

$\chi_{b1}(1P)$

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

Observed in radiative decay of the $\Upsilon(2S)$, therefore $C = +$. Branching ratio requires E1 transition, M1 is strongly disfavored, therefore $P = +$. $J = 1$ from SKWARNICKI 87.

$\chi_{b1}(1P)$ MASS

VALUE (MeV)	DOCUMENT ID
9892.78±0.26±0.31 OUR EVALUATION	From average γ energy below, using $\Upsilon(2S)$ mass = 10023.26 ± 0.31 MeV

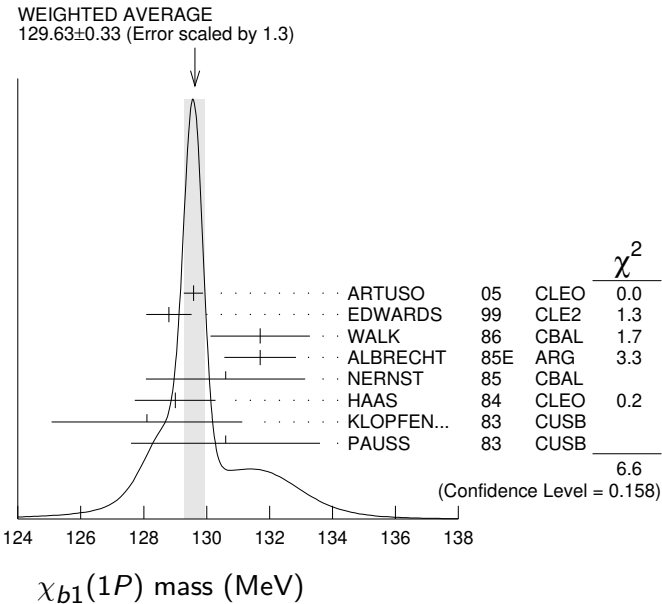
$m_{\chi_{b1}(1P)} - m_{\Upsilon(1S)}$

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
432.10±0.26±0.10	50	¹ AAIJ	24AC LHCb	$\chi_{b1}(1P) \rightarrow \Upsilon(1S)\mu^+\mu^-$

¹Observed in prompt $p\bar{p}$ production.

γ ENERGY IN $\Upsilon(2S)$ DECAY

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
129.63±0.33 OUR AVERAGE	Error includes scale factor of 1.3. See the ideogram below.		
129.58±0.09±0.29	ARTUSO	05	CLEO $\Upsilon(2S) \rightarrow \gamma X$
128.8 ±0.4 ±0.6	EDWARDS	99	CLE2 $\Upsilon(2S) \rightarrow \gamma\chi(1P)$
131.7 ±0.9 ±1.3	WALK	86	CBAL $\Upsilon(2S) \rightarrow \gamma\gamma\ell^+\ell^-$
131.7 ±0.3 ±1.1	ALBRECHT	85E	ARG $\Upsilon(2S) \rightarrow \text{conv.}\gamma X$
130.6 ±0.8 ±2.4	NERNST	85	CBAL $\Upsilon(2S) \rightarrow \gamma X$
129 ±0.8 ±1	HAAS	84	CLEO $\Upsilon(2S) \rightarrow \text{conv.}\gamma X$
128.1 ±0.4 ±3.0	KLOPFEN...	83	CUSB $\Upsilon(2S) \rightarrow \gamma X$
130.6 ±3.0	PAUSS	83	CUSB $\Upsilon(2S) \rightarrow \gamma\gamma\ell^+\ell^-$



