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

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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.

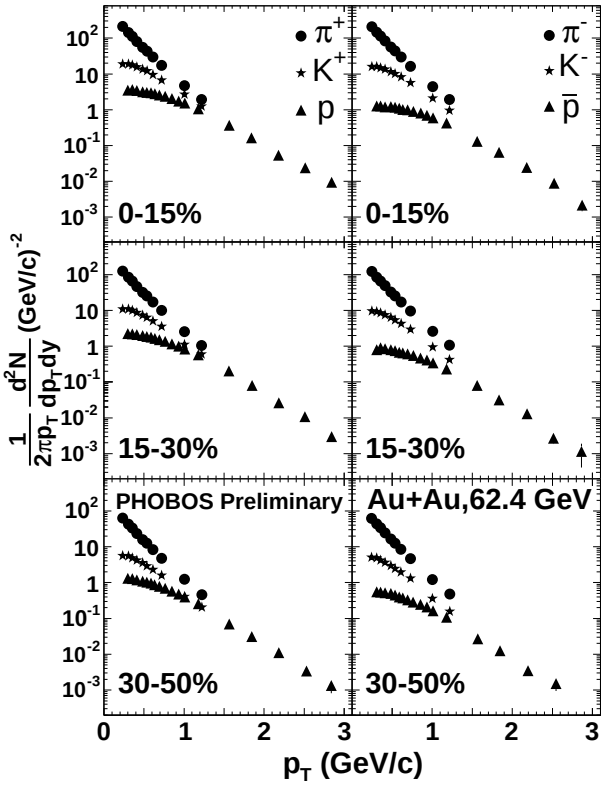

Figure 1. p_T spectra of $\pi^{\pm}$, $K^{\pm}$, p and $\bar{p}$ near mid-rapidity in Au+Au collisions at $\sqrt{s_{NN}}$ = 62.4 GeV.

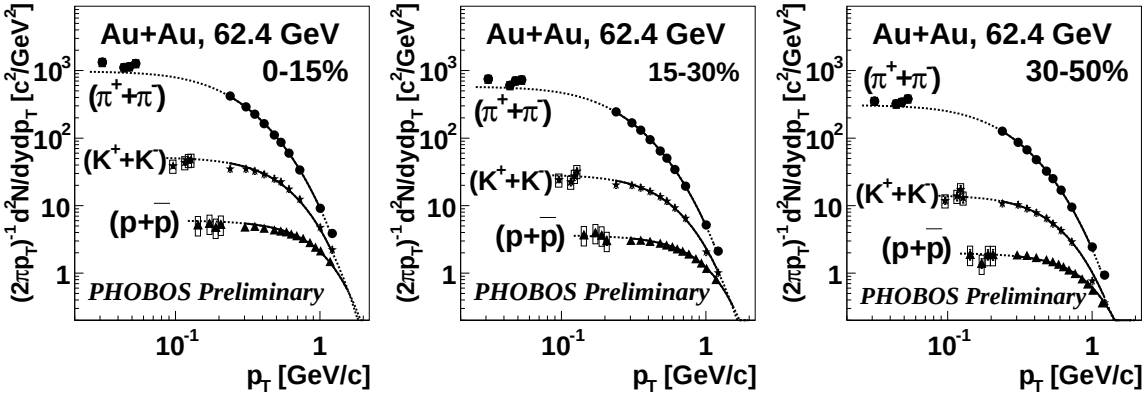

Figure 2. (π^++π^-), (K^++K^-) and (p+$\bar{p}$) yields at very low p_T in Au+Au collisions at $\sqrt{s_{NN}}$ = 62.4 GeV. Blast wave fits to the intermediate p_T data (solid lines) are extrapolated to low p_T (dashed lines).

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].

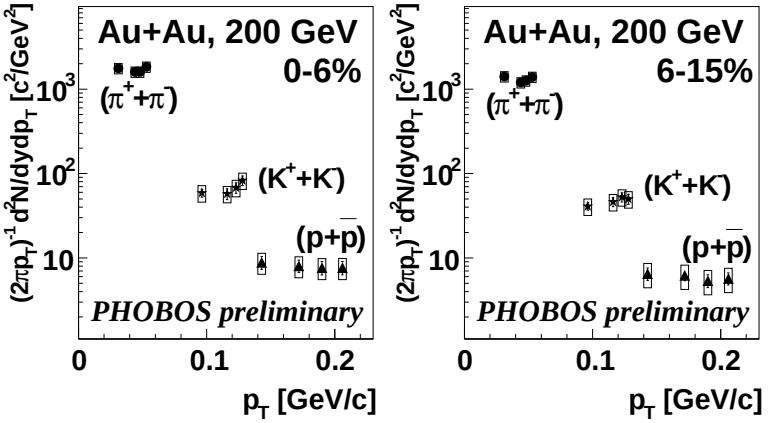

Figure 3. (π^++π^-), (K^++K^-) and (p+$\bar{p}$) yields at very low p_T in 0-6% and 6-15% central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV.

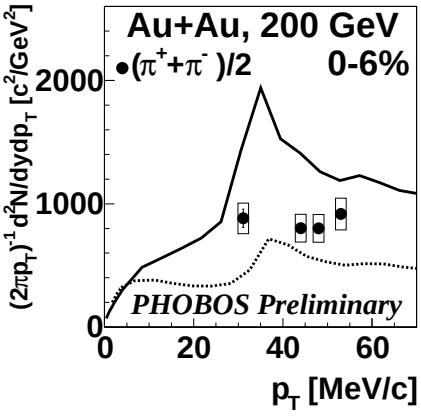

Figure 4. Optical model predictions [5,8] for pion spectra at low p_T compared to PHOBOS data (see text for details).

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

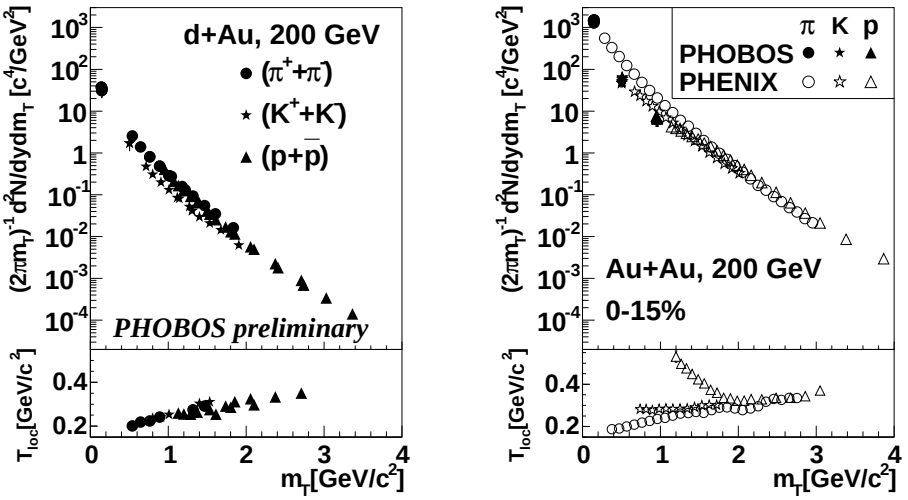

Figure 5. m_T spectra of (π^++π^-), (K^++K^-) and (p+$\bar{p}$) at very low and intermediate p_T measured in d+Au (left plot) and central Au+Au collisions (right plot). Inverse local slope parameters of m_T spectra are shown in the lower panels of each figure.

the local slopes of the (π^++π^-) m_T spectrum for Au+Au collision is consistent with that found for the local slopes of (π^++π^-), (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.

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