NODE=M207

$T_{b\bar{b}1}(10610)$

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

was $Z_b(10610)$, $X(10610)$

Properties incompatible with a $q\bar{q}$ structure (exotic state). See the review on non-$q\bar{q}$ states. NODE=M207

Observed by BONDAR 12 in $\Upsilon(5S)$ decays to $\Upsilon(\mathrm{nS})\pi^+\pi^-$ (n = 1, 2, 3) and $h_b(\mathrm{mP})\pi^+\pi^-$ (m = 1, 2). $J^P = 1^+$ is favored from angular analyses.

$T_{b\bar{b}1}(10610)^\pm$ MASS

NODE=M207M

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT	
10607.2±2.0	[1] BONDAR	12	BELL	$e^+e^- \to$ hadrons	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$10608.5 \pm 3.4^{+3.7}_{-1.4}$	[2] GARMASH	15	BELL	$e^+e^- \to \Upsilon(1S)\pi^+\pi^-$	
$10608.1 \pm 1.2^{+1.5}_{-0.2}$	[2] GARMASH	15	BELL	$e^+e^- \to \Upsilon(2S)\pi^+\pi^-$	OCCUR=2
$10607.4 \pm 1.5^{+0.8}_{-0.2}$	[2] GARMASH	15	BELL	$e^+e^- \to \Upsilon(3S)\pi^+\pi^-$	OCCUR=3
$10611 \pm 4 \pm 3$	[3] BONDAR	12	BELL	$e^+e^- \to \Upsilon(1S)\pi^+\pi^-$	OCCUR=2
$10609 \pm 2 \pm 3$	[3] BONDAR	12	BELL	$e^+e^- \to \Upsilon(2S)\pi^+\pi^-$	OCCUR=3
$10608 \pm 2 \pm 3$	[3] BONDAR	12	BELL	$e^+e^- \to \Upsilon(3S)\pi^+\pi^-$	OCCUR=4
$10605 \pm 2 {}^{+3}_{-1}$	[3] BONDAR	12	BELL	$e^+e^- \to h_b(1P)\pi^+\pi^-$	OCCUR=5
$10599 {}^{+6}_{-3} {}^{+5}_{-4}$	[3] BONDAR	12	BELL	$e^+e^- \to h_b(2P)\pi^+\pi^-$	OCCUR=6

[1] Average of the BONDAR 12 measurements in separate channels. NODE=M207M;LINKAGE=BO
[2] Correlated with the corresponding result from BONDAR 12. NODE=M207M;LINKAGE=A
[3] Superseded by the average measurement of BONDAR 12. NODE=M207M;LINKAGE=BN

$T_{b\bar{b}1}(10610)^0$ MASS

NODE=M207M0

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
10609±4±4	[1] KROKOVNY	13	BELL	$e^+e^- \to \Upsilon(2S)/\Upsilon(3S)\pi^0\pi^0$

NODE=M207M0

[1] From a simultaneous fit to the KROKOVNY 13 Dalitz analysis of $e^+e^- \to \Upsilon(2S)/\Upsilon(3S)\pi^0\pi^0$ decays with fixed width $\Gamma(T_{b\bar{b}1}(10610)^0) = 18.4$ MeV. NODE=M207M0;LINKAGE=A

$T_{b\bar{b}1}(10610)^\pm$ WIDTH

NODE=M207W

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT	
18.4± 2.4	[1] BONDAR	12	BELL	$e^+e^- \to$ hadrons	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$18.5 \pm 5.3^{+6.1}_{-2.3}$	[2] GARMASH	15	BELL	$e^+e^- \to \Upsilon(1S)\pi^+\pi^-$	
$20.8 \pm 2.5^{+0.3}_{-2.1}$	[2] GARMASH	15	BELL	$e^+e^- \to \Upsilon(2S)\pi^+\pi^-$	OCCUR=2
$18.7 \pm 3.4^{+2.5}_{-1.3}$	[2] GARMASH	15	BELL	$e^+e^- \to \Upsilon(3S)\pi^+\pi^-$	OCCUR=3
$22.3 \pm 7.7^{+3.0}_{-4.0}$	[3] BONDAR	12	BELL	$e^+e^- \to \Upsilon(1S)\pi^+\pi^-$	OCCUR=2
$24.2 \pm 3.1^{+2.0}_{-3.0}$	[3] BONDAR	12	BELL	$e^+e^- \to \Upsilon(2S)\pi^+\pi^-$	OCCUR=3
$17.6 \pm 3.0 \pm 3.0$	[3] BONDAR	12	BELL	$e^+e^- \to \Upsilon(3S)\pi^+\pi^-$	OCCUR=4
$11.4 {}^{+}_{-} {}^{4.5}_{3.9} {}^{+2.1}_{-1.2}$	[3] BONDAR	12	BELL	$e^+e^- \to h_b(1P)\pi^+\pi^-$	OCCUR=5
$13 {}^{+10}_{-8} {}^{+9}_{-7}$	[3] BONDAR	12	BELL	$e^+e^- \to h_b(2P)\pi^+\pi^-$	OCCUR=6

