Threshold Strangeness Production in Proton - Proton Interactions at COSY - Jülich

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Abstract

First experimental results of strangeness production at threshold in elementary $p-p$ interactions are presented. Data have been taken at the new accelerator COSY - Jülich for the production of both hyperons as well as η' mesons and K^+K^- meson pairs.

1 Introduction

Studies of the associated strangeness production in the p - p interaction involve a priori the question of strangeness content in hadrons. In addition, in meson production investigations via reactions like $pp \to ppX$ or $pd \to ^3\text{He}X$ (with X being a neutral meson like η' and Φ or a kaon system like K^+K^-) informations on both the reaction mechanism and the structure of the mesons can be addressed.

Studies of the $K\bar{K}$ channel will contribute to investigate the structure of the scalar objects f_0 and a_0 which is still under discussion as documented in many contributions to this conference.

The associated strangeness production via the K - hyperon channel as for instance $pp \to pK^+\Lambda$ or $pp \to pK^+\Sigma$ is devoted to questions like $s\bar{s}$-dissociation and reaction dynamics or more general the QCD in the confinement region. Furthermore cross sections for the elementary interactions are needed as input for calculations of the $s\bar{s}$-creation in heavy ion collisions which is an essential input to the physics of the possible quark-gluon plasma production. An enhancement of strangeness is supposed to be a signal for the phase transition.

2 Results

First results of elementary reactions have been obtained with COSY at the installation COSY-11 measuring the processes:

$pp \to pp\eta$, $pp \to pp\eta'$, $pp \to ppK^+K^-$, $pp \to pK^+\Lambda$ and $pp \to pK^+\Sigma^0$ and at the facility TOF for the $pp \to pK^+\Lambda$ reaction at higher excess energies.

The COSY-11 installation is an internal setup in a bending section of the COSY ring, fig. 1 shows a sketch of the experiment.

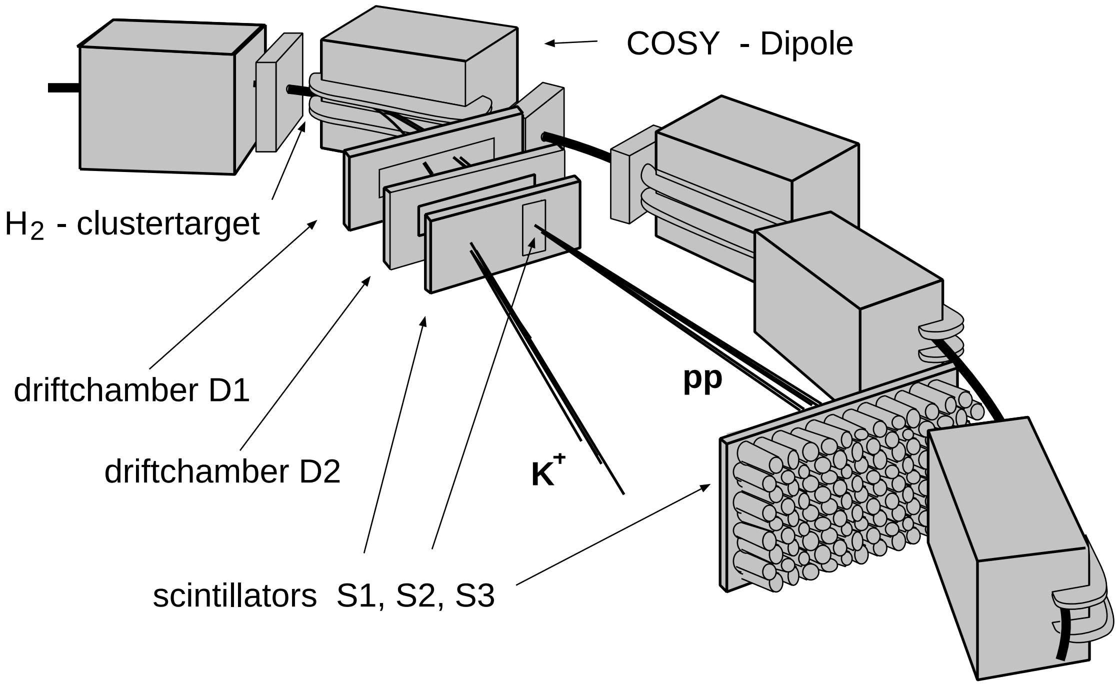

Figure 1: The COSY-11 installation in a bending section of the COSY ring. The ejectile momenta are reconstructed using the track information from the drift chambers D1, D2 and time of flight from the scintillator hodoscopes S1, S2 and S3. The plotted tracks result from MC calculations of some $pp \to ppK^+K^-$ events at an excess energy of 2 MeV.

In front of a machine dipole a hydrogen cluster target is installed. Positively charged reaction products - which have a reduced momentum compared to the primary proton beam - are bent to the inner region of the ring and are detected with a system of drift chambers and scintillators. Negatively charged ejectiles are detected by a silicon pad detetor arrangement in the dipole gap which is not seen in the figure.

In fig. 2 the available data of the $pp \to pK^+\Lambda$ reaction up to an excess energy of 200 MeV are shown. The lowest data point for the total production cross section was at $\approx$ 160 MeV excess energy. (Inclusive K^+ production for a limited angular range was performed at Saturne for lower excess energies [1].) In the threshold region several data have been added by experiments at COSY where the result at the highest momentum is consistent with the lowest bubble chamber data [2]. The lines represent different model calculations. The parametrisations of Randrup [3] and Schürmann [4] (solid lines) and new calculations of Fäldt and Wilkin [5] (range between dotted lines) and Sibirtsev [6] (center dotted line) are shown.

