Search for Single Top Quark Production at HERA

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On behalf of the H1 and ZEUS collaborations

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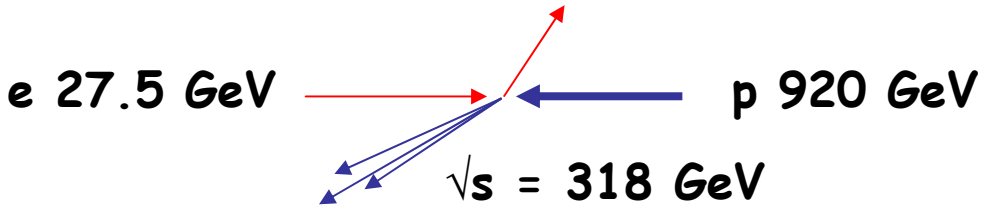
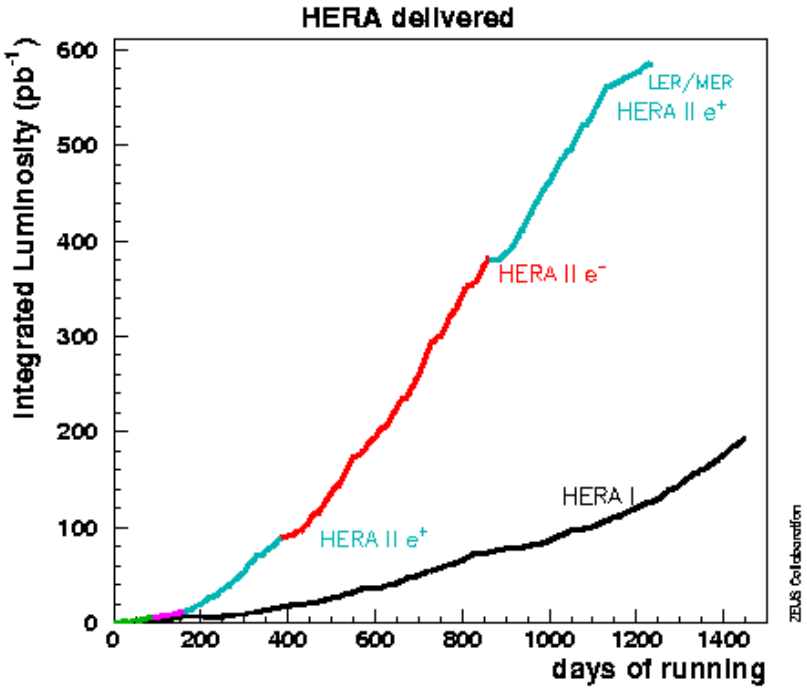
HERA performances



HERA running up to June 2007

Total integrated luminosity:
HERA I:
e+p ~ 100 pb^{-1}
e-p ~ 15 pb^{-1}

HERA II:
e+p ~ 200 pb^{-1}
e-p ~ 200 pb^{-1}



Results presented in this talk:

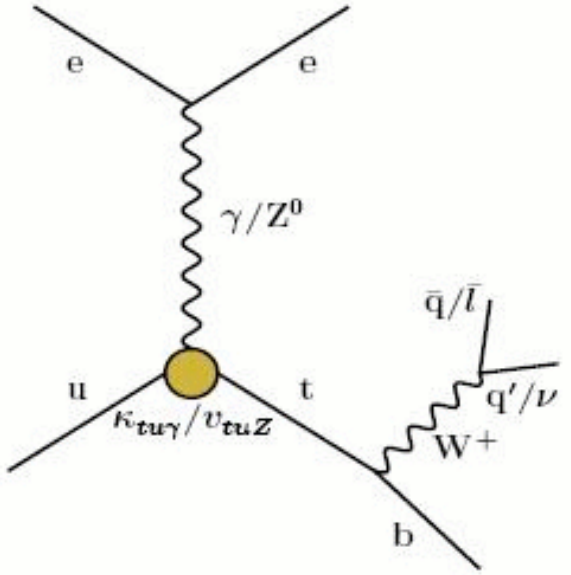
H1 474 pb^{-1}, full e±p data sample, published DESY-09-050
ZEUS: 277 pb^{-1} (HERA II prel.)
+ 120 pb^{-1} (HERA I PLB 559 (2003) 153)

Single top production at HERA

SM top production at HERA negligible,
σ < 1fb

BSM effects could enhance the cross section via FCNC effective couplings:

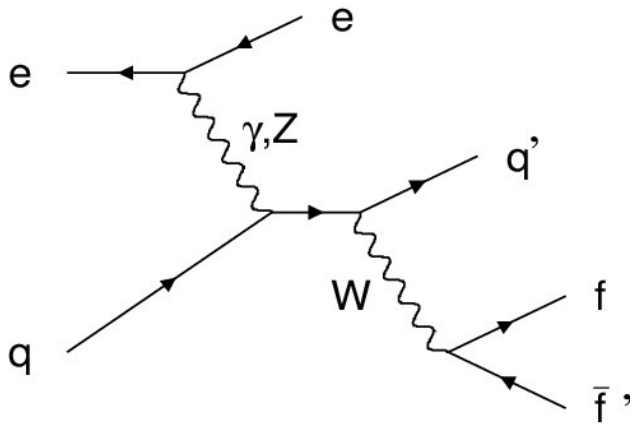
$$\mathcal{L} = \frac{e e_u}{\Lambda} \bar{t} \sigma_{\mu\nu} q^{\nu} \kappa_{\gamma} u A^{\mu}$$



