

$\eta_c(2S)$

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

Quantum numbers are quark model predictions.

 $\eta_c(2S)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
3637.5 ± 1.1 OUR AVERAGE		Error includes scale factor of 1.2.		
3635.1 ± 3.7 ± 2.9	106	XU	18 BELL	$e^+e^- \rightarrow e^+e^-\eta'\pi^+\pi^-$
3633.6 ± 1.7 ± 0.6	106	¹ AAIJ	17ADLHCB	$pp \rightarrow B^+X \rightarrow p\bar{p}K^+X$
3636.4 ± 4.1 ± 0.7	365	² AAIJ	17BBLHCB	$pp \rightarrow b\bar{b}X \rightarrow 2(K^+K^-)X$
3637.0 ± 5.7 ± 3.4	178	^{3,4} LEES	14E BABR	$\gamma\gamma \rightarrow K^+K^-\pi^0$
3635.1 ± 5.8 ± 2.1	47	^{3,5} LEES	14E BABR	$\gamma\gamma \rightarrow K^+K^-\eta$
3646.9 ± 1.6 ± 3.6	57 ± 17	ABLIKIM	13K BES3	$\psi(2S) \rightarrow \gamma K_S^0 K^\pm \pi^\mp \pi^+ \pi^-$
3637.6 ± 2.9 ± 1.6	127 ± 18	⁶ ABLIKIM	12G BES3	$\psi(2S) \rightarrow \gamma K^0 K\pi, KK\pi^0$
3638.5 ± 1.5 ± 0.8	624	³ DEL-AMO-SA...11M	BABR	$\gamma\gamma \rightarrow K_S^0 K^\pm \pi^\mp$
3640.5 ± 3.2 ± 2.5	1201	³ DEL-AMO-SA...11M	BABR	$\gamma\gamma \rightarrow K^+K^-\pi^+\pi^-\pi^0$
3636.1 ^{+3.9+0.7} _{-4.2-2.0}	128	⁷ VINOKUROVA 11	BELL	$B^\pm \rightarrow K^\pm(K_S^0 K^\pm \pi^\mp)$
3626 ± 5 ± 6	311	⁸ ABE	07 BELL	$e^+e^- \rightarrow J/\psi(c\bar{c})$
3645.0 ± 5.5 ^{+4.9} _{-7.8}	121 ± 27	AUBERT	05C BABR	$e^+e^- \rightarrow J/\psi c\bar{c}$
3642.9 ± 3.1 ± 1.5	61	ASNER	04 CLEO	$\gamma\gamma \rightarrow \eta_c \rightarrow K_S^0 K^\pm \pi^\mp$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
3639 ± 7	98 ± 52	⁹ AUBERT	06E BABR	$B^\pm \rightarrow K^\pm X_c \bar{c}$
3630.8 ± 3.4 ± 1.0	112 ± 24	¹⁰ AUBERT	04D BABR	$\gamma\gamma \rightarrow \eta_c(2S) \rightarrow K\bar{K}\pi$
3654 ± 6 ± 8	39 ± 11	¹¹ CHOI	02 BELL	$B \rightarrow K K_S K^-\pi^+$
3594 ± 5		¹² EDWARDS	82C CBAL	$e^+e^- \rightarrow \gamma X$

¹AAIJ 17AD report $m_{\psi(2S)} - m_{\eta_c(2S)} = 52.5 \pm 1.7 \pm 0.6$ MeV. We use the current value $m_{\psi(2S)} = 3686.097 \pm 0.025$ MeV to obtain the quoted mass.

²From a fit of the $\phi\phi$ invariant mass with the width of $\eta_c(2S)$ fixed to the PDG 16 value.

³Ignoring possible interference with continuum.

⁴With a width fixed to 11.3 MeV.

⁵With a width fixed to 11.3 MeV. Using both $\eta \rightarrow \gamma\gamma$ and $\eta \rightarrow \pi^+\pi^-\pi^0$ decays.

⁶From a simultaneous fit to $K_S^0 K^\pm \pi^\mp$ and $K^+K^-\pi^0$ decay modes.

⁷Accounts for interference with non-resonant continuum.

⁸From a fit of the J/ψ recoil mass spectrum. Supersedes ABE,K 02 and ABE 04G.

