Isolated leptons, W and single top at HERA

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What's the talk about?

Why these three topics? - What's the interest?

Isolated leptons - Real Ws at HERA?

New NLO W calculations - Pinning the theory down

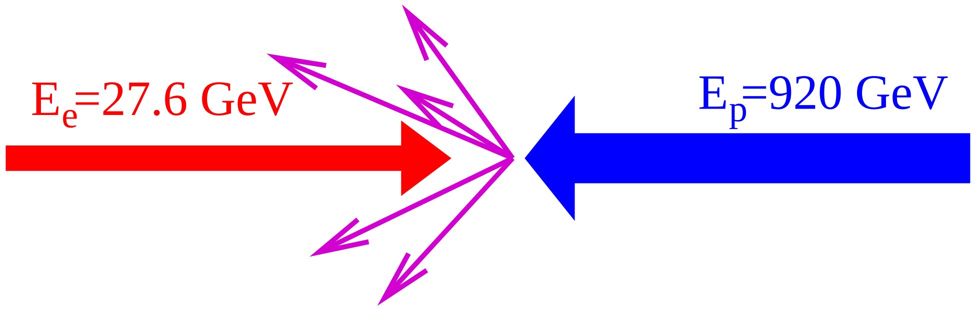
Single top - decaying leptonically

Single top - decaying hadronically

Conclusions and Outlook

Introduction II

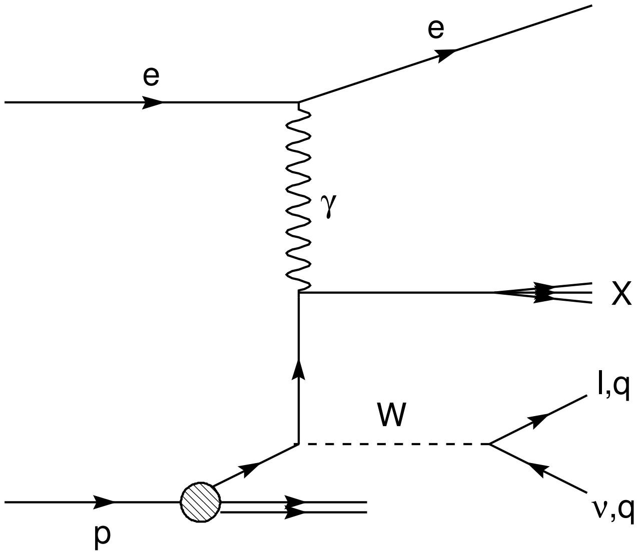
The HERA collider experiments...



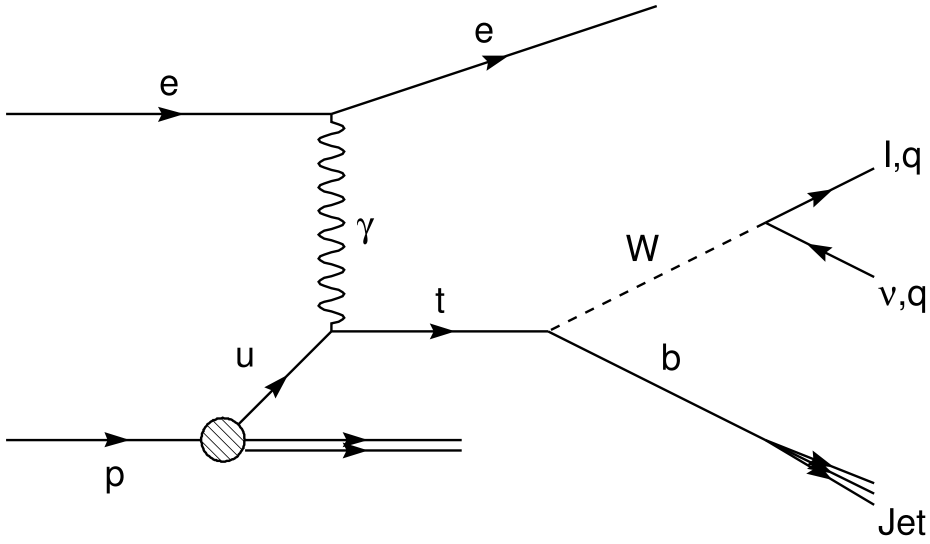
CoM 320 GeV (1998 $\longrightarrow$)

At large Bjorken x the hard subprocess has sufficient energy to produce heavy particles (W, t ...)

Introduction



SM W Production



FCNC Single top Production

Each processes has the same final state:

3 Jets in the hadron channel

Isolated high p_T lepton and missing total p_T in the lepton channel

Anomalous FCNC coupling parameterized by $k_{tu\gamma}$

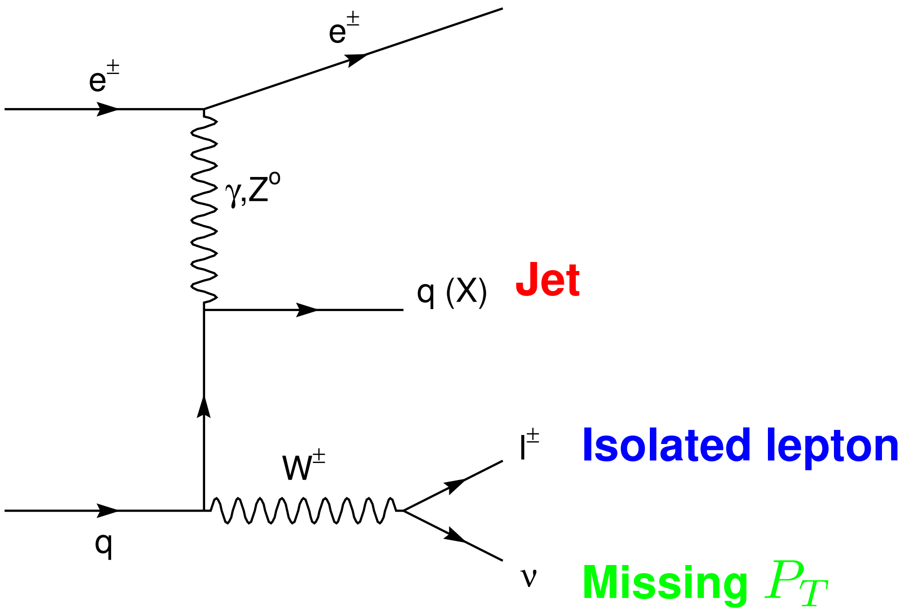
Isolated Leptons and missing p_T

Standard Model (LO) predicts

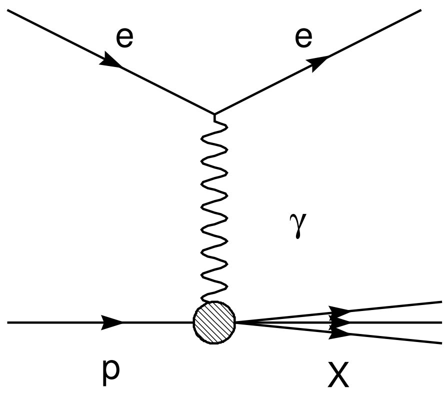
$\sigma(ep \rightarrow eW^{\pm}X) \approx 1pb$

Much of NLO calculation done -

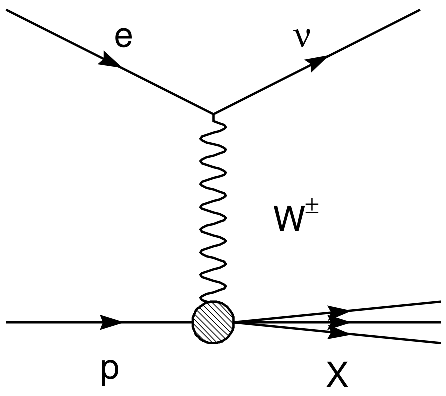
changes LO $\mathcal{O}(10\%)$



Backgrounds:



NC



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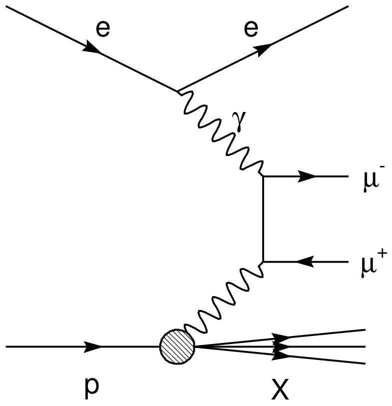


Lepton Pair

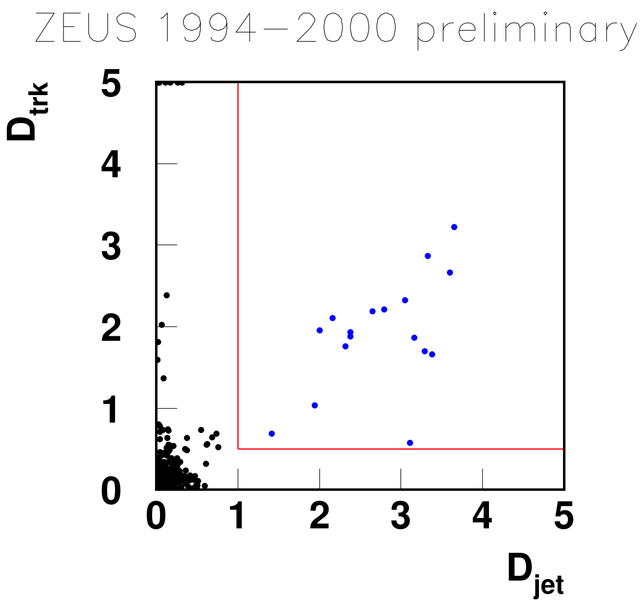
Isolated Leptons and missing p_T

Selection cuts:	H1	ZEUS
P_T^{Cal}	$>$ 12 GeV	$>$ 20 GeV
P_T^{lepton}	$>$ 10 GeV	
Lepton angle	$5^o \rightarrow 145^o$	$17^o \rightarrow 115^o$
Acoplanarity	$> 20^o$(e),$10^o(\mu)$	$> 11.5^o$

D_{track} $>$ 0.5 (Isolation of lepton wrt tracks)

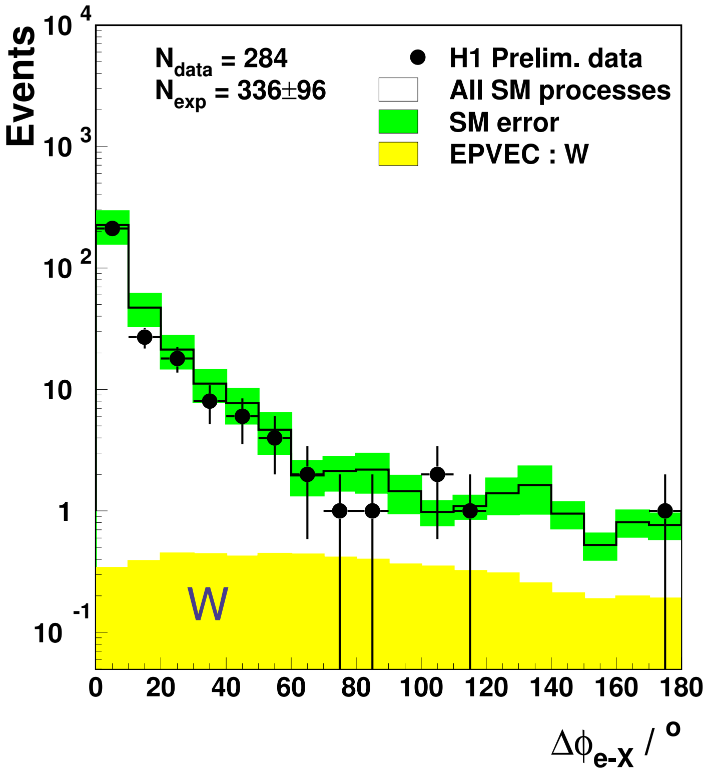
D_{jet} $>$ 1.0 (Isolation of lepton wrt jets)

$$D = (\Delta\eta^2 + \Delta\phi^2)^{\frac{1}{2}}$$

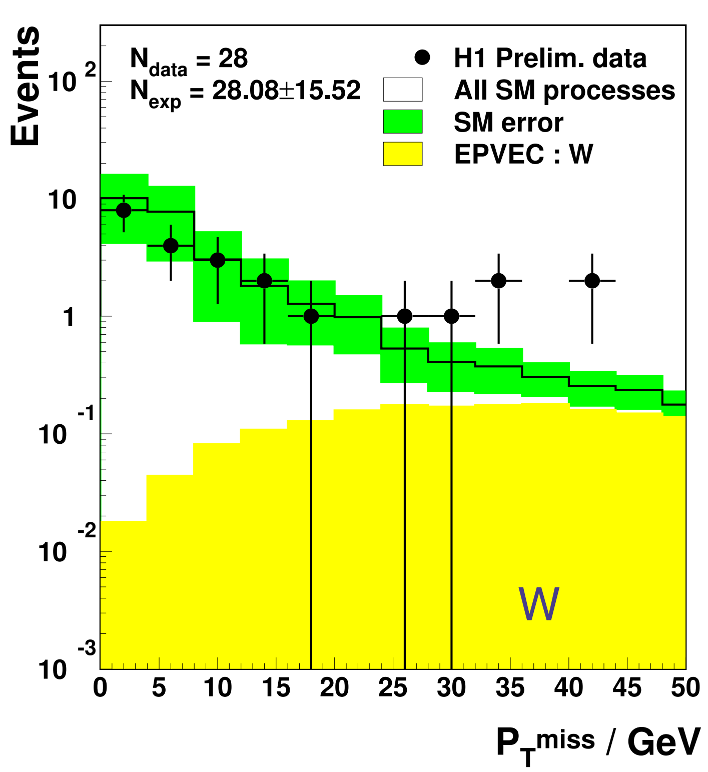


Isolated Leptons and missing p_T

H1 (e) (before acop. cut)



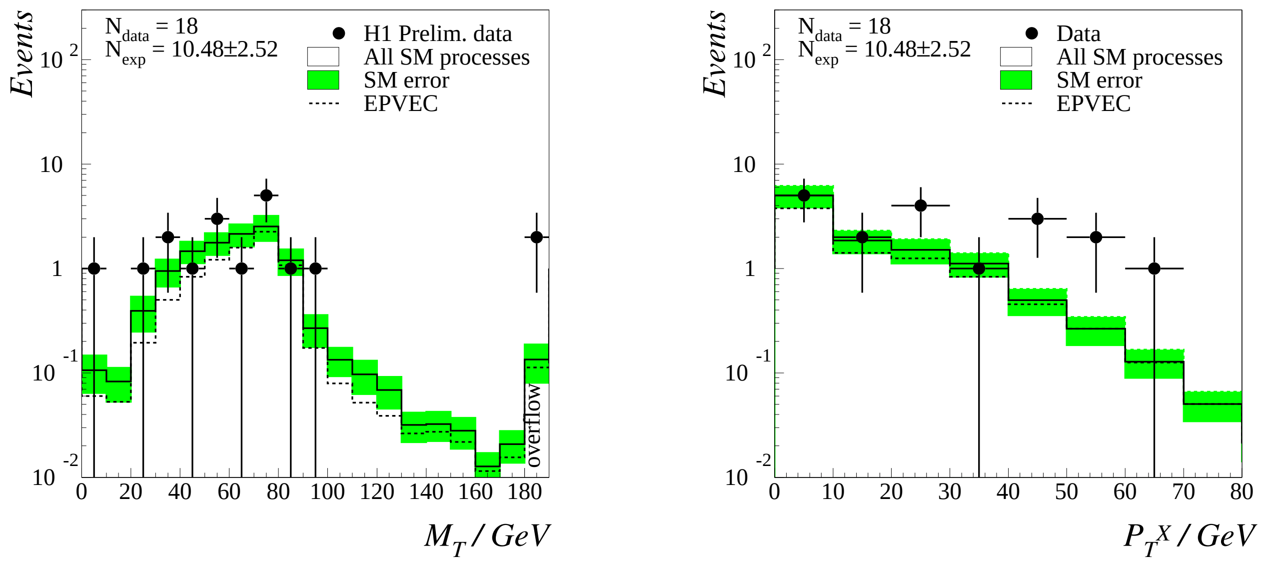
H1 (μ) (before $P_T^{\rm miss}$ cut)



