High p_t suppression in CuCu Collsions at $\sqrt{s_{NN}} = 200$ GeV at RHIC

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Abstract. Collisions between hadronic systems at relativistic energies provide a window on the small-x gluon distributions of fast moving nuclei. It has been predicted that gluon saturation effects will manifest themselves as a suppression in the transverse momentum (p_t) distribution at a scale which is connected with the rapidity of the measured particles. Saturation effects are most evident at large (pseudo)-rapidity, i.e., at small angles relative to the beam direction. The dependence of the nuclear modification factor on the number of participants provides a constraint on the mechanism underlying the high-p_t suppression. Here we present results for the nuclear modification factor R_{cp} at forward rapidity as a function of system mass comparing results from CuCu, AuAu and dAu collsions at $\sqrt{s_{NN}} = 200$ GeV.

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The main goal of the heavy ion program at the relativistic heavy ion collider(RHIC) is the creation and detection of the quark gluon plasma (QGP), a deconfined state of matter consisting of quarks and gluons(partons). High-p_t partons going through a QGP are expected to suffer significant energy loss resulting in fewer high-p_t particles in the exit channel than would be present without the QGP [1]. An experimental observation of such a supression in high energy heavy ion collisions would provide evidence that a QGP has been created. In contrast, the ratio of dAu to pp-collisions is expected to show an enhancement over a range in momentum, a phenomennon known as the Cronin effect [4]. The argument is that energy loss in the "cold matter" of dAu collisions is quite small and the Cronin effect is a result of p_t broadening due to multiple scattering. On the other hand, if a suppression is observed in dAu colisions at forward rapidities instead of the Cronin effect, it may be an indication that initial state effects are important. A marked high-p_t suppression with increasing pseudorapidity may thus be related to the initial conditions of the colliding deutron and gold nuclei, in particular to the possible existence of the color glass condensate(CGC)[2, 3].

The suppression of high-p_t hadron yields has commonly been investigated using the nuclear modification factor R_{AA} which is the ratio of the measured hadron spectra to a scaled reference spectra from pp collisions. The value of R_{AA} should be unity if particle production scales with the average number of binary nucleon-nucleon collisions N_{coll}. In the absence of a good pp reference, it is also possible to measure hadron suppression in terms of R_{cp},the ratio of central to peripheral data scaled by $< N_{coll} >$. If there are no medium effects, this ratio is also expected to be equal to unity.

$$R_{cp} = \frac{Yield^{central} / < N_{coll}^{central} >}{Yield^{peripheral} / < N_{coll}^{peripheral} >} \tag{1}$$

We present here preliminary results on R_{cp} in CuCu Collisions at 200 GeV measured at the BRAHMS experiment. The BRAHMS detector system [5] consists of global detectors for event characterization, a Mid-Rapidity Spectrometer (MRS) and a Forward Spectrometer (FS) covering forward rapidities. A multiplicity array(MA) consisting of scintillator tiles and silicon strip detectors mounted coaxially around the beam axis was used to characterize the centrality of collisions. For the present studies, the forward spectrometer was positioned at 4^{o} with respect to the beam direction, corresponding to an η range between 2.9 and 3.4. Events within $\pm$20 cm of the nominal interaction vertex were considered.

The motivation for the CuCu system was that it serves as a bridge between dAu and AuAu collisions in terms of the number of participants (N_{part}) and number of binary collisions. In particular, looking at the data in terms of N_{part} offers the possibility of studying the system size dependence of the nuclear modification factor, and may help disentangle the initial state versus final state scenarios put forward to explain the high p_t results at RHIC.

Experiments at RHIC have revealed that the matter produced in high energy heavy ion collisions is a strongly interacting dense medium , or sQGP. Results from Au+Au collisions at $\sqrt{s_{NN}}$ = 130 and 200 GeV have shown that hadron production at these energies is strongly suppressed relative to expectations based on an independent superposition of nucleon-nucleon collisions at p_t of 2-10 GeV.

The BRAHMS experiment has already measured the transverse momentum spectra of hadrons both at mid-rapidity and at forward rapidities in dAu and Au+Au collisions [6]. The absence of high p_t suppression at mid-rapidity in dAu collisions is consistent with the hypothesis of parton energy loss or/and parton recombination in the dense medium formed in Au+Au collisions indicating that the suppression may be due to final-state effects. However, forward rapidity results showed a suppression in dAu collisions suggesting that not only final-state effects but also initial-state effects such as CGC may also play a role.

