$X(3872)$

$I^G(J^{PC}) = 0^?(?^{?+})$

Seen by CHOI 03 in $B \to K\pi^+\pi^- J/\psi(1S)$ decays as a narrow peak in the invariant mass distribution of the $\pi^+\pi^- J/\psi(1S)$ final state, but not seen in the $\gamma\chi_{c1}$ final state of these decays. Possibly absent in the invariant mass spectrum of the final state $\pi^+\pi^- J/\psi(1S)$ in e^+e^- collisions. Interpretation as a 1^{--} charmonium state not favored. Isovector hypothesis excluded by AUBERT 05B and CHOI 11. A helicity amplitude analysis of the $X(3872) \to J/\psi\pi^+\pi^-$ decay gives two possible J^{PC} assignments: $J^{PC} = 1^{++}$ and 2^{-+} (ABULENCIA 07E and CHOI 11). A study of the 3π invariant mass distribution in $J/\psi\omega$ decays slightly favors $J^P = 2^-$ (DEL-AMO-SANCHEZ 10B).

See our note on "Developments in Heavy Quarkonium Spectroscopy".

$X(3872)$ MASS FROM $J/\psi X$ MODE

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
3871.68± 0.17 OUR AVERAGE					
3871.95± 0.48±0.12	0.6k	AAIJ	12H	LHCB	$pp \to J/\psi\pi^+\pi^- X$
3871.85± 0.27±0.19	∼ 170	[1] CHOI	11	BELL	$B \to K\pi^+\pi^- J/\psi$
$3873\ ^{+\ 1.8}_{-\ 1.6}$ ±1.3	27 ± 8	[2] DEL-AMO-SA.	10B	BABR	$B \to \omega J/\psi K$
3871.61± 0.16±0.19	6k	[2,3] AALTONEN	09AU	CDF2	$p\overline{p} \to J/\psi\pi^+\pi^- X$
3871.4 ± 0.6 ±0.1	93.4	AUBERT	08Y	BABR	$B^+ \to K^+ J/\psi\pi^+\pi^-$
3868.7 ± 1.5 ±0.4	9.4	AUBERT	08Y	BABR	$B^0 \to K^0_S J/\psi\pi^+\pi^-$
3871.8 ± 3.1 ±3.0	522	[2,4] ABAZOV	04F	D0	$p\overline{p} \to J/\psi\pi^+\pi^- X$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
3868.6 ± 1.2 ±0.2	8	[5] AUBERT	06	BABR	$B^0 \to K^0_S J/\psi\pi^+\pi^-$
3871.3 ± 0.6 ±0.1	61	[5] AUBERT	06	BABR	$B^- \to K^- J/\psi\pi^+\pi^-$
3873.4 ± 1.4	25	[6] AUBERT	05R	BABR	$B^+ \to K^+ J/\psi\pi^+\pi^-$
3871.3 ± 0.7 ±0.4	730	[2,7] ACOSTA	04	CDF2	$p\overline{p} \to J/\psi\pi^+\pi^- X$
3872.0 ± 0.6 ±0.5	36	[8] CHOI	03	BELL	$B \to K\pi^+\pi^- J/\psi$
3836 ±13	58	[2,9] ANTONIAZZI	94	E705	300 $\pi^\pm$ Li → $J/\psi\pi^+\pi^- X$

[1] The mass difference for the $X(3872)$ produced in B^+ and B^0 decays is $(-0.71 \pm 0.96 \pm 0.19)$ MeV.

[2] Width consistent with detector resolution.

[3] A possible equal mixture of two states with a mass difference greater than 3.6 MeV/c^2 is excluded at 95% CL.

[4] Calculated from the corresponding $m_{X(3872)} - m_{J/\psi}$ using $m_{J/\psi}$=3096.916 MeV.

[5] Calculated from the corresponding $m_{X(3872)} - m_{\psi(2S)}$ using $m_{\psi(2S)} = 3686.093$ MeV. Superseded by AUBERT 08Y.

[6] Calculated from the corresponding $m_{X(3872)} - m_{\psi(2S)}$ using $m_{\psi(2S)} = 3685.96$MeV. Superseded by AUBERT 06.

[7] Superseded by AALTONEN 09AU.
[8] Superseded by CHOI 11.
[9] A lower mass value can be due to an incorrect momentum scale for soft pions.

