

# $\eta_b(1S)$

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

OMITTED FROM SUMMARY TABLE

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

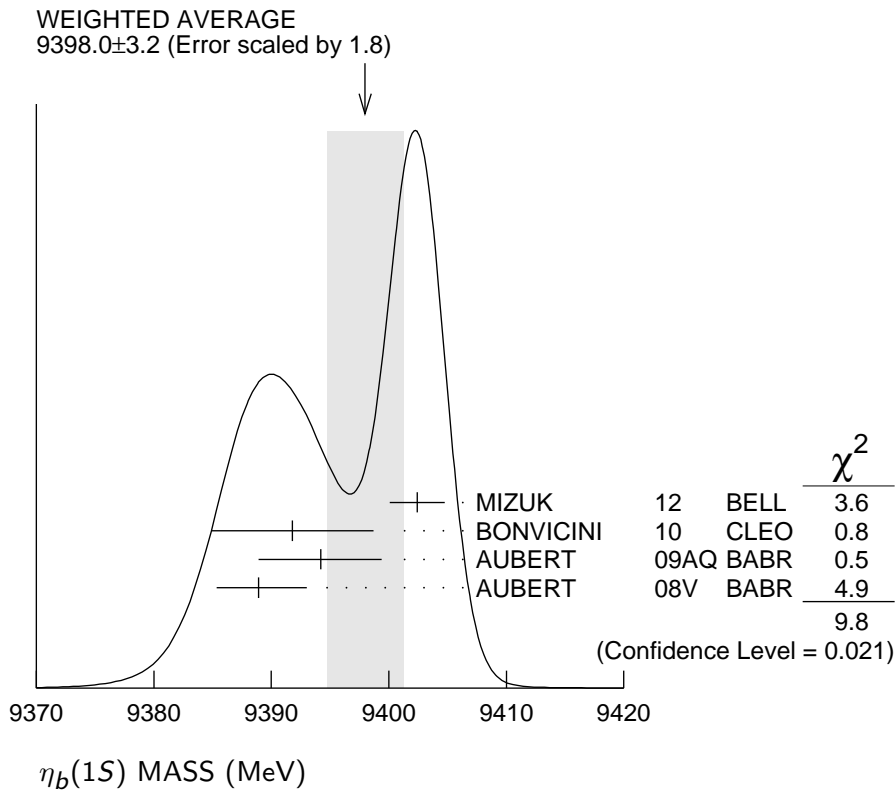
## $\eta_b(1S)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>9398.0 ± 3.2 OUR AVERAGE</b>		Error includes scale factor of 1.8. See the ideogram below.		
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	2.3 ± 0.5k	<sup>2</sup> BONVICINI	10 CLEO	$\Upsilon(3S) \rightarrow \gamma X$
9394.2 <sup>+</sup> <sub>-</sub> 4.8 <sup>+</sup> <sub>-</sub> 4.9 ± 2.0	13 ± 5k	<sup>2</sup> AUBERT	09AQ BABR	$\Upsilon(2S) \rightarrow \gamma X$
9388.9 <sup>+</sup> <sub>-</sub> 3.1 <sup>+</sup> <sub>-</sub> 2.3 ± 2.7	19 ± 3k	<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>+</sup> <sub>-4</sub>	<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.



