SPC Summary on Nucleon and Nuclear Matrix Elements

- Cold Nuclear Physics
  - Nucleon Matrix Elements
  - Parton Distribution Function and Moments
  - Hadron Spectroscopy
  - Hadron Interactions and Nuclei
- Experimental facilities
  - Present: JLab 12 GeV, RHIC, ATLAS, Fermilab
  - Future: FRIB, EIC

TMD Collaboration

All Hands Meeting

JLab, Apr. 20-21, 2018

Proposals

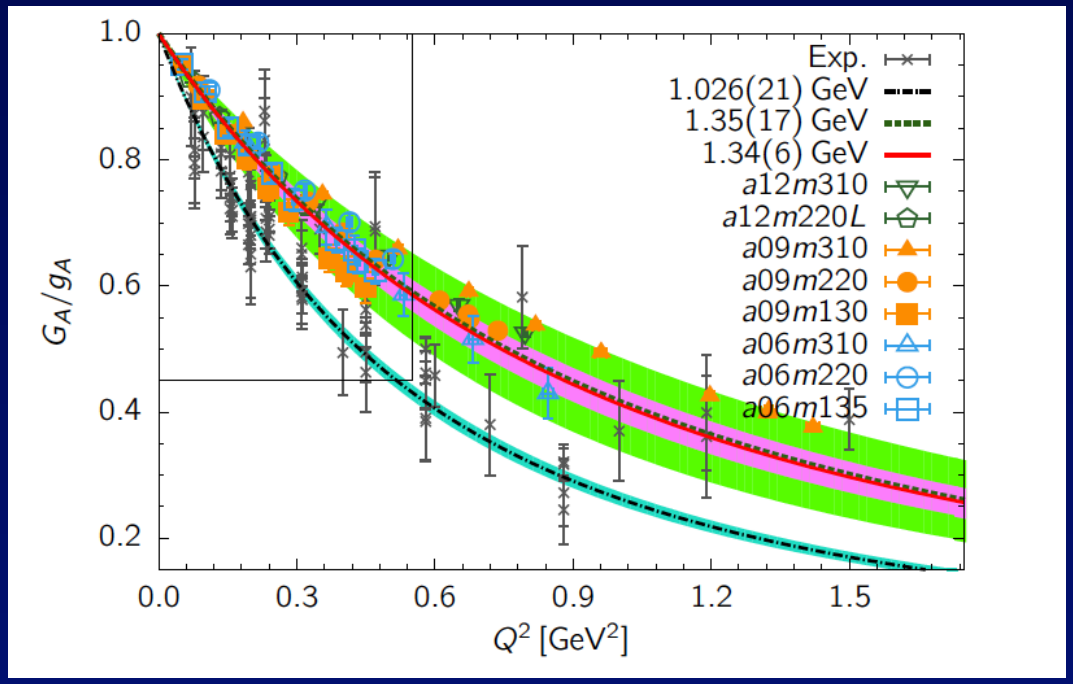
PI	Title	Status
Bhattacharya	Contribution of Theta, chromo EDM and Weinberg operators to nEDM	Continuation
Detmold	Nuclear Physics from Standard Model	Continuation
Engelhardt	Nucleon quark-gluon structure with Clover-Wilson fermion	Continuation
Gupta	Nucleon matrix elements with 2+1 flavor clover fermion	Continuation
Kronfeld	The Nucleon Axial-Vector Form Factor at the Physical Point with the HISQ Ensembles	Continuation
Liang	Lattice calculaiton of nucleon EDM and hadronic tensor	Continuation New
Shanahan	Gluon GPDs of the nucleon	Continuation
Sufian	Proton charge radius and neutral current FF	New
Syritsyn	Calculation of nucleon axial form factors, proton decay amplitudes, and nucleon EDMs induced by QCD theta term and quark chromo-EDM using domain wall fermions	Continuation
Yang	Proton Spin Decomposition with Non-perturbative renormalization	Continuation

