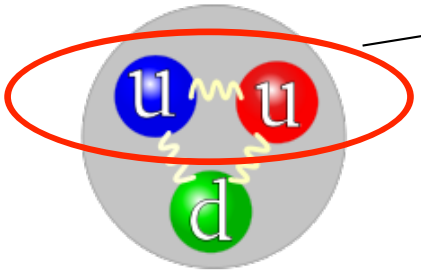
The ratio of fl2/fl1 at x = 1

Contributions to F1 and F2 form factors from the doubly (fl2) and singly (fl1) represented quarks

Bogdan Wojtsekhowski, Jefferson Lab

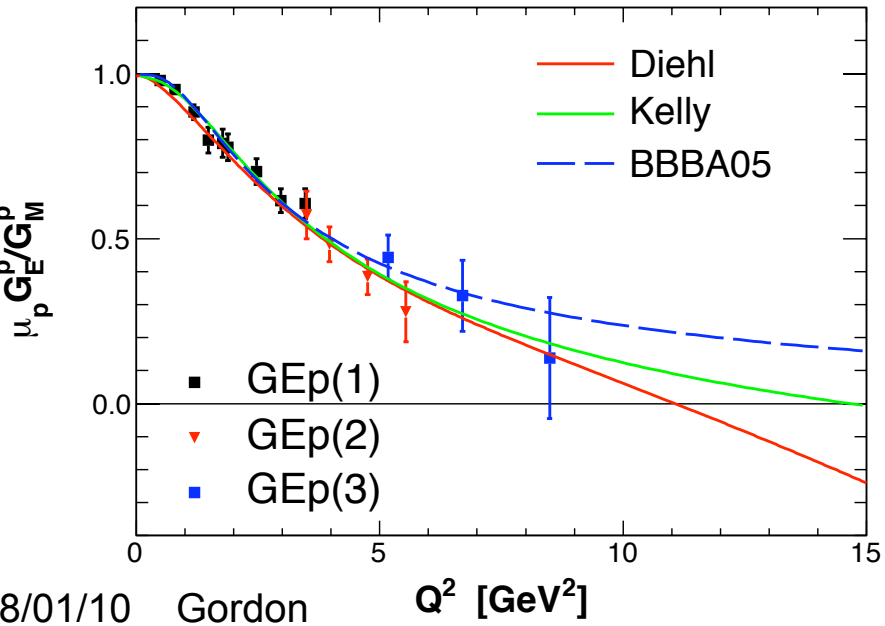
The goal is understanding of the nucleon

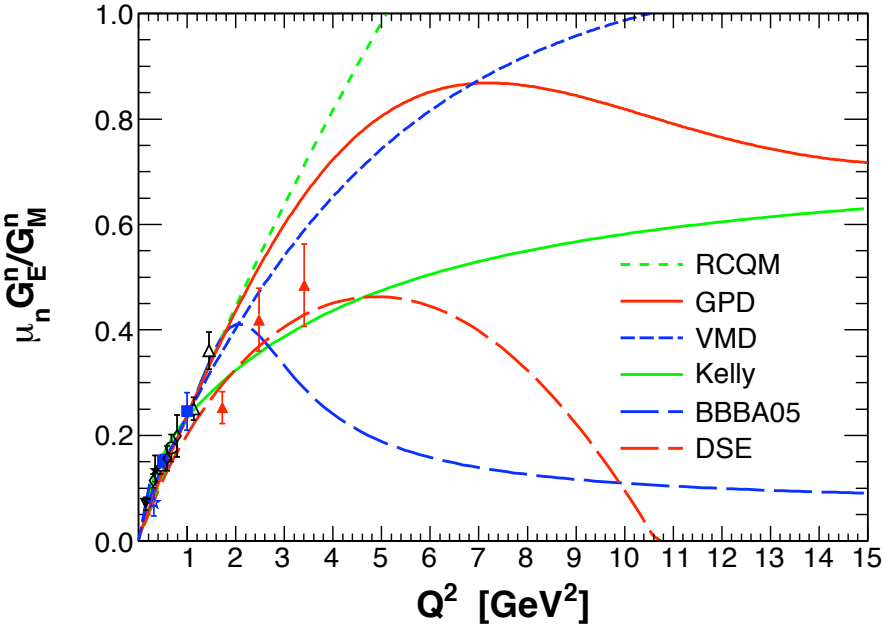


$$F_p = \frac{+2}{3} F_{dual} + \frac{-1}{3} F_{lone}$$

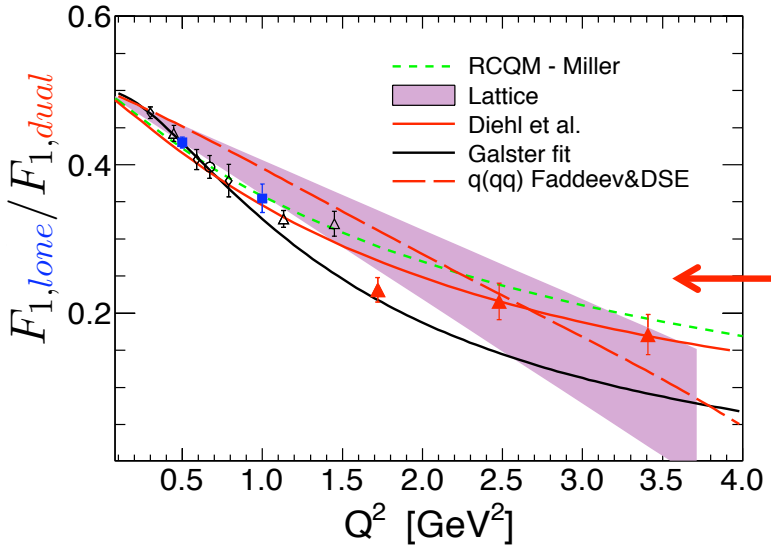
$$F_n = \frac{-1}{3} F_{dual} + \frac{+2}{3} F_{lone}$$

