b

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

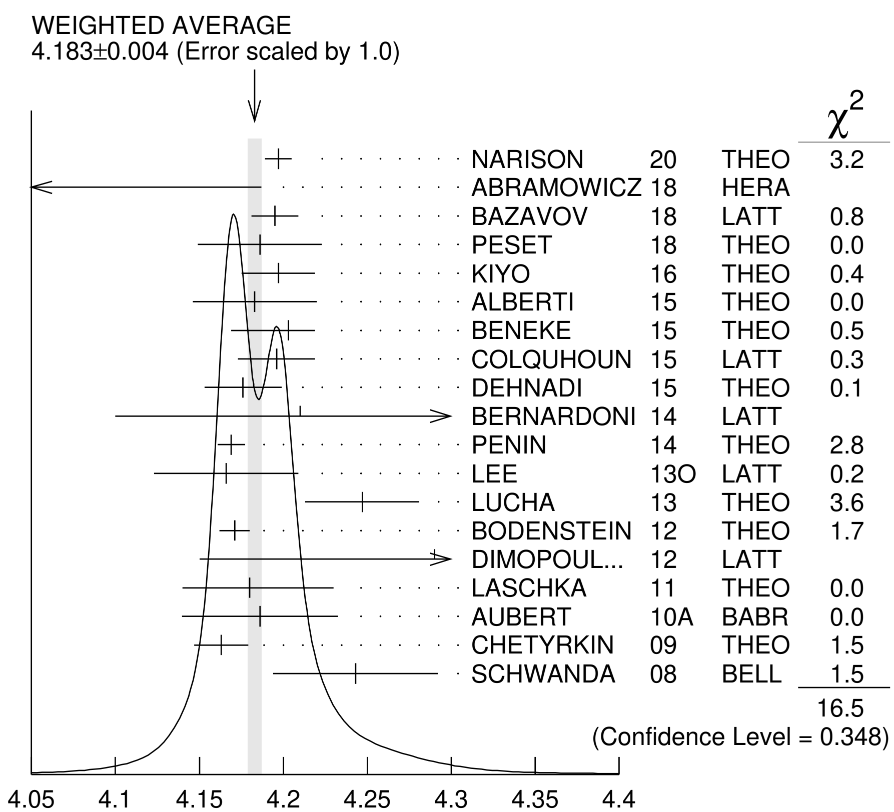
Charge $= -\frac{1}{3}\ e$ Bottom $= -1$

b-QUARK MASS

b-quark mass corresponds to the "running mass" $\overline{m}_b(\mu = \overline{m}_b)$ in the $\overline{\rm MS}$ scheme. We have converted masses in other schemes to the $\overline{\rm MS}$ mass using two-loop QCD perturbation theory with $\alpha_s(\mu = \overline{m}_b) = 0.223 \pm 0.008$. The value $4.18^{+0.04}_{-0.03}$ GeV for the $\overline{\rm MS}$ mass corresponds to 4.78 ± 0.06 GeV for the pole mass, using the two-loop conversion formula. A discussion of masses in different schemes can be found in the "Note on Quark Masses."

