Anisotropic flow in AuAu and CuCu at 62 GeV and 200 GeV

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We present STAR's measurements of directed flow (v_1) and elliptic flow (v_2) for charged hadrons in AuAu collisions at 62 and 200 GeV, as a function of pseudorapidity, p_t and centrality. v_2 results in CuCu collisions at 200 GeV are also presented.

1. MOTIVATION

Directed flow and elliptic flow are quantified by the first harmonic (v_1) and the second harmonic (v_2), respectively, in the Fourier expansion of the azimuthal distribution of produced particles with respect to the reaction plane [1], and carry information on the early stages of the collision [2]. The shape of $v_1(y)$ is of special interest because it has been identified as a possible QGP signature [2]. At much lower energies, $v_1(y)$ is an almost linear function of rapidity [3], whereas at RHIC, it is predicted to have a more complex shape, with the region near midrapidity having a slope of smaller magnitude than elsewhere [4,5]. It may exhibit a characteristic wiggle [4–7], whereby directed flow changes sign at midrapidity and at two other rapidities other than the spectator regions. At RHIC, the measurement and interpretation of elliptic flow has received much more attention than directed flow [2]. When centrality is varied in a heavy system like AuAu, the resulting change in v_2 is caused by the variation of both the number of participants and their initial spatial eccentricity; by studying a lighter system, we can hope to gain a better understanding of the separate role of these two factors. In this presentation, we include an initial study of elliptic flow in 200 GeV CuCu collisions.

2. DATA SETS AND ANALYSES

This study is based on five million 62 GeV AuAu events, three million 200 GeV AuAu events, and two million 200 GeV CuCu events, all from a minimum-bias trigger. All errors are statistical. The centrality definition and cuts used are the same as in Ref. [8].

The suppression of non-flow effects (azimuthal correlations unrelated to the reaction plane) is emphasized in this investigation. v_1 results are obtained using the three-particle cumulant method ($v_1\{3\}$) [9], the event plane method with mixed harmonics ($v_1\{\mathrm{EP}_1, \mathrm{EP}_2\}$) [1,8], and for the first time at RHIC, the standard method [1] with the first-order event plane reconstructed from spectator neutrons ($v_1\{\text{ZDC-SMD}\}$) [10]. v_2 results come from a diverse set of analyses: the standard method, the cumulant method ($v_2\{2\}$

*For the full list of STAR authors and acknowledgements, see appendix 'Collaborations' in this volume.

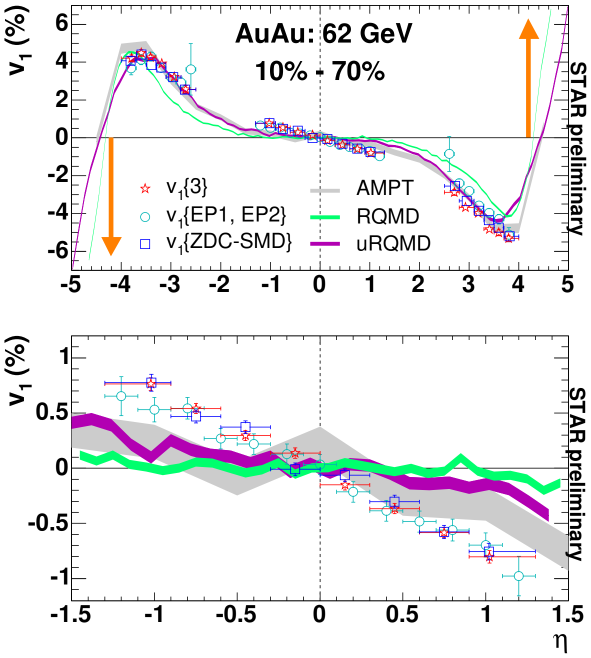

Figure 1. Charged hadron v_1 vs. pseudorapidity, for 62 GeV AuAu. The lower panel shows the mid-pseudorapidity region in more detail.

