THE ZEUS EXPERIMENT AT HERA.

Proposal 760

Bristol, Glasgow, Imperial College London, University College London, Oxford, Rutherford Appleton Laboratory

in collaboration with

Argonne, Bologna, Bonn, Brookhaven, Calabria, Chonnan, Columbia, DESY, DESY-Zeuthen, Florence, Frascati, Freiburg, Hamburg, Iowa, Jülich, KEK, Krakow, Kyungpook, Madison (Wisconsin), Madrid, McGill, Moscow, NIKHEF, Ohio, Padova, Pennsylvania, Rome, Santa Cruz, Seoul, Siegen, Tel Aviv, Tokyo, Tokyo Metropolitan Univ., Torino, Toronto, Warsaw, Weizmann Inst., Yale, Yokohama, York (Ontario).

Introduction

The first long HERA shutdown for two years enabled the machine group to complete the upgrade of the vacuum pumps and RF cavities of the electron ring. Consequently, in 1998, HERA ran with 27.5 GeV electrons (e^- instead of e^+) for the first time since 1994. The proton beam energy was also raised to 920 GeV after successful tests at the end of the 1997 running period. As the electron beam line was vented during the shutdown HERA required some time to clean the vacuum, but nevertheless luminosity running started on schedule at the start of August 1998.

To date the machine has delivered 7pb^{-1}, of which ZEUS had written 4pb^{-1} to tape - more than quadrupling the amount of e^- data available for physics analysis since HERA began operation in 1992. The average ZEUS efficiency for the first four months of the run is 60%, with performance over the last weeks approaching that of last year. The current data-taking period will continue until early December, followed by a short shutdown over Christmas, and then continue until Easter next year. After a 6 week break we expect to continue taking electron data until the start of the long shutdown for the HERA luminosity upgrade at the turn of the century.

The UK groups continue to play a leading role in the data-taking, once again providing two of the four run coordinators in 1998, as well as a significant proportion of the designated shift leaders and crew. We also provide the ZEUS tracking coordinator, coordinators of two of the physics groups, the ZEUS Analysis Coordinator (responsable for the co-ordination of all ZEUS analyses), a convenor of the HERA Monte Carlo workshop and the ZEUS Monte Carlo code editor/manager.

From early in 1999 the spokesman of the experiment will also be a UK physicist.

The ZEUS UK groups are also working in the current HERA Monte Carlo workshop. One of the organisers and three of the working group conveners are from UK groups, and we are active in the areas of NLO QCD calculations, Monte Carlo development and tuning for QCD, W production and Exotic physics.

Hardware developments.

Several major hardware upgrades were completed over the long shutdown.

1. The Forward Plug Calorimeter (FPC) was installed. First data from the FPC are currently being analysed. The FPC installation required some changes to the ZEUS interaction region, including a new beampipe and changes to the synchrotron radiation collimators.
2. The entire Barrel Presampler (BPRES) installation was completed and the detector is being commissioned.

3. Installation of the Forward Hadron-Electron Separator (FHES) was completed. The FHES uses silicon diodes placed at a depth of $3X_0$ in the forward calorimeter to identify electrons in dense jets.

Status of the new ZEUS Microvertex Detector (MVD).

ZEUS UK has responsibilities in three areas of the MVD project: the procedures and mechanics for installation inside the CTD, the internal and global alignment of the MVD, and the clock and control electronics for the MVD readout system.

The installation scheme has been designed to be compatible with the installation of the new magnets and the beampipe required for the luminosity upgrade. Detailed drawings of the scheme and necessary equipment are currently in production. It is planned that this equipment will be manufactured by September 1999, ready for installation during the HERA winter shutdown in 2000.

It is necessary to align precisely the MVD internally and to the rest of the ZEUS detector to allow the intrinsic precision of the silicon detectors to be fully exploited.

An independent opto-electrical alignment system will complement the software that is being developed to make detailed alignment measurements using charged tracks. The prototype system has been designed and built and is currently being tested.

The clock and control electronics provides key communication between the global first level trigger (GFLT), the ADC crates and the HELIX on-detector electronics. Detailed design of the clock and control electronics has been completed and a prototype system has been built and tested. This milestone of the MVD project has been successfully met. The final system will be ready for tests in mid 1999.

CTD performance.

The Central Tracking Detector (CTD), together with its associated readout and trigger electronics, has been the major contribution made by the UK groups to the ZEUS detector, and it remains our joint task to operate it effectively and obtain from it the optimum results. The CTD is an essential component of almost all ZEUS triggers and of all ZEUS physics analyses.

The CTD has continued to perform very reliably during 1998 data-taking. The HERA beam conditions at the start of luminosity running were such as to cause a substantial increase in the chamber currents compared to previous years. This was eventually cured by adjusting a HERA collimator. The chamber efficiency and resolution continue to be satisfactory and stable. A power outage blew several tens of FADC 'hybrids' (there is one hybrid for each of the 4608 sense wires). Fortunately we had sufficient spares, and the blown hybrids are reparable. However, the incident underlines the issues of spares and maintainability, as we plan to run the CTD through to 2005.

We continue in efforts to streamline the CTD operation as far as possible. Data-quality monitoring from the UK (i.e. 'remote') is now an established part of the CTD operation.

Physics analyses.

During 1998 14 ZEUS analyses were accepted for publication ([1] - [14]) by various journals.

In the following summary, we concentrate as usual on those physics areas where the UK members of ZEUS have been particularly active.

1. *Prompt photons.* Last year, ZEUS published the first results on prompt photon production in hard photoproduction, in which a high transverse energy photon was observed accompanied by a balancing jet. This programme of study has been extended at higher statistics

by observing also inclusive distributions of prompt photons. We are now beginning to have sensitivity to the various models for the hadronic structure of the photon, as illustrated in fig. 1. Measured pseudorapidity distributions are compared with predictions from the PYTHIA Monte Carlo and from two next-to-leading order (NLO) calculations.

The cross sections in figure 1 (a), (b) are for the inclusive reaction $\gamma + p \to \gamma + X$, i.e. for isolated final state photons (prompt photons) with $5 < E_T < 10$ GeV. For figure 1 (c) the same prompt photon requirements are imposed, but also an accompanying jet. Jets are found experimentally with a cone algorithm using the signals in the full ZEUS calorimeter system, and are corrected to a hadron level requirement of a jet with cone angle 1.0, $E_T > 5$ GeV and $-1.5 < \eta < 1.8$.

The PYTHIA predictions in (a) show the radiative contribution, its sum with the resolved contribution and the total sum including the direct contribution. There is fair agreement with the data, which however are a little higher than the predictions. Error bars show the statistical errors; there is a common systematic error of $\approx 15\%$ on the data points. In (b), (c), comparison is made with calculations of Gordon, and of Krawczyk and Zembrzuski. Although both are performed at NLO, these calculations differ in some details. (Both include a radiative component as well as direct and resolved.) The agreement with the GRV photon parton densities is satisfactory in each case, while the GS prediction appears a little low.

2. *Charm Production in Deep Inelastic Scattering*

   In deep inelastic scattering (DIS), charm is produced principally via the boson gluon fusion mechanism and hence it is a key process through which the gluon density of the proton may be probed. Insight may also be gained into the evolution of the charm production mechanism with Q^2. Open charm is principally studied using the $D^{*\pm} \to D^0\pi_s^\pm$, $D^0 \to K^\mp\pi^\pm$ and $D^0 \to K^\mp\pi^\pm\pi^\mp\pi^\pm$ decay channels. Both differential $D^{*\pm}$ cross sections and the proton structure function F_2^{charm} have been measured using the channel $D^{*\pm} \to K^\mp\pi^\pm$, from the combined 1996-97 data sample, which corresponds to an integrated luminosity of 36.6 pb^{-1}. Preliminary results were presented in the spring which were updated for the summer conferences by including extra data taken with a specially-tailored $D^{*\pm}$ trigger. Final results will be published early next year. Studies of the $D^{*\pm}$ decay channel where the D^0 decays to $K^\mp\pi^\pm\pi^\mp\pi^\pm$ are also well underway for the combined 1996-97 dataset. The latest F_2^{charm} results are shown in figure 2.

3. *Charm Production in Diffractive Scattering*

   Charm production in diffractive interactions is a crucial process through which the underlying mechanism behind diffraction may be probed. Photon dissociative diffractive interactions (i.e. those in which the photon dissociates into a hadronic system X while the proton remains intact) are of principal interest here and can be identified by the presence of a rapidity gap between the system X and the outgoing proton. The importance of charm production in such interactions is due to its sensitivity to the presence of gluons and the different roles which gluons play in the different theoretical models available to describe diffraction. Once again, the charm is identified via $D^{*\pm}$ reconstruction and events are only identified as diffractive if the measured rapidity gap is found to be at least two units. Differential $D^{*\pm}$ cross sections and the fraction of diffractively produced $D^{*\pm}$ candidates have been measured using the combined 1995-97 data sample and were presented at the summer conferences. These results are shown in figures 3 and 4.

