$\chi_{b1}(2P)$

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

Observed in radiative decay of the $\Upsilon(3S)$, therefore $C = +$. Branching ratio requires E1 transition, M1 is strongly disfavored, therefore $P = +$.

$\chi_{b1}(2P)$ MASS

VALUE (MeV)	DOCUMENT ID
10255.46±0.22±0.50 OUR EVALUATION	From γ energy below, using $\Upsilon(3S)$ mass = 10355.2 ± 0.5 MeV

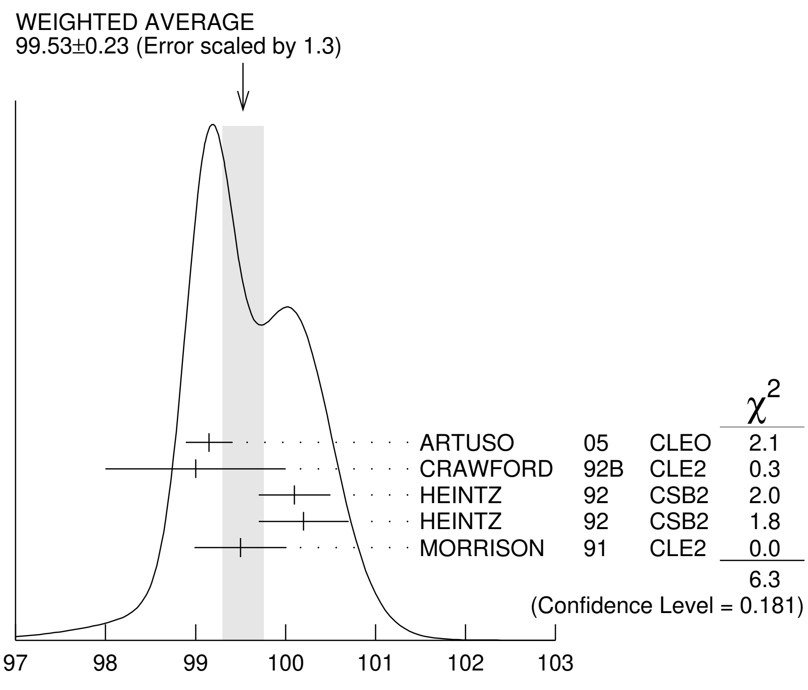
$m_{\chi_{b1}(2P)} - m_{\chi_{b0}(2P)}$

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
23.5±0.7±0.7	[1] HEINTZ	92	CSB2	$e^+e^- \to \gamma X, \ell^+\ell^-\gamma\gamma$

[1] From the average photon energy for inclusive and exclusive events. Supersedes NARAIN 91.

γ ENERGY IN $\Upsilon(3S)$ DECAY

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
99.26±0.22 OUR EVALUATION		Treating systematic errors as correlated			
99.53±0.23 OUR AVERAGE		Error includes scale factor of 1.3. See the ideogram below.			
99.15±0.07±0.25		ARTUSO	05	CLEO	$\Upsilon(3S) \to \gamma X$
99 ±1	169	CRAWFORD	92B	CLE2	$e^+e^- \to \ell^+\ell^-\gamma\gamma$
100.1 ±0.4	11147	[2] HEINTZ	92	CSB2	$e^+e^- \to \gamma X$
100.2 ±0.5	223	[3] HEINTZ	92	CSB2	$e^+e^- \to \ell^+\ell^-\gamma\gamma$
99.5 ±0.1 ±0.5	25759	MORRISON	91	CLE2	$e^+e^- \to \gamma X$



γ energy in $\Upsilon(3S)$ decay (MeV)

[2] A systematic uncertainty on the energy scale of 0.9% not included. Supersedes NARAIN 91.
[3] A systematic uncertainty on the energy scale of 0.9% not included. Supersedes HEINTZ 91.

