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

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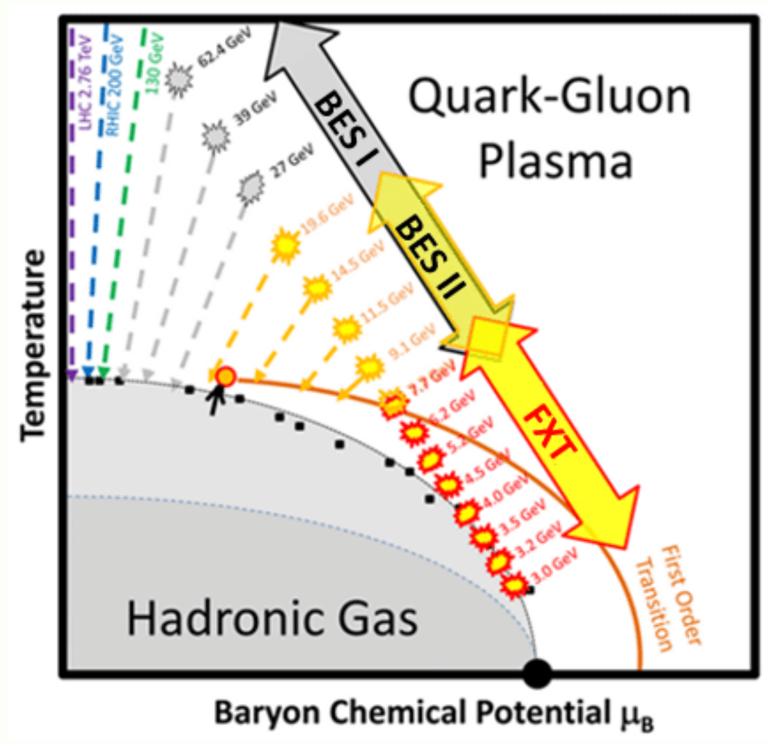
Abstract

Quantum Chromodynamics (QCD), the theory of strong interaction, predicts that at sufficiently high temperature and/or energy density normal nuclear matter converts into a de-confined state of quarks and gluons, known as the Quark-Gluon Plasma (QGP). To investigate the phase diagram of the QCD matter, the Relativistic Heavy Ion Collider (RHIC) started the Beam Energy Scan (BES) program. In the first phase (BES-I), Au+Au collision data were taken at $\sqrt{s_{NN}}$ = 7.7 to 62.4 GeV. In the second phase (BES-II), a high statistics dataset from Au+Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV was recorded by the STAR experiment in 2017. The transverse momentum (p_T) spectra of identified hadrons are essential to study 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 can shed light on the particle production mechanisms in heavy-ion collisions. In this poster, we present the p_T spectra of identified hadrons ($\pi^{\pm}$, $K^{\pm}$, p, and $\bar{p}$) at mid-rapidity (|y| < 0.1) in Au+Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV. We also present the energy dependence of particle ratios and freeze-out parameters.

I. Motivation

RHIC Beam Energy Scan (BES) Program:

- To understand the QCD phase diagram
- Search of QCD critical point
- Search for the first order phase transition



Kathryn Meehan, Nuclear Physics A 967, 2017

System: Au+Au

BES I

$\sqrt{s_{NN}}$ = 7.7, 11.5, 14.5, 19.6, 27, 39, and 62.4 GeV

BES II

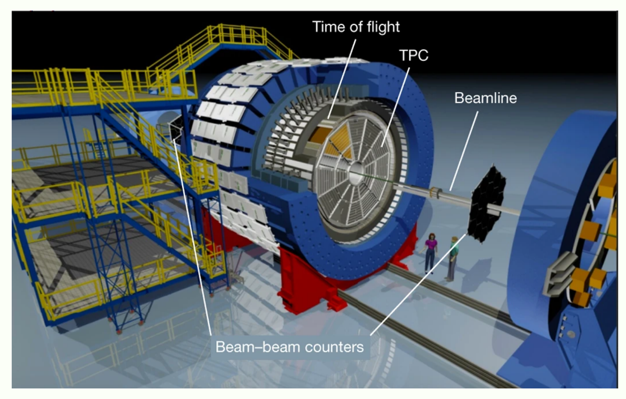
$\sqrt{s_{NN}}$ = 7.7, 9.2, 11.5, 14.6 ,17.3, 19.6, 27, and 54.4 GeV

$\sqrt{s_{NN}}$ = 3.0, 3.2, 3.5, 3.9, 4.5, 5.2, 6.2, 7.2, 7.7, 9.2, 11.5, and 13.7 GeV (FXT)

