Identified Particle Anisotropic Flow in p/d/^{3}He+Au Collisions at 200 GeV

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Abstract

Recent results from small collision systems at RHIC and LHC indicate that many of the signatures of collective behavior observed in AA collisions are also present in small systems in high-multiplicity events. The PHENIX experiment has performed comprehensive studies of long-range particle correlations and anisotropic flow in p/d/^{3}He+Au collisions. Mass ordering has been observed in the elliptic flow coefficients(v_2) as a function of p_T in d+Au [1] and ^{3}He+Au collisions. This poster presents a new measurement of $v_2(p_T)$ of pions, kaons and protons in p+Au collisions at 200 GeV. These measurements are compared to previous results from d+Au and ^{3}He+Au collisions at the same center-of-mass energy.

Motivation

In p+Au collisions, the elliptic flow of inclusive hadrons, $v_2(p_T)$, has smaller values than those observed in d+Au and ^{3}He+Au collisions, as expected from the initial geometry [2]. Measurements of $v_2(p_T)$ for identified particles would provide additional information to constrain model calculations. In particular, the magnitude of radial flow in the system could be inferred from the mass dependence of $v_2(p_T)$.

Experimental Details

Particles are identified using the PHENIX Central Arm tracking detectors (Drift Chamber and Pad Chambers), and the Time-of-Flight West detector (Fig. 1). The BBC, FVTX, and Central Arms are used for event-plane determination (Fig. 2).

- Data set: Run 15 p+Au collisions at $\sqrt{S_{NN}}$ = 200 GeV

The most central 5% data with central trigger are used. The trigger performance for the minimum bias and the central triggers is shown in Fig. 3.

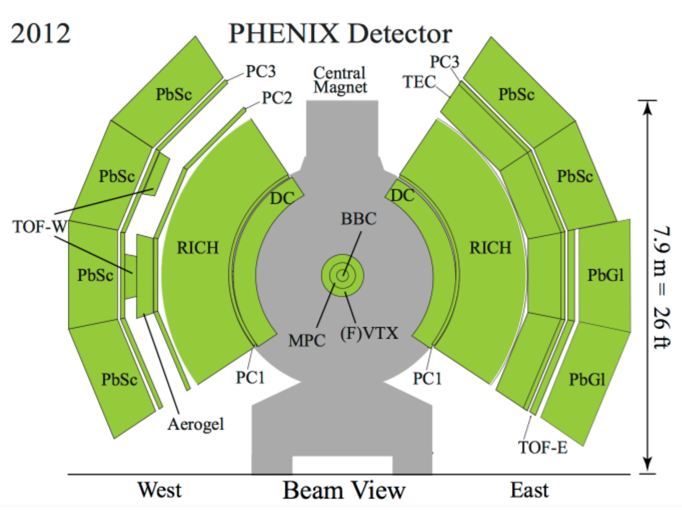

Figure 1. PHENIX Detector configuration in Run 15

Event Plane Method

The event plane method is used to calculate v_2:

$$v_2 = \frac{\cos[2(\varphi - \Psi_{2,FVTXs})]}{Res(\Psi_{2,FVTXs})}$$

The event plane angle is determined with the FVTXs detector in the Au-going direction. A standard event-plane flattening technique is applied to remove the residual non-uniformities in the distribution of event-plane angles $\Psi_{2,FVTXs}$.

The three-sub event method is used to evaluate the resolution of second order event plane for FVTXs.

