W and Anomalous Single Top Production

Deep Inelastic Scattering Workshop
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- 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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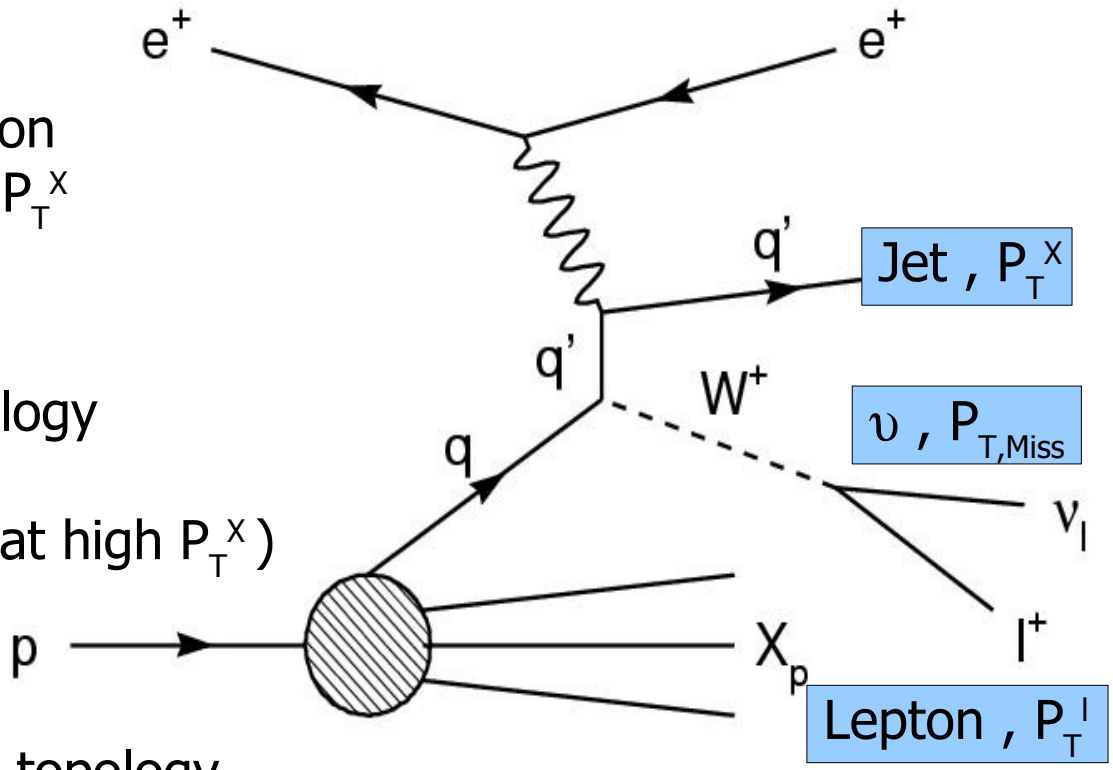
Observation of events with isolated lepton & large missing P_T

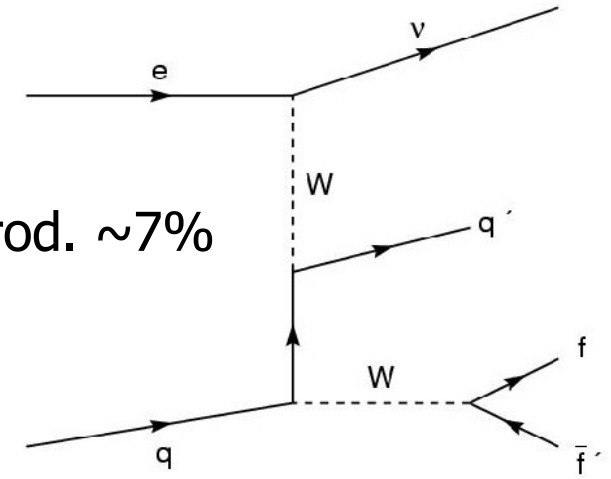
Main SM contribution: real W production
- hadronic system of typically low P_T^X

