Search for Anomalous Single Top Production at HERA

Stefano Antonelli on behalf H1 and ZEUS Coll.

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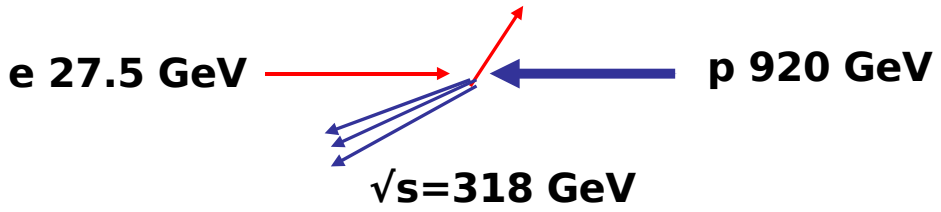
Madrid, DIS09

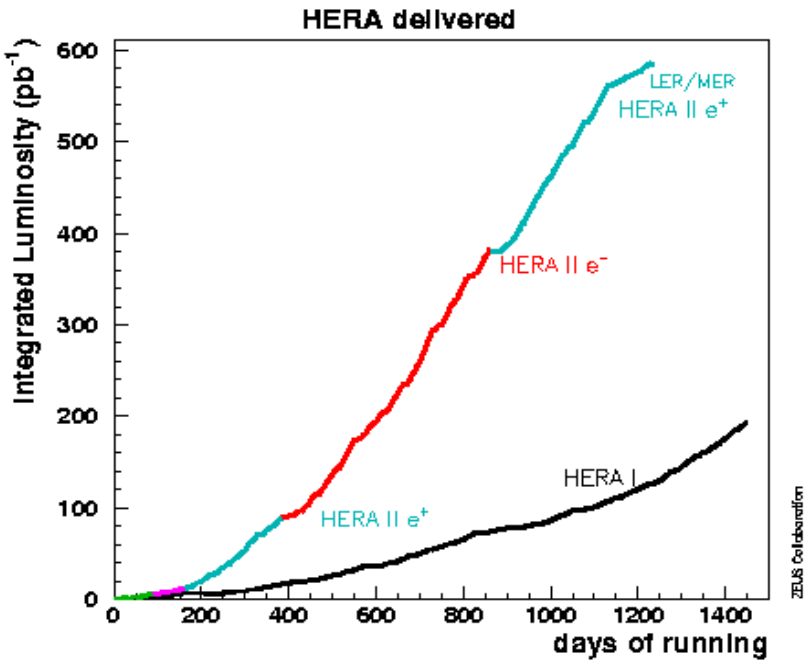
HERA performances



Lumi integrated by experiments:

HERA I
e+p ~ 100 pb-1
e-p ~ 15 pb-1

HERA II (polarisation ~ 30%)
e+p ~200 pb-1
e-p ~ 200 pb-1



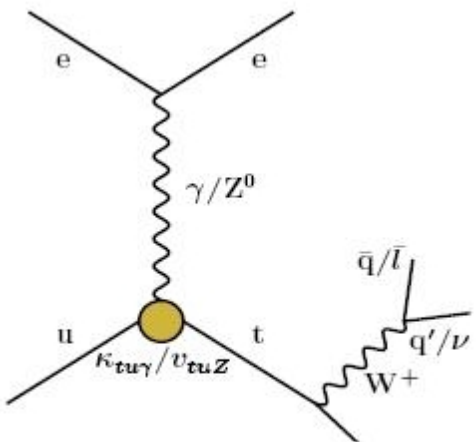
HERA running up to summer 2007

Results on anomalous single top production presented

H1 474 pb^{-1} full $e^{\pm}p$ data sample, **HERAI+II published DESY-09-050**
ZEUS 277 pb^{-1} (HERAII prelim.) + 120 pb^{-1} (HERAI, publ. PLB 559 (2003) 153)

Anomalous Single Top Production

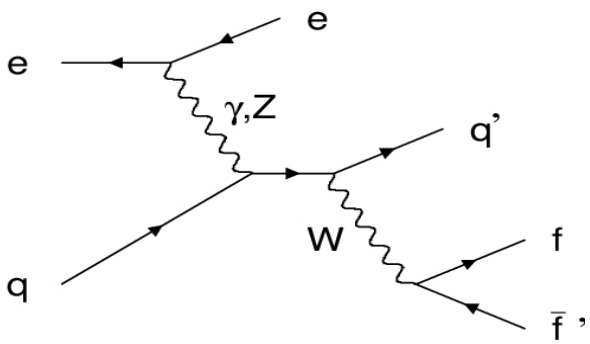
At HERA single top search is related to events with high-p_T leptons and high missing p_T but also the hadronic decay of W can be exploited.



Anomalous single top production (BSM) proceeds via FCNC with a coupling $\kappa_{tu\gamma}$.

$$\mathcal{L} = \frac{ee_u}{\Lambda}\bar{t}\sigma_{\mu\nu}q^{\nu}\kappa_{\gamma}uA^{\mu}$$

couplings to c and Z are neglected



In SM, events with isolated lepton are mainly due to W production ($\sim 1.2\,pb$).

