FlaviA net

The FLAG working group: making lattice results accessible to phenomenologists

Gilberto Colangelo
(on behalf of the FLAG)

b
UNIVERSITÄT
BERN

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Outline

What/Who is FLAG?

FLAG = FLAVIAnet Lattice Averaging Group

FLAVIAnet

European network
on Flavour Physics
Start: 1.10.2006
End: 30.09.2010

"Entering the high-precision era of flavour physics through the alliance of lattice simulations, effective field theories and experiment"

What/Who is FLAG?

FLAG = FLAVIAnet Lattice Averaging Group

Members:

Gilberto Colangelo (Bern)
Stephan Dürr (Jülich, BMW)
Andreas Jüttner (Mainz, 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?

FLAG = FLAVIAnet Lattice Averaging Group

History and status:

- FLAG start: Orsay, November 2007
- Meetings: Bern, March 2008 and April 2009
- draft and webpage are being finalized
- will be made public in summer 2009*

*Statements and numbers in the present talk are *preliminary*

What exactly will FLAG offer?

An answer to the questions

- what is the best 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's
- decay constants
- form factors
- B_K

What exactly will FLAG offer?

For each quantity we provide:

- 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.)

Color coding – our present definition

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

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- 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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- 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
  - ★ $(M_\pi L)_{\mathrm{min}} > 4$ or at least 3 volumes
  - ● $(M_\pi L)_{\mathrm{min}} > 3$ and at least 2 volumes
  - ■ otherwise
- renormalization (where applicable)
  - ★ non-perturbative
  - ● 2-loop perturbation theory (converging series)
  - ■ otherwise

Averages

Different lattice results will be 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

Experiment + unitarity

Unitarity + experiment: PDG (08)

$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 1 \qquad \left[|V_{ub}| = 3.39(36) \cdot 10^{-3}\right]$$

Experiment: FLAVIAnet Kaon WG (08)

$$\begin{aligned} |V_{us} f_+(0)| &= 0.21661(47) \\ \left|\frac{V_{us} f_K}{V_{ud} f_\pi}\right| &= 0.27599(59) \end{aligned}$$

3 relations and 4 unknowns

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

$\Rightarrow$ get the other three

Lattice calculations of $f_+(0)$ and f_K/f_π

$f_+(0)$	N_f		publication status	chiral extrapol.	finite volume	continuum extrapol.	action
0.9644(33)(34)(14)	2+1	RBC/UKQCD 08	A	●	★	■	DWF
0.956(3)(5)	2	ETM 08	C	●	●	●	max. tmQCD
$0.9647(15)_{stat}$	2	QCDSF 07	C	■	★	■	clover (NP)
0.968(9)(6)	2	RBC 06	A	■	★	■	DWF
0.967(6)	2	JLQCD 05	C	■	★	■	clover (NP)

Legenda publication status:

