Status of RBC/UKQCD g-2 program

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Yikai Huo
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HLbL update (2304.04423)

Hadronic light-by-light contribution to the muon anomaly from lattice QCD with infinite volume QED at physical pion mass

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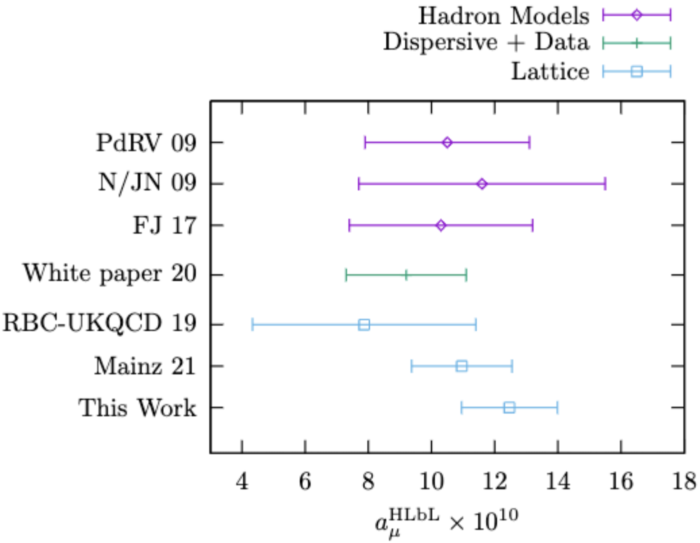
(Dated: April 11, 2023)

The hadronic light-by-light scattering contribution to the muon anomalous magnetic moment, $(g-2)/2$, is computed in the infinite volume QED framework with lattice QCD. We report $a_\mu^{\mathrm{HLbL}} = 12.47(1.15)(0.99)\times 10^{-10}$ where the first error is statistical and the second systematic. The result is mainly based on the 2+1 flavor Möbius domain wall fermion ensemble with inverse lattice spacing $a^{-1} = 1.73$ GeV, lattice size $L = 5.5$ fm, and $m_\pi = 139$ MeV, generated by the RBC-UKQCD collaborations. The leading systematic error of this result comes from the lattice discretization. This result is consistent with previous determinations.

HLbL update (2304.04423)



HVP short-distance and intermediate-distance window update (2301.08696)

An update of Euclidean windows of the hadronic vacuum polarization

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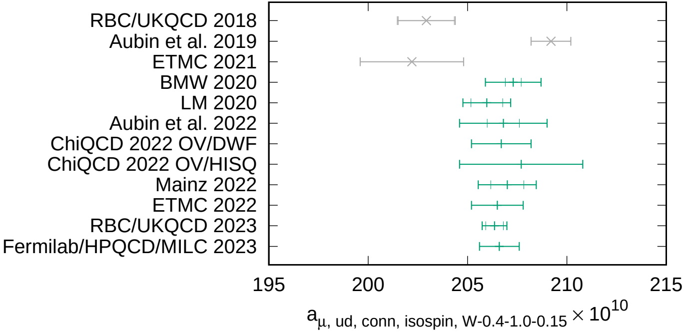
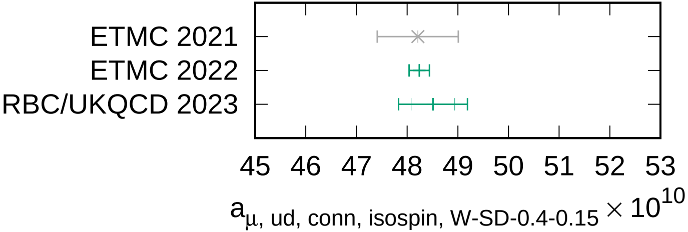
C. Lehner,[6,*] N. Matsumoto,[7] R. D. Mawhinney,[9] A. S. Meyer,[13,14] and J. T. Tsang[10,15]
(RBC and UKQCD Collaborations)

