

$b\bar{b}$ MESONS (including possibly non- $q\bar{q}$ states)

$\eta_b(1S)$

$$I^G(J^{PC}) = 0^+(0^{-+})$$

Mass $m = 9399.0 \pm 2.3$ MeV (S = 1.6)

Full width $\Gamma = 10^{+5}_{-4}$ MeV

| $\eta_b(1S)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | p (MeV/c) |
|--------------------------|--------------------------------|------------------|----------------|
| hadrons | seen | | — |
| $3h^+ 3h^-$ | not seen | | 4673 |
| $2h^+ 2h^-$ | not seen | | 4689 |
| $\gamma\gamma$ | not seen | | 4700 |
| $\mu^+ \mu^-$ | $< 9 \times 10^{-3}$ | 90% | 4698 |
| $\tau^+ \tau^-$ | $< 8\%$ | 90% | 4351 |

$\Upsilon(1S)$

$$I^G(J^{PC}) = 0^-(1^{--})$$

Mass $m = 9460.30 \pm 0.26$ MeV (S = 3.3)

Full width $\Gamma = 54.02 \pm 1.25$ keV

$\Gamma_{ee} = 1.340 \pm 0.018$ keV

| $\Upsilon(1S)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|----------------------------|--------------------------------|-----------------------------------|----------------|
| $\tau^+ \tau^-$ | (2.60 \pm 0.10) % | | 4384 |
| $e^+ e^-$ | (2.38 \pm 0.11) % | | 4730 |
| $\mu^+ \mu^-$ | (2.48 \pm 0.05) % | | 4729 |

Hadronic decays

| | | | |
|------------------------|------------------------------------|-------------------------|------|
| ggg | (81.7 \pm 0.7) % | | — |
| γgg | (2.2 \pm 0.6) % | | — |
| $\eta'(958)$ anything | (2.94 \pm 0.24) % | | — |
| $J/\psi(1S)$ anything | (5.4 \pm 0.4) $\times 10^{-4}$ | S=1.4 | 4223 |
| $J/\psi(1S)\eta_c$ | < 2.2 | $\times 10^{-6}$ CL=90% | 3623 |
| $J/\psi(1S)\chi_{c0}$ | < 3.4 | $\times 10^{-6}$ CL=90% | 3429 |
| $J/\psi(1S)\chi_{c1}$ | (3.9 \pm 1.2) $\times 10^{-6}$ | | 3382 |
| $J/\psi(1S)\chi_{c2}$ | < 1.4 | $\times 10^{-6}$ CL=90% | 3359 |
| $J/\psi(1S)\eta_c(2S)$ | < 2.2 | $\times 10^{-6}$ CL=90% | 3317 |
| $J/\psi(1S)X(3940)$ | < 5.4 | $\times 10^{-6}$ CL=90% | 3148 |
| $J/\psi(1S)X(4160)$ | < 5.4 | $\times 10^{-6}$ CL=90% | 3018 |

| | | | | |
|---|----------------------------------|------------------|--------|------|
| $X(4350)$ anything, $X \rightarrow$ $J/\psi(1S)\phi$ | < 8.1 | $\times 10^{-6}$ | CL=90% | — |
| $Z_c(3900)^\pm$ anything, $Z_c \rightarrow$ $J/\psi(1S)\pi^\pm$ | < 1.3 | $\times 10^{-5}$ | CL=90% | — |
| $Z_c(4200)^\pm$ anything, $Z_c \rightarrow$ $J/\psi(1S)\pi^\pm$ | < 6.0 | $\times 10^{-5}$ | CL=90% | — |
| $Z_c(4430)^\pm$ anything, $Z_c \rightarrow$ $J/\psi(1S)\pi^\pm$ | < 4.9 | $\times 10^{-5}$ | CL=90% | — |
| X_{cs}^\pm anything, $X \rightarrow$ $J/\psi K^\pm$ | < 5.7 | $\times 10^{-6}$ | CL=90% | — |
| $\chi_{c1}(3872)$ anything, $\chi_{c1} \rightarrow$ $J/\psi(1S)\pi^+\pi^-$ | < 9.5 | $\times 10^{-6}$ | CL=90% | — |
| $\psi(4260)$ anything, $\psi \rightarrow$ $J/\psi(1S)\pi^+\pi^-$ | < 3.8 | $\times 10^{-5}$ | CL=90% | — |
| $\psi(4260)$ anything, $\psi \rightarrow$ $J/\psi(1S)K^+K^-$ | < 7.5 | $\times 10^{-6}$ | CL=90% | — |
| $\chi_{c1}(4140)$ anything, $\chi_{c1} \rightarrow$ $J/\psi(1S)\phi$ | < 5.2 | $\times 10^{-6}$ | CL=90% | — |
| χ_{c0} anything | < 4 | $\times 10^{-3}$ | CL=90% | — |
| χ_{c1} anything | $(1.90 \pm 0.35) \times 10^{-4}$ | | | — |
| $\chi_{c1}(1P)X_{tetra}$ | < 3.78 | $\times 10^{-5}$ | CL=90% | — |
| χ_{c2} anything | $(2.8 \pm 0.8) \times 10^{-4}$ | | | — |
| $\psi(2S)$ anything | $(1.23 \pm 0.20) \times 10^{-4}$ | | | — |
| $\psi(2S)\eta_c$ | < 3.6 | $\times 10^{-6}$ | CL=90% | 3345 |
| $\psi(2S)\chi_{c0}$ | < 6.5 | $\times 10^{-6}$ | CL=90% | 3124 |
| $\psi(2S)\chi_{c1}$ | < 4.5 | $\times 10^{-6}$ | CL=90% | 3070 |
| $\psi(2S)\chi_{c2}$ | < 2.1 | $\times 10^{-6}$ | CL=90% | 3043 |
| $\psi(2S)\eta_c(2S)$ | < 3.2 | $\times 10^{-6}$ | CL=90% | 2994 |
| $\psi(2S)X(3940)$ | < 2.9 | $\times 10^{-6}$ | CL=90% | 2797 |
| $\psi(2S)X(4160)$ | < 2.9 | $\times 10^{-6}$ | CL=90% | 2642 |
| $\psi(4260)$ anything, $\psi \rightarrow$ $\psi(2S)\pi^+\pi^-$ | < 7.9 | $\times 10^{-5}$ | CL=90% | — |
| $\psi(4360)$ anything, $\psi \rightarrow$ $\psi(2S)\pi^+\pi^-$ | < 5.2 | $\times 10^{-5}$ | CL=90% | — |
| $\psi(4660)$ anything, $\psi \rightarrow$ $\psi(2S)\pi^+\pi^-$ | < 2.2 | $\times 10^{-5}$ | CL=90% | — |
| $X(4050)^\pm$ anything, $X \rightarrow$ $\psi(2S)\pi^\pm$ | < 8.8 | $\times 10^{-5}$ | CL=90% | — |
| $Z_c(4430)^\pm$ anything, $Z_c \rightarrow$ $\psi(2S)\pi^\pm$ | < 6.7 | $\times 10^{-5}$ | CL=90% | — |
| $\rho\pi$ | < 3.68 | $\times 10^{-6}$ | CL=90% | 4697 |
| $\omega\pi^0$ | < 3.90 | $\times 10^{-6}$ | CL=90% | 4697 |
| $\pi^+\pi^-$ | < 5 | $\times 10^{-4}$ | CL=90% | 4728 |
| K^+K^- | < 5 | $\times 10^{-4}$ | CL=90% | 4704 |

