

$\chi_{b1}(2P)$

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

$J$  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 $e^+e^- \rightarrow \gamma X, l^+l^- \gamma\gamma$

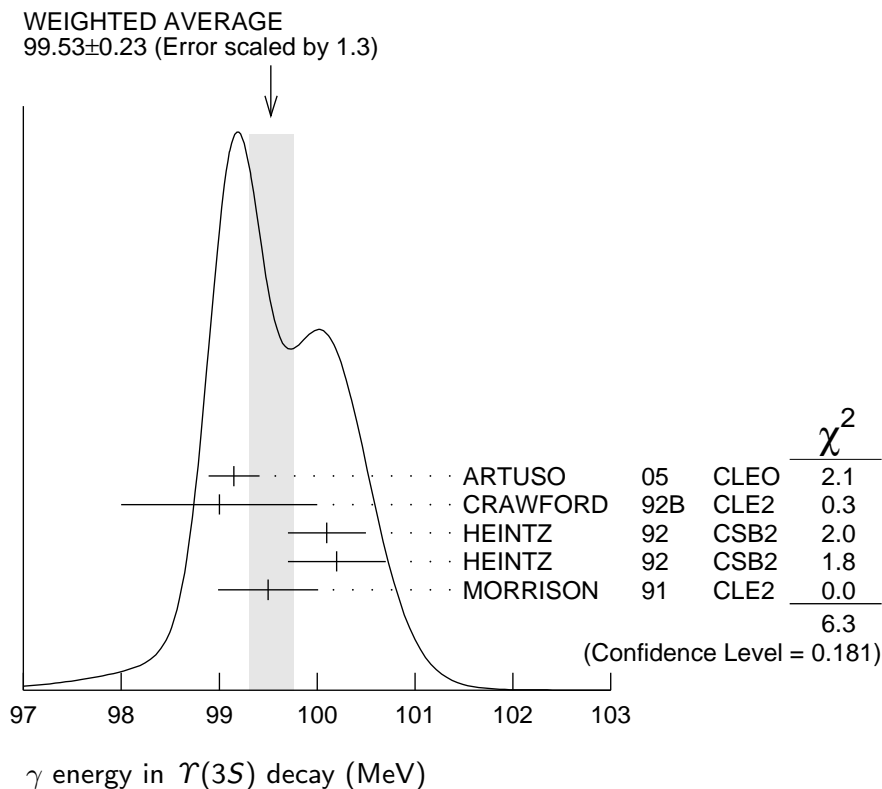
<sup>1</sup>From the average photon energy for inclusive and exclusive events. Supersedes NARAIN 91.

### $\gamma$ 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 $e^+e^- \rightarrow \gamma X$

<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
$\Gamma_1$ $\omega \gamma(1S)$	$(1.63^{+0.40}_{-0.34})\%$	
$\Gamma_2$ $\gamma \gamma(2S)$	$(19.9 \pm 1.9)\%$	
$\Gamma_3$ $\gamma \gamma(1S)$	$(9.2 \pm 0.8)\%$	1.1
$\Gamma_4$ $\pi\pi\chi_{b1}(1P)$	$(9.1 \pm 1.3) \times 10^{-3}$	
$\Gamma_5$ $D^0 X$	$(8.8 \pm 1.7)\%$	
$\Gamma_6$ $\pi^+\pi^-K^+K^-\pi^0$	$(3.1 \pm 1.0) \times 10^{-4}$	
$\Gamma_7$ $2\pi^+\pi^-K^-K_S^0$	$(1.1 \pm 0.5) \times 10^{-4}$	
$\Gamma_8$ $2\pi^+\pi^-K^-K_S^0 2\pi^0$	$(7.7 \pm 3.2) \times 10^{-4}$	
$\Gamma_9$ $2\pi^+ 2\pi^- 2\pi^0$	$(5.9 \pm 2.0) \times 10^{-4}$	
$\Gamma_{10}$ $2\pi^+ 2\pi^- K^+ K^-$	$(10 \pm 4) \times 10^{-5}$	
$\Gamma_{11}$ $2\pi^+ 2\pi^- K^+ K^- \pi^0$	$(5.5 \pm 1.8) \times 10^{-4}$	
$\Gamma_{12}$ $2\pi^+ 2\pi^- K^+ K^- 2\pi^0$	$(10 \pm 4) \times 10^{-4}$	
$\Gamma_{13}$ $3\pi^+ 2\pi^- K^- K_S^0 \pi^0$	$(6.7 \pm 2.6) \times 10^{-4}$	
$\Gamma_{14}$ $3\pi^+ 3\pi^-$	$(1.2 \pm 0.4) \times 10^{-4}$	
$\Gamma_{15}$ $3\pi^+ 3\pi^- 2\pi^0$	$(1.2 \pm 0.4) \times 10^{-3}$	
$\Gamma_{16}$ $3\pi^+ 3\pi^- K^+ K^-$	$(2.0 \pm 0.8) \times 10^{-4}$	

$\Gamma_{17}$	$3\pi^+3\pi^-K^+K^-\pi^0$	$(6.1 \pm 2.2) \times 10^{-4}$
$\Gamma_{18}$	$4\pi^+4\pi^-$	$(1.7 \pm 0.6) \times 10^{-4}$
$\Gamma_{19}$	$4\pi^+4\pi^-2\pi^0$	$(1.9 \pm 0.7) \times 10^{-3}$

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

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

<u>VALUE (units <math>10^{-2}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>1.63^{+0.35+0.16}_{-0.31-0.15}</math></b>	$32.6^{+6.9}_{-6.1}$	<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  $B(\Upsilon(1S) \rightarrow \ell^+\ell^-) = 2$   
 $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = 2 (2.48 \pm 0.06)\%$ .

