$\eta_c(2S)$

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

Quantum numbers are quark model predictions.

$\eta_c(2S)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
3637.8 ±0.6 OUR AVERAGE		Error includes scale factor of 1.1.			
3637.8 ±0.8 ±0.2	1.6k	ABLIKIM	24J	BES3	$\psi(2S) \to \gamma\eta_c \to \gamma K\overline{K}\pi$
3637.90±0.54±1.40	3.7k	AAIJ	23AH	LHCB	$B^+ \to K^+(K^0_S K\pi)$
3643.4 ±2.3 ±4.4	569	ABLIKIM	22Q	BES3	$\psi(2S) \to \gamma 3(\pi^+\pi^-)$
3635.1 ±3.7 ±2.9	106	XU	18	BELL	$e^+e^- \to e^+e^-\eta'\pi^+\pi^-$
3633.6 ±1.7 ±0.6	106	[1] AAIJ	17AD	LHCB	$pp \to B^+X \to p\overline{p}K^+X$
3636.4 ±4.1 ±0.7	365	[2] AAIJ	17BB	LHCB	$pp \to b\overline{b}X \to 2(K^+K^-)X$
3637.0 ±5.7 ±3.4	178	[3,4] LEES	14E	BABR	$\gamma\gamma \to K^+K^-\pi^0$
3635.1 ±5.8 ±2.1	47	[3,5] LEES	14E	BABR	$\gamma\gamma \to K^+K^-\eta$
3646.9 ±1.6 ±3.6	57	ABLIKIM	13K	BES3	$\psi(2S) \to \gamma K^0_S K^\pm\pi^\mp\pi^+\pi^-$
3637.6 ±2.9 ±1.6	127	[6] ABLIKIM	12G	BES3	$\psi(2S) \to \gamma K^0 K\pi$, $KK\pi^0$
3638.5 ±1.5 ±0.8	624	[3] DEL-AMO-SA..	11M	BABR	$\gamma\gamma \to K^0_S K^\pm\pi^\mp$
3640.5 ±3.2 ±2.5	1201	[3] DEL-AMO-SA..	11M	BABR	$\gamma\gamma \to K^+K^-\pi^+\pi^-\pi^0$
3636.1 $^{+3.9}_{-4.2}$ $^{+0.7}_{-2.0}$	128	[7] VINOKUROVA	11	BELL	$B^\pm \to K^\pm(K^0_S K^\pm\pi^\mp)$
3626 ±5 ±6	311	[8] ABE	07	BELL	$e^+e^- \to J/\psi(c\overline{c})$
3645.0 ±5.5 $^{+4.9}_{-7.8}$	121	AUBERT	05C	BABR	$e^+e^- \to J/\psi c\overline{c}$
3642.9 ±3.1 ±1.5	61	ASNER	04	CLEO	$\gamma\gamma \to \eta'_c \to K^0_S K^\pm\pi^\mp$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
3639 ±7	98	[9] AUBERT	06E	BABR	$B^\pm \to K^\pm X_{c\overline{c}}$
3630.8 ±3.4 ±1.0	112	[10] AUBERT	04D	BABR	$\gamma\gamma \to \eta_c(2S) \to K\overline{K}\pi$
3654 ±6 ±8	39	[11] CHOI	02	BELL	$B \to KK_S K^-\pi^+$
3594 ±5		[12] EDWARDS	82C	CBAL	$e^+e^- \to \gamma X$

[1] AAIJ 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.

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

[3] Ignoring possible interference with continuum.

[4] With a width fixed to 11.3 MeV.

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

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

[7] Accounts for interference with non-resonant continuum.

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

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

[10] Superseded by DEL-AMO-SANCHEZ 11M.
[11] Superseded by VINOKUROVA 11.
[12] Assuming mass of $\psi(2S)$ = 3686 MeV.

