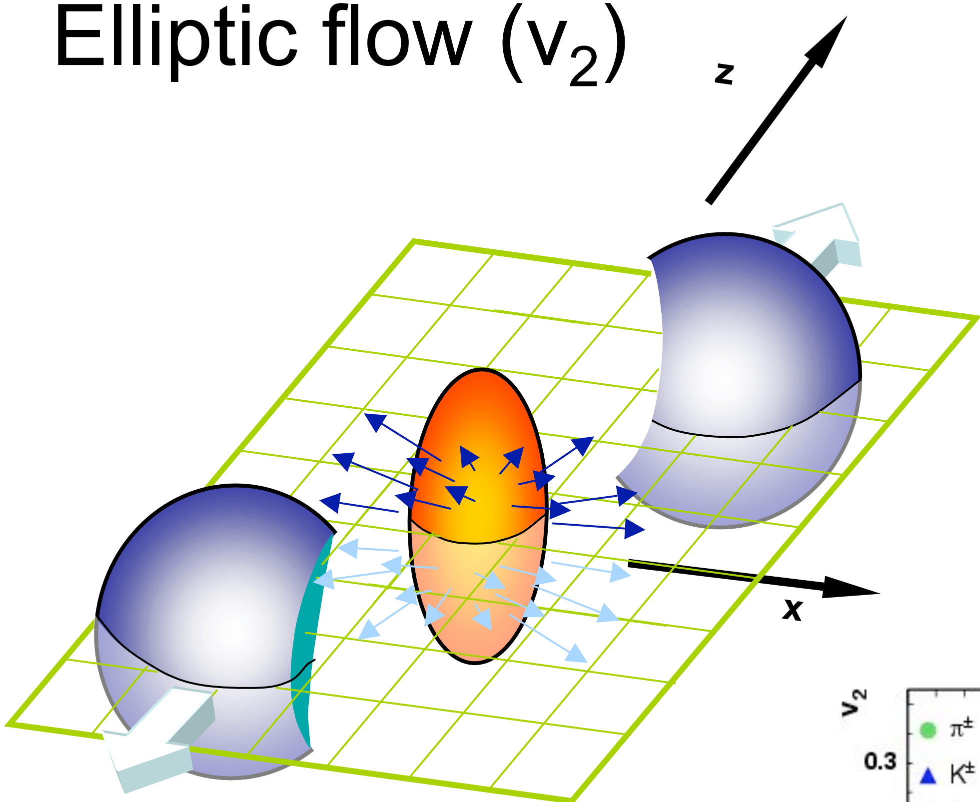
Jet - flow(v_2) correlation

ShinIchi Esumi
Inst. of Physics, Univ. of Tsukuba

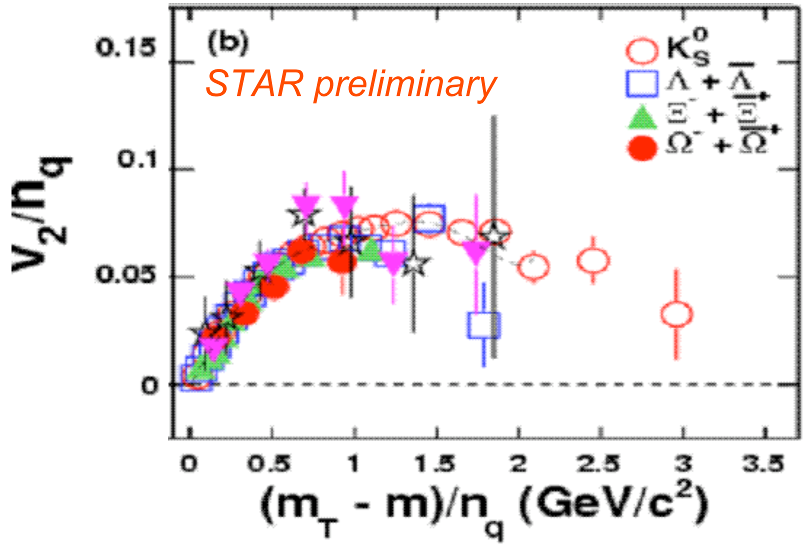
v_2 - R_{AA}
- hydro, N_{quark} scaling
- energy loss, re-distribution

di-hadron correlation
- mach-cone like shape
- reaction plane dependence
- left-right asymmetry
- forward-backward asymmetry

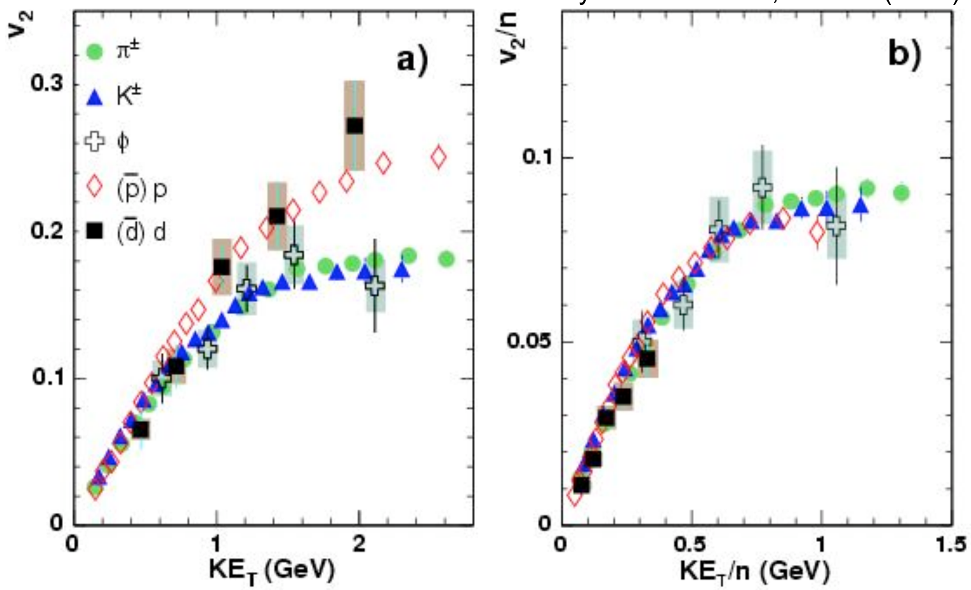
Elliptic flow (v_2)



QM06



Phys. Rev. Lett. 99, 052301 (2007)

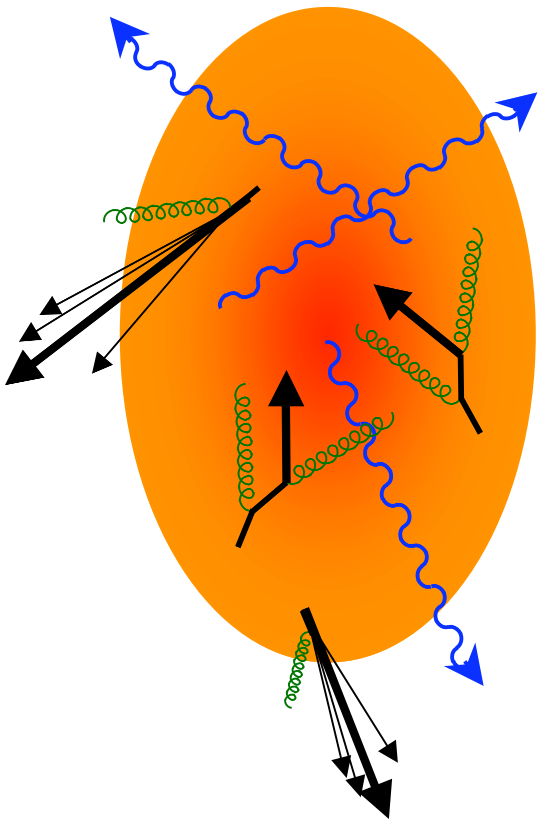


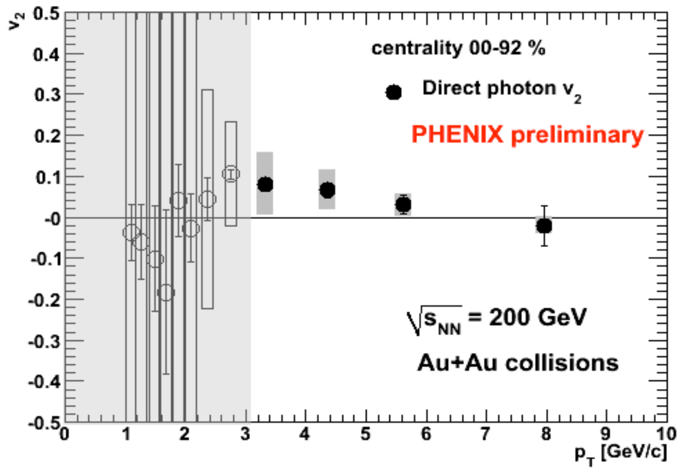
hydro-model success
quark degree of freedom

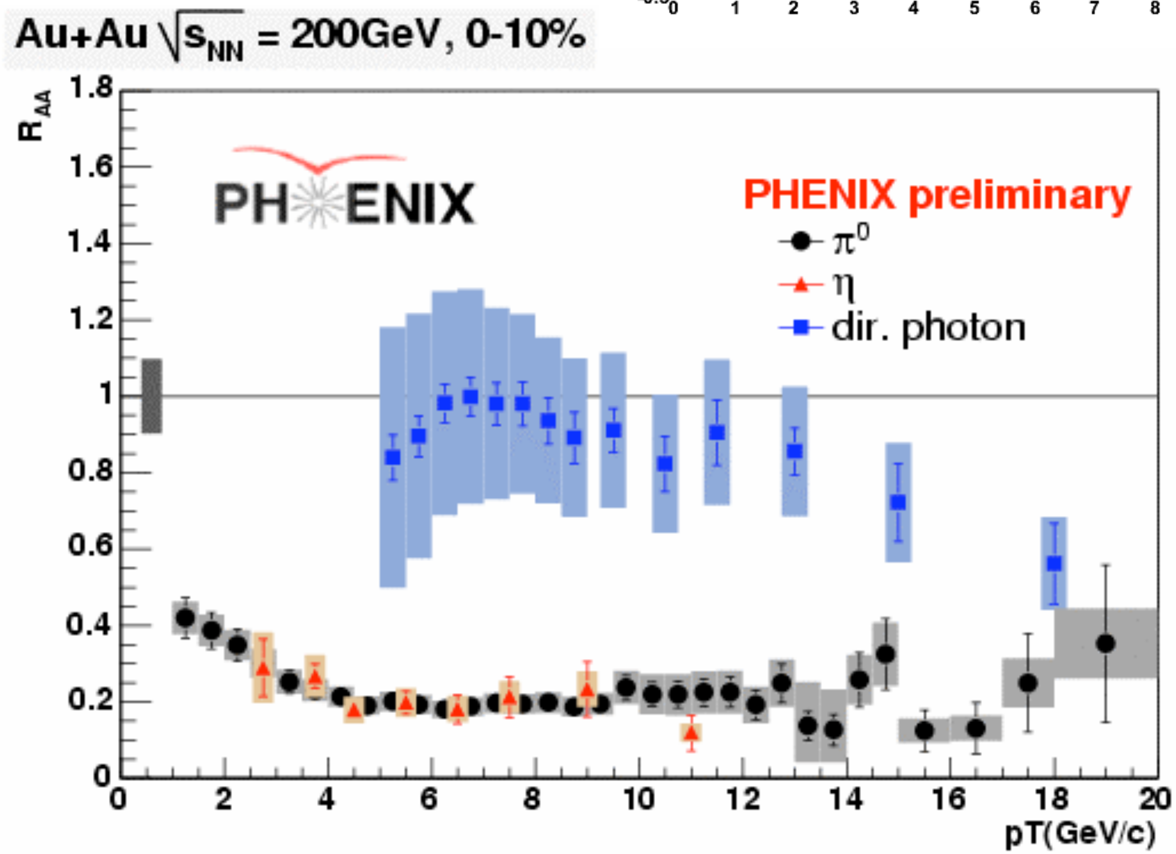
↔

high p_T suppression from energy loss
re-distribution of the lost energy

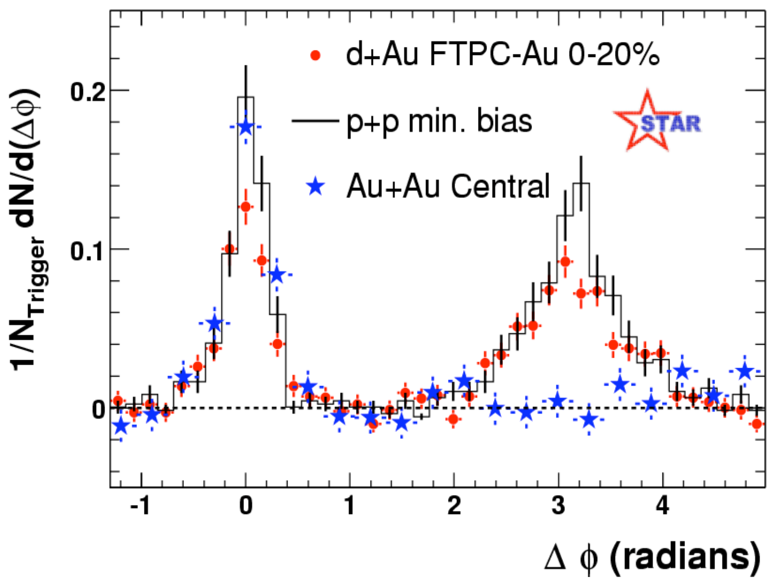
Hadron large suppression
Direct γ NO suppression

