Probing hadronic rescattering via K^{*0} resonance production at RHIC

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Abstract

In these proceedings, we will report precision measurements of K^{*0} meson production in isobar (Zr+Zr and Ru+Ru) collisions at $\sqrt{s_{NN}} = 200$ GeV, and in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7 - 27 GeV, using high-statistics STAR BES-II data. Results will include transverse momentum (p_T) spectra and yields (dN/dy) measurements. Additionally, the K^{*0}/K ratio as a function of multiplicity across different systems and energies will be discussed, providing insights into the underlying physics of the hadronic medium.

Keywords:
RHIC, Resonances, Hadronic rescattering, Beam Energy Scan

1. Introduction

Relativistic heavy-ion collisions provide a unique setting to investigate QCD matter under varied temperatures and densities [1]. As the collision energy decreases, the baryon chemical potential (μ_B) rises, resulting in a mid-rapidity region rich in baryons at the lower Beam Energy Scan (BES) program energies and in mesons at top RHIC energies [2]. Short-lived resonances like K^{*0} (lifetime $\sim$ 4.16 fm/c) are effective probes of the hadronic medium [3]. As they primarily decay within the fireball, their decay products undergo in-medium effects like rescattering and regeneration, potentially modifying K^{*0} yields. However, due to change in the chemical composition of the system produced at low and high collision energies, distinct difference in the particle interaction can be expected. The measurement of K^{*0} meson over a broad collision energy range will help shed light on this phenomenon. In this work, the $K^{*0}(\overline{K^{*0}})$ meson is reconstructed via its hadronic decay channel K^{*0} ($\overline{K^{*0}}$)$\rightarrow$ $K^+\pi^-$ ($K^-\pi^+$) (branching ratio $\sim$ 66.6%). For the current analysis at BES energies K^{*0} and $\overline{K^{*0}}$ are combined and denoted as K^{*0}, similarly charged kaons are combined and denoted as K.

2. Results

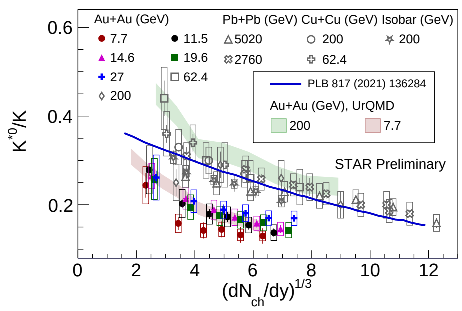

Figure 1: Resonance to non-resonance ratio as a function of $(dN_{ch}/dy)^{1/3}$ The bars and boxes denote the statistical and systematic uncertainties, respectively.

If the K^{*0} meson decays before kinetic freeze-out, the decay daughters (π and K) can re-scatter with other hadrons in the medium. These interactions can change the momenta of the decay daughters, making it impossible to reconstruct the original K^{*0} resonance. As a result, the observed yield of K^{*0} mesons may be reduced. At the same time, pions and kaons that are already present in the medium can also interact through pseudo-elastic scattering, which can regenerate the K^{*0} resonance. This process increases the measured yield. Hence the final observed yield of the resonance is affected by the relative contribution of these in-medium effects, which can be probed with the help of resonance to non resonance ratio (eg. K^{*0}/K) [3, 4].

Figure 1 shows the multiplicity dependence of the K^{*0}/K ratio at different collision systems and energies. In all the systems and energies studied, this ratio decreases from peripheral to central collisions, suggesting a dominant hadronic rescattering over regeneration in central heavy-ion collisions. The measurements from isobar collisions at $\sqrt{s_{NN}} = 200$ GeV are consistent with results from Au+Au collisions at the same energy and Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ and 5.02 TeV. In isobar collisions, the K^{*0}/K ratio in central collisions is observed to be significantly lower than in peripheral collisions, with a difference of more than 3σ.

At top RHIC and LHC energies, the K^{*0}/K ratio appears to follow a universal scaling with multiplicity. However, at lower BES energies, this scaling breaks down, with the ratio deviating more from the high-energy trend as the collision energy decreases. A phenomenological model that includes only meson-meson interactions describes the high-energy data well [5], but it fails at lower energies. On the other hand, the UrQMD model, which includes both meson-meson and meson-baryon interactions, qualitatively reproduces the behavior observed across both high and low energies. Therefore, the deviation from the universal multiplicity scaling observed at high energies of the resonance to non resonance ratio at lower energies can be attributed to enhanced meson-baryon interactions in the baryon-rich medium created at low collision energies, which lead to a significant reduction in the final observed yield of the resonance [6].

3. Summary

The precision measurements of K^{*0} meson production are reported from isobar collisions (Ru+Ru and Zr+Zr at $\sqrt{s_{NN}}$=200 GeV) and Au+Au collisions at BES-II energies ($\sqrt{s_{NN}}$=7.7–27 GeV). The measured K^{*0} ratio shows a decreasing trend from peripheral to central collisions across all systems and energies, which indicates the dominance of hadronic rescattering over regeneration in central heavy-ion collisions. At top RHIC and LHC energies, the K^{*0}/K ratio scales with charged-particle multiplicity, but this scaling breaks down at lower BES energies. Comparison with UrQMD model suggests that the suppression is attributed to stronger meson-baryon interactions in the baryon-rich medium.

References

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