31302: New H1 Results at High Q^2

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Abstract. From the 1994-1996 data samples,the H1 and ZEUS collaborations at HERA reported an excess of events at high Q^2 [1, 2]. We present here the update of the H1 publication using in addition the first half of the data taken in 1997, which corresponds to a total luminosity of 23.7 pb^{-1}. These data allow also for an improved measurement of the double differential neutral current cross-section up to $Q^2 = 5000$ GeV^2 and x=0.32. Within these data events with missing p_t and isolated leptons were observed, which are compared to expectations from W production.

1 Introduction

At the HERA ep collider, the interaction of 27.5 GeV positrons with 820 GeV protons allows for precise measurements of the proton structure functions via t-channel exchange of virtual photons or weak bosons [3]. New particles can be produced in the s-channel, such as leptoquarks, leptogluons or R-parity violating squarks with masses up to 300 GeV. Above these masses, contact term interactions may be found in the t or u channel.

The H1 detector is a multipurpose, nearly 4π detector. Its highly segmented liquid Argon calorimeter has a resolution of $12\%/\sqrt{E}$ for the electromagnetic section and $50\%/\sqrt{E}$ for the hadronic section. The energy scale of the scattered electron is known within 3% and its polar angle with a precision of 2-5 mrad. The energy scale error on the inclusive measurement of the hadronic final state is about 4%. The redundancy in the measurement of the scattered lepton and the hadronic final state allows for a variety of methods to reconstruct the kinematics, which can also be used for detector calibration, studies of initial QED radition and a good control of different systematic errors.

The ω method was developped, in order to compare the high Q^2 events of the H1 and ZEUS collaboration. The explanation of the excess observed by the two experiments [1, 2] as due to a single narrow resonnance was rendered unlikely by the comparison of the two datasets [4], as shown in figure 1.

Since then, the data taken until the end of june 1997, has been analysed, increasing the total luminosity from positron-proton scattering accumulated since 1994 to 23.7 pb^{-1}. Besides an update of the observation of events at very high Q^2, we present a measurement of the Neutral Current (NC) cross-section at high Q^2. We could also identify five events in the 94-97 data sample with a high missing p_t in the liquid Argon calorimeter and a clearly identified isolated lepton. These events are compared to expectations from W production.

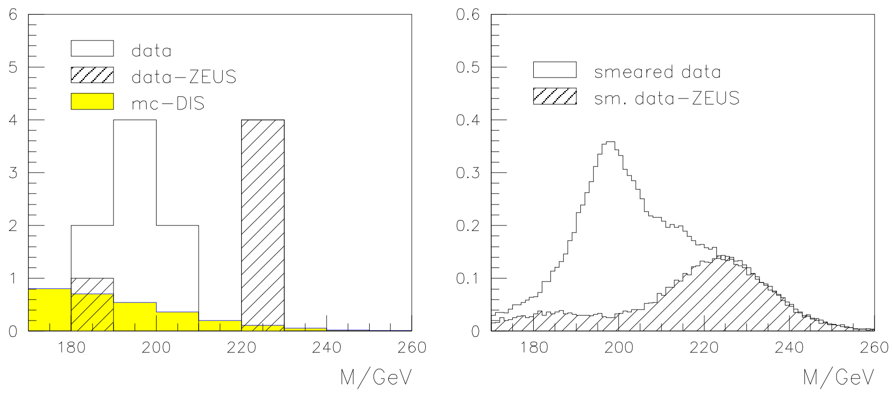

Fig. 1. Comparison of H1 and ZEUS high Q^2 events using the ω method.

2 $\mathbf{F_2}$ Measurement at High Q^2

In deep inelastic scattering (DIS) the double differential NC cross-section can be written as

$$\frac{d^2\sigma}{dx\, dQ^2} = \frac{2\pi\alpha^2}{xQ^4}\left[Y_+ F_2(x,Q^2) - y^2 F_L(x,Q^2) - Y_- xF_3(x,Q^2)\right] \qquad (1)$$

with the helicity term $Y_\pm(y) = 1 \pm (1-y)^2$. In this notation, F_L is the longitudinal structure function, F_2 is the generalized structure functions which contains a contribution from pure photon exchange F_2^{em}, a weak contribution from the Z^0 exchange supressed by M_Z^4, and a contribution from the interference of both terms suppressed by M_Z^2, while xF_3 is due to the Z^0 exchange only. In the following we are presenting $F_2 = F_2^{em}$. The correction to F_2 arising from the weak contributions to the cross-sections is below 1% at $Q^2 < 1500$ GeV^2 and about 10% at $Q^2 = 5000$ GeV^2 and $x = 0.08$. The correction from the longitudinal cross-section is about 5% at $y = 0.9$ and negligible at $y < 0.5$.