- Study of transverse momentum spectra of identified hadrons are essential to study the bulk properties of the medium produced
- It also gives insight into the freeze-out properties of the medium which is crucial to understand the QCD phase

II. Experiment

- Solenoidal Tracker At RHIC (STAR) is a general purpose experiment at RHIC
- The Time Projection Chamber (TPC) and the Time-Of-Flight (TOF) are the main sub-detectors for particle identification at STAR

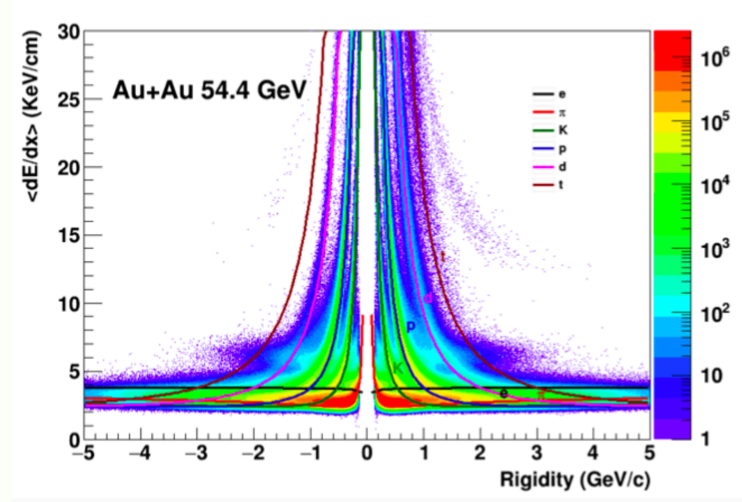


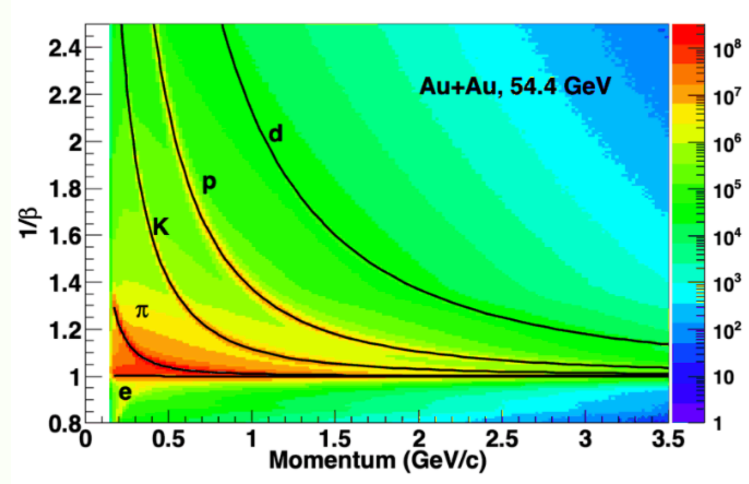
Time Projection Chamber (TPC)

- Tracking, momentum measurement
- PID through dE/dx

Time of Flight (TOF)

- PID through velocity (1/β)
- Timing resolution: ~85 ps





III. Analysis method

Particle identification: Using <dE/dx> information from TPC [1] and mass square (m^2) information from TOF

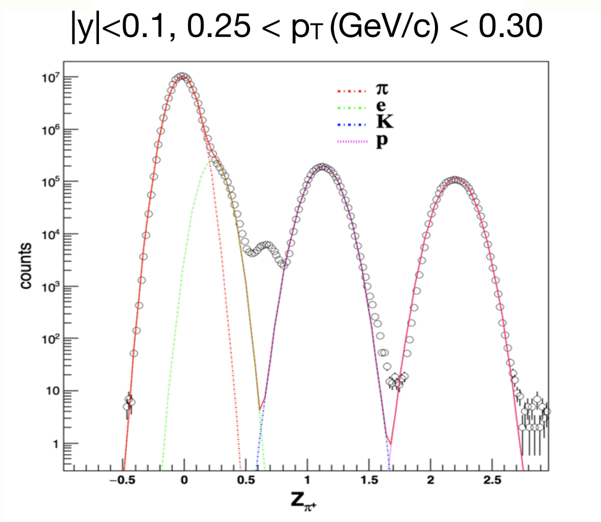
z- variable is defined as:

$$z_i = \ln\left(\frac{\langle dE/dx\rangle_{measured}}{\langle dE/dx\rangle_{theory}}\right)$$

