

W and Anomalous Single Top Production

Deep Inelastic Scattering Workshop
London, UK
7th-11th March 2008

- Introduction
- Isolated Leptons with High $P_{T,miss}$
- Cross Section Determination
- Measurement of W Polarisation Fractions
- Anomalous Single Top Production
- Conclusions

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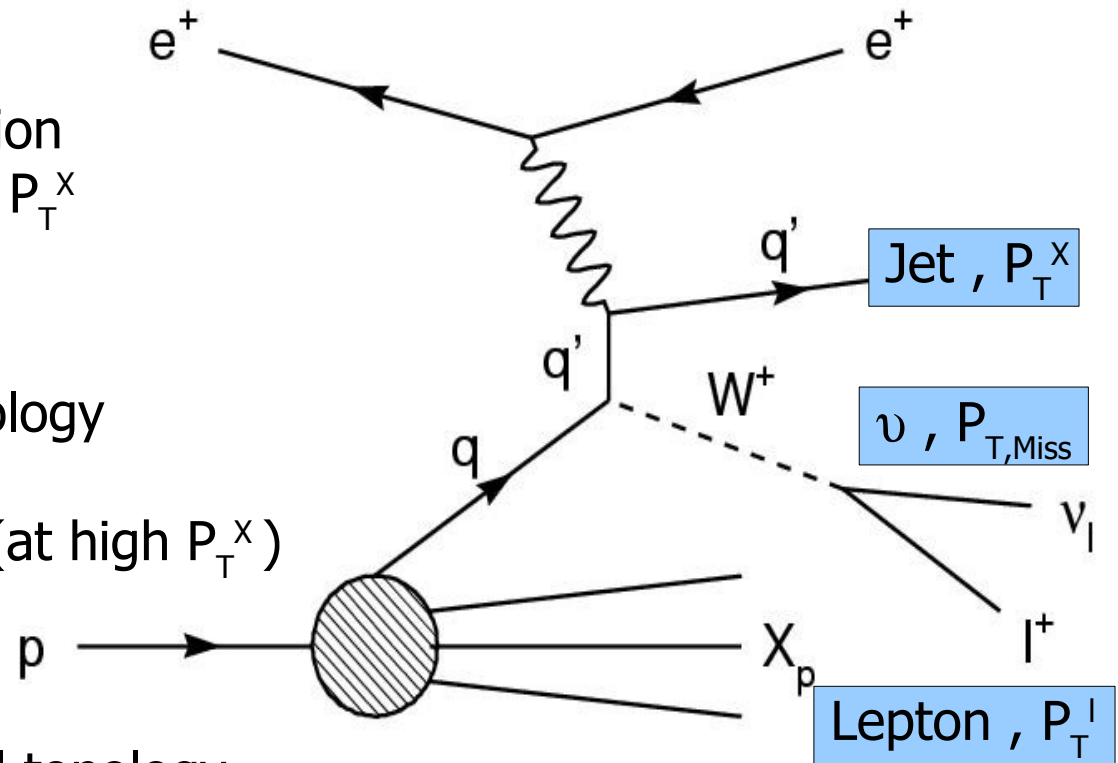


Observation of events with isolated lepton & large missing P_T

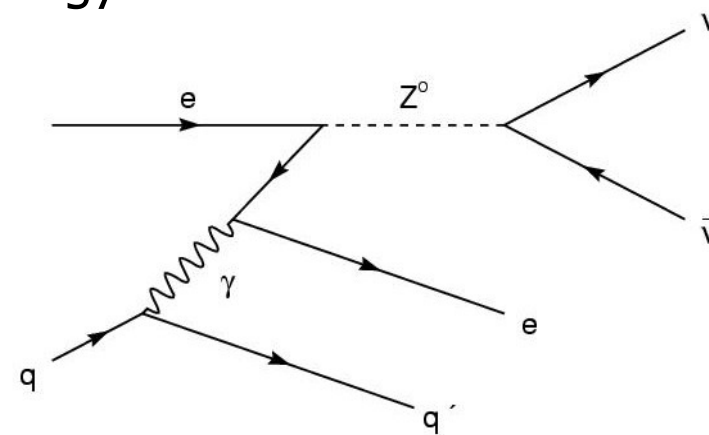
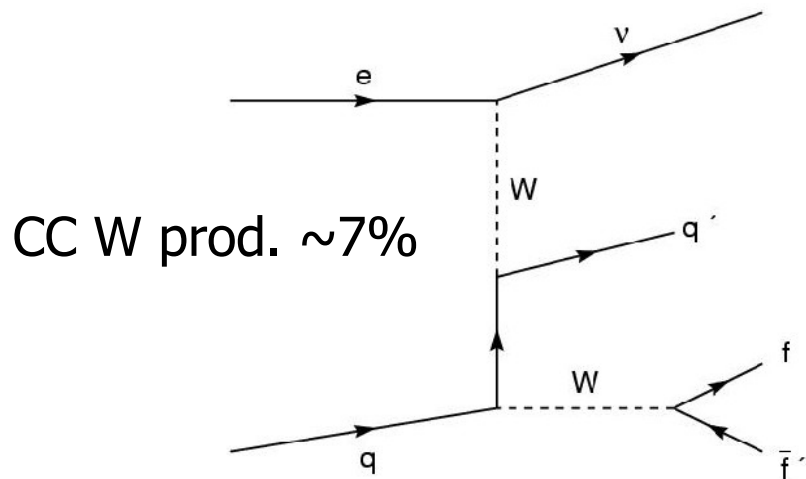
Main SM contribution: real W production
 - hadronic system of typically low P_T^X