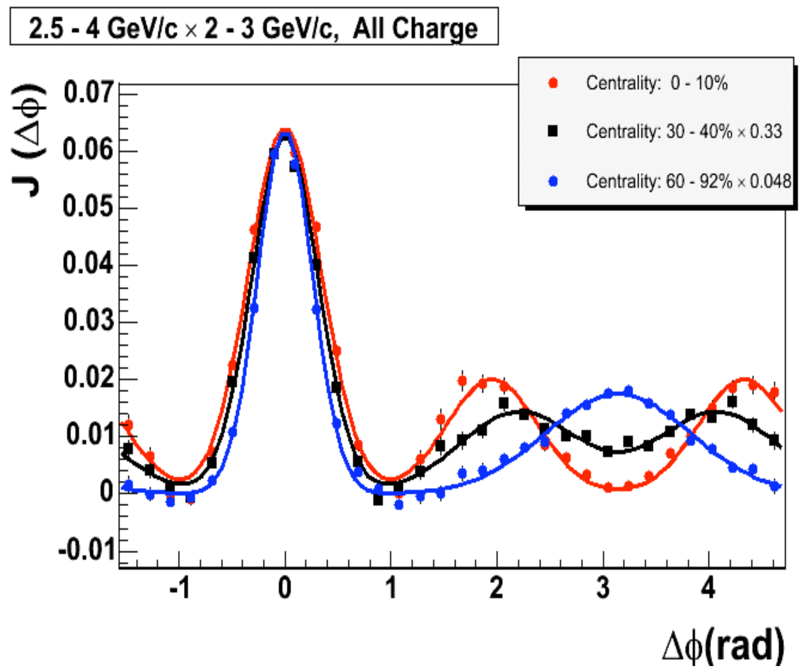




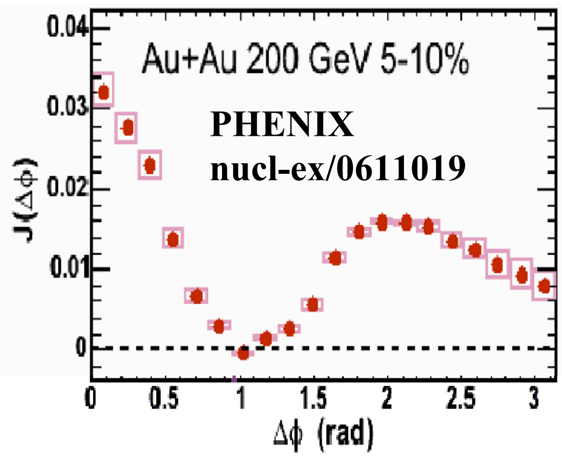


Jet suppression ➡ modification with 2-particle Δφ correlation

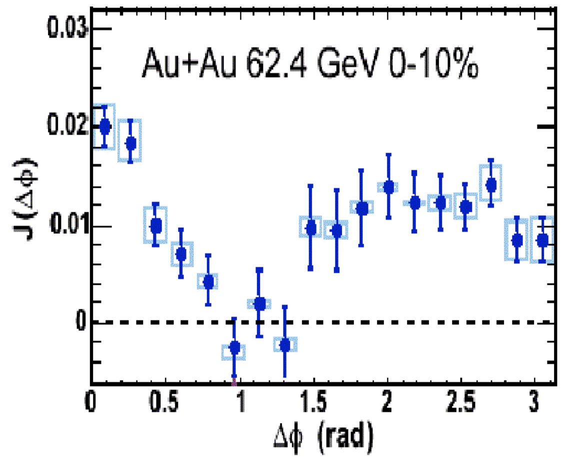




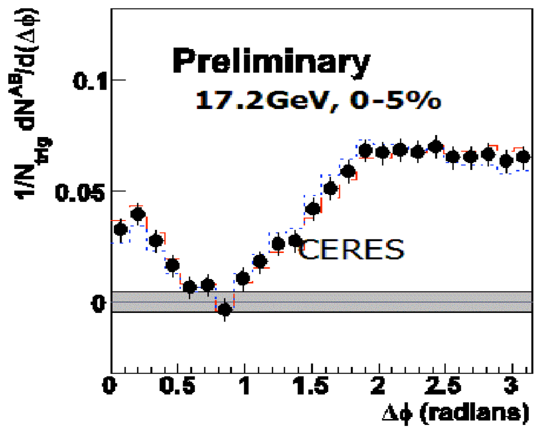
RHIC 200GeV



RHIC 62GeV

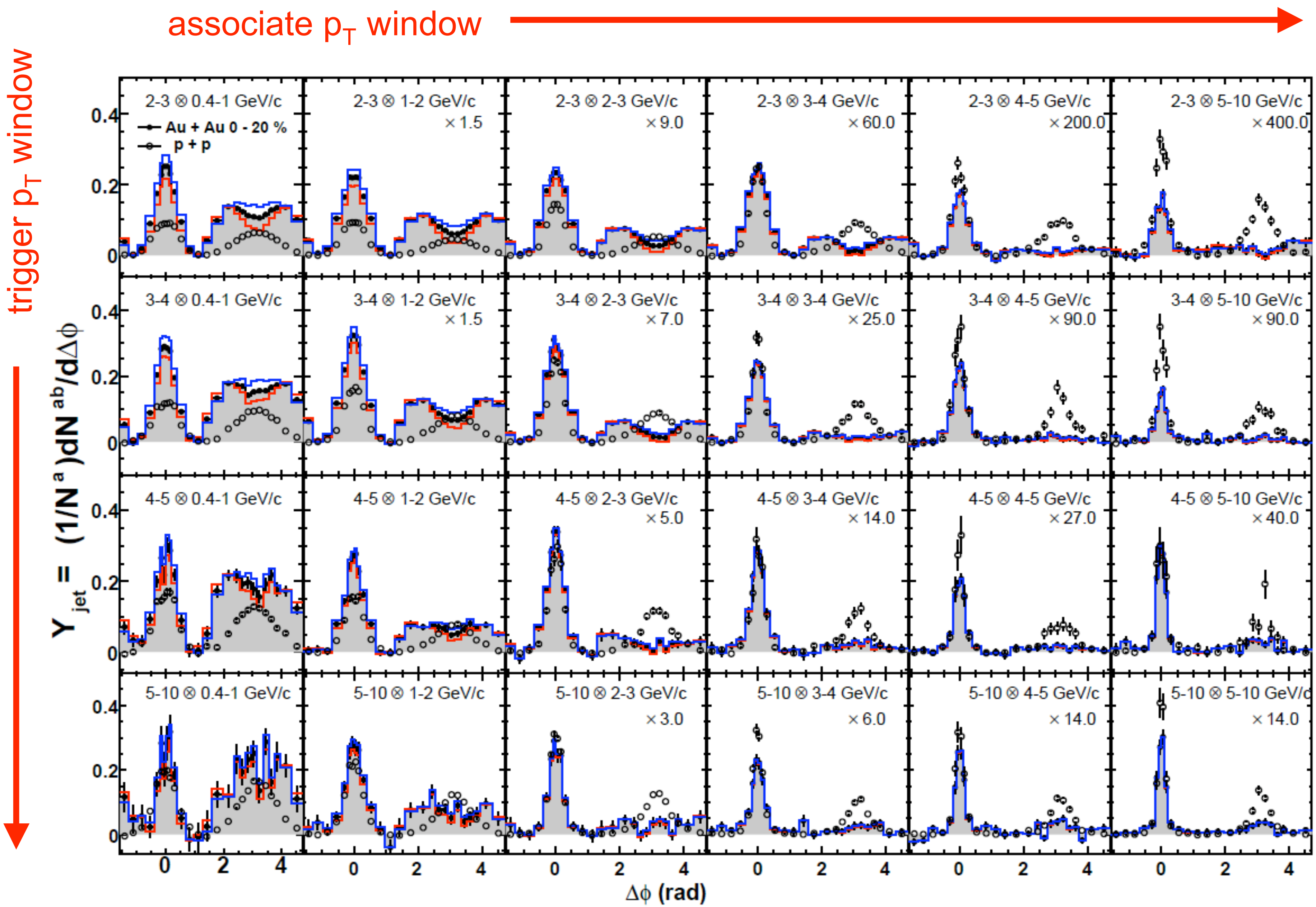


SPS 17GeV



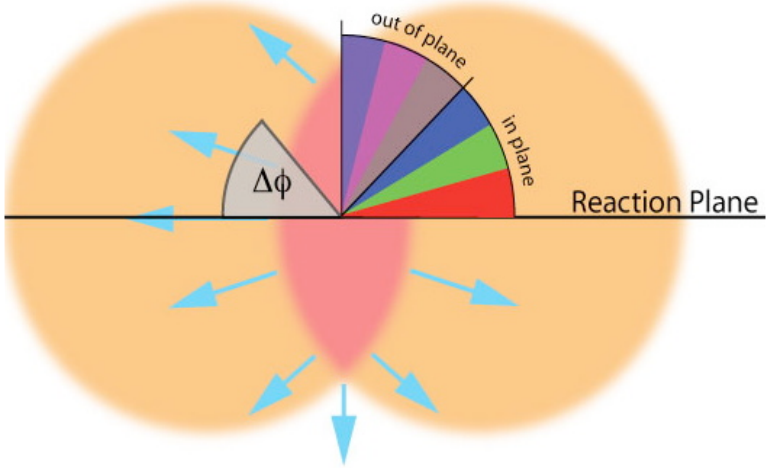
S.Kniege, ISMD 2007

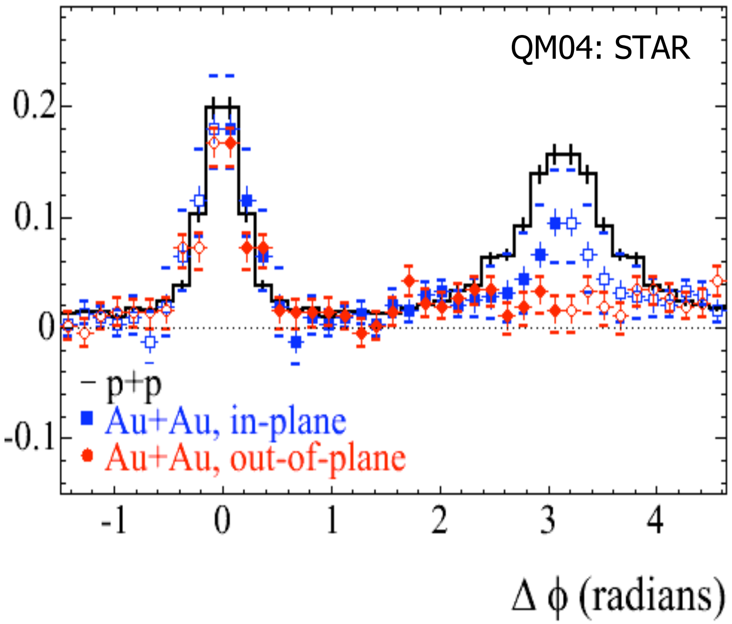
h-h correlation at "p+p 200GeV" vs "Au+Au 200GeV central 0-20%"

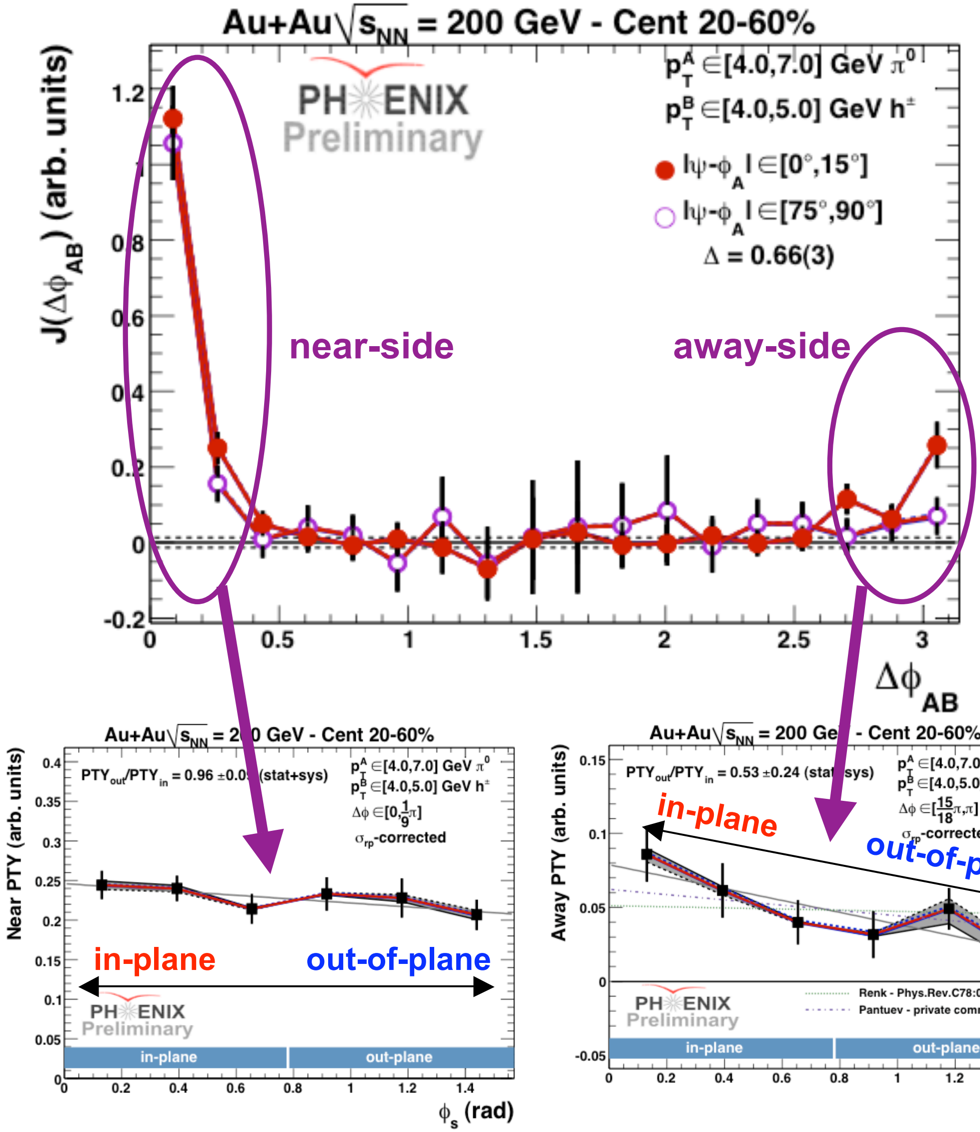


RP dependent correlations

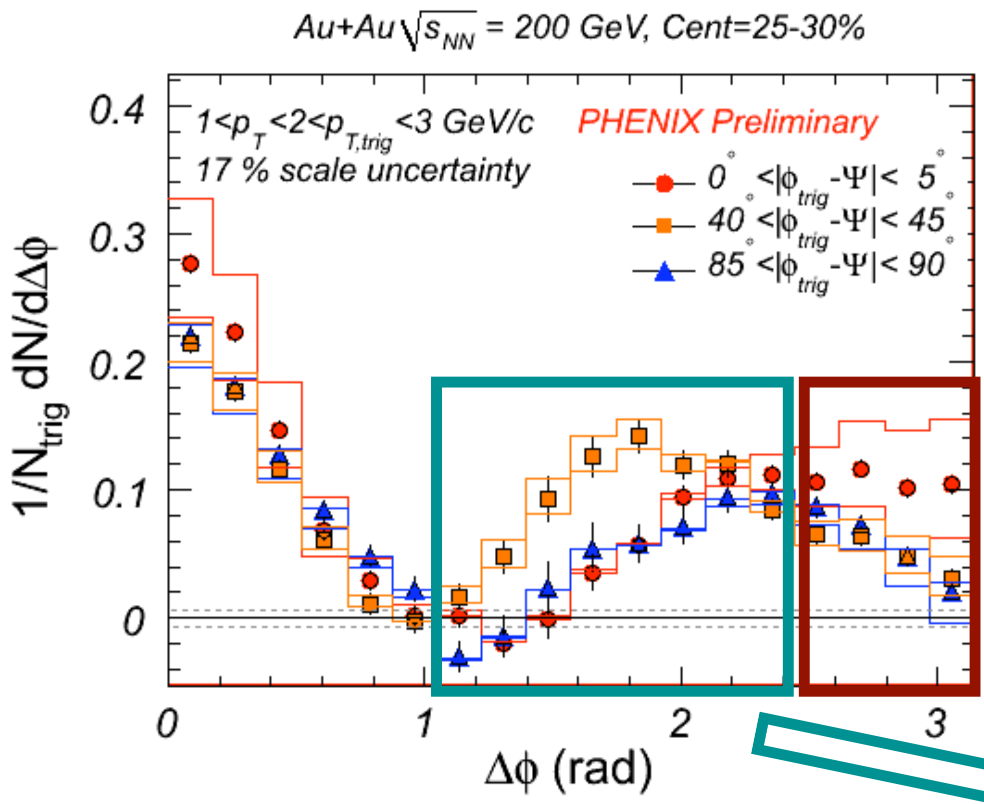
QM09, C. H. Chen



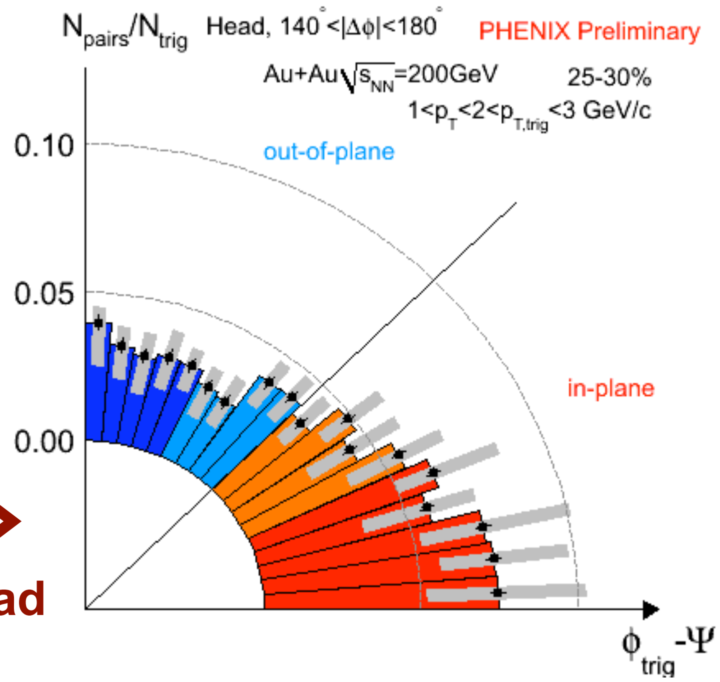




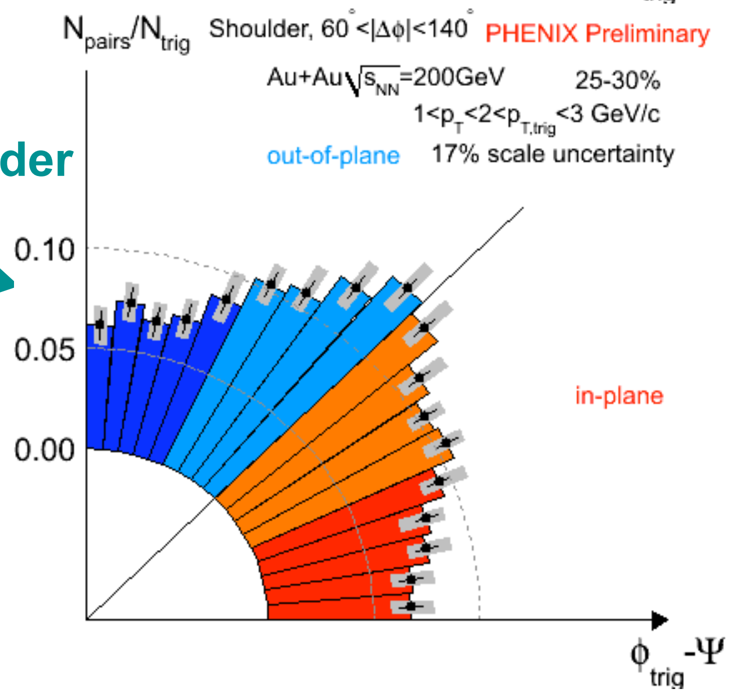
QM09, W. G. Holzmann



Head

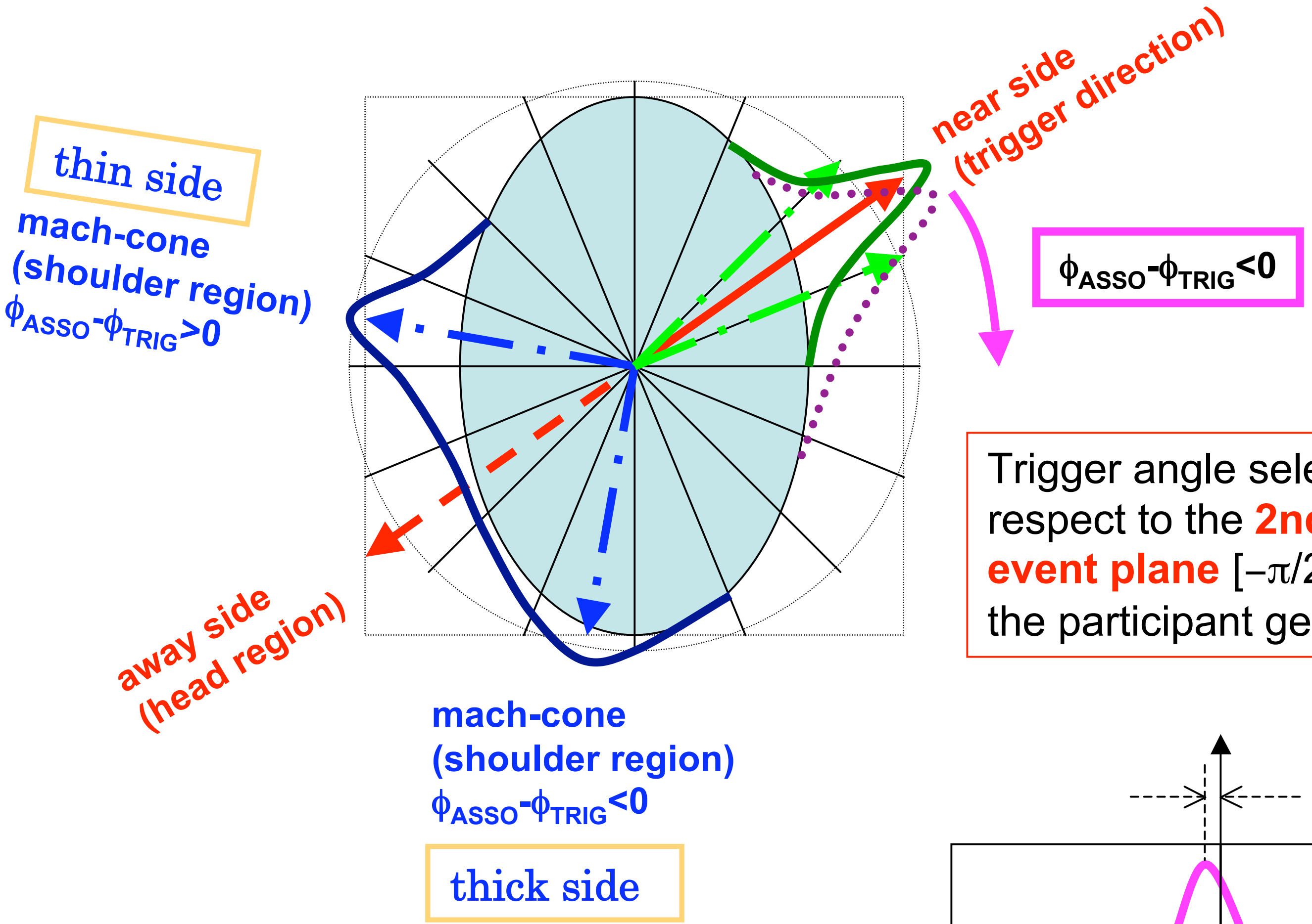


Shoulder

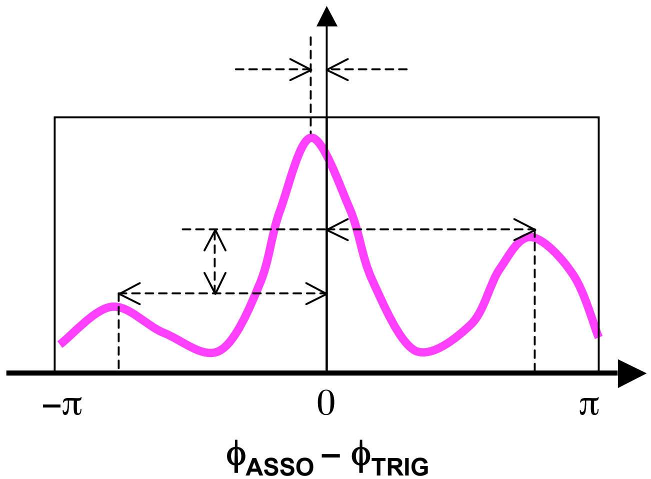


head: yield confirms simple picture of energy loss vs. path length; in- and out-of-plane show similar away-side width

shoulder: geometry effects harder to disentangle

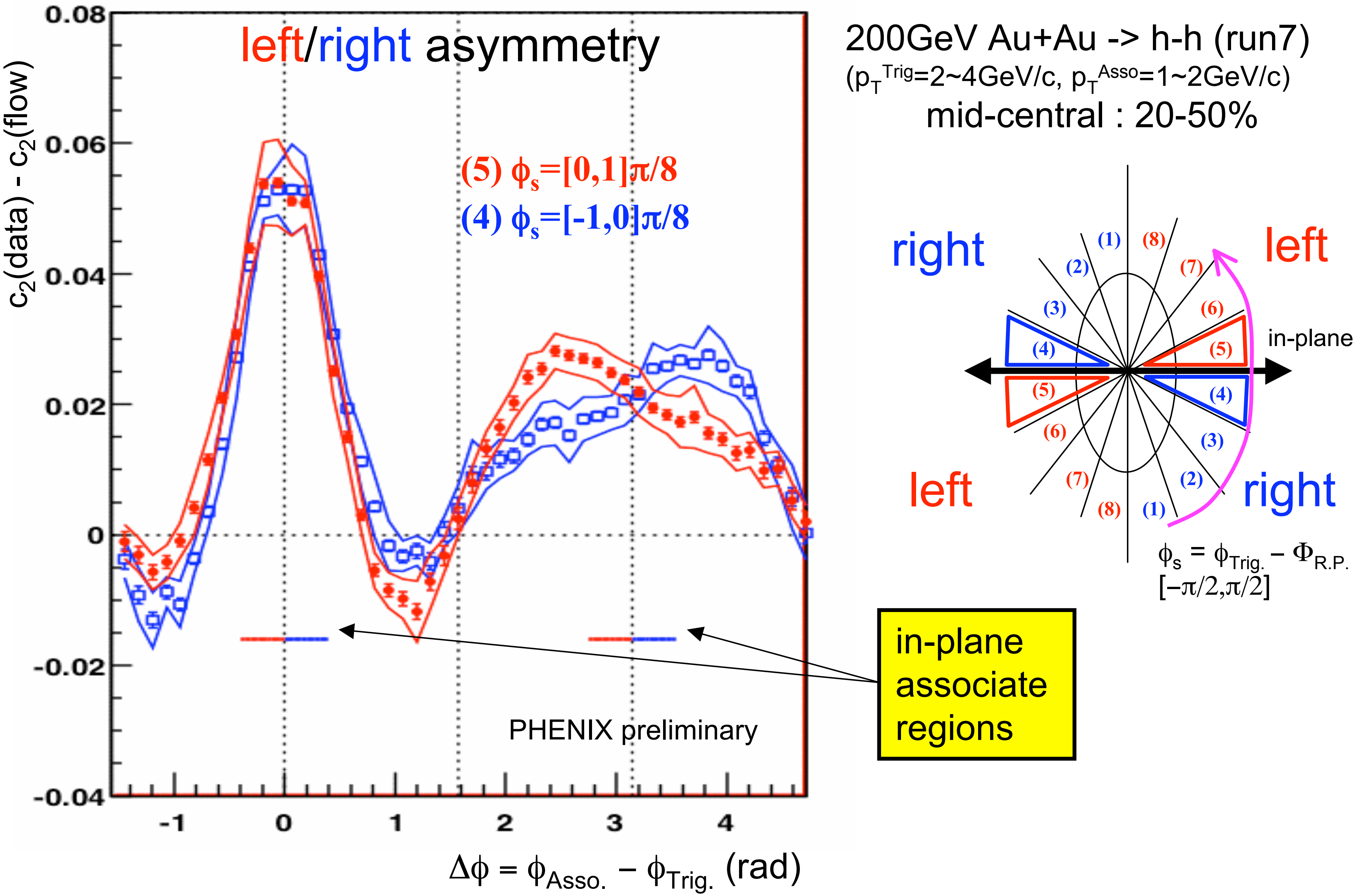


Trigger angle selected with respect to the **2nd moment event plane** [−π/2,π/2] to probe the participant geometry

