The study of heavy contribution in diffractive parton distribution functions

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Abstract. In this paper we give a brief introduction to the description of QCD analysis in order to determine the diffractive parton distribution functions (DPDFs) at the next-to-leading order (NLO) approximation. We focus on key features of analysis for all available diffractive HERA data and outline challenges for considering heavy quark contributions within the framework of the fixed flavour number scheme (FFNS) which is in full agreement with the diffractive heavy quark experimental data.

1. Introduction

Diffraction process in high energy physics is very important to complete the understanding of strong interactions. This can give us a better understanding of the mechanisms of production and make the eventual corrections on the calculations. Significant progress has been made in understanding diffraction in terms of QCD by studying virtual photon dissociation in deep inelastic scattering (DIS) at HERA [1]. As well as being sensitive to novel features of parton dynamics in the high density, low x regime, diffractive DIS cross sections are used to extract DPDFs, an essential ingredient in predicting many diffractive processes at the LHC [2, 3].

We have previously extracted DPDFs from H1 2006 data [4] in Refs. [5, 6]. Here, we perform a global fit on all available HERA data [4, 7, 8, 9, 10, 11, 12]. We believe that the full HERA data sample analysis is a powerful technique to achieve the best precision possible in extracting DPDFs. In this paper, the extracted parton distributions from the current analysis have been used to predict heavy structure functions and the comparison of their predictions with experimental data are presented.

2. Theoretical background of the QCD analysis

Global fits to determine parton distributions [13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 5, 24, 25] use available data and the most up-to-date QCD calculations to best determine the parton distributions. Consequently, we consider all three methods of selecting observables at H1 and ZEUS to achieve the best result. At HERA, diffractive events were selected either by the detection of the final state proton (the Leading Proton Spectrometer, LPS, in the ZEUS case and the Forward Proton Spectrometer, FPS, in the H1 case) [7, 9, 11, 12] or on the basis of a
large rapidity gap between the system X and the outgoing proton (LRG method) [4, 11]. The diffractive contribution was also identified by the $M_X$ method [8, 10] based on the shape of the mass distribution of the system X. In order to keep the compatibility between all data sets, cross section measurements from FPS/LPS and $M_X$ methods are corrected to H1 LRG domain, by multiplying them with the appropriate global factors.

We summarize the key features of our QCD analysis here. In our calculation, we consider pomeron as an object with parton distribution function. These DPDFs are parametrized at a starting scale and are evolved to higher factorization scales using a numerical solution of the DGLAP evolution equations [26] in FFNS with three massless quarks and heavy charm treated as massive particles. In other word, the number of active (light) flavors $n_f$ appearing in the splitting functions and the corresponding Wilson coefficients will be fixed, $n_f=3$. Furthermore, the evaluation of the running strong coupling $\alpha_s(Q^2)$ requires to match $\alpha_s^{n_f}(m_h)$ at $Q=m_h$ ($m_c=1.41$ GeV, $m_b=4.50$ GeV, $m_t=175$ GeV), i.e. $\alpha_s^{n_f}(m_b) = \alpha_s^{n_f-1}(m_h)$. we have performed all $Q^2$-evolutions in Mellin n-moment space and used the QCD-PEGASUS program [27] for the NLO evolution.

Finally, we extract DPDFs from the global $\chi^2$ fit on all HERA diffractive DIS data obtained by various methods with very large uncertainties associated with the treatment of proton dissociation processes using the CERN subroutine MINUIT [28].

3. Open charm production in diffraction

The data from the HERA running period 1998-2000 were analyzed by both H1 [29] and ZEUS [30] collaborations. The charm quark was tagged by the reconstruction of $D^{\pm}(2010)$ meson in diffractive DIS and PHP regimes. H1 used also another method based on the measurement of the displacement of tracks from primary vertex to identify the $D^*$ production in the sample of DIS events only. In figures 1 and 2 we show our results for heavy diffractive cross section and

Figure 1. Comparison of our result for the contribution of the charm quarks to the diffractive cross section with H1 DPDF Fit A and Fit B [4] shown as a function of $\beta$ for two different values of $x_P$. The data are obtained from the H1 displaced track method and $D^*$ production in DIS [29]. The error bars of the data points represent the statistical and systematic error in quadrature.
Figure 2. Comparison of our result for the contribution of the charm quarks to the diffractive structure function with H1 DPDF Fit A and Fit B [4] shown as a function of $\beta$ for two different values of $x_{IP}$. The data are obtained from the ZEUS $D^*$ production in DIS [30]. The error bars of the data points represent the statistical and systematic error in quadrature.

Structure function together with H1 2006 DPDF [4] Fit A and Fit B and we compare them with H1 and ZEUS data.

4. Conclusion
In the present paper, all the most up-to-date data on diffractive deep inelastic scattering processes for the structure functions and reduced cross-section which allow us to be quite confident about the reliability of our predictions, have been analyzed in the standard parton model approach of perturbative QCD. Within large errors a good agreement is observed in figures 1 and 2, which supports the validity of QCD factorization in diffractive DIS.

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