Clear topology in the leptonic channel:
high pt leptons, large missing pt
also the hadronic channel can be exploited

In SM such events predominantly due to W production (σ~1pb)

HERA experiments sensitive to anomalous coupling involving u-quark and γ exchange



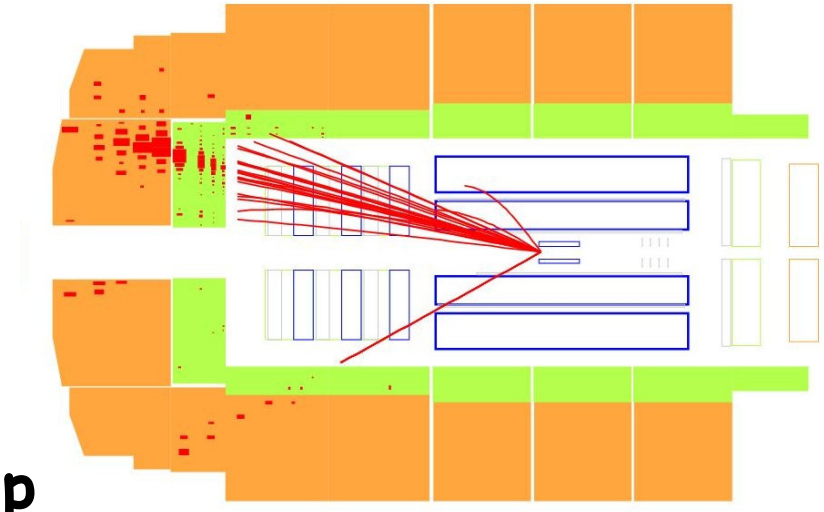
H1 - Analysis

Published: DESY-09-050

- Full data sample used, 474 pb^{-1}

- Exploited electron, muon and hadron channels

- Multivariate discriminant technique based on a neural network used to discriminate top production from SM background

