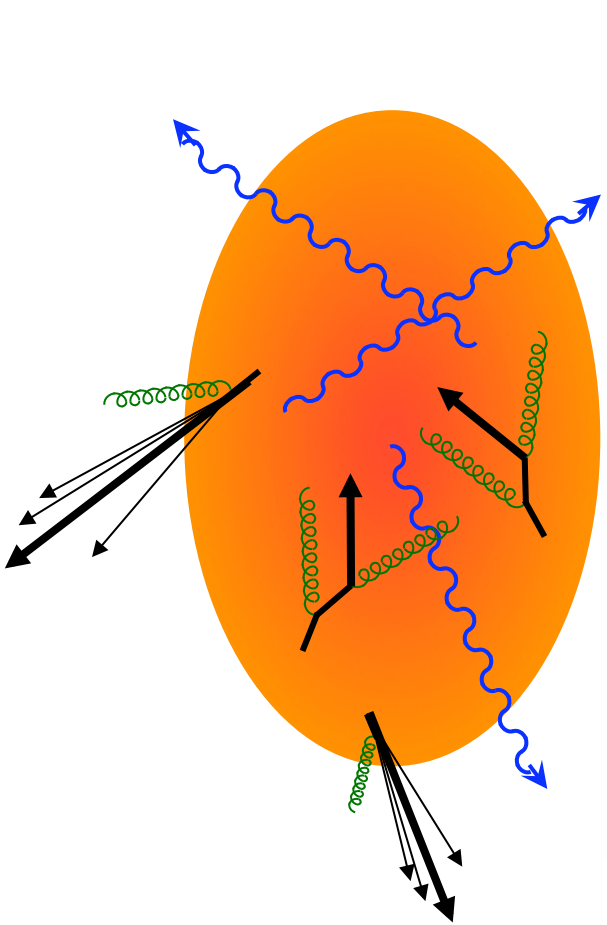
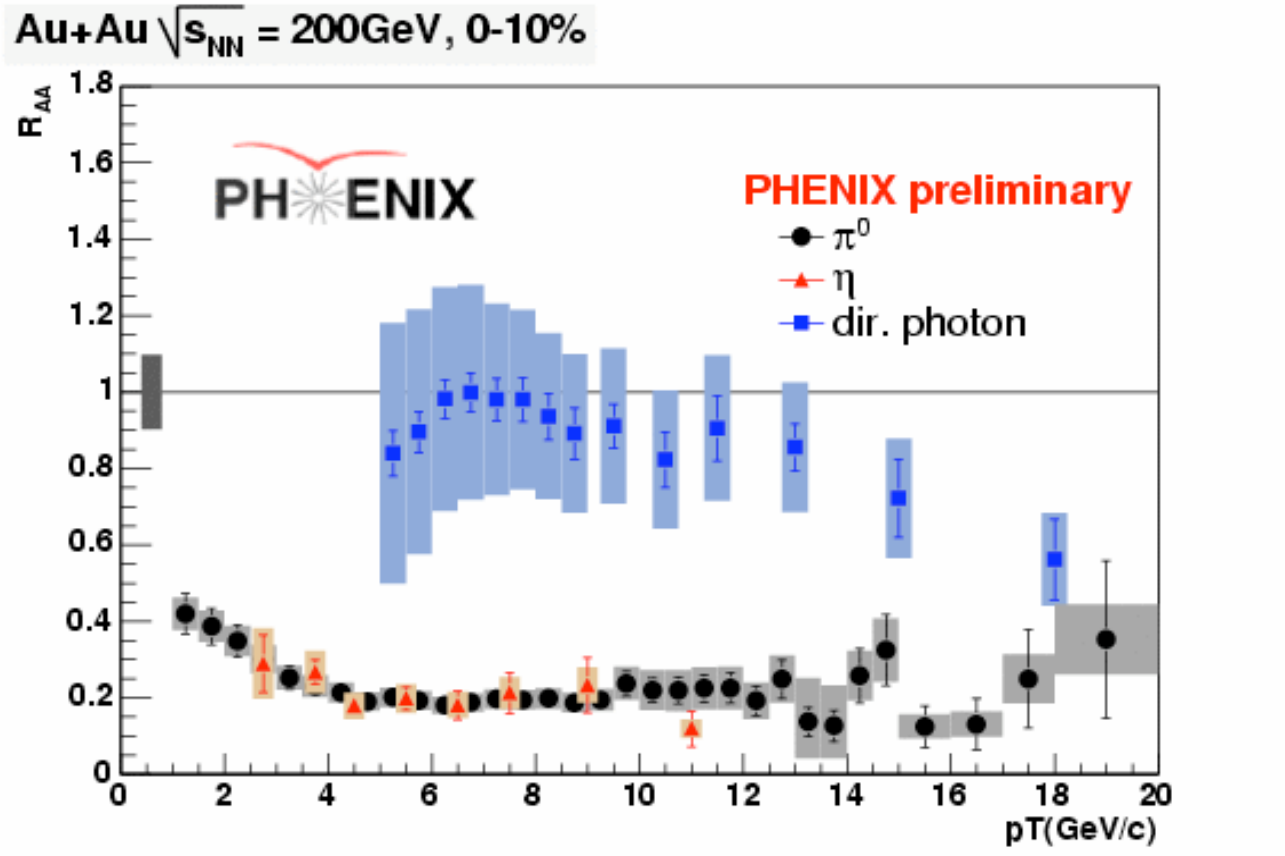
Gamma-Jet results
Jets, di-Jet results
Mach-cone, Ridge results
J-cal proposal/approval

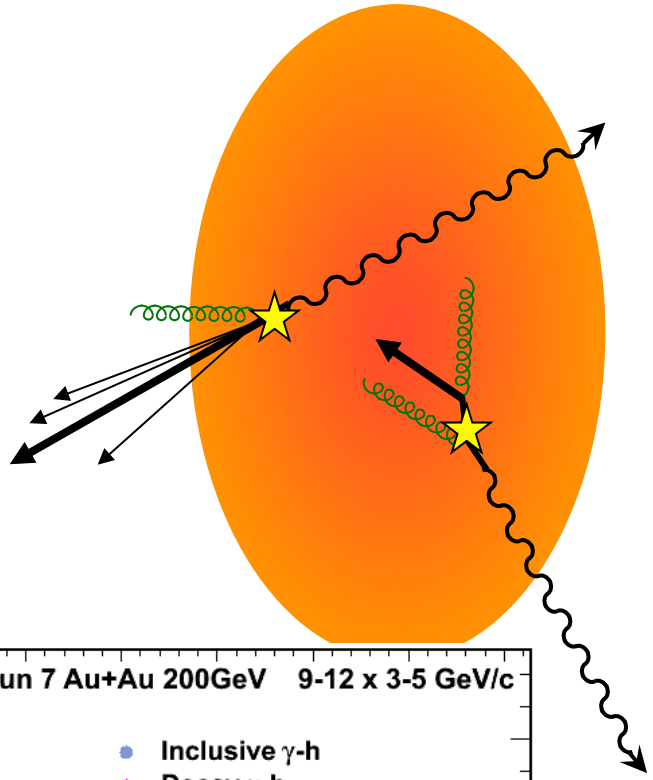
Hadron large suppression
Direct γ NO suppression

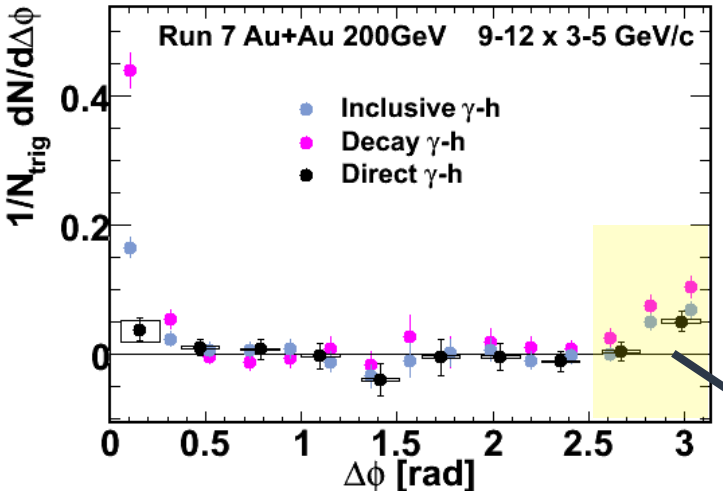




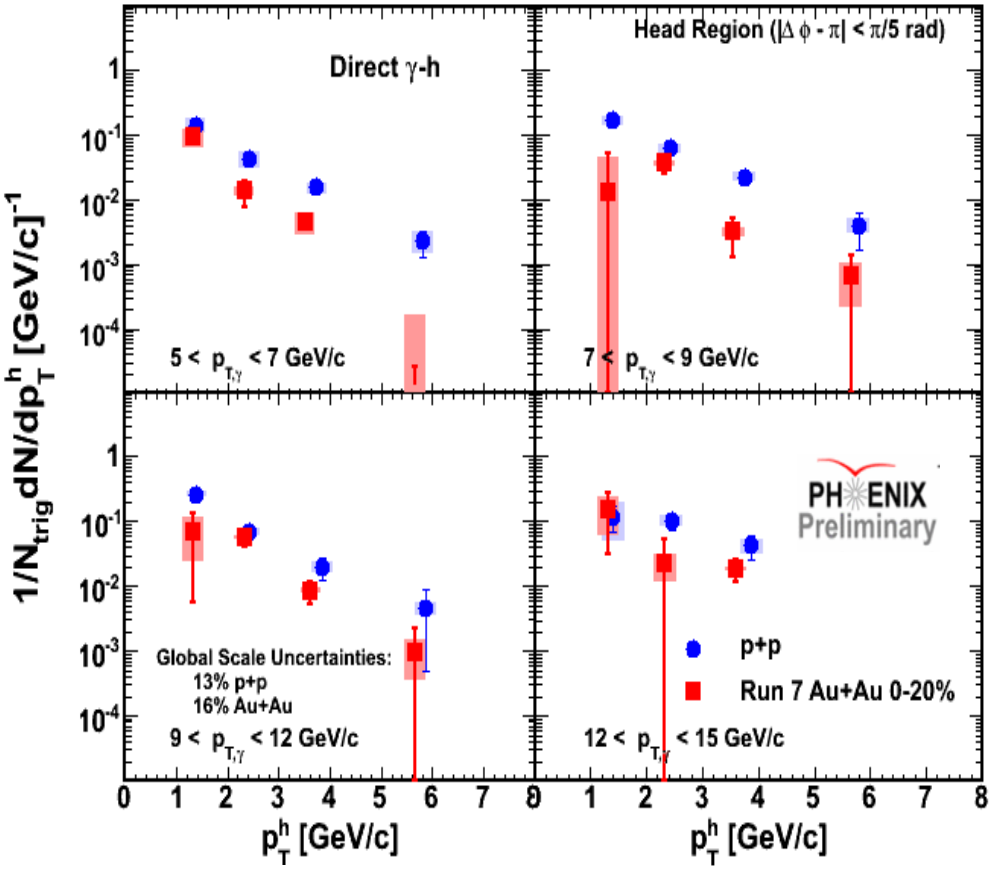
Direct γ - hadron coincidence

QM09, M. Connors



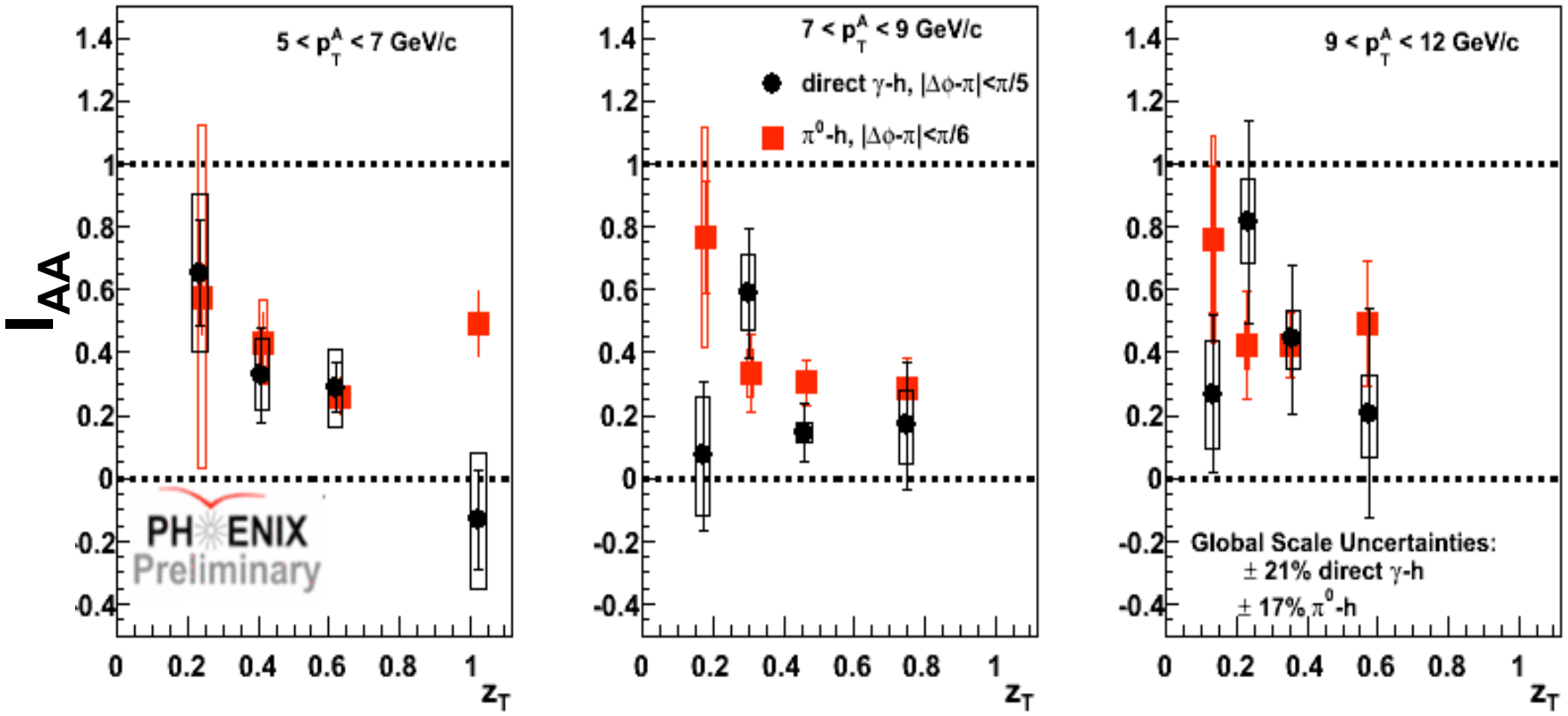


Head region



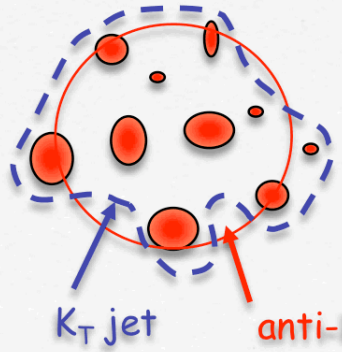
I_{AA} vs Z_T for direct γ-h compared with π^0-h

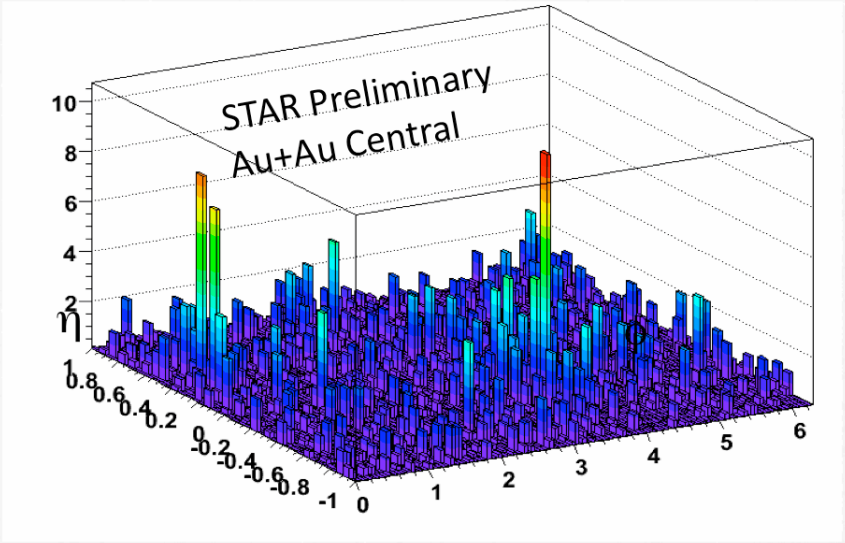
$$z_T = p_T^h / p_T^\gamma$$



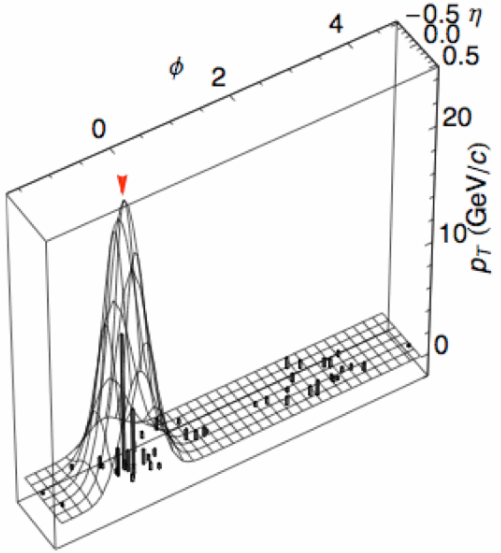
QM09, A. Majumder

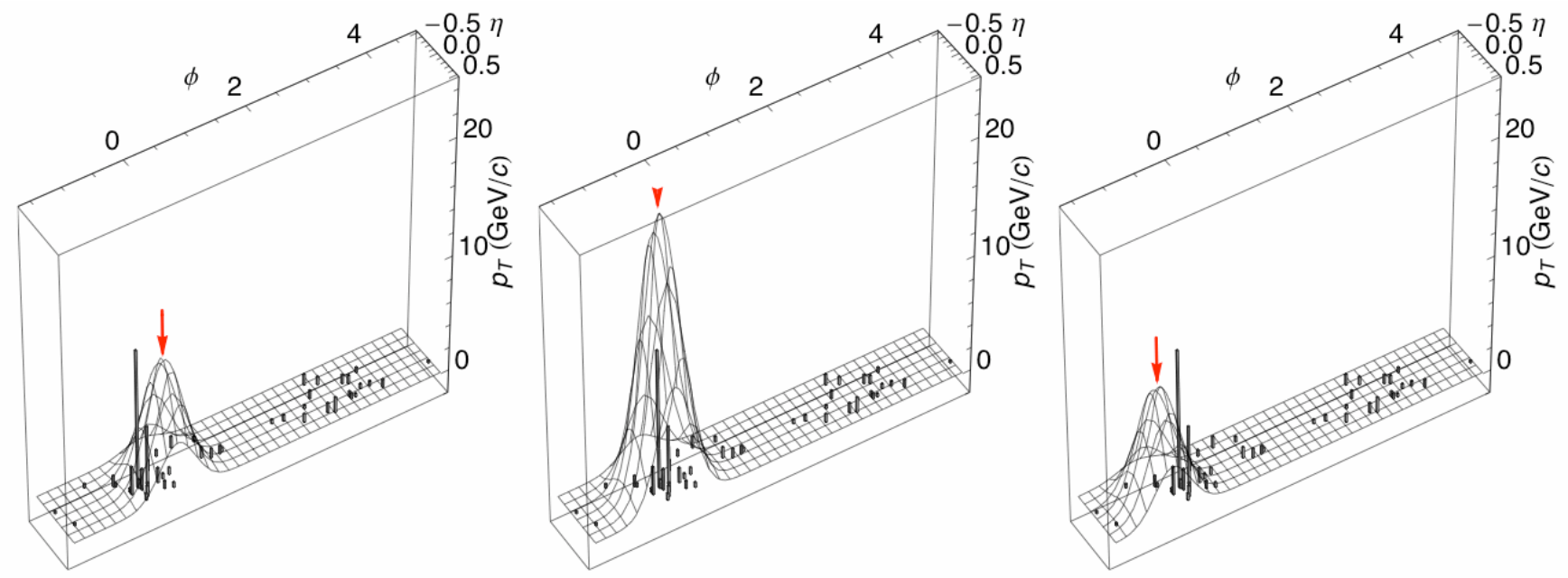
STAR
k_T, anti-k_T

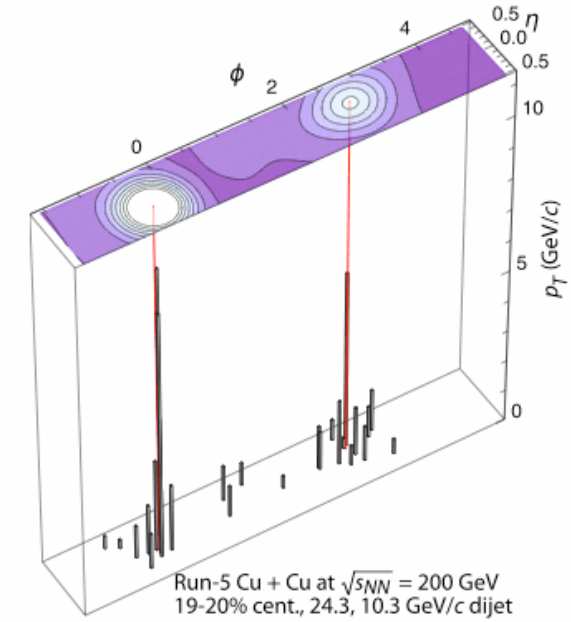


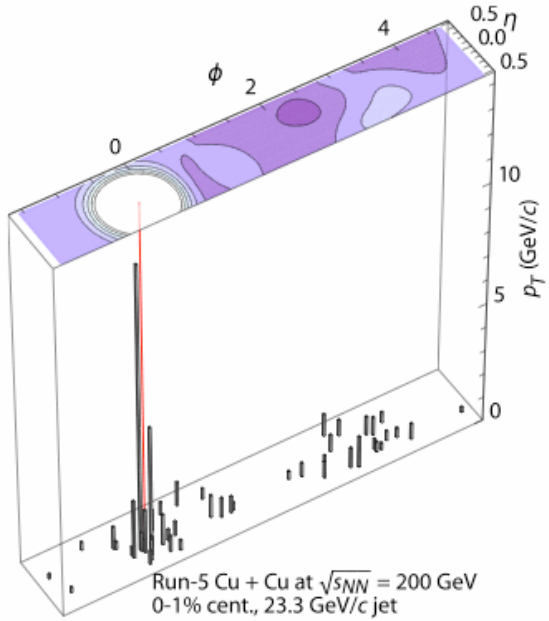


PHENIX
Gaussian filter

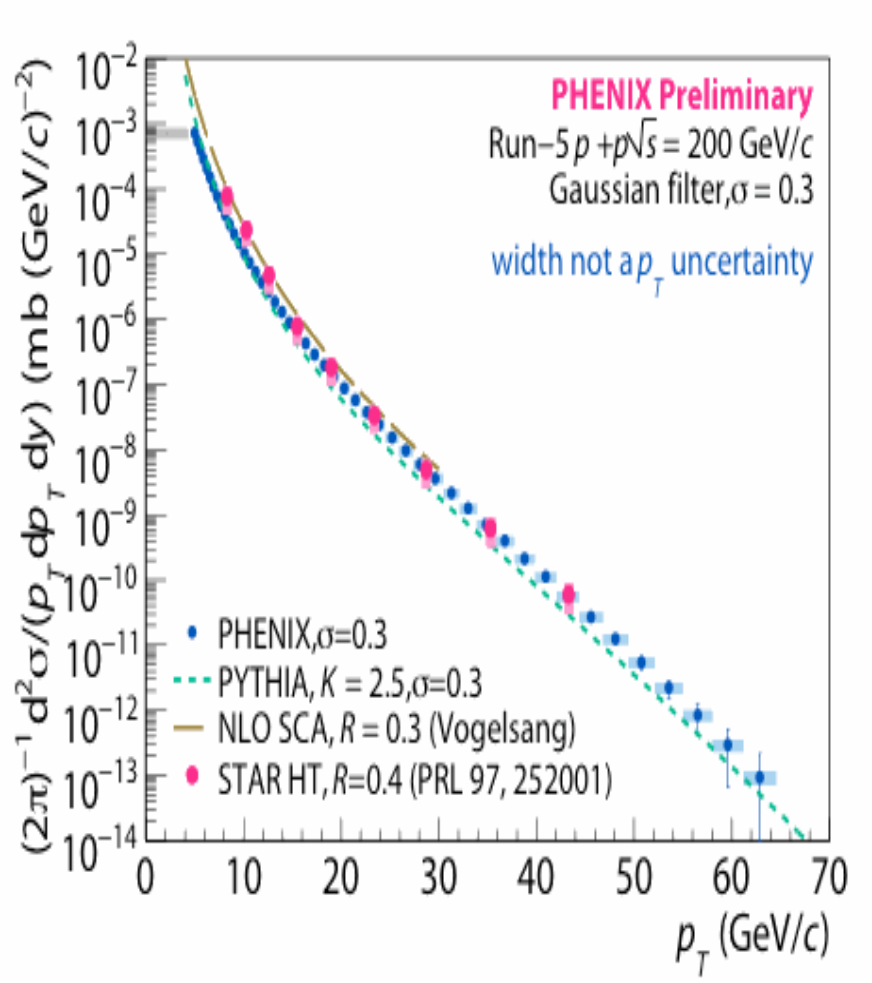


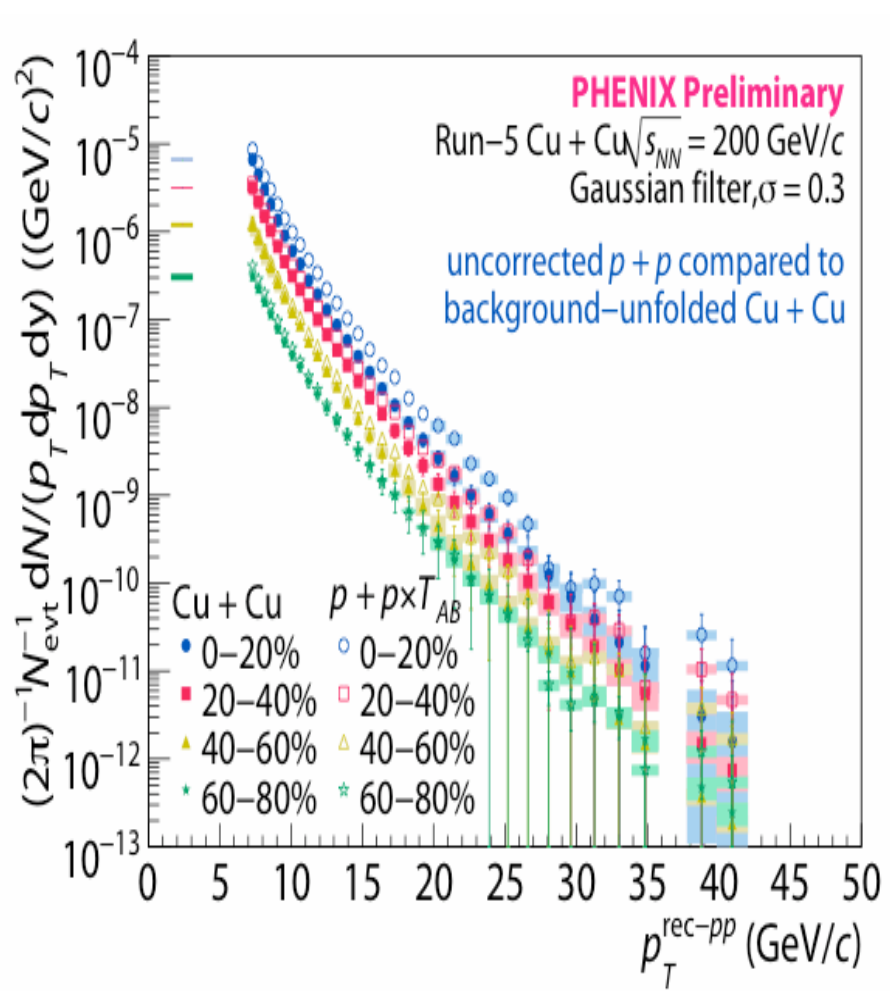

ϕ
η
p_T (GeV/c)

