JefLab - seminar
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Alternative approach

to Semi-Inclusive DIS

and

Tests of Independent Fragmentation

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based on papers written with

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The goal: to obtain the polarized parton densities

$$\Delta u \Rightarrow \Delta u_V, \quad \Delta\bar{u}$$
$$\Delta d \Rightarrow \Delta d_V, \quad \Delta\bar{d}$$
$$\Delta s, \Delta\bar{s}$$
$$\Delta G$$

We have:

- polarized DIS asymmetries in $\overrightarrow{l} + \overrightarrow{N} \to l' + X$:

$$\Delta A_N = \frac{\Delta\sigma_N^{DIS}}{\sigma_N^{DIS}} = \frac{\sum e_q^2(\Delta q + \Delta\bar{q})}{\sum e_q^2(q + \bar{q})}$$

  determine only the combinations

$$\Delta u + \Delta\bar{u}, \quad \Delta d + \Delta\bar{d}, \quad \Delta s + \Delta\bar{s}, \quad \Delta G.$$

- polarized SIDIS asymmetries in $\overrightarrow{l} + \overrightarrow{N} \to l' + h + X$:

$$\Delta A_N^h = \frac{\Delta\sigma_N^h}{\sigma_N^h} = \frac{\sum e_q^2\, \Delta q\, D_q^h}{\sum e_q^2\, q\, D_q^h}, \qquad h = \pi^\pm, K^\pm ...$$

SIDIS

- determines Δq and $\Delta\bar{q}$ separately $\to D_q \neq D_{\bar{q}}$
- we need to know D_q and $D_{\bar{q}}$
- up to now: D_q^h assumed to be known from $e^+e^- \to h + X$ $\Rightarrow$ purities

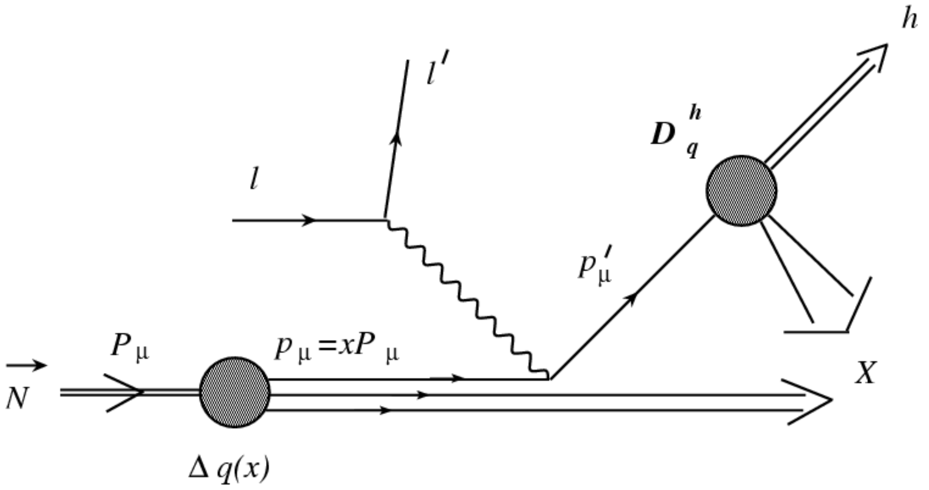
$$D_q \Rightarrow P_q^h = \frac{e_q^2\, q(x) D_q^h}{\sum_q e_q^2\, q(x) D_q^h}$$

- different assumptions about polarized sea quarks $\Delta\bar{q}(x)$

$$\Delta\bar{u} = \Delta\bar{d} = \Delta\bar{s}$$

Semi-Inclusive DIS

$$\Delta A_N^h = \frac{\Delta\sigma_N^h}{\sigma_N^h} = \frac{\sum e_q^2\,\Delta q\,D_q^h}{\sum e_q^2\,q\,D_q^h}, \qquad h = \pi^\pm, K^\pm ...$$