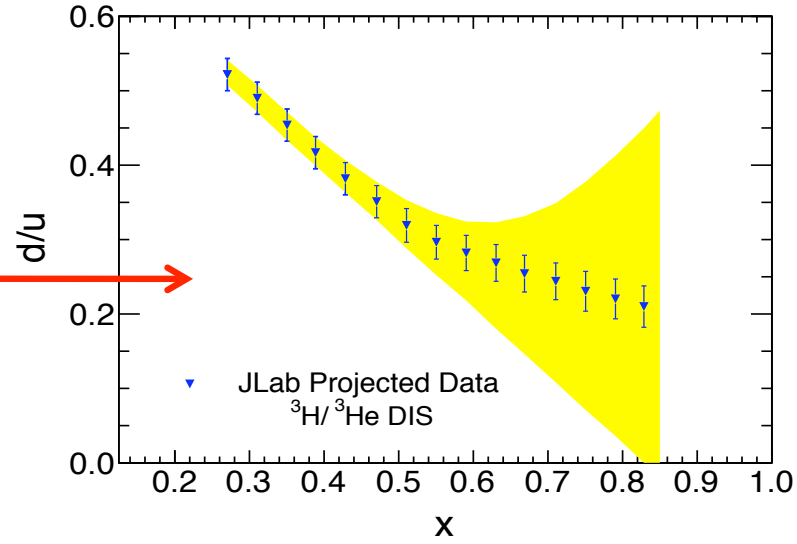
$$F_{1,dual} = F_1^{u,p} = 2\,F_{1p} + F_{1n} \qquad F_{1,lone} = F_1^{d,p} = 2\,F_{1n} + F_{1p}$$

