Dihadron Correlations Relative to the Event Plane in 200 GeV Au+Au Collisions from STAR

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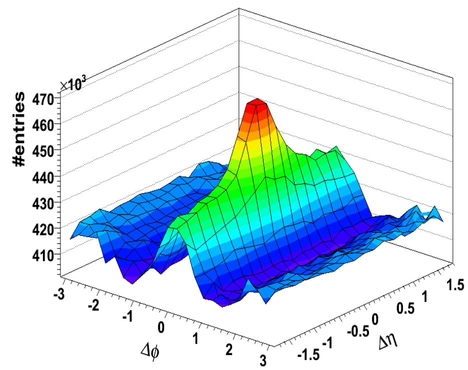
PURDUE UNIVERSITY

STAR

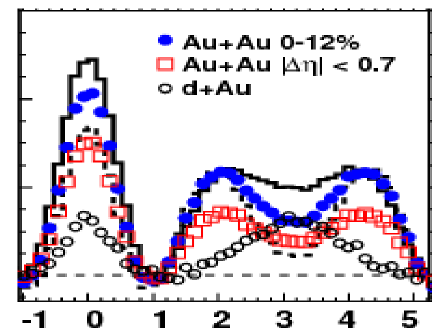
Physics Motivations

- Novel phenomena:
  - The near-side ridge
  - The away-side cone

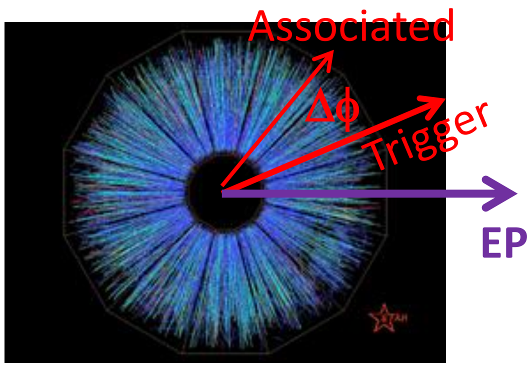
STAR, PRC80 (2009)



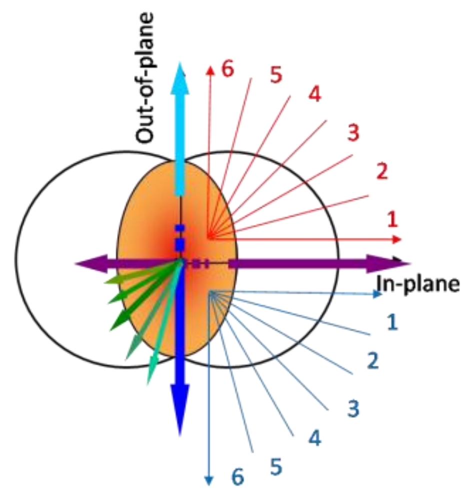
STAR, PRC82 (2010)



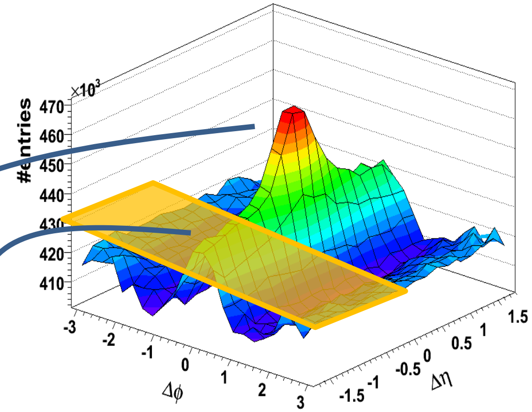
- Investigate their behaviors relative to the reaction plane.