$\overline{\rm MS}$ *MASS* (GeV)	*DOCUMENT ID*		*TECN*
4.18 $^{+0.03}_{-0.02}$ **OUR EVALUATION** of $\overline{\rm MS}$ Mass. See the ideogram below.			
4.197 ± 0.008	[1] NARISON	20	THEO
$4.049^{+0.138}_{-0.118}$	[2] ABRAMOWICZ	18	HERA
4.195 ± 0.014	[3] BAZAVOV	18	LATT
4.186 ± 0.037	[4] PESET	18	THEO
4.197 ± 0.022	[5] KIYO	16	THEO
4.183 ± 0.037	[6] ALBERTI	15	THEO
$4.203^{+0.016}_{-0.034}$	[7] BENEKE	15	THEO
4.196 ± 0.023	[8] COLQUHOUN	15	LATT
4.176 ± 0.023	[9] DEHNADI	15	THEO
4.21 ± 0.11	[10] BERNARDONI	14	LATT
$4.169 \pm 0.002 \pm 0.008$	[11] PENIN	14	THEO
4.166 ± 0.043	[12] LEE	13O	LATT
4.247 ± 0.034	[13] LUCHA	13	THEO
4.171 ± 0.009	[14] BODENSTEIN	12	THEO
4.29 ± 0.14	[15] DIMOPOUL...	12	LATT
$4.18^{+0.05}_{-0.04}$	[16] LASCHKA	11	THEO
$4.186 \pm 0.044 \pm 0.015$	[17] AUBERT	10A	BABR
4.163 ± 0.016	[18] CHETYRKIN	09	THEO
4.243 ± 0.049	[19] SCHWANDA	08	BELL
• • • We do not use the following data for averages, fits, limits, etc. • • •			
4.184 ± 0.011	[20] NARISON	18A	THEO
4.188 ± 0.008	[21] NARISON	18B	THEO
4.07 ± 0.17	[22] ABRAMOWICZ	14A	ZEUS
4.201 ± 0.043	[23] AYALA	14A	THEO
4.236 ± 0.069	[24] NARISON	13	THEO
4.213 ± 0.059	[25] NARISON	13A	THEO
$4.235 \pm 0.003 \pm 0.055$	[26] HOANG	12	THEO
4.212 ± 0.032	[27] NARISON	12	THEO
4.177 ± 0.011	[28] NARISON	12	THEO
4.171 ± 0.014	[29] NARISON	12A	THEO
4.164 ± 0.023	[30] MCNEILE	10	LATT
4.173 ± 0.010	[31] NARISON	10	THEO

5.26 ±1.2	[32] ABDALLAH	08D	DLPH
4.42 ±0.06 ±0.08	[33] GUAZZINI	08	LATT
4.347±0.048±0.08	[34] DELLA-MOR...	07	LATT
4.164±0.025	[35] KUHN	07	THEO
4.19 ±0.40	[36] ABDALLAH	06D	DLPH
4.205±0.058	[37] BOUGHEZAL	06	THEO
4.20 ±0.04	[38] BUCHMUEL...	06	THEO
4.19 ±0.06	[39] PINEDA	06	THEO
4.4 ±0.3	[40] GRAY	05	LATT
4.22 ±0.06	[41] AUBERT	04X	THEO
4.17 ±0.03	[42] BAUER	04	THEO
4.22 ±0.11	[43] HOANG	04	THEO
4.25 ±0.11	[44] MCNEILE	04	LATT
4.22 ±0.09	[45] BAUER	03	THEO
4.19 ±0.05	[46] BORDES	03	THEO
4.20 ±0.09	[47] CORCELLA	03	THEO
4.33 ±0.10	[48] DEDIVITIIS	03	LATT
4.24 ±0.10	[49] EIDEMULLER	03	THEO
4.207±0.03	[50] ERLER	03	THEO
4.33 ±0.06 ±0.10	[51] MAHMOOD	03	CLEO
4.190±0.032	[52] BRAMBILLA	02	THEO
4.346±0.070	[53] PENIN	02	THEO



b-QUARK $\overline{\rm MS}$ MASS (GeV)

[1] NARISON 20 determines the quark mass using QCD Laplace sum rules from the B_c mass, combined with previous determinations of the QCD condensates and c and b masses.

[2] ABRAMOWICZ 18 determine $\overline{m}_b(\overline{m}_b) = 4.049^{+0.104}_{-0.109}{}^{+0.090}_{-0.032}{}^{+0.001}_{-0.031}$ from the production of b quarks in $e p$ collisions at HERA using combined H1 and ZEUS data. The experimental/fitting errors, and those from modeling and parameterization have been combined in quadrature.

[3] BAZAVOV 18 determine the b mass using a lattice computation with staggered fermions and five active quark flavors.

[4] PESET 18 determine $\overline{m}_c(\overline{m}_c)$ and $\overline{m}_b(\overline{m}_b)$ using an N3LO calculation of the η_c, η_b and B_c masses.

[5] KIYO 16 determine $\overline{m}_b(\overline{m}_b)$ from the $\Upsilon(1S)$ mass at order α_s^3 (N3LO).

