System Size and Shape Dependence of Anisotropic Flow

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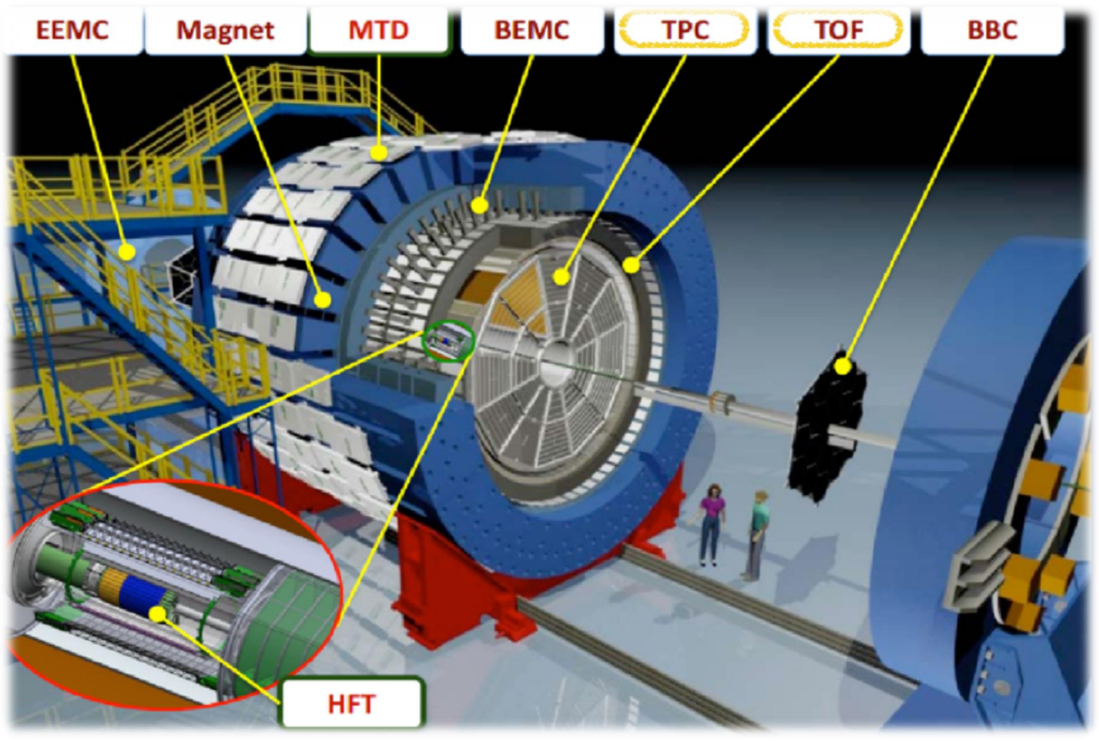
Abstract

In this work, we studied the first three flow harmonics, v_1^{even} , v_2 *and* v_3, as a function of mean multiplicity, ⟨Mult⟩, in U+U, Au+Au, Cu+Au, Cu+Cu, d+Au and p+Au collisions at $\sqrt{s_{NN}}$~200 GeV. The measurements confirm the impacts of initial geometry (shape and dimensionless size) on the flow harmonics. Such an effect is consistent with the dispersion relation for sound propagation in the hot and dense medium created in these collisions. Our measurements indicate that v_1^{even} *and* v_3 are system independent and the scaled v_2 shows a common trend for all systems.

STAR Detector



Uniform acceptance in $|\eta| < 1$

Correlation function

- Two particle correlation function $Cr(\Delta\varphi)$ used in this analysis

$$Cr(\Delta\varphi) = \frac{dN/d\Delta\varphi(same)}{dN/d\Delta\varphi(mix)}$$

- Non-flow signals, as well as some residual detector effects suppressed with $|\Delta\eta| > 0.7$ cut.

