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Search for Events with Isolated Leptons and Missing Transverse Momentum: Update

H1 Collaboration

This document presents an update of the previous preliminary results in the search for events with isolated leptons (electrons or muons) and missing transverse momentum in $e^{\pm}p$ collisions with the H1 detector at HERA in the period 1994–2006 [1]. The analysed data sample now corresponds to an integrated luminosity of 384 pb^{-1}, which includes 95 pb^{-1} of $e^{+}p$ data (2003-04 and 2006) and 170 pb^{-1} of $e^{-}p$ data (2004-06) from the new HERA II phase. A total of 50 events are observed in the data, compared to a Standard Model (SM) prediction of 48.1 $\pm$ 6.7.

At large hadronic transverse momentum $P_T^X > 25$ GeV, a total of 20 events are observed compared to a SM prediction of 12.9 $\pm$ 2.1. In this region, 17 events are observed in the $e^{+}p$ data compared to a SM prediction of 6.0 $\pm$ 1.0, whereas in the $e^{-}p$ data 3 events are observed compared to a SM prediction of 6.9 $\pm$ 1.0. Events with large transverse momentum are observed in both the HERA I and II $e^{+}p$ samples. Further details of the analysis may be found in [2].

A comparison of the efficiency of the H1 and ZEUS experiments to detect events containing isolated electrons or muons and missing transverse momentum is also presented.

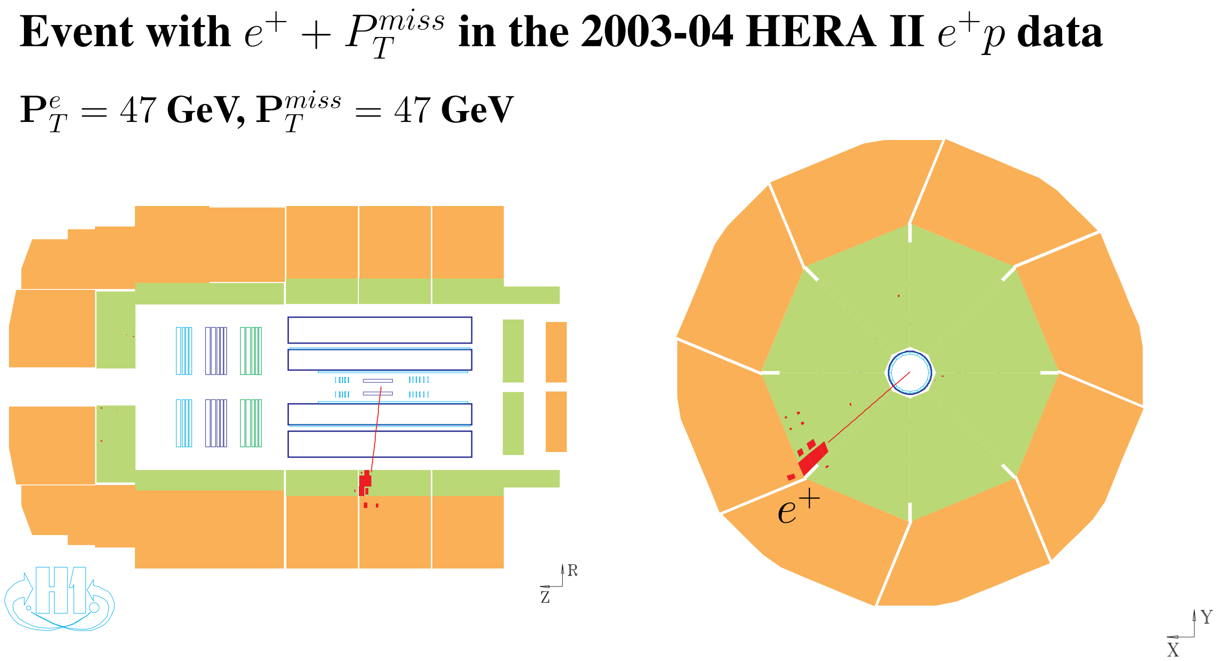

Figure 1: Display of an event with an isolated electron and missing transverse momentum: a candidate for elastic W production in the 2003-04 HERA II e^+p data.

