Multi-Lepton and Isolated Lepton Events at HERA

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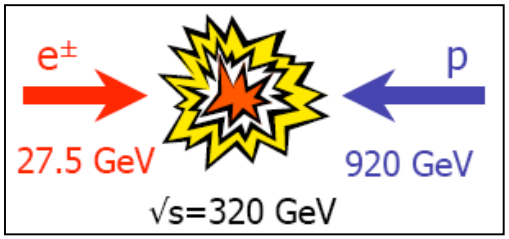
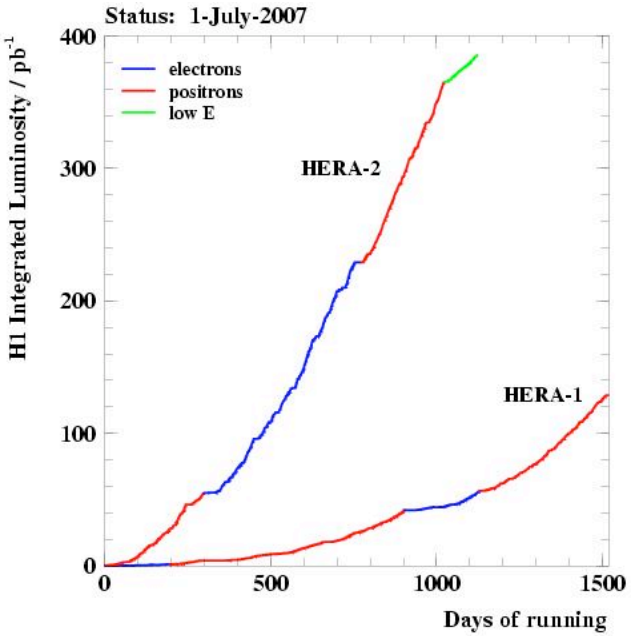
on behalf of the H1 and ZEUS Collaborations

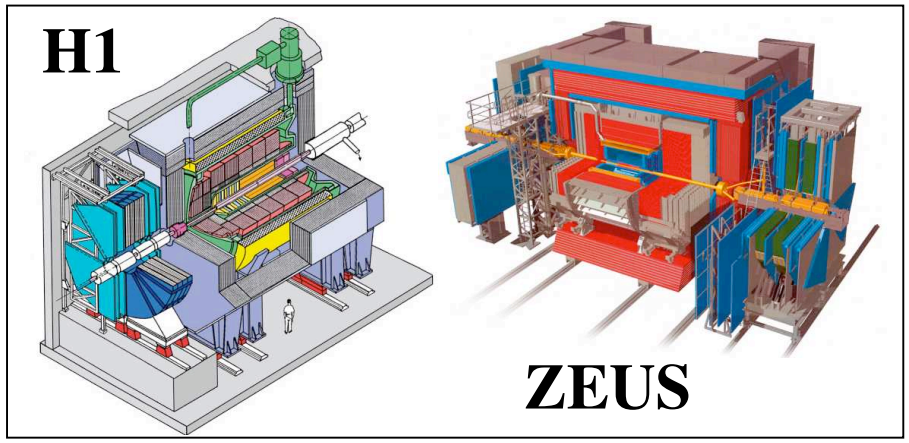
- Introduction to H1, ZEUS and HERA
- Multi-Lepton Events
- Events with Isolated Leptons and Missing Transverse Momentum
- Summary

The H1 and ZEUS Experiments at HERA



Data taking
1994 - 2007





Two multi-purpose experiments
located at the ep interaction points

- Large increase in data per experiment from HERA II (x3)
- Large increase (x12) in data taken from e^-p collisions; HERA I mostly e^+p data

Final combined HERA dataset ~ 1 fb^{-1}

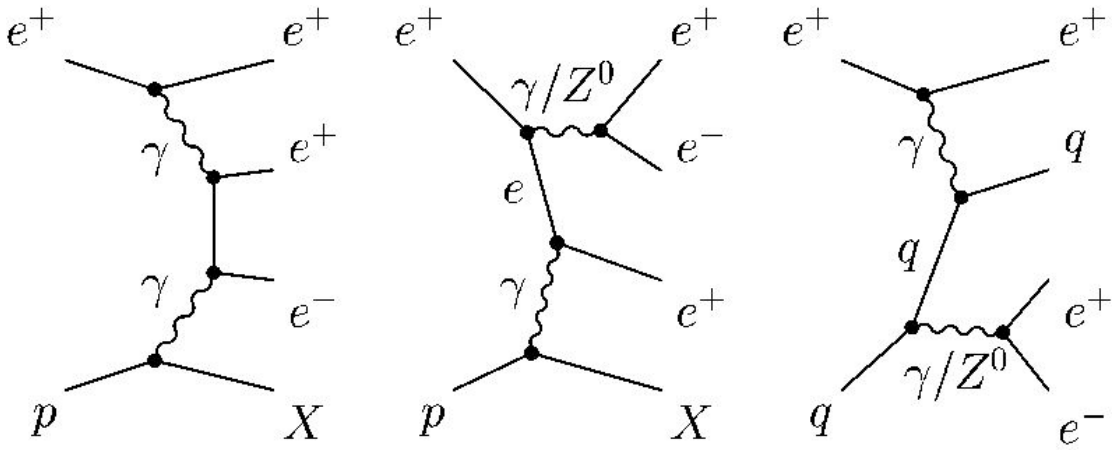
Events with Isolated Leptons at HERA

- Look for events with one or more isolated leptons in the final state as well as in combination with missing P_T: sensitive signature to BSM physics
  - Good lepton ID and HFS reconstruction of experiments means such topologies provide a clean signal

- The SM expectation for such events at HERA is low, so the analysis benefits from the combination of the H1 and ZEUS data: full HERA data ~ 1 fb^{-1}
  - Measure cross sections of rare processes
  - Increase sensitivity to new possible phenomena

Multi-Lepton Events

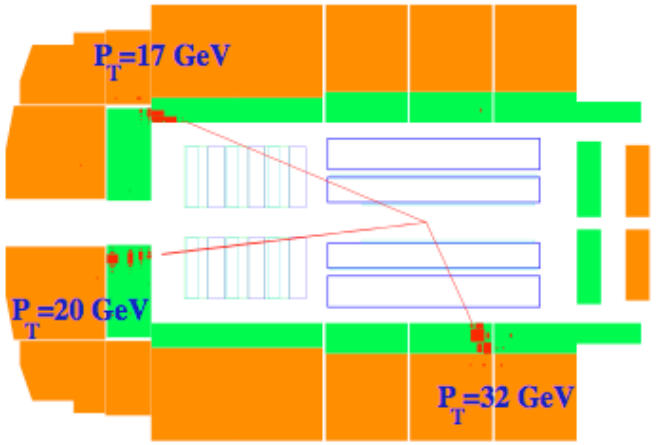
- The main SM process in ep interactions with multi-leptons in the final state is the $\gamma\gamma$ process:



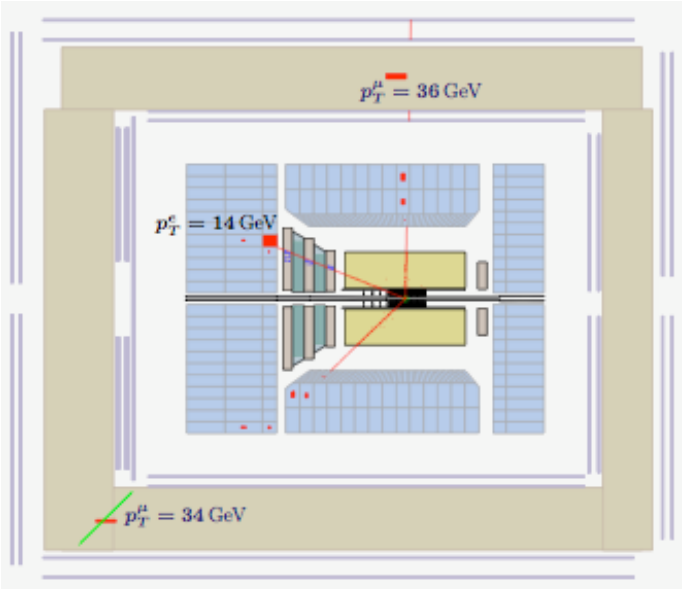
- This QED process has a precise SM prediction, modelled using GRAPE
- Cross section is low at high mass, high P_T: look for deviations from the SM prediction: indications of new phenomena
- Main SM backgrounds: NC-DIS, QED Compton for multi-electron events; multi-muon events have very low background (non-ep from cosmic rays)

Multi-Lepton Event Selection

- Events are selected by requiring at least two, isolated high P_T electrons or muons in the final state
- Electrons identified in the polar angle region $5^O<\theta<175^O$ with E >10 GeV, with E >5 GeV in the backward region ($\theta>150^O$)
- Muons identified in the polar angle region $20^O<\theta<160^O$ with P_T >2 GeV
- Events are then classified into independent, exclusive samples:
  - ee, eee, μμ, eμ, eμμ and so on..
- At least two of the leptons must be in the region $20^O<\theta<150^O$ and have P_T >5, 10 GeV



eee event in H1



eμμ event in ZEUS

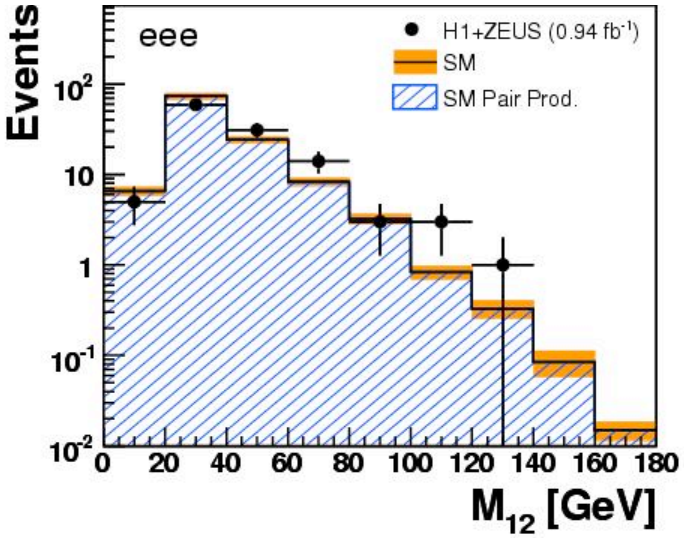
Results of Different Multi-lepton Topologies

