Submitted to

31st International Conference on High Energy Physics, ICHEP02, July 24, 2002, Amsterdam

Abstract: **1023**

Parallel Session **10**

www-h1.desy.de/h1/www/publications/conf/conf_list.html

Search for W production in the hadronic decay channel at HERA

H1 Collaboration

Abstract

The H1 experiment has reported an excess of events with an isolated lepton, missing transverse momentum and a high E_T hadronic system. The kinematics of these events are mostly compatible with a leptonic W decay. Here we investigate W production in the jet decay channel. Using an integrated luminosity of 117.3 pb^{-1}, jets are selected using the inclusive k_T algorithm with a minimum transverse energy of 25 GeV for the highest E_T jet. The phase space has been optimized to maximize the acceptance for W events and to reject other Standard Model processes. The data are compared to QCD expectations as a function of the E_T of the hadronic system excluding the W.

1 Introduction

The H1 Collaboration has reported on the observation of events with a lepton of high transverse momentum and with missing transverse momentum [1, 2, 3]. The kinematics of these events are mostly compatible with a leptonic W decay. At P_T^X greater than 40 GeV, 6 events were found compared to 0.99 ± 0.28 expected, where P_T^X is the transverse momentum of the hadronic system.

In this analysis a search for W production in the dominant hadronic decay mode is performed. In analogy to the leptonic channel the data are compared to the Standard Model expectation as a function of P_T^X, which can be reconstructed by subtracting the hadronic decay products of the W from the total hadronic system.

This paper is based on e^+p and e^-p data samples collected with the H1 detector in the years 1995-2000 and correspond to an integrated luminosity of 117.3 pb^{-1}. The analysis has been tuned to maximize the acceptance for W events and to reject other Standard Model processes.

2 Standard Model Predictions

The direct and resolved photoproduction of jets is modeled by the PYTHIA event generator [4]. It contains the Born level QCD matrix elements. Higher order QCD effects are accounted for by leading logarithmic parton showers. The hadronization of the outgoing partons is based on the Lund String model. The GRV LO parton density functions [5] are used for the photon and the proton. Analogue to [6], PYTHIA is scaled by a factor 1.2 to obtain a correct normalization to the data.

Event rates from neutral current deep inelastic scattering are calculated using DJANGO [7] and RAPGAP [8] models.

The production of W events is modeled using EPVEC [9]. Final state parton showers are simulated using the PYTHIA framework [10]. An error of $31\% - 46\%$, which varies as a function of P_T^X, is quoted for the W cross section calculation. The main contributions to this error originate from the uncertainties in the photon parton density functions and the scale at which the calculation is performed. Moreover the uncertainty of the efficiency, estimated using the event generator PYTHIA, is included in this error.

3 Event Selection

Jets are selected using the inclusive k_T algorithm [11, 12] with a minimum transverse energy of 25 GeV for the leading jet and 20 GeV for the second highest E_T jet. A third jet with a transverse momentum above 5 GeV is allowed for. The dijet combination with invariant mass M_{ij} closest to the W mass is used as the W candidate. The pseudorapidity $\eta_{i,j}$ of each jet is restricted to the range $-0.5 < \eta_{i,j} < 2.5$. The inelasticity y, reconstructed using hadronic variables [13], is required to be in the range $0.1 < y < 1.2$ to account for resolution effects and to reject background.

A cut on the missing transverse energy $E_{T,\mathrm{miss}} < 20$ GeV is applied to reject charge current and non-ep scattering background. Neutral current events where the electron[1] is misidentified as a jet are rejected.

In order to optimize the phase space cuts for W production a two-dimensional likelihood analysis was performed in the $(M_{ij}, |\cos\hat{\theta}|)$-plane, where $\hat{\theta}$ is the decay angle of the two jets closest to the W mass in the W rest frame. Two-dimensional probability densities $P(M_{ij}, |\cos\hat{\theta}|)$ of simulated W and QCD events are used to evaluate the likelihood L of an event:

$$L = \frac{P_{\mathrm{W}}(M_{ij}, |\cos\hat{\theta}|)}{P_{\mathrm{W}}(M_{ij}, |\cos\hat{\theta}|) + P_{\mathrm{QCD}}(M_{ij}, |\cos\hat{\theta}|)}.$$

The upper limit $\sigma^{95\% C.L.}$ assuming that all data are QCD events is calculated at 95% confidence level (C.L.) for each possible likelihood cut value. The minimum value of $\sigma^{95\% C.L.}$ determines the likelihood cut value, which corresponds roughly to the region $M_{ij} > 72$ GeV and $|\cos\hat{\theta}| < 0.6$. The distributions of $|\cos\hat{\theta}|$ and M_{ij} are shown in figure 1 and respectively 3, where the above cuts are indicated. The systematic uncertainty of the Standard Model expectation is indicated by a grey band. The error bars denote the statistical uncertainty.