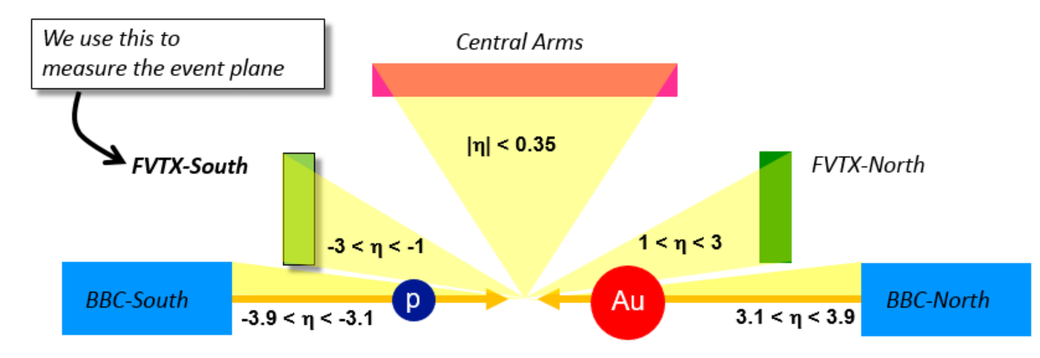

Figure 2. Pseudorapidity coverage of the detectors used in the event-plane measurement.

Particle Identification

The particles are identified by their mass [3]. Figure 3 shows m^2 vs charge × p_T, where clear pion, kaon and proton bands are seen. Figure 4 shows a 1D projection of the m^2 distribution in the p_T range 1.3-1.4 GeV for positive particles. The three peaks correspond to pions, kaons and protons. We fit each particle peak with a Gaussian function, get the mean and standard deviation, σ_{m^2}, values as a function of p_T. The p_T dependence of σ_{m^2} is well described by the following function:

$$\sigma_{m^2}^2 = \frac{\sigma_\alpha^2}{K^2}(4m^4p^2) + \frac{\sigma_{ms}^2}{K^2}\left(4m^4\left(1+\frac{m^2}{p^2}\right)\right) + \frac{\sigma_t^2c^2}{L^2}\left(4p^2(m^2+p^2)\right)$$

where K is the magnetic field integral, σ_α is the angular resolution of the Drift Chamber, σ_{ms} is the momentum resolution due to multiple scattering, and σ_t is the timing resolution.

The particles selected for analysis have m^2 within 2σ of the mean value, as shown with the bands in Fig. 4. Purity better than 90% is achieved for pions below 3 GeV, for kaons - below 2 GeV, and for protons - below 4 GeV.

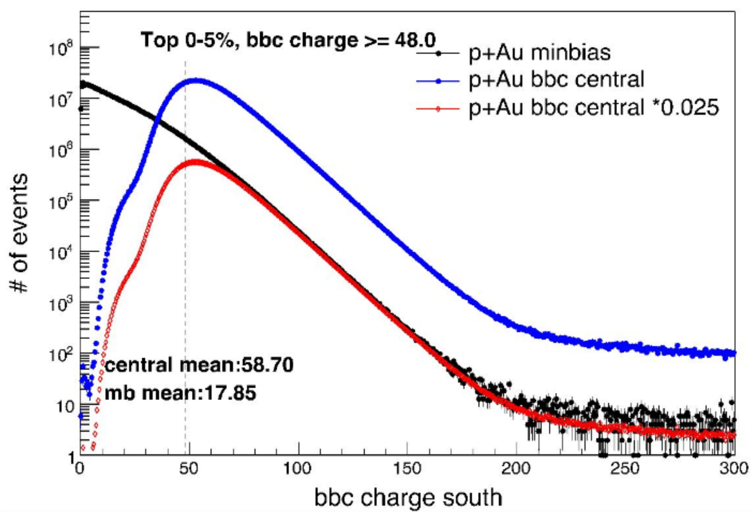

Figure 3. Trigger performance for p+Au minimum bias trigger and central trigger.

