Light Quarks (u, d, s)

OMITTED FROM SUMMARY TABLE

u-QUARK MASS

The u-, d-, and s-quark masses are estimates of so-called "current-quark masses," in a mass- independent subtraction scheme such as $\overline{\text{MS}}$. The ratios m_u/m_d and m_s/m_d are extracted from pion and kaon masses using chiral symmetry. The estimates of d and u masses are not without controversy and remain under active investigation. Within the literature there are even suggestions that the u quark could be essentially massless. The s-quark mass is estimated from SU(3) splittings in hadron masses.

We have normalized the $\overline{\text{MS}}$ masses at a renormalization scale of $\mu = 2$ GeV. Results quoted in the literature at $\mu = 1$ GeV have been rescaled by dividing by 1.35. The values of "Our Evaluation" were determined in part via Figures 1 and 2.

$\overline{\text{MS}}$ *MASS* (MeV)	*DOCUMENT ID*		*TECN*
2.2 $^{+0.6}_{-0.4}$ OUR EVALUATION	See the ideogram below.		
$2.27\pm0.06\pm0.06$	[1] FODOR	16	LATT
2.36 ± 0.24	[2] CARRASCO	14	LATT
$2.57\pm0.26\pm0.07$	[3] AOKI	12	LATT
$2.15\pm0.03\pm0.10$	[4] DURR	11	LATT
1.9 ± 0.2	[5] BAZAVOV	10	LATT
$2.24\pm0.10\pm0.34$	[6] BLUM	10	LATT
2.01 ± 0.14	[7] MCNEILE	10	LATT
2.9 ± 0.2	[8] DOMINGUEZ	09	THEO
• • • We do not use the following data for averages, fits, limits, etc. • • •			
2.01 ± 0.14	[7] DAVIES	10	LATT
2.9 ± 0.8	[9] DEANDREA	08	THEO
3.02 ± 0.33	[10] BLUM	07	LATT
2.7 ± 0.4	[11] JAMIN	06	THEO
1.9 ± 0.2	[12] MASON	06	LATT
2.8 ± 0.2	[13] NARISON	06	THEO
1.7 ± 0.3	[14] AUBIN	04A	LATT

[1] FODOR 16 is a lattice simulation with $N_f = 2 + 1$ dynamical flavors and includes partially quenched QED effects.

[2] CARRASCO 14 is a lattice QCD computation of light quark masses using $2 + 1 + 1$ dynamical quarks, with $m_u = m_d \neq m_s \neq m_c$. The u and d quark masses are obtained separately by using the K meson mass splittings and lattice results for the electromagnetic contributions.

[3] AOKI 12 is a lattice computation using $1 + 1 + 1$ dynamical quark flavors.

[4] DURR 11 determine quark mass from a lattice computation of the meson spectrum using $N_f = 2 + 1$ dynamical flavors. The lattice simulations were done at the physical quark mass, so that extrapolation in the quark mass was not needed. The individual m_u, m_d values are obtained using the lattice determination of the average mass m_{ud} and of the ratio m_s/m_{ud} and the value of $Q = (m_s^2 - m_{\text{ud}}^2) \,/\, (m_d^2 - m_u^2)$ as determined from $\eta \rightarrow 3\pi$ decays.

[5] BAZAVOV 10 is a lattice computation using 2+1 dynamical quark flavors.

[6] BLUM 10 determines light quark masses using a QCD plus QED lattice computation of the electromagnetic mass splittings of the low-lying hadrons. The lattice simulations use 2+1 dynamical quark flavors.

[7] DAVIES 10 and MCNEILE 10 determine $\overline{m}_c(\mu)/\overline{m}_s(\mu) = 11.85 \pm 0.16$ using a lattice computation with $N_f = 2 + 1$ dynamical fermions of the pseudoscalar meson masses. Mass m_u is obtained from this using the value of m_c from ALLISON 08 or MCNEILE 10 and the BAZAVOV 10 values for the light quark mass ratios, $m_s/\overline{m}$ and m_u/m_d.

[8] DOMINGUEZ 09 use QCD finite energy sum rules for the two-point function of the divergence of the axial vector current computed to order α_s^4.

[9] DEANDREA 08 determine $m_u - m_d$ from $\eta \rightarrow 3\pi^0$, and combine with the PDG 06 lattice average value of $m_u + m_d = 7.6 \pm 1.6$ to determine m_u and m_d.

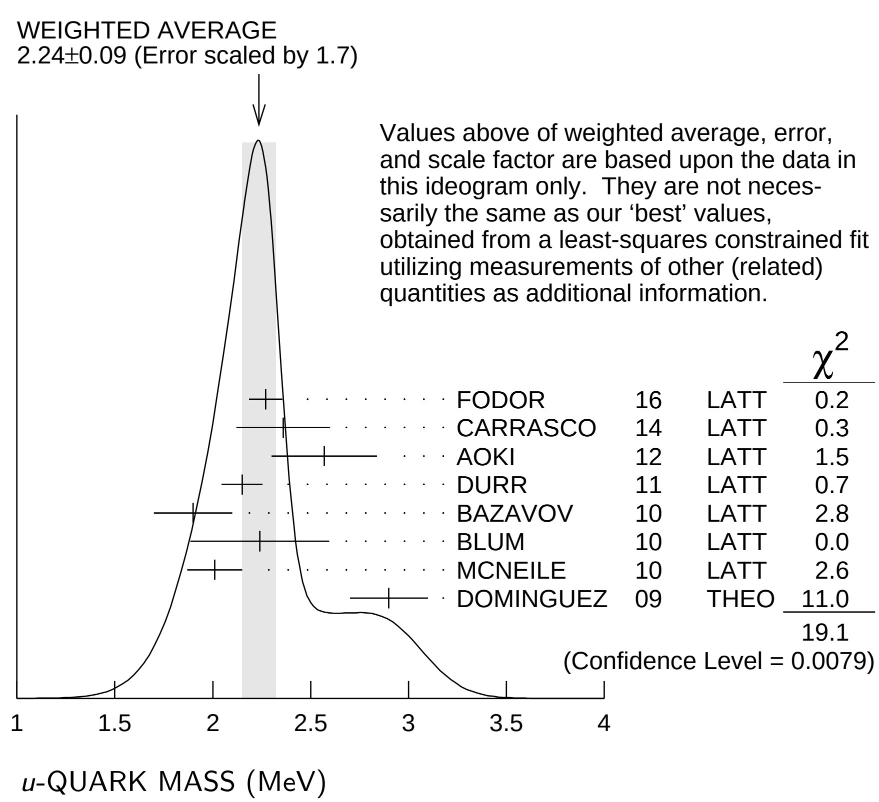
[10] BLUM 07 determine quark masses from the pseudoscalar meson masses using a QED plus QCD lattice computation with two dynamical quark flavors.

