

# Nuclear Modification Factors in d+Au and Au+Au collisions at $\sqrt{s_{NN}}=200$ GeV<sup>\*</sup>

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## Abstract

BRAHMS has measured the identified charged hadron production at mid- and forward rapidities in Au+Au and d+Au collisions at  $\sqrt{s_{NN}} = 200$  GeV. The centrality and rapidity dependence of nuclear modification factors  $R_{AuAu}$  and  $R_{dAu}$  provides a better way to study how the dense medium is distributed in the longitudinal direction.

*Key words:* Particle production, Nuclear modification factor, Suppression, Forward rapidity

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High  $p_T$  suppression has been observed in central Au+Au collisions at RHIC energy (200 GeV) [1] and may be interpreted as a consequence of the energy loss due to the hard scattering process, as partons traverse through the hot and dense medium. Since there is no hot and dense final state medium in d+Au collisions, suppression effects due to nuclear shadowing and/or gluon saturation are expected at large rapidity probing the small  $x$  region in the Au nucleus. BRAHMS [2] has reported the transverse momentum dependence of the nuclear modification factors  $R_{dAu}$  and  $R_{AuAu}$  of charged hadrons and showed a high  $p_T$  suppression at forward rapidity [3,4]. The nuclear modification factors of identified particles in central Au+Au collisions at both  $y = 0$  and  $\eta = 2.2$  show a suppression for pions, but not for protons at intermediate  $p_T$  [5]. Studying nuclear modification factors of various particle species in Au+Au and d+Au collisions as a function of centrality and rapidity provides information to understand the extend of the hot medium in the longitudinal direction.

The nuclear medium effects on hadron production are quantified by the use of nuclear modification factors, which are defined as  $R_{AA}$  or  $R_{CP}$ .  $R_{AA}$  gives the deviation in yields

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from A+A collisions relative to the scaled yields from nucleon-nucleon collisions.  $R_{CP}$  can provide similar information based on the relative yield in central(C) and peripheral(P) collisions scaled by the mean number of binary collisions, but does not depend on the reference nucleon-nucleon system. The nuclear modification factor  $R_{AA}$  and  $R_{CP}$  as a function of  $p_T$  for the most central Au+Au collisions (0-10%) at  $\eta = 0, 0.8, 2.6, 3.0$  and  $3.6$  are shown in Figure 1. The high  $p_T$  suppression persists over a wide range in pseudorapidity for the most central Au+Au collisions. At all pseudorapidities,  $R_{AuAu}$  reaches a maximum value of 0.6 - 0.8 at  $p_T \sim 2$  GeV/c, following a decrease at higher  $p_T$ .  $R_{CP}$  shows a roughly constant suppression, when goes from midrapidity to forward rapidity. The observed behavior of nuclear modification factors seems to be consistent with the jet surface emission picture [6].

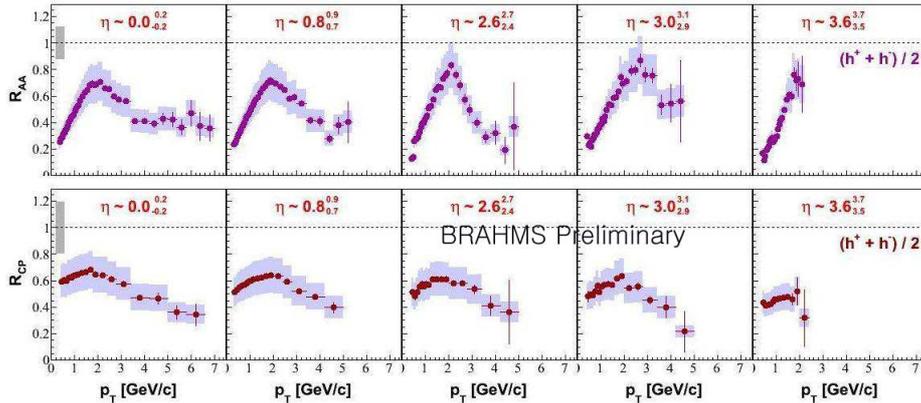


Fig. 1. Nuclear modification factor  $R_{AA}$  at different  $\eta$  for the most central collisions (0-10% centrality), and  $R_{CP}$  for charged hadrons in Au+Au collisions at  $\sqrt{s_{NN}}=200$  GeV for pseudorapidities  $\eta=0, 0.8, 2.6, 3.0, 3.6$  as a function of  $p_T$ . The systematic uncertainties are shown as the shaded boxes around the data points. The shaded bands at  $R_{AA}(R_{CP}) = 1$  show the systematic uncertainty in the number of binary collisions.

