

# $\chi_{b0}(2P)$

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

$J$  needs confirmation.

Observed in radiative decay of the  $\Upsilon(3S)$ , therefore  $C = +$ . Branching ratio requires E1 transition, M1 is strongly disfavored, therefore  $P = +$ .

## $\chi_{b0}(2P)$ MASS

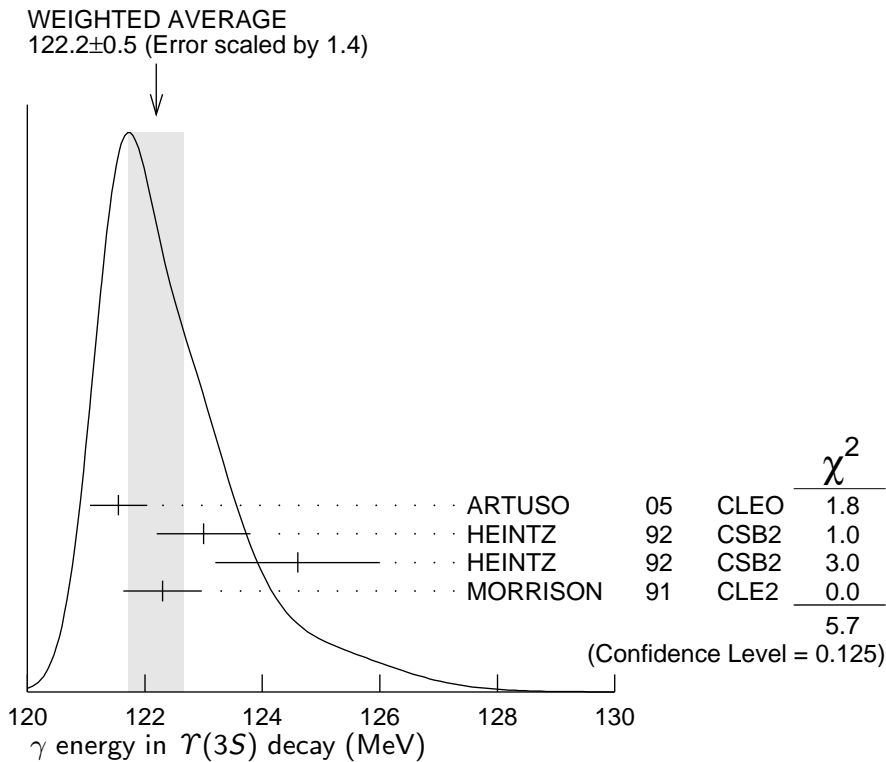
VALUE (MeV)	DOCUMENT ID
<b><math>10232.5 \pm 0.4 \pm 0.5</math> OUR EVALUATION</b>	From $\gamma$ energy below, using $\Upsilon(3S)$ mass = $10355.2 \pm 0.5$ MeV

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

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b><math>23.8 \pm 1.7</math></b>	LEES	14M BABR	$\Upsilon(3S) \rightarrow \gamma\gamma\mu^+\mu^-$

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

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>121.9 \pm 0.4</math> OUR EVALUATION</b>		Treating systematic errors as correlated		
<b><math>122.2 \pm 0.5</math> OUR AVERAGE</b>		Error includes scale factor of 1.4. See the ideogram below.		
$121.55 \pm 0.16 \pm 0.46$		ARTUSO	05 CLEO	$\Upsilon(3S) \rightarrow \gamma X$
$123.0 \pm 0.8$	4959	<sup>1</sup> HEINTZ	92 CSB2	$e^+e^- \rightarrow \gamma X$
$124.6 \pm 1.4$	17	<sup>2</sup> HEINTZ	92 CSB2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$
$122.3 \pm 0.3 \pm 0.6$	9903	MORRISON	91 CLE2	$e^+e^- \rightarrow \gamma X$



<sup>1</sup>A systematic uncertainty on the energy scale of 0.9% not included. Supersedes NARAIN 91.

