

X(1835)

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

OMITTED FROM SUMMARY TABLE

Could be a superposition of two states, one with small width appearing as threshold enhancement in $p\bar{p}$, the other one with a larger width. For the former ABLIKIM 12D determine $J^{PC} = 0^-+$.

X(1835) MASS

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
1826.5^{+13.0}_{-3.4} OUR AVERAGE				
1825.3 ± 2.4 ^{+17.3} _{-2.4}		¹ ABLIKIM	16J BES3	$J/\psi \rightarrow \gamma\pi^+\pi^-\eta'$
1844 ± 9 ⁺¹⁶ ₋₂₅		ABLIKIM	15T BES3	$J/\psi \rightarrow \gamma K_S^0 K_S^0 \eta$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1839 ± 26 ± 26		² ABLIKIM	18I BES3	$J/\psi \rightarrow \gamma\gamma\phi(1020)$
1909.5 ± 15.9 ^{+9.4} _{-27.5}		³ ABLIKIM	16J BES3	$J/\psi \rightarrow \gamma\pi^+\pi^-\eta'$
1842.2 ± 4.2 ^{+7.1} _{-2.6}	0.6k	ABLIKIM	13U BES3	$J/\psi \rightarrow \gamma 3(\pi^+\pi^-)$
1832 ⁺¹⁹ ₋₅ ± 26		⁴ ABLIKIM	12D BES3	$J/\psi \rightarrow \gamma p\bar{p}$
1836.5 ± 3.0 ^{+5.6} _{-2.1}	4265	⁵ ABLIKIM	11C BES3	$J/\psi \rightarrow \gamma\pi^+\pi^-\eta'$
1877.3 ± 6.3 ^{+3.4} _{-7.4}		⁶ ABLIKIM	11J BES3	$J/\psi \rightarrow \omega(\eta\pi^+\pi^-)$
1837 ⁺¹⁰ ₋₁₂ ⁺⁹ ₋₇	231	^{7,8} ALEXANDER	10 CLEO	$J/\psi \rightarrow \gamma p\bar{p}$
1833.7 ± 6.1 ± 2.7	264	ABLIKIM	05R BES2	$J/\psi \rightarrow \gamma\pi^+\pi^-\eta'$
1831 ± 7		^{8,9} ABLIKIM	05R BES2	$J/\psi \rightarrow \gamma p\bar{p}$
1859 ⁺³ ₋₁₀ ⁺⁵ ₋₂₅		⁸ BAI	03F BES2	$J/\psi \rightarrow \gamma p\bar{p}$

¹ From a fit of the measured $\pi^+\pi^-\eta'$ lineshape that accounts for the abrupt distortion observed at the $p\bar{p}$ threshold through interference with a second previously unseen narrow resonance near 1870 MeV. The fit uses Breit-Wigner functions for the signal shapes and includes known backgrounds and contributors.

² From a fit to $\gamma\phi$ invariant mass. Angular analysis consistent with $J^{PC} = 0^-+$. Other J^{PC} not excluded.

³ Pole mass from a fit of the measured $\pi^+\pi^-\eta'$ lineshape to a Flatte formula that accounts for the abrupt distortion observed at the $p\bar{p}$ threshold; the fit also includes known backgrounds and contributors, as well as an *ad hoc* Breit-Wigner function ($M \approx 1919$ MeV; $\Gamma \approx 51$ MeV) that is required for a good fit.

⁴ From the fit including final state interaction effects in isospin 0 S-wave according to SIBIRTSEV 05A. Supersedes ABLIKIM 10G.

⁵ From a fit of the $\pi^+\pi^-\eta'$ mass distribution to a combination of $\gamma f_1(1510)$, $\gamma X(1835)$, and two states $\gamma X(2120)$ and $\gamma X(2370)$, for $M(\pi^+\pi^-\eta') < 2.8$ GeV, and accounting for backgrounds from non- η' events and $J/\psi \rightarrow \pi^0\pi^+\pi^-\eta'$.

