$\psi(4040)$

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

$\psi(4040)$ MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
4039 ± 1 OUR ESTIMATE				
4039.6± 4.3	[1] ABLIKIM	08D	BES2	$e^+e^- \to$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •				
4034 ± 6	[2] MO	10	RVUE	$e^+e^- \to$ hadrons
4037 ± 2	[3] SETH	05A	RVUE	$e^+e^- \to$ hadrons
4040 ± 1	[4] SETH	05A	RVUE	$e^+e^- \to$ hadrons
4040 ±10	BRANDELIK	78C	DASP	e^+e^-

[1] Reanalysis of data presented in BAI 02C. From a global fit over the center-of-mass energy region 3.7–5.0 GeV covering the $\psi(3770)$, $\psi(4040)$, $\psi(4160)$, and $\psi(4415)$ resonances. Phase angle fixed in the fit to $\delta = (130 \pm 46)^\circ$.

[2] Reanalysis of data presented in BAI 00 and BAI 02C. From a global fit over the center-of-mass energy 3.8-4.8 GeV covering the $\psi(4040)$, $\psi(4160)$ and $\psi(4415)$ resonances and including interference effects.

[3] From a fit to Crystal Ball (OSTERHELD 86) data.

[4] From a fit to BES (BAI 02C) data.

$\psi(4040)$ WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
80 ±10 OUR ESTIMATE				
84.5±12.3	[5] ABLIKIM	08D	BES2	$e^+e^- \to$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •				
87 ±11	[6] MO	10	RVUE	$e^+e^- \to$ hadrons
85 ±10	[7] SETH	05A	RVUE	$e^+e^- \to$ hadrons
89 ± 6	[8] SETH	05A	RVUE	$e^+e^- \to$ hadrons
52 ±10	BRANDELIK	78C	DASP	e^+e^-

[5] Reanalysis of data presented in BAI 02C. From a global fit over the center-of-mass energy region 3.7–5.0 GeV covering the $\psi(3770)$, $\psi(4040)$, $\psi(4160)$, and $\psi(4415)$ resonances. Phase angle fixed in the fit to $\delta = (130 \pm 46)^\circ$.

[6] Reanalysis of data presented in BAI 00 and BAI 02C. From a global fit over the center-of-mass energy 3.8-4.8 GeV covering the $\psi(4040)$, $\psi(4160)$ and $\psi(4415)$ resonances and including interference effects.

[7] From a fit to Crystal Ball (OSTERHELD 86) data.

[8] From a fit to BES (BAI 02C) data.

$\psi(4040)$ DECAY MODES

Due to the complexity of the $c\overline{c}$ threshold region, in this listing, "seen" ("not seen") means that a cross section for the mode in question has been measured at effective $\sqrt{s}$ near this particle's central mass value, more (less) than 2σ above zero, without regard to any peaking behavior in $\sqrt{s}$ or absence thereof. See mode listing(s) for details and references.

	Mode	Fraction (Γ_i/Γ)		Confidence level
Γ_1	e^+e^-	$(1.07\pm0.16)\times10^{-5}$		
Γ_2	$D\overline{D}$	seen		
Γ_3	$D^0\overline{D}^0$	seen		
Γ_4	D^+D^-	seen		
Γ_5	$D^*\overline{D}+$ c.c.	seen		
Γ_6	$D^*(2007)^0\overline{D}^0+$ c.c.	seen		
Γ_7	$D^*(2010)^+D^-+$ c.c.	seen		
Γ_8	$D^*\overline{D}^*$	seen		
Γ_9	$D^*(2007)^0\overline{D}^*(2007)^0$	seen		
Γ_{10}	$D^*(2010)^+D^*(2010)^-$	seen		
Γ_{11}	$D\overline{D}\pi$ (excl. $D^*\overline{D}$)			
Γ_{12}	$D^0D^-\pi^+$+c.c. (excl. $D^*(2007)^0\overline{D}^0$ +c.c., $D^*(2010)^+D^-$ +c.c.)	not seen		
Γ_{13}	$D\overline{D}^*\pi$ (excl. $D^*\overline{D}^*$)	not seen		
Γ_{14}	$D^0\overline{D}^{*-}\pi^+$+c.c. (excl. $D^*(2010)^+D^*(2010)^-$)	seen		
Γ_{15}	$D_s^+D_s^-$	seen		
Γ_{16}	$J/\psi(1S)$ hadrons			
Γ_{17}	$J/\psi\pi^+\pi^-$	<4	$\times10^{-3}$	90%
Γ_{18}	$J/\psi\pi^0\pi^0$	<2	$\times10^{-3}$	90%
Γ_{19}	$J/\psi\eta$	$(5.2\ \pm0.7\ )\times10^{-3}$		
Γ_{20}	$J/\psi\pi^0$	<2.8	$\times10^{-4}$	90%
Γ_{21}	$J/\psi\pi^+\pi^-\pi^0$	<2	$\times10^{-3}$	90%
Γ_{22}	$\chi_{c1}\gamma$	<1.1	%	90%
Γ_{23}	$\chi_{c2}\gamma$	<1.7	%	90%
Γ_{24}	$\chi_{c1}\pi^+\pi^-\pi^0$	<1.1	%	90%
Γ_{25}	$\chi_{c2}\pi^+\pi^-\pi^0$	<3.2	%	90%
Γ_{26}	$h_c(1P)\pi^+\pi^-$	<3	$\times10^{-3}$	90%
Γ_{27}	$\phi\pi^+\pi^-$	<3	$\times10^{-3}$	90%
Γ_{28}	$\mu^+\mu^-$			

