

$\chi_{b2}(2P)$

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

J needs confirmation.

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

$\chi_{b2}(2P)$ MASS

VALUE (MeV)	DOCUMENT ID
10268.65 ± 0.22 ± 0.50 OUR EVALUATION	From γ energy below, using $\Upsilon(3S)$ mass = 10355.2 ± 0.5 MeV

$m_{\chi_{b2}(2P)} - m_{\chi_{b1}(2P)}$

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
13.10 ± 0.24 OUR AVERAGE			
12.3 ± 2.6 ± 0.6	¹ AAIJ	14BG LHCb	$pp \rightarrow \gamma \mu^+ \mu^- X$
13.04 ± 0.26	LEES	14M BABR	$\Upsilon(3S) \rightarrow \gamma \mu^+ \mu^-$
13.5 ± 0.4 ± 0.5	² HEINTZ	92 CSB2	$e^+ e^- \rightarrow \gamma X, \ell^+ \ell^- \gamma \gamma$

¹ From the $\chi_{bj}(2P) \rightarrow \Upsilon(1S)\gamma$ transition.
² 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
86.19 ± 0.22 OUR EVALUATION				Treating systematic errors as correlated
86.40 ± 0.18 OUR AVERAGE				
86.04 ± 0.06 ± 0.27		ARTUSO	05 CLEO	$\Upsilon(3S) \rightarrow \gamma X$
86 ± 1	101	CRAWFORD	92B CLE2	$e^+ e^- \rightarrow \ell^+ \ell^- \gamma \gamma$
86.7 ± 0.4	10319	³ HEINTZ	92 CSB2	$e^+ e^- \rightarrow \gamma X$
86.9 ± 0.4	157	⁴ HEINTZ	92 CSB2	$e^+ e^- \rightarrow \ell^+ \ell^- \gamma \gamma$
86.4 ± 0.1 ± 0.4	30741	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.

$\chi_{b2}(2P)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)	Confidence level
$\Gamma_1 \quad \omega \Upsilon(1S)$	(1.10 ^{+0.34} _{-0.30}) %	
$\Gamma_2 \quad \gamma \Upsilon(2S)$	(8.9 ± 1.2) %	
$\Gamma_3 \quad \gamma \Upsilon(1S)$	(6.6 ± 0.8) %	
$\Gamma_4 \quad \pi \pi \chi_{b2}(1P)$	(5.1 ± 0.9) × 10 ⁻³	
$\Gamma_5 \quad D^0 X$	< 2.4 %	90%
$\Gamma_6 \quad \pi^+ \pi^- K^+ K^- \pi^0$	< 1.1 × 10 ⁻⁴	90%

Γ_7	$2\pi^+\pi^-K^-K_S^0$	< 9	$\times 10^{-5}$	90%
Γ_8	$2\pi^+\pi^-K^-K_S^02\pi^0$	< 7	$\times 10^{-4}$	90%
Γ_9	$2\pi^+2\pi^-2\pi^0$	(3.9 ± 1.6)	$\times 10^{-4}$	
Γ_{10}	$2\pi^+2\pi^-K^+K^-$	(9 ± 4)	$\times 10^{-5}$	
Γ_{11}	$2\pi^+2\pi^-K^+K^-\pi^0$	(2.4 ± 1.1)	$\times 10^{-4}$	
Γ_{12}	$2\pi^+2\pi^-K^+K^-2\pi^0$	(4.7 ± 2.3)	$\times 10^{-4}$	
Γ_{13}	$3\pi^+2\pi^-K^-K_S^0\pi^0$	< 4	$\times 10^{-4}$	90%
Γ_{14}	$3\pi^+3\pi^-$	(9 ± 4)	$\times 10^{-5}$	
Γ_{15}	$3\pi^+3\pi^-2\pi^0$	(1.2 ± 0.4)	$\times 10^{-3}$	
Γ_{16}	$3\pi^+3\pi^-K^+K^-$	(1.4 ± 0.7)	$\times 10^{-4}$	
Γ_{17}	$3\pi^+3\pi^-K^+K^-\pi^0$	(4.2 ± 1.7)	$\times 10^{-4}$	
Γ_{18}	$4\pi^+4\pi^-$	(9 ± 5)	$\times 10^{-5}$	
Γ_{19}	$4\pi^+4\pi^-2\pi^0$	(1.3 ± 0.5)	$\times 10^{-3}$	

