Nonflow to the U-Shape Paper
A Hijing model study

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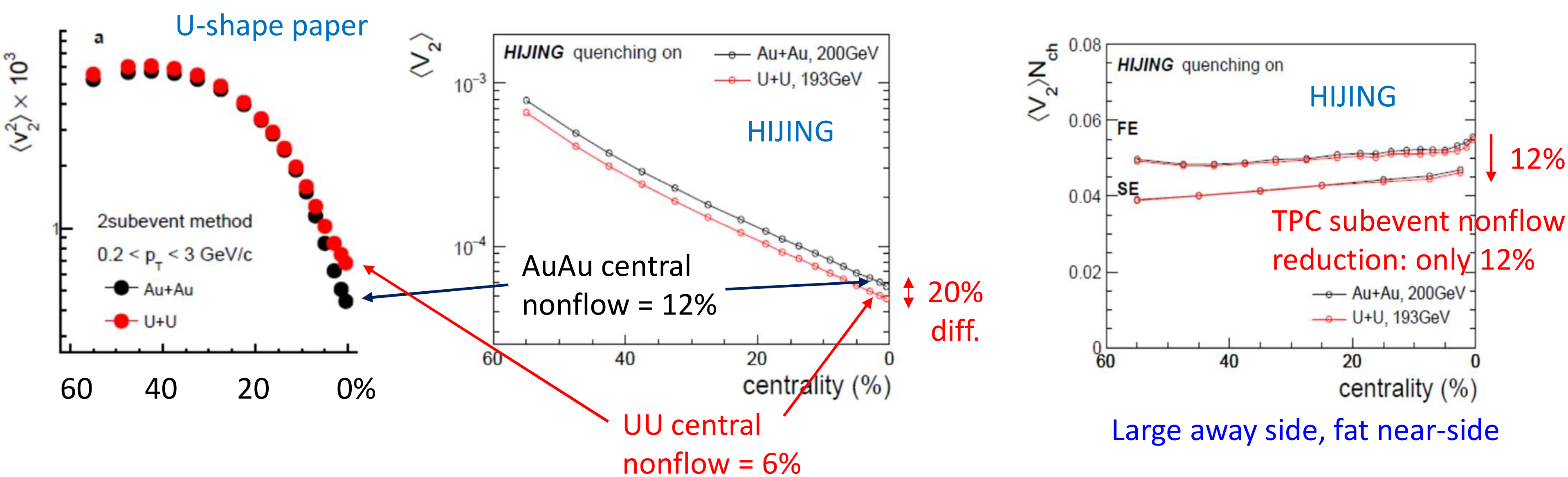
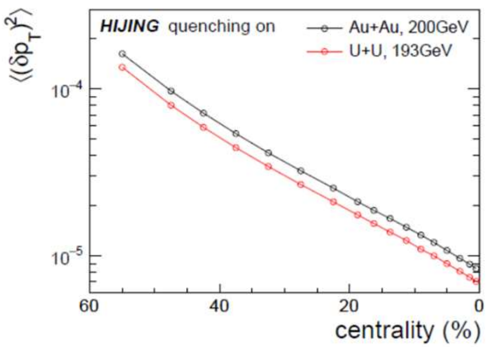
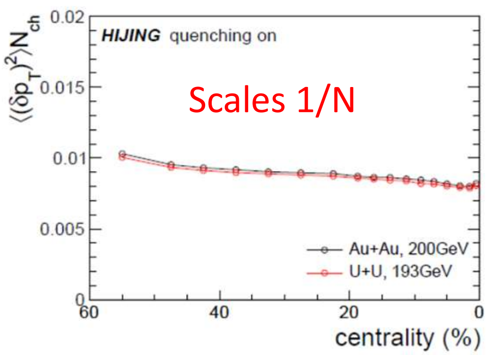
HIJING v_2 anisotropy

- Hijing is not a hydro model. All v_2 in Hijing is nonflow.
- Absolutely no question in HIJING that there's nonflow and it is relatively large (likely lower limit for real data)
- Interested in nonflow, so use simplest WS densities, spherical nuclei for both Au and U.

