Two particle correlations with respect to higher harmonic plane in Au+Au 200 GeV collisions at RHIC-PHENIX

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Outline

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   - ✓Backgrounds from v_n in correlations
   - ✓v_n subtracted correlations
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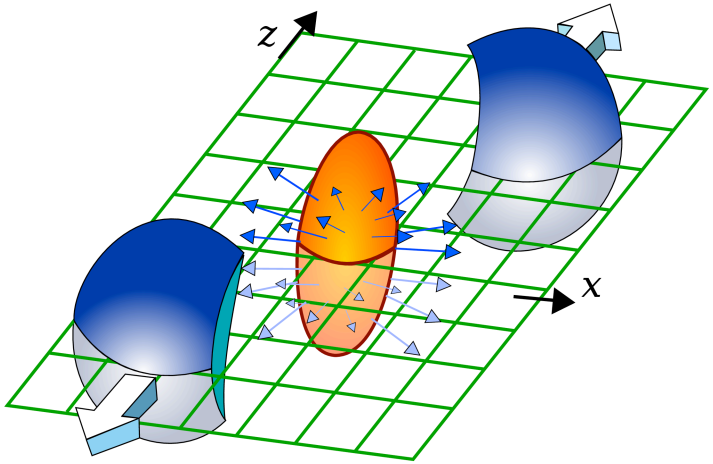
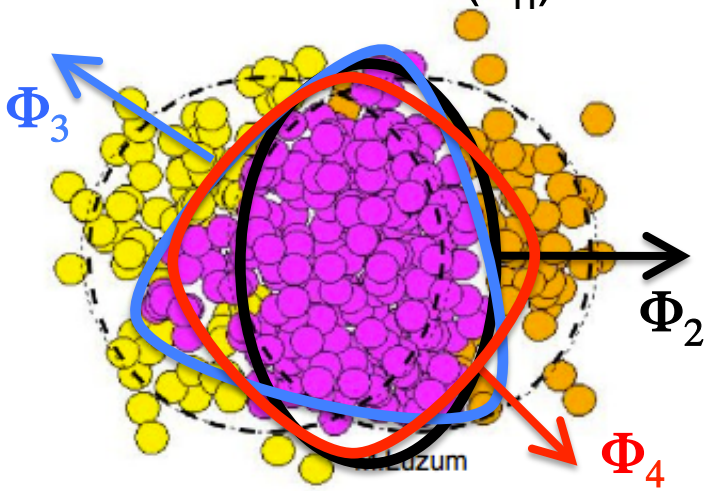
   - ✓Φ_2 & Φ_3 dependence
5. **Summary**

Higher harmonic event plane & flow

- **Previous picture; Assumed a "reaction plane" defined by impact parameter vector and beam axis vector**
- **Recent picture; Higher harmonic deformation due to fluctuations of collision geometry**
  - ✓ Deformation transferred to momentum space by collective expansion → higher harmonic flow(v_n)



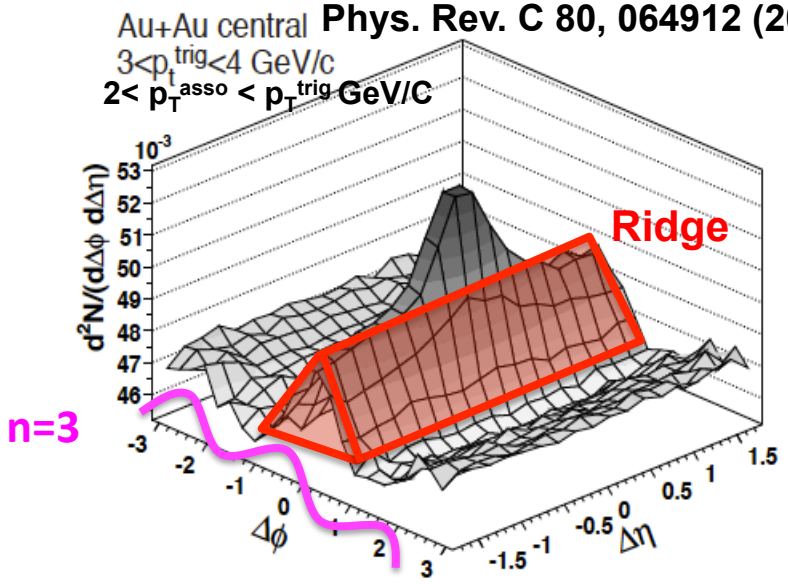


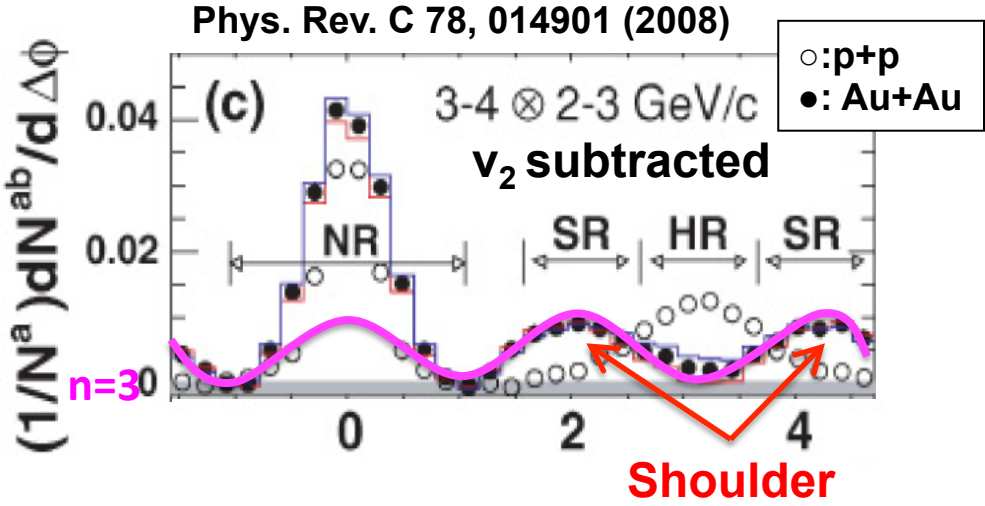
Azimuth. distribution

$$\frac{dN}{d\phi} \propto 1 + 2v_2 \cos 2(\phi - \Phi_2) + 2v_3 \cos 3(\phi - \Phi_3) + 2v_4[\Phi_4] \cos 4(\phi - \Phi_4)$$

