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The Structure Function $F_2(x, Q^2)$ at Low Q^2 from Radiative Events at HERA

H1 Collaboration

Abstract

Using the 1994 data collected with the H1 detector, preliminary results of a measurement of the proton structure function $F_2(x, Q^2)$ have been determined for Q^2 values down to $1.5\,\mathrm{GeV}^2$ and $x > 10^{-4}$ using deep inelastic radiative events with hard photon emission collinear with the incident electron. Values of Q^2 are smaller than for non-radiative events because the center of mass energy is reduced. The results are compared with other measurement, model predictions, and a QCD extrapolation to the low Q^2 values of the previously measured structure function.

1 Introduction

One of the radiative processes being studied at HERA, the first machine of 27.6 GeV electrons/positrons colliding with 820 GeV protons, concerns deep inelastic events with hard photon emission collinear with the initial electron. These events can be interpreted as non-radiative events with reduced electron beam energy, and therefore allow us to extend the new kinematic domain opened by HERA to lower Q^2 values (at comparable x and W^2 values) than that of non-radiative events, where Q^2, x and W^2 are respectively the momentum transfer carried by the exchanged boson, the Bjorken variable, and the invariant mass of the hadronic final state squared.

A first experimental study of this process together with other hard photon radiative processes has been recently published[1] by the H1 collaboration using its 1993 data which were still limited for a quantitative measure of the proton structure function $F_2(x, Q^2)$. A tenfold increase of the integrated luminosity ($\int\mathcal{L} = 2.9\,\mathrm{pb}^{-1}$) in 1994 has made for the first time such a significant measurement possible for Q^2 values down to $1.5\,\mathrm{GeV}^2$.

2 Method

The analysis of the proton structure function $F_2(x, Q^2)$ using radiative events is similar to that for low Q^2 non-radiative events[2] concerning the scattered electrons, which are detected in the backward electromagnetic calorimeter. The additional requirement of a hard photon detected in the photon detector of the luminosity system makes this analysis different and challenging on the background subtraction and the kinematic reconstruction. In this analysis, two kinematic reconstruction methods have been used to cross check the results and control the different systematic effects. One is the electron method (e), which is based only on the energy and the angle of the scattered electrons. The other is the sigma method (Σ)[3] which uses information from both the electron and the hadronic final state. The relevant quantities needed in the two methods are shown in Fig.1 for data and Monte Carlo[1]. The two main cuts have been of 8 GeV on E_e and 4 GeV on E_γ, as it can be seen from the plots. The estimated background from the coincidental overlap of an elastic bremsstrahlung event either with a deep inelastic event[2] (both non-radiative and radiative, the shaded histogram) or with a photoproduction event (the hatched one) are also shown. Good agreement has been seen in all quantities shown except for $\sum_i(E^i - P_z^i)$, the sum over all particles detected in the whole detector. While the peak values agree, the resolution in data appears to be larger than in the simulation.

[1] Both radiative and non-radiative Monte Carlo events are generated using GRV parametrization[4]. For comparison with data, the Monte Carlo events have been reweighted according to the QCD extrapolation to the lower Q^2 values of the previously measured structure function[2].

[2] Events in the kinematic peak have been efficiently rejected by comparing the energy measured in the photon detector with the expected one derived from the kinematic quantities measured in the main detector[1].

3 Results

Preliminary results on the proton structure function $F_2(x, Q^2)$ have been determined for 6 Q^2 bins[3] from $1.5\,\mathrm{GeV}^2$ to $8.5\,\mathrm{GeV}^2$ and 5 or 4 x bins depending on the Q^2 value using the two kinematic methods, which are in good agreement (Fig.2). Detailed systematic studies have been made for many different sources ranging from the various detector measurement errors to the theoretical uncertainties for the longitudinal structure function $F_L(x, Q^2)$ and for the higher order correction to the radiative process. The detector measurement systematic errors are typically smaller than 7% while a conservative estime of the high order contribution may reach up to 10%. This contribution is absent in the Monte Carlo and will bring the measured F_2 values down if applied. The uncertainty due to the longitudinal structure function $F_L(x, Q^2)$ is generally small but can be as large as 10% at the lowest x points shown.

The $F_2(x, Q^2)$ measured in this analysis can be directly compared with the other independent measurement[5] from non-radiative events (the open squares) in the common x range, and they are in good agreement.

Fig.2 also contains the recent F_2 measurement[6] at high x values from E665 and NMC. Two observations are in order. First, the F_2 evolves nicely from high to low x values and F_2 is still rising at $Q^2 = 1.5\,\mathrm{GeV}^2$. Secondly, due to the reduced center of mass energy the F_2 measured in this analysis allow us to fill the gap between the HERA measurements from non-radiative events and that of fixed target experiments.