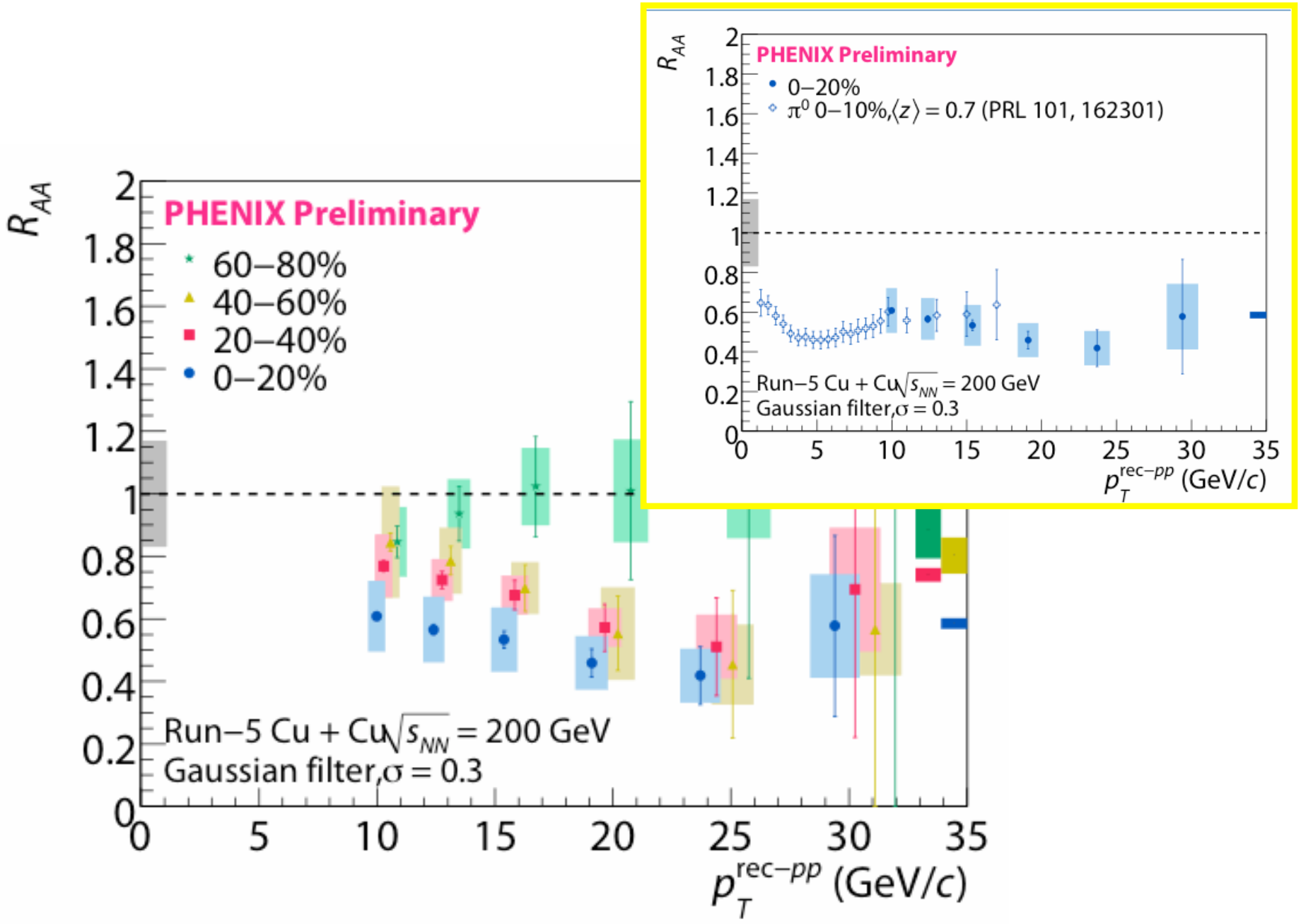

ϕ
η
p_T (GeV/c)
Run-5 Cu + Cu at $\sqrt{s_{NN}}$ = 200 GeV
19-20% cent., 24.3, 10.3 GeV/c dijet

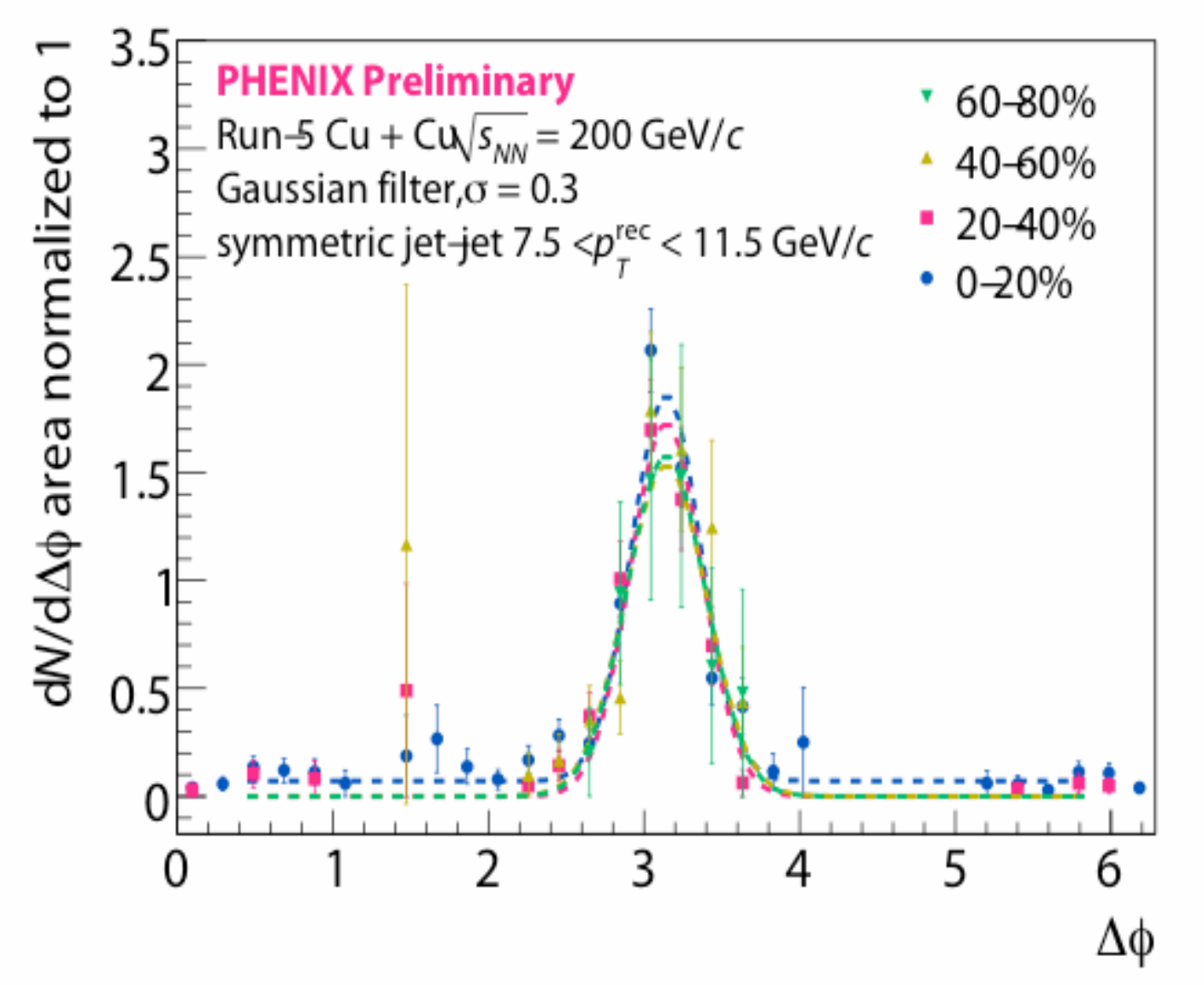

ϕ
η
p_T (GeV/c)
Run-5 Cu + Cu at $\sqrt{s_{NN}}$ = 200 GeV
0-1% cent., 23.3 GeV/c jet

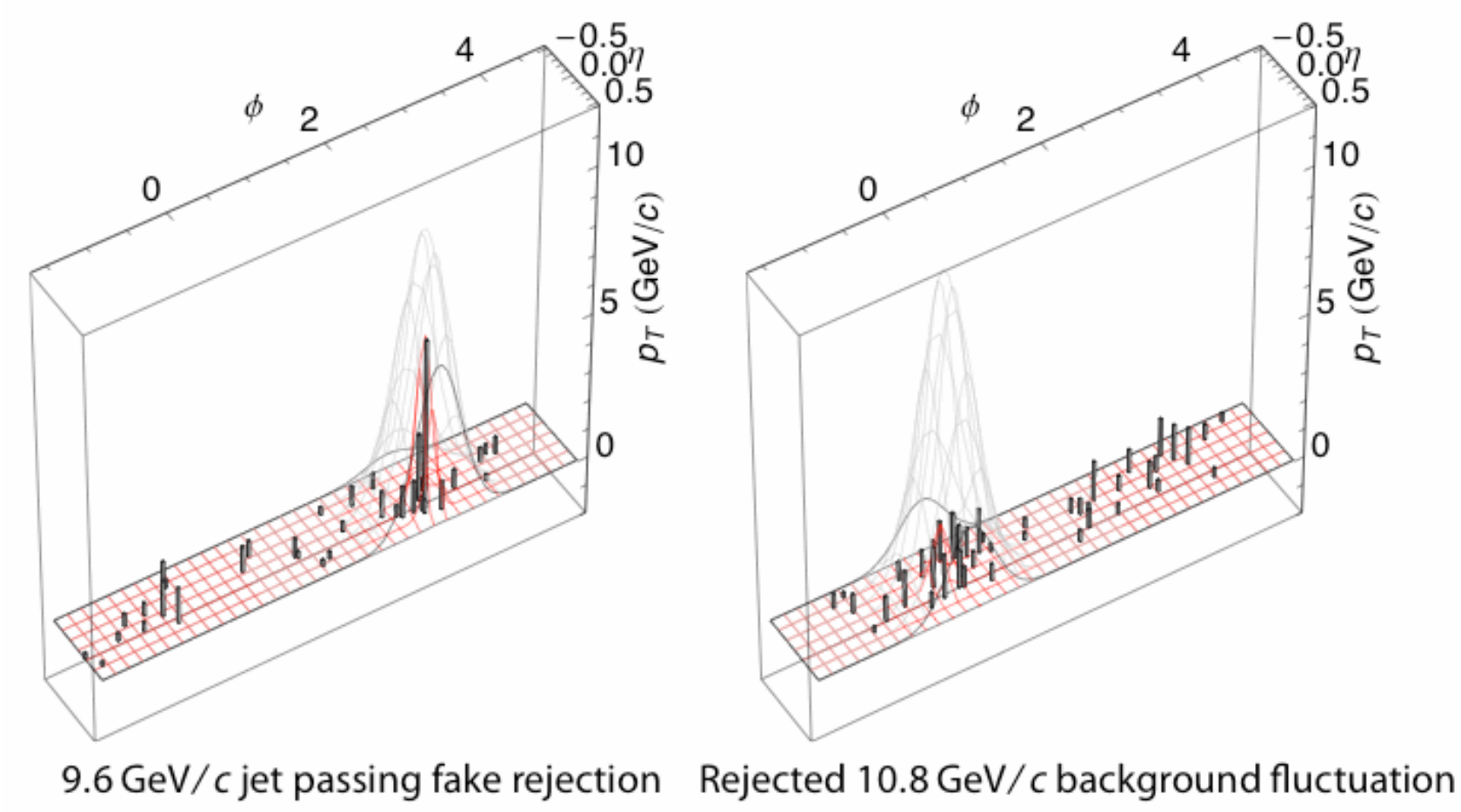
RHIC-AGS'09, Y. S. Lai





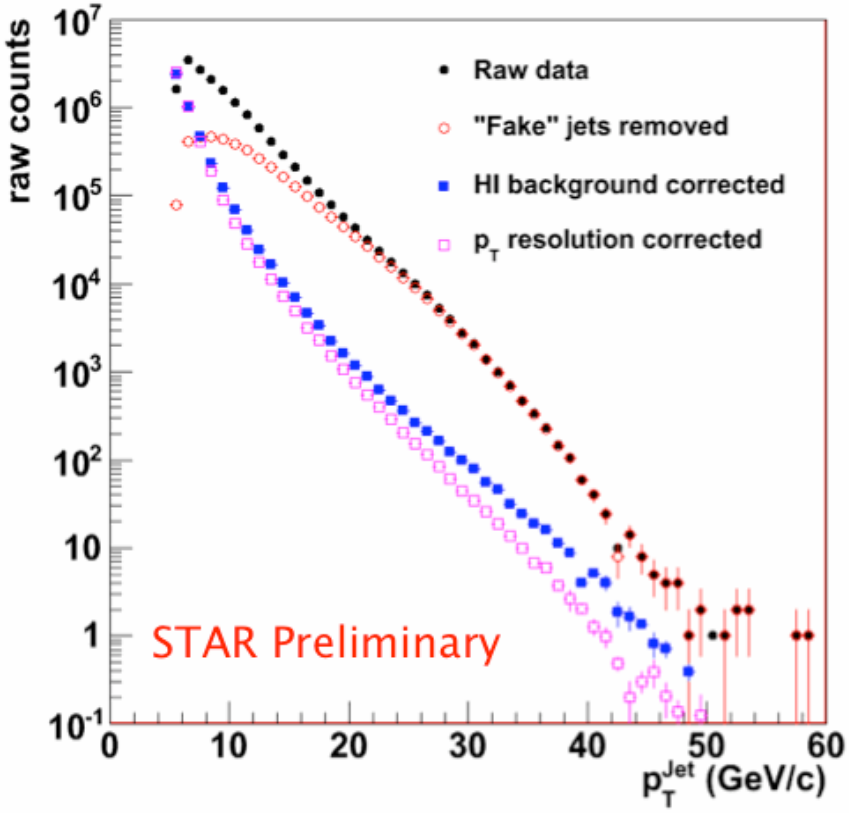

PHENIX Preliminary
60–80%
40–60%
20–40%
0–20%
Run–5 Cu + Cu $\sqrt{s_{NN}}$ = 200 GeV
Gaussian filter, σ = 0.3
R_{AA}
p_T^{rec-pp} (GeV/c)
PHENIX Preliminary
0–20%
π^0 0–10%, $\langle z \rangle$ = 0.7 (PRL 101, 162301)
Run–5 Cu + Cu $\sqrt{s_{NN}}$ = 200 GeV
Gaussian filter, σ = 0.3
R_{AA}
p_T^{rec-pp} (GeV/c)

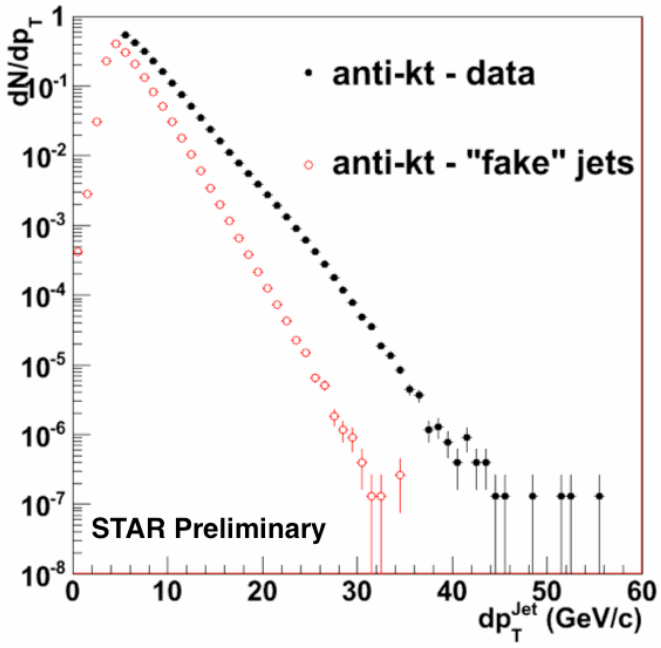

PHENIX Preliminary
Run-5 Cu + Cu $\sqrt{s_{NN}}$ = 200 GeV/c
Gaussian filter, σ = 0.3
symmetric jet-jet 7.5 < p_T^{rec} < 11.5 GeV/c
60-80%
40-60%
20-40%
0-20%
dN/d$\Delta\phi$ area normalized to 1
$\Delta\phi$
0
0.5
1
1.5
2
2.5
3
3.5
0
1
2
3
4
5
6

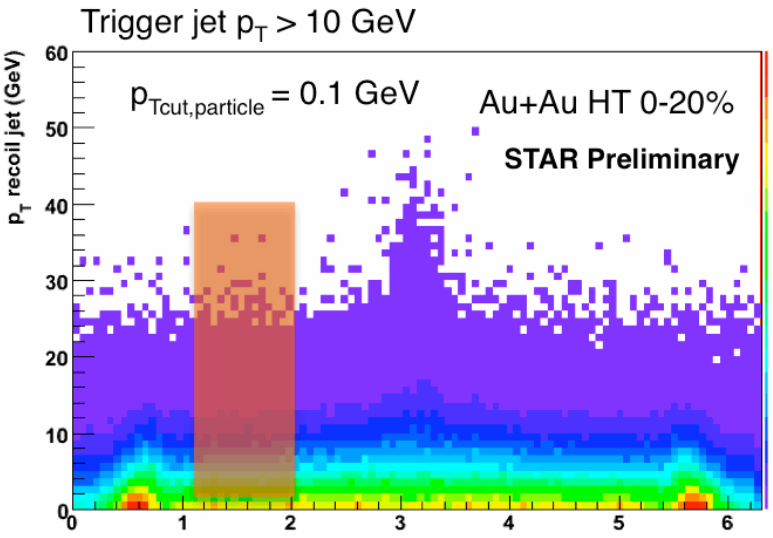


9.6 GeV/c jet passing fake rejection

Rejected 10.8 GeV/c background fluctuation

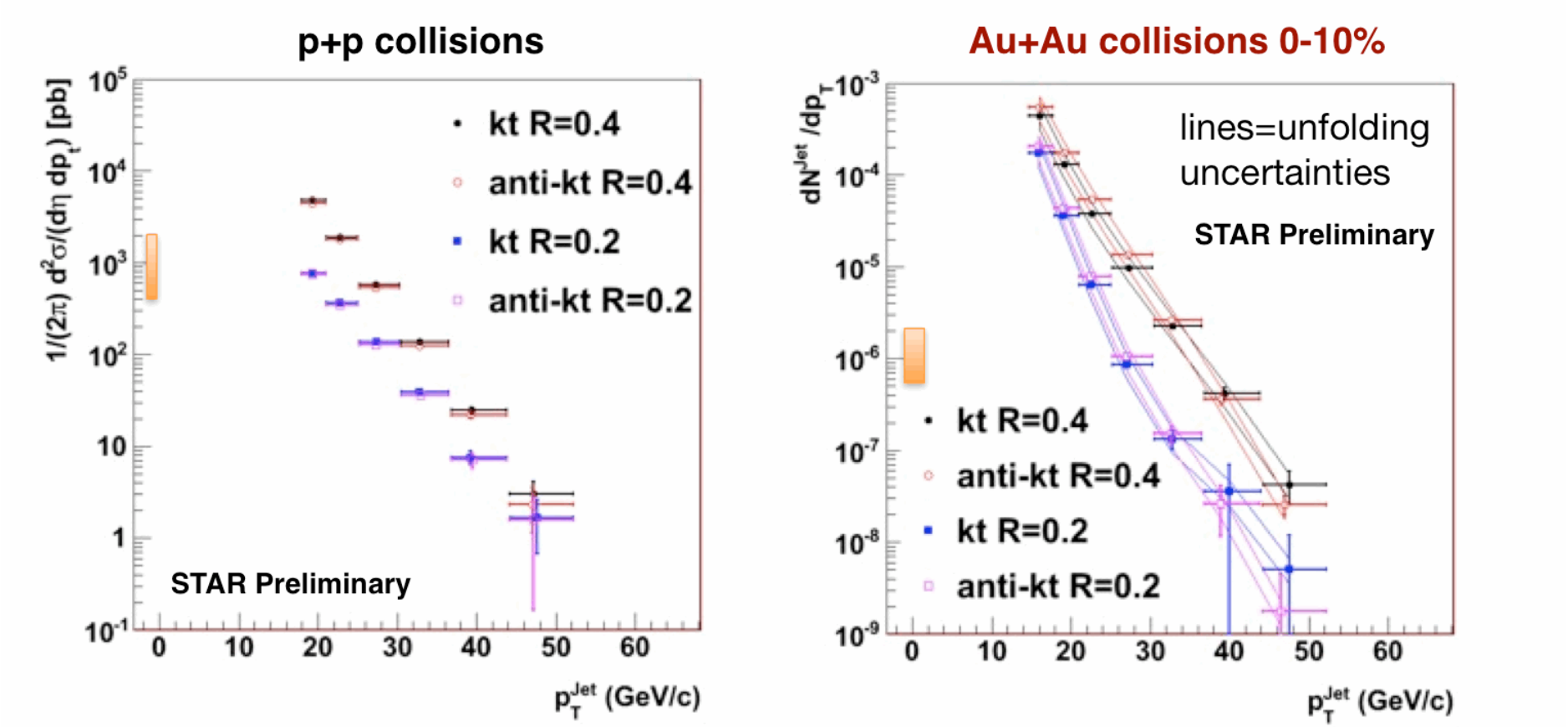

raw counts
Raw data
"Fake" jets removed
HI background corrected
p_T resolution corrected
STAR Preliminary
p_T^{Jet} (GeV/c)


dN/dp_T
anti-kt - data
anti-kt - "fake" jets
STAR Preliminary
dp_T^{Jet} (GeV/c)

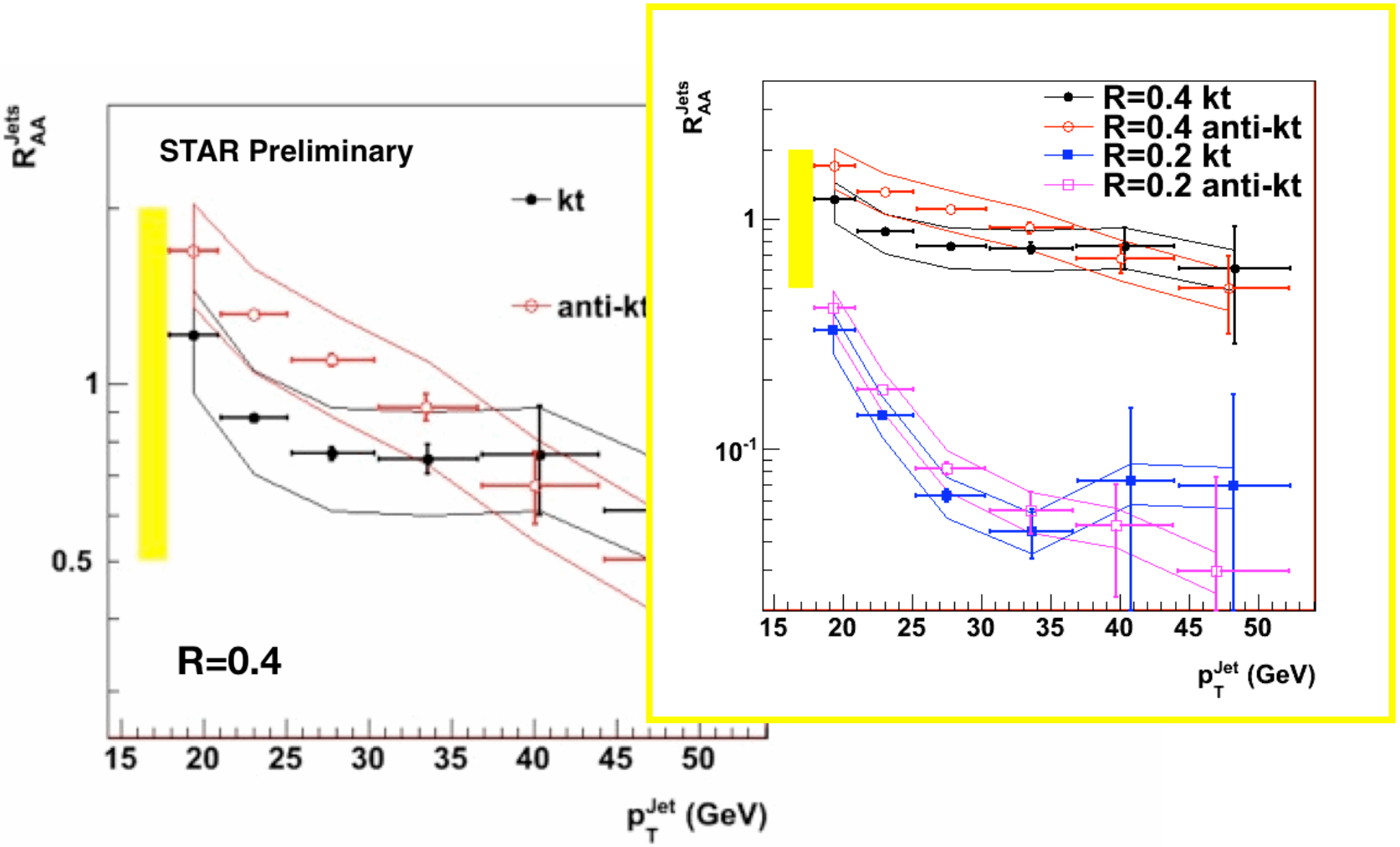

Trigger jet p_T > 10 GeV
$p_{Tcut,particle}$ = 0.1 GeV
Au+Au HT 0-20%
STAR Preliminary
p_T recoil jet (GeV)

Inclusive Jet cross section in p+p and in central Au+Au at RHIC

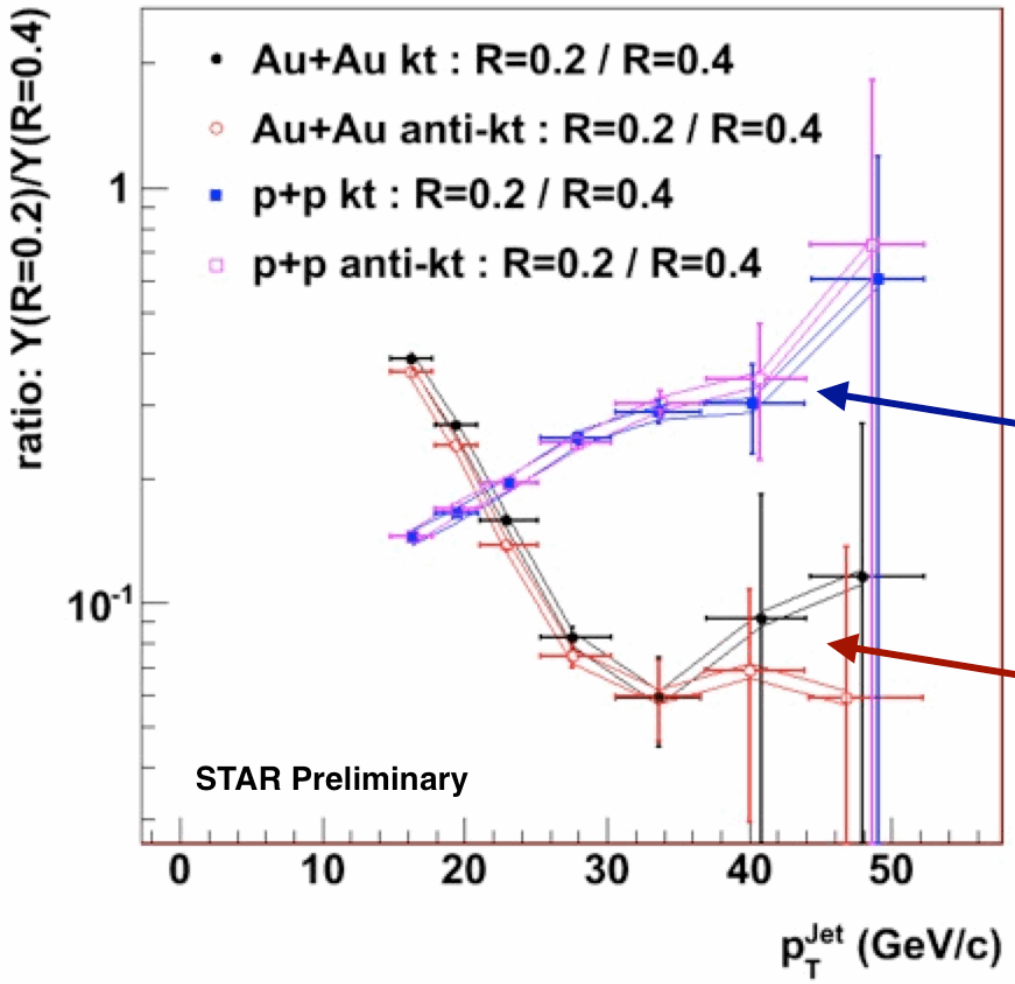
QM09, M. Ploskon

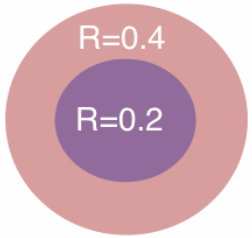


- **Inclusive Jet spectrum measured in central Au+Au collisions at RHIC**



- **We see a substantial fraction of jets**
  - in contrast to x5 suppression for light hadron R_{AA}
- **k_T and Anti-k_T known to have different sensitivities to background**



