High-$p_T$ Strange Particle Spectra and Correlations in STAR

Jana Bielcikova for the STAR Collaboration

Physics Department, Yale University, New Haven, CT 06520, USA

Abstract

We present results on strange particle production in $p+p$, $d+Au$ and $Au+Au$ collisions at $\sqrt{s_{NN}} = 200$ GeV. We discuss the nuclear modification factors ($R_{CP}$) and ratios of particle yields in order to investigate the range of anomalous baryon production. The medium modification of the fragmentation process is further explored by studying azimuthal correlations at intermediate-$p_T$ for $K^0_S$, $\Lambda$ and $\bar{\Lambda}$ trigger particles. The results are compared to fragmentation and recombination models.

The observed suppression of inclusive $p_T$ spectra of identified particles in central $Au+Au$ collisions with respect to $p+p$ ($R_{AA}$) and peripheral $Au+Au$ collisions ($R_{CP}$) [1,2], together with enhanced baryon/meson ratios [3], show that in the intermediate-$p_T$ range of 2-6 GeV/$c$, baryons and mesons behave differently than in $p+p$ collisions. This indicates that jet fragmentation is not a dominant source of particle production and parton recombination and coalescence models have been suggested as alternative mechanisms [4,5,6,7]. In addition, studies of two-particle correlations of charged particles in $Au+Au$ revealed the presence of additional long-range pseudo-rapidity correlations on the near-side (commonly referred to as the ridge) [8]. These are absent in $p+p$ and $d+Au$ collisions.

The wealth of data collected by the STAR experiment in $p+p$, $d+Au$ and $Au+Au$ collisions at $\sqrt{s_{NN}} = 200$ GeV allows a detailed study of strangeness production up to high $p_T$. In this paper, we discuss the behaviour of strange baryon/meson ratios and identified particle $R_{CP}$ in order to investigate the range of the baryon anomaly. We further explore the medium modification of the fragmentation process by studying two particle azimuthal correlations at intermediate-$p_T$ using strange trigger particles ($K^0_S$, $\Lambda$, $\bar{\Lambda}$) associated with unidentified charged particles.

Figure 1(a) shows the $\Lambda/K^0_S$ ratio for various centralities in $Au+Au$ collisions. The high statistics Year 4 data significantly increase the reach in $p_T$ and we
observe that by $p_T = 6$ GeV/$c$, the ratio becomes similar for all centralities and is consistent with that in p+p. Similarly, the $R_{CP}$ of identified particles (Fig. 1(b)), demonstrates that in the intermediate-$p_T$ region mesons have smaller $R_{CP}$ than baryons, but above $p_T = 6$ GeV/$c$, they both show the same suppression. Recombination/coalescence models predict a turn-over in the $\Lambda/K^0_S$ ratio, however its exact position and shape of the distribution are not reproduced well \[4,5,6,7\]. The model combining soft particle production at low $p_T$ with a leading order pQCD at high $p_T$ incorporating gluonic baryon junctions and GLV formalism \[9\] predicts the turn-over in the ratio as well, but also fails to describe its position and shape in detail \[10\].

In the following paragraphs we discuss properties of the near-side azimuthal correlations using identified strange trigger particles ($\Lambda$, $\bar{\Lambda}$, and $K^0_S$) associated with charged particles. The azimuthal distributions, normalized to the number of trigger particles, are corrected for the reconstruction efficiency of associated particles and elliptic flow. The near-side yield of associated particles is calculated as the area under the Gaussian peak obtained from the fit. We study separately the jet and ridge contributions to the near-side yield by analyzing the correlations in two $\Delta \eta$ windows: $\Delta \eta < 0.5$ containing both jet and ridge contributions, and $\Delta \eta > 0.5$ containing the ridge-like correlations.

Comparing d+Au and Au+Au collisions, we observe an increase of the near-side yields by a factor of 3-4 going from d+Au to central Au+Au collisions. While the jet yield is independent of centrality, the ridge yield is responsible for the strong increase of the total near-side yield (not shown here, see \[11\]). No significant baryon/meson or particle/anti-particle differences are observed.

