DEEPLY VIRTUAL COMPTON SCATTERING AND PROMPT PHOTON PRODUCTION AT ZEUS AND H1 EXPERIMENTS

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Recent results on prompt photon production and Deeply Virtual Compton Scattering (DVCS) from ZEUS and H1 experiments are presented.

1. Deeply Virtual Compton Scattering

The interest of Deeply Virtual Compton Scattering (DVCS), i.e. exclusive photon production off the proton $\gamma^* p \longrightarrow \gamma p$ (see Fig. 1a), is in the insight it gives to the applicability of perturbative Quantum Chromo Dynamics (QCD) in the field of diffractive interactions and to the nucleon partonic structure. The hard interaction between the photon and the proton proceeds via the exchange of at least two quarks at leading order or two gluons at next-to-leading order in a colour neutral state. The transition from a virtual to a real photon forces the fractional momenta of the two partons involved to be different ("skewed"). To take into account this skewing effect, one has to consider generalised parton distributions (GPDs) which are an extension of the standard parton densities (PDFs) including additional information on the correlations between partons and their transverse motion. The measurements presented here are compared with a NLO QCD prediction in which the DVCS cross section has been calculated using GPD parametrisations [1] based on the ordinary PDFs in the DGLAP formalism and where the skewedness is dynamically generated. The t dependence of the GPDs, where t is the square of the four-momentum exchanged at the proton vertex, is taken to be $e^{-b|t|}$.

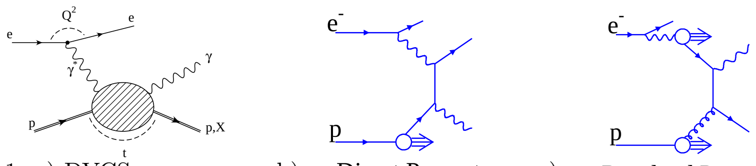

Fig 1: a) DVCS b) Direct Prompt γp c) Resolved Prompt γp

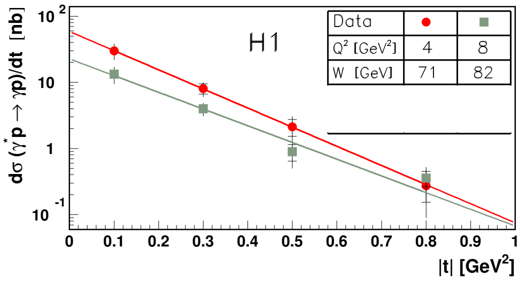

Fig. 2. *The cross section $\gamma^* p \to \gamma p$ differential in t, for $Q^2 = 4$ GeV^2 and $Q^2 = 8$ GeV^2. The inner error bars represent the statistical and the full error bars the quadratic sum of the statistical and systematic uncertainties.*

This paper presents measurements of DVCS cross sections performed by the H1 [2] and the ZEUS [3] experiments. The DVCS cross section has been measured differentially in t by the H1 collaboration for two different values of the photon virtuality Q^2 as shown in Fig. 2. The observed fast decrease with $|t|$ can be described by the form $e^{-b|t|}$. Combining data from both Q^2 range, the $|t|$ slope is measured to be $b = 6.02 \pm 0.35(\text{stat.}) \pm 0.39(\text{syst.})$ GeV^{-2} at $Q^2 = 8$ GeV^2 and $W = 82$ GeV. The measurement constrains models as their normalisation depends directly on the t slope parameter.

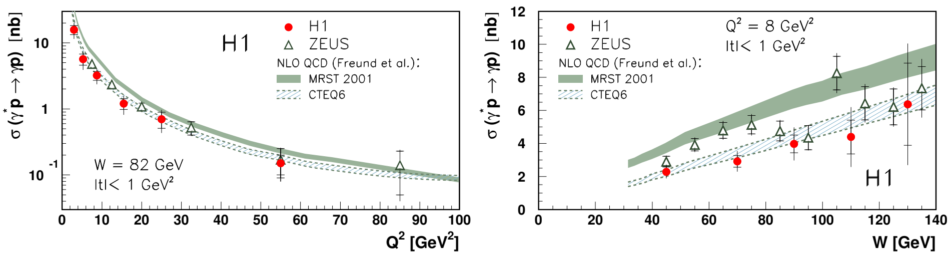

Fig. 3. *The $\gamma^* p \to \gamma p$ cross section as a function of Q^2 for $W = 82$ GeV (left) and as a function of W for $Q^2 = 8$ GeV^2 (right). The H1 measurement is shown together with the results of ZEUS and NLO QCD predictions based on MRST 2001 and CTEQ6 PDFs. The band associated with each prediction corresponds to the uncertainty on the measured t-slope.*

The $\gamma^* p \longrightarrow \gamma p$ cross section is presented in Fig. 3 as a function of Q^2 and the photon-proton centre-of-mass energy W. The W dependence can be parametrised as $\sigma \propto W^\delta$ yielding $\delta = 0.77 \pm 0.23 \pm 0.19$ at $Q^2 = 8$ GeV^2, which is similar to J/Ψ production [5] indicating a hard scattering process. Fig. 3 also compares the measurements with the NLO QCD predictions [1] where the PDFs of MRST2001 and CTEQ6 are used as input for the GPDs. The theoretical estimates agree well with the data both in shape and absolute normalisation. Reducing further the experimental errors will set constraints on different GPDs models.

