

# $\eta_b(1S)$

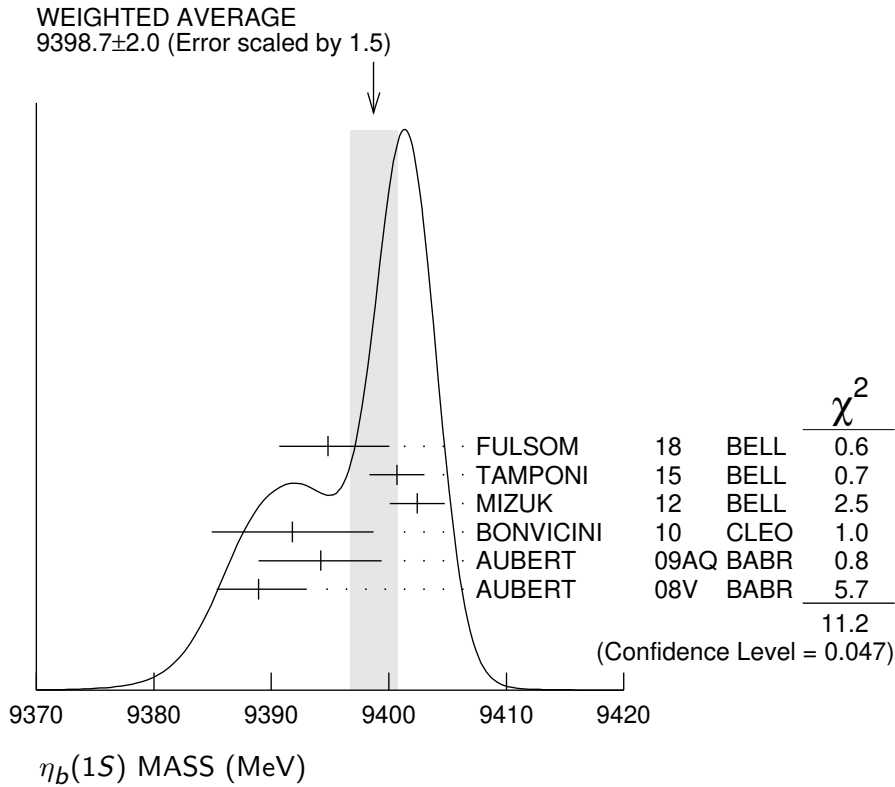
$$I^G(J^{PC}) = 0^+(0^{-+})$$

Quantum numbers shown are quark-model predictions. Observed in radiative decay of the  $\Upsilon(3S)$ , therefore  $C = +$ .

## $\eta_b(1S)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>9398.7 ± 2.0 OUR AVERAGE</b>		Error includes scale factor of 1.5. See the ideogram below.		
9394.8 <sup>+2.7</sup> <sub>-3.1</sub>	4.5 2.7	29k	FULSOM 18 BELL	$\Upsilon(2S) \rightarrow \gamma X$
9400.7 ± 1.7	± 1.6	33.1k	TAMPONI 15 BELL	$e^+ e^- \rightarrow \gamma \eta + \text{hadrons}$
9402.4 ± 1.5	± 1.8	34k	<sup>1</sup> MIZUK 12 BELL	$e^+ e^- \rightarrow \gamma \pi^+ \pi^- + \text{hadrons}$
9391.8 ± 6.6	± 2.0	2.3k	<sup>2</sup> BONVICINI 10 CLEO	$\Upsilon(3S) \rightarrow \gamma X$
9394.2 <sup>+4.8</sup> <sub>-4.9</sub>	± 2.0	13k	<sup>2</sup> AUBERT 09AQ BABR	$\Upsilon(2S) \rightarrow \gamma X$
9388.9 <sup>+3.1</sup> <sub>-2.3</sub>	± 2.7	19k	<sup>2</sup> AUBERT 08V BABR	$\Upsilon(3S) \rightarrow \gamma X$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
9393.2 ± 3.4	± 2.3	10	<sup>2,3</sup> DOBBS 12	$\Upsilon(2S) \rightarrow \gamma \text{hadrons}$
9300 ± 20	± 20		HEISTER 02D ALEP	181–209 $e^+ e^-$

