Study of the charged pions, kaons and protons production in Au+Au collisions at $\sqrt{s_{NN}} = 27$ GeV in STAR at RHIC

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Introduction

According to Quantum Chromodynamics (QCD) there is a phase transition from hadronic matter to Quark-Gluon Plasma (QGP) phase at sufficiently high temperature and high energy density [1]. The QCD phase diagram is characterized as temperature (T) vs. baryon chemical potential (μ_B). Lattice QCD calculations indicate that at $\mu_B = 0$ and large T, the quark-hadron transition is a rapid crossover. At larger μ_B, QCD based model calculations predict the transition to be a first-order. The point in the QCD phase diagram at which the first-order phase transition ends, is called QCD critical point. The main goal of the Beam Energy Scan (BES) program at RHIC is to search the QCD critical point and map the QCD phase diagram by varying the collision energies. The yields and transverse momentum spectra of the particles produced in the collisions are used to study the chemical and kinetic freeze-out properties of the system.

The new result presented here are the yields and particle ratios of pions, kaons and protons produced in Au+Au collisions at $\sqrt{s_{NN}} = 27$ GeV. Similar measurements at other BES energies are reported in [2].

Detector setup and Analysis details

The detector used for this work is the Solenoidal Tracker at RHIC (STAR) [3]. Out of the many subdetectors, Time Projection Chamber (TPC) is the main tracking device and it is used to identify the charged particles at lower momentum region. The extension to higher momentum region is done using the Time-Of-Flight (TOF) detector system. In this analysis the pions, kaons and protons yields are measured in the mid-rapidity region $|y| < 0.1$. Pion yield is corrected for contribution from their weak decay contributions, whereas the proton yields presented are inclusive of all production contributions.

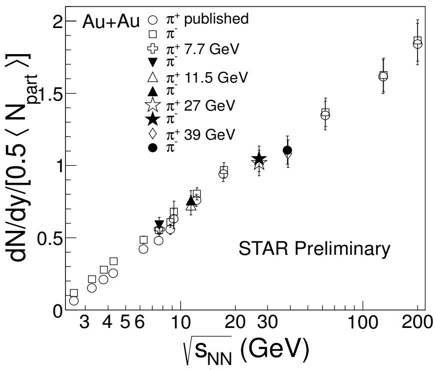

FIG. 1: dN/dy of $\pi^{\pm}$ normalized by $\langle N_{part} \rangle/2$ as a function of energy. Errors are the quadratic sum of statistical and systematic uncertainties.

Results

Figures 1 and 2 show the energy dependence of yields per participating nucleon pair for $\pi^{\pm}$ and $K^{\pm}$ respectively, for central collisions. The result from $\sqrt{s_{NN}} = 27$ GeV falls in the same increasing trend of dN/dy with beam energy as seen for other BES energies (39, 11.5 and 7.7 GeV). It is also compared with the previously published results of AGS, SPS, and RHIC [4]. While the π^+ and π^- yields are comparable for BES energies, the K^- yields are lower compared to K^+ yields at $\sqrt{s_{NN}} = 27$ GeV. The K^- and K^+ yields approach each other at higher collision energies. Errors are the quadratic sum of statistical and systematic uncertainties.

Figures 3, 4 and 5 show the collision energy dependence of the anti-particle to particle ratios π^-/π^+, K^-/K^+ and $\bar{p}/p$, respectively, in central heavy-ion collisions. The results from Au+Au collisions at $\sqrt{s_{NN}} = 27$ GeV follow

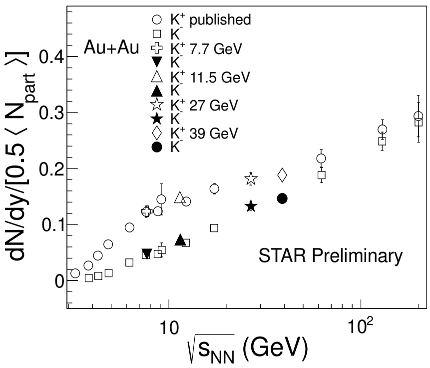

FIG. 2: dN/dy of $K^{\pm}$ normalized by $\langle N_{part} \rangle/2$ as a function of energy. Errors are the quadratic sum of statistical and systematic uncertainties.

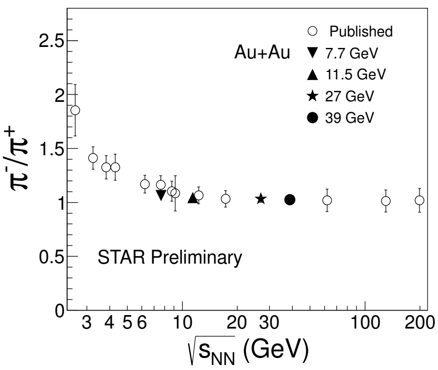

FIG. 3: π^-/π^+ ratio for 0–5% centrality in Au+Au collisions at $\sqrt{s_{NN}} = 27$ GeV compared with the other BES energies and previous published results. Errors are the quadratic sum of statistical and systematic uncertainties.

a systematic trend with other BES energies and also with the published results. The p_T-integrated π^-/π^+ ratio at $\sqrt{s_{NN}} = 27$ GeV is around 1.03±0.03 (statistical error). Those at lower beam energies have values much larger than unity, which could be due to significant contributions from resonance decays (such as Δ baryons). The $\bar{p}/p$ ratio increases with increasing collision energy and approaches unity for top RHIC energies. This indicates that at higher beam energies, the p ($\bar{p}$) production at mid-rapidity is dominated by pair production. The K^-/K^+ ratio approaches unity as collision energy increases, indicating the dominance of kaon pair production while at BES

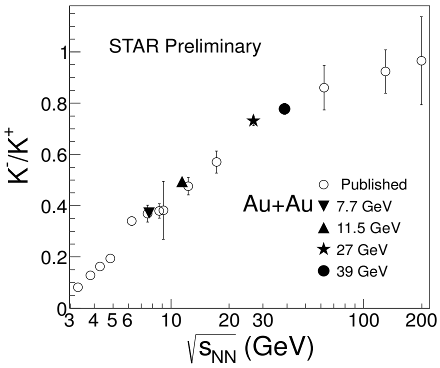

FIG. 4: K^-/K^+ ratio for 0–5% centrality in Au+Au collisions at $\sqrt{s_{NN}} = 27$ GeV compared with the other BES energies and previous published results. Errors are the quadratic sum of statistical and systematic uncertainties.

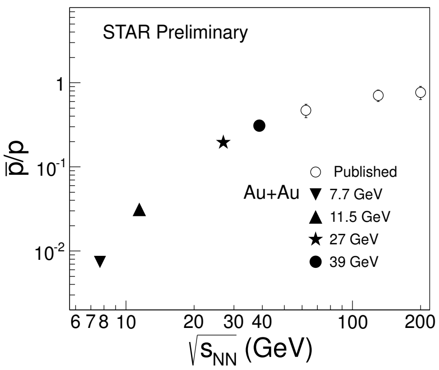

FIG. 5: $\bar{p}/p$ ratio for 0–5% centrality in Au+Au collisions at $\sqrt{s_{NN}} = 27$ GeV compared with the other BES energies and previous published results. Errors are the quadratic sum of statistical and systematic uncertainties.

energies associated production of K^+ dominates. The details of the studies will be discussed.

References

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