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, Columbia, DESY, DESY-Zeuthen, Florence, Frascati, Freiburg, Hamburg, Iowa, Jülich, Krakow, Kyungpook, Louisiana, Madison (Wisconsin), Madrid, Manitoba, 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

In 1997 HERA again ran with 820 GeV protons and 27.5 GeV positrons. The expectation that a short shutdown in the winter of 1996/1997 would lead to a rapid startup and high efficiencies for both HERA and ZEUS was fully met. A total of 36 pb^{-1} was delivered of which almost 27 pb^{-1} was collected by the ZEUS experiment for physics analysis. Thus HERA delivered more than twice as much luminosity in 1997 as in 1996, and the average efficiency of ZEUS was 75% - significantly higher than for any previous year. This was at least partly due to the fact that very few changes were made between the 1996 and 1997 run periods. Another benefit of this policy is that as triggers and detector configurations are practically identical for both years, the 1996 and 1997 data samples can easily be combined into a single sample. Analysis of the combined sample is already well advanced, and first results from the earlier part of the 1997 data have already been presented at the summer conferences.

The UK groups have continued to play a full part in the data-taking, providing two of the four run coordinators in 1997, as well as several of the designated shift leaders and crew. We also supply the gas officer for the whole experiment. Other roles played by UK physicists in 1997 include overall tracking coordinator, Monte Carlo code editor/manager, a coordinator of one of the four physics groups, and as of this summer, the physics chairperson.

Hardware developments.

Although few changes were made during the shutdown, there have been nevertheless significant developments on the hardware front towards the end of the running period.

1. Towards the end of 1997 running, the beampipe calorimeter (BPC), a calorimeter which measures electrons which are deflected through small angles, was augmented by a small angle silicon tracker. This will greatly enhance the Q^2 resolution for Q^2 below a few GeV^2, by improving the measurement of the vertex.
2. Again in the latter stages of the run, the first modules of barrel presampler (BPRES) were read out. The BPRES will be fully installed in front of the barrel calorimeter during the 1997/1998 shutdown and will improve the measurement of jets and electrons in the central region.
3. Preparations for the installation of the forward plug calorimeter (FPC) were brought to a conclusion. The FPC will also be installed in the current shutdown, and will extend the rapidity reach of the calorimetry by one unit of pseudorapidity in the proton direction, bringing particular benefits to low x and diffractive physics.

4. Finally, design and construction of the microvertex detector (MVD) began. The MVD will be installed in conjunction with the HERA luminosity upgrade and will greatly enhance the tracking capabilities of ZEUS, in particular providing the ability to measure secondary vertices at a few hundreds of microns from the primary. This will lead to a whole new reach in high statistics heavy quark studies, and will also extend the possibilities for measuring new physics. The ZEUS UK collaboration has a significant participation in the MVD project, the progress of which is summarised below.

MVD status.

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 and detailed drawings of the necessary equipment will soon be produced. It is planned that this equipment will be manufactured at the beginning of 1999, ready for installation during the HERA winter shutdown between 1999 and 2000.

It is necessary to precisely align 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 opto-electrical alignment system is being designed to provide accurate position measurements during assembly and periodically during running. This will complement the software that is being developed to make detailed alignment measurements using charged tracks.

The clock and control electronics provides key communication between the global first level trigger (GFLT), the ADC crates and the HELIX on-detector electronics. The functionality of the clock and control electronics is now fully specified, and detailed designs are underway, with the goal being to provide a prototype system by the summer of 1998. The final system should 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 the optimum results from it. The CTD is an essential component of almost all ZEUS triggers and of all ZEUS physics analyses.

The CTD has continued to perform reliably in 1997. The experimental downtime attributable to the CTD was less than 1%, mostly attributable to a single hardware failure. The chamber efficiency and resolution have remained stable and there are still fewer than 2% dead channels.

Work on upgrading the monitoring, analysis and Monte Carlo software has continued. Trials of data quality monitoring remotely from the UK were carried out with a view to reducing the manpower requirements at DESY and proved successful. It is planned to make greater use of remote monitoring in the future provided the performance of the international networks continues to permit it.

Physics analysis.

During 1997, 14 ZEUS analyses were accepted for publication by various journals. With these, the analysis of 1994 data is essentially complete. The increased statistics of the 1995 and 1996 data have already shown their value, and 1997 analyses are well underway, with some results already presented at conferences.

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

1. *Hadronic Final States in DIS.* The fragmentation functions, $D(x_p, Q^2)$, are comparable to structure functions in as much as neither can be calculated in perturbative QCD but

given a measured starting distribution one knows how to evolve in Q^2 for a given x_p, where x_p is the scaled momentum $2p/Q$ in the current region of the Breit frame. The scaling violations of the fragmentation function with increasing Q are due to increased phase space for gluon radiation leading to softer particle spectra; the scaling violations at large x_p allow a measurement of α_s. The cross sections, $1/\sigma_{\rm tot} d\sigma/dx_p$, for charged particle production in the current fragmentation region of the Breit frame were measured using 1994 data and published this year [5]. Clear evidence for scaling violation was observed, in agreement with NLO theoretical calculations.

2. *Jet Physics.* Dijet cross sections from 1994 data were published this year [2], and preliminary results from 1995 and 1996 data have been presented. At high transverse energies (E_T^{jet}), these results can be understood in terms of next to leading (NLO) QCD and are thus expected to lead eventually to direct constraints on photon and proton structure. At lower E_T^{jet}, there are large disagreements between the data and perturbative QCD expectations. These results touch on the transition region between soft and hard physics. Explorations of multi-jet topologies, internal jet structure and multi-jet cross sections are being pursued with the aim of increasing our understanding of this interesting area of strong interaction physics. Effects such as colour coherence and multiparton interactions are being investigated. This work has been presented at summer conferences - see for example the triple jet x_γ^{OBS} in Fig.1 - and has been the subject of workshops in Tokyo and Oxford.

   Jet cross section results have also been extended to higher photon virtualities (Q^2), where the hadronic nature of the photon is expected to be suppressed. Fig.2 shows the ratio of resolved to direct photoproduction as a function of photon virtuality. Again, this is an important area in which to test and extend our understanding of strong interaction physics.

   The potential of dijet studies if polarised protons were available was investigated as part of the "1997 Workshop on physics with polarized protons at HERA", March-September, 1997, DESY-Hamburg and DESY-Zeuthen. The results indicate that there are good possibilities for studying the polarised parton distributions of the photon with such techniques, and will appear in the proceedings.

3. *Prompt Photons.* In addition to dijet processes mentioned above, photoproduced final states with a single high E_T jet accompanied by a high E_T photon were measured in 1995 data and published this year [7]. The UK involvement in this analysis is continuing now as the 1996 and 1997 data samples are studied. As well as being a valuable test of QCD, it is hoped that these processes could eventually provide a clean measurement of the parton distributions in the photon.

4. *Rapidity Gaps between Jets in Photoproduction.* In 1994 ZEUS published an excess of events with a large rapidity gap between jets over what would be expected from non-diffractive processes. This can be interpreted as a signal for diffraction taking place within the regime of perturbative QCD and studying this process could help to unravel the overlap between QCD and Regge phenomenology. The excess has been confirmed in the 1995 data (see Fig.3), and analysis of the later samples continues. As demonstrated in the HERA workshop, this is a topic which should benefit greatly from the installation of the FPC.