The data are further compared with a NLO QCD fit[7] (solid line) to the H1 data[2] and NMC, E665, and BCDMS proton data, and with predictions from the GRV[4](the dashed line), and the CKMT parametrization[8] (the dotted line).

4 Conclusion

The proton structure function $F_2(x, Q^2)$ have been measured for the first time from the hard photon radiative events from data taken by the H1 detector in 1994. This measurement has made it possible to further extend the new kinematic domain opened by HERA to lower Q^2 values ($1.5\,\mathrm{GeV}^2$) at comparable x and W^2 values and to fill the gap between the HERA measurements from non-radiative events and that of fixed target experiments.

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[3]The bin size is defined according to the kinematic resolution, statistical precision, and the background contribution (should be less than 30%).

References

[1] H1 Collab., T. Ahmed et al., Z. Phys. C66 (1995) 529

[2] H1 Collab., T. Ahmed et al., Nucl. Phys. B439 (1995) 471

[3] U. Bassler and G. Bernardi, DESY-94-231 (1994), submitted to Nucl. Instrum. Meth.

[4] M. Glück, E. Reya, and A. Vogt, DESY 94-206, to appear in Z. Phys. C

[5] H1 Collab., Contribution to Brussels

[6] Contributions from E665 and NMC to the 3rd Workshop on Deep Inelastic Scattering and QCD, Paris, April 1995

[7] H1 Collab., Presented by F. Zomer in the 3rd Workshop on Deep Inelastic Scattering and QCD, Paris, April 1995

[8] A. Capella et al., Phys. Lett. B337 (1994) 358

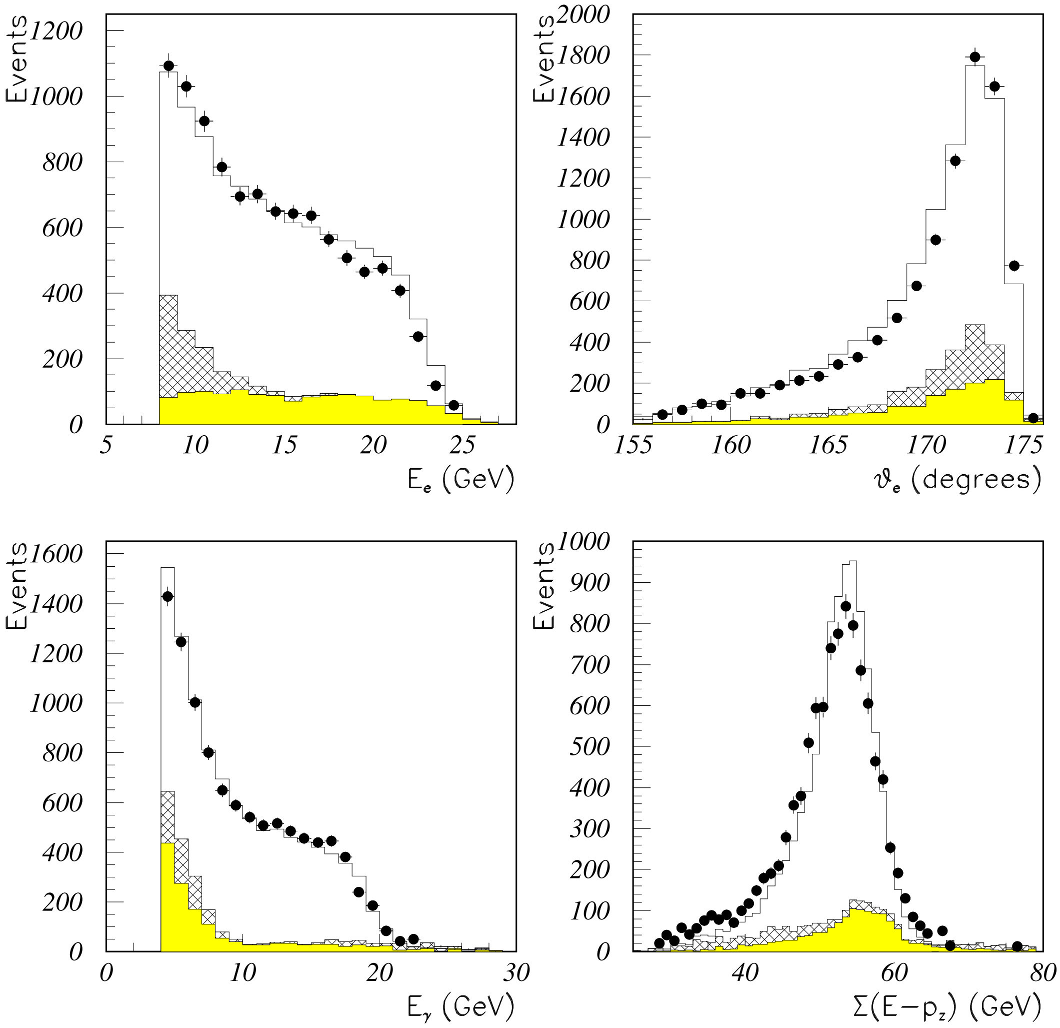

Figure 1: A comparison of the scattered electron energy (E_e) and angle (θ_e), the hard photon spectum (E_γ), and the sum of $E - p_z$ between data (the points) and Monte Carlos for hard radiative events (the top histogram) and background events from an elastic bremsstrahlung event superimposed either with a deep inelastic event (the shaded histogram) or with a photoproduction event (the hatched one).

