System and rapidity dependence of baryon to meson ratios at RHIC

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The rapidity and centrality dependence of baryon to meson ratios in Au+Au, Cu+Cu and p+p collisions at $\sqrt{s_{NN}} = 200$ GeV at RHIC is presented.

1. Introduction

One of the unexpected observations at RHIC was the enhancement of proton and antiproton yields relative to pion yields at intermediate p_T around midrapidity [1], which was not seen in elementary hadronic collisions. An explanation for this behavior was proposed by the combination of pQCD calculations with soft physics and jet quenching [2]. It has been demonstrated that the fragmentation functions at large momentum fraction play an important role in hadron production [3]. Alternative models that attempt to describe these baryon to meson ratios include a phase-space determined parton coalescence picture [4,5], as well as the dynamics driven models of recombination [6], baryon-junction transport [7,8], and hydrodynamic flow [9]. Central Au+Au collisions are expected to provide a partonic medium where the coalescence of soft partons can occur. Coalescence will depend on the system size of the partonic fluid and is expected to be less influential for the Cu+Cu system. In this process, the p/π ratios can provide important information on the dynamics of how the medium evolves longitudinally. The BRAHMS experiment[10,11] has studied rapidity dependent baryon to meson ratios at $y = 0$ and $\eta \sim 3.2$ for Au+Au, Cu+Cu, and p+p collisions at $\sqrt{s_{NN}} = 200$ GeV.

2. Results

The data were obtained with two movable BRAHMS spectrometer arms, the Mid-Rapidity Spectrometer (MRS) at 90°, and the Forward Spectrometer (FS) at 4°, and global detectors for event characterization. Particle identification was done using time-of-flight and threshold gas Cherenkov measurements in the MRS, and a ring imaging Cherenkov detector (RICH) for the FS. Figure 1 shows the $\bar{p}/\pi^-$ ratios as a function of p_T obtained at midrapidity and forward rapidity for the 0-10%, 10-20%, 30-50% and 60-80% centrality bins in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. The data for the same energy p+p collisions are also shown. The antiproton to π^- ratios show a smooth increase from peripheral to central collisions, and the data for peripheral Au+Au collisions approach the p+p results. The centrality dependence is stronger at midrapidity than at forward rapidity, and the peak in the $\bar{p}/\pi^-$ ratio is lower at forward rapidity as compared to midrapidity. Theoretical model calculations for p/π ratios are compared to the exper-

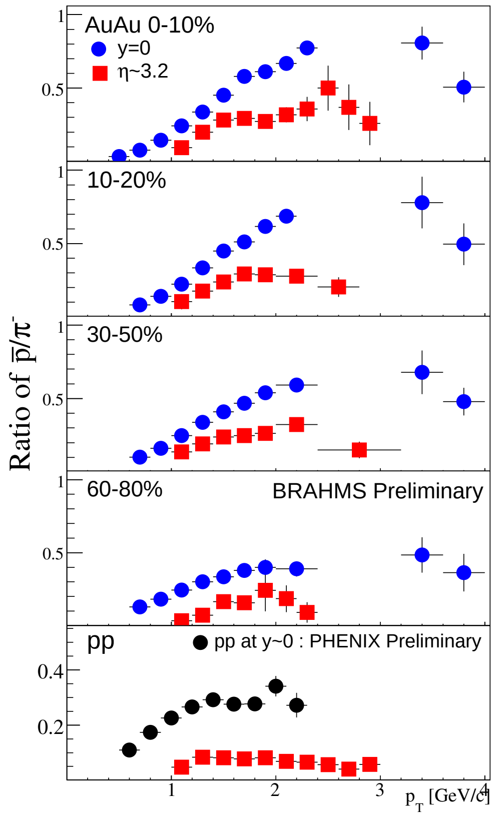

Figure 1. Centrality dependent $\bar{p}/\pi^-$ ratios at $y = 0$ and $\eta \sim 3.2$ in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. Data at p+p collisions at $\sqrt{s_{NN}} = 200$ GeV are also shown. No $\bar{\Lambda}$ feed-down correction applied. Error bars are statistical only.