⁶ The selected process is $J/\psi \rightarrow \omega a_0(980)\pi$. This state may be due also to $\eta_2(1870)$ or to a combination of $X(1835)$ and $\eta_2(1870)$.

⁷ From a fit of the $p\bar{p}$ mass distribution to a combination of $\gamma X(1835)$, γR with $M(R) = 2100$ MeV and $\Gamma(R) = 160$ MeV, and $\gamma p\bar{p}$ phase space, for $M(p\bar{p}) < 2.85$ GeV.

⁸Evidence for a threshold enhancement in the $p\bar{p}$ mass spectrum was also reported by ABE 02K, AUBERT,B 05L, and WANG 05A in $B^+ \rightarrow p\bar{p}K^+$, WANG 05A in $B^0 \rightarrow p\bar{p}K_S^0$, ABE 02W in $\bar{B}^0 \rightarrow p\bar{p}D^0$, DEL-AMO-SANCHEZ 12 in $B \rightarrow D(D^*)p\bar{p}(\pi)$, and WEI 08 in $B^+ \rightarrow p\bar{p}\pi^+$ decays. Not seen by ATHAR 06 in $\Upsilon(1S) \rightarrow p\bar{p}\gamma$.

⁹From the fit including final state interaction effects in isospin 0 S -wave according to SIBIRTSEV 05A. Systematic errors not estimated.

X(1835) WIDTH

VALUE (MeV)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
242	+14				
-15					OUR AVERAGE
245.2 ± 13.1		4.6	¹ ABLIKIM	16J BES3	$J/\psi \rightarrow \gamma\pi^+\pi^-\eta'$
		9.6			
192	+20	+62	ABLIKIM	15T BES3	$J/\psi \rightarrow \gamma K_S^0 K_S^0 \eta$
	-17	-43			
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
175 ± 57	± 25		² ABLIKIM	18I BES3	$J/\psi \rightarrow \gamma\gamma\phi(1020)$
273.5 ± 21.4	+ 6.1		³ ABLIKIM	16J BES3	$J/\psi \rightarrow \gamma\pi^+\pi^-\eta'$
	-64.0				
83 ± 14	± 11	0.6k	ABLIKIM	13U BES3	$J/\psi \rightarrow \gamma 3(\pi^+\pi^-)$
< 76		90	⁴ ABLIKIM	12D BES3	$J/\psi \rightarrow \gamma p\bar{p}$
190 ± 9	+38	4265	⁵ ABLIKIM	11C BES3	$J/\psi \rightarrow \gamma\pi^+\pi^-\eta'$
	-36				
57 ± 12	+19		⁶ ABLIKIM	11J BES3	$J/\psi \rightarrow \omega(\eta\pi^+\pi^-)$
	-4				
0	+44	231	^{7,8} ALEXANDER	10 CLEO	$J/\psi \rightarrow \gamma p\bar{p}$
	-0				
67.7 ± 20.3	± 7.7	264	ABLIKIM	05R BES2	$J/\psi \rightarrow \gamma\pi^+\pi^-\eta'$
< 153		90	^{8,9} ABLIKIM	05R BES2	$J/\psi \rightarrow \gamma p\bar{p}$
< 30			⁸ BAI	03F BES2	$J/\psi \rightarrow \gamma p\bar{p}$

¹From a fit of the measured $\pi^+\pi^-\eta'$ lineshape that accounts for the abrupt distortion observed at the $p\bar{p}$ threshold through interference with a second previously unseen narrow resonance near 1870 MeV. The fit uses Breit-Wigner functions for the signal shapes and includes known backgrounds and contributors.

²From a fit to $\gamma\phi$ invariant mass. Angular analysis consistent with $J^{PC} = 0^{-+}$. Other J^{PC} not excluded.

³Pole width from a fit of the measured $\pi^+\pi^-\eta'$ lineshape to a Flatté formula that accounts for the abrupt distortion observed at the $p\bar{p}$ threshold; the fit also includes known backgrounds and contributors, as well as an *ad hoc* Breit-Wigner function ($M \approx 1919$ MeV; $\Gamma \approx 51$ MeV) that is required for a good fit.