| | | | | |
|--|-----------------------|------------------|--------|------|
| $p\bar{p}$ | < 5 | $\times 10^{-4}$ | CL=90% | 4636 |
| $\pi^+\pi^-\pi^0$ | (2.1 \pm 0.8) | $\times 10^{-6}$ | | 4725 |
| ϕK^+K^- | (2.4 \pm 0.5) | $\times 10^{-6}$ | | 4622 |
| $\omega\pi^+\pi^-$ | (4.5 \pm 1.0) | $\times 10^{-6}$ | | 4694 |
| $K^*(892)^0 K^- \pi^+ + \text{c.c.}$ | (4.4 \pm 0.8) | $\times 10^{-6}$ | | 4667 |
| $\phi f'_2(1525)$ | < 1.63 | $\times 10^{-6}$ | CL=90% | 4549 |
| $\omega f_2(1270)$ | < 1.79 | $\times 10^{-6}$ | CL=90% | 4611 |
| $\rho(770)a_2(1320)$ | < 2.24 | $\times 10^{-6}$ | CL=90% | 4605 |
| $K^*(892)^0 \bar{K}_2^*(1430)^0 + \text{c.c.}$ | (3.0 \pm 0.8) | $\times 10^{-6}$ | | 4579 |
| $K_1(1270)^\pm K^\mp$ | < 2.41 | $\times 10^{-6}$ | CL=90% | 4631 |
| $K_1(1400)^\pm K^\mp$ | (1.0 \pm 0.4) | $\times 10^{-6}$ | | 4613 |
| $b_1(1235)^\pm \pi^\mp$ | < 1.25 | $\times 10^{-6}$ | CL=90% | 4649 |
| $\pi^+\pi^-\pi^0\pi^0$ | (1.28 \pm 0.30) | $\times 10^{-5}$ | | 4720 |
| $K_S^0 K^+ \pi^- + \text{c.c.}$ | (1.6 \pm 0.4) | $\times 10^{-6}$ | | 4696 |
| $K^*(892)^0 \bar{K}^0 + \text{c.c.}$ | (2.9 \pm 0.9) | $\times 10^{-6}$ | | 4675 |
| $K^*(892)^- K^+ + \text{c.c.}$ | < 1.11 | $\times 10^{-6}$ | CL=90% | 4675 |
| $f_1(1285)$ anything | (4.6 \pm 3.1) | $\times 10^{-3}$ | | – |
| $D^*(2010)^\pm$ anything | (2.52 \pm 0.20) | % | | – |
| $f_1(1285) X_{tetra}$ | < 6.24 | $\times 10^{-5}$ | CL=90% | – |
| 2H anything | (2.85 \pm 0.25) | $\times 10^{-5}$ | | – |
| Sum of 100 exclusive modes | (1.200 \pm 0.017) | % | | – |

Radiative decays

| | | | | |
|--------------------------------|-------------------------|------------------|--------|------|
| $\gamma\pi^+\pi^-$ | (6.3 \pm 1.8) | $\times 10^{-5}$ | | 4728 |
| $\gamma\pi^0\pi^0$ | (1.7 \pm 0.7) | $\times 10^{-5}$ | | 4728 |
| $\gamma\pi^0\eta$ | < 2.4 | $\times 10^{-6}$ | CL=90% | 4713 |
| γK^+K^- | [a] (1.14 \pm 0.13) | $\times 10^{-5}$ | | 4704 |
| $\gamma p\bar{p}$ | [b] < 6 | $\times 10^{-6}$ | CL=90% | 4636 |
| $\gamma 2h^+2h^-$ | (7.0 \pm 1.5) | $\times 10^{-4}$ | | 4720 |
| $\gamma 3h^+3h^-$ | (5.4 \pm 2.0) | $\times 10^{-4}$ | | 4703 |
| $\gamma 4h^+4h^-$ | (7.4 \pm 3.5) | $\times 10^{-4}$ | | 4679 |
| $\gamma\pi^+\pi^- K^+K^-$ | (2.9 \pm 0.9) | $\times 10^{-4}$ | | 4686 |
| $\gamma 2\pi^+2\pi^-$ | (2.5 \pm 0.9) | $\times 10^{-4}$ | | 4720 |
| $\gamma 3\pi^+3\pi^-$ | (2.5 \pm 1.2) | $\times 10^{-4}$ | | 4703 |
| $\gamma 2\pi^+2\pi^- K^+K^-$ | (2.4 \pm 1.2) | $\times 10^{-4}$ | | 4658 |
| $\gamma\pi^+\pi^- p\bar{p}$ | (1.5 \pm 0.6) | $\times 10^{-4}$ | | 4604 |
| $\gamma 2\pi^+2\pi^- p\bar{p}$ | (4 \pm 6) | $\times 10^{-5}$ | | 4563 |
| $\gamma 2K^+2K^-$ | (2.0 \pm 2.0) | $\times 10^{-5}$ | | 4601 |
| $\gamma\eta'(958)$ | < 1.9 | $\times 10^{-6}$ | CL=90% | 4682 |
| $\gamma\eta$ | < 1.0 | $\times 10^{-6}$ | CL=90% | 4714 |
| $\gamma f_0(980)$ | < 3 | $\times 10^{-5}$ | CL=90% | 4678 |
| $\gamma f'_2(1525)$ | (3.8 \pm 0.9) | $\times 10^{-5}$ | | 4607 |
| $\gamma f_2(1270)$ | (1.01 \pm 0.09) | $\times 10^{-4}$ | | 4644 |
| $\gamma\eta(1405)$ | < 8.2 | $\times 10^{-5}$ | CL=90% | 4625 |

| | | | | |
|---|--------------|------------------|--------|------|
| $\gamma f_0(1500)$ | < 1.5 | $\times 10^{-5}$ | CL=90% | 4611 |
| $\gamma f_0(1710)$ | < 2.6 | $\times 10^{-4}$ | CL=90% | 4573 |
| $\gamma f_0(1710) \rightarrow \gamma K^+ K^-$ | < 7 | $\times 10^{-6}$ | CL=90% | — |
| $\gamma f_0(1710) \rightarrow \gamma \pi^0 \pi^0$ | < 1.4 | $\times 10^{-6}$ | CL=90% | — |
| $\gamma f_0(1710) \rightarrow \gamma \eta \eta$ | < 1.8 | $\times 10^{-6}$ | CL=90% | — |
| $\gamma f_4(2050)$ | < 5.3 | $\times 10^{-5}$ | CL=90% | 4515 |
| $\gamma f_0(2200) \rightarrow \gamma K^+ K^-$ | < 2 | $\times 10^{-4}$ | CL=90% | 4475 |
| $\gamma f_J(2220) \rightarrow \gamma K^+ K^-$ | < 8 | $\times 10^{-7}$ | CL=90% | 4469 |
| $\gamma f_J(2220) \rightarrow \gamma \pi^+ \pi^-$ | < 6 | $\times 10^{-7}$ | CL=90% | — |
| $\gamma f_J(2220) \rightarrow \gamma p \bar{p}$ | < 1.1 | $\times 10^{-6}$ | CL=90% | — |
| $\gamma \eta(2225) \rightarrow \gamma \phi \phi$ | < 3 | $\times 10^{-3}$ | CL=90% | 4469 |
| $\gamma \eta_c(1S)$ | < 5.7 | $\times 10^{-5}$ | CL=90% | 4260 |
| $\gamma \chi_{c0}$ | < 6.5 | $\times 10^{-4}$ | CL=90% | 4114 |
| $\gamma \chi_{c1}$ | < 2.3 | $\times 10^{-5}$ | CL=90% | 4079 |
| $\gamma \chi_{c2}$ | < 7.6 | $\times 10^{-6}$ | CL=90% | 4062 |
| $\gamma \chi_{c1}(3872) \rightarrow \pi^+ \pi^- J/\psi$ | < 1.6 | $\times 10^{-6}$ | CL=90% | — |
| $\gamma \chi_{c1}(3872) \rightarrow \pi^+ \pi^- \pi^0 J/\psi$ | < 2.8 | $\times 10^{-6}$ | CL=90% | — |
| $\gamma X(3915) \rightarrow \omega J/\psi$ | < 3.0 | $\times 10^{-6}$ | CL=90% | — |
| $\gamma \chi_{c1}(4140) \rightarrow \phi J/\psi$ | < 2.2 | $\times 10^{-6}$ | CL=90% | — |
| γX | [c] < 4.5 | $\times 10^{-6}$ | CL=90% | — |
| $\gamma X \bar{X} (m_X < 3.1 \text{ GeV})$ | [d] < 1 | $\times 10^{-3}$ | CL=90% | — |
| $\gamma X \bar{X} (m_X < 4.5 \text{ GeV})$ | [e] < 2.4 | $\times 10^{-4}$ | CL=90% | — |
| $\gamma X \rightarrow \gamma + \geq 4 \text{ prongs}$ | [f] < 1.78 | $\times 10^{-4}$ | CL=95% | — |
| $\gamma a_1^0 \rightarrow \gamma \mu^+ \mu^-$ | [g] < 9 | $\times 10^{-6}$ | CL=90% | — |
| $\gamma a_1^0 \rightarrow \gamma \tau^+ \tau^-$ | [a] < 1.30 | $\times 10^{-4}$ | CL=90% | — |
| $\gamma a_1^0 \rightarrow \gamma g g$ | [h] < 1 | % | CL=90% | — |
| $\gamma a_1^0 \rightarrow \gamma s \bar{s}$ | [h] < 1 | $\times 10^{-3}$ | CL=90% | — |

