A model prediction for polarized antiquark flavor asymmetry

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$\bar{u}/\bar{d}$ asymmetry

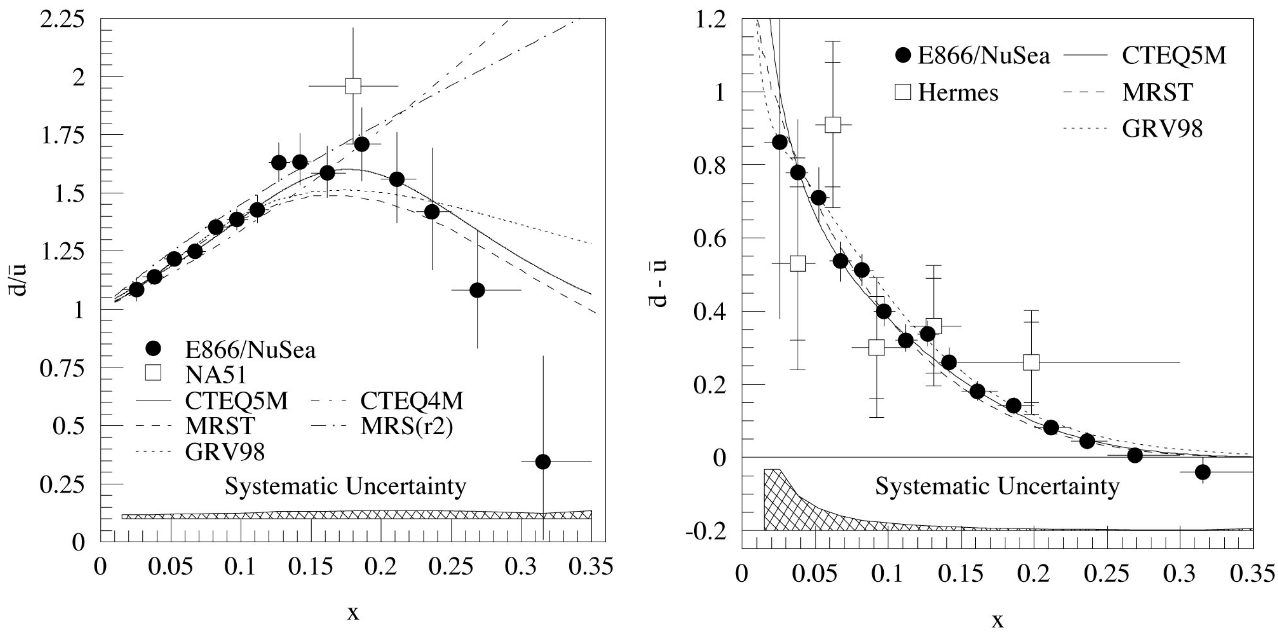
- Gottfried sum (NMC $S_G = 0.235 \pm 0.026$)

$$S_G = \int_0^1 \frac{dx}{x}\,[F_2^{\mu p}(x) - F_2^{\mu n}(x)]$$

$$= \frac{1}{3} + \frac{2}{3}\int_0^1 dx\,[\bar{u}(x) - \bar{d}(x)]$$

- Drell-Yan, semi-inclusive DIS

Fermilab E772/E866, NA51, HERMES



(from hep-ex/0103030)

see SK, Phys. Rep. 303 (1998) 183

$\bar{u}/\bar{d}$ asymmetry

- unpolarized: well established
- polarized ?

measured in the near future

$W^{\pm}$, semi-inclusive DIS, ...

theory $\longrightarrow$ unclear

(1) pQCD

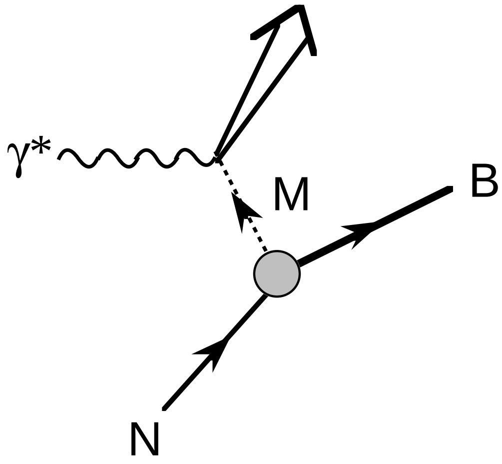
(2) nonperturbative models

meson clouds, soliton,

Pauli exclusion, ...

