NODE=M208

 $\Gamma_{b\bar{b}1}(10650)$

 $I^{G}(J^{PC}) = 1^{+}(1^{+})$ I, G, C need confirmation.

was $Z_b(10650)$, $X(10650)^{\pm}$

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

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

$T_{b\overline{b}1}(10650)^+$ MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
10652.2±1.5 • • • We do not use the follov	¹ BONDAR ving data for avera	12 iges, fi	BELL ts, limits	$e^+e^- ightarrow$ hadrons s, etc. • • •
10656.7 \pm 5.0 $^{+1.1}_{-3.1}$	² GARMASH	15	BELL	$e^+e^- ightarrow \Upsilon(1S)\pi^+\pi^-$
$10650.7 \pm 1.5 {+0.5 \atop -0.2}$	² GARMASH	15	BELL	$e^+e^- \rightarrow \Upsilon(2S)\pi^+\pi^-$
$10651.2 \pm 1.0 \substack{+0.4 \\ -0.3}$	² GARMASH	15	BELL	$e^+e^- \rightarrow \Upsilon(3S)\pi^+\pi^-$
$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	³ BONDAR ³ BONDAR ³ BONDAR	12 12 12	BELL BELL BELL	$\begin{array}{ccc} e^+ e^- \rightarrow & \Upsilon(1S) \pi^+ \pi^- \\ e^+ e^- \rightarrow & \Upsilon(2S) \pi^+ \pi^- \\ e^+ e^- \rightarrow & \Upsilon(3S) \pi^+ \pi^- \end{array}$
10654 $\pm 3 \ \begin{array}{c} +1 \\ -2 \end{array}$	³ BONDAR	12	BELL	$e^+e^- \rightarrow h_b(1P)\pi^+\pi^-$
$10651 \begin{array}{c} +2 \\ -3 \end{array} \begin{array}{c} +3 \\ -2 \end{array}$	³ BONDAR	12	BELL	$e^+e^- \rightarrow h_b(2P)\pi^+\pi^-$

¹Average of the BONDAR 12 measurements in separate channels.

 2 Correlated with the corresponding result from BONDAR 12.

 3 Superseded by the average measurement of BONDAR 12.

$T_{b\overline{b}1}(10650)^+$ WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
11.5± 2.2 • • • We do not use the followi	¹ BONDAR ing data for average	12 ges, fi ^r	BELL ts, limits	$e^+e^- ightarrow$ hadrons
$12.1 + 11.3 + 2.7 \\ - 4.8 - 0.6$	² GARMASH	15	BELL	$e^+e^- ightarrow ~\Upsilon(1S)\pi^+\pi^-$
$14.2\pm~3.7{+}_{-}{0.9}_{0.4}$	² GARMASH	15	BELL	$e^+e^- \rightarrow \Upsilon(2S)\pi^+\pi^-$
$9.3\pm~2.2^+$ 0.3	² GARMASH	15	BELL	$e^+e^- \rightarrow \Upsilon(3S)\pi^+\pi^-$
$16.3\pm \ 9.8 {+} {-} {2.0} \$	³ BONDAR	12	BELL	$e^+e^- \rightarrow \Upsilon(1S)\pi^+\pi^-$
$13.3 \pm 3.3 + 4.0 = 3.0$	³ BONDAR	12	BELL	$e^+e^- \rightarrow \Upsilon(2S)\pi^+\pi^-$
$8.4\pm~2.0\pm~2.0$	³ BONDAR	12	BELL	$e^+e^- \rightarrow \Upsilon(3S)\pi^+\pi^-$
20.9^+ $\begin{array}{c} 5.4+$ $\begin{array}{c} 2.1\\ 4.7 \begin{array}{c} 5.7\end{array}$	³ BONDAR	12	BELL	$e^+e^- \rightarrow h_b(1P)\pi^+\pi^-$
19 \pm 7 $^{+11}_{-7}$	³ BONDAR	12	BELL	$e^+e^- \rightarrow h_b(2P)\pi^+\pi^-$

¹Average of the BONDAR 12 measurements in separate channels.

 2 Correlated with the corresponding result from BONDAR 12.

 $^3 \, {\rm Superseded}$ by the average measurement of BONDAR 12.