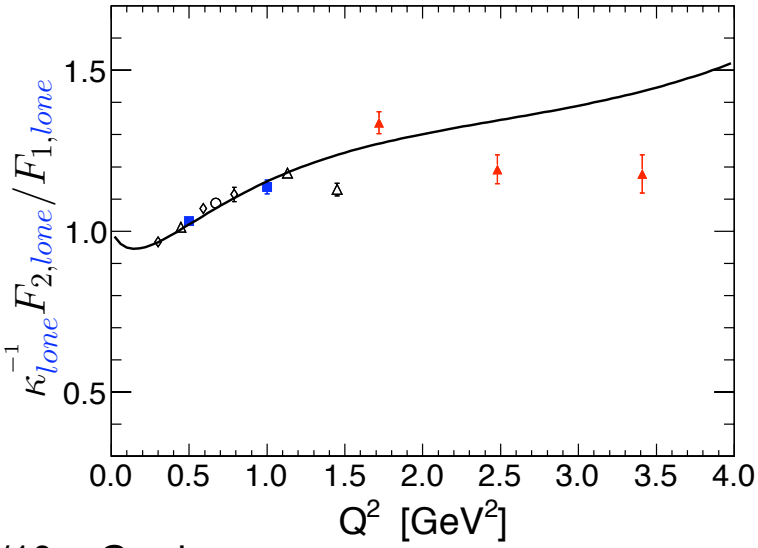


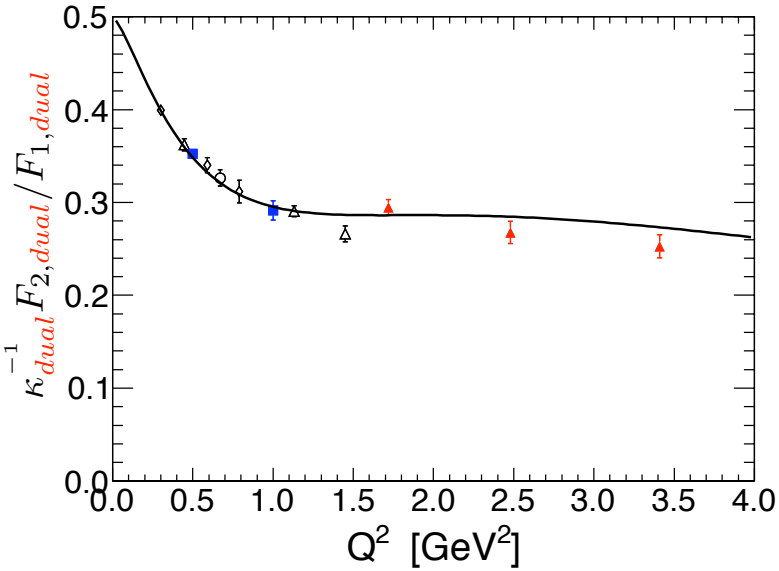


Form Factors ratios

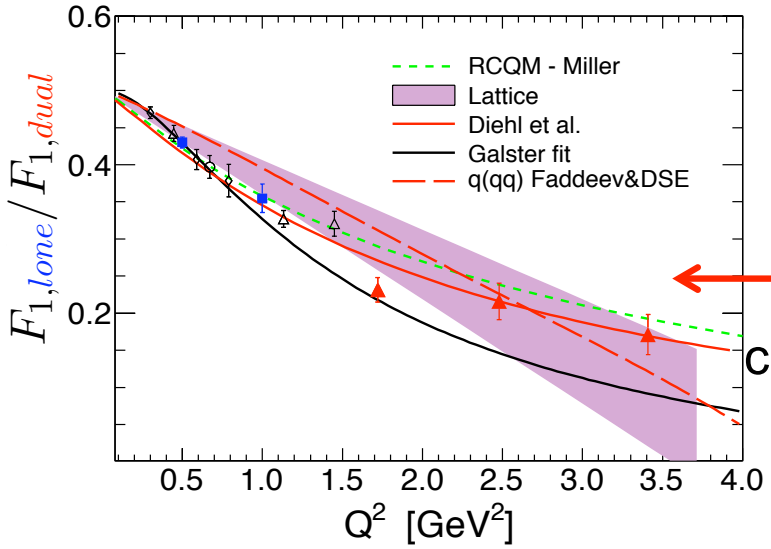




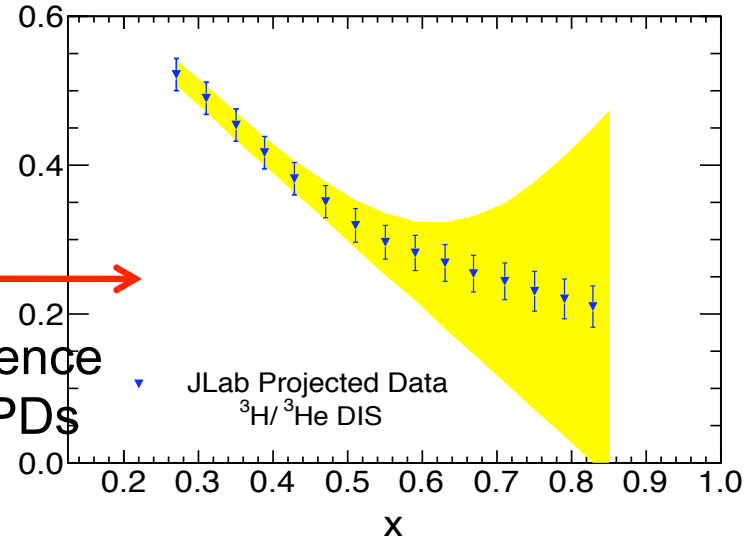


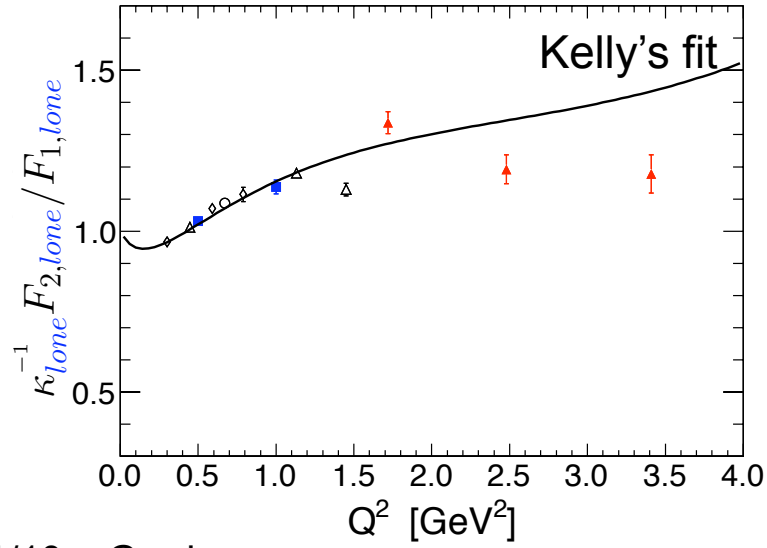


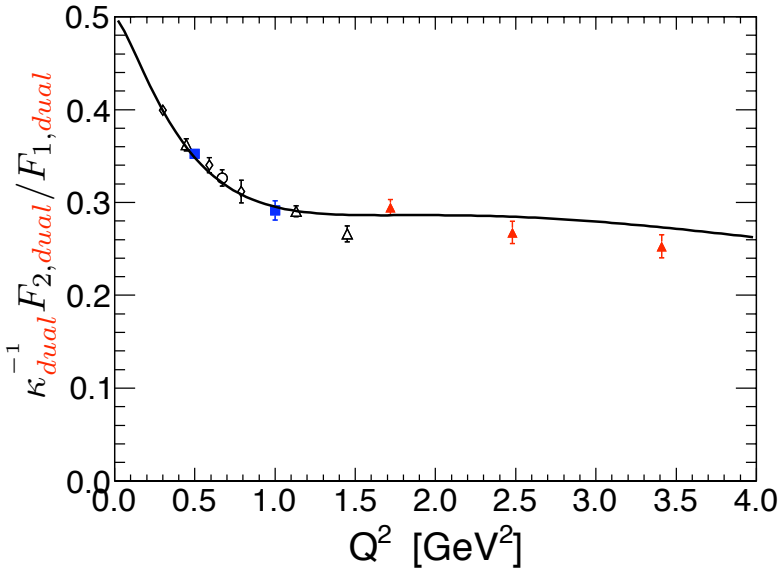
Form Factors ratios



correspondence
e.g. via GPDs





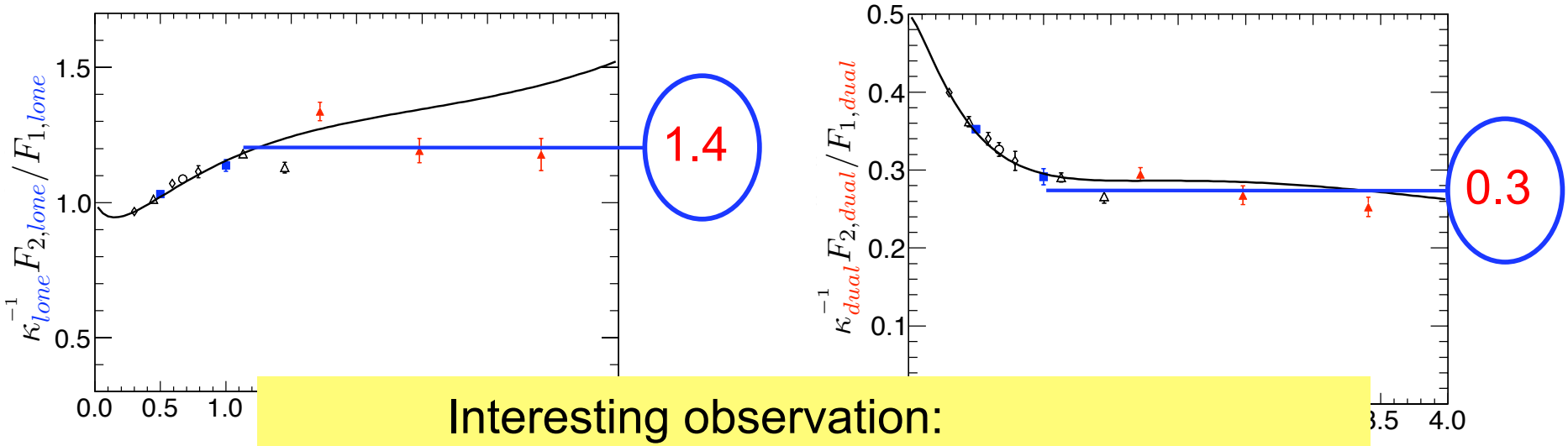


The goal is understanding of the nucleon

- A diquark configuration?
- An effect of orbital motion?

$$F_{1,dual} = F_1^{u,p} = 2\,F_{1p} + F_{1n} \qquad F_{1,lone} = F_1^{d,p} = 2\,F_{1n} + F_{1p}$$

Results of E02-013 Hall A GEn



Interesting observation:
F2/F1 = R is constant in the Q^2-range 1 - 3.5 GeV^2

The goal is understanding of the nucleon

What is the nature of this result: a strong reduction of the d-quark contribution with increase of Q^2?

What is the reason for the F2/F1 ratio to be constant?