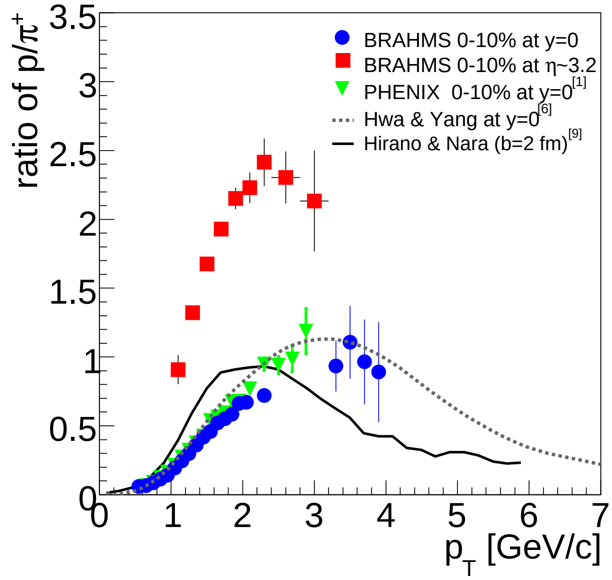

Figure 2. Preliminary p/π for 0-10% central Au+Au collisions at rapidity $y = 0$ and $\eta \sim 3.2$. Feed-down corrections are applied at $y = 0$, but not at $\eta \sim 3.2$. Comparisons with model calculations are shown by curves.

imental data in Fig. 2. Parton coalescence [4] and recombination [6] models describe the observed ratios well at midrapidity, but three-dimensional (3-D) hydrodynamic model [9] also reproduce the observed features of p/π enhancement without depending on baryon junction or coalescence. In the 3-D hydrodynamic model, the interplay between soft and hard reaction components is expected to occur at intermediate p_T, and the model defines a crossing point in transverse momentum, $p_{T,cross}$, which might be related to the peaks evident in Fig. 1. The p/π ratios are enhanced at forward rapidity, as shown in Fig. 2. The current hydro calculations do not show a rapidity dependence since baryon or isospin chemical potentials are not included in their schemes. Even though protons at high rapidity are expected to develop mostly from the projectile, rapidity dependent recombination and/or radial flow effects at the partonic level, or the inclusion of a varying baryo-chemical potential in the hydro calculations, will likely be needed to fully understand the experimental observations.

The p/π ratios for different collision systems as a function of transverse momentum at

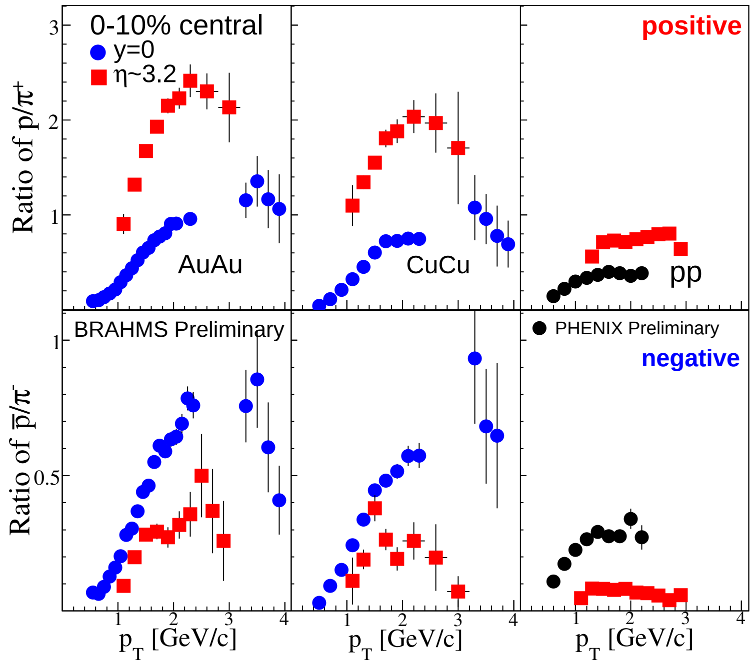

Figure 3. p/π ratios as a function of p_T for different systems, Au+Au, Cu+Cu, and p+p collisions at midrapidity and forward rapidity. No Λ and $\bar{\Lambda}$ feed-down corrections applied, and the error bars are statistical only.

