# b

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

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

## b-QUARK MASS

The first value is the "running mass" $\overline{m}_b(\mu = \overline{m}_b)$ in the $\overline{\text{MS}}$ scheme, and the second value is the $1S$ mass, which is half the mass of the $\Upsilon(1S)$ in perturbation theory. For a review of different quark mass definitions and their properties, see EL-KHADRA 02. The $1S$ mass is better suited for use in analyzing $B$ decays than the $\overline{\text{MS}}$ mass because it gives a stable perturbative expansion. We have converted masses in other schemes to the $\overline{\text{MS}}$ mass and $1S$ mass using two-loop QCD perturbation theory with $\alpha_s(\mu = \overline{m}_b) = 0.22$. The values $4.20^{+0.17}_{-0.07}$ GeV for the $\overline{\text{MS}}$ mass and $4.68^{+0.17}_{-0.07}$ GeV for the $1S$ mass correspond to $4.79^{+0.19}_{-0.08}$ 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."

| $\overline{\text{MS}}$ *MASS* (GeV) | *1S MASS* (GeV) | *DOCUMENT ID* | | *TECN* |
|---|---|---|---|---|
| **$4.20^{+0.17}_{-0.07}$ OUR EVALUATION** of $\overline{\text{MS}}$ Mass. See the ideogram below. | | | | |
| **$4.68^{+0.17}_{-0.07}$ OUR EVALUATION** of $1S$ Mass. See the ideogram below. | | | | |
| 4.347±0.048 | 4.838 ± 0.053 | [1] DELLA-MOR... | 07 | LATT |
| 4.164±0.025 | 4.635 ± 0.028 | [2] KUHN | 07 | THEO |
| 4.205±0.058 | 4.68 ± 0.06 | [3] BOUGHEZAL | 06 | THEO |
| 4.20 ±0.04 | 4.67 ± 0.04 | [4] BUCHMULLER | 06 | THEO |
| 4.19 ±0.06 | 4.66 ± 0.07 | [5] PINEDA | 06 | THEO |
| 4.4 ±0.3 | 4.9 ± 0.3 | [6,7] GRAY | 05 | LATT |
| 4.22 ±0.06 | 4.72 ± 0.07 | [8] AUBERT | 04X | THEO |
| 4.17 ±0.03 | 4.68 ± 0.03 | [9] BAUER | 04 | THEO |
| 4.22 ±0.11 | 4.72 ± 0.12 | [7,10] HOANG | 04 | THEO |
| 4.25 ±0.11 | 4.76 ± 0.12 | [7,11] MCNEILE | 04 | LATT |
| 4.22 ±0.09 | 4.74 ± 0.10 | [12] BAUER | 03 | THEO |
| 4.19 ±0.05 | 4.66 ± 0.05 | [13] BORDES | 03 | THEO |
| 4.20 ±0.09 | 4.67 ± 0.10 | [14] CORCELLA | 03 | THEO |
| 4.33 ±0.10 | 4.84 ± 0.11 | [7,15] DEDIVITIIS | 03 | LATT |
| 4.24 ±0.10 | 4.72 ± 0.11 | [16] EIDEMULLER | 03 | THEO |
| 4.207±0.031 | 4.682 ± 0.035 | [17] ERLER | 03 | THEO |
| 4.33 ±0.06 ±0.10 | 4.82 ± 0.07 ± 0.11 | [18] MAHMOOD | 03 | THEO |
| 4.190±0.032 | 4.663 ± 0.036 | [19] BRAMBILLA | 02 | THEO |
| 4.346±0.070 | 4.837 ± 0.078 | [20] PENIN | 02 | THEO |
| 4.05 ±0.06 | 4.51 ± 0.07 | [21] NARISON | 01B | THEO |
| 4.210±0.090±0.025 | 4.69 ± 0.100 ± 0.028 | [22] PINEDA | 01 | THEO |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 4.19 ±0.40 | 4.66 ± 0.45 | [23] ABDALLAH | 06D | DLPH |
| 3.95 ±0.57 | 4.40 ± 0.63 | [24] ABBIENDI | 01S | OPAL |