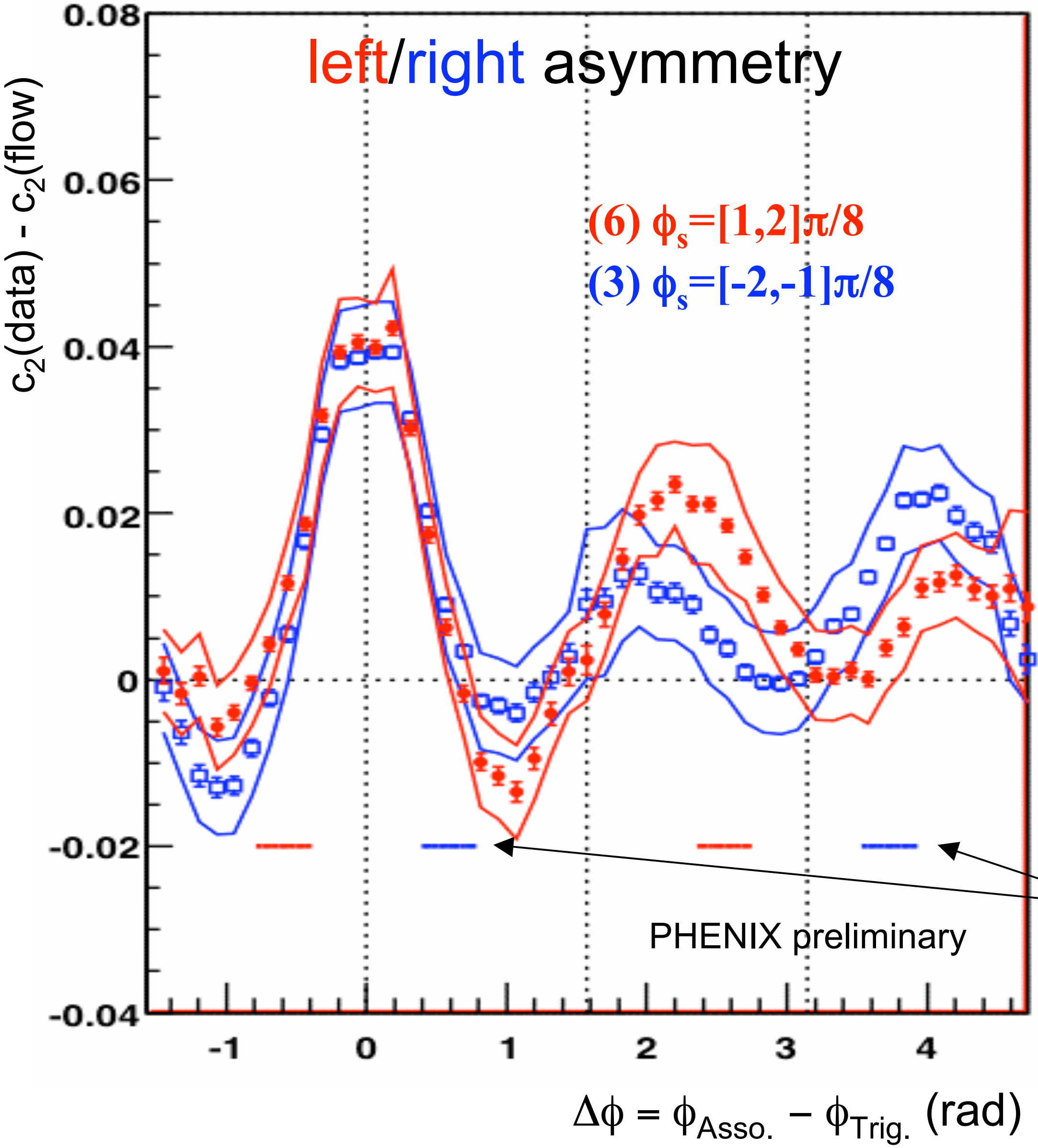


If trigger angle is fixed around +/−(π/4), the associate particles emitted left or right w.r.t. trigger direction would feel the different thickness of the almond. It is because the almond shaped medium is asymmetric w.r.t. jet axis.

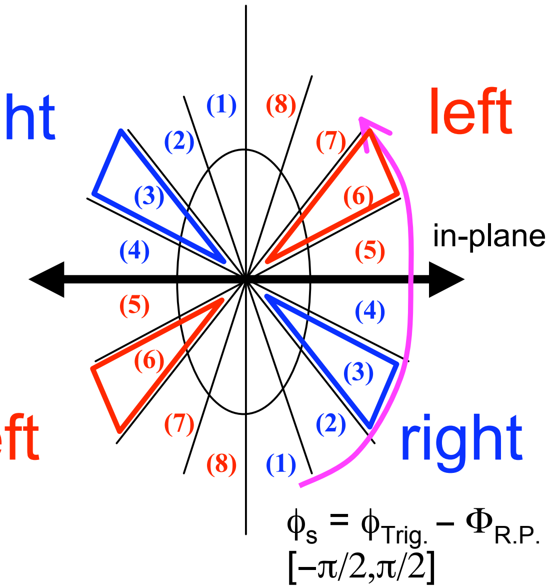
Angle (4)/(5) (mid-central)



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%

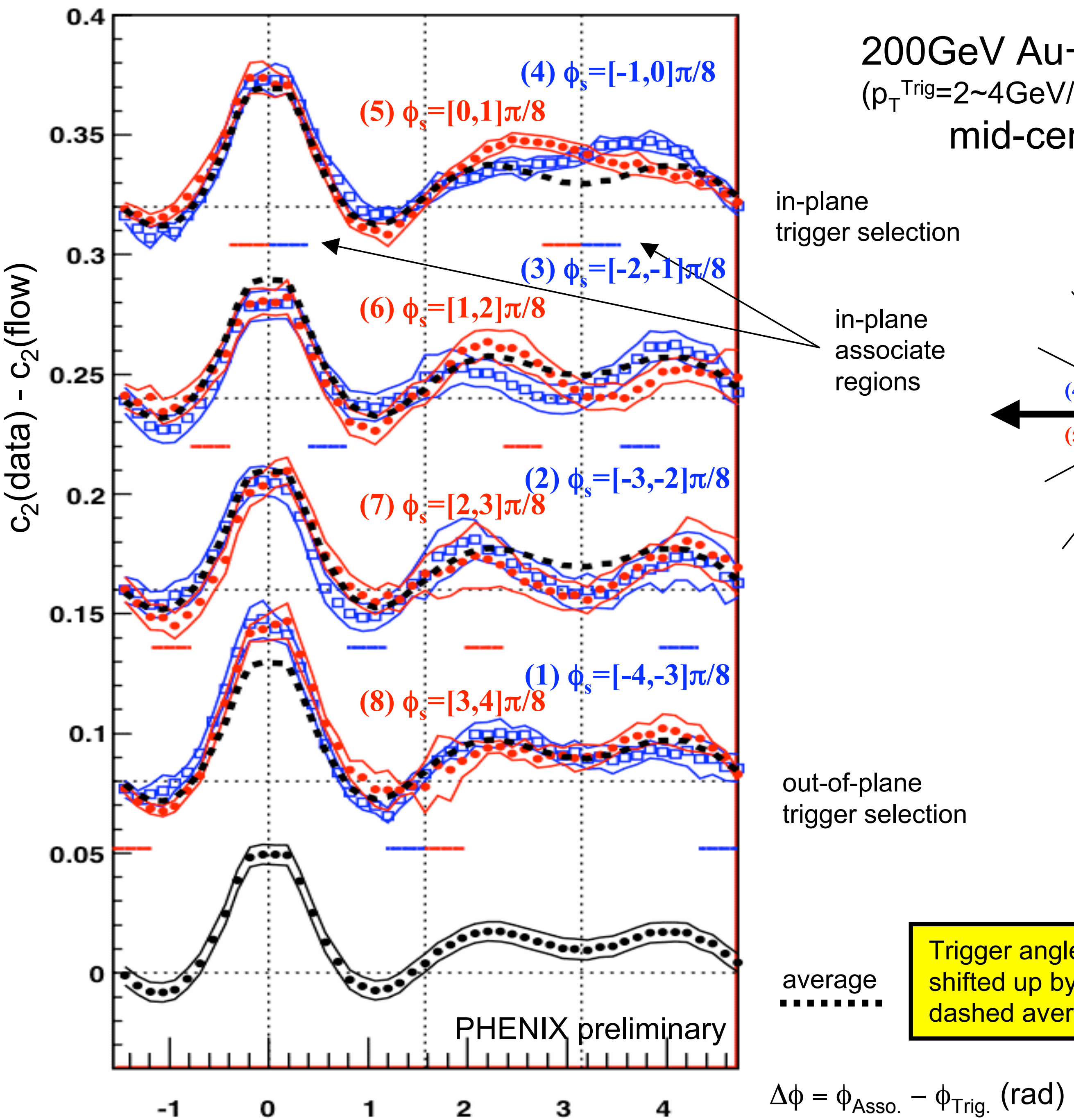


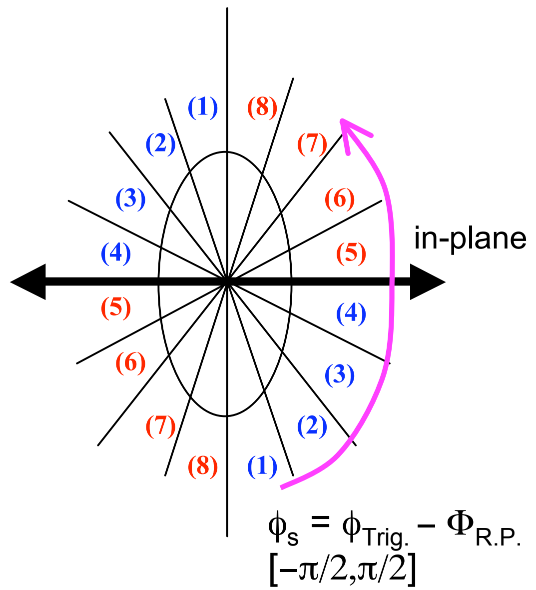
in-plane associate regions

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

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

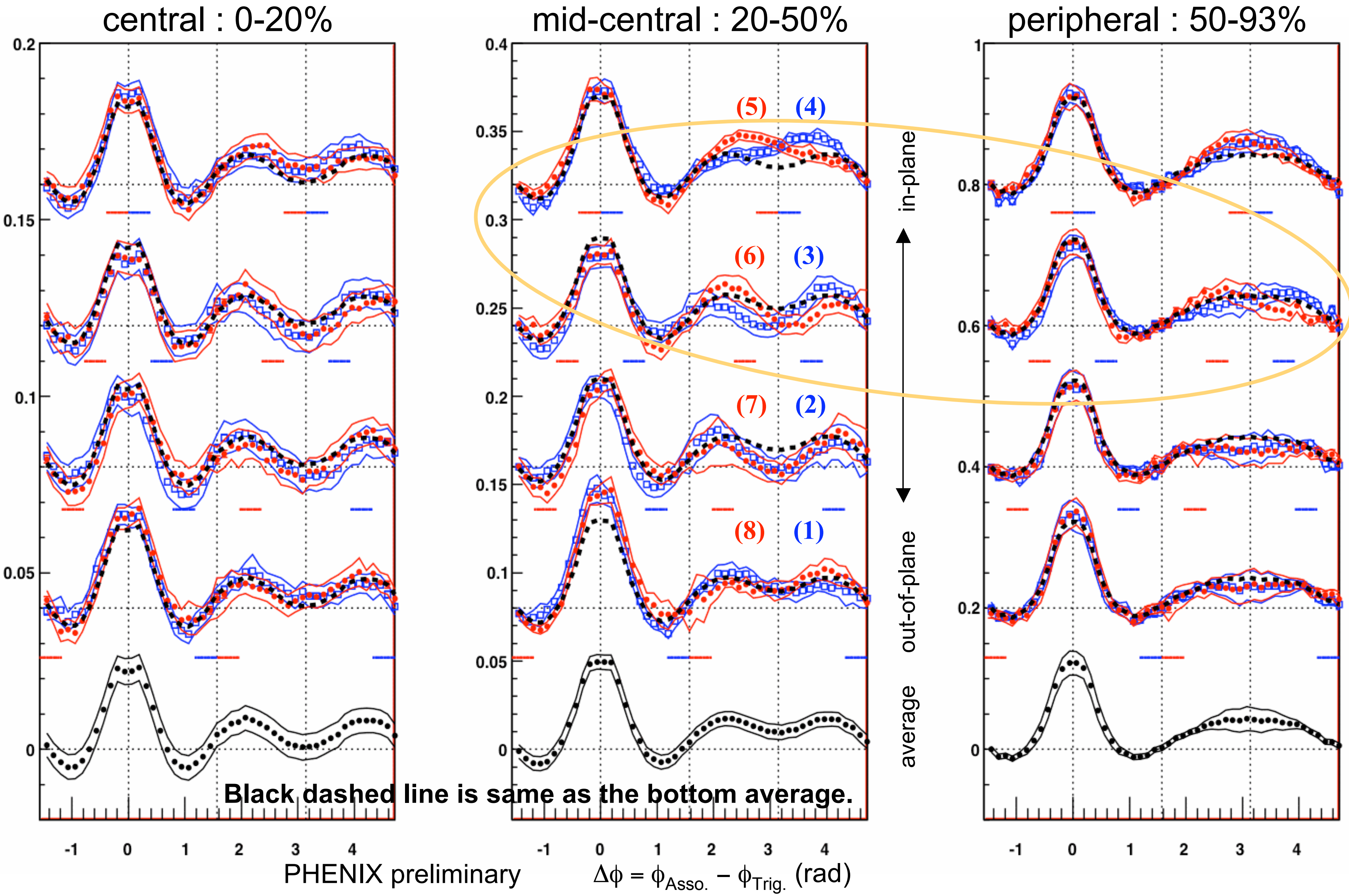
mid-central : 20-50%

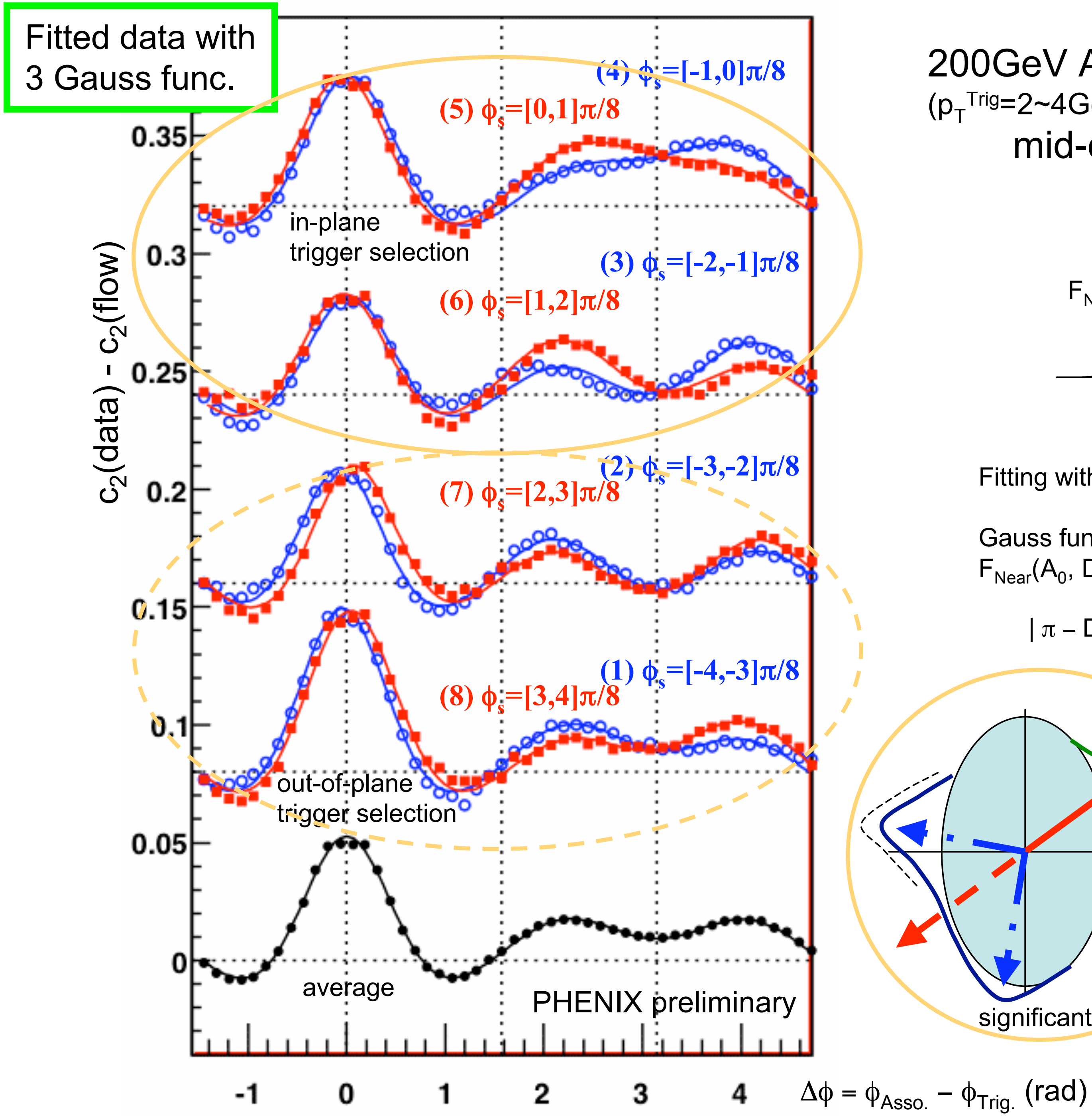




Trigger angle selected curves are shifted up by constant offsets, dashed average lines are overlaid.