$T_{b\overline{b}1}$ (10650) DECAY MODES

	Mode	Fraction (Γ_i/Γ)	
Γ_1	$\Upsilon(1S)\pi^+$	$(1.7^{+0.8}_{-0.6}) imes 10^{-3}$	DESIG=1
Γ2	$\Upsilon(2S)\pi^+$	$(1.4^{+0.6}_{-0.4})\%$	DESIG=2
Γ ₃	$\Upsilon(3S)\pi^+$	$(1.6^{+0.7}_{-0.5})\%$	DESIG=3
Γ4	$h_b(1P)\pi^+$	$(8.4^{+2.9}_{-2.4})\%$	DESIG=4
Γ ₅	$h_b(2P)\pi^+$	(15 ±4)%	DESIG=5
Γ_6	$B^+ \overline{B}^0$	not seen	DESIG=8
Γ ₇	$B^+\overline{B}{}^{*0} + B^{*+}\overline{B}{}^0$	not seen	DESIG=6
Γ ₈	$B^{*+}\overline{B}^{*0}$	(74 + 4) - 6)%	DESIG=7

NODE=M208M

NODE=M208M

OCCUR=2 OCCUR=3 OCCUR=2 OCCUR=3 OCCUR=4 OCCUR=5 OCCUR=6

NODE=M208M;LINKAGE=BO NODE=M208M;LINKAGE=A NODE=M208M;LINKAGE=BN

NODE=M208W

NODE=M208W

OCCUR=2 OCCUR=3 OCCUR=2 OCCUR=3 OCCUR=4 OCCUR=5

OCCUR=6 NODE=M208W;LINKAGE=BO NODE=M208W;LINKAGE=A

NODE=M208W;LINKAGE=BN

NODE=M208215;NODE=M208

NODE=M208

$T_{b\overline{b}1}$ (10650) BRANCHING RATIOS

$\Gamma(\Upsilon(1S)\pi^+)/\Gamma_{ ext{total}}$					Γ_1/Γ
VALUE (units 10 ⁻³)	DOCUMENT ID		TECN	COMMENT	
1.7 +0.7+0.3 1	GARMASH	16	BELL	$e^+e^- \rightarrow \pi^- B^{*+}$	⊢ <i>B</i> *0
 We do not use the following 	data for averag	es, fit	s, limits	, etc. ● ● ●	
seen	GARMASH	15 12	BELL	$e^+ e^- \rightarrow \Upsilon(1S) \tau$	$\pi^+ \pi^-$ +
$\frac{1}{1}$ Accuming the T (10650) do	BUNDAR	12	DELL	$e^+e^- \rightarrow T(13)^{7}$	$\tau \cdot \pi$
$\pi^+ h_b(1P, 2P)$, and $B^{*+}\overline{B}^{*0}$,	and using the re	esults	from B	ONDAR 12 and MIZ	23, 33), 2UK 16.
$\Gamma(\Upsilon(2S)\pi^+)/\Gamma_{total}$					Г <u>2</u> /Г
/ALUE (units 10 ⁻²)	DOCUMENT ID		TECN	COMMENT	
1.39+0.48+0.34 1 -0.38-0.23	GARMASH	16		$e^+e^- \rightarrow \pi^- B^{*+}$	\overline{B}^{*0}
• • We do not use the following	data for averag	es, fit	s, limits	, etc. ● ● ●	
een een	GARMASH BONDAR	15 12	BELL BELL	$e^+ e^- \rightarrow \Upsilon(2S) \tau$ $e^+ e^- \rightarrow \Upsilon(2S) \tau$	$\pi^+\pi^-$ $\pi^+\pi^-$
¹ Assuming the T_{1,T_1} (10650) de	cay width is satu	urated	by the	channels $\pi^+ \gamma(1S, 2)$	2S. 3S).
$\pi^+ h_b(1P, 2P)$, and $B^{*+}\overline{B}^{*0}$,	and using the re	esults	from B(ONDAR 12 and MIZ	UK 16.
$\Gamma(\Upsilon(3S)\pi^+)/\Gamma_{total}$					Г ₃ /Г
/ALUE (units 10 ⁻²)	DOCUMENT ID		TECN	COMMENT	
1.63 ^{+0.53+0.39} 1 -0.42-0.28	GARMASH	16	BELL	$e^+e^- \rightarrow \pi^- B^{*+}$	\overline{B}^{*0}