Final cuts $P_T^{\rm miss} > 12$ GeV, $(E - p_z) < 45$ GeV (e),
no $2^{\rm nd}\mu$ (μ channel) and anti-NC cuts

H1 Results 94-00 Isolated Leptons

Electron and Muon	H1 Prel. e^+p Data	SM expectation	W	Other SM processes
$P_T^X > 0$ GeV	18	10.48 ± 2.53	8.19 ± 2.46	2.29 ± 0.59
$P_T^X > 12$ GeV	13	5.14 ± 1.31	4.22 ± 1.27	0.92 ± 0.33
$P_T^X > 25$ GeV	10	2.82 ± 0.73	2.34 ± 0.70	0.48 ± 0.18
$P_T^X > 40$ GeV	6	0.99 ± 0.28	0.93 ± 0.28	0.06 ± 0.04



H1 observe no events in e^-p data sample cf 1.46 ± 0.30 (e) and 0.32 ± 0.09 (μ)

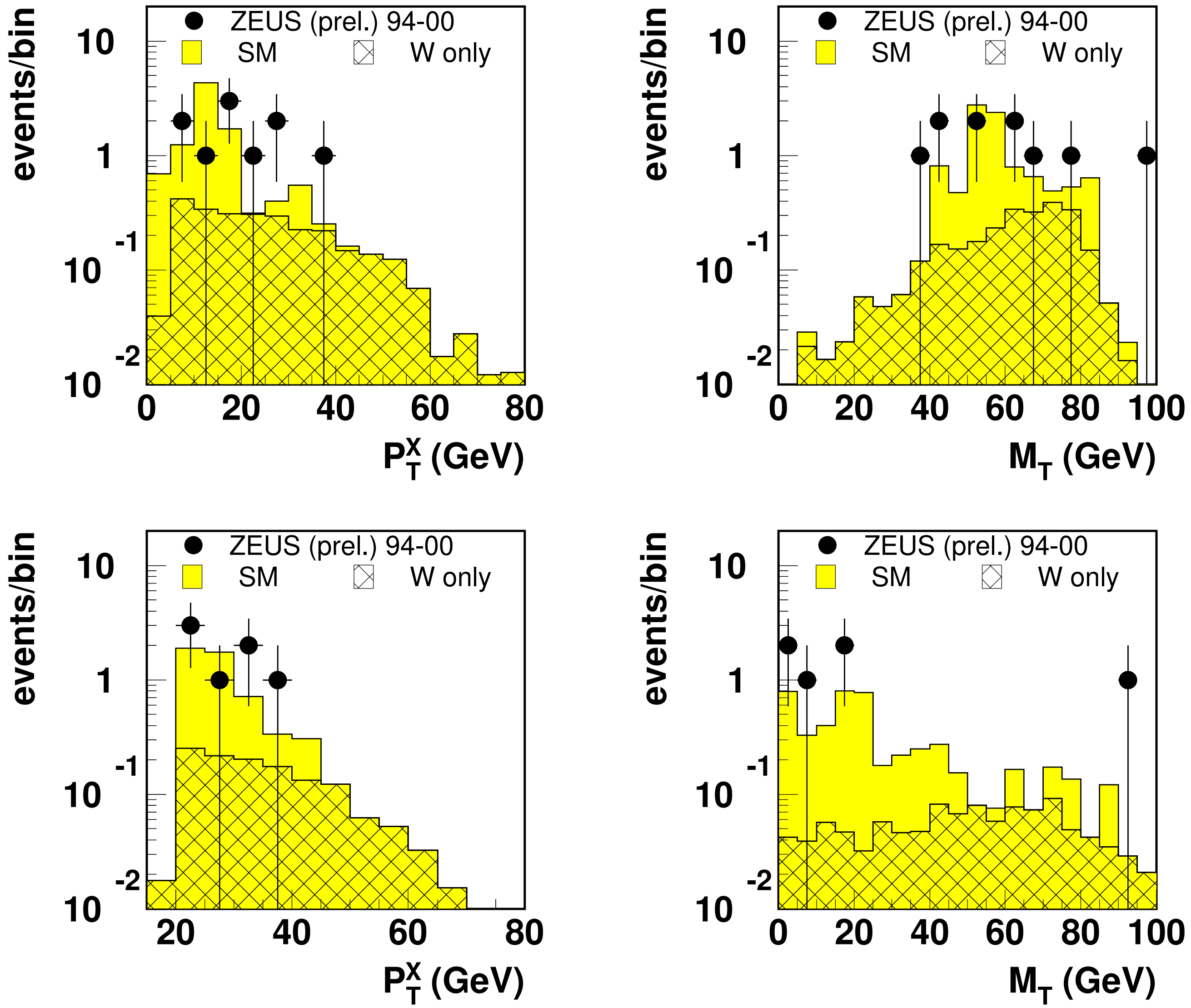
ZEUS Results 94-00 e^+p - Isolated Leptons

10 cf 11.0$\pm$1.6

e channel

7 cf 5.4$\pm$0.7

μ channel



ZEUS Results 94-00 - Isolated Leptons

ZEUS preliminary 1994-2000	Electrons Observed/expected (W)	Muons Observed/expected (W)
e^+p 114 pb^{-1}	7 / 9.9 $\pm$ 1.6 (2.4)	7 / 4.6 $\pm$ 0.6 (1.1)
e^-p 16 pb^{-1}	3 / 1.1 $\pm$ 0.4 (0.3)	0 / 0.8 $\pm$ 0.1 (0.2)
Total 130 pb^{-1}	10 / 11.0 $\pm$ 1.6 (2.7)	7 / 5.4 $\pm$ 0.7 (1.3)

Final selection isolating W component:

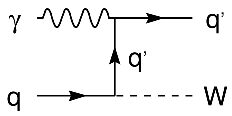
ZEUS preliminary 1994-2000 $e^\pm p$ 130 pb^{-1}	Electrons Observed/expected (W)	Muons Observed/expected (W)
$P_T^X > 25$ GeV	1 / 1.14 $\pm$ 0.06 (1.10)	1 / 1.29 $\pm$ 0.16 (0.95)
$P_T^X > 40$ GeV	0 / 0.46 $\pm$ 0.03 (0.46)	0 / 0.50 $\pm$ 0.08 (0.41)

