Intermediate-distance Window

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Zoomland
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Why Windows?

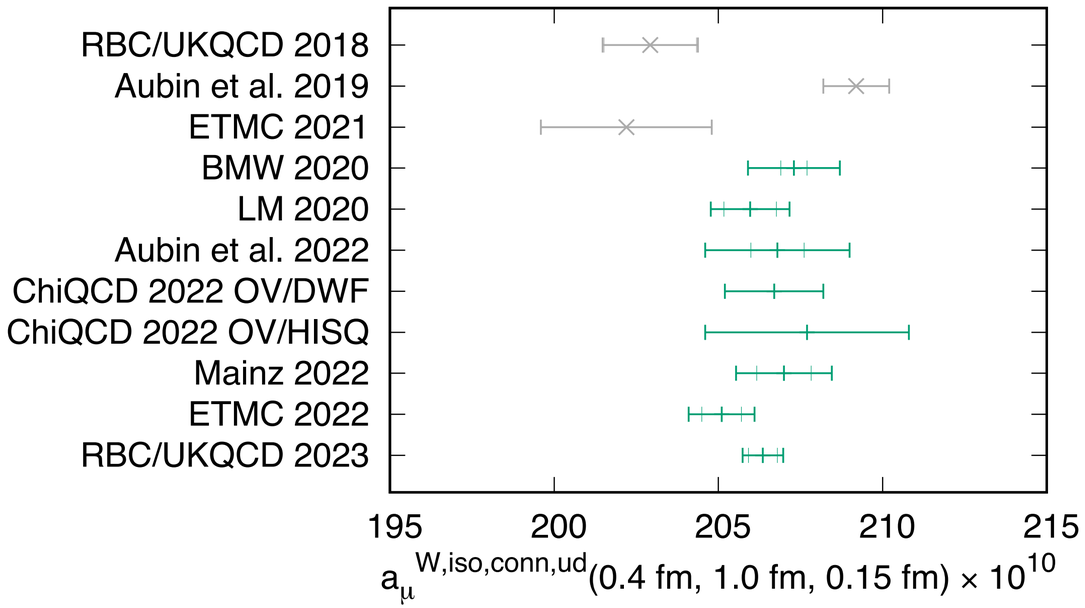
- RBC/UKQCD collaboration introduced filters in Euclidean time to reduce contribution from long time tail. PRL121, 022003 (2018)
  - allows precise comparisons among different lattice calculations
  - allows comparison with data driven approach to explore apparent current difference of 2.2 σ
  - Initially three filters: short distance (SD), intermediate distance (W), and long distance (LD)
  - Here we consider W
  - *Should the white paper also consider SD?*
- $\mathscr{W}\left(t, t_0, t_1, \Delta\right) = \frac{1}{2}\left[\tanh\left(\frac{t-t_0}{\Delta}\right) - \tanh\left(\frac{t-t_1}{\Delta}\right)\right] + (t \to -t)$ defines the window function, plotted on future slides