HERA experiments are sensitive to u (valence quark) and anomalous γ exchange

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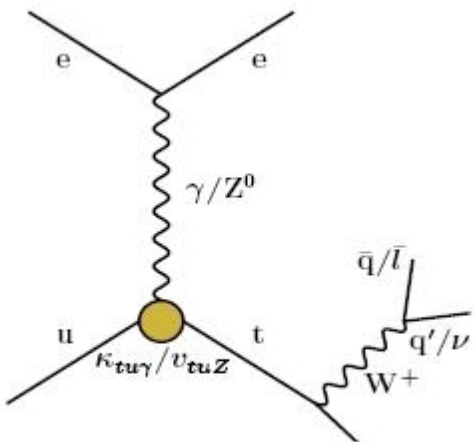

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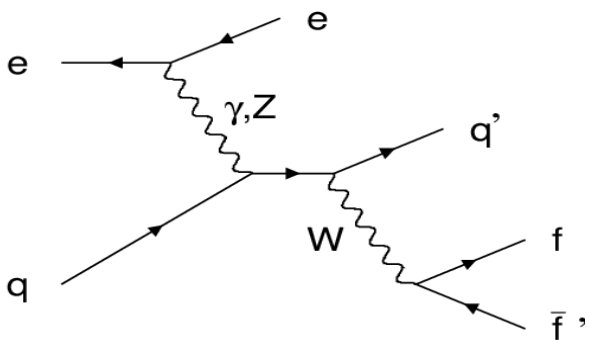

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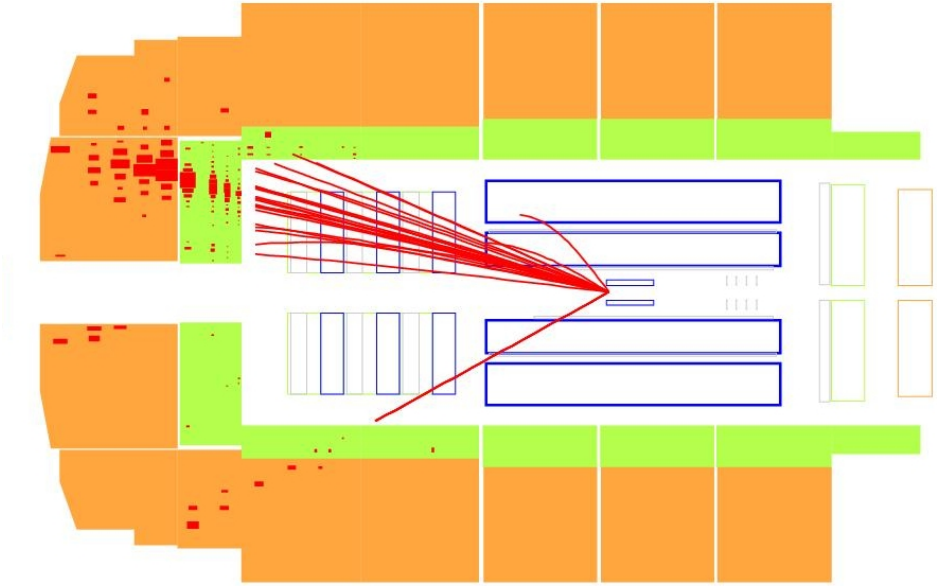
H1 Anomalous Single Top Search

Result published:
DESY-09-050

Full data sample collected by H1 at HERA: integrated luminosity $474 pb^{-1}$

Search for anomalous top production looking at **muon**, **electron** and **hadron** channels

Multivariate discriminant method based on a neural network used to differentiate top quark production from SM background



Leptonic Channel - H1

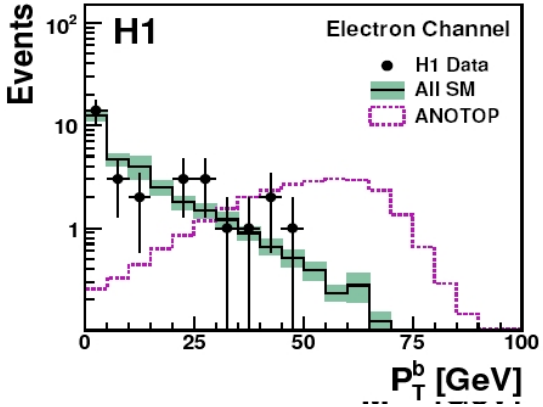
Leptonic Channel
(based on the isolated lepton analysis arXiv:0901.0488)

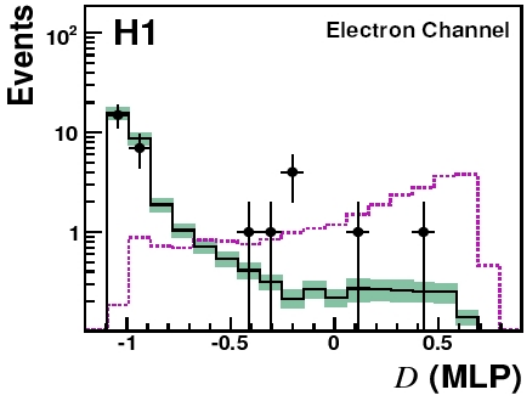
Leptons isolated from jets and other tracks in the event and:

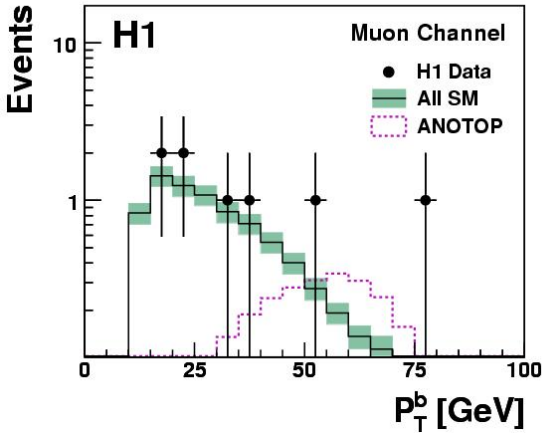
$p_{T,miss} > 12\ GeV$

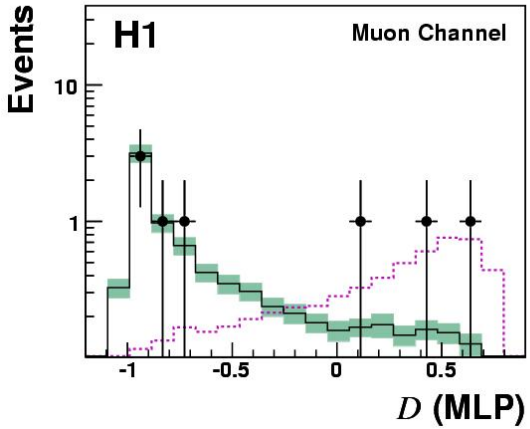
p_T of the leptons $> 10\ GeV$

polar angle $0.1 < \theta < 2.4\ rad$









The data are in overall agreement with the SM pred. A slight excess of data in the signal region is visible.