Topics in Proposals

- nEDM Θ term - Bhattacharya, Liang, Syritsyn
  Chromo EDM - Bhattacharya, Syritsyn
- g_A and axial form factor – Engelhardt, Gupta, Kronfeld, Syritsyn, Yang
- Scalar and tensor charges – Detmold (Nuclei), Gupta
- Electromagnetic form factors – Engelhardt, Gupta, Sufian, Syritsyn
- Qaurk spin, momentum and AM fractions – Engelhardt, Yang
- TMD – Engelhardt
- Glue GPDs – Shanahan, Yang

Samples of Progress on Projects

- g_A -- 1.195(33)(20) [PNDME, 1606.07049, PRD (2016)]
  1.278(21)(26) [CalLat, 1704.01114],
  -- talk by Boram Yoon
- g_A form factor



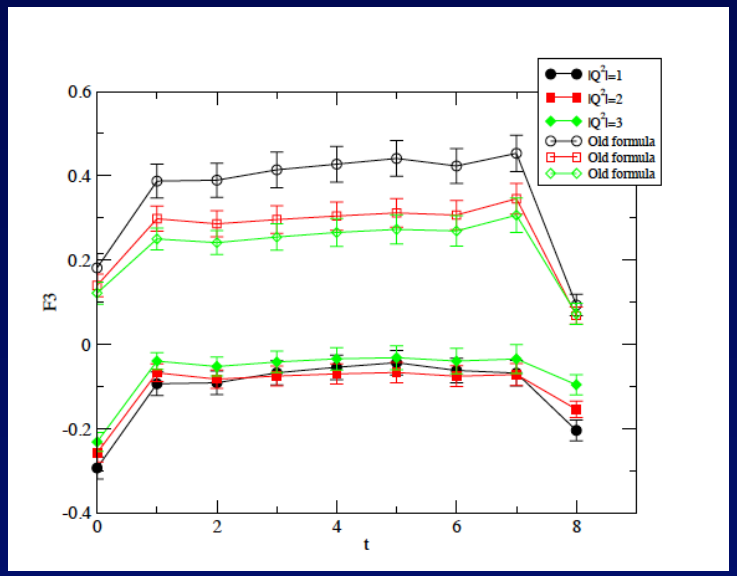
R. Gupta et al. (PNDME), 1705.06834, PRD (2017)

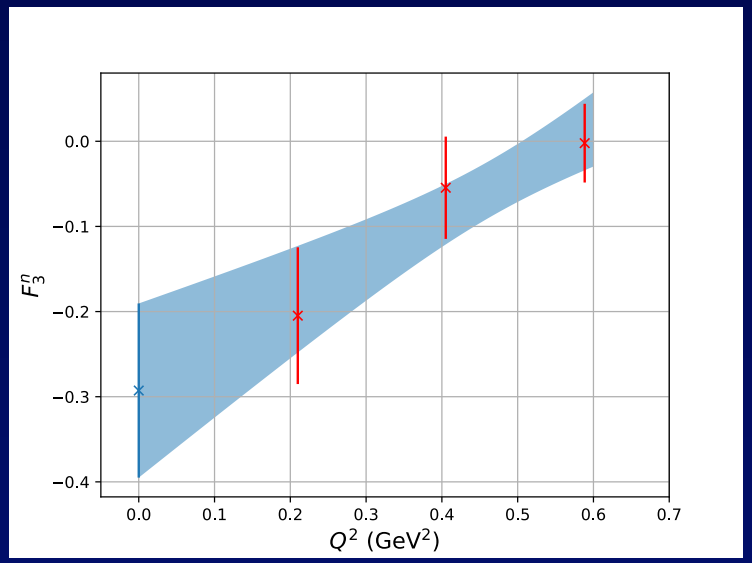
M. Engelhardt (PI) – separate u and d contribution to axial form factor