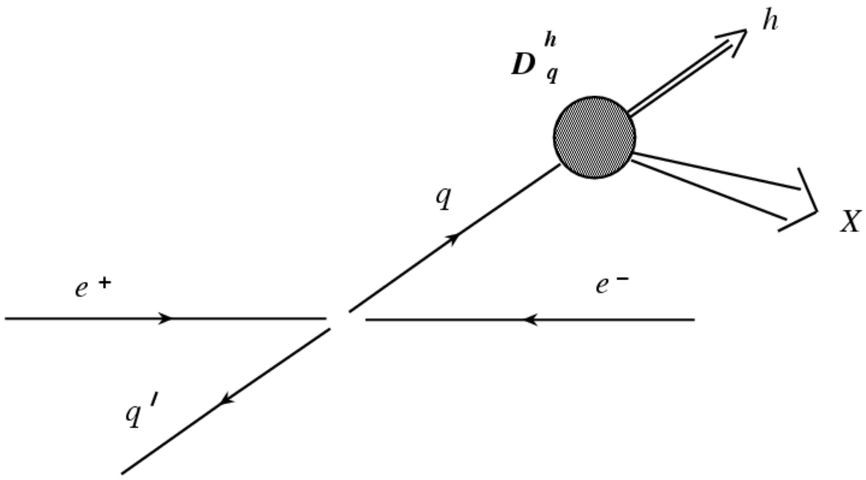
$$D_q^h(z) \Rightarrow E_h = z p_0'$$

For SIDIS we need both $q(x)$ or $\Delta q(x)$ and $D_q^h(z)$

$$\boldsymbol{D_q^h =?}$$

$$\Downarrow$$

$$\boldsymbol{e^+e^- \to h + X}$$



- **the cross section:** $d\boldsymbol{\sigma}^h|_{LO} \simeq \sum e_i^2 \left(D_{q_i}^h + D_{\bar{q}_i}^h\right)$
- **only** $D_q^h + D_{\bar{q}}^h$ **can be measured in principle** $\Rightarrow$ **LO & NLO**
  $\sim$ **in DIS** $\Rightarrow$ $(q + \bar{q})$, $(\Delta q + \Delta\bar{q})$ **only**
- **in SIDIS** D_q^h **and** $D_{\bar{q}}^h$ **needed separately**
  $\Rightarrow$ **always additional theor. assumptions about favoured and unfavoured transitions are made.**
  different sets of FFs exist:

Bienneweis
Kretzer,
Kniehl, Kramer Pötter,
Bourhis, Fontanna, Guillet, Werlen

We consider SIDIS

$$\Downarrow$$

$$l + N \to l' + h + X, \qquad \overrightarrow{l} + \overrightarrow{N} \to l' + h + X$$

What can we learn from SIDIS - pol. and unpol. without assuming any knowledge:

- about D_q and $D_{\bar q}$ separately, only $D_q + D_{\bar q}$ known
- about $\Delta\bar u$, $\Delta\bar d$, Δs, $\Delta\bar s$

We shall use information that comes only directly from measurable quantities

We show that one can determine directly:

- Δu_V , $\Delta d_V \to$ LO and NLO
- $\Delta\bar u - \Delta\bar d \to$ LO and NLO
- $s(x) - \bar s(x)$, $\Delta s(x) - \Delta\bar s(x) \to$ LO and NLO
- $D_u^{\pi^+-\pi^-} \to$ LO and NLO
- possible tests of LO

We work with the measurable quantities:

$$\Delta A_N^h = \frac{\Delta\sigma_N^h}{\sigma_N^h}, \qquad \Delta A_N^{DIS} = \frac{\Delta\sigma_N^{DIS}}{\sigma_N^{DIS}}, \qquad R_N^h = \frac{\sigma_N^h}{\sigma_N^{DIS}},$$

$h = \pi^\pm$, $K^\pm$, etc. and their sum $h^\pm$

$$\underline{\overrightarrow{l} + \overrightarrow{N} \to l' + \pi^{\pm} + X}$$

$$\begin{aligned} \sigma_N^{\pi^\pm} &= \sum e_q^2 q(x,Q^2) D_q^{\pi^\pm}(z,Q^2) \\ \Delta\sigma_N^{\pi^\pm} &= \sum e_q^2 \Delta q(x,Q^2) D_q^{\pi^\pm}(z,Q^2) \end{aligned}$$

SU(2) and C invariance $\Rightarrow$ only 3 FFs $= D_u^{\pi^+}$, $D_d^{\pi^+}$, $D_s^{\pi^+}$

$$D_u^{\pi^+} = D_d^{\pi^-} = D_{\bar{d}}^{\pi^+} = D_{\bar{u}}^{\pi^-}$$

$$D_d^{\pi^+} = D_u^{\pi^-} = D_{\bar{u}}^{\pi^+} = D_{\bar{d}}^{\pi^-}$$

$$D_s^{\pi^+} = D_s^{\pi^-} = D_{\bar{s}}^{\pi^+} = D_{\bar{s}}^{\pi^-}$$

or only two FF for $(\pi^+ - \pi^-)$:

$$D_u^{\pi^+-\pi^-} = -D_d^{\pi^+-\pi^-}$$

$$D_s^{\pi^+-\pi^-} = D_{\bar{s}}^{\pi^+-\pi^-} = 0$$

Notation :

$$D_q^{\pi^+-\pi^-} \equiv D_q^{\pi^+} - D_q^{\pi^-}$$

$$\Delta A_N^{\pi^+-\pi^-} \equiv \frac{\Delta\sigma_N^{\pi^+} - \Delta\sigma_N^{\pi^-}}{\sigma_N^{\pi^+} - \sigma_N^{\pi^-}}$$