5. *Inclusive K^0 and charged particle production in Jets.* A study of charged particles and K^0 mesons in photoproduced jets has been published recently [1]. The association of particles with high E_T^{jet} jets allows a measurement of the fragmentation function in photoproduction, as the jet provides the hard scale (which is provided by the photon virtuality in DIS, see above). Thus an investigation of the universality of fragmentation processes was made, via a comparison with Tevatron, LEP and ZEUS DIS data, as well as with theoretical fits and

with Monte Carlos. In general, the results agree well with data from other experiments, and with the theoretical fits for both charged hadrons and neutral kaons as Fig.4 shows. However, with respect to the default parameters of the PYTHIA MC, the inclusion of multiparton interactions and a suppression of strangeness production is favoured.

6. *Charm Production in Jets.* Tagging charm inside jets provides extra information about QCD kinematics and dynamics. A first interesting question is whether there are charm quarks 'inside' the photon in same way as there are light quarks. This has a strong influence on the size of the charm production cross section. If jets are reconstructed, x_γ^{OBS} can be measured and the effect of charm inside the photon would be expected to show up as an increase in the cross section at low x_γ^{OBS}. Fig.5 shows the x_γ^{OBS} distribution, as presented in summer conferences, where each event has at least one jet containing a charm quark, as tagged by the $D^{*\pm} \rightarrow D^0\pi_s^\pm$, $D^0 \rightarrow K^\mp\pi^\pm$ decay mode. The MC expectations for direct and resolved contributions are shown. Clearly some resolved contribution is required. Further studies using semi-leptonic tags and eventually the MVD will thoroughly unravel the nature of charm photoproduction, and allow the investigation of instrinic charm in the photon.

7. *Charm Production in Deep Inelastic Scattering.* Charm production in DIS proceeds mainly via the photon gluon fusion mechanism. Thus measurement of the charm production cross section is of great importance for understanding the gluon dynamics of the proton; it can also provide insight into the charm production mechanism and test ideas about the origin of charm in the proton. Charm is identified by the $D^{*\pm} \rightarrow D^0\pi_s^\pm$, $D^0 \rightarrow K^\mp\pi^\pm$ or $D^0 \rightarrow K^\mp\pi^\pm\pi^\pm\pi^\mp$ decay channels. The charm tagged photon structure function F_2^{charm} has been measured for 1995 data, and measurements exploiting the much higher statistics of the 1996 and 1997 data are underway. Fig.6 shows the preliminary F_2^{charm} results shown this summer.

8. *Charm Production in Diffraction.* The rate of charm production in diffractive processes (that is, processes where the hadronic final state can be clearly separated into two regions, one associated with the dissociated photon, the other with the proton) provides important clues about the nature of diffraction and how it might be described within QCD. Preliminary results have been shown for 1995 data. Charm is tagged using the usual D^* method, and diffractive processes are isolated by demanding a rapidity gap between X (the hadronic system of the dissociated photon) and the low mass system in the proton direction of at least two units. Fig.7 shows the distribution of the mass difference $M(D^*) - M(D^0)$ in 1995 data and clearly indicates the presence of diffractively produced charm. The fraction of DIS D^* production which is diffractive is $(20 \pm 10)\%$. Analysis of the combined 1996 and 1997 sample is well underway.

9. *Charged Hadron Distributions in DIS with a Large Rapidity Gap.* Charged hadron distributions have been analysed in the range of $130 \leq W \leq 185\,\mathrm{GeV}$ and $7 \leq Q^2 \leq 160\,\mathrm{GeV}^2$ where W is the γ^*-proton cms energy and Q^2 is the negative square of the four momentum exchanged between the electron and the proton. The scaled longitudinal momentum (x_F) distribution and the mean square of the transverse momentum as a function of x_F (seagull plot) have been measured in the cms of the observed hadronic final state, which is equivalent to the $\gamma^*\ \mathbb{P}$ cms , if the LRG events are interpreted in the pomeron exchange picture. Both the x_F distributions and the seagull plot are symmetric around $x_F = 0$. This contrasts with the results in the $\gamma^* p$ cms for non–rapidity gap μp DIS, where the effect of the leading baryon production for negative x_F is observed and the seagull plot is asymmetric. This is attributed to a suppression of gluon radiation in the negative x_F range (in the $\gamma^* p$ cms).

   If the LRG events are interpreted as diffractive DIS events the symmetry of the x_F distribution and the seagull plots in the γ^* $\mathbb{P}$ cms indicates that the partonic substructure of the exchanged object consists, in the simplest form, of a $q\bar{q}$ or gg configuration. More complicated configurations like $qg\bar{q}g$ would involve higher order QCD processes. Comparison with calculations using one of the pomeron exchange models shows that a $q\bar{q}$ configuration is favoured over a gg configuration.

10. *F_2 and the $\gamma^* p$ cross section at low Q^2.*

    One of the most important tasks of the HERA experiments is the measurement of neutral and charged current cross sections, and the proton structure functions, over the widest possible range of Q^2. From the beginning, UK groups have played an important part in this effort.

    The precise data that ZEUS has collected at low Q^2 using the shifted vertex technique and in particular that from the BPC has allowed the transition region from real photoproduction ($Q^2 = 0$) to the 'safely' deep inelastic ($Q^2 > 4\,\mathrm{GeV}^2$) to be studied in detail. Using a combination of standard NLO QCD fitting with decreasing starting scale Q_0^2 and a Donnachie-Landshoff Regge inspired approach from low Q^2, the transition from a non-perturbative to a perturbative description of the total $\gamma^* p$ (or F_2) occurs in the range $0.8 < Q^2 < 1.5\,\mathrm{GeV}^2$. Fig.8 shows F_2 data from HERA at low Q^2 with a variety of models that combine various features of pQCD and soft physics. It is clear that the quality of the ZEUS data is instrumental in distinguishing between them.

    The low and intermediate Q^2 measurements are now limited by systematic errors. Efforts to reduce these errors continue. In addition, a special series of runs was taken in 1997 to measure the total photon-proton cross section for almost real photons. Efforts are also underway to use radiative events to measure the photon density of the proton and F_L.

11. *NC and CC DIS Cross Section measurements at high Q^2.*

    Interest is increasing in the highest accessible regions of Q^2, which are extended with each run as greater statistics are accumulated. One major motivation for such studies is the possibility of new physics, as may be suggested by the excess [14] in the cross section observed at $x > 0.55, y > 0.25$, where for a sample including data from 1994 until approximately two thirds of the way through the 1997 run, five events were observed for a standard model expectation of 1.51 ± 0.13. Another motivation was spelled out in the UK contributions to the HERA workshop, where the potential of measuring the non-singlet structure functions of the proton and making measurements of electroweak parameters is clear.

    Realising such potential requires a long term effort to thoroughly understand the data, building on knowledge accumulated over many years and using consistent techniques for electron and positron runs to maximise the accuracy of comparisons between data from different years. To achieve this, a coherent effort amongst the UK institutes has been started. CC cross sections have already been measured using 1995 and 1996 data, as shown in Fig.9, and and work is well underway on extending this into the 1997 sample, and soon into samples from the electron running expected in 1998 and 1999.