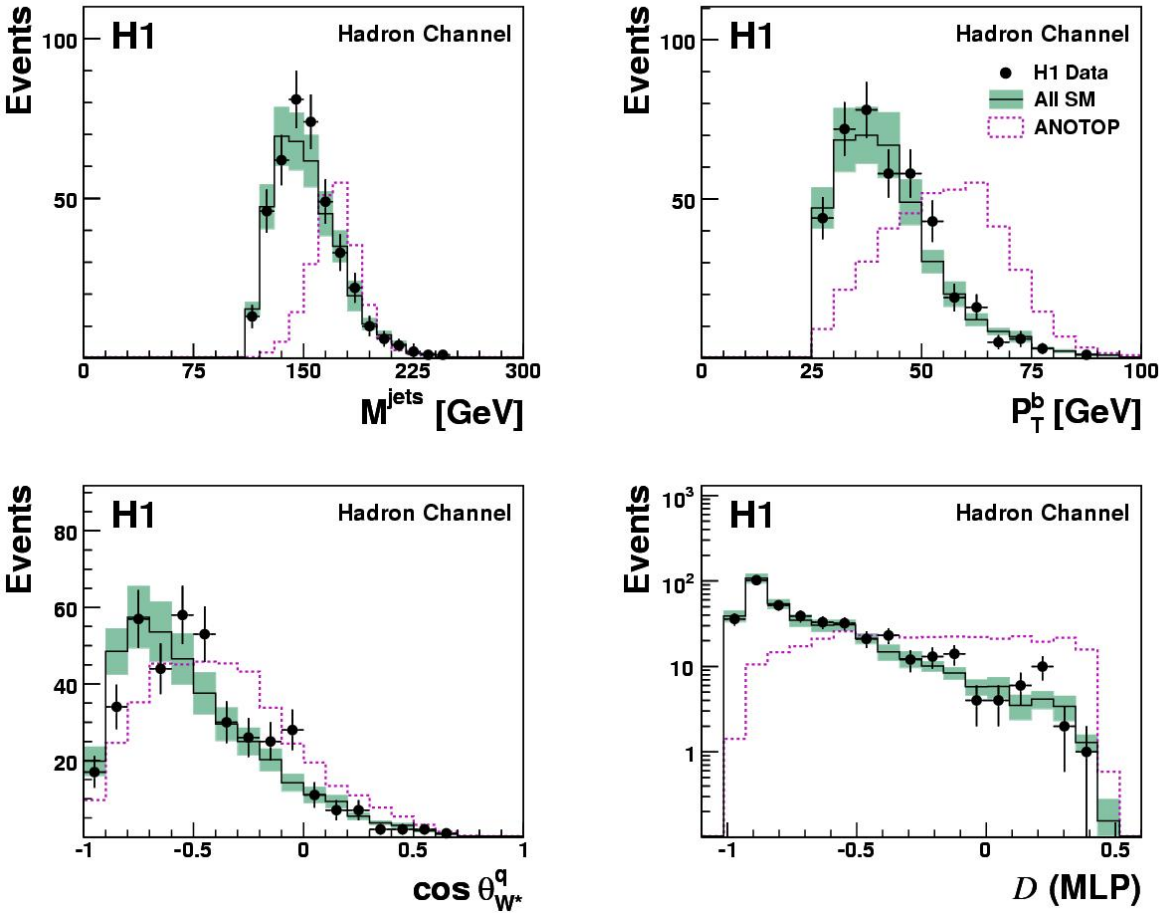
Hadronic channel - H1

Hadronic Channel

Events with at least three jets in $-0.5 < \eta < 2.5$

Jets ordered in transverse momenta: $p_{T,1} > 40\ GeV$, $p_{T,2} > 30\ GeV$, $p_{T,3} > 15\ GeV$

Cut on the scalar sum of the jet transverse momenta $\sum p_{T,jet} > 110\ GeV$



Good overall agreement between data and SM prediction.

H1 Limit Setting

No significant excess is seen $\Rightarrow$ limits on the single top production have been set

H1 Search for Single Top Production $e^{\pm}p, 474pb^{-1}$				
	Upper Limit at 95% CL			
Channel	$\sigma(ep \to tX, \sqrt{s} = 319\,GeV)$ 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

The limits are larger than the expected ones evaluated with a toy model assuming a pure SM scenario, since a slight excess of events, compatible with the signal, have been observed.

H1 has included NLO corrections to the signal cross section in the coupling limit evaluation.

$\Lambda = M_{top} = 175\,GeV$; left values of κ and Br assume $\Lambda = M_{top} = 170\,GeV$.

Systematic errors are taken into account.

