Interface of expt, phenomenology, and lattice QCD
-- Nucleon Structure of Quarks and Glue

$$(\bar{u}\gamma_\mu D_\nu u + \bar{d}\gamma_\mu D_\nu d)(t)$$

$$\bar{\Psi}\gamma_\mu D_\nu \Psi(t)(u,d,s)$$

$$F_{\mu\alpha}F_{\nu\alpha} - \frac{1}{4}\delta_{\mu\nu}F$$

t_0 t_f t_0 t_f t_0 t_f
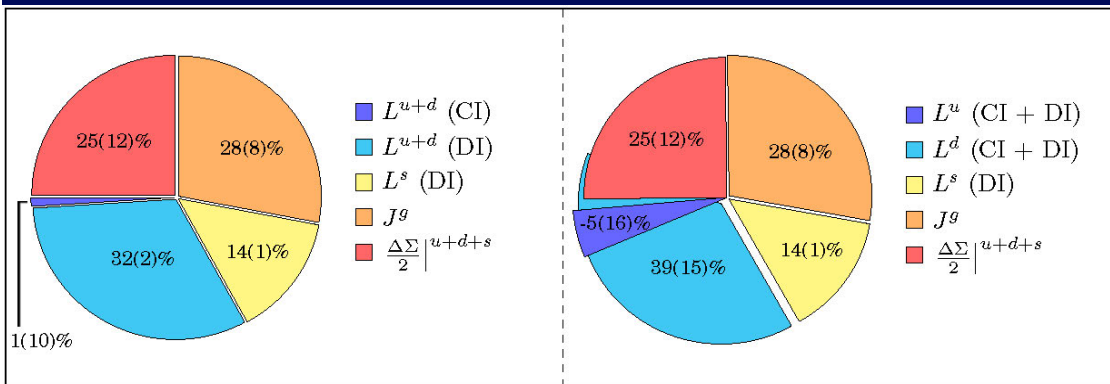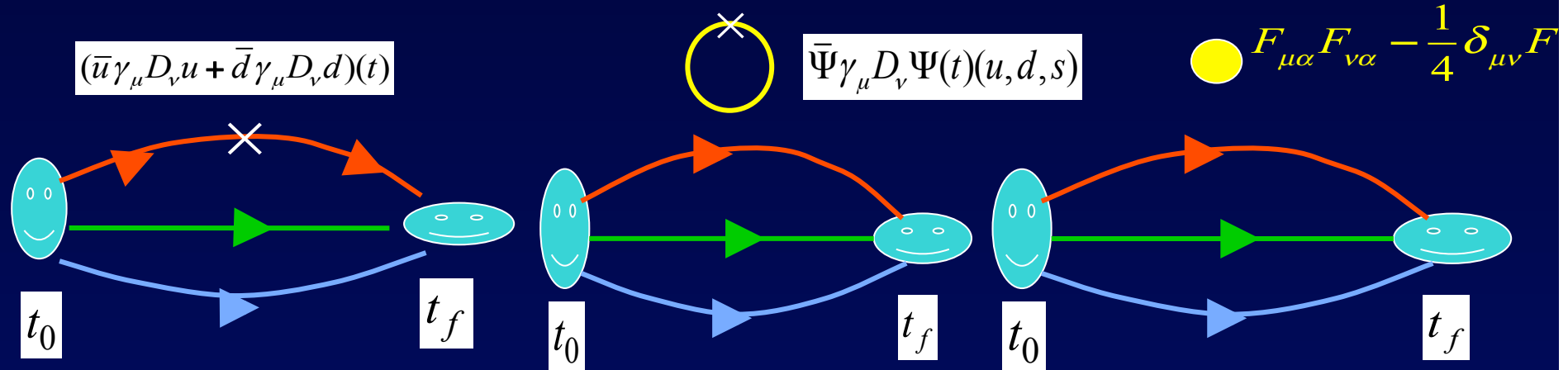
Experiments:

Quark Spin (DIS, SIDIS)
Gluon Helicity (STAR, COMPASS)
Orbital AM (GPD, JLAB)
NEDM (nEDM, Oak Ridge)
Proton Charge Radius (JLAB)
Strange EM FF (JLAB)

$$\Delta q \approx 0.25;$$

$$2\,L_q \approx 0.47\ (0.01(\text{valence})+0.46(\text{sea}));$$
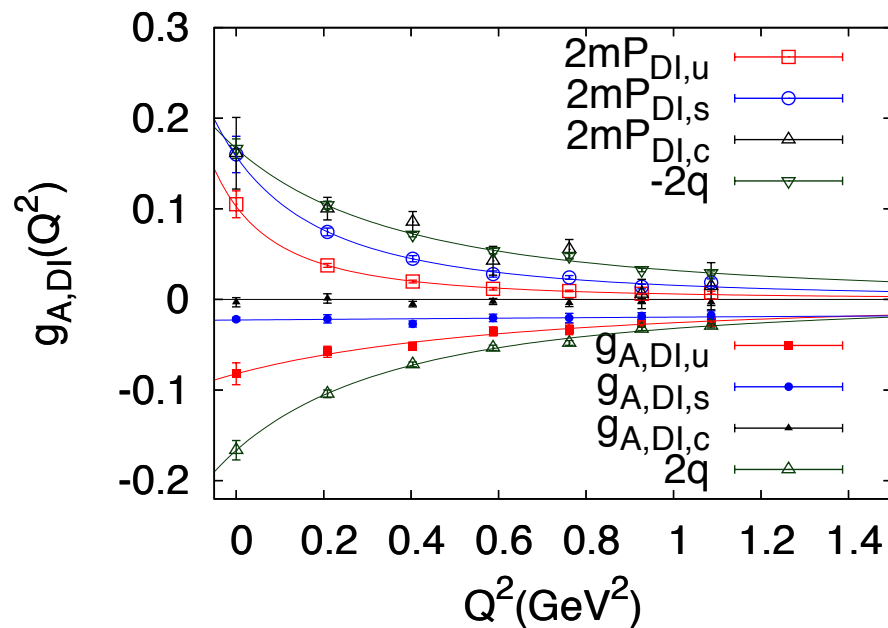
$$2\,J_g \approx 0.28$$

M. Deka et al. (χQCD), 1312.4816

Example 1: the origin of `proton spin crisis' -- need a physical picture

Quark Spin from Anomalous Ward Identity

$$Z_A \, \partial_\mu A_\mu = 2mP + 2N_f q$$

$24^3 \times 64$ 2+1-flavor DWF Conf.