$\Delta\bar{u}/\Delta\bar{d}$ and $\Delta_T\bar{u}/\Delta_T\bar{d}$ could be appropriate quantities for testing nonperturbative models.

Meson-cloud model



unpolarized : e.g. $\pi^+(u\bar{d})$

$\Rightarrow$ $\bar{d}$ excess : $\bar{u} - \bar{d} < 0$

ρ contribution to $\Delta\bar{u} - \Delta\bar{d}$

see also the works: Fries - Schäfer
Phys. Lett. B443 (1998) 40.

$$\left[\Delta\bar{q}(x,Q^2)\right]_{MNB} = \int_x^1 \frac{dy}{y}\, \Delta f_{MNB}(y)\, \Delta\bar{q}_M(x/y,Q^2)$$

polarized : e.g. $\rho^+(u\bar{d})$

$\Rightarrow$ $\Delta\bar{d}$ excess : $\Delta\bar{u} - \Delta\bar{d} < 0$

Our studies: g_2^ρ type contributions

$\Delta\bar{u} - \Delta\bar{d}$ distribution

naive quark model

$$\rho^{+}\left(u\bar{d}\right),\quad \rho^{0}\left((u\bar{u}-d\bar{d})/\sqrt{2}\right),\quad \rho^{-}\left(\bar{u}d\right)$$

$$\begin{aligned}\left[\Delta\bar{u}-\Delta\bar{d}\right]_{\rho NB} = {} & \Delta f_{\rho^{+}pn}\otimes\left[\Delta\bar{u}-\Delta\bar{d}\right]_{\rho^{+}} \\ & + \Delta f_{\rho^{0}pp}\otimes\left[\Delta\bar{u}-\Delta\bar{d}\right]_{\rho^{0}} \\ & + \Delta f_{\rho^{+}p\Delta^{0}}\otimes\left[\Delta\bar{u}-\Delta\bar{d}\right]_{\rho^{+}} \\ & + \Delta f_{\rho^{0}p\Delta^{+}}\otimes\left[\Delta\bar{u}-\Delta\bar{d}\right]_{\rho^{0}} \\ & + \Delta f_{\rho^{-}p\Delta^{++}}\otimes\left[\Delta\bar{u}-\Delta\bar{d}\right]_{\rho^{-}}\end{aligned}$$

Charge symmetry in ρ

$$\Delta\bar{u}^{val}_{\rho^{-}} = \Delta\bar{d}^{val}_{\rho^{+}} = 2\Delta\bar{u}^{val}_{\rho^{0}} = 2\Delta\bar{d}^{val}_{\rho^{0}} = \Delta v_{\rho}$$

$$\left[\Delta\bar{u}-\Delta\bar{d}\right]_{\rho NB} = \left(-2\,\Delta f_{\rho NN} + \tfrac{2}{3}\,\Delta f_{\rho N\Delta}\right)\otimes\Delta v_{\rho}$$

g_1 and g_2

$$W_A^{\mu\nu}(P_N, q)$$
$$= i\,\varepsilon^{\mu\nu\rho\sigma}\, q_\rho \left[\frac{S_{N\sigma}}{P_N \cdot q}\, g_1 + \left(P_N \cdot q\, S_{N\sigma} - S_N \cdot q\, P_{N\sigma} \right) \frac{1}{(P_N \cdot q)^2}\, g_2 \right]$$

$$P^{\mu\nu} \equiv -\frac{i}{2} \frac{m_N^2}{P_N \cdot q}\, \varepsilon^{\mu\nu\alpha\beta}\, q_\alpha\, S_{N\beta}$$

$$\boxed{\gamma^2 \equiv 4\, x^2 \frac{m_N^2}{Q^2}}$$

$$P_{\mu\nu}\, W_A^{\mu\nu}(P_N, q) = \frac{m_N^2}{(P_N \cdot q)^2} \left\{ q^2 + (S_N \cdot q)^2 \right\} g_1 - \gamma^2\, g_2$$

