$\chi_{b1}(2P)$

$I^G(J^{PC}) = 0^+(1^{++})$
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	$e^+e^- \rightarrow \gamma X, \ell^+\ell^-\gamma\gamma$

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

$m_{\chi_{b1}(2P)} - m_{\Upsilon(1S)}$

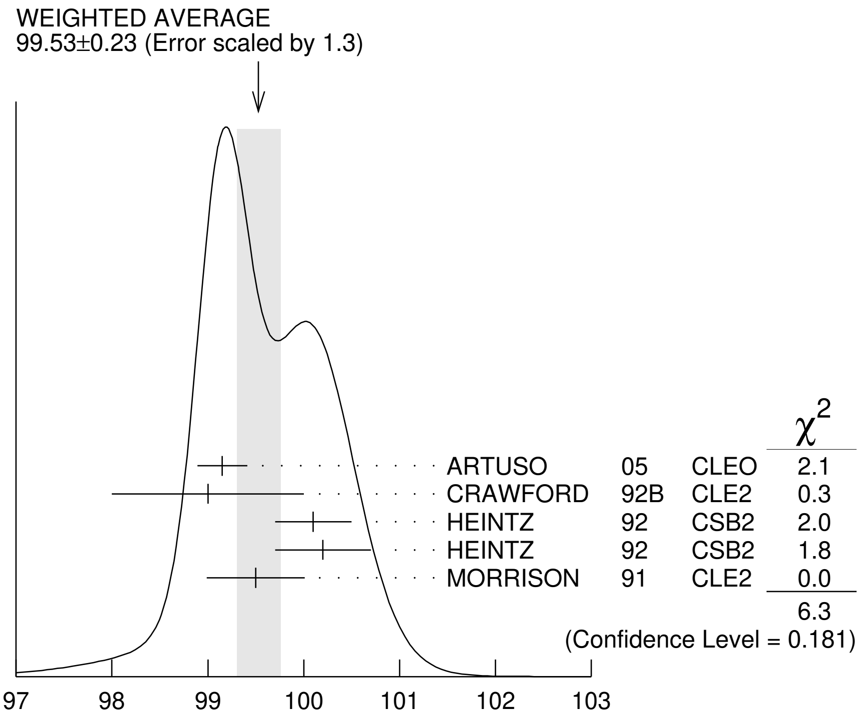
VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
793.57±0.75±0.22	50	[2] AAIJ	24AC	LHCB	$\chi_{b1}(2P) \rightarrow \Upsilon(1S)\mu^+\mu^-$

[2] Observed in prompt pp production.

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	$\Upsilon(3S) \rightarrow \gamma X$
99 ±1	169	CRAWFORD	92B	CLE2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$
100.1 ±0.4	11147	[3] HEINTZ	92	CSB2	$e^+e^- \rightarrow \gamma X$
100.2 ±0.5	223	[4] HEINTZ	92	CSB2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$
99.5 ±0.1 ±0.5	25759	MORRISON	91	CLE2	$e^+e^- \rightarrow \gamma X$

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



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

$\chi_{b1}(2P)$ 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

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

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
$1.63^{+0.35+0.16}_{-0.31-0.15}$	$32.6^{+6.9}_{-6.1}$	[5] CRONIN-HEN..04	CLE3	$\Upsilon(3S) \to \gamma\omega\Upsilon(1S)$

[5] 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)%.

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

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

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

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

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

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

[10] CRAWFORD 92B quotes B($\Upsilon(3S) \to \gamma\chi_{b1}(2P)$) ×B($\chi_{b1}(2P) \to \gamma\Upsilon(2S)$) × 2 B($\Upsilon(2S) \to \ell^+\ell^-$) = (10.23 ± 1.20 ± 1.26) 10^{-4}.

[11] Recalculated by us. HEINTZ 92 quotes B($\Upsilon(3S) \to \gamma\chi_{b1}(2P)$) ×B($\chi_{b1}(2P) \to \gamma\Upsilon(2S)$) = (2.29 ± 0.23 ± 0.21) % using B($\Upsilon(2S) \to \mu^+\mu^-$) = (1.44 ± 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		[12,13,14] LEES 14M	BABR	$\Upsilon(3S) \to \gamma\gamma\mu^+\mu^-$
0.098±0.005±0.009	15k	[15] LEES 11J	BABR	$\Upsilon(3S) \to X\gamma$
0.103±0.023±0.009		[12,16] CRAWFORD 92B	CLE2	$e^+e^- \to \ell^+\ell^-\gamma\gamma$
0.075±0.010±0.007		[12,17] HEINTZ 92	CSB2	$e^+e^- \to \ell^+\ell^-\gamma\gamma$

[12] Assuming B($\Upsilon(1S) \to \mu^+\mu^-$) = (2.48 ± 0.05)%.

