

# $\chi_{b0}(1P)$

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

$J$  needs confirmation.

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

## $\chi_{b0}(1P)$ MASS

VALUE (MeV)	DOCUMENT ID
<b>9859.44 ± 0.42 ± 0.31 OUR EVALUATION</b>	From average $\gamma$ energy below, using $\Upsilon(2S)$ mass = 10023.26 ± 0.31 MeV

$m_{\chi_{b1}(1P)} - m_{\chi_{b0}(1P)}$	VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>32.49 ± 0.93</b>		LEES	14M BABR	$\Upsilon(2S) \rightarrow \gamma\gamma\mu^+\mu^-$

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

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>162.5 ± 0.4 OUR AVERAGE</b>			
162.56 ± 0.19 ± 0.42	ARTUSO	05 CLEO	$\Upsilon(2S) \rightarrow \gamma X$
162.0 ± 0.8 ± 1.2	EDWARDS	99 CLE2	$\Upsilon(2S) \rightarrow \gamma\chi(1P)$
162.1 ± 0.5 ± 1.4	ALBRECHT	85E ARG	$\Upsilon(2S) \rightarrow \text{conv.}\gamma X$
163.8 ± 1.6 ± 2.7	NERNST	85 CBAL	$\Upsilon(2S) \rightarrow \gamma X$
158.0 ± 7 ± 1	HAAS	84 CLEO	$\Upsilon(2S) \rightarrow \text{conv.}\gamma X$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
149.4 ± 0.7 ± 5.0	KLOPFEN...	83 CUSB	$\Upsilon(2S) \rightarrow \gamma X$

## $\chi_{b0}(1P)$ DECAY MODES

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level
$\Gamma_1$ $\gamma \Upsilon(1S)$	( 1.94 ± 0.27 ) %	
$\Gamma_2$ $D^0 X$	< 10.4 %	90%
$\Gamma_3$ $\pi^+\pi^- K^+ K^- \pi^0$	< 1.6 × 10 <sup>-4</sup>	90%
$\Gamma_4$ $2\pi^+\pi^- K^- K_S^0$	< 5 × 10 <sup>-5</sup>	90%
$\Gamma_5$ $2\pi^+\pi^- K^- K_S^0 2\pi^0$	< 5 × 10 <sup>-4</sup>	90%
$\Gamma_6$ $2\pi^+ 2\pi^- 2\pi^0$	< 2.1 × 10 <sup>-4</sup>	90%
$\Gamma_7$ $2\pi^+ 2\pi^- K^+ K^-$	( 1.1 ± 0.6 ) × 10 <sup>-4</sup>	
$\Gamma_8$ $2\pi^+ 2\pi^- K^+ K^- \pi^0$	< 2.7 × 10 <sup>-4</sup>	90%
$\Gamma_9$ $2\pi^+ 2\pi^- K^+ K^- 2\pi^0$	< 5 × 10 <sup>-4</sup>	90%
$\Gamma_{10}$ $3\pi^+ 2\pi^- K^- K_S^0 \pi^0$	< 1.6 × 10 <sup>-4</sup>	90%
$\Gamma_{11}$ $3\pi^+ 3\pi^-$	< 8 × 10 <sup>-5</sup>	90%
$\Gamma_{12}$ $3\pi^+ 3\pi^- 2\pi^0$	< 6 × 10 <sup>-4</sup>	90%

$\Gamma_{13}$	$3\pi^+ 3\pi^- K^+ K^-$	$(2.4 \pm 1.2) \times 10^{-4}$	
$\Gamma_{14}$	$3\pi^+ 3\pi^- K^+ K^- \pi^0$	$< 1.0 \times 10^{-3}$	90%
$\Gamma_{15}$	$4\pi^+ 4\pi^-$	$< 8 \times 10^{-5}$	90%
$\Gamma_{16}$	$4\pi^+ 4\pi^- 2\pi^0$	$< 2.1 \times 10^{-3}$	90%
$\Gamma_{17}$	$J/\psi J/\psi$	$< 7 \times 10^{-5}$	90%
$\Gamma_{18}$	$J/\psi \psi(2S)$	$< 1.2 \times 10^{-4}$	90%
$\Gamma_{19}$	$\psi(2S) \psi(2S)$	$< 3.1 \times 10^{-5}$	90%
$\Gamma_{20}$	$J/\psi(1S)$ anything	$< 2.3 \times 10^{-3}$	90%

