Search for Single Top Production in ep Collisions at HERA *

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In this talk a search for the single production of top quarks performed at the H1 experiment is presented. No evidence for anomalous top production via FCNC processes is found and limits on the anomalous magnetic coupling constant $\kappa_{tu\gamma}$ are given.

1 Introduction

Since the first observation of an isolated muon event with large missing transverse momentum ($p_T^{\rm miss}$) and a high p_T jet [1] by the H1 experiment, this "isolated lepton" event class has been the subject of many studies performed at HERA [2, 3, 4]. The main SM process with a charged lepton, a jet and a neutrino ($p_T^{\rm miss}$) in the final state is the production of W bosons which decay leptonically. For large transverse momenta of the hadronic final state, $p_T^X > 25$ GeV, six events (1e + 5μ) were observed for an expectation of 3.2 [2] in the analysis of the 36.5 pb^{-1} of e^+p data taken from 1994-97. Recently, the full HERA I data set has been analysed [3] combining e^+p data and e^-p data with a total integrated luminosity which is 118.3 pb^{-1}. With an improved SM background suppression, 10 events were observed to be compared to 2.9 expected, confirming the excess. A similar analysis performed by the ZEUS collaboration [4] does not confirm the excess; their data were found to be in agreement with the SM. However, in a recent analysis of the $t \to b\ \tau^+\nu_\tau$ channel 2 events were seen to be compared to 0.12 expected [5].

The isolated lepton event class was discussed as a possible signal for the anomalous production of single top quarks at HERA [6] with subsequent semi-leptonic decay: $t \to b\ \ell^+\nu$. The SM expectation for single top quark production at HERA is of the order of 1 fb and is negligible. Therefore single top

*This talk was given on behalf of the H1 collaboration production at HERA provides an excellent testing ground for the search for FCNC processes beyond the SM. These processes are predicted for instance by supersymmetric models, dynamical EWSB[1], extended Higgs sectors or other additional symmetries.

In this talk a search for the single production of top quarks performed at the H1 experiment is presented.

1.1 Selection of the leptonic decay $t \rightarrow b\,\ell^+\nu$

The search here presented [7] is based on the selection of isolated lepton events [8]. The main preselection cuts are: a minimum transverse momentum of the electron or muon $p_T^\ell > 10$ GeV, a missing neutrino $p_T^{\rm miss} > 10$ GeV, a high $p_T^X >$ 25 GeV hadronic final state, acoplanarity between the lepton and the hadronic final state and the isolation of the lepton from jets in the event $D_{\ell,{\rm jet}} > 1$. In addition, specific selection criteria to enrich the single top signature are applied: the b-jet has to have a minimum p_T of 25 (35) GeV in the central (forward[2]) part of the detector; the transverse mass of the lepton-neutrino system $M_T^{\ell\nu}$ has to exceed 10 GeV and the reconstructed charge of the top quark has to be positive, as HERA is mainly sensitive to the FCNC transition $u \rightarrow t$. The top selection efficiency was simulated using the ANOTOP generator, see [8] and references therein, and found to be 37% for the electron channel and 45% for the muon channel. After this selection, H1 sees 5 events for 1.8 ± 0.5 expected. By applying a W mass constraint, the top candidate mass can be calculated after reconstructing the neutrino kinematics. For each event up to two solutions are possible. All calculated masses are compatible with the expected top mass distribution.

1.2 Selection of the hadronic decay: $t \rightarrow b\,j\,j$

Hadronic top candidates are searched for in the three jet final state topology. The three jets are ordered in $p_T^{\rm jet}$ and are required to have more than 40, 25, 20 GeV, respectively. Only jets in the central and forward part of the detector, $-0.5 < \eta_{\rm jet} < 2.5$, are considered, with η being the pseudorapidity. The total transverse energy has to fulfill $E_T^{\rm tot} > 110$ GeV and events with identified

[1] Electroweak Symmetry Breaking

[2] The direction of the proton beam defines the forward region.