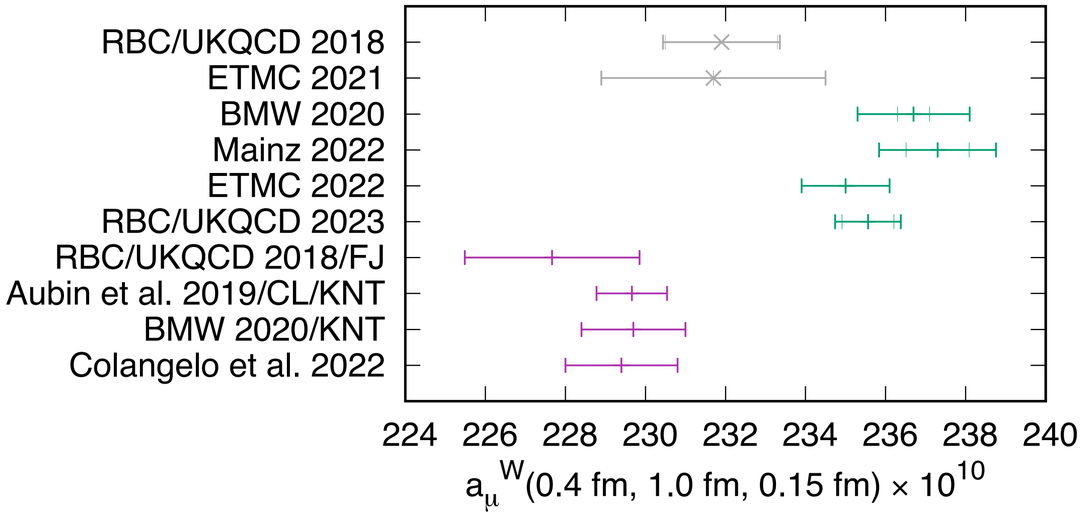
Literature Search

✦ Found 8 archival papers and 4 lattice proceedings from mid-2022 to present

- Wang:2022lkq, Muon g-2 with overlap valence fermions
- Aubin:2022hgm, Muon anomalous magnetic moment with staggered fermions: Is the lattice spacing small enough?
- Ce:2022kxy, Window observable for the hadronic vacuum polarization contribution to the muon g-2 from lattice QCD
- ExtendedTwistedMass:2022jpw, Lattice calculation of the short and intermediate time-distance hadronic vacuum polarization contributions to the muon magnetic moment using twisted-mass fermions
- FermilabLattice:2022izv, Windows on the hadronic vacuum polarization contribution to the muon anomalous magnetic moment
- Chao:2022ycy, Coordinate-space calculation of the window observable for the hadronic vacuum polarization contribution to g-2
- FermilabLatticeHPQCD:2023jof, Light-quark connected intermediate-window contributions to the muon g-2 hadronic vacuum polarization from lattice QCD
- RBC:2023pvn, Update of Euclidean windows of the hadronic vacuum polarization

