Searches at ZEUS

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The results of recent searches for scalar and vector leptoquarks and anomalous single top production in $e^{\pm}$ collisions at HERA are presented. The searches make use of the full ZEUS data set corresponding to 0.5 fb^{-1}. No evidence for leptoquarks signals is found and limits are set on the Yukawa coupling, λ, as a function of the leptoquark mass for different leptoquark types within the Buchmüller-Rückl-Wyler model. No evidence for top production is found and upper limits on the single top cross section via flavour changing neutral current and on the anomalous coupling $\kappa_{tu\gamma}$ are set.

1 Search for leptoquarks

Many extensions of the Standard Model (SM) predict the existence of particles, such as leptoquarks (LQs), carrying both lepton and baryon numbers [1]. At HERA, LQs could be resonantly produced in the s-channel or exchanged in the u-channel between the initial state lepton of energy 27.6 GeV and a quark coming from the proton of energy up to 920 GeV with subsequent decays into electron and quark or neutrino and quark, Fig. 1. These decays have a topology similar to deep-inelastic scattering (DIS) neutral current (NC) or charged current (CC).

Analysis searches for deviations from the SM in the lepton-jet invariant mass spectrum at different lepton scattering angle (θ^*) in the lepton-jet scattering frame to reduce DIS background. Two plots of mass spectra measured for NC-like and CC-like events for 106 pb^{-1} data set are showed in Fig. 2.

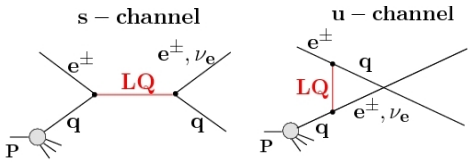

Figure 1: Leptoquark diagrams: s-channel LQ production (left) and u-channel LQ exchange (right).

Since no evidence for any leptoquark signal is found, limits are derived on the Yukawa coupling λ as a function of the mass for different leptoquark states as described by the Buchmüller-Rückl-Wyler model (BRW) [1]. Limits are evaluated including also data recorded with the ZEUS detector in 1994-2000, as published in [2], for a total of 0.5 fb^{-1}. Table 3 shows mass limit for the 14 BRW LQs at $\lambda = 0.3$. Figures 4 show the limits on the S_0^L and $S_{1/2}^L$ compared to the limits from CMS [3], D0 [4] and L3 [5]. Assuming $\lambda = 0.3$, the mass limits range from 291 to 629 GeV.

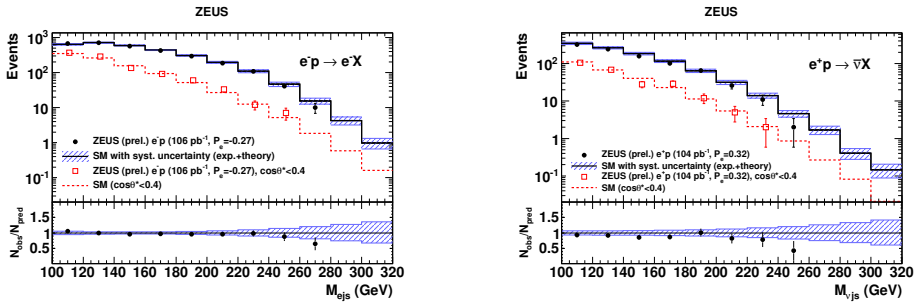

Figure 2: On the left: comparison of the left-handed e^-p sample (dots) and the NC SM expectation (solid histogram) for the reconstructed invariant mass M_{ejs} in the $e^-p \to e^-X$ topology. On the right: comparison of the right-handed e^+p sample (dots) and the CC SM expectation (solid histogram) for the reconstructed invariant mass $M_{\nu js}$ in the $e^+p \to \nu X$ topology. The data (open squares) and SM expectation (dashed histogram) after the $cos\theta^* < 0.4$ are also shown. The shaded area shows the overall uncertainty of the SM MC expectation. The lower half of the plot shows the ratio between the data and the SM expectation before the $cos\theta^*$ cut.

LQ Type (F=0)	V_0^L	V_0^R	$\tilde{V}_0^R$	V_1^L	$S_{1/2}^L$	$S_{1/2}^R$	$\tilde{S}_{1/2}^L$
M_{LQ}(GeV) ZEUS (prel.)	504	293	343	629	322	300	293
LQ Type (F=2)	S_0^L	S_0^R	$\tilde{S}_0^R$	S_1^L	$V_{1/2}^L$	$V_{1/2}^R$	$\tilde{V}_{1/2}^L$
M_{LQ}(GeV) ZEUS (prel.)	435	326	291	466	292	324	409

Figure 3: Limits for 7 scalar + 7 vector states assuming em coupling $\lambda = \sqrt{4\pi\alpha} = 0.3$.

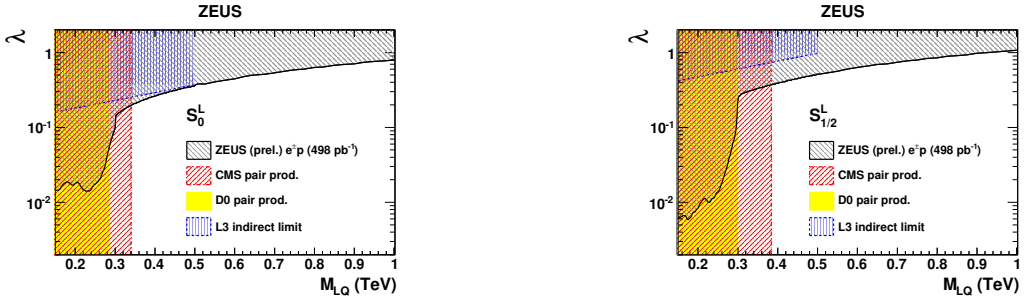

Figure 4: Coupling limit as a function of LQ mass for the S_0^L (left) and $S_{1/2}^L$ (right) from ZEUS, CMS, D0, L3 .

