

$\Upsilon(11020)$

$$J^{PC} = 0^{-}(1^{- -})$$

 $\Upsilon(11020)$ MASS

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
11000 ± 4 OUR AVERAGE			
11000.0 ^{+4.0} _{-4.5} ± 1.0 ^{+1.0} _{-1.3}	¹ MIZUK	19	BELL $e^+e^- \rightarrow \Upsilon(1S, 2S, 3S)\pi^+\pi^-$
10999.0 ^{+7.3} _{-7.8} ± 16.9 ^{+16.9} _{-1.0}	² MIZUK	16	BELL $e^+e^- \rightarrow h_b(1P, 2P)\pi^+\pi^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
11001 ± 1	³ DONG	20A	$e^+e^- \rightarrow b\bar{b}$
11003.0 ± 1.1 ^{+0.9} _{-1.0}	^{4,5} SANTEL	16	BELL $e^+e^- \rightarrow$ hadrons
10987.5 ^{+6.4} _{-2.5} ± 9.1 ^{+9.1} _{-2.3}	^{6,7} SANTEL	16	BELL $e^+e^- \rightarrow \Upsilon(1S, 2S, 3S)\pi^+\pi^-$
10996 ± 2	⁸ AUBERT	09E	BABR $e^+e^- \rightarrow$ hadrons
11019 ± 5 ± 7	BESSION	85	CLEO $e^+e^- \rightarrow$ hadrons
11020 ± 30	LOVELOCK	85	CUSB $e^+e^- \rightarrow$ hadrons

¹ From a simultaneous fit to the $\Upsilon(nS)\pi^+\pi^-$, $n = 1, 2, 3$, cross sections at 28 energy points within $\sqrt{s} = 10.6\text{--}11.05$ GeV, including the initial-state radiation at $\Upsilon(10860)$.

² From a simultaneous fit to the $h_b(nP)\pi^+\pi^-$, $n = 1, 2$ cross sections at 22 energy points within $\sqrt{s} = 10.77\text{--}11.02$ GeV to a pair of interfering Breit-Wigner amplitudes modified by phase space factors, with eight resonance parameters (a mass and width for each of $\Upsilon(10860)$ and $\Upsilon(11020)$, a single relative phase, a single relative amplitude, and two overall normalization factors, one for each n). The systematic error estimate is dominated by possible interference with a small nonresonant continuum amplitude.

³ From a fit to the dressed cross sections of AUBERT 09E by BaBar and SANTEL 16 by Belle above 10.68 GeV with a coherent sum of a continuum amplitude and three Breit-Wigner functions with constant widths.

⁴ From a fit to the total hadronic cross sections measured at 60 energy points within $\sqrt{s} = 10.82\text{--}11.05$ GeV to a pair of interfering Breit-Wigner amplitudes and two floating continuum amplitudes with $1/\sqrt{s}$ dependence, one coherent with the resonances and one incoherent, with six resonance parameters (a mass, width, and an amplitude for each of $\Upsilon(10860)$ and $\Upsilon(11020)$, one relative phase, and one decoherence coefficient).

⁵ Not including uncertain and potentially large systematic errors due to assumed continuum amplitude $1/\sqrt{s}$ dependence and related interference contributions.

⁶ From a simultaneous fit to the $\Upsilon(nS)\pi^+\pi^-$, $n = 1, 2, 3$, cross sections at 25 energy points within $\sqrt{s} = 10.6\text{--}11.05$ GeV to a pair of interfering Breit-Wigner amplitudes modified by phase space factors, with fourteen resonance parameters (a mass, width, and three amplitudes for each of $\Upsilon(10860)$ and $\Upsilon(11020)$, a single universal relative phase, and three decoherence coefficients, one for each n). Continuum contributions were measured (and therefore fixed) to be zero.

⁷ Superseded by MIZUK 19.

⁸ In a model where a flat non-resonant $b\bar{b}$ -continuum is incoherently added to a second flat component interfering with two Breit-Wigner resonances. Systematic uncertainties not estimated.

