ON EXTRACTING POLARIZED PARTON DENSITIES FROM SEMI-INCLUSIVE DIS.

ELLIOT LEADER
BIRKBECK COLLEGE, LONDON.

1) ARGUE THAT GLOBAL ANALYSIS IN LO OF INCLUSIVE AND SEMI-INCLUSIVE DATA IS DANGEROUS.

2) SUGGEST STRATEGY FOR ANALSIS WITH EMPHASIS ON SAFEGUARDS.

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1) Danger of fake information in DIS.
2) Criticism of LO "PURITY" approach
3) Strategic approach to LO analysis.
4) Can we determine $\Delta s(x)$?
5) Conclusions.

Work done in collaboration with E. Christova, Bulgarian Academy of Sciences.

Sometimes useful to parametrize Δq_V, $\Delta \bar{q}$ separately.

For simplicity : $\Delta \bar{u} = \Delta \bar{d} = \lambda \Delta s$

" χ^2 analysis favours $\lambda = 1$ "

NONSENSE ! Must be hidden biases in minimization procedure.

NOTE Although measure only two observables

$$g_1^p(x, Q^2) \qquad\qquad g_1^n(x, Q^2)$$

PERFECT DATA $\Longrightarrow$ KNOWLEDGE OF ALL

$\Delta u + \Delta \bar{u}$, $\Delta d + \Delta \bar{d}$, Δs, ΔG

because of evolution eqns.

Another example from study of both inclusive and SMC semi-inclusive :-

"Present semi-inclusive data alone fail to define a Δd_v consistent with those extracted from inclusive data".

MORAL :- Parameter space is complicated. Trust physics, NOT numerical minimization.

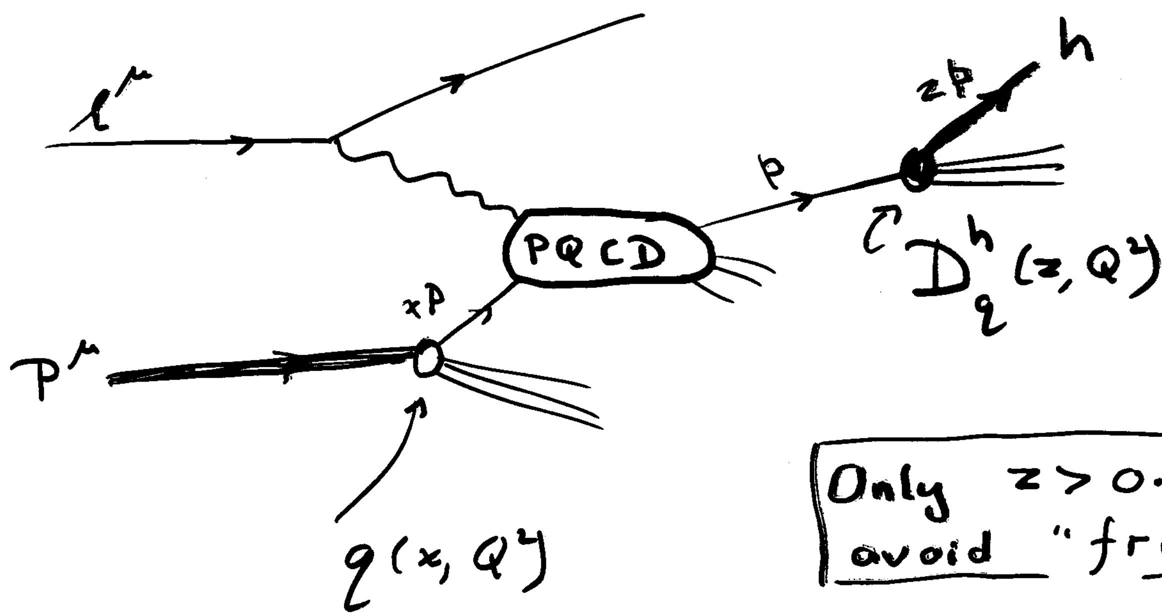
Will discuss LO strategy for semi-inclusive ..... can be generalised to NLO, but much less straightforward.

