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Directed Flow in 10.8 GeV/nucleon Au+Au Collisions Measured in Experiment E917 at the AGS

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Analysis of directed flow observables for protons and pions from Au+Au collisions at 10.8 GeV/nucleon from experiment E917 at the AGS is presented. Using a Fourier series expansion, the first Fourier component, v_1, was extracted as a function of rapidity for mid-central collisions (17-24%). Clear evidence for positive directed flow is found in the proton data, and a weak, possibly negative directed flow signal is observed for π^+ and π^-.

1 Introduction

The study of collective flow in relativistic nucleus-nucleus collisions provides unique insight into the complicated dynamics of these reactions. Most simply, collective flow can be understood as the global response of the combined system to the pressure gradients that develop in the high density region of the collision. These gradients manifest themselves through different forms of flow

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signals, such as directed and elliptic flow. As the theoretical understanding of flow phenomena has progressed, it has become increasingly apparent that they carry information on processes such as thermalization, mean field effects, and phase transitions, including the possible creation of the quark-gluon plasma. The latter transition has been predicted to cause the pressure gradient from the baryon dense region to be reduced, or even entirely absent. In addition, flow signals of produced particles (e.g. pions, kaons, anti-protons, etc.) yield important information on the magnitude of rescattering and absorption processes. Thus, it is important to study the evolution of the various flow signals both as a function of energy and of particle species.

2 Flow Determination in Experiment E917

Experiment E917 is a fixed-target experiment in which Au + Au collisions at 6, 8 and 10.8 GeV/nucleon were measured. Flow signatures from experiment E917 have been measured at AGS beam energies of 8 and 10.8 GeV/nucleon. The preliminary results presented here are for the full energy and consist of about 1/3 of the total data which will eventually be available for analysis.

The three main experimental components for the flow analysis contained in this report are a beam vertexing detector [1] (BVER) located in front of the target to measure the trajectory of each incoming Au beam particle, a hodoscope located 11.4 meters downstream from the target to measure the distribution of light (e.g. proton, deuteron) charged particles from the beam projectile remnant, and a movable magnetic spectrometer to measure particle yields from mid-rapidity (y_{cm}=1.61) towards the target rapidity ($y \approx 0.6$). The movable magnetic spectrometer is used to measure particle yields relative to the deduced reaction plane. A more detailed description of the experimental setup and reaction plane determination can be found elsewhere in this proceedings[2].

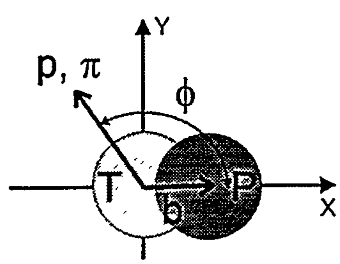

Figure 1: Schematic diagram of target (T) and projectile (P) when viewed along the beam (z) axis. The reaction plane (i.e. the $\vec{b}$-z plane) is determined for each event and the particle yields (i.e. $dN/d\phi$) are extracted as a function of the angle ϕ relative to this plane.

3 Directed Flow for Protons and Pions

The directed flow results presented here utilize the method of Fourier analysis. The azimuthal distribution of emitted particles is determined with respect to the reaction plane in the (x-y) plane perpendicular to the beam (z) axis (see Fig. 1).

In the analysis, this distribution, $dN/d\phi$, is obtained for a series of rapidity and centrality cuts. The resulting angular distributions for a particular particle species are then described by an expansion in a Fourier series. In this representation, the directed flow component corresponds to the first Fourier component $v_1 =< \cos\phi >$, and elliptic flow corresponds the second component $v_2 =< \cos 2\phi >$ in the Fourier sum. Proton directed flow v_1 coefficients were extracted from the $d^2N/dyd\phi$ distributions for eight bins in ϕ using Eq. 1.

$$\frac{dN}{d\phi}|_y = A\,(1 + 2v_1 \cos\phi) \tag{1}$$

The preliminary results of this analysis for five rapidity bins (Δy=0.2) and a mid-central event selection (17-24% centrality) are shown in Fig. 2.

Since the data are measured in the target rapidity region, positive directed flow corresponds to an excess yield of particles 180° away from the impact parameter vector $\vec{b}$. The excess yield at $\phi = \pm\pi$ (radians) is clearly evident in Fig. 2(a). The rapidity dependence of this yield is given in panels (a-e) and the extracted values of v_1 (Eq. 1) are shown in Fig. 2(f). The magnitude of v_1 for protons is found to be $v_1 \approx -0.09 \pm 0.01$ at rapidity y=0.6. A value of $v_1 \approx 0 \pm 0.02$ is found at the most central rapidity point (y=1.4), as required by symmetry arguments.

The flow signals of produced particles have also been obtained using the excellent particle identification of the magnetic spectrometer. As a first step, flow signals for pions were extracted and the preliminary results are compared with the proton directed flow results in Fig. 3.