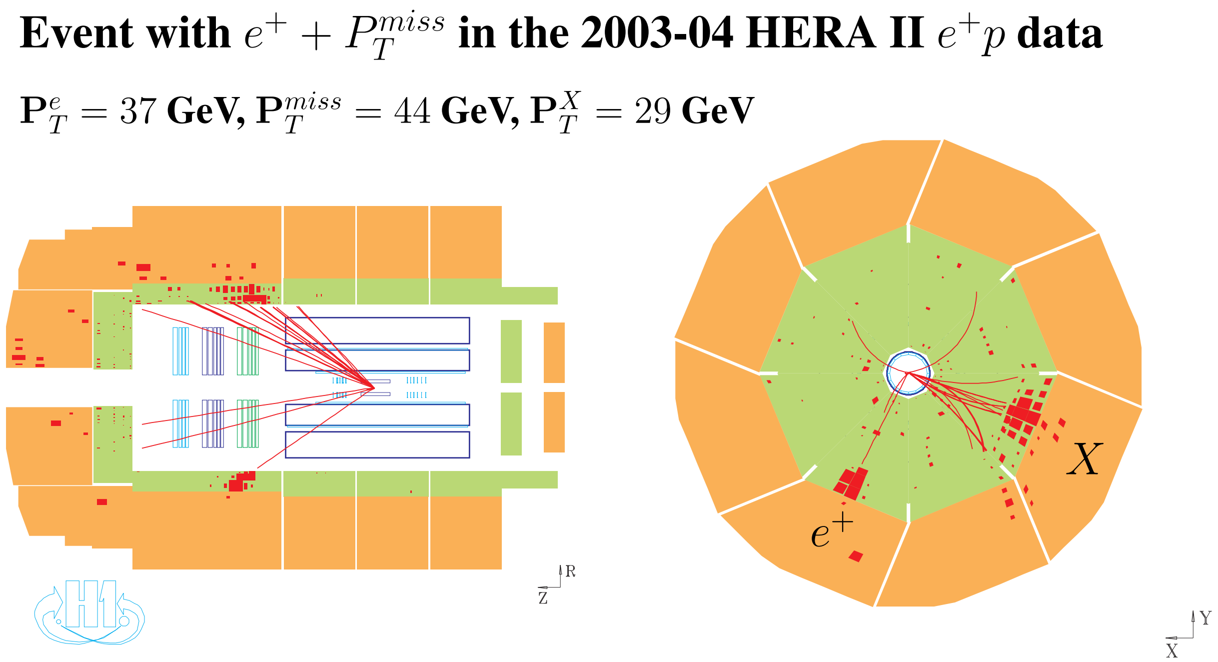

Figure 2: Display of an event with an isolated electron, missing transverse momentum and a prominent hadronic jet in the 2003-04 HERA II e^+p data.

Event with $\mu^- + P_T^{miss}$ in the HERA II e^-p data

$P_T^{\mu} = 38$ GeV, $P_T^{miss} = 51$ GeV, $P_T^{X} = 24.7$ GeV

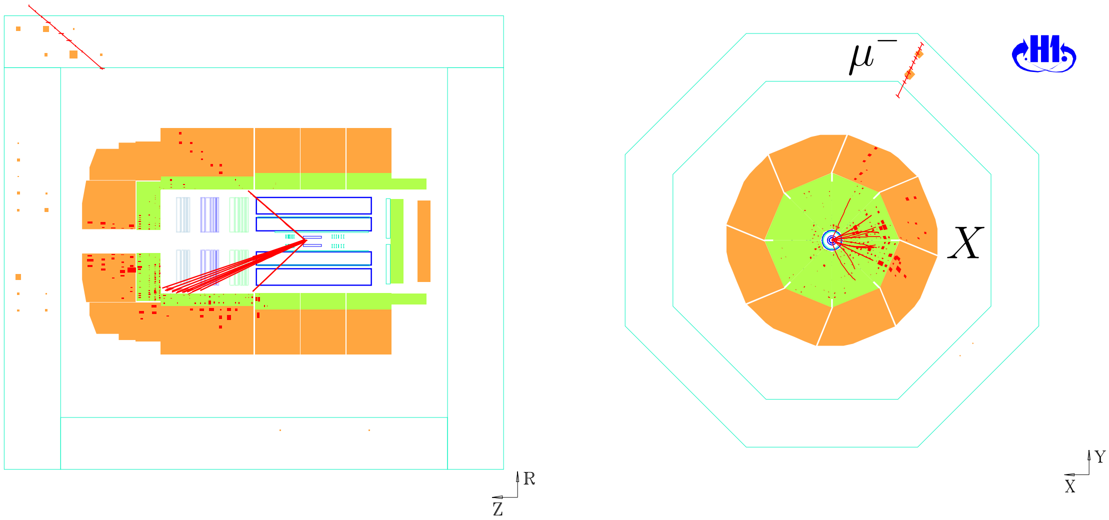

Figure 3: Display of an event with an isolated muon, missing transverse momentum and a prominent hadronic jet in the HERA II e^-p data.

