Resonance Production in $\sqrt{s} = 7$ TeV pp collisions with ALICE.

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Abstract. The study of pp collisions at LHC energies is important not only as a baseline for future analysis in heavy-ion events at ALICE but aiding also in the calibration of QCD inspired models at LHC energies. ALICE has measured the $\Sigma^*(1385)$, $\phi(1020)$ and $K^*(892)$ resonances in pp collisions at $\sqrt{s} = 7$ TeV, measurements include the mass and width of the Σ^* resonance, normalised spectra and particle ratios. The Σ^*, ϕ and K^*, measurements are compared to QCD inspired models with additional ϕ measurements at $\sqrt{s} = 2.76$ TeV giving a greater range in transverse momentum than in earlier analysis.

1. Introduction

The production of resonances with proton-proton collisions at ALICE can be studied as a useful probe to help understand the underlying event in the collisions, due to the majority of the final state particles originating from these resonances [1]. These measurements can be used to tune QCD inspired models such as PYTHIA [2] and PHOJET [3], which are tuned to LHC energy values. In heavy-ion collisions, some resonances are sensitive probes of the environment within the created fireball. Due to the short lifetime of the order of 1-10 fm/c, resonances such as the Σ^* and ϕ decay within the medium before freeze-out. For heavy-ion collision analysis a baseline in proton-proton collisions is needed for comparison.

2. Analysis Method

Resonance studies at $\sqrt{s} = 7$ TeV exploit the Inner Tracking System (ITS) and Time Projection Chamber (TPC) for vertex reconstruction and tracking. The position of the primary vertex along the beam axis is required to be within ± 10 cm from the centre of the ALICE Barrel. Resonances are reconstructed at mid-rapidity through their dominant hadronic decay channel, $K^* \to \pi^{\pm} + K^{\mp}$, $\phi \to K^+ + K^-$, $\Sigma^{*+} \to \Lambda + \pi^+$, $\Sigma^{*-} \to \Lambda + \pi^-$, $\bar{\Sigma}^{*+} \to \bar{\Lambda} + \pi^+$ and $\bar{\Sigma}^{*-} \to \bar{\Lambda} + \pi^-$. The ϕ and K^* analyses combined the information from the TPC and Time Of Flight (TOF) detectors for the particle identification of the decay product candidates. These candidates where identified by requiring a TPC energy loss or Time of Flight measurement within at least 3σ of the expected value for a given candidate. This requirement was relaxed in the $\sqrt{s} = 2.76$ TeV pp analysis of the ϕ resonance allowing the maximum p_T for ϕ reconstruction to be increased from 7 GeV/c to 20 GeV/c. The Σ^* analysis required the Λ candidate to be identified via its weak decay, with the daughters having a Distance of Closest Approach (DCA) of lower than 0.05 cm. Resonance peaks are reconstructed from the invariant-mass distribution of the identified daughters. The combinatorial background is estimated and removed using the event-mixing technique. The resonance peaks are fitted with a Breit-Wigner (for the K^{*0}) or a convolution of a Breit-Wigner with a gaussian (for the ϕ) function plus a polynomial (to describe the shape of the residual background). The Σ^* signal was also fitted with a Breit-Wigner function plus a polynomial (for the residual background), but in addition a Gaussian function was used to fit the $\Lambda-\pi$ pairs resulting from the $\Lambda(1520)$ contamination. The inclusion of this contamination within the fitting process was critical in producing a stable fit throughout the p_T range measured. The raw yields are corrected for acceptance and efficiency ($A \times \epsilon$) from Monte Carlo simulations with the PYTHIA 6.4 event generator (tune Perugia 0 for the mesonic analysis and tune Perugia 0 [4] for the baryonic analysis) and a GEANT3-based simulation of the ALICE detector response [5].

3. Results

The masses and widths of the extracted Σ^* as a function of transverse momentum p_T are shown in figure 1. Both the mass and width values show no overall p_T dependence and no significant deviation from the PDG values. The ratios of the yields of Σ^* over Ξ^-, π^- and K^- as a function of collision energy in figure 2 are in an agreement with the ratio obtained from the Σ^* STAR analysis [6] and the π, K and Ξ STAR analysis [7] [8]. The measured ratios are also in agreement with the predictions of a statistical hadronization model with $T = 170$ MeV and a strangeness suppression factor $\gamma_s = 0.6$ by Becattini [9]. The value for Σ^* has been provided by the author in private communication and was obtained with the same model.

