Study of Rare Exclusive EW Processes at HERA

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On behalf of

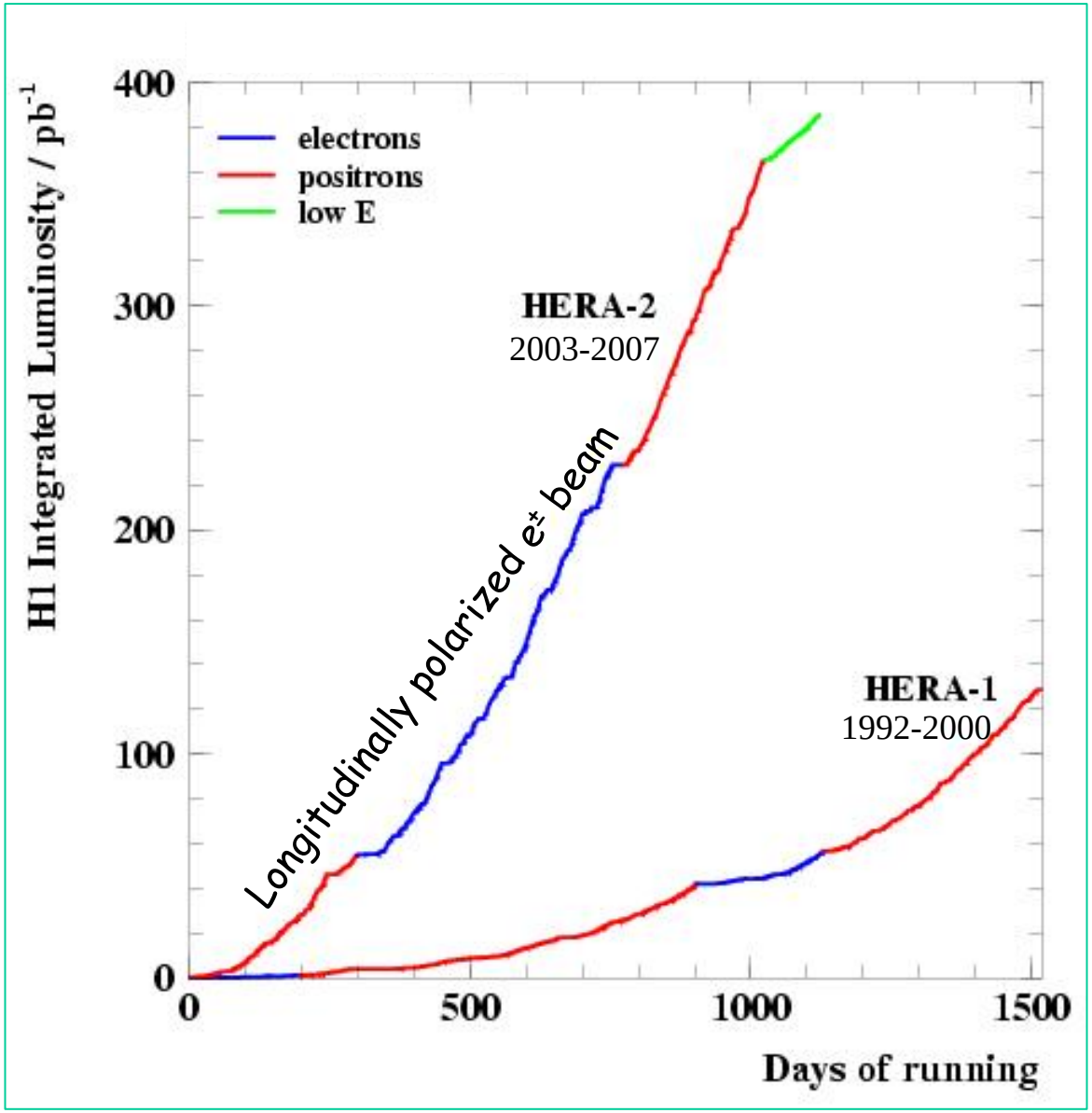
OUTLINE

- Introduction
- 1 Multi-lepton events at high P_T
- 2 Isolated lepton events with large missing P_T
- 3 Single W production
- Summary

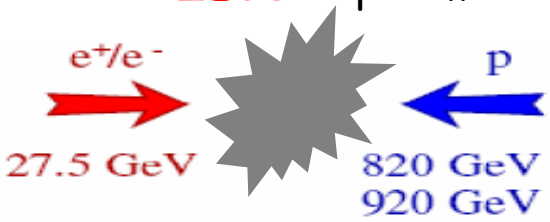
Covered abstracts: 100, 101, 823, 824 825, 831, 626 and 627