Interpreted in 3 ways here:

- generic analysis of this event topology
- in context of W production
- anomalous single top production (at high P_T^X)



Two small SM contributions to signal topology



Cabibbo-Parisi Z^0 production ~3% (e channel only)

Quick reminder of event selection in both channels

$$5^\circ < \theta_{\text{lep}} < 140^\circ$$

$$P_{T,e/\mu} > 10 \text{ GeV}$$

$$P_{T,\text{miss}} > 12 \text{ GeV}$$

lepton-jet distance > 1 unit in η - Φ

Further selections applied for background rejection (see previous talk)

Use complete HERA I+II data set 478 pb^{-1}
(e^+p & e^-p scattering data sets)

combine electron & muon samples

Backgrounds:

Neutral Current events with fake missing P_T

Charged Current events with isolated hadron misidentified as lepton

Lepton pair production ($\gamma\gamma$ process) with fake missing P_T and one lost lepton

Photoproduction with fake missing P_T and misidentified hadron

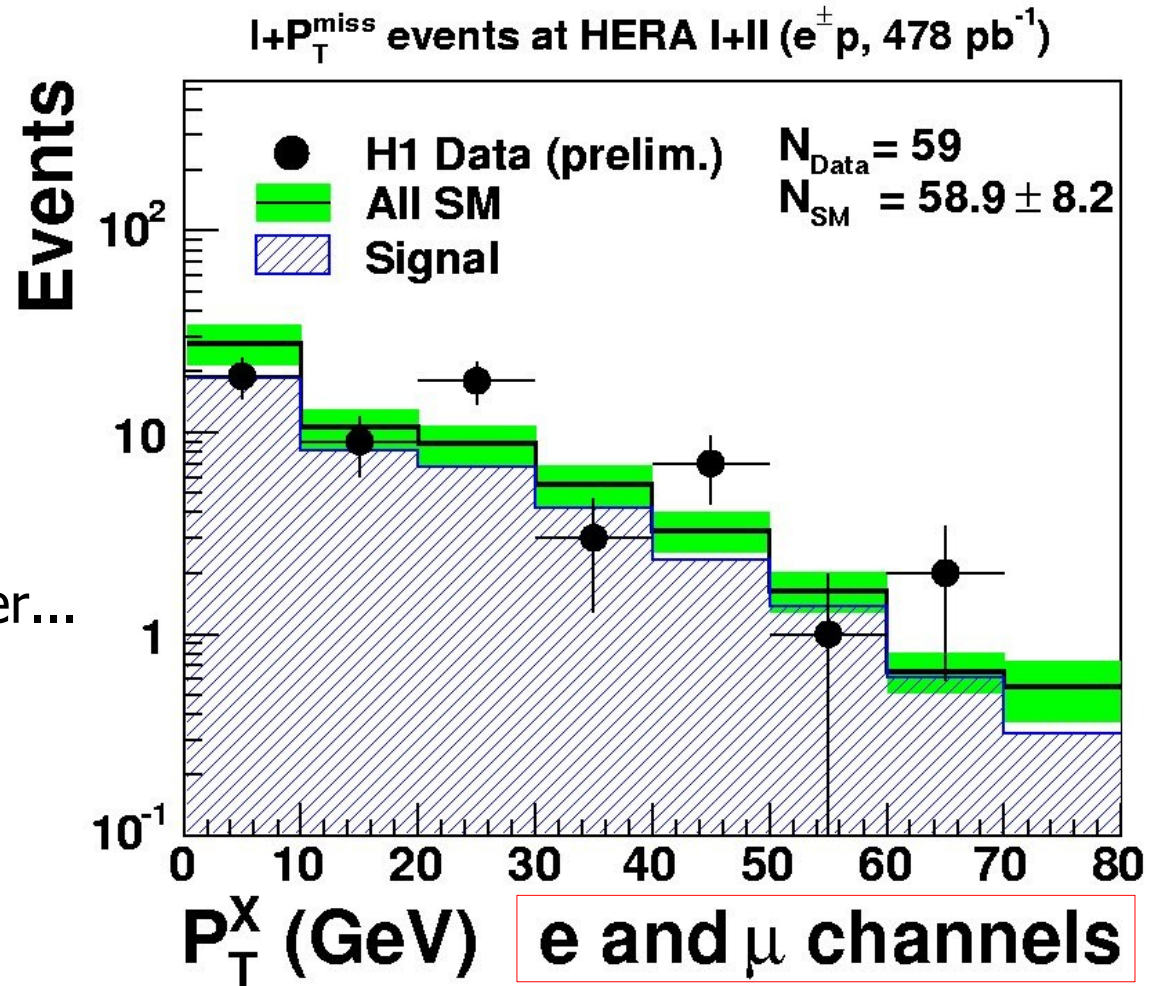
Sample dominated by W production
(signal contribution > 70%)

