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.

In this talk, we will 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 $\sqrt{s_{\mathrm{NN}}} = 54.4$ GeV. The centrality dependence of dN/dy, particle ratios, and kinetic freeze-out parameters will also be presented, and their physics implications will be discussed. In addition, we will 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

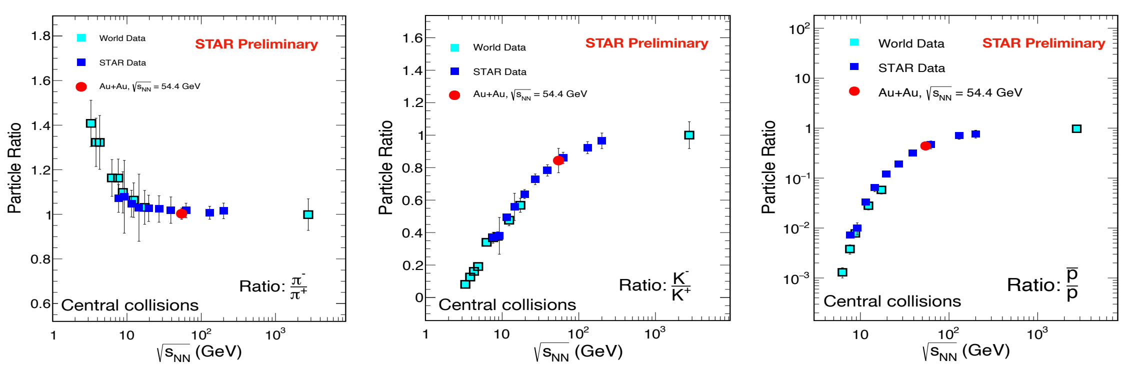

Figure 1: π^-/π^+, K^-/K^+, and $\bar{p}/p$ ratios at mid-rapidity ($|y| < 0.1$) in 0–5% Au+Au collisions at $\sqrt{s_{NN}} = 7.7$–200 GeV. The uncertainties are statistical and systematic added in quadrature.

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^+ ratios exceed unity due to the contributions from resonance decays like Δ baryons. The K^-/K^+ ratios show 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 $\bar{p}/p$ ratios increase 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 [2] of AGS, SPS, RHIC, and LHC.

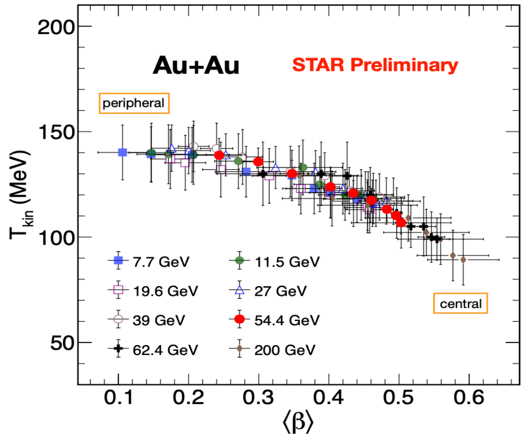

Figure 2: Variation of T_{kin} with $\langle\beta\rangle$ for various centralities in different collision energies.

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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