Bound kaonic nuclear states with ANKE@COSY

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Study of deeply bound kaonic nuclear states deals with one of the most important, yet unsolved, problems in hadron physics: how the hadron masses and hadron interactions change in the nuclear medium and what is the structure of cold dense hadronic matter. The hypothesis of deeply bound kaonic nuclear states (also indicated as kaonic nuclear clusters) is six years old, in the structured form of a phenomenological model [1]. A successful example of deeply bound pionic atomic states did already exist, after their observation at GSI in 1996 [2, 3]. Some experimental indications of kaonic nuclear clusters have been recently obtained at E471, E549, E548@KEK-PS [4], FINUDA@DAFNE [5], FOPI@GSI [6], OBELIX [7] and E930@BNL-AGS [8].

In the FINUDA experiment, the evidence of the kaon-bound state K^-pp through its decay into a Λ and a proton has been observed. The invariant-mass distribution of the Λp pair shows a significant mass decrease with respect to the mass of the system expected in case of a simple K^-pp absorption. The mass of the K^-pp system is equal to 2370 MeV/c^2. The state K^-pp has a binding energy of $115^{+6}_{-5}(stat)^{+3}_{-4}(syst)$ MeV and a decay width of $67^{+14}_{-11}(stat)^{+2}_{-3}(syst)$ MeV.

In the re-analysis of the DISTO data obtained in the $pp \to pK^+\Lambda$ reaction measured at a proton beam energy of 2.85 GeV a large broad peak has been observed [9]. It is then concluded that the structure with a mass of 2265 MeV/c^2 and a width of 118 MeV/c^2 is most likely due to a K^-pp bound state formed in the $pp \to K^+X^+$ reaction followed by the $X^+ \to p\Lambda$ decay. The signal has been observed only with a selection of large–angle proton emission in the restricted phase space. The maximum of the observed peak coincides with the $\pi\Sigma N$ threshold. In the chiral framework such a broad state in the deep subthreshold region would be interpreted in terms of $\pi\Sigma N$ dynamics [10].

The $pp \to K^+X^+$ reaction has been investigated with ANKE@COSY at a beam energy of 2.83 GeV, see Ref. [11] for more experimental details. Assuming a decay of the X^+ into $p\Lambda$, followed by the $\Lambda \to p\pi^-$ decay, the final state comprising of K^+, two protons and π^- could be observed: $pp \to K^+X^+ \to K^+p\Lambda \to K^+pp\pi^-$. Positively charged kaons were measured in telescopes. The protons from the X^+ decay were identified in the forward counters and protons from the Λ decay in telescopes and side-wall scintillators.

In Fig. 1 the missing-mass $MM(K^+)$ distribution measured with ANKE@COSY is shown (blue points). In addition, there is indicated a mass of the ppK^- system together with a binding energy and a width measured by the FINUDA collaboration. No events have been found for $MM(K^+)$ <2365 MeV/c^2. Since ANKE can identify both positively charge kaons and negatively charged pions in a limited momentum range, *i.e.* K^+ with momenta lower than 700 MeV/c^2 in the telescope counters and π^- with momenta higher than 200 MeV/c^2, we conclude that a restricted acceptance of the ANKE spectrometer is responsible for a non-observation of the X^+ with a mass of 2255 MeV/c^2 and a width of 67 MeV/c^2, if it exists.

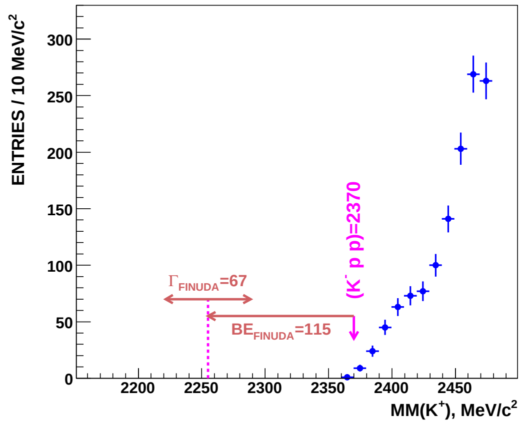

Fig. 1: The experimental missing-mass $MM(K^+)$ distribution measured in the reaction $pp \to K^+X^+$ (blue points). There is indicated a mass of the ppK^- system together with a binding energy and a width measured by the FINUDA collaboration. All values are in MeV/c^2.

In Fig. 2 the $MM(K^+)$ vs K^+ momentum distribution calculated for the $pp \to K^+X^+$ reaction is shown (black points). The horizontal box shows a $MM(K^+)$ mass range expected for the X^+ with a mass of 2255 MeV/c^2 and a width of 67 MeV/c^2. As it is seen, the mass ∼2255 MeV/c^2 could be connected with kaons produced at higher momenta up to ∼1.5 GeV/c. So, it is possible to identify the $pp \to K^+X^+$ reaction by measuring kaons in the side–wall counters together with protons from the X^+ decay in telescopes and protons from the Λ decay in forward part of the ANKE detector system. Such simulated spectrum is shown in Fig. 3. The analysis of data under the above specified conditions could be considered.

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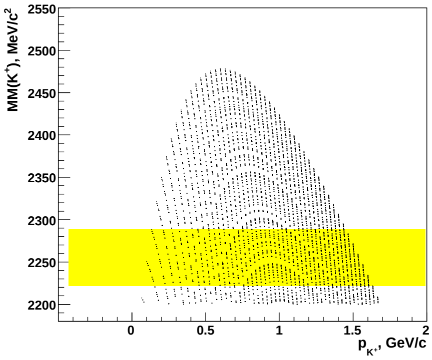

Fig. 2: The missing-mass $MM(K^+)$ vs K^+ momentum distribution calculated for the $pp \to K^+X^+$ reaction is shown as black points. The horizontal box shows a $MM(K^+)$ mass range expected for the X^+ with a mass of 2255 MeV/c^2 and a width of 67 MeV/c^2.

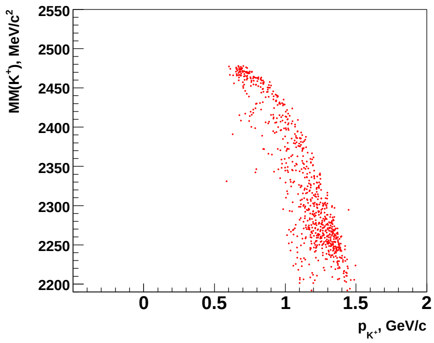

Fig. 3: The simulated missing-mass $MM(K^+)$ vs K^+ momentum distribution with kaons identified in side-wall scintillators, protons from the X^+ decay identified in telescopes and protons from the Λ decay in forward part of the ANKE detector system.

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