Longitudinal polarization

$$S_N^\mu = \frac{\lambda_N}{m_N} \left(\left| \vec{P_N} \right|,\ 0\ ,\ 0\ ,\ E_N \right)$$

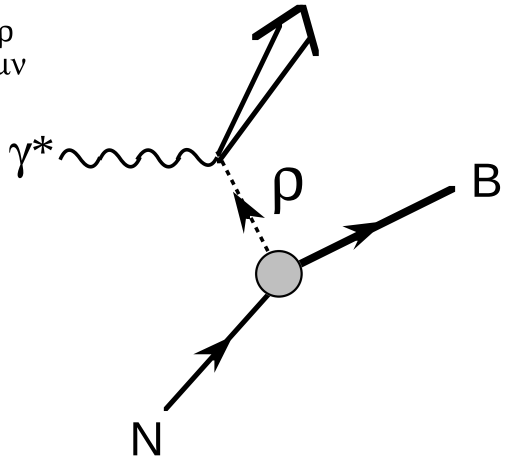
$$\Rightarrow \left[P_{\mu\nu}\, W_A^{\mu\nu} \right]_L = g_1 - \gamma^2\, g_2$$

$$g_2(x) = -g_1(x) + \int_x^1 \frac{dy}{y}\, g_1(y) + \bar{g}_2(x)$$

ρ-meson contribution to g_1

$$W_{\mu\nu} = \int \frac{d^3 p_B}{(2\pi)^3} \frac{2\, m_\rho\, m_B}{E_B} \left| \Gamma_{\rho NB} \right|^2 W^\rho_{\mu\nu}$$

calculate $P^{\mu\nu} W_{\mu\nu}$



Longitudinal polarization

$$\left[g_1(x) - \gamma^2\, g_2(x) \right]_{\rho NB}$$

$$= \int_x^1 \frac{dy}{y} \left[\Delta f^{1L}_{\rho NB}(y)\;\; g^\rho_1\!\left(\frac{x}{y}\right) - \Delta f^{2L}_{\rho NB}(y)\;\; g^\rho_2\!\left(\frac{x}{y}\right) \right]$$

Transverse polarization

$$\gamma^2 \left[g_1(x) + g_2(x) \right]_{\rho NB}$$

$$= \int_x^1 \frac{dy}{y} \left[\Delta f^{1T}_{\rho NB}(y)\;\; g^\rho_1\!\left(\frac{x}{y}\right) - \Delta f^{2T}_{\rho NB}(y)\;\; g^\rho_2\!\left(\frac{x}{y}\right) \right]$$

$$\Downarrow$$

$$\left[g_1(x) \right]_{\rho NB}$$

$$= \frac{1}{1+\gamma^2} \int_x^1 \frac{dy}{y} \Big[\Delta f^{1L}_{\rho NB}(y)\;\; g^\rho_1\!\left(\frac{x}{y}\right) - \Delta f^{2L}_{\rho NB}(y)\;\; g^\rho_2\!\left(\frac{x}{y}\right)$$

$$+ \Delta f^{1T}_{\rho NB}(y)\;\; g^\rho_1\!\left(\frac{x}{y}\right) - \Delta f^{2T}_{\rho NB}(y)\;\; g^\rho_2\!\left(\frac{x}{y}\right) \Big]$$