ZEUS Anomalous Single Top Search

Muon Channel:

$| Z_{vtx} | < 30\, cm$

$E - p_Z < 70\, GeV$

$p_{T,miss} > 10\, GeV$

Muon Candidate:

$p_T > 8\, GeV$

track from primary vertex and isolated from other tracks in the event

Electron Channel

$| Z_{vtx} | < 30\, cm$

$5 < E - p_Z < 50\, GeV$

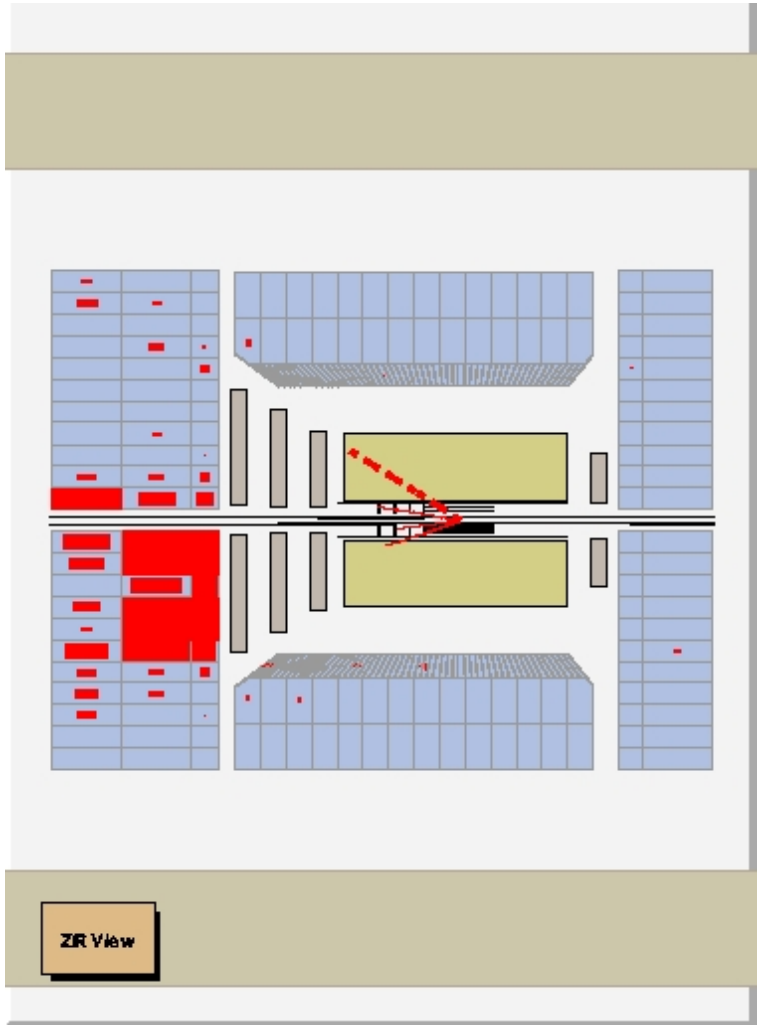
$p_{T,miss} > 12\, GeV$

Electron Candidate:

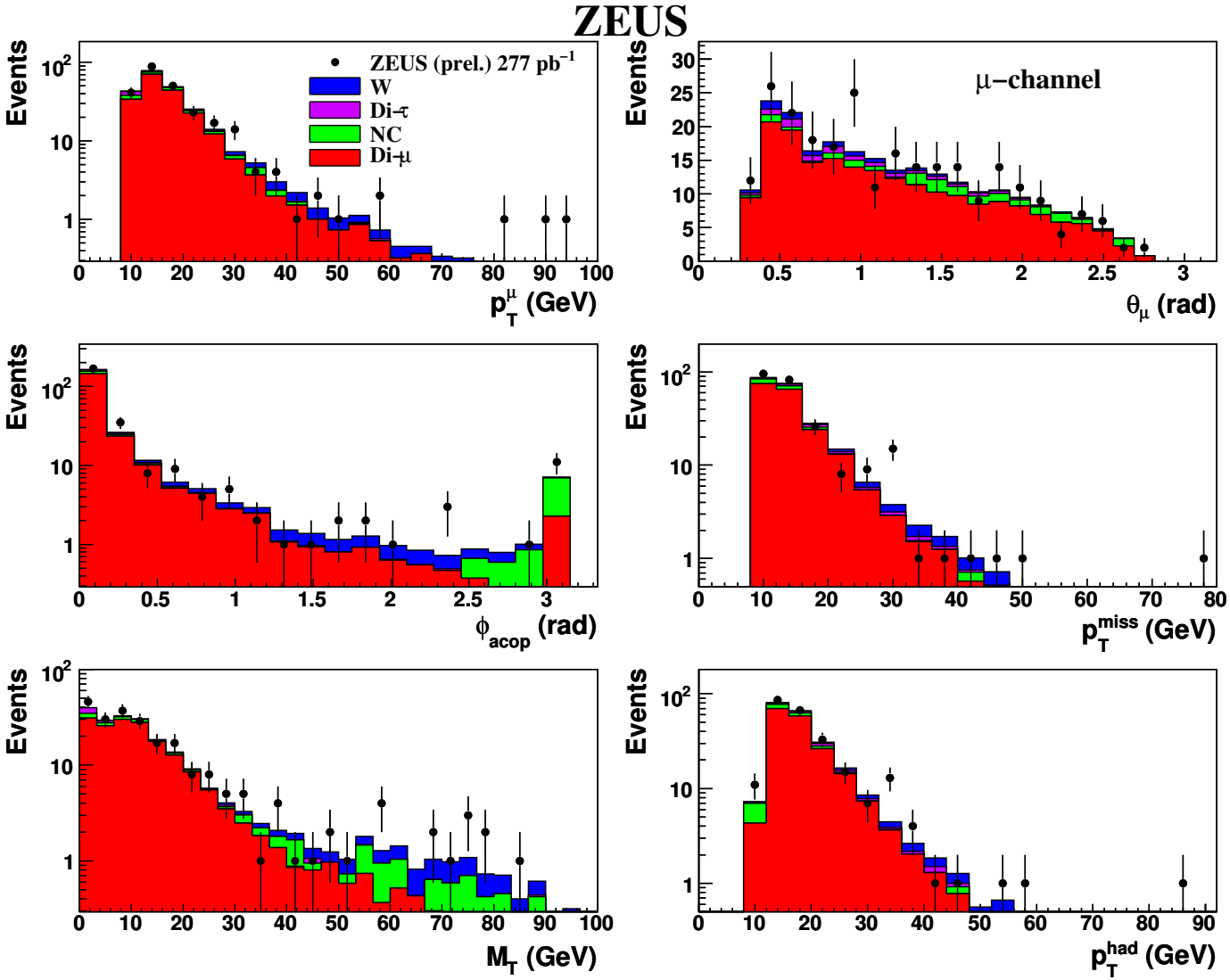
$p_T > 10\, GeV$

track from primary vertex and isolated from other tracks in the event

$0.1 < acoplanarity < \pi - 0.1\, rad$



Muonic Channel - ZEUS

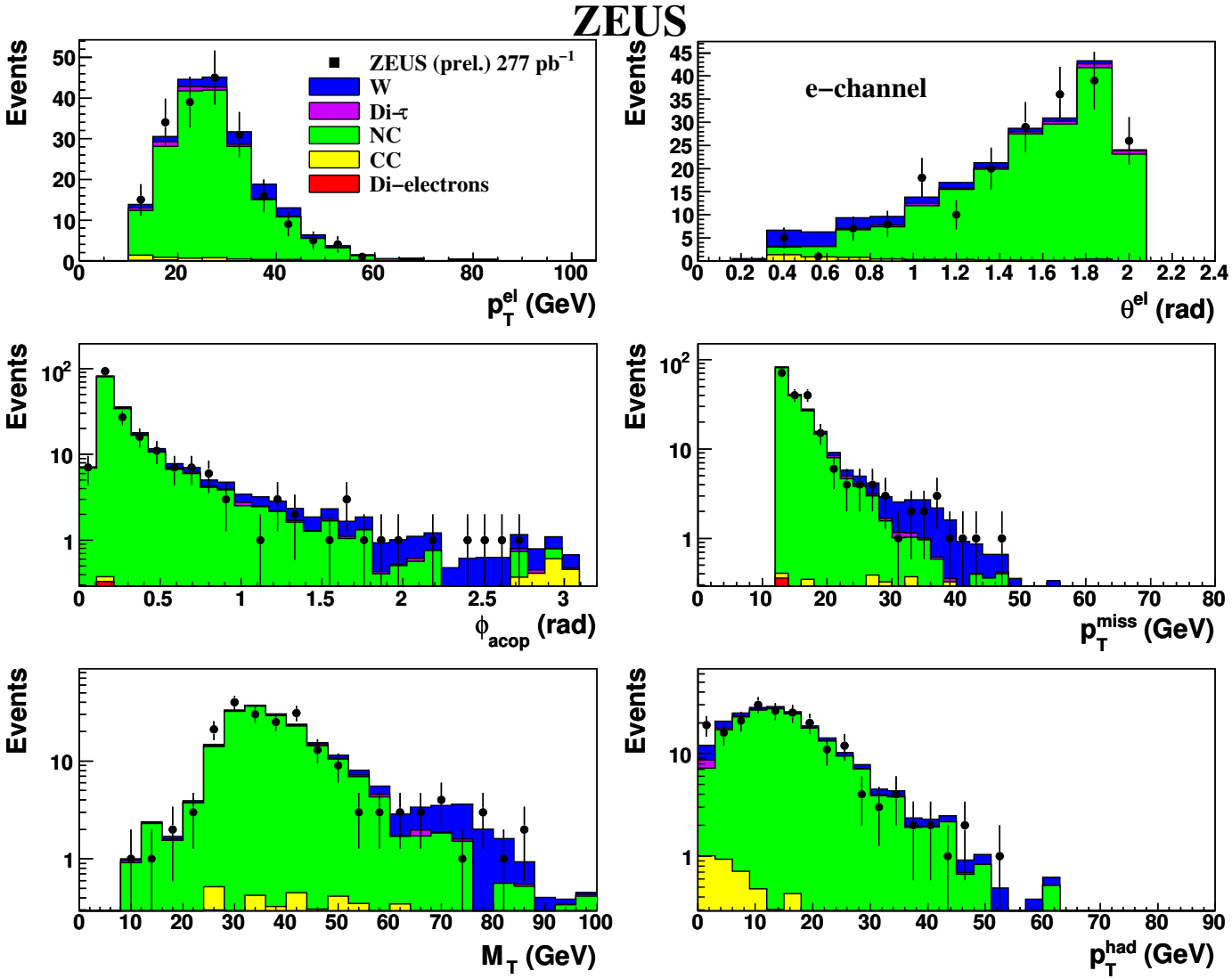


Acceptable agreement between data MonteCarlo.

Main background: di-muon production.

W contribution visible at high transverse mass M_T.

Electronic Channel - ZEUS



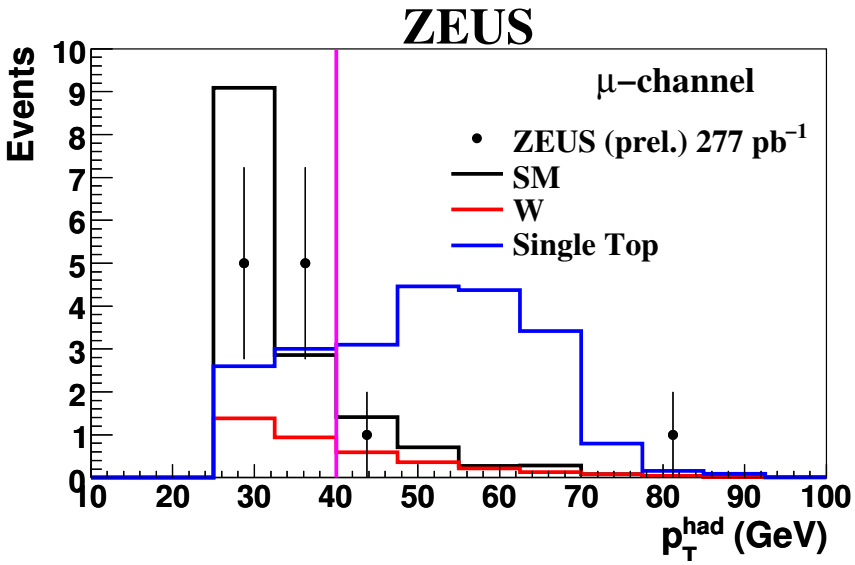
Good agreement between data MonteCarlo.