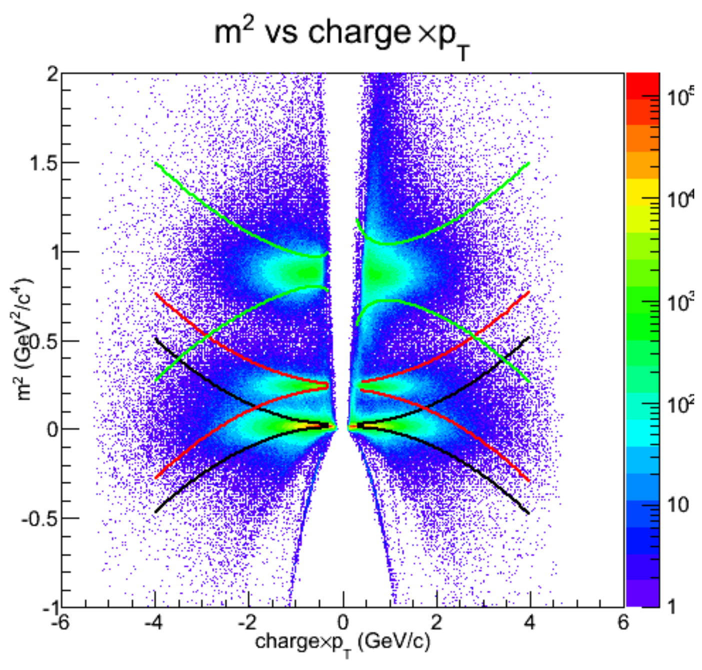

Figure 4. Particle identification in the TOF-West detector using m^2 vs charge*p_T.

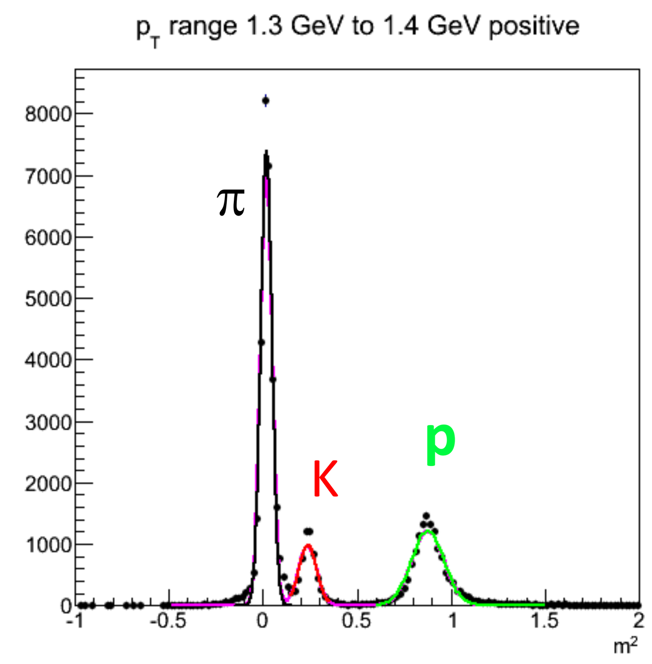

Figure 5. Projection of the left plot onto the p_T range of 1.3 GeV to 1.4 GeV.

Results

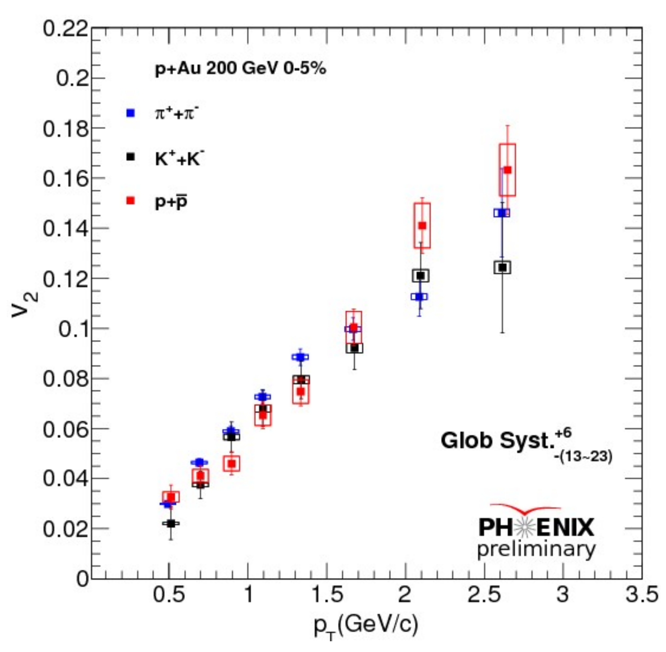

Figure 6. Elliptic anisotropy v_2 of pions, kaons and protons in 0-5% central events in p+Au at 200 GeV.