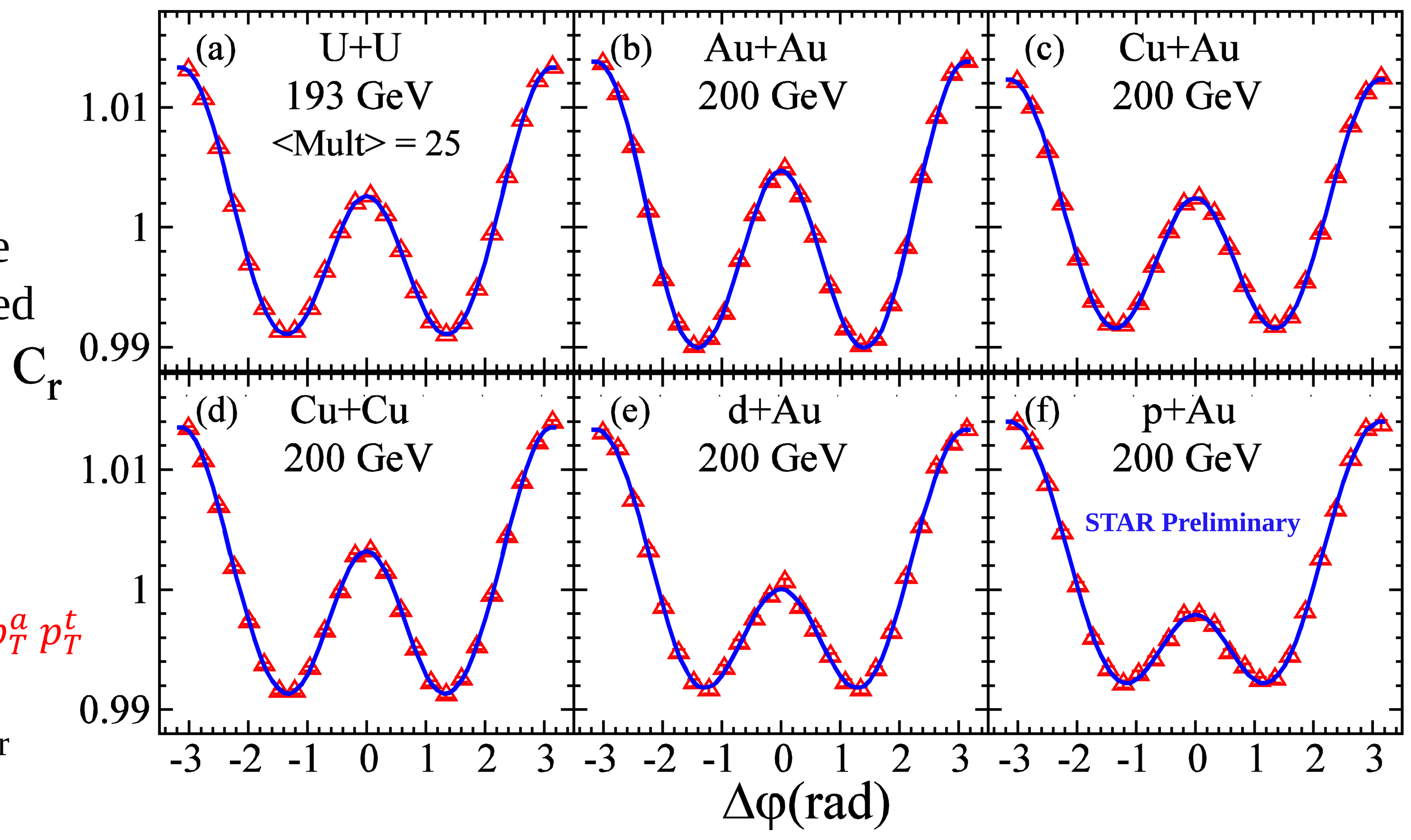
For n > 1,

$$v_{nn}(p_T^a, p_T^t) = v_n(p_T^a)\, v_n(p_T^t)$$

For n = 1,

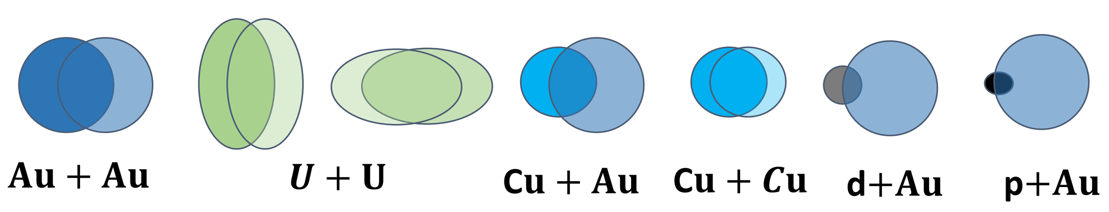
$$v_{11}(p_T^a, p_T^t) = v_1^{even}(p_T^a) v_1^{even}(p_T^t) - C\, p_T^a\, p_T^t$$

