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MEASUREMENT OF Δ AND K^* PRODUCTION IN d+Au COLLISIONS AT $\sqrt{s_{NN}}$ = 200 GeV

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Abstract. The measurements of the transverse momentum spectra and the invariant mass distributions of Δ(1232) → πp, K^*(892) → πK resonances in d+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV using the STAR Time Projection Chamber (TPC) at RHIC are presented. The in-medium modification of the Δ and K^* mass and width has been studied as a function of transverse momentum (p_T). The particle ratios K^*/K, Δ/p and the average transverse momentum $\langle p_T \rangle$ as a function of different collision centrality has been reported. The nuclear modification factors (R_{CP} and R_{dAu}) of Δ and K^* are discussed.

Key words: transverse momentum spectra, resonance production, RHIC, STAR, modification factor, particle ratio.

1. INTRODUCTION

In a relativistic heavy ion collision an extended hot and dense matter is formed. At such a state, it is expected that nuclear matter goes through a phase transition from a confined (hadronic) matter to a de-confined phase or quark-gluon plasma (QGP). The studies of hadronic resonance with extremely short lifetimes (~ few fm/c) have the unique characteristics to probe the hadron production and the collision dynamics through their decays and re-generation. In the hot and dense matter, resonances and their hadronic decay daughters undergo re-scattering and re-generation, which affects various resonance properties such as yields, masses, widths and also in the modification in the observed momentum distributions of the resonances [1]. Resonances with higher p_T have a greater chance to be detected than the ones with lower p_T. That means higher momentum resonances leave the medium very fast and decay outside the medium, hence their daughter particles interact less with the medium [2]. The effect of re-scattering of the decayed daughters from resonances can destroy part of the primordial resonance yields. On the other hand, hadrons can interact with each other inside the medium and can enhance the primordial resonance yields [3]. Thus, measuring the resonance yields and their ratios with respect to the corresponding stable particles in heavy ion collisions, compared to the same in $p + p$ collisions, can provide the information about hadronization and the dynamics between the chemical and kinetic freeze-outs and possible medium effects.

In this report we present some results of the above mentioned study, through the production of Δ and K^* resonance in d+Au collision data taken by the STAR (Solenoidal Tracker At RHIC) experiment in 2002-2003 RHIC run. Comparing the results from d+Au collisions with the same from $p + p$ and Au+Au collisions will enables us to understand the in-medium effects.

2. ANALYSIS

In the present analysis, the Δ and K^* resonances signals were measured via their hadronic decay channels $\Delta^{++} \to p\pi^+$, $\overline{\Delta}^{--} \to \overline{p}\pi^+$, $K^{*0} \to K^+\pi^-$, $\overline{K^{*0}} \to$ $\to K^-\pi^+$ and $K^{*\pm} \to K^0_S\pi^\pm$ in d+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. The main tracking device in the STAR experiment is the TPC [4], which provides both the momentum information and the particle identification of the charged particles by measuring their ionization energy loss (dE/dx) in the TPC. The minimum bias trigger was defined by requiring at least one beam-rapidity neutron in the Zero Degree Calorimeter (ZDC) in the Au beam direction, which is assigned the negative pseudorapidity (η) [5]. The centrality of the d+Au collisions was determined by the charged particle multiplicity (N_{ch}) within a pseudorapidity window of $-3.8 < \eta < -2.8$ was measured by the Forward TPC (FTPC) along the

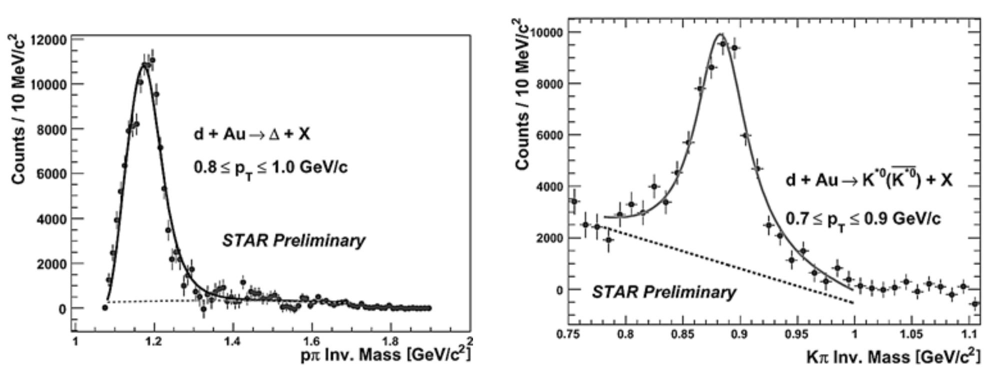


Fig. 1 – (a) The $p\pi$ pair invariant mass spectrum. (b) The $K\pi$ pair invariant mass spectrum after mixed-event background subtraction fitted with BW $\times$ PS + background.