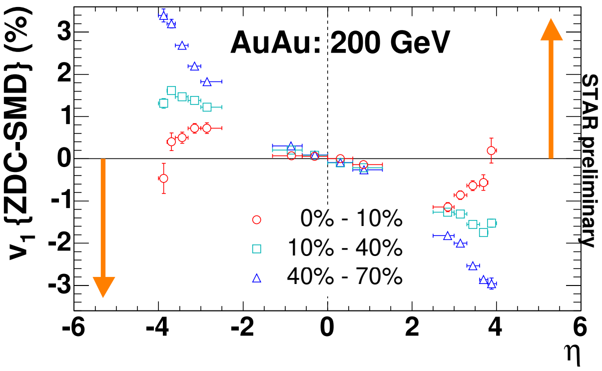

Figure 2. Charged hadron v_1 vs. pseudorapidity, for 200 GeV AuAu. Here, only the v_1\{ZDC-SMD\} method is used, and three centrality intervals are plotted.

and $v_2\{4\}$), v_2\{ZDC-SMD\}, the scalar product method (v_2\{AuAu-pp\} and v_2\{CuCu-pp\}) [8,11], and a method that involves fitting the distribution of the lengths of the flow vectors normalized by the square root of the multiplicity (v_2\{qDist\}) [8,11].

3. RESULTS

3.1. Directed Flow

Fig. 1 shows charged hadron v_1 as a function of pseudorapidity, η, for centrality 10%–70% in 62 GeV AuAu collisions. The arrows indicate the direction of flow for spectators. The arrow positions on the η axis correspond to where the incident ions lie on a rapidity scale. STAR has a gap in η coverage between the central Time Projection Chamber (TPC) and the Forward TPCs. Results from the three different methods agree with each other very well. AMPT [12], RQMD [13] and uRQMD [14] model calculations all underpredict the charged hadron $v_1(\eta)$ within a unit or so of midrapidity, but then predict an increase in such a way that they come into good agreement with data over the region $2.5 < |\eta| < 4.0$.

Fig. 2 presents charged hadron v_1 vs. η in three centrality bins for 200 GeV AuAu. The arrows have the same meaning as in Fig. 1. The centrality dependence is qualitatively similar to the trend seen at SPS by NA49 [15]. STAR's coverage is such that we can probe the interesting region $|\eta| \sim 3.5$ to 4 where v_1 changes sign for centrality 0 to 10%. The sign change of v_1 may provide insights into the stronger stopping in more central collisions.

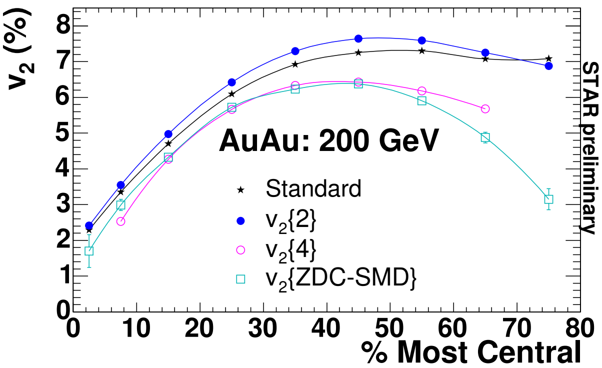

Figure 3. Charged hadron v_2, integrated over p_t and η, vs. centrality, for 200 GeV AuAu.

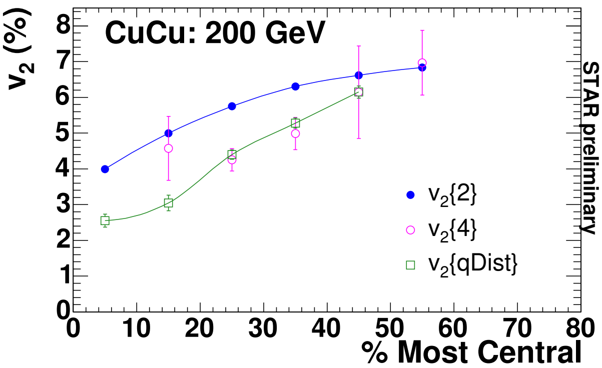

Figure 4. Charged hadron v_2, integrated over p_t and η, vs. centrality, for 200 GeV CuCu.