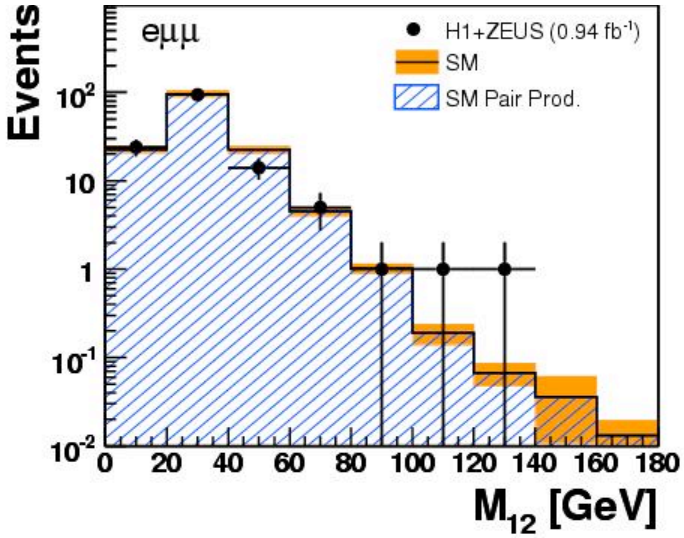
Multi-Leptons at HERA ($0.94\ \text{fb}^{-1}$)

Sample	Data	SM	Pair Production (GRAPE)	NC DIS + QEDC
ee	873	895 ± 57	724 ± 41	171 ± 28
$\mu\mu$	298	320 ± 36	320 ± 36	< 0.5
$e\mu$	173	167 ± 10	152 ± 9	15 ± 3
eee	116	119 ± 7	117 ± 6	< 4
$e\mu\mu$	140	147 ± 15	147 ± 15	< 0.5
$(\gamma\gamma)_e$	284	293 ± 18	289 ± 18	4 ± 1
$(\gamma\gamma)_\mu$	235	247 ± 26	247 ± 26	< 0.5

Overall good agreement seen with the SM prediction

$\gamma\gamma$ selections used to measure the cross sections in the photoproduction regime





Looking at the high mass region, a few interesting events show up in the data

H1+ZEUS Multi-lepton Events at High Mass

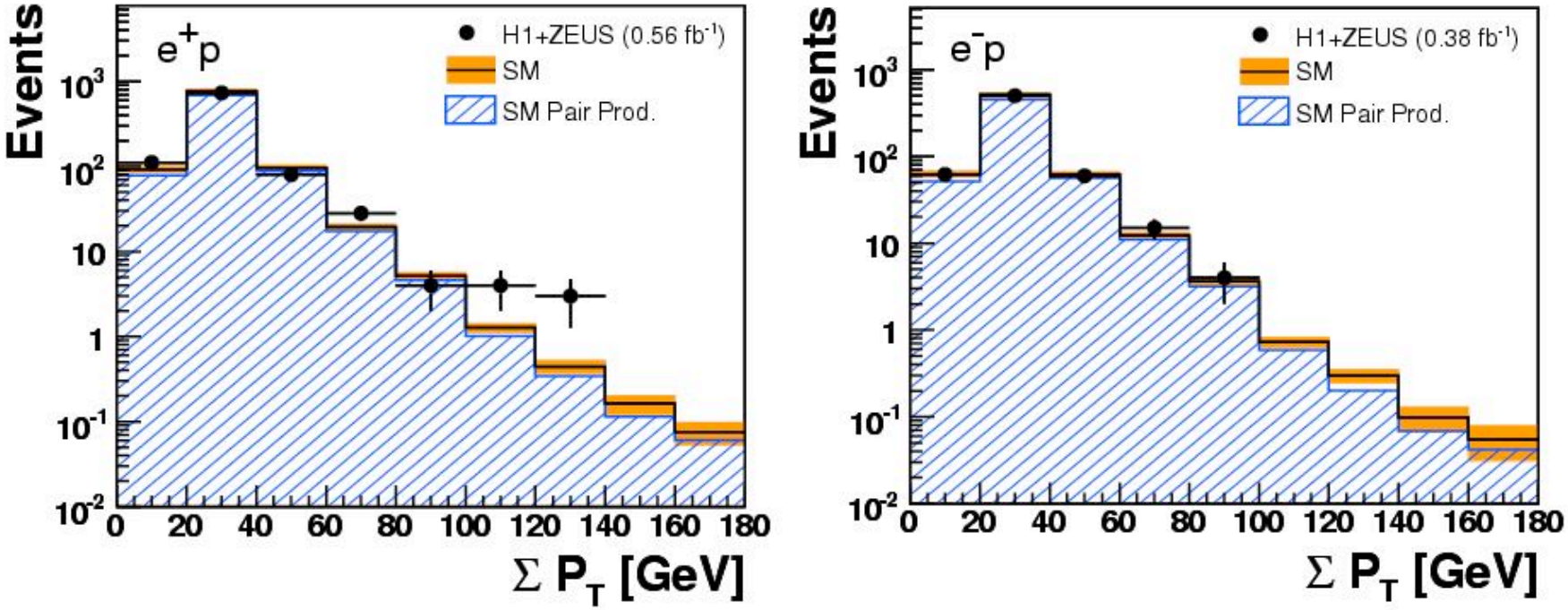
All high mass events seen in the e^+p data:
9 from H1
3 from ZEUS

Multi-Leptons at HERA (0.94 fb^{-1})

M_{12} >100 GeV

Sample	Data	SM	Pair Production (GRAPE)	NC DIS + QEDC
		e^+p collisions (0.56 fb^{-1})		
ee	4	1.68 ± 0.18	0.94 ± 0.11	0.74 ± 0.12
$\mu\mu$	1	0.32 ± 0.08	0.32 ± 0.08	< 0.01
$e\mu$	1	0.40 ± 0.05	0.39 ± 0.05	< 0.02
eee	4	0.79 ± 0.09	0.79 ± 0.09	< 0.03
$e\mu\mu$	2	0.16 ± 0.04	0.16 ± 0.04	< 0.01
		e^-p collisions (0.38 fb^{-1})		
ee	0	1.25 ± 0.13	0.71 ± 0.11	0.54 ± 0.08
$\mu\mu$	0	0.23 ± 0.10	0.23 ± 0.10	< 0.01
$e\mu$	0	0.26 ± 0.03	0.25 ± 0.03	< 0.02
eee	0	0.49 ± 0.07	0.49 ± 0.07	< 0.03
$e\mu\mu$	0	0.14 ± 0.05	0.14 ± 0.05	< 0.01
		All data (0.94 fb^{-1})		
ee	4	2.93 ± 0.28	1.65 ± 0.16	1.28 ± 0.18
$\mu\mu$	1	0.55 ± 0.12	0.55 ± 0.12	< 0.01
$e\mu$	1	0.65 ± 0.07	0.64 ± 0.06	< 0.02
eee	4	1.27 ± 0.12	1.27 ± 0.12	< 0.03
$e\mu\mu$	2	0.31 ± 0.06	0.31 ± 0.06	< 0.01

H1+ZEUS Multi-lepton Events at High ΣP_T



Multi-Leptons at HERA (0.94 fb^{-1})

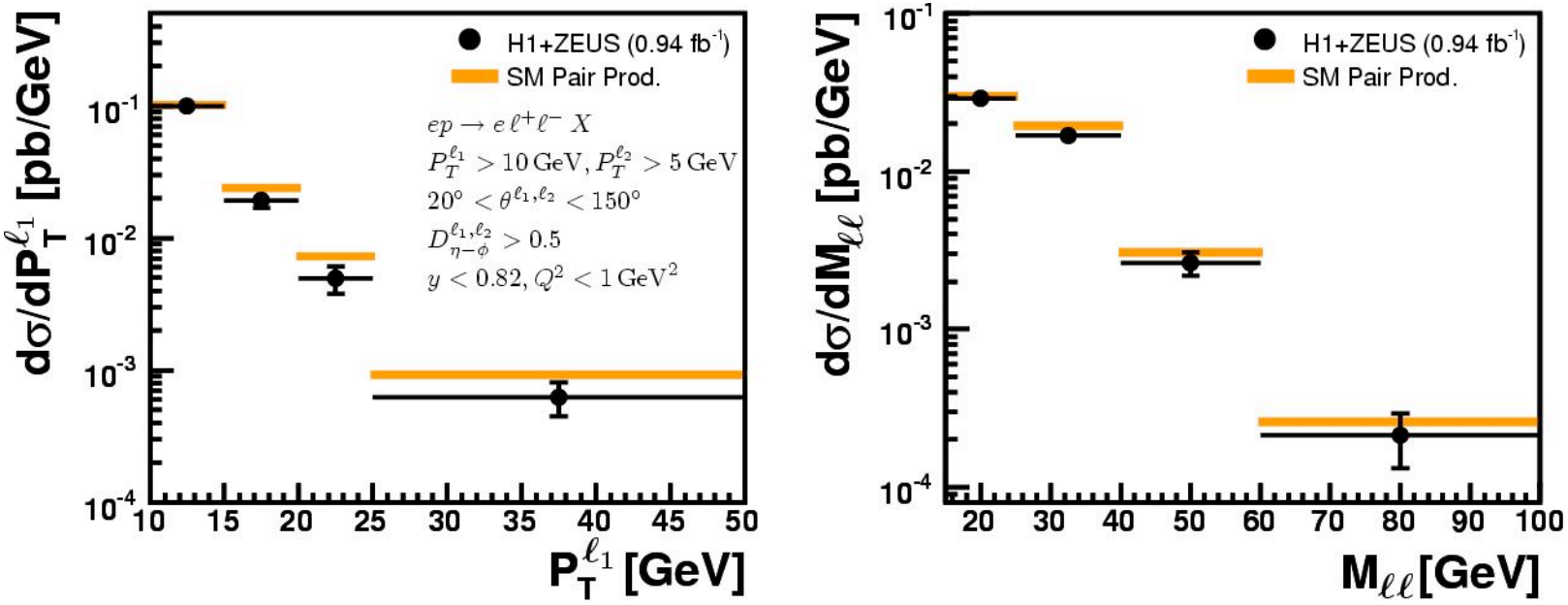
$\sum P_T$ >100 GeV

Data sample	Data	SM	Pair Production (GRAPE)	NC DIS + QEDC
e^+p (0.56 fb^{-1})	7	1.94 ± 0.17	1.52 ± 0.14	0.42 ± 0.07
e^-p (0.38 fb^{-1})	0	1.19 ± 0.12	0.90 ± 0.10	0.29 ± 0.05
All (0.94 fb^{-1})	7	3.13 ± 0.26	2.42 ± 0.21	0.71 ± 0.10

- 7 events observed in the e^+p data with ΣP_T > 100 GeV, where the significance of excess of SM expectation is 2.6σ