Overall excellent agreement

Use this to extract cross sections

Excess visible for $P_T^X > 25$ GeV
will look at possible interpretation later...

SM uncertainty (green band)
± 15% W production
± 30% remaining SM b/g



H1 $e^\pm p$ data HERA I+II (478 pb^{-1})	e channel obs. / exp. (signal)	μ channel obs. / exp. (signal)	e and μ channels obs. / exp. (signal)
Full sample	42 / 46.7 ± 6.5 (69%)	17 / 12.2 ± 1.8 (82%)	59 / 58.9 ± 8.2 (72%)
$P_T^X > 25$ GeV	14 / 8.5 ± 1.5 (68%)	10 / 7.3 ± 1.2 (79%)	24 / 15.8 ± 2.3 (73%)

Use this sample to extract cross section for Isolated e/ μ & Large $P_{T,miss}$: $\sigma_{\ell+P_T}$

Defined purely in terms of event topology

Includes all processes with real isolated e/ μ and genuine $P_{T,miss}$

$$\sigma = \frac{N_{data} - N_{bkd}^{MC}}{\mathcal{L} \mathcal{A}} \quad \text{with} \quad \mathcal{A} = \frac{N_{rec}^{MC}}{N_{gen}^{MC}} \quad \text{smeared detector acceptance from reconstructed \& generated SM / signal MC events}$$

Good SM description and large W production contribution allows cross section for single W^\pm production ($W \rightarrow e/\mu + X$): σ_W

Differ in definition of 'signal' processes e.g. Z^0 production is signal for $\sigma_{\ell+P_T}$ only

Include Branching ratio = 0.24 for $W \rightarrow e/\mu + X$

leptonic W decay to any final state with e/ μ + X

Both cross sections based on identical event selection

cross sections defined for: $5^\circ < \theta_{\text{lep}} < 140^\circ$

$$P_{T,e/\mu} > 10 \text{ GeV}$$

$$P_{T,\text{miss}} > 12 \text{ GeV}$$

lepton-jet distance > 1 unit in η - Φ

H1	HERA I+II Data / pb	SM / pb
$\sigma_{\sigma_{\ell+\cancel{E}_T}}$	0.24 ± 0.05 (stat) ± 0.05 (sys)	0.26 ± 0.04 (th.sys)
σ_W	1.23 ± 0.25 (stat) ± 0.22 (sys)	1.31 ± 0.20 (th.sys)

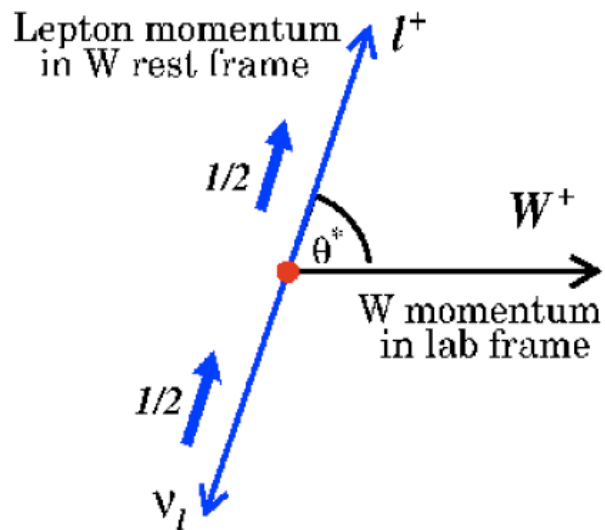
Systematic uncertainties on the measurement:

- dominated by MC model uncertainties
- smaller contributions from lepton ID efficiency
- calorimeter scale and polar angle measurement uncertainties negligible
- theoretical uncertainty includes estimate of higher NLO corrections

Excellent agreement with SM prediction

Selection gives ~ 35 events - study angular decay properties...

