Scheme Dependence in Polarized Deep Inelastic Scattering

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Abstract

We study the effect of scheme dependence upon the NLO QCD analysis of the world data on polarized DIS. The reliability of an analysis at NLO is demonstrated by the consistency of our polarized densities with the NLO transformation rules relating them to each other. We stress the importance of the chiral JET scheme in which all the hard effects are consistently absorbed in the Wilson coefficient functions.

PACS numbers: 13.60.Hb; 13.88+e; 14.20.Dh; 12.38.-t
There has been a major effort in the past decade to obtain reliable information about the polarized parton densities in the nucleon, and especially to try to determine the degree of polarization of the gluon. Aside from its fundamental interest and its potential as a testing ground for QCD, such information is vital for the planning of experiments at the RHIC collider, due to come into operation in 1999.

A great improvement in the quality of the data on inclusive deep inelastic scattering of leptons on nucleons has been achieved recently \[1, 2, 3\] and, concomitantly, several detailed NLO QCD analyses of the data have been carried out \[4] - \[13\], of which the most comprehensive are in refs. \[7, 13\].

It is well known that at NLO and beyond, parton densities become dependent on the renormalization (or factorization) scheme employed.\[4] It is perhaps less well known that there are significant differences in the polarized case, as a consequence of the axial anomaly and of the ambiguity in the handling of $\gamma_5$ in $n$ dimensions.

In this paper we study the effect of carrying out the data analysis in different schemes, in the $\overline{MS}$, AB and what is called the JET scheme, whose importance we wish to stress. In the latter all hard effects are consistently absorbed into the Wilson coefficient functions. The parton densities in each scheme are, by definition, related to each other by certain NLO transformation rules. On the other hand, the $Q^2$ evolution in each scheme is controlled by the splitting functions (or the anomalous dimensions in Mellin n-moment space) relevant to that scheme. Thus, in principle, for any two schemes labelled 1 and 2 and for any generic polarized density $\Delta f$ one has symbolically:

\begin{align}
NLO \text{ data analysis in Scheme } 1 & \Rightarrow \Delta f_1, \\
NLO \text{ data analysis in Scheme } 2 & \Rightarrow \Delta f_2, \\
NLO \text{ transformation rules on } \Delta f_1 & \Rightarrow \Delta f_2
\end{align}

and it is a major test of the stability of the analysis and of the consistency of the theory that the results for $\Delta f_2$ in (2) and (3) should coincide. In fact, built into the theoretical structure is the feature that the two results actually should differ by terms of NNLO order. Hence the degree to which the results agree is a measure of the reliability of carrying out an analysis at NLO. Moreover, in the set of schemes we study, the non-

\[1\] Of course, physical quantities such as the virtual photon-nucleon asymmetry $A_1(x, Q^2)$ and the polarized structure function $g_1(x, Q^2)$ are independent of choice of the factorization convention.
singlet and gluon densities are the same in all the schemes. That this feature should emerge from the data analysis provides a further test of the stability and reliability of the analysis. The importance of an analysis of this kind was first stressed in ref. [6].

In the unpolarized case the most commonly used schemes are the $\overline{\text{MS}}$, MS and DIS and parton densities in different schemes differ from each other by terms of order $\alpha_s(Q^2)$, which goes to zero as $Q^2$ increases.

There are two significant differences in the polarized case:

i) The singlet densities $\Delta\Sigma(x, Q^2)$, in two different schemes, will differ by terms of order

$$\alpha_s(Q^2)\Delta G(x, Q^2),$$

which appear to be of order $\alpha_s$. But it is known [14, 15] that, as a consequence of the axial anomaly, the first moment of the polarized gluon density $\Delta G(x, Q^2)$

$$\int_0^1 dx \Delta G(x, Q^2) \propto [\alpha_s(Q^2)]^{-1},$$

and thus grows in such a way with $Q^2$ as to compensate for the factor $\alpha_s(Q^2)$ in (4). Thus the difference between $\Delta\Sigma$ in different schemes is only apparently of order $\alpha_s(Q^2)$, and could be quite large.

ii) Because of ambiguities in handling the renormalization of operators involving $\gamma_5$ in $n$ dimensions, the specification $\overline{\text{MS}}$ does not define a unique scheme. Really there is a family of $\overline{\text{MS}}$ schemes which, strictly, should carry a sub-label indicating how $\gamma_5$ is handled. What is now conventionally called $\overline{\text{MS}}$ is in fact the scheme due to Vogelsang and Mertig and van Neerven [16], in which the first moment of the non-singlet densities is conserved, i.e. is independent of $Q^2$, corresponding to the conservation of the non-singlet axial-vector Cabibbo currents.