Backgrounds from v_n in 2 particle correlations

$$Jet(\Delta\phi) = CF(\Delta\phi) - b_0 Flow(\Delta\phi)$$



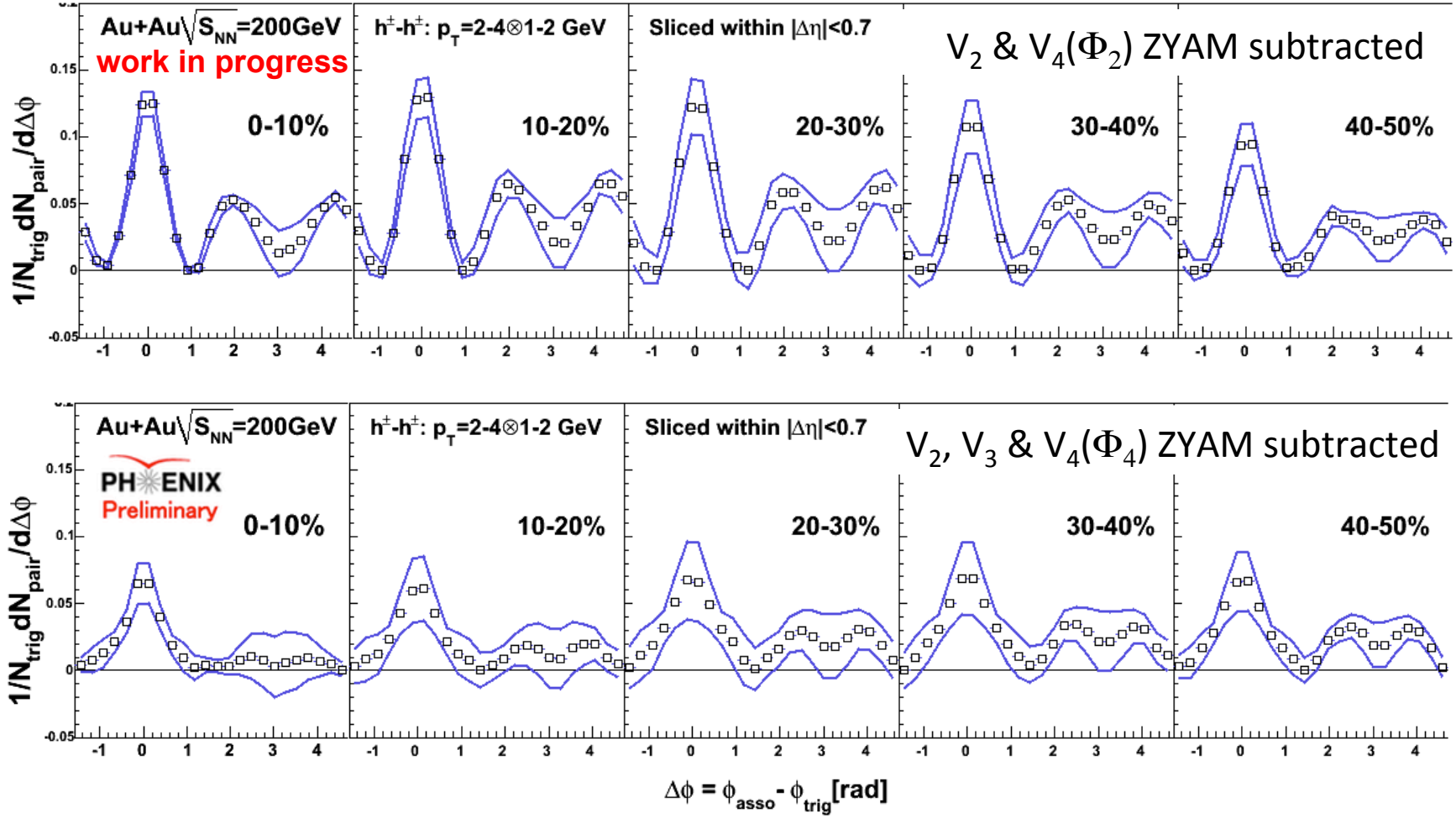


Ridge : near side long range $\Delta\eta$ correlations

Shoulder: double hump at away side of $\Delta\phi$ correlations (also long in $\Delta\eta$)

- **Backgrounds from v_n** $\sim b_0 2 v_n^{trig} v_n^{asso} \cos n\Delta\phi$
  - ✓ v_n (especially v_3) subtraction reduce "Ridge" and "Shoulder"
  - ✓ v_n subtractions help to see more "real" correlation shape

