Measurement of the proton structure function F_2 at low Q^2 in QED Compton scattering at HERA

Ewelina Maria Łobodzińska

DESY, Zeuthen Germany and INP, Cracow Poland

Abstract. The proton structure function F_2 is measured using inelastic QED Compton events. The data were collected by H1 experiment at the HERA in 1997 and correspond to a luminosity of 9.25 pb^{-1}. QED Compton events allow to access very low Q^2 region, down to 0.5 GeV^2 and Bjorken x up to ~ 0.06, a region that has not been covered by previous inclusive measurements at HERA. The results are in agreement with measurements from fixed targed lepton-nucleon scattering experiments.

Keywords: proton structure function F_2, inelastic QED Compton, low Q^2, medium x, low y, H1, HERA, ep scattering
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INTRODUCTION

Radiative processes in ep scattering - depicted in Fig.1 - are of special interest, since the photon emission from the lepton line gives rise to event kinematics which open new ways of investigating proton structure . In the present analysis [1] the QED Compton (QEDC) process is considered, which is characterised by low viruality of the exchanged photon and high virtuality of the exchanged electron. To account for the additional photon in the final state the standard kinematic variables x and Q^2 have to be redefined:

$$Q^2 = -q^2 = -(l - l' - k)^2, \qquad x = \frac{Q^2}{2P \cdot (l - l' - k)},$$

where k,l,l' represent the four-momenta of the radiated photon, incoming and outgoing electron, respectively.

In this analysis inelastic QEDC events were used. For these events the proton breaks up, so the $\gamma^* p$ cross section is defined through the proton structure functions F_2 and F_L. In the kinematical range studied in this analysis (low y region) the contribution from F_L can be neglected, such that the cross section is proportional to F_2.

QEDC EVENT SIMULATION

In order to investigate inelastic QEDC events an improved version of the COMPTON generator was developed [2]. For the simulation of the hadronic final state, the SOPHIA program [3] was used in the range of low Q^2 ($Q^2 < 2$ GeV^2) or low masses W ($W <$ 5 GeV). The SOPHIA model provides an accurate description of photon-hadron interactions reproducing large sets of available data. The simulation includes the production

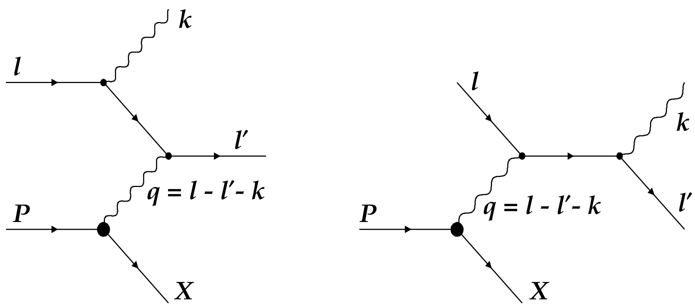

FIGURE 1. Lowest order Feynman diagrams for the radiative process $ep \to e\gamma X$ with photon emission from the electron line. The four-momenta of incoming electron and proton, outgoing electron, photon and hadronic final state are represented by l, P, l', k and X respectively.

of the major baryon resonances, direct pion production, multiparticle production based on the Dual Parton Model with subsequent Lund string fragmentation, as well as the diffractive production of the light vector mesons ρ and ω.

BACKGROUND REJECTION

The dominant background to the QEDC process arises from inclusive DIS events in which one particle from the hadronic final state (typically a π^0) fakes the outgoing photon. At high y, where the hadronic final state lies mostly in the backward region, this process is hampering a clean QEDC event selection. Therefore, the analysis had to be constrained to the low y values. Remaining background coming from this source is modelled using an inclusive DIS Monte Carlo simulation. Another source of significant background comes from the inelastic Deeply Virtual Compton Scattering (DVCS) events, in which the final state photon is diffractively produced in the virtual photon proton collision. This source of background is estimated to contribute 5.5% to the measured cross section. Elastic QEDC and DVCS events may also contribute to the measured cross section if the noise in the calorimeter is missidentified as hadronic activity. This source of background contributes 0-2% to the measured signal. Other background sources are even less significant [1].

EVENT SELECTION

To select QEDC events, two energetic clusters in the backward electromagnetic calorimeter are required. The sum of both energies must be close to the electron beam energy and the azimuthal angle between both clusters is supposed to be close to π. In addition, a well reconstructed interaction vertex is required. In order to remove elastic events at least one particle from the hadronic final state has to be detected in the calorimeter.