12. *Study of ρ^0 Photoproduction at HERA.* A measurement has been performed using the ZEUS Leading Proton Spectrometer (LPS) which detects protons scattered at very small angles, and submitted for publication very recently. The quasi-elastic ρ-production cross section, as well as the process where the proton dissociates into a low mass state, have been measured and submitted for publication very recently. The slope of the t distribution is found to be much shallower when the proton dissociates than when it does not. An extraction of the spin density matrix elements shows consistency with s-channel helicity conservation. These measurements also allow an extraction, within the Söding approach,

of the πp cross section at 50 GeV of $\sigma_{\pi p} = 31 \pm 2(\text{stat}) \pm 3(\text{syst})$ mb, with an additional model dependent uncertainty of 15%. This result is consistent with the predictions of fits to πp data based on the "soft" pomeron approach.

13. *High P_T leptons.* A search for events with high P_T electrons together with missing P_T has been used to place limits on the W production cross section in ep collisions. This has enabled 95 % confidence limits $\Delta\kappa < 7\,(\lambda = 0)$ and $|\lambda| < 11.7\,(\Delta\kappa = 0)$ to be placed on the anomalous couplings at the $WW\gamma$ vertex. W production is also the most serious background to many searches for physics beyond the Standard Model, in particular both R_P conserving and certain R_P violating SUSY processes. Work is presently close to completion on extending the search to include all data up to 1997 and to include events with high P_T muons. This should allow a first measurement of the W production cross section. Fig.10 shows a candidate $W \to e\nu$ event from 1997. The high P_T positron has a large angle of acoplanarity with respect to the jet, resulting in a transverse mass for the event of 79 GeV.

Ph.D Theses.

1. S. Campbell-Robson, (Bristol) *A study of charm production in deep inelastic scattering in e^+p collisions.*
2. A.S. Cassidy, (Bristol) *Optimising the Central Tracking Detector Readout at ZEUS and Measuring the longitudinal structure function at HERA.*
3. J.D. McFall, (Oxford) *The performance of the ZEUS first level tracking trigger and a study of diffractive D^* production in deep inelastic scattering at HERA.*
4. A. Quadt (Oxford) *Measurement and QCD analysis of the proton structure function F_2 from the 1994 HERA data using the ZEUS detector.*
5. R.L. Saunders (UCL) *A Measurement of Dijet Photoproduction at HERA using the ZEUS detector.*
6. J.R. Tickner, (Oxford) *Proton structure functions at low Q^2*
7. A. Vorvolakos (IC) *Artificial neural network methods in high energy physics and their application to the identification of quark and gluon jets in electron-proton collisions.*
8. A.S. Wilson (Glasgow) *A study of neutral kaons and charged particles in photoproduced jets at HERA.*

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

1. J. Bromley, *Fragmentation functions at ZEUS.*, DIS 97, Chicago, 1997.
2. N.H. Brook, *Fragmentation at HERA*, Fragmentation Symposium, Vancouver, 1997.
3. N.H. Brook, *Summer School lecture on DIS.*, Gomel, Belarus, 1997.
4. J.M. Butterworth, *Photoproduction of Jets.*, Ringberg workshop on Physics at HERA, Tegernsee, May 1997.
5. J.M. Butterworth, *Jet Production at HERA.*, International Workshop on HERA physics, KODEL, Seoul, 1997.
6. R.J. Cashmore, *New Directions in detectors.* Invited talk at EPS HEP, Jerusalem, 1997.
7. R.J. Cashmore, *Recent results on ep scattering from ZEUS* IOP annual conference, "Particle Physics and the Early Universe", Cambridge, 1997.

8. R.C.E. Devenish, *Structure Functions.* Invited talk at EPS HEP, Jerusalem, 1997.
9. A.T. Doyle, *Summary of Hadronic Final States.*, DIS97, Chicago (Convener of working group).
10. A.T. Doyle, *Summer School lectures on Diffraction: QCD Effects in Colour Singlet Exchange.*, SLAC, 1997.
11. M. E. Hayes, *Dijet Cross Sections and Rapidity Gaps between Jets in photoproduction at HERA.* Photon97, Egmond aan Zee, 1997.
12. G.P. Heath, *Charm Production at HERA.*, at "Irresistible rise of the Standard Model", San Miniato, 1997.
13. L. Lamberti, *Vector meson and heavy flavour production at HERA.*, Winter conference on particle physics, Aspen, 1997.
14. N.A.McCubbin, *Proton Structure Functions.*, Physics in Collisions, Bristol, 1997.
15. J.D. McFall, *Inclusive diffraction at HERA: Hadronic final states.*, at "Interplay between soft and hard interactions in DIS", Heidelberg, 1997.
16. V.A. Noyes, *Searches for new particles at HERA.* XII Hadron Collider Conference, Stony Brook, 1997.
17. N.A. Pavel *Hadronic final states in deep inelastic scattering at HERA.* Topical workshop on "The irresistible rise of the Standard Model", San Miniato, 1997
18. N.A. Pavel *Hadron distributions in deep inelastic Electon-Nucleus scattering.* International conference on theoretical physics, Trieste, 1997.
19. A. Prinias, *Gluon and charm measurement in DIS at HERA.*, International Europhysics conference, Jerusalem, 1997.
20. A. Quadt, *Simulation of Parallel Processing Systems.* CHEP97, Berlin, 1997.
21. A. Quadt, *Structure Functions at HERA.* Invited talk at the DPG annual HEP meeting, Munich, 1997.
22. R.L. Saunders, *Recent Photoproduction results from ZEUS.*, DIS97, Chicago, 1997.
23. D. Sideris, *DIS open charm production at HERA Madrid workshop for low-x physics at HERA*, Workshop on low x physics, Madrid, 1997.
24. L. E. Sinclair, *Recent results from the study of QCD and jets at HERA by the ZEUS and H1 Collaborations.*, Lake Louise Winter Institute, Canada, 1997.
25. E.J. Strickland, *Jet Shapes and Multijet Events in Hard Photoproduction at HERA.*, Photon97, Egmond aan Zee, 1997.

References

[1] ZEUS Collaboration; J.Breitweg et al. *Charged Particles and Neutral Kaons in Photoproduced Jets at HERA* DESY-97-229 (November 1997) accepted by Zeitschrift f. Physik - MS 756

[2] ZEUS Collaboration; J.Breitweg et al. *Dijet Cross Sections in Photoproduction at HERA* DESY-97-196 (October 1997) accepted by Zeitschrift f. Physik - MS 756

[3] ZEUS Collaboration; J.Breitweg et al. *Measurement of Jet Shapes in Photoproduction at HERA* DESY 97-191 (September 1997) accepted by Zeitschrift f. Physik

[4] ZEUS Collaboration; J.Breitweg et al. *Measurement of the Diffractive Structure Function $F_2^{D(4)}$ at HERA* DESY 97-184 (September 1997) accepted by Zeitschrift f. Physik - MS 741

[5] ZEUS Collaboration; J.Breitweg et al. *Observation of Scaling Violations in Scaled Momentum Distributions at HERA* DESY 97-183 (September 1997) accepted by Physics Letters B - Mo 5050 (PLB 12055)

[6] ZEUS Collaboration; J.Breitweg et al. *Measurement of Inelastic J/Ψ Photoproduction at HERA* DESY 97-147 (July 1997) accepted by Zeitschrift f. Physik - MS 745

[7] ZEUS Collaboration; J.Breitweg et al. *Observation of Isolated High E_T Photons in Photoproduction at HERA* DESY 97-146 (July 1997) Phys Lett B413 (1997) 201-216

[8] ZEUS Collaboration; J.Breitweg et al. *Measurement of the Proton Structure Function F_2 and $\sigma_{tot}^{\gamma^* p}$ at Low Q^2 and Very Low x at HERA* DESY 97-135 (July 1997) Physics Letters B407 (1997) 434-448

