

# $\chi_{b2}(1P)$

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

$J$  needs confirmation.

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

## $\chi_{b2}(1P)$ MASS

VALUE (MeV)	DOCUMENT ID
<b>9912.21 ± 0.26 ± 0.31 OUR EVALUATION</b>	From average $\gamma$ energy below, using $\Upsilon(2S)$ mass = 10023.26 ± 0.31 MeV

## $m_{\chi_{b2}(1P)} - m_{\chi_{b1}(1P)}$

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>19.10 ± 0.25 OUR AVERAGE</b>	Error includes scale factor of 1.1.		
19.81 ± 0.65 ± 0.20	<sup>1</sup> AAIJ	14BG LHCB	$pp \rightarrow \gamma \mu^+ \mu^- X$
19.01 ± 0.24	LEES	14M BABR	$\Upsilon(2S) \rightarrow \gamma \mu^+ \mu^-$

<sup>1</sup>From the  $\chi_{bj}(1P) \rightarrow \Upsilon(1S)\gamma$  transition.

## $\gamma$ ENERGY IN $\Upsilon(2S)$ DECAY

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>110.44 ± 0.29 OUR AVERAGE</b>	Error includes scale factor of 1.1.		
110.58 ± 0.08 ± 0.30	ARTUSO	05 CLEO	$\Upsilon(2S) \rightarrow \gamma X$
110.8 ± 0.3 ± 0.6	EDWARDS	99 CLE2	$\Upsilon(2S) \rightarrow \gamma \chi(1P)$
107.0 ± 1.1 ± 1.3	WALK	86 CBAL	$\Upsilon(2S) \rightarrow \gamma \gamma \ell^+ \ell^-$
110.6 ± 0.3 ± 0.9	ALBRECHT	85E ARG	$\Upsilon(2S) \rightarrow \text{conv.} \gamma X$
110.4 ± 0.8 ± 2.2	NERNST	85 CBAL	$\Upsilon(2S) \rightarrow \gamma X$
109.5 ± 0.7 ± 1.0	HAAS	84 CLEO	$\Upsilon(2S) \rightarrow \text{conv.} \gamma X$
108.2 ± 0.3 ± 2.0	KLOPFEN...	83 CUSB	$\Upsilon(2S) \rightarrow \gamma X$
108.8 ± 4.0	PAUSS	83 CUSB	$\Upsilon(2S) \rightarrow \gamma \gamma \ell^+ \ell^-$

## $\chi_{b2}(1P)$ DECAY MODES

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level
$\Gamma_1 \quad \gamma \Upsilon(1S)$	(18.0 ± 1.0) %	
$\Gamma_2 \quad D^0 X$	< 7.9 %	90%
$\Gamma_3 \quad \pi^+ \pi^- K^+ K^- \pi^0$	( 8 ± 5 ) × 10 <sup>-5</sup>	
$\Gamma_4 \quad 2\pi^+ \pi^- K^- K_S^0$	< 1.0 × 10 <sup>-4</sup>	90%
$\Gamma_5 \quad 2\pi^+ \pi^- K^- K_S^0 2\pi^0$	( 5.3 ± 2.4 ) × 10 <sup>-4</sup>	
$\Gamma_6 \quad 2\pi^+ 2\pi^- 2\pi^0$	( 3.5 ± 1.4 ) × 10 <sup>-4</sup>	
$\Gamma_7 \quad 2\pi^+ 2\pi^- K^+ K^-$	( 1.1 ± 0.4 ) × 10 <sup>-4</sup>	
$\Gamma_8 \quad 2\pi^+ 2\pi^- K^+ K^- \pi^0$	( 2.1 ± 0.9 ) × 10 <sup>-4</sup>	
$\Gamma_9 \quad 2\pi^+ 2\pi^- K^+ K^- 2\pi^0$	( 3.9 ± 1.8 ) × 10 <sup>-4</sup>	
$\Gamma_{10} \quad 3\pi^+ 2\pi^- K^- K_S^0 \pi^0$	< 5 × 10 <sup>-4</sup>	90%