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

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.199 \pm 0.019</math> OUR AVERAGE</b>				
$0.190 \pm 0.018 \pm 0.017$	4.3k	<sup>5</sup> LEES	11J BABR	$\Upsilon(3S) \rightarrow X\gamma$
$0.356 \pm 0.042 \pm 0.092$		<sup>6</sup> CRAWFORD	92B CLE2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$
$0.199 \pm 0.020 \pm 0.022$		<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  $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.37 \pm 0.26)\%$ ,  $B(\Upsilon(3S) \rightarrow \gamma\gamma \Upsilon(2S)) \times 2 B(\Upsilon(2S) \rightarrow$   
 $\mu^+\mu^-) = (10.23 \pm 1.20 \pm 1.26) \times 10^{-4}$ , 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.

$\Gamma(\gamma \Upsilon(1S))/\Gamma_{\text{total}}$   $\Gamma_3/\Gamma$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.092 \pm 0.008</math> OUR AVERAGE</b>				Error includes scale factor of 1.1.
$0.098 \pm 0.005 \pm 0.009$	15k	<sup>8</sup> LEES	11J BABR	$\Upsilon(3S) \rightarrow X\gamma$
$0.120 \pm 0.021 \pm 0.021$		<sup>9</sup> CRAWFORD	92B CLE2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$
$0.080 \pm 0.009 \pm 0.007$		<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  $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.57 \pm 0.07)\%$ ,  $B(\Upsilon(3S) \rightarrow \gamma\gamma \Upsilon(1S)) \times 2 B(\Upsilon(1S) \rightarrow$   
 $\mu^+\mu^-) = (6.47 \pm 1.12 \pm 0.82) \times 10^{-4}$  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.

**$\Gamma(\pi\pi\chi_{b1}(1P))/\Gamma_{\text{total}}$**   **$\Gamma_4/\Gamma$**

<u>VALUE (units <math>10^{-3}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>9.1 \pm 1.3</math></b>	<b>OUR AVERAGE</b>			
$9.2 \pm 1.1 \pm 0.8$	31k	<sup>11</sup> LEES	11C BABR	$e^+e^- \rightarrow \pi^+\pi^-X$
$8.6 \pm 2.3 \pm 2.1$		<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.

**$\Gamma(D^0X)/\Gamma_{\text{total}}$**   **$\Gamma_5/\Gamma$**

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

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

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>3.1 \pm 1.0 \pm 0.3</math></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><math>1.1 \pm 0.5 \pm 0.1</math></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.

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>7.7 \pm 3.1 \pm 0.7</math></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  $[\Gamma(\chi_{b1}(2P) \rightarrow 2\pi^+\pi^-K^-K_S^0 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P))] = (97 \pm 30 \pm 26) \times 10^{-6}$  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><math>5.9 \pm 2.0 \pm 0.5</math></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.

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

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<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.

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

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<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.

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

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<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.

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

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>6.7±2.5±0.6</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.

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

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>1.2±0.4±0.1</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>12±4±1</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>2.0±0.7±0.2</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>6.1±2.1±0.6</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>1.7±0.6±0.2</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.

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<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**

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

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

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

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>2.4 \pm 0.1 \pm 0.2</math></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><math>1.16 \pm 0.07 \pm 0.12</math></b>	31k	LEES	11C	BABR $e^+ e^- \rightarrow \pi^+ \pi^- X$

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

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

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

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

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

LEES	11C	PR D84 011104	J.P. Lees <i>et al.</i>	(BABAR Collab.)
LEES	11J	PR D84 072002	J.P. Lees <i>et al.</i>	(BABAR Collab.)
ASNER	08A	PR D78 091103	D.M. Asner <i>et al.</i>	(CLEO Collab.)
BRIERE	08	PR D78 092007	R.A. Briere <i>et al.</i>	(CLEO Collab.)
BRIERE	07	PR D76 012005	R.A. Briere <i>et al.</i>	(CLEO Collab.)
CAWLFIELD	06	PR D73 012003	C. Cawfield <i>et al.</i>	(CLEO Collab.)
ARTUSO	05	PRL 94 032001	M. Artuso <i>et al.</i>	(CLEO Collab.)
CRONIN-HEN...	04	PRL 92 222002	D. Cronin-Hennessy <i>et al.</i>	(CLEO Collab.)
CRAWFORD	92B	PL B294 139	G. Crawford, R. Fulton	(CLEO Collab.)
HEINTZ	92	PR D46 1928	U. Heintz <i>et al.</i>	(CUSB II Collab.)
HEINTZ	91	PRL 66 1563	U. Heintz <i>et al.</i>	(CUSB Collab.)
MORRISON	91	PRL 67 1696	R.J. Morrison <i>et al.</i>	(CLEO Collab.)
NARAIN	91	PRL 66 3113	M. Narain <i>et al.</i>	(CUSB Collab.)