$\chi_{b1}(2P)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$\omega\,\Upsilon(1S)$	$(1.63^{+0.40}_{-0.34})$ %
Γ_2	$\gamma\,\Upsilon(2S)$	$(18.1\ \pm 1.9)$ %
Γ_3	$\gamma\,\Upsilon(1S)$	$(9.9\ \pm 1.0)$ %
Γ_4	$\pi\pi\chi_{b1}(1P)$	$(9.1\ \pm 1.3) \times 10^{-3}$
Γ_5	$D^0 X$	$(8.8\ \pm 1.7)$ %
Γ_6	$\pi^+\pi^- K^+ K^- \pi^0$	$(3.1\ \pm 1.0) \times 10^{-4}$
Γ_7	$2\pi^+\pi^- K^- K^0_S$	$(1.1\ \pm 0.5) \times 10^{-4}$
Γ_8	$2\pi^+\pi^- K^- K^0_S 2\pi^0$	$(7.7\ \pm 3.2) \times 10^{-4}$
Γ_9	$2\pi^+ 2\pi^- 2\pi^0$	$(5.9\ \pm 2.0) \times 10^{-4}$
Γ_{10}	$2\pi^+ 2\pi^- K^+ K^-$	$(10\ \pm 4) \times 10^{-5}$
Γ_{11}	$2\pi^+ 2\pi^- K^+ K^- \pi^0$	$(5.5\ \pm 1.8) \times 10^{-4}$
Γ_{12}	$2\pi^+ 2\pi^- K^+ K^- 2\pi^0$	$(10\ \pm 4) \times 10^{-4}$
Γ_{13}	$3\pi^+ 2\pi^- K^- K^0_S \pi^0$	$(6.7\ \pm 2.6) \times 10^{-4}$
Γ_{14}	$3\pi^+ 3\pi^-$	$(1.2\ \pm 0.4) \times 10^{-4}$
Γ_{15}	$3\pi^+ 3\pi^- 2\pi^0$	$(1.2\ \pm 0.4) \times 10^{-3}$
Γ_{16}	$3\pi^+ 3\pi^- K^+ K^-$	$(2.0\ \pm 0.8) \times 10^{-4}$
Γ_{17}	$3\pi^+ 3\pi^- K^+ K^- \pi^0$	$(6.1\ \pm 2.2) \times 10^{-4}$
Γ_{18}	$4\pi^+ 4\pi^-$	$(1.7\ \pm 0.6) \times 10^{-4}$
Γ_{19}	$4\pi^+ 4\pi^- 2\pi^0$	$(1.9\ \pm 0.7) \times 10^{-3}$

$\chi_{b1}(2P)$ BRANCHING RATIOS

$\Gamma(\omega\,\Upsilon(1S))/\Gamma_{\text{total}}$ — Γ_1/Γ

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
$\mathbf{1.63^{+0.35}_{-0.31}{}^{+0.16}_{-0.15}}$	$32.6^{+6.9}_{-6.1}$	[4] CRONIN-HEN..04	CLE3	$\Upsilon(3S) \to \gamma\omega\,\Upsilon(1S)$

[4] Using B($\Upsilon(3S) \to \gamma\chi_{b1}(2P)$) = (11.3 ± 0.6)% and B($\Upsilon(1S) \to \ell^+\ell^-$) = 2 B($\Upsilon(1S) \to \mu^+\mu^-$) = 2 (2.48 ± 0.06)%.

$\Gamma(\gamma\,\Upsilon(2S))/\Gamma_{\text{total}}$ — Γ_2/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.181±0.019 OUR AVERAGE					
0.211±0.017±0.019		[5,6,7] LEES	14M	BABR	$\Upsilon(3S) \to \gamma\gamma\mu^+\mu^-$
0.190±0.018±0.017	4.3k	[8] LEES	11J	BABR	$\Upsilon(3S) \to X\gamma$
0.206±0.035±0.019		[5,9] CRAWFORD	92B	CLE2	$e^+e^- \to \ell^+\ell^-\gamma\gamma$
0.132±0.018±0.012		[5,10] HEINTZ	92	CSB2	$e^+e^- \to \ell^+\ell^-\gamma\gamma$

[5] Assuming B($\Upsilon(2S) \to \mu^+\mu^-$) = (1.93 ± 0.17)%.

[6] LEES 14M quotes $\Gamma(\chi_{b1}(2P) \rightarrow \gamma\Upsilon(2S))/\Gamma_{total} \times \Gamma(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P))/\Gamma_{total}$ = (2.66 ± 0.22)% combining the results from $\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$ samples with and without photon conversions.

[7] LEES 14M reports $[\Gamma(\chi_{b1}(2P) \rightarrow \gamma\Upsilon(2S))/\Gamma_{total}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P))] = (2.66 \pm 0.22) \times 10^{-2}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

[8] LEES 11J reports $[\Gamma(\chi_{b1}(2P) \rightarrow \gamma\Upsilon(2S))/\Gamma_{total}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P))] = (2.4 \pm 0.1 \pm 0.2) \times 10^{-2}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

[9] CRAWFORD 92B quotes $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) \times B(\chi_{b1}(2P) \rightarrow \gamma\Upsilon(2S)) \times 2\, B(\Upsilon(2S) \rightarrow \ell^+\ell^-) = (10.23 \pm 1.20 \pm 1.26)\ 10^{-4}$.

