FLAG phase 2: status and prospects

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(on behalf of FLAG)

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Outline

Introduction: some history

FLAG-2

Current status of the review

Conclusions

Many thanks to all FLAG colleagues,
in particular to Andreas Jüttner and Urs Wenger

Lattice and precision physics

- search for new physics through precision studies more important than ever
  → talks by J. Serrano and C. Tarantino
- main hurdle on the theory side: hadronic effects
  examples: $(g-2)_\mu$, ϵ_K, ϵ'/ϵ, ΔA_{CP}, ...
  → T. Blum's talk
  more examples: talks by J. Serrano and C. Tarantino
- theoretical tools:
  lattice, sum rules, χPT, dispersion relations
- progress is sometimes slow and reaching the necessary accuracy may take several years
- pressure to provide an answer now! can be very high

Lattice and precision physics

- digging into the lattice literature not easy for non-experts (ask the next-door lattice colleague?)
- this kind of situation occurred already in other fields
- solution: compilation of results ready-to-use for non-experts
- examples: PDG, HFAG, etc.
- recently two initiatives inside the lattice community: FLAG and Laiho-Lunghi-Van de Water
  $\Rightarrow$ now: FLAG-2

What/Who is FLAG-1?

FLAG = FLAVIAnet Lattice Averaging Group

Members:

Gilberto Colangelo (Bern)
Stephan Dürr (Jülich, BMW)
Andreas Jüttner (Southampton, RBC/UKQCD)
Laurent Lellouch (Marseille, BMW)
Heiri Leutwyler (Bern)
Vittorio Lubicz (Rome 3, ETM)
Silvia Necco (CERN, Alpha)
Chris Sachrajda (Southampton, RBC/UKQCD)
Silvano Simula (Rome 3, ETM)
Tassos Vladikas (Rome 2, Alpha and ETM)
Urs Wenger (Bern, ETM)
Hartmut Wittig (Mainz, Alpha)

What/Who is FLAG-1?

FLAG = FLAVIAnet Lattice Averaging Group

History and status:

- Beginning: FLAVIAnet meeting, Orsay, November 2007
- Start of the actual work: Bern, March 2008
- ...
- first paper appeared in November 2010 arXiv.1011.4408
  updated and published in May 2011 on EPJC
- webpage made public in 2011:
  `http://itpwiki.unibe.ch/flag`

What exactly did FLAG-1 offer?

An answer to the questions

- what is the current lattice value for quantity X?
- what is a reliable estimate of the uncertainty?

in a way easily accessible to non-experts

Quantities considered in the first edition:

- light quark masses
- LEC
- decay constants (of pions and kaons)
- form factors (of pions and kaons)
- B_K

What exactly did FLAG-1 offer?

For each quantity we provided:

- complete list of references
- summary of relevant formulae and notation
- summary of the essential aspects of each calculation:
  - lattice action
  - number of dynamical quarks (N_f)
  - minimal value and range of quark masses
  - minimal value and range of lattice spacing
  - maximal value and range of lattice volumes
  - renormalization method (where applicable)

  in a unified and easy to read (color coding) manner
- averages (if sensible)
- and a “lattice dictionary” for non-experts
  (details of lattice actions, etc.)

What exactly did FLAG-1 offer?

We also offered some original contributions:

- thorough discussion and parametrization of electromagnetic contributions to meson masses
  (and their role in the determination of quark masses)
- some new χPT two-loop formulae
  (either completely new or written in a user-friendly way)
- a thorough consistency test of lattice calculations of $f_+(0)$ and f_K/f_π assuming unitarity of the CKM matrix

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and begged readers to always quote the original references too

Color coding – FLAG-1 definition

[subject to change before each new edition]

- chiral extrapolation
  - ★ $M_{\pi,\mathrm{min}} < 250$ MeV
  - ● $250 \text{ MeV} \leq M_{\pi,\mathrm{min}} \leq 400$ MeV
  - ■ $M_{\pi,\mathrm{min}} > 400$ MeV

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  - ■ $M_{\pi,\mathrm{min}} > 400$ MeV
- continuum extrapolation
  - ★ 3 or more lattice spacings, at least 2 points below 0.1 fm
  - ● 2 or more lattice spacings, at least 1 point below 0.1 fm
  - ■ otherwise

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  - ● 2 or more lattice spacings, at least 1 point below 0.1 fm
  - ■ otherwise
- finite volume effects
  - ★ $(M_\pi L)_{\mathrm{min}} > 4$ or at least 3 volumes
  - ● $(M_\pi L)_{\mathrm{min}} > 3$ and at least 2 volumes
  - ■ otherwise

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- finite volume effects
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  - ● $(M_\pi L)_{\mathrm{min}} > 3$ and at least 2 volumes
  - ■ otherwise
- renormalization (where applicable)
  - ★ non-perturbative
  - ● 2-loop perturbation theory (well behaved series)
  - ■ otherwise

Averages

Different lattice results were averaged *if*

- published
  [lattice proceedings not enough]
- no red tags
- same N_f
  [no average of $N_f = 2$ and $N_f = 3$ calculations]

Final FLAG number:

- average or single *no-red-tag* $N_f = 3$ number (if available)
- average or single *no-red-tag* $N_f = 2$ number (if available)

