c

$I(J^P) = 0(\frac{1}{2}^+)$

Charge = $\frac{2}{3}$ e Charm = +1

c-QUARK MASS

The c-quark mass corresponds to the "running" mass m_c ($\mu = m_c$) in the $\overline{\rm MS}$ scheme. We have converted masses in other schemes to the $\overline{\rm MS}$ scheme using two-loop QCD perturbation theory with $\alpha_s(\mu{=}m_c) = 0.38 \pm 0.03$. The value 1.27 ± 0.03 GeV for the $\overline{\rm MS}$ mass corresponds to 1.67 ± 0.07 GeV for the pole mass (see the "Note on Quark Masses").

VALUE (GeV)			*DOCUMENT ID*		*TECN*	*COMMENT*
1.27	**±0.03**	**OUR EVALUATION**	See the ideogram below.			
1.246	±0.023		[1] KIYO	16	THEO	$\overline{\rm MS}$ scheme
1.2715	±0.0095		[2] CHAKRABOR...	15	LATT	$\overline{\rm MS}$ scheme
1.288	±0.020		[3] DEHNADI	15	THEO	$\overline{\rm MS}$ scheme
1.348	±0.046		[4] CARRASCO	14	LATT	$\overline{\rm MS}$ scheme
1.26	±0.05	±0.04	[5] ABRAMOWICZ	13C	COMB	$\overline{\rm MS}$ scheme
1.24	±0.03	$^{+0.03}_{-0.07}$	[6] ALEKHIN	13	THEO	$\overline{\rm MS}$ scheme
1.282	±0.011	±0.022	[7] DEHNADI	13	THEO	$\overline{\rm MS}$ scheme
1.286	±0.066		[8] NARISON	13	THEO	$\overline{\rm MS}$ scheme
1.159	±0.075		[9] SAMOYLOV	13	NOMD	$\overline{\rm MS}$ scheme
1.36	±0.04	±0.10	[10] ALEKHIN	12	THEO	$\overline{\rm MS}$ scheme
1.261	±0.016		[11] NARISON	12A	THEO	$\overline{\rm MS}$ scheme
1.278	±0.009		[12] BODENSTEIN	11	THEO	$\overline{\rm MS}$ scheme
1.28	$^{+0.07}_{-0.06}$		[13] LASCHKA	11	THEO	$\overline{\rm MS}$ scheme
1.196	±0.059	±0.050	[14] AUBERT	10A	BABR	$\overline{\rm MS}$ scheme
1.28	±0.04		[15] BLOSSIER	10	LATT	$\overline{\rm MS}$ scheme
1.279	±0.013		[16] CHETYRKIN	09	THEO	$\overline{\rm MS}$ scheme
1.25	±0.04		[17] SIGNER	09	THEO	$\overline{\rm MS}$ scheme
• • • We do not use the following data for averages, fits, limits, etc. • • •						
1.01	±0.09	±0.03	[18] ALEKHIN	11	THEO	$\overline{\rm MS}$ scheme
1.299	±0.026		[19] BODENSTEIN	10	THEO	$\overline{\rm MS}$ scheme
1.273	±0.006		[20] MCNEILE	10	LATT	$\overline{\rm MS}$ scheme
1.261	±0.018		[21] NARISON	10	THEO	$\overline{\rm MS}$ scheme
1.268	±0.009		[22] ALLISON	08	LATT	$\overline{\rm MS}$ scheme
1.286	±0.013		[23] KUHN	07	THEO	$\overline{\rm MS}$ scheme
1.295	±0.015		[24] BOUGHEZAL	06	THEO	$\overline{\rm MS}$ scheme
1.24	±0.09		[25] BUCHMUEL...	06	THEO	$\overline{\rm MS}$ scheme
1.224	±0.017	±0.054	[26] HOANG	06	THEO	$\overline{\rm MS}$ scheme
1.33	±0.10		[27] AUBERT	04X	THEO	$\overline{\rm MS}$ scheme
1.29	±0.07		[28] HOANG	04	THEO	$\overline{\rm MS}$ scheme
1.319	±0.028		[29] DEDIVITIIS	03	LATT	$\overline{\rm MS}$ scheme
1.19	±0.11		[30] EIDEMULLER	03	THEO	$\overline{\rm MS}$ scheme
1.289	±0.043		[31] ERLER	03	THEO	$\overline{\rm MS}$ scheme
1.26	±0.02		[32] ZYABLYUK	03	THEO	$\overline{\rm MS}$ scheme

[1] KIYO 16 determine $\overline{m}_c(\overline{m}_c)$ from the $J/\psi(1S)$ mass at order α_s^3 (N3LO).