Measurement of the $\gamma\gamma \to l^+l^-$ Cross Section

- Two-photon channels used to measure the H1+ZEUS weighted average cross section for electron and muon pair production in the kinematic region indicated

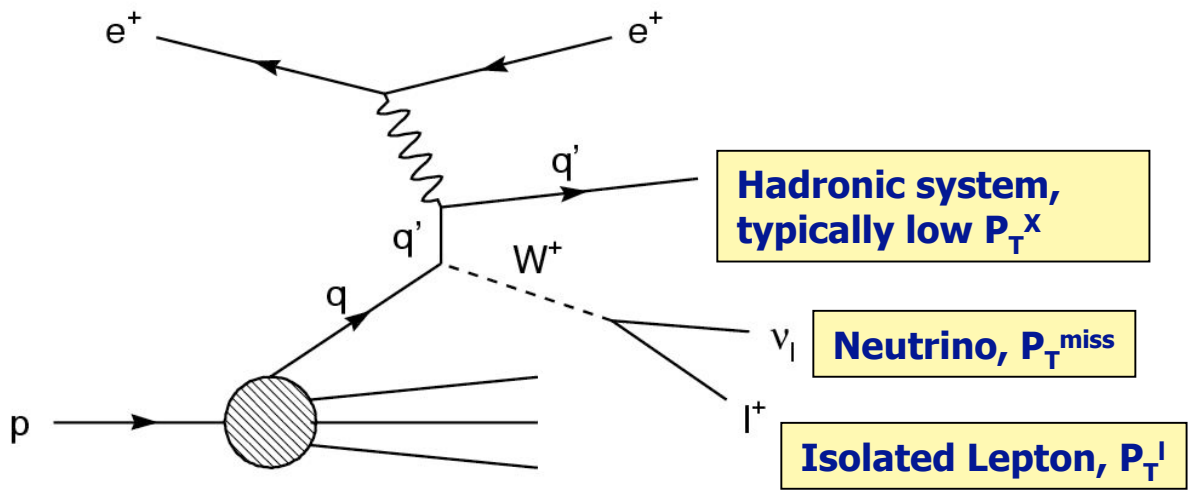


- Differential cross sections measured as a function of the P_T of the leading lepton and the invariant mass of the lepton pair

- Total visible cross section measured 0.66 ± 0.03 (stat.) ± 0.03 (sys.) pb in good agreement with the SM prediction of 0.69 ± 0.02 pb from GRAPE

Events with Isolated Leptons and Missing P_T

- The main SM process in ep interactions with a single, high P_T isolated lepton in coincidence with missing transverse momentum the final state is single W production:

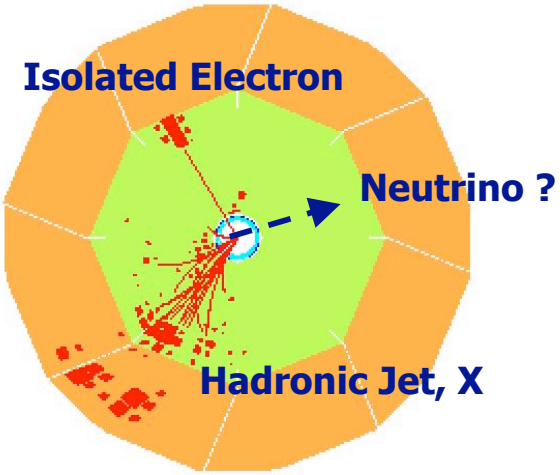


- Smaller additional contributions occur to the signal via the equivalent diagram in CC-DIS, as well as from Z^O production with decay to neutrinos

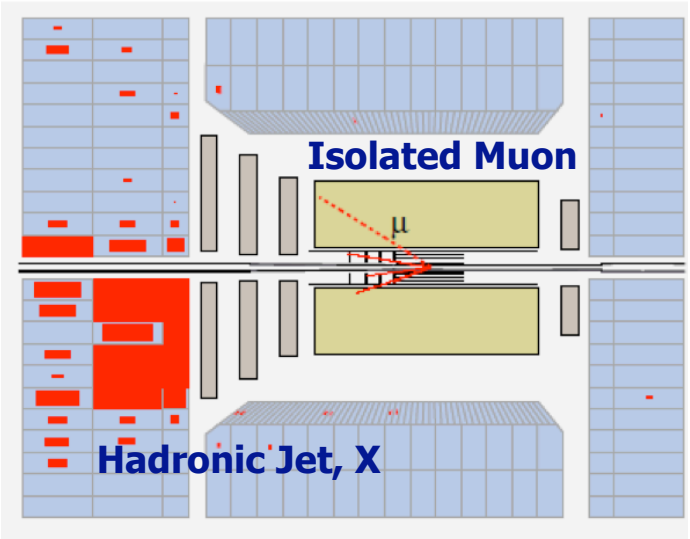
- Total cross section ~ 1.3 pb, with 10% of W decays to each lepton flavour
- Modelled at HERA using EPVEC with a NLO correction, uncertainty 15%
- Main SM backgrounds: NC-DIS, CC-DIS and lepton pair production

Isolated Lepton and Missing P_T Event Selection

- Events characterized by a high P_T lepton (electron or muon), in the main body of the detector, in events with large missing transverse momentum
- Common H1+ZEUS analysis phase space defined as events with an electron or muon satisfying $P_T>10$ GeV, $15^O<\theta<120^O$ and $P_T^{Miss}>12$ GeV
- The lepton is also required to be well isolated from the nearest jet and track in the event (rejects mainly CC events with a lepton in the jet)
- Further cuts applied to reduce SM background such as rejecting back-to-back topologies (NC, lepton-pairs)
- Electron and muon channels are exclusive, and are combined, also in the cross section measurement

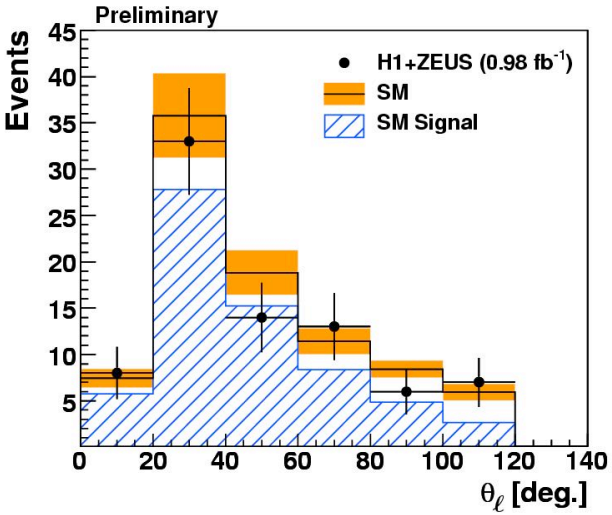


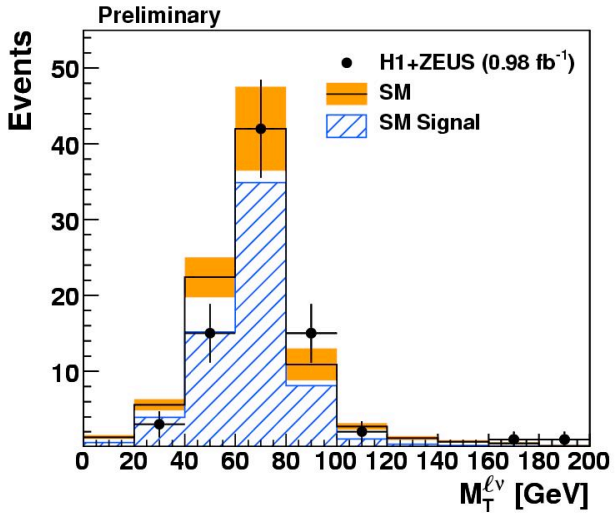
e + P_T^{Miss} event in H1

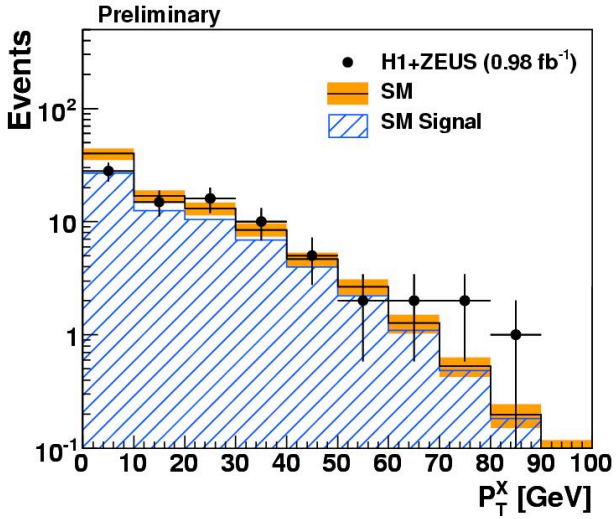


μ + P_T^{Miss} event in ZEUS

H1+ZEUS Isolated Leptons: Results





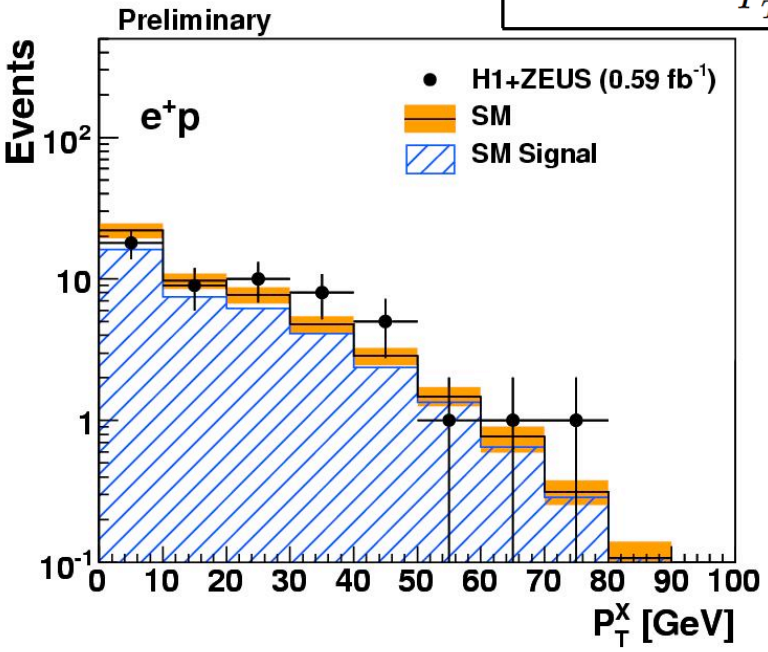


H1+ZEUS Preliminary 1994-2007 $e^{\pm}p$ 0.98 fb^{-1}		Data	SM Expectation	SM Signal	Other SM Processes
Electron	Total	61	69.19 ± 8.18	48.31 ± 7.38	20.88 ± 3.19
	$P_T^X > 25$ GeV	16	13.03 ± 1.70	9.95 ± 1.55	3.08 ± 0.65
Muon	Total	20	18.62 ± 2.69	16.43 ± 2.60	2.20 ± 0.51
	$P_T^X > 25$ GeV	13	10.96 ± 1.62	9.77 ± 1.56	1.19 ± 0.32
Combined	Total	81	87.82 ± 10.55	64.74 ± 9.88	23.08 ± 3.32
	$P_T^X > 25$ GeV	29	23.99 ± 3.24	19.71 ± 3.09	4.27 ± 0.77