[10] Recalculated by us. HEINTZ 92 quotes $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) \times B(\chi_{b1}(2P) \rightarrow \gamma\Upsilon(2S)) = (2.29 \pm 0.23 \pm 0.21)$ % using $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.44 \pm 0.10)$%. Supersedes HEINTZ 91.

$\Gamma(\gamma\Upsilon(1S))/\Gamma_{total}$ Γ_3/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.099±0.010 OUR AVERAGE					
0.107±0.006±0.010		[11,12,13] LEES	14M	BABR	$\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$
0.098±0.005±0.009	15k	[14] LEES	11J	BABR	$\Upsilon(3S) \rightarrow X\gamma$
0.103±0.023±0.009		[11,15] CRAWFORD	92B	CLE2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$
0.075±0.010±0.007		[11,16] HEINTZ	92	CSB2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$

[11] Assuming $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.05)$%.

[12] LEES 14M quotes $\Gamma(\chi_{b1}(2P) \rightarrow \gamma\Upsilon(1S))/\Gamma_{total} \times \Gamma(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P))/\Gamma_{total} = (13.48 \pm 0.72) \times 10^{-3}$ combining the results from samples of $\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$ with and without converted photons.

[13] LEES 14M reports $[\Gamma(\chi_{b1}(2P) \rightarrow \gamma\Upsilon(1S))/\Gamma_{total}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P))] = (13.48 \pm 0.72) \times 10^{-3}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

[14] LEES 11J reports $[\Gamma(\chi_{b1}(2P) \rightarrow \gamma\Upsilon(1S))/\Gamma_{total}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P))] = (12.4 \pm 0.3 \pm 0.6) \times 10^{-3}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

[15] CRAWFORD 92B quotes $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) \times B(\chi_{b1}(2P) \rightarrow \gamma\Upsilon(1S)) \times 2\, B(\Upsilon(1S) \rightarrow \ell^+\ell^-) = (6.47 \pm 1.12 \pm 0.82)\ 10^{-4}$.

[16] Recalculated by us. HEINTZ 92 quotes $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) \times B(\chi_{b1}(2P) \rightarrow \gamma\Upsilon(1S)) = (0.91 \pm 0.11 \pm 0.06)$% using $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.57 \pm 0.05)$%. Supersedes HEINTZ 91.

$\Gamma(\pi\pi\chi_{b1}(1P))/\Gamma_{total}$ Γ_4/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
9.1±1.3 OUR AVERAGE					
9.2±1.1±0.8	31k	[17] LEES	11C	BABR	$e^+e^- \rightarrow \pi^+\pi^- X$
8.6±2.3±2.1		[18] CAWLFIELD	06	CLE3	$\Upsilon(3S) \rightarrow 2(\gamma\pi\ell)$

[17] LEES 11C measures $B(\Upsilon(3S) \rightarrow \chi_{b1}(2P)X) \times B(\chi_{b1}(2P) \rightarrow \chi_{b1}(1P)\pi^+\pi^-) = (1.16 \pm 0.07 \pm 0.12) \times 10^{-3}$. We derive the value assuming $B(\Upsilon(3S) \rightarrow \chi_{b1}(2P)X) = B(\Upsilon(3S) \rightarrow \chi_{b1}(2P)\gamma) = (12.6 \pm 1.2) \times 10^{-2}$.

[18] CAWLFIELD 06 quote $\Gamma(\chi_b(2P) \to \pi\pi\chi_b(1P)) = 0.83 \pm 0.22 \pm 0.08 \pm 0.19$ keV assuming I-spin conservation, no D-wave contribution, $\Gamma(\chi_{b1}(2P)) = 96 \pm 16$keV, and $\Gamma(\chi_{b2}(2P)) = 138 \pm 19$ keV.

$\Gamma(D^0 X)/\Gamma_{total}$ — Γ_5/Γ

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN	COMMENT
8.8±1.5±0.8	2243	[19] BRIERE	08	CLEO	$\Upsilon(3S) \to \gamma D^0 X$

[19] For $p_{D^0} > 2.5$ GeV/c.

