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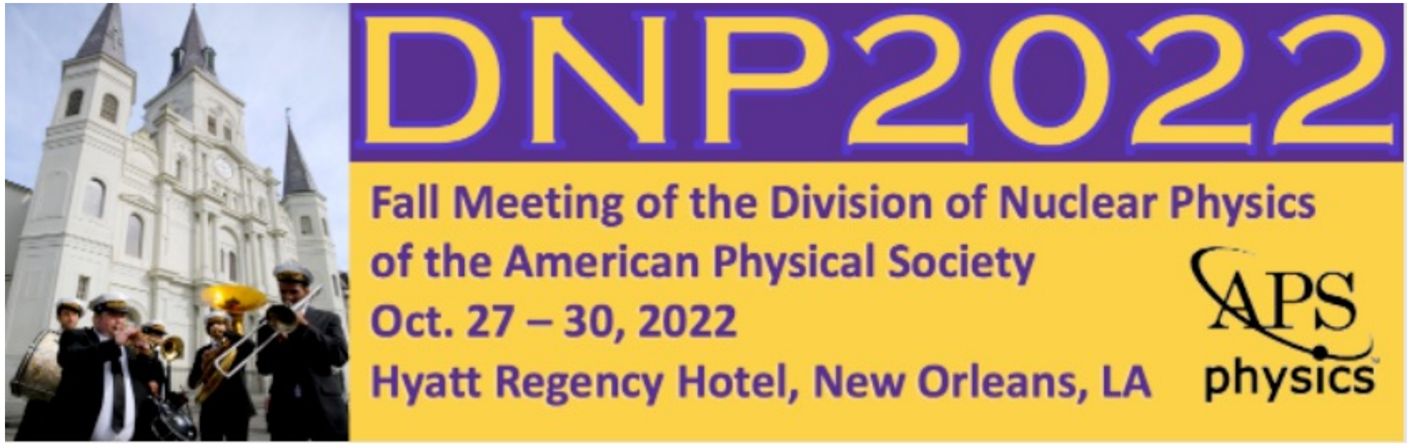
Beam-energy dependence of transverse momentum and flow correlations in STAR



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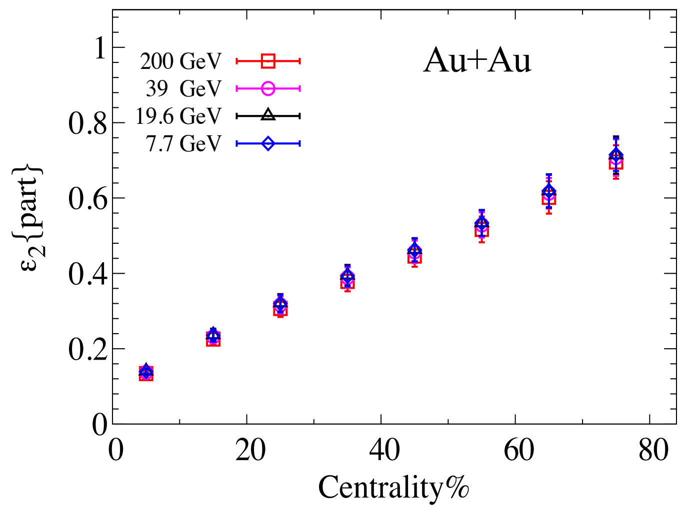
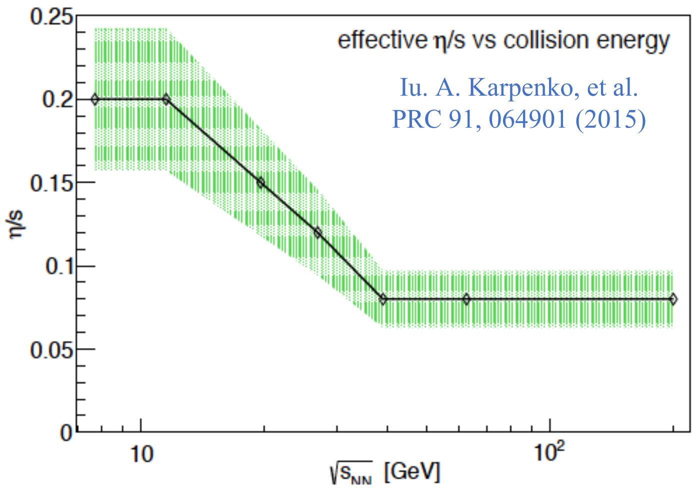
Motivation:

- The beam-energy dependence of flow and p_T correlations will reflect the respective roles of ϵ_n, its fluctuations and $\frac{\eta}{s}$ as a function of T and μ_B

Beam energy dependence for a given collision system:





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PLB 821 136625 (2021)

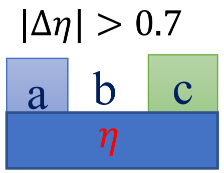
Piotr Bozek
PRC 93, 044908 (2016)

- Initial-state ε_2 is approximately energy independent
- Viscous attenuation ($\propto \frac{\eta}{s}(T)$) is beam energy dependent

The Pearson correlation, $v_n - [p_T]$ correlation, coefficient (PCC) is expected to be susceptible to the initial conditions of heavy-ion collisions.

Analysis procedure:

❖Transverse momentum-flow correlations:



$\Delta\eta_{b\grave{b}} > 0.2$

$$Var(v_n^2)_{dyn} = v_n^4\{2\} - v_n^4\{4\}$$

$$C_k = \left\langle \frac{\sum_b \sum_{b'} w_b w_{b'} \left(p_{T,b} - \langle[p_T]\rangle\right)\left(p_{T,b'} - \langle[p_T]\rangle\right)}{\left((\sum_b w_b)^2 - \sum_b (w_b)^2\right)} \right\rangle$$

J. Jia, M. Zhou, A. Trzupek, PRC 96 034906 (2017)

ATLAS Collaboration, Eur. Phys. J. C 79, 985 (2019)

Piotr Bozek PRC 93, 044908 (2016)

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$$cov(v_n^2, [p_T]) = Re\left(\left\langle \frac{\sum_{a,c} w_a\, w_c\, e^{in(\phi_a - \phi_c)} \left([p_T] - \langle[p_T]\rangle\right)_b}{\sum_{a,c} w_a\, w_c} \right\rangle\right)$$

$$\rho(v_n^2, [p_T]) = \frac{cov(v_n^2, [p_T])}{\sqrt{Var(v_n^2)_{dyn}\, C_{\{k\}}}}$$

The Pearson correlation coefficient (PCC) measures the strength of the v_n-$[p_T]$ correlation.

❖Transverse momentum-flow correlations:

The beam-energy dependance of the transverse momentum-flow correlations using hydro model with URQMD initial state

- ➢ $Var(v_2^2)_{dyn}$ decreases with beam-energy
- ➢ $\sqrt{C_k}/\langle p_T \rangle$ shows no change with beam energy
- ➢ $cov(v_2^2, [p_T])$ decreases with beam-energy
- ➢**The Pearson correlation, $\rho(v_2^2, [p_T])$ shows no change with beam energy**