ZEUS H1 H1 & ZEUS

Introduction: HERA-1+2 Data Sample



Unique **ep collider** for
H1 and **ZEUS** experiments



➔ $\sqrt{s}$=300, 318 GeV

	HERA-1	HERA-2
e-	~20pb^{-1}	~200pb^{-1}
e+	~100pb^{-1}	~200pb^{-1}

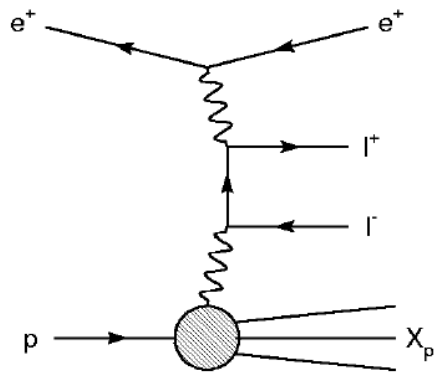
➔ H1/ZEUS: 0.5fb^{-1}/exp

➔ H1+ZEUS: ~1fb^{-1}

Study rare SM or new exotic processes with cross-sections down to 1pb

1. Multi-Lepton Events @ High P_T

- **Excess reported in 2003 by H1 in 2e, 3e modes**
  (H1 Collab., Eur. Phys. J. C31 (2003) 17)



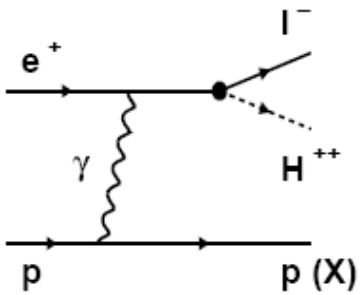
- **Dominant SM processes:**

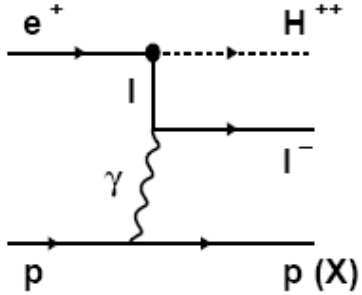
  Signal (Grape): $\gamma\gamma \rightarrow ll$ ($l=e,\mu,\tau$)

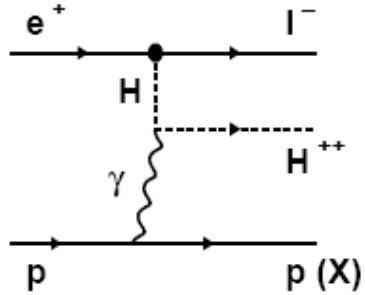
  Background: NC DIS, QED Compton

- **Sensitive to new phenomena at large invariant masses**

  (e.g. Doubly-charged Higgs boson $H^{++} \rightarrow e^+l^+$):