$\Gamma(\pi^+\pi^- K^+ K^- \pi^0)/\Gamma_{total}$ — Γ_6/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
3.1±1.0±0.3	30	[20] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma\pi^+\pi^- K^+ K^- \pi^0$

[20] ASNER 08A reports $[\Gamma(\chi_{b1}(2P) \to \pi^+\pi^- K^+ K^- \pi^0)/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma\chi_{b1}(2P))] = (39 \pm 8 \pm 9) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \to \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+\pi^- K^- K^0_S)/\Gamma_{total}$ — Γ_7/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
1.1±0.5±0.1	10	[21] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 2\pi^+\pi^- K^- K^0_S$

[21] ASNER 08A reports $[\Gamma(\chi_{b1}(2P) \to 2\pi^+\pi^- K^- K^0_S)/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma\chi_{b1}(2P))] = (14 \pm 5 \pm 3) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \to \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+\pi^- K^- K^0_S 2\pi^0)/\Gamma_{total}$ — Γ_8/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
7.7±3.1±0.7	15	[22] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 2\pi^+\pi^- K^- 2\pi^0$

[22] ASNER 08A reports $[\Gamma(\chi_{b1}(2P) \to 2\pi^+\pi^- K^- K^0_S 2\pi^0)/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma\chi_{b1}(2P))] = (97 \pm 30 \pm 26) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \to \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+ 2\pi^- 2\pi^0)/\Gamma_{total}$ — Γ_9/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
5.9±2.0±0.5	36	[23] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 2\pi^+ 2\pi^- 2\pi^0$

[23] ASNER 08A reports $[\Gamma(\chi_{b1}(2P) \to 2\pi^+ 2\pi^- 2\pi^0)/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma\chi_{b1}(2P))] = (74 \pm 16 \pm 19) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \to \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+ 2\pi^- K^+ K^-)/\Gamma_{total}$ — Γ_{10}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
1.0±0.4±0.1	12	[24] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 2\pi^+ 2\pi^- K^+ K^-$

[24] ASNER 08A reports $[\Gamma(\chi_{b1}(2P) \to 2\pi^+ 2\pi^- K^+ K^-)/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma\chi_{b1}(2P))] = (12 \pm 4 \pm 3) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \to \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+ 2\pi^- K^+ K^- \pi^0)/\Gamma_{total}$ — Γ_{11}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
5.5±1.7±0.5	38	[25] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 2\pi^+ 2\pi^- K^+ K^- \pi^0$

[25] ASNER 08A reports $[\Gamma(\chi_{b1}(2P) \to 2\pi^+ 2\pi^- K^+ K^- \pi^0)/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma \chi_{b1}(2P))] = (69 \pm 13 \pm 17) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \to \gamma \chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+ 2\pi^- K^+ K^- 2\pi^0)/\Gamma_{total}$ — Γ_{12}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
9.6±3.5±0.9	27	[26] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 2\pi^+ 2\pi^- K^+ K^- 2\pi^0$

[26] ASNER 08A reports $[\Gamma(\chi_{b1}(2P) \to 2\pi^+ 2\pi^- K^+ K^- 2\pi^0)/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma \chi_{b1}(2P))] = (121 \pm 29 \pm 33) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \to \gamma \chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(3\pi^+ 2\pi^- K^- K^0_S \pi^0)/\Gamma_{total}$ — Γ_{13}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
6.7±2.5±0.6	17	[27] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 3\pi^+ 2\pi^- K^- K^0_S \pi^0$

[27] ASNER 08A reports $[\Gamma(\chi_{b1}(2P) \to 3\pi^+ 2\pi^- K^- K^0_S \pi^0)/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma \chi_{b1}(2P))] = (85 \pm 23 \pm 22) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \to \gamma \chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(3\pi^+ 3\pi^-)/\Gamma_{total}$ — Γ_{14}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
1.2±0.4±0.1	18	[28] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 3\pi^+ 3\pi^-$

[28] ASNER 08A reports $[\Gamma(\chi_{b1}(2P) \to 3\pi^+ 3\pi^-)/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma \chi_{b1}(2P))] = (15 \pm 4 \pm 3) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \to \gamma \chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(3\pi^+ 3\pi^- 2\pi^0)/\Gamma_{total}$ — Γ_{15}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
12±4±1	44	[29] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 3\pi^+ 3\pi^- 2\pi^0$