A = published article

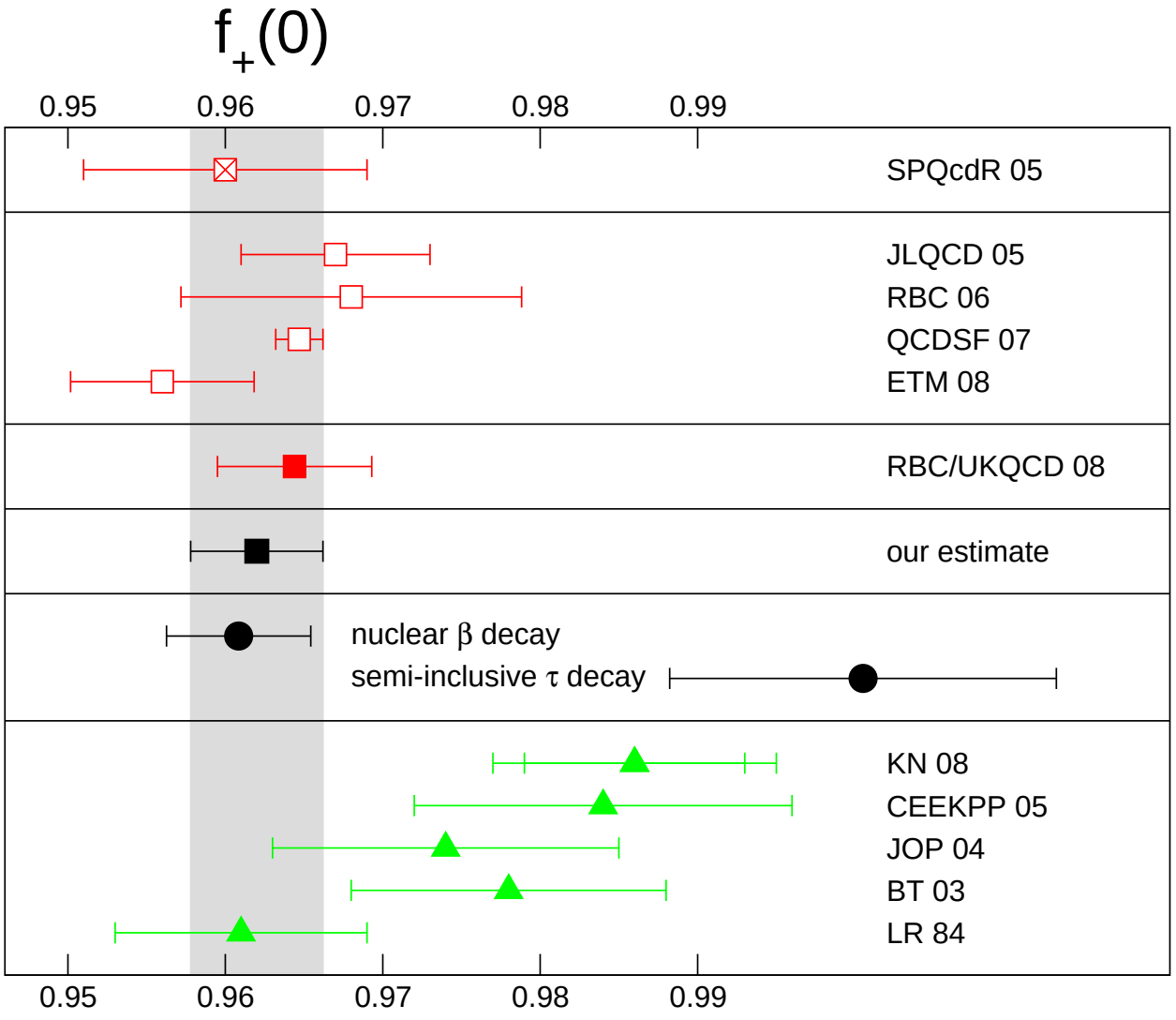
P = preprint

C = conference proceedings

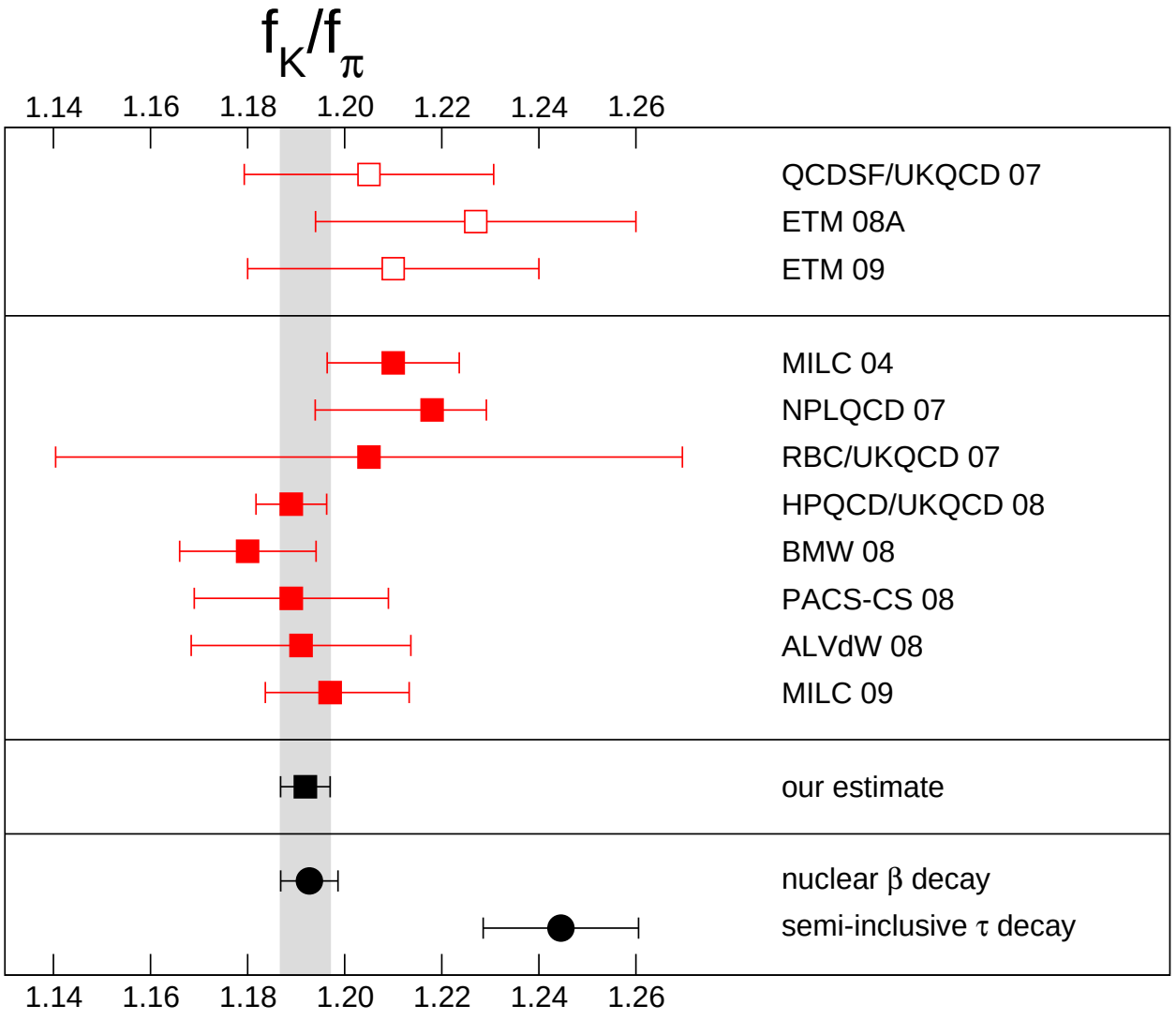
Lattice calculations of $f_+(0)$ and f_K/f_π