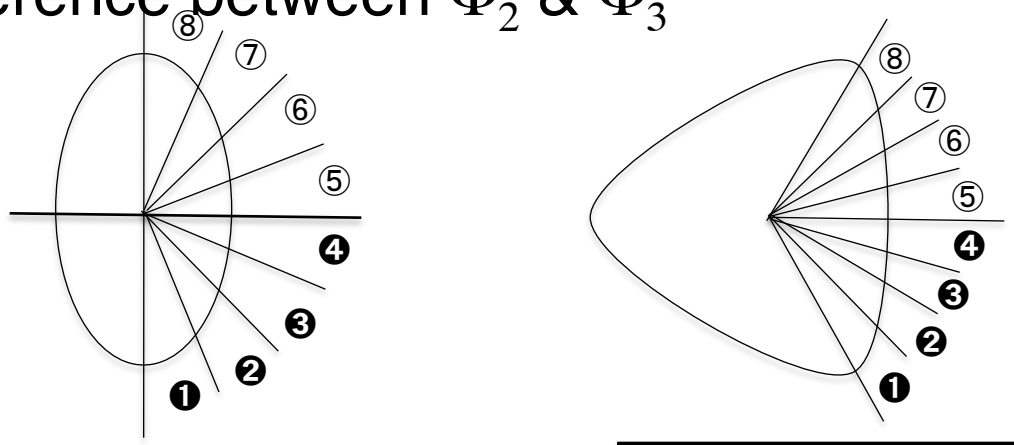
v_n subtracted correlations



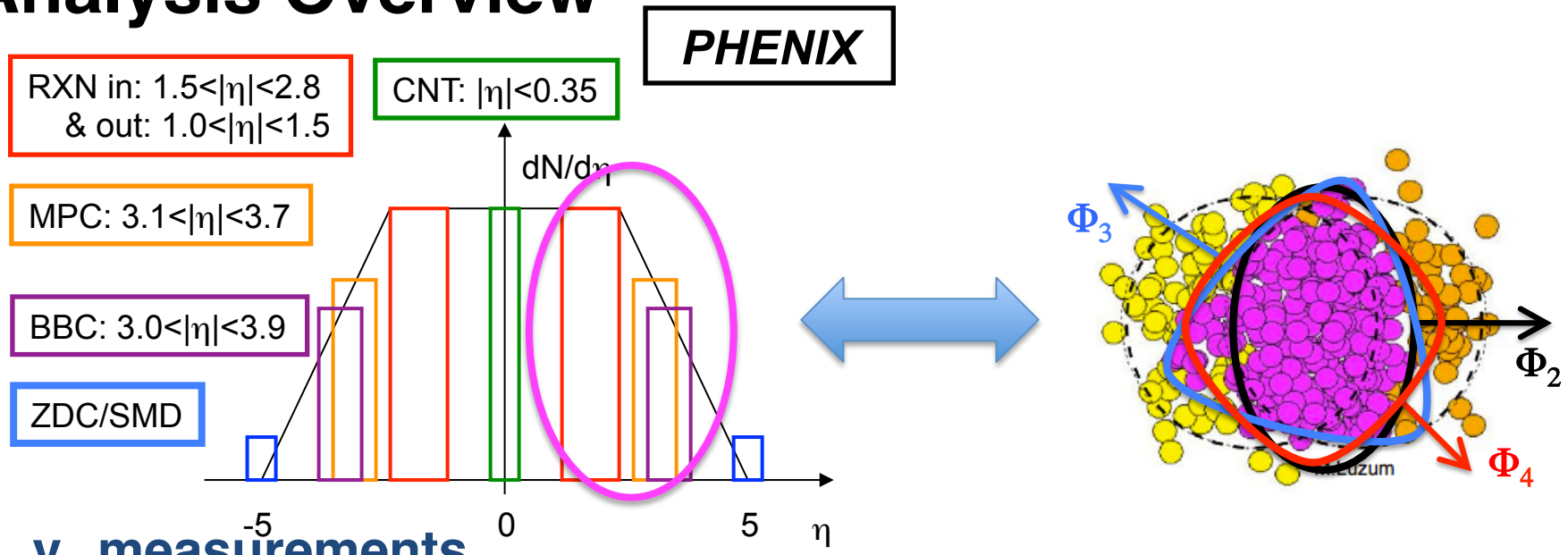
- Shoulder is described by v_n in central collisions
- Shoulder is still seen in mid-central collisions

Physics Motivations

- **v_n subtracted correlations still show double-hump structure in ways side in mid-central collisions**
  - ✓ Average of jets flying to various direction in bulk
- **Detailed survey of away side peaks**
  - ✓ Two particle correlations with trigger selection relative to Φ_2 & Φ_3
    - Modification of away side w.r.t. Φ_2 & Φ_3
    - Difference between Φ_2 & Φ_3

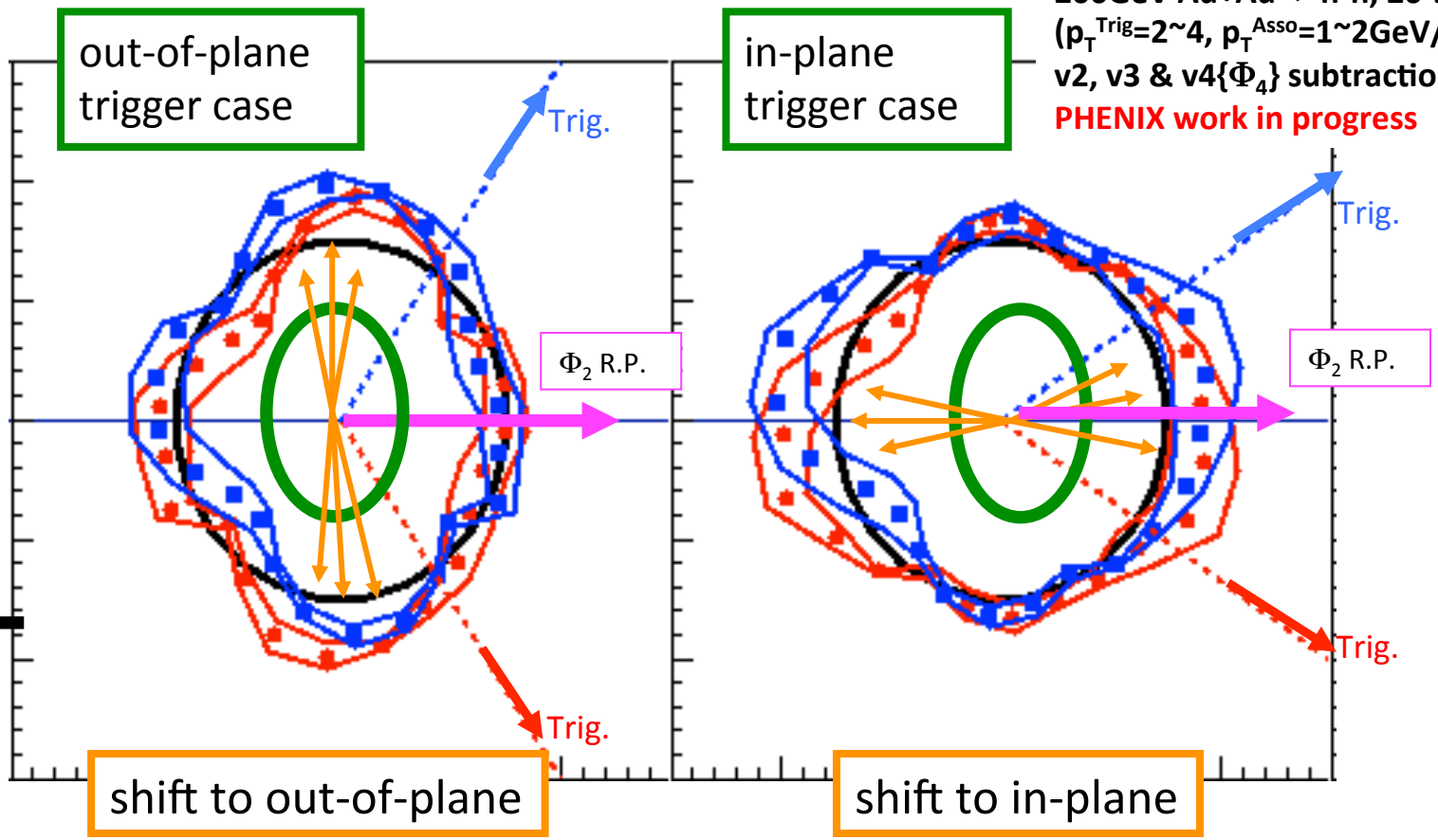


Analysis Overview



- **v_n measurements**
  - ✓ Forward Event Plane(RXN) - Charged Hadrons in mid-rapidity
    - To exclude autocorrelations by jet
- **Selection of Trigger Directions**
  - ✓ Forward Event Plane(RXN)-Charged Hadron Trigger in mid-rapidity
- **2 particle charged hadron correlations in azimuth**
  - ✓ Mid-rapidity Trigger – Mid-rapidity Associate, p_T : 2-4 & 1-2 [GeV/c]
- **Subtract v_n modulated backgrounds by ZYAM Method**

Φ_2 dependent correlations



- **Two competitive effects**
  - ✓ Away-side peak shift to in/out of plane with in/out of plane trigger