### $\chi_{b0}(1P)$ BRANCHING RATIOS

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

VALUE (%)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
<b>1.94 ± 0.27 OUR AVERAGE</b>					
2.07 ± 0.24 ± 0.21			1,2 LEES	14M BABR	$\Upsilon(2S) \rightarrow \gamma \gamma \mu^+ \mu^-$
1.76 ± 0.30 ± 0.18		87	3,4 KORNICER	11 CLEO	$e^+ e^- \rightarrow \gamma \gamma \ell^+ \ell^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 4.6	90		5 LEES	11J BABR	$\Upsilon(2S) \rightarrow X \gamma$
< 6	90		WALK	86 CBAL	$\Upsilon(2S) \rightarrow \gamma \gamma \ell^+ \ell^-$
< 11	90		PAUSS	83 CUSB	$\Upsilon(2S) \rightarrow \gamma \gamma \ell^+ \ell^-$

<sup>1</sup> LEES 14M quotes  $\Gamma(\chi_{b0}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P))/\Gamma_{\text{total}} = (7.75 \pm 0.91) \times 10^{-4}$  combining the results from samples of  $\Upsilon(2S) \rightarrow \gamma \gamma \mu^+ \mu^-$  with and without converted photons. Assumes  $B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (2.48 \pm 0.05)\%$ .

<sup>2</sup> LEES 14M reports  $[\Gamma(\chi_{b0}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P))] = (7.75 \pm 0.91) \times 10^{-4}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P)) = (3.8 \pm 0.4) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>3</sup> Assuming  $B(\Upsilon(1S) \rightarrow \ell^+ \ell^-) = (2.48 \pm 0.05)\%$ .

<sup>4</sup> KORNICER 11 reports  $[\Gamma(\chi_{b0}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P))] = (6.59 \pm 0.96 \pm 0.60) \times 10^{-4}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P)) = (3.8 \pm 0.4) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>5</sup> LEES 11J quotes a central value of  $\Gamma(\chi_{b0}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P))/\Gamma_{\text{total}} = (8.3 \pm 5.6^{+3.7}_{-2.6}) \times 10^{-4}$ .

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

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt; 10.4 × 10<sup>-2</sup></b>	90	6,7 BRIERE	08	CLEO $\Upsilon(2S) \rightarrow \gamma D^0 X$

<sup>6</sup> For  $p_{D^0} > 2.5$  GeV/c.

<sup>7</sup> The authors also present their result as  $(5.6 \pm 3.6 \pm 0.5) \times 10^{-2}$ .

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

VALUE (units 10 <sup>-4</sup> )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt; 1.6</b>	90	8 ASNER	08A	CLEO $\Upsilon(2S) \rightarrow \gamma \pi^+ \pi^- K^+ K^- \pi^0$

<sup>8</sup> ASNER 08A reports  $[\Gamma(\chi_{b0}(1P) \rightarrow \pi^+ \pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P))] < 6 \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P)) = 3.8 \times 10^{-2}$ .

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

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;0.5</b>	90	<sup>9</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 2\pi^+\pi^-K^-K_S^0$

<sup>9</sup> ASNER 08A reports  $[\Gamma(\chi_{b0}(1P) \rightarrow 2\pi^+\pi^-K^-K_S^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P))]$   $< 2 \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P)) = 3.8 \times 10^{-2}$ .

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

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

<sup>10</sup> ASNER 08A reports  $[\Gamma(\chi_{b0}(1P) \rightarrow 2\pi^+\pi^-K^-K_S^0 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P))]$   $< 18 \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P)) = 3.8 \times 10^{-2}$ .

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

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;2.1</b>	90	<sup>11</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 2\pi^+2\pi^-2\pi^0$

<sup>11</sup> ASNER 08A reports  $[\Gamma(\chi_{b0}(1P) \rightarrow 2\pi^+2\pi^-2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P))]$   $< 8 \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P)) = 3.8 \times 10^{-2}$ .

