$\psi(4360)$

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

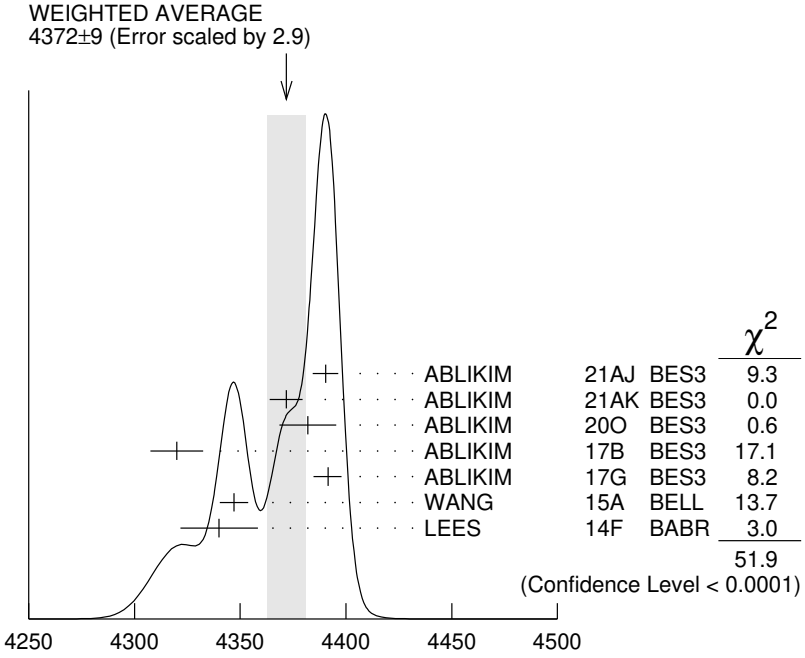
also known as $Y(4360)$; was $X(4360)$

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

Seen in radiative return from e^+e^- collisions at $\sqrt{s} = 9.54$–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*
4372 ± 9 OUR AVERAGE					Error includes scale factor of 2.9. See the ideogram below.
$4390.3 \pm 6.0 \pm 0.7$		[1] ABLIKIM	21AJ	BES3	$e^+e^- \to \pi^+\pi^-\psi(2S)$
$4371.7 \pm 7.5 \pm 1.8$		[2] ABLIKIM	21AK	BES3	$e^+e^- \to \gamma\chi_{c2} \to \gamma\gamma J/\psi$
$4382.0 \pm 13.3 \pm 1.7$		[3] ABLIKIM	20O	BES3	$e^+e^- \to \eta J/\psi$
$4320.0 \pm 10.4 \pm 7.0$		[4] ABLIKIM	17B	BES3	$e^+e^- \to \pi^+\pi^- J/\psi$
$4391.5^{+\ 6.3}_{-\ 6.8} \pm 1.0$		ABLIKIM	17G	BES3	$e^+e^- \to \pi^+\pi^- h_c$
$4347 \pm 6 \pm 3$	279	[5] WANG	15A	BELL	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$
$4340 \pm 16 \pm 9$	37	[6] LEES	14F	BABR	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$4383.8 \pm 4.2 \pm 0.8$		[7] ABLIKIM	17V	BES3	$e^+e^- \to \pi^+\pi^-\psi(2S)$
$4383.7 \pm 2.9 \pm 6.2$		[8] ZHANG	17B	RVUE	$e^+e^- \to \pi^+\pi^-\psi(2S)$
$4386.4 \pm 2.1 \pm 6.4$		[9] ZHANG	17C	RVUE	$e^+e^- \to \pi^+\pi^- J/\psi$ or $\psi(2S)$
$4355\ ^{+\ 9}_{-10} \pm 9$	74	[10] LIU	08H	RVUE	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$
4324 ± 24		[11] AUBERT	07S	BABR	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$
$4361 \pm 9 \pm 9$	47	[6] WANG	07D	BELL	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$