• • We do not use the following	data for averag	es, fit	s, limits	, etc. ● ● ●	
jeen	GARMASH	15	BELL	$e^+e^- \rightarrow \Upsilon(3S)\tau$	$\pi^+\pi^-$
een	BONDAR	12	BELL	$e^+e^- \rightarrow \Upsilon(3S)\tau$	$\tau^+\pi^-$
¹ Assuming the $T_{b\overline{b}1}(10650)$ de $\pi^+ h_b(1P, 2P)$, and $B^{*+}\overline{B}^{*0}$,	cay width is satu and using the re	urated esults	by the from B	channels $\pi^+~ \Upsilon(1{ m S},2)$	2S, 3S), 2UK 16.
$\Gamma(h_{h}(1P)\pi^{+})/\Gamma_{total}$	-				
(''D(1')''')''' total	DOCUMENT ID		TECN	COMMENT	• 4/ •
1 + 2.43 + 1.49		10			- - ∗0
$\frac{1.41}{-2.12} - 1.06$	GARMASH	16	BELL	$e^+e^- \rightarrow \pi^- B^{*+}$	B≁o
 • • We do not use the following 2 	data for average	es, fit	s, limits	, etc. • • • (1 P)	+ -
een 2 oon 3		16 12	BELL	$e^+e^- \rightarrow h_b(1P)$ $e^+e^- \rightarrow h_b(1P)$	$\pi^+\pi^-$ $\pi^+\pi^-$
¹ Assuming the $T_{b\overline{b}1}(10650)$ de $\pi^+ h_b(1P, 2P)$, and $B^{*+}\overline{B}^{*0}$, ² Using e^+e^- energies near the ³ Using e^+e^- energies near the	cay width is satuand using the re $\Upsilon(11020).$ $\Upsilon(10860).$	urated	by the from B(channels $\pi^+ \Upsilon(15, 2)$	2S, 3S), 2UK 16.
$\Gamma(h_b(2P)\pi^+)/\Gamma_{total}$					Г ₅ /Г
<i>VALUE</i> (units 10 ⁻²)	DOCUMENT ID		TECN	COMMENT	
14.7 +3.2+2.8 1	GARMASH	16	BELL	$e^+e^- \rightarrow \pi^- B^{*+}$	\overline{B}^{*0}
• • We do not use the following	data for averag	es, fit	s, limits	, etc. ● ● ●	1
possibly seen 2 peen 3	MIZUK BONDAR	16 12	BELL BELL	$e^+ e^- \rightarrow h_b(2P)$ $e^+ e^- \rightarrow h_b(2P)$	$\pi^{+}\pi^{-}$ $\pi^{+}\pi^{-}$
¹ Assuming the $T_{b\overline{b}1}(10650)$ de $\pi^+ h_b(1P, 2P)$, and $B^{*+}\overline{B}^{*0}$, ² Using e^+e^- energies near the ³ Using e^+e^- energies near the	cay width is satuand using the rest $\Upsilon(11020)$. $\Upsilon(10860)$.	urated	by the from B(channels π^+ $\Upsilon(1S, z)$	2S, 3S), 2UK 16.
$\Gamma(B^+\overline{B}{}^0)/\Gamma_{total}$					Г ₆ /Г
<u>VALUE</u>	<u>DOCUMENT ID</u> GARMASH	16	_ <u>TECN</u> RFI I	$\begin{array}{c} \underline{COMMENT} \\ e^+ e^- \rightarrow \pi^- R \end{array}$	$+\overline{R}0$
 [Γ(<u></u> β+ <u></u> β*0) ₊ Γ(<u></u> ε*+ <u></u> ρ0)]/r	•	10	ULL	<i></i> . D	Г., /Г
	total DOCUMENT ID)		COMMENT	י7/1
not seen	GARMASH	16	BELL	$e^+e^- \rightarrow \pi^- B^- B^- B^- B^+$	$+\overline{B}^{*0}$,

