$$\boxed{\chi_{b1}(2P)} \qquad I^G(J^{PC}) = 0^+(1^{++})$$

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

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

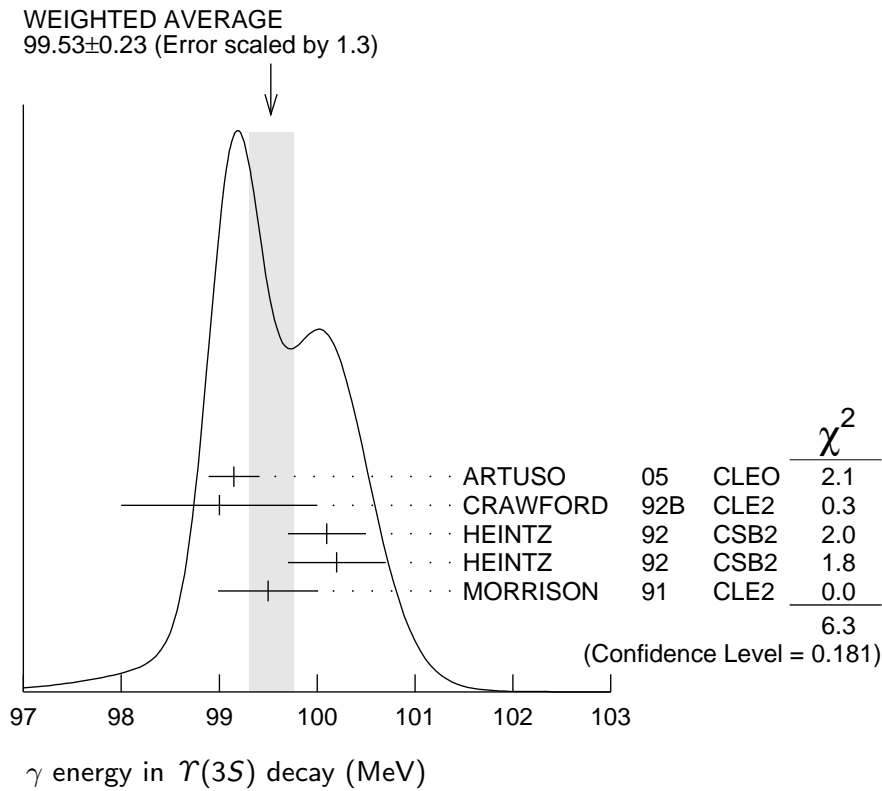| VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
23.5±0.7±0.7	[1] HEINTZ	92	CSB2	$e^+e^- \to \gamma X, \ell^+\ell^-\gamma\gamma$

[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	$e^+e^- \to \gamma X$

[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.

WEIGHTED AVERAGE
99.53±0.23 (Error scaled by 1.3)

			χ^2
ARTUSO	05	CLEO	2.1
CRAWFORD	92B	CLE2	0.3
HEINTZ	92	CSB2	2.0
HEINTZ	92	CSB2	1.8
MORRISON	91	CLE2	0.0
			6.3

(Confidence Level = 0.181)

97   98   99   100   101   102   103

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 ±1.9) %
Γ_3	$\gamma\,\Upsilon(1S)$	(9.9 ±1.0) %
Γ_4	$\pi\pi\,\chi_{b1}(1P)$	(9.1 ±1.3) $\times 10^{-3}$
Γ_5	$D^0 X$	(8.8 ±1.7) %
Γ_6	$\pi^+\pi^- K^+ K^- \pi^0$	(3.1 ±1.0) $\times 10^{-4}$
Γ_7	$2\pi^+\pi^- K^- K^0_S$	(1.1 ±0.5) $\times 10^{-4}$
Γ_8	$2\pi^+\pi^- K^- K^0_S 2\pi^0$	(7.7 ±3.2) $\times 10^{-4}$
Γ_9	$2\pi^+ 2\pi^- 2\pi^0$	(5.9 ±2.0) $\times 10^{-4}$
Γ_{10}	$2\pi^+ 2\pi^- K^+ K^-$	(10 ±4) $\times 10^{-5}$
Γ_{11}	$2\pi^+ 2\pi^- K^+ K^- \pi^0$	(5.5 ±1.8) $\times 10^{-4}$
Γ_{12}	$2\pi^+ 2\pi^- K^+ K^- 2\pi^0$	(10 ±4) $\times 10^{-4}$
Γ_{13}	$3\pi^+ 2\pi^- K^- K^0_S \pi^0$	(6.7 ±2.6) $\times 10^{-4}$
Γ_{14}	$3\pi^+ 3\pi^-$	(1.2 ±0.4) $\times 10^{-4}$
Γ_{15}	$3\pi^+ 3\pi^- 2\pi^0$	(1.2 ±0.4) $\times 10^{-3}$
Γ_{16}	$3\pi^+ 3\pi^- K^+ K^-$	(2.0 ±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