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

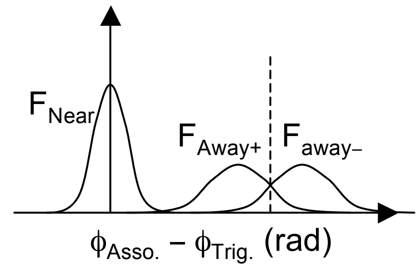




200GeV Au+Au -> h-h (run7)

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

mid-central : 20-50%

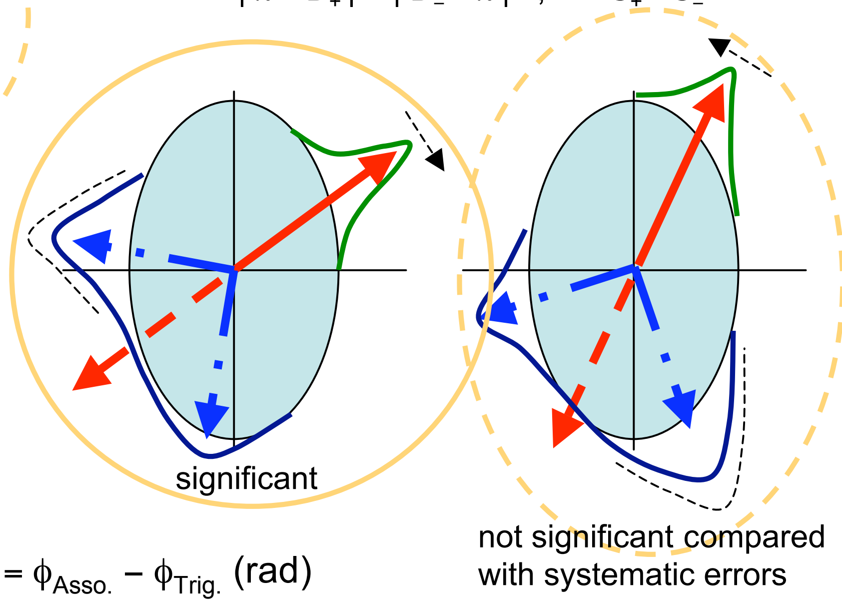


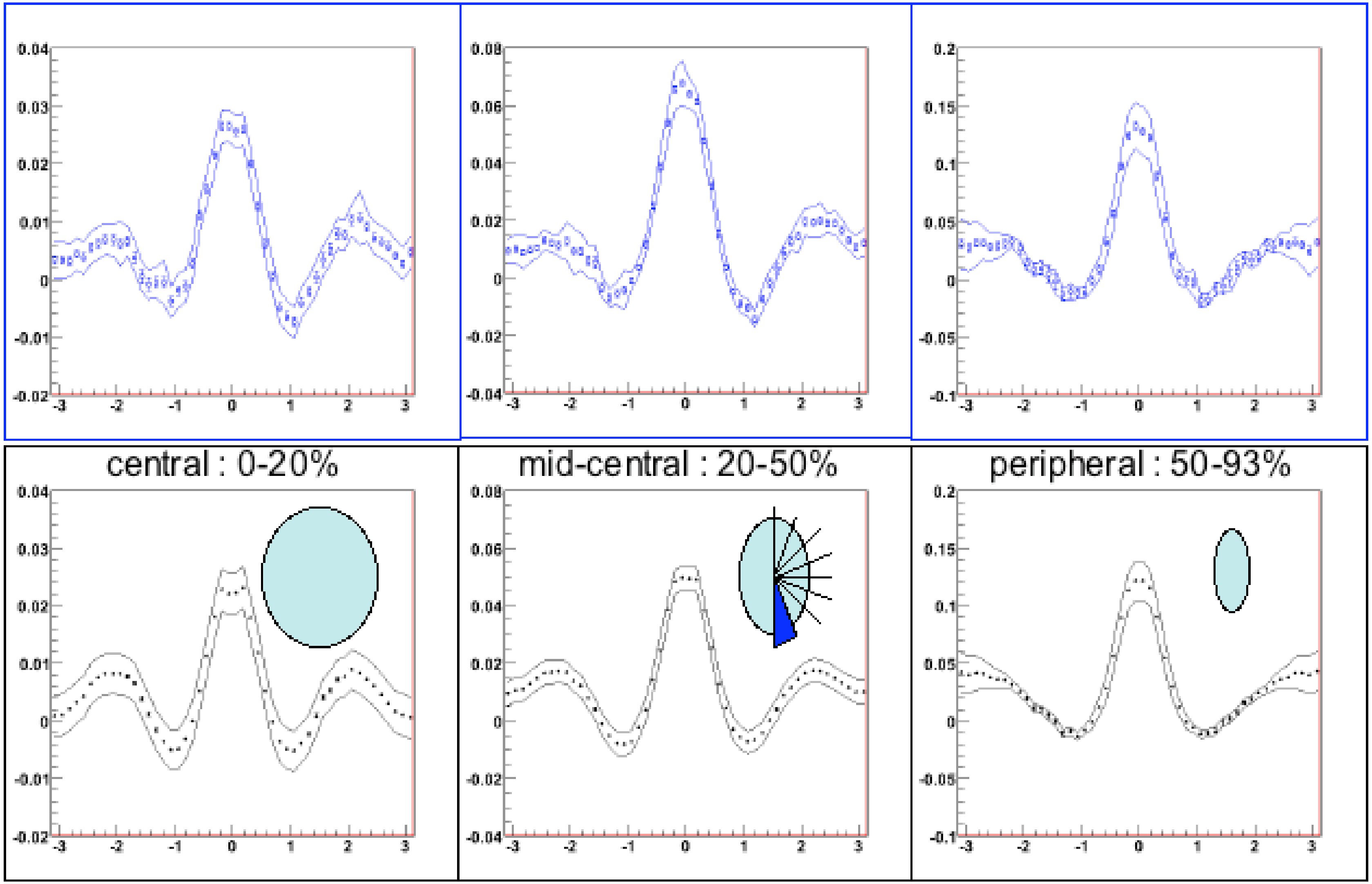
Fitting with 3 Gaussian functions

Gauss function : F(height, mean, width)

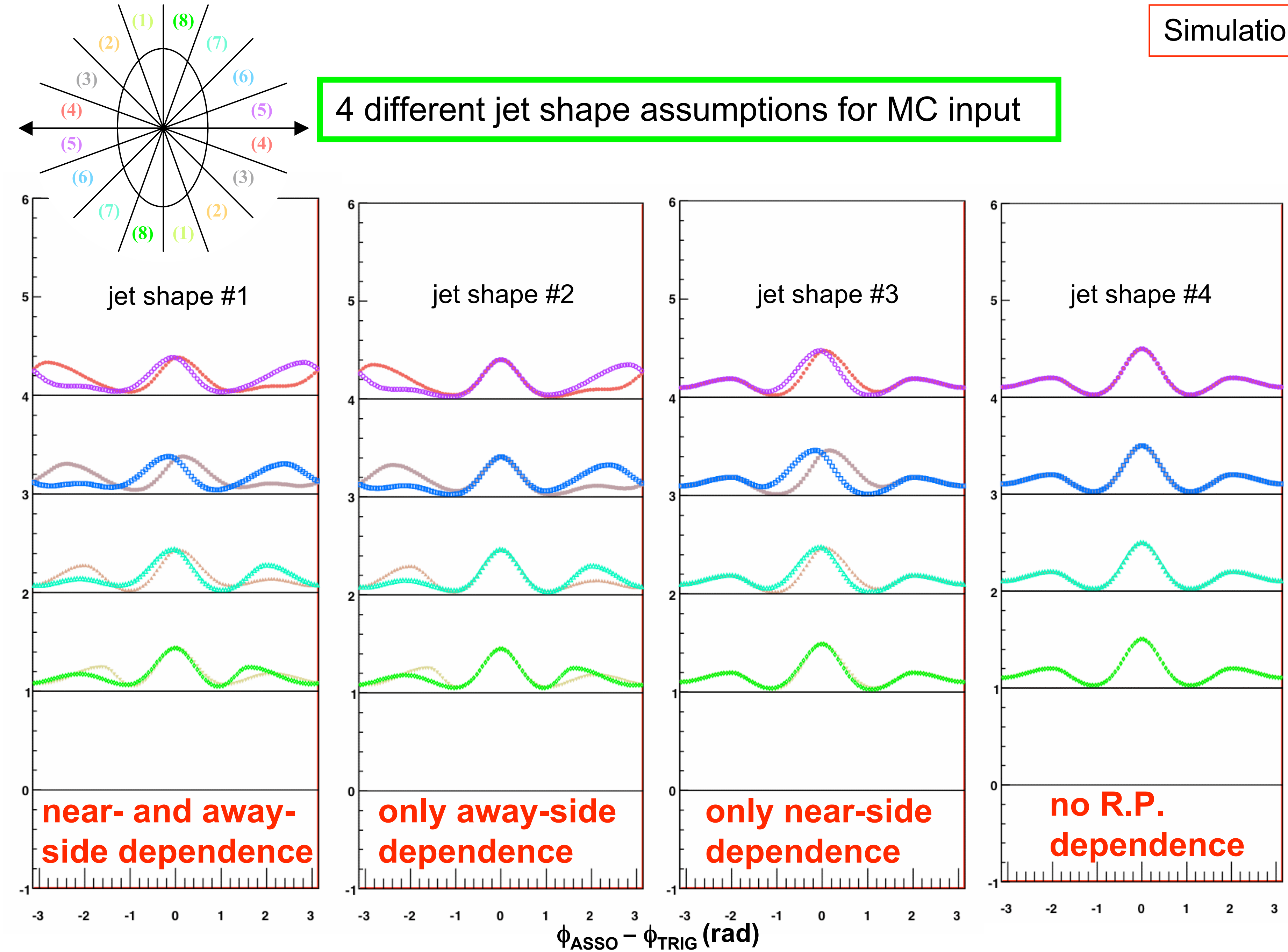
$F_{Near}(A_0, D_0, S_0)$ + $F_{Away+}(A_+, D_+, S_+)$ + $F_{Away-}(A_-, D_-, S_-)$

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




central : 0-20%
mid-central : 20-50%
peripheral : 50-93%

4 different jet shape assumptions for MC input



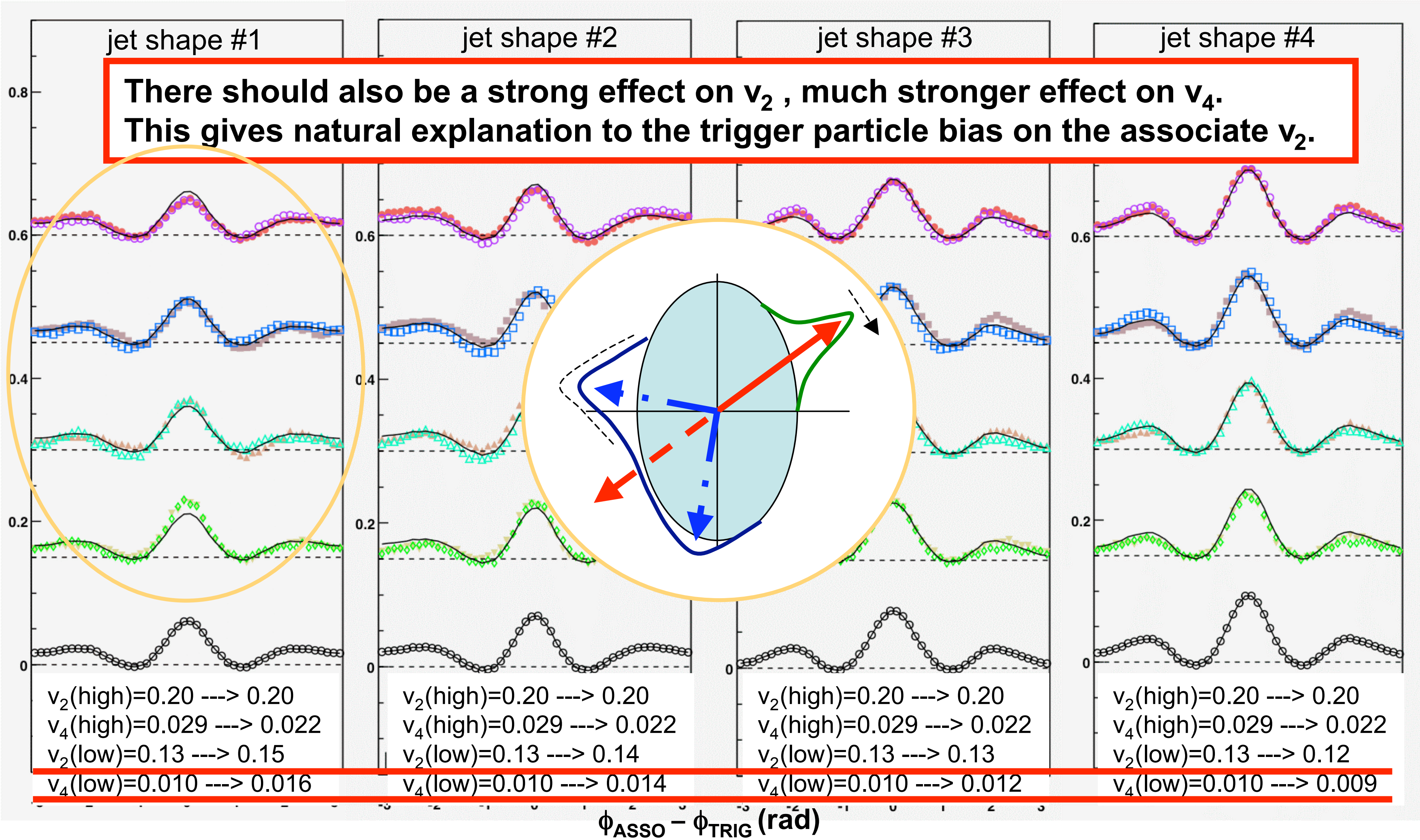
n_{Trig} / eve (soft) = 3
n_{Asso} / eve (soft) = 8
n_{Jet} / eve (hard) = 1
n_{PTY} / jet (hard) = 1.25

$v_{2,4}^{Trig}$ (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

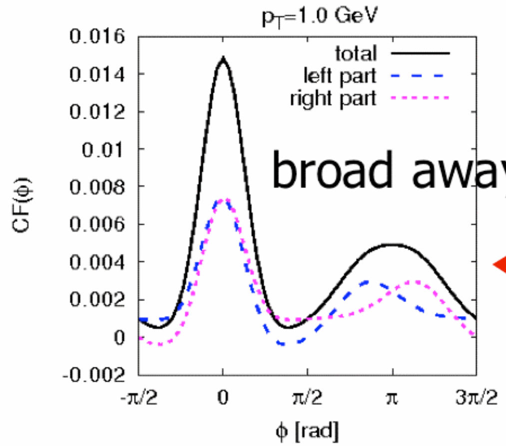
Comparison with data would tell us that there should be near- and away-side modification in experimental data.

Simulation

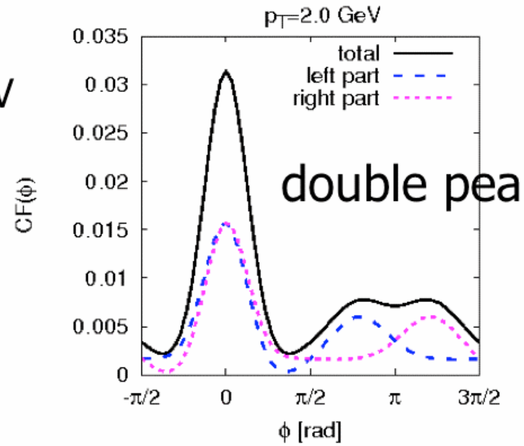
There should also be a strong effect on v_2 , much stronger effect on v_4.
This gives natural explanation to the trigger particle bias on the associate v_2.



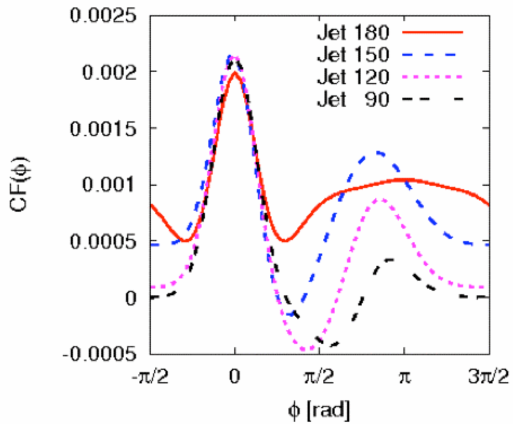
E_{tot} = 5 GeV
p_T^{trig} = 3.5 GeV



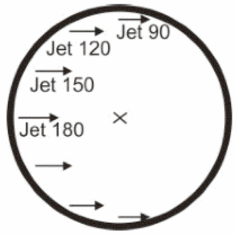
broad away-side peak

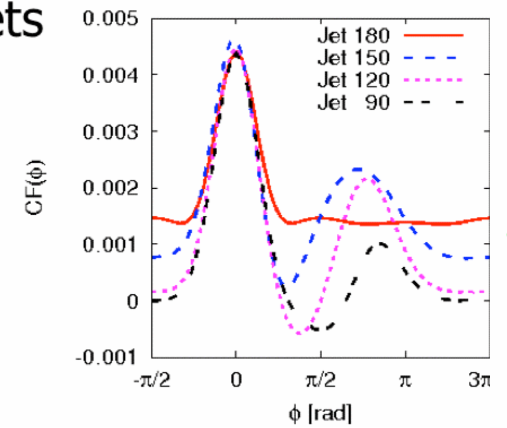


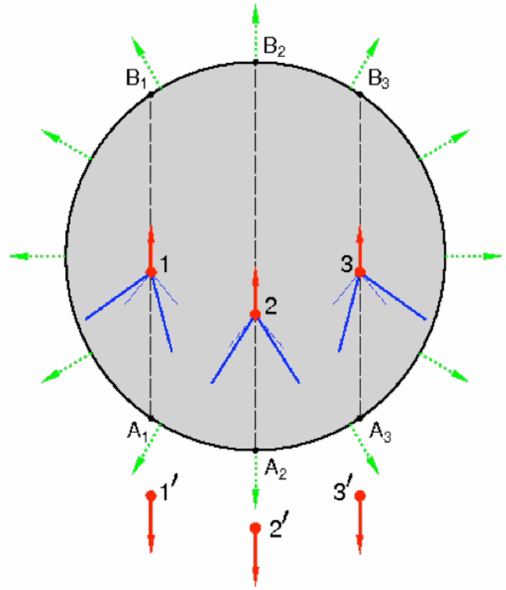
double peaked structure



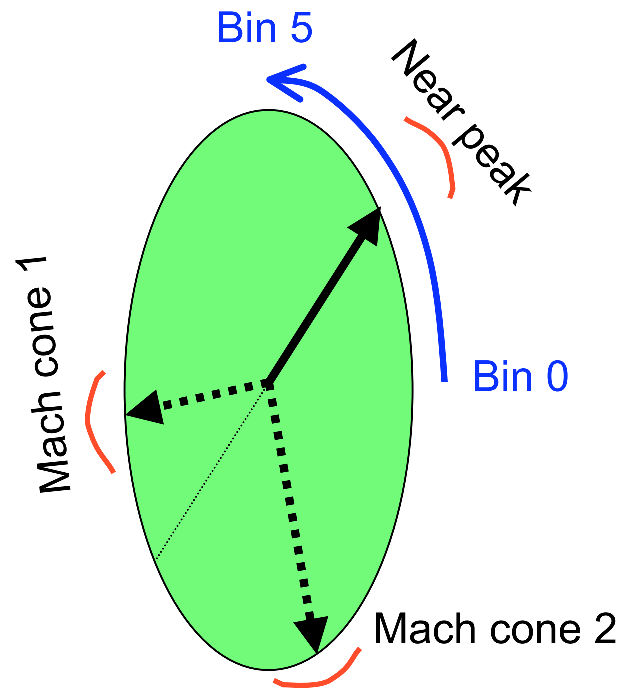
due to
non-central jets







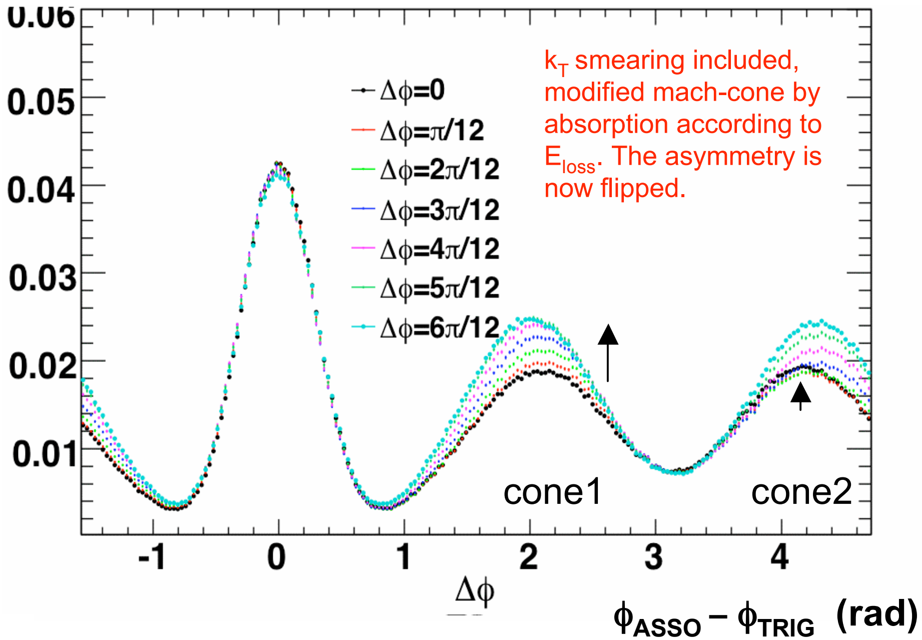
Satarov et al, PLB 627:64 (2005)