⁹From the fit of the kaon momentum spectrum. Systematic errors not evaluated.

¹⁰Superseded by DEL-AMO-SANCHEZ 11M.

¹¹Superseded by VINOKUROVA 11.

¹²Assuming mass of $\psi(2S) = 3686$ MeV.

$\eta_c(2S)$ WIDTH

VALUE (MeV)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
11.3⁺₋ 3.2 2.9					OUR AVERAGE
9.9 \pm 4.8 \pm 2.9		57 \pm 17	ABLIKIM	13K BES3	$\psi(2S) \rightarrow \gamma K_S^0 K^\pm \pi^\mp \pi^+ \pi^-$
16.9 \pm 6.4 \pm 4.8		127 \pm 18	¹³ ABLIKIM	12G BES3	$\psi(2S) \rightarrow \gamma K^0 K \pi,$ $K K \pi^0$
13.4 \pm 4.6 \pm 3.2		624	¹⁴ DEL-AMO-SA..11M	BABR	$\gamma\gamma \rightarrow K_S^0 K^\pm \pi^\mp$
6.6 ⁺ ₋ 8.4+2.6 5.1-0.9		128	¹⁵ VINOKUROVA 11	BELL	$B^\pm \rightarrow K^\pm (K_S^0 K^\pm \pi^\mp)$
6.3 \pm 12.4 \pm 4.0		61	ASNER	04 CLEO	$\gamma\gamma \rightarrow \eta_c \rightarrow K_S^0 K^\pm \pi^\mp$

• • • We do not use the following data for averages, fits, limits, etc. • • •

< 23	90	98 \pm 52	¹⁶ AUBERT	06E BABR	$B^\pm \rightarrow K^\pm X_{c\bar{c}}$
22 \pm 14		121 \pm 27	AUBERT	05C BABR	$e^+ e^- \rightarrow J/\psi c\bar{c}$
17.0 \pm 8.3 \pm 2.5		112 \pm 24	¹⁷ AUBERT	04D BABR	$\gamma\gamma \rightarrow \eta_c(2S) \rightarrow K\bar{K}\pi$
<55	90	39 \pm 11	¹⁸ CHOI	02 BELL	$B \rightarrow K K_S K^- \pi^+$
<8.0	95		¹⁹ EDWARDS	82C CBAL	$e^+ e^- \rightarrow \gamma X$

¹³ From a simultaneous fit to $K_S^0 K^\pm \pi^\mp$ and $K^+ K^- \pi^0$ decay modes.

¹⁴ Ignoring possible interference with continuum.

¹⁵ Accounts for interference with non-resonant continuum.

¹⁶ From the fit of the kaon momentum spectrum. Systematic errors not evaluated.

¹⁷ Superseded by DEL-AMO-SANCHEZ 11M.

¹⁸ For a mass value of 3654 ± 6 MeV. Superseded by VINOKUROVA 11.

¹⁹ For a mass value of 3594 ± 5 MeV

 $\eta_c(2S)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)	Confidence level
Γ_1 hadrons	not seen	
Γ_2 $K\bar{K}\pi$	(1.9 \pm 1.2) %	
Γ_3 $K\bar{K}\eta$	(5 \pm 4) $\times 10^{-3}$	
Γ_4 $2\pi^+ 2\pi^-$	not seen	
Γ_5 $\rho^0 \rho^0$	not seen	
Γ_6 $3\pi^+ 3\pi^-$	not seen	
Γ_7 $K^+ K^- \pi^+ \pi^-$	not seen	
Γ_8 $K^{*0} \bar{K}^{*0}$	not seen	
Γ_9 $K^+ K^- \pi^+ \pi^- \pi^0$	(1.4 \pm 1.0) %	
Γ_{10} $K^+ K^- 2\pi^+ 2\pi^-$	not seen	
Γ_{11} $K_S^0 K^- 2\pi^+ \pi^- + c.c.$	seen	
Γ_{12} $2K^+ 2K^-$	not seen	
Γ_{13} $\phi\phi$	not seen	