$\chi_{b2}(2P)$ BRANCHING RATIOS

$\Gamma(\omega \Upsilon(1S))/\Gamma_{\text{total}}$					Γ_1/Γ
VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT	
$1.10^{+0.32+0.11}_{-0.28-0.10}$	$20.1^{+5.8}_{-5.1}$	⁵ CRONIN-HEN..04	CLE3	$\Upsilon(3S) \rightarrow \gamma\omega \Upsilon(1S)$	

⁵ Using $B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P)) = (11.4 \pm 0.8)\%$ and $B(\Upsilon(1S) \rightarrow \ell^+\ell^-) = 2 B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = 2 (2.48 \pm 0.06)\%$.

$\Gamma(\gamma \Upsilon(2S))/\Gamma_{\text{total}}$					Γ_2/Γ
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT	
0.089 ± 0.012 OUR AVERAGE					
$0.085 \pm 0.010 \pm 0.010$		^{6,7,8} LEES	14M BABR	$\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$	
$0.084 \pm 0.011 \pm 0.010$	2.5k	⁹ LEES	11J BABR	$\Upsilon(3S) \rightarrow X\gamma$	
$0.096 \pm 0.022 \pm 0.012$		^{7,10} CRAWFORD	92B CLE2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$	
$0.106 \pm 0.016 \pm 0.013$		^{7,11} HEINTZ	92 CSB2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$	

⁶ LEES 14M quotes $\Gamma(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(2S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P))/\Gamma_{\text{total}} = (1.12 \pm 0.13)\%$ combining the results from samples of $\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$ with and without converted photons.

⁷ Assuming $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.93 \pm 0.17)\%$.

⁸ LEES 14M reports $[\Gamma(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(2S))/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P))] = (1.12 \pm 0.13) \times 10^{-2}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P)) = (13.1 \pm 1.6) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

⁹ LEES 11J reports $[\Gamma(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(2S))/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P))] = (1.1 \pm 0.1 \pm 0.1) \times 10^{-2}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P)) = (13.1 \pm 1.6) \times 10^{-2}$. 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 $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) \times B(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(2S)) \times 2 B(\Upsilon(2S) \rightarrow \ell^+\ell^-) = (4.98 \pm 0.94 \pm 0.62) 10^{-4}$.

¹¹ Recalculated by us. HEINTZ 92 quotes $B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P)) \times B(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(2S)) = (1.90 \pm 0.23 \pm 0.18) \%$ using $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.44 \pm 0.10)\%$. Supersedes HEINTZ 91.

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

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.066±0.008 OUR AVERAGE				
0.061±0.004±0.007	12,13,14	LEES	14M BABR	$\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$
0.070±0.004±0.008	11k 15	LEES	11J BABR	$\Upsilon(3S) \rightarrow X\gamma$
0.077±0.018±0.009	13,16	CRAWFORD	92B CLE2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$
0.061±0.009±0.007	13,17	HEINTZ	92 CSB2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$

¹² LEES 14M quotes $\Gamma(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P))/\Gamma_{\text{total}} = (8.03 \pm 0.50) \times 10^{-3}$ combining the results from samples of $\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$ with and without converted photons.

¹³ Assuming $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.05)\%$.

¹⁴ LEES 14M reports $[\Gamma(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P))] = (8.03 \pm 0.50) \times 10^{-3}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P)) = (13.1 \pm 1.6) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

¹⁵ LEES 11J reports $[\Gamma(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P))] = (9.2 \pm 0.3 \pm 0.4) \times 10^{-3}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P)) = (13.1 \pm 1.6) \times 10^{-2}$. 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 $B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P)) \times B(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(1S)) \times 2 B(\Upsilon(1S) \rightarrow \ell^+\ell^-) = (5.03 \pm 0.94 \pm 0.63) 10^{-4}$.