nEDM with the Θ term

- M. Abramczyk, S. Aoki, T. Blum, T. Izubuchi, H. Ohki, S. Syritsyn, arXiv: 1701.07792

$$F_3 = \hat{F}_3 - 2\alpha_5 F_2$$





S. Syritsyn (PI) -- 24^3 x 64 DWF, a = 0.114 fm, m_π=330 MeV

Note: Q ~√V

J. Liang (PI) -- 24^3 x 64 DWF, a = 0.114 fm, m_π=330 MeV

- Chromo-EDM: T. Bhattacharya, S. Syritsyn

Electromagnetic Form Factors

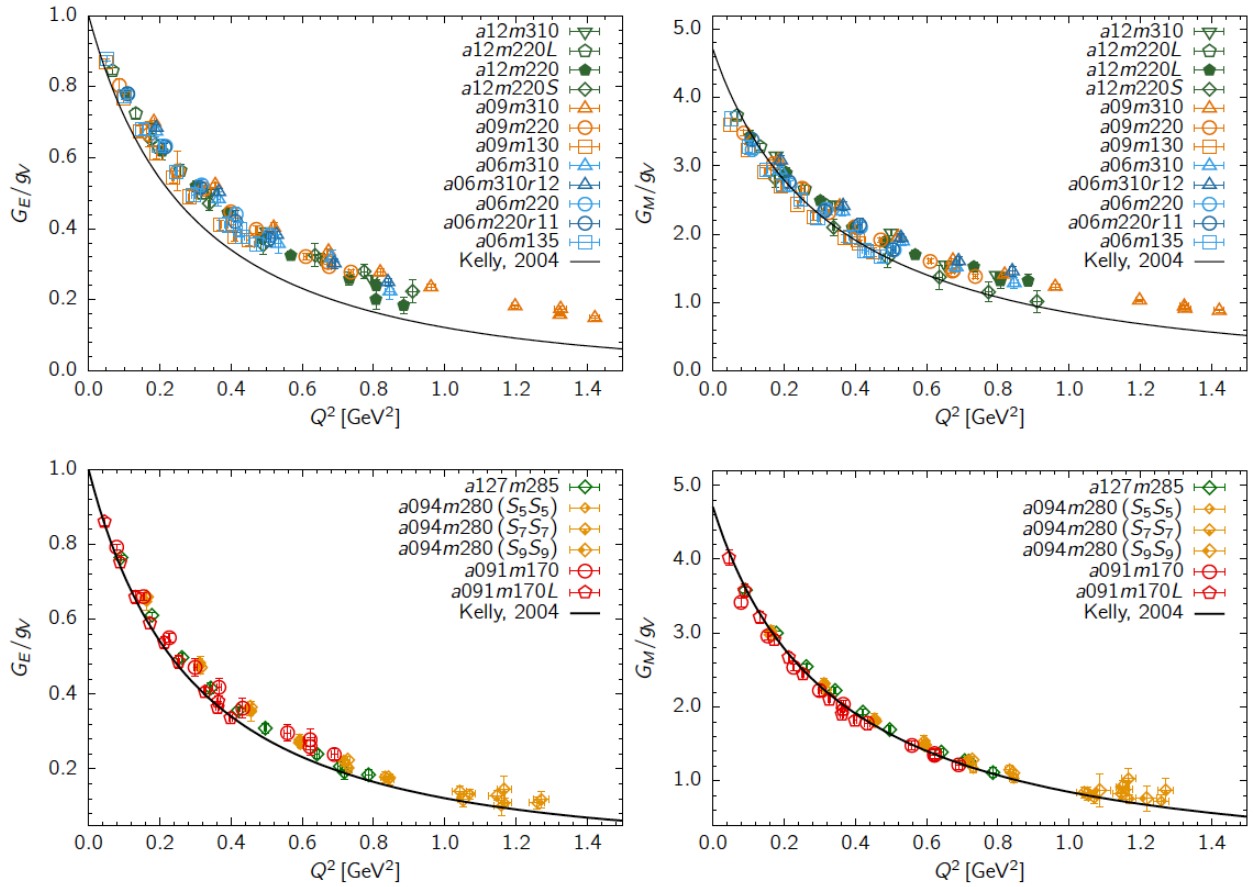


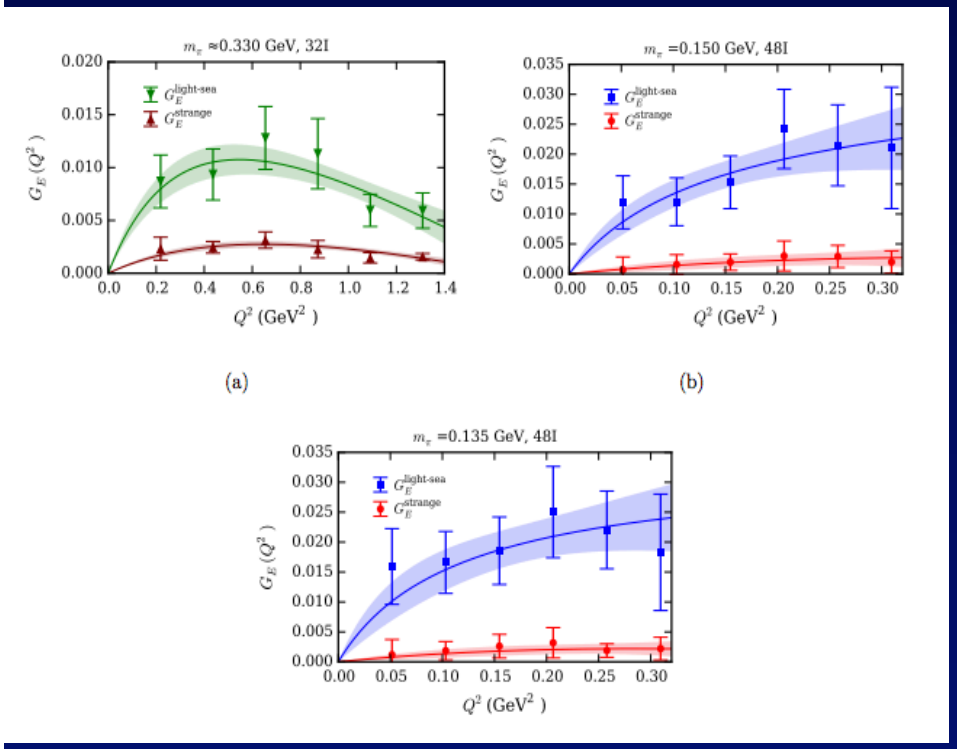
FIG. 3: (Top) The data for the renormalized isovector form factors $G_E(Q^2)/g_V$ (left) and $G_M(Q^2)/g_V$ (right) from twelve clover-on-HISQ calculations and the Kelly parameterization of the experimental data plotted versus Q^2 in units of GeV^2. (Bottom) The clover-on-clover data.

