EPS-0466
Submitted to EPS Conference sessions PL 3, 19 and PA 1

Measurement of the Differential Cross Sections for Charged Current and Neutral Current Interactions at HERA

H1 Collaboration

Abstract

Using the 1994 charged and neutral current e^+p event samples obtained with the H1 detector Q^2 distributions are determined for transverse momenta larger than 25 GeV and compared with the theoretical expectation.

1 Introduction

The processes $e^+p \to \overline{\nu} + hadrons$ and $e^+p \to e^+ + hadrons$ are investigated simultaneously at the HERA ep-collider, in which 27.5 GeV positrons collide with 820 GeV protons. The data selection follows closely the charged current (CC) analysis described in [1]. Its main requirement is a measured transverse momentum imbalance of the hadronic final state of at least 25 GeV. Neutral current (NC) events are signalled by the presence of an identified positron. Both the NC and CC events are treated on the same footing by imposing identical criteria to their hadronic final states. This ensures in the NC/CC ratio a cancelation of several of the systematic uncertainties. The kinematic properties of the positron are only used for efficiency and calibration purposes. The final event samples consist of 47 CC and 536 NC events corresponding to 2.7 pb^{-1}. The analysis described in [1] was improved by including also the forward tracking system which increases the previous 41 by 6 CC events with hadronic activity in the forward region and improves the detection efficiencies to 80-90 % depending upon the kinematic region.

The aim of this contribution is to obtain differential cross sections in Q^2 with $p_\perp > 25$ GeV for both channels.

2 Method

The kinematic quantity Q^2, the squared four momentum transfer, is reconstructed from the two directly measured observables, the transverse and longitudinal momentum of the hadronic final state. The observed and the unfolded Q^2-distributions are related to each other by the detector response function A

$$(d\sigma/dQ^2)_{meas} = \int dQ^2 A(Q^2_{meas}, Q^2) d\sigma/dQ^2. \qquad (1)$$

which includes the resolution in the kinematic quantity as well as all acceptances. It is determined by Monte Carlo [2] methods. All relevant features are cross checked by NC data making use of the complementary information provided by the positron. This includes also studies of the hadron energy scale which affects significantly the slope of the NC Q^2 distribution.

The distributions $(d\sigma/dQ^2)_{meas}$ are measured in 4 Q^2 intervals chosen appropriately according to statistics and migration. The bin limits are : 625, 1400, 2900, 5900, 90200 GeV^2. The detector response function is binned accordingly. The resulting matrix equations are inverted to obtain the unfolded distributions. The uncertainty in the unfolded distribution resulting from resolution and selection efficiencies is small compared to the statistical error and is included in the error bars shown in the figures below.

3 Results

The unfolded distributions are shown in fig.1. The first bin starts at 625 GeV^2 reflecting the fact that the data had to satisfy the selection criterion of 25 GeV in the observed transverse momentum of the hadron system. The largest systematic effect comes from

the uncertainty in the hadronic energy scale which is presently known to 5 % [1] and affects both the total and differential cross sections. In fact, a shift of +1 % increases the total NC cross section by 3.5 %, while only by 1.5 % for CC. In the NC/CC ratio the importance of the scale uncertainty decreases gradually with increasing Q^2.

The data are compared with the Standard Model prediction as indicated by the solid line. Good agreement is found both in absolute value and shape. The total CC cross section inferred from the differential distribution agrees with the previously published value [1]. The NC distribution exhibits the expected strong decrease due to the photon propagator. Also shown by the dotted line is the contribution expected from photon exchange alone which happens to be above the solid line as a consequence of the $\gamma - Z$ interference. Only at large values of Q^2 this difference is sizeable enough to be eventually measurable.

Fig.2 shows the Q^2-distribution of the NC/CC ratio. At small values of Q^2 the behaviour is dominated by the photon propagator. At values of Q^2 larger than the weak boson masses squared the two cross sections become comparable. Incidentally, the NC cross section is everywhere larger than the CC cross section. The predicted increase at $Q^2 > 10000$ GeV^2 is attributed to the quark flavors relevant for e^+p scattering.

