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Understanding the rescattering effect on Λ(1520) resonance production in different systems and collision energies with ALICE at LHC

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Hadronic resonances are effective tools for studying the hadronic phase in ultrarelativistic heavy-ion collisions. In fact, their lifetime is comparable to that of the hadronic phase, therefore resonances are sensitive to effects such as rescattering and regeneration processes, which affect their yields and the shape of the transverse momentum spectra. These processes can be studied by considering the yield ratio of resonance to the corresponding long-lived particle as a function of the charged-particle multiplicity. A significant suppression is observed for $\mathrm{K}^{*0}/\mathrm{K}$ with increasing multiplicity from pp to central Pb–Pb collisions. On the contrary, such suppression is not observed for the ϕ/K ratio. The $\Lambda(1520)$ resonance is of particular interest due to its lifetime being of 13 fm/c, which is in between the lifetimes of the K^{*0}(4 fm/c) and ϕ(46 fm/c) resonances, and thus provides more insight into the properties of the hadronic phase. These proceedings present the recent results on $\Lambda(1520)$ resonance production and the effect of rescattering on this resonance production in pp, p–Pb and Pb–Pb collisions with ALICE.

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1. Introduction

Lattice QCD calculations mark substantial progress in comprehending the properties of hadronic matter, providing a vital tool to explore fundamental physics in extreme conditions. These calculations predict a phase transition from ordinary nuclear matter to a deconfined plasma of quarks and gluons (QGP), a state created at the Large Hadron Collider (LHC) through relativistic high-energy collisions. In ultrarelativistic heavy-ion collisions, resonance particles provide insights into the properties of the hadronic phase, created between the chemical and the kinetic freeze-out. Long-lived hadron yields are consistent between the chemical and the kinetic freeze-outs. Interactions with hadrons may cause pseudo-elastic rescattering or regeneration effects on resonance particles, which affect their yields and transverse momenta. The regeneration process increases the resonance yield while rescattering diminishes the reconstructible yield compared to the production at the chemical freeze-out phase.

Recent results from ALICE reveal a suppression in the yield of $K^{*0}(892)$ and $\Lambda(1520)$ in central Pb–Pb collisions, that is in contrast with the absence of such suppression for the $\phi(1020)$ resonance [1, 2]. In smaller systems, $K^{*0}(892)$ exhibits suppression, whereas no suppression is observed for $\Lambda(1520)$ and $\phi(1020)$ resonances [3, 4]. The $\Lambda(1520)$ resonance, with a lifetime of approximately 13 fm/c, positioned between the lifetimes of K^{*0} (4 fm/c) and ϕ (46 fm/c), provides unique insights into the characteristics of the hadronic phase.

2. Experimental and analysis details

Due to their short lifetime, resonances are not directly detectable and are reconstructed from their hadronic decay products using the invariant mass method. The ALICE detector at the LHC is specifically designed for studying the quark-gluon plasma with heavy-ion collisions. Various subdetectors within ALICE play crucial roles in the analysis of resonances. The Inner Tracking System (ITS) and the Time Projection Chamber (TPC) contribute to determining the primary vertex, tracking particles, and allowing particle identification (PID) through specific energy loss measurements. The Time-Of-Flight (TOF) detector specializes in PID by precisely measuring particle time of flight. Additionally, the V0A ($2.8 < \eta < 5.1$) and V0C ($-3.7 < \eta < -1.7$) detectors are employed for event triggering and event selection based on charged-particle multiplicity at forward rapidities [5].

The production of $\Lambda(1520)$ resonance is determined through invariant mass reconstruction of its hadronic decay channel: $\Lambda(1520) \rightarrow pK^-$ ($\overline{\Lambda}(1520) \rightarrow \overline{p}K^+$). In heavy-ion collisions at midrapidity (|y| < 0.5), the measurements of resonance production involve, as a first analysis step, estimating the combinatorial background using the event-mixing technique. After background subtraction, A Voigtian function is used to fit the signal in the invariant mass distribution, with a second-order polynomial accounting for residual background. Subsequently, the raw p_{T} spectra are corrected for the detector's acceptance × efficiency and branching ratio.