⁴From the fit including final state interaction effects in isospin 0 S -wave according to SIBIRTSEV 05A. Supersedes ABLIKIM 10G.

⁵From a fit of the $\pi^+\pi^-\eta'$ mass distribution to a combination of $\gamma f_1(1510)$, $\gamma X(1835)$, and two states $\gamma X(2120)$ and $\gamma X(2370)$, for $M(\pi^+\pi^-\eta') < 2.8$ GeV, and accounting for backgrounds from non- η' events and $J/\psi \rightarrow \pi^0\pi^+\pi^-\eta'$.

⁶The selected process is $J/\psi \rightarrow \omega a_0(980)\pi$. This state may be due also to $\eta_2(1870)$ or to a combination of $X(1835)$ and $\eta_2(1870)$.

⁷From a fit of the $p\bar{p}$ mass distribution to a combination of $\gamma X(1835)$, γR with $M(R) = 2100$ MeV and $\Gamma(R) = 160$ MeV, and $\gamma p\bar{p}$ phase space, for $M(p\bar{p}) < 2.85$ GeV.

⁸Evidence for a threshold enhancement in the $p\bar{p}$ mass spectrum was also reported by ABE 02K, AUBERT,B 05L, and WANG 05A in $B^+ \rightarrow p\bar{p}K^+$, WANG 05A in $B^0 \rightarrow$

$p\bar{p}K_S^0$, ABE 02W in $\bar{B}^0 \rightarrow p\bar{p}D^0$, DEL-AMO-SANCHEZ 12 in $B \rightarrow D(D^*)p\bar{p}(\pi)$, and WEI 08 in $B^+ \rightarrow p\bar{p}\pi^+$ decays. Not seen by ATHAR 06 in $\Upsilon(1S) \rightarrow p\bar{p}\gamma$.

⁹From the fit including final state interaction effects in isospin 0 S -wave according to SIBIRTSEV 05A. Systematic errors not estimated.

X(1835) DECAY MODES

Mode	Fraction (Γ_i/Γ)
Γ_1 $p\bar{p}$	seen
Γ_2 $\eta'\pi^+\pi^-$	seen
Γ_3 $\gamma\gamma$	
Γ_4 $K_S^0 K_S^0 \eta$	seen
Γ_5 $\gamma\phi(1020)$	possibly seen
Γ_6 $3(\pi^+\pi^-)$	seen

X(1835) $\Gamma(i)\Gamma(\gamma\gamma)/\Gamma(\text{total})$

$\Gamma(\eta'\pi^+\pi^-) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$					$\Gamma_2\Gamma_3/\Gamma$
VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT	

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<35.6	90	¹ ZHANG	12A BELL	$e^+e^- \rightarrow e^+e^-\eta'\pi^+\pi^-$	
<83	90	² ZHANG	12A BELL	$e^+e^- \rightarrow e^+e^-\eta'\pi^+\pi^-$	

¹From a two-resonance fit and constructive interference of the $\eta(1760)$ and $X(1835)$, a significance of 2.8σ .

²From a two-resonance fit and destructive interference of the $\eta(1760)$ and $X(1835)$, a significance of 2.8σ .

X(1835) BRANCHING RATIOS

$\Gamma(p\bar{p})/\Gamma(\eta'\pi^+\pi^-)$				Γ_1/Γ_2
VALUE	DOCUMENT ID	TECN	COMMENT	

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

0.333	ABLIKIM	05R BES2	$J/\psi \rightarrow \gamma\pi^+\pi^-\eta'$	
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$\Gamma(\eta'\pi^+\pi^-)/\Gamma(K_S^0 K_S^0 \eta)$				Γ_2/Γ_4
VALUE	DOCUMENT ID	TECN	COMMENT	

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

6.7 ± 1.8	¹ ABLIKIM	15T BES3	$J/\psi \rightarrow \gamma K_S^0 K_S^0 \eta$	
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¹Using results from ABLIKIM 05R.