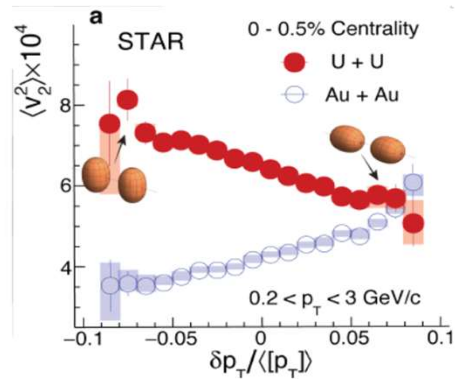


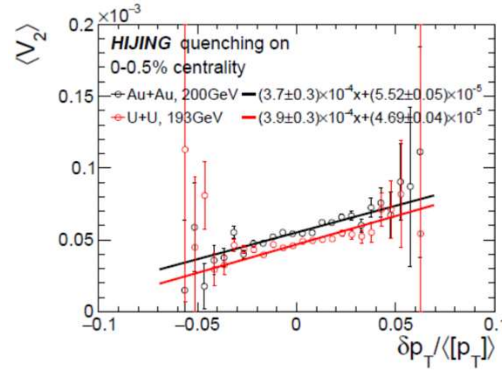
p_T-p_T and v_2-p_T correlations

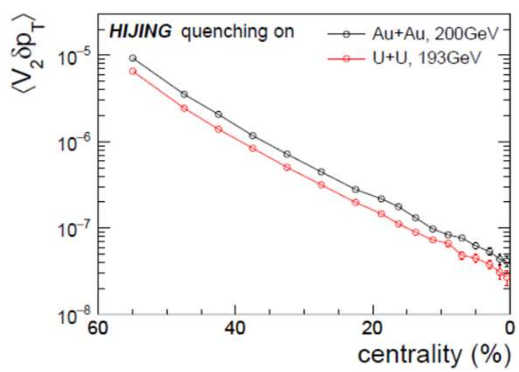


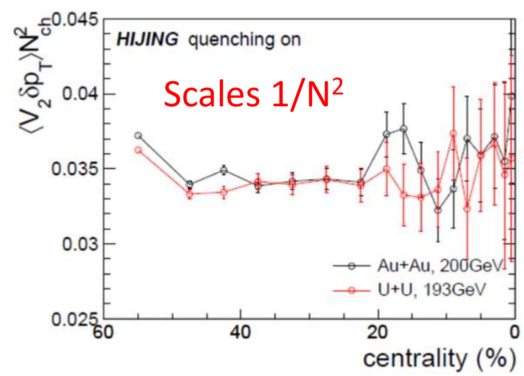


Dynamical p_T fluctuations
Possible source: jet production









Positive correlations between V_2 and δp_T. Possible sources:

- Resonance decays: larger p_T, smaller opening angle, larger V_2
- Jet production: more jets, larger p_T and larger V_2

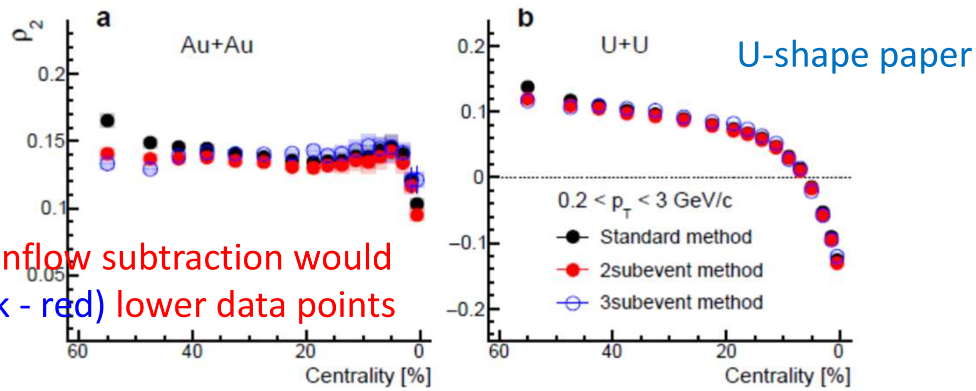


Fig. 5 | Impact of non-flow correlations. The centrality dependence of $\rho_2 = \frac{\langle v_2^2 \delta p_T \rangle}{\langle v_2^2 \rangle \sqrt{\langle (\delta p_T)^2 \rangle}}$ in Au+Au (a) and U+U (b) collisions, where $\langle v_2^2 \delta p_T \rangle$ is calculated using the standard, two-subevent and three-subevent correlation methods. The components in the denominator $\langle v_2^2 \rangle$ and $\langle (\delta p_T)^2 \rangle$ are calculated using the two-subevent method.

