Collective Flow of Charged Hadrons in Cu+Cu collisions at $\sqrt{s_{NN}} = 200$ GeV at RHIC PHENIX

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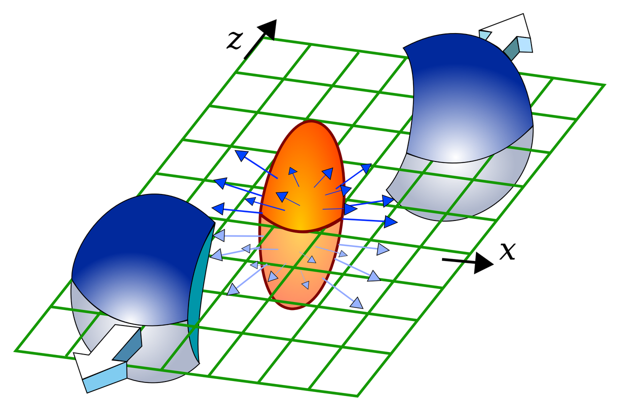
Motivation

The collective flow of charged hadrons produced in heavy ion collisions can be characterized using the Fourier coefficient v_2 (elliptic flow), as well as with the higher order coefficients like v_3 resulting primarily from fluctuations in the initial conditions of the colliding nuclei. The coefficient, v_3, has been used recently to discriminate between different models and the role of viscocity. Here we investigate v_2 and v_3 for Cu+Cu at $\sqrt{s_{NN}} = 200$ GeV using the long range correlation method and compare it to Au+Au at the same energy.

Event Plane Measurement

About the event plane:

- The reaction plane defined by impact parameter and beam direction but is difficult to measure.
- The greatest particle production observed in event plane which is close to reaction plane.
- Measurements must be corrected for the difference between the two.



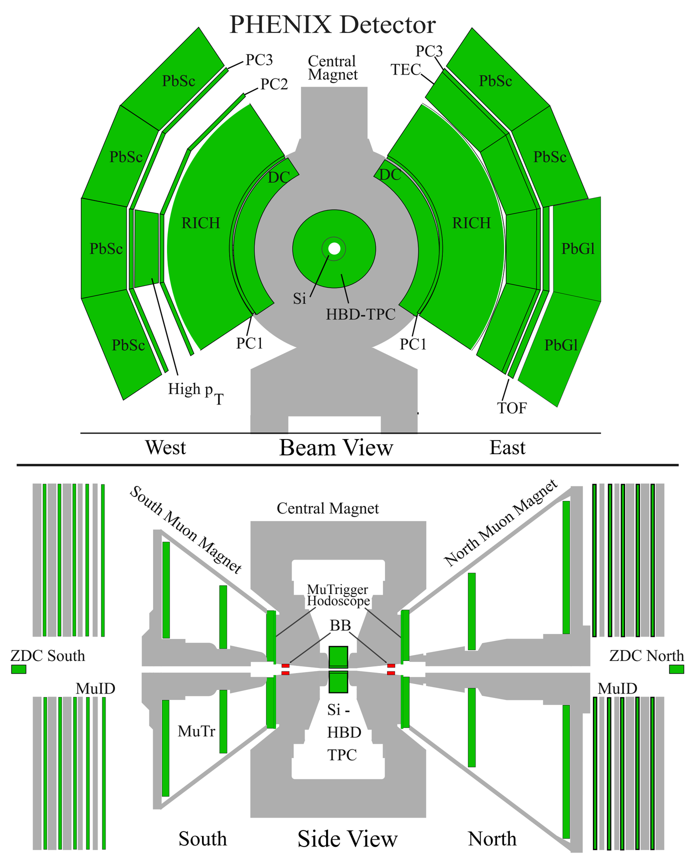
The single particle azimuthal distribution can be represented by

$$\frac{dN}{d\phi} \propto 1 + \sum_{n=1} 2v_n \cos\left(n\left[\phi - \Psi_n\right]\right)$$

Ψ_n represents the measured nth harmonic event plane. Harmonics correspond to the Fourier transform of the single particle distribution

The v_n can be extracted using

$$v_n = \frac{\langle \cos\left(n\left[\phi - \Psi_n\right]\right)\rangle}{Res\left(\Psi_n\right)}$$



- $Res\left(\Psi_n\right)$ is the correction factor that comes from our ability to measure the event plane.
- This event plane resolution is affected by the ececntricity and multiplicity.
- Some systematic uncertainties come from this step alone.
- The event plane at PHENIX with the 2005 configuration was determined by the Beam Beam Counters (BBC).
- The $\Delta\eta$ between the BBC ($3.1 < |\eta_{\text{BBC}}| < 4.0$) and the central arm ($|\eta_{\text{CNT}}| < 0.35$) suppresses the non-flow effects.

