

$\psi(4415)$ 

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

### $\psi(4415)$ MASS

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

<sup>1</sup> 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  $\delta = (234 \pm 88)^\circ$ .

<sup>2</sup> 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.

<sup>3</sup> Systematic uncertainties not estimated.

<sup>4</sup> From a fit to Crystal Ball (OSTERHELD 86) data.

<sup>5</sup> From a fit to BES (BAI 02C) data.

### $\psi(4415)$ WIDTH

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

<sup>6</sup> 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  $\delta = (234 \pm 88)^\circ$ .

<sup>7</sup> 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.

<sup>8</sup> Systematic uncertainties not estimated.

<sup>9</sup> From a fit to Crystal Ball (OSTERHELD 86) data.

<sup>10</sup> 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  $2\sigma$  above zero, without regard to any peaking behavior in  $\sqrt{s}$  or absence thereof. See mode listing(s) for details and references.

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level
$\Gamma_1$ $D\bar{D}$	not seen	
$\Gamma_2$ $D^0\bar{D}^0$	seen	
$\Gamma_3$ $D^+D^-$	seen	
$\Gamma_4$ $D^*\bar{D} + \text{c.c.}$	not seen	
$\Gamma_5$ $D^*(2007)^0\bar{D}^0 + \text{c.c.}$	seen	
$\Gamma_6$ $D^*(2010)^+D^- + \text{c.c.}$	seen	
$\Gamma_7$ $D^*\bar{D}^*$	not seen	
$\Gamma_8$ $D^*(2007)^0\bar{D}^*(2007)^0 + \text{c.c.}$	seen	
$\Gamma_9$ $D^*(2010)^+D^*(2010)^- + \text{c.c.}$	seen	
$\Gamma_{10}$ $D^0D^-\pi^+$ (excl. $D^*(2007)^0\bar{D}^0$ +c.c., $D^*(2010)^+D^-$ +c.c.)	< 2.3 %	90%
$\Gamma_{11}$ $D\bar{D}_2^*(2460) \rightarrow D^0D^-\pi^+ + \text{c.c.}$	(10 $\pm$ 4) %	
$\Gamma_{12}$ $D^0D^{*-}\pi^+ + \text{c.c.}$	< 11 %	90%
$\Gamma_{13}$ $D_s^+D_s^-$	not seen	
$\Gamma_{14}$ $D_s^{*+}D_s^{*-} + \text{c.c.}$	seen	
$\Gamma_{15}$ $D_s^{*+}D_s^{*-}$	not seen	
$\Gamma_{16}$ $J/\psi\eta$	< 6 $\times 10^{-3}$	90%
$\Gamma_{17}$ $e^+e^-$	(9.4 $\pm$ 3.2) $\times 10^{-6}$	

## $\psi(4415)$ PARTIAL WIDTHS

$\Gamma(e^+e^-)$	VALUE (keV)	DOCUMENT ID	TECN	COMMENT	$\Gamma_{17}$
<b>0.58<math>\pm</math>0.07 OUR ESTIMATE</b>					
<b>0.35<math>\pm</math>0.12</b>		<sup>11</sup> ABLIKIM	08D BES2	$e^+e^- \rightarrow$ hadrons	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.4 to 0.8		<sup>12</sup> MO	10 RVUE	$e^+e^- \rightarrow$ hadrons	
0.72 $\pm$ 0.11		<sup>13</sup> SETH	05A RVUE	$e^+e^- \rightarrow$ hadrons	
0.64 $\pm$ 0.23		<sup>14</sup> 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	$e^+e^-$	

<sup>11</sup> 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  $\delta = (234 \pm 88)^\circ$ .

<sup>12</sup> 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.

<sup>13</sup> From a fit to Crystal Ball (OSTERHELD 86) data.

<sup>14</sup> From a fit to BES (BAI 02C) data.

**$\psi(4415) \Gamma(i)\Gamma(e^+e^-)/\Gamma(\text{total})$**

$\Gamma(J/\psi\eta) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$					$\Gamma_{16}\Gamma_{17}/\Gamma$
VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT	
<3.6	90	WANG	13B	BELL	$e^+e^- \rightarrow J/\psi\eta\gamma$

**$\psi(4415)$  BRANCHING RATIOS**

$\Gamma(D^0\bar{D}^0)/\Gamma_{\text{total}}$					$\Gamma_2/\Gamma$
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  $e^+e^- \rightarrow D^0\bar{D}^0\gamma$

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

$\Gamma(D\bar{D})/\Gamma(D^*\bar{D}^*)$					$\Gamma_1/\Gamma_7$
VALUE		DOCUMENT ID	TECN	COMMENT	

$0.14 \pm 0.12 \pm 0.03$  AUBERT 09M BABR  $e^+e^- \rightarrow \gamma D^{(*)}\bar{D}^{(*)}$

$\Gamma(D^*(2007)^0\bar{D}^0 + \text{c.c.})/\Gamma_{\text{total}}$					$\Gamma_5/\Gamma$
VALUE		DOCUMENT ID	TECN	COMMENT	

seen AUBERT 09M BABR  $e^+e^- \rightarrow D^{*0}\bar{D}^0\gamma$

$\Gamma(D^*(2010)^+D^- + \text{c.c.})/\Gamma_{\text{total}}$					$\Gamma_6/\Gamma$
VALUE		DOCUMENT ID	TECN	COMMENT	

seen AUBERT 09M BABR  $e^+e^- \rightarrow D^{*+}D^-\gamma$

seen PAKHLOVA 07 BELL  $e^+e^- \rightarrow D^{*+}D^-\gamma$

$\Gamma(D^*\bar{D} + \text{c.c.})/\Gamma(D^*\bar{D}^*)$					$\Gamma_4/\Gamma_7$
VALUE		DOCUMENT ID	TECN	COMMENT	

$0.17 \pm 0.25 \pm 0.03$  AUBERT 09M BABR  $e^+e^- \rightarrow \gamma D^{(*)}\bar{D}^{(*)}$

$\Gamma(D^*(2007)^0\bar{D}^*(2007)^0 + \text{c.c.})/\Gamma_{\text{total}}$					$\Gamma_8/\Gamma$
VALUE		DOCUMENT ID	TECN	COMMENT	

seen AUBERT 09M BABR  $e^+e^- \rightarrow D^{*0}\bar{D}^{*0}\gamma$

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

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

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

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

<sup>15</sup> Using  $4421 \pm 4$  MeV for the mass and  $62 \pm 20$  MeV for the width of  $\psi(4415)$ .

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

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;0.22</b>	90	<sup>16</sup> PAKHLOVA	08A	BELL $10.6 e^+ e^- \rightarrow D^0 D^- \pi^+ \gamma$

<sup>16</sup> Using  $4421 \pm 4$  MeV for the mass and  $62 \pm 20$  MeV for the width of  $\psi(4415)$ .

$\Gamma(D^0 D^{*-} \pi^+ + \text{c.c.})/\Gamma_{\text{total}} \times \Gamma(e^+ e^-)/\Gamma_{\text{total}}$   $\Gamma_{12}/\Gamma \times \Gamma_{17}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;0.99 × 10<sup>-6</sup></b>	90	<sup>17</sup> PAKHLOVA	09	BELL $e^+ e^- \rightarrow D^0 D^{*-} \pi^+$

<sup>17</sup> Using  $4421 \pm 4$  MeV for the mass of  $\psi(4415)$ .

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

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

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

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

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

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

**$\psi(4415)$  REFERENCES**

WANG	13B	PR D87 051101	X.L. Wang <i>et al.</i>	(BELLE Collab.)
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 091101	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 011103	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)

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