Although mathematically correct it is a peculiarity of this factorization scheme that certain soft contributions are included in the Wilson coefficient functions, rather than being absorbed completely into the parton densities. As a consequence, the first moment of $\Delta\Sigma$ is not conserved so that it is difficult to know how to compare the DIS results on $\Delta\Sigma$ with the results from constituent quark models at low $Q^2$.

To avoid these idiosyncrasies Ball, Forte and Ridolfi [6] introduced what they called the AB scheme, which involves a minimal modification of the $\overline{\text{MS}}$ scheme, and for which the transformation equations are:

$$\Delta\Sigma(x, Q^2)_{AB} = \Delta\Sigma(x, Q^2)_{\overline{\text{MS}}} + N_f \frac{\alpha_s(Q^2)}{2\pi} \int_x^1 \frac{dy}{y} \Delta G(y, Q^2)_{\overline{\text{MS}}},$$

$$\Delta G(x, Q^2)_{AB} = \Delta G(x, Q^2)_{\overline{\text{MS}}}$$

(6)
or, in Mellin \( n \)-moment space,

\[
\Delta \Sigma(n, Q^2)_{AB} = \Delta \Sigma(n, Q^2)_{\overline{MS}} + N_f \frac{\alpha_s(Q^2)}{2\pi n} \Delta G(n, Q^2)_{\overline{MS}},
\]

\[
\Delta G(n, Q^2)_{AB} = \Delta G(n, Q^2)_{\overline{MS}} + N_f \frac{\alpha_s(Q^2)}{2\pi n} \Delta G(n, Q^2)_{\overline{MS}}.
\]  

(7)

That \( \Delta \Sigma(n = 1)_{AB} \) is independent of \( Q^2 \) to all orders follows from the Adler-Bardeen theorem \[17\]. In (6) and (7) \( N_f \) denotes the number of flavours.

The singlet part of the first moment of the structure function \( g_1 \)

\[
\Gamma_1^{(s)}(Q^2) \equiv \int_0^1 dx g_1^{(s)}(x, Q^2)
\]  

then depends on \( \Delta \Sigma \) and \( \Delta G \) only in the combination

\[
a_0(Q^2) = \Delta \Sigma(1, Q^2)_{\overline{MS}} = \Delta \Sigma(1)_{AB} - N_f \frac{\alpha_s(Q^2)}{2\pi} \Delta G(1, Q^2)
\]  

and the unexpectedly small value for the axial charge \( a_0 \) found by the EMC \[18\], which triggered the ”spin crisis in the parton model” \[19\], can be nicely explained as due to a cancellation between a reasonably sized \( \Delta \Sigma(1) \) and the gluon contribution. Of importance for such an explanation are both the positive sign and the large value (of order \( \mathcal{O}(1) \)) for the first moment of the polarized gluon density \( \Delta G(1, Q^2) \) at small \( Q^2 \sim 1 - 10 \text{ GeV}^2 \). Note that what follows from QCD is that \(|\Delta G(1, Q^2)|\) grows with \( Q^2 \) (see Eq. (5)) but its value at small \( Q^2 \) is unknown in the theory at present and has to be determined from experiment.

