

$\psi(4360)$

$$I^G(J^{PC}) = 0^-(1^{--})$$

also known as $Y(4360)$; was $X(4360)$

This state shows properties different from a conventional $q\bar{q}$ state.
A candidate for an exotic structure. See the review on non- $q\bar{q}$ states.

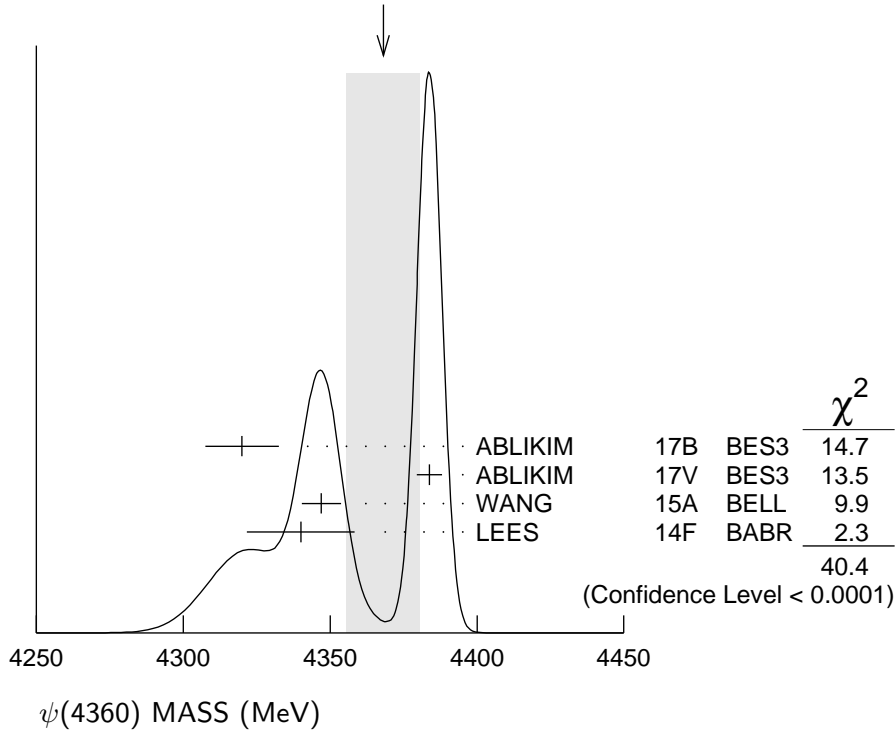
Seen in radiative return from e^+e^- collisions at $\sqrt{s} = 9.54\text{--}10.58$ GeV by AUBERT 07S, WANG 07D, and LEES 14F. See also the review on "Spectroscopy of mesons containing two heavy quarks."

 $\psi(4360)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
4368 ± 13	OUR AVERAGE	Error includes scale factor of 3.7. See the ideogram below.		
4320.0 ± 10.4 ± 7.0		¹ ABLIKIM 17B	BES3	$e^+e^- \rightarrow \pi^+\pi^- J/\psi$
4383.8 ± 4.2 ± 0.8		² ABLIKIM 17V	BES3	$e^+e^- \rightarrow \pi^+\pi^- \psi(2S)$
4347 ± 6 ± 3	279	³ WANG 15A	BELL	10.58 $e^+e^- \rightarrow \gamma\pi^+\pi^- \psi(2S)$
4340 ± 16 ± 9	37	⁴ LEES 14F	BABR	10.58 $e^+e^- \rightarrow \gamma\pi^+\pi^- \psi(2S)$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
4383.7 ± 2.9 ± 6.2		⁵ ZHANG 17B	RVUE	$e^+e^- \rightarrow \pi^+\pi^- \psi(2S)$
4386.4 ± 2.1 ± 6.4		⁶ ZHANG 17C	RVUE	$e^+e^- \rightarrow \pi^+\pi^- J/\psi$ or $\psi(2S)$
4355 $^{+9}_{-10}$ ± 9	74	⁷ LIU 08H	RVUE	10.58 $e^+e^- \rightarrow \gamma\pi^+\pi^- \psi(2S)$
4324 ± 24		⁸ AUBERT 07S	BABR	10.58 $e^+e^- \rightarrow \gamma\pi^+\pi^- \psi(2S)$
4361 ± 9 ± 9	47	⁴ WANG 07D	BELL	10.58 $e^+e^- \rightarrow \gamma\pi^+\pi^- \psi(2S)$