Main background: Neutral Current.

W contribution visible at high-p_T and high transverse mass M_T.

Final Cuts - ZEUS

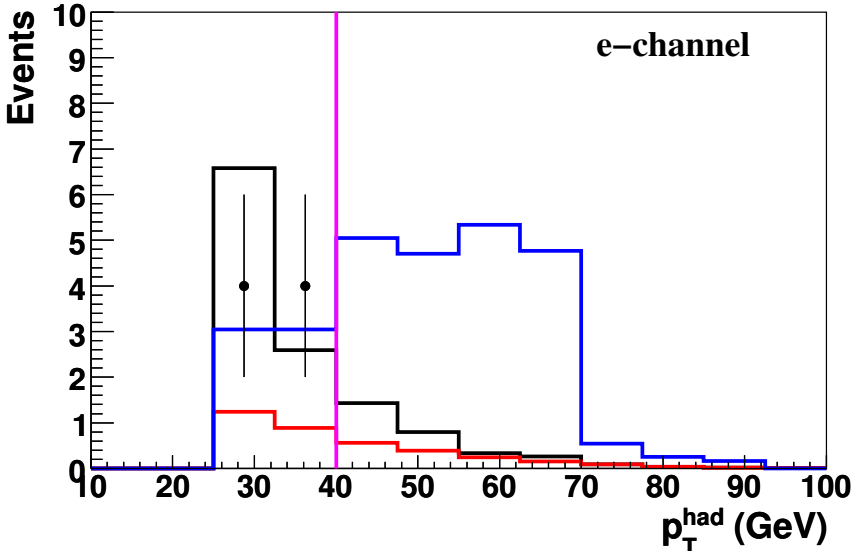
For the final selection a cut on $p_{T,had} > 40\,GeV$ has been required



Muon Channel

$Acoplanarity > 0.05\,rad$

Events with more than one isolated muon have been rejected



Electron Channel

$Acoplanarity > 0.15\,rad$

$p_{T,miss} > 15.\,GeV$

Good agreement between data-MC; no discrepancy at high $p_{T,had}$

ZEUS Limit Setting

Single Top Selection

	N_{obs}	N_{pred}	$W[\%]$	Eff. $\times$ 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

These results have been converted into limit on the signal cross section using a Bayesian approach. Assuming a constant prior on the signal cross section. The following upper limit on the cross section has been obtained:

$$\sigma < 0.23\, pb \;\; (95\%\, C.L.)$$

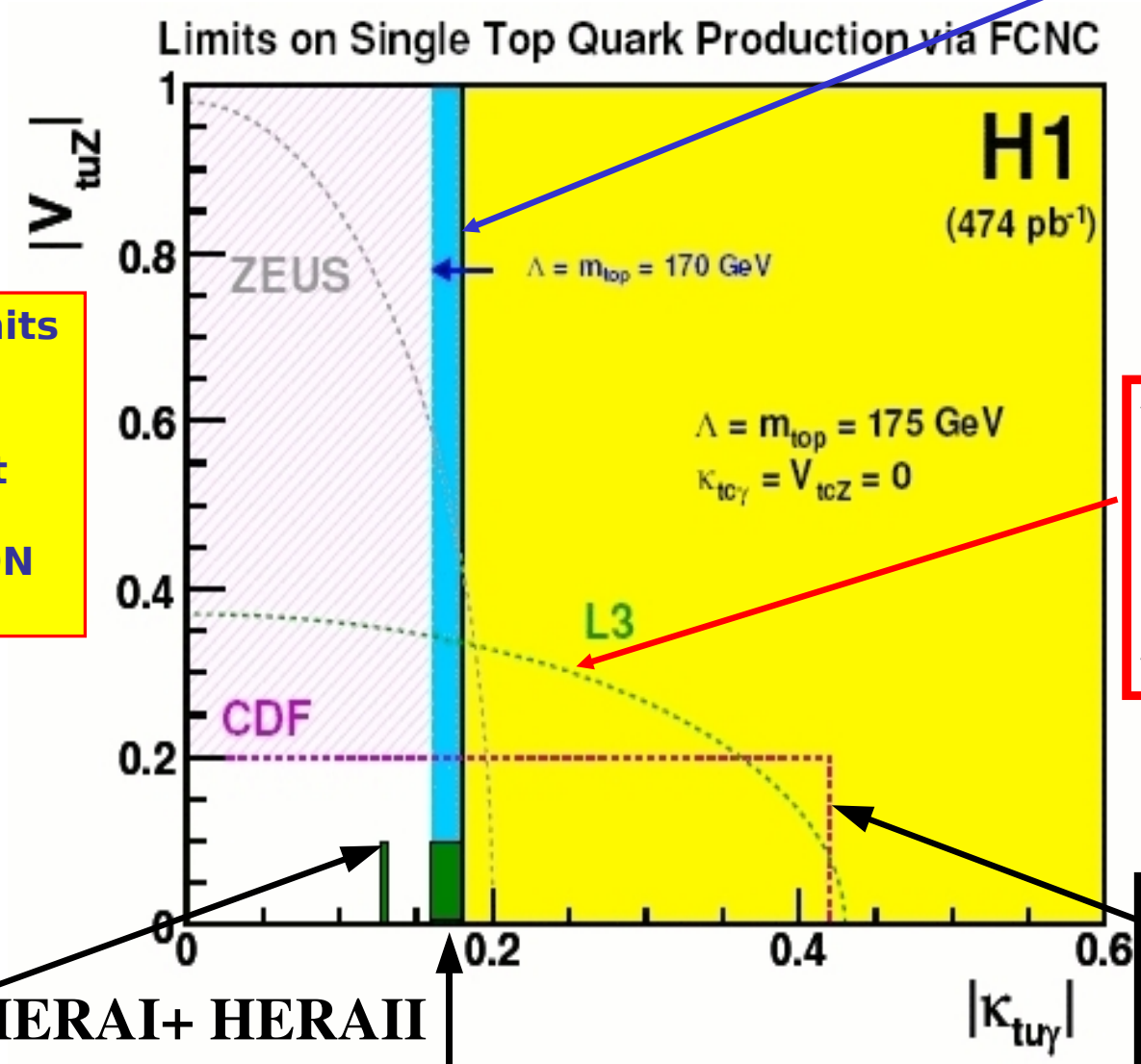
The limit on the cross section has been converted into a limit on the coupling $\kappa_{tu\gamma}$