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

### $\chi_{b0}(2P)$ DECAY MODES

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level
$\Gamma_1 \quad \gamma \Upsilon(2S)$	$(1.38 \pm 0.30) \%$	
$\Gamma_2 \quad \gamma \Upsilon(1S)$	$(3.8 \pm 1.7) \times 10^{-3}$	
$\Gamma_3 \quad D^0 X$	$< 8.2 \quad \%$	90%
$\Gamma_4 \quad \pi^+ \pi^- K^+ K^- \pi^0$	$< 3.4 \quad \times 10^{-5}$	90%
$\Gamma_5 \quad 2\pi^+ \pi^- K^- K_S^0$	$< 5 \quad \times 10^{-5}$	90%
$\Gamma_6 \quad 2\pi^+ \pi^- K^- K_S^0 2\pi^0$	$< 2.2 \quad \times 10^{-4}$	90%
$\Gamma_7 \quad 2\pi^+ 2\pi^- 2\pi^0$	$< 2.4 \quad \times 10^{-4}$	90%
$\Gamma_8 \quad 2\pi^+ 2\pi^- K^+ K^-$	$< 1.5 \quad \times 10^{-4}$	90%
$\Gamma_9 \quad 2\pi^+ 2\pi^- K^+ K^- \pi^0$	$< 2.2 \quad \times 10^{-4}$	90%
$\Gamma_{10} \quad 2\pi^+ 2\pi^- K^+ K^- 2\pi^0$	$< 1.1 \quad \times 10^{-3}$	90%
$\Gamma_{11} \quad 3\pi^+ 2\pi^- K^- K_S^0 \pi^0$	$< 7 \quad \times 10^{-4}$	90%
$\Gamma_{12} \quad 3\pi^+ 3\pi^-$	$< 7 \quad \times 10^{-5}$	90%
$\Gamma_{13} \quad 3\pi^+ 3\pi^- 2\pi^0$	$< 1.2 \quad \times 10^{-3}$	90%
$\Gamma_{14} \quad 3\pi^+ 3\pi^- K^+ K^-$	$< 1.5 \quad \times 10^{-4}$	90%
$\Gamma_{15} \quad 3\pi^+ 3\pi^- K^+ K^- \pi^0$	$< 7 \quad \times 10^{-4}$	90%
$\Gamma_{16} \quad 4\pi^+ 4\pi^-$	$< 1.7 \quad \times 10^{-4}$	90%
$\Gamma_{17} \quad 4\pi^+ 4\pi^- 2\pi^0$	$< 6 \quad \times 10^{-4}$	90%

### $\chi_{b0}(2P)$ BRANCHING RATIOS

$\Gamma(\gamma \Upsilon(2S))/\Gamma_{\text{total}}$	$\Gamma_1/\Gamma$			
VALUE (%)	CL%	DOCUMENT ID	TECN	COMMENT
<b>1.38 ± 0.30 OUR AVERAGE</b>				
$1.31 \pm 0.27^{+0.13}_{-0.12}$	3,4	LEES	14M BABR	$\Upsilon(3S) \rightarrow \gamma \gamma \mu^+ \mu^-$
$3.6 \pm 1.6 \pm 0.3$	3,5	HEINTZ	92 CSB2	$e^+ e^- \rightarrow \ell^+ \ell^- \gamma \gamma$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$< 2.8$	90	<sup>6</sup> LEES	11J BABR	$\Upsilon(3S) \rightarrow X \gamma$
$< 8.9$	90	<sup>7</sup> CRAWFORD	92B CLE2	$e^+ e^- \rightarrow \ell^+ \ell^- \gamma \gamma$

<sup>3</sup> Assuming  $B(\Upsilon(2S) \rightarrow \mu^+ \mu^-) = (1.93 \pm 0.17)\%$ .

<sup>4</sup> LEES 14M reports  $[\Gamma(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(2S))/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P))] = (7.7 \pm 1.6) \times 10^{-4}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P)) = (5.9 \pm 0.6) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>5</sup> Recalculated by us. HEINTZ 92 quotes  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P)) \times B(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(2S)) = (0.28 \pm 0.12 \pm 0.03)\%$  using  $B(\Upsilon(2S) \rightarrow \mu^+ \mu^-) = (1.44 \pm 0.10)\%$ . Supersedes HEINTZ 91.

<sup>6</sup> LEES 11J quotes a central value of  $\Gamma(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(2S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P))/\Gamma_{\text{total}} = (-0.3 \pm 0.2^{+0.5}_{-0.4})\%$ .

<sup>7</sup> Using  $B(\Upsilon(2S) \rightarrow \mu^+ \mu^-) = (1.37 \pm 0.26)\%$ ,  $B(\Upsilon(3S) \rightarrow \gamma \gamma \Upsilon(2S)) \times 2 B(\Upsilon(2S) \rightarrow \mu^+ \mu^-) < 1.19 \times 10^{-4}$ , and  $B(\Upsilon(3S) \rightarrow \chi_{b0}(2P) \gamma) = 0.049$ .

