DESY Seminar

Tuesday August 29 2000

W Production at H1

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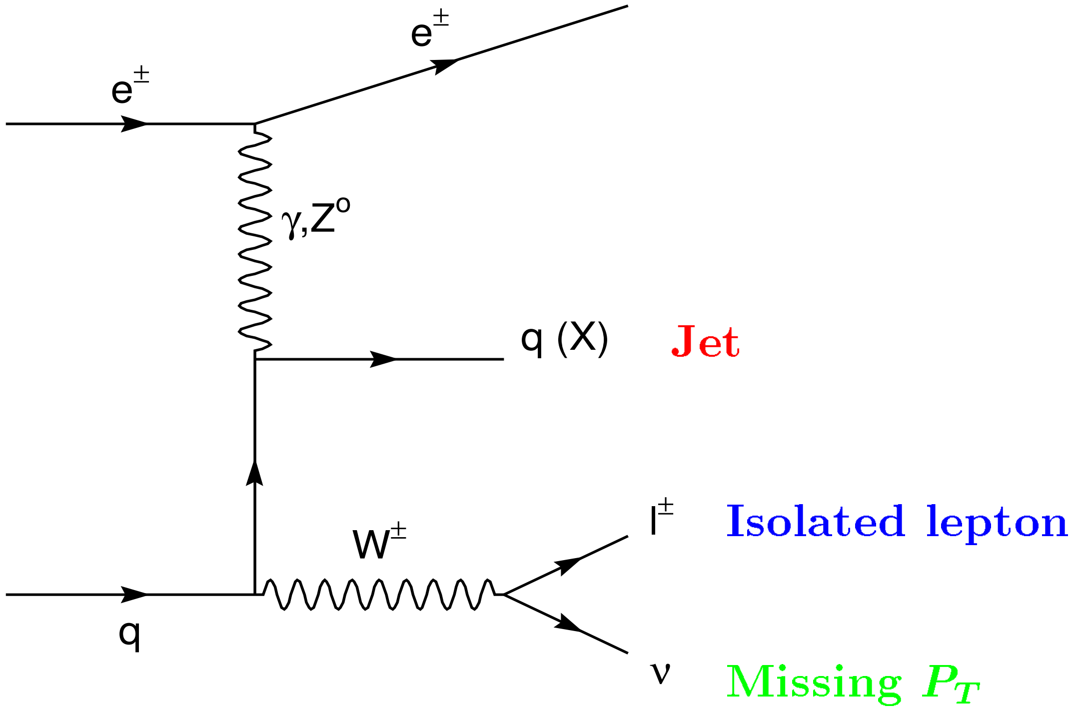
- Introduction
- 1994-1997 published W search reminder
- Selection cuts
- Control of backgrounds
- Latest e^+p results from 1999/2000 data
- Summary

Introduction(1)

The **H1** and **ZEUS** detectors at the HERA ep collider have now each recorded $\approx 100pb^{-1}$ of data

$\rightarrow$ Sensitivity to **rare** SM physics processes
e.g. W production :

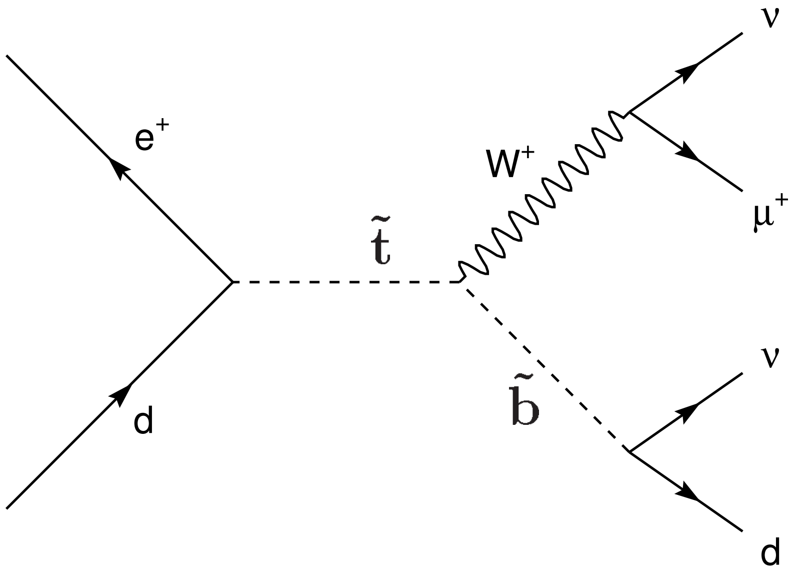


Standard Model (EPVEC – QCD LO) predicts
$\sigma(ep \rightarrow eW^{\pm}X) \approx$ 1pb

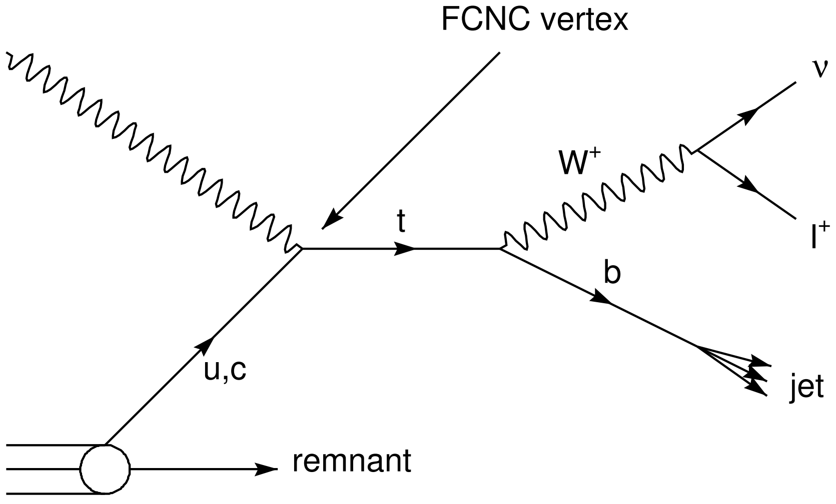
Uncertainties on proton/photon structure functions and QCD scale
give $\approx 30\%$ uncertainty on cross section

Introduction(2)