Long Range Correlation Method

The standard two particle azimuthal correlation involves measuring particle pair distributions in relative azimuthal angle ($\Delta\phi$).

$$\frac{dN^{\text{pairs}}}{d\Delta\phi} \propto \left(1 + \sum_{n=1} 2v_{n,n}(p_T^a, p_T^b)\cos(n\Delta\phi)\right)$$

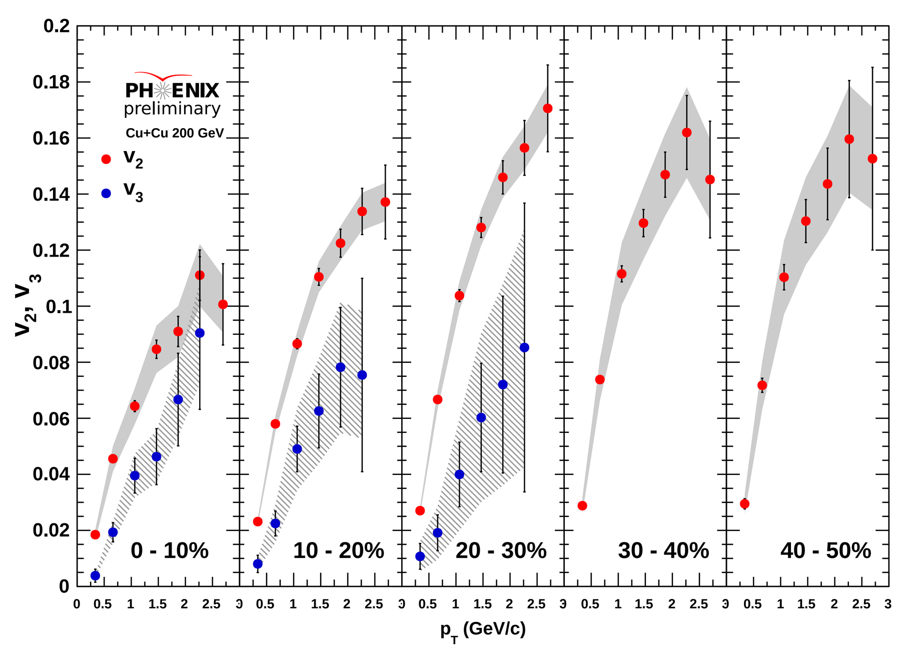
We then factorize $v_{n,n}(p_T^a, p_T^b) = v_n(p_T^a)v_n(p_T^b)$

- In this analyis we correlate tracks with the BBC to obtain $v_{n,n}^{\text{BBC-CNT}}$.
- The BBC does not have track resolution rather the signal seen in its channels are proportional to the number of tracks that pass through it. Therefore in the two particle correlation, the azimuthal angles are weighted with the signal observed.
- Since the event plane need not be determined, it does not have that systematic uncertainty.
- Correlations made between channels in the BBC the give us $v_{n,n}^{\text{BBC-BBC}}$.

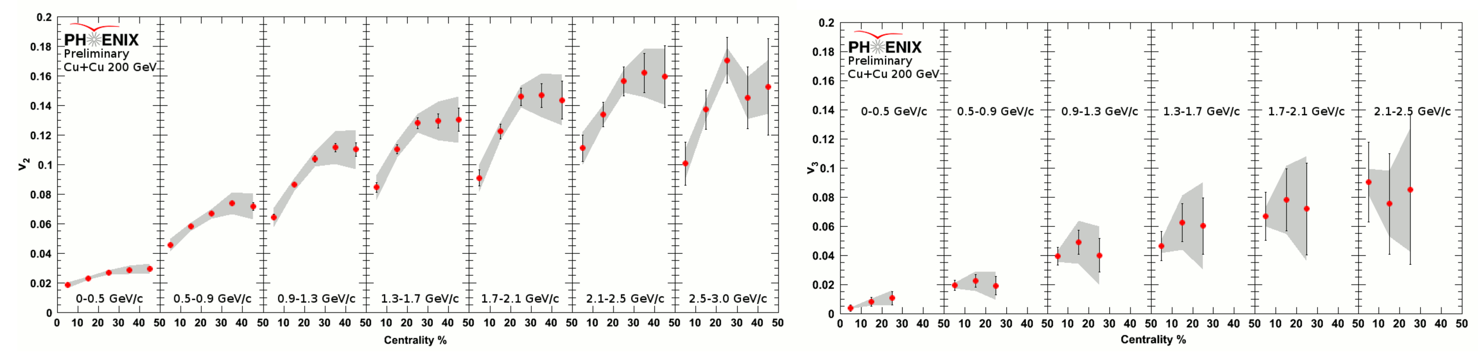
Finally we can get v_n^{CNT} by

$$v_n^{\text{CNT}} = \frac{v_{n,n}^{\text{BBC-CNT}}}{\sqrt{v_{n,n}^{\text{BBC-BBC}}}}$$