¹⁷ Recalculated by us. HEINTZ 92 quotes $B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P)) \times B(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(1S)) = (0.77 \pm 0.11 \pm 0.05)\%$ using $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.57 \pm 0.05)\%$. Supersedes HEINTZ 91.

$\Gamma(\pi\pi\chi_{b2}(1P))/\Gamma_{\text{total}}$ Γ_4/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID	TECN	COMMENT
5.1±0.9 OUR AVERAGE				
4.9±0.7±0.6	17k	18 LEES	11C BABR	$e^+e^- \rightarrow \pi^+\pi^-X$
6.0±1.6±1.4		19 CAWLFIELD	06 CLE3	$\Upsilon(3S) \rightarrow 2(\gamma\pi\ell)$

¹⁸ $(0.64 \pm 0.05 \pm 0.08) \times 10^{-3}$. We derive the value assuming $B(\Upsilon(3S) \rightarrow \chi_{b2}(2P)X) = B(\Upsilon(3S) \rightarrow \chi_{b2}(2P)\gamma) = (13.1 \pm 1.6) \times 10^{-2}$.

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

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

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<2.4 × 10⁻²	90	20,21 BRIERE	08 CLEO	$\Upsilon(3S) \rightarrow \gamma D^0 X$

²⁰ For $p_{D^0} > 2.5$ GeV/c.

²¹ The authors also present their result as $(0.2 \pm 1.4 \pm 0.1) \times 10^{-2}$.

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

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT
<1.1	90	22 ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma\pi^+\pi^-K^+K^-\pi^0$

²² ASNER 08A reports $[\Gamma(\chi_{b2}(2P) \rightarrow \pi^+\pi^-K^+K^-\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P))] < 14 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P)) = 13.1 \times 10^{-2}$.

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

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT
<0.9	90	²³ ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+\pi^-K^-K_S^0$
²³ ASNER 08A reports $[\Gamma(\chi_{b2}(2P) \rightarrow 2\pi^+\pi^-K^-K_S^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P))] < 12 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P)) = 13.1 \times 10^{-2}$.				

$\Gamma(2\pi^+\pi^-K^-K_S^02\pi^0)/\Gamma_{\text{total}}$ Γ_8/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT
<7	90	²⁴ ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+\pi^-K^-2\pi^0$
²⁴ ASNER 08A reports $[\Gamma(\chi_{b2}(2P) \rightarrow 2\pi^+\pi^-K^-K_S^02\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P))] < 87 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P)) = 13.1 \times 10^{-2}$.				

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

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$3.9 \pm 1.6 \pm 0.5$	23	²⁵ ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+2\pi^-2\pi^0$
²⁵ ASNER 08A reports $[\Gamma(\chi_{b2}(2P) \rightarrow 2\pi^+2\pi^-2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P))] = (51 \pm 16 \pm 13) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P)) = (13.1 \pm 1.6) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.				

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

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$0.9 \pm 0.4 \pm 0.1$	11	²⁶ ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+2\pi^-K^+K^-$
²⁶ ASNER 08A reports $[\Gamma(\chi_{b2}(2P) \rightarrow 2\pi^+2\pi^-K^+K^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P))] = (12 \pm 4 \pm 3) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P)) = (13.1 \pm 1.6) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.				

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

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$2.4 \pm 1.0 \pm 0.3$	16	²⁷ ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+2\pi^-K^+K^-\pi^0$
²⁷ ASNER 08A reports $[\Gamma(\chi_{b2}(2P) \rightarrow 2\pi^+2\pi^-K^+K^-\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P))] = (32 \pm 11 \pm 8) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P)) = (13.1 \pm 1.6) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.				