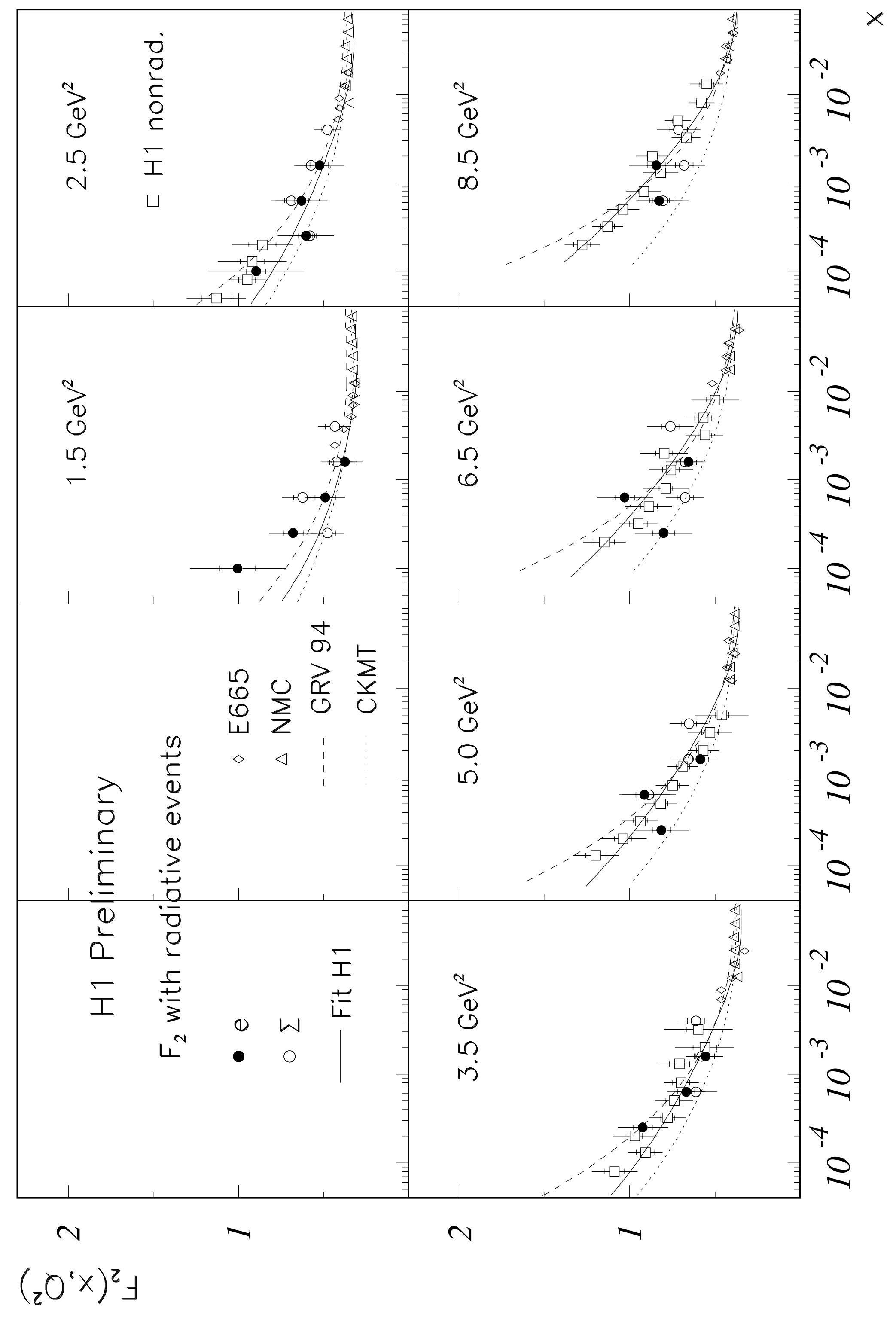

Figure 2: Preliminary $F_2(x,Q^2)$ results measured from the radiative events with the electron (e) and sigma (Σ) methods. The inner error bar is the statistical error. The full error bar represents the statistical and systematic errors added in quadrature, not including the systematic error of the luminosity measurement of 4.5%.