As mentioned above, to suppress the DIS background, the analysis is constrained to the low y region. The additional suppression of the DIS, photoproduction and dielectron

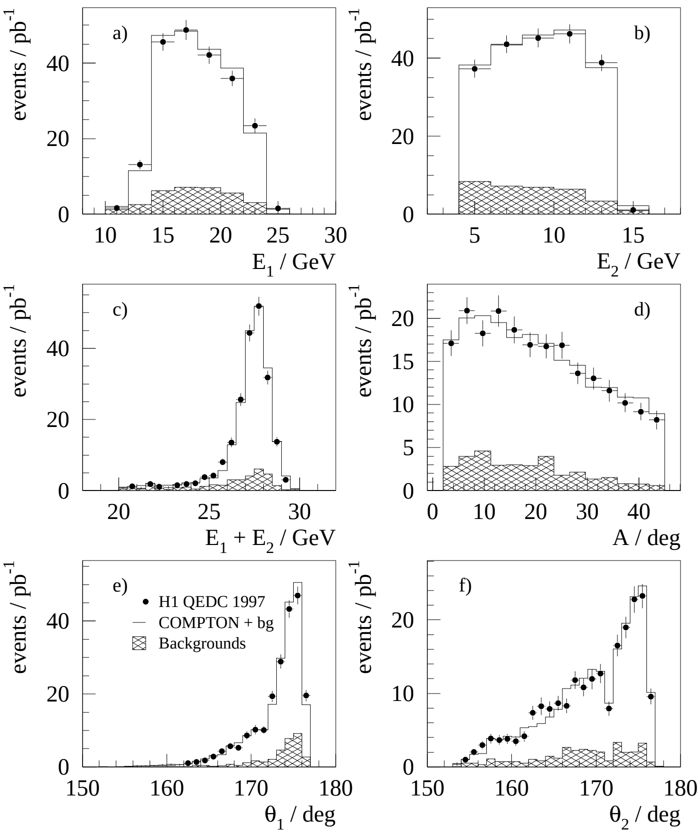

FIGURE 2. Control distributions for the measured electron and photon final state: a.) energy of the particle with the higher energy; b.) energy of the particle with the lower energy; c.) sum of both energies; d.) $e\gamma$ acoplanarity; e.) polar angle of the particle with the higher energy and f.) polar angle of the particle with the lower energy.

background is performed by requiring the residual energy in the electromagnetic Spacal to be below 1 GeV. Furthermore, to separate electrons and photons from hadrons, cuts on the shower shape estimators are performed. The control distributions shown in Fig.2 illustrate the good description of the electron-photon final state provided by the simulation.

RESULTS

In order to extract the structure function F_2 the data sample is divided into subsamples corresponding to a grid in y and Q^2. The bin sizes are adapted to the resolution in the maesured kinematic quantities such that the stability and purity in all bins shown are greater than 30%. [1] The statistical errors lie in the range 6 - 10%, while the systematic

[1] Here, the stability (purity) is defined as the number of simulated QEDC events originating from and reconstructed in a specific bin to the number of generated (reconstructed) events in the same bin.

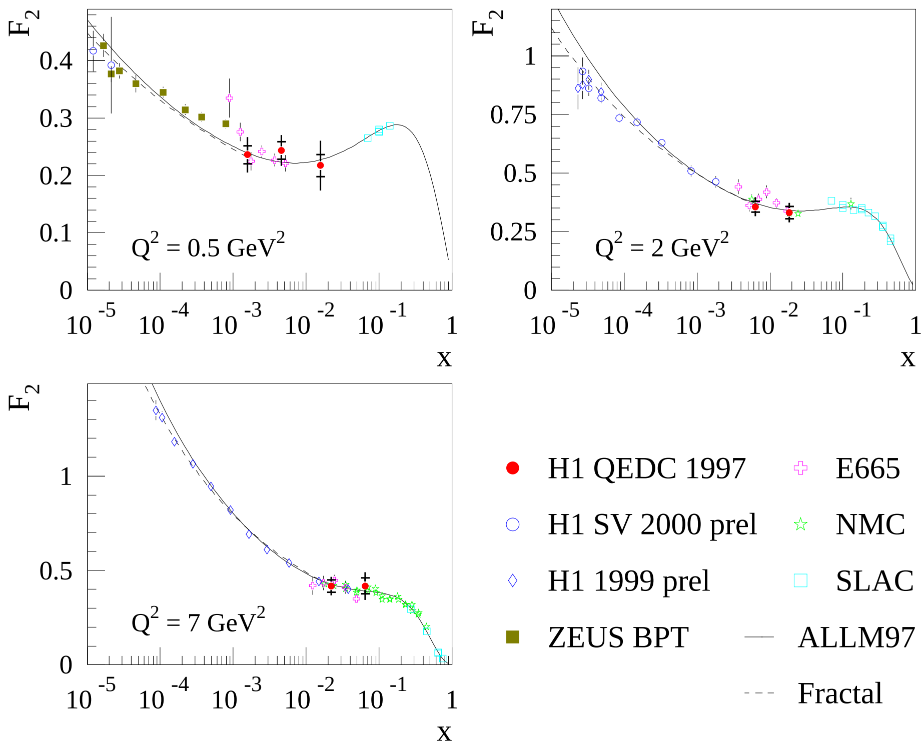

FIGURE 3. F_2 measurements from QED Compton scattering by H1 compared to other measurements at HERA and fixed targed experiments.

uncertainties are typically 9 - 12%, rising to 18% in the lowest y region. The total errors are obtained by adding the statistical and systematic uncertainties.

The F_2 values as measured with the QED Compton process are depicted in Fig.3 as a function of x for fixed Q^2 and compared to other HERA [4] and fixed targed data [5].

The present analysis extends the kinematic range of HERA measurements at low Q^2 towards higher x values, thus complementing standard inclusive and shifted vertex measurements. QEDC F_2 data are consistent with the results from fixed targed experiments.

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