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

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$4.7 \pm 2.2 \pm 0.6$	14	²⁸ ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+2\pi^-K^+K^-2\pi^0$
²⁸ ASNER 08A reports $[\Gamma(\chi_{b2}(2P) \rightarrow 2\pi^+2\pi^-K^+K^-2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P))] = (62 \pm 23 \pm 17) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(2P)) = (13.1 \pm 1.6) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.				

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

<u>VALUE (units 10^{-4})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<4	90	²⁹ ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 3\pi^+ 2\pi^- K^- K_S^0 \pi^0$

²⁹ ASNER 08A reports $[\Gamma(\chi_{b2}(2P) \rightarrow 3\pi^+ 2\pi^- K^- K_S^0 \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P))]$ $< 58 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P)) = 13.1 \times 10^{-2}$.

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

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$0.9 \pm 0.4 \pm 0.1$	14	³⁰ ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 3\pi^+ 3\pi^-$

³⁰ ASNER 08A reports $[\Gamma(\chi_{b2}(2P) \rightarrow 3\pi^+ 3\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P))]$ $= (12 \pm 4 \pm 3) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P)) = (13.1 \pm 1.6) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$12 \pm 4 \pm 1$	45	³¹ ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 3\pi^+ 3\pi^- 2\pi^0$

³¹ ASNER 08A reports $[\Gamma(\chi_{b2}(2P) \rightarrow 3\pi^+ 3\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P))]$ $= (159 \pm 33 \pm 43) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P)) = (13.1 \pm 1.6) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$1.4 \pm 0.7 \pm 0.2$	12	³² ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 3\pi^+ 3\pi^- K^+ K^-$

³² ASNER 08A reports $[\Gamma(\chi_{b2}(2P) \rightarrow 3\pi^+ 3\pi^- K^+ K^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P))]$ $= (19 \pm 7 \pm 5) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P)) = (13.1 \pm 1.6) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$4.2 \pm 1.7 \pm 0.5$	16	³³ ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 3\pi^+ 3\pi^- K^+ K^- \pi^0$

³³ ASNER 08A reports $[\Gamma(\chi_{b2}(2P) \rightarrow 3\pi^+ 3\pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P))]$ $= (55 \pm 16 \pm 15) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P)) = (13.1 \pm 1.6) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$0.9 \pm 0.4 \pm 0.1$	9	³⁴ ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 4\pi^+ 4\pi^-$

³⁴ ASNER 08A reports $[\Gamma(\chi_{b2}(2P) \rightarrow 4\pi^+ 4\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P))]$ $= (12 \pm 5 \pm 3) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P)) = (13.1 \pm 1.6) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
13±5±2	27	³⁵ ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 4\pi^+ 4\pi^- 2\pi^0$

³⁵ ASNER 08A reports $[\Gamma(\chi_{b2}(2P) \rightarrow 4\pi^+ 4\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P))]$
 $= (165 \pm 46 \pm 50) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P))$
 $= (13.1 \pm 1.6) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\chi_{b2}(2P)$ Cross-Particle Branching Ratios

$\Gamma(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P))/\Gamma_{\text{total}}$
 $\Gamma_3/\Gamma \times \Gamma_{20}^{\Upsilon(3S)}/\Gamma \Upsilon(3S)$

VALUE (units 10^{-3})	EVTS	DOCUMENT ID	TECN	COMMENT
9.2±0.3±0.4	11k	LEES	11J BABR	$\Upsilon(3S) \rightarrow X\gamma$

$\Gamma(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(2S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P))/\Gamma_{\text{total}}$
 $\Gamma_2/\Gamma \times \Gamma_{20}^{\Upsilon(3S)}/\Gamma \Upsilon(3S)$

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
1.1±0.1±0.1	2.5k	LEES	11J BABR	$\Upsilon(3S) \rightarrow X\gamma$

$B(\chi_{b2}(2P) \rightarrow \chi_{b2}(1P)\pi^+\pi^-) \times B(\Upsilon(3S) \rightarrow \chi_{b2}(2P)X)$