$\Gamma(\omega\,\Upsilon(1S))/\Gamma_{total}$ $\hspace{4cm}$ Γ_1/Γ

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

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

$\Gamma(\gamma\,\Upsilon(2S))/\Gamma_{total}$ $\hspace{4cm}$ Γ_2/Γ

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.181±0.019 OUR AVERAGE				
$0.211\pm0.017\pm0.019$		[5,6,7] LEES	14M BABR	$\Upsilon(3S) \to \gamma\gamma\mu^+\mu^-$
$0.190\pm0.018\pm0.017$	4.3k	[8] LEES	11J BABR	$\Upsilon(3S) \to X\gamma$
$0.206\pm0.035\pm0.019$		[5,9] CRAWFORD	92B CLE2	$e^+e^- \to \ell^+\ell^-\gamma\gamma$
$0.132\pm0.018\pm0.012$		[5,10] HEINTZ	92 CSB2	$e^+e^- \to \ell^+\ell^-\gamma\gamma$

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

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

[7] LEES 14M reports $[\Gamma(\chi_{b1}(2P) \to \gamma\,\Upsilon(2S))/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma\chi_{b1}(2P))] =$ $(2.66 \pm 0.22) \times 10^{-2}$ 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.

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

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

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

$\Gamma(\gamma\,\Upsilon(1S))/\Gamma_{total}$ $\hspace{4cm}$ Γ_3/Γ

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.099±0.010 OUR AVERAGE				
$0.107\pm0.006\pm0.010$		[11,12,13] LEES	14M BABR	$\Upsilon(3S) \to \gamma\gamma\mu^+\mu^-$
$0.098\pm0.005\pm0.009$	15k	[14] LEES	11J BABR	$\Upsilon(3S) \to X\gamma$
$0.103\pm0.023\pm0.009$		[11,15] CRAWFORD	92B CLE2	$e^+e^- \to \ell^+\ell^-\gamma\gamma$
$0.075\pm0.010\pm0.007$		[11,16] HEINTZ	92 CSB2	$e^+e^- \to \ell^+\ell^-\gamma\gamma$

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

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

[13] LEES 14M reports $[\Gamma(\chi_{b1}(2P) \to \gamma \Upsilon(1S))/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma \chi_{b1}(2P))] = (13.48 \pm 0.72) \times 10^{-3}$ 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.

[14] 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.

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

[16] 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	[17] LEES	11C	BABR	$e^+ e^- \to \pi^+ \pi^- X$
8.6±2.3±2.1		[18] CAWLFIELD	06	CLE3	$\Upsilon(3S) \to 2(\gamma \pi \ell)$

[17] 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 $B(\Upsilon(3S) \to \chi_{b1}(2P)X) = B(\Upsilon(3S) \to \chi_{b1}(2P)\gamma) = (12.6 \pm 1.2) \times 10^{-2}$.

[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.

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

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

[21] ASNER 08A reports $[\Gamma(\chi_{b1}(2P) \to 2\pi^+ \pi^- K^- K_S^0)/\Gamma_{total}] \times [B(\Upsilon(3S) \to \gamma \chi_{b1}(2P))] = (14 \pm 5 \pm 3) \times 10^{-6}$ 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.

$\Gamma\left(2\pi^+\pi^- K^- K^0_S 2\pi^0\right)/\Gamma_{total}$ $\qquad$ 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.

$\Gamma\left(2\pi^+ 2\pi^- 2\pi^0\right)/\Gamma_{total}$ $\qquad$ 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.

$\Gamma\left(2\pi^+ 2\pi^- K^+ K^-\right)/\Gamma_{total}$ $\qquad$ 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.

$\Gamma\left(2\pi^+ 2\pi^- K^+ K^- \pi^0\right)/\Gamma_{total}$ $\qquad$ 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.

$\Gamma\left(2\pi^+ 2\pi^- K^+ K^- 2\pi^0\right)/\Gamma_{total}$ $\qquad$ 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.