Light, Intermediate Contribution

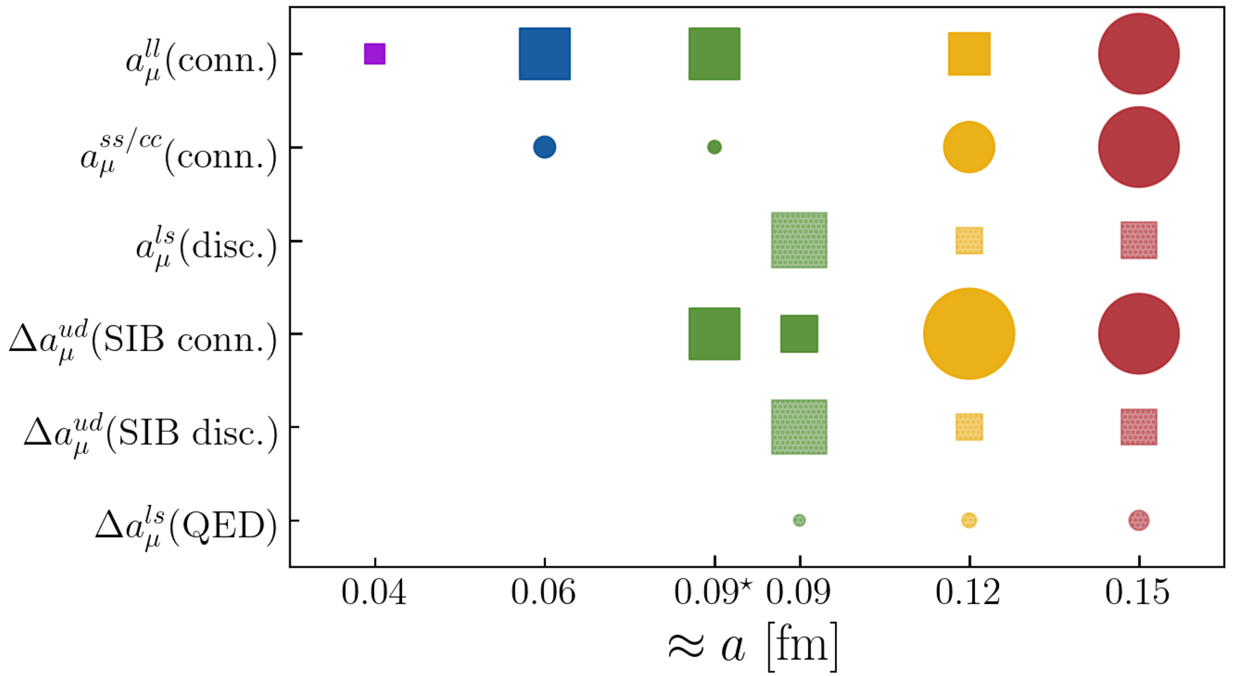




- (Left) results from various groups for light connected contribution
- (Right) Complete contribution to the intermediate window. Includes strange, and charm quarks, disconnected contributions, isospin breaking and electromagnetic corrections. 10.1103/PhysRevD.108.054507; arXiv:2301.08696