If *both* $N_f = 3$ *and* $N_f = 2$ numbers available:

agreement $\Rightarrow$ more confidence in the final number

Similar initiative: Laiho, Lunghi and Van de Water

- began in 2009 to provide lattice-QCD inputs for the CKM unitarity-triangle analysis and other flavor-physics phenomenology LLVdW, Phys.Rev. D81 (2010) 034503
- main differences wrt FLAG-1:
  - only include $N_f = 2 + 1$ flavor results
  - no strict publication-only rule provided complete and reasonable systematic error budgets
  - heavy-quark quantities included from the start
  - unitarity triangle fits with lattice input
  - whenever a source of error is at all correlated between two lattice calculations (e.g. use the same gauge configurations, same theoretical tools, or experimental inputs), conservatively assume that the degree-of-correlation is 100%
- web page (`www.latticeaverages.org`) also popular

FLAG-2

FLAG = Flavour Lattice Averaging Group
has now entered its phase 2 and has been extended in various directions

- quantities to be reviewed
  main extension: light quarks $\rightarrow$ + heavy quarks
- represented lattice collaborations:
  Alpha, BMW, ETMC, RBC/UKQCD $\rightarrow$ + CLS, Fermilab, HPQCD, JLQCD, MILC, PACS-CS, SWME
- represented world regions: Europe $\rightarrow$ + Japan and US
- number of people: 12 $\rightarrow$ 28

FLAG-2 organization

- Advisory Board:
  S. Aoki, C. Bernard, C. Sachrajda
- Editorial Board:
  GC, H. Leutwyler, T. Vladikas, U. Wenger
- Working Groups
  - Quark masses — L. Lellouch, T. Blum, V. Lubicz
  - V_{us}, V_{ud} — A. Jüttner, T. Kaneko, S. Simula
  - LEC — S. Dürr, H. Fukaya, S. Necco
  - B_K — H. Wittig, J. Laiho, S. Sharpe
  - α_s — R. Sommer, T. Onogi, J. Shigemitsu
  - f_B, B_B — A. El Khadra, Y. Aoki, M. Della Morte
  - $B \to H\ell\nu$ — R. Van de Water, E. Lunghi, C. Pena

FLAG-2 plans and rules

- next review: end 2012
- regularly update the webpage
- new published review: every 2nd year

- some internal FLAG rules
  - members of the advisory board have a 4-year mandate
  - AB = EU+J+US
  - regular members can stay longer
  - replacements must keep/improve the balance of FLAG
  - WG members belong to 3 different lattice coll.
  - a paper is not reviewed (color-coded) by an author

FLAG-2 status

- kick-off meeting: Les Houches, May 7-11 2012
- work on the update of the review is in progress
- WG for the new sections are working on defining their own quality criteria
- first draft (internal) of the new review: September 2012
- publication of the new review: early 2013
- it will cover all results published until December 31 2012

FLAG-2 status

Two important policy changes wrt FLAG-1

- use of one-loop renormalization will not necessarily mean a red tag
- error calculation for the averages:
  LLVdW procedure will be adopted as default
  (final error may be stretched if not convincingly conservative)

One less important cosmetic change:

- ● $\rightarrow$ ○

Quark masses

Collaboration	publ.	$m_{ud} \to 0$	$a \to 0$	FV	renorm.	m_{ud}	m_s
PACS-CS 12	P	★	■	■	★	3.12(24)(8)	83.60(0.58)(2.23)
RBC/UKQCD 12	C	★	○	★	★	3.39(9)(4)(2)(7)	94.2(1.9)(1.0)(0.4)(2.1)
LVdW 11	C	○	★	★	○	3.31(7)(20)(17)	94.2(1.4)(3.2)(4.7)
PACS-CS 10	A	★	■	■	★	2.78(27)	86.7(2.3)
MILC 10A	C	○	★	★	○	3.19(4)(5)(16)	–
HPQCD 10	A	○	★	★	★	3.39(6)	92.2(1.3)
BMW 10A, 10B^{+}	A	★	★	★	★	3.469(47)(48)	95.5(1.1)(1.5)
RBC/UKQCD 10A	A	○	○	★	★	3.59(13)(14)(8)	96.2(1.6)(0.2)(2.1)
Blum 10	A	○	■	○	★	3.44(12)(22)	97.6(2.9)(5.5)
PACS-CS 09	A	★	■	■	★	2.97(28)(3)	92.75(58)(95)
HPQCD 09	A	○	★	★	★	3.40(7)	92.4(1.5)
MILC 09A	C	○	★	★	○	3.25 (1)(7)(16)(0)	89.0(0.2)(1.6)(4.5)(0.1)
MILC 09	A	○	★	★	○	3.2(0)(1)(2)(0)	88(0)(3)(4)(0)
PACS-CS 08	A	★	■	■	■	2.527(47)	72.72(78)
RBC/UKQCD 08	A	○	■	★	★	3.72(16)(33)(18)	107.3(4.4)(9.7)(4.9)
CP-PACS/ JLQCD 07	A	■	★	★	■	$3.55(19)(^{+56}_{-20})$	$90.1(4.3)(^{+16.7}_{-4.3})$
HPQCD 05	A	○	○	○	○	3.2(0)(2)(2)(0)	87(0)(4)(4)(0)
MILC 04, HPQCD/ MILC/UKQCD 04	A	○	○	○	■	2.8(0)(1)(3)(0)	76(0)(3)(7)(0)

