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EVENTS WITH HIGH P_T LEPTONS AND MISSING P_T AND ANOMALOUS TOP AT HERA

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Events are observed at HERA containing a high P_T isolated electron or muon and large missing transverse momentum. In the HERA I data sample, corresponding to 118 pb^{-1}, 19 events are observed compared to a Standard Model expectation of 14.5 $\pm$ 2.0, which is dominated by real W production. The events have been examined in the context of anomalous single top production and a competitive limit on the coupling $\kappa_{tu\gamma}$ has been derived. Additionally, the first 17 pb^{-1} of data from the HERA II programme have been analysed and new isolated lepton candidates have been observed.

1 Introduction to the "Isolated Lepton" Analysis

Events containing a high transverse momentum (P_T), isolated electron or muon and large missing transverse momentum have been observed at HERA [1,2,3]. The main Standard Model (SM) "signal" contribution to such a topology comes from the production of real W bosons via photoproduction $ep \rightarrow eW^{\pm}X$ with subsequent leptonic decay $W \rightarrow l\nu$. Additional small signal contributions arise from the equivalent charged current process $ep \rightarrow \nu W^{\pm}X$ and via Cabibbo-Paresi Z^o production with subsequent decay to neutrinos. The main SM background is due to neutral current, charged current and lepton pair production.

The isolated lepton event selection employed by H1 is based on the coincidence of missing transverse momentum with the identification of a high P_T isolated lepton. A high level of background rejection is achieved by using variables sensitive to the presence of high energy undetected particles in the event. Full details of the analysis performed on the complete HERA I data, equivalent to $\mathcal{L}$ = 118 pb^{-1}, can be found in [3].

In the search for events containing a high P_T isolated electron or muon and large missing transverse momentum 19 events are observed in the data, compared to a SM prediction of 14.5 $\pm$ 2.0, which is dominated by signal processes (10.7 $\pm$ 1.8). At large values of hadronic transverse momentum $P_T^X > 25$ GeV an excess of data events is observed over the SM expectation.

2 Anomalous Top Production at HERA

A possible interpretation of the spectacular events observed by H1 at high P_T^X is the anomalous production of top quarks [4,5]. Whereas in the SM top production is negligible, an anomalous $tu\gamma$ coupling $\kappa_{tu\gamma}$ would allow top production via the flavour changing neutral current (FCNC) mechanism. The decay of the top quark

$t \to bW^+$ followed by the leptonic decay $W \to l^+\nu$ would give rise to the same topology as W production events and the hadronic jet produced by the b quark would have substantial transverse momentum.

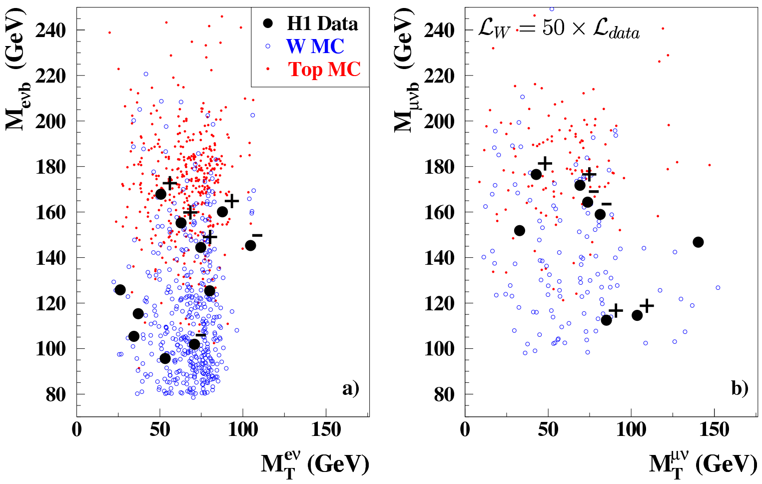

Figure 1. The invariant mass $M_{l\nu b}$ versus the lepton–neutrino transverse mass $M_T^{l\nu}$ for the isolated electron (a) and muon (b) events after neutrino reconstruction. If well determined, the lepton charge of each data event is also indicated.

The search for single top quarks begins by requiring, in addition to the isolated lepton selection, a good kinematic reconstruction of the top quark decay. The b quark is reconstructed as the sum of all reconstructed jets. The neutrino is reconstructed by applying a constraint on the W mass. The invariant mass $M_{l\nu b}$ of the 19 isolated lepton events is displayed versus the lepton–neutrino transverse mass in figure 1. Several data events are observed at masses $M_{l\nu b}$ close to the top mass and have a transverse mass $M_T^{l\nu}$ compatible with the presence of a W boson in the event. The selection then rejects events containing negative charge leptons, as the decay $t \to bW^+ \to bl^+\nu$ produces only positively charged leptons. Kinematic cuts are placed on the transverse momentum of the b candidate $P_T^b > 30$ GeV and on the invariant mass of the lepton–neutrino–b candidate system $M_{l\nu b} > 140$ GeV. After this selection, 3 electron and 2 muon events are observed compared to a SM expectation of 0.65 ± 0.10 and 0.66 ± 0.12 respectively. The main contribution to the SM expectation is from W production.