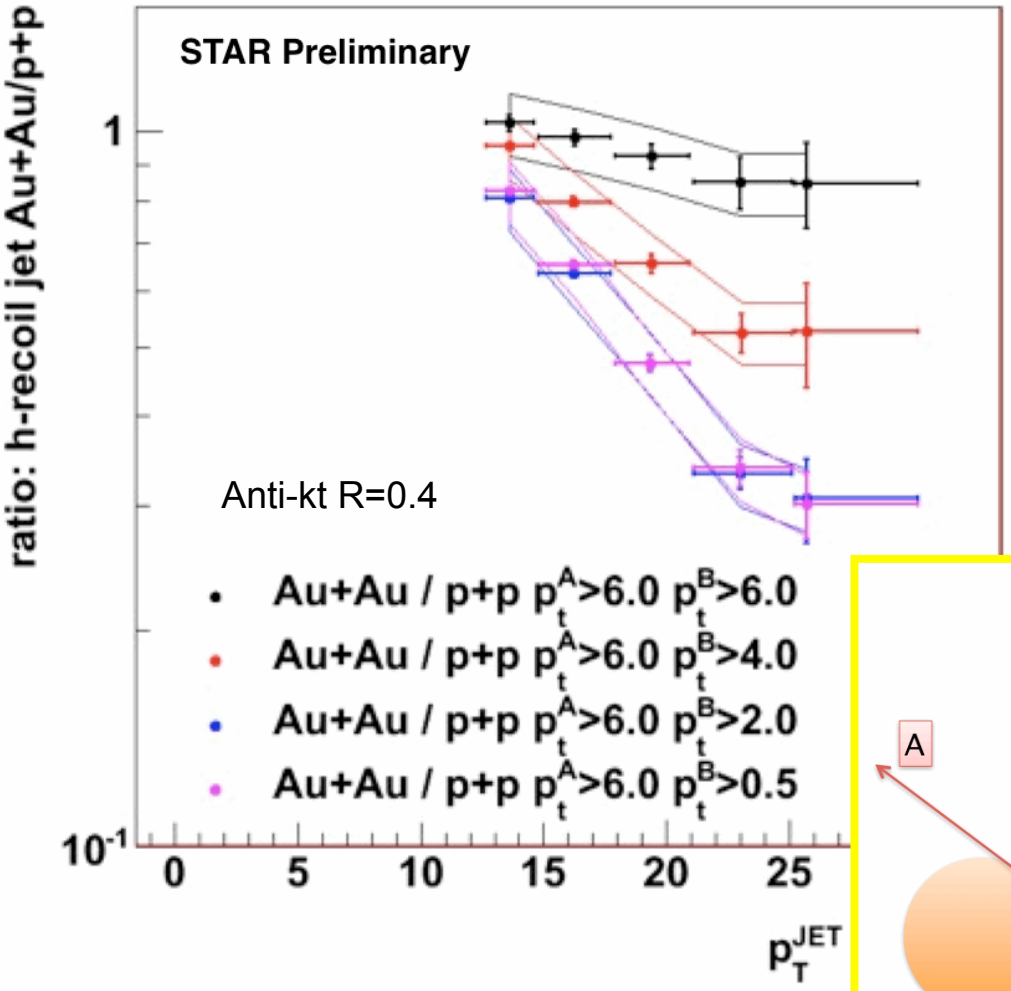


p+p: "Narrowing" of the jet structure with increasing jet energy

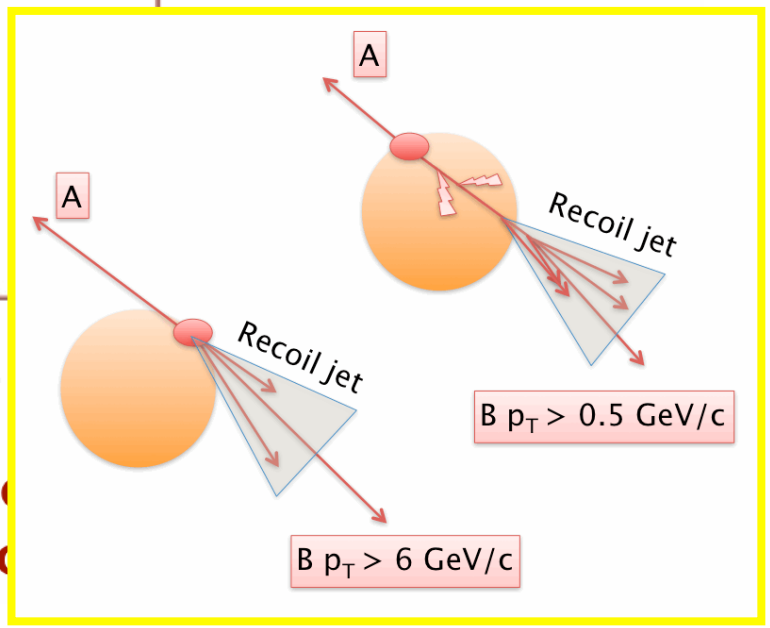
Au+Au: "Deficit" of jet energy of jets reconstructed with R=0.2

Strong evidence of broadening in the jet energy profile

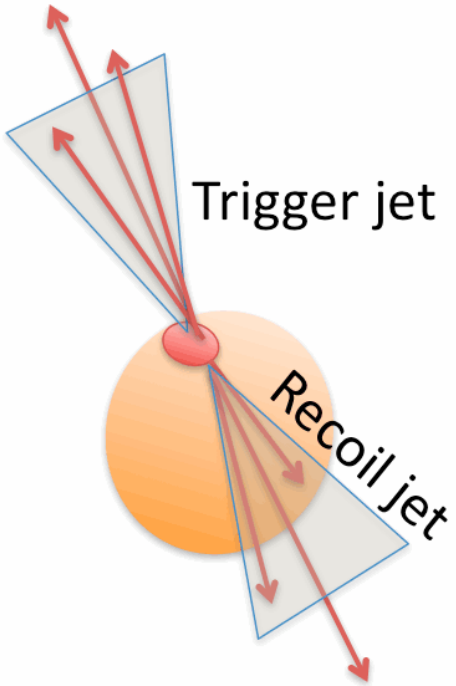
Trigger on high p_T π^0 and look at jet recoil spectrum



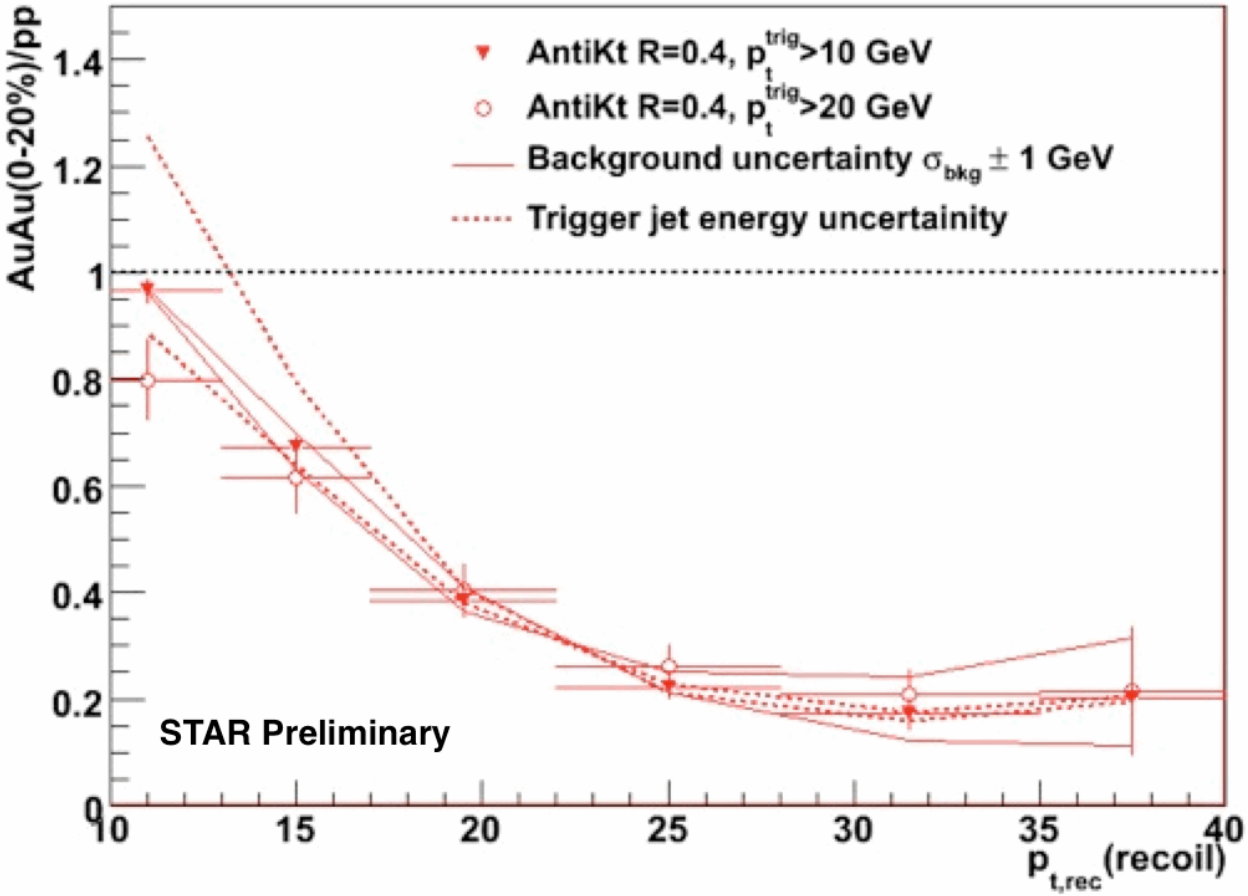
Increasing pathlength of recoil jets



Significant suppression in hadron-j
measurements of the unbiased reco

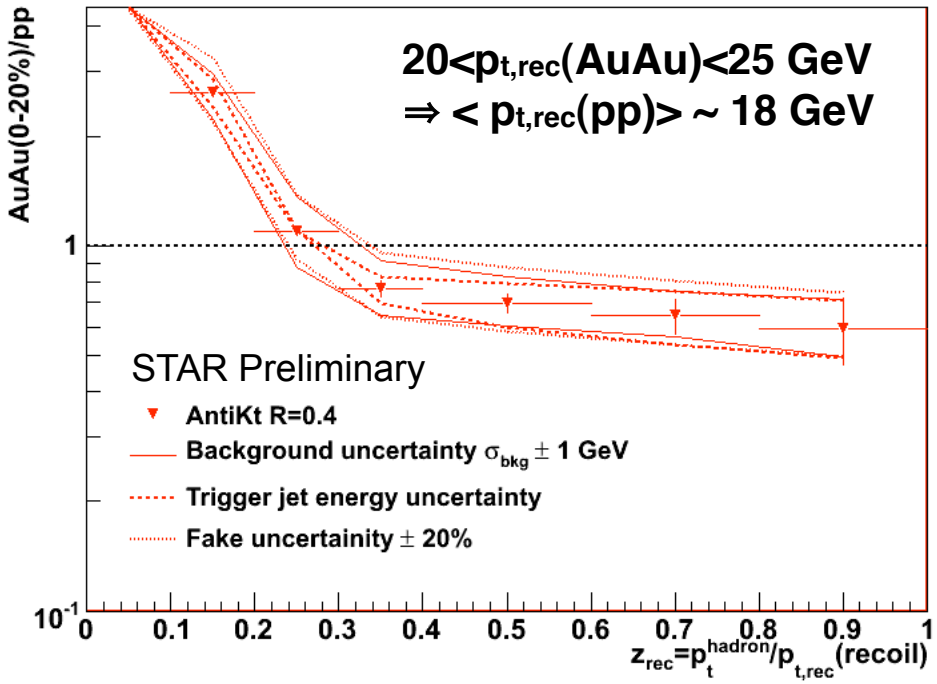


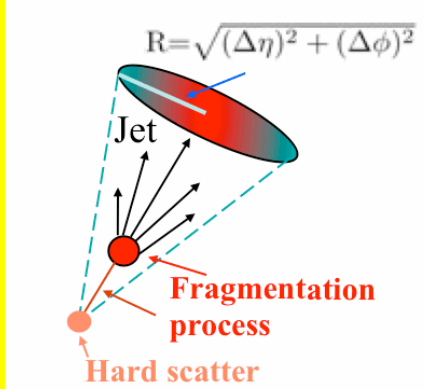
QM09, E. Bruna

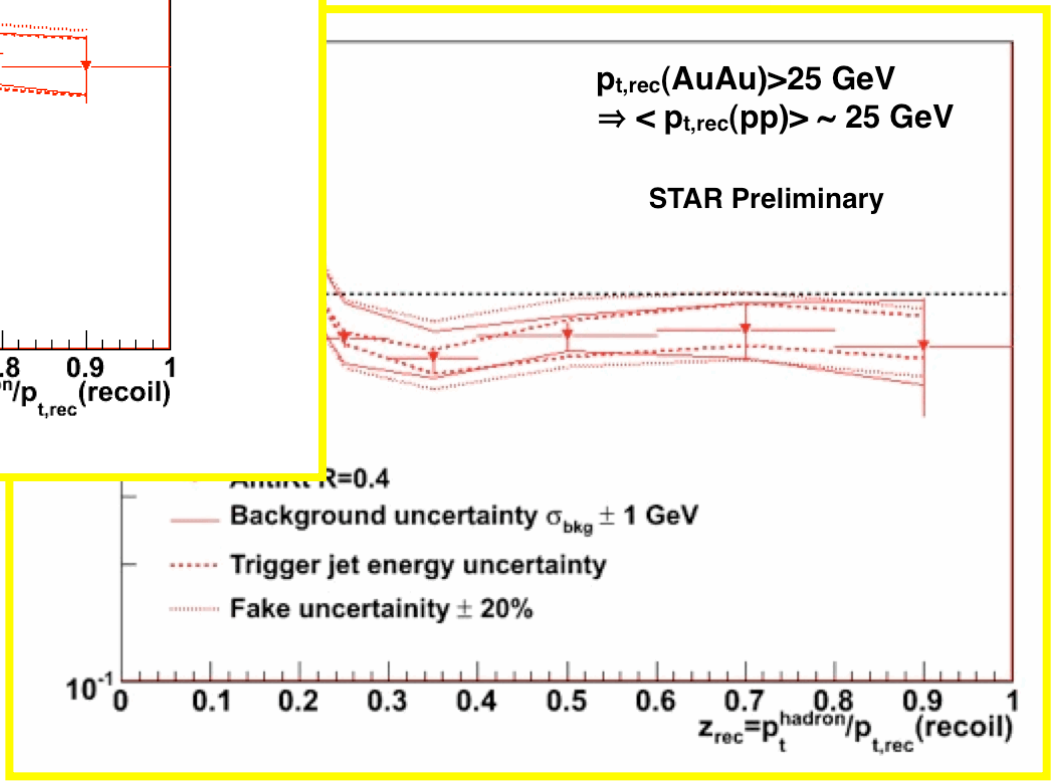


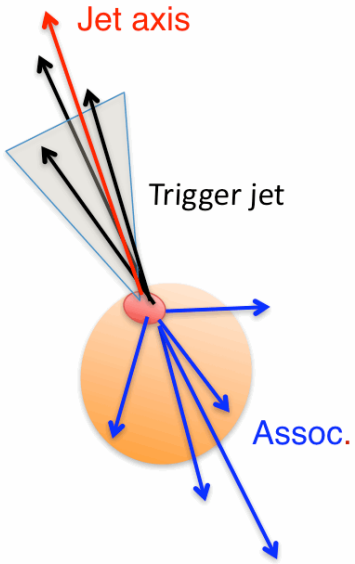
- **Selecting unmodified trigger jet maximizes pathlength for the back-to-back jets: "extreme" selection of jet population**
- **Significant suppression in di-jet coincidence measurements**

large uncertainties due to background
(further systematic evaluation needed)





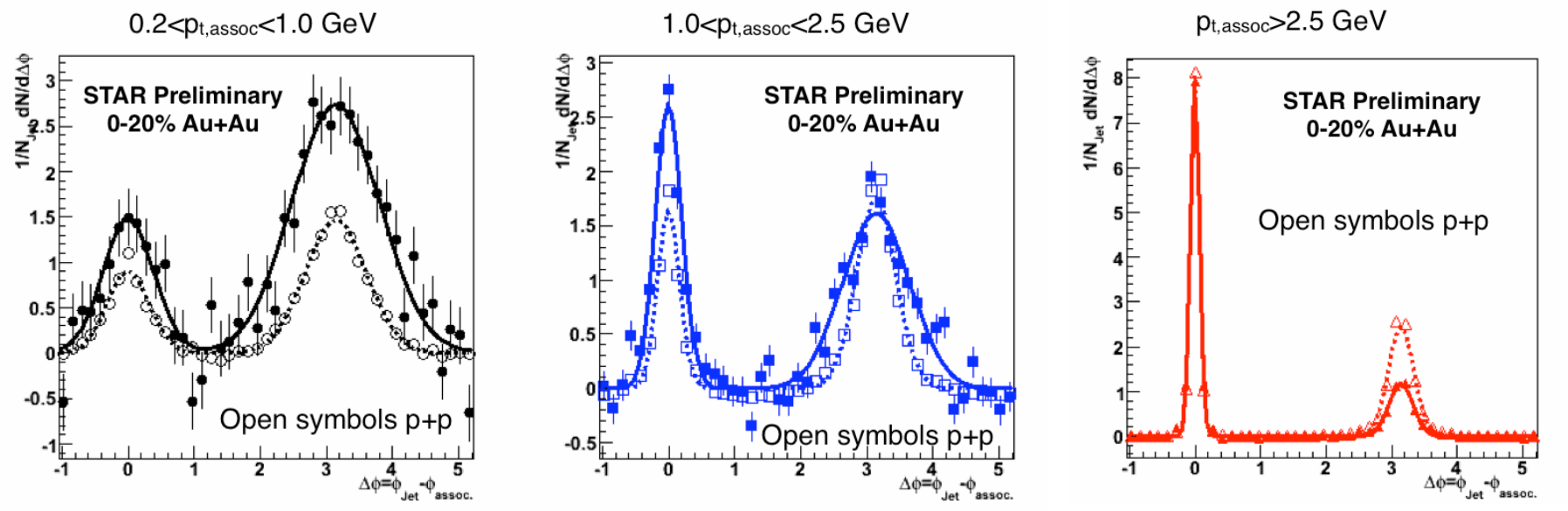


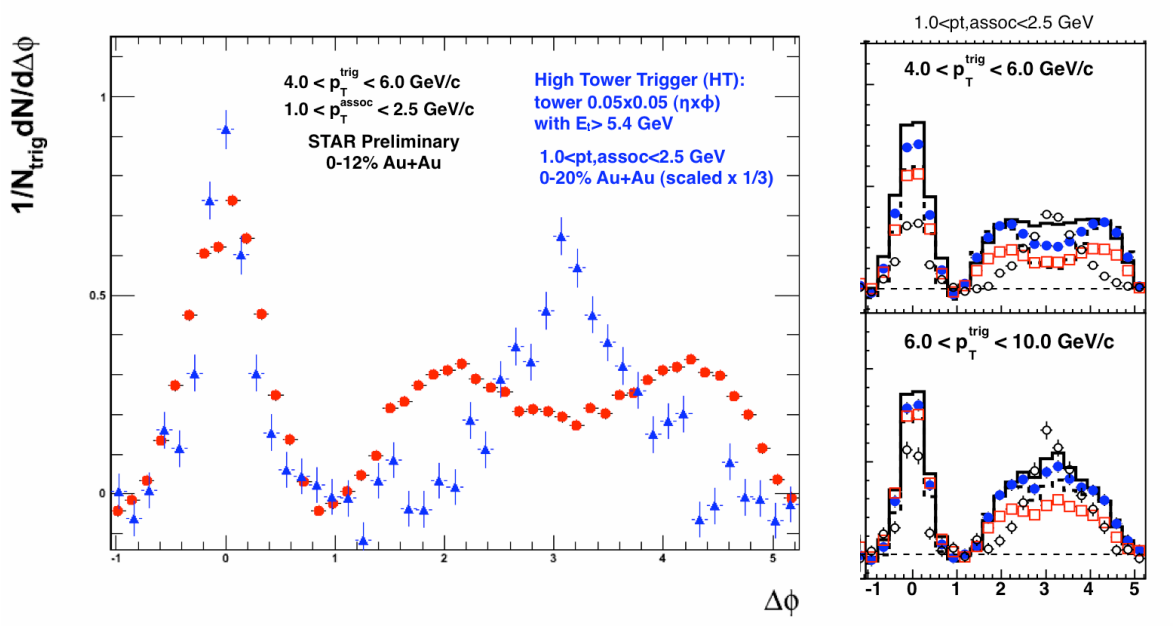


Jet - hadron correlation

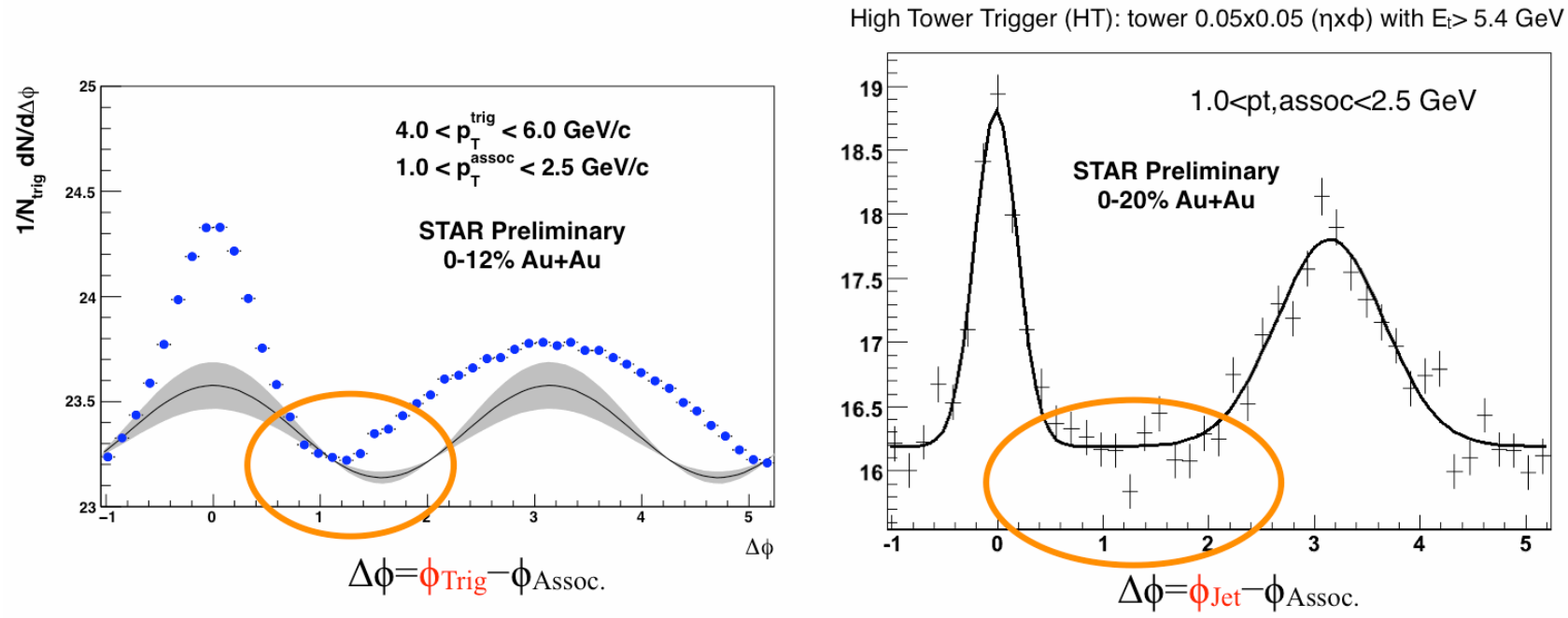
RHIC-AGS'09, J. Putschke

High Tower Trigger (HT) : (ηxϕ)=(0.05x0.05) E_T>5.4GeV

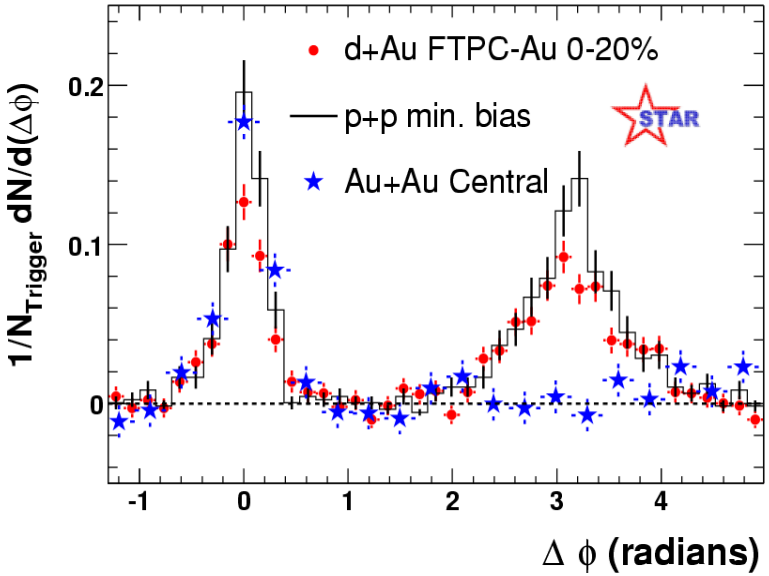


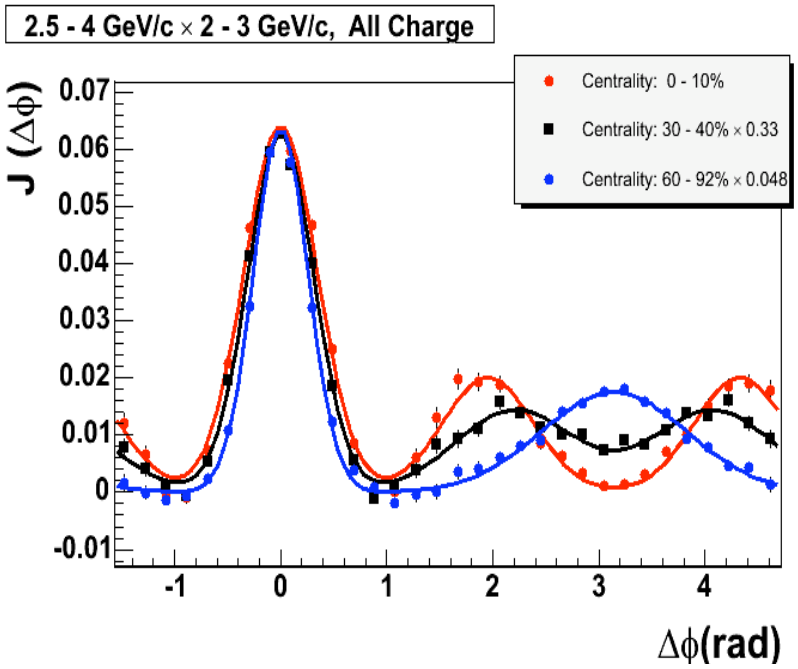


RHIC-AGS'09, J. Putschke (from his back-up slides)

