Determination of strange sea distributions from νN DIS

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[arXiv:0812.4448]

Motivation

- the strange sea contribution is by the order of magnitude is comparable to the non-strange one, in particular for the W-production at the LHC
- an accurate estimate of the all sea quark uncertainties is impossible without the flavour separation
- a precise determination of the strange sea is necessary for the precision physics – the NuTeV anomaly can be explained by the small charge asymmetry in the strange distribution, $(s - \bar{s})$

(Davidson-... 01)

The $\boldsymbol{\nu N}$ DIS charm production

$$\frac{d\sigma^{\overset{(-)}{\nu}N}_{charm}}{dxdy} = \frac{G_F^2 M E_{\overset{(-)}{\nu}}}{\pi(1+Q^2/M_W^2)^2}\left[\left(1-y-\frac{Mxy}{2E}\right)F^{\overset{(-)}{\nu}N}_{2,c}(x,Q)+\right.$$

$$\left.+\frac{y^2}{2}F^{\overset{(-)}{\nu}N}_{T,c}(x,Q)\overset{+}{(-)}y\left(1-\frac{y}{2}\right)xF^{\overset{(-)}{\nu}N}_{3,c}(x,Q)\right]$$

In the leading order of QCD

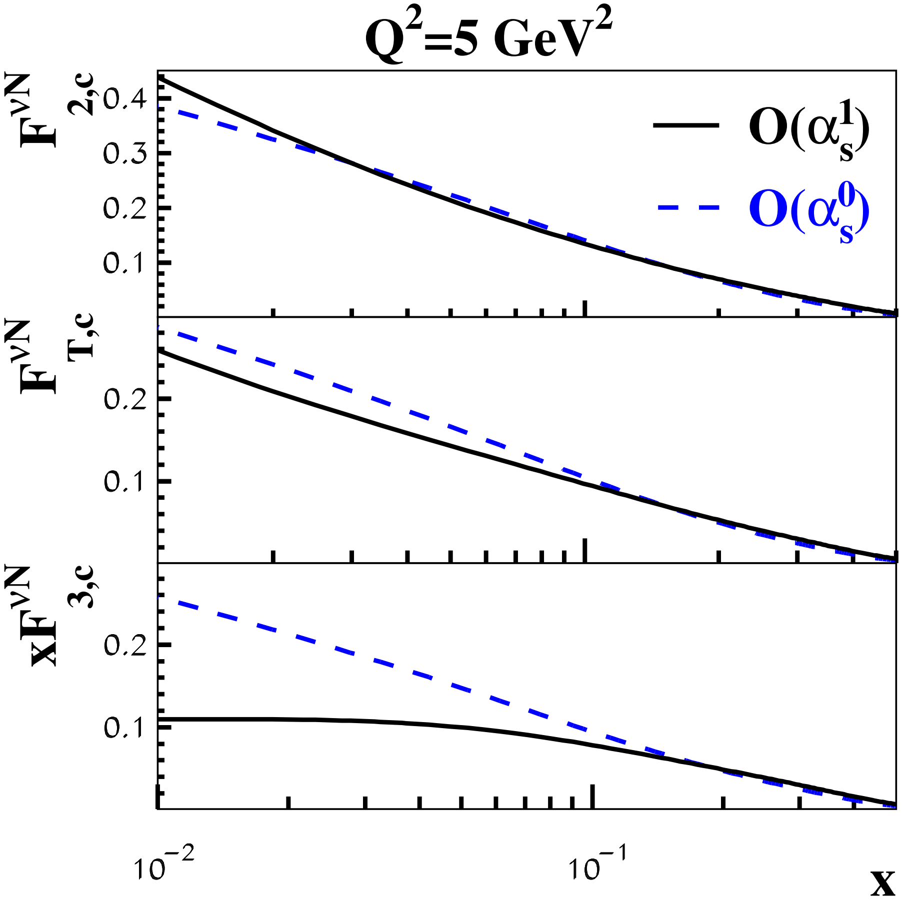
$$F_{2,c}^{\overset{(-)}{\nu}N}(x,Q) = 2\xi\left[|V_{cs}|^2\,\overset{(-)}{s}(\xi,\mu) + |V_{cd}|^2\,\frac{\overset{(-)}{u}(\xi,\mu)+\overset{(-)}{d}(\xi,\mu)}{2}\right]$$

