Lattice QCD Highlights since last time

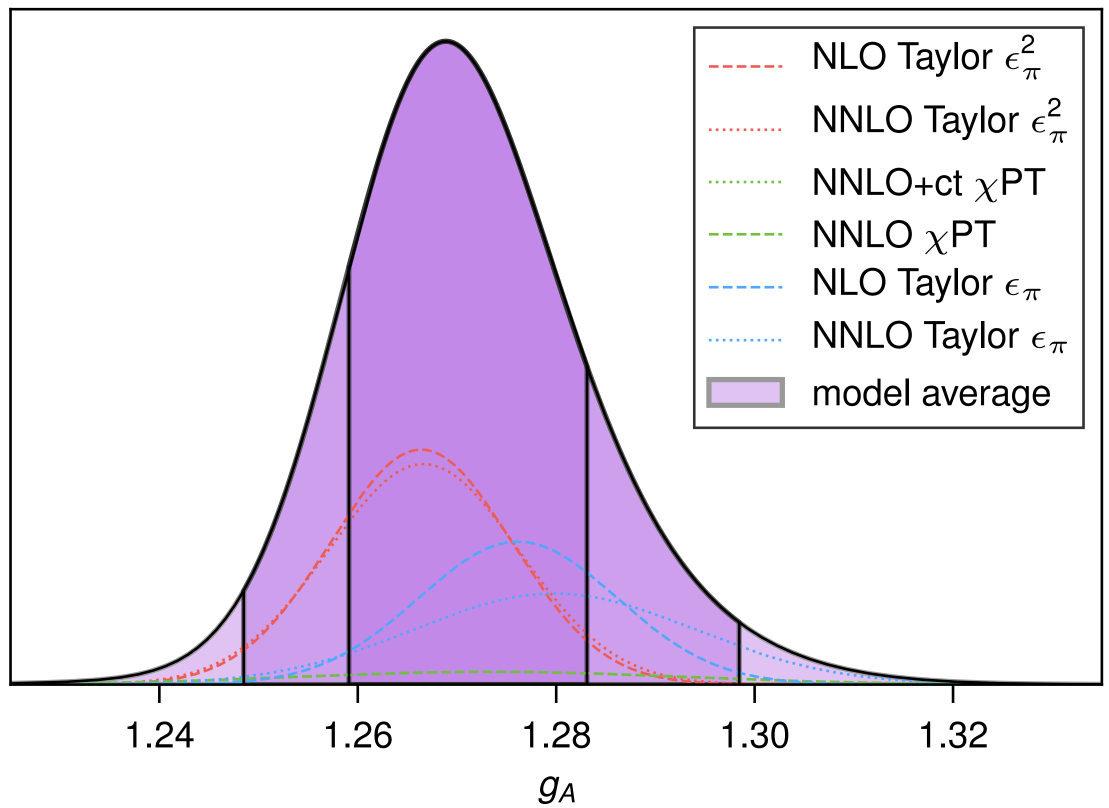
- g_A
- quark CMDM operators in the nucleon
- $0\nu\beta\beta$ operators
- People