X(3872) MASS FROM $\overline{D}^{*0} D^0$ MODE

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$3872.9^{+0.6}_{-0.4}{}^{+0.4}_{-0.5}$	50	[10,11] AUSHEV	10	BELL	$B \to \overline{D}^{*0} D^0 K$
$3875.1^{+0.7}_{-0.5} \pm 0.5$	33 ± 6	[11] AUBERT	08B	BABR	$B \to \overline{D}^{*0} D^0 K$
$3875.2 \pm 0.7^{+0.9}_{-1.8}$	24 ± 6	[11,12] GOKHROO	06	BELL	$B \to D^0 \overline{D}^0 \pi^0 K$

[10] Calculated from the measured $m_{X(3872)} - m_{D^{*0}} - m_{\overline{D}^0} = 1.1^{+0.6}_{-0.4}{}^{+0.1}_{-0.3}$ MeV.
[11] Experiments report $D^{*0}\overline{D}^0$ invariant mass above $D^{*0}\overline{D}^0$ threshold because D^{*0} decay products are kinematically constrained to the D^{*0} mass, even though the D^{*0} may decay off-shell.
[12] Superseded by AUSHEV 10.

$m_{X(3872)} - m_{J/\psi}$

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
774.9±3.1±3.0	522	ABAZOV	04F	D0	$p\overline{p} \to J/\psi \pi^+ \pi^- X$

$m_{X(3872)} - m_{\psi(2S)}$

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
187.4 ± 1.4	25	[13] AUBERT	05R	BABR	$B^+ \to K^+ J/\psi \pi^+ \pi^-$

[13] Superseded by AUBERT 06.

X(3872) WIDTH

VALUE (MeV)	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
<1.2	90		CHOI	11	BELL	$B \to K \pi^+ \pi^- J/\psi$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<3.3	90		AUBERT	08Y	BABR	$B^+ \to K^+ J/\psi \pi^+ \pi^-$
<4.1	90	69	AUBERT	06	BABR	$B \to K \pi^+ \pi^- J/\psi$
<2.3	90	36	[14] CHOI	03	BELL	$B \to K \pi^+ \pi^- J/\psi$

[14] Superseded by CHOI 11.

X(3872) WIDTH FROM $\overline{D}^{*0} D^0$ MODE

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$3.9^{+2.8}_{-1.4}{}^{+0.2}_{-1.1}$	50	[15] AUSHEV	10	BELL	$B \to \overline{D}^{*0} D^0 K$
$3.0^{+1.9}_{-1.4} \pm 0.9$	33 ± 6	AUBERT	08B	BABR	$B \to \overline{D}^{*0} D^0 K$

[15] With a measured value of $B(B \to X(3872)K) \times B(X(3872) \to D^{*0}\overline{D}^{0}) = (0.80 \pm 0.20 \pm 0.10) \times 10^{-4}$, assumed to be equal for both charged and neutral modes.

X(3872) DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	e^+e^-	
Γ_2	$\pi^+\pi^- J/\psi(1S)$	>2.6 %
Γ_3	$\rho^0 J/\psi(1S)$	
Γ_4	$\omega J/\psi(1S)$	>1.9 %
Γ_5	$D^0\overline{D}^0\pi^0$	$>3.2 \times 10^{-3}$
Γ_6	$\overline{D}^{*0}D^0$	$>5 \times 10^{-3}$
Γ_7	$\gamma\gamma$	
Γ_8	$D^0\overline{D}^0$	
Γ_9	D^+D^-	
Γ_{10}	$\gamma\chi_{c1}$	
Γ_{11}	$\eta J/\psi$	
Γ_{12}	$\gamma J/\psi$	$>6 \times 10^{-3}$
Γ_{13}	$\gamma\psi(2S)$	[a] >3.0 %

[a] BHARDWAJ 11 does not observe this decay and presents a stronger 90% CL limit than this value. See measurements listings for details.

X(3872) PARTIAL WIDTHS

$\Gamma(e^+e^-)$ Γ_1

VALUE (keV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.28	90	[16] YUAN	04	RVUE	$e^+e^- \to \pi^+\pi^- J/\psi$

[16] Using BAI 98E data on $e^+e^- \to \pi^+\pi^-\ell^+\ell^-$. Assuming that $\Gamma(\pi^+\pi^- J/\psi)$ of $X(3872)$ is the same as that of $\psi(2S)$ (85.4 keV).