$\Gamma_{11}$	$3\pi^+ 3\pi^-$	$(7.0 \pm 3.1) \times 10^{-5}$	
$\Gamma_{12}$	$3\pi^+ 3\pi^- 2\pi^0$	$(1.0 \pm 0.4) \times 10^{-3}$	
$\Gamma_{13}$	$3\pi^+ 3\pi^- K^+ K^-$	$< 8 \times 10^{-5}$	90%
$\Gamma_{14}$	$3\pi^+ 3\pi^- K^+ K^- \pi^0$	$(3.6 \pm 1.5) \times 10^{-4}$	
$\Gamma_{15}$	$4\pi^+ 4\pi^-$	$(8 \pm 4) \times 10^{-5}$	
$\Gamma_{16}$	$4\pi^+ 4\pi^- 2\pi^0$	$(1.8 \pm 0.7) \times 10^{-3}$	
$\Gamma_{17}$	$J/\psi J/\psi$	$< 4 \times 10^{-5}$	90%
$\Gamma_{18}$	$J/\psi \psi(2S)$	$< 5 \times 10^{-5}$	90%
$\Gamma_{19}$	$\psi(2S) \psi(2S)$	$< 1.6 \times 10^{-5}$	90%
$\Gamma_{20}$	$J/\psi(1S)$ anything	$(1.5 \pm 0.4) \times 10^{-3}$	

### $\chi_{b2}(1P)$ BRANCHING RATIOS

$\Gamma(\gamma \Upsilon(1S))/\Gamma_{\text{total}}$	$\Gamma_1/\Gamma$			
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.180 ± 0.010 OUR AVERAGE</b>				

0.164 <sup>+0.009</sup> <sub>-0.010</sub> ± 0.008	503k	<sup>1</sup> FULSOM	18	BELL	$\Upsilon(2S) \rightarrow \gamma X$
0.185 ± 0.008 ± 0.009		<sup>2,3,4</sup> LEES	14M	BABR	$\Upsilon(2S) \rightarrow \gamma \gamma \mu^+ \mu^-$
0.186 ± 0.011 ± 0.009	1770	<sup>4,5</sup> KORNICER	11	CLEO	$e^+ e^- \rightarrow \gamma \gamma \ell^+ \ell^-$
0.194 <sup>+0.014</sup> <sub>-0.017</sub> ± 0.009	8k	<sup>6</sup> LEES	11J	BABR	$\Upsilon(2S) \rightarrow X \gamma$
0.25 ± 0.06 ± 0.01	35	<sup>4,7,8</sup> WALK	86	CBAL	$\Upsilon(2S) \rightarrow \gamma \gamma \ell^+ \ell^-$
0.20 ± 0.05		KLOPFEN...	83	CUSB	$\Upsilon(2S) \rightarrow \gamma \gamma \ell^+ \ell^-$

<sup>1</sup> FULSOM 18 reports  $[\Gamma(\chi_{b2}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))] = (1.17 \pm 0.01^{+0.06}_{-0.07}) \times 10^{-2}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>2</sup> LEES 14M quotes  $\Gamma(\chi_{b2}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))/\Gamma_{\text{total}} = (1.32 \pm 0.06)\%$  combining the results from samples of  $\Upsilon(2S) \rightarrow \gamma \gamma \mu^+ \mu^-$  with and without converted photons.

<sup>3</sup> LEES 14M reports  $[\Gamma(\chi_{b2}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))] = (1.32 \pm 0.06) \times 10^{-2}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

<sup>5</sup> KORNICER 11 reports  $[\Gamma(\chi_{b2}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))] = (1.33 \pm 0.04 \pm 0.07) \times 10^{-2}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>6</sup> LEES 11J reports  $[\Gamma(\chi_{b2}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))] = (13.9 \pm 0.5^{+0.9}_{-1.1}) \times 10^{-3}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>7</sup> WALK 86 quotes  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) \times B(\chi_{b2}(1P) \rightarrow \gamma \Upsilon(1S)) \times B(\Upsilon(1S) \rightarrow \ell^+ \ell^-) = (4.4 \pm 0.9 \pm 0.5)\%$ .

