Monte-Carlo Studies Related to Charge Separation Measurements

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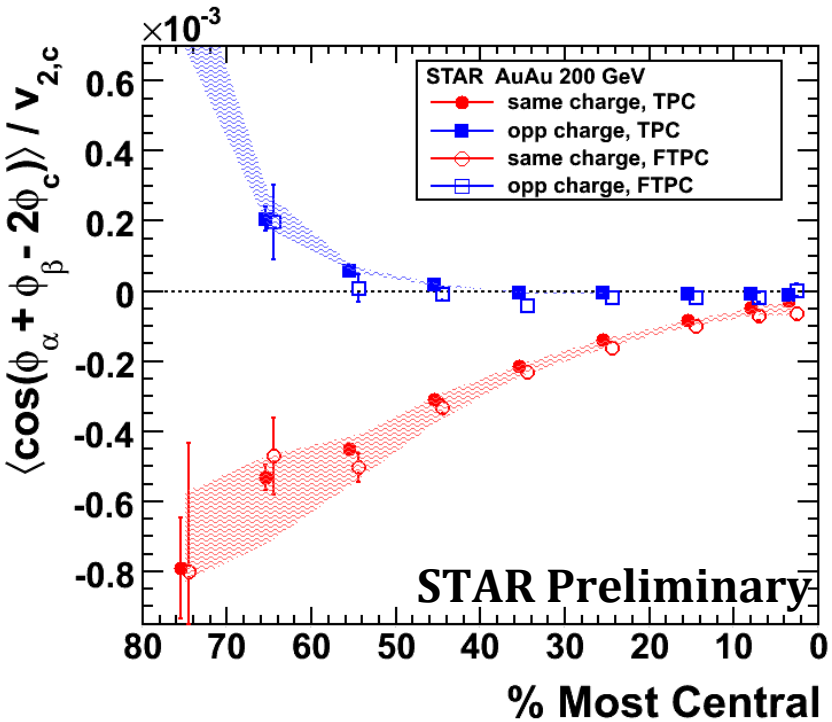
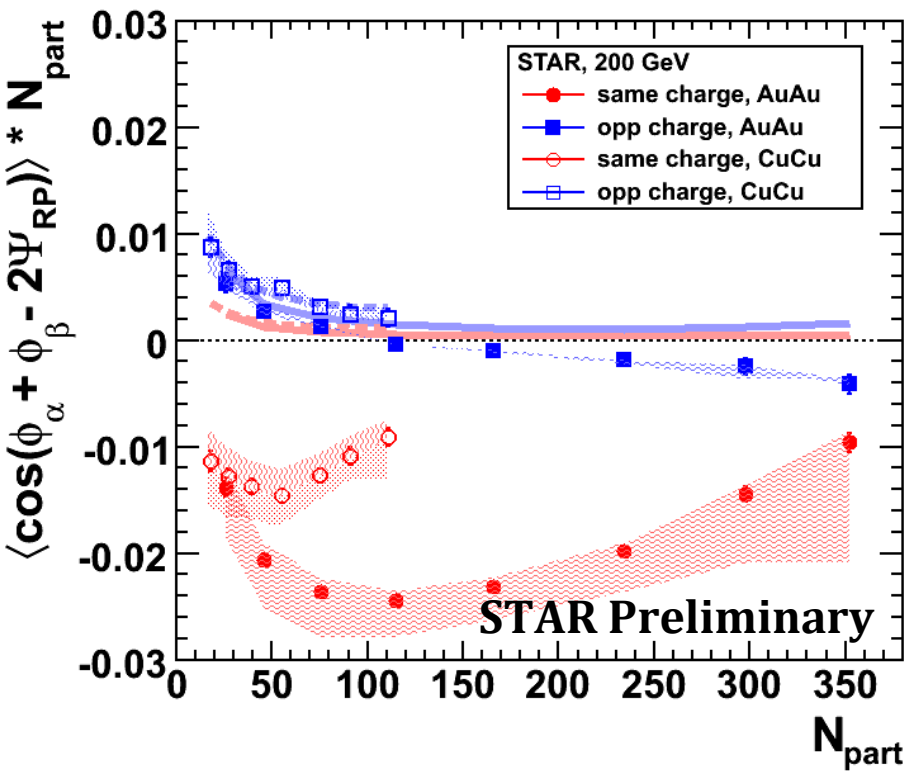
STAR Collaboration

STAR measurements for $<\cos(\varphi_a+\varphi_b-2\varphi_c)>/v_{2,c}$

- Recall that 'naïve' expectation for PV signal is ++,-- less than zero, +- greater than zero, decreases with N_{ch}



Versus centrality



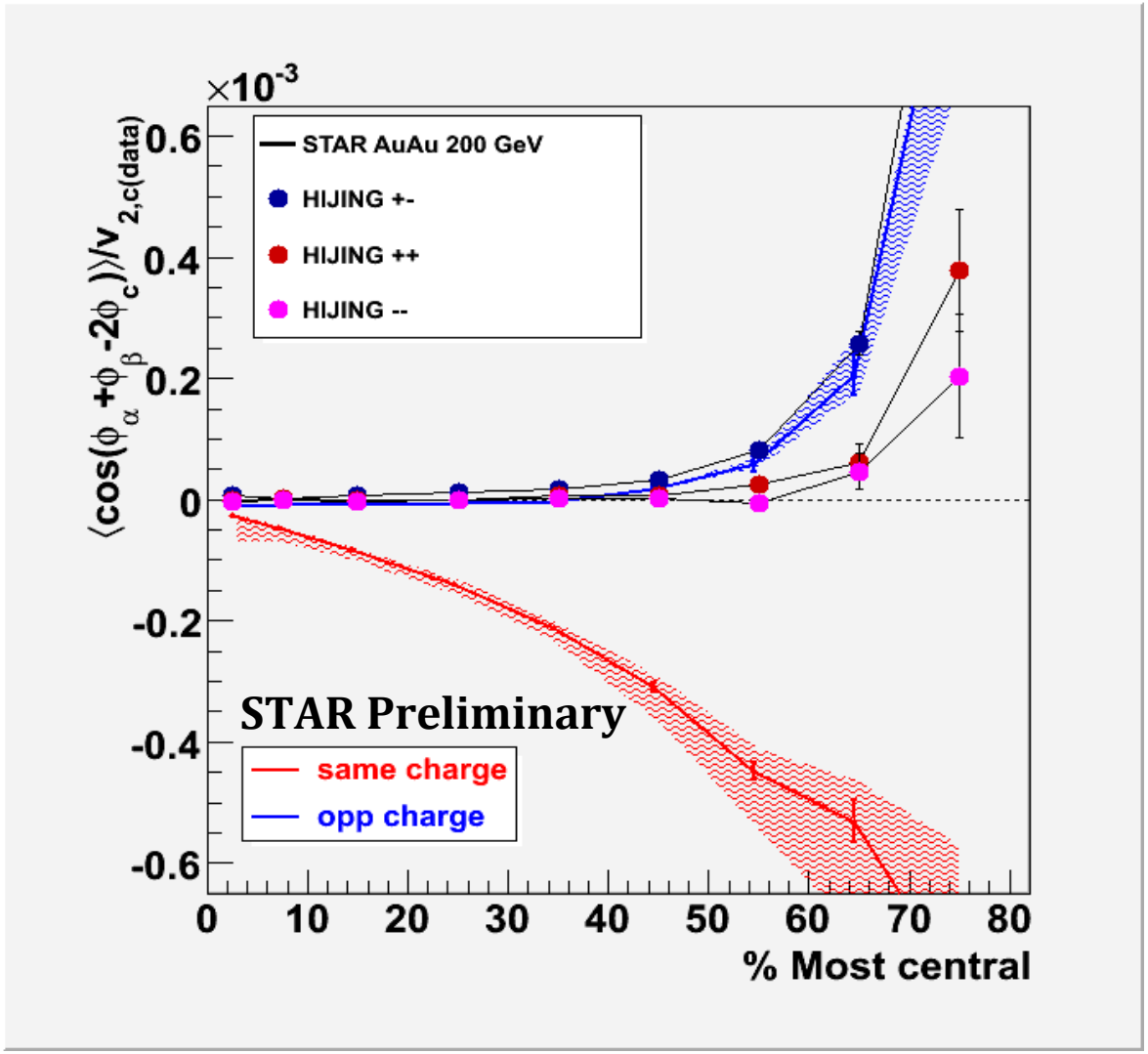
Versus N_{part} (and scaled by N_{part}).