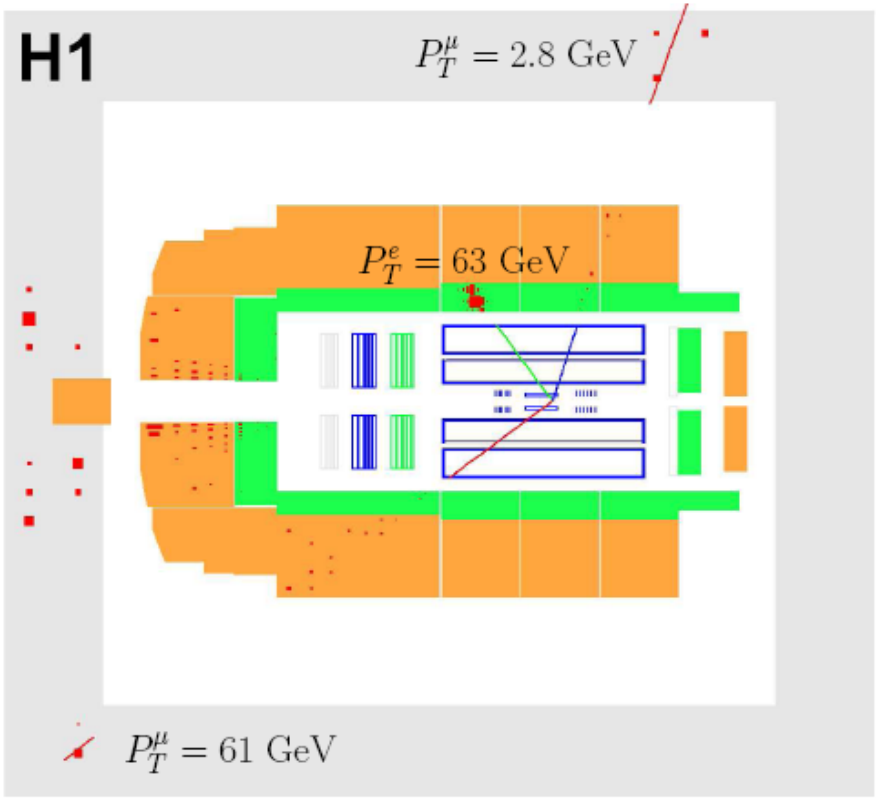


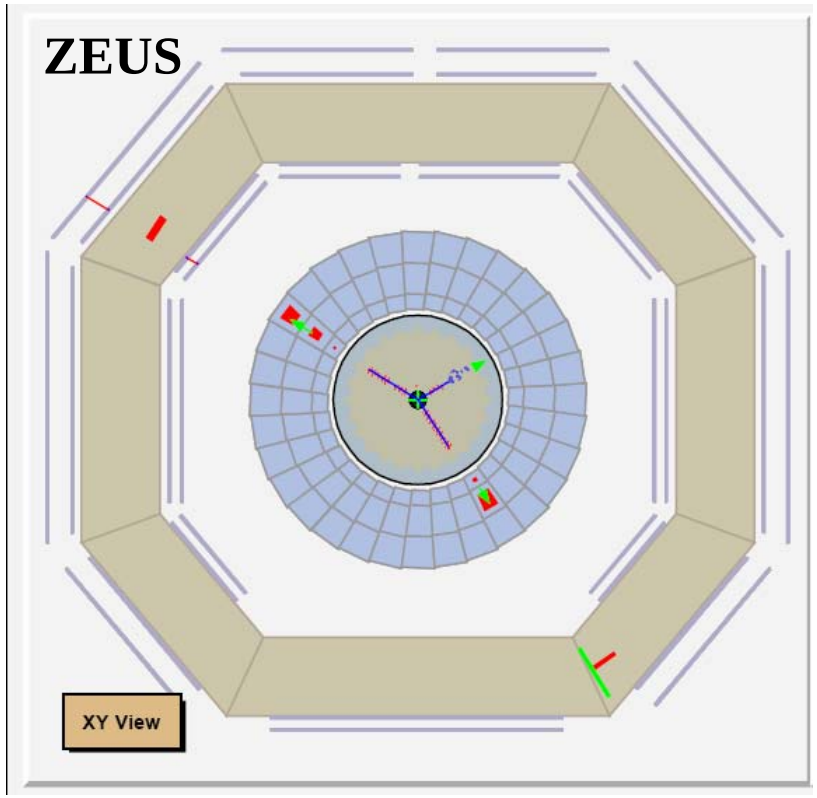


1. Two Examples of Observed Events

Model independent analysis with main selection cuts:

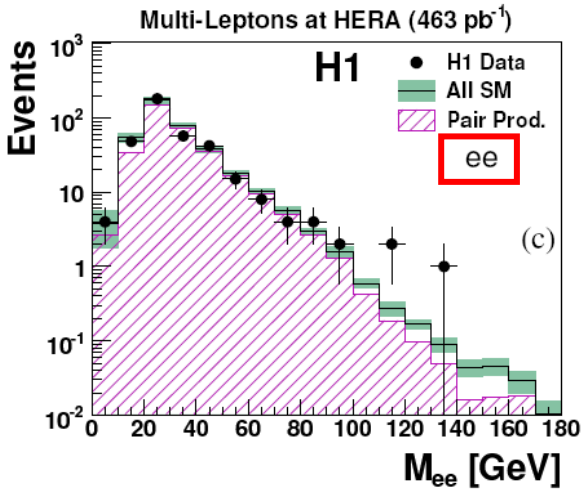
- at least two leptons (e,μ): $20^o<\theta<150^o$, $P_{T1}>10GeV$, $P_{T2}>5GeV$
- additional e: $5^o<\theta<175^o$, $P_T>5GeV$
- additional μ: $20^o<\theta<160^o$, $P_T>2GeV$