4 Conclusion

Differential cross sections for neutral current and charged current interactions at HERA as well as their ratio have been measured. The results compare well with expectations from the Standard Model.

Acknowledgement

We are grateful to the HERA machine group whose outstanding efforts made this experiment possible. We appreciate the immense effort of the engineers and technicians who constructed and maintained the detector. We thank the funding agencies for financial support. We acknowledge the support of the DESY technical staff. We also wish to thank the DESY directorate for the hospitality extended to the non-DESY members of the collaboration.

References

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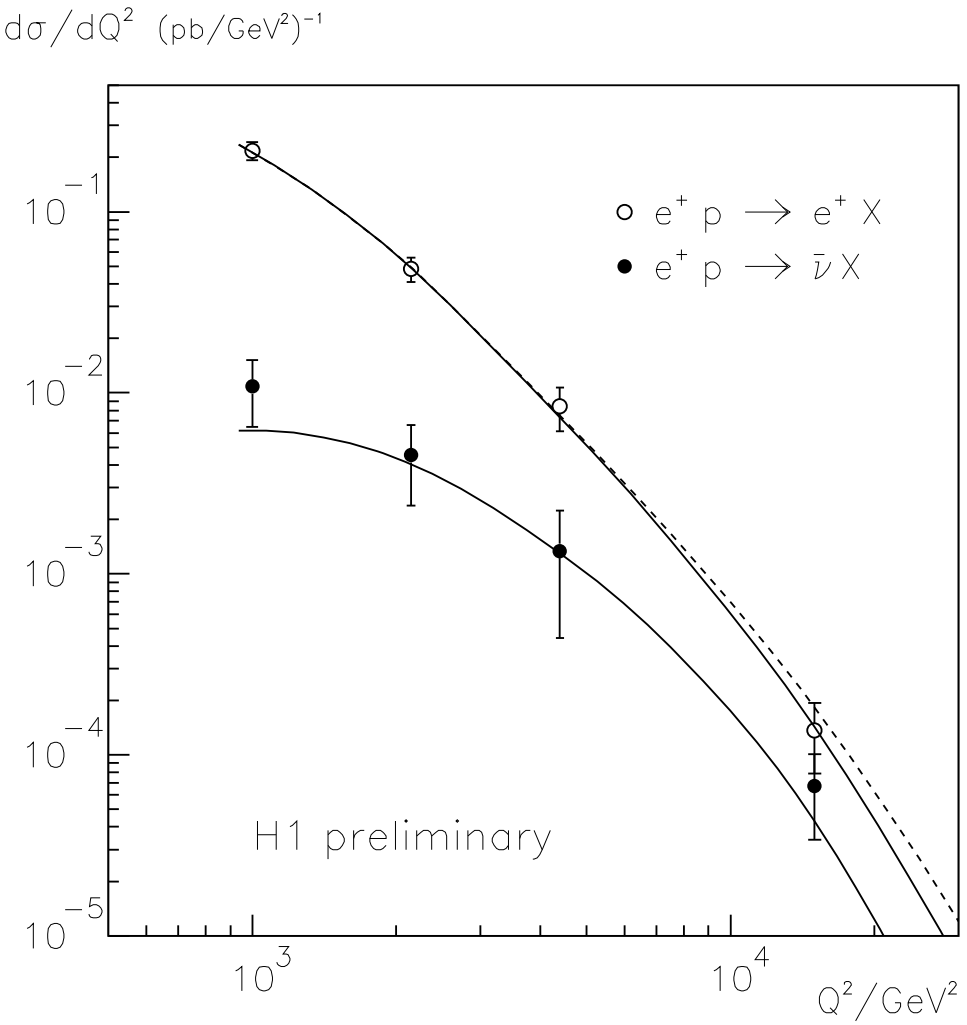

Figure 1: The unfolded Q^2 distributions are shown for charged and neutral current interactions for $p_\perp > 25$ GeV. The points are bin center corrected. All uncertainties except for the hadron energy scale (see text) are included in the error bars. The solid line indicates the Standard Model prediction. The dotted shows the prediction from photon exchange alone.

