Close to threshold Λ production at COSY-11 with a polarized proton beam

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At present little is known about the strength of the hyperon–nucleon interaction at low energies (parameterized by the scattering length) and even less about its spin dependence. Most of the data are available for the Λ-p system but also here the experimentally extracted low energy parameters of s-wave scattering, the scattering length a and the effective range r, have large uncertainties. Furthermore, a clear separation of the spin singlet and triplet channels is not possible as long as no polarized target/beam system is used. A detailed analysis of the world data set for elastic Λp scattering gave $a_s = -1.8^{+2.3}_{-4.2}$ fm and $a_t = -1.6^{+1.1}_{-0.8}$ fm [1] for the spin singlet and spin triplet scattering lengths, respectively, where the errors are strongly correlated.

The reaction $pp \to K^+ p\Lambda$ at low excess energies has been investigated by the COSY-11 collaboration [2] to determine the low energy parameters of the ΛN interaction. An average value of -2 ± 0.2 fm for the ΛN scattering length was extracted in an analysis that utilizes the effective range expansion which, however, is only applicable for systems where the scattering length is significantly larger than the effective range. In addition, using this procedure one encounters strong correlations between the effective range parameters a and r that can only be disentangled by including other data, e.g. ΛN elastic cross sections, into the analysis [2].

A new method to determine the Λp scattering lengths was proposed in Ref. [3]. It allows the extraction of the YN scattering lengths from the production data directly with a theoretical uncertainty of at most 0.3 fm.

In Ref. [3] it was also shown that already a measurement of a single spin asymmetry in $\vec{p}p \to YNK$ allows to isolate the spin triplet contribution from the final YN state, since the Pauli Principle strongly limits the number of structures possible for the initial state. It was especially shown that the asymmetry :

$$\frac{d^2\sigma(\uparrow)}{dm'^2 dt} - \frac{d^2\sigma(\downarrow)}{dm'^2 dt}$$

gets contributions from the spin triplet final state only, as long as the kaon in the final state is emitted at 90^o in the center of mass system (cms) and the outgoing YN is in an S–wave.

In order to extract the spin triplet scattering length of the $p\Lambda$ system, the $\vec{p}p \to K^+ p\Lambda$ reaction was studied with the COSY-11 installation at a beam momentum of 2.457 GeV/c, corresponding to an excess energy of 40 MeV. The acceptance of the COSY-11 detection system covers the full azimuthal angular range of the kaon emission angle with a rather flat distribution around 90^o (cms) which is the relevant region for this investigation.

A proton beam polarisation of about 80 % was achieved which was checked by measurements with the EDDA detector and monitored with the COSY-11 polarimeter system. The spin direction was flipped after each 20 minutes measurement cycle to reduce systematic uncertainties.

The reaction channel $\vec{p}p \to K^+ p\Lambda$ can be well separated with the standard missing mass technique used at COSY-11. The four momenta of two charged particles were measured by momentum reconstruction using the drift chamber tracks and the missing mass was calculated. In fig.1 a distribution of the invariant mass of one charged particle versus the missing mass is given. The data sample results from cuts on the invariant mass of the first charged particle to be a proton and a cut on the emission angle of the second charged particle to be within $-0.2 < \cos\Theta_{cm} < 0.2$. A clear enhancement in the expected region indicated by the cross point of the lines for the K^+ and Λ masses is seen.

The data are presently under evaluation.

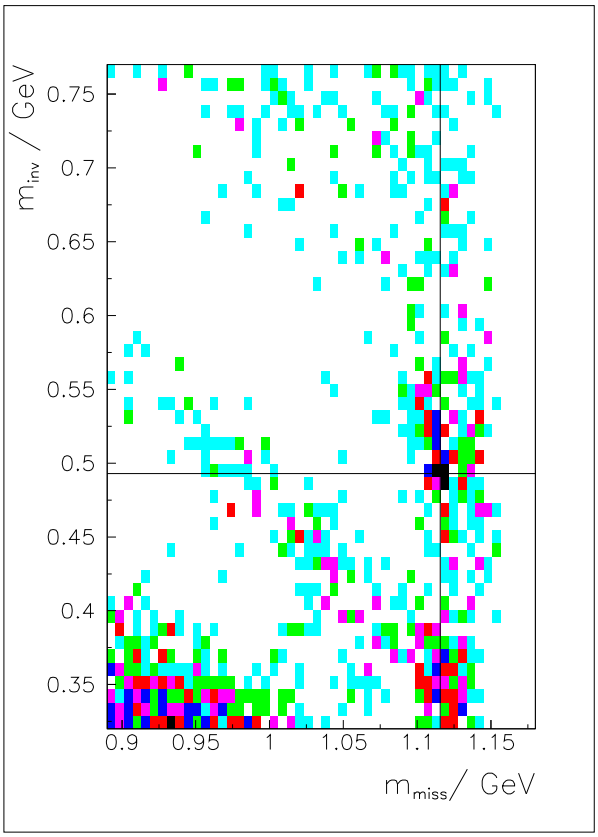

Fig. 1: Invariant mass of a charged particle measured with COSY-11 versus calculated missing mass. The lines indicate the K^+ and Λ masses.

References:

[1] G. Alexander et al., Phys. Rev. 173 (1968) 1452.
[2] J. T. Balewski *et al.*, Eur. Phys. J. A **2**, (1998) 99.
[3] A. Gasparyan et al., Phys. Rev. C 69 (2004) 034006.