

1 Production of K^{*0} in Au+Au collisions at $\sqrt{s_{NN}} = 19.6$ GeV 2 from RHIC BES-II

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5 **Abstract.** We present the study of K^{*0} in Au+Au collisions at $\sqrt{s_{NN}} = 19.6$
6 GeV from RHIC BES-II. The ratio of resonance to non-resonance (K^{*0}/K) is
7 shown as function of centrality and center-of-mass energy, which implies the
8 dominance of hadronic re-scattering over regeneration in central A+A colli-
9 sions. The lower limit of hadronic phase lifetime ($t_{kin} - t_{chem}$) is also reported
10 using a toy model ansatz. The results are compared with previous RHIC and
11 LHC measurements.

12 1 Introduction

13 Relativistic heavy-ion collisions provide a unique opportunity to understand the deconfined
14 state of matter called the Quark-Gluon Plasma. The short-lived hadronic resonances are a
15 very good probe to study the hadron gas phase, which characterises the late-stage evolution
16 of heavy-ion collisions. $K^{*0}(892)$ has a lifetime ~ 4.16 fm/c which is smaller compared to
17 that of fireball (~ 10 fm/c). Due to its short lifetime, the decay daughters may interact with the
18 medium and change the properties of the resonances. In between chemical (CFO) and kinetic
19 (KFO) freeze out, the daughter particles of $K^{*0}(892)$ could undergo in-medium effects like
20 re-scattering and regeneration. Hence the final yield of the $K^{*0}(892)$ depends on the interplay
21 of these effects, and can be used to study the hadronic phase of heavy-ion collisions [1].

22 2 Data Sets and Analysis Details

23 In these proceedings, we report the production yield of K^{*0} meson in Au+Au collisions at
24 $\sqrt{s_{NN}} = 19.6$ GeV, accumulated by the STAR experiment in 2019 as part of the RHIC BES-II
25 program. The $K^{*0}(\overline{K^{*0}})$ is reconstructed via its decay channel $K^{*0}(\overline{K^{*0}}) \rightarrow K^+\pi^- (K^-\pi^+)$.
26 The vertex positions along the beam (V_z) and radial (V_r) directions are required to be within
27 $|V_z| < 145$ cm and $|V_r| < 2$ cm. The daughter particles are identified using both the Time
28 Projection Chamber (TPC) and the Time Of Flight (TOF) detector. In BES-II, the inner part
29 of the TPC has been upgraded for better momentum resolution, wider transverse momentum
30 (p_T) and pseudo-rapidity coverages.

31 The combinatorial background is estimated using the track rotation method, where one of
32 the daughter (here π) track momentum is rotated by 180° in transverse plane in order to break
33 the correlation among the pairs originating from same parent resonance (K^{*0}). The K^{*0} signal
34 is obtained after subtracting the combinatorial background from the same event $K\pi$ pairs,

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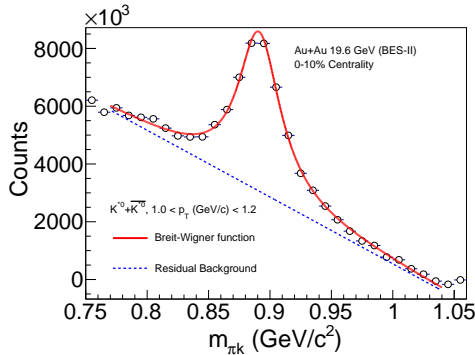


Figure 1. K^{*0} signal for $1.0 < p_T < 1.2$ GeV/c in 0-10% Au+Au collisions at $\sqrt{s_{NN}} = 19.6$ GeV.

35 which is then fitted with the Breit-Wigner function and a first-order polynomial representing
 36 the residual background. Figure 1 shows an example of K^{*0} signal extraction for $1.0 < p_T$
 37 < 1.2 GeV/c in 0-10% Au+Au collisions at $\sqrt{s_{NN}} = 19.6$ GeV. The yield is estimated by
 38 integrating the signal within $0.77 < m_{\pi K} < 1.04$ GeV/c² after residual background subtraction.

39 **3 Results**

40 **3.1 Particle ratios**

41 If the K^{*0} meson decays before KFO, the decay daughters (π and K) can re-scatter with other
 42 hadrons present in the medium, so that their momenta may get changed. Hence, one may not
 43 be able to reconstruct the parent resonance. On the other hand pions and kaons present in
 44 the medium may regenerate K^{*0} via pseudo-elastic scattering ($\pi K \rightarrow K^{*0}$). Hence the yield
 45 of the resonance is controlled by the relative contribution of these in-medium effects. The
 46 resonance to non resonance ratio (K^{*0}/K) can help us probe this phenomenon.

47 The left panel of Fig. 2 shows the K^{*0}/K and ϕ/K ratio as a function of the average
 48 number of participating nucleons $\langle N_{part} \rangle$. Here, we observe that the K^{*0}/K ratio decreases
 49 from peripheral to central collisions, while ϕ/K remains almost constant throughout all cen-
 50 tralities. The thermal model prediction overestimates the K^{*0}/K , whereas the ϕ/K ratio is
 51 consistent with the prediction. In right panel of Fig. 2 we present K^{*0}/K as a function of col-
 52 lision energy for both elementary and heavy-ion collisions. Here we observe the ratio in A+A
 53 collisions is suppressed as compared to the elementary collisions. All these measurements
 54 indicate a dominant hadronic re-scattering effect over regeneration in central A+A collisions.
 55 The ϕ meson, which has a long lifetime (~ 46 fm/c), may remain immune to these in-medium
 56 effects.

