Ratio of photon anisotropic flow

Rupa Chatterjee[1], Pingal Dasgupta[2] [Presenter], and Guo-Liang Ma[2]

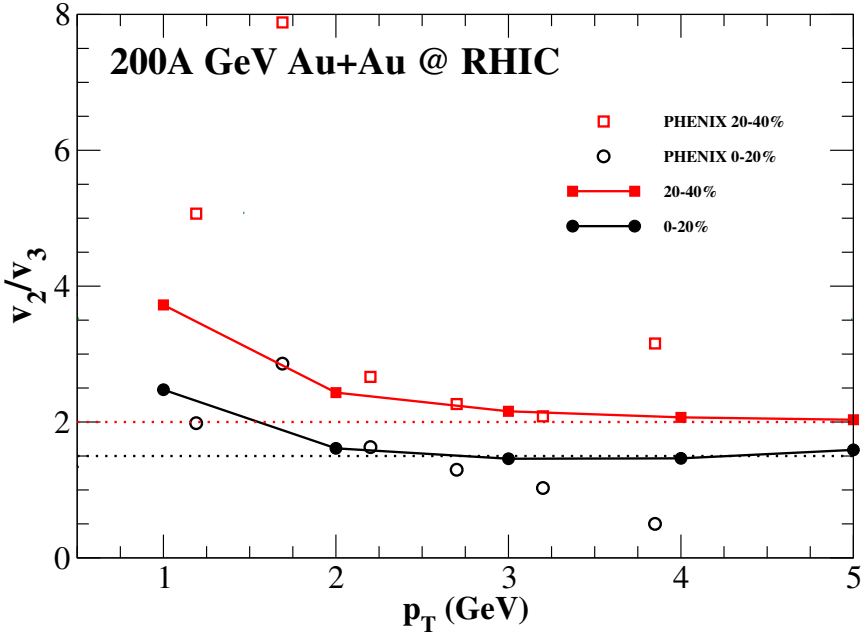
[1]Variable Energy Cyclotron Centre, HBNI, 1/AF, Bidhan Nagar, Kolkata, India

[2]Key Laboratory of Nuclear Physics and Ion-beam Application (MOE), Institute of Modern Physics, Fudan University, Shanghai, China

- The discrepancy between experimental photon anisotropic flow data and results from theoretical model calculations, known as the "direct photon puzzle", is not well understood yet.
- The ratio of photon v_n can be a potential observable in this regard by minimizing the non-thermal contributions.

$$v_n = \frac{v_n^{\rm th} \times dN^{\rm th}}{dN^{\rm th} + dN^{\rm non\text{-}th}}$$

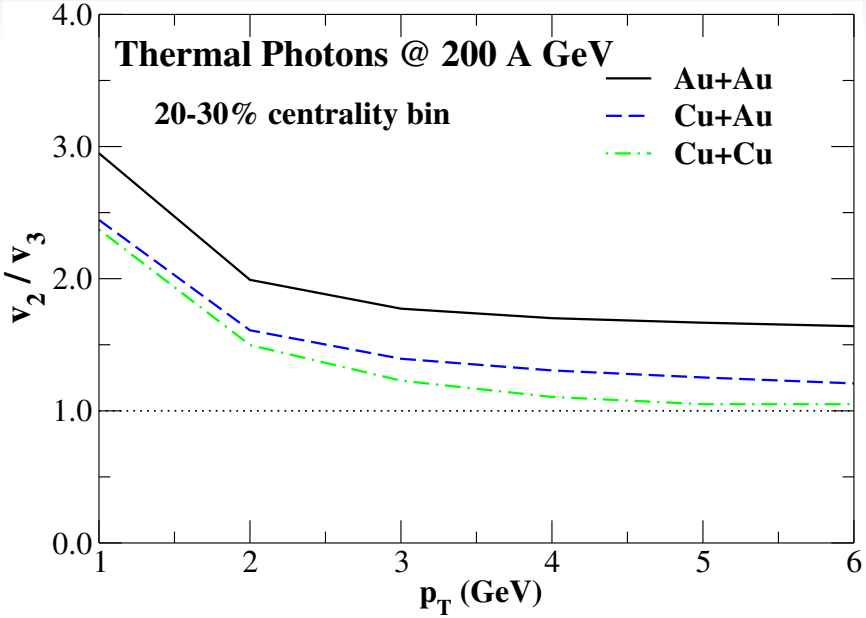
- The ratio is found to be larger for peripheral collisions than for central collisions.
  However, the p_T dependent behavior of the ratio is found to be different than the individual flow parameters.