4. *Phenomenology of F_2 at low Q^2*

   UK groups were strongly involved with the completion of the ZEUS paper on the 'Phenomenology of F_2 at low x and low Q^2' [2]. The paper draws together the publication of the 1995 shifted vertex (SVX95) F_2, which covers the Q^2 range $0.6 < Q^2 < 17\,\mathrm{GeV}^2$, with a phenomenological study of these data and those at even lower Q^2 taken with the ZEUS beam pipe calorimeter (BPC95) ($0.11 < Q^2 < 0.65\,\mathrm{GeV}^2$) [16] and a NLO QCD analysis of the SVX95 data together with the 1994 F_2 data [15]. Considering F_2 as the γ^*p total cross-section, the paper shows that it is possible to fit the Q^2 dependence of the BPC95 data with a simple generalised vector dominance approach and the W^2 (W is the γ^*p CM energy) dependence with a two component Regge model. At Q^2 values greater than $0.9\,\mathrm{GeV}^2$ these simple non-perturbative approaches fail and in particular the data show a steeper rise with W^2 than one expects from hadron-hadron data. Other information presented in the paper on the 'transition' from non-perturbative to perturbative regimes are the logarithmic slopes of F_2 – $d\ln F_2/d\ln(1/x)$ and $dF_2/d\ln Q^2$ – the latter, shown in figure 5, is also known as the 'Caldwell plot' as a consequence of the interest it has aroused since it was first presented by Allen Caldwell at DESY in 1997 [17]. Within perturbative QCD $dF_2/d\ln Q^2$ is a measure of scaling violations and is directly related to the gluon momentum density. The turn-over that the data show at Q^2 values of $5\,\mathrm{GeV}^2$ and the decrease in the value of the slope at lower Q^2 values indicate that the gluon density is decreasing at very low Q^2. As F_2 continues to rise at low x and low Q^2 the consequence should be that the sea quark density is non-vanishing in this region. These, perhaps naive, conclusions are supported by a full NLO QCD fit. Results are shown in figure 6 for the gluon and quark singlet (essentially that of the $q\bar{q}$ sea at low x) momentum densities. The error bands shown in the figure correspond to the quadratic sum of experimental and systematic errors, uncertainties in α_S and the effect of changing the functional form of the gluon density parameterisation. The fact that one can get a good description of F_2 data using 'standard' NLO DGLAP Q^2 evolution down to Q^2 values as low as $1\,\mathrm{GeV}^2$ is remarkable and has provoked much debate.

5. *Charm Photoproduction*

Photoproduction of 'open' charm (as opposed to $c\bar{c}$ bound states) can take place at HERA via photon-gluon fusion, gluon-gluon fusion or charm excitation. In the first of these processes the photon interacts directly with a gluon from the proton. In the other two, the photon fluctuates into a hadronic state, and partons from the photon then undergo hard scattering with partons from the proton. In the first two processes, two jets containing charmed hadrons are produced. In the third, one charmed jet is produced and the the photon remnant carries off the second charmed hadron.

The first process is sensitive to the gluon distribution in the proton. The second is sensitive to the gluon distribution inside the photon, whilst the third addresses the question as to whether charm is somehow generated 'inside' the photon.

Charm has been tagged in ZEUS using the D^* tagging method [21]. Jets are defined using the K_T algorithm [22] in 'inclusive' mode [23]. Separation of direct and resolved samples is possible using the variable [24]:

$$x_\gamma^{OBS} = \frac{\Sigma_{\text{jets}}(E_T^{jet}\; e^{-\eta^{jet}})}{2E_e y}$$

which is the fraction of the photon's momentum which participates in the production of the two highest E_T^{jet} jets. Thus LO direct process have $x_\gamma^{OBS} = 1$ and LO resolved processes have lower x_γ^{OBS}.

The cross section $d\sigma/dx_\gamma^{OBS}$ is shown in figure 7 [25]. The cross section at lower x_γ^{OBS} values is significant, indicating that LO direct processes alone cannot describe charm production successfully. In particular, the data are inconsistent with the LO Direct process in HERWIG shown in the figure, even after the effects of parton showering and hadronisation are included in the Monte Carlo. Such effects can populate the low x_γ^{OBS} region even with direct events, but do not do so sufficiently. In fact the data require a $(45 \pm 5)\%$ LO resolved contribution from HERWIG. Furthermore, according to HERWIG this resolved contribution is almost entirely charm excitation.

Also shown, in the lower half of figure 7 is a NLO massive calculation of $d\sigma/dx_\gamma^{OBS}$. The calculation lies below the data at low x_γ^{OBS}. Hadronisation is not included in the NLO calculation and this may affect the comparison. Nevertheless, the data suggest a larger resolved contribution than is present in the calculation.

The data represent a challenge to the theory to understand completely charm production 'inside' the photon. This challenge is likely to get tougher as more accurate measurements over wider kinematic regimes become possible from both H1 and ZEUS with micro-vertex detectors, the introduction of other tagging methods and higher luminosity from the coming HERA upgrade.

6. *High p_T Leptons and W Production.*

ZEUS have searched for W production and decay to leptons in 46.6 pb^{-1} of e^+p data selecting events primarily on the basis of large, calorimeter-measured, missing p_T [26]. Demanding that the missing p_T be greater than 20 GeV and that an electron with $p_T >$ 10 GeV be acoplanar with the recoiling hadronic system, the overall efficiency for selecting $W \to e\nu$ events is 38%. With the dominant W production reaction $e^+p \to e^+W^\pm X$ having a cross section of $\sim$ 1 pb, this gives an expected 2 events. Combined with an estimated 1 background event, mainly due to neutral and charged current DIS at high Q^2, this is in good agreement with the 3 observed events, the properties of which are shown in figure 8.

With good agreement between data and Monte Carlo, a preliminary cross section has been extracted :

$$\sigma(e^+p \to e^+W^\pm X) \quad = \quad 1.0 \ {}^{+\,1.0}_{-\,0.7} \ \text{(stat)} \ \pm \ 0.3 \ \text{(syst)} \ \text{pb} \ . \tag{1}$$

In addition, a 95% CL upper limit on the W production cross section of 3.2 pb has been calculated. This can be converted into constraints on the anomalous $WW\gamma$ couplings $-7.6 < \Delta\kappa < 3.9$ and $-7.5 < \lambda < 7.5$.

ZEUS have also searched for muons in events with large calorimeter missing p_T. With a loose muon p_T cut of 5 GeV, a calorimeter p_T cut of 20 GeV results in a single observed event against an expectation of 0.6 (W) plus 1.7 (other) from Monte Carlo. No data events survive a cut of 30 GeV against an expectation of 0.3 (W) plus 0.5 (other) from Monte Carlo. The $W \to \mu\nu$ selection efficiency, at around 38-40%, exhibits only a small dependence on the true hadronic p_T in this region. The resulting 95% CL upper limits on the cross section for $W \to \mu\nu$ are therefore 0.22 and 0.17 pb for calorimeter p_T cuts at 20 and 30 GeV respectively. These limits exclude W production in the presence of large hadronic p_T as the source of all the recently reported H1 high p_T muon events [27].

7. *Three-jet Cross Section*

The integrated luminosity delivered by HERA is now sufficient to allow the direct study of QCD beyond leading order through events in which several jets are produced. The high-mass three-jet photoproduction cross section was presented in a preliminary form at summer conferences. The final results are now accepted for publication [1]. The measured three-jet angular distributions are dramatically different from a uniform population of the available phase space as shown in figure 9. $\mathcal{O}(\alpha\alpha_s^2)$ pQCD calculations are able to describe the data and a Monte Carlo study has indicated that these data are sensitive to the important QCD phenomenon of colour coherence.

8. *Dijet Cross Sections using Real and Virtual Photons*

A suppression of the hadronic component of the photon with increasing photon virtuality is a fundamental prediction of QCD. This suppression has been observed as the ratio of the 'resolved' ($x_\gamma^{obs} < 0.75$) to the 'direct' ($x_\gamma^{obs} \geq 0.75$) dijet cross section falling as a function of the photon's virtuality, Q^2. This ratio has been extended to higher Q^2, entering the DIS regime. (figure 10). A second jetfinder, KTCLUS, has also been used, confirming the conclusions obtained from the cone algorithm. Studies of the systematic uncertainties have been performed and these results have been presented at the ICHEP98 conference this summer in Vancouver.

9. *Breit frame analyses.*

   Analyses have been performed in the Breit frame of reference. Event shapes in Deep Inelastic Scattering have been measured in the current fragmentation region. These measurements have been compared with theoretical work involving NLO QCD calculations and power corrections to determine the hadronisation contributions. The values of the event variables exhibit the qualitative Q^2 dependence expected from the NLO calculations. (figure 11.)

   In addition the inclusive single particle distributions have been investigated in the current fragmentation region and, for the first time, the target region. The results in the current fragmentation region are compared to e^+e^- data, NLO QCD calculations, MLLA predictions and LO Monte Carlo generators. They are consistent with universality of fragmentation. The MLLA calculations were unable to describe the data over the whole Q^2 range investigated. The results in the current region are compared to the similar phase space region in the target region. There is a marked difference in the momentum distributions in the two regions, although the transverse momentum distributions were remarkably similar. The target region was also compared with LO Monte Carlo generators. It was observed that the models based on the DGLAP evolution equations were unable to describe the data. (figure 12.)

10. *High Q^2 Physics*

    UK physicists have long played a leading role in studies of high Q^2 physics at HERA. With the increasing luminosity this experience is having significant impact in this area.

    The collider experiments at HERA provide a unique opportunity to study proton structure at high Q^2 using a charged lepton probe. Whilst both neutrino and anti-neutrino beams have been used to study charged and neutral currrent phenomena, a comparison of the CC cross sections of positively and negatively charged leptons has never been undertaken, and the comparison of the charge dependence of the NC cross section has only been possible at low Q^2 where the contribution of the Z^0 is negligible. We have shown that comparison of the present positron-proton data set with an electron-proton data set of similar size which we expect to collect over the next year, will provide significant information on the electroweak sector of the Standard Model.

    The analysis of the data taken up to the end of the positron running is now almost complete. Figure 13 shows the differential cross section $d\sigma/dQ^2$ as a function of Q^2 for charged and neutral current scattering using electron and positron beams. The data show that at high Q^2 the CC cross section becomes of equal magnitude to the NC cross section. The e^+p data corresponds to a luminosity of 46.6 pb^{-1} while the e^-p data set is limited to the ~ 0.8 pb^{-1} collected in running in 1993 and early 1994. At the end of running this year ZEUS had recorded 4.8 pb^{-1} a six fold increase in the size of the e^-p data set.