W polarisation fraction defined in $\cos(\theta^*)$ variable:
 angle between decay lepton in W rest frame & W momentum in lab frame



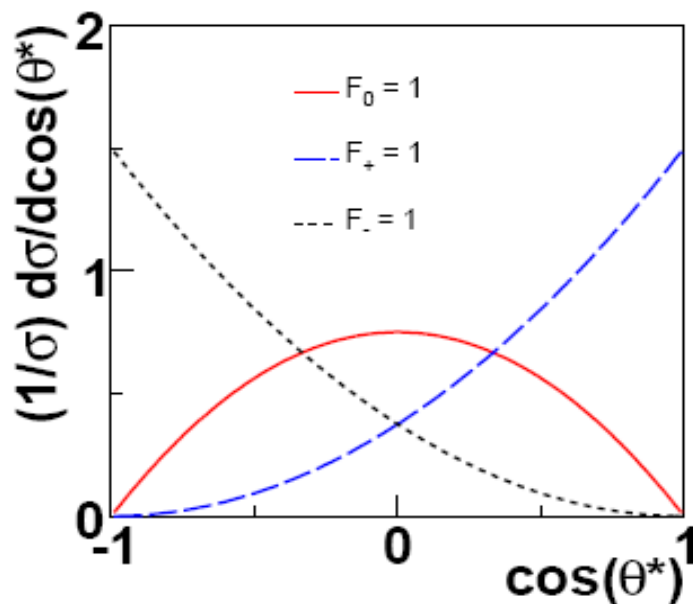
For W^+ decays the angular distribution is given by:

$$\frac{d\sigma_W}{d\cos\theta^*} \propto (1 - F_- - F_0) \cdot \frac{3}{8} (1 + \cos\theta^*)^2 \quad \text{left}$$

$$+ F_0 \cdot \frac{3}{4} (1 - \cos^2\theta^*) \quad \text{longitudinal}$$

$$+ F_- \cdot \frac{3}{8} (1 - \cos\theta^*)^2 \quad \text{right}$$

with $F_+ \equiv 1 - F_- - F_0$.



W^- decays the signs are swapped
 So, study: $q_l \cdot \cos(\theta^*)$
 $q_l =$ lepton charge

Distribution for
 left handed $W^- =$ right handed W^+

Additional selection criteria employed to reconstruct W and neutrino

Majority of events yield two neutrino solutions: forward / backward

Forward solution chosen when $\theta^l < 35^\circ$ (about 80% success rate)

Require reliable lepton charge measurement:

$$\theta^l > 20^\circ$$

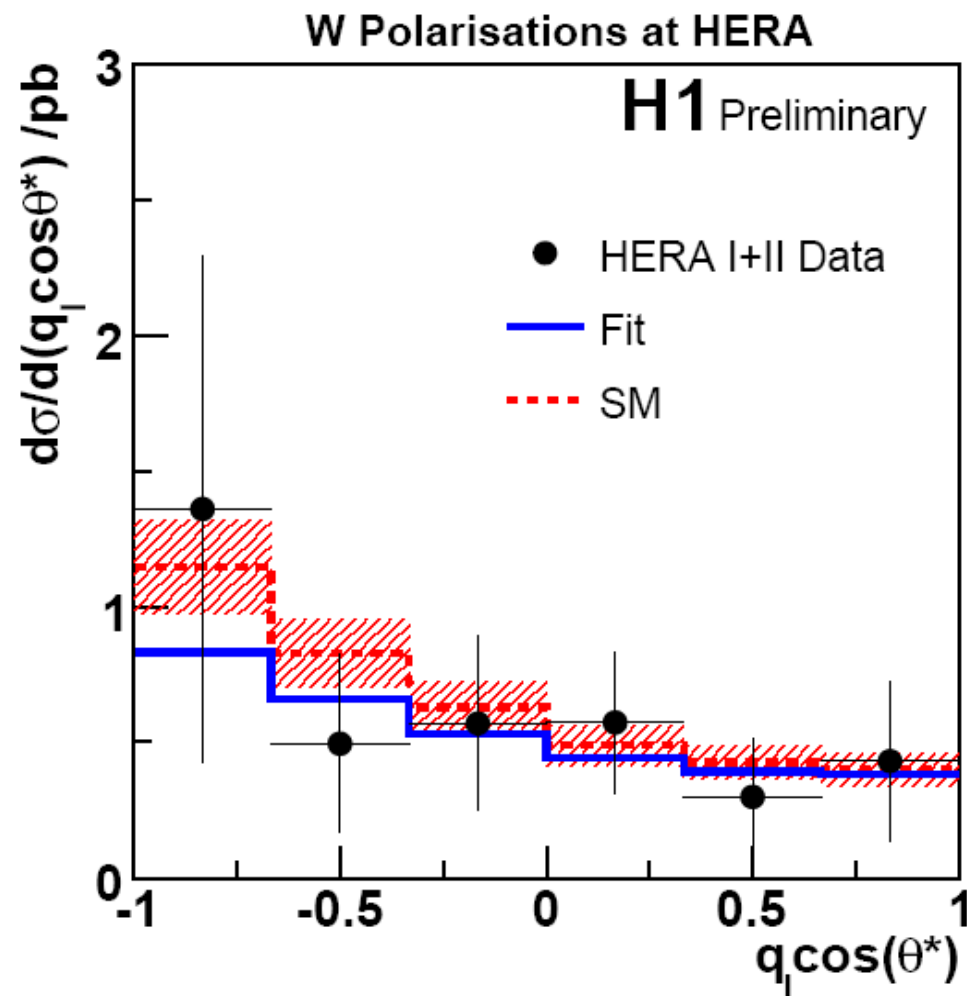
Charged track: curvature significance > 1