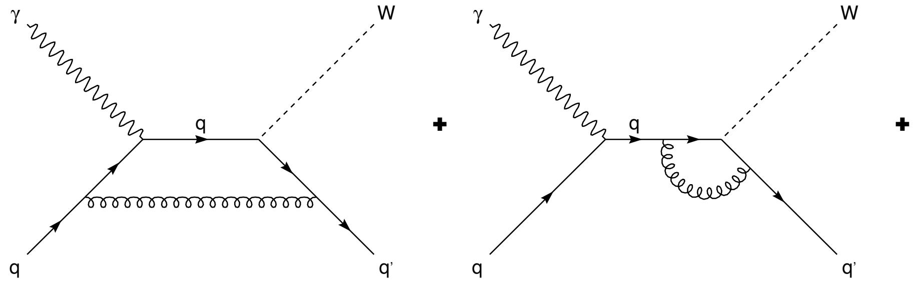
W Production at (N)LO

QCD corrections to the dominant direct part have been calculated:

K. Diener, C. Schwanenberger and M. Spira - hep-ph/0203269

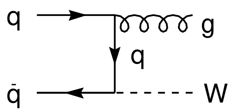
DIR (LO)



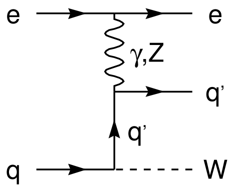


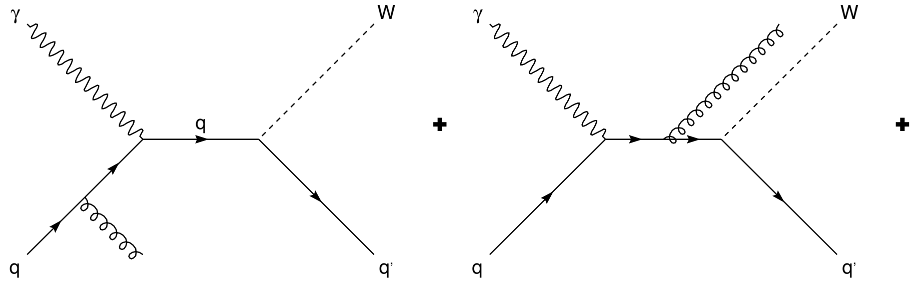
(NLO) Virtual corrections

RES (LO)



DIS (LO)