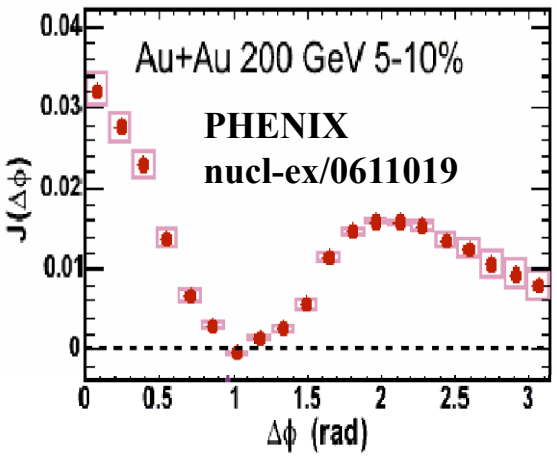


Jet suppression➡modification with 2-particle Δφ correlation

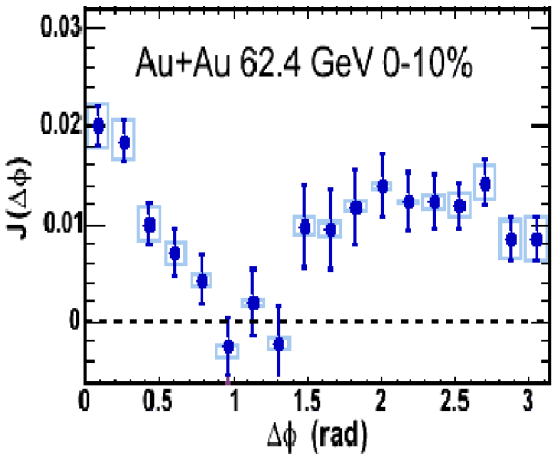




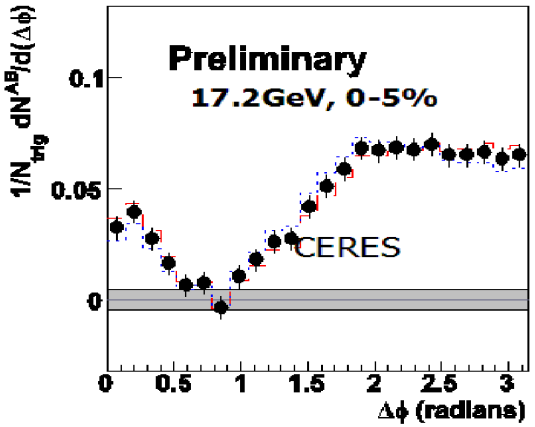
RHIC 200GeV



RHIC 62GeV



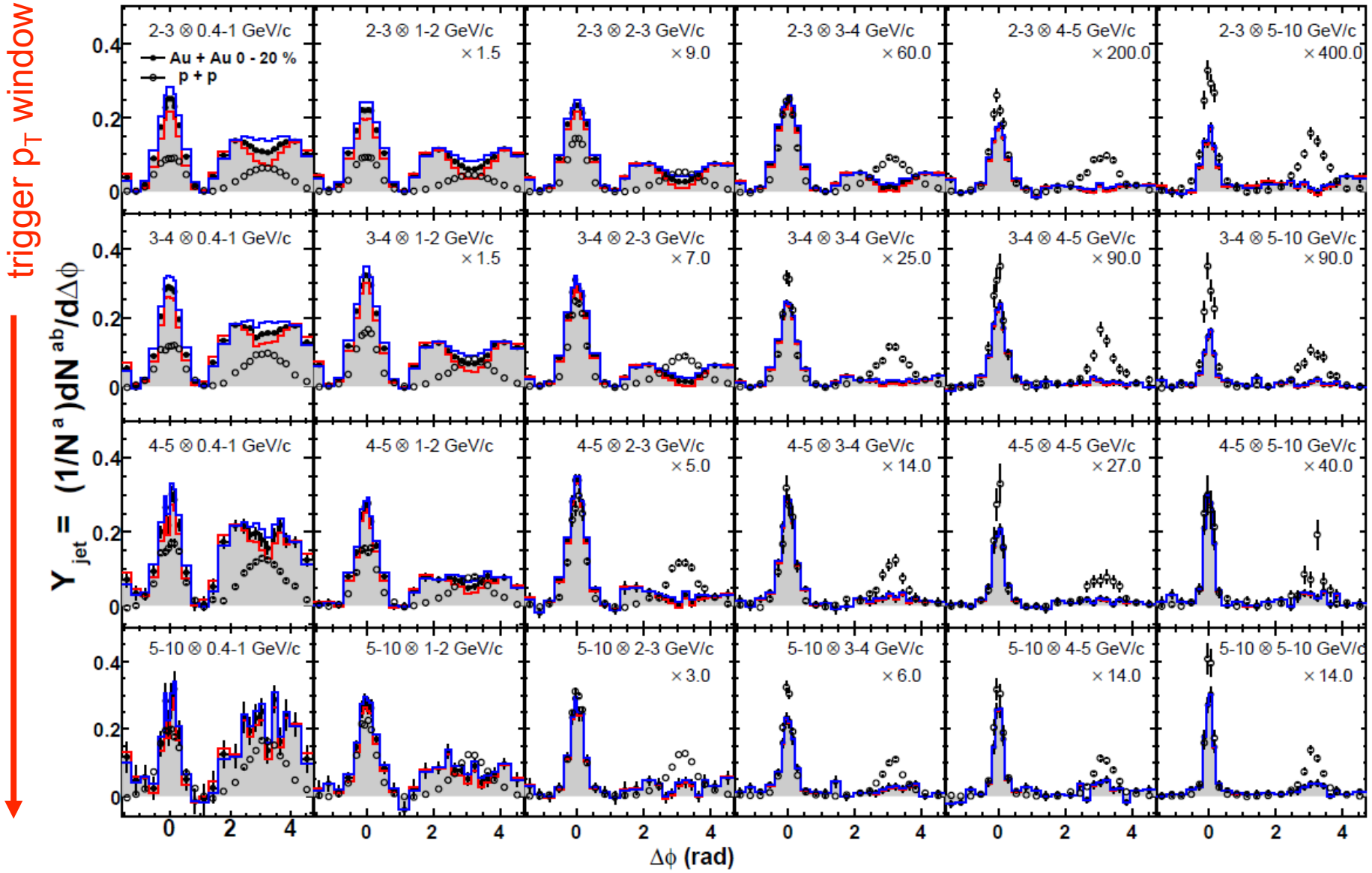
SPS 17GeV



S.Kniege, ISMD 2007

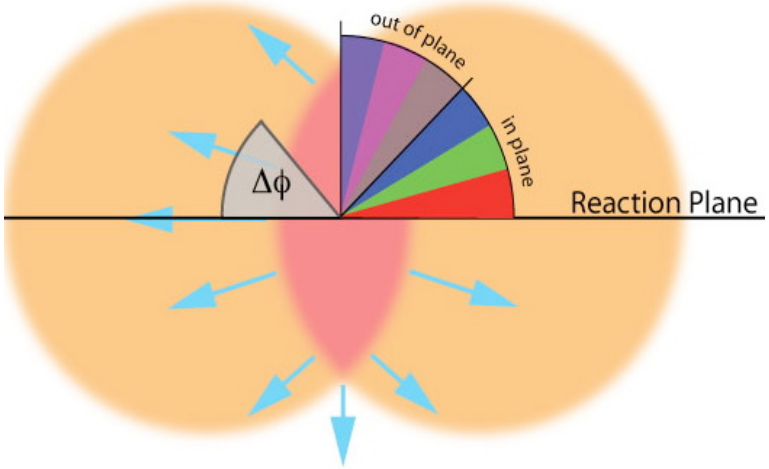
h-h correlation at “p+p 200GeV” vs “Au+Au 200GeV central 0-20%”

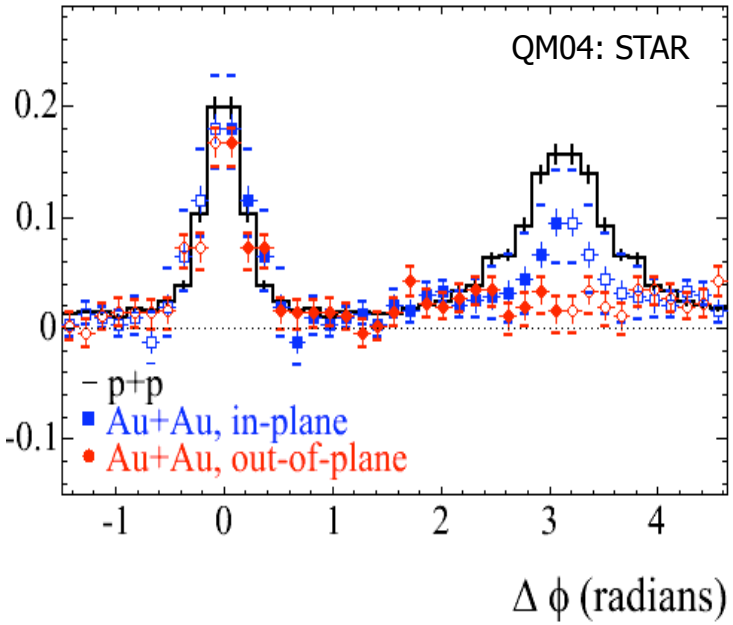
associate p_T window

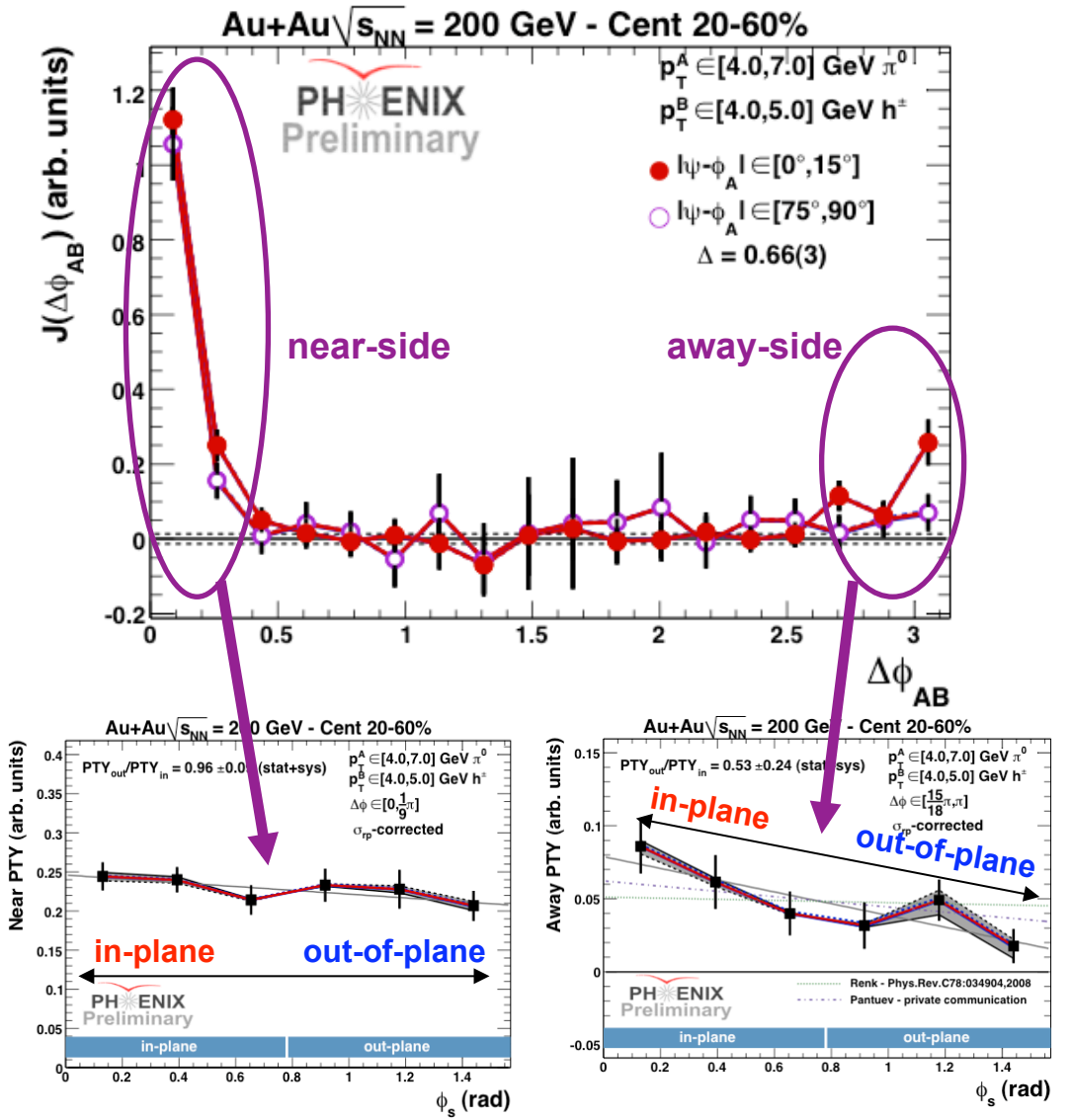


RP dependent correlations

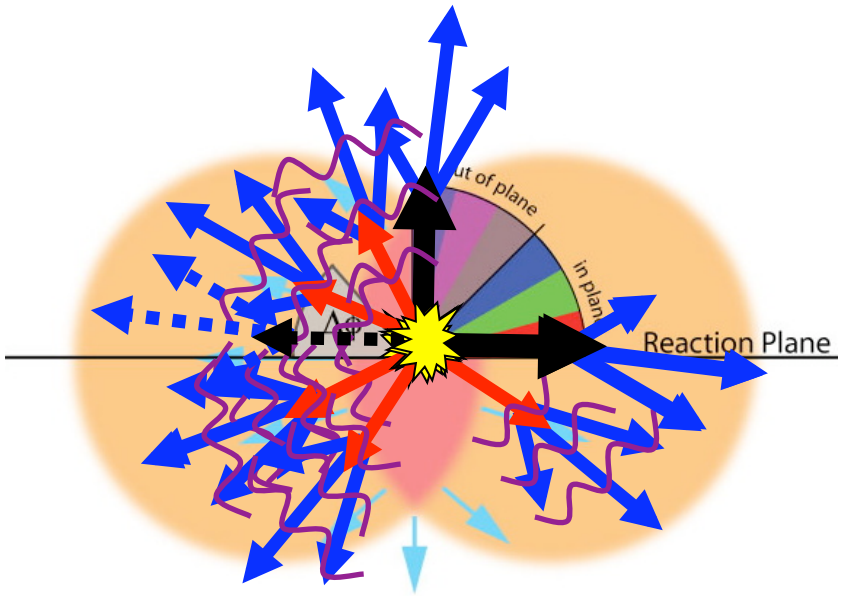
QM09, C. H. Chen



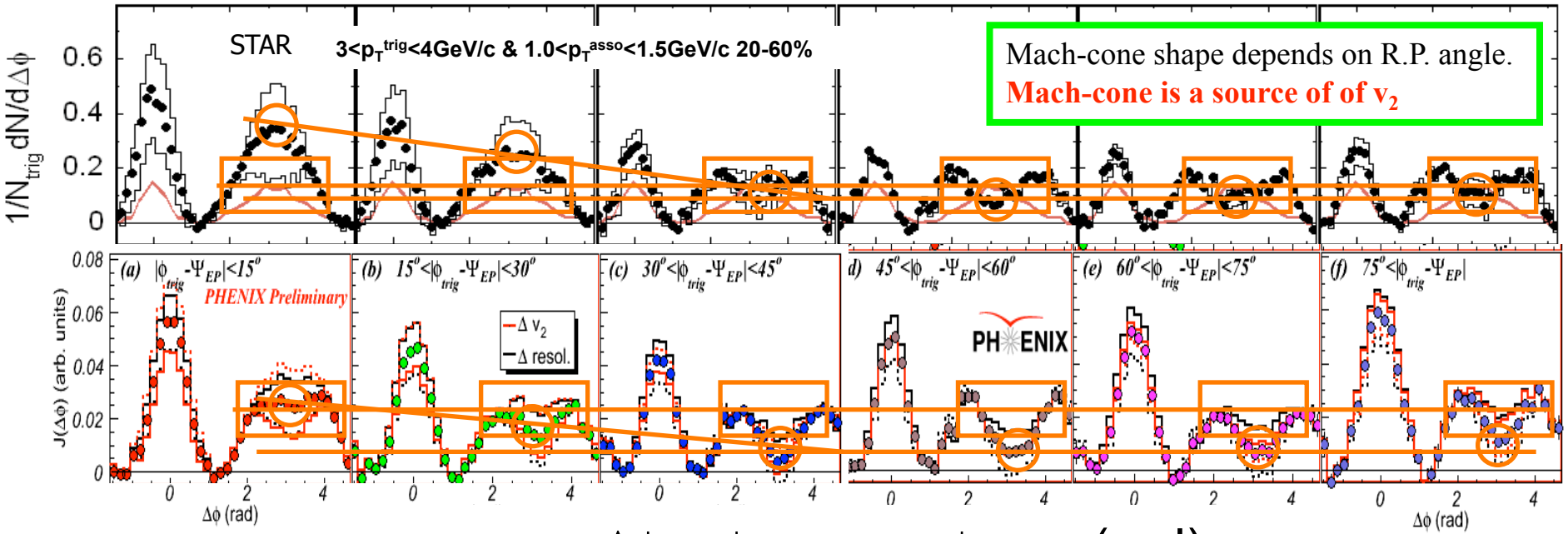




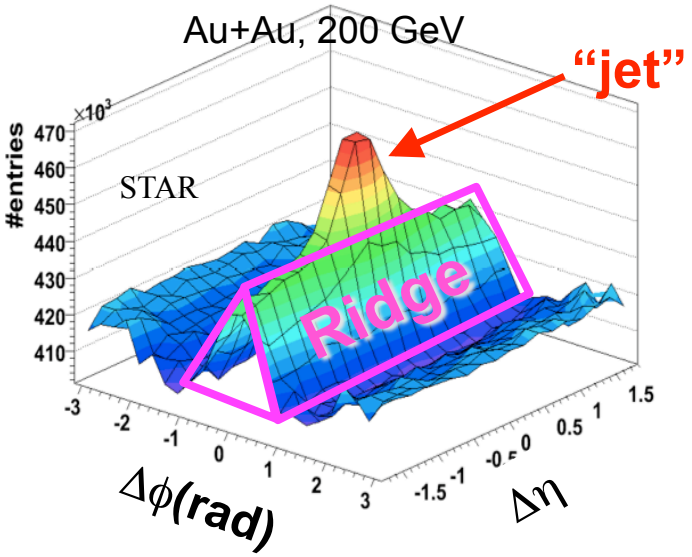
Jet modification and geometry (and v_2)

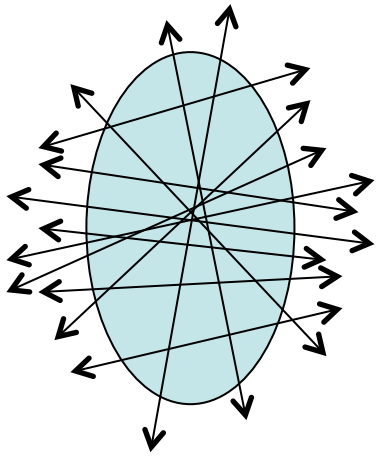


QM08: STAR, PHENIX

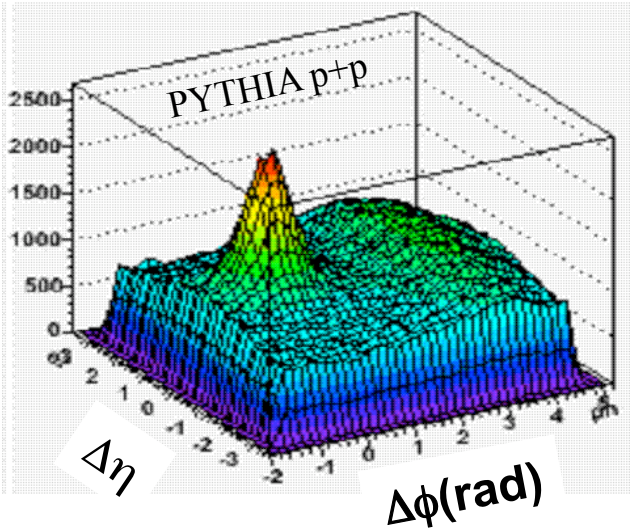


$\Delta\phi = \phi_{associate} - \phi_{trigger}$ (rad)