[2] CHAKRABORTY 15 is a lattice QCD computation using 2+1+1 dynamical flavors. Moments of pseudoscalar current-current correlators are matched to α_s^3-accurate QCD perturbation theory with the η_c meson mass tuned to experiment.

[3] DEHNADI 15 determine $\overline{m}_c(\overline{m}_c)$ using sum rules for $e^+ e^- \rightarrow$ hadrons at order α_s^3 (N3LO), and fitting to both experimental data and lattice results.

[4] 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.

[5] ABRAMOWICZ 13C determines m_c from charm production in deep inelastic $e p$ scattering, using the QCD prediction at NLO order. The uncertainties from model and parameterization assumptions, and the value of α_s, of ± 0.03, ± 0.02, and ± 0.02 respectively, have been combined in quadrature.

[6] ALEKHIN 13 determines m_c from charm production in deep inelastic scattering at HERA using approximate NNLO QCD.

[7] DEHNADI 13 determines m_c using QCD sum rules for the charmonium spectrum and charm continuum to order α_s^3 (N3LO). The statistical and systematic experimental errors of ± 0.006 and ± 0.009 have been combined in quadrature. The theoretical uncertainties ± 0.019 from truncation of the perturbation series, ± 0.010 from α_s, and ± 0.002 from the gluon condensate have been combined in quadrature.

[8] NARISON 13 determines m_c using QCD spectral sum rules to order α_s^2 (NNLO) and including condensates up to dimension 6.

[9] SAMOYLOV 13 determines m_c from a study of charm dimuon production in neutrino-iron scattering using the NLO QCD result for the charm quark production cross section.

[10] ALEKHIN 12 determines m_c from heavy quark production in deep inelastic scattering at HERA using approximate NNLO QCD.

[11] NARISON 12A determines m_c using sum rules for the vector current correlator to order α_s^3, including the effect of gluon condensates up to dimension eight.

[12] BODENSTEIN 11 determine $\overline{m}_c$(3 GeV) $= 0.987 \pm 0.009$ GeV and $\overline{m}_c(\overline{m}_c) = 1.278 \pm 0.009$ GeV using QCD sum rules for the charm quark vector current correlator.

[13] LASCHKA 11 determine the c mass from the charmonium spectrum. The theoretical computation uses the heavy $Q\overline{Q}$ potential to order $1/m_Q$ obtained by matching the short-distance perturbative result onto lattice QCD result at larger scales.

[14] AUBERT 10A determine the b- and c-quark masses from a fit to the inclusive decay spectra in semileptonic B decays in the kinetic scheme (and convert it to the $\overline{\text{MS}}$ scheme).

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

[16] CHETYRKIN 09 determine m_c and m_b from the $e^+ e^- \rightarrow Q\overline{Q}$ cross-section and sum rules, using an order α_s^3 computation of the heavy quark vacuum polarization. They also determine m_c(3 GeV) $= 0.986 \pm 0.013$GeV.

[17] SIGNER 09 determines the c-quark mass using non-relativistic sum rules to analyze the $e^+ e^- \rightarrow c\overline{c}$ cross-section near threshold. Also determine the PS mass $m_{PS}(\mu_F = 0.7$ GeV) $= 1.50 \pm 0.04$ GeV.

[18] ALEKHIN 11 determines m_c from heavy quark production in deep inelastic scattering using fixed target and HERA data, and approximate NNLO QCD.

[19] BODENSTEIN 10 determines $\overline{m}_c$(3 GeV) $= 1.008 \pm 0.026$ GeV using finite energy sum rules for the vector current correlator. The authors have converted this to $\overline{m}_c(\overline{m}_c)$ using $\alpha_s(M_Z) = 0.1189 \pm 0.0020$.

[20] MCNEILE 10 determines m_c by comparing the order α_s^3 perturbative results for the pseudo-scalar current to lattice simulations with $N_f = 2+1$ sea-quarks by the HPQCD collaboration.

