Strangeness Production in the p+p Interaction at Threshold at the Experimental Facility COSY-11

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The strangeness content of the nucleon is still under discussion. We have used the p+p system for the investigation of the $s\bar{s}$ quark pair production in the $pp \longrightarrow pK^+\Lambda$, $pp \longrightarrow pK^+\Sigma^\circ$ and $pp \longrightarrow ppK^+K^-$ reactions.

In each case the excess energy has been chosen to be only a few MeV, allowing mainly S-wave contributions to the reaction mechanism process. Thus the correlated production of the hyperon-kaon pair provides a possibility to study various theoretical models of the strangeness dissociation mechanism [1].

However, especially at threshold, effects of initial and final state interactions (ISI, FSI) might be very significant and have to be disentangled from the reaction mechanism part. Experimental data on the $FSI_{p-\Lambda}$ allow investigation of various meson exchange models of the nucleon-hyperon interaction [2].

In addition, the knowledge of the kaon production cross section in the elementary N-N interaction is important for studies of the production of hyper-nuclei in the nucleon interaction with nuclei [3].

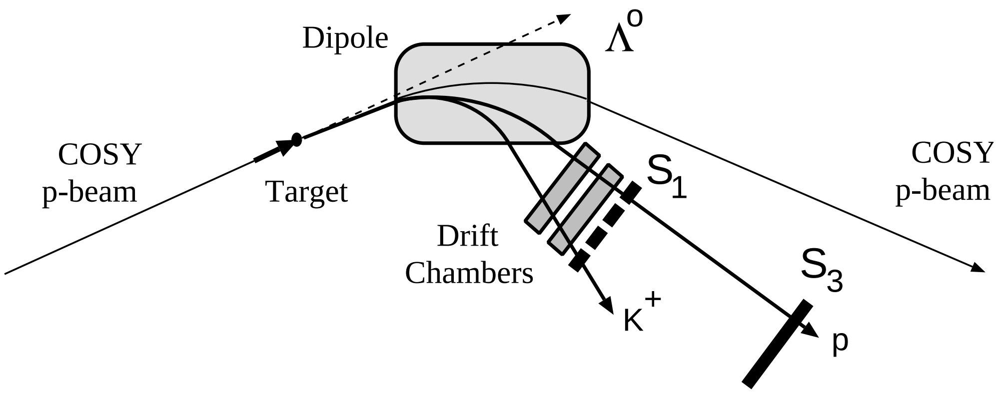

Figure 1. Sketch of the experimental layout for the $pp \longrightarrow pK^+\Lambda$ measurement.

Measurements were performed at the COSY-Jülich synchrotron, using the internal target facility COSY-11 [4]. The principle of the experimental layout is shown in figure 1.

The outgoing protons and positively charged kaons were identified by means of particle momentum reconstruction combined with a time of flight measurement. The four-momentum of the unobserved particle, i.e. Λ-hyperon , Σ° or K^-, was calculated from conservation rules. Details of the applied experimental technique are given elsewhere [5]. The geometrical acceptance of the COSY-11 detection system was in the range from 30% to 5%, depending on the selected excess energy.

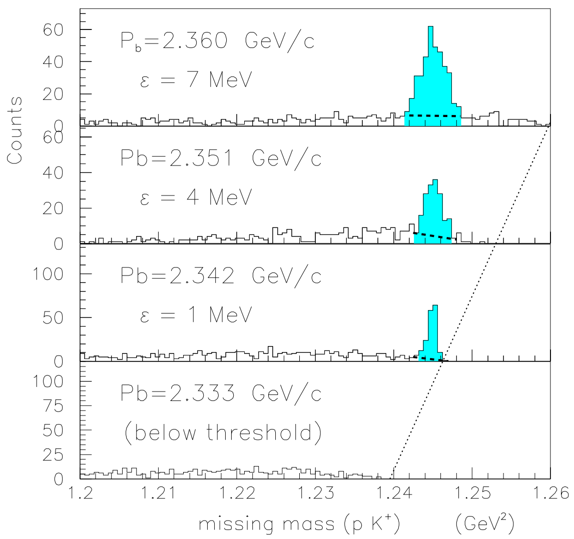

Figure 2. Squared missing mass (MM) of the pK$^+$ subsystem measured at different beam momenta. The indicated peaks correspond to the Λ-particle mass from the $pp \longrightarrow pK^+\Lambda$ reaction, the dashed line depicts the background level. The dotted line marks the kinematical limit of the MM spectra.