[11] JAMIN 06 determine m_u(2 GeV) by combining the value of m_s obtained from the spectral function for the scalar $K\pi$ form factor with other determinations of the quark mass ratios.

[12] MASON 06 extract light quark masses from a lattice simulation using staggered fermions with an improved action, and three dynamical light quark flavors with degenerate u and d quarks. Perturbative corrections were included at NNLO order. The quark masses m_u and m_d were determined from their $(m_u + m_d)/2$ measurement and AUBIN 04A m_u/m_d value.

[13] NARISON 06 uses sum rules for $e^+ e^- \rightarrow$ hadrons to order α_s^3 to determine m_s combined with other determinations of the quark mass ratios.

[14] AUBIN 04A employ a partially quenched lattice calculation of the pseudoscalar meson masses.



d-QUARK MASS

See the comment for the *u* quark above.

We have normalized the $\overline{\mathrm{MS}}$ masses at a renormalization scale of $\mu = 2$ GeV. Results quoted in the literature at $\mu = 1$ GeV have been rescaled by dividing by 1.35. The values of "Our Evaluation" were determined in part via Figures 1 and 2.

$\overline{\mathrm{MS}}$ *MASS* (MeV)	*DOCUMENT ID*		*TECN*
4.7 $^{+0.5}_{-0.4}$ **OUR EVALUATION**	See the ideogram below.		
4.67±0.06±0.06	[1] FODOR	16	LATT
5.03±0.26	[2] CARRASCO	14	LATT
3.68±0.29±0.10	[3] AOKI	12	LATT
4.79±0.07±0.12	[4] DURR	11	LATT
4.6 ±0.3	[5] BAZAVOV	10	LATT
4.65±0.15±0.32	[6] BLUM	10	LATT
4.77±0.15	[7] MCNEILE	10	LATT
5.3 ±0.4	[8] DOMINGUEZ	09	THEO
• • • We do not use the following data for averages, fits, limits, etc. • • •			
4.79±0.16	[7] DAVIES	10	LATT
4.7 ±0.8	[9] DEANDREA	08	THEO
5.49±0.39	[10] BLUM	07	LATT
4.8 ±0.5	[11] JAMIN	06	THEO
4.4 ±0.3	[12] MASON	06	LATT
5.1 ±0.4	[13] NARISON	06	THEO
3.9 ±0.5	[14] AUBIN	04A	LATT

[1] FODOR 16 is a lattice simulation with $N_f = 2 + 1$ dynamical flavors and includes partially quenched QED effects.

[2] CARRASCO 14 is a lattice QCD computation of light quark masses using 2 + 1 + 1 dynamical quarks, with $m_u = m_d \neq m_s \neq m_c$. The *u* and *d* quark masses are obtained separately by using the *K* meson mass splittings and lattice results for the electromagnetic contributions.

[3] AOKI 12 is a lattice computation using 1 + 1 + 1 dynamical quark flavors.

[4] DURR 11 determine quark mass from a lattice computation of the meson spectrum using $N_f = 2 + 1$ dynamical flavors. The lattice simulations were done at the physical quark mass, so that extrapolation in the quark mass was not needed. The individual m_u, m_d values are obtained using the lattice determination of the average mass m_{ud} and of the ratio m_s/m_{ud} and the value of $Q = (m_s^2 - m_{\mathrm{ud}}^2) / (m_d^2 - m_u^2)$ as determined from $\eta \rightarrow 3\pi$ decays.

[5] BAZAVOV 10 is a lattice computation using 2+1 dynamical quark flavors.

[6] BLUM 10 determines light quark masses using a QCD plus QED lattice computation of the electromagnetic mass splittings of the low-lying hadrons. The lattice simulations use 2+1 dynamical quark flavors.

[7] DAVIES 10 and MCNEILE 10 determine $\overline{m}_c(\mu)/\overline{m}_s(\mu) = 11.85 \pm 0.16$ using a lattice computation with $N_f = 2 + 1$ dynamical fermions of the pseudoscalar meson masses. Mass m_d is obtained from this using the value of m_c from ALLISON 08 or MCNEILE 10 and the BAZAVOV 10 values for the light quark mass ratios, $m_s/\overline{m}$ and m_u/m_d.

[8] DOMINGUEZ 09 use QCD finite energy sum rules for the two-point function of the divergence of the axial vector current computed to order α_s^4.

[9] DEANDREA 08 determine $m_u - m_d$ from $\eta \rightarrow 3\pi^0$, and combine with the PDG 06 lattice average value of $m_u + m_d = 7.6 \pm 1.6$ to determine m_u and m_d.