Although the AB scheme corrects the most glaring weakness of the \( \overline{MS} \) scheme, it does not consistently put all hard effects into the coefficient functions. As pointed out in \[20\] one can define a family of schemes labelled by a parameter \( a \):

\[
\left( \begin{array}{c}
\Delta \Sigma \\
\Delta G
\end{array} \right)_{a} = \left( \begin{array}{c}
\Delta \Sigma \\
\Delta G
\end{array} \right)_{\overline{MS}} + \alpha_s \left( \begin{array}{cc}
0 & z(a)_{qG} \\
0 & 0
\end{array} \right) \otimes \left( \begin{array}{c}
\Delta \Sigma \\
\Delta G
\end{array} \right)_{\overline{MS}}
\]  

(10)

where

\[
z_{qG}(x; a) = N_f [(2x - 1)(a - 1) + 2(1 - x)] ,
\]  

(11)

in all of which (3) holds, but which differ in their expression for the higher moments. (The AB scheme corresponds to taking \( a = 2 \)).

Amongst these we believe there are compelling reasons to choose what we shall call the JET scheme \( (a = 1) \), i.e.

\[
z_{qG}^{\text{JET}} = 2N_f(1 - x) .
\]  

(12)

This is the scheme originally suggested by Carlitz, Collins and Mueller \[15\] and also advocated by Anselmino, Efremov, Leader and Teryaev in refs. \[21, 22\]. In it all hard

\[†\] There is misprint in Eq. (8.2.6) of \[22\]. The term \( \ln(\frac{1-x/x'}{x/x'}) \) should be \( \ln(\frac{1-x/x'}{x/x'}) - 1 \).
effects are absorbed into the coefficient functions. In this scheme the gluon coefficient function is exactly the one that would appear in the cross section for

\[ pp \rightarrow jet(\mathbf{k}_T) + jet(-\mathbf{k}_T) + X, \]  

(13)
i.e., the production of two jets with large transverse momentum \( \mathbf{k}_T \) and \(-\mathbf{k}_T \), respectively.

More recently Müller and Teryaev [23] have advanced rigorous and compelling arguments, based upon a generalization of the axial anomaly to bilocal operators, that removal of all anomaly effects from the quark densities leads to the JET scheme. Also a different argument by Cheng [24] leads to the same conclusion. (Cheng calls the JET scheme a chirally invariant (CI) scheme.)

The transformation from the \( \overline{\text{MS}} \) scheme of Mertig, van Neerven and Vogelsang to the JET scheme is given in moment space by

\[
\Delta \Sigma(n, Q^2)_\text{JET} = \Delta \Sigma(n, Q^2)_\overline{\text{MS}} + 2N_f \frac{\alpha_s(Q^2)}{2\pi n(n+1)} \Delta G(n, Q^2)_\overline{\text{MS}}, \\
\Delta G(n, Q^2)_\text{JET} = \Delta G(n, Q^2)_\overline{\text{MS}}.
\]

(14)

Note that (14) implies that the strange sea \( \Delta \bar{s} \) is different in the two schemes. Of course, (14) and (14) become the same for \( n = 1 \).

The NLO Wilson coefficient functions \( \Delta C^{(1)}_i(x) \) and polarized splitting functions \( \Delta P^{(1)}_{ij}(x) \) (or the corresponding anomalous dimensions \( \Delta \gamma^{(1)}_{ij}(n) \)) for the \( \overline{\text{MS}} \) and AB schemes can be found in refs. [16] and [8], respectively. The NLO coefficient functions and anomalous dimensions in the JET scheme are related to those of the \( \overline{\text{MS}} \) scheme by [23]

\[
\Delta C^{(1)}_q(n)_\text{JET} = \Delta C^{(1)}_q(n)_{\overline{\text{MS}}}, \quad \Delta C^{(1)}_G(n)_\text{JET} = \Delta C^{(1)}_G(n)_{\overline{\text{MS}}} - \frac{2N_f}{n(n+1)},
\]

(15)

\[
\Delta \gamma^{(1)}_{qq}(n)_\text{JET} = \Delta \gamma^{(1)}_{qq}(n)_{\overline{\text{MS}}} + \frac{4N_f}{n(n+1)} \Delta \gamma^{(0)}_{Gq}(n), \\
\Delta \gamma^{(1)}_{qG}(n)_\text{JET} = \Delta \gamma^{(1)}_{qG}(n)_{\overline{\text{MS}}} + \frac{4N_f}{n(n+1)} [\Delta \gamma^{(0)}_{GG}(n) - \Delta \gamma^{(0)}_{qq}(n) + 2\beta_0], \\
\Delta \gamma^{(1)}_{Gq}(n)_\text{JET} = \Delta \gamma^{(1)}_{Gq}(n)_{\overline{\text{MS}}}, \\
\Delta \gamma^{(1)}_{GG}(n)_\text{JET} = \Delta \gamma^{(1)}_{GG}(n)_{\overline{\text{MS}}} - \frac{4N_f}{n(n+1)} \Delta \gamma^{(0)}_{Gq}(n).
\]

