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K^+ production from *pn*, *pp* and *pd* interactions at ANKE/COSY*

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In order to understand experimental data for K^+ production in proton-deuteron interactions and draw conclusions about the ratio between K^+ production in *pn* and *pp*, one needs to develop an approach for the description of all relevant *pp* results. We perform an analysis of the *pp* data available in COSY energy range for three reaction channels. It can be concluded that Λ and Σ^0 production channels can be well described by the three-body phase space incorporating the hyperon-nucleon final-state interactions under the assumption of a constant matrix element. Experimental data on the $pp \to K^+n\Sigma^+$ reaction channel are very poor and more information is needed to understand a strange behavior of the energy dependence of the total cross section. Using ANKE inclusive K^+ data at 2.85 and 2.95 GeV/c, preliminary values for the total cross-section of Σ^+ production in *pp* interactions has been extracted applying a simple phase space approach. This gives a result roughly one order of magnitude less than that of the recently published exclusive measurement.

Keywords: kaon production; strangeness; Sigma production

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There are a lot of data available on strangeness production in proton-proton interactions. However, there are no analogous data existing in *pn* interaction in the close-to-threshold region. Due to the low quality of the neutron beams, the only way to investigate K^+ production on the neutron is to use a deuterium target[1]. In order to extract the required information on the neutron one needs either to detect the slow spectator proton or use some assumption about the production on the proton based on the existing *pp* data[2,3,4].

The COoler-SYncrotron COSY-Jülich[5] provides beams of polarized and unpolarized protons and deuterons with momenta up to 3.7 GeV/c. The COSY momentum range thus allows one to produce, not only K^+, hyperon and up to two pions in

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the final state, but also a K^+K^- pair. We concentrate here on reactions with three particles in the final state.

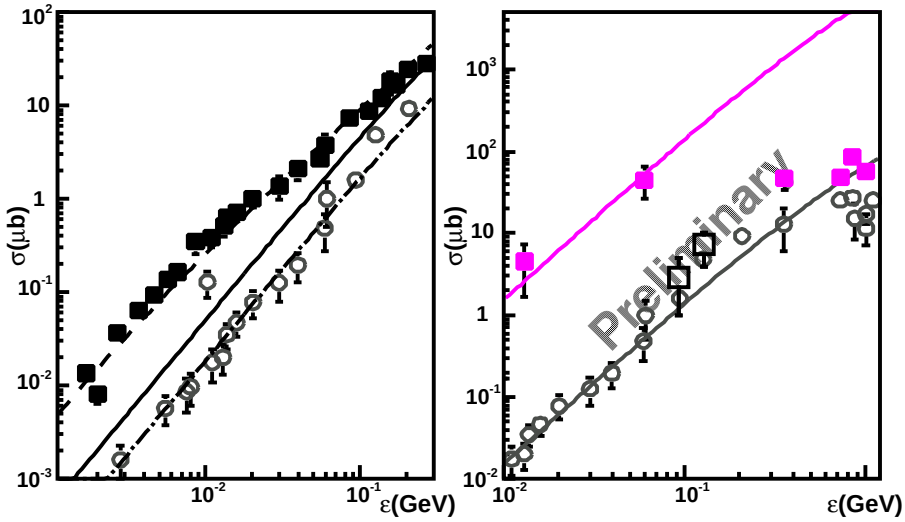

Fig. 1. a) Total cross section for the reaction $pp \to pK^+\Lambda$ (squares) and $pp \to pK^+\Sigma^0$ (circles) as a functions of the excess energy. The curves are: three-body phase-space normalized to the constant matrix element without FSI effect (solid and dashed-dotted lines) and with FSI effect (dashed line). b) Total cross section for the reactions $pp \to pK^+\Sigma^0$ (circles) and $pp \to pK^+\Sigma^+$ (squares) as functions of the excess energy. Preliminary results of the analysis of ANKE data for the $pp \to pK^+\Sigma^+$ reaction channel are shown by open squares. The curves are parameterizations of the total cross section for both reaction channels taken from Ref. 11.

The dominant K^+ production channel in pp interactions in the momentum range of interest is $pp \to K^+p\Lambda$. In Fig. 1 the world data set for the total cross section of this reactions is shown[2,4]. The energy dependence of the total cross section can be very well described assuming a constant matrix element in the three-body phase space but incorporating the Λp final state interaction, as was pointed out for instance in Ref. 6.

Another well investigated K^+ production channel in the discussed momentum range is the production with $K^+\Sigma^0p$ in the final state[3,4]. As seen from Fig. 1, the energy dependence of the total cross section can be described by the same approach as for the Λ case. But, in contrast to Λ production, there is almost no room for any visible Σ^0p final state interaction.

