

$b\bar{b}$ MESONS

$\Upsilon(1S)$

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

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) | 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

| | | | |
|-----------------------|----------------------------------|-----|------|
| $\eta'(958)$ anything | $(2.94 \pm 0.24) \%$ | | — |
| $J/\psi(1S)$ anything | $(6.5 \pm 0.7) \times 10^{-4}$ | | 4223 |
| χ_{c0} anything | $< 5 \times 10^{-3}$ | 90% | — |
| χ_{c1} anything | $(2.3 \pm 0.7) \times 10^{-4}$ | | — |
| χ_{c2} anything | $(3.4 \pm 1.0) \times 10^{-4}$ | | — |
| $\psi(2S)$ anything | $(2.7 \pm 0.9) \times 10^{-4}$ | | — |
| $\rho\pi$ | $< 2 \times 10^{-4}$ | 90% | 4697 |
| $\pi^+ \pi^-$ | $< 5 \times 10^{-4}$ | 90% | 4728 |
| $K^+ K^-$ | $< 5 \times 10^{-4}$ | 90% | 4704 |
| $p\bar{p}$ | $< 5 \times 10^{-4}$ | 90% | 4636 |
| $\pi^0 \pi^+ \pi^-$ | $< 1.84 \times 10^{-5}$ | 90% | 4725 |
| \bar{d} anything | $(2.86 \pm 0.28) \times 10^{-5}$ | | — |

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 |
| $\gamma\pi^0 \eta$ | $< 2.4 \times 10^{-6}$ | 90% | 4713 |
| $\gamma K^+ K^-$ | [a] $(1.14 \pm 0.13) \times 10^{-5}$ | | 4704 |
| $\gamma p\bar{p}$ | [b] $< 6 \times 10^{-6}$ | 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 | $\times 10^{-6}$ | 90% | 4682 |
| $\gamma\eta$ | < 1.0 | $\times 10^{-6}$ | 90% | 4714 |
| $\gamma f_0(980)$ | < 3 | $\times 10^{-5}$ | 90% | 4679 |
| $\gamma f_2'(1525)$ | $(3.7^{+1.2}_{-1.1}) \times 10^{-5}$ | | | 4607 |
| $\gamma f_2(1270)$ | $(1.01 \pm 0.09) \times 10^{-4}$ | | | 4644 |
| $\gamma\eta(1405)$ | < 8.2 | $\times 10^{-5}$ | 90% | 4625 |
| $\gamma f_0(1500)$ | < 1.5 | $\times 10^{-5}$ | 90% | 4610 |
| $\gamma f_0(1710)$ | < 2.6 | $\times 10^{-4}$ | 90% | 4574 |
| $\gamma f_0(1710) \rightarrow \gamma K^+ K^-$ | < 7 | $\times 10^{-6}$ | 90% | — |
| $\gamma f_0(1710) \rightarrow \gamma \pi^0 \pi^0$ | < 1.4 | $\times 10^{-6}$ | 90% | — |
| $\gamma f_0(1710) \rightarrow \gamma \eta \eta$ | < 1.8 | $\times 10^{-6}$ | 90% | — |
| $\gamma f_4(2050)$ | < 5.3 | $\times 10^{-5}$ | 90% | 4515 |
| $\gamma f_0(2200) \rightarrow \gamma K^+ K^-$ | < 2 | $\times 10^{-4}$ | 90% | 4475 |
| $\gamma f_J(2220) \rightarrow \gamma K^+ K^-$ | < 8 | $\times 10^{-7}$ | 90% | 4469 |
| $\gamma f_J(2220) \rightarrow \gamma \pi^+ \pi^-$ | < 6 | $\times 10^{-7}$ | 90% | — |
| $\gamma f_J(2220) \rightarrow \gamma p \bar{p}$ | < 1.1 | $\times 10^{-6}$ | 90% | — |
| $\gamma\eta(2225) \rightarrow \gamma \phi \phi$ | < 3 | $\times 10^{-3}$ | 90% | 4469 |
| γX | [c] < 3 | $\times 10^{-5}$ | 90% | — |
| $\gamma X \bar{X}$ | [d] < 1 | $\times 10^{-3}$ | 90% | — |
| $\gamma X \rightarrow \gamma + \geq 4$ prongs | [e] < 1.78 | $\times 10^{-4}$ | 95% | — |

