W PRODUCTION AND SEARCH FOR TOP AT HERA

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Investigations of W production and events with missing transverse momentum and an isolated lepton are performed in ep collisions at HERA. The observed events are compared with the expectations from the Standard Model and are used to set limits on the reaction $ep \to etX$ and on a possible flavour changing neutral current $tu\gamma$ coupling.

1 W production

The HERA collaborations H1 and ZEUS have investigated events which fulfil the topology of a W produced in ep collisons ($ep \to eWX$) at centre of mass energy ≈ 300 GeV[1,2,3]. In the analyses reported here only the electron and muon decay of the W are discussed but see[4] for a study on the τ and hadronic decay channels. W candidates are separated from the very large background by searching for events with missing transverse momentum and an isolated electron or muon.

ZEUS performs a search for events with isolated tracks in association with missing transverse momentum, followed by lepton identification. H1 performs a similar search but applies extra cuts against Standard Model processes other than W production. The advantage of the ZEUS selection is that a simpler set of cuts is employed. It does mean, however, that there is a higher expectation from non-W processes when compared to the H1 selection. The other major difference between the selections is that H1 searches in a larger range of polar angle[a] of the decay lepton, $5° < \theta_l < 145°$, compared to ZEUS, $17.2° < \theta_l < 114.6°$.

ZEUS observes 11 events in 82 pb^{-1} of data in good agreement with the Standard Model expectation of 9.8. Of these 11 events 3 were observed in the e^+p data from 1994-1997[5] and the remainder were recorded in more recent data. The breakdown of the events into each lepton channel and the different running periods is listed in table 1.

H1 observes 14 events in the 82 pb^{-1} of e^+p scattering data compared to a Standard Model expectation of 8.2. No events were seen in the 14 pb^{-1} of e^-p data. The observed excess above Standard Model expectations becomes more striking at large values of transverse momentum of the hadronic system P_T^X as can be seen in table 2. In the region $P_T^X > 25$ GeV 9 events are seen when only 2.26 are expected from the Standard Model. Of these 9 events 5 were first seen in the e^+p data from 1994-1997[6] and the remainder were recorded in more recent data.

Various distributions are compared for the selected events. Two examples are shown here. In Fig. 1 the distribution in P_T^X of ZEUS events from the muon channel are compared to the Standard Model expectation. As can be seen the 4 muons events lie at low values in good agreement with the Standard Model expectation, which is dominated by the two photon process ($ep \to e\mu^+\mu^-X$). All other distributions of the ZEUS events show good agreement with the Standard Model. In Fig. 2 the transverse mass of the neutrino-lepton system M_T is shown for the H1 events. The events generally have large values of M_T that are centred about the W mass. Although there is a difference in normalisation, the shape of the distribution is well described by the Monte Carlo prediction. The shapes of all other distributions of the H1 events, be-

[a]Polar angle is defined in the LAB frame with the proton beam direction at $\theta = 0$.

ZEUS	Electrons observed/expected (W)	Muons observed/expected (W)
94-97 e^+p 48 pb^{-1} published	3 / 3.5±0.7 (0.9)	0 / 2.0±0.4 (0.4)
98-99 e^-p 16 pb^{-1} preliminary	2 / 0.8±0.4 (0.5)	0 / 0.8±0.1 (0.2)
99 e^+p 18 pb^{-1} preliminary	2 / 1.8±0.4 (0.5)	4 / 0.9±0.1 (0.2)
Total 82 pb^{-1}	7 / 6.1±0.9 (1.9)	4 / 3.7±0.4 (0.8)

Table 1. The number of observed events from ZEUS compared to the Standard Model prediction and its W component for each data taking period.

Electron and Muon	H1 Prelim. Data	SM expectation	W	Other SM processes
$P_T^X > 0$ GeV	14	8.16 ± 1.97	6.36 ± 1.91	1.80 ± 0.46
$P_T^X > 12$ GeV	12	4.07 ± 1.03	3.30 ± 0.99	0.77 ± 0.27
$P_T^X > 25$ GeV	9	2.26 ± 0.57	1.83 ± 0.55	0.43 ± 0.15
$P_T^X > 40$ GeV	6	0.79 ± 0.22	0.74 ± 0.22	0.05 ± 0.03

Table 2. H1 observed and predicted event rates in the electron and muon decay channels combined for all e^+p data (82 pb^{-1}). Only the electron channel contributes for $P_T^X < 12$ GeV.