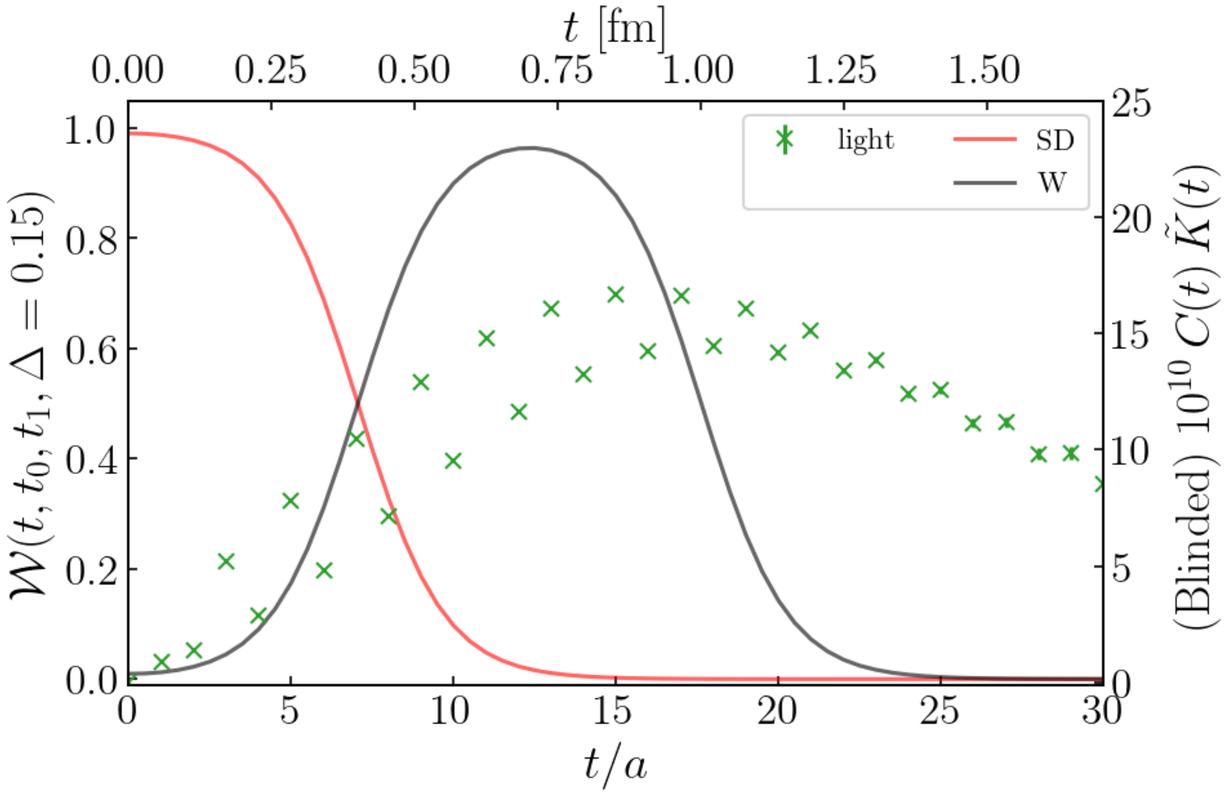
Ensembles Used by Fermilab/HPQCD/MILC

- Circles denote truncated solver method (TSM)
- Squares are for low mode improved (LMI)
- Area of symbol proportional to statistics. Several smaller symbols are runs in progress.
- Solid colors for local vector current; hatched for 1-link current
- 0.09* is a better tuned ensemble started by CalLat, extended by MILC