2) Criticism of LO "PURITY" approach.

Use

$$\tilde{\sigma} = \frac{x\,(P+\ell)^2}{4\pi\,\alpha^2}\left[\frac{2y^2}{1+(1-y)^2}\right]\frac{d^3\sigma}{dx\,dy\,dz}$$

$$\Delta\tilde{\sigma} = \frac{x\,(P+\ell)^2}{4\pi\alpha^2}\left[\frac{y}{2-y}\right]\left\{\frac{d^3\sigma_{+-}}{dx\,dy\,dz} - \frac{d^3\sigma_{++}}{dx\,dy\,dz}\right\}$$



$\boxed{\text{Only } z > 0.2 \text{ to avoid "fracture"}}$

$$\left.\begin{aligned} \Delta\tilde{\sigma}(x,z,Q^2) &= \sum_{q,\bar{q}} e_q^2\,\Delta q_i(x,Q^2)\,D_i^h(z,Q^2) \\ \tilde{\sigma}(x,z,Q^2) &= \sum_{q,\bar{q}} e_q^2\,q_i(x,Q^2)\,D_i^h(z,Q^2) \end{aligned}\right\}$$

Indep. Fragmentation.

and

Same D_i^h

SMC and HERMES :

$$\frac{\Delta\tilde{\sigma}}{\tilde{\sigma}} = \sum_{q,\bar{q}} P_i^h(x) \cdot \frac{\Delta q_i(x)}{q_i(x)}$$

where

PURITY $$P_i^h(x) = \frac{e_q^2 q_i(x) \int_{0.2}^{1} dz\, D_i^h(z)}{\sum_{q,\bar{q}} e_q^2\, q_i(x) \int_{0.2}^{1} dz\, D_i^h(z)}$$

THEY ASSUME $P_i^h(x)$ KNOWN.

1) WHY ?????

WHY TRUST $D_i^h(z)$?? Errors ??

e.g. Binneweis et al obtain

D_i^h from $e^+e^- \to$ hadrons

Fit has 31 parameters.

No errors.

2) How good is LO approximation ???

ANTI PURITY SUMMARY:

1) Gives an absolute status to fragmentation functions that they don't deserve.

2) Blocks possibity to check reliability of LO approach.

Discuss a strategic approach which tests LO at each step.

N.B. In principle inclusive + semi-inclusive data could determine also the fragmentation functions

3) A strategic approach to the analysis of semi-inclusive DIS.

Will involve relating certain densities to combinations of data.

May find errors on combinations are big.

This is a fact of life, not a consequence of method of analysis.

Simply, a global analysis hides this fact.

Define

$$\Delta R^{h^+ \pm h^-}_{p,n} = \frac{\Delta \tilde{\sigma}^{h^+}_{p,n} \pm \Delta \tilde{\sigma}^{h^-}_{p,n}}{\tilde{\sigma}^{h^+}_{p,n} \pm \tilde{\sigma}^{h^-}_{p,n}}$$

h^+ = any ⊕charge or sum of them

h^- = Anti particles of h^+

$$\Delta R^{h^+ \pm h^-}_{p \pm n} = \frac{\Delta \tilde{\sigma}^{h^+ \pm h^-}_{p} \pm \Delta \tilde{\sigma}^{h^+ \pm h^-}_{n}}{\tilde{\sigma}^{h^+ \pm h^-}_{p} \pm \tilde{\sigma}^{h^+ \pm h^-}_{n}}$$

The main test of LO :-

$$\Delta R^{h^+ + h^-}_{p-n}(x, z, Q^2) = \underbrace{\frac{g_1^p(x,Q^2) - g_1^n(x,Q^2)}{F_1^p(x,Q^2) - F_1^n(x,Q^2)}}_{\text{No } z\text{-dependence}}$$

NB

Error on this indicates probable error on parton densities extracted.

