PROCEEDINGS OF SCIENCE

Search for Single-Top Production in ep Collisions at HERA

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Results of a recent search for single-top production in $e^{\pm}p$ collisions at HERA are presented. The search for single-top production, $ep \to etX$, has been performed with the ZEUS detector at HERA collider using data corresponding to an integrated luminosity of 0.37 fb^{-1}. No evidence for top production was found, consistent with the expectation from the Standard Model. Limits were computed for single-top production via flavour changing neutral current transitions. The result was combined with a previous ZEUS result yielding a total luminosity of 0.50 fb^{-1}. A 95% Credibility Level upper limit of 0.13 pb was obtained for the cross section at the centre-of-mass energy of $\sqrt{s} = 315$ GeV.

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1. Introduction

In ep[1] collisions at HERA, the production of single-top quark is possible due to the large centre-of-mass energy $\sqrt{s} = 318$ GeV. The dominant production process of single top quarks in the Standard Model (SM) is the charged current (CC) deep inelastic scattering (DIS) reaction $ep \to \nu t X$ [1, 2] which has a cross section of less than 1 fb.

No sizeable production is hence expected in our data sample and any excess can be attributed to new physics. In several extensions of the SM [3], single-top production can happen via a flavour changing neutral current (FCNC) process mediated by an effective coupling which allows a u–t or c–t transition via a neutral vector boson (γ or Z), see Fig.1.
Owing to the large Z mass, this process is more sensitive to a coupling of the type $tq\gamma$. Furthermore, large values of x, the fraction of the proton momentum carried by the struck quark, are needed to produce a top quark. Since the u-quark parton distribution function (PDF) of the proton is dominant at large x, the production of single top quark is most sensitive to the $tu\gamma$ coupling.

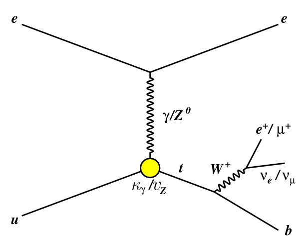

Figure 1: Anomalous single-top production via flavour changing neutral current transitions at HERA with subsequent decays $t \to bW^+$ and $W^+ \to \nu_e(\nu_\mu)e^+(\mu+)$.

The analysis has been performed with 0.37 fb^{-1} and extends the previously published ZEUS results [4] corresponding to 0.13 fb^{-1}. Limits for single-top production via FCNC were computed combining this result with the previous ZEUS one [4] for a total luminosity of 0.50 fb^{-1}.

2. Event selection

The event selection was optimised for single-top production via photon exchange, looking for the dominant decay $t \to bW$ and subsequent W decay to e and μ and their respective neutrinos. The selection is based on requiring an isolated high-p_T lepton, large missing transverse momentum and high hadronic P_T.

The main preselection cuts were the following:

- $P_{T,miss} > 10$ (12) GeV μ- (e-) channel;
- leptonic $p_T > 8$ (10) GeV μ- (e-) channel;
- transverse mass $M_T > 10$ GeV e-channel only;

The main final cuts where the following:

- hadronic $P_T > 40$ GeV for both channels;
- $P_{T,miss} > 15$ GeV e-channel.

[1] Here and in the following, e denotes both the electron and the positron.

Figure 2 shows the preselection plots in the muon (left) and electron (right) channels. Black dots are data, green area is MC and the dark-shaded region is the W contribution; reasonable agreement is observed in all cases.

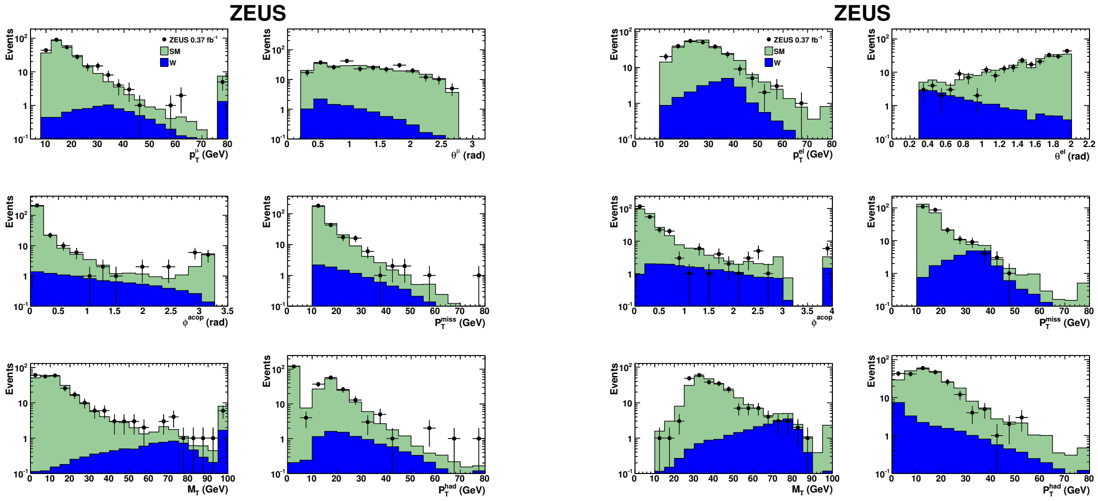

Figure 2: Preselection plots in the muon (left) and electron (right) channels. Black dots are data, green area is MC and the dark-shaded region is the W contribution.