Event with $\mu^- + P_T^{miss}$ in the 2006 HERA II e^+p data

$P_T^{\mu} = 51$ GeV, $P_T^{miss} = 39$ GeV, $P_T^{X} = 48$ GeV

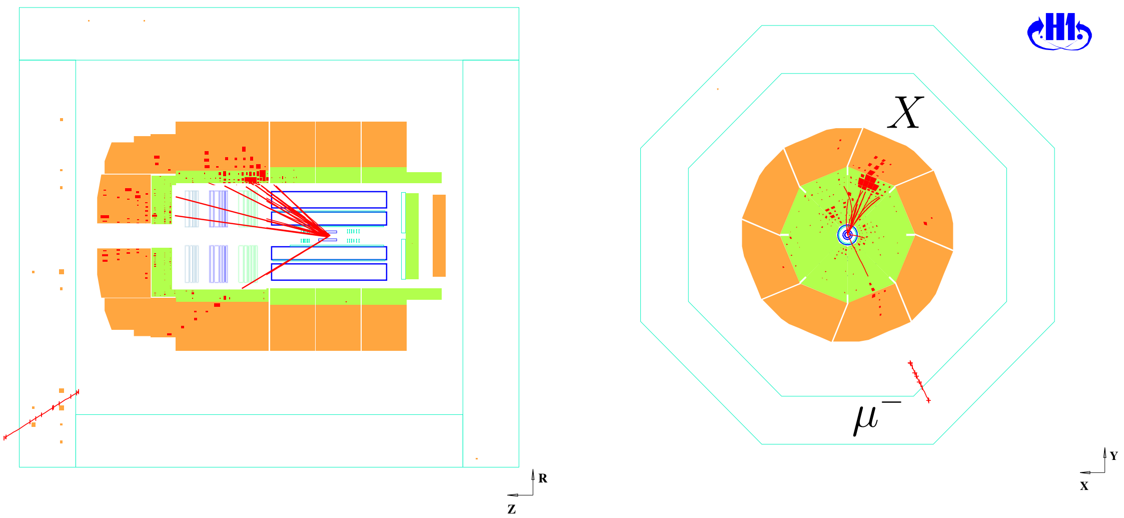

Figure 4: Display of an event with an isolated muon, missing transverse momentum and a prominent hadronic jet in the 2006 HERA II e^+p data.

H1 Preliminary, HERA II e^+p 2003-06 $\mathcal{L} = 95$ pb^{-1}

Electron	H1 Data	SM Expectation	SM Signal
Total	11	8.8 ± 1.3	6.0 ± 1.0
P_T^X >25 GeV	6	1.6 ± 0.3	1.1 ± 0.2
Muon	**H1 Data**	**SM Expectation**	**SM Signal**
Total	3	2.4 ± 0.3	1.9 ± 0.3
P_T^X >25 GeV	1	1.5 ± 0.2	1.2 ± 0.2
Combined	**H1 Data**	**SM Expectation**	**SM Signal**
Total	14	11.2 ± 1.6	7.9 ± 1.3
P_T^X >25 GeV	7	3.1 ± 0.5	2.3 ± 0.4

Table 1: The results of the search for events with isolated electrons or muons and missing transverse momentum in the HERA II e^+p data ($\mathcal{L}$=95 pb^{-1}): observed and predicted numbers of events in the electron channel, the muon channel and the sum of electron and muon channels. The signal component of the SM expectation, dominated by real W production, is also given. The quoted errors contain statistical and systematic uncertainties added in quadrature.

H1 Preliminary, HERA II e$^-$p 2004-06 $\mathcal{L} = 170$ pb^{-1}

Electron	H1 Data	SM Expectation	SM Signal
Total	15	17.7 $\pm$ 2.5	11.7 $\pm$ 1.9
P_T^X >25 GeV	2	3.5 $\pm$ 0.6	2.1 $\pm$ 0.4
Muon	**H1 Data**	**SM Expectation**	**SM Signal**
Total	2	4.7 $\pm$ 0.7	3.7 $\pm$ 0.6
P_T^X >25 GeV	0	2.9 $\pm$ 0.4	2.1 $\pm$ 0.4
Combined	**H1 Data**	**SM Expectation**	**SM Signal**
Total	17	22.4 $\pm$ 3.1	15.3 $\pm$ 2.4
P_T^X >25 GeV	2	6.4 $\pm$ 1.0	4.2 $\pm$ 0.7

Table 2: The results of the search for events with isolated electrons or muons and missing transverse momentum in the HERA II e^-p data ($\mathcal{L}$=170 pb^{-1}): observed and predicted numbers of events in the electron channel, the muon channel and the sum of electron and muon channels. The signal component of the SM expectation, dominated by real W production, is also given. The quoted errors contain statistical and systematic uncertainties added in quadrature.

H1 Preliminary		Electron obs./exp. (Signal contribution)	Muon obs./exp. (Signal contribution)	Combined obs./exp. (Signal contribution)
1994-2006 e^+p 200 pb^{-1}	Full Sample	21 / 18.7 $\pm$ 2.6 (70%)	11 / 4.9 $\pm$ 0.8 (84%)	32 / 23.6 $\pm$ 3.3 (73%)
	$P_T^X > 25$ GeV	10 / 3.1 $\pm$ 0.6 (77%)	7 / 2.9 $\pm$ 0.5 (84%)	17 / 6.0 $\pm$ 1.0 (80%)
1998-2006 e^-p 184 pb^{-1}	Full Sample	16 / 19.4 $\pm$ 2.7 (65%)	2 / 5.1 $\pm$ 0.7 (78%)	18 / 24.4 $\pm$ 3.4 (68%)
	$P_T^X > 25$ GeV	3 / 3.8 $\pm$ 0.6 (61%)	0 / 3.1 $\pm$ 0.5 (74%)	3 / 6.9 $\pm$ 1.0 (67%)
1994-2006 $e^\pm p$ 384 pb^{-1}	Full Sample	37 / 38.1 $\pm$ 5.3 (68%)	13 / 10.0 $\pm$ 1.5 (81%)	50 / 48.1 $\pm$ 6.7 (71%)
	$P_T^X > 25$ GeV	13 / 6.9 $\pm$ 1.2 (67%)	7 / 6.0 $\pm$ 1.0 (78%)	20 / 12.9 $\pm$ 2.1 (72%)

Table 3: Summary of the H1 results of searches for events with isolated electrons or muons and missing transverse momentum for the e^+p data ($\mathcal{L}$=200 pb^{-1}), e^-p data ($\mathcal{L}$=184 pb^{-1}) and the full HERA data set ($\mathcal{L}$=384 pb^{-1}). 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 prediction. The signal component of the SM expectation, dominated by real W production, is given as a percentage in parentheses. The quoted errors contain statistical and systematic uncertainties added in quadrature.

