Paper pa02-078
Submitted to the 28th International Conference on High Energy Physics
ICHEP'96, Warsaw, Poland, July 1996

Charged Current Differential Cross Sections for e^-p and e^+p Interactions at very high Q^2

H1 Collaboration

Abstract

Recent measurements of Charged Current differential cross sections made at very high 4-momentum transfer squared Q^2 by the H1 Collaboration are reported, using electron-proton (e^-p) and positron-proton (e^+p) interaction data collected at the HERA collider. The W propagator mass derived from the Q^2 distributions agrees with the on-shell mass measured at the Tevatron. The differential cross sections as a function of the Bjorken variables x and y behave as expected in the Standard Model. Combining the e^+p data collected in 1994 and 1995 and taking advantage of the helicity structure of the weak interaction, the down-type quark density in the proton is extracted at a very high average Q^2 of 2800 GeV^2.

1 Physics motivations

Within the parton model, the Charged Current (CC) differential cross sections for e^-p and e^+p interactions as function of the 4-momentum transfer squared Q^2 and the scaling Bjorken-x and y variables can be written as

$$\frac{d^2\sigma(e^-p)}{dxdQ^2} = \frac{G_F^2}{2\pi}\left(\frac{1}{1+Q^2/M_W^2}\right)^2 \left[\ (u+c) + \ (1-y)^2(\bar{d}+\bar{s})\ \right] \quad (1)$$

$$\frac{d^2\sigma(e^+p)}{dxdQ^2} = \frac{G_F^2}{2\pi}\left(\frac{1}{1+Q^2/M_W^2}\right)^2 \left[\ (\bar{u}+\bar{c})\ +\ (1-y)^2(d+s)\ \right] \quad (2)$$

where G_F is the Fermi coupling constant.

The propagator term gives access to the W propagator mass through the normalisations and shapes of the Q^2 differential cross sections. The quark and anti-quark densities within the proton can be disentangled, taking advantage of the V-A helicity structure of the weak interaction, which results in a different behaviour as a function of y of the quark and anti-quark components.

2 Experimental aspects

The results presented here are based on e^-proton collisions collected in 1993 and 1994 and on e^+proton collisions collected in 1994 and 1995. A detailed description of the H1 detector can be found elsewhere [1].

The high Q^2 CC candidates are selected requiring a large missing transverse momentum expected from the unobserved outgoing neutrino, together with a vertex reconstructed from the tracks of the outgoing hadrons. The missing transverse momentum p_T is measured from the visible hadronic transverse momentum sum $p_{T,h}$. A cut at $p_{T,h} > 25$ GeV rejects the background induced by high energy photoproduction interactions which are in general balanced in transverse momentum. The background induced by cosmic and halo muons is removed using topological and timing information from the muon tracker, central tracker and liquid argon calorimeter. The residual background is discarded by visual scanning. The final sample statistics is summarized in table 1. The numbers quoted for 1995 are still preliminary.

Table 1: Luminosity and Number of CC events.

	e^- $93+94$	e^+ 94	e^+ (prel.) 95
$\mathcal{L}$ (pb^{-1})	0.7	2.7	3.7
No. of CC events	25	47	58

The CC samples are corrected for trigger and selection efficiencies, which are estimated from pseudo-CC data built by removing the scattered electron from Neutral Current events. The kinematic variables are computed from the liquid argon calorimeter cells with the Jacquet-Blondel method [2] and unfolded for experimental effects using a detailed simulation of the detector response.

3 Results

The Charged Current and Neutral Current differential cross sections as a function of Q^2 have recently been published [3]. Both are of similar magnitude when Q^2 is of the order of the mass squared scale of the W boson, namely ≈ 6000 GeV^2. The propagator mass M_W was extracted from the shapes and normalizations of the Q^2 dependences of the differential e^+p and e^-p CC cross sections using an extended log-likelihood fit with M_W as a free parameter. This yielded :

$$M_W^{H1} = 84^{+9+5}_{-6-4} \text{ GeV}$$

where the first error is statistical and the second one systematic. The mass of the propagator is in good agreement with the on-shell W mass measured [4] at the Tevatron : 80.22 ± 0.26 GeV.

The differential x and y CC Born cross sections for e^+p collisions are shown in figures 1 and 2, combining data collected in 1994 and 1995. These cross sections are still preliminary. The average Q^2 of the data sample is 2800 GeV^2. The x distribution is in agreement with the expectation from the MRSH-DIS parametrization [5] simulated with HERACLES [6]. The y distribution shows the expected rise at low y, which is related to the helicity dependence of the dominating d-quark contribution to the cross section (equation (2)). Taking into account the uncertainty of the theoretical prediction and the correlated systematic errors, the tendency of the Standard Model expectation to lie below the measurements is at the level of 2.0 standard deviations.