Meson distributions for $\gamma \to 0$

$$\boxed{\gamma^2 \equiv 4\,x^2\,\frac{m_N^2}{Q^2}}$$

$$\Delta f^{2L}_{\rho NB}(y)\,,\;\; \Delta f^{1T}_{\rho NB}(y)\,,\;\; \Delta f^{2T}_{\rho NB}(y)\;\;\to\;\;0$$

$$\Delta f^{1L}_{\rho NB}(y)$$

$$\to \Delta f_{\rho NB}(y) = \frac{1}{16\pi^2}\int_0^{\max(k_\perp^2)} dk_\perp^2\,\frac{\left|F_{\rho NB}(y,k_\perp^2)\right|^2\;\Delta V_{\rho NB}(y,k_\perp^2)}{\left[m_N^2 - M_{\rho B}^2(y,k_\perp^2)\right]^2}$$

$$\left[g_1(x)\right]_{\rho NB}$$

$$= \frac{1}{1+\cancel{\gamma^2}}\int_x^1 \frac{dy}{y}\left[\Delta f^{1L}_{\rho NB}(y)\;g_1^\rho\!\left(\frac{x}{y}\right) - \cancel{\Delta f^{2L}_{\rho NB}(y)}\;g_2^\rho\!\left(\frac{x}{y}\right)\right.$$

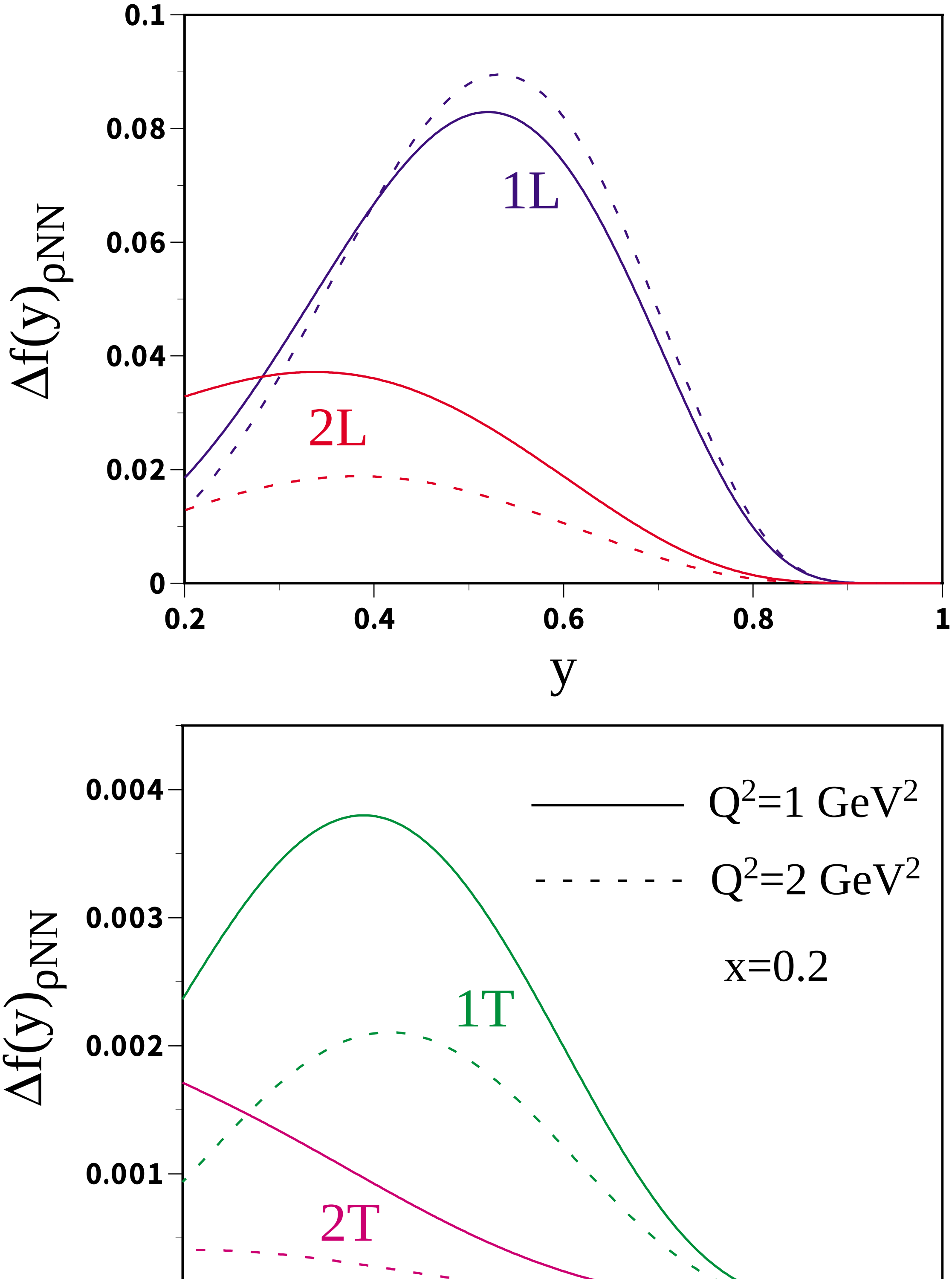
$$\left. + \cancel{\Delta f^{1T}_{\rho NB}(y)}\;g_1^\rho\!\left(\frac{x}{y}\right) - \cancel{\Delta f^{2T}_{\rho NB}(y)}\;g_2^\rho\!\left(\frac{x}{y}\right)\right]$$