Lepton Flavor (LF) violating or Invisible decays

| | | | | | |
|--------------------|-----------|---------|------------------|-----|------|
| $\mu^\pm \tau^\mp$ | <i>LF</i> | < 6.0 | $\times 10^{-6}$ | 95% | 4563 |
| invisible | | < 2.5 | $\times 10^{-3}$ | 90% | — |

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

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

Mass $m = 9859.44 \pm 0.42 \pm 0.31$ MeV

| $\chi_{b0}(1P)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | P (MeV/c) |
|---------------------------------|------------------------------------|------------------|----------------|
| $\gamma \Upsilon(1S)$ | < 6 % | 90% | 391 |
| $D^0 X$ | < 10.4 % | 90% | — |
| $\pi^+ \pi^- K^+ K^- \pi^0$ | < 1.6 $\times 10^{-4}$ | 90% | 4875 |
| $2\pi^+ \pi^- K^- K_S^0$ | < 5 $\times 10^{-5}$ | 90% | 4875 |
| $2\pi^+ \pi^- K^- K_S^0 2\pi^0$ | < 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 |

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

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

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 \pm 8) % | | 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 |
| $2\pi^+ \pi^- K^- K_S^0 2\pi^0$ | < 6 $\times 10^{-4}$ | 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 |

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

$I^G(J^{PC}) = 0^+(2^{++})$
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 | ^{<i>P</i>} (MeV/ <i>c</i>) |
|-----------------------------------------------|--------------------------------|------------------|-----------------------------------------|
| $\gamma \Upsilon(1S)$ | (22 ± 4) % | | 442 |
| $D^0 X$ | < 7.9 % | 90% | — |
| $\pi^+ \pi^- K^+ K^- \pi^0$ | (8 ± 5) × 10 ⁻⁵ | | 4902 |
| $2\pi^+ \pi^- K^- K_S^0$ | < 1.0 × 10 ⁻⁴ | 90% | 4901 |
| $2\pi^+ \pi^- K^- K_S^0 2\pi^0$ | (5.3±2.4) × 10 ⁻⁴ | | 4873 |
| $2\pi^+ 2\pi^- 2\pi^0$ | (3.5±1.4) × 10 ⁻⁴ | | 4931 |
| $2\pi^+ 2\pi^- K^+ K^-$ | (1.1±0.4) × 10 ⁻⁴ | | 4888 |
| $2\pi^+ 2\pi^- K^+ K^- \pi^0$ | (2.1±0.9) × 10 ⁻⁴ | | 4872 |
| $2\pi^+ 2\pi^- K^+ K^- 2\pi^0$ | (3.9±1.8) × 10 ⁻⁴ | | 4855 |
| $3\pi^+ 2\pi^- K^- K_S^0 \pi^0$ | < 5 × 10 ⁻⁴ | 90% | 4854 |
| $3\pi^+ 3\pi^-$ | (7.0±3.1) × 10 ⁻⁵ | | 4931 |
| $3\pi^+ 3\pi^- 2\pi^0$ | (1.0±0.4) × 10 ⁻³ | | 4908 |
| $3\pi^+ 3\pi^- K^+ K^-$ | < 8 × 10 ⁻⁵ | 90% | 4854 |
| $3\pi^+ 3\pi^- K^+ K^- \pi^0$ | (3.6±1.5) × 10 ⁻⁴ | | 4835 |
| $4\pi^+ 4\pi^-$ | (8 ± 4) × 10 ⁻⁵ | | 4907 |
| $4\pi^+ 4\pi^- 2\pi^0$ | (1.8±0.7) × 10 ⁻³ | | 4877 |