f_K/f_π	N_f		publication status	chiral extrapol.	finite volume	continuum extrapol.	action
1.210(6)(15)(9)	2	ETM 09	P	●	●	★	max. tmQCD
$1.197(3)(^{+6}_{-13})$	2+1	MILC 09	A	★	●	★	$\mathrm{KS}^{\mathrm{MILC}}_{\mathrm{MILC}}$
1.191(16)(16)	2+1	AUBIN 08	C	★	■	●	$\mathrm{KS}_{\mathrm{MILC}}/\mathrm{DWF}$
1.189(20)	2+1	PACS-CS 08	P	★	■	■	clover (NP)
1.227(9)(24)	2	ETM 08A	A	●	●	■	max. tmQCD
1.18(1)(1)	2+1	BMW 08	C	★	★	★	impr. Wilson
1.189(2)(7)	2+1	HPQCD/UKQCD 08	A	★	●	★	$\mathrm{KS}^{\mathrm{HISQ}}_{\mathrm{MILC}}$
1.205(18)(62)	2+1	RBC/UKQCD 07	A	●	★	■	DWF
1.21(3)	2	QCDSF/UKQCD 07	C	●	★	●	clover (NP)
$1.218(2)(^{+11}_{-24})$	2+1	NPLQCD 07	A	●	■	■	$\mathrm{KS}_{\mathrm{MILC}}/\mathrm{DWF}$
1.210(4)(13)	2+1	MILC 04	A	★	●	●	$\mathrm{KS}^{\mathrm{MILC}}_{\mathrm{MILC}}$

Lattice


f+(0)
0.95
0.96
0.97
0.98
0.99
SPQcdR 05
JLQCD 05
RBC 06
QCDSF 07
ETM 08
RBC/UKQCD 08
our estimate
nuclear β decay
semi-inclusive τ decay
KN 08
CEEKPP 05
JOP 04
BT 03
LR 84

Lattice


f_K/f_π
1.14
1.16
1.18
1.20
1.22
1.24
1.26
QCDSF/UKQCD 07
ETM 08A
ETM 09
MILC 04
NPLQCD 07
RBC/UKQCD 07
HPQCD/UKQCD 08
BMW 08
PACS-CS 08
ALVdW 08
MILC 09
our estimate
nuclear β decay
semi-inclusive τ decay

Lattice calculations of $f_+(0)$ and f_K/f_π

According to our policy only three results are relevant

$f_+(0)$	$=$	$0.964(3)(4)$	RBC/UKQCD 08
f_K/f_π	$=$	$1.197(3)(^{+6}_{-13})$	MILC 09
f_K/f_π	$=$	$1.189(2)(7)$	HPQCD/UKQCD 08

all three can be translated into a value for V_{us}:

$\lvert V_{us}\rvert$	$=$	$0.2246(9)(9)$	RBC/UKQCD 08
$\lvert V_{us}\rvert$	$=$	$0.2247(7)(^{+23}_{-11})$	MILC 09
$\lvert V_{us}\rvert$	$=$	$0.2261(6)(13)$	HPQCD/UKQCD 08
		— and averaged —	
$\lvert V_{us}\rvert$	$=$	$0.2253(4)(9)$	our average

Lattice calculations of $f_+(0)$ and f_K/f_π

According to our policy only three results are relevant

$f_+(0)$	$=$	$0.964(3)(4)$	RBC/UKQCD 08
f_K/f_π	$=$	$1.197(3)(^{+6}_{-13})$	MILC 09
f_K/f_π	$=$	$1.189(2)(7)$	HPQCD/UKQCD 08

or of any other of the four unknowns

$\lvert V_{ud}\rvert$	$=$	$0.97427(9)(20)$	our average
$f_+(0)$	$=$	$0.9620(20)(37)$	our average
f_K/f_π	$=$	$1.1919(16)(48)$	our average

Other sources of information on V_{ud} and V_{us}

Super-allowed nuclear β decays

$$|V_{ud}| = 0.97425(22)$$ Hardy & Towner 08

$$\Rightarrow |V_{us}| = 0.22544(95) \quad f_+(0) = 0.9608(46) \quad f_K/f_\pi = 1.1927(59)$$

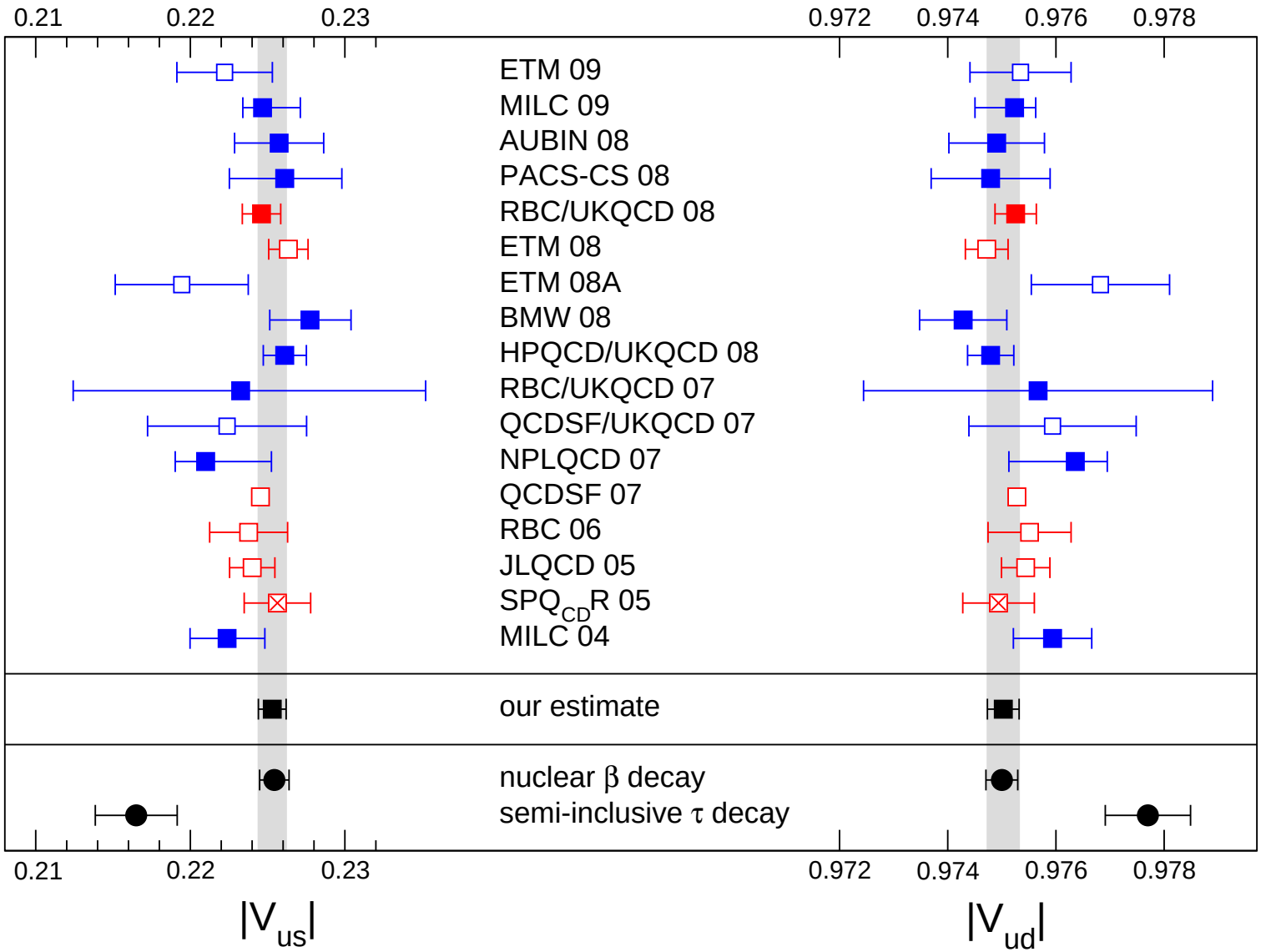
$\tau \to [\text{hadrons}(S=1)] + \nu$ decays