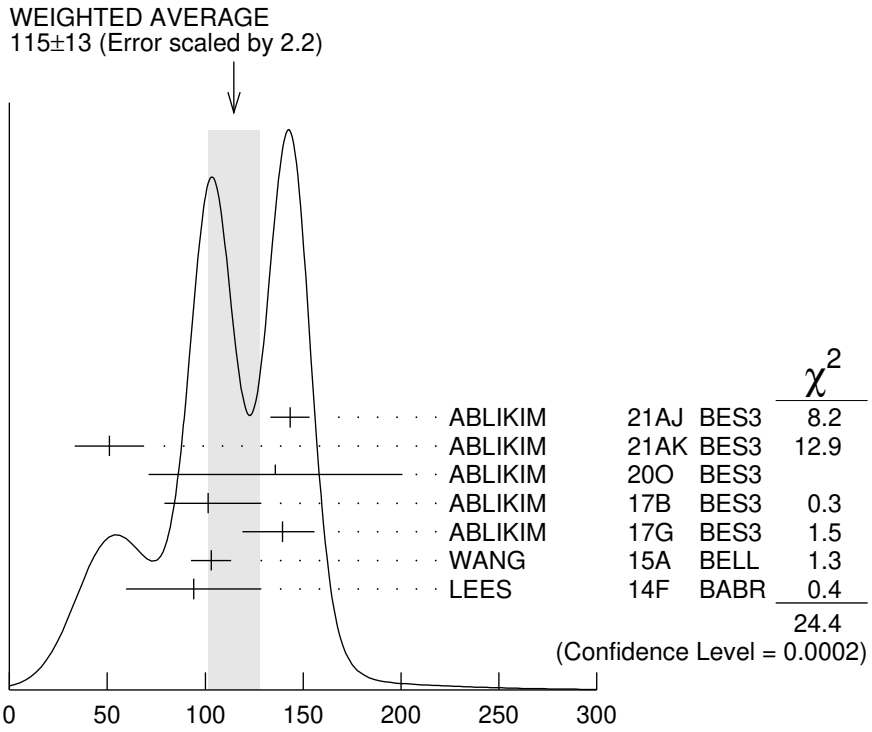
[1] From a three-resonance fit to the Born cross section in the range $\sqrt{s}$ = 4.008–4.698 GeV.
[2] From a five-resonance fit to the cross section for $e^+e^- \to \gamma\gamma J/\psi \to \gamma\gamma\ell^+\ell^-$.
[3] From a fit of the measured cross section in the range $\sqrt{s}$ = 3.808–4.600 GeV.
[4] From a three-resonance fit.
[5] From a two-resonance fit. Supersedes WANG 07D.
[6] From a two-resonance fit.
[7] From a fit to the cross section for $e^+e^- \to \pi^+\pi^-\psi(2S) \to 2(\pi^+\pi^-)\ell^+\ell^-$ obtained from 16 center-of-mass energies between 4.008 and 4.600 GeV and comprising 5.1 fb^{-1}. Superseded by ABLIKIM 21AJ.
[8] From a three-resonance fit.
[9] From a combined fit of BELLE, BABAR and BES3 $e^+e^- \to \pi^+\pi^- J/\psi$ and $e^+e^- \to \pi^+\pi^-\psi(2S)$ data.
[10] From a combined fit of AUBERT 07S and WANG 07D data with two resonances.
[11] From a single-resonance fit. Systematic errors not estimated.

$\psi(4360)$ MASS (MeV)