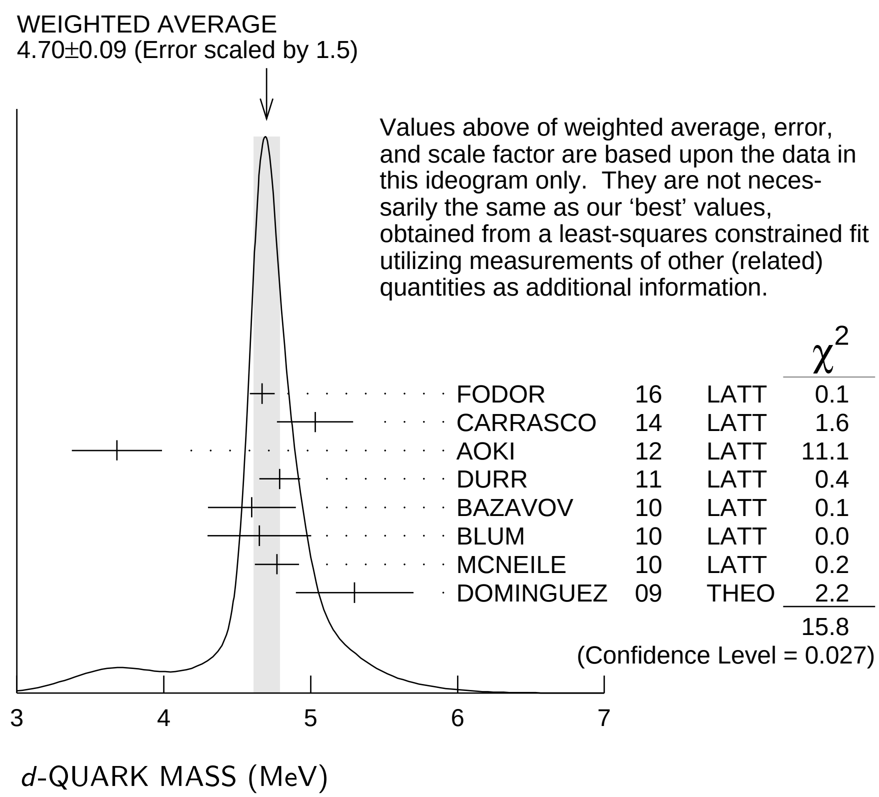
[10] BLUM 07 determine quark masses from the pseudoscalar meson masses using a QED plus QCD lattice computation with two dynamical quark flavors.

[11] JAMIN 06 determine m_d(2 GeV) by combining the value of m_s obtained from the spectral function for the scalar $K\pi$ form factor with other determinations of the quark mass ratios.

[12] MASON 06 extract light quark masses from a lattice simulation using staggered fermions with an improved action, and three dynamical light quark flavors with degenerate u and d quarks. Perturbative corrections were included at NNLO order. The quark masses m_u and m_d were determined from their $(m_u+m_d)/2$ measurement and AUBIN 04A m_u/m_d value.

[13] NARISON 06 uses sum rules for $e^+e^- \rightarrow$ hadrons to order α_s^3 to determine m_s combined with other determinations of the quark mass ratios.

[14] AUBIN 04A perform three flavor dynamical lattice calculation of pseudoscalar meson masses, with continuum estimate of electromagnetic effects in the kaon masses, and one-loop perturbative renormalization constant.



$\overline{m} = (m_u + m_d)/2$

See the comments for the u quark above.

We have normalized the $\overline{\rm MS}$ masses at a renormalization scale of $\mu = 2$ GeV. Results quoted in the literature at $\mu = 1$ GeV have been rescaled by dividing by 1.35. The values of "Our Evaluation" were determined in part via Figures 1 and 2.

$\overline{\rm MS}$ *MASS* (MeV)	*DOCUMENT ID*		*TECN*
3.5 $^{+0.7}_{-0.3}$ OUR EVALUATION	See the ideogram below.		
3.70 ±0.17	[1] CARRASCO	14	LATT
3.45 ±0.12	[2] ARTHUR	13	LATT
3.59 ±0.21	[3] AOKI	11A	LATT
3.469±0.047±0.048	[4] DURR	11	LATT
3.6 ±0.2	[5] BLOSSIER	10	LATT
3.39 ±0.06	[6] MCNEILE	10	LATT
4.1 ±0.2	[7] DOMINGUEZ	09	THEO
3.72 ±0.41	[8] ALLTON	08	LATT
3.55 $^{+0.65}_{-0.28}$	[9] ISHIKAWA	08	LATT
4.25 ±0.35	[10] BLUM	07	LATT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
3.40 ±0.07	[6] DAVIES	10	LATT
3.85 ±0.12 ±0.4	[11] BLOSSIER	08	LATT
≥ 4.85 ±0.20	[12] DOMINGUEZ...	08B	THEO
4.026±0.048	[13] NAKAMURA	08	LATT
4.08 ±0.25 ±0.42	[14] GOCKELER	06	LATT
4.7 ±0.2 ±0.3	[15] GOCKELER	06A	LATT
3.2 ±0.3	[16] MASON	06	LATT
3.95 ±0.3	[17] NARISON	06	THEO
2.8 ±0.3	[18] AUBIN	04	LATT
4.29 ±0.14 ±0.65	[19] AOKI	03	LATT
3.223±0.3	[20] AOKI	03B	LATT
4.4 ±0.1 ±0.4	[21] BECIREVIC	03	LATT
4.1 ±0.3 ±1.0	[22] CHIU	03	LATT

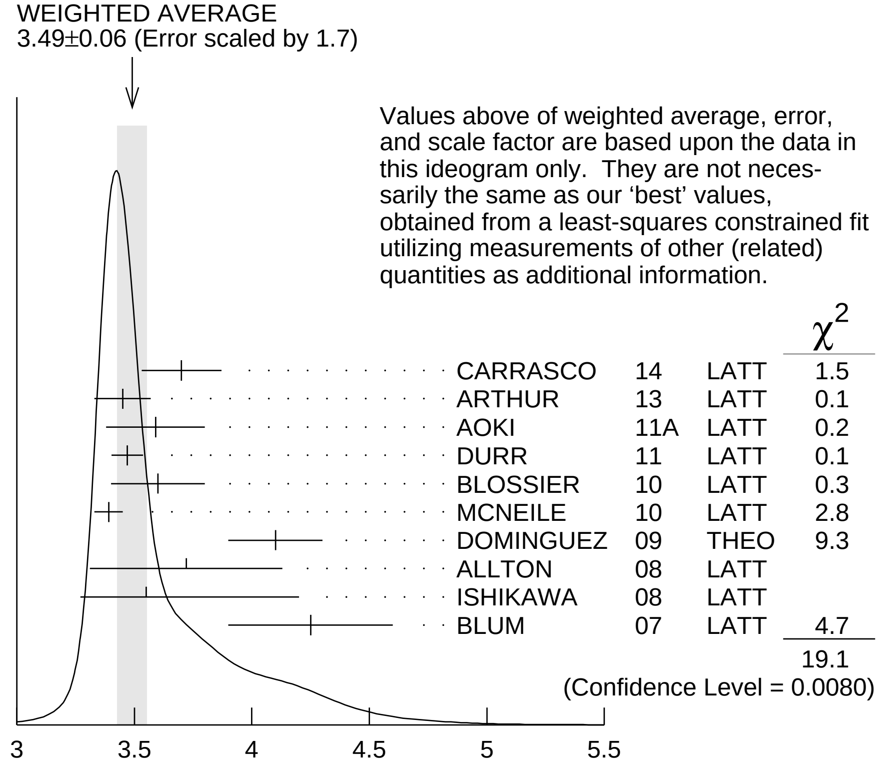
[1] CARRASCO 14 is a lattice QCD computation of light quark masses using 2 + 1 + 1 dynamical quarks, with $m_u = m_d \neq m_s \neq m_c$. The u and d quark masses are obtained separately by using the K meson mass splittings and lattice results for the electromagnetic contributions.

