Spectroscopy at HERA

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Abstract. Searches for strange and charmed pentaquark candidates by the ZEUS and H1 experiments in *ep* collisions at HERA are presented. The analyses are based on deep-inelastic scattering and also photoproduction data at a center-of-mass energy of 300-318 GeV using the full HERA I luminosity.

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INTRODUCTION

Recently observations of a narrow baryonic state decaying to K^+n or $K^0_S p$ by fixed-target experiments at low center-of-mass energies have triggered intense experimental activity, followed by many observations but also non-observations by several experiments [1]. Results by the ZEUS and H1 experiments on searches for a strange pentaquark Θ^+ and also for a possible charm pentaquark in deep inelastic *ep* scattering (DIS) at HERA are presented here.

STRANGE PENTAQUARK SEARCHES AT HERA

A search for the strange pentaquark decaying to $K^0_S p(\bar{p})$ has been performed by the ZEUS experiment [2]. The analysed HERA-I data correspond to an integrated luminosity of 121 pb^{-1}. The K^0_S mesons are identified through its decay into charged pions, and proton candidates are selected based on the measurement of the ionisation energy loss dE/dx at proton momenta $p(pr) < 1.5$ GeV. The invariant mass distribution of $K^0_S p(\bar{p})$ combinations for photon virtualities $Q^2 > 20$ GeV^2 is shown in Fig.1a. A fit of the sum of a background function and two Gaussian distributions yields a signal of 221 ± 48 events at a mass of 1521.5 ± 1.5 MeV. The significance of the signal is estimated to be 4.6σ. The Θ^+ production cross section is extracted [3] in the kinematic region $Q^2 > 20$ GeV^2, $0.04 < y < 0.95$, $p_T(K^0_S p(\bar{p})) > 0.5$ GeV and $|\eta(K^0_S p(\bar{p}))| < 1.5$ and is found to be $\sigma_{vis} = 125 \pm 27(\text{stat.})^{+36}_{-28}(\text{syst.})$pb. A similar analysis has been performed by the H1 experiment [4], using 71 pb^{-1} of DIS data in the kinematic range defined by $0.1 < y < 0.6$, $5 < Q^2 < 100$ GeV^2. Protons are selected using particle identificiation with likelihood cuts based on the dE/dx measurement. No signal is observed and Q^2 and mass dependent upper limits on the Θ^+ production cross section at 95 % C.L. are extracted, which are found to vary between 30 and 90 pb. In order to compare the upper limits more directly to the observation by the ZEUS experiment, the analysis was repeated restricted to the kinematic range $p(pr) < 1.5$ GeV and $Q^2 > 20$ GeV. The

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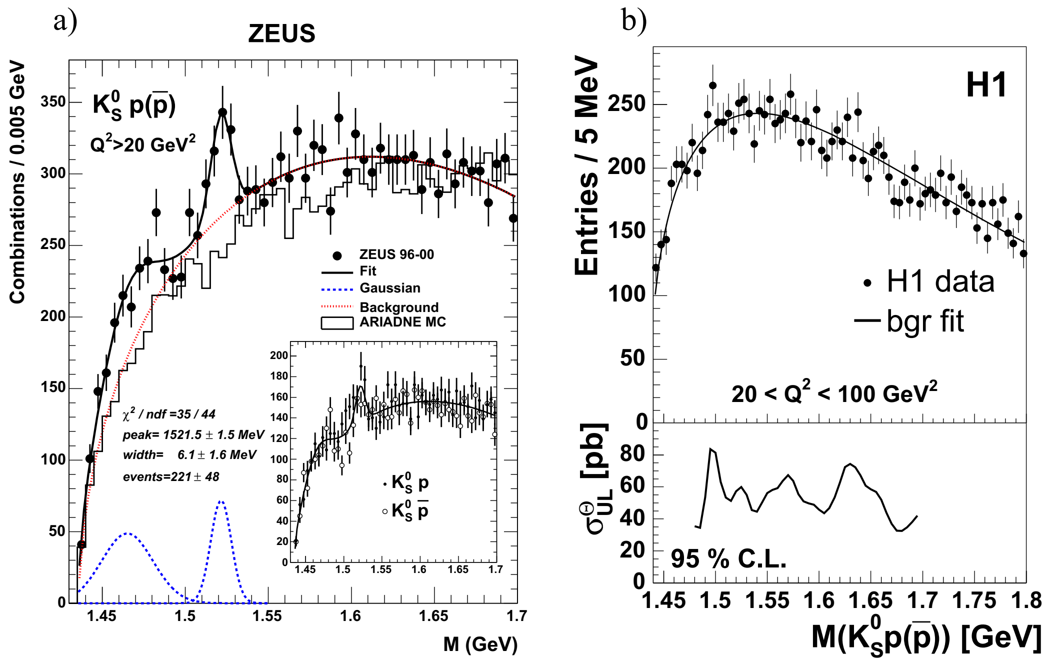

FIGURE 1. a) The invariant $K_S^0 p(\bar{p})$ mass spectrum observed by ZEUS for $Q^2 > 20$ GeV^2 together with a fit of a background function and two Gaussian distributions. b) The invariant mass spectrum and upper limit observed by H1 for $Q^2 > 20$ GeV^2 and $p(pr) < 1.5$ GeV.

resulting invariant $K_s^0 p(\bar{p})$ mass spectrum and upper limit are shown in Fig.1b. At a mass of 1522 MeV an upper limit of 72 pb is found, which does not exclude the cross section observed by ZEUS. ZEUS has also carried out a search for a resonance in the invariant $\Xi\pi$ spectrum, but no signal is found [5].