$N_f = 2 + 1$

Quark masses

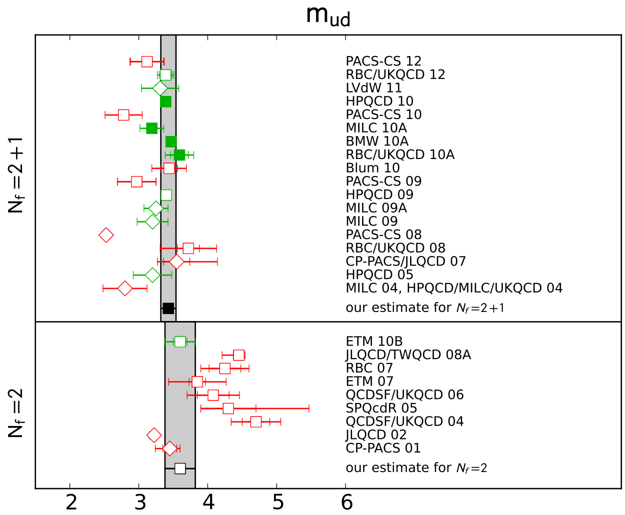
Collaboration	publ.	$m_{ud} \to 0$	$a \to 0$	FV	renorm.	m_{ud}	m_s
ALPHA 12	P	○	★	★	★	–	102(3)(1)
ETM 10B	A	○	★	○	★	3.6(1)(2)	95(2)(6)
JLQCD/TWQCD 08A	A	○	■	■	★	$4.452(81)(38)\left(^{+0}_{-227}\right)$	–
RBC 07†	A	■	■	★	★	4.25(23)(26)	119.5(5.6)(7.4)
ETM 07	A	○	■	○	★	3.85(12)(40)	105(3)(9)
QCDSF/ UKQCD 06	A	■	★	■	★	4.08(23)(19)(23)	111(6)(4)(6)
SPQcdR 05	A	■	○	○	★	$4.3(4)(^{+1.1}_{-0.0})$	$101(8)(^{+25}_{-0})$
ALPHA 05	A	■	○	★	★	–	97(4)(18)
QCDSF/ UKQCD 04	A	■	★	■	★	4.7(2)(3)	119(5)(8)
JLQCD 02	A	■	■	○	■	$3.223(^{+46}_{-69})$	$84.5(^{+12.0}_{-1.7})$
CP-PACS 01	A	■	■	★	■	$3.45(10)(^{+11}_{-18})$	$89(2)(^{+2}_{-6})^{\star}$

$N_f = 2$

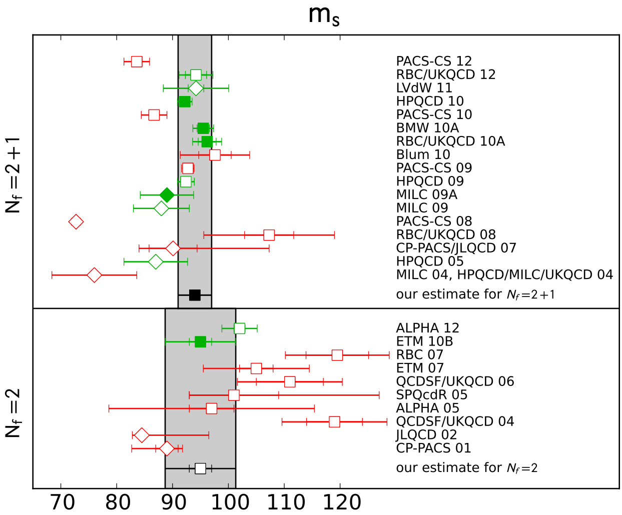
Quark masses

Collaboration	N_f	publ.	$m_{ud} \to 0$	$a \to 0$	FV	m_s/m_{ud}
PACS-CS 12	2+1	P	★	■	■	26.8(2.0)
LVdW 11	2+1	C	○	★	★	28.4(0.5)(1.3)
BMW 10A, 10B	2+1	A	★	★	★	27.53(20)(8)
RBC/UKQCD 10A	2+1	A	○	○	★	26.8(0.8)(1.1)
Blum 10	2+1	A	○	■	○	28.31(0.29)(1.77)
PACS-CS 09	2+1	A	★	■	■	31.2(2.7)
MILC 09A	2+1	C	○	★	★	27.41(5)(22)(0)(4)
MILC 09	2+1	A	○	★	★	27.2(1)(3)(0)(0)
PACS-CS 08	2+1	A	★	■	■	28.8(4)
RBC/UKQCD 08	2+1	A	○	■	★	28.8(0.4)(1.6)
MILC 04, HPQCD/ MILC/UKQCD 04	2+1	A	○	○	○	27.4(1)(4)(0)(1)
ETM 10B	2	A	○	★	○	27.3(5)(7)
RBC 07	2	A	■	■	★	28.10(38)
ETM 07	2	A	○	■	○	27.3(0.3)(1.2)
QCDSF/UKQCD 06	2	A	■	★	■	27.2(3.2)