Beyond the Standard Model, W production is background to other processes with a jet, an isolated lepton and missing P_T
e.g. anomalous $WW\gamma$ couplings, compositeness, R_p violating SUSY:



or anomalous single top production

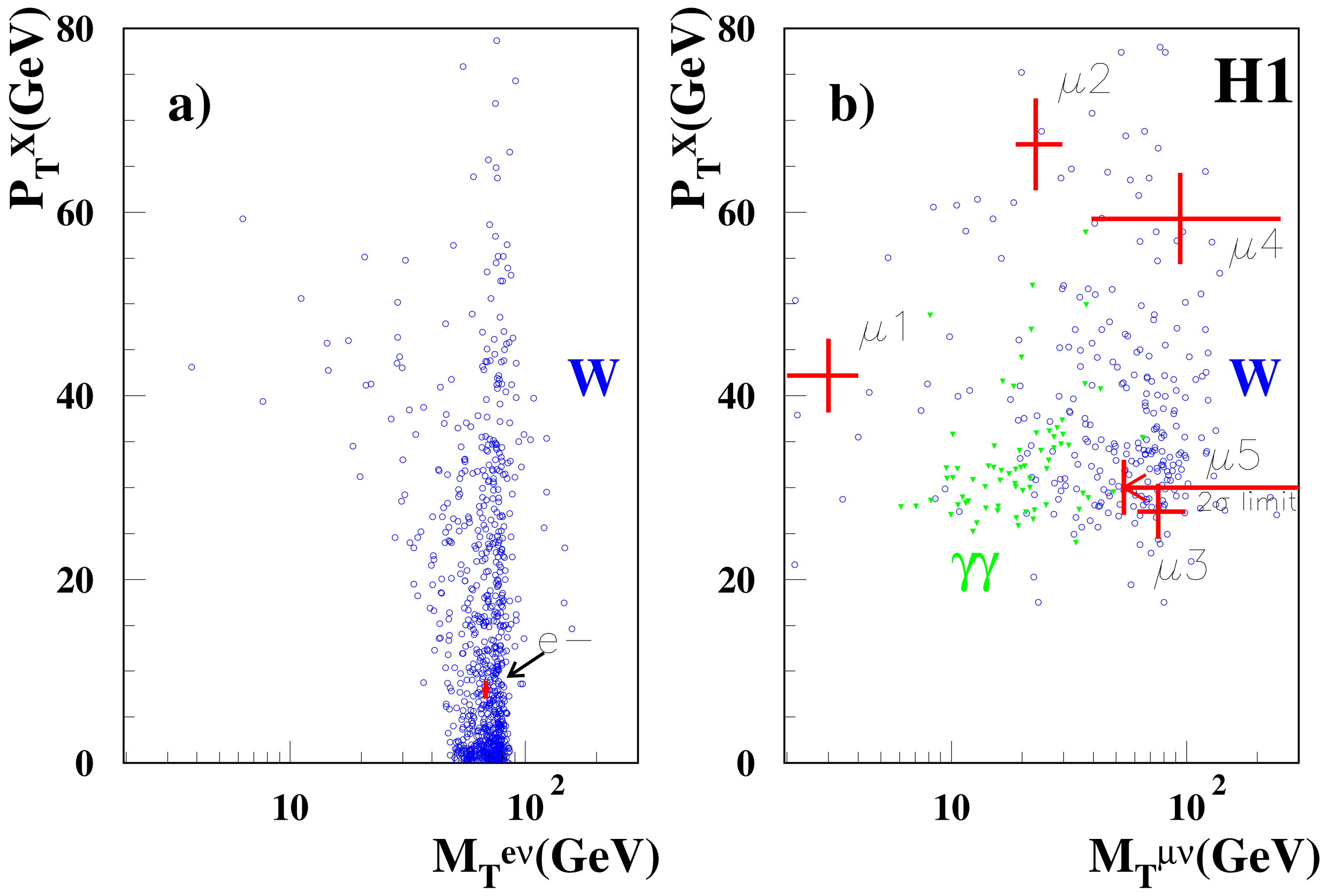


An important process for searches

H1 published 94-97 e^+p data

Searches for Ws and Events with Isolated leptons with Missing P_T

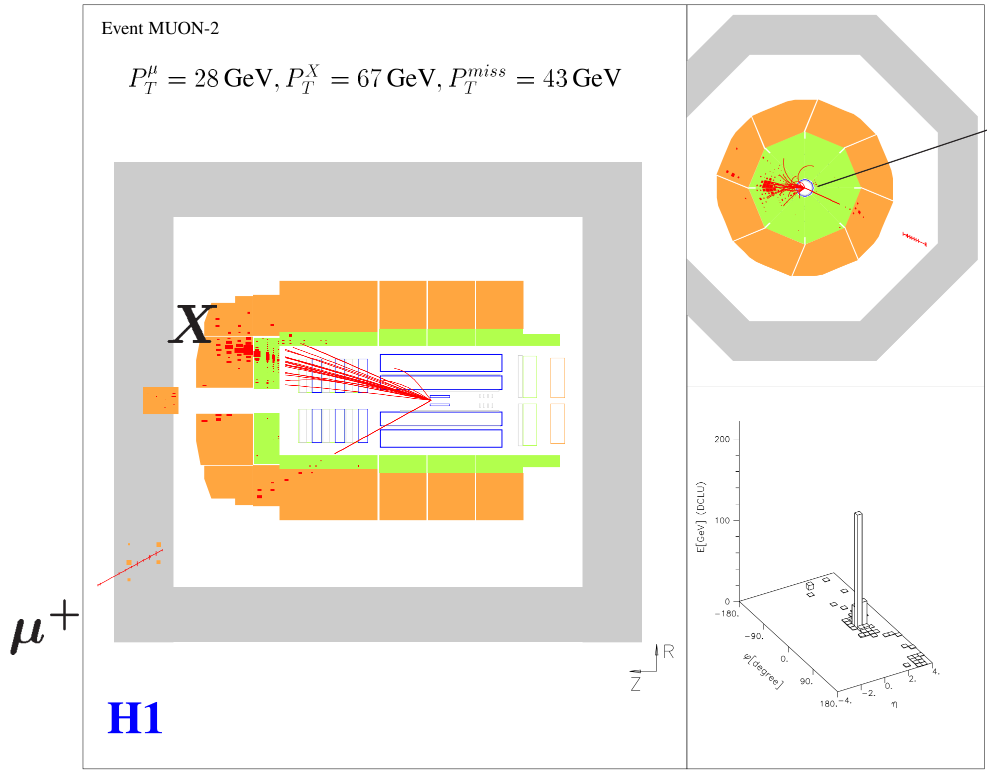
Data lumi= 36.5 pb^{-1} MC lumi = 500 x data



