Flavor asymmetry in polarized antiquark distributions

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- ρ-meson contributions
- Results
- Summary

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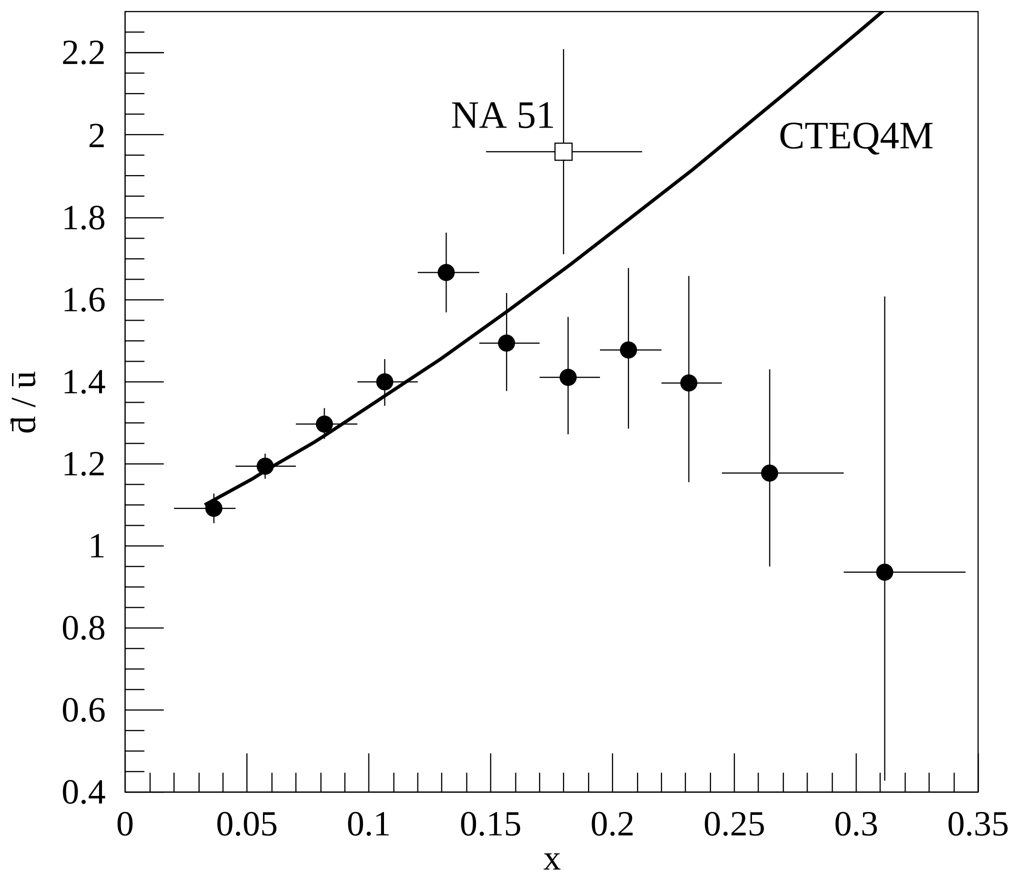
$\bar{u}/\bar{d}$ **asymmetry**

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

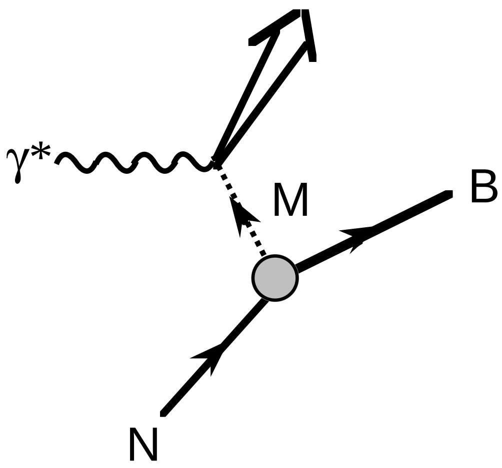
$$
\begin{aligned}
S_G &= \int_0^1 \frac{dx}{x} \left[F_2^{\mu p}(x) - F_2^{\mu n}(x) \right] \\
&= \frac{1}{3} + \frac{2}{3} \int_0^1 dx \left[\bar{u}(x) - \bar{d}(x) \right]
\end{aligned}
$$

- Drell-Yan p-d asymmetry (NA51, E866)



- Semi-inclusive DIS (HERMES)

Meson-cloud model



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

$\downarrow$

$\bar{d}$ 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.

