Evidence of an excited hyperon state in $pp \to pK^+Y^{0*}$

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The reaction $pp \to pK^+Y$ has been studied with the ANKE spectrometer to investigate heavy hyperon production. The missing mass spectra $MM(pK^+)$ have been analyzed and compared with extensive Monte Carlo simulations. Indications for a hyperon resonance $Y^{0*}(1480)$ have been found.

The measurements were performed at a proton beam momentum of 3.65 GeV/c incident on a a hydrogen cluster–jet target. The average luminosity during the measurements was $L = (1.38 \pm 0.15) \times 10^{31} \mathrm{s}^{-1} \mathrm{cm}^{-2}$.

At the COSY beam momentum of 3.65 GeV/c hyperons Y with masses up to 1540 MeV/c^2 can be produced in the reaction $pp \to pK^+Y$. A final state comprising a proton, a positively charged kaon, a pion of either charge and an unidentified residue X was investigated in the reaction $pp \to pK^+Y \to pK^+\pi^\pm X^\mp$.

The missing mass spectrum in the reaction $pp \to pK^+\pi^+X^-$ consists of a flat plateau with a peak at approximately 1195 MeV. The peak corresponds to the decay $Y \to \pi^+\Sigma^-(1197)$. In the charge–mirrored $pp \to pK^+\pi^-X^+$ case, the π^- may originate from different sources, *e.g.* a decay with the $\Sigma^+(1189)$ or a secondary decay of $\Lambda \to p\pi^-$, arising from the major background reaction $pp \to pK^+\Lambda \to pK^+\pi^-p$. Protons from this reaction can be easily rejected by cutting $MM(pK^+\pi^-)$ around the proton mass. Nevertheless the missing mass distribution for the (π^-X^+)-final state is more complicated.

If only events around the Σ mass are selected, then the missing mass $MM(pK^+)$ spectrum in the reaction $pp \to pK^+\pi^+X^-$ shows two peaks, see upper part in Fig. 1. One of them corresponds to the contribution of $\Sigma^0(1385)$ and $\Lambda(1405)$ hyperons. The second peak is located at a mass $\sim$1480 MeV/c^2. In the π^-X^+ case, the distribution also peaks at 1480 MeV/c^2, lower part in Fig. 1.

We have tried to explain the measured missing mass $MM(pK^+)$ spectra by the production of hyperon resonances and non-resonant contributions. Detailed Monte Carlo simulations have been performed including the production of well established excited hyperons ($\Sigma^0(1385), \Lambda(1405)$ and $\Lambda(1520)$) and non-resonant contributions like $pp \to pK^+\pi X$ and $pp \to pK^+\pi\pi X$, X denotes any hyperon which could be produced in the experiment. From the comparison of measured and simulated missing mass distributions it turned out that it is necessary to include another excited hyperon Y^{0*} with a mass $M(Y^{0*}) = (1480 \pm 15)$ MeV/c^2 and a width $\Gamma(Y^{0*}) = (60 \pm 15)$ MeV/c^2.

In summary, we have found indications in proton–proton collisions at 3.65 GeV/c for a neutral hyperon resonance Y^{0*} decaying into π^+X^- and π^-X^+ final states. Since it is neutral, it can be either a Λ or Σ hyperon. The production cross section is of the order of few hundred nanobarns. It seems to be difficult to integrate a $Y^{0*}(1480)$ hyperon within the existing classification of $3q$-baryons [1, 2]. On the basis of available data we cannot decide whether it is a 3–quark baryon or an exotic state, although some preference towards its exotic nature may be deduced from theoretical considerations [3, 4, 5, 6, 7, 8].

Further studies are required to determine its quantum numbers. At ANKE, using a deuterium cluster target and spectator proton tagging, one can search for the charged Y^{-*} hyperon in the reaction $pn \to pK^+Y^{-*} \to pK^+\pi^-X^0$. The investigation of Y^* decays with photons in the final state is foreseen with the WASA detector at COSY [9].

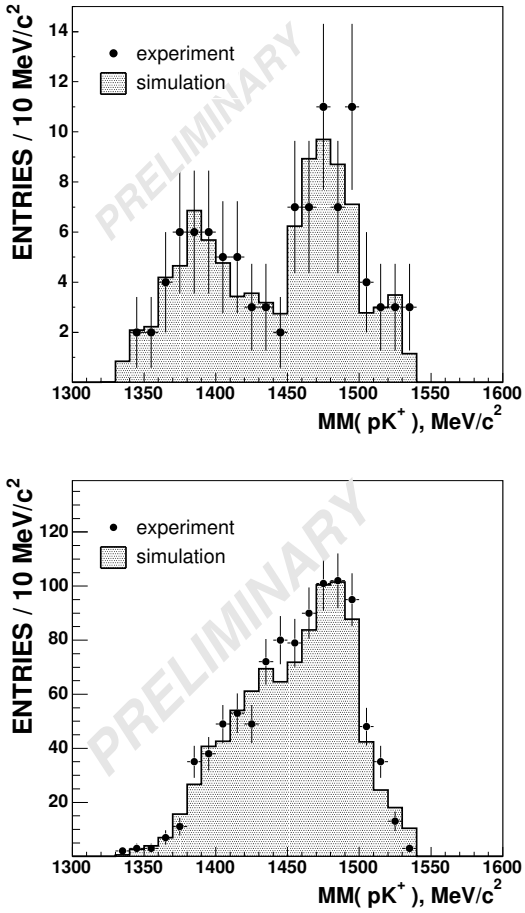

Fig. 1: Experimental and simulated missing mass $MM(pK^+)$ spectra for the reaction $pp \to pK^+\pi^+X^-$(upper) and $pp \to pK^+\pi^-X^+$(lower). The shaded histogram shows the fitted Monte Carlo simulations.

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