- The individual v_2 and v_3 results from hydrodynamical model calculations under-estimate the data by a significant margin. However, the v_2/v_3 from both experimental data and model calculations is found to be close to each other in the 2–3.5 GeV p_T region. This p_T range is dominated by the QGP radiation in the direct photon spectrum.

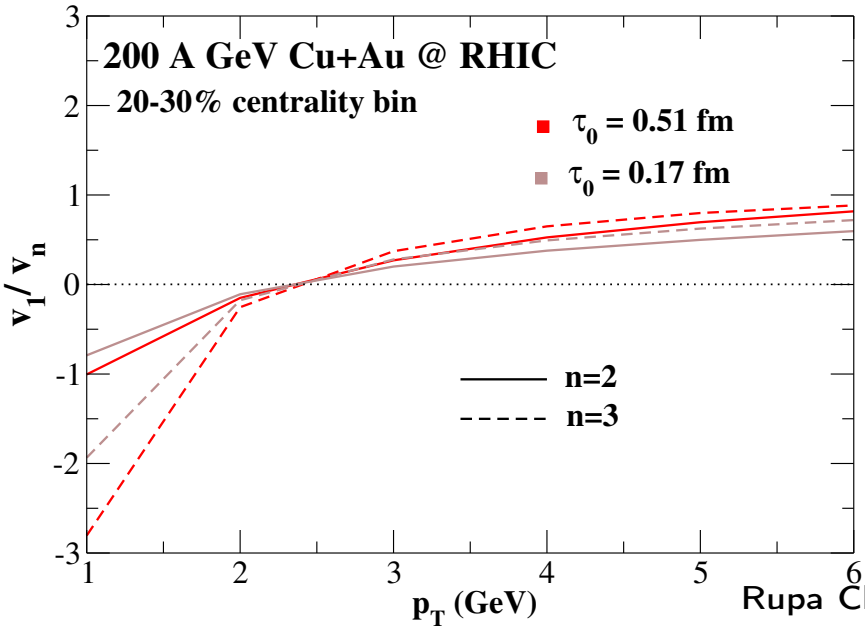
Rupa Chatterjee and Pingal Dasgupta, Phys. Rev. C 104, 064907 (2021)

System size dependece of v_2/v_3 at RHIC



- A similar qualitative nature for all three cases has been observed. The ratio is found to be largest for the Au+Au collisions.
- We do not see any significant difference in the p_T dependent nature between the symmetric and asymmetric collisions.
- The effect of initial state fluctuations is more for smaller systems.