$m_\pi \sim 330$ MeV $(L = 2.8$ fm$)$

Overlap valence fermion

$\Delta c \sim 0$

$\Delta s = -0.6(3)$

$\Delta u \,(DI) = -0.17(3)$

$g_A^0 = \Delta u + \Delta d + \Delta s = 0.17(9)$

$48^3 \times 96, \, m_\pi = 140$ MeV, L = 5.5 fm $\Rightarrow$ 100 Mhrs

$64^3 \times 128, \, m_\pi = 140$ MeV, L = 5.5 fm $\Rightarrow$ 300 Mhrs

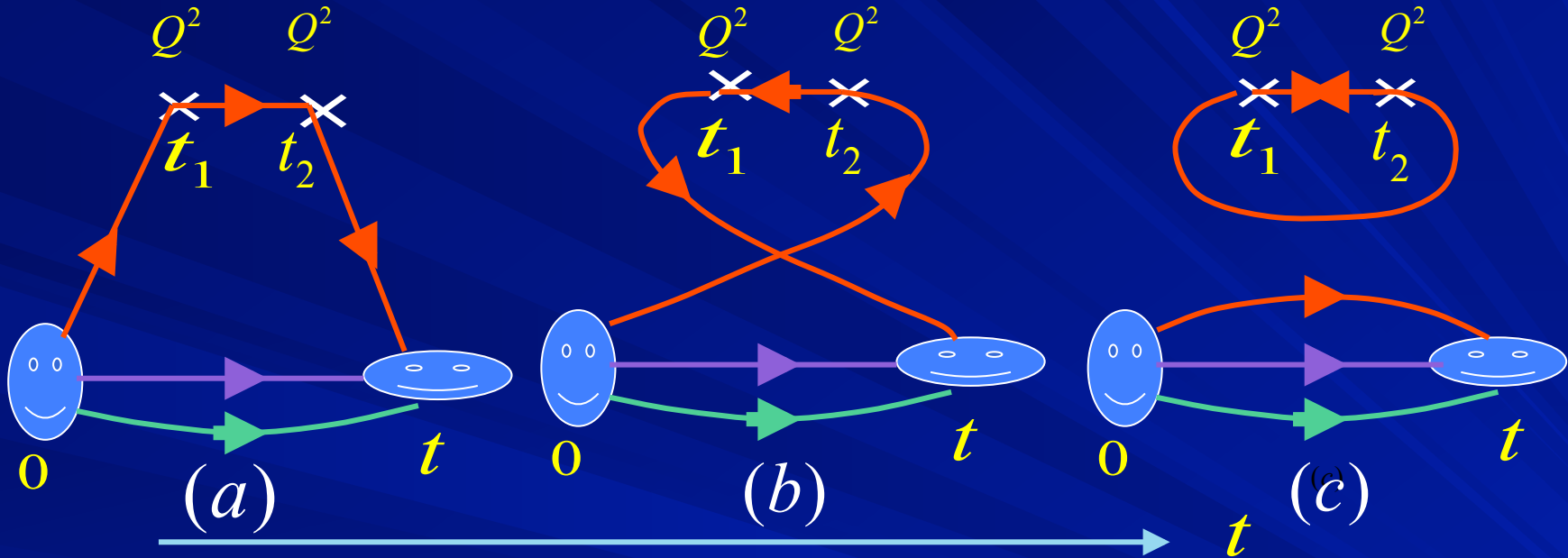$80^2 \times 96 \times 192, \, m_\pi = 140$ MeV, $L_x = 5.4$ fm $\Rightarrow$ 1100 Mhrs (?)

Human resources

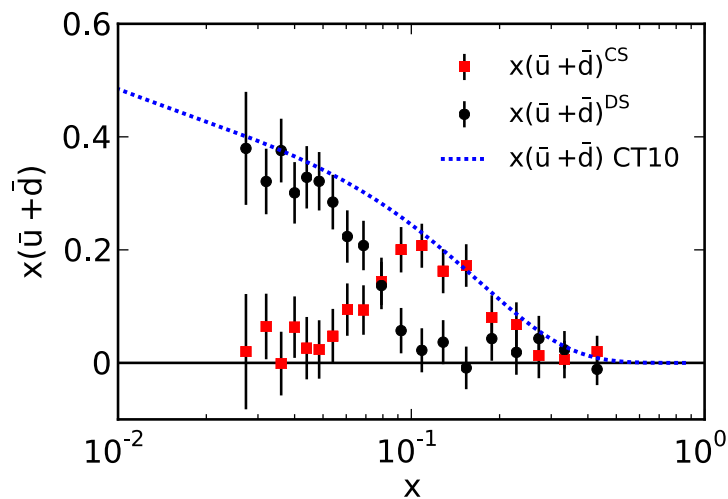Example 2: Connected sea partons   Hadronic Tensor in DIS

K.F. Liu, PRD 62, 074501 (2000)

- Connected sea from expt + global PDF + lattice;
- CS evolves like the valence --> evolution equations need to be modified to allow CS and DS separated at different Q^2.
- Four-point function gives cross-section to be compared with expt directly → PDF;
- Flavor dependence at medium and large x, intrinsic charm