Particle production at very low and intermediate transverse momenta in d+Au and Au+Au collisions

Adam Trzupek[a] (for the PHOBOS* Collaboration)

[a]Institute of Nuclear Physics PAN, Kraków, Poland

The transverse momentum (p_T) spectra of identified charged particles have been measured at very low and intermediate transverse momenta in Au+Au collisions at $\sqrt{s_{NN}}$ = 62.4 GeV and d+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV using the PHOBOS detector at RHIC. New results on charged particle production at very low p_T in central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV in the centrality intervals 0-6% and 6-15% are presented. A comparison of the PHOBOS low-p_T data with predictions of a recent optical model is shown. The shapes of m_T spectra for d+Au and Au+Au collisions are compared.

1. INTRODUCTION

In nucleus-nucleus collisions, an enhanced production of low-p_T particles could signal new long-wavelength physics phenomena [1,2]. It is also expected that yields of particles with higher masses, like protons and antiprotons can be modified due to collective transverse expansion of the system [3,4]. Measurements at very low p_T can also provide a critical test for models predicting a pronounced modification of the low-p_T particle emission pattern, see e.g. [5].

The PHOBOS experiment has the unique capability to measure charged particles at transverse momenta as low as 30, 90 and 140 MeV/c for charged pions, kaons and for protons and antiprotons, respectively, using a multi-layer, magnetic spectrometer. Yields at very low transverse momenta are determined using a reconstruction procedure developed to look for particles which range out in the fifth silicon layer of the PHOBOS spectrometer. A description of the "stopping algorithm" is presented in [6]. At intermediate p_T, particle momentum and charge are obtained from the curvature of particle trajectories in a 2T magnetic field and particle identification is provided by the specific energy loss (dE/dx) in the spectrometer and by Time-of-Flight detectors. Details on tracking, particle identification, event selection and centrality determination in the PHOBOS detector can be found in [7].

2. p_T SPECTRA IN Au+Au COLLISIONS AT $\sqrt{s_{NN}}$ = 62.4 GeV

The preliminary particle yields for $\pi^{\pm}$, $K^{\pm}$, p and $\bar{p}$ are presented in Fig. 1 for three centrality intervals: 0-15%, 15-30% and 30-50%. The data are corrected for detector effects (acceptance, efficiency, momentum resolution) and background particles including feed-down from weak decays and secondary particles produced in the beam pipe and detector material. The rapidity coverage of measured yields extends from about 0.4 to 1.4 for $\pi^{\pm}$, from 0.2 to 1.2 for $K^{\pm}$ and

*For the full list of PHOBOS authors and acknowledgments, see appendix 'Collaborations' of this volume.

from 0.2 to 1.1 for p and $\bar{p}$. The preliminary results on antiparticle to particle ratios have been obtained for the 15% most central collisions. The results of 0.84 $\pm$ 0.02 (stat.) $\pm$ 0.08 (syst.) for K^-/K^+ and 0.37 $\pm$ 0.01 (stat.) $\pm$ 0.06 (syst.) for $\bar{p}/p$ fit smoothly into the energy evolution of antiparticle to particle ratios from the AGS up to the highest RHIC energy.

Low-p_T yields of (π^++π^-), (K^++K^-) and (p+$\bar{p}$) near mid-rapidity in Au+Au collisions at $\sqrt{s_{NN}}$ = 62.4 GeV, corrected for detector effects and background particles, are shown in Fig. 2 in the same centrality bins. One can see that (K^++K^-) and (p+$\bar{p}$) yields are quite consistent with extrapolations of blast wave functions (BWF) [4] fitted to the spectra at higher transverse momenta. Some disagreement between the measured yield of pions and BWF at low p_T could be attributed to a contribution from resonances which is not included in the model. A similar behavior was observed for p_T yields measured in the 15% most central Au + Au collisions at $\sqrt{s_{NN}}$ = 200 GeV [6], indicating that at both energies no significant enhancement of particle production is observed at very low p_T. Also, a flattening of the (p+$\bar{p}$) spectra down to very low transverse momentum is observed. This could be a consequence of collective transverse expansion of the medium created in heavy ion collisions at RHIC.

