Preliminary Flow Analysis in Experiment E917 at the AGS

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1 Introduction

The study of directed flow in heavy ion collisions as a probe of collision dynamics has been of heightened interest to the physics community in recent years. The E917 collaboration is addressing this interest by investigating signatures of flow as a function of rapidity and centrality for fixed target gold on gold collisions at 11.7A GeV/c. The purpose of this report is to demonstrate E917's capability to establish the reaction plane on an event-by-event basis and present preliminary results of the proton data collected at Brookhaven National Laboratory's Alternating Gradient Synchrotron (AGS) facility.
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2 Experimental Details in E917's Reaction Plane Determination

The E917 experimental set-up, shown in Fig. 1, was an outgrowth of the E866 experiment\textsuperscript{1}, with a moving spectrometer arm (Henry Higgins), a series of global detectors (HODO, NMA, ZCAL), and a beam vertexing detector (BVER). The BVER detector consisted of two X-Y planes of scintillating fibers before the target. This determined the Z-axis in the reaction plane calculation by defining a projection onto the target and a trajectory to the Hodoscope detector (HODO) 11 m downstream. With beam intensities as great as $\sim 2 \times 10^5$ Au particles/second, the BVER operated with an efficiency exceeding 99% and a precision of $\sigma \approx 150 \mu m$ at the target position\textsuperscript{2}. Measured flow signals are small (typically $\leq 10\%$) effects which require a very precise measure of the initial beam trajectory. The position resolution of the BVER detector projected to the hodoscope ($\sim 1.2$ mm) was more than sufficient, since the overall resolution for determining the reaction plane is dominated by counting statistics and the physical 1-cm width of each scintillating slat of the hodoscope detector. An event-by-event measure of the beam trajectory was also necessary due to the large difference in beam divergence between the horizontal and vertical planes for AGS beams.

![Figure 1: Experiment E917.](Image)

The Hodoscope detector consisted of two perpendicular planes each with 38 plastic scintillator slats 1 cm in width, which essentially measured the first moment of the charge distribution ($nZ^2$) of light charged particles from the beam fragment in both X and Y. The reaction plane was thus determined event-by-event from the deviation of the post-collision mean $<X>$ and $<Y>$ of the
beam fragments, defined by the hodoscope, from the initial beam trajectory position deduced by the BVER detector. Following several corrections, based on detector response functions and centrality as determined by the zero-degree calorimeter (ZCAL), an accurate depiction of the reaction plane was obtained with a resolution of approximately 50 degrees.

3 Flow Determination and Results

Once the calibration of the detectors and their responses were well understood, the spectrometer triggered proton data set was divided into five bins of centrality (0-12%, 12-17%, 17-24%, 24-32%, and 32-43%) and 8 bins of reaction plane angle (from $-\pi$ to $\pi$ such that $-\pi$ is in the direction away from the spectrometer arm). The resultant transverse mass distributions were fit to a Boltzmann $1$. An example of how the inverse slope parameter and integrated yield $d^2N/dy d\phi$ varies with reaction plane angle in the most central bin and a mid-centrality bin for two rapidity intervals is shown in Fig. 2. For the most

Figure 2: Inverse slope parameter and $d^2N/dy d\phi$ versus reaction plane angle in two bins of centrality and two regions of rapidity.

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central bin the inverse slope parameter is relatively flat with little dependence on reaction plane, while the mid-central bin at target-like rapidity \((y = 0.6)\) exhibits a slight reaction plane dependence. (Midrapidity for experiment E917 is 1.6.) As expected, the magnitude of the inverse slope parameter increases with rapidity. When comparing the \(d^2N/dydy\) for the two centrality bins, the dependence of yield on reaction plane angle is strongest for the mid-central bin at target-like rapidity.

The mean value of the transverse flow, mean \(p_x\), summed over all reaction plane angle cuts has been calculated for each bin of rapidity. The results of the most central two selections are shown in Fig. 3. The starred points without error bars are the initial values determined without correction for the reaction plane resolution. The solid circles represent the corrected values and the open circles are their reflection about mid-rapidity. A line is then fit through the corrected data. The magnitude of the flow signal is a function of the slope of this line. To put the E917 data in context, Fig. 4 displays an excitation function of flow between 100A MeV and 12A GeV determined for a wide range of experiments\(^3\); the E917 data point is shown as the filled star. The flow data is expressed in terms of center-of-mass rapidity and scaled by system mass. The centrality was chosen to compare with the value determined by AGS experiment E877 and the two values concur within error bars.

![Figure 3: Mean \(p_x\) versus rapidity, reflected and fit, in two bins of centrality.](image.png)
Figure 4: An excitation function of flow.

4 Future Studies

Future plans include a further evaluation of a proton flow for other centrality cuts, since a mid-peripheral cut would likely yield a larger signal. The flow of deuterons, antiprotons and kaons will also be pursued.

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References