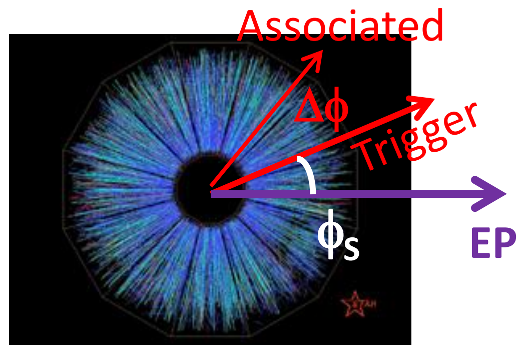


STAR, arXiv:1010.0690

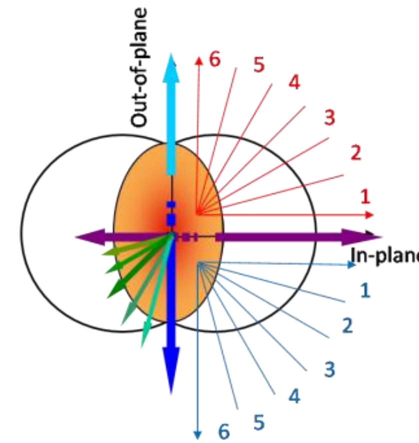


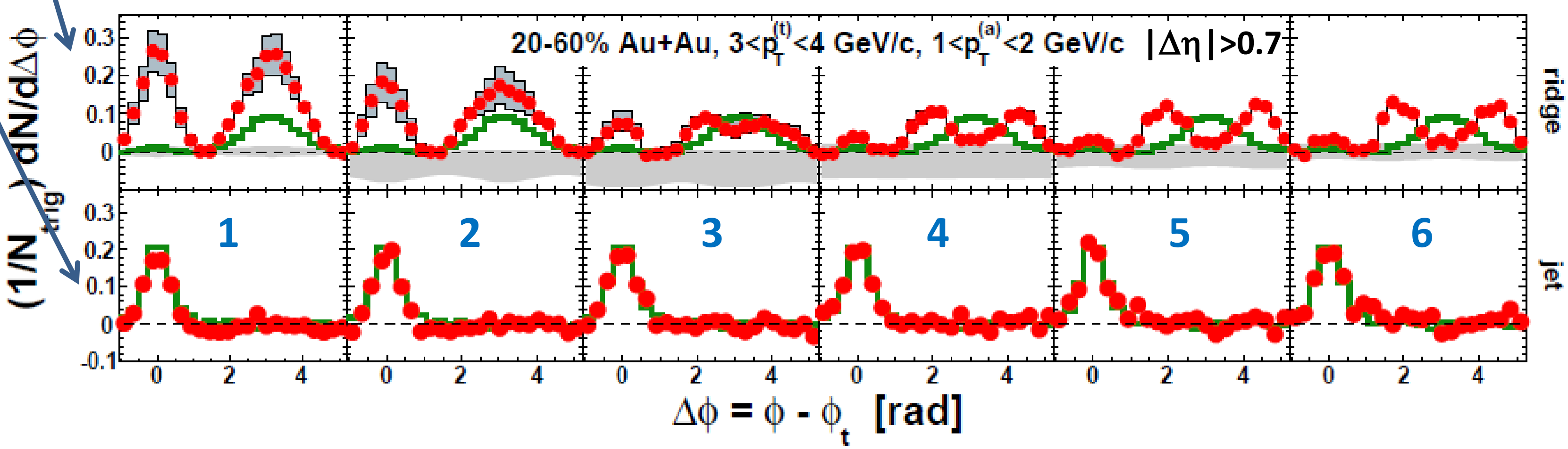
Dihadron correlations w.r.t. EP





STAR, arXiv:1010.0690v1

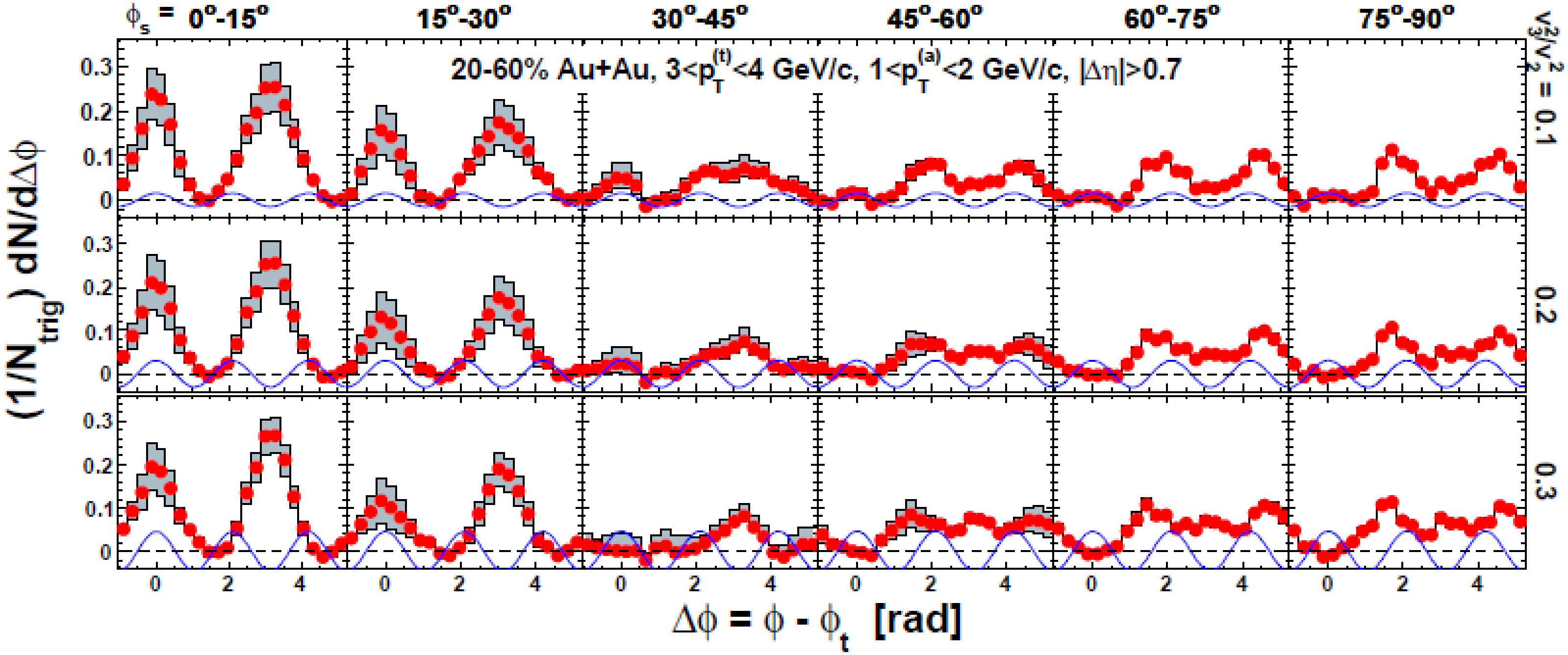




- Jet-like correlations independent of ϕ_S.
- Strong variations of large-$\Delta\eta$ correlations with ϕ_S.
- No v_3 correction at the time. Only estimated the v_3 effect.

