High-p_T π^0, η, identified and inclusive charged hadron spectra from PHENIX

M. Shimomura[a] (for the PHENIX* Collaboration)

[a]Graduate School of Pure and Applied Sciences, Univ. of Tsukuba, Tenno-dai 1-1-1, Tsukuba, Ibaraki, Japan

PHENIX has extended the measurement of the π^0, η, identified and inclusive charged hadrons up to 20 GeV/c, and extended the measurement to the Cu+Cu collision system. A strong suppression is observed for both π^0 and charged hadron yields in central Au+Au and Cu+Cu collisions. Both in the Au+Au and Cu+Cu systems R_{AA} becomes independent of p_T above 5 GeV/c. Its centrality dependence is compared to two models in order to test for universal N_{part} scaling that is independent of system; results are inconclusive. The results are compatible with energy loss predictions. In addition, the ratio of η to π^0 approaches, within uncertainties, a constant value of $0.4 \sim 0.5$ at high p_T in p+p, d+Au, and Au+Au, while the ratio of K_s to π^0 is also consistent with a constant value at high p_T in d+Au and p+p. These results are compatible with normal jet fragmentation.

1. PHYSICS MOTIVATION

We have previously observed that π^0, η and charged hadron yields are significantly suppressed especially for the high p_T region ($p_T \geq 4 \sim 5$ GeV/c) in Au+Au collision at 200 GeV compared with p+p collisions [1–4]. Since there is no suppression in d+Au collisions at high p_T [3], it is understood that the suppression occurs due to some final state interaction in the collision such as gluon radiation in the hot dense matter. Another evidence for the suppression being a final state effect comes from the non-suppression of the direct photon yield in Au+Au collisions [5]. In order to better understand the character of the suppression, measurements made with different size systems (p+p/d+Au/Cu+Cu/Au+Au) have been compared. Also, the large Au+Au dataset collected in Run-4 (2004) allowed us to extend the p_T reach to 20 GeV/c.

2. DATA ANALYSIS, π^0, K_s, CHARGED HADRON AND η

We made new measurements of the following spectra.

- π^0 spectra with extended p_T range in Au+Au at 200GeV
- π^0 and charged hadron spectra in Cu+Cu at 200GeV
- K_s spectra in d+Au and p+p at 200GeV [6]

*For the full list of PHENIX authors and acknowledgements, see Appendix 'Collaborations' of this volume.

- Newly finalized η spectra in p+p, d+Au, and Au+Au [7]

The PHENIX experiment consists of four spectrometer arms (two central arms and two muon arms) and a set of global detectors. Each central arm covers the pseudorapidity range $|\ \eta\ | \leq 0.35$ and 90 degrees in azimuth. Charged particles are tracked by a drift chamber (DC) and pad chambers (PC) in each central arms. The electromagnetic calorimeters (EMCal) are used to measure γ energy deposit and construct the invariant masses of $\pi^0(\rightarrow 2\gamma)$, $K_s(\rightarrow 2\pi^0 \rightarrow 4\gamma)$ and $\eta(\rightarrow 2\gamma)$ [4][8].

3. THE NUCLEAR MODIFICATION FACTOR R_{AA}

3.1. Charged Hadron, π^0 and η

Fig. 1 shows the comparison of R_{AA} for π^0 and charged hadrons in 0-10 % most central Au+Au and Cu+Cu collisions as function of p_T. Both π^0 and charged hadron are strongly suppressed in both Au+Au and Cu+Cu collision. The difference between π^0 and charged hadron for $p_T \leq 5$ GeV/c comes from the proton contribution. For more central collisions, the suppression is getting stronger and the difference between π^0 and charged hadron is getting larger. Above 5 GeV/c, $\pi^0 R_{AA}$ becomes flat out to 20 GeV/c. These results are consistent with the model predicting parton energy loss in the medium [9] and the model predicting shadowing, Cronin effect, and parton energy loss in the medium [10]. In addition, η is also suppressed in central Au+Au collisions and the suppression pattern is similar to π^0 [7].