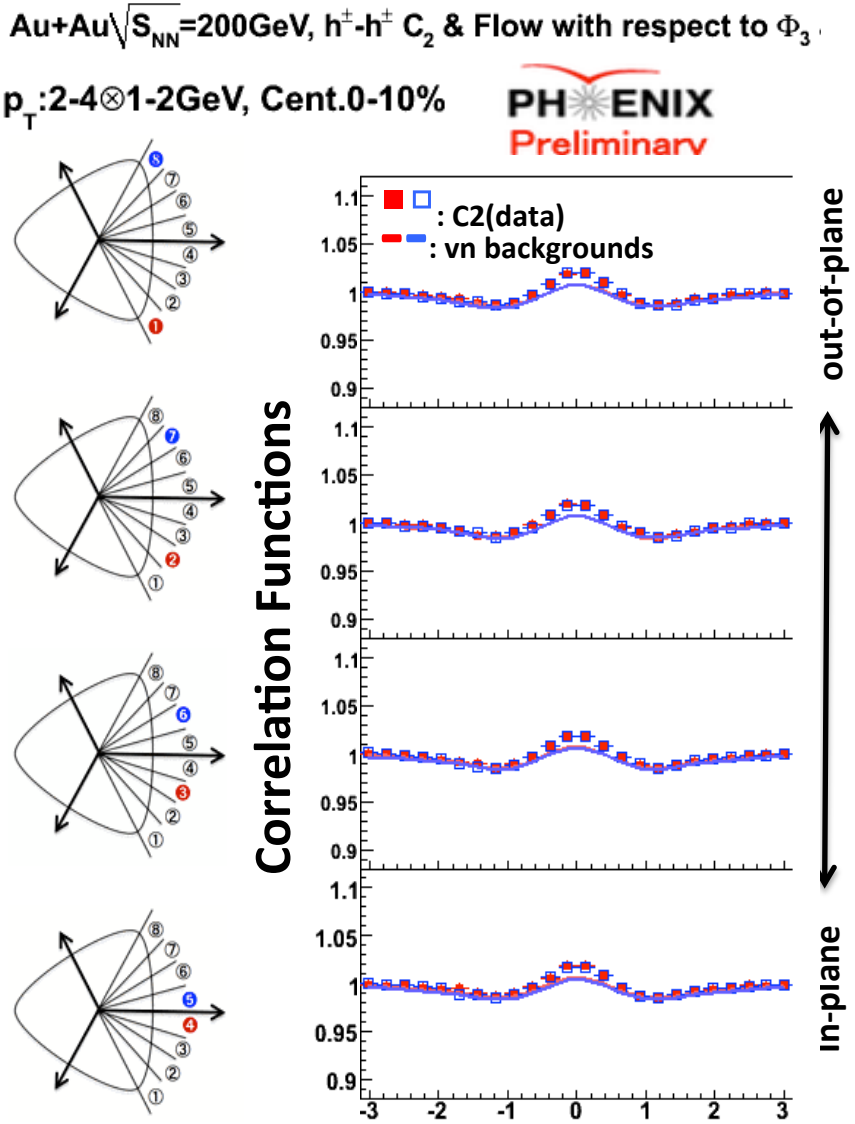
Φ_3 dependence before v_n subtractions

- **Subtraction shows no evident dependence**
- **Difference b/w Φ_2 & Φ_3**

✓ Φ_2 dominated by almond shape

✓ Φ_3 dominated by fluctuations

✓ Would be related to differences



Summary

- **Measured two particle correlations with trigger selection relative to Φ_2 & Φ_3**

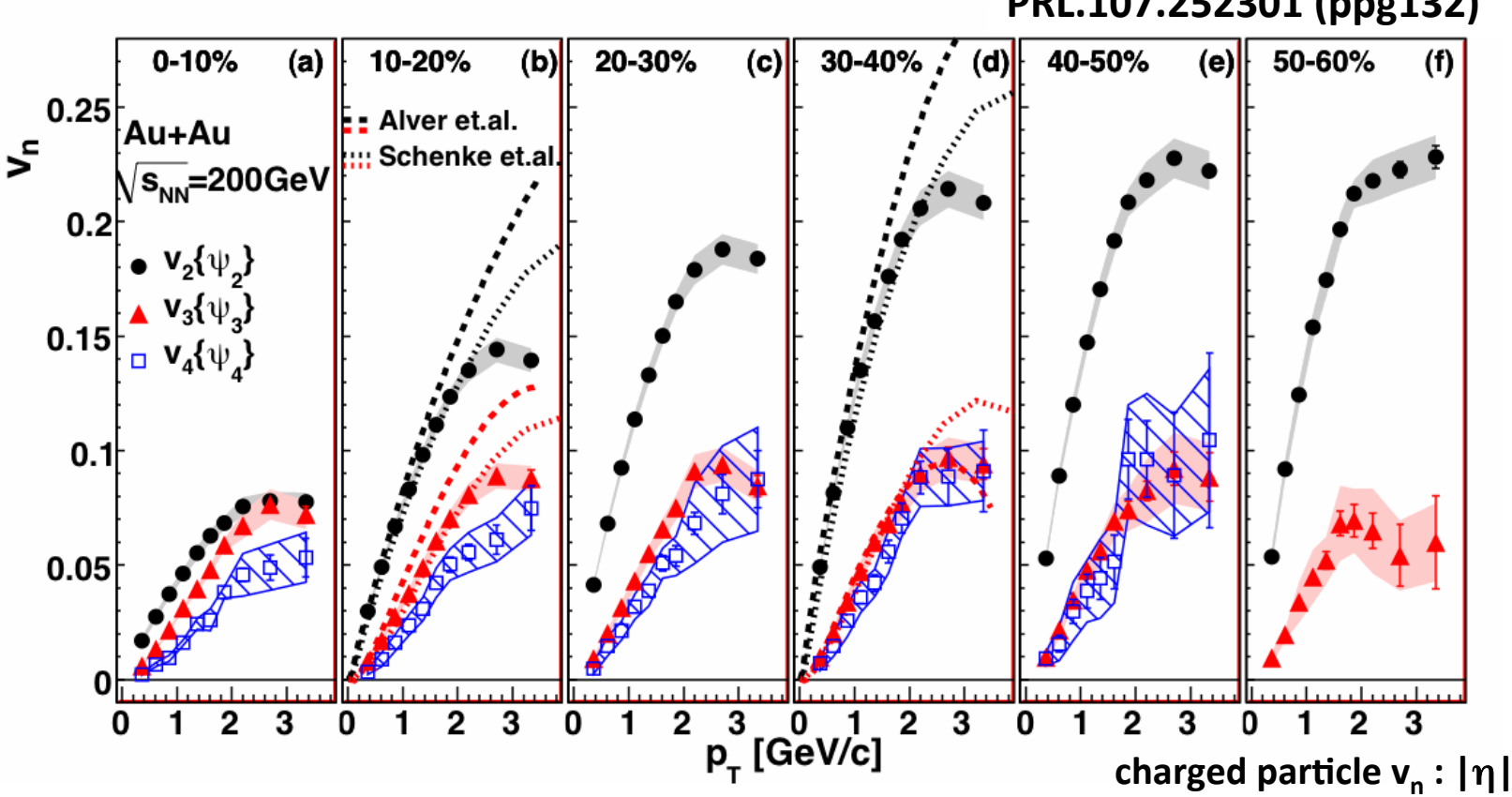
- **Φ_2 dependent correlations show two competitive effects**
  - ✓ Away-side peak shift to in/out of plane with in/out of plane trigger