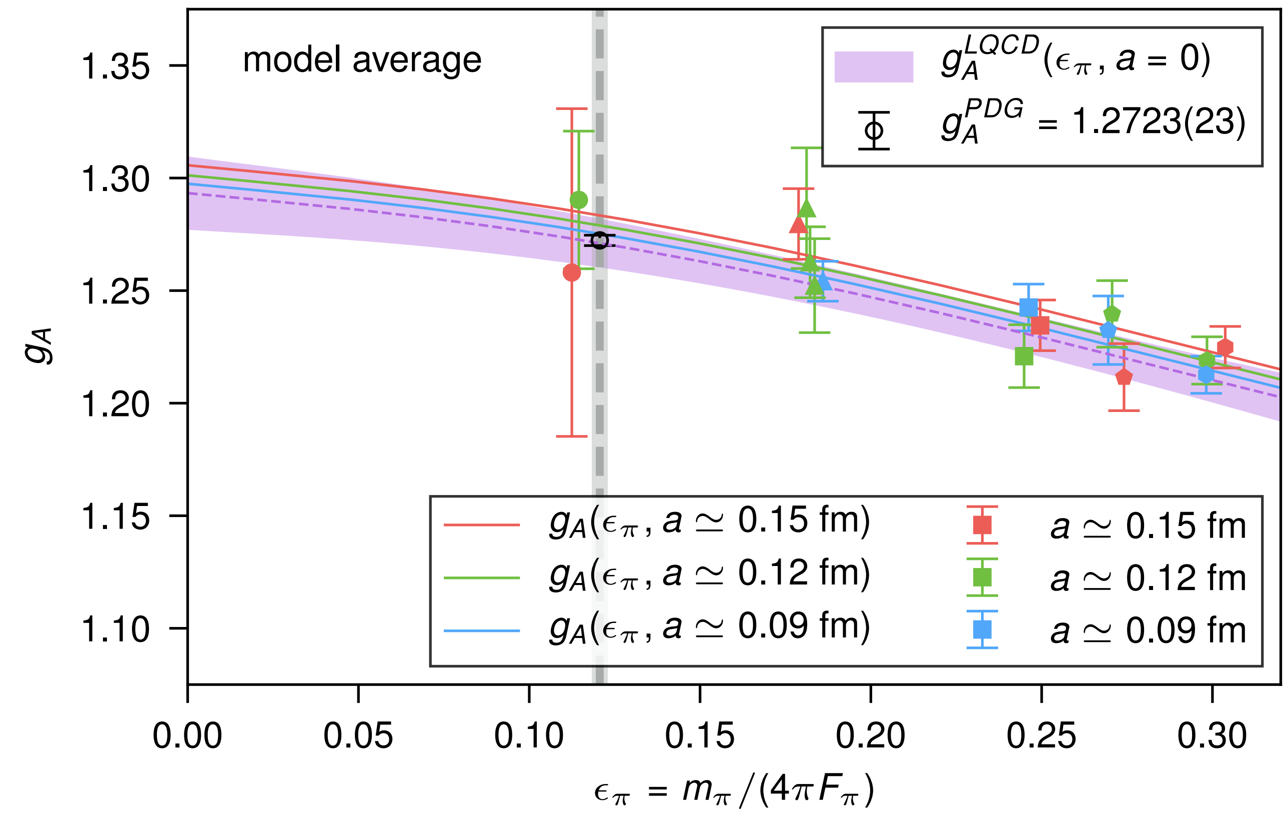
Lattice QCD Team

red = postdoc
blue = grad student

Glasgow: Chris Bouchard
INT: Chris Monahan
JLab: Balint Jóo
Jülich: Evan Berkowitz
LBL/UCB: David Brantley, Chia Cheng (Jason) Chang, T. Kurth (NERSC), Henry Monge-Camacho, AWL
LLNL: Pavlos Vranas
Liverpool: Nicolas Garron
NVIDIA: Kate Clark
RIKEN/BNL: Enrico Rinaldi
UNC: Amy Nicholson
William and Mary: Kostas Orginos

plus a few others





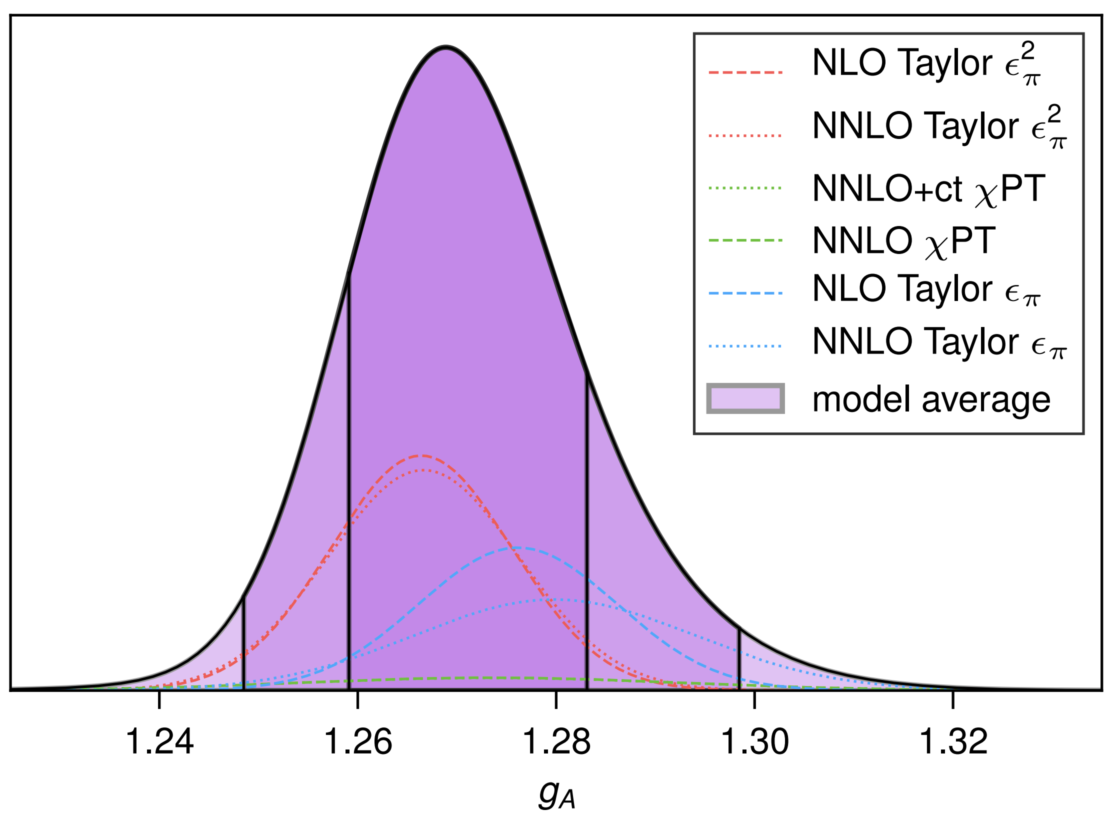
$$g_A^{QCD} = 1.2711(103)^s(39)^\chi(15)^a(19)^v(04)^I(55)$$

