Search for Events with Isolated Leptons and Large Missing Transverse Momentum

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Abstract.
Events with isolated leptons and large missing transverse momentum are searched for in the e^+p and e^-p data recorded by the H1 experiment at HERA. In previous analyses of the HERA I e^+p data ($\mathscr{L} = 104.7$ pb^{-1}), an excess of events with isolated electrons or muons and large missing transverse momentum was found. No significant excess was found in the HERA I e^-p data ($\mathscr{L} = 13.6$ pb^{-1}). In the following, new results of the search for events with isolated leptons and large missing transverse momentum in the HERA II e^+p and e^-p datasets are presented. The analysed HERA II data correspond to integrated luminosities of 53 pb^{-1} and 21 pb^{-1} in e^+p and e^-p collisions, respectively.

Keywords: ep, isolated lepton
PACS: 13.60.-r

HERA I RESULTS

In previous H1 analyses of the HERA I e^+p dataset [1, 2], an excess of events with isolated electrons or muons and large missing transverse momentum has been observed.

Within the Standard Model, the dominant process yielding such kind of events is the production of real W bosons via neutral current interactions $ep \to eW^{\pm}X$ with subsequent leptonic decay $W \to \ell\nu$ of the W (henceforth denoted as "signal"). The cross-section for W boson production in ep collisions is expected to be about 1.2 pb at HERA centre-of-mass energies of $\sqrt{s} = 318$ GeV [3]. Small additional contributions to the signal arise from the equivalent charged current process $ep \to \nu W^{\pm}X$ and from the production of real Z bosons with subsequent decay of the Z into two neutrinos, in events where the beam electron is scattered into the main detector. The event selection of the analysis is tuned to optimize the acceptance for the rare signal and to reduce the contribution from all other SM processes (henceforth denoted as "background").

In the HERA I e^+p dataset ($\mathscr{L} = 104.7$ pb^{-1}), 18 events with isolated electrons or muons and large missing transverse momentum are selected, exceeding a SM expectation of 12.4 ± 1.7, which is dominated by the contribution from signal processes (9.4 ± 1.6 events). The observed excess is concentrated in the region of large hadronic transverse momenta (abbreviated as P_T^X in the following). In the region $P_T^X > 25$ GeV, 10 events are observed, while only 2.9 ± 0.5 are expected from all SM processes.

In the HERA I e^-p dataset ($\mathscr{L} = 13.6$ pb^{-1}), 1 event passes the event selection, in agreement with a SM expectation of 2.1 ± 0.3. From the HERA I data alone, no conclusion can be made whether the excess observed in e^+p collisions is also present in

$e^- p$ collisions or not, due to the small integrated luminosity of the HERA I $e^- p$ dataset, however.

Preliminary results of the search for events with isolated tau leptons have been presented [4]. The analysis of the tau channel is based on HERA I $e^+ p$ and $e^- p$ datasets recorded between 1996 and 2000 ($\mathscr{L} = 108$ pb^{-1}). In this dataset, events with collimated jets containing a single isolated track as expected for hadronic "one-prong" tau decays are selected. In total, 5 candidate events pass the event selection, in agreement with a SM expectation of 5.8 ± 1.4. The SM expectation is dominated by the contributions from background processes at small P_T^X and by signal processes in the region of large hadronic transverse momenta. The events observed in the data are all concentrated at small P_T^X, where the contribution from background processes is expected to be dominant. In the region $P_T^X > 25$ GeV, where the excess observed in the electron and muon channels is concentrated, no event is observed in the tau channel. Taking the significantly lower selection efficiency in the tau channel into account, the non-observation of an excess in this channel is compatible with the excess observed in the electron and muon channels.

NEW HERA II RESULTS

The new HERA II results presented at the DIS 2005 conference are based on an analysis of the $e^+ p$ and $e^- p$ datasets of H1 recorded between October 2003 and March 2005. In this dataset, events with isolated electrons or muons are searched for. In the $e^+ p$ dataset, corresponding to an integrated luminosity of 53 pb^{-1}, 10 events (9 events with isolated electrons and 1 event with an isolated muon) are selected, exceeding a SM expectation of 6.1 ± 0.9. The excess observed in the HERA II $e^+ p$ data is concentrated in the region of large hadronic transverse momenta, as was the case in the HERA I $e^+ p$ data. In the region $P_T^X > 25$ GeV, 5 events are observed, while only 1.7 ± 0.3 are expected from all SM processes. In the $e^- p$ dataset, corresponding to an integrated luminosity of 21 pb^{-1}, 5 events (all containing isolated electrons) pass the event selection, while 2.8 ± 0.4 are expected from all Standard Model processes. In the region $P_T^X > 25$ GeV, in which the excess of events in the $e^+ p$ data is observed, only 1 event is found, in agreement with a SM expectation of 0.7 ± 0.1.

