Search for single top at HERA

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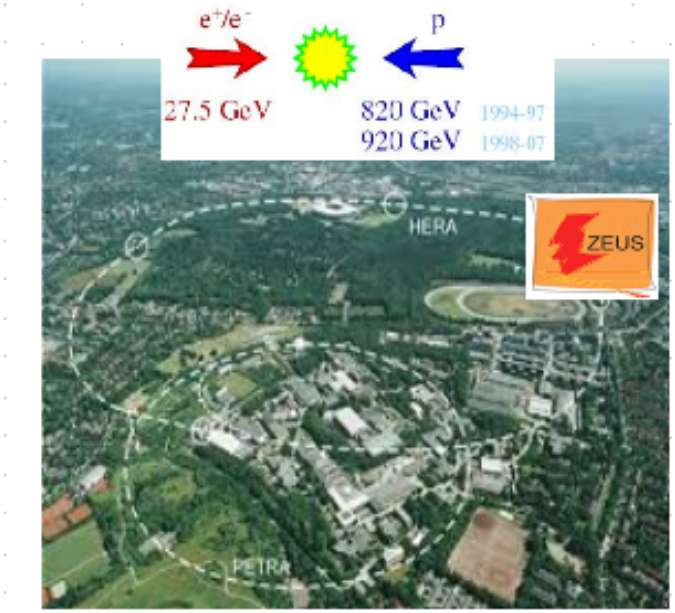
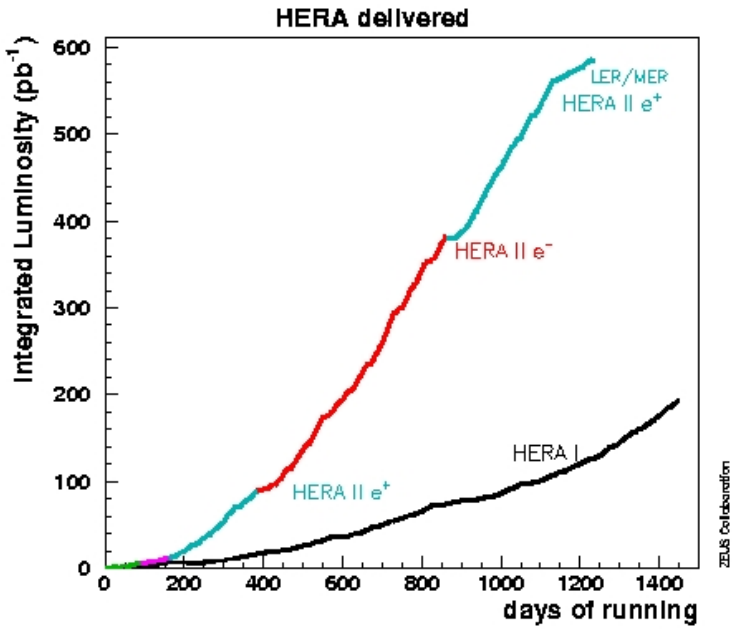
ZEUS data taking

Data taking 1992-2007

HERA I (1992-2000) $\mathcal{L} = 130 pb^{-1}$ mostly e^+p

HERA II (2002-2007) $\mathcal{L} = 370 pb^{-1}$ polarization $\sim 30\%$ e^+/e^-p balanced





