Study of re-scattering effect on elliptic flow and production of resonances using AMPT

Kishora Nayak[1],* Subhash Singha[2], Md. Nasim[3], and Bedangadas Mohanty[4]
[1,4]*National Institute of Science Education and Research, HBNI, Jatni, 752050, INDIA*
[2]*Kent State University, Kent, Ohio, 44242, USA and*
[3]*University of California, Los Angeles, California, 90095, USA*

Introduction

Relativistic heavy-ion collision experiments are performed to understand a deconfined state of matter, called Quark Gluon Plasma [1]. Study of resonances are important as their lifetime is comparable to that of the fireball created in such collisions. There are several experimentally measured resonance particles, $f_2(1270)$, $\rho(770)^0$, K*$(892)^0$, $\Lambda(1520)$ and $\phi(1020)$ with lifetime 1.1 fm/c, 1.6 fm/c, 4.2 fm/c, 12.6 fm/c and 46 fm/c, respectively. Their lifetime covers a typical time-scale of the fireball produced in heavy-ion collisions. In this work the K*$(892)^0$ and $\phi(1020)$ mesons are used as probe for the study of the hadronic medium formed in Pb–Pb collisions because of their similar masses and large difference in lifetime.

The system formed in heavy-ion collisions evolves and cools down with time. There are two different kind of freeze-outs to characterised the evolving system. At a temperature called chemical freeze-out ($T_{\rm ch}$) all the inelastic collision ceases whereas at kinetic freeze-out ($T_{\rm kin}$) the in-elastic interactions stops as the distance between particles becomes larger than their mean free path. When a short lived resonance such as K*$(892)^0$ decays before $T_{\rm kin}$, there is a probability that the decay daughters i.e π and K may re-scatter by changing their momentum with the in-medium particles. Therefore, the parent K*$(892)^0$ could not be reconstructed. On the other hand, the pions and kaons in the medium might regenerate resonances (e.g πK $\rightarrow$ K*$(892)^0$, KK $\rightarrow \phi(1020)$) through pseudo-elastic scattering. The final yield of resonances are determined by the interplay between re-scattering and regeneration. Both experimental and transport model calculations showed that re-scattering dominates over regeneration for K*$(892)^0$ in heavy-ions collisions [2, 3].

In this analysis, We performed a study to understand the transverse momentum ($p_{\rm T}$) dependence of re-scattering effect on K*$(892)^0$ and $\phi(1020)$ production using A Multi Phase Transport (AMPT) model [4]. We also study the effect of re-scattering on elliptic flow (v_2) of K*$(892)^0$ and $\phi(1020)$. The elliptic flow is a measure of anisotropy of produced particles in momentum space as defined in Eq. 1 [5].

$$v_2 = < cos2(\phi - \psi_2) > \qquad (1)$$

where ϕ is the azimuthal angle of produced particles and ψ_2 is the second order event plane angle.

In this report the average value of K*$(892)^0$ and $\overline{\rm K^*}(892)^0$, and $\phi(1020)$ are denoted as K*^{0} and ϕ, respectively.

Results

The results present in this analysis are using a string melting version of AMPT which is a transport model [4]. In AMPT one can vary the hadron cascade time ($\tau_{\rm HC}$) which is proportional to the time of the hadronic phase between chemical and kinetic freeze-outs. In order to study the effect of re-scattering on the observable presented here, we varied τ_{HC} from 0.6 to 30 fm/c. The number of minimum bias i.e MB (0-100%) events analysed is around 1.5×10^4 for the Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV in each configuration (various hadron cascade timing). The analysis is performed within the rapidity of $|y| < 1$.

*Electronic address: k.nayak1234@gmail.com

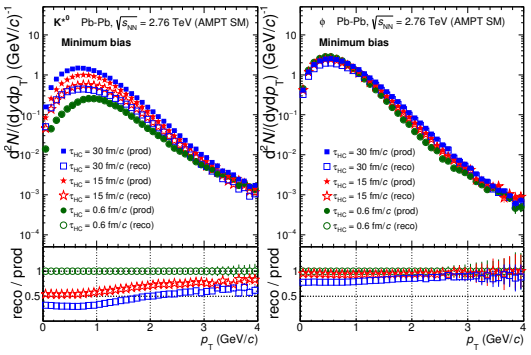

FIG. 1: $p_{\rm T}$-spectra of K^{*0} (left panel) and ϕ (right panel) for different $\tau_{\rm HC}$ values in MB Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV.

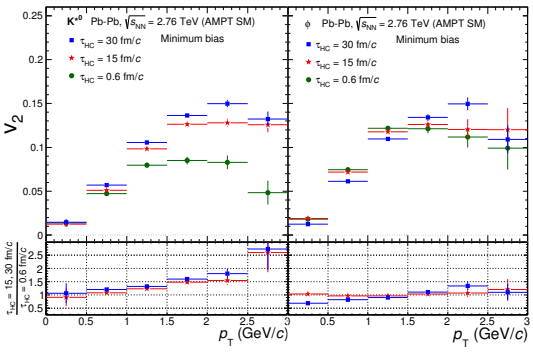

FIG. 2: v_2 of K^{*0} (left panel) and ϕ (right panel) as a function of $p_{\rm T}$ for different $\tau_{\rm HC}$ values in MB Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV.

On the left and right panel of Fig. 1, the solid markers represents the $p_{\rm T}$-spectra of all produced (prod) and open marker represents the reconstructable (reco) [i.e each component of decay daughter's momentum remains unchanged during the evolution of the systems] K^{*0} and ϕ mesons, respectively for different $\tau_{\rm HC}$ in MB Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV. Higher value of $\tau_{\rm HC}$ corresponds to longer time between T_{ch} and T_{kin}, so the decay daughters of K^{*0} gets more time to interact in the medium and hence there is more re-scattering effect. As ϕ meson have relatively longer lifetimes compared to K^{*0}, it decays outside the medium and so the decay daughters remain almost unaffected and no prominent re-scattering effect is observed for ϕ.

Fig. 2 shows the v_2 vs. $p_{\rm T}$ of K^{*0} (left panel) and ϕ (right panel) for different $\tau_{\rm HC}$ in MB Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV. In the bottom panels, the corresponding v_2 ratios w.r.t to the $\tau_{\rm HC}$ = 0.6 fm/c are shown. In case of K^{*0}, there observed a large value of v_2 for $\tau_{\rm HC}$ = 30 fm/c as compared to $\tau_{\rm HC}$ = 15 and 0.6 fm/c unlike ϕ and it might be due to the re-scattering effect which is more prominent for $\tau_{\rm HC}$ = 30 fm/c. It is also observed that the difference in v_2 for $\tau_{\rm HC}$ = 30 fm/c and 0.6 fm/c is increases with $p_{\rm T}$. The observation of higher v_2 value of K^{*0} as compared to corresponding ϕ v_2 value indicates that the hadronic cascade timing is affecting the K^{*0} more than the ϕ meson.

Conclusion

The phenomenon of re-scattering is observed prominently while comparing the reconstructable and produced K^{*0} $p_{\rm T}$ spectra in minimum bias Pb–Pb collision at $\sqrt{s_{\rm NN}}$ = 2.76 TeV for $\tau_{\rm HC}$ = 0.6, 15 and 20 fm/c in the string melting version of AMPT. However, for ϕ the re-scattering effect is almost negligible as compared to K^{*0}. We have also observed that with increase in the hadronic cascade time and hence the re-scattering effect, the K^{*0} v_2 also increases, whereas the ϕ v_2 is almost independent of $\tau_{\rm HC}$ and hence not affected much by re-scattering.

Acknowledgments

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