[29] ASNER 08A reports $[\Gamma(\chi_{b1}(2P) \to 3\pi^+ 3\pi^- 2\pi^0)/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma \chi_{b1}(2P))] = (150 \pm 30 \pm 40) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \to \gamma \chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(3\pi^+ 3\pi^- K^+ K^-)/\Gamma_{total}$ — Γ_{16}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
2.0±0.7±0.2	16	[30] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 3\pi^+ 3\pi^- K^+ K^-$

[30] ASNER 08A reports $[\Gamma(\chi_{b1}(2P) \to 3\pi^+ 3\pi^- K^+ K^-)/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma \chi_{b1}(2P))] = (25 \pm 7 \pm 6) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \to \gamma \chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(3\pi^+3\pi^-K^+K^-\pi^0)/\Gamma_{total}$ — Γ_{17}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
6.1±2.1±0.6	25	[31] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 3\pi^+3\pi^-K^+K^-\pi^0$

[31] ASNER 08A reports $[\Gamma(\chi_{b1}(2P) \to 3\pi^+3\pi^-K^+K^-\pi^0)/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma\chi_{b1}(2P))] = (77 \pm 17 \pm 21) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \to \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(4\pi^+4\pi^-)/\Gamma_{total}$ — Γ_{18}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
1.7±0.6±0.2	16	[32] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 4\pi^+4\pi^-$

[32] ASNER 08A reports $[\Gamma(\chi_{b1}(2P) \to 4\pi^+4\pi^-)/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma\chi_{b1}(2P))] = (22 \pm 6 \pm 5) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \to \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(4\pi^+4\pi^-2\pi^0)/\Gamma_{total}$ — Γ_{19}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
19±7±2	41	[33] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 4\pi^+4\pi^-2\pi^0$

[33] ASNER 08A reports $[\Gamma(\chi_{b1}(2P) \to 4\pi^+4\pi^-2\pi^0)/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma\chi_{b1}(2P))] = (241 \pm 47 \pm 72) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \to \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\chi_{b1}(2P)$ Cross-Particle Branching Ratios

$\Gamma(\chi_{b1}(2P) \to \gamma\Upsilon(1S))/\Gamma_{total} \times \Gamma(\Upsilon(3S) \to \gamma\chi_{b1}(2P))/\Gamma_{total}$ — $\Gamma_3/\Gamma \times \Gamma_{21}^{\Upsilon(3S)}/\Gamma^{\Upsilon(3S)}$

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
12.4±0.3±0.6	15k	LEES	11J	BABR	$\Upsilon(3S) \to X\gamma$

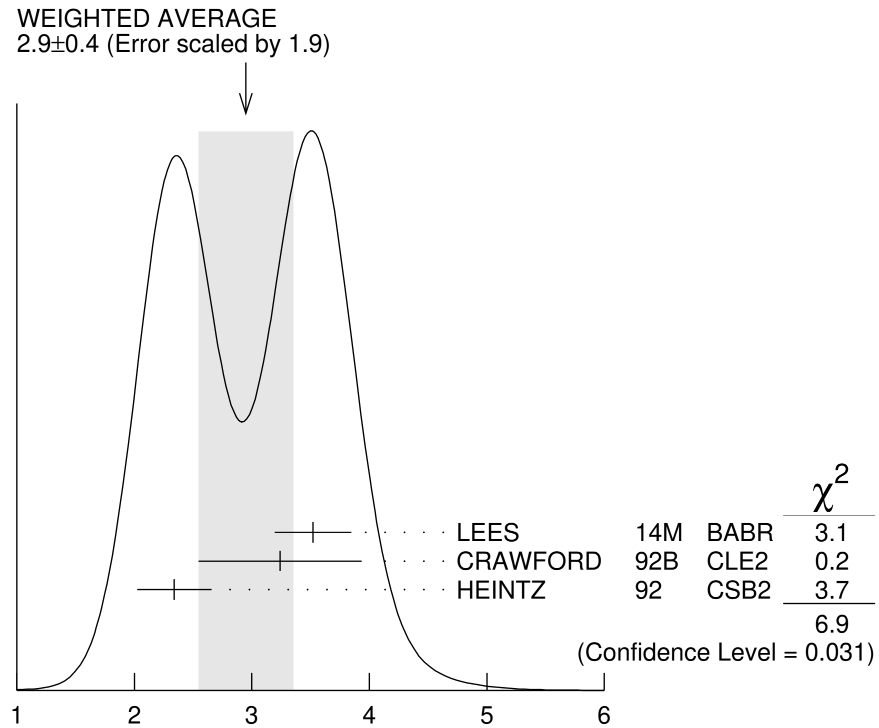
$B(\chi_{b1}(2P) \to \gamma\Upsilon(1S)) \times B(\Upsilon(3S) \to \gamma\chi_{b1}(2P)) \times B(\Upsilon(1S) \to \ell^+\ell^-)$