$1\ e^-$ cf 2.4 ± 0.5 SM
$5\ \mu^{\pm}$ cf 0.8 ± 0.2 SM

Events seen at very high P_T^X where SM is low

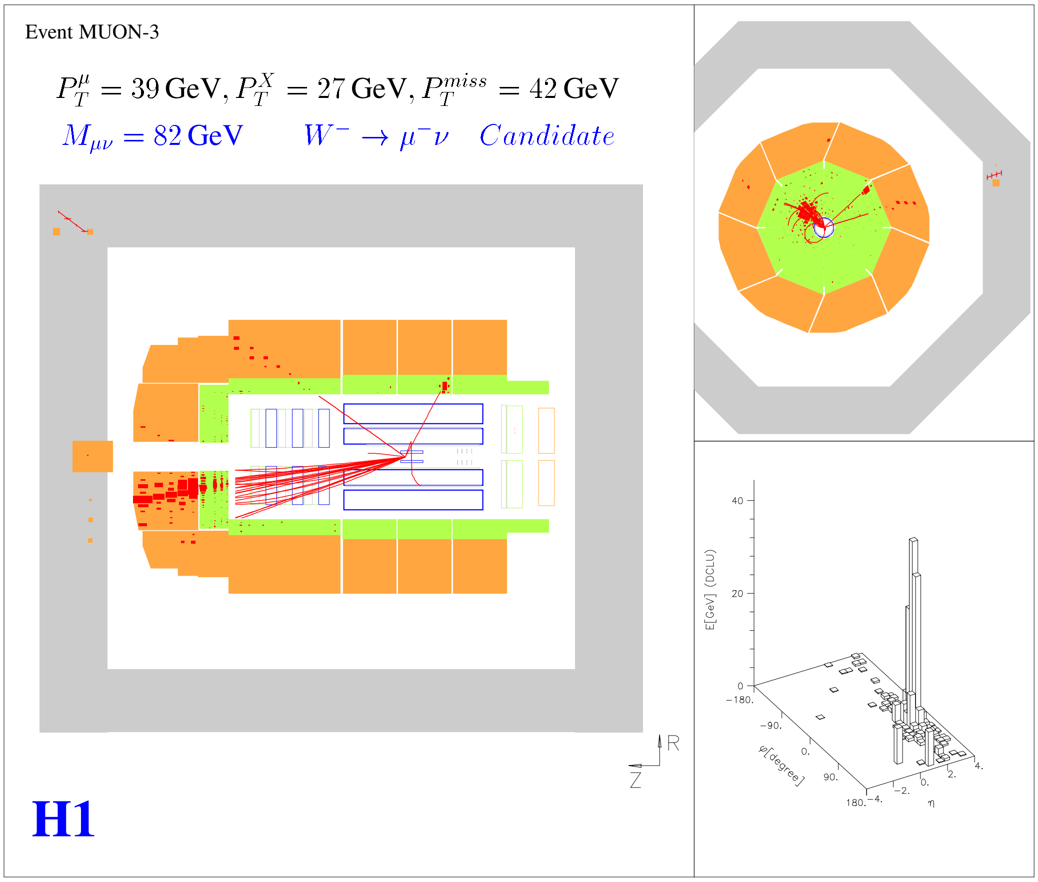
H1 94-97 result : 2 Example Events



P_T^{miss}=43 GeV

P_T^μ=28 GeV

P_T^X=67 GeV
(Hadronic Jet)



Tagged Scattered
Positron ⇒

$M_{\mu\nu}$=82 GeV

P_T^X=27 GeV
(Hadronic Jet)

W Event Selection -Discriminating Variables

P_T^l	–	Trans. mom. of lepton
P_T^{miss}	–	Trans. mom.of unseen particles
P_T^{Calo}	–	Trans. mom. from calorimeter
P_T^X	–	Trans. mom. of hadronic system
		Distance in η–ϕ space
D_{jet}	–	to nearest jet
D_{track}	–	to nearest track
ζ^2	–	$= Q^2$ for NC events
$\Delta\phi_{l-X}$	–	Lepton-Hadrons acoplanarity
δ_{miss}	–	$= 2E_e$-$(E - P_Z)_{\mathrm{total}}$
$\frac{V_{ap}}{V_p}$	–	Ratio of anti-parallel to parallel final state particle momentum components wrt to vector of P_T^{miss}

Cuts use missing particle detection
+ isolated lepon id to tag W events
Designed to give good background rejection
+ reasonable W efficiency $\longrightarrow$

W Event Selection - The Cuts

Selection requirements common to both decay channels :

Variable	Requirement
P_T^l	> 10 GeV
θ_l	$5^o < \theta_l < 145^o$
P_T^{Calo}	> 12 GeV
D_{jet}	> 1.0
P_T^{miss}	> 12 GeV

Selection requirements specific to each decay channel :

Variable	Electron	Muon
ζ^2	> 500 GeV^2 > 5000 GeV^2 for P_T^{Cal} <25 GeV	- -
$\frac{V_{ap}}{V_p}$	< 0.5 (< 0.15 for $P_T^e < 25$ GeV)	< 0.4 (< 0.15 for P_T^{Cal} <25 GeV)
D_{track}	> 0.5 for $\theta_e \geq 45^o$ > 0.5 for $\frac{E_{cone}}{E^l} > 0.05$	> 0.5
$\Delta\phi_{l-X}$	$> 20^o$	$> 10^o$ for ≤ 2 ctrl tracks
# iso. μ	0	1
δ_{miss}	> 5 GeV $^+$	-

$^+$ if only one e candidate is detected, which has the same charge as the beam lepton.

+ μ channel restricted to $P_T^X > 12$ GeV due to trigger

Selection efficiencies for SM W production

	Efficiency	
	e	μ
$P_T^X > 0$ GeV	0.44	0.15
$P_T^X > 12$ GeV	0.40	0.39
$P_T^X > 25$ GeV	0.39	0.49
$P_T^X > 40$ GeV	0.39	0.53

- No efficiency for $P_T^X < 12$ GeV in μ channel
- Similar efficiencies in e and μ channels for $P_T^X > 12$ GeV

SM Background Proceses to W production

- Charged Current (CC) $(ep \rightarrow \nu X)$ - Events have large P_T^{miss}. Can fake W if FSR photon or hadronic final state particle fakes lepton.

- Neutral Current (NC) $(ep \rightarrow eX)$ - Only produces $W \rightarrow e\nu$ candidates by non-containment or mismeasurement of energy.

