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DEEPLY VIRTUAL COMPTON SCATTERING AT HERA

LAURENT FAVART
On behalf of the H1 Collaboration
I.I.H.E., Université Libre de Bruxelles, Belgium
E-mail: lfavart@ulb.ac.be

The Deeply Virtual Compton Scattering (DVCS) $\gamma^* p \to \gamma p$ cross section has been measured with the H1 detector at HERA with an increased precision and in an extended kinematic domain: at photon virtualities $4 < Q^2 < 80$ GeV^2, and photon-proton c.m.s. energy $30 < W < 140$ GeV. The measurement is compared to NLO QCD calculations and to Colour Dipole model predictions.

1 Introduction

Deeply Virtual Compton Scattering (DVCS), sketched in Fig. 1a, consists of the hard diffractive scattering of a virtual photon off a proton. It contributes to the reaction $e^+p \to e^+\gamma p$ as the purely electromagnetic Bethe-Heitler (BH) process (Figs. 1b and c) and the interference between the two processes.

The interest of the DVCS process resides in the particular insight it gives to the applicability of perturbative Quantum Chromo Dynamics (QCD) in the field of diffractive interactions. In the presence of a hard scale, the DVCS scattering amplitude factorises into a hard scattering part calculable in perturbative QCD and parton distributions which contain the non-perturbative effects due to the proton structure. The DVCS process is similar to diffractive vector meson electroproduction but with a real photon replacing the final state vector meson. It avoids the theoretical complications and uncertainties associated with the unknown vector meson wave function. However, even at photon virtualities Q^2 values above a few GeV^2, non perturbative effects can still take place. The wide kinematic range in the photon virtuality, Q^2, accessible at HERA, provides a powerful probe for the interplay between the perturbative and non-perturbative regimes in QCD. Furthermore the DVCS process gives access to the Generalised Parton Distributions (GPD) which are generalisation and unification of the familiar parton distributions and form factors, and also includes parton momentum correlations.

At high energy, first cross section measurements of the DVCS process were published by H1 [1] and ZEUS [2]. Here, the new H1 measurement is reported, in an extended kinematic range: $4 < Q^2 < 80$ GeV^2, $30 < W < 140$ GeV and $|t| < 1$ GeV^2, where t is the squared 4 momentum transfer between the incoming and the scattered protons. The analysis relies on the integrated luminosity of 26 pb^{-1} of data taken during the year 2000 (i.e. 3.5 times larger than the previously published by H1 [1]). More details on the present analysis can be found in [3].

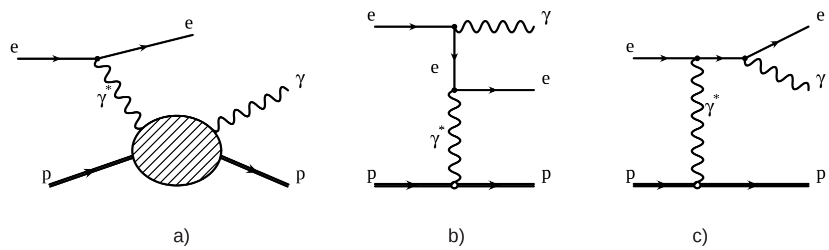

Figure 1. *The DVCS (a) and the Bethe-Heitler (b and c) processes.*

2 Analysis strategy

At these small values of t the reaction $ep \to e\gamma p$ is dominated by the purely electromagnetic BH process whose cross section, depending only on QED calculations and proton elastic form factors, is precisely known and therefore can be subtracted. To enhance the ratio of selected DVCS events to BH events the outgoing photon is selected in the forward, or outgoing proton, region with transverse momentum larger than 2 GeV. Large values of the incoming photon virtuality Q^2 are selected by detecting the scattered electron in the SPACAL calorimeter with energy larger than 15 GeV. The outgoing proton escapes down the beam-pipe in the forward direction. In order to reject inelastic and proton dissociation events, no further cluster in the calorimeters with energy above noise level is allowed and an absence of activity in forward detectors is required.

Nevertheless an important contamination subsists from the DVCS process with proton dissociation: $e^+ + p \to e^+ + \gamma + Y$, when the decay products of the baryonic system Y are not detected in the forward detectors. This typically occurs for Y systems with masses below 1.6 GeV. The sum of DVCS and BH contributions, in which the proton does not survive intact, has been estimated to be $11 \pm 6\,\%$ of the final sample. This uncertainty constitutes the main systematic error on the measurement, with the 7% uncertainty due to acceptance and bin center corrections.