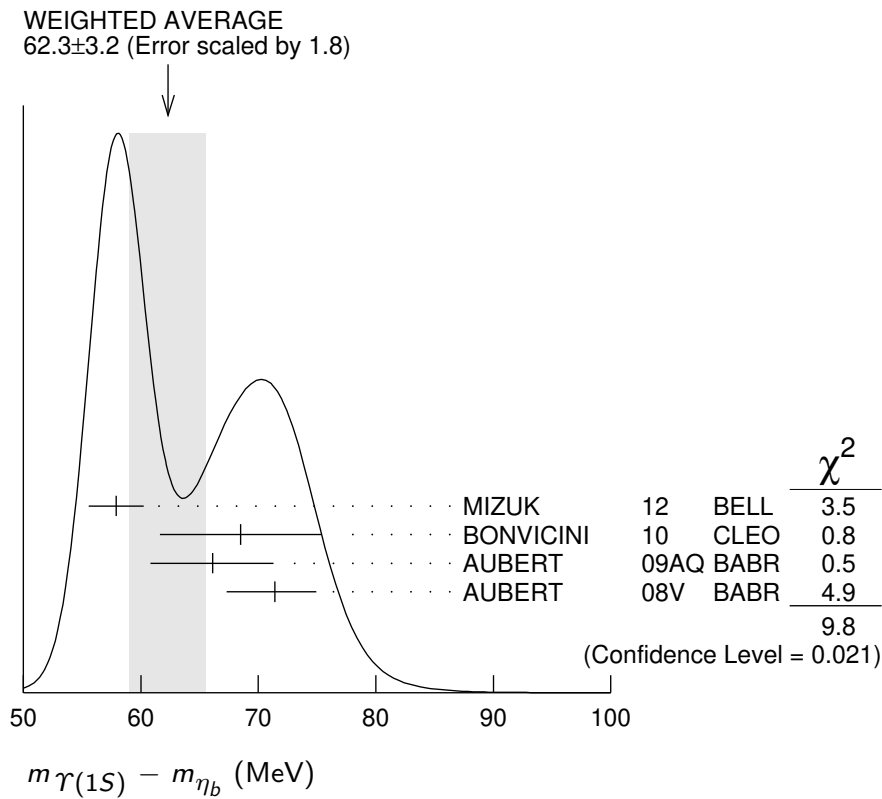
<sup>1</sup> With floating width. Not independent of the corresponding mass difference measurement.  
<sup>2</sup> Assuming  $\Gamma_{\eta_b(1S)} = 10$  MeV. Not independent of the corresponding  $\gamma$  energy or mass difference measurements.  
<sup>3</sup> Obtained by analyzing CLEO III data but not authored by the CLEO Collaboration.



### $m_{\Upsilon(1S)} - m_{\eta_b}$

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>62.3 \pm 3.2</math> OUR AVERAGE</b>	Error includes scale factor of 1.8. See the ideogram below.			
$57.9 \pm 1.5 \pm 1.8$	34k	<sup>1</sup> MIZUK	12 BELL	$e^+e^- \rightarrow \gamma\pi^+\pi^- + \text{hadrons}$
$68.5 \pm 6.6 \pm 2.0$	$2.3 \pm 0.5k$	<sup>2</sup> BONVICINI	10 CLEO	$\Upsilon(3S) \rightarrow \gamma X$
$66.1^{+4.8}_{-4.9} \pm 2.0$	$13 \pm 5k$	<sup>2</sup> AUBERT	09AQ BABR	$\Upsilon(2S) \rightarrow \gamma X$
$71.4^{+2.3}_{-3.1} \pm 2.7$	$19 \pm 3k$	<sup>2</sup> AUBERT	08V BABR	$\Upsilon(3S) \rightarrow \gamma X$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$67.1 \pm 3.4 \pm 2.3$	$10^{+5}_{-4}$	<sup>2,3</sup> DOBBS	12	$\Upsilon(2S) \rightarrow \gamma \text{hadrons}$

- <sup>1</sup> With floating width. Not independent of the corresponding mass measurement.  
<sup>2</sup> Assuming  $\Gamma_{\eta_b(1S)} = 10$  MeV. Not independent of the corresponding  $\gamma$  energy or mass measurements.  
<sup>3</sup> Obtained by analyzing CLEO III data but not authored by the CLEO Collaboration.



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

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>920.6^{+2.8}_{-3.2}</math> OUR AVERAGE</b>				
$918.6 \pm 6.0 \pm 1.9$	$2.3 \pm 0.5k$	<sup>1</sup> BONVICINI	10 CLEO	$\Upsilon(3S) \rightarrow \gamma X$
$921.2^{+2.1}_{-2.8} \pm 2.4$	$19 \pm 3k$	<sup>1</sup> AUBERT	08V BABR	$\Upsilon(3S) \rightarrow \gamma X$

<sup>1</sup> Assuming  $\Gamma_{\eta_b(1S)} = 10$  MeV. Not independent of the corresponding mass or mass difference measurements.

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

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>609.3<sup>+4.6</sup><sub>-4.5</sub> ± 1.9</b>	13 ± 5k	<sup>1</sup> AUBERT	09AQ BABR	$\Upsilon(2S) \rightarrow \gamma X$

<sup>1</sup> Assuming  $\Gamma_{\eta_b(1S)} = 10$  MeV. Not independent of the corresponding mass or mass difference measurements.