Estimated v_3 effect

In arXiv:1010.0690v1



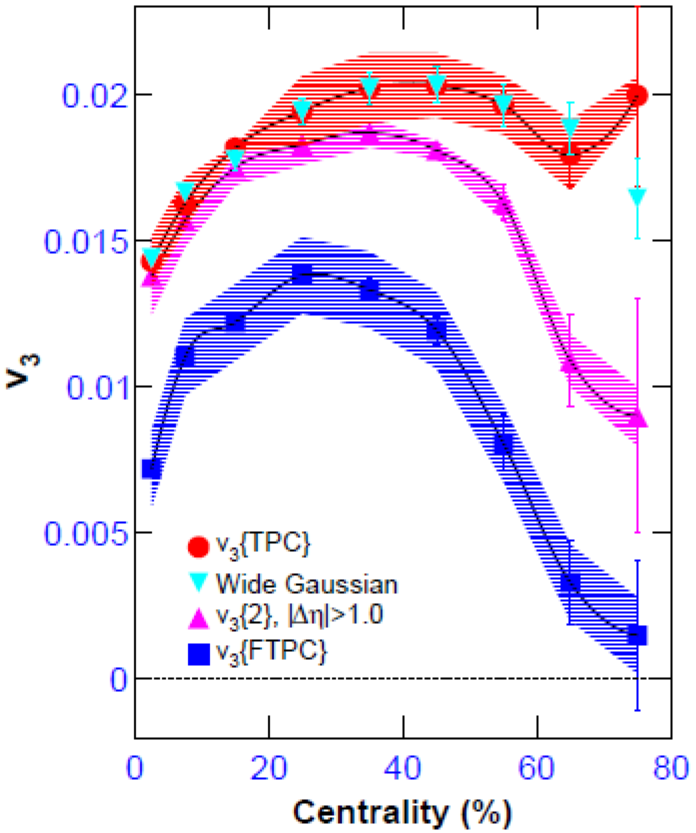
- V_3 effect does not change with ϕ_S.
- V_3 does not account entirety for the observed ridge or double-peak away-side.

What's new?

- Better understanding of v_n, both theoretically & experimentally.
- Experimental measurements of v_n

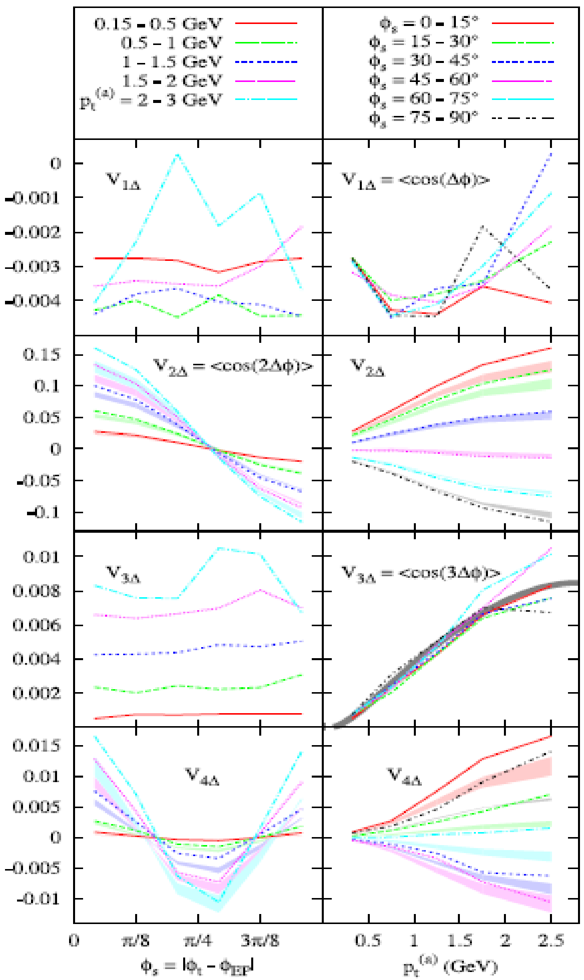
- Subtraction of v_3
- Further exploration of the limits of possible v_n effects

STAR, arXiv:1301.2187

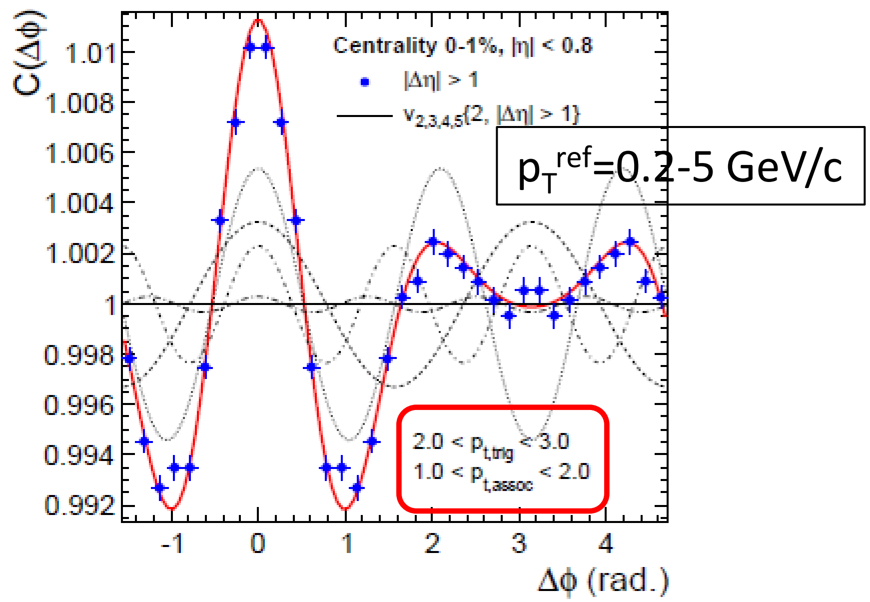


Word of caution: With non-vanishing odd harmonics, nothing really prevents people from fitting everything to v_n. Fine in itself, but dangerous if people subsequently take it as entirely flow.

