W and Anomalous Single Top Production at HERA

Eram Rizvi*

Queen Mary, University of London - Dept of Physics
Mile End Rd, London, E1 4NS - UK

The analysis of W production and the search for anomalous single top production is performed with the H1 detector at HERA with an integrated luminosity of 0.5 fb^{-1}, consisting of the complete high energy data from the HERA programme. Production cross section measurements of single W production, as well as W polarisation fractions in events containing isolated leptons and missing transverse momentum are also presented. In the context of a search for single top production an upper limit on the top production cross section $\sigma_{ep\to etX} < 0.16$ pb is established at the 95% confidence level, corresponding to an upper bound on the anomalous magnetic coupling $\kappa_{tu\gamma} < 0.14$.

1 Events with Isolated Leptons and P_T^{miss}

Events containing a high P_T isolated electron or muon and associated with missing transverse momentum have been observed at HERA [1, 2]. An excess of HERA I data events (1994–2000, mostly in e^+p collisions) compared to the SM prediction at large hadronic transverse momentum P_T^X was reported by the H1 Collaboration [2].

The main SM contribution is the production of real W bosons via photoproduction with subsequent leptonic decay $ep \to eW^{\pm}(\to l\nu)X$, where the hadronic system X is typically of low P_T.

The event selection employed by the H1 [4] analysis may be summarised as follows: The identified lepton should have high transverse momentum $P_T^l > 10$ GeV, be observed in the central region of the detector and be isolated with respect to jets and other tracks in the event. The event should also contain a large transverse momentum imbalance, $P_T^{miss} > 12$ GeV. Further cuts are then applied, which are designed to reduce SM background, whilst preserving a high level of signal purity.

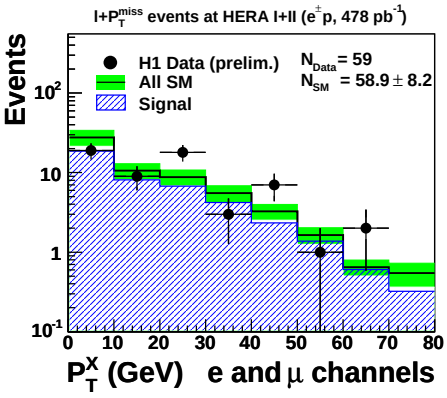

Figure 1: The P_T^X distribution of the data (points) compared to the SM expectation (open histogram). The signal component of the SM expectation is given by the hatched histogram. N_{Data} is the total number of data events observed, N_{SM} is the total SM expectation. The total error on the SM expectation is given by the shaded band.

The analysis has recently been performed on the electron and muon channels using the complete HERA I+II data sets, which corresponds to 478 pb^{-1} [4]. A total of 59 events are observed in the data, compared to a SM prediction of 58.9 ± 8.2. For $P_T^X > 25$ GeV, a total of 24 events are observed compared to a SM prediction of 15.8 ± 2.5, of which 21 events are observed in the e^+p

*On behalf of the H1 Collaboration

data compared to a SM prediction of 8.9 ± 1.5. The observed data excess in the HERA I e^+p data thus remains at the 3.0σ level for the complete H1 e^+p dataset. The results of the analysis are summarised in Table 1.

Figure 1 shows the P_T^X distribution of the $e^\pm p$ data for the combined electron and muon channels. The signal contribution, dominated by real W production, is seen to dominate the total SM expectation in all data samples. Overall there is good agreement with the SM expectation. A possible contribution from anomalous single top production would be expected to contribute at high P_T^X

2 Cross Sections and W Polarisation Fractions

The selection results described in section 1 are used to calculate production cross sections for events with an energetic isolated lepton and missing transverse momentum ($\sigma_{\ell+P_T^{miss}}$) and for single W boson production (σ_W), for which the branching ratio for leptonic W decay is taken into account [7]. The results are shown below with statistical (stat) and systematic (sys) uncertainties compared to the SM prediction, quoted with a theoretical systematic error (th.sys) of 15%.

H1	HERA I+II Data	SM
$\sigma_{\ell+P_T^{miss}}$	$0.24 \pm 0.05\,(\text{stat}) \pm 0.05\,(\text{sys})$	$0.26 \pm 0.04\,(\text{th.sys})$
σ_W	$1.23 \pm 0.25\,(\text{stat}) \pm 0.22\,(\text{sys})$	$1.31 \pm 0.20\,(\text{th.sys})$

A measurement of the W polarisation fractions is also performed since new physics may modify the SM polarisation fractions of Ws from single top decays [6] and is described in [7]. Additional selection criteria are applied to ensure good reconstruction of the W and the missing ν. Using a 2D fit, optimal values of the left-handed (F_-) and longitudinal (F_0) fractions are extracted, as shown in figure 2 (left) compared to the SM and a FCNC single top model [8]. The data are in agreement with the SM expectation albeit within large experimental uncertainties.

3 Search for Single Top Quark Production

The excess of events at high P_T^X may be interpreted in terms of anomalous single top production via flavour changing neutral currents with coupling $\kappa_{tu\gamma}$ between t and u quarks and the exchange photon. Such a search has been reported by H1 previously [9, 10].

In this analysis, decays of top quarks into a b quark and a W boson with subsequent decay of the W in the leptonic electron and muon channels are studied. Therefore a top preselection is applied by requiring good top mass reconstruction and a lepton charge compatible top production.

