Journal of Physics: Conference Series

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To cite this article: A Karasu Uysal and the ALICE Collaboration 2014 *J. Phys.: Conf. Ser.* **562** 012014

Production of Hadronic Resonances at LHC Energies with the ALICE Experiment

A. Karasu Uysal for the ALICE Collaboration

KTO Karatay University, Konya, Turkey

E-mail: akarasu@cern.ch

Abstract. Hadronic resonances are strongly decaying particles with extremely short lifetimes of about few *fm/c*, which are comparable to or smaller than the lifetime of the system formed in relativistic collisions. Due to their short lifetimes, resonance particles can be used to investigate the freeze-out mechanisms after hadronization. This contribution summarizes the results of resonance particle productions measured by the ALICE collaboration at LHC from various colliding systems and energies. Measured mass, width, transverse momentum and particle ratios of those resonances have been reported. Theoretical predictions from thermal model calculations are also presented.

1. Introduction

The production of resonances in relativistic collisions is sensitive to the properties of strongly interacting matter produced in these collisions. Modification of the production rates and the in-medium properties of hadronic resonances can be used as signatures of a possible phase transition of nuclear matter to a deconfined state of quarks and gluons [1].

The lifetime of resonances is expected to be less than the lifetime of the formed system. Therefore, resonances are expected to decay, re-scatter and regenerate all the way throughout the kinetic freeze-out [2]. The measurement of the resonance yield can provide information about hadronization and the time evolution of source from chemical to kinetic freeze-out [3].

ALICE [4] is the only LHC detector mainly dedicated to the study of ultrarelativistic heavy-ion collisions, in order to investigate the properties of the Quark-Gluon Plasma (QGP). It is a very well suited device for resonance measurement as it provides extensive particle tracking and identification at mid-rapidity ($|\eta| < 0.9$).

This proceedings present the measured results of the $K^*(892)^0$ and $\phi(1020)$ resonances in pp collisions at $\sqrt{s}$ = 7 TeV, in p–Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV and in Pb–Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV using the ALICE Detector at the LHC.

2. Reconstruction of Resonances

The Inner Tracking System (ITS), the Time Projection Chamber (TPC), the Time-of-Flight Detector (TOF) and the Vertex-0 (V0) Detector are sub-detectors of ALICE used to measure the resonance production through the detection of its hadronic decay products.

Resonances are reconstructed using their decay channels: $K^* \rightarrow K^+\pi^-$ and $\phi \rightarrow K^+K^-$ by invariant mass method only after kinetic freeze-out, when decay products do not re-scatter. Event-mixing technique [5] is used to remove the combinatorial background present in the invariant mass spectra. After the

subtraction of the combinatorial background, the signal fitted with Breit-Wigner and polynomial functions to describe the peak and the remaining residual background, respectively.
Measured mass and width of K^* and ϕ resonances in Pb–Pb collisions are presented in Figure 1. The mass and width of resonances are in agreement with vacuum (Particle Data Group - PDG [6]) values.

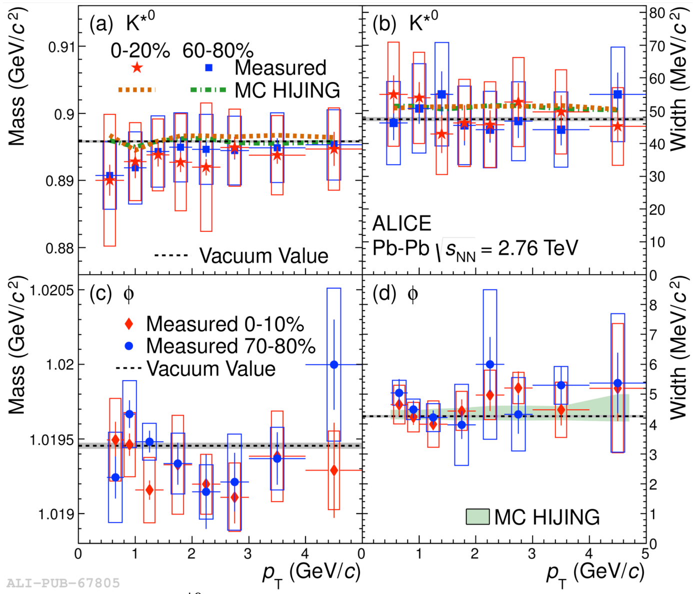

Figure 1. (Upper Panel) Measured K^{*0} meson mass (a) and width (b) in Pb–Pb collisions at 2.76 TeV in the 0-20% and 60-80% centrality intervals, along with the values extracted from Monte-Carlo HIJING simulations. (Lower Panel) Measured ϕ meson mass (c) and width (d) in Pb–Pb collisions at 2.76 TeV in the 0-10% and 70-80% centrality intervals. The ϕ width extracted from HIJING simulations is also shown. The vacuum values of the K^{*0} and ϕ mass and width [PDG] are indicated by the horizontal dashed lines. The statistical uncertainties are shown as bars and the total systematic uncertainties are shown as boxes.

3. Results

The raw counts of K^* and ϕ extracted from the invariant mass fits have been corrected for reconstruction efficiency, acceptance and branching ratio in order to obtain the transverse momentum spectra. Figure 2 shows the corrected transverse momentum spectra of K^* and ϕ spectra in different collision centrality classes in p–Pb collisions at 5.02 TeV. The results on K^* and ϕ production in pp and in Pb–Pb collisions can be found in [7] and [8].