The different helicity sensitivity of the quark and anti-quark components to the weak interaction (equation (2)) can be used to disentangle their relative contributions. This is done neglecting the Q^2 evolution of the parton densities within our Q^2 range, a small effect compared to our statistical precision. The method is based on the fact that at a given x, both the y-dependence of the anti-quark component (flat) and the p_T cut effect ($p_T^2 \propto xy(1-y)$) have a symmetric behaviour with respect to the medium value $y = 0.5$. In contrast, the quark component is concentrated at low y. Therefore, after proper weighting for the propagator term and after subtracting the differential x-cross section measured for $y > 0.5$ from the one measured for $y < 0.5$, the pure down-type quark density within the proton is extracted. The result is corrected for the small residual p_T cut effect on the quark density alone. It is shown in figure 3. There is agreement with the MRSH-DIS parametrization of the sum of the d and s-quark densities at $Q^2 = 2800$ GeV^2.

Acknowledgments

We are grateful to the HERA machine group whose outstanding efforts have made and continue to make this experiment possible. We thank the engineers and technicians for their work in constructing and now maintaining the H1 detector, our funding agencies for financial support, the DESY technical staff for continual assistance, and the DESY directorate for the hospitality which they extend to the non–DESY members of the collaboration.

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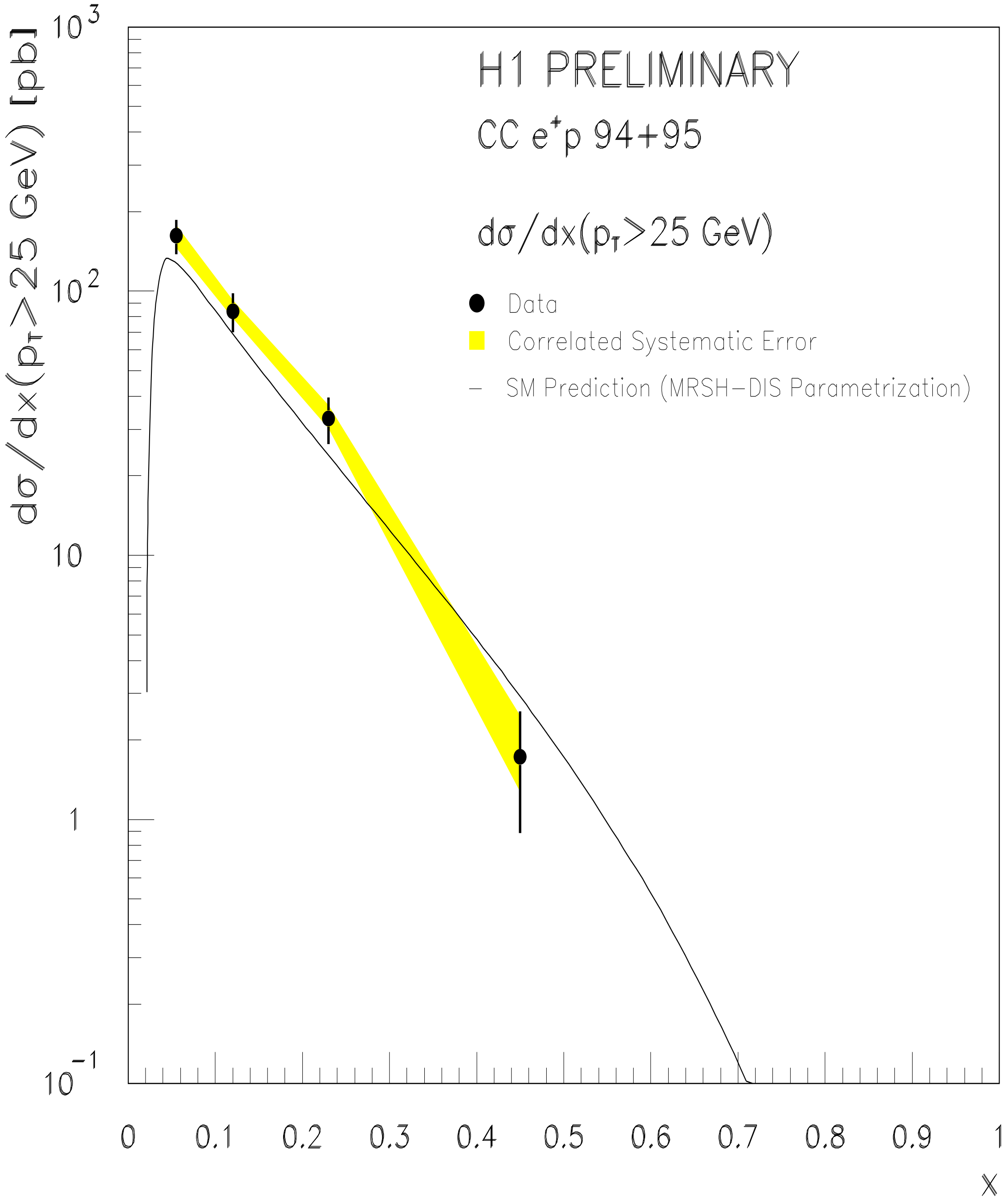