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

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

$\downarrow$

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

g_1 and g_2 (γ^2 contributions)

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

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

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

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

Longitudinal polarization

$$S_N^\mu = \frac{\lambda_N}{m_N} \left(\left| \vec{P}_N \right|, 0, 0, E_N \right) \Rightarrow \underline{g_1 - \gamma^2 g_2}$$

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

ρ-meson contribution to g_1

Longitudinal polarization

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

Transverse polarization

$$\gamma^2\,\delta\left[g_1(x) + g_2(x)\right]$$
$$= \int_x^1 \frac{dy}{y}\left[\Delta f^{1T}_{\rho NB}(y)\ \ g_1^{\rho}\left(\frac{x}{y}\right) - \Delta f^{2T}_{\rho NB}(y)\ \ g_2^{\rho}\left(\frac{x}{y}\right)\right]$$

$$\Downarrow$$

$$\delta g_1(x)$$
$$= \frac{1}{1+\gamma^2}\int_x^1 \frac{dy}{y}\Big[\Delta f^{1L}_{\rho NB}(y)\ \ g_1^{\rho}\left(\frac{x}{y}\right) - \Delta f^{2L}_{\rho NB}(y)\ \ g_2^{\rho}\left(\frac{x}{y}\right)$$
$$+ \Delta f^{1T}_{\rho NB}(y)\ \ g_1^{\rho}\left(\frac{x}{y}\right) - \Delta f^{2T}_{\rho NB}(y)\ \ g_2^{\rho}\left(\frac{x}{y}\right)\Big]$$

Meson distributions

$$\Delta f_{\rho NB}(y) = f_{\rho NB}^{\lambda=+1}(y) - f_{\rho NB}^{\lambda=-1}(y)$$

$$\Delta f_{\rho NB}(y)$$

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

Momentum of ρ: $\vec{k} = \vec{k}_\perp + y' \vec{P}_N$ $\qquad y = \dfrac{k \cdot q}{P_N \cdot q}$

$$y' = \frac{y}{1 + \left(1 + \gamma^2\right)^{1/2}}\left[1 + \left\{1 + \frac{\gamma^2}{y^2 m_N^2}\left(k_\perp^2 + m_\rho^2\right)\right\}^{1/2}\right]$$

$$M_{\rho B}^2(y', k_\perp^2) = \frac{k_\perp^2 + m_\rho^2}{1 - y'} + \frac{k_\perp^2 + m_B^2}{y'}$$

Form factor : $F_{\rho NB}(y', k_\perp^2) = \exp\left[\dfrac{m_N^2 - M_{\rho B}^2(y', k_\perp^2)}{2\Lambda_{\rho NB}^2}\right]$