$$\Big\Downarrow\;\gamma \to 0$$

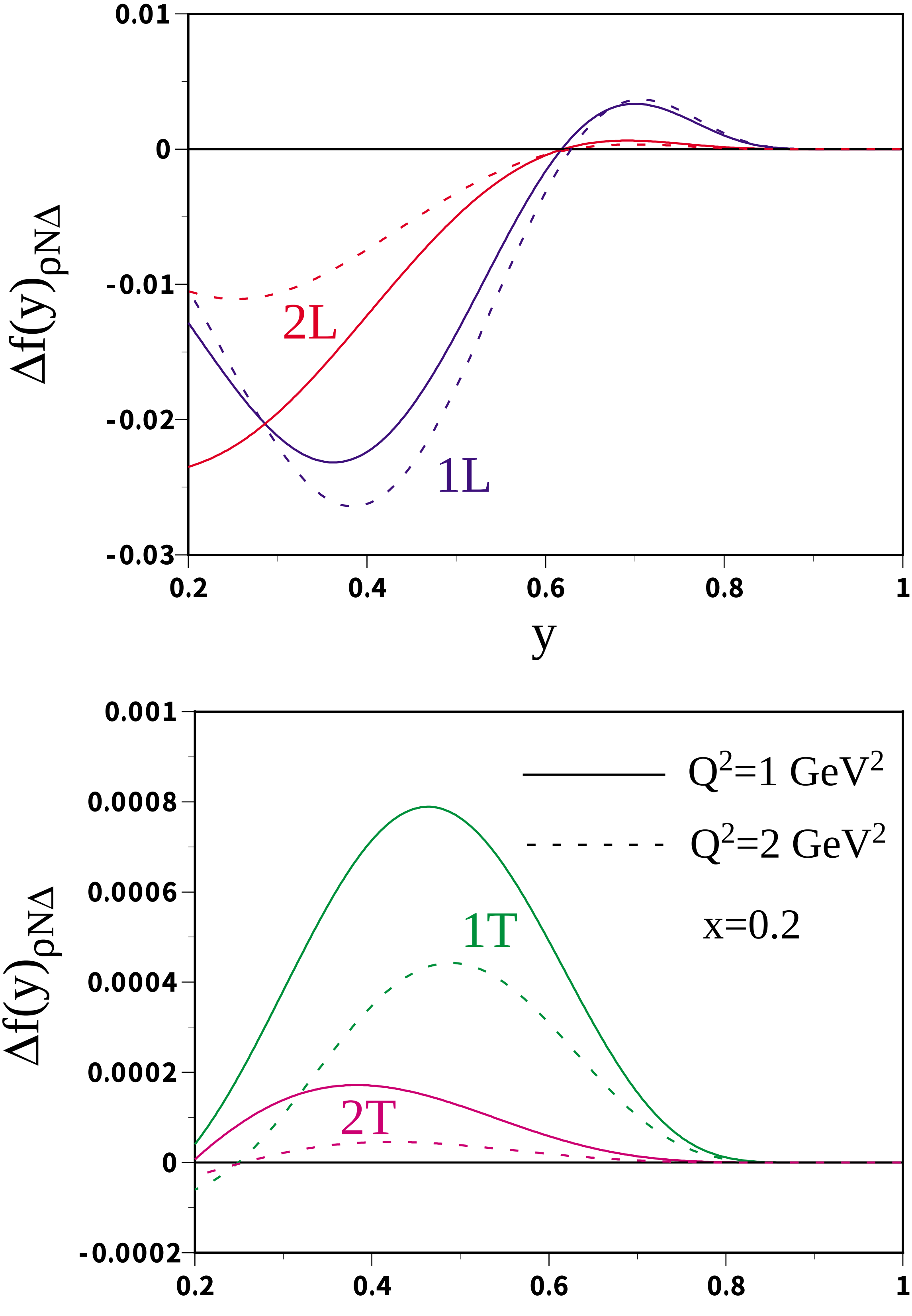
$$\left[g_1(x)\right]_{\rho NB} = \int_x^1 \frac{dy}{y}\,\Delta f_{\rho NB}(y)\;g_1^\rho\!\left(\frac{x}{y}\right)$$