Modest differences are observed between the standard method and subvent methods for all observables, particularly towards the peripheral collisions. Some of these differences are attributable to non-flow contributions, while the remainder could arise from longitudinal flow decorrelations. We obtain default results as the average of the standard method and two-subevent method, and half of the differences are assigned as systematic uncertainties. They are 1–2% for $\langle v_2^2 \rangle$, 1–3% for $\langle (\delta p_T)^2 \rangle$, and 2–4% for $\langle v_2^2 \delta p_T \rangle$ in the 0–40% centrality range, respectively.

The total systematic uncertainties are combined in quadrature from different sources, and in some cases, they are larger than the statistical uncertainties. The total uncertainties of $\langle v_2^2 \rangle$, $\langle (\delta p_T)^2 \rangle$, and $\langle v_2^2 \delta p_T \rangle$ are 2.5–4%, 2–5%, and 4–10%, respectively. Note that for the ratios between U+U and Au+Au, their uncertainties are evaluated for each source and combined in quadrature to form the total systematic uncertainties. This process results in a partial cancellation of the uncertainties between the two systems.

methods [47]. In the two-subevent method, particles i and j are taken from ranges of $-1 < \eta_i < -0.1$ and $0.1 < \eta_j < 1$, while particle k can be taken from either subevents. In the three-subevent method, all three particles i, j and k are taken from distinct η ranges, namely $-1 < \eta_i < -0.4$, $0.4 < \eta_j < 1$, and $|\eta_k| < 0.3$. The inclusion of a pseudorapidity gap between the particle pairs or triplets suppresses the short-range "non-flow" correlations arising from resonance decays and jets [74].

The results in Fig. 4 are obtained using the two-subevent method. However, as discussed earlier, $\langle v_2^2 \delta p_T \rangle$ has contributions from non-flow correlations, which can be explored by comparing results obtained from the standard, two-subevent and three-subevent methods. The results for ρ_2 are shown in Fig. 5. In this figure, $\langle v_2^2 \rangle$ and $\langle (\delta p_T)^2 \rangle$ are calculated using the two-subevent method, so any variations in ρ_2 arise only from $\langle v_2^2 \delta p_T \rangle$.