Overall good agreement seen with the SM prediction

H1+ZEUS Isolated Leptons: Positron Data

H1+ZEUS Preliminary 1994-2007 e^+p 0.59 fb^{-1}		Data	SM Expectation	SM Signal	Other SM Processes
Electron	Total	37	38.62 ± 4.71	28.89 ± 4.42	9.73 ± 1.40
	$P_T^X > 25$ GeV	12	7.41 ± 1.01	5.96 ± 0.94	1.45 ± 0.33
Muon	Total	16	11.20 ± 1.62	9.86 ± 1.56	1.34 ± 0.33
	$P_T^X > 25$ GeV	11	6.62 ± 0.98	5.85 ± 0.94	0.77 ± 0.22
Combined	Total	53	49.82 ± 6.18	38.75 ± 5.92	11.06 ± 1.51
	$P_T^X > 25$ GeV	23	14.02 ± 1.94	11.81 ± 1.86	2.22 ± 0.43

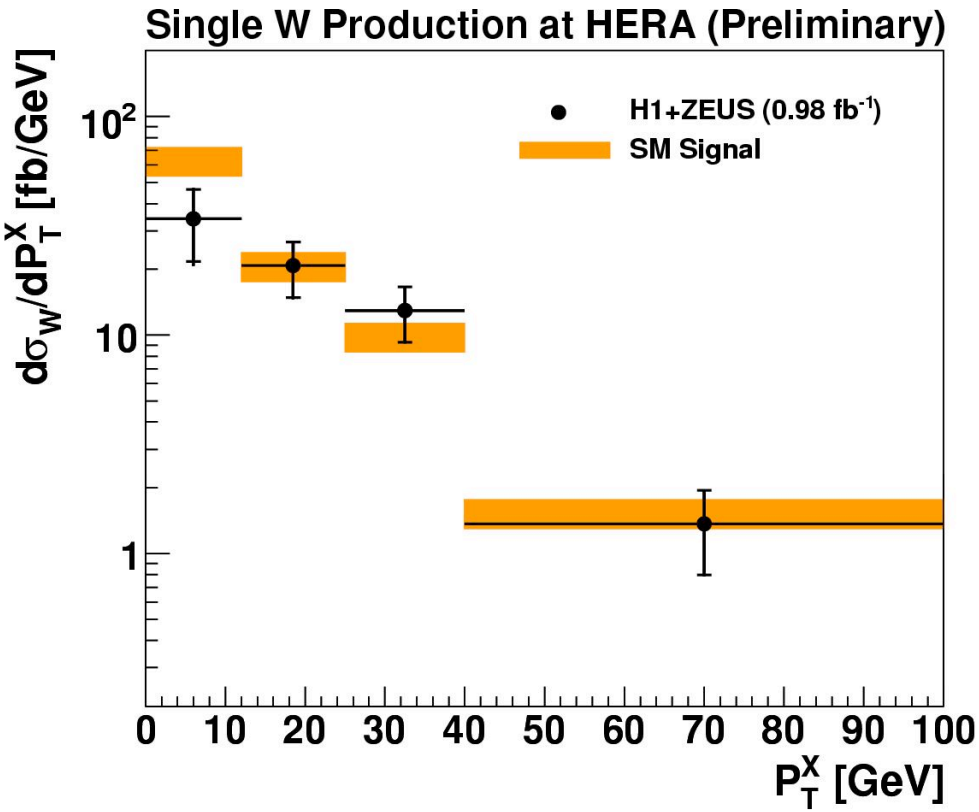


- Excess of data events seen in the published H1 analysis at large P_T^X, an area of phase space where the SM expectation is small
  - Not confirmed in the ZEUS analysis
- Excess remains in the common phase space of the combined analysis but with less significance of around 1.9σ
  - Still driven by the H1 data

Single W Cross Section

- Measurement of the Single W cross section performed in the common phase space
- Branching ratio of W decays to leptons used to calculate the full W production cross section
- Measurement done differentially as a function of hadronic transverse momentum, P_T^X
  - There is no measurement in the $P_T^X < 12$ GeV bin in the muon channel, so the electron channel is used under the assumption of lepton universality:

$$\sigma_\ell^{All\,P_T^X} = \sigma_e^{P_T^X>12} + \sigma_\mu^{P_T^X>12} + 2\sigma_e^{P_T^X<12}$$



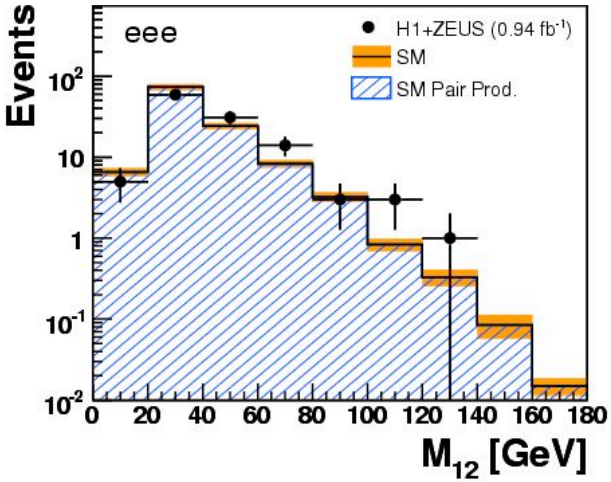
- Inclusive single W cross section measured 1.07 ±0.16 (stat.) ± 0.08 (sys.) pb in good agreement with the SM prediction of 1.26 ± 0.19 pb from EPVEC at NLO

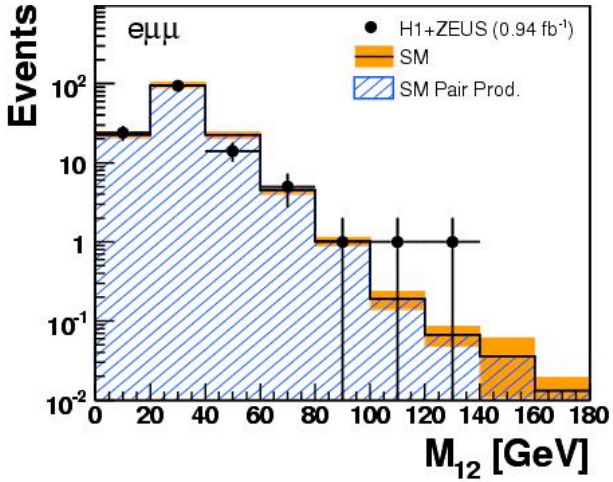
Summary

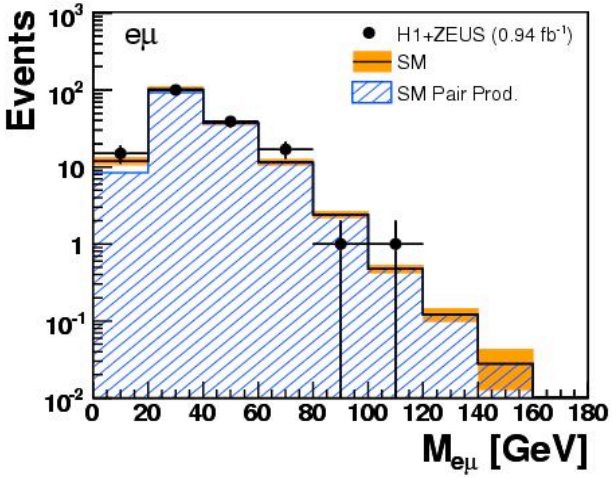
- Analyses of events with multi-leptons and isolated leptons with P_T^{Miss} recently published individually by H1 and ZEUS
- Combined H1+ZEUS analyses performed to take advantage of full HERA statistics
  - Multi-leptons: DESY-09-108, [hep-ex] shortly
  - Isolated Leptons + P_T^{Miss}: H1prelim-09-161 / ZEUS-prel-09-014
- In general good agreement with the SM observed
  - Cross sections of rare processes measured with greater statistical precision
- Interesting events remain at high P_T and high mass in the e^+p HERA data, from both H1 and ZEUS, where the SM expectation is low

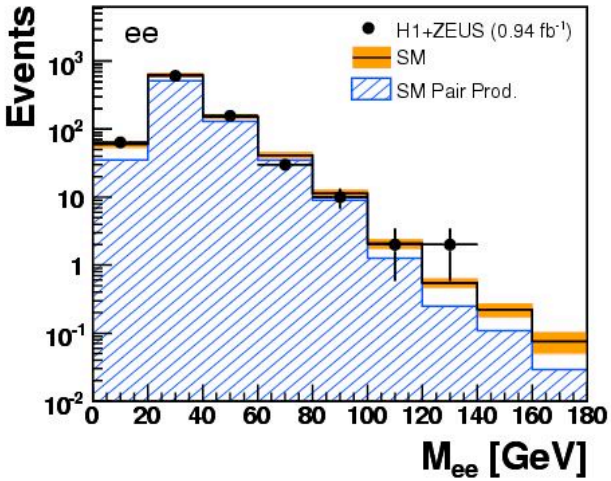
Extras

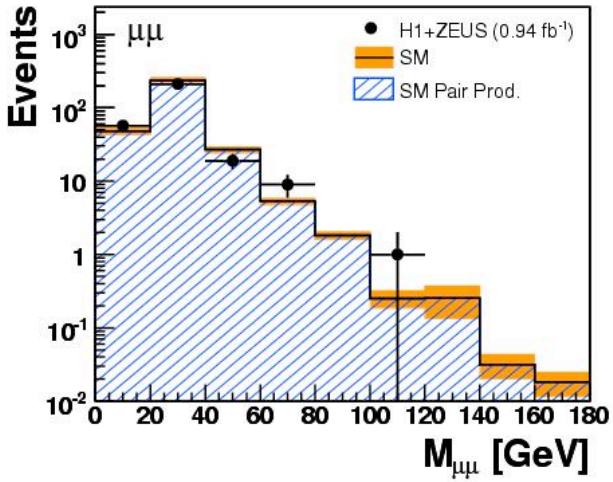
Multi-lepton Channels Mass Distributions