electrons are rejected to suppress background from NC deep inelastic scattering. The top decay is then reconstructed to further suppress the SM background. The two jets originating from the W decay are selected by choosing that jet pairing for which the invariant mass M_W^{jj} is closest to the nominal W mass. This prescription gives the correct pairing in 70% of the events. The reconstructed W mass is then required to be compatible with the real mass: $70 < M_W < 90$ GeV. To further suppress QCD background, the opening angle $\Theta^\star$ of the two W jets reconstructed in the top rest frame has to fulfill $\cos\Theta^\star > -0.5$ (acolinearity) and the top mass reconstructed from all three jets has to fulfill $150 < M_{jets} < 210$ GeV. The top selection efficiency after all cuts is 27%. In total 14 candidate events are found for a SM expectation of 19.6 ± 7.8. The systematic error of about 40% is largely dominated by a 30% uncertainty on the QCD background prediction.

2 Results

In the leptonic top decay a slight excess of events is observed whereas in the hadronic channel a slight deficit is seen. By combining both channels a limit at the 95% confidence level on the top cross section of $\sigma_{320}(ep \to etX) < 0.43$ pb is obtained for a cms energy of 320 GeV. Here a branching ratio of $BR(t \to bW) = 100\%$ is assumed. The hadronic channel alone gives $\sigma_{320}(ep \to etX) < 0.40$ pb, which is better than the combination due to the excess in the lepton channel. The combined limit can be directly converted into a limit on the FCNC anomalous magnetic coupling of the top quark to a u-quark and a photon: $\kappa_{tu\gamma} < 0.22$ (95% CL). This limit includes NLO corrections for both the top signal [9] and the SM W background cross section [10]. Similar results were also obtained by the ZEUS collaboration [11]. These are slightly more constraining than those obtained by H1 due to the absence of the excess in the leptonic channel. A comparison of all experimental limits is shown in Fig. 1. This shows also limits obtained at LEP from a search for single top production and limits from the Tevatron from the study of radiative top decays. The figure shows that HERA has an unique discovery potential for an anomalous magnetic coupling of the top quark in a parameter space not excluded by other experiments.

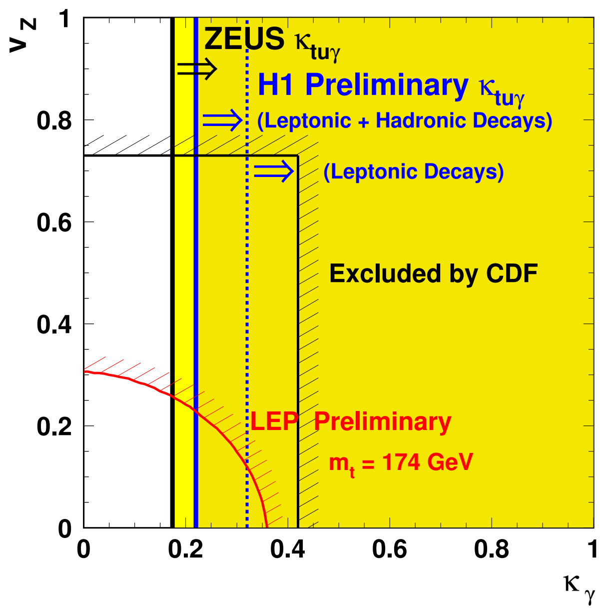

Figure 1: Summary plot of experimental limits on the anomalous coupling constants κ_γ and v_Z. H1 limits are valid for the anomalous $\kappa_{tu\gamma}$ coupling only and were derived from the leptonic decay only and from the combination with the hadronic decay.

3 Conclusion and Outlook

Motivated by the excess of events seen in the isolated lepton topology the H1 experiment has studied the anomalous production of top quarks. The interpretation that single top production contributes to the isolated lepton events is not excluded by the results obtained in the hadronic channel, which suffers from large systematic errors. Therefore, higher order QCD calculations are vital to improve the top sensitivity in this channel. HERA has a unique discovery potential for anomalous top quark production. A further improvement of the sensitivity is expected with the startup of HERA II, which will deliver higher luminosities and larger event samples in the coming years.

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