3 Results

The $\gamma^* p$ cross section for the DVCS process is shown in Fig. 2 as a function of Q^2 for $W = 82$ GeV, and in Fig. 3 as a function of W for $Q^2 = 8$ GeV^2. In the upper plot of Fig. 2 the measurement is compared to the NLO QCD prediction [4,5] using two different GPD parametrisations [6]. The t dependence is parametrised as $e^{-b|t|}$, with $b = b_0(1 - 0.15 \log(Q^2/2))$ GeV^{-2}. The classic PDF $q(x, \mu^2)$ of MRST2001 and CTEQ6 are used in the DGLAP region ($x > \xi$) such that $\mathcal{H}$, which is the only important GPD at small x is given at the scale μ by: $\mathcal{H}^q(x, \xi, t; \mu^2) = q(x; \mu^2)\, e^{-b|t|}$ for quark singlet and $\mathcal{H}^g(x, \xi, t; \mu^2) = x\ g(x; \mu^2)\, e^{-b|t|}$ for gluons, i.e. independent of the skewing parameter ξ. Keeping this parametrisation in the ERBL region ($|x| < \xi$) would lead to a prediction overshooting the data by a factor 4-5. Therefore, a parametrisation is proposed by the authors to suppress the region of very

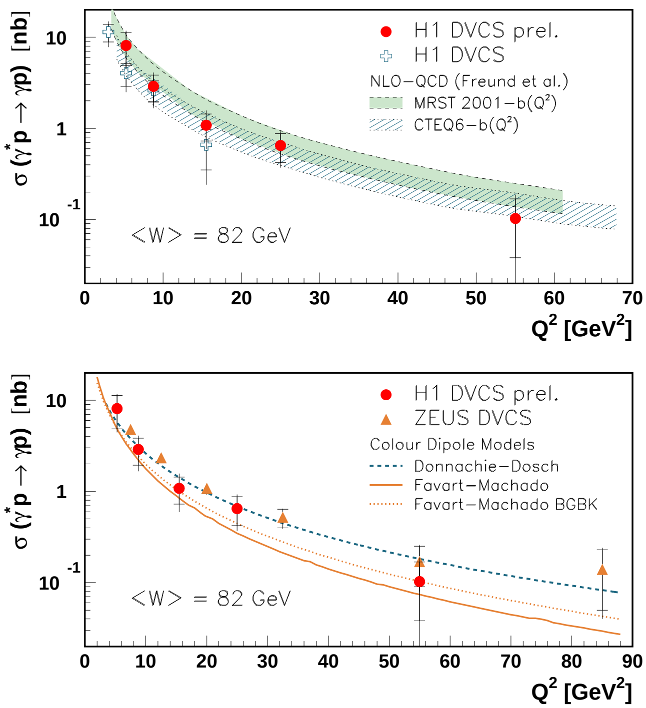

Figure 2. $\gamma^* p \to \gamma p$ cross section as a function of Q^2 for $< W >= 82$ GeV. The inner error bars are statistical and the full error bars include the systematic errors added in quadrature. The measurement is compared (upper plot) to the NLO QCD prediction [4,5] using GPD parametrisations based on MRST2001 and CTEQ6 [6] The bands correspond to b_0 values between 5 and 9 GeV^{-2}. On the lower plot, the measurement is compared to two different Colour Dipole models predictions, by Donnachie and Dosch [8] and by Favart, Machado [7] at the fixed value $b = 7$ GeV^{-2}. The BGBK notation indicates the additional DGLAP evolution of the dipole cross section added to the basic prediction.

small x (for details see [6]). This emphasises the interesting sensitivity to the ERBL region. The NLO QCD predictions are in good agreement with the data, for both GPD parametrisations. Since the main difference between the two parametrisations resulting in the normalisation, it emphasizes the need for a direct t dependence measurement.

In the lower plots of Fig. 2 the measurement is compared to two different Colour Dipole models predictions, by Donnachie and Dosch [8] and by Favart and Machado [7]. They are based on a factorisation into the incoming photon wave function, a $q\bar{q}$-p cross section and the outgoing photon wave function. The models differ in the way the quark dipole cross section is parametrised. Donnachie and Dosch [8] basically connect a soft Pomeron with large dipole size and a hard Pomeron with small dipole size. Favart and Machado [7] apply the saturation model of Golec-Biernat et al. [9] to the DVCS process, with a possible DGLAP evolution [10,11] quoted BGBK on the plot. In both cases an exponential t-dependence, $e^{-b|t|}$, is

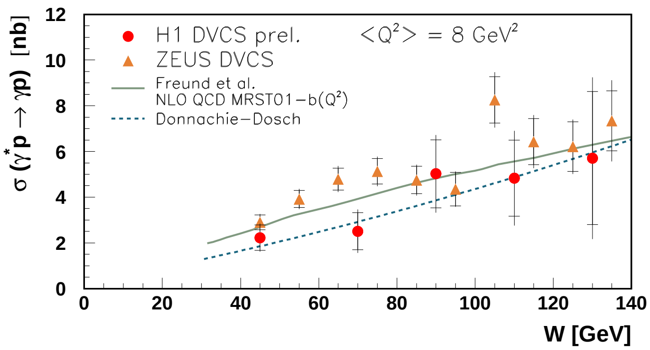

Figure 3. $\gamma^* p \rightarrow \gamma p$ cross section as a function of W for $< Q^2 >= 8$ GeV^2. The measurement is compared to the NLO QCD prediction [4,5] using GPD parametrisation based on MRST2001 [6] and to the Colour Dipole models prediction of Donnachie and Dosch [8].

assumed. All presented Colour Dipole model predictions describe well the data in shape and in normalisation for the same value of $b = 7$ GeV^{-2}.

The new measurement is also compared to the previous measurement by H1 [1] and to the ZEUS measurement [2]. The two H1 measurements are in good agreement. The new H1 measurement is in fair agreement with ZEUS results except for $W \sim 70$ GeV, where H1 points are lower by about two standard deviations.

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