Lepton Family number (LF) violating modes

| | | | | | |
|--------------------|----|---------|------------------|--------|------|
| $\mu^\pm \tau^\mp$ | LF | < 6.0 | $\times 10^{-6}$ | CL=95% | 4563 |
|--------------------|----|---------|------------------|--------|------|

Other decays

| | | | | | |
|-----------|--|---------|------------------|--------|---|
| invisible | | < 3.0 | $\times 10^{-4}$ | CL=90% | — |
|-----------|--|---------|------------------|--------|---|

$\chi_{b0}(1P)$ [i]

$$I^G(J^{PC}) = 0^+(0^{++})$$

J needs confirmation.

$$\text{Mass } m = 9859.44 \pm 0.42 \pm 0.31 \text{ MeV}$$

| $\chi_{b0}(1P)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | $\frac{p}{\text{MeV}/c}$ |
|---|--------------------------------|------------------|--------------------------|
| $\gamma \Upsilon(1S)$ | (1.94 ± 0.27) % | | 391 |
| $D^0 X$ | < 10.4 | % | 90% |
| $\pi^+ \pi^- K^+ K^- \pi^0$ | < 1.6 | $\times 10^{-4}$ | 90% |
| $2\pi^+ \pi^- K^- K_S^0$ | < 5 | $\times 10^{-5}$ | 90% |

| | | | | |
|-----------------------------|-----------------|------------------|-----|------|
| $2\pi^+\pi^-K^-K_S^02\pi^0$ | < 5 | $\times 10^{-4}$ | 90% | 4846 |
| $2\pi^+2\pi^-2\pi^0$ | < 2.1 | $\times 10^{-4}$ | 90% | 4905 |
| $2\pi^+2\pi^-K^+K^-$ | (1.1 ± 0.6) | $\times 10^{-4}$ | | 4861 |
| $2\pi^+2\pi^-K^+K^-\pi^0$ | < 2.7 | $\times 10^{-4}$ | 90% | 4846 |
| $2\pi^+2\pi^-K^+K^-2\pi^0$ | < 5 | $\times 10^{-4}$ | 90% | 4828 |
| $3\pi^+2\pi^-K^-K_S^0\pi^0$ | < 1.6 | $\times 10^{-4}$ | 90% | 4827 |
| $3\pi^+3\pi^-$ | < 8 | $\times 10^{-5}$ | 90% | 4904 |
| $3\pi^+3\pi^-2\pi^0$ | < 6 | $\times 10^{-4}$ | 90% | 4881 |
| $3\pi^+3\pi^-K^+K^-$ | (2.4 ± 1.2) | $\times 10^{-4}$ | | 4827 |
| $3\pi^+3\pi^-K^+K^-\pi^0$ | < 1.0 | $\times 10^{-3}$ | 90% | 4808 |
| $4\pi^+4\pi^-$ | < 8 | $\times 10^{-5}$ | 90% | 4880 |
| $4\pi^+4\pi^-2\pi^0$ | < 2.1 | $\times 10^{-3}$ | 90% | 4850 |
| $J/\psi J/\psi$ | < 7 | $\times 10^{-5}$ | 90% | 3836 |
| $J/\psi\psi(2S)$ | < 1.2 | $\times 10^{-4}$ | 90% | 3571 |
| $\psi(2S)\psi(2S)$ | < 3.1 | $\times 10^{-5}$ | 90% | 3273 |
| $J/\psi(1S)$ anything | < 2.3 | $\times 10^{-3}$ | 90% | — |

$\chi_{b1}(1P)$ [1]

$$J^G(J^{PC}) = 0^+(1^{++})$$

J needs confirmation.

$$\text{Mass } m = 9892.78 \pm 0.26 \pm 0.31 \text{ MeV}$$

| $\chi_{b1}(1P)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | P (MeV/c) |
|---|--------------------------------|------------------|----------------|
| $\gamma \Upsilon(1S)$ | $(35.0 \pm 2.1) \%$ | | 423 |
| $D^0 X$ | $(12.6 \pm 2.2) \%$ | | — |
| $\pi^+\pi^-K^+K^-\pi^0$ | $(2.0 \pm 0.6) \times 10^{-4}$ | | 4892 |
| $2\pi^+\pi^-K^-K_S^0$ | $(1.3 \pm 0.5) \times 10^{-4}$ | | 4892 |
| $2\pi^+\pi^-K^-K_S^02\pi^0$ | < 6 | 90% | 4863 |
| $2\pi^+2\pi^-2\pi^0$ | $(8.0 \pm 2.5) \times 10^{-4}$ | | 4921 |
| $2\pi^+2\pi^-K^+K^-$ | $(1.5 \pm 0.5) \times 10^{-4}$ | | 4878 |
| $2\pi^+2\pi^-K^+K^-\pi^0$ | $(3.5 \pm 1.2) \times 10^{-4}$ | | 4863 |
| $2\pi^+2\pi^-K^+K^-2\pi^0$ | $(8.6 \pm 3.2) \times 10^{-4}$ | | 4845 |
| $3\pi^+2\pi^-K^-K_S^0\pi^0$ | $(9.3 \pm 3.3) \times 10^{-4}$ | | 4844 |
| $3\pi^+3\pi^-$ | $(1.9 \pm 0.6) \times 10^{-4}$ | | 4921 |
| $3\pi^+3\pi^-2\pi^0$ | $(1.7 \pm 0.5) \times 10^{-3}$ | | 4898 |
| $3\pi^+3\pi^-K^+K^-$ | $(2.6 \pm 0.8) \times 10^{-4}$ | | 4844 |
| $3\pi^+3\pi^-K^+K^-\pi^0$ | $(7.5 \pm 2.6) \times 10^{-4}$ | | 4825 |
| $4\pi^+4\pi^-$ | $(2.6 \pm 0.9) \times 10^{-4}$ | | 4897 |
| $4\pi^+4\pi^-2\pi^0$ | $(1.4 \pm 0.6) \times 10^{-3}$ | | 4867 |
| ω anything | $(4.9 \pm 1.4) \%$ | | — |
| ωX_{tetra} | < 4.44 | 90% | — |
| $J/\psi J/\psi$ | < 2.7 | 90% | 3857 |

| | | | | |
|-----------------------|----------|------------------|-----|------|
| $J/\psi\psi(2S)$ | < 1.7 | $\times 10^{-5}$ | 90% | 3594 |
| $\psi(2S)\psi(2S)$ | < 6 | $\times 10^{-5}$ | 90% | 3298 |
| $J/\psi(1S)$ anything | < 1.1 | $\times 10^{-3}$ | 90% | — |
| $J/\psi(1S)X_{tetra}$ | < 2.27 | $\times 10^{-4}$ | 90% | — |

$h_b(1P)$

$$I^G(J^{PC}) = ??(1^{+-})$$

Mass $m = 9899.3 \pm 0.8$ MeV

| $h_b(1P)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\eta_b(1S)\gamma$ | $(52^{+6}_{-5})\%$ | 488 |

$\chi_{b2}(1P)$ [i]

$$I^G(J^{PC}) = 0^+(2^{++})$$

J needs confirmation.

