$g_1(x)$ and $g_2(x)$ in the Meson Cloud Model

Tony Signal

Institute of Fundamental Sciences

Massey University

New Zealand

South Pacific Ocean
Tasman Sea
Auckland
Hamilton
Tauranga
North Island
West Island
Gisborne
New Plymouth
Napier
Cook Strait
Palmerston North
WELLINGTON
Greymouth
South Island
Christchurch
South Pacific Ocean
Dunedin
Invercargill
Stewart Island

Overview

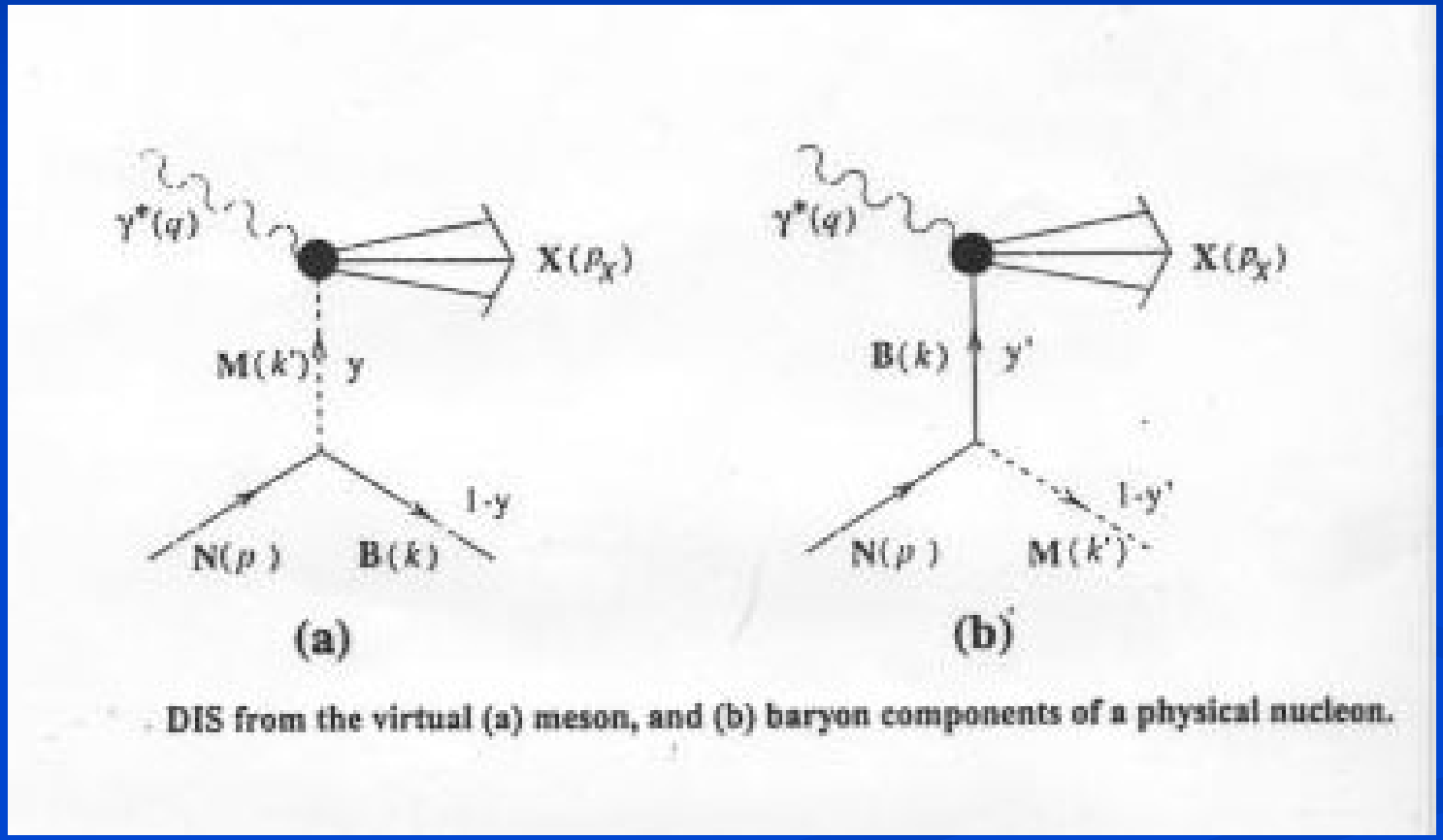
- Meson Cloud model
- Meson cloud contributions to spin structure functions
- Conclusion

Meson Cloud Model

- Crucial observation (Sullivan 72) -
  - Pion cloud contribution to DIS scales
  - Implies quark dists of proton modified
  - Convolution

$$\delta q^p(x) = \int_x^1 \frac{dy}{y} f_{p\pi}(y) q^\pi(\frac{x}{y})$$

Meson Cloud Model



DIS from the virtual (a) meson, and (b) baryon components of a physical nucleon.