Γ_{14}	$p\bar{p}$	seen		
Γ_{15}	$p\bar{p}\pi^+\pi^-$	seen		
Γ_{16}	$\gamma\gamma$	$(1.9\pm 1.3)\times 10^{-4}$		
Γ_{17}	$\gamma J/\psi(1S)$	< 1.4	%	90%
Γ_{18}	$\pi^+\pi^-\eta$	not seen		
Γ_{19}	$\pi^+\pi^-\eta'$	not seen		
Γ_{20}	$\pi^+\pi^-\eta_c(1S)$	< 25	%	90%

$\eta_c(2S)$ PARTIAL WIDTHS

$\Gamma(\gamma\gamma)$ Γ_{16}

VALUE (keV)	EVTS	DOCUMENT ID	TECN	COMMENT
-------------	------	-------------	------	---------

• • • We do not use the following data for averages, fits, limits, etc. • • •

0.44 ± 0.14	106	²⁰ XU	18	BELL $e^+e^- \rightarrow e^+e^-\eta'\pi^+\pi^-$
1.3 ± 0.6		²¹ ASNER	04	CLEO $\gamma\gamma \rightarrow \eta_c \rightarrow K_S^0 K^\pm \pi^\mp$

²⁰ Assuming that the branching fraction into $\eta'\pi^+\pi^-$ is the same as for $\eta_c(1S)$.

²¹ They measure $\Gamma(\eta_c(2S)\gamma\gamma) B(\eta_c(2S) \rightarrow K\bar{K}\pi) = (0.18 \pm 0.05 \pm 0.02) \Gamma(\eta_c(1S)\gamma\gamma) B(\eta_c(1S) \rightarrow K\bar{K}\pi)$. The value for $\Gamma(\eta_c(2S) \rightarrow \gamma\gamma)$ is derived assuming that the branching fractions for $\eta_c(2S)$ and $\eta_c(1S)$ decays to $K_S K\pi$ are equal and using $\Gamma(\eta_c(1S) \rightarrow \gamma\gamma) = 7.4 \pm 0.4 \pm 2.3$ keV.

$\Gamma(\gamma\gamma) \times \Gamma(\pi^+\pi^-\eta')/\Gamma_{\text{total}}$ $\Gamma_{16}\Gamma_{19}/\Gamma$

VALUE (eV)	EVTS	DOCUMENT ID	TECN	COMMENT
------------	------	-------------	------	---------

$5.6_{-1.1}^{+1.2} \pm 1.1$	106	XU	18	BELL $e^+e^- \rightarrow e^+e^-\eta'\pi^+\pi^-$
-----------------------------	-----	----	----	---

$\eta_c(2S) \Gamma(i)\Gamma(\gamma\gamma)/\Gamma(\text{total})$

$\Gamma(2\pi^+2\pi^-) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\Gamma_4\Gamma_{16}/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
------------	-----	-------------	------	---------

< 6.5	90	UEHARA	08	BELL $\gamma\gamma \rightarrow \eta_c(2S) \rightarrow 2(\pi^+\pi^-)$
---------	----	--------	----	--

$\Gamma(K\bar{K}\pi) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\Gamma_2\Gamma_{16}/\Gamma$

VALUE (eV)	EVTS	DOCUMENT ID	TECN	COMMENT
------------	------	-------------	------	---------

$41 \pm 4 \pm 6$	624	²² DEL-AMO-SA..11M	BABR	$\gamma\gamma \rightarrow K_S^0 K^\pm \pi^\mp$
------------------	-----	-------------------------------	------	--

²² Not independent from other measurements reported in DEL-AMO-SANCHEZ 11M.

$\Gamma(K^+K^-\pi^+\pi^-) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\Gamma_7\Gamma_{16}/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
------------	-----	-------------	------	---------

< 5.0	90	UEHARA	08	BELL $\gamma\gamma \rightarrow \eta_c(2S) \rightarrow K^+K^-\pi^+\pi^-$
---------	----	--------	----	---

$\Gamma(K^+K^-\pi^+\pi^-\pi^0) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\Gamma_9\Gamma_{16}/\Gamma$

VALUE (eV)	EVTS	DOCUMENT ID	TECN	COMMENT
------------	------	-------------	------	---------

$30 \pm 6 \pm 5$	1201	²³ DEL-AMO-SA..11M	BABR	$\gamma\gamma \rightarrow K^+K^-\pi^+\pi^-\pi^0$
------------------	------	-------------------------------	------	--

