

Spectroscopy and pentaquarks at HERA

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Abstract.

Results of the H1 and ZEUS Collaborations on spectroscopy of light and charmed mesons and on pentaquark searches, obtained using the HERA I data, are summarised.

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INTRODUCTION

Light and charmed hadrons are produced copiously in ep collisions with a centre-of-mass energy of 318 GeV at HERA. During first phase of HERA operation (1992-2000), the H1 and ZEUS Collaborations accumulated data samples corresponding to $\sim 120\text{pb}^{-1}$ each. The H1 and ZEUS results on hadron spectroscopy and pentaquark searches are summarised in this note.

SPECTROSCOPY OF LIGHT AND CHARMED MESONS

Inclusive photoproduction of η , ρ^0 , $f_0(980)$ and $f_2(1270)$ mesons was measured at an average photon-proton centre-of-mass energy $W = 210\text{GeV}$ [1]. The differential cross sections for those mesons and for charged pions as a function of $p_T + m$, where m is the meson's nominal mass, show similar power-law behaviour. The results suggest a similar mechanism of the mesons production in fragmentation processes.

Measurement of inclusive $K_s^0 K_s^0$ production in deep inelastic scattering (DIS) revealed a state at 1537 MeV, consistent with $f_2'(1525)$, and another at 1726 MeV [2]. The state at 1726 MeV has a mass consistent with $f_0(1710)$, and is found in a gluon-rich region of phase space. This observation indicates that $f_0(1710)$ has a sizeable gluonic component.

The production of excited charmed and charmed-strange mesons was studied using their decays to final states involving $D^{*\pm}$ [3]. The measured rates of c quarks hadronising as D_1^0 , D_2^{*0} and D_{s1}^\pm mesons agree with those obtained in e^+e^- annihilations. The measured value of the helicity parameter for D_{s1}^\pm mesons is consistent with the observation of the CLEO Collaboration that the spin-parity of the D_{s1}^\pm is 1^+ . A search for the radially excited $D^{*'\pm}$ meson revealed no signal. The upper limit on the product of the fraction of c quarks hadronising as a $D^{*'+}$ meson and the branching ratio of the $D^{*'+}$ decay to $D^{*+}\pi^+\pi^-$ was estimated to be 0.7% (95% C.L.).

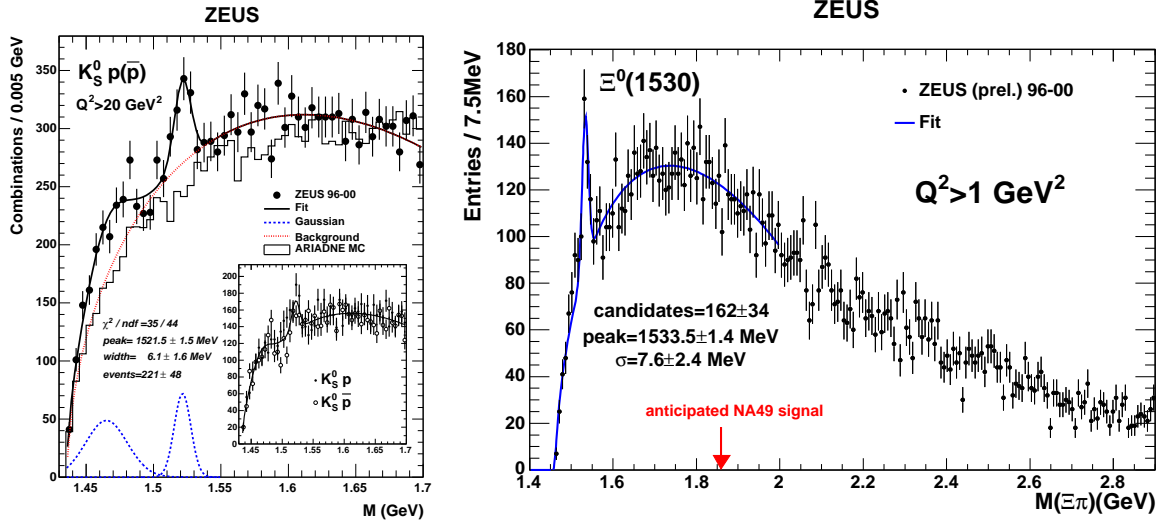


FIGURE 1. Invariant mass spectrum for the $K_s^0 p(\bar{p})$ combinations for $Q^2 > 20 \text{ GeV}^2$ (left) and for $\Xi\pi$ combinations for $Q^2 > 1 \text{ GeV}^2$ (right)

STRANGE PENTAQUARKS

A peak in the $K_s^0 p(\bar{p})$ invariant mass spectrum around 1520 MeV was observed in DIS by the ZEUS Collaboration [4]. In Fig. 1(left), the spectrum is shown for exchanged photon virtuality $Q^2 > 20 \text{ GeV}^2$. The statistical significance of the signal varies between 3.9σ and 4.6σ depending upon the treatment of the background. The signal is seen in both $K_s^0 p$ and $K_s^0 \bar{p}$ samples. If the signal corresponds to the pentaquark Θ^+ , this provides the first evidence for an anti-pentaquark with a quark content $\bar{u}\bar{u}\bar{d}\bar{d}s$. A ratio of the Θ^+ and Λ^0 production cross sections was measured to be $4.2 \pm 0.9(\text{stat.})_{-0.9}^{+1.2}(\text{syst.})\%$ [5].