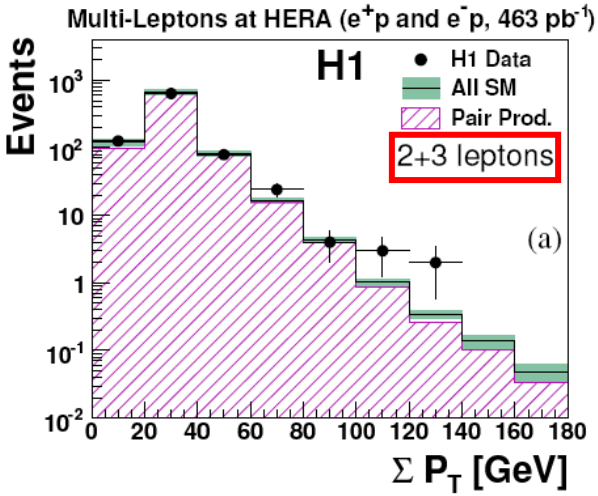




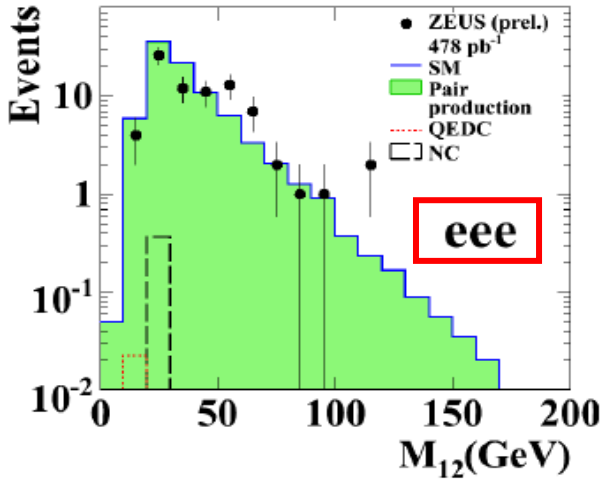
1. Mass and P_T Distributions

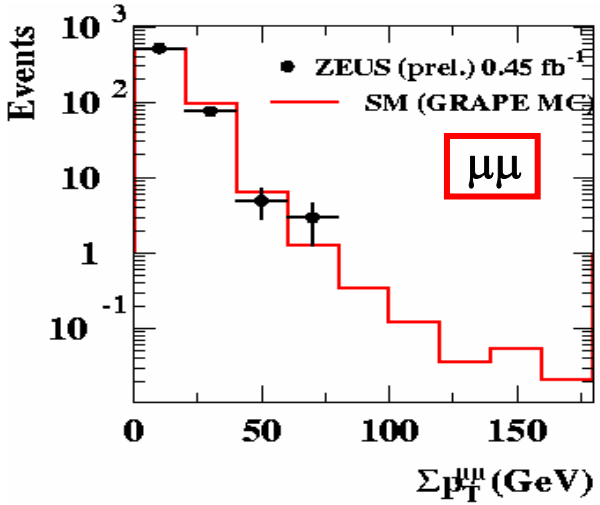
H1 publication (arxiv:0806.3987 [hep-ex])
covers ee, μμ, eμ, eee, eμμ, eeμ, eeee





ZEUS preliminary covers ee, eee, (e)μμ





1. Event Yields at High Mass and P_T

- At high mass (M_{ll} > 100 GeV):

Topology	H1 publication		ZEUS preliminary	
	Data	SM (pair)	Data	SM (pair)
ee	3	1.34±0.20 (0.83)	2	1.7±0.2 (0.9)
eμ	1	0.59±0.06 (0.59)		
eee	3	0.66±0.09 (0.66)	2	1.0±0.1 (1.0)
μμ	1	0.17±0.07 (0.17)		
eμμ	2	0.16±0.05 (0.16)		

- At high P_T (scalar sum >100 GeV):

Data set	H1 publication	
	Data	SM (pair)
e^+p	5	0.96±0.12 (0.78)
e^-p	0	0.64±0.09 (0.51)
All	5	1.60±0.20 (1.29)

➔ H1 excess observed only in e+ data sample

H1+ZEUS combination being performed

1. Cross Section Measurement

H1 phase space:

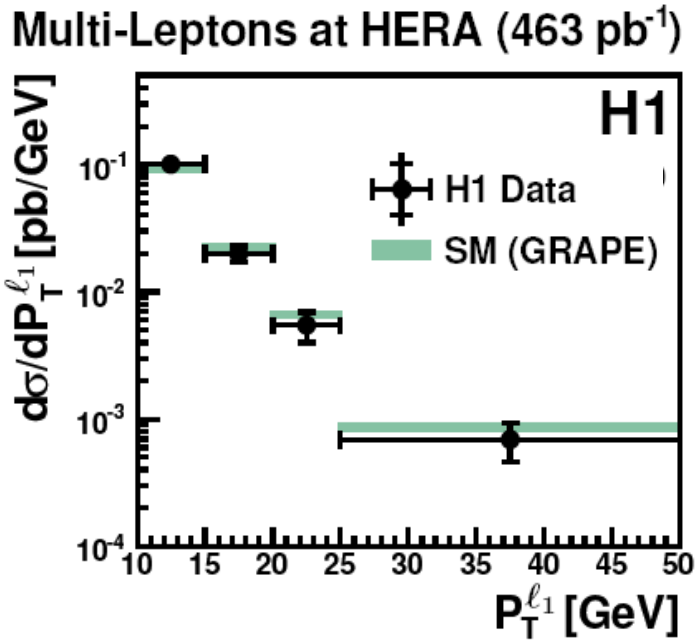
$e\,p \to e\,\ell^+\ell^-\,X$

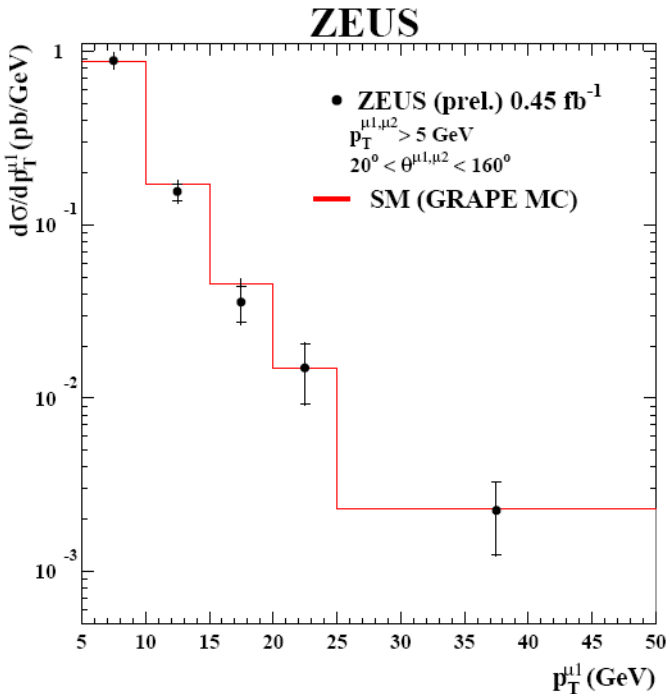
$P_T^{\ell_1} > 10$ GeV, $P_T^{\ell_2} > 5$ GeV

$20^\circ < \theta^{\ell_1,\ell_2} < 150^\circ$

$y < 0.82$, $Q^2 < 1$ GeV^2

Whereas H1 is the averaged cross section for e and mu samples, ZEUS is for di-mu sample only