- **Φ_3 harmonic plane dependence wouldn't be seen**
  - ✓ Φ_2 dominated by almond shape
  - ✓ Φ_3 dominated by fluctuations

Back Up Slides

Charged hadron v_n Centrality and p_T dependences

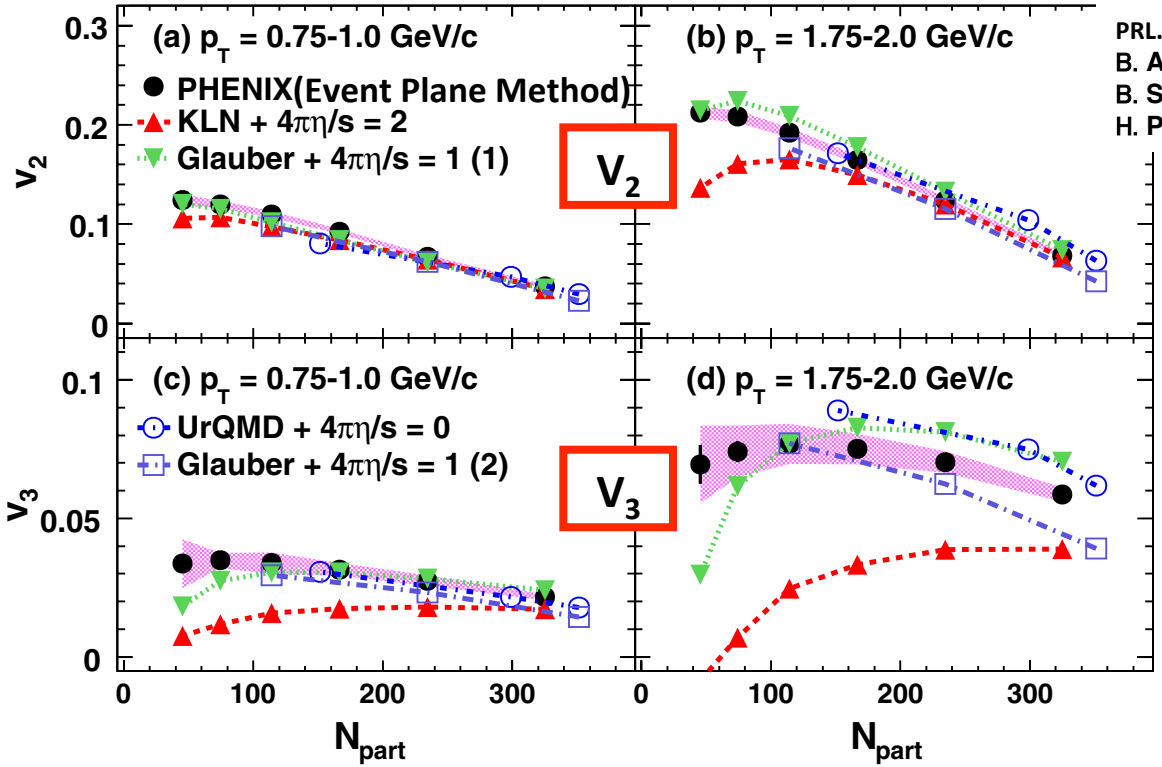
PRL.107.252301 (ppg132)



charged particle v_n : $|\eta|<0.35$
event plane Φ_n : $|\eta|=1.0\sim2.8$

- v_3 is comparable to v_2 at 0~10%
- v_2 rises up when centrality goes up, but v_3 hardly does
- $v_4\{\Phi_4\} \sim 2 \times v_4\{\Phi_2\}$

