Rapidity dependency of coalescence in Au-Au collisions at $\sqrt{s_{NN}}$= 200 GeV

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Abstract. The coalescence of protons and neutrons into deuterons is sensitive to the space-time extent of the baryon freeze-out region. Several experiments have measured the coalescence parameter, B_2, at mid-rapidity. BRAHMS has extended these measurements to forward rapidities and thus studied the longitudinal dependence of the freeze-out volume. At $\sqrt{s_{NN}}$= 200GeV near mid-rapdity the coalescence parameter is the same for baryons and antibaryons and similar in magnitude to lower energy results. We also find that B_2 remains constant from y=0 to y=3.2.

1. Introduction

Deuteron coalescence reflects the probability of a neutron and a proton, close in momentum space, forming a deuteron. An experimental measure of this probability is the coalescence parameter, B_2, which is given by:

$$B_2 = \frac{E_d \cdot \frac{d^3N}{dp_d^3}}{(E_p \cdot \frac{d^3N}{dp_p^3})^2} \tag{1}$$

It is worth noting that in (1) it is assumed that the proton and neutron distribution functions are the same. For more detailed work their differences should be taken into account. The formed deuteron will have a momentum, p_d, of approximately twice the forming proton momentum, p_p. Since the deuteron is a very loosely bound system with a binding energy of 2.22 MeV, the coalescence parameter serves as a probe of the heavy ion collision at the time of freeze-out.

Previously B_2 has been measured at numerous experiments at mid-rapidity, showing that for at least pre-RHIC energies B_2 decreases as a function of energy [1]. Furthermore measurements have shown that B_2 increases as a function of p_T, consistent with a transverse flow [2]. It has been proposed [3] that the coalescence parameter is inversely related to the volume of the system at the time of freeze-out.