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

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>1.1 \pm 0.6 \pm 0.1</math></b>	7	<sup>12</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 2\pi^+2\pi^-K^+K^-$

<sup>12</sup> ASNER 08A reports  $[\Gamma(\chi_{b0}(1P) \rightarrow 2\pi^+2\pi^-K^+K^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P))]$   $= (4 \pm 2 \pm 1) \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P)) = (3.8 \pm 0.4) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;2.7</b>	90	<sup>13</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 2\pi^+2\pi^-K^+K^-\pi^0$

<sup>13</sup> ASNER 08A reports  $[\Gamma(\chi_{b0}(1P) \rightarrow 2\pi^+2\pi^-K^+K^-\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P))]$   $< 10 \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P)) = 3.8 \times 10^{-2}$ .

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

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;5</b>	90	<sup>14</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 2\pi^+2\pi^-K^+K^-2\pi^0$

<sup>14</sup> ASNER 08A reports  $[\Gamma(\chi_{b0}(1P) \rightarrow 2\pi^+2\pi^-K^+K^-2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P))]$   $< 20 \times 10^{-6}$  which we divide by our best value  $B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P)) = 3.8 \times 10^{-2}$ .

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

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;1.6</b>	90	<sup>15</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 3\pi^+ 2\pi^- K^- K_S^0 \pi^0$
<sup>15</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(1P) \rightarrow 3\pi^+ 2\pi^- K^- K_S^0 \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P))]$ $< 6 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P)) = 3.8 \times 10^{-2}$ .				

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

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;0.8</b>	90	<sup>16</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 3\pi^+ 3\pi^-$
<sup>16</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(1P) \rightarrow 3\pi^+ 3\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P))]$ $< 3 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P)) = 3.8 \times 10^{-2}$ .				

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

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;6</b>	90	<sup>17</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 3\pi^+ 3\pi^- 2\pi^0$
<sup>17</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(1P) \rightarrow 3\pi^+ 3\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P))]$ $< 22 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P)) = 3.8 \times 10^{-2}$ .				

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

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>2.4 \pm 1.2 \pm 0.2</math></b>	9	<sup>18</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 3\pi^+ 3\pi^- K^+ K^-$
<sup>18</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(1P) \rightarrow 3\pi^+ 3\pi^- K^+ K^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P))]$ $= (9 \pm 4 \pm 2) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P)) = (3.8 \pm 0.4) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.				

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

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;10</b>	90	<sup>19</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 3\pi^+ 3\pi^- K^+ K^- \pi^0$
<sup>19</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(1P) \rightarrow 3\pi^+ 3\pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P))]$ $< 37 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P)) = 3.8 \times 10^{-2}$ .				

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

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;0.8</b>	90	<sup>20</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 4\pi^+ 4\pi^-$
<sup>20</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(1P) \rightarrow 4\pi^+ 4\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P))]$ $< 3 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P)) = 3.8 \times 10^{-2}$ .				

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

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;21</b>	90	<sup>21</sup> ASNER	08A CLEO	$\Upsilon(2S) \rightarrow \gamma 4\pi^+ 4\pi^- 2\pi^0$
<sup>21</sup> ASNER 08A reports $[\Gamma(\chi_{b0}(1P) \rightarrow 4\pi^+ 4\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P))]$ $< 77 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \rightarrow \gamma \chi_{b0}(1P)) = 3.8 \times 10^{-2}$ .				

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

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;7</b>	90	22 SHEN	12 BELL	$\Upsilon(2S) \rightarrow \gamma\psi X$
$^{22}$ SHEN 12 reports $< 7.1 \times 10^{-5}$ from a measurement of $[\Gamma(\chi_{b0}(1P) \rightarrow J/\psi J/\psi)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P))]$ assuming $B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P)) = (3.8 \pm 0.4) \times 10^{-2}$ .				

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

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;12</b>	90	23 SHEN	12 BELL	$\Upsilon(2S) \rightarrow \gamma\psi X$
$^{23}$ SHEN 12 reports $< 12 \times 10^{-5}$ from a measurement of $[\Gamma(\chi_{b0}(1P) \rightarrow J/\psi\psi(2S))/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P))]$ assuming $B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P)) = (3.8 \pm 0.4) \times 10^{-2}$ .				