¹ From a three-resonance fit.² From a fit to the cross section for $e^+e^- \rightarrow \pi^+\pi^- \psi(2S) \rightarrow 2(\pi^+\pi^-)\ell^+\ell^-$ obtained from 16 center-of-mass energies between 4.008 and 4.600 GeV and comprising 5.1 fb^{-1} .³ From a two-resonance fit. Supersedes WANG 07D.⁴ From a two-resonance fit.⁵ From a three-resonance fit.⁶ From a combined fit of BELLE, BABAR and BES3 $e^+e^- \rightarrow \pi^+\pi^- J/\psi$ and $e^+e^- \rightarrow \pi^+\pi^- \psi(2S)$ data.⁷ From a combined fit of AUBERT 07S and WANG 07D data with two resonances.⁸ From a single-resonance fit. Systematic errors not estimated.

WEIGHTED AVERAGE
 4368 ± 13 (Error scaled by 3.7)



$\psi(4360)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
96 ± 7 OUR AVERAGE				
$101.4^{+25.3}_{-19.7} \pm 10.2$		1 ABLIKIM 17B	BES3	$e^+e^- \rightarrow \pi^+\pi^- J/\psi$
$84.2 \pm 12.5 \pm 2.1$		2 ABLIKIM 17V	BES3	$e^+e^- \rightarrow \pi^+\pi^- \psi(2S)$
$103 \pm 9 \pm 5$	279	3 WANG 15A	BELL	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^- \psi(2S)$
$94 \pm 32 \pm 13$	37	4 LEES 14F	BABR	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^- \psi(2S)$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$94.2 \pm 7.3 \pm 2.0$		5 ZHANG 17B	RVUE	$e^+e^- \rightarrow \pi^+\pi^- \psi(2S)$
$96.0 \pm 6.7 \pm 2.7$		6 ZHANG 17C	RVUE	$e^+e^- \rightarrow \pi^+\pi^- J/\psi$ or $\psi(2S)$
$103^{+17}_{-15} \pm 11$	74	7 LIU 08H	RVUE	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^- \psi(2S)$
172 ± 33		8 AUBERT 07S	BABR	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^- \psi(2S)$
$74 \pm 15 \pm 10$	47	4 WANG 07D	BELL	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^- \psi(2S)$

¹ From a three-resonance fit.

² From a fit to the cross section for $e^+e^- \rightarrow \pi^+\pi^- \psi(2S) \rightarrow 2(\pi^+\pi^-)\ell^+\ell^-$ obtained from 16 center-of-mass energies between 4.008 and 4.600 GeV and comprising 5.1 fb^{-1} .

³ From a two-resonance fit. Supersedes WANG 07D.

⁴ From a two-resonance fit.

⁵ From a three-resonance fit.

⁶ From a combined fit of BELLE, BABAR and BES3 $e^+e^- \rightarrow \pi^+\pi^- J/\psi$ and $e^+e^- \rightarrow \pi^+\pi^- \psi(2S)$ data.

⁷ From a combined fit of AUBERT 07S and WANG 07D data with two resonances.

⁸ From a single-resonance fit. Systematic errors not estimated.