"theoretical systematic error"

Direct evaluation of VALENCE densities:

$$\Delta u_v(x,Q^2) = \frac{1}{2}\left\{(u_v+d_v)\Delta R_{p+n}^{h^+-h^-}(x,z,Q^2) + (u_v-d_v)\,\Delta R_{p-n}^{h^+-h^-}(x,z,Q^2)\right\}$$

No z-dependence.

$$\Delta d_v(x,Q^2) = \frac{1}{2}\left\{(u_v+d_v)\Delta R_{p+n}^{h^+-h^-}(x,z,Q^2) - (u_v-d_v)\,\Delta R_{p-n}^{h^+-h^-}(x,z,Q^2)\right\}$$

Lack of z-dependence crucial to test reliability of LO!

For $h^\pm = \pi^\pm$, $SU(2) \Longrightarrow$ simplification:

$$\Delta u_v = \frac{1}{15}\left\{4\,(4u_v-d_v)\Delta R_p^{\pi^+-\pi^-} + (4d_v-u_v)\Delta R_n^{\pi^+-\pi^-}\right\}$$

$$\Delta d_v = \frac{1}{15}\left\{4\,(4d_v-u_v)\,\Delta R_n^{\pi^+-\pi^-} + (4u_v-d_v)\Delta R_p^{\pi^+-\pi^-}\right\}$$

Sea quarks and fragmentation functions.

Best to import from INCLUSIVE

$$a_3(x,Q^2) = (\Delta u + \Delta \bar{u}) - (\Delta d + \Delta \bar{d})$$

Very well determined, without any influence of sea or gluons.

$$\underbrace{\underset{\text{positive}}{g_1^p(x,Q^2)} - \underset{\text{negative}}{g_1^n(x,Q^2)}}_{} = \frac{1}{6}\, a_3 \otimes \left[1 + \frac{\alpha_s(Q^2)}{2\pi}\, \delta C_q\right]$$

∴ well determined.

∴ USE $a_3(x,Q^2)$ IN SEMI-INCLUSIVE.

Examples of use of $a_3(x, Q^2)$

1)

$$\Delta\bar{u} - \Delta\bar{d} = \frac{1}{2}\left\{ a_3 + \Delta d_v - \Delta u_v \right\}$$

some theories expect this large.
We feel error on RHS make it unreliable.

2)

$$\underbrace{4 D_u^{h^+ + h^-}(z, Q^2) - D_d^{h^+ + h^-}(z, Q^2)}_{\text{independent of } x} = 9 \, \frac{\left\{ \Delta\tilde{\sigma}_p^{h^+ + h^-}(x, z, Q^2) - \Delta\tilde{\sigma}_n^{h^+ + h^-} \right\}}{a_3(x, Q^2)}$$

For $h^\pm = \pi^\pm$, $SU(2) \Longrightarrow$ simplification:

$$D_u^{\pi^+ + \pi^-}(z, Q^2) = D_d^{\pi^+ + \pi^-}(z, Q^2) = 3 \, \frac{\left\{ \Delta\tilde{\sigma}_p^{\pi^+ + \pi^-}(x, z, Q^2) - \Delta\tilde{\sigma}_n^{\pi^+ + \pi^-}(x, z, Q^2) \right\}}{a_3(x, Q^2)}$$

Interesting to compare with fragmentation functions from $e^+e^- \longrightarrow$ hadrons !

Can we measure $\Delta\bar{q}$ in LO ?

Need $(\Delta u + \Delta\bar{u} + \Delta d + \Delta\bar{d}) \equiv a_+(x, Q^2)$

Then

$$\Delta\bar{u} + \Delta\bar{d} = \frac{1}{2}\left\{ a_+ - \Delta u_v - \Delta d_v \right\}$$

Combine with

$$\Delta\bar{u} - \Delta\bar{d} = \frac{1}{2}\left\{ a_3 - \Delta u_v + \Delta d_v \right\}$$

BUT :- Even if a_+ determined accurately, LO errors may make LHS unreliable.