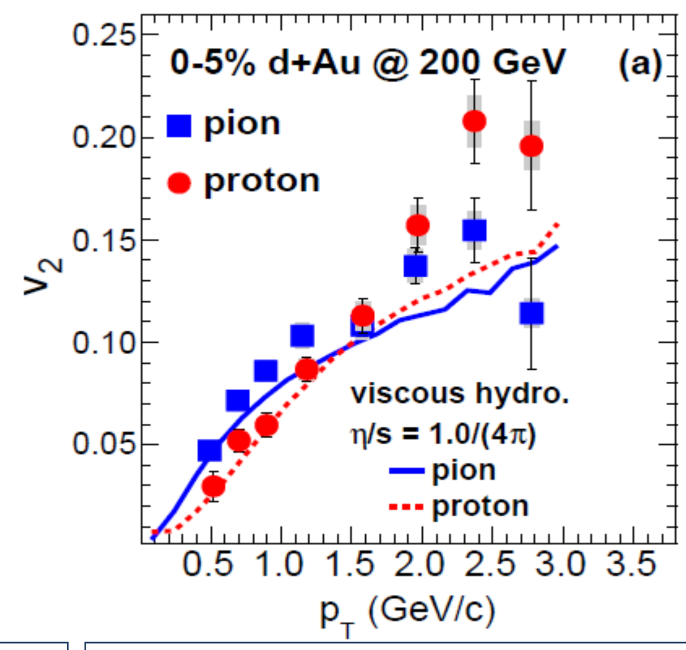

Figure 7. Elliptic anisotropy v_2 of pions, kaons and protons in 0-5% central events in d+Au at 200 GeV [1].

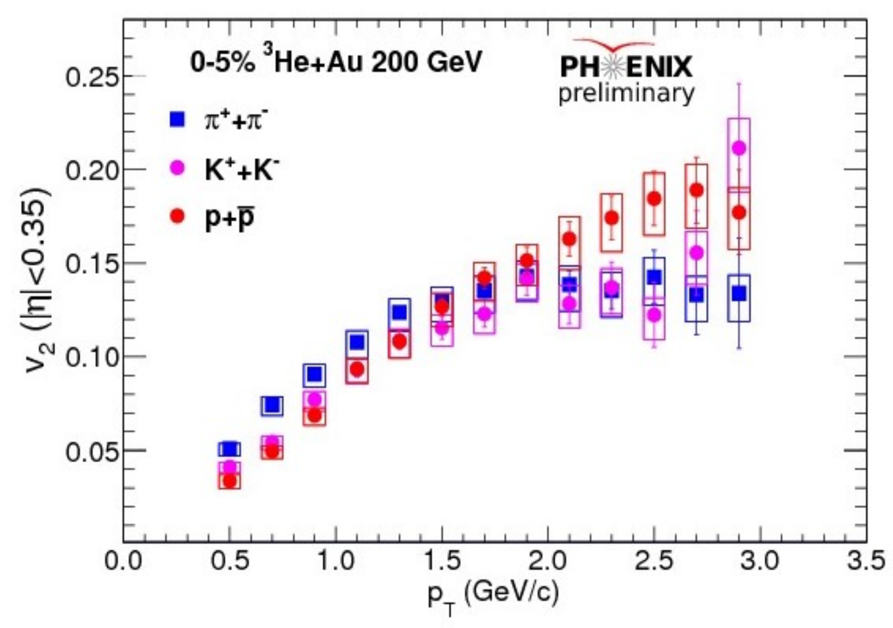

Figure 8. Elliptic anisotropy v_2 of pions, kaons and protons in 0-5% central events in ^{3}He+Au at 200 GeV .