$\psi(4360)$ WIDTH

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
115 ±13 OUR AVERAGE		Error includes scale factor of 2.2. See the ideogram below.			
$143.3 \pm 10.0 \pm 0.5$		[1] ABLIKIM	21AJ	BES3	$e^+e^- \to \pi^+\pi^-\psi(2S)$
$51.1 \pm 17.6 \pm 1.9$		[2] ABLIKIM	21AK	BES3	$e^+e^- \to \gamma\chi_{c2} \to \gamma\gamma J/\psi$
$135.8 \pm 60.8 \pm 22.5$		[3] ABLIKIM	20O	BES3	$e^+e^- \to \eta J/\psi$
$101.4^{+25.3}_{-19.7} \pm 10.2$		[4] ABLIKIM	17B	BES3	$e^+e^- \to \pi^+\pi^- J/\psi$
$139.5^{+16.2}_{-20.6} \pm 0.6$		ABLIKIM	17G	BES3	$e^+e^- \to \pi^+\pi^- h_c$
$103 \pm 9 \pm 5$	279	[5] WANG	15A	BELL	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$
$94 \pm 32 \pm 13$	37	[6] LEES	14F	BABR	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$84.2 \pm 12.5 \pm 2.1$		[7] ABLIKIM	17V	BES3	$e^+e^- \to \pi^+\pi^-\psi(2S)$
$94.2 \pm 7.3 \pm 2.0$		[8] ZHANG	17B	RVUE	$e^+e^- \to \pi^+\pi^-\psi(2S)$
$96.0 \pm 6.7 \pm 2.7$		[9] ZHANG	17C	RVUE	$e^+e^- \to \pi^+\pi^- J/\psi$ or $\psi(2S)$
$103 \ ^{+17}_{-15} \pm 11$	74	[10] LIU	08H	RVUE	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$
172 ± 33		[11] AUBERT	07S	BABR	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$
$74 \pm 15 \pm 10$	47	[6] WANG	07D	BELL	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$

[1] From a three-resonance fit to the Born cross section in the range $\sqrt{s}$ = 4.008–4.698 GeV.
[2] From a five-resonance fit to the cross section for $e^+e^- \to \gamma\gamma J/\psi \to \gamma\gamma\ell^+\ell^-$.
[3] From a fit of the measured cross section in the range $\sqrt{s}$ = 3.808–4.600 GeV.
[4] From a three-resonance fit.
[5] From a two-resonance fit. Supersedes WANG 07D.
[6] From a two-resonance fit.
[7] From a fit to the cross section for $e^+e^- \to \pi^+\pi^-\psi(2S) \to 2(\pi^+\pi^-)\ell^+\ell^-$ obtained from 16 center-of-mass energies between 4.008 and 4.600 GeV and comprising 5.1 fb^{-1}. Superseded by ABLIKIM 21AJ.
[8] From a three-resonance fit.
[9] From a combined fit of BELLE, BABAR and BES3 $e^+e^- \to \pi^+\pi^- J/\psi$ and $e^+e^- \to \pi^+\pi^-\psi(2S)$ data.
[10] From a combined fit of AUBERT 07S and WANG 07D data with two resonances.
[11] From a single-resonance fit. Systematic errors not estimated.



ψ(4360) DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	e^+e^-	
Γ_2	$h_c\pi^+\pi^-$	seen
Γ_3	$J/\psi\pi^+\pi^-$	
Γ_4	$\psi(2S)\pi^+\pi^-$	seen
Γ_5	$\psi(3770)\pi^+\pi^-$	possibly seen
Γ_6	$\psi_2(3823)\pi^+\pi^-$	possibly seen
Γ_7	$J/\psi\eta$	seen
Γ_8	$D^0D^{*-}\pi^+$	
Γ_9	$D_1(2420)\overline{D}+$ c.c.	possibly seen
Γ_{10}	$p\overline{p}\eta$	not seen
Γ_{11}	$p\overline{p}\omega$	not seen
Γ_{12}	$\chi_{c1}\gamma$	
Γ_{13}	$\chi_{c2}\gamma$	

ψ(4360) Γ(i) × Γ(e^+e^-)/Γ(total)

$\Gamma(h_c\pi^+\pi^-) \times \Gamma(e^+e^-)/\Gamma_{total}$ $\Gamma_2\Gamma_1/\Gamma$

VALUE (eV)	*DOCUMENT ID*		*TECN*	*COMMENT*
$11.6^{+5.0}_{-4.4}\pm1.9$	ABLIKIM	17G	BES3	$e^+e^- \to \pi^+\pi^- h_c$

$\Gamma(\psi(2S)\pi^+\pi^-) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_4\Gamma_1/\Gamma$

