$p_t$ Distributions of Identified Charged Hadrons Measured with the PHENIX Experiment at RHIC

J.Velkovska aMCSD|SUNY at Stony Brook for the PHENIX Collaboration *

Transverse momentum spectra of identified $\pi^+$, $\pi^-$, $K^+$, $K^-$, p and $\bar{p}$ were measured by the PHENIX experiment at mid-rapidity in Au-Au collisions at $\sqrt{s_{NN}} = 130$ GeV over a broad momentum range. Inverse slope parameters and $\langle p_t \rangle$ were measured in minimum bias events and as a function of the number of participating nucleons. The mass and centrality dependence of the inverse slope parameters and $\langle p_t \rangle$ is presented and discussed.

1. Introduction

With the beginning of RHIC operation in the summer of 2000, a new regime of heavy-ion collisions at ultra-relativistic energies has become available. A measurement of the hadron $p_t$ distributions gives important information about the evolution of the system and the conditions at freeze-out. The particle ratios, obtained from the transverse momentum spectra, are sensitive to the chemical properties of the system and the particle production mechanism [1].

2. Set-up and Data Analysis

The PHENIX detector has various particle identification (PID) capabilities [2], including excellent hadron identification over a broad momentum range. The measurement presented in this paper was performed using the Beam-Beam counters (BBC) and the Time-of-flight (TOF) counters as the timing system, while the drift chamber and pad chamber 1 provided the momentum measurement. The acceptance covers the pseudo-rapidity region $|\eta| < 0.35$ and azimuthal angle $\Delta \phi = \pi/4$. Hadron identification was done in mass $^2$ versus momentum space using momentum-dependent PID bands which take into account the measured TOF and momentum resolution. Corrections to the raw spectra were obtained using a single particle Monte-Carlo simulation. Multiplicity dependent efficiencies were studied by embedding Monte-Carlo tracks into real events. Track-by-track efficiency corrections were applied, taking into account the event multiplicity.

*For the full PHENIX Collaboration author list and acknowledgments see the contribution by W.A. Zajc (K. Adcox et al.) in this volume.
Figure 1. Minimum bias transverse momentum distributions for positive (left) and negative (right) identified hadrons. The error bars include statistical errors and systematic errors in the acceptance and decay corrections. Additional 20% systematic errors on the absolute normalization are not included.

3. Results and Discussion

Figure 1 shows the minimum bias $p_t$ spectra for $\pi^+/-, K^+/-, p$ and $\overline{p}$. The lower $p_t$-cutoffs were imposed due to loss of acceptance and tracking efficiency, while the higher $p_t$-cutoff values for $\pi^+/-$ and $K^+/-$ are dictated by the detector capability in $\pi/K$ mass separation.

The minimum bias data sample was divided into five centrality classes, using the correlation between the BBC and the Zero-degree calorimeters [4]. The number of nucleons, participating in the reaction ($N_{part}$), was obtained using a Glauber model. For each centrality class, $p_t$ distributions were obtained for the six measured particle species. As an example, Figure 2 shows the $p_t$ distributions for $\pi^-$ and $\overline{p}$. The centrality selections are indicated in the figure.

The centrality selected transverse mass spectra were fitted with $a*exp(-m_t/T_{eff})$ in the range $0.3 \text{ GeV/c} < p_t < 0.9 \text{ GeV/c}$ for $\pi^+/-$, $0.55 \text{ GeV/c} < p_t < 1.6 \text{ GeV/c}$ for $K^+, p$ and $0.75 \text{ GeV/c} < p_t < 1.6 \text{ GeV/c}$ for $K^-$. Figure 3 shows the inverse slope parameters ($T_{eff}$) as a function of particle mass for the top 5% of the total interaction cross-section, minimum bias and 60-92% central events. A clear mass dependence is seen in the central and minimum bias events, consistent with radial flow. In peripheral collisions, the mass dependence is weaker, approaching “$m_t$-scaling” behavior.

A complementary measure of the transverse momentum spectra is the mean $p_t$ for each particle species over the whole $p_t$ range. In order to extrapolate the range from 0 to infinity, the $p_t$ spectra were fitted with $a*(p_0+p_t)^{-n}$ for $\pi^+/-$ and $a*exp\left(-\sqrt{m^2 + p_t^2}/T\right)$.
Figure 2. Transverse momentum distributions for negative pions (left) and anti-protons (right) with different centrality selections. The most central spectra are on the top. The error bars include statistical errors only.

Figure 3. Inverse slope parameters as a function of particle mass for central, minimum bias and peripheral collisions. The error bars include statistical and systematic errors.
Figure 4. $\langle p_t \rangle$ as a function of $N_{\text{part}}$ for positive (left) and negative (right) hadrons. The error bars represent both statistical and systematic errors. The open points in the figure are interpolations to $\sqrt{s_{NN}} = 130$ GeV from $p\bar{p}$ collisions measured at lower and higher energies [4].

for $K^{+/−}$, $p$ and $\bar{p}$. The resulting $\langle p_t \rangle$ as a function of $N_{\text{part}}$ are plotted in Figure 4. At RHIC, the pion and kaon $\langle p_t \rangle$ is similar to that in $p\bar{p}$ collisions, and within errors is independent of $N_{\text{part}}$. The observed $\langle p_t \rangle$ for protons and anti-protons is higher than in $p\bar{p}$ collisions and seems to increase logarithmically with $N_{\text{part}}$.

4. Conclusion

The PHENIX measurement of transverse momentum distributions of identified charged hadrons at mid-rapidity in Au-Au collisions at $\sqrt{s_{NN}} = 130$ GeV covers a broad momentum range. We have obtained inverse slope parameters and $\langle p_t \rangle$ for $\pi^+$, $\pi^−$, $K^+$, $K^−$, $p$ and $\bar{p}$ as a function of centrality. The inverse slope parameters increase with particle mass, consistent with radial expansion of the system, which increases with centrality. High proton and anti-proton inverse slopes persist to high $p_t$ leading to significant baryon yield at $p_t > 2$ GeV/c. Baryons may dominate the charged-particle spectrum beyond this momentum.

REFERENCES
1. H.Ohnishi for the PHENIX collaboration, these proceedings.
2. H.Hamagaki for the PHENIX collaboration, these proceedings.
3. A.Milov for the PHENIX collaboration, these proceedings.
4. T.Alexopoulos et.al. Phys.Rev.,D48,984,(1993)