$\Upsilon(11020)$

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

$\Upsilon(11020)$ MASS

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

[1] From a simultaneous fit to the $\Upsilon(nS)\pi^+\pi^-$, $n = 1$, 2, 3, cross sections at 28 energy points within $\sqrt{s} = 10.6$–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 $\sqrt{s} = 10.77$–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 $\sqrt{s}$ = 10.82–11.05 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 25energy points within $\sqrt{s} = 10.6$–11.05 GeV to a pair of interfering Breit-Wigner amplitudesmodified by phase space factors, with fourteen resonance parameters (a mass, width, and threeamplitudes for each of $\Upsilon(10860)$ and $\Upsilon(11020)$, a single universal relativephase, and three decoherence coefficients, one for each n). Continuum contributions weremeasured (and therefore fixed) to be zero.

[7] Superseded by MIZUK 19.

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

$\Upsilon(11020)$ WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
$24\ ^{+\ 8}_{-\ 6}$ OUR AVERAGE				
$23.8^{+\ 8.0}_{-\ 6.8}{}^{+\ 0.7}_{-\ 1.8}$	[1] MIZUK	19	BELL	$e^+e^- \to \Upsilon(\mathrm{nS})\pi^+\pi^-$
$27\ ^{+27}_{-11}\ ^{+\ 5}_{-12}$	[2] MIZUK	16	BELL	$e^+e^- \to h_b(\mathrm{1P,2P})\pi^+\pi^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$35.1\pm\ 1.2$	[3] DONG	20A		$e^+e^- \to b\overline{b}$
$39.3^{+\ 1.7}_{-\ 1.6}{}^{+\ 1.3}_{-\ 2.4}$	[4,5] SANTEL	16	BELL	$e^+e^- \to$ hadrons
$61\ ^{+\ 9}_{-19}\ ^{+\ 2}_{-20}$	[6,7] SANTEL	16	BELL	$e^+e^- \to \Upsilon(\mathrm{1S,2S,3S})\pi^+\pi^-$
$37\ \pm\ 3$	[8] AUBERT	09E	BABR	$e^+e^- \to$ hadrons
$61\ \pm13\ \pm22$	BESSON	85	CLEO	$e^+e^- \to$ hadrons
$90\ \pm20$	LOVELOCK	85	CUSB	$e^+e^- \to$ hadrons

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

[2] From a simultaneous fit to the $h_b(\mathrm{nP})\pi^+\pi^-$, n = 1, 2 cross sections at 22 energy points within $\sqrt{s}$ = 10.77–11.02 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 $\sqrt{s}$ = 10.82–11.05 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 $\Upsilon(\mathrm{nS})\pi^+\pi^-$, n=1, 2, 3, cross sections at 25energy points within $\sqrt{s}$ = 10.6–11.05 GeV to a pair of interfering Breit-Wigner amplitudesmodified by phase space factors, with fourteen resonance parameters (a mass, width, and threeamplitudes for each of $\Upsilon(10860)$ and $\Upsilon(11020)$, a single universal relativephase, and three decoherence coefficients, one for each n). Continuum contributions weremeasured (and therefore fixed) to be zero.

[7] Superseded by MIZUK 19.

[8] In a model where a flat non-resonant $b\overline{b}$-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	$\chi_{bJ}(1P)\pi^+\pi^-\pi^0$	$(9\ {}^{+9}_{-8}\ )\times10^{-3}$
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

VALUE (keV)	*DOCUMENT ID*		*TECN*	*COMMENT*
0.130±0.030 OUR AVERAGE				
0.095±0.03 ±0.035	BESSON	85	CLEO	$e^+e^-\to$ hadrons
0.156±0.040	LOVELOCK	85	CUSB	$e^+e^-\to$ hadrons

$\Gamma(e^+e^-)\times\Gamma(\Upsilon(1S)\pi^+\pi^-)/\Gamma_{\rm total}$ $\Gamma_1\Gamma_2/\Gamma$

VALUE (eV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.46±0.08	[1,2] MIZUK	19	BELL	$e^+e^-\to\ \Upsilon(\text{nS})\pi^+\pi^-$

[1] From a simultaneous fit to the $\Upsilon(\text{nS})\pi^+\pi^-$, $n=1$, 2, 3, cross sections at 28 energy points within $\sqrt{s}=10.6$–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.

$\Gamma(e^+e^-)\times\Gamma(\Upsilon(2S)\pi^+\pi^-)/\Gamma_{\rm total}$ $\Gamma_1\Gamma_3/\Gamma$

VALUE (eV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.65±0.52	[1,2] MIZUK	19	BELL	$e^+e^-\to\ \Upsilon(\text{nS})\pi^+\pi^-$

[1] From a simultaneous fit to the $\Upsilon(\text{nS})\pi^+\pi^-$, $n=1$, 2, 3, cross sections at 28 energy points within $\sqrt{s}=10.6$–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.

$\Gamma(e^+e^-)\times\Gamma(\Upsilon(3S)\pi^+\pi^-)/\Gamma_{\rm total}$ $\Gamma_1\Gamma_4/\Gamma$

VALUE (eV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.33±0.16	[1,2] MIZUK	19	BELL	$e^+e^-\to\ \Upsilon(\text{nS})\pi^+\pi^-$

[1] From a simultaneous fit to the $\Upsilon(\text{nS})\pi^+\pi^-$, $n=1$, 2, 3, cross sections at 28 energy points within $\sqrt{s}=10.6$–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.

$\Gamma(\chi_{bJ}(1P)\pi^+\pi^-\pi^0)/\Gamma_{\rm total}$ Γ_5/Γ

VALUE (units 10^{-3})	*DOCUMENT ID*		*TECN*	*COMMENT*
$\mathbf{8.7\pm4.3^{+7.6}_{-6.6}}$	YIN	18	BELL	$e^+e^-\to$ hadrons

$\Gamma(\chi_{b1}(1P)\pi^+\pi^-\pi^0)/\Gamma_{\rm total}$ Γ_6/Γ

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
seen	YIN	18	BELL	$e^+e^-\to$ hadrons

$\Gamma(\chi_{b2}(1P)\pi^+\pi^-\pi^0)/\Gamma_{\text{total}}$ Γ_7/Γ

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
seen	YIN	18	BELL	$e^+e^- \to$ hadrons

$\Gamma(\chi_{b2}(1P)\pi^+\pi^-\pi^0)/\Gamma(\chi_{b1}(1P)\pi^+\pi^-\pi^0)$ Γ_7/Γ_6

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.4±0.2	YIN	18	BELL	$e^+e^- \to$ hadrons

$\Upsilon(11020)$ REFERENCES

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