$\Delta u_V, \Delta d_V - LO$

Consider the polarized SIDIS asymmetries:

Frankfurt et al, P.L. B (1989)
E. Ch. & E. Leader, P.L. B (1999)

$$\Delta A_p^{\pi^+-\pi^-}(x, \mathrm{z}, Q^2) = \frac{4\Delta u_V - \Delta d_V}{4u_V - d_V}(x, Q^2)$$
$$\Delta A_n^{\pi^+-\pi^-}(x, \mathrm{z}, Q^2) = \frac{4\Delta d_V - \Delta u_V}{4d_V - u_V}(x, Q^2)$$

$\Rightarrow$ 2 ***algebraic*** eqs. for Δu_V and $\Delta d_V \Rightarrow$

$$\Delta u_V = \frac{1}{15}\left\{4(4u_V - d_V)\Delta A_p^{\pi^+-\pi^-} + (4d_V - u_V)\Delta A_n^{\pi^+-\pi^-}\right\}$$
$$\Delta d_V = \frac{1}{15}\left\{4(4d_V - u_V)\Delta A_n^{\pi^+-\pi^-} + (4u_V - d_V)\Delta A_p^{\pi^+-\pi^-}\right\}$$

- no FFs
- no assumptions about any polarized sea densities, even $s \neq \bar{s}$ and $\Delta s \neq \Delta \bar{s}$
- only SU(2) and C inv. of strong ints. assumed
- only unpolarized u_V and d_V to be known
- test for LO $\Rightarrow z$ = passive observable

Analogous for $K^\pm$ or $\Lambda, \bar{\Lambda}$, but $s = \bar{s}$ and $\Delta s = \Delta \bar{s}$ to be assumed

If a small dependence on $z \Rightarrow$ it can be considered as a theor. uncertainty (system. error) in a LO analysis

SU(2) for the polarized sea : $(\Delta\bar{\mathrm{u}} - \Delta\bar{\mathrm{d}}) - \mathrm{LO}$

E. Ch. & E. Leader
N.P. B (2001)

from DIS we know:

$$\Delta q_3(x, Q^2) = (\Delta u + \Delta\bar{u}) - (\Delta d + \Delta\bar{d})$$

obtained directly through:

$$g_1^p(x, Q^2) - g_1^n(x, Q^2) = \frac{1}{6}\Delta q_3|_{LO}$$

not through $(\Delta u + \Delta\bar{u})$ and $(\Delta d + \Delta\bar{d})$ that depend on Δs and ΔG.

$\Rightarrow$ no influence from Δs and ΔG.

$$(\Delta\bar{u} - \Delta\bar{d})|_{LO} = [\Delta q_3 + \Delta d_V - \Delta u_V]\,|_{LO}$$

- SU(2) breaking without knowledge of $\Delta\bar{u}$ and $\Delta\bar{d}$
- Δq_3, Δd_V and Δu_V well determined in LO
  however their linear combination very small – NLO corrections important

$D_u^{\pi^+-\pi^-} - \mathrm{LO}$

$$\begin{aligned} D_u^{\pi^+-\pi^-}(z, Q^2) &= \frac{\sigma_p^{\pi^+-\pi^-}}{4u_V - d_V}(x, z, Q^2) \\ &= \frac{\sigma_n^{\pi^+-\pi^-}}{4d_V - u_V}(x, z, Q^2) \end{aligned}$$

- test of LO $\Rightarrow$ x = passive observable

analogous for $K^+ - K^-$, $\Lambda - \bar{\Lambda}$

$\underline{\underline{(\Delta s + \Delta \bar{s})/(s + \bar{s}) - LO}}$

If we know:

$$\Delta A_p^+ \equiv \frac{\Delta \sigma_p^{\pi^+ + \pi^-}}{\sigma_p^{\pi^+ + \pi^-}}$$

$$\Delta A_n^+ \equiv \frac{\Delta \sigma_n^{\pi^+ + \pi^-}}{\sigma_n^{\pi^+ + \pi^-}}$$