$$|V_{us}| = 0.2165(26)_{\text{exp}}(5)_{\text{th}}$$ Gamiz et al. 07

$$\Rightarrow |V_{ud}| = 0.9763(6) \quad f_+(0) = 1.001(12) \quad f_K/f_\pi = 1.245(16)$$

Problematic data: $\sum$ exclusive channels $\neq$ inclusive

Comparison between lattice and other determinations



$SU(3)$ low-energy constants

Determination based on masses and decay constants

	N_f	publication status	chiral extrapol.	finite volume	continuum extrapol.	renormalization	action
(a) RBC/UKQCD 08	2+1	A	●	★	■	★	DW
(b) PACS-CS 08	2+1	P	★	■	■	■	clover
(c) MILC 09	2+1	P	★ *	★	★	●	KS

*Based on value of lowest pion mass. Average of tastes would be more appropriate, but cannot be reconstructed from the paper.

	F_0[MeV]	$\Sigma_0^{1/3}$[MeV]	F/F_0	B/B_0	Σ/Σ_0	F_π/F
(a)	66.1(5.2)		1.229(59)	1.03(05)	1.55(21)	
(b)	83.8(6.4)	290(15)	1.078(44)	1.089(15)	1.245(10)	1.062(8)
(c)		$242(9)(^{+5}_{-17})(4)$	$1.15(5)(^{+13}_{-3})$		$1.52(17)(^{+38}_{-15})$	$1.052(2)(^{+6}_{-3})$

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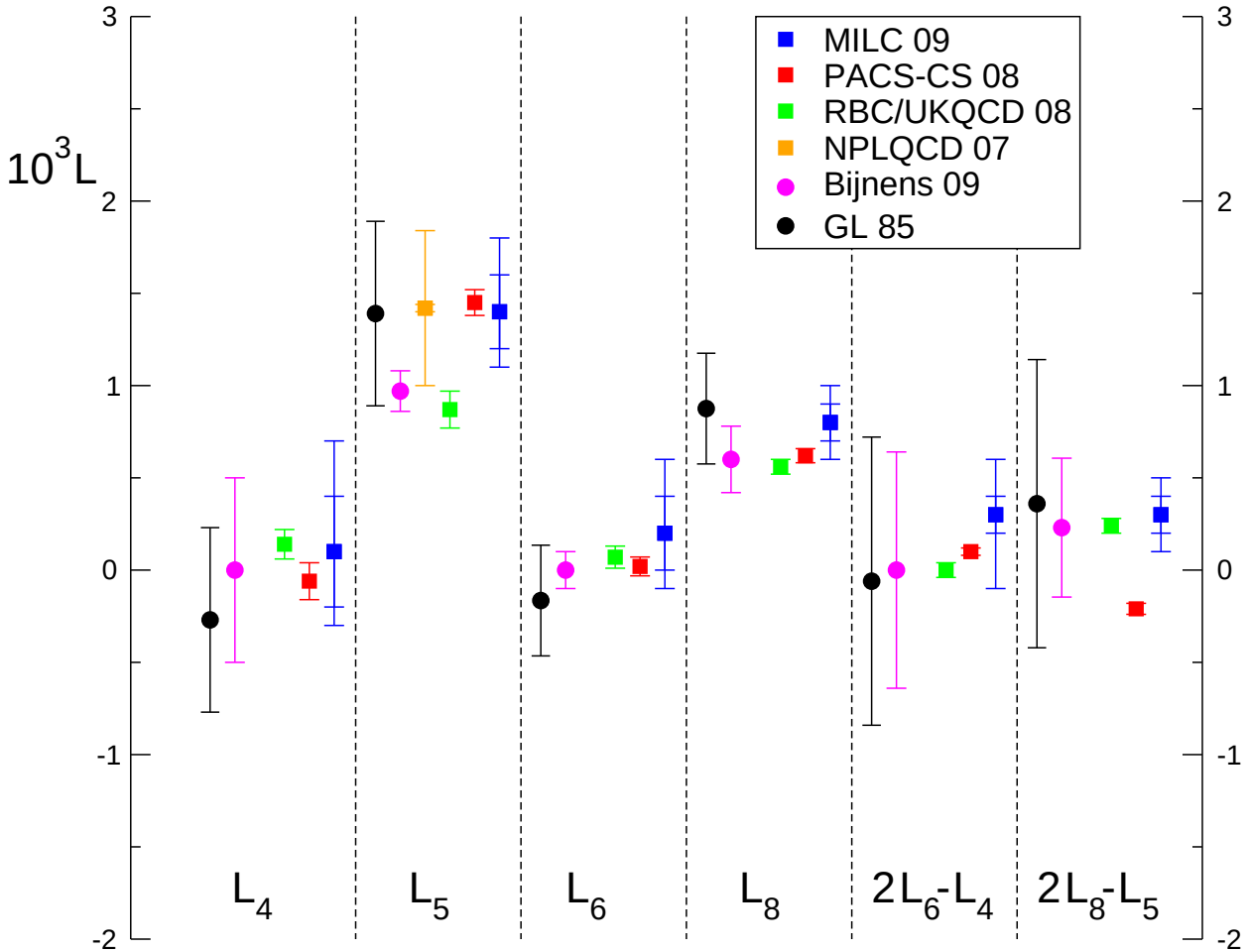
(b) PACS-CS 08	2+1	P	★	■	■	■	clover
(c) MILC 09	2+1	P	★ *	★	★	●	KS