(16)

†In ref. [23] these transformations are presented in Bjorken x space to all orders in \( \alpha_s \).
Note also that
\[ \Delta C_{NS}^{(1)}(n)_{JET} = \Delta C_{NS}^{(1)}(n)_{\overline{MS}} , \quad \Delta \gamma_{NS}^{(1)}(n)_{JET} = \Delta \gamma_{NS}^{(1)}(n)_{\overline{MS}} . \] (17)

In (16) a superscript “0” is used for the corresponding anomalous dimensions in the LO approximation.

Note that the transformation of the coefficient functions and anomalous dimensions from the \( \overline{MS} \) to the AB scheme is given by eqs. (15 - 17), in which the factor \( 2/n(n+1) \) should be replaced by \( 1/n \).

In each scheme the parton densities at \( Q_0^2 = 1 \text{ GeV}^2 \), as in [13], were parametrized in the form:
\[
\begin{align*}
x \Delta u_v(x, Q_0^2) &= \eta_u A_u x^{a_u} x u_v(x, Q_0^2) , \\
x \Delta d_v(x, Q_0^2) &= \eta_d A_d x^{a_d} x d_v(x, Q_0^2) , \\
x \Delta Sea(x, Q_0^2) &= \eta_S A_S x^{a_S} x Sea(x, Q_0^2) , \\
x \Delta G(x, Q_0^2) &= \eta_g A_g x^{a_g} x G(x, Q_0^2) ,
\end{align*}
\] (18)

where on R.H.S. of (18) we have used the recent MRST unpolarized densities [25]. The normalization factors \( A_f \) are determined in such a way as to ensure that the first moments of the polarized densities are given by \( \eta_f \).

The first moments of the valence quark densities \( \eta_u \) and \( \eta_d \) are fixed by the octet nucleon and hyperon \( \beta \) decay constants [26]
\[ g_A = F + D = 1.2573 \pm 0.0028 , \quad a_s = 3F - D = 0.579 \pm 0.025 . \] (19)

and in the case of SU(3) flavour symmetry of the sea (\( \Delta \bar{u} = \Delta \bar{d} = \Delta \bar{s} \) at \( Q_0^2 \))
\[ \eta_u = 0.918 , \quad \eta_d = -0.339 . \] (20)

The rest of the parameters in (18)
\[ \{ a_u, a_d, \eta_S, a_S, \eta_g, a_g \} , \] (21)
have to be determined from the best fit to the \( A_1^N(x, Q^2) \) data.

To calculate the virtual photon-nucleon asymmetry \( A_1^N(x, Q^2) \) in NLO QCD and then fit to the data we follow the procedure described in detail in our previous papers [3, 13], where the connection between measured quantities, Wilson coefficients and parton densities is given.
The numerical results of the fits in the JET, AB and $\overline{MS}$ schemes to the present experimental data on $A_N^1(x, Q^2)$ \cite{1,2,3,18,27,28,29} are listed in Table 1\footnote{After the completion of this work new data on $A_1^p$ and $g_1^p$ have been reported by the HERMES Collaboration \cite{30}.} The data used (118 experimental points) cover the following kinematic region:

$$0.004 < x < 0.75, \quad 1 < Q^2 < 72\, GeV^2.$$ \hspace{1cm} (22)

In this paper we present the results of the fit to the $A_N^1$ data averaged over $Q^2$ at each $x$. (In our previous work \cite{13} we also analyzed data in $(x, Q^2)$ bins. Our conclusion in the present paper also hold for this type of fit.) The total (statistical and systematic) errors are taken into account. The results presented in Table 1 correspond to an SU(3) symmetric sea. Note that in this case the first moment of the strange sea quarks $\eta_s \equiv \Delta \bar{s}(1, Q_0^2) = \eta_s/6$. As was shown in our previous work \cite{13}, the flavour decomposition of the sea does not affect the quality of the fit and the results on the polarized parton densities $\Delta \Sigma$, $\Delta \bar{s}$ and $\Delta G$.