[1] Average of the BONDAR 12 measurements in separate channels. NODE=M207W;LINKAGE=BO
[2] Correlated with the corresponding result from BONDAR 12. NODE=M207W;LINKAGE=A
[3] Superseded by the average measurement of BONDAR 12. NODE=M207W;LINKAGE=BN

$T_{b\bar{b}1}(10610)$ DECAY MODES

NODE=M207215;NODE=M207

	Mode	Fraction (Γ_i/Γ)	
Γ_1	$\Upsilon(1S)\pi^+$	$(5.4^{+1.9}_{-1.5}) \times 10^{-3}$	DESIG=1
Γ_2	$\Upsilon(1S)\pi^0$	not seen	DESIG=9
Γ_3	$\Upsilon(2S)\pi^+$	$(3.6^{+1.1}_{-0.8})$ %	DESIG=2
Γ_4	$\Upsilon(2S)\pi^0$	seen	DESIG=10
Γ_5	$\Upsilon(3S)\pi^+$	$(2.1^{+0.8}_{-0.6})$ %	DESIG=3
Γ_6	$\Upsilon(3S)\pi^0$	seen	DESIG=11
Γ_7	$h_b(1P)\pi^+$	$(3.5^{+1.2}_{-0.9})$ %	DESIG=4
Γ_8	$h_b(2P)\pi^+$	$(4.7^{+1.7}_{-1.3})$ %	DESIG=5
Γ_9	$B^+\overline{B}^0$	not seen	DESIG=8
Γ_{10}	$B^+\overline{B}^{*0} + B^{*+}\overline{B}^0$	$(85.6^{+2.1}_{-2.9})$ %	DESIG=6

$T_{b\bar{b}1}(10610)$ BRANCHING RATIOS

NODE=M207225

$\Gamma(\Upsilon(1S)\pi^+)/\Gamma_{total}$ — Γ_1/Γ

NODE=M207R01
NODE=M207R01

VALUE (units 10^{-3})	DOCUMENT ID		TECN	COMMENT
$\mathbf{5.4^{+1.6}_{-1.3}{}^{+1.1}_{-0.8}}$	[1] GARMASH	16	BELL	$e^+e^- \to \pi^- B^+ \overline{B}^{*0}$, $\pi^- \overline{B}^0 B^{*+}$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
seen	GARMASH	15	BELL	$e^+e^- \to \Upsilon(1S)\pi^+\pi^-$
seen	BONDAR	12	BELL	$e^+e^- \to \Upsilon(1S)\pi^+\pi^-$

[1] Assuming the $T_{b\bar{b}1}(10610)$ decay width is saturated by the channels $\pi^+\Upsilon(1S,2S,3S)$, $\pi^+ h_b(1P,2P)$, and $B^+\overline{B}^{*0} + \overline{B}^0 B^{*+}$, and using the results from BONDAR 12 and MIZUK 16.

NODE=M207R01;LINKAGE=A

$\Gamma(\Upsilon(1S)\pi^0)/\Gamma_{total}$ — Γ_2/Γ

NODE=M207R09
NODE=M207R09

VALUE	DOCUMENT ID		TECN	COMMENT
not seen	KROKOVNY	13	BELL	$e^+e^- \to \Upsilon(1S)\pi^0\pi^0$

