

$\psi(4415)$

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

$\psi(4415)$ MASS

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
4421 ± 4 OUR ESTIMATE			
4415.1 ± 7.9	¹ ABLIKIM	08D BES2	$e^+e^- \rightarrow$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •			
4412 ± 15	² MO	10 RVUE	$e^+e^- \rightarrow$ hadrons
4411 ± 7	³ PAKHLOVA	08A BELL	10.6 $e^+e^- \rightarrow D^0 D^- \pi^+ \gamma$
4425 ± 6	⁴ SETH	05A RVUE	$e^+e^- \rightarrow$ hadrons
4429 ± 9	⁵ SETH	05A RVUE	$e^+e^- \rightarrow$ hadrons
4417 ± 10	BRANDELIK	78C DASP	e^+e^-
4414 ± 7	SIEGRIST	76 MRK1	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 $\delta = (234 \pm 88)^\circ$.

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 Systematic uncertainties not estimated.

⁴ From a fit to Crystal Ball (OSTERHELD 86) data.

⁵ From a fit to BES (BAI 02C) data.

$\psi(4415)$ WIDTH

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
62 ± 20 OUR ESTIMATE			
71.5 ± 19.0	⁶ ABLIKIM	08D BES2	$e^+e^- \rightarrow$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •			
118 ± 32	⁷ MO	10 RVUE	$e^+e^- \rightarrow$ hadrons
77 ± 20	⁸ PAKHLOVA	08A BELL	10.6 $e^+e^- \rightarrow D^0 D^- \pi^+ \gamma$
119 ± 16	⁹ SETH	05A RVUE	$e^+e^- \rightarrow$ hadrons
118 ± 35	¹⁰ SETH	05A RVUE	$e^+e^- \rightarrow$ hadrons
66 ± 15	BRANDELIK	78C DASP	e^+e^-
33 ± 10	SIEGRIST	76 MRK1	e^+e^-

⁶ 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 $\delta = (234 \pm 88)^\circ$.

⁷ 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.

⁸ Systematic uncertainties not estimated.

⁹ From a fit to Crystal Ball (OSTERHELD 86) data.

¹⁰ From a fit to BES (BAI 02C) data.

$\psi(4415)$ 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 $D\bar{D}$	not seen	
Γ_2 $D^0\bar{D}^0$	seen	
Γ_3 D^+D^-	seen	
Γ_4 $D^*\bar{D} + \text{c.c.}$	not seen	
Γ_5 $D^*(2007)^0\bar{D}^0 + \text{c.c.}$	seen	
Γ_6 $D^*(2010)^+D^- + \text{c.c.}$	seen	
Γ_7 $D^*\bar{D}^*$	not seen	
Γ_8 $D^*(2007)^0\bar{D}^*(2007)^0 + \text{c.c.}$	seen	
Γ_9 $D^*(2010)^+D^*(2010)^- + \text{c.c.}$	seen	
Γ_{10} $D^0D^-\pi^+$ (excl. $D^*(2007)^0\bar{D}^0$ +c.c., $D^*(2010)^+D^-$ +c.c.)	< 2.3 %	90%
Γ_{11} $D\bar{D}_2^*(2460) \rightarrow D^0D^-\pi^+$ +c.c.	(10 \pm 4) %	
Γ_{12} $D^0D^{*-}\pi^+$ +c.c.	< 11 %	90%
Γ_{13} $D_s^+D_s^-$	not seen	
Γ_{14} $D_s^{*+}D_s^{*-}$ +c.c.	seen	
Γ_{15} $D_s^{*+}D_s^{*-}$	not seen	
Γ_{16} e^+e^-	(9.4 \pm 3.2) $\times 10^{-6}$	

$\psi(4415)$ PARTIAL WIDTHS

$\Gamma(e^+e^-)$	DOCUMENT ID	TECN	COMMENT	Γ_{16}
VALUE (keV)				
0.58\pm0.07 OUR ESTIMATE				
0.35\pm0.12	¹¹ ABLIKIM	08D BES2	$e^+e^- \rightarrow$ hadrons	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.4 to 0.8	¹² MO	10 RVUE	$e^+e^- \rightarrow$ hadrons	
0.72 \pm 0.11	¹³ SETH	05A RVUE	$e^+e^- \rightarrow$ hadrons	
0.64 \pm 0.23	¹⁴ SETH	05A RVUE	$e^+e^- \rightarrow$ hadrons	
0.49 \pm 0.13	BRANDELIK	78C DASP	e^+e^-	
0.44 \pm 0.14	SIEGRIST	76 MRK1	e^+e^-	

¹¹ 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 $\delta = (234 \pm 88)^\circ$.

¹² 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.

¹³ From a fit to Crystal Ball (OSTERHELD 86) data.

¹⁴ From a fit to BES (BAI 02C) data.