*Based on value of lowest pion mass. Average of tastes would be more appropriate, but cannot be reconstructed from the paper.

	$10^3 L_4$	$10^3 L_5$	$10^3 L_6$	$10^3 L_8$	$10^3(2L_6 - L_4)$	$10^3(2L_8 - L_5)$
(a)	0.14(8)(-)	0.87(10)(-)	0.07(6)(-)	0.56(4)(-)	0.00(4)(-)	0.24(4)(-)
(b)	-0.06(10)(-)	1.45(7)(-)	*0.02(5)(-)*	*0.62(4)(-)*	0.10(2)(-)	-0.21(3)(-)
(c)	$0.1(3)(^{+3}_{-1})$	$1.4(2)(^{+2}_{-1})$	$0.2(2)(^{+2}_{-1})$	0.8(1)(1)	$0.3(1)(^{+2}_{-3})$	0.3(1)(1)

$SU(3)$ low-energy constants

Determination based on masses and decay constants



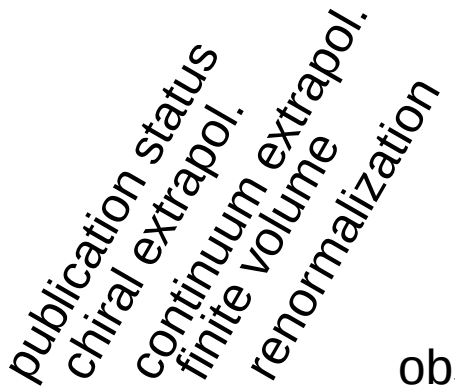
$SU(2)$ low-energy constants

	N_f	publication status	chiral extrapol.	continuum extrapol.	finite volume	renormalization	obs.	F[MeV]
JLQCD/TWQCD 08	2	A	●	■	■	★	M_π, F_π	$79.0(2.5)(0.7)\binom{+4.2}{-0.0}$
RBC/UKQCD 08	2+1	A	●	■	★	★	M_π, F_π	81.2(2.9)(5.7)
PACS-CS 08	2+1	A	★	■	■	■	M_π, F_π	89.4(3.3)
ETM 08A	2	A	●	●	●		", $\langle r_\pi^2\rangle_V$, c_π^V	86.6(7)(7)
JLQCD/TWQCD 08	2	A					$C_{PP,AA}$ (ϵ)	87.3(5.6)
A. Hasenfratz *et al* 08	2	A					$C_{PP,AA}$ (ϵ)	90(4)
DeGrand-Schaefer 07	2	A					RTM (ϵ)	84(5)

$SU(2)$ low-energy constants

	N_f	publication status	chiral extrapol.	continuum extrapol.	finite volume	renormalization	obs.	$\bar{\ell}_3$
CERN-TOV 07	2	A	●	●	■	★	M_π, F_π	3.0(5)(1)
ETM 08	2	A	●	●	●	★	M_π, F_π	3.42(8)(10)(27)
JLQCD/TWQCD 08	2	A	●	■	■	★	M_π, F_π	$3.38(40)(24)\binom{+31}{-0}$
RBC/UKQCD 08	2+1	A	●	■	★	★	M_π, F_π	3.13(33)(24)
PACS-CS 08	2+1	A	★	■	■	■	M_π, F_π	3.14(23)
ETM 08A	2	A	●	●	●		", $\langle r_\pi^2\rangle_V$, c_π^V	3.2(8)(2)