    Figure 14 shows the differential cross section $d\sigma/dx$ for e^+p NC DIS. The SM gives a good description of the data. The data is sensitive to the mass of the Z^0 as shown in the figure. The data clearly disfavour very small or very large values of the mass of the Z^0. By studying the difference between e^-p and e^+p NC DIS we anticipate that we will be able to use the 4.8 pb^{-1} of data which we have already collected to observe the effect of the Z^0 directly. We eagerly await the 1999 running when we confidently expect to record an e^-p data set as large as the e^+p data set. This will allow detailed studies of the Z^0 in DIS.

Ph.D Theses.

1. J.Bromley, (Glasgow) *Measurement of fragmentation functions in DIS at HERA.*
2. M.Hayes, (Bristol) *A study of parton-parton elastic scattering by colour singlet exchange.*
3. G.Howell, (IC) *Measurement of the* e^+p *charged current cross-section with the ZEUS detector at HERA.*
4. C.Nath, (Oxford) *Measurement of the inclusive jet cross section in high total transverse energy photoproduction at HERA.*
5. D.Roff, (Bristol) *The development of CVD diamond tracking detectors for high luminosity exeriments at the LHC and the photon structure of the proton.*
6. D.G.Sideris, (IC) *Measurement of the charm contribution to the proton structure function at HERA.*
7. M.R.Sutton, (UCL) *Charm in Dijet photoproduction at HERA.*
8. E.J.Strickland, (Glasgow) *A first study of multijet dynamics in hard photoproduction at HERA.*
9. D.Waters, (Oxford) *A first estimate of* $\sigma(e^+p \rightarrow e^+W^\pm X)$ *and studies of high* p_T *leptons with the ZEUS detector at HERA.*
10. R.Waugh, (Glasgow) *Measurement of event shape variables using the current region of the Breit frame in deep inelastic scattering.*

Talks on ZEUS and ZEUS-related physics given at major National or International Conferences.

1. D.Bailey, *New ZEUS results on* F_2^{charm}, DIS'98, Brussels, April 1998.
2. N.Brook, *QCD at HERA*, 2nd Latin American Symposium on High Energy Physics, Puerto Rico, 1998.
3. P.Bussey, *Physics with two photons at HERA*, Workshop on photon interactions and the photon structure, Lund, 1998.
4. J.Butterworth, *ZEUS results for Vancouver ICHEP98*, DESY Seminar, July 1998.
5. J.Butterworth, *Charm 'in' the photon*, Workshop on photon interactions and the photon structure, Lund, 1998.
6. J.Cole, *Experimental aspects of heavy flavour physics in DIS*, Keynote invited talk at Durham workshop, September 1998.
7. C.Cormack, *Measuring NC and CC DIS cross sections with* e^- *beams at HERA*, Durham workshop, September 1998.
8. C.Cormack, *Study of radiative corrections for high* Q^2 *DIS NC and CC*, Durham workshop, September 1998.
9. A.Doyle, *Structure functions. Highlights and open questions from ZEUS*, DIS'98, Brussels.
10. A.Doyle, *HERA physics*, IOP Conference on Particle Physics, Manchester, 1998.

11. A.Doyle, *Structure Functions*, ICHEP98, Vancouver, July 1998.
12. J.Gross-Knetter, *NC and CC cross sections at high Q^2 from ZEUS at HERA*, ICHEP98, Vancouver, 1998.
13. R.Hall-Wilton, *Diffractive Heavy Flavour Production at HERA*, Small x and Diffractive Workshop, FNAL, September 1998.
14. K.R.Long, *Searches for New Physics at HERA*, First European workshop on physics from the Electroweak scale to the Planck scale, Kazimierz, May 1998.
15. A.Quadt, *Measurement of the neutral current e^+p cross section at $Q^2 > 400$ GeV^2 with the ZEUS detector at HERA*, Meeting of the German Physical Society (DPG), Freiburg, March 1998.
16. A.Quadt, *The ZEUS central tracking detector Second level trigger*, Meeting of the German Physical Society (DPG), Freiburg, March 1998.
17. A.Quadt, *Measurement and phenomenology of the proton structure function F_2 from ZEUS at HERA*, ICHEP98, Vancouver, July 1998.
18. A.Quadt, *The proton structure function F_2 at low and medium Q^2 at ZEUS*, (awarded the Giuseppe P.S. Occhialini scholarship for the best experimental presentation) International school of subnuclear physics, Erice, September 1998.
19. L.E.Sinclair, *Dynamics of multijet processes in photoproduction*, DIS'98, Brussels.
20. L.E.Sinclair, *Jets and prompt photons in photoproduction*, ICHEP XXIX, Vancouver, 1998.
21. M.Sutton, *Charm in photoproduction at HERA*, DIS'98, Brussels, 1998.
22. D.Waters, *Physics beyond the standard model at HERA, experimental aspects*, Keynote invited talk at Durham workshop, September 1998.
23. R.Waugh, *Event shape variables in deep inelastic scattering*, DIS'98, Brussels.
24. M.Wing, *Photon structure and the hadronic final state in photoproduction at ZEUS*, Stara Lesna, Slovakia, 1998.

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[3] ZEUS Collaboration; J.Breitweg et al. *Exclusive Electroproduction of ρ^0 and J/Psi Mesons at HERA.* DESY 98-107 (August 1998) submitted to The European Physical Journal

[4] ZEUS Collaboration; J.Breitweg et al. *Measurement of Elastic Υ Photoproduction at HERA.* DESY 98-089 (July 1998) Physics Letters B 437 (1998) 432-444

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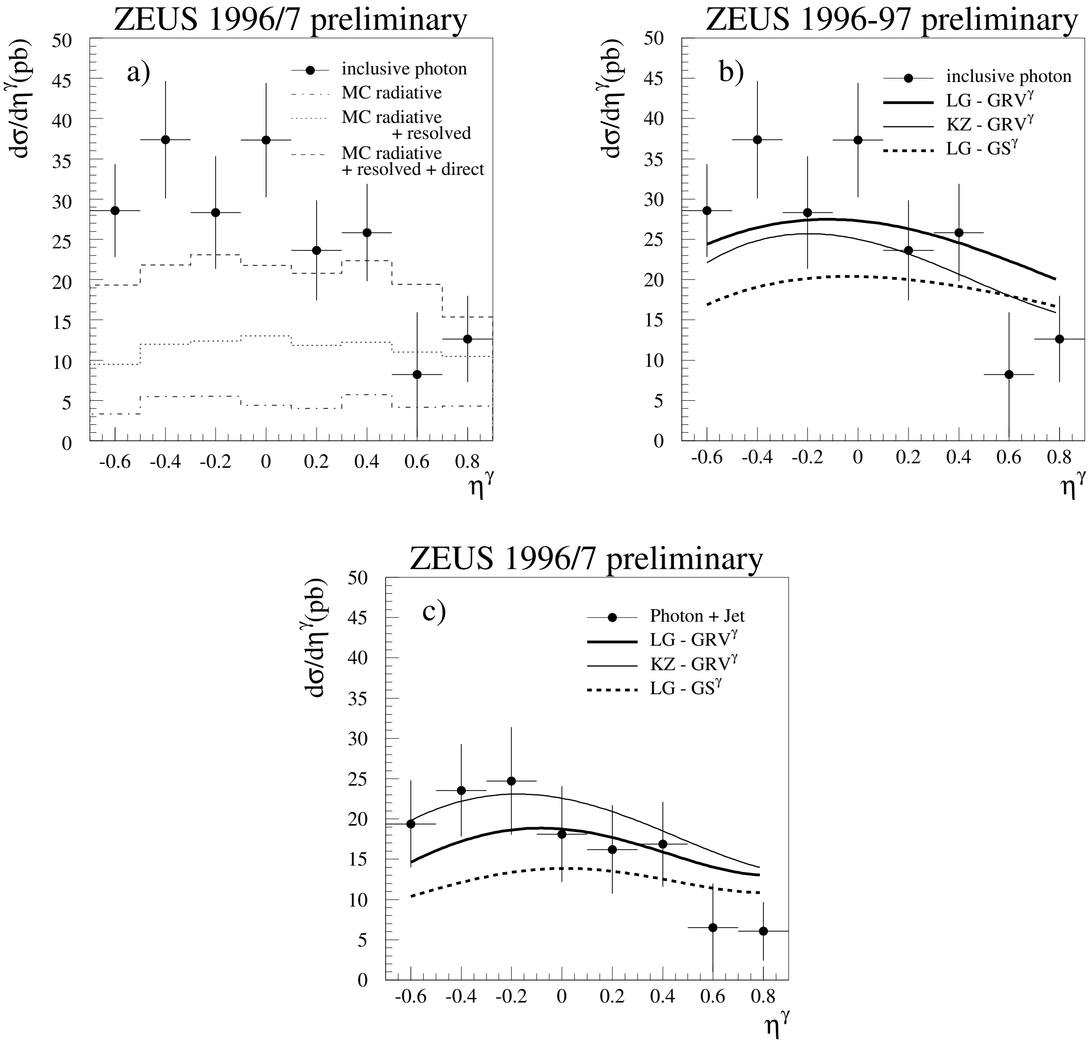

Figure 1: Inclusive cross section for prompt photon production measured by ZEUS at HERA, as a function of pseudorapidity (a) compared with PYTHIA predictions, (b) compared with predictions from Gordon (LG) using the GRV and GS photon structures, and Krawczyk and Zembrzuski (KZ) using the GRV photon structure, (c) with the additional requirement of a jet in the central region of the apparatus.