3.2. Elliptic Flow

Fig. 3 presents charged hadron v_2, integrated over p_t and η, vs. centrality for 200 GeV AuAu. Results from the standard method, $v_2\{2\}$ and $v_2\{4\}$ are from RHIC Run II data reported in Ref. [8]. A systematic check on v_2 measurements using the ZDC-SMD 1st harmonic event plane shows good agreement with $v_2\{4\}$, and reveals substantial non-flow effects in the standard method in peripheral collisions.

Charged hadron v_2 similarly integrated for 200 GeV CuCu is shown in Fig. 4. The methods $v_2\{4\}$ and $v_2\{\text{qDist}\}$ should each have relatively little contribution from non-flow, and their agreement within errors is consistent with this assumption. It is also evident that at 200 GeV, integrated elliptic flow is smaller in CuCu than in AuAu.

Fig. 5 and 6 show 200 GeV charged hadron v_2 vs. p_t, for AuAu and CuCu, respectively. The difference between $v_2\{2\}$ and $v_2\{\text{CuCu-pp}\}$ (believed to be mostly non-flow effects) increases with p_t and becomes very large above about 1 GeV/c. Comparing this pattern with AuAu, we conclude that the relative importance of non-flow is much larger in CuCu than in AuAu. In both systems, elliptic flow measurements based on $v_2\{4\}$ and $v_2\{\text{AA-pp}\}$ demonstrate reasonable consistency across a region of p_t (up to about 1.5 GeV/c). However, the divergence between $v_2\{4\}$ and $v_2\{\text{CuCu-pp}\}$ at higher p_t requires further investigation. Overall, at all p_t, $v_2\{4\}$ and $v_2\{\text{AA-pp}\}$ are lower in CuCu than in AuAu.

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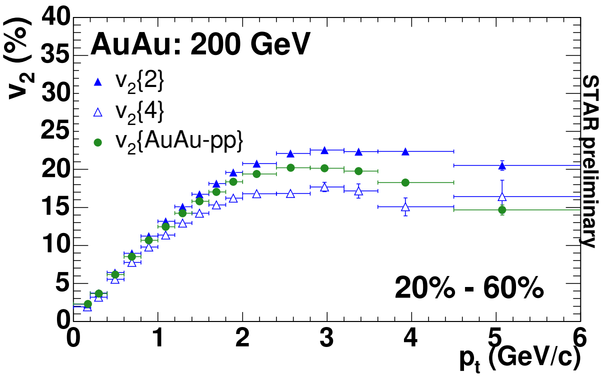

Figure 5. Charged hadron v_2 vs. p_t, for 200 GeV AuAu.

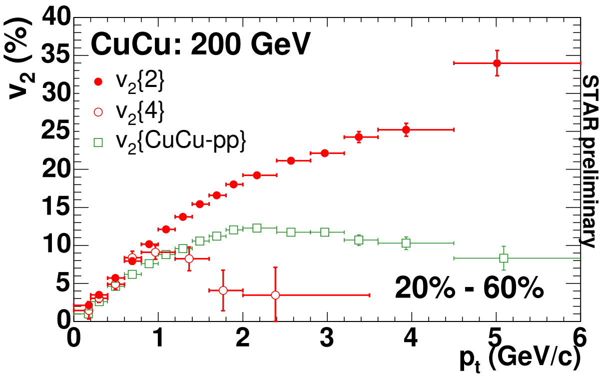

Figure 6. Charged hadron v_2 vs. p_t, for 200 GeV CuCu.

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