

$\chi_{b1}(1P)$

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

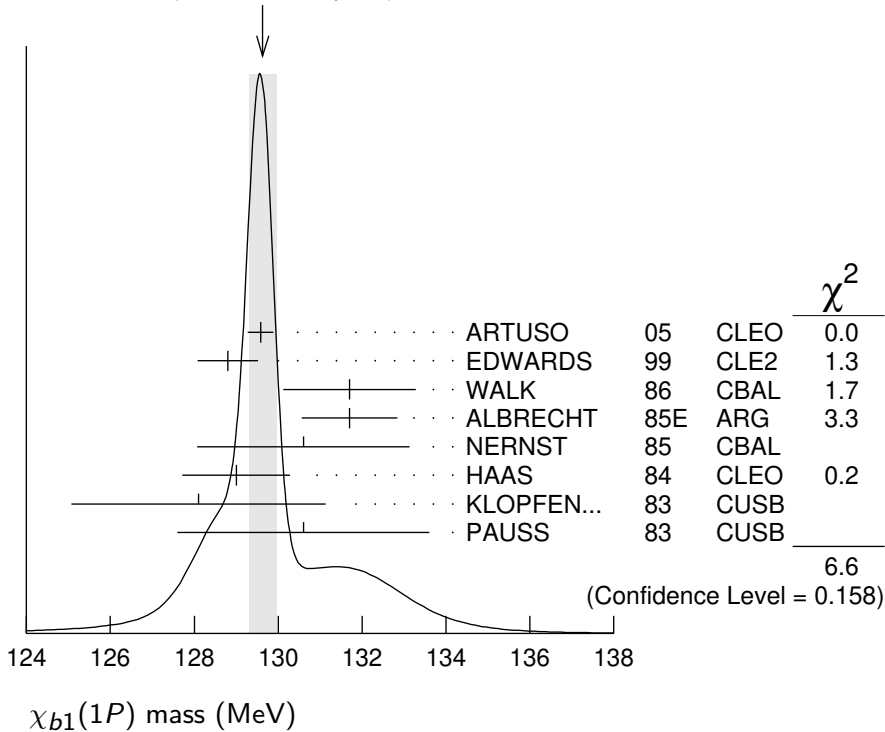
$\chi_{b1}(1P)$ MASS

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

γ ENERGY IN $\Upsilon(2S)$ DECAY

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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 $\Upsilon(2S) \rightarrow \gamma \gamma \ell^+ \ell^-$

WEIGHTED AVERAGE
 129.63 ± 0.33 (Error scaled by 1.3)



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

Mode	Fraction (Γ_i/Γ)	Confidence level
Γ_1 $\gamma \Upsilon(1S)$	(35.2 \pm 2.0) %	
Γ_2 $D^0 X$	(12.6 \pm 2.2) %	
Γ_3 $\pi^+ \pi^- K^+ K^- \pi^0$	(2.0 \pm 0.6) $\times 10^{-4}$	
Γ_4 $2\pi^+ \pi^- K^- K_S^0$	(1.3 \pm 0.5) $\times 10^{-4}$	
Γ_5 $2\pi^+ \pi^- K^- K_S^0 2\pi^0$	< 6 $\times 10^{-4}$	90%
Γ_6 $2\pi^+ 2\pi^- 2\pi^0$	(8.0 \pm 2.5) $\times 10^{-4}$	
Γ_7 $2\pi^+ 2\pi^- K^+ K^-$	(1.5 \pm 0.5) $\times 10^{-4}$	
Γ_8 $2\pi^+ 2\pi^- K^+ K^- \pi^0$	(3.5 \pm 1.2) $\times 10^{-4}$	
Γ_9 $2\pi^+ 2\pi^- K^+ K^- 2\pi^0$	(8.6 \pm 3.2) $\times 10^{-4}$	
Γ_{10} $3\pi^+ 2\pi^- K^- K_S^0 \pi^0$	(9.3 \pm 3.3) $\times 10^{-4}$	
Γ_{11} $3\pi^+ 3\pi^-$	(1.9 \pm 0.6) $\times 10^{-4}$	
Γ_{12} $3\pi^+ 3\pi^- 2\pi^0$	(1.7 \pm 0.5) $\times 10^{-3}$	
Γ_{13} $3\pi^+ 3\pi^- K^+ K^-$	(2.6 \pm 0.8) $\times 10^{-4}$	
Γ_{14} $3\pi^+ 3\pi^- K^+ K^- \pi^0$	(7.5 \pm 2.6) $\times 10^{-4}$	
Γ_{15} $4\pi^+ 4\pi^-$	(2.6 \pm 0.9) $\times 10^{-4}$	
Γ_{16} $4\pi^+ 4\pi^- 2\pi^0$	(1.4 \pm 0.6) $\times 10^{-3}$	
Γ_{17} ω anything	(4.9 \pm 1.4) %	
Γ_{18} ωX_{tetra}	< 4.44 $\times 10^{-4}$	90%
Γ_{19} $J/\psi J/\psi$	< 2.7 $\times 10^{-5}$	90%
Γ_{20} $J/\psi \psi(2S)$	< 1.7 $\times 10^{-5}$	90%
Γ_{21} $\psi(2S) \psi(2S)$	< 6 $\times 10^{-5}$	90%
Γ_{22} $J/\psi(1S)$ anything	< 1.1 $\times 10^{-3}$	90%
Γ_{23} $J/\psi(1S) X_{tetra}$	< 2.27 $\times 10^{-4}$	90%