$\Gamma(\Upsilon(2S)\pi^+)/\Gamma_{total}$ — Γ_3/Γ

NODE=M207R02
NODE=M207R02

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
$\mathbf{3.62^{+0.76}_{-0.59}{}^{+0.79}_{-0.53}}$	[1] GARMASH	16	BELL	$e^+e^- \to \pi^- B^+ \overline{B}^{*0}$, $\pi^- \overline{B}^0 B^{*+}$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
seen	GARMASH	15	BELL	$e^+e^- \to \Upsilon(2S)\pi^+\pi^-$
seen	BONDAR	12	BELL	$e^+e^- \to \Upsilon(2S)\pi^+\pi^-$

[1] Assuming the $T_{b\bar{b}1}(10610)$ decay width is saturated by the channels $\pi^+\Upsilon(1S,2S,3S)$, $\pi^+ h_b(1P,2P)$, and $B^+\overline{B}^{*0} + \overline{B}^0 B^{*+}$, and using the results from BONDAR 12 and MIZUK 16.

NODE=M207R02;LINKAGE=A

$\Gamma(\Upsilon(2S)\pi^0)/\Gamma_{total}$ — Γ_4/Γ

NODE=M207R10
NODE=M207R10

VALUE	DOCUMENT ID		TECN	COMMENT
seen	[1] KROKOVNY	13	BELL	$e^+e^- \to \Upsilon(2S)\pi^0\pi^0$

[1] Combined significance in $e^+e^- \to \Upsilon(2S)/\Upsilon(3S)\pi^0\pi^0$, including systematics, of 6.5σ.

NODE=M207R10;LINKAGE=A

$\Gamma(\Upsilon(3S)\pi^+)/\Gamma_{total}$ — Γ_5/Γ

NODE=M207R03
NODE=M207R03

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
$\mathbf{2.15^{+0.55}_{-0.42}{}^{+0.60}_{-0.43}}$	[1] GARMASH	16	BELL	$e^+e^- \to \pi^- B^+ \overline{B}^{*0}$, $\pi^- \overline{B}^0 B^{*+}$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
seen	GARMASH	15	BELL	$e^+e^- \to \Upsilon(3S)\pi^+\pi^-$
seen	BONDAR	12	BELL	$e^+e^- \to \Upsilon(3S)\pi^+\pi^-$

[1] Assuming the $T_{b\bar{b}1}(10610)$ decay width is saturated by the channels $\pi^+\Upsilon(1S,2S,3S)$, $\pi^+ h_b(1P,2P)$, and $B^+\overline{B}^{*0} + \overline{B}^0 B^{*+}$, and using the results from BONDAR 12 and MIZUK 16.

NODE=M207R03;LINKAGE=A

$\Gamma(\Upsilon(3S)\pi^0)/\Gamma_{total}$ — Γ_6/Γ

NODE=M207R11
NODE=M207R11

VALUE	DOCUMENT ID		TECN	COMMENT
seen	[1] KROKOVNY	13	BELL	$e^+e^- \to \Upsilon(3S)\pi^0\pi^0$

[1] Combined significance in $e^+e^- \to \Upsilon(2S)/\Upsilon(3S)\pi^0\pi^0$, including systematics, of 6.5σ. NODE=M207R11;LINKAGE=A

$\Gamma(h_b(1P)\pi^+)/\Gamma_{total}$ — Γ_7/Γ

NODE=M207R04
NODE=M207R04

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
$\mathbf{3.45^{+0.87+0.86}_{-0.71-0.63}}$	[1] GARMASH	16	BELL	$e^+e^- \to \pi^- B^+ \overline{B}^{*0}$, $\pi^- \overline{B}^0 B^{*+}$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
possibly seen	[2] MIZUK	16	BELL	$e^+e^- \to h_b(1P)\pi^+\pi^-$
seen	[3] BONDAR	12	BELL	$e^+e^- \to h_b(1P)\pi^+\pi^-$

[1] Assuming the $T_{b\overline{b}1}(10610)$ decay width is saturated by the channels $\pi^+\Upsilon(1S,2S,3S)$, $\pi^+ h_b(1P,2P)$, and $B^+\overline{B}^{*0} + \overline{B}^0 B^{*+}$, and using the results from BONDAR 12 and MIZUK 16. NODE=M207R04;LINKAGE=C

