

$\eta_c(2S)$

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

Quantum numbers are quark model predictions.

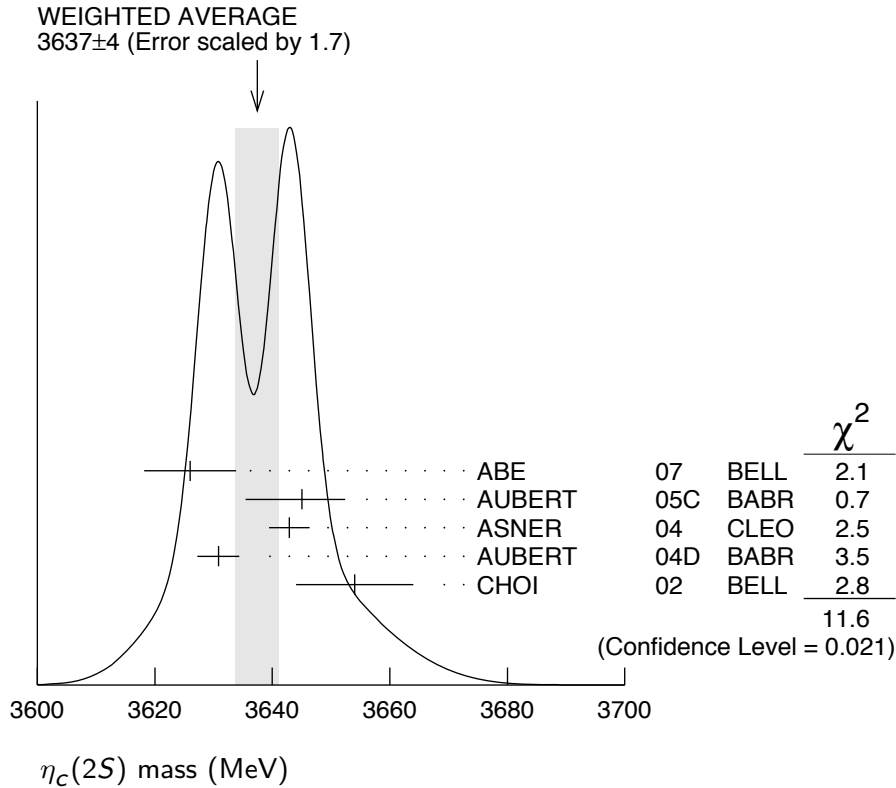
$\eta_c(2S)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
3637 ±4	OUR AVERAGE	Error includes scale factor of 1.7. See the ideogram below.		
3626 ±5 ±6	311	¹ 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	$\gamma\gamma \rightarrow \eta_c \rightarrow K_S^0 K^\pm \pi^\mp$
3630.8 ± 3.4 ± 1.0	112 ± 24	AUBERT	04D BABR	$\gamma\gamma \rightarrow \eta_c(2S) \rightarrow K\bar{K}\pi$
3654 ±6 ±8	39 ± 11	CHOI	02 BELL	$B \rightarrow K K_S K^- \pi^+$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
3639 ±7	98 ± 52	² AUBERT	06E BABR	$B^\pm \rightarrow K^\pm X_{c\bar{c}}$
3594 ±5		³ EDWARDS	82C CBAL	$e^+e^- \rightarrow \gamma X$

¹ From a fit of the J/ψ recoil mass spectrum. Supersedes ABE,K 02 and ABE 04G.

² From the fit of the kaon momentum spectrum. Systematic errors not evaluated.

³ Assuming mass of $\psi(2S) = 3686$ MeV.