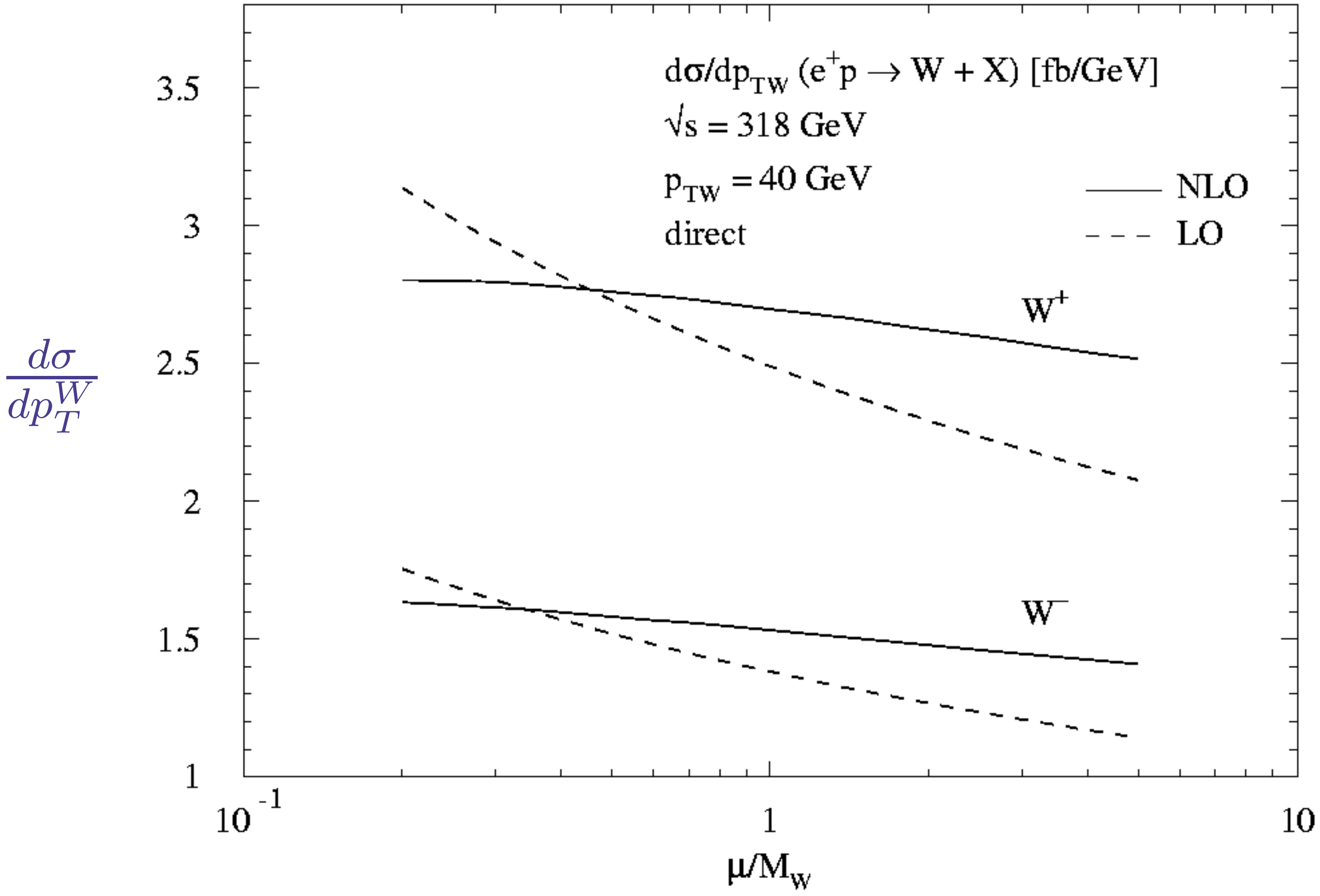




(NLO) Real corrections

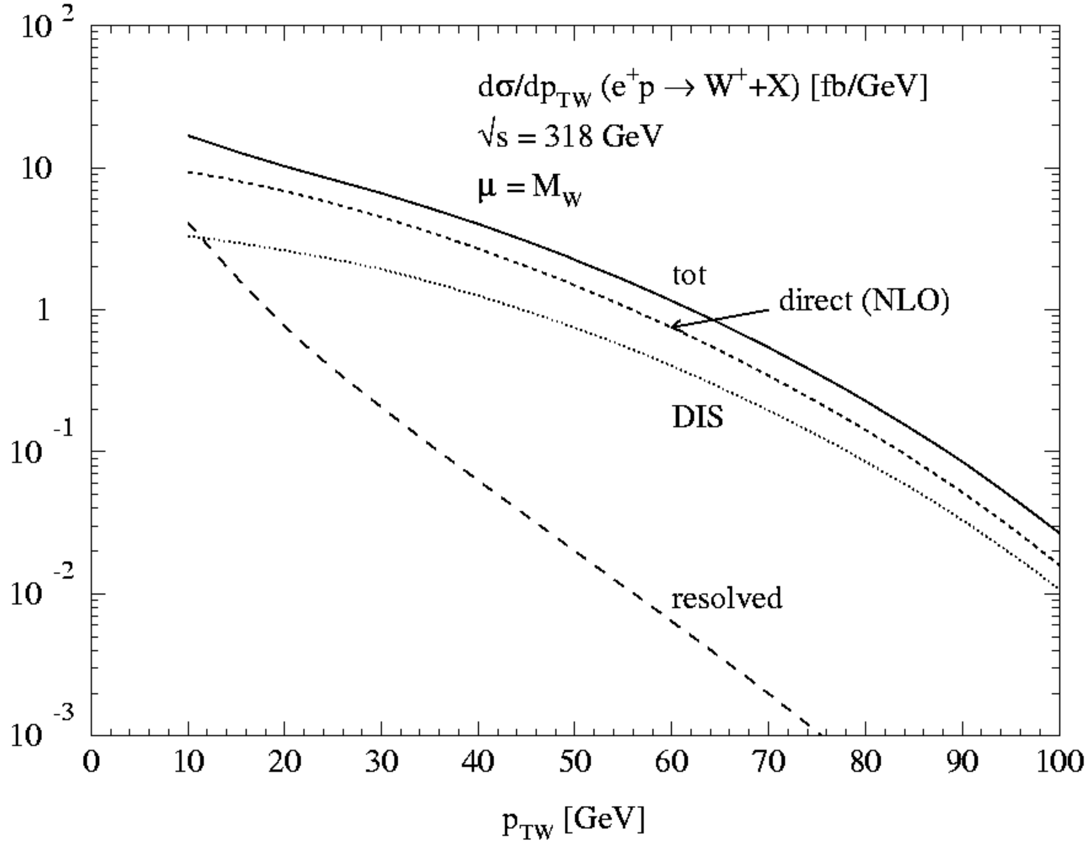
NLO Calculations

LO cross section has very little dependence on Q^2_{max} choice separating DIS and photoproduction regimes, although sensitive to factorisation scale



Higher order QCD corrections reduce the factorisation scale dependence significantly

NLO Calculations



NLO (LO)

P_T^W <25 GeV:

$\sigma(W^+)$ = 0.478 pb (0.366 pb)

$\sigma(W^-)$ = 0.484 pb (0.351 pb)

P_T^W >25 GeV:

$\sigma(W^+)$ = 0.150 pb (0.140 pb)

$\sigma(W^-)$ = 0.084 pb (0.076 pb)

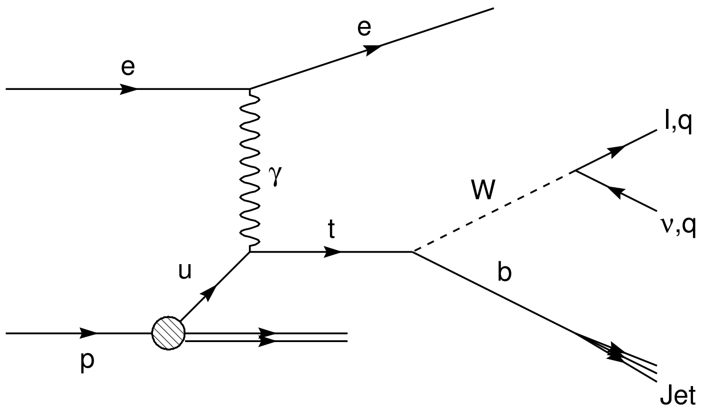
QCD corrections to the DIS part are still unknown

but expected to be similar size to NLO direct contribution

Corrections dominated by soft gluon effects $\longrightarrow$, little effect on $\frac{d\sigma}{dP_T}$.

Single top production

Interpret these kind of events as single top?



Recall : $P_T^X > 25$ GeV H1 report 10 cf. 2.82

and at $P_T^X > 40$ GeV ZEUS report 0 cf. 0.46

ZEUS observe no candidates for single top production and correspondingly set an upper limit (at 95% C.L.) of $k_{tu\gamma} < 0.257$ (leptonic decays only)

H1 add further cuts to separate top production from SM W:

$P_T^{\mathrm{Jet}} > 25$ GeV, $M_T^{l\nu} > 10$ GeV and only positive leptons!

(Hard b-jet) (Real W) (Very little $\bar{u}$ in proton)

H1 Single top - leptonic decay

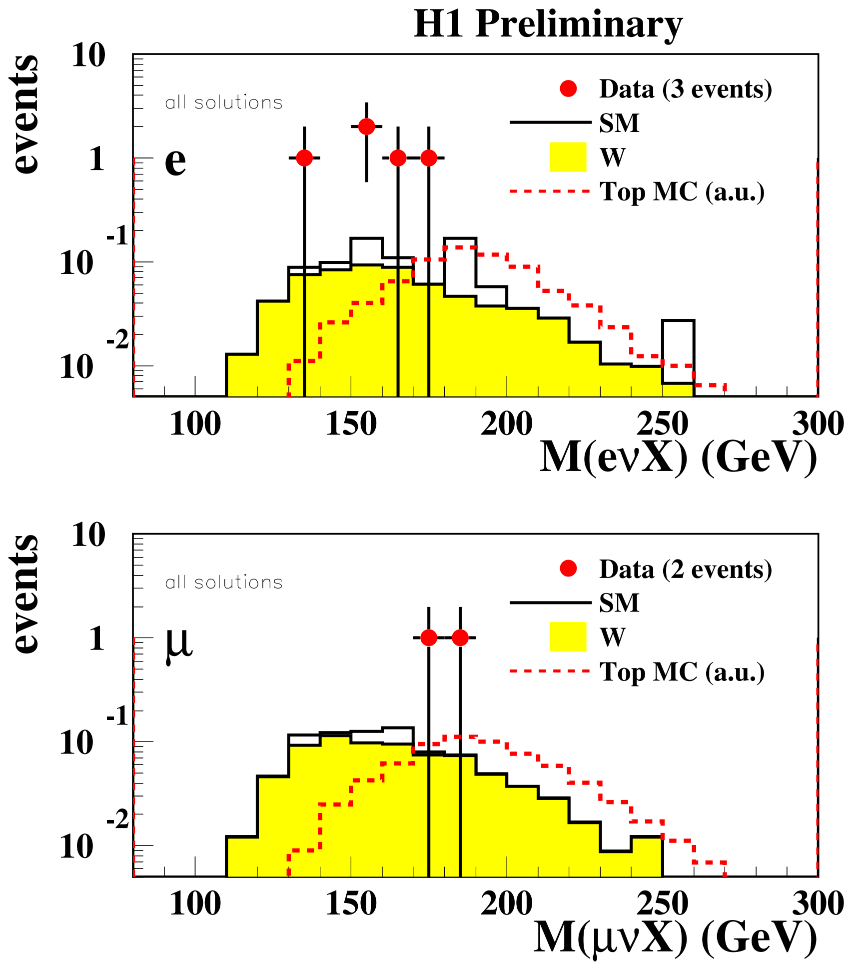
	Electron Channel	Muon Channel
Data	3	2
Total SM	0.75 ± 0.18	0.77 ± 0.21
W only	0.51 ± 0.16	0.68 ± 0.19
Efficiency	37%	45%

No events in small $e^- p$ data set (13.6 pb^{-1})

cf. 0.25 ± 0.05 expected

$\longrightarrow \sigma$(920 GeV) < 0.95 pb

$k_\gamma < 0.32$



Single top - Hadronic decay

Select events with:

At least 3 hadronic jets

Within the range : -0.5 $< \eta^{\rm jet} <$ 2.5 (H1)

-1 $< \eta^{\rm jet} <$ 2.5 (ZEUS)

Ordered in P_T:

$P_T^{\rm jet} >$25, 20, 15 GeV (H1 Control Sample)