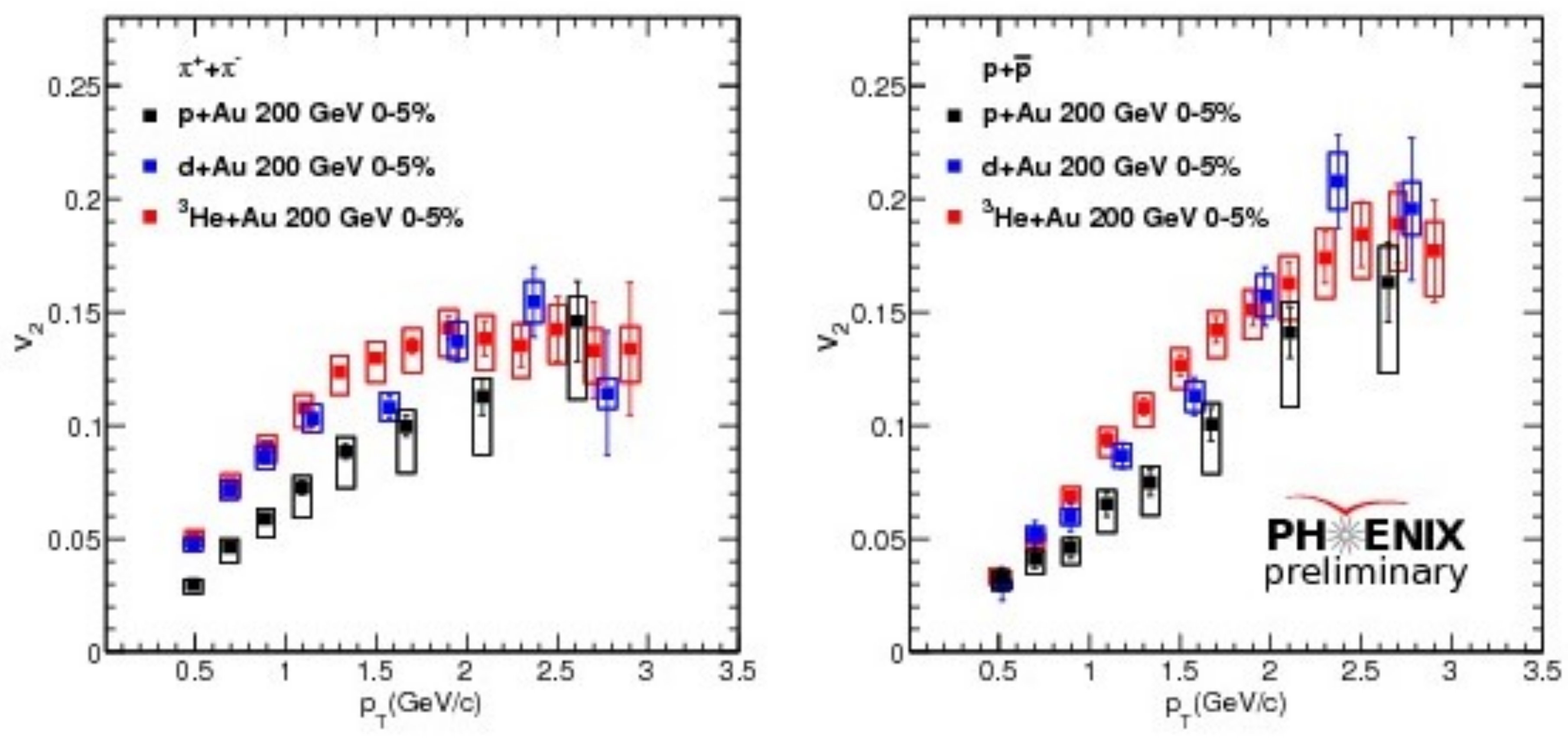

Figure 9. Elliptic anisotropy v_2 for pions (left) and protons (right) compared in the p+Au, d+Au and ^{3}He+Au systems.

Conclusions

- In all three collision systems, p+Au, d+Au, and ^{3}He+Au, the values of elliptic flow coefficients $v_2(p_T)$ are ordered by particle mass as expected for particles moving in a common velocity field.
- The mass-dependence of $v_2(p_T)$ in d+Au, and ^{3}He+Au collisions is larger than that in p+Au collisions. The magnitude of the elliptic flow is also larger in the d+Au, and ^{3}He+Au systems.

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References

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