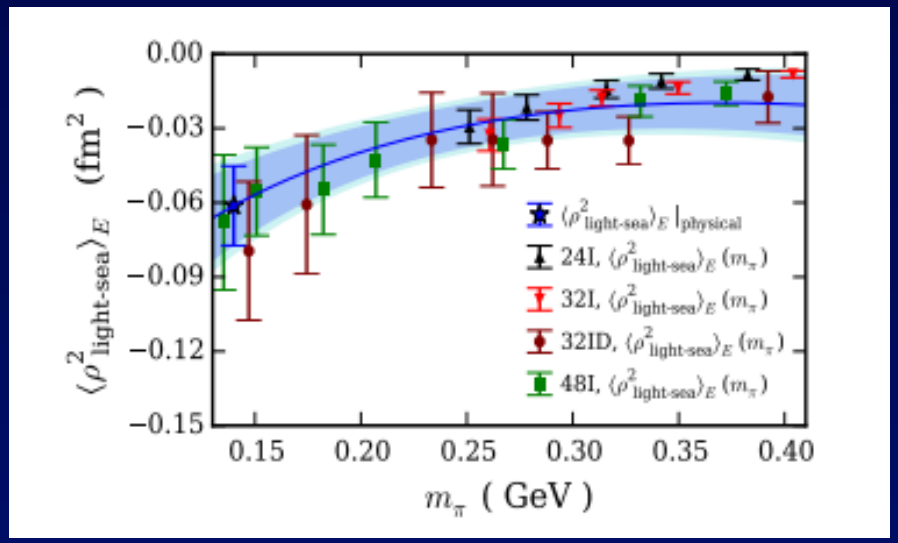
R. Gupta (PI)

Error of charge radii? Need disconnected insertion.

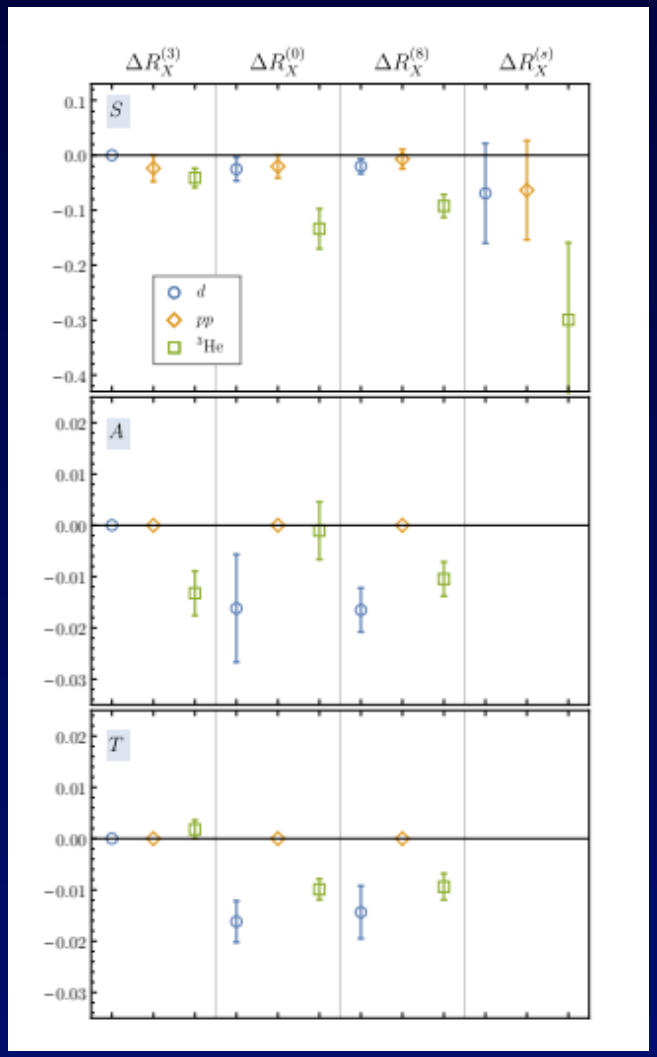
Electromagnetic Form Factors of the Disconnected insertions