BACKGROUNDS

- 2 categories I'll discuss:
  - 3(or more)-particle clusters, independent of reaction plane.
    - Affect factorization $\langle\cos(\varphi_a+\varphi_b-2\Psi_{r.p.})\rangle = \langle\cos(\varphi_a+\varphi_b-2\varphi_c)\rangle/v_{2,c}$
    - In principle reducible if we can determine reaction plane in a way uncorrelated with 'signal' particles.
    - Expected to scale as N_{ch}^{-2}
  - 2(or more)-particle clusters with reaction plane dependence.
    - Cannot disentangle just by better measurement of reaction plane.

I'll discuss reaction plane independent backgrounds first…

3-particle backgrounds in HIJING



- HIJING matches the unlike-sign correlations well, far from the like-sign correlations.

Scaling by N_{ch}^2, AuAu and CuCu from HIJING

α,β unlike sign:

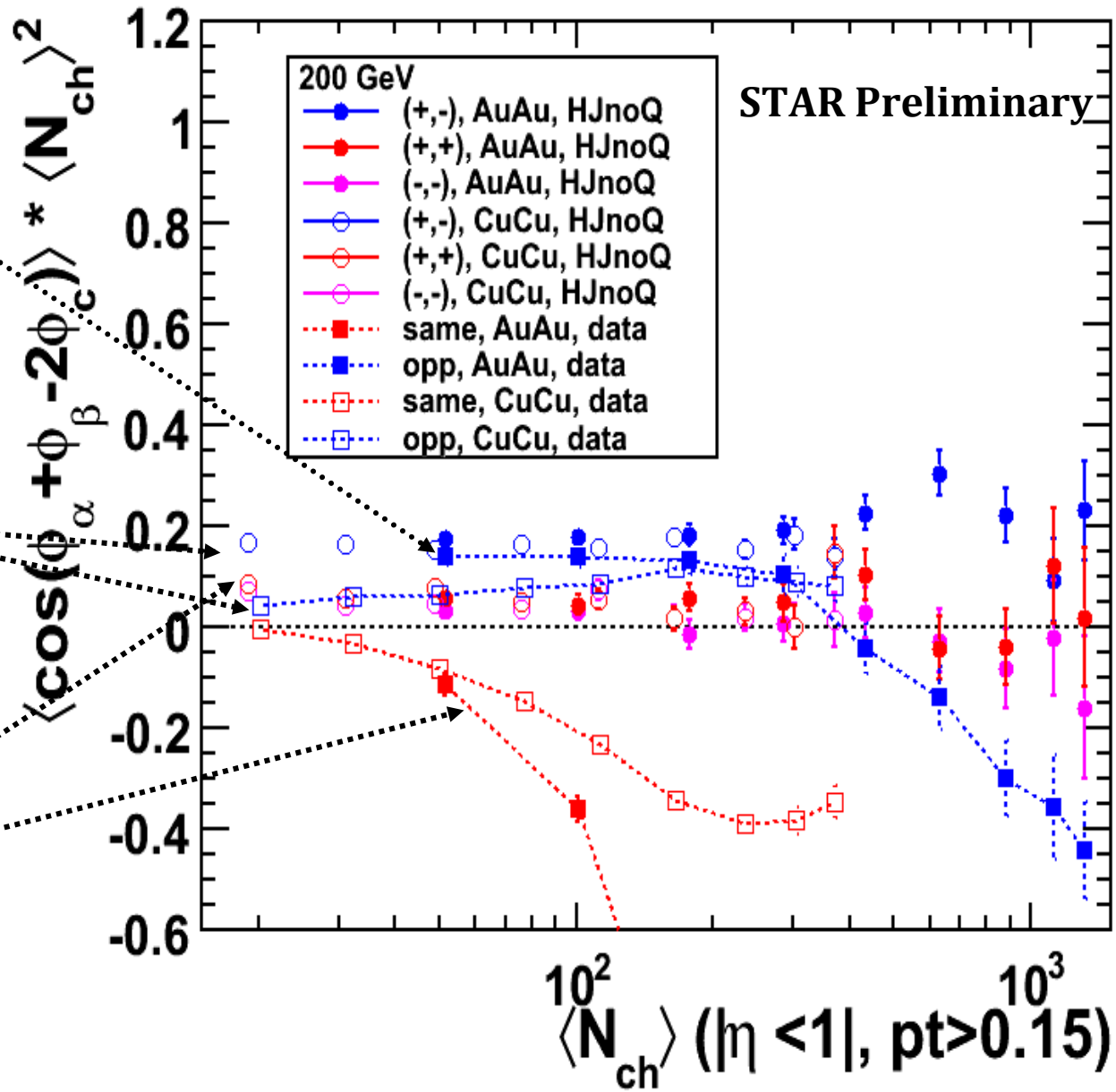
200 GeV AuAu: Data, HIJING opposite sign correlations both scale as N_{ch}^{-2}, as expected for 3 (or more) particle clusters.

200 Gev Cu-Cu: also scale as roughly N^{-2}. Some overall scaling difference due to matching of HIJING, data multiplicity distributions