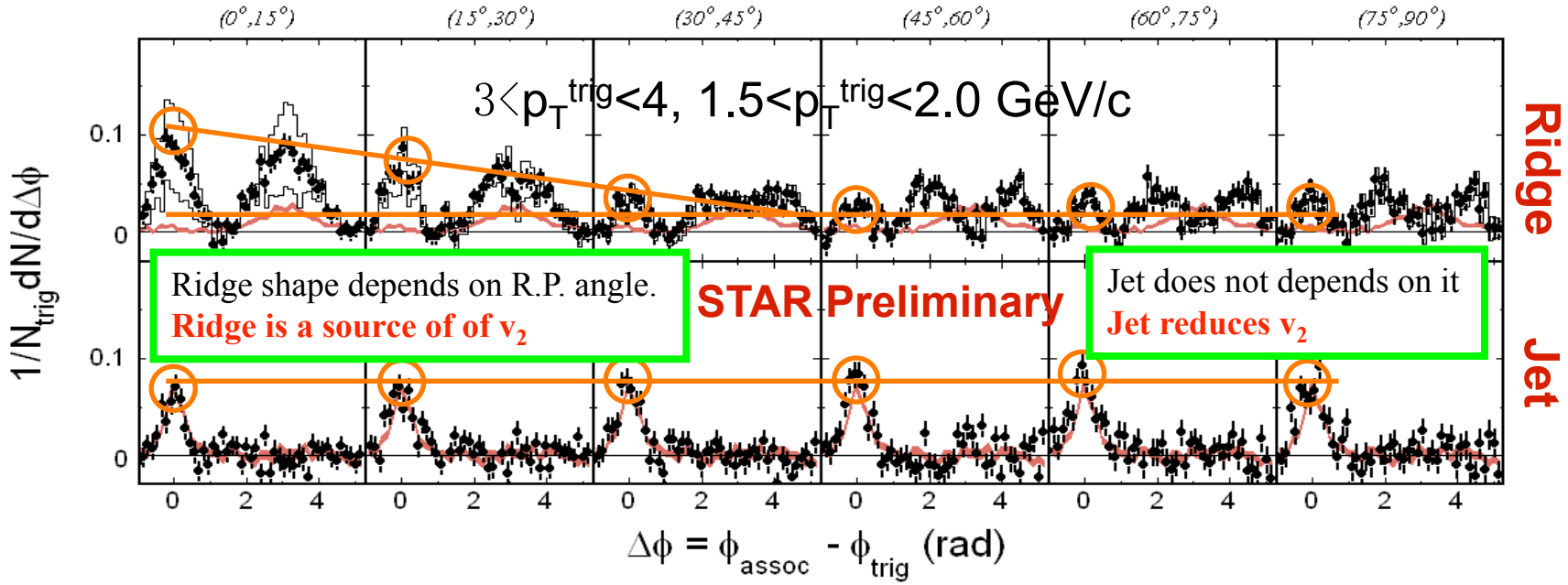


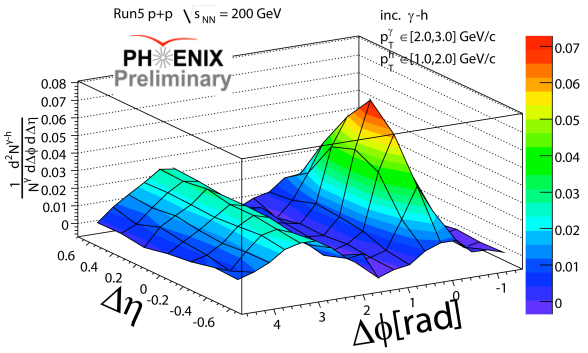


away side (in dϕ) of one di-jet can be near side (in dϕ) of another di-jet

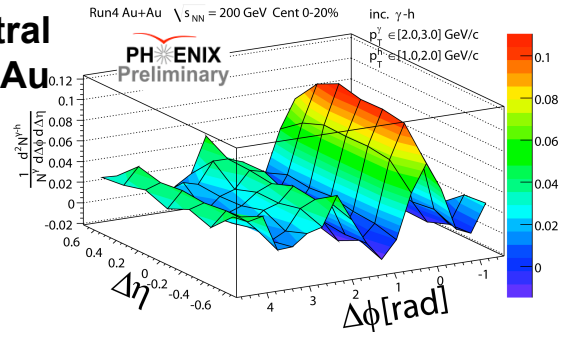


QM08 STAR



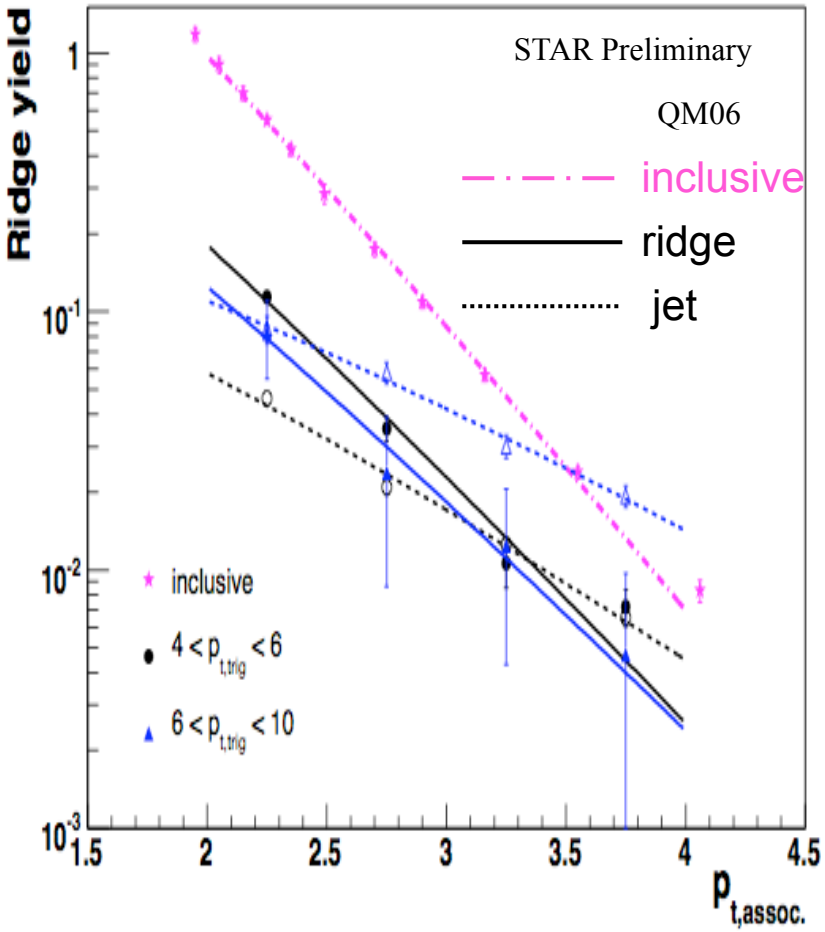


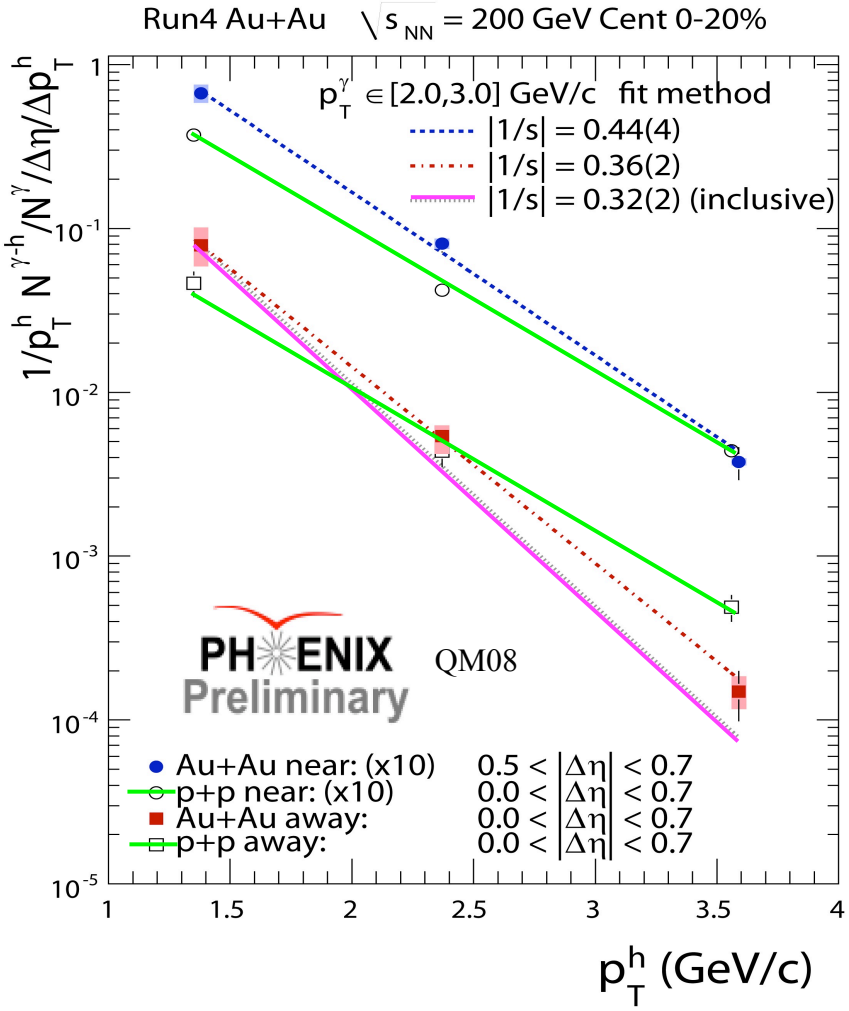
p+p and peripheral Au+Au



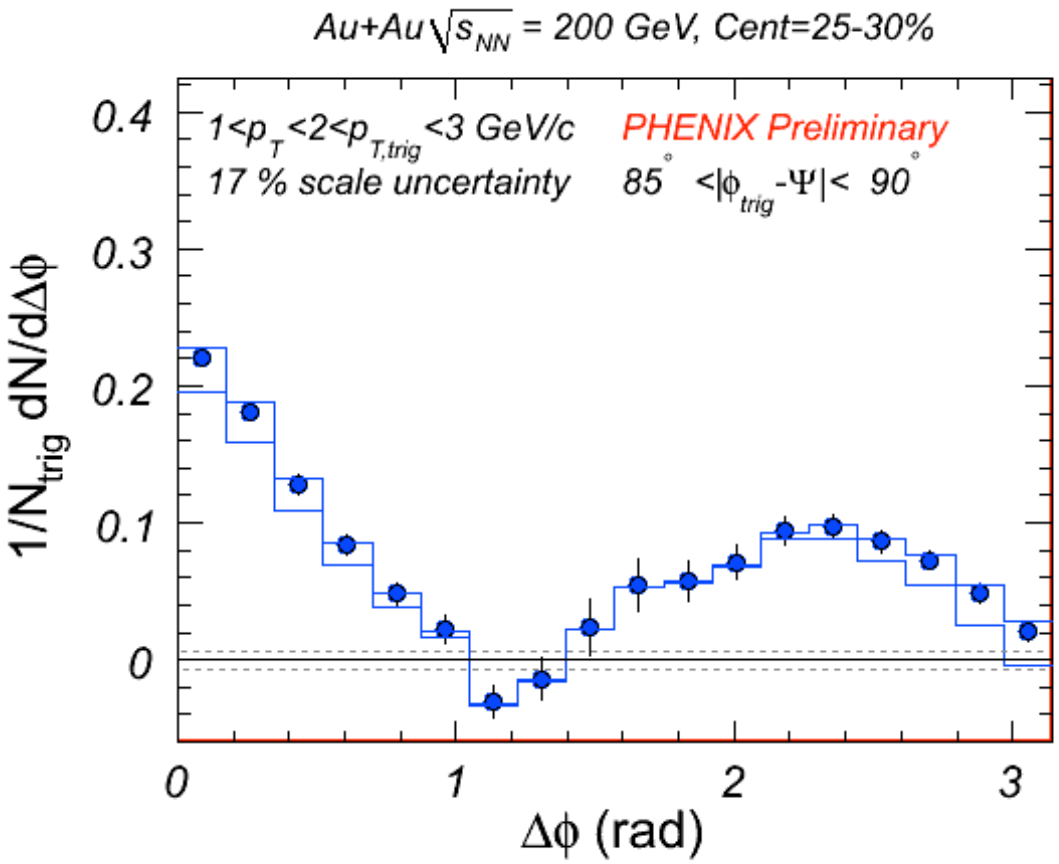
central Au+Au

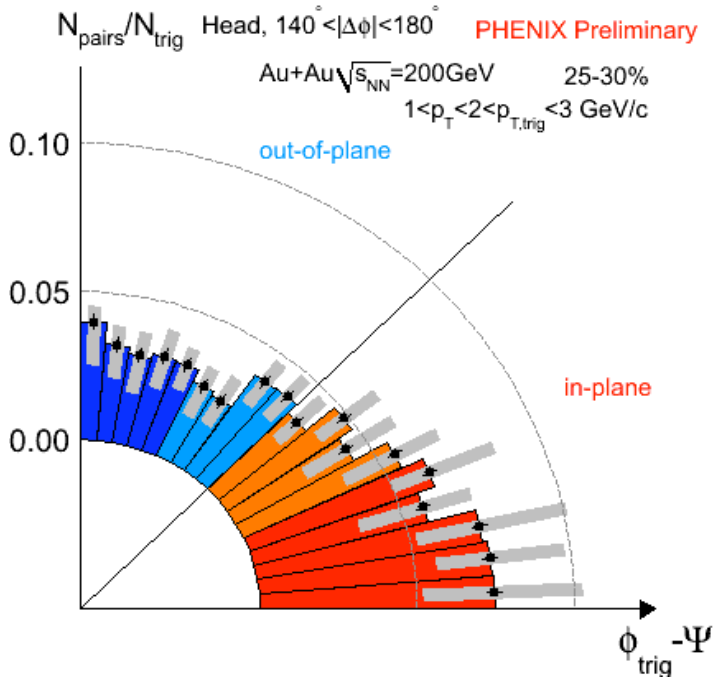
$$T_{Inclusive} \sim T_{Shoulder} \sim T_{Ridge} < T_{Jet}$$
$$(<) \qquad (<)$$

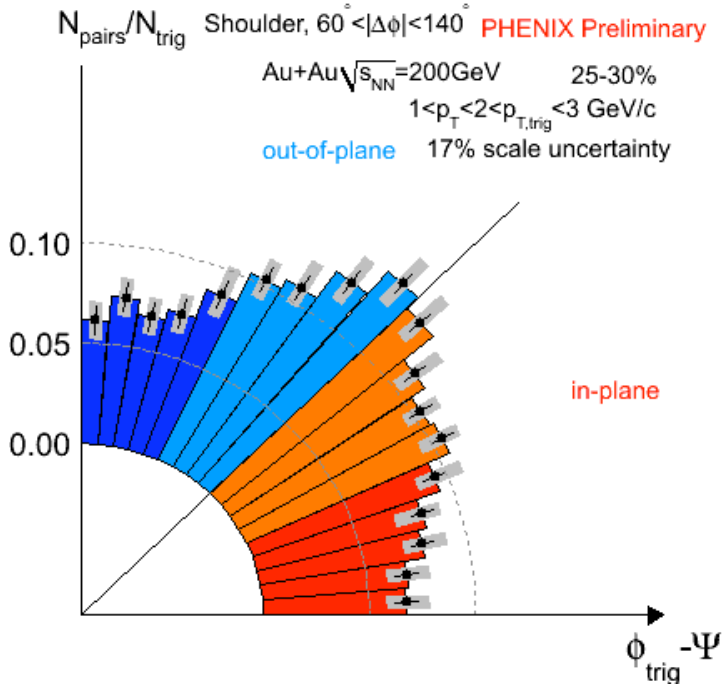




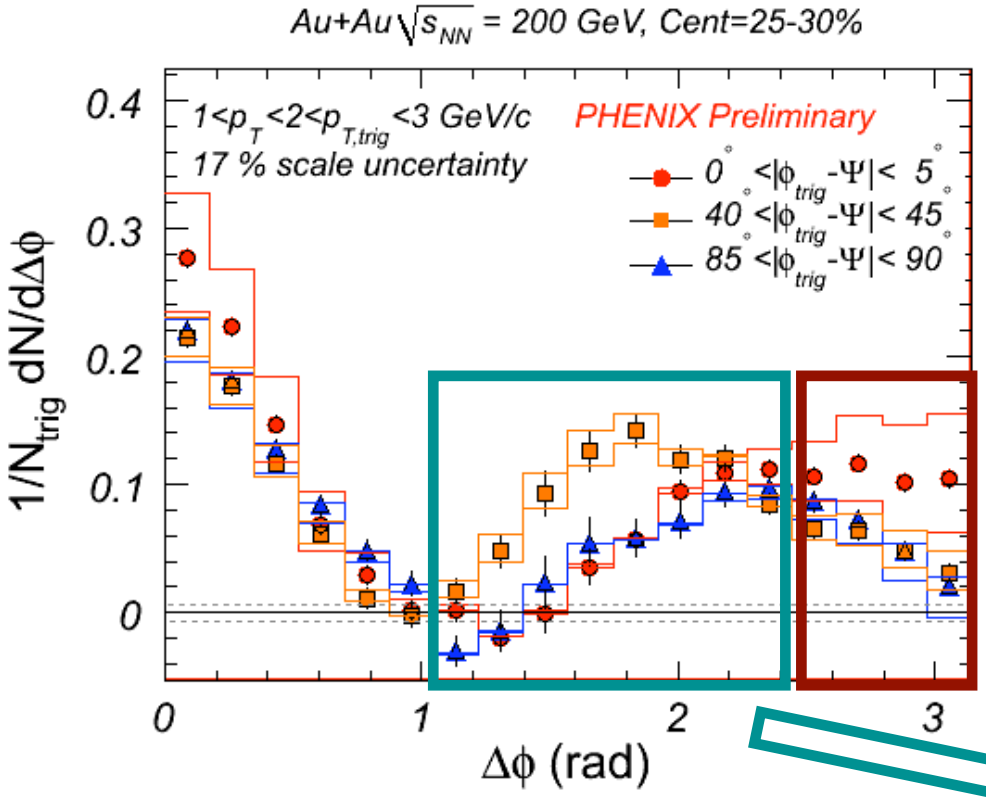
Relatively lower p_T region (1~4GeV/c)

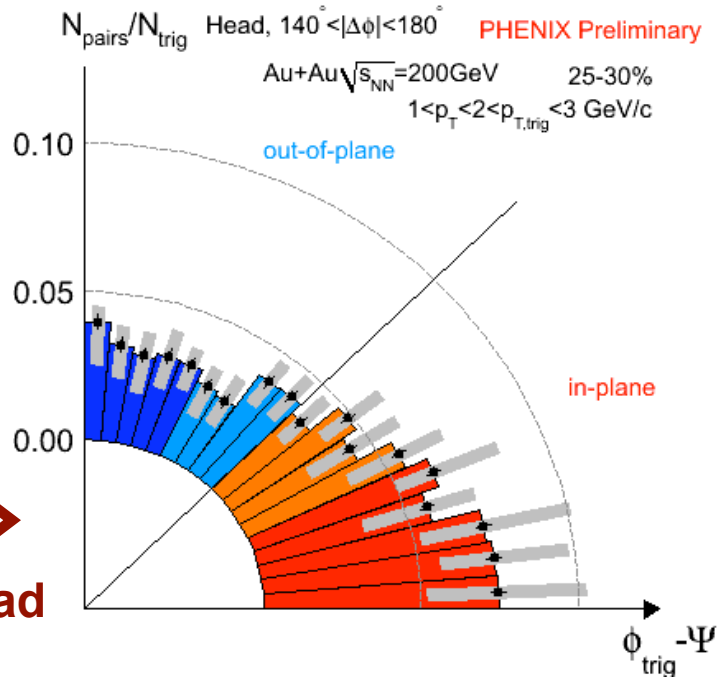






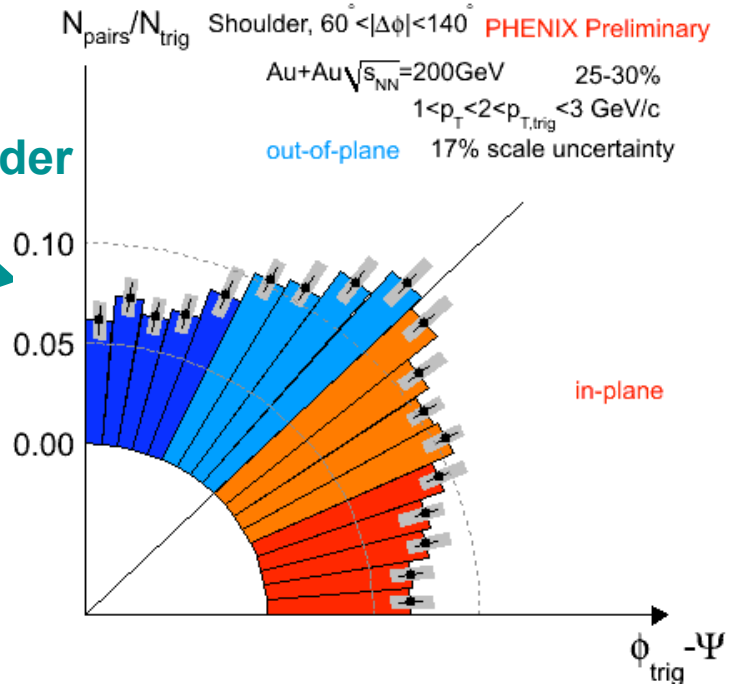
QM09, W. G. Holzmann





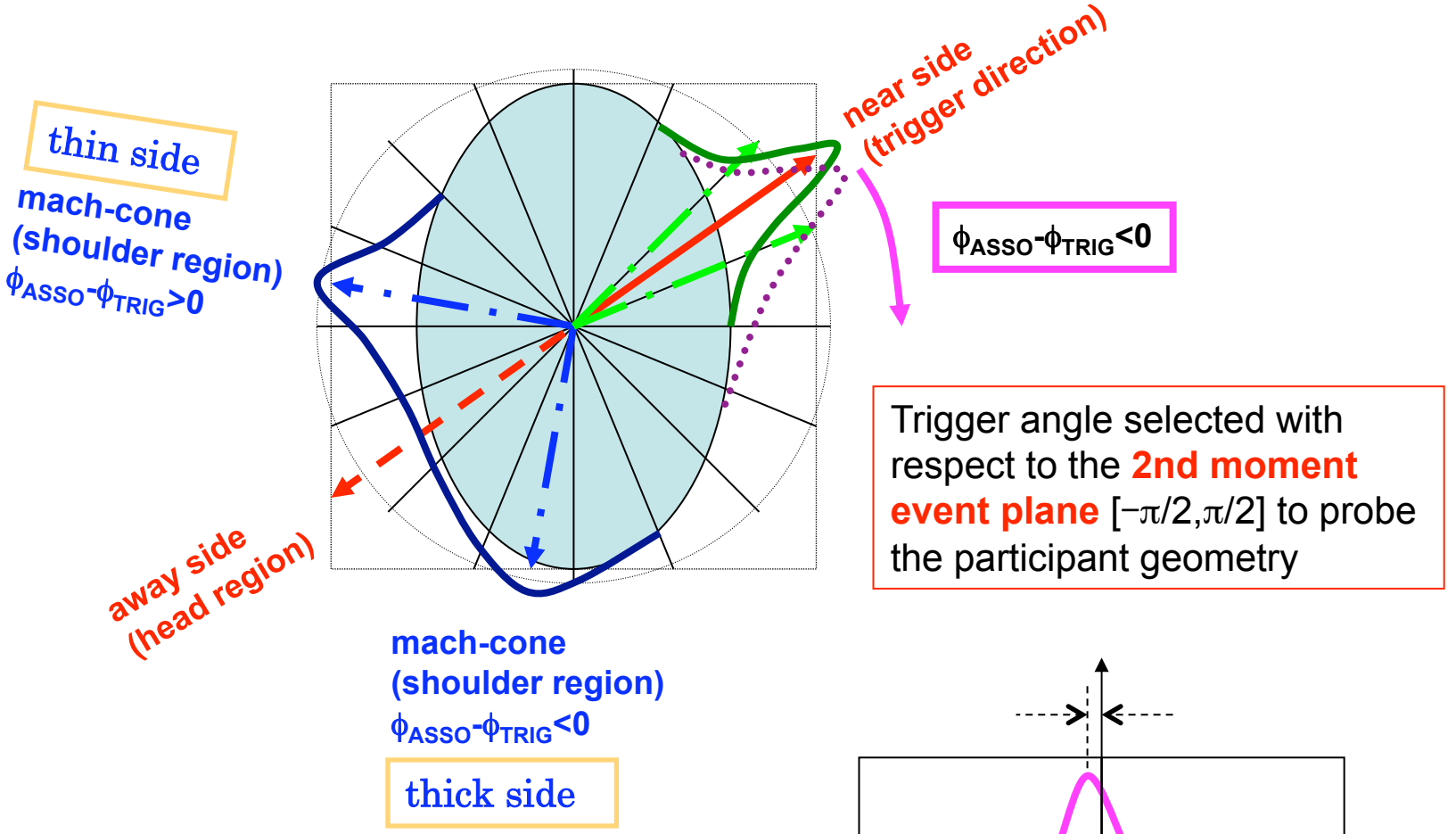
Head

Shoulder

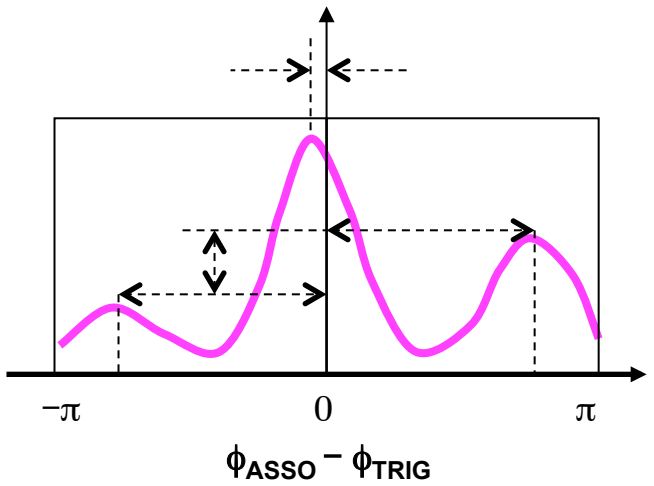


head: yield confirms simple picture of energy loss vs. path length; in- and out-of-plane show similar away-side width

shoulder: geometry effects harder to disentangle

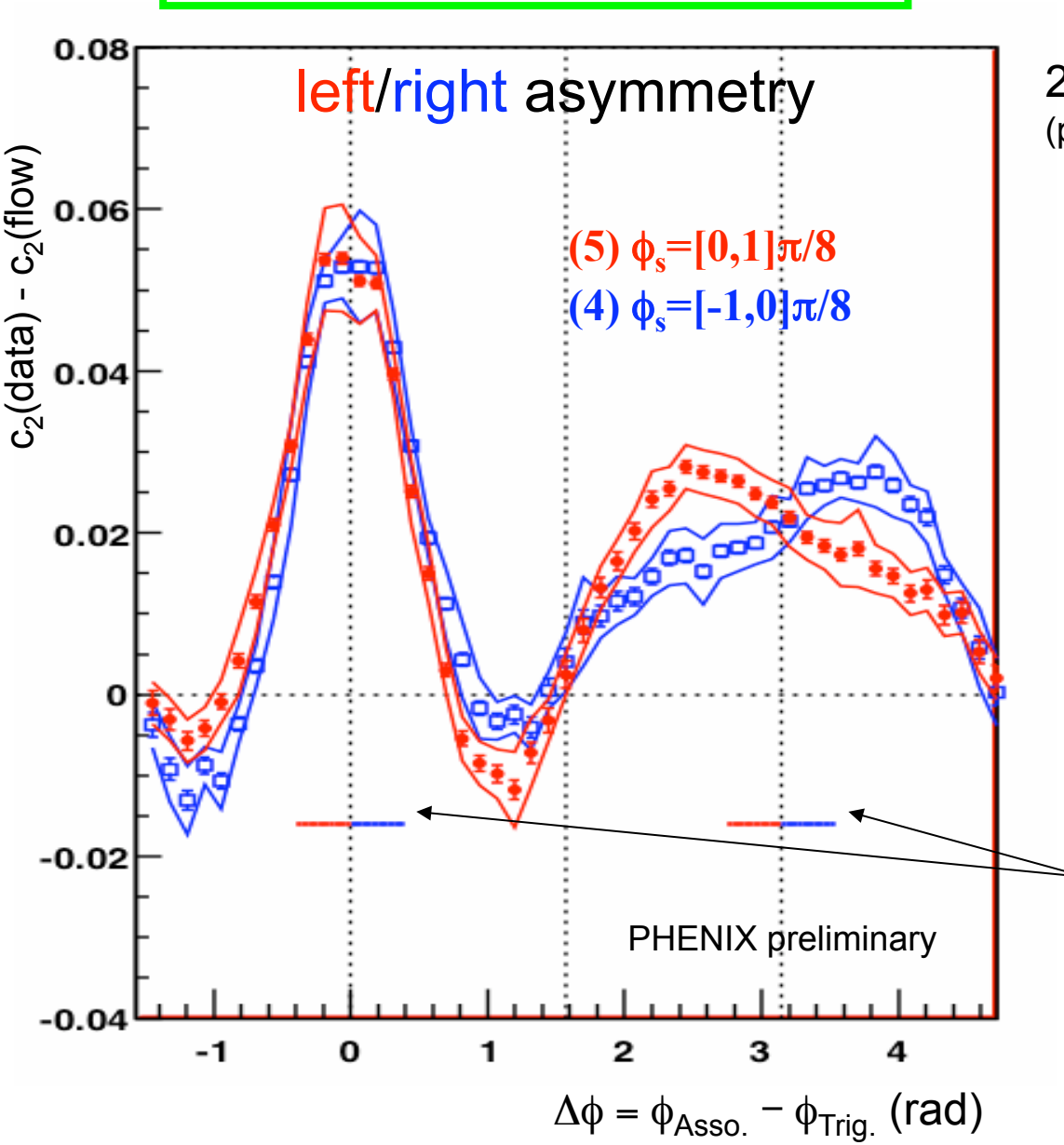


Trigger angle selected with respect to the **2nd moment event plane** $[-\pi/2,\pi/2]$ to probe the participant geometry

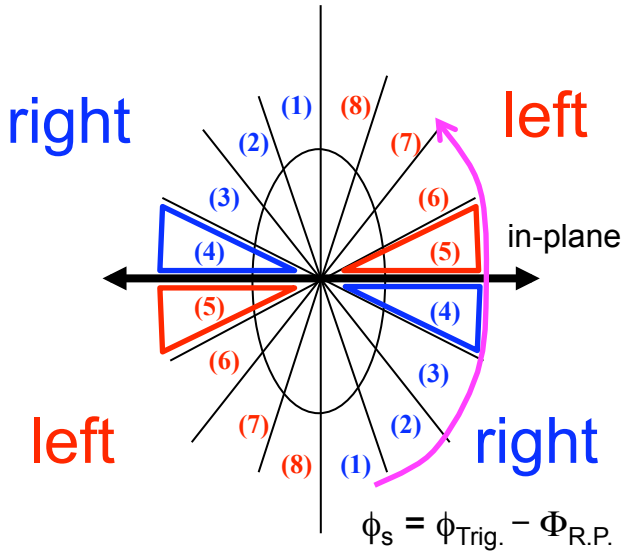


If trigger angle is fixed around $+/-(\pi/4)$, the associate particles emitted left or right w.r.t. trigger direction would feel the different thickness of the almond. It is because the almond shaped medium is asymmetric w.r.t. jet axis.

Angle (4)/(5) (mid-central)

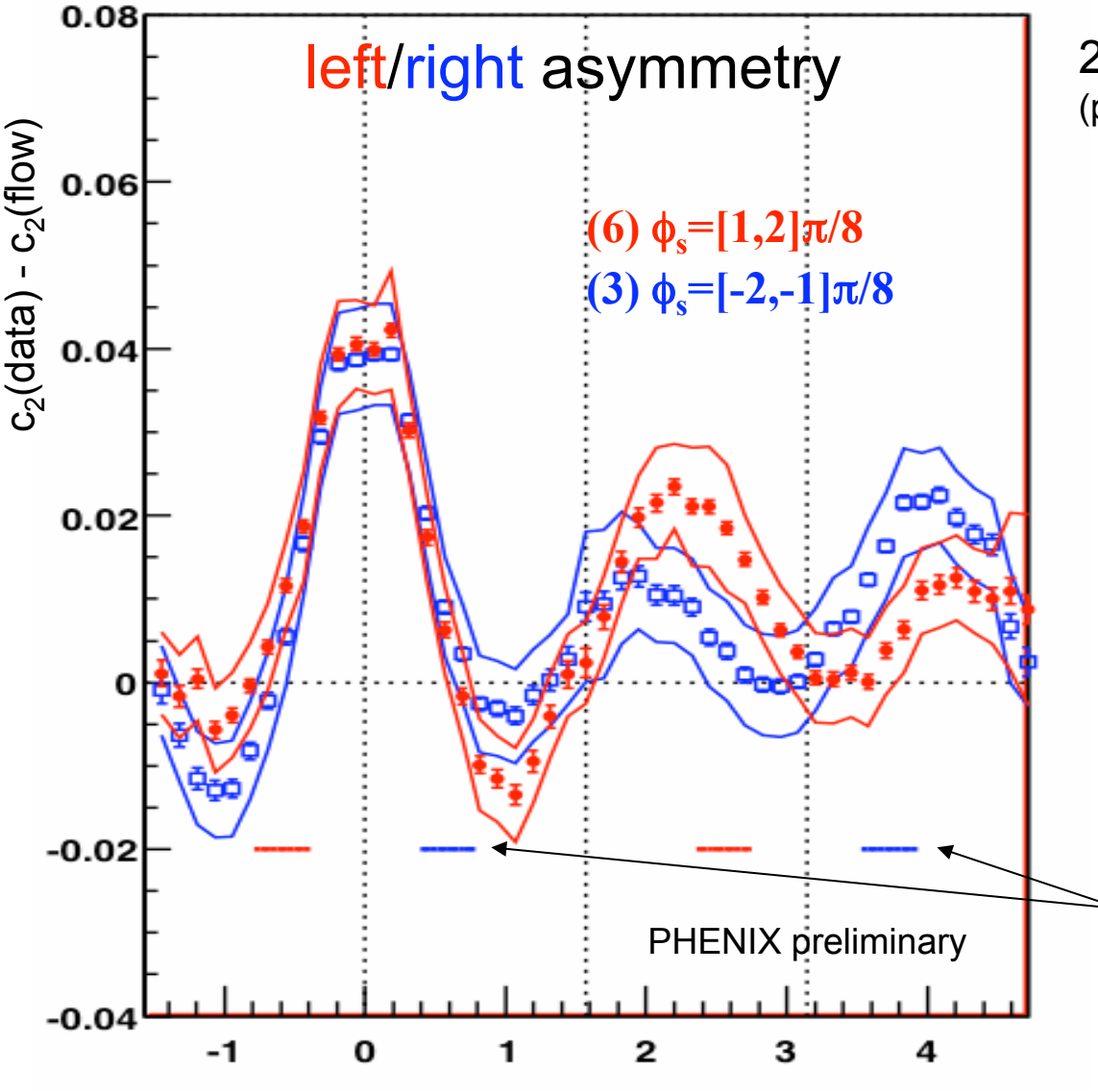


200GeV Au+Au -> h-h (run7)
(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)
mid-central : 20-50%

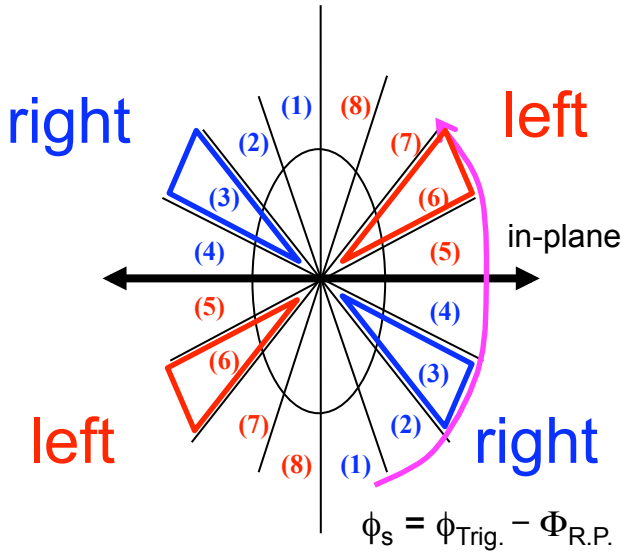


in-plane associate regions

Angle (3)/(6) (mid-central)