$y = 0$ and $\eta \sim 3.2$ are shown in Fig. 3. The proton to pion ratios in p_T increase with the colliding system size from p+p to Au+Au collisions. The peaks in the data, presumably related to crossing points in p_T, are at similar positions for Au+Au and Cu+Cu collisions at the same rapidity.

Figure 4 shows the centrality dependence of $\bar{p}/\pi^-$ ratios as a function of the number of participating nucleons, $< N_{part} >$, at different rapidities, $y = 0$ and $\eta \sim 3.2$, for Au+Au and Cu+Cu systems at $\sqrt{s_{NN}} = 200$ GeV. The integrated $\bar{p}/\pi^-$ ratios with $1.5 < p_T < 2.5$ are shown for each centrality bin. The data indicate that the particle ratios increase for both rapidities going to more central collisions up to $N_{part} \approx 100$, and show a weak dependence from the midcentral to the most central collisions. The $\bar{p}/\pi^-$ ratios with N_{part} from different colliding systems are independent of system size at both rapidities.

3. Summary

In summary, BRAHMS has measured rapidity dependent baryon to meson ratios in different colliding systems at $\sqrt{s_{NN}} = 200$ GeV as a function of p_T and centrality. The ratios are enhanced in nucleus-nucleus collisions compared to p+p collisions, and positive and negative ratios show similar interplay between soft and hard processes for different systems. No significant changes for the baryon-meson production are observed with colliding system size.

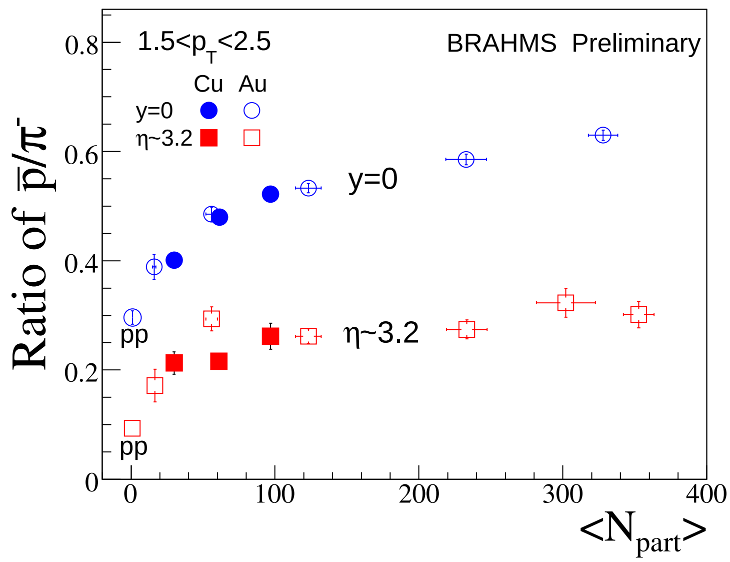

Figure 4. Rapidity and $< N_{part} >$ dependence of $\bar{p}/\pi^-$ ratios for $1.5 < p_T < 2.5$ at $y = 0$ and $\eta \sim 3.2$ in Au+Au and Cu+Cu collisions at $\sqrt{s_{NN}} = 200$ GeV. Circle(closed) symbols are the results at $y = 0$, and square(closed) symbols are the results at $\eta \sim 3.2$ in Au+Au (Cu+Cu) collisions. The error bars are statistical only.

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