Mass $m = 9912.21 \pm 0.26 \pm 0.31$ MeV

| $\chi_{b2}(1P)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | p (MeV/c) |
|---|--------------------------------|------------------|-------------|
| $\gamma \Upsilon(1S)$ | $(18.8 \pm 1.1)\%$ | | 442 |
| $D^0 X$ | $< 7.9\%$ | 90% | — |
| $\pi^+ \pi^- K^+ K^- \pi^0$ | $(8 \pm 5) \times 10^{-5}$ | | 4902 |
| $2\pi^+ \pi^- K^- K_S^0$ | $< 1.0 \times 10^{-4}$ | 90% | 4901 |
| $2\pi^+ \pi^- K^- K_S^0 2\pi^0$ | $(5.3 \pm 2.4) \times 10^{-4}$ | | 4873 |
| $2\pi^+ 2\pi^- 2\pi^0$ | $(3.5 \pm 1.4) \times 10^{-4}$ | | 4931 |
| $2\pi^+ 2\pi^- K^+ K^-$ | $(1.1 \pm 0.4) \times 10^{-4}$ | | 4888 |
| $2\pi^+ 2\pi^- K^+ K^- \pi^0$ | $(2.1 \pm 0.9) \times 10^{-4}$ | | 4872 |
| $2\pi^+ 2\pi^- K^+ K^- 2\pi^0$ | $(3.9 \pm 1.8) \times 10^{-4}$ | | 4855 |
| $3\pi^+ 2\pi^- K^- K_S^0 \pi^0$ | $< 5 \times 10^{-4}$ | 90% | 4854 |
| $3\pi^+ 3\pi^-$ | $(7.0 \pm 3.1) \times 10^{-5}$ | | 4931 |
| $3\pi^+ 3\pi^- 2\pi^0$ | $(1.0 \pm 0.4) \times 10^{-3}$ | | 4908 |
| $3\pi^+ 3\pi^- K^+ K^-$ | $< 8 \times 10^{-5}$ | 90% | 4854 |
| $3\pi^+ 3\pi^- K^+ K^- \pi^0$ | $(3.6 \pm 1.5) \times 10^{-4}$ | | 4835 |
| $4\pi^+ 4\pi^-$ | $(8 \pm 4) \times 10^{-5}$ | | 4907 |
| $4\pi^+ 4\pi^- 2\pi^0$ | $(1.8 \pm 0.7) \times 10^{-3}$ | | 4877 |
| $J/\psi J/\psi$ | $< 4 \times 10^{-5}$ | 90% | 3869 |
| $J/\psi\psi(2S)$ | $< 5 \times 10^{-5}$ | 90% | 3608 |
| $\psi(2S)\psi(2S)$ | $< 1.6 \times 10^{-5}$ | 90% | 3313 |
| $J/\psi(1S)$ anything | $(1.5 \pm 0.4) \times 10^{-3}$ | | — |

$\Upsilon(2S)$

$$J^{PC} = 0^{-}(1^{- -})$$

Mass $m = 10023.26 \pm 0.31$ MeV $m_{\Upsilon(3S)} - m_{\Upsilon(2S)} = 331.50 \pm 0.13$ MeVFull width $\Gamma = 31.98 \pm 2.63$ keV $\Gamma_{ee} = 0.612 \pm 0.011$ keV

| $\Upsilon(2S)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|--|---|-----------------------------------|----------------|
| $\Upsilon(1S)\pi^+\pi^-$ | (17.85 ± 0.26) % | | 475 |
| $\Upsilon(1S)\pi^0\pi^0$ | (8.6 ± 0.4) % | | 480 |
| $\tau^+\tau^-$ | (2.00 ± 0.21) % | | 4686 |
| $\mu^+\mu^-$ | (1.93 ± 0.17) % | S=2.2 | 5011 |
| e^+e^- | (1.91 ± 0.16) % | | 5012 |
| $\Upsilon(1S)\pi^0$ | < 4 | $\times 10^{-5}$ CL=90% | 531 |
| $\Upsilon(1S)\eta$ | (2.9 ± 0.4) $\times 10^{-4}$ | S=2.0 | 126 |
| $J/\psi(1S)$ anything | < 6 | $\times 10^{-3}$ CL=90% | 4533 |
| $J/\psi(1S)\eta_c$ | < 5.4 | $\times 10^{-6}$ CL=90% | 3984 |
| $J/\psi(1S)\chi_{c0}$ | < 3.4 | $\times 10^{-6}$ CL=90% | 3808 |
| $J/\psi(1S)\chi_{c1}$ | < 1.2 | $\times 10^{-6}$ CL=90% | 3765 |
| $J/\psi(1S)\chi_{c2}$ | < 2.0 | $\times 10^{-6}$ CL=90% | 3744 |
| $J/\psi(1S)\eta_c(2S)$ | < 2.5 | $\times 10^{-6}$ CL=90% | 3706 |
| $J/\psi(1S)X(3940)$ | < 2.0 | $\times 10^{-6}$ CL=90% | 3555 |
| $J/\psi(1S)X(4160)$ | < 2.0 | $\times 10^{-6}$ CL=90% | 3440 |
| χ_{c1} anything | (2.2 ± 0.5) $\times 10^{-4}$ | | — |
| $\chi_{c1}(1P)^0 X_{tetra}$ | < 3.67 | $\times 10^{-5}$ CL=90% | — |
| χ_{c2} anything | (2.3 ± 0.8) $\times 10^{-4}$ | | — |
| $\psi(2S)\eta_c$ | < 5.1 | $\times 10^{-6}$ CL=90% | 3732 |
| $\psi(2S)\chi_{c0}$ | < 4.7 | $\times 10^{-6}$ CL=90% | 3536 |
| $\psi(2S)\chi_{c1}$ | < 2.5 | $\times 10^{-6}$ CL=90% | 3488 |
| $\psi(2S)\chi_{c2}$ | < 1.9 | $\times 10^{-6}$ CL=90% | 3464 |
| $\psi(2S)\eta_c(2S)$ | < 3.3 | $\times 10^{-6}$ CL=90% | 3422 |
| $\psi(2S)X(3940)$ | < 3.9 | $\times 10^{-6}$ CL=90% | 3250 |
| $\psi(2S)X(4160)$ | < 3.9 | $\times 10^{-6}$ CL=90% | 3118 |
| $\overline{2H}$ anything | (2.78 ⁺ ₋ 0.30 / 0.26) $\times 10^{-5}$ | S=1.2 | — |
| hadrons | (94 ± 11) % | | — |
| ggg | (58.8 ± 1.2) % | | — |
| γgg | (1.87 ± 0.28) % | | — |
| $\phi K^+ K^-$ | (1.6 ± 0.4) $\times 10^{-6}$ | | 4910 |
| $\omega\pi^+\pi^-$ | < 2.58 | $\times 10^{-6}$ CL=90% | 4977 |
| $K^*(892)^0 K^- \pi^+ + c.c.$ | (2.3 ± 0.7) $\times 10^{-6}$ | | 4952 |
| $\phi f'_2(1525)$ | < 1.33 | $\times 10^{-6}$ CL=90% | 4841 |
| $\omega f_2(1270)$ | < 5.7 | $\times 10^{-7}$ CL=90% | 4899 |

