$X(10610)^\pm$

$I^G(J^P) = 1^+(1^+)$

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. Isospin $= 1$ is favored due to observation by KROKOVNY 13 of a corresponding neutral state produced in $\Upsilon(10860) \rightarrow \Upsilon(2S)/\Upsilon(3S)\pi^0\pi^0$ decays at a consistent mass.

$X(10610)^\pm$ MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
10607.2±2.0	[1] BONDAR	12	BELL	$e^+e^- \rightarrow$ 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	$e^+e^- \rightarrow \Upsilon(1S)\pi^+\pi^-$
$10608.1 \pm 1.2 ^{+1.5}_{-0.2}$	[2] GARMASH	15	BELL	$e^+e^- \rightarrow \Upsilon(2S)\pi^+\pi^-$
$10607.4 \pm 1.5 ^{+0.8}_{-0.2}$	[2] GARMASH	15	BELL	$e^+e^- \rightarrow \Upsilon(3S)\pi^+\pi^-$
$10611 \pm 4 \pm 3$	[3] BONDAR	12	BELL	$e^+e^- \rightarrow \Upsilon(1S)\pi^+\pi^-$
$10609 \pm 2 \pm 3$	[3] BONDAR	12	BELL	$e^+e^- \rightarrow \Upsilon(2S)\pi^+\pi^-$
$10608 \pm 2 \pm 3$	[3] BONDAR	12	BELL	$e^+e^- \rightarrow \Upsilon(3S)\pi^+\pi^-$
$10605 \pm 2 ^{+3}_{-1}$	[3] BONDAR	12	BELL	$e^+e^- \rightarrow h_b(1P)\pi^+\pi^-$
$10599 ^{+6}_{-3} {}^{+5}_{-4}$	[3] BONDAR	12	BELL	$e^+e^- \rightarrow h_b(2P)\pi^+\pi^-$

[1] Average 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[3] Superseded by the average measurement of BONDAR 12.

$X(10610)^\pm$ WIDTH

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

[4] Average of the BONDAR 12 measurements in separate channels.

[5] Correlated with the corresponding result from BONDAR 12.
[6] Superseded by the average measurement of BONDAR 12.

$X(10610)^+$ DECAY MODES

$X(10610)^-$ decay modes are charge conjugates of the modes below.

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

$X(10610)^\pm$ BRANCHING RATIOS

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

VALUE (units 10^{-3})	DOCUMENT ID		TECN	COMMENT
$\mathbf{5.4^{+1.6+1.1}_{-1.3-0.8}}$	[7] 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	$e^+e^- \to \Upsilon(1S)\pi^+\pi^-$

[7] Assuming the $X(10610)^\pm$ 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.

$\Gamma\left(\Upsilon(2S)\pi^+\right)/\Gamma_{\text{total}}$ Γ_2/Γ

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
$\mathbf{3.62^{+0.76+0.79}_{-0.59-0.53}}$	[8] 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	$e^+e^- \to \Upsilon(2S)\pi^+\pi^-$

[8] Assuming the $X(10610)^\pm$ 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.

$\Gamma\left(\Upsilon(3S)\pi^+\right)/\Gamma_{\text{total}}$ $\qquad\qquad$ Γ_3/Γ

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
$2.15^{+0.55+0.60}_{-0.42-0.43}$	[9] GARMASH	16	BELL	$e^+e^- \to \pi^- B^+\overline{B}{}^{*0}$, $\pi^-\overline{B}{}^0 B^{*+}$

$\bullet\bullet\bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet\bullet\bullet$

seen	GARMASH	15	BELL	$e^+e^- \to \Upsilon(3S)\pi^+\pi^-$
seen	BONDAR	12	BELL	$e^+e^- \to \Upsilon(3S)\pi^+\pi^-$

[9] Assuming the $X(10610)^{\pm}$ 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.

$\Gamma\left(h_b(1P)\pi^+\right)/\Gamma_{\text{total}}$ $\qquad\qquad$ Γ_4/Γ

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
$3.45^{+0.87+0.86}_{-0.71-0.63}$	[10] GARMASH	16	BELL	$e^+e^- \to \pi^- B^+\overline{B}{}^{*0}$, $\pi^-\overline{B}{}^0 B^{*+}$

$\bullet\bullet\bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet\bullet\bullet$

possibly seen	[11] MIZUK	16	BELL	$e^+e^- \to h_b(1P)\pi^+\pi^-$
seen	[12] BONDAR	12	BELL	$e^+e^- \to h_b(1P)\pi^+\pi^-$

[10] Assuming the $X(10610)^{\pm}$ 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.

[11] Using e^+e^- energies near the $\Upsilon(11020)$.

[12] Using e^+e^- energies near the $\Upsilon(10860)$.

$\Gamma\left(h_b(2P)\pi^+\right)/\Gamma_{\text{total}}$ $\qquad\qquad$ Γ_5/Γ

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
$4.67^{+1.24+1.18}_{-1.00-0.89}$	[13] GARMASH	16	BELL	$e^+e^- \to \pi^- B^+\overline{B}{}^{*0}$, $\pi^-\overline{B}{}^0 B^{*+}$

$\bullet\bullet\bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet\bullet\bullet$

possibly seen	[14] MIZUK	16	BELL	$e^+e^- \to h_b(2P)\pi^+\pi^-$
seen	[15] BONDAR	12	BELL	$e^+e^- \to h_b(2P)\pi^+\pi^-$

[13] Assuming the $X(10610)^{\pm}$ 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.

[14] Using e^+e^- energies near the $\Upsilon(11020)$.

[15] Using e^+e^- energies near the $\Upsilon(10860)$.

$\Gamma\left(B^+\overline{B}{}^0\right)/\Gamma_{\text{total}}$ $\qquad\qquad$ Γ_6/Γ

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

$\left[\Gamma\left(B^+\overline{B}{}^{*0}\right) + \Gamma\left(B^{*+}\overline{B}{}^0\right)\right]/\Gamma_{\text{total}}$ $\qquad$ Γ_7/Γ

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

[16] Assuming the $X(10610)^{\pm}$ 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 $X(10610)^{\pm}$ from BONDAR 12.

$\Gamma(B^{*+}\overline{B}^{*0})/\Gamma_{total}$ Γ_8/Γ

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

$\left[\Gamma(B^{+}\overline{B}^{*0}) + \Gamma(B^{*+}\overline{B}^{0})\right]/\left[\Gamma(\Upsilon(1S)\pi^{+}) + \Gamma(\Upsilon(2S)\pi^{+}) + \Gamma(\Upsilon(3S)\pi^{+}) + \Gamma(h_b(1P)\pi^{+}) + \Gamma(h_b(2P)\pi^{+})\right]$ $\Gamma_7/(\Gamma_1+\Gamma_2+\Gamma_3+\Gamma_4+\Gamma_5)$

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT

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

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
$5.93^{+0.99+1.01}_{-0.69-0.73}$	357	[17] GARMASH 16	BELL	$e^{+}e^{-} \to \pi^{-} B^{+}\overline{B}^{*0}$, $\pi^{-}\overline{B}^{0} B^{*+}$

[17] Combined with the results of BONDAR 12 and MIZUK 16. Not independent from $X(10610)^{\pm}$ branching fractions to $\pi^{+}\,\Upsilon(1S, 2S, 3S)$, $\pi^{+}\,h_b(1P, 2P)$, and $B^{+}\overline{B}^{*0} + \overline{B}^{0} B^{*+}$.

$X(10610)^{\pm}$ REFERENCES

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