Applying the selection criteria described above, the efficiencies as a function of P_T^X are shown in table 1. The reduction of the efficiency at $P_T^X > 12$ GeV is mainly due to the inevitable merging of one of the W decay quarks with the W recoil quark into one jet by the jet algorithm if their distance in the (η, ϕ)-plane is less than the separation parameter of the jet algorithm.

4 Systematic uncertainties

The following sources contribute to the systematic uncertainty of the QCD background:

- The difference in shape between Standard Model and data in the non-signal region amounts to 15%.
- The uncertainty of the parton density function at high transverse momentum results in an uncertainty of 10%.
- A 4 % uncertainty in the jet energy scale results in an uncertainty of 10%.
- Uncertainties arising from the high y region, electron-jet separation and background add up in an uncertainty of 10%.

All errors are added quadratically so that the overall systematic uncertainty is 23%.

[1] In this paper "electron" refers generically to both electrons and positrons.

5 Results

The measured data show an overall agreement with the Standard Model expectation up to the highest P_T^X values, which is corroborated in figure 4. In table 2 the data and the Standard Model expectation are presented for the cuts on P_T^X used in the leptonic search [2]. At $P_T^X > 40$, GeV 25 events are observed compared to 2.3 ± 0.7 expected from W production and 25.9 ± 6.5 from other Standard Model sources.

6 Summary

A search for W production in the hadronic decay channel has been performed in a data sample corresponding to a integrated luminosity of 117.3 pb^{-1}. No deviation from the Standard Model, which is dominated by QCD processes, was observed.

References

[1] H1 Collab., T. Ahmed et al., DESY preprint 94-248 (1994).

[2] H1 Collab., C. Adloff et al., *Eur. Phys. J.* **C 5** (1998) 575.

[3] ZEUS Collab., J. Breitweg et al., *Phys. Lett.* **B 471** (2000) 411.

[4] T. Sjostrand, CERN-TH-6488 (1992), *Comp. Phys. Commun.* **82** (1994) 74.

[5] M. Glück, E. Reya and A. Vogt , *Phys. Rev.* **D 45** (1992) 3986.

[6] C. Adloff *et al.* [H1 Collaboration], arXiv:hep-ex/0201006.

[7] K. Charchula et al., *Comp. Phys. Commun.* **81** (1994) 381.

[8] H. Jung, DESY-93-182 (1993), *Comp. Phys. Commun.* **86** (1995) 147.

[9] U.Baur, J.A.M. Vermaseren, D.Zeppenfeld, *Nucl. Phys.* **B 375** (1992) 3.

[10] C. Diaconu, "Monte Carlo Generators for HERA Physics", Proceedings of the workshop 1998/1999, DESY-PROC-1999-02, p.631.

[11] S.D. Ellis and D.E. Soper, *Phys. Rev.* **D 48** (1993) 3160.

[12] S. Catani, Yu.L. Dokshitzer, M.H. Seymour and B.R. Webber, *Nucl. Phys.* **B 406** (1993) 187.

[13] A. Blondel and F. Jacquet, Proceedings of the Study of an *ep* Facility for Europe ed. U. Amaldi, DESY 79/48 (1979) 391.