$\chi_{b1}(1P)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)	Confidence level
$\Gamma_1 \quad \gamma \Upsilon(1S)$	(35.2 $\pm$ 2.0) %	
$\Gamma_2 \quad D^0 X$	(12.6 $\pm$ 2.2) %	
$\Gamma_3 \quad \pi^+ \pi^- K^+ K^- \pi^0$	(2.0 $\pm$ 0.6) $\times 10^{-4}$	
$\Gamma_4 \quad 2\pi^+ \pi^- K^- K_S^0$	(1.3 $\pm$ 0.5) $\times 10^{-4}$	
$\Gamma_5 \quad 2\pi^+ \pi^- K^- K_S^0 2\pi^0$	< 6 $\times 10^{-4}$	90%
$\Gamma_6 \quad 2\pi^+ 2\pi^- 2\pi^0$	(8.0 $\pm$ 2.5) $\times 10^{-4}$	
$\Gamma_7 \quad 2\pi^+ 2\pi^- K^+ K^-$	(1.5 $\pm$ 0.5) $\times 10^{-4}$	
$\Gamma_8 \quad 2\pi^+ 2\pi^- K^+ K^- \pi^0$	(3.5 $\pm$ 1.2) $\times 10^{-4}$	
$\Gamma_9 \quad 2\pi^+ 2\pi^- K^+ K^- 2\pi^0$	(8.6 $\pm$ 3.2) $\times 10^{-4}$	
$\Gamma_{10} \quad 3\pi^+ 2\pi^- K^- K_S^0 \pi^0$	(9.3 $\pm$ 3.3) $\times 10^{-4}$	
$\Gamma_{11} \quad 3\pi^+ 3\pi^-$	(1.9 $\pm$ 0.6) $\times 10^{-4}$	
$\Gamma_{12} \quad 3\pi^+ 3\pi^- 2\pi^0$	(1.7 $\pm$ 0.5) $\times 10^{-3}$	
$\Gamma_{13} \quad 3\pi^+ 3\pi^- K^+ K^-$	(2.6 $\pm$ 0.8) $\times 10^{-4}$	
$\Gamma_{14} \quad 3\pi^+ 3\pi^- K^+ K^- \pi^0$	(7.5 $\pm$ 2.6) $\times 10^{-4}$	
$\Gamma_{15} \quad 4\pi^+ 4\pi^-$	(2.6 $\pm$ 0.9) $\times 10^{-4}$	
$\Gamma_{16} \quad 4\pi^+ 4\pi^- 2\pi^0$	(1.4 $\pm$ 0.6) $\times 10^{-3}$	
$\Gamma_{17} \quad \omega \text{ anything}$	(4.9 $\pm$ 1.4) %	
$\Gamma_{18} \quad \omega X_{tetra}$	< 4.44 $\times 10^{-4}$	90%
$\Gamma_{19} \quad J/\psi J/\psi$	< 2.7 $\times 10^{-5}$	90%
$\Gamma_{20} \quad J/\psi \psi(2S)$	< 1.7 $\times 10^{-5}$	90%
$\Gamma_{21} \quad \psi(2S) \psi(2S)$	< 6 $\times 10^{-5}$	90%
$\Gamma_{22} \quad J/\psi(1S) \text{ anything}$	< 1.1 $\times 10^{-3}$	90%
$\Gamma_{23} \quad J/\psi(1S) X_{tetra}$	< 2.27 $\times 10^{-4}$	90%

 $\chi_{b1}(1P)$ BRANCHING RATIOS

$\Gamma(\gamma \Upsilon(1S))/\Gamma_{\text{total}}$	Γ_1/Γ
VALUE	EVTs
DOCUMENT ID	TECN
COMMENT	

0.352 $\pm$ 0.020 OUR AVERAGE

0.356 $^{+0.016}_{-0.022} \pm 0.019$	964k	1	FULSOM	18	BELL	$\Upsilon(2S) \rightarrow \gamma X$
0.364 $\pm 0.017 \pm 0.019$		2,3,4	LEES	14M	BABR	$\Upsilon(2S) \rightarrow \gamma \gamma \mu^+ \mu^-$
0.331 $\pm 0.018 \pm 0.017$	3222	4,5	KORNICER	11	CLEO	$e^+ e^- \rightarrow \gamma \gamma \ell^+ \ell^-$
0.350 $\pm 0.023 \pm 0.018$	13k	6	LEES	11J	BABR	$\Upsilon(2S) \rightarrow X \gamma$
0.34 $\pm 0.07 \pm 0.02$	53	4,7,8	WALK	86	CBAL	$\Upsilon(2S) \rightarrow \gamma \gamma \ell^+ \ell^-$
0.47 ± 0.18			KLOPFEN...	83	CUSB	$\Upsilon(2S) \rightarrow \gamma \gamma \ell^+ \ell^-$