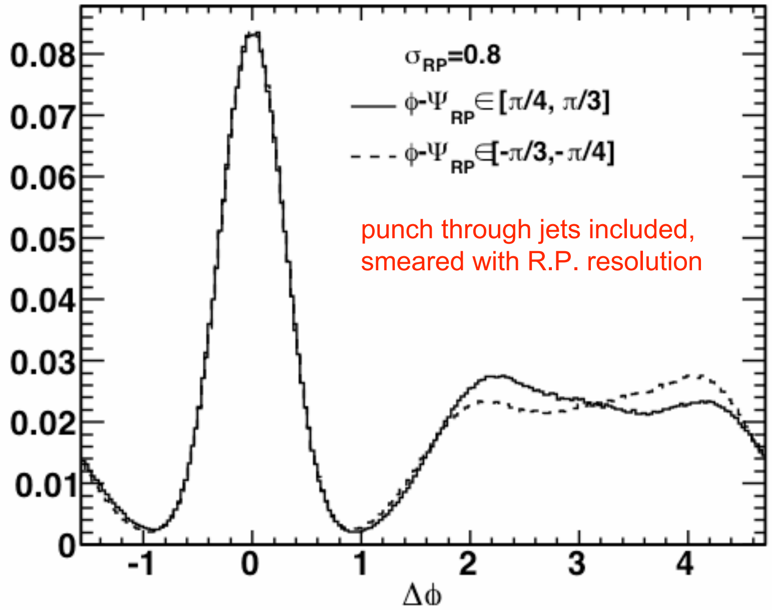


J.Jia, R.Wei, S.Esumi, arXiv:0903.3263

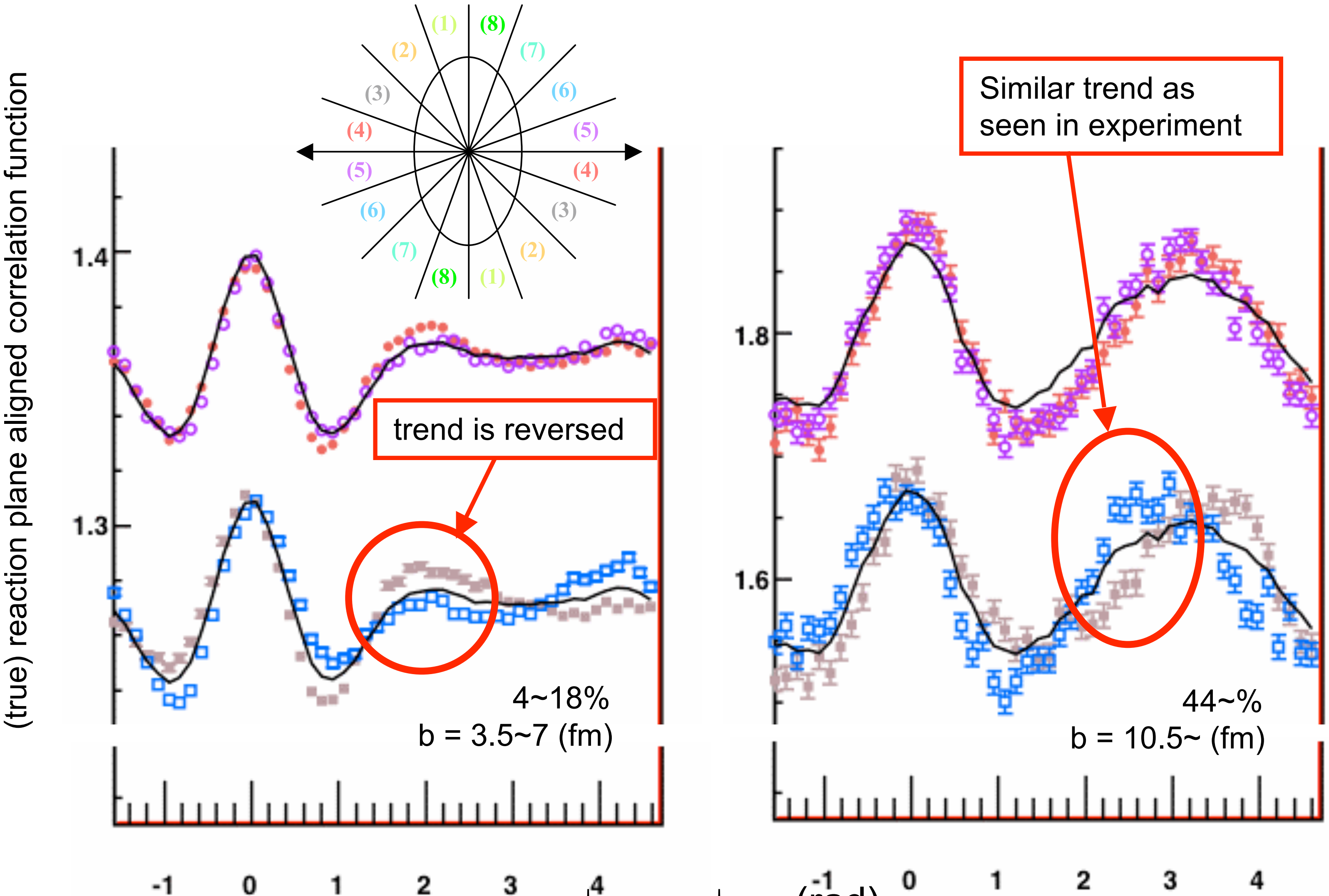
If the multiplicities reduces with the path length because of absorption...

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





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



$\phi_{Asso.} - \phi_{Trig.}$ (rad) with trigger angle selected w.r.t. R.P.

($p_T^{Asso.}$: 0.5~1.5GeV/c $p_T^{Trig.}$: 1.5~5.0GeV/c)

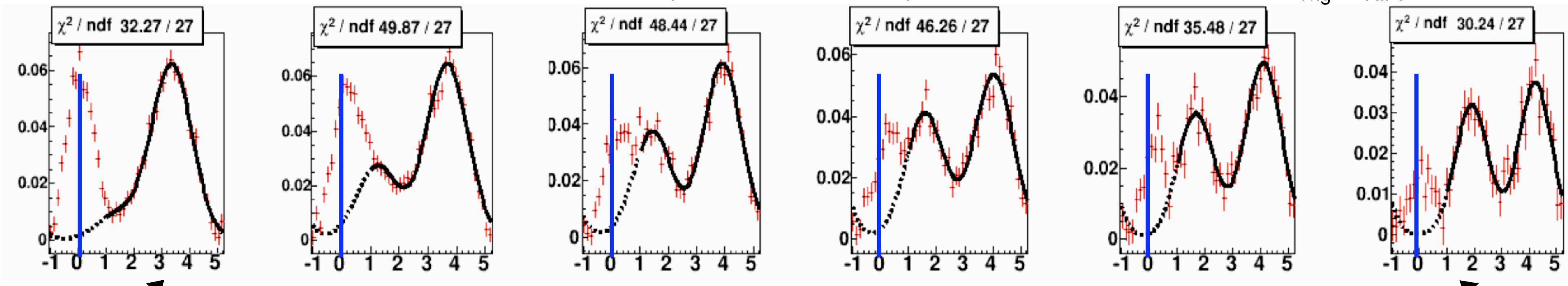
perfect R.P. resolution
no v_2 subtraction needed

Both near/away shapes show a strong v2 (in-plane preference) as well as a strong left/right asymmetry (in-plane preference)

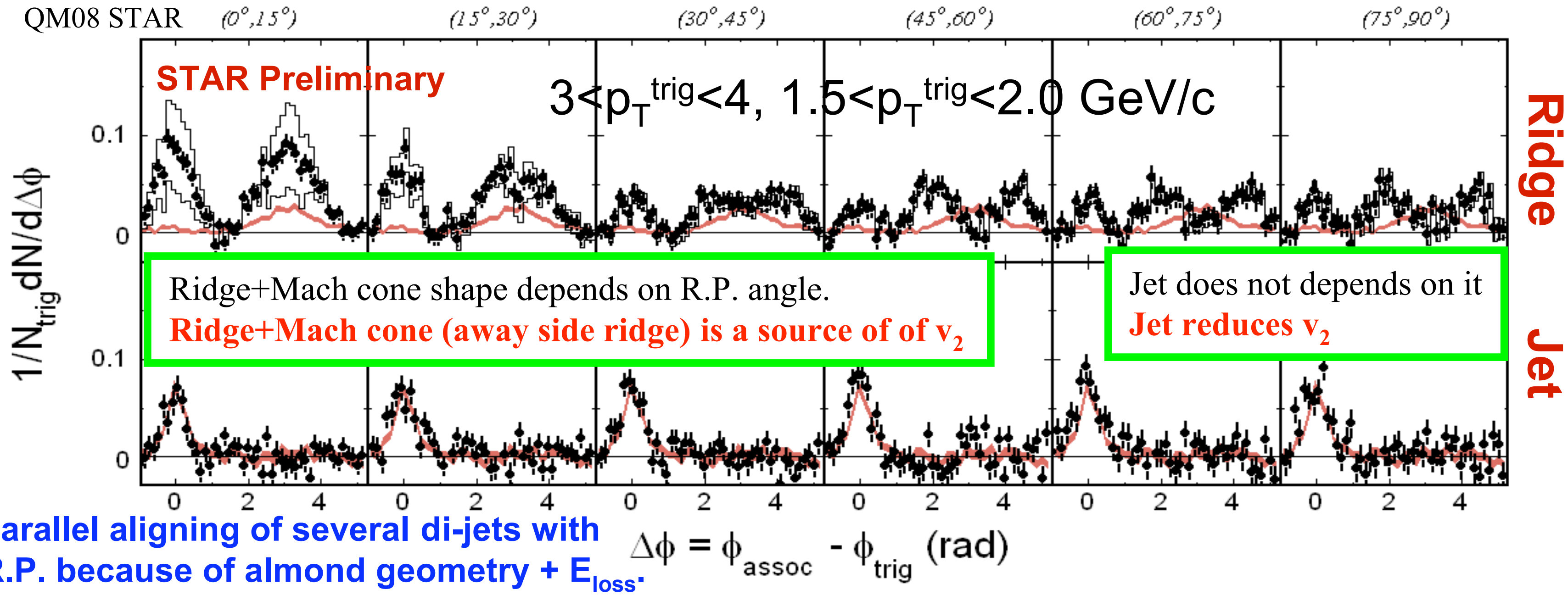
Ridge/Mach-cone like correlated pairs have been known to show similar properties as bulk in terms of inverse slope (apparent temperature) and particle ratios (Baryon/Meson)

QM09 STAR

200GeV Au+Au 20-60% (p_T^{Trig}=3~4GeV/c, p_T^{Asso}=1~1.5GeV/c, $|\Delta\eta|>0.7$, $\phi_{Trig}-\Phi_{R.P.}<0$)



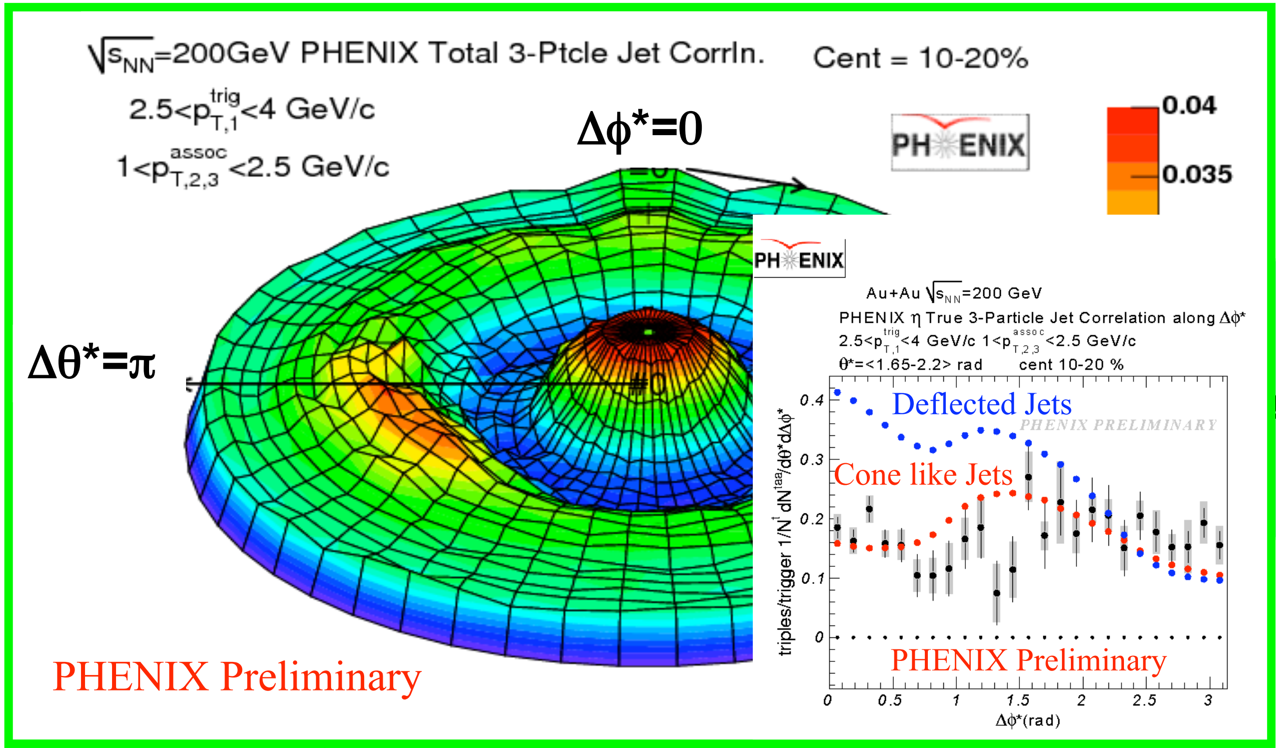
QM08 STAR

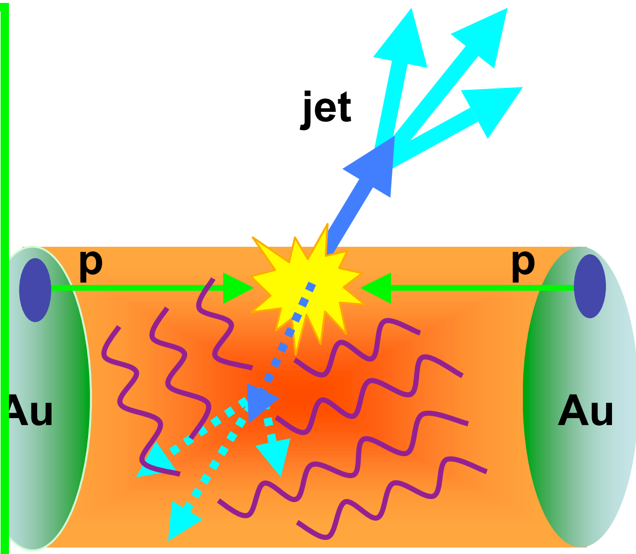


Ridge+Mach cone shape depends on R.P. angle.
Ridge+Mach cone (away side ridge) is a source of of v_2

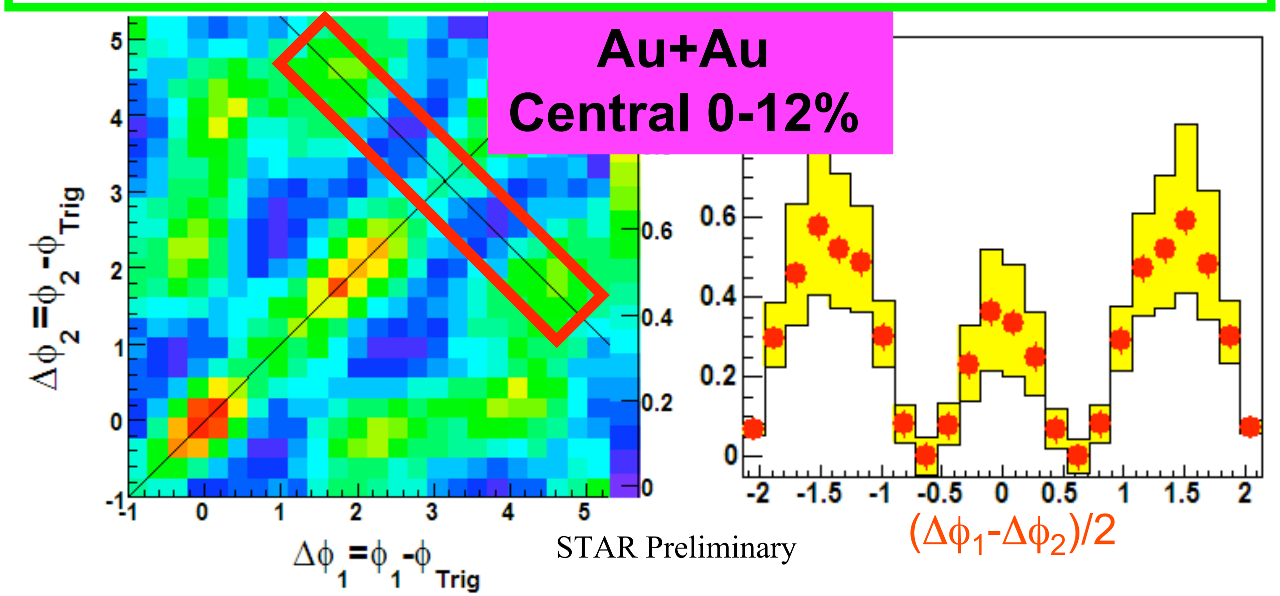
Jet does not depends on it
Jet reduces v_2

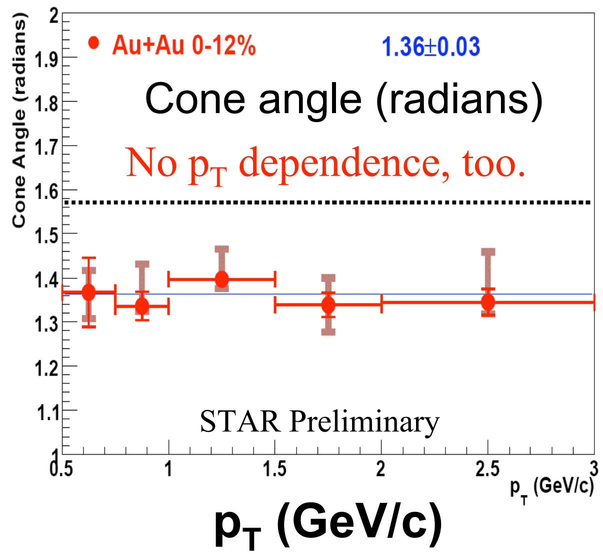
parallel aligning of several di-jets with R.P. because of almond geometry + E_{loss}.