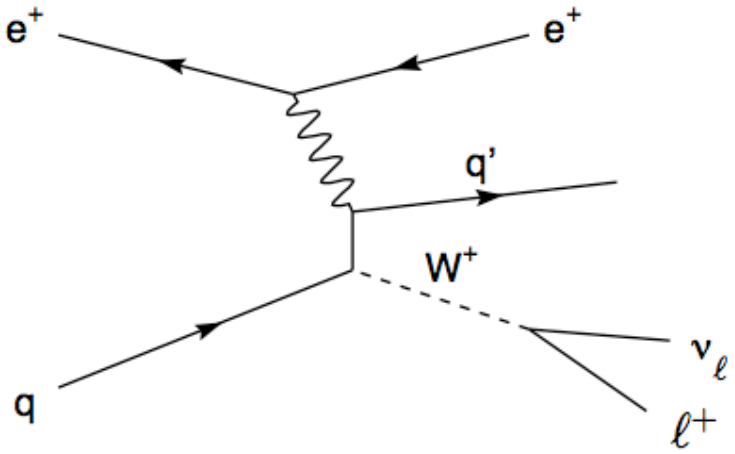
H1+ZEUS

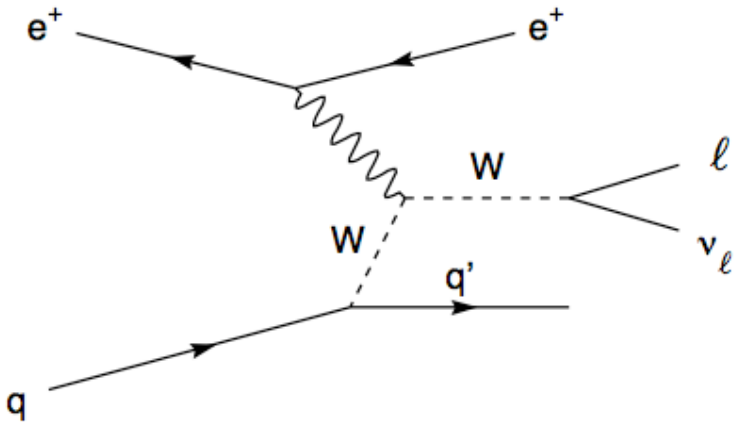
H1+ZEUS Multi-leptons: Cross Sections

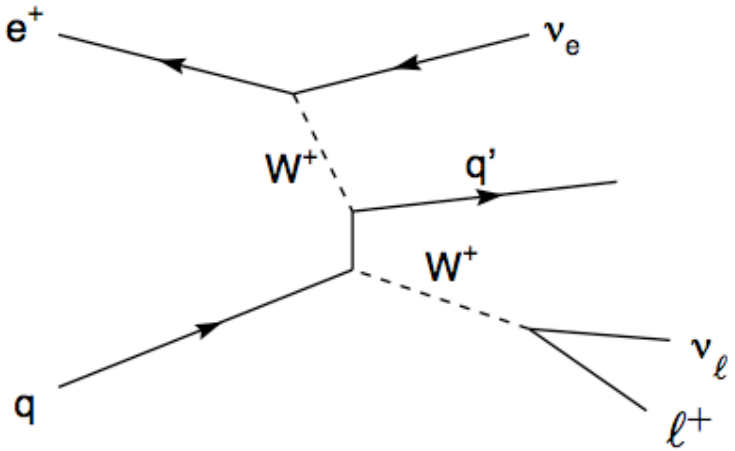
Multi-Leptons at HERA ($0.94\ \mathrm{fb}^{-1}$)

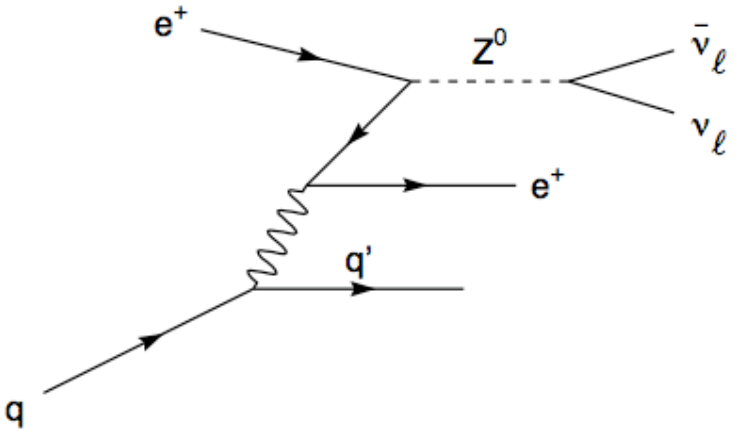
Variable range [GeV]	Measured (e^+e^-) [fb/GeV]	Measured $(\mu^+\mu^-)$ [fb/GeV]	Measured (average) [fb/GeV]	Pair Production (GRAPE) [fb/GeV]
$P_T^{\ell_1}$		$d\sigma/dP_T^{\ell_1}$		
$[10, 15]$	$101.1 \pm 7.1 \pm 5.5$	$97.7 \pm 7.7 \pm 9.2$	$99.9 \pm 5.3 \pm 4.9$	101.3 ± 3.1
$[15, 20]$	$22.4 \pm 3.1 \pm 1.3$	$15.9 \pm 3.2 \pm 1.7$	$19.4 \pm 2.3 \pm 1.0$	23.9 ± 0.7
$[20, 25]$	$5.0 \pm 1.5 \pm 0.6$	$4.9 \pm 1.6 \pm 0.6$	$5.0 \pm 1.1 \pm 0.4$	7.3 ± 0.2
$[25, 50]$	$0.56 \pm 0.22 \pm 0.05$	$0.75 \pm 0.29 \pm 0.09$	$0.63 \pm 0.18 \pm 0.04$	0.93 ± 0.03
$M_{\ell\ell}$		$d\sigma/dM_{\ell\ell}$		
$[15, 25]$	$27.3 \pm 2.8 \pm 1.5$	$31.9 \pm 2.9 \pm 3.0$	$29.0 \pm 2.1 \pm 1.5$	30.0 ± 0.9
$[25, 40]$	$18.4 \pm 1.6 \pm 1.1$	$14.9 \pm 1.8 \pm 1.4$	$16.9 \pm 1.2 \pm 0.9$	19.5 ± 0.6
$[40, 60]$	$3.4 \pm 0.6 \pm 0.2$	$2.0 \pm 0.5 \pm 0.2$	$2.6 \pm 0.4 \pm 0.2$	3.1 ± 0.1
$[60, 100]$	$0.17 \pm 0.09 \pm 0.03$	$0.32 \pm 0.15 \pm 0.04$	$0.21 \pm 0.08 \pm 0.02$	0.26 ± 0.01

Signal Diagrams for Isolated Leptons + P_T^{Miss}









H1+ZEUS Isolated Lepton Event Selection

Variable	Electron	Muon
θ_l	$15^o < \theta_l < 120^o$	
P_T^l	> 10 GeV	
P_T^{calo}	> 12 GeV	
M_T	> 10 GeV	
P_T^{miss}	> 12 GeV	
P_T^X	-	> 12 GeV
D_{jet}	> 1.0	
D_{track}	> 0.5 for $\theta_e \geq 45^o$	> 0.5
ζ_l^2	> 5000 GeV^2 for $P_T^{calo} < 25$ GeV	-
V_{ap}/V_p	< 0.5 (< 0.15 for $P_T^e < 25$ GeV)	< 0.5 (< 0.15 for $P_T^{calo} < 25$ GeV)
$\Delta\phi_{l\text{-}X}$	$< 160^o$	$< 170^o$
δ_{miss}	5 GeV < δ_{miss} < 50 GeV	
# isolated μ	0	1
# electrons	< 3	-

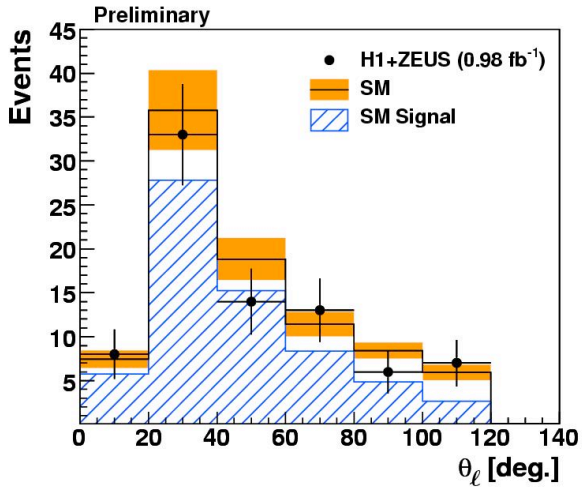
Major difference to H1 nominal analysis

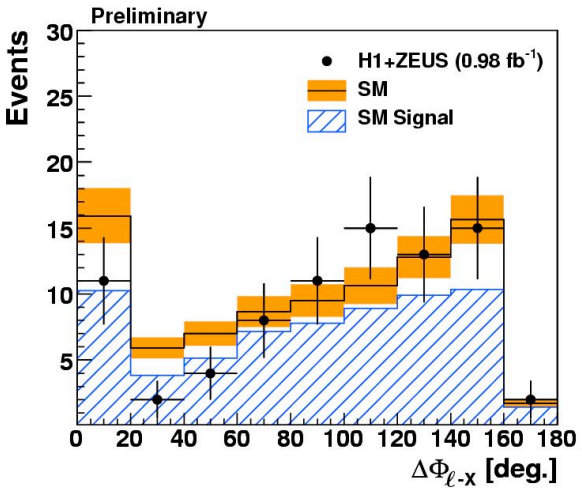
Analysis phase space selection

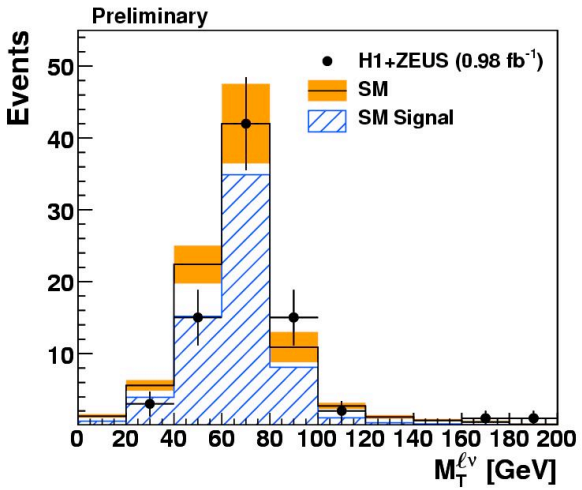
Isolation of lepton

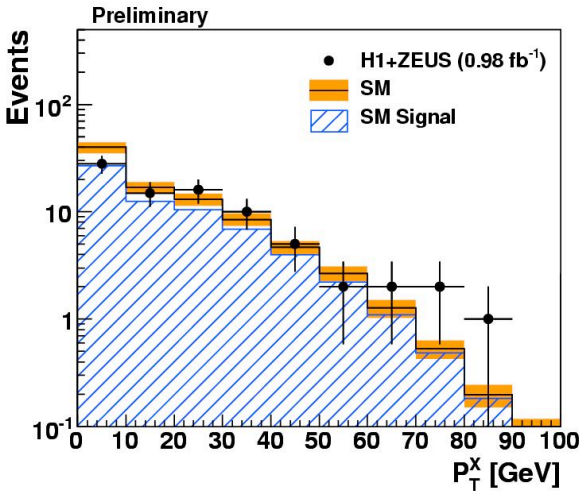
Cuts designed to reduce SM background, whilst preserving large signal purity