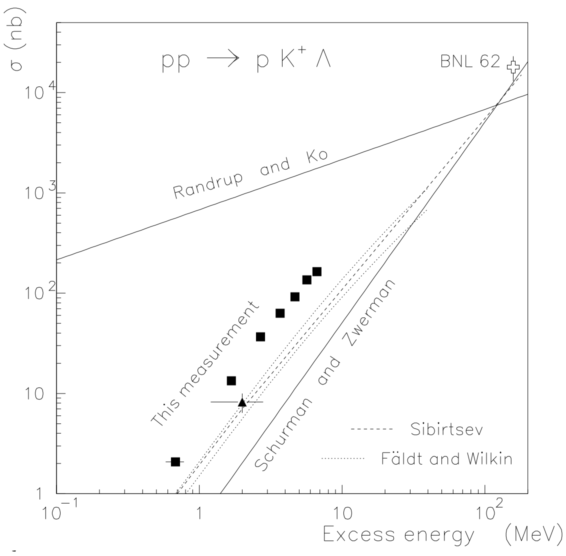

Figure 3. Preliminary experimental data (full squares) and different models describing the energy dependence of the $pp \longrightarrow pK^+\Lambda$ total cross section. A previous measurement from COSY-11 [5] is shown by the full triangle, higher energy data from BNL [11] by the cross.

Missing mass spectra of the measurement of the $pp \longrightarrow pK^+\Lambda$ reaction close to threshold are shown in figure 2. Preliminary values of the cross section are presented in figure 3, together with predictions given by different models.

The simple parametrization of the cross section normalized to high energy data, proposed by Randrup and Ko [6] and by Schürmann and Zwermann [7] are not able to describe the present data. Recently, Fäldt and Wilkin [8] presented a model which assumes a dominant role of the $S_{11}(1650)$ resonance for the K^+production in p+p interaction. This interpretation is in analogy to the η production, which is supposed to be mediated mainly via the $S_{11}(1535)$ resonance, with the one-pion-exchange model used for the excitation of the S_{11} resonance. A similar, more extended model was presented by Sibirtsev et al. [9]. The authors include also other N^* resonances beside the $S_{11}(1650)$ and allow for the exchange of heavier mesons.

The objective of the $pp \longrightarrow pK^+\Sigma^\circ$ measurement was the determination of the energy dependence of the cross section close to threshold. Additionally, it is expected to observe the postulated ΛN-ΣN coupling effect [2] in the momentum distribution of the kaons. A peak resulting from the $pK^+\Sigma^\circ$ events, measured in a test run, shows up with an intensity about 2 times stronger than the background (figure 4). The analysis and further measurements of this reaction are in progress.