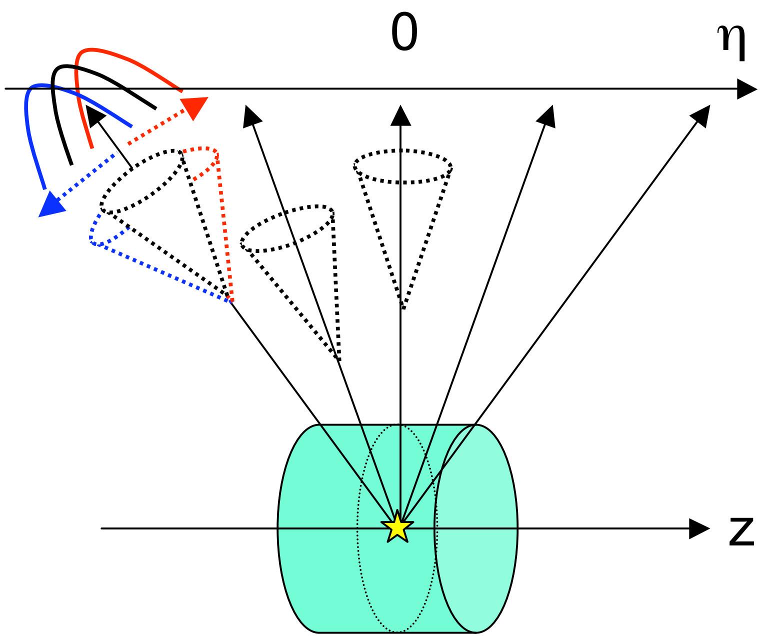


Both measurements prefer Mach-cone scenario.

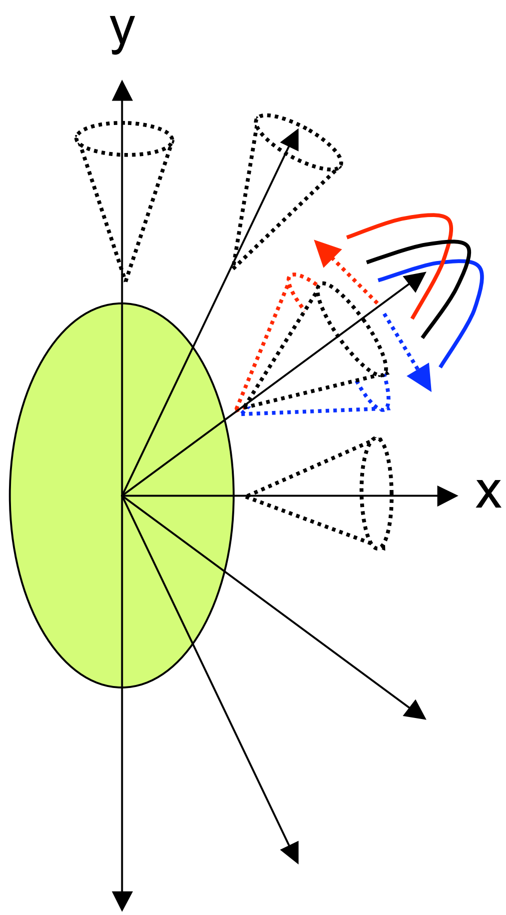




forward-backward asymmetry

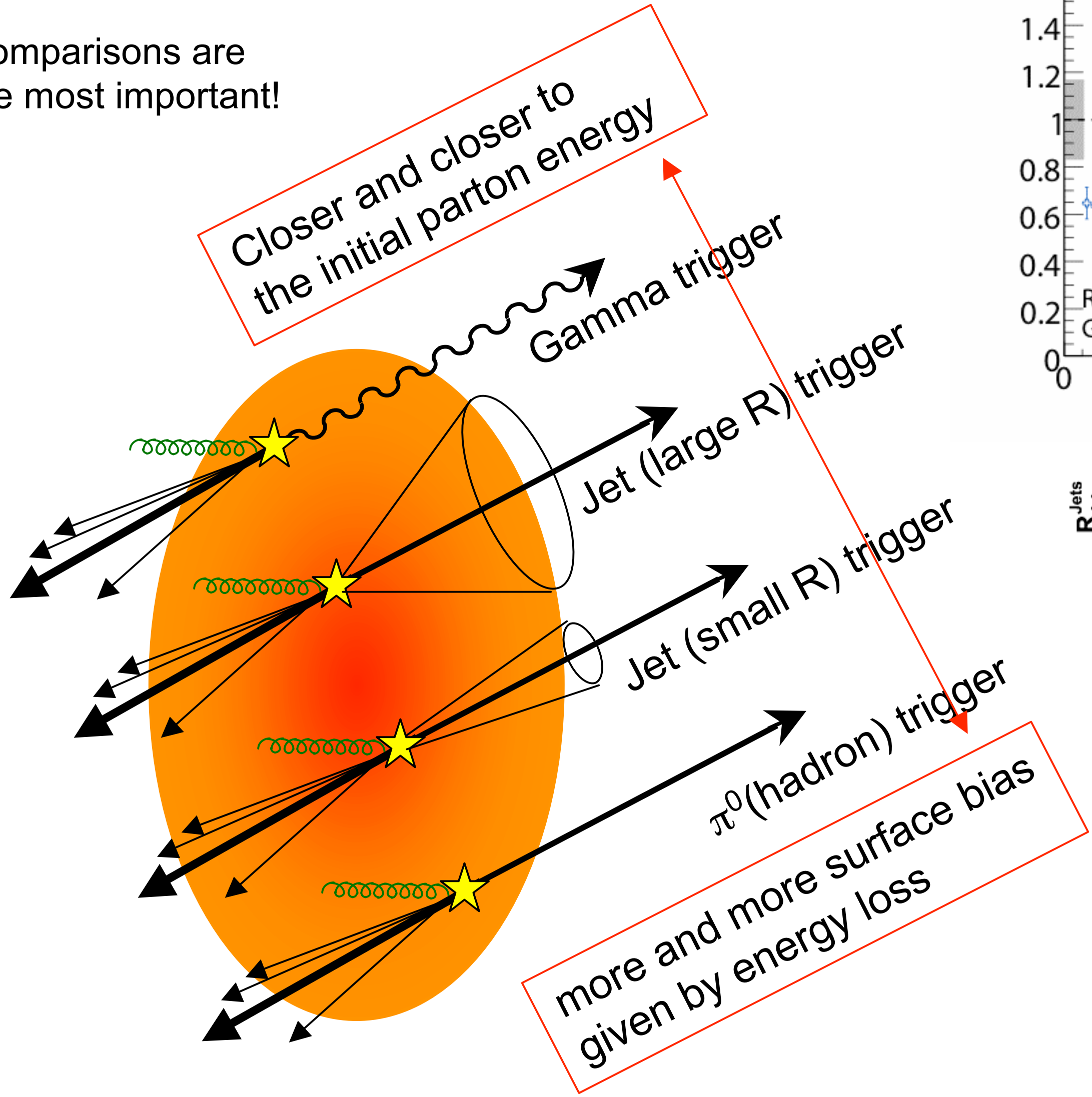


left-right asymmetry

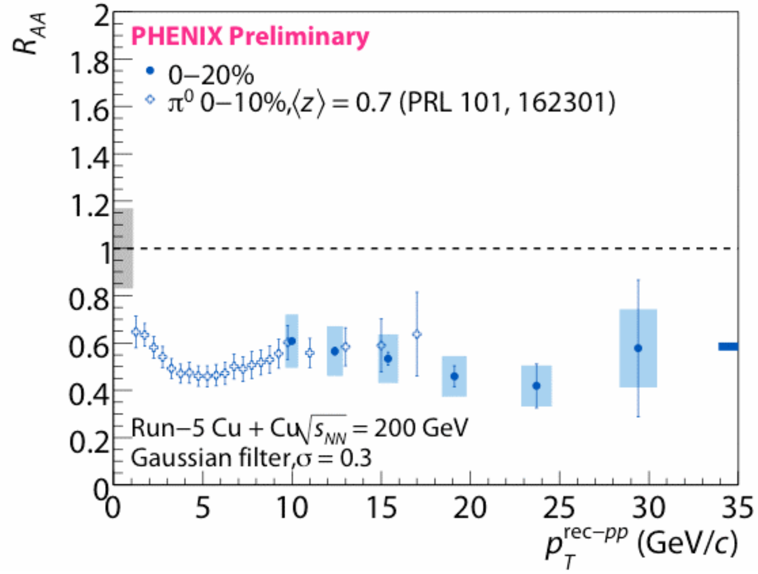


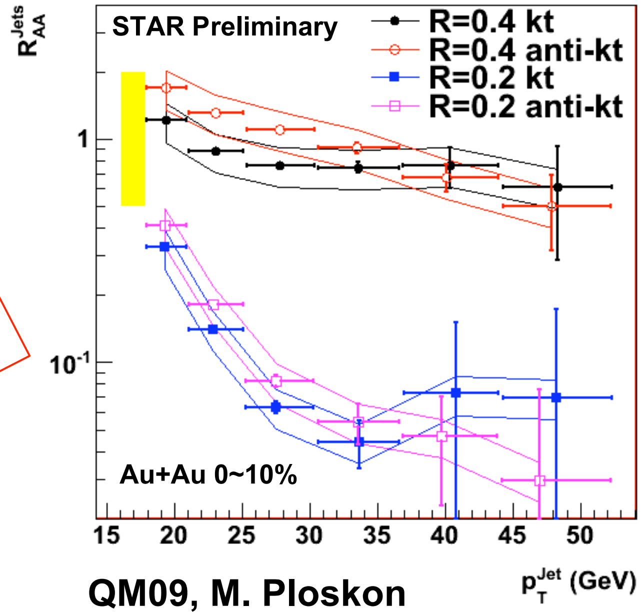
γ,Jet,π^0 - hadron correlation

Comparisons are
the most important!



RHIC-AGS'09, Y. S. Lai

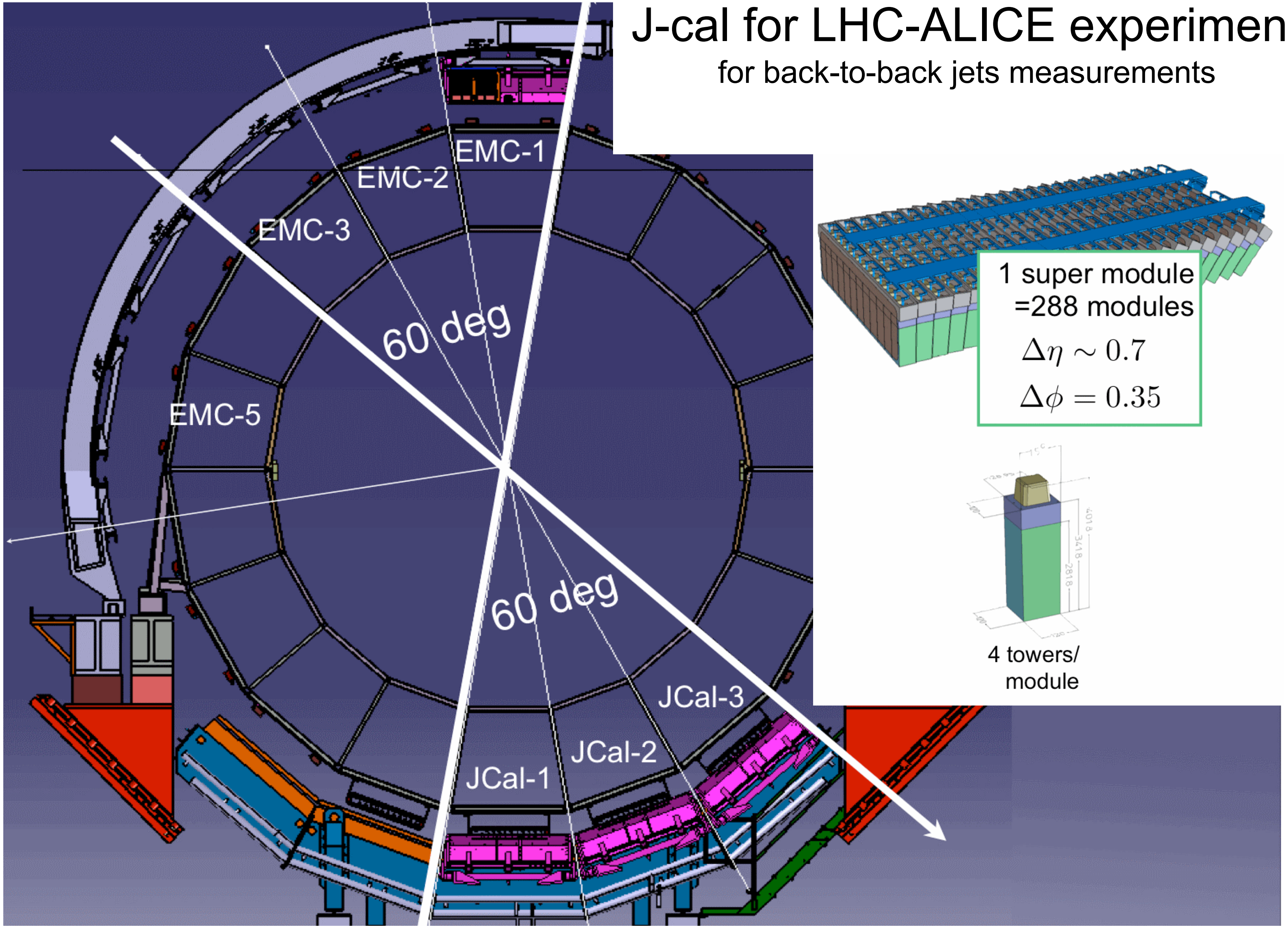




QM09, M. Ploskon

J-cal for LHC-ALICE experiment

for back-to-back jets measurements



Summary

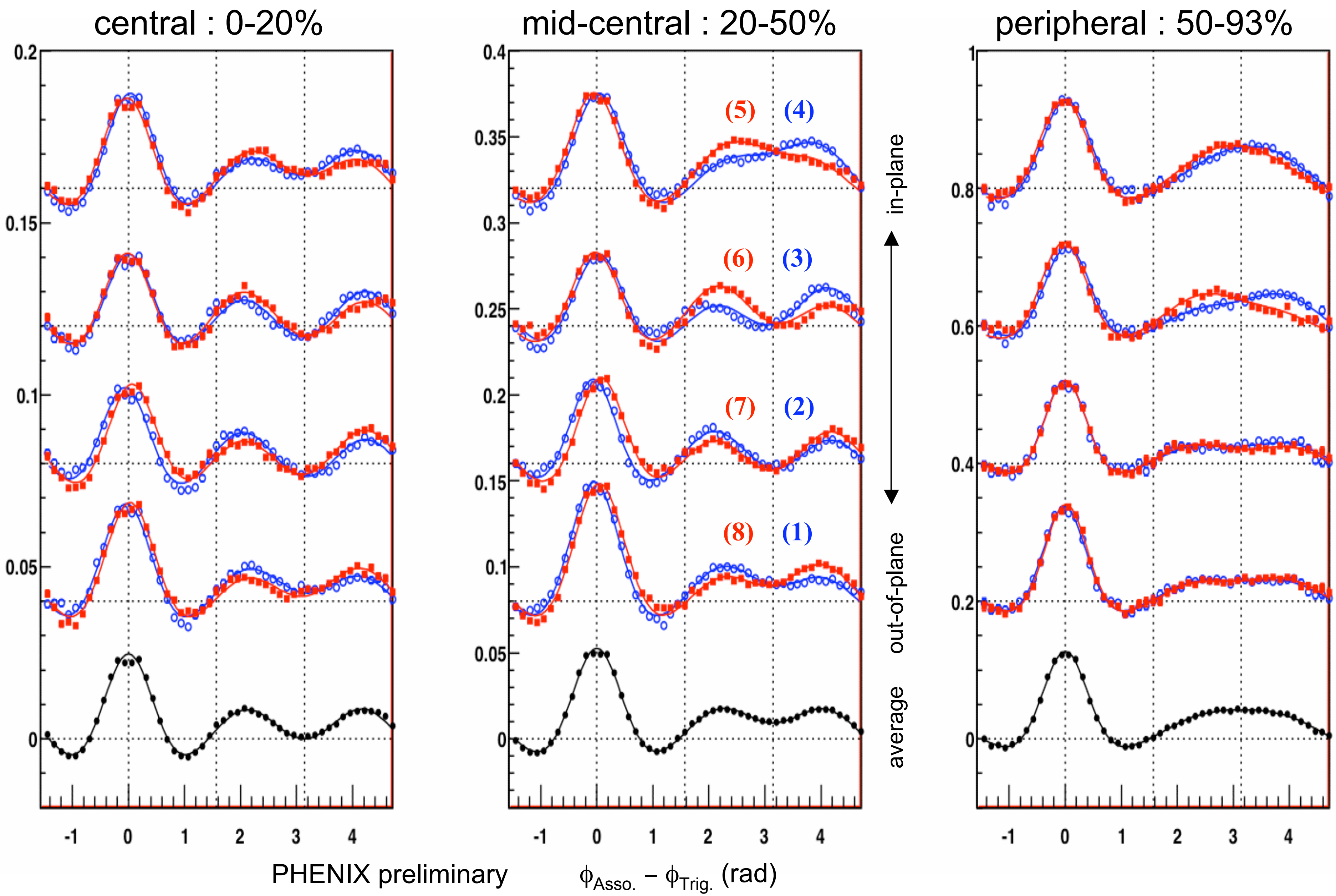
1) Gamma / Jet / hadron triggered correlation analysis
as a function of centrality and R.P.dependences
gives us the QGP tomography.

2) Mach-cone and Ridge like shape w.r.t.
   a) geometrical suppression from energy loss,
   b) re-distribution of the lost energy,
   c) connection with flow/expansion dynamics
   d) transverse, longitudinal and radial(surface) direction

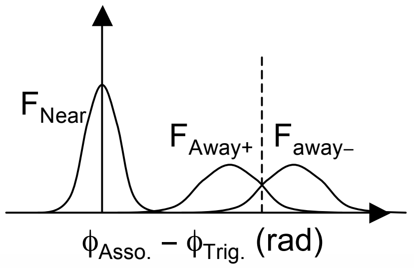
3) Low p_T v_2 can be biased by the triggered jet.
associated particle v_2^{hard} > inclusive v_2^{all} $\gtrsim$ thermal v_2^{soft}

4) Global understanding of R_{AA}, v_2 from low p_T (flow)
to high p_T (suppression), especially soft-hard interplay
at middle p_T region (jet without any flow subtraction?).