C is the momentum conservation parameter $C \propto \frac{1}{\langle \mathrm{Mult} \rangle \langle p_T^2 \rangle}$ [4].



Motivation

- Is the observed anisotropy in ion−ion collision a final- or initial- state effect?
- STAR collectd data for different systems;



Final-state ansatz

- The v_n measurements are sensitive to ε_n, RT and $\left(\frac{\eta}{s}, \frac{\zeta}{s}, \ldots\right)$[1-2].
- Acoustic ansatz
  - ✓ Sound attenuation in the viscous matter reduces the magnitude of v_n[1].
- Anisotropic flow attenuation;

$$\frac{v_n}{\varepsilon_n} \propto e^{-\beta n^2}, \ \beta \propto \frac{\eta}{s}\frac{1}{RT} + \cdots$$

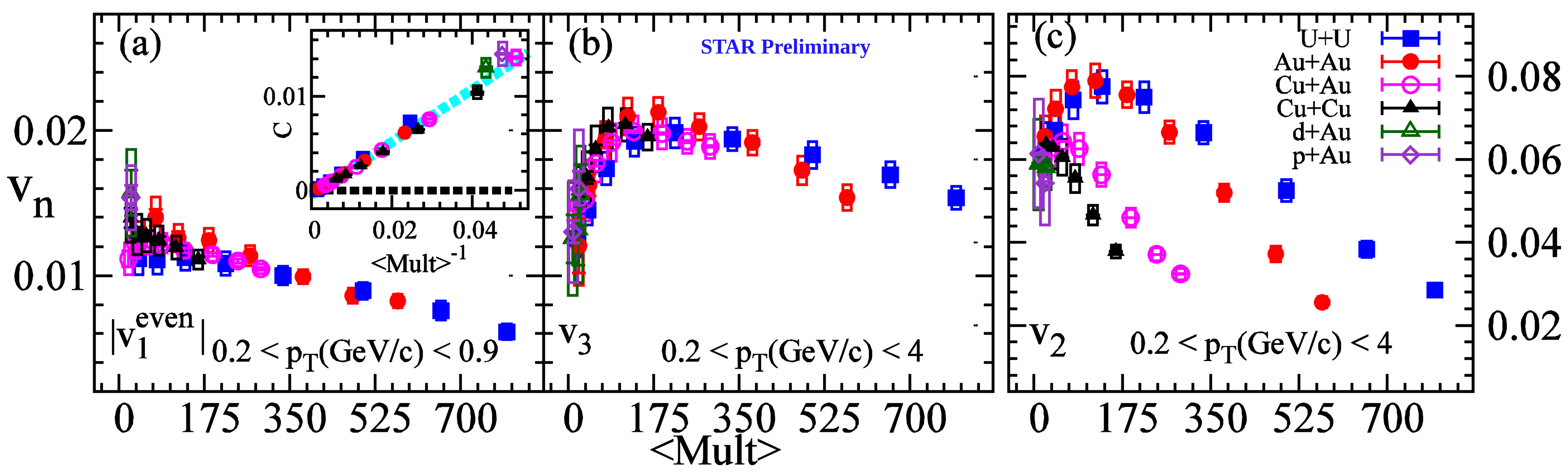
- From macroscopic entropy considerations $(RT)^3 \propto \frac{dN}{d\eta}$ [3].

$$ln\left(\frac{v_n}{\varepsilon_n}\right) \propto a\frac{\eta}{s}\left(\frac{dN}{d\eta}\right)^{\frac{-1}{3}}$$

$$ln(v_n) \propto a\left(\frac{\eta}{s}\right)\left(\frac{dN}{d\eta}\right)^{\frac{-1}{3}} + \ln(\varepsilon_n)$$

Scaling out the system size $\left(\frac{dN}{d\eta}\right)$ and shape $(\boldsymbol{\varepsilon_n})$ should give similar transport coefficient $\left(\frac{\eta}{s}\right)$ (i.e. similar v_n) for different systems (final-state effect).