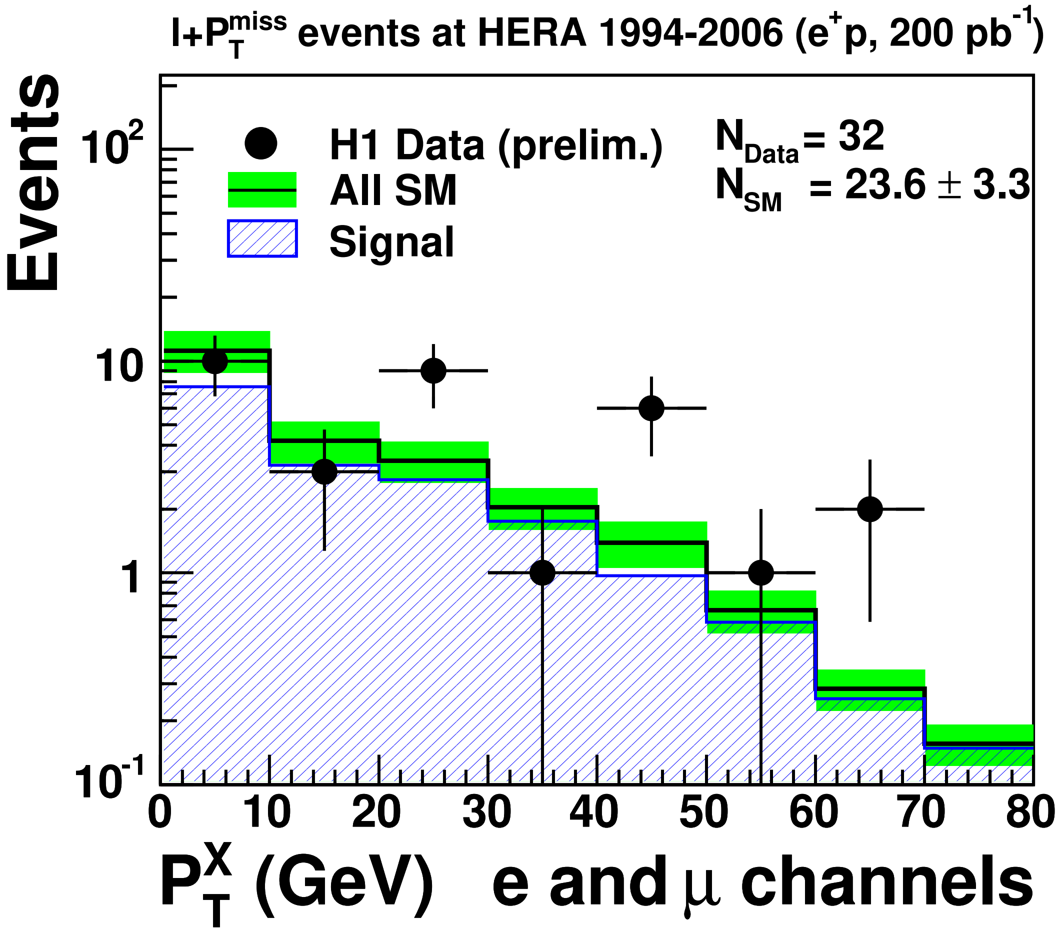

Figure 5: The hadronic transverse momentum distribution in the electron and muon channels combined: data (HERA e^+p, $\mathcal{L} = 200$ pb^{-1}) is compared to the SM expectation (open histogram). The signal component of the SM expectation, dominated by real W production, is given by the hatched histogram. $\mathrm{N_{Data}}$ is the total number of data events observed, $\mathrm{N_{SM}}$ is the total SM expectation. The total error on the SM expectation is given by the shaded band.