²³ Not independent from other measurements reported in DEL-AMO-SANCHEZ 11M.

$$\Gamma(2K^+2K^-) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}} \qquad \Gamma_{12}\Gamma_{16}/\Gamma$$

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
<2.9	90	UEHARA	08	BELL $\gamma\gamma \rightarrow \eta_c(2S) \rightarrow 2(K^+K^-)$

$$\Gamma(\pi^+\pi^-\eta_c(1S)) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}} \qquad \Gamma_{20}\Gamma_{16}/\Gamma$$

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
<133	90	LEES	12AE	BABR $e^+e^- \rightarrow e^+e^-\pi^+\pi^-\eta_c$

$$\eta_c(2S) \Gamma(i)\Gamma(\gamma\gamma)/\Gamma^2(\text{total})$$

$$\Gamma(p\bar{p})/\Gamma_{\text{total}} \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}} \qquad \Gamma_{14}/\Gamma \times \Gamma_{16}/\Gamma$$

VALUE (units 10^{-8})	CL%	DOCUMENT ID	TECN	COMMENT
< 5.6	90 ^{24,25,26}	AMBROGIANI	01	E835 $\bar{p}p \rightarrow \gamma\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 8.0	90 ^{24,25,27}	AMBROGIANI	01	E835 $\bar{p}p \rightarrow \gamma\gamma$
<12.0	90	25,27	AMBROGIANI	01 E835 $\bar{p}p \rightarrow \gamma\gamma$

²⁴ Including the measurements of of ARMSTRONG 95F in the AMBROGIANI 01 analysis.

²⁵ For a total width $\Gamma=5$ MeV.

²⁶ For the resonance mass region 3589–3599 MeV/ c^2 .

²⁷ For the resonance mass region 3575–3660 MeV/ c^2 .

$$\eta_c(2S) \text{ BRANCHING RATIOS}$$

$$\Gamma(\text{hadrons})/\Gamma_{\text{total}} \qquad \Gamma_1/\Gamma$$

VALUE	DOCUMENT ID	TECN	COMMENT
not seen	ABREU	98O	DLPH $e^+e^- \rightarrow e^+e^- + \text{hadrons}$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
seen	²⁸ EDWARDS	82C	CBAL $e^+e^- \rightarrow \gamma X$

²⁸ For a mass value of 3594 ± 5 MeV

$$\Gamma(K\bar{K}\pi)/\Gamma_{\text{total}} \qquad \Gamma_2/\Gamma$$

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
$1.9 \pm 0.4 \pm 1.1$	59 ± 12	²⁹ AUBERT	08AB	BABR $B \rightarrow \eta_c(2S)K \rightarrow K\bar{K}\pi K$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
seen	127 ± 18	ABLIKIM	13K	BES3 $\psi(2S) \rightarrow \gamma K\bar{K}\pi$
seen	39 ± 11	³⁰ CHOI	02	BELL $B \rightarrow K K_S K^- \pi^+$

²⁹ Derived from a measurement of $[B(B^+ \rightarrow \eta_c(2S)K^+) \times B(\eta_c(2S) \rightarrow K\bar{K}\pi)] / [B(B^+ \rightarrow \eta_c K^+) \times B(\eta_c \rightarrow K\bar{K}\pi)] = (9.6^{+2.0}_{-1.9} \pm 2.5)\%$ and using $B(B^+ \rightarrow \eta_c(2S)K^+) = (3.4 \pm 1.8) \times 10^{-4}$, and $[B(B^+ \rightarrow \eta_c K^+) \times B(\eta_c \rightarrow K\bar{K}\pi)] = (6.88 \pm 0.77^{+0.55}_{-0.66}) \times 10^{-5}$.

³⁰ For a mass value of 3654 ± 6 MeV

$$\Gamma(K\bar{K}\eta)/\Gamma(K\bar{K}\pi) \qquad \Gamma_3/\Gamma_2$$

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
$27.3 \pm 7.0 \pm 9.0$	225	³¹ LEES	14E	BABR $\gamma\gamma \rightarrow K^+K^-\gamma\gamma$

³¹ LEES 14E reports $B(\eta_c(2S) \rightarrow K^+K^-\eta)/B(\eta_c(2S) \rightarrow K^+K^-\pi^0) = 0.82 \pm 0.21 \pm 0.27$, which we divide by 3 to account for isospin symmetry.