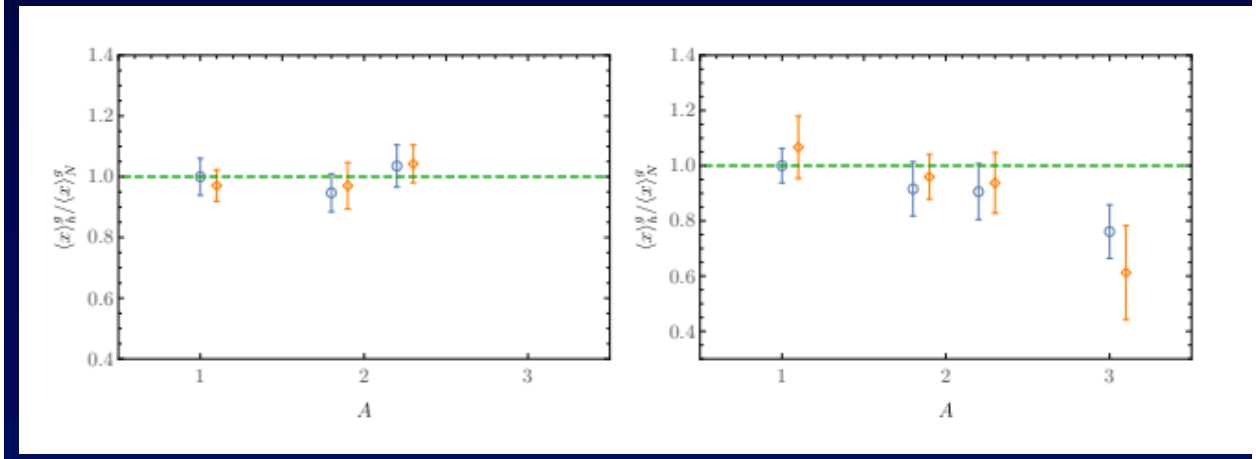
R. Sufian et al, 1705.05849, PRD (2017)





~ 1/3 of the discrepancy of $\langle r^2\rangle_E$ in proton charge radius puzzle.
Sizable for neutron charge radius.





$M_\pi \sim 450$ MeV

$M_\pi \sim 806$ MeV

First lattice QCD study of the gluonic structure of light nuclei
-- F. Winter et al. (NPLQCD), 1709.00395, PRD (2017)

Nuclear modification of scalar, axial, and tensor charges from lattice QCD
-- E. Chang et al. (NPLQCD), 1712.03221, PRL (2018)

