Nuclear Modification Factors at Forward Rapidity in Au-Au and CuCu collisions at $\sqrt{s_{NN}} = 62.4$ GeV

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Abstract. Data from Au-Au, Cu-Cu and p+p collisions at $\sqrt{s_{NN}} = 62.4$ GeV have been collected by the BRAHMS experiment from rapidity 0 to 3.1. Nuclear modification factors, R_{AA} at forward rapidity, with p_{T} up to $\sim$ 2 GeV, which corresponds to more than half of the available kinetic energy, are presented together with results from mid rapidity for Au-Au and Cu-Cu collisions. They will also be shown as a function of centrality.

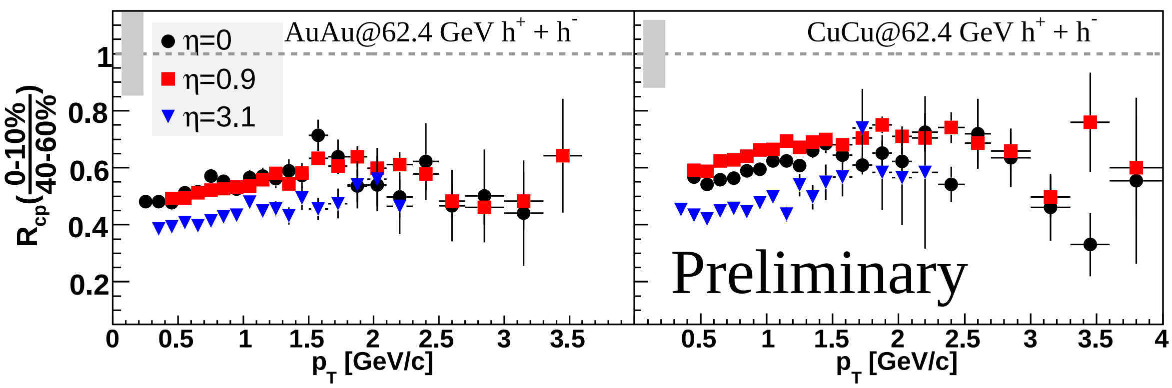

Figure 1. R_{cp} in Au-Au and Cu-Cu collisions at $\sqrt{s_{NN}} = 62.4$ GeV for charged hadrons. The shaded bar at 1 show the error on the scale.

Jet quenching in heavy ion collisions at the RHIC top energy has been a central indicator of the creation of strongly interacting quark gluon matter. In heavy ion collisions at $\sqrt{s_{NN}} = 200$ GeV, strong suppression of high p_{T} particles is observed, saturating from $p_{\mathrm{T}} \simeq 4$ and ~ 20 GeV. Through the study of $d - Au$ collisions at the same energy it has been established that the suppression is a final state effect, thought to be due to quark energy loss in the medium. The medium the partons go through have a high density of colour charges, and the partons can loose energy through gluon emission. The energy loss will then be proportional to L^2. These measurements show a strong contrast to earlier proton-nuclei and nucleus-nucleus collisions, performed at SPS and FERMILAB [1, 2, 4] at $\sqrt{s_{NN}} \simeq 20-30$ GeV, where an enhancement of the yield of the high p_{T} particles was seen. The enhancement is due to p_{T} broadening from multiple scatterings of the partons as they traverse the cold matter of the nucleon [3]. To get