X(3872) Γ(i)Γ(e^+e^-)/Γ(total)

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

VALUE (eV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
< 6.2	90	[17,18] AUBERT	05D	BABR	10.6 $e^+e^- \to K^+K^-\pi^+\pi^-\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 8.3	90	[18] DOBBS	05	CLE3	$e^+e^- \to \pi^+\pi^- J/\psi$
<10	90	[19] YUAN	04	RVUE	$e^+e^- \to \pi^+\pi^- J/\psi$

[17] Using $B(X(3872) \to J/\psi\pi^+\pi^-) \cdot B(J/\psi \to \mu^+\mu^-) \cdot \Gamma(X(3872) \to e^+e^-) < 0.37$ eV from AUBERT 05D and $B(J/\psi \to \mu^+\mu^-) = 0.0588 \pm 0.0010$ from the PDG 04.

[18] Assuming $X(3872)$ has $J^{PC} = 1^{--}$.

[19] Using BAI 98E data on $e^+e^- \to \pi^+\pi^-\ell^+\ell^-$. From theoretical calculation of the production cross section and using $B(J/\psi \to \mu^+\mu^-) = (5.88 \pm 0.10)\%$.

X(3872) Γ(i)Γ(γγ)/Γ(total)

$\Gamma(\gamma\gamma) \times \Gamma(\pi^+\pi^- J/\psi(1S))/\Gamma_{total}$ $\Gamma_7\Gamma_2/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<12.9	90	[20] DOBBS	05	CLE3	$e^+e^- \to \pi^+\pi^- J/\psi\gamma$

[20] Assuming $X(3872)$ has positive C parity and spin 0.

X(3872) BRANCHING RATIOS

$\Gamma(\pi^+\pi^- J/\psi(1S))/\Gamma_{total}$ Γ_2/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
>0.026	93 ± 17	[21] AUBERT	08Y	BABR	$B \to X(3872)K$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>0.04	30	[22] AUBERT	05R	BABR	$B^+ \to K^+ J/\psi\pi^+\pi^-$
>0.04	36 ± 7	[23] CHOI	03	BABR	$B^+ \to K^+ J/\psi\pi^+\pi^-$

[21] AUBERT 08Y reports $[\Gamma(X(3872) \to \pi^+\pi^- J/\psi(1S))/\Gamma_{total}] \times [B(B^+ \to X(3872)K^+)] = (8.4 \pm 1.5 \pm 0.7) \times 10^{-6}$ which we divide by our best value $B(B^+ \to X(3872)K^+) < 3.2 \times 10^{-4}$.

[22] Superseded by AUBERT 08Y. AUBERT 05R reports $[\Gamma(X(3872) \to \pi^+\pi^- J/\psi(1S))/\Gamma_{total}] \times [B(B^+ \to X(3872)K^+)] = (1.28 \pm 0.41) \times 10^{-5}$ which we divide by our best value $B(B^+ \to X(3872)K^+) < 3.2 \times 10^{-4}$.

[23] CHOI 03 reports $[\Gamma(X(3872) \to \pi^+\pi^- J/\psi(1S))/\Gamma_{total}] \times [B(B^+ \to X(3872)K^+)] / [B(B^+ \to \psi(2S)K^+)] / [B(\psi(2S) \to J/\psi(1S)\pi^+\pi^-)] = 0.063 \pm 0.012 \pm 0.007$ which we multiply or divide by our best values $B(B^+ \to X(3872)K^+) < 3.2 \times 10^{-4}$, $B(B^+ \to \psi(2S)K^+) = (6.39 \pm 0.33) \times 10^{-4}$, $B(\psi(2S) \to J/\psi(1S)\pi^+\pi^-) = (33.6 \pm 0.4) \times 10^{-2}$.

$\Gamma(\omega J/\psi(1S))/\Gamma_{total}$ Γ_4/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
>0.019	21 ± 7	[24] DEL-AMO-SA..10B		BABR	$B^+ \to \omega J/\psi K^+$

[24] DEL-AMO-SANCHEZ 10B reports $[\Gamma(X(3872) \to \omega J/\psi(1S))/\Gamma_{total}] \times [B(B^+ \to X(3872)K^+)] = (6 \pm 2 \pm 1) \times 10^{-6}$ which we divide by our best value $B(B^+ \to X(3872)K^+) < 3.2 \times 10^{-4}$. DEL-AMO-SANCHEZ 10B also reports $B(B^0 \to X(3872)K^0) \times B(X(3872) \to J/\psi\omega) = (6 \pm 3 \pm 1) \times 10^{-6}$.