| | | | | |
|--|---------------------|------------------|--------|------|
| $\rho(770) a_2(1320)$ | < 8.8 | $\times 10^{-7}$ | CL=90% | 4894 |
| $K^*(892)^0 \bar{K}_2^*(1430)^0 + \text{c.c.}$ | (1.5 ± 0.6) | $\times 10^{-6}$ | | 4869 |
| $K_1(1270)^\pm K^\mp$ | < 3.22 | $\times 10^{-6}$ | CL=90% | 4918 |
| $K_1(1400)^\pm K^\mp$ | < 8.3 | $\times 10^{-7}$ | CL=90% | 4901 |
| $b_1(1235)^\pm \pi^\mp$ | < 4.0 | $\times 10^{-7}$ | CL=90% | 4935 |
| $\rho \pi$ | < 1.16 | $\times 10^{-6}$ | CL=90% | 4981 |
| $\pi^+ \pi^- \pi^0$ | < 8.0 | $\times 10^{-7}$ | CL=90% | 5007 |
| $\omega \pi^0$ | < 1.63 | $\times 10^{-6}$ | CL=90% | 4980 |
| $\pi^+ \pi^- \pi^0 \pi^0$ | (1.30 ± 0.28) | $\times 10^{-5}$ | | 5002 |
| $K_S^0 K^+ \pi^- + \text{c.c.}$ | (1.14 ± 0.33) | $\times 10^{-6}$ | | 4979 |
| $K^*(892)^0 \bar{K}^0 + \text{c.c.}$ | < 4.22 | $\times 10^{-6}$ | CL=90% | 4959 |
| $K^*(892)^- K^+ + \text{c.c.}$ | < 1.45 | $\times 10^{-6}$ | CL=90% | 4960 |
| $f_1(1285) \text{ anything}$ | (2.2 ± 1.6) | $\times 10^{-3}$ | | — |
| $f_1(1285) X_{tetra}$ | < 6.47 | $\times 10^{-5}$ | CL=90% | — |
| Sum of 100 exclusive modes | (2.90 ± 0.30) | $\times 10^{-3}$ | | — |

Radiative decays

| | | | | |
|--|---------------------|------------------|--------|------|
| $\gamma X_{b1}(1P)$ | (6.9 ± 0.4) | % | | 130 |
| $\gamma X_{b2}(1P)$ | (7.15 ± 0.35) | % | | 110 |
| $\gamma X_{b0}(1P)$ | (3.8 ± 0.4) | % | | 162 |
| $\gamma f_0(1710)$ | < 5.9 | $\times 10^{-4}$ | CL=90% | 4864 |
| $\gamma f_2'(1525)$ | < 5.3 | $\times 10^{-4}$ | CL=90% | 4896 |
| $\gamma f_2(1270)$ | < 2.41 | $\times 10^{-4}$ | CL=90% | 4930 |
| $\gamma \eta_c(1S)$ | < 2.7 | $\times 10^{-5}$ | CL=90% | 4567 |
| γX_{c0} | < 1.0 | $\times 10^{-4}$ | CL=90% | 4430 |
| γX_{c1} | < 3.6 | $\times 10^{-6}$ | CL=90% | 4397 |
| γX_{c2} | < 1.5 | $\times 10^{-5}$ | CL=90% | 4381 |
| $\gamma X_{c1}(3872) \rightarrow \pi^+ \pi^- J/\psi$ | < 8 | $\times 10^{-7}$ | CL=90% | — |
| $\gamma X_{c1}(3872) \rightarrow \pi^+ \pi^- \pi^0 J/\psi$ | < 2.4 | $\times 10^{-6}$ | CL=90% | — |
| $\gamma X(3915) \rightarrow \omega J/\psi$ | < 2.8 | $\times 10^{-6}$ | CL=90% | — |
| $\gamma X_{c1}(4140) \rightarrow \phi J/\psi$ | < 1.2 | $\times 10^{-6}$ | CL=90% | — |
| $\gamma X(4350) \rightarrow \phi J/\psi$ | < 1.3 | $\times 10^{-6}$ | CL=90% | — |
| $\gamma \eta_b(1S)$ | (3.9 ± 1.5) | $\times 10^{-4}$ | | 605 |
| $\gamma \eta_b(1S) \rightarrow \gamma$ Sum of 26 exclusive modes | < 3.7 | $\times 10^{-6}$ | CL=90% | — |
| $\gamma X_{b\bar{b}} \rightarrow \gamma$ Sum of 26 exclusive modes | < 4.9 | $\times 10^{-6}$ | CL=90% | — |
| $\gamma X \rightarrow \gamma + \geq 4$ prongs | [j] < 1.95 | $\times 10^{-4}$ | CL=95% | — |
| $\gamma A^0 \rightarrow \gamma$ hadrons | < 8 | $\times 10^{-5}$ | CL=90% | — |
| $\gamma a_1^0 \rightarrow \gamma \mu^+ \mu^-$ | < 8.3 | $\times 10^{-6}$ | CL=90% | — |

Lepton Family number (LF) violating modes

| | | | | | |
|--------------------|----|-------|------------------|--------|------|
| $e^\pm \tau^\mp$ | LF | < 3.2 | $\times 10^{-6}$ | CL=90% | 4854 |
| $\mu^\pm \tau^\mp$ | LF | < 3.3 | $\times 10^{-6}$ | CL=90% | 4854 |

$\Upsilon_2(1D)$

$I^G(J^{PC}) = 0^-(2^{--})$

Mass $m = 10163.7 \pm 1.4$ MeV (S = 1.7)

| $\Upsilon_2(1D)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|--|--------------------------------|-------------|
| $\gamma\gamma \Upsilon(1S)$ | seen | 679 |
| $\gamma\chi_{bJ}(1P)$ | seen | 300 |
| $\eta \Upsilon(1S)$ | not seen | 426 |
| $\pi^+\pi^- \Upsilon(1S)$ | $(6.6 \pm 1.6) \times 10^{-3}$ | 623 |

$\chi_{b0}(2P)$ [i]

$I^G(J^{PC}) = 0^+(0^{++})$

J needs confirmation.

Mass $m = 10232.5 \pm 0.4 \pm 0.5$ MeV

| $\chi_{b0}(2P)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | p (MeV/c) |
|---|--------------------------------|------------------|-------------|
| $\gamma \Upsilon(2S)$ | $(1.38 \pm 0.30) \%$ | | 207 |
| $\gamma \Upsilon(1S)$ | $(3.8 \pm 1.7) \times 10^{-3}$ | | 743 |
| $D^0 X$ | < 8.2 % | 90% | — |
| $\pi^+\pi^- K^+ K^- \pi^0$ | < 3.4 $\times 10^{-5}$ | 90% | 5064 |
| $2\pi^+\pi^- K^- K_S^0$ | < 5 $\times 10^{-5}$ | 90% | 5063 |
| $2\pi^+\pi^- K^- K_S^0 2\pi^0$ | < 2.2 $\times 10^{-4}$ | 90% | 5036 |
| $2\pi^+ 2\pi^- 2\pi^0$ | < 2.4 $\times 10^{-4}$ | 90% | 5092 |
| $2\pi^+ 2\pi^- K^+ K^-$ | < 1.5 $\times 10^{-4}$ | 90% | 5050 |
| $2\pi^+ 2\pi^- K^+ K^- \pi^0$ | < 2.2 $\times 10^{-4}$ | 90% | 5035 |
| $2\pi^+ 2\pi^- K^+ K^- 2\pi^0$ | < 1.1 $\times 10^{-3}$ | 90% | 5019 |
| $3\pi^+ 2\pi^- K^- K_S^0 \pi^0$ | < 7 $\times 10^{-4}$ | 90% | 5018 |
| $3\pi^+ 3\pi^-$ | < 7 $\times 10^{-5}$ | 90% | 5091 |
| $3\pi^+ 3\pi^- 2\pi^0$ | < 1.2 $\times 10^{-3}$ | 90% | 5070 |
| $3\pi^+ 3\pi^- K^+ K^-$ | < 1.5 $\times 10^{-4}$ | 90% | 5017 |
| $3\pi^+ 3\pi^- K^+ K^- \pi^0$ | < 7 $\times 10^{-4}$ | 90% | 4999 |
| $4\pi^+ 4\pi^-$ | < 1.7 $\times 10^{-4}$ | 90% | 5069 |
| $4\pi^+ 4\pi^- 2\pi^0$ | < 6 $\times 10^{-4}$ | 90% | 5039 |

$\chi_{b1}(2P)$ [i]

$I^G(J^{PC}) = 0^+(1^{++})$

J needs confirmation.