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
2.9 ±0.4 OUR AVERAGE		Error includes scale factor of 1.9. See the ideogram below.			
$3.52^{+0.28}_{-0.27}{}^{+0.17}_{-0.18}$		[34] LEES	14M	BABR	$\Upsilon(3S) \to \gamma\gamma\mu^+\mu^-$
3.24±0.56±0.41	58	[35] CRAWFORD	92B	CLE2	$\Upsilon(3S) \to \gamma\gamma\ell^+\ell^-$
2.34±0.28±0.15		[36] HEINTZ	92	CSB2	$\Upsilon(3S) \to \gamma\gamma\ell^+\ell^-$

[34] From a sample of $\Upsilon(3S) \to \gamma\gamma\mu^+\mu^-$ with one converted photon.

[35] CRAWFORD 92B quotes $2\times B(\Upsilon(3S) \to \gamma\chi_{bJ}(2P))\ B(\chi_{bJ}(2P) \to \gamma\Upsilon(\text{nS}))\ B(\Upsilon(\text{nS}) \to \ell^+\ell^-)$.

[36] Calculated by us. HEINTZ 92 quotes $B(\Upsilon(3S) \to \gamma\chi_{b1}(2P)) \times B(\chi_{b1}(2P) \to \gamma\Upsilon(1S)) = (0.91 \pm 0.11 \pm 0.06)\%$ using $B(\Upsilon(1S) \to \mu^+\mu^-) = (2.57 \pm 0.05)\%$.



$B(\chi_{b1}(2P) \rightarrow \gamma \Upsilon(1S)) \times B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) \times B(\Upsilon(1S) \rightarrow \ell^+ \ell^-)$ (units 10^{-4})

$\Gamma(\chi_{b1}(2P) \rightarrow \gamma \Upsilon(2S))/\Gamma_{total} \times \Gamma(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))/\Gamma_{total}$ $\Gamma_2/\Gamma \times \Gamma_{21}^{\Upsilon(3S)}/\Gamma^{\Upsilon(3S)}$

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN	COMMENT
2.4±0.1±0.2	4.3k	LEES	11J	BABR	$\Upsilon(3S) \rightarrow X\gamma$

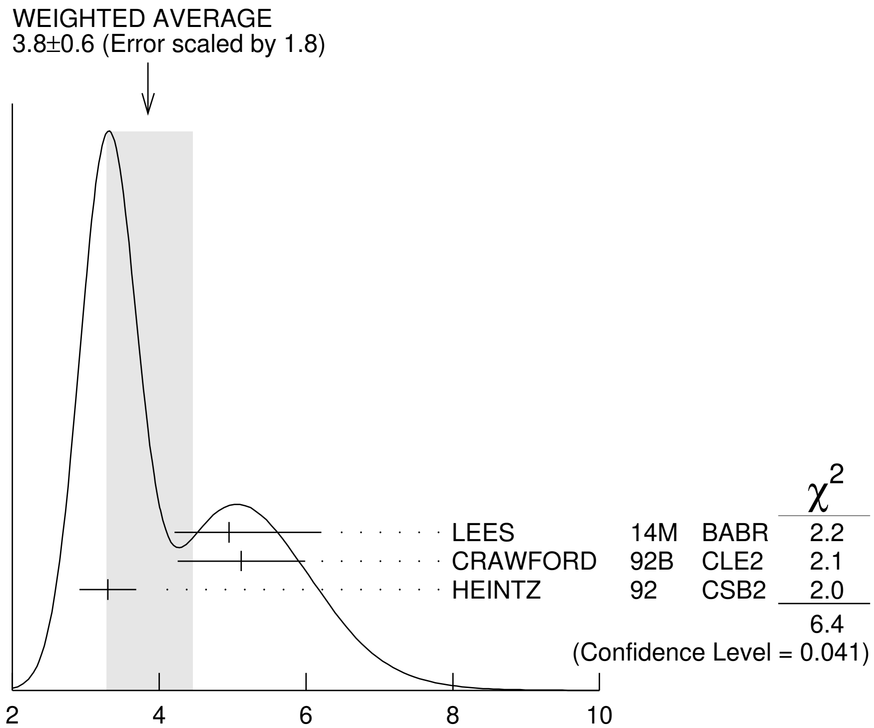
$B(\chi_{b1}(2P) \rightarrow \gamma \Upsilon(2S)) \times B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) \times B(\Upsilon(2S) \rightarrow \ell^+ \ell^-)$