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



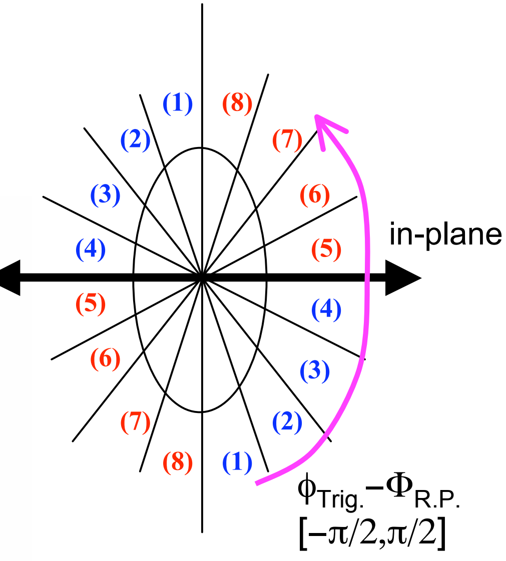
Results on fitting parameters

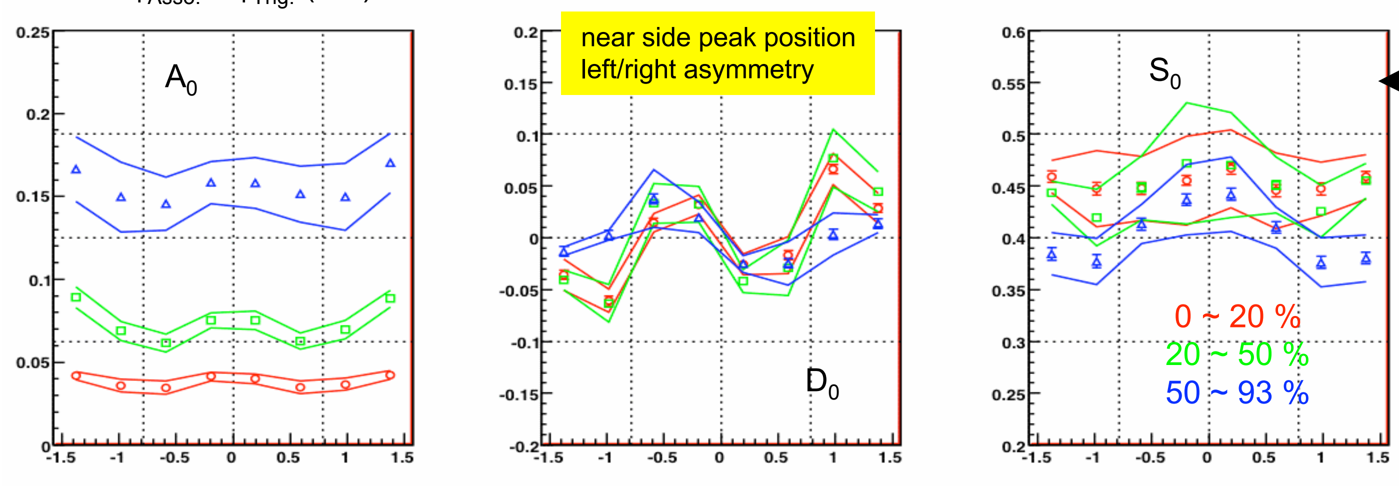


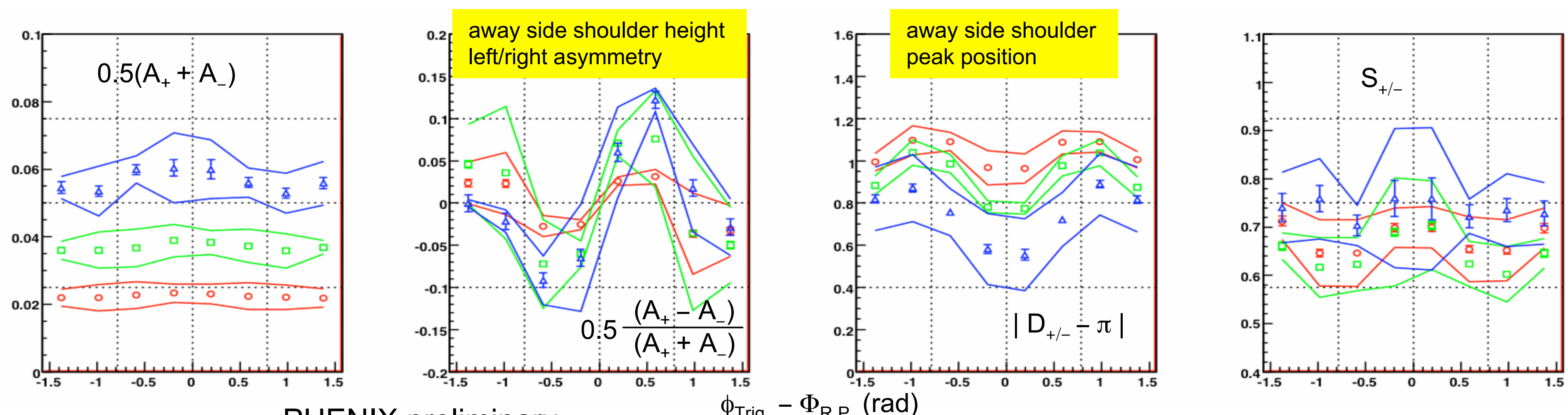
Gauss function : F(height, mean, width)

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

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







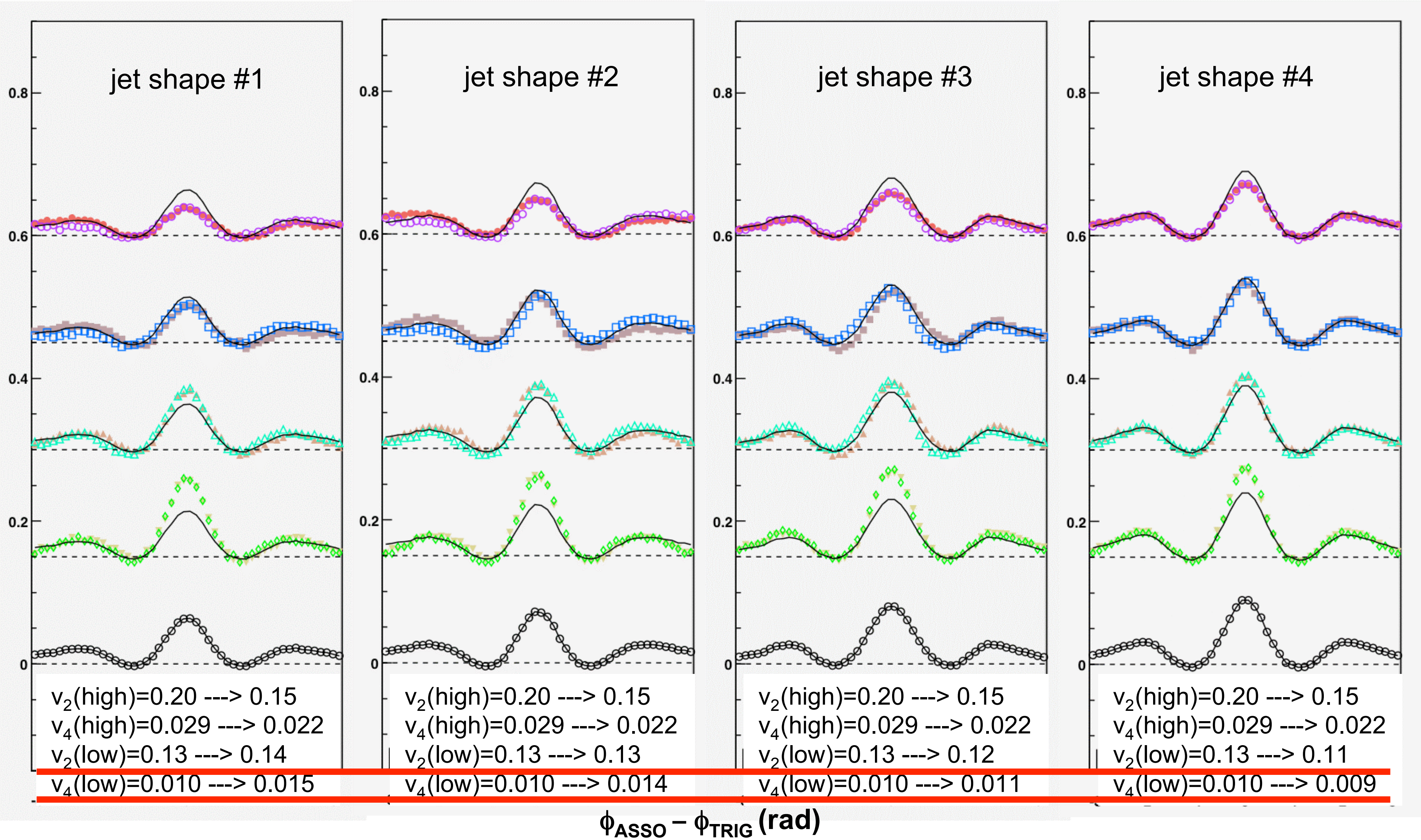
PHENIX preliminary

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

Simulation

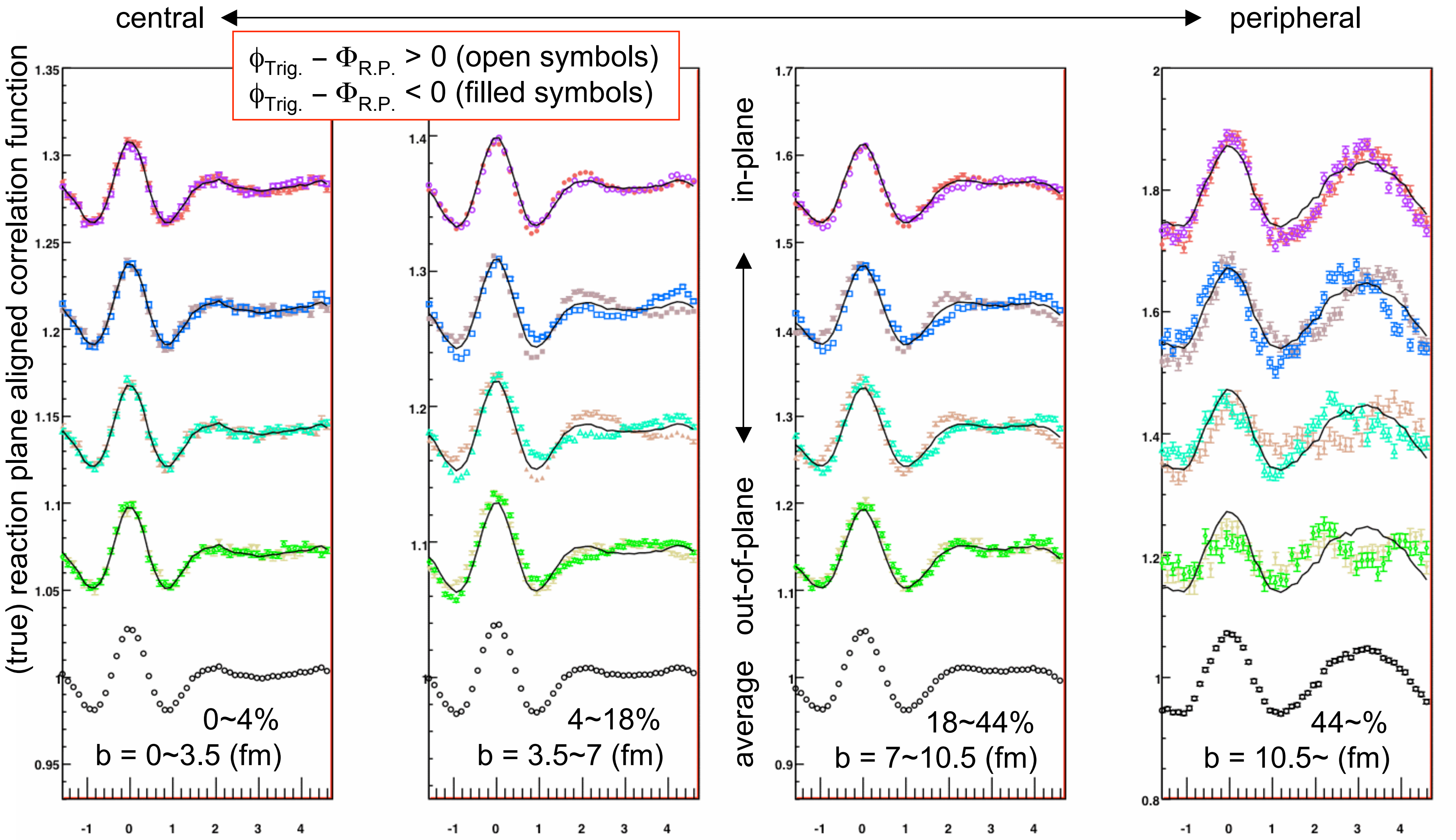
n_{Trig} / eve (soft) = 3
n_{Asso} / eve (soft) = 8
n_{Jet} / eve (hard) = 1
n_{PTY} / jet (hard) = 1.25

$v_{2,4}^{Trig}$ (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



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

AMPT

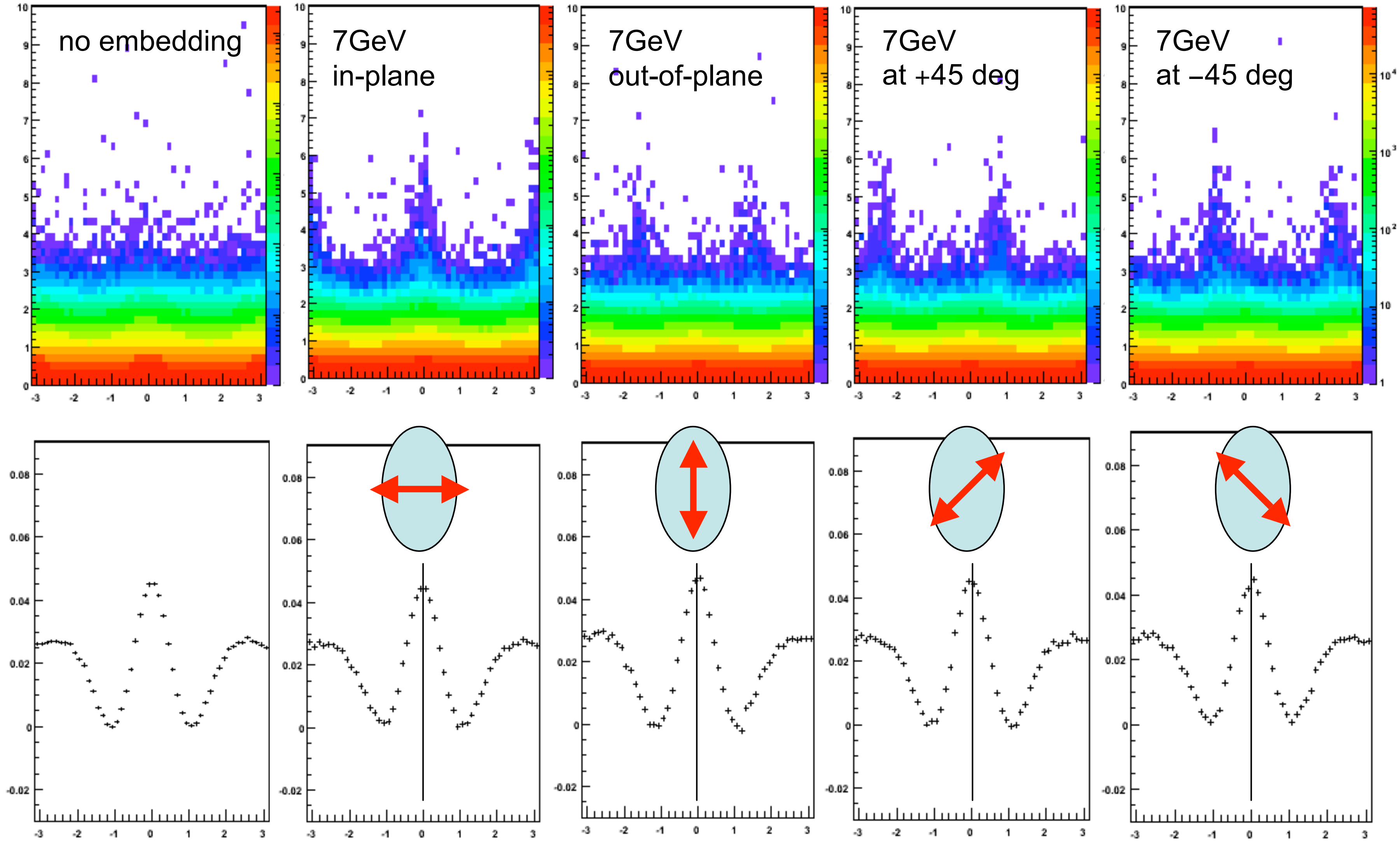


perfect R.P. resolution
no v_2 subtraction needed

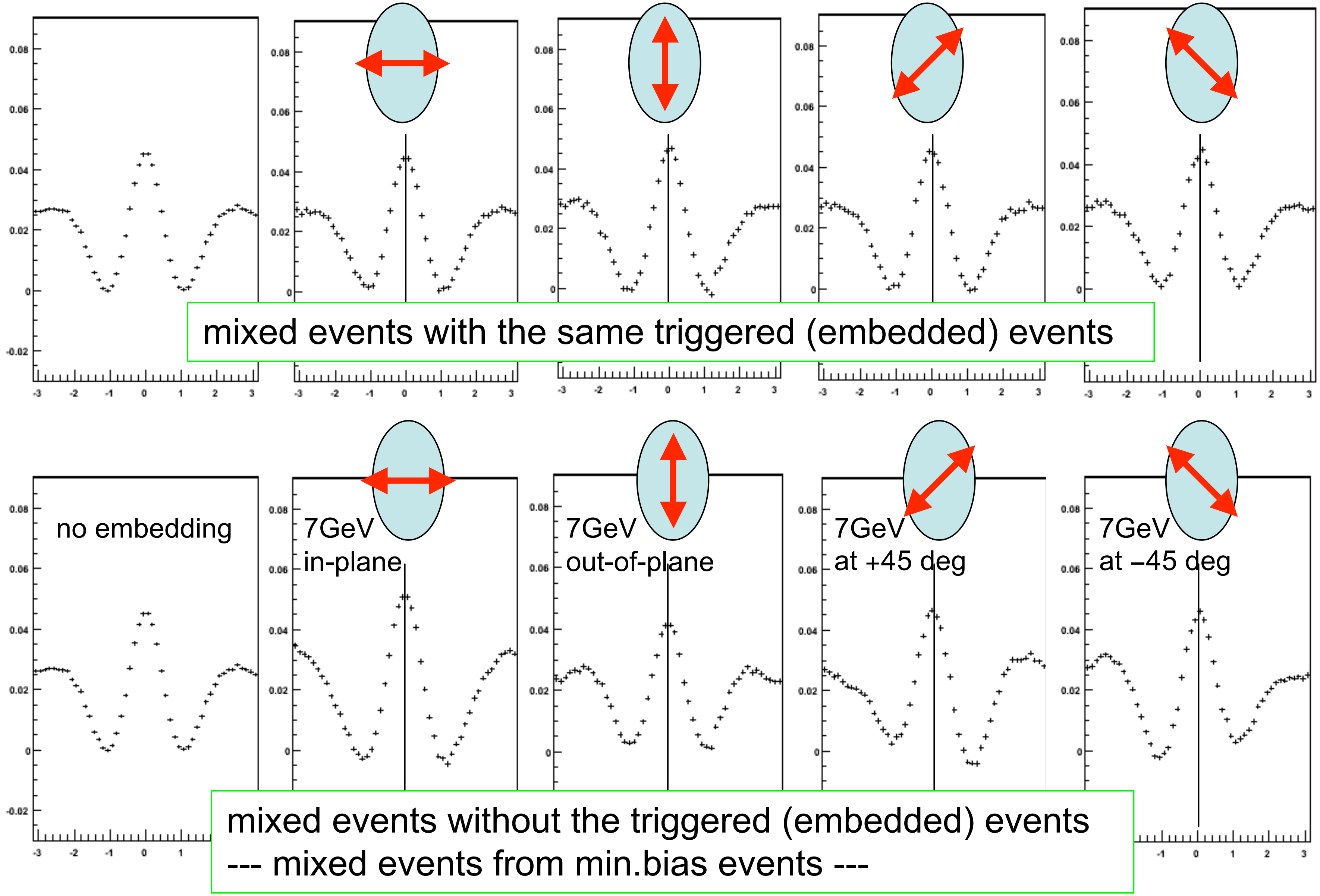
$\phi_{Asso.} - \phi_{Trig.}$ (rad) with trigger angle selected w.r.t. R.P.
($p_T^{Asso.}$: 0.5~1.5GeV/c $p_T^{Trig.}$: 1.5~5.0GeV/c)

AMPT(v1.25/v2.25 string melting) : Au+Au 200GeV b=7fm (with embedding option)

