Determination of $xs(x)$ and $x\bar{s}(x)$ from a global QCD analysis

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A new global QCD analysis of DIS data is presented. The νFe and $\bar{\nu} Fe$ differential cross-section data are included to constrain the strange component of the nucleon sea. As a result we found a hard strangeness at high-x and some evidence for an asymmetry between $xs(x)$ and $x\bar{s}(x)$.

1. INTRODUCTION

The starting point of the work presented in this communication is an evidence: what is measured by ν and $\bar{\nu}$ fixed target experiments are the differential cross-sections and not the structure functions. The former observables are described by a combination of three structure functions F_i^ν and $F_i^{\bar{\nu}}$ $(i = 1,2,3)$ and, within pQCD, $F_i^\nu \neq F_i^{\bar{\nu}}$. There is no magic, to solve a system of two equations with 6 unknowns one must provide some extra informations ... And the main part of these informations comes from the $W^+ + s \to c$ (plus higher order corrections) process: the deuce of structure functions $[F_2,\ F_3]$, extracted from the mixed ν and $\bar{\nu}$ data, received some large corrections and especially from the strange density [1].

Therefore, unlike what is currently done in the global QCD fits [2], we do not consider here the *deuce* $[F_2,\ F_3]$ but rather all the available differential cross-section measurements: BEBC(H and D targets), CDHS (H target) and CDHSW (Fe target)[3]. The fit presented here (see [4] for the details) is very similar to the CTEQ5F3 one [2]. The same combinations of parton densities are parametrised at $Q_0 = 2$GeV and evolved using the DGLAP equations [5]. In addition to the neutrino data sets, the data entering the fit are [3]: the fixed target and H1 charged lepton ($\ell^\pm$) beam F_2; the Drell-Yan differential cross sections and asymmetries. To avoid higher-twist corrections we also apply some data rejection cuts: $Q^2 \geq 3.5\text{GeV}^2$ and $W^2 \geq 10\text{GeV}^2$.

From this fit we can *i)* determine $xs(x)$ and $x\bar{s}(x)$ within an inclusive analysis, *ii)* test the compatibility between charged lepton and neutrino beam observables (see [1] where an incompatibility is reported). In this communication we concentrate on the strangeness and we shall thus start by giving, in section 2, some details concerning the nuclear corrections applied to the CDHSW data. This is an important feature since this data sample is the most significant statistically. The fit results concerning the two items *i)* and *ii)* pointed out above are given in section 3.

2. ON THE NUCLEAR CORRECTIONS APPLIED TO Fe TARGET DATA

All CDHSW data are obtained from scattering off Iron nuclei. Since the theoretical understanding of nuclear effects in heavy nuclei is still uncertain and model dependent [6], we adopt an empirical procedure to perform the nuclear corrections. The basis of the procedure is that, in the 'naive' QPM, $\ell^\pm$ and neutrino nucleon structure functions are proportional at high-$x >\approx 0.1$. The experimental $\nu(\bar{\nu})Fe$ differential cross sections are then fitted to $d\sigma^{\nu(\bar{\nu})Fe} = d\sigma_{iso}^{\nu(\bar{\nu})Fe}/R_{iso}^{\nu(\bar{\nu})}$, where $R_{iso}^{\nu(\bar{\nu})}$ is the correction factor for the non-isoscalarity of Iron

$$R_{iso}^{\nu(\bar{\nu})} = \frac{(d\sigma^{\nu(\bar{\nu})p} + d\sigma^{\nu(\bar{\nu})n})/2}{(Z\, d\sigma^{\nu(\bar{\nu})p} + (A-Z)\, d\sigma^{\nu(\bar{\nu})n})/A} \qquad (1)$$

and $d\sigma_{iso}^{\nu(\bar{\nu})Fe} = d\sigma^{\nu(\bar{\nu})D} \cdot R_{nucl}^{iso}$ with $R_{nucl}^{iso} = R_{Fe/D} \cdot R_{iso}^{\ell}$. The first factor of the last equation is the Fe/D structure function ratio $R_{Fe/D} = F_2^{\ell^\pm Fe}/F_2^{\ell^\pm D}$ which is obtained from a fit to the most precise experimental data on $F_2^{\ell^\pm Fe}/F_2^{\ell^\pm D}$

[7], uncorrected for isoscalarity (the x range is $[0.1, 0.65]$). The second factor contains the isoscalarity corrections and is computed from eq. (1) using $F_2^{\ell^\pm p,n}$. The different contributions to the nuclear corrections are shown in fig.1. This figure shows that isoscalar correction induces some large differences between the ν and $\bar{\nu}$ data at high-x. It is to be noticed that these corrections are also applied to the CCFR $[F_2,\, F_3]$ data [1] used actually to determine the valence quarks in the global fits [2].

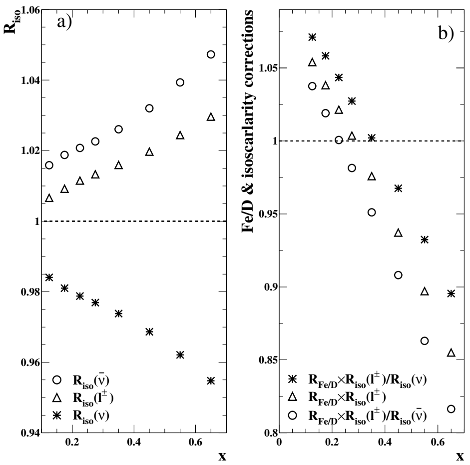

Figure 1. Nuclear correction applied to CDHSW data (see text).