$SU(2)$ low-energy constants

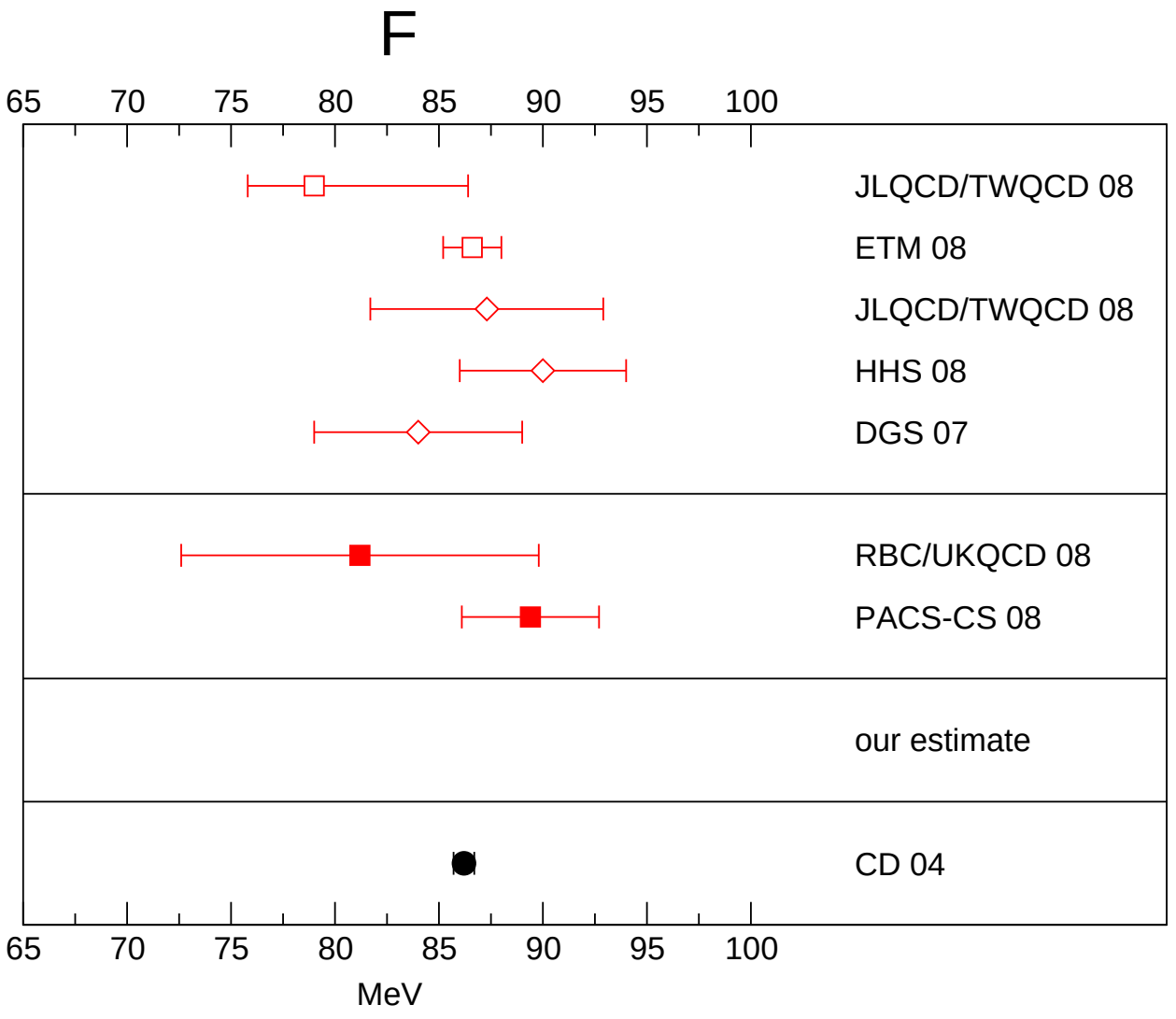


	N_f		obs.	$\bar{\ell}_4$
ETM 08	2	A ● ● ● ★	M_π, F_π	4.59(4)(2)(13)
JLQCD/TWQCD 08	2	A ● ■ ■ ★	M_π, F_π	$4.12(35)(30)\binom{+31}{-0}$
RBC/UKQCD 08	2+1	A ● ■ ★ ★	M_π, F_π	4.43(14)(77)
PACS-CS 08	2+1	A ★ ■ ■ ■	M_π, F_π	4.04(19)
ETM 08A	2	A ● ● ●	",$\langle r_\pi^2\rangle_V$, c_π^V	4.4(2)(1)
JLQCD/TWQCD 09	2	P ● ■ ■	$\langle r_\pi^2\rangle_V$, $\langle r_\pi^2\rangle_S$, c_π^V	4.09(50)(52)