Au beam direction. The *d*+Au centrality definition consists of three event centrality classes; 0–20%, 20–40% and 40–100% of the total *d*+Au inelastic cross section. In this analysis, about 11.7M and 15M *d*+Au minimum bias events have been used for Δ and K^* respectively. The Δ and K^* invariant mass spectra are reconstructed using the event-mixing technique [6]. Fig. 1, shows the invariant mass spectra for Δ and K^*, fitted with the *p*-wave Breit-Wigner function times the phase space factor (BW × PS) and a residual background function [7, 8]. For Δ case the residual background is described by a Gaussian function, whereas for K^* case it is described by a linear function.

3. RESULTS

On the left panel of the Fig. 2, one can see there is a mass shift for both K^{*0} and $K^{*\pm}$ at lower p_T bins. It is about 10 MeV/c^2 less compared to the standard Particle Data Group (PDG) [10] value for $p_T < 0.9$ GeV/c. The resonances produced with low p_T spent more time inside the medium than the high p_T resonances, resulting in a modification in their masses. The high p_T resonances leave the medium very fast and don't get modified. On the right panel shows the Δ mass distribution for $0.2 < p_T < 1.6$ GeV/c. Which shows the clear mass shift on the average up to about 50 MeV/c^2 observed. The relatively smaller reconstructed masses compared to the standard value may be attributed to the momentum loss

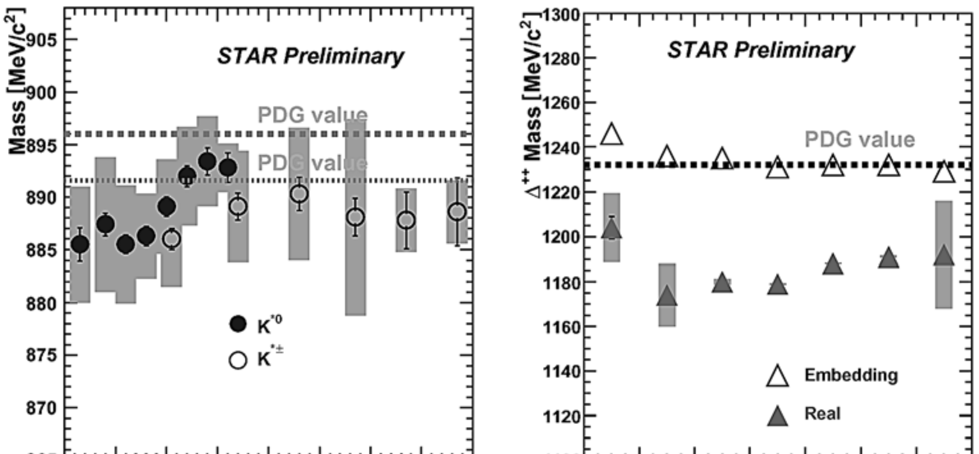


Fig. 2 – The resonance mass with their stat. and sys. uncertainties as a function of p_T, Left panel: for K^*, Right panel: for Δ mass from real data (filled symbols) compared with the results obtained from Monte Carlo (MC) simulation (open symbols).

from the re-scattering of decayed daughters. In Fig. 3, the width has been plotted as a function of p_T for both K^* and Δ. On the left panels of the figure we don't see any difference between the width of K^{*0} and $K^{*\pm}$ from their PDG value. The right panel shows an increase in Δ width with increase in p_T, excepting the last p_T bin, which is expected to be because of dynamical cut effects. From the fit to the invariant mass spectra, the Δ and K^* raw yield has been extracted and corrected for efficiency and acceptance. Fig. 4 shows the corrected p_T spectra for Δ and K^* for