$\Upsilon(11020)$ WIDTH

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
24 $\pm \frac{8}{6}$ OUR AVERAGE			
23.8 $^{+8.0+0.7}_{-6.8-1.8}$	¹ MIZUK	19 BELL	$e^+e^- \rightarrow \Upsilon(nS)\pi^+\pi^-$
27 $^{+27+5}_{-11-12}$	² MIZUK	16 BELL	$e^+e^- \rightarrow h_b(1P, 2P)\pi^+\pi^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
35.1 ± 1.2	³ DONG	20A	$e^+e^- \rightarrow b\bar{b}$
39.3 $^{+1.7+1.3}_{-1.6-2.4}$	^{4,5} SANTEL	16 BELL	$e^+e^- \rightarrow \text{hadrons}$
61 $^{+9+2}_{-19-20}$	^{6,7} SANTEL	16 BELL	$e^+e^- \rightarrow \Upsilon(1S, 2S, 3S)\pi^+\pi^-$
37 ± 3	⁸ AUBERT	09E BABR	$e^+e^- \rightarrow \text{hadrons}$
61 $\pm 13 \pm 22$	BESSION	85 CLEO	$e^+e^- \rightarrow \text{hadrons}$
90 ± 20	LOVELOCK	85 CUSB	$e^+e^- \rightarrow \text{hadrons}$

¹ From a simultaneous fit to the $\Upsilon(nS)\pi^+\pi^-$, $n = 1, 2, 3$, cross sections at 28 energy points within $\sqrt{s} = 10.6\text{--}11.05$ GeV, including the initial-state radiation at $\Upsilon(10860)$.

² From a simultaneous fit to the $h_b(nP)\pi^+\pi^-$, $n = 1, 2$ cross sections at 22 energy points within $\sqrt{s} = 10.77\text{--}11.02$ GeV to a pair of interfering Breit-Wigner amplitudes modified by phase space factors, with eight resonance parameters (a mass and width for each of $\Upsilon(10860)$ and $\Upsilon(11020)$, a single relative phase, a single relative amplitude, and two overall normalization factors, one for each n). The systematic error estimate is dominated by possible interference with a small nonresonant continuum amplitude.

³ From a fit to the dressed cross sections of AUBERT 09E by BaBar and SANTEL 16 by Belle above 10.68 GeV with a coherent sum of a continuum amplitude and three Breit-Wigner functions with constant widths.

⁴ From a fit to the total hadronic cross sections measured at 60 energy points within $\sqrt{s} = 10.82\text{--}11.05$ GeV to a pair of interfering Breit-Wigner amplitudes and two floating continuum amplitudes with $1/\sqrt{s}$ dependence, one coherent with the resonances and one incoherent, with six resonance parameters (a mass, width, and an amplitude for each of $\Upsilon(10860)$ and $\Upsilon(11020)$, one relative phase, and one decoherence coefficient).

⁵ Not including uncertain and potentially large systematic errors due to assumed continuum amplitude $1/\sqrt{s}$ dependence and related interference contributions.

⁶ From a simultaneous fit to the $\Upsilon(nS)\pi^+\pi^-$, $n=1, 2, 3$, cross sections at 25 energy points within $\sqrt{s} = 10.6\text{--}11.05$ GeV to a pair of interfering Breit-Wigner amplitudes modified by phase space factors, with fourteen resonance parameters (a mass, width, and three amplitudes for each of $\Upsilon(10860)$ and $\Upsilon(11020)$, a single universal relative phase, and three decoherence coefficients, one for each n). Continuum contributions were measured (and therefore fixed) to be zero.

⁷ Superseded by MIZUK 19.

⁸ In a model where a flat non-resonant $b\bar{b}$ -continuum is incoherently added to a second flat component interfering with two Breit-Wigner resonances. Systematic uncertainties not estimated.

$\Upsilon(11020)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)
Γ_1 $e^+ e^-$	$(5.4^{+1.9}_{-2.1}) \times 10^{-6}$
Γ_2 $\Upsilon(1S)\pi^+\pi^-$	
Γ_3 $\Upsilon(2S)\pi^+\pi^-$	
Γ_4 $\Upsilon(3S)\pi^+\pi^-$	
Γ_5 $\chi_{bJ}(1P)\pi^+\pi^-\pi^0$	$(9^{+9}_{-8}) \times 10^{-3}$
Γ_6 $\chi_{b1}(1P)\pi^+\pi^-\pi^0$	seen
Γ_7 $\chi_{b2}(1P)\pi^+\pi^-\pi^0$	seen

$\Upsilon(11020)$ PARTIAL WIDTHS

$\Gamma(e^+e^-)$					Γ_1
<u>VALUE (keV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
0.130±0.030 OUR AVERAGE					
0.095±0.03 ±0.035	BESSION	85	CLEO	$e^+e^- \rightarrow$ hadrons	
0.156±0.040	LOVELOCK	85	CUSB	$e^+e^- \rightarrow$ hadrons	

