Nuclear modification factor for identified hadrons at forward rapidity in Au+Au reactions at 200 GeV

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Herewith we present the production of identified hadrons in Au + Au and p + p collisions at $\sqrt{s_{NN}} = 200\,\mathrm{GeV}$ at forward rapidity, $y \approx 3.2$. Suppression of pions and kaons and enhancement for protons in central Au + Au collisions is observed. These results are found to be very similar in strength to that observed at midrapidity. Furthermore, we see a gradual decrease of the observed suppression towards more peripheral collissions.

1. Introduction

First collisions of gold ions at nucleon-nucleon center of mass energies 130 GeV at RHIC revealed a dramatic decrease of pion production at high transverse momentum (p_T), as compared to an incoherent sum of pions produced in the p + p collisions at the same energy [1]. High p_T hadrons are primarily produced from the fragmentation of the hard-scattered partons and observed suppression could be either due to initial state parton saturation inside the nuclei [2] or due to final state jet energy degradation [3]. The crucial test of these different mechanisms has been performed during the third RHIC run when collisions between deuterium and gold ions at $\sqrt{s_{NN}} = 200\,\mathrm{GeV}$ were investigated. The measurements showed that the particle production from d + Au collisions around midrapidity is not suppressed [4–7]. The absence of this phenomena suggests that the suppression observed in the Au + Au collisions is due to final state interactions. However it was also observed in the BRAHMS experiment that at forward pseudorapidity $\eta = 2.2$ inclusive negatively charged hadrons are suppressed in both Au + Au and minimum-bias d + Au collisions [5,8], which is often attributed to the possible existence of the nuclei in the Color Glass Condensate phase [2] prior to the collisions.

2. Results

Identified hadrons differential yields per event in Au + Au collision as seen by the BRAHMS experiment at rapidity $y \approx 3.2$ are presented in Figure 1. Also there we plot the differential yields for p + p collisions. No correction for decay, absorption or feeddown has been applied to the data presented in this report. Only statistical errors are shown unless stated otherwise.

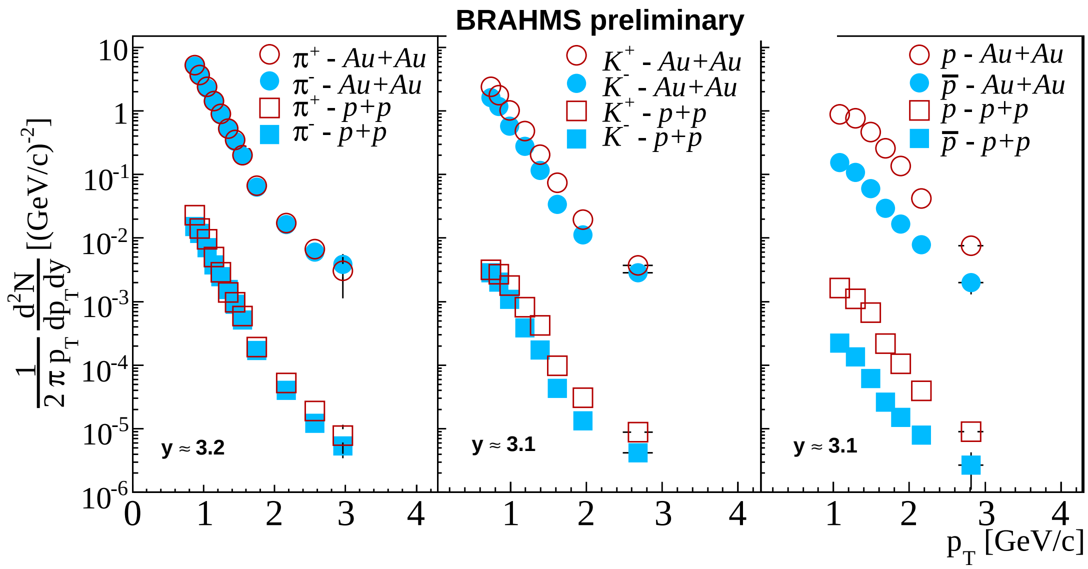

Figure 1. Identified particles spectra in transverse momentum from 0-10% central Au + Au (circles) and p + p (squares) collisions at 200 GeV. Yields for pions (left-hand panel), kaons (middle), and protons (right-hand), both negative (open) and positives (solid) are plotted.