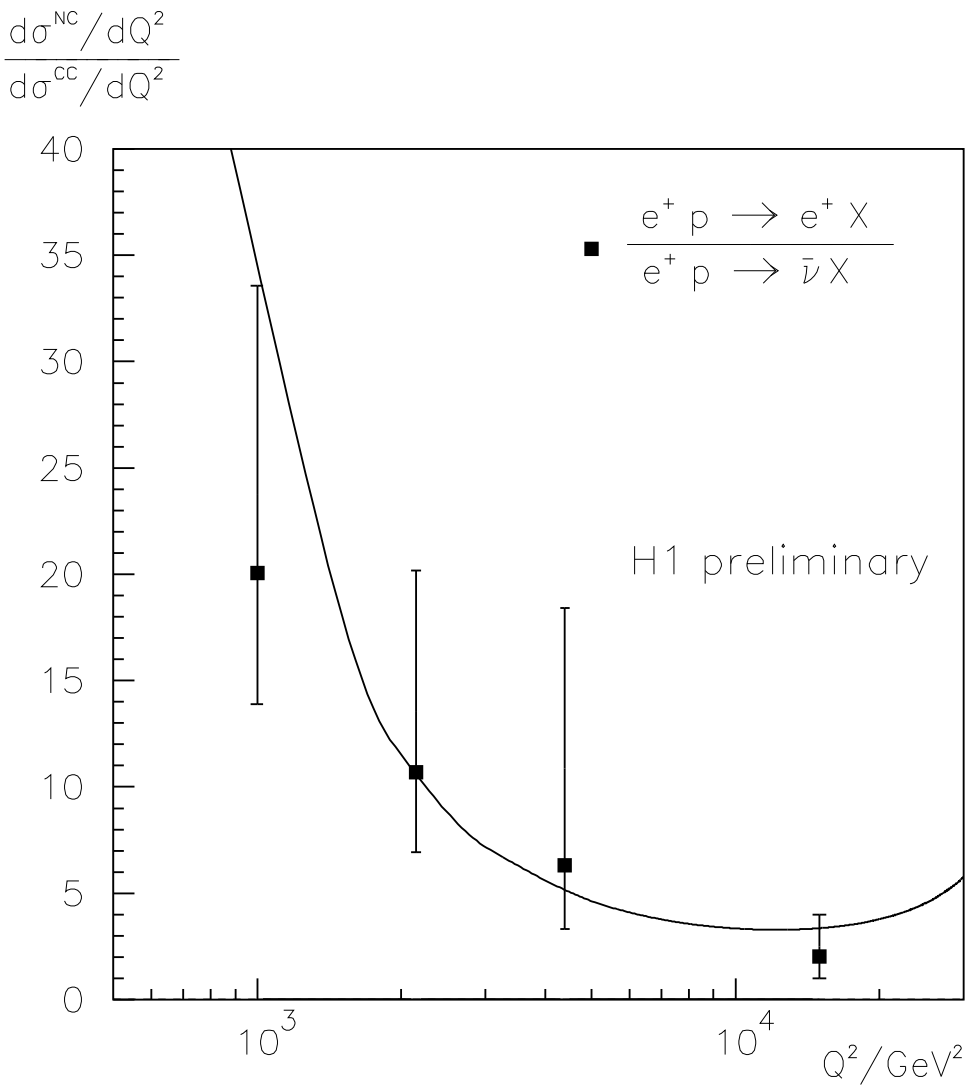

Figure 2: The ratio of the differential NC and CC cross sections vs. Q^2 for $p_\perp > 25$ GeV. All uncertainties except for the hadron energy scale (see text) are included in the error bars. The solid line indicates the Standard Model prediction. The points are bin center corrected.