Quark masses



Quark masses



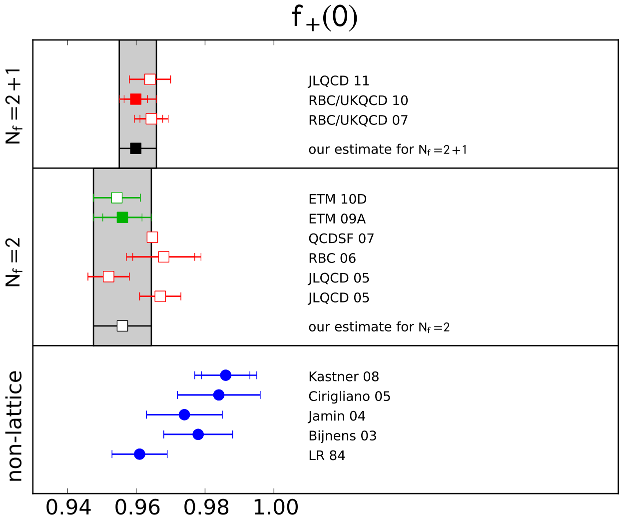
V_{us} and V_{ud} – tables

Collaboration	N_f	publ.	$m_{ud} \to 0$	$a \to 0$	FV	$f_+(0)$
JLQCD 11	2+1	C	○	■	★	0.964(6)
RBC/UKQCD 10	2+1	A	○	■	★	$0.9599(34)(^{+31}_{-47})(14)$
RBC/UKQCD 07	2+1	A	○	■	★	0.9644(33)(34)(14)
ETM 10D	2	C	○	★	○	$0.9544(68)_{stat}$
ETM 09A	2	A	○	○	○	0.9560(57)(62)
QCDSF 07	2	C	■	■	★	$0.9647(15)_{stat}$
RBC 06	2	A	■	■	★	0.968(9)(6)
JLQCD 05	2	C	■	■	★	0.967(6), 0.952(6)

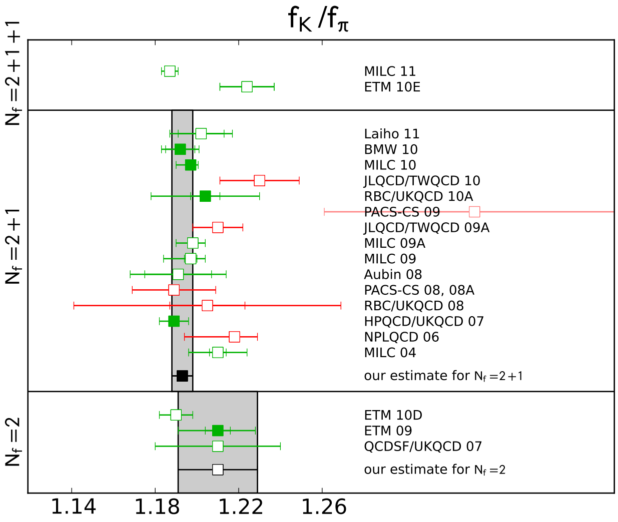
V_{us} and V_{ud} – tables

Collaboration	N_f	publ.	$m_{ud} \to 0$	$a \to 0$	FV	f_K/f_π
ETM 10E	2+1+1	C	○	○	○	$1.224(13)_{\rm stat}$
MILC 11	2+1+1	C	○	○	○	$1.1872(42)^{\dagger}_{\rm stat}$.
Laiho 11	2+1	C	○	○	○	$1.202(11)_{\rm stat}(9)_{\chi\rm PT}(2)_{\rm scale}(5)_{m_q}$ ††
MILC 10	2+1	C	○	★	★	$1.197(2)(^{+3}_{-7})$
JLQCD/TWQCD 10	2+1	C	○	■	★	1.230(19)
RBC/UKQCD 10A	2+1	A	○	○	★	1.204(7)(25)
PACS-CS 09	2+1	A	★	■	■	1.333(72)
BMW 10	2+1	A	★	★	★	1.192(7)(6)
JLQCD/TWQCD 09A	2+1	C	○	■	■	$1.210(12)_{\rm stat}$
MILC 09A	2+1	C	○	★	★	$1.198(2)(^{+6}_{-8})$
MILC 09	2+1	A	○	★	★	$1.197(3)(^{+6}_{-13})$
Aubin 08	2+1	C	○	○	○	1.191(16)(17)
PACS-CS 08,	2+1	A	★	■	■	1.189(20)
RBC/UKQCD 08	2+1	A	○	■	★	1.205(18)(62)
HPQCD/UKQCD 07	2+1	A	○	★	○	1.189(2)(7)
NPLQCD 06	2+1	A	○	■	■	$1.218(2)(^{+11}_{-24})$
MILC 04	2+1	A	○	○	○	1.210(4)(13)
ETM 10D	2	C	○	★	○	$1.190(8)_{stat}$
ETM 09	2	A	○	★	○	1.210(6)(15)(9)
QCDSF/UKQCD 07	2	C	○	○	★	1.21(3)

V_{us} and V_{ud} – figures



V_{us} and V_{ud} – figures



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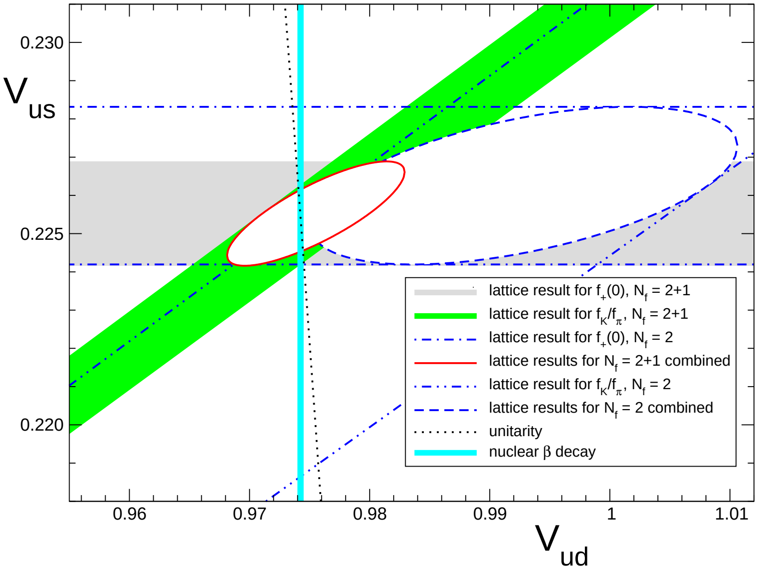