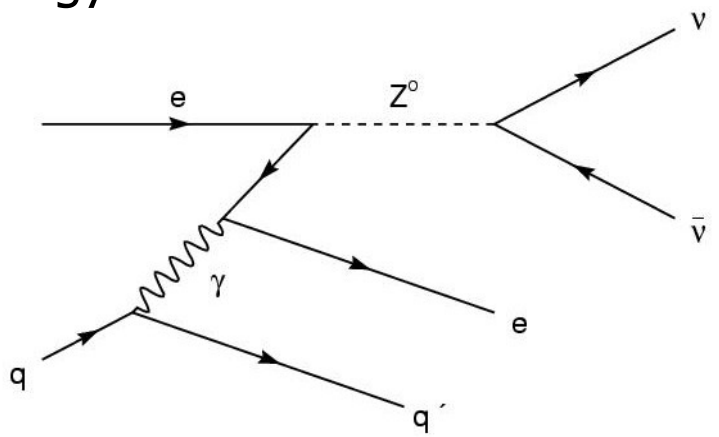
Interpreted in 3 ways here:
- generic analysis of this event topology
- in context of W production
- anomalous single top production (at high P_T^X)



Two small SM contributions to signal topology

CC W prod. ~7%





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

Quick reminder of event selection in both channels

$5° < \theta_{lep} < 140°$

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

$P_{T,miss} > 12$ 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

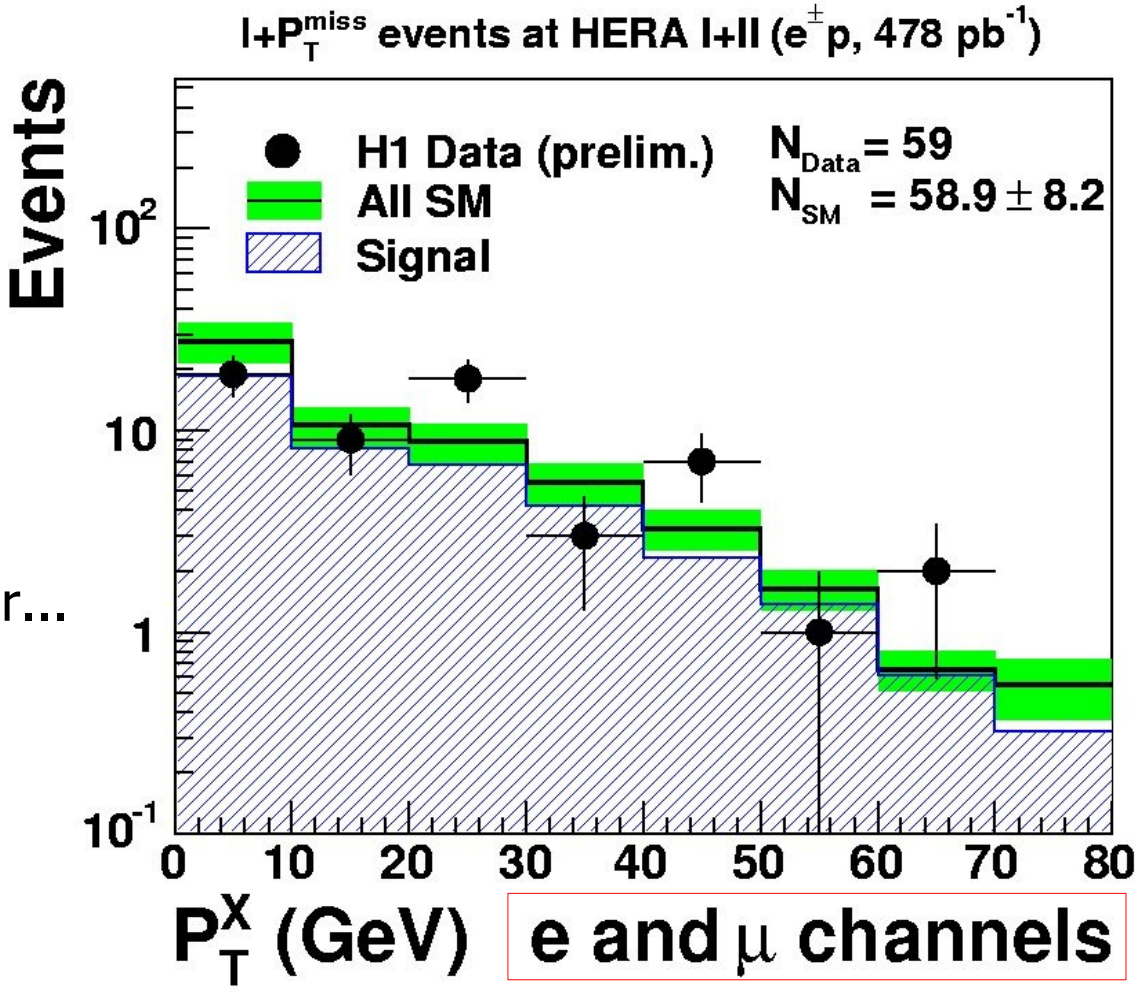
Sample dominated by W production
(signal contribution > 70%)