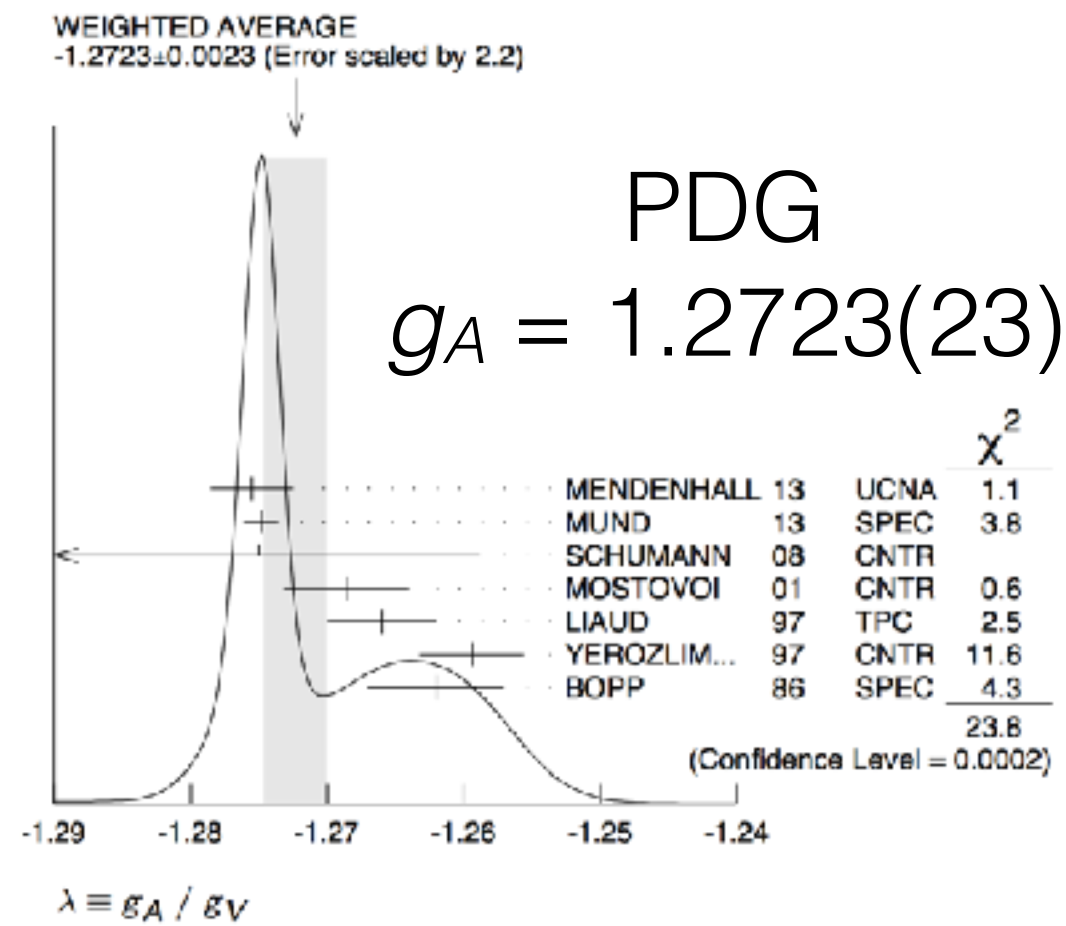
Lattice QCD Team

red = postdoc
blue = grad student

Glasgow:	Chris Bouchard
INT:	Chris Monahan
JLab:	Balint Jóo
Jülich:	Evan Berkowitz
LBL/UCB:	David Brantley, Chia Cheng (Jason) Chang, T. Kurth (NERSC), Henry Monge-Camacho, AWL
LLNL:	Pavlos Vranas
Liverpool:	Nicolas Garron
NVIDIA:	Kate Clark
RIKEN/BNL:	Enrico Rinaldi
UNC:	Amy Nicholson
William and Mary:	Kostas Orginos

plus a few others





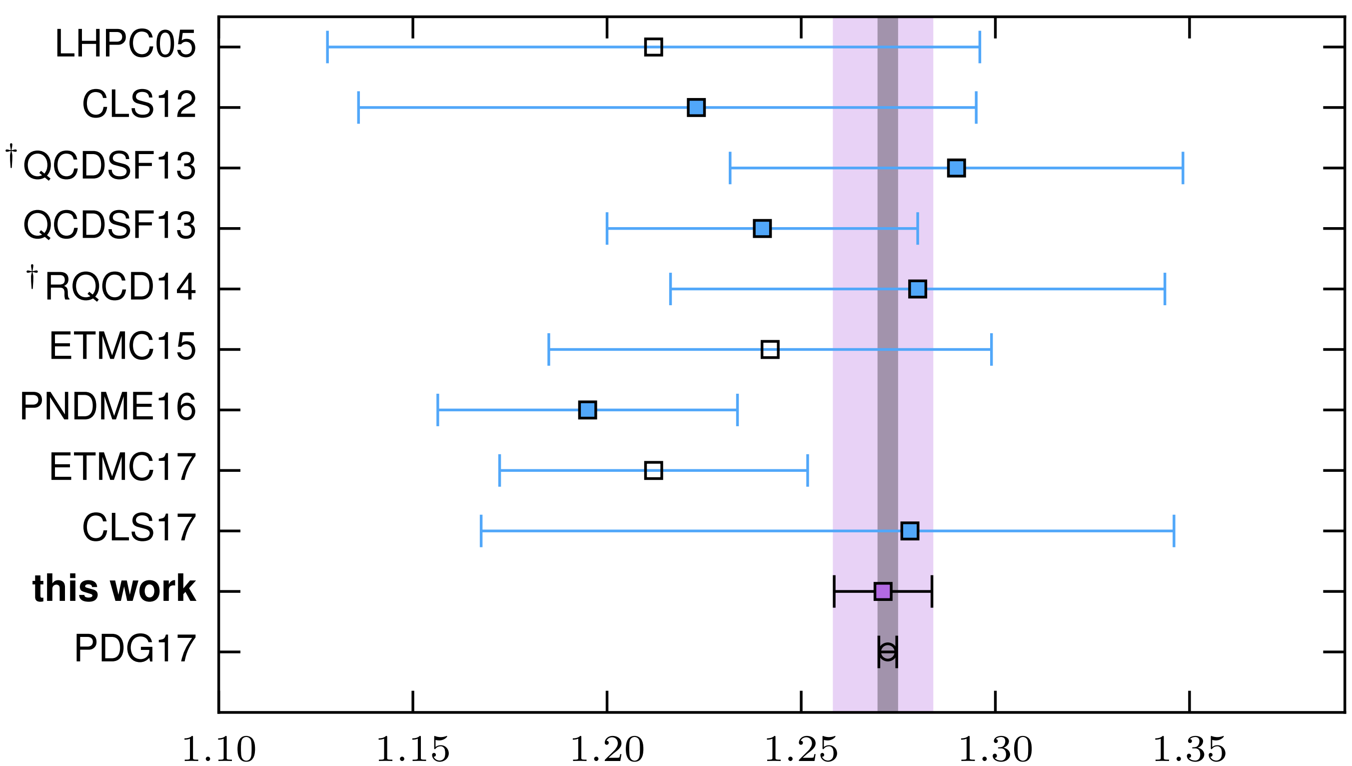
$$g_A^{QCD} = 1.2711(103)^s(39)^\chi(15)^a(19)^v(04)^I(55)$$