The ZEUS Collaboration performed also a search for two other pentaquarks, reported by the NA49 Collaboration, and observed no signal in the $\Xi\pi$ invariant mass spectrum [6]. In Fig. 1(right), the spectrum is shown for $Q^2 > 1 \text{ GeV}^2$. A clear peak with more than 160 $\Xi^0(1530)$ baryons indicates that the statistical sensitivity of the search is similar to that of the NA49 Collaboration.

CHARMED PENTAQUARKS

An observation of a candidate for the charmed pentaquark state, $\Theta_c^0 = uud\bar{d}\bar{c}$, decaying to $D^{*\pm} p^\mp$ was reported by the H1 Collaboration [7]. Fig. 2(left) shows the $D^{*\pm} p^\mp$ invariant-mass distributions in DIS with $Q^2 > 1 \text{ GeV}^2$ and in photoproduction with smaller Q^2 values. A fit of the signal in DIS yielded 50.6 ± 11.2 signal events and the mass of $3099 \pm 3(\text{stat.}) \pm 5(\text{syst.}) \text{ MeV}$. The observed resonance was reported to contribute roughly 1% of the $D^{*\pm}$ production rate in the kinematic range studied in DIS.

The observation of the H1 Collaboration was challenged by the ZEUS collaboration [8]. Using a larger sample of $D^{*\pm}$ mesons, ZEUS observed no signature of the narrow resonance in the $M(D^{*\pm} p^\mp)$ spectra shown in Fig. 2(right). The Monte Carlo

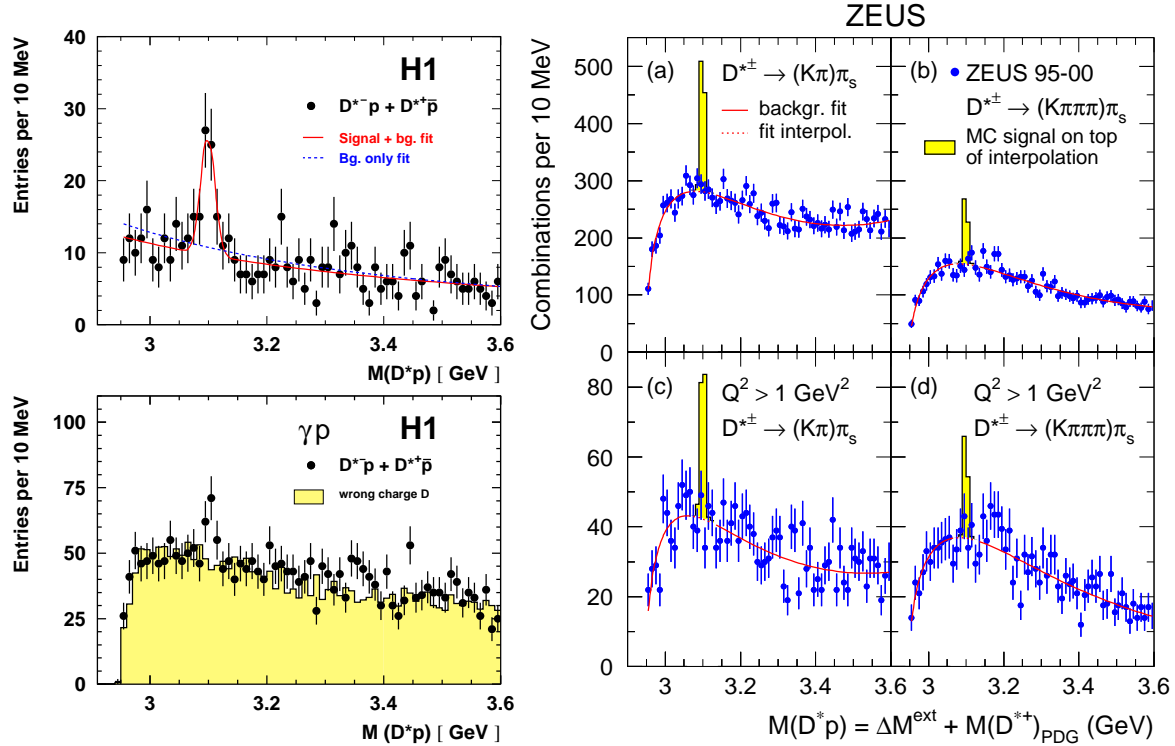


FIGURE 2. The distributions of $M(D^{*\pm}p^\mp)$ obtained by the H1 Collaboration (left) and by the ZEUS Collaborations (right)

Θ_c^0 signals normalised to 1% of the number of reconstructed $D^{*\pm}$ mesons are shown on top of the fitted backgrounds. The upper limit on the fraction of $D^{*\pm}$ mesons originating from Θ_c^0 decays was evaluated to be 0.23% (95% C.L.). The upper limit for DIS with $Q^2 > 1 \text{ GeV}^2$ is 0.35% (95% C.L.).

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