H1 SEARCH FOR A NARROW BARYONIC RESONANCE DECAYING TO $K_S^0 p(\bar{p})$

D. OZEROV*†

Institute for Theoretical and Experimental Physics, ITEP,
B.Cheremushkinskaya 25, Moscow 117259, Russia
E-mail: dmitri.ozerov@desy.de

The result of a search in deep inelastic ep scattering for a narrow baryonic resonance decaying to $K_s^0 p$ or $K_s^0 \bar{p}$ is reported. The $K_s^0 p$ and $K_s^0 \bar{p}$ invariant mass distributions presented here do not show any significant peak in the mass range from threshold up to 1.7 GeV. Mass dependent upper limits on the production cross section of a possible strange pentaquark Θ^+ are obtained at the 95% confidence level.

1. Introduction

During the last years several fixed-target experiments have published evidence[1] for the production of a strange pentaquark[2] Θ^+, with a minimal quark content of $uudd\bar{s}$, observed in the decay channels K^+n and $K_s^0 p$. This state has been reported with masses in the range of 1520 to 1540 MeV and with a narrow width, consistent with the experimental resolution in most of the observations. Evidence for Θ^+ production has been also obtained in deep inelastic ep scattering (DIS) at HERA by the ZEUS experiment[3]. Many non-observations have been also reported[1]. The experimental situation is thus controversial and further data are needed to establish the existence of this resonance.

A search for the strange pentaquark Θ^+ using $74\,\text{pb}^{-1}$ of deep inelastic ep scattering data taken with the H1 detector in the years 1996-2000 is presented[4]. A narrow resonance is searched for in the $K_s^0 p$ or $K_s^0 \bar{p}$ decay channel in the mass range from 1.48 to 1.7 GeV and in the range of the negative four-momentum transfer squared, Q^2, from 5 to 100 GeV^2 and of the inelasticity, y, from 0.1 to 0.6.

*Talk given on behalf of the H1 Collaboration at DIS2006.
†Work partially supported by INTAS fellowship Nr 05-110-5395

2. Selection of K_s^0 Meson and Proton Candidates

The K_s^0 meson is identified through its decay into charged pions $K_s^0 \to \pi^+\pi^-$. Events are accepted if they contain at least one K_s^0 candidate and at least one proton candidate track originating from the primary vertex. Candidate tracks for charged pions and protons should have transverse momenta $p_T > 0.15$ GeV and pseudorapidities $|\eta| < 1.75$. Candidates for the two charged pions should originate from the same vertex, displaced radially from the primary interaction vertex of the event by at least 2 cm. The K_s^0 candidate should have a transverse momentum $p_T > 0.3$ GeV and a pseudorapitidy $|\eta| < 1.5$. Contamination from Λ production is eliminated by the requirement that the invariant mass $M_{p\pi}$ of the two tracks is above 1.125 GeV. Background from converted photons is rejected by the requirement $M_{ee} > 50\,\mathrm{MeV}$. 133,000 K_s^0 candidates are reconstructed. Proton candidates are selected using the specific ionisation loss, dE/dx, measured for each track. The efficiency of the dE/dx selection is tested using protons from Λ decays. This efficiency varies between 65% and 100% as a function of momentum and is described by the Monte Carlo simulation to within 5%. The rejection power of the dE/dx selection is tested by using pions from $K_s^0 \to \pi^+\pi^-$ decays.

3. Analysis of $K_s^0 p$ Combinations

In order to search for a Θ^+ resonance, the candidate K_s^0 mesons are combined with the proton candidates. For the $K_s^0 p$ system, $p_T > 0.5$ GeV and $|\eta| < 1.5$ are required. The mass distributions of the $K_s^0 p$ system are shown in Fig. 1a-c) for three bins in Q^2. The shape of the invariant mass distributions is found to be reproduced by a background Monte Carlo simulation of inclusive DIS events using the DJANGOH event generator[5] and the H1 detector simulation based on GEANT(not shown). The data are well described by a phenomenological threshold function. No narrow resonance is observed in any of the Q^2 bins. Since the mass of the Θ^+ is not well established, mass dependent limits are derived in the range from 1.48 to 1.7 GeV. An upper limit at 95% confidence level (C.L.) on the number of expected $K_s^0 p$ combinations due to Θ^+ production, N_{UL}, is obtained from the observed, the background and the signal $M_{K_s^0 p}$ distributions using a modified frequentist approach based on likelihood ratios[6]. This takes into account statistical and systematic uncertainties of the signal and of the background number of $K_s^0 p$ combinations. The $M_{K_s^0 p}$ distribution for signal combinations is taken to be a Gaussian with a width corresponding