$\psi(4360)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)
Γ_1 e^+e^-	
Γ_2 $J/\psi\pi^+\pi^-$	
Γ_3 $\psi(2S)\pi^+\pi^-$	seen
Γ_4 $\psi_2(3823)\pi^+\pi^-$	possibly seen
Γ_5 $J/\psi\eta$	
Γ_6 $D^0D^{*-}\pi^+$	
Γ_7 $D_1(2420)\bar{D} + \text{c.c.}$	possibly seen
Γ_8 $\chi_{c1}\gamma$	
Γ_9 $\chi_{c2}\gamma$	

 $\psi(4360) \Gamma(i) \times \Gamma(e^+e^-)/\Gamma(\text{total})$ **$\Gamma(\psi(2S)\pi^+\pi^-) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_3\Gamma_1/\Gamma$**

VALUE (eV)	EVTS	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
7.3 ± 2.8		¹ ABLIKIM	19K BES3	$e^+e^- \rightarrow \pi^+\pi^-\psi(2S)$
11.0 ± 3.8		² ABLIKIM	19K BES3	$e^+e^- \rightarrow \pi^+\pi^-\psi(2S)$
$9.2 \pm 0.6 \pm 0.6$	279	³ WANG	15A BELL	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^-\psi(2S)$
$10.9 \pm 0.6 \pm 0.7$	279	⁴ WANG	15A BELL	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^-\psi(2S)$
$6.0 \pm 1.0 \pm 0.5$	37	¹ LEES	14F BABR	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^-\psi(2S)$
$7.2 \pm 1.0 \pm 0.6$	37	² LEES	14F BABR	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^-\psi(2S)$
$11.1^{+1.3}_{-1.2}$	74	⁵ LIU	08H RVUE	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^-\psi(2S)$
12.3 ± 1.2	74	⁶ LIU	08H RVUE	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^-\psi(2S)$
$10.4 \pm 1.7 \pm 1.5$	47	¹ WANG	07D BELL	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^-\psi(2S)$
$11.8 \pm 1.8 \pm 1.4$	47	² WANG	07D BELL	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^-\psi(2S)$

¹ Solution I of two equivalent solutions in a fit using two interfering resonances.² Solution II of two equivalent solutions in a fit using two interfering resonances.³ Solution I of two equivalent solutions from a fit using two interfering resonances. Supersedes WANG 07D.⁴ Solution II of two equivalent solutions from a fit using two interfering resonances. Supersedes WANG 07D.⁵ Solution I in a combined fit of AUBERT 07S and WANG 07D data with two resonances.⁶ Solution II in a combined fit of AUBERT 07S and WANG 07D data with two resonances. **$\Gamma(J/\psi\eta) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_5\Gamma_1/\Gamma$**

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
<6.8	90	WANG	13B BELL	$e^+e^- \rightarrow J/\psi\eta\gamma$

 $\Gamma(\chi_{c1}\gamma) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_8\Gamma_1/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
<0.57	90	¹ HAN	15 BELL	$10.58 e^+e^- \rightarrow \chi_{c1}\gamma$

¹ Using $B(\eta \rightarrow \gamma\gamma) = (39.41 \pm 0.21)\%$.

$\Gamma(\chi_{c2}\gamma) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$					$\Gamma_9\Gamma_1/\Gamma$
VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT	
<1.9	90	¹ HAN	15	BELL	10.58 $e^+e^- \rightarrow \chi_{c2}\gamma$

¹ Using $B(\eta \rightarrow \gamma\gamma) = (39.41 \pm 0.21)\%$.

 $\psi(4360)$ BRANCHING RATIOS

$\Gamma(D^0 D^{*-} \pi^+)/\Gamma(\psi(2S)\pi^+\pi^-)$					Γ_6/Γ_3
VALUE	CL%	DOCUMENT ID	TECN	COMMENT	
<8	90	PAKHLOVA	09	BELL	$e^+e^- \rightarrow \psi(4360) \rightarrow D^0 D^{*-} \pi^+$

$\Gamma(\psi(2S)\pi^+\pi^-)/\Gamma_{\text{total}}$					Γ_3/Γ
VALUE	DOCUMENT ID	TECN	COMMENT		
seen	¹ ABLIKIM	17V	BES3	$e^+e^- \rightarrow \pi^+\pi^-\psi(2S)$	

¹ From a fit to the cross section for $e^+e^- \rightarrow \pi^+\pi^-\psi(2S) \rightarrow 2(\pi^+\pi^-)\ell^+\ell^-$ obtained from 16 center-of-mass energies between 4.008 and 4.600 GeV and comprising 5.1 fb^{-1} .