$\Gamma(\omega J/\psi(1S))/\Gamma(\pi^+\pi^- J/\psi(1S))$ Γ_4/Γ_2

VALUE	DOCUMENT ID		TECN	COMMENT
0.8±0.3	[25] DEL-AMO-SA..10B		BABR	$B \to \omega J/\psi K$

[25] Statistical and systematic errors added in quadrature. Uses the values of $B(B \to X(3872)K) \times B(X(3872) \to J/\psi\pi^+\pi^-)$ reported in AUBERT 08Y, taking into account the common systematics.

$\Gamma(D^0\overline{D}^0\pi^0)/\Gamma_{total}$ Γ_5/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$>3.2\times10^{-3}$	17 ± 5	[26] GOKHROO	06	BELL	$B^+\to D^0\overline{D}^0\pi^0K^+$

[26] GOKHROO 06 reports $[\Gamma(X(3872)\to D^0\overline{D}^0\pi^0)/\Gamma_{total}]\times[B(B^+\to X(3872)K^+)] = (1.02\pm0.31^{+0.21}_{-0.29})\times10^{-6}$ which we divide by our best value $B(B^+\to X(3872)K^+) < 3.2\times10^{-4}$.

$\Gamma(\overline{D}^{*0}D^0)/\Gamma_{total}$ Γ_6/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$>5\times10^{-3}$	27 ± 6	[27] AUBERT	08B	BABR	$B^+\to\overline{D}^{*0}D^0K^+$

[27] AUBERT 08B reports $[\Gamma(X(3872)\to\overline{D}^{*0}D^0)/\Gamma_{total}]\times[B(B^+\to X(3872)K^+)] = (1.67\pm0.36\pm0.47)\times10^{-6}$ which we divide by our best value $B(B^+\to X(3872)K^+) < 3.2\times10^{-4}$.

$\Gamma(D^0\overline{D}^0\pi^0)/\Gamma(\pi^+\pi^-J/\psi(1S))$ Γ_5/Γ_2

VALUE	DOCUMENT ID		TECN	COMMENT
seen	[28] GOKHROO	06	BELL	$B\to D^0\overline{D}^0\pi^0K$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
seen	AUSHEV	10	BELL	$B\to D^0\overline{D}^0\pi^0K$

[28] May not necessarily be the same state as that observed in the $J/\psi\pi^+\pi^-$ mode. Supersedes CHISTOV 04.

$\Gamma(D^0\overline{D}^0)/\Gamma(\pi^+\pi^-J/\psi(1S))$ Γ_8/Γ_2

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	CHISTOV	04	BELL	$B\to KD^0\overline{D}^0$

$\Gamma(D^+D^-)/\Gamma(\pi^+\pi^-J/\psi(1S))$ Γ_9/Γ_2

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	CHISTOV	04	BELL	$B\to KD^+D^-$

$\Gamma(\gamma\chi_{c1})/\Gamma(\pi^+\pi^-J/\psi(1S))$ Γ_{10}/Γ_2

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.89	90	CHOI	03	BELL	$B\to K\pi^+\pi^-J/\psi$

$\Gamma(\eta J/\psi)/\Gamma(\pi^+\pi^-J/\psi(1S))$ Γ_{11}/Γ_2

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.6	90	AUBERT	04Y	BABR	$B\to K\eta J/\psi$

$\Gamma(\gamma J/\psi)/\Gamma_{total}$ Γ_{12}/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$>6\times10^{-3}$		[29] BHARDWAJ	11	BELL	$B^\pm\to\gamma J/\psi K^\pm$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$>9\times10^{-3}$	20	[30] AUBERT	09B	BABR	$B^+\to\gamma J/\psi K^+$
>0.010	19	[31] AUBERT,BE	06M	BABR	$B^+\to\gamma J/\psi K^+$

[29] BHARDWAJ 11 reports $[\Gamma(X(3872) \to \gamma J/\psi)/\Gamma_{\text{total}}] \times [\text{B}(B^+ \to X(3872)K^+)] = (1.78^{+0.48}_{-0.44} \pm 0.12) \times 10^{-6}$ which we divide by our best value $\text{B}(B^+ \to X(3872)K^+) < 3.2 \times 10^{-4}$.

[30] AUBERT 09B reports $[\Gamma(X(3872) \to \gamma J/\psi)/\Gamma_{\text{total}}] \times [\text{B}(B^+ \to X(3872)K^+)] = (2.8 \pm 0.8 \pm 0.1) \times 10^{-6}$ which we divide by our best value $\text{B}(B^+ \to X(3872)K^+) < 3.2 \times 10^{-4}$.