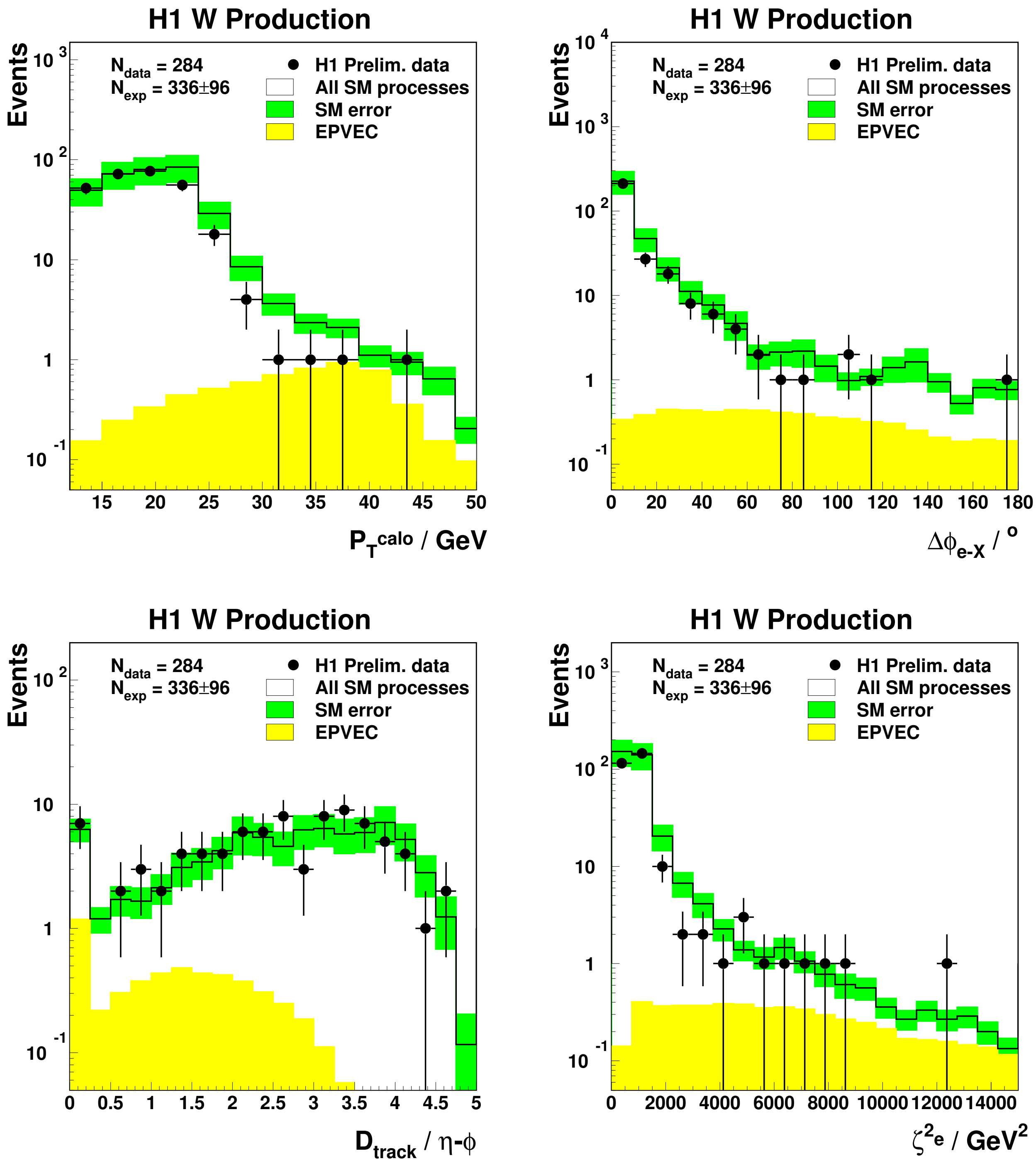
- Photoproduction processes $(\gamma p \rightarrow X)$ Only produces candidates by non-containment or mismeasurement of energy + real or fake lepton from hadronic system

- Lepton pair production in two photon $(\gamma\gamma \rightarrow l^+ l^-)$ interactions. One lepton is missed and mismeasurement leads to P_T^{miss}

H1 Control Distributions 99-00 e^+p Data

Check backgrounds with relaxed cuts

Electron channel:



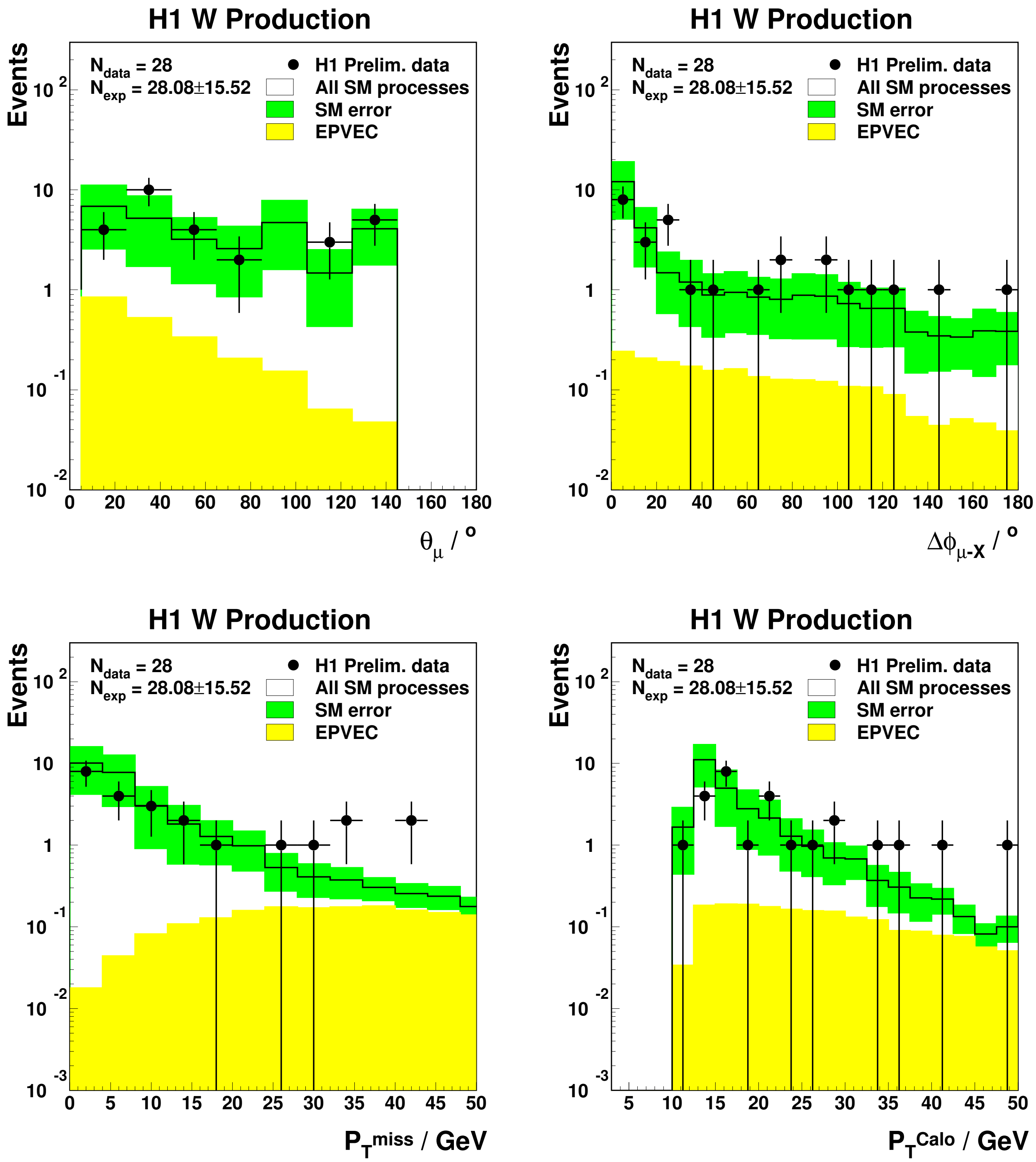
Background mainly from NC + CC events

Distributions well described in shape and normalisation

H1 Control Distributions 99-00 e^+p Data

Check backgrounds with relaxed cuts

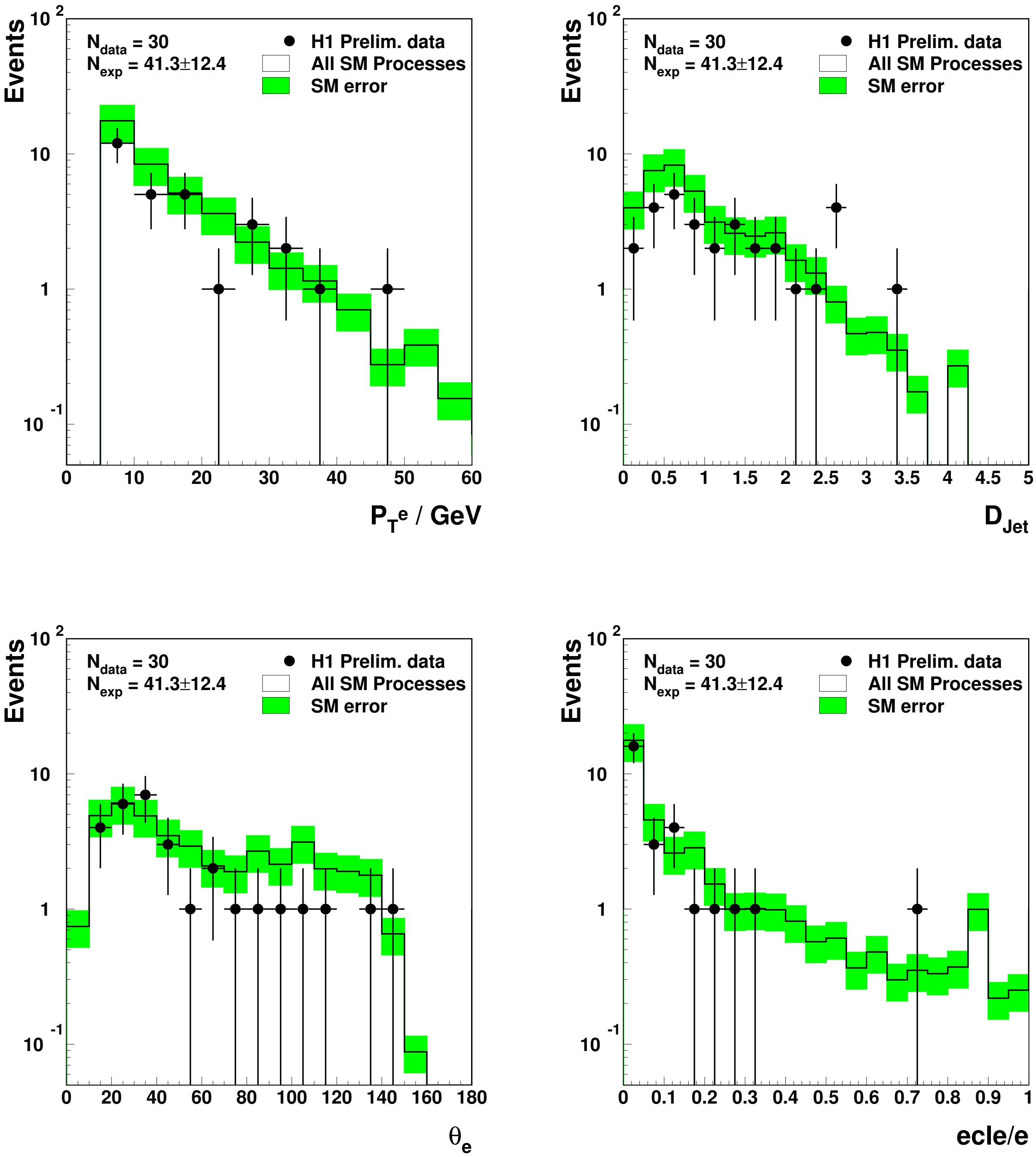
Muon channel:



Background mainly from $\gamma\gamma \to \mu^+\mu^-$

Distributions well described in shape and normalisation

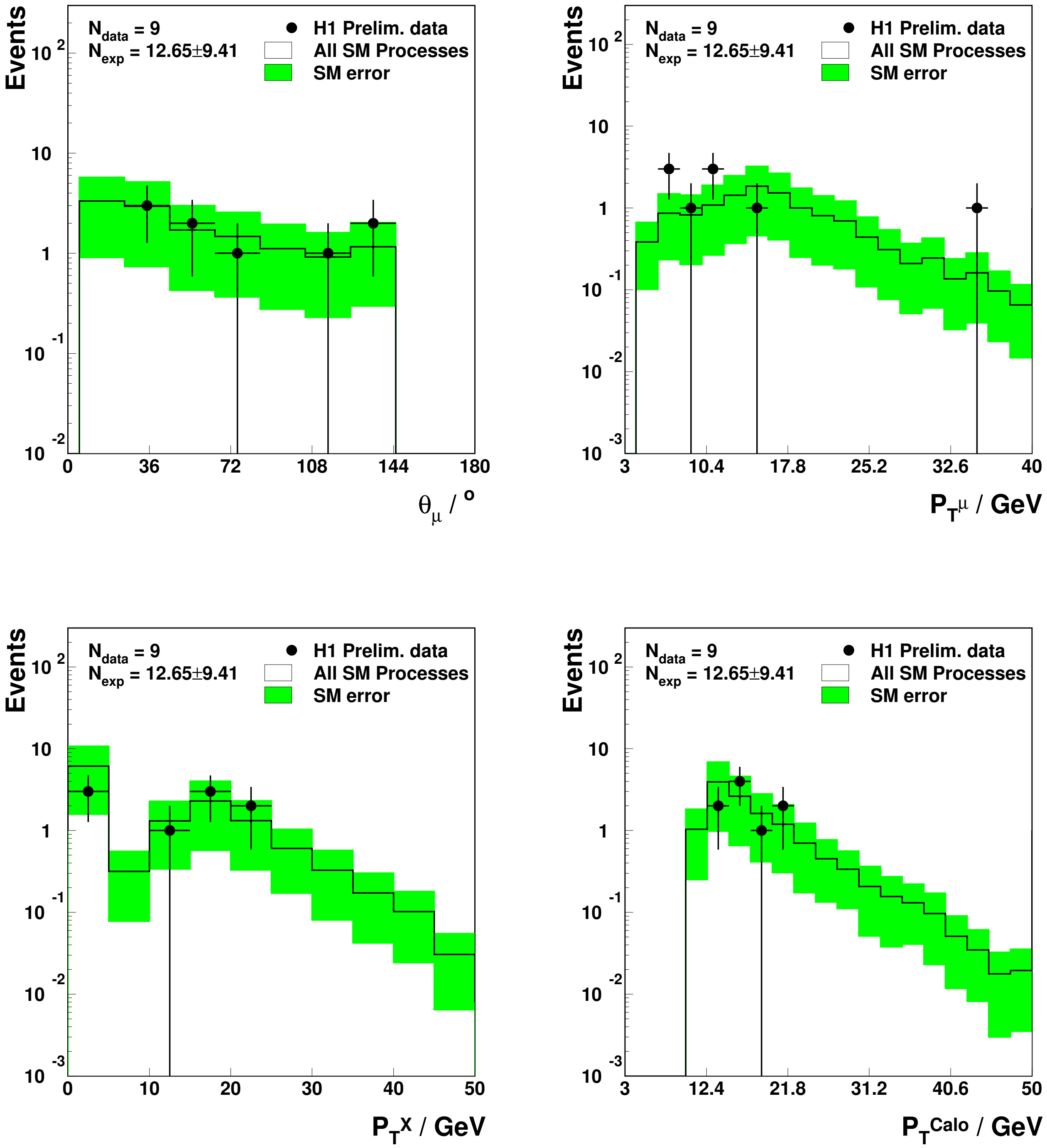
CC Sample + electron finder



- CC events with photon (radiation) or particle in jet faking an electron
- MC describes data in shape and normalisation within 30% error