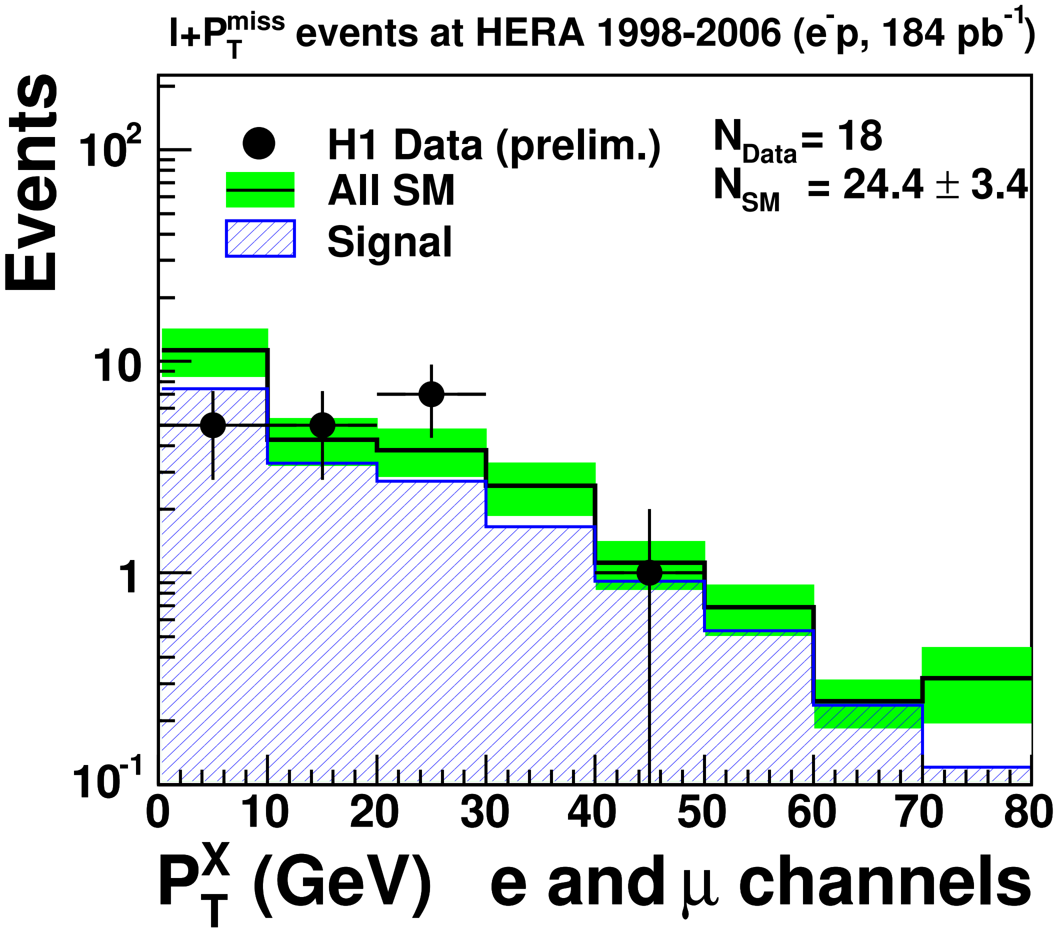

Figure 6: The hadronic transverse momentum distribution in the electron and muon channels combined: data (HERA e^-p, $\mathcal{L} = 184$ pb^{-1}) is compared to the SM expectation (open histogram). The signal component of the SM expectation, dominated by real W production, is given by the hatched histogram. $\mathrm{N_{Data}}$ is the total number of data events observed, $\mathrm{N_{SM}}$ is the total SM expectation. The total error on the SM expectation is given by the shaded band.