The figure 2(a) shows the measurement of F_2 from $Q^2 = 150$ GeV^2 to $Q^2 = 5000$ GeV^2 compared to NLO-QCD fit performed on low Q^2 H1, BCDMS and NMC data ($Q^2 < 120$ GeV^2) [5]. The DGLAP extrapolation of this fit into the measured kinematic region shows good agreement and verifies the validity of perturbative QCD (pQCD) within this kinematic domain.

In figure 2(b) the measurement of the reduced cross-section

$$\sigma(e^+p) = \frac{xQ^4}{2\pi\alpha^2}\frac{1}{Y_+}\frac{\mathrm{d}^2\sigma}{\mathrm{d}x\mathrm{d}Q^2} \qquad (2)$$

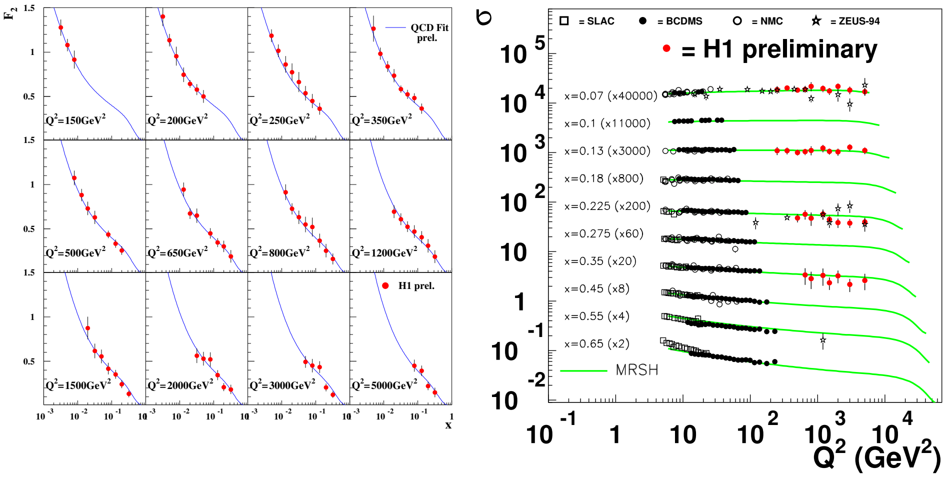

Fig. 2. (a) Preliminary F_2 measurement at high Q^2 compared to NLO QCD-fit performed on moderate Q^2 data ($Q^2 < 120$ GeV^2). (b) Reduced cross-section as function of Q^2 for fixed values of x, compared to fixed targed date and the MRSH parton density parametrisation.

is presented as a function of Q^2. The data are compared to the MRSH parton density parametrisation [6], which is used in the Standard Model expectation at very high Q^2. The new measurement shows no significant deviation from this parametrisation and supports a 6% uncertainty of the parton densities in the very high Q^2 region. The cross-section obtained from the QCD evolution is well constrained in this kinematic region by the low Q^2 fixed target data. It has essentially a flat behaviour in Q^2, except at $Q^2 > 10000$ GeV^2, where the suppression of the cross-section by the weak contribution becomes visible.

3 Events at Very High Q^2

The event selection applied for the very high Q^2 event sample can be found in [1]. For the NC event sample, it is essentially based on an identified scattered electron with $Q^2 > 2500$ GeV^2 within a y range between 0.1 to 0.9. The geometric acceptance is limited to an electron-scattering angle of 10° [1]. The background events, as well as events with strong initial state QED radiation are rejected using mainly kinematic criterias from energy-momentum conservation. The remaining background contribution was estimated to be less than 0.1%, the dominating source being jet-jet events from photoproduction.