<sup>8</sup> WALK 86 reports  $[\Gamma(\chi_{b2}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))] = (17.7 \pm 3.6 \pm 2.0) \times 10^{-3}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(D^0 X)/\Gamma_{\text{total}}$   $\Gamma_2/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<7.9 \times 10^{-2}$	90	1,2 BRIERE	08	CLEO $\Upsilon(2S) \rightarrow \gamma D^0 X$

<sup>1</sup> For  $p_{D^0} > 2.5$  GeV/c.

<sup>2</sup> The authors also present their result as  $(5.4 \pm 1.9 \pm 0.5) \times 10^{-2}$ .

$\Gamma(\pi^+ \pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}$   $\Gamma_3/\Gamma$

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
$0.84 \pm 0.50 \pm 0.04$	8	<sup>1</sup> ASNER	08A	CLEO $\Upsilon(2S) \rightarrow \gamma \pi^+ \pi^- K^+ K^- \pi^0$

<sup>1</sup> ASNER 08A reports  $[\Gamma(\chi_{b2}(1P) \rightarrow \pi^+ \pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))] = (6 \pm 3 \pm 2) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+ \pi^- K^- K_S^0)/\Gamma_{\text{total}}$   $\Gamma_4/\Gamma$

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
$<1.0$	90	<sup>1</sup> ASNER	08A	CLEO $\Upsilon(2S) \rightarrow \gamma 2\pi^+ \pi^- K^- K_S^0$

<sup>1</sup> ASNER 08A reports  $[\Gamma(\chi_{b2}(1P) \rightarrow 2\pi^+ \pi^- K^- K_S^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))] < 7 \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = 7.15 \times 10^{-2}$ .

$\Gamma(2\pi^+ \pi^- K^- K_S^0 2\pi^0)/\Gamma_{\text{total}}$   $\Gamma_5/\Gamma$

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
$5.3 \pm 2.4 \pm 0.3$	11	<sup>1</sup> ASNER	08A	CLEO $\Upsilon(2S) \rightarrow \gamma 2\pi^+ \pi^- K^- 2\pi^0$

<sup>1</sup> ASNER 08A reports  $[\Gamma(\chi_{b2}(1P) \rightarrow 2\pi^+ \pi^- K^- K_S^0 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))] = (38 \pm 14 \pm 10) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+ 2\pi^- 2\pi^0)/\Gamma_{\text{total}}$   $\Gamma_6/\Gamma$

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
$3.5 \pm 1.4 \pm 0.2$	19	<sup>1</sup> ASNER	08A	CLEO $\Upsilon(2S) \rightarrow \gamma 2\pi^+ 2\pi^- 2\pi^0$

<sup>1</sup> ASNER 08A reports  $[\Gamma(\chi_{b2}(1P) \rightarrow 2\pi^+ 2\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))] = (25 \pm 8 \pm 6) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+ 2\pi^- K^+ K^-)/\Gamma_{\text{total}}$   $\Gamma_7/\Gamma$

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
$1.1 \pm 0.4 \pm 0.1$	14	<sup>1</sup> ASNER	08A	CLEO $\Upsilon(2S) \rightarrow \gamma 2\pi^+ 2\pi^- K^+ K^-$

<sup>1</sup> ASNER 08A reports  $[\Gamma(\chi_{b2}(1P) \rightarrow 2\pi^+ 2\pi^- K^+ K^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))] = (8 \pm 2 \pm 2) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+2\pi^-K^+K^-\pi^0)/\Gamma_{\text{total}}$   $\Gamma_8/\Gamma$

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>2.1±0.9±0.1</b>	13	<sup>1</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 2\pi^+2\pi^-K^+K^-\pi^0$

<sup>1</sup> ASNER 08A reports  $[\Gamma(\chi_{b2}(1P) \rightarrow 2\pi^+2\pi^-K^+K^-\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma\chi_{b2}(1P))] = (15 \pm 5 \pm 4) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma\chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+2\pi^-K^+K^-2\pi^0)/\Gamma_{\text{total}}$   $\Gamma_9/\Gamma$