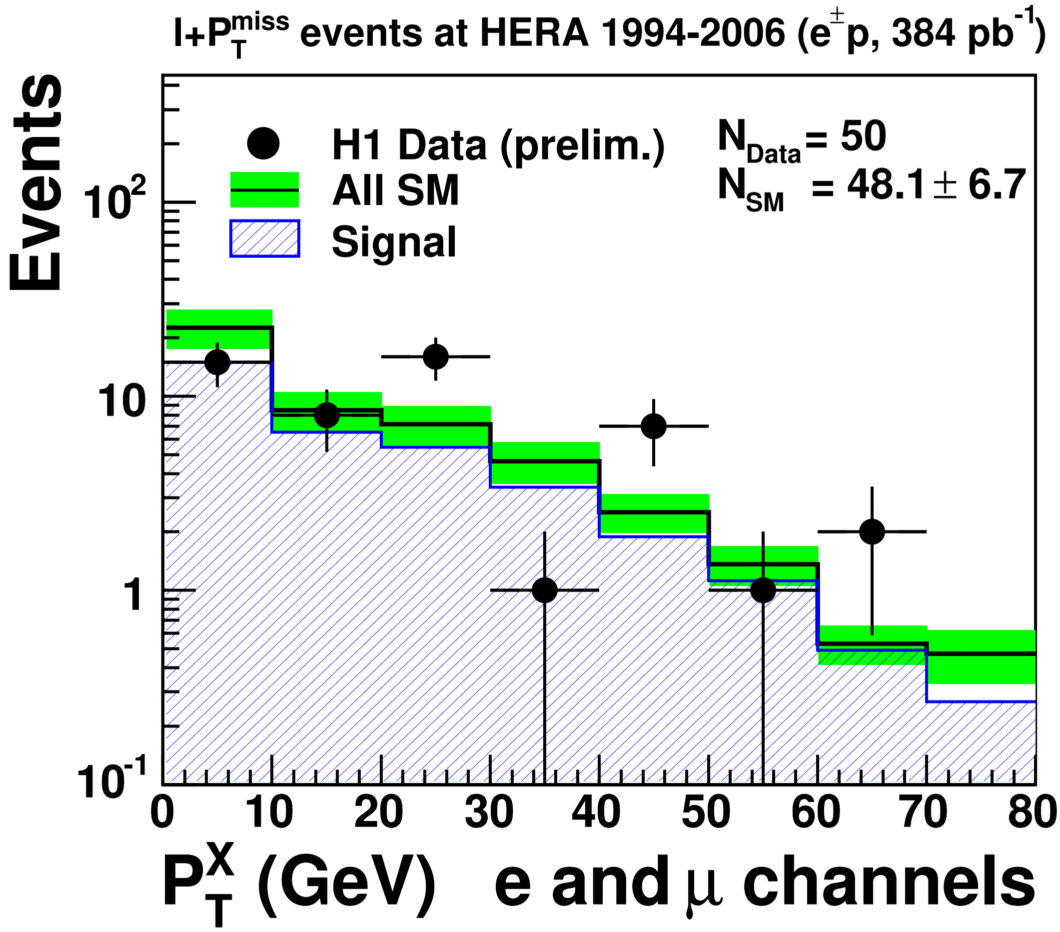

Figure 7: The hadronic transverse momentum distribution in the electron and muon channels combined: data (HERA $e^{\pm}p$, $\mathcal{L} = 384$ pb^{-1}) is compared to the SM expectation (open histogram). The signal component of the SM expectation, dominated by real W production, is given by the hatched histogram. $\mathrm{N}_{\mathrm{Data}}$ is the total number of data events observed, N_{SM} is the total SM expectation. The total error on the SM expectation is given by the shaded band.

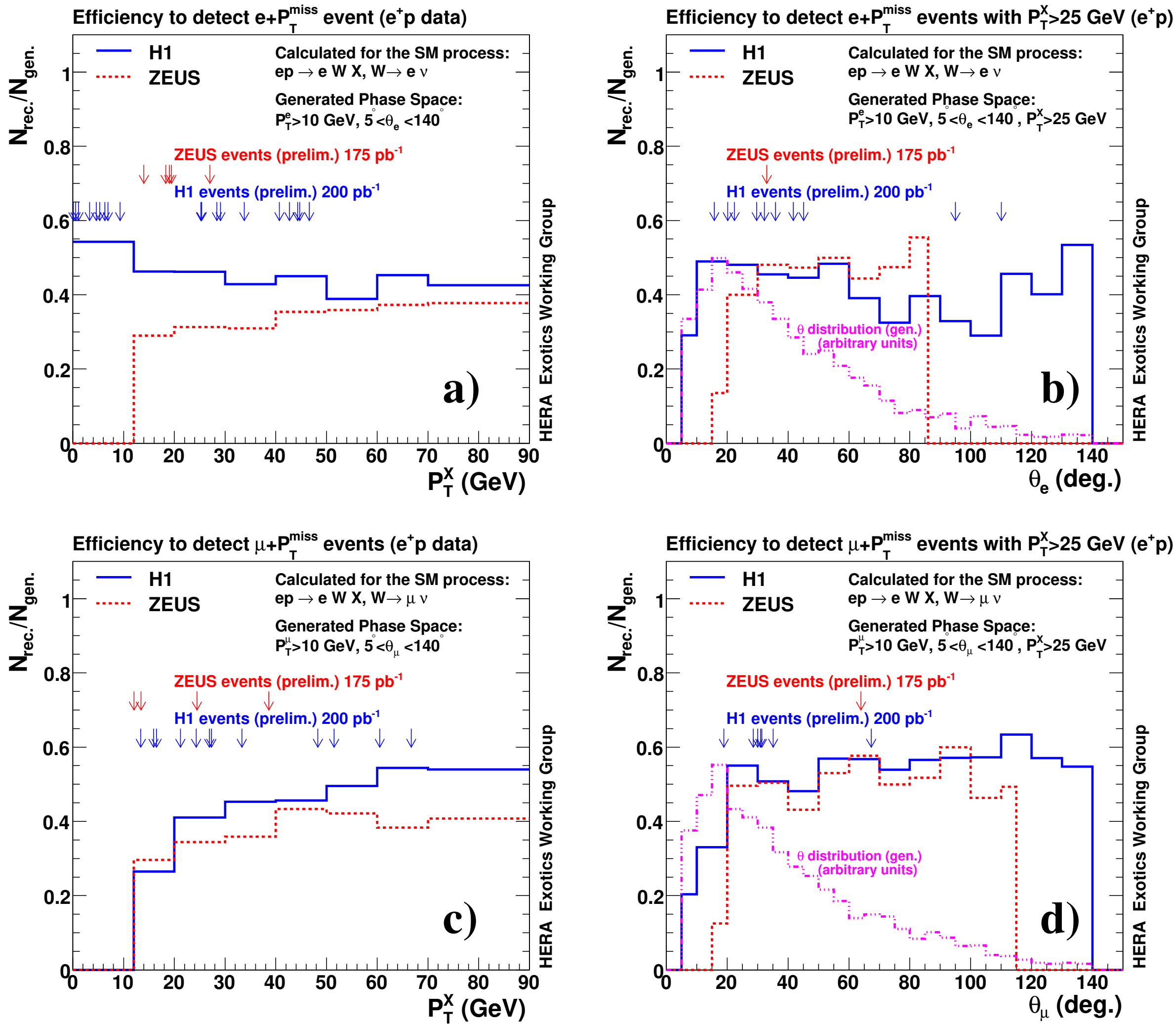

Figure 8: Comparisons of the efficiencies of the H1 and ZEUS analyses to select events containing isolated electrons or muons and missing transverse momentum in the HERA e^+p data. Figure a) displays the efficiency, defined as N_{rec} / N_{gen}, as function of hadronic transverse momentum P_T^X in the electron channel. Figure b) displays the efficiency in the electron channel at large $P_T^X > 25$ GeV as a function of electron polar angle. Figure c) displays the efficiency as function of hadronic transverse momentum P_T^X in the muon channel. Figure d) displays the efficiency in the muon channel at large $P_T^X > 25$ GeV as a function of muon polar angle. In all figures the H1 (ZEUS) efficiency is given by the solid (dashed) line. The data events observed by each experiment are indicated by the arrows. The θ_l distribution from EPVEC is also shown in figures b) and d).