[6] ALBERTI 15 determine $\overline{m}_b(\overline{m}_b)$ from fits to inclusive $B \rightarrow X_c e \overline{\nu}$ decay. They also find $m_b^{\text{kin}}(1\text{ GeV}) = 4.553 \pm 0.020$ GeV.

[7] BENEKE 15 determine $\overline{m}_b(\overline{m}_b)$ using sum rules for $e^+ e^- \rightarrow$ hadrons at order N3LO including finite m_c effects. They find $m_b^{\text{PS}}(2\text{ GeV}) = 4.532^{+0.013}_{-0.039}$ GeV, and $\overline{m}_b(\overline{m}_b) = 4.193^{+0.022}_{-0.035}$ GeV. The value quoted is obtained using the four-loop conversion given in BENEKE 16.

[8] COLQUHOUN 15 determine $\overline{m}_b(\overline{m}_b)$ from moments of the vector current correlator computed with a lattice simulation using the NRQCD action.

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

[10] BERNARDONI 14 determine m_b from $N_f = 2$ lattice calculations using heavy quark effective theory non-perturbatively renormalized and matched to QCD at $1/m$ order.

[11] PENIN 14 determine $\overline{m}_b(\overline{m}_b) = 4.169 \pm 0.008 \pm 0.002 \pm 0.002$ using an estimate of the order α_s^3 b-quark vacuum polarization function in the threshold region, including finite m_c effects. The errors of ± 0.008 from theoretical uncertainties, and ± 0.002 from α_s have been combined in quadrature.

[12] LEE 13O determines m_b using lattice calculations of the Υ and B_s binding energies in NRQCD, including three light dynamical quark flavors. The quark mass shift in NRQCD is determined to order α_s^2, with partial α_s^3 contributions.

[13] LUCHA 13 determines m_b from QCD sum rules for heavy-light currents using the lattice value for f_B of 191.5 $\pm$ 7.3 GeV.

[14] BODENSTEIN 12 determine m_b using sum rules for the vector current correlator and the $e^+ e^- \rightarrow Q\overline{Q}$ total cross-section.

[15] DIMOPOULOS 12 determine quark masses from a lattice computation using $N_f = 2$ dynamical flavors of twisted mass fermions.

[16] LASCHKA 11 determine the b 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.

[17] 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).

[18] 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 (N3LO) computation of the heavy quark vacuum polarization.

[19] SCHWANDA 08 measure moments of the inclusive photon spectrum in $B \rightarrow X_s \gamma$ decay to determine m_b^{1S}. We have converted this to $\overline{\text{MS}}$ scheme.

[20] NARISON 18A determines $\overline{m}_b(\overline{m}_b)$ as a function of α_s using QCD exponential sum rules and their ratios evaluated at the optimal scale $\mu = 9.5$ GeV at N2LO-N3LO of perturbative QCD and including condensates up to dimension 6–8 in the (axial-)vector and (pseudo-)scalar bottomonium channels.

[21] NARISON 18B determines $\overline{m}_b(\overline{m}_b)$ using QCD vector moment sum rules and their ratios at N2LO-N3LO of perturbative QCD and including condensates up to dimension 8.

[22] ABRAMOWICZ 14A determine $\overline{m}_b(\overline{m}_b) = 4.07 \pm 0.14^{+0.01}_{-0.07}{}^{+0.05}_{-0.00}{}^{+0.08}_{-0.05}$ from the production of b quarks in $e p$ collisions at HERA. The errors due to fitting, modeling,

PDF parameterization, and theoretical QCD uncertainties due to the values of α_s, m_c, and the renormalization scale μ have been combined in quadrature.

[23] AYALA 14A determine $\overline{m}_b(\overline{m}_b)$ from the $\Upsilon(1S)$ mass computed to N3LO order in perturbation theory using a renormalon subtracted scheme.

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

[25] NARISON 13A determines m_b using HQET sum rules to order α_s^2 (NNLO) and the B meson mass and decay constant.

[26] HOANG 12 determine m_b using non-relativistic sum rules for the Υ system at order α_s^2 (NNLO) with renormalization group improvement.

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

[28] Determines m_b to order α_s^3 (N3LO), including the effect of gluon condensates up to dimension eight combining the methods of NARISON 12 and NARISON 12A.