\Rightarrow charge misidentification $< 1\%$

signal purity $> 80\%$

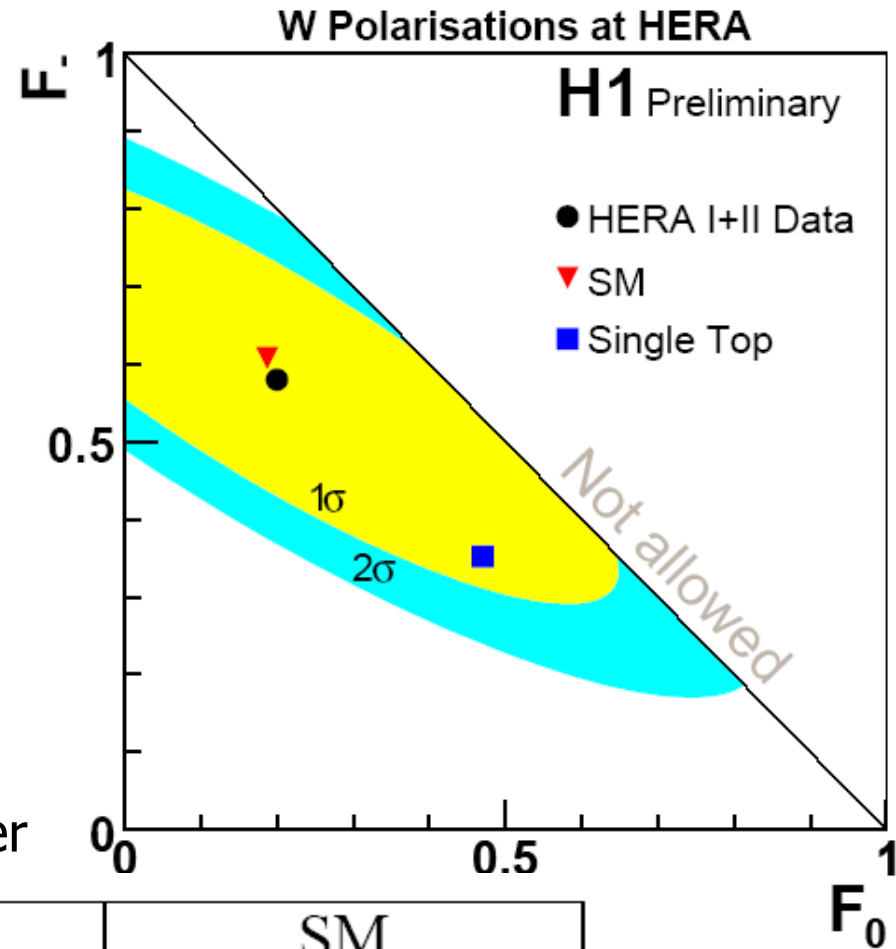
Contains all W^+ and W^- data

Solid Blue line = 2 parameter fit to data
for polarisation fractions



Perform simultaneous fit to F_- and F_+

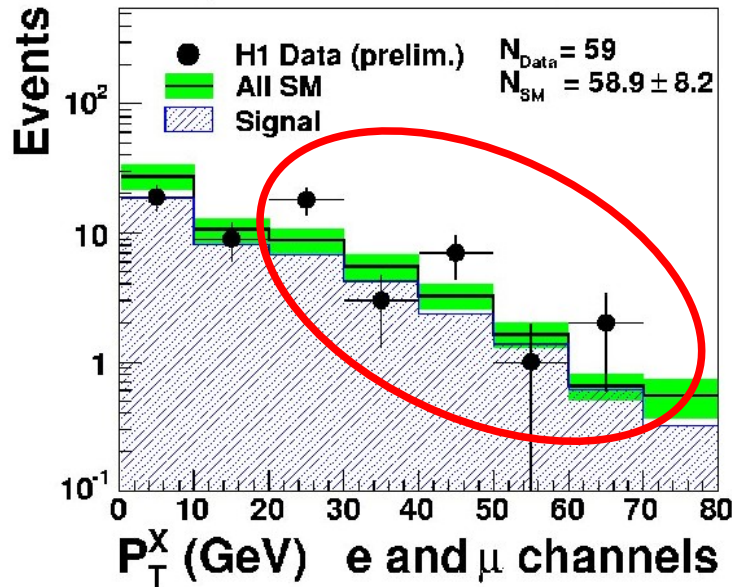
Results in agreement with SM



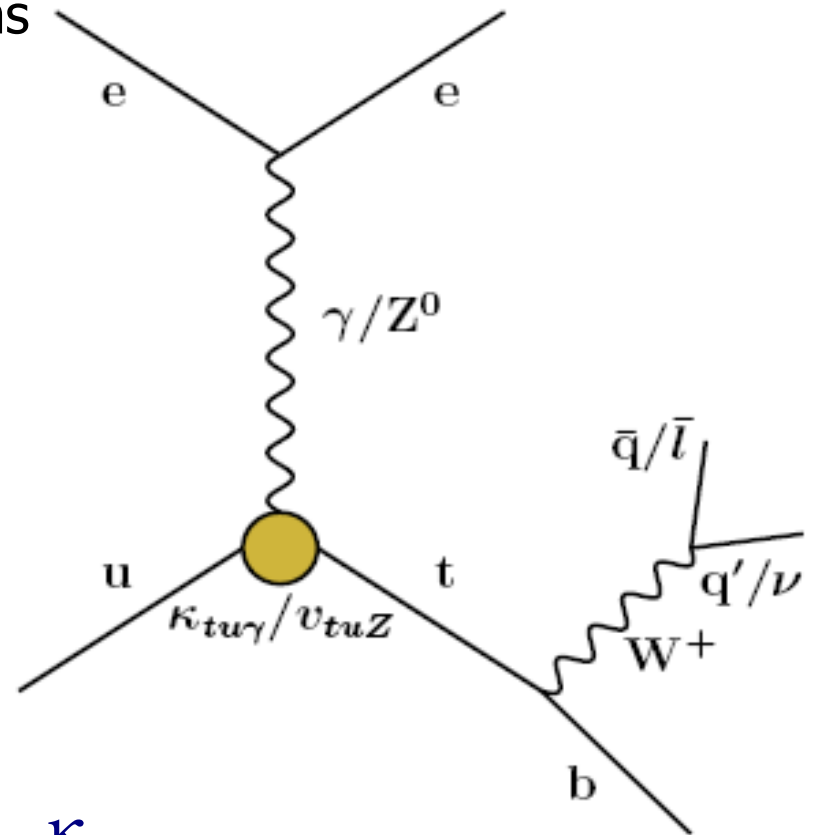
Polarisation fractions extracted in 1D fits constrained to SM for other parameter

H1	HERA I+II Data	SM
F_-	0.58 ± 0.15 (stat) ± 0.12 (sys)	0.61 ± 0.01 (stat)
F_0	0.15 ± 0.21 (stat) ± 0.09 (sys)	0.19 ± 0.01 (stat)

- W production cross section agrees well with SM
- But at high $P_{T,X} (>25)$ an excess remains



- Excess unlikely to be W production typical low $P_{T,X}$ process
- Topology is similar to top decay $t \rightarrow bW$
- Very small SM cross section $< 1\text{fb}$
- Possible cause:
 Anomalous single top production
 Flavour Changing Neutral Currents