[21] NARISON 10 determines m_c from ratios of moments of vector current correlators computed to order α_s^3 and including the dimension-six gluon condensate.

[22] ALLISON 08 determine m_c by comparing four-loop perturbative results for the pseudoscalar current correlator to lattice simulations by the HPQCD collaboration. The result has been updated in MCNEILE 10.

[23] KUHN 07 determine $\overline{m}_c(\mu = 3\text{ GeV}) = 0.986 \pm 0.013$ GeV and $\overline{m}_c(\overline{m}_c)$ from a four-loop sum-rule computation of the cross-section for $e^+ e^- \rightarrow$ hadrons in the charm threshold region.

[24] BOUGHEZAL 06 result comes from the first moment of the hadronic production cross-section to order α_s^3.

[25] BUCHMUELLER 06 determine m_b and m_c by a global fit to inclusive B decay spectra.

[26] HOANG 06 determines $\overline{m}_c(\overline{m}_c)$ from a global fit to inclusive B decay data. The B decay distributions were computed to order $\alpha_s^2 \beta_0$, and the conversion between different m_c mass schemes to order α_s^3.

[27] AUBERT 04X obtain m_c from a fit to the hadron mass and lepton energy distributions in semileptonic B decay. The paper quotes values in the kinetic scheme. The $\overline{\text{MS}}$ value has been provided by the BABAR collaboration.

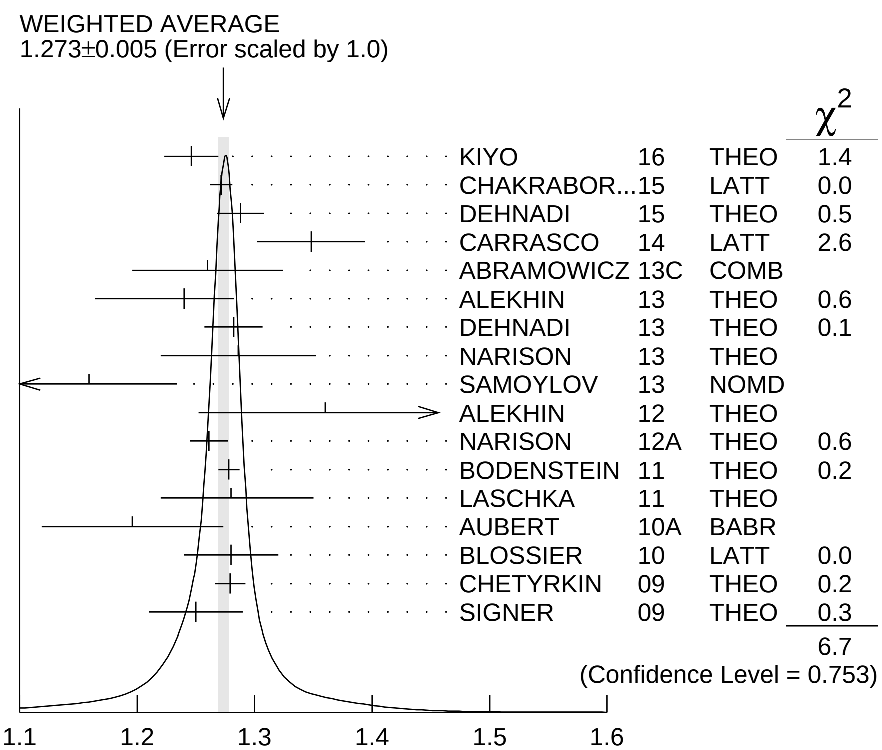
[28] HOANG 04 determines $\overline{m}_c(\overline{m}_c)$ from moments at order α_s^2 of the charm production cross-section in $e^+ e^-$ annihilation.

[29] DEDIVITIIS 03 use a quenched lattice computation of heavy-heavy and heavy-light meson masses.

[30] EIDEMULLER 03 determines m_b and m_c using QCD sum rules.

[31] ERLER 03 determines m_b and m_c using QCD sum rules. Includes recent BES data.