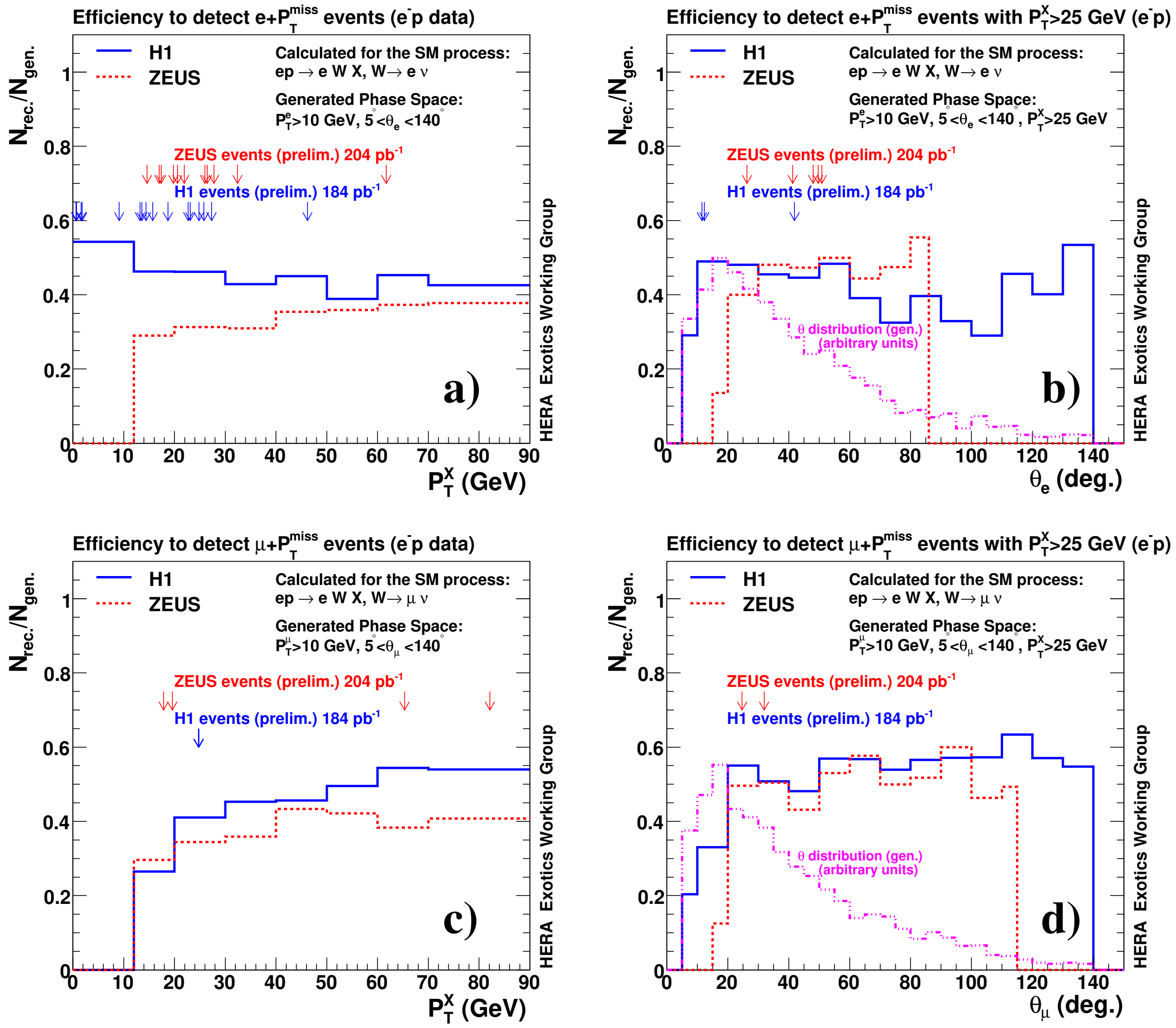

Figure 9: Comparisons of the efficiencies of the H1 and ZEUS analyses to select events containing isolated electrons or muons and missing transverse momentum in the HERA e^-p data. Figure a) displays the efficiency, defined as N_{rec} / N_{gen}, as function of hadronic transverse momentum P_T^X in the electron channel. Figure b) displays the efficiency in the electron channel at large $P_T^X > 25$ GeV as a function of electron polar angle. Figure c) displays the efficiency as function of hadronic transverse momentum P_T^X in the muon channel. Figure d) displays the efficiency in the muon channel at large $P_T^X > 25$ GeV as a function of muon polar angle. In all figures the H1 (ZEUS) efficiency is given by the solid (dashed) line. The data events observed by each experiment are indicated by the arrows. The θ_l distribution from EPVEC is also shown in figures b) and d).

