

$\psi(4040)$

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

$\psi(4040)$ MASS

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
4039 \pm 1 OUR ESTIMATE			
4039.6 \pm 4.3	¹ ABLIKIM	08D BES2	$e^+e^- \rightarrow$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •			
4034 \pm 6	² MO	10 RVUE	$e^+e^- \rightarrow$ hadrons
4037 \pm 2	³ SETH	05A RVUE	$e^+e^- \rightarrow$ hadrons
4040 \pm 1	⁴ SETH	05A RVUE	$e^+e^- \rightarrow$ hadrons
4040 \pm 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

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
80 \pm 10 OUR ESTIMATE			
84.5 \pm 12.3	⁵ ABLIKIM	08D BES2	$e^+e^- \rightarrow$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •			
87 \pm 11	⁶ MO	10 RVUE	$e^+e^- \rightarrow$ hadrons
85 \pm 10	⁷ SETH	05A RVUE	$e^+e^- \rightarrow$ hadrons
89 \pm 6	⁸ SETH	05A RVUE	$e^+e^- \rightarrow$ hadrons
52 \pm 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 $c\bar{c}$ 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^-	$(1.07 \pm 0.16) \times 10^{-5}$	
Γ_2 $D\bar{D}$	seen	
Γ_3 $D^0\bar{D}^0$	seen	
Γ_4 D^+D^-	seen	
Γ_5 $D^*\bar{D} + \text{c.c.}$	seen	
Γ_6 $D^*(2007)^0\bar{D}^0 + \text{c.c.}$	seen	
Γ_7 $D^*(2010)^+D^- + \text{c.c.}$	seen	
Γ_8 $D^*\bar{D}^*$	seen	
Γ_9 $D^*(2007)^0\bar{D}^*(2007)^0$	seen	
Γ_{10} $D^*(2010)^+D^*(2010)^-$	seen	
Γ_{11} $D\bar{D}\pi$ (excl. $D^*\bar{D}$)		
Γ_{12} $D^0D^-\pi^+ + \text{c.c.}$ (excl. $D^*(2007)^0\bar{D}^0 + \text{c.c.}$, $D^*(2010)^+D^- + \text{c.c.}$)	not seen	
Γ_{13} $D\bar{D}^*\pi$ (excl. $D^*\bar{D}^*$)	not seen	
Γ_{14} $D^0\bar{D}^{*-}\pi^+ + \text{c.c.}$ (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	$\times 10^{-3}$ 90%
Γ_{18} $J/\psi\pi^0\pi^0$	< 2	$\times 10^{-3}$ 90%
Γ_{19} $J/\psi\eta$	< 7	$\times 10^{-3}$ 90%
Γ_{20} $J/\psi\pi^0$	< 2	$\times 10^{-3}$ 90%
Γ_{21} $J/\psi\pi^+\pi^-\pi^0$	< 2	$\times 10^{-3}$ 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	$\times 10^{-3}$ 90%
Γ_{27} $\phi\pi^+\pi^-$	< 3	$\times 10^{-3}$ 90%
Γ_{28} $\mu^+\mu^-$		

$\psi(4040)$ PARTIAL WIDTHS **$\Gamma(e^+e^-)$ Γ_1**

<u>VALUE (keV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.86±0.07 OUR ESTIMATE			
0.83±0.20	⁹ ABLIKIM	08D	BES2 $e^+e^- \rightarrow$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.6 to 1.4	¹⁰ MO	10	RVUE $e^+e^- \rightarrow$ hadrons
0.88±0.11	¹¹ SETH	05A	RVUE $e^+e^- \rightarrow$ hadrons
0.91±0.13	¹² SETH	05A	RVUE $e^+e^- \rightarrow$ 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 **$\Gamma(e^+e^-)/\Gamma_{\text{total}}$ Γ_1/Γ**

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

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
seen	AUBERT	09M	BABR $e^+e^- \rightarrow D^0\bar{D}^0\gamma$
seen	CRONIN-HEN..09	CLEO	$e^+e^- \rightarrow D^0\bar{D}^0$
seen	PAKHLOVA	08	BELL $e^+e^- \rightarrow D^0\bar{D}^0\gamma$

 $\Gamma(D^+D^-)/\Gamma_{\text{total}}$ Γ_4/Γ

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

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.24±0.05±0.12	AUBERT	09M	BABR $e^+e^- \rightarrow \gamma D^{(*)}\bar{D}$

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.05±0.03	¹³ GOLDHABER	77	MRK1 e^+e^-

