Abstract. The preliminary results of $\pi^\pm$, $K^\pm$, $p$ and $\bar{p}$ spectra are reported from Au+Au collisions at $\sqrt{s_{NN}} = 62.4$ GeV. Particle identification is from the Time Projection Chamber and Time-of-Flight system at STAR. The nuclear modification factor $R_{CP}$ for mesons ($\pi^\pm$, $K^\pm$) and baryons ($p$, $\bar{p}$) will also be discussed.

1. Analysis methods and results

At STAR, charged particles can be identified up to $p_T \sim 1.1$ GeV/c by measuring their ionization energy loss ($dE/dx$) in the Time Projection Chamber (TPC) [10]. The $dE/dx$ resolution was calibrated to be better than 8% in 62.4 GeV Au+Au collisions for tracks with 70 cm in length inside the TPC. At momentum $p > 3$ GeV/c, the $dE/dx$ of $\pi^\pm$ has a $\sim 2\sigma$ separation from those of $K^\pm$ and $p(\bar{p})$ due to the relativistic rise of pion $dE/dx$. Thus charged pions can be identified at 3 < $p_T$ < 10 GeV/c [9]. The $dE/dx$ measurement in Fig. 1 (left) uses a normalized $dE/dx$: $n\sigma_X = \ln((dE/dx)^Y/I_{0X})/\sigma_X$, where $X, Y$ can be $e^\pm$, $\pi^\pm$, $K^\pm$ or $p(\bar{p})$, $(dE/dx)^Y$ is the measured $dE/dx$ of particle $Y$, $I_{0X}$
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is the expected \(dE/dx\) of particle \(X\), and \(\sigma_X\) is the \(dE/dx\) resolution of particle \(X\). With a perfect calibration, the \(n\sigma_X\) distribution should be a normal Gaussian while \(n\sigma_p\) and \(n\sigma_{\bar{p}}\) should be a Gaussian peaked at negative value. The method was introduced in [9]. A prototype multi-gap resistive plate chamber time-of-flight system (TOFr) [10] has been installed since 2003 with the coverage \(-1 < \eta < 0\) in pseudorapidity. With intrinsic timing resolution 85 ps [11], it extends particle identification up to \(p_T \sim 3\) GeV/c for \(p\) and \(\bar{p}\) and 1.6 GeV/c for \(\pi^\pm\) and \(K^\pm\). By the combination of \(m^2 = p^2(1/\beta^2 - 1)\) from TOFr and \(n\sigma_{\pi}, n\sigma_p\) information from TPC, \(\pi^\pm, p\) and \(\bar{p}\) can be identified up to \(p_T \sim 5\) GeV/c and \(K^\pm\) can be identified to at least 3 GeV/c, where \(\beta\) is the velocity. This method has been introduced in [12]. Fig. 1 (right) shows \(m^2\) versus \(n\sigma_{\pi}\).

A total of 6.8 million events after vertex cut \(|Vz| < 30\) cm were used for the analysis, where \(Vz\) is the \(z\) position of the vertex. Centrality tagging of Au+Au collisions was based on the charged particle multiplicity in \(-0.5 < \eta < 0.5\), measured by the TPC. The minimum-bias (0-80%) events were divided into four centralities: most central 10%, 20%, 20% and 40-80% of the hadronic cross section.

From TOFr, the raw yields of \(\pi^\pm, K^\pm, p\) and \(\bar{p}\) are obtained from Gaussian fits to the distributions in \(m^2 = p^2(1/\beta^2 - 1)\) each \(p_T\) bin w/o \(n\sigma\) cut. Acceptance and efficiency were studied by Monte Carlo simulations and by matching TPC track and TOFr hits in real data. From TPC, the raw yields of \(\pi^\pm\) were extracted from \(dE/dx\) distribution. The efficiency due to the additional \(n\sigma\) cut was also taken into account. Weak-decay feeddown (e.g. \(K_s^0 \to \pi^+\pi^-\)) to pions was not corrected for, which was estimated to contribute \(\sim 12\%\) at \(p_T < 1\) GeV/c and \(\sim 5\%\) at higher \(p_T\) to pion yields [11]. Inclusive \(p\) and \(\bar{p}\) production is presented without hyperon feeddown correction either. \(p\) and \(\bar{p}\) from hyperon decays have the same detection efficiency as primary \(p\) and \(\bar{p}\) [13-14] and the contributions to the inclusive \(p\) and \(\bar{p}\) yield range from \(\sim 20\%\) to \(\sim 40\%\) from \(p+p, d+Au\) to \(Au+Au\) collisions [11-13-14].