Degeneracy among models disentangled by v_3

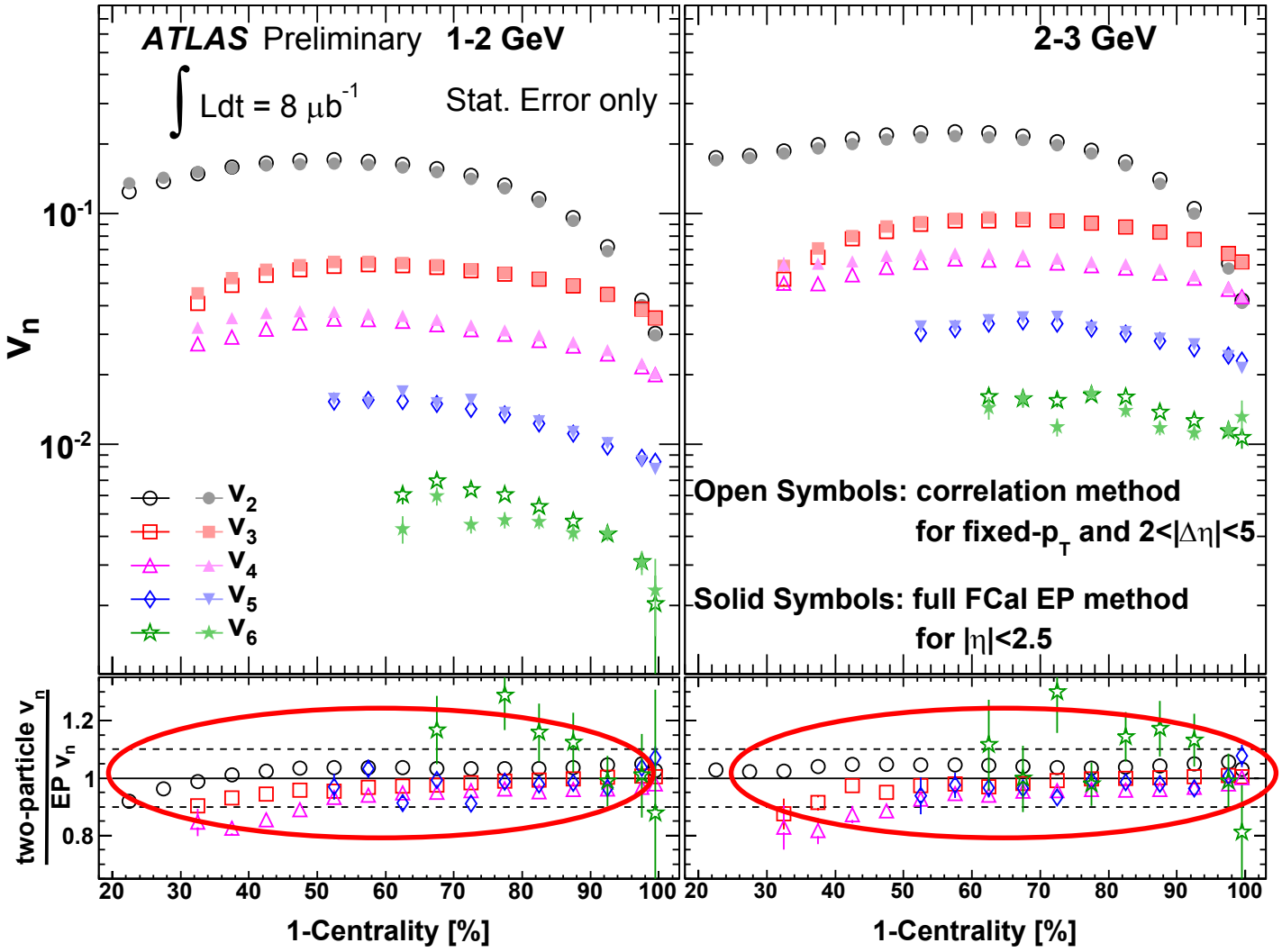


PRL.107.252301 (ppg132)
B. Alver et. al., PRC82, 034913(2010).
B. Schenke et. al., PRL106, 042301(2011).
H. Petersen et. al., PRC82, 041901(2010).

- **v_3 seems to prefer low viscosity**
  - ✓ Glauber+$4\pi\eta/s = 1$ works better
  - ✓ CGC-KLN+$4\pi\eta/s = 2$ failed
- **v_n provides more constraints to hydrodynamics calculations**