$\eta_c(2S)$ WIDTH

VALUE (MeV)	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
11.6 ± 1.4 OUR AVERAGE						
10.5 ± 1.7 ± 3.5		1.6k	ABLIKIM	24J	BES3	$\psi(2S) \to \gamma\eta_c \to \gamma K\overline{K}\pi$
10.77 ± 1.62 ± 1.08		3.7k	AAIJ	23AH	LHCB	$B^+ \to K^+ (K^0_S K\pi)$
19.8 ± 3.9 ± 3.1		569	ABLIKIM	22Q	BES3	$\psi(2S) \to \gamma 3(\pi^+\pi^-)$
9.9 ± 4.8 ± 2.9		57	ABLIKIM	13K	BES3	$\psi(2S) \to \gamma K^0_S K^\pm \pi^\mp \pi^+ \pi^-$
16.9 ± 6.4 ± 4.8		127	[1] ABLIKIM	12G	BES3	$\psi(2S) \to \gamma K^0 K\pi$, $KK\pi^0$
13.4 ± 4.6 ± 3.2		624	[2] DEL-AMO-SA..	11M	BABR	$\gamma\gamma \to K^0_S K^\pm \pi^\mp$
$6.6^{+8.4}_{-5.1}{}^{+2.6}_{-0.9}$		128	[3] VINOKUROVA	11	BELL	$B^\pm \to K^\pm (K^0_S K^\pm \pi^\mp)$
6.3 ± 12.4 ± 4.0		61	ASNER	04	CLEO	$\gamma\gamma \to \eta'_c \to K^0_S K^\pm \pi^\mp$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
< 23	90	98	[4] AUBERT	06E	BABR	$B^\pm \to K^\pm X_{c\overline{c}}$
22 ± 14		121	AUBERT	05C	BABR	$e^+e^- \to J/\psi c\overline{c}$
17.0 ± 8.3 ± 2.5		112	[5] AUBERT	04D	BABR	$\gamma\gamma \to \eta_c(2S) \to K\overline{K}\pi$
< 55	90	39	[6] CHOI	02	BELL	$B \to K K_S K^- \pi^+$
< 8.0	95		[7] EDWARDS	82C	CBAL	$e^+e^- \to \gamma X$

[1] From a simultaneous fit to $K^0_S K^\pm \pi^\mp$ and $K^+ K^- \pi^0$ decay modes.
[2] Ignoring possible interference with continuum.
[3] Accounts for interference with non-resonant continuum.
[4] From the fit of the kaon momentum spectrum. Systematic errors not evaluated.
[5] Superseded by DEL-AMO-SANCHEZ 11M.
[6] For a mass value of 3654 ± 6 MeV. Superseded by VINOKUROVA 11.
[7] For a mass value of 3594 ± 5 MeV

$\eta_c(2S)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)	Confidence level
Γ_1	hadrons	seen	
Γ_2	$K\overline{K}\pi$	$(1.9^{+1.2}_{-1.0})$ %	
Γ_3	$K\overline{K}\eta$	$(7\ ^{+5}_{-4}) \times 10^{-3}$	
Γ_4	$2\pi^+2\pi^-$	$< 2.6 \times 10^{-3}$	90%
Γ_5	$a_0(1450)\pi$	seen	
Γ_6	$a_2(1700)\pi$	seen	
Γ_7	$a_0(1710)\pi$	seen	

Γ_8	$\rho^0\rho^0$	< 2.3	$\times 10^{-3}$	90%
Γ_9	$3\pi^+3\pi^-$	$(1.7^{+0.9}_{-1.1})$	%	
Γ_{10}	$K^+K^-\pi^+\pi^-$	< 2.5	$\times 10^{-3}$	90%
Γ_{11}	$K^{*0}\overline{K}^{*0}$	< 4	$\times 10^{-3}$	90%
Γ_{12}	$K^+K^-\pi^+\pi^-\pi^0$	$(1.5^{+1.0}_{-0.9})$	%	
Γ_{13}	$K^+K^-2\pi^+2\pi^-$	< 1.8	%	90%
Γ_{14}	$K^0_S K^-2\pi^+\pi^- +$ c.c.	$(1.4^{+0.8}_{-1.0})$	%	
Γ_{15}	$2K^+2K^-$	< 1.4	$\times 10^{-3}$	90%
Γ_{16}	$K^*_2(1430)\overline{K} +$ c.c.	seen		
Γ_{17}	$K^*_0(1950)\overline{K} +$ c.c.	seen		
Γ_{18}	$K^*_0(2600)\overline{K} +$ c.c.	seen		
Γ_{19}	$\phi\phi$	< 1.4	$\times 10^{-3}$	90%
Γ_{20}	$p\overline{p}$	< 3.2	$\times 10^{-4}$	90%
Γ_{21}	$p\overline{p}\pi^+\pi^-$	seen		
Γ_{22}	$\gamma\gamma$	$(1.8^{+1.0}_{-1.1})$	$\times 10^{-4}$	
Γ_{23}	$\gamma J/\psi(1S)$	< 1.8	%	90%
Γ_{24}	$\pi^+\pi^-\eta$	$(5.5^{+3.3}_{-4.0})$	$\times 10^{-3}$	
Γ_{25}	$\pi^+\pi^-\eta'$	$(2.7^{+2.0}_{-1.8})$	$\times 10^{-3}$	
Γ_{26}	$\pi^+\pi^-\eta_c(1S)$	< 4	%	90%