Cut-off parameters $\Lambda_{\rho NN} = \Lambda_{\rho N\Delta} = 1.0$ GeV

Meson distributions $\gamma^2 \to 0$

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

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

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

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

$$\delta g_1(x)$$

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

$$\Downarrow$$

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

$\Longrightarrow$ Fries - Schäfer

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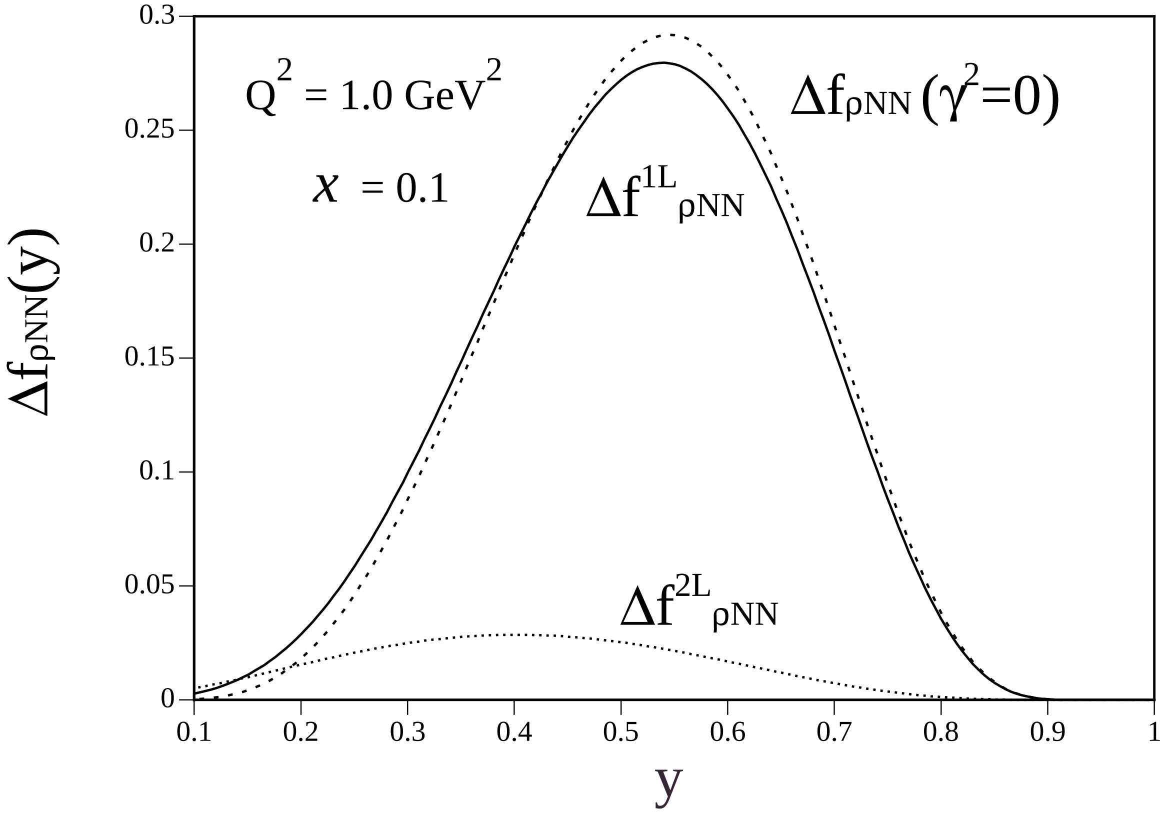
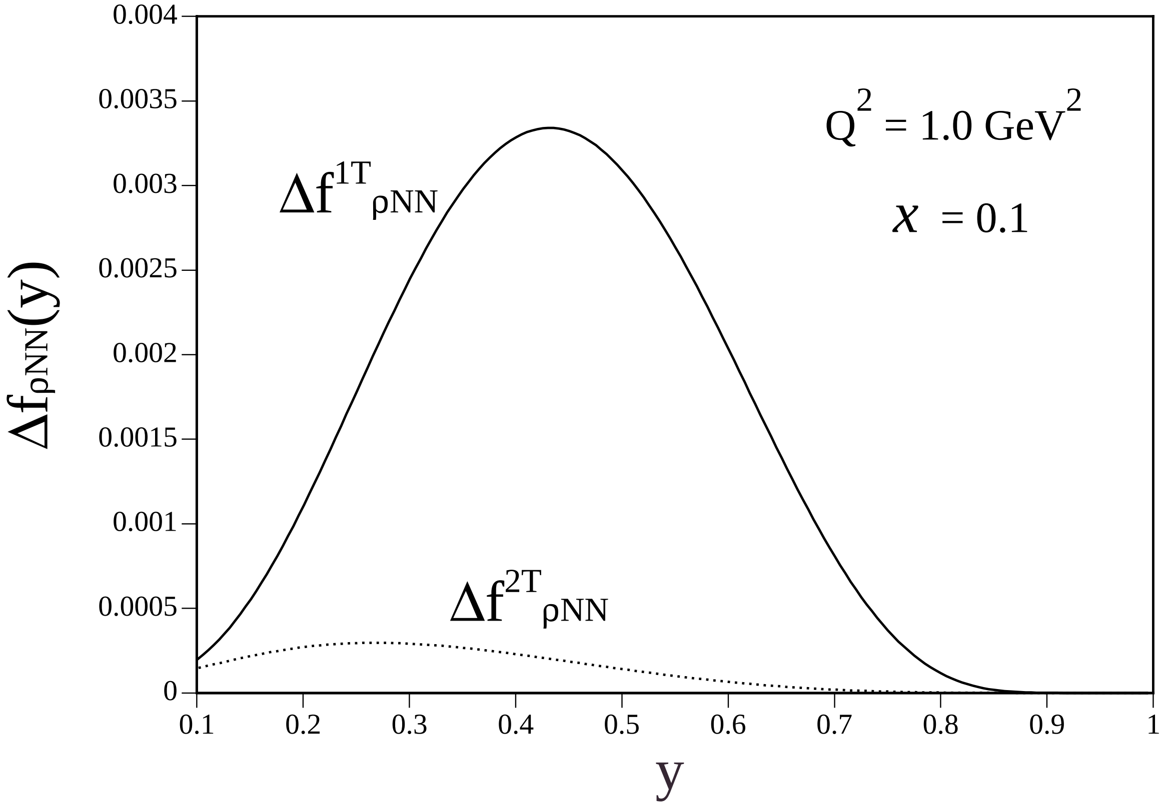
Meson distributions (ρNN)

