Search for Events with Isolated Tau Leptons and Missing Transverse Momentum at HERA

H1 Collaboration

Abstract

A search for the production of tau leptons in ep collisions with the H1 detector at HERA is presented. A data sample corresponding to a total integrated luminosity of $471\ pb^{-1}$ taken in the years 1994-2007 is analysed, representing the full HERA I+II high-energy data set. Tau leptons are identified using an identification algorithm based on the search for isolated charged tracks associated to narrow hadronic jets detected in the calorimeters, a typical signature of the one-prong hadronic tau decay. In the region where the hadronic system (X) has a transverse momentum $P_T^X > 25$ GeV one event is observed in the data where the Standard Model (SM) expectation is 0.99 ± 0.13 events.

1 Introduction

Events with isolated tau lepton candidates and missing transverse momentum are selected in ep collisions in the full HERA I+II high-energy data sample corresponding to an integrated luminosity of 471 pb^{-1}. This includes 287 pb^{-1} of e^+p data and 184 pb^{-1} of e^-p data.

The selection, summarised in Tab. 1, is based on the one used in the search for events with tau leptons and missing transverse momentum ($P_T^{\rm miss}$) in HERA I data, included in the paper on tau lepton production in ep collisions [1]. Improvements to the tau identification algorithm, in particular the track isolation, require the reanalysis of all data. In the final sample, 20 events are selected where 19.5 ± 3.2 are expected in the SM framework. The SM expectation is dominated by charged current events. At $P_T^X > 25$ GeV one event, shown in Fig. 4 (previously shown in [2]), is selected while 0.99 ± 0.13 are expected in the SM. In this region the contribution of real W production to the SM expectation, considered signal in this analysis, is about 60%.

This search complements the observation of isolated electrons and muons in events with missing transverse momentum in ep collisions at HERA I+II [3, 4].

References

[1] A. Aktas *et al.* [H1 Collaboration], *Tau Lepton Production in ep Collisions at HERA*, Eur.Phys.J.C, **C**48 (2006) 699-714, 04/06, [hep-ex/0604022].

[2] H1 Collaboration; *Search for Events with Tau Leptons at HERA*, [H1prelim-06-064].

[3] V. Andreev *et al.* [H1 collaboration], Phys. Lett. B **561** (2003) 241 [hep-ex/0301030].

[4] H1 Collaboration; *Search for Events with Isolated Leptons and Missing Transverse Momentum at HERA*, [H1prelim-07-063].

Inclusive CC	$P_T^{\text{calo}} > 12$ GeV $P_T^{\text{had}} > 12$ GeV $P_T^{\text{miss}} > 12$ GeV $\delta^{\text{miss}} > 5$ GeV $V_{ap}/V_p < 0.5$ (< 0.15 if $P_T^{\text{miss}} < 25$ GeV)
Narrow Jets	$P_T^{jet} > 7$ GeV $20 < \theta^{jet} < 120$ $R^{jet} < 0.12$ $N_{tracks}^{jet} \geq 1$, max(P_T^{track}) > 5 GeV
Isolation	$D_{em,\mu,jet} > 1.0$
Acoplanarity	$\Delta\varphi(\tau, X) < 170$ if $P_T^X > 5$ GeV
1-Prong Jets	$N_{tracks}^{Djet<1.0} = 1$
Final Selection	$N_{\text{DTNV}}^{D_{track}<0.3} = 1$

Table 1: Summary of selection requirements for isolated tau jets in events with P_T^{miss}. $N_{tracks}^{Djet<1.0}$ denotes the number of high-quality tracks in a cone of 1.0 in the $\eta - \varphi-$plane around the jet-axis. $N_{\text{DTNV}}^{D_{track}}$ denotes the number of non-vertex-fitted track segments in a cone of 0.3 in the $\eta - \varphi-$plane around the high-quality track.

H1 Preliminary τ+$P_T^{\rm miss}$ events at HERA I+II		H1 Data	SM Expectation	SM Signal	Other SM Processes
e^+p 287 pb^{-1}	Full Sample	10	10.8 ± 1.8	1.6 ± 0.3	9.2 ± 1.6
	$P_T^X > 25$ GeV	0	0.53 ± 0.07	0.38 ± 0.06	0.15 ± 0.01
e^-p 184 pb^{-1}	Full Sample	10	8.6 ± 1.5	1.0 ± 0.2	7.6 ± 1.4
	$P_T^X > 25$ GeV	1	0.47 ± 0.07	0.25 ± 0.04	0.22 ± 0.03
$e^{\pm}p$ 471 pb^{-1}	Full Sample	20	19.5 ± 3.2	2.7 ± 0.4	16.8 ± 2.8
	$P_T^X > 25$ GeV	1	0.99 ± 0.13	0.62 ± 0.10	0.37 ± 0.03

