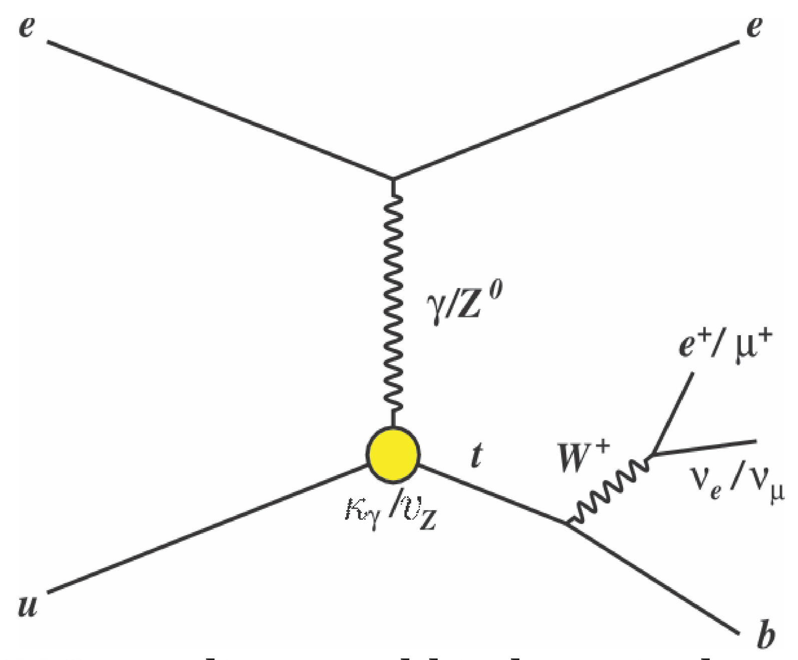
Search for single top production in *ep* collisions at HERA

S. Antonelli (CNAF-INFN Bologna) on behalf of the ZEUS Collaboration

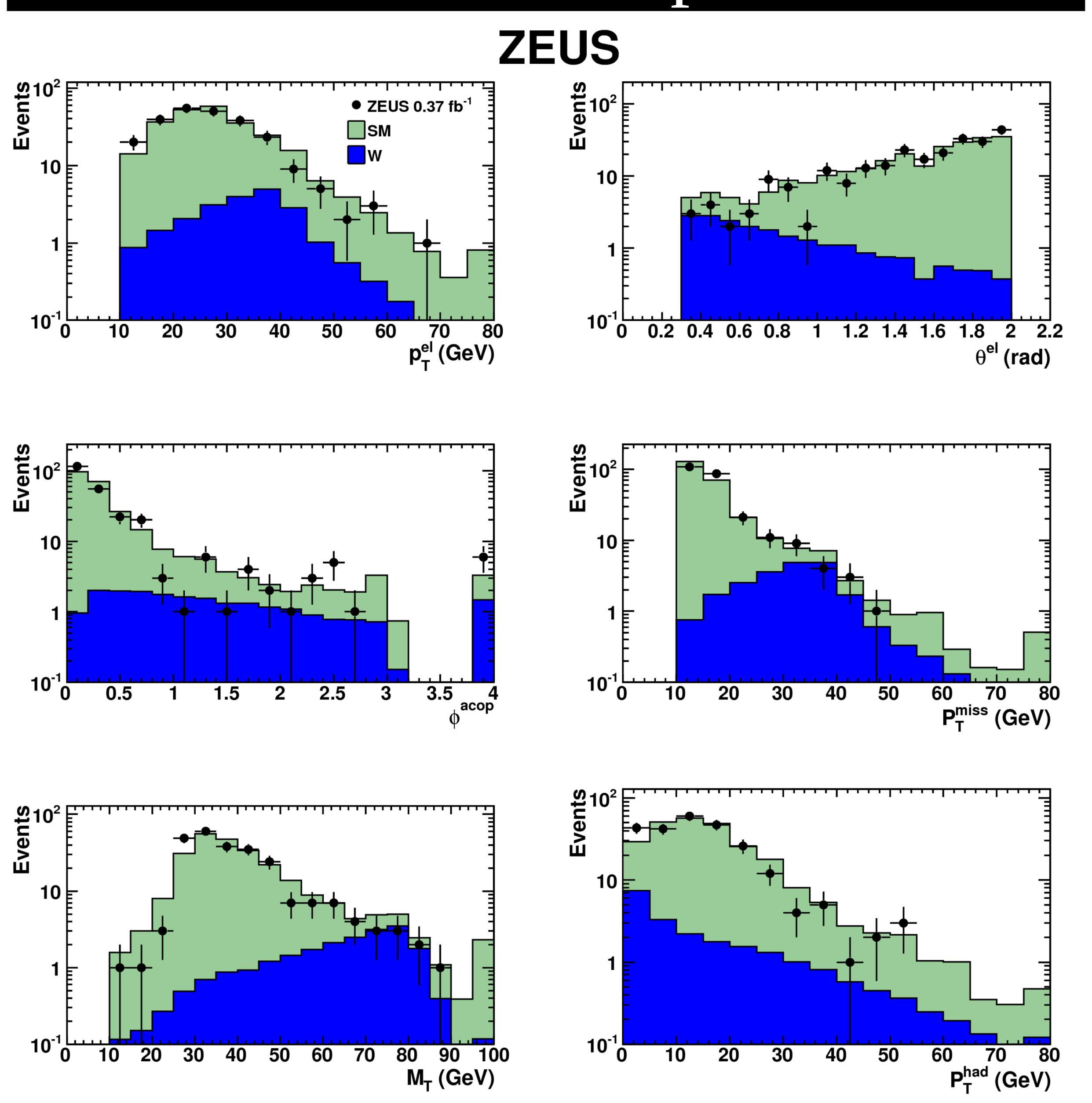
In *ep* (with *e* electron or positron) collisions at HERA, the production of single top quark is possible due to the large centre-of-mass energy $\sqrt{s}$ = 318 GeV. The dominant production process of single top quarks in the Standard Model (SM) is the charged current (CC) deep inelastic scattering (DIS) reaction $ep \rightarrow \nu tX$ [1], which has a cross section of less than 1 fb [2]. No sizeable production is hence expected in our data sample and any excess can be attributed to new physics. In several extensions of the SM, single top production can happen via a flavour changing neutral current (FCNC) process mediated by an effective coupling which allows a *u-t* or *c-t* transition via a neutral vector boson (γ or Z^0) [3]. The analysis has been performed with 0.37 fb^{-1} and extends the previously published ZEUS results [4] corresponding to 0.13 fb^{-1}. Limits for single top production via FCNC were computed combining this result with the previous ZEUS one [4], for a total luminosity of 0.50 fb^{-1}. The cross section upper limit at 95% Credibility Level (C.L.) was 0.13 pb at a centre-of-mass energy of $\sqrt{s}$ = 315 GeV. The results of this analysis have been published in [5].