Fries - Schäfer (1998)

Meson distributions (ρNN)



Meson distributions (ρNΔ)



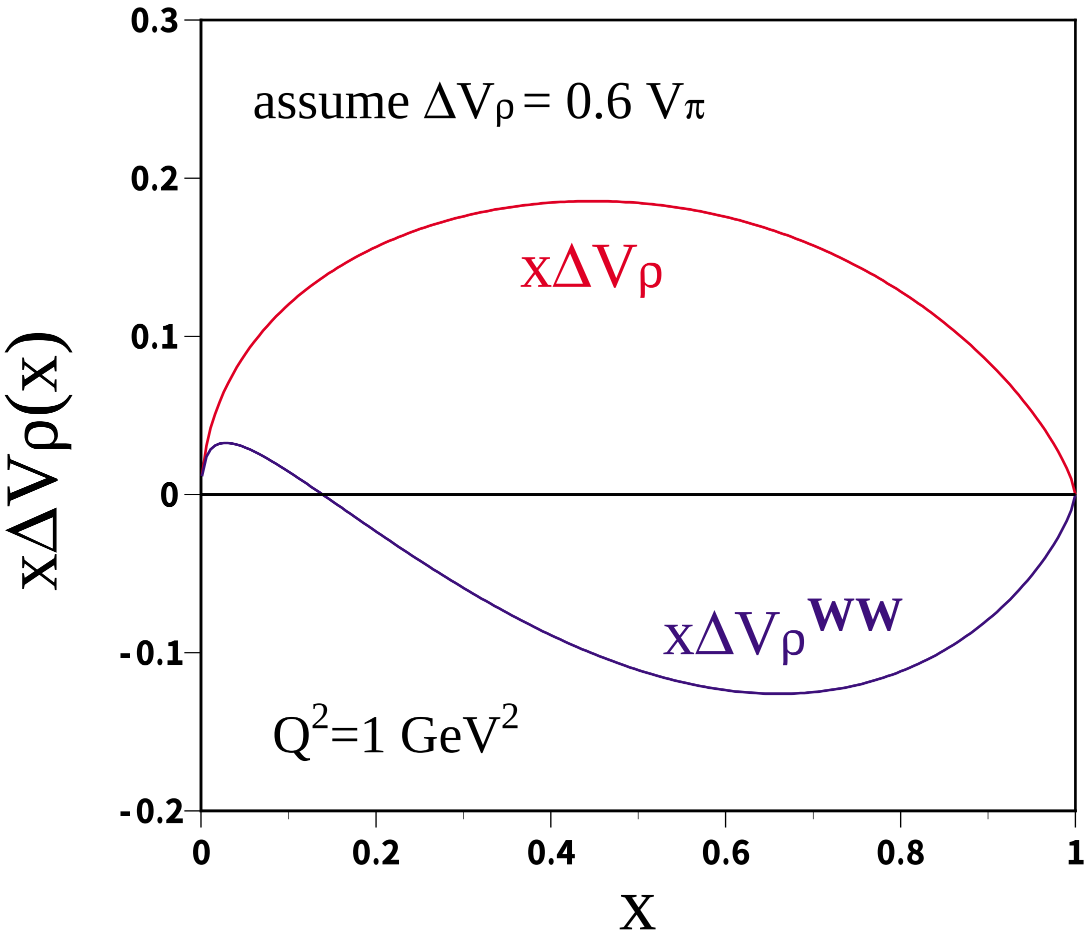
Parton distributions in ρ