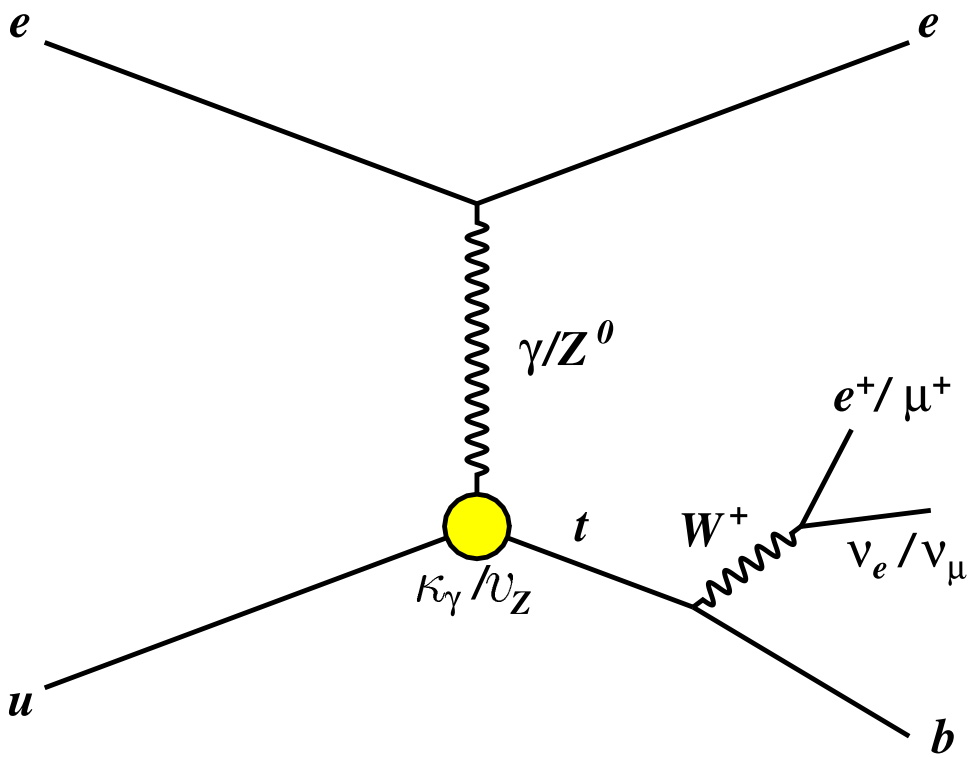
ZEUS located at ep interaction point

$\sqrt{s} = 318 GeV$

0.5 fb^{-1} data collected

Search for single top: signal topology

- SM single top cross section $\sim 1fb$ (CC process)
- BSM extra prod. possible via FCNC process
- Topology: high-p_T isolated leptons, missing P_T ($P_{T,miss}$) and high hadronic p_T ($p_{T,had}$)
- At HERA, most sensitive to $\kappa_{tu\gamma}$ coupling