$\Gamma\left(3\pi^+ 2\pi^- K^- K^0_S \pi^0\right)/\Gamma_{total}$ $\qquad$ 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.

$\Gamma\left(3\pi^+ 3\pi^-\right)/\Gamma_{\text{total}}$ $\hspace{2cm}$ 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 $[\Gamma(\chi_{b1}(2P) \to 3\pi^+ 3\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \to \gamma\chi_{b1}(2P))]$ $= (15 \pm 4 \pm 3) \times 10^{-6}$ 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.

$\Gamma\left(3\pi^+ 3\pi^- 2\pi^0\right)/\Gamma_{\text{total}}$ $\hspace{2cm}$ 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 $[\Gamma(\chi_{b1}(2P) \to 3\pi^+ 3\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \to \gamma\chi_{b1}(2P))]$ $= (150 \pm 30 \pm 40) \times 10^{-6}$ 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.

$\Gamma\left(3\pi^+ 3\pi^- K^+ K^-\right)/\Gamma_{\text{total}}$ $\hspace{2cm}$ 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 $[\Gamma(\chi_{b1}(2P) \to 3\pi^+ 3\pi^- K^+ K^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \to \gamma\chi_{b1}(2P))] = (25 \pm 7 \pm 6) \times 10^{-6}$ 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.

$\Gamma\left(3\pi^+ 3\pi^- K^+ K^- \pi^0\right)/\Gamma_{\text{total}}$ $\hspace{2cm}$ 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 $[\Gamma(\chi_{b1}(2P) \to 3\pi^+ 3\pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \to \gamma\chi_{b1}(2P))] = (77 \pm 17 \pm 21) \times 10^{-6}$ 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.

$\Gamma\left(4\pi^+ 4\pi^-\right)/\Gamma_{\text{total}}$ $\hspace{2cm}$ 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 $[\Gamma(\chi_{b1}(2P) \to 4\pi^+ 4\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \to \gamma\chi_{b1}(2P))]$ $= (22 \pm 6 \pm 5) \times 10^{-6}$ 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.

$\Gamma\left(4\pi^+ 4\pi^- 2\pi^0\right)/\Gamma_{\text{total}}$ $\hspace{2cm}$ 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 $[\Gamma(\chi_{b1}(2P) \to 4\pi^+ 4\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \to \gamma\chi_{b1}(2P))]$ $= (241 \pm 47 \pm 72) \times 10^{-6}$ 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

$\Gamma(\chi_{b1}(2P) \to \gamma\, \Upsilon(1S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(3S) \to \gamma\chi_{b1}(2P))/\Gamma_{\text{total}}$

$$\Gamma_3/\Gamma \times \Gamma_{21}^{\Upsilon(3S)}/\Gamma^{\Upsilon(3S)}$$

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.			
$3.52^{+0.28+0.17}_{-0.27-0.18}$		[34] LEES	14M	BABR	$\Upsilon(3S) \to \gamma\gamma\mu^+\mu^-$
$3.24\pm0.56\pm0.41$	58	[35] CRAWFORD	92B	CLE2	$\Upsilon(3S) \to \gamma\gamma\ell^+\ell^-$
$2.34\pm0.28\pm0.15$		[36] HEINTZ	92	CSB2	$\Upsilon(3S) \to \gamma\gamma\ell^+\ell^-$