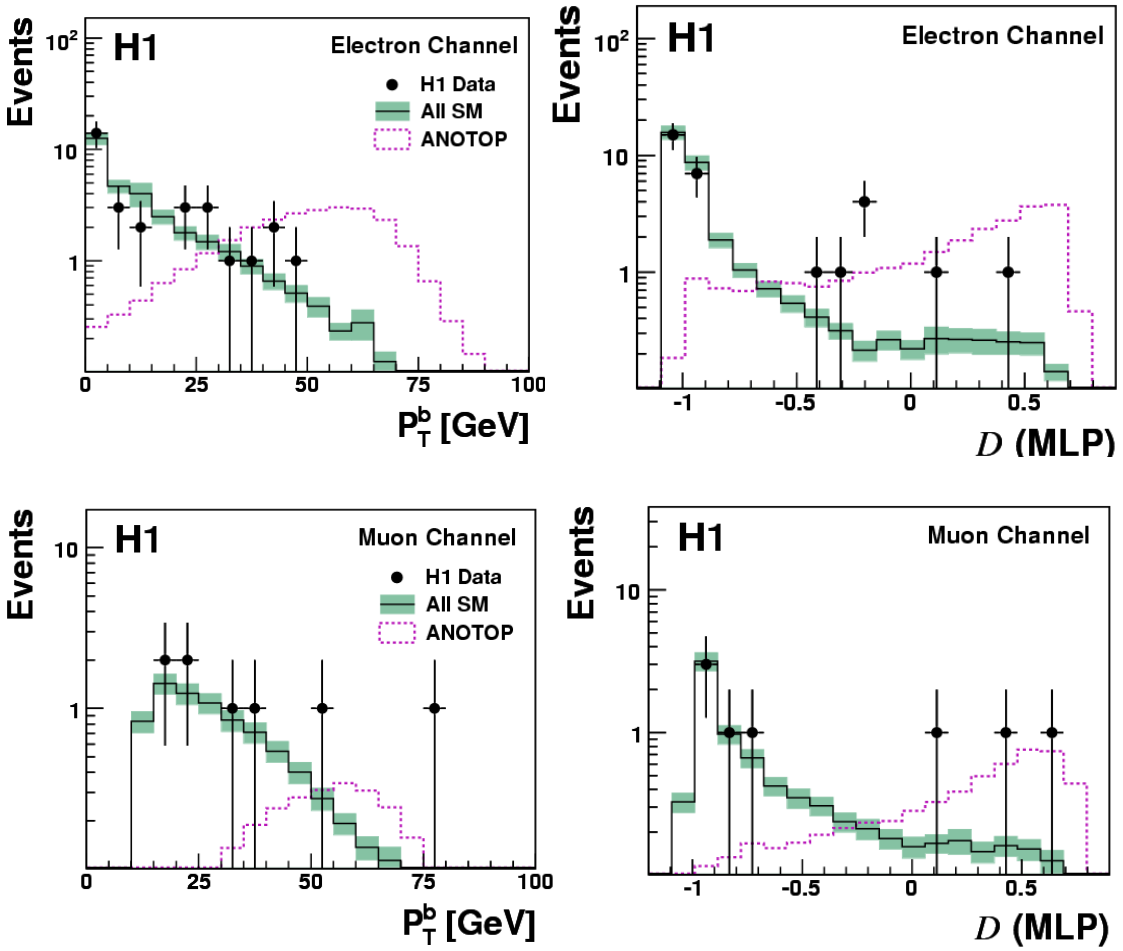


H1 - Leptonic channel

- Selection based on the isolated lepton analysis arXiv:0901.0488d

- Leptons isolated from jets and other tracks in the event

$P_{T,miss} > 12$ GeV
$p_{T,lep} > 10$ GeV
$0.1 < \theta_{lep} < 2.4$ rad



Data in overall agreement with the SM predictions
Slight excess of data in the signal region

H1 - Hadronic channel

- At least 3 jets in $-0.5 < \eta < 2.5$

- Jets ordered in P_T:

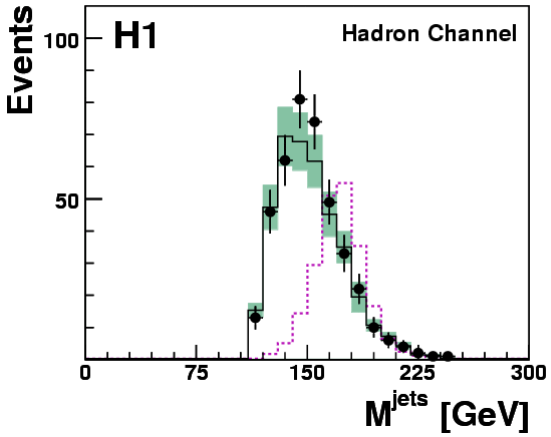
$P_{T,1} > 40$ GeV

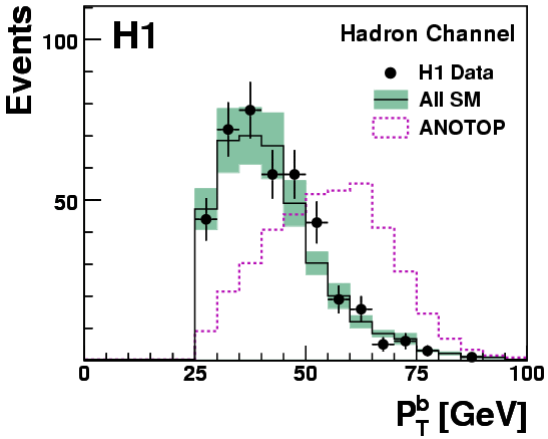
$P_{T,2} > 30$ GeV

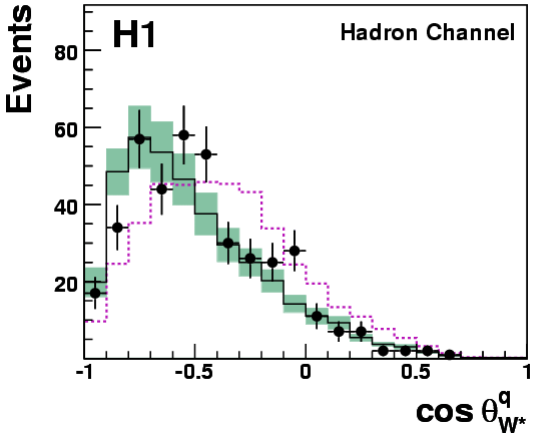
$P_{T,3} > 15$ GeV

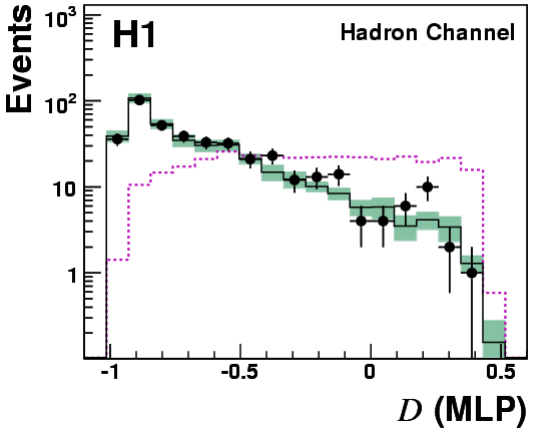
- Cut on the scalar sum of jet P_T

$\sum P_{T,jet} > 110$ GeV









Data in overall good agreement with the SM predictions

H1 - Results

No significant excess

→ **set limits on single top production**

H1 Search for Single Top Production $e^{\pm}p, 474pb^{-1}$

Channel	Upper Limit at 95% CL			
	$\sigma(ep \to tX, \sqrt{s} = 319\ GeV)$ Observed[pb]	Expected[pb]	$\kappa_{tu\gamma}$	$\mathcal{B}(t \to u\gamma)$ [%]
Electron	0.40	0.24	0.21 - 0.23	0.82 - 1.02
Muon	0.30	0.22	0.18 - 0.20	0.61 - 0.76
Electron+Muon	0.27	0.15	0.17 - 0.19	0.55 - 0.69
Hadronic	0.42	0.27	0.21 - 0.24	0.86 - 1.07
Combined	0.25	0.12	0.16 - 0.18	0.51 - 0.64