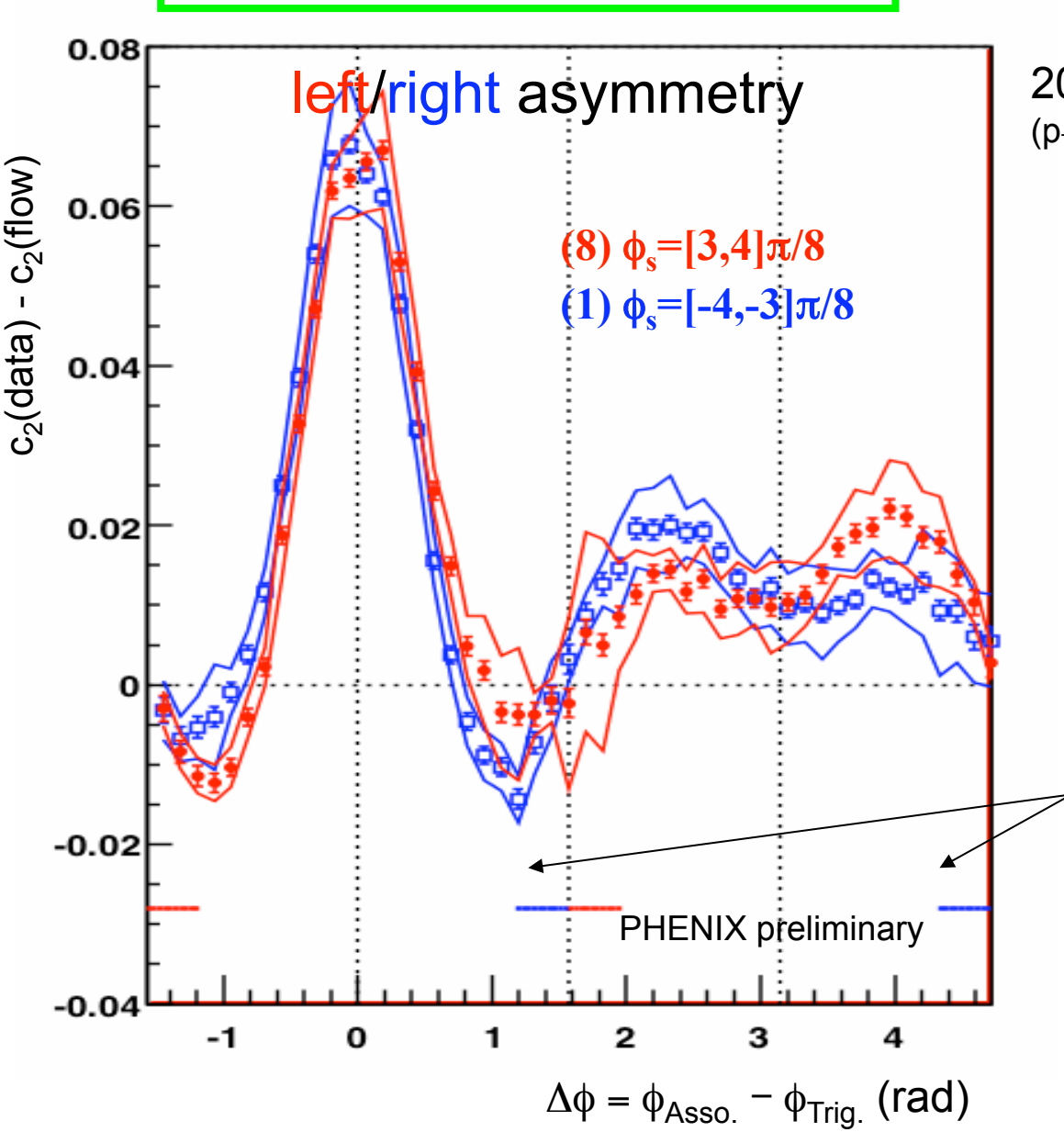


200GeV Au+Au -> h-h (run7)
(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)
mid-central : 20-50%

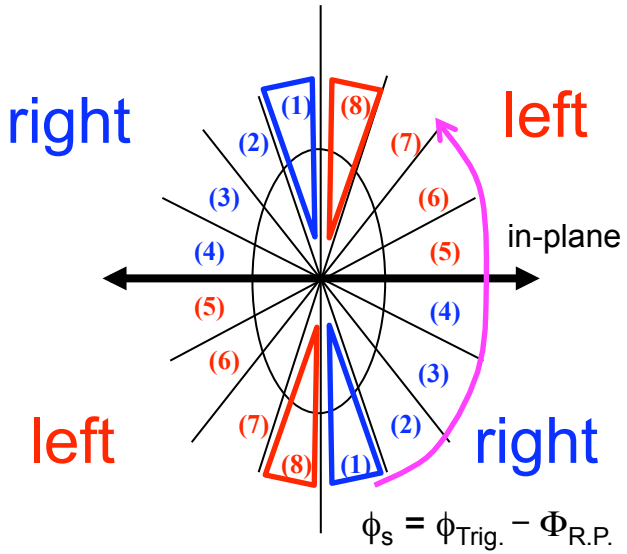


in-plane associate regions

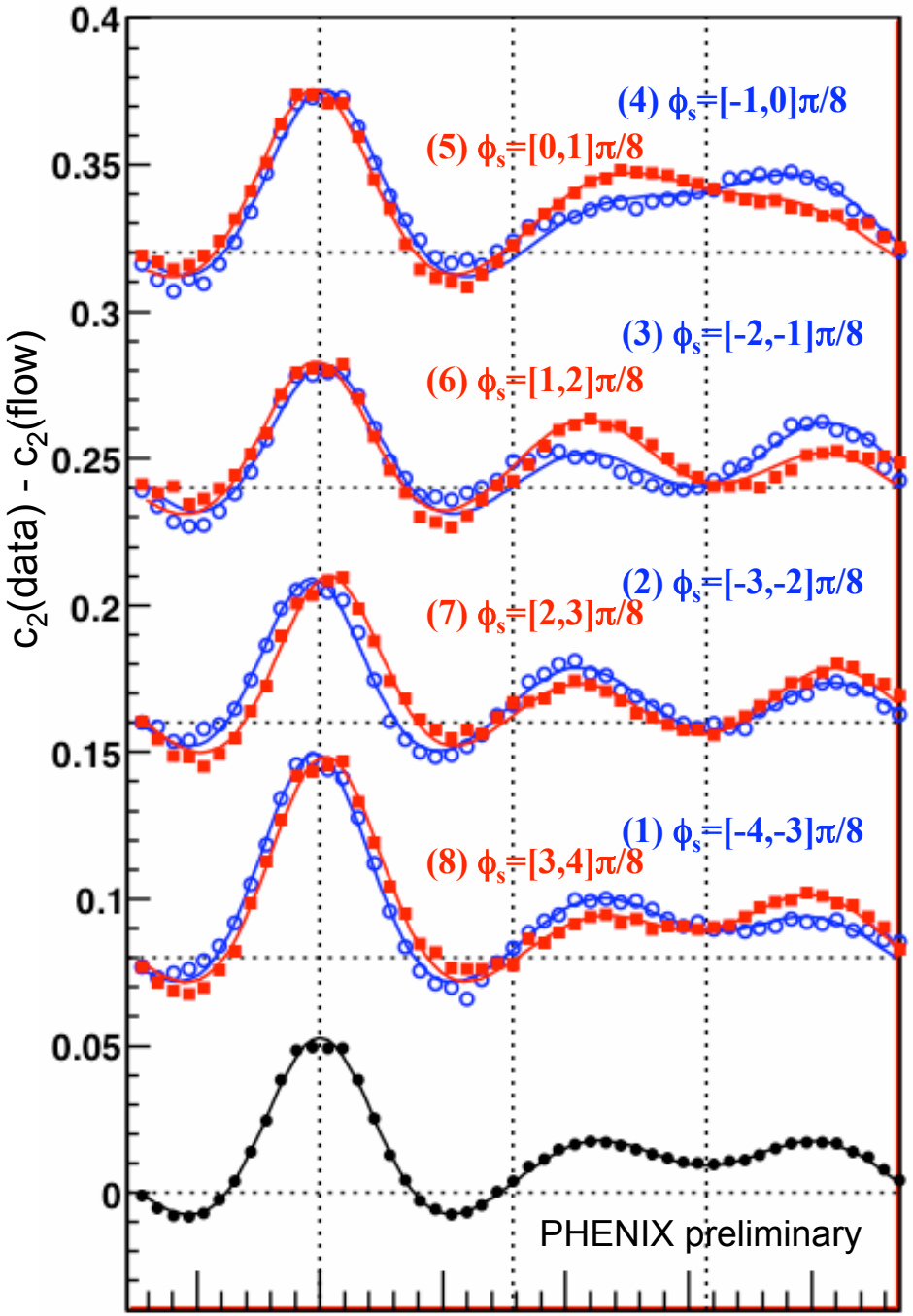
Angle (1)/(8) (mid-central)



200GeV Au+Au -> h-h (run7)
(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)
mid-central : 20-50%



in-plane associate regions



in-plane trigger selection

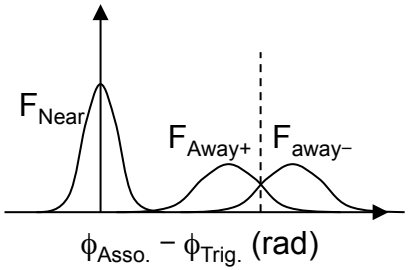
out-of-plane trigger selection

average

200GeV Au+Au -> h-h (run7)

(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)

mid-central : 20-50%



Fitting with 3 Gaussian functions

Gauss function : F(height, mean, width)

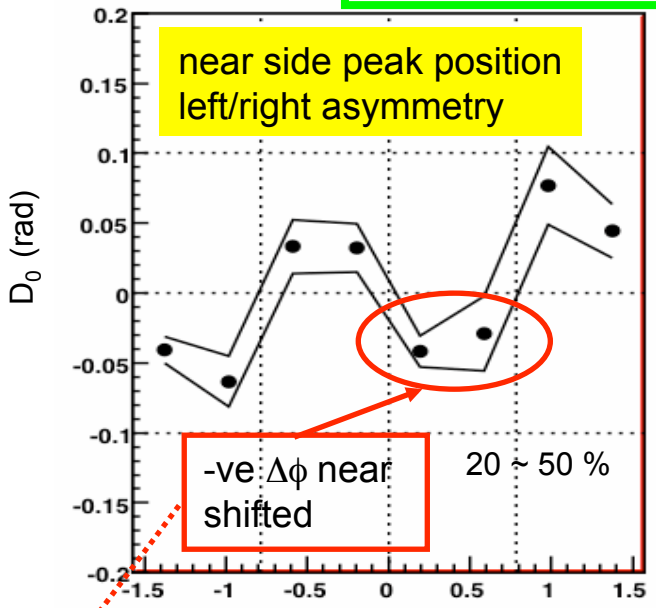
$F_{Near}(A_0, D_0, S_0) + F_{Away+}(A_+, D_+, S_+)$

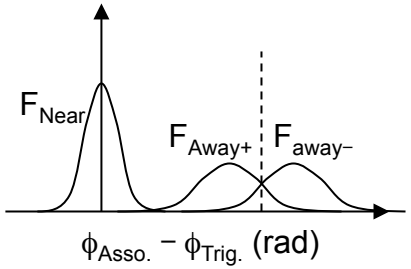
$+ F_{Away-}(A_-, D_-, S_-)$

$|\pi - D_+| = |D_- - \pi|$, $S_+ = S_-$

Fitted data with 3 Gauss func.

Results on fitting parameters



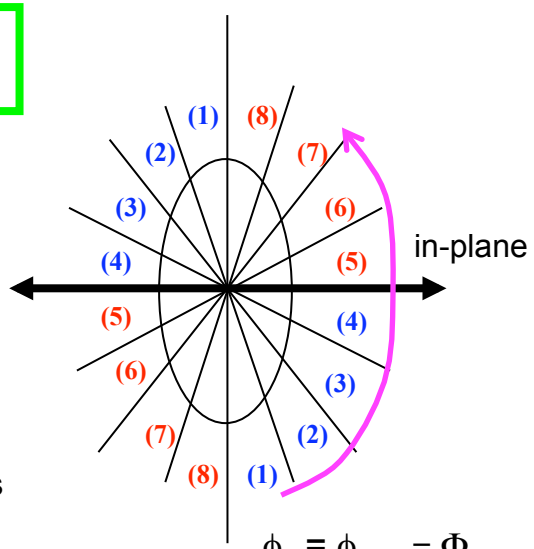


Fitting with 3 Gaussian functions

Gauss function : F(height, mean, width)

$F_{Near}(A_0, D_0, S_0) + F_{Away+}(A_+, D_+, S_+) + F_{Away-}(A_-, D_-, S_-)$

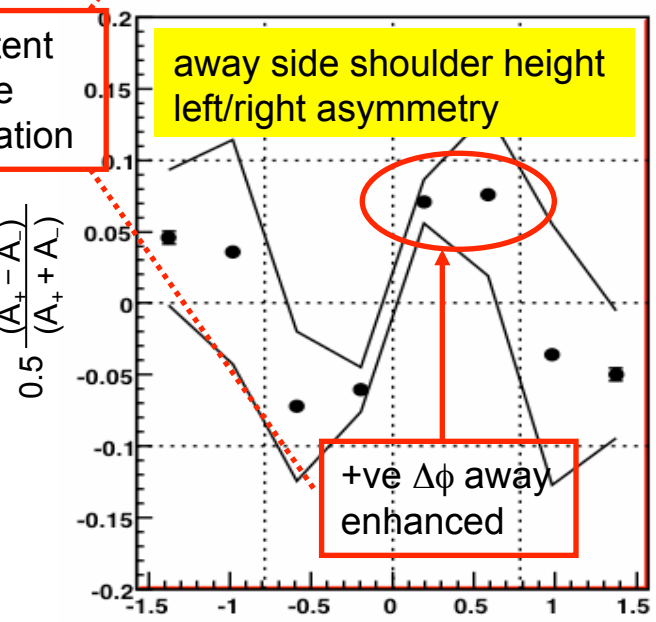
$|\pi - D_+| = |D_- - \pi|$, $S_+ = S_-$

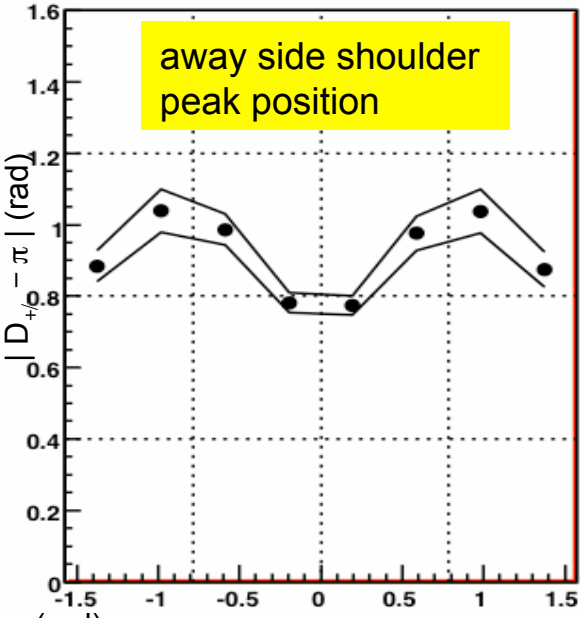


$\phi_s = \phi_{Trig.} - \Phi_{R.P.}$

$[-\pi/2, \pi/2]$

consistent with the speculation





$\phi_s = \phi_{Trig.} - \Phi_{R.P.}$ (rad)

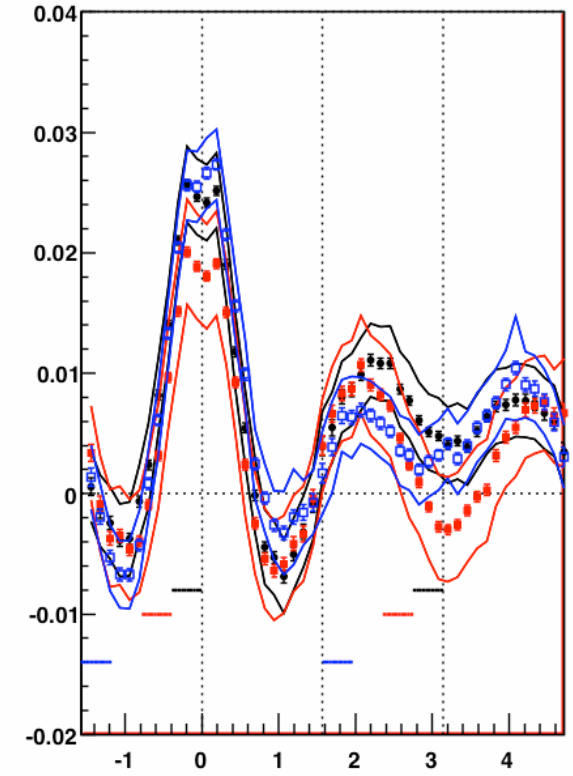
200GeV Au+Au (run7)
hadron-hadron
(p_T^{Trig}=2~4GeV/c,
p_T^{Asso}=1~2GeV/c)

PHENIX
preliminary

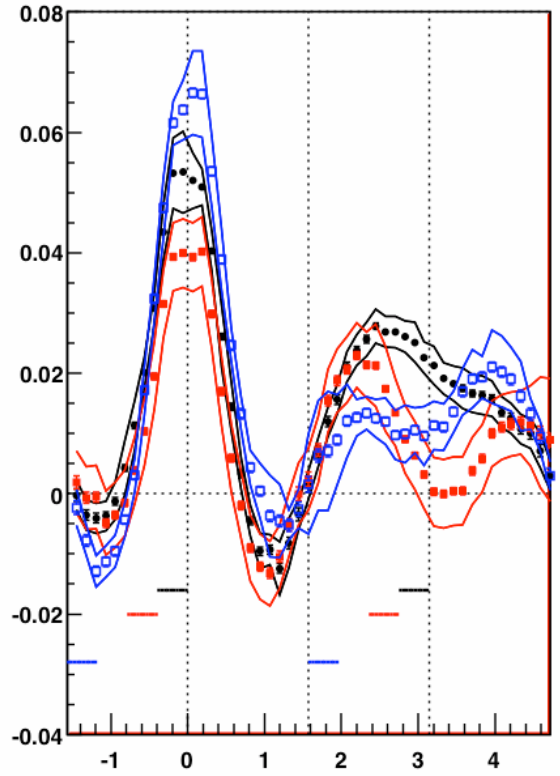
Summary Data for Left/right asymmetry

200GeV Au+Au -> h-h (run7)
(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)

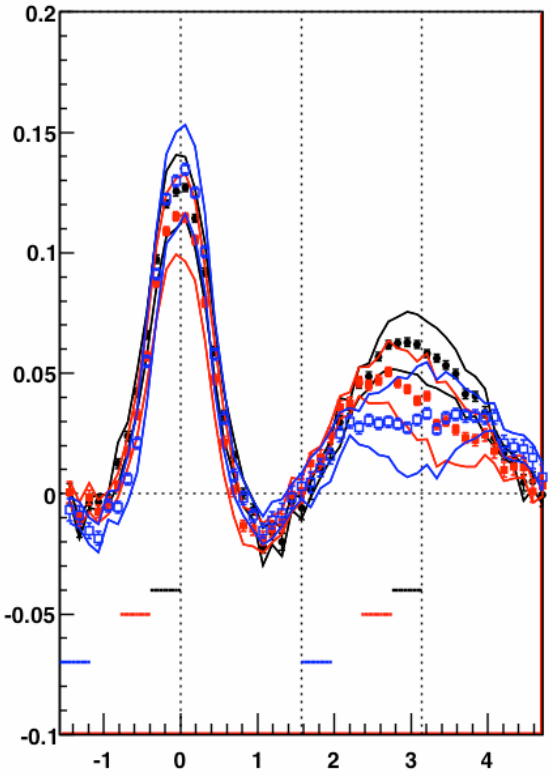
central : 0-20%



mid-central : 20-50%



peripheral : 50-93%



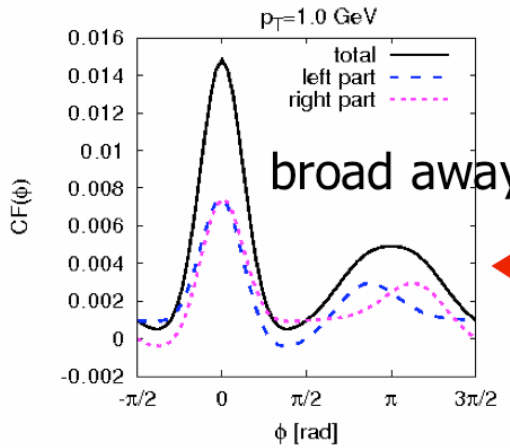
c_2(data) - c_2(flow)

- in-plane (5) : ϕ_s=[0,1]π/8
- middle (6) : ϕ_s=[1,2]π/8
- out-of-plane (8) : ϕ_s=[3,4]π/8

PHENIX preliminary

$\Delta\phi = \phi_{Asso.} - \phi_{Trig.}$ (rad)

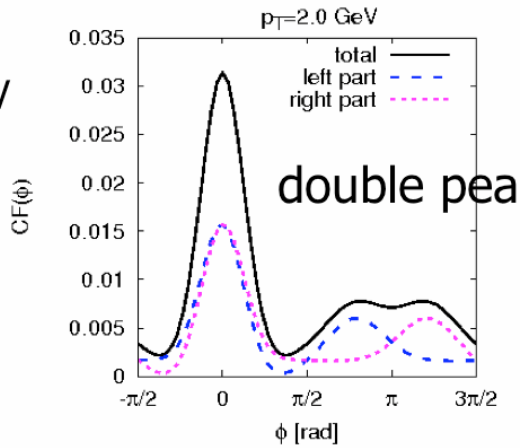
QM09, B. Betz



E_{tot} = 5 GeV

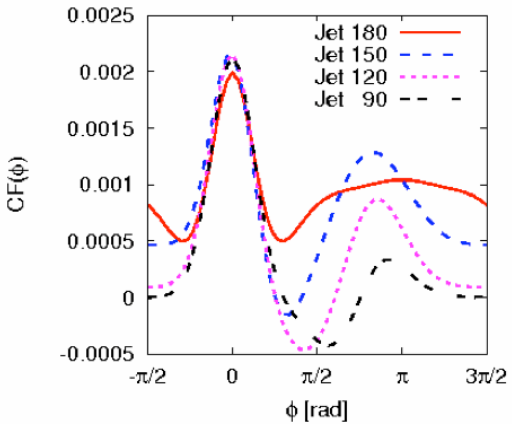
p_T^{trig} = 3.5 GeV

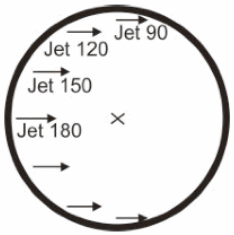
broad away-side peak

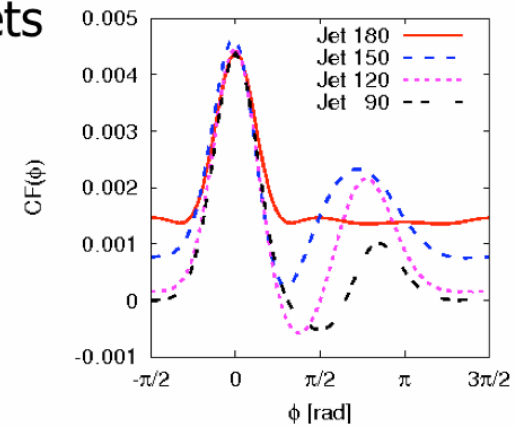


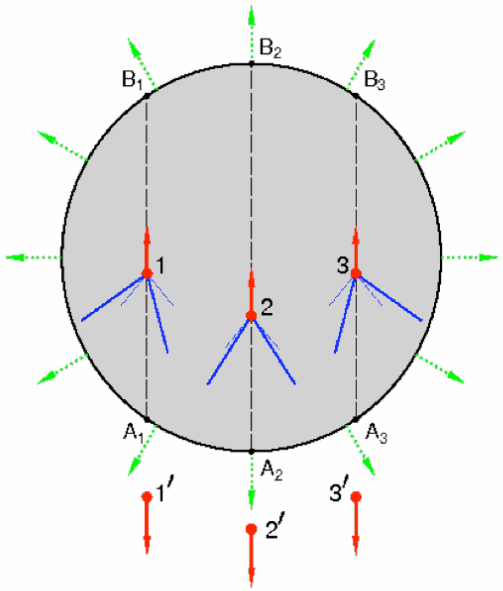
double peaked structure

due to non-central jets



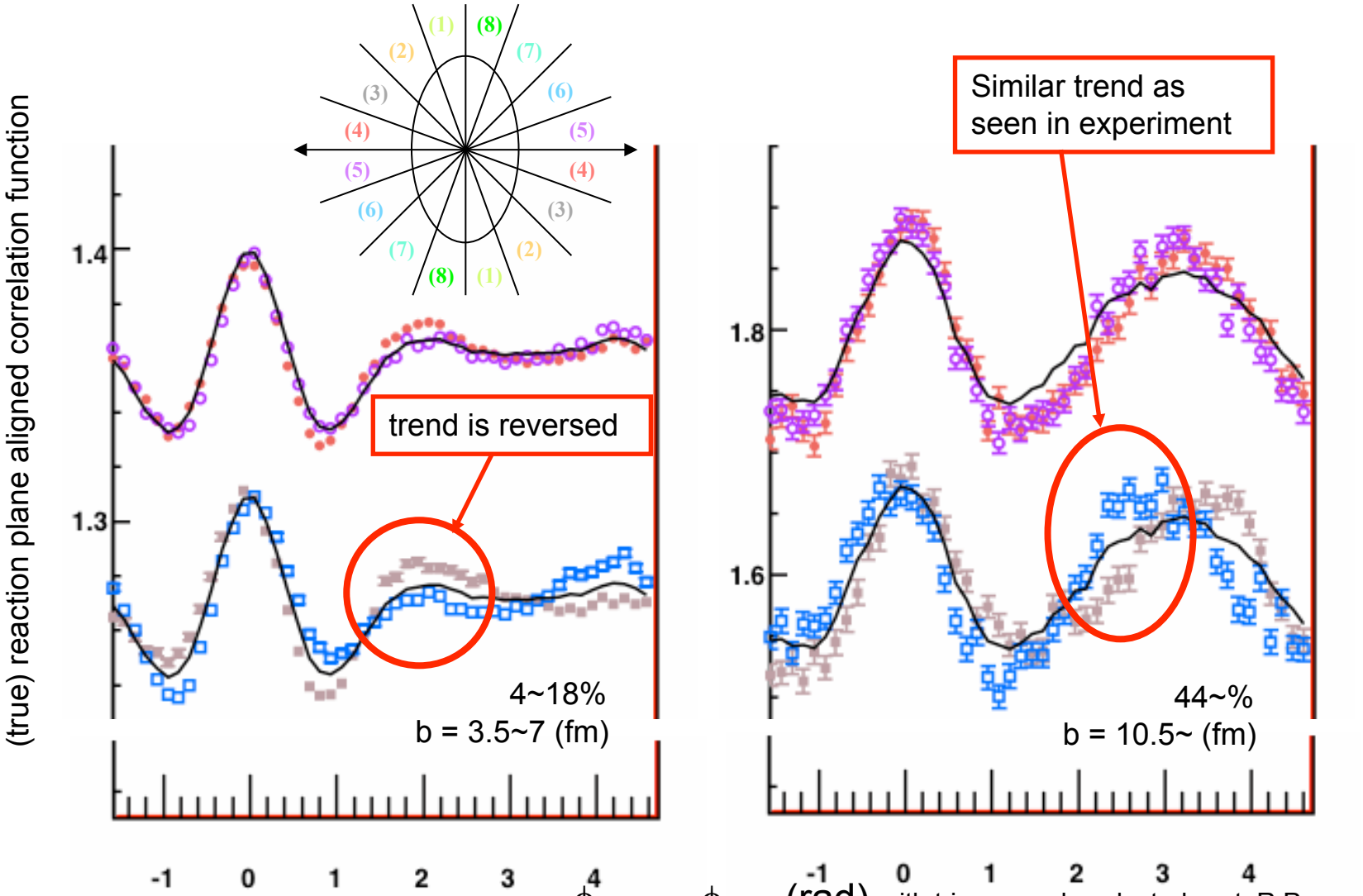






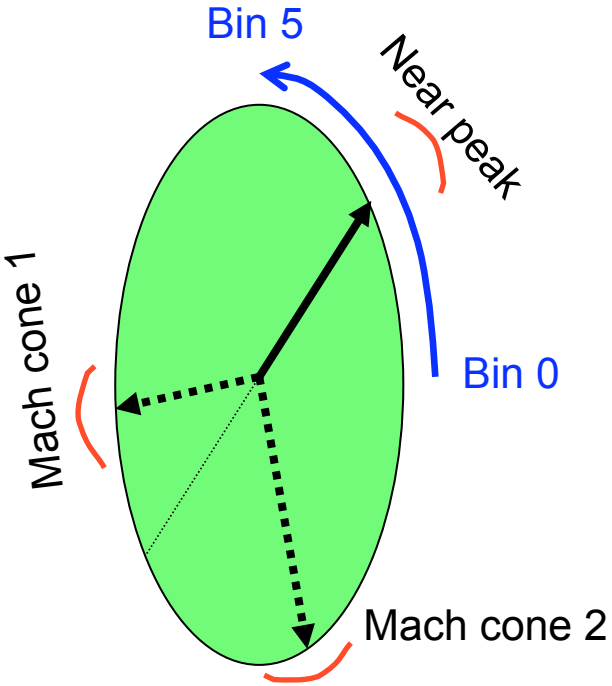
Satarov et al, PLB 627:64 (2005)

AMPT (v1.11, parton cascade with string melting v2.11) Au+Au at sqrt(s_{NN})=200GeV



perfect R.P. resolution
no v_2 subtraction needed

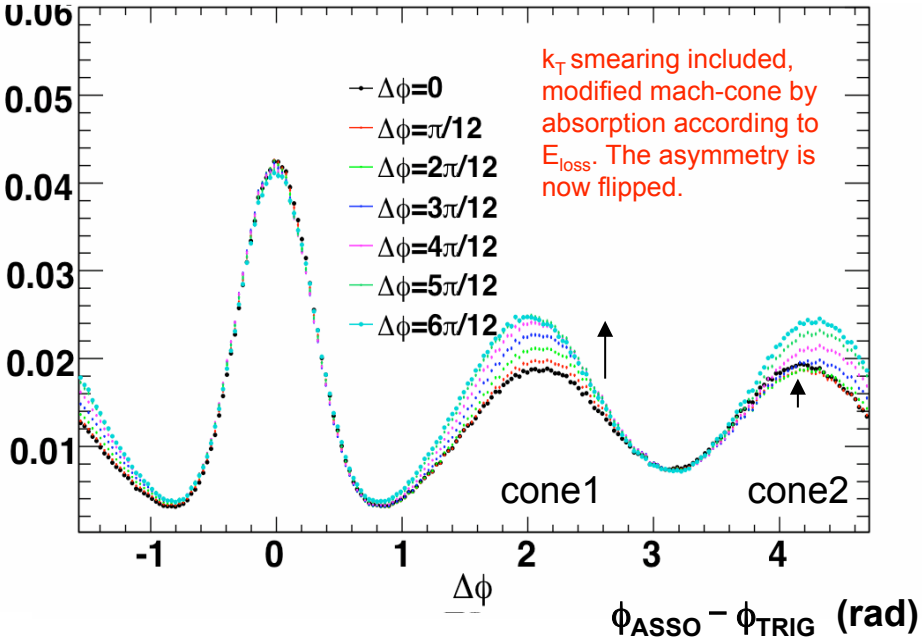
with trigger angle selected w.r.t. R.P.