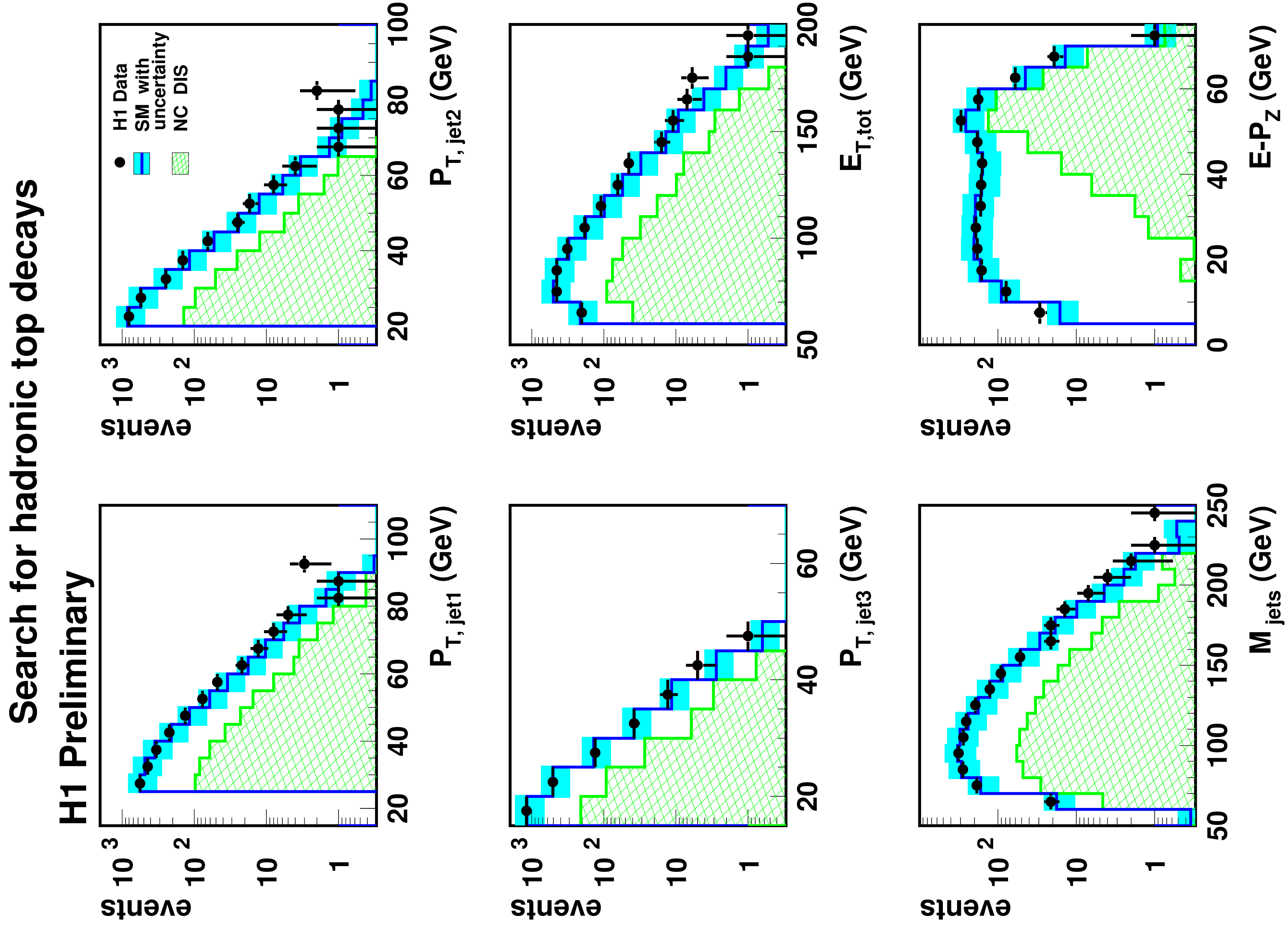
Final selection (H1) : $P_T^{\rm jet} >$40, 25, 20 GeV

$E_T^{\rm tot} >$110 GeV

Final selection (ZEUS) : $P_T^{\rm jet} >$40, 25, 14 GeV

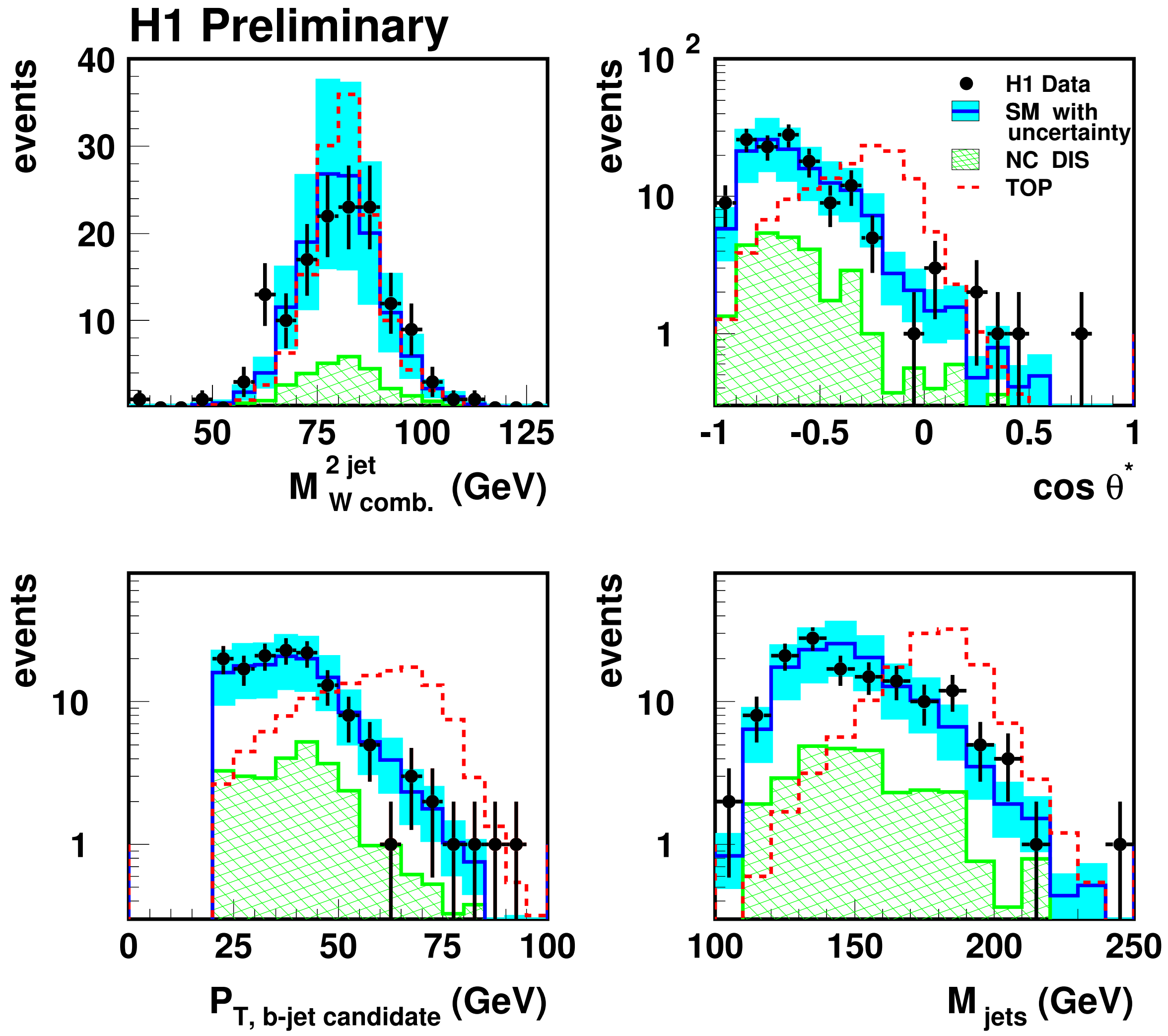
No DIS (reject electrons)

Single top - Hadronic decay (H1)



Single top - Hadronic decay - (H1)

