11/10/2004

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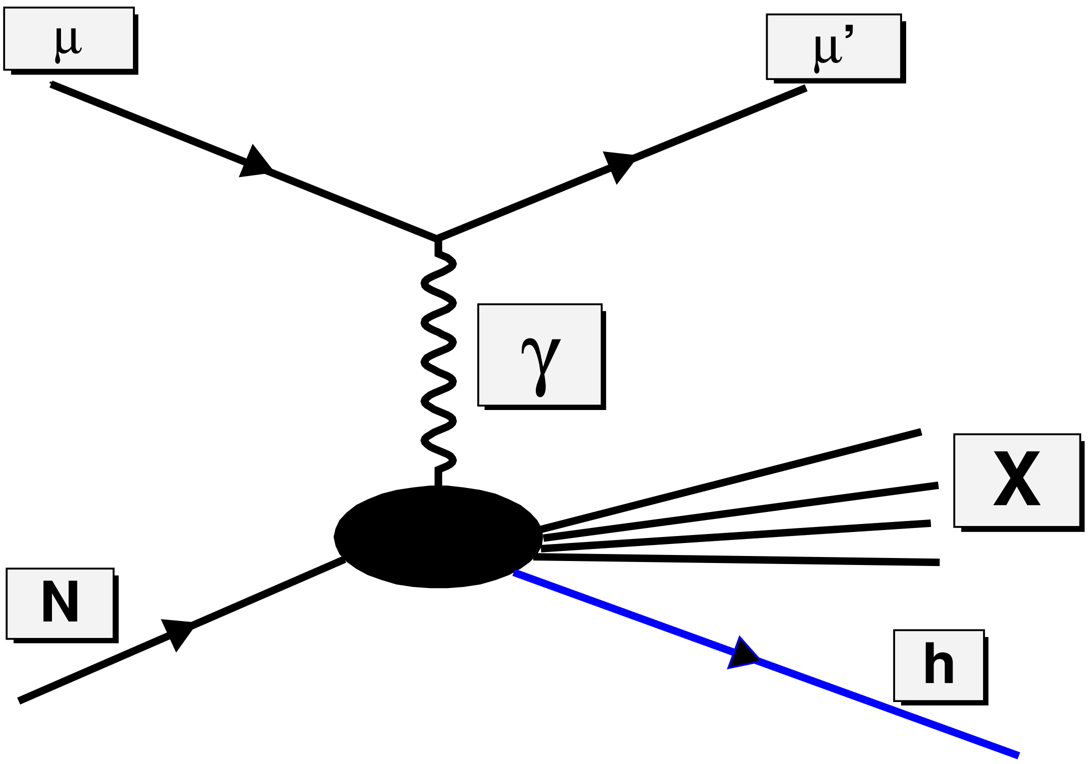
NLO QCD procedure with respect to first moments of polarized quark densities

Polarized SIDIS:



$$q = (E_\gamma, \vec{q}) \quad q^2 = -Q^2 < 0$$

$$x = \frac{Q^2}{2pq}, \quad y = \frac{pq}{p\mu} = \frac{E_h}{E_\gamma} \text{ (lab system)}$$

$$z_h = \frac{ph}{pq} = \frac{E_h}{E_\gamma} \text{ (lab system)}$$

$$\Delta q(x, Q^2) = q_{\uparrow\downarrow}(x, Q^2) - q_{\uparrow\uparrow}(x, Q^2)$$

$$q = (u, d, s; g)$$

- DIS: Only $\Delta q + \Delta\bar{q}$ can be extracted

$$A_p = \frac{\Sigma_{q=u,d,s}\, e_q^2(\Delta q(x,Q^2) + \Delta\bar{q}(x,Q^2))}{\Sigma_{q=u,d,s}\, e_q^2(q(x,Q^2) + \bar{q}(x,Q^2))} \quad \text{(LO)}$$

- SIDIS: Δq and $\Delta\bar{q}$ can be extracted separately

$$A_p^h = \frac{\Sigma_{q=u,d,s}\, e_q^2(\Delta q(x,Q^2)D_q^h(z_h,Q^2) + \Delta\bar{q}(x,Q^2)D_{\bar{q}}^h(z_h,Q^2))}{\Sigma_{q=u,d,s}\, e_q^2(q(x,Q^2)D_q^h(z_h,Q^2) + \bar{q}(x,Q^2)D_{\bar{q}}^h(z_h,Q^2))} \quad \text{(LO)}$$

  But! Fragmentation functions are involved.

- FFs: if we have $(A_{p,d}, A_{p,d}^{\pi^\pm}, A_{p,d}^{K^\pm})$ and $D_q^{\pi^\pm}$, $D_q^{K^\pm}$ $\longrightarrow$ we can extract full set $\Delta u, \Delta d, \Delta s, \Delta\bar{u}, \Delta\bar{d}, \Delta s, \Delta\bar{s}$.

  Rather well known: $D_q^{\pi^\pm}$ (except for $D_{s,\bar{s}}^{\pi^\pm} \simeq D_d^{\pi^+}$)

  Badly known: $D_q^{K^\pm}$ – small number of parametrizations with different assumptions

- Higher order corrections: Available to the modern SIDIS experiments avearge $Q^2 \le 10\, GeV^2$ (HERMES: $Q^2 \simeq 2.5\, GeV^2$) $\Rightarrow$ LO is not sufficient

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  $\Rightarrow$ at least NLO corrections are required for the analysis;
  NLO QCD analysis is very complicated

NLO QCD extraction method:

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- simple and transparent formalism, no assumptions, can be used for all types of asymmetries

Polarized SIDIS structure function:

$$\boxed{\begin{aligned} 2g_1^{p/h} &= \sum_{q,\bar{q}} e_q^2 \Delta q [1 + \otimes \frac{\alpha_s}{2\pi} \Delta C_{qq} \otimes] D_q^h \\ &+ (\sum_{q,\bar{q}} e_q^2 \Delta q) \otimes \frac{\alpha_s}{2\pi} \Delta C_{gq} \otimes D_g^h \\ &+ \Delta g \otimes \frac{\alpha_s}{2\pi} \Delta C_{qg} \otimes (\sum_{q,\bar{q}} e_q^2 D_q^h), \end{aligned}}$$

$$g_1^{n/h} = g_1^{p/h}|_{u \leftrightarrow d,\ s \leftrightarrow s},$$

$$[A \otimes B \otimes C](x, z) \equiv$$

$$\int_{\mathcal{D}} \int \frac{dx'}{x'} \frac{dz'}{z'} A\left(\frac{x}{x'}\right) B(x', z') C\left(\frac{z}{z'}\right).$$

$$\boxed{z = E_h/E_P(1-x)(\ \gamma p \text{ c.m. frame})}$$

The range of integration $\mathcal{D}$ has a very complicated form:

$$\frac{x}{x + (1-x)z} \leq x' \leq 1 \ with \ z \leq z' \leq 1,$$

if $x + (1-x)z \geq 1$, and, additionally, range

$$x \leq x' \leq x/(x + (1-x))z$$

with $x(1-x')/(x'(1-x)) \leq z' \leq 1$ if $x + (1-x)z \leq 1$.