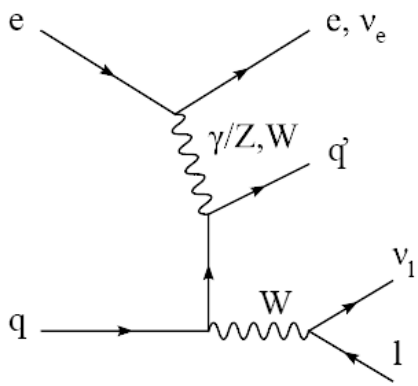




➔ Steeply falling cross section in agreement with the expectation

2. Isolated Lepton Events with Large Missing P_T

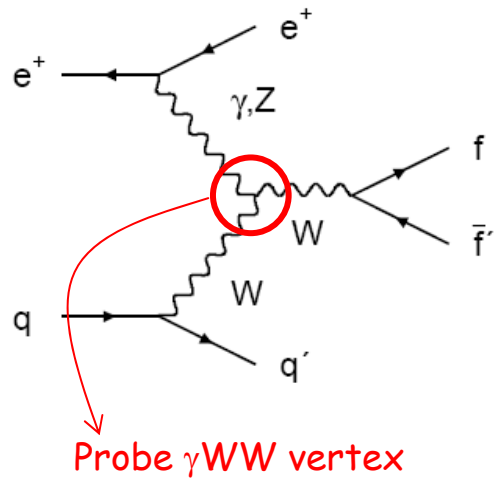
- **1st excess seen by H1 & published in 1998**
  (H1 Collab., Eur. Phys. J. C5 (98) 575)



- **Main SM processes:**

  Signal (Epvec): γp production
  NLO correction has 15% uncertainty

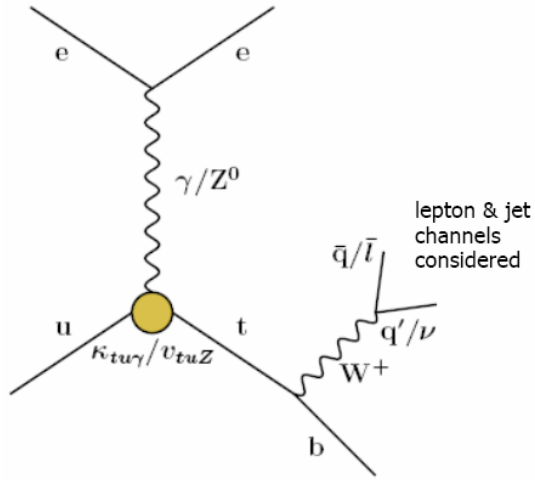
  Background: NC, CC DIS
  pair production
  $\gamma p \rightarrow X$



- **Exotic models:**

  e.g. single top production via
  Flavor Changing Neutral Current

  $k_{tu\gamma}$: anomalous γ magnetic coupling
  v_{tuZ}: anomalous Z vector coupling