Analysis assuming CKM unitarity

Unitarity + experiment:

$$|V_{ud}|^2+|V_{us}|^2+|V_{ub}|^2=1$$

$\left[|V_{ub}|=3.89(44)\cdot 10^{-3}, \text{PDG (10)}\right]$

Experiment: FLAVIAnet Kaon WG (10)

$$\begin{aligned} |V_{us}f_+(0)| &= 0.2163(5) \\ \left|\frac{V_{us}f_K}{V_{ud}f_\pi}\right| &= 0.2758(5) \end{aligned}$$

3 relations and 4 unknowns

determine anyone of V_{ud}, V_{us}, $f_+(0)$ or f_K/f_π

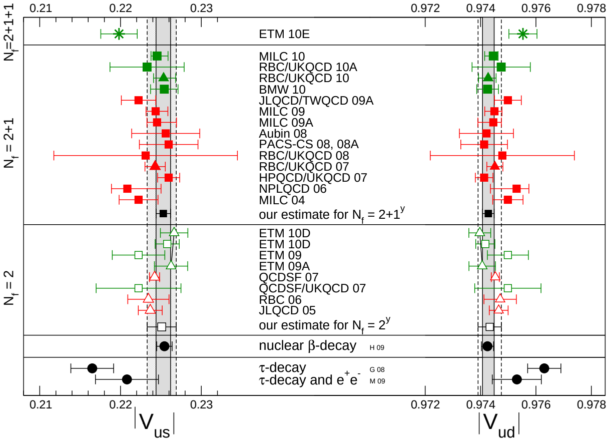
$\Rightarrow$ get the other three

Analysis assuming CKM unitarity

	$\|V_{us}\|$	$\|V_{ud}\|$	$f_+(0)$	f_K/f_π
$N_f = 2+1$	0.2253(9)	0.97428(21)	0.9599(38)	1.1927(50)
$N_f = 2$	0.2251(18)	0.97433(42)	0.9604(75)	1.194(10)
β-dec.[1]	0.22544(95)	0.97425(22)	0.9595(46)	1.1919(57)
τ-dec.[2]	0.2165(26)	0.9763(6)	0.999(12)	1.244(16)
τ-dec.[3]	0.2208(39)	0.9753(9)	0.980(18)	1.218(23)

[1] Hardy & Towner
[2] Gamiz et al.
[3] Maltman

Analysis assuming CKM unitarity



Assuming unitarity lattice predicts $|V_{ud}|$ with the same precision as super-allowed Fermi β-decays

LEC: Σ

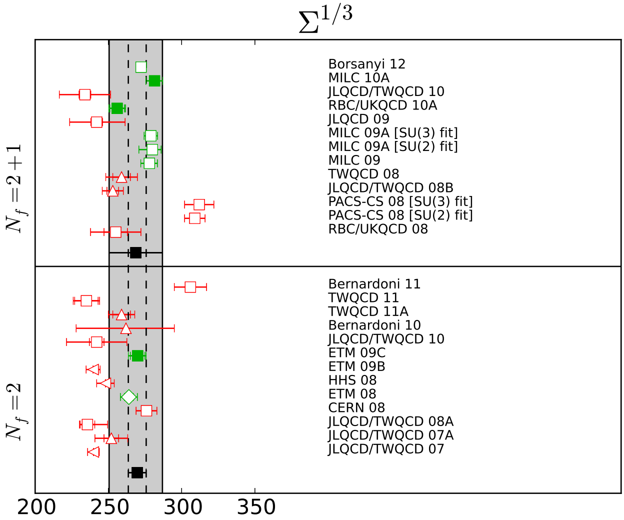
Collaboration	N_f	publ.	$m_{ud} \to 0$	$a \to 0$	FV	renormal.	$\Sigma^{1/3}$ [MeV]
Borsanyi 12	2+1	P	★	★	○	★	272.3(1.2)(1.4)
MILC 10A	2+1	C	○	★	★	○	$281.5(3.4)\left(^{+2.0}_{-5.9}\right)(4.0)$
JLQCD/TWQCD 10	2+1	A	★	■	○	★	234(4)(17)
RBC/UKQCD 10A	2+1	A	○	○	★	★	256(5)(2)(2)
JLQCD 09	2+1	A	★	■	○	★	$242(4)\left(^{+19}_{-18}\right)$
MILC 09A	2+1	C	○	★	★	○	279(1)(2)(4)
MILC 09A	2+1	C	○	★	★	○	$280(2)\left(^{+4}_{-8}\right)(4)$
MILC 09	2+1	A	○	★	★	○	$278(1)\left(^{+2}_{-3}\right)(5)$
TWQCD 08	2+1	A	○	■	■	★	259(6)(9)
JLQCD/TWQCD 08B	2+1	C	○	■	■	★	253(4)(6)
PACS-CS 08	2+1	A	★	■	■	■	312(10)
PACS-CS 08	2+1	A	★	■	■	■	309(7)
RBC/UKQCD 08	2+1	A	○	■	★	★	255(8)(8)(13)

