

# $\chi_{b1}(2P)$

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

$J$  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
<b>10255.46 ± 0.22 ± 0.50 OUR EVALUATION</b>	From $\gamma$ energy below, using $\Upsilon(3S)$ mass = 10355.2 ± 0.5 MeV

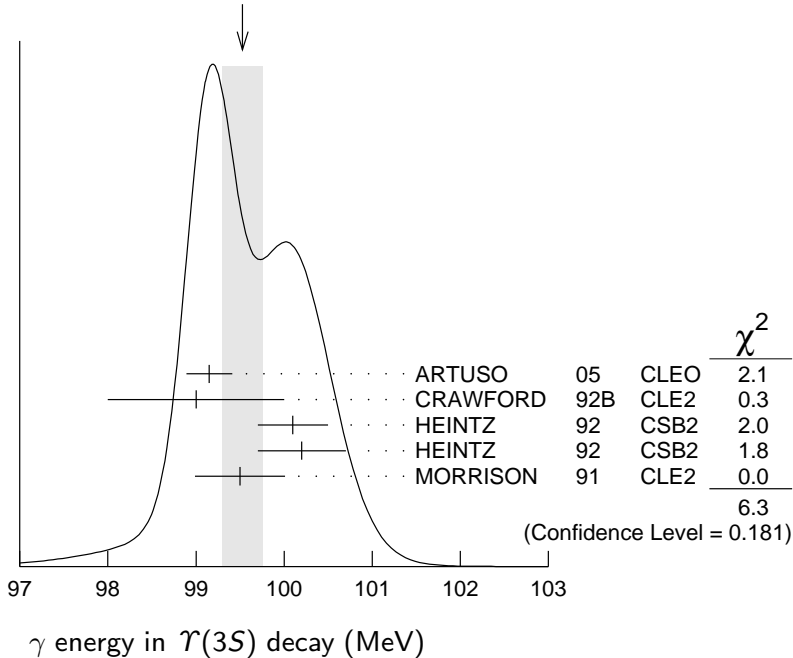
## $m_{\chi_{b1}(2P)} - m_{\chi_{b0}(2P)}$

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>23.5 ± 0.7 ± 0.7</b>	<sup>1</sup> HEINTZ	92	CSB2 $e^+e^- \rightarrow \gamma X, l^+l^- \gamma \gamma$
<sup>1</sup> From the average photon energy for inclusive and exclusive events. Supersedes NARAIN 91.			

## $\gamma$ ENERGY IN $\Upsilon(3S)$ DECAY

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>99.26 ± 0.22 OUR EVALUATION</b>		Treating systematic errors as correlated		
<b>99.53 ± 0.23 OUR AVERAGE</b>		Error includes scale factor of 1.3. See the ideogram below.		
99.15 ± 0.07 ± 0.25		ARTUSO	05	CLEO $\Upsilon(3S) \rightarrow \gamma X$
99 ± 1	169	CRAWFORD	92B	CLE2 $e^+e^- \rightarrow l^+l^- \gamma \gamma$
100.1 ± 0.4	11147	<sup>2</sup> HEINTZ	92	CSB2 $e^+e^- \rightarrow \gamma X$
100.2 ± 0.5	223	<sup>3</sup> HEINTZ	92	CSB2 $e^+e^- \rightarrow l^+l^- \gamma \gamma$
99.5 ± 0.1 ± 0.5	25759	MORRISON	91	CLE2 $e^+e^- \rightarrow \gamma X$

WEIGHTED AVERAGE  
99.53 ± 0.23 (Error scaled by 1.3)



<sup>2</sup>A systematic uncertainty on the energy scale of 0.9% not included. Supersedes NARAIN 91.

<sup>3</sup>A systematic uncertainty on the energy scale of 0.9% not included. Supersedes HEINTZ 91.