Meson Cloud Model

- Fock expansion of proton waveftn.

$$|p\rangle_{\rm phys} = \sqrt{Z}|p\rangle_{\rm bare} + \sum_{BM} \int dy\, dk_\perp^2\, \phi_{BM}(y, k_\perp^2)|B; M\rangle$$

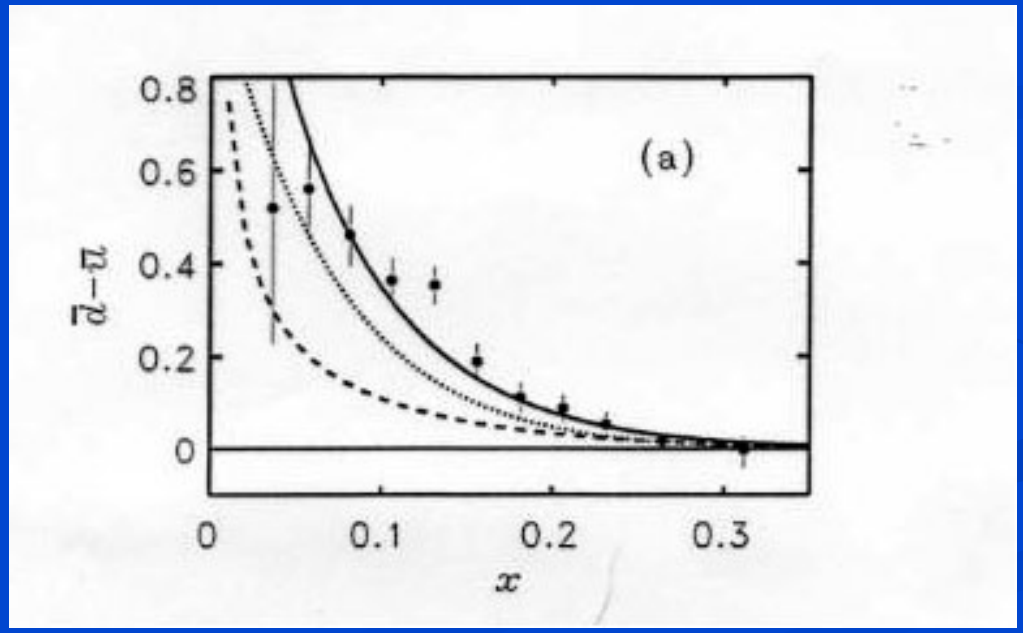
  - Bare states are SU(6) symmetric
  - $p \to BM$ vertices described by L_{int} plus form factor
  - FF constrained by elastic cross-sec
  - Quick convergence $\Leftrightarrow$ Small prob. of high mass states
- Model incorporates structure + interactions
- Can investigate high-energy $\leftrightarrow$ low-energy pictures, symmetry breaking etc.

Gottfried Sum Rule

- Isospin broken in sea

$$p \rightarrow n(udd) + \pi^+(u\bar{d})$$
$$p \rightarrow \Delta^{++}(uuu) + \pi^-(d\bar{u})$$

