Constraining K^0 production channels in proton-proton collisions for transport models*

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The HADES collaboration performed measurements of strangeness production in p+p and p+^{93}Nb collisions at a beam kinetic energy of 3.5 GeV. The analysis of the K^0-meson emission in p+Nb collisions aims to refine the knowledge of the kaon in-medium behaviour in terms of the repulsive potential and the in-medium kaon-nucleon scattering cross sections. The tool to extract these characteristics is a transport code incorporating kaon production mechanisms and kaon final state interactions with nuclear environment. The measurement of kaons in p+p collisions serves as an important reference, which allows to constrain production cross sections of the different final states in transport models.

Spectra of kaons produced in p+p collisions were compared with the GiBUU [1] simulations based on the resonance model by Tsushima et al. [2]. In this model, all hyperon-kaon pairs are products of the nucleon resonances decays, e.g. $N(1650) \rightarrow \Lambda + K$. The resonance model incorporates all possible channels of type $B + B \rightarrow B + Y + K$, where B can be either a nucleon or a $\Delta(1232)$-resonance, Y is a hyperon (Λ or Σ) and K stands for a positively charged or a neutral kaon. It was shown that for the case of inclusive K^0 production in p+p reactions the resonance model significantly overestimates the K^0 yield.

A systematical comparison of the various kaon production channels, implemented in the resonance model, with available published data shows that: i) the channel $p\pi^+\Lambda K^0$ is significantly overestimated by the resonance model; ii) the channel $p\Sigma^+K^0$ is slightly overestimated as well.

Besides overestimation of the major K^0 production channels, the resonance model [2] has other shortcomings. One of the main assumptions of the model is that all nucleon-nucleon reactions with the pion in the final state ($N + N \rightarrow N + \pi + Y + K$) proceed through an intermediate $\Delta(1232)$-resonance with its subsequent decay $\Delta(1232) \rightarrow N + \pi$. These final states can be, however, produced in a non-resonant way as well. An on-going analysis of the exclusive kaon production in the reaction $p + p \rightarrow p + \pi^+ + K^0 + Y$ allows to disentangle the two production mechanisms. The missing mass to the reconstructed $p\pi^+\pi^-\pi^+$ system after pre-selection of K^0 candidates (accessible via $K^0_S \rightarrow \pi^+\pi^-$ decays) is shown on Fig. 1. The three peaks correspond to the missed neutron (background reaction $p + p \rightarrow p + n + \pi^+ + \pi^+ + \pi^-$), $\Lambda(1116)$- and $\Sigma^0(1192)$-hyperon. A further inspection of the $p\pi^+$ invariant mass distribution will allow to separate two production mechanisms (with or without intermediate $\Delta(1232)^{++}$ state).

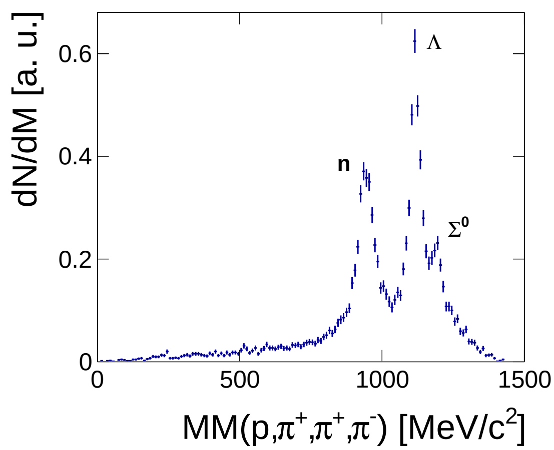

Figure 1: Distribution of the missing mass to $p\pi^+\pi^+\pi^-$-system. Peaks marked "n", "Λ" and "Σ^0" originate from reactions $p + p \rightarrow p + n + \pi^+ + \pi^+ + \pi^-$, $p + p \rightarrow p + \pi^+ + \Lambda + K^0$ and $p + p \rightarrow p + \pi^+ + \Sigma^0 + K^0$, respectively.

After taking into account the experimentally obtained constraints on the kaon production in elementary collisions, tuned transport models can be used to simulate proton-nucleus and nucleus-nucleus collisions. This will lead to the reliable determination of in-medium characteristics of kaon-nucleon interactions. Further information is expected from on-going investigations of other strange particles (Λ, $\phi(1020)$, $K^*(892)$) produced in p+p and p+Nb reactions.

References

[1] O. Buss *et al.*, "Transport-theoretical Description of Nuclear Reactions", Phys. Rept. **512** (2012) 1.

[2] K. Tsushima, A. Sibirtsev and A. W. Thomas, "Resonance model study of kaon production in baryon baryon reactions for heavy ion collisions", Phys. Rev. C **59** (1999) 369.

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