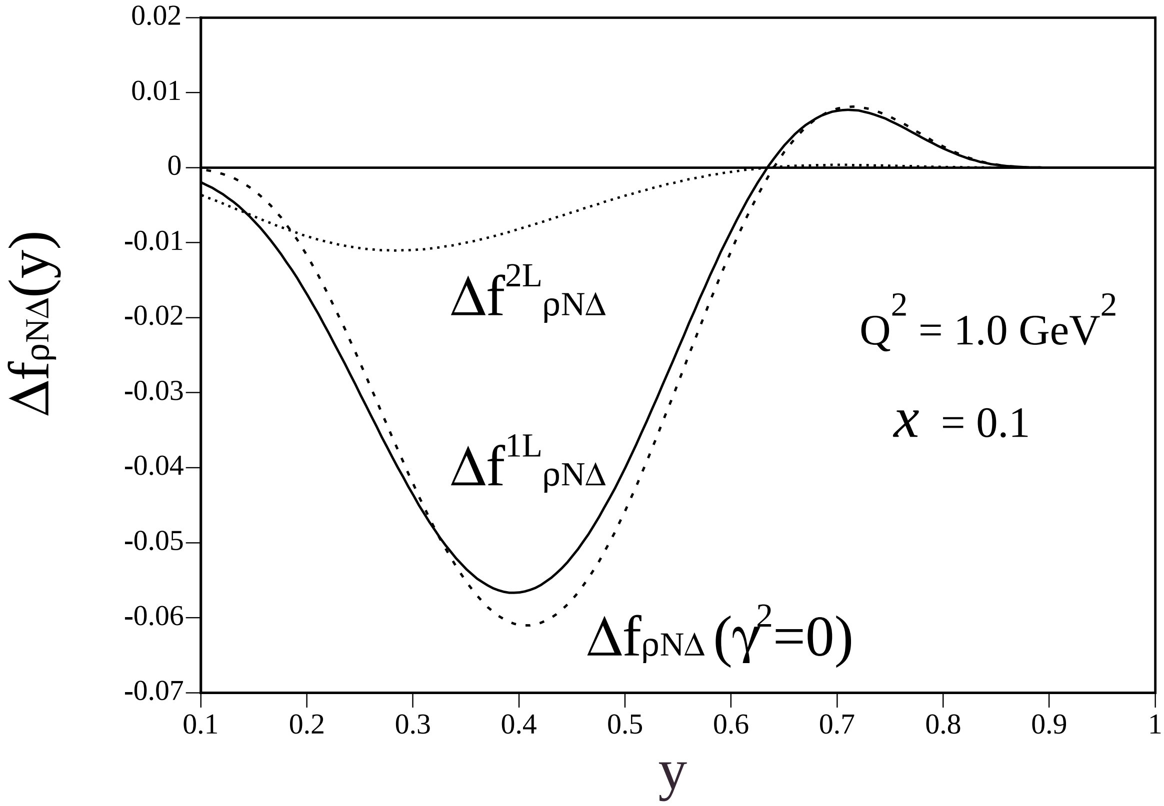
Preliminary

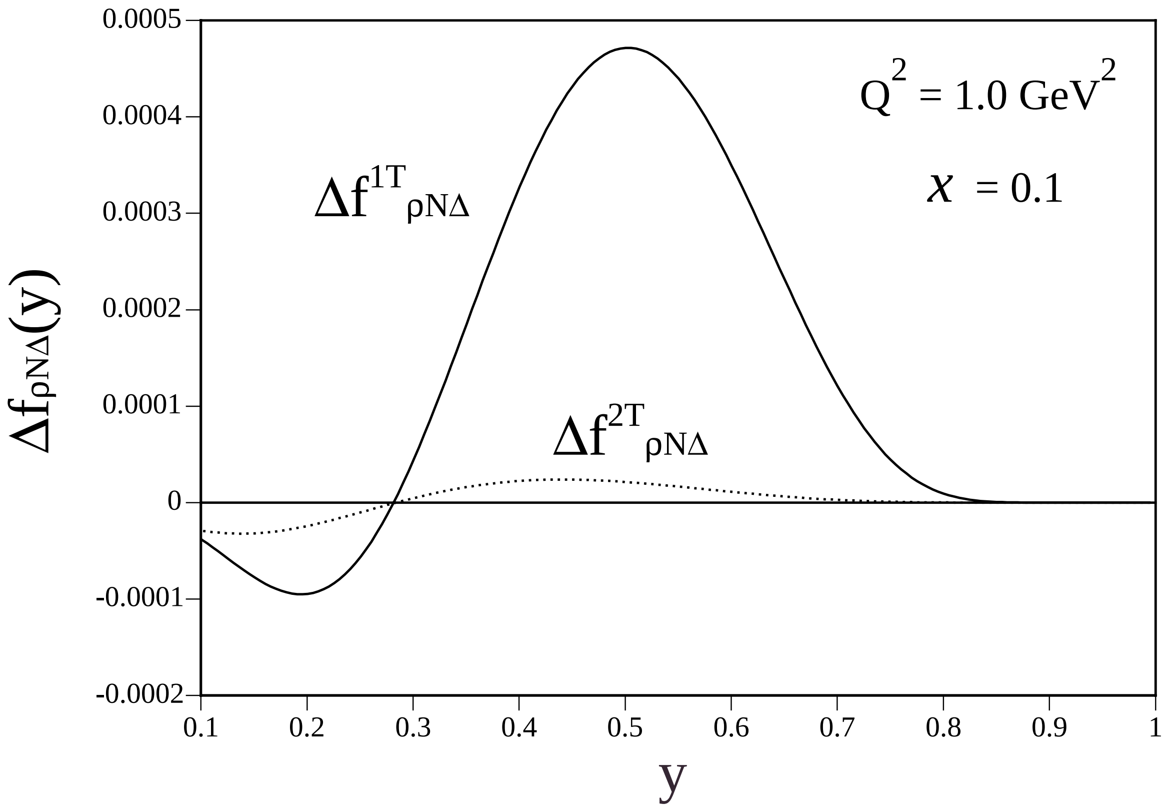




Meson distributions (ρNΔ)