Next, we study the dependence of the near-side yield on the transverse momentum of the trigger particle, $p_T^{\text{trigger}}$, shown in Figure 2. While the ridge yield increases with $p_T^{\text{trigger}}$ and flattens off for $p_T^{\text{trigger}} > 3.0$ GeV/$c$, the jet yield keeps increasing with $p_T^{\text{trigger}}$. The jet yield for $\Lambda$ triggers is systematically below that of charged and $K^0_S$ triggers. Two effects could possibly explain
Fig. 2. Dependence of the ridge yield (a) and jet yield (b) on $p_T^{\text{trigger}}$ for various trigger species in central (0-10%) Au+Au collisions.

this difference: (1) the heavier baryon takes away more energy than the meson and thus less energy is available for the associated particle production, (2) an artificial track merging affects more $\Lambda$ than $K_0^S$ and charged particles resulting in a lower associated yield. Both effects are currently under investigation.

Fig. 3(a) shows the invariant $p_T$ distribution of associated charged particles on the near side in central Au+Au collisions for $p_T^{\text{trigger}} = 3$-6 GeV/c. We have fit the data with an exponential function $Ae^{-p_T^2/T}$ and extracted the inverse slope $T$. The jet spectrum has $T \sim 520$ MeV and is on average 80 MeV harder than the jet+ridge spectrum with $T \sim 440$ MeV. In order to make a comparison with the parton recombination model [12], we have calculated a central-to peripheral ratio of the near-side yields in Au+Au as shown in

Fig. 3. (a) Invariant $p_T$ distribution of associated charged particles on the near side in central Au+Au collisions. (b) The central-to-peripheral ratio of the near-side yield in Au+Au collisions as a function of $p_T^{\text{associated}}$. The dashed line is from [12].
Figure 3(b). The ratio is about 3 at $p_T^{\text{associated}} = 1$ GeV/c and decreases with $p_T^{\text{associated}}$. Although the calculation has been done for charged pions, our results qualitatively agree with the model and point toward a significant role of thermal-shower recombination in central Au+Au collisions. To draw any quantitative conclusions, the calculation should be done for the same centrality, $p_T^{\text{trigger}}$ selection and reproduce properties of the $\Delta \eta$ correlations.

In summary, we have reported recent results on strangeness production at intermediate-$p_T$ at RHIC. The strange baryon/meson ratios and identified particle $R_{CP}$ show that the anomalous baryon production is limited to $p_T = 2$-6 GeV/c and above $p_T > 6$ GeV/c both baryons and mesons behave similarly. Two-particle correlations with identified strange trigger particles reveal a strong contribution from the long-range pseudo-rapidity correlations at near-side. Ongoing studies using identified associated particles will help to constrain the origin of these correlations. The central-to-peripheral ratio of the near-side yields and its decrease with $p_T^{\text{associated}}$ is in a qualitative agreement with the recombination model. The crucial test of this model will be correlations with multiply-strange trigger particles ($\Xi, \Omega$) which are under investigation.

References

[1] S. S. Adler, et al., Phys. Rev. Lett. 91 (2003) 172301.
[2] J. Adams, et al., Phys. Rev. Lett. 92 (2004) 052302.
[3] J. Adams, et al., nucl-ex/0601042.
[4] R. J. Fries, B. Muller, C. Nonaka, S. A. Bass, Phys. Rev. C68 (2003) 044902.
[5] V. Greco, C. M. Ko, P. Levai, Phys. Rev. C68 (2003) 034904.
[6] V. Greco, C. M. Ko, P. Levai, Phys. Rev. Lett. 90 (2003) 202302.
[7] R. C. Hwa, C. B. Yang, Phys. Rev. C67 (2003) 034902.
[8] J. Putschke, STAR Collaboration, these proceedings.
[9] M. Gyulassy, P. Levai, I. Vitev, Phys. Rev. Lett. 85 (2000) 5535–5538.
[10] I. Vitev, M. Gyulassy, Phys. Rev. C65 (2002) 041902.
[11] J. Bielcikova, STAR, Hot Quarks 2006, to be published in Eur.J.Phys.C.
[12] R. C. Hwa, Z. Tan, Phys. Rev. C72 (2005) 057902.