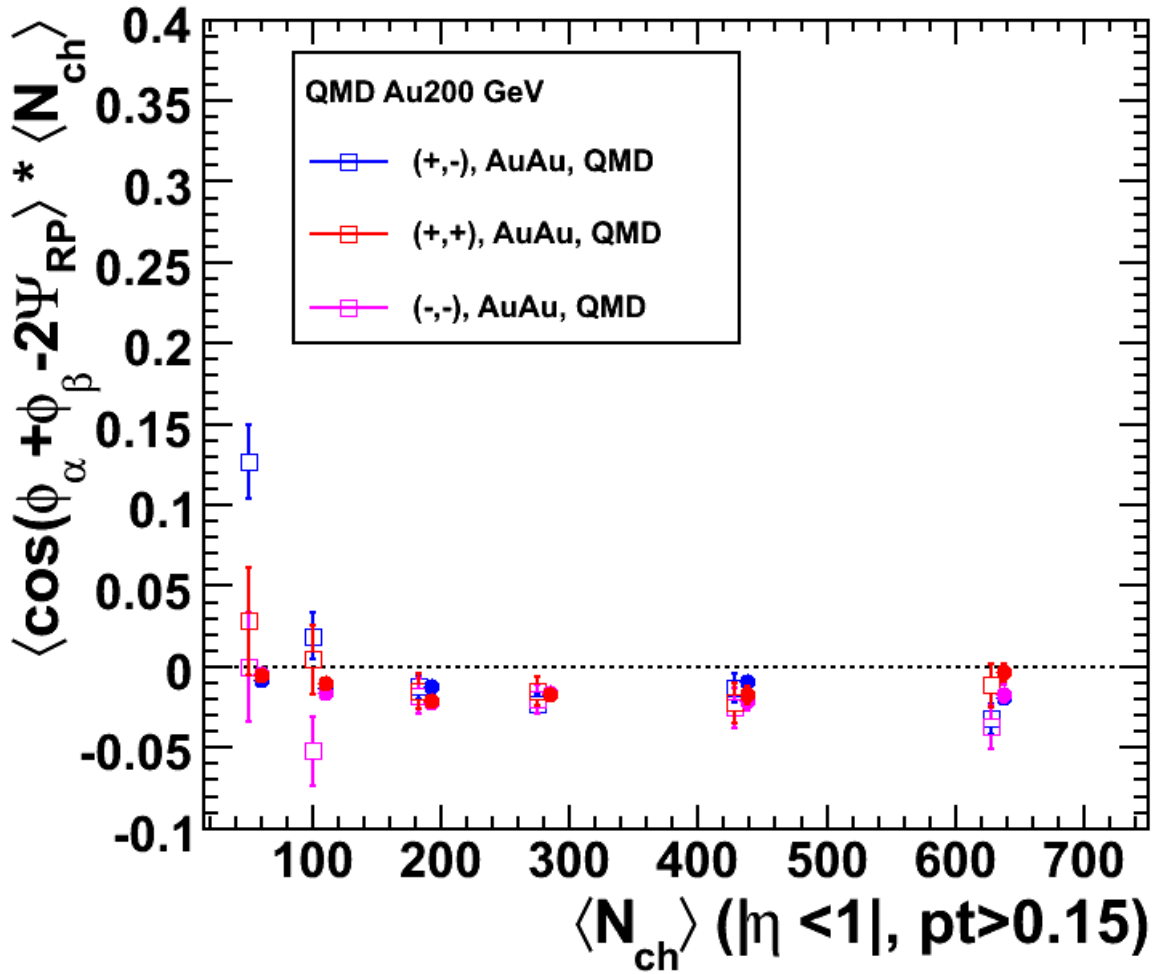
α,β like sign:

HIJING scales as N^{-2}

Data does not

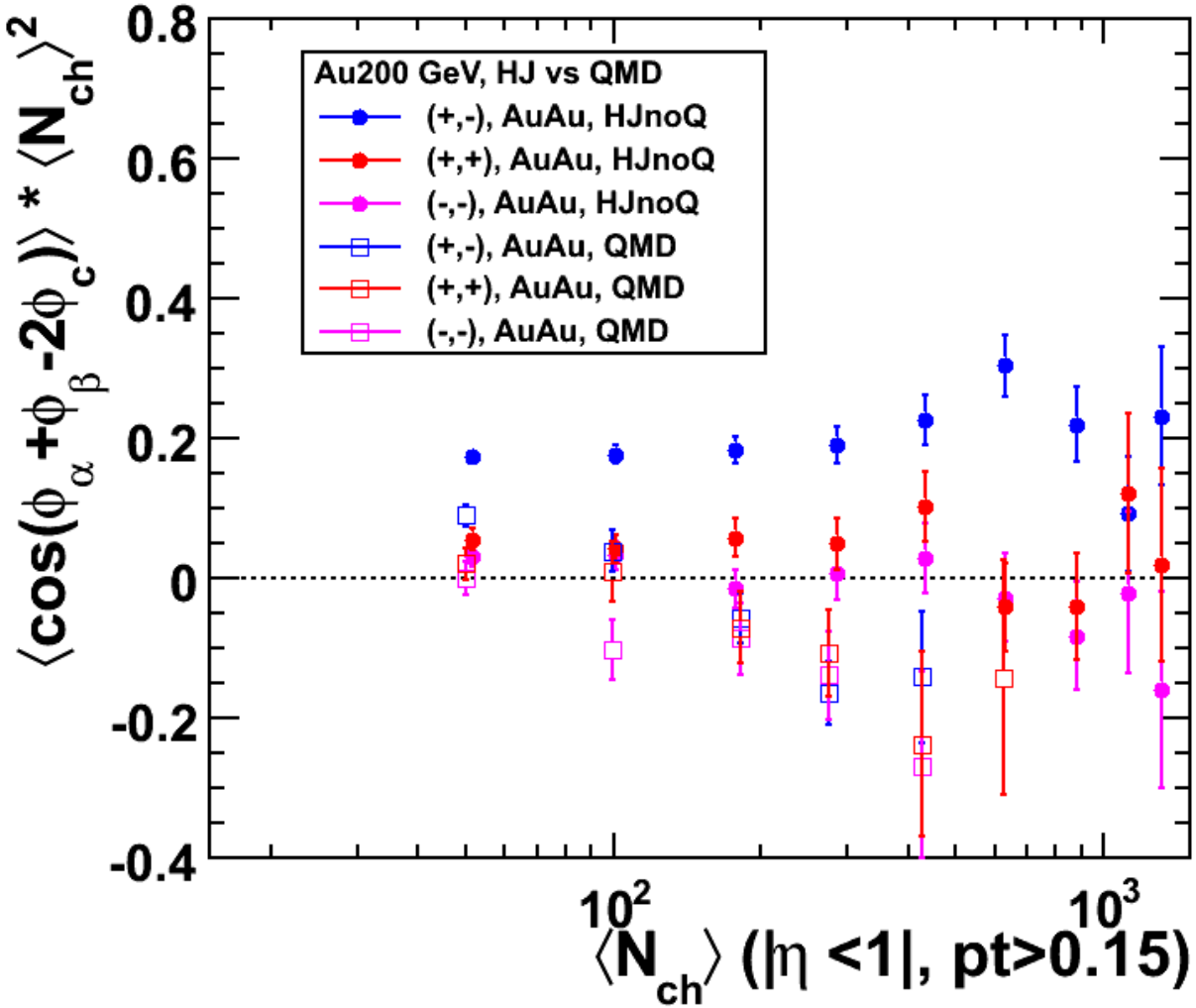


UrQMD 3-particle correlations



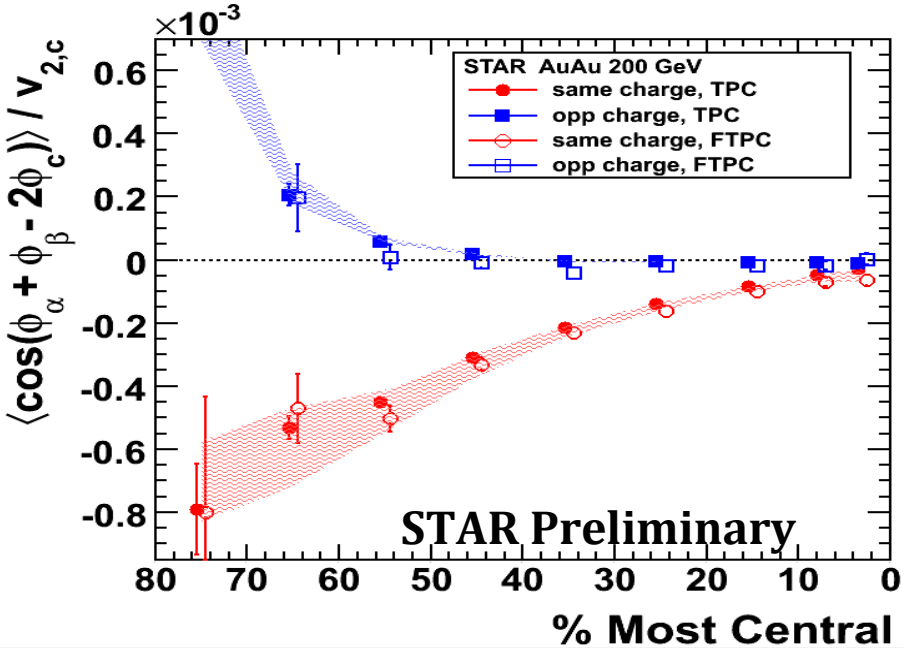
By 3rd bin (50-60% bin), factorization holds for UrQMD, as we can see from agreement of hollow points ($<\cos(\varphi_a+\varphi_b-2\varphi_c)>/ v_{2,c}$) and solid points $<\cos(\varphi_a+\varphi_b-2\Psi)$

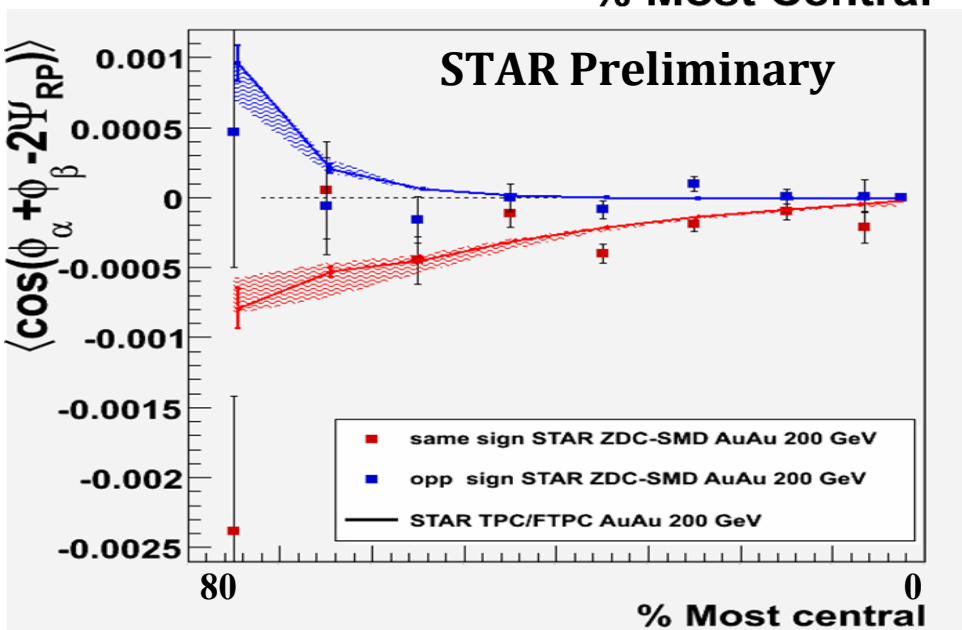
UrQMD 3-particle correlations



In most peripheral (70-80% centrality) bin, UrQMD gives about 40% of the 3-particle contribution that HIJING does

DATA: particle ‘c’ in TPC / FTPC / ZDC-SMD

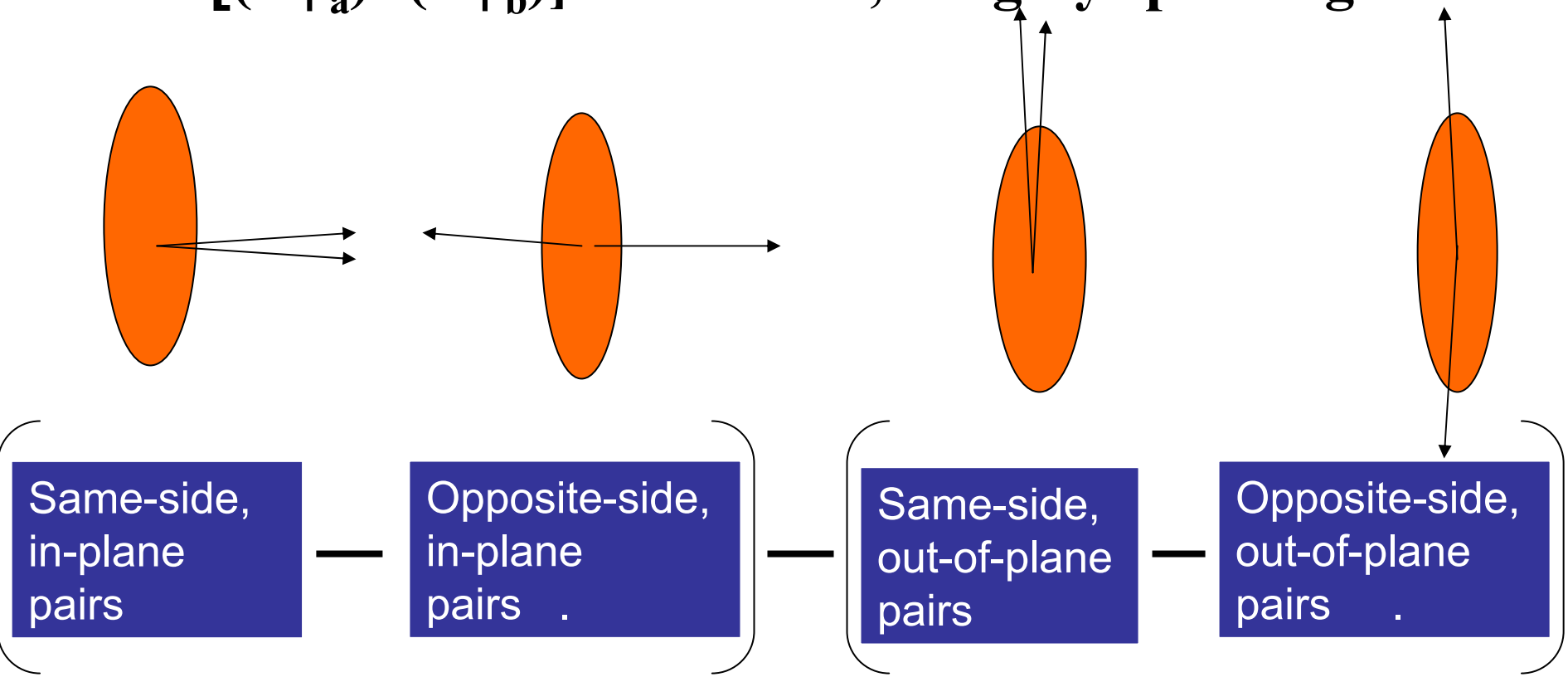




- Similar behavior with third particle in TPC or FTPC (ZDC?).
  - Evidence for factorization (i.e. $<\cos(\varphi_a+\varphi_b-2\varphi_c)>/v_{2,c} = <\cos(\varphi_a+\varphi_b-2\Psi)$
  - Cluster/minijet correlation width in rapidity?