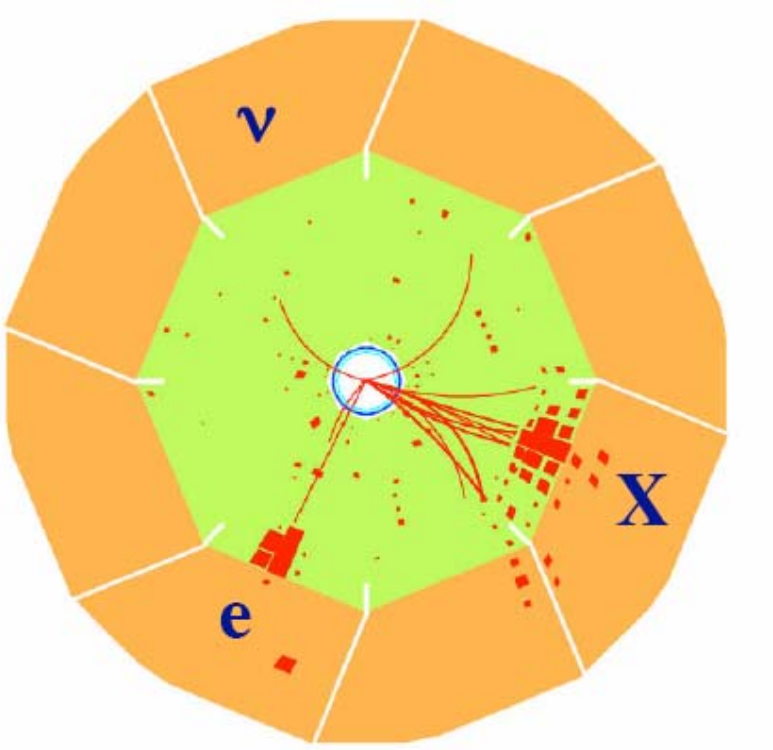


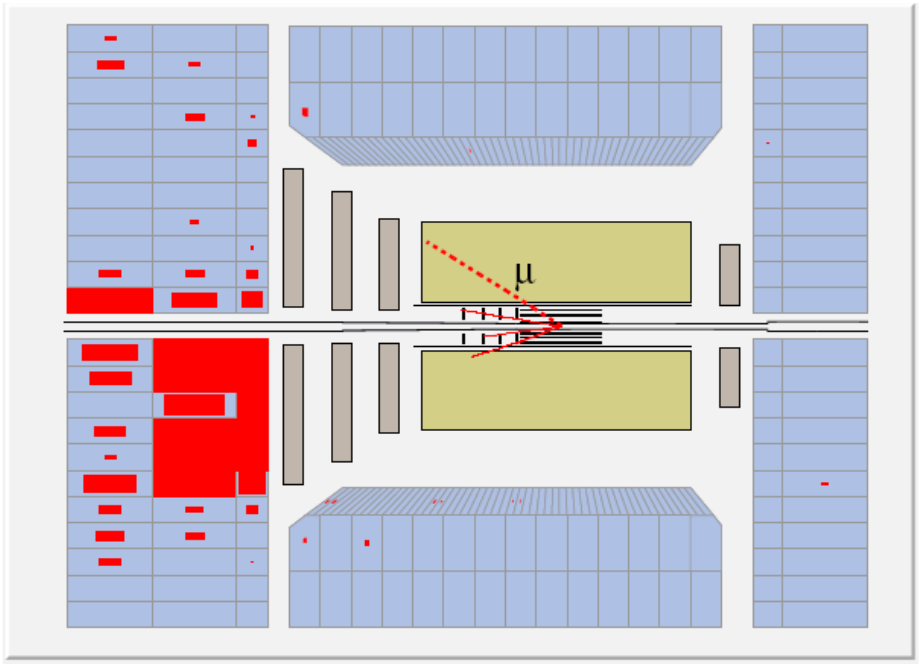
2. Two Examples of Observed Events

Model independent analysis (e,μ phase space cuts):

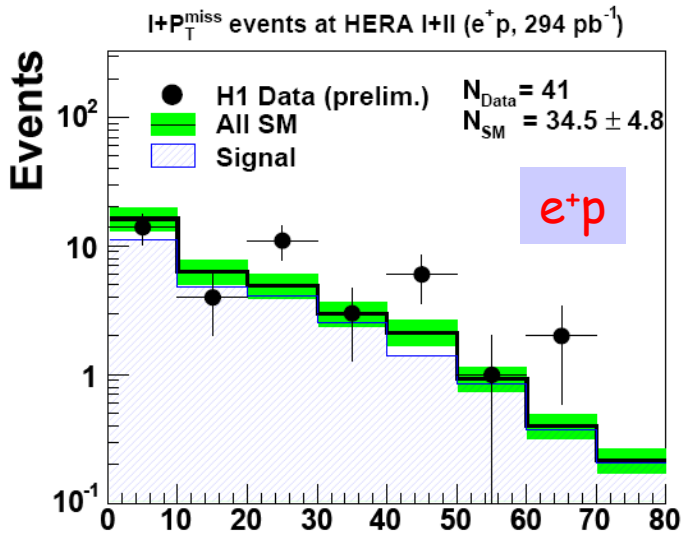
H1: $5^o<\theta_l<140^o$, $P_{Tl}>10GeV$
$P_{Tcalo}>12GeV$, $P_{TX}>12GeV$

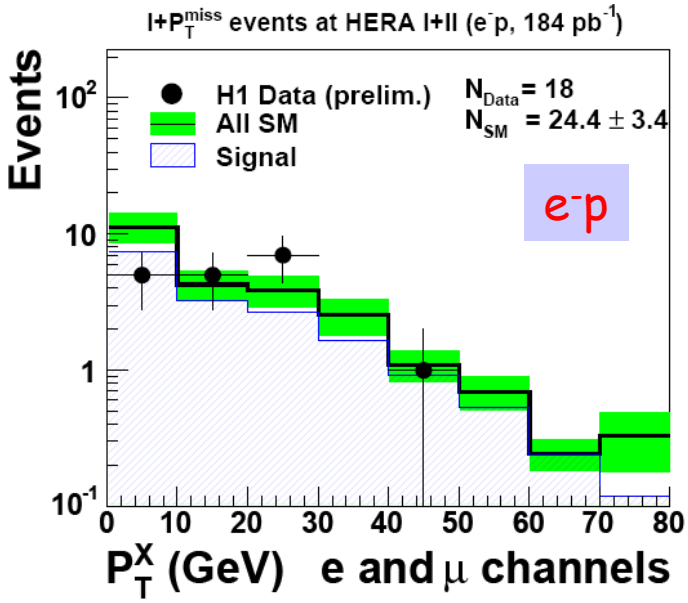
ZEUS: $15^o<\theta_l<120^o$, $P_{Tl}>10GeV$
$P_{Tcalo}>12GeV$, $P_{TX}>12GeV$