A multivariate analysis is then performed to discriminate top from SM background (dominated by real W production) using the transverse momentum of the reconstructed b quark candidate P_T^b, the reconstructed top mass $M_{\ell\nu b}$, and the W decay angle $\cos\theta_W^\ell$ calculated as the angle between the lepton momentum in the W rest frame and the W direction in the top quark rest frame. A multivariate discriminator is trained using ANOTOP [8] as the signal model and EPVEC [11] as the background model. The discriminator is based on a phase space density estimator using a range search algorithm [12].

The observed data distributions of these quantities agree well with the SM expectation within the uncertainties. No evidence for single top production is observed. Using a maximum likelihood method an upper limit on the anomalous top production cross section of $\sigma_{ep\to etX} < 0.16$ pb is established at 95% CL. The corresponding H1 limit on the coupling $\kappa_{tu\gamma} < 0.14$ is shown in figure 2 (right) and is currently the best limit compared to those from other colliders [13, 14].

References

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H1 Preliminary l+$P_T^{\rm miss}$ events at HERA I+II		Electron obs./exp. (Signal contribution)	Muon obs./exp. (Signal contribution)	Combined obs./exp. (Signal contribution)
e^+p	Full Sample	26 / 27.3 ± 3.8 (71%)	15 / 7.2 ± 1.1 (85%)	41 / 34.5 ± 4.8 (74%)
294 pb^{-1}	$P_T^X > 25$ GeV	11 / 4.7 ± 0.9 (75%)	10 / 4.2 ± 0.7 (85%)	21 / 8.9 ± 1.5 (80%)
e^-p	Full Sample	16 / 19.4 ± 2.7 (65%)	2 / 5.1 ± 0.7 (78%)	18 / 24.4 ± 3.4 (68%)
184 pb^{-1}	$P_T^X > 25$ GeV	3 / 3.8 ± 0.6 (61%)	0 / 3.1 ± 0.5 (74%)	3 / 6.9 ± 1.0 (67%)
$e^\pm p$	Full Sample	42 / 46.7 ± 6.5 (69%)	17 / 12.2 ± 1.8 (82%)	59 / 58.9 ± 8.2 (72%)
478 pb^{-1}	$P_T^X > 25$ GeV	14 / 8.5 ± 1.5 (68%)	10 / 7.3 ± 1.2 (79%)	24 / 15.8 ± 2.5 (73%)

Table 1: Summary of the H1 results of searches for events with isolated electrons or muons and missing transverse momentum for the e^+p data (294 pb^{-1}), e^-p data (184 pb^{-1}) and the full HERA I+II data set (478 pb^{-1}). The results are shown for the full selected sample and for the subsample at large $P_T^X > 25$ GeV. The number of observed events is compared to the SM prediction. The signal component of the SM expectation, dominated by real W production, is given as a percentage in parentheses. The quoted errors contain statistical and systematic uncertainties added in quadrature.

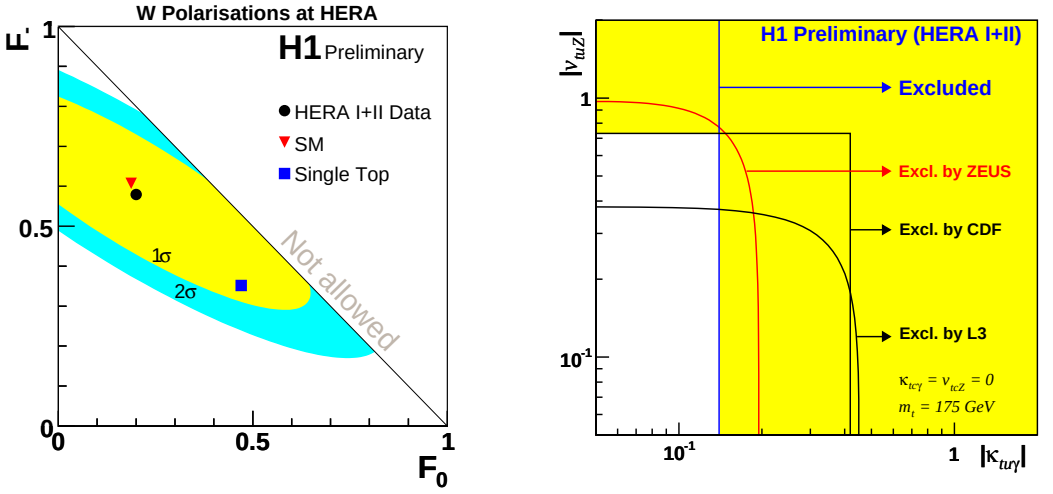

Figure 2: Left: The fit result for the simultaneously extracted left handed (F_-) and longitudinal (F_0) W boson polarisation fractions (point) at 1 and 2σ CL (contours). Also shown are the values for the SM prediction (triangle) and anomalous single top production via FCNC (square). Right: Exclusion limits at the 95% CL in the search for single top production on the anomalous $\kappa_{tu\gamma}$ and v_{tuZ} couplings obtained at LEP (L3 experiment [13]), the TeVatron (CDF experiment [14], the result shown is from [15]), and HERA (H1 [10] and ZEUS [3] experiments). Anomalous couplings of the charm quark are neglected $\kappa_{tc\gamma} = v_{tcZ} = 0$. Limits are shown assuming a top mass $m_t = 175$ GeV.