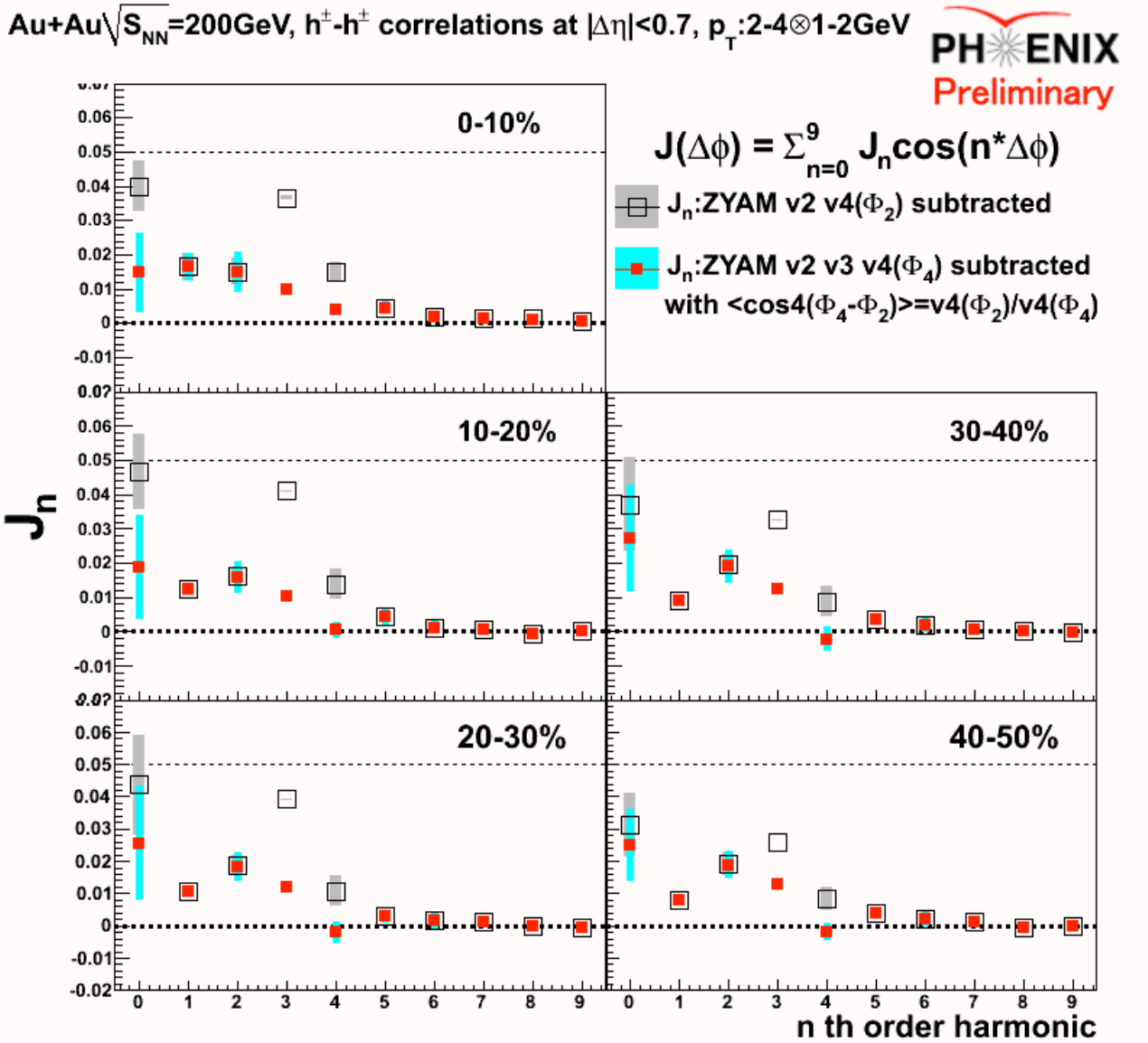
Compare with the Event Plane method

QM2011, ATLAS

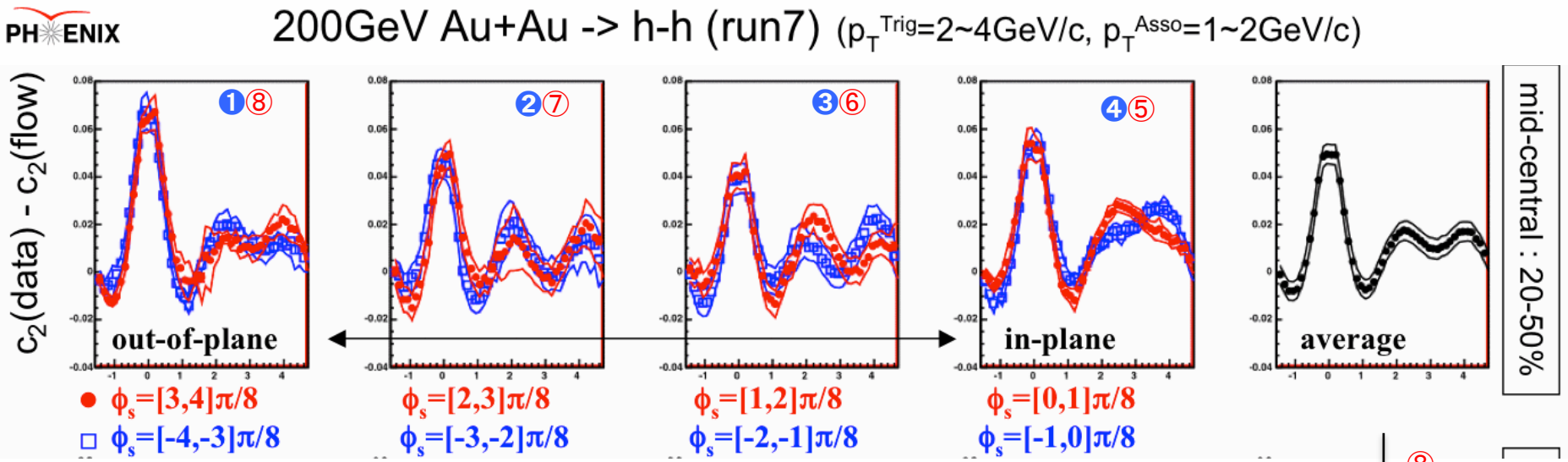


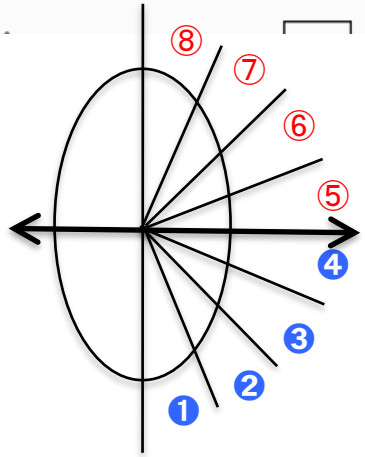
Consistent between the 2PC and full FCal EP method (Similar for $FCal_{P(N)}$).

Fourier decomposition of flow subtracted correlations



Φ_2 dependence with v_2 & $v_4(\Phi_2)$ subtraction





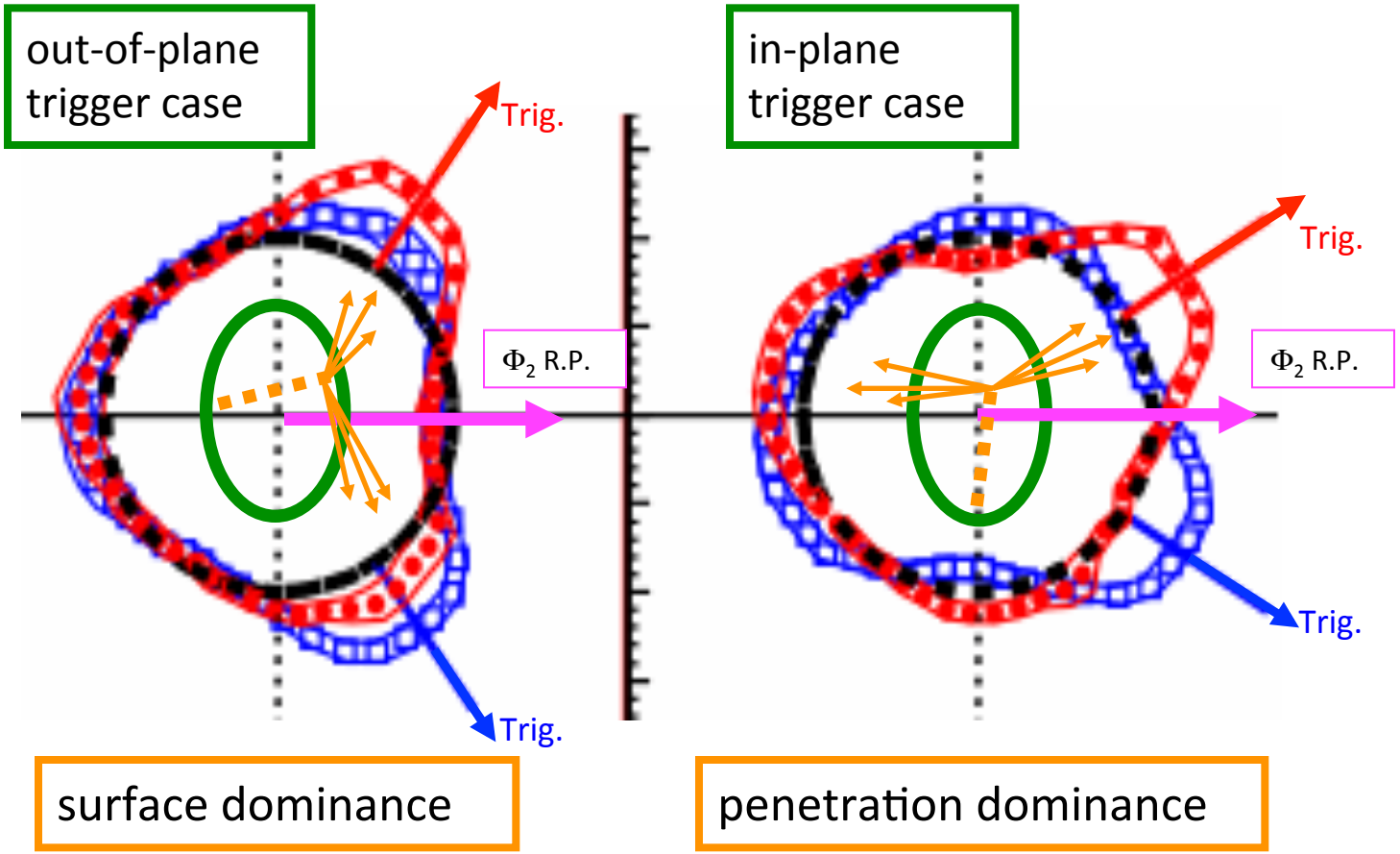
Trigger dependence relative to event plane

200GeV Au+Au -> h-h, 20-50%
(p_T^{Trig}=2~4, p_T^{Asso}=1~2GeV/c)
v_2,$v_4\{\Phi_2\}$ only subtraction
PHENIX preliminary

Trigger angle selection w.r.t. Φ_2 separately for left(up) / right (down)

Trigger angle selected 2-part. corr. data are plotted in polar coordinate by rotating Φ_2 R.P. angle as X-axis.