A search for single top production in the hadronic decay channel $t \to bW \to bq\bar{q}'$ is also performed, where the decay cascade yields events with at least three high P_T jets. Multi–jet events are selected with $P_T^{jet1} > 40$ GeV, $P_T^{jet2} > 30$ GeV and $P_T^{jet3} > 15$ GeV. Additionally, a large total transverse energy $E_T^{tot} > 110$ GeV is required and one pair of jets should have an invariant mass that is compatible with the W mass, 65 GeV $< M_{jets} <$ 95 GeV. Further kinematic cuts are then applied to discriminate between SM background and top production. In the final sample, 18 data events are observed compared to a SM expectation of 20.6 ± 3.6. The hadronic decay channel is less sensitive to W production than the leptonic channel and the SM expectation is dominated by neutral current DIS.

A multivariate discriminator analysis approach is also used to select top quark candidates [5]. The same 5 leptonic candidates are found as the cut based analysis described above. The results in the hadronic channel are in good agreement with the QCD background and are not in contradiction with the single top analysis in the leptonic channel. A maximum likelihood fit using the multivariate discriminator distributions as input is employed to derive a measured single top production cross section of $\sigma(ep \rightarrow etX) = 0.29^{+0.15}_{-0.14}$ pb. Alternatively, given the low statistics of the sample, an upper limit of $\sigma(ep \rightarrow etX) < 0.55$ pb on the production cross section and 0.27 on the $\kappa_{tu\gamma}$ coupling are established at 95% confidence level. This limit is competitive with those from other experiments as shown in figure 2.

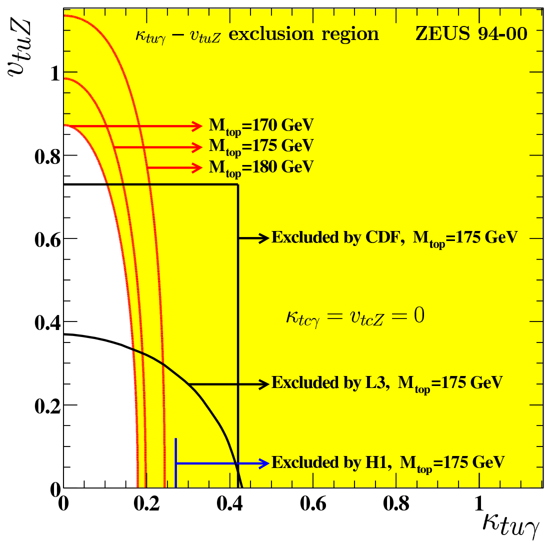

Figure 2. The H1 exclusion limit at 95% confidence level on the anomalous $\kappa_{tu\gamma}$ coupling compared to the limits derived by the ZEUS [4], CDF [6] and the L3 [7] experiments.

3 Analysis of HERA II Data

An extensive luminosity upgrade programme to both the HERA machine and the H1 experiment has recently been completed and the first analyses of HERA II data have been presented at this conference. The search for events containing a high P_T isolated electron or muon and large missing transverse momentum is performed on 17 pb^{-1} of HERA II data. Three events are observed compared to a SM prediction of 2.1 ± 0.3 (1.4 ± 0.3 from signal processes). All 3 data events contain an isolated electron. The P_T^X spectrum from the HERA II analysis is displayed in figure 3. Two of the HERA II events have large values of hadronic transverse momentum ($P_T^X > 25$ GeV), the region of phase space where an excess of data over the SM expectation was observed in the HERA I data.

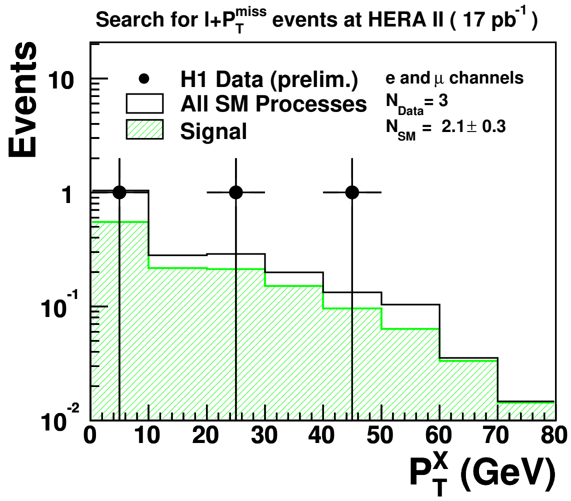

Figure 3. The hadronic transverse momentum spectrum of the observed events in the HERA II data sample ($\mathcal{L} = 17$ pb^{-1}) compared to the SM expectation.

4 Summary and Conclusions

Events are observed at HERA containing a high P_T isolated electron or muon and large missing transverse momentum. The dominant source of such events within the framework of the SM is W production with subsequent leptonic decay. An excess of data events is observed at large values of hadronic transverse momentum, a region of phase space atypical of SM W production. The events have been examined in the context of anomalous single top production and a competitive limit on the coupling $\kappa_{tu\gamma}$ has been derived. The first 17 pb^{-1} of data from the HERA II programme have been analysed and new isolated lepton candidates have been observed.

References

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