How to get $a_+(x, Q^2)$?

$$\Delta\tilde{\sigma}_{p+n}^{\pi^+ + \pi^-} = \frac{1}{9}\left\{ 5\, a_+ D_u^{\pi^+ + \pi^-} + \cancel{4\, \Delta s\, D_s^{\pi^+ + \pi^-}} \right\}$$

neglect

Get

$$a_+(x,Q^2) \approx \frac{3}{5}\left\{\frac{\Delta\tilde{\sigma}_p^{\pi^+ + \pi^-}(x,z,Q^2) + \Delta\tilde{\sigma}_n^{\pi^+ + \pi^-}(x,z,Q^2)}{\Delta\tilde{\sigma}_p^{\pi^+ + \pi^-} - \Delta\tilde{\sigma}_n^{\pi^+ + \pi^-}}\right\} a_3(x,Q^2)$$

independent of z.

<u>If</u> K^0 can be detected, without neglect of Δs, have

$$a_+(x,Q^2) = \left[u+\bar{u}+d+\bar{d}\right]\left\{\frac{\Delta\tilde{\sigma}_{p+n}^{K^+ + K^-} - \Delta\tilde{\sigma}_{p+n}^{K^0 + \bar{K}^0}}{\tilde{\sigma}_{p+n}^{K^+ + K^-} - \tilde{\sigma}_{p+n}^{K^0 + \bar{K}^0}}\right\}$$

Other things can measure :-

$D_u^{h^+} - D_u^{h^-}$; $D_d^{h^+} - D_d^{h^-}$; $D_u^{\pi^\pm}$ - - - - - -

Test usual assumption

$D_d^{K^+} = D_d^{K^-}$

Can we determine Δs and compare it with $\Delta\bar{u}$ and $\Delta\bar{d}$ in LO ?

Can give explicit expression for Δs (E.Christova + E.L) BUT PESSIMISTIC in LO :

For pions compare

$\Delta u\, D_u^{\pi}$ with $\Delta s\, D_s^{\pi}$

$|\Delta u| \gg |\Delta s|$ and $|D_u^{\pi}| \gg |D_s^{\pi}|$

$\Rightarrow$ Δs term $\approx$ error of LO approx.

For kaons somewhat better:

$|\Delta u| \gg |\Delta s|$ but $|D_u^{K}| \approx |D_s^{K}|$

BUT : similar to inclusive case.

There NLO causes 100% change in Δs . $\therefore$ still pessimistic.

Only hope:

$$h = \phi \quad !$$

Now expect

$$|D_u^\phi| << |D_s^\phi|$$

so LO determination may be reliable.

Preliminary work in

Phys. Lett. B 468 (1999) 299.

NLO treatment in preparation.

$$\Delta\tilde{\sigma}^h = \sum e_q^2 \Big\{ \Delta q_i \cdot D_i^h + \frac{\alpha_s}{2\pi}\Big[\Delta q_i \otimes \Delta C_{qq} \otimes D_i^h + \Delta q_i \otimes \Delta C_{qG} \otimes D_G^h + \Delta G \otimes \Delta C_{Gq} \otimes D_i^h \Big]\Big\}$$

Summary.

1) The complex parameter space $\Rightarrow$ danger of fake results in global analysis.

2) The LO approach using PURITY is unreliable. It does not take account of errors on fragmentation functions and fails to test crucial aspects of LO.

3) A systematic step-by-step analysis in LO is possible, with tests of the reliability of LO at each step.

4) It does not seem possible to determine Δs reliably in LO, except if ϕ production can be measured. Also $\Delta\bar{u}$, $\Delta\bar{d}$ not reliably determined in LO.

5) Many results can be extended to NLO. Should be possible to fix $\Delta\bar{u}$, $\Delta\bar{d}$, Δs, but care with Scheme dependence.

6) To really optimize the analysis it is important to take all data in same x, z, Q^2 bins.

7) In principle, with good enough data, can determine also the fragmentation functions...... provided we take $q_3(x, Q^2)$ from inclusive DIS. This is a valid strategy.