Nuclear modification factor of inclusive charged particles and strange hadrons in Au+Au collisions with the STAR experiment.

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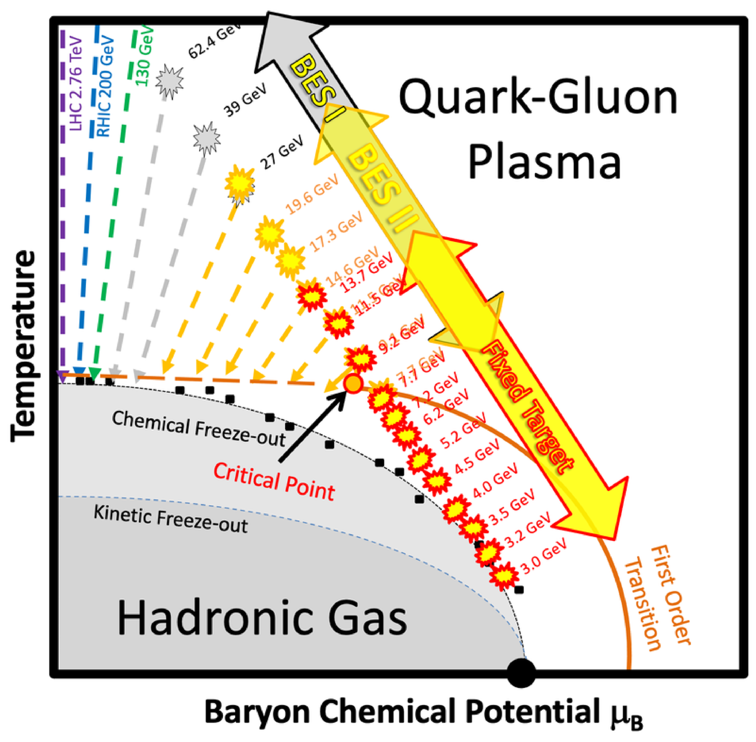
Abstract

The exploration of the Quantum Chromodynamics (QCD) phase diagram via heavy-ion collisions is central to understanding the transition from hadronic matter to a deconfined quark-gluon plasma (QGP). The nuclear modification factor R_{CP} serves as a key observable for probing parton energy loss and the properties of the created hot and dense medium. Simultaneously, strange hadrons provide unique insights into the QCD transition and chemical freeze-out conditions due to their sensitivity to strangeness enhancement - a proposed signature of QGP formation.

We present measurements from the STAR experiment on the R_{CP} for inclusive charged particles and strange hadrons in Au+Au collisions at BES energies. These results are compared to model calculations to critically evaluate theoretical descriptions of medium effects. The behavior of R_{CP} at higher transverse momenta (p_T) is analyzed to investigate potential jet quenching signatures in the BES energies. Precise measurements of strangeness production and its modification factor offer deeper insights into the formation and properties of QGP matter.

Introduction



- **QCD Phase Diagram**
  - Cross-over transition expected at low baryon chemical potential (μ_B)
  - First-order transition expected at high μ_B
  - Critical point is the end point of the first-order phase transition
- **Beam Energy Scan (BES)**
  - Explore the QCD matter by colliding gold ions at different energies - and search for the potential QCD critical point
  - Seeking to map onset of deconfinement, and the predicted QCD critical point