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

VALUE	DOCUMENT ID	TECN	COMMENT
not seen	UEHARA 08	BELL	$\gamma\gamma \rightarrow \eta_c(2S)$

 $\Gamma(\rho^0\rho^0)/\Gamma_{\text{total}}$ Γ_5/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
not seen	ABLIKIM 11H	BES3	$\psi(2S) \rightarrow \gamma 2\pi^+ 2\pi^-$

 $\Gamma(K^+K^-\pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_7/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
not seen	UEHARA 08	BELL	$\gamma\gamma \rightarrow \eta_c(2S)$

 $\Gamma(K^+K^-\pi^+\pi^-\pi^0)/\Gamma(K\bar{K}\pi)$ Γ_9/Γ_2

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
$0.73 \pm 0.17 \pm 0.17$	1201	³² DEL-AMO-SA..11M	BABR	$\gamma\gamma \rightarrow K^+K^-\pi^+\pi^-\pi^0$

³²We have multiplied the value of $\Gamma(K^+K^-\pi^+\pi^-\pi^0)/\Gamma(K_S^0K^\pm\pi^\mp)$ reported in DEL-AMO-SANCHEZ 11M by a factor 1/3 to obtain $\Gamma(K^+K^-\pi^+\pi^-\pi^0)/\Gamma(K\bar{K}\pi)$. Not independent from other measurements reported in DEL-AMO-SANCHEZ 11M.

 $\Gamma(K^{*0}\bar{K}^{*0})/\Gamma_{\text{total}}$ Γ_8/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
not seen	ABLIKIM 11H	BES3	$\psi(2S) \rightarrow \gamma K^+K^-\pi^+\pi^-$

 $\Gamma(K_S^0K^-2\pi^+\pi^- + \text{c.c.})/\Gamma_{\text{total}}$ Γ_{11}/Γ

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
seen	57 ± 17	ABLIKIM 13K	BES3	$\psi(2S) \rightarrow \gamma K_S^0K^\pm\pi^\mp\pi^+\pi^-$

 $\Gamma(2K^+2K^-)/\Gamma_{\text{total}}$ Γ_{12}/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
not seen	UEHARA 08	BELL	$\gamma\gamma \rightarrow \eta_c(2S)$

 $\Gamma(\phi\phi)/\Gamma_{\text{total}}$ Γ_{13}/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
not seen	ABLIKIM 11H	BES3	$\psi(2S) \rightarrow \gamma K^+K^-K^+K^-$

 $\Gamma(p\bar{p})/\Gamma_{\text{total}}$ Γ_{14}/Γ

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
seen	106	³³ AAIJ 17AD	LHCB	$pp \rightarrow B^+X \rightarrow p\bar{p}K^+X$

³³AAIJ 17AD report a 6.4 standard deviation signal, with $B(B^+ \rightarrow \eta_c(2S)K^+ \rightarrow p\bar{p}K^+)/B(B^+ \rightarrow J/\psi K^+ \rightarrow p\bar{p}K^+) = (1.58 \pm 0.33 \pm 0.09) \times 10^{-2}$.

 $\Gamma(p\bar{p}\pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_{15}/Γ

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
seen	110	³⁴ CHILIKIN 19	BELL	$e^+e^- \rightarrow \Upsilon(4S)$

³⁴CHILIKIN 19 reports signals in $B^+ \rightarrow \eta_c(2S)K^+$ and $B^0 \rightarrow \eta_c(2S)K_S^0$ with 12.3 and 5.9 standard deviations, respectively.

$$\Gamma(\gamma\gamma)/\Gamma_{\text{total}} \qquad \Gamma_{16}/\Gamma$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
-------	-----	-------------	------	---------