LEC: Σ

Collaboration	N_f	publ.	$m_{ud} \to 0$	$a \to 0$	FV	renormal.	$\Sigma^{1/3}$ [MeV]
Bernardoni 11	2	C	○	■	■	○	306(11)
TWQCD 11	2	P	★	■	■	★	235(8)(4)
TWQCD 11A	2	A	★	■	■	★	259(6)(7)
Bernardoni 10	2	A	○	■	■	★	$262\binom{+33}{-34}\binom{+4}{-5}$
JLQCD/TWQCD 10	2	A	★	■	■	★	242(5)(20)
ETM 09C	2	A	○	★	○	★	$270(5)\binom{+3}{-4}$
ETM 08	2	A	○	○	○	★	264(3)(5)
CERN 08	2	A	○	■	○	★	276(3)(4)(5)
JLQCD/TWQCD 08A	2	A	○	■	■	★	$235.7(5.0)(2.0)\binom{+12.7}{-0.0}$
JLQCD/TWQCD 07A	2	A	○	■	■	★	252(5)(10)
ETM 09B	2	C	★	○	■	★	239.6(4.8)
HHS 08	2	A	★	■	○	★	248(6)
JLQCD/TWQCD 07	2	A	★	■	■	★	239.8(4.0)

upper table: p-regime
lower table: ϵ-regime

LEC: Σ

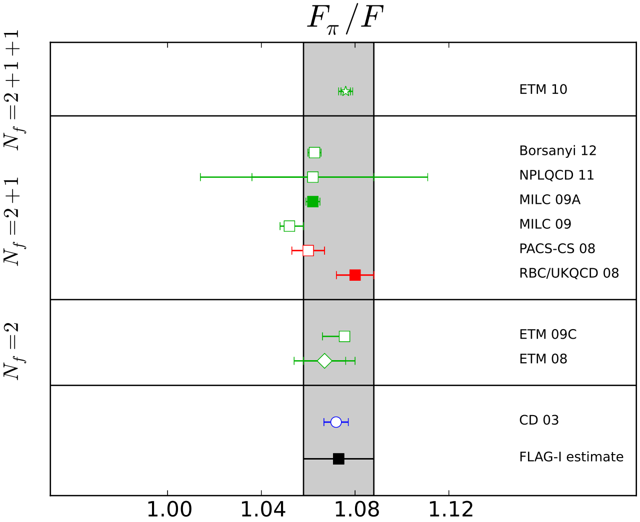


$\Sigma^{1/3}$
$N_f = 2+1$
$N_f = 2$
Borsanyi 12
MILC 10A
JLQCD/TWQCD 10
RBC/UKQCD 10A
JLQCD 09
MILC 09A [SU(3) fit]
MILC 09A [SU(2) fit]
MILC 09
TWQCD 08
JLQCD/TWQCD 08B
PACS-CS 08 [SU(3) fit]
PACS-CS 08 [SU(2) fit]
RBC/UKQCD 08
Bernardoni 11
TWQCD 11
TWQCD 11A
Bernardoni 10
JLQCD/TWQCD 10
ETM 09C
ETM 09B
HHS 08
ETM 08
CERN 08
JLQCD/TWQCD 08A
JLQCD/TWQCD 07A
JLQCD/TWQCD 07
200
250
300
350

LEC: F_π and F

Collaboration	N_f	publ.	$m_{ud} \to 0$	$a \to 0$	FV	renormal.	F [MeV]	F_π / F
ETM 11	2+1+1	C	○	★	○	★	85.60(4)	
ETM 10	2+1+1	A	○	○	○†	★	85.66(6)(13)	1.076(2)(2)
Borsanyi 12	2+1	P	★	★	○	★	86.78(05)(25)	1.0627(06)(27)
NPLQCD 11	2+1	P	★	○	★			$1.062(26)(^{+42}_{-40})$
MILC 10A	2+1	C	○	★	★	○	$87.5(1.0)(^{+0.7}_{-2.6})$	*1.05(1)*
MILC 10	2+1	C	○	★	★	○	87.0(4)(5)	*1.06(5)*
MILC 09A	2+1	C	○	★	★	○	86.8(2)(4)	1.062(1)(3)
MILC 09	2+1	A	○	★	★	○		$1.052(2)(^{+6}_{-3})$
PACS-CS 08	2+1	A	★	■	■	■	89.4(3.3)	1.060(7)
RBC/UKQCD 08	2+1	A	○	■	★	★	81.2(2.9)(5.7)	1.080(8)
Bernardoni 11	2	C	○	■	■	○	79(4)	
TWQCD 11	2	P	★	■	■	★	83.39(35)(38)	
ETM 09C	2	A	○	★	○	★		$1.0755(6)(^{+8}_{-94})$
ETM 08	2	A	○	○	○	★	86.6(7)(7)	1.067(9)(9)
JLQCD/TWQCD 08A	2	A	○	■	■	★	$79.0(2.5)(0.7)(^{+4.2}_{-0.0})$	*1.17(4)*
ETM 09B	2	C	★	○	■	★	90.2(4.8)§	*1.02(5)*
HHS 08	2	A	★	■	○	★	90(4)	*1.02(5)*
JLQCD/TWQCD 07	2	A	★	■	■	★	87.3(5.6)	*1.06(7)*
CD 03							86.2(5)	1.0719(52)