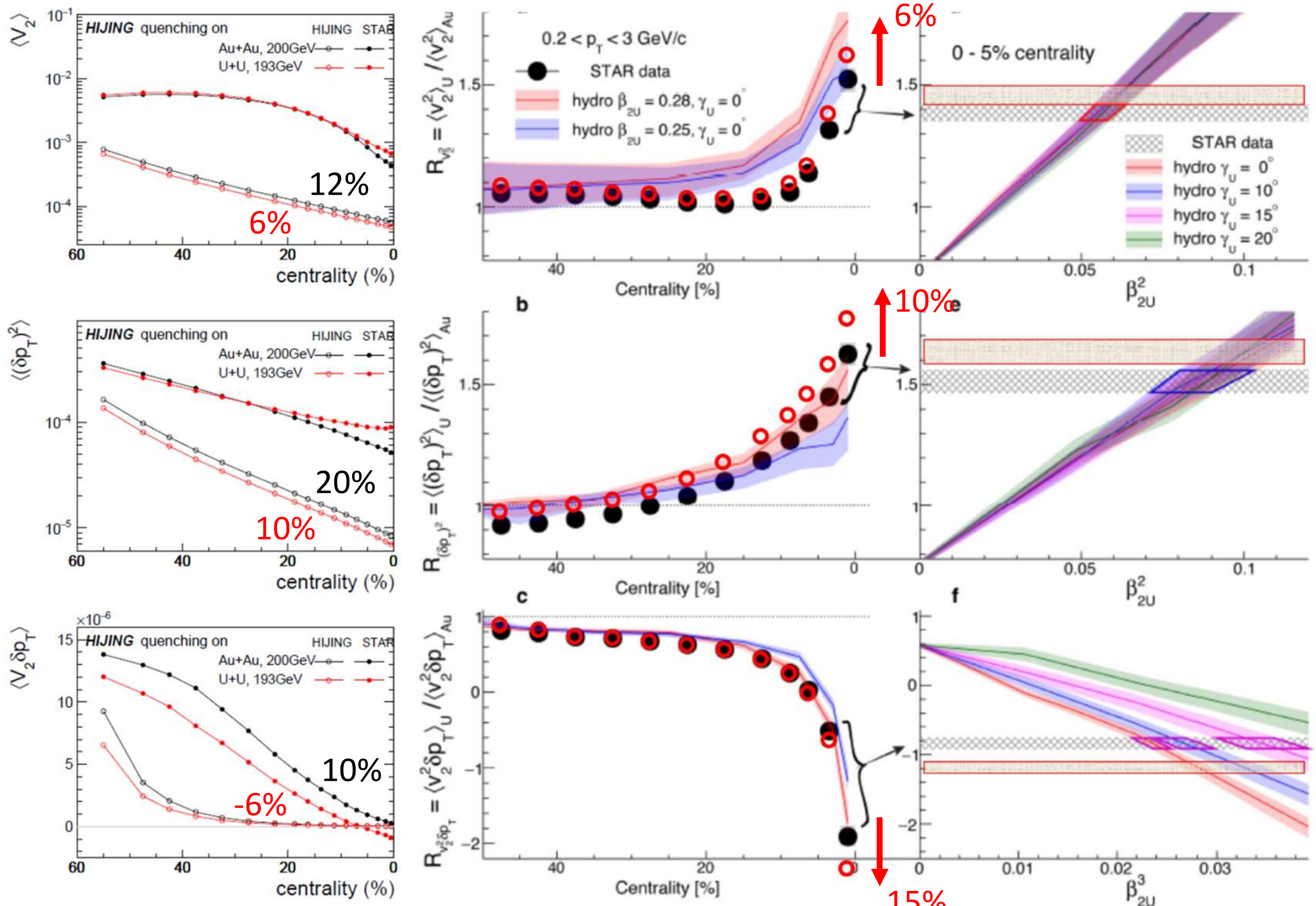
- According to HIJING, TPC subevent nonflow reduction is only 12%. Half of that was taken as syst. error in the U-shape paper, and that corresponded to syst. errors 1-2% for v_2^2, 1-3% for $(\delta p_T)^2$, 2-4% for $v_2^2\ \delta p_T$ in the 0-40% centrality.
- Taking HIJING full nonflow (x15 larger), the syst. errors would be 15-30% for v_2^2, 15-45% for $(\delta p_T)^2$, 30-60% for $v_2^2 \delta p_T$. These would dominate the total error.
- This is actually syst. error, NOT syst. uncertainty.
- These are estimated from HIJING + paper propositions of nonflow effects.
- Real data may be different, but the conclusion should be robust that nonflow is a big issue for this paper.

Effect of nonflow subtraction by Hijing

20% nonflow difference due to multiplicity difference.
If nonflow is 12% (according to HIJING), then 2% effect.

In reality, worse: nonflow is smaller in UU (deformity). UU/AuAu difference is larger, actually 6%.

Data nonflow 20-30%, so effect could be larger.



Conclusions

- Nonflow is large; Hijing indicates ~10%, and subevent reduction is small
- U-shape paper nonflow syst. uncertainties severely underestimated
- Nonflow is a syst. error, rather than a syst. uncertainty
- Correcting for nonflow according to Hijing would cause the data points to be off by several times the estimated nonflow syst. uncertainty, even beyond the total uncertainty
- The U-shape paper results are therefore premature
- Nonflow/non-hydro effects must be corrected, and faithful syst. uncertainty be assessed, before data are compared to hydro to extract physics