RECENT PROGRESS IN VALIDATION OF THE PDFS *

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We discuss extraction of the nucleon PDFs from the global QCD fits with account of the high-order QCD corrections, in particular, the 3-loop corrections to the DIS coefficient functions and the 2-loop corrections to the Drell-Yan process coefficient functions. The compatibility of different data sets used in the fit is considered with peculiar attention payed on the choice of the confidence interval for the PDFs uncertainties.

The Parton Distribution Functions (PDFs) is mandatory ingredient for a quantitative interpretation of the hadronic processes in terms of the parton model. Precise knowledge of PDFs is particularly important for the forthcoming searches of the phenomena beyond Standard Model at the LHC. One of the most important issues for validation of PDFs is account of the high-order (HO) QCD corrections since the PDFs extracted with the HO corrections taken into account are less sensitive to the QCD scale variations and therefore more experimental data can be included into the fit of PDFs with theoretical uncertainties kept under control.

We consider impact of recent calculations of the 3-loop QCD corrections to the DIS coefficient functions[1] on example of the NNLO QCD fit of PDFs[2] to the global DIS data. The gluon distribution obtained in the approximate N^3LO variant of fit[2] with the 3-loop corrections to the splitting and coefficient functions taken into account is given in Fig.1. One can see progressive increase of the gluon distribution at small x and Q from the case of NLO to the case of approximate N^3LO and the numerical difference is big enough to be important for modeling underlying processes at the

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LHC. The N^{3}LO correction brings into agreement the QCD calculations with the H1 data[3] on longitudinal structure functions F_{L} at small x and Q (see Fig.1). At the same time big variation of the approximate N^{3}LO calculations for F_{L} with respect to the NNLO case might indicate on the perturbative instability of QCD in this region. Additional study of impact of the 4-loop corrections to the splitting functions, which are necessary for the consistent N^{3}LO calculations, is required to clarify this point.

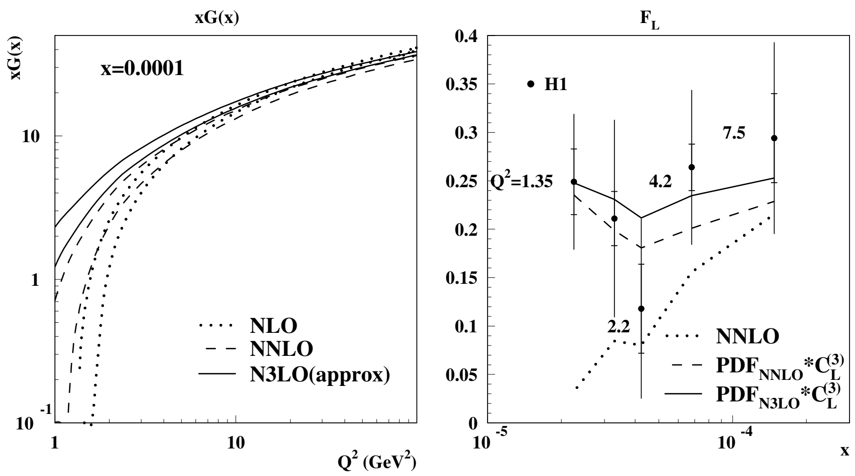

Figure 1. Impact of the high-order QCD correction on the PDFs fit. Left panel: 1σ bands for the gluon distribution obtained in the NLO (dots), the NNLO (dashes), and the approximate N^{3}LO (solid). Right panel: Comparison of the twist-2 DIS longitudinal structure function F_{L} calculated in the NNLO (dots) and approximate N^{3}LO (solid) with the data by H1 collaboration. The result of convolution of the NNLO PDFs with the 3-loop coefficient functions for F_{L} is given for comparison (dashes).

At the same time the PDFs obtained from the global fits are not too sensitive to the details of description of the DIS data at smallest x used. This is illustrated in Fig.2 using variants of the NNLO fit[2] with different low-x cuts. The variation of PDFs due to removing the data at lowest x is within the PDFs uncertainties that is in line with results of the similar NLO study[4] and does not support conclusion[5] about instability of PDFs extracted using data in this kinematical region, presumably due to big HO QCD corrections.