¹FULSOM 18 reports [$\Gamma(\chi_{b1}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}$] $\times$ [B($\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P)$)] = (2.45 $\pm$ 0.02 $^{+0.11}_{-0.15}$) $\times 10^{-2}$ which we divide by our best value B($\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P)$) = (6.9 $\pm$ 0.4) $\times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

²LEES 14M quotes $\Gamma(\chi_{b1}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))/\Gamma_{\text{total}}$ = (2.51 $\pm$ 0.12) % combining the results from samples of $\Upsilon(2S) \rightarrow \gamma \gamma \mu^+ \mu^-$ with and without converted photons.

³ LEES 14M reports $[\Gamma(\chi_{b1}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))] = (2.51 \pm 0.12) \times 10^{-2}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P)) = (6.9 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

⁴ Assuming $B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (2.48 \pm 0.05)\%$.

⁵ KORNICER 11 reports $[\Gamma(\chi_{b1}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))] = (22.8 \pm 0.4 \pm 1.2) \times 10^{-3}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P)) = (6.9 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

⁶ LEES 11J reports $[\Gamma(\chi_{b1}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))] = (24.1 \pm 0.6 \pm 1.5) \times 10^{-3}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P)) = (6.9 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

⁷ WALK 86 quotes $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P)) \times B(\chi_{b1}(1P) \rightarrow \gamma \Upsilon(1S)) \times B(\Upsilon(1S) \rightarrow \ell^+ \ell^-) = (5.8 \pm 0.9 \pm 0.7)\%$.

⁸ WALK 86 reports $[\Gamma(\chi_{b1}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))] = (23.4 \pm 3.63 \pm 2.82) \times 10^{-3}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P)) = (6.9 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(D^0 X)/\Gamma_{\text{total}}$ Γ_2/Γ

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
$12.6 \pm 1.9 \pm 1.1$	2310	¹ BRIERE	08	CLEO $\Upsilon(2S) \rightarrow \gamma D^0 X$

¹ For $p_{D^0} > 2.5 \text{ GeV}/c$.

$\Gamma(\pi^+ \pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}$ Γ_3/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$2.0 \pm 0.6 \pm 0.1$	18	¹ ASNER	08A	CLEO $\Upsilon(2S) \rightarrow \gamma \pi^+ \pi^- K^+ K^- \pi^0$

¹ ASNER 08A reports $[\Gamma(\chi_{b1}(1P) \rightarrow \pi^+ \pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))] = (14 \pm 3 \pm 3) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P)) = (6.9 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+ \pi^- K^- K_S^0)/\Gamma_{\text{total}}$ Γ_4/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$1.3 \pm 0.5 \pm 0.1$	11	¹ ASNER	08A	CLEO $\Upsilon(2S) \rightarrow \gamma 2\pi^+ \pi^- K^- K_S^0$

¹ ASNER 08A reports $[\Gamma(\chi_{b1}(1P) \rightarrow 2\pi^+ \pi^- K^- K_S^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))] = (9 \pm 3 \pm 2) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P)) = (6.9 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+ \pi^- K^- K_S^0 2\pi^0)/\Gamma_{\text{total}}$ Γ_5/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT
< 6	90	¹ ASNER	08A	CLEO $\Upsilon(2S) \rightarrow \gamma 2\pi^+ \pi^- K^- 2\pi^0$

¹ ASNER 08A reports $[\Gamma(\chi_{b1}(1P) \rightarrow 2\pi^+ \pi^- K^- K_S^0 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))] < 42 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P)) = 6.9 \times 10^{-2}$.