$\Upsilon(2S)$

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

Mass $m = 10.02326 \pm 0.00031$ GeV

Full 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 | ρ (MeV/c) |
|----------------------------------------------|-------------------------------------------|-----------------------------------|-------------------|
| $\Upsilon(1S)\pi^+\pi^-$ | (18.1 \pm 0.4) % | | 475 |
| $\Upsilon(1S)\pi^0\pi^0$ | (8.6 \pm 0.4) % | | 480 |
| $\tau^+\tau^-$ | (2.00 \pm 0.21) % | | 4686 |
| $\mu^+\mu^-$ | (1.93 \pm 0.17) % | S=2.2 | 5011 |
| e^+e^- | (1.91 \pm 0.16) % | | 5012 |
| $\Upsilon(1S)\pi^0$ | < 1.8 | $\times 10^{-4}$ CL=90% | 531 |
| $\Upsilon(1S)\eta$ | (2.1 $^{+0.8}_{-0.7}$) $\times 10^{-4}$ | | 126 |
| $J/\psi(1S)$ anything | < 6 | $\times 10^{-3}$ CL=90% | 4533 |
| \bar{d} anything | (3.4 \pm 0.6) $\times 10^{-5}$ | | – |
| hadrons | (94 \pm 11) % | | – |

Radiative decays

| | | | |
|-----------------------------------------------|-----------------------|-------------------------|------|
| $\gamma\chi_{b1}(1P)$ | (6.9 \pm 0.4) % | | 130 |
| $\gamma\chi_{b2}(1P)$ | (7.15 \pm 0.35) % | | 110 |
| $\gamma\chi_{b0}(1P)$ | (3.8 \pm 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% | 4931 |
| $\gamma\eta_b(1S)$ | < 5.1 | $\times 10^{-4}$ CL=90% | 614 |
| $\gamma X \rightarrow \gamma + \geq 4$ prongs | [g] < 1.95 | $\times 10^{-4}$ CL=95% | – |

Lepton Flavor (LF) violating decays

| | | | | |
|-------------------|----|--------|-------------------------|------|
| $\mu^\pm\tau^\mp$ | LF | < 1.44 | $\times 10^{-5}$ CL=95% | 4854 |
|-------------------|----|--------|-------------------------|------|

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

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

J needs confirmation.

$$\text{Mass } m = 10.2325 \pm 0.0004 \pm 0.0005 \text{ GeV}$$

| $\chi_{b0}(2P)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | p (MeV/c) |
|---------------------------------|--------------------------------|------------------|----------------|
| $\gamma \Upsilon(2S)$ | $(4.6 \pm 2.1) \%$ | | 207 |
| $\gamma \Upsilon(1S)$ | $(9 \pm 6) \times 10^{-3}$ | | 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 |

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

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

J needs confirmation.

$$\text{Mass } m = 10.25546 \pm 0.00022 \pm 0.00050 \text{ GeV}$$

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

| $\chi_{b1}(2P)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor | p (MeV/c) |
|---------------------------------|--------------------------------|--------------|----------------|
| $\omega \Upsilon(1S)$ | $(1.63^{+0.40}_{-0.34}) \%$ | | 135 |
| $\gamma \Upsilon(2S)$ | $(21 \pm 4) \%$ | 1.5 | 230 |
| $\gamma \Upsilon(1S)$ | $(8.5 \pm 1.3) \%$ | 1.3 | 764 |
| $\pi\pi \chi_{b1}(1P)$ | $(8.6 \pm 3.1) \times 10^{-3}$ | | 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 |

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

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

J needs confirmation.