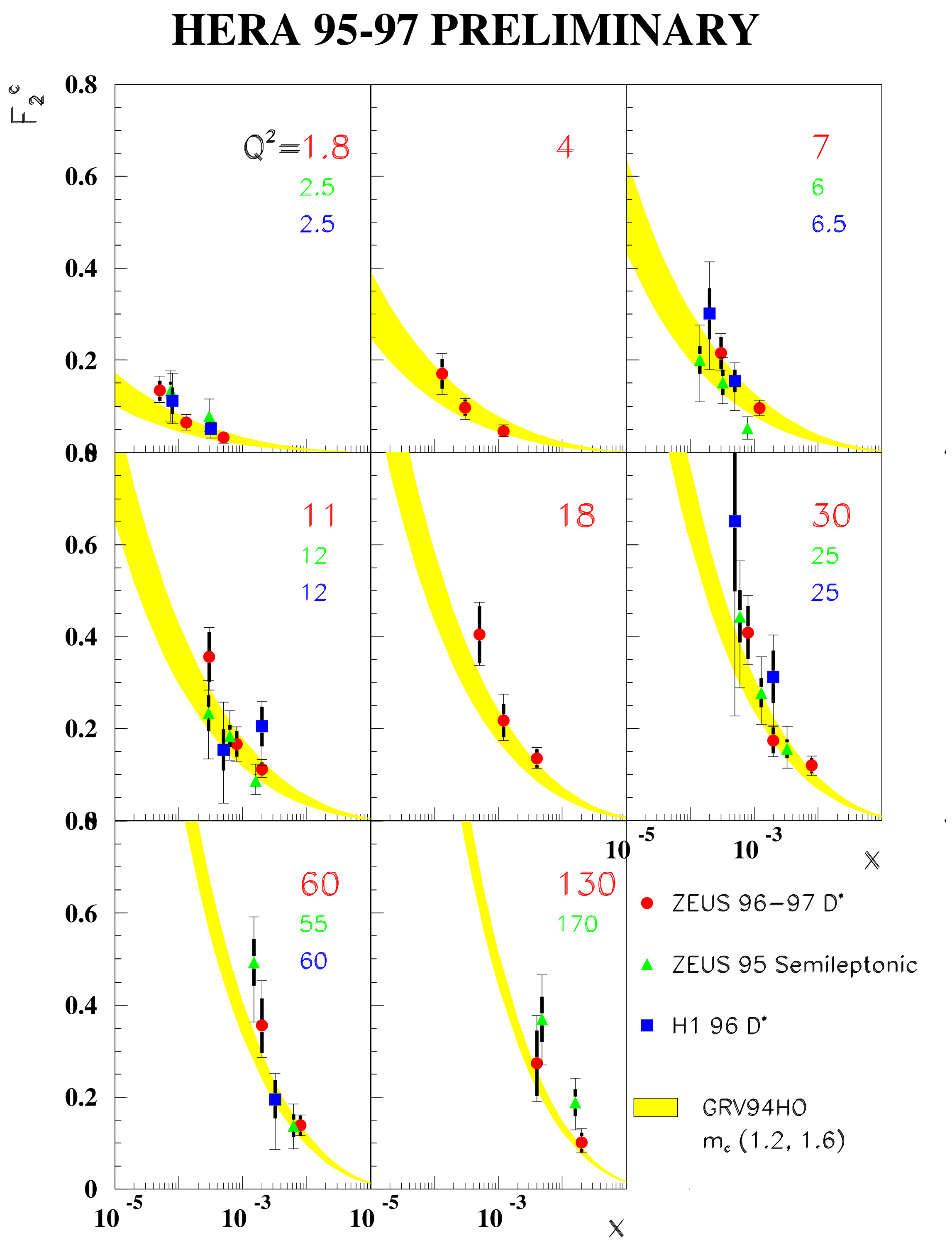

Figure 2: The measured $F_2^{c\bar{c}}$ at Q^2 values between 1.8 and 130 GeV^2 as a function of Bjorken-x. The inner error bars show the statistical errors. The data are compared with the NLO QCD calculations of [18] [19] (shaded band) and the results of the NLO QCD ZEUS fit to F_2 [20] (solid and dashed curves).

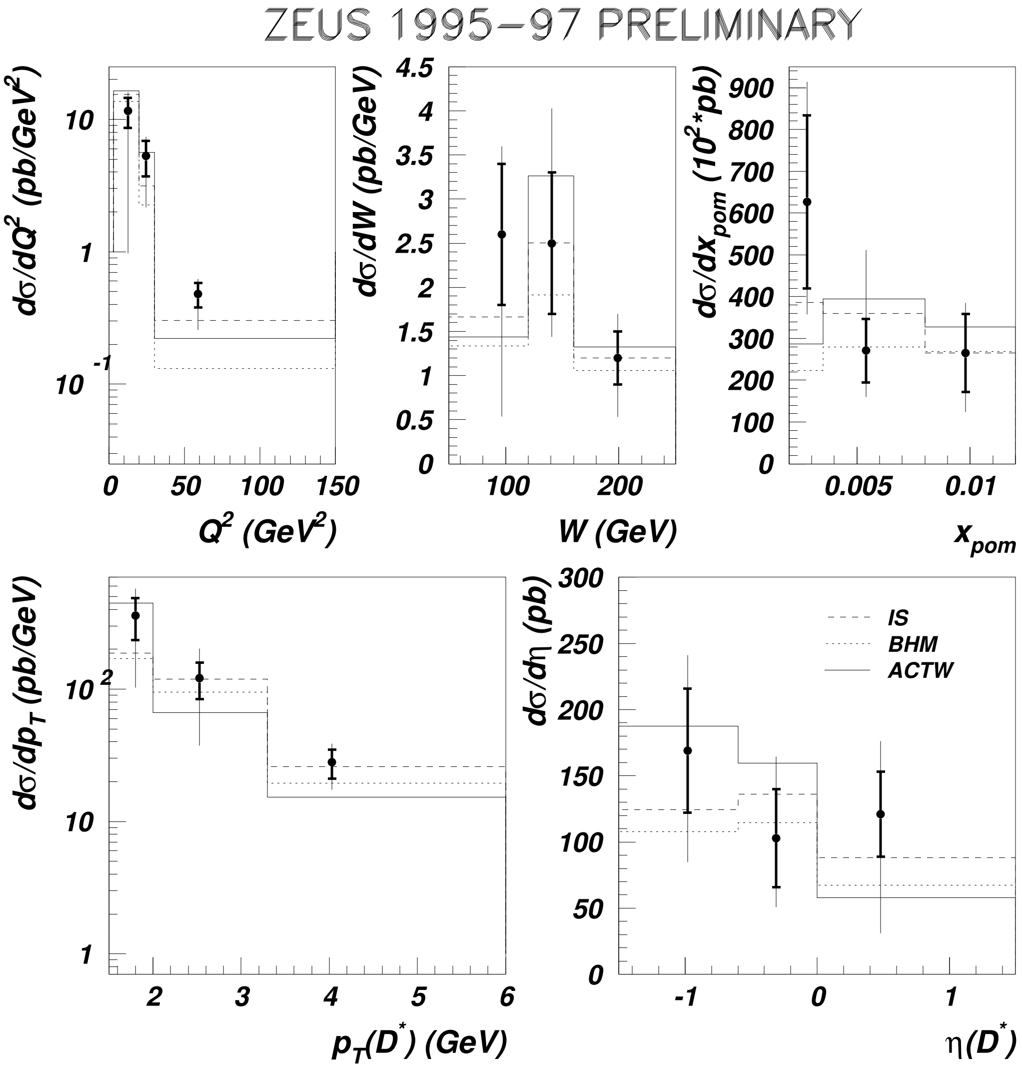

Figure 3: The differential diffractive $D^{*\pm}$ cross sections versus Q^2, W, x_{IP}, $p_T(D^{*\pm})$ and $\eta(D^{*\pm})$. The black dots are the data points, whose inner bars indicate the statistical errors only. The outer error bars are the systematic and statistical errors added in quadrature. The bin width over which the differential cross sections were averaged are indicated by the binning of the predictions from the different models used for comparison.

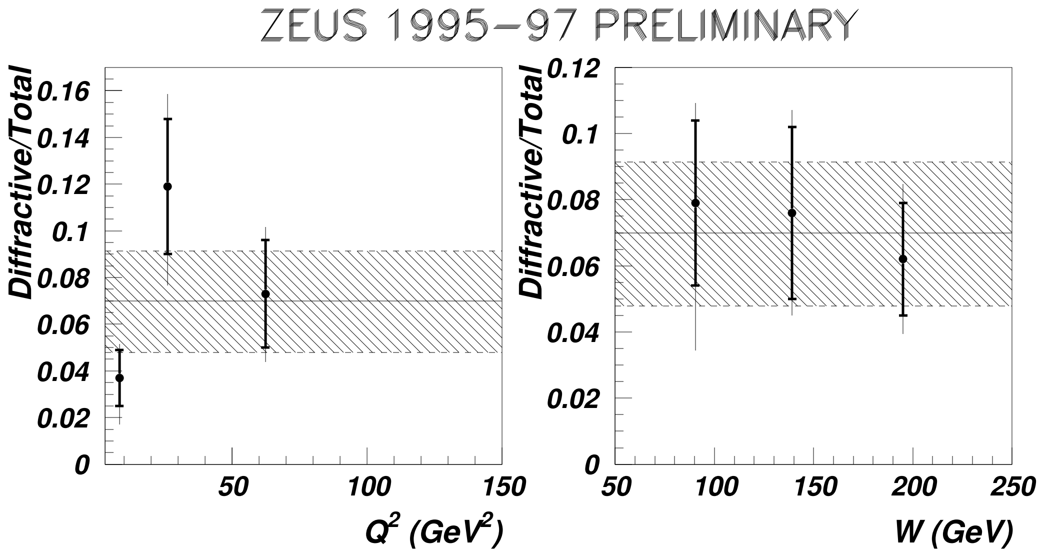

Figure 4: The ratio of diffractively produced $D^{*\pm}$s to total $D^{*\pm}$s in the kinematic range selected. The left plot shows the ratio versus Q^2 while the right plot shows the ratio versus W. The inner bars indicate the statistical errors, while the outer ones indicate the statistical and systematic errors added in quadrature. The hatched band indicates the statistical and systematic errors of the overall ratio.