[9] ZEUS Collaboration; J.Breitweg et al. *A Search for Excited Fermions in e^+p Collisions at HERA* DESY 97-112 (June 1997) accepted by Zeitschrift f. Physik - MS 739

[10] ZEUS Collaboration; J.Breitweg et al. *D^* Production in Deep Inelastic Scattering at HERA* DESY 97-089 (May 1997) Physics Letters B 407 (1997) 402

[11] ZEUS Collaboration; J.Breitweg et al. *Study of Photon Dissociation in Diffractive Photoproduction at HERA* DESY 97-061 (March 1997) Zeitschrift f. Physik C75 (1997) 421-435

[12] ZEUS Collaboration; J.Breitweg et al. *Measurement of Elastic J/Ψ Photoproduction at HERA* DESY 97-060 (March 1997) Zeitschrift f. Physik, C75 (1997) 215-228

[13] ZEUS Collaboration; J.Breitweg et al. *Differential Cross Sections of D^{*+-} Photoproduction in ep Collisions at HERA* DESY 97-026 (February 1997) Phys. Letters B 401 (1997) 192-206

[14] ZEUS Collaboration; J.Breitweg et al. *Comparison of ZEUS Data with Standard Model Predictions for $e^+p \to e^+X$ Scattering at High x and Q^2* DESY 97-025 (February 1997) Zeitschrift f. Physik C74 (1997) 207-220

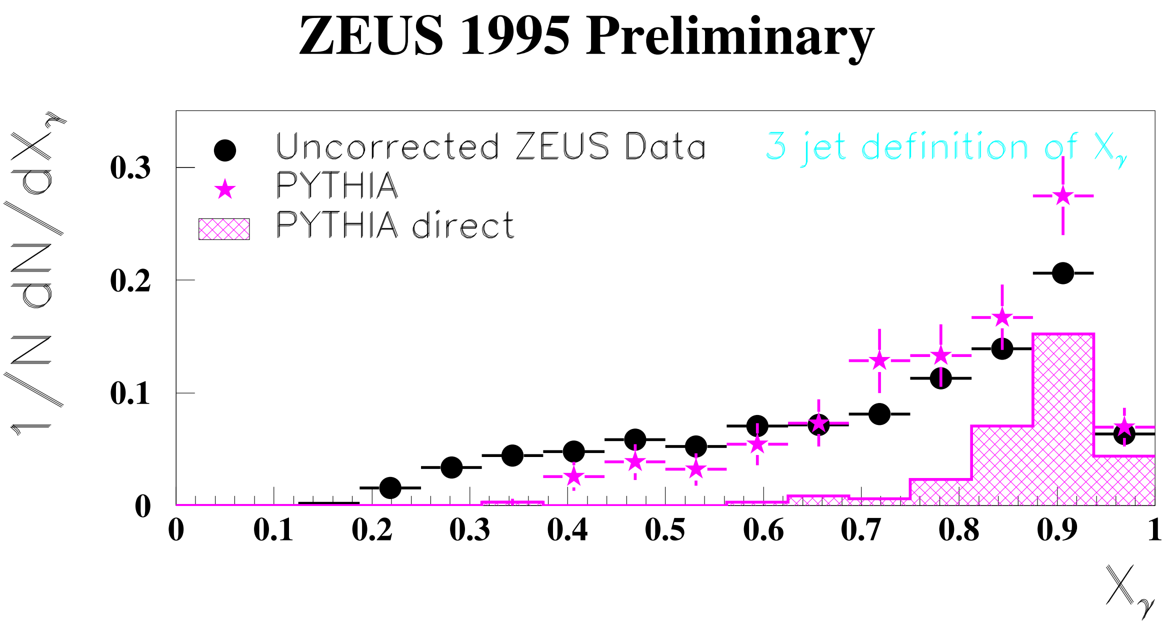

Figure 1: The fraction, x_γ^{OBS}, of the photons's momentum entering into the three highest E_T^{jet} jets. The data are not corrected for detector efficiency and resolution, but are compared to MC events which have been passed through a full simulation of the detector. The MC is normalised to the number of events in the data. The comparison indicates that there are relatively fewer three jet events at low x_γ^{OBS} in the MC than in the data.

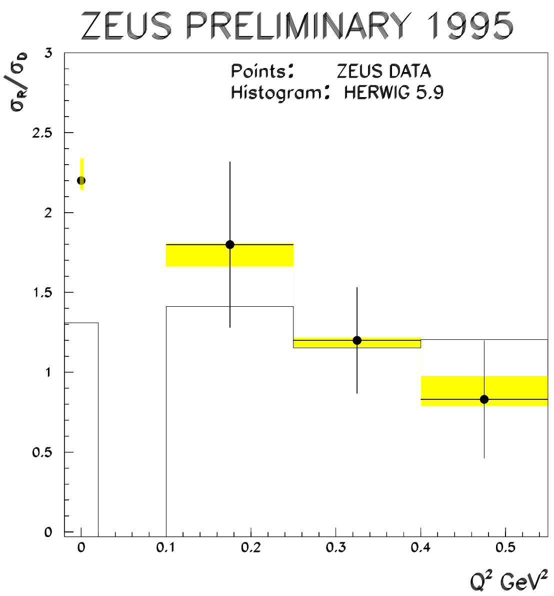

Figure 2: The ratio of 'resolved' ($x_\gamma^{OBS} < 0.75$) to direct ($x_\gamma^{OBS} \geq 0.75$) dijet photproduction and a function of photon virtuality. The data are corrected to the final state particle level, and the prediction of HERWIG is also shown, using a parton distribution for the photon which has no suppression as the photon virtuality increases. The data exhibit a decreasing fraction of resolved photon events as photon virtuality increases, which is not seen in the MC.