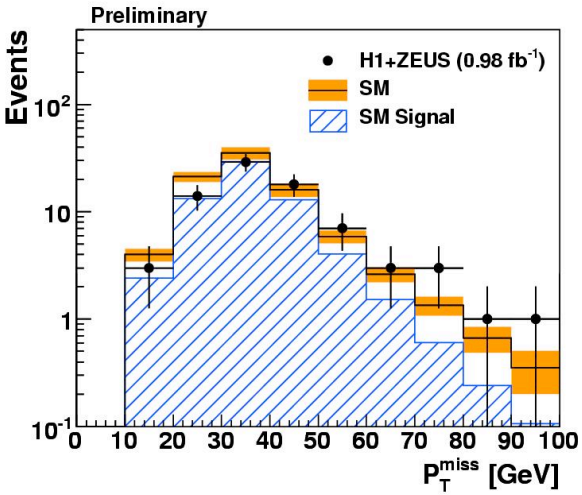
H1+ZEUS Isolated Leptons: All Distributions

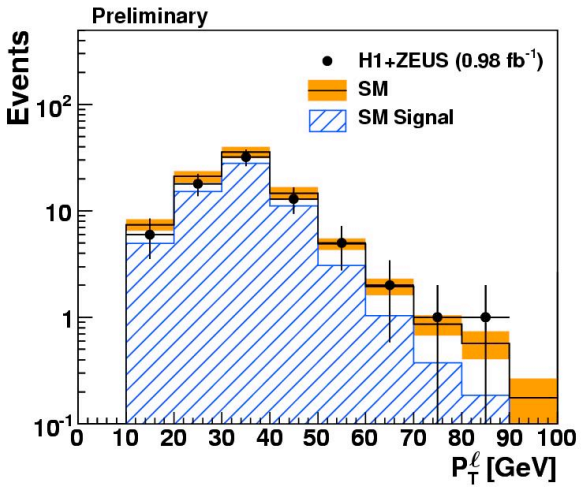




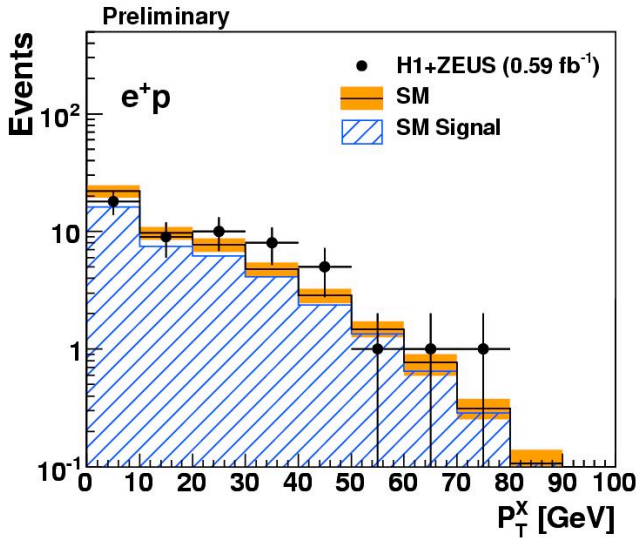


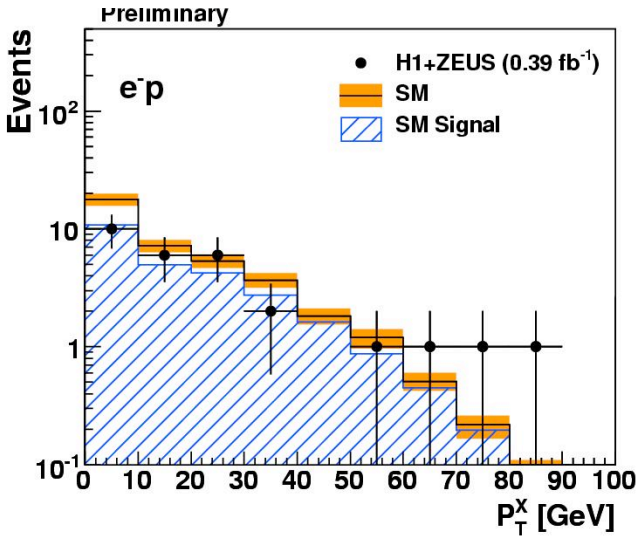






H1+ZEUS Isolated Leptons: e^+p and e^-p





H1+ZEUS Preliminary 1994-2007 e^+p 0.59 fb^{-1}		Data	SM Expectation	SM Signal	Other SM Processes
Electron	Total	37	38.62 ± 4.71	28.89 ± 4.42	9.73 ± 1.40
	$P_T^X > 25$ GeV	12	7.41 ± 1.01	5.96 ± 0.94	1.45 ± 0.33
Muon	Total	16	11.20 ± 1.62	9.86 ± 1.56	1.34 ± 0.33
	$P_T^X > 25$ GeV	11	6.62 ± 0.98	5.85 ± 0.94	0.77 ± 0.22
Combined	Total	53	49.82 ± 6.18	38.75 ± 5.92	11.06 ± 1.51
	$P_T^X > 25$ GeV	23	14.02 ± 1.94	11.81 ± 1.86	2.22 ± 0.43

H1+ZEUS Preliminary 1998-2006 e^-p 0.39 fb^{-1}		Data	SM Expectation	SM Signal	Other SM Processes
Electron	Total	24	30.58 ± 3.60	19.42 ± 2.97	11.16 ± 1.94
	$P_T^X > 25$ GeV	4	5.62 ± 0.76	3.99 ± 0.63	1.63 ± 0.42
Muon	Total	4	7.43 ± 1.08	6.57 ± 1.04	0.86 ± 0.26
	$P_T^X > 25$ GeV	2	4.34 ± 0.66	3.92 ± 0.63	0.42 ± 0.17
Combined	Total	28	38.00 ± 3.40	25.98 ± 3.40	12.02 ± 1.97
	$P_T^X > 25$ GeV	6	9.96 ± 1.34	7.91 ± 1.24	2.06 ± 0.45

H1+ZEUS Isolated Leptons: Cross Section

H1+ZEUS Differential Single W Production Cross Section (Preliminary)		
P_T^X [GeV]	Measured $\pm$ stat. $\pm$ sys. [fb / GeV]	SM NLO [fb / GeV]
$0-12$	$34.0 \pm 12.3 \pm 5.0$	62.7 ± 9.4
$12-25$	$20.8 \pm 5.9 \pm 1.8$	20.7 ± 3.1
$25-40$	$12.9 \pm 3.6 \pm 0.9$	9.8 ± 1.5
$40-100$	$1.4 \pm 0.6 \pm 0.1$	1.5 ± 0.2

Multi-Leptons: H1 Published Results

Multi-Leptons at HERA (463 pb^{-1})

Selection	Data	SM	Pair Production (GRAPE)	NC DIS + Compton
ee	368	390 ± 46	332 ± 26	58 ± 30
$\mu\mu$	201	211 ± 32	211 ± 32	< 0.005
$e\mu$	132	128 ± 9	118 ± 8	10.0 ± 2.5
eee	73	70 ± 7	69.8 ± 7.0	0.2 ± 0.1
$e\mu\mu$	97	102 ± 14	102 ± 14	< 0.005
$ee\mu$	4	1.43 ± 0.26	1.18 ± 0.20	0.25 ± 0.14
$eeee$	1	0.33 ± 0.07	0.33 ± 0.07	< 0.005
$(\gamma\gamma)_e$	146	138 ± 12	135 ± 11	3.0 ± 1.0
$(\gamma\gamma)_\mu$	163	162 ± 24	162 ± 24	< 0.005

M_{12} >100 GeV

Selection	Data	SM	Pair Production (GRAPE)	NC DIS + Compton
All data (463 pb^{-1})				
ee	3	1.34 ± 0.20	0.83 ± 0.11	0.51 ± 0.13
$\mu\mu$	1	0.17 ± 0.07	0.17 ± 0.07	< 0.005
$e\mu$	1	0.59 ± 0.06	0.59 ± 0.06	< 0.005
eee	3	0.66 ± 0.09	0.66 ± 0.09	< 0.005
$e\mu\mu$	2	0.16 ± 0.05	0.16 ± 0.05	< 0.005
e^+p collisions (285 pb^{-1})				
ee	3	0.76 ± 0.11	0.49 ± 0.07	0.27 ± 0.07
$\mu\mu$	1	0.10 ± 0.04	0.10 ± 0.04	< 0.005
$e\mu$	1	0.35 ± 0.04	0.35 ± 0.04	< 0.005
eee	3	0.39 ± 0.05	0.39 ± 0.05	< 0.005
$e\mu\mu$	2	0.09 ± 0.03	0.09 ± 0.03	< 0.005
e^-p collisions (178 pb^{-1})				
ee	0	0.58 ± 0.09	0.34 ± 0.04	0.24 ± 0.07
$\mu\mu$	0	0.07 ± 0.03	0.07 ± 0.03	< 0.005
$e\mu$	0	0.24 ± 0.03	0.24 ± 0.03	< 0.005
eee	0	0.27 ± 0.04	0.27 ± 0.04	< 0.005
$e\mu\mu$	0	0.07 ± 0.03	0.07 ± 0.03	< 0.005

