Available online at www.sciencedirect.com

SciVerse ScienceDirect

Nuclear Physics B (Proc. Suppl.) 233 (2012) 253–258

NUCLEAR PHYSICS B PROCEEDINGS SUPPLEMENTS

www.elsevier.com/locate/npbps

Precision Tests of QCD at HERA

Martin Brinkmann, on behalf of the H1 and ZEUS collaborations

Deutsches Elektronen-Synchroton (DESY),
Notkestrasse 85, 22607 Hamburg, Germany

Abstract

The study of inclusive deep inelastic scattering (DIS) and jet production processes in electron-proton scattering at HERA allows precision tests of QCD and to constrain the parton density functions (PDF) of the proton which are of particular importance for the measurements at the LHC. A selection of new measurements of structure functions and hadronic final state observables by the H1 and ZEUS collaborations is presented. Recent results on PDF fits (HERAPDF) using the inclusive DIS and jet data from both experiments are shown.

Keywords: HERA, structure functions, DIS, jets

1. Introduction

The HERA accelerator at DESY in Hamburg was operated with 27.5 GeV electrons and 920 GeV protons colliding at a centre of mass energy of $\sqrt{s} = 318$ GeV. The two multipurpose 4π detectors H1 and ZEUS were build surrounding the two collision points. There were two running periods: the HERAI period from 1992-2000 delivering an integrated luminosity L of $L \sim 120\,\mathrm{pb}^{-1}$ and after a luminosity upgrade the HERAII period from 2003-2007 with $L \sim 380\,\mathrm{pb}^{-1}$. At the end of the HERAII running period low energy runs were performed ($L \sim 20\,\mathrm{pb}^{-1}$) with proton beam energies of 460 GeV and 575 GeV.

The electron proton scattering can be described in lowest order via the exchange of a electro weak gauge boson between the electron and a parton from the proton. The most important kinematic variables are the boson virtuality Q^2 and the Bjorken variable x which denotes in the quark parton model the fraction of the proton momentum carried by the parton scattered off. The measurements at HERA are made in two kinematic regions. In the photoproduction regime (γp) the photon virtuality is small, $Q^2 \approx 0\,\mathrm{GeV}^2$, whereas deep inelastic scattering (DIS) is characterized by $Q^2 > 1\,\mathrm{GeV}^2$.

For the description of the measurements presented here the QCD factorisation theorem holds which allows the production cross section to be written as the convolution of the parton distribution functions (PDFs) and the hard scattering matrix element. The hard scattering part can be treated with perturbative QCD (pQCD) in the presence of a hard scale. Important processes at leading order of the strong coupling constant α_s are boson gluon fusion in which a quark-antiquark pair is created and QCD compton scattering where a quark from the proton is scattered off and radiates a gluon. These processes are enriched in jet samples compared to inclusive DIS. Therefore jet measurements provide direct sensitivity to the gluon density in the proton and to α_s.

Inclusive and jet measurements provide a good testing ground for perturbative QCD and constrain the PDF. The PDFs measured at HERA can also be used to calculate predictions for the pp collisions at the LHC where instead of the electron a parton from the other proton enters the hard process. The HERA data cover the x range of the LHC. The evolution of the PDFs to higher Q^2 is done via the DGLAP equations based on the work of Dokshitzer, Gribov, Lipatov, Altarelli and Parisi.

0920-5632/$ – see front matter
doi:10.1016/j.nuclphysbps.2012.12.086

2. Inclusive DIS

Inclusive neutral current (NC) DIS *ep* cross sections have been measured by H1 [1] covering a kinematic region of photon virtuality $Q^2 = 120 - 30000\,\mathrm{GeV}^2$. This brand-new measurement covers the full HERA data set. In Fig. 1 the reduced cross section is shown in bins of Q^2 for different values of x separately for e^+ and e^- data. A very high precision is achieved with a statistical accuracy of $1 - 3\%$ and a systematic uncertainty of about 1.5% for $Q^2 < 1000\,\mathrm{GeV}^2$. The cross sections are compared to predictions from the H1 NLO QCD fit (H1PDF2012) which describes the data well over this wide range of x, Q^2. ZEUS also provides a similar measurement [2]. The cross sections measured with a similar precision are well described by predictions from a HERA NLO QCD fit.