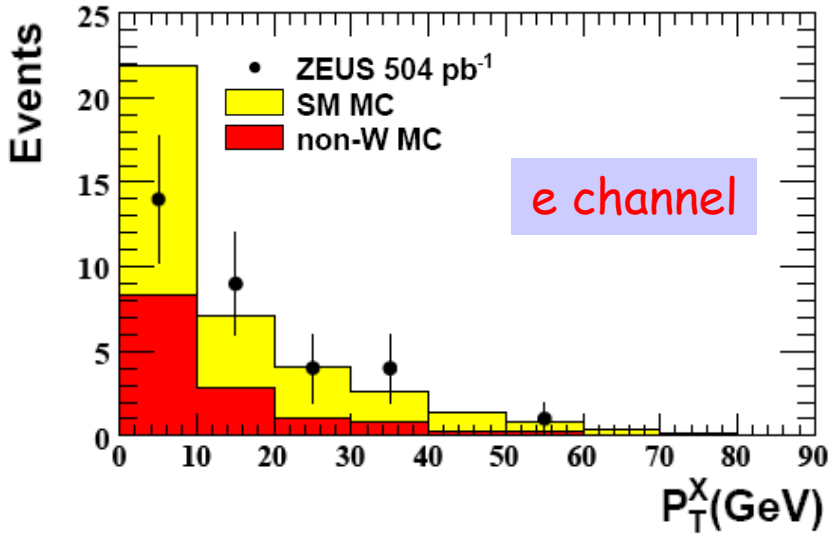


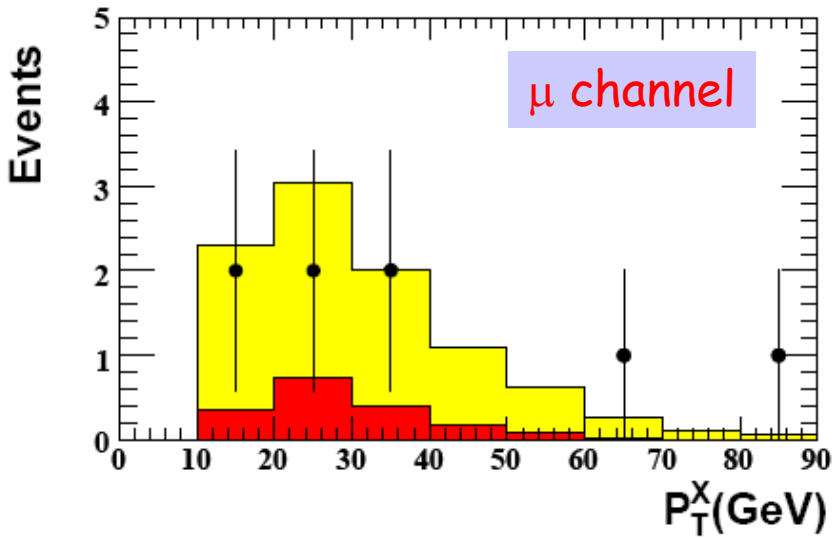
2. Missing P_{TX} Distributions





ZEUS publication (arxiv: 0807.589)





2. Event Yields and Cross Section

- Event yields at high P_{TX} (> 25 GeV):

Data set	Channel	H1 preliminary		ZEUS publication	
		Data	Exp (signal)	Data	Exp (signal)
e^+p	e	11	4.7±0.9 (75%)	3	4.0±0.6 (77%)
	μ	10	4.2±0.7 (85%)	3	3.4±0.5 (81%)
	τ	0	0.5±0.1 (72%)		
e^-p	e	3	3.8±0.6 (61%)	3	3.2±0.5 (69%)
	μ	0	3.1±0.5 (74%)	2	2.3±0.4 (85%)
	τ	1	1.0±0.1 (63%)		

- Cross section at high P_T ($5^o<\theta_l<140^o$, P_{Tl} > 10 GeV and P_{Tmiss}>12GeV):

H1 preliminary: $\sigma_{l+PTmiss}$ = 0.24 ± 0.05 (stat) ± 0.05 (syst) [pb]

SM expectation: 0.26 ± 0.04 [pb]

3. W Production Cross Section

The isolated lepton with large missing P_T is dominated by SM W production

➔ This same sample is used to measure the W production cross section

ZEUS:

$\sigma_{ep\to lWX} = 0.89^{+0.25}_{-0.22}$ (stat) ± 0.10 (syst) [pb] @ $\sqrt{s}$=316 GeV

H1 (preliminary):

$\sigma_{ep\to lWX}$ = 1.23 ± 0.25 (stat) ± 0.22 (syst) [pb] @ $\sqrt{s}$=320 GeV

In agreement with the SM expectation:

$\sigma_{ep\to lWx}$ = 1.2 ± 0.2 [pb] @ $\sqrt{s}$=316 GeV
= 1.3 ± 0.2 [pb] @ $\sqrt{s}$=320 GeV