Table 2: Summary of the H1 search for events with tau leptons and missing transverse momentum for the e^+p data ($\mathcal{L}$=287 pb^{-1}), e^-p data ($\mathcal{L}$=184 pb^{-1}) and the full HERA data set ($\mathcal{L}$=471 pb^{-1}). The results are shown for the full selected sample and for the subsample at $P_T^X > 25$ GeV. The number of observed events is compared to the SM prediction. The SM signal (W decay into tau) and the background contributions are also shown. The quoted errors contain statistical and systematic uncertainties added in quadrature.

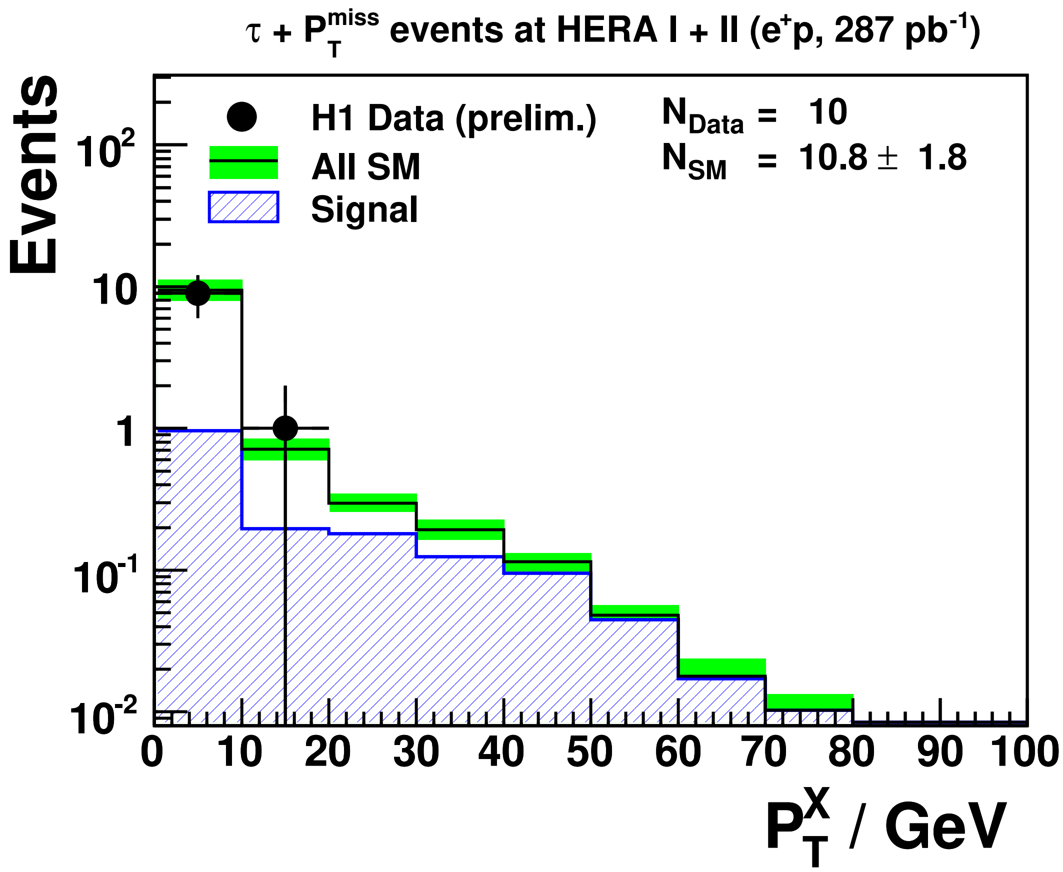

Figure 1: The hadronic transverse momentum distribution of $\tau + P_T^{\rm miss}$ events in HERA e^+p data ($\mathcal{L} = 287$ pb^{-1}) is compared to the SM expectation (open histogram). The signal component of the SM expectation, dominated by real W production, is given by the hatched histogram. $\rm N_{Data}$ is the total number of data events observed, $\rm N_{SM}$ is the total SM expectation. The total error on the SM expectation is given by the shaded band.