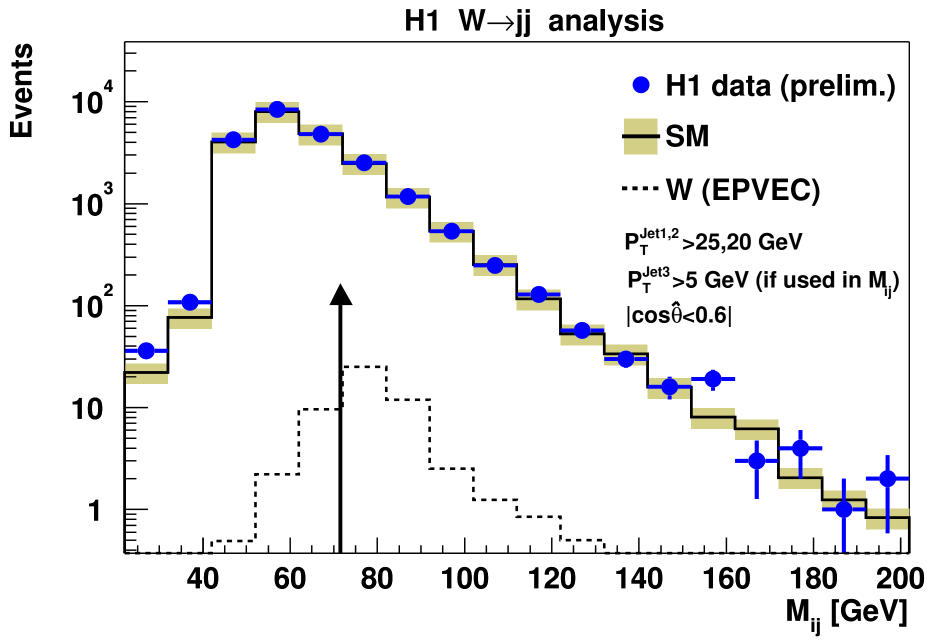

Figure 1: Invariant mass M_{ij} of the two jets closest to the W mass before the cut of $M_{ij} > 72$ GeV.

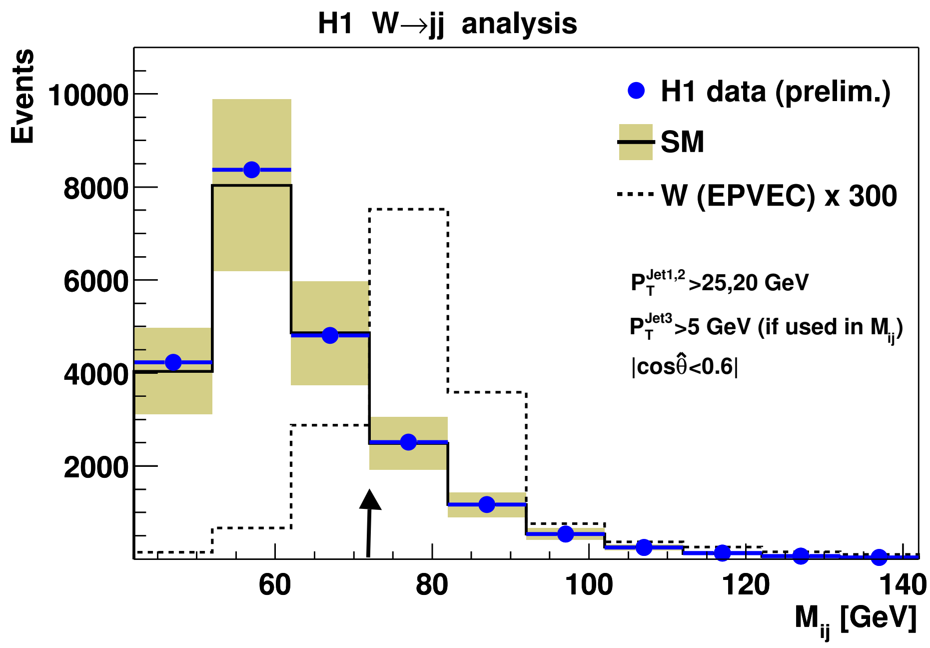

Figure 2: Same as figure 1 on a linear scale.