Mass $m = 10255.46 \pm 0.22 \pm 0.50$ MeV

$m_{\chi_{b1}(2P)} - m_{\chi_{b0}(2P)} = 23.5 \pm 1.0$ MeV

| $\chi_{b1}(2P)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---------------------------------|--------------------------------|-------------|
| $\omega \Upsilon(1S)$ | $(1.63^{+0.40}_{-0.34})\%$ | 135 |
| $\gamma \Upsilon(2S)$ | $(18.1 \pm 1.9)\%$ | 230 |
| $\gamma \Upsilon(1S)$ | $(9.9 \pm 1.0)\%$ | 764 |
| $\pi\pi \chi_{b1}(1P)$ | $(9.1 \pm 1.3) \times 10^{-3}$ | 238 |
| $D^0 X$ | $(8.8 \pm 1.7)\%$ | — |
| $\pi^+ \pi^- K^+ K^- \pi^0$ | $(3.1 \pm 1.0) \times 10^{-4}$ | 5075 |
| $2\pi^+ \pi^- K^- K_S^0$ | $(1.1 \pm 0.5) \times 10^{-4}$ | 5075 |
| $2\pi^+ \pi^- K^- K_S^0 2\pi^0$ | $(7.7 \pm 3.2) \times 10^{-4}$ | 5047 |
| $2\pi^+ 2\pi^- 2\pi^0$ | $(5.9 \pm 2.0) \times 10^{-4}$ | 5104 |
| $2\pi^+ 2\pi^- K^+ K^-$ | $(10 \pm 4) \times 10^{-5}$ | 5062 |
| $2\pi^+ 2\pi^- K^+ K^- \pi^0$ | $(5.5 \pm 1.8) \times 10^{-4}$ | 5047 |
| $2\pi^+ 2\pi^- K^+ K^- 2\pi^0$ | $(10 \pm 4) \times 10^{-4}$ | 5030 |
| $3\pi^+ 2\pi^- K^- K_S^0 \pi^0$ | $(6.7 \pm 2.6) \times 10^{-4}$ | 5029 |
| $3\pi^+ 3\pi^-$ | $(1.2 \pm 0.4) \times 10^{-4}$ | 5103 |
| $3\pi^+ 3\pi^- 2\pi^0$ | $(1.2 \pm 0.4) \times 10^{-3}$ | 5081 |
| $3\pi^+ 3\pi^- K^+ K^-$ | $(2.0 \pm 0.8) \times 10^{-4}$ | 5029 |
| $3\pi^+ 3\pi^- K^+ K^- \pi^0$ | $(6.1 \pm 2.2) \times 10^{-4}$ | 5011 |
| $4\pi^+ 4\pi^-$ | $(1.7 \pm 0.6) \times 10^{-4}$ | 5080 |
| $4\pi^+ 4\pi^- 2\pi^0$ | $(1.9 \pm 0.7) \times 10^{-3}$ | 5051 |

$\chi_{b2}(2P)$ [i]

$I^G(J^{PC}) = 0^+(2^{++})$
 J needs confirmation.

Mass $m = 10268.65 \pm 0.22 \pm 0.50$ MeV
 $m_{\chi_{b2}(2P)} - m_{\chi_{b1}(2P)} = 13.10 \pm 0.24$ MeV

| $\chi_{b2}(2P)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | p (MeV/c) |
|---------------------------------|--------------------------------|------------------|-------------|
| $\omega \Upsilon(1S)$ | $(1.10^{+0.34}_{-0.30})\%$ | | 194 |
| $\gamma \Upsilon(2S)$ | $(8.9 \pm 1.2)\%$ | | 242 |
| $\gamma \Upsilon(1S)$ | $(6.6 \pm 0.8)\%$ | | 777 |
| $\pi\pi \chi_{b2}(1P)$ | $(5.1 \pm 0.9) \times 10^{-3}$ | | 229 |
| $D^0 X$ | $< 2.4\%$ | 90% | — |
| $\pi^+ \pi^- K^+ K^- \pi^0$ | $< 1.1 \times 10^{-4}$ | 90% | 5082 |
| $2\pi^+ \pi^- K^- K_S^0$ | $< 9 \times 10^{-5}$ | 90% | 5082 |
| $2\pi^+ \pi^- K^- K_S^0 2\pi^0$ | $< 7 \times 10^{-4}$ | 90% | 5054 |
| $2\pi^+ 2\pi^- 2\pi^0$ | $(3.9 \pm 1.6) \times 10^{-4}$ | | 5110 |
| $2\pi^+ 2\pi^- K^+ K^-$ | $(9 \pm 4) \times 10^{-5}$ | | 5068 |
| $2\pi^+ 2\pi^- K^+ K^- \pi^0$ | $(2.4 \pm 1.1) \times 10^{-4}$ | | 5054 |

| | | | |
|---------------------------------|--------------------------------|-----|------|
| $2\pi^+ 2\pi^- K^+ K^- 2\pi^0$ | $(4.7 \pm 2.3) \times 10^{-4}$ | | 5037 |
| $3\pi^+ 2\pi^- K^- K_S^0 \pi^0$ | $< 4 \times 10^{-4}$ | 90% | 5036 |
| $3\pi^+ 3\pi^-$ | $(9 \pm 4) \times 10^{-5}$ | | 5110 |
| $3\pi^+ 3\pi^- 2\pi^0$ | $(1.2 \pm 0.4) \times 10^{-3}$ | | 5088 |
| $3\pi^+ 3\pi^- K^+ K^-$ | $(1.4 \pm 0.7) \times 10^{-4}$ | | 5036 |
| $3\pi^+ 3\pi^- K^+ K^- \pi^0$ | $(4.2 \pm 1.7) \times 10^{-4}$ | | 5017 |
| $4\pi^+ 4\pi^-$ | $(9 \pm 5) \times 10^{-5}$ | | 5087 |
| $4\pi^+ 4\pi^- 2\pi^0$ | $(1.3 \pm 0.5) \times 10^{-3}$ | | 5058 |