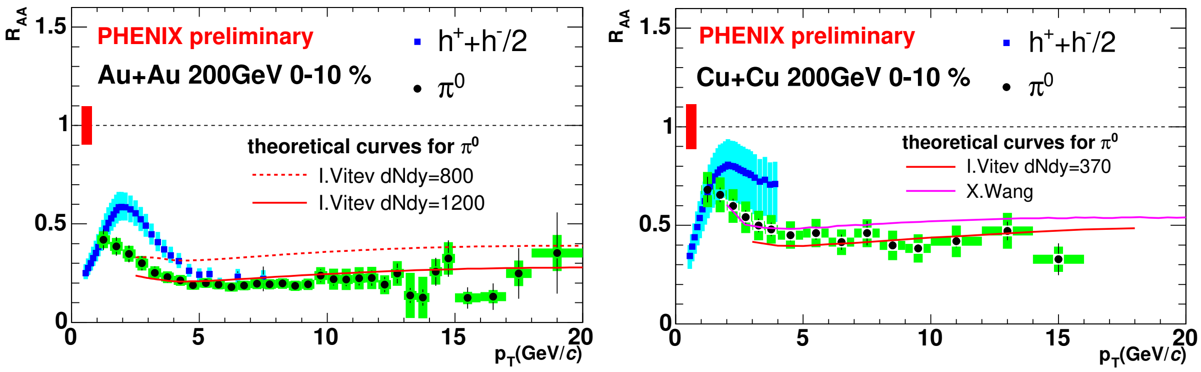
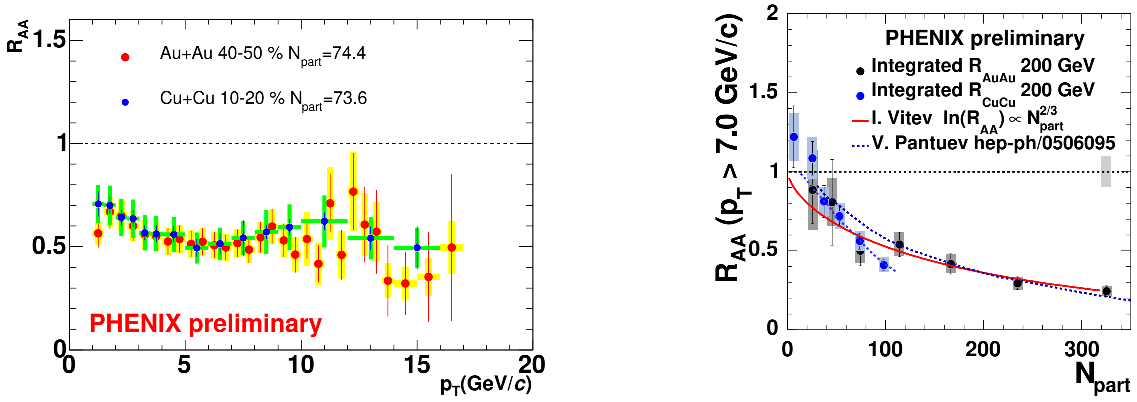


Figure 1. The comparison of R_{AA} for π^0 and charged hadron at 0-10 % centrality bin in Au+Au (left) and Cu+Cu (right) collisions as a function of p_T with theoretical prediction (purple [9] and red [10] lines). Error bars are statistical, boxes are the systematic error.

3.2. Comparison between Au+Au and Cu+Cu

In Fig 2(a), the comparison of R_{AA} in Au+Au to that in Cu+Cu with similar N_{part} is shown. The suppression is similar for similar N_{part} at mid-centrality. Although a universal N_{part} scaling (that holds at least approximately) has been suggested [11], due to the magnitude of our uncertainties it is still unclear whether a single scaling curve can exactly describe the suppression (R_{AA}) in both systems simultaneously. In Fig. 2(b), we show the integrated R_{AA} of π^0 at $7.0 \leq p_T \leq 20.0$ GeV/c with two different theoretical curves [10][12] as a function of N_{part}. Both models are consistent with the data from mid-central to central collisions.



(a) (b)

Figure 2. (a) The comparison between π^0 R_{AA} in Au+Au and Cu+Cu at similar N_{part} (~ 74). (b) The integrated R_{AA} at $7 \leq p_T \leq 20$ GeV/c with theoretical curves [10][12] as a function of N_{part}.

4. PARTICLE RATIOS

The ratio of η to π^0 is $\sim 0.4-0.5$ in all systems and for all centralities as shown in Fig. 3 [7]. Also, the ratio of K_s to π^0 at p+p and d+Au becomes flat at high p_T as shown in Fig. 4 [6]. Therefore, the mesons are affected by the medium in the same way in different collision systems. These results are consistent with jet fragmentation at high p_T.