$\psi(4040)$ PARTIAL WIDTHS

$\Gamma(e^+e^-)$ Γ_1

VALUE (keV)	DOCUMENT ID		TECN	COMMENT
0.86±0.07 OUR ESTIMATE				
0.83±0.20	[9] ABLIKIM	08D	BES2	$e^+e^- \to$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.6 to 1.4	[10] MO	10	RVUE	$e^+e^- \to$ hadrons
0.88±0.11	[11] SETH	05A	RVUE	$e^+e^- \to$ hadrons
0.91±0.13	[12] SETH	05A	RVUE	$e^+e^- \to$ hadrons
0.75±0.15	BRANDELIK	78C	DASP	e^+e^-

[9] Reanalysis of data presented in BAI 02C. From a global fit over the center-of-mass energy region 3.7–5.0 GeV covering the $\psi(3770)$, $\psi(4040)$, $\psi(4160)$, and $\psi(4415)$ resonances. Phase angle fixed in the fit to $\delta = (130 \pm 46)^\circ$.

[10] Reanalysis of data presented in BAI 00 and BAI 02C. From a global fit over the center-of-mass energy 3.8-4.8 GeV covering the $\psi(4040)$, $\psi(4160)$ and $\psi(4415)$ resonances and including interference effects. Four sets of solutions are obtained with the same fit quality, mass and total width, but with different e^+e^- partial widths. We quote only the range of values.

[11] From a fit to Crystal Ball (OSTERHELD 86) data.

[12] From a fit to BES (BAI 02C) data.

$\psi(4040)$ BRANCHING RATIOS

$\Gamma(e^+e^-)/\Gamma_{total}$ Γ_1/Γ

VALUE (units 10^{-5})	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
~ 1.0	FELDMAN	77	MRK1	e^+e^-

$\Gamma(D^0\overline{D}^0)/\Gamma_{total}$ Γ_3/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	AUBERT	09M	BABR	$e^+e^- \to D^0\overline{D}^0\gamma$
seen	CRONIN-HEN..	09	CLEO	$e^+e^- \to D^0\overline{D}^0$
seen	PAKHLOVA	08	BELL	$e^+e^- \to D^0\overline{D}^0\gamma$

$\Gamma(D^+D^-)/\Gamma_{total}$ Γ_4/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	AUBERT	09M	BABR	$e^+e^- \to D^+D^-\gamma$
seen	CRONIN-HEN..	09	CLEO	$e^+e^- \to D^+D^-$
seen	PAKHLOVA	08	BELL	$e^+e^- \to D^+D^-\gamma$

$\Gamma(D\overline{D})/\Gamma(D^*\overline{D}+\text{c.c.})$ Γ_2/Γ_5

VALUE	DOCUMENT ID		TECN	COMMENT
0.24±0.05±0.12	AUBERT	09M	BABR	$e^+e^- \to \gamma D^{(*)}\overline{D}$

$\Gamma(D^0\overline{D}^0)/\Gamma(D^*(2007)^0\overline{D}^0+\text{c.c.})$ Γ_3/Γ_6

VALUE	DOCUMENT ID		TECN	COMMENT
0.05±0.03	[13] GOLDHABER	77	MRK1	e^+e^-

[13] Phase-space factor (p^3) explicitly removed.