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

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;3.1</b>	90	24 SHEN	12 BELL	$\Upsilon(2S) \rightarrow \gamma\psi X$
$^{24}$ SHEN 12 reports $< 3.1 \times 10^{-5}$ from a measurement of $[\Gamma(\chi_{b0}(1P) \rightarrow \psi(2S)\psi(2S))/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P))]$ assuming $B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P)) = (3.8 \pm 0.4) \times 10^{-2}$ .				

$\Gamma(J/\psi(1S)\text{anything})/\Gamma_{\text{total}}$   $\Gamma_{20}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;2.3 <math>\times 10^{-3}</math></b>	90	JIA	17A BELL	$e^+e^- \rightarrow \text{hadrons}$

**$\chi_{b0}(1P)$  CROSS-PARTICLE BRANCHING RATIOS**

$\Gamma(\chi_{b0}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P))/\Gamma_{\text{total}}$   
 $\Gamma_1/\Gamma \times \Gamma_{52}^{\Upsilon(2S)}/\Gamma \Upsilon(2S)$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;1.7 <math>\times 10^{-3}</math></b>	90	25 LEES	11J BABR	$\Upsilon(2S) \rightarrow X\gamma$
$^{25}$ LEES 11J quotes a central value of $\Gamma(\chi_{b0}(1P) \rightarrow \gamma \Upsilon(1S))/\Gamma_{\text{total}} \times \Gamma(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P))/\Gamma_{\text{total}} = (8.3 \pm 5.6^{+3.7}_{-2.6}) \times 10^{-4}$ and derives a 90% CL upper limit of $\Gamma(\gamma \Upsilon(1S))/\Gamma_{\text{total}} < 4.6\%$ using $B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P)) = (3.8 \pm 0.4)\%$ .				

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

VALUE (units $10^{-5}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>1.67 <math>\pm</math> 0.28 OUR AVERAGE</b>				
2.9 $^{+1.7}_{-1.4}$ $^{+0.1}_{-0.8}$		26 LEES	14M BABR	$\Upsilon(2S) \rightarrow \gamma\gamma\mu^+\mu^-$
1.63 $\pm$ 0.24 $\pm$ 0.15	87	KORNICER	11 CLEO	$e^+e^- \rightarrow \gamma\gamma\ell^+\ell^-$
$^{26}$ From a sample of $\Upsilon(2S) \rightarrow \gamma\gamma\mu^+\mu^-$ with one converted photon.				

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

VALUE (%)	DOCUMENT ID	TECN	COMMENT
<b>3.28 <math>\pm</math> 0.37</b>	27 LEES	14M BABR	$\Upsilon(2S) \rightarrow \gamma\gamma\mu^+\mu^-$
$^{27}$ From a sample of $\Upsilon(2S) \rightarrow \gamma\gamma\mu^+\mu^-$ without converted photons.			

## $\chi_{b0}(1P)$ REFERENCES

JIA	17A	PR D96 112002	S. Jia <i>et al.</i>	(BELLE Collab.)
LEES	14M	PR D90 112010	J.P. Lees <i>et al.</i>	(BABAR Collab.)
SHEN	12	PR D85 071102	C.P. Shen <i>et al.</i>	(BELLE Collab.)
KORNICER	11	PR D83 054003	M. Kornicer <i>et al.</i>	(CLEO 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.)
EDWARDS	99	PR D59 032003	K.W. Edwards <i>et al.</i>	(CLEO Collab.)
WALK	86	PR D34 2611	W.S. Walk <i>et al.</i>	(Crystal Ball Collab.)
ALBRECHT	85E	PL 160B 331	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
NERNST	85	PRL 54 2195	R. Nernst <i>et al.</i>	(Crystal Ball Collab.)
HAAS	84	PRL 52 799	J. Haas <i>et al.</i>	(CLEO Collab.)
KLOPFEN...	83	PRL 51 160	C. Klopfenstein <i>et al.</i>	(CUSB Collab.)
PAUSS	83	PL 130B 439	F. Pauss <i>et al.</i>	(MPIM, COLU, CORN, LSU+)

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