Figure 1(a) shows the ratio R_{cp} of yields from CuCu collisions, at $\eta = 3.2$, of a given centrality class to yield from the most peripheral collisions(40-60%) scaled by the number of binary collisions in each sample. The data for the different centrality classes are obtained from the same collider run. As a result, the ratios are largely free of systematic errors associated with run-by-run collider and detector performance. The dominant systematic error in the R_{cp} ratios come from the determination of N_{coll} in the centrality bins. One can see that the R_{cp} increases for more central collisions.

Figure 1(b) shows R_{cp} in CuCu in comparison with those measured in dAu and AuAu collisions at the same pseudo-rapidity. It is evident that the suppression in CuCu follows a similar trend as in dAu and AuAu. An important question is whether R_{cp} values in CuCu and AuAu are similar if one considers the case where the mean number of participants at the same collision energy are equal. As can be seen from the plots, R_{cp} is very similar in both CuCu and AuAu collisions for a similar number of participants.

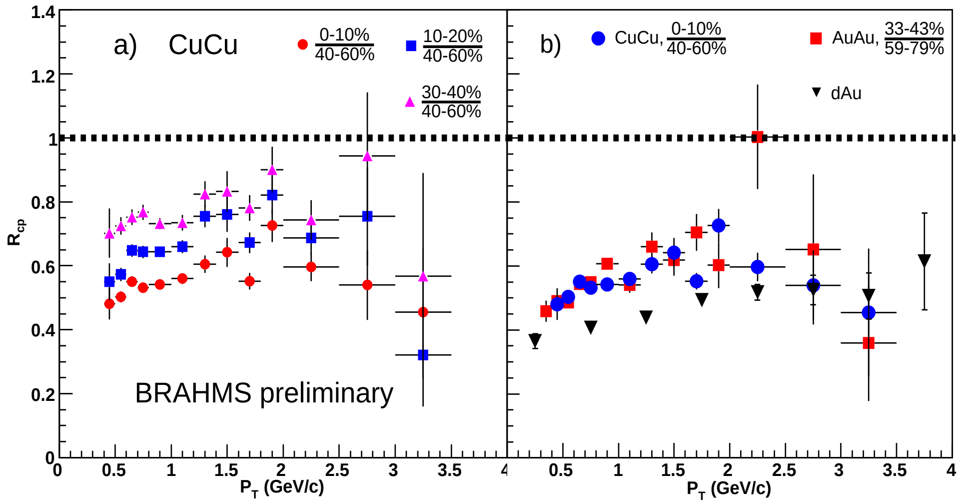

FIGURE 1. R_{cp} at $\eta = 3.2$ in CuCu Collisions as a function of p_t,(a) Centrality dependence, (b) comparison to results from dAu and AuAu Collisions. For CuCu, $0-10\%$ corresponds to $N_{part} \approx 96.8$ and $40-60\%$ to $N_{part} \approx 18.7$. For AuAu $33-43\%$ corresponds to $N_{part} \approx 96.3$ and $59-79\%$ to $N_{part} \approx 17.8$.

In summary, we have presented preliminary results on R_{cp} in CuCu collisions at $\sqrt{s_{NN}} = 200$ GeV and $\eta = 3.2$. Our results show that one obtains similar results for R_{cp} considering the same number of participants in both CuCu and AuAu collisions. The implication here may be that what matters is the geometry of the interaction region, i.e., the volume through which produced hadrons have to travel. To complete the system mass systematics, we are currently extending these studies to the midrapidity region and to the lower energy of $\sqrt{s_{NN}} = 62$ GeV.

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REFERENCES

1. R. Baier, D. Schiff and B.G. Zakarov, Ann. Rev. Nucl. Part. Sci. 50, 37 (2000)
2. L.V. Gribov, E. M. Levin, M.G.Ryskin, Phys. Rep. 100 (1983) 1
3. D. Kharzeev, E. Levin, L. McLerran, Phys. Lett. B 561 (2003) 93
4. R.C. Hwa and X.-N. Wang, eds Quark-Gluon Plasma (World Scientific,Singapore,2004) p.123, M.Guylassy, I.Vitev, X.N.Wang, and B.W.Zhang, arXiv:nucl-th/0302077
5. The BRAHMS Collaboration, Nuclear Instruments and Methods A499, 437 (2003)
6. The BRAHMS Collaboration, Phys. Rev. Lett. 93, 242303 (2004), Phys. Rev. Lett. 91, 072305 (2003)