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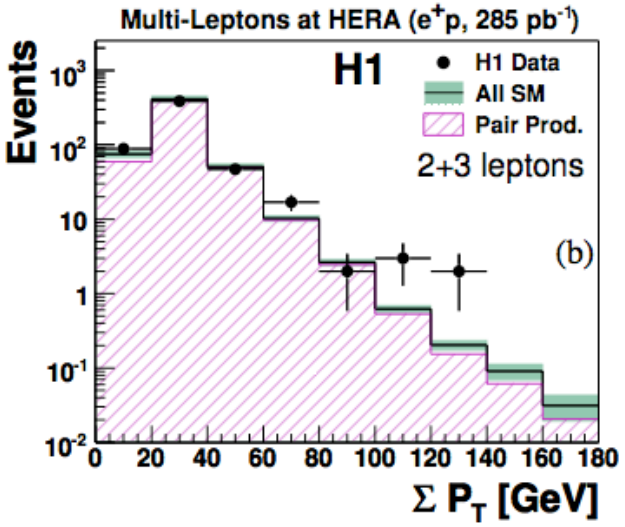
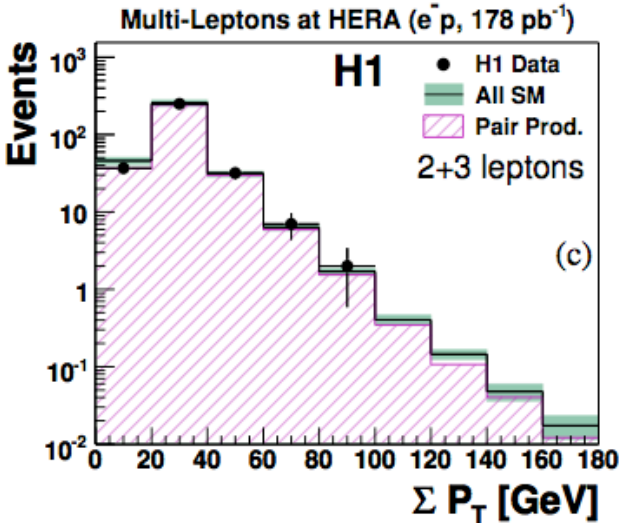
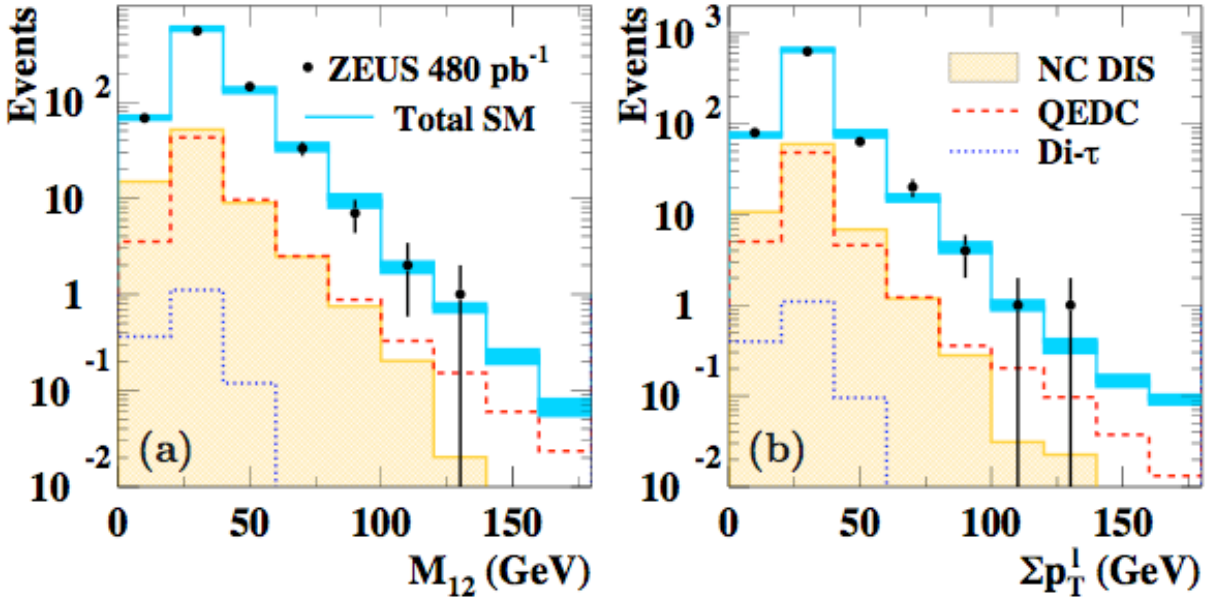




Multi-Leptons: ZEUS Published Results

submitted to Phys. Lett. B, arXiv:0906.1504 [hep-ex]



ZEUS ($\mathcal{L} = 480\,\mathrm{pb}^{-1}$)

Topology, $M_{12} > 100$ GeV	Data	Total SM	Multi-lepton Production	NC DIS	Compton
ee	1	1.7 ± 0.2	0.9 ± 0.1	0.2 ± 0.1	0.6 ± 0.1
$\mu\mu$	0	0.4 ± 0.1	0.4 ± 0.1	< 0.01	–
$e\mu$	0	$0.06^{+0.03}_{-0.01}$	0.05 ± 0.02	< 0.02	–
eee	2	0.7 ± 0.1	0.7 ± 0.1	< 0.01	< 0.02
$e\mu\mu$	0	0.18 ± 0.05	0.18 ± 0.05	< 0.01	–

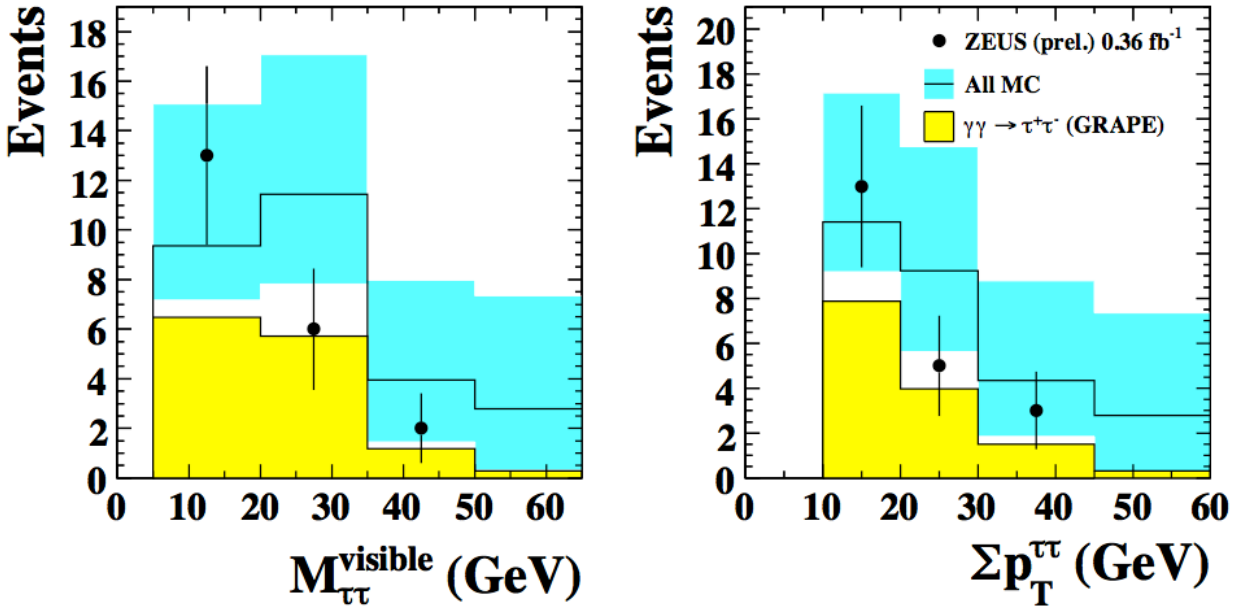
Multi-Leptons: ZEUS Multi-Tau Analysis

ZEUS-prel-08-009

ZEUS ditau events HERA II data (L=0.36 fb^{-1})

Topology	All	jet-jet	e-jet-jet	e-jet	e-e-jet
D cut		0.80	0.50	0.90	0.90
Data	21	14	3	4	0
Total SM	$27.2^{+7.1}_{-6.3}$	$20.2^{+6.8}_{-5.7}$	$1.4^{+3.3}_{-0.2}$	$4.9^{+3.1}_{-1.3}$	$0.7^{+4.4}_{-0.1}$
ditau MC	$13.2^{+0.6}_{-1.0}$	$9.1^{+0.4}_{-0.8}$	1.4 ± 0.1	2.2 ± 0.1	0.5 ± 0.1
(purity)	(49%)	(45%)	(97%)	(46%)	(74%)

- Analysis uses HERA II data
- Topologies with jets and electrons investigated



Isolated Leptons: ZEUS Published Results

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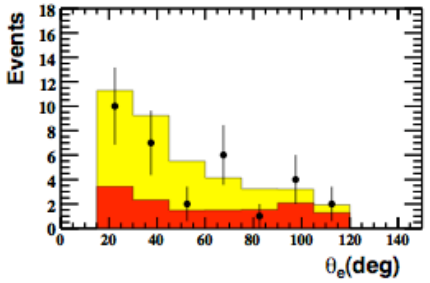
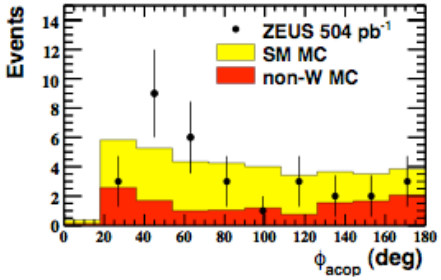
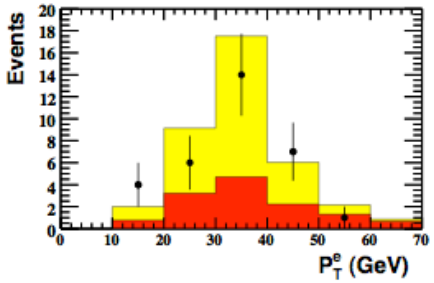
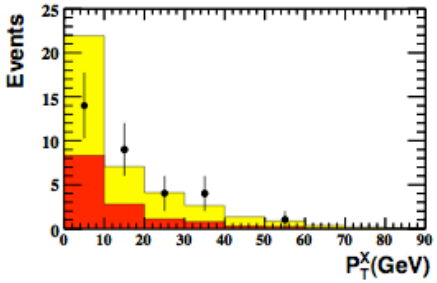
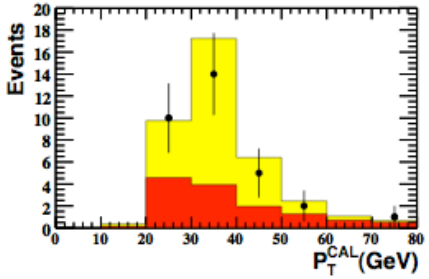
electron channel