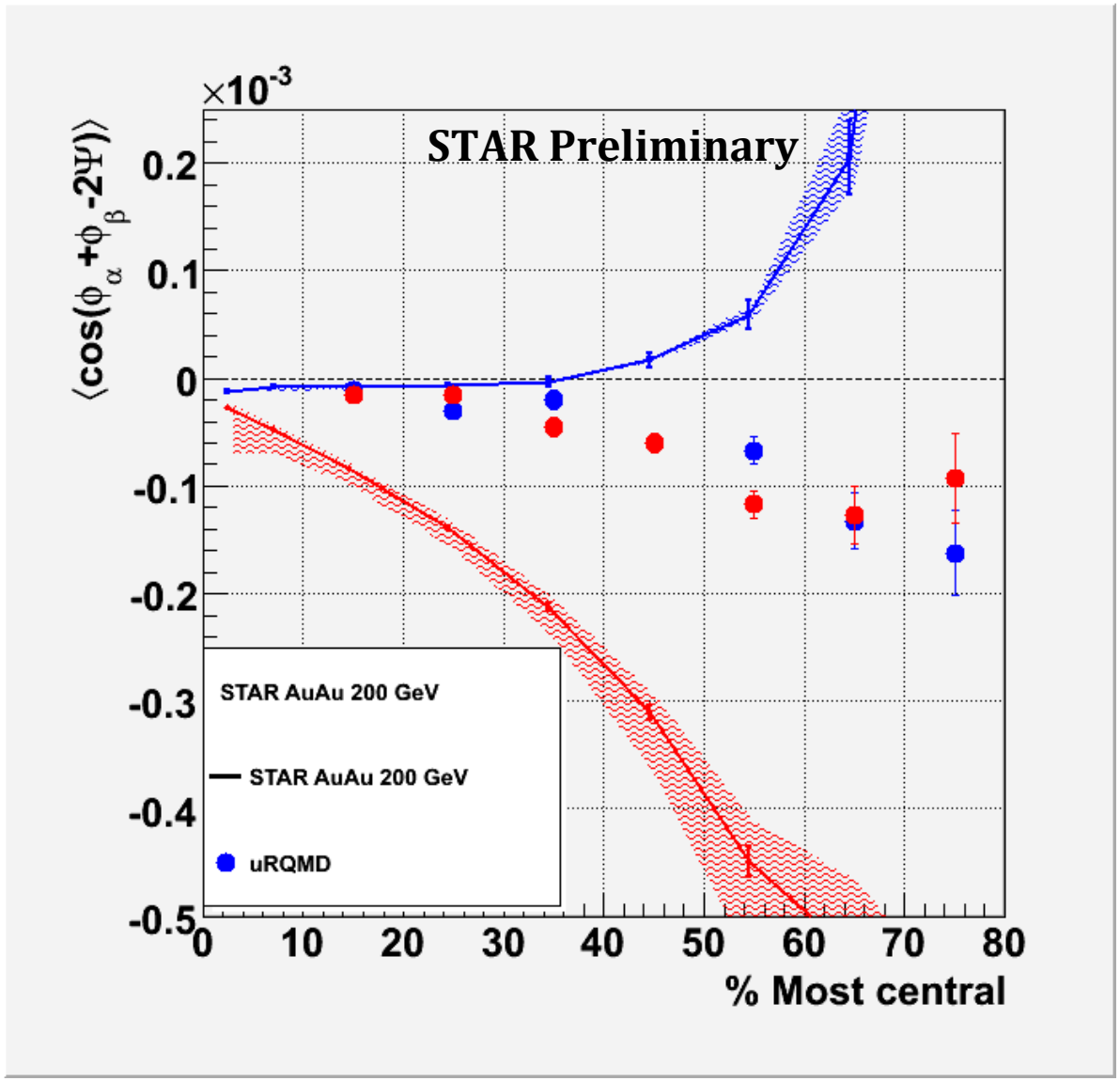
2-particle correlations w.r.t. the reaction plane

$<\cos[(\Delta\varphi_a)+(\Delta\varphi_b)]>$ measures, roughly speaking…



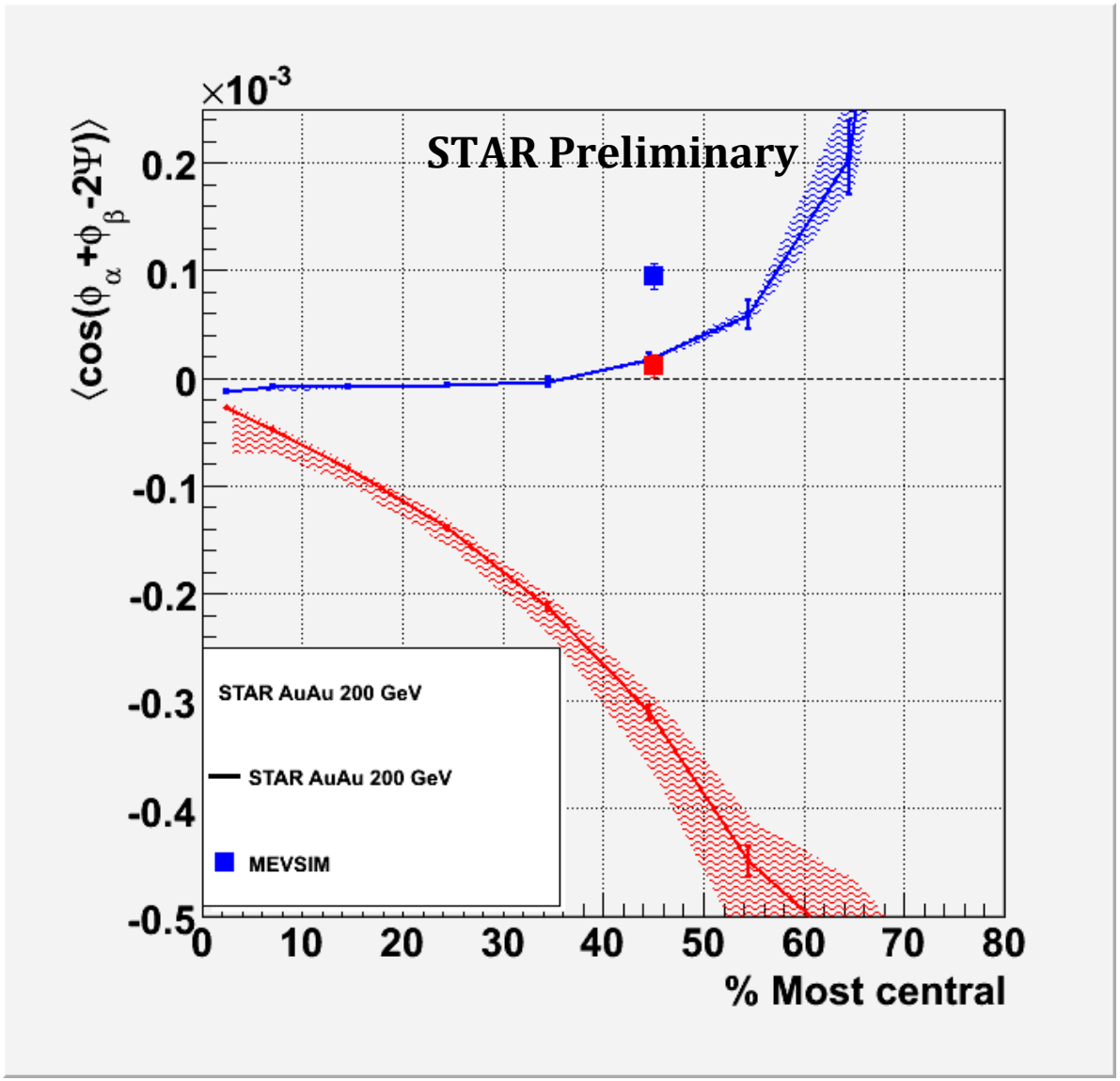
Potential problems include clusters (jets/minijets/resonances) whose production or properties depend on orientation with respect to the reaction plane. For example, a resonance which decays generally with a small opening angle and has positive v_2 gives a positive contribution.