K_{tuy}
 V_{tuZ} anomalous couplings of γ/Z

Charm contributions neglected
 Vector couplings to Z^0 neglected

Use 'standard' selection +

- good lepton charge determination
- good top quark reconstruction

4 vector reconstruction:

- b quark = sum of all hadronic jets
- neutrino reconstructed as before
- top quark = lepton + ν + b

$$0 < M_{l\nu b} < 300 \text{ GeV}$$

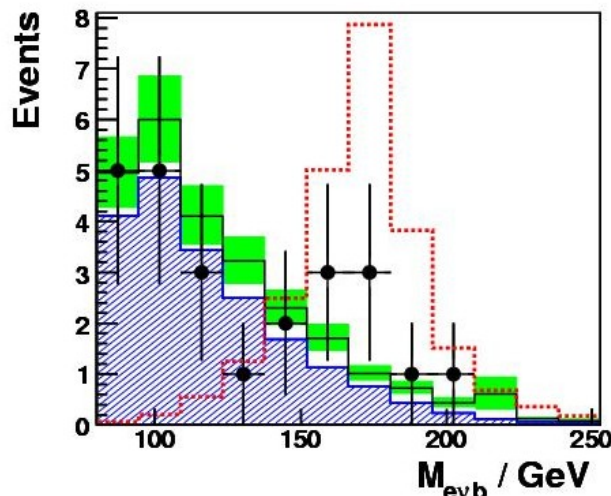
Selected events:

e: 24 (SM: 26 ± 4)

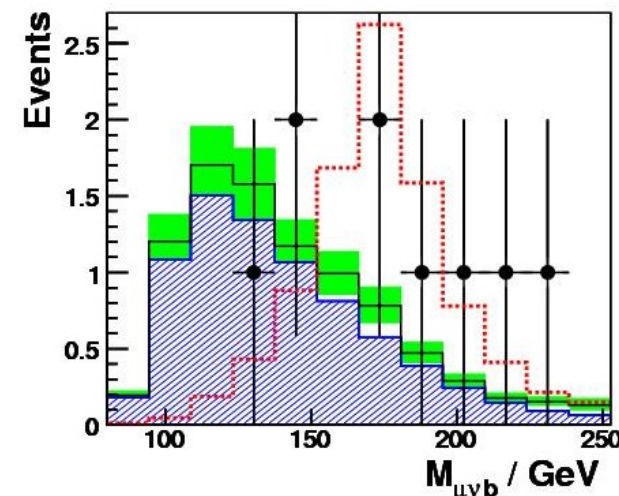
μ : 10 (SM: 9.3 ± 1.3)

Multivariate discriminator:
separate signal and b/g

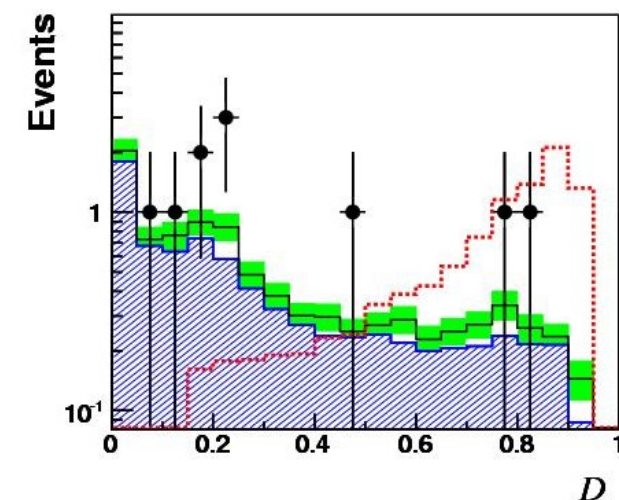
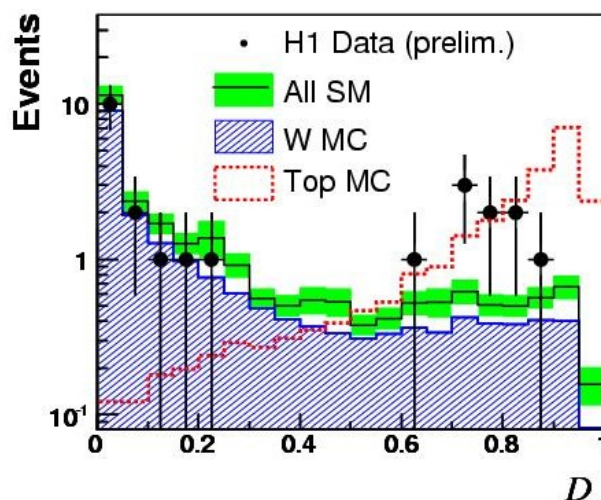
$$P_T^b, M_{l\nu b} \text{ and } \theta_W^l$$