v_1/v_n $(n = 2, 3)$ for Cu+Au collisions at RHIC

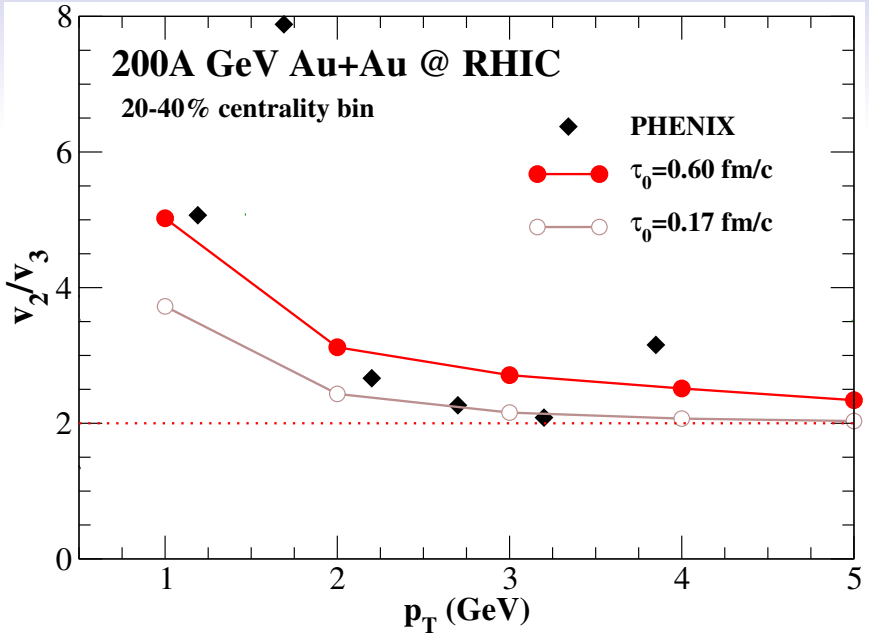


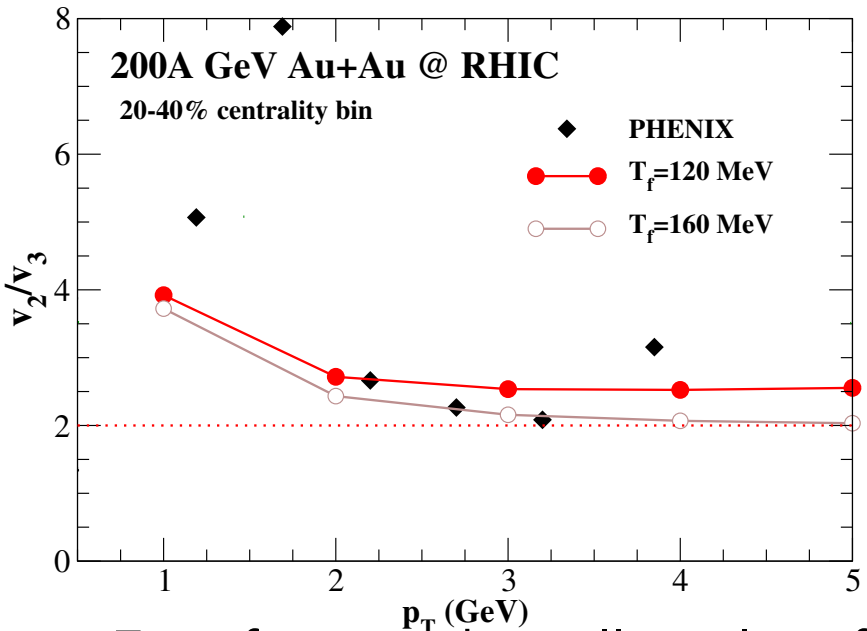
- The v_1/v_2 (or v_1/v_3) ratio shows a completely different p_T dependent nature compared to v_2/v_3 of photons.
- v_1/v_n, in comparison to v_2/v_3, has been found to be more senstive to hadronic phase evolution.

Rupa Chatterjee and Pingal Dasgupta, Phys. Rev. C 104, 064907 (2021)

Model parameter dependene of v_2/v_3

- A larger τ_0 increases the anisotropic flow significantly at larger p_T values, whereas, a larger τ_0 affects the ratio maximum in the lower p_T region.





- We consider a constant freeze-out temperature for all the systems at different centrality bins which is fixed by reproducing the charged particle multiplicity.

