DEEPLY VIRTUAL COMPTON SCATTERING AT HERA

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Results on Deeply Virtual Compton Scattering at HERA measured by the H1 and ZEUS Collaborations are presented. The cross section, measured for the first time, is reported for $Q^2 > 2\,\mathrm{GeV}^2$.

1 Introduction

Along these last years, the exclusive vector meson production (as ρ and J/Ψ) has been studied extensively at HERA and has provided very interesting results, in particular, testing for the domain of applicability and the relevance of perturbative QCD in the field of diffraction (see e.g.[1,2]). Here, we report the first analyses of a similar process, the Deeply Virtual Compton Scattering, consisting in the hard diffractive scattering of a virtual photon off a proton (Fig. 1). The DVCS process offers a new and comparatively clean way to study diffraction at HERA. In comparison to vector meson production it avoids large uncertainties on the theoretical predictions due to the meson wave-function. The largest interest comes from the access it gives to the skewed parton distributions of the proton[3].

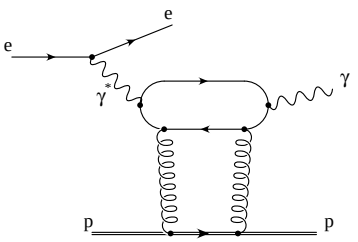

Figure 1. DVCS process.

The DVCS process contributes to the reaction $e^+p \to e^+\gamma p$, whose total cross section is dominated by the purely electromagnetic Bethe–Heitler process (Fig. 2).

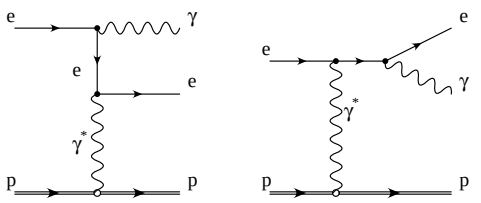

Figure 2. Bethe–Heitler process.

Since the virtual photon is scattered onto mass shell in the final state it is necessary to transfer longitudinal momentum from the photon to the proton, i.e. forcing a nonforward kinematic situation[3,4]. In the picture of the two gluon exchange the fractional momentum of the gluons are therefore not equal, which implies the involvement of the skewed (or nonforward) parton distribution.

In presence of a hard scale the DVCS process can be completely calculated in perturbative QCD. In the present case, the photon virtuality Q^2, above a few GeV^2, insures the presence of a hard scale. LO QCD calculations exist, based on the two gluon exchange model[5]. The factorization theorem in perturbative QCD having been demonstrated[4,6], the DVCS process provides a unique way to extract these distributions from experimental data through the measurement of the asymmetry of the photon azimuthal angle distribution due to the interference with the Bethe–Heitler process[7].

From an experimental point of view, HERA kinematic enables the DVCS process to be studied in a large range in Q^2, W and t and offers the possibility to study this diffractive mechanism in detail.

2 Analysis strategy

Around the interaction region both experiments, H1 and ZEUS, are equipped with tracking devices which are surrounded by calorimeters. Since the proton escapes the main detector through the beam pipe only the scattered electron and photon are measured. Therefore the event selection is based on demanding two electromagnetic clusters, one in the backward and one in the central or forward part of the detector ($\theta \lesssim 140^o$ - the backward direction ($\theta = 0$) is defined as the direction of the incoming electron). If a track can be reconstructed it has to be associated to one of the clusters and determines the electron candidate. To enhance the DVCS contribution in comparison to the Bethe–Heitler process the phase space has to be restricted by demanding the photon candidate in the forward part of the detector.

The H1 analysis selects more specifically the elastic component by using, in addition, detectors which are placed close to the beam pipe and which are used to identify particles originating from proton dissociation processes.

3 Results

3.1 ZEUS

The first observation of the DVCS process was reported by the ZEUS collaboration in 1999[8]. In the analysis a photon virtuality $Q^2 > 6\,\mathrm{GeV}^2$ is demanded. In Fig. 3 the polar angular distribution of the photon candidates is shown. A clear signal above the expectations for the Bethe–Heitler process is observed. The LO calculation including the DVCS and the Bethe–Heitler processes achives a good description of the experimental data. A clear DVCS signal is still seen after the photon energy cut is increased. Also a shower shape analysis of the calorimetric clusters was performed that shows that the signal originates from photons and not from π^0 background.