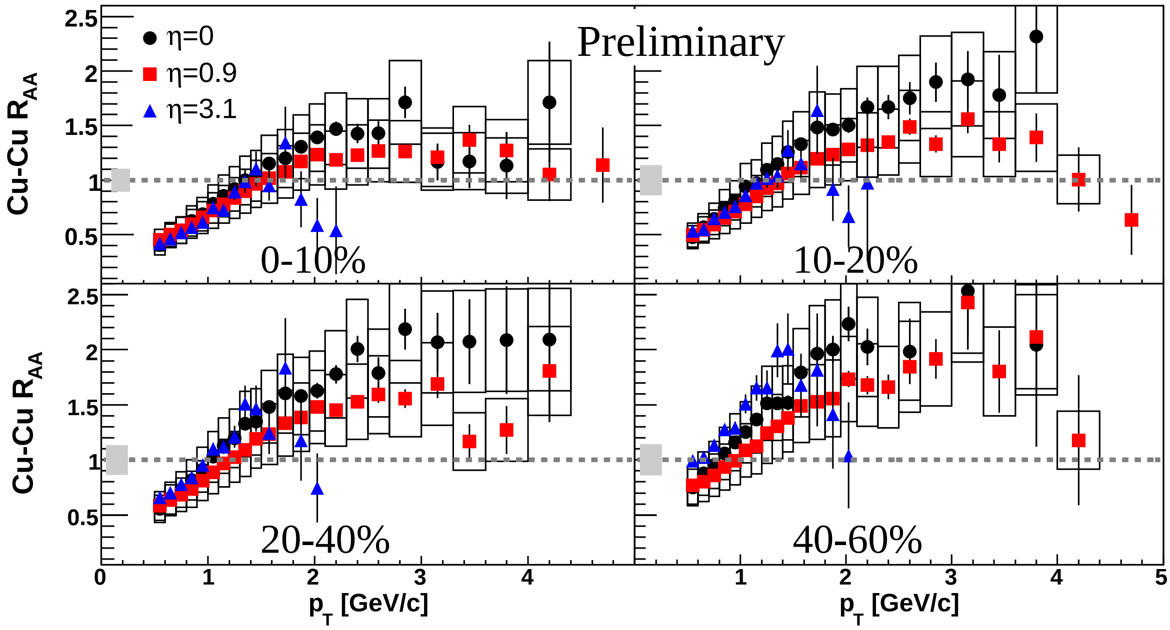

Figure 2. R_{AA} in Cu-Cu and collisions at $\sqrt{s_{NN}} = 62.4$ GeV. The midrapidity results, $\eta = 0$ and 0.9, uses p+p reference spectra from ISR [8]. The systematic errors are shown as boxes around the points. The $\eta = 3.1$ uses BRAHMS own preliminary p+p reference data taken in the exact same pseudorapidity bin. Systematic errors for these results should be $\sim 5\%$ on the scale. The shaded bar at 1 show the errors on the scale.

a better understanding of these mechanisms the RHIC community has carried out a program of measurements at an intermediate energy, $\sqrt{s_{NN}} = 62.4$ GeV, with various system sizes. Measuring the nuclear modification factor as a function of centrality and pseudorapidity will give information on the matter created in the fireball.

This article presents the first BRAHMS results of collisions of Au-Au, Cu-Cu and p+p at $\sqrt{s_{NN}} = 62.4$ GeV, as a function of pseudorapidity and centrality. The BRAHMS experiment has earlier performed such measurement at the RHIC top energy, and data has now also been collected, from mid- to forward rapidity, at $\sqrt{s_{NN}} = 62.4$ GeV. The nuclear modification factor for a light system, Cu-Cu, as well as a heavy system, Au-Au, will be presented here.

The BRAHMS experiment consists of two movable magnetic spectrometers, covering -0.1< η <3.5, and a set of detectors to determine the multiplicity of charged particles and the interaction point [7]. For the p+p collisions additional Čherenkov radiators, positioned around the beam pipe at -3 m, 1.8 m and 3 m away from the nominal interaction point, were used to determine the point of interaction, with a resolution of ~ 2 cm. From dedicated runs, it was determined that their coverage of the total cross section was 12 mb out of the 36 mb. This information was used when the minimum bias transverse momentum spectrum was calculated.