| | | | | |
|---|---|---|---|---|
| $4.203 \pm 0.026$ | $4.678 \pm 0.029$ | [25] BRAMBILLA | 01 | THEO |
| $4.21 \pm 0.05$ | $4.69 \pm 0.06$ | [26] KUHN | 01 | THEO |
| $4.7 \pm 0.74$ | $5.23 \pm 0.82$ | [27] BARATE | 00V | ALEP |
| $4.20 \pm 0.06$ | $4.71 \pm 0.03$ | [28] HOANG | 00 | THEO |
| $4.437^{+0.045}_{-0.029}$ | $4.938^{+0.050}_{-0.032}$ | [29] LUCHA | 00 | THEO |
| $4.454^{+0.045}_{-0.029}$ | $4.957^{+0.050}_{-0.032}$ | [29] PINEDA | 00 | THEO |
| $4.25 \pm 0.08$ | $4.73 \pm 0.09$ | [30] BENEKE | 99 | THEO |
| $3.8^{+0.77}_{-2.0}$ | $4.23^{+0.86}_{-2.0}$ | [31] BRANDENB... | 99 | |
| $4.25 \pm 0.09$ | $4.73 \pm 0.10$ | [32] HOANG | 99 | THEO |
| $4.2 \pm 0.1$ | $4.67 \pm 0.11$ | [33] MELNIKOV | 99 | THEO |
| $4.21 \pm 0.11$ | $4.69 \pm 0.12$ | [34] PENIN | 99 | THEO |
| $3.91 \pm 0.67$ | $4.35 \pm 0.75$ | [35] ABREU | 98I | DLPH |
| $4.14 \pm 0.04$ | $4.61 \pm 0.05$ | [36] KUEHN | 98 | THEO |
| $4.15 \pm 0.05 \pm 0.20$ | $4.62 \pm 0.06 \pm 0.22$ | [37] GIMENEZ | 97 | LATT |
| $4.19 \pm 0.06$ | $4.66 \pm 0.07$ | [38] JAMIN | 97 | THEO |
| $4.16 \pm 0.32 \pm 0.60$ | $4.63 \pm 0.36 \pm 0.67$ | [39] RODRIGO | 97 | THEO |

[1] 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 $1/m$.

[2] KUHN 07 determine $\overline{m}_b(\mu = 10$ 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 $e^+ e^- \to$ hadrons in the bottom threshold region. We have converted this to the 1S scheme.

[3] BOUGHEZAL 06 $\overline{\text{MS}}$ scheme result comes from the first moment of the hadronic production cross-section to order $\alpha_s^3$. We have converted it to the 1S scheme.

[4] BUCHMULLER 06 determine $m_b$ and $m_c$ by a global fit to inclusive $B$ decay spectra. We have converted this to the 1S scheme.

[5] PINEDA 06 $\overline{\text{MS}}$ scheme result comes from a partial NNLL evaluation (complete at NNLO) of sum rules of the bottom production cross-section in $e^+ e^-$ annihilation. We have converted it to the 1S scheme.

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

[7] We have converted $m_b$ to the 1S scheme.

[8] 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, and we have converted this to the 1S scheme.

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

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

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

[12] 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 $1/\text{m}^3$, and $\alpha_s^2 \beta_0$.

[13] BORDES 03 determines $\text{m}_b$ using QCD finite energy sum rules to order $\alpha_s^2$.

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

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

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

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

[18] MAHMOOD 03 determines $m_b^{1S}$ by a fit to the lepton energy moments in $B \rightarrow X_c \ell \nu_\ell$ 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.

[19] BRAMBILLA 02 determine $\overline{m}_b(\overline{m}_b)$ from a computation of the $\Upsilon(1S)$ mass to order $\alpha_s^4$, including finite $m_c$ corrections. We have converted this to the 1S scheme.

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

[21] NARISON 01B uses pseudoscalar sum rules in the $B$ and $D$ meson channels.

[22] PINEDA 01 uses the $\Upsilon(1S)$ system to determine the quark mass. The errors are due to theory, and the uncertainty in $\alpha_s$.

[23] ABDALLAH 06D determine $m_b(M_Z) = 2.85 \pm 0.32$ GeV from $Z$-decay three-jet events containing a $b$-quark. We have converted this to $\overline{m}_b(\overline{m}_b)$ and $m_b^{1S}$.