$\Gamma(D^*(2007)^0\overline{D}^0 + \text{c.c.})/\Gamma_{\text{total}}$ Γ_6/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	AUBERT	09M	BABR	$e^+e^- \to D^{*0}\overline{D}^0\gamma$
seen	CRONIN-HEN..09		CLEO	$e^+e^- \to D^{*0}\overline{D}^0$

$\Gamma(D^*(2010)^+ D^- + \text{c.c.})/\Gamma_{\text{total}}$ Γ_7/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	AUBERT	09M	BABR	$e^+e^- \to D^{*+}D^-\gamma$
seen	CRONIN-HEN..09		CLEO	$e^+e^- \to D^{*+}D^-$
seen	PAKHLOVA	07	BELL	$e^+e^- \to D^{*+}D^-\gamma$

$\Gamma(D^*(2010)^+ D^- + \text{c.c.})/\Gamma(D^*(2007)^0\overline{D}^0 + \text{c.c.})$ Γ_7/Γ_6

VALUE	DOCUMENT ID		TECN	COMMENT
0.95±0.09±0.10	AUBERT	09M	BABR	$e^+e^- \to \gamma D^*\overline{D}$

$\Gamma(D^*\overline{D}^*)/\Gamma(D^*\overline{D} + \text{c.c.})$ Γ_8/Γ_5

VALUE	DOCUMENT ID		TECN	COMMENT
0.18±0.14±0.03	AUBERT	09M	BABR	$e^+e^- \to \gamma D^{(*)}\overline{D}^{(*)}$

$\Gamma(D^*(2007)^0\overline{D}^*(2007)^0)/\Gamma_{\text{total}}$ Γ_9/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	AUBERT	09M	BABR	$e^+e^- \to D^{*0}\overline{D}^{*0}\gamma$
seen	CRONIN-HEN..09		CLEO	$e^+e^- \to D^{*0}\overline{D}^{*0}$

$\Gamma(D^*(2007)^0\overline{D}^*(2007)^0)/\Gamma(D^*(2007)^0\overline{D}^0 + \text{c.c.})$ Γ_9/Γ_6

VALUE	DOCUMENT ID		TECN	COMMENT
32.0±12.0	[14] GOLDHABER	77	MRK1	e^+e^-

[14] Phase-space factor (p^3) explicitly removed.

$\Gamma(D^*(2010)^+ D^*(2010)^-)/\Gamma_{\text{total}}$ Γ_{10}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	AUBERT	09M	BABR	$e^+e^- \to D^{*+}D^{*-}\gamma$
seen	CRONIN-HEN..09		CLEO	$e^+e^- \to D^{*+}D^{*-}$
seen	PAKHLOVA	07	BELL	$e^+e^- \to D^{*+}D^{*-}\gamma$

$\Gamma(D^0 D^-\pi^+ + \text{c.c. (excl. } D^*(2007)^0\overline{D}^0 + \text{c.c., } D^*(2010)^+ D^- + \text{c.c.}))/\Gamma_{\text{total}}$ Γ_{12}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
not seen	PAKHLOVA	08A	BELL	$e^+e^- \to D^0 D^-\pi^+\gamma$

$\Gamma(D\overline{D}^*\pi(\text{excl. } D^*\overline{D}^*))/\Gamma_{\text{total}}$ Γ_{13}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
not seen	CRONIN-HEN..09		CLEO	$e^+e^- \to D\overline{D}^*\pi$

$\Gamma(D^0\overline{D}^{*-}\pi^+ + \text{c.c. (excl. } D^*(2010)^+ D^*(2010)^-))/\Gamma_{\text{total}}$ Γ_{14}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	PAKHLOVA	09	BELL	$e^+e^- \to D^0 D^{*-}\pi^+\gamma$

$\Gamma(D_s^+ D_s^-)/\Gamma_{total}$ Γ_{15}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	PAKHLOVA	11	BELL	$e^+e^- \to D_s^+ D_s^- \gamma$
seen	DEL-AMO-SA..	10N	BABR	$e^+e^- \to D_s^+ D_s^- \gamma$
seen	CRONIN-HEN..	09	CLEO	$e^+e^- \to D_s^+ D_s^-$

$\Gamma(J/\psi\pi^+\pi^-)/\Gamma_{total}$ Γ_{17}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<4	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

$\Gamma(J/\psi\pi^0\pi^0)/\Gamma_{total}$ Γ_{18}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<2	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

$\Gamma(J/\psi\eta)/\Gamma_{total}$ Γ_{19}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
5.2±0.5±0.5		[15] ABLIKIM	12K	BES3	$e^+e^- \to \ell^+\ell^- 2\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<7	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

[15] ABLIKIM 12K measure $\sigma(e^+e^- \to J/\psi\eta) = 32.1 \pm 2.8 \pm 1.3$ pb. They assume the $\eta J/\psi$ fully originates from $\psi(4040)$ decays.