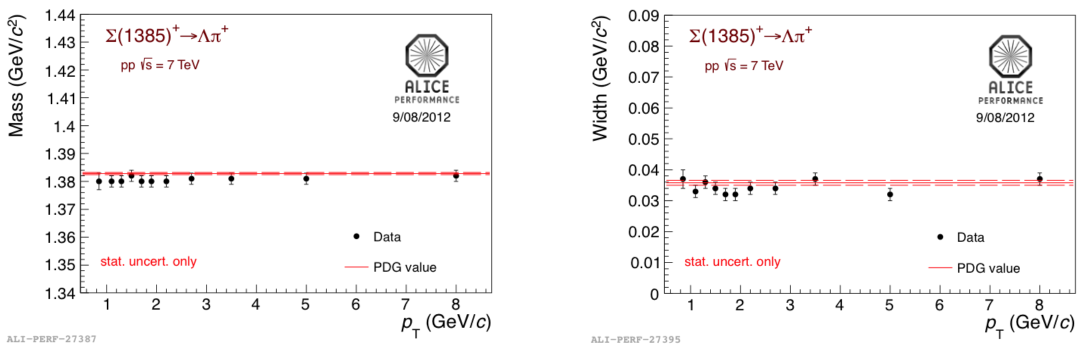

Figure 1. Mass and width values for $\Sigma^+(1385)$.

Figure 3 shows the extracted p_T spectra of ϕ, K^* and Σ^* at 7 TeV compared to theoretical models. There is little agreement for both ϕ and K^* with the best agreement found with PYTHIA D6T tune. PYTHIA ATLAS-CSC and PHOJET over-predict the ϕ and K spectra at low p_T while the PYTHIA and Perugia 0 tune underestimates both by nearly a factor two. The Σ^* spectrum is underestimated for all tunes with the largest deviation in line shape resulting from the D6T tune. The analysis of the ϕ spectra at the lower collision energy of $\sqrt{s} = 2.76$ TeV allows further investigation of the spectra at a higher p_T ($> 7GeV/c$) than the 7 TeV analysis. Figure 4 shows the ratio of ϕ/π as a function of p_T for different collision energies, including results from PHENIX at $\sqrt{s} = 200$ GeV [10] and preliminary plots from PHENIX at $\sqrt{s} = 62.4$ GeV. With the $\sqrt{s} = 2.76$ TeV analysis this ratio can be extended up to higher p_T where a saturation is observed in the ratio.

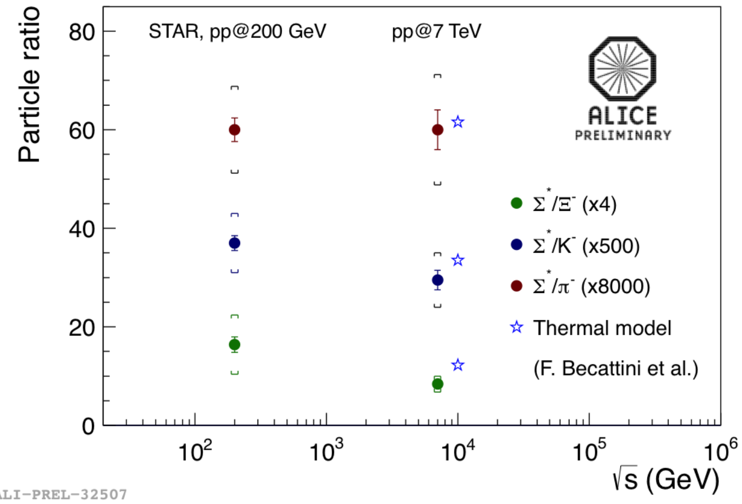

Figure 2. Σ^* ratios to stable particles as a function of collision energy with comparison to Becattini thermal model [9].