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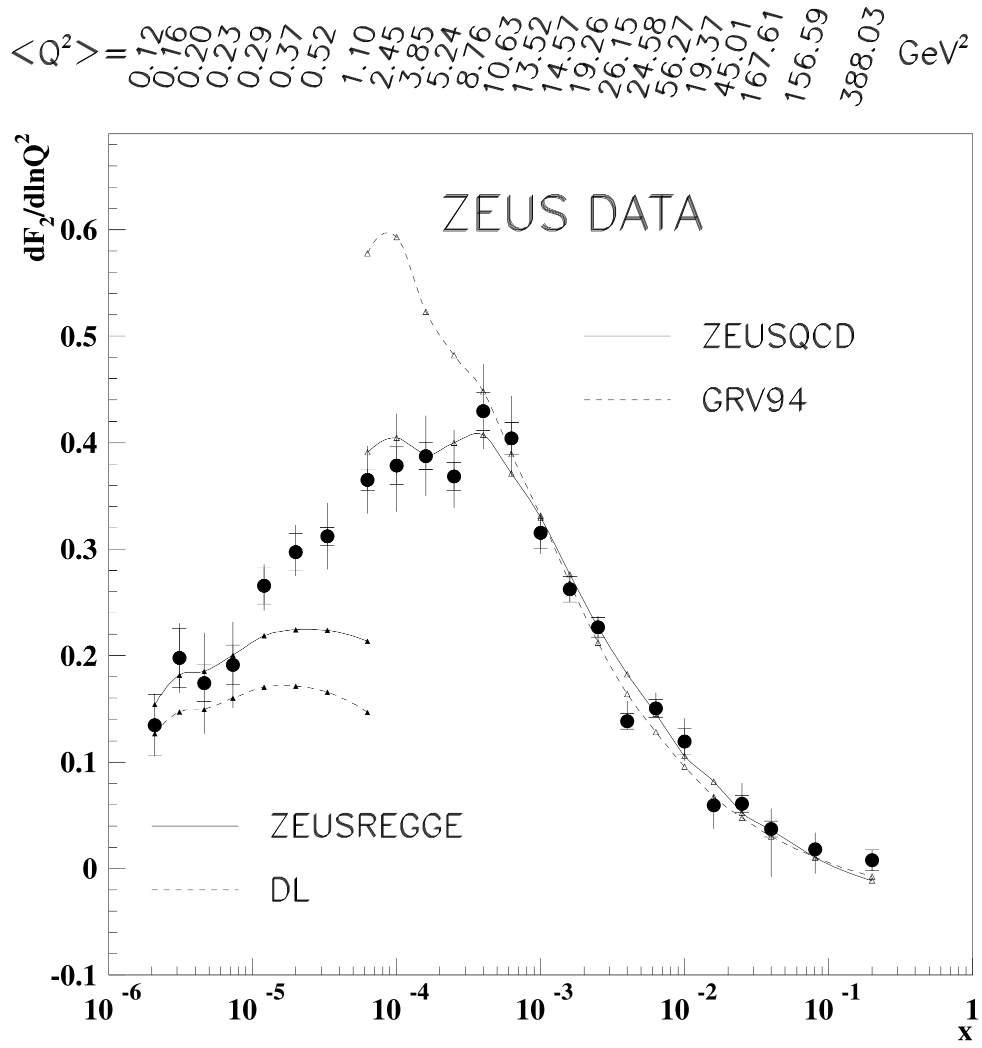

Figure 5: $dF_2/d\ln Q^2$ as a function of x from ZEUS F_2 data. The inner error bar shows the statistical error and the outer the total statistical and systematic error added in quadrature. The curves refer to two component Regge fits (DL is that of Donnachie and Landshoff) and to the ZEUS and GRV94 NLO QCD approaches.

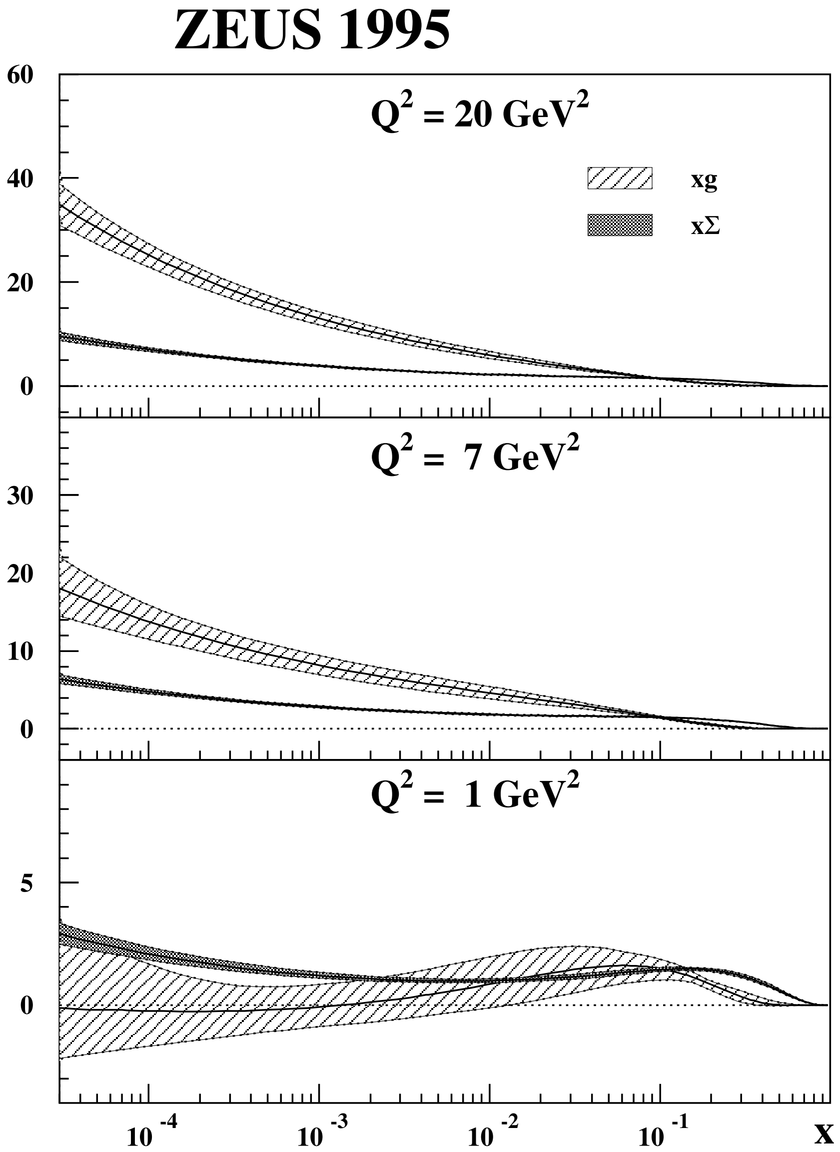

Figure 6: The gluon (xg) and quark singlet ($x\Sigma$) momentum distributions from the ZEUS NLO QCD fit to F_2 data.