$$F_{T,c}^{\overset{(-)}{\nu}N} = \overset{+}{(-)}xF_{3,c}^{\overset{(-)}{\nu}N} = \frac{x}{\xi}F_{2,c}^{\overset{(-)}{\nu}N}$$

$$|V_{cs}| \gg |V_{cd}|$$

The NLO QCD corrections

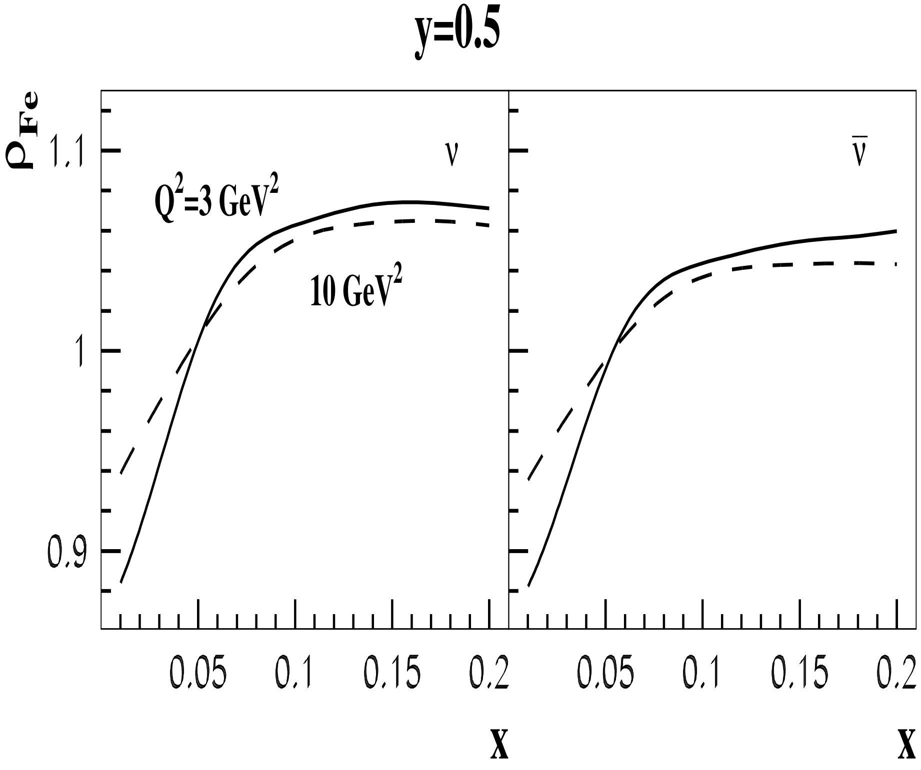
(Gottschalk 81)
(Glück-Kretzer-Reya 96)



LO: $Wq \to c$
NLO: $Wq \to cg$
$Wg \to cq$

The magnitude is similar for the ν- and $\bar{\nu}$-beam.

The nuclear corrections



(Kulagin-Petti 07)

The nuclear corrections depend on the beam type and the momentum transfer Q^2.

The νN DIS dimuon production

$$\frac{d\sigma_{\mu\mu}^{\overset{(-)}{\nu} N}}{dxdy} = B_\mu \frac{d\sigma_{\rm charm}^{\overset{(-)}{\nu} N}}{dxdy}$$

$$B_\mu = \sum f_h Br(h \to \mu X)$$

B_μ depends on the neutrino beam type and energy through the charmed-hadrons production rates f_h. For the rates measured by the E-531 emulsion experiment $B_\mu = (9.2 \pm 0.9)\%$, averaged over beam type at $E_\nu > 30$ GeV

(Bolton 97)

A simultaneous fit of B_μ and $s(\bar{s})$ is possible due to the cross section slope is sensitive to the strange sea magnitude through the QCD evolution

$$\frac{ds(x,\mu)}{d\ln\mu} \sim \int_x^1 \frac{dy}{y}\left[P_{qq}(x/y)s(y,\mu) + \ldots\right]$$