NLO method of $\Delta_1\bar{u} - \Delta_1\bar{d}$ extraction with the difference asymmetries

$$z_h = E_h/E_\gamma \text{ lab. system }, \; z_h > Z = 0.2$$

$$[A \otimes B \otimes C] = \int_x^1 \frac{dx'}{x'} \int_{z_h}^1 \frac{dz'}{z'} A\left(\frac{x}{x'}\right) B(x', z')\, C\left(\frac{z_h}{z'}\right).$$

$$N^h_{\uparrow\downarrow(\uparrow\uparrow)}(x, Q^2)|_Z = \int_Z^1 dz_h \; n^h_{\uparrow\downarrow(\uparrow\uparrow)}(x, Q^2; z_h)$$

$$A_N^{h-\bar{h}}(x, Q^2)|_Z = \frac{1}{P_B P_T f D} \frac{(N^h_{\uparrow\downarrow} - N^{\bar{h}}_{\uparrow\downarrow}) - (N^h_{\uparrow\uparrow} - N^{\bar{h}}_{\uparrow\uparrow})}{(N^h_{\uparrow\downarrow} - N^{\bar{h}}_{\uparrow\downarrow}) + (N^h_{\uparrow\uparrow} - N^{\bar{h}}_{\uparrow\uparrow})}|_Z =$$

$$= \frac{\int_Z^1 dz_h (g_1^{N/h} - g_1^{N/\bar{h}})}{\int_Z^1 dz_h (F_1^{N/h} - F_1^{N/\bar{h}})} \quad (N = p, d),$$

$$A_p^{\pi^+-\pi^-}(x,Q^2)|_Z = \frac{(4\Delta u_V - \Delta d_V)\int_Z^1 dz_h[1+\otimes\frac{\alpha_s}{2\pi}\delta C_{qq}\otimes](D_1-D_2)}{(4u_V - d_V)\int_Z^1 dz_h[1+\otimes\frac{\alpha_s}{2\pi}C_{qq}\otimes](D_1-D_2)},$$

$$A_d^{\pi^+-\pi^-}(x,Q^2)|_Z = \frac{(\Delta u_V + \Delta d_V)\int_Z^1 dz_h[1+\otimes\frac{\alpha_s}{2\pi}\delta C_{qq}\otimes](D_1-D_2)}{(u_V + d_V)\int_Z^1 dz_h[1+\otimes\frac{\alpha_s}{2\pi}C_{qq}\otimes](D_1-D_2)},$$

$D_1 \equiv D_u^{\pi^+} = D_{\bar{u}}^{\pi^-} = D_{\bar{d}}^{\pi^+} = D_d^{\pi^-}$ – favored,
$D_2 \equiv D_d^{\pi^+} = D_{\bar{d}}^{\pi^-} = D_u^{\pi^-} = D_{\bar{u}}^{\pi^+}$ – unfavored.

The proposed NLO QCD procedure is based on:

- 1) Application of difference asymmetries.
- 2) $M^n[A\otimes B] \equiv \int_0^1 dx x^{n-1} \int_x^1 \frac{dy}{y} A\left(\frac{x}{y}\right) B(y)$ $= M^n(A) M^n(B)$.
- 3) BSR in the form

$$\Delta_1\bar{u} - \Delta_1\bar{d} = \frac{1}{2}\left|\frac{g_A}{g_V}\right| - \frac{1}{2}(\Delta_1 u_V - \Delta_1 d_V)$$

Result:

$$\boxed{\Delta\bar{u} - \Delta\bar{d} = \frac{1}{2}\frac{g_A}{g_V} - \frac{2\mathcal{A}_p^{exp} - 3\mathcal{A}_d^{exp}}{10(L_1 - L_2)}.}$$

$$L_q^h \equiv \int_Z^1 dz_h \left[D_q^h(z_h) + \frac{\alpha_s}{2\pi}\int_{z_h}^1 \frac{dz'}{z'}\ \Delta_1 C_{qq}(z') D_q^h\left(\frac{z_h}{z'}\right)\right],$$

$$\begin{aligned} L_1 &\equiv L_u^{\pi^+} = L_{\bar{u}}^{\pi^-} = L_{\bar{d}}^{\pi^+} = L_d^{\pi^-}, \\ L_2 &\equiv L_d^{\pi^+} = L_{\bar{d}}^{\pi^-} = L_u^{\pi^-} = L_{\bar{u}}^{\pi^+}. \end{aligned}$$

$$\boxed{\begin{aligned} &\mathcal{A}_p^{exp} \equiv \int_0^1 dx\ A_p^{\pi^+-\pi^-}|_Z (4u_V - d_V) \\ &\times \int_Z^1 dz_h [1 + \otimes\frac{\alpha_s}{2\pi} C_{qq} \otimes](D_1 - D_2), \end{aligned}}$$

$$\boxed{\begin{aligned} &\mathcal{A}_d^{exp} \equiv \int_0^1 dx\ A_d^{\pi^+-\pi^-}|_Z (u_V + d_V) \\ &\times \int_Z^1 dz_h [1 + \otimes\frac{\alpha_s}{2\pi} C_{qq} \otimes](D_1 - D_2). \end{aligned}}$$

Errors on the difference asymmetries

$$A_{p(n,d)}^{\pi^+-\pi^-} = \frac{1}{D}\left[\frac{(N_{\uparrow\downarrow}^{\pi^+} - N_{\uparrow\downarrow}^{\pi^-})L_{\uparrow\uparrow} - (N_{\uparrow\uparrow}^{\pi^+} - N_{\uparrow\uparrow}^{\pi^-})L_{\uparrow\downarrow}}{(N_{\uparrow\downarrow}^{\pi^+} - N_{\uparrow\downarrow}^{\pi^-})L_{\uparrow\uparrow} + (N_{\uparrow\uparrow}^{\pi^+} - N_{\uparrow\uparrow}^{\pi^-})L_{\uparrow\downarrow}}\right],$$

$$L_{\uparrow\uparrow(\uparrow\downarrow)} = (n\Phi)_{\uparrow\uparrow(\uparrow\downarrow)}$$

$$\boxed{\begin{aligned}&\delta^2(A_{p(n,d)}^{\pi^+-\pi^-}) = \\ &\frac{4L_{\uparrow\uparrow}^2 L_{\uparrow\downarrow}^2}{D^2}\frac{(N_{\uparrow\uparrow}^{\pi^+} - N_{\uparrow\uparrow}^{\pi^-})^2[N_{\uparrow\downarrow}^{\pi^+} + N_{\uparrow\downarrow}^{\pi^-}] + (N_{\uparrow\downarrow}^{\pi^+} - N_{\uparrow\downarrow}^{\pi^-})^2[N_{\uparrow\uparrow}^{\pi^+} + N_{\uparrow\uparrow}^{\pi^-}]}{[(N_{\uparrow\downarrow}^{\pi^+}L_{\uparrow\uparrow} + N_{\uparrow\uparrow}^{\pi^+}L_{\uparrow\downarrow}) - (N_{\uparrow\downarrow}^{\pi^-}L_{\uparrow\uparrow} + N_{\uparrow\uparrow}^{\pi^-}L_{\uparrow\downarrow})]^4}\end{aligned}}$$

$$N^{\pi^\pm} = N_{\uparrow\uparrow}^{\pi^\pm} + N_{\downarrow\downarrow}^{\pi^\pm}$$

$$\boxed{\delta^2(A_{p(n,d)}^{\pi^+-\pi^-}) = \frac{16L_{\uparrow\downarrow}^2 L_{\uparrow\uparrow}^2}{D^2(L_{\uparrow\downarrow} + L_{\uparrow\uparrow})^4}\,\frac{N^{\pi^+} + N^{\pi^-}}{(N^{\pi^+} - N^{\pi^-})^2}}$$