We compute the standard Euclidean window of the hadronic vacuum polarization using multiple independent blinded analyses. We improve the continuum and infinite-volume extrapolations of the dominant quark-connected light-quark isospin-symmetric contribution and address additional sub-leading systematic effects from sea-charm quarks and residual chiral-symmetry breaking from first principles. We find $a_\mu^{\mathrm{W}} = 235.56(65)(50) \times 10^{-10}$, which is in 3.8σ tension with the recently published dispersive result of $a_\mu^{\mathrm{W}} = 229.4(1.4) \times 10^{-10}$ [1] and in agreement with other recent lattice determinations. We also provide a result for the standard short-distance window. The results reported here are unchanged compared to our presentation at the Edinburgh workshop of the g-2 Theory Initiative in 2022 [2].

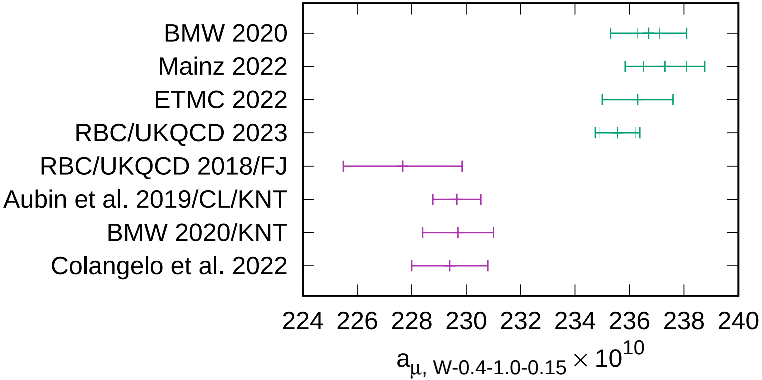
HVP short-distance and intermediate-distance window update (2301.08696)



HVP short-distance and intermediate-distance window update (2301.08696)

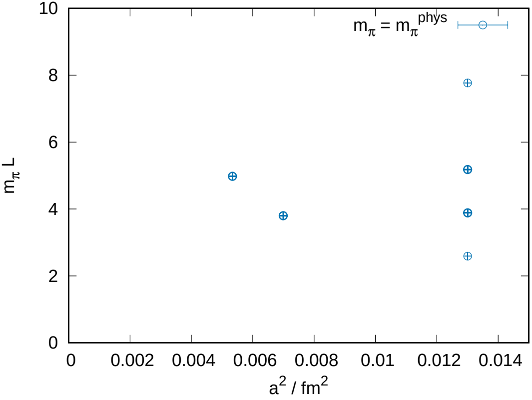


HVP short-distance and intermediate-distance window update (2301.08696)



Next step: long-distance window

- In progress: blind analysis with 5 analysis groups
- Blind all vector currents with group-specific blinding factor
- Ensembles used for this analysis:



- Follow our improved bounding method strategy of 1910.11745; distillation data with 60 laplace eigenmodes for $m_\pi L \approx 4$ ensembles and 200 laplace eigenmodes for $m_\pi L \approx 5$ ensembles

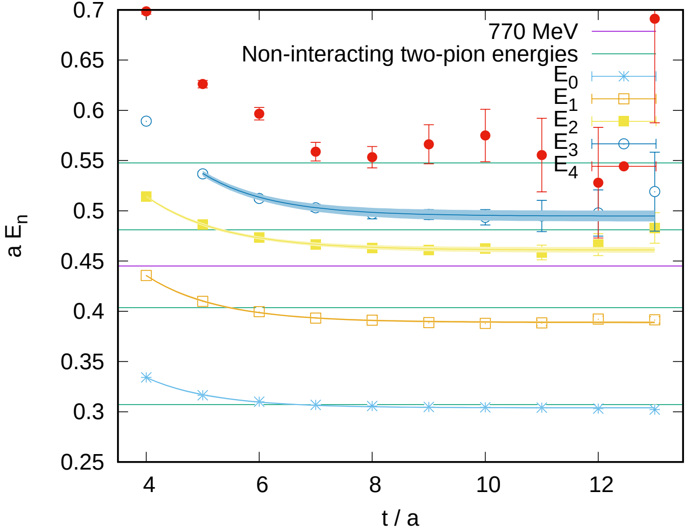
A quick look at group A

- In following show blind results for group A for single ensemble ($a^{-1} = 1.73$ GeV, $m_\pi L \approx 4$, $m_\pi = m_\pi^{\rm phys}$) to illustrate method