p_T Spectra

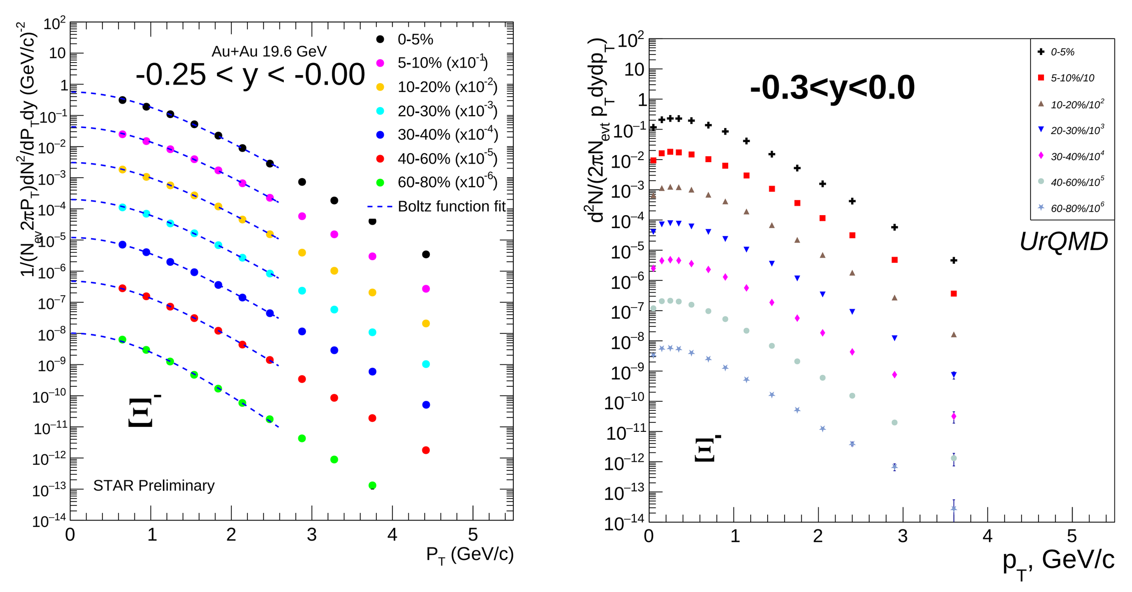


Figure 2: Transverse momentum distribution of Ξ^- for collision energy of 19.6 GeV from STAR BES II (left plot) and UrQMD (right plot). Each spectrum corresponds to a certain centrality class and is multiplied by coefficient from $1 - 10^6$ for visibility.

From figure 2, it can be noticed that UrQMD shows similar trend but less yield compared to BES II.

Nuclear modification factor of inclusive charged particles

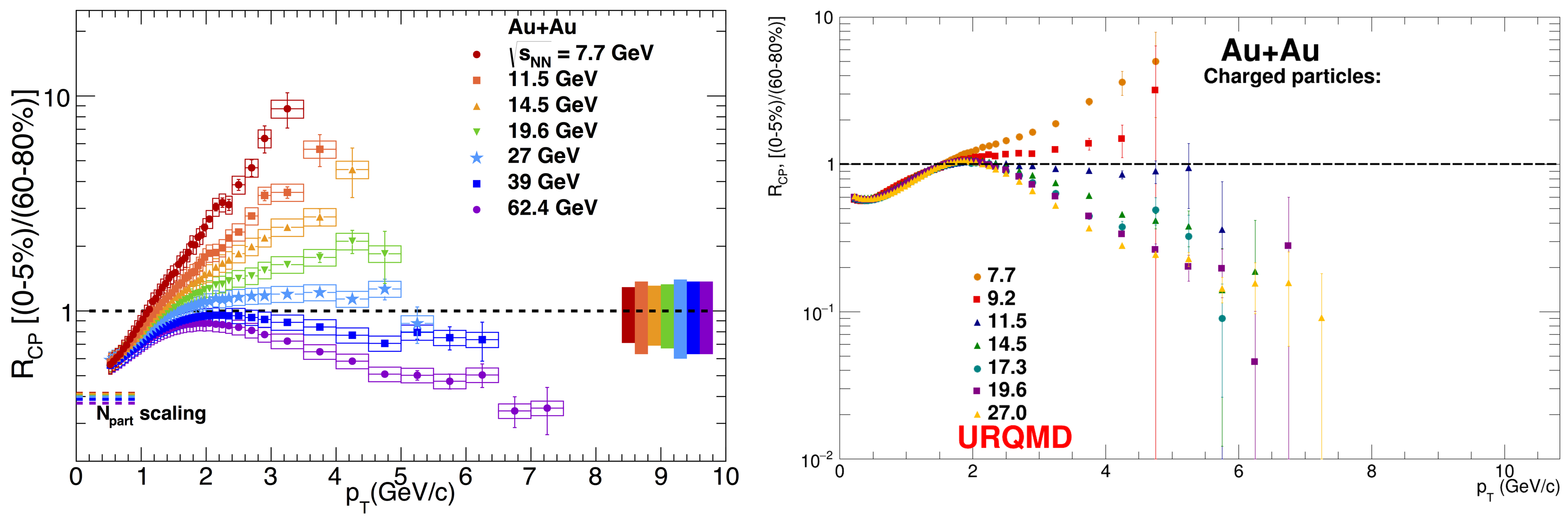


Figure 1: R_{CP} for inclusive charged particles at $\sqrt{s_{NN}}$ = 7.7-27 GeV collision energies from STAR BES I (left plot) and UrQMD (right plot).