$\eta_c(2S)$ WIDTH

VALUE (MeV)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
14 ± 7 OUR AVERAGE					
6.3 ± 12.4 ± 4.0		61	ASNER	04 CLEO	$\gamma\gamma \rightarrow \eta_c \rightarrow K_S^0 K^\pm \pi^\mp$
17.0 ± 8.3 ± 2.5		112 ± 24	AUBERT	04D BABR	$\gamma\gamma \rightarrow \eta_c(2S) \rightarrow K\bar{K}\pi$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
<23	90	98 ± 52	⁴ AUBERT	06E BABR	$B^\pm \rightarrow K^\pm X_c \bar{c}$
22 ± 14		121 ± 27	AUBERT	05C BABR	$e^+ e^- \rightarrow J/\psi c \bar{c}$
<55	90	39 ± 11	⁵ CHOI	02 BELL	$B \rightarrow K K_S K^- \pi^+$
<8.0	95		⁶ EDWARDS	82C CBAL	$e^+ e^- \rightarrow \gamma X$
⁴ From the fit of the kaon momentum spectrum. Systematic errors not evaluated.					
⁵ For a mass value of 3654 ± 6 MeV					
⁶ 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 ± 1.2) %	
Γ_3 $2\pi^+ 2\pi^-$	not seen	
Γ_4 $3\pi^+ 3\pi^-$	not seen	
Γ_5 $K^+ K^- \pi^+ \pi^-$	not seen	
Γ_6 $K^+ K^- \pi^+ \pi^- \pi^0$	not seen	
Γ_7 $K^+ K^- 2\pi^+ 2\pi^-$	not seen	
Γ_8 $K_S^0 K^- 2\pi^+ \pi^- + c.c.$	not seen	
Γ_9 $2K^+ 2K^-$	not seen	
Γ_{10} $p\bar{p}$	not seen	
Γ_{11} $\gamma\gamma$	< 5 × 10 ⁻⁴	90%
Γ_{12} $\pi^+ \pi^- \eta$	not seen	
Γ_{13} $\pi^+ \pi^- \eta'$	not seen	
Γ_{14} $K^+ K^- \eta$	not seen	
Γ_{15} $\pi^+ \pi^- \eta_c(1S)$	not seen	

$\eta_c(2S)$ PARTIAL WIDTHS

$\Gamma(\gamma\gamma)$	DOCUMENT ID	TECN	COMMENT	Γ_{11}
1.3 ± 0.6	⁷ ASNER	04 CLEO	$\gamma\gamma \rightarrow \eta_c \rightarrow K_S^0 K^\pm \pi^\mp$	
⁷ 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.				

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

$\Gamma(2\pi^+2\pi^-) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$					$\Gamma_3\Gamma_{11}/\Gamma$
VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT	
<5.6	90	UEHARA	08	BELL	$\gamma\gamma \rightarrow \eta_c(2S) \rightarrow 2(\pi^+\pi^-)$

$\Gamma(K^+K^-\pi^+\pi^-) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$					$\Gamma_5\Gamma_{11}/\Gamma$
VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT	
<5.0	90	UEHARA	08	BELL	$\gamma\gamma \rightarrow \eta_c(2S) \rightarrow K^+K^-\pi^+\pi^-$

$\Gamma(2K^+2K^-) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$					$\Gamma_9\Gamma_{11}/\Gamma$
VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT	
<2.9	90	UEHARA	08	BELL	$\gamma\gamma \rightarrow \eta_c(2S) \rightarrow 2(K^+K^-)$

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

$\Gamma(p\bar{p})/\Gamma_{\text{total}} \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$					$\Gamma_{10}/\Gamma \times \Gamma_{11}/\Gamma$
VALUE (units 10^{-8})	CL%	DOCUMENT ID	TECN	COMMENT	
< 5.6	90	8,9,10 AMBROGIANI	01	E835	$\bar{p}p \rightarrow \gamma\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 8.0	90	8,9,11 AMBROGIANI	01	E835	$\bar{p}p \rightarrow \gamma\gamma$
<12.0	90	9,11 AMBROGIANI	01	E835	$\bar{p}p \rightarrow \gamma\gamma$

⁸ Including the measurements of of ARMSTRONG 95F in the AMBROGIANI 01 analysis.

