The p/π ratio p_T-dependence in the RHIC range of baryo-chemical potential

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The BRAHMS measurement of proton-to-pion ratios in Au+Au and p+p collisions at $\sqrt{s_{NN}} = 62.4$ GeV and $\sqrt{s_{NN}} = 200$ GeV is presented as a function of transverse momentum and collision centrality within the pseudorapidity range $0 \leq \eta \leq 3$. The baryo-chemical potential, μ_B, for the indicated data spans from $\mu_B \approx 26$ MeV ($\sqrt{s_{NN}} = 200$ GeV, $\eta = 0$) to $\mu_B \approx 260$ MeV ($\sqrt{s_{NN}} = 62.4$ GeV, $\eta \approx 3$) [1]. The p/π ratio measured for Au+Au system at $\sqrt{s_{NN}} = 62.4$ GeV, $\eta \approx 3$ reaches astounding value of 8-10 at $p_T \geq 1.5$ GeV/c. For these energy and pseudorapidity interval no centrality dependency of p/π ratio is observed. Moreover, the baryon-to-meson ratio of nucleus-nucleus data are consistent with results obtained for p+p interactions.

I. INTRODUCTION

In the last decades, the intense theoretical and experimental investigations of the QCD phase diagram in the regime of partonic and hadronic gas phases led us to the picture depicted in Fig. 1. The dashed-dotted red (online) line represents the crossover from Quark Gluon Plasma to the hadronic state procured from the lattice QCD calculation [2]. The experiemntal measurement of hadronic species abundances allows us to outline the dotted blue (online) line as the chemical freeze-out of the hadronic gas. It is remarkable that at low baryo-chemical potential that two curves overlap, albeit at large μ_B a significant gap between the temperature of the transition from the partonic to the hadronic phase, T_c, and the temperature of chemical freeze-out is predicted.

The data of elliptic flow [3] and p/$\pi(p_T)$ [4, 5] around midrapidity (low μ_B) have shown that the final hadronic state remembers the partonic fluid features. This is reflected in constituent quark scaling of v_2 and an enhancement of baryon-to-meson ratios that scales with the size of the created systems (see [4], Fig. 2).

These results support the view of hadronization process driven by the parton recombination [6] with the negligible final state interactions between produced hadrons. From Fig. 1 one can conclude that at large μ_B this picture might be spoiled by the final state hadron interactions leading to the transition from parton recombination scheme to the hydrodynamical description with the common velocity field of baryons and mesons [7, 8].

II. EXPERIMENTAL LAYOUT AND ANALYSIS

The BRAHMS detector setup [9] consists of two movable, narrow spectrometer arms: the Midrapidity Spectrometer which operates in the polar angle interval from $90° \leq \Theta \leq 30°$ (that corresponds in the pseudorapidity interval $0 \leq \eta \leq 1.3$) and the Forward Spectrometer that operates

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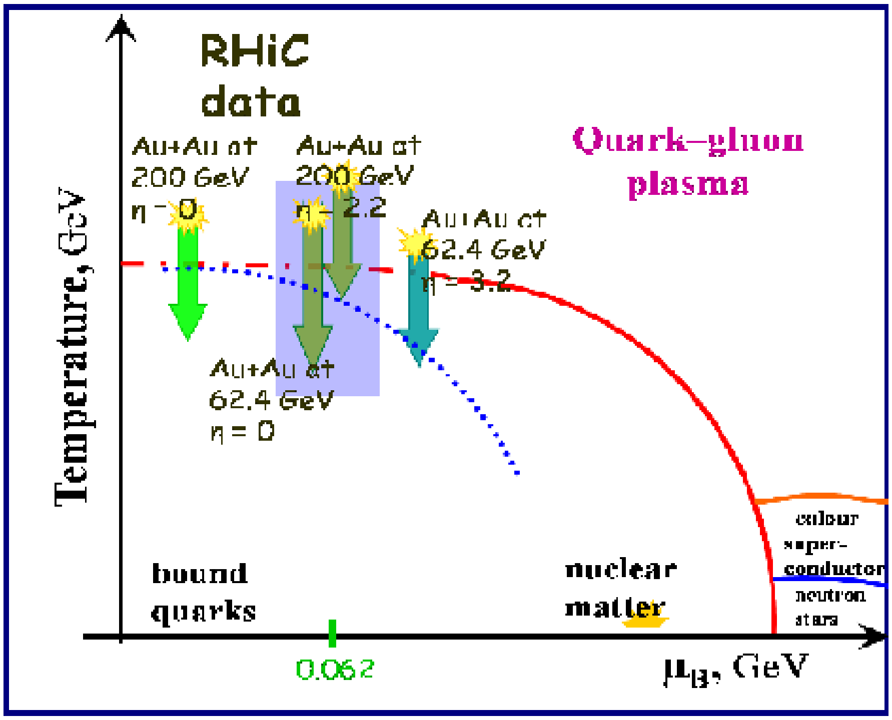