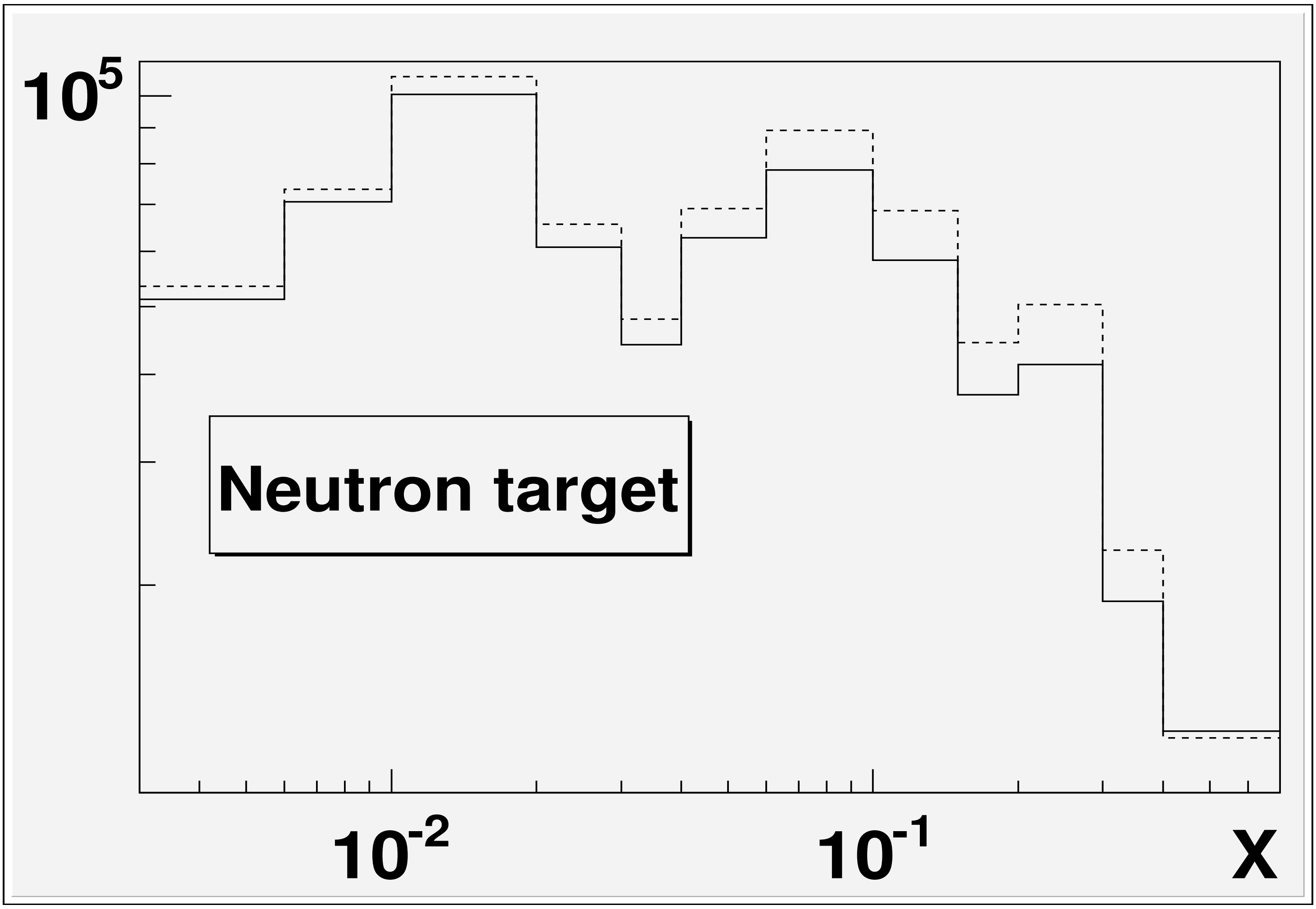

Figure 1: N^{π^+} and N^{π^-} for neutron target. The dashed and continuous lines correspond to π^+, and π^- productions, respectively.

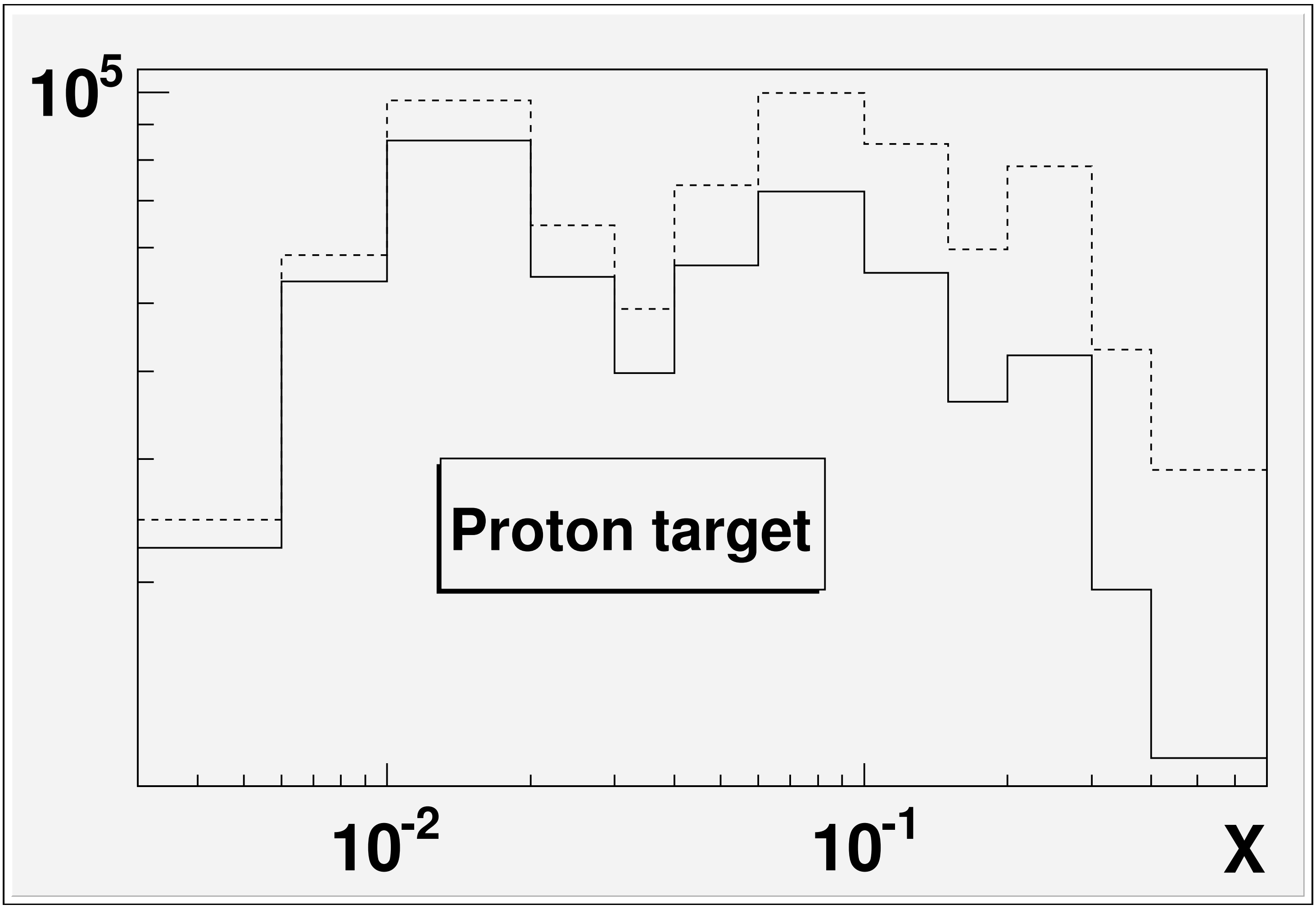

Figure 2: N^{π^+} and N^{π^-} for proton target. The dashed and continuous lines correspond to π^+, and π^- productions, respectively.