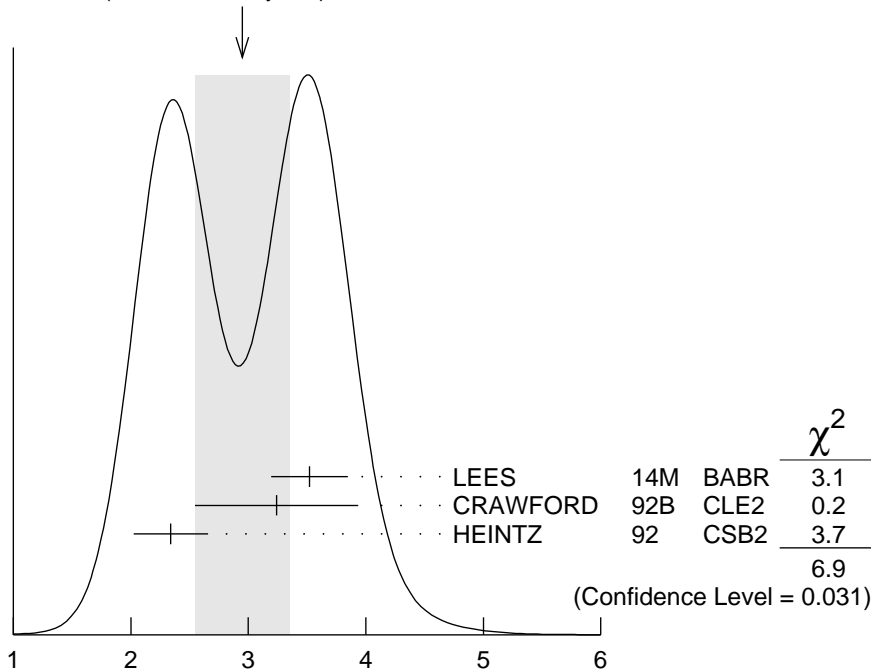[34] From a sample of $\Upsilon(3S) \to \gamma\gamma\mu^+\mu^-$ with one converted photon.

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

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

WEIGHTED AVERAGE
2.9±0.4 (Error scaled by 1.9)

			χ^2
LEES	14M	BABR	3.1
CRAWFORD	92B	CLE2	0.2
HEINTZ	92	CSB2	3.7
			6.9

(Confidence Level = 0.031)

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

$\Gamma(\chi_{b1}(2P) \to \gamma\, \Upsilon(2S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(3S) \to \gamma\chi_{b1}(2P))/\Gamma_{\text{total}}$

$$\Gamma_2/\Gamma \times \Gamma_{21}^{\Upsilon(3S)}/\Gamma^{\Upsilon(3S)}$$

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

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

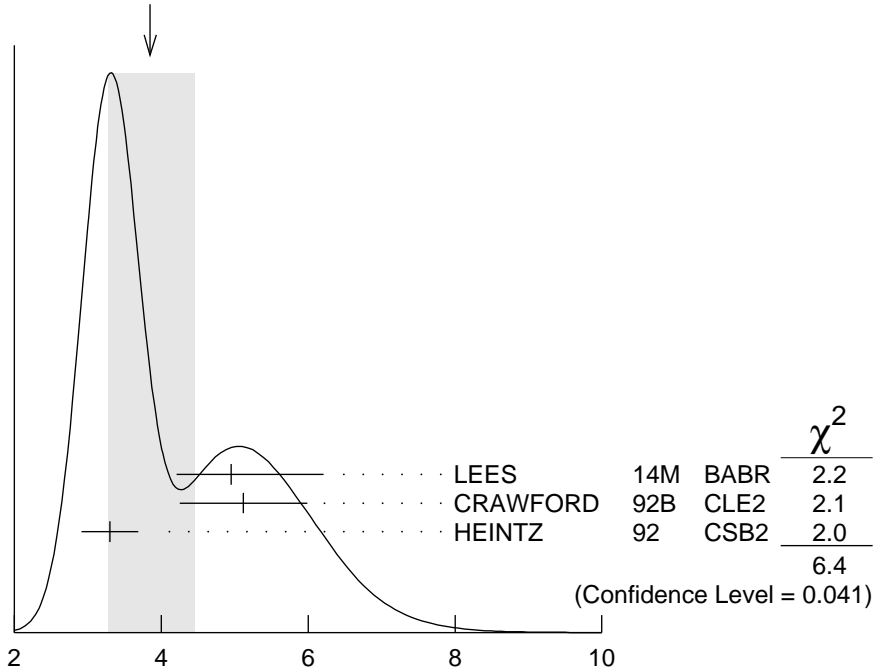| VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
3.8 ±0.6 OUR AVERAGE		Error includes scale factor of 1.8. See the ideogram below.			
$4.95^{+0.75}_{-0.70}{}^{+1.01}_{-0.24}$		[37] LEES		14M BABR	$\Upsilon(3S) \to \gamma\gamma\mu^+\mu^-$
$5.12 \pm 0.60 \pm 0.63$	111	[38] CRAWFORD	92B	CLE2	$\Upsilon(3S)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

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

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

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

WEIGHTED AVERAGE
3.8±0.6 (Error scaled by 1.8)

			χ^2
LEES	14M	BABR	2.2
CRAWFORD	92B	CLE2	2.1
HEINTZ	92	CSB2	2.0
			6.4

(Confidence Level = 0.041)

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