The present status of the search for events with isolated leptons and large missing transverse momentum is summarized in Table 1, in which the number of events with isolated electrons, muons or tau leptons selected in the HERA I and II $e^+ p$ and $e^- p$ datasets are compared with the SM expectation. The signal component is given as percentage of the expectation for all SM processes. Note the small contribution from background processes, especially at large $P_T^X > 25$ GeV. The current significance of the excess observed at large hadronic transverse momenta may be inferred from Figure 1, which shows the P_T^X spectrum of the observed events in comparison to the SM expectation.

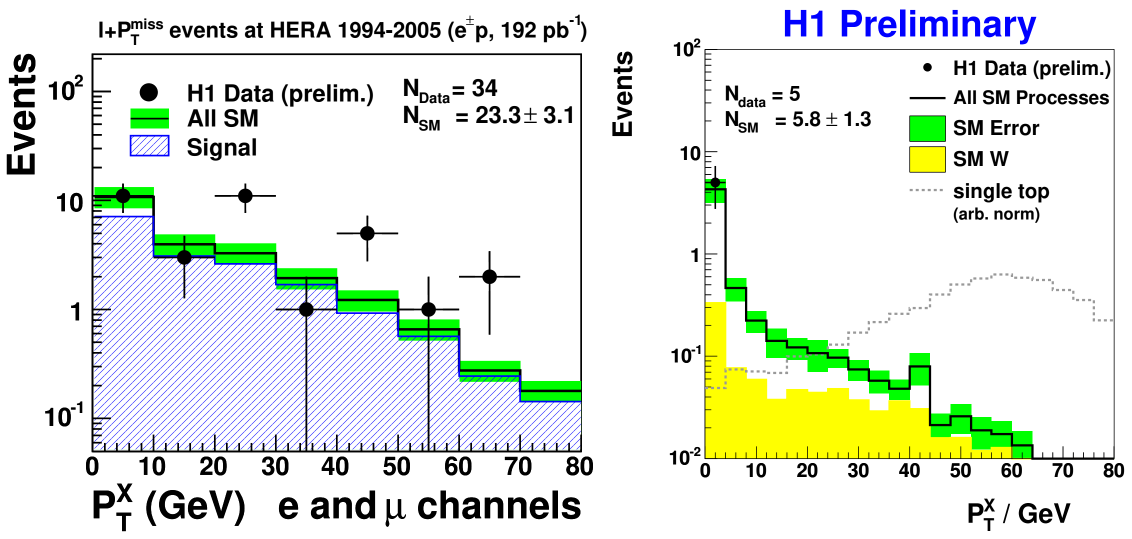

FIGURE 1. The hadronic transverse momentum spectrum of the events with isolated electrons or muons (left) and tau leptons (right) observed in the HERA I and II e^+p and e^-p datasets compared to the SM expectation. In the tau channel, P_T^X is defined as the transverse momentum of all hadrons not contained within the collimated jet associated with the hadronic tau decay. The dashed grey line shown in the plot on the right represents the P_T^X distribution expected for a particular process beyond the Standard Model that may explain the excess observed in the electron and muon channels [5], the production of single top quarks by flavour-changing neutral current interactions.

SUMMARY

Results of the search for events with isolated leptons and large missing transverse momentum in the full HERA I and II e^+p and e^-p datasets of H1 have been presented. The excess of events with isolated electrons or muons observed at large hadronic transverse momenta in the HERA I e^+p dataset continues to be seen in the HERA II e^+p data. In the HERA I and II e^-p datasets, there is no evidence for an excess of events in the region $P_T^X > 25$ GeV, where the excess observed in the e^+p datasets is concentrated.

The integrated luminosity of the e^-p datasets is not yet sufficiently large to conclude whether the excess observed in the e^+p data is also present in e^-p collisions.

The continuing analysis of the HERA II data, in particular that of the increasing e^-p dataset, will hopefully provide an insight into the nature of the excess observed at high P_T^X in the HERA e^+p data.

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TABLE 1. Summary of the H1 results of searches for events with isolated leptons and large missing transverse momentum. The results are shown for the full selected sample and for the subsample at large $P_T^X > 25$ GeV. The number of observed events is compared to the SM expectation, the signal fraction of which is given in percent in parentheses. The quoted errors contain statistical and systematic uncertainties added in quadrature.

H1 Preliminary **1994-2005** $e^{\pm}p$ 192 $\mathbf{pb}^{-1}$	**Electron** **obs./exp.** **(Signal contribution)**	**Muon** **obs./exp.** **(Signal contribution)**	$e+\mu$ **Combined** **obs./exp.** **(Signal contribution)**	**Tau*** **obs./exp.** **(Signal contribution)**
Full Sample	$25/18.4 \pm 2.5$ (70%)	$9/4.9 \pm 0.8$ (85%)	$34/23.3 \pm 3.2$ (73%)	$5/5.8 \pm 1.4$ (15%)
$P_T^X > 25$ GeV	$11/2.9 \pm 0.6$ (81%)	$6/2.9 \pm 0.6$ (86%)	$17/5.8 \pm 1.1$ (84%)	$0/0.5 \pm 0.1$ (49%)

* Results for 1996-2000 $e^{\pm}p$ Data only ($\mathscr{L} = 108$ pb^{-1})