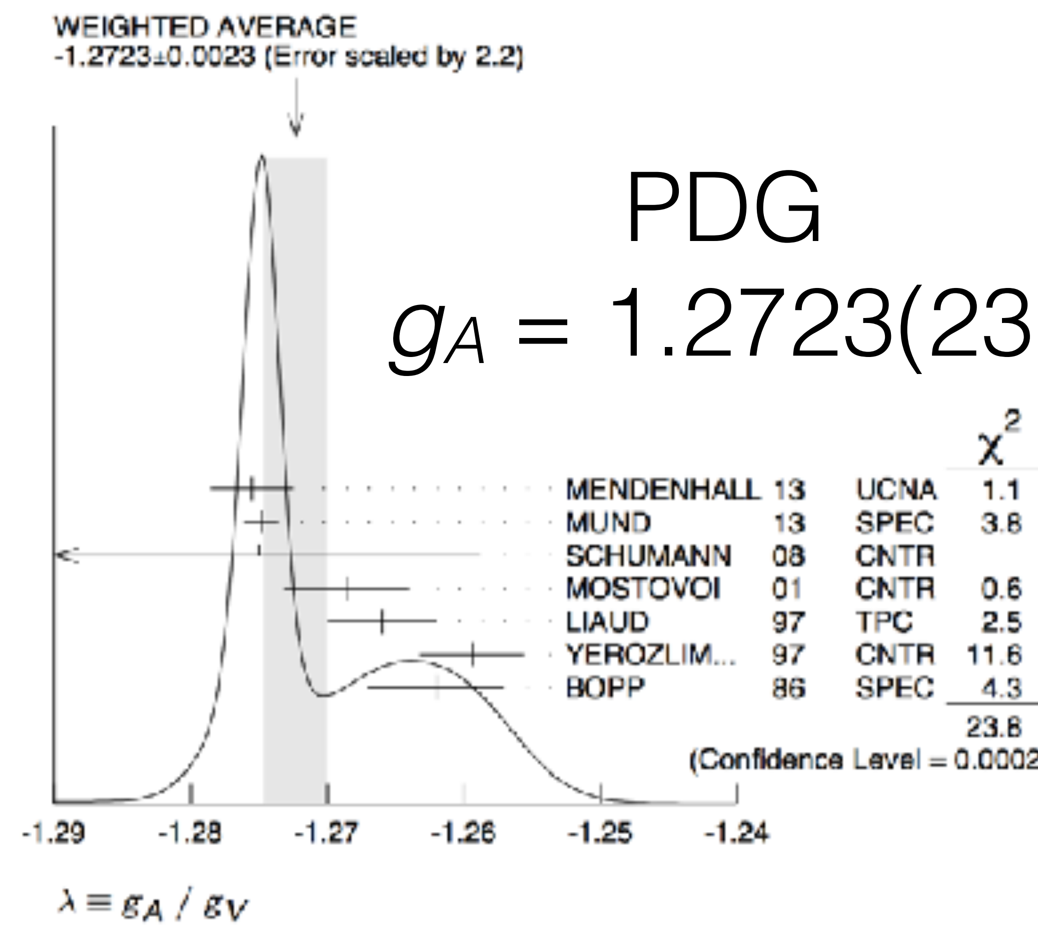
Lattice QCD Team

Glasgow: Chris Bouchard
INT: Chris Monahan
JLab: Balint Jóo
Jülich: Evan Berkowitz
LBL/UCB: David Brantley, Chia Cheng (Jason) Chang, T. Kurth (NERSC), Henry Monge-Camacho, AWL
LLNL: Pavlos Vranas
Liverpool: Nicolas Garron
NVIDIA: Kate Clark
RIKEN/BNL: Enrico Rinaldi
UNC: Amy Nicholson
William and Mary: Kostas Orginos