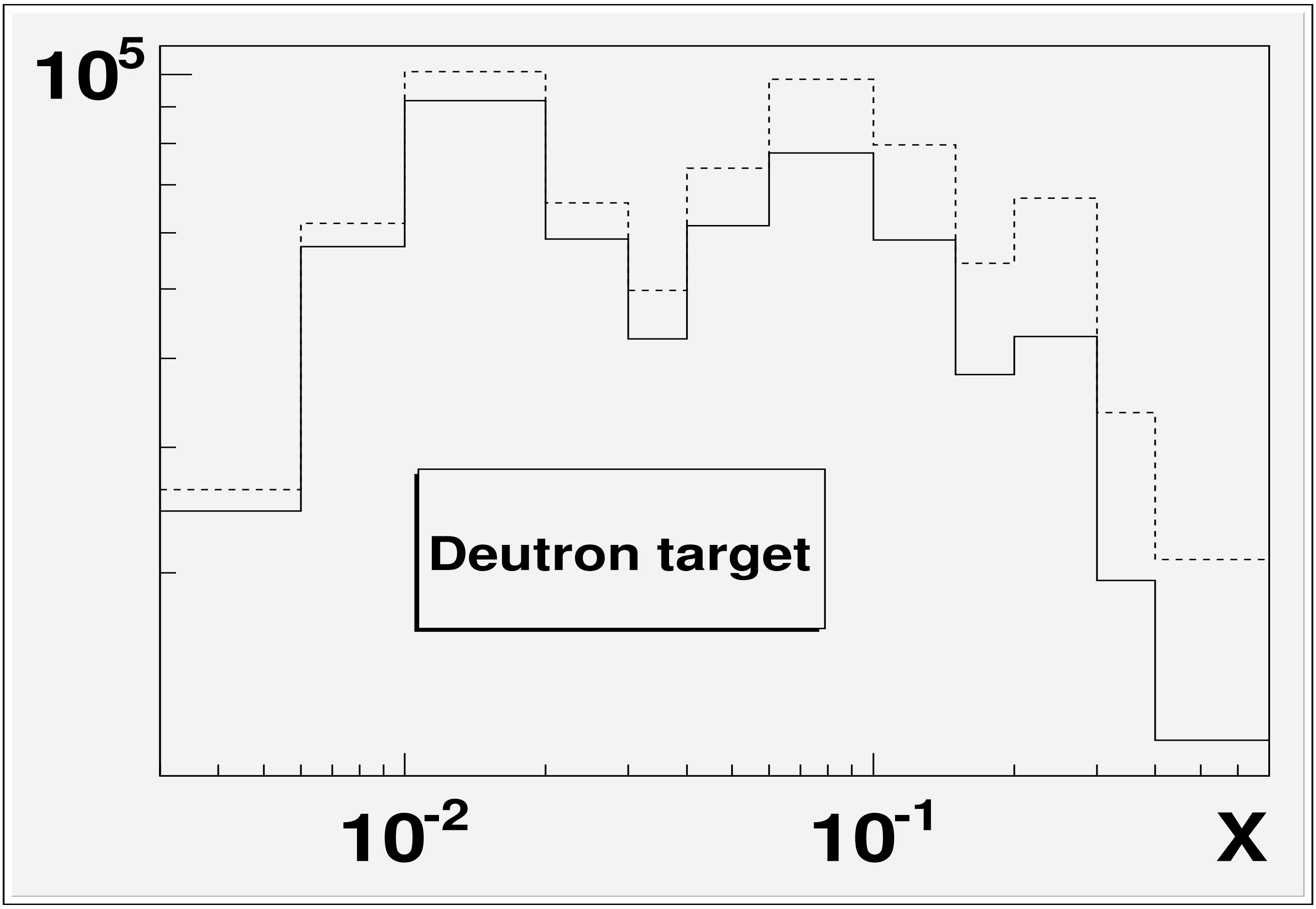

Figure 3: N^{π^+} and N^{π^-} for deutron target. The dashed and continuous lines correspond to π^+, and π^- productions, respectively.

