$\Lambda(1405)$ production in pp collisions

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The $\Lambda(1405)$ is a particularly interesting baryonic state because its structure is not yet understood and it is difficult to obtain in quark models. The $\Lambda(1405)$ can be the spin-multiplet partner of $J^P = 3/2^-$ $\Lambda(1520)$, or a meson-baryon resonance, or $\bar{K}N$ quasibound state. The first indication about a resonance now known as the $\Lambda(1405)$ has been presented in 1960 [1]. In 1985 after the measurement of the $\Lambda(1405)$ in K^-p reactions [2] there has been a hope that "the debate as to whether the $\Lambda(1405)$ is a pure quark state or a $\bar{K}N$ bound state may soon be clarified." Recent theoretical investigations based on chiral dynamics predict two poles for the $\Lambda(1405)$, one with a mass 1390 MeV/c^2 and a width of about 130 MeV/c^2 coupling strongly to $\pi\Sigma$ states and the other one with a mass around 1425 MeV/c^2 and a width of about 30 MeV/c^2 coupling mostly to $\bar{K}N$ states [3]. Earlier references could be found in the Review of Particle Physics 2000 Edition [4].

We report on measurements done with the ANKE spectrometer at COSY-Jülich. The reaction $pp \to pK^+Y^{0*}$ has been studied at a beam momentum of 3.65 GeV/c to investigate the production of excited hyperon resonances Y^{0*} decaying via $\Sigma^0\pi^0$. In case of $\Lambda(1405)$ production in pp collisions there are two protons, one positively charged kaon and negatively charged pion in the final state: $pp \to pK^+\Lambda(1405) \to pK^+\Sigma^0\pi^0 \to pK^+\Lambda\gamma\pi^0 \to pK^+p\pi^-\pi^0\gamma$. At ANKE those particles are measured with *different* parts of the detection system: a positively charged kaon is registered in a telescope, a vertex proton in a forward detector, a decay proton in a positive-side detector (telescope or side-wall counter) and a negatively charged pion in a negative counter.

In Fig. 1 the missing–mass distribution $MM(p_{FD}K^+)$ vs $MM(pK^+p\pi^-)$ is shown for the 3.65 GeV/c pp collisions.

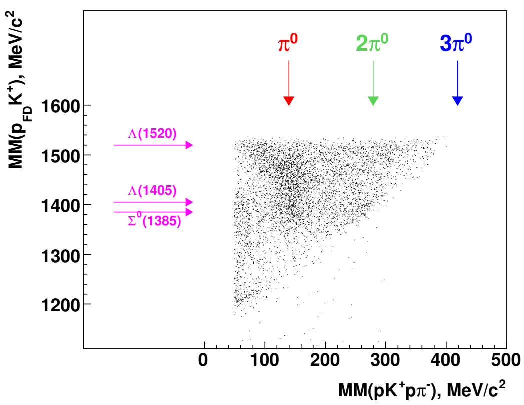

Fig. 1: The missing–mass distribution $MM(p_{FD}K^+)$ vs $MM(pK^+p\pi^-)$ for the 3.65 GeV/c pp collisions.

The triangular shape of the distributions is due to the combination of kinematics and ANKE acceptance.

The missing and invariant mass techniques are used to identify the $\Lambda(1405)$ resonance. Cutting on the invariant mass of $p\pi^-$ we detect protons and negative pions from Λ decay. Furthermore we request the missing mass $MM(pK^+p\pi^-)$ to be higher than a mass of π^0 to separate the $\Lambda(1405)$ hyperon.

In Fig. 2 the missing–mass $MM(p_{FD}K^+)$ spectrum measured under above conditions is shown. The most prominent peak corresponds to the $\Lambda(1405)$.

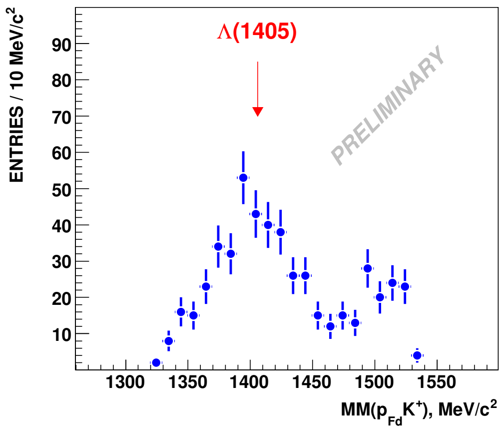

Fig. 2: The missing–mass $MM(p_{FD}K^+)$ distribution with a peak corresponding to the $\Lambda(1405)$ mass.

It is the first observation of the direct production of $\Lambda(1405)$ in pp collisions decaying via $\Sigma^0\pi^0$. Preliminary number of events in the $\Lambda(1405)$ peak is 250 ± 50.

In the next step, the missing–mass spectra both $MM(p_{FD}K^+)$ and $MM(pK^+p\pi^-)$ will be analysed and compared with extensive Monte Carlo simulations. The phase-space distribution as well as the $\Lambda(1405)$ mass distribution for the $\Sigma^0\pi^0$ decay channel obtained in a chiral unitary model [5] will be exploited.

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