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

$\Gamma(\gamma \Upsilon(1S))/\Gamma_{total}$	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 $\Upsilon(2S) \rightarrow \gamma \gamma \ell^+ \ell^-$

¹ FULSOM 18 reports $[\Gamma(\chi_{b1}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{total}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))]$ = (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.

² LEES 14M quotes $\Gamma(\chi_{b1}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{total} \times \Gamma(\Upsilon(2S) \rightarrow \gamma \chi_{b1}(1P))/\Gamma_{total}$ = (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±1.9±1.1	2310	¹ BRIERE	08	CLEO $\Upsilon(2S) \rightarrow \gamma D^0 X$

¹ For $p_{D^0} > 2.5$ 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±0.6±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±0.5±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

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
17±5±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

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
2.6±0.8±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

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
7.5±2.6±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

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
2.6±0.9±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

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
14±5±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

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

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

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

¹ For 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 $\Upsilon(2S) \rightarrow \gamma\psi X$

¹ SHEN 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 $\Upsilon(2S) \rightarrow \gamma\psi X$

¹ SHEN 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 $\Upsilon(2S) \rightarrow \gamma\psi X$

¹ SHEN 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 $e^+e^- \rightarrow$ 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 $e^+e^- \rightarrow$ hadrons

¹ For 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} .

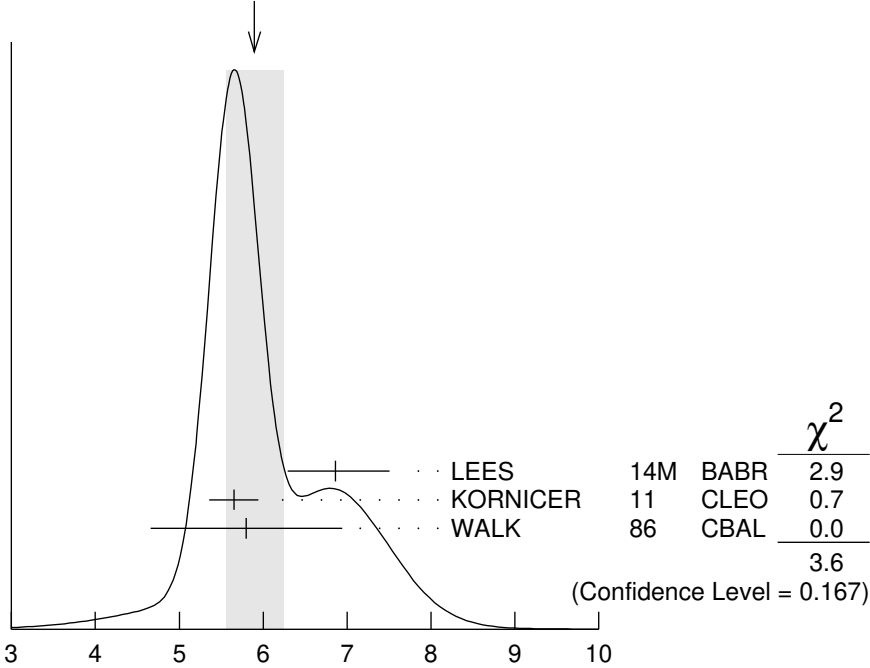
 $\chi_{b1}(1P)$ Cross-Particle Branching Ratios $\Gamma(\chi_{b1}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{total} \times \Gamma(\Upsilon(2S) \rightarrow \gamma\chi_{b1}(1P))/\Gamma_{total}$
 $\Gamma_1/\Gamma \times \Gamma_{59}^{\Upsilon(2S)}/\Gamma_{\Upsilon(2S)}$

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

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

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
5.90 ± 0.34	OUR AVERAGE	Error includes scale factor of 1.3. See the ideogram below.		
$6.86^{+0.47+0.44}_{-0.45-0.35}$		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	$\Upsilon(2S) \rightarrow \gamma \gamma \ell^+ \ell^-$

WEIGHTED AVERAGE
 5.90 ± 0.34 (Error scaled by 1.3)



¹ From 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})

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

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

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

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

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

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

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

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

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