High  $p_T$  suppression shows a particle species dependence. Nuclear modification factors for identified charged hadrons,  $\pi^\pm$ ,  $p$ , and  $\bar{p}$ , in 0-10% central Au+Au collisions are presented in Figure 2.  $R_{AuAu}$  for both positive and negative mesons exhibit suppression at all measured rapidities, and a very similar behavior at  $y \sim 0$  and  $y \sim 3.1$ . The  $R_{AuAu}$  for protons and antiprotons show an enhancement in the intermediate  $p_T$  ranges, and no significant difference between midrapidity and forward rapidity. These observations might be related to in-medium parton recombination processes, which favor the production of baryons over mesons in the intermediate  $p_T$  region [7,8].

Figure 3 shows the centrality dependence of  $R_{dAu}$  for charged pions, kaons and protons in d+Au collisions at midrapidity and forward rapidity. There is a difference of  $R_{dAu}$  in central and peripheral collisions.  $R_{dAu}$  for protons reaches a large value at  $p_T \sim 2$  GeV/c at midrapidity in both central and peripheral collisions, while our  $p_T$  ranges for pions and kaons are too limited to make any conclusion with given results. At forward rapidity  $y = 3$ ,  $R_{dAu}$  for identified charged particles are suppressed up to  $p_T < 2.5$  GeV/c for central collisions.

In summary, BRAHMS has measured the rapidity dependence of nuclear modification factors in Au+Au and d+Au collisions at  $\sqrt{s_{NN}} = 200$  GeV. For charged hadrons,

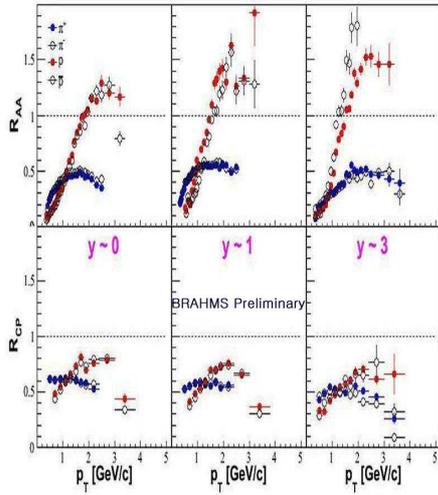


Fig. 2. Nuclear modification factor  $R_{AuAu}$  for  $\pi^\pm$ ,  $p$  and  $\bar{p}$  at different rapidity for 0-10% centrality bin. Error bars are statistical. The dotted lines indicate the expectation of binary scaling.

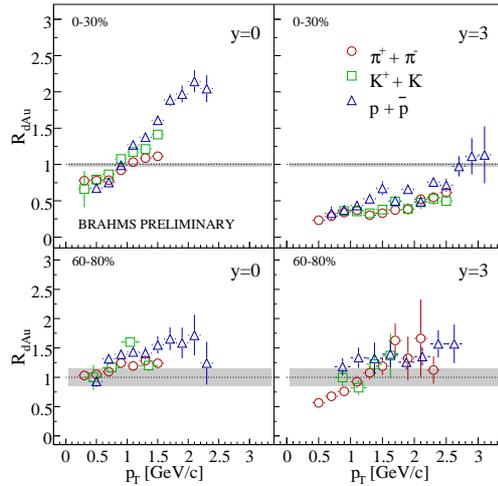


Fig. 3. Nuclear modification factor  $R_{dAu}$  for identified charged hadrons at rapidity  $y = 0$  and  $y = 3$ . Top panel shows 0-30% centrality bin, and bottom one shows 60-80% centrality bin. Grey bands around  $R_{dAu}=1$  are the systematic uncertainties propagated from  $\langle N_{coll} \rangle$ .

$R_{AuAu}$  and  $R_{CP}$  in Au+Au collisions show very little variation with rapidity, and a suppression of  $R_{AuAu}$  extends to the most forward rapidity,  $\eta \sim 3.6$ . The observed rapidity independence in Au+Au collisions might indicate the presence of a longitudinally extended hot and dense partonic medium.  $R_{AuAu}$  for identified charged hadrons shows a different meson/baryon dependence at both rapidities, and for  $R_{dAu}$  at forward rapidity in d+Au collisions, suppression is observed in central collisions.

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