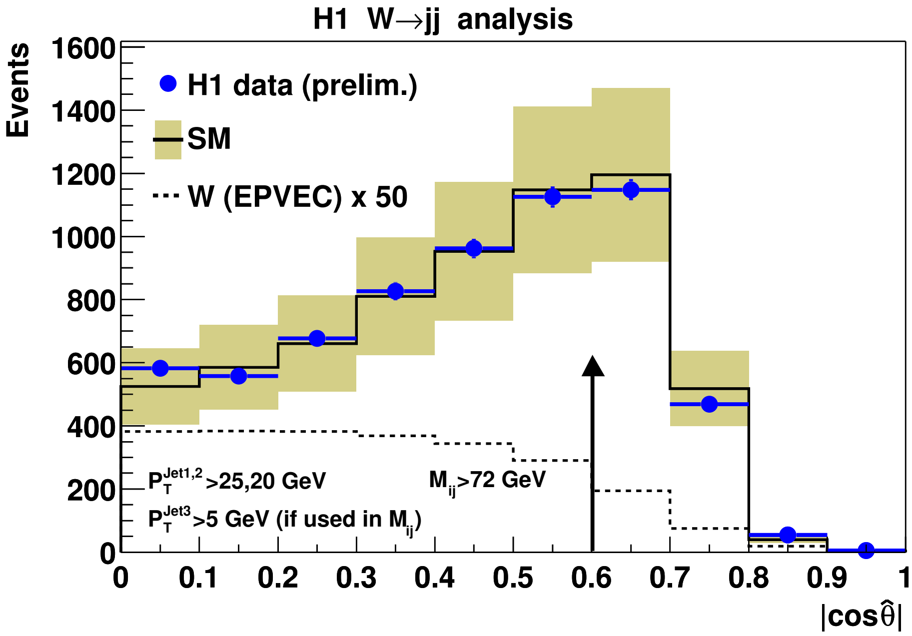

Figure 3: Cosine of the decay angle of the two jets closest to the W mass in the W rest frame before the cut of $|\cos\hat{\theta}| < 0.6$.

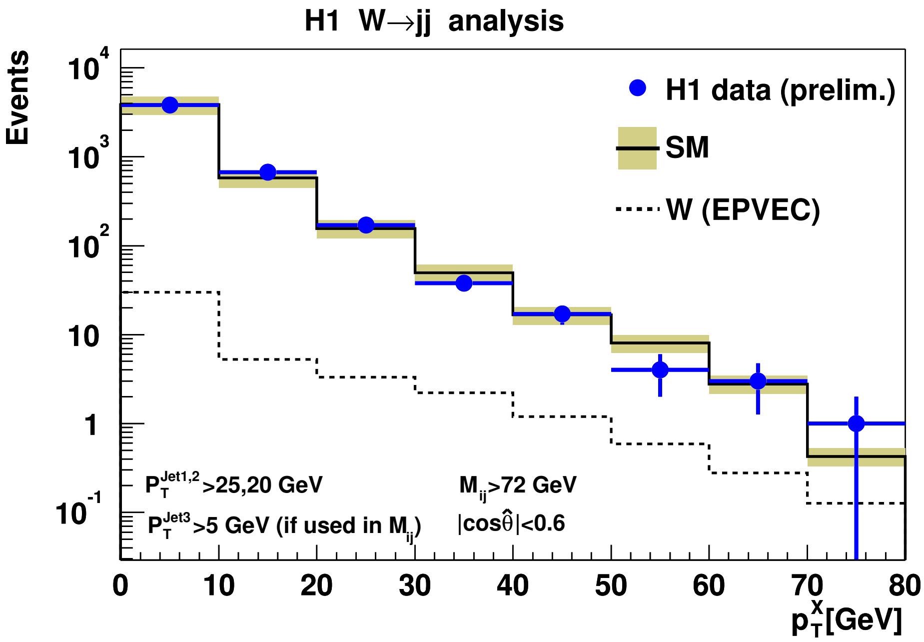

Figure 4: P_T^X of the final data sample.

Cut on P_T^X	Efficiency
P_T^X >0 GeV	0.38
P_T^X >12 GeV	0.27
P_T^X >25 GeV	0.27
P_T^X >40 GeV	0.27

Table 1: Efficiencies of the final selection for W decay in the hadronic channel as a function of the cut on P_T^X calculated with the EPVEC generator.

Cut on P_T^X	Data	SM expectation	W	Other SM processes
P_T^X >0 GeV	4731	4683 $\pm$1160	43.0 $\pm$14.7	4640 $\pm$ 1160
P_T^X >12 GeV	683	622 $\pm$150	11.8 $\pm$3.6	610 $\pm$150
P_T^X >25 GeV	119	136 $\pm$33	5.9 $\pm$1.8	130$\pm$ 33
P_T^X >40 GeV	25	28.2 $\pm$6.5	2.3 $\pm$0.7	25.9 $\pm$ 6.5

Table 2: Observed and predicted event rates in the hadronic channel for the final selection.