3. Results and discussion

The p_{T} spectra for the $\Lambda(1520)$ resonance are shown for various collision systems and energies in Figure 1. The hardening of the p_{T} spectra is observed with increasing multiplicity, resembling

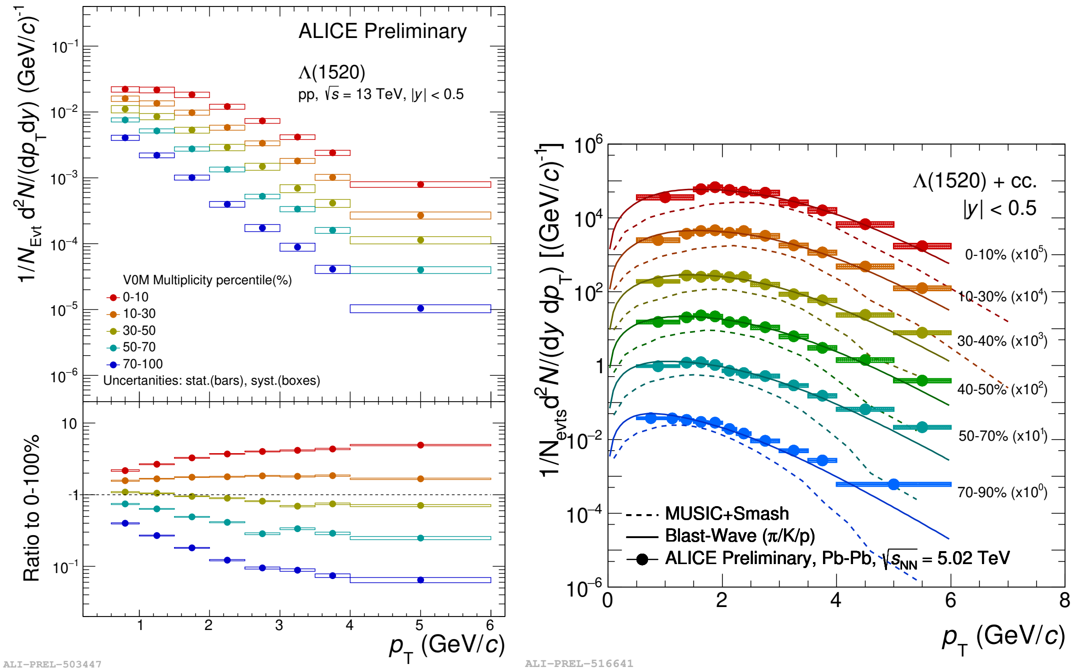

Figure 1: $\Lambda(1520)$ p_{T} spectra for different multiplicity and centrality classes at mid rapidity in pp collisions at 13 TeV (left side) and Pb–Pb collisions at 5.02 TeV (right side) respectively.

flow-like effects in heavy-ion collisions. For Pb–Pb collisions at 5.02 TeV, the spectral shapes are well-described by the blast-wave model [6] and are well reproduced by the MUSIC with SMASH afterburner prediction [7] at low p_{T}, while they diverge at high p_{T}. The $\langle p_{\mathrm{T}} \rangle$ of $\Lambda(1520)$ resonance