Luzum, PLB 696 (2011)



ALICE, PRL 107 (2011)



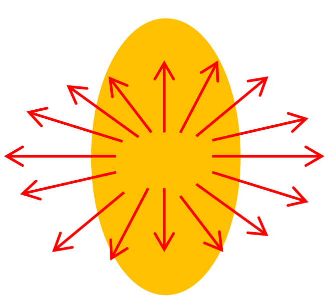
If $p_T^{assoc}=p_T^{ref}$, then

"flow" $v_n(p_T^{trig})v_n(p_T^{assoc})$ = trig-assoc dihadron correlation

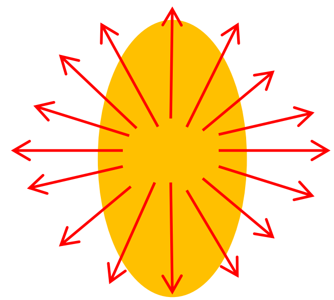
→ signal = data – data = 0.

The real question is what's in v_n?

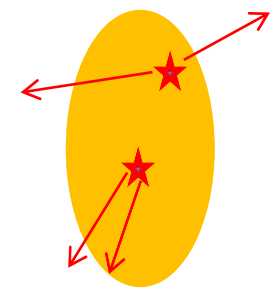
What is in v_n?



Flow due to hydrodynamic pressure



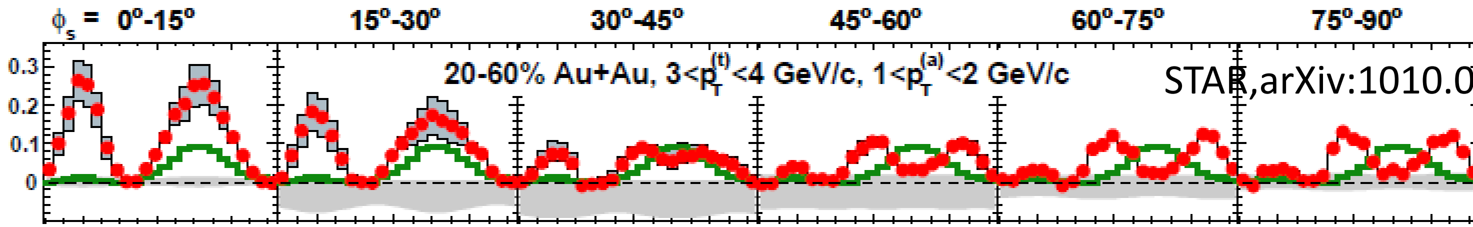
Anisotropy due to pathlength-dep. energy loss



Nonflow correlations

- Flow → factorization (with caveats); Factorization $\nrightarrow$ flow
- Fourier components do not give further insights.
- The real challenge is to separate flow and nonflow in v_n.

Update: revised v_2 syst. uncertainty



STAR,arXiv:1010.0690v1

$v_2 = (v_2\{2\} + v_2\{4\})/2$ $\qquad$ $v_4\{\psi_2\} = 1.15 v_2^2$

$$\frac{dN}{d\Delta\phi} = B\left[1 + 2v_2^{(a)}v_2^{(t,R)}\cos(2\Delta\phi) + 2v_4^{(a)}\{\psi_2\}v_4^{(t,R)}\{\psi_2\}\cos(4\Delta\phi)\right]$$

Lower bound: $v_2\{4\}$ from 4-particle cumulant

Upper bound: $v_2\{2\text{,Away-side}\}$, good if only even harmonics

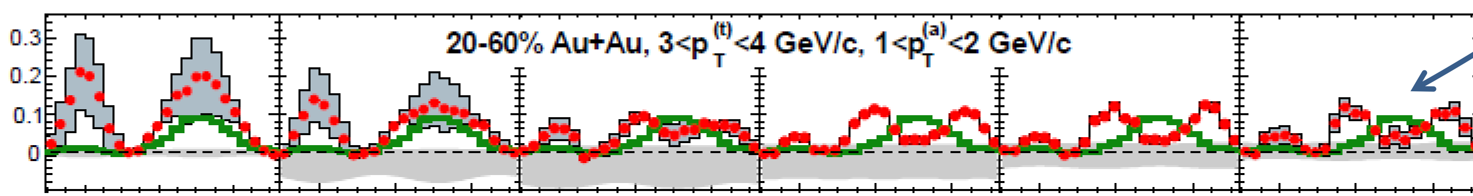
$v_2^{max}\{2,\eta_{gap}=0.7\}$ with a reference particle 0.15<p_T<2 GeV/c

NEW!

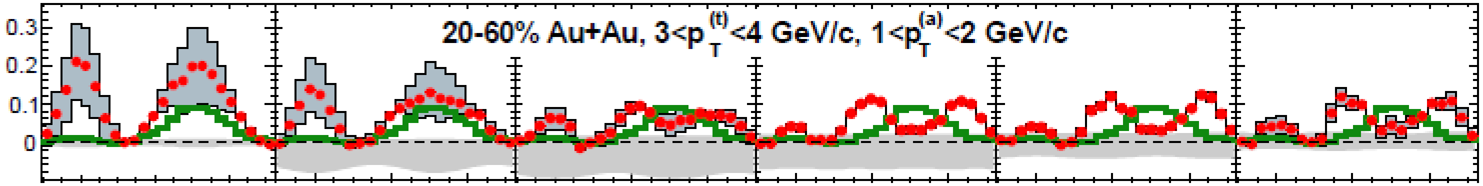
$$v_n\{2\}(p_T) = \frac{V_n\{p_T\text{-ref}, \eta_{gap}=0.7\}}{\sqrt{V_n\{\text{ref-ref}, \eta_{gap}=0.7\}}}$$