$<\cos(\varphi_a+\varphi_b-2\Psi)>$ (with Ψ known)



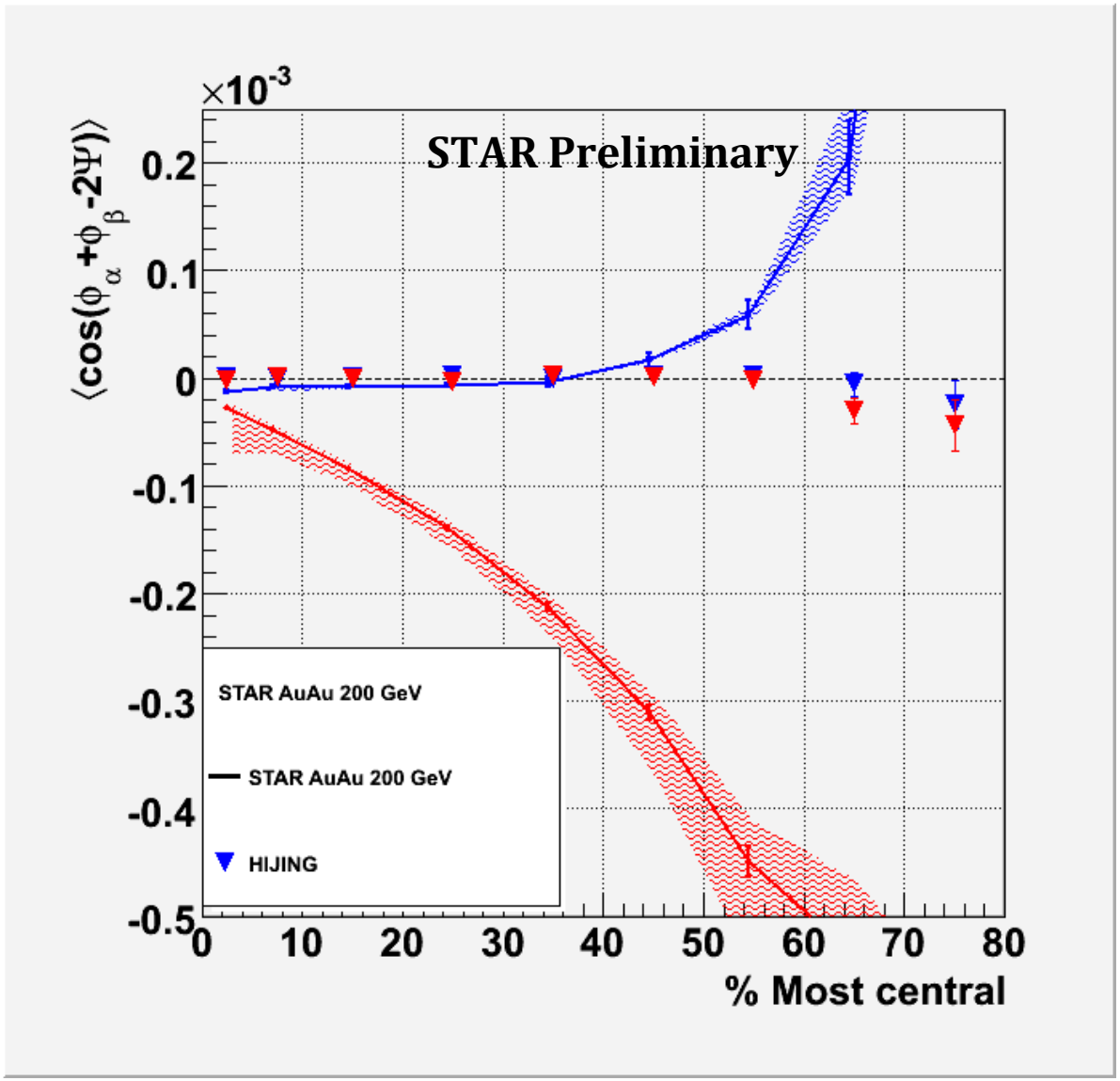
- URQMD

$<\cos(\varphi_a+\varphi_b-2\Psi)>$ (with Ψ known)