The basic features of the fit

- B_μ is fitted simultaneously with

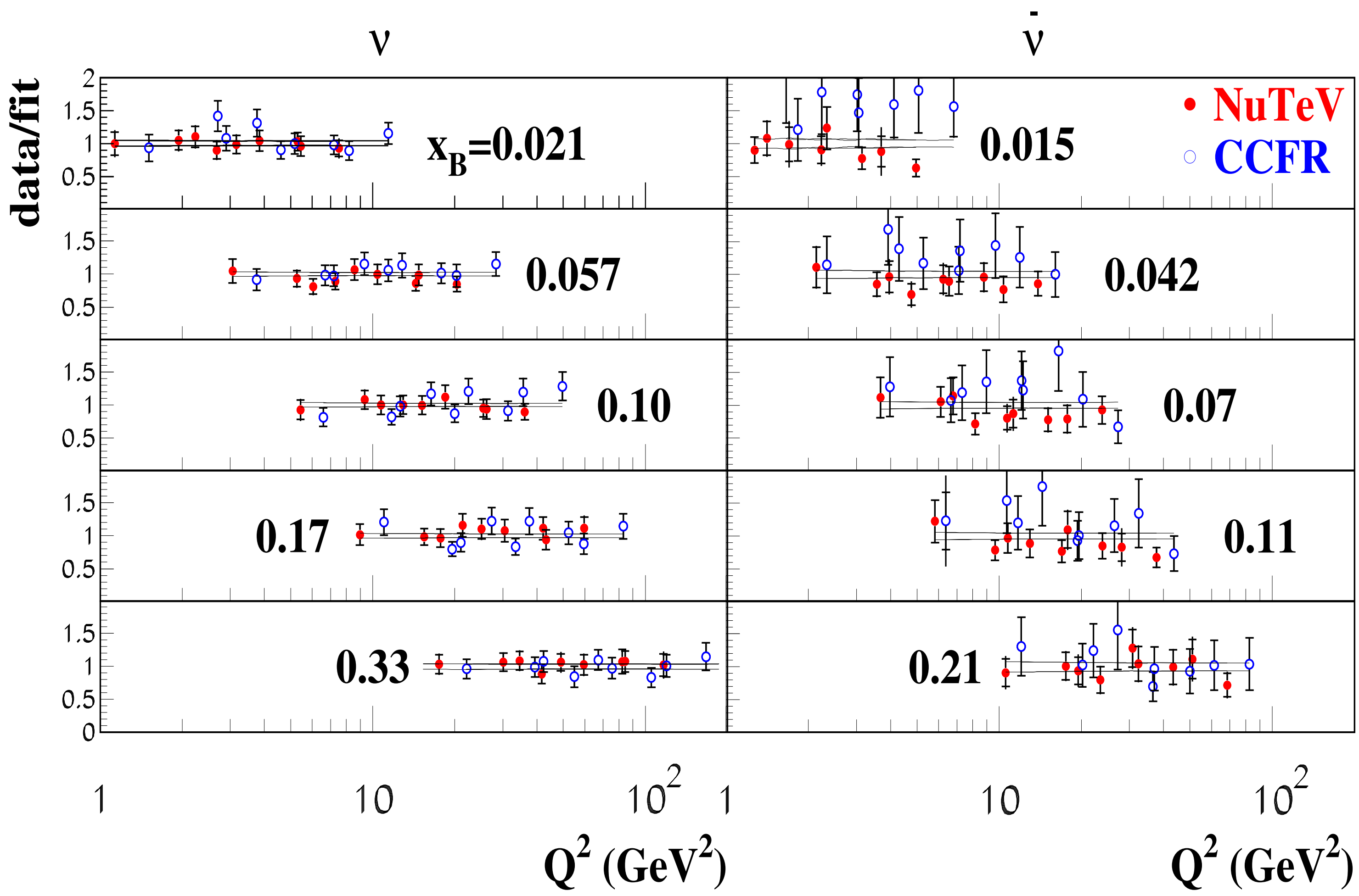
$$x \overset{(-)}{s} (x, Q_0^2) = \overset{(-)}{A_s}\, x^{\overset{(-)}{a_s}} (1-x)^{\overset{(-)}{b_s}}$$

  and other PDFs.

- The dimuon NuTeV and CCFR data, both for the ν- and $\bar{\nu}$-beams with similar energy, are combined with the fixed-target Drell-Yan data (constraint on the non-strange sea) and the inclusive charged-leptons DIS data (constrain the gluons and valence quarks).

- The NNLO approximation for the PDFs evolution and the light-parton coefficient functions. The heavy dimuon νN c.s. are calculated in $O(\alpha_\mathrm{s})$, in the FFN scheme.