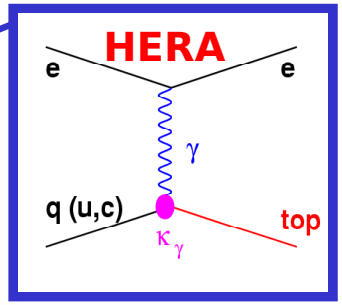
$$\kappa_{tu\gamma} < 0.17\, (0.16 - 0.18,\; M_{top} = 171.2 \pm 2.1 GeV)$$

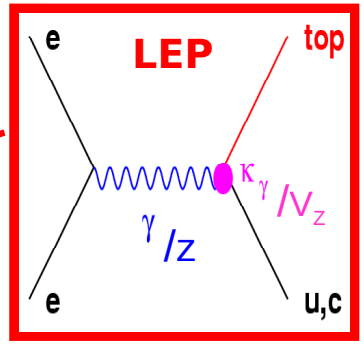
The result has been combined with the HERA I limit (using only samples at $\sqrt{s} = 318\, GeV$) for a total integrated luminosity of $359\, pb^{-1}$:

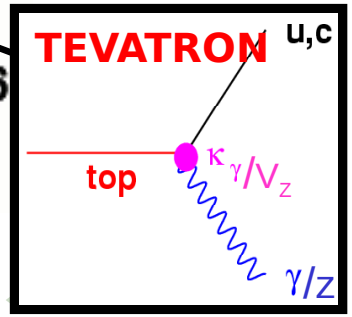
$$\sigma < 0.13\, pb,\;\; \kappa_{tu\gamma} < 0.13\, (Br(t \to u - \gamma) < 0.34\%)$$

Comparison of HERA Limits with Other Experiments









HERA limits for $k_{tu\gamma}$ more stringent than TEVATRON and LEP

ZEUS HERAI+ HERAII combined (prel.)

ZEUS HERAII (prel.)

Conclusions

H1 has published analysis on anomalous single top production exploiting full HERAI + HERAII statistics (**DESY-09-050**), $\sigma < 0.25\,pb$, $\kappa_{tu\gamma} < 0.18$

ZEUS has produced preliminary result with HERAII statistics ($\sigma < 0.23\,pb$; $\kappa_{tu\gamma} < 0.17$) and combined it with HERAI result (PLB 559 (2003) 153) ($\sigma < 0.13\,pb$; $\kappa_{tu\gamma} < 0.13$)

The study on single top production is a good example of complementarity between different colliders

For the process involving a $u - top$ transition mediated by photon, HERA constraints are the best to date

