# 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 $\overline{\rm MS}$ 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 $\overline{\rm MS}$ mass because it gives a stable perturbative expansion. We have converted masses in other schemes to the $\overline{\rm MS}$ mass and $1S$ mass using two-loop QCD perturbation theory with $\alpha_s(\mu = \overline{m}_b) = 0.22$. The range 4.1–4.4 for the $\overline{\rm MS}$ mass corresponds to 4.6–4.9 for the $1S$ mass and 4.7–5.0 GeV for the pole mass.

| $\overline{\rm MS}$ MASS (GeV) | 1S MASS (GeV) | DOCUMENT ID | | TECN |
|---|---|---|---|---|
| **4.20 ±0.07 OUR EVALUATION** of $\overline{\rm MS}$ Mass | | | | |
| **4.70 ±0.07 OUR EVALUATION** of $1S$ Mass | | | | |
| 4.4 ±0.3 | 4.9 ± 0.3 | [1,2] GRAY | 05 | LATT |
| 4.22 ±0.06 | 4.72 ± 0.07 | [3] AUBERT | 04X | THEO |
| 4.17 ±0.03 | 4.68 ± 0.03 | [4] BAUER | 04 | THEO |
| 4.22 ±0.11 | 4.72 ± 0.12 | [2,5] HOANG | 04 | THEO |
| 4.25 ±0.11 | 4.76 ± 0.12 | [2,6] MCNEILE | 04 | LATT |
| 4.22 ±0.09 | 4.74 ± 0.10 | [7] BAUER | 03 | THEO |
| 4.19 ±0.05 | 4.66 ± 0.05 | [8] BORDES | 03 | THEO |
| 4.20 ±0.09 | 4.67 ± 0.10 | [9] CORCELLA | 03 | THEO |
| 4.33 ±0.10 | 4.84 ± 0.11 | [2,10] DEDIVITIIS | 03 | LATT |
| 4.24 ±0.10 | 4.72 ± 0.11 | [11] EIDEMULLER | 03 | THEO |
| 4.207±0.031 | 4.682 ± 0.035 | [12] ERLER | 03 | THEO |
| 4.33 ±0.06 ±0.10 | 4.82 ± 0.07 ± 0.11 | [13] MAHMOOD | 03 | THEO |
| 4.346±0.070 | 4.837 ± 0.078 | [14] PENIN | 02 | THEO |
| 3.95 ±0.57 | 4.40 ± 0.63 | [15] ABBIENDI | 01S | OPAL |
| 4.21 ±0.05 | 4.69 ± 0.06 | [16] KUHN | 01 | THEO |
| 4.05 ±0.06 | 4.51 ± 0.07 | [17] NARISON | 01B | THEO |
| 4.210±0.090±0.025 | 4.69 ± 0.100 ± 0.028 | [18] PINEDA | 01 | THEO |
| 4.7 ±0.74 | 5.23 ± 0.82 | [19] BARATE | 00V | ALEP |
| 4.20 ±0.06 | 4.71 ± 0.03 | [20] HOANG | 00 | THEO |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $4.437^{+0.045}_{-0.029}$ | $4.938^{+0.050}_{-0.032}$ | [21] LUCHA | 00 | THEO |
| $4.454^{+0.045}_{-0.029}$ | $4.957^{+0.050}_{-0.032}$ | [21] PINEDA | 00 | THEO |
| 4.25 ±0.08 | 4.73 ± 0.09 | [22] BENEKE | 99 | THEO |
| $3.8\ ^{+0.77}_{-2.0}$ | $4.23^{+0.86}_{-2.0}$ | [23] BRANDENB... | 99 | |
| 4.25 ±0.09 | 4.73 ± 0.10 | [24] HOANG | 99 | THEO |
| 4.2 ±0.1 | 4.67 ± 0.11 | [25] MELNIKOV | 99 | THEO |

| | | | | |
|---|---|---|---|---|
| 4.21 ±0.11 | 4.69 ± 0.12 | [26] PENIN | 99 | THEO |
| 3.91 ±0.67 | 4.35 ± 0.75 | [27] ABREU | 98I | DLPH |
| 4.14 ±0.04 | 4.61 ± 0.05 | [28] KUEHN | 98 | THEO |
| 4.15 ±0.05 ±0.20 | 4.62 ± 0.06 ± 0.22 | [29] GIMENEZ | 97 | LATT |
| 4.19 ±0.06 | 4.66 ± 0.07 | [30] JAMIN | 97 | THEO |
| 4.16 ±0.32 ±0.60 | 4.63 ± 0.36 ± 0.67 | [31] RODRIGO | 97 | THEO |

[1] 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.

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

[3] 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.

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

[5] 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.

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

[7] 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 $\alpha_s^2 \beta_0$.

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

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

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

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

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

[13] 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 $1/\text{m}^3$ and $\alpha_s^2 \beta_0$. We have converted their result to the $\overline{\text{MS}}$ scheme.

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

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

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

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

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

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

[20] 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.

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

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

[23] 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 $\mu=\overline{m}_b$.

[24] 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.

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

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

[27] ABREU 98I determines the $\overline{\text{MS}}$ 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 $\alpha_s = 0.118 \pm 0.003$.

[28] 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 $\overline{\text{MS}}$ scheme.

[29] 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 $\overline{\text{MS}}$ mass is an estimate of the effects of higher-order corrections in the matching of the HQET operators (renormalon effects).

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

[31] RODRIGO 97 determines the $\overline{\text{MS}}$ 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 REFERENCES


| | | | | |
|---|---|---|---|---|
| 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.) |
| 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.) |
| 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 | |