Z.W.Lin, J.Jia,
S. Mohapatra,
S. Esumi

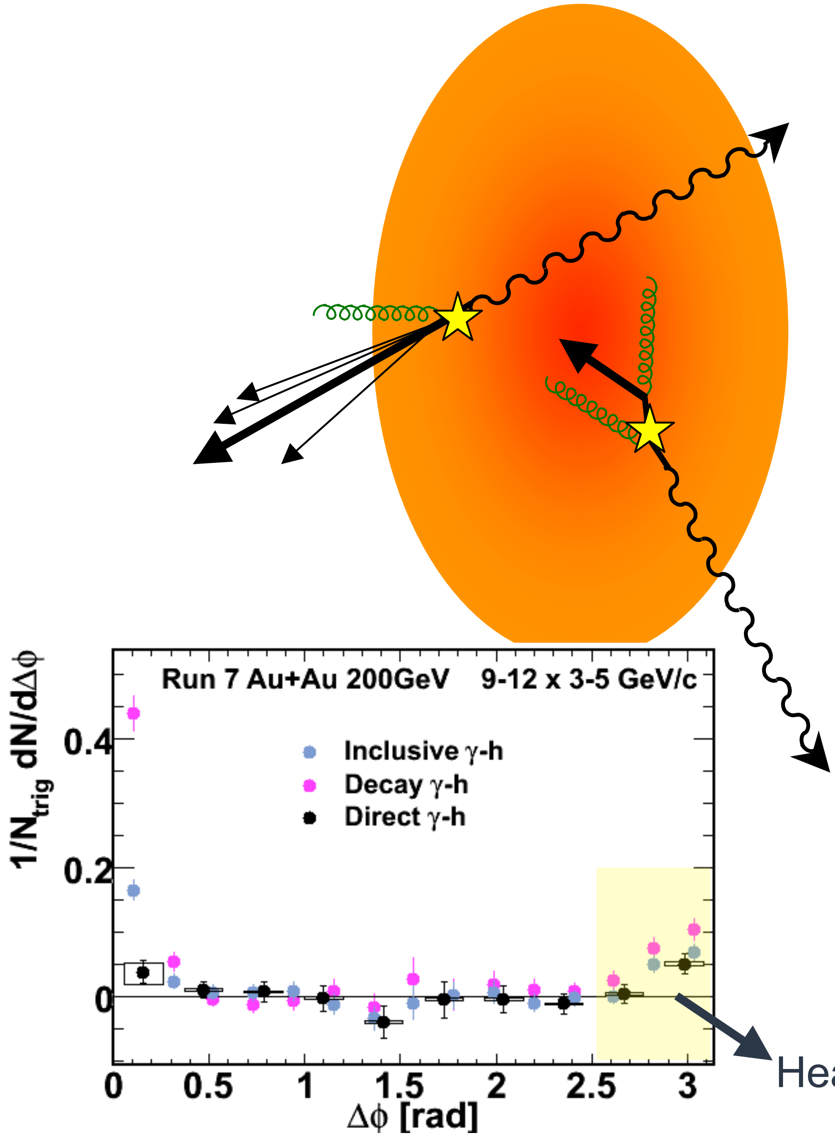


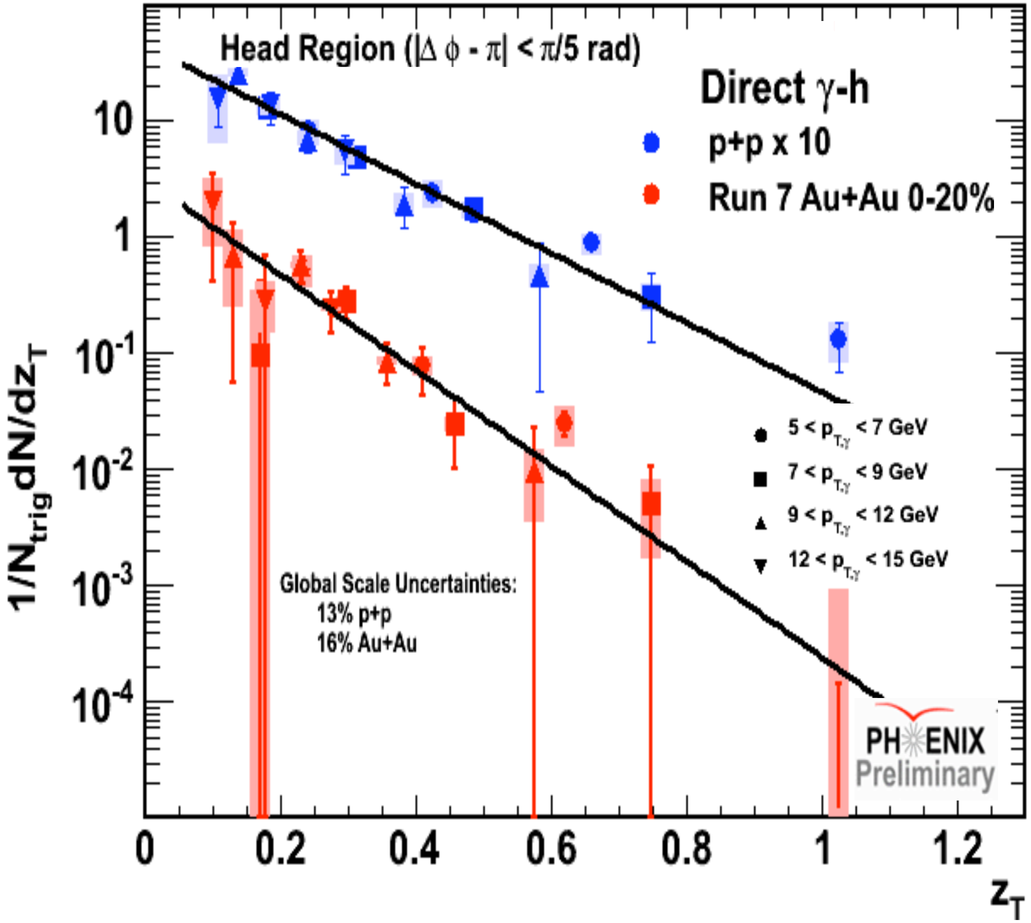
mixed events with the same triggered (embedded) events

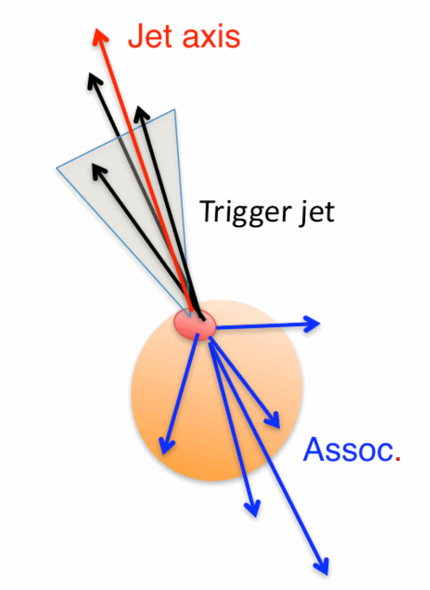

mixed events with the same triggered (embedded) events
no embedding
7GeV
in-plane
7GeV
out-of-plane
7GeV
at +45 deg
7GeV
at –45 deg
mixed events without the triggered (embedded) events
--- mixed events from min.bias events ---

Direct γ - hadron coincidence

QM09, M. Connors



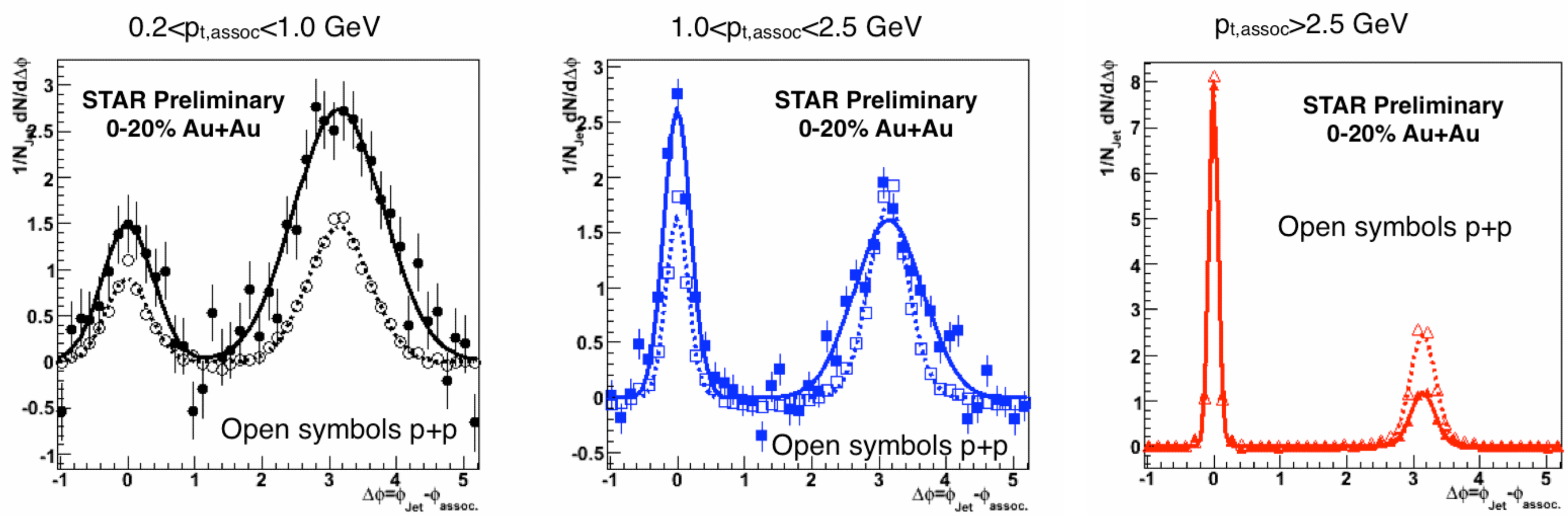


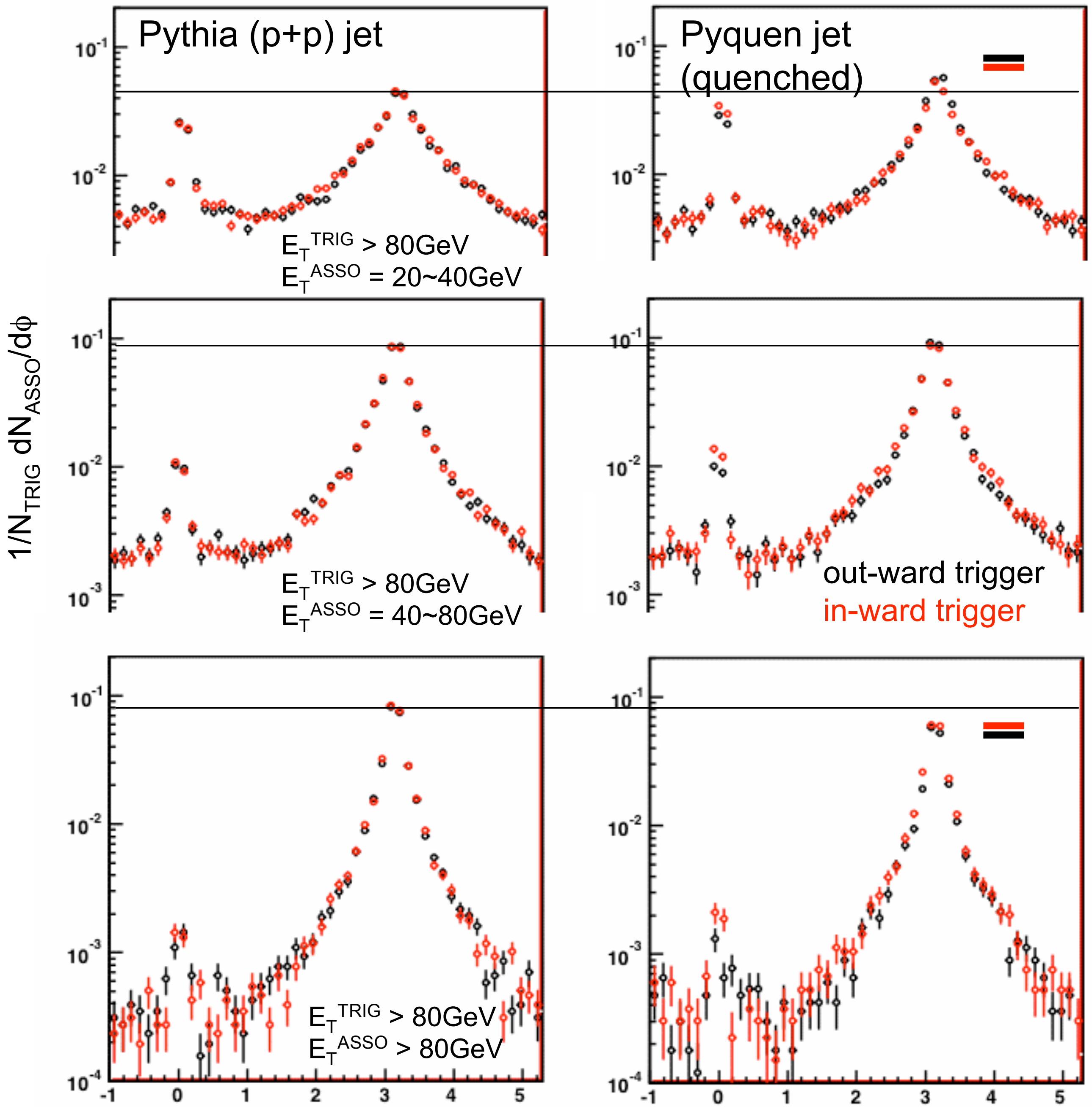


Jet - hadron correlation

RHIC-AGS'09, J. Putschke

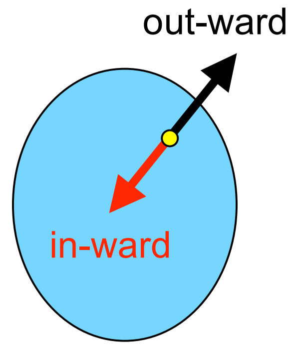
High Tower Trigger (HT) : $(\eta x \phi)=(0.05x0.05)$ $E_T>5.4GeV$



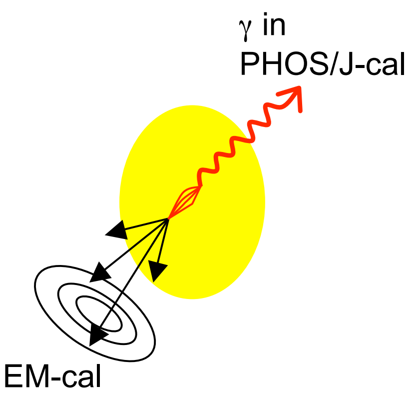


Di-jet simulation at 5.5TeV

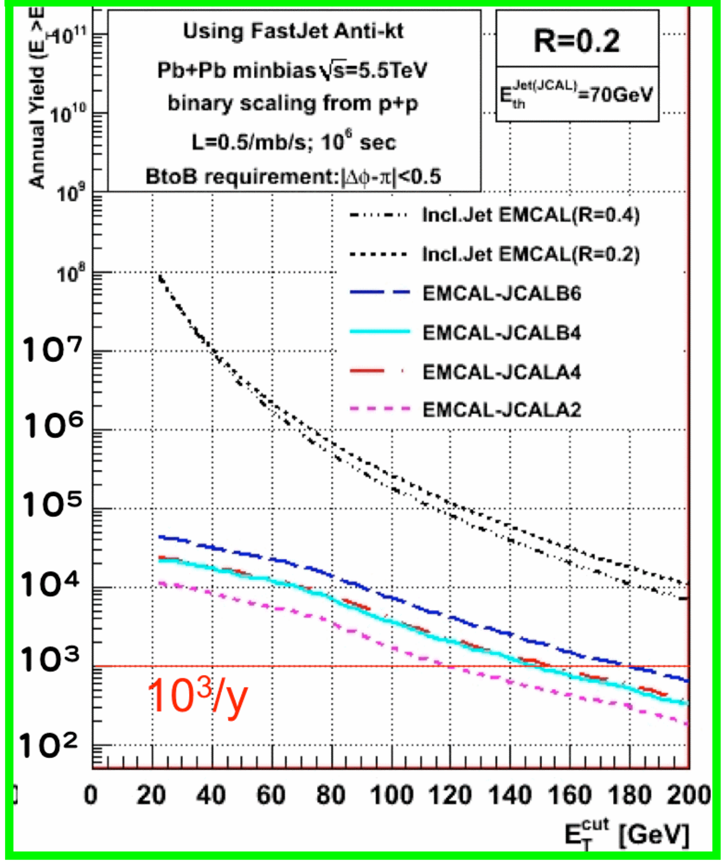
between
pythia (p+p)
and
pyquen
(quench model)

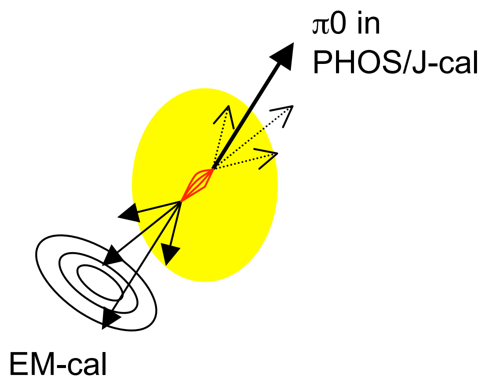


D. Sakata,
Grad. Student of Tsukuba

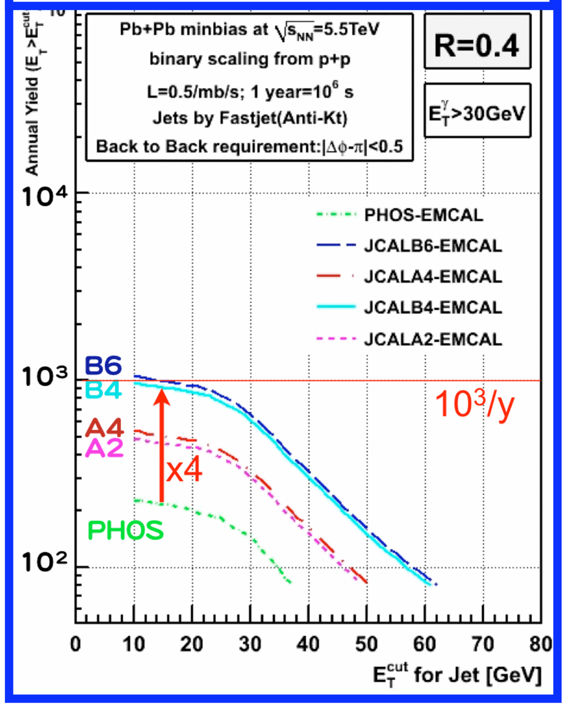


Recoil Di-jet E_T^{jet1}>70GeV

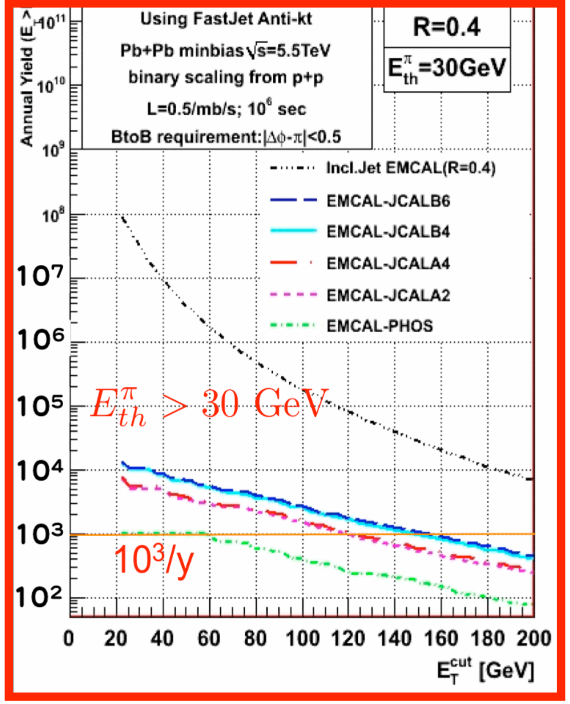


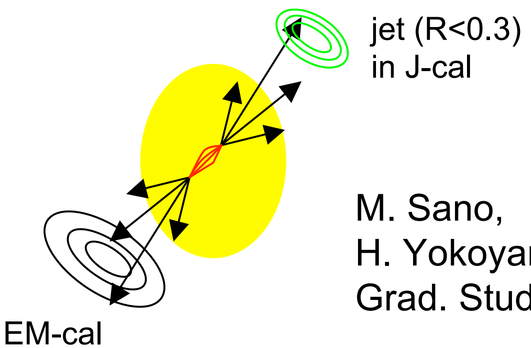


Recoil γ-jet E_T^{γ}>30GeV



Recoil π^0-jet $E_T^{\pi 0}$>30GeV





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

Improvement in jet energy resolution