➔ Both measurements have a significance of ~5 standard deviations

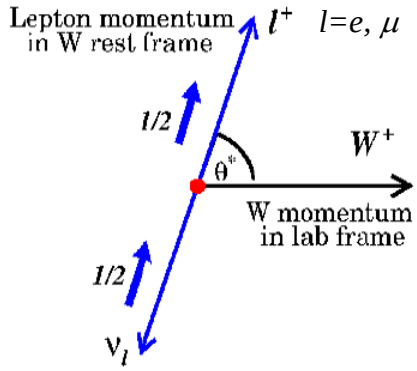
3. W Polarization Fractions @ HERA

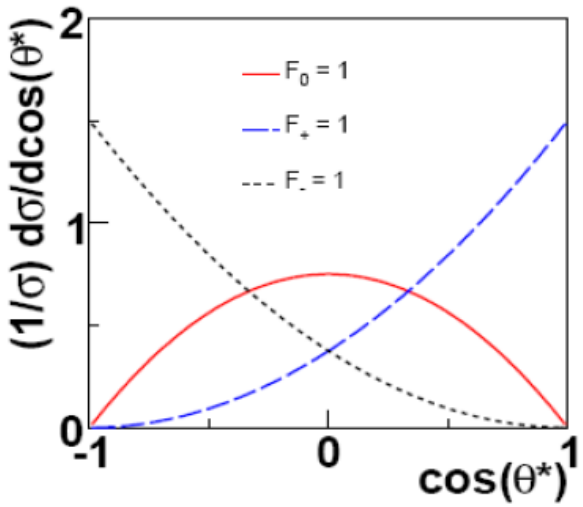
Restricted to the isolated lepton sample in which a W is reconstructed

Angular distribution and polarization fractions:

$$\frac{dN}{d\cos\theta^*} = F_- \frac{3}{8}\left(1-\cos\theta^*\right)^2 + F_0 \frac{3}{4}\sin^2\theta^* + F_+ \left(1+\cos\theta^*\right)^2$$

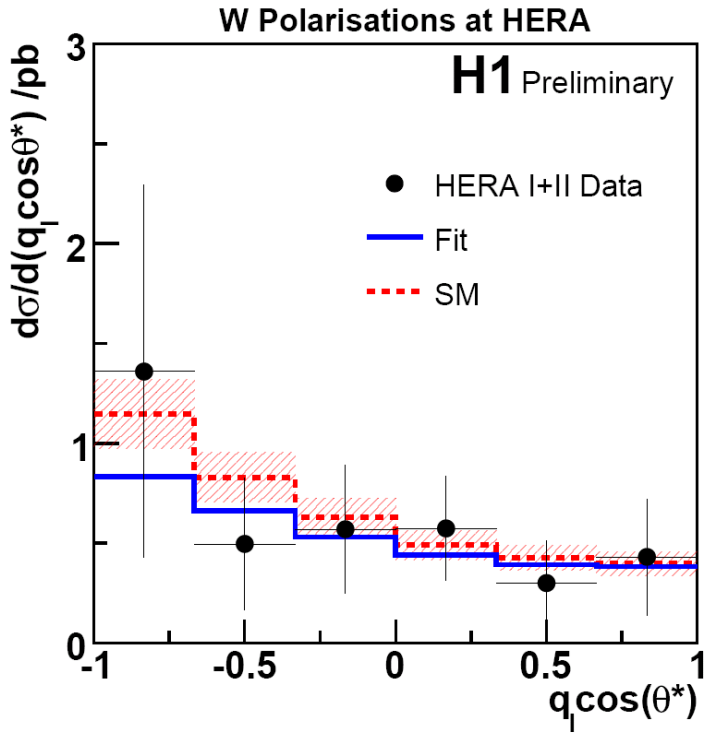
left longitudinal right $F_+ = 1 - F_- - F_0$





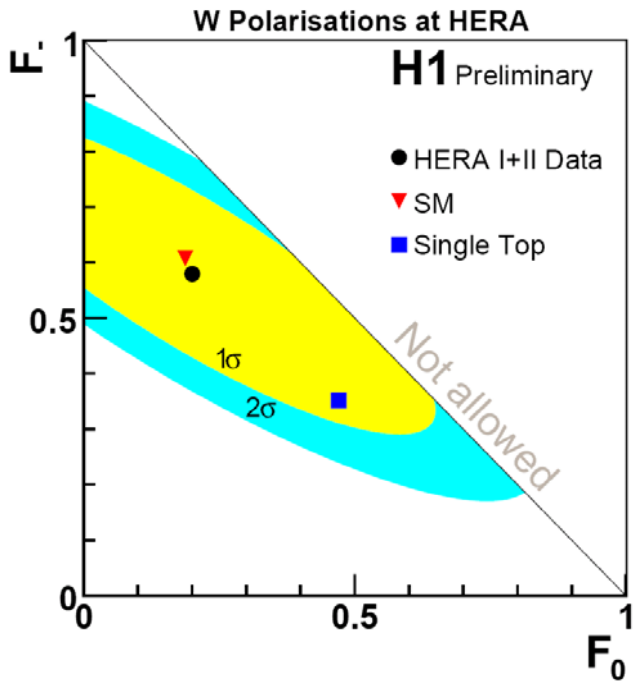
➔ Three components
left ($F_-=1$)
right ($F_+=1$)
longitudinal ($F_0=1$)
have well distinct distributions

3. W Polarization Fractions @ HERA



One parameter fit

Two parameter fit



Fraction	H1 result	SM
F_0	$0.15 \pm 0.21_{stat} \pm 0.09_{sys}$	$0.19 \pm 0.01_{stat}$
F_-	$0.58 \pm 0.15_{stat} \pm 0.12_{sys}$	$0.61 \pm 0.01_{stat}$

Summary

- Full HERA 1+2 data analyzed
- H1+ZEUS combinations are/being performed
- In all results, general agreement between data and the SM, some interesting excess at high mass/P_T observed

More information is available at H1 and ZEUS working group web page:

http://www.desy.de/h1zeus/exotics/index.html