To study the in-medium effects on the spectra it is often useful to plot nuclear modification factor, which is the ratio of the yield obtained from nucleus-nucleus collisions scaled with the number of binary collisions, to the yield from elementary nucleon-nucleon collisions:

$$R_{AA} = \frac{\mathrm{d}^2N_{AA}/\mathrm{d}p_T\mathrm{d}y}{N_{coll} \times \mathrm{d}^2N_{NN}/\mathrm{d}p_T\mathrm{d}y} \qquad (1)$$

In the absence of any nuclear effects the ratio, R_{AA}, should saturate at unity for high p_T, where production is dominated by hard scatterings and is proportional to the number of binary collisions, N_{coll}. Production in the low p_T region is dominated by soft processes and scales with the number of participant pairs, N_{part}, which is *circa* three times smaller for central Au + Au collisions than N_{coll}. The ratio however, plotted in Figure 2 as a function of transverse momentum, show deviations from unity for all identified hadrons.

Figure 2 show R_{AA} for identified hadrons at rapidity $y \approx 3.2$ for $0{-}10\%$ central Au + Au collisions at $\sqrt{s_{NN}} = 200\,\mathrm{GeV}$. Dashed and dotted lines represent the expectation of scaling with N_{coll} and N_{part}, respectively, while the shaded boxes are the systematic errors resulting from the uncertainties of N_{coll} and N_{part}. This figure shows suppression of the light mesons: pions (left-hand panel) and kaons (middle panel), similar for both signs, and basically independent of the transverse momenta, at values of about 0.4 and 0.7, respectively. R_{AA} for protons however, plotted in the right panel, exhibit an enhancement peak at $p_T \approx 2\,\mathrm{GeV}/c$.

In Figure 3 we compare the R_{AA} calculated for pions and protons at $y \approx 3.2$ with the ratios obtained by the PHENIX Collaboration at midrapidity. Data show very similar behaviour for both rapidities in the p_T range covered by BRAHMS, which, combined with other BRAHMS results [5], indicates the flatness of R_{AA} with rapidity.

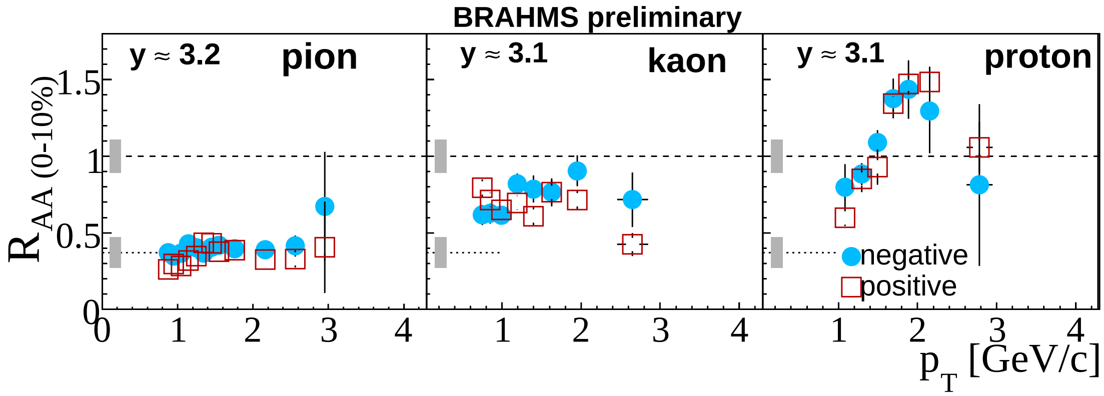

Figure 2. Nuclear modification factors for identified particles: pions, kaons and protons, panels from left to right, respectively. Solid circles are for negative particles, while open squares for positive.