The invariant yields \(d^2N/2\pi p_T dp_T dy\) of \(\pi^-, K^-,\) and \(\bar{p}\) at mid-rapidity, after the efficiency correction, are shown as symbols in Fig. 2 (left) for 62.4 GeV minimum bias \(Au+Au\) collisions. In the overlapping \(p_T\) region, the results from TOFr and from TPC are consistent. Fig. 2 (middle) shows the anti-particle to particle ratios versus \(p_T\).
Within the errors, $\pi^-/\pi^+$, $K^-/K^+$ and $\bar{p}/p$ are flat with $p_T$. The average anti-particle to particle ratios were obtained with a fit of constant value: $\pi^-/\pi^+ = 1.02 \pm 0.01$, $K^-/K^+ = 0.84 \pm 0.01$ and $\bar{p}/p = 0.46 \pm 0.01$. The errors are statistical. The systematical errors are similar to those presented at [11,13]. At 200 GeV, $\bar{p}/p = 0.77 \pm 0.05$. The decrease of $\bar{p}/p$ ratio at 62 GeV indicates the increase of the baryon chemical potential. The mid-rapidity yield $dN/dy$ of $\pi^-$ was extracted with a Bose-Einstein fit [13]. Fig. 2 (right) shows the $dN/dy$ of $\pi^-$ versus $N_{\text{part}}$ in Au+Au collisions at 62 and 200 GeV [13]. The $dN/dy$ at 62 GeV is a factor of ~1.5 smaller than that at 200 GeV [13].

Nuclear effects on hadron production in Au+Au collisions were measured through comparison to the p+p spectrum scaled by the number of underlying nucleon-nucleon inelastic collisions ($N_{\text{bin}}$). Fig. 3 (left) shows the $R_{AA}$ versus $p_T$ from our measurement in most central 0-10% Au+Au collisions at 62.4 GeV. Also shown in this plot is the $R_{AA}$ in most central 0-10% Au+Au collisions at 200 GeV from PHENIX measurement [2]. It’s evident that the suppression exists at 62.4 GeV and that the magnitude of suppression is smaller than that at 200 GeV. Fig. 3 (middle) shows $R_{CP}$ of charged hadron ($h$) and $\pi^\pm$ from 62.4 GeV Au+Au collisions. $R_{CP}$ of $h$ [15] is larger than that of $\pi^\pm$ at $2 < p_T < 5$ GeV/c and approaches that of $\pi^\pm$ at $5 < p_T < 7$ GeV/c. This may indicate the disappearance of particle-species dependence of nuclear modification factor at high $p_T$. Fig. 3 (right) shows $R_{CP}$ of $\pi^\pm, K^\pm$ and $p + \bar{p}$ from 62.4 GeV Au+Au collisions. $R_{CP}$ of protons seems to follow $N_{\text{bin}}$ scaling at intermediate $p_T$ and be larger than those of pions. The statistic for kaons is too poor to address physics issues.

Fig. 4 shows the ratios of $p/\pi^+$ and $\bar{p}/\pi^-$ as a function of $p_T$ in Au+Au collision at
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62.4 GeV. The p/π⁺ and ¯p/π⁻ ratios are observed to be a factor of 2 ~ 3 higher than those in p+p collisions at similar energy at 2 < p_T < 4 GeV/c. p/π⁺ and ¯p/π⁻ ratios reach maximum at around 2 GeV/c and seem to decrease with increasing p_T at higher p_T. This is consistent with the trends of R_{CP} of h and π. At p_T ~ 5 GeV/c, p/π⁺ and ¯p/π⁻ ratios in 62 GeV Au+Au collisions are close to those in p+p collisions [16]. This may indicate that fragmentation mechanism dominates above this p_T region.

2. Summary

We report the STAR preliminary results of π±, K±, p and ¯p spectra from 62.4 GeV Au+Au collisions. π± and p(¯p) were identified up to p_T ~ 7 GeV/c and 5 GeV/c, respectively. At this beam energy, ¯p/p = 0.46±0.01. A significant suppression for pions is observed for the most central collisions, but the effect is weaker than that observed in 200 GeV central Au+Au collisions [2] at p_T < 7 GeV/c. At intermediate p_T, the nuclear modification factor R_{CP} of h is 20% higher than that of π, R_{CP} of p + ¯p is larger than that of π, and the ratios of p/π⁺ and ¯p/π⁻ are a factor of 2-3 higher than those in p+p collisions at similar energies [16].

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