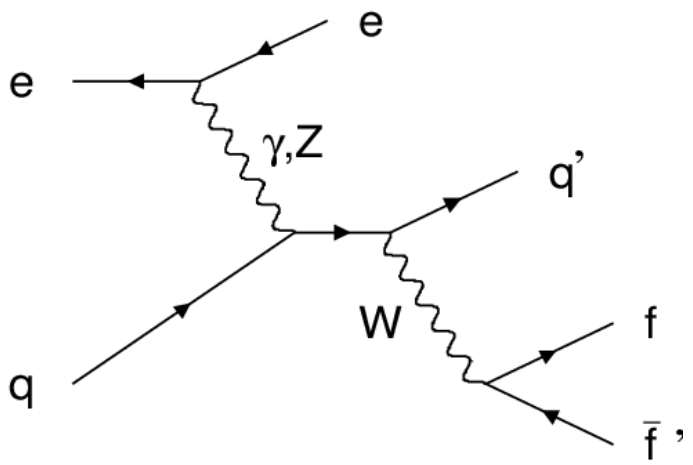


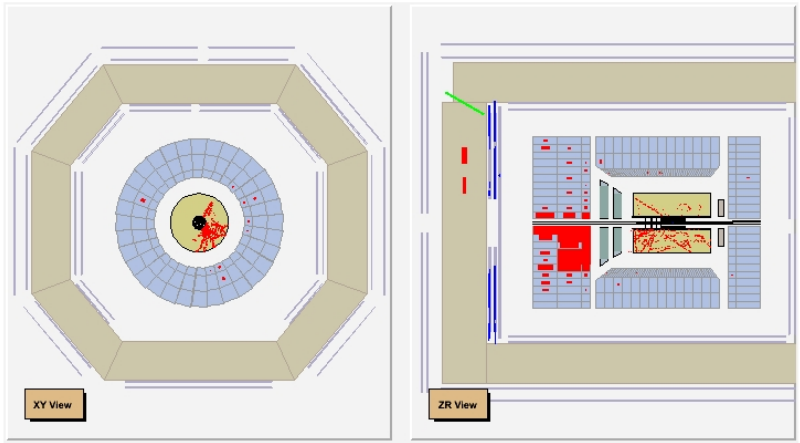
All HERA data ($0.5fb^{-1}$), published in Physics Letters B 708 (2012) 27-36

Search for single top: high p_T leptons

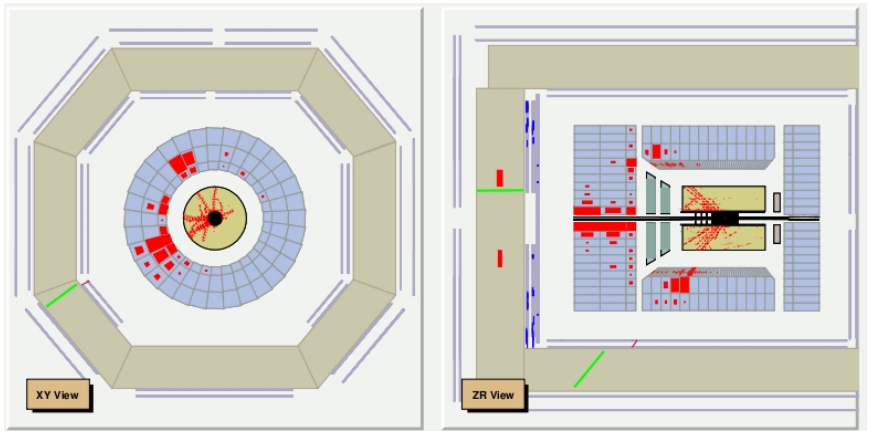
Study of high p_T isolated leptons suited for searches of physics BSM

- Clear and striking signature
- In SM: low cross section, mainly due to W production ($\sim 1pb$)
- Low $p_{T,had}$ differently from single top





μ decay channel of W



e decay channel of W

Preselection cuts

The event selection was optimised for single-top production via photon exchange, looking for the dominant decay $t \to bW$ and subsequent W decay to e and μ and their respective neutrinos. The selection was based on requiring an isolated high-p_T lepton, large missing transverse momentum $P_{T,miss}$ and high transverse mass M_T (e-channel).