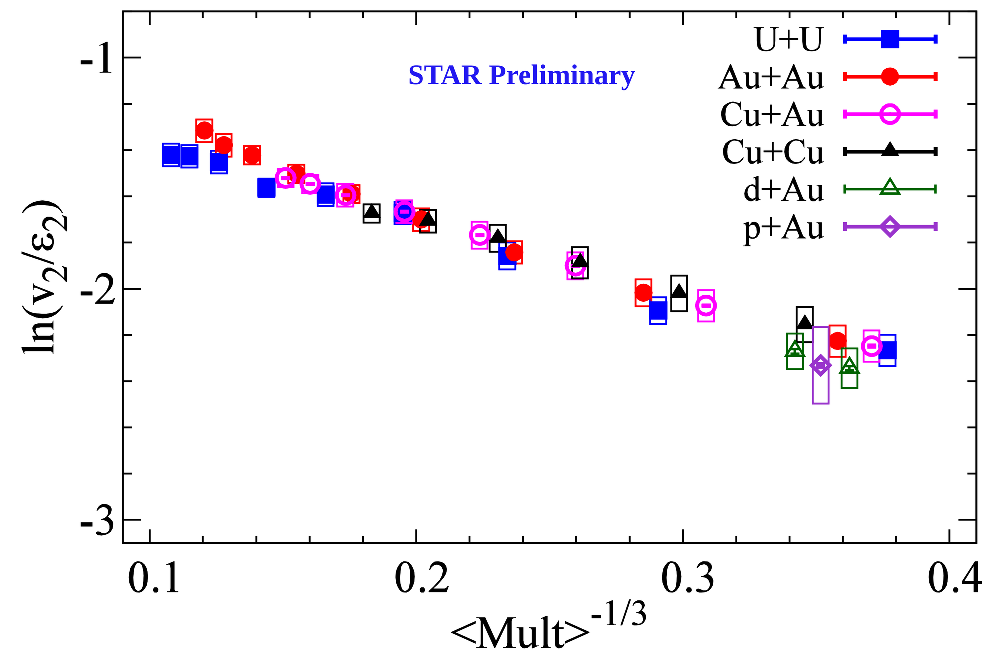
v_n *vs* ⟨Mult⟩



The measurements of v_1^{even}, v_2 *and* v_3 as a function of ⟨Mult⟩ for U+U, Au+Au, Cu+Au, Cu+Cu, d+Au and p+Au collisions at $\sqrt{s_{NN}}$~200 GeV. For the same ⟨Mult⟩ or size, v_1^{even} *and* v_3 are system independent, while v_2 is system dependent.

v_2/ϵ_2 *vs* < *Mult* >

- The eccentricity-scaled v_2 as a function of $\langle \mathrm{Mult} \rangle^{-1/3}$ for U+U, Au+Au, Cu+Au, Cu+Cu, d+Au and p+Au collisions at $\sqrt{s_{NN}}$~200 GeV.
- The scaled v_2 shows a common trend for all systems.



References

[1] arXiv:1305.3341, Roy A. Lacey, A. Taranenko, J. Jia, et al.
[2] PRC84 034908 (2011) P.Staig and E.Shuryak
[3] arXiv:1601.06001, Roy A. Lacey,, et al.
[4] PRC 86, 014907 (2012), ATLAS Collaboration

Conclusion

- The two-particle correlation technique has been used to study v_1^{even}, v_2 *and* v_3 as a function of ⟨Mult⟩ for U+U, Au+Au, Cu+Au, Cu+Cu, d+Au and p+Au collisions at $\sqrt{s_{NN}}$~200 GeV.
- At the same size (⟨Mult⟩), v_1^{even} *and* v_3 are system independent, while v_2 is system dependent.
- The scaled v_2 shows a common trend for all systems.

Acknowledgment

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