$\Gamma(\psi(2S)\pi^+\pi^-)/\Gamma(J/\psi\pi^+\pi^-)$					Γ_3/Γ_2
VALUE	DOCUMENT ID	TECN	COMMENT		
• • • We do not use the following data for averages, fits, limits, etc. • • •					
($0.81 \pm 0.12 \pm 0.13$) to ($42 \pm 15 \pm 15$)	¹ ZHANG	17C	RVUE	$e^+e^- \rightarrow \pi^+\pi^- J/\psi$ or $\psi(2S)$	

¹ From a combined fit of BELLE, BABAR and BES3 $e^+e^- \rightarrow \pi^+\pi^- J/\psi$ and $e^+e^- \rightarrow \pi^+\pi^-\psi(2S)$ data.

$\Gamma(\psi_2(3823)\pi^+\pi^-)/\Gamma_{\text{total}}$					Γ_4/Γ
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT	
possibly seen	19	¹ ABLIKIM	15S	BES3	$e^+e^- \rightarrow \pi^+\pi^-\chi_{c1}\gamma$

¹ From a fit of $e^+e^- \rightarrow \pi^+\pi^-\psi_2(3823)$, $\psi_2(3823) \rightarrow \chi_{c1}\gamma$ cross sections taken at \sqrt{s} values of 4.23, 4.26, 4.36, 4.42, and 4.60 GeV to the $\psi(4360)$ line shape.

$\Gamma(D^0 D^{*-} \pi^+)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$					$\Gamma_6/\Gamma \times \Gamma_1/\Gamma$
VALUE	CL%	DOCUMENT ID	TECN	COMMENT	
< 0.72×10^{-6}	90	¹ PAKHLOVA	09	BELL	$e^+e^- \rightarrow \psi(4360) \rightarrow D^0 D^{*-} \pi^+$

¹ Using $4355^{+9}_{-10} \pm 9 \text{ MeV}$ for the mass of $\psi(4360)$.

$\Gamma(D_1(2420)\bar{D} + \text{c.c.})/\Gamma_{\text{total}}$					Γ_7/Γ
VALUE	DOCUMENT ID	TECN	COMMENT		
possibly seen	¹ ABLIKIM	19AR	BES3	$e^+e^- \rightarrow \pi^+\pi^-\bar{D}\bar{D}$	

¹ Evidence for $e^+e^- \rightarrow D_1(2420)\bar{D} + \text{c.c.}$ between $\sqrt{s} = 4.3$ and 4.6 GeV, not necessarily resonant.

$\psi(4360)$ REFERENCES

ABLIKIM	19AR	PR D100 032005	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	19K	PR D99 019903 (errata.)	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	17B	PRL 118 092001	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	17V	PR D96 032004	M. Ablikim <i>et al.</i>	(BESIII Collab.)
Also		PR D99 019903 (errata.)	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ZHANG	17B	PR D96 054008	J. Zhang, J. Zhang	
ZHANG	17C	EPJ C77 727	J. Zhang, L. Yuan	
ABLIKIM	15S	PRL 115 011803	M. Ablikim <i>et al.</i>	(BESIII Collab.)
HAN	15	PR D92 012011	Y.L. Han <i>et al.</i>	(BELLE Collab.)
WANG	15A	PR D91 112007	X.L. Wang <i>et al.</i>	(BELLE Collab.)
LEES	14F	PR D89 111103	J.P. Lees <i>et al.</i>	(BABAR Collab.)
WANG	13B	PR D87 051101	X.L. Wang <i>et al.</i>	(BELLE Collab.)
PAKHLOVA	09	PR D80 091101	G. Pakhlova <i>et al.</i>	(BELLE Collab.)
LIU	08H	PR D78 014032	Z.Q. Liu, X.S. Qin, C.Z. Yuan	
AUBERT	07S	PRL 98 212001	B. Aubert <i>et al.</i>	(BABAR Collab.)
WANG	07D	PRL 99 142002	X.L. Wang <i>et al.</i>	(BELLE Collab.)