2. Prompt Photon Production

Prompt photons in the final state of high energy collisions (Fig. 1b and 1c) provide a detailed study of perturbative QCD. The term "prompt" refers to photons which are radiated directly from partons of the hard interaction, instead of stemming from the decay of hadrons or from QED radiation from the electrons. In contrast to jets, prompt photons are not affected by hadronisation resulting in the reduction of this theoretical uncertainty. The main experimental difficulty is the separation of the prompt photons from hadronic background, in particular from signals due to π^0 mesons. Separation is performed on basis of properties of the energy deposit structure in the calorimeters of the H1 and ZEUS experiments.

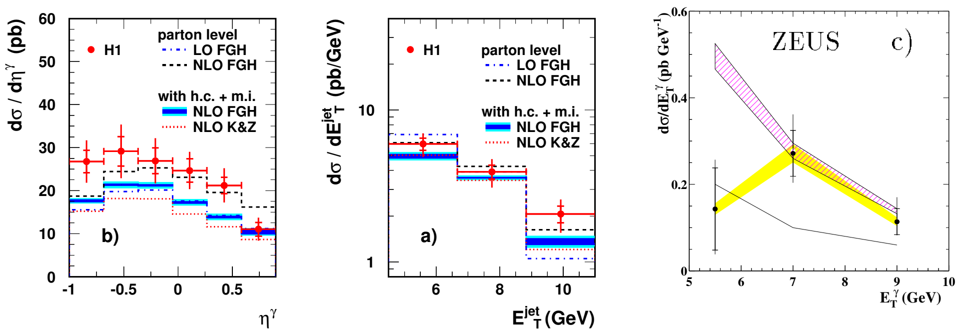

Fig. 4. Prompt photon differential cross sections. a) in inclusive photoproduction, b) in photoproduction with a jet, c) in DIS with a jet - the hatched band represents the NLO QCD prediction and the solid line the contribution from QED radiation.

Fig. 4a shows the differential inclusive prompt photon cross section as a function of the photon pseudorapidity η^γ in the photoproduction regime ($Q^2 < 1$ GeV^2 and $142 < W < 266$ GeV) as measured by H1 [6]. Similar results have been obtained by the ZEUS experiments [7]. The data are compared to NLO perturbative QCD calculations by Fontannaz, Guillet and Heinrich (FGH) [8] and by Krawczyk and Zembrzuski (K&Z) [9] which both provide a good description in shape but are 20-30% lower. The cross section for prompt photons when an additional jet with $E_T^{jet} > 4.5$ GeV and $-1 < \eta_{jet} < 2.3$ is required is shown on Fig. 4b as a function of the jet transverse energy E_T^{jet}. Both NLO perturbative QCD calculations [10, 11] provide a good description of the data in shape and normalisation.

The inclusive prompt photon cross section in DIS ($Q^2 > 35$ GeV^2) with a jet ($E_T^{jet} > 6$ GeV and $-1.5 < \eta_{jet} < 1.8$) as measured by the

ZEUS collaboration [12] is shown in Fig. 4c versus the prompt photon transverse energy E_T^γ. The data are compared to a NLO QCD calculation [13] which includes QED radiative corrections on the electron lines and a good description is obtained except at low E_T^γ and in the more forward (outgoing proton beam) direction. Without QED radiative corrections, the NLO QCD calculation would undershoot the data.

The HERWIG and PYTHIA Monte Carlo predictions undershoot the data both in photoproduction and DIS cases, see [6, 12] for more details.

REFERENCES

[1] A. Freund, M.F. McDermott and M. Strikman, Phys. Rev. D **67** (2003) 036001 [hep-ph/0208160].

[2] C. Adloff *et al.* [H1 Collaboration], Phys. Lett. B **517** (2001) 47 [hep-ex/0107005].

[3] S.Chekanov *et al.* [ZEUS collaboration], Phys. Lett. B **573** (2003) 46-62 [hep-ex/0305028].

[4] A. Aktas *et al.* [H1 Collaboration], DESY 05-065, accepted by Eur. Phys. J.C, [hep-ex/0505061].

[5] C. Adloff *et al.* [H1 Collaboration], Phys. Lett. B **483** (2000) 23 [arXiv:hep-ex/0003020].

[6] A. Aktas *et al.* [H1 Collaboration], Eur. Phys. J. C **38** (2005) 437-445, [hep-ex/0407018].

[7] J. Breitweg *et al.* [ZEUS Collaboration], Phys. Lett. B **472** (2000) 175 [hep-ex/9910045].

[8] M. Fontannaz, J. P. Guillet and G. Heinrich, Eur. Phys. J. C **21** (2001) 303 [hep-ph/0105121].

[9] M. Krawczyk and A. Zembrzuski, Phys. Rev. D **64** (2001) 114017 [hep-ph/0105166].

[10] M. Fontannaz, J. P. Guillet and G. Heinrich, Eur. Phys. J. C **22** (2001) 303 [hep-ph/0107262].

[11] A. Zembrzuski and M. Krawczyk, hep-ph/0309308.

[12] S. Chekanov *et al.* [ZEUS Collaboration], Phys. Lett. B **595** (2004) 86 [hep-ex/0402019].

[13] A. Gehrmann-De Ridder, G. Kramer and H. Spiesberger, Nucl. Phys. B **578** (2000) 326 [hep-ph/0003082].

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