Measurement of near Threshold Σ^0-and Λ-Production

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As an extension of the COSY-11-measurements of the reaction $pp \longrightarrow pK^+\Lambda$ close to threshold, which have been puplished in [1], the hyperon production at the $pK^+\Sigma^0$ threshold was investigated. The comparison of the Λ and the Σ^0 production yield at the same excess energies, relative to their respective thresholds, provides useful information for the understanding of the coupling constants and the production mechanisms in the presence of strong channel couplings.

At the COSY-11 facility the four-momenta of the positively charged p and K^+ are determined directly, whereas the neutral hyperon is identified using the missing mass method. In figure 1 the detected invariant mass of the second particle with the first particle being an identified proton is plotted versus the missing mass for a beam energy above the $pK^+\Sigma^0$ -threshold. A band in the K^+-mass region is visible which shows enhancements at the Λ- and the Σ^0-masses.

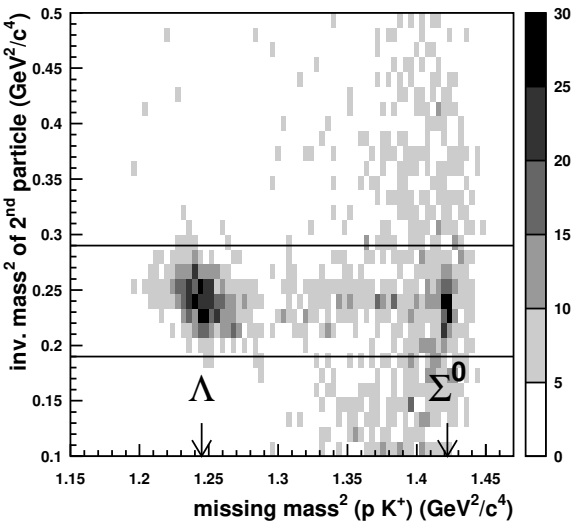

Fig. 1: Squared inv. mass of the K^+ versus the missing mass of the (pK$^+$) subsystem

Comparing the results of the first run for Σ^0-production with data from [1] has shown a large difference of the cross section between Λ- and Σ^0-production. To optimize for equal experimental conditions COSY was used in the supercycle mode, which allows a repetition of a sequence of spills of different energy. We used 10 or 20 spills at beam momenta equivalent to one excess energy above the Σ^0-threshold followed by one spill equivalent to the same excess energy for Λ-production. The length of the spills was 5 minutes. The value of the missing mass of the hyperon can be determined with an accuracy of 0.4 MeV. In figure 2 the determined cross section values are presented graphically.

Near threshold the following cross section ratio for the two hyperon productions is obtained:

$$R(Q) = \frac{\sigma(pp \longrightarrow pK^+\Lambda)}{\sigma(pp \longrightarrow pK^+\Sigma^0)} \approx 28. \qquad (1)$$

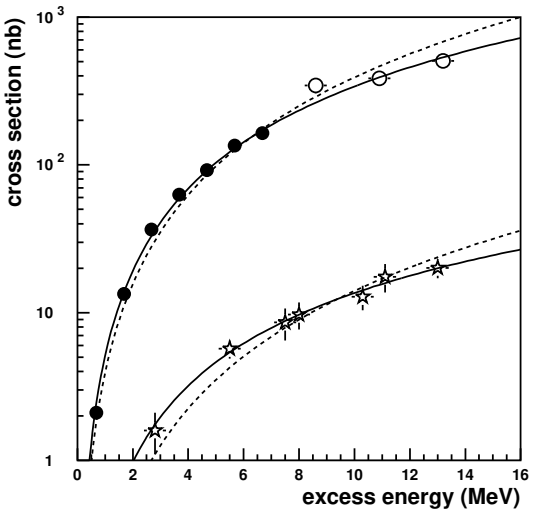

Fig. 2: Cross section of $pp \longrightarrow pK^+\Lambda$ (circles) and $pp \longrightarrow pK^+\Sigma^0$ (stars) [2]. The data of the filled circles have been puplished in [1]. The dashed curves show phase-space fits to the data. The solid curves are fits, which also include proton-hyperon final state interaction.

Both π^0 and K^+ exchange diagrams can contribute to the hyperon production. Assuming only K^+ exchange, the value of the SU(6) prediction of 27/1 for the ratio $R(Q)$ is in very good agreement the measured one. In reality one has to consider significant π^0 exchange, which favours the Σ^0 above the Λ production [2]. However, the measured ratio can be explained, if virtually produced Σ's are converted into Λ's due to strong $\Sigma N \longrightarrow \Lambda p$ final state interaction. Evidences for these effects are well known in the literature. K^- absorption in deuteron $K^- d \longrightarrow \pi^- \Lambda p$ [3] shows a very clear indication for the following two-step process $K^- d \longrightarrow \pi^- (\Sigma N \longrightarrow \Lambda p)$. An additional hint might be the clearly visible irregularity in the mass spectrum of the pΛ at the Σ threshold in the $pp \longrightarrow pK^+\Lambda$ reaction measured at COSY-TOF [4].

References:

[1] J. Balewski et al., Phys. Lett. **B 420** (1998) 211
[2] submitted to Phys. Rev. Lett.
[3] T.H. Tan, Phys. Rev. Lett. **23** (1969) 395
[4] R. Bilger et al., Phys. Lett. **B 420** (1998) 217