Main preselection cuts

Muon Channel

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

$p_T > 8\ GeV$

Electron Channel

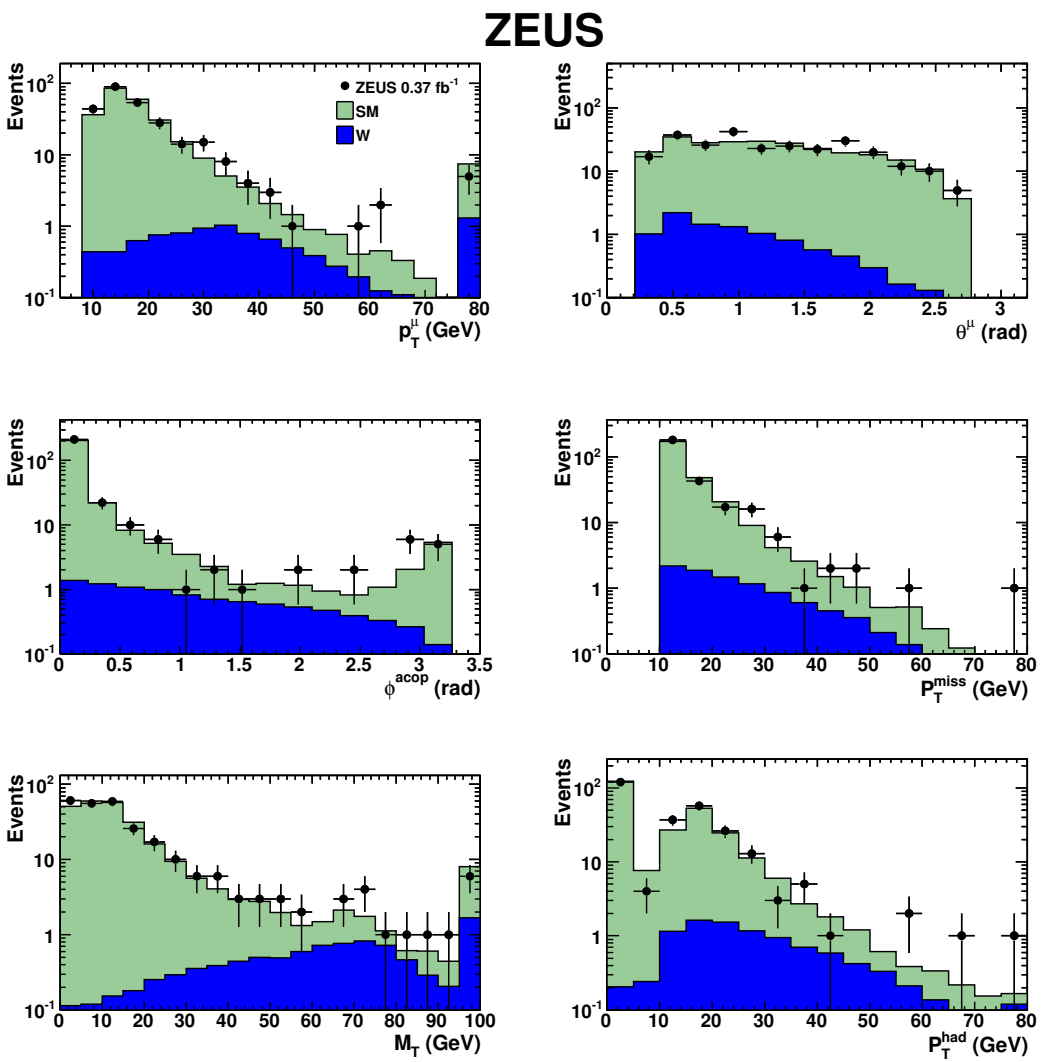
$P_{T,miss} > 12\ GeV$

$p_T > 10\ GeV$

$M_T > 10\ GeV$

Cosmic rejection and other non ep sources made by request on event vertex, timing vetoes and distance of primary vertex tracks respect to the beam spot.