Then we can determine:

$$\frac{\Delta s + \Delta \bar{s}}{s + \bar{s}}(x, Q^2) = \\ = \frac{\Delta A_p^+ \, \Delta A_n^+ (F_1^p - F_1^n) + g_1^n \, \Delta A_p^+ - g_1^p \, \Delta A_n^+}{(g_1^n - g_1^p) + (\Delta A_p^+ \, F_1^p - \Delta A_n^+ \, F_1^n)}(x, \mathrm{z}, Q^2)$$

$$\frac{D_s^{\pi^+ + \pi^-}}{D_u^{\pi^+ + \pi^-}}(x, Q^2) = \\ = 1 + \frac{9 \left[(g_1^p - g_1^n) - (\Delta A_p^+ \, F_1^p - \Delta A_n^+ \, F_1^n) \right]}{s \, (\Delta A_p^+ - \Delta A_n^+)}(\mathrm{x}, z, Q^2)$$

- **check of consistency for LO**

Testing LO -

independent fragmentation, factorization, LLA

1. on p and n

$$\frac{\Delta\sigma_p^{h+\bar{h}} - \Delta\sigma_n^{h+\bar{h}}}{\sigma_p^{h+\bar{h}} - \sigma_n^{h+\bar{h}}}(x, \mathrm{z}, Q^2) = \frac{\Delta\sigma_p^{DIS} - \Delta\sigma_n^{DIS}}{\sigma_p^{DIS} - \sigma_n^{DIS}}(x, Q^2) = \frac{g_1^p - g_1^n}{F_1^p - F_1^n}(x, Q^2)$$

$h = \pi^{\pm}$, $K^{\pm}$, etc. and their sum $h^{\pm}$

Advantages:

- z is a passive observable
- no dependence on $\Delta\bar{q}$, $\Delta\bar{s}$, g and D_q^h
- only measurable quantities enter in the l.h.s. and in the r.h.s.

$$\Delta q_3(x, Q^2) = (\Delta u + \Delta\bar{u}) - (\Delta d + \Delta\bar{d})$$

obtained directly through:

$$g_1^p(x, Q^2) - g_1^n(x, Q^2) = \frac{1}{6}\Delta q_3|_{LO}$$

not through $(\Delta u + \Delta\bar{u})$ and $(\Delta d + \Delta\bar{d})$ that depend on Δs and ΔG.

$\Rightarrow$ no influence from Δs and ΔG.

Needed:

- $\Delta\sigma_p^{h+\bar{h}}$, $\Delta\sigma_n^{h+\bar{h}}$, $\Delta\sigma_p^{DIS}$, $\Delta\sigma_n^{DIS}$
  to be measured in the same bins of both x and z

Integrated:

$$\frac{\int dx \int dz [\Delta\sigma_p^{h+\bar{h}} - \Delta\sigma_n^{h+\bar{h}}]}{\int dx \int dz [\sigma_p^{h+\bar{h}} - \sigma_n^{h+\bar{h}}]} = \frac{g_A/g_V}{3S_G}$$

- used:

The Bjorken sum rule:

$$\begin{aligned} \int dx (g_1^p - g_1^n) &= (\Delta\tilde{u} - \Delta\tilde{d})|_{LO} = g_A/g_V \\ g_A/g_V &= 1.2670 \pm 0.0035 \end{aligned}$$

The Gottfried sum rule:

$$\begin{aligned} \int dx \frac{F_2^p - F_2^n}{x} &= e_u^2 - e_d^2 + \frac{2}{3} \int dx (\bar{u} - \bar{d}) \\ S_G &= 0.235 \pm 0.026 \end{aligned}$$

- remark

The Bjorken sum rule in NLO:

$$\begin{aligned} \int dx (g_1^p - g_1^n) &= \frac{1}{6}(\Delta\tilde{u} - \Delta\tilde{d}) \left(1 - \frac{\alpha_s(Q^2)}{\pi}\right) \\ &= \frac{1}{6} g_A/g_V \left(1 - \frac{\alpha_s(Q^2)}{\pi}\right) \end{aligned}$$

2. What if one target only – on p or n separately?

- depends on the final hadron:

Jefferson Lab - proposal

Pions

$$\frac{\Delta\sigma_p^{\pi^++\pi^-}}{\sigma_p^{\pi^++\pi^-}}(x, \mathrm{z}, Q^2) \simeq \frac{\Delta\sigma_p^{DIS}}{\sigma_p^{DIS}}\left[1+\left(\frac{2s}{4\tilde{u}+\tilde{d}}-\frac{2\Delta s}{4\Delta\tilde{u}+\Delta\tilde{d}}\right)\left(1-\frac{D_s^{\pi^++\pi^-}}{D_u^{\pi^++\pi^-}}\right)\right]$$
$$\simeq \frac{\Delta\sigma_p^{DIS}}{\sigma_p^{DIS}}\left[1+\frac{2s}{4\tilde{u}+\tilde{d}}-\frac{2\Delta s}{4\Delta\tilde{u}+\Delta\tilde{d}}\right](x, Q^2)$$
$$\simeq \frac{\Delta\sigma_p^{DIS}}{\sigma_p^{DIS}}(x, Q^2)$$