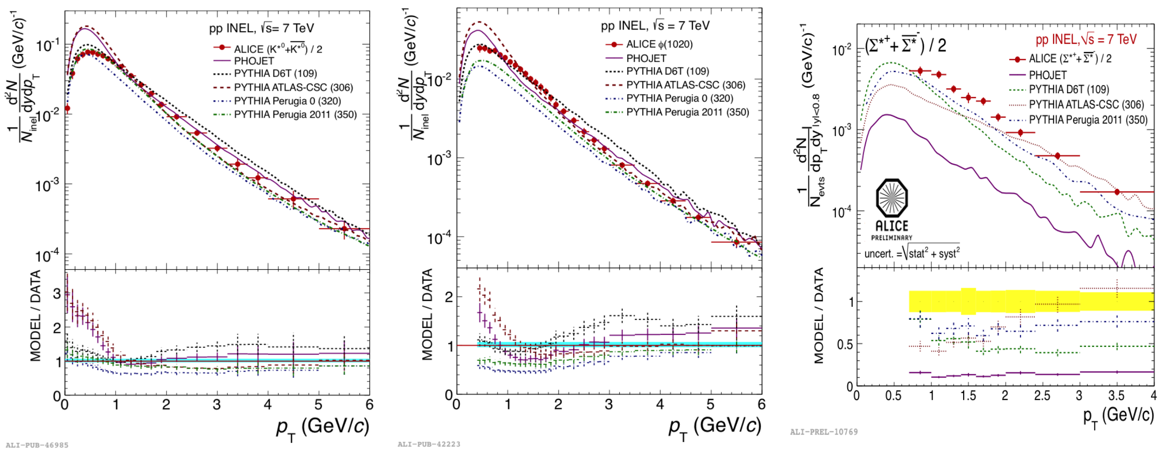

Figure 3. K^* (a), ϕ (b) and Σ (c) spectra as compared to theoretical predictions in pp collisions with PHOJET and PYTHIA tunes D6T (109), ATLAS-CSC (306) and Perugia 0 (320).

4. Conclusions

Resonances such as K^*, ϕ and Σ^* have been measured by ALICE in pp collisions. In particular, masses and widths show no p_T dependence and are within reasonable agreement with the PDG values. The particle ratios for the Σ^* resonance show agreement with previous STAR analysis and Becattini model for π^-, K^- and Ξ^-. There is little agreement between the extracted spectra of ϕ, K^* and Σ^* at 7 TeV compared to PYTHIA and PHOJET models, with the Σ^* predictions especially showing a large under-prediction for all model tunes. Analysis of the ϕ resonance at 2.76 TeV extends the spectra to a larger p_T range and shows a saturation in the ϕ/π ratio at the higher p_T.

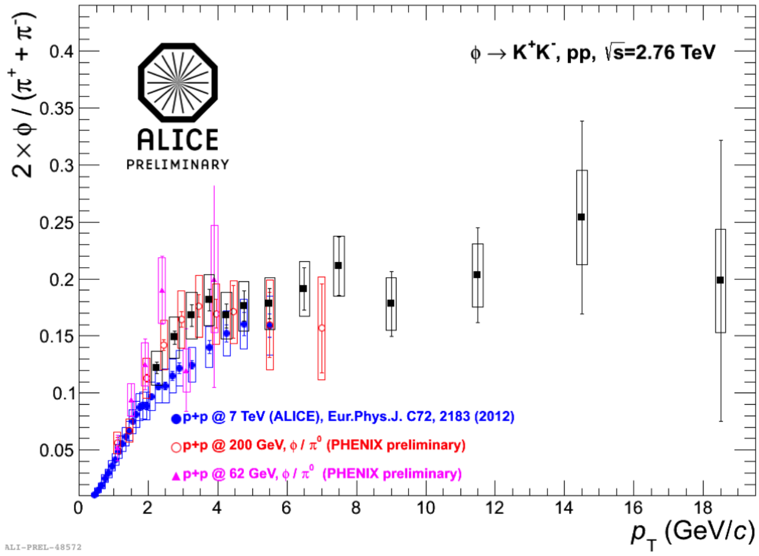

Figure 4. ϕ/π ratio as a function p_T for a number of collision energies including ALICE $\sqrt{s} =$ 2.76 TeV.

References

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