[2] ARTHUR 13 is a lattice computation using 2+1 dynamical domain wall fermions. Masses at $\mu = 3$ GeV have been converted to $\mu = 2$ GeV using conversion factors given in their paper.

[3] AOKI 11A determine quark masses from a lattice computation of the hadron spectrum using $N_f = 2 + 1$ dynamical flavors of domain wall fermions.

[4] DURR 11 determine quark mass from a lattice computation of the meson spectrum using $N_f = 2 + 1$ dynamical flavors. The lattice simulations were done at the physical quark mass, so that extrapolation in the quark mass was not needed.

[5] BLOSSIER 10 determines quark masses from a computation of the hadron spectrum using N_f=2 dynamical twisted-mass Wilson fermions.



$\overline{m} = (m_u + m_d)\big/2$ (MeV)

[6] DAVIES 10 and MCNEILE 10 determine $\overline{m}_c(\mu)/\overline{m}_s(\mu) = 11.85 \pm 0.16$ using a lattice computation with $N_f = 2 + 1$ dynamical fermions of the pseudoscalar meson masses. Mass $\overline{m}$ is obtained from this using the value of m_c from ALLISON 08 or MCNEILE 10 and the BAZAVOV 10 values for the light quark mass ratio, $m_s/\overline{m}$.

[7] DOMINGUEZ 09 use QCD finite energy sum rules for the two-point function of the divergence of the axial vector current computed to order α_s^4.

[8] ALLTON 08 use a lattice computation of the π, K, and Ω masses with 2+1 dynamical flavors of domain wall quarks, and non-perturbative renormalization.

[9] ISHIKAWA 08 use a lattice computation of the light meson spectrum with 2+1 dynamical flavors of $\mathcal{O}(a)$ improved Wilson quarks, and one-loop perturbative renormalization.

[10] BLUM 07 determine quark masses from the pseudoscalar meson masses using a QED plus QCD lattice computation with two dynamical quark flavors.

[11] BLOSSIER 08 use a lattice computation of pseudoscalar meson masses and decay constants with 2 dynamical flavors and non-perturbative renormalization.

[12] DOMINGUEZ-CLARIMON 08B obtain an inequality from sum rules for the scalar two-point correlator.

[13] NAKAMURA 08 do a lattice computation using quenched domain wall fermions and non-perturbative renormalization.

[14] GOCKELER 06 use an unquenched lattice computation of the axial Ward Identity with $N_f = 2$ dynamical light quark flavors, and non-perturbative renormalization, to obtain $\overline{m}(2\text{ GeV}) = 4.08 \pm 0.25 \pm 0.19 \pm 0.23$ MeV, where the first error is statistical, the second and third are systematic due to the fit range and force scale uncertainties, respectively. We have combined the systematic errors linearly.

[15] GOCKELER 06A use an unquenched lattice computation of the pseudoscalar meson masses with $N_f = 2$ dynamical light quark flavors, and non-perturbative renormalization.

[16] MASON 06 extract light quark masses from a lattice simulation using staggered fermions with an improved action, and three dynamical light quark flavors with degenerate u and d quarks. Perturbative corrections were included at NNLO order.

[17] NARISON 06 uses sum rules for $e^+ e^- \to$ hadrons to order α_s^3 to determine m_s combined with other determinations of the quark mass ratios.

[18] AUBIN 04 perform three flavor dynamical lattice calculation of pseudoscalar meson masses, with one-loop perturbative renormalization constant.

[19] AOKI 03 uses quenched lattice simulation of the meson and baryon masses with degenerate light quarks. The extrapolations are done using quenched chiral perturbation theory.

[20] The errors given in AOKI 03B were $^{+0.046}_{-0.069}$. We changed them to ± 0.3 for calculating the overall best values. AOKI 03B uses lattice simulation of the meson and baryon masses with two dynamical light quarks. Simulations are performed using the $\mathcal{O}(a)$ improved Wilson action.

[21] BECIREVIC 03 perform quenched lattice computation using the vector and axial Ward identities. Uses $\mathcal{O}(a)$ improved Wilson action and nonperturbative renormalization.

[22] CHIU 03 determines quark masses from the pion and kaon masses using a lattice simulation with a chiral fermion action in quenched approximation.

m_u/m_d MASS RATIO

VALUE	DOCUMENT ID		TECN	COMMENT
0.38–0.58 OUR EVALUATION	See the ideogram below.			
0.485 ± 0.011 ± 0.016	[1] FODOR	16	LATT	
$0.4482^{+0.0173}_{-0.0206}$	[2] BASAK	15	LATT	
0.470 ± 0.056	[3] CARRASCO	14	LATT	
0.698 ± 0.051	[4] AOKI	12	LATT	
0.42 ± 0.01 ± 0.04	[5] BAZAVOV	10	LATT	
0.4818 ± 0.0096 ± 0.0860	[6] BLUM	10	LATT	
0.550 ± 0.031	[7] BLUM	07	LATT	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.43 ± 0.08	[8] AUBIN	04A	LATT	
0.410 ± 0.036	[9] NELSON	03	LATT	
0.553 ± 0.043	[10] LEUTWYLER	96	THEO	Compilation

[1] FODOR 16 is a lattice simulation with $N_f = 2 + 1$ dynamical flavors and includes partially quenched QED effects.