3. RESULTS

Two fits were performed. In `fit1`, we fixed $s = \bar{s}$ but, unlike what is done in ref. [2], we parametrise s independently of the non-strange sea. In `fit2` s and $\bar{s}$ are parametrised independently requiring $\int_0^1 (s(x) - \bar{s}(x))dx = 0$. Of course, other parton densities are parametrised in order to determine all the observables entering the fits.

As a first result we indicate that from a statistical point of view a perfect agreement between $\ell^\pm$ and $\nu(\bar{\nu})$ beam observables is observed with both fits. The disagreement observed in [1] is therefore most likely related to extraction procedure of the deuce $[F_2,\, F_3]$. A good agreement is also found between the BEBC $\nu(\bar{\nu})$ D target data and the CDHSW data. This gives us some confidence in the large nuclear corrections described in the previous section.

The strange density determined by `fit1` is shown in fig. 2 where the error bands include the propagation of all the experimental uncertainties. A good agreement is found with the CCFR di-muon analysis [8] results and one can also remark that $xs(x)$ is 'hard' at $x > 0.4$. Notice that a worse χ^2 (significantly worse) is obtained if, as in ref. [2],one fixes $s = \bar{s} = (\bar{u} + \bar{d})/4$ in `fit1`.

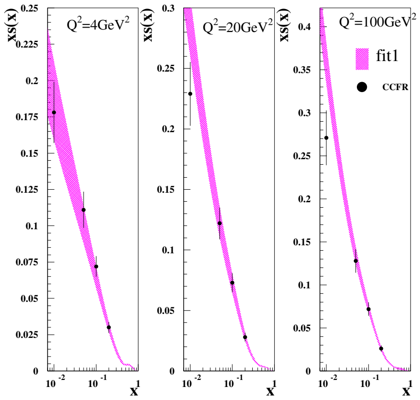

Figure 2. Results of `fit1` (see text).

The results of `fit2` for $xs(x) - x\bar{s}(x)$ and $s(x)/\bar{s}(x)$ are shown in fig.3. A significant non-singlet $x(s(x) - \bar{s}(x))$ component is observed. From `fit1` to `fit2` the contribution of the νFe data to the global χ^2 decreases. Our results for $s(x)/\bar{s}(x)$ are again not incompatible with the determination of CCFR [8]. In fig.4 the following observable

$$\Delta^{\nu-\bar{\nu}} \equiv \frac{4\pi x(M_W^2+Q^2)^2}{G_F^2 M_W^4}\left[\frac{d^2\sigma^{\nu N}}{dxdQ^2}-\frac{d^2\sigma^{\bar{\nu}N}}{dxdQ^2}\right].$$

is compared to `fit1` and `fit2`. In the QPM one has $\Delta^{\nu-\bar{\nu}} \propto xs(x) - x\bar{s}(x) + Y_-[xu_v(x)+xd_v(x)]$ so that fig.4 clearly demonstrate the sensitivity of the inclusive $\nu(\bar{\nu})$ data to the strange quarks.

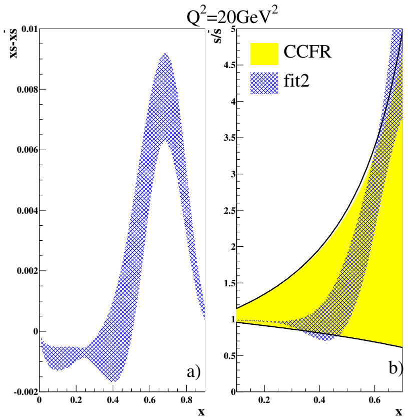

Figure 3. Results of `fit2` (see text).

4. SUMMARY

We have shown that if the $\nu(\bar{\nu})$ differential cross section enters the pQCD fits instead of the neutrino structure functions one obtains: *i)* a good agreement between $\ell^{\pm}$ and $\nu(\bar{\nu})$ DIS observables; *ii)* a constraint on xs and $x\bar{s}$. However, since the nuclear corrections applied to the $\nu(\bar{\nu})Fe$ data are large and determined empirically our results may be taken at a qualitative level: we have obtained some 'hard' xs and $x\bar{s}$ - with xs 'harder' than $x\bar{s}$ - distributions at high-x and a non vanishing non-singlet density $x(s-\bar{s})$.

Finally, let us emphasize that a more quantitative determination of the strangeness may be possible in a near future using the forthcoming $\nu(\bar{\nu})Fe$ CCFR (see U.K. Yang's contribution) and $\nu(\bar{\nu})Pb$ CHORUS (see R. Oldeman's contribution) cross-section measurements.

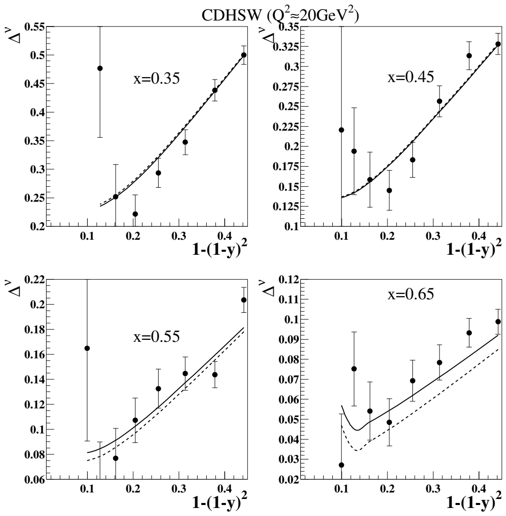

Figure 4. Comparison between `fit1` (hashed line) and `fit2` (full line) (see text).

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