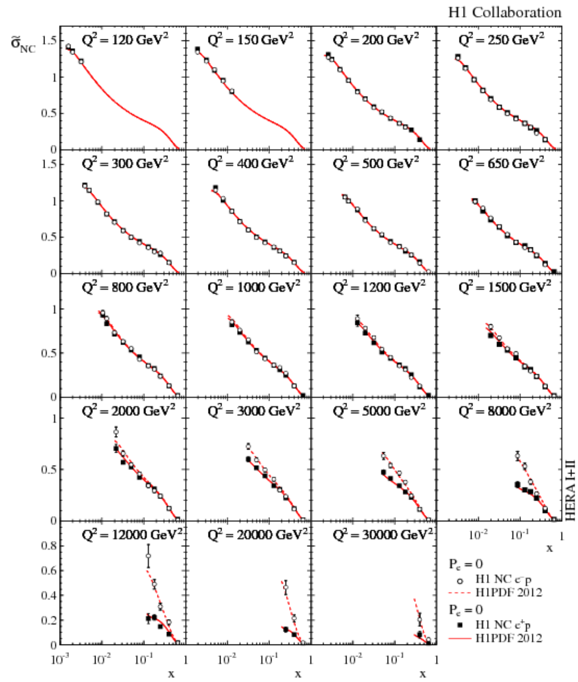

Figure 1: Reduced cross section in bins of Q^2 for different values of x for e^+ and e^- data measured by H1. The data are compared with NLO pQCD fit (H1PDF2012).

ZEUS performed an extension of the NC DIS measurement to higher values of x up to 1 [3] using a new reconstruction method for the kinematical variables. The data are in good agreement with standard model NLO predictions using different PDF sets. This analysis is expected to provide an important constraint on PDF at largest x.

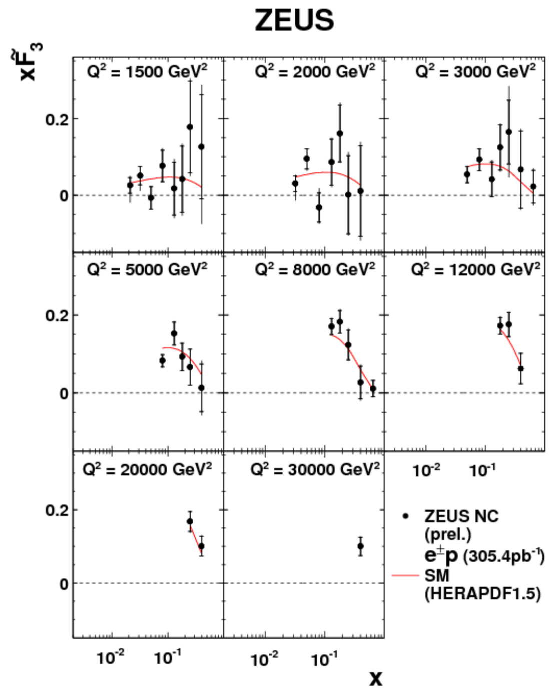

Figure 2: Measured xF_3 from NC DIS in bins of Q^2 for different values of x. The measured values (points) are compared to the standard model prediction from the HERAPDF1.5 fit.

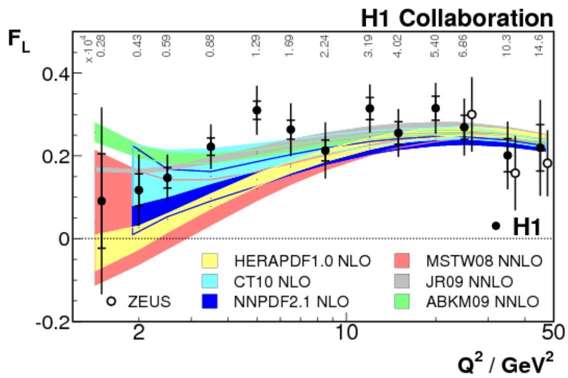

Figure 3: Measured F_L as a function of Q^2. Shown are the measurements from H1 (massive dots) and ZEUS (open points) and NLO (NNLO) pQCD predictions from different PDF groups.