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

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

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

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

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

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

VALUE	DOCUMENT ID	TECN	COMMENT
0.95 ± 0.09 ± 0.10	AUBERT 09M	BABR	$e^+ e^- \rightarrow \gamma D^{*+} \bar{D}^0$

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

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

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

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

$\Gamma(D^*(2007)^0 \bar{D}^*(2007)^0)/\Gamma(D^*(2007)^0 \bar{D}^0 + \text{c.c.})$ 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	$e^+ e^- \rightarrow D^{*+} D^{*-} \gamma$
seen	CRONIN-HEN..09	CLEO	$e^+ e^- \rightarrow D^{*+} D^{*-}$
seen	PAKHLOVA 07	BELL	$e^+ e^- \rightarrow D^{*+} D^{*-} \gamma$

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

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

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

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

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

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

$\Gamma(D_s^+ D_s^-)/\Gamma_{\text{total}}$					Γ_{15}/Γ
<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
seen		PAKHLOVA	11	BELL	$e^+ e^- \rightarrow D_s^+ D_s^- \gamma$
seen		DEL-AMO-SA..10N	BABR	$e^+ e^- \rightarrow D_s^+ D_s^- \gamma$	
seen		CRONIN-HEN..09	CLEO	$e^+ e^- \rightarrow D_s^+ D_s^-$	

$\Gamma(J/\psi \pi^+ \pi^-)/\Gamma_{\text{total}}$					Γ_{17}/Γ
<u>VALUE (units 10^{-3})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<4	90	COAN	06	CLEO	3.97–4.06 $e^+ e^- \rightarrow$ hadrons

$\Gamma(J/\psi \pi^0 \pi^0)/\Gamma_{\text{total}}$					Γ_{18}/Γ
<u>VALUE (units 10^{-3})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<2	90	COAN	06	CLEO	3.97–4.06 $e^+ e^- \rightarrow$ hadrons

$\Gamma(J/\psi \eta)/\Gamma_{\text{total}}$					Γ_{19}/Γ
<u>VALUE (units 10^{-3})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<7	90	COAN	06	CLEO	3.97–4.06 $e^+ e^- \rightarrow$ hadrons

$\Gamma(J/\psi \pi^0)/\Gamma_{\text{total}}$					Γ_{20}/Γ
<u>VALUE (units 10^{-3})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<2	90	COAN	06	CLEO	3.97–4.06 $e^+ e^- \rightarrow$ hadrons

$\Gamma(J/\psi \pi^+ \pi^- \pi^0)/\Gamma_{\text{total}}$					Γ_{21}/Γ
<u>VALUE (units 10^{-3})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<2	90	COAN	06	CLEO	3.97–4.06 $e^+ e^- \rightarrow$ hadrons

$\Gamma(\chi_{c1} \gamma)/\Gamma_{\text{total}}$					Γ_{22}/Γ
<u>VALUE (units 10^{-3})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<11	90	COAN	06	CLEO	3.97–4.06 $e^+ e^- \rightarrow$ hadrons

$\Gamma(\chi_{c2} \gamma)/\Gamma_{\text{total}}$					Γ_{23}/Γ
<u>VALUE (units 10^{-3})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<17	90	COAN	06	CLEO	3.97–4.06 $e^+ e^- \rightarrow$ hadrons

$\Gamma(\chi_{c1} \pi^+ \pi^- \pi^0)/\Gamma_{\text{total}}$					Γ_{24}/Γ
<u>VALUE (units 10^{-3})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<11	90	COAN	06	CLEO	3.97–4.06 $e^+ e^- \rightarrow$ hadrons

$\Gamma(\chi_{c2} \pi^+ \pi^- \pi^0)/\Gamma_{\text{total}}$					Γ_{25}/Γ
<u>VALUE (units 10^{-3})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<32	90	COAN	06	CLEO	3.97–4.06 $e^+ e^- \rightarrow$ hadrons

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

VALUE (units 10^{-3})	CL%	DOCUMENT ID	TECN	COMMENT
<3	90	¹⁵ PEDLAR	11	CLEO $e^+e^- \rightarrow h_c(1P)\pi^+\pi^-$

¹⁵ From several values of \sqrt{s} near the peak of the $\psi(4040)$, PEDLAR 11 measures $\sigma(e^+e^- \rightarrow h_c(1P)\pi^+\pi^-) = 1.0 \pm 8.0 \pm 5.4 \pm 0.2$ pb, where the errors are statistical, systematic, and due to uncertainty in $B(\psi(2S) \rightarrow \pi^0 h_c(1P))$, respectively.

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

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

$\psi(4040)$ REFERENCES

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