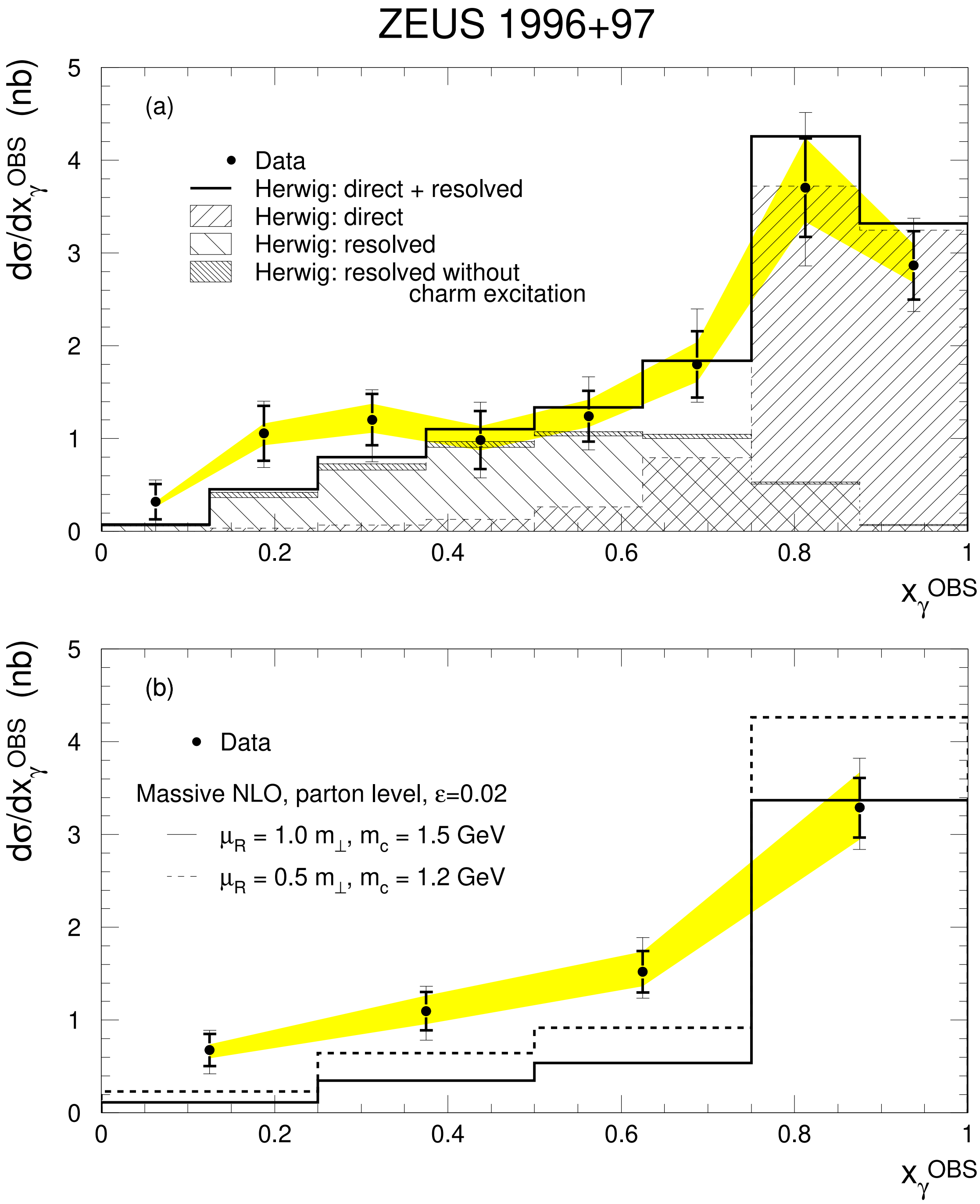

Figure 7: $d\sigma/dx_\gamma^{OBS}$ *The MRSG and GRV-G HO parton density functions are used for the proton and the photon respectively.*

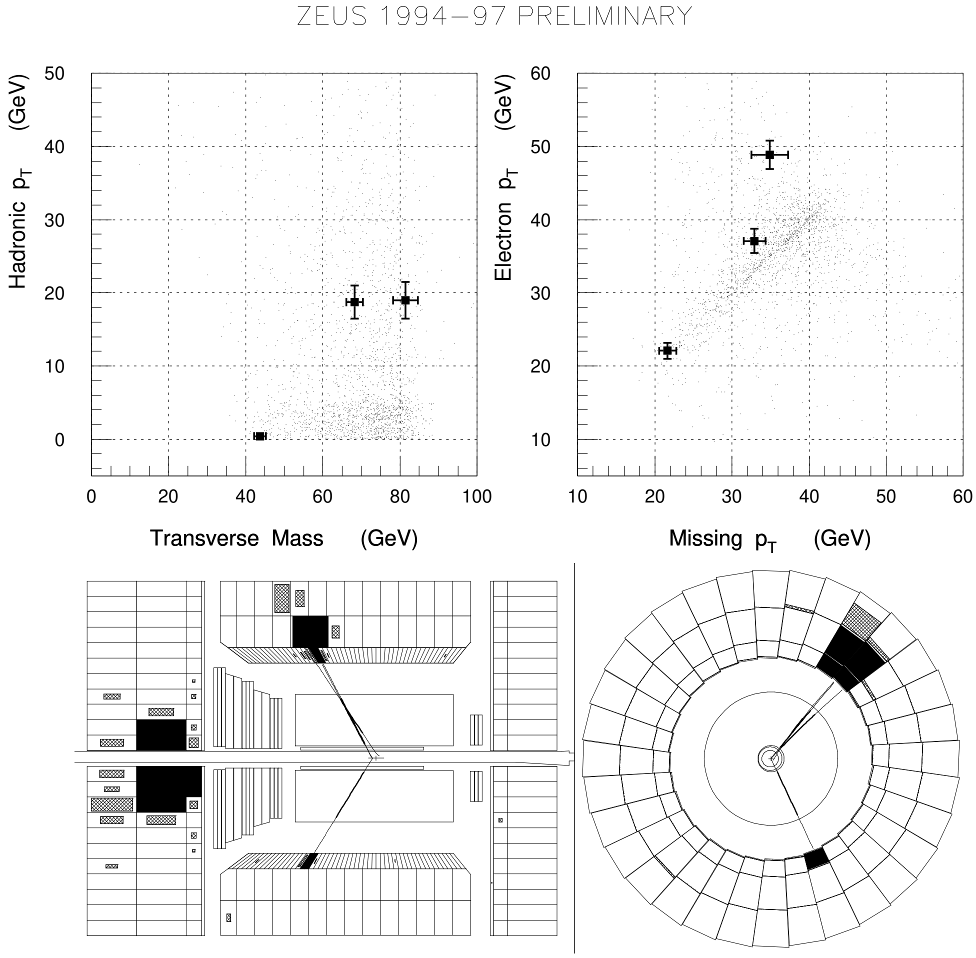

Figure 8: The distribution of selected events in the search for $W \to e\nu$ decay, plotted in the hadronic p_T versus transverse mass (top left) and electron p_T versus missing p_T planes (top right) respectively. W production Monte Carlo corresponding to 50 fb^{-1} and with all selection cuts applied is given by the small dots in each case. The event with a transverse mass of 81.4 ± 3.2 GeV is shown below. In the right hand view perpendicular to the beam axis, the large angle of acoplanarity between the scattered positron in the lower half of the detector and the jet in the upper half of the detector is clearly visible.

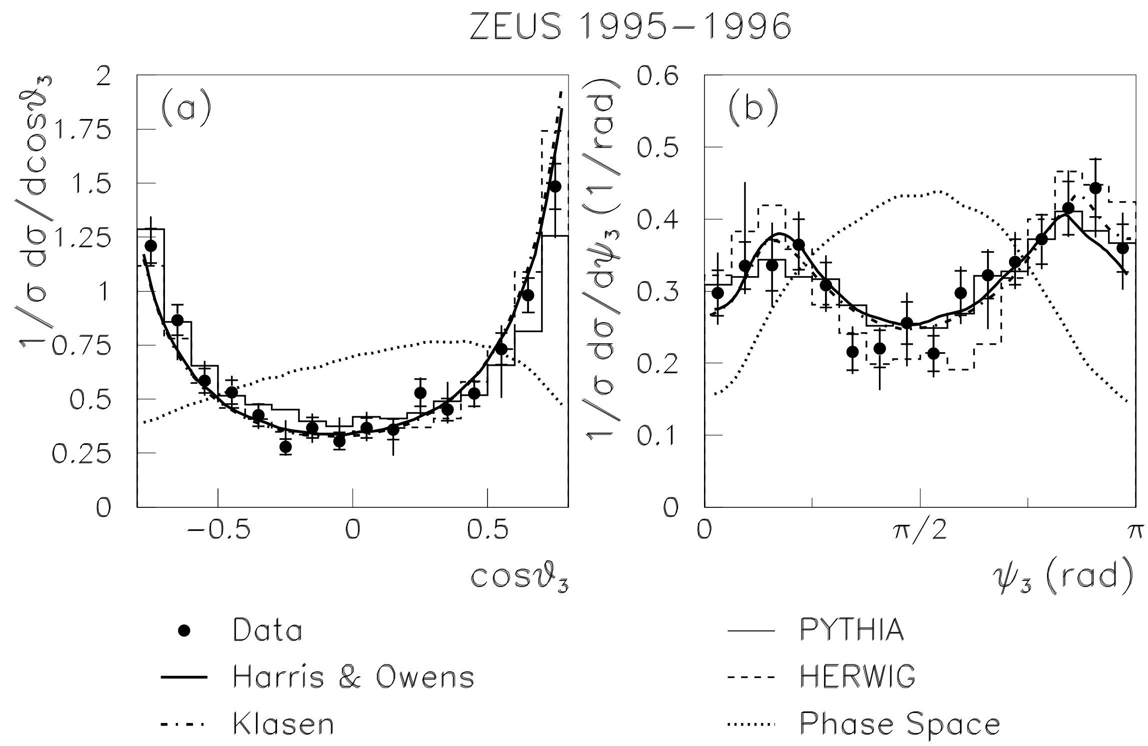

Figure 9: Distributions of the three-jet scattering angles $\cos\vartheta_3$ and ψ_3. The dots show the data. The inner error bars show the statistical error. The outer error bars show the quadratic sum of the statistical and systematic uncertainties. $\mathcal{O}(\alpha\alpha_s^2)$ pQCD calculations by two groups of authors are shown by thick solid and dot-dashed lines. The thin solid and dashed histograms show the predictions from the parton shower models PYTHIA and HERWIG. The dotted curve shows the distribution for a constant matrix element.

