Threshold Production of Σ^+ at COSY-11

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In studies of threshold hyperon production at COSY-11 [1] the cross section ratio of $\sigma(pp \to pK^+\Lambda)/\sigma(pp \to pK^+\Sigma^0)$ was measured to be in the order of 30 in contradiction to a ratio of about 2.5 measured at higher excess energies ($Q > 350 MeV$). To explain this unexpected behaviour different theoretical scenarios were proposed. In theoretical models of the hyperon production generally pion and kaon exchanges are included but also additional production mechanisms like heavy meson exchange (ρ, ω and K^*) and/or production via nucleon resonances are considered [2], [3], [4], [5], [6].

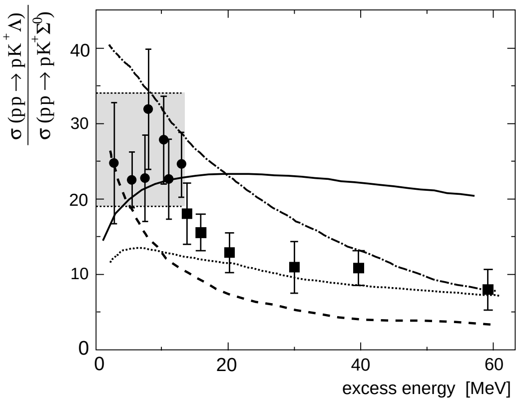

Fig. 1: Data on the cross section ratio $\sigma(\Lambda)/\sigma(\Sigma^0)$ close to threshold [1], [7]. The curves are the results of different model descriptions, solid line: destructive π/K interference [2], dotted line: incoherent π/K exchange [6], dashed line: resonance model [6], dashed-dotted line: effective lagrangian model with resonance excitation [4].

The present data are not sufficient to definitely exclude possible explanations. Studies on the other isospin projections are promising for a better understanding. Within the Jülich meson exchange model the cross section ratio $\sigma(\Lambda)/\sigma(\Sigma^0)$ is reproduced by a destructive interference of π and K exchange amplitudes. Calculations of the Σ^+ production within this model predict a factor of three higher cross section compared to the Σ^0 channel. A production via resonance excitation is not possible for the $n(K^+\Sigma^+)$ reaction.

The study of the Σ^+ production via $pp \to nK^+\Sigma^+$ will be performed at the COSY-11 facilty [8].

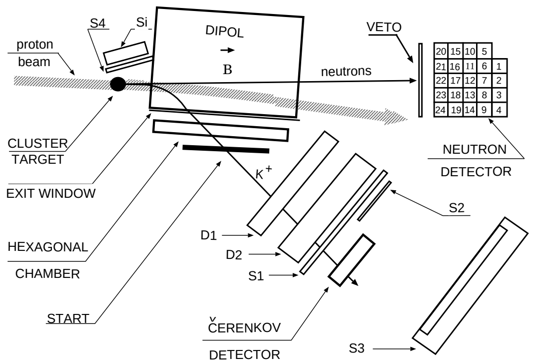

Fig. 2: COSY-11 setup with neutron detector [9] and additional kaon start scintillator to perform the measurement of the threshold Σ^+ production.

The four-momentum of the K^+ will be determined by the standard COSY-11 setup with an additional kaon start scintillator. Assuming a hit in the neutron detector being due to a neutron, the four-vector of the neutron is given by the measured velocity, the direction of the neutron which can be reconstructed with an accuracy of at least the size of the module (9x9 cm^2) and the known mass. The background from charged particles hitting the neutron detector is discriminated very effectively by veto scintillators in front of the neutron detector. The Σ^+ - will be identified by the missing mass technique.

In fig. 3 the missing mass distribution resulting from realistic Monte Carlo studies for the Σ^+ production at an excess energy of 13 MeV is shown. Compared to the experimental technique used in the Λ and Σ^0 production studies the missing mass resolution of 8.8 MeV (FWHM) is only a factor of two worse than the Σ^0 resolution which is due to the less precise knowledge of the neutron momentum components.

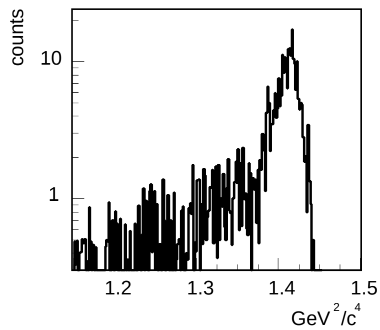

Fig. 3: Expected missing mass distribution for Σ^+ generated with a realistic Monte Carlo study.

The efficiency for the detection of an $nK^+\Sigma^+$ event at an excess energy of 13 MeV is about 0.8 % which is comparable to the detection efficieny of an $pK^+\Sigma^0$ event with 0,99 % +/- 0,03. An estimate of the background can be done from the Σ^0 data where a total background event rate of 4 events/MeV/day (for a luminosity of $1 \cdot 10^{30}(1/cm^2/s)$) was observed.

Expecting the same rate for the Σ^+ studies within a $2 \times$ FWHM region around the Σ^+ peak 70 background events/day are expected. Assuming a luminosity of $10^{30}(1/cm^2/s)$, a cross section of 230 nb (predicted by the Jülich model [3]) and a detection efficiency of 0.8 % a counting rate of 160 events/day is realistic. This means that in one week about 1100 events could be detected with a statistical error of 6 % under the assumed conditions.

References:

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