MEASUREMENT OF THE PROTON STRUCTURE FUNCTION $F_2(X, Q^2)$ USING RADIATIVE EVENTS AT HERA

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Deep-inelastic positron-proton scattering with initial state radiation is investigated using the H1 detector at HERA. The proton structure function F_2 is measured in the range $0.35 \leq Q^2 \leq 20$ GeV^2 and $2 \cdot 10^{-5} \leq x \leq 2 \cdot 10^{-2}$.

1 Introduction

This study [1] extends the kinematic range where F_2 is measured by H1 towards low values of Q^2 by making use of deep–inelastic scattering (DIS) events with a photon radiated collinear to the incident positron (ISR events). These events, which can be identified by detecting the radiated photon in a small angle calorimeter of the luminosity system, effectively have a lower initial positron beam energy and thus, for a given angular acceptance for the scattered positron, allow access to the low-Q^2 regime. The measurements cover a region, in which perturbative calculations are clearly valid ($Q^2 = 20$ GeV^2), to a phase space regime where only phenomenological models can describe the data ($Q^2 < 1$ GeV^2) due to the large influence of non-perturbative effects. The data thus contribute to the understanding of the transition between DIS and real photon interactions at $Q^2 \approx 0$.

2 Analysis strategy

The presented results are derived from data which were recorded with the H1 detector [2] during the 1997 data taking period and correspond to an integrated luminosity of 11.1 pb^{-1}. The analysis strategy is based on the detection of a photon with an energy E_γ above 8 GeV in the photon detector of the H1 luminosity system and the requirement of a positron signature in the backward calorimeter, SpaCal, with an energy $E_e > 5$ GeV. In addition, the selection demands a vertex within ± 35 cm at the nominal interaction point and requires that several constraints derived from momentum/energy conservation be satisfied in order to reduce background due to the overlap of Bethe-Heitler reactions ($ep \to e\gamma p$) with non-radiative events.

3 Results

The data presented are corrected for QED radiative effects in addition to the collinear photon radiation off the incident lepton [3,4,5]. These corrections take into account the contributions of those terms at $\mathcal{O}(\alpha)$ that involve leading and next-to-leading large logarithms. The calculations were adapted to the specific selection criteria of this analysis.

Systematic uncertainties were determined by studying the stability of the results to variations of the energy scales and the detector resolutions within their quoted accuracy. Variations of selection efficiencies, changes of the background normalization and modification of the theoretical input were considered. The dominant systematic errors come from the uncertainty on the vertex reconstruction efficiency ($\pm 4\%$ to 5%) and uncertainties associated with the probability of overlap of Bethe-Heitler and ISR events. Both result in an uncertainity of 5% on the F_2 measurement. The hadronic energy scale uncertainty effects F_2 by about 4%. The uncertainties of the positron energy scale, the photon energy scale and the photon detector energy resolution result in systematic error contributions of 3% on F_2.

The preliminary results of the measurement are given in Figure 1 which shows F_2 in bins of x and Q^2 for $2 \cdot 10^{-5} \leq x \leq 2 \cdot 10^{-2}$ and $0.35 \leq Q^2 \leq 20$ GeV^2. The data points are compared to predictions from the ALLM97 [6] parameterization and the most recent H1 QCD-fit to H1 and BCDMS non-radiative F_2 data [7] with $Q^2 > 3.5$ GeV^2. At larger Q^2, the data are well described by the pQCD based H1 parameterization, thus illustrating the good agreement of this new measurement with the most recent H1 precision F_2 results. For Q^2 values below 1 GeV^2 perturbative QCD, however, fails and only non-perturbative models like those which incorporate Regge phenomenology, as done in the ALLM97 parameterization, can describe the measurement.

4 Conclusion

Deep-inelastic scattering data with initial state photon radiation are used to extract the proton structure function F_2 for four-momentum transfers $0.35 \leq Q^2 \leq 20$ GeV^2 and Bjorken-x values of $2 \cdot 10^{-5} \leq x \leq 2 \cdot 10^{-2}$. Based on a single coherent data set the results provide a link between the deep-inelastic scattering (DIS) regime and photoproduction and aid the development of an understanding of the transition from regions where pQCD calculations hold into the domain in which non-perturbative effects dominate. The data are in agreement with previous structure function measurements performed at HERA and with predictions based on a phenomenological approach to the

transition region between DIS and photoproduction.

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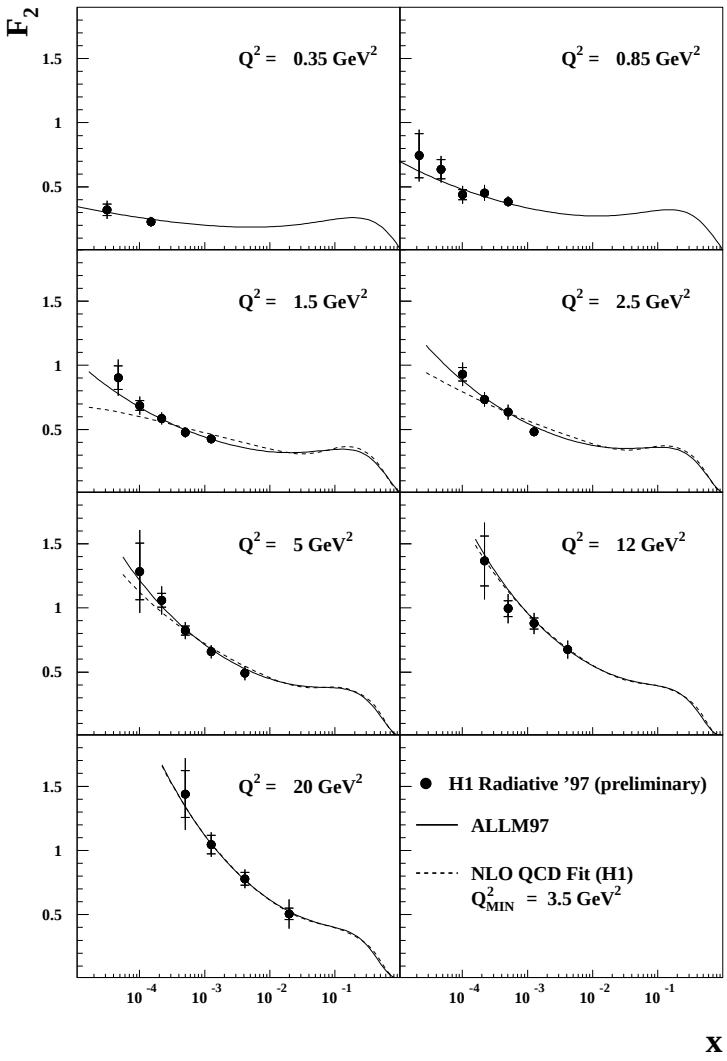

Figure 1. The structure function F_2 as determined from ISR events as a function of x for fixed values of Q^2. The inner error bars represent the statistical and the outer error bars the total uncertainty of the measurement. The data are compared to the ALLM97 (solid curve) parameterization and the most recent H1 NLO QCD fit (dashed curve) to non-radiative F_2 data starting at $Q^2_{\rm MIN} = 3.5$ GeV^2