ELECTRON CHANNEL

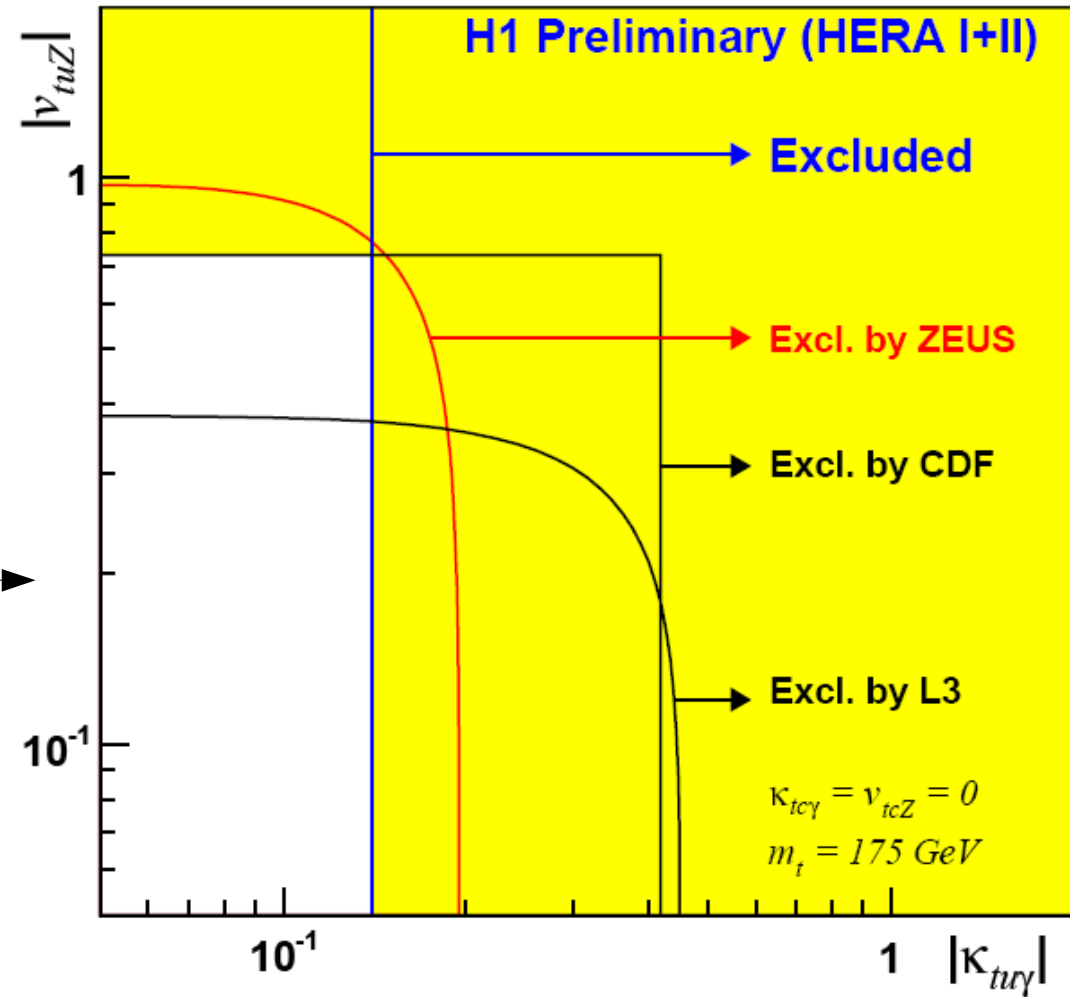


MUON CHANNEL



Anomalous single top MC used for signal training & W production for b/g
Few events are compatible with top - no large significance

- Use max. likelihood method to extract cross section limit for FCNC
- New H1 upper bound on cross section at 95% CL:
 $(ep \rightarrow etX) < 0.16 \text{ pb}$
- Upper bound on the anomalous coupling
 $\kappa_{t\gamma} < 0.14$



Recent updated CDF result on vector coupling

Conclusions

- H1 analysed complete HERA I+II 478 pb⁻¹
- Cross section measured for topology of:
isolated leptons with large missing P_T
excellent SM agreement (excess at high P_T)
- Cross Section measurement extended to W production
- Polarisation fractions for W production have been determined
in good agreement with SM
- High P_T excess interpreted as anomalous single top production
- No significant anomalous coupling observed
limits set on ep → etX: < 0.16 pb
κ_{tuy} < 0.14 most stringent limit