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 $P_{T,miss}$: $\sigma_{\ell+\not{P}_T}$

Defined purely in terms of event topology

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

$$\sigma = \frac{N_{data} - N_{bkd}^{MC}}{\mathcal{L} \quad \mathcal{A}} \qquad \text{with} \qquad \mathcal{A} = \frac{N_{rec}^{MC}}{N_{gen}^{MC}}$$

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 $\sigma_{\ell+\not{P}_T}$ 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: $5° < \theta_{lep} < 140°$

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

$P_{T,miss} > 12$ GeV

lepton-jet distance > 1 unit in η-Φ

H1	HERA I+II Data / pb	SM / pb
$\sigma_{\sigma_{\ell+\not{P}_T}}$	$0.24 \pm 0.05\,(\text{stat}) \pm 0.05\,(\text{sys})$	$0.26 \pm 0.04\,(\text{th.sys})$
σ_W	$1.23 \pm 0.25\,(\text{stat}) \pm 0.22\,(\text{sys})$	$1.31 \pm 0.20\,(\text{th.sys})$

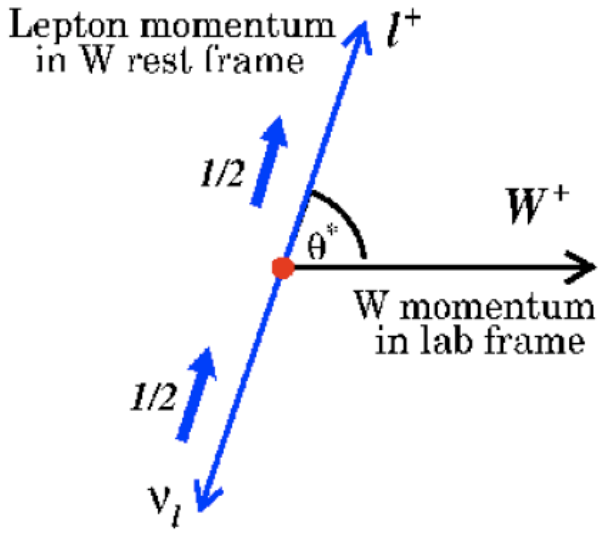
Systematic uncertainties on the measurement:

- 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(θ*) variable:
angle between decay lepton in W rest frame & W momentum in lab frame