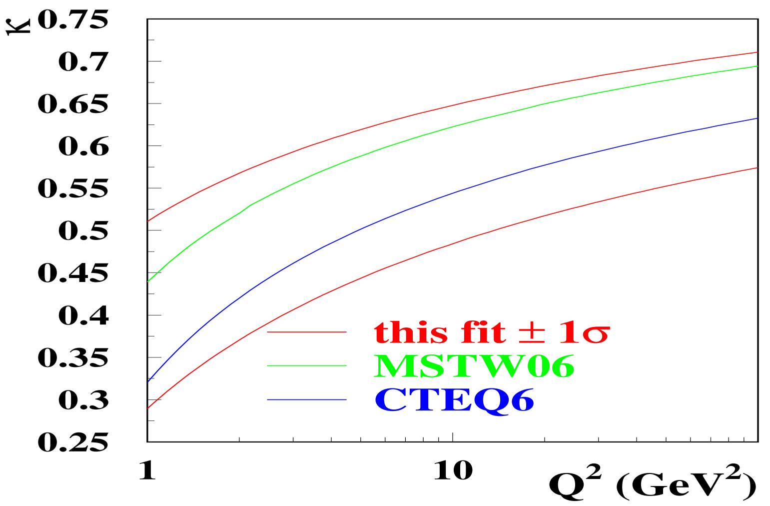
The pulls for unconstrained fit

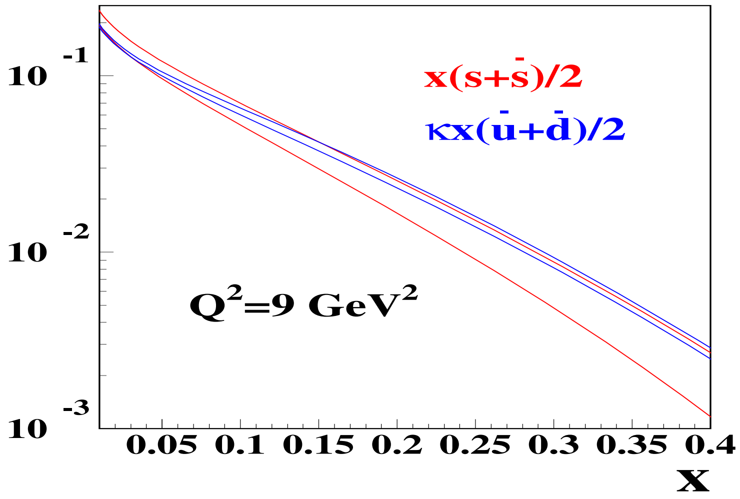


$\chi^2/NDP = 63/89$ for CCFR and 38/89 for NuTeV.

Checks of the fit consistency

- No beam type dependence of B_μ is observed: $B_\mu = (9.4 \pm 1.1)\%$ for neutrino and $(8.9 \pm 2.2)\%$ for antineutrino.
- No energy dependence of B_μ is observed: the fitted energy slope of B_μ is consistent with zero.
- The NuTeV and CCFR data demonstrate some inconsistency: $B_\mu = (7.2 \pm 1.7)\%$ for the variant of fit with the NuTeV data only and $(9.7 \pm 1.1)\%$ for CCFR.





- The value of strange sea suppression factor

$$\kappa = \frac{\int_0^1 x\,[s(x)+\overline{s}(x)]\,dx}{\int_0^1 x\left[\overline{u}(x)+\overline{d}(x)\right]dx}$$

depends on Q and $\kappa(Q^2 = 20\ \mathrm{GeV}^2) = 0.59\pm0.08$. This is bigger than $\kappa(20\ \mathrm{GeV}^2) = 0.48\,^{+0.06}_{-0.05}$ obtained in the CCFR NLO QCD fit.

