Events with isolated leptons and missing transverse momentum and anomalous top production at HERA

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Events with high energy isolated leptons and missing energy have been observed with H1 detector in *ep* collisions at HERA. In a data sample corresponding to an integrated luminosity of 115.2 pb^{-1}, 18 events have been selected for an expectation of 10.5$\pm$2.5 from Standard Model processes, dominated by real W production. The interpretation of the observed events in terms of anomalous single top production is explored and a limit on anomalous effective coupling $\kappa_{\gamma ut}$ is calculated.

1 Introduction

Events with high transverse momentum (P_T) leptons (ℓ) and missing energy have been observed at HERA [1,2]. Those events are best explained in the Standard Model (SM) framework by the production of real W-bosons and their subsequent leptonic decays. This spectacular topology can also be a signature for physics beyond the Standard Model. The H1 observation on 1994-1997 data corresponding to an integrated luminosity of 36.5 pb^{-1} revealed interesting events containing muons, missing energy and high P_T hadronic systems, atypical for SM W production. In this paper, the observation of $\ell + P_T^{\rm miss}$ events in the full HERA I data sample is reported. The interpretation of those events in terms of anomalous top production via flavour changing neutral currents (FCNC) is investigated.

2 Observation of $\ell + P_T^{\rm miss}$ events

The selection is based on the signature of missing transverse momentum correlated with lepton identification. The 1994-1997 analysis [1] was based on a cut on transverse momentum measured by the calorimeter $P_T^{\rm calo} > 25$ GeV which provided an efficient background rejection. Recently [3] the analysis was upgraded and extended in a new phase space by using a lower limit $P_T^{\rm calo} > 12$ GeV and an enforced background rejection. This strategy allows the comparison of the observed events with the W production within a high purity sample and over larger phase space.

The main results are presented in Table 1 for the full e^+p data corresponding to an integrated luminosity of 101.6 pb^{-1}. No candidate event is observed in e^-p data sample (13.6 pb^{-1}) for 1.8 events expected.

Table 1: Observed events and expected rates in electron and muon channels in e^+p colllisons data corresponding to an integrated luminosity of 101.6 pb^{-1}. The errors are dominated by theoretical uncertainty related to the W production prediction.

H1 94-00 e+p 101.6 pb^{-1}	Electrons Data/SM	Muons Data/SM	e+μ combined Data/SM
full sample	10 / 7.9 $\pm$ 1.9	8 / 2.6 $\pm$ 0.7	18 / 10.5 $\pm$ 2.5
$P_T^X > 25$ GeV	4 / 1.3 $\pm$ 0.3	6 / 1.5 $\pm$ 0.4	10 / 2.8 $\pm$ 0.7

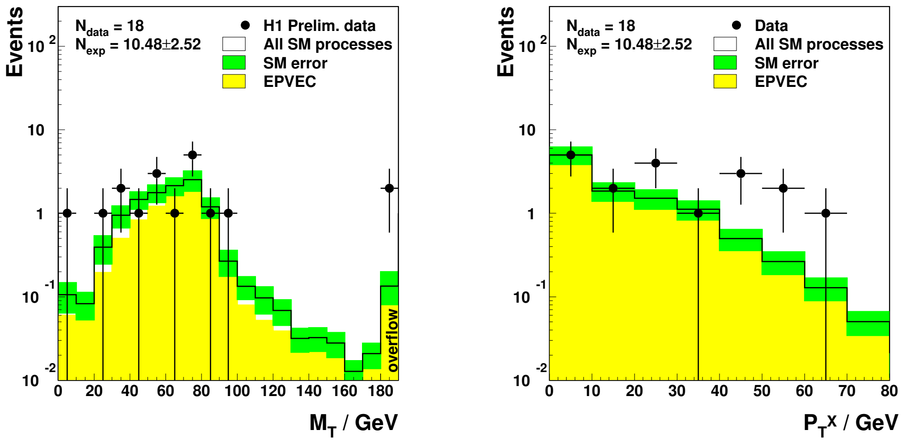

Figure 1: Transverse mass of lepton and neutrino (left) and hadronic transverse momentum P_T^X spectra (right) for the observed events compared to SM prediction.

The observed events are compared to the SM prediction dominated by W production in Figure 2. A good agreement in shape is observed for the transverse mass distribution defined as the invariant mass of the transverse momenta vectors of the leptons and neutrino (computed from missing transverse momentum). The hadronic transverse momentum spectrum (P_T^X) shows a good agreement at low P_T^X and an excess of data events above 25 GeV.

The ZEUS colaboration has also searched for $\ell + P_T^{\mathrm{miss}}$ events [4], and has found two events with $P_T^X > 25$ GeV for 2.4 expected in a data sample of 130 pb^{-1}. Both experiments have similar acceptances at high P_T^X and the SM rates predicted in the two analysis are consistent.