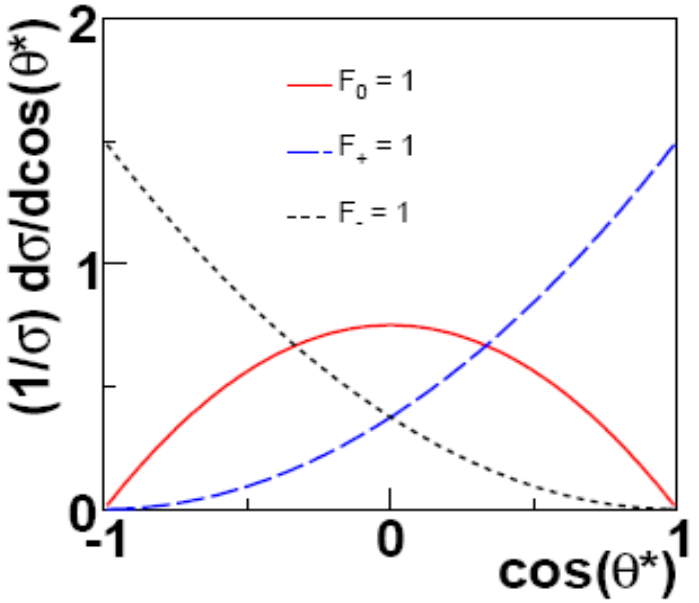
For W^+ decays the angular distribution is given by:

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

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

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

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 $\theta^l < 35°$ (about 80% success rate)

Require reliable lepton charge measurement:
$\theta^l > 20°$

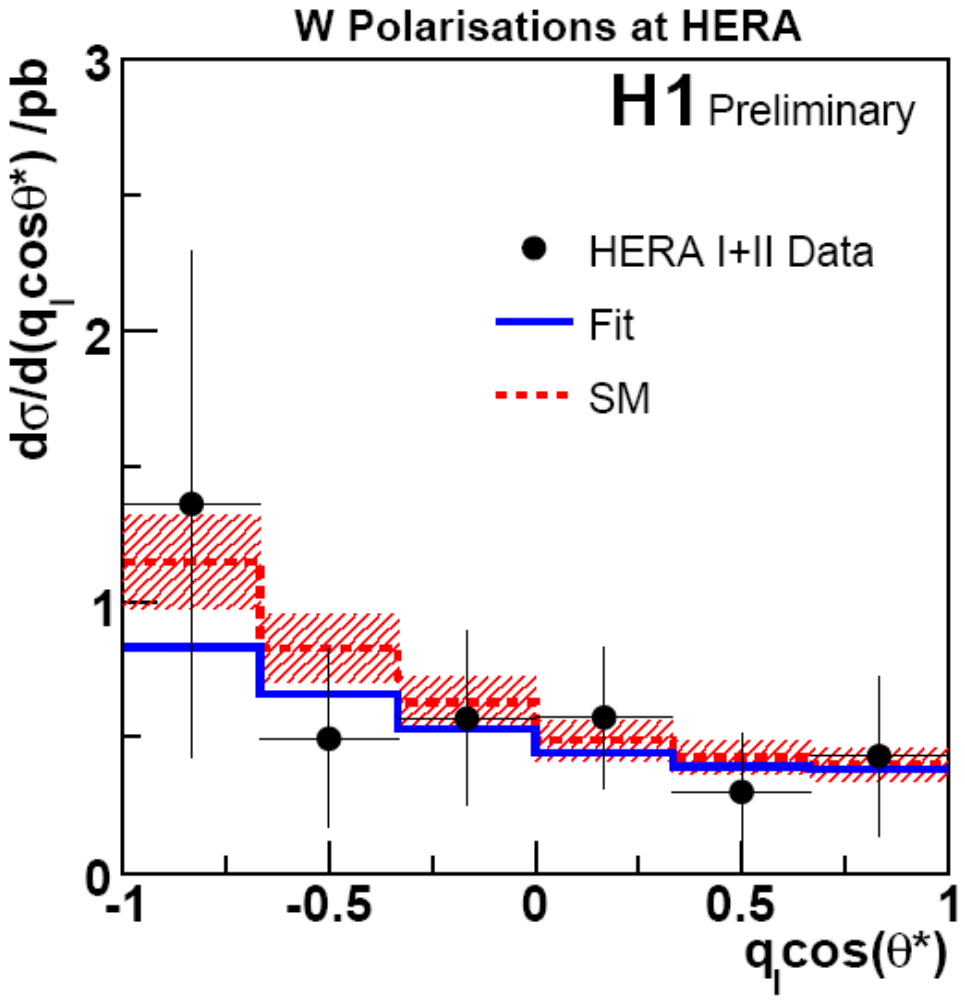
Charged track: curvature significance > 1