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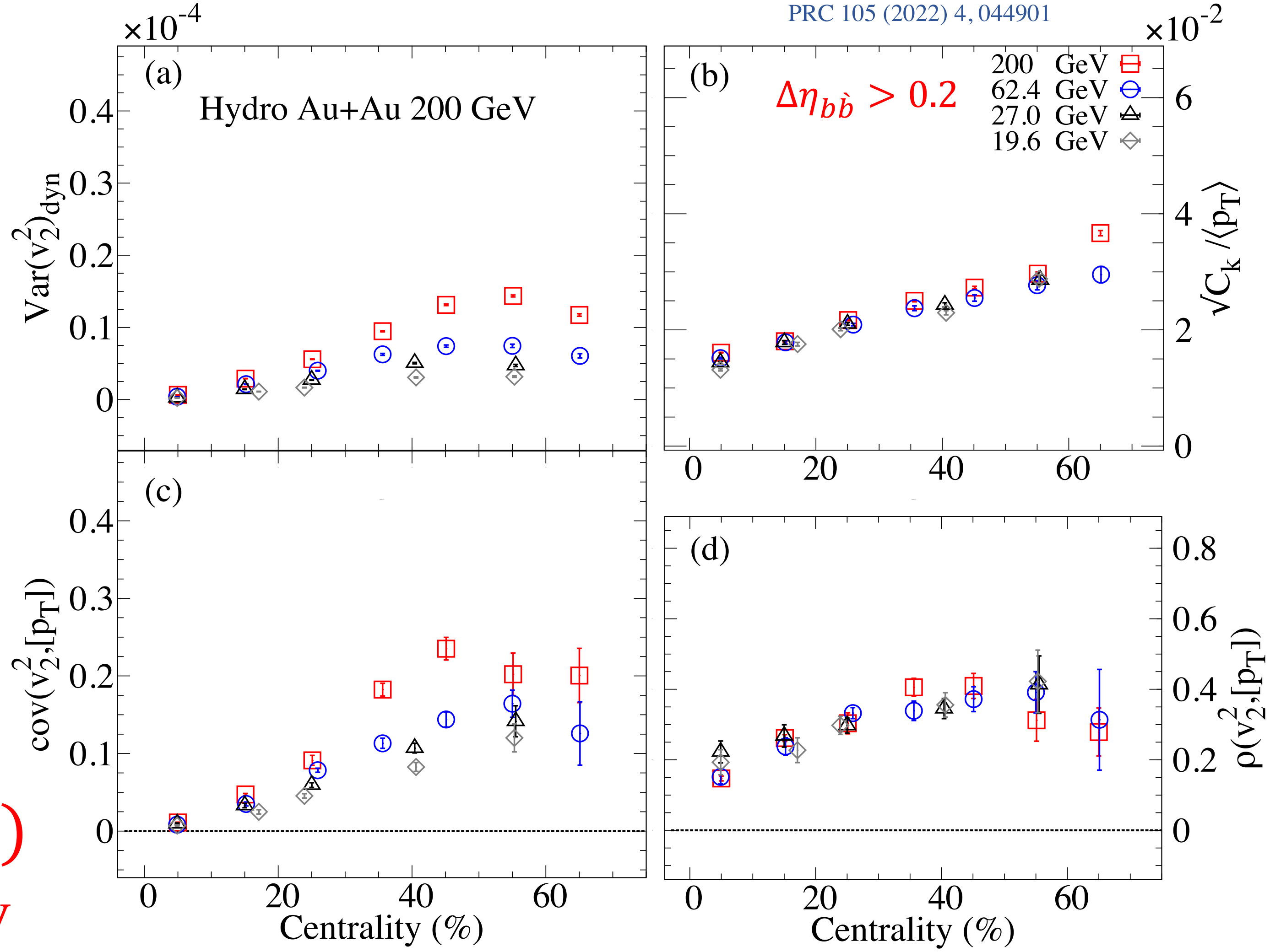

❖Transverse momentum-flow correlations:

The beam-energy dependance of the transverse momentum-flow correlations using hydro model with URQMD initial state

- ➢$Var(v_2^2)_{dyn}$ decreases with increasing η/s
- ➢$\sqrt{C_k}/\langle p_T\rangle$ shows no change with η/s
- ➢$cov(v_2^2,[p_T])$ decreases with increasing η/s
- ➢The Pearson correlation, $\rho(v_2^2,[p_T])$ shows little change with η/s