$$g_2^\rho(x) = g_2^{\rho\,WW}(x) + \bar{g}_2^\rho(x)$$

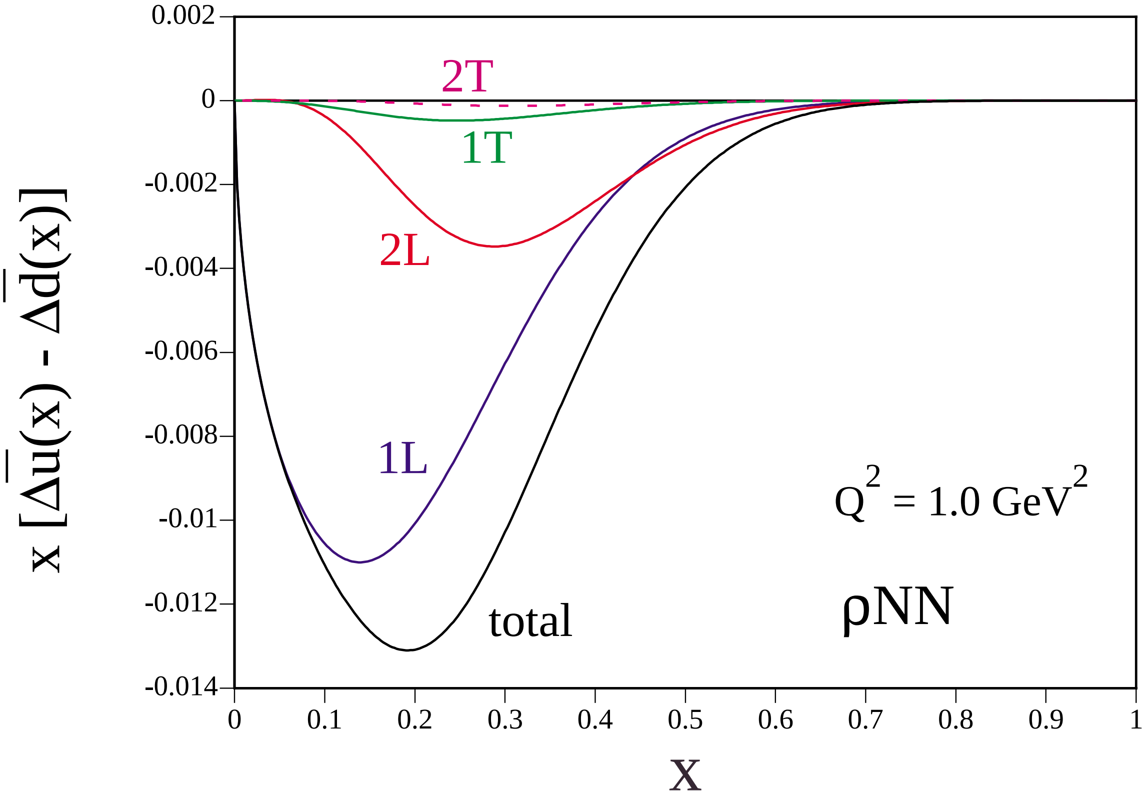
$$g_2^{\rho\,WW}(x) = -g_1^\rho(x) + \int_x^1 \frac{dy}{y} g_1^\rho(y)$$