Preliminary





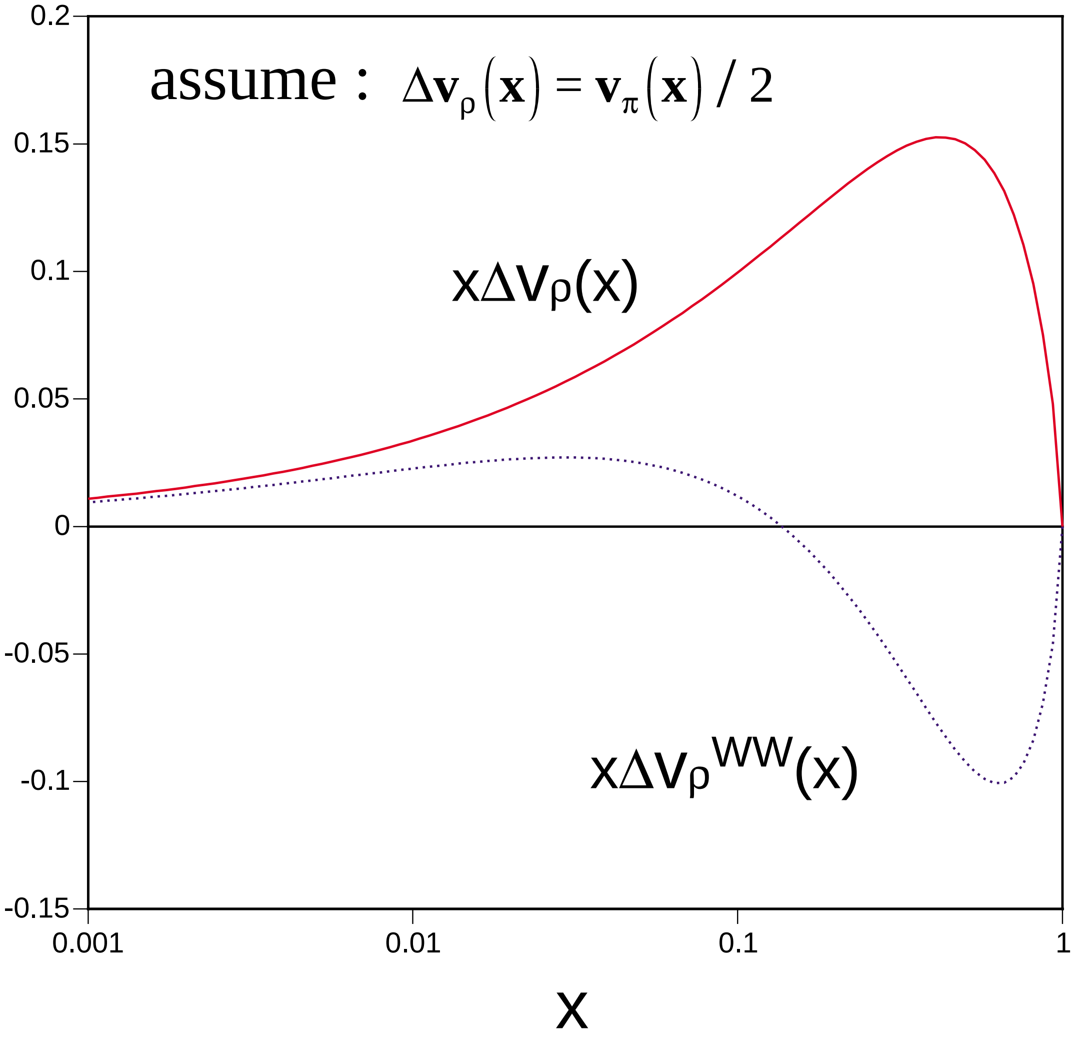
Parton distributions of ρ

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

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