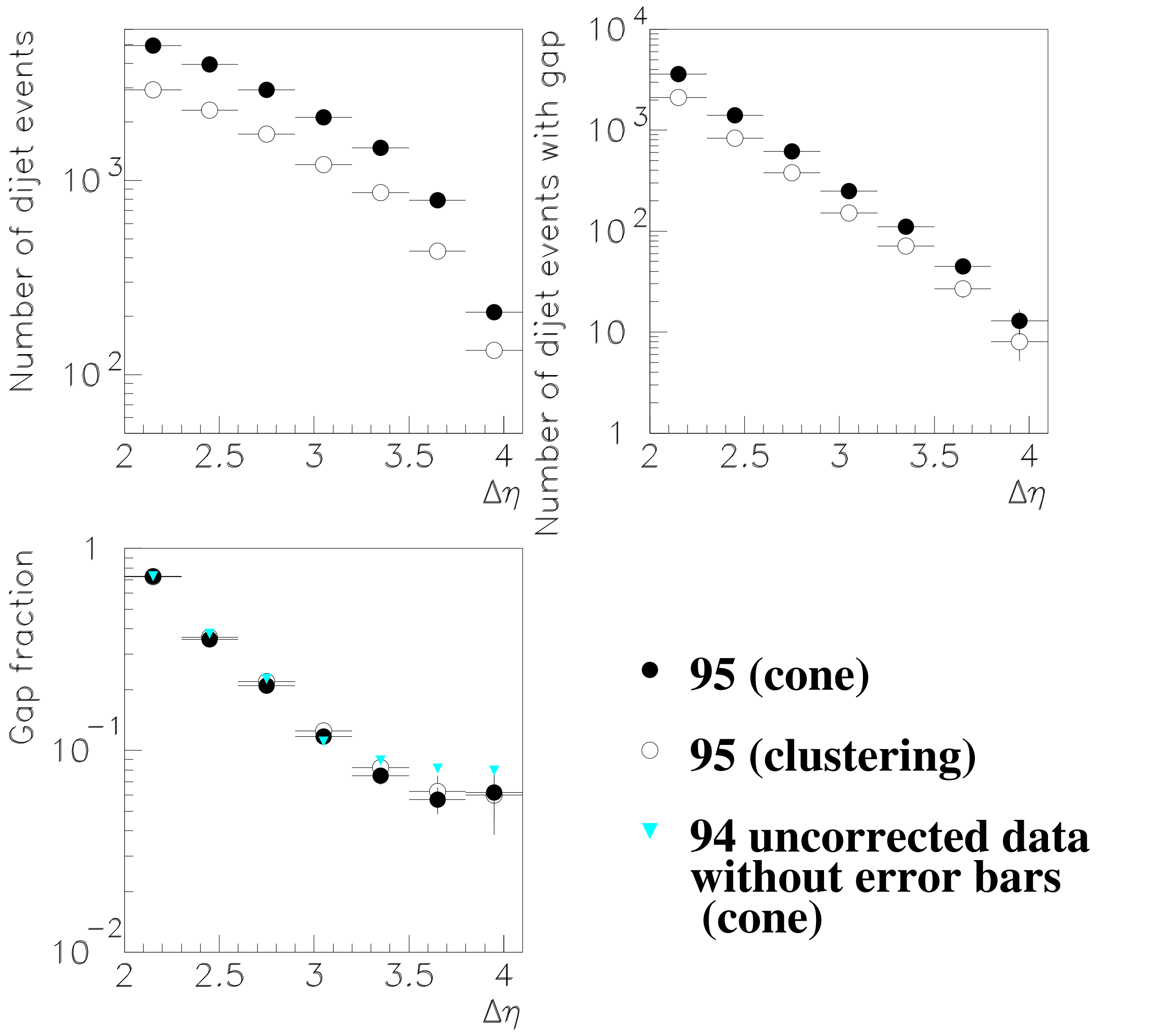

Figure 3: The rate of dijet events as a function of $\Delta\eta$ between the jets, a) inclusively, b) for the case when the rapidity interval between the jets is empty and c) the ratio of the two. The exponentail fall in the first four bins is the behaviour expected for non-diffractive physics, and the flattening in the last bins could be an indication of the presence of a diffractive exchange at high t. The data are uncorrected. The published 1994 results are compared to preliminary 1995 results for two different jet algorithms (a cone algorithm and the K_T cluster algorithm).

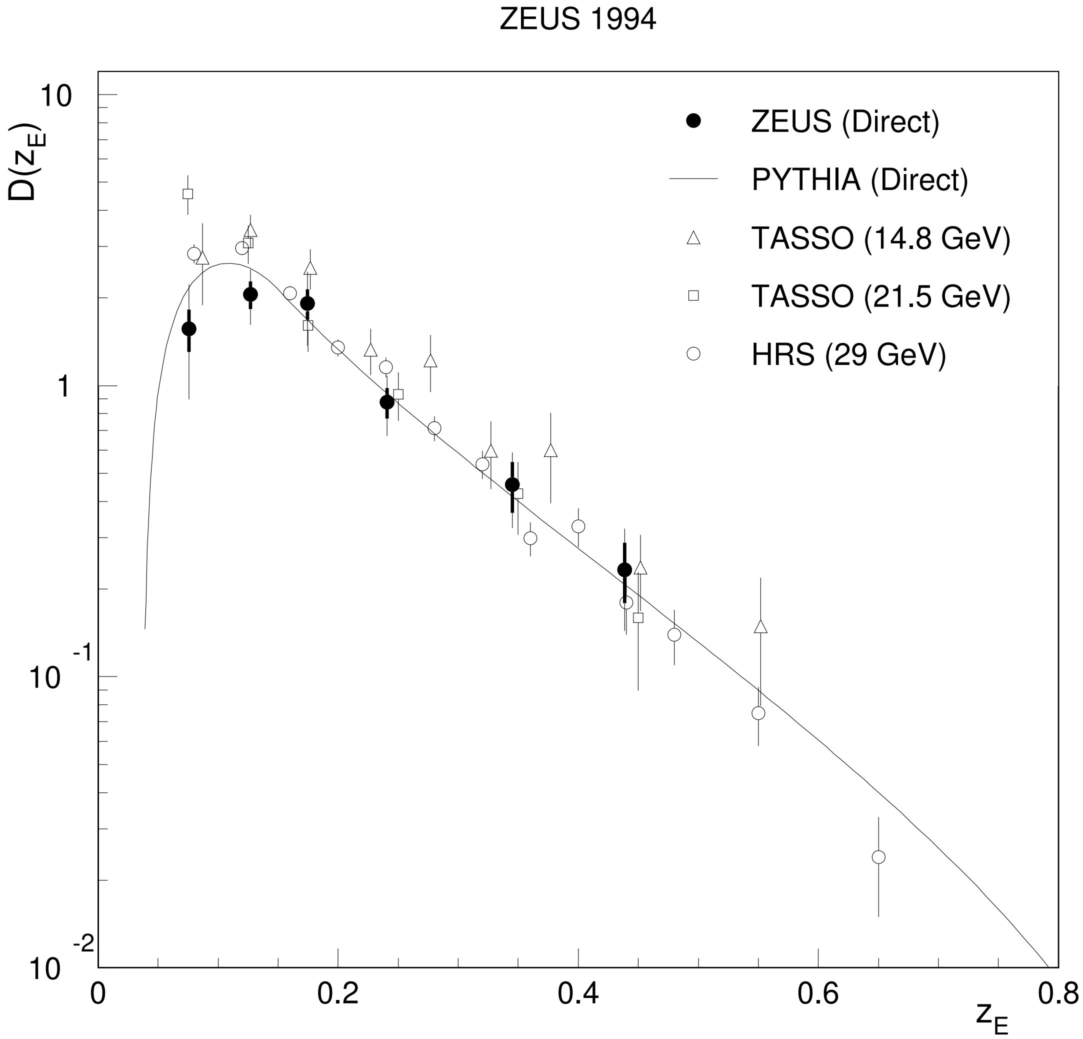

Figure 4: K_0 fragmentation function $D(z_E)$ where $z_E = E(K_0)/E(jet)$, obtained from high x_γ^{OBS} photoproduction events and corrected to the LO definiton of 'direct' photoproduction. Also plotted are the default PYTHIA prediction for LO direct photoproduction and data from previous experiments at similar jet energies.

