Identified hadron production at mid-rapidity in Au+Au collisions at $\sqrt{s_{NN}} = 54.4$ GeV at STAR

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Abstract

Quantum Chromodynamics (QCD) predicts that at sufficiently high temperature (T) and/or baryon chemical potential (μ_B), the state of matter is in the form of quarks and gluons, which are no longer confined within hadrons. This deconfined state of matter is known as the Quark-Gluon Plasma (QGP). The goal of relativistic heavy-ion collision experiments is to create such a hot and dense state of matter and study its properties. Measurements of identified particle spectra in Au+Au collisions provide information on the bulk properties, such as integrated yield (dN/dy), average transverse momenta ($\langle p_T \rangle$), particle ratios, and freeze-out parameters of the medium produced. The systematic study of bulk properties sheds light on the particle production mechanism in these collisions. Also, the centrality dependence of the freeze-out parameters provides an opportunity to explore the QCD phase diagram.

We present the transverse momentum spectra of identified hadrons ($\pi^{\pm}$, $K^{\pm}$, p, and $\bar{p}$) at mid-rapidity ($|y| < 0.1$) in Au+Au collisions at $\sqrt{s_{\rm NN}} = 54.4$ GeV. The centrality dependence of dN/dy, particle ratios, and kinetic freeze-out parameters are also presented, and their physics implications are discussed. In addition, we compare our results with previously published results at other collision energies.

1 Introduction

Quantum Chromodynamics (QCD) predicts the formation of the Quark-Gluon Plasma (QGP), a new state of matter, in heavy-ion collisions at high energy density or temperature [1]. Studying transverse momentum spectra in heavy-ion collisions provides crucial information on QGP bulk properties, contributing to our understanding of the QCD phase diagram, particle production mechanisms, and freeze-out properties of the created medium. In this report, we present the transverse momentum spectra of identified hadrons in Au+Au collisions at $\sqrt{s_{NN}} = 54.4$ GeV using the Time Projection Chamber (TPC) and Time of Flight (TOF) detectors at STAR.

2 Results and Discussions

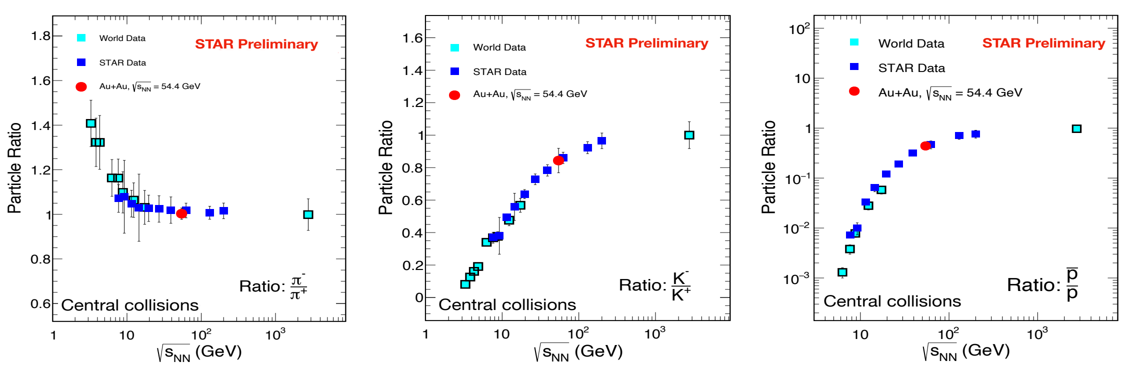

Figure 1: π^-/π^+, K^-/K^+, and $\bar{p}/p$ ratios at mid-rapidity ($|y| < 0.1$) in 0–5% Au+Au collisions at $\sqrt{s_{NN}} = 7.7$–200 GeV. The uncertainties are statistical and systematic added in quadrature.

Figure 1 shows particle ratios (π^-/π^+, K^-/K^+, and $\bar{p}/p$) in the most central (0-5%) collisions as a function of collision energy. At lower beam energies, the π^-/π^+ ratio exceeds unity due to the contributions from resonance decays like Δ baryons. The K^-/K^+ ratio shows an increasing trend with increasing $\sqrt{s_{NN}}$ and approaches unity at higher beam energies, signifying the associated production of K^+ at lower energies. The $\bar{p}/p$ ratio increases with increasing $\sqrt{s_{NN}}$ but approach unity at the highest RHIC energy, indicating stronger baryon stopping at lower energies. The 54.4 GeV results follow the trend shown from previous measurements of AGS, SPS, RHIC, and LHC [2].

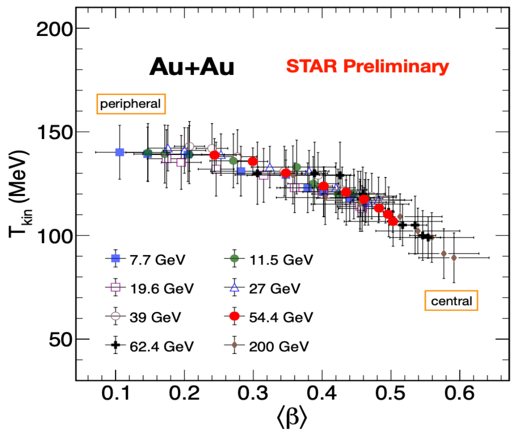

Figure 2: Variation of T_{kin} with $\langle\beta\rangle$ for various centralities in different collision energies.

A simultaneous fit to the p_T spectra of π, K, p, and their antiparticles was performed in different centrality intervals for Au+Au collisions at $\sqrt{s_{NN}} = 54.4$ GeV using the blast-wave model [3, 4] to study the kinetic freeze-out properties of the medium. Figure 2 shows that as we move from central to peripheral collisions, there is a decrease in transverse flow velocity ($\langle\beta\rangle$) and an increase in kinetic freeze-out temperature (T_{kin}), consistent with the expectation of a shorter lived fireball towards peripheral collisions [5].

References

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