Hadronic resonance production measured with the ALICE detector at the LHC

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Abstract. Hadronic resonance production has been studied with the ALICE detector in different collision systems at LHC energies. The aim is to disentangle initial-state effects from genuine medium-induced effects, which may occur in the hot and dense hadronic matter after the chemical freeze-out in Pb–Pb collisions. In these proceedings, transverse-momentum spectra of $\phi(1020)$ and $K^*(892)^0$ and the ratio of their yield to long-lived particles are discussed in this light.

1 Introduction

In ultra-relativistic heavy-ion collisions, a hot and dense state of matter, the quark-gluon plasma, is produced [1], which is expected to undergo a transition from partonic to hadronic phase (the so-called chemical freeze-out) at a predicted temperature of $T_c \approx 156$ MeV [2]. Particle yields at chemical freeze-out have been found to be successfully predicted by statistical models, but the measured resonance yields may deviate from the predictions because hadronic processes such as regeneration and re-scattering, which affect the short-lived resonances, occur in the hadronic phase before kinetic freeze-out [3]. Therefore, reconstructing resonances in their hadronic decay channel can provide some insight into the dynamical evolution of the fireball between chemical and kinetic freeze-out.

Both meson and baryon resonances have been measured by the ALICE experiment [4] in different collision systems (pp, p–Pb, Pb–Pb) at LHC energies [5–8]. The study of resonance production in pp and p–Pb collisions provides a necessary baseline to disentangle initial-state effects from genuine medium-induced effects, which may occur in Pb–Pb collisions. In these proceedings, focus is given to the meson resonances $\phi(1020)$ and $K^*(892)^0$, reconstructed at mid-rapidity in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV [5] and in p–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV. Transverse-momentum distributions and particle ratios to stable particles as function of the multiplicity are discussed in Section 2 and 3, respectively, suggesting that in central Pb–Pb collisions $K^*0$ suffers from re-scattering due to its short lifetime ($\tau \approx 4$ fm/c), while compared to it, $\phi$ ($\tau \approx 45$ fm/c) behaves as a long lived particle.

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2 Transverse momentum spectra

The transverse momentum distributions of the φ and K*0 resonances in central (0–20%) and peripheral (60–80%) Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV [5] are compared in Figure 1 to the blast-wave [9] prediction for the spectral shapes. The parameters of the blast-wave curves are obtained from a simultaneous fit to the transverse-momentum distributions of charged particles (pions, kaons and protons) in Pb–Pb collisions [10]. The curves are normalized to the measured yields of the charged kaons in Pb–Pb collisions [10], multiplied by the φ/K and K*0/K ratios given by a thermal-model fit to ALICE data [2]. This provides the expected yields if no re-scattering effects occur.

For the φ meson the predictions are satisfactorily describing the data over all the measured $p_T$ range, in both central and peripheral collisions. The data/theory ratio is around unity up to $p_T \approx 2$ GeV/c. The same conclusions hold for the K*0 in peripheral collisions, where the data/theory ratio does not appear to deviate significantly from unity for $p_T < 2$ GeV/c. On the contrary, in central collisions the K*0 appears suppressed by a factor $\gtrsim 1/3$. The deviation is about three times larger than the uncertainties, giving some hints that K*0 has undergone non-negligible re-scattering effects.

3 Particle ratios

Figure 2 shows the ratios of particle yields, K*/K− and φ/K− for Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV [5], p–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV and pp collisions at $\sqrt{s} = 7$ TeV [7]. These ratios are presented as function of $(dN_{ch}/d\eta)^{1/3}$, where $dN_{ch}/d\eta$ is the charged-particle multiplicity density. The cube root relates $dN_{ch}/d\eta$ to the system radius [11].
Figure 2. Ratios of particle yields, $K^0/K^-$ and $\phi/K^-$, as function of the cube root of the charged-particle multiplicity density, $dN_{ch}/d\eta$ [5, 7]. Thermal model predictions [2] are given for central Pb–Pb collisions.

The $\phi/K^-$ ratio in central Pb–Pb collisions is consistent with the values measured in pp and p–Pb collisions, as well as with the prediction of a thermal model [2], which has a chemical freeze-out temperature of 156 MeV and a baryochemical potential of 0 MeV and does not include re-scattering effects. The parameters of the model are obtained by fitting particle yields measured in central Pb–Pb collisions, including the $\phi$ yield and excluding the $K^0$ yield. The $K^0/K^-$ ratio in central Pb–Pb collisions appears significantly lower than in peripheral collisions, as well as in pp and p–Pb collisions. This suppression of the $K^0/K^-$ ratio in more central Pb–Pb collisions may be related to re-scattering effects, which affect only the $K^0$ meson due to its shorter lifetime compared to the lifetime of the fireball.

References