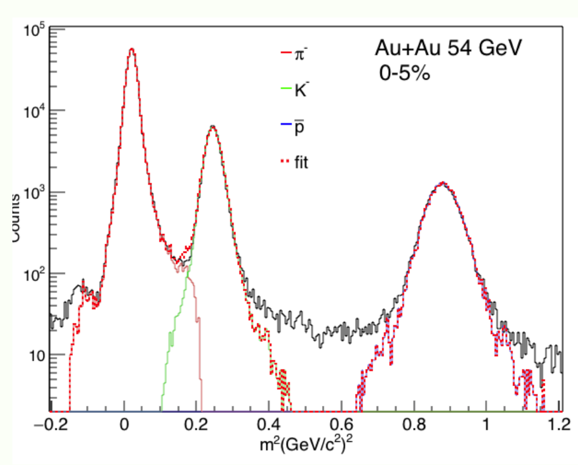
m^2 is obtained as:

$$m^2 = p^2\left(\frac{1}{\beta^2} - 1\right)$$

|y|<0.1, 0.25 < p_T (GeV/c) < 0.30

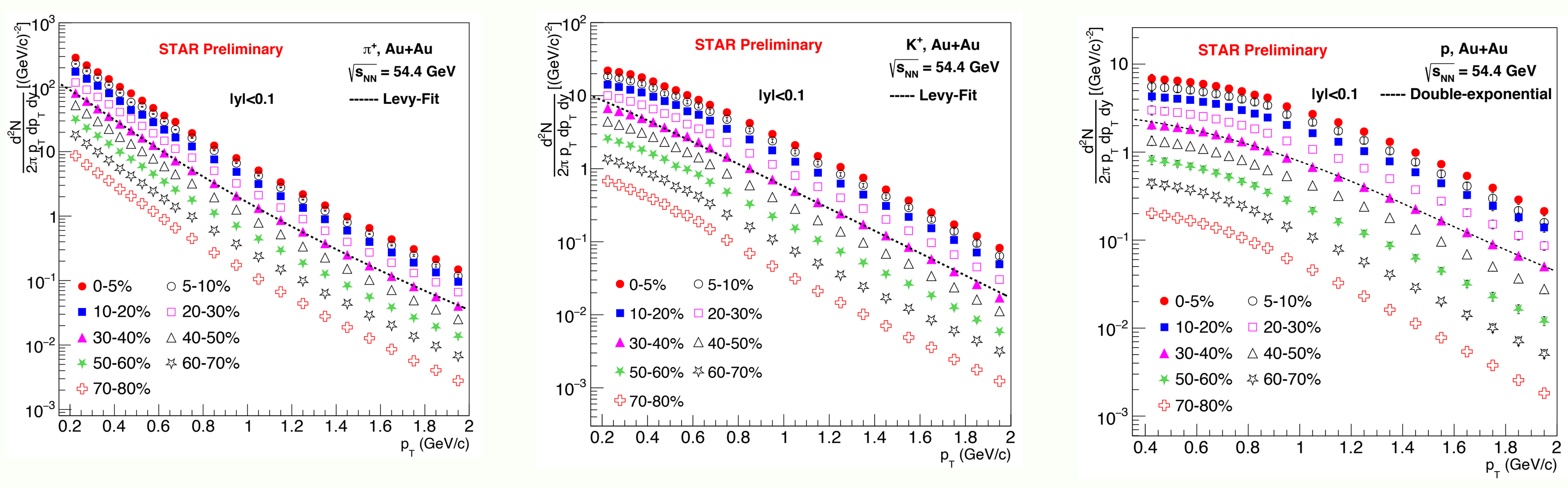


|y|<0.1, 0.8 < p_T (GeV/c) < 0.9

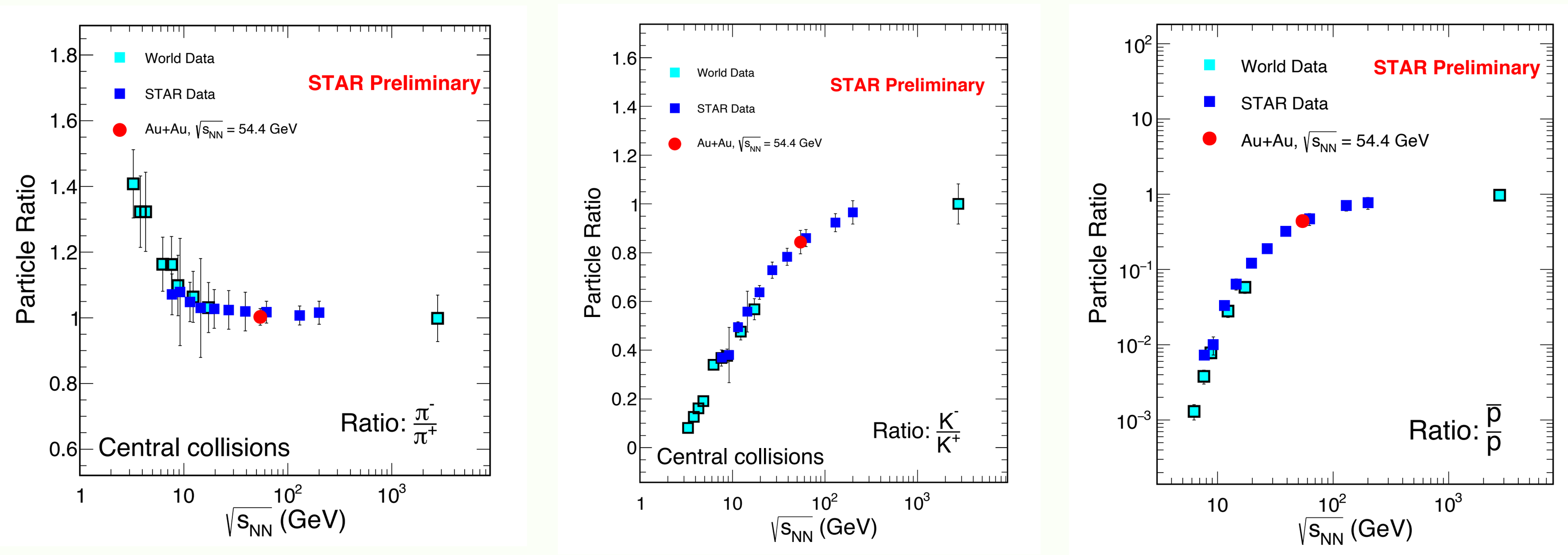


IV. Results

- p_T spectra of identified hadrons show a clear particle species and centrality dependence



- Particle ratios for 54.4 GeV follow the collision energy dependence established by measurements from AGS [2], SPS [3], RHIC [4,5], and LHC [6] energies



Blast-wave model: A hydrodynamic model [7]

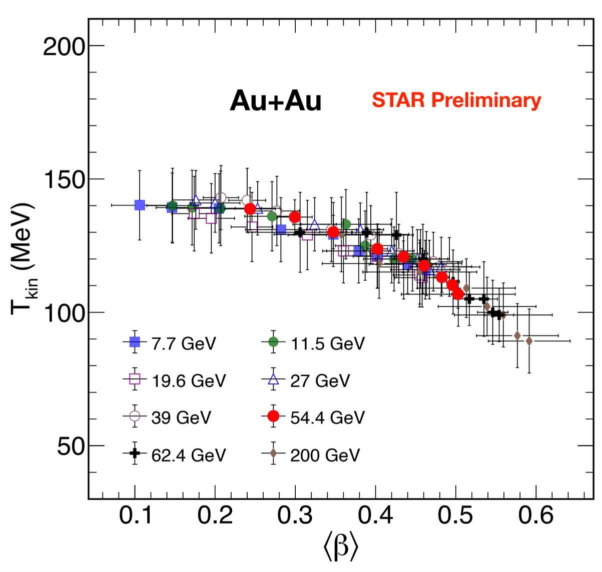
$$\frac{dN}{p_T dp_T} \propto \int_0^R r\,dr\,m_T I_0\left(\frac{p_T \sinh\rho(r)}{T_{kin}}\right) \times K_1\left(\frac{m_T \cosh\rho(r)}{T_{kin}}\right)$$

I_0, K_1: Modified Bessel functions

$\rho(r) = \tanh^{-1}\beta$

β = Transverse radial flow velocity

T_{kin}: Kinetic freeze-out temperature



- T_{kin} increases from central to peripheral
- ⟨β⟩ decreases from central to peripheral

V. Summary

- Transverse momentum spectra of $\pi^{\pm}$, $K^{\pm}$, p and $\bar{p}$ at mid-rapidity (|y| < 0.1) for $\sqrt{s_{NN}}$ = 54.4 GeV Au+Au collisions have been obtained
- The p_T -integrated π^-/π^+ ratios at very low energies have values larger than unity due to contributions from resonance decays
- The K^-/K^+ ratios at BES energies are much less than unity, indicating a significant contribution to K^+ yield from associated production at low collision energies
- The $\bar{p}/p$ ratio increases with increasing collision energy and approaches unity for top RHIC energies due to more baryon stopping at lower energies
- Kinetic freeze-out temperature and flow velocity show anti-correlation

References

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