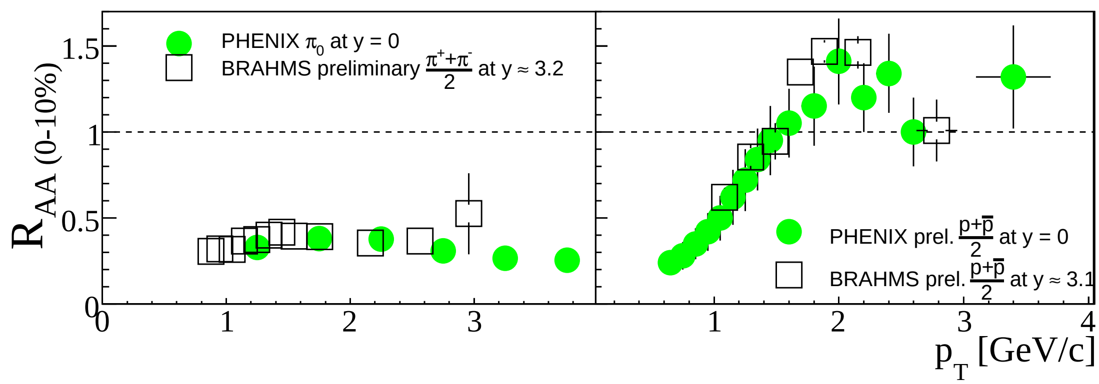

Figure 3. Comparison of R_{AA} for pions (left-hand panel) and protons(right-hand panel) at midrapidity and $y \approx 3.2$. Solid circles are PHENIX [9] data at midrapidity, open squares show BRAHMS preliminary data.

The magnitude of the suppression can also be studied as a function of the system size. Averaged R_{AA} for pions in the p_T range: $2 < p_T < 3.0\,\mathrm{GeV}/c$ has been plotted in Figure 4 as a function of N_{part}. As expected, the strength of the suppression is decreasing for peripheral events. When compared with the PHENIX data obtained for neutral pions at midrapidity we can see that although for central events R_{AA} seems to be independent of rapidity, for the peripheral events nuclear modification factor seen at forward rapidity reaches value close to unity, larger that the PHENIX data.

3. Conclusions

BRAHMS experiment has measured particle distributions for identified hadrons in Au + Au and p + p collisions at $\sqrt{s_{NN}} = 200\,\mathrm{GeV}$ at forward rapidity of $y \approx 3.2$. Spectra were used to construct the nuclear modification factor, which shows suppression for mesons independent of the transverse momenta, and enhancement for protons and antiprotons around $p_T \approx 2\,\mathrm{GeV}/c$. Observed suppression in Au + Au central collisions

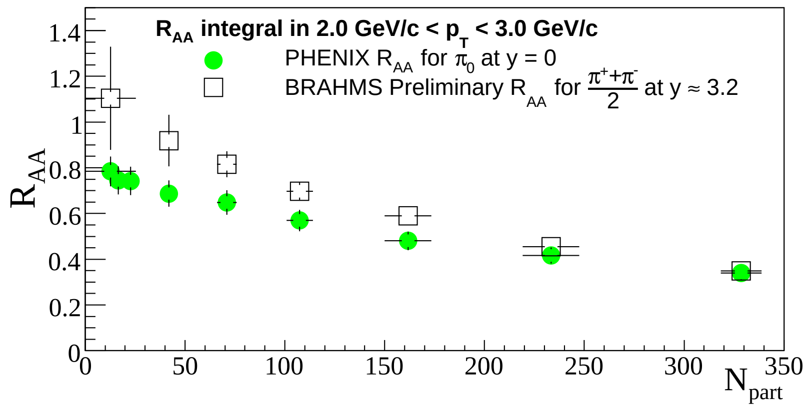

Figure 4. Change of averagend nuclear modification factor with centrality. solid circles are PHENIX [9] data at midrapidity, open squares show BRAHMS preliminary data.

and decreasing of the effect with decreasing centrality, as well as with decreasing system size [8] may be due to jet quenching. Systematic difference between mesons and baryons, which moreover seems to be independent of rapidity (at least up to rapidity $y \approx 3.2$ for central events), suggests existence of other mechanisms of particle production, which depend on the quark content, such as baryon junction [10,11] or parton recombination [12]. Puzzling consistency of the investigated ratios with rapidity can be relatively easy explained in the surface emission picture [13], where changes in $\mathrm{d}N/\mathrm{d}\eta$ result in a nearly flat dependence of R_{AA}, albeit an increase of R_{AA} is expected for $y > 3$.

Surprising feature is revealed when comparing nuclear modification factor dependence on centrality at midrapidity and at large rapidity. Observed enhancement of the ratio at $y \approx 3.2$ for the peripheral events may indicate change of the medium properties when going from central to peripheral events at this rapidity.

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