### $\chi_{b1}(2P)$ DECAY MODES

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor
$\Gamma_1$ $\omega \Upsilon(1S)$	( 1.63 <sup>+0.40</sup> <sub>-0.34</sub> ) %	
$\Gamma_2$ $\gamma \Upsilon(2S)$	(19.9 ± 1.9 ) %	
$\Gamma_3$ $\gamma \Upsilon(1S)$	( 9.2 ± 0.8 ) %	1.1
$\Gamma_4$ $\pi\pi\chi_{b1}(1P)$	( 9.1 ± 1.3 ) × 10 <sup>-3</sup>	
$\Gamma_5$ $D^0 X$	( 8.8 ± 1.7 ) %	
$\Gamma_6$ $\pi^+\pi^-K^+K^-\pi^0$	( 3.1 ± 1.0 ) × 10 <sup>-4</sup>	
$\Gamma_7$ $2\pi^+\pi^-K^-K_S^0$	( 1.1 ± 0.5 ) × 10 <sup>-4</sup>	
$\Gamma_8$ $2\pi^+\pi^-K^-K_S^02\pi^0$	( 7.7 ± 3.2 ) × 10 <sup>-4</sup>	
$\Gamma_9$ $2\pi^+2\pi^-2\pi^0$	( 5.9 ± 2.0 ) × 10 <sup>-4</sup>	
$\Gamma_{10}$ $2\pi^+2\pi^-K^+K^-$	(10 ± 4 ) × 10 <sup>-5</sup>	
$\Gamma_{11}$ $2\pi^+2\pi^-K^+K^-\pi^0$	( 5.5 ± 1.8 ) × 10 <sup>-4</sup>	
$\Gamma_{12}$ $2\pi^+2\pi^-K^+K^-2\pi^0$	(10 ± 4 ) × 10 <sup>-4</sup>	
$\Gamma_{13}$ $3\pi^+2\pi^-K^-K_S^0\pi^0$	( 6.7 ± 2.6 ) × 10 <sup>-4</sup>	
$\Gamma_{14}$ $3\pi^+3\pi^-$	( 1.2 ± 0.4 ) × 10 <sup>-4</sup>	
$\Gamma_{15}$ $3\pi^+3\pi^-2\pi^0$	( 1.2 ± 0.4 ) × 10 <sup>-3</sup>	
$\Gamma_{16}$ $3\pi^+3\pi^-K^+K^-$	( 2.0 ± 0.8 ) × 10 <sup>-4</sup>	
$\Gamma_{17}$ $3\pi^+3\pi^-K^+K^-\pi^0$	( 6.1 ± 2.2 ) × 10 <sup>-4</sup>	
$\Gamma_{18}$ $4\pi^+4\pi^-$	( 1.7 ± 0.6 ) × 10 <sup>-4</sup>	
$\Gamma_{19}$ $4\pi^+4\pi^-2\pi^0$	( 1.9 ± 0.7 ) × 10 <sup>-3</sup>	

### $\chi_{b1}(2P)$ BRANCHING RATIOS

$\Gamma(\omega \Upsilon(1S))/\Gamma_{\text{total}}$   $\Gamma_1/\Gamma$

VALUE (units 10 <sup>-2</sup> )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>1.63<sup>+0.35+0.16</sup><sub>-0.31-0.15</sub></b>	32.6 <sup>+6.9</sup> <sub>-6.1</sub>	<sup>4</sup> CRONIN-HEN..04	CLE3	$\Upsilon(3S) \rightarrow \gamma\omega \Upsilon(1S)$

<sup>4</sup> Using  $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) = (11.3 \pm 0.6)\%$  and  $B(\Upsilon(1S) \rightarrow \ell^+\ell^-) = 2$   
 $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = 2 (2.48 \pm 0.06)\%$ .

$\Gamma(\gamma \Upsilon(2S))/\Gamma_{\text{total}}$   $\Gamma_2/\Gamma$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.199 ± 0.019 OUR AVERAGE</b>				
0.190 ± 0.018 ± 0.017	4.3k	<sup>5</sup> LEES	11J BABR	$\Upsilon(3S) \rightarrow X\gamma$
0.356 ± 0.042 ± 0.092		<sup>6</sup> CRAWFORD	92B CLE2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$
0.199 ± 0.020 ± 0.022		<sup>7</sup> HEINTZ	92 CSB2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$

<sup>5</sup> LEES 11J reports  $[\Gamma(\chi_{b1}(2P) \rightarrow \gamma \Upsilon(2S))/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))] = (2.4 \pm 0.1 \pm 0.2) \times 10^{-2}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>6</sup> Using  $B(\Upsilon(2S) \rightarrow \mu^+ \mu^-) = (1.37 \pm 0.26)\%$ ,  $B(\Upsilon(3S) \rightarrow \gamma \Upsilon(2S)) \times 2 B(\Upsilon(2S) \rightarrow \mu^+ \mu^-) = (10.23 \pm 1.20 \pm 1.26) \times 10^{-4}$ , and  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = 0.105^{+0.003}_{-0.002} \pm 0.013$ .

<sup>7</sup> Using  $B(\Upsilon(2S) \rightarrow \mu^+ \mu^-) = (1.44 \pm 0.10)\%$ ,  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = (11.5 \pm 0.5 \pm 0.5)\%$  and assuming  $e\mu$  universality. Supersedes HEINTZ 91.