FIT INFORMATION

A multiparticle fit to $\eta_c(2S)$ and $\psi(2S)$ with 4 branching ratios uses 5 measurements to determine 3 parameters. The overall fit has a $\chi^2 = 2.6$ for 2 degrees of freedom.

The following *off-diagonal* array elements are the correlation coefficients $\left\langle \delta x_i \delta x_j \right\rangle / (\delta x_i \cdot \delta x_j)$, in percent, from the fit to the branching fractions, $x_i \equiv \Gamma_i/\Gamma_{\text{total}}$.

x_3	92
	x_2

$\eta_c(2S)$ PARTIAL WIDTHS

$\Gamma(\gamma\gamma)$ Γ_{22}

VALUE (keV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.44 ± 0.14	106	[1] XU	18	BELL	$e^+e^- \to e^+e^-\eta'\pi^+\pi^-$
1.3 ± 0.6		[2] ASNER	04	CLEO	$\gamma\gamma \to \eta'_c \to K^0_S K^\pm \pi^\mp$

[1] Assuming that the branching fraction into $\eta' \pi^+ \pi^-$ is the same as for $\eta_c(1S)$.
[2] 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.

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

$\Gamma(K\overline{K}\pi) \times \Gamma(\gamma\gamma)/\Gamma_{total}$ — $\Gamma_2\Gamma_{22}/\Gamma$

VALUE (eV)	EVTS	DOCUMENT ID	TECN	COMMENT
39 ±6 OUR AVERAGE				
41 ±4 ±6	624	DEL-AMO-SA..11M	BABR	$\gamma\gamma \to K^0_S K^\pm \pi^\mp$
33.6±7.2±8.1		[1] NAKAZAWA 08	BELL	$\gamma\gamma \to K^0_S K^\pm \pi^\mp$

[1] NAKAZAWA 08 reports B$(\eta_c(2S) \to K^0_S K^\pm \pi^\mp) \times \Gamma(\gamma\gamma) = 11.2 \pm 2.4 \pm 2.7$ eV which we multiplied by 3 to account for isospin symmetry.

$\Gamma(2\pi^+2\pi^-) \times \Gamma(\gamma\gamma)/\Gamma_{total}$ — $\Gamma_4\Gamma_{22}/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
<6.5	90	UEHARA 08	BELL	$\gamma\gamma \to \eta_c(2S) \to 2(\pi^+\pi^-)$

$\Gamma(K^+K^-\pi^+\pi^-) \times \Gamma(\gamma\gamma)/\Gamma_{total}$ — $\Gamma_{10}\Gamma_{22}/\Gamma$

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

$\Gamma(K^+K^-\pi^+\pi^-\pi^0) \times \Gamma(\gamma\gamma)/\Gamma_{total}$ — $\Gamma_{12}\Gamma_{22}/\Gamma$

VALUE (eV)	EVTS	DOCUMENT ID	TECN	COMMENT
30±6±5	1201	DEL-AMO-SA..11M	BABR	$\gamma\gamma \to K^+K^-\pi^+\pi^-\pi^0$

$\Gamma(2K^+2K^-) \times \Gamma(\gamma\gamma)/\Gamma_{total}$ — $\Gamma_{15}\Gamma_{22}/\Gamma$

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

$\Gamma(\pi^+\pi^-\eta') \times \Gamma(\gamma\gamma)/\Gamma_{total}$ — $\Gamma_{25}\Gamma_{22}/\Gamma$