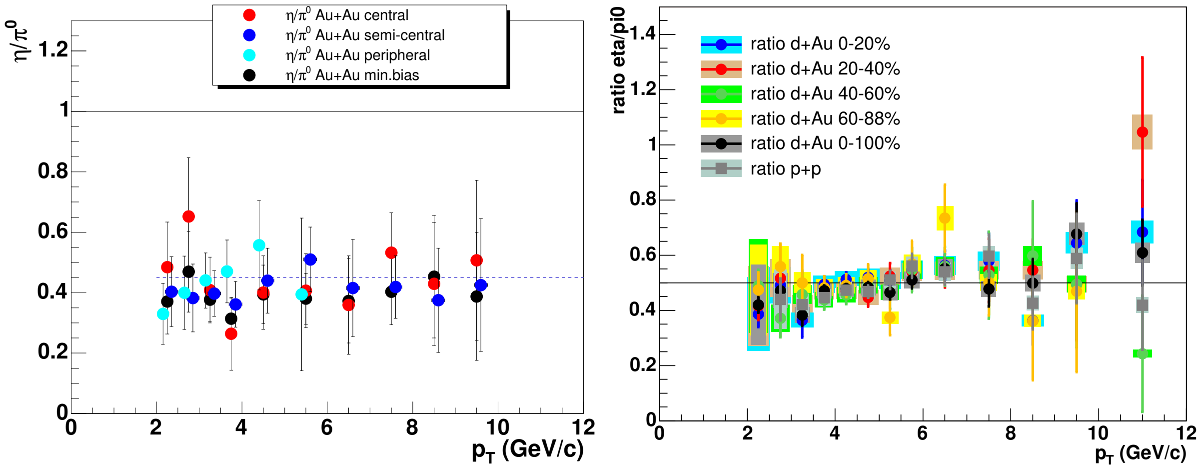


Figure 3. The ratio of η to π^0 in Au+Au (left), d+Au (right) and p+p (right) as a function of p_T at $\sqrt{s} = 200$ GeV. Error bars are statistical error, boxes are the systematic error.

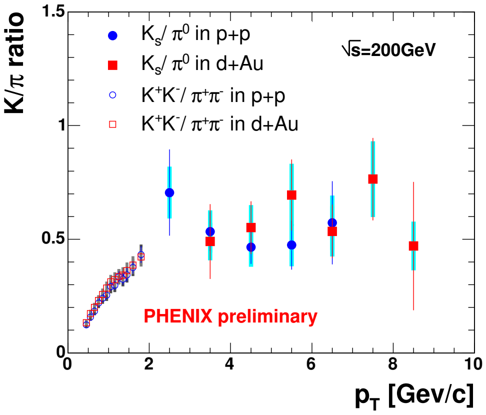


Figure 4. Closed symbols are the ratio of K_s to π^0 in p+p and d+Au as a function of p_T. Open symbols show the ratio of of $K^{\pm}$ to $\pi^{\pm}$ as reference [13]. The error bars are statistical error, and the boxes are systematic error.

5. SUMMARY

We have studied π^0,η, K_s and charged hadron spectra in Au+Au, Cu+Cu, d+Au and p+p at high p_T. For π^0 and charged hadron, we observed the suppressions in both Cu+Cu and Au+Au collisions compared with p+p collisions, and no suppression is observed in d+Au collisions. The R_{AA} comparison between Au+Au and Cu+Cu indicates that the suppression is almost the same for similar N_{part}. A universal N_{part} scaling of R_{AA}, independent of system, describes the data in an approximate sense, but it cannot be confirmed exactly due to experimental uncertainties. In addition, the high p_T π^0 suppression is flat out to 20 GeV/c and its magnitude is quantitatively consistent with parton energy loss model calculations. η has a similar suppression pattern as π^0 does. The ratio of π^0 to η is independent of centralities and system size. Similarly, the K_s to π^0 ratio is constant within uncertainties at high p_T for both p+p and d+Au. These particle ratios are consistent with normal jet fragmentation.

REFERENCES

1. S. S Adler *et al.*, PHENIX Collaboration, Phys. Rev. Lett. 91, 241803 (2003).
2. S. S Adler *et al.*, PHENIX Collaboration, Phys. Rev. Lett. 91, 072301 (2003).
3. S. S Adler *et al.*, PHENIX Collaboration, Phys. Rev. Lett. 91, 072303 (2003).
4. S. S Adler *et al.*, PHENIX Collaboration, Phys. Rev. C 69, 034910 (2004).
5. S. S Adler *et al.*, PHENIX Collaboration, Phys. Rev. Lett. 94, 232301 (2005).
6. V. Ryabov for the PHENIX Collaboration, (in this Proceedings)
7. S. S Adler *et al.*, PHENIX Collaboration, Update of "High p_T η meson production in p+p, d+Au and Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV", to be submitted to PLB
8. K. Adcox *et al.*, Nucl. Instrum. Methods A499, 469 (2003).
9. X. Wang, Phys. Lett. B 595, 165-170 (2004).
10. I. Vitev, Phys. Rev. Lett. 89, 252301 (2002).
11. A. Drees, H. Feng, J. Jia, Phys. Rev. C 71, 034909 (2005).
12. V. S. Pantuev, hep-ph/0506095 (2005).
13. S. S Adler *et al.*, PHENIX Collaboration, Update of "Identified charged hadron production in $\sqrt{s} = 200$ GeV p+p collisions", to be submitted to PRD