$\Gamma(2\pi^+ 2\pi^- 2\pi^0)/\Gamma_{\text{total}}$ Γ_6/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$8.0 \pm 2.4 \pm 0.4$	46	¹ ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 2\pi^+ 2\pi^- 2\pi^0$

¹ ASNER 08A reports $[\Gamma(\chi_{b1}(1P) \rightarrow 2\pi^+ 2\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))]$
 $= (55 \pm 9 \pm 14) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))$
 $= (6.9 \pm 0.4) \times 10^{-2}$. 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_7/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$1.5 \pm 0.5 \pm 0.1$	18	¹ ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 2\pi^+ 2\pi^- K^+ K^-$

¹ ASNER 08A reports $[\Gamma(\chi_{b1}(1P) \rightarrow 2\pi^+ 2\pi^- K^+ K^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))]$
 $= (10 \pm 3 \pm 2) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))$
 $= (6.9 \pm 0.4) \times 10^{-2}$. 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_8/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$3.5 \pm 1.2 \pm 0.2$	22	¹ ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 2\pi^+ 2\pi^- K^+ K^- \pi^0$

¹ ASNER 08A reports $[\Gamma(\chi_{b1}(1P) \rightarrow 2\pi^+ 2\pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))]$
 $= (24 \pm 6 \pm 6) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))$
 $= (6.9 \pm 0.4) \times 10^{-2}$. 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_9/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$8.6 \pm 3.2 \pm 0.4$	26	¹ ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 2\pi^+ 2\pi^- K^+ K^- 2\pi^0$

¹ ASNER 08A reports $[\Gamma(\chi_{b1}(1P) \rightarrow 2\pi^+ 2\pi^- K^+ K^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))]$
 $= (59 \pm 14 \pm 17) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))$
 $= (6.9 \pm 0.4) \times 10^{-2}$. 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_{10}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$9.3 \pm 3.3 \pm 0.5$	21	¹ ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 3\pi^+ 2\pi^- K^- K_S^0 \pi^0$

¹ ASNER 08A reports $[\Gamma(\chi_{b1}(1P) \rightarrow 3\pi^+ 2\pi^- K^- K_S^0 \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))]$
 $= (64 \pm 16 \pm 16) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))$
 $= (6.9 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

 $\Gamma(3\pi^+ 3\pi^-)/\Gamma_{\text{total}}$ Γ_{11}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$1.9 \pm 0.6 \pm 0.1$	25	¹ ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 3\pi^+ 3\pi^-$

¹ ASNER 08A reports $[\Gamma(\chi_{b1}(1P) \rightarrow 3\pi^+ 3\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))]$
 $= (13 \pm 3 \pm 3) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))$
 $= (6.9 \pm 0.4) \times 10^{-2}$. 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_{12}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$17 \pm 5 \pm 1$	56	¹ ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 3\pi^+ 3\pi^- 2\pi^0$

¹ ASNER 08A reports $[\Gamma(\chi_{b1}(1P) \rightarrow 3\pi^+ 3\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))]$
 $= (119 \pm 18 \pm 32) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))$
 $= (6.9 \pm 0.4) \times 10^{-2}$. 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_{13}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$2.6 \pm 0.8 \pm 0.1$	21	¹ ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 3\pi^+ 3\pi^- K^+ K^-$

¹ ASNER 08A reports $[\Gamma(\chi_{b1}(1P) \rightarrow 3\pi^+ 3\pi^- K^+ K^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))]$
 $= (18 \pm 4 \pm 4) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))$
 $= (6.9 \pm 0.4) \times 10^{-2}$. 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_{14}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$7.5 \pm 2.6 \pm 0.4$	28	¹ ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 3\pi^+ 3\pi^- K^+ K^- \pi^0$

¹ ASNER 08A reports $[\Gamma(\chi_{b1}(1P) \rightarrow 3\pi^+ 3\pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))]$
 $= (52 \pm 11 \pm 14) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))$
 $= (6.9 \pm 0.4) \times 10^{-2}$. 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_{15}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$2.6 \pm 0.9 \pm 0.1$	24	¹ ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 4\pi^+ 4\pi^-$

¹ ASNER 08A reports $[\Gamma(\chi_{b1}(1P) \rightarrow 4\pi^+ 4\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))]$
 $= (18 \pm 4 \pm 5) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))$
 $= (6.9 \pm 0.4) \times 10^{-2}$. 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_{16}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$14 \pm 5 \pm 1$	26	¹ ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 4\pi^+ 4\pi^- 2\pi^0$