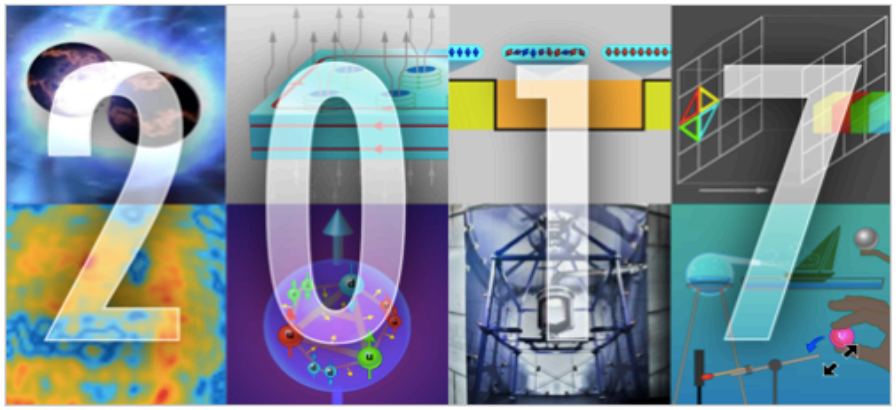
Glue Spin

Physics ABOUT BROWSE PRESS COLLECTIONS

Highlights of the Year

December 18, 2017 • *Physics* 10, 137

Physics **looks back at its favorite stories from 2017.**



Y. Yang et al, PRL 118, 102001 (2017), 1609.05837

More Challenges…

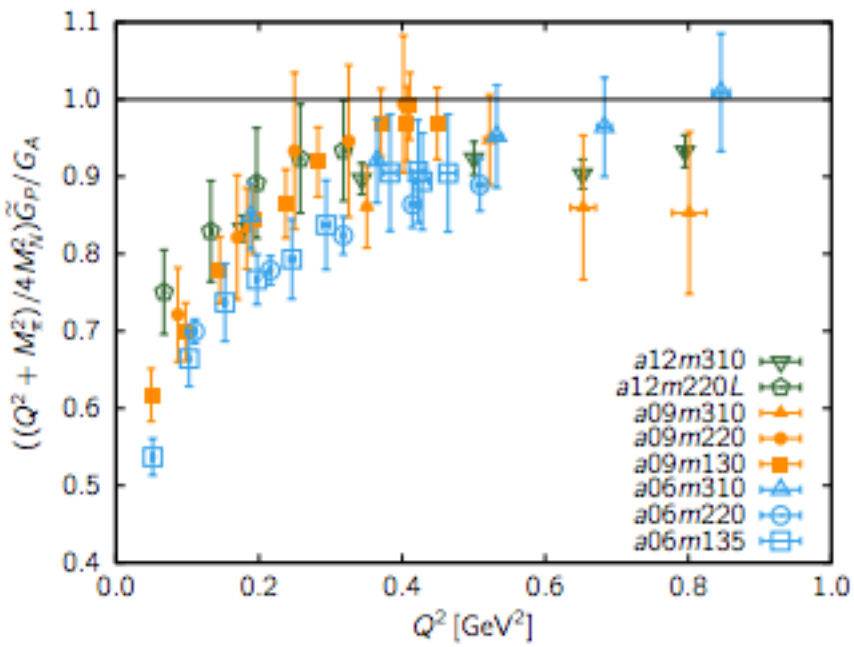
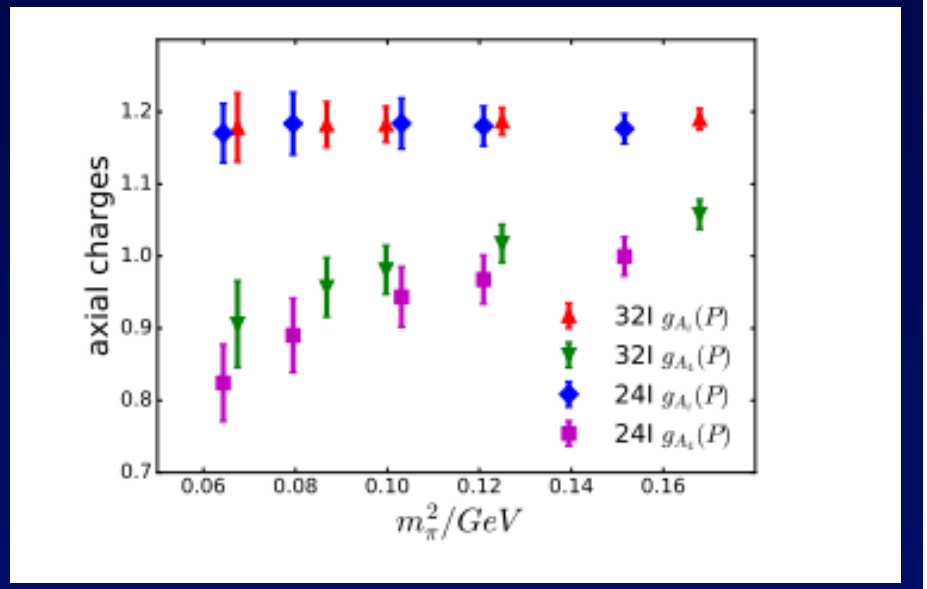


FIG. 13. Plot of the ratio $(Q^2+M_\pi^2)\tilde{G}_P(Q^2)/(4M_p^2 G_A(Q^2))$ versus Q^2 for the eight ensembles. Validity of the pion pole-dominance hypothesis, given in Eq. (11), requires that this ratio is unity for all Q^2. Our data show significant deviations, especially for $Q^2 \lesssim 0.2$ GeV^2.

R. Gupta et al. (PNDME), 1705.06834, PRD (2017)



J. Liang et al. (\chi QCD) 1612.04388, PRD (2017)