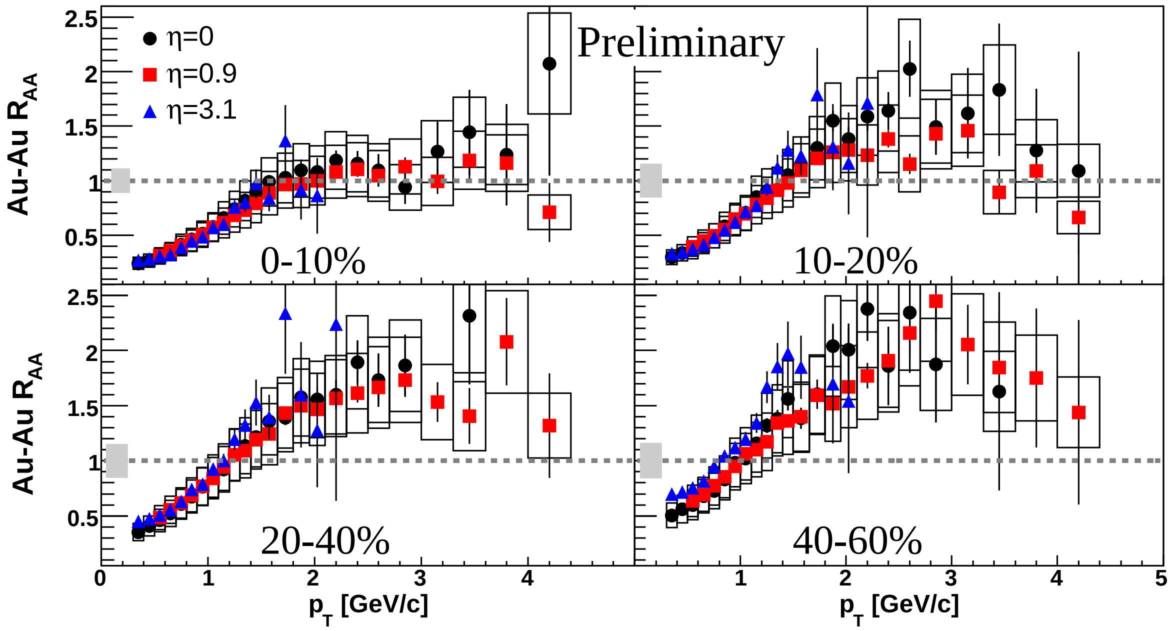

Figure 3. R_{AA} in Au-Au and collisions at $\sqrt{s_{NN}} = 62.4$ GeV. The midrapidity results, $\eta = 0$ and 0.9 see [9], The systematic are shown as boxes around the points. The $\eta = 3.1$ uses BRAHMS own preliminary p+p reference data taken in the exact same pseudorapidity bin. The shaded bar at 1 show the errors on the scale. Only statistical errors are shown for the forward result, but they have an $\sim 5\%$ uncertainty on the scale.

The nuclear modification factor is given as:

$$R_{AA}(\eta, p_{\mathrm{T}}) = \left(\frac{d^2 N^{AA}}{\langle N_{bin}^{AA} \rangle \, dp_T d\eta} \right) \cdot \left(\frac{d^2 N^{pp}}{dp_T d\eta} \right)^{-1} \quad (1)$$

where $< N_{bin}^{AA}$ is the number of partons collisions in one of the colliding nucleons go through. The results presented here will use a parametrisation of the transverse momentum spectra from ISR [8] at midrapidity, $\eta = 0$ and 0.9, and BRAHMS own p+p spectra at $\eta = 3.1$. These data were collected at the same magnetic field settings as the heavy ion data in order to minimize systematic errors. The parametrisation of the ISR p_{T} spectra has an estimated uncertainty of about $\sim 20\%$.

Another quantity one can study is the central-to-peripheral ratio:

$$R_{cp} = \left(\frac{d^2 N_{0-10\%}^{AA}}{\langle N_{0-10\%}^{AA} \rangle \, dp_T d\eta} \right) \cdot \left(\frac{d^2 N_{40-60\%}^{AA}}{\langle N_{40-60\%}^{AA} \rangle \, dp_T d\eta} \right)^{-1} \quad (2)$$

The central, $0-10\%$, and peripheral, $40-60\%$ p_{T} spectra are both taken at the same time, and is therefore largely free of systematic errors.