[2] BASAK 15 is a lattice computation using 2+1 dynamical quark flavors.

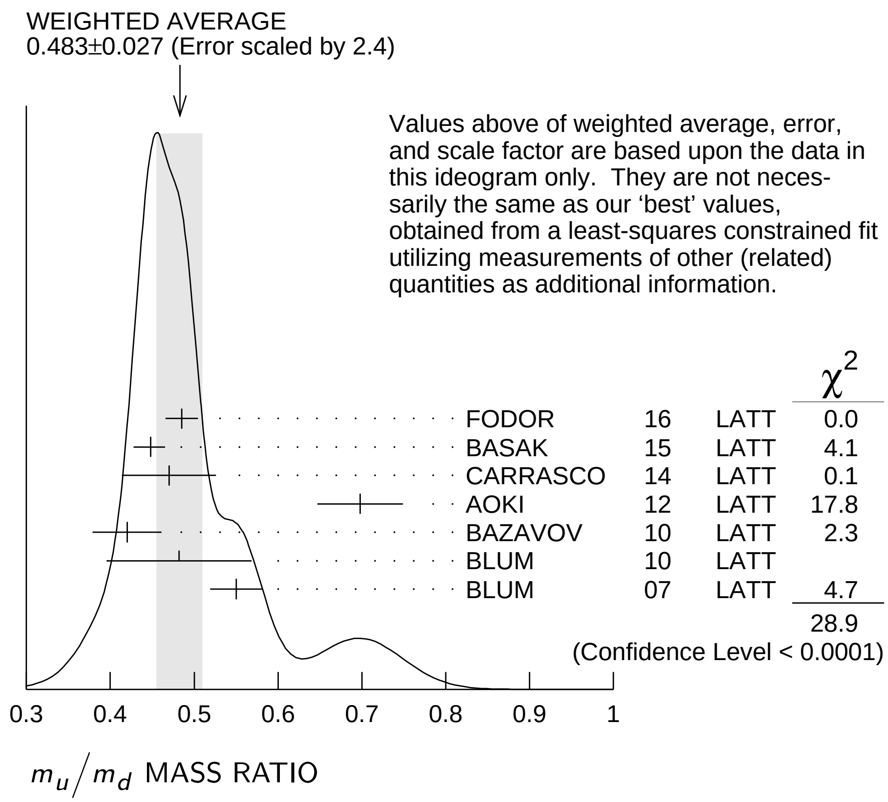
[3] CARRASCO 14 is a lattice QCD computation of light quark masses using $2 + 1 + 1$ dynamical quarks, with $m_u = m_d \neq m_s \neq m_c$. The u and d quark masses are obtained separately by using the K meson mass splittings and lattice results for the electromagnetic contributions.

[4] AOKI 12 is a lattice computation using $1 + 1 + 1$ dynamical quark flavors.

[5] BAZAVOV 10 is a lattice computation using 2+1 dynamical quark flavors.

[6] BLUM 10 is a lattice computation using 2+1 dynamical quark flavors.

[7] BLUM 07 determine quark masses from the pseudoscalar meson masses using a QED plus QCD lattice computation with two dynamical quark flavors.
[8] AUBIN 04A perform three flavor dynamical lattice calculation of pseudoscalar meson masses, with continuum estimate of electromagnetic effects in the kaon masses.
[9] NELSON 03 computes coefficients in the order p^4 chiral Lagrangian using a lattice calculation with three dynamical flavors. The ratio m_u/m_d is obtained by combining this with the chiral perturbation theory computation of the meson masses to order p^4.
[10] LEUTWYLER 96 uses a combined fit to $\eta \rightarrow 3\pi$ and $\psi' \rightarrow J/\psi\ (\pi,\eta)$ decay rates, and the electromagnetic mass differences of the π and K.



s-QUARK MASS

See the comment for the u quark above.

We have normalized the $\overline{\mathrm{MS}}$ masses at a renormalization scale of $\mu = 2$ GeV. Results quoted in the literature at $\mu = 1$ GeV have been rescaled by dividing by 1.35.

$\overline{\mathrm{MS}}$ *MASS* (MeV)	*DOCUMENT ID*		*TECN*
96 $^{+8}_{-4}$ OUR EVALUATION	See the ideogram below.		
87.6 ± 6.0	[1] ANANTHANA..	16	THEO
93.6 ± 0.8	[2] CHAKRABOR..	15	LATT
99.6 ± 4.3	[3] CARRASCO	14	LATT
94.4 ± 2.3	[4] ARTHUR	13	LATT
94 ± 9	[5] BODENSTEIN	13	THEO
102 ± 3 ± 1	[6] FRITZSCH	12	LATT

96.2 ± 2.7	[7] AOKI	11A	LATT
$95.5 \pm 1.1 \pm 1.5$	[8] DURR	11	LATT
95 ± 6	[9] BLOSSIER	10	LATT
$97.6 \pm 2.9 \pm 5.5$	[10] BLUM	10	LATT
107.3 ± 11.7	[11] ALLTON	08	LATT
102 ± 8	[12] DOMINGUEZ	08A	THEO
$90.1^{+17.2}_{-6.1}$	[13] ISHIKAWA	08	LATT