FIG. 1: The scheme of QCD phased diagram: the dashed-dotted red (online) line emblematizes the crossover between Quark Gluon Plasma and hadronic phase. The dotted blue (online) curve represents the chemical freeze-out.The arrows denote the value of baryo-chemical potential for definite colliding systems [10].

in the polar angle range from $2.3^\circ \leq \Theta \leq 15^\circ$ ($2 \leq \eta \leq 4$). Additionally, BRAHMS setup consists of the global detectors used to determine the overall particle multiplicity, collision vertex and centrality.

The Midrapidity Spectrometer is composed of the single dipole magnet (D5) placed between two TPCs which are made use of tracking. Particle identification is based on the Cherenkov detector (C4 - signs like in [9]) and Time of Flight Wall (TOFW) measurement.

The front forward arm is composed of two Time Projection Chambers (constituted track recognition in a high multiplicity enviroment), the back part - of three Drift Chambers and in the aggregate deliver particle track segments with high momentum resolution using three dipole magnets. To identify low momentum particles the Time of Flight (hodoscope H2) is used. For higher mometa, particle identification is provided via then Ring Imaging Cherenkov detector, situated behind H2 hodoscope.

For data analysis we assume that acceptance and tracking efficiency are canceled in the baryon-to-meson ratio but the proton and pion yield have been corrected for PID efficiency, interactions of emitted particles with the beampipe, the spectrometers natural budget and for the decays in fly.

III. RESULTS AND DISCUSSION

It has been already shown that the p/π ratios at the intermediate p_T range can vary very strongly depending on both charge and pseudorapidity of indicated species, as well as on energy and size of colliding system. Fig. 2, [4], presents the p/$\pi(p_T)$ ratio at midrapidity for Au+Au at $\sqrt{s_{NN}} = 200$

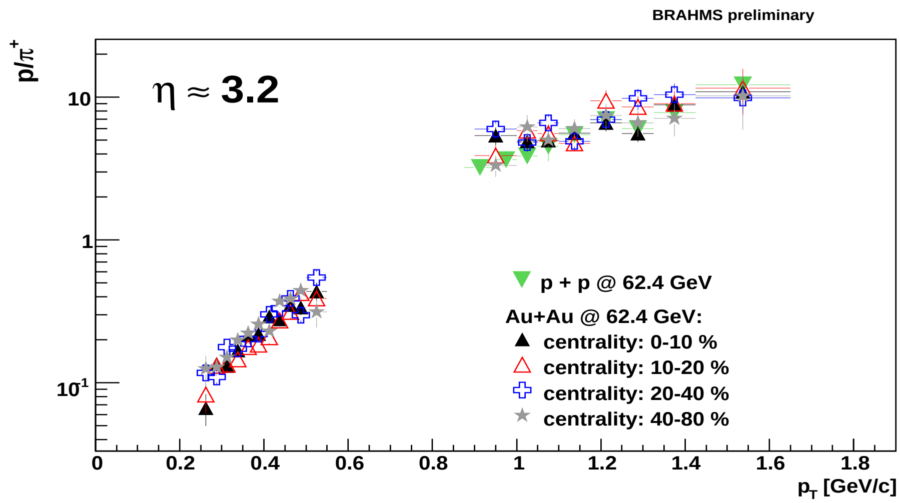

FIG. 2: Centrality dependent ratio of p/π for Au+Au system at $\sqrt{s_{NN}}$ = 62.4 GeV for η = 3.2 in comparison with p+p collisions. The errors are only statistical.

GeV (μ_B = 26 MeV) in comparison with theoretical predictions based on parton recombination model [11] and hydrodynamical descritpion. The characteristic growth at intermediate p_T region, predicted by above-mentioned descriptions, seems to be more consistent with the depiction of recombination model. The hydrodynamic scenario, proposed in [7], describes properly only the low momentum data associated mainly with the soft component.

Fig. 2 compares the p/π ratio from p+p and Au+Au collisions at $\sqrt{s_{NN}}$ = 62.4 GeV and η = 3.2 ($\mu_B \approx 250$ MeV, [1]). Unexpected high value of 10 at p_T = 1.5 GeV/c of proton-to-meson ratio [12] is observed.