VALUE (eV)	EVTS	DOCUMENT ID	TECN	COMMENT
$5.6^{+1.2}_{-1.1}\pm1.1$	106	XU 18	BELL	$e^+e^- \to e^+e^-\eta'\pi^+\pi^-$

$\Gamma(\pi^+\pi^-\eta_c(1S)) \times \Gamma(\gamma\gamma)/\Gamma_{total}$ — $\Gamma_{26}\Gamma_{22}/\Gamma$

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

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

$\Gamma(p\overline{p})/\Gamma_{total} \times \Gamma(\gamma\gamma)/\Gamma_{total}$ — $\Gamma_{20}/\Gamma \times \Gamma_{22}/\Gamma$

VALUE (units 10^{-8})	CL%	DOCUMENT ID	TECN	COMMENT
< 5.6	90	[1,2,3] AMBROGIANI 01	E835	$\overline{p}p \to \gamma\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 8.0	90	[1,2,4] AMBROGIANI 01	E835	$\overline{p}p \to \gamma\gamma$
<12.0	90	[2,4] AMBROGIANI 01	E835	$\overline{p}p \to \gamma\gamma$

[1] Including the measurements of of ARMSTRONG 95F in the AMBROGIANI 01 analysis.
[2] For a total width Γ=5 MeV.
[3] For the resonance mass region 3589–3599 MeV/c^2.
[4] For the resonance mass region 3575–3660 MeV/c^2.

$\eta_c(2S)$ BRANCHING RATIOS

Γ(hadrons)/Γtotal — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	ABREU	98O	DLPH	$e^+e^- \to e^+e^- +$ hadrons
seen	[1] EDWARDS	82C	CBAL	$e^+e^- \to \gamma X$

[1] For a mass value of 3594 ± 5 MeV

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

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN	COMMENT
$1.9^{+1.2}_{-1.0}$ OUR FIT					
1.9±0.4±1.1	59 ± 12	[1] 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	127 ± 18	ABLIKIM	12G	BES3	$\psi(2S) \to \gamma K\overline{K}\pi$
seen	39 ± 11	[2] CHOI	02	BELL	$B \to KK_S K^-\pi^+$

[1] 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 $[B(B^+ \to \eta_c K^+) \times B(\eta_c \to K\overline{K}\pi)] = (6.88 \pm 0.77^{+0.55}_{-0.66}) \times 10^{-5}$.
[2] For a mass value of 3654 ± 6 MeV

$\Gamma(K\overline{K}\eta)/\Gamma(K\overline{K}\pi)$ — Γ_3/Γ_2

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN	COMMENT
39 ±10 OUR FIT Error includes scale factor of 1.3.					
27.3± 7.0±9.0	225	[1] LEES	14E	BABR	$\gamma\gamma \to K^+K^-\gamma\gamma$

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

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

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	UEHARA	08	BELL	$\gamma\gamma \to \eta_c(2S)$

$\Gamma(a_0(1450)\pi)/\Gamma_{total}$ — Γ_5/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	[1] AAIJ	23AH	LHCB	$B^+ \to K^+(K^0_S K\pi)$

[1] From a Dalitz plot analysis of $\eta_c(2S) \to K^0_S K^+\pi^- +$ c.c..

$\Gamma(a_2(1700)\pi)/\Gamma_{total}$ Γ_6/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
seen	[1] AAIJ 23AH	LHCB	$B^+ \to K^+(K^0_S K\pi)$

[1] From a Dalitz plot analysis of $\eta_c(2S) \to K^0_S K^+\pi^- +$ c.c..

$\Gamma(a_0(1710)\pi)/\Gamma_{total}$ Γ_7/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
seen	[1] AAIJ 23AH	LHCB	$B^+ \to K^+(K^0_S K\pi)$

[1] From a Dalitz plot analysis of $\eta_c(2S) \to K^0_S K^+\pi^- +$ c.c..