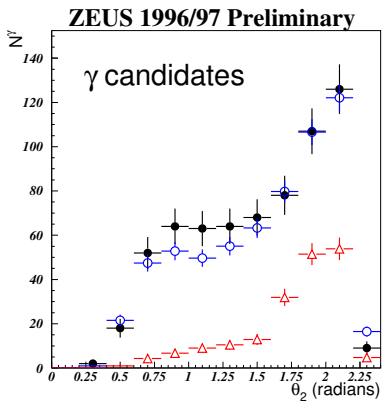

Figure 3. Distribution (uncorrected) of the polar angle of the photon candidate with an energy above 2 GeV. Data correspond to the full circles. The prediction for the Bethe–Heitler process is indicated by the open triangles. The prediction of Frankfurt et al. based on calculations including the Bethe–Heitler and the DVCS process is shown by the open circles.

3.2 H1

In the H1 analysis, the DVCS cross section is measured in the kinematic region: $2 < Q^2 < 20\,\mathrm{GeV}^2$, $|t| < 1\,\mathrm{GeV}^2$ and $30 < W < 120\,\mathrm{GeV}$. The proton dissociation background has been estimated at around 10% and subtracted statistically assuming the same W and Q^2 dependence as for the elastic component. The acceptance, initial state radiation of real photons and detector effects have been estimated by MC to extract the elastic cross section.

In Fig. 4 the differential cross sections as a function of Q^2 and of W are shown. The data are compared with the Bethe–Heitler

prediction alone and with the full calculation including Bethe–Heitler and DVCS. The description of the data by the calculations is good, in shape and in absolute normalization when a t slope is chosen between 7 and 10 GeV^{-2}.

It is important to notice that, at the LO, the interference term cancels when integrating over the azimuthal angle of the final state photon (as in the differential cross sections in Q^2 and of W).

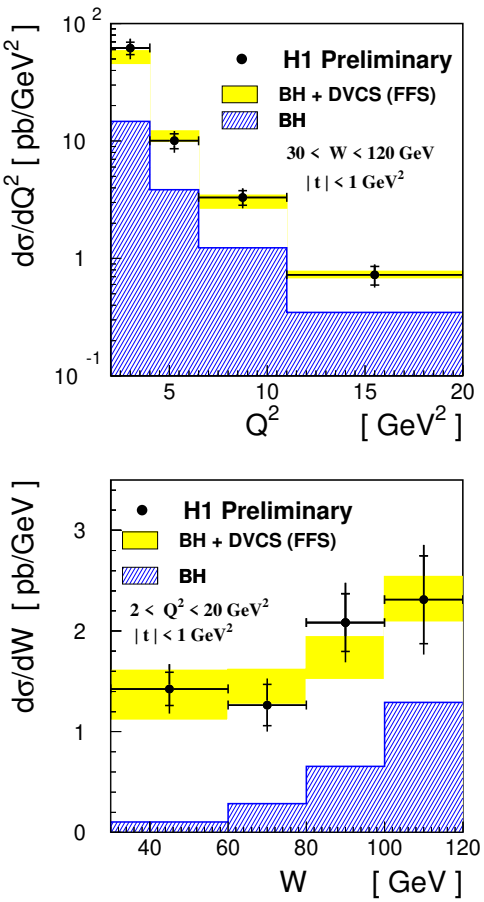

Figure 4. The measured cross sections of the reaction $e^+p \to e^+\gamma p$ as a function of Q^2 and W are shown and compared to theoretical predictions. The uncertainty in the theoretical prediction, shown here as a shaded band is dominated by the unknown slope of the t-dependence of the DVCS part of the cross section, assuming $7 < b < 10\,\mathrm{GeV}^{-2}$

4 Conclusion

The DVCS process has been observed by the H1 and ZEUS Collaborations. Cross section measurements have been presented for the first time. The experimental results are well described by the calculations of Frankfurt et al.

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