• • • We do not use the following data for averages, fits, limits, etc. • • •

$<4 \times 10^{-4}$	90	³⁵ WICHT	08	BELL $B^\pm \rightarrow K^\pm \gamma\gamma$
not seen		AMBROGIANI	01	E835 $\bar{p}p \rightarrow \gamma\gamma$
<0.01	90	LEE	85	CBAL $\psi' \rightarrow \text{photons}$

³⁵ WICHT 08 reports $[\Gamma(\eta_c(2S) \rightarrow \gamma\gamma)/\Gamma_{\text{total}}] \times [B(B^+ \rightarrow \eta_c(2S)K^+)] < 0.18 \times 10^{-6}$ which we divide by our best value $B(B^+ \rightarrow \eta_c(2S)K^+) = 4.4 \times 10^{-4}$.

$$\Gamma(\pi^+ \pi^- \eta_c(1S))/\Gamma(K\bar{K}\pi) \qquad \Gamma_{20}/\Gamma_2$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
-------	-----	-------------	------	---------

<3.33	90	³⁶ LEES	12AE BABR	$e^+e^- \rightarrow e^+e^-\pi^+\pi^-\eta_c$
------------------------------	----	--------------------	-----------	---

³⁶ We divided the reported limit by 3 to take into account isospin relations.

$\eta_c(2S)$ CROSS-PARTICLE BRANCHING RATIOS

$$\Gamma(\eta_c(2S) \rightarrow K\bar{K}\eta)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma\eta_c(2S))/\Gamma_{\text{total}} \qquad \Gamma_3/\Gamma \times \Gamma_{166}^{\psi(2S)}/\Gamma\psi(2S)$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
-------	-----	-------------	------	---------

• • • We do not use the following data for averages, fits, limits, etc. • • •

$<11.8 \times 10^{-6}$	90	³⁷ CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma K^+ K^- \eta$
------------------------	----	------------------------------	------	--

³⁷ CRONIN-HENNESSY 10 reports a limit of $< 5.9 \times 10^{-6}$ for the decay $\eta_c(2S) \rightarrow K^+ K^- \eta$ which we multiply by 2 account for isospin symmetry. It assumes $\Gamma(\eta_c(2S)) = 14$ MeV. It also gives the analytic dependence of limits on width.

$$\Gamma(\eta_c(2S) \rightarrow 2\pi^+ 2\pi^-)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma\eta_c(2S))/\Gamma_{\text{total}} \qquad \Gamma_4/\Gamma \times \Gamma_{166}^{\psi(2S)}/\Gamma\psi(2S)$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
-------	-----	-------------	------	---------

$<14.6 \times 10^{-6}$	90	³⁸ CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma 2\pi^+ 2\pi^-$
---	----	------------------------------	------	---

³⁸ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$$\Gamma(\eta_c(2S) \rightarrow \rho^0 \rho^0)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma\eta_c(2S))/\Gamma_{\text{total}} \qquad \Gamma_5/\Gamma \times \Gamma_{166}^{\psi(2S)}/\Gamma\psi(2S)$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
-------	-----	-------------	------	---------

$<12.7 \times 10^{-7}$	90	ABLIKIM	11H BES3	$\psi(2S) \rightarrow \gamma 2\pi^+ 2\pi^-$
---	----	---------	----------	---

$$\Gamma(\eta_c(2S) \rightarrow 3\pi^+ 3\pi^-)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma\eta_c(2S))/\Gamma_{\text{total}} \qquad \Gamma_6/\Gamma \times \Gamma_{166}^{\psi(2S)}/\Gamma\psi(2S)$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
-------	-----	-------------	------	---------

$<13.2 \times 10^{-6}$	90	³⁹ CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma 3\pi^+ 3\pi^-$
---	----	------------------------------	------	---

³⁹ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$$\Gamma(\eta_c(2S) \rightarrow K^+ K^- \pi^+ \pi^-) / \Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma \eta_c(2S)) / \Gamma_{\text{total}}$$

$$\Gamma_7 / \Gamma \times \Gamma_{166}^{\psi(2S)} / \Gamma_{\psi(2S)}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<9.6 \times 10^{-6}$	90	40 CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma K^+ K^- \pi^+ \pi^-$