- All results still preliminary

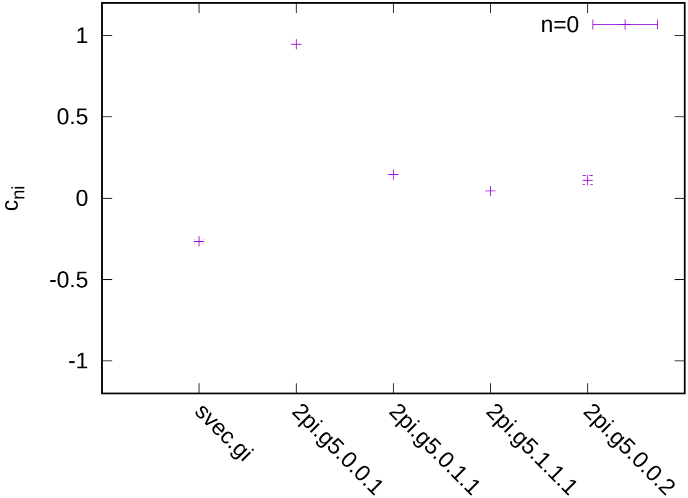
The $I = 1$ spectrum (group A, blind, preliminary)

Using smeared vector current and two-pion operators up to relative momentum of $\vec{p}^2 = 4(2\pi/L)^2$



Optimized operators (group A, blind, preliminary)

Out of 5 operator basis, construct operators that project out single finite-volume state:



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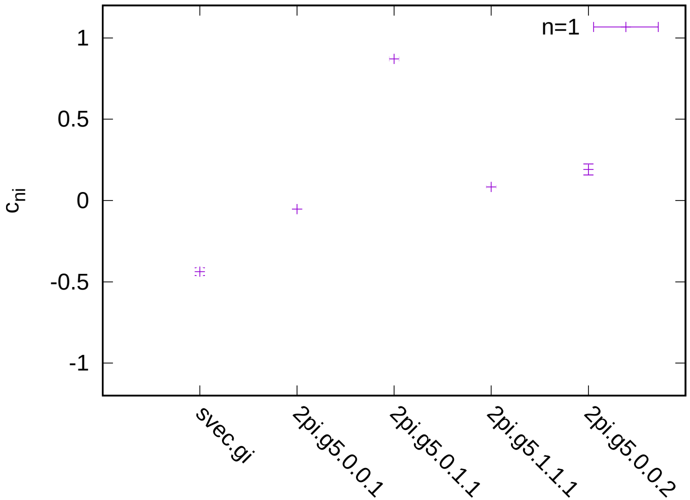

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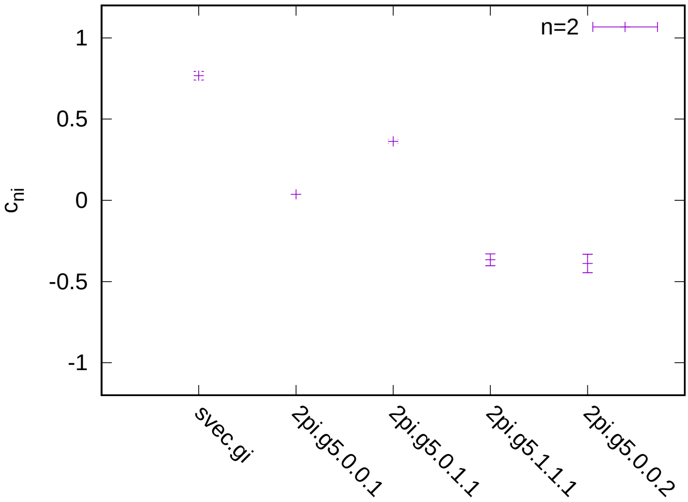