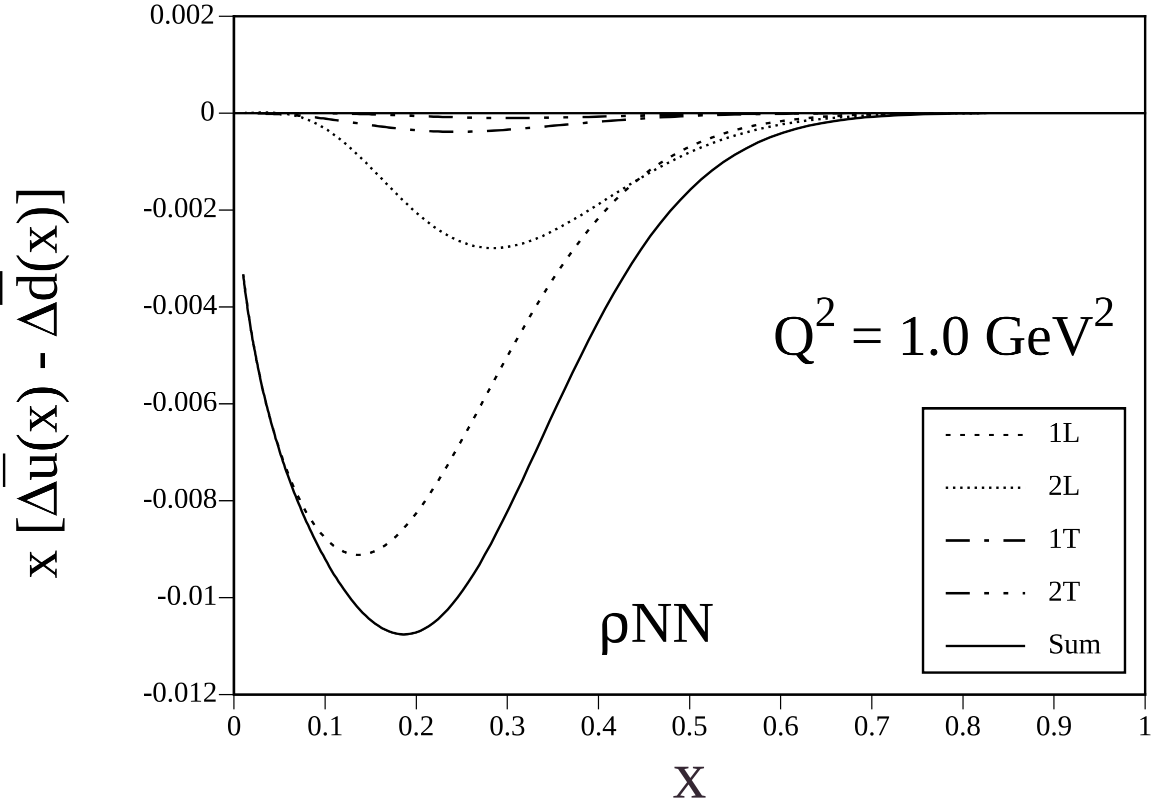
$$\Rightarrow \quad \Delta v_\rho{}^{WW}(x) = -\Delta v_\rho(x) + \int_x^1 \frac{dy}{y}\, \Delta v_\rho(y)$$

