$\eta_c(2S)$

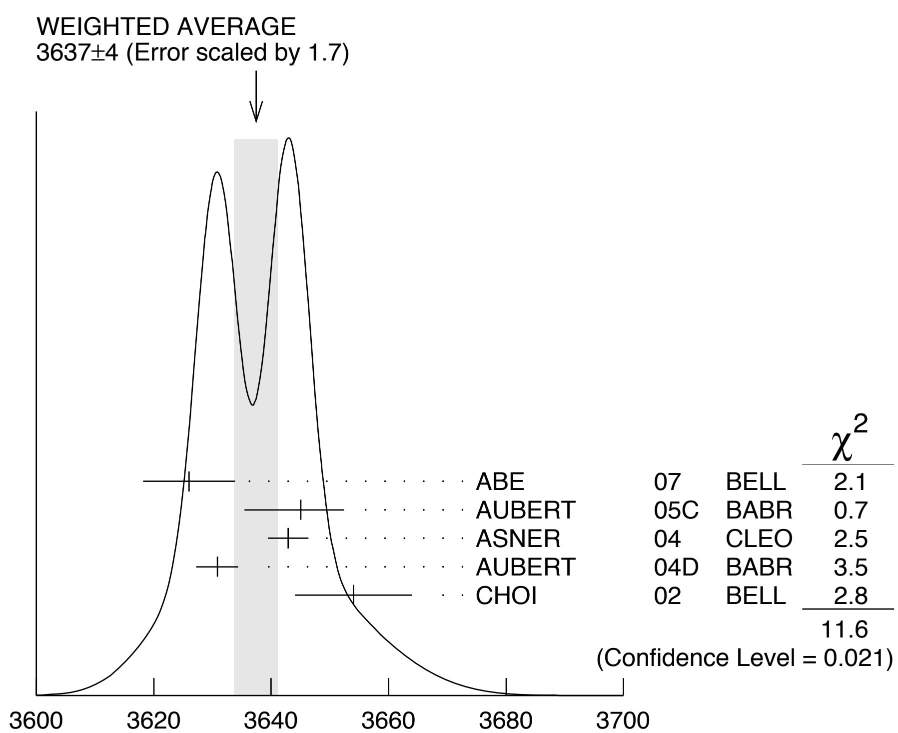
$I^G(J^{PC}) = 0^+(0^{-+})$

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	$e^+e^- \to J/\psi(c\overline{c})$
$3645.0\pm5.5^{+4.9}_{-7.8}$	121 ± 27	AUBERT	05C	BABR	$e^+e^- \to J/\psi c\overline{c}$
3642.9±3.1±1.5	61	ASNER	04	CLEO	$\gamma\gamma \to \eta_c \to K^0_S K^\pm \pi^\mp$
3630.8±3.4±1.0	112 ± 24	AUBERT	04D	BABR	$\gamma\gamma \to \eta_c(2S) \to K\overline{K}\pi$
3654 ±6 ±8	39 ± 11	CHOI	02	BELL	$B \to K K_S K^- \pi^+$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
3639 ±7	98 ± 52	[2] AUBERT	06E	BABR	$B^\pm \to K^\pm X_{c\overline{c}}$
3594 ±5		[3] EDWARDS	82C	CBAL	$e^+e^- \to \gamma X$

[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.



$\eta_c(2S)$ mass (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	$\gamma\gamma \to \eta_c \to K^0_S K^\pm \pi^\mp$
17.0± 8.3±2.5		112 ± 24	AUBERT	04D	BABR	$\gamma\gamma \to \eta_c(2S) \to K\overline{K}\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<23	90	98 ± 52	[4] AUBERT	06E	BABR	$B^\pm \to K^\pm X_{c\overline{c}}$
22 ±14		121 ± 27	AUBERT	05C	BABR	$e^+e^- \to J/\psi c\overline{c}$
<55	90	39 ± 11	[5] CHOI	02	BELL	$B \to K K_S K^- \pi^+$
<8.0	95		[6] EDWARDS	82C	CBAL	$e^+e^- \to \gamma X$

[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	$K\overline{K}\pi$	(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	$K^0_S K^- 2\pi^+\pi^-$ + c.c.	not seen	
Γ_9	$2K^+2K^-$	not seen	
Γ_{10}	$p\overline{p}$	not seen	
Γ_{11}	$\gamma\gamma$	$< 5 \times 10^{-4}$	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