red = postdoc
blue = grad student

plus a few others





PDG

$g_A = 1.2723(23)$

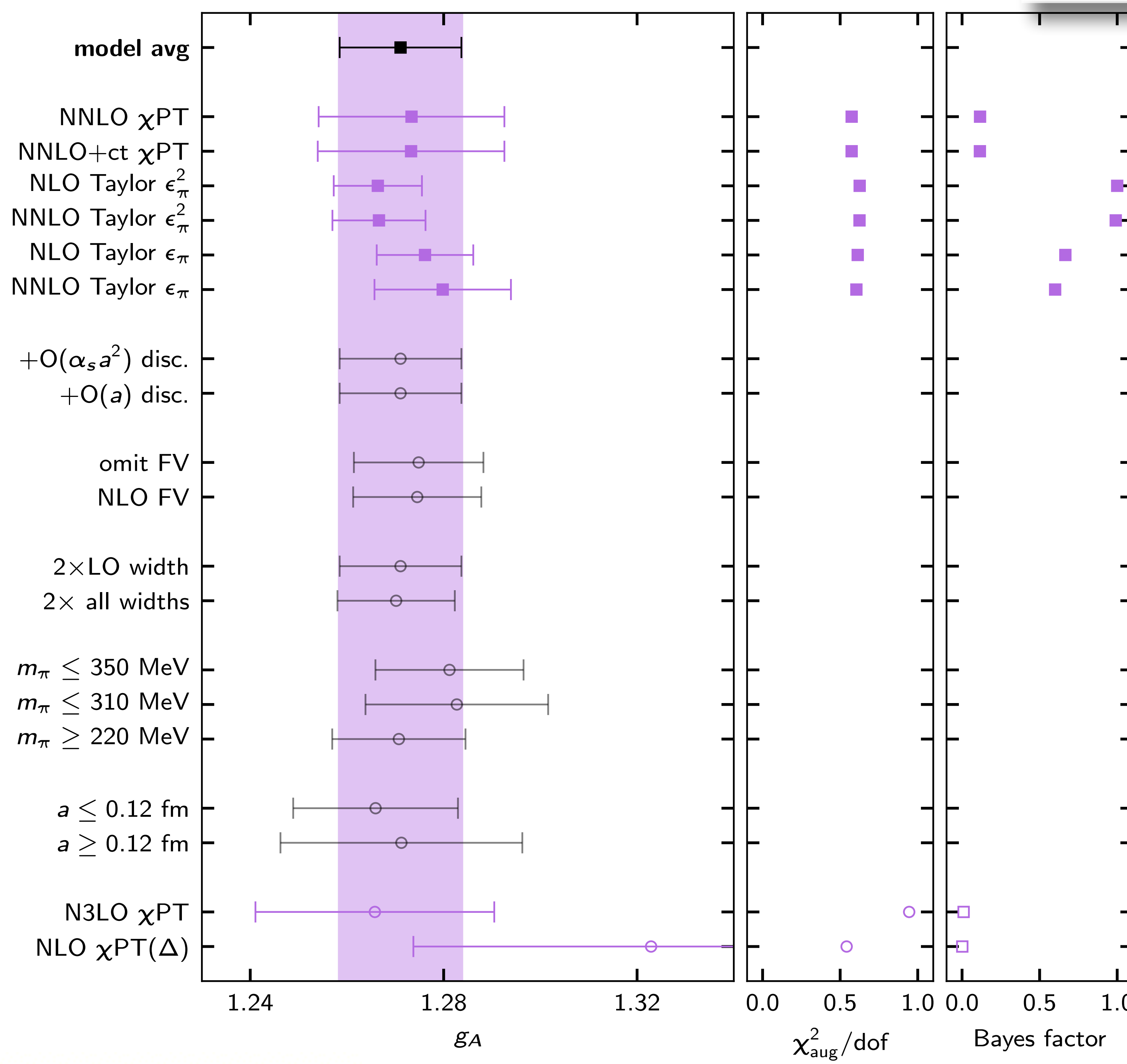
$$g_A^{QCD} = 1.2711(103)^s(39)^\chi(15)^a(19)^v(04)^I(55)$$

Lattice QCD Team

Glasgow:	Chris Bouchard
INT:	Chris Monahan
JLab:	Balint Jóo
Jülich:	Evan Berkowitz
LBL/UCB:	David Brantley, Chia Cheng (Jason) Chang, T. Kurth (NERSC), Henry Monge-Camacho, AWL
LLNL:	Pavlos Vranas
Liverpool:	Nicolas Garron
NVIDIA:	Kate Clark
RIKEN/BNL:	Enrico Rinaldi
UNC:	Amy Nicholson
William and Mary:	Kostas Orginos