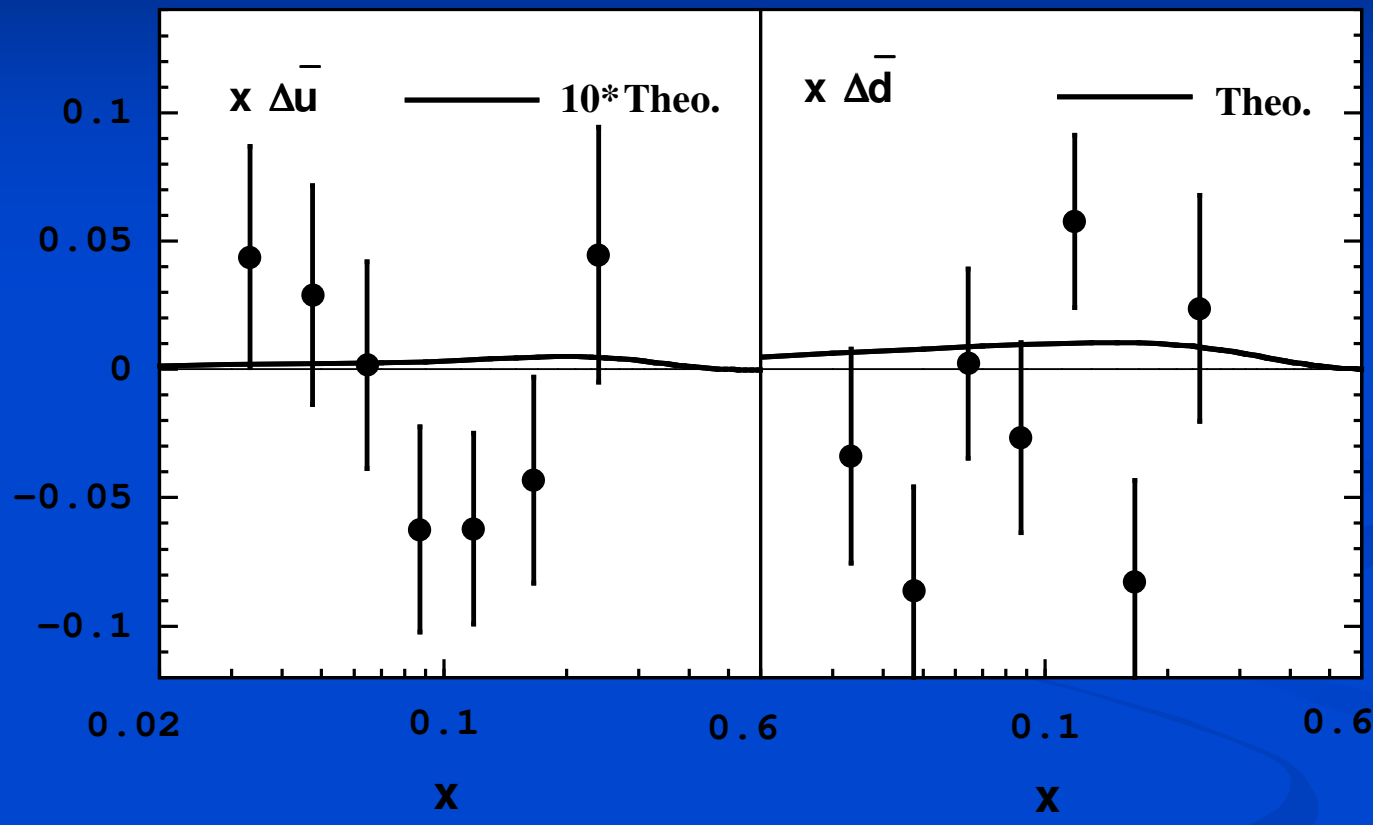
- MCM gives good fit to $\bar{d}(x) - \bar{u}(x)$



Spin dependent Quark Dists.

- Extend MCM to include vector mesons
  - π cloud dilutes proton spin
  - ρ, ω, K^* able to carry spin
- Include interference terms
- Get reasonably good agreement with HERMES semi-inclusive data for sea distributions

Spin Dependent Sea Dists.



- Data from Hermes
- Small symmetry breaking

Spin Dependent Structure Functions

- Dominated by valence distributions
  - $N \rightarrow N\pi$, $N \rightarrow \Delta\pi$ most important fluctuations

$$\mathcal{L}_{int} = ig_{NN\pi}\bar{\psi}\gamma_5\pi\psi, \quad f_{N\Delta\pi}\bar{\psi}\pi\partial_\mu\chi^\mu + \text{h.c.}$$

- At finite Q^2 spin of cloud hadrons are not parallel with initial nucleon spin
- Both longitudinal and transverse spin components of cloud contribute to observed structure functions