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

[30] MCNEILE 10 determines m_b by comparing order α_s^3 (N3LO) perturbative results for the pseudo-scalar current to lattice simulations with N_f = 2+1 sea-quarks by the HPQCD collaboration.

[31] NARISON 10 determines m_b from ratios of moments of vector current correlators computed to order α_s^3 and including the dimension-six gluon condensate. These values are taken from the erratum to that reference.

[32] ABDALLAH 08D determine $\overline{m}_b(M_Z) = 3.76 \pm 1.0$ GeV from a leading order study of four-jet rates at LEP.

[33] GUAZZINI 08 determine $\overline{m}_b(\overline{m}_b)$ from a quenched lattice simulation of heavy meson masses. The ± 0.08 is an estimate of the quenching error.

[34] DELLA-MORTE 07 determine $\overline{m}_b(\overline{m}_b)$ from a computation of the spin-averaged B meson mass using quenched lattice HQET at order $1/m$. The ± 0.08 is an estimate of the quenching error.

[35] KUHN 07 determine $\overline{m}_b(\mu = 10 \text{ GeV}) = 3.609 \pm 0.025$ GeV and $\overline{m}_b(\overline{m}_b)$ from a four-loop sum-rule computation of the cross-section for $e^+ e^- \rightarrow$ hadrons in the bottom threshold region.

[36] ABDALLAH 06D determine $m_b(M_Z) = 2.85 \pm 0.32$ GeV from Z-decay three-jet events containing a b-quark.

[37] BOUGHEZAL 06 $\overline{\text{MS}}$ scheme result comes from the first moment of the hadronic production cross-section to order α_s^3.

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

[39] PINEDA 06 $\overline{\text{MS}}$ scheme result comes from a partial NNLL evaluation (complete at order α_s^2 (NNLO)) of sum rules of the bottom production cross-section in $e^+ e^-$ annihilation.

[40] GRAY 05 determines $\overline{m}_b(\overline{m}_b)$ from a lattice computation of the Υ spectrum. The simulations have 2+1 dynamical light flavors. The b quark is implemented using NRQCD.

[41] AUBERT 04X obtain m_b 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.

[42] BAUER 04 determine m_b, m_c and $m_b - m_c$ by a global fit to inclusive B decay spectra.

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

[44] MCNEILE 04 use lattice QCD with dynamical light quarks and a static heavy quark to compute the masses of heavy-light mesons.

[45] BAUER 03 determine the b quark mass by a global fit to B decay observables. The experimental data includes lepton energy and hadron invariant mass moments in semileptonic

$B \to X_c \ell \nu_\ell$ decay, and the inclusive photon spectrum in $B \to X_s \gamma$ decay. The theoretical expressions used are of order $1/\mathrm{m}^3$, and $\alpha_s^2 \beta_0$.

[46] BORDES 03 determines m_b using QCD finite energy sum rules to order α_s^2.

[47] CORCELLA 03 determines $\overline{m}_b$ using sum rules computed to order α_s^2. Includes charm quark mass effects.

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

[49] EIDEMULLER 03 determines $\overline{m}_b$ and $\overline{m}_c$ using QCD sum rules.

[50] ERLER 03 determines $\overline{m}_b$ and $\overline{m}_c$ using QCD sum rules. Includes recent BES data.

[51] MAHMOOD 03 determines m_b^{1S} by a fit to the lepton energy moments in $B \to X_c \ell \nu_\ell$ decay. The theoretical expressions used are of order $1/\mathrm{m}^3$ and $\alpha_s^2 \beta_0$. We have converted their result to the $\overline{\mathrm{MS}}$ scheme.

[52] BRAMBILLA 02 determine $\overline{m}_b(\overline{m}_b)$ from a computation of the $\Upsilon(1S)$ mass to order α_s^4, including finite m_c corrections.