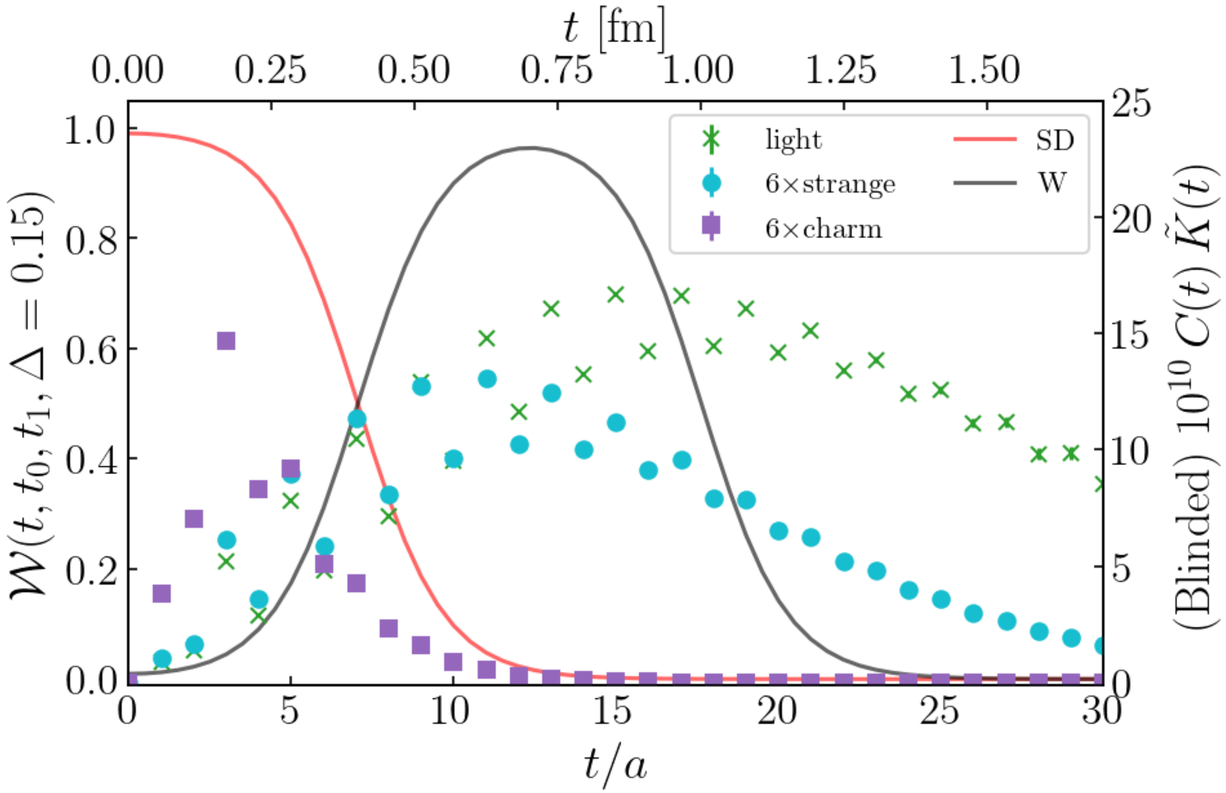
Example of Windows

- Results for $a \approx 0.06$ fm
- Red curve is SD filter out to 0.4 fm
- Black curve is W filter 0.4 to 1 fm
- In each case width is 0.15 fm
  - scale is on left
- Data for light quarks shows effect of staggering
- Data is blinded & preliminary
  - scale is on right
- Light contribution extends well beyond W, i.e., long distance contribution to g-2 is substantial.

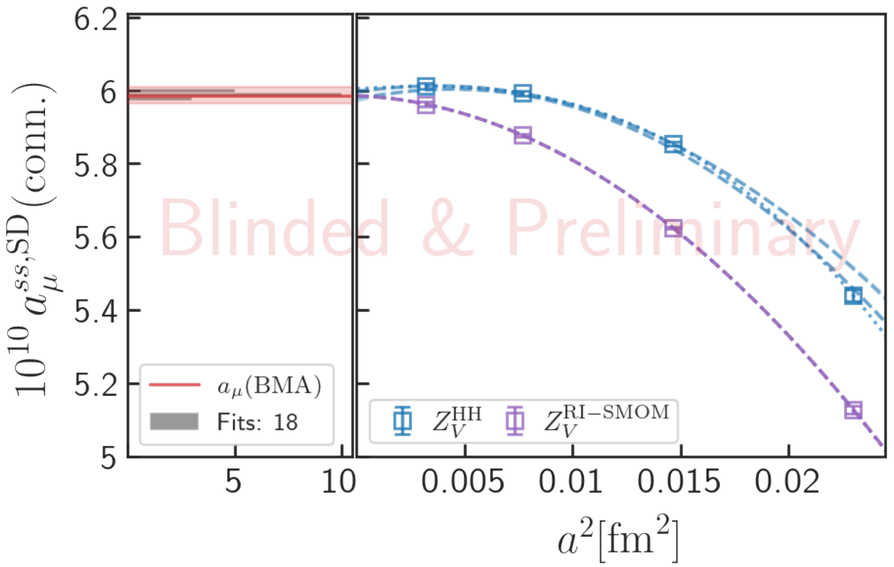


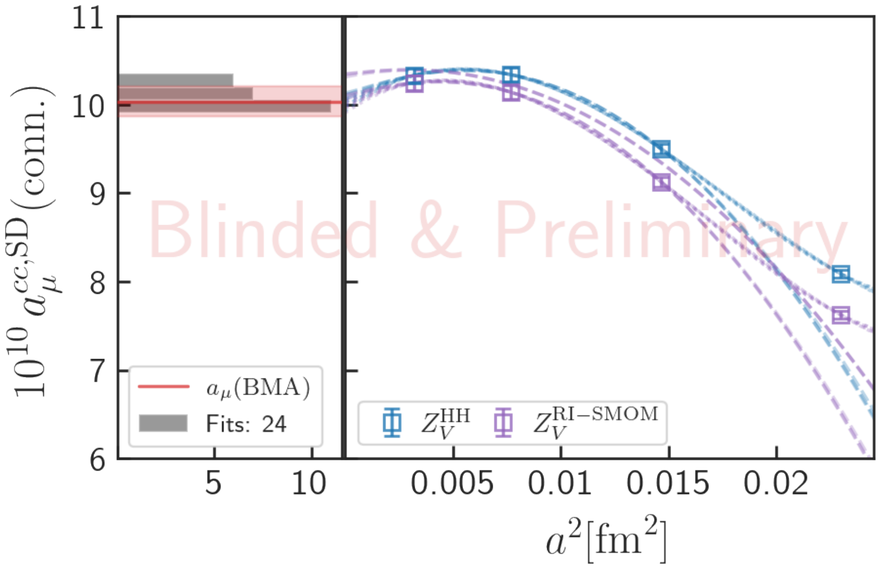
Example of Windows II

- Results for $a \approx 0.06$ fm
- Red curve is SD filter out to 0.4 fm
- Black curve is W filter 0.4 to 1 fm
- In each case width is 0.15 fm
- We add results for strange (blue), and charm (purple) quarks. They are both multiplied by 6 as they are small.
- Strange is mostly within W
- Charm mostly within SD