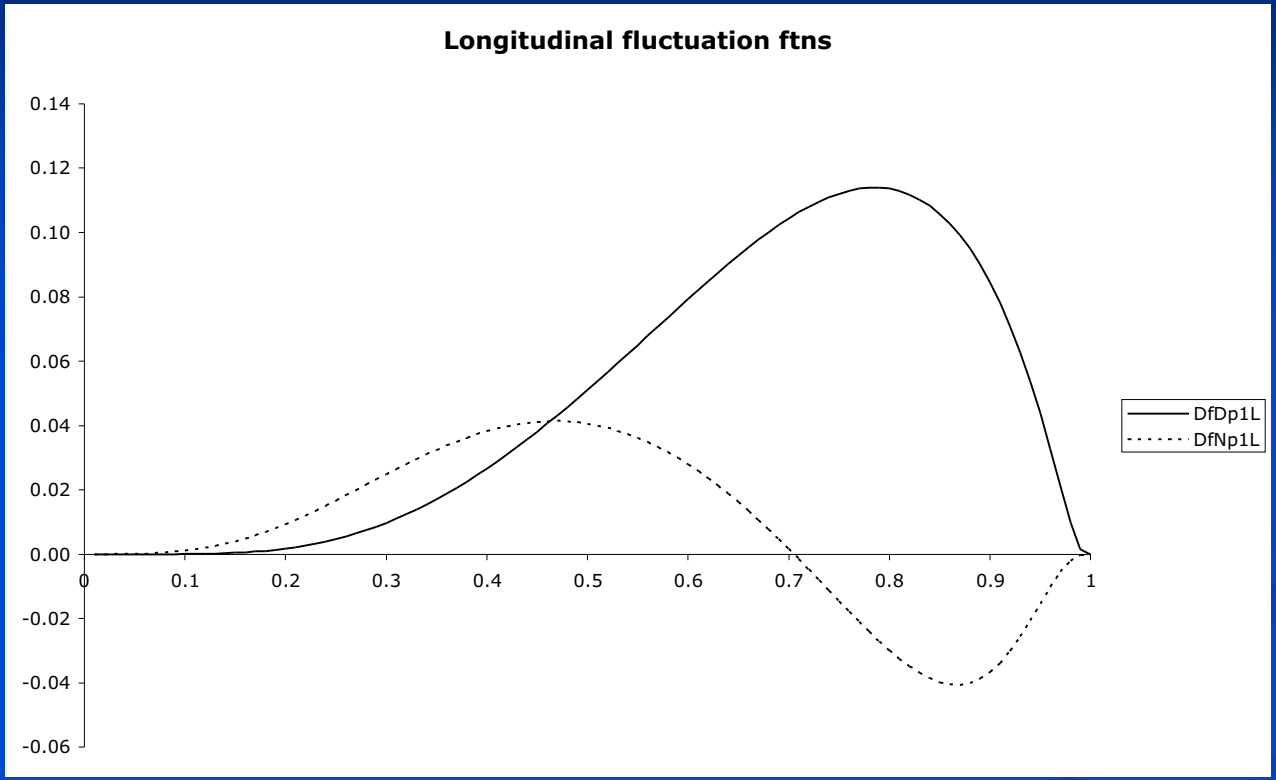
Spin Dependent Structure Functions

$$\delta g_1(x,Q^2) = \frac{1}{1+\gamma^2}\int_x^1 \frac{dy}{y}\left([\Delta f_{1L}(y)+\Delta f_{1T}(y)]g_1^B(\frac{x}{y},Q^2) + [\Delta f_{2L}(y)+\Delta f_{2T}(y)]g_2^B(\frac{x}{y},Q^2)\right)$$

$$\delta g_2(x,Q^2) = -\frac{1}{1+\gamma^2}\int_x^1 \frac{dy}{y}\left([\Delta f_{1L}(y)-\Delta f_{1T}(y)/\gamma^2]g_1^B(\frac{x}{y},Q^2) - [\Delta f_{2L}(y)-\Delta f_{2T}(y)/\gamma^2]g_2^B(\frac{x}{y},Q^2)\right)$$