V_n=<cos($n\Delta\phi$)>

Syst. error small because $v_2^{(a)}$ & $v_2^{(t,R)}$ anticorrelated



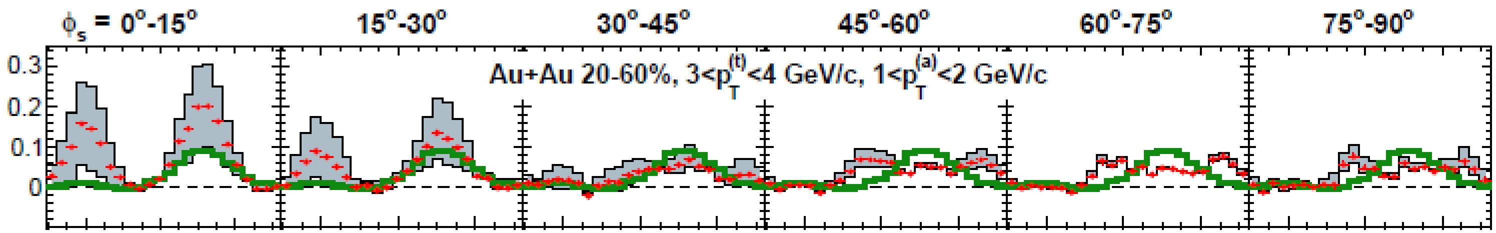
Update: v_3 subtraction



$v_2 = (v_2\{2\} + v_2\{4\})/2$ $v_4\{\psi_2\} = 1.15 v_2^2$

$$\frac{dN}{d\Delta\phi} = B\left[1 + 2v_2^{(a)}v_2^{(t,R)}\cos(2\Delta\phi) + 2v_4^{(a)}\{\psi_2\}v_4^{(t,R)}\{\psi_2\}\cos(4\Delta\phi) + 2v_3^{(a)}v_3^{(t)}\cos(3\Delta\phi)\right]$$

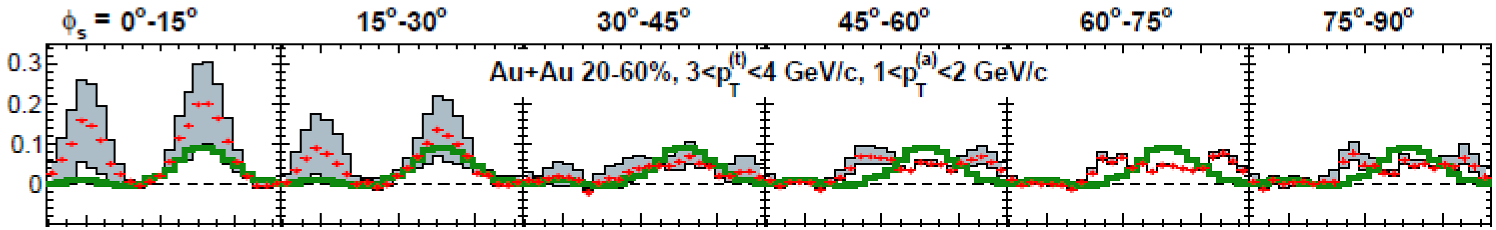
$v_3\{2,\eta_{gap}=0.7\}$ with a reference particle $v_n\{2\}(p_T) = \frac{V_n\{p_T\text{-ref}, \eta_{gap}=0.7\}}{\sqrt{V_n\{\text{ref-ref}, \eta_{gap}=0.7\}}}$ NEW!



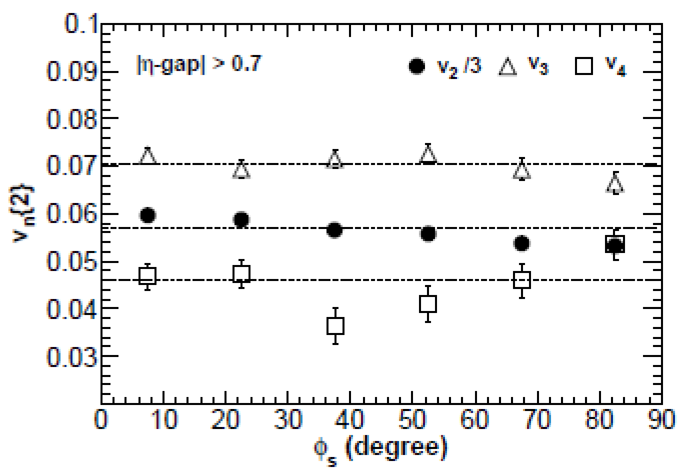
Testing the limits of effect of vn subtraction:

- The subtracted v_3 is upper bound, may contain nonflow contributions.
- Residual ridge remains on near side; away side double-peak persists.

Exploring other v_n limits



$v_2 = (v_2\{2\} + v_2\{4\})/2$ $v_3\{2, \eta_{gap}=0.7\}$ $v_4\{\psi_2\} = 1.15 v_2^2$



$$v_n\{p_T\text{-}p_T\}(\phi_s) = \sqrt{V_n\{p_T\text{-}p_T, \eta_{\rm gap}{=}0.7\}(\phi_s)}$$

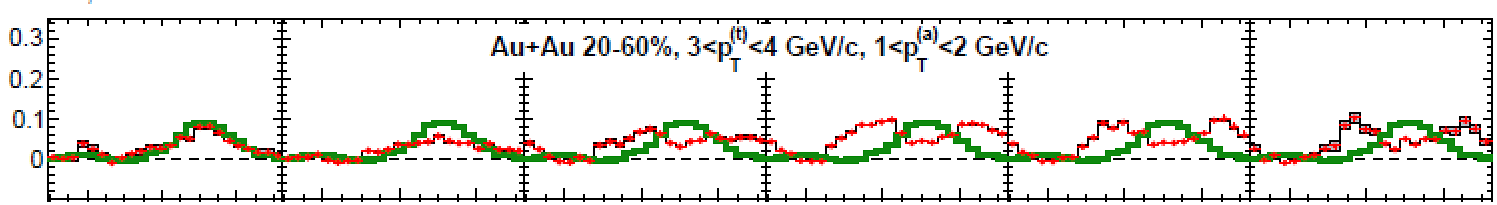
NEW!

which again may contain
(or even be dominated by) nonflow.