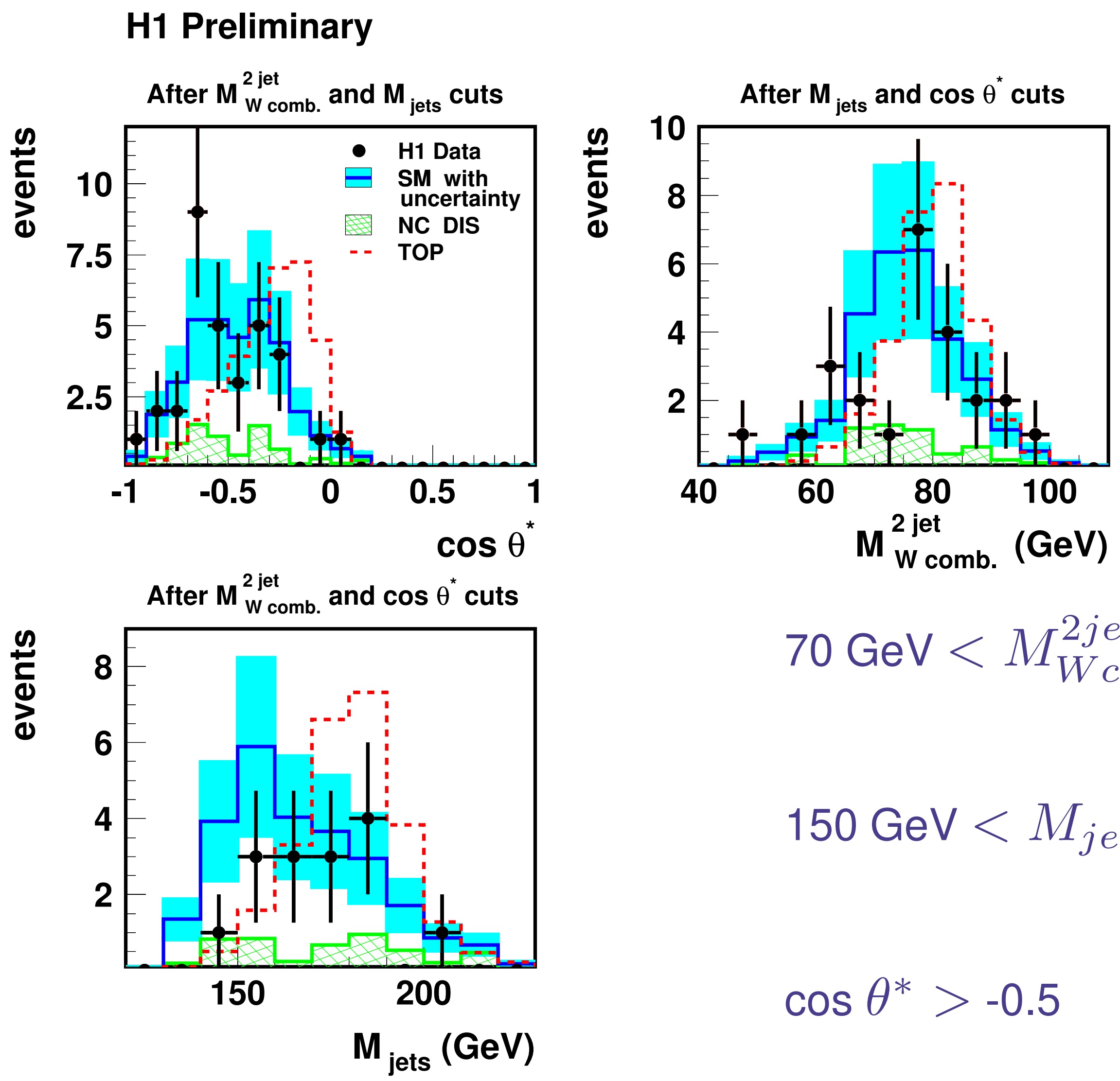
Search for hadronic top decays - high E_T sample



Top Ansatz assigns two jets closest to 80 GeV to the W.

θ^* is angle between W jets in top system

Single top - Hadronic decay - (H1)

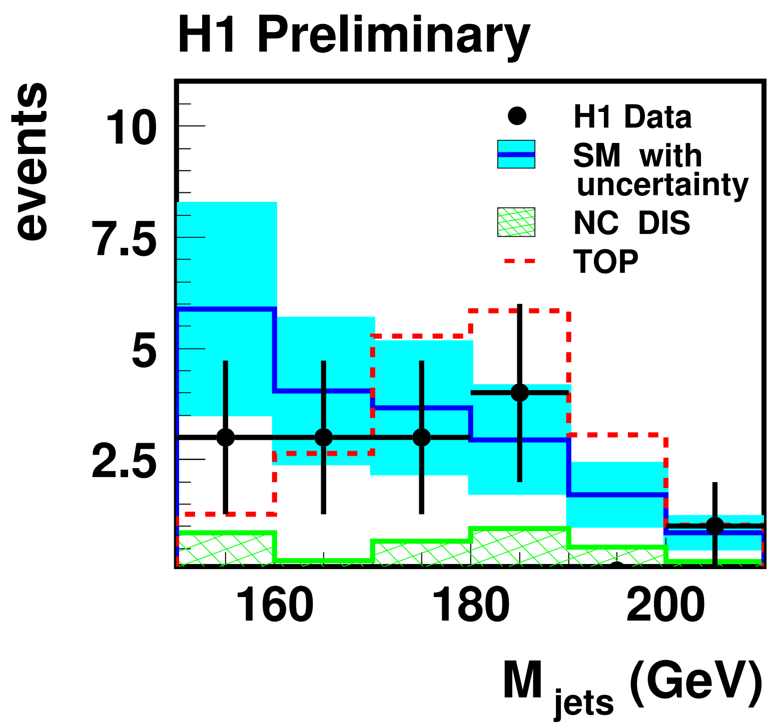


70 GeV $< M^{2jet}_{W comb.} <$ 90 GeV

150 GeV $< M_{jets} <$ 210 GeV

cos $\theta^* >$ -0.5

Single top - Hadronic decay - (H1)



After all top cuts

After top cuts:

14 events selected cf. 19.6 $\pm$ 7.8

Efficiency ($t \longrightarrow$ 3 jets) 27%

Exclusion limits at 95% C.L.:

Hadronic Channel : σ_{top} (320 GeV) $<$ 0.40 pb

Hadronic and Leptonic Channel : σ_{top} (320 GeV) $<$ 0.43 pb

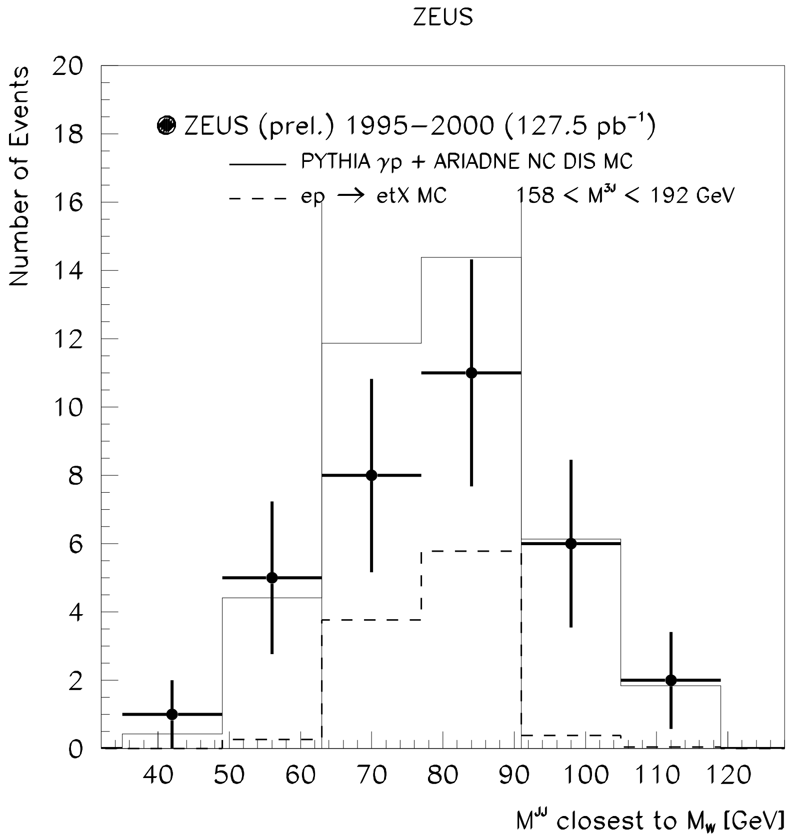
$k_{tu\gamma} <$ 0.22

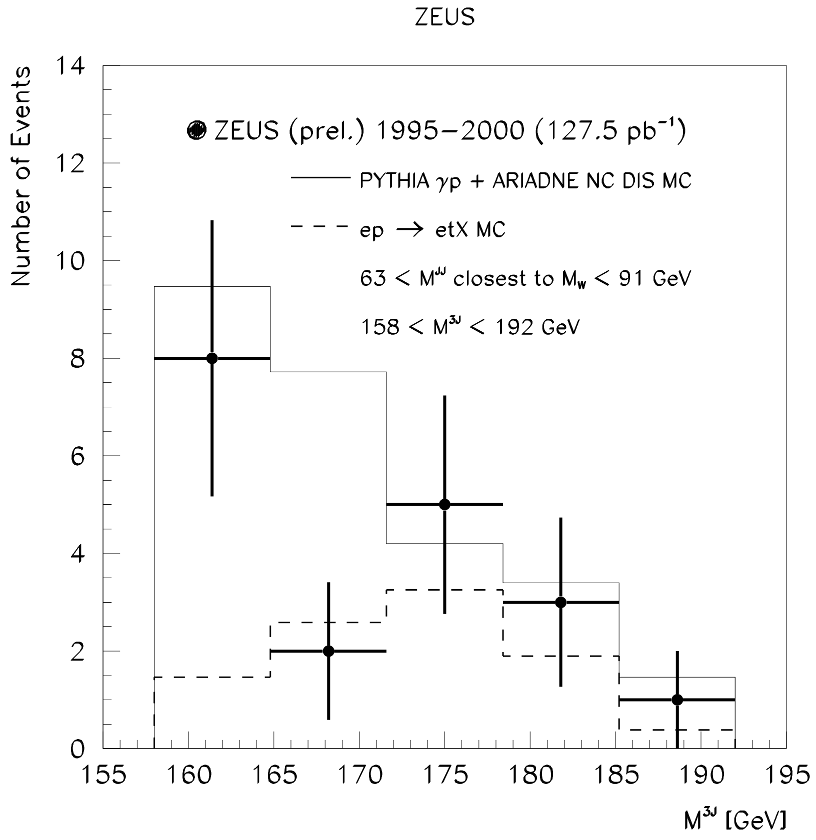
Single top - Hadronic decay - (ZEUS)

$63 < M^{JJ}$ closest to $M_W < 91$ GeV

and

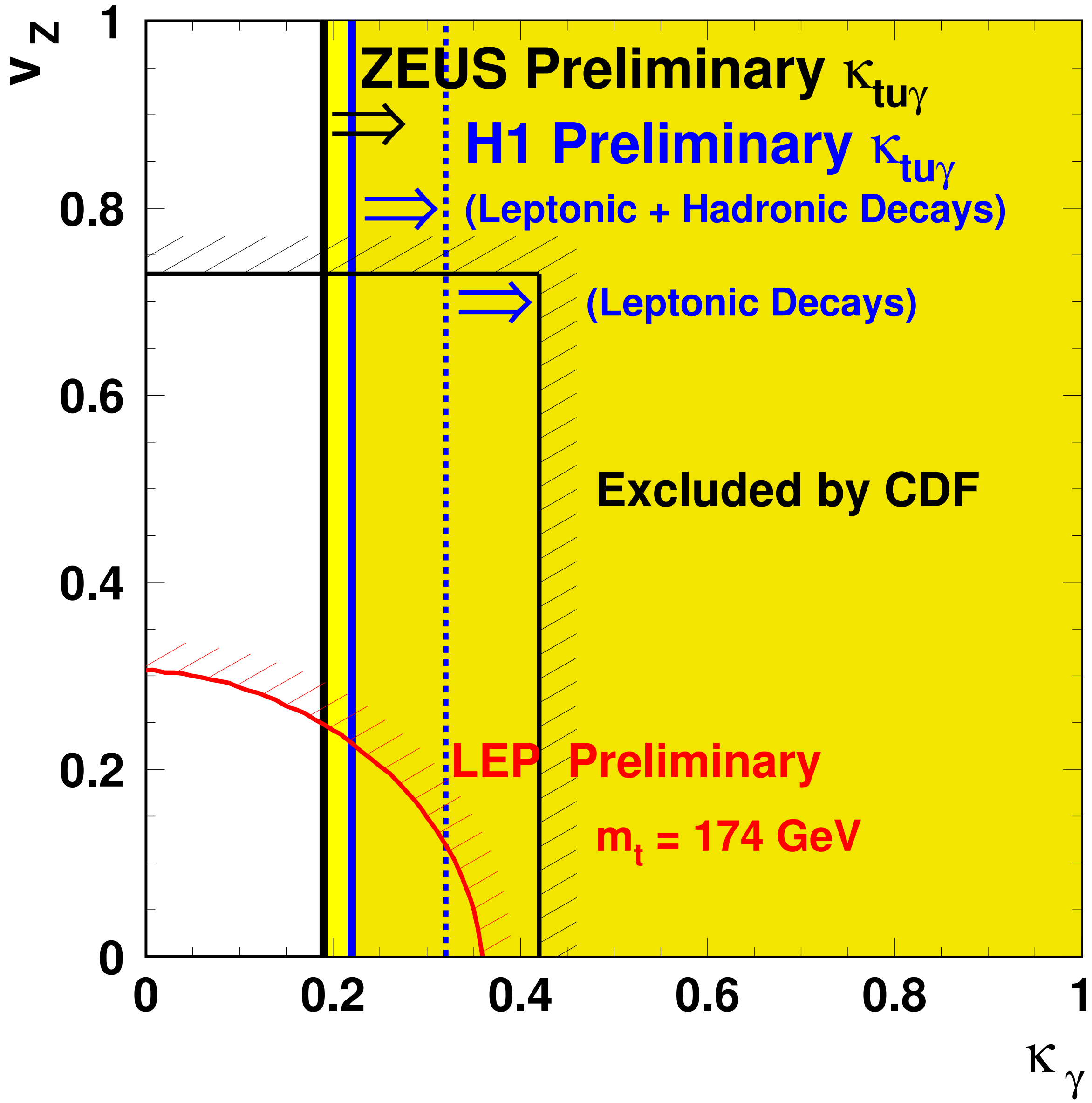
$158 < M^{3J} < 192$ GeV





19 events selected cf. 20.0 expected

Limits on single top - (H1 and ZEUS)



$k_{tu\gamma} < 0.22$ (H1)

$k_{tu\gamma} < 0.19$ (ZEUS)

Conclusions and Outlook

The HERA experiments already have access to rare heavy particle production

Intriguing results in leptonic channel

Theory becoming very well controlled (NLO W)

H1 and ZEUS competing globally in $k_{tu\gamma}$ phase space

Imminent HERA II data is keenly awaited...