red = postdoc
blue = grad student

plus a few others

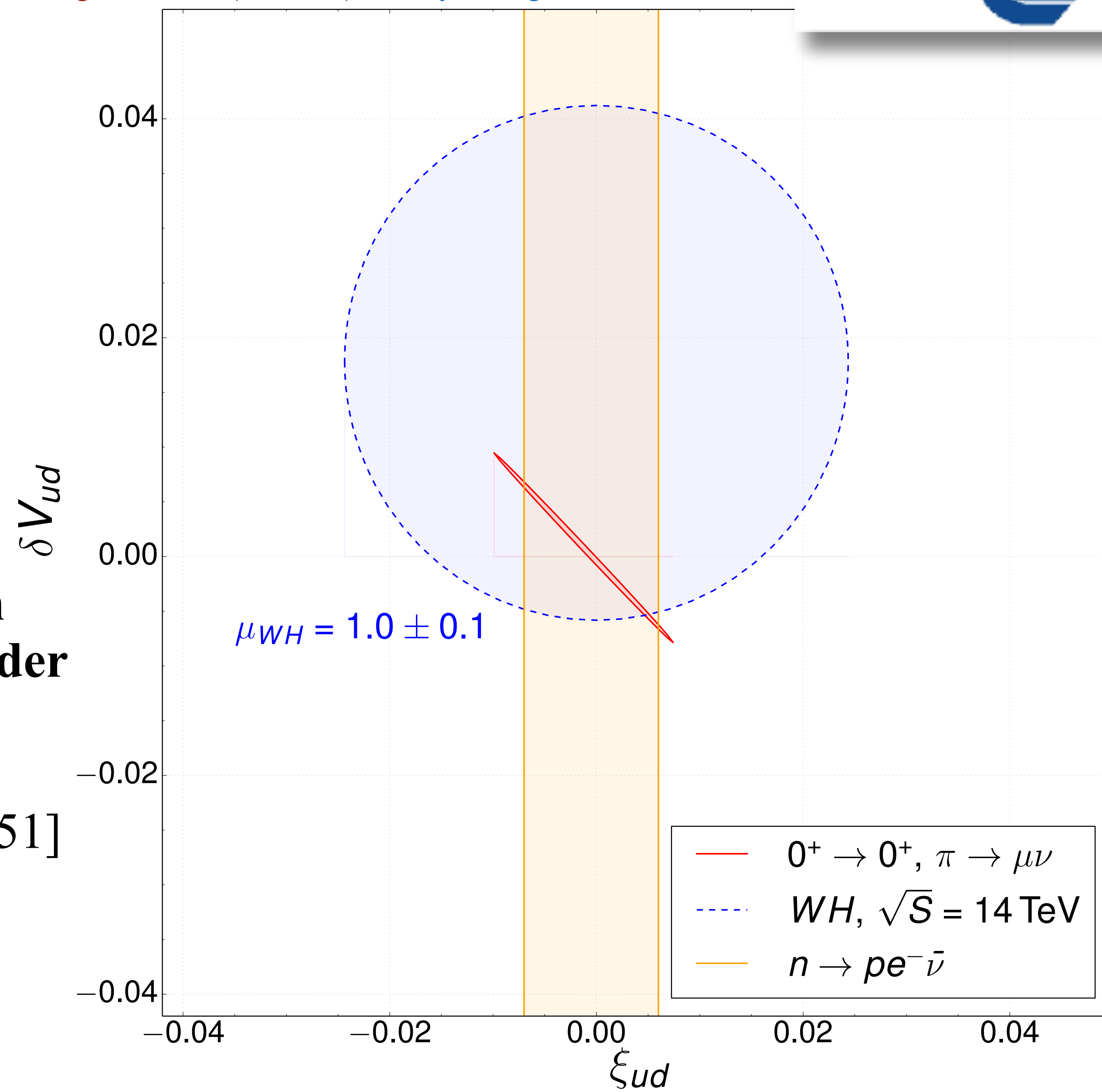


Lattice QCD Team

red = postdoc
blue = grad student

Glasgow:	Chris Bouchard
INT:	Chris Monahan
JLab:	Balint Jóo
Jülich:	Evan Berkowitz
LBL/UCB:	David Brantley, Chia Cheng (Jason) Chang, T. Kurth (NERSC), Henry Monge-Camacho, AWL
LLNL:	Pavlos Vranas
Liverpool:	Nicolas Garron
NVIDIA:	Kate Clark
RIKEN/BNL:	Enrico Rinaldi
UNC:	Amy Nicholson
William and Mary:	Kostas Orginos

