Collective flow in Au+Au collisions between 2-8A GeV at AGS

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The E895 collaboration has undertaken a systematic and exclusive study of Au+Au collisions between 2-8A GeV. We present preliminary results on collective flow observables as a function of beam energy. Data are compared with theoretical predictions.

1. Introduction

The 2-8A GeV energy range is one of only two regions between a few MeV per nucleon and CERN SPS energy where heavy-ion collisions are still largely unexplored. Collective effects observed at Bevalac/SIS energies [4] and at maximum AGS energy [5] suggest that a measurable flow signal should be observed in E895. Hydrodynamic and transport models indicate that collective effects are sensitive to various features of the nuclear equation of state at high density. Specifically, if a Quark-Gluon Plasma (QGP) phase transition occurs, hydrodynamics [1] predicts that directed flow may decline rapidly at E895 energies. Another important observable is elliptic flow [2], where the transition from out-of-plane emission to in-plane emission will help us understand the interplay of early pressure buildup and system expansion.

In this paper, a short description of the E895 experiment is presented, followed by preliminary results. The data used for these analyses represent a subset of the available statistics.

2. The Experiment E895

The E895 experiment investigates the global characteristics of nuclear matter at high energy and baryon density, with a specific emphasis on the beam energy dependence of

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collective observables. During January 1996 and November 1996, high statistics Au beam data were recorded at four beam energies: 2, 4, 6 and $8A$ GeV. The main E895 detector subsystem is the EOS TPC [3], located inside the MPS magnet operated with a field of 0.75 or 1 T. The TPC provides continuous tracking, nearly 4π acceptance, and particle identification via energy loss measurement.

The TPC is constructed in the shape of a rectangular box and its active drift volume is 154 cm long in the beam direction, 96 cm wide in the bending direction and 75 cm high in the drift direction. The TPC tracks charged particles of $Z < 8$ by measuring the ionization loss and the time taken for this ionization to reach the bottom pad plane of the TPC. The pad plane is segmented into 128 rows and 120 columns of pads. Each pad samples 140 time buckets (100ns each) along the drift direction, thereby providing a complete 3 dimensional event readout.

3. Results and Discussion

The nucleon azimuthal distribution with respect to the reaction plane in a certain rapidity window can be deconvoluted using the Fourier expansion [6,7],

$$\frac{dN}{d\phi} \approx v_0(1 + 2v_1\cos(\phi) + 2v_2\cos(2\phi)) \tag{1}$$

where the angle ϕ is the angle difference between nucleons and the reaction plane ϕ_r. v_0 is a normalization constant, and v_1 and v_2 are a measure of directed flow and elliptic flow, respectively.

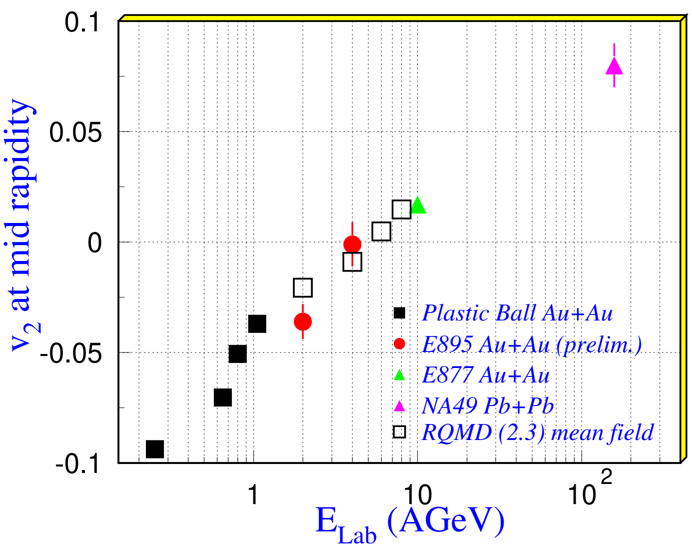

Figure 1. The systematics of v_2 as a function of beam energy. RQMD mean field calculations are shown also.