$\Gamma(\gamma\gamma)$ — Γ_{11}

VALUE (keV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1.3±0.6	[7] ASNER	04	CLEO	$\gamma\gamma \to \eta_c \to K^0_S K^\pm \pi^\mp$

[7] They measure $\Gamma(\eta_c(2S)\gamma\gamma)$ B$(\eta_c(2S) \to K\overline{K}\pi) = (0.18 \pm 0.05 \pm 0.02)$ $\Gamma(\eta_c(1S)\gamma\gamma)$ B$(\eta_c(1S) \to K\overline{K}\pi)$. The value for $\Gamma(\eta_c(2S) \to \gamma\gamma)$ 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 $\Gamma(\eta_c(1S) \to \gamma\gamma) = 7.4 \pm 0.4 \pm 2.3$ 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
<6.5	90	UEHARA	08	BELL	$\gamma\gamma \to \eta_c(2S) \to 2(\pi^+\pi^-)$

$\Gamma(K^+K^-\pi^+\pi^-) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ — $\Gamma_5\Gamma_{11}/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID		TECN	COMMENT
<5.0	90	UEHARA	08	BELL	$\gamma\gamma \to \eta_c(2S) \to K^+K^-\pi^+\pi^-$

$\Gamma(2K^+2K^-) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ — $\Gamma_9\Gamma_{11}/\Gamma$

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

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

$\Gamma(p\overline{p})/\Gamma_{\text{total}} \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ — $\Gamma_{10}/\Gamma \times \Gamma_{11}/\Gamma$

VALUE (units 10^{-8})	CL%	DOCUMENT ID		TECN	COMMENT
< 5.6	90	[8,9,10] AMBROGIANI	01	E835	$\overline{p}p \to \gamma\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 8.0	90	[8,9,11] AMBROGIANI	01	E835	$\overline{p}p \to \gamma\gamma$
<12.0	90	[9,11] AMBROGIANI	01	E835	$\overline{p}p \to \gamma\gamma$

[8] Including the measurements of of ARMSTRONG 95F in the AMBROGIANI 01 analysis.
[9] For a total width Γ=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	98O	DLPH	$e^+e^- \to e^+e^- +$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •				
seen	[12] EDWARDS	82C	CBAL	$e^+e^- \to \gamma X$

[12] For a mass value of 3594 ± 5 MeV

$\Gamma(K\overline{K}\pi)/\Gamma_{\text{total}}$ — Γ_2/Γ

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN	COMMENT
1.9±0.4±1.1	59 ± 12	[13] AUBERT	08AB	BABR	$B \to \eta_c(2S)K \to K\overline{K}\pi K$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
seen	39 ± 11	[14] CHOI	02	BELL	$B \to KK_S K^-\pi^+$

[13] Derived from a measurement of $[B(B^+ \to \eta_c(2S)K^+) \times B(\eta_c(2S) \to K\overline{K}\pi)]$ / $[B(B^+ \to \eta_c K^+) \times B(\eta_c \to K\overline{K}\pi)] = (9.6^{+2.0}_{-1.9} \pm 2.5)\%$ and using $B(B^+ \to \eta_c(2S)K^+) = (3.4 \pm 1.8) \times 10^{-4}$, and $[B(B^+ \to \eta_c K^+) \times B(\eta_c \to K\overline{K}\pi)] = (6.88 \pm 0.77^{+0.55}_{-0.66}) \times 10^{-5}$.
[14] For a mass value of 3654 ± 6 MeV

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

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

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

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

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

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

VALUE	DOCUMENT ID		TECN	COMMENT
not seen	AMBROGIANI	01	E835	$\overline{p}p \to \gamma\gamma$

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

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<5 \times 10^{-4}$	90	[15] WICHT	08	BELL	$B^\pm \to K^\pm \gamma\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.01	90	LEE	85	CBAL	$\psi' \to$ photons

[15] WICHT 08 reports $[\Gamma(\eta_c(2S) \to \gamma\gamma)/\Gamma_{total}] \times [B(B^+ \to \eta_c(2S) K^+)] < 0.18 \times 10^{-6}$ which we divide by our best value $B(B^+ \to \eta_c(2S) K^+) = 3.4 \times 10^{-4}$.

