Charged hadron elliptic and triangular flow in Cu+Au at $\sqrt{s_{NN}} = 200\text{GeV}$

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Quark-gluon-plasma(QGP) is considered to be a hot and dense nuclear matter which is a phase of matter in quantum chromodynamics. A QGP was created by colliding nuclei at the Relativistic Heavy Ion Collider(RHIC) .

One of the strong evidence to prove the formation of QGP is that the low momentum particle production is anisotropic. Azimuthal anisotropy originates from initial spatial geometry. For low momentum particles, anisotropic collective flow is considered to result from the hydrodynamic expansion of QGP. Further the strength of azimuthal anisotropic flow has been used to determine the specific viscosity over entropy ratio(η/s) of QGP and the initial spatial condition by comparing it with the theoretical model. Thus measuring the azimuthal anisotropic flow is a good method to investigate the bulk property of QGP and the space time expansion mechanism.

The produced particle distribution is expressed as a Fourier expansion series as follows

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

where $v_n = \langle \cos(n(\phi - \Psi_n)) \rangle$ n(1,2,3,4,,,) corresponds to the strength of anisotropic flow, ϕ is the azimuthal angle of the produced particle, Ψ_n is the n_{th} order event plane that is the average of all emitted particles angles. So far the 2_{nd} order flow harmonic v_2 which is called elliptic flow has been studied in symmetric systems such as Au+Au, the 3_{rd} order flow harmonic v_3 which is called triangular flow was not predicted to exist because initial geometry was considered to be symmetric. However recently, a large v_3 was measured at RHIC. The v_3 is assumed to have originated from the initial spatial fluctuation.

In 2012, a Cu+Au collision was performed at RHIC. In Cu+Au collisions, the initial spatial geometry is asymmetric. The pressure gradient is predicted to be different for the Au and Cu sides. Thus the different expansion at the Au and Cu sides will lead to the asymmetric emission of particles. The v_n in the Cu+Au collision could help determine η/s and the initial spatial condition.

Figure 1 illustrates the N_{part} dependence of v_2 and v_3 for three collision systems. The system size dependence of v_2 is clearly seen. The v_2 values in Cu+Au collisions are between those in Au+Au and Cu+Cu data sets and v_2 in all systems increases as N_{part} decreases, the difference of v_2 values between the different systems reduce with a decreasing N_{part}. The N_{part} dependencies of v_2 and v_3 could be expected from those of 2_{nd} and 3_{rd} order initial spatial anisotropies(ϵ_2 and ϵ_3). The ϵ_2 and ϵ_3 are calculated using a Glauber Monte Carlo simulation. Figure 2 illustrates comparison between v_2 and v_3 as a function of p_T with event-by-event hydrodynamical calculation with η/s for 20-30 % centrality bin. In this hydrodynamical calculation, Glauber Monte Carlo simulations are employed as the initial spatial condition and $4\pi/s = 1$ or $4\pi/s = 2$ is used. The hydrodynamical calculation with $4\pi/s = 1$ has better agreement with v_2 and v_3 at low p_T than $4\pi/s = 2$, whereas at high p_T hydrodynamical calculation with $4\pi/s = 2$ has better agreement with v_2 and v_3 than $4\pi/s = 1$.

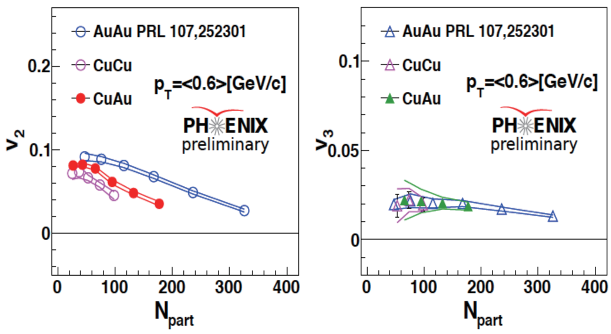

Fig. 1. Comparison of v_2 and v_3 as a function of N_{part} for four centrality bins in Au+Au, Cu+Cu and Cu+Au

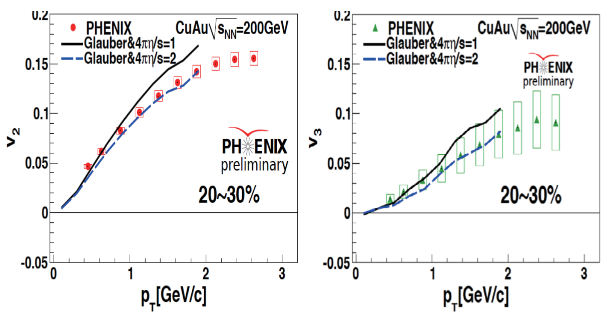

Fig. 2. v_2 and v_3 as a function of p_T for 20-30% centrality bin. Comparison of PHENIX experimental data points and hydrodynamical calculation

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References

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