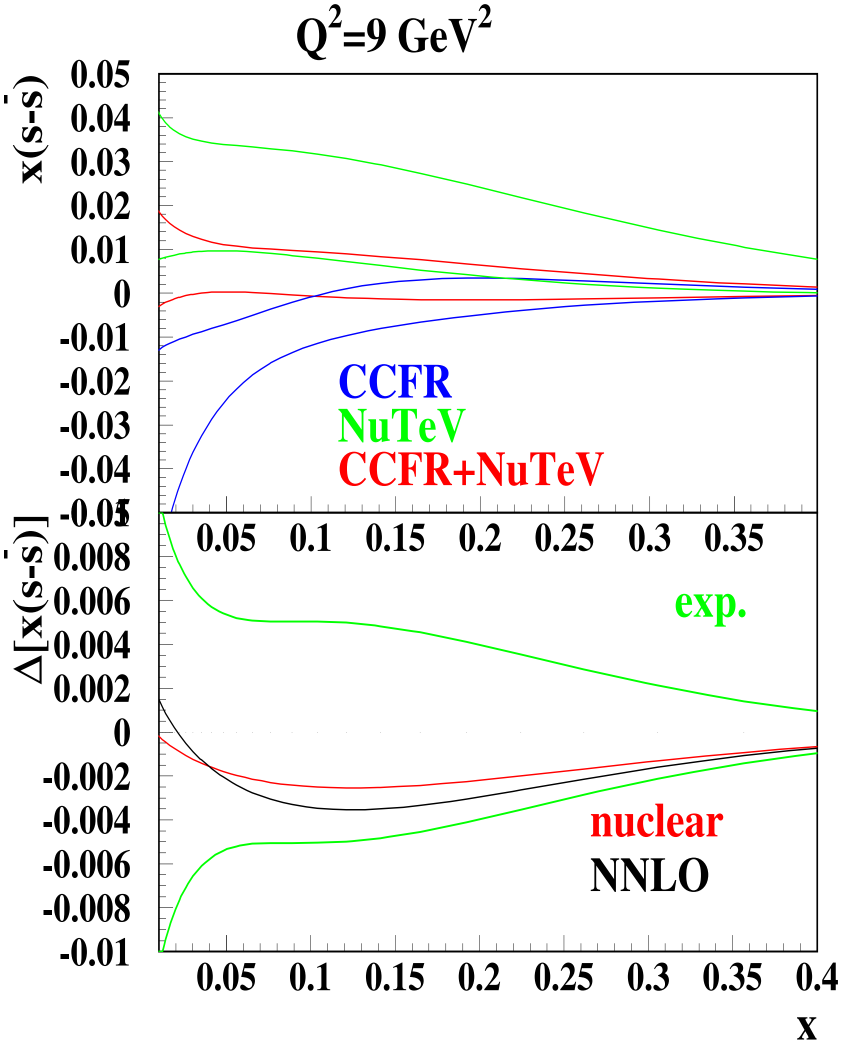
- The x-shape of strange sea is some softer than the non-strange one.

The constraints on B_μ from the emulsion experiments

With B_μ fixed $\kappa(20\ \mathrm{GeV}^2) = 0.59 \pm 0.03$ (compare with 0.59 ± 0.08 for B_μ fitted). The value of $B_\mu = (9.1 \pm 1.0)\%$ obtained in our fit is consistent with one obtained by Bolton, $B_\mu = (9.2 \pm 0.9)\%$.

Measurement	$E_\nu > 5$ GeV	$E_\nu > 30$ GeV
CHORUS	$7.30 \pm 0.82\%$	$8.50 \pm 1.08\%$
E531	$7.86 \pm 0.49\%$	$8.86 \pm 0.57\%$
Weighted average	$7.94 \pm 0.38\%$	$8.78 \pm 0.50\%$

With the additional input for B_μ we get substantial improvement in the strange sea magnitude, $\kappa(20\ \mathrm{GeV}^2) = 0.62 \pm 0.04$.



- The $s/\overline{s}$ asymmetry is comparable to zero within the errors, at $Q^2 = 20$ GeV^2 $\int_0^1 x[s(x) - \overline{s}(x)]dx = 0.0010(13)$ $(0.0013(9)$ with the additional input for $B_\mu)$.
- The asymmetry has different sign for the CCFR and NuTeV cases and is sensitive to the nuclear and NNLO corrections.

Summary

- The nucleon strange sea is extracted from a global fit including the (anti)neutrino dimuon data by the CCFR and NuTeV collaborations, the inclusive charged lepton-nucleon DIS and Drell-Yan data. The fit is constrained by the semi-leptonic charmed-hadron branching ratio $B_\mu = (8.8 \pm 0.5)\%$, determined from the inclusive charmed hadron measurements performed by FNAL-E-531 and CHORUS.
- The strange sea suppression factor $0.62 \pm 0.04(\text{exp.}) \pm 0.03(\text{QCD})$ at $Q^2 = 20~\text{GeV}^2$ is obtained.
- The total strange sea is slightly softer than the non-strange sea.
- The asymmetry between strange and anti-strange quark distributions consistent with zero (integrated over x it is equal to $0.0013 \pm 0.0009(\text{exp.}) \pm 0.0002(\text{QCD})$) at $Q^2 = 20~\text{GeV}^2$).