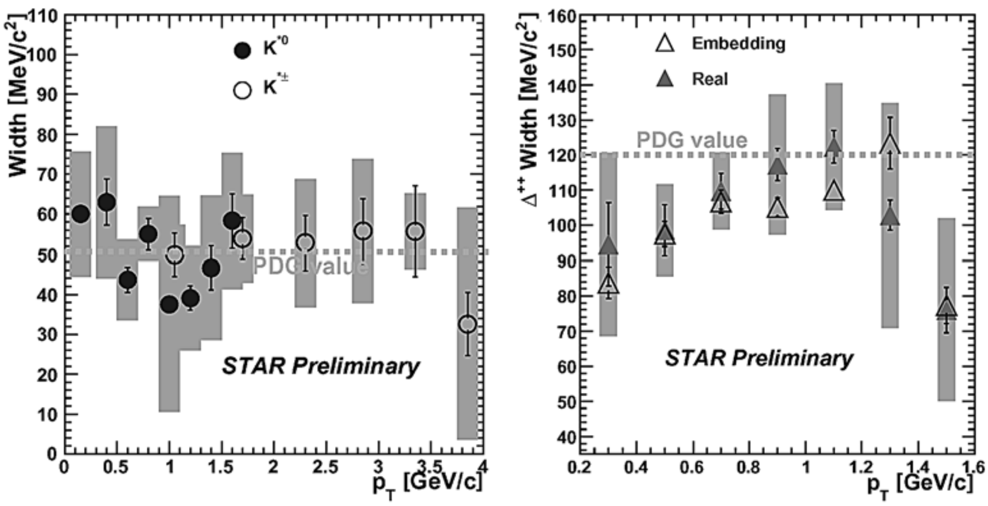


Fig. 3 – Left panel: the K^* width with their stat. and sys. uncertainties as a function of p_T, Right panel: the Δ mass from real data (filled symbols) and the Monte Carlo (MC) simulation (open symbols) as a function of p_T.

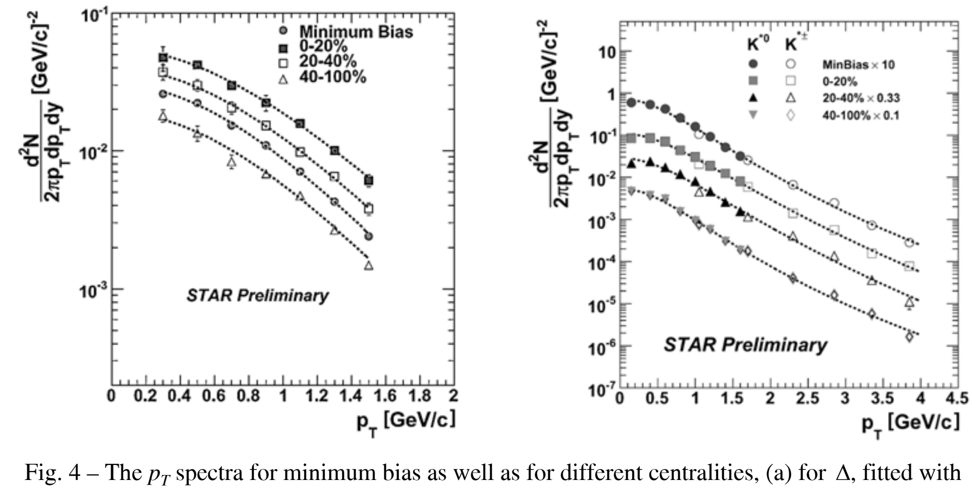
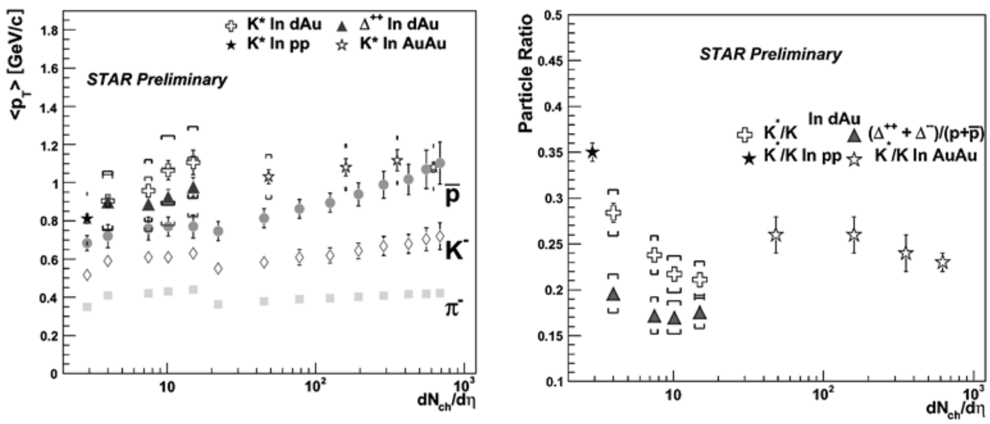