$\Gamma(\rho^0\rho^0)/\Gamma_{total}$ Γ_8/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
not seen	ABLIKIM 11H	BES3	$\psi(2S) \to \gamma 2\pi^+ 2\pi^-$

$\Gamma(K^+K^-\pi^+\pi^-)/\Gamma_{total}$ Γ_{10}/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
not seen	UEHARA 08	BELL	$\gamma\gamma \to \eta_c(2S)$

$\Gamma(K^{*0}\overline{K}^{*0})/\Gamma_{total}$ Γ_{11}/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
not seen	ABLIKIM 11H	BES3	$\psi(2S) \to \gamma K^+K^-\pi^+\pi^-$

$\Gamma(K^+K^-\pi^+\pi^-\pi^0)/\Gamma(K\overline{K}\pi)$ Γ_{12}/Γ_2

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$0.73\pm0.17\pm0.17$	1201	[1] DEL-AMO-SA..11M	BABR	$\gamma\gamma \to K^+K^-\pi^+\pi^-\pi^0$

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

$\Gamma(K^0_S K^- 2\pi^+\pi^- + \text{c.c.})/\Gamma_{total}$ Γ_{14}/Γ

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
seen	57 ± 17	ABLIKIM 13K	BES3	$\psi(2S) \to \gamma K^0_S K^\pm\pi^\mp\pi^+\pi^-$

$\Gamma(2K^+2K^-)/\Gamma_{total}$ Γ_{15}/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
not seen	UEHARA 08	BELL	$\gamma\gamma \to \eta_c(2S)$

$\Gamma(K_2^*(1430)\overline{K}+\text{c.c.})/\Gamma_{total}$ Γ_{16}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	[1] AAIJ	23AH	LHCB	$B^+ \to K^+(K^0_S K\pi)$

[1] From a Dalitz plot analysis of $\eta_c(2S) \to K^0_S K^+ \pi^- +$ c.c..

$\Gamma(K_0^*(1950)\overline{K}+\text{c.c.})/\Gamma_{total}$ Γ_{17}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	[1] AAIJ	23AH	LHCB	$B^+ \to K^+(K^0_S K\pi)$

[1] From a Dalitz plot analysis of $\eta_c(2S) \to K^0_S K^+ \pi^- +$ c.c..

$\Gamma(K_0^*(2600)\overline{K}+\text{c.c.})/\Gamma_{total}$ Γ_{18}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	[1] AAIJ	23AH	LHCB	$B^+ \to K^+(K^0_S K\pi)$

[1] From a Dalitz plot analysis of $\eta_c(2S) \to K^0_S K^+ \pi^- +$ c.c..

$\Gamma(\phi\phi)/\Gamma_{total}$ Γ_{19}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	ABLIKIM	11H	BES3	$\psi(2S) \to \gamma K^+ K^- K^+ K^-$

$\Gamma(p\overline{p})/\Gamma_{total}$ Γ_{20}/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
seen	106	[1] AAIJ	17AD	LHCB	$pp \to B^+ X \to p\overline{p} K^+ X$

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

$\Gamma(p\overline{p}\pi^+\pi^-)/\Gamma_{total}$ Γ_{21}/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
seen	110	[1] CHILIKIN	19	BELL	$e^+ e^- \to \Upsilon(4S)$

[1] CHILIKIN 19 reports signals in $B^+ \to \eta_c(2S) K^+$ and $B^0 \to \eta_c(2S) K^0_S$ with 12.3 and 5.9 standard deviations, respectively.

$\Gamma(\gamma\gamma)/\Gamma_{total}$ Γ_{22}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<4 \times 10^{-4}$	90	[1] WICHT	08	BELL	$B^{\pm} \to K^{\pm}\gamma\gamma$
not seen		AMBROGIANI	01	E835	$\overline{p}p \to \gamma\gamma$
<0.01	90	LEE	85	CBAL	$\psi' \to$ photons

[1] 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($B^+ \to \eta_c(2S) K^+$) $= 4.4 \times 10^{-4}$.

$\Gamma(\pi^+\pi^-\eta_c(1S))/\Gamma(K\overline{K}\pi)$ — Γ_{26}/Γ_2

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<3.33	90	[1] LEES	12AE	BABR	$e^+e^- \to e^+e^-\pi^+\pi^-\eta_c$

[1] We divided the reported limit by 3 to take into account isospin relations.