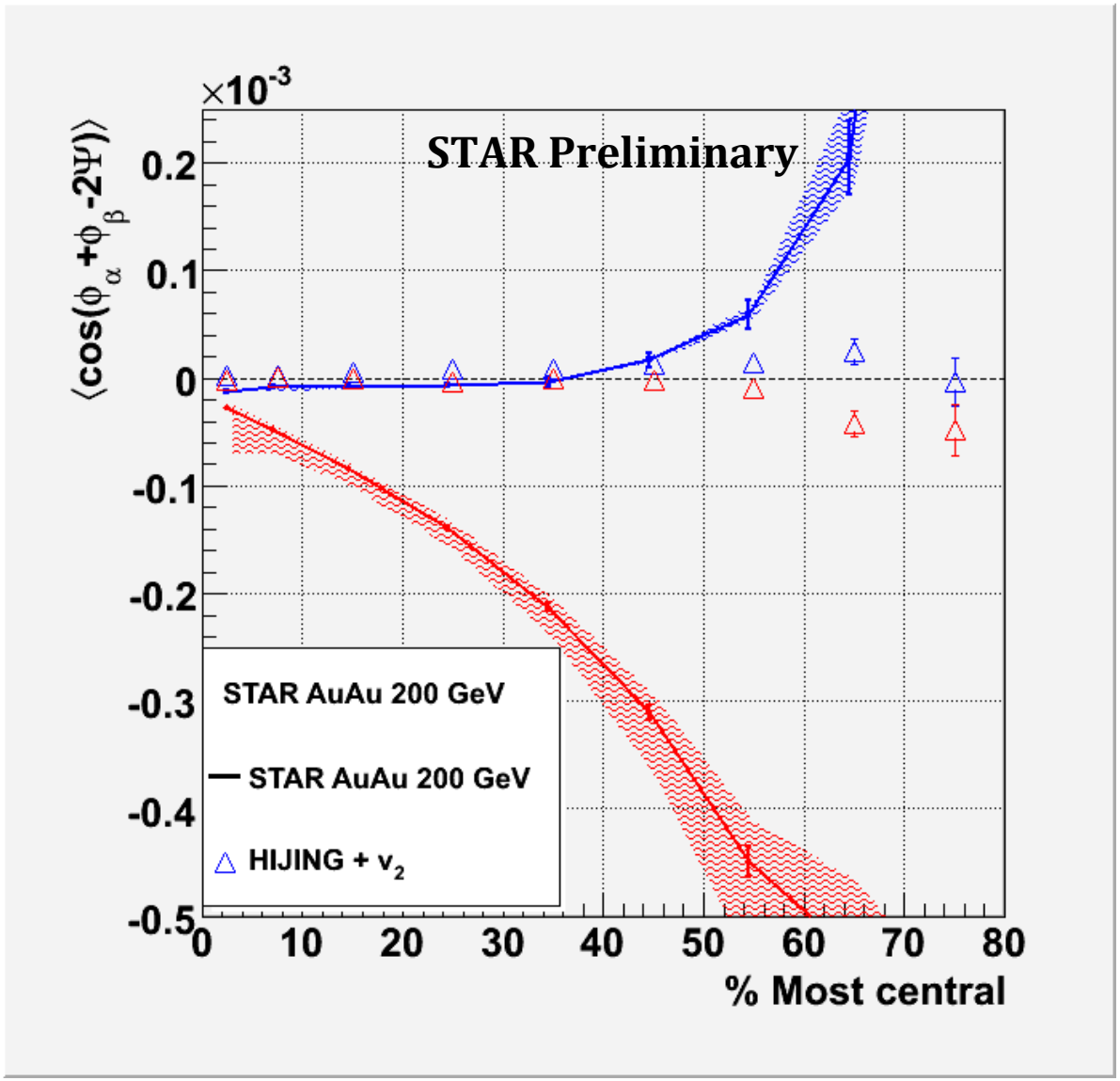
- MEVSIM

$<\cos(\varphi_a+\varphi_b-2\Psi)>$ (with Ψ known)



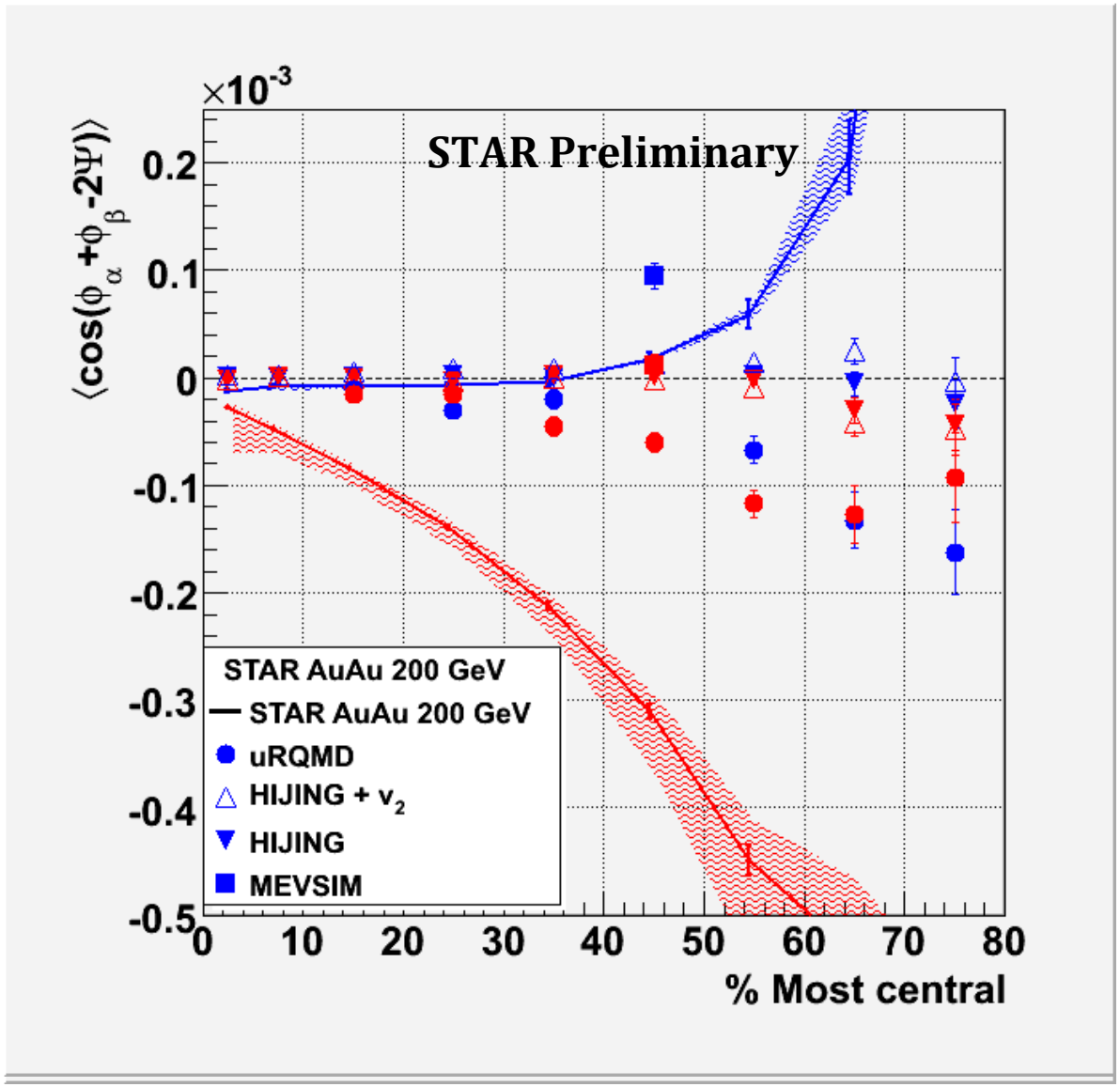
- HIJING

$<\cos(\varphi_a+\varphi_b-2\Psi)>$ (with Ψ known)