VALUE (units 10^{-3})	EVTS	DOCUMENT ID	TECN	COMMENT
0.64±0.05±0.08	17k	LEES	11C BABR	$e^+e^- \rightarrow \pi^+\pi^-X$

$B(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(1S)) \times B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P)) \times B(\Upsilon(1S) \rightarrow \ell^+\ell^-)$

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
2.02±0.18 OUR AVERAGE				

1.95 ^{+0.22+0.10} _{-0.21-0.16}		³⁶ LEES	14M BABR	$\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$
2.52±0.47±0.32	48	³⁷ CRAWFORD	92B CLE2	$\Upsilon(3S) \rightarrow \gamma\gamma\ell^+\ell^-$
1.98±0.28±0.12		³⁸ HEINTZ	92 CSB2	$\Upsilon(3S) \rightarrow \gamma\gamma\ell^+\ell^-$

³⁶ From a sample of $\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$ with converted photons.

³⁷ CRAWFORD 92B quotes $2 \times B(\Upsilon(3S) \rightarrow \gamma \chi_{bJ}(2P)) B(\chi_{bJ}(2P) \rightarrow \gamma \Upsilon(nS))$
 $B(\Upsilon(nS) \rightarrow \ell^+\ell^-)$.

³⁸ Calculated by us. HEINTZ 92 quotes $B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P)) \times B(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(1S)) = (0.77 \pm 0.11 \pm 0.05)\%$ using $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.57 \pm 0.05)\%$.

$[B(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(1S)) \times B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P))] / [B(\chi_{b1}(2P) \rightarrow \gamma \Upsilon(1S)) \times B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))]$

VALUE (%)	DOCUMENT ID	TECN	COMMENT
66.6±3.0	³⁹ LEES	14M BABR	$\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$

³⁹ From a sample of $\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$ events without converted photons.

$B(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(2S)) \times B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P)) \times B(\Upsilon(2S) \rightarrow \ell^+ \ell^-)$

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
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2.74 ± 0.29 OUR AVERAGE

3.22 ^{+0.58+0.16} _{-0.53-0.71}		40 LEES	14M BABR	$\Upsilon(3S) \rightarrow \gamma \gamma \mu^+ \mu^-$
2.49 ± 0.47 ± 0.31	53	41 CRAWFORD	92B CLE2	$\Upsilon(3S) \rightarrow \gamma \gamma \ell^+ \ell^-$
2.74 ± 0.33 ± 0.18		42 HEINTZ	92 CSB2	$\Upsilon(3S) \rightarrow \gamma \gamma \ell^+ \ell^-$

⁴⁰ From a sample of $\Upsilon(3S) \rightarrow \gamma \gamma \mu^+ \mu^-$ with converted photons.

⁴¹ CRAWFORD 92B quotes $2 \times B(\Upsilon(3S) \rightarrow \gamma \chi_{bJ}(2P)) B(\chi_{bJ}(2P) \rightarrow \gamma \Upsilon(nS)) B(\Upsilon(nS) \rightarrow \ell^+ \ell^-)$.

⁴² Calculated by us. HEINTZ 92 quotes $B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P)) \times B(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(2S)) = (1.90 \pm 0.23 \pm 0.18) \%$ using $B(\Upsilon(2S) \rightarrow \mu^+ \mu^-) = (1.44 \pm 0.10) \%$.

$[B(\chi_{b2}(2P) \rightarrow \gamma \Upsilon(2S)) \times B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P))] / [B(\chi_{b1}(2P) \rightarrow \gamma \Upsilon(2S)) \times B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))]$

VALUE (%)	DOCUMENT ID	TECN	COMMENT
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46.9 ± 2.0	43 LEES	14M BABR	$\Upsilon(3S) \rightarrow \gamma \gamma \mu^+ \mu^-$
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⁴³ From a sample of $\Upsilon(3S) \rightarrow \gamma \gamma \mu^+ \mu^-$ without converted photons.

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