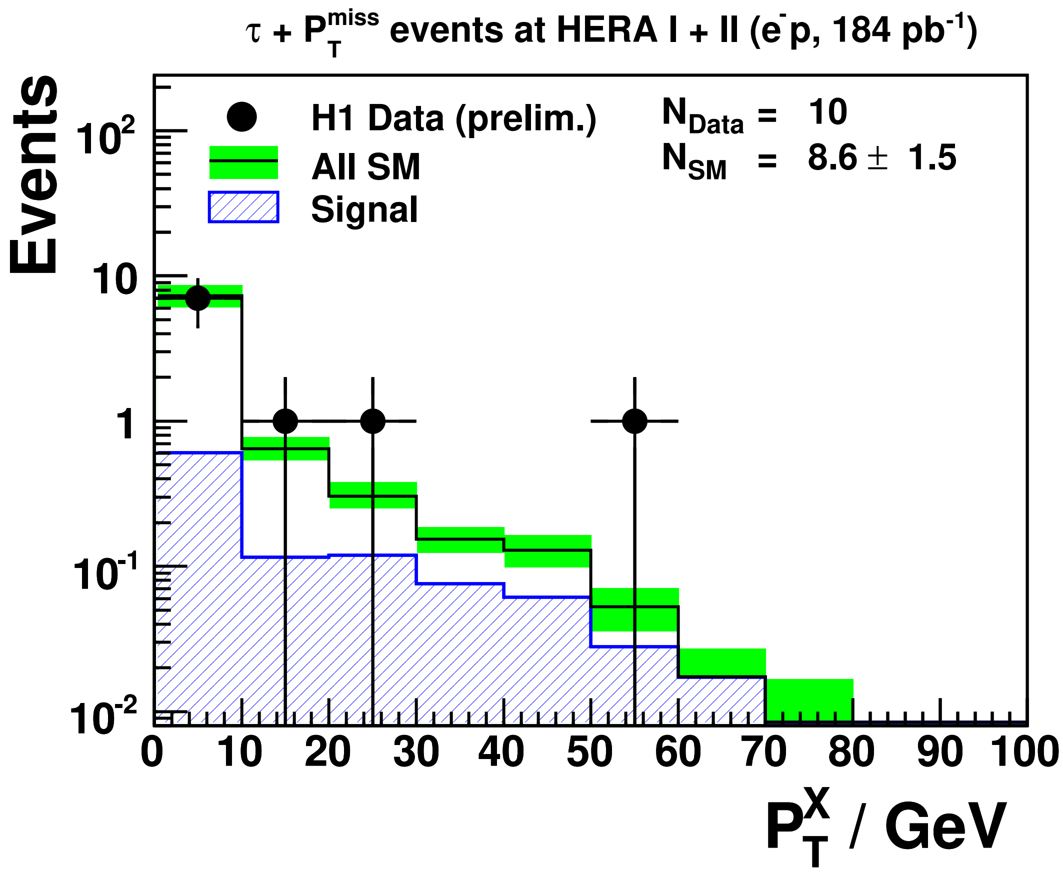

Figure 2: The hadronic transverse momentum distribution of $\tau + P_T^{\rm miss}$ events in HERA $e^- p$ data ($\mathcal{L} = 184$ pb^{-1}) is compared to the SM expectation (open histogram). The signal component of the SM expectation, dominated by real W production, is given by the hatched histogram. $\rm N_{Data}$ is the total number of data events observed, $\rm N_{SM}$ is the total SM expectation. The total error on the SM expectation is given by the shaded band.