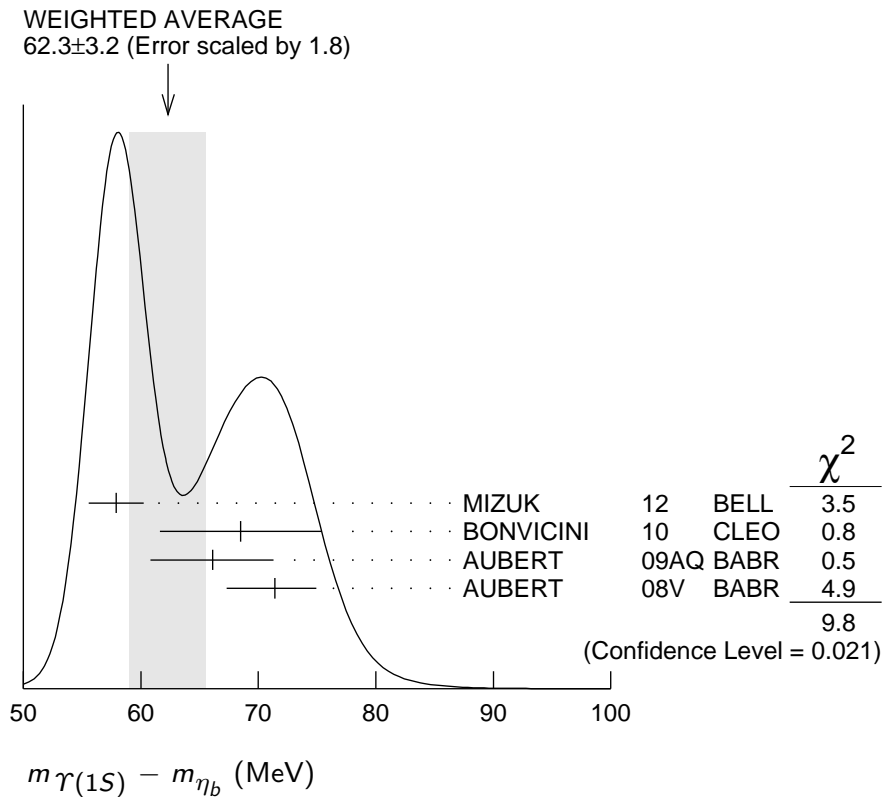
### $m_{\Upsilon(1S)} - m_{\eta_b}$

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>62.3±3.2 OUR AVERAGE</b>	Error includes scale factor of 1.8. See the ideogram below.			
57.9±1.5±1.8	34k	<sup>4</sup> MIZUK	12 BELL	$e^+e^- \rightarrow \gamma\pi^+\pi^- + \text{hadrons}$
68.5±6.6±2.0	2.3±0.5k	<sup>5</sup> BONVICINI	10 CLEO	$\Upsilon(3S) \rightarrow \gamma X$
66.1 <sup>+4.8</sup> <sub>-4.9</sub> ±2.0	13±5k	<sup>5</sup> AUBERT	09AQ BABR	$\Upsilon(2S) \rightarrow \gamma X$
71.4 <sup>+2.3</sup> <sub>-3.1</sub> ±2.7	19±3k	<sup>5</sup> AUBERT	08V BABR	$\Upsilon(3S) \rightarrow \gamma X$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
67.1±3.4±2.3	10 <sup>+5</sup> <sub>-4</sub>	<sup>5,6</sup> DOBBS	12	$\Upsilon(2S) \rightarrow \gamma \text{hadrons}$

<sup>4</sup> With floating width. Not independent of the corresponding mass measurement.

<sup>5</sup> Assuming  $\Gamma_{\eta_b(1S)} = 10$  MeV. Not independent of the corresponding  $\gamma$  energy or mass measurements.

<sup>6</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>920.6<sup>+2.8</sup><sub>-3.2</sub> OUR AVERAGE</b>				
918.6±6.0±1.9	2.3±0.5k	<sup>7</sup> BONVICINI	10 CLEO	$\Upsilon(3S) \rightarrow \gamma X$
921.2 <sup>+2.1</sup> <sub>-2.8</sub> ±2.4	19±3k	<sup>7</sup> AUBERT	08V BABR	$\Upsilon(3S) \rightarrow \gamma X$

<sup>7</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
$609.3^{+4.6}_{-4.5} \pm 1.9$	$13 \pm 5k$	<sup>8</sup> AUBERT	09AQ BABR	$\Upsilon(2S) \rightarrow \gamma X$

<sup>8</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
$10.8^{+4.0+4.5}_{-3.7-2.0}$	34k	<sup>9</sup> MIZUK	12 BELL	$e^+e^- \rightarrow \gamma\pi^+\pi^- +$ hadrons

<sup>9</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	
$\Gamma_4$ $4h^+4h^-$		
$\Gamma_5$ $\gamma\gamma$	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
------------	-----	-------------	------	---------

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

<660	95	ABDALLAH 06	DLPH	161–209 $e^+e^-$
------	----	-------------	------	------------------

$\eta_b(1S)$  BRANCHING RATIOS

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

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
-------	------	-------------	------	---------

seen	34k	MIZUK 12	BELL	$e^+e^- \rightarrow \gamma\pi^+\pi^- + \text{hadrons}$
------	-----	----------	------	--

$\Gamma(\mu^+\mu^-)/\Gamma_{\text{total}}$   $\Gamma_6/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
-------	-----	-------------	------	---------

$<9 \times 10^{-3}$	90	<sup>10</sup> AUBERT 09Z	BABR	$e^+e^- \rightarrow \Upsilon(2S,3S) \rightarrow \gamma\eta_b$
---------------------	----	--------------------------	------	---

<sup>10</sup> Obtained using  $B(\Upsilon(2S) \rightarrow \gamma\eta_b) = (4.2_{-1.0}^{+1.1} \pm 0.9) \times 10^{-4}$  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
-------	-----	-------------	------	---------

$<8 \times 10^{-2}$	90	AUBERT 09P	BABR	$e^+e^- \rightarrow \gamma\tau^+\tau^-$
---------------------	----	------------	------	---

$\eta_b(1S)$  REFERENCES

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.)