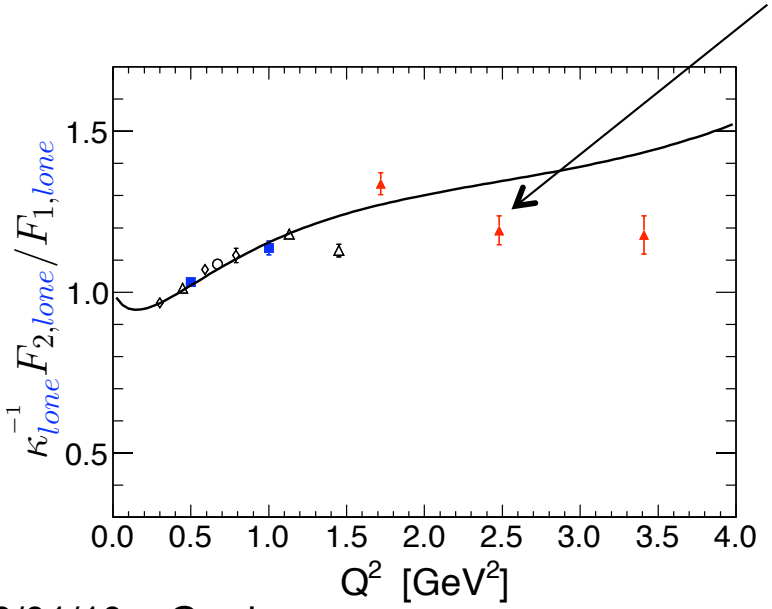
The goal is understanding of the nucleon

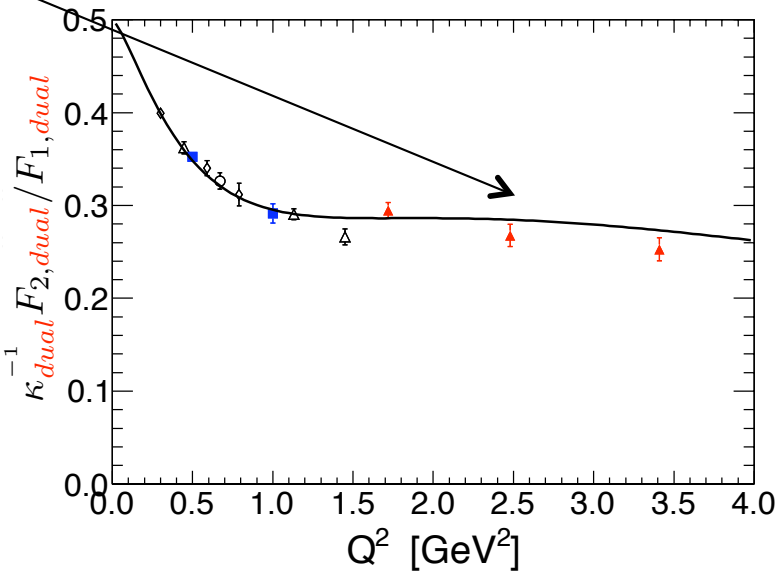
- What is a unique signature of the diquark configuration?

$$F_p = \frac{+2}{3} F_{dual} + \frac{-1}{3} F_{lone}$$

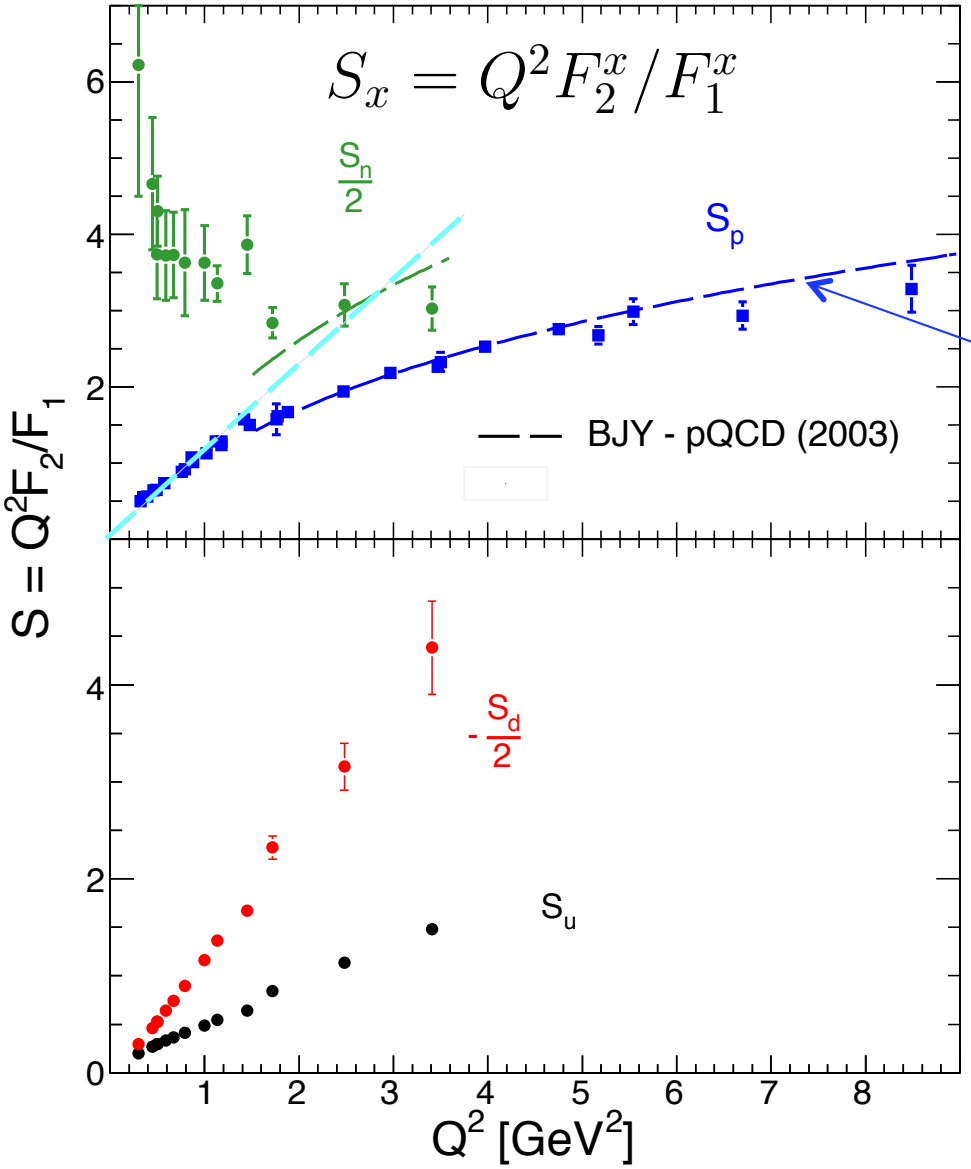
$$F_n = \frac{-1}{3} F_{dual} + \frac{+2}{3} F_{lone}$$

Results of E02-013 Hall A GEn





The goal is understanding of the nucleon



pQCD prediction for large Q^2:

$$S \to Q^2 F_2 / F_1$$

pQCD updated prediction:

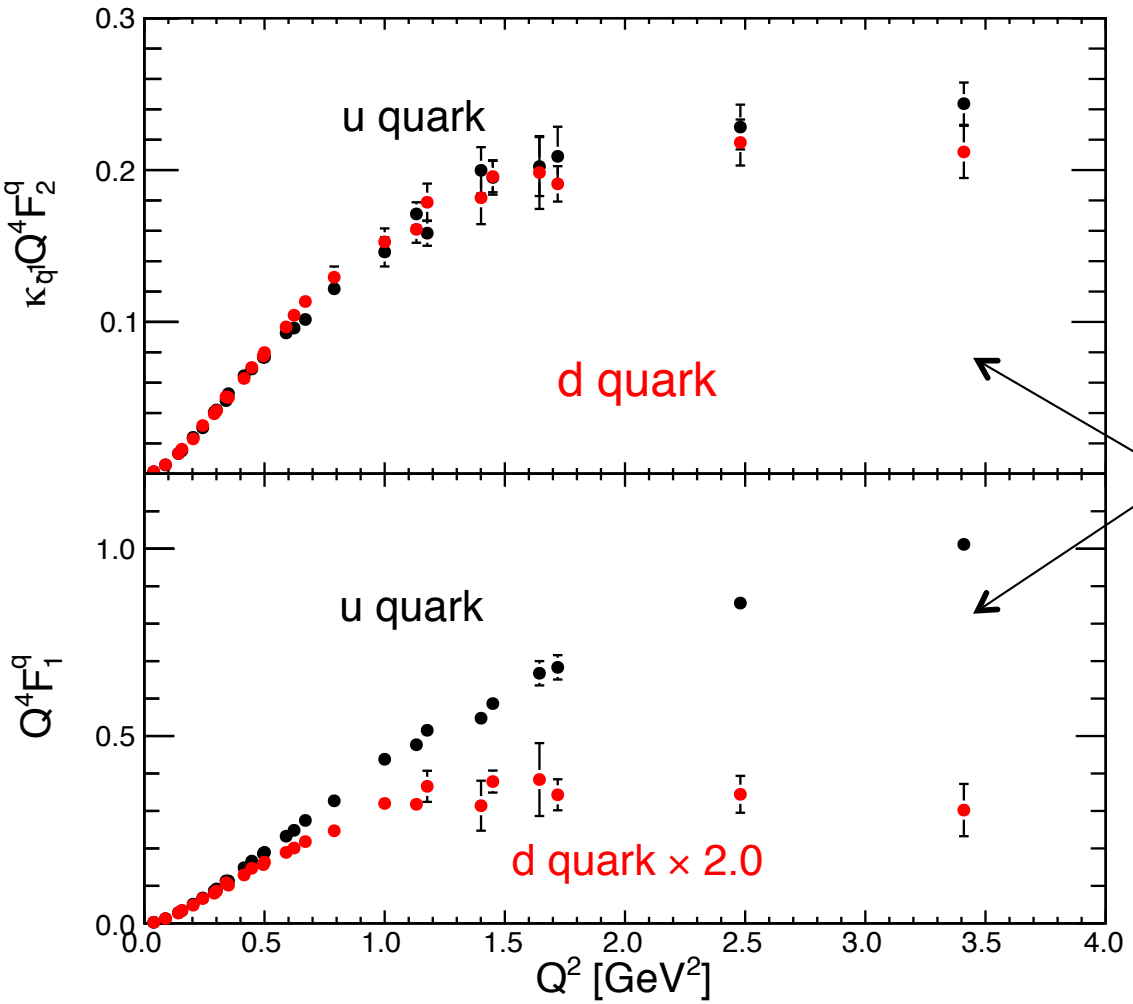
$$S \to \left[Q^2 / \ln^2(Q^2/\Lambda^2)\right] F_2/F_1$$

Flavor separated contribution: The log scaling for the proton Form Factor ratio at few GeV^2 may be “accidental”.

The lines for individual flavor are straight! unlikely accidental

Cates, Jager, Riordan, BW
Physical Review Letters, 106, 252003 (2011)

The flavor disparity in the nucleon



CJRW (u/d with new GEn data)
Phys. Rev. Lett. 106 (2011)

Qattan, Arrington (2-γ effects)
Phys.Rev. C86 (2012) 065210

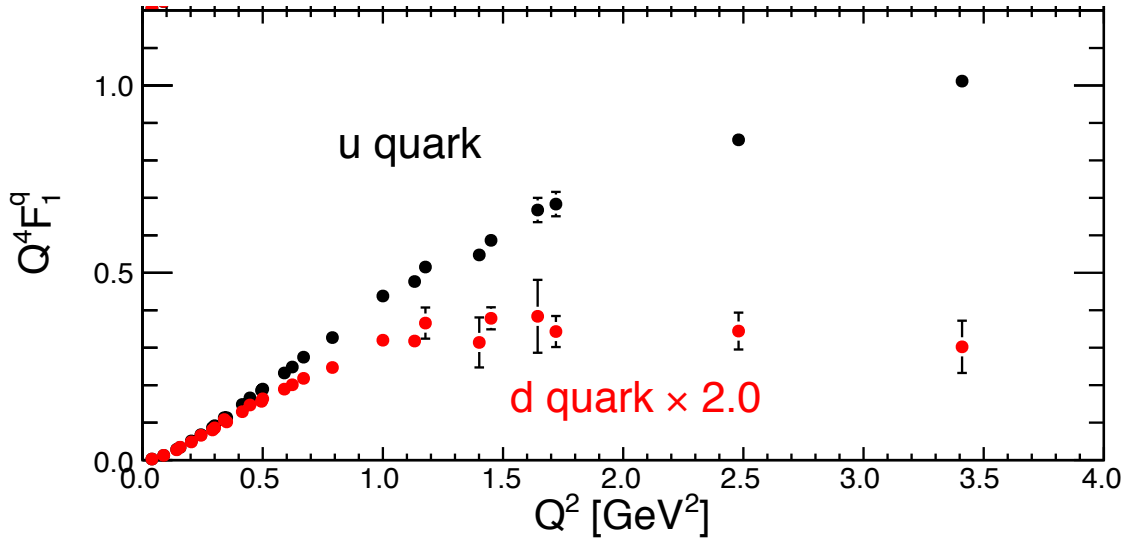
M.Diehl and P.Kroll (GPDs)
Eur.Phys.J. C73 (2013) 2397