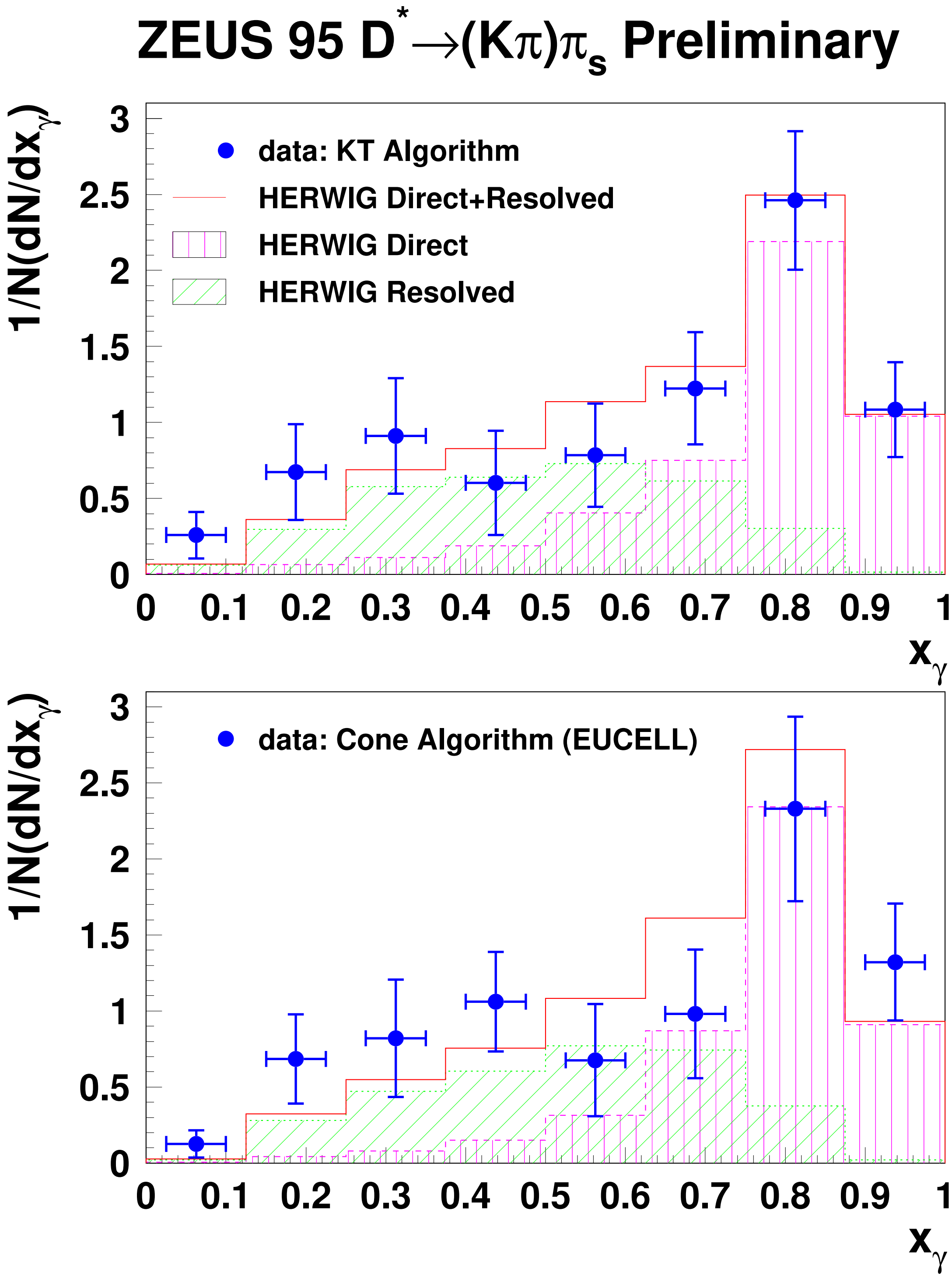

Figure 5: The fraction, x_γ^{OBS}, of the photons's momentum entering into the two highest E_T^{jet} jets, where at least one of the jets contains a D^*. The data are not corrected for detector efficiency and resolution, but are compared to MC events which have been passed through a full simulation of the detetor. The MC is normalised to the number of events in the data. The comparison indicates that both resolved and direct MC contributions are needed to describe the data. This result is shown to hold for two different jet algorithms (a cone algorithm and the K_T cluster algorithm).

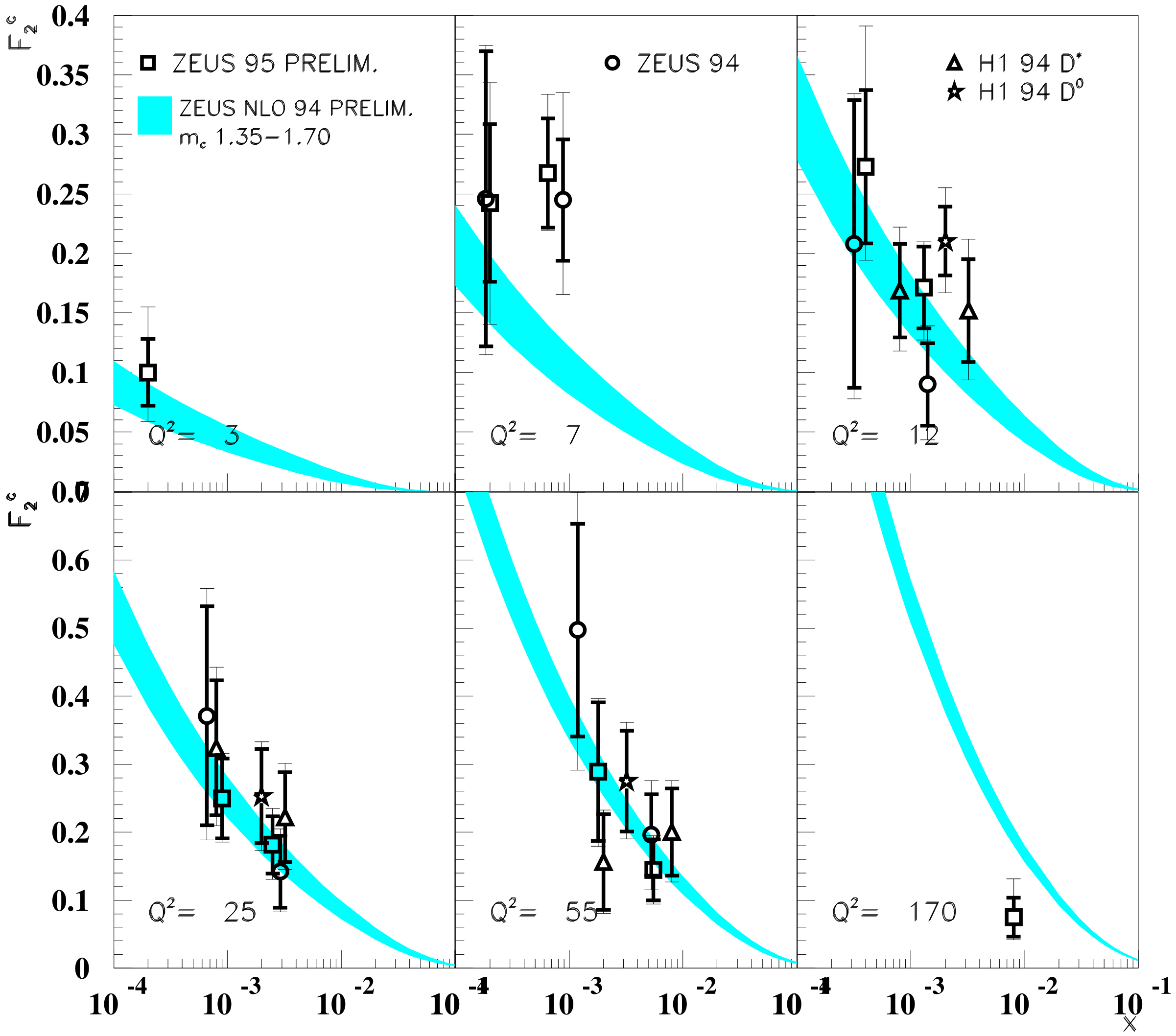

Figure 6: The charm-tagged proton structure function F_2^{charm}, for preliminary ZEUS 1995 data. The H1 and ZEUS 1994 results are also shown.