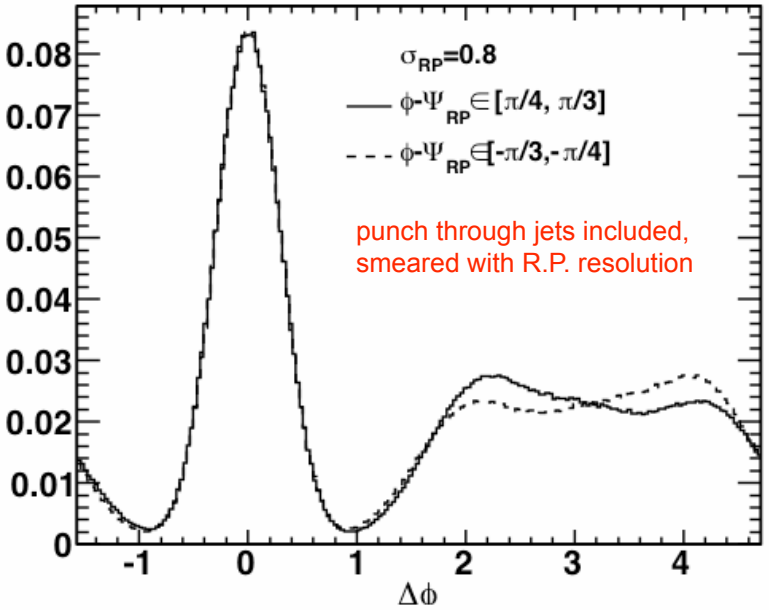


J.Jia, R.Wei, S.E, arXiv:0903.3263

If the multiplicities reduces with the path length because of absorption...

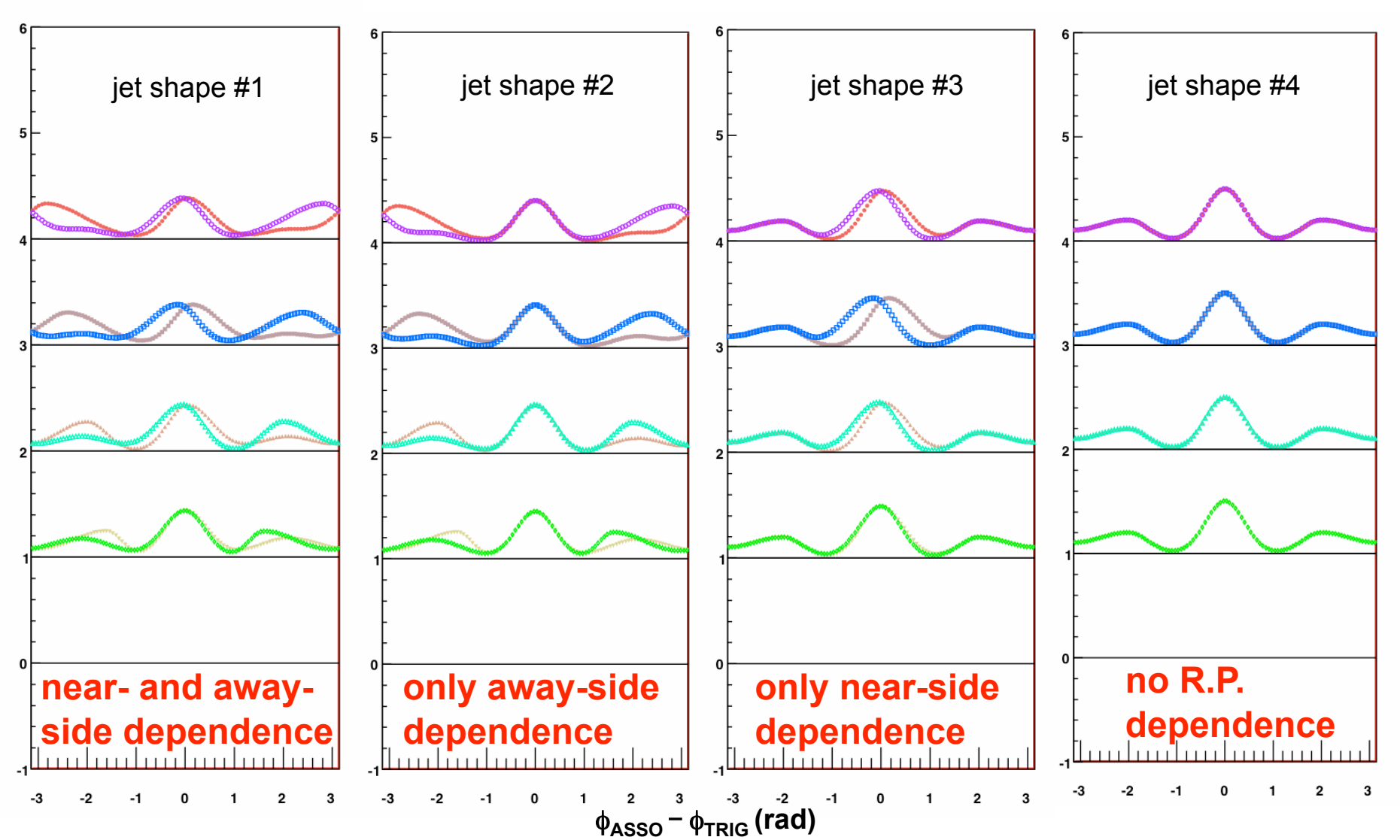
Note: original jets are generated according to N_{coll} profile





Simulation

4 different jet shape assumptions for MC input

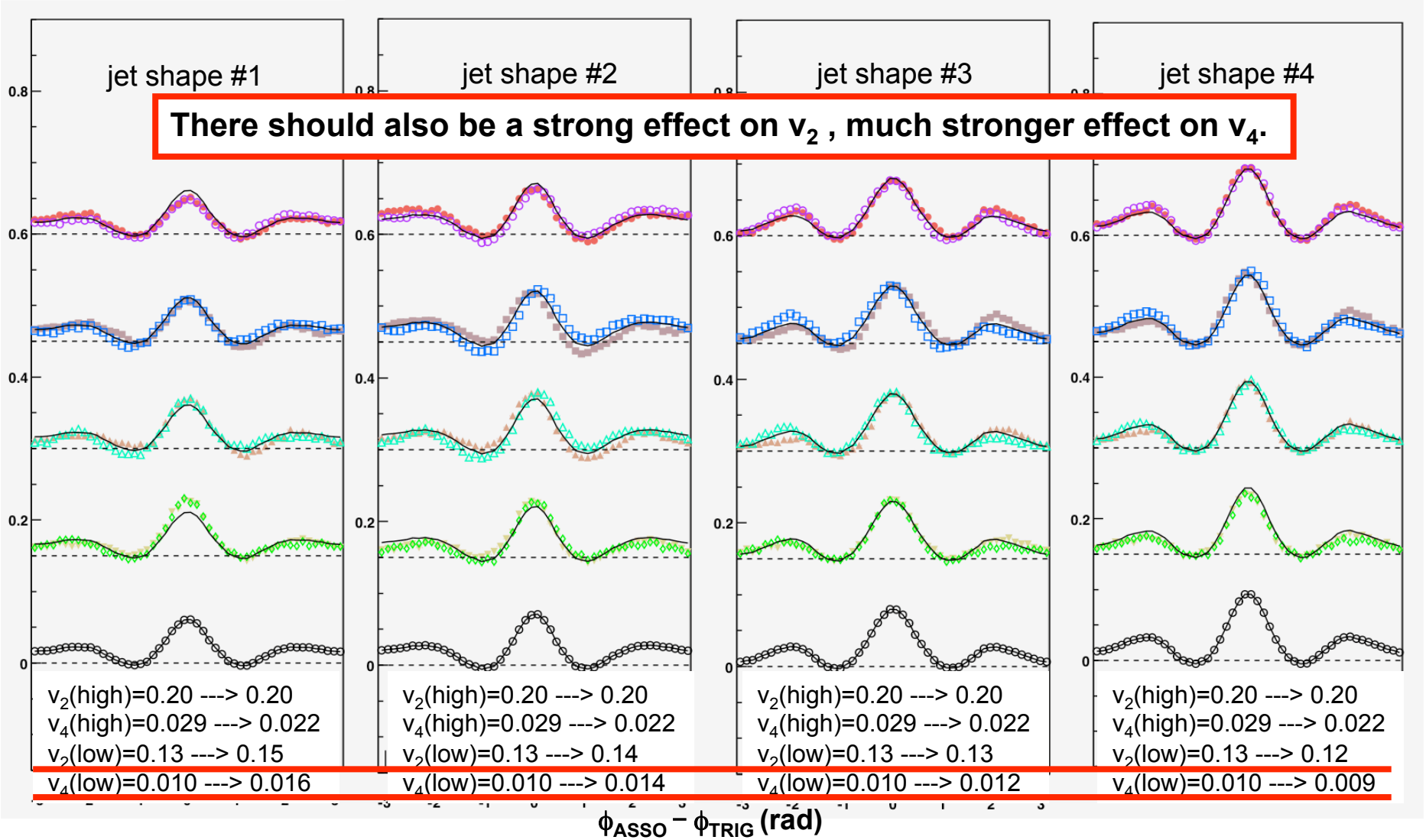


Simulation

n_{Trig} / eve (soft) = 3
n_{Asso} / eve (soft) = 8
n_{Jet} / eve (hard) = 1
n_{PTY} / jet (hard) = 1.25

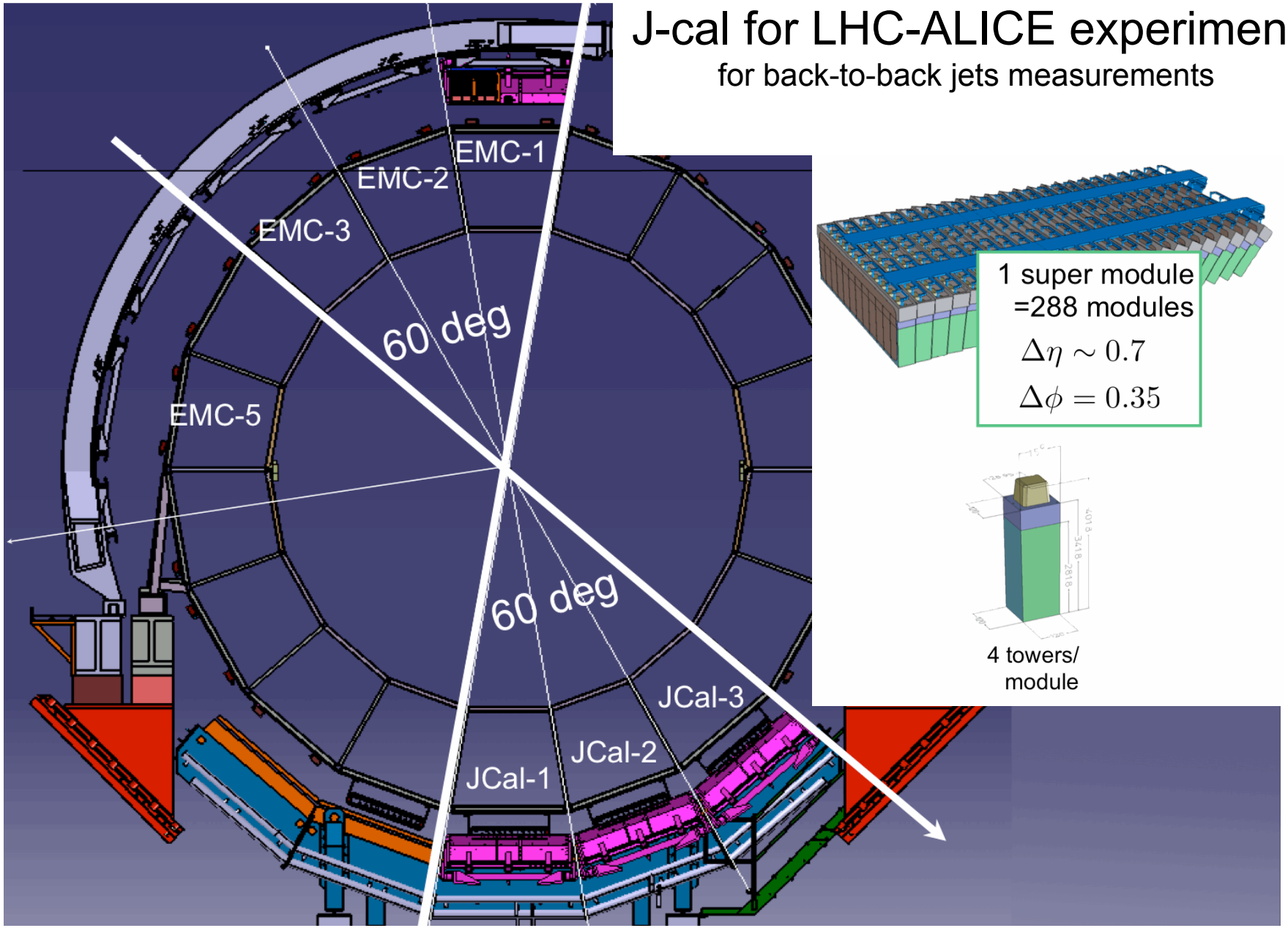
$v_{2,4}^{Trig}$ (soft) = 0.2, 0.029
$v_{2,4}^{Asso}$ (soft) = 0.13, 0.010
$v_{2,4}^{Jet}$ (hard) = 0.2, 0.0
$v_{2,4}^{PTY}$ (hard) = 0.15, 0.0

Comparison with data would tell us that there should be near- and away-side modification in experimental data.



J-cal for LHC-ALICE experiment

for back-to-back jets measurements

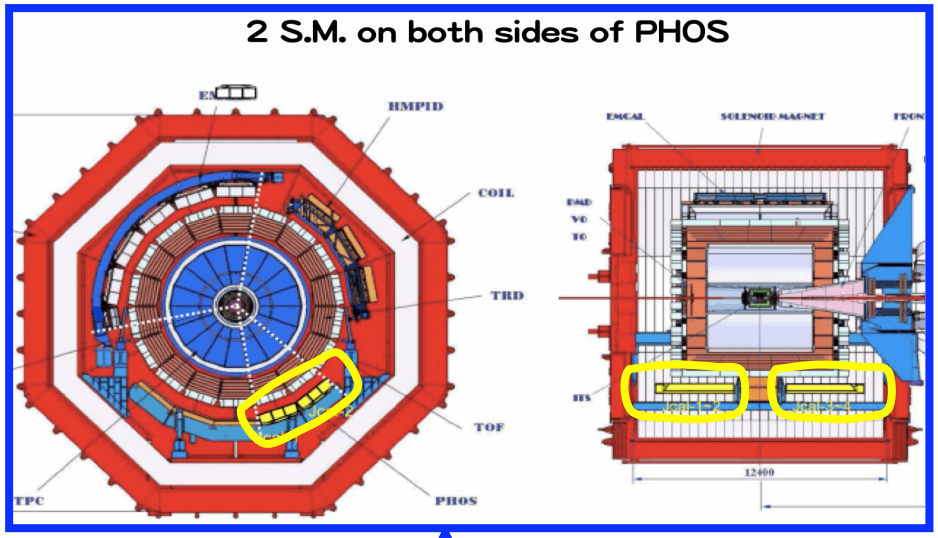


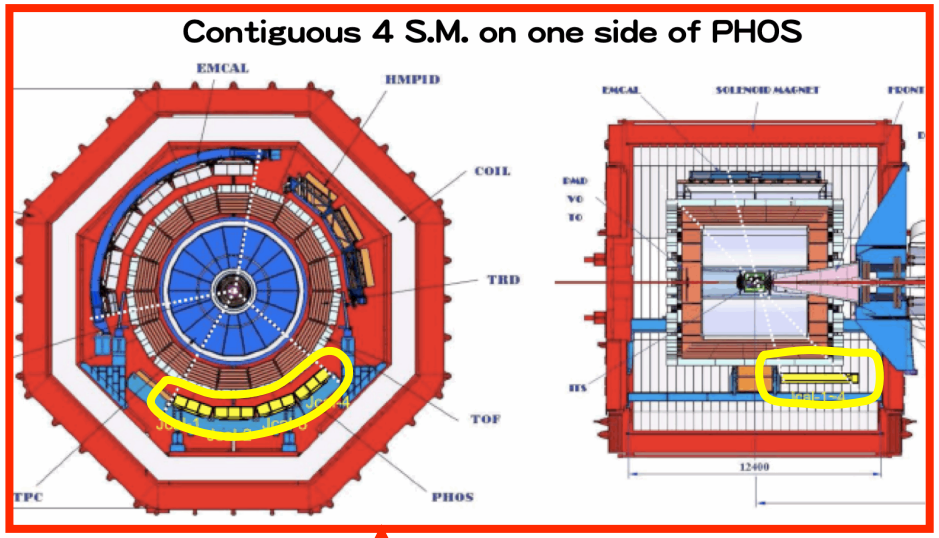
1 super module
=288 modules

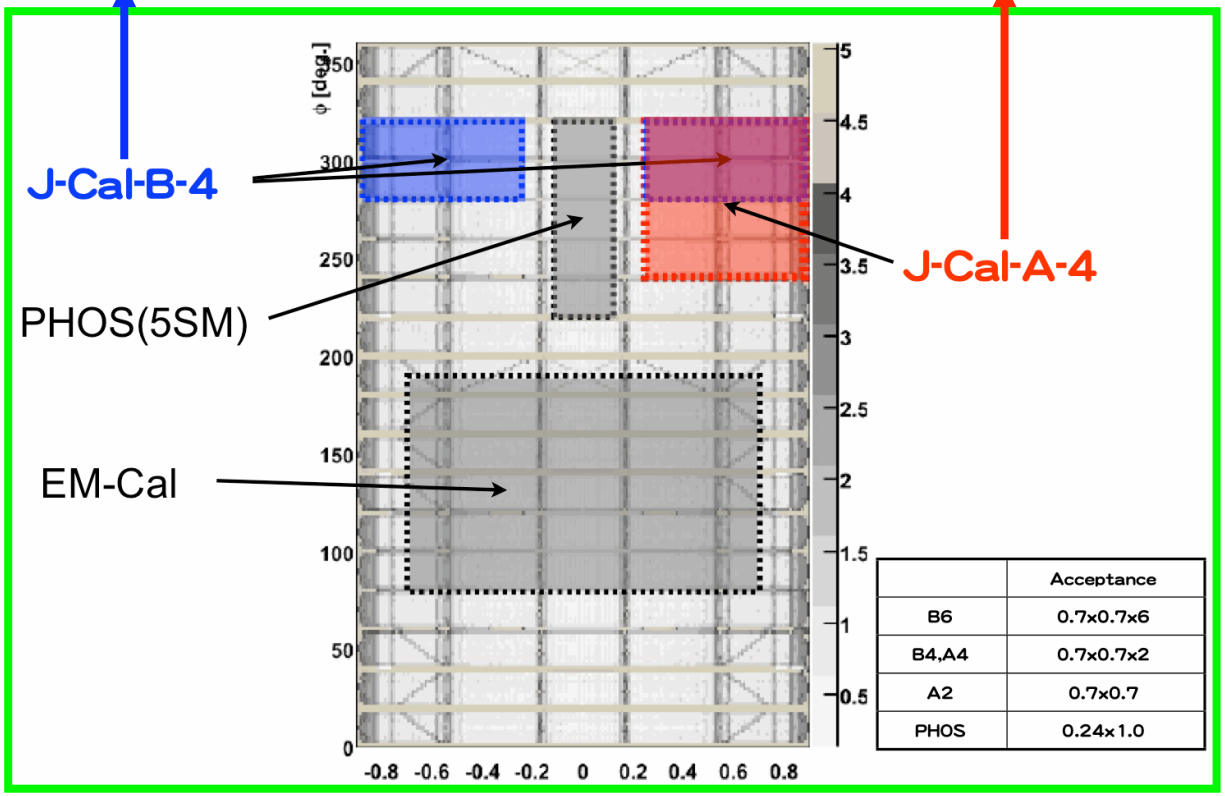
$\Delta\eta \sim 0.7$

$\Delta\phi = 0.35$

4 towers/
module



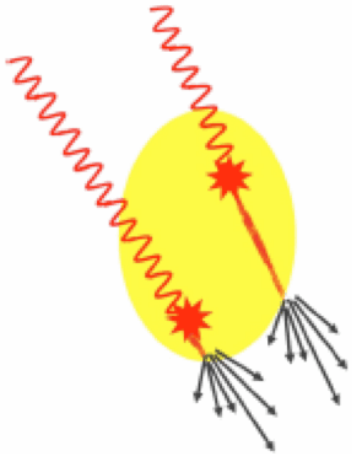




	Acceptance
B6	0.7x0.7x6
B4,A4	0.7x0.7x2
A2	0.7x0.7
PHOS	0.24x1.0

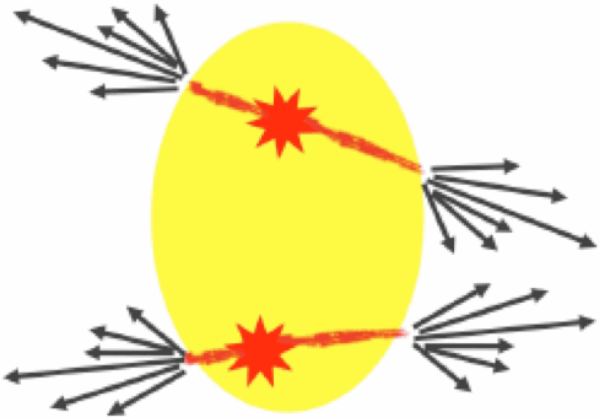
Y.Miake (Tsukuba)
presented at the upgrade meeting
during the last ALICE week, 29/Jun

γ-Jet



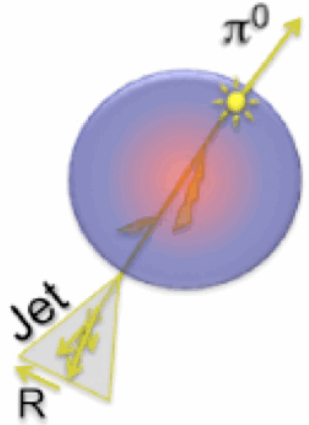
- ✓Quark Jet
- ✓Small Xsection
- ✓Experimentally difficult