Preselection plots: muonic channel

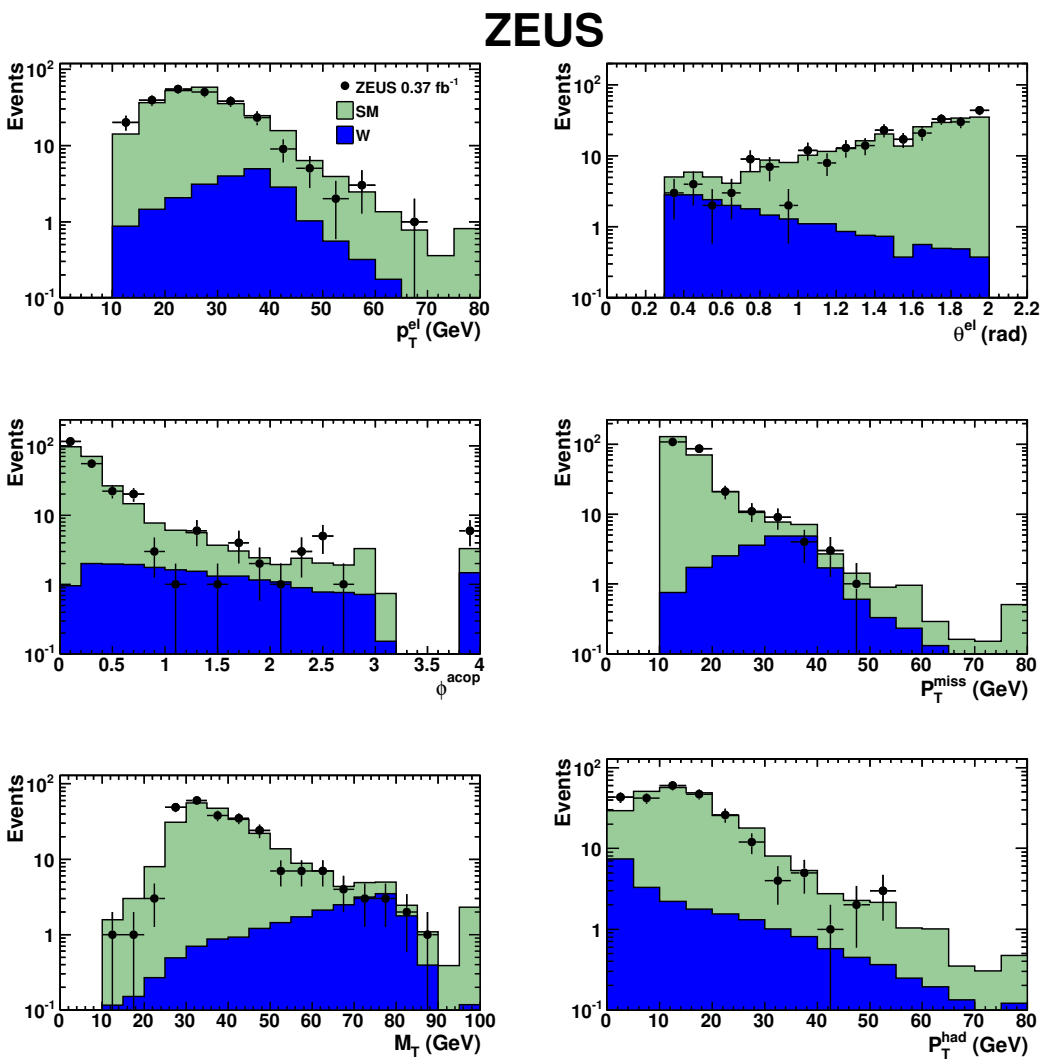


Acceptable agreement between data MonteCarlo.

Main background: di-muon production.

W contribution visible at high transverse mass M_T.

Preselection plots: electronic channel



Good agreement between data MonteCarlo.

Main background: Neutral Current.

