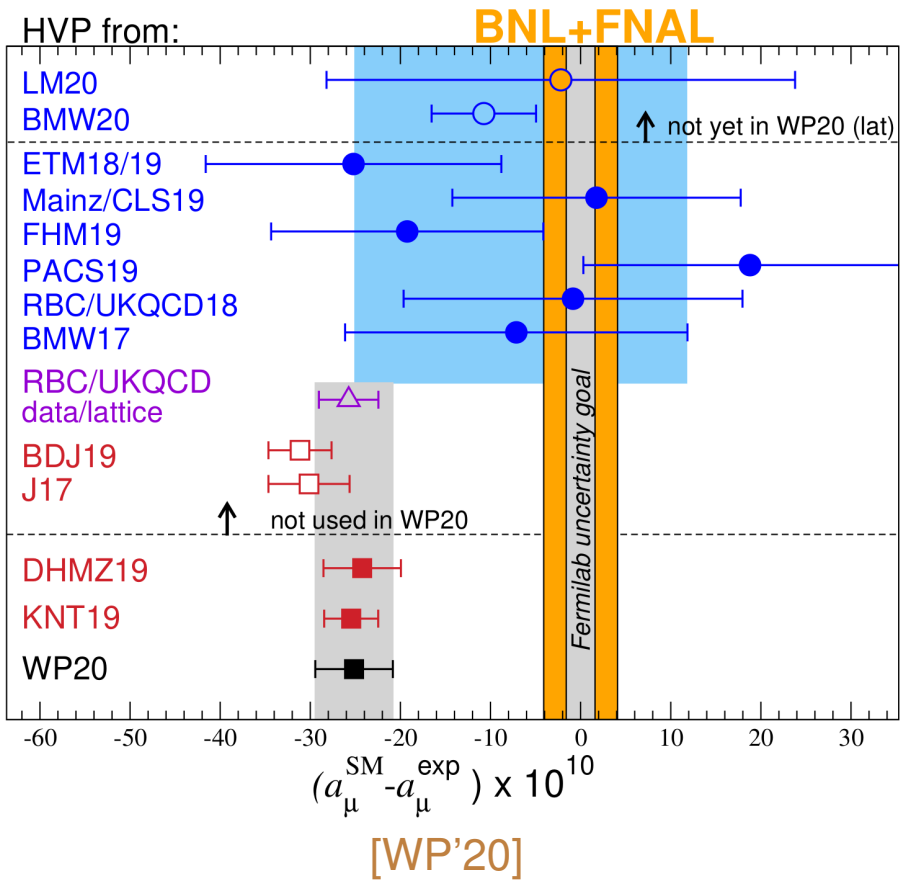
Total HVP: lattice

Laurent Lellouch

CPT Marseille
CNRS & Aix-Marseille U.

Present situation



[WP'20]

- $a_\mu^{\text{LO-HVP}}$ situation unchanged since WP'20: no new result!
- During same period, Fermilab divided uncertainty on a_μ measurement by 2.9!
- Nevertheless much learned (and "unlearned"):
  - 9 lattice calculations agree on intermediate window [Ruth's talk]
  - 3 lattice calculations agree on short-distance window
  - Still missing lattice confirmation of BMWc'20 0.8% computation of total $a_\mu^{\text{LO-HVP}}$ or similarly precise computation of long-distance window
  - Data-driven determination more uncertain since:
    - CMD-3 2023 measurement of $\sigma(e^+e^- \to \pi^+\pi^-)$!
    - limitations of PHOKHARA radiative corrections uncovered [BaBar'23] ...
  - But limitations better understood and implications studied [BaBar'23, Davier et al '23]

Main points in section at present

- Original WP averaged results published before March 2020
- Average done flavor by flavor w/ added common FV, SIB and QED corrections
  $\rightarrow$ broad agreement among collaborations
- Total final uncertainty was 2.6% dominated by: FV, stats and $a \rightarrow 0$
  $\rightarrow$ consistent w/ data-driven, BNL and now Fermilab
- Situation changed w/ BMWc'20's 0.8% determination of $a_\mu^{\text{LO-HVP}}$:
  - Competitive w/ 0.6% WP'20 data-driven determination whose uncertainty is underestimated due to possibly underestimated systematics in some $\sigma(e^+e^- \rightarrow \pi^+\pi^-)$ measurements
  - WP'20 vs BNL'06 is $3.6\sigma \rightarrow 1.6\sigma$ w/ BMWc'20
  - vs BNL'06 + FNAL'21, $4.2\sigma \rightarrow 1.5\sigma$ w/ BMWc'20
  - vs BNL'06 + FNAL'21 & '23, $5.1\sigma \rightarrow 1.7\sigma$ w/ BMWc'20
- Also not included in lattice WA of WP'20: LM'20 & ABGP'22 which agree w/ BMWc'20 but w/ larger uncertainties

Main points in section at present

- BMWc'20's 0.6% precision intermediate window displays 3.8σ discrepancy w/ DHMZ 0.6% precision result [BMWc-DMHZ'23]