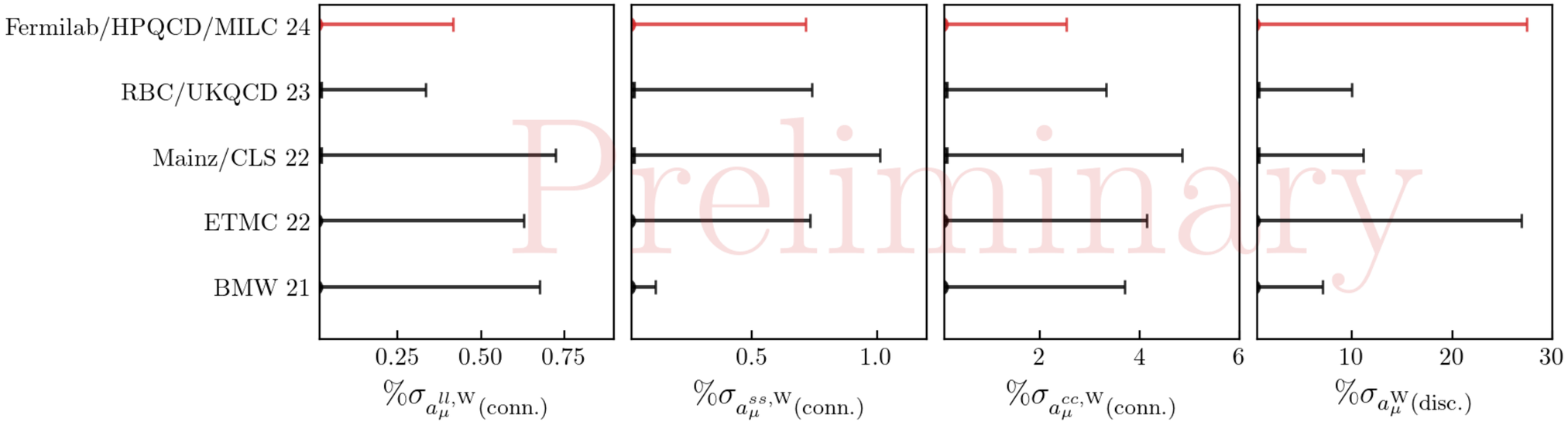
Short Distance Window for Heavier Quarks





- Contribution of strange quark (L) and charm quark (R). Note difference in size.
- Charm contribution to SD somewhat larger than strange.
- The dependence on lattice spacing is notably different than for W where continuum limit is approached from above.

Preliminary Error Comparison from FHM



- We compare our preliminary errors with four other recent calculations for connected contributions in the W window for light, strange, and charm quarks.
- The fourth panel shows the disconnected contribution summed over flavors.
- Note that the highest precision is for the largest contribution, light connected.

Conclusions

- There have been a number of papers published since the first white paper.
  - We are expected to produce three pages for this section
  - Should be try to cover both intermediate and short distance windows?
  - We plan to cover both flavor specific connected contributions, and complete contribution to the window(s).
- Please let us know if we are missing references.
  - We are looking forward to more contributions that can be added to the comparisons.

Additional Slides

Light, Connected Intermediate Contribution

- Similar to left graph on slide 4, but includes result from Fermilab Lattice, HPQCD, and MILC Collaborations.
- Light gray points near bottom have been superseded.
- For the top point, inner error bar is the statistical error.