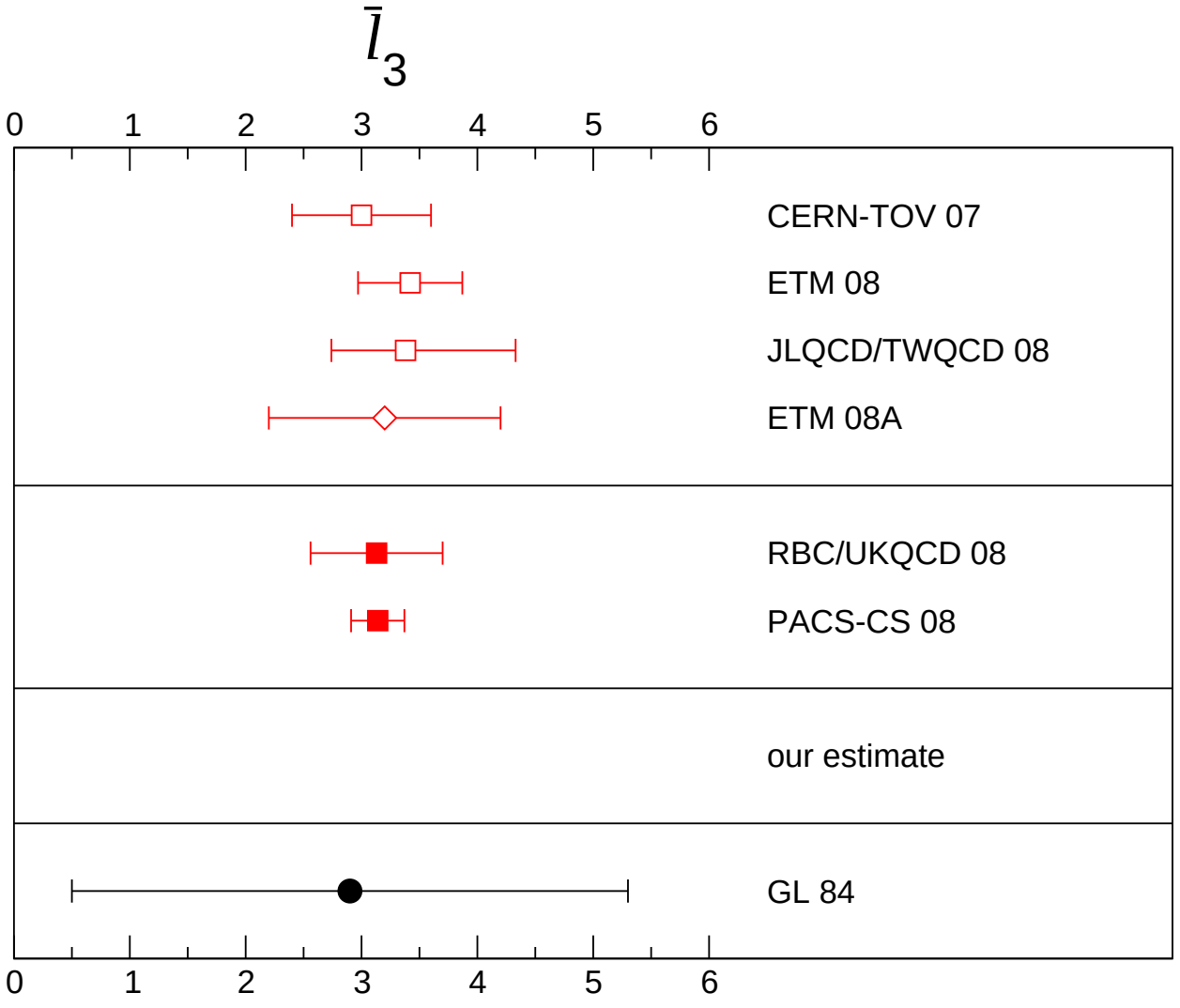
$SU(2)$ low-energy constants

	N_f	publication status	chiral extrapol.	continuum extrapol.	finite volume	obs.	$\bar{\ell}_6$
ETM 08	2	A	●	●	●	$M_\pi, F_\pi, \langle r_\pi^2\rangle_V$, c_π^V	14.9(1.2)(0.7)
JLQCD/TWQCD 09	2	P	●	■	■	$\langle r_\pi^2\rangle_V$, $\langle r_\pi^2\rangle_S$, c_π^V	11.9(0.7)(1.0)
RBC/UKQCD 08	2+1	A	●	■	★	$F_V^\pi(q^2)$	12.2(9)
Bijnens *et al* 98							16.0(5)(7)