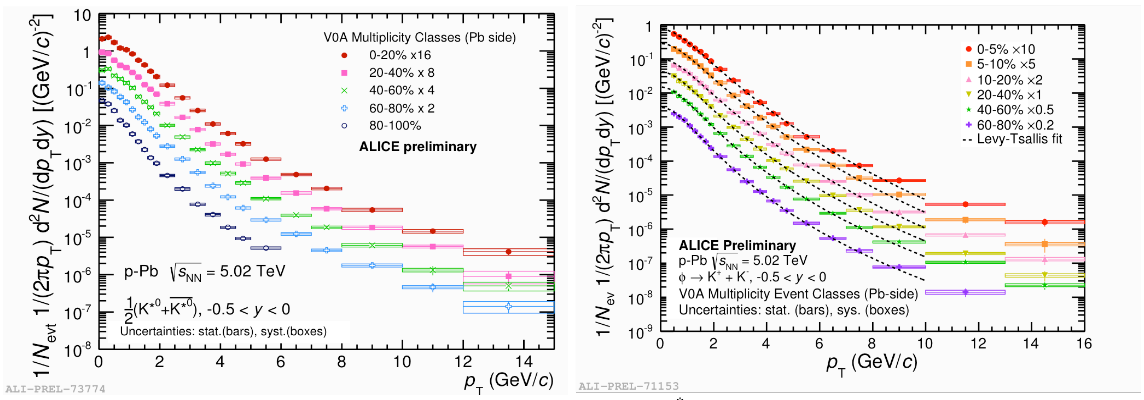

Figure 2. Transverse momentum spectra of (left panel) K^* and (right panel) ϕ resonances in p–Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. Bars and boxes represent statistical and systematic uncertainties, respectively [9].

p/ϕ, ϕ/K and K*/K particle ratios presented in Figure 3. In the most central Pb–Pb collisions p/ϕ ratio is flat below 3 GeV/c. In central p–Pb collisions, the ratio shows a flattening for p_T<1.5 GeV/c and it is similar to 60-80% peripheral Pb–Pb collisions. In peripheral Pb–Pb, peripheral p–Pb and pp collisions the p/ϕ ratios are similar and decrease rapidly with transverse momentum. The measured ratios ϕ/K and K*/K presented in right panel of Figure 3. The ϕ/K ratio is independent from system size and reaches the value predicted by a grand-canonical thermal model with T = 156 MeV [10], the K*/K ratio is decreasing towards more central Pb–Pb collisions, where the measured ratio is about 60 % of the thermal model value.

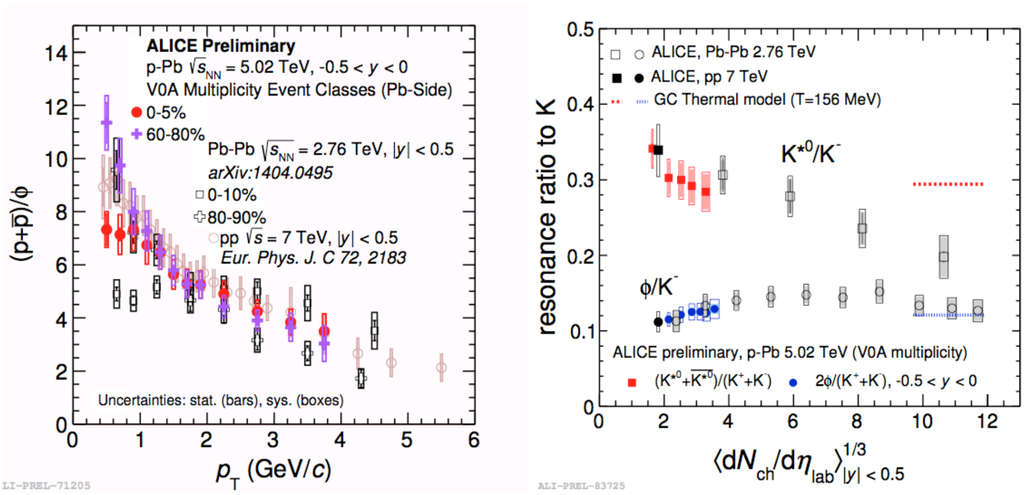

Figure 3. (Left panel) $(p+p^-)/\phi$ ratio measured in p–Pb in 0-5% (red dot) and 60-80% (purple cross) V0A multiplicity classes, compared to pp (pink), 0-5% (black hollow squares) and 60-80% (black hollow cross) Pb–Pb collisions. (Right panel) ratio of resonances to charged kaons measured in the three collision systems, as a function of the system size [9].

4. Conclusions

The spectra, mass, and width of the K* and ϕ mesons have been measured in pp, p–Pb and Pb–Pb collisions using the ALICE detector at LHC energies. Mass and width of the resonances are consistent with the nominal values. Because of the measured K*/K ratio is significantly lower than the thermal model estimation suggests that in central Pb–Pb collisions, K* suffer from re-scattering due to the short lifetime [7].

Acknowledgment

This work was supported by Scientific and Technological Research Council of Turkey (TUBITAK, Project No 113F221).

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