$v_4\{2, \eta_{gap}=0.7\}$ with a reference particle

$$V_4\{\rm uc\} = v_4^{(t)}\{2\} v_4^{(a)}\{2\} - v_4^{(t)}\{\psi_2\} v_4^{(a)}\{\psi_2\}$$

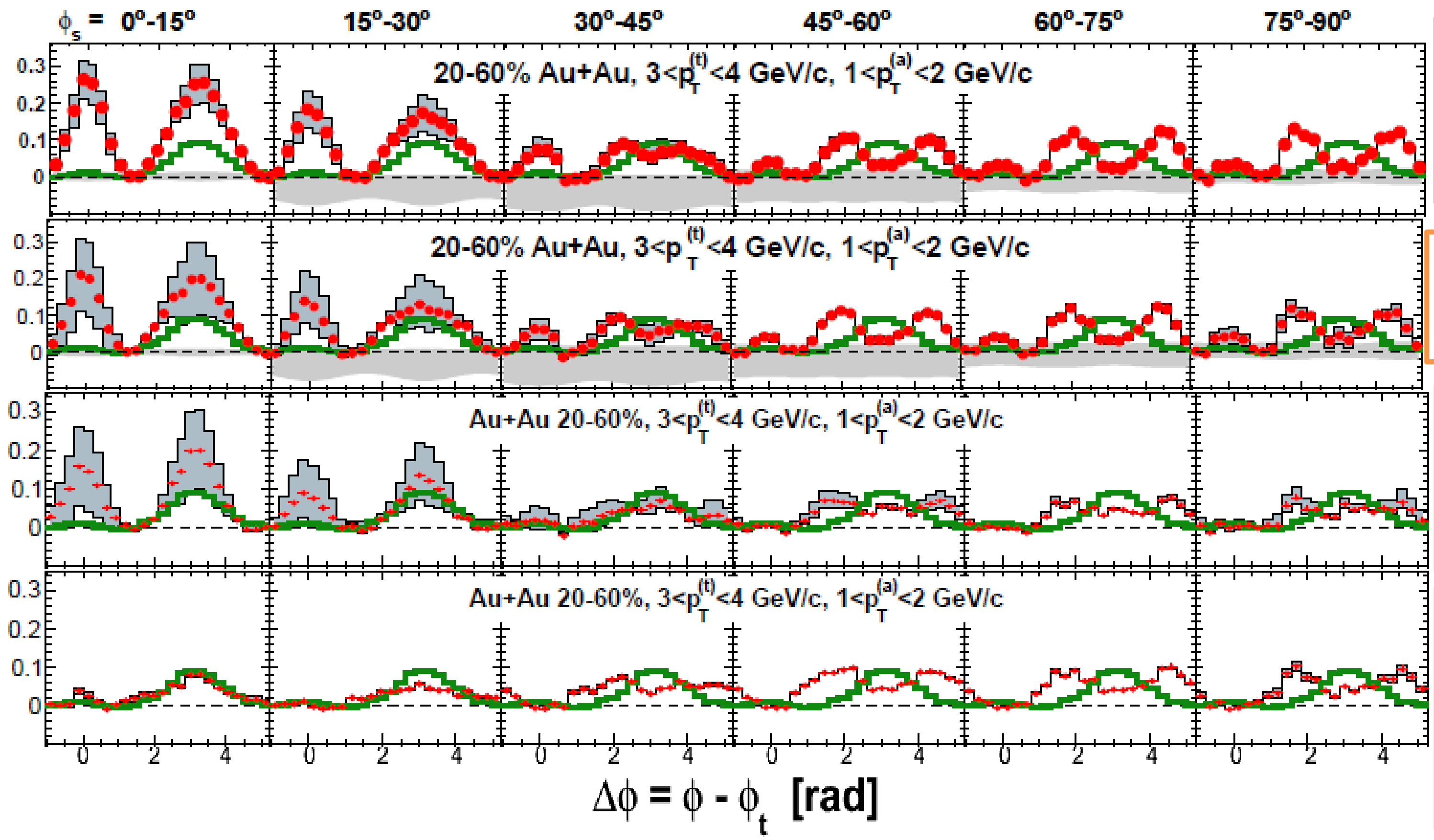
$$\frac{dN}{d\Delta\phi} = B\left[1 + 2v_2^{(a)}v_2^{(t,R)}\cos(2\Delta\phi) + 2v_4^{(a)}\{\psi_2\}v_4^{(t,R)}\{\psi_2\}\cos(4\Delta\phi) + 2v_3^{(a)}v_3^{(t)}\cos(3\Delta\phi) + 2V_4\{\rm uc\}\cos(4\Delta\phi)\right]$$



- The ridge is further reduced (maybe gone). Away-side double-peak persists.