• • • We do not use the following data for averages, fits, limits, etc. • • •

92.4 ± 1.5	[14] DAVIES	10	LATT
92.2 ± 1.3	[14] MCNEILE	10	LATT
$105 \pm 3 \pm 9$	[15] BLOSSIER	08	LATT
105.6 ± 1.2	[16] NAKAMURA	08	LATT
119.5 ± 9.3	[17] BLUM	07	LATT
$105 \pm 6 \pm 7$	[18] CHETYRKIN	06	THEO
$111 \pm 6 \pm 10$	[19] GOCKELER	06	LATT
$119 \pm 5 \pm 8$	[20] GOCKELER	06A	LATT
92 ± 9	[21] JAMIN	06	THEO
87 ± 6	[22] MASON	06	LATT
104 ± 15	[23] NARISON	06	THEO
$\geq 71 \pm 4,\ \leq 151 \pm 14$	[24] NARISON	06	THEO
$96\ ^{+5}_{-3}\ ^{+16}_{-18}$	[25] BAIKOV	05	THEO
81 ± 22	[26] GAMIZ	05	THEO
125 ± 28	[27] GORBUNOV	05	THEO
93 ± 32	[28] NARISON	05	THEO
76 ± 8	[29] AUBIN	04	LATT
$116 \pm 6 \pm 0.65$	[30] AOKI	03	LATT
$84.5^{+12}_{-1.7}$	[31] AOKI	03B	LATT
$106 \pm 2 \pm 8$	[32] BECIREVIC	03	LATT
$92 \pm 9 \pm 16$	[33] CHIU	03	LATT
117 ± 17	[34] GAMIZ	03	THEO
103 ± 17	[35] GAMIZ	03	THEO

[1] ANANTHANARAYAN 16 determine $\overline{m}_s$(2 GeV) $= 106.70 \pm 9.36$ MeV and 74.47 ± 7.77 MeV from fits to ALEPH and OPAL τ decay data, respectively. We have used the weighted average of the two.

[2] CHAKRABORTY 15 is a lattice QCD computation that determines m_c and m_c/m_s using pseudoscalar mesons masses tuned on gluon field configurations with 2+1+1 dynamical flavors of HISQ quarks with u/d masses down to the physical value.

[3] CARRASCO 14 is a lattice QCD computation of light quark masses using $2+1+1$ dynamical quarks, with $m_u = m_d \neq m_s \neq m_c$. The u and d quark masses are obtained separately by using the K meson mass splittings and lattice results for the electromagnetic contributions.

[4] ARTHUR 13 is a lattice computation using 2+1 dynamical domain wall fermions. Masses at $\mu = 3$ GeV have been converted to $\mu = 2$ GeV using conversion factors given in their paper.

[5] BODENSTEIN 13 determines m_s from QCD finite energy sum rules, and the perturbative computation of the pseudoscalar correlator to five-loop order.

[6] FRITZSCH 12 determine m_s using a lattice computation with $N_f = 2$ dynamical flavors.

[7] AOKI 11A determine quark masses from a lattice computation of the hadron spectrum using $N_f = 2 + 1$ dynamical flavors of domain wall fermions.

[8] DURR 11 determine quark mass from a lattice computation of the meson spectrum using $N_f = 2 + 1$ dynamical flavors. The lattice simulations were done at the physical quark mass, so that extrapolation in the quark mass was not needed.

[9] BLOSSIER 10 determines quark masses from a computation of the hadron spectrum using N_f=2 dynamical twisted-mass Wilson fermions.

[10] BLUM 10 determines light quark masses using a QCD plus QED lattice computation of the electromagnetic mass splittings of the low-lying hadrons. The lattice simulations use 2+1 dynamical quark flavors.

[11] ALLTON 08 use a lattice computation of the π, K, and Ω masses with 2+1 dynamical flavors of domain wall quarks, and non-perturbative renormalization.

[12] DOMINGUEZ 08A make determination from QCD finite energy sum rules for the pseudoscalar two-point function computed to order α_s^4.

[13] ISHIKAWA 08 use a lattice computation of the light meson spectrum with 2+1 dynamical flavors of $\mathcal{O}(a)$ improved Wilson quarks, and one-loop perturbative renormalization.

[14] DAVIES 10 and MCNEILE 10 determine $\overline{m}_c(\mu)/\overline{m}_s(\mu) = 11.85 \pm 0.16$ using a lattice computation with $N_f = 2 + 1$ dynamical fermions of the pseudoscalar meson masses. Mass m_s is obtained from this using the value of m_c from ALLISON 08 or MCNEILE 10.

[15] BLOSSIER 08 use a lattice computation of pseudoscalar meson masses and decay constants with 2 dynamical flavors and non-perturbative renormalization.

[16] NAKAMURA 08 do a lattice computation using quenched domain wall fermions and non-perturbative renormalization.

[17] BLUM 07 determine quark masses from the pseudoscalar meson masses using a QED plus QCD lattice computation with two dynamical quark flavors.

[18] CHETYRKIN 06 use QCD sum rules in the pseudoscalar channel to order α_s^4.

[19] GOCKELER 06 use an unquenched lattice computation of the axial Ward Identity with $N_f = 2$ dynamical light quark flavors, and non-perturbative renormalization, to obtain $\overline{m}_s(2\text{ GeV}) = 111 \pm 6 \pm 4 \pm 6$ MeV, where the first error is statistical, the second and third are systematic due to the fit range and force scale uncertainties, respectively. We have combined the systematic errors linearly.

[20] GOCKELER 06A use an unquenched lattice computation of the pseudoscalar meson masses with $N_f = 2$ dynamical light quark flavors, and non-perturbative renormalization.

[21] JAMIN 06 determine $\overline{m}_s(2\text{ GeV})$ from the spectral function for the scalar $K\pi$ form factor.

[22] MASON 06 extract light quark masses from a lattice simulation using staggered fermions with an improved action, and three dynamical light quark flavors with degenerate u and d quarks. Perturbative corrections were included at NNLO order.

[23] NARISON 06 uses sum rules for $e^+ e^- \rightarrow$ hadrons to order α_s^3.

[24] NARISON 06 obtains the quoted range from positivity of the spectral functions.

[25] BAIKOV 05 determines $\overline{m}_s(M_\tau) = 100^{+5}_{-3}{}^{+17}_{-19}$ from sum rules using the strange spectral function in τ decay. The computations were done to order α_s^3, with an estimate of the α_s^4 terms. We have converted the result to $\mu = 2$ GeV.

[26] GAMIZ 05 determines $\overline{m}_s(2\text{ GeV})$ from sum rules using the strange spectral function in τ decay. The computations were done to order α_s^2, with an estimate of the α_s^3 terms.

[27] GORBUNOV 05 use hadronic tau decays to N^{3}LO, including power corrections.

