DESY 11-050 LPN11-16
DO 11/05

$\alpha_s(M_Z^2)$ in NNLO Analyses of Deep-Inelastic World Data

S. Alekhin[1,2], J. Blümlein[1], H. Böttcher[1], and S.-O. Moch[1]

[1] Deutsches Elektronen-Synchrotron, DESY, Platanenallee 6, D-15738 Zeuthen, Germany
[2] Institute for High Energy Physics, 142281 Protvino, Moscow Region, Russia

The present world data of deep-inelastic scattering (DIS) reached a precision which allows the measurement of $\alpha_s(M_Z^2)$ from their scaling violations with an error of $\delta\alpha_s(M_Z^2) \simeq 1\%$. This requires at least NNLO analyses, since NLO fits exhibit scale uncertainties of $\Delta_{r,f}\alpha_s(M_Z^2) \sim 0.0050$. The NNLO values for α_s obtained are summarized in the following Table.

	$\alpha_s(M_Z^2)$	
BBG	$0.1134\ ^{+0.0019}_{-0.0021}$	valence analysis, NNLO [1]
GRS	0.112	valence analysis, NNLO [2]
ABKM	0.1135 ± 0.0014	HQ: FFNS $N_f = 3$ [3]
ABKM	0.1129 ± 0.0014	HQ: BSMN-approach [3]
JR	0.1124 ± 0.0020	dynamical approach [4]
JR	0.1158 ± 0.0035	standard fit [4]
MSTW	0.1171 ± 0.0014	[5]
ABM	0.1147 ± 0.0012	FFNS, incl. combined H1/ZEUS data [6]
Gehrmann et al.	$0.1153 \pm 0.0017 \pm 0.0023$	e^+e^- thrust [7]
Abbate et al.	$0.1135 \pm 0.0011 \pm 0.0006$	e^+e^- thrust [8]
BBG	$0.1141\ ^{+0.0020}_{-0.0022}$	valence analysis, N^3LO [1]
world average	0.1184 ± 0.0007	[9]

NNLO non-singlet data analyses have been performed in [1, 2]. The analysis of Ref. [1] is based on an experimental combination of flavor non-singlet data referring to $F_2^{p,d}(x, Q^2)$ for $x < 0.35$ and using the respective valence approximations for $x > 0.35$. The $\overline{d} - \overline{u}$ distributions and the $O(\alpha_s^2)$ heavy flavor corrections were accounted for. At low Q^2 and at large x also at low W^2 higher twist corrections have to be taken into account [10]. The corresponding region was cut out in [1] performing the fits for the leading twist terms only. The analysis could be extended to N^3LO effectively due to the dominance of the Wilson coefficient in this order [11] if compared to the anomalous dimension, cf. [1,12]. This analysis led to an increase of $\alpha_s(M_Z^2)$ by $+0.0007$ if compared to the NNLO value.

A combined singlet and non-singlet NNLO analysis based on the DIS world data, including the Drell-Yan and di-muon data, needed for a correct description of the sea-quark densities, was performed in [3]. In the fixed flavor number scheme (FFNS) the value of $\alpha_s(M_Z^2)$ is the same as in the non-singlet case [1]. The comparison between the FFNS and the BMSN scheme [13] for the description of the heavy flavor contributions induces a systematic uncertainty $\Delta\alpha_s(M_Z^2) = 0.0006$. The NNLO analyses of Ref. [4] are statistically compatible with the results of [1–3], while those of [5] yield a higher value.

In Ref. [6] the combined H1 and ZEUS data were accounted for in a NNLO analysis for the first time, which led to a shift of $+0.0012$. However, running quark mass effects [14] and the account of recent F_L data reduce this value again to the NNLO value given in [3]. We mention that other recent NNLO analyses of precision data, as the measurement of $\alpha_s(M_Z^2)$

using thrust in high energy e^+e^- annihilation data [7,8], result in lower values than the 2009 world average [9] based on NLO, NNLO and N^{3}LO results. The sensitivity of the fits to a precise description of the longitudinal structure function F_L has been demonstrated in [15] recently, in the case of the NMC data. Inconsistent descriptions of F_L induce a high value of α_s of ~ 0.1170 to be compared with that obtained in [5]. It is observed that the values of

$\alpha_s(M_Z^2)$	with $\sigma_{\rm NMC}$	with $F_2^{\rm NMC}$	difference
NNLO	0.1135(14)	0.1170(15)	$+0.0035 \simeq 2.3\sigma$
NNLO $+F_L$ $O(\alpha_s^3)$	0.1122(14)	0.1171(14)	$+0.0050 \simeq 3.6\sigma$

α_s found in NLO fits are systematically higher than those in NNLO analyses. α_s measurements based on jet data can be performed presently at NLO only. Here typical values obtained are $\alpha_s(M_Z^2) = 0.1156\ ^{+0.0041}_{-0.0034}$ [16], $\alpha_s(M_Z^2) = 0.1161\ ^{+0.0041}_{-0.0048}$ [17] in recent examples. The precise knowledge of $\alpha_s(M_Z^2)$ is of instrumental importance for the correct prediction of the Higgs boson cross section at Tevatron and the LHC [18].

References

[1] J. Blümlein, H. Böttcher and A. Guffanti, Nucl. Phys. **B774** (2007) 182; Nucl. Phys. Proc. Suppl. **135** (2004) 152.

[2] M. Glück, E. Reya and C. Schuck, Nucl. Phys. **B754** (2006) 178.

[3] S. Alekhin, J. Blümlein, S. Klein and S. Moch, Phys. Rev. **D81** (2010) 014032.

[4] P. Jimenez-Delgado and E. Reya, Phys. Rev. **D79** (2009) 074023.

[5] A. D. Martin, W. J. Stirling, R. S. Thorne, G. Watt, Eur. Phys. J. **C64** (2009) 653.

[6] S. Alekhin, J. Blümlein and S. O. Moch, PoS D **IS2010** (2010) 021, and in preparation.

[7] T. Gehrmann, M. Jaquier, G. Luisoni, Eur. Phys. J. **C67** (2010) 57.

[8] R. Abbate, M. Fickinger, A. H. Hoang, V. Mateu, I. W. Stewart, arXiv:1006.3080 [hep-ph].

[9] S. Bethke, Eur. Phys. J. **C64** (2009) 689.

[10] S. I. Alekhin, S. A. Kulagin and S. Liuti, Phys. Rev. D **69** (2004) 114009;
J. Blümlein and H. Böttcher, Phys. Lett. B **662** (2008) 336.

[11] J. A. M. Vermaseren, A. Vogt, S. Moch, Nucl. Phys. **B724** (2005) 3.

[12] P. A. Baikov, K. G. Chetyrkin, Nucl. Phys. Proc. Suppl. **160** (2006) 76.

[13] M. Buza, Y. Matiounine, J. Smith, W. L. van Neerven, Eur. Phys. J. **C1** (1998) 301. I. Bierenbaum, J. Blümlein and S. Klein, Phys. Lett. B **672** (2009) 401.

[14] S. Alekhin, S. Moch, arXiv:1011.5790 [hep-ph].

[15] S. Alekhin, J. Blümlein and S. Moch, arXiv:1101.5261 [hep-ph].

[16] R. Frederix, S. Frixione, K. Melnikov, G. Zanderighi, JHEP **1011** (2010) 050.

[17] V. M. Abazov *et al.* [D0 Collaboration], Phys. Rev. **D80** (2009) 111107.

[18] S. Alekhin, J. Blümlein, P. Jimenez-Delgado, S. Moch and E. Reya, Phys. Lett. **B697** (2011) 127.