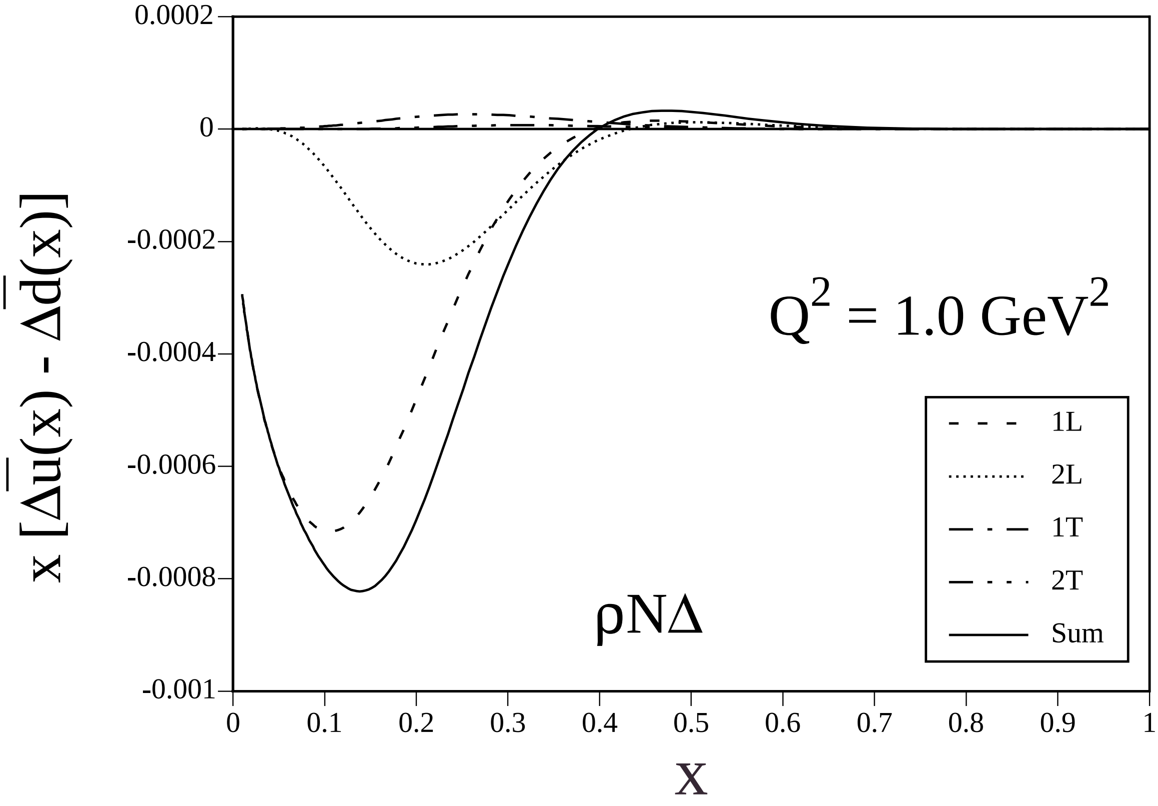
M. Glück et al. (GRV), Z. Phys. C 53 (1992) 651