2 Search for single top production

In ep collisions at HERA, the production of single top quarks is possible due to the large centre of mass energy, $\sqrt{s} = 318$ GeV. The dominant process for SM single top production, charged cur-

rent process $ep \to \nu t X$, has a cross section of less than 1 fb [6, 7] so no sizeable production is expected and any excess can be attributed to new physics. In several extensions of the SM [8], single top production can happen via a flavour changing neutral current (FCNC) process mediated by an effective coupling which allows a $u-t$ transition via a neutral vector boson γ ($tu\gamma$) or Z (tuZ), see Fig. 5 Due to the large Z mass the process is more sensitive to a coupling $tq\gamma$. Furthermore, the production of single top quark is most sensitive to the $tu\gamma$ coupling because large values of x, the fraction of the proton momentum carried by the struck quark, are needed to produce a top quark and, at large x, u-quark parton distribution function (PDF) of the proton is dominant.

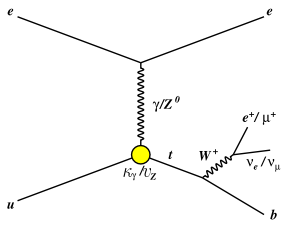

Figure 5: Anomalous single-top production via flavour changing neutral current transitions at HERA with subsequent decays $t \to bW^+$ and $W^+ \to \nu_e(\nu_\mu)e^+(\mu+)$.

The search has been performed in the electron and muon channels. Figure 6 shows the preselection plots in the muon (left) and electron (right) channels.

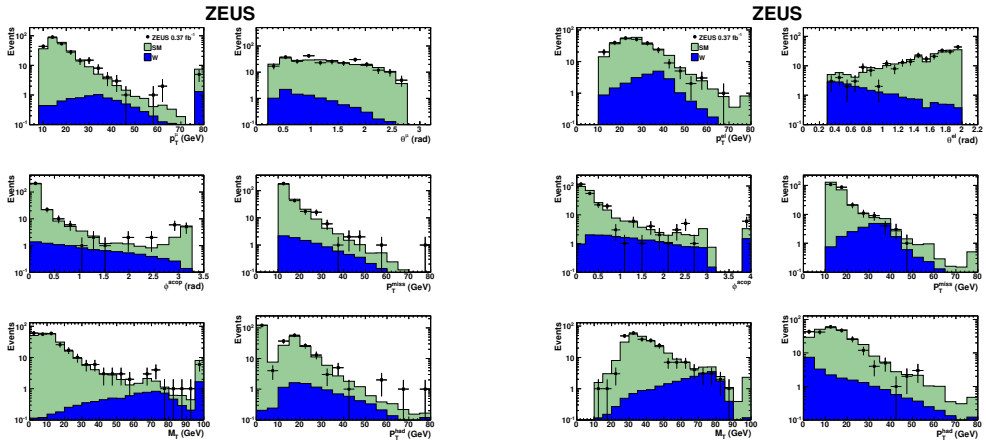

Figure 6: Preselection plots in the muon (left) and electron (right) channels.

Since no excess of events above the SM expectations is observed, a further selection is made to improve the limit on FCNC cross section under the assumption of no signals. The 95% C.L. limit on the cross section is found to be: $\sigma < 0.24$ pb at $\sqrt{s} = 318$ GeV. The limit on the cross section is converted into a limit on the coupling κ_γ: $\kappa_\gamma < 0.18$ (95% C.L.). This result has been combined with a previous ZEUS result [9] giving the following results: $\sigma < 0.13$ pb and $\kappa_\gamma < 0.13$ (95 % C.L.) [10]. Constraints on the anomalous top branching ratios (Br) $t \to u\gamma$ and $t \to uZ$ were also evaluated assuming a non-zero v_Z. Figure 7 shows the ZEUS boundary in the $(\mathrm{Br_{u\gamma}}, \mathrm{Br_{uZ}})$ plane compared to limits from H1 [11], ALEPH [14], CDF [12], D0 [13]. For low values of v_Z , resulting in branching ratios of $t \to uZ$ of less than 4%, this paper provides the current best limits.

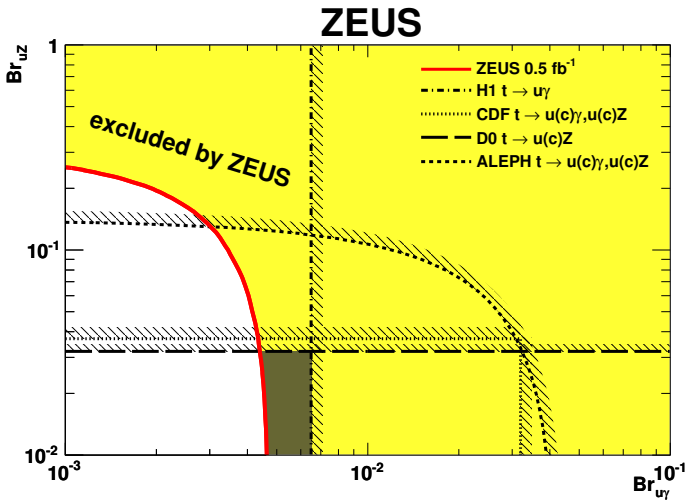

Figure 7: ZEUS boundary in the $(\mathrm{Br}_{u\gamma}, \mathrm{Br}_{uZ})$ plane. Also shown are boundaries of H1 [11], CDF [12], D0 [13] and ALEPH [14]. The shaded area is excluded. The dark shaded region denotes the area uniquely excluded by ZEUS.

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