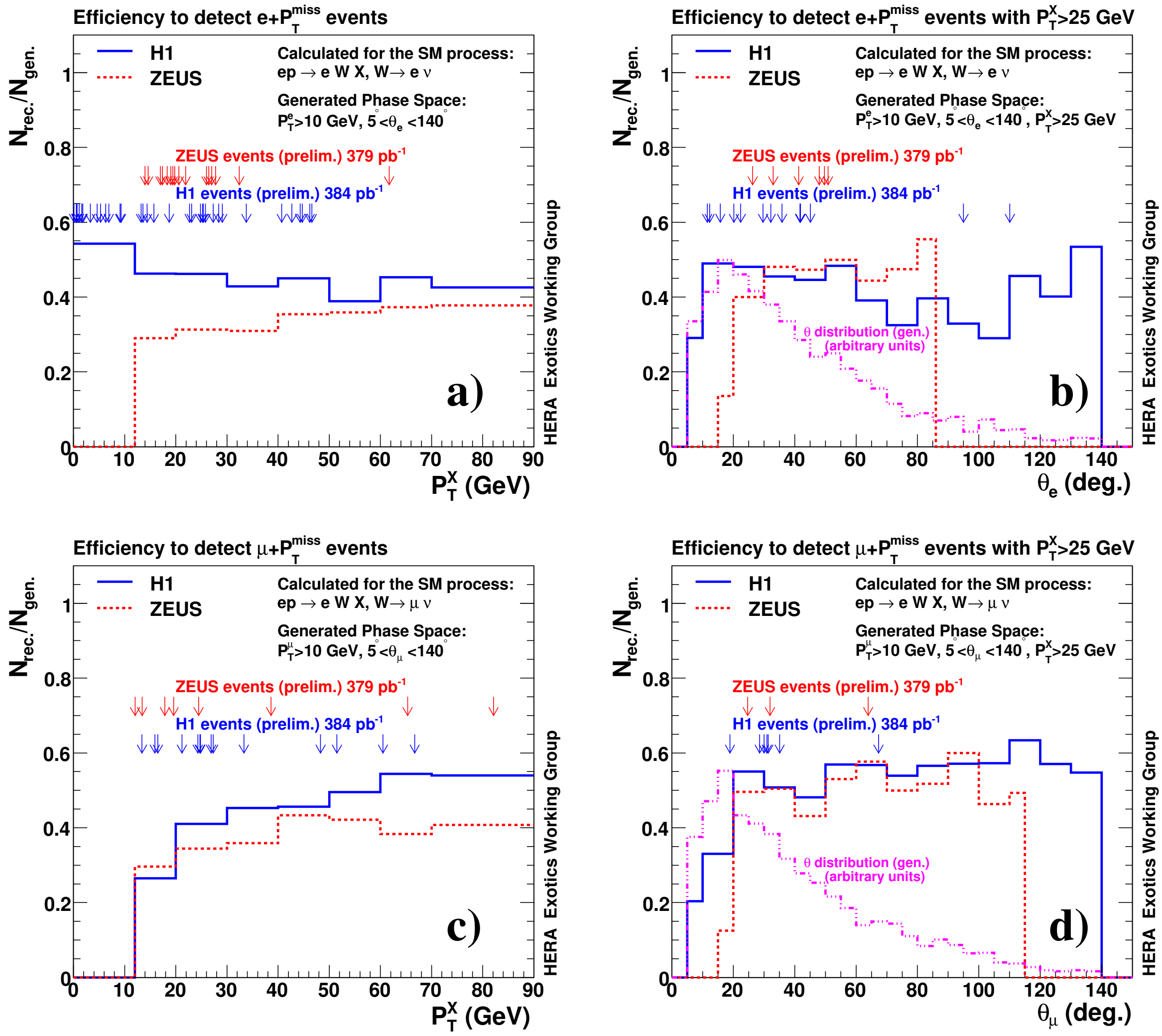

Figure 10: Comparisons of the efficiencies of the H1 and ZEUS analyses to select events containing isolated electrons or muons and missing transverse momentum in the HERA $e^{\pm}p$ data. Figure a) displays the efficiency, defined as N_{rec} / N_{gen}, as function of hadronic transverse momentum P_T^X in the electron channel. Figure b) displays the efficiency in the electron channel at large $P_T^X > 25$ GeV as a function of electron polar angle. Figure c) displays the efficiency as function of hadronic transverse momentum P_T^X in the muon channel. Figure d) displays the efficiency in the muon channel at large $P_T^X > 25$ GeV as a function of muon polar angle. In all figures the H1 (ZEUS) efficiency is given by the solid (dashed) line. The data events observed by each experiment are indicated by the arrows. The θ_l distribution from EPVEC is also shown in figures b) and d).

References

[1] H1 Collaboration; *"Search for Events with Isolated Leptons and Missing Transverse Momentum at HERA"*, contributed paper to *The XXXIII International Conference on High Energy Physics, ICHEP06*, Moscow 2006.

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