$\Gamma(\gamma \Upsilon(1S))/\Gamma_{\text{total}}$   $\Gamma_2/\Gamma$ 

VALUE (%)	CL%	DOCUMENT ID	TECN	COMMENT
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**0.38 ± 0.17 OUR AVERAGE**

0.36 ± 0.17 ± 0.03		8,9,10 LEES	14M BABR	$\Upsilon(3S) \rightarrow \gamma \gamma \mu^+ \mu^-$
0.9 ± 0.7 ± 0.1		9,11 HEINTZ	92 CSB2	$e^+ e^- \rightarrow \ell^+ \ell^- \gamma \gamma$

• • • We do not use the following data for averages, fits, limits, etc. • • •

<1.2	90	12 LEES	11J BABR	$\Upsilon(3S) \rightarrow X \gamma$
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<2.5	90	13 CRAWFORD	92B CLE2	$e^+ e^- \rightarrow \ell^+ \ell^- \gamma \gamma$
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<sup>8</sup> LEES 14M quotes  $\Gamma(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P))/\Gamma_{\text{total}} = (2.1 \pm 1.0) \times 10^{-4}$  combining the results from  $\Upsilon(3S) \rightarrow \gamma \gamma \mu^+ \mu^-$  samples with and without photon conversions.

<sup>9</sup> Assuming  $B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (2.48 \pm 0.05)\%$ .

<sup>10</sup> LEES 14M reports  $[\Gamma(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P))] = (2.1 \pm 1.0) \times 10^{-4}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P)) = (5.9 \pm 0.6) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>11</sup> Recalculated by us. HEINTZ 92 quotes  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P)) \times B(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(1S)) = (0.05 \pm 0.04 \pm 0.01)\%$  using  $B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (2.57 \pm 0.05)\%$ . Supersedes HEINTZ 91.

<sup>12</sup> LEES 11J quotes a central value of  $\Gamma(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P))/\Gamma_{\text{total}} = (3.9 \pm 2.2^{+1.2}_{-0.6}) \times 10^{-4}$ .

<sup>13</sup> Using  $B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (2.57 \pm 0.07)\%$ ,  $B(\Upsilon(3S) \rightarrow \gamma \gamma \Upsilon(1S)) \times 2 B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) < 0.63 \times 10^{-4}$ , and  $B(\Upsilon(3S) \rightarrow \chi_{b0}(2P) \gamma) = 0.049$ .

 $\Gamma(D^0 X)/\Gamma_{\text{total}}$   $\Gamma_3/\Gamma$ 

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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<b>&lt;8.2 × 10<sup>-2</sup></b>	90	14,15 BRIERE	08 CLEO	$\Upsilon(3S) \rightarrow \gamma D^0 X$
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<sup>14</sup> For  $p_{D^0} > 2.5 \text{ GeV}/c$ .

<sup>15</sup> The authors also present their result as  $(4.1 \pm 3.0 \pm 0.4) \times 10^{-2}$ .

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

VALUE (units 10 <sup>-4</sup> )	CL%	DOCUMENT ID	TECN	COMMENT
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<b>&lt;0.34</b>	90	16 ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma \pi^+ \pi^- K^+ K^- \pi^0$
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<sup>16</sup> ASNER 08A reports  $[\Gamma(\chi_{b0}(2P) \rightarrow \pi^+ \pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P))] < 2 \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P)) = 5.9 \times 10^{-2}$ .

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

VALUE (units 10 <sup>-4</sup> )	CL%	DOCUMENT ID	TECN	COMMENT
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<b>&lt;0.5</b>	90	17 ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+ \pi^- K^- K_S^0$
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<sup>17</sup> ASNER 08A reports  $[\Gamma(\chi_{b0}(2P) \rightarrow 2\pi^+ \pi^- K^- K_S^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P))] < 3 \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P)) = 5.9 \times 10^{-2}$ .

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;2.2</b>	90	<sup>18</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+\pi^-K^-2\pi^0$
<sup>18</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(2P) \rightarrow 2\pi^+\pi^-K^-K_S^0 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P))]$ < $13 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P)) = 5.9 \times 10^{-2}$ .				