[53] PENIN 02 determines $\overline{m}_b$ from the spectrum of the Υ system.

m_b/m_s MASS RATIO

VALUE	DOCUMENT ID		TECN
53.94±0.12	[1] BAZAVOV	18	LATT

[1] BAZAVOV 18 determine the quark masses using a lattice computation with staggered fermions and four active quark flavors for the u, d, s, c quarks and five active flavors for the b quark.

b-QUARK REFERENCES

NARISON	20	PL B802 135221	S. Narison	(MONP)
ABRAMOWICZ	18	EPJ C78 473	H. Abramowicz *et al.*	(H1 and ZEUS Collabs.)
BAZAVOV	18	PR D98 054517	A. Bazavov *et al.*	(Fermilab Lattice, MILC, TUMQCD)
NARISON	18A	IJMP A33 1850045	S. Narison	(MONP)
NARISON	18B	PL B784 261	S. Narison	(MONP)
PESET	18	JHEP 1809 167	C. Peset, A. Pineda, J. Segovia	(BARC, TUM)
BENEKE	16	PoS RADCOR2015 035	M. Beneke *et al.*	
KIYO	16	PL B752 122	Y. Kiyo, G. Mishima, Y. Sumino	
ALBERTI	15	PRL 114 061802	A. Alberti *et al.*	
BENEKE	15	NP B891 42	M. Beneke *et al.*	
COLQUHOUN	15	PR D91 074514	B. Colquhoun *et al.*	(HPQCD Collab.)
DEHNADI	15	JHEP 1508 155	B. Dehnadi, A.H. Hoang, V. Mateu	
ABRAMOWICZ	14A	JHEP 1409 127	H. Abramowicz *et al.*	(ZEUS Collab.)
AYALA	14A	JHEP 1409 045	C. Ayala, G. Cvetic, A. Pineda	
BERNARDONI	14	PL B730 171	F. Bernardoni *et al.*	(ALPHA Collab.)
PENIN	14	JHEP 1404 120	A.A. Penin, N. Zerf	
LEE	13O	PR D87 074018	A.J. Lee *et al.*	(HPQCD Collab.)
LUCHA	13	PR D88 056011	W. Lucha, D. Melikhov, S. Simula	(VIEN, MOSU+)
NARISON	13	PL B718 1321	S. Narison	(MONP)
NARISON	13A	PL B721 269	S. Narison	(MONP)
BODENSTEIN	12	PR D85 034003	S. Bodenstein *et al.*	(CAPE, VALE, MAINZ+)
DIMOPOUL...	12	JHEP 1201 046	P. Dimopoulos *et al.*	(ETM Collab.)
HOANG	12	JHEP 1210 188	A.H. Hoang, P. Ruiz-Femenia, M. Stahlhofen	(WIEN+)
NARISON	12	PL B707 259	S. Narison	(MONP)
NARISON	12A	PL B706 412	S. Narison	(MONP)
LASCHKA	11	PR D83 094002	A. Laschka, N. Kaiser, W. Weise	
AUBERT	10A	PR D81 032003	B. Aubert *et al.*	(BABAR 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)
ABDALLAH	08D	EPJ C55 525	J. Abdallah *et al.*	(DELPHI Collab.)
GUAZZINI	08	JHEP 0801 076	D. Guazzini, R. Sommer, N. Tantalo	

SCHWANDA	08	PR D78 032016	C. Schwanda *et al.*	(BELLE Collab.)
DELLA-MOR...	07	JHEP 0701 007	M. Della Morte *et al.*	
KUHN	07	NP B778 192	J.H. Kuhn, M. Steinhauser, C. Sturm	
ABDALLAH	06D	EPJ C46 569	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)
PINEDA	06	PR D73 111501	A. Pineda, A. Signer	
GRAY	05	PR D72 094507	A. Gray *et al.*	(HPQCD and UKQCD Collab.)
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	
MCNEILE	04	PL B600 77	C. McNeile, C. Michael, G. Thompson	(UKQCD Collab.)
BAUER	03	PR D67 054012	C.W. Bauer *et al.*	
BORDES	03	PL B562 81	J. Bordes, J. Penarrocha, K. Schilcher	
CORCELLA	03	PL B554 133	G. Corcella, A.H. Hoang	
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	
MAHMOOD	03	PR D67 072001	A.H. Mahmood *et al.*	(CLEO Collab.)
BRAMBILLA	02	PR D65 034001	N. Brambilla, Y. Sumino, A. Vairo	
PENIN	02	PL B538 335	A. Penin, M. Steinhauser	