Topology



The FCNC couplings could induce single-top production in *ep* collisions, $ep \rightarrow etX$, in which the incoming lepton exchanges a γ or Z with an up quark in the proton, yielding a top quark in the final state. Owing to the large Z mass, this process is more sensitive to a coupling of the type $tq\gamma$. Furthermore, large values of x, the fraction of the proton momentum carried by the struck quark, are needed to produce a top quark. Since the *u*-quark parton distribution function (PDF) of the proton is dominant at large x, the production of single top quark is most sensitive to the $tu\gamma$ coupling.

Preselection plots



Data-MC comparison at the preselection level for the e-channel; good agreement is observed.

Event selection

The event selection was optimised for single-top production via photon exchange, looking for the dominant decay $t \rightarrow bW$ and subsequent W decay to e and μ and their respective neutrinos. The selection is based on requiring an isolated high-p_T lepton, large missing transverse momentum and high hadronic P_T.

The main preselection cuts where the following:

- $P_{T,miss} > 10$ (12) GeV μ- (e-) channel;
- leptonic $p_T > 8$ (10) GeV μ- (e-) channel;
- transverse mass $M_T > 10$ GeV e-channel only;

The main final cuts where the following:

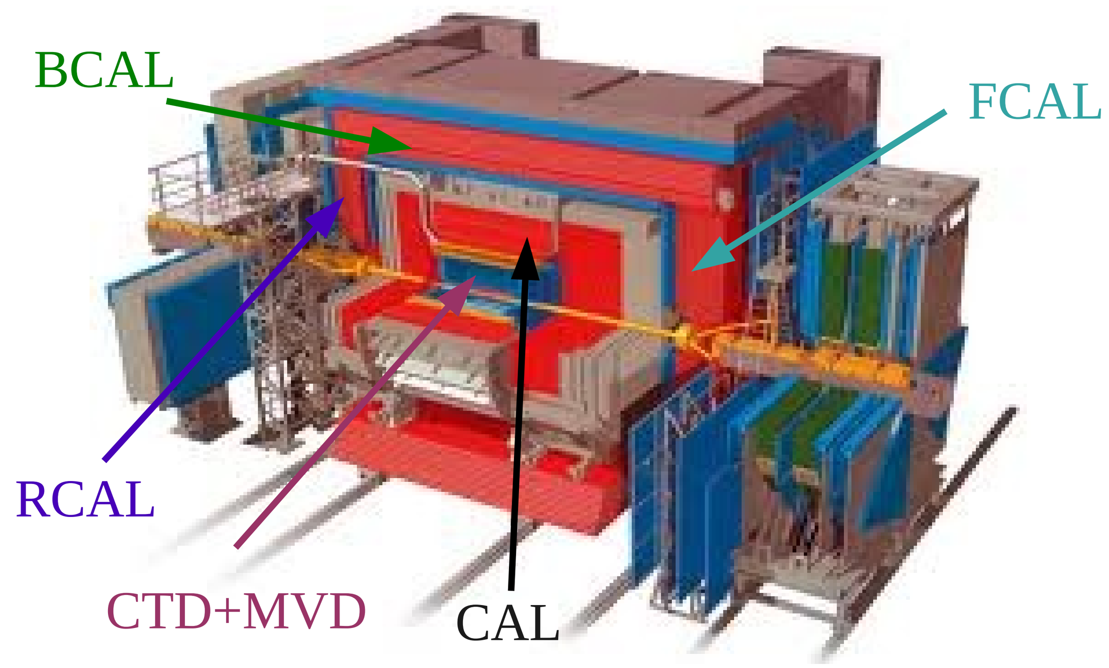
- hadronic $P_T > 40$ GeV for both channels;
- $P_{T,miss} > 15$ GeV e-channel.

Systematic uncertainties

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

ZEUS detector



Components of the detector that were more relevant for the analysis:

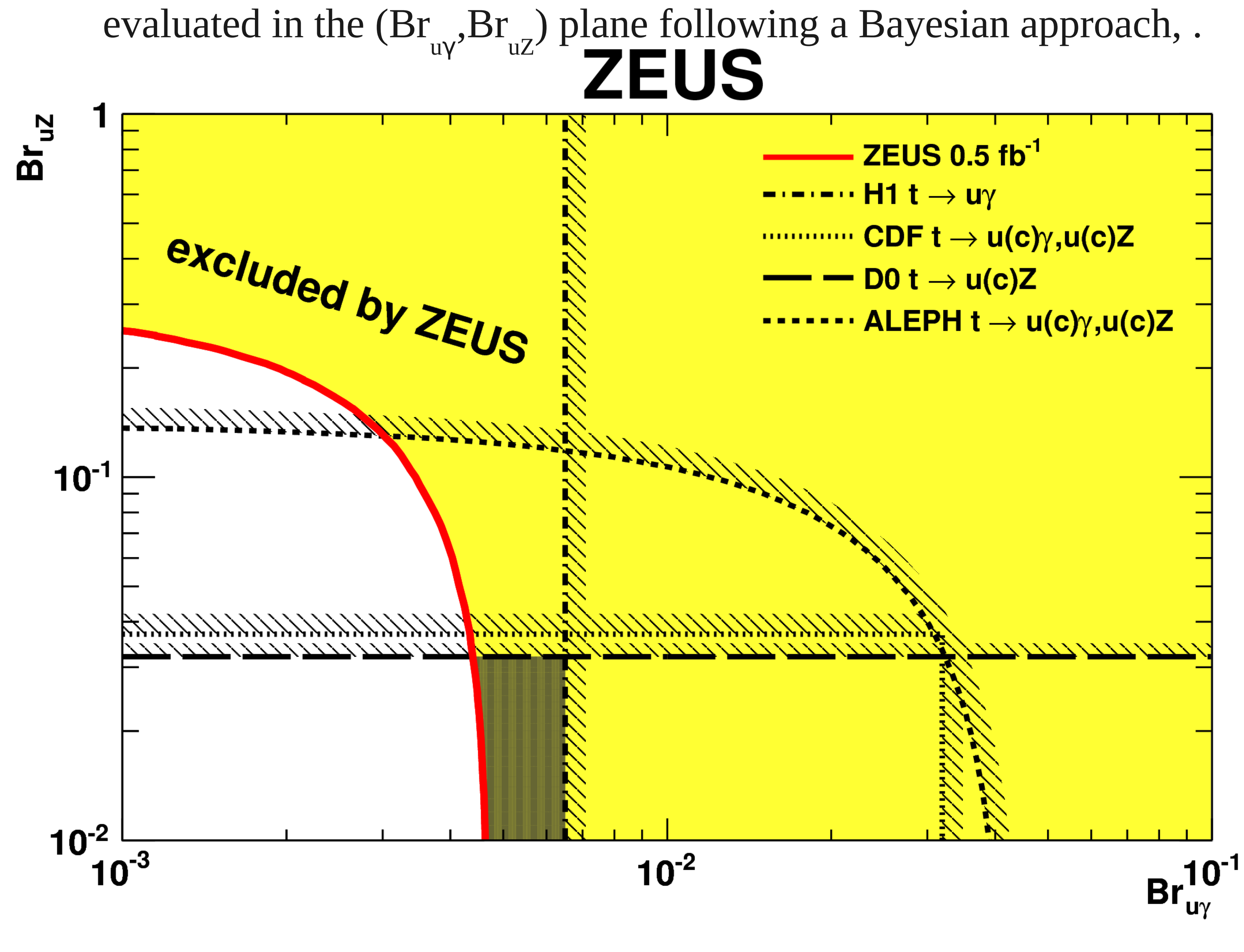
- central tracking detector (CTD) complemented by a silicon vertex detector (MVD)
- calorimeter, consisting of a forward (FCAL), rear (RCAL) and barrel (BCAL) parts
- Luminosity detector, consisting of a lead-scintillator calorimeter at z=107 m from the nominal interaction point along the outgoing e-beam direction