⁹ For a total width $\Gamma=5$ MeV.

¹⁰ For the resonance mass region 3589–3599 MeV/ c^2 .

¹¹ For the resonance mass region 3575–3660 MeV/ c^2 .

$\eta_c(2S)$ BRANCHING RATIOS

$\Gamma(\text{hadrons})/\Gamma_{\text{total}}$					Γ_1/Γ
VALUE		DOCUMENT ID	TECN	COMMENT	
not seen		ABREU	980	DLPH	$e^+e^- \rightarrow e^+e^- + \text{hadrons}$

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

seen ¹² EDWARDS 82C CBAL $e^+e^- \rightarrow \gamma X$

¹² For a mass value of 3594 ± 5 MeV

$\Gamma(K\bar{K}\pi)/\Gamma_{\text{total}}$					Γ_2/Γ
VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT	
$1.9 \pm 0.4 \pm 1.1$	59 ± 12	¹³ 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 39 ± 11 ¹⁴ CHOI 02 BELL $B \rightarrow KK_S K^-\pi^+$

¹³ 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 $[B(B^+ \rightarrow \eta_c K^+) \times B(\eta_c \rightarrow K\bar{K}\pi)] = (6.88 \pm 0.77^{+0.55}_{-0.66}) \times 10^{-5}$.

¹⁴ For a mass value of 3654 ± 6 MeV

$\Gamma(2\pi^+2\pi^-)/\Gamma_{\text{total}}$ Γ_3/Γ

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

$\Gamma(K^+K^-\pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_5/Γ

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

$\Gamma(2K^+2K^-)/\Gamma_{\text{total}}$ Γ_9/Γ

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

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
not seen		AMBROGIANI 01	E835	$\bar{p}p \rightarrow \gamma\gamma$

$\Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ Γ_{11}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<5 \times 10^{-4}$	90	¹⁵ WICHT 08	BELL	$B^\pm \rightarrow K^\pm \gamma\gamma$

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

<0.01	90	LEE 85	CBAL	$\psi' \rightarrow \text{photons}$
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¹⁵ 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 $B(B^+ \rightarrow \eta_c(2S)K^+) = 3.4 \times 10^{-4}$.

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

$\Gamma(\eta_c(2S) \rightarrow 2\pi^+2\pi^-)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma\eta_c(2S))/\Gamma_{\text{total}}$
 $\Gamma_3/\Gamma \times \Gamma_{110}^{\psi(2S)}/\Gamma\psi(2S)$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<14.6 \times 10^{-6}$	90	¹⁶ CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma 2\pi^+ 2\pi^-$

¹⁶ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$\Gamma(\eta_c(2S) \rightarrow 3\pi^+3\pi^-)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma\eta_c(2S))/\Gamma_{\text{total}}$
 $\Gamma_4/\Gamma \times \Gamma_{110}^{\psi(2S)}/\Gamma\psi(2S)$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<13.2 \times 10^{-6}$	90	¹⁷ CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma 3\pi^+ 3\pi^-$

¹⁷ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$\Gamma(\eta_c(2S) \rightarrow K^+K^-\pi^+\pi^-)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \gamma\eta_c(2S))/\Gamma_{\text{total}}$
 $\Gamma_5/\Gamma \times \Gamma_{110}^{\psi(2S)}/\Gamma\psi(2S)$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<9.6 \times 10^{-6}$	90	¹⁸ CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma K^+ K^- \pi^+ \pi^-$

¹⁸ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$$\frac{\Gamma(\eta_c(2S) \rightarrow K^+ K^- \pi^+ \pi^- \pi^0)}{\Gamma_{\text{total}}} \times \frac{\Gamma(\psi(2S) \rightarrow \gamma \eta_c(2S))}{\Gamma_{\text{total}}} \times \frac{\Gamma_6/\Gamma \times \Gamma_{110}^{\psi(2S)}/\Gamma\psi(2S)}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<43.0 \times 10^{-6}$	90	19 CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma K^+ K^- \pi^+ \pi^- \pi^0$