[2] Using e^+e^- energies near the $\Upsilon(11020)$. NODE=M207R04;LINKAGE=A

[3] Using e^+e^- energies near the $\Upsilon(10860)$. NODE=M207R04;LINKAGE=B

$\Gamma(h_b(2P)\pi^+)/\Gamma_{total}$ — Γ_8/Γ

NODE=M207R05
NODE=M207R05

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
$\mathbf{4.67^{+1.24+1.18}_{-1.00-0.89}}$	[1] GARMASH	16	BELL	$e^+e^- \to \pi^- B^+ \overline{B}^{*0}$, $\pi^- \overline{B}^0 B^{*+}$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
possibly seen	[2] MIZUK	16	BELL	$e^+e^- \to h_b(2P)\pi^+\pi^-$
seen	[3] BONDAR	12	BELL	$e^+e^- \to h_b(2P)\pi^+\pi^-$

[1] Assuming the $T_{b\overline{b}1}(10610)$ decay width is saturated by the channels $\pi^+\Upsilon(1S,2S,3S)$, $\pi^+ h_b(1P,2P)$, and $B^+\overline{B}^{*0} + \overline{B}^0 B^{*+}$, and using the results from BONDAR 12 and MIZUK 16. NODE=M207R05;LINKAGE=C

[2] Using e^+e^- energies near the $\Upsilon(11020)$. NODE=M207R05;LINKAGE=A

[3] Using e^+e^- energies near the $\Upsilon(10860)$. NODE=M207R05;LINKAGE=B

$\Gamma(B^+\overline{B}^0)/\Gamma_{total}$ — Γ_9/Γ

NODE=M207R08
NODE=M207R08

VALUE	DOCUMENT ID		TECN	COMMENT
not seen	GARMASH	16	BELL	$e^+e^- \to \pi^- B^+ \overline{B}^0$

$[\Gamma(B^+\overline{B}^{*0}) + \Gamma(B^{*+}\overline{B}^0)]/\Gamma_{total}$ — Γ_{10}/Γ

NODE=M207R00
NODE=M207R00

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN	COMMENT
$\mathbf{85.6^{+1.5+1.5}_{-2.0-2.1}}$	357	[1] GARMASH	16	BELL	$e^+e^- \to \pi^- B^+ \overline{B}^{*0}$, $\pi^- B^{*+} \overline{B}^0$

[1] Assuming the $T_{b\overline{b}1}(10610)$ decay width is saturated by the channels $\pi^+\Upsilon(1S,2S,3S)$, $\pi^+ h_b(1P,2P)$, and $B^+\overline{B}^{*0} + B^{*+}\overline{B}^0$, and using the results from BONDAR 12 and MIZUK 16. Using the mass and width of the $T_{b\overline{b}1}(10610)$ from BONDAR 12. NODE=M207R00;LINKAGE=A

$[\Gamma(B^+\overline{B}^{*0}) + \Gamma(B^{*+}\overline{B}^0)]/[\Gamma(\Upsilon(1S)\pi^+) + \Gamma(\Upsilon(2S)\pi^+) + \Gamma(\Upsilon(3S)\pi^+) + \Gamma(h_b(1P)\pi^+) + \Gamma(h_b(2P)\pi^+)]$ — $\Gamma_{10}/(\Gamma_1+\Gamma_3+\Gamma_5+\Gamma_7+\Gamma_8)$

NODE=M207R07
NODE=M207R07

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$5.93^{+0.99+1.01}_{-0.69-0.73}$	357	[1] GARMASH	16	BELL	$e^+e^- \to \pi^- B^+ \overline{B}^{*0}$, $\pi^- \overline{B}^0 B^{*+}$

[1] Combined with the results of BONDAR 12 and MIZUK 16. Not independent from $T_{b\overline{b}1}(10610)$ branching fractions to $\pi^+\Upsilon(1S,2S,3S)$, $\pi^+ h_b(1P,2P)$, and $B^+\overline{B}^{*0} + \overline{B}^0 B^{*+}$. NODE=M207R07;LINKAGE=A

$T_{b\overline{b}1}(10610)$ REFERENCES

NODE=M207

GARMASH	16	PRL 116 212001	A. Garmash *et al.*	(BELLE Collab.)	REFID=57446
MIZUK	16	PRL 117 142001	R. Mizuk *et al.*	(BELLE Collab.)	REFID=57465
GARMASH	15	PR D91 072003	A. Garmash *et al.*	(BELLE Collab.)	REFID=56811
KROKOVNY	13	PR D88 052016	P. Krokovny *et al.*	(BELLE Collab.)	REFID=55588
BONDAR	12	PRL 108 122001	A. Bondar *et al.*	(BELLE Collab.)	REFID=53963