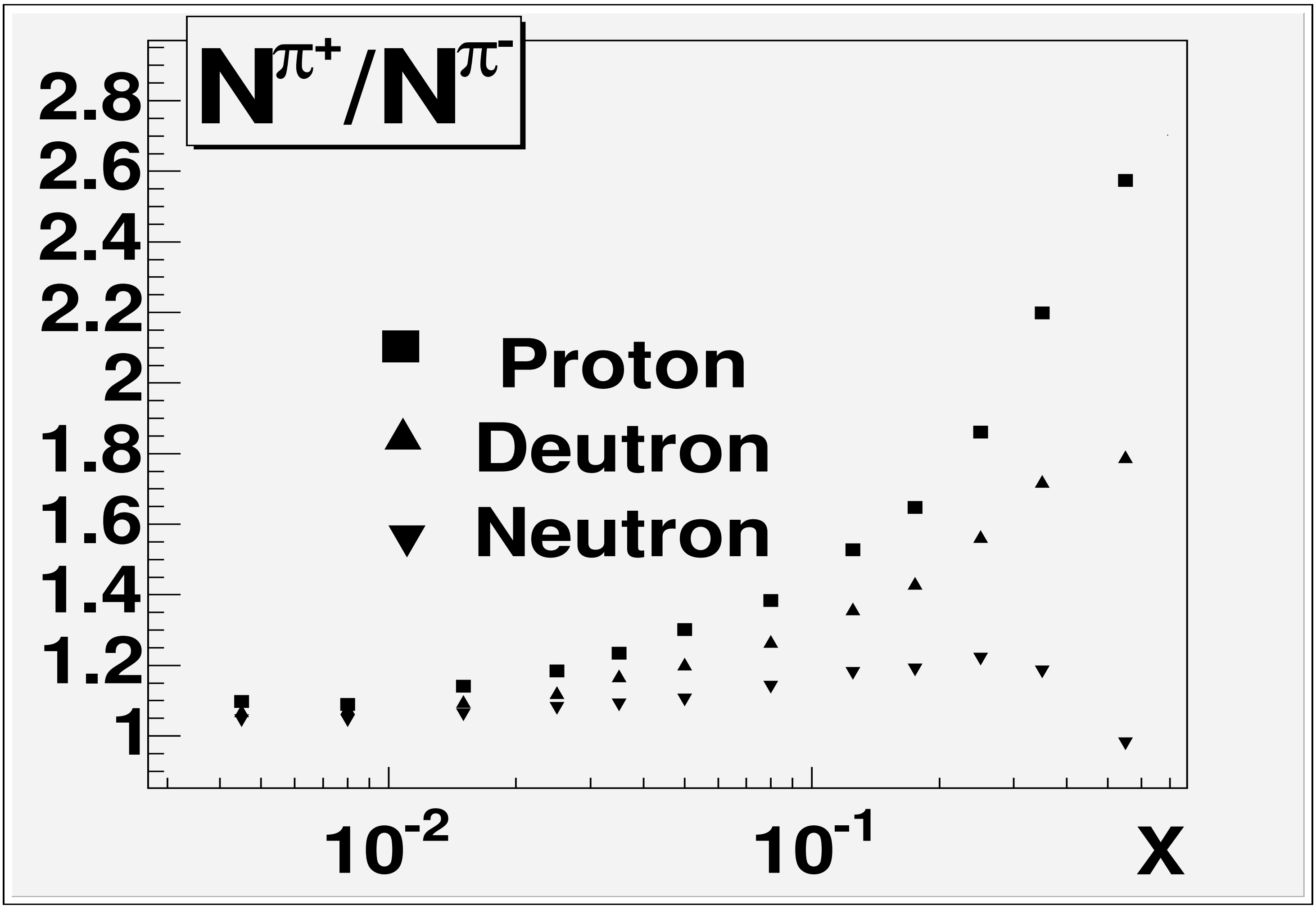

Figure 4: Ratios of $N^{\pi^+} \equiv N^{\pi^+}_{\uparrow\downarrow} + N^{\pi^+}_{\uparrow\uparrow}$ and $N^{\pi^-} \equiv N^{\pi^-}_{\uparrow\downarrow} + N^{\pi^-}_{\uparrow\uparrow}$ obtained with the polarized event generator PEPSI for the different targets. The picture is in good agreement with the respective EMC result.

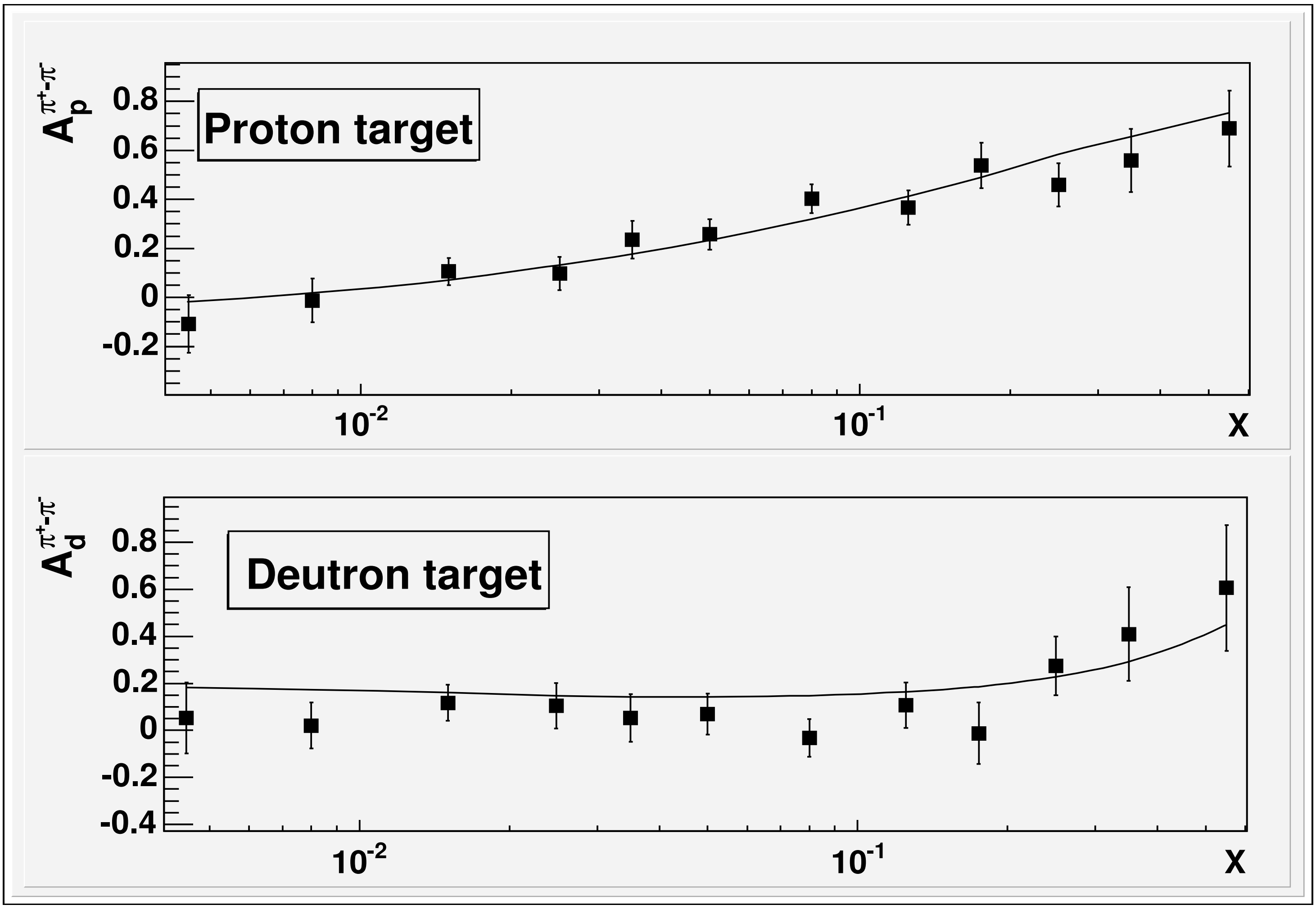

Figure 5: Simulated and theoretical pion difference asymmetries for proton and deutron targets. The continuous lines correspond to the theoretical asymmetries obtained from Eq. (3) with GRSV2000**LO**(broken sea) parametrizations for the valence distributions.