The three panels (a,c,e) on the left-hand side of Fig. 3 show the proton, π^+ and π^- azimuthal $dN/d\phi$ distributions for a common rapidity slice of y=0.8±0.1, respectively. The three right-hand panels (b,d,f) of Fig. 3 show the deduced v_1 flow coefficients as a function of rapidity. The results are consistent with positive directed flow for the protons and zero, or slightly negative, directed flow for the pions.

Inclusive directed flow results for charged particles in Au+Au collisions at a similar AGS beam energy have been published by experiment E877[3]. A direct comparison between the two experiments is not possible due to the fact that the E877 experiment did not allow for separation between the different charged

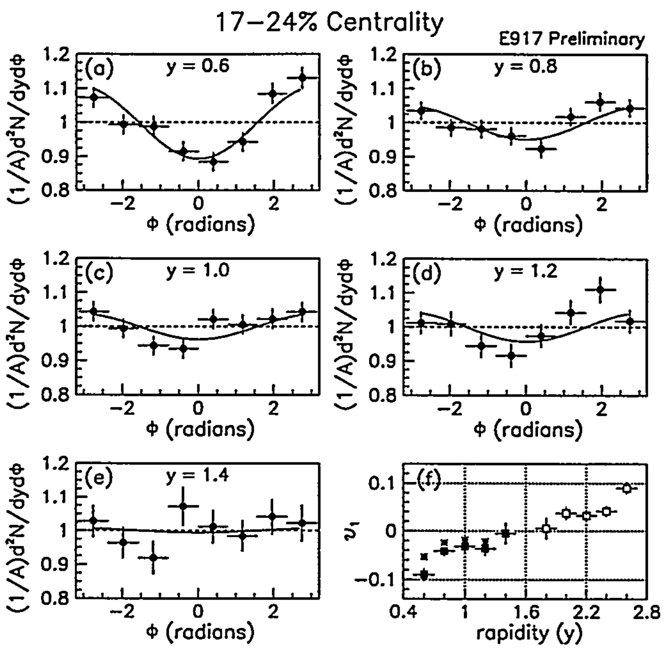

Figure 2: Proton directed flow as a function of rapidity for a centrality bin of 17-24%. Panels (a)-(e) are the normalized yields fit to Eq. 1 and panel (f) is the resulting v_1 Fourier component values from the fits. In panel (f) the star (*) symbols are the fit values, solid squares with errors are corrected for reaction plane resolution and open squares are the values reflected (by symmetry) about $y_{cm} = 1.61$.

particle species at these rapidities. Despite this, there is qualitative agreement between the decomposed flow parameters for nucleons and pions from E877 and the preliminary exclusive results presented here. Both experiments point to a clear positive directed flow signal for protons, and a weak, possibly negative, result for the pions.

4 Conclusions

Experiment E917 is in a good position to make detailed flow studies by combining the excellent particle identification properties of the magnetic spectrometer with a reliable event-by-event reaction plane determination. Preliminary results have been shown for proton, π^+ and π^- directed flow which demonstrate

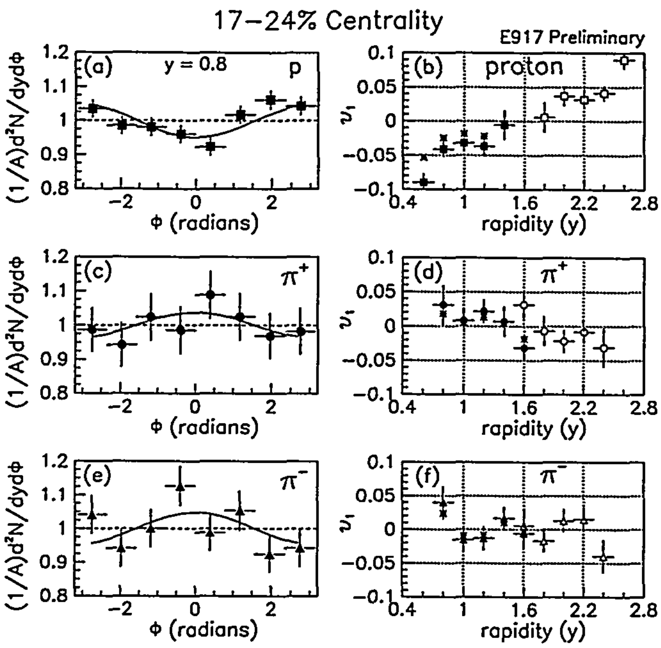

Figure 3: Comparison of proton (a,b), π^+ (c,d) and π^- (e,f) directed flow signals for a centrality class of 17-24%. Panels (a), (c) and (e) are the normalized yields fit to Eq. 1 for protons, π^+ and π^- respectively at rapidity y=0.8. Panels (b), (d) and (f) are the resulting v_1 Fourier component values from the fits as a function of rapidity. In these panels, the star (*) symbols are the fit values, solid symbols with errors are corrected for the reaction plane resolution and open symbols are the values reflected about $y_{cm} = 1.61$.

a positive directed flow signal for protons and a small, possibly negative, flow signal for both π^+ and π^-. A direct comparison between these exclusive flow results and theory is now becoming possible.

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