Flow subtracted yield is shown radially with base line. ■■■■■■



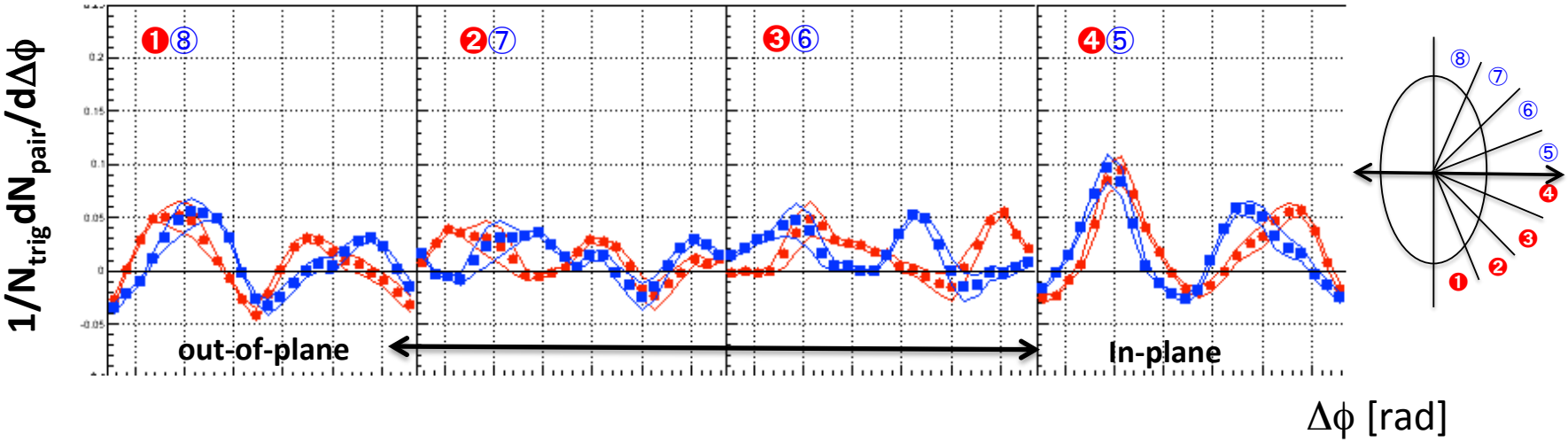
Two competing processes seen

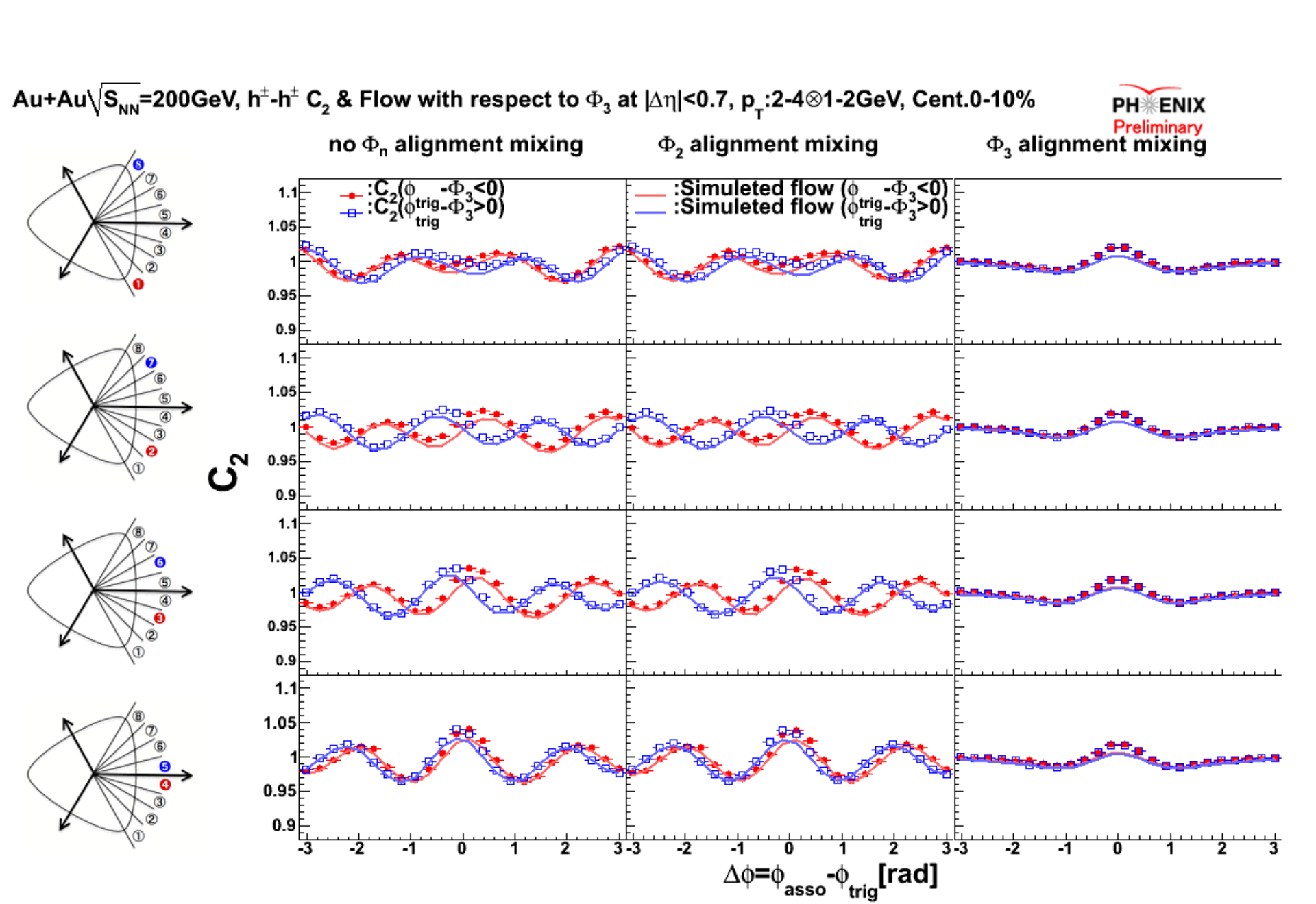
RHIC-PHENIX Flow plenary S.E.

Φ_2 dependence with v_2 & v_3 & v_4 subtraction

200GeV Au+Au -> h-h, 20-50%
(p_T^{Trig}=2~4, p_T^{Asso}=1~2GeV/c)
v2,v3,v4{Φ_4} subtraction

PHENIX Work in progress




Au+Au$\sqrt{S_{NN}}$=200GeV, $h^{\pm}$-$h^{\pm}$ C_2 & Flow with respect to Φ_3 at $|\Delta\eta|$<0.7, p_T:2-4⊗1-2GeV, Cent.0-10%
PHENIX
Preliminary
no Φ_n alignment mixing
Φ_2 alignment mixing
Φ_3 alignment mixing
:$C_2(\phi - \Phi_3<0)$
:$C_2(\phi^{trig}_{trig} - \Phi_3>0)$
:Simuleted flow $(\phi - \Phi_3<0)$
:Simuleted flow $(\phi^{trig}_{trig} - \Phi_3>0)$
C_2
$\Delta\phi=\phi_{asso}-\phi_{trig}$[rad]