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

$\Gamma(\eta_c(2S) \to 2\pi^+ 2\pi^-)/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma\eta_c(2S))/\Gamma_{total}$ — $\Gamma_3/\Gamma \times \Gamma_{113}^{\psi(2S)}/\Gamma^{\psi(2S)}$

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

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

$\Gamma(\eta_c(2S) \to 3\pi^+ 3\pi^-)/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma\eta_c(2S))/\Gamma_{total}$ — $\Gamma_4/\Gamma \times \Gamma_{113}^{\psi(2S)}/\Gamma^{\psi(2S)}$

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

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

$\Gamma(\eta_c(2S) \to K^+ K^- \pi^+ \pi^-)/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma\eta_c(2S))/\Gamma_{total}$ — $\Gamma_5/\Gamma \times \Gamma_{113}^{\psi(2S)}/\Gamma^{\psi(2S)}$

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

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

$\Gamma(\eta_c(2S) \to K^+ K^- \pi^+ \pi^- \pi^0)/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma \eta_c(2S))/\Gamma_{total}$ $\Gamma_6/\Gamma \times \Gamma_{113}^{\psi(2S)}/\Gamma^{\psi(2S)}$

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

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

$\Gamma(\eta_c(2S) \to K^+ K^- 2\pi^+ 2\pi^-)/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma \eta_c(2S))/\Gamma_{total}$ $\Gamma_7/\Gamma \times \Gamma_{113}^{\psi(2S)}/\Gamma^{\psi(2S)}$

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

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

$\Gamma(\eta_c(2S) \to K^0_S K^- 2\pi^+ \pi^- + \text{c.c.})/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma \eta_c(2S))/\Gamma_{total}$ $\Gamma_8/\Gamma \times \Gamma_{113}^{\psi(2S)}/\Gamma^{\psi(2S)}$

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

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

$\Gamma(\eta_c(2S) \to \pi^+ \pi^- \eta)/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma \eta_c(2S))/\Gamma_{total}$ $\Gamma_{12}/\Gamma \times \Gamma_{113}^{\psi(2S)}/\Gamma^{\psi(2S)}$

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

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

$\Gamma(\eta_c(2S) \to \pi^+ \pi^- \eta')/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma \eta_c(2S))/\Gamma_{total}$ $\Gamma_{13}/\Gamma \times \Gamma_{113}^{\psi(2S)}/\Gamma^{\psi(2S)}$

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

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

$\Gamma(\eta_c(2S) \to K^+ K^- \eta)/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma \eta_c(2S))/\Gamma_{total}$ $\Gamma_{14}/\Gamma \times \Gamma_{113}^{\psi(2S)}/\Gamma^{\psi(2S)}$

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

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

$\Gamma(\eta_c(2S) \to \pi^+\pi^-\eta_c(1S))/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \to \gamma\eta_c(2S))/\Gamma_{\text{total}}$ $\Gamma_{15}/\Gamma \times \Gamma_{113}^{\psi(2S)}/\Gamma^{\psi(2S)}$

VALUE	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
<1.7 × 10^{-4}	90	[25] CRONIN-HEN..10	CLEO	$\psi(2S) \to \gamma\pi^+\pi^-\eta_c(1S)$

[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 *et al.*	(CLEO Collab.)
AUBERT	08AB	PR D78 012006	B. Aubert *et al.*	(BABAR Collab.)
UEHARA	08	EPJ C53 1	S. Uehara *et al.*	(BELLE Collab.)
WICHT	08	PL B662 323	J. Wicht *et al.*	(BELLE Collab.)
ABE	07	PRL 98 082001	K. Abe *et al.*	(BELLE Collab.)
AUBERT	06E	PRL 96 052002	B. Aubert *et al.*	(BABAR Collab.)
AUBERT	05C	PR D72 031101R	B. Aubert *et al.*	(BABAR Collab.)
ABE	04G	PR D70 071102	K. Abe *et al.*	(BELLE Collab.)
ASNER	04	PRL 92 142001	D.M. Asner *et al.*	(CLEO Collab.)
AUBERT	04D	PRL 92 142002	B. Aubert *et al.*	(BABAR Collab.)
ABE,K	02	PRL 89 142001	K. Abe *et al.*	(BELLE Collab.)
CHOI	02	PRL 89 102001	S.-K. Choi *et al.*	(BELLE Collab.)
AMBROGIANI	01	PR D64 052003	M. Ambrogiani *et al.*	(FNAL E835 Collab.)
ABREU	98O	PL B441 479	P. Abreu *et al.*	(DELPHI Collab.)
ARMSTRONG	95F	PR D52 4839	T.A. Armstrong *et al.*	(FNAL, FERR, GENO+)
LEE	85	SLAC 282	R.A. Lee	(SLAC)
EDWARDS	82C	PRL 48 70	C. Edwards *et al.*	(CIT, HARV, PRIN+)