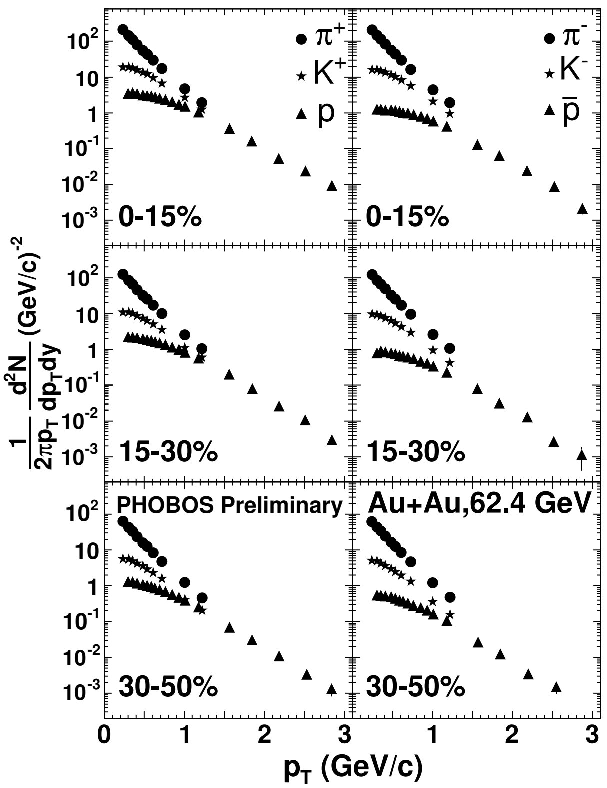

Figure 1. p_T spectra of $\pi^{\pm}$, $K^{\pm}$, p and $\bar{p}$ near mid-rapidity in Au+Au collisions at $\sqrt{s_{NN}}$ = 62.4 GeV.

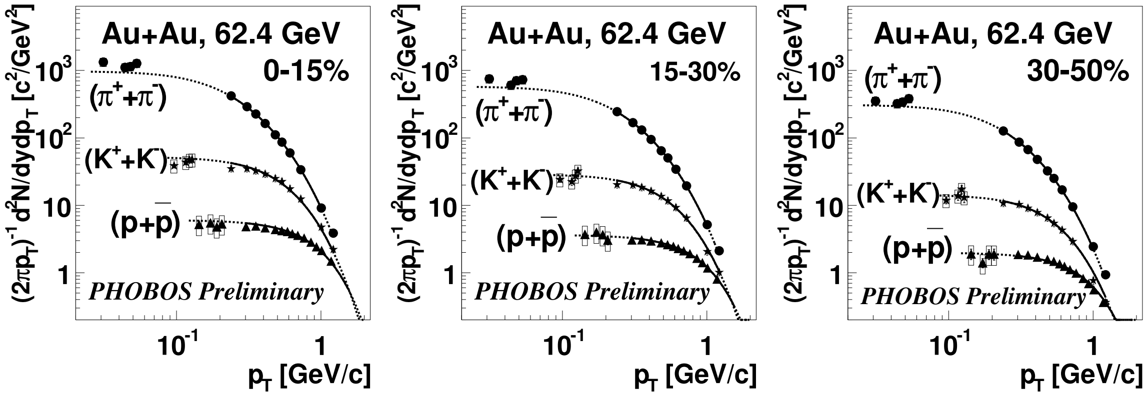

Figure 2. (π^++π^-), (K^++K^-) and (p+$\bar{p}$) yields at very low p_T in Au+Au collisions at $\sqrt{s_{NN}}$ = 62.4 GeV. Blast wave fits to the intermediate p_T data (solid lines) are extrapolated to low p_T (dashed lines).