⁴⁰ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$$\Gamma(\eta_c(2S) \rightarrow K^{*0} \bar{K}^{*0}) / \Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma \eta_c(2S)) / \Gamma_{\text{total}}$$

$$\Gamma_8 / \Gamma \times \Gamma_{166}^{\psi(2S)} / \Gamma_{\psi(2S)}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<19.6 \times 10^{-7}$	90	ABLIKIM	11H BES3	$\psi(2S) \rightarrow \gamma K^+ K^- \pi^+ \pi^-$

$$\Gamma(\eta_c(2S) \rightarrow K^+ K^- \pi^+ \pi^- \pi^0) / \Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma \eta_c(2S)) / \Gamma_{\text{total}}$$

$$\Gamma_9 / \Gamma \times \Gamma_{166}^{\psi(2S)} / \Gamma_{\psi(2S)}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<43.0 \times 10^{-6}$	90	41 CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma K^+ K^- \pi^+ \pi^- \pi^0$

⁴¹ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$$\Gamma(\eta_c(2S) \rightarrow K^+ K^- 2\pi^+ 2\pi^-) / \Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma \eta_c(2S)) / \Gamma_{\text{total}}$$

$$\Gamma_{10} / \Gamma \times \Gamma_{166}^{\psi(2S)} / \Gamma_{\psi(2S)}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<9.7 \times 10^{-6}$	90	42 CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma K^+ K^- 2\pi^+ 2\pi^-$

⁴² Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$$\Gamma(\eta_c(2S) \rightarrow K_S^0 K^- 2\pi^+ \pi^- + \text{c.c.}) / \Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma \eta_c(2S)) / \Gamma_{\text{total}}$$

$$\Gamma_{11} / \Gamma \times \Gamma_{166}^{\psi(2S)} / \Gamma_{\psi(2S)}$$

VALUE (units 10^{-6})	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
$7.03 \pm 2.10 \pm 0.7$	60		ABLIKIM	13K BES3	$\psi(2S) \rightarrow \gamma K_S^0 K^- 2\pi^+ \pi^- + \text{c.c.}$

• • • We do not use the following data for averages, fits, limits, etc. • • •

< 15.2	90	43 CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma K_S^0 K^- 2\pi^+ \pi^- + \text{c.c.}$
----------	----	-------------------	------	--

⁴³ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$$\Gamma(\eta_c(2S) \rightarrow \phi \phi) / \Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma \eta_c(2S)) / \Gamma_{\text{total}}$$

$$\Gamma_{13} / \Gamma \times \Gamma_{166}^{\psi(2S)} / \Gamma_{\psi(2S)}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<7.8 \times 10^{-7}$	90	ABLIKIM	11H BES3	$\psi(2S) \rightarrow \gamma K^+ K^- K^+ K^-$

$$\Gamma(\eta_c(2S) \rightarrow p\bar{p})/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma\eta_c(2S))/\Gamma_{\text{total}} \quad \Gamma_{14}/\Gamma \times \Gamma_{166}^{\psi(2S)}/\Gamma_{\psi(2S)}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<1.4 \times 10^{-6}$	90	ABLIKIM 13V	BES3	$\psi(2S) \rightarrow \gamma p\bar{p}$

$$\Gamma(\eta_c(2S) \rightarrow \gamma J/\psi(1S))/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma\eta_c(2S))/\Gamma_{\text{total}} \quad \Gamma_{17}/\Gamma \times \Gamma_{166}^{\psi(2S)}/\Gamma_{\psi(2S)}$$

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
$<9.7 \times 10^{-6}$	90	33	44 ABLIKIM 17N	BES3	$\psi(2S) \rightarrow \gamma\gamma J/\psi$

⁴⁴ Uses $B(J/\psi \rightarrow e^+e^-) = (5.971 \pm 0.032)\%$ and $B(J/\psi \rightarrow \mu^+\mu^-) = (5.961 \pm 0.033)\%$.

$$\Gamma(\eta_c(2S) \rightarrow \pi^+\pi^-\eta)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma\eta_c(2S))/\Gamma_{\text{total}} \quad \Gamma_{18}/\Gamma \times \Gamma_{166}^{\psi(2S)}/\Gamma_{\psi(2S)}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<4.3 \times 10^{-6}$	90	45 CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma\pi^+\pi^-\eta$