- **Slight excess of events compatible with signal**
  → **limits larger than expected from a toy model assuming a pure SM scenario**
- **NLO corrections to single top production accounted for**
- **Coupling and Br limits range due to M_{top} uncertainties (170-175 GeV)**

ZEUS - Analysis

Preliminary results:
277 pb-1 of data collected in 2005-2007

Muon channel preselection:

$P_{T,miss}$ > 10 GeV

Muon candidate:

p_T>8 GeV, isolated from other tracks and jets

Electron channel preselection:

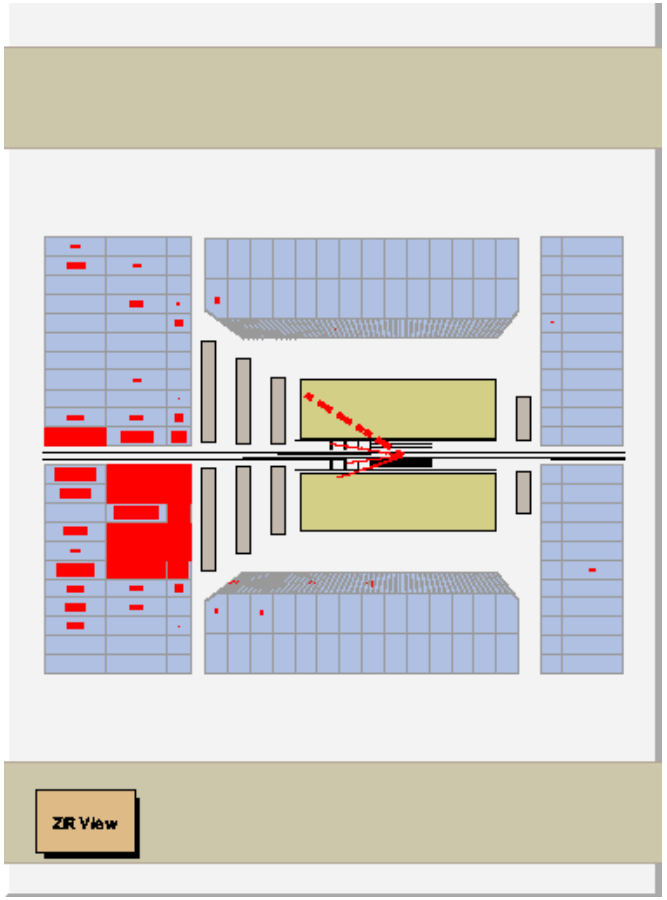
5 < $E-P_Z$ < 50 GeV

$P_{T,miss}$ > 12 GeV

Electron candidate:

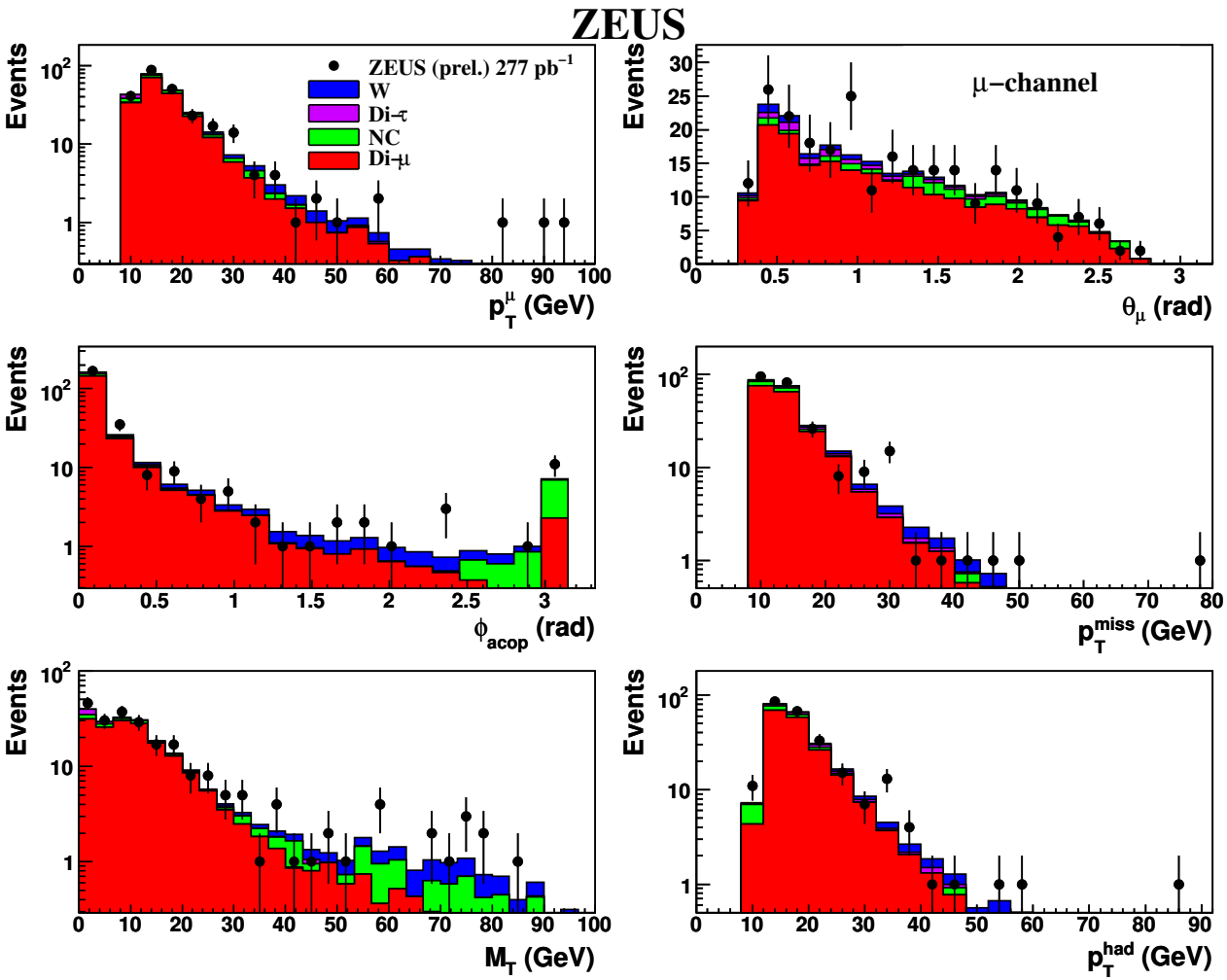
p_T > 10 GeV, isolated from other tracks and jet