Due to rapidity distribution for the Drell-Yan process now can be calculated taking into account the 2-loop corrections to the coefficient functions[6]

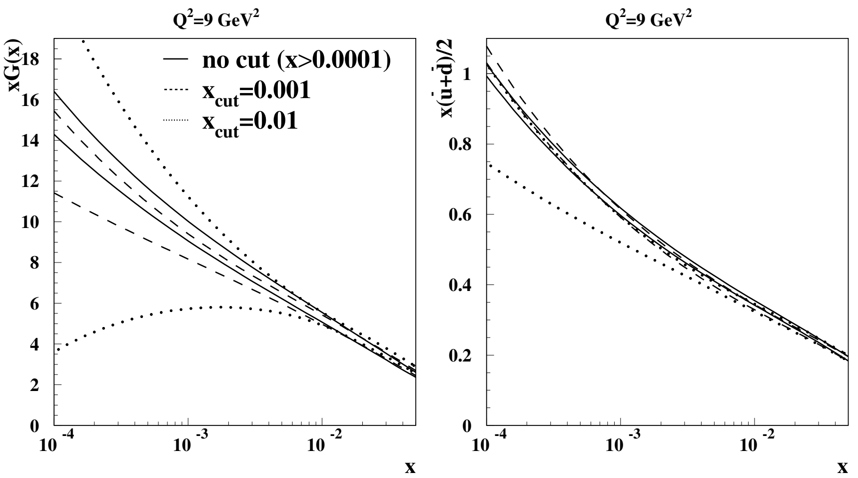

Figure 2. Impact of the low-x cut for the DIS data used in the global fit on the fitted gluon distribution (left panel) and the non-strange sea distribution (right panel). The curves give 1σ band for the distributions obtained with the cuts $x > 0.01$ (dots), $x > 0.001$ (dashes), and no cut (solid). The upper bound dotted curve in the right panel is poorly visible since it almost coincides with other curves in the plot.

one can include the dimuon production data into consistent NNLO fit of PDFs. This input is mostly important for pinning down the sea quarks distribution at large x, which is quite sensitive to the existing fixed-target Drell-Yan data. Uncertainty in the sea distribution obtained from the NNLO fit of PDFs[7] to the DIS data[2] combined with the Drell-Yan data by the Fermilab experiments E-605 and E-866[8] is less than 20% up to $x \sim 0.7$ (see Fig.3). The data used in this fit demonstrate good self-consistency. The value of χ^2/NDP=2861/2537=1.13 that is not too far from the ideal case. Moreover, it can be reduced to the ideal value of 1 by rescaling the errors in data for experiments with $\chi^2/NDP > 1$ by factors, which are less than 1.2. Increase in the PDFs errors due to such rescaling of the errors in data is also less than factor of 1.2, therefore use of the standard statistical criterion $\Delta\chi^2 = 1$ for estimation of the PDFs errors is justified in this case.

Theoretical uncertainty in the sea distribution due to variation of the QCD scales for the Drell-Yan c.s. in the range of $M_{\mu^+\mu^-}$ to $2M_{\mu^+\mu^-}$ practically does not exceed the experimental one (see Fig.3). Account of the NNLO corrections to the Drell-Yan c.s. is important at this point: For the variant of the fit with only NLO corrections to the Drell-Yan c.s.taken into account the theoretical uncertainty in the sea distribution at large x is twice bigger and overwhelms the experimental error, therefore statistical potential of the data is lost in this case.

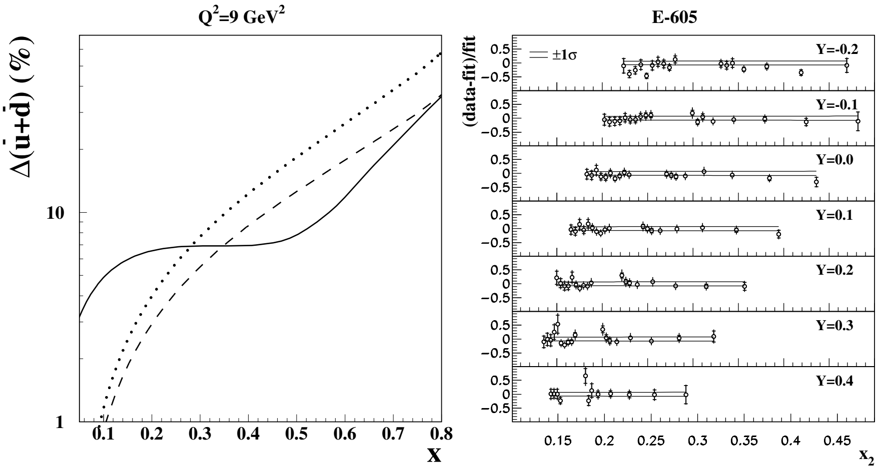

Figure 3. Results for the NNLO QCD fit of PDFs to the global DIS data combined with the fixed-target Drell-Yan data. Left panel: The uncertainties in the non-strange sea distribution (solid: uncertainty due to propagation of the errors in the experimental data; dashes: the QCD scale variation uncertainty; dots: the QCD scale variation uncertainty for the variant of fit with the Drell-Yan c.s. calculated in the NLO). Right panel: Pulls for the fixed-target Drell-Yan experiment FNAL-E-605 used in the fit (two curves give $\pm 1\sigma$ error band due to the PDFs uncertainty).

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