Summary of updates

Updates in red



arXiv:1010.0690
$v_2^{max}\{2,AS\}$
$v_4\{\psi_2\}=1.15v_2^2$

$v_2^{max}\{2,\eta_{gap}=0.7\}$
$v_4\{\psi_2\}=1.15v_2^2$

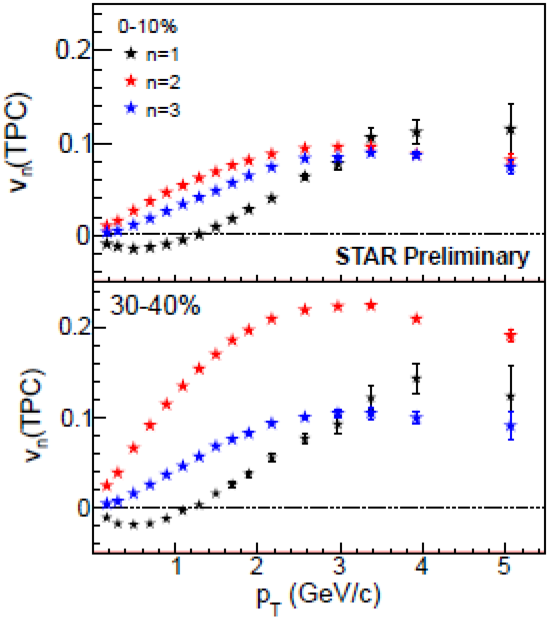
$v_2^{max}\{2,\eta_{gap}=0.7\}$
$v_3\{2,\eta_{gap}=0.7\}$
$v_4\{\psi_2\}=1.15v_2^2$

$v_2\{2\}(\phi_S)$
$v_3\{2,\eta_{gap}=0.7\}$
$v_4\{\psi_2\}=1.15v_2^2$
$v_4\{uncorr.\}$

The question of v_1

- In the pt=1-2 GeV/c region, directed flow fluctuation effect may be negligible.

Pandit (STAR), arXiv:1211.7162

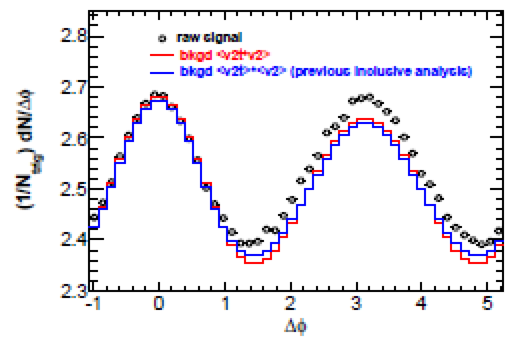


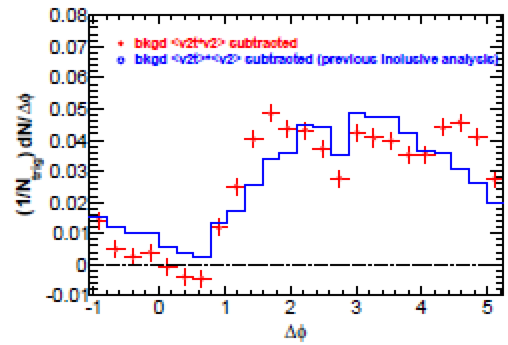
Remarks and Summary

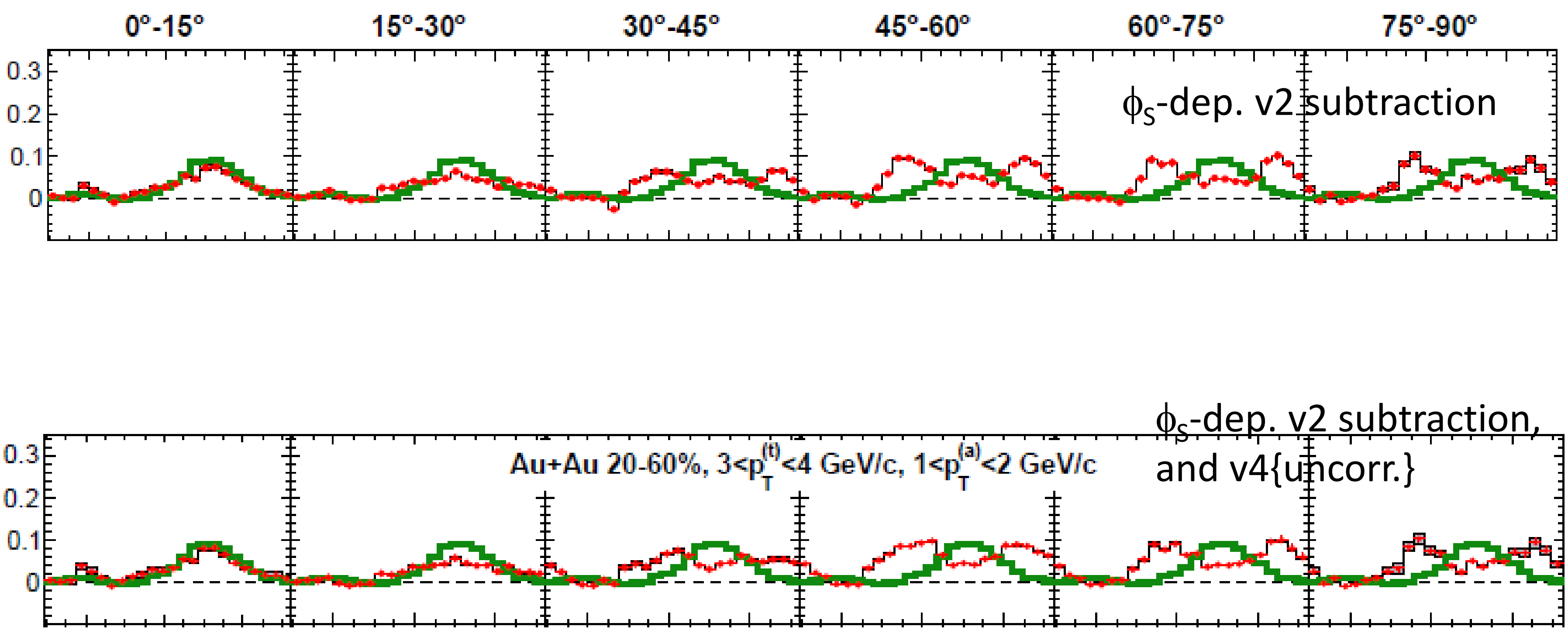
- Recent progress in theo. and exp. understanding of v_n
- Improvement in dihadron correlation analysis in STAR
- We cannot conclude on the nature of the ridge just from two-particle correlations alone:
  - If including long-range correlation in v_n, then any ridge would be subtracted.
  - On the other hand, we cannot rule out ridge not being part of hydrodynamic response.
- Away-side broadening (and perhaps double-peak) seems robust against wide range of flow subtraction
- More work needed to understand nonflow contributions in v_n