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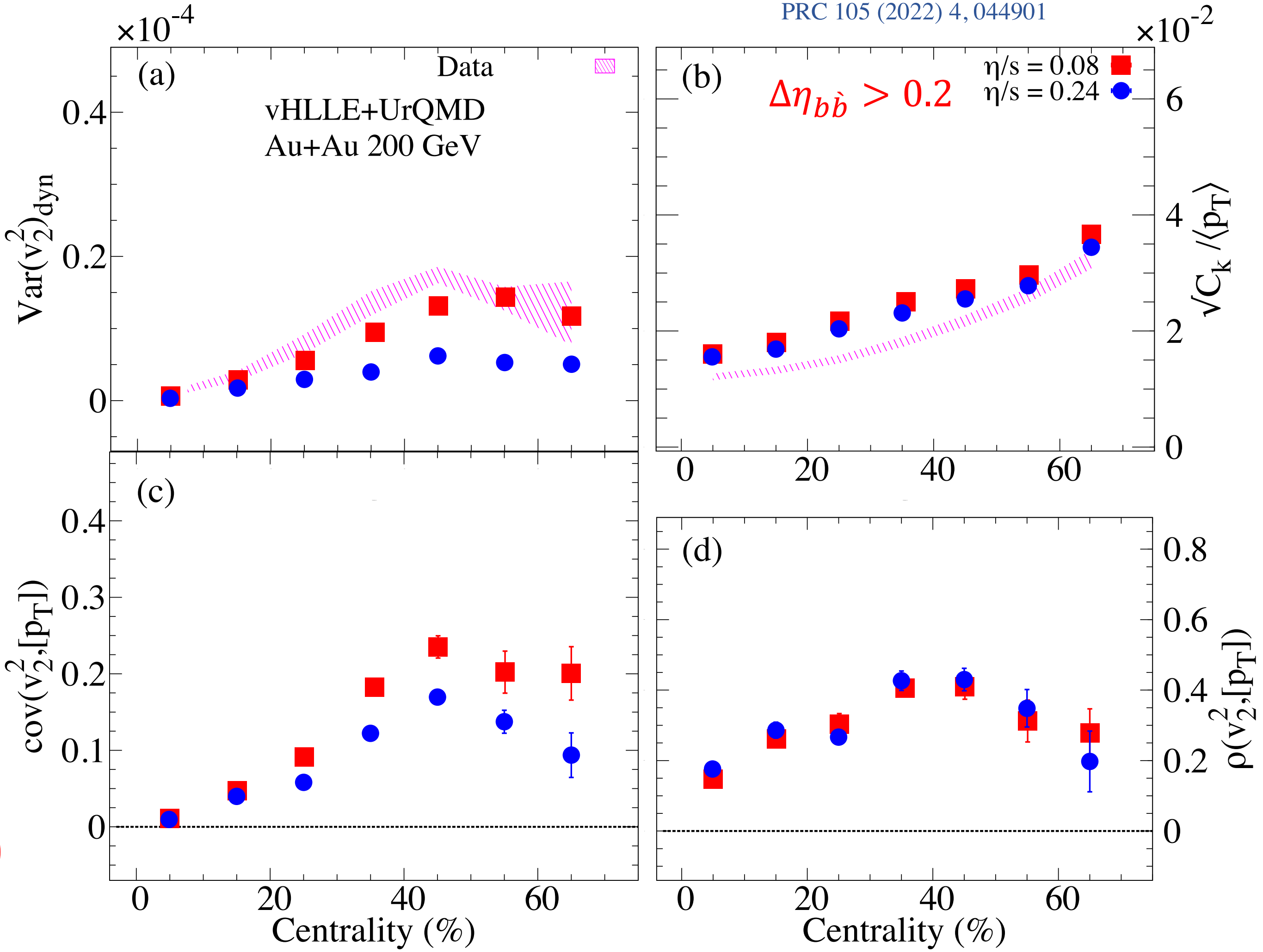
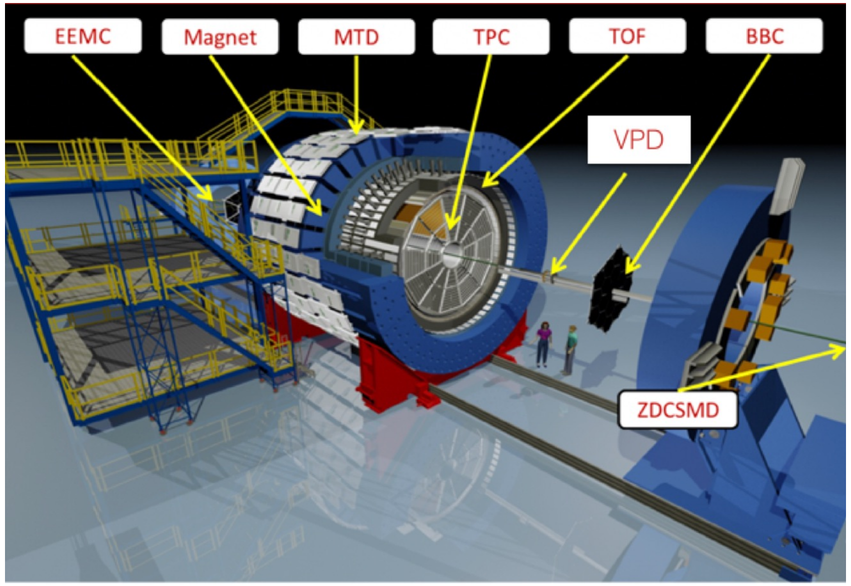


❖Transverse momentum-flow correlations:

- Data set:
  - ✓ Au +Au BES $\sqrt{s_{NN}} = 19.6 - 200$ GeV



The STAR experiment at RHIC

- Time Projection Chamber
  Tracking of charged particles with:
  - ✓ Full azimuthal coverage
  - ✓ $|\eta| < 1$ coverage

- In this analyses we used tracks with:
  $0.2 < p_T < 2.0$ GeV/c

- Hydro models:

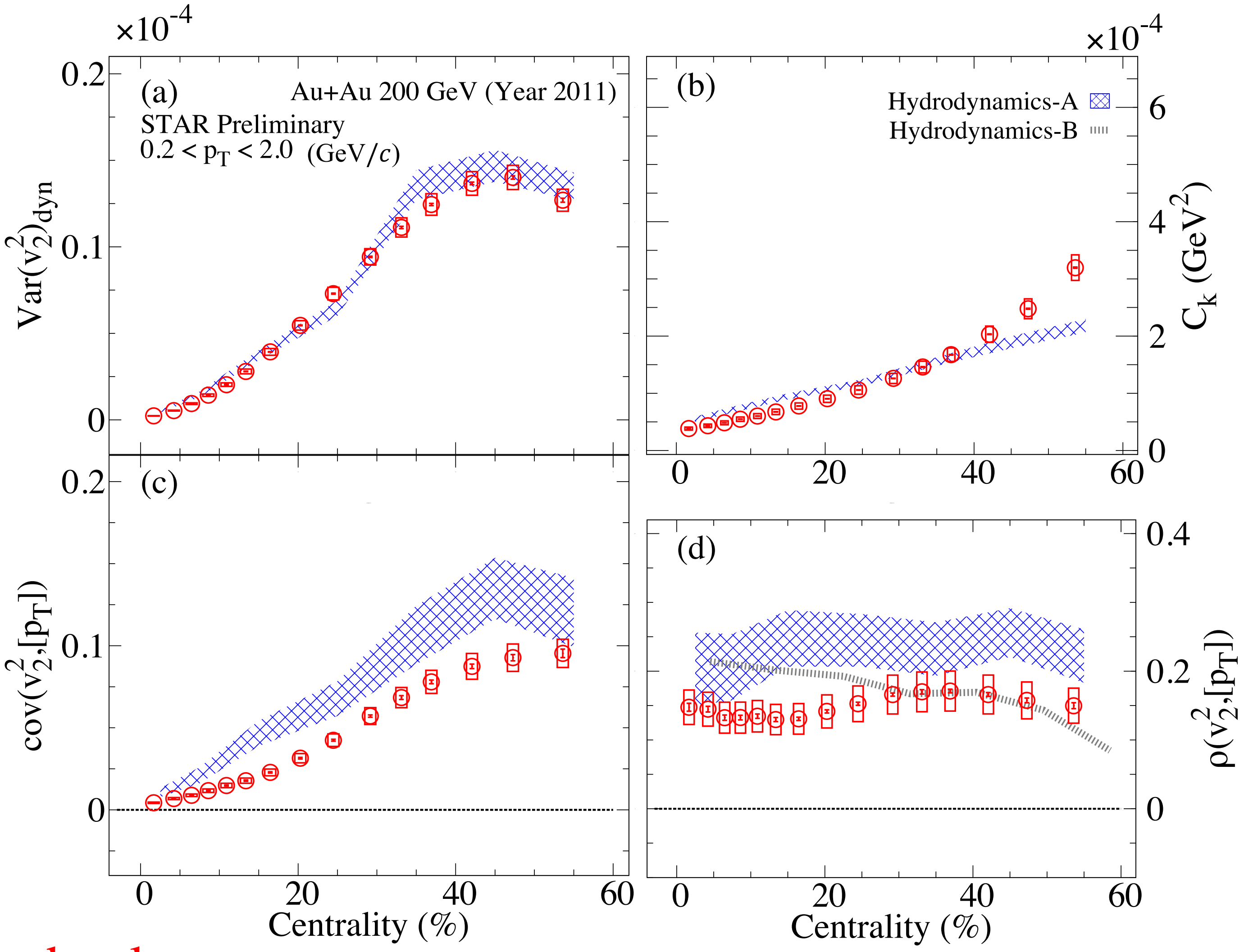
	Hydro-A	Hydro-B
η/s	0.12	0.05
Initial conditions	IP-Glasma	TRENTO
Contributions	Hydro + Hadronic cascade	Hydro + Direct decay

- (A) B.Schenke, C.Shen, and P.Tribedy PRC 99, 044908 (2019)
- (B) P. Alba, et al. PRC 98 , 034909 (2018)

Transverse momentum-flow correlations measurements:

❖ Hydro comparisons

- ➢ $Var(v_2^2)_{dyn}$ shows a good agreement with Hydro-A
- ➢ C_k shows a good agreement with Hydro-A from central to mid central
- ➢ Hydro-A overestimate $cov(v_2^2, [p_T])$



- ➢ Hydro models can qualitatively describe the data
  - ✓ Both Hydro-A and -B overestimate $\rho(v_2^2, [p_T])$