As in the case of the $\overline{MS}$ scheme \cite{13}, the value of $a_g$ is not well determined by the fits in the JET and AB schemes to the existing data, i.e. $\chi^2/DOF$ practically does not change when $a_g$ varies in the range: $0 \leq a_g \leq 1$. In Table 1 we present the results of the fits corresponding to $a_g = 0.6$.

| Scheme | JET | AB | $\overline{MS}$ |
|--------|-----|----|----------------|
| DOF    | 118 - 5 | 118 - 5 | 118 - 5 |
| $\chi^2$ | 86.39 | 86.35 | 86.11 |
| $\chi^2/DOF$ | 0.764 | 0.764 | 0.762 |
| $a_u$  | 0.267 $\pm$ 0.035 | 0.267 $\pm$ 0.036 | 0.255 $\pm$ 0.028 |
| $a_d$  | 0.124 $\pm$ 0.123 | 0.124 $\pm$ 0.125 | 0.148 $\pm$ 0.113 |
| $a_s$  | 1.469 $\pm$ 0.460 | 1.558 $\pm$ 0.583 | 0.817 $\pm$ 0.223 |
| $\eta_s$ | -0.027 $\pm$ 0.004 | -0.022 $\pm$ 0.005 | -0.049 $\pm$ 0.005 |
| $\eta_g$ | 0.50 $\pm$ 0.12 | 0.56 $\pm$ 0.14 | 0.82 $\pm$ 0.32 |
| $\Delta \Sigma(1)$ | 0.416 $\pm$ 0.036 | 0.444 $\pm$ 0.040 | 0.287 $\pm$ 0.041 |
| $a_0(1\, GeV^2)$ | 0.30 $\pm$ 0.04 | 0.31 $\pm$ 0.05 | 0.29 $\pm$ 0.04 |

Table 1. Results of the NLO QCD fits in the JET, AB and $\overline{MS}$ schemes to the world $A_N^1$ data ($Q_0^2 = 1\, GeV^2$). The errors shown are total (statistical and systematic). $a_g = 0.6$ (fixed).
It is seen from the Table 1 that the values of $\chi^2/DOF$ coincide almost exactly in the different factorization schemes, which is a good indication of the stability of the analysis. The NLO QCD predictions are in a very good agreement with the presently available data on $A_1^N$, as is illustrated in the JET scheme fit in Fig. 1. We would like to draw special attention to the excellent fit to the very accurate E154 neutron data ($\chi^2 = 1.1$ for 11 experimental data points).

The extracted valence and gluon polarized densities at $Q^2_0 = 1 GeV^2$ for the different schemes are shown in Fig. 2 (solid, dotted and dashed curves correspond to JET, AB and $\overline{MS}$ scheme, respectively). Note that the valence densities $x\Delta u_v$ and $x\Delta d_v$ in the JET and AB schemes are almost identical so the dotted curves corresponding to $x\Delta u_v$ and $x\Delta d_v$ are not shown in Fig. 2. The difference between $x\Delta u_v$ and $x\Delta d_v$ in the $\overline{MS}$ and JET scheme is negligible. The results of the fit for the polarized valence densities are in an excellent agreement with what follows from the theory, namely, that they should be the same in the factorization schemes under consideration.

The results on the polarized gluon densities determined by the fit in the JET, AB and $\overline{MS}$ schemes are also consistent. The values of their first moments $\eta_g$ coincide within errors (see Table 1). However, as a consequence of the uncertainty in determining the gluon density from the present data, the central values of $\eta_g$ and therefore, the gluon densities themselves, differ somewhat in the various schemes.

