PROCEEDINGS OF SCIENCE

Effect of low-Q^2 DIS data on fits to TMD parton distributions.

Sara Taheri Monfared[*]
School of Particles and Accelerators, Institute for Research in Fundamental Sciences (IPM),
P.O. Box 19395-5531, Tehran-Iran
Department of Physics, Faculty of Basic Science, Islamic Azad University Central Tehran
Branch (IAUCTB), P.O. Box 14676-86831, Tehran, Iran
E-mail: sara.taheri@ipm.ir

Hannes Jung
Deutsches Elektronen Synchrotron, D-22603 Hamburg
E-mail: hannes.jung@desy.de;

Francesco Hautmann
Dept. of Theoretical Physics, University of Oxford, Oxford OX1 3NP
E-mail: francesco.hautmann@physics.ox.ac.uk

A new parton-branching Monte Carlo method has been recently presented to solve the QCD DGLAP evolution equations. It has been used to construct both collinear and transverse momentum dependent (TMD) parton distribution functions. Based on this method, we perform fits to the recently released high-precision deep inelastic scattering (DIS) measurements, and examine the impact of low-Q^2 data on TMD distributions.

XXIV International Workshop on Deep-Inelastic Scattering and Related Subjects
11-15 April, 2016
DESY Hamburg, Germany

PoS(DIS2016)037

---

[*]Speaker.

1. Introduction

The collinear factorization formalism in QCD provides straightforward approach to calculate high energy hadron collisions. It interprets cross sections as a convolution of hard and soft processes. The parton distribution functions (PDFs) include the soft part and are independent of hard scattering process. PDFs in wide kinematic ranges of bjorken-x and momentum fraction Q^2 are an important tool for the cross section predictions. Extraction of the PDFs from data analysis is crucial to the LHC physics program [1, 2].

A transverse momentum dependent (TMD) factorization ansatz goes beyond the standard factorization framework by allowing the PDFs to depend on the parton's transverse momentum in addition to the usual x and Q^2 variables [3]. For instance, in the high energy limit the cross section can be written as a convolution of the TMD parton density functions with off-shell k_t-dependent partonic matrix elements as [4]

$$\sigma_{j=2,L}(x,Q^2) = \int_x^1 dz \int d^2k_t \hat{\sigma}_j(x,Q^2,z,k_t)A(z,k_t,p)\ . \tag{1.1}$$

The TMD PDFs, similarly to the collinear PDFs, can be determined from fits to inclusive cross sections, but the transverse momentum dependence has not yet been well constrained.

Most of the PDFs are successfully determined by using the DGLAP evolution equations. Applying higher order calculations of DGLAP improves the precision of the extracted PDFs. Recently, a new parton-branching Monte Carlo method has been presented to solve the QCD DGLAP evolution equations [5]. Formulation within Monte Carlo framework is desirable because it allows to study complete events. The main purpose of the Monte Carlo solution of the evolution equation is generating branchings where explicit energy momentum conservation is applied. By using this approach, both collinear and TMD parton densities can be extracted. In this paper we apply this method to perform fits to the high-precision deep inelastic scattering (DIS) measurements [6].

2. Computational Techniques

We employ the xFitter open-source QCD package to perform the fits. Its general structure and choice of options are presented in [8]. The package implements TMD PDFs via the Monte Carlo method [7]. We use the solution of QCD DGLAP evolution equations given in [5].

Recently new experimental results on inclusive $e^{\pm}p$ deep inelastic cross sections for neutral and charged current scattering have been presented in Ref. [6]. Combined cross section observables are provided for $0.045 < Q^2 < 50000$ GeV^2 and $6 \times 10^{-7} < x < 0.65$ with high precision.

We perform fits to these data. We intend to investigate in particular the low-Q^2 region.

3. Results

We consider the HERA I+II data over the full kinematic range in x. We find that the quality of the fits is sensitive to the choice of the starting scale of evolution. The results that follow are obtained by taking the starting scale of $Q_{start} = 1$ GeV^2.

To study the effect of low-Q^2 data and obtain a reasonable fit, we vary the minimum cut on the data range from $Q^2 > 1.5$GeV^2 to $Q^2 > 5$ GeV^2. We obtain a χ^2/ndf close to 1, for both scenarios. These results are obtained at the leading order of the approach [5] to DGLAP evolution for $\Lambda_{QCD} = 0.2$ GeV.