‡ For the full authorlist and acknowledgements see the appendix of this volume

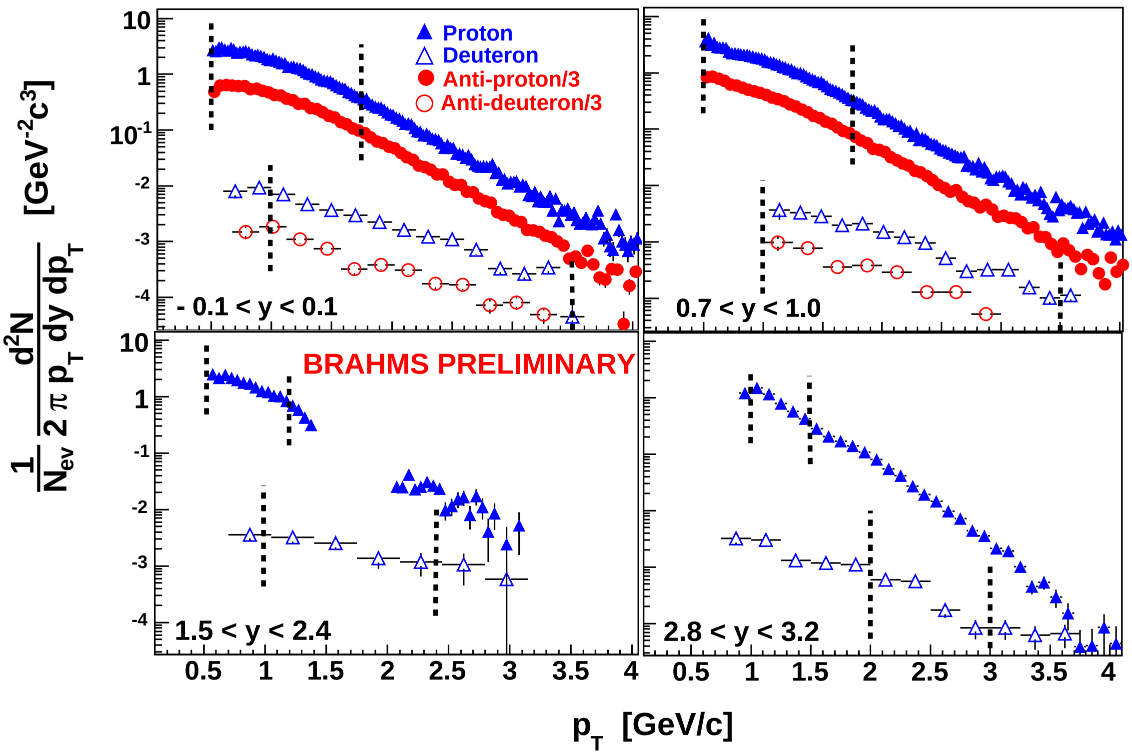

Figure 1. Invariant proton and deuteron spectra at four rapidity bins, and their anti-particle counterpart spectra at rapidity $y \sim 0$ and $y \sim 1$. The vertical dashed lines indicate the interval for each spectrum, used to construct the coalescence parameter. Solid blue triangles denote protons, open blue triangles denote deuterons, solid red circles denote anti-protons and open red circles denote anti-deuterons .

All these previous measurements have been conducted in the midrapidity region, whereas the aim for this work is to utilize the unique possibility of the BRAHMS experiment, to measure charged particles at very forward rapidities.

2. Results

The data presented in this analysis were obtained at the BRAHMS experiment [4] which has two movable magnetic spectrometers and global detectors for event characterization. In the midrapidity region, particle identification was done using time-of-flight walls. At forward rapidities, paricle identification was done using a ring imaging Cherenkov detector [5] in conjunction with time-of-flight walls. B_2 will be presented for a centrality selection of 0-20% for Au-Au collisions at $\sqrt{s_{NN}}$ = 200 GeV in four rapidity ranges, specifically: $-0.1 < y < 0.1$, $0.7 < y < 1.0$, $1.5 < y < 2.4$, and $2.8 < y < 3.2$.

In figure 1 the invariant proton and deuteron spectra for all four rapidity bins are presented. For the midrapidity bins anti-proton and anti-deuteron spectra are also presented in figure 1. The (anti-)proton spectra presented have been corrected for

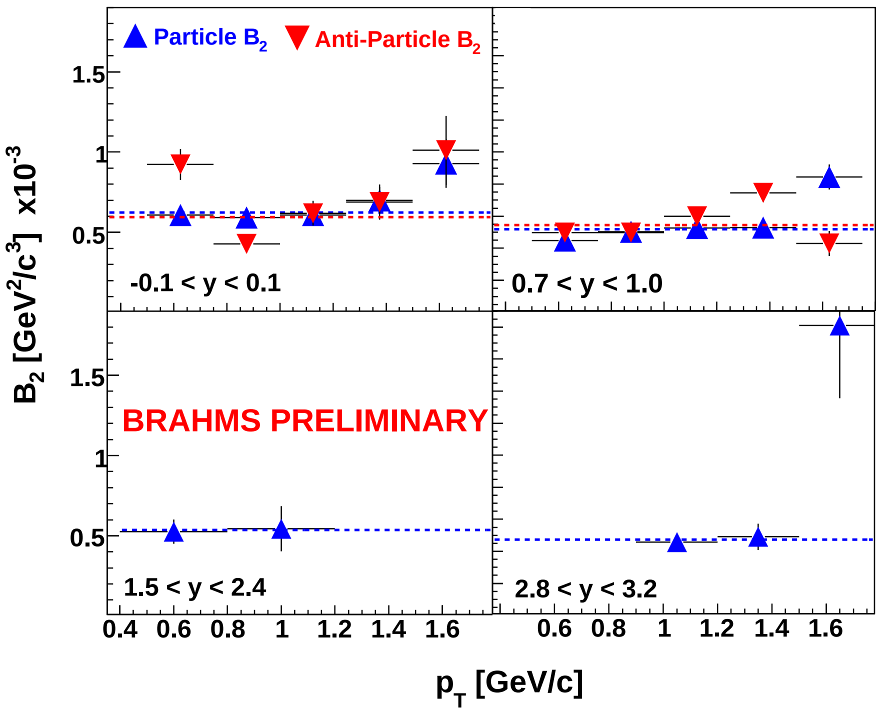

Figure 2. Particle and anti-particle B_2 as a function of transverse momentum, at four rapidity bins. The dashed horizontal lines are the weighted averages of each set of points.

multiple scattering, absorbtion and weak decay. The (anti-)deuteron spectra have not been corrected for these effects.