3. LOW-p_T YIELDS IN CENTRAL Au+Au COLLISIONS AT $\sqrt{s_{NN}}$ = 200 GeV

The spectra of (π^++π^-), (K^++K^-) and (p+$\bar{p}$) at very low transverse momentum in the 15% most central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV, measured in the PHOBOS experiment, are presented in [6]. In order to confront the extrapolations from a recent optical model [5], which were available only for more central collisions, with measurements, the published data sample was split into two finer centrality bins. Fig. 3 shows the p_T yields, corrected for detector effects and background particles, measured in the centrality intervals 0-6% and 6-15%. In Fig. 4, the pion yield measured in the 6% most central Au+Au collisions is compared to the optical model predictions for the spectrum of negative pions at mid-rapidity. The originally published extrapolation is shown by the dashed curve, while the solid curve depicts the recently modified model calculations [5,8].

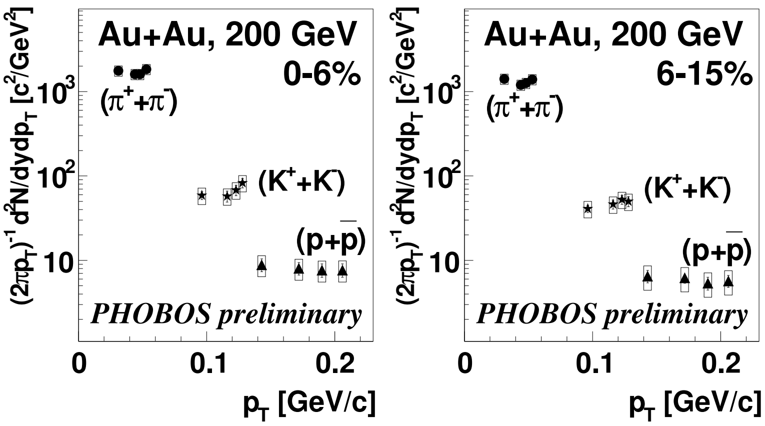

Figure 3. (π^++π^-), (K^++K^-) and (p+$\bar{p}$) yields at very low p_T in 0-6% and 6-15% central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV.

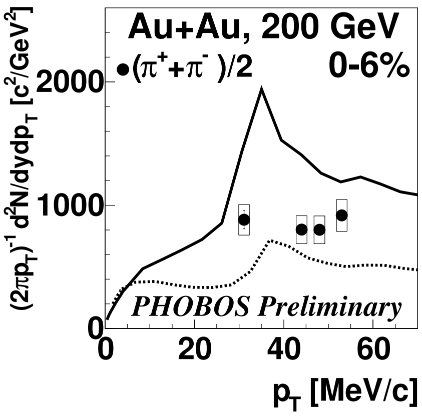

Figure 4. Optical model predictions [5,8] for pion spectra at low p_T compared to PHOBOS data (see text for details).

4. m_T SCALING

It is interesting to compare the particle yields at very low and intermediate p_T in d+Au and central Au+Au collision at the same energy of $\sqrt{s_{NN}}$ = 200 GeV. Yields of (π^++π^-), (K^++K^-) and (p+$\bar{p}$) in d+Au collisions, corrected for detector effects and background particles, are shown in Fig. 5. One can see that in d+Au collisions (π^++π^-) and (p+$\bar{p}$) m_T spectra are similar while the (K^++K^-) spectrum is systematically lower (by a factor of about 2) due to strangeness suppression. The m_T spectra for the 15% most central Au+Au collisions measured by the PHOBOS [6] and PHENIX [9] experiments at very low and intermediate tranverse momenta, respectively, are also shown in Fig. 5. In order to compare the shapes of the m_T spectra, inverse local slope parameters were calculated by fitting locally exponential functions to each spectrum (see bottom panels of Fig. 5). We can see that for d+Au collisions local slopes are similar for all particle species both at low and intermediate p_T. In contrast, Au+Au spectral shapes are similar at higher transverse masses (m_T > 1.7 GeV) while at low m_T a flattening of (K^++K^-) and (p+$\bar{p}$) spectra is observed. This flattening of the (p+$\bar{p}$) spectrum is significantly stronger than the one observed for the spectra of charged kaons. One can also see that the m_T dependence of