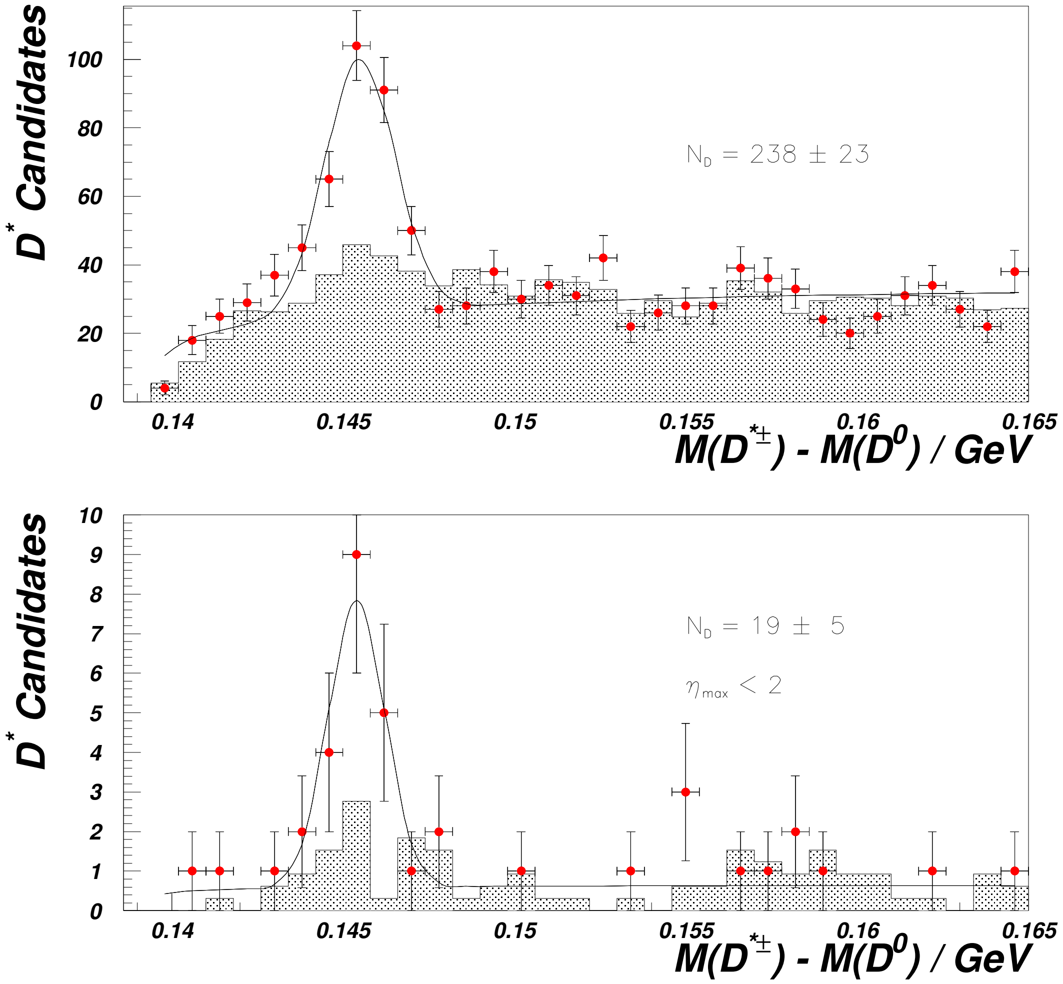

Figure 7: The mass difference distribution for DIS efore (top) and after (bottom) the demand of a rapidity gap.

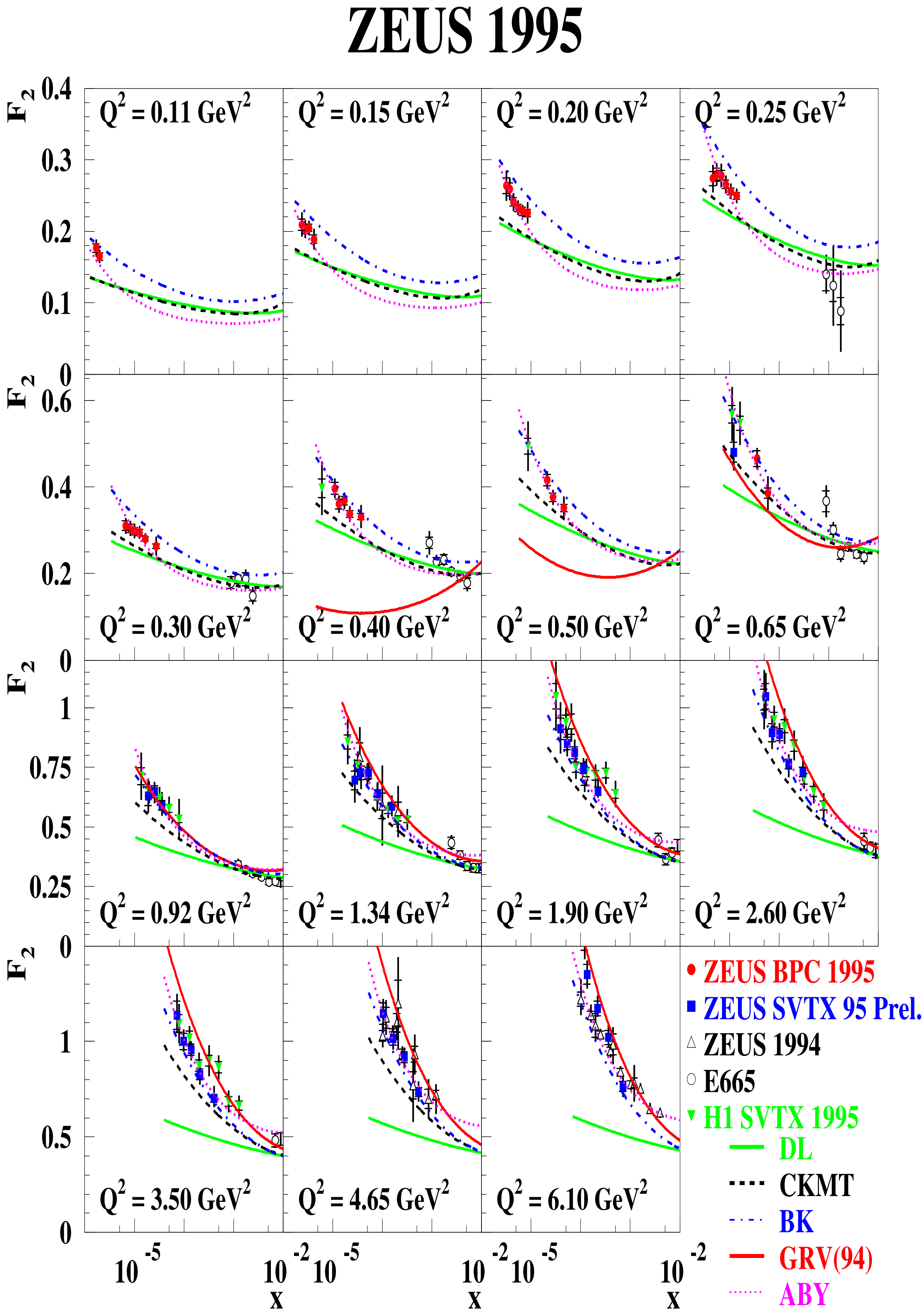

Figure 8: The proton structure function F_2 at low Q^2.