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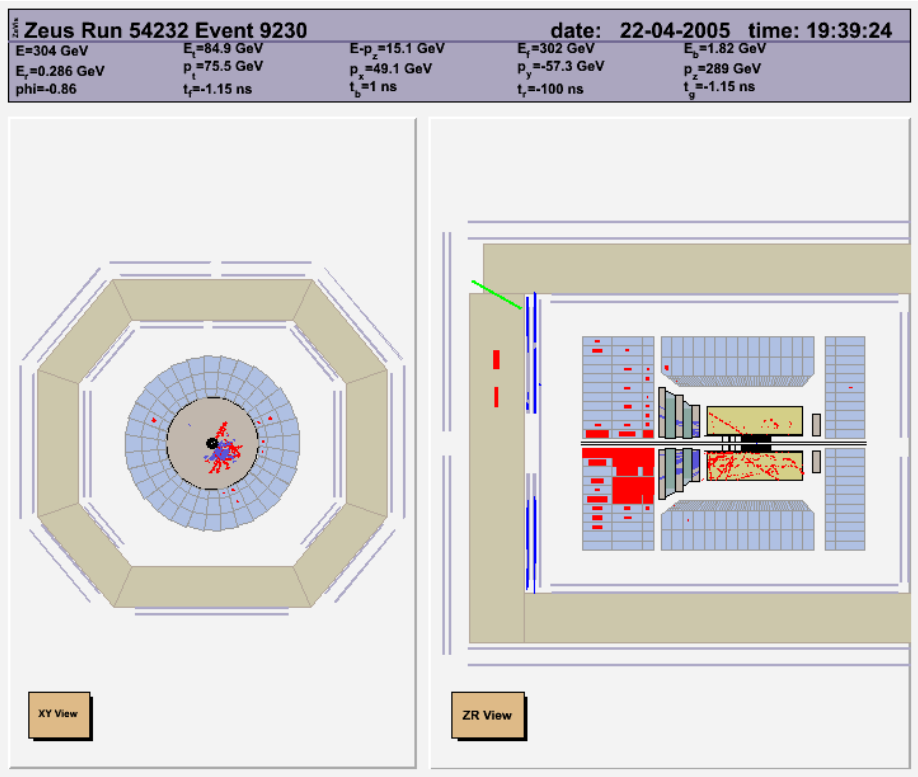
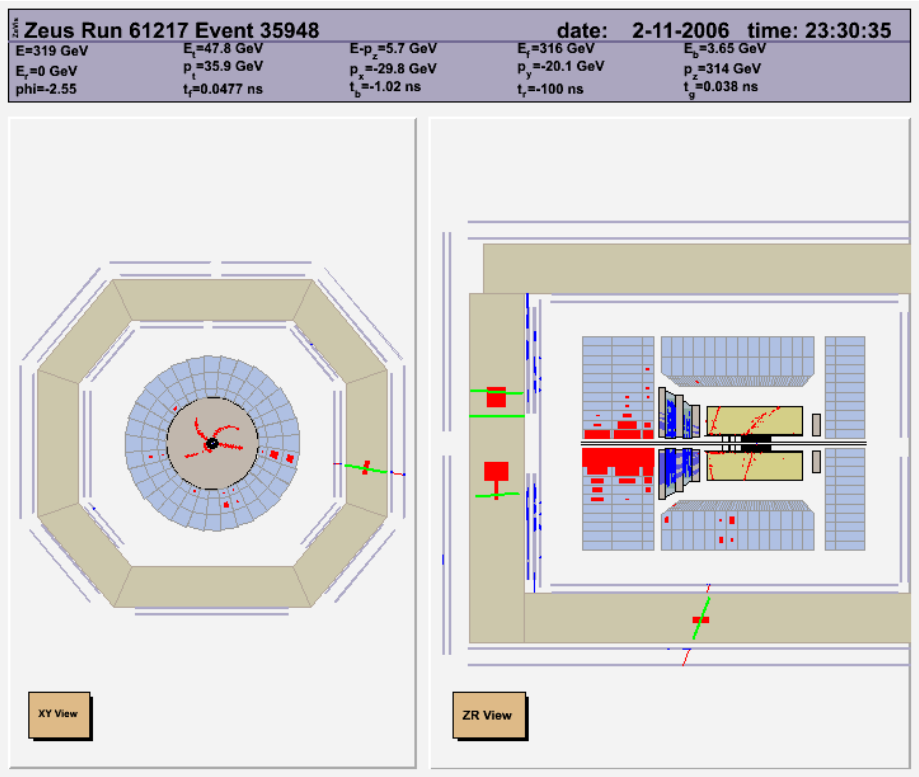
Backup


Zeus Run 54232 Event 9230
date: 22-04-2005 time: 19:39:24
E=304 GeV
E_t=84.9 GeV
E-p_z=15.1 GeV
E_l=302 GeV
E_b=1.82 GeV
E_r=0.286 GeV
p_t=75.5 GeV
p_x=49.1 GeV
p_y=-57.3 GeV
p_z=289 GeV
phi=-0.86
t_l=-1.15 ns
t_b=1 ns
t_r=-100 ns
t_g=-1.15 ns
XY View
ZR View


Zeus Run 61217 Event 35948
date: 2-11-2006 time: 23:30:35
E=319 GeV
E_t=47.8 GeV
E-p_z=5.7 GeV
E_l=316 GeV
E_b=3.65 GeV
E_r=0 GeV
p_t=35.9 GeV
p_x=-29.8 GeV
p_y=-20.1 GeV
p_z=314 GeV
phi=-2.55
t_l=0.0477 ns
t_b=-1.02 ns
t_r=-100 ns
t_g=0.038 ns
XY View
ZR View

Backup

Cuts optimization $\Rightarrow$ minimizing the cross section upper limit (σ_{lim}) assuming a pure SM scenario:

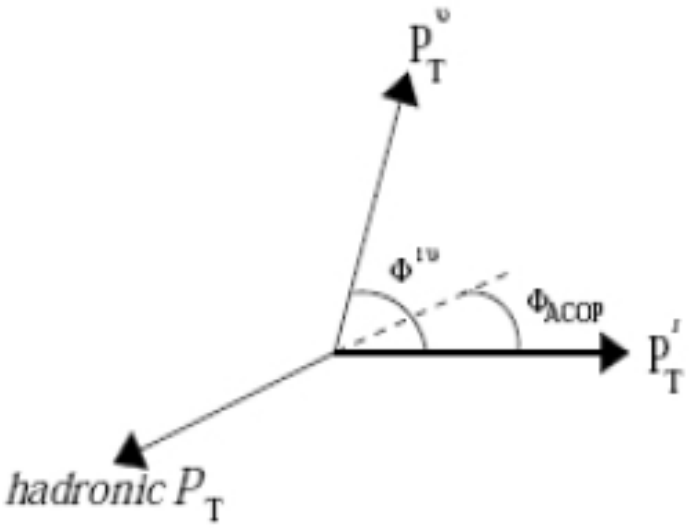
$$\langle \sigma_{lim} \rangle = \frac{\langle N_{sig}^{lim} \rangle}{\epsilon \mathcal{L}}$$

where ϵ is the signal efficiency, $\mathcal{L}$ is the integrated luminosity and $\langle N_{sig}^{lim} \rangle$ is the limit on the number of signal events averaged over the possible observed events;

$$\langle N_{sig}^{lim} \rangle = \sum_{N_{obs}=0}^{\infty} P(N_{obs}, N_{bkg}) \cdot N_{sig}^{lim}(N_{obs}, N_{bkg}),$$

$N_{sig}^{lim}(N_{obs}, N_{bkg})$ being the limit on the number of the signal events at 95% C.L.

Backup



Acoplanarity is the angle in the transverse plane between the lepton and the vector balancing the hadronic p_T