- double suppressed by the small s-quarks and $D_s^{\pi^++\pi^-}/D_u^{\pi^++\pi^-}$
- SU(2) + C.C. of strong interactions for pions
- analogous for a neutron target

Notation:

$$\Delta\tilde{u} = \Delta u + \Delta\bar{u}, \quad \Delta\tilde{d} = \Delta d + \Delta\bar{d}, \quad \tilde{u} = u + \bar{u}, \quad \tilde{d} = d + \bar{d}$$

Kaons

$$\frac{\Delta\sigma_p^{K^++K^--(K^0+\bar{K}^0)}}{\sigma_p^{K^++K^--(K^0+\bar{K}^0)}}(x, \mathrm{z}, Q^2) = \frac{4\Delta\tilde{u}-\Delta\tilde{d}}{4\tilde{u}-\tilde{d}}(x, Q^2)$$

- an exact equation
- SU(2) + C.C. of strong interactions for Kaons

$\Rightarrow$ neutral Kaons needed

- It is not possible to form a LO test with K^+ and K^- only.

NLO

LO		NLO
alg. eqs. (simple products)	$\Rightarrow$	int. eqs. (convolutions)

$$q(x,Q^2) \;\Rightarrow\; \int \frac{dx'}{x'} q\left(\frac{x}{x'}\right) C(x') = q \otimes C$$

$$q(x,Q^2)D(z,Q^2) \;\Rightarrow\; \int \frac{dx'}{x'} \int \frac{dz'}{z'} q\left(\frac{x}{x'}\right) C(x',z') D\left(\frac{z}{z'}\right)$$

$$= \; q \otimes C \otimes D$$

C are ***known*** Wilson coefficients.

LO : $\Rightarrow$ no gluons in the cross section

NLO : $\Rightarrow$ gluons enter the cross section:

\- $G(x)$, $\Delta G(x)$, $D_G^h(z)$

- polarized DIS

$$g_1^p(x,Q^2) \;=\; \frac{1}{2}\sum_i e_i^2 \left[\Delta q_i \left(1 + \otimes \frac{\alpha_s(Q^2)}{2\pi} \delta C_q\right) + \right. \\ \left. + \frac{\alpha_s(Q^2)}{2\pi} \Delta G \otimes \delta C_G \right]$$

- unpolarized DIS

$$\tilde{\sigma}^{DIS}|_{LO} = 2F_1 \quad \Rightarrow \quad \tilde{\sigma}^{DIS}|_{NLO} = 2F_1 \left[1 + 2\gamma(y) R\right],$$

$$R = \frac{\sigma_L}{\sigma_T}, \qquad \gamma(y) = \frac{1-y}{1+(1-y)^2}.$$

- **inclusive $e^+e^- \to h + X$:**

$$\sigma_T^h(z,Q^2) \simeq \left\{\sum_i e_i^2 D_{q_i}^h \left(1 + \otimes \frac{\alpha_s}{2\pi} C_q^T\right) + \right. \\ \left. + \sum_i e_i^2 D_G^h \otimes \frac{\alpha_s}{2\pi} C_G^T \right\}$$

- **unpolarized SIDIS:** **Graudenz, N.P. B 1994**

$$\tilde{\sigma}_p^h = \sum_i e_i^2 q_i \left[1 + \otimes \frac{\alpha_s}{2\pi} C_{qq} \otimes\right] D_{q_i}^h + \\ + \underbrace{\left(\sum_i e_i^2 q_i\right)} \otimes \frac{\alpha_s}{2\pi} C_{qg} \otimes D_G^h$$

$$+ G \otimes \frac{\alpha_s}{2\pi} C_{gq} \otimes \underbrace{\left(\sum_i e_i^2 D_{q_i}^h\right)}$$

- **polarized SIDIS:** **de Florian et al, N.P. B 1996**

$$\Delta\tilde{\sigma}_p^h = \sum_i e_i^2 \Delta q_i \left[1 + \otimes \frac{\alpha_s}{2\pi} \Delta C_{qq} \otimes\right] D_{q_i}^h + \\ + \underbrace{\left(\sum_i e_i^2 \Delta q_i\right)} \otimes \frac{\alpha_s}{2\pi} \Delta C_{qg} \otimes D_G^h +$$

$$+ \Delta G \otimes \frac{\alpha_s}{2\pi} \Delta C_{gq} \otimes \underbrace{\left(\sum_i e_i^2 D_{q_i}^h\right)}$$