Using the D&K table of F^u, F^d

The down quark contribution to the F_1 proton form factor is strongly suppressed at high Q^2

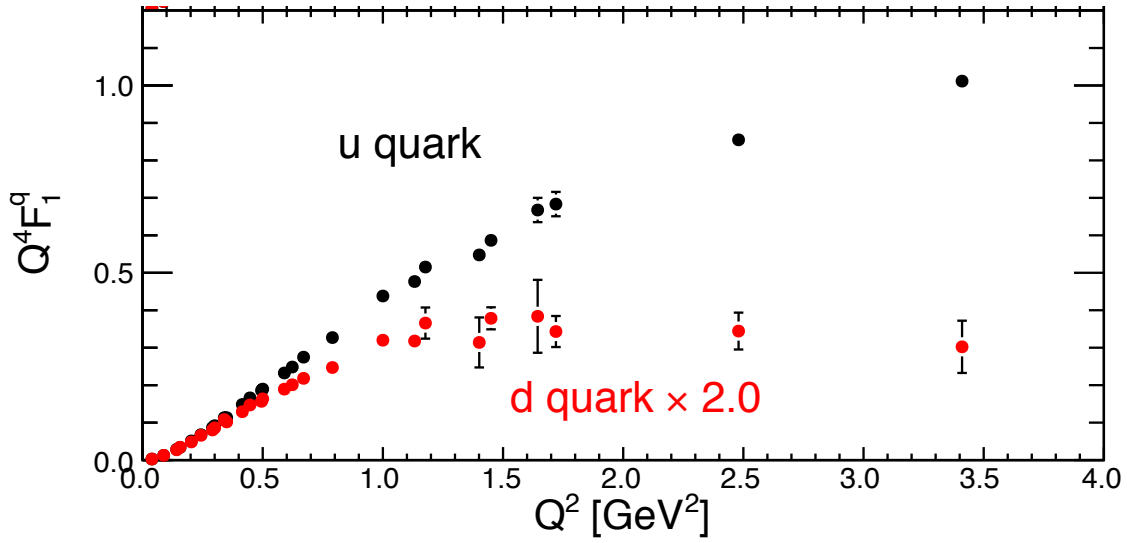
When the virtual photon of 3 GeV^2 interacts with the down quark the proton more likely falls apart than in the case of the up quark

The flavor disparity in the nucleon



The contribution of the down quark to the F_{1p} form factor at Q^2=3.4 GeV^2 is three times less than the contribution of the up quarks (corrected for the number of quarks and their charge).

The flavor disparity in the nucleon



The experiment suggests that the probability of proton survival after absorption of a massive virtual photon is much higher when the photon interacts with an up quark, which is doubly represented in the proton.

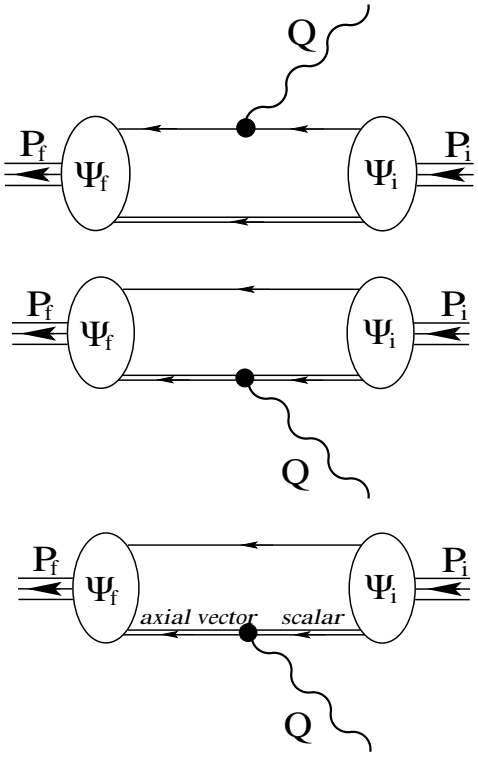
This may be interpreted as an indication of the up-up correlation. At high Q^2 a correlation usually enhances the high momentum component and the interaction cross section.

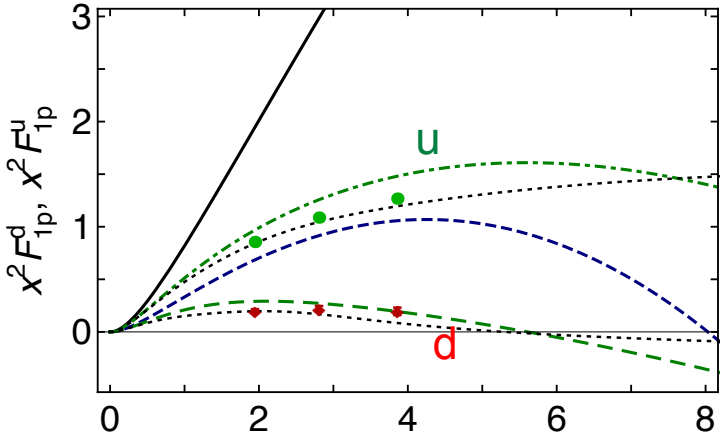
The relatively weak down quark contribution to the F_{1p} indicates a suppression of the up-down correlation or a mutual cancellation of different types of up-down correlations.

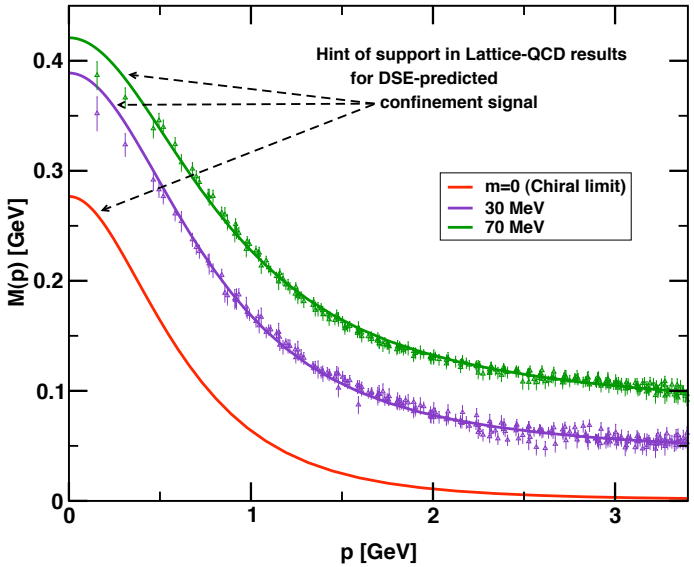
The goal is understanding of the nucleon