3 Anomalous top production at HERA

A possible interpretation of the $\ell + P_T^{\rm miss}$ events is the anomalous production of top quarks in ep collisions [5]. While SM top production is negligible, an anomalous photon-u-t coupling would allow top production through flavour changing neutral coupling (FCNC). The top production and decay $t \to bW^+$ followed by the leptonic decay $W^+ \to \ell^+\nu$ would produce events with isolated leptons, missing energy and a high P_T hadronic jet. Based on the selection described in the previous section, the top channel with leptonic decay is searched by requiring in addition a high P_T hadronic jet $P_T^{\rm jet} > 35(25)$ GeV with a polar angle measured with respect to the incoming proton direction $\theta^{\rm jet} > 35°(\theta^{\rm jet} < 35°)$. The lepton-neutrino transverse mass is required to be above 10 GeV and leptons of negative polarity are rejected.

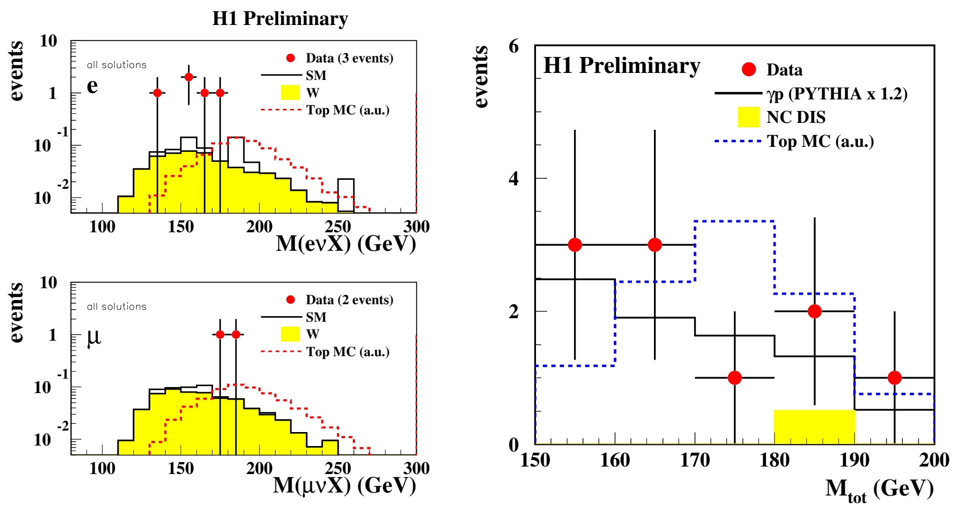

Figure 2: Invariant mass spectra for leptonic channels (left) and hadronic channel (right) for the final anomalous top search sample. At most two solution for the $\ell\nu X$ mass are possible in the leptonic channel due to the quadratic W mass constraint used for ν reconstruction.

The hadronic decay $W \to q\bar{q}$ is also searched. Events with at least three high P_T hadronic jets are selected with $P_T$jet$1,2,3 > 25, 15, 10$ GeV, with at least a jet pair within W mass window $70 < M_{\rm jj} < 90$ GeV and the total jets invariant mass in the top mass window $150 < M_{\rm alljets} < 198$ GeV are selected.

Table 2: Top selection results in leptonic and hadronic channels.

Channel	Electrons	Muons	e+μ combined (L=115.2 pb^{-1})	hadrons (L=36.5 pb^{-1})
Data/SM	$3/0.88 \pm 0.22$	$2/0.89 \pm 0.24$	$5\ /1.8 \pm 0.5$	$10/\ 8.3^{+5.9}_{-4.6}$

The results from leptonic and hadronic channels are summarized in Table 2. Mass spectra obtained with the events selected in leptonic and hadronic channels are presented in Figure 2. The measurement in leptonic and hadronic channels are combined and a limit on the effective $\kappa_{\gamma ut}$ coupling is calculated. The limit value $\kappa_{\gamma ut} < 0.305$ @95% C.L. is competitive with those obtained at LEP [6] (0.38 for $\kappa_{Zut} = 0$) and Tevatron[7] (0.42). ZEUS obtained $\kappa_{\gamma ut} < 0.19$ in a similar analysis on the full data sample [8].

4 Conclusion

Events with isolated high P_T leptons and missing transverse momentum have been observed in *ep* collisions at HERA. The most probable interpretation in SM framework is the real W production and subsequent leptonic decay, which predicts mainly low P_T hadronic system in the $\ell + P_T^{\rm miss}$ events. Intriguing events containing high P_T hadronic system are part of the selected $\ell + P_T^{\rm miss}$ sample. The interpretation of those events in terms of anomalous top quark production has been explored and competitive limit on $\kappa_{\gamma ut}$ effective coupling have been calculated.

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