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

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

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

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

[17] Recalculated 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 $B(\Upsilon(1S) \to \mu^+ \mu^-) = (2.57 \pm 0.05)\%$. 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	[18] LEES	11C	BABR	$e^+ e^- \to \pi^+ \pi^- X$
8.6±2.3±2.1		[19] CAWLFIELD	06	CLE3	$\Upsilon(3S) \to 2(\gamma \pi \ell)$

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

[19] 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	[20] BRIERE	08	CLEO	$\Upsilon(3S) \to \gamma D^0 X$

[20] 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	[21] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma \pi^+ \pi^- K^+ K^- \pi^0$

[21] 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	[22] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 2\pi^+ \pi^- K^- K^0_S$

[22] 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	[23] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 2\pi^+ \pi^- K^- 2\pi^0$

[23] 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	[24] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 2\pi^+ 2\pi^- 2\pi^0$

[24] 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	[25] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 2\pi^+ 2\pi^- K^+ K^-$

[25] 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	[26] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 2\pi^+ 2\pi^- K^+ K^- \pi^0$

[26] 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	[27] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 2\pi^+ 2\pi^- K^+ K^- 2\pi^0$

[27] 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	[28] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 3\pi^+ 2\pi^- K^- K^0_S \pi^0$

[28] 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	[29] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 3\pi^+ 3\pi^-$

[29] 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	[30] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 3\pi^+ 3\pi^- 2\pi^0$

[30] 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	[31] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 3\pi^+ 3\pi^- K^+ K^-$

[31] 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	[32] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 3\pi^+ 3\pi^- K^+ K^- \pi^0$

[32] 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	[33] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 4\pi^+ 4\pi^-$

[33] 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	[34] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma 4\pi^+ 4\pi^- 2\pi^0$

[34] 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	$\Upsilon(3S) \to X\gamma$

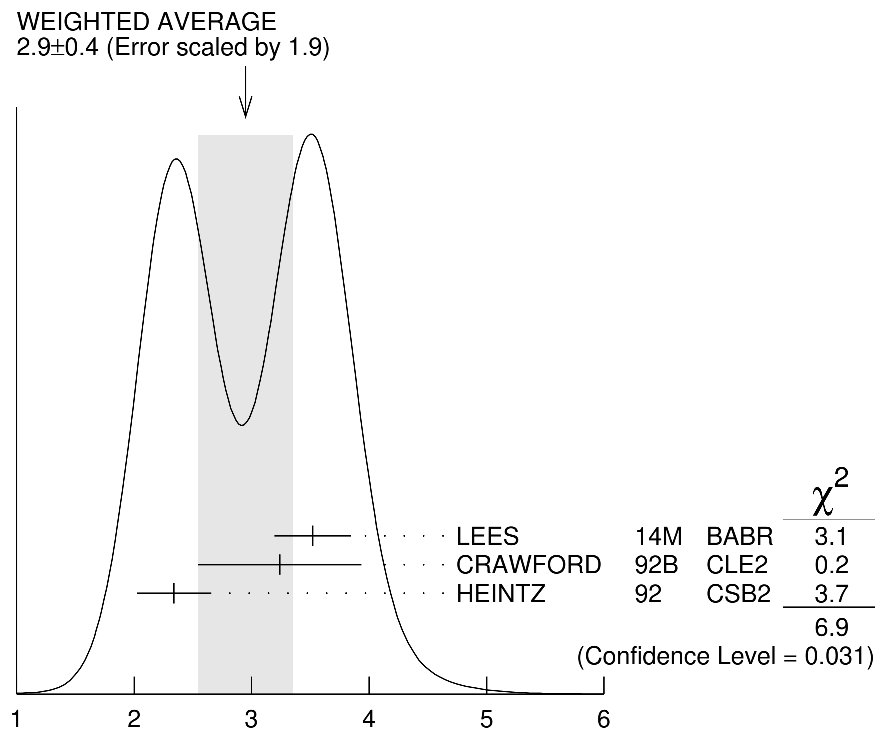
$B(\chi_{b1}(2P) \to \gamma \Upsilon(1S)) \times B(\Upsilon(3S) \to \gamma \chi_{b1}(2P)) \times B(\Upsilon(1S) \to \ell^+ \ell^-)$