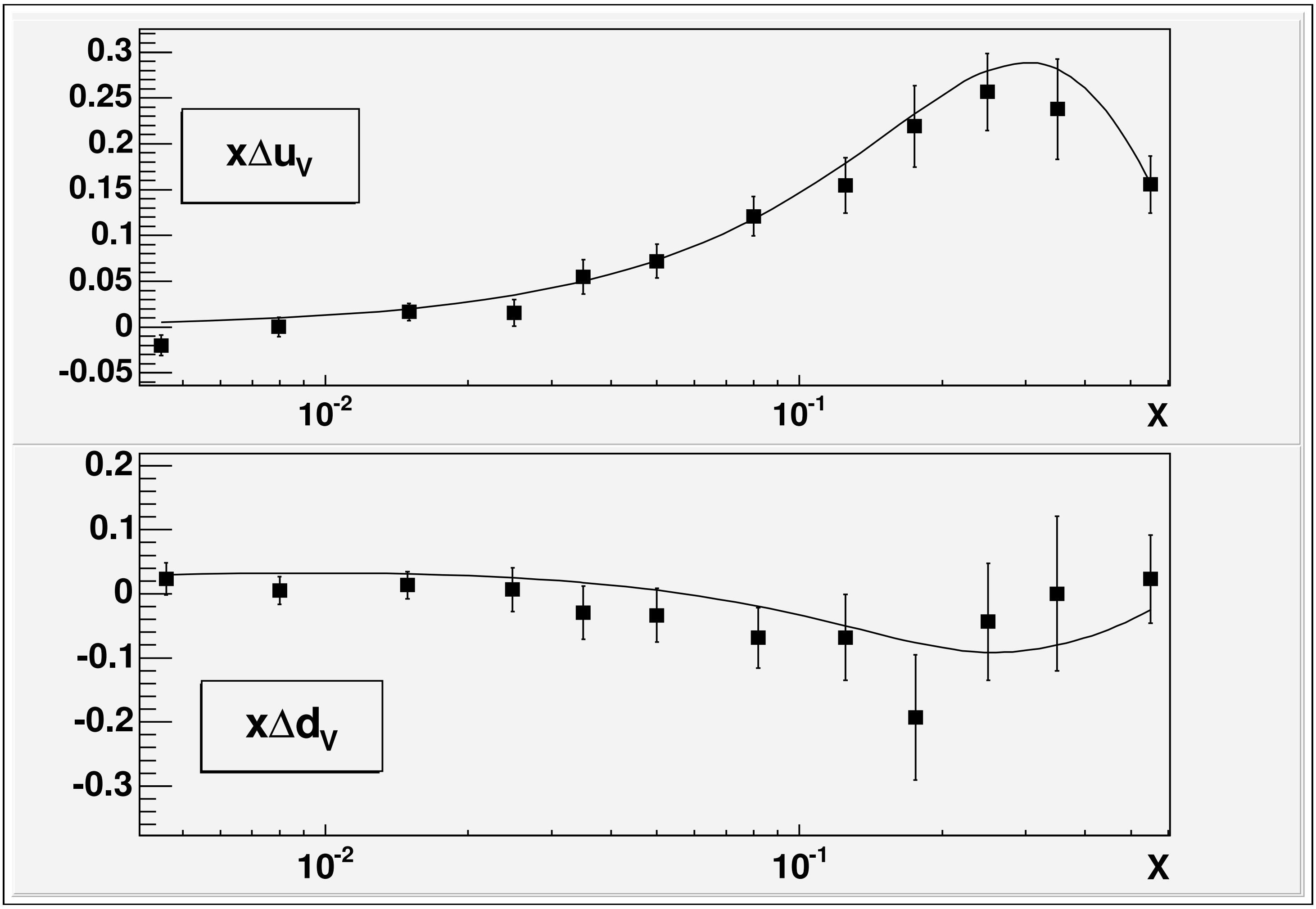

Figure 6: Polarized valence distributions. The continuous lines corresponds to the respective GRSV2000**LO**(broken sea) paramterizations.

To perform the NLO QCD analysis, we first choose the GRSV2000**NLO** parametrization as an input. The conditions of simulations are presented in Table 1 and correspond to HERMES and SMC (COMPASS) kinematics.

Table 1: Simulation conditions. A and B correspond to HERMES and SMC (COMPASS) kinematics, respectively. Here x_B and x_F are the Bjorken and Feynman x variables, respectively, $z_h =$ is the standard hadronic variable and W is the invariant mass of the final hadronic state.

	Kinematics A	Kinematics B
E_{lepton}	$27.5\,GeV$	$160\,GeV$
x_B	$0.023 < x_B < 0.6$	$0.003 < x_B < 0.7$
x_F	$x_F > 0.1$	$x_F > 0.1$
z_h	$z_h > Z = 0.2$	$z_h > Z = 0.2$
W^2	$W^2 > 10\,GeV^2$	$W^2 > 10\,GeV^2$
Events	$3 \cdot 10^6$	$3 \cdot 10^6$

Broken sea scenario

Table 2: GRSV2000**NLO**(broken sea) parametrization. Results on $\Delta_1^* u_V$, $\Delta_1^* d_V$ and $[\Delta_1^*\bar{u} - \Delta_1^*\bar{d}]_{BSR}$ extracted from the simulated difference asymmetries applying the proposed NLO procedure.

Kinematics	Q^2_{mean}	$\Delta_1^* u_V$	$\Delta_1^* d_V$	$[\Delta_1^*\bar{u} - \Delta_1^*\bar{d}]_{BSR}$
A	$2.4\,GeV^2$	0.585 ± 0.017	-0.147 ± 0.037	0.268 ± 0.020
B	$7.0\,GeV^2$	0.602 ± 0.032	-0.110 ± 0.080	0.278 ± 0.040

Table 3: Results on $\Delta_1^* u_V$, $\Delta_1^* d_V$, $\Delta_1^*\bar{u} - \Delta_1^*\bar{d}$ and $[\Delta_1^*\bar{u} - \Delta_1^*\bar{d}]_{BSR}$ obtained from integration of the GRSV2000**NLO**(broken sea) parametrization of the quark distributions over the total and experimentally available Bjorken x regions. The fifth column is obtained by direct integration of the respective parametrizations. The sixth column is obtained using BSR and the parametrizations for the valence distributions.

x_B	Q^2	$\Delta_1^* u_V$	$\Delta_1^* d_V$	$\Delta_1^*\bar{u} - \Delta_1^*\bar{d}$	$[\Delta_1^*\bar{u} - \Delta_1^*\bar{d}]_{BSR}$
$0.0001 < x_{Bj} < 0.99$	$2.4\,GeV^2$	0.605	-0.031	0.310	0.315
$0.023 < x_{Bj} < 0.6$	$2.4\,GeV^2$	0.569	-0.114	$\underline{0.170}$	0.292
$0.0001 < x_{Bj} < 0.99$	$7.0\,GeV^2$	0.604	-0.032	0.309	0.315
$0.003 < x_{Bj} < 0.7$	$7.0\,GeV^2$	0.598	-0.065	$\underline{0.262}$	0.302

$$[\Delta_1\bar{u} - \Delta_1\bar{d}]_{exact} \simeq [\Delta_1^*\bar{u} - \Delta_1^*\bar{d}]_{25} = \int_{0.0001}^{0.99} dx[\Delta\bar{u} - \Delta\bar{d}]_{parametrization} = 0.310,$$

$$[\Delta_1^*\bar{u} - \Delta_1^*\bar{d}]_{35} = \int_{0.023}^{0.6} dx[\Delta\bar{u} - \Delta\bar{d}]_{parametrization} = 0.170.$$

$$\begin{aligned}[\Delta_1\bar{u} - \Delta_1\bar{d}]^{BSR}_{36} = \frac{1}{2}\frac{g_A}{g_V} - \frac{1}{2}\int_{0.023}^{0.6} dx[\Delta u_V - \Delta d_V]_{parametrization} \\ = 0.292,\end{aligned}$$

Symmetric sea scenario

Table 4: The upper part presents the results on $\Delta_1^* u_V$, $\Delta_1^* d_V$ and $[\Delta_1^*\bar{u} - \Delta_1^*\bar{d}]_{BSR}$ obtained from integration of the GRSV2000**NLO**(symmetric sea) parametrization. The lower part presents the results on $\Delta_1^* u_V$, $\Delta_1^* d_V$ and $[\Delta_1^*\bar{u} - \Delta_1^*\bar{d}]_{BSR}$ extracted from the simulated difference asymmetries applying the proposed NLO procedure with parametrization GRSV2000**NLO**(symmetric sea) entering the generator as the input.

x_B	Q^2	$\Delta_1^* u_V$	$\Delta_1^* d_V$	$[\Delta_1^*\bar{u} - \Delta_1^*\bar{d}]_{BSR}$
$0.023 < x_{Bj} < 0.6$	$2.4\,GeV^2$	0.749	-0.276	0.121
$0.003 < x_{Bj} < 0.7$	$7.0\,GeV^2$	0.866	-0.320	0.041
$0.0001 < x_{Bj} < 0.99$	$2.4\,GeV^2$	0.916	-0.339	0.006
$0.0001 < x_{Bj} < 0.99$	$7.0\,GeV^2$	0.914	-0.339	0.007

Kinematics	Q^2_{mean}	$\Delta_1^* u_V$	$\Delta_1^* d_V$	$\Delta_1^*\bar{u} - \Delta_1^*\bar{d}$
A	2.4	0.736 ± 0.017	-0.310 ± 0.037	0.111 ± 0.020
B	$7.0\,GeV^2$	0.842 ± 0.032	-0.300 ± 0.069	0.063 ± 0.038

NLO method of $\Delta_1 s$ extraction with the sum asymmetries

$$A_N^{h+\bar{h}}(x,Q^2)|_Z =$$

$$\frac{1}{P_B P_T f D}\frac{(N^h_{\uparrow\downarrow}+N^{\bar{h}}_{\uparrow\downarrow})-(N^h_{\uparrow\uparrow}+N^{\bar{h}}_{\uparrow\uparrow})}{(N^h_{\uparrow\downarrow}+N^{\bar{h}}_{\uparrow\downarrow})+(N^h_{\uparrow\uparrow}+N^{\bar{h}}_{\uparrow\uparrow})}|_Z =$$

$$= \frac{\int_Z^1 dz_h(g_1^{N/h}+g_1^{N/\bar{h}})}{\int_Z^1 dz_h(F_1^{N/h}+F_1^{N/\bar{h}})} \quad (N=p,d)$$

The proposed NLO procedure is based on:

1) Sum asymmetry for the deutron target.