Acoplanarity > 0.1 rad



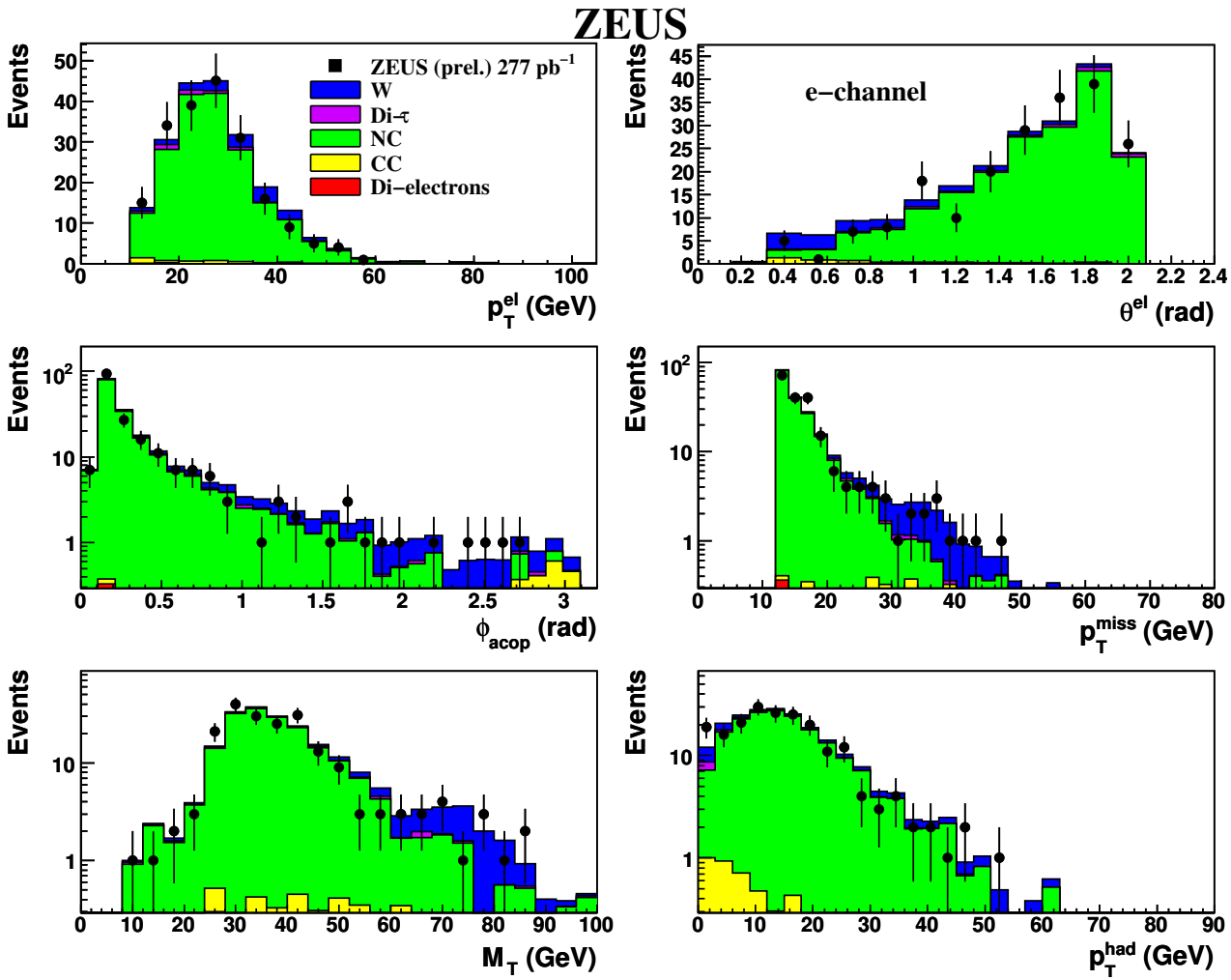
ZEUS - Muon channel

- Overall reasonable agreement between data and SM expectations
- Dominant background QED di-muon production
- SM W production visible at large acoplanarity and M_T
- No significant excess at large hadronic P_T, where single top signal is expected

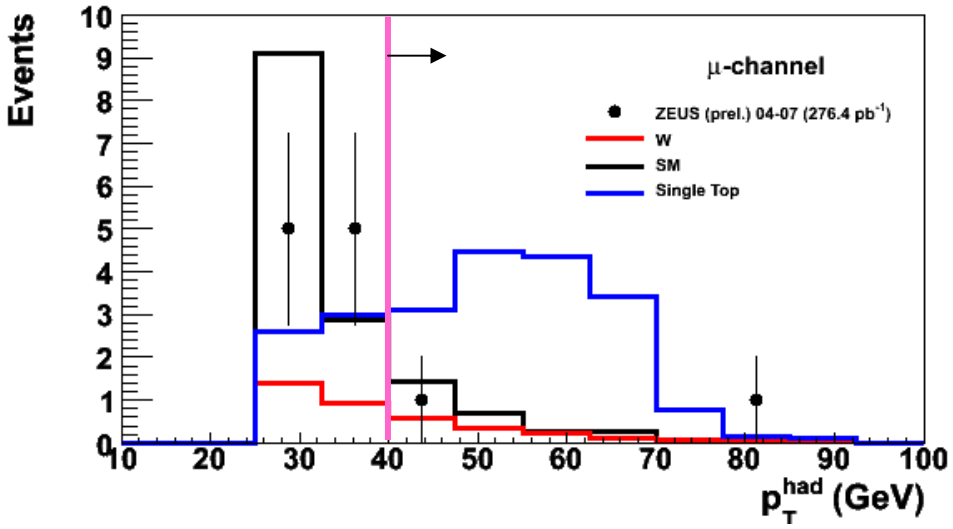


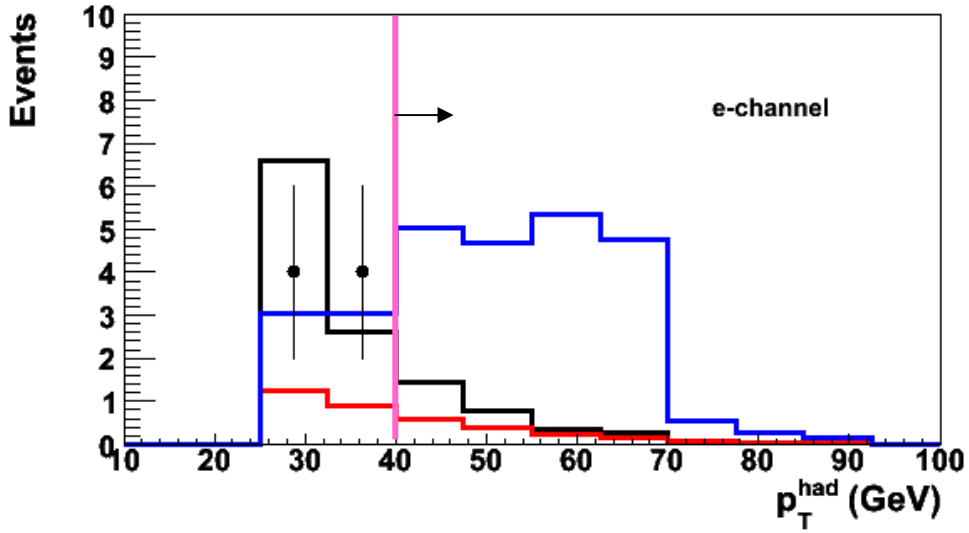
ZEUS - Electron channel

- Overall good agreement between data and SM expectations
- Dominant background Neutral Current DIS
- SM W production visible at large acoplanarity, M_T and $P_{T,miss}$
- No significant excess at large hadronic P_T, where single top signal is expected



ZEUS - Final selection





Muon channel:

Acoplanarity > 0.05 rad
Event rejected if more than one muon

Electron channel:

Acoplanarity > 0.15 rad
$P_{T,miss}$ > 15 GeV

Both channels:

$P_{T,had}$ > 40 GeV

Good agreement between data and MC
No excess at high $P_{T,had}$

ZEUS - Results

Final Selection

	N_{obs}	N_{pred}	W[%]	Eff. × Br.
Muon Channel 04-05 e^-p	1	1.5±0.4	47	0.026
Muon Channel 06-07 e^+p	1	1.4±0.4	50	0.026
Electron Channel 04-05 e^-p	0	2.1±0.6	38	0.033
Electron Channel 06-07 e^+p	0	0.9 ±0.3	78	0.033

Results of the selection converted in limits on signal cross section using a Bayesian approach and assuming a constant prior on the signal cross section:

$$\sigma < 0.23 \text{ pb (95\% C.L.)}$$

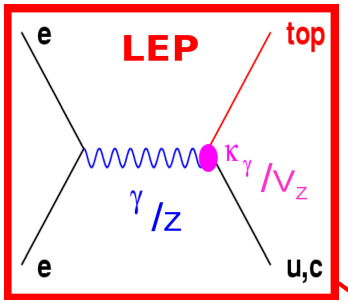
corresponding to a limit on the coupling $k_{tu\gamma}$:

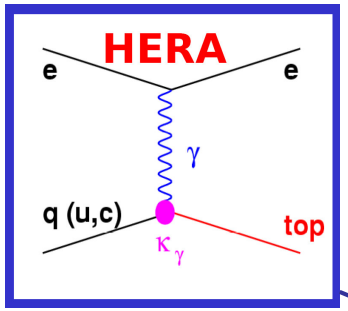
$$k_{tu\gamma} < 0.17 \text{ (0.16-0.18)}, \; M_{top} = 171.2 \pm 2.1 \text{ GeV}$$

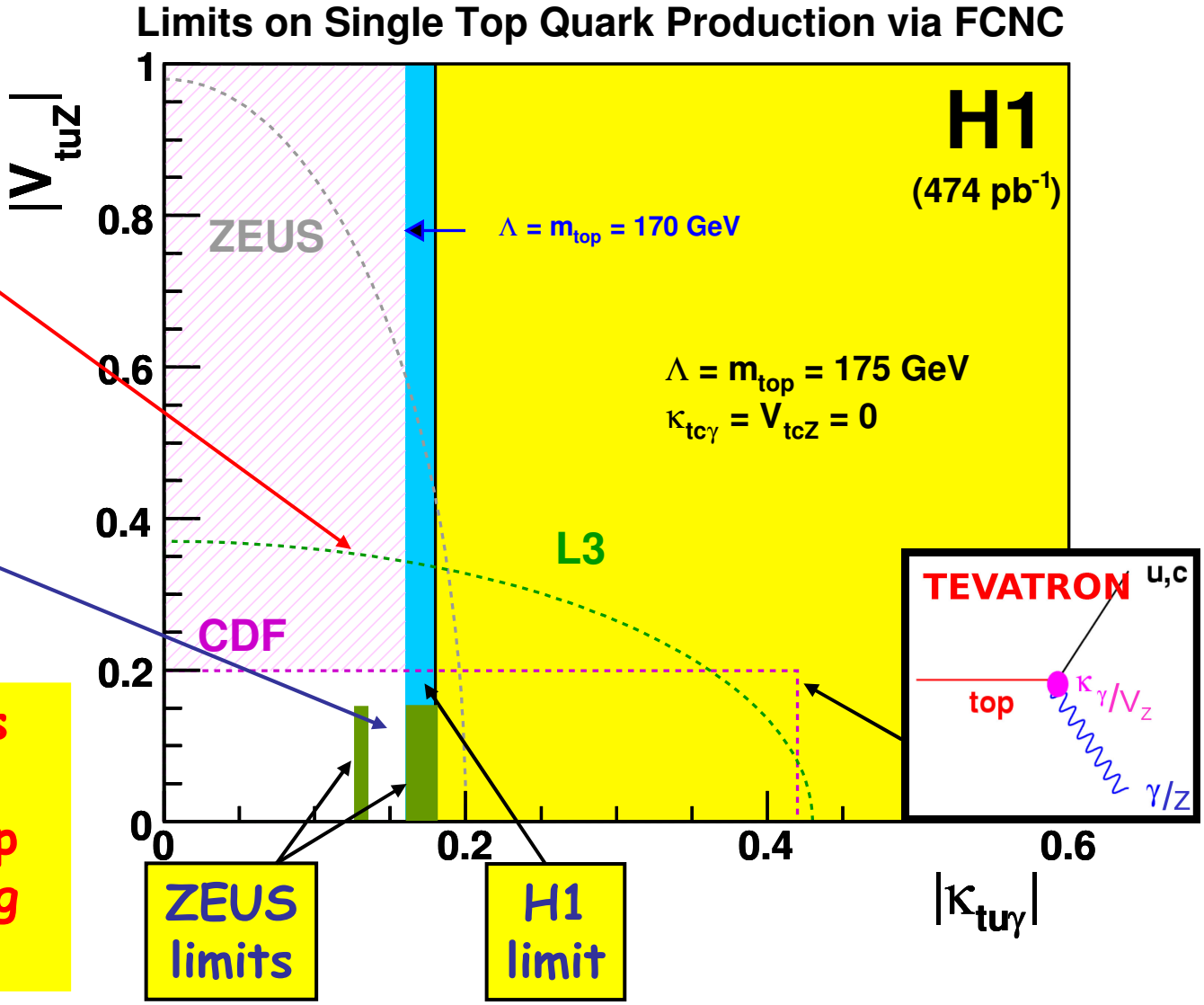
This result has been combined with the HERA I limit (using only the samples at $\sqrt{s}$=318 GeV) for a total int. luminosity of 359 pb^{-1}:

$$\sigma < 0.13 \text{ pb}, \; k_{tu\gamma} < 0.13 \Longrightarrow \text{Br}(t \to u\gamma) < 0.34\%$$