Fig. 4 – The p_T spectra for minimum bias as well as for different centralities, (a) for Δ, fitted with exponential function and (b) for K^*, fitted with Levy function.

minimum bias as well as for different collision centralities. From the fitting to the p_T spectra one can get the resonance yield (dN/dy) at mid-rapidity and the inverse slope parameter T for Δ and K^* for d+Au collisions [8, 9]. As has been discussed earlier, the resonances having higher p_T have greater probability to be detected than the low p_T ones, thus we expect higher mean transverse momentum $(\left(\langle p_T \rangle\right))$ values in heavy ion collisions than in elementary collisions, such as $p + p$ collisions [3]. In the left panel of Fig. 5, one can see, the $\langle p_T \rangle$ values for K^* increase with centrality and higher than the same obtained from $p + p$ collisions at same center of mass energy, whereas there is no centrality dependence observed in Au+Au collisions [8]. In the same figure for the case of Δ, there is a slight increase in $\langle p_T \rangle$ as we go from peripheral to central collisions. The middle panel of the Fig. 5, we can see that the K^*/K ratios in d+Au and Au+Au collisions are significantly



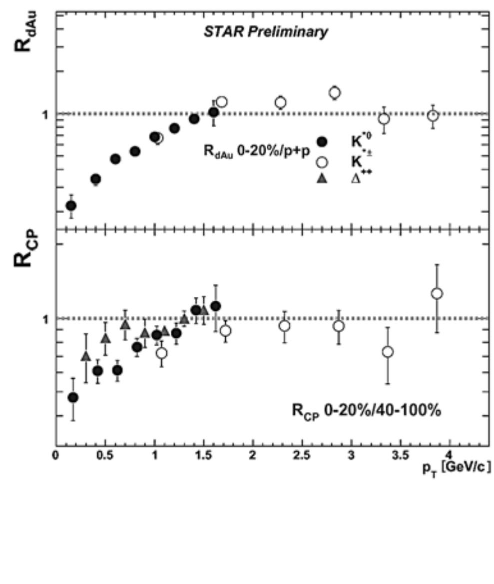


Fig. 5 – Left: The Δ and K^* $\langle p_T \rangle$ as function of charged hadrons compared with π^-, K^{*-}, $\bar{p}$, middle: K^*/K and Δ/p ratio as a function of charged hadrons, right: Δ and K^* nuclear modification factor as a function of p_T.

smaller than the same in $p+p$ collisions. The K^*/K ratio suppression may indicate that between the chemical and kinetic freeze-out, K^* signals are predominantly destroyed due to the re-scattering of daughter particles which cannot be compensated by the re-generation effect. Where as for $(\Delta^{++}+\overline{\Delta}^{--})/(p+\overline{p})$ ratios don't show any centrality dependence in d+Au collisions. The right panel of the Fig. 5 shows the nuclear modification factor R_{dAu} and R_{CP} for Δ and K^* as a function of p_T. The R_{CP} values are less than unity at low p_T region. But R_{dAu} and R_{CP} close to unity at $p_T > 1.5$ GeV/c for both Δ and K^*. The lower value of R_{CP} for low p_T region seem to be a result of re-scattering of daughter particles inside the medium.

4. CONCLUSIONS

The preliminary results on Δ and K^* resonances measured using the TPC in STAR experiment at mid-rapidity in d+Au collisions at $\sqrt{s_{NN}}$ are reported. The downward mass shift (~ 10 MeV) observed at lower p_T bins are observed for K^* and there is a clear mass shift (up to ~ 50 MeV) observed for Δ resonance over all p_T bins. The observed K^*/K ratios in d+Au collisions are significantly smaller than that for $p+p$ collisions. On the other hand Δ/p ratios in d Au collisions are independent of centrality. The $\langle p_T \rangle$ for K^* in d Au collisions is higher than the same obtained from $p+p$ collisions, in agreement with p_T-dependence of daughter particles' re-scattering effect. The nuclear modification factor is close to unity for both Δ and K^* resonaces at $p_T > 1.5$ GeV/c.

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