### $\eta_b(1S)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>10 <sup>+5</sup><sub>-4</sub> OUR AVERAGE</b>				
8 <sup>+6</sup> <sub>-5</sub> ± 5	33.1k	<sup>1</sup> TAMPONI	15 BELL	$e^+ e^- \rightarrow \gamma \eta + \text{hadrons}$
10.8 <sup>+4.0+4.5</sup> <sub>-3.7-2.0</sub>	34k	<sup>1</sup> MIZUK	12 BELL	$e^+ e^- \rightarrow \gamma \pi^+ \pi^- + \text{hadrons}$

<sup>1</sup> With floating mass.

### $\eta_b(1S)$ DECAY MODES

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level
$\Gamma_1$ hadrons	seen	
$\Gamma_2$ $3h^+ 3h^-$	not seen	
$\Gamma_3$ $2h^+ 2h^-$	not seen	
$\Gamma_4$ $4h^+ 4h^-$	not seen	
$\Gamma_5$ $\gamma\gamma$	not seen	
$\Gamma_6$ $\mu^+ \mu^-$	$< 9 \times 10^{-3}$	90%
$\Gamma_7$ $\tau^+ \tau^-$	$< 8 \%$	90%

### $\eta_b(1S)$ $\Gamma(i)\Gamma(\gamma\gamma)/\Gamma(\text{total})$

**$\Gamma(3h^+ 3h^-) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_2 \Gamma_5/\Gamma$**

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
<470	95	ABDALLAH	06 DLPH	161–209 $e^+ e^-$
<132	95	HEISTER	02D ALEP	181–209 $e^+ e^-$

**$\Gamma(2h^+ 2h^-) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_3 \Gamma_5/\Gamma$**

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
<190	95	ABDALLAH	06 DLPH	161–209 $e^+ e^-$
< 48	95	HEISTER	02D ALEP	181–209 $e^+ e^-$

$\Gamma(4h^+4h^-) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_4\Gamma_5/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$<660$	95	ABDALLAH	06	DLPH	161–209 $e^+e^-$
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**$\eta_b(1S)$  BRANCHING RATIOS**

$\Gamma(\text{hadrons})/\Gamma_{\text{total}}$   $\Gamma_1/\Gamma$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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<b>seen</b>	34k	MIZUK	12	BELL	$e^+e^- \rightarrow \gamma\pi^+\pi^- + \text{hadrons}$
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$\Gamma(\mu^+\mu^-)/\Gamma_{\text{total}}$   $\Gamma_6/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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$<9 \times 10^{-3}$	90	<sup>1</sup> AUBERT	09Z	BABR	$e^+e^- \rightarrow \Upsilon(2S,3S) \rightarrow \gamma\eta_b$
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<sup>1</sup>Obtained using  $B(\Upsilon(2S) \rightarrow \gamma\eta_b) = (4.2^{+1.1}_{-1.0} \pm 0.9) \times 10^{-4}$  and  $B(\Upsilon(3S) \rightarrow \gamma\eta_b) = (4.8 \pm 0.5 \pm 0.6) \times 10^{-4}$ . This limit is equivalent to  $B(\eta_b \rightarrow \mu^+\mu^-) = (-0.25 \pm 0.51 \pm 0.33)\%$  measurement.

$\Gamma(\tau^+\tau^-)/\Gamma_{\text{total}}$   $\Gamma_7/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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$<8 \times 10^{-2}$	90	AUBERT	09P	BABR	$e^+e^- \rightarrow \gamma\tau^+\tau^-$
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**$\eta_b(1S)$  REFERENCES**

FULSOM	18	PRL 121 232001	B.G. Fulsom <i>et al.</i>	(BELLE Collab.)
TAMPONI	15	PRL 115 142001	U. Tamponi <i>et al.</i>	(BELLE Collab.)
DOBBS	12	PRL 109 082001	S. Dobbs <i>et al.</i>	
MIZUK	12	PRL 109 232002	R. Mizuk <i>et al.</i>	(BELLE Collab.)
BONVICINI	10	PR D81 031104	G. Bonvicini <i>et al.</i>	(CLEO Collab.)
AUBERT	09AQ	PRL 103 161801	B. Aubert <i>et al.</i>	(BABAR Collab.)
AUBERT	09P	PRL 103 181801	B. Aubert <i>et al.</i>	(BABAR Collab.)
AUBERT	09Z	PRL 103 081803	B. Aubert <i>et al.</i>	(BABAR Collab.)
AUBERT	08V	PRL 101 071801	B. Aubert <i>et al.</i>	(BABAR Collab.)
ABDALLAH	06	PL B634 340	J.M. Abdallah <i>et al.</i>	(DELPHI Collab.)
HEISTER	02D	PL B530 56	A. Heister <i>et al.</i>	(ALEPH Collab.)