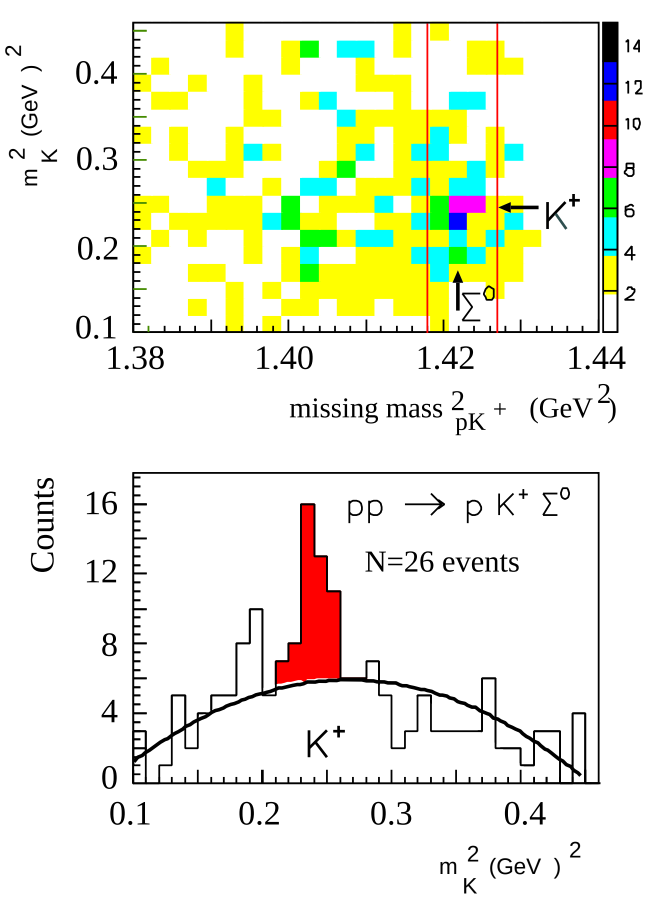

Figure 4. Two dimensional display of the squared kaon invariant mass versus missing mass of the (pK$^+$)-system (top) and projection of the events between the solid lines on the kaon mass axis (bottom) with the $pp \longrightarrow pK^+\Sigma^\circ$ signal measured at a beam momentum of 2.581 GeV/c,

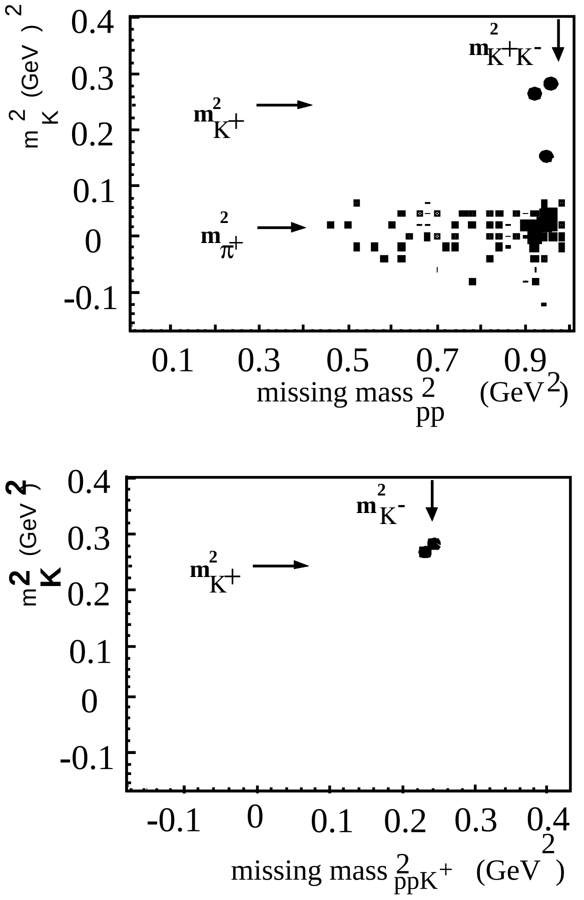

Figure 5. Final selection of the $pp \longrightarrow ppK^+K^-$ events from the measurement at a beam momentum of 3.321 GeV/c.

The still unsolved nature of the $f_\circ(980)$ meson, in detail discussed in the lecture of Haidenbauer [10] during this conference, stimulated the COSY-11 collaboration to measure the cross section of the $pp \longrightarrow ppK^+K^-$ reaction. The set of measurements was performed at different excess energies close to the reaction threshold. The analysis of the data taken at an excess energy of 6 MeV results finally in two accepted events, which lead to a cross section of 0.21±0.15 nb. Measurements at other excess energies, taken with much higher luminosity, are still under evaluation.

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