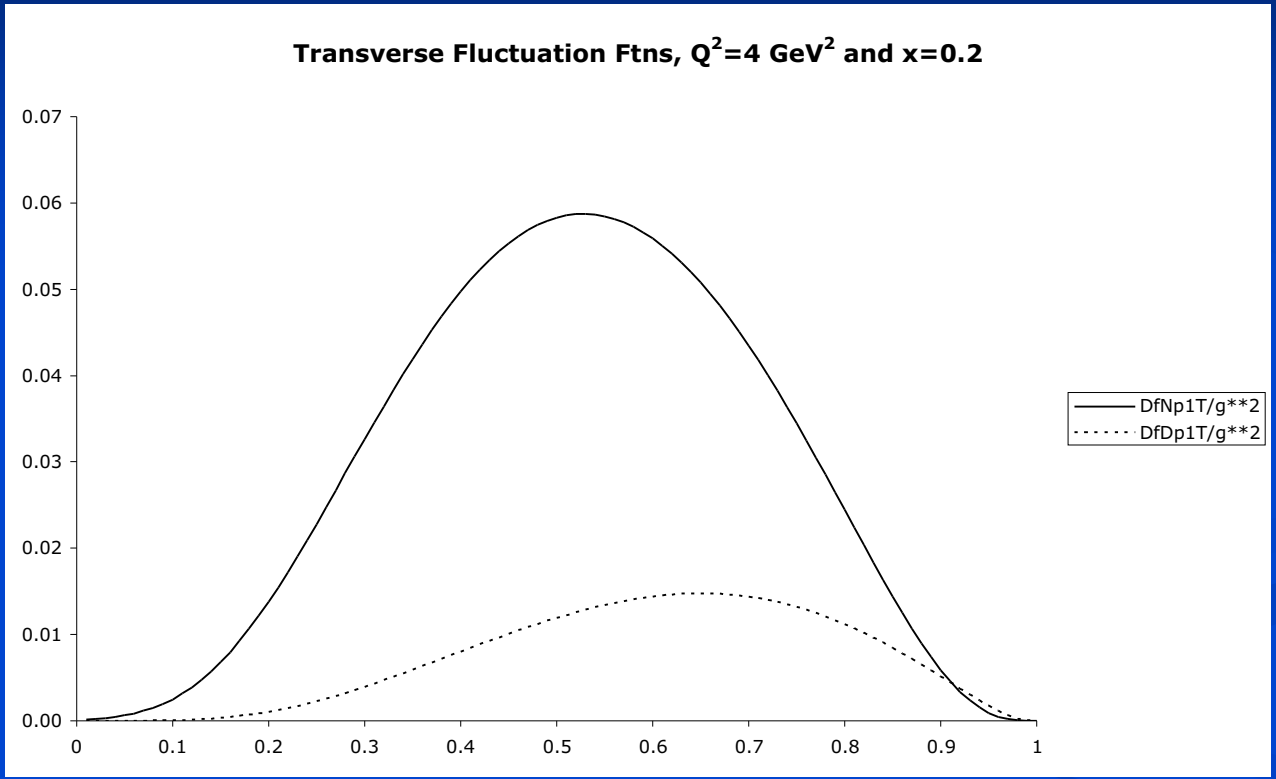
$$\gamma^2 = \frac{4x^2m_N^2}{Q^2}$$

Spin Dependent Fluctuations



- Long. Fluctuations require both N and Δ
  - s = 3/2 state important

Spin Dependent Fluctuations



- N is more important for transverse fluct.
  - n.b $\gamma \approx 0.19$

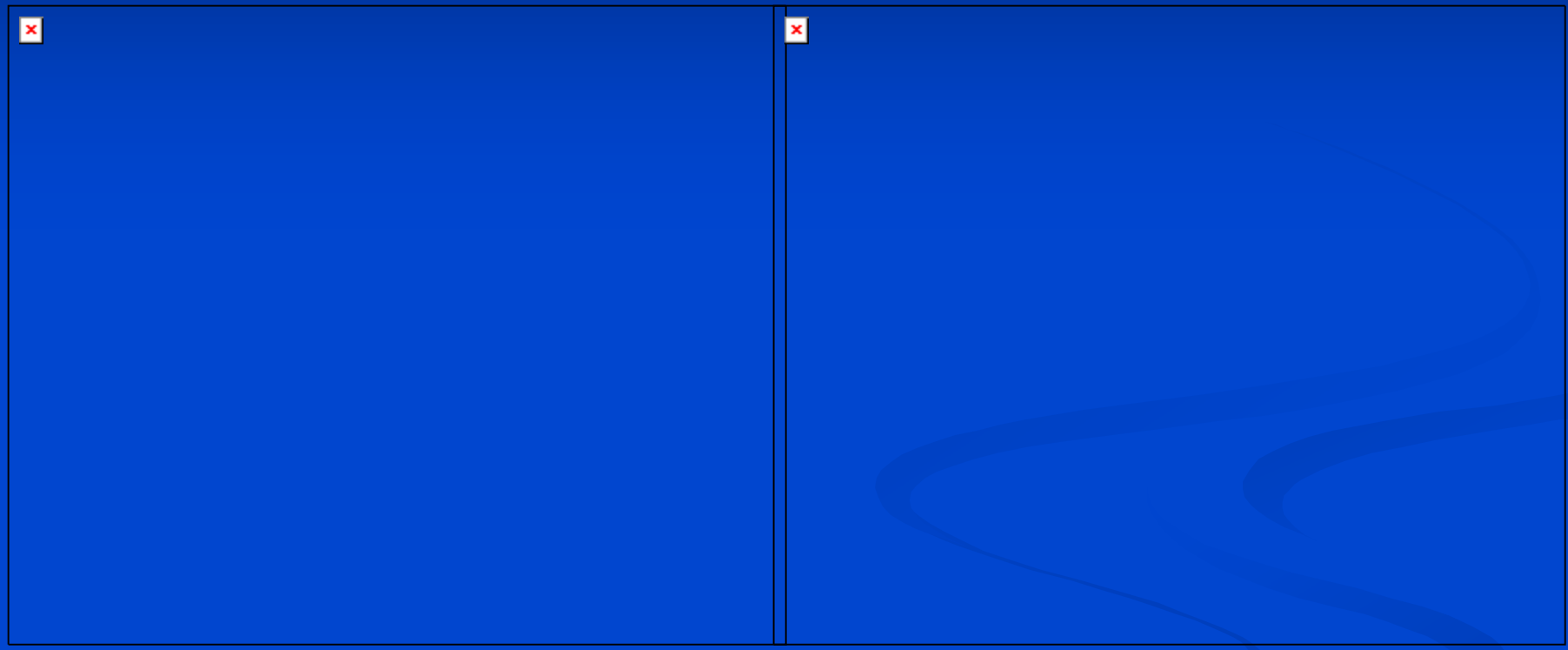
‘Bare’ Hadron SFs

- Use bag model for N, Δ parton dists
  - Add Δg(x) ‘by hand’
  - Hyperfine splitting between N and Δ
  - Use NLO evolution
  - Unpol. dists agree with DIS data
- $g_2(x)$ from Wandzura-Wilczek

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

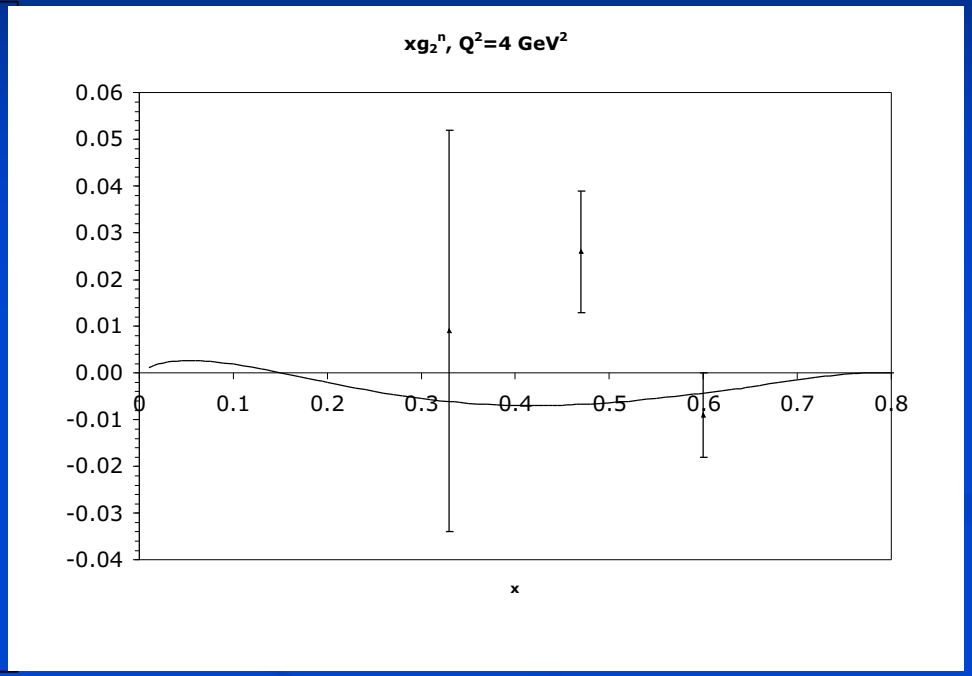
  - No higher twist component

‘Bare’ Hadron $g_1(x)$



- Data from Hermes

‘Bare’ Hadron $g_2(x)$



- Data from E155, Jlab E-99-117

MCM Contributions to g_1^p

MCM Contributions to g_1^n

MCM Contributions to g_2^p

MCM Contributions to g_2^n

Summary

- Longitudinal (g_1) structure ftns of cloud hadrons affect observed transverse (g_2) structure ftns
- MCM contributions to g_1 and g_2 of proton are small
- MCM contributions to g_1, g_2 of neutron are 10%
  - Similar size to higher twist in g_2^n
  - Theorists have to be careful!

Thanks

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