Figure 1: Preliminary e^+p differential CC Born cross section as a function of x for $p_T > 25$ GeV. The error bars include the statistical and uncorrelated systematic errors. The shaded area corresponds to the correlated systematic uncertainties. The curve shows the Standard Model prediction obtained with the MRSH-DIS parametrization.

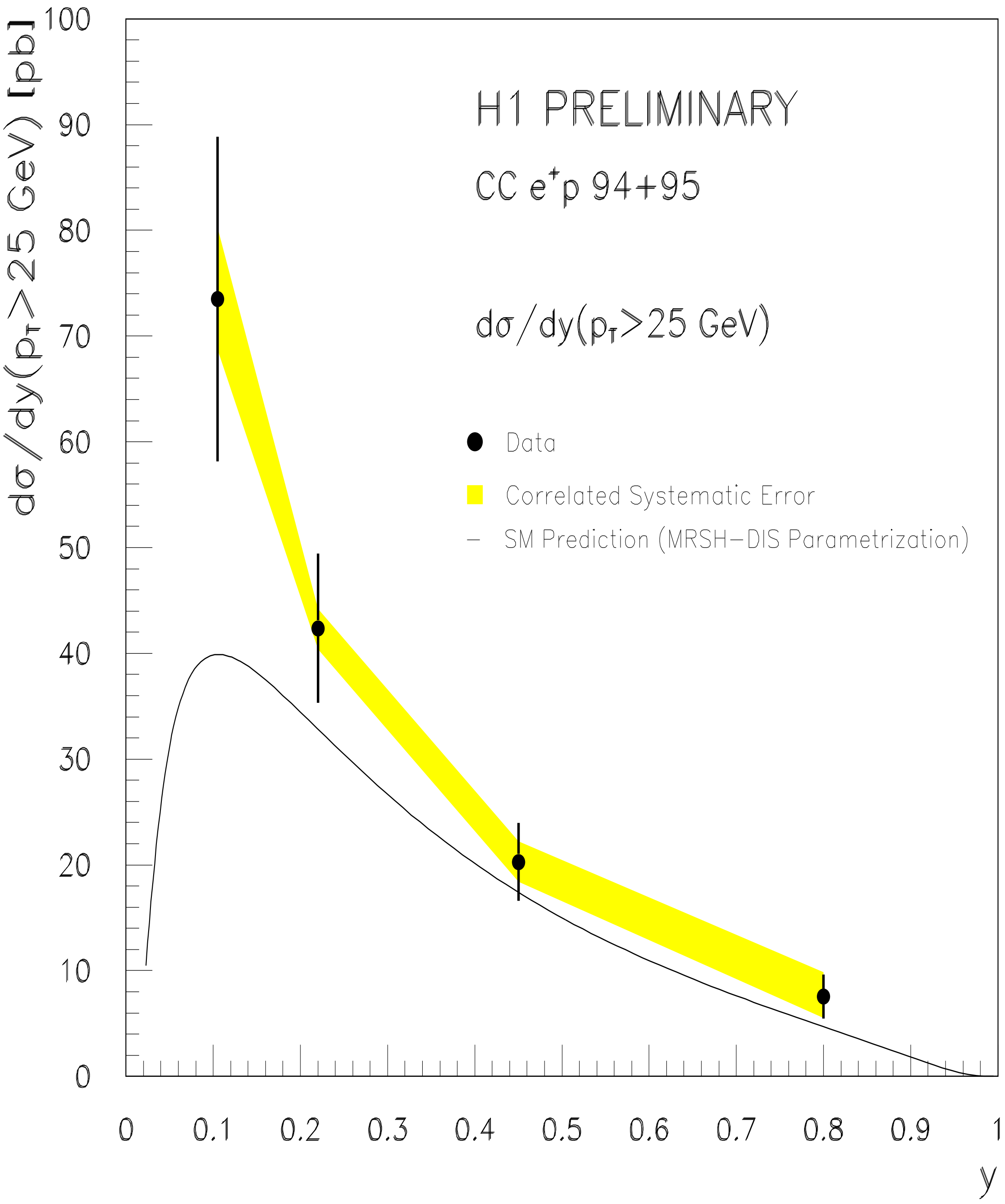

Figure 2: Preliminary e^+p differential CC Born cross section as a function of y for $p_T > 25$ GeV. The error bars include the statistical and uncorrelated systematic errors. The shaded area corresponds to the correlated systematic uncertainties. The curve shows the Standard Model prediction obtained with the MRSH-DIS parametrization.