¹⁹ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$$\frac{\Gamma(\eta_c(2S) \rightarrow K^+ K^- 2\pi^+ 2\pi^-)}{\Gamma_{\text{total}}} \times \frac{\Gamma(\psi(2S) \rightarrow \gamma \eta_c(2S))}{\Gamma_{\text{total}}} \times \frac{\Gamma_7/\Gamma \times \Gamma_{110}^{\psi(2S)}/\Gamma\psi(2S)}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<9.7 \times 10^{-6}$	90	20 CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma K^+ K^- 2\pi^+ 2\pi^-$

²⁰ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$$\frac{\Gamma(\eta_c(2S) \rightarrow K_S^0 K^- 2\pi^+ \pi^- + \text{c.c.})}{\Gamma_{\text{total}}} \times \frac{\Gamma(\psi(2S) \rightarrow \gamma \eta_c(2S))}{\Gamma_{\text{total}}} \times \frac{\Gamma_8/\Gamma \times \Gamma_{110}^{\psi(2S)}/\Gamma\psi(2S)}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<15.2 \times 10^{-6}$	90	21 CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma K_S^0 K^- 2\pi^+ \pi^- + \text{c.c.}$

²¹ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$$\frac{\Gamma(\eta_c(2S) \rightarrow \pi^+ \pi^- \eta)}{\Gamma_{\text{total}}} \times \frac{\Gamma(\psi(2S) \rightarrow \gamma \eta_c(2S))}{\Gamma_{\text{total}}} \times \frac{\Gamma_{12}/\Gamma \times \Gamma_{110}^{\psi(2S)}/\Gamma\psi(2S)}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<4.3 \times 10^{-6}$	90	22 CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma \pi^+ \pi^- \eta$

²² Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$$\frac{\Gamma(\eta_c(2S) \rightarrow \pi^+ \pi^- \eta')}{\Gamma_{\text{total}}} \times \frac{\Gamma(\psi(2S) \rightarrow \gamma \eta_c(2S))}{\Gamma_{\text{total}}} \times \frac{\Gamma_{13}/\Gamma \times \Gamma_{110}^{\psi(2S)}/\Gamma\psi(2S)}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<14.2 \times 10^{-6}$	90	23 CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma \pi^+ \pi^- \eta'$

²³ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$$\frac{\Gamma(\eta_c(2S) \rightarrow K^+ K^- \eta)}{\Gamma_{\text{total}}} \times \frac{\Gamma(\psi(2S) \rightarrow \gamma \eta_c(2S))}{\Gamma_{\text{total}}} \times \frac{\Gamma_{14}/\Gamma \times \Gamma_{110}^{\psi(2S)}/\Gamma\psi(2S)}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<5.9 \times 10^{-6}$	90	24 CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma K^+ K^- \eta$

²⁴ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$$\frac{\Gamma(\eta_c(2S) \rightarrow \pi^+ \pi^- \eta_c(1S))}{\Gamma_{\text{total}}} \times \frac{\Gamma(\psi(2S) \rightarrow \gamma \eta_c(2S))}{\Gamma_{\text{total}}} \times \frac{\Gamma_{15}}{\Gamma} \times \frac{\Gamma_{110}^{\psi(2S)}}{\Gamma_{\psi(2S)}}$$

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$<1.7 \times 10^{-4}$	90	25 CRONIN-HEN..10	CLEO	$\psi(2S) \rightarrow \gamma \pi^+ \pi^- \eta_c(1S)$

²⁵ Assuming $\Gamma(\eta_c(2S)) = 14$ MeV. CRONIN-HENNESSY 10 gives the analytic dependence of limits on width.

$\eta_c(2S)$ REFERENCES

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 031101R	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+)