[24] ABBIENDI 01S find $\overline{m}_b$ $(M_Z)$ to be $2.67 \pm 0.4$ GeV from an analysis of $Z \rightarrow$ $b$ decays.

[25] BRAMBILLA 01 determine $\overline{m}_b(\overline{m}_b)$ from a computation of the $J/\psi$ mass. We have converted this to the 1S scheme.

[26] KUHN 01 uses an analysis of the $e^+ e^-$ total cross section to hadrons.

[27] BARATE 00V obtain the $b$ quark mass $\overline{m}_b(M_Z) = 3.27 \pm 0.22(\mathrm{stat}) \pm 0.22(\mathrm{exp}) \pm 0.38(\mathrm{had}) \pm 0.16(\mathrm{thy})$ from an analysis of event shape variables in $Z$ decays. We have converted this to $\mu = \overline{m}_b$.

[28] HOANG 00 uses a NNLO calculation of the vacuum polarization function to determine spectral moments of the masses and electronic decay widths of the $\Upsilon$ mesons.

[29] LUCHA 00, PINEDA 00 obtain the $b$-quark mass from a perturbative calculation of the $\Upsilon$ spectrum and decay widths to order $\alpha_s^4$.

[30] BENEKE 99 uses a calculation of the $b\overline{b}$ production cross section and the mass of the $\Upsilon$ meson at NNLO.

[31] BRANDENBURG 99 obtain a $b$-quark mass of $\overline{m}_b(M_Z) = 2.56 \pm 0.27^{+0.28}_{-0.38}{}^{+0.49}_{-1.48}$ from a study of three-jet events at the $Z$. We have converted this to $\mu = \overline{m}_b$.

[32] HOANG 99 uses a NNLO calculation of the vacuum polarization function to determine spectral moments of the masses and electronic decay widths of the $\Upsilon$ mesons.

[33] MELNIKOV 99 compute the quark mass using $\Upsilon$ sum rules at NNLO.

[34] PENIN 99 compute the quark mass using $\Upsilon$ sum rules at NNLO.

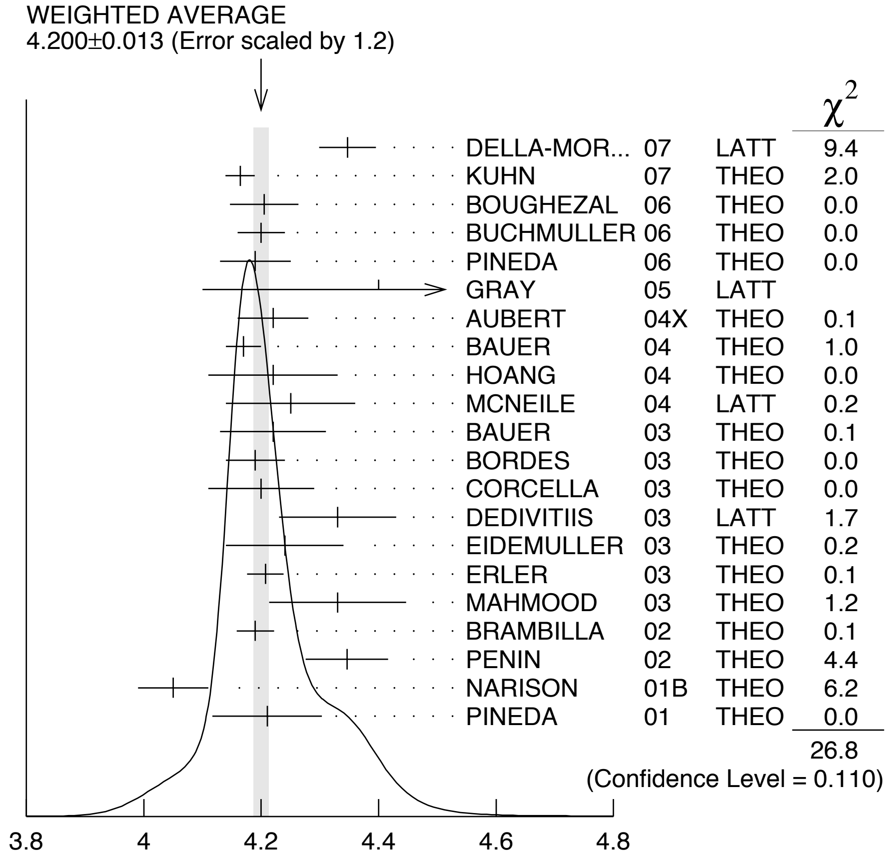
[35] ABREU 98I determines the $\overline{\mathrm{MS}}$ mass $\overline{m}_b = 2.67 \pm 0.25 \pm 0.34 \pm 0.27$ GeV at $\mu = M_Z$ from three jet heavy quark production at LEP. ABREU 98I have rescaled the result to $\mu = \overline{m}_b$ using $\alpha_s = 0.118 \pm 0.003$.

