Analysis of $pp \to pK^0\pi^+\Lambda$ at ANKE

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The reaction $pp \to pK^0\pi^+\Lambda$, measured at ANKE at a beam momentum of $p_p = 3.65\,\text{GeV/c}$, allows for the production of a pentaquark $\Theta^+(1540)$. Recent negative results on the Θ^+, mostly obtained at higher energies, have put the existence of the pentaquark under scrutiny. It has been shown, however, that the production of Θ^+ is strongly suppressed compared to the $\Lambda(1520)$ at higher energies [1], therefore hadronic experiments at lower energies become crucial to reveal fate of the pentaquark. The search of the Θ^+ decaying into the pK^0 system in the reaction $pp \to \Theta^+\pi^+\Lambda$ was the main motivation of the analysis made.

The reaction at ANKE has been identified by detecting four particles simultaneously, the π^+ coming from the reaction vertex, the proton from vertex/Θ^+ decay, and the products of the Λ decay: proton and π^-. Besides individual particle identification, the final state is fixed by the missing mass technique. As it is seen in Fig. 1, a clear enhancement in the scatter plot corresponds to the masses of K^0 and Λ in the missing mass of four detected particles and the missing mass of π^-p, respectively. Unfortunately, a sizable background remains after cuts on masses are made, and this background is removed by the side band subtraction method.

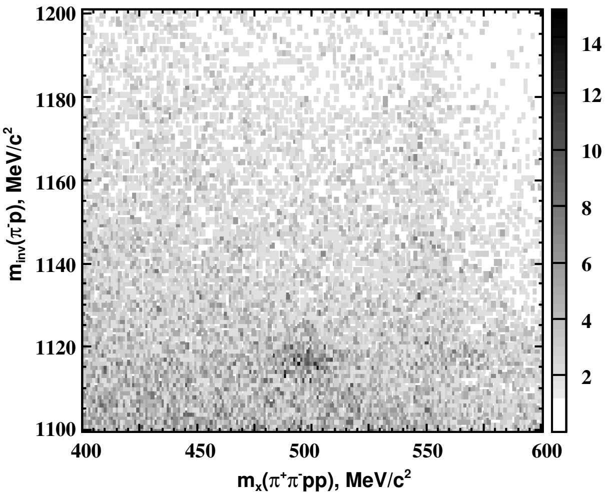

Fig. 1: Mass scatter plot: invariant mass of π^-p versus missing mass of $\pi^+\pi^-pp$.

For normalisation of the data the reaction $pp \to pK^+\Lambda$ has been used. This reaction was measured simultaneously during the experiment. Again all four particles in the final state have been detected. Such normalisation procedure, when the reaction with known cross section [2, 3] and nearly the same final state is measured allows to get rid of most of the systematic uncertainties connected with particle identification and detector efficiencies.

The missing mass distribution $m(\pi^+\Lambda)$, presented in Fig. 2, is the one where the signal from the pentaquark is expected to appear. A combined fit with the sum of resonant and non-resonant channels obtained from the Monte Carlo simulations has been performed (the solid line in Fig. 2), and the hatched area shows a signal produced by the Θ^+. As one can see, there is only a moderate agreement between experimental data and the simulations. While at the high mass part of the spectrum the agreement is nice, an obvious excess of experimental events is observed around $1.47\,\text{GeV/c}^2$. Such an enhancement may be connected with the production of some resonance at an intermediate stage of the reaction. Candidates for this are e.g. $K^*(892)$, Δ^{++}, $N^*(1650)$ or $N^*(1710)$, and $\Sigma(1385)$. Analysis of these possibilities is ongoing.

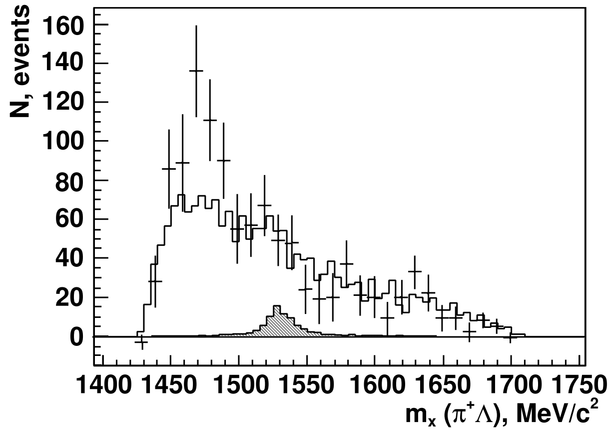

Fig. 2: Missing mass spectrum of $\pi^+\Lambda$ system. The hatched area shows the result of Monte Carlo simulations corresponding to the production of Θ^+. The solid line is the sum of resonant and non resonant contributions.

The number of events in the missing mass of $\pi^+\Lambda$ amounts to 50 ± 30 events, which can be treated as an upper limit for possible Θ^+ production and corresponds to the cross section of

$$\sigma_{\Theta^+\pi^+\Lambda} = 0.17 \pm 0.10\mu b,$$

which is close to the theoretical expectations of less than $1\,\mu$b at this energy [4]. The total cross section for the reaction $pp \to pK^0\pi^+\Lambda$ including resonant and non-resonant channels is

$$\sigma_{pK^0\pi^+\Lambda} = 1.33 \pm 0.14\mu b.$$

The errors given are statistical only. The value for the total cross section agrees nicely with the calculations made in Ref. [3]. Although both resonant and non-resonant production cross sections are supported by theory, the discrepancy in the low $\pi^+\Lambda$ missing mass region has yet to be understood.

References:

[1] A. I. Titov et al., Phys. Rev. C70 (2004) 042202.
[2] R. I. Louttit et al., Phys. Rev. 123 (1961) 1465-1471.
[3] K. Tsushima et al., Phys. Rev. C 59 (1999) 369-387.
[4] W. Liu and C. M. Ko., Phys. Rev. C68 (2003) 045203.

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