Next-to-next-to-leading order analysis of the Fermilab data for the xF_3 structure function of νN deep-inelastic scattering: higher twists and $\alpha_s(M_Z)$ extraction [1]

A.L.Kataev[1], G. Parente[2] and A.V. Sidorov[3]

1) *Theory Division, CERN, Geneva, Switzerland and Institute for Nuclear Research, Moscow, Russia*

2) *University of Santiago de Compostela, Santiago de Compostela, Spain*

3) *Bogoliubov Laboratory of Theoretical Physics, JINR. Dubna, Russia*

Contribution to Poster Session of ACAT 2000, Fermilab.

*) The method of the Jacobi polynomials was applied to extract the theoretical behaviour of xF_3 structure function of neutrino-nucleon deep inelastic scattering at the next-to-next-to-leading order (NNLO) of perturbative QCD and compare it with experimental data, obtained at Fermilab (CCFR/NuTeV- collaboration). The analytical expressions of the NNLO corrections to the coefficient function of DGLAP-equation for xF_3 (Reference: E.B. Zijlstra and W.L. van Neerven, *Phys. Lett.* **B297**(1992) 377) and of the NNLO corrections to the anomalous dimensions of even non-singlet Mellin moments (Reference: S.A. Larin, P. Nogueira, T. van Ritbergen and J.A.M. Vermaseren, *Nucl. Phys.* B492 (1997) 338) were used.

*) This work is the physical application of the results of several multiloop analytical calculations.

*) The Jacobi polinomial method was realized as the FORTRAN program, originaly created at JINR, Dubna (Referencies: V.G. Krivokhizhin et al., *Zeit. Phys.* **C36** (1987) 51; V.G. Krivokhizhin et al., *Z. Phys.* **C48** (1990) 347).

*) The fits of the data, which gave as the output the values of the QCD parameter $\Lambda_{\overline{MS}}$, normalized to the $n_f = 4$ numbers of flavours and the x-behaviour of the nonperturbative contribution, modeled as $h(x)/Q^2$, were done at the PC Pentium II 223 MHz in Dubna and at Digital Alpha Station with Alpha processor 21064A working at 233 MHz in Santiago de Compostela. The typical running time of the programs are over 5 min at Dubna and 1 minute at Santiago de Compostela, although sometimes it works longer, depending on the number of fitted parameters. Say, sometimes at Dubna the work is taking over 1.5 hours.

The value of $\Lambda^{(4)}_{\overline{MS}}$ was transformed in the expression of $\alpha_s(M_Z)$ using the NNLO $\overline{MS}$ matching condition, analytically calculated at 3-loops in W. Bernreuther and W. Wetzel, *Nucl. Phys.* **B197** (1982); Err. *Nucl. Phys.* **B513** (1998) 758; S. A. Larin, T. van Ritbergen and J.A.M. Vermaseren, *Nucl. Phys.* **B438** (1995) 275 and at 4-loops in K.G. Chetyrkin, B.A. Kniehl and M. Steinhauser, *Phys. Rev. Lett.* **79** (1997) 2184. This transformation was done with the help pf the package, written at MATCAD analytical program, in several seconds.

*) Main referencies are:

1. A.L. Kataev, A.V. Kotikov, G. Parente and A.V. Sidorov, *Phys. Lett.* **B417** (1998) 374;

2. A.L. Kataev, G. Parente and A.V. Sidorov, *Nucl. Phys.* **B573** (2000) 405.

*) Abstract was not presented at ACAT 2000

[1] Supported in part by Grants of RFBI (99-01-00091, 00-02-17-17432), Xunta de Galicia (PGIDT00PXI2O615PR) and CICYT (AEN99-0589-C02-02)

*) At present this is one of the most precise NNLO multiloop perturbative QCD analysis for the important and classical case of deep-inelastic scattering structure function xF_3 with taking into account NNLO perturbative QCD effects and $1/Q^2$-corrections. ¿From theoretical point of view the analysis allows to study the problem of asymptotic behaviour of perturbative QCD series.

*) The most interesting technical observation is that using the Jacobi polynomial method it is possible to reconstruct the structure function from rather small number of its Mellin moments (in our case from 10 moments) with rather high precision.

The most interesting physical foundation, which was first discovered in the process of the analysis of Fermilab data for xF_3 structure function by A.L. Kataev, A.V. Kotikov, G. Parente and A.V. Sidorov, *Phys. Lett.* **B417** (1998) 374, is that there is the interplay between the effects of the NNLO perturbative QCD corrections and $1/Q^2$-contributions, which result in the effective "shadowing" of the power supressed terms by the perturbative NNLO effects. The similar conclusion was also made later in the process of the NNLO analysis of the SLAC and BCDMS data for deep-inelastic ratio $R = F_2(1 + 4Mx^2/Q^2)/2xF_1 - 1$ (U.K. Yang and A. Bodek, *Phys. Rev. Lett.* **82** (1999) 2467).

*) Among other results is the determination of the NNLO value of $\alpha_s(M_Z)$: $\alpha_s(M_Z) = 0.118 \pm 0.002$ $(stat) \pm$ $0.005(syst) \pm$ $0.003(theory)$ provided $1/Q^2$-corrections are fixed through the special model, and $\alpha_s(M_Z) = 0.121^{+0.007}_{0.010}$ $(stat) \pm 0.055$ $(syst)$ provided $1/Q^2$-contributions are considered as free parameters.

The drastical minimization of the theoretical uncertainties of extracted values of $\alpha_s(M_Z)$ as the result of taking into account of the NNLO perturbative QCD corrections was demonstrated.

The peculiar feature of theoretical behaviour of perturbative series for $n = 2$ Mellin moment, namely the manifestation of the outburst of the asymptotic perturbative series at the NNLO was discovered.

*) At present we are working on the fixation of the remaining theoretical uncertainties, including into the fits the NNLO analytically calculated corrections to anomalous dimensions of odd Mellin moments and the N^{3}LO contributions to the coefficient functions of off Mellin moments (up to n=13). (For the analytical evaluation of these corrections see A. Retrey and J.A.M. Vermaseren, preprint TTP00-13, NIKHEF-2000-018, hep-ph/0007294).