$\Rightarrow$ charge misidentification <1%

signal purity > 80%

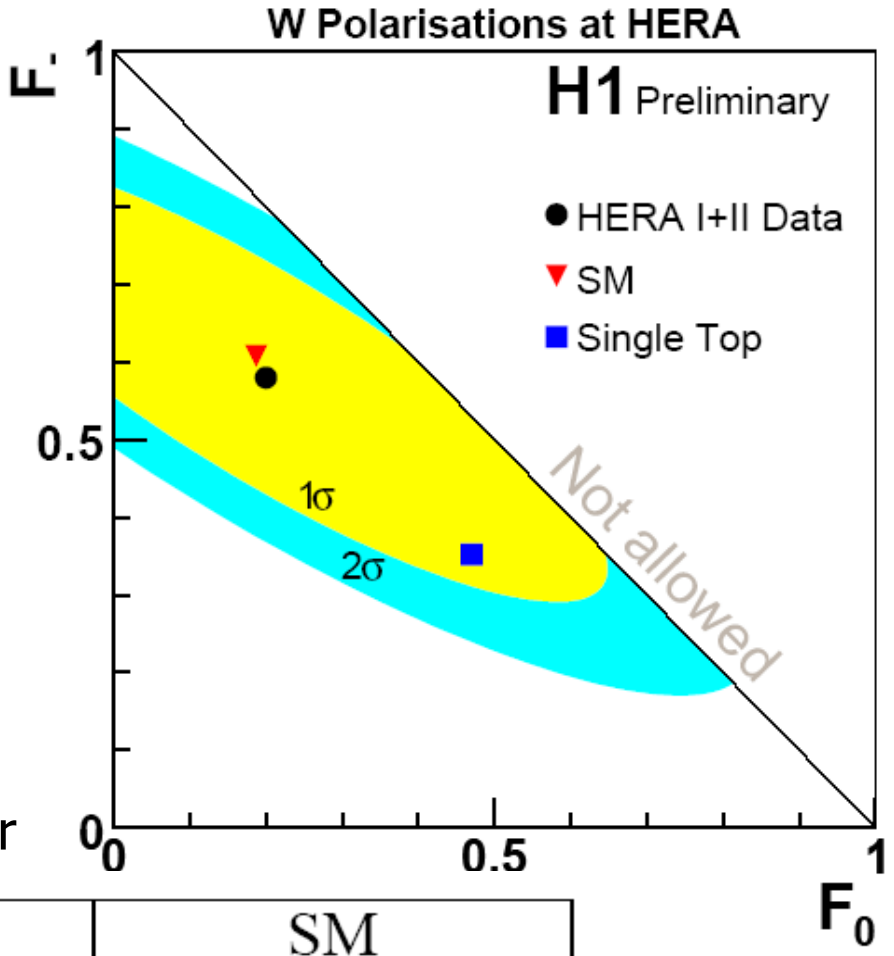
Contains all W^+ and W^- data

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



Perform simultaneous fit to F_- and F_+

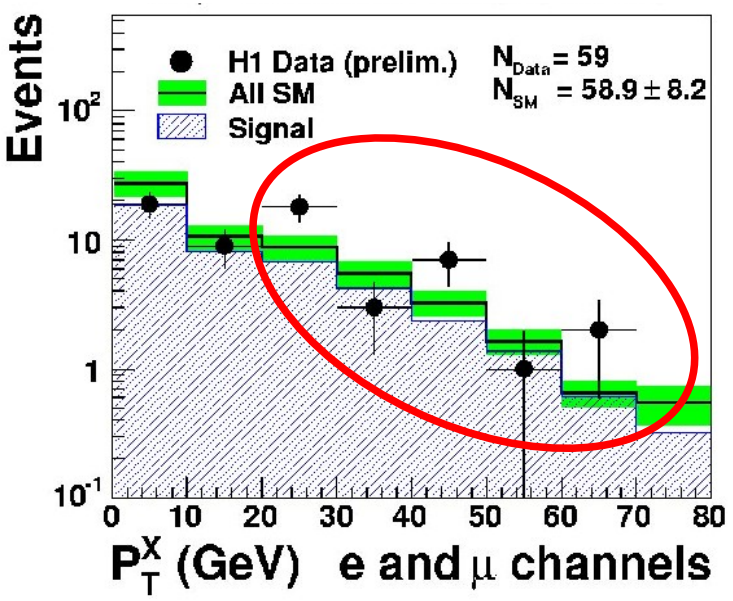
Results in agreement with SM

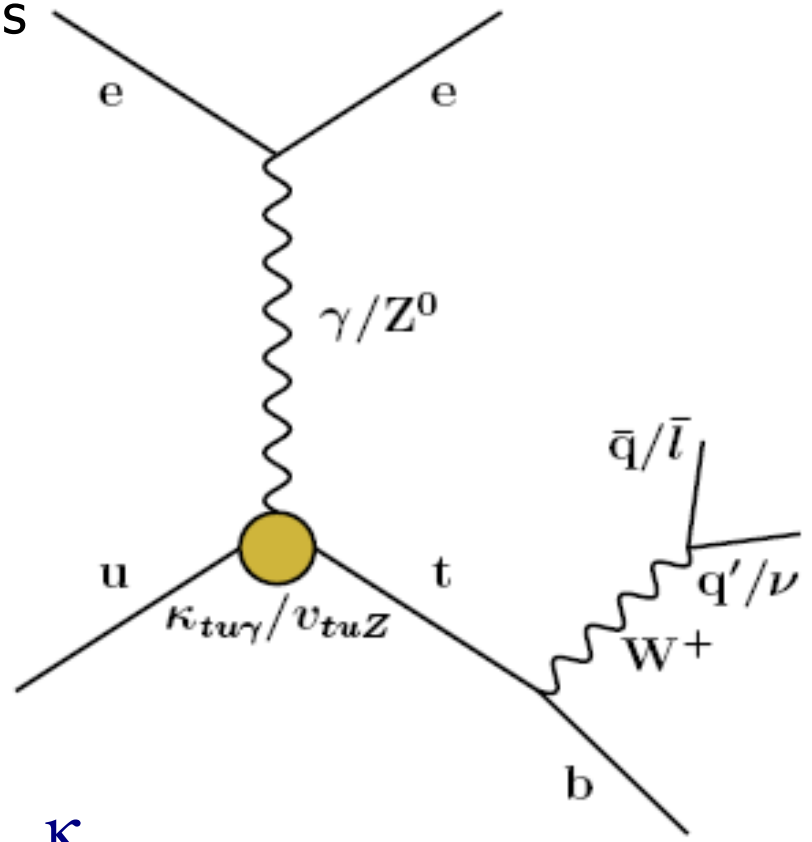


Polarisation fractions extracted in 1D fits constrained to SM for other parameter

H1	HERA I+II Data	SM
F_-	$0.58 \pm 0.15\,(\text{stat}) \pm 0.12\,(\text{sys})$	$0.61 \pm 0.01\,(\text{stat})$
F_0	$0.15 \pm 0.21\,(\text{stat}) \pm 0.09\,(\text{sys})$	$0.19 \pm 0.01\,(\text{stat})$

- 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 < 1fb
- Possible cause:
  Anomalous single top production
  Flavour Changing Neutral Currents

$\kappa_{tu\gamma}$
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:

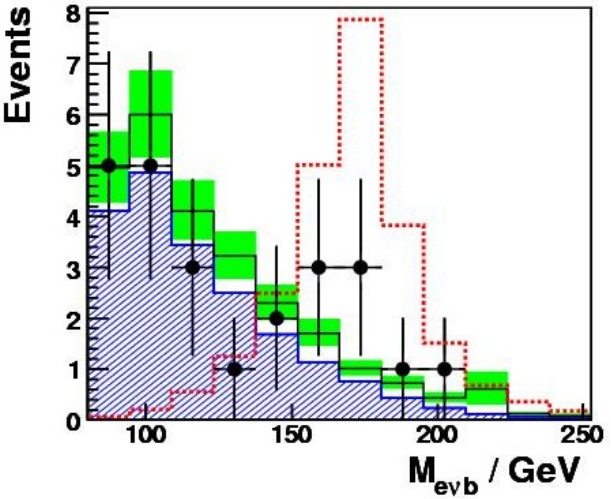
- b quark = sum of all hadronic jets
- neutrino reconsructed as before
- top quark = lepton + ν + b

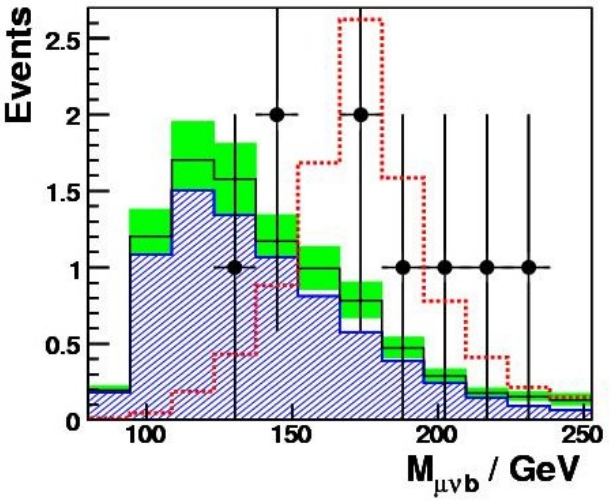
  $0 < M_{l\nu b} < 300$ GeV

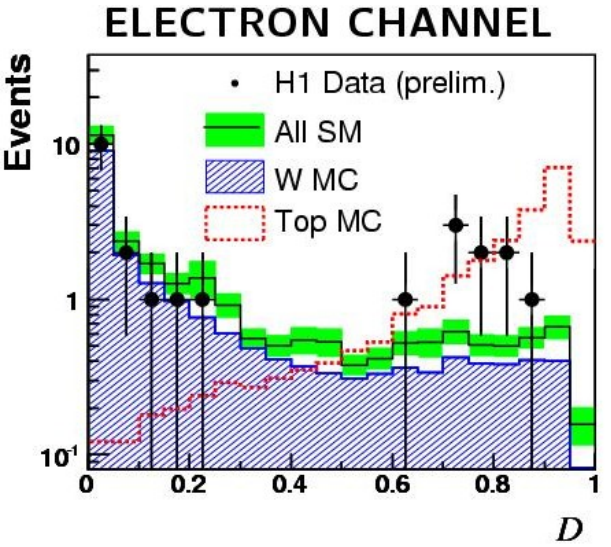
Selected events:
e: 24 (SM: 26 ± 4)
μ: 10 (SM: 9.3 ± 1.3)

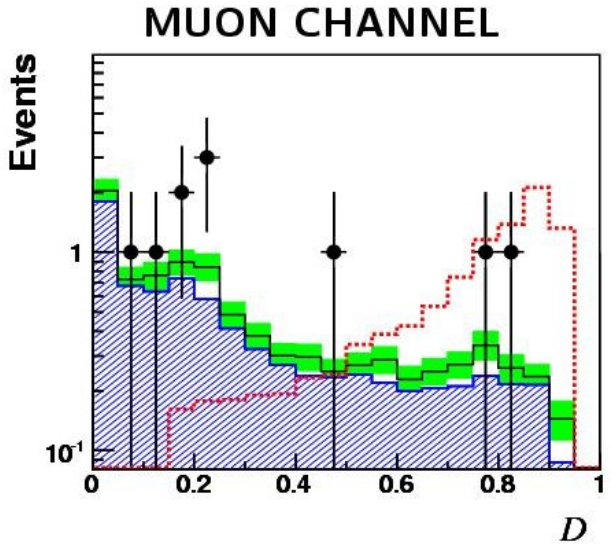
Multivariate discriminator:
separate signal and b/g