$$\text{Mass } m = 10.26865 \pm 0.00022 \pm 0.00050 \text{ GeV}$$

$$m_{\chi_{b2}(2P)} - m_{\chi_{b1}(2P)} = 13.5 \pm 0.6 \text{ MeV}$$

| $\chi_{b2}(2P)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | ^P (MeV/c) |
|-----------------------------------------------|----------------------------------|------------------|-------------------------|
| $\omega \Upsilon(1S)$ | $(1.10^{+0.34}_{-0.30}) \%$ | | 194 |
| $\gamma \Upsilon(2S)$ | $(16.2 \pm 2.4) \%$ | | 242 |
| $\gamma \Upsilon(1S)$ | $(7.1 \pm 1.0) \%$ | | 777 |
| $\pi\pi \chi_{b2}(1P)$ | $(6.0 \pm 2.1) \times 10^{-3}$ | | 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 |

$\Upsilon(3S)$

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

$$\text{Mass } m = 10.3552 \pm 0.0005 \text{ GeV}$$

$$\text{Full width } \Gamma = 20.32 \pm 1.85 \text{ keV}$$

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

| $\Upsilon(3S)$ DECAY MODES | Fraction (Γ_i/Γ) | Scale factor/ Confidence level | ρ (MeV/c) |
|----------------------------------------------|--------------------------------|-----------------------------------|-------------------|
| $\Upsilon(2S)$ anything | (10.6 \pm 0.8) % | | 296 |
| $\Upsilon(2S)\pi^+\pi^-$ | (2.45 \pm 0.23) % | S=1.1 | 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 |
| $\Upsilon(1S)\pi^+\pi^-$ | (4.40 \pm 0.10) % | | 813 |
| $\Upsilon(1S)\pi^0\pi^0$ | (2.20 \pm 0.13) % | | 816 |
| $\Upsilon(1S)\eta$ | < 1.8 $\times 10^{-4}$ | CL=90% | 677 |
| $\Upsilon(1S)\pi^0$ | < 7 $\times 10^{-5}$ | CL=90% | 846 |
| $\tau^+\tau^-$ | (2.29 \pm 0.30) % | | 4863 |
| $\mu^+\mu^-$ | (2.18 \pm 0.21) % | S=2.1 | 5177 |
| e^+e^- | seen | | 5178 |

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 |
| $\gamma\chi_{b2}(1P)$ | < 1.9 % | CL=90% | 434 |
| $\gamma\chi_{b1}(1P)$ | < 1.7 $\times 10^{-3}$ | CL=90% | 452 |
| $\gamma\chi_{b0}(1P)$ | (3.0 \pm 1.1) $\times 10^{-3}$ | | 484 |
| $\gamma\eta_b(2S)$ | < 6.2 $\times 10^{-4}$ | CL=90% | – |
| $\gamma\eta_b(1S)$ | (4.8 \pm 1.3) $\times 10^{-4}$ | | 921 |
| $\gamma X \rightarrow \gamma + \geq 4$ prongs | [h] < 2.2 $\times 10^{-4}$ | CL=95% | – |

Lepton Flavor (LF) violating decays

| | | | | |
|-------------------|----|-------------------------|--------|------|
| $\mu^\pm\tau^\mp$ | LF | < 2.03 $\times 10^{-5}$ | CL=95% | 5025 |
|-------------------|----|-------------------------|--------|------|

**$\Upsilon(4S)$
or $\Upsilon(10580)$**

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

Mass $m = 10.5794 \pm 0.0012$ GeV

Full width $\Gamma = 20.5 \pm 2.5$ MeV

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

| $\Upsilon(4S)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | P (MeV/c) |
|----------------------------------------------|--------------------------------------|------------------|----------------|
| $B\bar{B}$ | > 96 % | 95% | 328 |
| B^+B^- | (51.6 \pm 0.6) % | | 334 |
| D_s^+ anything + c.c. | (18.2 \pm 2.5) % | | – |
| $B^0\bar{B}^0$ | (48.4 \pm 0.6) % | | 328 |
| $J/\psi K_S^0 (J/\psi, \eta_c) K_S^0$ | < 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 |
| $J/\psi(1S)$ anything | < 1.9 $\times 10^{-4}$ | 95% | – |
| D^{*+} anything + c.c. | < 7.4 % | 90% | 5099 |
| ϕ anything | (7.1 \pm 0.6) % | | 5240 |
| $\phi\eta$ | < 2.5 $\times 10^{-6}$ | 90% | 5226 |
| $\Upsilon(1S)$ anything | < 4 $\times 10^{-3}$ | 90% | 1053 |
| $\Upsilon(1S)\pi^+\pi^-$ | (8.0 \pm 0.7) $\times 10^{-5}$ | | 1026 |
| $\Upsilon(1S)\eta$ | (1.96 \pm 0.11) $\times 10^{-4}$ | | 924 |
| $\Upsilon(2S)\pi^+\pi^-$ | (8.6 \pm 1.3) $\times 10^{-5}$ | | 468 |
| \bar{d} anything | < 1.3 $\times 10^{-5}$ | 90% | – |