Comparison with other colliders







HERA experiments have the best sensitivity to u-top transitions involving γ-exchange

Conclusions

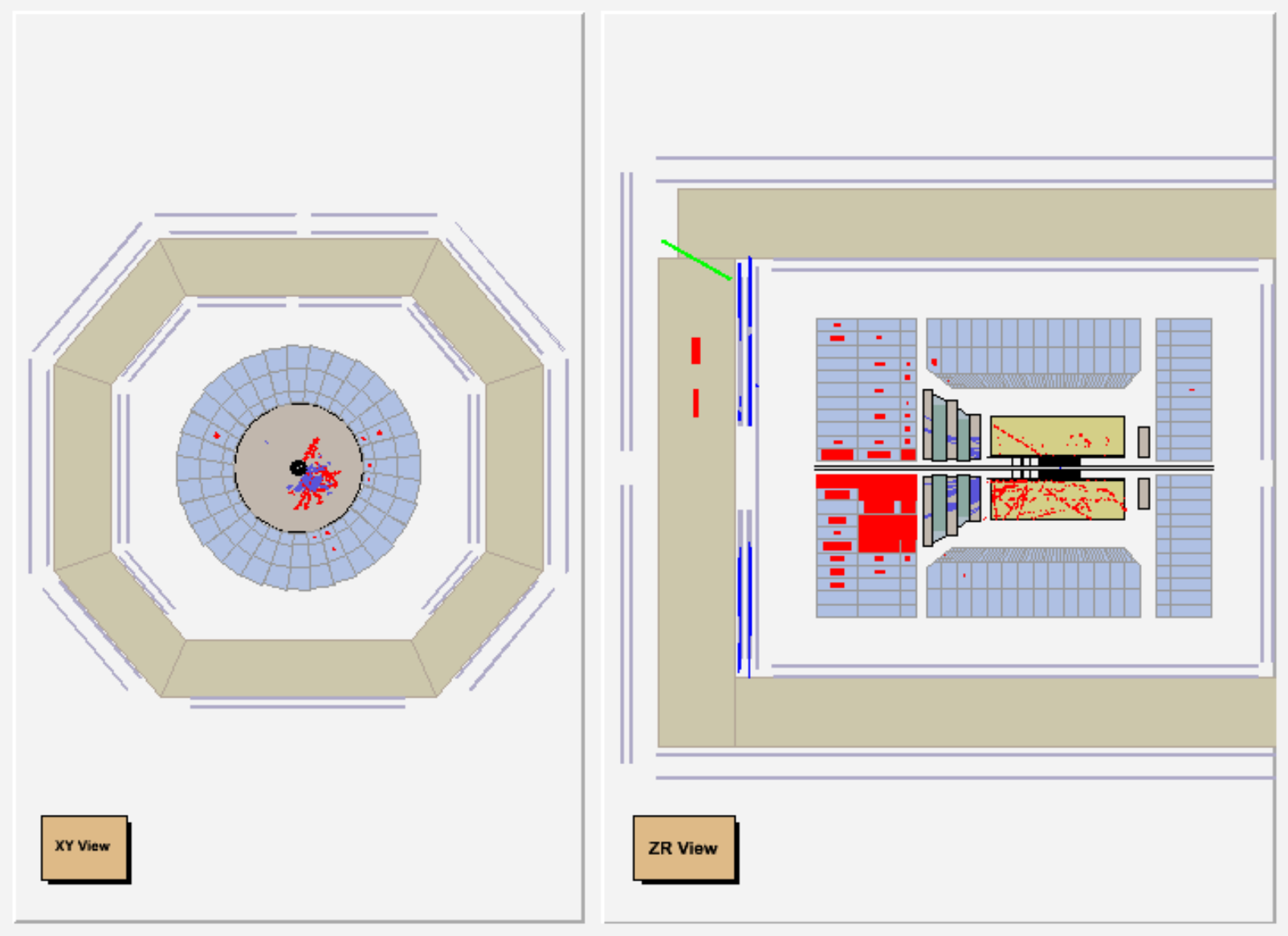
• Both HERA experiments H1 and ZEUS have produced competitive constraints studying single top production mediated by FCNC couplings

• Due to its peculiar initial state HERA is largely complementary with respect to other colliders:

LEP and Tevatron better constrain processes involving c-top transitions or mediated by Z-exchange

On the other hand HERA limits are the best to date for u-top transitions and γ-exchange

Selected events



Selected events