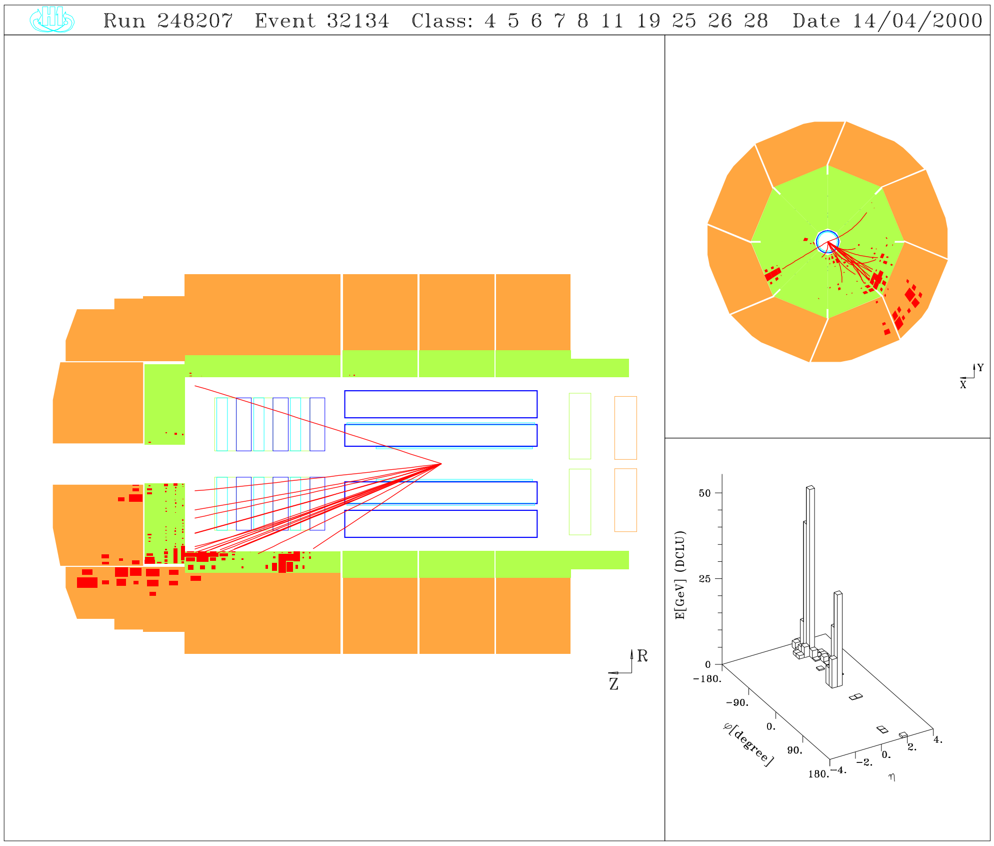
$ep \to eX\mu^+ \ \mu^-$ Sample

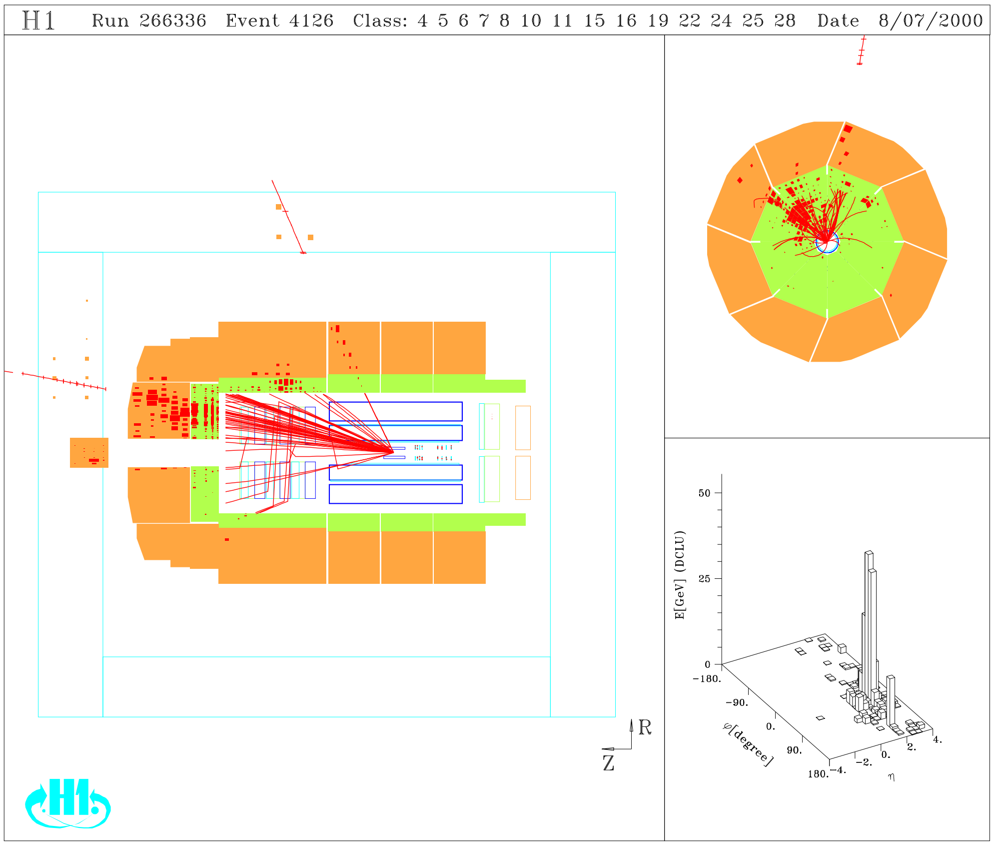
- Subset of muon control plots - require $\geq$ 2 isolated muons



- MC describes data in shape and normalisation within 75% error

H1 Displays of events from 99-00





New H1 Results : 1994 - 2000 data

Tables show:
observed events /expectation from all SM processes

H1 94-00 e^+p 82 pb^{-1} Preliminary	Electrons	Muons	combined $e+\mu$
$P_T^X > 0$ GeV	6 / 6.1±1.5	–	14/8.2±2.0 (only W 6.4)
$P_T^X > 12$ GeV	4 / 2.1±0.5	8 /2.0±0.5	12/4.1±1.0 (only W 3.3)
$P_T^X > 25$ GeV	3 /1.1±0.3	6 / 1.2±0.3	9/2.3±0.6 (only W 1.8)
$P_T^X > 40$ GeV	2 / 0.3 ±0.1	4 / 0.5 ±0.1	6/0.8±0.2 (only W 0.7)

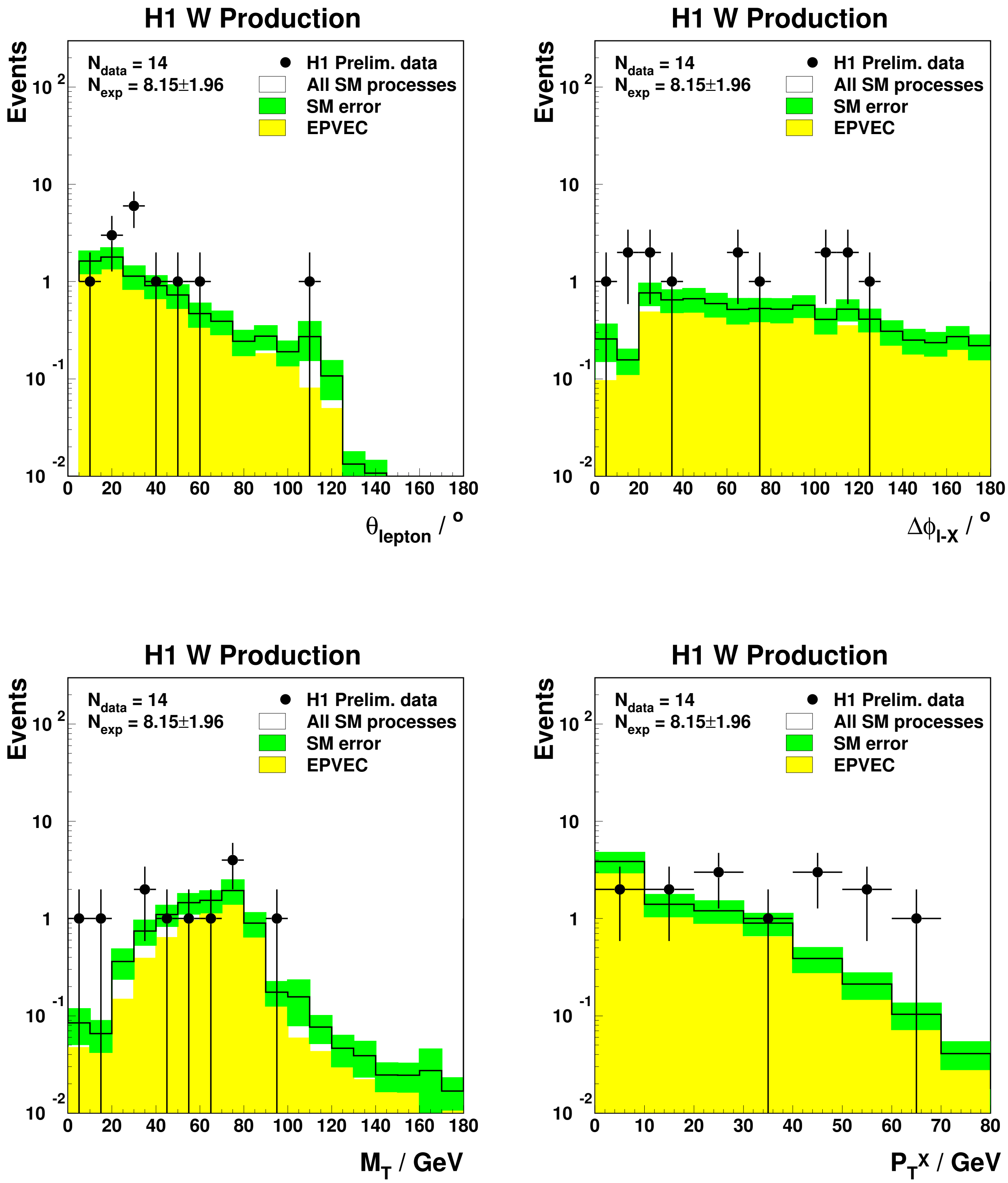
- No events found in 13.6 pb^{-1} of e^-p data