The suppression effect of charged particle production with high transverse momenta ($p_T > 2$ GeV/c) is one of the most interesting results observed at the Solenoidal Tracker At RHIC (STAR) experiment during the BES-I program. This effect has been interpreted as the increase in energy loss of partons in the quark-gluon plasma produced at high energy heavy ion-collisions. It is commonly referred to as jet quenching in dense partonic matter and was predicted as a sign of the formation of the QGP phase, where simple model of hadron scattering cannot describe the observations. This effect can be quantified using the nuclear modification factor R_{CP}:

$$R_{CP} = \frac{\langle N_{coll}\rangle_{Peripheral}}{\langle N_{coll}\rangle_{Central}} \frac{\left(\frac{d^2N}{dp_T d\eta}\right)_{Central}}{\left(\frac{d^2N}{dp_T d\eta}\right)_{Peripheral}} \tag{1}$$

Nuclear modification factor of strange hadrons

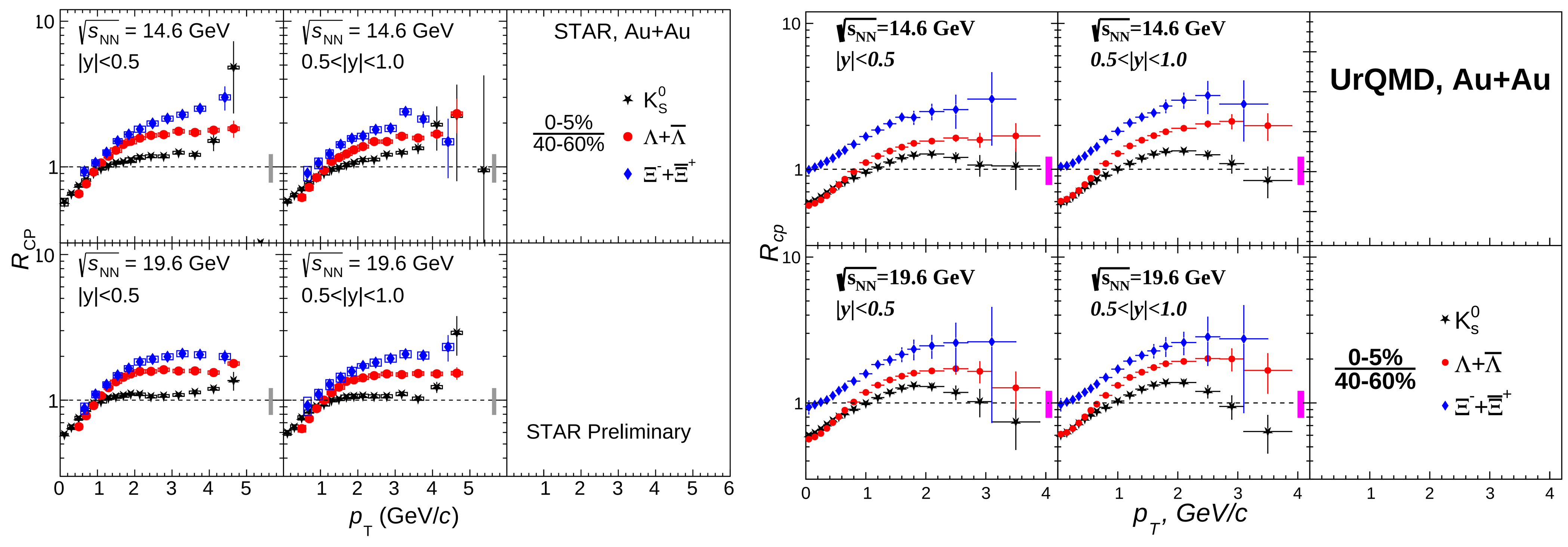


Figure 3: R_{CP} for strange hadrons at $\sqrt{s_{NN}}$ = 14.6 and 19.6 GeV collision energies from STAR BES II (left plot) and UrQMD (right plot).

The strangeness production was suggested as the sign of formation of QGP in high energy collisions. At low p_T ($< 2\ GeV/c$) the growth of R_{cp} can be seen. At 19.6 GeV energy as p_T increases, R_{CP} of K^0_s, Λ and Ξ reaches a plateau and at $p_T \approx 4\ GeV/c$ R_{CP} of K^0_s starts to growth . At 14.6 GeV similar behavior seen for Λ while Ξ and K^0_s shows slow growth.

Conclusion

New data from the BES-II allow to extend investigation of the particle production modification in medium to the region of high transverse momenta p_T. The UrQMD data show behavior similar to the BES II data for K^0_s and Λ at $\sqrt{s_{NN}} = 14.6$ and $19.6\ GeV$ in $p_T < 2\ GeV/c$ range and for inclusive charged particles for BES II collision energies in the same p_T range. An energy-dependent study of the R_{CP} on BES II data should allow a better map position of the phase transition from hadronic to partonic degrees of freedom in nuclear matter.

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References

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