The vertical dashed lines in figure 1 illustrate the transverse momentum intervals used to construct B_2 for each spectrum. The difference in range for protons and deuterons stems from the fact that protons(neutrons) at momentum, p, coalesce into a deuteron at momentum 2p, i.e. the deuteron range is twice the proton range.

Figure 2 shows the B_2 vs. p_T of the (anti-)proton for each rapidity bin. B_2 is found to be rising as a function of p_T for both particles and anti-particles at midrapidity, i.e. $y \sim 0$ and $y \sim 1$, in accordance with previous experiments. We can not yet draw a conclusion about any p_T dependency at forward rapidity. The dashed lines in figure 2 are the weighted averages of the particle and anti-particle B_2 respectively. In this work the average of the p_T-dependant coalescence parameter for a certain rapidity bin will be used as the coalescence parameter for that rapidity bin.

Figure 3 shows B_2 as a function of rapidity. The statistical errors on the BRAHMS points are shown as lines, whereas the error box shows the total error, i.e the statistical error plus an estimated systematic error of 10 %. Included in the figure are results of an analysis where we have deduced B_2 values using the published spectra from the PHENIX experiment [6].

The deuteron coalescence parameter is found to be constant over the explored

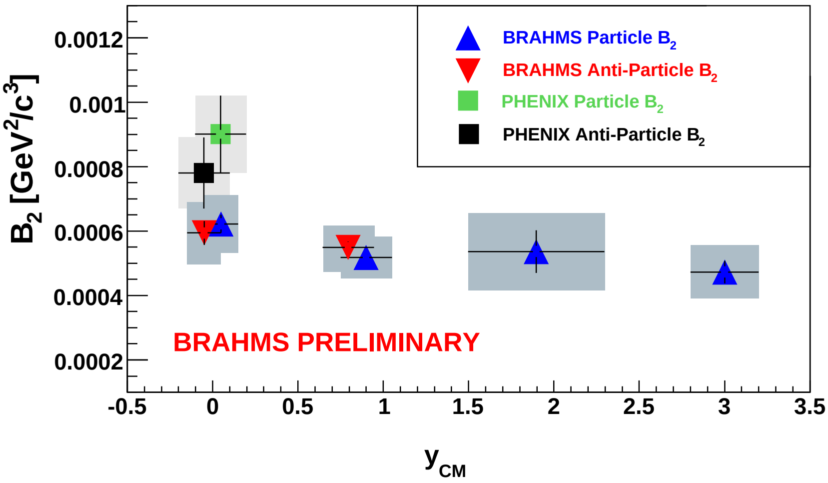

Figure 3. B_2 as a function of rapidity. The results of the BRAHMS experiment are shown as blue (particle) and red (anti-particle) triangles. B_2 values deduced using published proton and deuteron spectra of the PHENIX experiment [6] are shown by the green (particle) and black (anti-particle) squares. The error bars and shaded error regions for the BRAHMs results indicate statistical and total uncertainties, respectively. Only total uncertainties are indicated for the PHENIX points.

rapidity range and appears to be the same for particles and anti-particles. The absence of a rapidity dependence for the B_2 value over an extended rapidity range suggests that the extent of the interaction region at freeze-out is also largely independent of rapidity over this range. Other observables at RHIC that have also been shown to vary slowly with rapidity include the nuclear modification factor [7], the p_T dependence of identified particle elliptic flow [8], and Hanbury-Brown-Twiss radii [9].

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