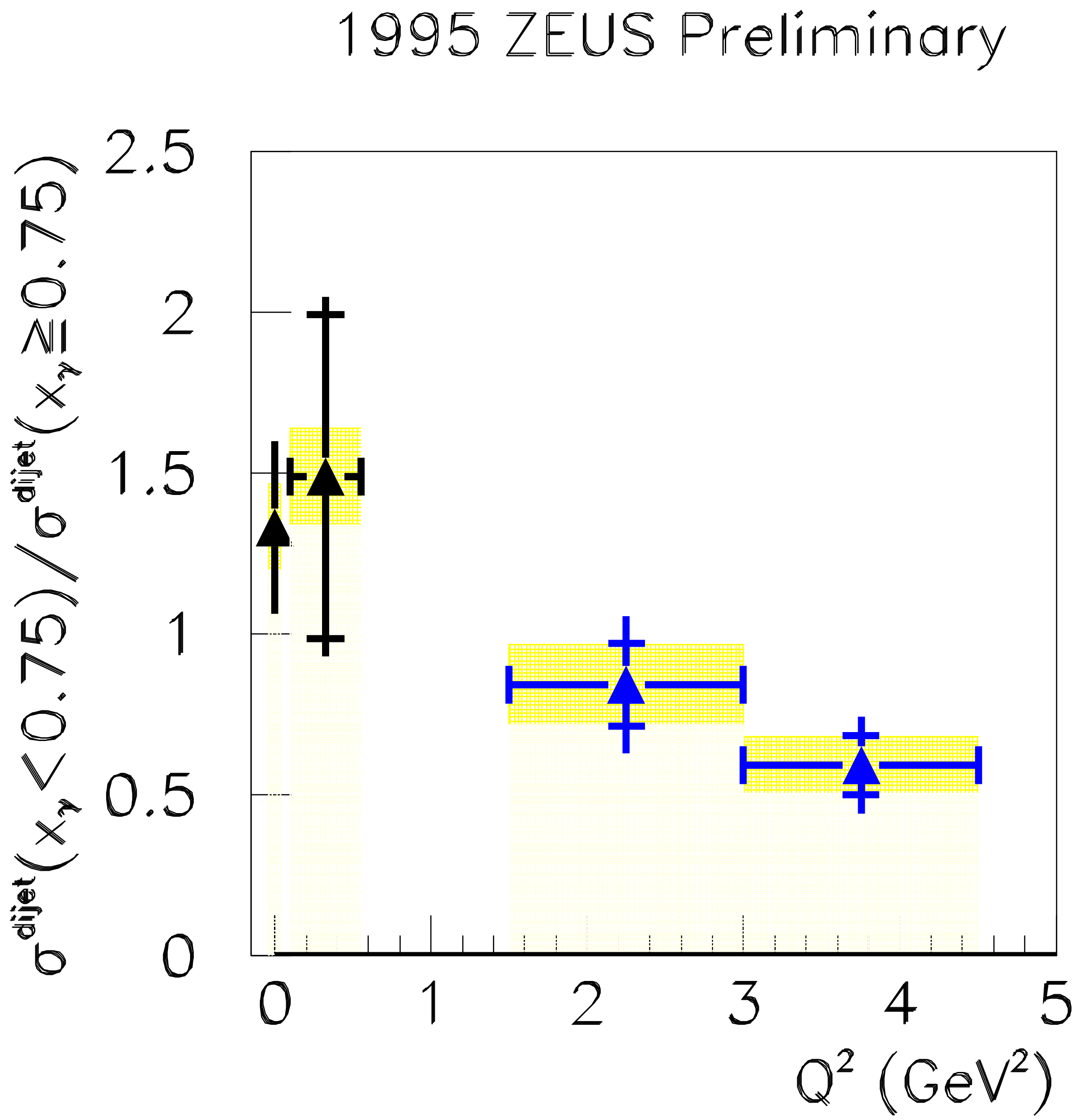

Figure 10: The ratio of the 'resolved' ($x_\gamma^{obs} < 0.75$) to the 'direct' ($x_\gamma^{obs} \geq 0.75$) dijet cross section as a function of the photon virtuality. The data have been corrected for detector effects. The inner error bars show the statistical error. The outer error bars show the quadratic sum of the statistical and systematic uncertainties with the exception of the absolute energy scale uncertainty which is shown separately as a shaded band.

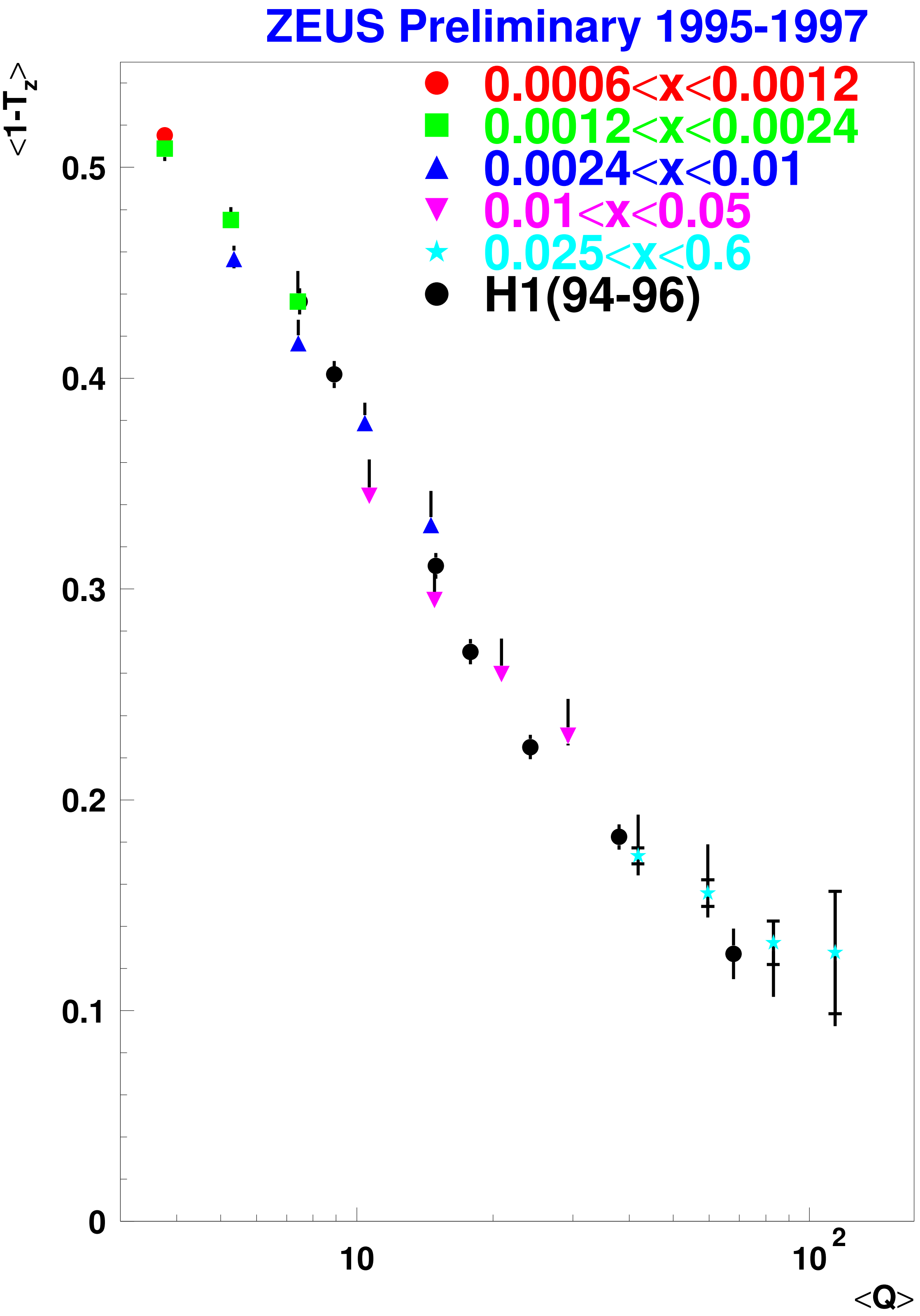

Figure 11: Mean (1 - Thrust) as a function of Q over several x ranges. The data show a clear x and Q dependence. Also shown are the H1 (1994-96) data.