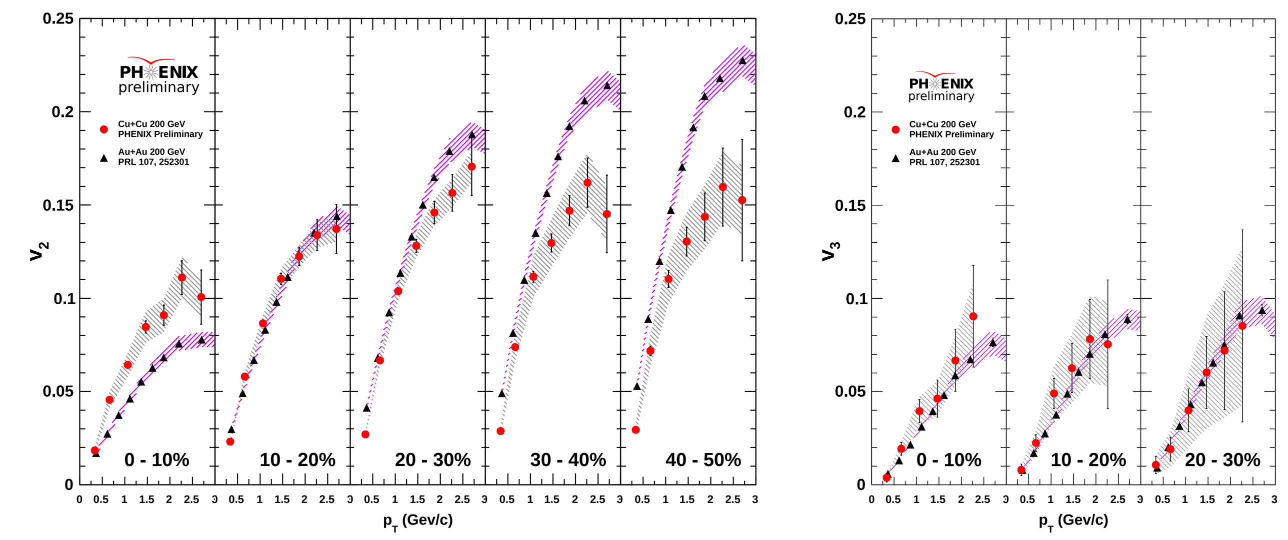
Cu+Cu $\sqrt{s_{NN}} = 200 GeV$ v_n Results



- The v_2 results correspond well with the event plane measurement.
- It increases for peripheral collisions, consistent with increasing eccentricity but plateaus beyond 30% centrality.



Comparison to Au+Au at $\sqrt{s_{NN}} = 200GeV$

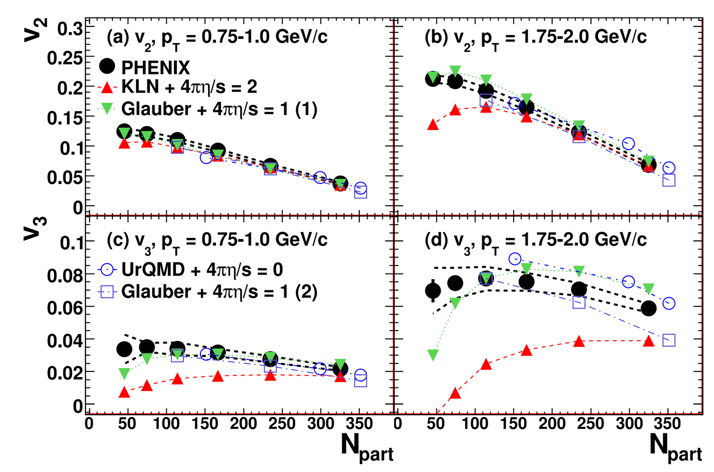


- The v_2 starts off higher for the Cu+Cu than for the Au+Au but then is quickly overtaken.
- Saturation of v_2 after $p_T > 2$ GeV/c may indicate that only hydrodynamics may no longer be applicable.
- We see that the Cu+Cu saturates whereas the Au+Au does not within the first 50% in centrality.
- Note: For the same centralities, the N_{part} is drastically different.
- The v_3 in both cases is similar and is centrality independent.

Model Constraints

The v_3 measurement can impose additional constraints on theoretical models. In this figure for Au+Au at 200 GeV, some competing models fit v_2 well for reasonable N_{part}

- The degeneracy is broken, once it is plotted along with v_3.
- The MC-KLN model falls far below the v_3 points.



- A study similar to this can be done for a smaller system like Cu+Cu.

References

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