⁴⁵ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$$\Gamma(\eta_c(2S) \rightarrow \pi^+\pi^-\eta')/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma\eta_c(2S))/\Gamma_{\text{total}} \quad \Gamma_{19}/\Gamma \times \Gamma_{166}^{\psi(2S)}/\Gamma_{\psi(2S)}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<14.2 \times 10^{-6}$	90	46 CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma\pi^+\pi^-\eta'$

⁴⁶ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$$\Gamma(\eta_c(2S) \rightarrow \pi^+\pi^-\eta_c(1S))/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma\eta_c(2S))/\Gamma_{\text{total}} \quad \Gamma_{20}/\Gamma \times \Gamma_{166}^{\psi(2S)}/\Gamma_{\psi(2S)}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<1.7 \times 10^{-4}$	90	47 CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma\pi^+\pi^-\eta_c(1S)$

⁴⁷ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$\eta_c(2S)$ REFERENCES

CHILIKIN	19	PR D100 012001	K. Chilikin <i>et al.</i>	(BELLE Collab.)
XU	18	PR D98 072001	Q.N. Xu <i>et al.</i>	(BELLE Collab.)
AAIJ	17AD	PL B769 305	R. Aaij <i>et al.</i>	(LHCb Collab.)
AAIJ	17BB	EPJ C77 609	R. Aaij <i>et al.</i>	(LHCb Collab.)
ABLIKIM	17N	PR D95 072004	M. Ablikim <i>et al.</i>	(BESIII Collab.)
PDG	16	CP C40 100001	C. Patrignani <i>et al.</i>	(PDG Collab.)
LEES	14E	PR D89 112004	J.P. Lees <i>et al.</i>	(BABAR Collab.)
ABLIKIM	13K	PR D87 052005	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	13V	PR D88 112001	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	12G	PRL 109 042003	M. Ablikim <i>et al.</i>	(BESIII Collab.)
LEES	12AE	PR D86 092005	J.P. Lees <i>et al.</i>	(BABAR Collab.)
ABLIKIM	11H	PR D84 091102	M. Ablikim <i>et al.</i>	(BESIII Collab.)
DEL-AMO-SA...	11M	PR D84 012004	P. del Amo Sanchez <i>et al.</i>	(BABAR Collab.)
VINOKUROVA	11	PL B706 139	A. Vinokurova <i>et al.</i>	(BELLE Collab.)
CRONIN-HEN...	10	PR D81 052002	D. Cronin-Hennessey <i>et al.</i>	(CLEO Collab.)
AUBERT	08AB	PR D78 012006	B. Aubert <i>et al.</i>	(BABAR Collab.)

UEHARA	08	EPJ C53 1	S. Uehara <i>et al.</i>	(BELLE Collab.)
WICHT	08	PL B662 323	J. Wicht <i>et al.</i>	(BELLE Collab.)
ABE	07	PRL 98 082001	K. Abe <i>et al.</i>	(BELLE Collab.)
AUBERT	06E	PRL 96 052002	B. Aubert <i>et al.</i>	(BABAR Collab.)
AUBERT	05C	PR D72 031101	B. Aubert <i>et al.</i>	(BABAR Collab.)
ABE	04G	PR D70 071102	K. Abe <i>et al.</i>	(BELLE Collab.)
ASNER	04	PRL 92 142001	D.M. Asner <i>et al.</i>	(CLEO Collab.)
AUBERT	04D	PRL 92 142002	B. Aubert <i>et al.</i>	(BABAR Collab.)
ABE,K	02	PRL 89 142001	K. Abe <i>et al.</i>	(BELLE Collab.)
CHOI	02	PRL 89 102001	S.-K. Choi <i>et al.</i>	(BELLE Collab.)
AMBROGIANI	01	PR D64 052003	M. Ambrogiani <i>et al.</i>	(FNAL E835 Collab.)
ABREU	98O	PL B441 479	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ARMSTRONG	95F	PR D52 4839	T.A. Armstrong <i>et al.</i>	(FNAL, FERR, GENO+)
LEE	85	SLAC 282	R.A. Lee	(SLAC)
EDWARDS	82C	PRL 48 70	C. Edwards <i>et al.</i>	(CIT, HARV, PRIN+)