In Table 1 we also present our results in the different schemes for the first moments $\Delta \Sigma(1)$ of the polarized singlet quark density as well as for the axial charge $a_0$. The obtained singlet densities $\Delta \Sigma(x, Q^2_0)$ are shown in Fig 3a. It is seen from the table that the first moments $\Delta \Sigma(1)$ in the JET and AB schemes are in a very good agreement. (We recall that according to the definition of the JET and AB schemes $\Delta \Sigma(1)$ should be the same in the both schemes.) The corresponding densities $\Delta \Sigma(x, Q^2)$, however, are slightly different (see Fig. 3a) because their higher moments are not equal.

Our result for $\Delta \Sigma(1)_{\overline{MS} \Rightarrow JET, AB}$ using the values of $\Delta \Sigma(1)_{\overline{MS}}$ and $(\eta_g)_{\overline{MS}}$ from Table 1 and the NLO transformation rules (see eqs. (7) and (14) for $n = 1$)

$$\Delta \Sigma(1)_{\overline{MS} \Rightarrow JET, AB} = 0.476 \pm 0.084$$ (23)

coincides within errors with the values of $\Delta \Sigma(1)_{JET}$ and $\Delta \Sigma(1)_{AB}$

$$\Delta \Sigma(1)_{JET} = 0.416 \pm 0.036, \quad \Delta \Sigma(1)_{AB} = 0.444 \pm 0.040$$ (24)

determined directly by the fit to the data in the JET and AB schemes as presented in Table 1. The singlet densities $\Delta \Sigma(x, Q^2_0)_{JET}$ (solid curve) and $\Delta \Sigma(x, Q^2_0)_{\overline{MS} \Rightarrow JET}$ (dashed curve) are shown in Fig. 3b.
Finally, we would like to draw attention to the excellent agreement between the values of the axial charge $a_0(1 \text{ GeV}^2)$ determined in the different schemes (see Table 1), which illustrates impressively how our analysis respects the scheme-independence of physical quantities.

In conclusion, we have performed a next-to leading order QCD analysis of the world data on inclusive polarized deep inelastic lepton-nucleon scattering in the JET, AB and $\overline{\text{MS}}$ schemes. The QCD predictions have been confronted with the data on the virtual photon-nucleon asymmetry $A_1^N(x, Q^2)$, rather than with the polarized structure function $g_1^N(x, Q^2)$, in order to minimize higher twist effects. Using the simple parametrization (18) (with only 5 free parameters) for the input polarized parton densities it was demonstrated that the polarized DIS data are in an excellent agreement with the pQCD predictions for $A_1^N(x, Q^2)$ in all the factorization schemes considered.

Moreover, we have demonstrated the consistency between the results of the analysis in each scheme and the NLO transformation equations relating them. Such consistency gives us confidence that the NLO analysis is reliable.

Acknowledgments

We are grateful to O. V. Teryaev for useful discussions and remarks.

This research was partly supported by a UK Royal Society Collaborative Grant, by the Russian Fund for Fundamental Research Grant No 96-02-17435a and by the Bulgarian Science Foundation under Contract Ph 510.

References

[1] SLAC/E154 Collaboration, K. Abe et al., Phys. Rev. Lett. 79 (1997) 26.
[2] SMC, D. Adeva et al., Phys. Lett. B 412 (1997) 414.
[3] SLAC E143 Collaboration, K. Abe et al., Preprint SLAC-PUB-7753, Feb 1998, e-Print Archive:hep-ph/9802357.
[4] T. Gehrmann and W. J. Stirling, Phys. Rev. D 53 (1996) 6100.
[5] M. Glück, E. Reya, M. Stratmann and W. Vogelsang, Phys. Rev. D 53 (1996) 4775.
[6] R. D. Ball, S. Forte and G. Ridolfi, Phys. Lett. B 378 (1996) 255.

[7] G. Altarelli, R. D. Ball, S. Forte and G. Ridolfi, Nucl. Phys. B 496 (1997) 337; Acta Phys. Polon. B 29 (1998) 1145, e-Print Archive: hep-ph/9803237.

[8] SLAC/E154 Collaboration, K. Abe et al., Phys. Lett. B 405 (1997) 180.

[9] E. Leader, A. V. Sidorov and D. B. Stamenov, e-Print Archive: hep-ph/9708337 (to be published in IJMPA).