3.1. Elliptic Flow

The systematics of the v_2 variable as a function of beam energy is shown in Figure 1. We see that v_2 approaches zero at $4A$ GeV. It is interesting that RQMD (version 2.3) [8] cascade calculations show a positive v_2 at 2, 4, 6 and 8A GeV, while the mean field calculations using the same model are in good agreement with the v_2 data.

3.2. Directed Flow

Detection of a majority of the charged particles in the TPC allows us to study the average p_t correlation with the reaction plane directly. The global transverse momentum analysis of Danielewicz and Odyniec [9] has been performed to study the directed flow.

The impact parameter of the collision is inferred from the measured charged baryon multiplicity. The data are divided into multiplicity bins in a manner similar to the Plastic Ball analysis [10]. The following analysis is confined to the impact parameter range where the flow signals are largest (Mult 3).

In Figure 2, we show the measured $\langle p_x \rangle$ for protons projected onto the reaction plane as a function of rapidity. The error bar includes statistical and systematic errors. The data are corrected for efficiency while pion contamination is not removed at 6A GeV. The curves are fits using linear + cubic term in y/y_{cm}. Figure 3 shows the directed flow observable F obtained from the slope of the linear term as a function of beam energy.

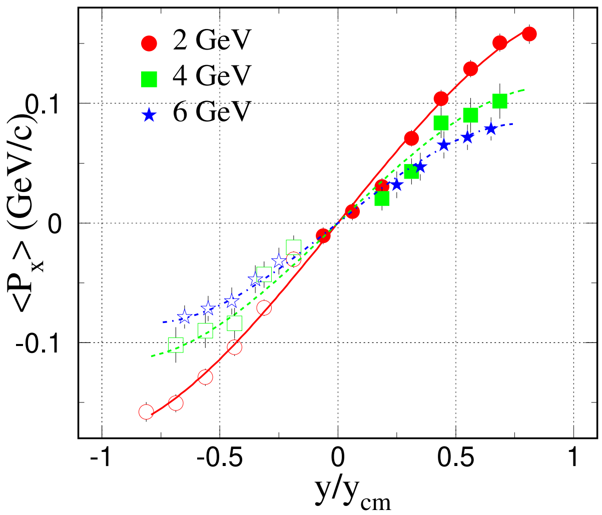

Figure 2. Average p_x as a function of normalized rapidity. The closed symbols are direct measurements and the open symbols are generated by reflection about midrapidity.

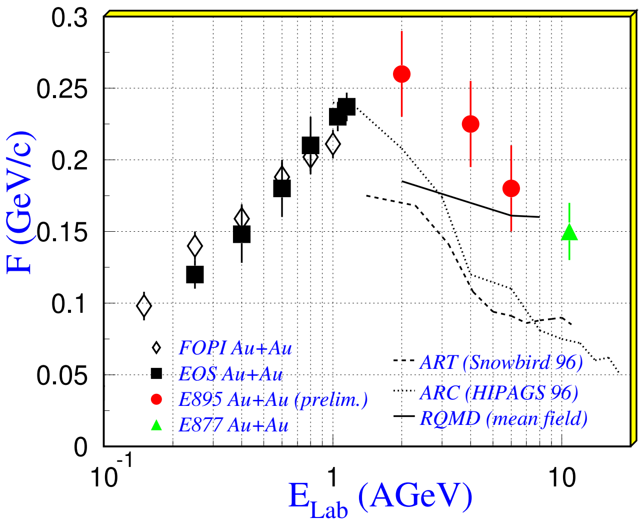

Figure 3. Directed flow as a function of beam energy. Theoretical predictions are from RQMD (mean field) calculations and from refs. [11] and [12].

4. Summary

We have presented preliminary data on collective flow of protons produced in Au+Au collisions using the 4π detector EOS TPC. The directed flow in terms of $\langle p_x \rangle$ drops smoothly from 2 to 6A GeV, and elliptic flow changes sign near 4A GeV.

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