There is remarkably little difference in the pi/p ratios from a very wide range of systems. This is in contrast to the trends at midrapidity and forward rapidity regimes for Au+Au at $\sqrt{s_{NN}}$ = 200 GeV where significant medium effect of baryon-to-meson ratios depending on system size is seen. However, it must be admitted that at forward pseudorapidity a lot of protons come from beam fragmentation, that high value of proton-to-pion ratio for all intervals of centrality for nucleus-nucleus collisions is a puzzle indicating that mechanism of baryons-to-mesons production is taking place rather on elementary interaction domain.

Fig. 3 presents the Au+Au collisions for η = 0.0 at $\sqrt{s_{NN}}$ = 62.4 GeV marked with open red (online) triangles and the Au+Au reactions for η = 2.2 at $\sqrt{s_{NN}}$ = 200 GeV marked with the black triangles. The selection of pseudorapidity intervals namely η = 0.0 for Au+Au @ 62.4 GeV and η = 2.2 for Au+Au @ 200 GeV allow to obtain overlap in $\bar{p}$/p, thus μ_B, for the observed phase space of system at various energies. As indicated in Fig. 1 the shown data are measured at $\mu_B^{Au+Au@200GeV} = \mu_B^{Au+Au@62.4GeV}$ = 62 MeV. Considerably lower value depicted by grey stars displays the p/π ratio for p+p system at $\sqrt{s_{NN}}$ = 200 GeV. The astonishing conformity proton-to-pion ratios for collate heavy ions collisions evidences that the baryon and meson production at the covered p_T interval is dominated by medium effects. These effects can be seen throughout the observed enhancement of p/$\pi(p_T)$ for nucleus-nucleus systems with reference to the results for elementary interactions. The data infer possible scaling of baryon-to-meson ratio with baryo-chemical potential for dense systems. In addition it is presented the comparison with THERMINATOR model with well-defined collective expansion and successive evaporation of hadrons from the hypersurface of the fireball [8].

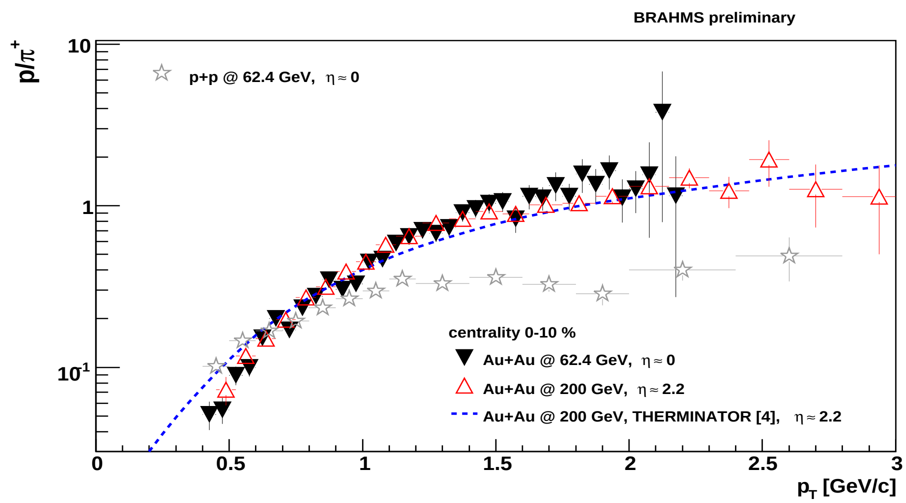

FIG. 3: Proton-to-pion ratio for Au+Au (0-10% centrality) and p+p collisions measured at the same value of baryo-chemical potential $\mu_B = 62$ MeV. The errors are only statistical.

IV. SUMMARY

Concluding, the BRAHMS experiment has presented the proton-to-pion ratios in Au+Au and p+p collisions at $\sqrt{s_{NN}} = 62.4$ GeV and $\sqrt{s_{NN}} = 200$ GeV as a function of transverse momentum and collision centrality. As it has been shown the indicated data give the possibility of studying baryon and meson production in the wide range of baryo-chemical potential μ_B. For Au+Au and p+p measurement at $\sqrt{s_{NN}} = 62.4$ GeV for $\eta = 3.2$ the astounding value of p/$\pi(p_T)$ ratio has been noted. At these energy and pseudorapidity interval no centrality dependency of p/π ratio is observed. Furthermore, the baryon-to-meson ratio of nucleus-nucleus data are consistent with results obtained for elementary p+p reactions.

To test the effect of baryo chemical potential we have compared $\eta = 2.2$ and $\sqrt{s_{NN}} = 200$ GeV with $\eta = 0.0$ and $\sqrt{s_{NN}} = 62.4$ GeV. The pi/p ratios are remarkably similar.

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