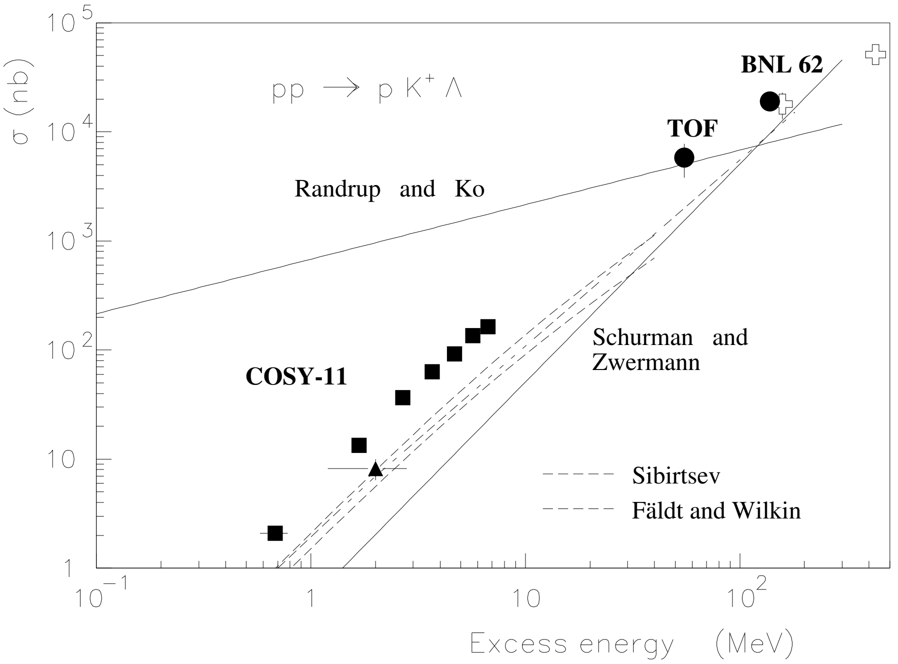

Figure 2: Existing data set in the threshold region for the $ppK^+\Lambda$ production.

A crucial point for measuring cross sections in the threshold region is the exact knowledge of the beam momentum which is the dominant error for the excitation curve. The COSY-11 data were used by itself for the calibration of the beam momentum. The absolute momentum setting for a fixed COSY-optics is limited to the order of 10^{-3} due to the insufficient knowledge of the orbit length of the COSY beam. The relative error for a momentum change at the same optics however is negligible. Therefore a data set taken in one run with a fixed optics can be used for the calibration. The data are fitted by a phase space distribution including $p\Lambda$-final state interaction and the Coulomb correction for the pK^+-system from which the correct excess energy could be extracted. The deviation from the nominal excess energy given by COSY was as little as 0.2 MeV [7].

The production of a K^+K^- meson pair is very interesting in view of the existence of $K\bar{K}$ molecules and especially for the structure of the objects f_0 and a_0.

The first results on the K^+K^- meson pair production in pp-reaction are shown in fig. 3 and 4.

The data result from a run at 3.321 GeV/c which corresponds to an excess energy of 6 MeV. Two events could be selected with a clear signature for the K^+K^- production. In the control measurement with a comparable luminosity below threshold no event was observed. The resulting cross section is $\approx 500pb$.

At COSY-11 further data on the K^+K^- production have been taken at different excess energies with an expected yield of some ten events for each momentum

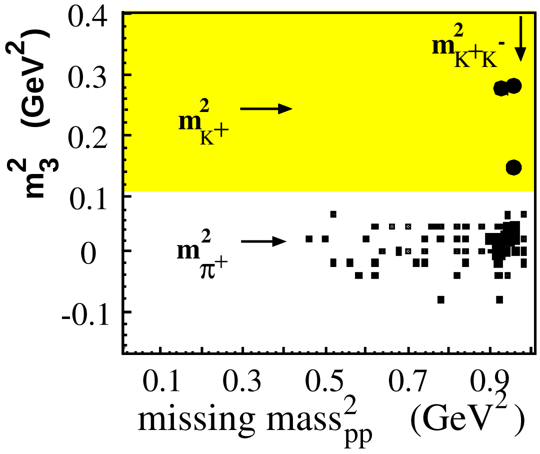

Figure 3: Squared invariant mass of the third charged ejectile versus the squared missing mass in the pp-system for data at 3.321 GeV/c beam momentum. The gray region indicates the invariant mass range which is accepted for the kaons in the further analysis. The arrows indicate the position of a perfect event.

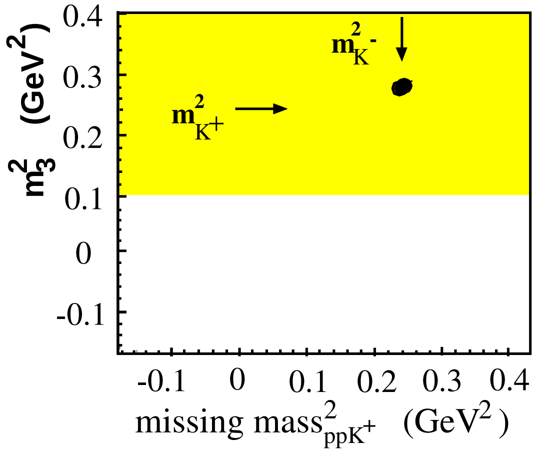

Figure 4: Squared invariant mass of the third particle versus the missing mass in the ppK^+-system. Two events are left which are consistent with a $pp \rightarrow ppK^+K^-$ hypothesis. The observed deviations are consistent with the errors on momentum reconstruction and time of flight measurement.

setting. The data are under evaluation and will give an excitation curve in the threshold region which will be sufficient for a first comparison to theoretical calculations.

References

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