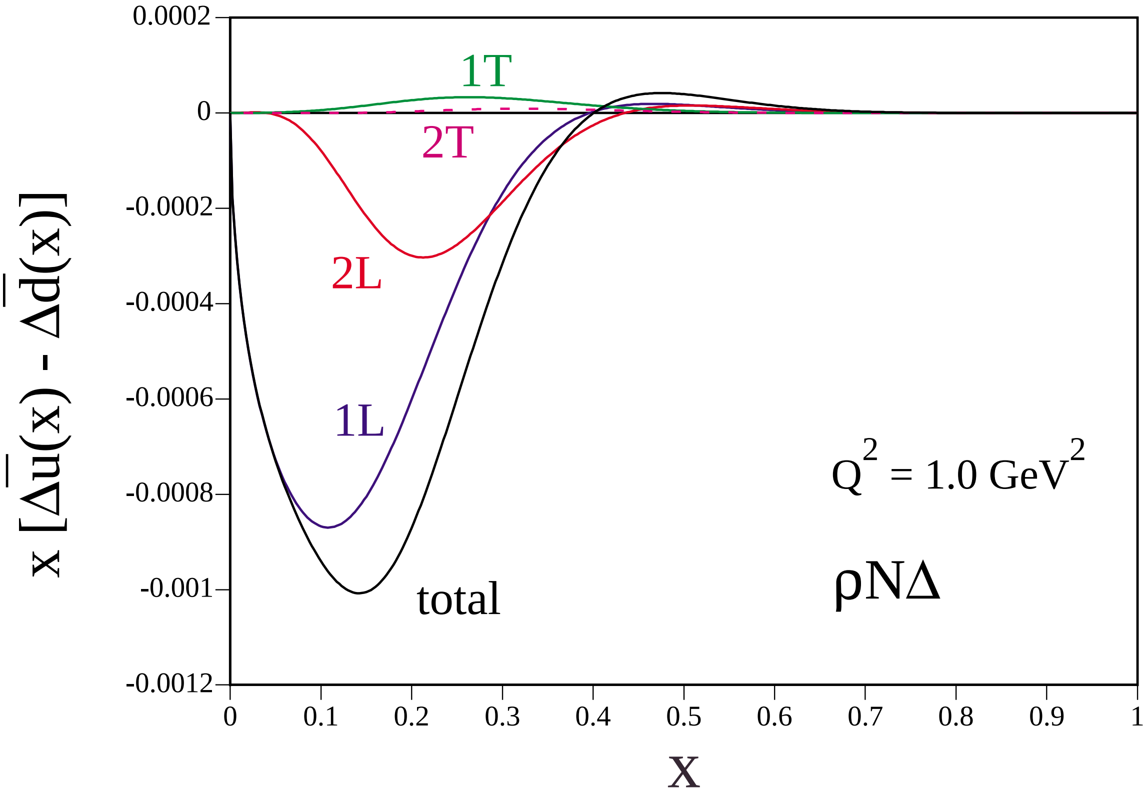
$$\Rightarrow \quad \Delta v_\rho^{WW}(x) = -\Delta v_\rho(x) + \int_x^1 \frac{dy}{y} \Delta v_\rho(y)$$

M. Glück et al. (GRS), Euro. Phys. J. C10 (1999) 313



$\Delta\bar{u} - \Delta\bar{d}$ distributions





Summary

(1) Meson-cloud model

- ρ effects $\rightarrow \Delta\bar{u} - \Delta\bar{d} < 0$

(2) Contributions from $\gamma^2 = 4x^2 m_N^2 / Q^2$ terms

- could become important
  at medium & large x with small Q^2

(3) Clarification of previous calculations

- Fries-Schäfer $\leftrightarrow$ Cao-Signal

(4) Measurements

- W production, semi-inclusive DIS
- Drell-Yan