[31] Superseded by AUBERT 09B. AUBERT,BE 06M reports $[\Gamma(X(3872) \to \gamma J/\psi)/\Gamma_{\text{total}}] \times [\text{B}(B^+ \to X(3872)K^+)] = (3.3 \pm 1.0 \pm 0.3) \times 10^{-6}$ which we divide by our best value $\text{B}(B^+ \to X(3872)K^+) < 3.2 \times 10^{-4}$.

$\Gamma(\gamma\psi(2S))/\Gamma_{\text{total}}$ Γ_{13}/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
not seen		[32] BHARDWAJ	11	BELL	$B^+ \to \gamma\psi(2S)K^+$
>0.030	25 ± 7	[33] AUBERT	09B	BABR	$B^+ \to \gamma\psi(2S)K^+$

[32] BHARDWAJ 11 reports $\text{B}(B^+ \to K^+X(3872)) \times \text{B}(X \to \gamma\psi(2S)) < 3.45 \times 10^{-6}$ at 90% CL.

[33] AUBERT 09B reports $[\Gamma(X(3872) \to \gamma\psi(2S))/\Gamma_{\text{total}}] \times [\text{B}(B^+ \to X(3872)K^+)] = (9.5 \pm 2.7 \pm 0.6) \times 10^{-6}$ which we divide by our best value $\text{B}(B^+ \to X(3872)K^+) < 3.2 \times 10^{-4}$.

$\Gamma(\gamma\psi(2S))/\Gamma(\gamma J/\psi)$ Γ_{13}/Γ_{12}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<2.1	90	BHARDWAJ	11	BELL	$B^+ \to K^+\psi(2S)\gamma$
3.4±1.4		AUBERT	09B	BABR	$B^+ \to \gamma c\overline{c}K'$

$X(3872)$ REFERENCES

AAIJ	12H	EPJ C72 1972	R. Aaij *et al.*	(LHCb Collab.)
BHARDWAJ	11	PRL 107 091803	V. Bhardwaj *et al.*	(BELLE Collab.)
CHOI	11	PR D84 052004	S.-K. Choi *et al.*	(BELLE Collab.)
AUSHEV	10	PR D81 031103R	T. Aushev *et al.*	(BELLE Collab.)
DEL-AMO-SA...	10B	PR D82 011101R	P. del Amo Sanchez *et al.*	(BABAR Collab.)
AALTONEN	09AU	PRL 103 152001	T. Aaltonen *et al.*	(CDF Collab.)
AUBERT	09B	PRL 102 132001	B. Aubert *et al.*	(BABAR Collab.)
AUBERT	08B	PR D77 011102R	B. Aubert *et al.*	(BABAR Collab.)
AUBERT	08Y	PR D77 111101R	B. Aubert *et al.*	(BABAR Collab.)
ABULENCIA	07E	PRL 98 132002	A. Abulencia *et al.*	(CDF Collab.)
AUBERT	06	PR D73 011101R	B. Aubert *et al.*	(BABAR Collab.)
AUBERT,BE	06M	PR D74 071101R	B. Aubert *et al.*	(BABAR Collab.)
GOKHROO	06	PRL 97 162002	G. Gokhroo *et al.*	(BELLE Collab.)
AUBERT	05B	PR D71 031501R	B. Aubert *et al.*	(BABAR Collab.)
AUBERT	05D	PR D71 052001	B. Aubert *et al.*	(BABAR Collab.)
AUBERT	05R	PR D71 071103R	B. Aubert *et al.*	(BABAR Collab.)
DOBBS	05	PRL 94 032004	S. Dobbs *et al.*	(CLEO Collab.)
ABAZOV	04F	PRL 93 162002	V.M. Abazov *et al.*	(D0 Collab.)
ACOSTA	04	PRL 93 072001	D. Acosta *et al.*	(CDF Collab.)
AUBERT	04Y	PRL 93 041801	B. Aubert *et al.*	(BaBar Collab.)
CHISTOV	04	PRL 93 051803	R. Chistov *et al.*	(BELLE Collab.)
PDG	04	PL B592 1	S. Eidelman *et al.*	(PDG Collab.)
YUAN	04	PL B579 74	C.Z. Yuan *et al.*	
CHOI	03	PRL 91 262001	S.-K. Choi *et al.*	(BELLE Collab.)
BAI	98E	PR D57 3854	J.Z. Bai *et al.*	(BES Collab.)
ANTONIAZZI	94	PR D50 4258	L. Antoniazzi *et al.*	(E705 Collab.)