[36] KUEHN 98 uses a calculation of the vacuum polarization function, including resumming threshold effects, to determine spectral moments of the masses of the $\Upsilon$ mesons. We have converted their extracted value of $4.75 \pm 0.04$ for the pole mass to the $\overline{\mathrm{MS}}$ scheme.

[37] GIMENEZ 97 uses lattice computations of the $B$-meson propagator and the $B$-meson binding energy $\overline{\Lambda}$ in the HQET. Their systematic (second) error for the $\overline{\mathrm{MS}}$ mass is an estimate of the effects of higher-order corrections in the matching of the HQET operators (renormalon effects).

[38] JAMIN 97 apply the QCD moment method to the $\Upsilon$ system. They also find a pole mass of $4.60 \pm 0.02$.

[39] RODRIGO 97 determines the $\overline{\mathrm{MS}}$ mass $\overline{m}_b = 2.85 \pm 0.22 \pm 0.20 \pm 0.36$ GeV at $\mu = M_Z$ from three jet heavy quark production at LEP. We have rescaled the result.




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

## *b*-QUARK REFERENCES


| | | | | |
|---|---|---|---|---|
| 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 | |
| BUCHMULLER | 06 | PR D73 073008 | O.L. Buchmuller, H.U. Flacher | |
| PINEDA | 06 | PR D73 111501R | A. Pineda, A. Signer | |
| GRAY | 05 | PR D72 094507 | A. Gray *et al.* | (HPQCD, 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 | |
| EL-KHADRA | 02 | ARNPS 52 201 | A.X. El-Khadra, M. Luke | |
| PENIN | 02 | PL B538 335 | A. Penin, M. Steinhauser | |
| ABBIENDI | 01S | EPJ C21 411 | G. Abbiendi *et al.* | (OPAL Collab.) |
| BRAMBILLA | 01 | PL B513 381 | N. Brambilla, Y. Sumino, A. Vairo | |
| KUHN | 01 | NP B619 588 | J.H. Kuhn, M. Steinhauser | |
| NARISON | 01B | PL B520 115 | S. Narison | |
| PINEDA | 01 | JHEP 0106 022 | A. Pineda | |
| BARATE | 00V | EPJ C18 1 | R. Barate *et al.* | (ALEPH Collab.) |

| | | | | |
|---|---|---|---|---|
| HOANG | 00 | PR D61 034005 | A.H .Hoang | |
| LUCHA | 00 | PR D62 097501 | W. Lucha, F.F. Schoeberl | |
| PINEDA | 00 | PR D61 077505 | A. Pineda, F.J. Yndurain | |
| BENEKE | 99 | PL B471 233 | M. Beneke, A. Signer | |
| BRANDENB... | 99 | PL B468 168 | A. Brandenburg *et al.* | |
| HOANG | 99 | PR D59 014039 | A.H. Hoang | |
| MELNIKOV | 99 | PR D59 114009 | K. Melnikov, A. Yelkhovsky | |
| PENIN | 99 | NP B549 217 | A.A. Penin, A.A. Pivovarov | |
| ABREU | 98I | PL B418 430 | P. Abreu *et al.* | (DELPHI Collab.) |
| KUEHN | 98 | NP B534 356 | J.H. Kuehn, A.A. Penin, A.A. Pivovarov | |
| GIMENEZ | 97 | PL B393 124 | V. Gimenez, G. Martinelli, C.T. Sachrajda | |
| JAMIN | 97 | NP B507 334 | M. Jamin, A. Pich | |
| RODRIGO | 97 | PRL 79 193 | G. Rodrigo, A. Santamaria, M.S. Bilenky | |