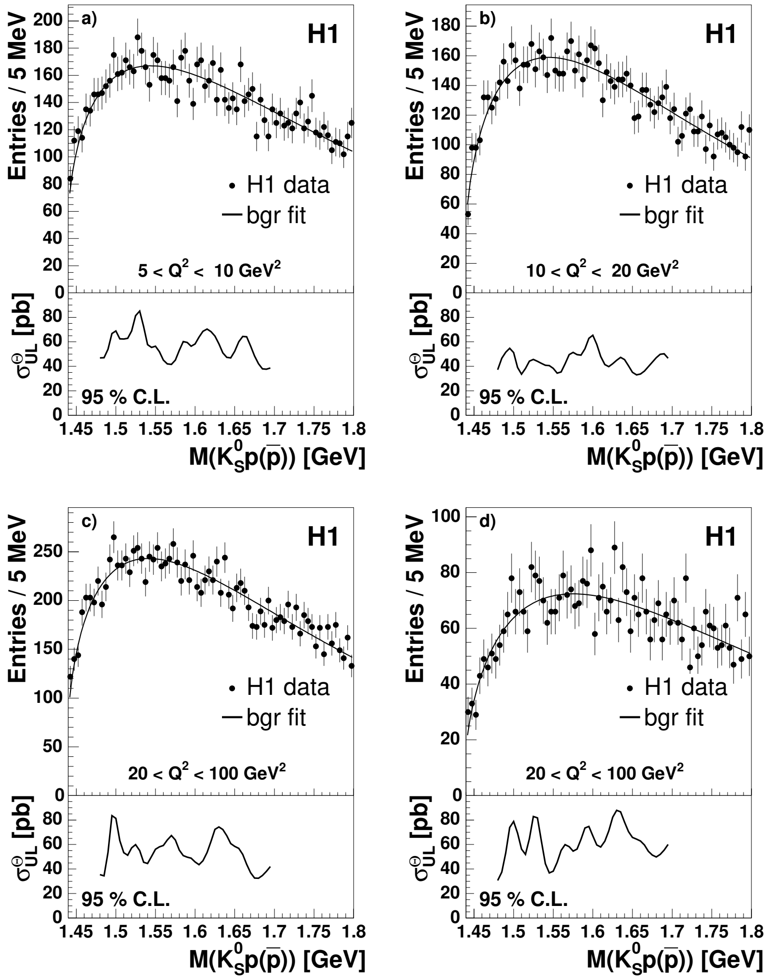

Figure 1. a-c) Invariant $K_s^0 p(\bar{p})$ mass spectra in bins of Q^2 and d) for $20 < Q^2 < 100$ GeV^2 for proton candidates with momenta below 1.5 GeV. The full line shows the result from the fit of the background function to the data. The upper limits on the cross section σ_{UL}^{Θ} at 95% confidence level are shown below the mass spectra.

to the experimental mass resolution as obtained in the Θ^+ Monte Carlo simulations. The background $M_{K_s^0 p}$ distribution is taken to be the fitted threshold function. The upper limit on the cross section, σ_{UL}^{Θ}, is then calculated from N_{UL} using the integrated luminosity, acceptances of the DIS and the Θ^+ event selections and the branching ratio for the transition of K^0 to

K_s^0 and its decay into charged pions. The limits vary between 30 and 90 pb for different Q^2 bins and over the mass range from 1.48 to 1.7 GeV. The invariant mass spectra for positive $K_s^0 p$ and negative $K_s^0 \bar{p}$ combinations are also studied separately and no narrow resonance is observed.

The ZEUS experiment has reported a positive Θ^+ observation at a mass of 1.522 GeV in DIS for $Q^2 > 20$ GeV^2 and $0.04 < y < 0.95$ using a data sample corresponding to an integrated luminosity of 121 pb^{-1}. Since the proton momentum in the ZEUS analysis was restricted to be below 1.5 GeV, the analysis described above has been repeated using protons with the same requirement on the momentum. The resulting invariant $K_s^0 p(\bar{p})$ mass spectra are shown in Fig. 1d) for $20 < Q^2 < 100$ GeV^2 and $0.1 < y < 0.6$. Also in this low momentum proton selection no significant pentaquark signal is observed. At a Θ^+ mass of 1.52 GeV an upper limit on the cross section of 72 pb at 95% C.L. is found. Assuming the same y-dependence of the production cross section of the Θ^+ as of ordinary strange baryons, the limit on the cross section is 100 pb at 95% C.L, when extrapolated to the ZEUS y-range. This can be compared with the reported[7] preliminary cross section for ZEUS signal, $125 \pm 27(stat)^{+36}_{-28}(syst)$ pb.

4. Summary and Conclusion

A search for the strange pentaquark Θ^+ in deep inelastic ep scattering using H1 data is presented. No signal for Θ^+ production is observed in the decay mode $\Theta \to K_s^0 p$. The mass dependent limit on the cross section are derived in intervals of Q^2. The analysis is repeated, restricted to the kinematic region where the ZEUS collaboration observes evidence for a Θ^+ signal. Also for this selection no signal is found.

References

1. K. Hicks, Prog Part. Nucl. Phys. **55** (2005) 647 [hep-ex/0504027].
2. D. Diakonov, V. Petrov and M. Polyakov, Z. Phys. A **359**, 305 (1997) [hep-ph/9703373];
3. S. Chekanov *et al.* [ZEUS Collaboration], Phys. Lett. **B591** (2004) 7 [hep-ex/0403051].
4. A. Aktas *et al.* [H1 Collaboration], accepted for publication in Phys. Lett. **B** [hep-ex/0604056].
5. K. Charchula, G.A. Schuler and H. Spiesberger, Comput. Phys. Commun. **81** (1994) 381.
6. T. Junk, Nucl. Inst. Meth. A **434** (1999) 435 [hep-ex/9902006].
7. S. Chekanov *et al.* [ZEUS Collaboration], Contributed paper to 32nd International Conference on High Energy Physics, Beijing(2004), 10-0273.