57 **3.2 Hadronic phase lifetime**

Here the time difference between CFO and KFO is considered as the hadronic phase lifetime.
 Since it's span can not be measured directly, we can use the K^{*0}/K ratio to extract the lower
 limit of hadronic phase lifetime [1] using the following [24] relation:

$$\left(\frac{K^{*0}}{K}\right)_{KFO} = \left(\frac{K^{*0}}{K}\right)_{CFO} \times e^{-\Delta t/\tau_{K^{*0}}}, \quad (1)$$

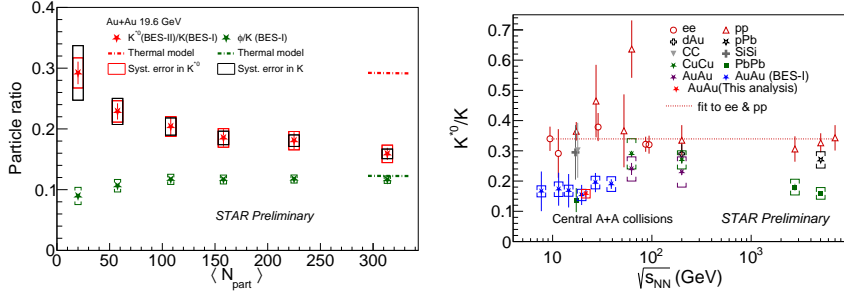


Figure 2. Left panel: Resonance to non-resonance ratio as a function of $\langle N_{part} \rangle$ along with the thermal model predication . Here K^{*0}/K and ϕ/K (BES-I)[2] denotes $(K^{*0} + \bar{K}^{*0})/(K^+ + K^-)$ and $2\phi/(K^+ + K^-)$ respectively. Here the K^{*0} measurement is based on BES-II data, whereas the measurement of kaons is from BES-I [3]. Hence their systematic uncertainties are denoted by different boxes. Right panel: K^{*0}/K as a function of collision energy [4–23]. The bars and caps (boxes) denote the statistical and systematic uncertainties respectively.

58 Here the $(K^{*0}/K)_{CFO}$ and $(K^{*0}/K)_{KFO}$ are taken to be the K^{*0}/K ratios measured in elementary
 59 elementary and heavy-ion collisions respectively. This method assumes that no K^{*0} regeneration
 60 takes place between the chemical and kinetic freeze out, and all K^{*0} that decay before the
 61 kinetic freeze out are lost due to the re-scattering effect. The calculated Δt is boosted by the
 62 lorentz factor which is estimated as $\sqrt{1 + (\langle p_T \rangle / mc)^2}$.

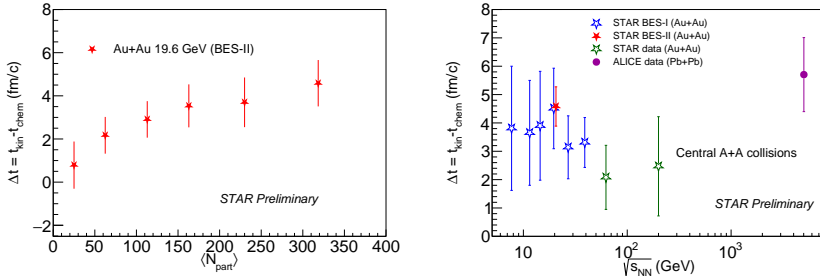


Figure 3. Left panel: Lower limit of hadronic phase lifetime (Δt) as a function of $\langle N_{part} \rangle$. Right panel: Lower limit of hadronic phase lifetime (Δt) as a function of collision energy. The result is compared with previous STAR and ALICE measurements [11, 13, 25]. The error bars are the quadratic sum of statistical and systematic uncertainties.

63 The left panel of Fig. 3 denotes the lower limit of hadronic phase lifetime as a function of
 64 N_{part} . The lifetime seems to increase from central to peripheral collisions. In the right panel
 65 of Fig. 3, Δt is plotted as a function of $\sqrt{s_{NN}}$ for central A+A collisions. RHIC measurement
 66 seems to be smaller compared to that of LHC, but the measurement uncertainties are large.

4 Summary

Measurement of K^{*0} at mid-rapidity in Au+Au collisions at 19.6 GeV (BES-II) is presented. The K^{*0}/K in central collisions appears to be less than that in peripheral collisions, and also the ratio is suppressed in heavy-ion collisions in comparison with elementary collisions. On the other hand, ϕ/K remains almost independent of centrality. This suggests that the hadronic phase formed in A+A collisions is mostly re-scattering dominated. The lower limit of hadronic phase lifetime is estimated using the K^{*0}/K ratio, which seems to be smaller as compared to LHC measurements in central heavy-ion collisions. A study with high statistics BES-II data across various energies is needed to draw definitive conclusions.

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