H1 search for a narrow baryonic resonance decaying to $K^0_S p(\bar{p})$

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Abstract. Preliminary results from the H1 experiment on the search for the production of a candidate for the strange pentaquark in the decay channel $\Theta^+ \to K^0_s p$ and its antiparticle in the invariant mass combinations of K^0_s mesons with protons and antiprotons in deep-inelastic ep-scattering at HERA are presented.

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INTRODUCTION

Recently several experiments have observed narrow baryonic resonances in various reaction processes [1] which can be interpreted as strange pentaquark Θ^+. However, negative results have been reported [1] from pp and ep collisions, e^+e^- annihilation and also from fixed target photo-production experiments. Preliminary results on the search for the strange pentaquark Θ^+ [1] decaying into $K^0_s p$ in deep-inelastic ep scattering (DIS) with the H1 detector are presented here. Despite the lack of understanding of the pentaquark production mechanism in high energy processes it is assumed that pentaquark formation is part of the fragmentation process. Since no significant signal was found upper limits are derived on the visible Θ^+ cross section in DIS at HERA.

ANALYSIS OF K^0_S P COMBINATIONS

The analysed data was collected with the H1 detector in the years 1996 to 2000 and corresponds to an integrated luminosity of $71\,\mathrm{pb}^{-1}$. A detailed description of the H1 detector can be found elsewhere [4]. DIS events were selected by requiring a reconstructed scattered electron in the backward calorimeter of H1 and an exchanged photon virtuality of $Q^2 > 5\,\mathrm{GeV}^2$. The condition $0.1 < y < 0.6$ ensures substantial hadronic final state energies in the central detector region. K^0_s meson decays are reconstructed via the decay mode $K^0_s \to \pi^+\pi^-$ by requiring a radial displacement of the decay vertex of at least 2 cm from the primary interaction point. Only those K^0_s candidates having transverse momenta $p_\mathrm{T}(K^0_s) \geq 0.3$ GeV and pseudorapidities $|\eta(K^0_s)| \leq 1.5$ in the laboratory frame are accepted. About $142000 K^0_S$ mesons are reconstruced. Candidate K^0_s mesons within

[1] The charge conjugate state is always implied if not otherwise stated expliciely.

$\pm 2\sigma$ of the measured K_s^0 mass are further combined with tracks originating from the primary vertex assigned the proton mass. These proton tracks are selected using the measurement of the ionisation loss d$E/$dx in the central drift chambers of H1 yielding a resolution of about 8% for minimum ionizing particles. From the difference of the measurement and a Bethe-Bloch-like parameterisation the likelihoods for different particle hypotheses are calculated which are used for particle identification.

The selected K_s^0 meson and proton candidates are combined and the invariant mass $M(K_s^0 p)$ of these combinations is formed by fixing the K_s^0 mass to its nominal value [5]. For the $K_s^0 p$ system $p_t(K_s^0 p) > 0.5$ GeV^2 and $|\eta(K_s^0 p)| < 1.5$ is required. The $M(K_s^0 p)$ distributions for three different bins in Q^2, $5 < Q^2 < 10\,\mathrm{GeV}^2$, $10 < Q^2 < 20\,\mathrm{GeV}^2$ and $20 < Q^2 < 100\,\mathrm{GeV}^2$ are shown in Fig. 1 together with a fit of a background function. No significant structure is observed in neither of the Q^2 bins. The $M(K_s^0 p)$