Have to rethink about inclusive dihadron

- We have used so far $<v^t\{2\}*v^a\{2\}>=<v^t\{2\}>*<v^a\{2\}>$. This is OK because fluctuations are already included in v{2}.
- However, if v{2} depends on slice, then $<v^t\{2\}_{slice}*v^a\{2\}_{slice}>\neq<v^t\{2\}_{slice}>*<v^a\{2\}_{slice}>$.
- $<v^t\{2\}_{slice}*v^a\{2\}_{slice}> = (v^t\{2\}_1*v^a\{2\}_1 + v^t\{2\}_6*v^a\{2\}_6)/2$
  $= (v^t\{2\}_1*v^a\{2\}_1 + v^t\{2\}_6*v^a\{2\}_1 - v^t\{2\}_6*v^a\{2\}_1 + v^t\{2\}_6*v^a\{2\}_6)/2$
  $= <v^t\{2\}>*v^a\{2\}_1 - v^t\{2\}_6*(v^a\{2\}_1 - v^a\{2\}_6)/2$
  $> <v^t\{2\}>*v^a\{2\}_1$ which is the maximum.

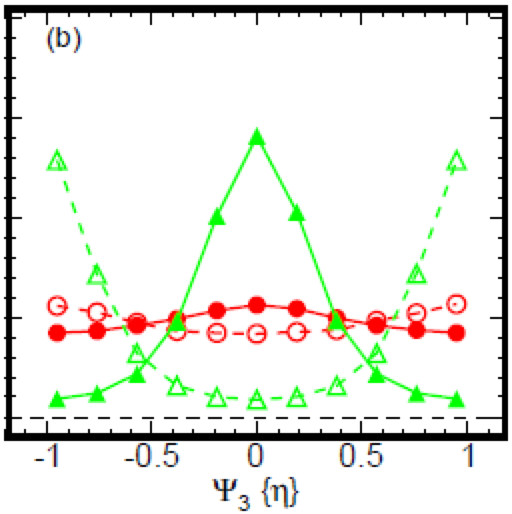


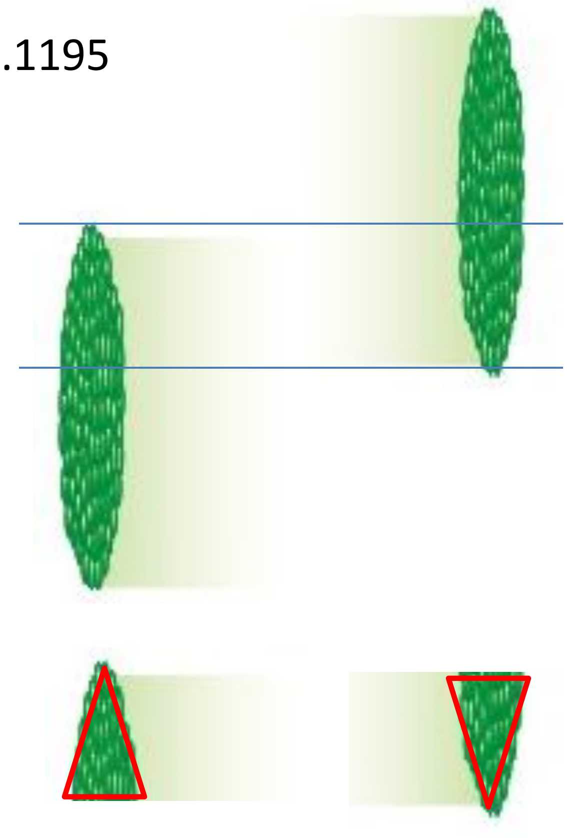



0°-15°
15°-30°
30°-45°
45°-60°
60°-75°
75°-90°
0.3
0.2
0.1
0
ϕ_S-dep. v2 subtraction
Au+Au 20-60%, $3<p_T^{(t)}<4$ GeV/c, $1<p_T^{(a)}<2$ GeV/c
ϕ_S-dep. v2 subtraction,
and v4{uncorr.}

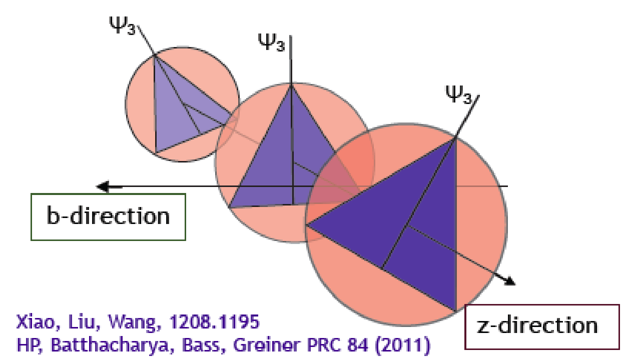
Large Δη to reduce nonflow?

Xiao et al. arXiv:1208.1195





Petersen, QM 2012



Backward rapidity

Forward rapidity

Harmonic planes may decorrelate over Δη