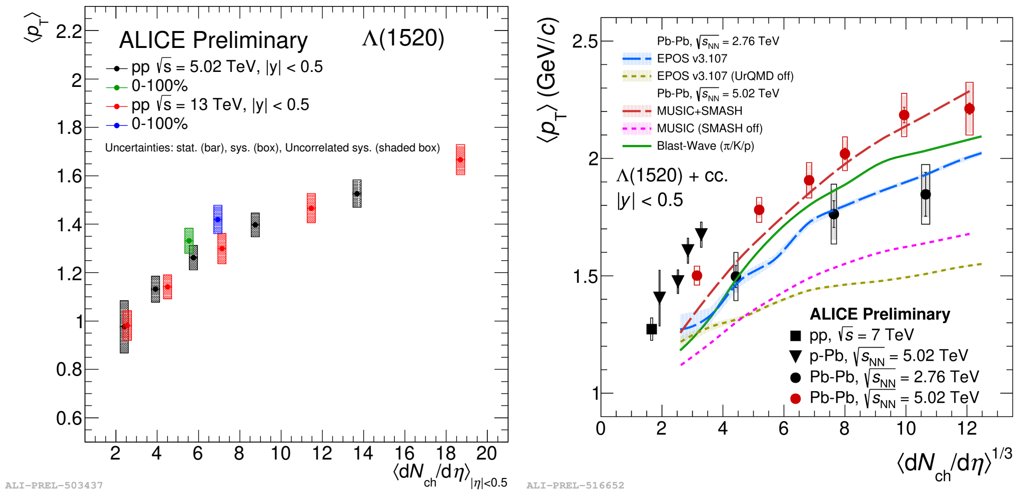

Figure 2: The mean transverse momentum ($\langle p_{\mathrm{T}} \rangle$) of $\Lambda(1520)$ as a function of charge particle multiplicity (left side) and $\langle dN_{\mathrm{ch}}/d\eta \rangle^{1/3}$ (right side) in pp collisions at 13 TeV and Pb–Pb collisions at 5.02 TeV respectively.

in different systems and energies are shown in Figure 2. It increases with event multiplicity and rises from peripheral Pb–Pb to central Pb–Pb collisions.

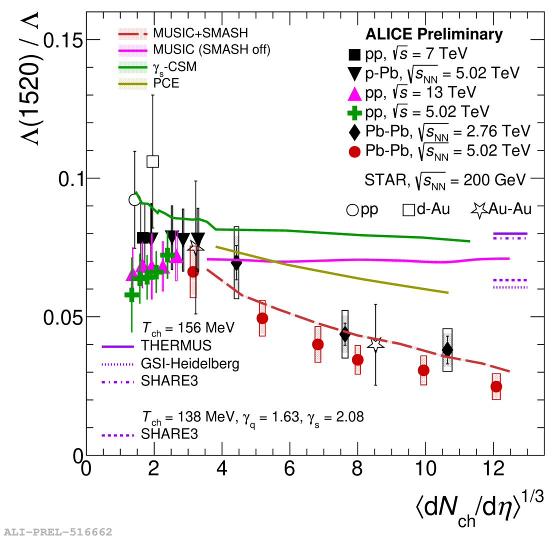

Figure 3: The p_{T}-integrated ratio of $\Lambda(1520)/\Lambda$ production as a function of $\langle dN_{\mathrm{ch}}/d\eta\rangle^{1/3}$.

The $\Lambda(1520)/\Lambda$ ratio is shown in Figure 3. The ratio is suppressed in central Pb–Pb collisions compared to pp and peripheral Pb–Pb collisions. No suppression is observed in the $\Lambda(1520)/\Lambda$ ratio for p–Pb at $\sqrt{s_{\mathrm{NN}}} = 5.02$ and pp collisions at $\sqrt{s} = 5.02$ and 13 TeV. The suppression in the resonance yield could be attributed to the presence of the hadronic phase, where the rescattering effect affects the resonance yield in heavy-ion collisions.

4. Conclusion

The p_{T} spectra of $\Lambda(1520)$ exhibit a hardening trend with increasing multiplicity irrespective of the system and energies. The $\Lambda(1520)/\Lambda$ ratio is suppressed in central Pb–Pb collisions, indicating potential rescattering dominance over regeneration. No suppression is observed in p–Pb and pp collisions suggesting the influence of the hadronic phase on resonance yield in heavy-ion collisions.

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