NODE=M208225

NODE=M208R01 NODE=M208R01

NODE=M208R01;LINKAGE=A

NODE=M208R02 NODE=M208R02

NODE=M208R02;LINKAGE=A

NODE=M208R03 NODE=M208R03

NODE=M208R03;LINKAGE=A

NODE=M208R04 NODE=M208R04

NODE=M208R04;LINKAGE=C

NODE=M208R04;LINKAGE=A NODE=M208R04;LINKAGE=B

NODE=M208R05 NODE=M208R05

NODE=M208R05;LINKAGE=C

NODE=M208R05;LINKAGE=A NODE=M208R05;LINKAGE=B

NODE=M208R08 NODE=M208R08

NODE=M208R00 NODE=M208R00

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NODE=M208

$\Gamma(B^{*+}\overline{B}^{*0})/\Gamma_{\text{tota}}$	h				Г ₈ /Г	NODE=M208R06	
VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT		NODE=M208R06	
73.7 ^{+3.4} +2.7 -4.4-3.5	161	¹ GARMASH 10	5 BELL	$e^+e^- \rightarrow \pi^- B^{*+}$	\overline{B}^{*0}		
1 Assuming the ${\cal T}_b$ $\pi^+ h_b(1{ m P},2{ m P})$, a Using the mass a	$b\overline{b}1^{(10650)}$ and $B^{*+}\overline{B}^{*+}$ nd width o	decay width is satura 1^{*0} , and using the result of the $\mathcal{T}_{b\overline{b}1}(10650)$ fr	ted by the Ilts from B om BOND	channels π^+ $\Upsilon(1\mathrm{S},2\mathrm{S})$ ONDAR 12 and MIZU AR 12.	S, 3S), JK 16.	NODE=M208R06;LINKAGE=A	
$\Gamma(B^{*+}\overline{B}^{*0})/[\Gamma(\Upsilon(1S)\pi^+)+\Gamma(\Upsilon(2S)\pi^+)+\Gamma(\Upsilon(3S)\pi^+)+$							
$\Gamma(B^{*+}\overline{B}^{*0})/[\Gamma(1)]$	$r(1S)\pi^+$	Γ) + $\Gamma(\Upsilon(2S)\pi^+)$	+Γ(<i>Υ</i> (3	$S(\pi^{+}) +$			
$\frac{\Gamma(B^{*+}\overline{B}^{*0})}{\Gamma(h_b(1P)\pi^+)} + \Gamma$	r(1S)π ⁺ (h _b (2P)	$\left[\pi^{+} ight) + \Gamma(\Upsilon(2S)\pi^{+}) \cdot \pi^{+} ight]$	+ ר(<i>۲</i> (3 ר	S)π ⁺) + ₈ /(Γ ₁ +Γ ₂ +Γ ₃ +Γ ₄ :	+Γ ₅)	NODE=M208R07	
$\frac{\Gamma(B^{*+}\overline{B}^{*0})}{\Gamma(h_b(1P)\pi^+)} + \Gamma$ <i>VALUE</i> (units 10 ⁻²)	r(1S)π ⁺ - (h _b (2P) - <u></u>	$(\pi^+) + \Gamma(\Upsilon(2S)\pi^+) + \pi^+)]$	+ Γ(<i>Υ</i> (3 Γ <u>ΤΕCΝ</u>	S)π ⁺) + ₈ /(Γ ₁ +Γ ₂ +Γ ₃ +Γ ₄ <u>^{COMMENT}</u>	+Γ ₅)	NODE=M208R07 NODE=M208R07	
$\frac{\Gamma(B^{*+}\overline{B}^{*0})}{\Gamma(h_b(1P)\pi^+) + \Gamma}$ <u>VALUE (units 10⁻²)</u> ••• We do not use	$\Gamma(1S)\pi^+$ $\Gamma(h_b(2P))$ $= \frac{EVTS}{2}$ the follow	$\frac{\Gamma}{\pi^{+}} + \Gamma(\Upsilon(2S)\pi^{+}) + \frac{\Gamma(\Upsilon(2S)\pi^{+})}{DOCUMENT ID}$ <i>Document ID ing data for averages,</i>	+ Г(𝔅(3 Г <u>TECN</u> fits, limits	$S)\pi^+) + \\ B/(\Gamma_1 + \Gamma_2 + \Gamma_3 + \Gamma_4) \\ \frac{COMMENT}{S}, \text{ etc. } \bullet \bullet \bullet$	+Γ ₅)	NODE=M208R07 NODE=M208R07	
$\frac{\Gamma(B^{*+}\overline{B}^{*0})}{\Gamma(h_b(1P)\pi^+) + \Gamma}$ <u>VALUE (units 10⁻²)</u> ••• We do not use 2.80 ^{+0.69+0.54} -0.40-0.36	Γ(1S) π ⁺ Γ(h _b (2P) <u>EVTS</u> e the follow 161	$\frac{\Gamma}{\pi^{+}} + \Gamma(\Upsilon(2S)\pi^{+}) + \frac{\Gamma}{\pi^{+}}$ $\frac{DOCUMENT \ ID}{\Gamma}$ <i>ing</i> data for averages, $\frac{1}{\Gamma} GARMASH} = 10$	+ Г(<i>Ť</i>(3) Г <u>TECN</u> fits, limits 6 BELL	$S)\pi^{+}) + B/(\Gamma_{1}+\Gamma_{2}+\Gamma_{3}+\Gamma_{4})$ $\frac{COMMENT}{e^{+}e^{-} \rightarrow \pi^{-}B^{*+}}$	+ Г 5) 	NODE=M208R07 NODE=M208R07	

$T_{b\overline{b}1}$ (10650) REFERENCES

GARMASH	16PRL11621200116PRL11714200115PRD9107200312PRL108122001	A. Garmash <i>et al.</i>	(BELLE Collab.)	REFID=57446
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BONDAR		A. Bondar <i>et al.</i>	(BELLE Collab.)	REFID=53963