Di-jet

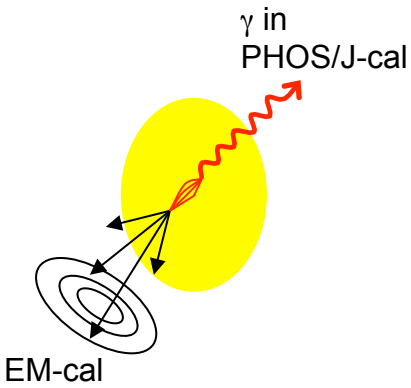


- ✓Mostly Gluon Jet
- ✓Larger Xsection
- ✓Interpretation may be difficult

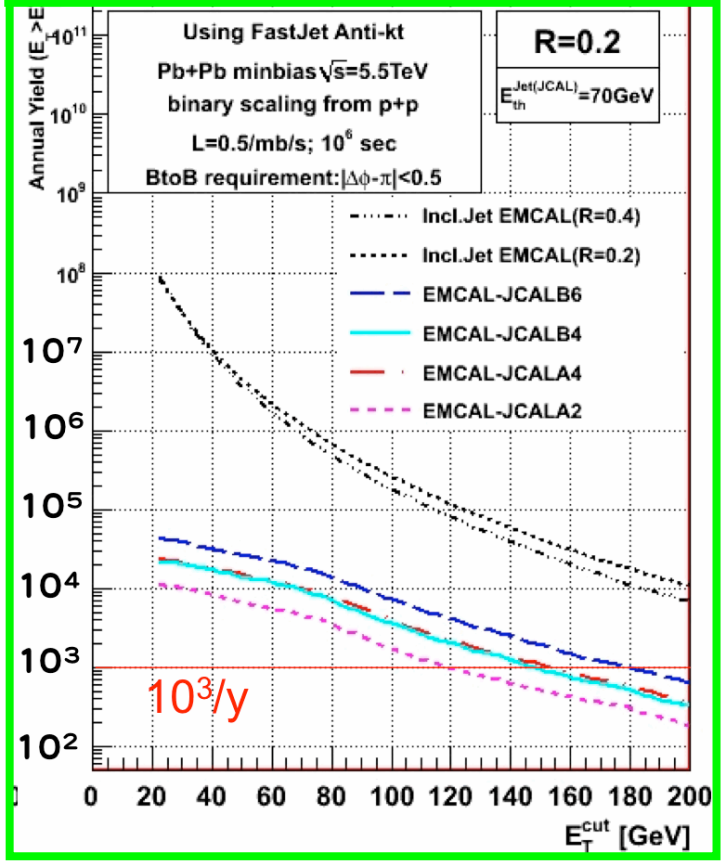
π^0-Jet

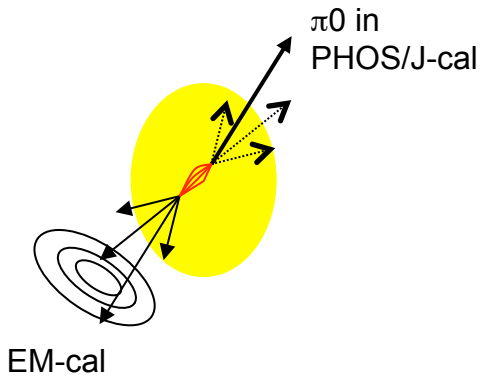


- ✓Clean π^0 trig
- ✓Large Xsection
- ✓Important for J-Cal

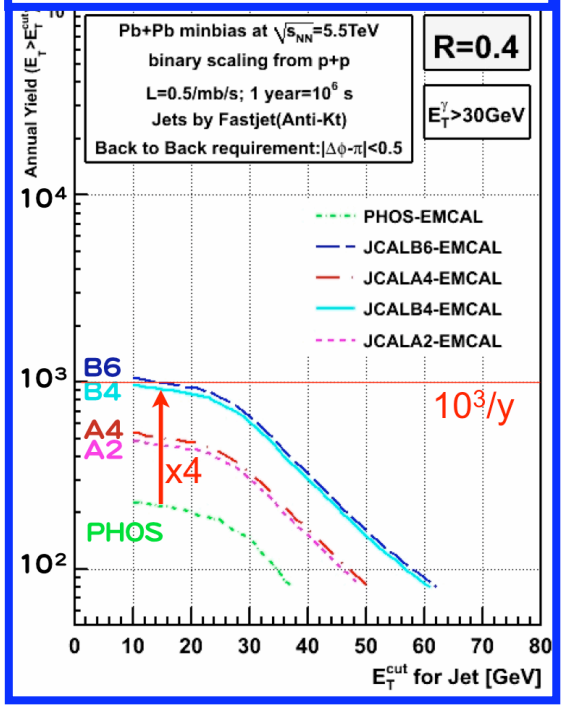


Recoil Di-jet E_T^{jet1}>70GeV

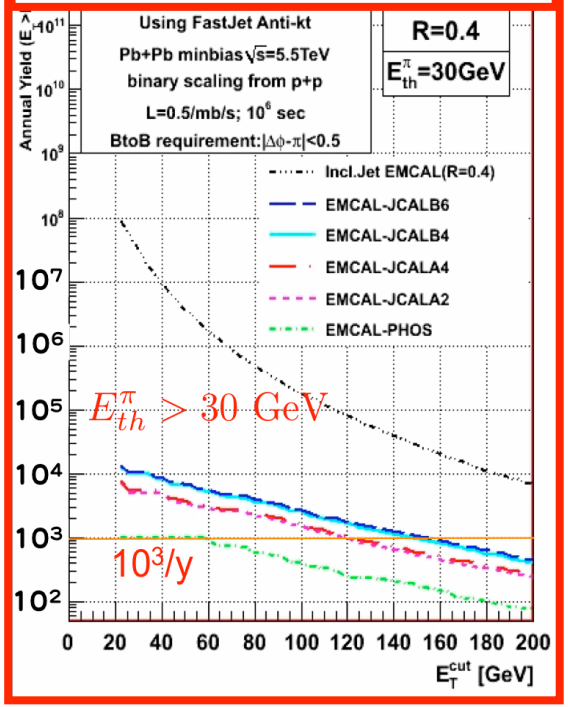


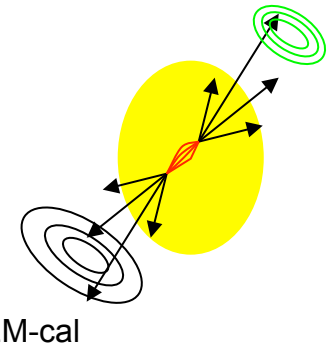


Recoil γ-jet E_T^{γ}>30GeV

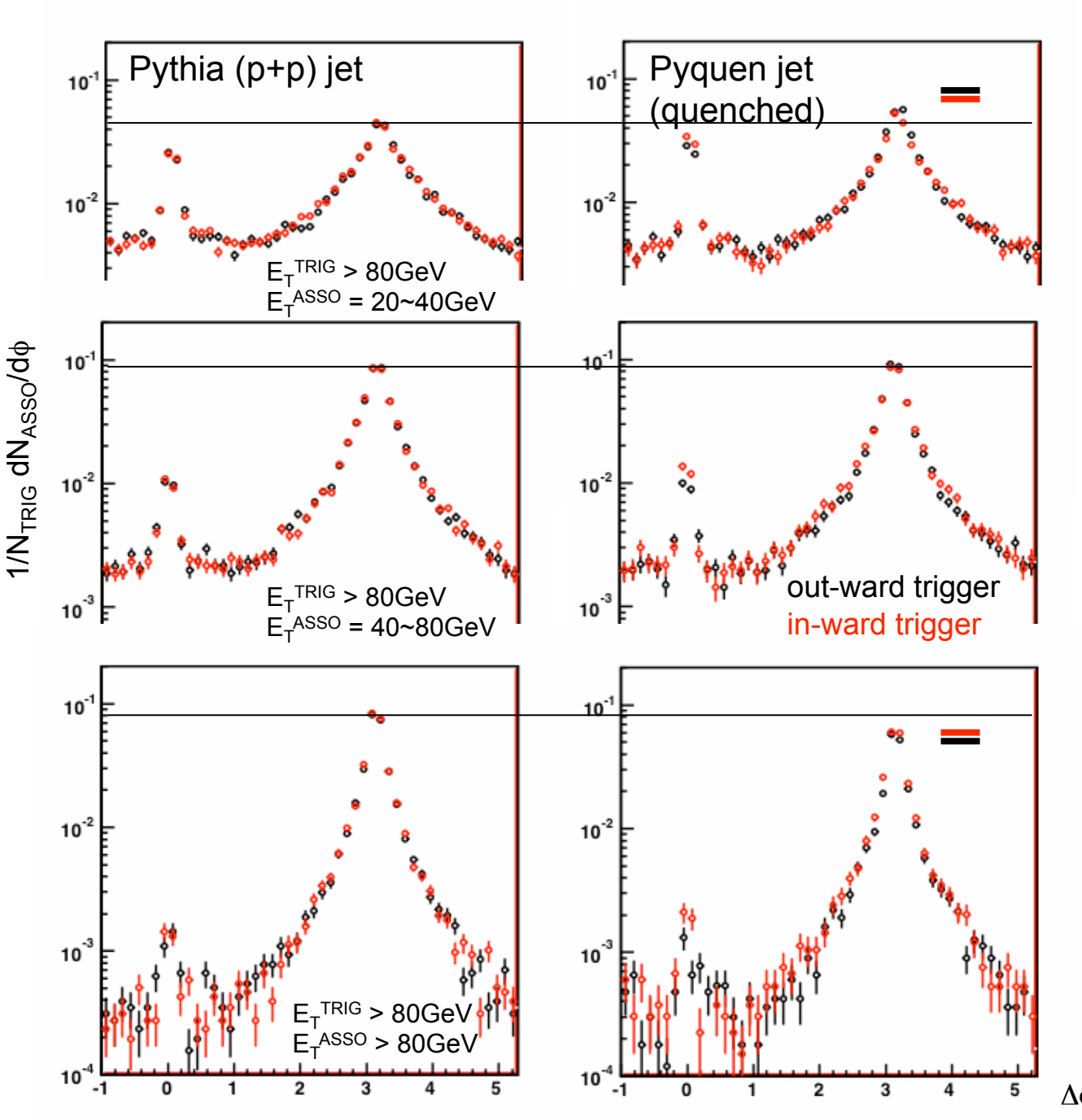


Recoil π^0-jet $E_T^{\pi^0}$>30GeV



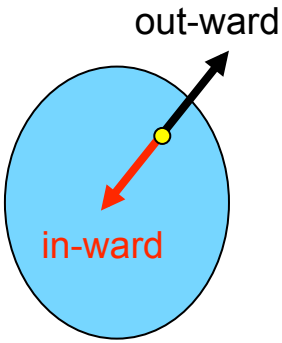


M. Sano,
H. Yokoyama,
Grad. Student of Tsukuba



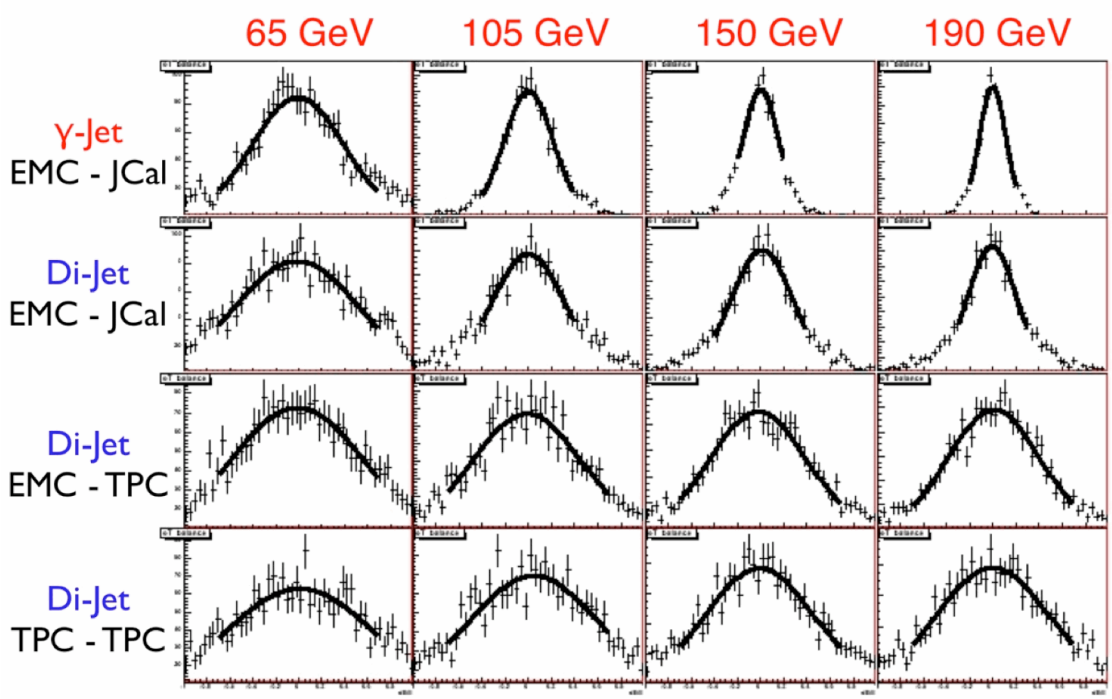
Di-jet simulation at 5.5TeV

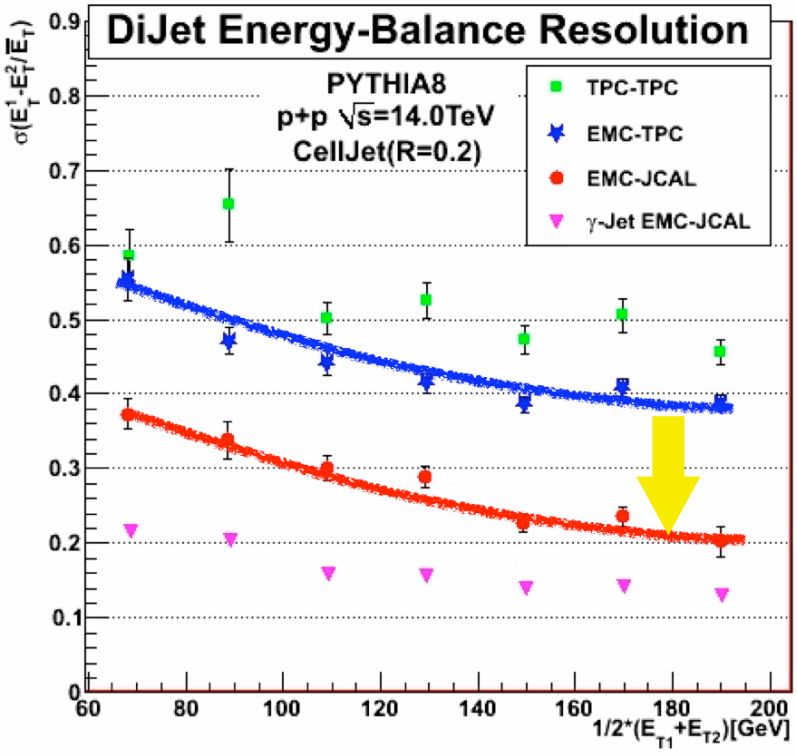
between
pythia (p+p)
and
pyquen
(quench model)



D. Sakata,
Grad. Student of Tsukuba

Improvement in jet energy resolution





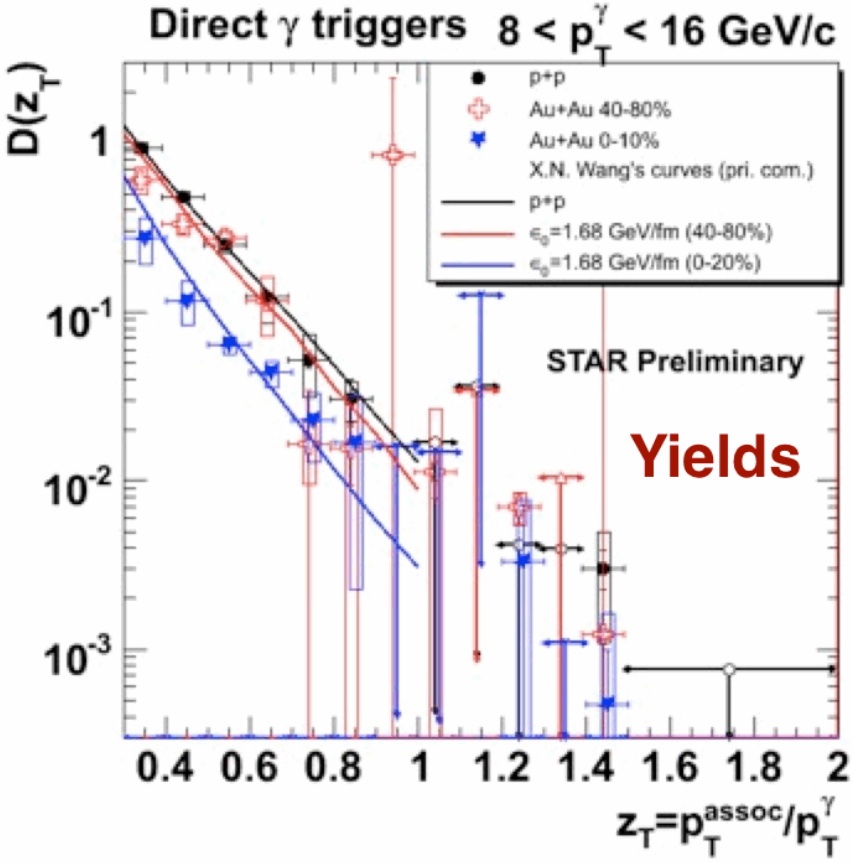
Summary

QGP tomography has started using Jets
and Di-Jets, Gamma-Jets, Mach-cone, Ridge.

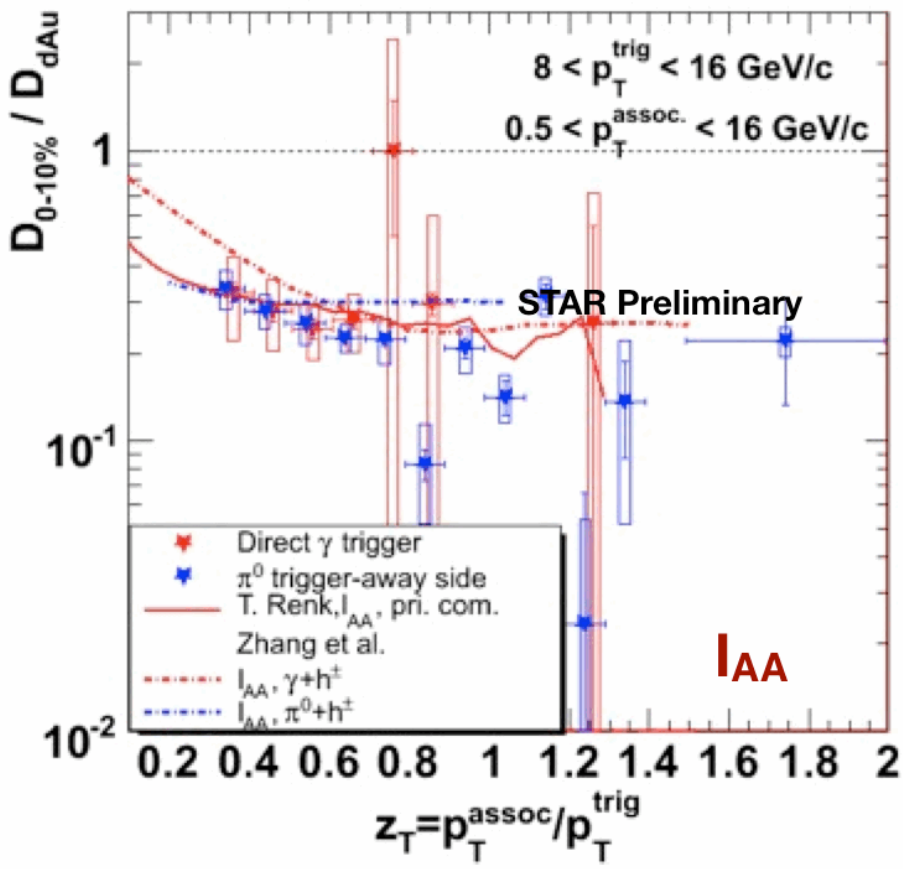
Jet modification does have an strong implication
to flow/event anisotropy interpretations.

We will continue in RHIC-PHENIX,
and prepare for LHC-ALICE with
additional J-cal opposite side of EMcal.

QM09, A. Hamed



New: d+Au reference



To cone or not to cone!

PHENIX

A. Sickles, W. Holzman, S. Esumi,

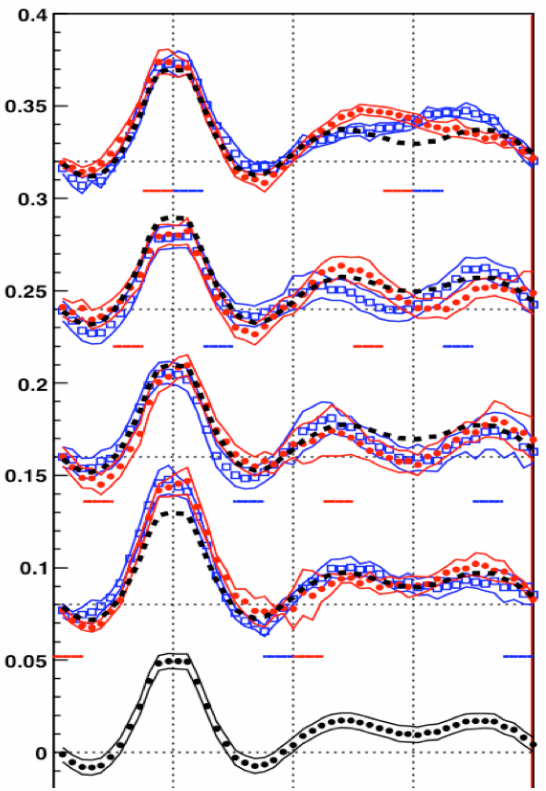
Is there a cone or not on the away side ?

This is really an experimental question

We now have the cone as a function of the reaction plane

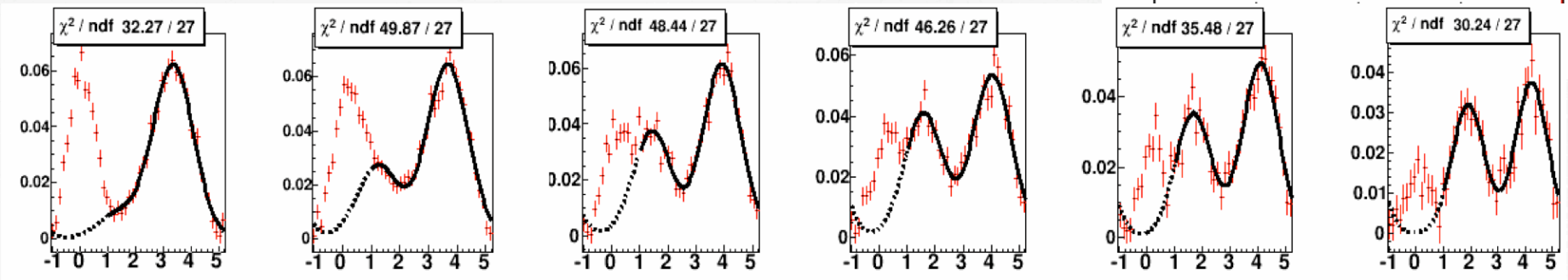
200GeV Au+Au -> h-h (run7)
(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)
mid-central : 20-50%

QM09, A. Majumder



(STAR)P. Netraknati, J. Konzer

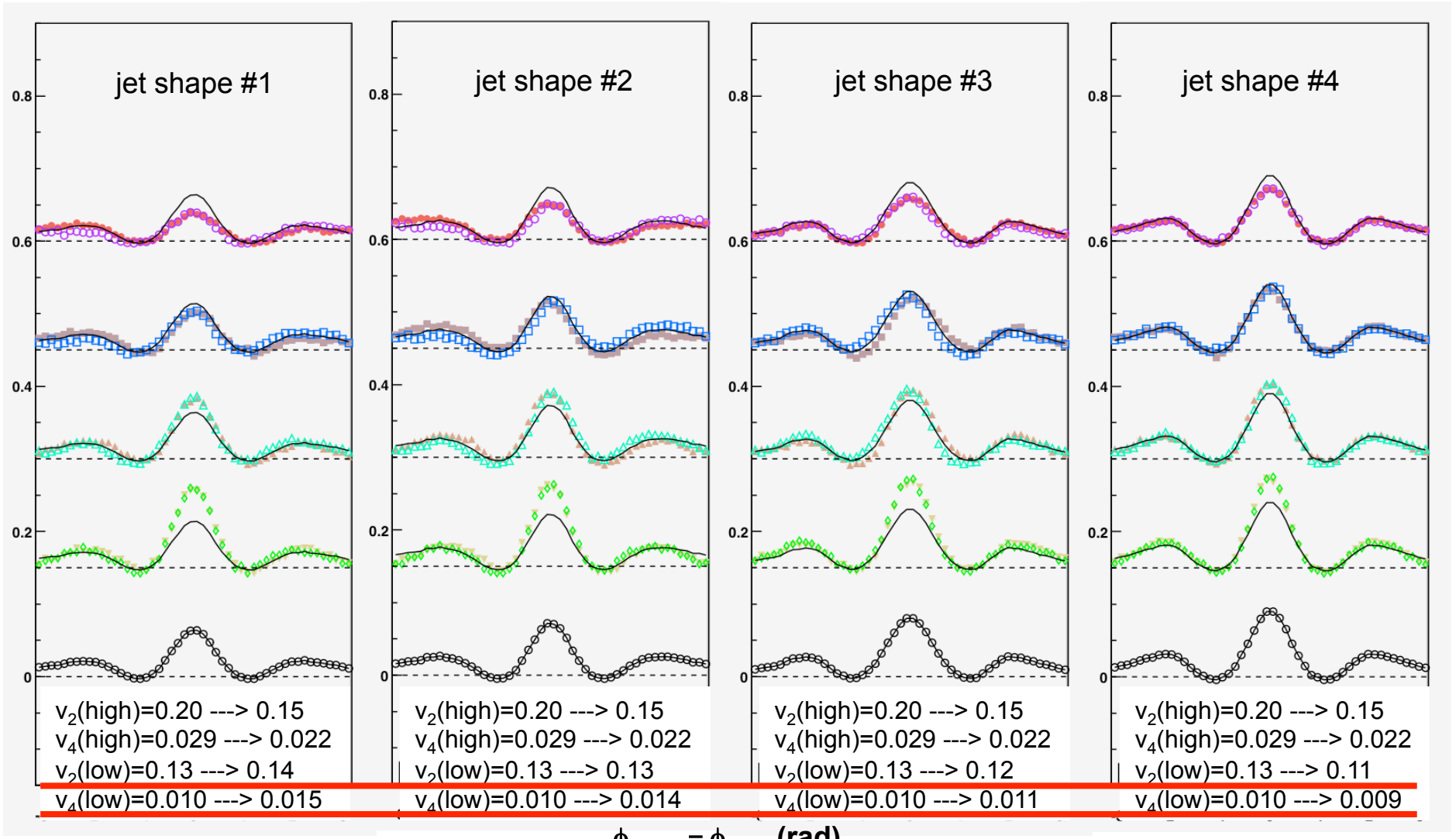
$3<p_T^{Trig}<4$ GeV/c **$1<p_T^{Assoc}<1.5$ GeV/c** Au+Au 20-60%



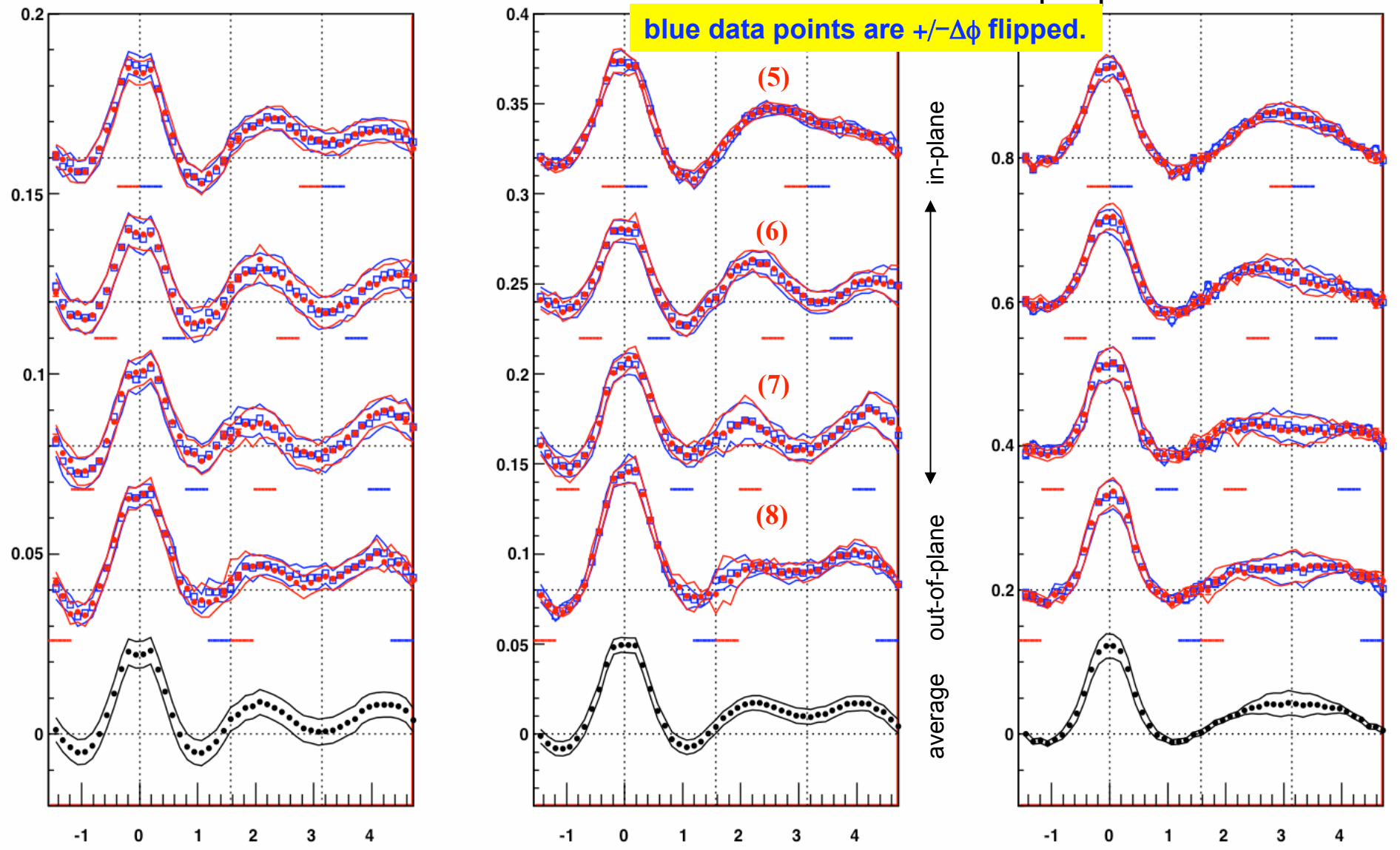
Simulation

n_{Trig} / eve (soft) = 3
n_{Asso} / eve (soft) = 8
n_{Jet} / eve (hard) = 1
n_{PTY} / jet (hard) = 1.25

$v_{2,4}^{Trig}$ (soft) = 0.2, 0.029
$v_{2,4}^{Asso}$ (soft) = 0.13, 0.010
$v_{2,4}^{Jet}$ (hard) = 0.0, 0.0
$v_{2,4}^{PTY}$ (hard) = 0.0, 0.0



200GeV Au+Au -> h-h (run7)(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)



200GeV Au+Au -> h-h (run7)(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)