Charged hadron results from Au+Au at 19.6 GeV

D. Cebra for the STAR Collaboration
Physics Department, University of California, Davis, CA, 95616, USA
E-mail: cebra@physics.ucdavis.edu

Abstract.
Results from a one day $\sqrt{s_{NN}} = 19.6$ GeV Au+Au test run at RHIC using the STAR detector are presented. The quality of these results from only 175,000 triggered events demonstrates some of STAR’s physics capabilities for the upcoming beam energy scan at RHIC. From these 19.6 GeV Au+Au collisions, we have analyzed the transverse mass spectra of $\pi^{\pm}$, $K^{\pm}$, $p$, and $\bar{p}$ at midrapidity and $m_{T} - m_{0} < 1.0$ GeV/$c^2$. We have also measured the two-pion interferometry source radii. The collision energy ($\sqrt{s_{NN}} = 19.6$ GeV) of this low energy Au+Au RHIC collider run is very close to that of the 158 AGeV fixed-target Pb+Pb runs at the SPS ($\sqrt{s_{NN}} = 17.3$ GeV). We present comparisons between these STAR data and the results published by NA49, NA44, WA98, and CERES.

PACS numbers: 25.75.-z, 25.75.Ag, 25.75.Dw, 25.75.Nq

1. Introduction

One of the goals of relativistic heavy-ion experiments is to determine the properties of nuclear matter over a wide range of temperatures and densities. This requires an understanding of interactions within the medium at both the partonic and hadronic levels. At sufficient densities, heavy-ion collisions are expected to form a quark-gluon plasma (QGP). The plasma expands, cools, and hadronizes at the chemical freeze-out point. The hadron gas continues to expand and cool until it reaches a point of kinetic freeze-out. Although the single-particle spectra and the HBT radii are not fixed until the final stage of the collision, they still provide important constraints allowing us to model the evolution of nuclear matter from high energy density to kinetic freeze-out.

In this analysis, we study the charged hadron spectra and the HBT radii from Au+Au collisions at $\sqrt{s_{NN}} = 19.6$ GeV at RHIC. At this collision energy, we are studying heavy-ion collisions with an energy density similar to that created in the top energy (158 AGeV) fixed-target Pb+Pb collisions at the CERN SPS (with a corresponding $\sqrt{s_{NN}}$ of 17.3 GeV). The results presented in this paper provide an important cross check between the collider program at RHIC and the fixed-target heavy-ion program at the SPS. These measurements provide a baseline to allow better interpretation of the results from the higher energy collisions studied at RHIC and for the proposed future low energy running of RHIC.
Figure 1. The 19.6 GeV transverse mass spectra compared with the results of SPS experiments NA44, NA49, and WA98. All the results correspond to the most central impact parameter and rapidity data sets analyzed by each experiment. The solid red stars are the STAR 19.6 GeV results, the open squares NA49 [2], the open circles NA44 [1], and the open triangles WA98 [3]. All the SPS results are from the Pb+Pb runs at $\sqrt{s_{NN}} = 17.3$ GeV.

2. The STAR Experiment

The data presented in this study have been obtained using the STAR experiment. These data were taken with a minimum bias trigger on the final day of the RHIC run II heavy-ion running period. This beam energy had not been planned prior to closing the experimental halls and little time was available either for trigger optimization or data taking. The total STAR data set with no quality cuts was 175466 events. This is a small data sample by RHIC or SPS standards; however one of the strengths of the STAR detector is the wide coverage in both rapidity and azimuth. Therefore, even with the modest number of events recorded, we still obtained inclusive spectra and HBT radii.

3. Results

Fig. 1 shows the transverse mass distributions of $\pi^+$, $\pi^-$, $K^+$, $K^-$, $p$, and $\bar{p}$ at midrapidity, $-0.1 < y < 0.1$, from the top 10% most central Au+Au collisions at 19.6 GeV. These midrapidity charged particle spectra are compared with SPS Pb+Pb results at 17.3 GeV (NA44 [1], NA49 [2], and WA98 [3]). In general, the spectra are
Charged hadron results from Au+Au at 19.6 GeV

Figure 2. The $K^-/K^+$ and $K/\pi$ ratios as a function of $\sqrt{s_{NN}}$ for the most central collisions at midrapidity. The published values from E866/917 [7], E802 [8], NA49 [2], NA44 [1], WA98 [3], PHENIX [5], PHOBOS [9], BRAHMS [10], and STAR [6] are shown for comparison.

quite similar to those measured at the SPS, although close attention should be paid to the differences in $N_{\text{part}}$, $\sqrt{s_{NN}}$, and rapidity range. NA49 has the hardest centrality selection. The extra 2.3 GeV of center of mass energy increases the midrapidity yields of all particle, except protons. STAR has the strictest rapidity definition. The NA44 and WA98 experiments have $m_t - m_0$ dependent rapidity acceptances, which effect the shapes of the spectra.