The results of both fits for $Q^2 = 6.5,\ 15,\ 150$ and 1500 GeV^2 are compared in Fig. 1.

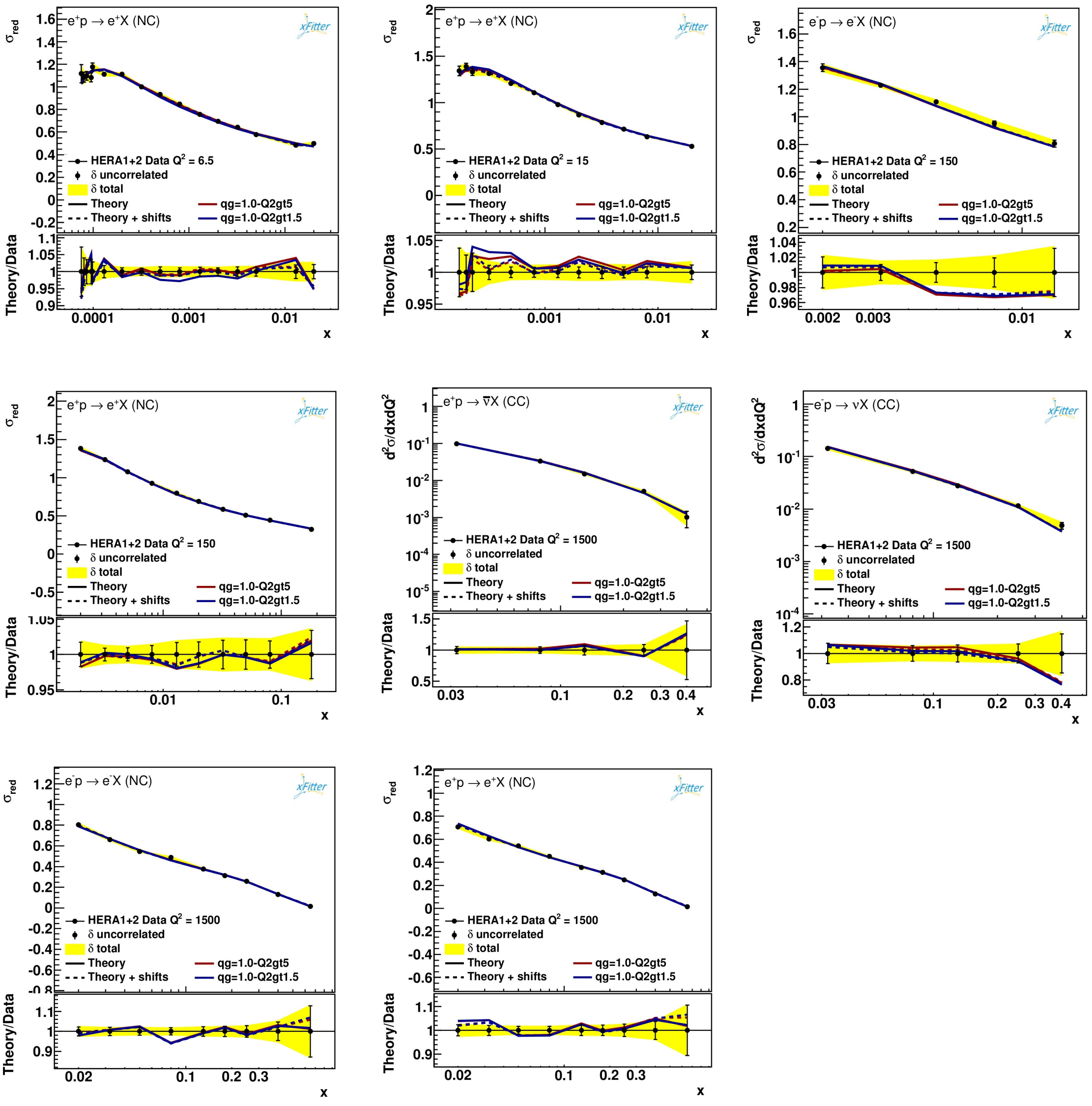

Figure 1: The fit to high-precision data [6].