[10] M. Stratmann, Preprint DO-TH 97/22, October 1997, e-Print Archive: hep-ph/9710379.

[11] A. De Roeck at al., Preprint DESY 97-249, e-Print Archive: hep-ph/9801300.

[12] C. Bourrely, F. Buccella, O. Pisanti, P. Santorelli and J. Soffer, Preprint CPT-97/P 3578, e-Print Archive: hep-ph/9803229.

[13] E. Leader, A. V. Sidorov and D. B. Stamenov, e-Print Archive: hep-ph/9807251 (to appear in Phys. Rev. D).

[14] A. V. Efremov and O. V. Teryaev, Dubna report E2-88-287, 1988 (published in the Proceedings of the Int. Hadron Symposium, Bechyne, Czechoslovakia, 1988, eds. J. Fischer et al. (Czech Academy of Science, Prague, 1989), p. 302); G. Altarelli and G. G. Ross, Phys. Lett. B 212 (1988) 381.

[15] R. D. Carlitz, J. C. Collins and A.H. Mueller, Phys. Lett. B 214 (1988) 229.

[16] R. Mertig and W. L. van Neerven, Z. Phys. C 70 (1996) 637; W. Vogelsang, Phys. Rev. D 54 (1996) 2023.

[17] S. Adler and W. Bardeen, Phys. Rev. 182 (1969) 1517.

[18] EMC, J. Ashman et al., Phys. Lett. B 206 (1988) 364; Nucl. Phys. B 328 (1989) 1.

[19] E. Leader and M. Anselmino, Z. Phys. C 41 (1988) 239.

[20] E. B. Zijlstra and W. L. van Neerven, Nucl. Phys. B 147 (1994) 61.

[21] A. V. Efremov and O. V. Teryaev, SPIN-89, in Proc. of III International Workshop, p. 77.

[22] M. Anselmino, A. V. Efremov and E. Leader, Phys. Rep. 261 (1995) 1.
[23] D. Müller and O. V. Teryaev, Phys. Rev. D 56 (1997) 2607.

[24] Hai-Yang Cheng, Phys. Lett. B 427 (1998) 371.

[25] A. D. Martin, R. G. Roberts, W. J. Stirling and R. S. Torn, Eur. Phys. J. C 4 (1998) 463.

[26] Particle Data Group, L. Montanet et al., Phys. Rev. D 50 (1994) 1173; F. E. Close and R. G. Roberts, Phys. Lett. B 313 (1993) 165.

[27] SLAC E142 Collaboration, P. L. Anthony et al., Phys. Rev. D 54 (1996) 6620.

[28] SMC, D. Adams et al., Phys. Lett. B 396 (1997) 338.

[29] HERMES Collaboration, K. Ackerstaff et al., Phys. Lett. B 404 (1997) 383.

[30] HERMES Collaboration, A. Airapetian et al., e-Print Archive: hep-ex/9807015.
Figure Captions

**Fig. 1** Comparison of our NLO results in the JET scheme for $A_1^N(x, Q^2)$ with the experimental data at the measured $x$ and $Q^2$ values. Errors bars represent the total error.

**Fig. 2** Next-to-leading order input polarized valence and gluon distributions at $Q^2 = 1\, GeV^2$ in different factorization schemes. Solid, dotted and dashed curves correspond to the JET, AB and $\overline{MS}$ scheme, respectively.

**Fig. 3** (a) Next-to-leading order input polarized singlet distributions $\Delta \Sigma(x)$ at $Q^2 = 1\, GeV^2$ in different factorization schemes. Solid, dotted and dashed curves correspond to the JET, AB and $\overline{MS}$ scheme, respectively. (b) Comparison between the singlet density $\Delta \Sigma(x)_{JET}$ obtained from the fit (solid curve) and $\Delta \Sigma(x)_{\overline{MS}\to JET}$ determined by eq. (14) (dashed curve), at $Q^2 = 1\, GeV^2$. 


Fig. 1
$Q^2 = 1 \text{ GeV}^2$
$x\Delta \Sigma$

$Q^2 = 1 \text{ GeV}^2$

Fig. 3