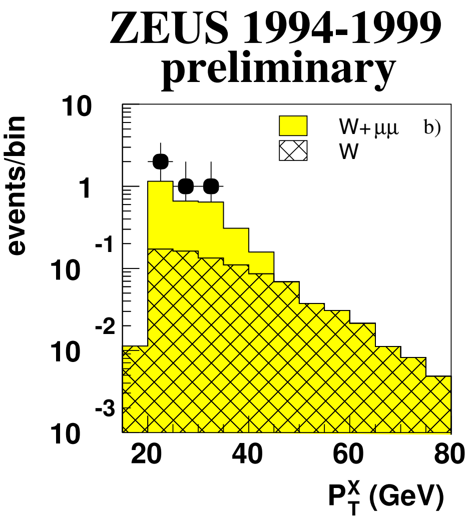

Figure 1. Distribution of P_T^X of the ZEUS muon events, compared with the Standard Model expectation.

sides that of P_T^X, show good agreement with the expectation.

Since the analysis cuts that are used by the two collaborations are rather different, the Standard Model expectations are also different. In order to facilitate a clearer comparison between the experiments ZEUS repeated their analysis with some extra cuts against non-W processes and for $P_T^X > 25$ GeV. H1 repeated their analysis but restricted the measurement to range of lepton polar angle of the ZEUS analysis ($17.2° < \theta_l < 114.6°$). ZEUS sees 1 event for a Standard Model expectation of 1.6. H1 sees 9 events compared to a Standard Model expectation 1.8. In both experiments the Standard Model is dominated by W production.

From the above results it is clear that the differences in event yield between ZEUS and H1 cannot be put down to differences in experimental technique. The most likely explanation is a statistical fluctuation in one experiment. We must wait until after the luminosity upgrade of HERA, when each experiment is expected to receive 1 fb^{-1} of data, to see whether the events are a product of new physics or merely a statistical fluctuation.

2 Top production

Since top decays dominantly via $t \to bW$, the W results may also be used to set lim-

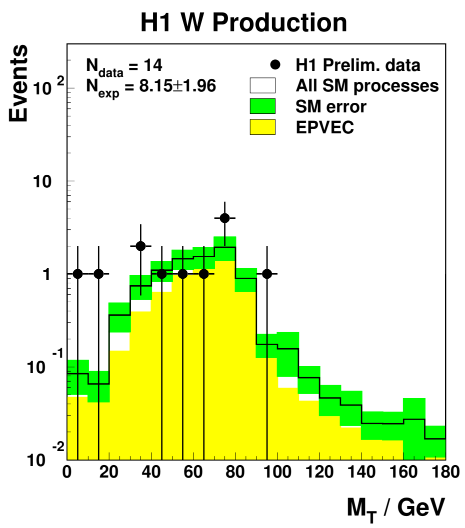

Figure 2. Distribution of M_T of the H1 events, compared with the Standard Model expectation.

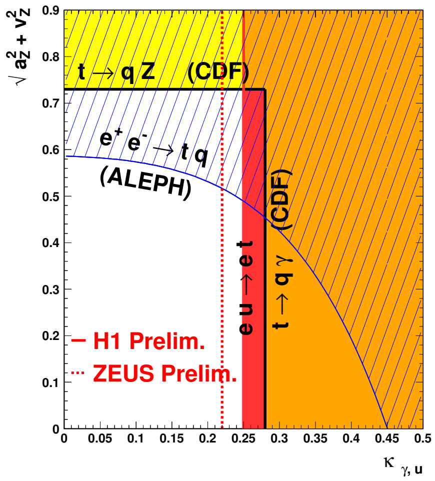

Figure 3. Limits on the anomolous $tu\gamma$ (magnetic) coupling $\kappa_{\gamma,u}$ and on the anomolous tuZ (vector) coupling $\sqrt{a_Z^2 + v_Z^2}$ obtained at the Tevatron (CDF), LEP (ALEPH) and HERA (H1 and ZEUS).

its on top production at HERA. In the Standard Model the cross section is extremely low, but certain extensions predict anomalous flavour changing neutral current coupling $\kappa_{\gamma,u}$[7], which could result in an observable rate of single top production at HERA. The experiments select events which fulfil the W requirements and in addition have $P_T^X > 25(40)$ GeV for H1 (ZEUS). H1 applies some extra cuts to further reject Standard Model W production. H1 also searches in the hadronic decay of the W by selecting events with 3 or more jets any two of which are close in mass to M_W.

No clear evidence for top production was found, although H1 sees an excess of 5 data events in the leptonic decay channel compared with an expectation from the Standard Model of 1.2. ZEUS sees 0 events with an expectation of 0.65 from the Standard Model. In the hadronic decay channel H1 sees 10 events compared with 8.3 expected from the Standard Model. These results are used to place limits on $\kappa_{\gamma,u}$, which are shown in Fig.3. As can be seen the HERA results are very competitive with those from other colliders.

References

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