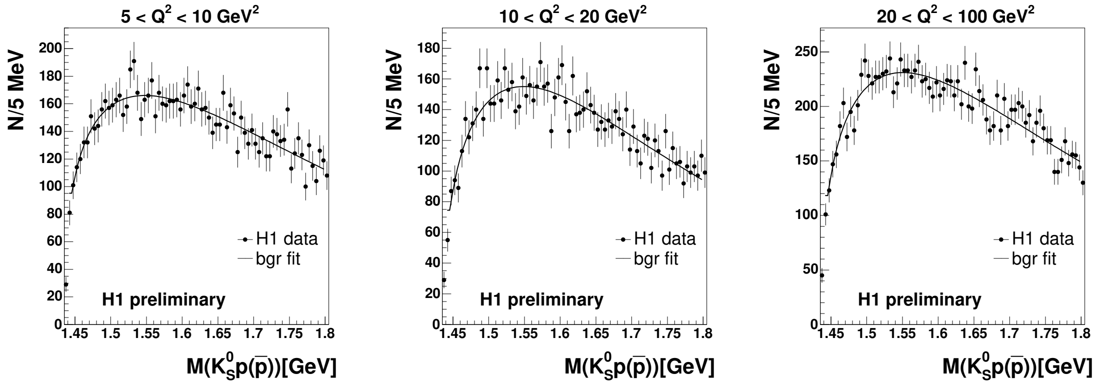

FIGURE 1. Invariant $K_S^0 p(\bar{p})$ mass spectra for the standard dE/dx selection in bins of Q^2, which are used for the limit extraction. The full line shows the result from the fit of a background function to the data. The mass spectra show upward fluctuations at different masses but no significant peak is observed.

distributions are used to derive mass dependent upper limits at 95 % confidence level (C.L.) on the visible Θ^+ production cross section $\sigma(ep \to e\Theta^+ X \to K^0 pX)$. In order to set limits, it is assumed that strange pentaquarks are produced by fragmentation. The acceptances were calculated using the RAPGAP 3.1 [6] event generator incorporating fragmentation according to the Lund string model [7] implemented in PYTHIA 6.2 [8]. The experimental resolution of a possible state with zero width decaying to $K_s^0\ p$ is expected to be $\sigma(M(K_s^0 p)) = 5$ MeV.

The experimental systematic uncertainties comprise contributions from e.g. the DIS event selection, uncertainties of the efficiencies of track reconstruction and d$E/$dx selection and variations of the fitting method. The total systematic uncertainty is 18%.

The resulting upper limits on the Θ^+ cross section $\sigma_{u.l.}(ep \to e\Theta^+ X \to K^0 pX)$ in the visible range defined by $5 < Q^2 < 100\,\mathrm{GeV}^2$, $0.1 < y < 0.6$, $pt(K_s^0 p) > 0.5\,\mathrm{GeV}$ and $|\eta(K_s^0 p)| < 1.5$ at 95% confidence level are shown in Fig. 2 in different Q^2 bins. The upper limit on the number of Θ^+ is derived assuming a width of a possible signal of 5 and 8 MeV, using signal mass windows of ± 10 and ± 16 MeV, respectively, shown as full and dashed lines. In the lowest Q^2 bin an upward fluctuation of the upper limit in the interesting mass region 1.52 to 1.54 GeV is observed. However, a different shape of the fluctuations of the limits for the different Q^2 bins is found. The 95% C.L. upper

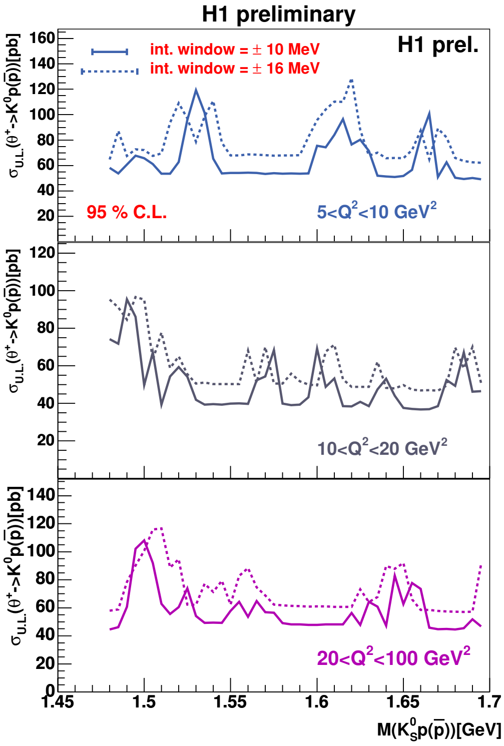

FIGURE 2. Upper limits on the cross section $\sigma_{U.L.}(ep \to e\theta^+X \to eK^0p(\bar{p})X)$ at 95% confidence level in bins of Q^2 in the visible range $p_T(K_s^0p) > 0.5$ GeV and $|\eta(K_S^0p)| < 1.5$. The full and dashed line represents the limit using ± 10 and ± 16 MeV mass windows, respectively.

limits vary between 40 and 120 *pb* for the different Q^2 regions and over the mass range from 1.48 to 1.7 GeV. The upper limits for the decay $\Theta^+ \to K_s^0 p$ and its charge conjugate $\bar{\Theta}^- \to K_s^0\bar{p}$ were found to be of comparable size and the fluctuations of the corresponding limits were found to be at different masses.