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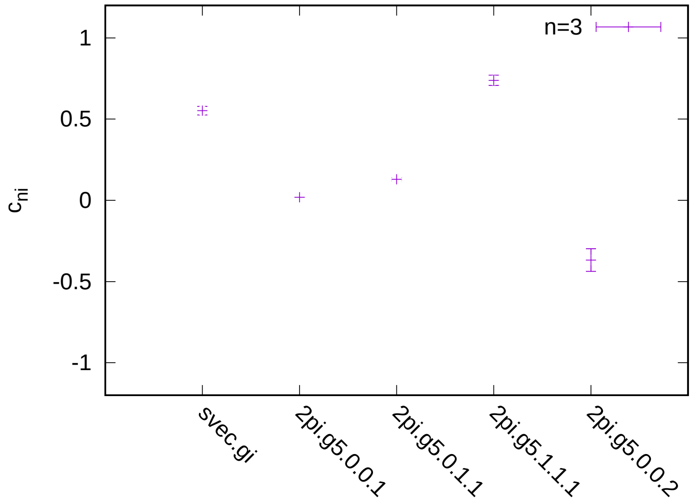
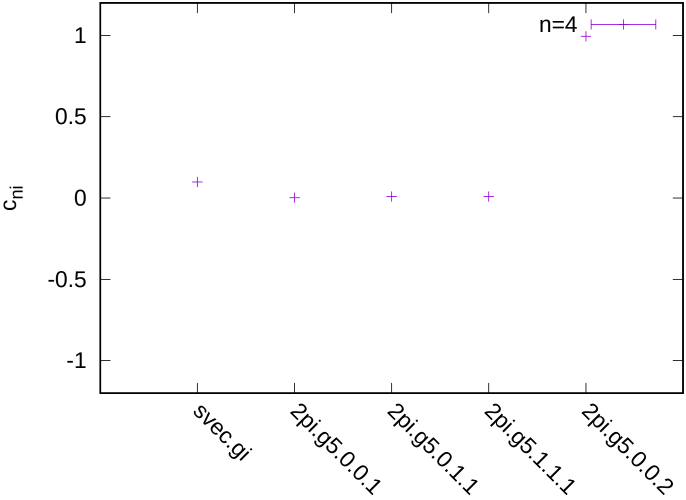


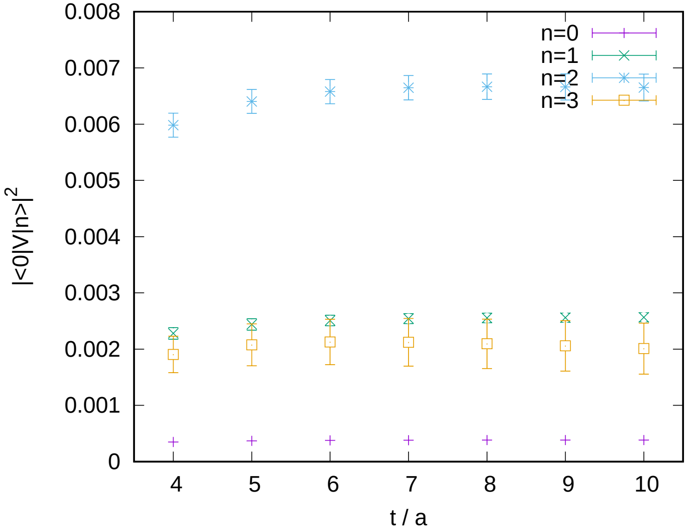
Optimized operators (group A, blind, preliminary)

Out of 5 operator basis, construct operators that project out single finite-volume state:



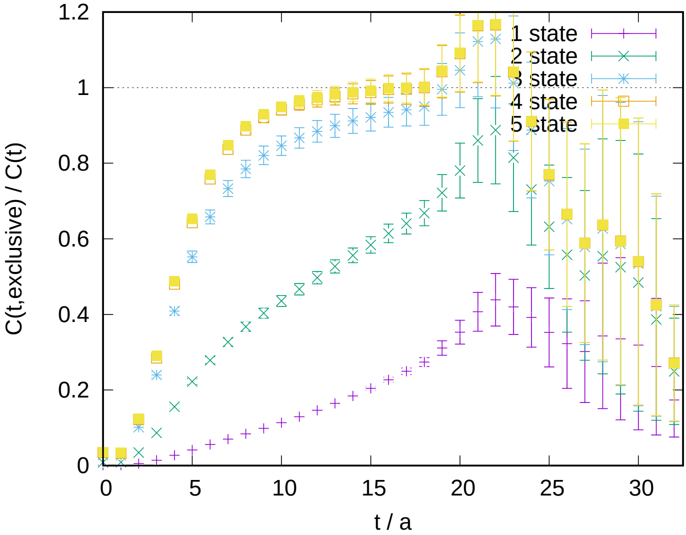
Overlap with local vector current (group A, blind, preliminary)

Next, study correlators of single-state operators with local vector current to obtain $\langle 0|V_i|n\rangle$ matrix elements:



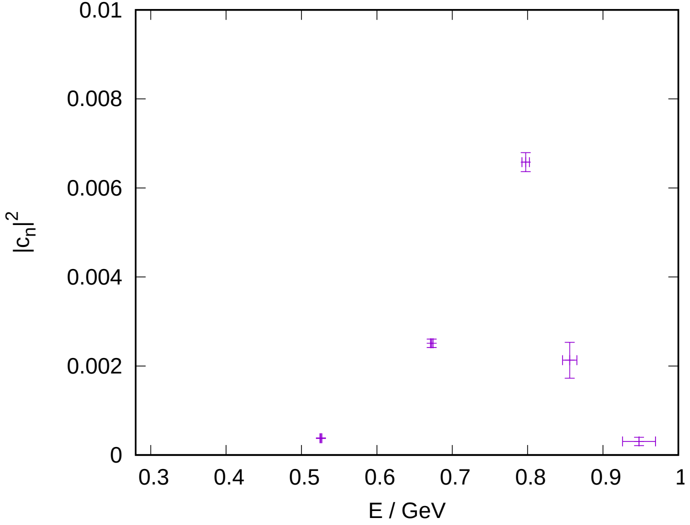
Exclusive-state reconstruction (group A, blind, preliminary)

Next, reconstruct correlator from lowest *n* states:



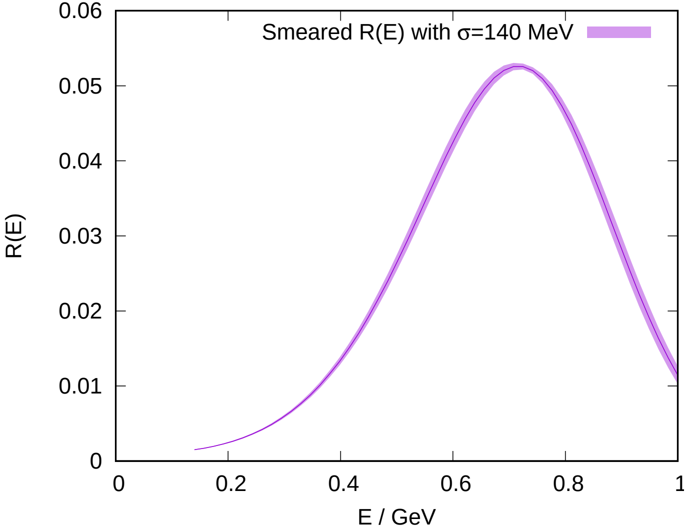
Finite-volume states (group A, blind, preliminary)

Nice to plot this as $|c_n|^2 = |\langle 0|V_i|n\rangle|^2$ versus energy of finite-volume state E_n:



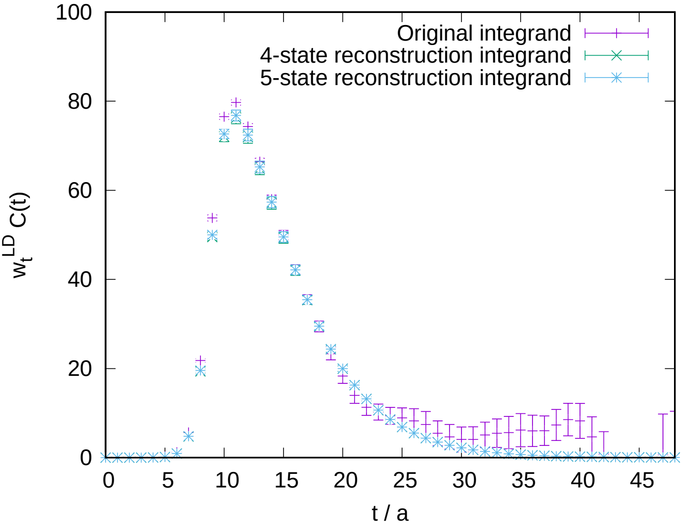
Side-stepping inverse Laplace problem (group A, blind, preliminary)

As noticed in 2012.11488, this allows for a nice way to side-step the inverse Laplace problem. Demonstrate this here with $\sigma = 140$ MeV Gaussian-kernel smeared R-ratio $R(E)$:



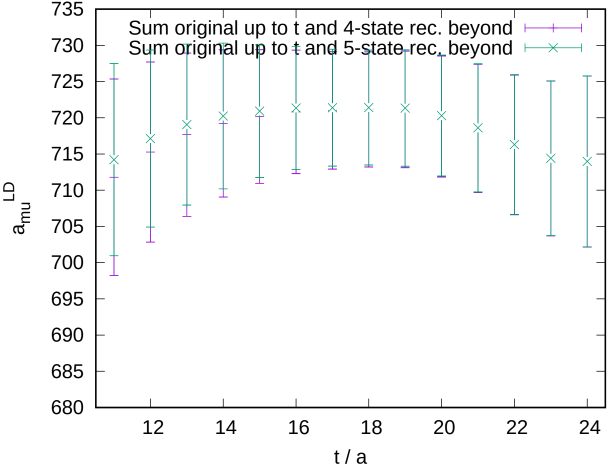
Long-distance integrand (group A, blind, preliminary)

Obtain integrand from origial vector-vector data and reconstruction:



Long-distance window estimator (group A, blind, preliminary)

Sum vector-vector for times up to t and reconstructed integrand above:

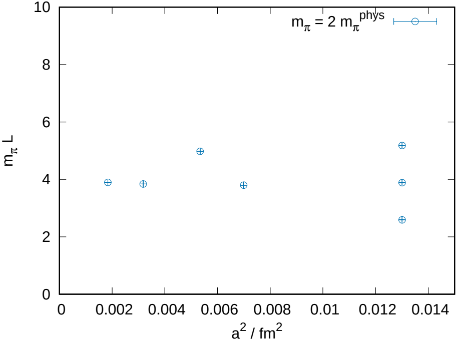


Vector current is blinded allowing for a factor of 4 variation. Aim for error of $O(4 \times 10^{-10})$.

Improved bounding method can be used to further refine the estimator.

Further steps to complete program

- Re-use of HLbL data sets for update of full QED+SIB corrections in progress
- Additional ensembles at twice $m_\pi^{\rm phys}$ have been generated to further consolidate continuum limit (see my GPT talk for scripts to generate them):



- Additional ensembles to study sea charm, $m_{\rm res}$, and quark-mass dependence available
- Will update our 2018 strange, charm, and disconnected results early next year

Summary

- Update of HLbL with QED_∞ out: 2304.04423
- Short-distance and intermediate-window results for HVP at desired precision out: 2301.08696 (blind analysis, 5 groups)
- Long-distance window analysis in progress. Still blind, 5 groups.
- Aim at better than 0.5% precision for total a_μ^{HVP} in 2024.