[32] ZYABLYUK 03 determines m_c by using QCD sum rules in the pseudoscalar channel and comparing with the η_c mass.



c-QUARK MASS (GeV)

m_c/m_s MASS RATIO

VALUE	DOCUMENT ID		TECN
11.72 ±0.25 OUR EVALUATION	See the ideogram below.		
11.652±0.065	[1] CHAKRABOR..	15	LATT
$11.747\pm0.019^{+0.059}_{-0.043}$	[2] BAZAVOV	14A	LATT
11.62 ±0.16	[3] CARRASCO	14	LATT
11.27 ±0.30 ±0.26	[4] DURR	12	LATT
12.0 ±0.3	[5] BLOSSIER	10	LATT
11.85 ±0.16	[6] DAVIES	10	LATT

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

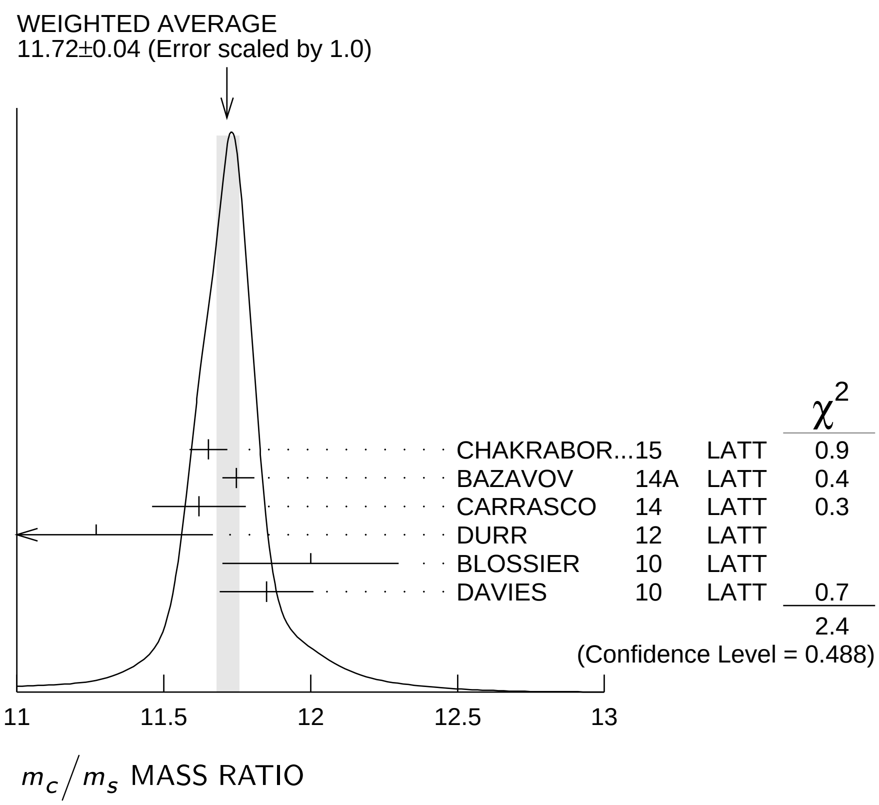
[2] BAZAVOV 14A is a lattice computation using 4 dynamical flavors of HISQ fermions.

[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] DURR 12 determine m_c/m_s using a lattice computation with $N_f = 2$ dynamical fermions. The result is combined with other determinations of m_c to obtain m_s(2 GeV) $= 97.0 \pm 2.6 \pm 2.5$ MeV.

[5] BLOSSIER 10 determine m_c/m_s from a computation of the hadron spectrum using $N_f = 2$ dynamical twisted-mass Wilson fermions.

[6] DAVIES 10 determine m_c/m_s from meson masses calculated on gluon fields including u, d, and s sea quarks with lattice spacing down to 0.045 fm. The Highly Improved Staggered quark formalism is used for the valence quarks.



m_b/m_c MASS RATIO

VALUE	DOCUMENT ID	TECN
4.528±0.054	[1] CHAKRABOR..15	LATT

[1] CHAKRABORTY 15 is a lattice computation using 4 dynamical quark flavors.

m_b-m_c QUARK MASS DIFFERENCE

VALUE (GeV)	DOCUMENT ID		TECN
3.45 ±0.05 OUR EVALUATION			
• • • We do not use the following data for averages, fits, limits, etc. • • •			
3.472±0.032	[1] AUBERT	10A	BABR
3.42 ±0.06	[2] ABDALLAH	06B	DLPH
3.44 ±0.03	[3] AUBERT	04X	BABR
3.41 ±0.01	[3] BAUER	04	THEO

[1] AUBERT 10A determine the b- and c-quark masses from a fit to the inclusive decay spectra in semileptonic B decays in the kinetic scheme.