LEC: F_π and F

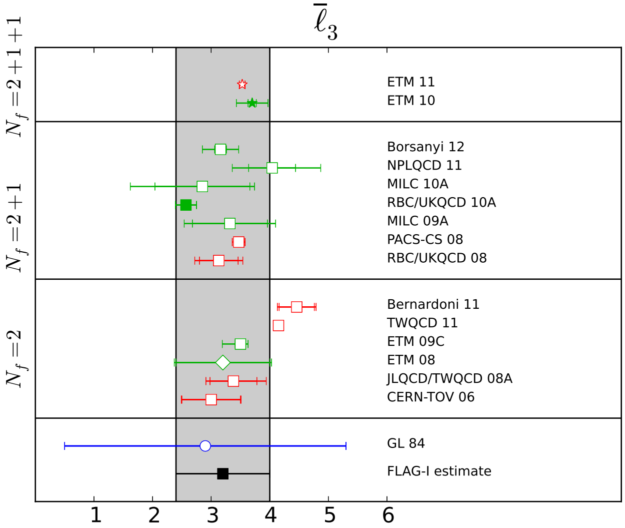


F_π / F
$N_f = 2+1+1$
$N_f = 2+1$
$N_f = 2$
ETM 10
Borsanyi 12
NPLQCD 11
MILC 09A
MILC 09
PACS-CS 08
RBC/UKQCD 08
ETM 09C
ETM 08
CD 03
FLAG-I estimate
1.00
1.04
1.08
1.12

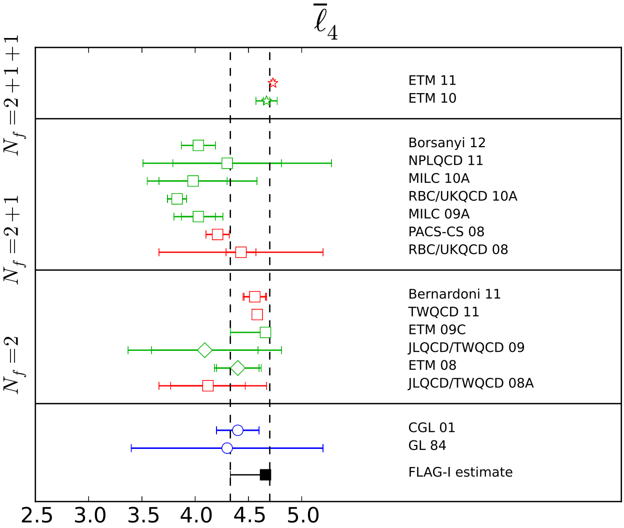
LEC: $\bar{\ell}_3$ and $\bar{\ell}_4$

Collaboration	N_f	publ.	$m_{ud} \to 0$	$a \to 0$	FV	$\bar{\ell}_3$	$\bar{\ell}_4$
ETM 11	2+1+1	C	○	★	○	3.53(5)	4.73(2)
ETM 10	2+1+1	A	○	○	○	3.70(7)(26)	4.67(3)(10)
Borsanyi 12	2+1	P	★	★	○	3.16(10)(29)	4.03(03)(16)
NPLQCD 11	2+1	P	★	○	★	$4.04(40)(^{+73}_{-55})$	$4.30(51)(^{+84}_{-60})$
MILC 10A	2+1	C	○	★	★	$2.85(81)\binom{+37}{-92}$	$3.98(32)\binom{+51}{-28}$
MILC 10	2+1	C	○	★	★	3.18(50)(89)	4.29(21)(82)
RBC/UKQCD 10A	2+1	A	○	○	★	2.57(18)	3.83(9)
MILC 09A	2+1	C	○	★	★	3.32(64)(45)	4.03(16)(17)
MILC 09A	2+1	C	○	★	★	$3.0(6)\binom{+9}{-6}$	3.9(2)(3)
PACS-CS 08	2+1	A	★	■	■	3.47(11)	4.21(11)
PACS-CS 08	2+1	A	★	■	■	3.14(23)	4.04(19)
RBC/UKQCD 08	2+1	A	○	■	★	3.13(33)(24)	4.43(14)(77)
Bernardoni 11	2	C	○	■	■	4.46(30)(14)	4.56(10)(4)
TWQCD 11	2	P	★	■	■	4.149(35)(14)	4.582(17)(20)
ETM 09C	2	A	○	★	○	$3.50(9)\binom{+9}{-30}$	$4.66(4)\binom{+4}{-33}$
JLQCD/TWQCD 09	2	A	○	■	■		4.09(50)(52)
ETM 08	2	A	○	○	○	3.2(8)(2)	4.4(2)(1)
JLQCD/TWQCD 08A	2	A	○	■	■	$3.38(40)(24)\binom{+31}{-0}$	$4.12(35)(30)\binom{+31}{-0}$
CERN-TOV 06	2	A	○	○	■	3.0(5)(1)	