Figure 3(a,c) is showing the Q^2 distribution of these events compared to the expectation from DIS using the MRSH parton densities parametrisation. We see a good agreement between the data and the expectation up

[1] the polar angle is measured at HERA w.r.t. the proton beam direction

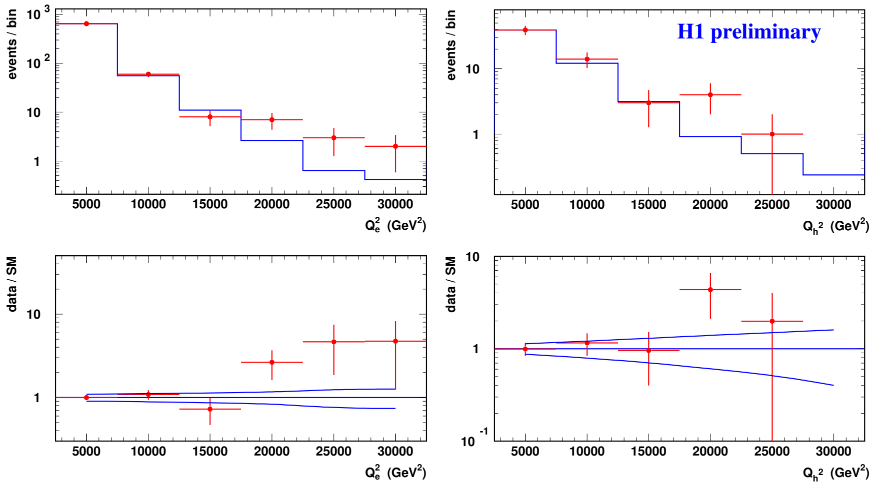

Fig. 3. Q^2 distribution of 94-97 data compared to expectation (MRSH) for Neutral Current (a) and Charged Current (b).

to Q^2 values of 15000 GeV^2. Above this Q^2 value the data are lying above the expectation: for $Q^2 > 2500$ GeV^2 724 events are observed compared to 714 $\pm$ 69 expected, whereas at $Q^2 > 15000$ GeV^2 18 events are observed compared to 8 $\pm$ 1.2 expected. This corresponds to a Poisson probability $\mathcal{P}(\mathcal{N} \geq \mathcal{N}obs) = 3\times10^{-3}$. The significance of the excess has slightly decreased compared to the observation on the 94-96 data only, where for $Q^2 > 15000$ GeV^2 12 events were observed againts 4.71 $\pm$ 0.76 expected corresponding to a Poisson probablity $\mathcal{P}(\mathcal{N} \geq \mathcal{N}obs) = 6 \times 10^{-3}$. The number of charged current events (figure 3 b,d) as function of Q^2 shows also good agreement up to Q^2 values of 15000 GeV^2. At $Q^2 > 15000$ GeV^2 6 events are observed against 2.9 expected.

In the mass bin of 200 GeV $\pm$ 12.5 GeV with y> 0.4, where in 94-96 data 7 events accumulated against 0.95 expected, only one new event was added during the first half of the 1997 data taking (fig.4).Now 8 events are observed within this mass window compared to 1.53 $\pm$ 0.29 expected. This corresponds to a Poisson probability $\mathcal{P}(\mathcal{N} \geq \mathcal{N}obs) = 3.3 \times 10^{-4}$.

4 Events with Isolated Leptons

A first event showing an isolated μ and large missing p_t has been found during the 1994 data taking [7]. Based on the charged current event selection, i.e. on events with missing $p_t > 25$ GeV in the liquid Argon calorimeter, four more events were found with isolated leptons carrying more than 10 GeV of p_t since then. The isolation crieria are based both on track and calorimetric isolation in rapidity and azimuth. The isolated leptons could be identified as

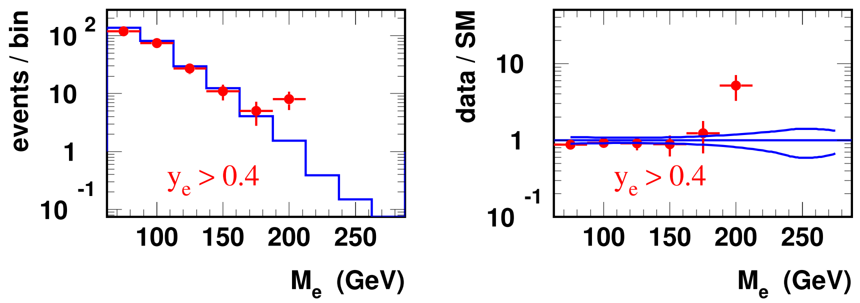

Fig. 4. Mass distribution of events with $Q^>$ 15000 GeV^2 and y> 0.4. One more event was observed in 97 in the mass bin around 200 GeV.

being μ^+ in two events (μ-1, μ-2), μ^- in two events (μ-3, μ-4) and an electron in one event. The event properties are summarized in table 2 of [8].