$\Upsilon(3S)$

$$J^{PC} = 0^-(1^--)$$

Mass $m = 10355.2 \pm 0.5$ MeV

$m_{\Upsilon(3S)} - m_{\Upsilon(2S)} = 331.50 \pm 0.13$ MeV

Full width $\Gamma = 20.32 \pm 1.85$ keV

$\Gamma_{ee} = 0.443 \pm 0.008$ keV

| $\Upsilon(3S)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | p (MeV/c) |
|---|----------------------------------|-----------------------------------|----------------|
| $\Upsilon(2S)$ anything | $(10.6 \pm 0.8) \%$ | | 296 |
| $\Upsilon(2S) \pi^+ \pi^-$ | $(2.82 \pm 0.18) \%$ | S=1.6 | 177 |
| $\Upsilon(2S) \pi^0 \pi^0$ | $(1.85 \pm 0.14) \%$ | | 190 |
| $\Upsilon(2S) \gamma \gamma$ | $(5.0 \pm 0.7) \%$ | | 327 |
| $\Upsilon(2S) \pi^0$ | $< 5.1 \times 10^{-4}$ | CL=90% | 298 |
| $\Upsilon(1S) \pi^+ \pi^-$ | $(4.37 \pm 0.08) \%$ | | 813 |
| $\Upsilon(1S) \pi^0 \pi^0$ | $(2.20 \pm 0.13) \%$ | | 816 |
| $\Upsilon(1S) \eta$ | $< 1 \times 10^{-4}$ | CL=90% | 677 |
| $\Upsilon(1S) \pi^0$ | $< 7 \times 10^{-5}$ | CL=90% | 846 |
| $h_b(1P) \pi^0$ | $< 1.2 \times 10^{-3}$ | CL=90% | 426 |
| $h_b(1P) \pi^0 \rightarrow \gamma \eta_b(1S) \pi^0$ | $(4.3 \pm 1.4) \times 10^{-4}$ | | — |
| $h_b(1P) \pi^+ \pi^-$ | $< 1.2 \times 10^{-4}$ | CL=90% | 353 |
| $\tau^+ \tau^-$ | $(2.29 \pm 0.30) \%$ | | 4863 |
| $\mu^+ \mu^-$ | $(2.18 \pm 0.21) \%$ | S=2.1 | 5177 |
| $e^+ e^-$ | $(2.18 \pm 0.20) \%$ | | 5178 |
| hadrons | $(93 \pm 12) \%$ | | — |
| $g g g$ | $(35.7 \pm 2.6) \%$ | | — |
| $\gamma g g$ | $(9.7 \pm 1.8) \times 10^{-3}$ | | — |
| 2H anything | $(2.33 \pm 0.33) \times 10^{-5}$ | | — |

Radiative decays

| | | | |
|------------------------|--------------------------------|-------|-----|
| $\gamma \chi_{b2}(2P)$ | $(13.1 \pm 1.6) \%$ | S=3.4 | 86 |
| $\gamma \chi_{b1}(2P)$ | $(12.6 \pm 1.2) \%$ | S=2.4 | 99 |
| $\gamma \chi_{b0}(2P)$ | $(5.9 \pm 0.6) \%$ | S=1.4 | 122 |
| $\gamma \chi_{b2}(1P)$ | $(9.9 \pm 1.2) \times 10^{-3}$ | S=1.9 | 434 |
| $\gamma \chi_{b1}(1P)$ | $(9 \pm 5) \times 10^{-4}$ | S=1.8 | 452 |

| | | | |
|---|--------------------------------|--------|-----|
| $\gamma\chi_{b0}(1P)$ | $(2.7 \pm 0.4) \times 10^{-3}$ | | 484 |
| $\gamma\eta_b(2S)$ | $< 6.2 \times 10^{-4}$ | CL=90% | 350 |
| $\gamma\eta_b(1S)$ | $(5.1 \pm 0.7) \times 10^{-4}$ | | 912 |
| $\gamma A^0 \rightarrow \gamma \text{hadrons}$ | $< 8 \times 10^{-5}$ | CL=90% | — |
| $\gamma X \rightarrow \gamma + \geq 4 \text{ prongs}$ | $[k] < 2.2 \times 10^{-4}$ | CL=95% | — |
| $\gamma a_1^0 \rightarrow \gamma \mu^+ \mu^-$ | $< 5.5 \times 10^{-6}$ | CL=90% | — |
| $\gamma a_1^0 \rightarrow \gamma \tau^+ \tau^-$ | $[l] < 1.6 \times 10^{-4}$ | CL=90% | — |

Lepton Family number (LF) violating modes

| | | | | |
|--------------------|----|------------------------|--------|------|
| $e^\pm \tau^\mp$ | LF | $< 4.2 \times 10^{-6}$ | CL=90% | 5025 |
| $\mu^\pm \tau^\mp$ | LF | $< 3.1 \times 10^{-6}$ | CL=90% | 5025 |

$\chi_{b1}(3P)$

$$J^{PC} = 0^+(1^{++})$$

Mass $m = 10512.1 \pm 2.3 \text{ MeV}$

| $\chi_{b1}(3P)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------|-------------|
| $\Upsilon(1S)\gamma$ | seen | 999 |
| $\Upsilon(2S)\gamma$ | seen | 477 |
| $\Upsilon(3S)\gamma$ | seen | 156 |

$\Upsilon(4S)$

$$J^{PC} = 0^-(1^{--})$$

Mass $m = 10579.4 \pm 1.2 \text{ MeV}$

Full width $\Gamma = 20.5 \pm 2.5 \text{ MeV}$

$\Gamma_{ee} = 0.272 \pm 0.029 \text{ keV}$ ($S = 1.5$)

| $\Upsilon(4S)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | p (MeV/c) |
|--|----------------------------------|------------------|-------------|
| $B\bar{B}$ | $> 96 \%$ | 95% | 326 |
| $B^+ B^-$ | $(51.4 \pm 0.6) \%$ | | 331 |
| $D_s^+ \text{ anything} + \text{ c.c.}$ | $(17.8 \pm 2.6) \%$ | | — |
| $B^0 \bar{B}^0$ | $(48.6 \pm 0.6) \%$ | | 326 |
| $J/\psi K_S^0 + (J/\psi, \eta_c) K_S^0$ | $< 4 \times 10^{-7}$ | 90% | — |
| non- $B\bar{B}$ | $< 4 \%$ | 95% | — |
| $e^+ e^-$ | $(1.57 \pm 0.08) \times 10^{-5}$ | | 5290 |
| $\rho^+ \rho^-$ | $< 5.7 \times 10^{-6}$ | 90% | 5233 |
| $K^*(892)^0 \bar{K}^0$ | $< 2.0 \times 10^{-6}$ | 90% | 5240 |
| $J/\psi(1S) \text{ anything}$ | $< 1.9 \times 10^{-4}$ | 95% | — |
| $D^{*+} \text{ anything} + \text{ c.c.}$ | $< 7.4 \%$ | 90% | 5099 |
| $\phi \text{ anything}$ | $(7.1 \pm 0.6) \%$ | | 5240 |

| | | | | |
|--------------------------|----------------------------------|------------------|-----|------|
| $\phi\eta$ | < 1.8 | $\times 10^{-6}$ | 90% | 5226 |
| $\phi\eta'$ | < 4.3 | $\times 10^{-6}$ | 90% | 5196 |
| $\rho\eta$ | < 1.3 | $\times 10^{-6}$ | 90% | 5247 |
| $\rho\eta'$ | < 2.5 | $\times 10^{-6}$ | 90% | 5217 |
| $\Upsilon(1S)$ anything | < 4 | $\times 10^{-3}$ | 90% | 1053 |
| $\Upsilon(1S)\pi^+\pi^-$ | $(8.2 \pm 0.4) \times 10^{-5}$ | | | 1026 |
| $\Upsilon(1S)\eta$ | $(1.81 \pm 0.18) \times 10^{-4}$ | | | 924 |
| $\Upsilon(2S)\pi^+\pi^-$ | $(8.2 \pm 0.8) \times 10^{-5}$ | | | 468 |
| $h_b(1P)\pi^+\pi^-$ | not seen | | | 600 |
| $h_b(1P)\eta$ | $(2.18 \pm 0.21) \times 10^{-3}$ | | | 390 |
| 2H anything | < 1.3 | $\times 10^{-5}$ | 90% | — |

Double Radiative Decays

| | | | | |
|--|-------|------------------|-----|---|
| $\gamma\gamma \Upsilon(D) \rightarrow \gamma\gamma\eta \Upsilon(1S)$ | < 2.3 | $\times 10^{-5}$ | 90% | — |
|--|-------|------------------|-----|---|