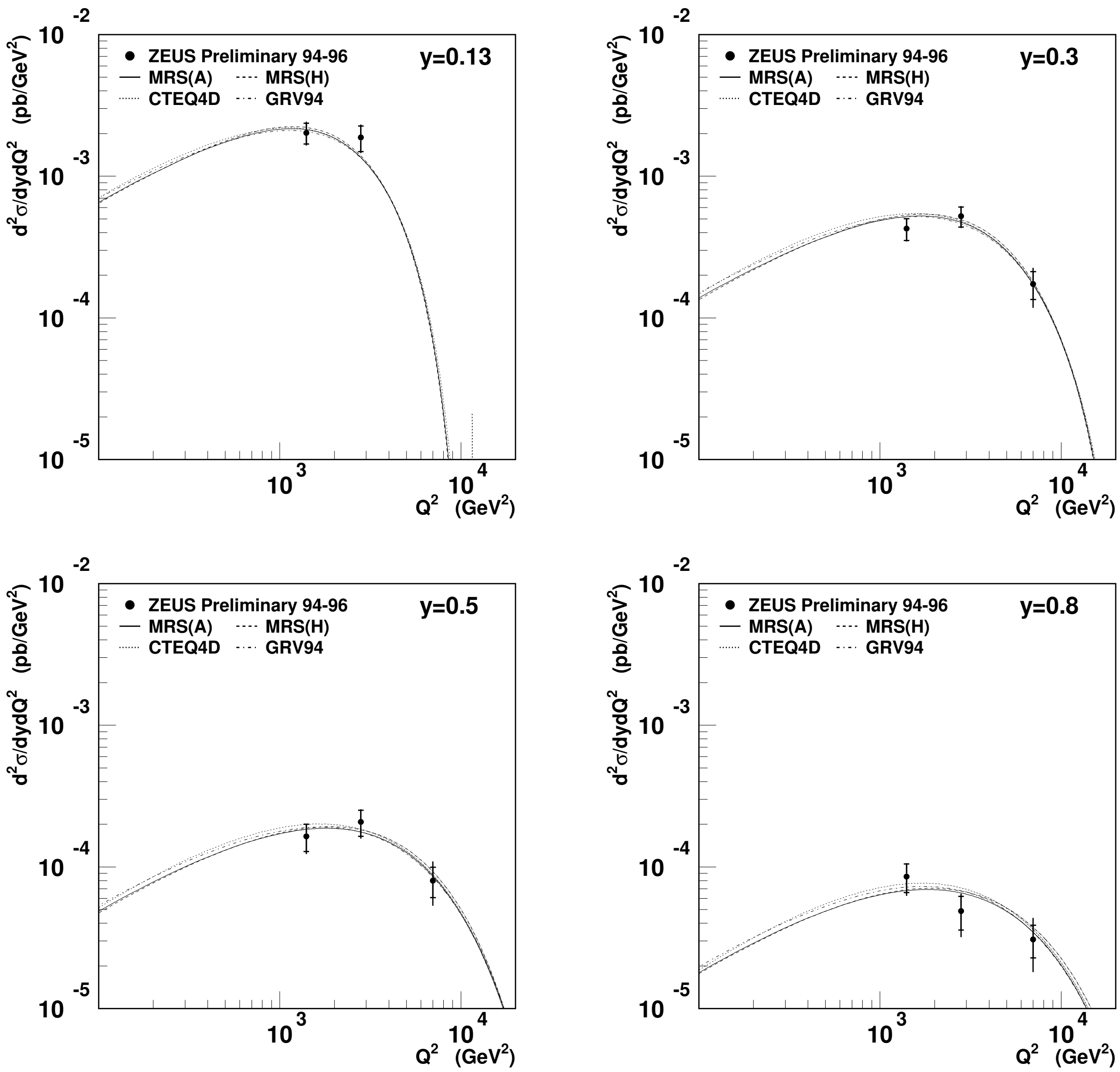

Figure 9: The double differential cross-section $d^2\sigma/dydQ^2$ versus Q^2 at four fixed values of y. The points are ZEUS measurements. The curves indicate the results of various parametrisations of the parton density functions. Statistical and systematic errors are also indicated.

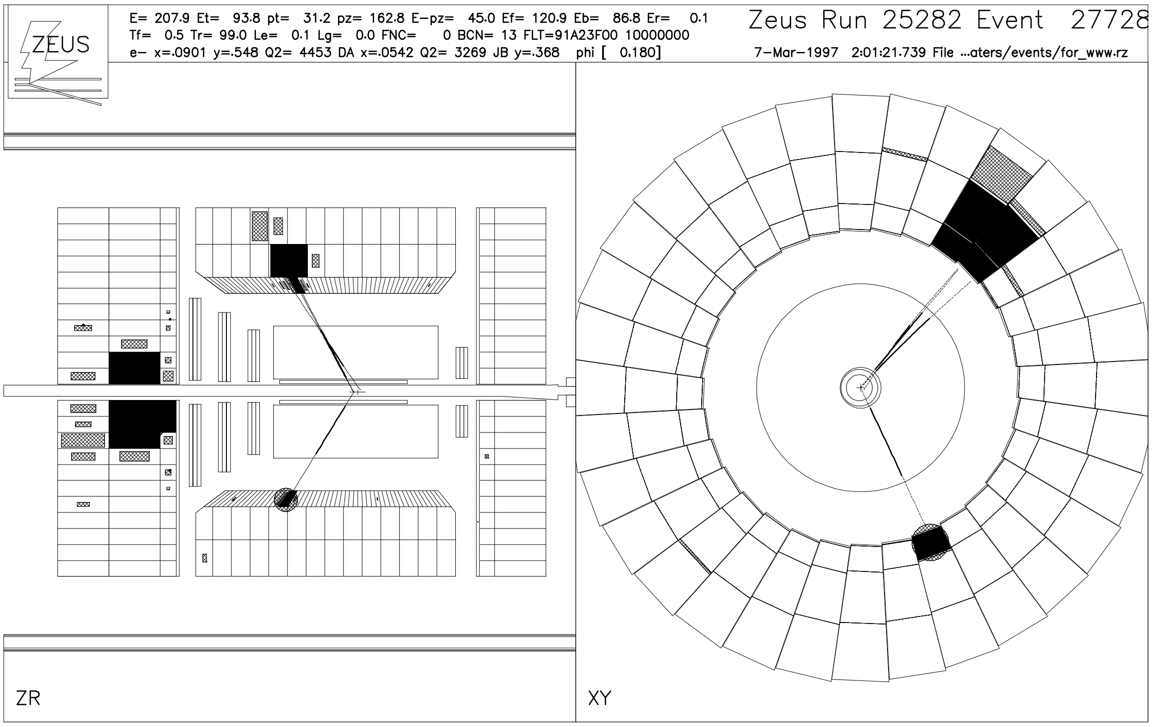

Figure 10: *A candidate $W \to e\nu$ event taken during 1997 running. A scattered positron is visible in the BCAL with a large angle of acoplanarity with respect to the jet. The transverse mass for the event is* 79 GeV.