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

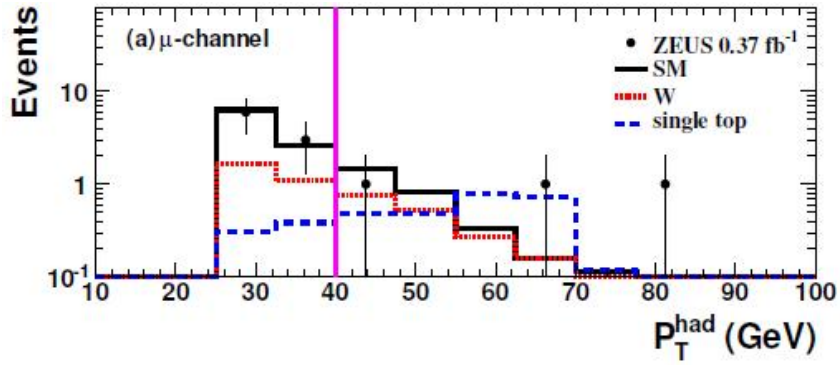
Single top: analysis

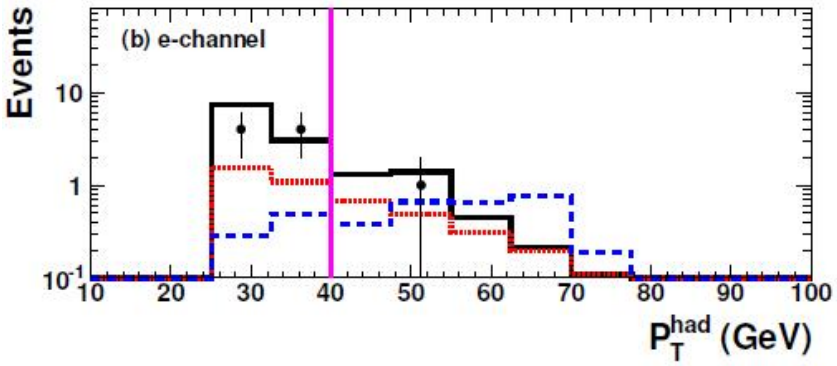
Analysis performed in the leptonic decay channels of the $W(\mu, e)$