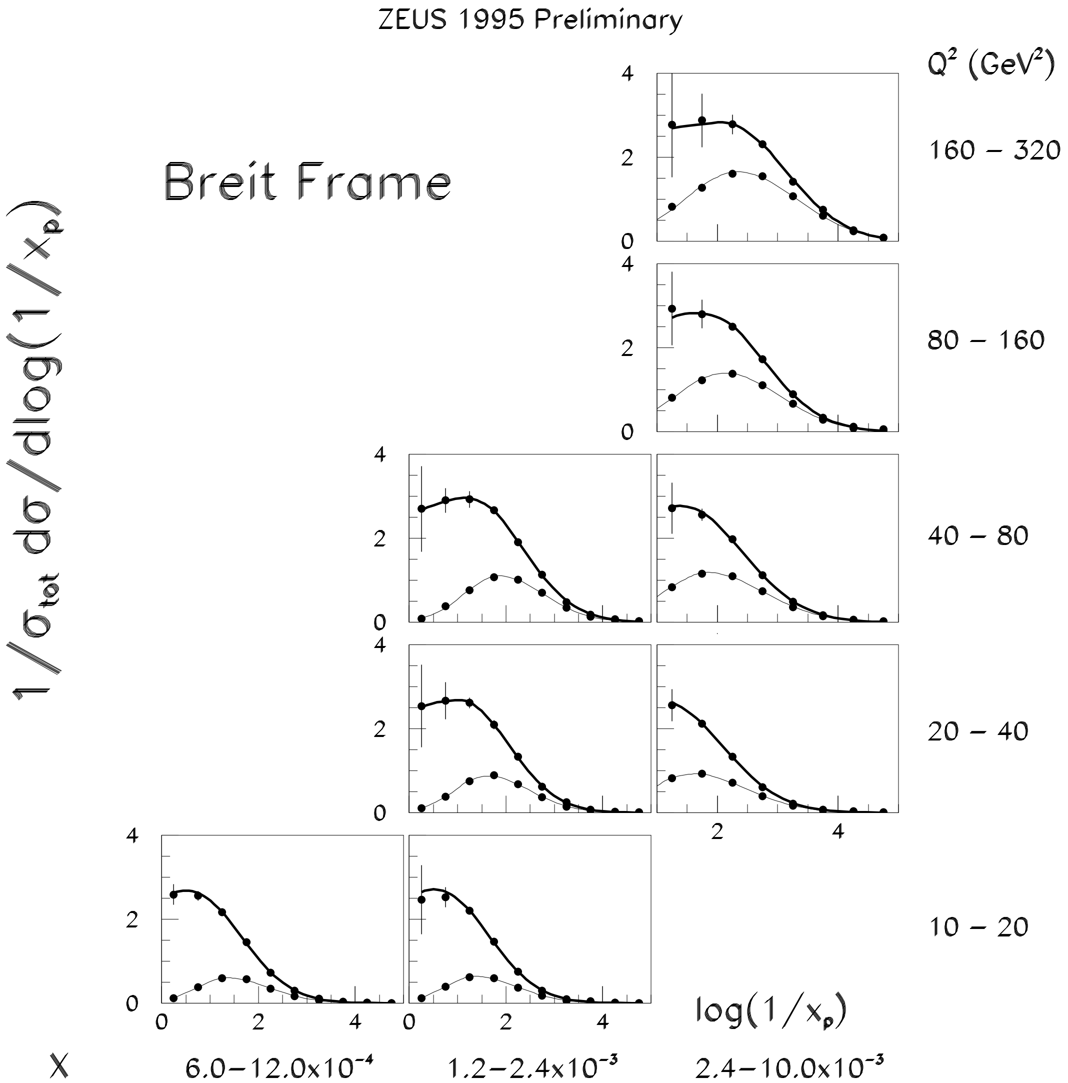

Figure 12: The corrected $\log(1/x_p)$ distributions for the target (upper points) and current (lower points) regions for the preliminary 1995 data. To guide the eye, fitted two-piece normal distributions are shown. The heavy line corresponds to the target region, the light line to the current region. The error bars are the sum of the statistical and systematic errors in quadrature.

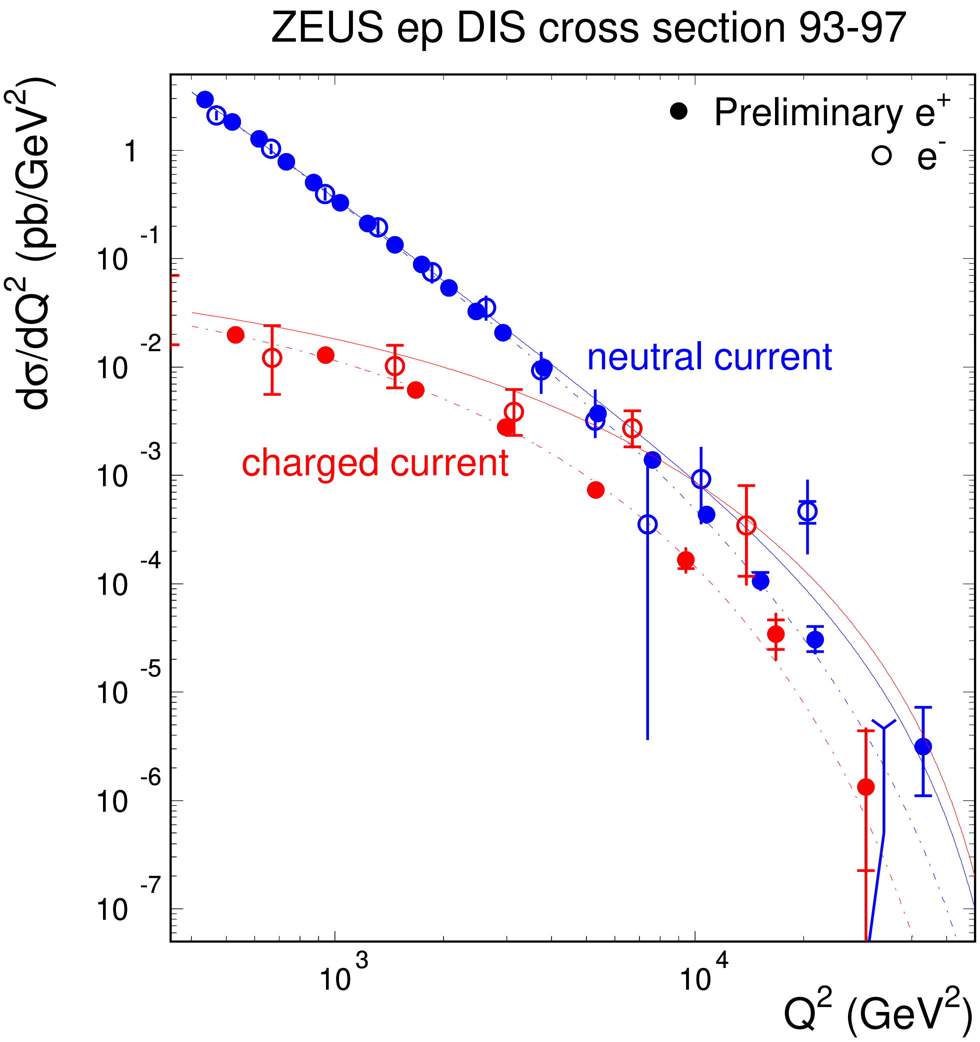

Figure 13: The figure shows the differential cross section $d\sigma/dQ^2$ for charged and neutral current e^-p deep inelastic scattering. The 46.6 pb^{-1} of e^+p data are shown as the filled circles. The 0.8 pb^{-1} of e^-p data taken in 1993 and early 1994 are shown as the open circles. The expectations of the Standard Model, evaluated using the CTEQ4 parton density functions, are shown by the solid and dashed lines.

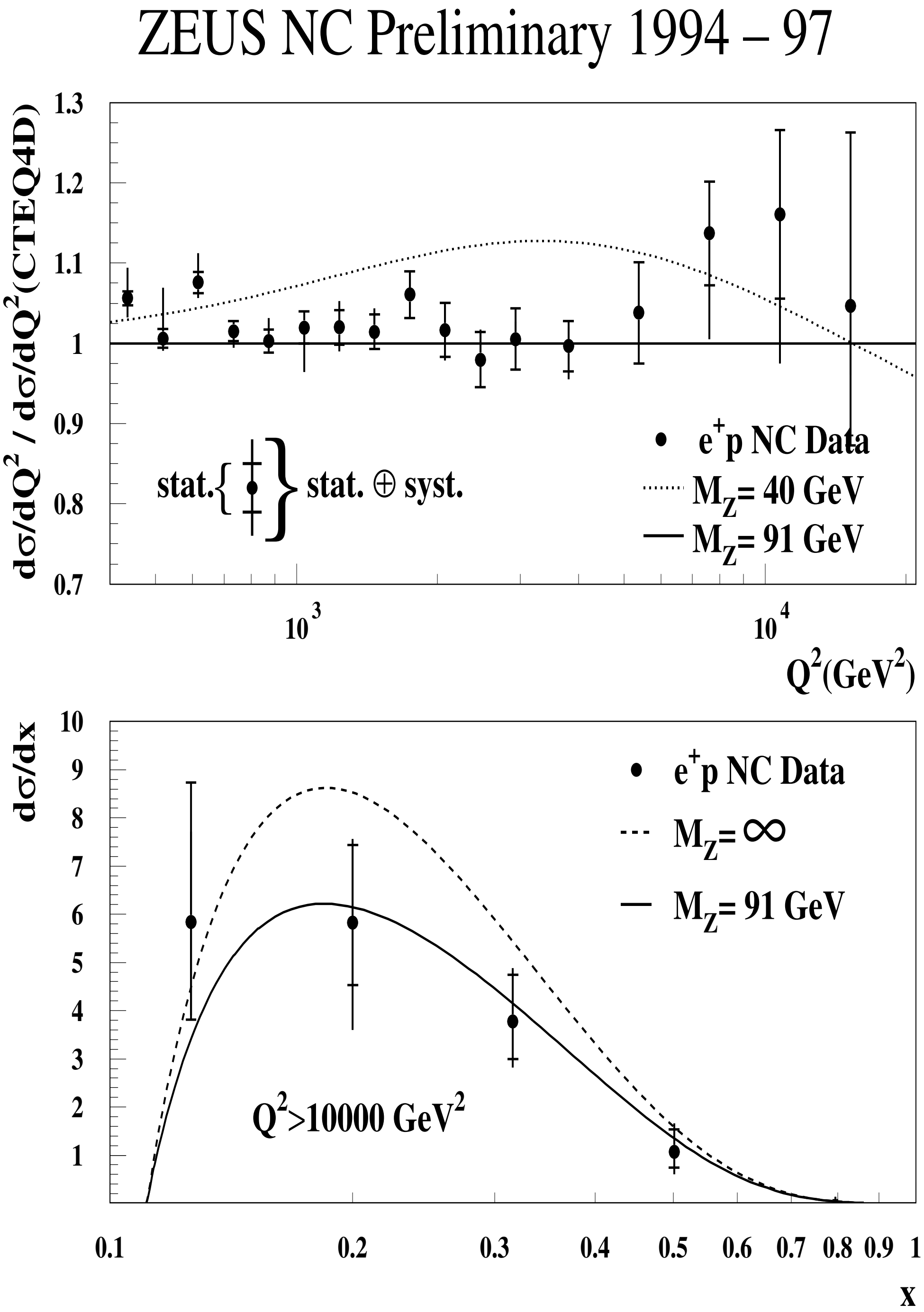

Figure 14: A comparison of the measured and predicted differential cross sections $d\sigma/dQ^2$ and $d\sigma/dx$ (for $Q^2 > 10000$ GeV^2) under different Z-boson mass assumptions. Measurements (solid points) are plotted together with the predictions of the Standard Model evaluated using the CTEQ4 parton density functions. The values of the Z-boson mass used in the evaluation of the expectation of the Standard Model are shown in the figure.