$\psi(4415)$ BRANCHING RATIOS

$\Gamma(D^0\bar{D}^0)/\Gamma_{\text{total}} \qquad \Gamma_2/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
seen	PAKHLOVA 08	BELL	$e^+e^- \rightarrow D^0\bar{D}^0\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
not seen	AUBERT 09M	BABR	$e^+e^- \rightarrow D^0\bar{D}^0\gamma$

$\Gamma(D^+D^-)/\Gamma_{\text{total}} \qquad \Gamma_3/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
seen	PAKHLOVA 08	BELL	$e^+e^- \rightarrow D^+D^-\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
not seen	AUBERT 09M	BABR	$e^+e^- \rightarrow D^+D^-\gamma$

$\Gamma(D\bar{D})/\Gamma(D^*\bar{D}^*) \qquad \Gamma_1/\Gamma_7$

VALUE	DOCUMENT ID	TECN	COMMENT
0.14 ± 0.12 ± 0.03	AUBERT 09M	BABR	$e^+e^- \rightarrow \gamma D^{(*)}\bar{D}^{(*)}$

$\Gamma(D^*(2007)^0\bar{D}^0 + \text{c.c.})/\Gamma_{\text{total}} \qquad \Gamma_5/\Gamma$

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

$\Gamma(D^*(2010)^+D^- + \text{c.c.})/\Gamma_{\text{total}} \qquad \Gamma_6/\Gamma$

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

$\Gamma(D^*\bar{D} + \text{c.c.})/\Gamma(D^*\bar{D}^*) \qquad \Gamma_4/\Gamma_7$

VALUE	DOCUMENT ID	TECN	COMMENT
0.17 ± 0.25 ± 0.03	AUBERT 09M	BABR	$e^+e^- \rightarrow \gamma D^{(*)}\bar{D}^{(*)}$

$\Gamma(D^*(2007)^0\bar{D}^*(2007)^0 + \text{c.c.})/\Gamma_{\text{total}} \qquad \Gamma_8/\Gamma$

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

$\Gamma(D^*(2010)^+D^*(2010)^- + \text{c.c.})/\Gamma_{\text{total}} \qquad \Gamma_9/\Gamma$

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

$\Gamma(D\bar{D}_2^*(2460) \rightarrow D^0D^-\pi^+ + \text{c.c.})/\Gamma_{\text{total}} \qquad \Gamma_{11}/\Gamma$

VALUE (units 10^{-2})	DOCUMENT ID	TECN	COMMENT
10.5 ± 2.4 ± 3.8	¹⁵ PAKHLOVA 08A	BELL	$10.6 e^+e^- \rightarrow D^0D^-\pi^+\gamma$

¹⁵ Using 4421 ± 4 MeV for the mass and 62 ± 20 MeV for the width of $\psi(4415)$.

$$\frac{\Gamma(D^0 D^- \pi^+ (\text{excl. } D^*(2007)^0 \bar{D}^0 + \text{c.c.}, D^*(2010)^+ D^- + \text{c.c.}) / \Gamma(D \bar{D}_2^*(2460) \rightarrow D^0 D^- \pi^+ + \text{c.c.})}{\Gamma_{10}/\Gamma_{11}}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.22	90	¹⁶ PAKHLOVA 08A	BELL	10.6 $e^+ e^- \rightarrow D^0 D^- \pi^+ \gamma$

¹⁶ Using 4421 ± 4 MeV for the mass and 62 ± 20 MeV for the width of $\psi(4415)$.

$$\frac{\Gamma(D^0 D^{*-} \pi^+ + \text{c.c.})/\Gamma_{\text{total}} \times \Gamma(e^+ e^-)/\Gamma_{\text{total}}}{\Gamma_{12}/\Gamma \times \Gamma_{16}/\Gamma}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.99 $\times 10^{-6}$	90	¹⁷ PAKHLOVA 09	BELL	$e^+ e^- \rightarrow D^0 D^{*-} \pi^+$

¹⁷ Using 4421 ± 4 MeV for the mass of $\psi(4415)$.

$$\frac{\Gamma(D_s^+ D_s^-)/\Gamma_{\text{total}}}{\Gamma_{13}/\Gamma}$$

VALUE	DOCUMENT ID	TECN	COMMENT
not seen	PAKHLOVA 11	BELL	$e^+ e^- \rightarrow D_s^+ D_s^- \gamma$
not seen	DEL-AMO-SA...10N	BABR	$e^+ e^- \rightarrow D_s^+ D_s^- \gamma$

$$\frac{\Gamma(D_s^{*+} D_s^- + \text{c.c.})/\Gamma_{\text{total}}}{\Gamma_{14}/\Gamma}$$

VALUE	DOCUMENT ID	TECN	COMMENT
seen	PAKHLOVA 11	BELL	$e^+ e^- \rightarrow D_s^{*+} D_s^- \gamma$
seen	DEL-AMO-SA...10N	BABR	$e^+ e^- \rightarrow D_s^{*+} D_s^- \gamma$

$$\frac{\Gamma(D_s^{*+} D_s^{*-})/\Gamma_{\text{total}}}{\Gamma_{15}/\Gamma}$$

VALUE	DOCUMENT ID	TECN	COMMENT
not seen	PAKHLOVA 11	BELL	$e^+ e^- \rightarrow D_s^{*+} D_s^{*-} \gamma$
not seen	DEL-AMO-SA...10N	BABR	$e^+ e^- \rightarrow D_s^{*+} D_s^{*-} \gamma$

$\psi(4415)$ REFERENCES

PAKHLOVA 11	PR D83 011101	G. Pakhlova <i>et al.</i>	(BELLE 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.)
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.)
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.)
SIEGRIST 76	PRL 36 700	J.L. Siegrist <i>et al.</i>	(LBL, SLAC)