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>3.9±1.8±0.2</b>	11	<sup>1</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 2\pi^+2\pi^-K^+K^-2\pi^0$

<sup>1</sup> ASNER 08A reports  $[\Gamma(\chi_{b2}(1P) \rightarrow 2\pi^+2\pi^-K^+K^-2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma\chi_{b2}(1P))] = (28 \pm 11 \pm 7) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma\chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(3\pi^+2\pi^-K^-K_S^0\pi^0)/\Gamma_{\text{total}}$   $\Gamma_{10}/\Gamma$

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;5</b>	90	<sup>1</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 3\pi^+2\pi^-K^-K_S^0\pi^0$

<sup>1</sup> ASNER 08A reports  $[\Gamma(\chi_{b2}(1P) \rightarrow 3\pi^+2\pi^-K^-K_S^0\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma\chi_{b2}(1P))] < 36 \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma\chi_{b2}(1P)) = 7.15 \times 10^{-2}$ .

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

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.70±0.31±0.03</b>	9	<sup>1</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 3\pi^+3\pi^-$

<sup>1</sup> ASNER 08A reports  $[\Gamma(\chi_{b2}(1P) \rightarrow 3\pi^+3\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma\chi_{b2}(1P))] = (5 \pm 2 \pm 1) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma\chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(3\pi^+3\pi^-2\pi^0)/\Gamma_{\text{total}}$   $\Gamma_{12}/\Gamma$

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>10.2±3.6±0.5</b>	34	<sup>1</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 3\pi^+3\pi^-2\pi^0$

<sup>1</sup> ASNER 08A reports  $[\Gamma(\chi_{b2}(1P) \rightarrow 3\pi^+3\pi^-2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma\chi_{b2}(1P))] = (73 \pm 16 \pm 20) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma\chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(3\pi^+3\pi^-K^+K^-)/\Gamma_{\text{total}}$   $\Gamma_{13}/\Gamma$

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;0.8</b>	90	<sup>1</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 3\pi^+3\pi^-K^+K^-$

<sup>1</sup> ASNER 08A reports  $[\Gamma(\chi_{b2}(1P) \rightarrow 3\pi^+3\pi^-K^+K^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma\chi_{b2}(1P))] < 6 \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma\chi_{b2}(1P)) = 7.15 \times 10^{-2}$ .

**$\Gamma(3\pi^+3\pi^-K^+K^-\pi^0)/\Gamma_{\text{total}}$**   **$\Gamma_{14}/\Gamma$**

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
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<b><math>3.6 \pm 1.5 \pm 0.2</math></b>	14	<sup>1</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 3\pi^+ 3\pi^- K^+ K^- \pi^0$
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<sup>1</sup> ASNER 08A reports  $[\Gamma(\chi_{b2}(1P) \rightarrow 3\pi^+ 3\pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))] = (26 \pm 8 \pm 7) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

**$\Gamma(4\pi^+4\pi^-)/\Gamma_{\text{total}}$**   **$\Gamma_{15}/\Gamma$**

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
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<b><math>0.84 \pm 0.40 \pm 0.04</math></b>	7	<sup>1</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 4\pi^+ 4\pi^-$
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<sup>1</sup> ASNER 08A reports  $[\Gamma(\chi_{b2}(1P) \rightarrow 4\pi^+ 4\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))] = (6 \pm 2 \pm 2) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

**$\Gamma(4\pi^+4\pi^-2\pi^0)/\Gamma_{\text{total}}$**   **$\Gamma_{16}/\Gamma$**

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
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<b><math>18 \pm 7 \pm 1</math></b>	29	<sup>1</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 4\pi^+ 4\pi^- 2\pi^0$
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<sup>1</sup> ASNER 08A reports  $[\Gamma(\chi_{b2}(1P) \rightarrow 4\pi^+ 4\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))] = (132 \pm 31 \pm 40) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

**$\Gamma(J/\psi J/\psi)/\Gamma_{\text{total}}$**   **$\Gamma_{17}/\Gamma$**

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
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<b><math>&lt; 5</math></b>	90	<sup>1</sup> SHEN	12 BELL	$\Upsilon(2S) \rightarrow \gamma \psi X$
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<sup>1</sup> SHEN 12 reports  $< 4.5 \times 10^{-5}$  from a measurement of  $[\Gamma(\chi_{b2}(1P) \rightarrow J/\psi J/\psi)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))]$  assuming  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ .

**$\Gamma(J/\psi \psi(2S))/\Gamma_{\text{total}}$**   **$\Gamma_{18}/\Gamma$**

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
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<b><math>&lt; 5</math></b>	90	<sup>1</sup> SHEN	12 BELL	$\Upsilon(2S) \rightarrow \gamma \psi X$
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<sup>1</sup> SHEN 12 reports  $< 4.9 \times 10^{-5}$  from a measurement of  $[\Gamma(\chi_{b2}(1P) \rightarrow J/\psi \psi(2S))/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))]$  assuming  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ .

**$\Gamma(\psi(2S) \psi(2S))/\Gamma_{\text{total}}$**   **$\Gamma_{19}/\Gamma$**

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
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<b><math>&lt; 1.6</math></b>	90	<sup>1</sup> SHEN	12 BELL	$\Upsilon(2S) \rightarrow \gamma \psi X$
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<sup>1</sup> SHEN 12 reports  $< 1.6 \times 10^{-5}$  from a measurement of  $[\Gamma(\chi_{b2}(1P) \rightarrow \psi(2S) \psi(2S))/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P))]$  assuming  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$ .

$\Gamma(J/\psi(1S)\text{anything})/\Gamma_{\text{total}}$					$\Gamma_{20}/\Gamma$
VALUE (units $10^{-3}$ )	EVTS	DOCUMENT ID	TECN	COMMENT	
<b><math>1.50 \pm 0.34 \pm 0.22</math></b>	462	JIA	17A	BELLE	$e^+e^- \rightarrow \text{hadrons}$

### $\chi_{b2}(1P)$ Cross-Particle Branching Ratios

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

$$\Gamma_1/\Gamma \times \Gamma_{60}^{\Upsilon(2S)}/\Gamma^{\Upsilon(2S)}$$

VALUE (units $10^{-3}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>13.9 \pm 0.5^{+0.9}_{-1.1}</math></b>	8k	LEES	11J	BABR $\Upsilon(2S) \rightarrow X\gamma$

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

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>3.38 \pm 0.16</math> OUR AVERAGE</b>				

$3.63^{+0.36+0.18}_{-0.34-0.19}$		<sup>1</sup> LEES	14M	BABR $\Upsilon(2S) \rightarrow \gamma\gamma\mu^+\mu^-$
$3.29 \pm 0.09 \pm 0.16$	1770	KORNICER	11	CLEO $e^+e^- \rightarrow \gamma\gamma\ell^+\ell^-$
$4.4 \pm 0.9 \pm 0.5$	35	WALK	86	CBAL $\Upsilon(2S) \rightarrow \gamma\gamma\ell^+\ell^-$

<sup>1</sup> From a sample of  $\Upsilon(2S) \rightarrow \gamma\gamma\mu^+\mu^-$  with converted photons.

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

VALUE (%)	DOCUMENT ID	TECN	COMMENT
<b><math>55.6 \pm 1.6</math></b>	<sup>1</sup> LEES	14M	BABR $\Upsilon(2S) \rightarrow \gamma\gamma\mu^+\mu^-$

<sup>1</sup> From a sample of  $\Upsilon(2S) \rightarrow \gamma\gamma\mu^+\mu^-$  events without converted photons.

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

VALUE (units $10^{-5}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>3.8 \pm 0.5</math> OUR AVERAGE</b>				

$4.68^{+0.99}_{-0.92} \pm 0.37$		<sup>1</sup> LEES	14M	BABR $\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$
$3.56 \pm 0.40 \pm 0.41$	126	KORNICER	11	CLEO $e^+e^- \rightarrow \gamma\gamma\ell^+\ell^-$

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

### $\chi_{b2}(1P)$ REFERENCES

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