Cut on hadronic p_T to optimize signal over W background

Hadronic p_T distribution; good agreement data/MC

Final cut at $40 GeV$ to set limits on top production

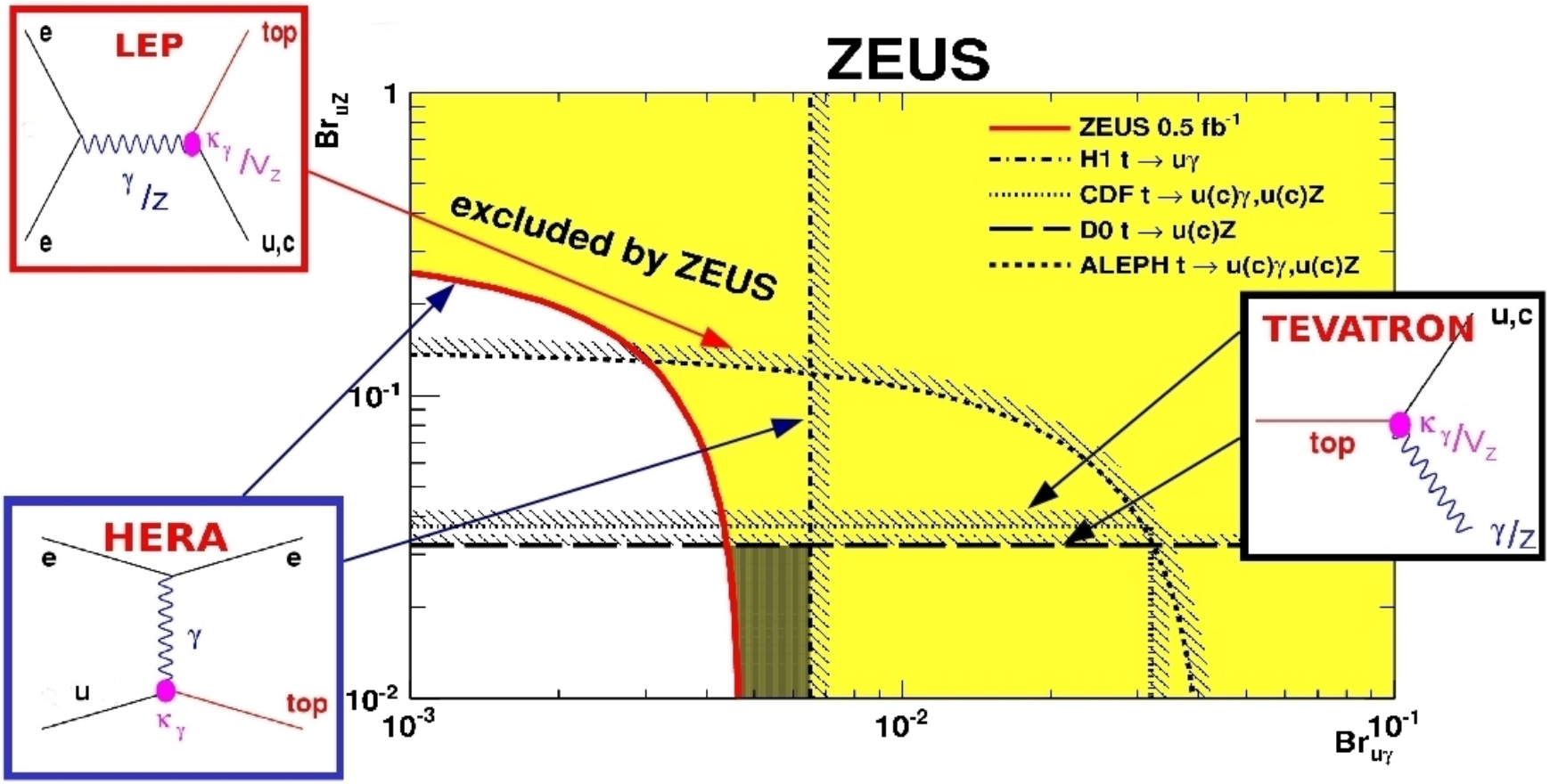




No evidence of single top found

Limits are set on anomalous single top production

Single top: limits



ZEUS boundary in the ($\mathbf{Br_{u\gamma}}$, $\mathbf{Br_{uZ}}$) plane. Dark shaded area is uniquely excluded by ZEUS. Same couplings probed in different processes: e^-e^+ (LEP), $p\bar{p}$ (Tevatron), $e^\pm p$ (HERA). Limits in the region where $\mathbf{Br_{uZ}} < 3\%$ are the best to date.

Conclusions

Overview of ZEUS results on single top has been presented

No evidence of new physics found

ZEUS constraints are still competitive with other experiments

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Backup - Results

No visible excess found respect to the SM prediction $\Rightarrow$ limit on the signal cross section using a Bayesian approach (assuming a constant prior on the cross section σ:

$\sigma < 0.24 pb$ (95% C.L.) at $\sqrt{s} = 318 GeV$

$\kappa_\gamma < 0.18$ (95% C.L.)

The result of this analysis was combined with the previous ZEUS result

ZEUS Coll., S. Chekanov et al., Phys. Lett. B 559, 153 (2003) giving:

$\sigma < 0.13 pb$ (95% C.L.) at $\sqrt{s} = 315 GeV$

$\kappa_\gamma < 0.13$ (95% C.L.)

Backup - MonteCarlo

Single-top

- COMPHEP 4.5.1; interfaced with PYTHIA 6.14 (parton showering, hadronisation, particle decay)
  - top mass set to $M_t = 175 GeV$
  - different sets for the two different production modes (γ- and Z-mediated) and for the two decay modes ($t \to bW$ and $t \to uZ$)
- HEXF: alternative sets were also generated, only for the γ-mediated process, assuming top-quark masses of 170 and $175 GeV$ to study the small effect of M_t on the selection efficiency

W

- EPVEC; events from EPVEC were scaled by a factor dependent on the transverse momentum and rapidity of the W, such that the resulting cross section corresponded to a calculation including QCD corrections at next-to-leading order

Backup - Systematics

The main contribution to the systematical uncertainties on the predicted SM events is due to the following sources:

- the theoretical uncertainty on the W background normalisation $\pm 15\%$;
- the statistical uncertainty on the total SM prediction after the final selection $\pm 13\%$ and $\pm 9\%$ for the e- and μ- channel respectively;
- the uncertainty on the NC DIS background $\pm 15\%$ for the preselection and $\pm 6\%$ for the final selection in the e-channel and negligible in the μ-channel.