Z_b(10610)

$$I^G(J^{PC}) = 1^+(1^{+-})$$

Mass $m = 10607.2 \pm 2.0$ MeV

Full width $\Gamma = 18.4 \pm 2.4$ MeV

| Z_b(10610) DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|---|--------------------------------------|-------------|
| $\Upsilon(1S)\pi^+$ | $(5.4^{+1.9}_{-1.5}) \times 10^{-3}$ | 1077 |
| $\Upsilon(1S)\pi^0$ | not seen | 1077 |
| $\Upsilon(2S)\pi^+$ | $(3.6^{+1.1}_{-0.8}) \%$ | 551 |
| $\Upsilon(2S)\pi^0$ | seen | 552 |
| $\Upsilon(3S)\pi^+$ | $(2.1^{+0.8}_{-0.6}) \%$ | 207 |
| $\Upsilon(3S)\pi^0$ | seen | 210 |
| $h_b(1P)\pi^+$ | $(3.5^{+1.2}_{-0.9}) \%$ | 671 |
| $h_b(2P)\pi^+$ | $(4.7^{+1.7}_{-1.3}) \%$ | 313 |
| $B^+\bar{B}^0$ | not seen | 505 |
| $B^+\bar{B}^{*0} + B^{*+}\bar{B}^0$ | $(85.6^{+2.1}_{-2.9}) \%$ | — |
| $B^{*+}\bar{B}^{*0}$ | not seen | † |

$\Upsilon(10860)$

$$I^G(J^{PC}) = 0^-(1^{--})$$

Mass $m = 10889.9^{+3.2}_{-2.6}$ MeV

Full width $\Gamma = 51^{+6}_{-7}$ MeV

$\Gamma_{ee} = 0.31 \pm 0.07$ keV ($S = 1.3$)

| $T(10860)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | ρ (MeV/c) |
|--|---|------------------|-------------------|
| $B\bar{B}X$ | (76.2 $^{+2.7}_{-4.0}$) % | | — |
| $B\bar{B}$ | (5.5 ± 1.0) % | | 1332 |
| $B\bar{B}^* + \text{c.c.}$ | (13.7 ± 1.6) % | | — |
| $B^*\bar{B}^*$ | (38.1 ± 3.4) % | | 1138 |
| $B\bar{B}^{(*)}\pi$ | < 19.7 % | 90% | 1027 |
| $B\bar{B}\pi$ | (0.0 ± 1.2) % | | 1027 |
| $B^*\bar{B}\pi + B\bar{B}^*\pi$ | (7.3 ± 2.3) % | | — |
| $B^*\bar{B}^*\pi$ | (1.0 ± 1.4) % | | 756 |
| $B\bar{B}\pi\pi$ | < 8.9 % | 90% | 574 |
| $B_s^{(*)}\bar{B}_s^{(*)}$ | (20.1 ± 3.1) % | | 919 |
| $B_s\bar{B}_s$ | (5 ± 5) $\times 10^{-3}$ | | 919 |
| $B_s\bar{B}_s^* + \text{c.c.}$ | (1.35 ± 0.32) % | | — |
| $B_s^*\bar{B}_s^*$ | (17.6 ± 2.7) % | | 566 |
| no open-bottom | (3.8 $^{+5.0}_{-0.5}$) % | | — |
| e^+e^- | (6.1 ± 1.6) $\times 10^{-6}$ | | 5445 |
| $K^*(892)^0\bar{K}^0$ | < 1.0 $\times 10^{-5}$ | 90% | 5397 |
| $\Upsilon(1S)\pi^+\pi^-$ | (5.3 ± 0.6) $\times 10^{-3}$ | | 1310 |
| $\Upsilon(2S)\pi^+\pi^-$ | (7.8 ± 1.3) $\times 10^{-3}$ | | 788 |
| $\Upsilon(3S)\pi^+\pi^-$ | (4.8 $^{+1.9}_{-1.7}$) $\times 10^{-3}$ | | 445 |
| $\Upsilon(1S)K^+K^-$ | (6.1 ± 1.8) $\times 10^{-4}$ | | 965 |
| $h_b(1P)\pi^+\pi^-$ | (3.5 $^{+1.0}_{-1.3}$) $\times 10^{-3}$ | | 907 |
| $h_b(2P)\pi^+\pi^-$ | (5.7 $^{+1.7}_{-2.1}$) $\times 10^{-3}$ | | 548 |
| $\chi_{b0}(1P)\pi^+\pi^-\pi^0$ | < 6.3 $\times 10^{-3}$ | 90% | 899 |
| $\chi_{b0}(1P)\omega$ | < 3.9 $\times 10^{-3}$ | 90% | 638 |
| $\chi_{b0}(1P)(\pi^+\pi^-\pi^0)_{\text{non-}\omega}$ | < 4.8 $\times 10^{-3}$ | 90% | — |
| $\chi_{b1}(1P)\pi^+\pi^-\pi^0$ | (1.85 ± 0.33) $\times 10^{-3}$ | | 865 |
| $\chi_{b1}(1P)\omega$ | (1.57 ± 0.30) $\times 10^{-3}$ | | 589 |
| $\chi_{b1}(1P)(\pi^+\pi^-\pi^0)_{\text{non-}\omega}$ | (5.2 ± 1.9) $\times 10^{-4}$ | | — |
| $\chi_{b2}(1P)\pi^+\pi^-\pi^0$ | (1.17 ± 0.30) $\times 10^{-3}$ | | 846 |
| $\chi_{b2}(1P)\omega$ | (6.0 ± 2.7) $\times 10^{-4}$ | | 559 |
| $\chi_{b2}(1P)(\pi^+\pi^-\pi^0)_{\text{non-}\omega}$ | (6 ± 4) $\times 10^{-4}$ | | — |
| $\gamma X_b \rightarrow \gamma \Upsilon(1S)\omega$ | < 3.8 $\times 10^{-5}$ | 90% | — |

Inclusive Decays.

These decay modes are submodes of one or more of the decay modes above.

| | | |
|-----------------------|-----------------------------|---|
| ϕ anything | (13.8 $^{+2.4}_{-1.7}$) % | — |
| D^0 anything + c.c. | (108 ± 8) % | — |

| | | |
|-----------------------|----------------|---|
| D_s anything + c.c. | (46 ±6) % | — |
| J/ψ anything | (2.06±0.21) % | — |
| B^0 anything + c.c. | (77 ±8) % | — |
| B^+ anything + c.c. | (72 ±6) % | — |

| | | |
|---|--------------------------------------|-------------|
| $\Upsilon(11020)$ | $I^G(J^{PC}) = 0^-(1^{--})$ | |
| Mass $m = 10992.9^{+10.0}_{-3.1}$ MeV Full width $\Gamma = 49^{+9}_{-15}$ MeV $\Gamma_{ee} = 0.130 \pm 0.030$ keV | | |
| $\Upsilon(11020)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
| $e^+ e^-$ | $(2.7^{+1.0}_{-0.8}) \times 10^{-6}$ | 5496 |

NOTES

- [a] $2m_\tau < M(\tau^+ \tau^-) < 9.2$ GeV
- [b] 2 GeV $< m_{K^+ K^-} < 3$ GeV
- [c] $X =$ scalar with $m < 8.0$ GeV
- [d] $X \bar{X} =$ vectors with $m < 3.1$ GeV
- [e] X and $\bar{X} =$ zero spin with $m < 4.5$ GeV
- [f] 1.5 GeV $< m_X < 5.0$ GeV
- [g] 201 MeV $< M(\mu^+ \mu^-) < 3565$ MeV
- [h] 0.5 GeV $< m_X < 9.0$ GeV, where m_X is the invariant mass of the hadronic final state.
- [i] Spectroscopic labeling for these states is theoretical, pending experimental information.
- [j] 1.5 GeV $< m_X < 5.0$ GeV
- [k] 1.5 GeV $< m_X < 5.0$ GeV
- [l] For $m_{\tau^+ \tau^-}$ in the ranges 4.03–9.52 and 9.61–10.10 GeV.