$\Gamma(\eta' \pi^+ \pi^-)/\Gamma_{\text{total}}$ Γ_2/Γ

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
seen	¹ ABLIKIM 16J	BES3	$J/\psi \rightarrow \gamma \pi^+ \pi^- \eta'$

¹ ABLIKIM 16J quotes $B(J/\psi \rightarrow \gamma X(1835)) \times B(X(1835) \rightarrow \pi^+ \pi^- \eta') = (3.93 \pm 0.38^{+0.31}_{-0.84}) \times 10^{-4}$ from a fit of the measured $\pi^+ \pi^- \eta'$ lineshape that accounts for the abrupt distortion observed at the $p\bar{p}$ threshold with a Flatte formula in addition to known backgrounds and contributors, as well as an *ad hoc* Breit-Wigner ($M \approx 1919$ MeV; $\Gamma \approx 51$ MeV) that is required for a good fit. Another explanation for the distortion provided by ABLIKIM 16J is that a second resonance near 1870 MeV interferes with the $X(1835)$; fits to this possibility yield product branching fraction values compatible with that shown within the respective systematic uncertainties.

 $\Gamma(\gamma\phi(1020))/\Gamma_{\text{total}}$ Γ_5/Γ

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
possibly seen	¹ ABLIKIM 18I	BES3	$J/\psi \rightarrow \gamma \gamma \phi(1020)$

¹ Seen as a peak in $\gamma\phi$ invariant mass. Angular analysis consistent with $J^{PC} = 0^{-+}$. Other J^{PC} not excluded.

 $\Gamma(\gamma\gamma)/\Gamma(\eta' \pi^+ \pi^-)$ Γ_3/Γ_2

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$<9.80 \times 10^{-3}$	90	¹ ABLIKIM 18O	BES3	$\psi(2S) \rightarrow \pi^+ \pi^- \gamma \gamma$

¹ Using results from ABLIKIM 16J.

 $\Gamma(3(\pi^+ \pi^-))/\Gamma_{\text{total}}$ Γ_6/Γ

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
seen	0.6k	ABLIKIM 13U	BES3	$J/\psi \rightarrow \gamma 3(\pi^+ \pi^-)$

X(1835) REFERENCES

ABLIKIM 18I	PR D97 051101	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM 18O	PR D97 072014	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM 16J	PRL 117 042002	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM 15T	PRL 115 091803	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM 13U	PR D88 091502	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM 12D	PRL 108 112003	M. Ablikim <i>et al.</i>	(BESIII Collab.) JPC
DEL-AMO-SA... 12	PR D85 092017	P. del Amo Sanchez <i>et al.</i>	(BABAR Collab.)
ZHANG 12A	PR D86 052002	C.C. Zhang <i>et al.</i>	(BELLE Collab.)
ABLIKIM 11C	PRL 106 072002	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM 11J	PRL 107 182001	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM 10G	CP C34 421	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ALEXANDER 10	PR D82 092002	J.P. Alexander <i>et al.</i>	(CLEO Collab.)
WEI 08	PL B659 80	J.-T. Wei <i>et al.</i>	(BELLE Collab.)
ATHAR 06	PR D73 032001	S.B. Athar <i>et al.</i>	(CLEO Collab.)
ABLIKIM 05R	PRL 95 262001	M. Ablikim <i>et al.</i>	(BES Collab.)
AUBERT,B 05L	PR D72 051101	B. Aubert <i>et al.</i>	(BABAR Collab.)
SIBIRTSEV 05A	PR D71 054010	A. Sibirtsev, J. Haidenbauer	
WANG 05A	PL B617 141	M.-Z. Wang <i>et al.</i>	(BELLE Collab.)
BAI 03F	PRL 91 022001	J.Z. Bai <i>et al.</i>	(BES II Collab.)
ABE 02K	PRL 88 181803	K. Abe <i>et al.</i>	(BELLE Collab.)
ABE 02W	PRL 89 151802	K. Abe <i>et al.</i>	(BELLE Collab.)