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

$\Gamma_3/\Gamma$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.092±0.008 OUR AVERAGE</b>		Error includes scale factor of 1.1.		
0.098±0.005±0.009	15k	<sup>8</sup> LEES	11J BABR	$\Upsilon(3S) \rightarrow X\gamma$
0.120±0.021±0.021		<sup>9</sup> CRAWFORD	92B CLE2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$
0.080±0.009±0.007		<sup>10</sup> HEINTZ	92 CSB2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$

<sup>8</sup> LEES 11J reports  $[\Gamma(\chi_{b1}(2P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))] = (12.4 \pm 0.3 \pm 0.6) \times 10^{-3}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>9</sup> Using  $B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (2.57 \pm 0.07)\%$ ,  $B(\Upsilon(3S) \rightarrow \gamma \Upsilon(1S)) \times 2 B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (6.47 \pm 1.12 \pm 0.82) \times 10^{-4}$  and  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = 0.105^{+0.003}_{-0.002} \pm 0.013$ .

<sup>10</sup> Using  $B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (2.57 \pm 0.07)\%$ ,  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = (11.5 \pm 0.5 \pm 0.5)\%$  and assuming  $e\mu$  universality. Supersedes HEINTZ 91.

### $\Gamma(\pi\pi\chi_{b1}(1P))/\Gamma_{\text{total}}$

$\Gamma_4/\Gamma$

VALUE (units $10^{-3}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>9.1±1.3 OUR AVERAGE</b>				
9.2±1.1±0.8	31k	<sup>11</sup> LEES	11C BABR	$e^+e^- \rightarrow \pi^+\pi^-X$
8.6±2.3±2.1		<sup>12</sup> CAWLFIELD	06 CLE3	$\Upsilon(3S) \rightarrow 2(\gamma\pi\ell)$

<sup>11</sup> LEES 11C measures  $B(\Upsilon(3S) \rightarrow \chi_{b1}(2P)X) \times B(\chi_{b1}(2P) \rightarrow \chi_{b1}(1P)\pi^+\pi^-) = (1.16 \pm 0.07 \pm 0.12) \times 10^{-3}$ . We derive the value assuming  $B(\Upsilon(3S) \rightarrow \chi_{b1}(2P)X) = B(\Upsilon(3S) \rightarrow \chi_{b1}(2P)\gamma) = (12.6 \pm 1.2) \times 10^{-2}$ .

<sup>12</sup> 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.

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

$\Gamma_5/\Gamma$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>8.8±1.5±0.8</b>	2243	<sup>13</sup> BRIERE	08 CLEO	$\Upsilon(3S) \rightarrow \gamma D^0 X$

<sup>13</sup> For  $p_{D^0} > 2.5$  GeV/c.

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

$\Gamma_6/\Gamma$

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>3.1±1.0±0.3</b>	30	<sup>14</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma\pi^+\pi^-K^+K^-\pi^0$

<sup>14</sup> ASNER 08A reports  $[\Gamma(\chi_{b1}(2P) \rightarrow \pi^+\pi^-K^+K^-\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P))] = (39 \pm 8 \pm 9) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+\pi^-K^-K_S^0)/\Gamma_{\text{total}}$   $\Gamma_7/\Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1.1±0.5±0.1</b>	10	<sup>15</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+\pi^-K^-K_S^0$

<sup>15</sup> ASNER 08A reports  $[\Gamma(\chi_{b1}(2P) \rightarrow 2\pi^+\pi^-K^-K_S^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P))]$  =  $(14 \pm 5 \pm 3) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+\pi^-K^-K_S^02\pi^0)/\Gamma_{\text{total}}$   $\Gamma_8/\Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>7.7±3.1±0.7</b>	15	<sup>16</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+\pi^-K^-2\pi^0$

<sup>16</sup> ASNER 08A reports  $[\Gamma(\chi_{b1}(2P) \rightarrow 2\pi^+\pi^-K^-K_S^02\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P))]$  =  $(97 \pm 30 \pm 26) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>5.9±2.0±0.5</b>	36	<sup>17</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+2\pi^-2\pi^0$

<sup>17</sup> ASNER 08A reports  $[\Gamma(\chi_{b1}(2P) \rightarrow 2\pi^+2\pi^-2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P))]$  =  $(74 \pm 16 \pm 19) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1.0±0.4±0.1</b>	12	<sup>18</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+2\pi^-K^+K^-$

<sup>18</sup> ASNER 08A reports  $[\Gamma(\chi_{b1}(2P) \rightarrow 2\pi^+2\pi^-K^+K^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P))]$  =  $(12 \pm 4 \pm 3) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>5.5±1.7±0.5</b>	38	<sup>19</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+2\pi^-K^+K^-\pi^0$

<sup>19</sup> ASNER 08A reports  $[\Gamma(\chi_{b1}(2P) \rightarrow 2\pi^+2\pi^-K^+K^-\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P))]$  =  $(69 \pm 13 \pm 17) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>9.6±3.5±0.9</b>	27	<sup>20</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+2\pi^-K^+K^-2\pi^0$