2) $M^n(A\otimes B) = M^n(A)M^n(B)$.

3) $\mathrm{SU(3)_f}$ sum rule:

$$a_8 \equiv \Delta_1 u(Q^2)+\Delta_1\bar{u}(Q^2)+\Delta_1 d(Q^2)+\Delta_1\bar{d}(Q^2)$$
$$-2(\Delta_1 s(Q^2)+\Delta_1\bar{s}(Q^2))$$
$$=3F-D=0.579\pm 0.025.$$

Result:

$$(\Delta s+\Delta\bar{s})=\frac{\mathcal{A}_d^{\pi^++\pi^-}-5\,(3F-D)\left(L_1^{[qq]}+L_2^{[qq]}+2L_g^{[gq]}\right)}{10\left(L_1^{[qq]}+L_2^{[qq]}\right)+4L_s^{[qq]}+24L_g^{[gq]}}$$

$$\mathcal{A}_d^{h^++h^-}\equiv \int_0^1 dx\; A_d^{h^++h^-}|_Z \int_Z^1 dz_h \left(F_{1d}^{N/h^+}+F_{1d}^{N/h^-}\right)$$

$$L_q^{[qq]\,h}(Q^2)\equiv\int_Z^1 dz_h\left[D_q^h(z_h,Q^2)+ \frac{\alpha_s}{2\pi}\int_{z_h}^1\frac{dz'}{z'}\,\Delta C_{qq}(z')D_q^h(\frac{z_h}{z'},Q^2)\right]$$

$$L_g^{[gq]\,h}(Q^2)\equiv\frac{\alpha_s}{2\pi}\int_Z^1 dz_h\,\frac{dz'}{z'}\,\Delta C_{gq}(z')\,D_g^h(\frac{z_h}{z'},Q^2)$$

$D_1\equiv D_u^{\pi^+}=D_{\bar{u}}^{\pi^-}=D_{\bar{d}}^{\pi^+}=D_d^{\pi^-}$
– favored,
$D_2\equiv D_d^{\pi^+}=D_{\bar{d}}^{\pi^-}=D_u^{\pi^-}=D_{\bar{u}}^{\pi^+}$
– unfavored,
$D_s\equiv D_s^{\pi^+}=D_s^{\pi^-}=D_{\bar{s}}^{\pi^+}=D_{\bar{s}}^{\pi^-}$
– unfavored.

Simulation results for sum asymmetries.

Simulation conditions.

E_{lepton}	x_{Bj}	x_F	z_h	Events
$160\ GeV$	$0.003 < x_{Bj} < 0.7$	$x_F > 0.1$	$z_h > Z = 0.2$	$3 \cdot 10^6$

Results on $\Delta_1 s + \Delta_1 \bar{s}$ obtained from integration of GRSV2000NLO parametrization (symmetric sea I and broken sea II scenario).

x_{Bj}	Q^2	$[\Delta_1 s + \Delta_1 \bar{s}]_{\mathrm{I}}$	$[\Delta_1 s + \Delta_1 \bar{s}]_{\mathrm{II}}$
$0.0001 < x_{Bj} < 0.99$	$7.45\,\mathrm{GeV}^2$	-0.119	-0.001

GRSV2000NLO (symmetric sea I and asymmetric sea II scenario). Results on $\Delta_1 s + \Delta_1 \bar{s}$ extracted from the simulated sum asymmetry.

x_{Bj}	Q^2_{mean}	$[\Delta_1 s + \Delta_1 \bar{s}]_{\mathrm{I}}$	$[\Delta_1 s + \Delta_1 \bar{s}]_{\mathrm{II}}$
$0.003 < x_{Bj} < 0.7$	$7.45\,\mathrm{GeV}^2$	-0.10 ± 0.01	0.01 ± 0.01