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;2.4</b>	90	<sup>19</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+2\pi^-2\pi^0$
<sup>19</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(2P) \rightarrow 2\pi^+2\pi^-2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P))]$ < $14 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P)) = 5.9 \times 10^{-2}$ .				

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;1.5</b>	90	<sup>20</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+2\pi^-K^+K^-$
<sup>20</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(2P) \rightarrow 2\pi^+2\pi^-K^+K^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P))]$ < $9 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P)) = 5.9 \times 10^{-2}$ .				

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;2.2</b>	90	<sup>21</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+2\pi^-K^+K^-\pi^0$
<sup>21</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(2P) \rightarrow 2\pi^+2\pi^-K^+K^-\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P))]$ < $13 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P)) = 5.9 \times 10^{-2}$ .				

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;11</b>	90	<sup>22</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 2\pi^+2\pi^-K^+K^-2\pi^0$
<sup>22</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(2P) \rightarrow 2\pi^+2\pi^-K^+K^-2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P))]$ < $63 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P)) = 5.9 \times 10^{-2}$ .				

**$\Gamma(3\pi^+2\pi^-K^-K_S^0\pi^0)/\Gamma_{\text{total}}$**   **$\Gamma_{11}/\Gamma$**

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;7</b>	90	<sup>23</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 3\pi^+2\pi^-K^-K_S^0\pi^0$
<sup>23</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(2P) \rightarrow 3\pi^+2\pi^-K^-K_S^0\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P))]$ < $39 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P)) = 5.9 \times 10^{-2}$ .				

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

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;0.7</b>	90	<sup>24</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 3\pi^+ 3\pi^-$
<sup>24</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(2P) \rightarrow 3\pi^+ 3\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P))]$ $< 4 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P)) = 5.9 \times 10^{-2}$ .				

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

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;12</b>	90	<sup>25</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 3\pi^+ 3\pi^- 2\pi^0$
<sup>25</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(2P) \rightarrow 3\pi^+ 3\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P))]$ $< 72 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P)) = 5.9 \times 10^{-2}$ .				

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

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;1.5</b>	90	<sup>26</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 3\pi^+ 3\pi^- K^+ K^-$
<sup>26</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(2P) \rightarrow 3\pi^+ 3\pi^- K^+ K^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P))]$ $< 9 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P)) = 5.9 \times 10^{-2}$ .				

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

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;7</b>	90	<sup>27</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 3\pi^+ 3\pi^- K^+ K^-\pi^0$
<sup>27</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(2P) \rightarrow 3\pi^+ 3\pi^- K^+ K^-\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P))]$ $< 43 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P)) = 5.9 \times 10^{-2}$ .				

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

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;1.7</b>	90	<sup>28</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 4\pi^+ 4\pi^-$
<sup>28</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(2P) \rightarrow 4\pi^+ 4\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P))]$ $< 10 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P)) = 5.9 \times 10^{-2}$ .				

$\Gamma(4\pi^+4\pi^-2\pi^0)/\Gamma_{\text{total}}$   $\Gamma_{17}/\Gamma$

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;6</b>	90	<sup>29</sup> ASNER	08A CLEO	$\Upsilon(3S) \rightarrow \gamma 4\pi^+ 4\pi^- 2\pi^0$
<sup>29</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(2P) \rightarrow 4\pi^+ 4\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P))]$ $< 38 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P)) = 5.9 \times 10^{-2}$ .				

$\Gamma(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P))/\Gamma_{\text{total}}$   
 $\Gamma_2/\Gamma \times \Gamma_{22}^{\Upsilon(3S)}/\Gamma \Upsilon(3S)$

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;8.2</b>	90	<sup>30</sup> LEES	11J BABR	$\Upsilon(3S) \rightarrow X\gamma$
<sup>30</sup> LEES 11J quotes a central value of $\Gamma(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P))/\Gamma_{\text{total}} = (3.9 \pm 2.2_{-0.6}^{+1.2}) \times 10^{-4}$ and derives a 90% CL upper limit of $B(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(1S)) < 1.2\%$ using $B(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(2P)) = (5.9 \pm 0.6)\%$ .				