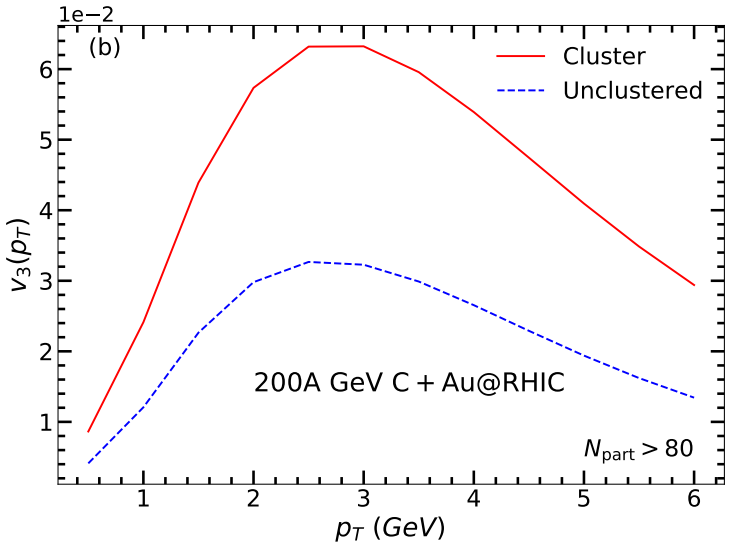
.

- Even for a much smaller value of T_f, the ratio does not change much in the lower p_T region and a small change can be observed only for larger p_T. However, a smaller T_f increases the photon v_2 and v_3 significantly in the entire p_T region.

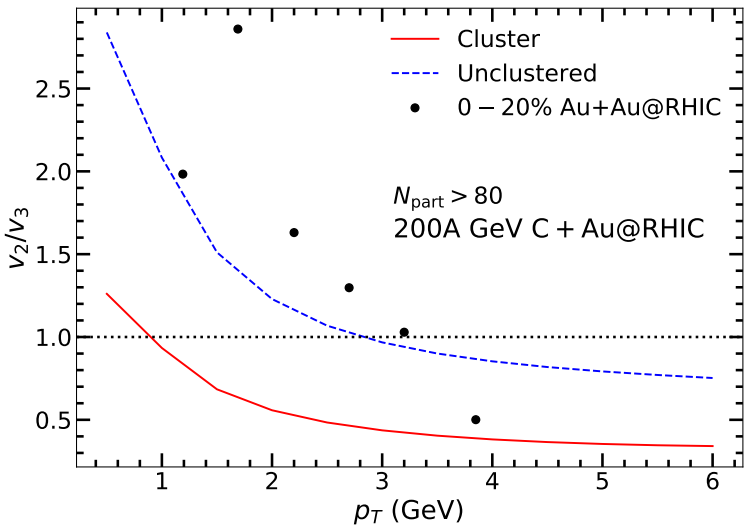
Rupa Chatterjee and Pingal Dasgupta, Phys. Rev. C 104, 064907 (2021)

v_2/v_3 as a sensitive probe of α-cluster in C+Au collisions at RHIC

- α-clustered structure in the light nuclei (i.e., C^{12}, O^{16}) produces different exotic shapes in nuclear structure studies at low energies.
- Triangular α-clustered carbon can produce significant initial triangular anisotropy in C+Au collisions.



➢ The photon v_3 for the clustered case is found to be twice as large as the same obtained for the unclustered case. The v_2 does not show much difference for the two cases.



➢ The ratio for the unclustered case, which is found to be about 2.0 at $p_T \sim 1.0$ GeV, and above $p_T > 3$ GeV the ratio gets closer to 1. However, for the clustered case, we observe that the ratio is smaller than 1 in the region $p_T > 1$ GeV.

Summary & conclusions

- Although the individual elliptic and triangular flow parameters underpredict the PHENIX data, their ratio is found to be close to the data in the p_T region 2-3.5 GeV which is believed to be dominated the by thermal radiation.
- The ratio does not depend strongly on the initial parameters of the model calculation as we see the change in ratio is marginal when we increase the initial formation time of the plasma from 0.17 fm/c to 0.60 fm/c and also decrease the final freeze-out temperature from 160 MeV to 120 MeV.
- The thermal photon spectra and anisotropic flow parameter changes significantly when τ_0 is increased and T_f is decreased in that range.
- The ratio of photon v_2 (or v_3) with the directed flow parameter also shows interesting features as a function of p_T.
- Anisotropic flow from collisions of heavy nuclei with clustered carbon may provide valuable information about the initial state.

Thank you for your attention