¹ ASNER 08A reports $[\Gamma(\chi_{b1}(1P) \rightarrow 4\pi^+ 4\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))]$
 $= (96 \pm 24 \pm 29) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))$
 $= (6.9 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(\omega \text{ anything})/\Gamma_{\text{total}}$ Γ_{17}/Γ

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
$4.9 \pm 1.3 \pm 0.6$	51k	JIA	17A BELL	$e^+ e^- \rightarrow \text{hadrons}$

$\Gamma(\omega X_{\text{tetra}})/\Gamma_{\text{total}}$ Γ_{18}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$< 44.4 \times 10^{-5}$	90	¹ JIA	17A BELL	$e^+ e^- \rightarrow \text{hadrons}$

¹For a tetraquark state X_{tetra} , with mass in the range 1.16–2.46 GeV and width in the range 0–0.3 GeV. Measured 90% CL limits as a function of X_{tetra} mass and width range from 3.3×10^{-5} to 44.4×10^{-5} .

$\Gamma(J/\psi J/\psi)/\Gamma_{total}$ Γ_{19}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	COMMENT
<2.7	90	¹ SHEN 12	BELL	$\Upsilon(2S) \rightarrow \gamma \psi X$

¹SHEN 12 reports $< 2.7 \times 10^{-5}$ from a measurement of $[\Gamma(\chi_{b1}(1P) \rightarrow J/\psi J/\psi)/\Gamma_{total}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))]$ assuming $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P)) = (6.9 \pm 0.4) \times 10^{-2}$.

$\Gamma(J/\psi \psi(2S))/\Gamma_{total}$ Γ_{20}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	COMMENT
<1.7	90	¹ SHEN 12	BELL	$\Upsilon(2S) \rightarrow \gamma \psi X$

¹SHEN 12 reports $< 1.7 \times 10^{-5}$ from a measurement of $[\Gamma(\chi_{b1}(1P) \rightarrow J/\psi \psi(2S))/\Gamma_{total}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))]$ assuming $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P)) = (6.9 \pm 0.4) \times 10^{-2}$.

$\Gamma(\psi(2S) \psi(2S))/\Gamma_{total}$ Γ_{21}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	COMMENT
<6	90	¹ SHEN 12	BELL	$\Upsilon(2S) \rightarrow \gamma \psi X$

¹SHEN 12 reports $< 6.2 \times 10^{-5}$ from a measurement of $[\Gamma(\chi_{b1}(1P) \rightarrow \psi(2S) \psi(2S))/\Gamma_{total}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))]$ assuming $B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P)) = (6.9 \pm 0.4) \times 10^{-2}$.

$\Gamma(J/\psi(1S) \text{ anything})/\Gamma_{total}$ Γ_{22}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<1.1 $\times 10^{-3}$	90	JIA	17A BELL	$e^+ e^- \rightarrow \text{hadrons}$

$\Gamma(J/\psi(1S) X_{tetra})/\Gamma_{total}$ Γ_{23}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<22.7 $\times 10^{-5}$	90	¹ JIA	17A BELL	$e^+ e^- \rightarrow \text{hadrons}$

¹For a tetraquark state X_{tetra} , with mass in the range 1.16–2.46 GeV and width in the range 0–0.3 GeV. Measured 90% CL limits as a function of X_{tetra} mass and width range from 1.8×10^{-5} to 22.7×10^{-5} .

$\chi_{b1}(1P)$ Cross-Particle Branching Ratios

$\Gamma(\chi_{b1}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{total} \times \Gamma(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))/\Gamma_{total}$ $\Gamma_1/\Gamma \times \Gamma_{71}^{\Upsilon(2S)}/\Gamma^{\Upsilon(2S)}$