[2] ABDALLAH 06B determine m_b-m_c from moments of the hadron invariant mass and lepton energy spectra in semileptonic inclusive B decays.

[3] Determine m_b-m_c from a global fit to inclusive B decay spectra.

c-QUARK REFERENCES

KIYO	16	PL B752 122	Y. Kiyo, G. Mishima, Y. Sumino	
CHAKRABOR...	15	PR D91 054508	B. Chakraborty et al.	(HPQCD Collab.)
DEHNADI	15	JHEP 1508 155	B. Dehnadi, A.H. Hoang, V. Mateu	
BAZAVOV	14A	PR D90 074509	A. Bazavov et al.	(Fermi-LAT and MILC Collabs.)
CARRASCO	14	NP B887 19	N. Carrasco et al.	(European Twisted Mass Collab.)
ABRAMOWICZ	13C	EPJ C73 2311	H. Abramovicz et al.	(H1 and Zeus Collabs.)
ALEKHIN	13	PL B720 172	S. Alekhin et al.	(SERP, DESYZ, WUPP+)
DEHNADI	13	JHEP 1309 103	B. Dehnadi et al.	(SHRZ, VIEN, MPIM+)
NARISON	13	PL B718 1321	S. Narison	(MONP)
SAMOYLOV	13	NP B876 339	O. Samoylov et al.	(NOMAD Collab.)
ALEKHIN	12	PL B718 550	S. Alekhin et al.	(SERP, WUPP, DESY+)
DURR	12	PRL 108 122003	S. Durr, G. Koutsou	(WUPP, JULI, CYPR)
NARISON	12A	PL B706 412	S. Narison	(MONP)
ALEKHIN	11	PL B699 345	S. Alekhin, S. Moch	(DESY, SERP)
BODENSTEIN	11	PR D83 074014	S. Bodenstein et al.	
LASCHKA	11	PR D83 094002	A. Laschka, N. Kaiser, W. Weise	
AUBERT	10A	PR D81 032003	B. Aubert et al.	(BABAR Collab.)
BLOSSIER	10	PR D82 114513	B. Blossier et al.	(ETM Collab.)
BODENSTEIN	10	PR D82 114013	S. Bodenstein et al.	
DAVIES	10	PRL 104 132003	C.T.H. Davies et al.	(HPQCD Collab.)
MCNEILE	10	PR D82 034512	C. McNeile et al.	(HPQCD Collab.)
NARISON	10	PL B693 559	S. Narison	(MONP)
Also		PL B705 544 (errat.)	S. Narison	(MONP)
CHETYRKIN	09	PR D80 074010	K.G. Chetyrkin et al.	(KARL, BNL)
SIGNER	09	PL B672 333	A. Signer	(DURH)
ALLISON	08	PR D78 054513	I. Allison et al.	(HPQCD Collab.)
KUHN	07	NP B778 192	J.H. Kuhn, M. Steinhauser, C. Sturm	
ABDALLAH	06B	EPJ C45 35	J. Abdallah et al.	(DELPHI Collab.)
BOUGHEZAL	06	PR D74 074006	R. Boughezal, M. Czakon, T. Schutzmeier	
BUCHMUEL...	06	PR D73 073008	O.L. Buchmueller, H.U. Flacher	(RHBL)
HOANG	06	PL B633 526	A.H. Hoang, A.V. Manohar	
AUBERT	04X	PRL 93 011803	B. Aubert et al.	(BABAR Collab.)
BAUER	04	PR D70 094017	C. Bauer et al.	
HOANG	04	PL B594 127	A.H. Hoang, M. Jamin	
DEDIVITIIS	03	NP B675 309	G.M. de Divitiis et al.	
EIDEMULLER	03	PR D67 113002	M. Eidemuller	
ERLER	03	PL B558 125	J. Erler, M. Luo	
ZYABLYUK	03	JHEP 0301 081	K.N. Zyablyuk	(ITEP)