- Agreement with SM expectation for $P_T^X < 25$ GeV
- An excess for $P_T^X > 25$ GeV

4 new events in 99-00 data (5 events in 94-97)

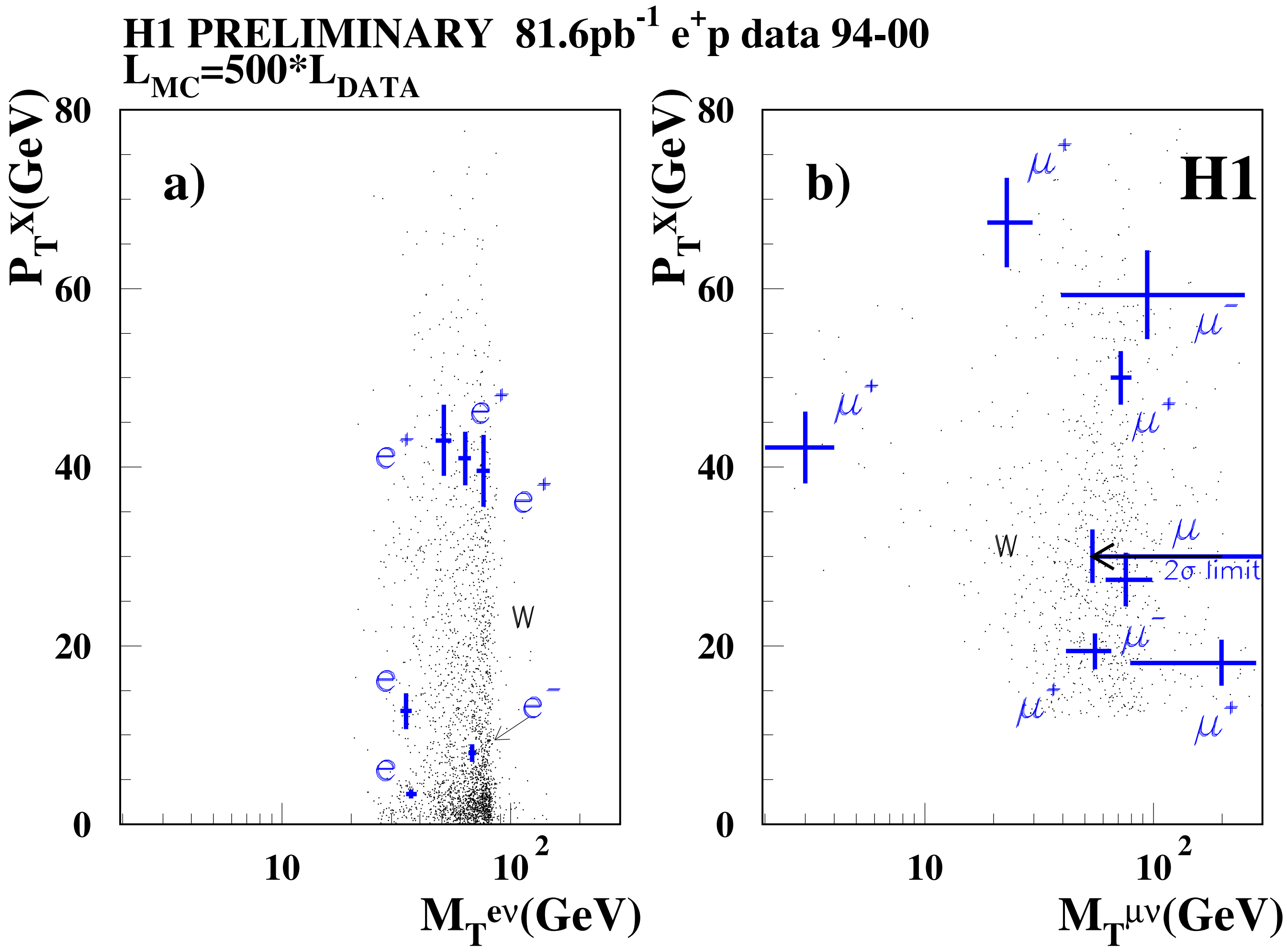
H1 Final Distributions

Electrons and muons combined



Excess over expectation at large P_T^X
Shapes of other distributions compatible with expectation

H1 94-00 e^+p data



Events seen at very high P_T^X in both electron and muon channels

Most events near $M_T = M_W$, although some have lower values

Personal Comments

Excess is intriguing because:

- Statitistical fluctuation has a low probability

- Events are seen at high P_T^X, where new phsycis (e.g. 3 body decay) may be expected

- New data $\rightarrow$ New events. Doubling the luminosity since publication yielded almost double the events

- Many events are far above $P_T^X = 25$ GeV boundary.

Including all new events

Event	R248207 E32134 e^+	R252020 E30485 e^+	R268338 E70014 e^+	R266336 E4126 μ^+
P_T^l / GeV	32 ± 1	25 ± 2	28 ± 1	21 ± 3
P_T^X / GeV	41 ± 3	43 ± 4	39 ± 4	50 ± 3
P_T^{miss} / GeV	43 ± 5	42 ± 4	57 ± 5	66 ± 7
$M_{l\nu}^T$ / GeV	63 ± 4	51 ± 4	76 ± 5	72 ± 8
$M_{l\nu}$ / GeV		77^{+21}_{-14}		

- Need lumi upgrade to settle this issue

Summary: W production at H1

Events with isolated lepton and missing transverse momentum observed at H1

Such events interpreted in SM as W production with leptonic decay

In 1994-2000 e^+p collisions, H1 see 14 events with e or μ, compared to SM prediction 8.2±2.0

At large hadronic recoil (P_T^X >25 GeV), H1 see 9 events compared to SM prediction 2.3±0.60

4 of the high P_T^X events are seen in the new 99-00 data cf. 5 in 94-97

Data after HERA upgrade will prove whether this interesting signal is new physics or a statistical fluctuation

(See Masahiro Kuze's talk for H1-ZEUS comparisons and top results)