Nucleon and Roper electromagnetic elastic and transition form factors

Wilson, Cloet, Chang, Roberts, PRC 85, 025205 (2012)





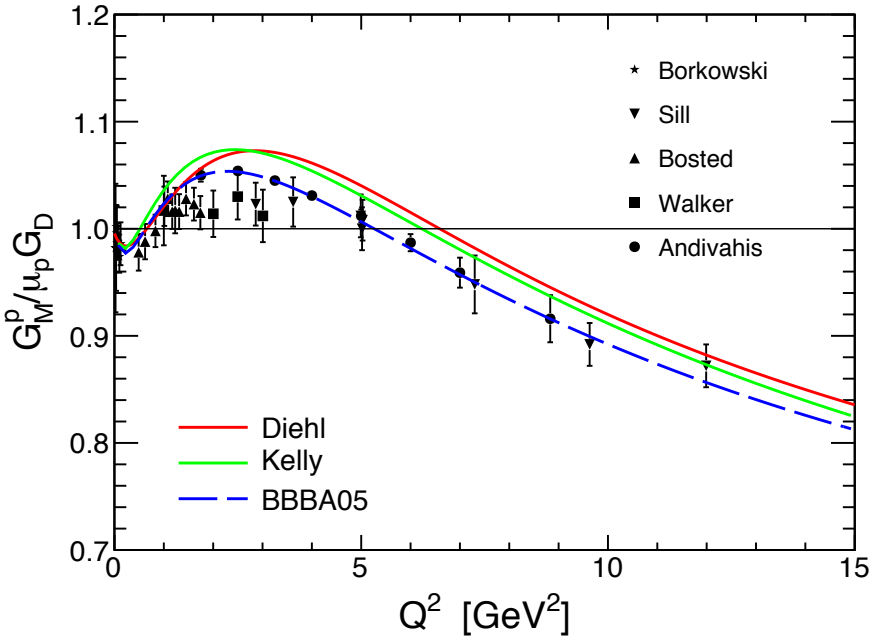


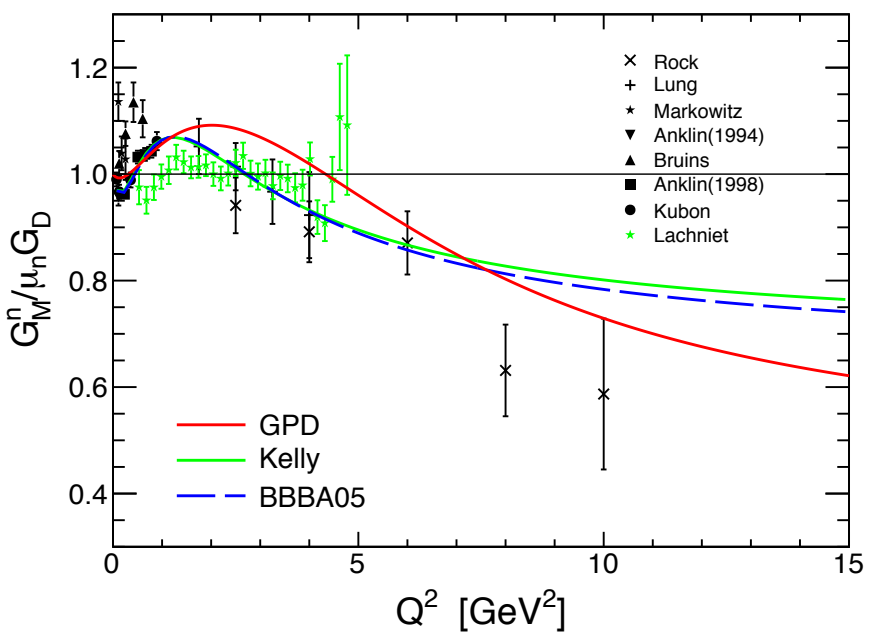
QCD based prediction:

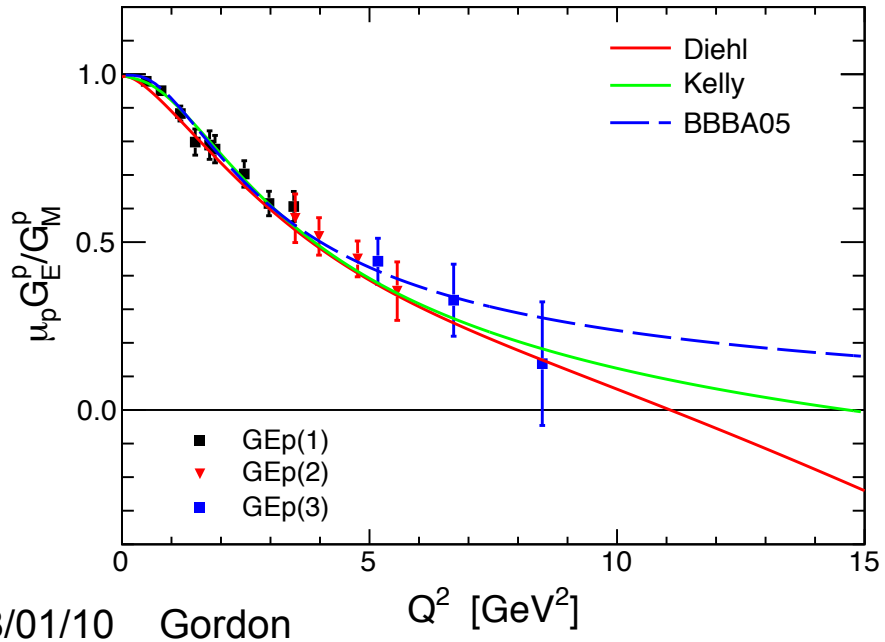
Interplay between the [qq] and {qq} diquarks creates a zero crossing