There have been very few measurements of the Σ^+ production channel. In Fig. 1 one can find all the data available for this production channel, including the recently published COSY-11 close-to-threshold data[10]. The parameterization taken from Ref. 11 is shown by the solid line in Fig. 1. The form was normalized to the newest data points, and therefore is not able to describe all the available data at

higher energies. The significant discrepancy between the proposed parameterization and other available data makes it extremely important to clarify the real energy dependence of the total cross section. It is quite difficult to measure this reaction channel exclusively since, for the reconstruction of Σ^+ particle in the missing mass, one has detect both the neutron and K^+ in the final state. Therefore, the authors of Ref. 7 analyzed K^+ inclusive momentum spectra measured at different angles with different beam momenta in order to isolate the contribution from the Σ^+ channel. They propose the comparison of a measured K^+ momentum spectrum with that calculated analytically from the three-body phase-space corrected for the final state interactions. Since the literature contains mostly high energy data, we have analyzed the inclusive momentum spectra measured at ANKE.

ANKE[8] is a magnetic spectrometer and detection system placed at an internal target position of COSY. One of the main features of the spectrometer is the K^+ identification system based on the detection of its decay products. This method allows one to isolate K^+ mesons on a 10^6 times higher background. The details of the analysis, as well as the particle identification, are given in Ref. 9.

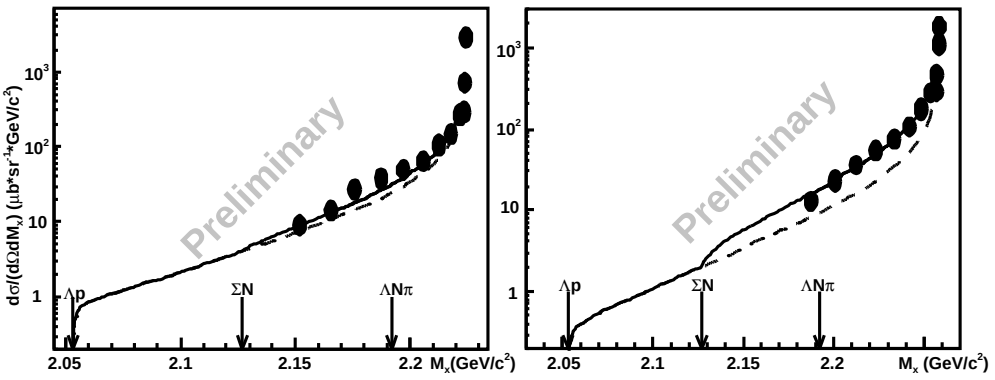

Fig. 2. Double-differential cross sections for $pp \to K^+X$ production at 2.85 and 2.95 GeV/c compared with model calculations.

In the Fig. 2 the K^+ inclusive missing-mass spectra measured at 2.85 and 2.95 GeV/c are shown. The advantage of studying such spectra is that one can unambiguously identify reactions that contribute to the differential cross section measured at a certain angle and at fixed beam momentum. The thresholds for three reaction channels are shown in the Fig. 2 by arrows. The curves in the figure are inclusive single particle momentum spectra from the three-body phase space calculated for the Λ and Σ reaction production channels. Unfortunately, among the currently available ANKE data, there is no region in the inclusive missing-mass spectra where it is possible to isolate a contribution from the Λ reaction channel. However, the analysis of inclusive data from other experiments[7] shows that the contribution from the $pp \to pK^+\Lambda$ reaction to the inclusive spectra can be well fixed

by its phase space normalized to the constant matrix element extracted from the parameterization of the total cross section (solid line in the Fig. 1).

The contribution of the Σ reaction channel was obtained by subtracting the Λ contribution from the experimental data. The total cross section obtained in this way is the sum of two production channels with $pK^+\Sigma^0$ and $nK^+\Sigma^+$ in the final state. Using the knowledge of the Σ^0 reaction total cross section, we have deduced the Σ^+ total cross section at two excess energies. The preliminary results for total cross section of the $pp \to nK^+\Sigma+$ reaction channel are in range of 1–5μb and 5–10μb at 93 and 128 MeV, respectively. The ANKE data points are at somewhat higher energies than the recently published close-to-threshold data[10], and additional data in this region would be needed to draw firm conclusions about the energy dependence of this K^+ production channel.

A lot of data on inclusive K^+ production double differential cross sections in pD collisions has recently become available from ANKE[1]. However, in order to deduce the ratio between K^+ production on the proton and neutron, it is necessary to fix the contribution from the Σ^+ production channel over the complete range of COSY energies. This kind of measurement can be performed at ANKE-COSY.

1. References

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