plus a few others

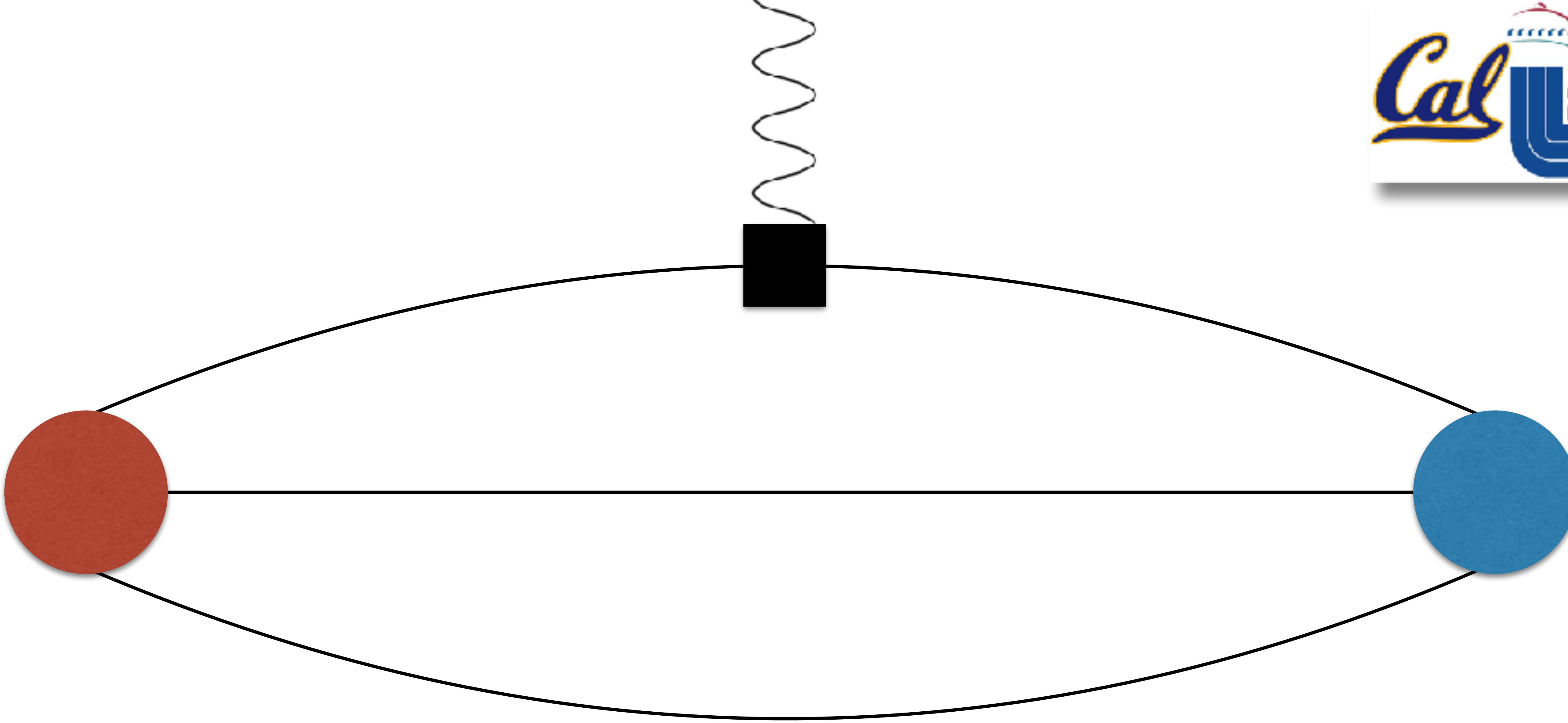


updated figure from
Right-handed charged currents in the era of the Large Hadron Collider
Alioli, Cirigliano, Dekens, de Vries and Mereghetti
JHEP 1705 (2017) [arXiv:1703.04751]

U.S. DEPARTMENT OF ENERGY INCITE LEADERSHIP COMPUTING

OLCF Oak Ridge Leadership Computing Facility

SciDAC Scientific Discovery through Advanced Computing



- Previously (for g_A) our method required us to chose a specific current and a specific momentum transfer
- We believe we know how to generalize our method to insert arbitrary currents/momentum transfers - finalizing the code and then will test

CP-odd pion-nucleon couplings

- Standard Model CP-violation insufficient to explain baryon asymmetry
- BSM CP-violation may manifest as higher-dimension operators: quark EDM operators, quark chromo-EDM operators, Weinberg Operator, etc.
- Symmetry relates CP-odd operators to CP-even ones

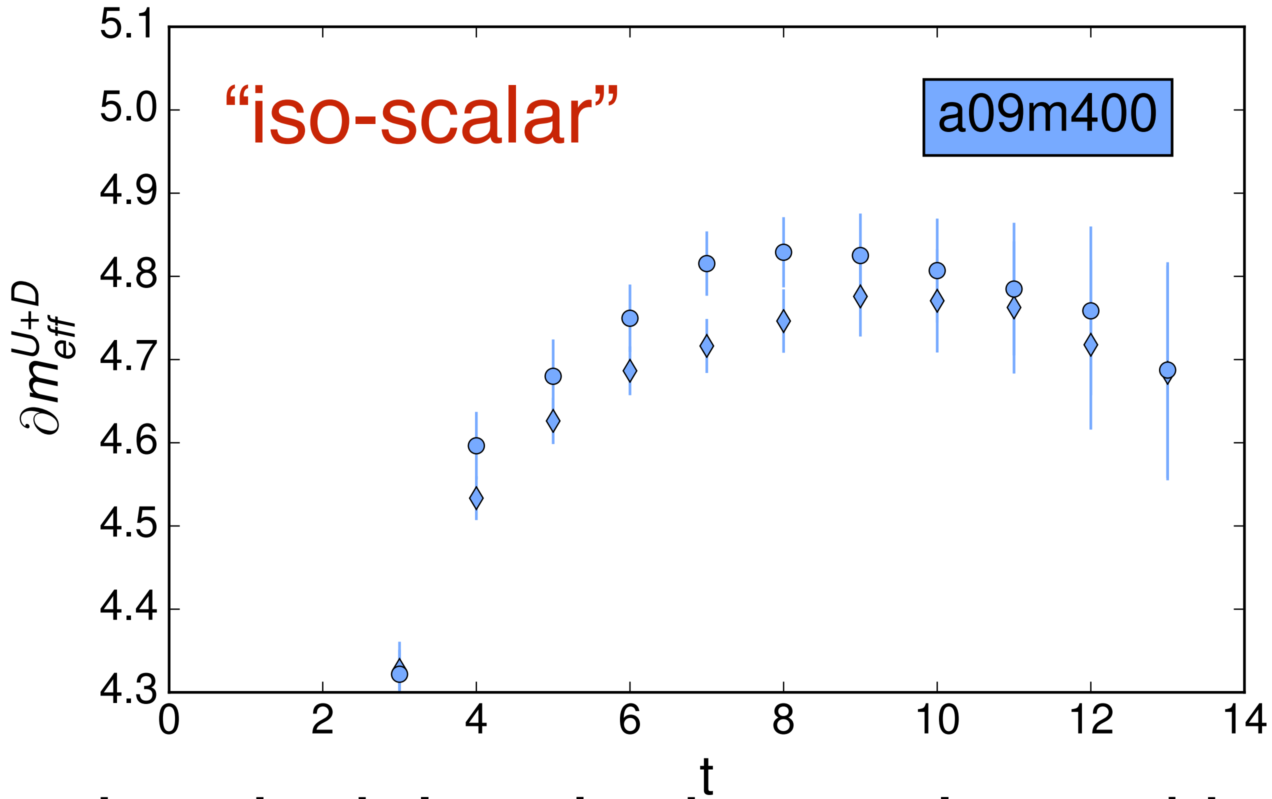
$$\mathcal{L}^6_{\bar{q}q} = -\frac{i}{2}\bar{q}\sigma^{\mu\nu}\gamma_5(\tilde{d}_0 + \tilde{d}_1\tau_3)G_{\mu\nu}q - \frac{1}{2}\bar{q}\sigma^{\mu\nu}(\tilde{c}_1\tau_3 + \tilde{c}_0)G_{\mu\nu}q$$