A positive Θ^+ observation in DIS at HERA has been reported at a mass of 1.522 GeV by the ZEUS experiment [2] with an observed visible cross section of $\sigma(e^\pm p \to e^\pm\Theta^+X \to e^\pm K^0 pX) = 125 \pm 27(stat.)^{+36}_{-28}(syst.)$ pb in the kinematic range $Q^2 > 20\,\mathrm{GeV}^2$, $0.04 < y < 0.95$ using a data sample with an integrated luminosity of 121 pb^{-1}. In order to be able to compare the upper limits on the Θ^+ production more directly to these results, the analysis was repeated using a proton selection more similar to that used in [2], in the following called "low momentum dE/dx selection". The dE/dx-likelihood proton selection was replaced by a visual selection, requiring dE/d$x > 1.15$, $p(p) < 1.5$ GeV and $f_1 <$ dE/d$x < f_2$, where f_i are functions enclosing 98 % of the proton dE/dx band. The invariant $K_s^0 p(\bar{p})$ mass spectrum for $20 < Q^2 < 100\,\mathrm{GeV}^2$ and the resulting upper limits on the Θ^+ cross section at 95 % confidence level are shown in Fig. 3. Around the mass of 1.52 GeV an upper limit on the cross section of roughly 100 pb is found, which does not contradict the cross section of the ZEUS experiment quoted above. Also for this low momentum dE/dx selection the upper limits for the positive and nevative combinations were investigated separetely and the up- and down-

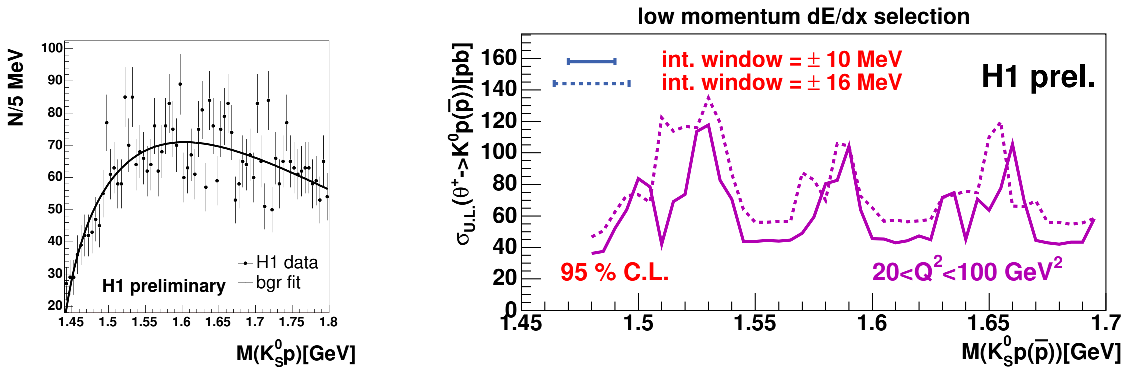

FIGURE 3. Invariant $K_S^0 p$ mass spectra in the highest Q^2 bin, $20 < Q^2 < 100$ GeV^2, for the low momentum dE/dx selection (left) and the corresponding upper limit at 95 % confidence level on the Θ^+ cross section $\sigma_{U.L.}(ep \to e\theta^+ X \to eK^0 p(\bar{p})X)$ (right).

ward fluctuations were found to be at different masses in the respective upper limits on the Θ^+ ($\bar{\Theta}^-$) cross section.

CONCLUSIONS

The preliminary results of the search for the strange pentaquark Θ^+ in deep-inelastic ep scattering has been presented. No significant signal for Θ^+ production in the decay mode $\Theta^+ \to K_s^0 p(\bar{p})$ has been observed in the $K_s^0\ p(\bar{p})$ mass distribution for different regions in Q^2 between 5 and 100 GeV^2. With the assumption that pentaquarks are produced by fragmentation mass dependent upper limits on the cross section $\sigma(ep \to e\Theta^+ X \to K^0 p(\bar{p})X)$ are derived as a function of Q^2 and found to vary between 40 and 120 pb over the mass range of 1.48 to 1.7 GeV. In order to compare to the previous measurement of the visible Θ^+ cross section by the ZEUS collaboration, the analysis was repeated with a low momentum dE/dx selection. The resulting upper limit does not exclude the previosly observed cross section [9]. The present statistical precision in the HERA I data sample is not sufficient to draw a stronger conclusion.

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