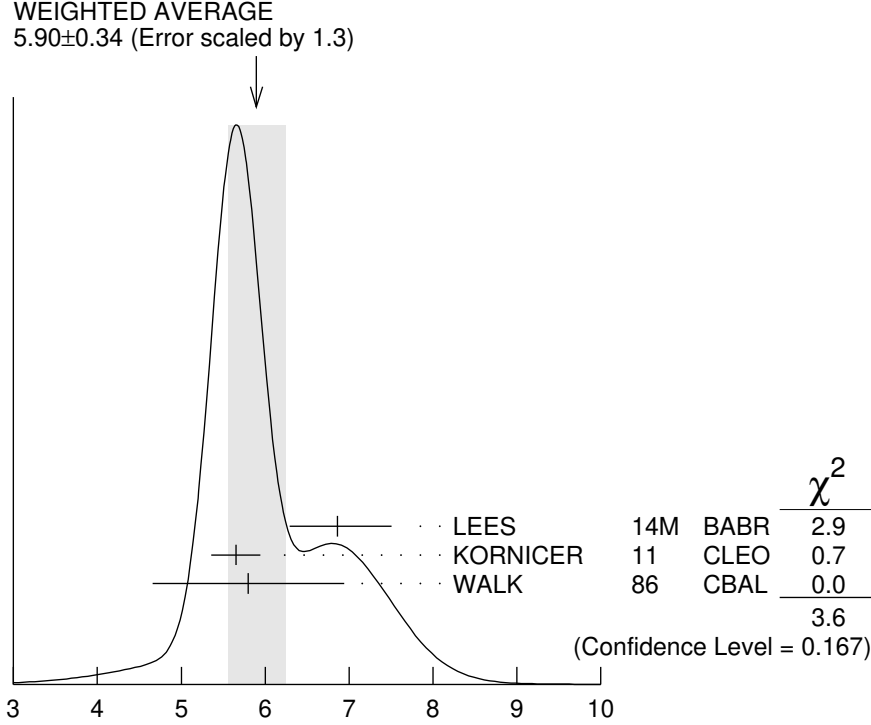
VALUE (units 10^{-3})	EVTS	DOCUMENT ID	TECN	COMMENT
24.1 $\pm$ 0.6 $\pm$ 1.5	13k	LEES	11J BABR	$\Upsilon(2S) \rightarrow X \gamma$

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

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
5.90 $\pm$ 0.34 OUR AVERAGE		Error includes scale factor of 1.3. See the ideogram below.		

6.86 $^{+0.47}_{-0.45}$ $^{+0.44}_{-0.35}$		¹ LEES	14M BABR	$\Upsilon(2S) \rightarrow \gamma \gamma \mu^+ \mu^-$
5.65 $\pm$ 0.11 $\pm$ 0.27	3222	KORNICER	11 CLEO	$e^+ e^- \rightarrow \gamma \gamma \ell^+ \ell^-$
5.8 $\pm$ 0.9 $\pm$ 0.7	53	WALK	86 CBAL	$\Upsilon(2S) \rightarrow \gamma \gamma \ell^+ \ell^-$

¹From a sample of $\Upsilon(2S) \rightarrow \gamma\gamma\mu^+\mu^-$ with one converted photon.



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

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

VALUE (units 10^{-5})	EVTS	DOCUMENT ID	TECN	COMMENT
1.30±0.34 OUR AVERAGE				
1.16 ^{+0.78+0.14} _{-0.67-0.16}		¹ LEES	14M BABR	$\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$
1.33±0.30±0.23	50	KORNICER	11 CLEO	$e^+e^- \rightarrow \gamma\gamma\ell^+\ell^-$

¹From a sample of $\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$ with converted photons.

$B(\chi_{b2}(1P) \rightarrow pX + \bar{p}X)/B(\chi_{b1}(1P) \rightarrow pX + \bar{p}X)$

VALUE	DOCUMENT ID	TECN	COMMENT
1.068±0.010±0.040	BRIERE	07 CLEO	$\Upsilon(2S) \rightarrow \gamma\chi_{bJ}(1P)$

$B(\chi_{b0}(1P) \rightarrow pX + \bar{p}X)/B(\chi_{b1}(1P) \rightarrow pX + \bar{p}X)$

VALUE	DOCUMENT ID	TECN	COMMENT
1.11±0.15±0.20	BRIERE	07 CLEO	$\Upsilon(2S) \rightarrow \gamma\chi_{bJ}(1P)$

$\chi_{b1}(1P)$ REFERENCES

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