$\Gamma(e^+e^-) \times \Gamma(\Upsilon(1S)\pi^+\pi^-)/\Gamma_{\text{total}}$					$\Gamma_1\Gamma_2/\Gamma$
<u>VALUE (eV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
0.46±0.08	^{1,2} MIZUK	19	BELL	$e^+e^- \rightarrow \Upsilon(nS)\pi^+\pi^-$	
¹ From a simultaneous fit to the $\Upsilon(nS)\pi^+\pi^-$, $n = 1, 2, 3$, cross sections at 28 energy points within $\sqrt{s} = 10.6\text{--}11.05$ GeV, including the initial-state radiation at $\Upsilon(10860)$.					
² Reported as the range 0.38–0.54 eV obtained from multiple solutions of an amplitude fit within a model composed as a sum of Breit-Wigner functions.					

$\Gamma(e^+e^-) \times \Gamma(\Upsilon(2S)\pi^+\pi^-)/\Gamma_{\text{total}}$					$\Gamma_1\Gamma_3/\Gamma$
<u>VALUE (eV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
0.65±0.52	^{1,2} MIZUK	19	BELL	$e^+e^- \rightarrow \Upsilon(nS)\pi^+\pi^-$	
¹ From a simultaneous fit to the $\Upsilon(nS)\pi^+\pi^-$, $n = 1, 2, 3$, cross sections at 28 energy points within $\sqrt{s} = 10.6\text{--}11.05$ GeV, including the initial-state radiation at $\Upsilon(10860)$.					
² Reported as the range 0.13–1.16 eV obtained from multiple solutions of an amplitude fit within a model composed as a sum of Breit-Wigner functions.					

$\Gamma(e^+e^-) \times \Gamma(\Upsilon(3S)\pi^+\pi^-)/\Gamma_{\text{total}}$					$\Gamma_1\Gamma_4/\Gamma$
<u>VALUE (eV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
0.33±0.16	^{1,2} MIZUK	19	BELL	$e^+e^- \rightarrow \Upsilon(nS)\pi^+\pi^-$	
¹ From a simultaneous fit to the $\Upsilon(nS)\pi^+\pi^-$, $n = 1, 2, 3$, cross sections at 28 energy points within $\sqrt{s} = 10.6\text{--}11.05$ GeV, including the initial-state radiation at $\Upsilon(10860)$.					
² Reported as the range 0.17–0.49 eV obtained from multiple solutions of an amplitude fit within a model composed as a sum of Breit-Wigner functions.					

$\Gamma(\chi_{bJ}(1P)\pi^+\pi^-\pi^0)/\Gamma_{\text{total}}$				Γ_5/Γ
<u>VALUE (units 10^{-3})</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
$8.7 \pm 4.3^{+7.6}_{-6.6}$	YIN	18	BELL	$e^+e^- \rightarrow \text{hadrons}$
$\Gamma(\chi_{b1}(1P)\pi^+\pi^-\pi^0)/\Gamma_{\text{total}}$				Γ_6/Γ
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
seen	YIN	18	BELL	$e^+e^- \rightarrow \text{hadrons}$
$\Gamma(\chi_{b2}(1P)\pi^+\pi^-\pi^0)/\Gamma_{\text{total}}$				Γ_7/Γ
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
seen	YIN	18	BELL	$e^+e^- \rightarrow \text{hadrons}$
$\Gamma(\chi_{b2}(1P)\pi^+\pi^-\pi^0)/\Gamma(\chi_{b1}(1P)\pi^+\pi^-\pi^0)$				Γ_7/Γ_6
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
0.4 ± 0.2	YIN	18	BELL	$e^+e^- \rightarrow \text{hadrons}$

$\Upsilon(11020)$ REFERENCES

DONG	20A	CP C44 083001	X.-K. Dong <i>et al.</i>	
MIZUK	19	JHEP 1910 220	R. Mizuk <i>et al.</i>	(BELLE Collab.)
YIN	18	PR D98 091102	J.H. Yin <i>et al.</i>	(BELLE Collab.)
MIZUK	16	PRL 117 142001	R. Mizuk <i>et al.</i>	(BELLE Collab.)
SANTEL	16	PR D93 011101	D. Santel <i>et al.</i>	(BELLE Collab.)
AUBERT	09E	PRL 102 012001	B. Aubert <i>et al.</i>	(BABAR Collab.)
BESSION	85	PRL 54 381	D. Besson <i>et al.</i>	(CLEO Collab.)
LOVELOCK	85	PRL 54 377	D.M.J. Lovelock <i>et al.</i>	(CUSB Collab.)