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
3.8 ±0.6 OUR AVERAGE		Error includes scale factor of 1.8. See the ideogram below.			
$4.95^{+0.75}_{-0.70}{}^{+1.01}_{-0.24}$		[37] LEES	14M	BABR	$\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$
5.12±0.60±0.63	111	[38] CRAWFORD	92B	CLE2	$\Upsilon(3S) \rightarrow \gamma\gamma\ell^+\ell^-$
3.30±0.33±0.20		[39] HEINTZ	92	CSB2	$\Upsilon(3S) \rightarrow \gamma\gamma\ell^+\ell^-$

[37] From a sample of $\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$ with one converted photon.

[38] CRAWFORD 92B quotes $2 \times B(\Upsilon(3S) \rightarrow \gamma\chi_{bJ}(2P))$ $B(\chi_{bJ}(2P) \rightarrow \gamma\Upsilon(\text{nS}))$ $B(\Upsilon(\text{nS}) \rightarrow \ell^+\ell^-)$.

[39] Calculated by us. HEINTZ 92 quotes $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) \times B(\chi_{b1}(2P) \rightarrow \gamma\Upsilon(2S)) = (2.29 \pm 0.23 \pm 0.21)$ % using$B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.44 \pm 0.10)$%.



$B(\chi_{b1}(2P) \to \gamma \Upsilon(2S)) \times B(\Upsilon(3S) \to \gamma \chi_{b1}(2P)) \times B(\Upsilon(2S) \to \ell^+ \ell^-)$ (units 10^{-4})

$B(\chi_{b1}(2P) \to \chi_{b1}(1P)\pi^+\pi^-) \times B(\Upsilon(3S) \to \chi_{b1}(2P)X)$

VALUE (units 10^{-3})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1.16±0.07±0.12	31k	LEES	11C	BABR	$e^+e^- \to \pi^+\pi^- X$

$B(\chi_{b2}(2P) \to pX + \overline{p}X)/B(\chi_{b1}(2P) \to pX + \overline{p}X)$

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
1.109±0.007±0.040	BRIERE	07	CLEO	$\Upsilon(3S) \to \gamma \chi_{bJ}(2P)$

$B(\chi_{b0}(2P) \to pX + \overline{p}X)/B(\chi_{b1}(2P) \to pX + \overline{p}X)$

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
1.082±0.025±0.060	BRIERE	07	CLEO	$\Upsilon(3S) \to \gamma \chi_{bJ}(2P)$

$\chi_{b1}(2P)$ REFERENCES

LEES	14M	PR D90 112010	J.P. Lees et al.	(BABAR Collab.)
LEES	11C	PR D84 011104	J.P. Lees et al.	(BABAR Collab.)
LEES	11J	PR D84 072002	J.P. Lees et al.	(BABAR Collab.)
ASNER	08A	PR D78 091103	D.M. Asner et al.	(CLEO Collab.)
BRIERE	08	PR D78 092007	R.A. Briere et al.	(CLEO Collab.)
BRIERE	07	PR D76 012005	R.A. Briere et al.	(CLEO Collab.)
CAWLFIELD	06	PR D73 012003	C. Cawlfield et al.	(CLEO Collab.)
ARTUSO	05	PRL 94 032001	M. Artuso et al.	(CLEO Collab.)
CRONIN-HEN...	04	PRL 92 222002	D. Cronin-Hennessy et al.	(CLEO Collab.)
CRAWFORD	92B	PL B294 139	G. Crawford et al.	(CLEO Collab.)
HEINTZ	92	PR D46 1928	U. Heintz et al.	(CUSB II Collab.)
HEINTZ	91	PRL 66 1563	U. Heintz et al.	(CUSB Collab.)
MORRISON	91	PRL 67 1696	R.J. Morrison et al.	(CLEO Collab.)
NARAIN	91	PRL 66 3113	M. Narain et al.	(CUSB Collab.)