VALUE (eV)	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
10.7±4.1		[1] ABLIKIM	21AJ	BES3	$e^+e^- \to \pi^+\pi^-\psi(2S)$
20.7±2.5		[2] ABLIKIM	21AJ	BES3	$e^+e^- \to \pi^+\pi^-\psi(2S)$
9.9±4.1		[3] ABLIKIM	21AJ	BES3	$e^+e^- \to \pi^+\pi^-\psi(2S)$
19.4±2.0		[4] ABLIKIM	21AJ	BES3	$e^+e^- \to \pi^+\pi^-\psi(2S)$
7.3±2.8		[5] ABLIKIM	19K	BES3	$e^+e^- \to \pi^+\pi^-\psi(2S)$
11.0±3.8		[6] ABLIKIM	19K	BES3	$e^+e^- \to \pi^+\pi^-\psi(2S)$
9.2±0.6±0.6	279	[7] WANG	15A	BELL	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$
10.9±0.6±0.7	279	[8] WANG	15A	BELL	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$
6.0±1.0±0.5	37	[5] LEES	14F	BABR	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$
7.2±1.0±0.6	37	[6] LEES	14F	BABR	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$
$11.1^{+1.3}_{-1.2}$	74	[9] LIU	08H	RVUE	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$
12.3±1.2	74	[10] LIU	08H	RVUE	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$
10.4±1.7±1.5	47	[5] WANG	07D	BELL	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$
11.8±1.8±1.4	47	[6] WANG	07D	BELL	10.58 $e^+e^- \to \gamma\pi^+\pi^-\psi(2S)$

[1] Solution I of four equivalent solutions in a fit using three interfering resonances. Supersedes ABLIKIM 19K.
[2] Solution II of four equivalent solutions in a fit using three interfering resonances. Supersedes ABLIKIM 19K.
[3] Solution III of four equivalent solutions in a fit using three interfering resonances. Supersedes ABLIKIM 19K.
[4] Solution IV of four equivalent solutions in a fit using three interfering resonances. Supersedes ABLIKIM 19K.
[5] Solution I of two equivalent solutions in a fit using two interfering resonances.
[6] Solution II of two equivalent solutions in a fit using two interfering resonances.
[7] Solution I of two equivalent solutions from a fit using two interfering resonances. Supersedes WANG 07D.
[8] Solution II of two equivalent solutions from a fit using two interfering resonances. Supersedes WANG 07D.
[9] Solution I in a combined fit of AUBERT 07S and WANG 07D data with two resonances.
[10] Solution II in a combined fit of AUBERT 07S and WANG 07D data with two resonances.

$\Gamma(J/\psi\eta) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_7\Gamma_1/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
3.4±2.2		[1] ABLIKIM	20O	BES3	$e^+e^- \to \eta J/\psi$
1.5±1.0		[2] ABLIKIM	20O	BES3	$e^+e^- \to \eta J/\psi$
1.7±1.1		[3] ABLIKIM	20O	BES3	$e^+e^- \to \eta J/\psi$
<6.8	90	WANG	13B	BELL	$e^+e^- \to J/\psi\eta\gamma$

[1] Solution 1 of three equivalent fit solutions using three resonant structures.
[2] Solution 2 of three equivalent fit solutions using three resonant structures.
[3] Solution 3 of three equivalent fit solutions using three resonant structures.

$\Gamma(\chi_{c1}\gamma) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_{12}\Gamma_1/\Gamma$

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

[1] Using B($\eta \to \gamma\gamma$) = (39.41 ± 0.21)%.

$\Gamma(\chi_{c2}\gamma) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_{13}\Gamma_1/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID		TECN	COMMENT
<1.9	90	[1] HAN	15	BELL	10.58 $e^+e^- \to \chi_{c2}\gamma$

[1] Using B($\eta \to \gamma\gamma$) = (39.41 ± 0.21)%.

$\psi(4360)$ BRANCHING RATIOS

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

VALUE	DOCUMENT ID		TECN	COMMENT
seen	ABLIKIM	17G	BES3	$e^+e^- \to \pi^+\pi^- h_c$

$\Gamma(\psi(2S)\pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_4/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	[1] ABLIKIM	17V	BES3	$e^+e^- \to \pi^+\pi^-\psi(2S)$

[1] From a fit to the cross section for $e^+e^- \to \pi^+\pi^-\psi(2S) \to 2(\pi^+\pi^-)\ell^+\ell^-$ 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_4/Γ_3

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

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

$\Gamma(\psi(3770)\pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_5/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
possibly seen	[1] ABLIKIM	19AR	BES3	$e^+e^- \to \pi^+\pi^- D\overline{D}$

[1] Observe $e^+e^- \to \pi^+\pi^-\psi(3770)$ at $\sqrt{s}$ = 4.26, 4.36, and 4.42 GeV but cannot establish if continuum or resonant.