***known quantities — NLO*:**

- **the unpolarized parton densities** $u_V, d_V, \bar{u}, \bar{d}, s$
- **the polarized** Δq_3**:**

$$\Delta q_3(x, Q^2) = (\Delta u + \Delta \bar{u}) - (\Delta d + \Delta \bar{d})$$

obtained directly through:

$$g_1^p(x, Q^2) - g_1^n(x, Q^2) = \frac{1}{6} \Delta q_3 \otimes \left(1 + \frac{\alpha_s(Q^2)}{2\pi} \delta C_q\right)$$

not **through** $(\Delta u + \Delta \bar{u})$ **and** $(\Delta d + \Delta \bar{d})$ **that depend on** Δs **and** ΔG**.**

***unknown quantities*:**

- **the FFs**
- **all polarized parton densities, except** Δq_3

$\underline{\Delta u_V, \Delta d_V - NLO}$

- **From unpolarized SIDIS** $\Rightarrow D_u^{\pi^+-\pi^-}(z,Q^2)$:

$$R_p^{\pi^+-\pi^-} = \frac{[4u_V - d_V][1 + \otimes(\alpha_s/2\pi)C_{qq}\otimes]D_u^{\pi^+-\pi^-}}{18F_1^p\,[1+2\gamma(y)\,R^p]}$$
$$R_n^{\pi^+-\pi^-} = \frac{[4d_V - u_V][1 + \otimes(\alpha_s/2\pi)C_{qq}\otimes]D_u^{\pi^+-\pi^-}}{18F_1^n\,[1+2\gamma(y)\,R^n]}.$$

$\Rightarrow$ **2 eqs. for** $D_u^{\pi^+-\pi^-}(z,Q^2)$
$\Rightarrow$ $D_u^{\pi^+-\pi^-}(z,Q^2)$ **is a non-singlet and it does not mix with other FFs**

- **From polarized SIDIS** $\Rightarrow \Delta u_V$ **and** Δd_V:

$$\Delta A_p^{\pi^+-\pi^-} = \frac{(4\Delta u_V - \Delta d_V)[1 + \otimes(\alpha_s/2\pi)\Delta C_{qq}\otimes]D_u^{\pi^+-\pi^-}}{(4u_V - d_V)[1 + \otimes(\alpha_s/2\pi)C_{qq}\otimes]D_u^{\pi^+-\pi^-}}$$

$$\Delta A_n^{\pi^+-\pi^-} = \frac{(4\Delta d_V - \Delta u_V)[1 + \otimes(\alpha_s/2\pi)\Delta C_{qq}\otimes]D_u^{\pi^+-\pi^-}}{(4d_V - u_V)[1 + \otimes(\alpha_s/2\pi)C_{qq}\otimes]D_u^{\pi^+-\pi^-}}$$

$\Rightarrow$ **2 eqs. for** Δu_V **and** Δd_V
$\Rightarrow$ Δu_V **and** Δd_V **are non-singlets and no not mix with the other quark and gluon densities.**

$\underline{Sea\quad quarks\quad (\Delta\bar{u} - \Delta\bar{d}) - NLO}$

$$(\Delta\bar{u} - \Delta\bar{d})|_{NLO} = \frac{1}{2}\left[\Delta q_3 + \Delta d_V - \Delta u_V\right]|_{NLO}$$

where g_3 **is obtained directly through:**

$$g_1^p(x,Q^2) - g_1^n(x,Q^2) = \frac{1}{6}\Delta q_3 \otimes \left(1 + \frac{\alpha_s(Q^2)}{2\pi}\delta C_q\right)$$

$\underline{s - \bar{s} = ?, \quad \Delta s - \Delta\bar{s} = ? - NLO}$

- **From** $K^+ - K^-$

$$\left.\begin{array}{l} R_p^{K^+-K^-} \\ \\ R_n^{K^+-K^-} \end{array}\right\} \begin{array}{l} u_V, d_V = known \\ \\ D_u^{K^+-K^-}, (s-\bar{s})D_s^{K^+-K^-} = unknown \end{array} \tag{1}$$

$$\left.\begin{array}{l} \Delta A_p^{K^+-K^-} \\ \\ \Delta A_n^{K^+-K^-} \end{array}\right\} \begin{array}{l} \Delta u_V, \Delta d_V = known \\ \\ D_u^{K^+-K^-}, (s-\bar{s})D_s^{K^+-K^-}, \\ \\ (\Delta s - \Delta\bar{s})D_s^{K^+-K^-} = unknown \end{array} \tag{2}$$