[28] NARISON 05 determines $\overline{m}_s(2\text{ GeV})$ from sum rules using the strange spectral function in τ decay. The computations were done to order α_s^3.

[29] AUBIN 04 perform three flavor dynamical lattice calculation of pseudoscalar meson masses, with one-loop perturbative renormalization constant.

[30] AOKI 03 uses quenched lattice simulation of the meson and baryon masses with degenerate light quarks. The extrapolations are done using quenched chiral perturbation theory. Determines $m_s = 113.8 \pm 2.3^{+5.8}_{-2.9}$ using K mass as input and $m_s = 142.3 \pm 5.8^{+22}_{-0}$ using ϕ mass as input. We have performed a weighted average of these values.

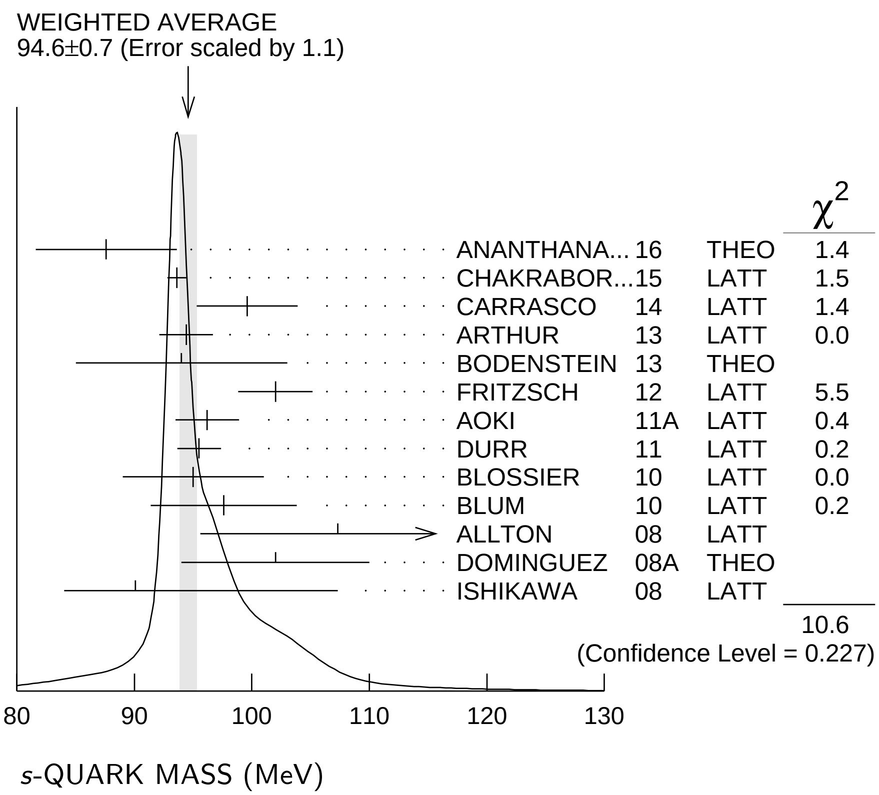
[31] AOKI 03B uses lattice simulation of the meson and baryon masses with two dynamical light quarks. Simulations are performed using the $\mathcal{O}(a)$ improved Wilson action.

[32] BECIREVIC 03 perform quenched lattice computation using the vector and axial Ward identities. Uses $\mathcal{O}(a)$ improved Wilson action and nonperturbative renormalization. They also quote $\overline{m}/m_s$=24.3 ± 0.2 ± 0.6.

[33] CHIU 03 determines quark masses from the pion and kaon masses using a lattice simulation with a chiral fermion action in quenched approximation.

[34] GAMIZ 03 determines m_s from SU(3) breaking in the τ hadronic width. The value of V_{us} is chosen to satisfy CKM unitarity.

[35] GAMIZ 03 determines m_s from SU(3) breaking in the τ hadronic width. The value of V_{us} is taken from the PDG.



OTHER LIGHT QUARK MASS RATIOS

m_s/m_d MASS RATIO

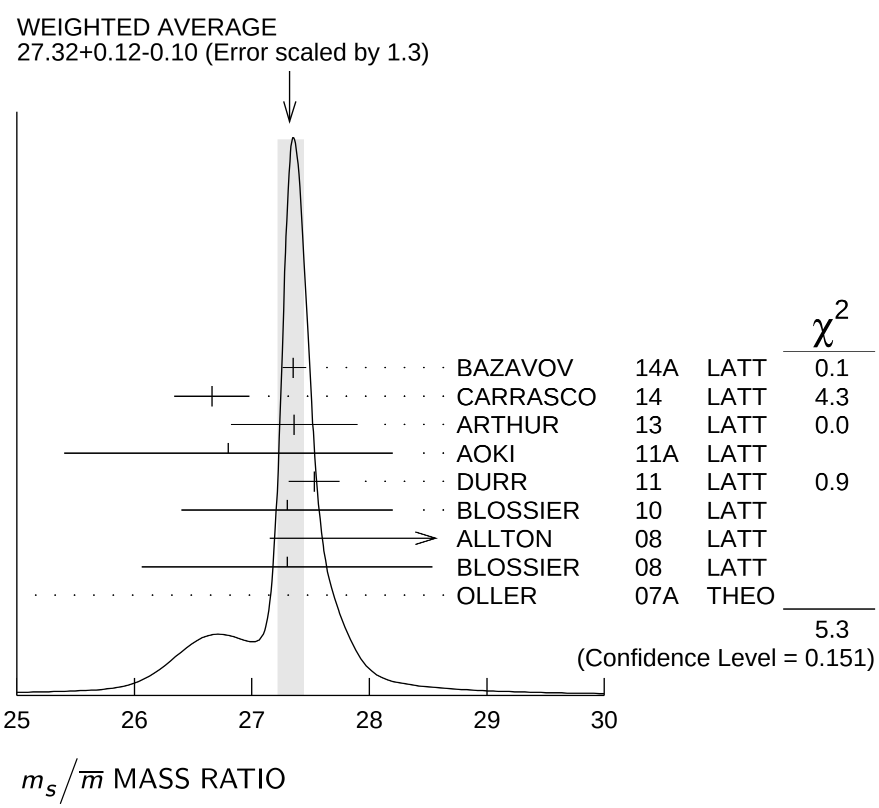
VALUE	DOCUMENT ID		TECN	COMMENT
17–22 OUR EVALUATION				
• • • We do not use the following data for averages, fits, limits, etc. • • •				
20.0	[1] GAO	97	THEO	
18.9±0.8	[2] LEUTWYLER	96	THEO	Compilation
21	[3] DONOGHUE	92	THEO	
18	[4] GERARD	90	THEO	
18 to 23	[5] LEUTWYLER	90B	THEO	