The central-to-peripheral ratio, R_{cp} is shown in fig 1 for Cu-Cu and Au-Au collisions. The R_{cp} at $\eta = 3.1$ is smaller than at midrapidity, but shows a similar p_{T} dependence. No dependence on the charge (h^+ or h^-) at forward rapidity has been seen.

The R_{AA} for Cu-Cu and Au-Au collisions at $\sqrt{s_{NN}} = 62.4$ GeV are shown in fig 2 and 3. There is no difference between the measurements at midrapidity and at forward

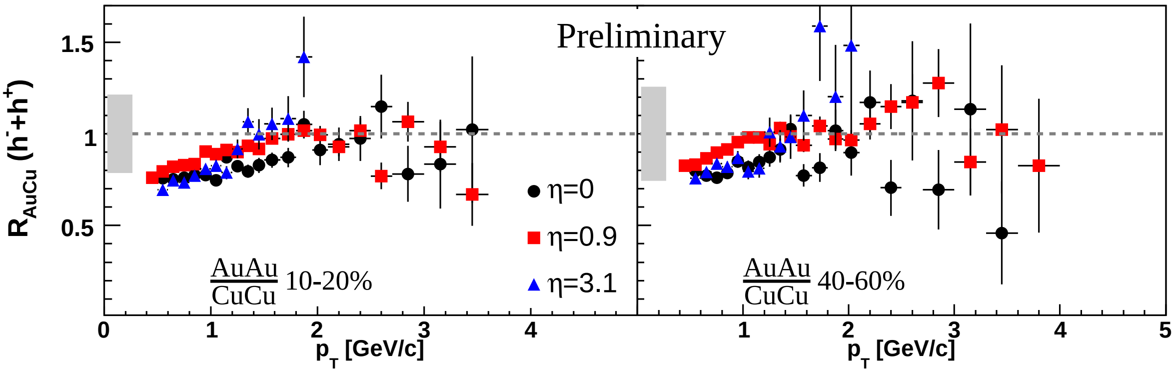

Figure 4. The figure shows the Au-Au $p_{\rm T}$ spectra divided by Cu-Cu spectra at $\sqrt{s_{NN}}$ = 62.4 GeV, scaled to the number of binary collisions in their respective centralities, R_{AuCu}. Left panel shows the scaled ratio of $10-20\%$ centrality, and the right panel the $40-60\%$. The point to point error is statistical only, but most systematic error should cancel. The error on the scale is the shaded bar around 1.

rapidity. The R_{AA} does not, like the R_{cp}, show any dependence in the charge (h^+ or h^-). There is more enhancement or less suppression in Cu-Cu $R_{AA}0-10\%$ compared to Au-Au $R_{AA}0-10\%$. The same trend is seen as one goes to more peripheral collisions, indicating, as expected that the R_{AA} depends on the geometry of the system.

Fig 4 show a ratio, R_{AuCu} of Au-Au spectra to Cu-Cu spectra, scaled with the number of binary collisions for their respective centralities. The shape of the ratio is very similar to the R_{cp}, but is consistent with one. The ratio becomes flat just above ~ 1 GeV.

At $\sqrt{s_{NN}} = 62.4$ GeV we find less suppression of hight $p_{\rm T}$ spectra than at $\sqrt{s_{NN}} = 200$ GeV. For AuAu collisions BRAHMS has already shown that at $\sqrt{s_{NN}} = 200$ GeV R_{AA} has very little rapidity dependence within $0 < \eta < 3.5$ [10]. These new data show the same effect at $\sqrt{s_{NN}} = 62.4$ GeV. Futhermore the comparison of the Au-Au and Cu-Cu data shows that the energy loss, over a wide range of eta, is dominated by the volume of the colliding system, not its shape.

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