These events can be compared to expectations from W production with subsequent leptonic decay (fig.4). The expected kinematic signature for W-production would be a small hadronic p_t and a Jacobian peak in $M_{T(l\nu)}$ close to the W-mass. Figure 6 compares the observed events to W-production events simulated in the H1 detector with 500 times the luminosity of the data sample. The observed events are indicated by the lines which are giving the errors on the recontruction of p_t and the transverse mass. In the case of W-production with an $e\nu$ decay, the observed event can be compared to 1.34 events expected and its kinematics is lying in the bulk part of events from W-production. For W-production with a $\mu\nu$ decay we expect 0.41 events, and 4 events are observed with muons in the final state. The μ-1 and μ-2 events are at very low mass and high p_t, whereas μ-3 and μ-4 have masses close to the W mass. The estimated background for these events is below 0.05 events, mainly events from heavy quark production in γp and $\gamma\gamma \rightarrow \tau^+\tau-$.

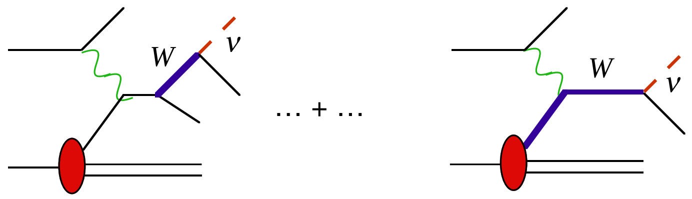

Fig. 5. The W production with leptonic decay.In the H1 detector the scattered electron would escape undected in the beam-pipe and large missing p_t would be observed due to the neutrinos.

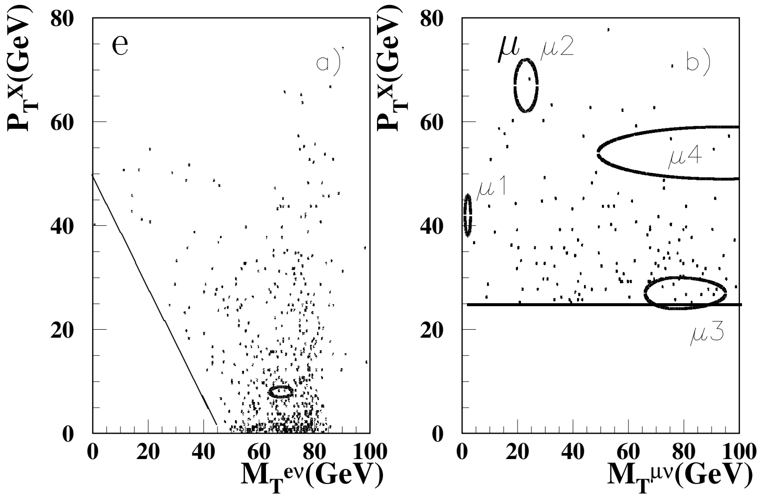

Fig. 6. Transverse mass distribution of the event with an isolted electron in the hadronic final state (a) and of the 4 events with an isolated muon compared to expectations from W-production. The lines indicate the acceptance due to the selection cuts.

5 Summary

The 1997 data taking has been very succesfull, already with the data accumulated up to june 97, the accuracy of the proton structure function measurement in the kinematic region of Q^2 below 5000 GeV^2 has been substantially improved. The cross-section in this kinematic region is in good agreement with the expectation from the pQCD. At very high Q^2, above 15000 GeV^2, 18 Neutral Current events are observed in this data sample againts 8 events expected, decreasing slightly the significance of the observation on the 94-96 data sample only. Four events with isolated muons and missing p_t were observed and compared to W production.

References

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