$\Gamma(J/\psi\pi^0)/\Gamma_{total}$ Γ_{20}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<0.28	90	[16] ABLIKIM	12K	BES3	$e^+e^- \to \ell^+\ell^- 2\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<2	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

[16] ABLIKIM 12K measure $\sigma(e^+e^- \to J/\psi\pi^0) <1.6$ pb. They assume the $\eta J/\psi$ fully originates from $\psi(4040)$ decays.

$\Gamma(J/\psi\pi^+\pi^-\pi^0)/\Gamma_{total}$ Γ_{21}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<2	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

$\Gamma(\chi_{c1}\gamma)/\Gamma_{total}$ Γ_{22}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<11	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

$\Gamma(\chi_{c2}\gamma)/\Gamma_{total}$ Γ_{23}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<17	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

$\Gamma(\chi_{c1}\pi^+\pi^-\pi^0)/\Gamma_{total}$ Γ_{24}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<11	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

$\Gamma(\chi_{c2}\pi^+\pi^-\pi^0)/\Gamma_{total}$ Γ_{25}/Γ

VALUE (units 10^{-3})	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<32	90	COAN	06	CLEO	3.97–4.06 e^+e^- → hadrons

$\Gamma(h_c(1P)\pi^+\pi^-)/\Gamma_{total}$ Γ_{26}/Γ

VALUE (units 10^{-3})	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<3	90	[17] PEDLAR	11	CLEO	$e^+e^- \to h_c(1P)\pi^+\pi^-$

[17] From several values of $\sqrt{s}$ near the peak of the $\psi(4040)$, PEDLAR 11 measures $\sigma(e^+e^- \to h_c(1P)\pi^+\pi^-) = 1.0 \pm 8.0 \pm 5.4 \pm 0.2$ pb, where the errors are statistical, systematic, and due to uncertainty in B($\psi(2S) \to \pi^0 h_c(1P)$), respectively.

$\Gamma(\phi\pi^+\pi^-)/\Gamma_{total}$ Γ_{27}/Γ

VALUE (units 10^{-3})	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<3	90	COAN	06	CLEO	3.97–4.06 e^+e^- → hadrons

$\psi(4040)$ REFERENCES

ABLIKIM	12K	PR D86 071101	M. Ablikim *et al.*	(BES III Collab.)
PAKHLOVA	11	PR D83 011101	G. Pakhlova *et al.*	(BELLE Collab.)
PEDLAR	11	PRL 107 041803	T. Pedlar *et al.*	(CLEO Collab.)
DEL-AMO-SA...	10N	PR D82 052004	P. del Amo Sanchez *et al.*	(BABAR Collab.)
MO	10	PR D82 077501	X.H. Mo, C.Z. Yuan, P. Wang	(BHEP)
AUBERT	09M	PR D79 092001	B. Aubert *et al.*	(BABAR Collab.)
CRONIN-HEN...	09	PR D80 072001	D. Cronin-Hennessy *et al.*	(CLEO Collab.)
PAKHLOVA	09	PR D80 091101	G. Pakhlova *et al.*	(BELLE Collab.)
ABLIKIM	08D	PL B660 315	M. Ablikim *et al.*	(BES Collab.)
PAKHLOVA	08	PR D77 011103	G. Pakhlova *et al.*	(BELLE Collab.)
PAKHLOVA	08A	PRL 100 062001	G. Pakhlova *et al.*	(BELLE Collab.)
PAKHLOVA	07	PRL 98 092001	G. Pakhlova *et al.*	(BELLE Collab.)
COAN	06	PRL 96 162003	T.E. Coan *et al.*	(CLEO Collab.)
SETH	05A	PR D72 017501	K.K. Seth	
BAI	02C	PRL 88 101802	J.Z. Bai *et al.*	(BES Collab.)
BAI	00	PRL 84 594	J.Z. Bai *et al.*	(BES Collab.)
OSTERHELD	86	SLAC-PUB-4160	A. Osterheld *et al.*	(SLAC Crystal Ball Collab.)
BRANDELIK	78C	PL 76B 361	R. Brandelik *et al.*	(DASP Collab.)
Also		ZPHY C1 233	R. Brandelik *et al.*	(DASP Collab.)
FELDMAN	77	PRPL 33C 285	G.J. Feldman, M.L. Perl	(LBL, SLAC)
GOLDHABER	77	PL 69B 503	G. Goldhaber *et al.*	(Mark I Collab.)