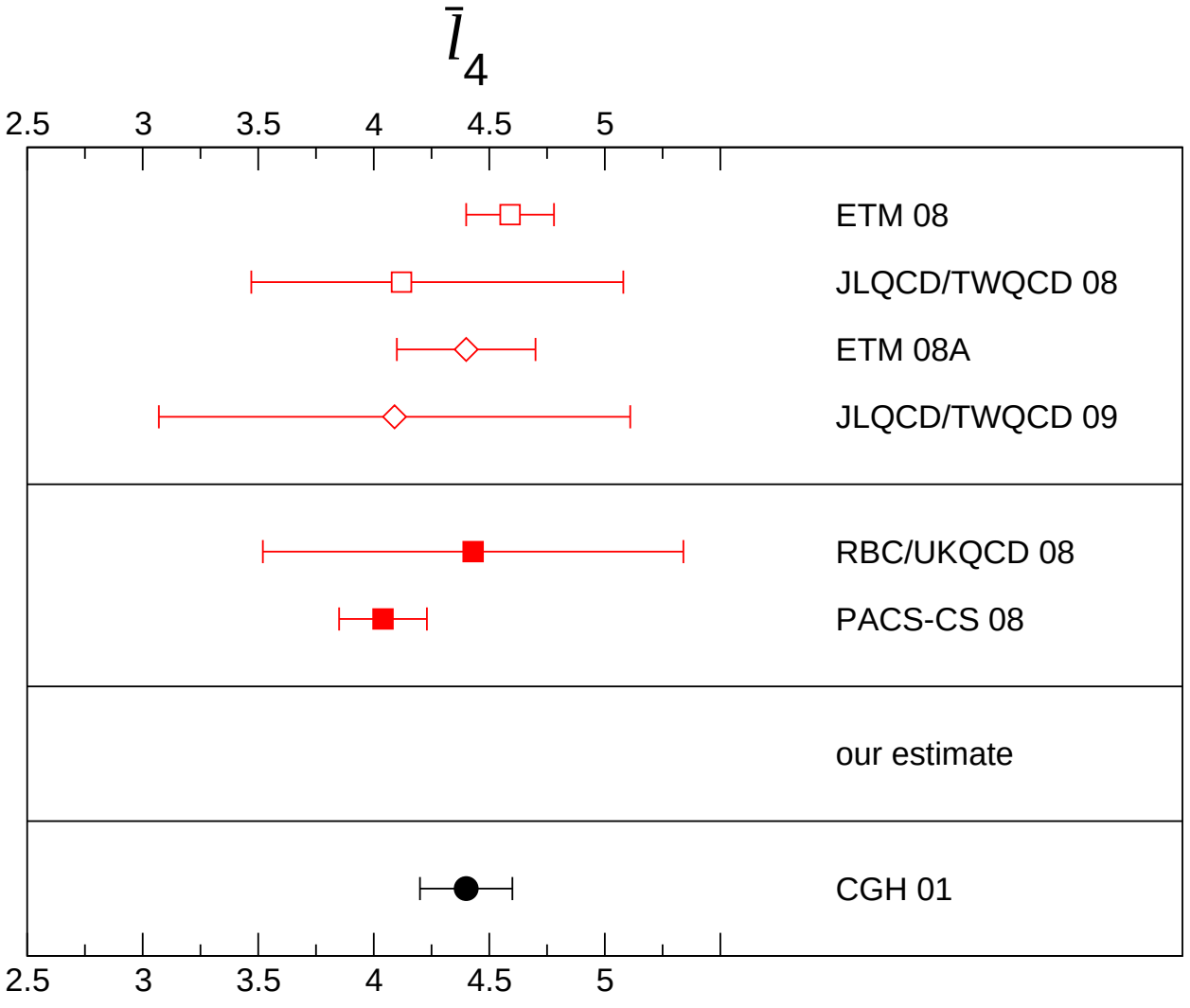
$SU(2)$ low-energy constants



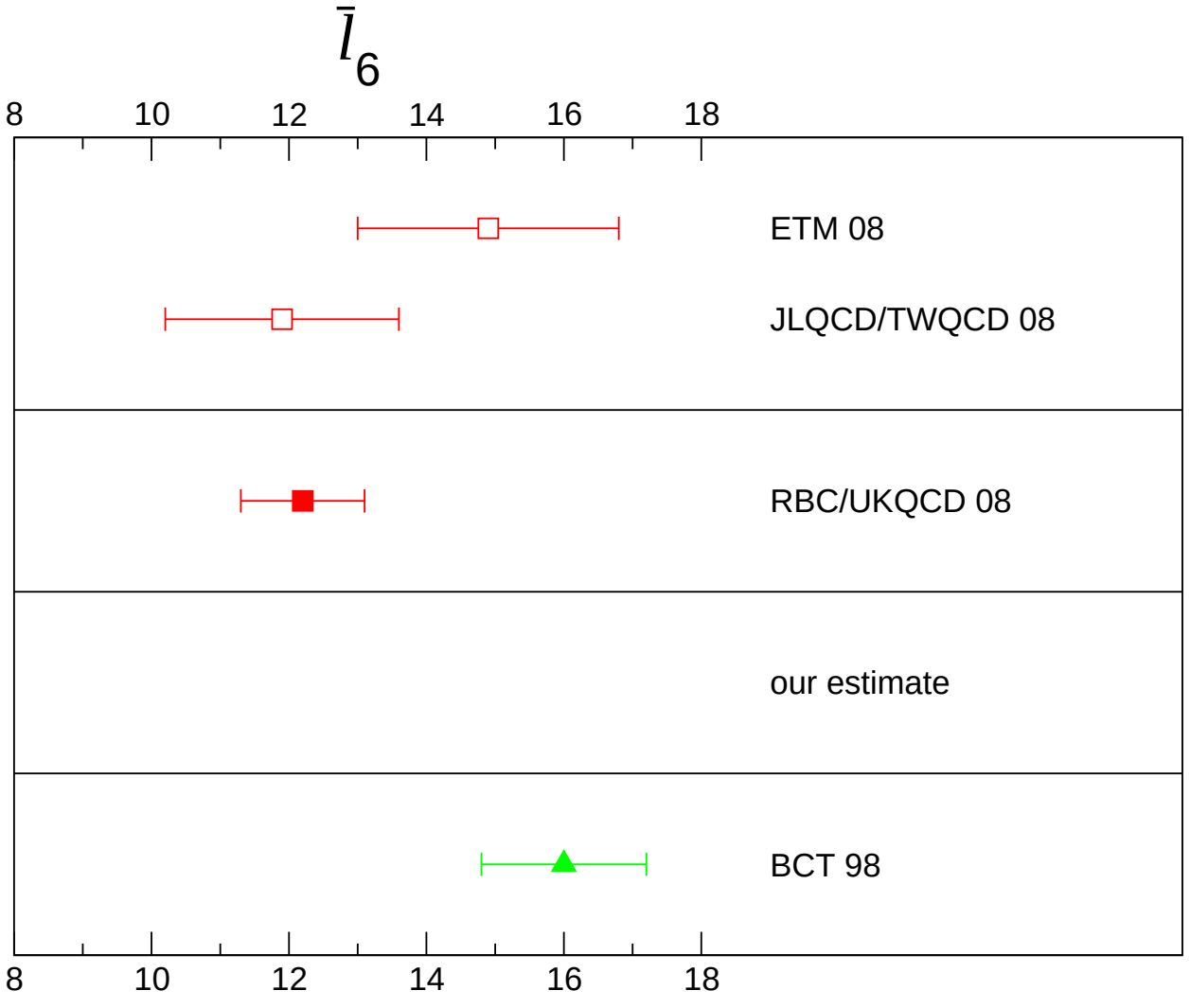
$SU(2)$ low-energy constants



$SU(2)$ low-energy constants



$SU(2)$ low-energy constants



Outlook

- FLAG aims to provide a summary of lattice results relevant for the phenomenology accessible to non-experts
- paper and webpage will become public this summer
- we plan to have yearly updates
- for the future we are open to and encourage contributions from outside Europe
- if you are interested and/or have suggestions or criticisms you are most welcome