<sup>20</sup> ASNER 08A reports  $[\Gamma(\chi_{b1}(2P) \rightarrow 2\pi^+2\pi^-K^+K^-2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P))]$  =  $(121 \pm 29 \pm 33) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>6.7 \pm 2.5 \pm 0.6</math></b>	17	<sup>21</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 3\pi^+ 2\pi^- K^- K_S^0 \pi^0$

<sup>21</sup> ASNER 08A reports  $[\Gamma(\chi_{b1}(2P) \rightarrow 3\pi^+ 2\pi^- K^- K_S^0 \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))] = (85 \pm 23 \pm 22) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>1.2 \pm 0.4 \pm 0.1</math></b>	18	<sup>22</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 3\pi^+ 3\pi^-$

<sup>22</sup> ASNER 08A reports  $[\Gamma(\chi_{b1}(2P) \rightarrow 3\pi^+ 3\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))] = (15 \pm 4 \pm 3) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>12 \pm 4 \pm 1</math></b>	44	<sup>23</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 3\pi^+ 3\pi^- 2\pi^0$

<sup>23</sup> ASNER 08A reports  $[\Gamma(\chi_{b1}(2P) \rightarrow 3\pi^+ 3\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))] = (150 \pm 30 \pm 40) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>2.0 \pm 0.7 \pm 0.2</math></b>	16	<sup>24</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 3\pi^+ 3\pi^- K^+ K^-$

<sup>24</sup> ASNER 08A reports  $[\Gamma(\chi_{b1}(2P) \rightarrow 3\pi^+ 3\pi^- K^+ K^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))] = (25 \pm 7 \pm 6) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>6.1 \pm 2.1 \pm 0.6</math></b>	25	<sup>25</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 3\pi^+ 3\pi^- K^+ K^-\pi^0$

<sup>25</sup> ASNER 08A reports  $[\Gamma(\chi_{b1}(2P) \rightarrow 3\pi^+ 3\pi^- K^+ K^-\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))] = (77 \pm 17 \pm 21) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>1.7 \pm 0.6 \pm 0.2</math></b>	16	<sup>26</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 4\pi^+ 4\pi^-$

<sup>26</sup> ASNER 08A reports  $[\Gamma(\chi_{b1}(2P) \rightarrow 4\pi^+ 4\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))] = (22 \pm 6 \pm 5) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = (12.6 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>19±7±2</b>	41	<sup>27</sup> ASNER 08A	CLEO	$\Upsilon(3S) \rightarrow \gamma 4\pi^+ 4\pi^- 2\pi^0$

<sup>27</sup> ASNER 08A reports  $[\Gamma(\chi_{b1}(2P) \rightarrow 4\pi^+ 4\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))]$   
 $= (241 \pm 47 \pm 72) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))$   
 $= (12.6 \pm 1.2) \times 10^{-2}$ . 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

$\Gamma(\chi_{b1}(2P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))/\Gamma_{\text{total}}$   
 $\Gamma_3/\Gamma \times \Gamma_{20}^{\Upsilon(3S)}/\Gamma \Upsilon(3S)$

VALUE (units $10^{-3}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>12.4±0.3±0.6</b>	15k	LEES	11J	BABR $\Upsilon(3S) \rightarrow X\gamma$

$\Gamma(\chi_{b1}(2P) \rightarrow \gamma \Upsilon(2S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))/\Gamma_{\text{total}}$   
 $\Gamma_2/\Gamma \times \Gamma_{20}^{\Upsilon(3S)}/\Gamma \Upsilon(3S)$

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

$B(\chi_{b1}(2P) \rightarrow \chi_{b1}(1P)\pi^+\pi^-) \times B(\Upsilon(3S) \rightarrow \chi_{b1}(2P)X)$

VALUE (units $10^{-3}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>1.16±0.07±0.12</b>	31k	LEES	11C	BABR $e^+e^- \rightarrow \pi^+\pi^-X$

$B(\chi_{b2}(2P) \rightarrow \rho X + \bar{\rho} X)/B(\chi_{b1}(2P) \rightarrow \rho X + \bar{\rho} X)$

VALUE	DOCUMENT ID	TECN	COMMENT
<b>1.109±0.007±0.040</b>	BRIERE 07	CLEO	$\Upsilon(3S) \rightarrow \gamma \chi_{bJ}(2P)$

$B(\chi_{b0}(2P) \rightarrow \rho X + \bar{\rho} X)/B(\chi_{b1}(2P) \rightarrow \rho X + \bar{\rho} X)$

VALUE	DOCUMENT ID	TECN	COMMENT
<b>1.082±0.025±0.060</b>	BRIERE 07	CLEO	$\Upsilon(3S) \rightarrow \gamma \chi_{bJ}(2P)$

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