- **Analogous for** $\Lambda - \bar{\Lambda}$:

$$\left.\begin{array}{l} R_p^{\Lambda-\bar{\Lambda}} \\ \\ R_n^{\Lambda-\bar{\Lambda}} \end{array}\right\} \begin{array}{l} u_V, d_V = known \\ \\ D_u^{\Lambda-\bar{\Lambda}}, (s-\bar{s})D_s^{\Lambda-\bar{\Lambda}} = unknown \end{array} \tag{3}$$

$$\left.\begin{array}{l} \Delta A_p^{\Lambda-\bar{\Lambda}} \\ \\ \Delta A_n^{\Lambda-\bar{\Lambda}} \end{array}\right\} \begin{array}{l} \Delta u_V, \Delta d_V = known \\ \\ D_u^{\Lambda-\bar{\Lambda}}, (s-\bar{s})D_s^{\Lambda-\bar{\Lambda}}, \\ \\ (\Delta s - \Delta\bar{s})D_s^{\Lambda-\bar{\Lambda}} = unknown \end{array} \tag{4}$$

HERMES & e^+e^- data

1. HERMES data: $e + p \to e + \pi^\pm + X$, [Eur. Phys. J C21(2001)]
$< Q^2 >= 2.5\, GeV^2$, $< x >= 0.082$, $z = 0.2 - 0.87$

- $$R_p^{\pi^+} = \frac{1}{9\tilde{\sigma}_p^{DIS}} \left\{ (4u + \bar{d}) D_u^{\pi^+} + (4\bar{u} + d) D_d^{\pi^+} + (s + \bar{s})\, D_s^{\pi^+} \right\}$$

- $$R_p^{\pi^-} = \frac{1}{9\tilde{\sigma}_p^{DIS}} \left\{ (4\bar{u} + d) D_u^{\pi^+} + (4u + \bar{d}) D_d^{\pi^+} + (s + \bar{s})\, D_s^{\pi^+} \right\}$$

2. LEP data: $e^+ + e^- \to Z^0 \to \pi^\pm + X$

- $$D_\Sigma^{\pi^+} = 2 \left(D_u^{\pi^+} + D_d^{\pi^+} + D_s^{\pi^+} \right)$$

We have:

- 3 eqs. for $D_u^{\pi^+}$, $D_d^{\pi^+}$, $D_s^{\pi^+}$
- no assumptions about fav. and unfav. transitions.

the uncertainty:

$D_\Sigma^{\pi^+}(z, Q^2)$ = a flavour singlet

$D_\Sigma^{\pi^+}(Q^2 = m_Z^2) \longrightarrow D_\Sigma^{\pi^+}(Q^2 = 2.5 GeV^2) \Rightarrow D_G^h$ enters
$D_G^{\pi^+}$= poorly defined, unreliable

S. Kretzer, E. Leader, E.Ch.
Eur. Phys. J. C22 (2001) 269

HERMES & e^+e^- data

1. From LEP: $e^+ + e^- \to Z \to \pi^\pm + X$

$$D^\pi_{meas}(m_Z^2) = \hat{e}_u^2(D_u + D_{\bar{u}})^{\pi^+} + \hat{e}_d^2(D_d + D_{\bar{d}} + D_s + D_{\bar{s}})^{\pi^+}$$

$\hat{e}(s)$ = the effective charge

$$\hat{e}_u^2 \simeq (\gamma^2 + \gamma Z + Z^2)$$

We need:

$$D^\pi_\Sigma = (D_u + D_{\bar{u}})^\pi + (D_d + D_{\bar{d}})^\pi + (D_s + D_{\bar{s}})^\pi,$$

i.e.

$$\hat{e}_u^2 \simeq \hat{e}_d^2$$

At m_Z^2:

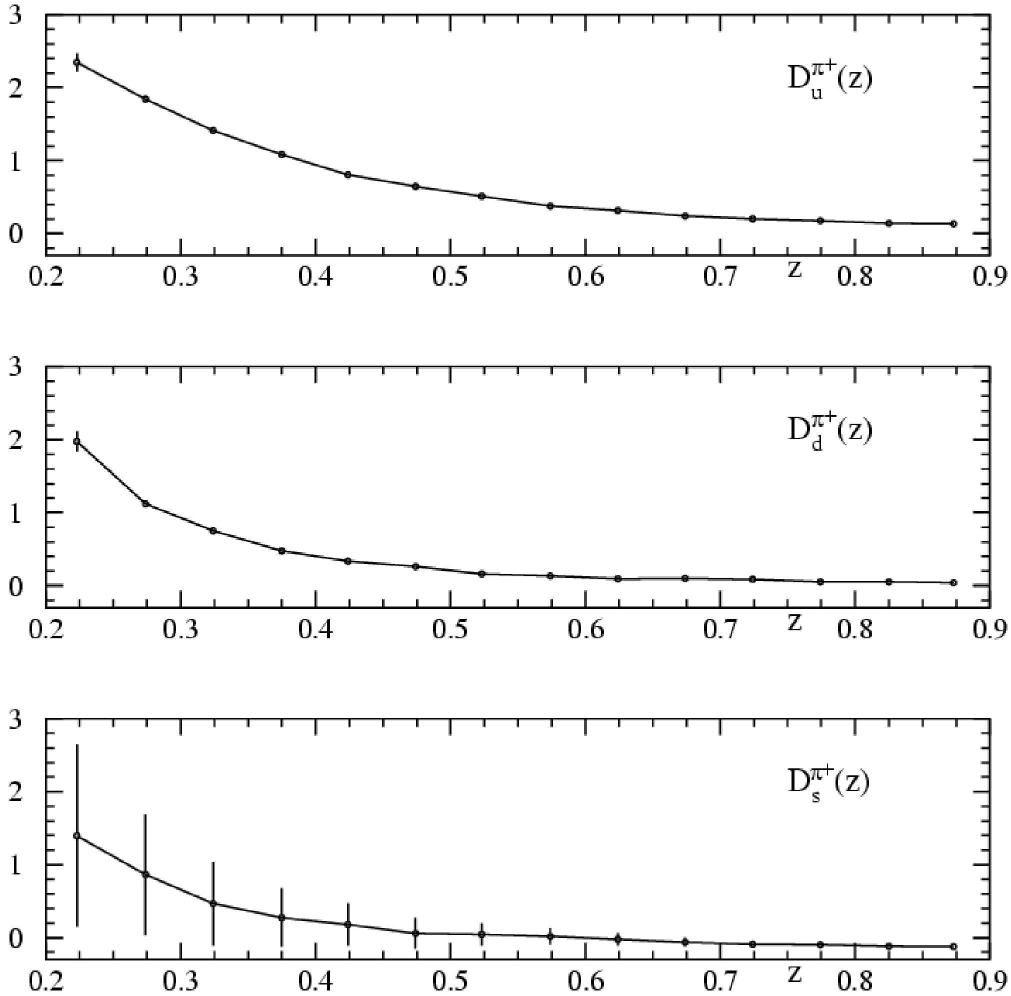
$$D^\pi_{meas}(m_Z^2) \simeq D^\pi_\Sigma(m_Z^2)$$

2. Combined with HERMES data: $e + p \to e + \pi^\pm + X$:

$$D_u^{\pi^+} - D_d^{\pi^+} = \frac{9\left(R_p^{\pi^+} - R_p^{\pi^-}\right)\sigma_p^{DIS}}{4u_V - d_v}$$

$$D_u^{\pi^+} + D_d^{\pi^+} = \frac{9\left(R_p^{\pi^+} + R_p^{\pi^-}\right)\sigma_p^{DIS} - 2sD_\Sigma^{\pi^+}}{4(u + \bar{u} - s) + d + \bar{d}}$$

$$D_s^{\pi^+} = \frac{-9\left(R_p^{\pi^+} + R_p^{\pi^-}\right)\sigma_p^{DIS} + [2(u + \bar{u}) + (d + \bar{d})/2]\, D_\Sigma^{\pi^+}}{4(u + \bar{u} - s) + d + \bar{d}}$$



$D_u^{\pi+}(z)$
$D_d^{\pi+}(z)$
$D_s^{\pi+}(z)$
z
0
1
2
3
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

CONCLUSIONS

We suggest an approach to SIDIS different from the "purity" approach used up to now.

advantage : only directly measurable quantities are used.

- $D_q^{h-\bar{h}}$ are determined directly from unpol. SIDIS
  $\rightarrow$ LO & NLO
- with these $D_q^{h-\bar{h}}$– pol. SIDIS determines
  Δu_V, Δd_V and $\Delta\bar{u} - \Delta\bar{d}$ unambiguously
  $\rightarrow$ LO & NLO
  $\rightarrow$ no assumptions about $\Delta\bar{u}$, $\Delta\bar{d}$, $\Delta\bar{s}$, ΔG
- test for the reliability of LO – ***passive*** variable
- we considerably simplify the NLO expr. for SIDIS cross section using exper. inform. from DIS and $e^+e^- \rightarrow h + X$
- $D_u^{\pi^+}$, $D_d^{\pi^+}$, $D_s^{\pi^+}$ are obtained
  $\rightarrow$ no assumptions about fav. and unfav. transitions
  $\rightarrow$ unpol. SIDIS (HERMES data) and $e^+e^- \rightarrow h + X$.