P_T^b, $M_{l\nu b}$ and θ^l_W



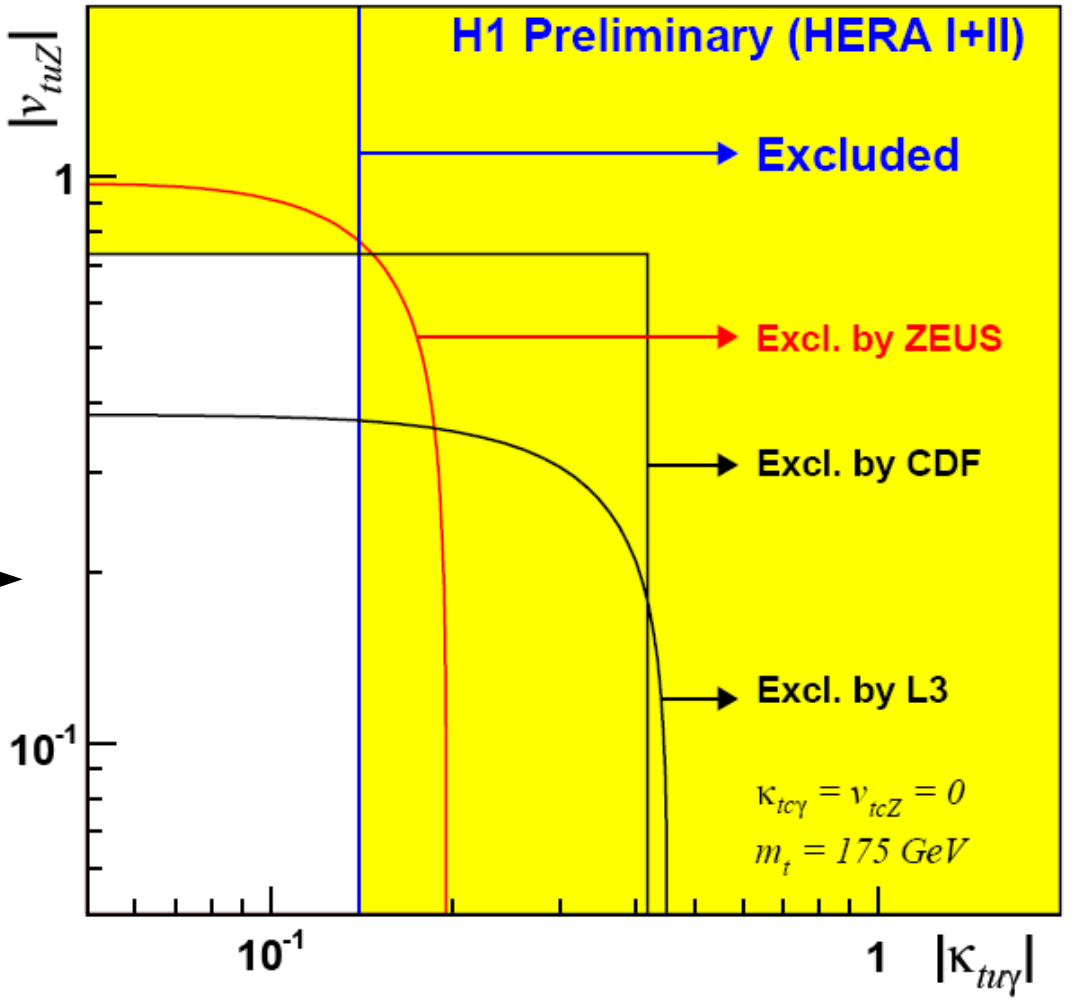






Anomalous single top MC used for signal training & W production for b/g
Few events are compatible with top - no large significance

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



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 measurment 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 $ep \rightarrow etX$: < 0.16 pb
  $\kappa_{tu\gamma} < 0.14$ most stringent limit