CHARM PENTAQUARK SEARCHES AT HERA

H1 has performed a search for a possible charmed pentaquark candidate and reported evidence for a narrow resonance in the D^*p mass spectrum around 3.1 GeV [6], shown in Fig.2a, using 75 pb^{-1} of DIS HERA-I data at $1 < Q^2 < 100$ GeV^2. The D^*-mesons are identified by evaluating the mass difference between the D^* and the D^0, $\Delta M = M(K\pi\pi_s) - M(K\pi)$, and protons are selected via dE/dx likelihoods. A fit to the data of a background function and a Gaussian yields 50.6 ± 11.2 signal events. The probability that the background distribution fluctuates to produce the signal is estimated from a fit using only the background function to be 4×10^{-8}, assuming Poisson statistics. The acceptance corrected ratio of the D^*p to the D^* cross section in the visible kinematic range is found to be $R_{cor}(D^*p(3100)/D^*) = 1.59 \pm 0.33^{+0.33}_{-0.45}$ [7]. ZEUS has performed a similar analysis using 126 pb^{-1} of DIS and photoproduction (γp) data. The D^* decay channels $K\pi\pi_s$ and also $K\pi\pi\pi\pi_s$ are investigated using a different kinematic range than that used by H1. No resonance is observed in the invariant $M(D^*p)$ spectra. The upper limit on the ratio of D^*-mesons orginating from $D^*p(3100)$ decays is extrated to be 0.59 % at 95 % C.L. for the DIS sample at $Q^2 > 1$ GeV^2 using the $K\pi\pi_s$ decay channel. The

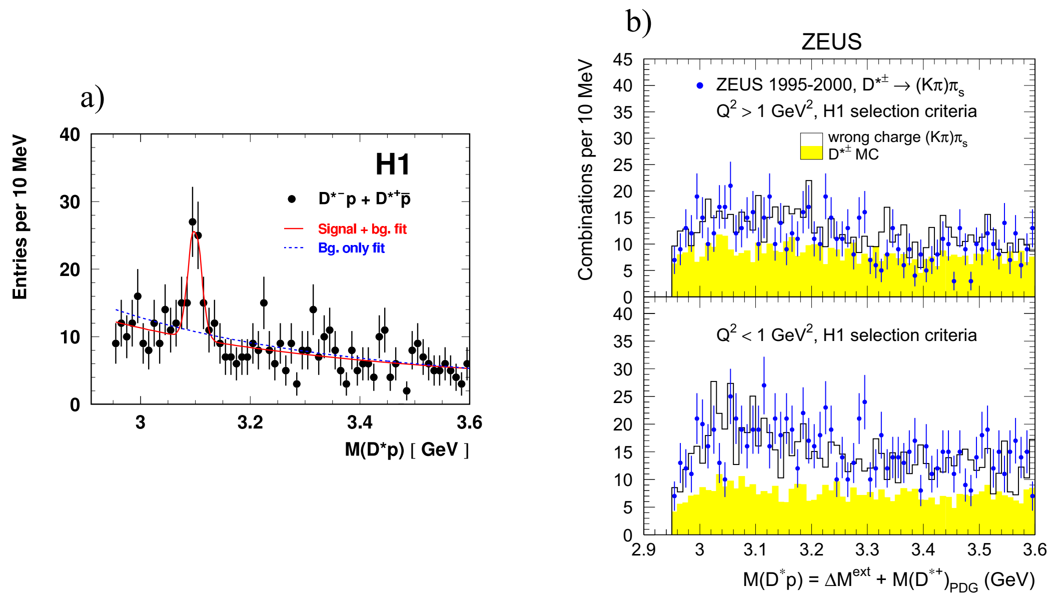

FIGURE 2. a) $M(D^*p)$ mass distribution from opposite-charge D^*p combinations together with a fit of a background (dashed) and a background plus signal function(full line) measured by H1. b) $M(D^*p)$ mass distribution observed by ZEUS for DIS (top) and γp (bottom) events in the $K\pi\pi_s$ decay channel.

analysis has been repeated with selection cuts similar to those used by H1. The resulting mass spectra are shown in Fig.2b for the DIS (top) and the photoproduction sample (bottom). No signal is observed and the H1 observation is not confirmed by ZEUS.

CONCLUSIONS

The observation of a Θ^+ candidate by ZEUS can not be confirmed by H1, but the extracted upper limits on the production cross section do not exclude this observation. While H1 observes a narrow baryonic resonance decaying to D^*p, ZEUS does not. The ongoing high-luminosity data taking at HERA-II, may help to clarify these open questions.

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