In Fig. 2, we compare the most central midrapidity $K^-/K^+$ and $K/\pi$ ratios with other experiments (E866/917 [7], E802 [8], NA44 [1], NA49 [1], WA98 [3], PHENIX [5], PHOBOS [9], BRAHMS [10], and STAR [6]). The 19.6 GeV STAR data agree well with the trends established by the previously published data. As the energy increases, the $K^-/K^+$ ratio rises toward unity. The $p/\bar{p}$ ratio is found to be $0.10 \pm 0.01$, which is consistent with SPS results. In a QGP, the energy threshold for producing an $s\bar{s}$ pair is lower than in a hadron gas. To study strangeness production, we look at the ratios of charged kaons, which carry the bulk of produced strangeness, and pions, the most abundantly produced hadrons from the collisions. The $K^+/\pi^+$ and $K^-/\pi^-$ ratios are shown in Fig. 2. The excitation functions of the positive and negative ratios are found to vastly differ which may be suggestive about the nature of the medium.

We have also studied the two-pion interferometry as a function of $m_t$. Fig. 3 shows a direct comparison with STAR’s measurement of Au+Au collisions at $\sqrt{s_{NN}} = 19.6$ GeV and Pb+Pb results at $\sqrt{s_{NN}} = 17.3$ GeV from CERES [11] and NA49 [12]. As seen, STAR results are consistent with those from the SPS experiments.
Charged hadron results from Au+Au at 19.6 GeV

Figure 3. The two-pion interferometry radii as a function of $m_t$ compared to the results of CERES [11] and NA49 [12].

4. Summary

In summary, STAR has measured the transverse mass spectra for $\pi^\pm$, $K^\pm$, $p$, and $\bar{p}$ from Au+Au collisions at $\sqrt{s_{NN}} = 19.6$ GeV. Comparisons of spectra and particle ratios are made to the published SPS and RHIC results. After accounting for differences between number of participants, the rapidity of the data, and the bombarding energy, the yields were comparable for all experiments. The $K^-/K^+$ ratio is about 0.6 and $\bar{p}/p$ about 0.1. The $K/\pi$ ratios are consistent with the established trends as a function of $\sqrt{s_{NN}}$. The pion interferometry results are consistent with the published SPS results.

References

[1] [NA44] Phys. Rev. C 66, 044907 (2002), Phys. Lett. B 471, 6 (1999).
[2] [NA49] Phys. Rev. C 66, 054902 (2002), Phys. Rev. C 69, 024902 (2004), Phys. Rev. C 73, 044910 (2006), Prog. Theo. Phys. Supp. 156, 37 (2004), Eur. Phys. J. C 33, S621 (2004).
[3] [WA98] Phys. Rev. Lett. 83, 926 (1999), Nucl. Phys. A 698, 647 (2002), Phys. Rev. C 67, 014906 (2003).
[4] E. Schnedermann and J. Sollfrank and U. Heinz, Phys. Rev C 48, 2462 (1993).
[5] [PHENIX] Nucl. Phys. A 715, 151 (2003), Nucl. Phys. A 715, 498 (2003), Phys. Rev. C 69, 034909 (2004).
[6] [STAR] Phys. Rev. Lett. 92, 112301 (2003), Phys. Lett. B 595, 143 (2004), Phys. Rev. Lett. 86, 4778 (2001), Phys. Lett. B 567, 167 (2003).
[7] [E866] Phys. Lett. B 476, 1 (2000), Phys. Lett. B 490, 53 (2000).
[8] [E802] Nucl. Phys. A 610, 139c (1996), Phys. Rev. Lett. 81, 2650 (1998).
[9] [PHOBOS] Phys. Rev. Lett. 85, 3100 (2000), Phys. Rev. Lett. 88, 022302 (2002), Nucl. Phys. A 715, 490 (2002), Phys. Rev. Lett. 91, 072302 (2003).
[10] [BRAHMS] Phys. Rev. Lett. 91, 072305 (2003), Phys. Rev. Lett. 90, 102301 (2003), Jour. Phys. G 30, S667 (2004).
[11] [CERES] Nucl. Phys. A 714, 124 (2003).
[12] [NA49] arXiv:0709.4507v2 sub. to Phys. Rev. C.