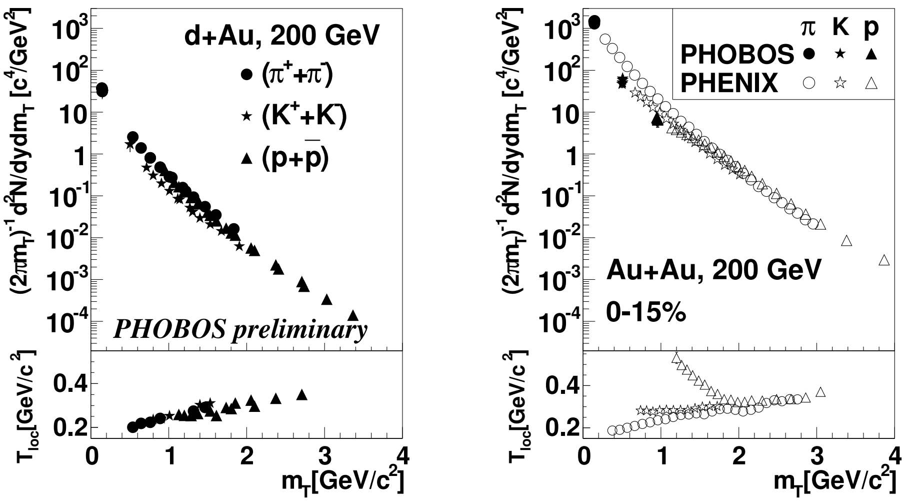

Figure 5. m_T spectra of $(\pi^+{+}\pi^-)$, $(K^+{+}K^-)$ and $(p{+}\bar{p})$ at very low and intermediate p_T measured in d+Au (left plot) and central Au+Au collisions (right plot). Inverse local slope parameters of m_T spectra are shown in the lower panels of each figure.

the local slopes of the $(\pi^+{+}\pi^-)$ m_T spectrum for Au+Au collision is consistent with that found for the local slopes of $(\pi^+{+}\pi^-)$, $(K^+{+}K^-)$ and $(p{+}\bar{p})$ spectra in d+Au collisions.

5. SUMMARY

Yields of pions, kaons and protons and antiprotons at very low and intermediate p_T near mid-rapidity in Au+Au collisions at $\sqrt{s_{NN}}$ = 62.4 and 200 GeV, measured in the PHOBOS experiment, indicate that there is no evidence for enhanced production of particles at very low transverse momentum. The pion low-p_T data can constrain the recent optical model predictions. A significant flattening of the $(p{+}\bar{p})$ m_T spectrum down to very low p_T is observed in central Au+Au collisions at both energies which could be a consequence of the collective transverse expansion of the system. In d+Au collisions, no flattening is observed and the shapes of the m_T spectra are similar at very low and intermediate p_T.

REFERENCES

1. W. Busza, ”Particle Production in Highly Excited Matter”, Plenum Press, New York, 1993, p. 149.
2. J. Bjorken, Acta Phys. Pol. B28 (1997) 2773.
3. P.F. Kolb and R. Rapp, Phys. Rev. C67 (2003) 044903.
4. E. Schnedermann, J. Sollfrank and U. Heinz, Phys. Rev. C48 (1993) 2462.
5. J.G. Cramer, G.A.Miller, J.M.S. Wu and J. Yoon, Phys. Rev. Lett. 94 (2005) 102302.
6. B.B. Back, et al., (PHOBOS Collab.), Phys. Rev. C70 (2004) 051901(R).
7. B.B. Back, et al., (PHOBOS Collab.), Nucl. Phys. A757 (2005) 28.
8. B.B. Back, et al., (PHOBOS Collab.), nucl-ex/0506008, J.G. Cramer, 2005, (private communication, erratum to be published).
9. S.S. Adler, et al., (PHENIX Collab.), Phys. Rev. C69 (2004) 034909.