Threshold Production of Σ^+ at COSY-11

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The threshold production of hyperons has been studied via the $pp \to pK^+\Lambda(\Sigma^0)$ reaction at COSY-11 [1–3] resulting in a cross section ratio $R = \sigma(\Lambda)/\sigma(\Sigma^0)$ of about 28 which exceeds the ratio at high energies by an order of magnitude. To explain this unexpected behaviour different theoretical scenarios were proposed. In the various models for 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 [4–8]. Since definite conclusions are up to now not possible, further studies of other isospin channels are needed.

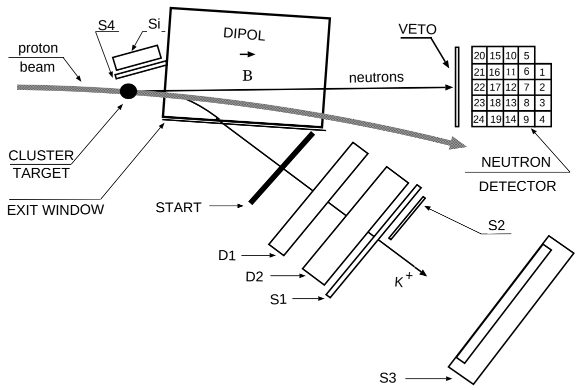

Fig. 1: Sketch of the COSY-11 setup with neutron detector and additional kaon start scintillator to perform the measurement of the threshold Σ^+ production.The neutron detector on the figure is enlarged in comparison to all the other detectors

The Σ^+ production was measured at the COSY-11 installation via the $pp \to nK^+\Sigma^+$ reaction at Q = 13 MeV and Q = 60 MeV [9]. The Σ^+ hyperon was identified via the missing mass technique by detecting the remaining reaction products - K^+ and neutron. The four-momentum of the K^+ was determined by the standard COSY-11 setup (see Fig. 1) with an additional kaon start scintillator.

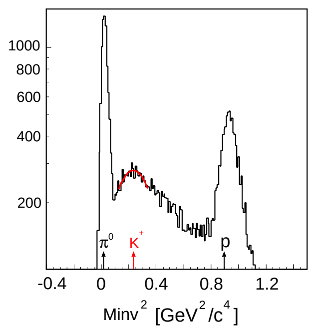

Fig. 2: The invariant mass distribution. The events are selected by the requirement to have a hit in the neutron detector; additional cuts are presently developed for further selection of the K^+ signal.

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 and the known mass. The background from charged particles hitting the neutron detector is discriminated by veto scintillators in front of the neutron detector.

The invariant mass distribution determined from the reconstructed drift chamber tracks and the time–of–flight between the START and the S1 scintillators is shown in fig. 2. The events are selected by the requirement to have a hit in the neutron detector within the expected time window and a missing mass around the Σ^+ mass. A clear kaon peak within the large background of pions and protons is seen.

By cutting on the kaon region the resulting missing mass distribution, gives an enhancement at the expected Σ^+ mass (fig. 3.). The dotted line in figure 3a corresponds to the background contribution determined by the “side bands”, i.e. missing mass distributions for cuts in the invariant mass distribution beside the kaon region. In fig. 3b the background is subtracted (upper figure) and compared to the expected distribution from Monte Carlo studie (lower figure).

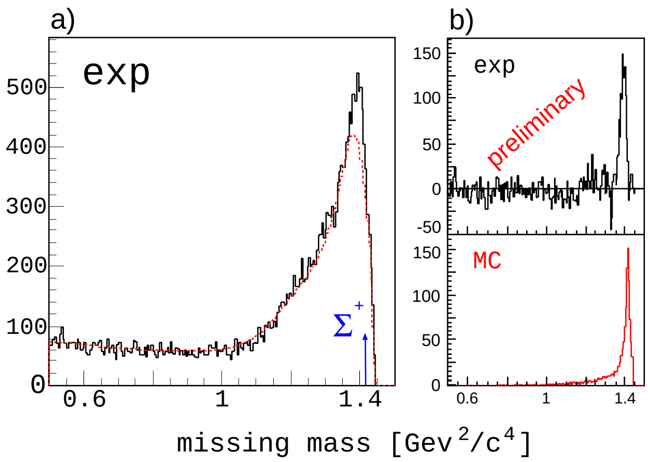

Fig. 3: a) Missing mass distribution after kaon cut. The dotted line corresponds to the background contribution determined by the “side bands” beside the kaon region. b) Missing mass distribution after background subtraction compared to the MC expectation (lower figure)

Presently extensive Monte Carlo studies including all possible background channels like the $pp \to pp2\pi^0$, $pp \to np\pi^+2\pi^0$ or $pp \to pK^+\Lambda\gamma$ reactions are performed in order to fully understand the resulting experimental distribution before an extraction of the number of Σ^+ events will be done.

References:

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