Study of medium properties with two particle correlations in d+Au collisions at $\sqrt{s_{NN}} = 200$ GeV at PHENIX

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Two-particle correlation is a powerful method to study jet-medium interaction and the collective motion of particles. Interesting new results are revealed by LHC data when $p+p$ collisions with two-particle correlations are studied. Upon observing low-multiplicity $p+p$ collisions at 7 TeV, the $\Delta\eta$-$\Delta\phi$ correlation function is, as expected, found to have a single nearside peak at $\Delta\eta \approx 0$ and $\Delta\eta \approx 0$ and an away-side peak at $\Delta\phi \approx \pi$ along $\Delta\eta$. For high-multiplicity $p+p$ collisions at the same energy, an enhancement along $\Delta\eta$ at $\Delta\phi \approx 0$, or a "ridge" structure, is observed [1]. Finally, p+Pb collisions at 5.02 TeV with similar multiplicity selection, exhibit ridge structure as well [2].

This long-range correlation along the $\Delta\eta$ direction at $\Delta\phi \approx 0$ has been observed at RHIC previously. In two-particle $\Delta\eta$-$\Delta\phi$ correlations in central Au+Au collisions, an enhancement along $\Delta\eta$ at $\Delta\phi \approx 0$ has been observed [3]. It has also been found that this long-range correlation extends to as far as $\Delta\eta \approx 4$ [4]. Similar phenomena has been confirmed in Pb+Pb collisions at LHC [5].

This long-range correlation along $\Delta\eta$, or "ridge", was originally believed to exist only in central Au+Au collisions, but now has also been observed in $p+p$ and p+Pb collisions in LHC. The fact that the ridge appears in both system leads to the question of whether the ridge observed in $p+p$ and p+Pb in LHC is the same as that seen in heavy-ion collisions at RHIC.

Triggered by the new results from LHC, it is important to investigate whether a similar effect exists in d+Au collisions at RHIC. Studying d+Au collisions will certainly provide new insights into the p+Pb data at LHC. First, d+Au is collided at 200 GeV, which is considerably smaller than p+Pb at 5.02 TeV at LHC. Further, in d+Au collisions, the two nucleons in the deuteron may make the initial colliding geometry more complicated than in p+Pb collisions.

At PHENIX, it is possible to measure the two particle correlations with a large η gap by correlating a charged hadron in the central arm spectrometer ($|\eta| < 0.35$) and the energy cluster in the Muon Piston Calorimeter (MPC, $3.1 < |\eta| < 3.9$). A large $\Delta\eta$ separation can strongly suppress the non-flow contribution, and thus the remaining correlation should reflect the properties of the produced medium.

Since d+Au is an asymmetric system, in central d+Au collision, the multiplicity distribution, or $dN/d\eta$, is asymmetric along the direction of η [6], where the multiplicity is larger in the Au-going direction than in the d-going direction. Therefore a comparison of the correlation in d+Au to $p+p$, might reveal some new properties in d+Au collisions.

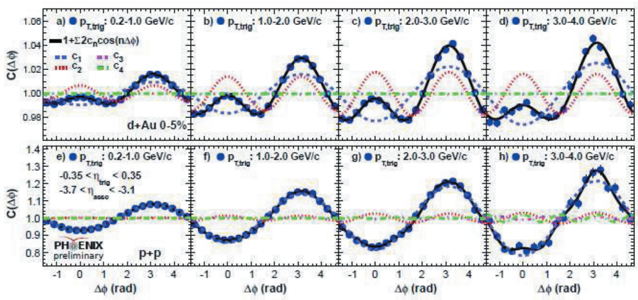

Fig. 1. The unidentified charged hadron in the central arm correlated with energy clusters in MPC in the Au-going direction ($-3.9 < \eta < -3.1$) in d+Au and $p+p$ collisions.

Figure 1 depicts the correlation function of the charged hadron in mid-rapidity correlated with the energy cluster in MPC in the Au-going direction in the most central d+Au collisions (0-5%) for various hadron p_T. This is compared with the same correlation function measured in $p+p$ collisions. In $p+p$ collisions, the correlation function has a local minimum at $\Delta\phi \approx 0$. In the case of d+Au correlation functions, the nearside shape is significantly different from the shape in $p+p$. Instead of showing a local minimum, it is either peaked at $\Delta\phi \approx 0$, or there is a strong correlation at $\Delta\phi \approx 0$.

We further measure the Fourier coefficients of the correlation functions. In $p+p$, the correlation functions are well described by c_1, which could be understood as conservation of momentum with very little contribution from other harmonics. In central d+Au collisions, we observe a significant contribution not only from c_1, but also c_2. This indicates that in central d+Au collisions, something similar to elliptic flow in heavy ion collisions has been seen.

References

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