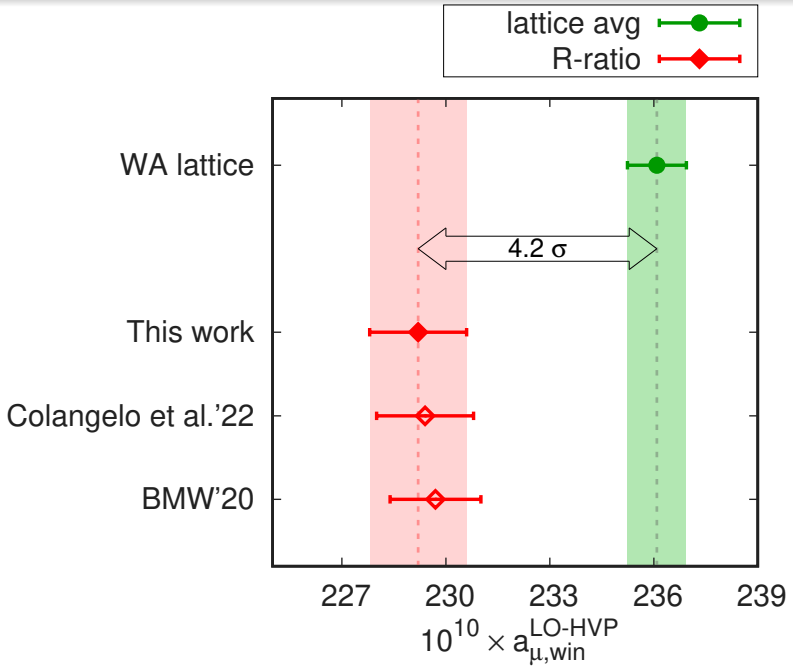
  → confirmed w/ comparable precision:

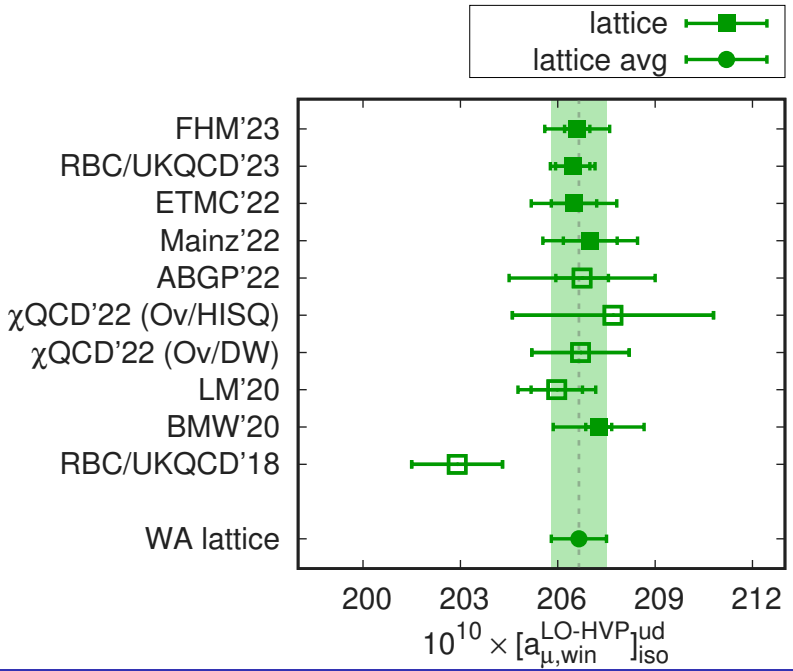
  - Total, by 3 groups [Mainz'22, ETM'22, RBC/UKQCD'23], including SIB and QED effects [Mainz'22, RBC/UKQCD'23]
  - Light connected in 5 further computations [LM'20, χQCD'22, ABGP'22, FHM'23]

  → see Ruth's talk

- Hopefully *new lattice results* for $a_\mu^{\text{LO-HVP}}$!

  → comparisons among them and w/ older ones





Obtaining a WA lattice result for $a_\mu^{\text{LO-HVP}}$

- Catastrophic scenario: no new results $\rightarrow$ lattice WA $a_\mu^{\text{LO-HVP}}$ = BMWc'20 result?
- Expected scenario: new results for total $a_\mu^{\text{LO-HVP}}$ or all 3 windows

  $\rightarrow$ study individual contribs/windows, correlations, QED schemes, ...

A. All agree w/ p-value ≥ 0.05 ↙ ↘ B. Some disagree w/ p-value < 0.05

1. Avg available total $a_\mu^{\text{LO-HVP}}$ results
   - $\rightarrow$ w/ correlations à la FLAG
   - $\rightarrow$ individual contribs/windows in each calculation already combined consistently
   - $\rightarrow$ eliminates issues w/ correlations among contribs/windows and QED scheme used in each calculation
2. Do same as B

- Take most precise avg as lattice WA

- FLAG avg contribs/windows which agree among all calculations (e.g. $a_{\mu,\text{win}}^{\text{LO-HVP}}$)
- Combine other contribs/windows, w/ appropriately enlarged systematics
- Combine all avg/combinations into a total $a_\mu^{\text{LO-HVP}}$
  - $\rightarrow$ account for correlations among contribs/windows and for QED schemes w/in and among given calculations
- Much more work than A.1, but can use results from other lattice HVP sections (e.g. those on different windows)

Final words

- Challenging to make progress w/out knowing if new results will be available
- Only results accepted for publication will be included (cf. 23/04/2024 plenary)
- Will need time to make appropriate combinations

  → very helpful to get a heads up asap
- Close collaboration necessary w/ authors of other lattice HVP sections: "Intermediate window", "Isospin symmetric HVP", "Isospin breaking corrections", "Methodology", "SD window"?, "LD window"?
- Important that all groups account for stat and syst error correlations between all of their contribs/windows when combining them
- Credibility of lattice on the line

  → important to provide a competitive result for $a_\mu^{\text{LO-HVP}}$ in time for Fermilab's final measurement of a_μ
- Comments, suggestions, questions are welcome