[1] GAO 97 uses electromagnetic mass splittings of light mesons.
[2] LEUTWYLER 96 uses a combined fit to $\eta \to 3\pi$ and $\psi' \to J/\psi\ (\pi,\eta)$ decay rates, and the electromagnetic mass differences of the π and K.
[3] DONOGHUE 92 result is from a combined analysis of meson masses, $\eta \to 3\pi$ using second-order chiral perturbation theory including nonanalytic terms, and $(\psi(2S) \to J/\psi(1S)\pi)/(\psi(2S) \to J/\psi(1S)\eta)$.
[4] GERARD 90 uses large N and η-η' mixing.
[5] LEUTWYLER 90B determines quark mass ratios using second-order chiral perturbation theory for the meson and baryon masses, including nonanalytic corrections. Also uses Weinberg sum rules to determine L_7.

$m_s/\overline{m}$ MASS RATIO

$\overline{m} \equiv (m_u + m_d)/2$

VALUE	DOCUMENT ID		TECN
27.3 ±0.7 OUR EVALUATION	See the ideogram below.		
$27.35\pm0.05^{+0.10}_{-0.07}$	[1] BAZAVOV	14A	LATT
26.66 ± 0.32	[2] CARRASCO	14	LATT
27.36 ± 0.54	[3] ARTHUR	13	LATT
26.8 ± 1.4	[4] AOKI	11A	LATT
$27.53\pm0.20\pm0.08$	[5] DURR	11	LATT
27.3 ± 0.9	[6] BLOSSIER	10	LATT
28.8 ± 1.65	[7] ALLTON	08	LATT
$27.3\pm0.3\pm1.2$	[8] BLOSSIER	08	LATT
23.5 ± 1.5	[9] OLLER	07A	THEO
• • • We do not use the following data for averages, fits, limits, etc. • • •			
27.4 ± 0.4	[10] AUBIN	04	LATT



[1] BAZAVOV 14A is a lattice computation using 4 dynamical flavors of HISQ fermions.
[2] CARRASCO 14 is a lattice QCD computation of light quark masses using 2 + 1 + 1 dynamical quarks, with $m_u = m_d \neq m_s \neq m_c$. The u and d quark masses are obtained separately by using the K meson mass splittings and lattice results for the electromagnetic contributions.
[3] ARTHUR 13 is a lattice computation using 2+1 dynamical domain wall fermions.
[4] AOKI 11A determine quark masses from a lattice computation of the hadron spectrum using $N_f = 2 + 1$ dynamical flavors of domain wall fermions.
[5] DURR 11 determine quark mass from a lattice computation of the meson spectrum using $N_f = 2 + 1$ dynamical flavors. The lattice simulations were done at the physical quark mass, so that extrapolation in the quark mass was not needed.
[6] BLOSSIER 10 determines quark masses from a computation of the hadron spectrum using N_f=2 dynamical twisted-mass Wilson fermions.
[7] ALLTON 08 use a lattice computation of the π, K, and Ω masses with 2+1 dynamical flavors of domain wall quarks, and non-perturbative renormalization.
[8] BLOSSIER 08 use a lattice computation of pseudoscalar meson masses and decay constants with 2 dynamical flavors and non-perturbative renormalization.
[9] OLLER 07A use unitarized chiral perturbation theory to order p^4.
[10] Three flavor dynamical lattice calculation of pseudoscalar meson masses.

Q MASS RATIO

$$Q \equiv \sqrt{(m^2{}_s - \overline{m}^2)/(m^2{}_d - m^2{}_u)}; \quad \overline{m} \equiv (m_u + m_d)/2$$

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE	DOCUMENT ID		TECN
22.0±0.7	[1] COLANGELO	17	
23.4±0.4±0.5	[2] FODOR	16	LATT
22.8±0.4	[3] MARTEMYA...	05	THEO
22.7±0.8	[4] ANISOVICH	96	THEO

[1] COLANGELO 17 obtain Q from a dispersive analysis of KLOE collaboration data on $\eta \to \pi^+\pi^-\pi^0$ decays and chiral perturbation theory input.
[2] FODOR 16 is a lattice simulation with $N_f = 2 + 1$ dynamical flavors and includes partially quenched QED effects.
[3] MARTEMYANOV 05 determine Q from $\eta \to 3\pi$ decay.
[4] ANISOVICH 96 find Q from $\eta \to \pi^+\pi^-\pi^0$ decay using dispersion relations and chiral perturbation theory.

LIGHT QUARKS (*u*, *d*, *s*) REFERENCES

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CHAKRABOR...	15	PR D91 054508	B. Chakraborty et al.	(HPQCD Collab.)
BAZAVOV	14A	PR D90 074509	A. Bazavov et al.	(Fermi-LAT and MILC Collabs.)
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ARTHUR	13	PR D87 094514	R. Arthur et al.	(RBC and UKQCD Collabs.)
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MCNEILE	10	PR D82 034512	C. McNeile et al.	(HPQCD Collab.)
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BLOSSIER	08	JHEP 0804 020	B. Blossier *et al.*	(ETM Collab.)
DEANDREA	08	PR D78 034032	A. Deandrea, A. Nehme, P. Talavera	
DOMINGUEZ	08A	JHEP 0805 020	C.A. Dominguez *et al.*	
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MARTEMYA...	05	PR D71 017501	B.V. Martemyanov, V.S. Sopov	
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LEUTWYLER	90B	NP B337 108	H. Leutwyler	(BERN)