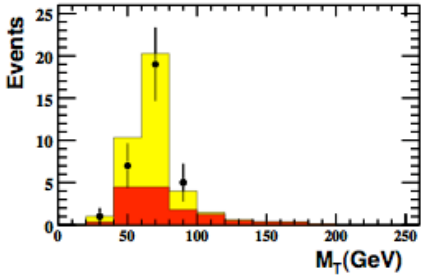




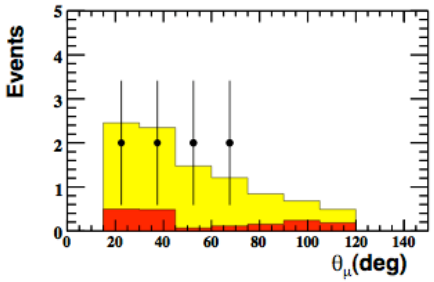


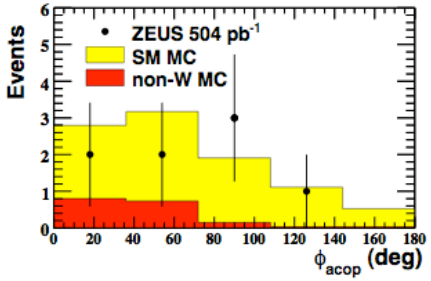


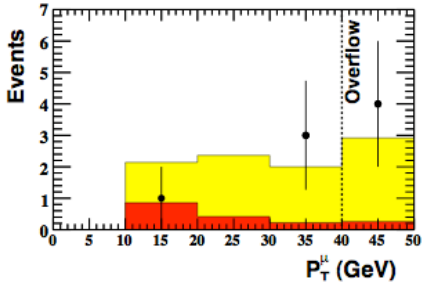


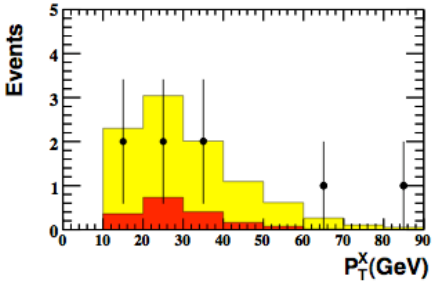


muon channel









Isolated Lepton Candidates	$P_T^X < 12$ GeV	$12 < P_T^X < 25$ GeV	$P_T^X > 25$ GeV
e^-p 208 pb^{-1}	$9/11.3 \pm 1.5$ (54%)	$6/5.1 \pm 0.7$ (67%)	$5/5.5 \pm 0.8$ (75%)
e^+p 296 pb^{-1}	$7/12.6 \pm 1.7$ (68%)	$7/6.2 \pm 0.9$ (75%)	$6/7.4 \pm 1.0$ (79%)
$e^\pm p$ 504 pb^{-1}	$16/23.9 \pm 3.1$ (61%)	$13/11.2 \pm 1.5$ (71%)	$11/12.9 \pm 1.7$ (77%)

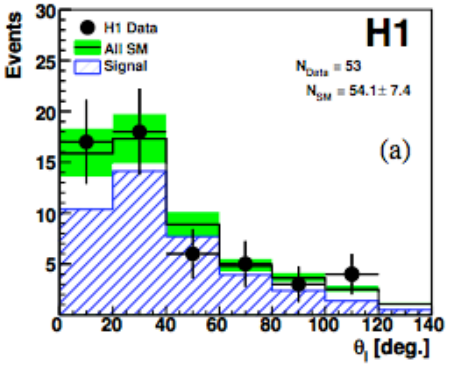
$$\sigma_{ep\to lWX} = 0.89^{+0.25}_{-0.22}\,(\text{stat.}) \pm 0.10(\text{syst.})\,\text{pb}$$

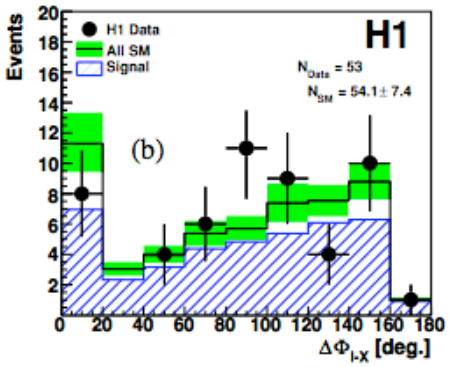
SM cross section: 1.2 pb

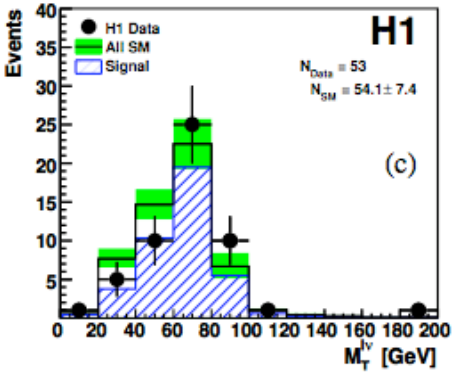
e^-p (208 pb^{-1})	20 / 21.8 ± 2.7
e^+p (296 pb^{-1})	20 / 26.2 ± 3.2
$e^\pm p$ (504 pb^{-1})	40 / 48.0 ± 5.9

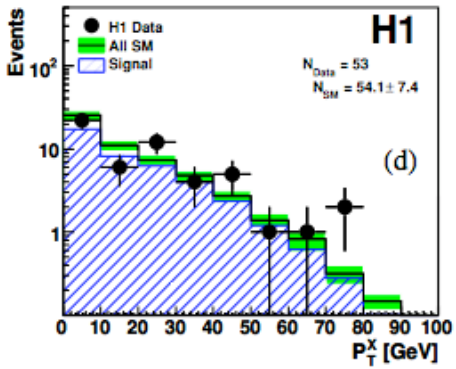
Isolated Leptons: H1 Published Results

submitted to Eur. Phys. J. C, arXiv:0901.0488 [hep-ex]









Main difference to combined H1+ZEUS analysis: extended polar angle range down to **5°**

H1	1994-2007 $e^{\pm}p$ 474 pb^{-1}	Data	SM Expectation	SM Signal	Other SM Processes
Electron	Total	39	43.1 ± 6.0	30.3 ± 4.8	12.9 ± 3.4
	$P_T^X > 25$ GeV	10	7.5 ± 1.3	5.79 ± 0.99	1.71 ± 0.71
Muon	Total	14	11.0 ± 1.8	10.1 ± 1.7	0.88 ± 0.29
	$P_T^X > 25$ GeV	8	6.1 ± 1.0	5.64 ± 0.99	0.47 ± 0.15
Combined	Total	53	54.1 ± 7.4	40.4 ± 6.3	13.7 ± 3.5
	$P_T^X > 25$ GeV	18	13.6 ± 2.2	11.4 ± 1.9	2.18 ± 0.80

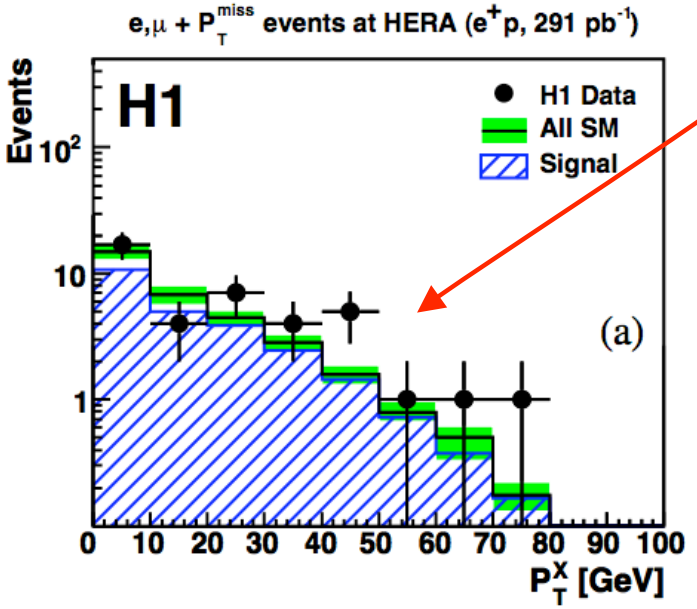
$$\sigma_W = 1.14 \pm 0.25\ (\text{stat.}) \pm 0.14\ (\text{sys.})\ \text{pb}$$

SM cross section: 1.27 ± 0.19 pb

Isolated Leptons: H1 Published Results: e^+p Data

H1	1994-2007 e^+p 291 pb^{-1}	Data	SM Expectation	SM Signal	Other SM Processes
Electron	Total	28	25.6 ± 3.5	18.6 ± 2.9	6.9 ± 1.7
	$P_T^X > 25$ GeV	9	4.32 ± 0.71	3.56 ± 0.61	0.76 ± 0.32
Muon	Total	12	6.7 ± 1.1	6.2 ± 1.0	0.55 ± 0.18
	$P_T^X > 25$ GeV	8	3.70 ± 0.63	3.42 ± 0.60	0.28 ± 0.09
Combined	Total	40	32.3 ± 4.4	24.8 ± 3.9	7.5 ± 1.8
	$P_T^X > 25$ GeV	17	8.0 ± 1.3	7.0 ± 1.2	1.04 ± 0.37

submitted to Eur. Phys. J. C, arXiv:0901.0488 [hep-ex]



H1 Isolated Leptons: Tau Channel

submitted to Eur. Phys. J. C, arXiv:0901.0488 [hep-ex]

- Look for hadronic 1-prong tau decays in events with P_T^{Miss}
- Topology is challenging, unlike electron and muon channels the SM expectation is dominated by background (mainly CC)

H1	Tau Channel	Data	SM Expectation	SM Signal	Other SM Processes
1994-2007 e^+p	Total	9	12.3 ± 2.0	1.66 ± 0.25	10.6 ± 1.8
291 pb^{-1}	$P_T^X > 25$ GeV	0	0.82 ± 0.12	0.38 ± 0.06	0.44 ± 0.06
1999-2006 e^-p	Total	9	11.0 ± 1.9	1.00 ± 0.15	10.0 ± 1.8
183 pb^{-1}	$P_T^X > 25$ GeV	1	0.68 ± 0.11	0.21 ± 0.03	0.47 ± 0.07
1994-2007 $e^\pm p$	Total	18	23.2 ± 3.8	2.66 ± 0.40	20.6 ± 3.4
474 pb^{-1}	$P_T^X > 25$ GeV	1	1.50 ± 0.21	0.59 ± 0.09	0.91 ± 0.12

H1 Isolated Leptons: Tau Channel

submitted to Eur. Phys. J. C, arXiv:0901.0488 [hep-ex]