	N_obs	N_pred	W [%]
e-channel	1	3.6±0.6	52±9
μ-channel	3	3.0±0.4	64±7

Table showing the number of events passing the final selection, N_obs, compared to the SM prediction, N_pred. The last column shows the W contribution as a percentage of the SM prediction. The uncertainties have been obtained by adding systematic and statistical contributions in quadrature

Limits evaluation

Since no visible excess was found respect to the SM prediction, a limit, assuming a vanishing v_Z was evaluated on the signal cross section using a Bayesian approach, assuming a constant prior on the cross section σ. The result was $\sigma < 0.24$ (95 % C.L.) pb at $\sqrt{s}$ = 318 GeV. Such limit was converted into a limit on the coupling κ_γ : $\kappa_\gamma < 0.18$ (95 % C.L.). The result of this analysis was combined with the previous ZEUS result [4]: $\sigma < 0.13$ (95 % C.L.) pb at $\sqrt{s}$ = 315 GeV and $\kappa_\gamma < 0.13$ (95% C.L.). Constraints on the anomalous top branching ratios $t \rightarrow u\gamma$ ($Br_{u\gamma}$) and $t \rightarrow uZ$ (Br_{uZ}) were also evaluated assuming a non-zero coupling v_Z. Such limits were evaluated in the ($Br_{u\gamma}$,Br_{uZ}) plane following a Bayesian approach, .



This figure shows the ZEUS boundary in the ($Br_{u\gamma}$,Br_{uZ}) plane compared to limits from other experiments. The e^+e^- and hadron colliders, contrary to HERA, have similar sensitivities to *u*- and *c*-quarks; their limits are hence on both decays $t \rightarrow qV$ with $q = u,c$. The yellow area is excluded by ZEUS. The dark shaded region denotes the area uniquely excluded by ZEUS. The limits set by the ZEUS experiments in the region where Br_{uZ} is less than ~4% are the best to date.

References

[1] G.A.Schuler, Nucl.Phys. B 299, 21 (1988), U. Baur and J.J. van der Bij, Nucl. Phys. B 304, 451 (1988) J.J. van der Bij and G.J. van Oldenborgh, Z. Phys. C 51, 477 (1991)

[2] T. Stelzer, Z. Sullivan and S. Willenbrock, Phys. Rev. D 56, 5919 (1997) S. Moretti and K. Odagiri, Phys. Rev. D 57, 3040 (1998)

[3] H. Fritzsch, Phys. Lett. B 224, 423 (1989) T. Han, R.D. Peccei and X. Zhang, Nucl. Phys. B 454, 527 (1995)

[4] ZEUS Coll., S. Chekanov et al., Phys. Lett. B 559, 153 (2003)

[5] ZEUS Collaboration; H. Abramowicz et al., Phys. Lett. B 708 (2012) 27-36

[6] K. Nakamura et al. (Particle Data Group), J. Phys. G 37, 075021 (2010)