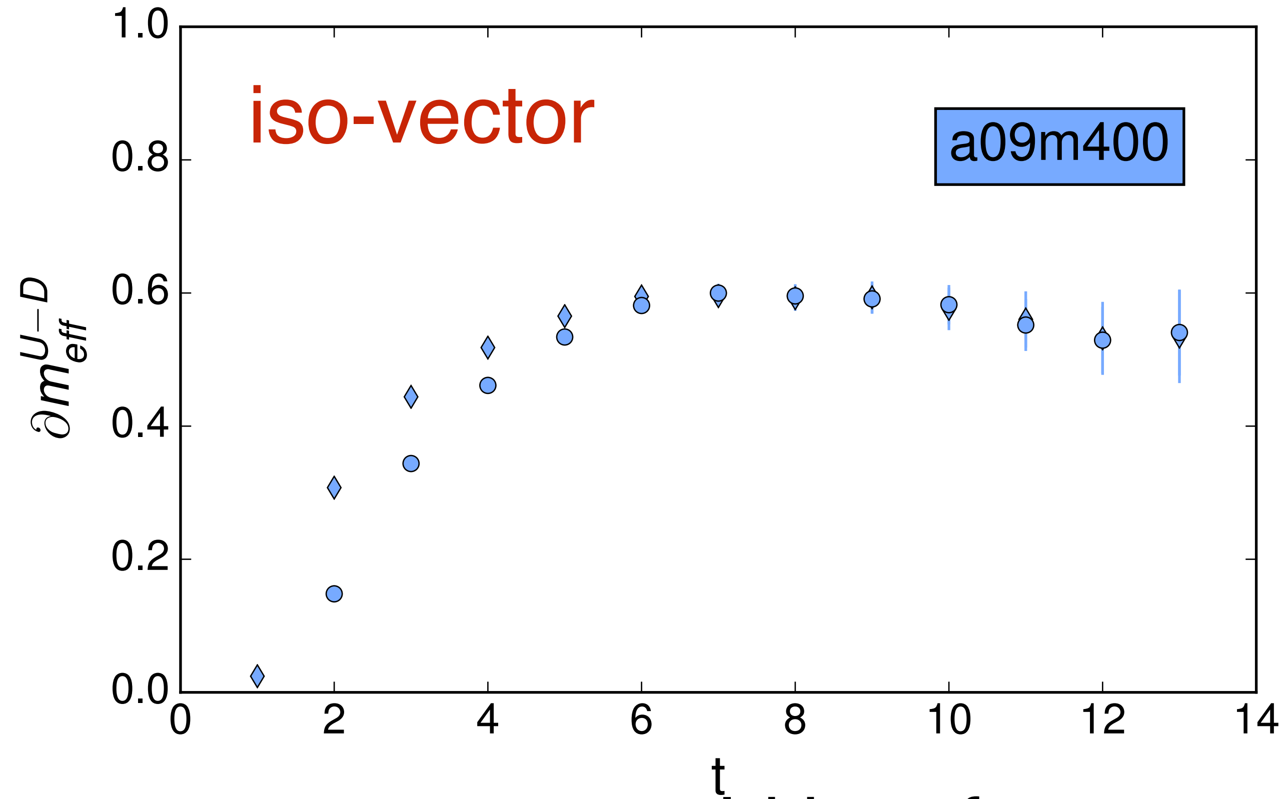
- exploit this symmetry to compute CP-even matrix elements and extract CP-odd pion-nucleon couplings

Lattice QCD spectroscopy for hadronic CP violation
J. de Vries, E. Mereghetti, C-Y. Seng and AWL
Phys. Let. B766 (2017) [arXiv:1612.01567]

CP-odd pion-nucleon couplings

- chromo-magnetic dipole operators $\langle N|\bar{q}\sigma_{\mu\nu}G_{\mu\nu}q|N\rangle$
  (David - grad student supported by this TC)





- in principle - the iso-scalar and iso-vector operators could be of the same order of magnitude

- just like the quark mass operators $\langle N|\bar{q}m_q q|N\rangle$ the iso-vector operator (m_n-m_p) is suppressed an order of magnitude compared to the iso-scalar (pion-nucleon-sigma term)

- renormalization still needed

0νββ

- Where is our $\pi^- \rightarrow \pi^+$ result?
  - The hold up was the non-perturbative renormalization (NPR) - we had to learn how to overcome a challenge with the NPR
  - Paper should be arXiv'd in February

- We think we know how to generalize our Feynman-Hellmann method (used for g_A) to 4-quark operators
  - Henry (grad student supported by this TC) is coding up the method now, and we hope to test it very quickly on one of the $\pi^- \rightarrow \pi^+$ operators
  - We will then use it in the two-nucleon calculation of 4-quark ops
  - It should also work for parity-odd 4-quark operators

People

- This topical collaboration supported two graduate students working with me (and CalLat) since the beginning of the collaboration

  David Brantley - focussed on CP-violation

  Henry Monge-Camacho - focussed on 4-quark for $0\nu\beta\beta$

- I anticipate both of them will graduate this year

  David plans to accept a position at LLNL

  Henry is coming to UNC as a postdoc with Amy

- Success!