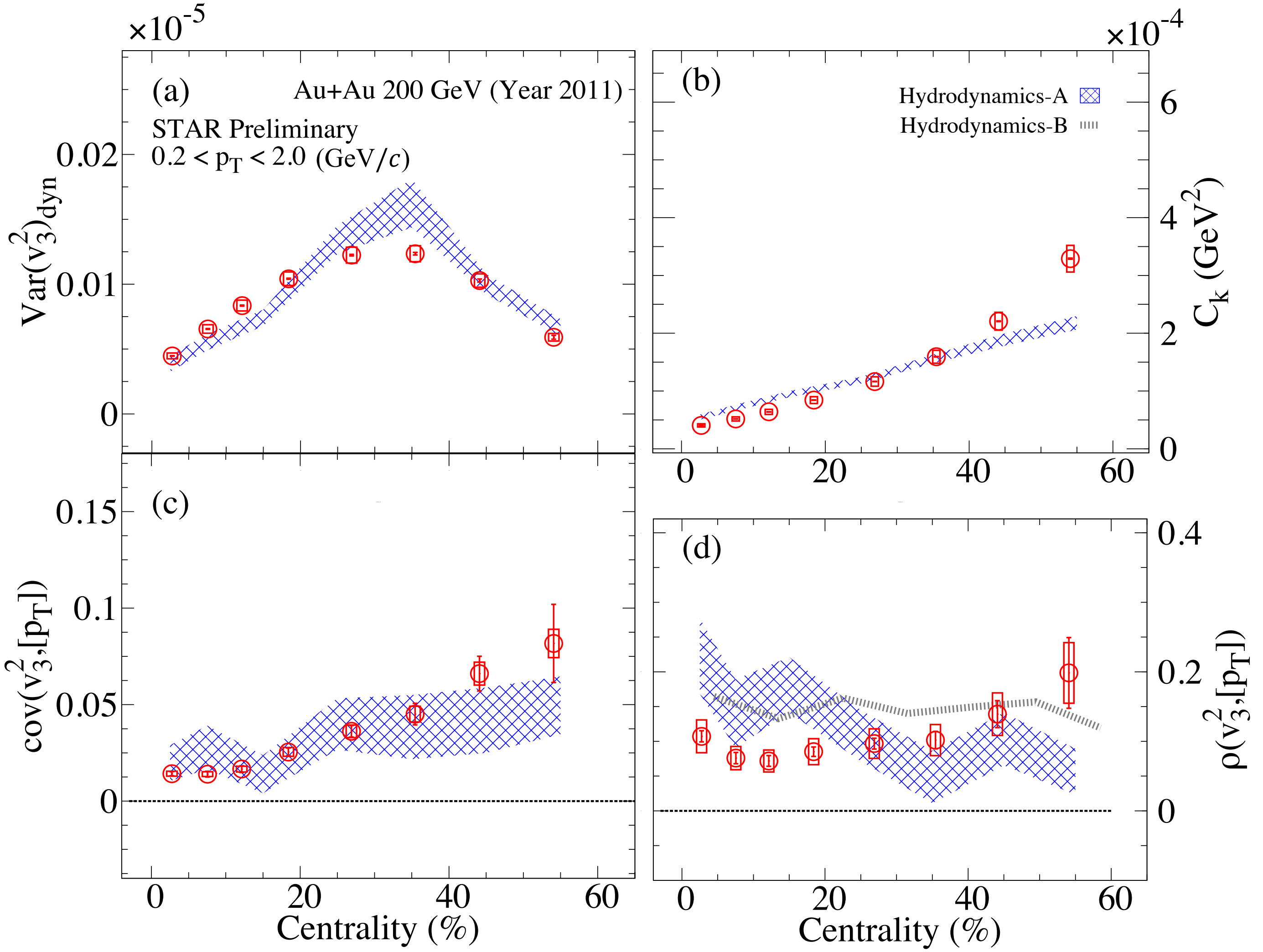
Transverse momentum-flow correlations measurements:

❖ Hydro comparisons

➢ $Var(v_3^2)_{dyn}$ shows a good agreement with Hydro-A

➢ C_k shows a good agreement with Hydro-A from central to mid central

➢ Hydro-A within the uncertainty shows a good agreement with $cov(v_3^2, [p_T])$



➢ Hydro models can qualitatively describe the data

✓ Both Hydro-A and -B overestimate $\rho(v_3^2, [p_T])$ in more central collisions