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

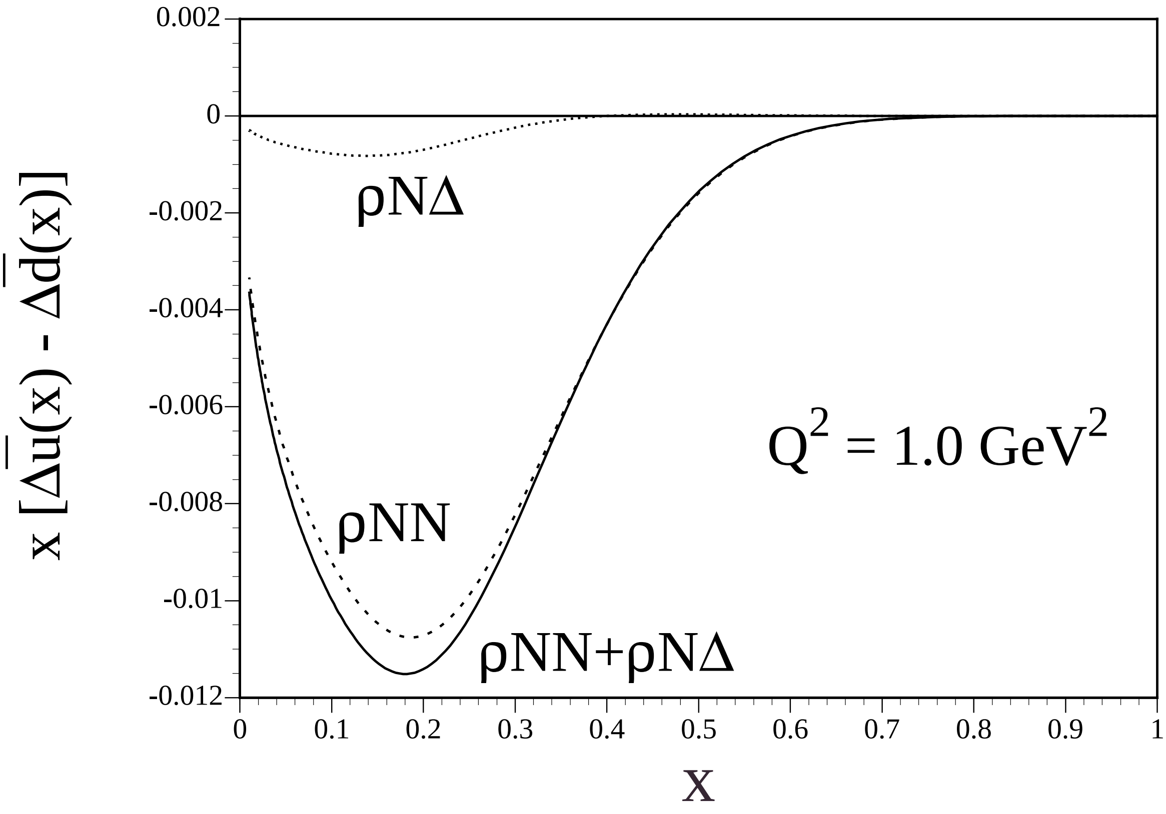
Preliminary

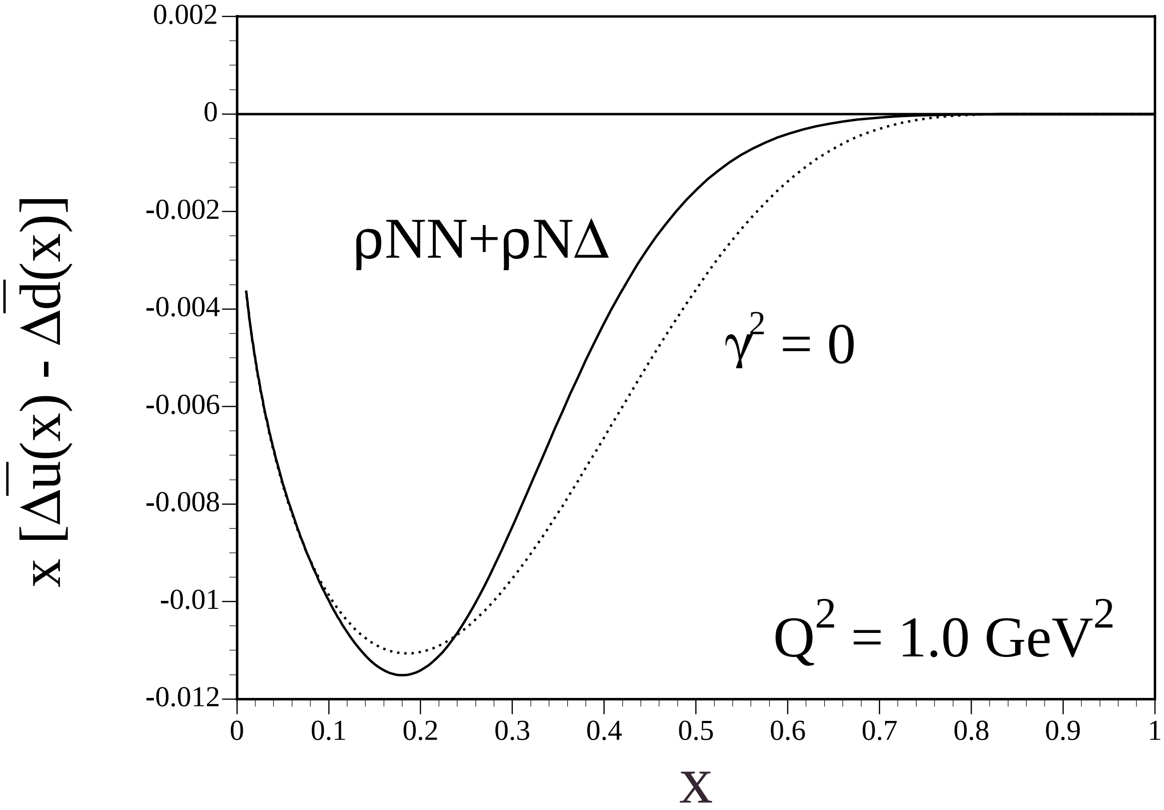




$\Delta\bar{u}$ - $\Delta\bar{d}$ distribution

Preliminary





Summary

- Meson-cloud model
  - ρ-cloud effect $\longrightarrow$ $\Delta\bar{u} - \Delta\bar{d} < 0$
  - $\rho N\Delta \ll \rho NN$

- contributions from $\gamma^2 \equiv 4x^2 \frac{m_N^2}{Q^2}$ terms
  - not so small,
    particularly at small Q^2 and large x
  - transverse pol. << longitudinal pol.

- How to measure ?
  - W-production
  - Semi-inclusive DIS
  - pd Drell-Yan process ?
    S. Kumano and M. Miyama
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