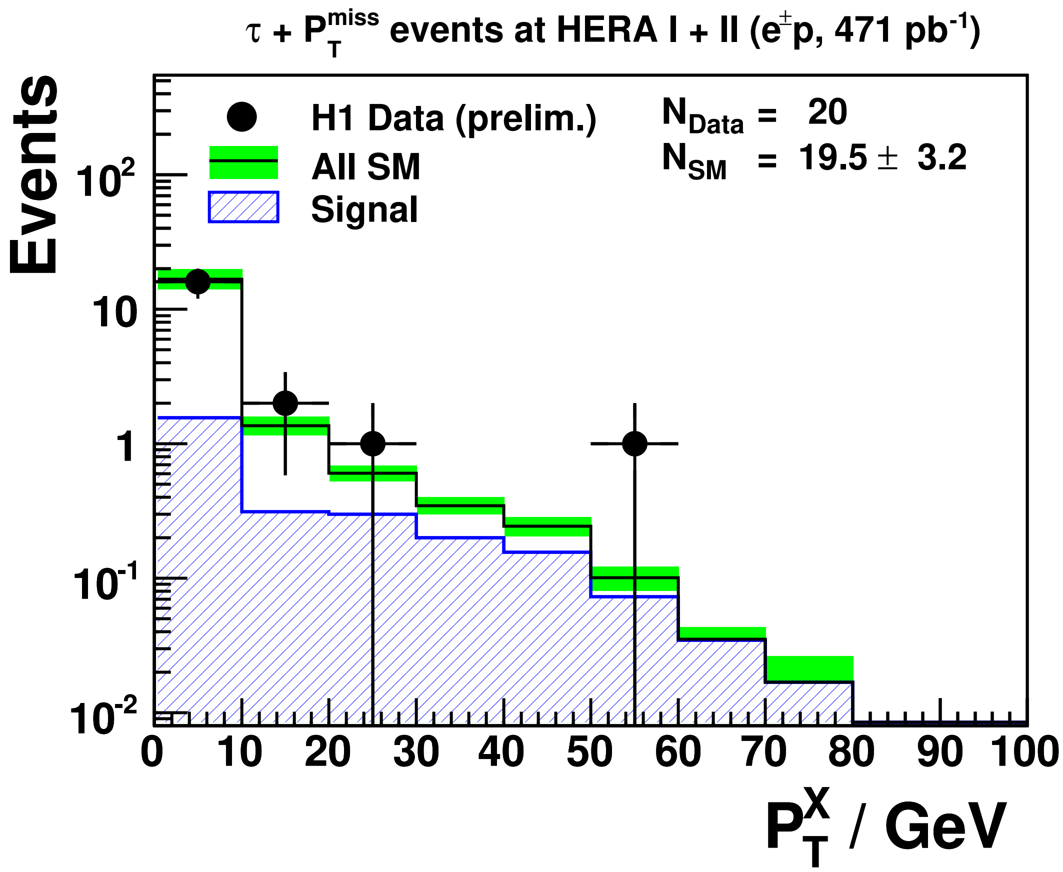

Figure 3: The hadronic transverse momentum distribution of $\tau + P_T^{\rm miss}$ events in HERA $e^{\pm}p$ data ($\mathcal{L} = 278$ pb^{-1}) is compared to the SM expectation (open histogram). The signal component of the SM expectation, dominated by real W production, is given by the hatched histogram. $\rm N_{Data}$ is the total number of data events observed, $\rm N_{SM}$ is the total SM expectation. The total error on the SM expectation is given by the shaded band.

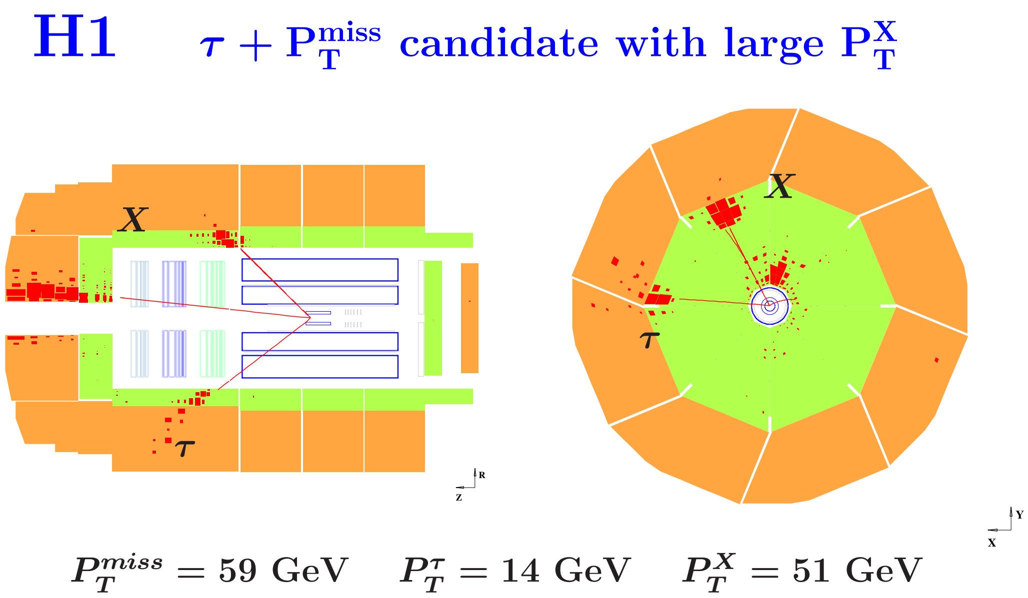

Figure 4: Candidate event with an isolated tau and $P_T^{\rm miss}$ containing a prominent hadronic system X.