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.			
$3.52^{+0.28}_{-0.27}{}^{+0.17}_{-0.18}$		[35] LEES	14M	BABR	$\Upsilon(3S) \to \gamma\gamma\mu^+\mu^-$
3.24±0.56±0.41	58	[36] CRAWFORD	92B	CLE2	$\Upsilon(3S) \to \gamma\gamma\ell^+\ell^-$
2.34±0.28±0.15		[37] HEINTZ	92	CSB2	$\Upsilon(3S) \to \gamma\gamma\ell^+\ell^-$

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

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

[37] 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 $B(\Upsilon(1S) \to \mu^+\mu^-) = (2.57 \pm 0.05)\%$.



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

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

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

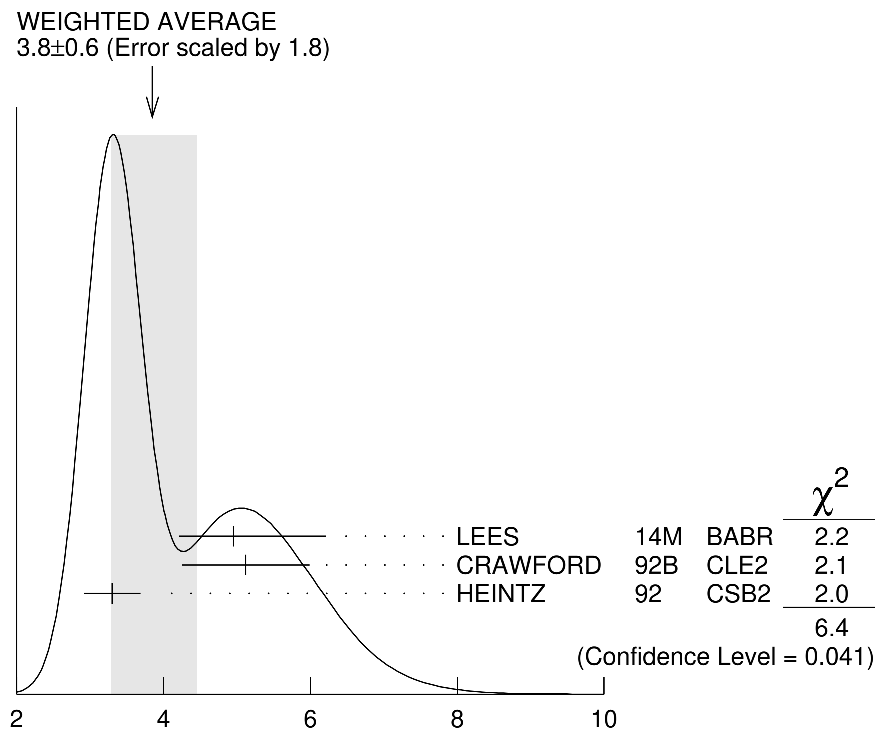
B($\chi_{b1}(2P) \rightarrow \gamma \Upsilon(2S)$) × B($\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)$) × B($\Upsilon(2S) \rightarrow \ell^+ \ell^-$)

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.			
$4.95^{+0.75}_{-0.70}{}^{+1.01}_{-0.24}$		[38] LEES	14M	BABR	$\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$
$5.12 \pm 0.60 \pm 0.63$	111	[39] CRAWFORD	92B	CLE2	$\Upsilon(3S) \rightarrow \gamma\gamma\ell^+\ell^-$
$3.30 \pm 0.33 \pm 0.20$		[40] HEINTZ	92	CSB2	$\Upsilon(3S) \rightarrow \gamma\gamma\ell^+\ell^-$

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

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

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



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

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

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

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

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

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

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

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

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ASNER	08A	PR D78 091103	D.M. Asner *et al.*	(CLEO Collab.)
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