**$B(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(1S)) \times B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P)) \times B(\Upsilon(1S) \rightarrow \ell^+ \ell^-)$**

VALUE (units $10^{-5}$ )	DOCUMENT ID	TECN	COMMENT
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**1.4 ± 0.9 OUR AVERAGE**

$1.7^{+1.5+0.1}_{-1.4-1.2}$	31 LEES	14M BABR	$\Upsilon(3S) \rightarrow \gamma \gamma \mu^+ \mu^-$
$1.3 \pm 1.0 \pm 0.3$	32 HEINTZ	92 CSB2	$\Upsilon(3S) \rightarrow \gamma \gamma \ell^+ \ell^-$

<sup>31</sup> From a sample of  $\Upsilon(3S) \rightarrow \gamma \gamma \mu^+ \mu^-$  with one converted photon.

<sup>32</sup> Calculated by us. HEINTZ 92 quotes  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P)) \times B(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(1S)) = (0.05 \pm 0.04 \pm 0.01)\%$  using  $B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (2.57 \pm 0.05)\%$ .

**$[B(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(1S)) \times B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P))] / [B(\chi_{b1}(2P) \rightarrow \gamma \Upsilon(1S)) \times B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))]$**

VALUE (%)	DOCUMENT ID	TECN	COMMENT
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<b>1.71 ± 0.80</b>	33 LEES	14M BABR	$\Upsilon(3S) \rightarrow \gamma \gamma \mu^+ \mu^-$
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<sup>33</sup> From a sample of  $\Upsilon(3S) \rightarrow \gamma \gamma \mu^+ \mu^-$  without converted photons.

**$\Gamma(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(2S)) / \Gamma_{\text{total}} \times \Gamma(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P)) / \Gamma_{\text{total}}$   
 $\Gamma_1 / \Gamma \times \Gamma_{22}^{\Upsilon(3S)} / \Gamma \Upsilon(3S)$**

VALUE (units $10^{-3}$ )	CL%	DOCUMENT ID	TECN	COMMENT
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<b>&lt; 1.6</b>	90	34 LEES	11J BABR	$\Upsilon(3S) \rightarrow X \gamma$
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<sup>34</sup> LEES 11J quotes a central value of  $\Gamma(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(2S)) / \Gamma_{\text{total}} \times \Gamma(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P)) / \Gamma_{\text{total}} = (-0.3 \pm 0.2^{+0.5}_{-0.4})\%$  and derives a 90% CL upper limit of  $B(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(2S)) < 2.8\%$  using  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P)) = (5.9 \pm 0.6)\%$ .

**$B(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(2S)) \times B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P)) \times B(\Upsilon(2S) \rightarrow \ell^+ \ell^-)$**

VALUE (units $10^{-5}$ )	DOCUMENT ID	TECN	COMMENT
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**4.4 ± 1.6 OUR AVERAGE**

$6.6^{+4.9+2.0}_{-4.0-0.3}$	35 LEES	14M BABR	$\Upsilon(3S) \rightarrow \gamma \gamma \mu^+ \mu^-$
$4.0 \pm 1.7 \pm 0.3$	36 HEINTZ	92 CSB2	$\Upsilon(3S) \rightarrow \gamma \gamma \ell^+ \ell^-$

<sup>35</sup> From a sample of  $\Upsilon(3S) \rightarrow \gamma \gamma \mu^+ \mu^-$  with one converted photon.

<sup>36</sup> Calculated by us. HEINTZ 92 quotes  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P)) \times B(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(2S)) = (0.28 \pm 0.12 \pm 0.03)\%$  using  $B(\Upsilon(2S) \rightarrow \mu^+ \mu^-) = (1.44 \pm 0.10)\%$ .

**$[B(\chi_{b0}(2P) \rightarrow \gamma \Upsilon(2S)) \times B(\Upsilon(3S) \rightarrow \gamma \chi_{b0}(2P))] / [B(\chi_{b1}(2P) \rightarrow \gamma \Upsilon(2S)) \times B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P))]$**

VALUE (%)	DOCUMENT ID	TECN	COMMENT
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<b>3.31 ± 0.56</b>	37 LEES	14M BABR	$\Upsilon(3S) \rightarrow \gamma \gamma \mu^+ \mu^-$
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<sup>37</sup> From a sample of  $\Upsilon(3S) \rightarrow \gamma \gamma \mu^+ \mu^-$  without converted photons.

## $\chi_{b0}(2P)$ REFERENCES

LEES	14M	PR D90 112010	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.)
ARTUSO	05	PRL 94 032001	M. Artuso <i>et al.</i>	(CLEO Collab.)
CRAWFORD	92B	PL B294 139	G. Crawford <i>et al.</i>	(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.)

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