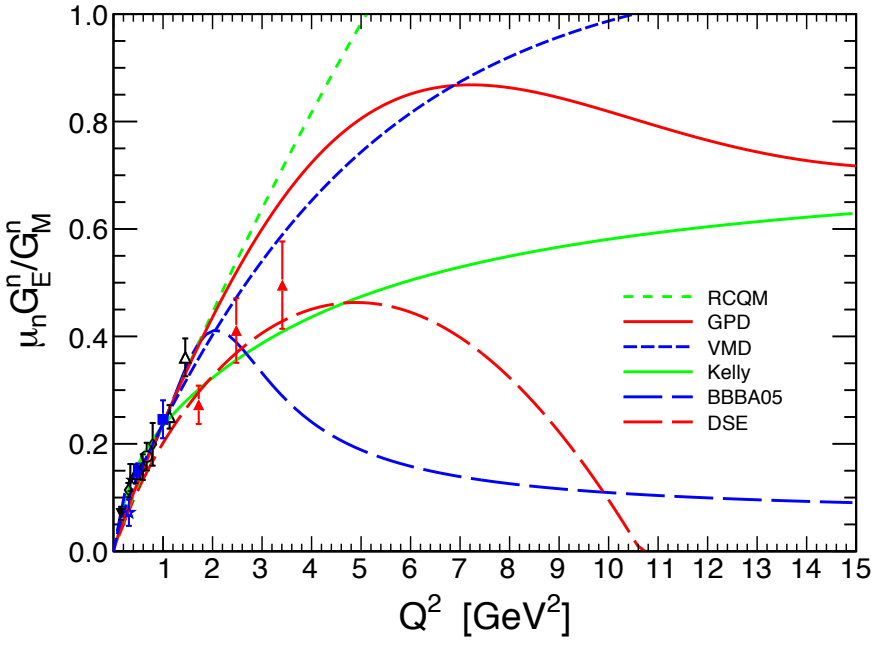
Cloet, Eichmann, El-Bennich, Klahn and C. D. Roberts, arXiv:0812.0416

Sachs Form Factors of the nucleon

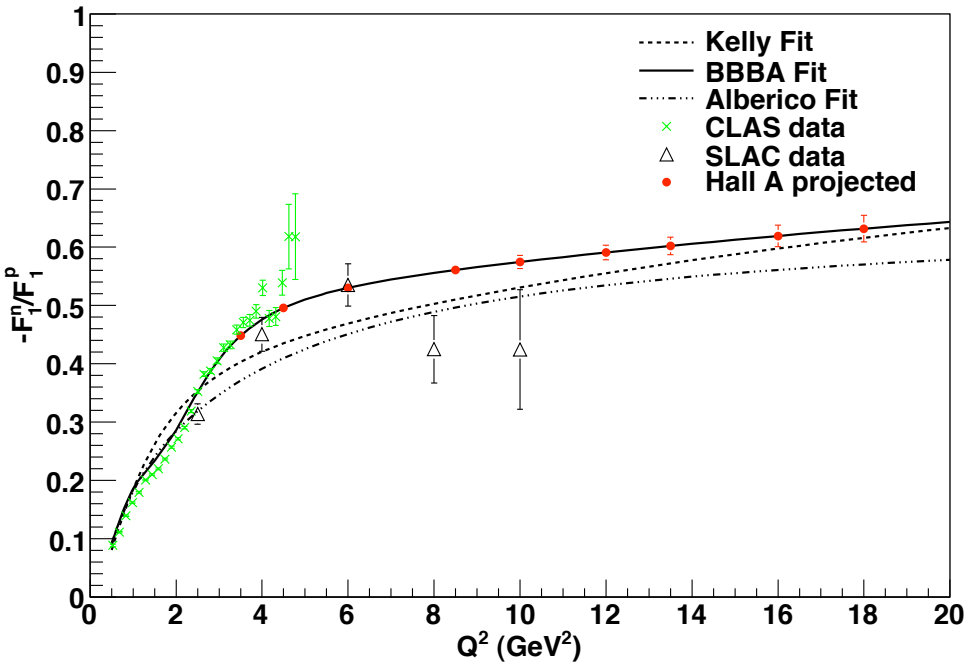








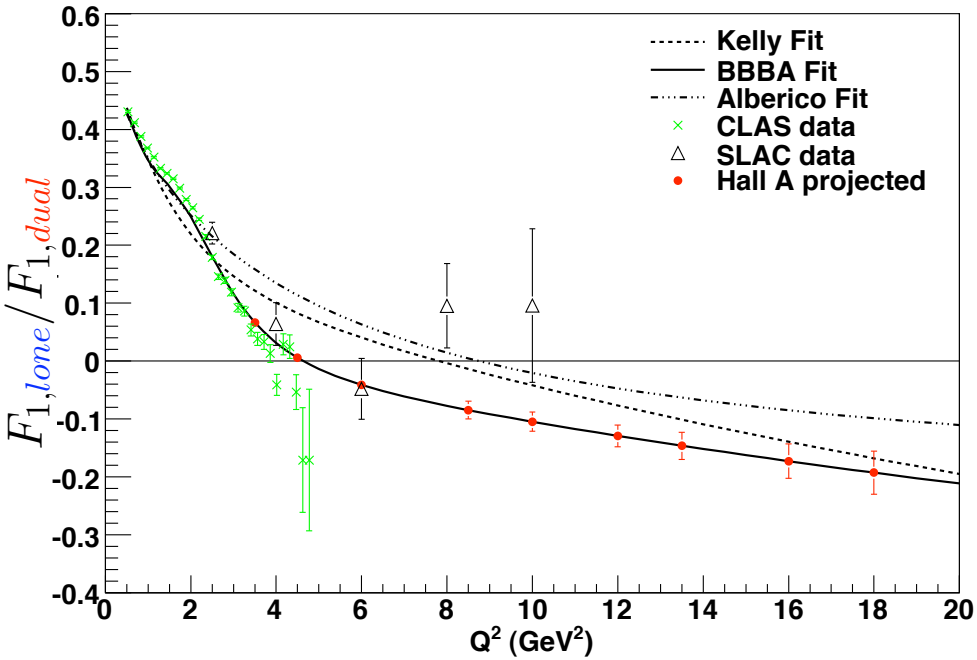
GMn/GMp and GPDs



GPD model (Guidal etal):

$$F_1^u(t) = \int_0^1 dx u_v(x) e^{-t\alpha' \ln x},$$

$$F_1^d(t) = \int_0^1 dx d_v(x) e^{-t\alpha' \ln x}.$$



$F_1^d < 0$ presents an interesting challenge to such a model

The goal is understanding of the nucleon

What is the nature of the result: a strong reduction of the d-quark contribution with increase of Q^2?

A singly represented quark has a wider distribution in the impact parameter space than the doubly represented quarks. Why is it wider?

What is the reason for the F2/F1 ratio to be constant?

F2 and F1 are originated by the same object.
There is no indication of the orbital moment.

The goal is understanding of the nucleon

What is the nature of the result: a strong reduction of the d-quark contribution with increase of Q^2?

Diquarks are in the nucleon!
Expected (due to the baryon spectrum) since the 1960s (the problem of the missing resonances)

What is the reason for the F2/F1 ratio to be constant?

F2 and F1 are originated by the same object.