$\Upsilon(10860)$

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

Mass $m = 10.865 \pm 0.008$ GeV (S = 1.1)

Full width $\Gamma = 110 \pm 13$ MeV

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

| $\Upsilon(10860)$ DECAY MODES | Fraction (Γ_i/Γ) | Confidence level | P (MeV/c) |
|-------------------------------------------------|------------------------------------|------------------|----------------|
| e^+e^- | (2.8 \pm 0.7) $\times 10^{-6}$ | | 5432 |
| $B\bar{B}X$ | (59 \pm 14) % | | – |
| $B\bar{B}$ | < 13.8 % | 90% | 1280 |
| $B\bar{B}^* +$ c.c. | (14 \pm 6) % | | – |
| $B^*\bar{B}^*$ | (44 \pm 11) % | | – |
| $B\bar{B}^{(*)}\pi$ | < 19.7 % | 90% | – |
| $B\bar{B}\pi\pi$ | < 8.9 % | 90% | 442 |
| $B_s^{(*)}\bar{B}_s^{(*)}(X)$ | (19.3 \pm 2.9) % | | – |
| $\Upsilon(1S)\pi^+\pi^-$ | (5.3 \pm 0.6) $\times 10^{-3}$ | | 1288 |
| $\Upsilon(2S)\pi^+\pi^-$ | (7.8 \pm 1.3) $\times 10^{-3}$ | | 763 |
| $\Upsilon(3S)\pi^+\pi^-$ | (4.8 \pm 1.9) $\times 10^{-3}$ | | 416 |
| $\Upsilon(1S)K^+K^-$ | (6.1 \pm 1.8) $\times 10^{-4}$ | | 933 |

Inclusive Decays.

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

| | | |
|-----------------------|--------------------------------------------------------------------|---|
| ϕ anything | $(13.8 \begin{smallmatrix} + 2.4 \\ - 1.7 \end{smallmatrix}) \%$ | — |
| D^0 anything + c.c. | $(108 \pm 8) \%$ | — |
| D_s anything + c.c. | $(46 \pm 6) \%$ | — |
| J/ψ anything | $(2.06 \pm 0.21) \%$ | — |

$\Upsilon(11020)$

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

Mass $m = 11.019 \pm 0.008$ GeV

Full width $\Gamma = 79 \pm 16$ MeV

$\Gamma_{ee} = 0.130 \pm 0.030$ keV

| $\Upsilon(11020)$ DECAY MODES | Fraction (Γ_i/Γ) | p (MeV/c) |
|-------------------------------------------------|--------------------------------|-------------|
| $e^+ e^-$ | $(1.6 \pm 0.5) \times 10^{-6}$ | 5510 |

NOTES

[a] $2m_\tau < M(\tau^+ \tau^-) < 7500$ MeV.

[b] $2 < m_{K^+ K^-} < 3$ GeV.

[c] $X =$ pseudoscalar with $m < 7.2$ GeV

[d] $X \bar{X} =$ vectors with $m < 3.1$ GeV

[e] 1.5 GeV $< m_X < 5.0$ GeV

[f] Spectroscopic labeling for these states is theoretical, pending experimental information.

[g] 1.5 GeV $< m_X < 5.0$ GeV

[h] 1.5 GeV $< m_X < 5.0$ GeV