LEC: $\bar{\ell}_3$ and $\bar{\ell}_4$



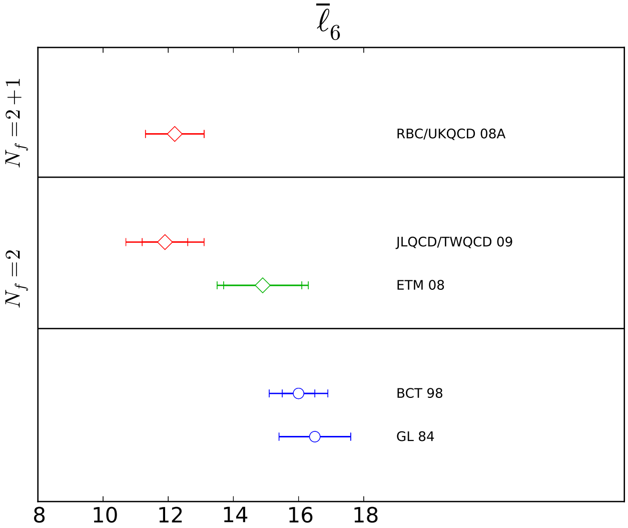
LEC: $\bar{\ell}_3$ and $\bar{\ell}_4$



LEC: $\bar{\ell}_6$

Collaboration	N_f	publ.	$m_{ud} \to 0$	$a \to 0$	FV	$\langle r^2 \rangle^{\pi}_{V}$ [fm^2]	c_V (GeV^{-4})	$\bar{\ell}_6$
RBC/UKQCD 08A	2+1	A	○	■	★	0.418(31)	—	12.2(9)
LHP 04	2+1	A	○	■	○	0.310(46)	—	—
JLQCD/TWQCD 09	2	A	○	■	■	0.409(23)(37)	3.22(17)(36)	11.9(0.7)(1.0)
ETM 08	2	A	○	○	○	0.456(30)(24)	3.37(31)(27)	14.9(1.2)(0.7)
QCDSF/UKQCD 06A	2	A	★	○	○	0.441(19)(56)(29)	—	—
BCT 98						0.437(16)	3.85(60)	16.0(0.5)(0.7)
NA7 86						0.439(8)		
GL 84								16.5(1.1)

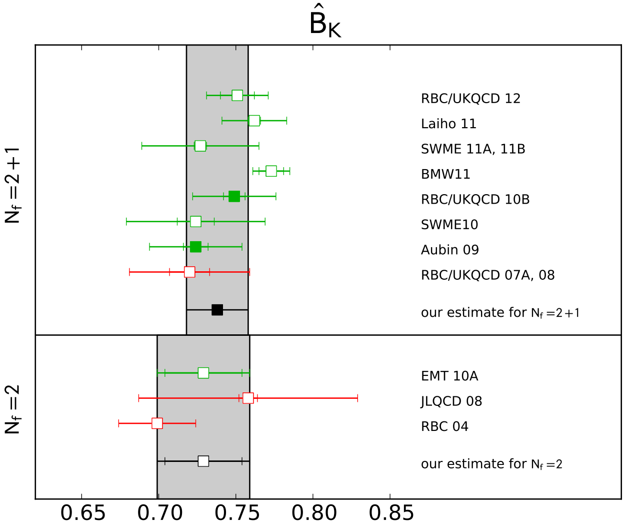
LEC: $\bar{\ell}_6$


$\bar{\ell}_6$
$N_f = 2+1$
$N_f = 2$
RBC/UKQCD 08A
JLQCD/TWQCD 09
ETM 08
BCT 98
GL 84
8
10
12
14
16
18

B_K

Collaboration	N_f	publ.	$a \to 0$	$m_{ud} \to 0$	FV	renorm.	running	B_K	$\hat{B}_K$
RBC/UKQCD 12	2+1	C	○	★	★	★	*a*	0.549(5)(26)	0.751(11)(17)
Laiho 11	2+1	C	★	○	○	★	—	0.5572(28)(150)	0.7655(38)(207)
SWME 11A, 11B	2+1	A	★	○	○	○‡	—	0.531(3)(27)	0.727(4)(38)
BMW 11	2+1	A	★	★	★	★	*b*	0.5644(59)(58)	0.7727(81)(84)
RBC/UKQCD 10B	2+1	A	○	○	★	★	*a*	0.549(5)(26)	0.749(7)(26)
SWME 10	2+1	A	★	○	○	○	—	0.529(9)(32)	0.724(12)(43)
Aubin 09	2+1	A	○	○	○	★	—	0.527(6)(21)	0.724(8)(29)
RBC/UKQCD 07A, 08	2+1	A	■	■	★	★	—	0.524(10)(28)	0.720(13)(37)
HPQCD/UKQCD 06	2+1	A	■	■*	★	■	—	0.618(18)(135)	0.83(18)
ETM 10A	2	A	★	○	○	★	*c*	0.516(18)(12)	0.729(25)(17)
JLQCD 08	2	A	■	○	■	★	—	0.537(4)(40)	0.758(6)(71)
RBC 04	2	A	■	■	■†	★	—	0.495(18)	0.699(25)
UKQCD 04	2	A	■	■	■†	■	—	0.49(13)	0.69(18)

B_K



$\hat{B}_K$
$N_f = 2+1$
RBC/UKQCD 12
Laiho 11
SWME 11A, 11B
BMW11
RBC/UKQCD 10B
SWME10
Aubin 09
RBC/UKQCD 07A, 08
our estimate for $N_f = 2+1$
$N_f = 2$
EMT 10A
JLQCD 08
RBC 04
our estimate for $N_f = 2$
0.65
0.70
0.75
0.80
0.85

New sections

The new quantities considered require different quality criteria
exact definition in progress

- Heavy quarks:
  - finite volume: requirements may be relaxed
  - heavy quark treatment: very important, will be tagged with yes/no
  - weak operator treatment:renormalization, order of improvement and method for matching to the continuum ($\rightarrow$ yes/no)
- α_s:
  - scale where perturbation theory is used and which PT (bare vs. renormalized or lattice vs. continuum)
  - agreement with perturbative running
  - continuum limit for large μ requires requires $a\mu \ll 1$

Conclusions

- it is a responsibility of the lattice community to provide experimentalists and non-lattice theorists with a review of phenomenologically relevant lattice results
- FLAG has now started its phase 2 with a larger group and broader scope
- we hope that this initiative continues to gain momentum and the support of the whole lattice community
- I have reviewed the current status also as far as the physics is concerned:
  - current updates of light-quark related quantities
  - issues in defining quality criteria for heavy quarks and α_s