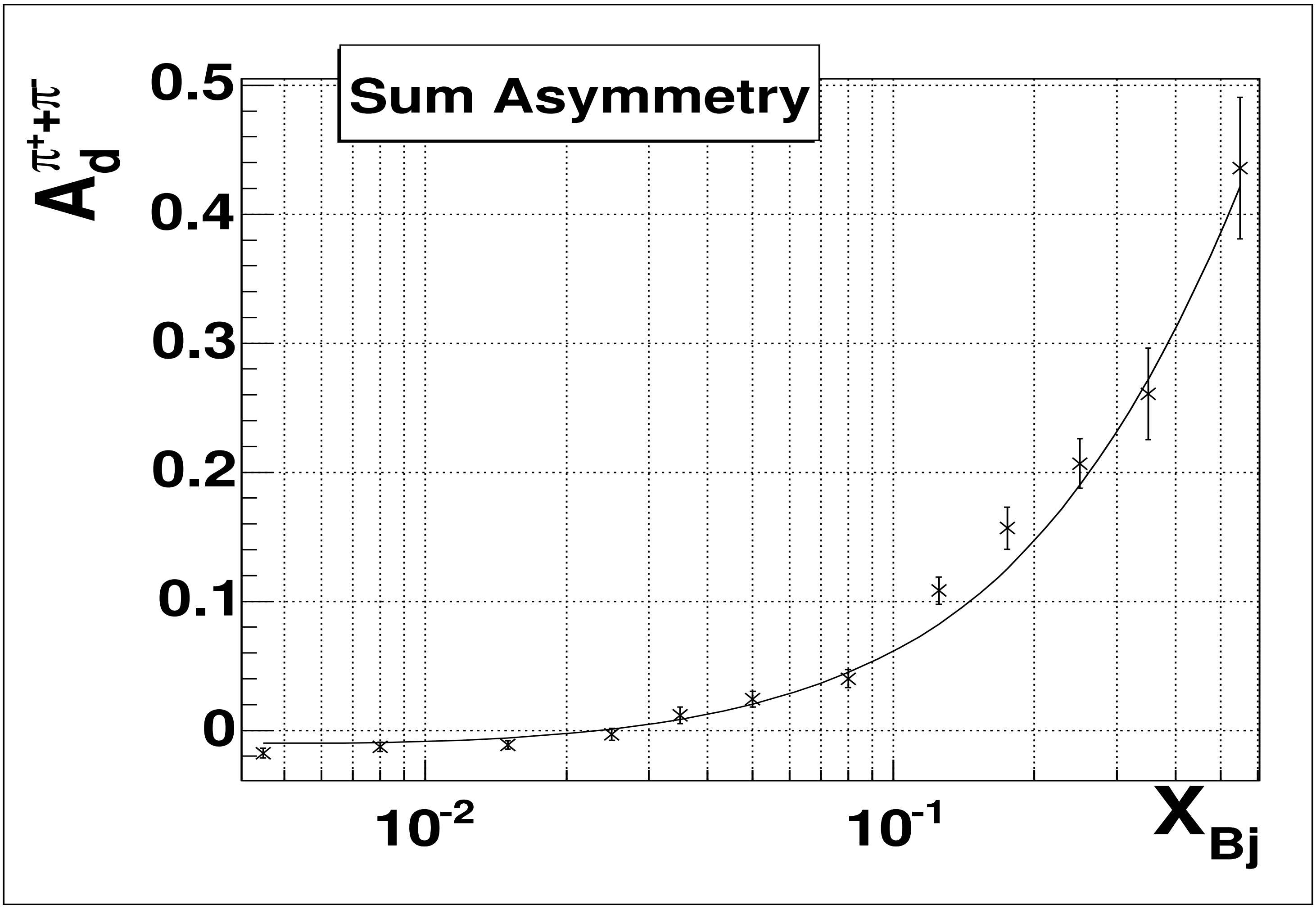

Figure 7: Simulated and theoretical pion sum asymmetries for deutron target. The continuous line correspond to the theoretical asymmetry constructed in NLO with GRSV2000**NLO**(symmetric sea) parametrization.

The final systems of equations for extraction of Δq from the different sets of asymmetries measured at COMPASS (deutron target) have a remarkably simple form – these are purely algebraic equations. For example:

$$\begin{pmatrix} 5(1-\alpha_s/\pi) & 5(1-\alpha_s/\pi) & 4(1-\alpha_s/\pi) \\ 4L_1+L_3 & 4L_2+L_3 & 2L_2+2L_1 \\ \tilde{L}_1+4\tilde{L}_2 & \tilde{L}_1+4\tilde{L}_2 & 4\tilde{L}_1 \end{pmatrix} \begin{pmatrix} \Delta u+\Delta d \\ \Delta\bar{u}+\Delta\bar{d} \\ \Delta s=\Delta\bar{s} \end{pmatrix} = \begin{pmatrix} \mathcal{A}_d \\ \mathcal{A}_d^{K^+} \\ \mathcal{A}_d^{K^0_S} \end{pmatrix},$$

where the coefficients L are the integrals over the hadronic z variable of the NLO QCD Wilson coefficients convoluted with the respective fragmentation functions D: $D_1 = D_{\bar{s}}^{K^+} = ...$(favoured), $D_2 = D_{\bar{s}}^{K^-} = ...$(unfavoured), $D_3 = D_{\bar{d}}^{K^-} = ...$(unfavoured); $\tilde{D}_1 = D_{\bar{s}}^{K^0_S} = ...$(favoured), $\tilde{D}_2 = D_u^{K^0_S} = ...$(unfavoured); the quantities $\mathcal{A}$ contain measured asymmetries and unpolarized Wilson coefficients convoluted with fragmentation functions and unpolarized quark distributions.

Certainly, extracting $(\Delta u + \Delta d, \Delta\bar{u} + \Delta\bar{d}, \Delta s = \Delta\bar{s})$ one can choose another minimal sets of asymmetries entering to the quantities $\mathcal{A}$, for example, $(A_d, A_d^{K^-}, A_d^{K^0_s})$ or $(A_d, A_d^{K^+-K^-}, A_d^{K^++K^-})$. In the last case the respective system reads:

$$\begin{pmatrix} 5(1-\alpha_s/\pi) & 5(1-\alpha_s/\pi) & 4(1-\alpha_s/\pi) \\ 4L_1+4L_2+2L_3 & 4L_1+4L_2+L_3 & 4L_1+4L_2 \\ L_1-L_2 & L_2-L_1 & 0 \end{pmatrix} \begin{pmatrix} \Delta u+\Delta d \\ \Delta\bar{u}+\Delta\bar{d} \\ \Delta s=\Delta\bar{s} \end{pmatrix} = \begin{pmatrix} \mathcal{A}_d \\ \mathcal{A}_d^{K^++K^-} \\ \mathcal{A}_d^{K^+-K^-} \end{pmatrix},$$

where $\mathcal{A}_d^{K^+-K^-}$ and $\mathcal{A}_d^{K^++K^-}$ contain so called "difference" $A_d^{K^+-K^-}$ and and sum $A_d^{K^++K^-}$ asymmetries, respectively.

It is of importance that the quantities entering to these systems for extraction of Δq in NLO QCD in the COMPASS conditions, contain only the measured asymmetries, NLO QCD expressions for the Wilson coefficients and the known unpolarized data.

The presented systems, are, certainly, a minimal systems of equations – nondegenerate systems with the minimal sets of asymmetries allowing to directly solve the system with respect to NLO QCD quanitities $\Delta u + \Delta d, \Delta\bar{u} + \Delta\bar{d}, \Delta s = \Delta\bar{s}$.

On the other hand, one can improve the precision of analysis using the additional asymmetries within the fit method via the minimization of

$$\chi^2 = (\vec{\mathcal{A}}_m - \vec{\mathcal{A}}_T)^T \mathrm{Cov}_A^{-1} (\vec{\mathcal{A}}_m - \vec{\mathcal{A}}_T),$$

where $\vec{\mathcal{A}}_m = (\mathcal{A}_d, \mathcal{A}_d^{K^+}, \mathcal{A}_d^{K^-}, \mathcal{A}_d^{K_S^0}, \mathcal{A}_d^{h^+}, \mathcal{A}_d^{h^-})$, $\vec{\mathcal{A}}_T$ is the same quantity computed as a function of a fit parameters $(\Delta u + \Delta d, \Delta\bar{u} + \Delta\bar{d}, \Delta s = \Delta\bar{s})$.

NLO results on $\Delta_1 q$ with the latest HERMES data

(HERMES collaboration, DESY-04-107, Jul 2004; hep-ex/0407032.)

HERMES kinematics:

E_{lepton}	$27.5\,GeV$
x_B	$0.023 < x_B < 0.6$
x_F	$x_F > 0.1$
z_h	$z_h > Z = 0.2$
W^2	$W^2 > 10\,GeV^2$
Events	$1.2 \cdot 10^6$

Asymmetries: $A_{p,d}$, $A^{\pi^\pm}_{p,d}$

Testing of the procedure (Simulation results)

- $\Delta_1 \bar{q} = \Delta_1 \bar{u} = \Delta_1 \bar{d} = \Delta_1 s = \Delta_1 \bar{s}$

Input parametrization	GRSV2000NLO(symmetric sea)		
	$\Delta_1 u$	$\Delta_1 d$	$\Delta_1 \bar{q}$
Input	0.724	-0.302	-0.026
Output	0.684±0.031	-0.275±0.038	-0.022±0.019

NLO results from HERMES data

- $\Delta_1 \bar{q} = \Delta_1 \bar{u} = \Delta_1 \bar{d} = \Delta_1 s = \Delta_1 \bar{s}$

$\Delta_1 u$	$\Delta_1 d$	$\Delta_1 \bar{q}$
0.726±0.044	-0.39±0.050	0.0136±0.039

NLO parametrizations with symmetric sea

	GRSV2000	LSS2001	AAC2000	AAC2003	BB
$\Delta_1 u$	0.723	0.755	0.734	0.691	0.667
$\Delta_1 d$	-0.301	-0.289	-0.274	-0.293	-0.274
$\Delta_1 \bar{q}$	-0.026	-0.039	-0.024	-0.034	-0.024