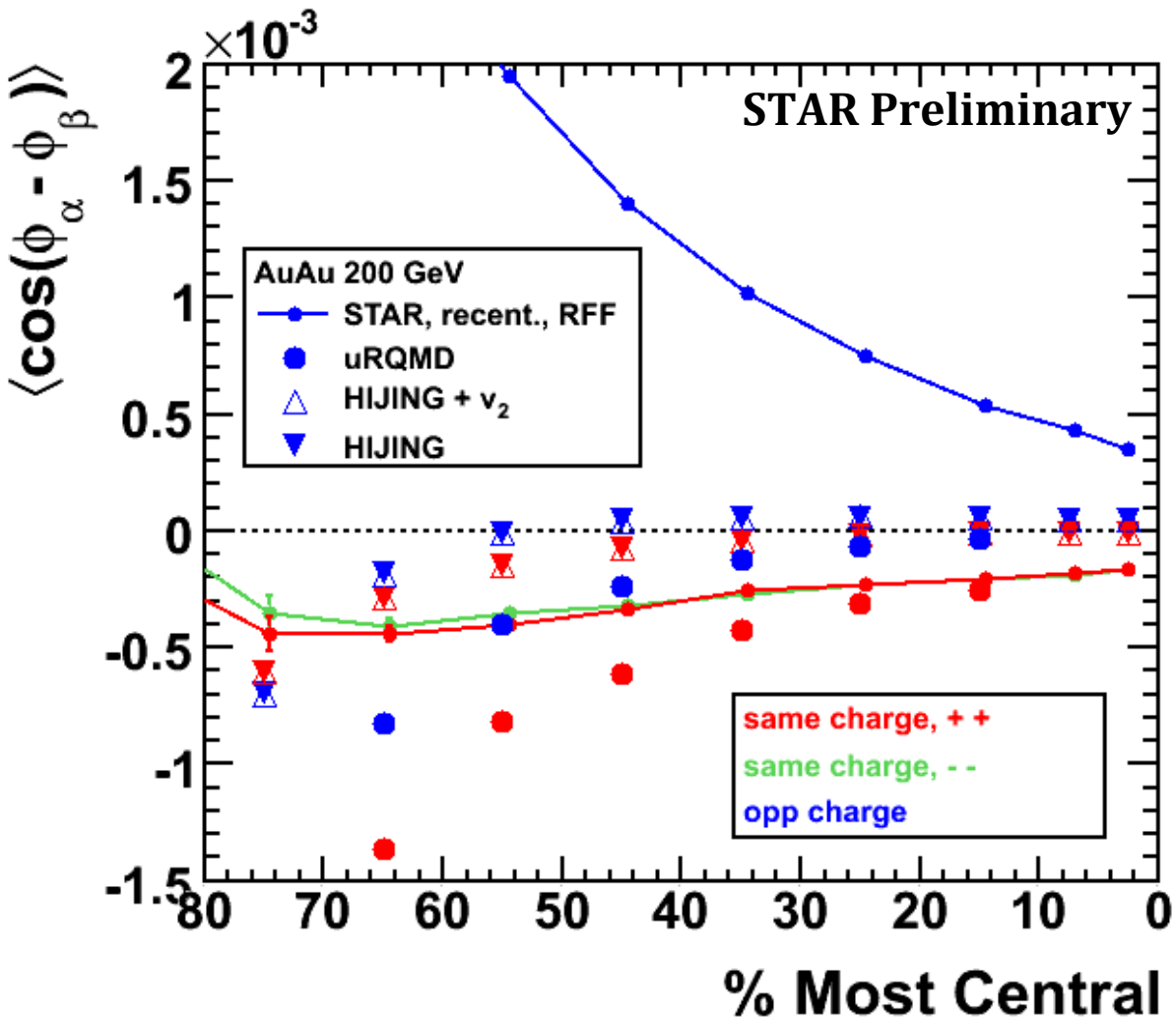
- HIJING+ v2

$<\cos(\varphi_a+\varphi_b-2\Psi)>$ (with Ψ known)



How do these models do with other correlations?

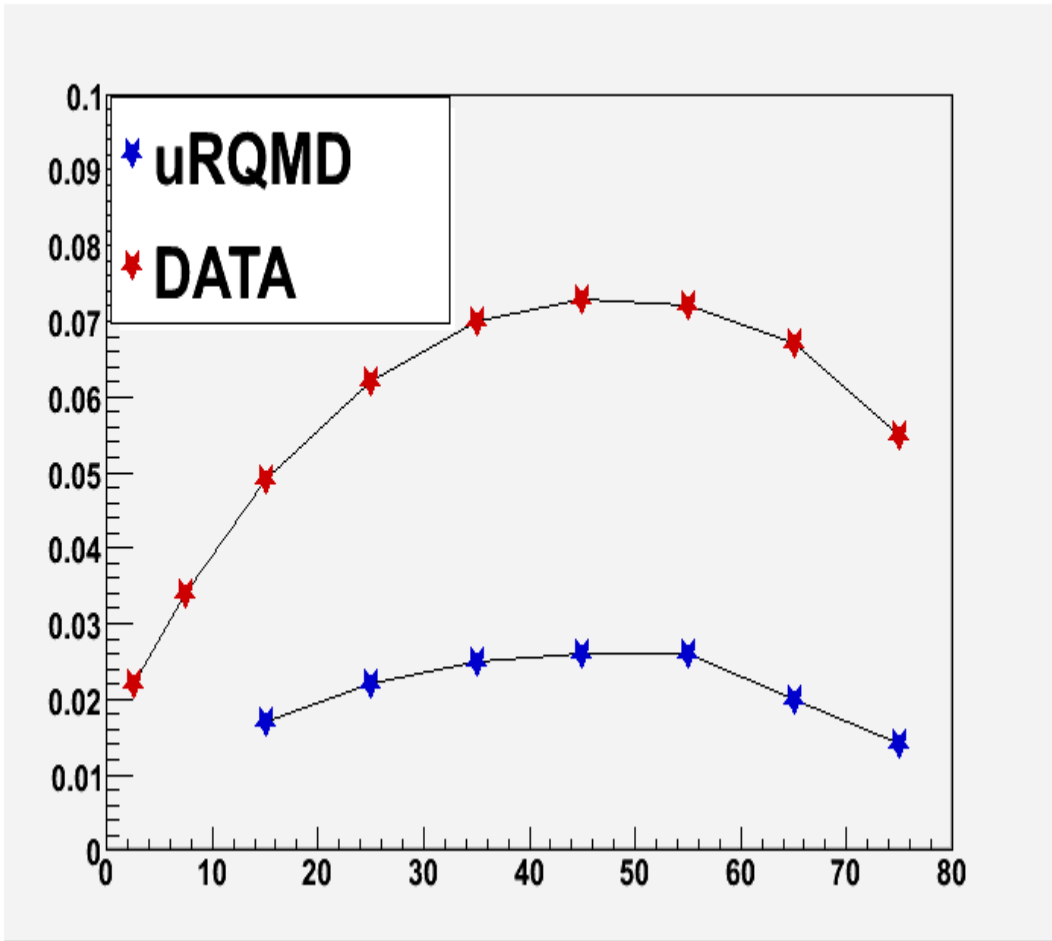
$\langle\cos(\varphi_a-\varphi_b)\rangle$ in various models



This is the sum of $\langle\cos\varphi_a\cos\varphi_b\rangle$ and $\langle\sin\varphi_a\sin\varphi_b\rangle$ rather than the difference. Model predictions are generally quite different than data, particularly for unlike sign correlations.

v_2 in URQMD

v_2 for charged tracks with $.150<p_t<2$, $|\eta|<1$ in UrQMD compared with values used from data to calculate $<\cos(\varphi_a+\varphi_b-2\varphi_c)>/v_{2,c}$



AMPT

- We were advised (by the code authors) that comparisons with AMPT for such charged dependent correlations are unreliable as charge is not strictly conserved in AMPT.
- Quick summary of AMPT results (default settings-quenching off)
  - $<\cos(\varphi_a-\varphi_b)>$ values are similar to UrQMD
  - v_2 values are similar to data, $\cos(\varphi_a+\varphi_b-2\Psi)$ values scale similarly to UrQMD , but larger in magnitude (not quite x2).

SIMULATIONS SUMMARY

- Simulation studies: 2 main points:
  - The 3-particle rxn plane independent correlation signal in HIJING is consistent with many measured data points for the unlike-sign signal.
  - No clear explanation within these models for the like-sign signal. Models generally don't do well for average correlations either.

Overall Summary(of previous 2 talks):

- Same sign correlations
  - Agree with roughly the magnitude, centrality, and rapidity dependence expected for PV signal. p_t dependence does not match initial expectations, but may be accommodated within theory(?).
  - We have not found any known background to match the magnitude of the signal.
- Opposite sign correlations
  - Follow some expected features of PV signal but largely explainable by three-particle clusters in HIJING.
  - Very small or even “wrong” sign signal may be accommodated, but this needs real quantitative theoretical work!