$\Gamma(\psi_2(3823)\pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_6/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
possibly seen	19	[1] ABLIKIM	15S	BES3	$e^+e^- \to \pi^+\pi^-\chi_{c1}\gamma$

[1] From a fit of $e^+e^- \to \pi^+\pi^-\psi_2(3823)$, $\psi_2(3823) \to \chi_{c1}\gamma$ 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.

$\Gamma(J/\psi\eta)/\Gamma_{\text{total}}$ Γ_7/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	[1] ABLIKIM	20O	BES3	$e^+e^- \to \eta J/\psi$

[1] With a significance of 6.0 σ.

$\Gamma(D^0D^{*-}\pi^+)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_8/\Gamma \times \Gamma_1/\Gamma$

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.72 × 10^{-6}	90	[1] PAKHLOVA	09	BELL	$e^+e^- \to \psi(4360) \to D^0D^{*-}\pi^+$

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

$\Gamma(D^0 D^{*-}\pi^+)/\Gamma(\psi(2S)\pi^+\pi^-)$ Γ_8/Γ_4

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<8	90	PAKHLOVA	09	BELL	$e^+e^- \to \psi(4360) \to D^0 D^{*-}\pi^+$

$\Gamma(D_1(2420)\overline{D}+\text{c.c.})/\Gamma_{\text{total}}$ Γ_9/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
possibly seen	[1] ABLIKIM	19AR	BES3	$e^+e^- \to \pi^+\pi^- D\overline{D}$

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

$\Gamma(p\overline{p}\eta)/\Gamma_{\text{total}}$ Γ_{10}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
not seen	ABLIKIM	21AN	BES3	$e^+e^- \to p\overline{p}\eta$

$\Gamma(p\overline{p}\omega)/\Gamma_{\text{total}}$ Γ_{11}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
not seen	ABLIKIM	21AN	BES3	$e^+e^- \to p\overline{p}\omega$

$\psi(4360)$ REFERENCES

ABLIKIM	21AJ	PR D104 052012	M. Ablikim *et al.*	(BESIII Collab.)
ABLIKIM	21AK	PR D104 092001	M. Ablikim *et al.*	(BESIII Collab.)
ABLIKIM	21AN	PR D104 092008	M. Ablikim *et al.*	(BESIII Collab.)
ABLIKIM	20O	PR D102 031101	M. Ablikim *et al.*	(BESIII Collab.)
ABLIKIM	19AR	PR D100 032005	M. Ablikim *et al.*	(BESIII Collab.)
ABLIKIM	19K	PR D99 019903 (errat.)	M. Ablikim *et al.*	(BESIII Collab.)
ABLIKIM	17B	PRL 118 092001	M. Ablikim *et al.*	(BESIII Collab.)
ABLIKIM	17G	PRL 118 092002	M. Ablikim *et al.*	(BESIII Collab.)
ABLIKIM	17V	PR D96 032004	M. Ablikim *et al.*	(BESIII Collab.)
Also		PR D99 019903 (errat.)	M. Ablikim *et al.*	(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 *et al.*	(BESIII Collab.)
HAN	15	PR D92 012011	Y.L. Han *et al.*	(BELLE Collab.)
WANG	15A	PR D91 112007	X.L. Wang *et al.*	(BELLE Collab.)
LEES	14F	PR D89 111103	J.P. Lees *et al.*	(BABAR Collab.)
WANG	13B	PR D87 051101	X.L. Wang *et al.*	(BELLE Collab.)
PAKHLOVA	09	PR D80 091101	G. Pakhlova *et al.*	(BELLE Collab.)
LIU	08H	PR D78 014032	Z.Q. Liu, X.S. Qin, C.Z. Yuan	
AUBERT	07S	PRL 98 212001	B. Aubert *et al.*	(BABAR Collab.)
WANG	07D	PRL 99 142002	X.L. Wang *et al.*	(BELLE Collab.)