From the fits we can construct TMD parton densities as described in [5]. In Fig. 2, we represent the TMD gluon as a function of k_t for the fit from $Q^2 > 5$ GeV^2 and the one with $Q^2 > 1.5$ at small x . They are indicated with ‘test’ and ‘test1’ respectively. For comparison the gluon distribution `ccfm-JH-2013-set2` [9] obtained from CCFM evolution equations is also shown. The fit to high-precision measurements and different evolution equations lead to significant differences in the TMD gluon density.

Plots are prepared with the online plotter tool tmdplotter.desy.de [10].

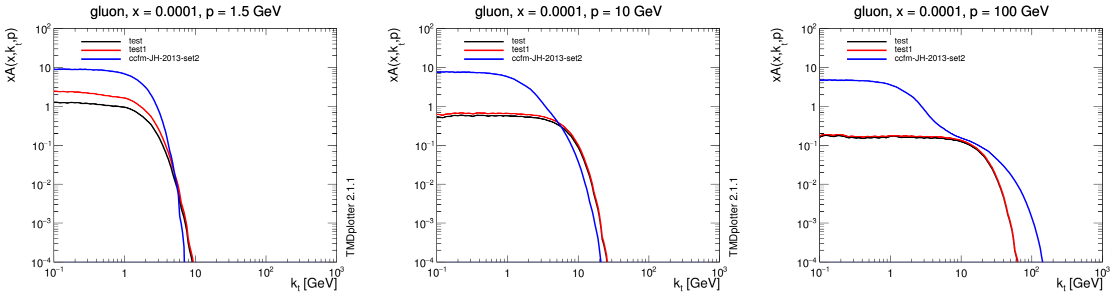

Figure 2: TMD gluon density at different evolution scale as a function of k_t for $x = 0.0001$. The results are compared with `ccfm-JH-2013-set2` [9].

Our study indicates that fits to the high-precision DIS data based on DGLAP evolution show sensitivity to the value of the starting scale for evolution. In this paper we have used the DGLAP Monte Carlo solution [5] at leading order and we have taken the starting scale $Q_{start} = 1$ GeV^2. We find a good fit in the data range $Q^2 > 1.5$ GeV^2. We have then performed the first determination of TMD parton density functions from recent high-precision data based on the DGLAP Monte Carlo method.

4. Acknowledgments

We thank the Organizers of the DIS2016 conference for their warm hospitality and support.

References

[1] A. Accardi *et al.*, Eur. Phys. J. C **76**, no. 8, 471 (2016) doi:10.1140/epjc/s10052-016-4285-4 [arXiv:1603.08906 [hep-ph]].

[2] J. Butterworth *et al.*, J. Phys. G **43**, 023001 (2016) doi:10.1088/0954-3899/43/2/023001 [arXiv:1510.03865 [hep-ph]].

[3] R. Angeles-Martinez *et al.*, Acta Phys. Polon. B **46** (2015) no.12, 2501 doi:10.5506/APhysPolB.46.2501 [arXiv:1507.05267 [hep-ph]].

[4] S. Catani, M. Ciafaloni and F. Hautmann, Phys. Lett. B **242**, 97 (1990). doi:10.1016/0370-2693(90)91601-7

[5] F. Hautmann, H. Jung and A. Lelek, DESY preprint DESY 16-174 (2016).

[6] H. Abramowicz *et al.* [H1 and ZEUS Collaborations], Eur. Phys. J. C **75**, no. 12, 580 (2015) doi:10.1140/epjc/s10052-015-3710-4 [arXiv:1506.06042 [hep-ex]].

[7] F. Hautmann, H. Jung and S. T. Monfared, Eur. Phys. J. C **74**, 3082 (2014) doi:10.1140/epjc/s10052-014-3082-1 [arXiv:1407.5935 [hep-ph]].

[8] S. Alekhin *et al.*, Eur. Phys. J. C **75**, no. 7, 304 (2015) doi:10.1140/epjc/s10052-015-3480-z [arXiv:1410.4412 [hep-ph]] , xfitter.org

[9] F. Hautmann and H. Jung, Nucl. Phys. B **883** (2014) 1 doi:10.1016/j.nuclphysb.2014.03.014 [arXiv:1312.7875 [hep-ph]].

[10] F. Hautmann, H. Jung, M. Kramer, P. J. Mulders, E. R. Nocera, T. C. Rogers and A. Signori, Eur. Phys. J. C **74**, 3220 (2014) doi:10.1140/epjc/s10052-014-3220-9 [arXiv:1408.3015 [hep-ph]].