3. Systematic uncertainties

The main contribution to the systematical uncertainties on the predicted SM events is due to the following sources:

- the theoretical uncertainty on the W background normalisation; $\pm 15\%$;
- the statistical uncertainty on the total SM prediction after the final selection; $\pm 13\%$ and $\pm 9\%$ for the e- and μ-channel respectively;
- the uncertainty on the NC DIS background; $\pm 15\%$ for the preselection and $\pm 6\%$ for the final selection in the e-channel and negligible in the μ-channel.

4. Limits evaluation

Since no excess of events above the SM expectations is observed, a further selection is made to evaluate the limit on FCNC cross section under the assumption of no signals. The 95% Credibility Level (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 $\kappa_\gamma < 0.18$ (95% C.L.). This limit has been combined with a previous ZEUS result [4] giving the following constraints: $\sigma < 0.13$ pb and $\kappa_\gamma < 0.13$ (95% C.L.) [5]. Constraints on the anomalous top branching ratios $t \to u\gamma$ ($\mathrm{Br}_{\mathrm{u}\gamma}$) and $t \to uZ$ ($\mathrm{Br}_{\mathrm{uZ}}$) were also evaluated assuming a non-zero v_Z. Figure 3 shows the ZEUS boundary in the ($\mathrm{Br}_{\mathrm{u}\gamma}, \mathrm{Br}_{\mathrm{uZ}}$) plane compared to limits from H1 [6], ALEPH [7], CDF [8], D0 [9]. 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.

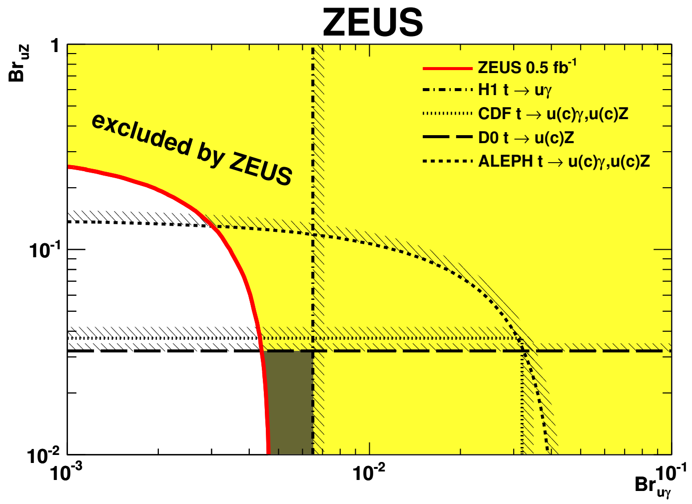

Figure 3: ZEUS boundary in the ($\mathrm{Br}_{u\gamma}, \mathrm{Br}_{uZ}$) plane. Also shown are boundaries of H1 [6], CDF [8], D0 [9] and ALEPH [7]. The shaded area is excluded. The dark shaded region denotes the area uniquely excluded by ZEUS.

5. Conclusions

A search for possible deviations from the Standard Model predictions due to flavour- changing neutral current top production in events with high-p_T leptons and high missing transverse momentum was performed using an integrated luminosity of 0.37 fb^{-1}, collected by the ZEUS detector in 2004-2007. Since no significant deviation from the expectation was observed, the results were used to set limits on the anomalous production of single top at HERA. A 95% C.L. upper limit on the cross section of $\sigma < 0.24$ pb at a centre-of-mass energy of 318 GeV was obtained. The limit was combined with a previous ZEUS result [4], obtained using HERA I data, for a total integrated luminosity of 0.50 fb^{-1} , giving a combined 95% credibility-level upper limit of $\sigma < 0.13$ pb at $\sqrt{s} = 315$ GeV. This limit, assuming a vanishing coupling of the top quark to the Z boson (v_Z), corresponds to a constraint on the coupling of the top to the γ of $\kappa_\gamma < 0.13$. Constraints on the anomalous top branching ratios $t \to u\gamma$ and $t \to uZ$ were also evaluated assuming a non-zero v_Z . For low values of v_Z , resulting in branching ratios of $t \to uZ$ of less than 4%, see Fig. 3, this paper provides the current best limits.

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