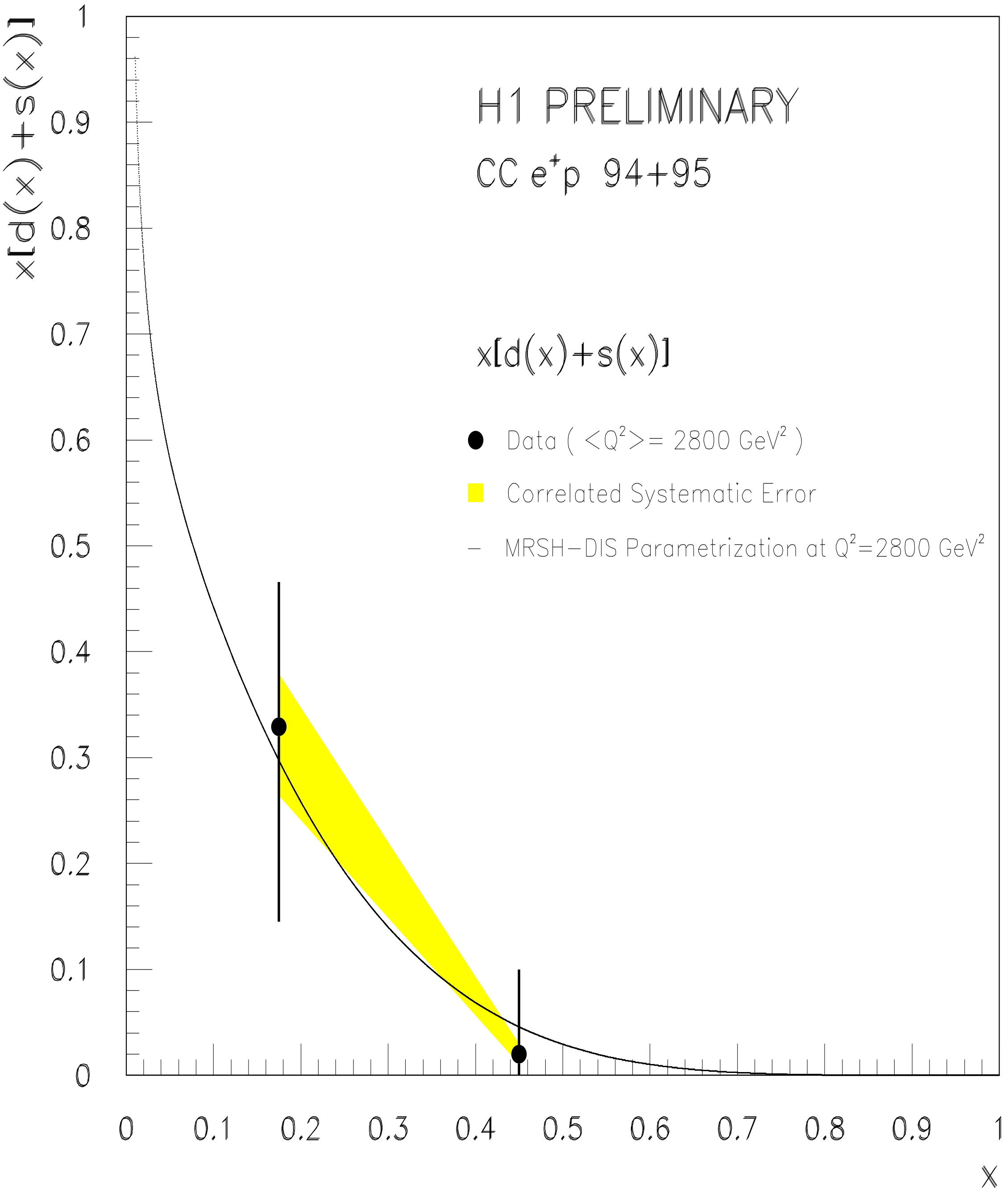

Figure 3: Preliminary extraction of the down-type quark density within the proton at an average Q^2 value of 2800 GeV^2. The error bars include the statistical and uncorrelated systematic errors. The shaded area corresponds to the correlated systematic uncertainties. The curve shows the MRSH-DIS parametrization of the sum of the d and s-quark densities at $Q^2 = 2800$ GeV^2.