Transverse momentum-flow correlations measurements:

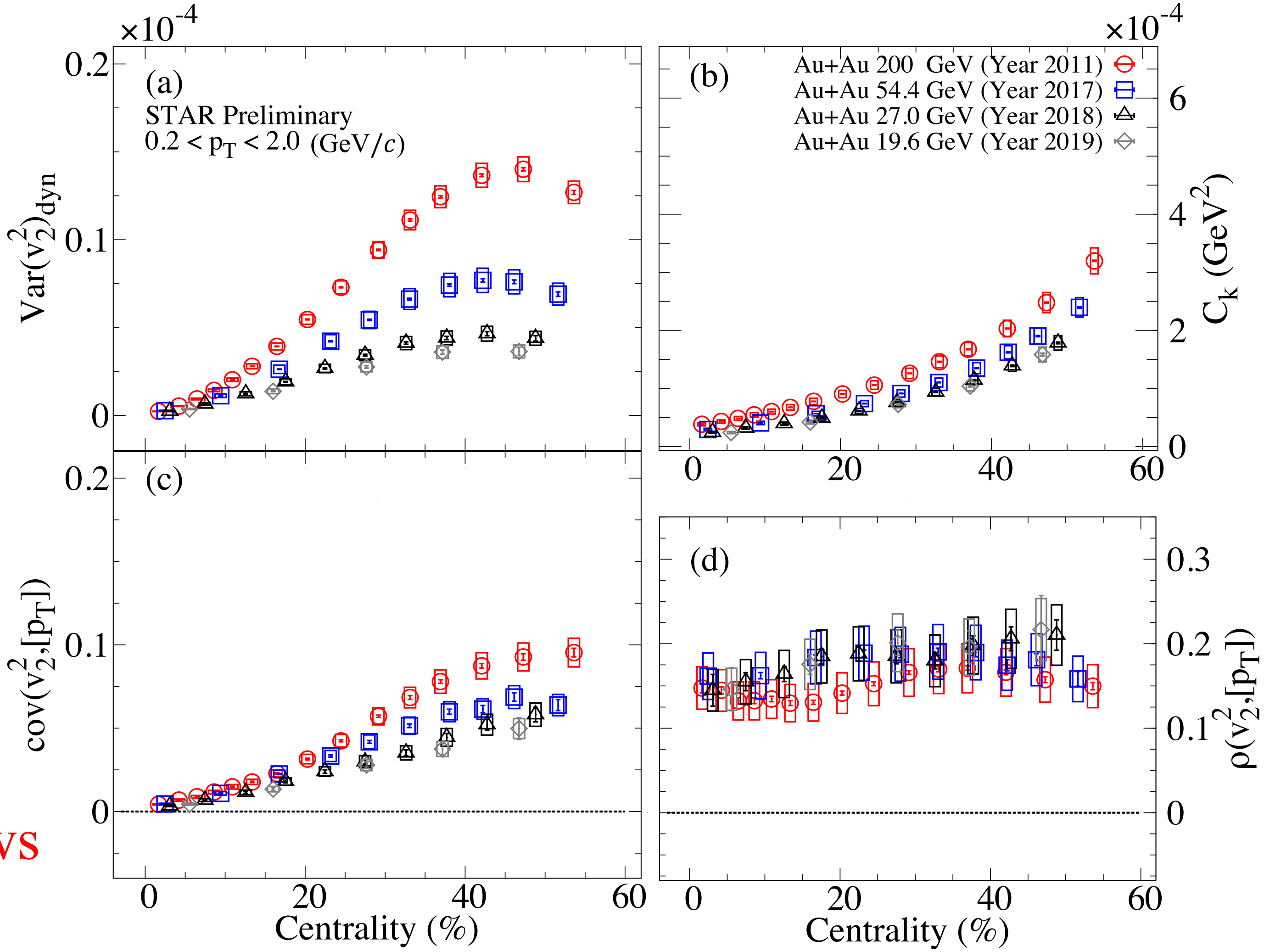
❖ The beam-energy dependence of the transverse momentum-flow correlations

➢ $Var(v_2^2)_{dyn}$ decreases with beam-energy

➢ C_k decreases with beam-energy

➢ $cov(v_2^2, [p_T])$ decreases with beam-energy

➢ The Pearson correlation, $\rho(v_2^2, [p_T])$, shows no significant energy dependence within the systematic uncertainties



Transverse momentum-flow correlations measurements:

❖ The beam-energy dependance of the transverse momentum-flow correlations

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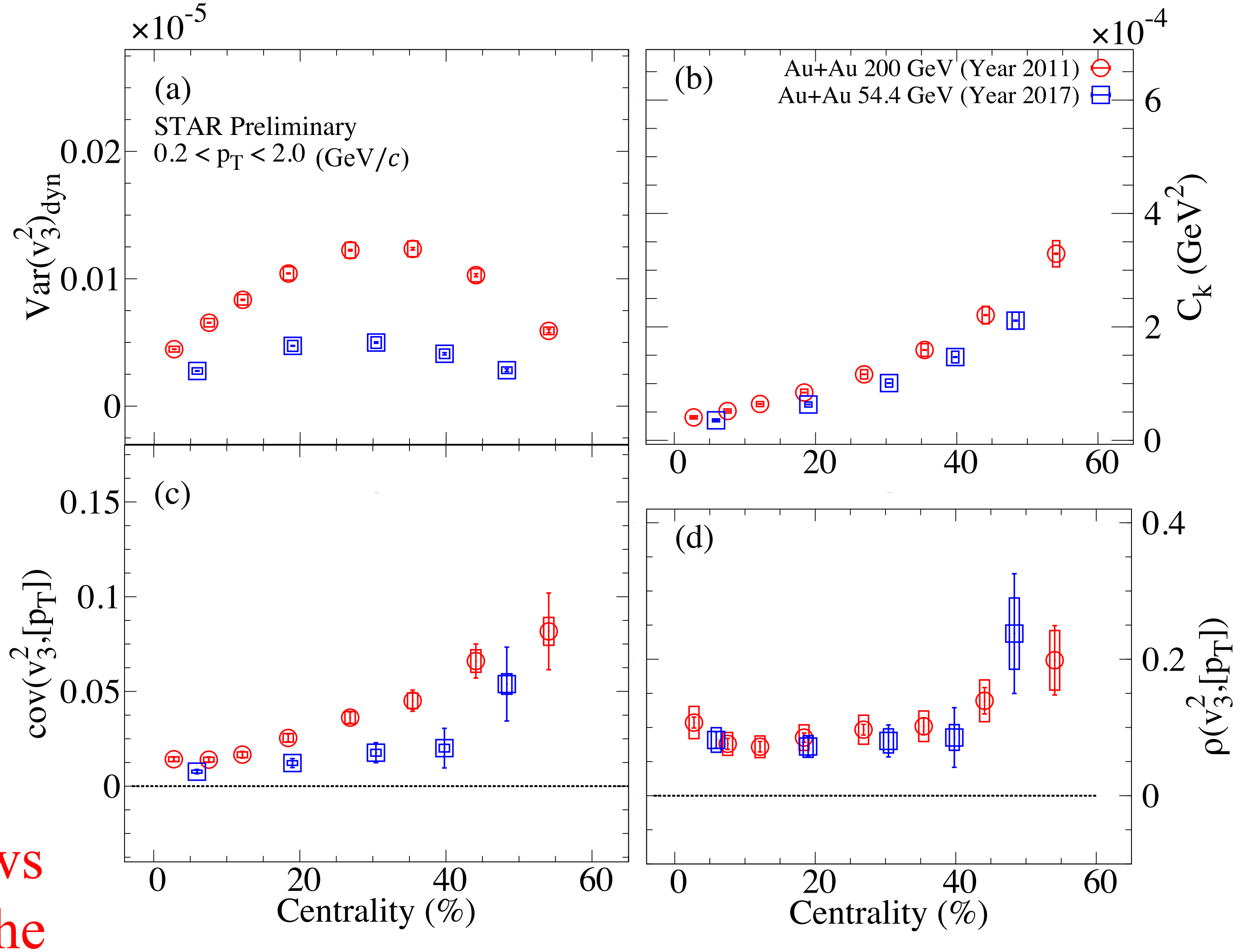

Conclusions

STAR ☆

We studied the transverse momentum-flow correlations as a function of centrality for different beam energies

- Transverse momentum-flow correlations:
  - ✓ The $cov(v_{\mathrm{n}}^2, [p_T])$ increases with beam energy
  - ✓ The normalized $\rho(v_n^2, [p_T])$:
    Show little, if any, change with beam energy

The $\rho(v_{\mathrm{n}}^2, [p_T])$ measurements show little, if any, change with beam energy, suggesting that $\rho(v_{\mathrm{n}}^2, [p_T])$ is dominated by initial state effects.

Thank You