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

$\Gamma(\eta_c(2S)\to K\overline{K}\pi)/\Gamma_{total} \times \Gamma(\psi(2S)\to\gamma\eta_c(2S))/\Gamma_{total}$ — $\Gamma_2/\Gamma \times \Gamma_{185}^{\psi(2S)}/\Gamma^{\psi(2S)}$

VALUE (units 10^{-5})	EVTS	DOCUMENT ID		TECN	COMMENT
1.03±0.12 OUR FIT Error includes scale factor of 1.2.					
1.00±0.10 OUR AVERAGE					
0.97±0.06±0.09	1.6k	ABLIKIM	24J	BES3	$\psi(2S) \to \gamma\eta_c \to \gamma K\overline{K}\pi$
1.30±0.20±0.30	127	ABLIKIM	12G	BES3	$\psi(2S) \to \gamma\eta_c \to \gamma K\overline{K}\pi$

$\Gamma(\eta_c(2S)\to K\overline{K}\eta)/\Gamma_{total} \times \Gamma(\psi(2S)\to\gamma\eta_c(2S))/\Gamma_{total}$ — $\Gamma_3/\Gamma \times \Gamma_{185}^{\psi(2S)}/\Gamma^{\psi(2S)}$

VALUE (units 10^{-6})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
4.0 ±1.0 OUR FIT Error includes scale factor of 1.3.						
4.78±0.64±0.68		362	[1] ABLIKIM	24BW	BES3	$\psi(2S) \to \gamma K^+K^-\eta$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<11.8	90		[2] CRONIN-HEN..10		CLEO	$\psi(2S) \to \gamma K^+K^-\eta$

[1] ABLIKIM 24BW reports a value of $(2.39 \pm 0.32 \pm 0.34) \times 10^{-6}$ for the decay $\eta_c(2S) \to K^+K^-\eta$ which we multiply by 2 to account for isospin symmetry.
[2] CRONIN-HENNESSY 10 reports a limit of $< 5.9 \times 10^{-6}$ for the decay $\eta_c(2S) \to K^+K^-\eta$ 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.

$\Gamma(\eta_c(2S)\to 2\pi^+2\pi^-)/\Gamma_{total} \times \Gamma(\psi(2S)\to\gamma\eta_c(2S))/\Gamma_{total}$ — $\Gamma_4/\Gamma \times \Gamma_{185}^{\psi(2S)}/\Gamma^{\psi(2S)}$

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
< 1.43 × 10^{-6}	90	ABLIKIM	24BT	BES3	$\psi(2S) \to \gamma 2\pi^+2\pi^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<14.6 × 10^{-6}	90	[1] CRONIN-HEN..10		CLEO	$\psi(2S) \to \gamma 2\pi^+2\pi^-$

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

$\Gamma(\eta_c(2S)\to \rho^0\rho^0)/\Gamma_{total} \times \Gamma(\psi(2S)\to\gamma\eta_c(2S))/\Gamma_{total}$ — $\Gamma_8/\Gamma \times \Gamma_{185}^{\psi(2S)}/\Gamma^{\psi(2S)}$

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<12.7 × 10^{-7}	90	ABLIKIM	11H	BES3	$\psi(2S) \to \gamma 2\pi^+2\pi^-$

$\Gamma(\eta_c(2S) \to 3\pi^+3\pi^-)/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma\eta_c(2S))/\Gamma_{total}$ $\Gamma_9/\Gamma \times \Gamma_{185}^{\psi(2S)}/\Gamma^{\psi(2S)}$

VALUE (units 10^{-6})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
9.2±1.0±1.2		569	ABLIKIM	22Q	BES3	$\psi(2S) \to \gamma 3(\pi^+\pi^-)$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<13.2	90		[1] CRONIN-HEN..10		CLEO	$\psi(2S) \to \gamma 3\pi^+ 3\pi^-$

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

$\Gamma(\eta_c(2S) \to K^+K^-\pi^+\pi^-)/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma\eta_c(2S))/\Gamma_{total}$ $\Gamma_{10}/\Gamma \times \Gamma_{185}^{\psi(2S)}/\Gamma^{\psi(2S)}$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<9.6 × 10^{-6}	90	[1] CRONIN-HEN..10	CLEO	$\psi(2S) \to \gamma K^+K^-\pi^+\pi^-$

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

$\Gamma(\eta_c(2S) \to K^{*0}\overline{K}^{*0})/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma\eta_c(2S))/\Gamma_{total}$ $\Gamma_{11}/\Gamma \times \Gamma_{185}^{\psi(2S)}/\Gamma^{\psi(2S)}$

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

$\Gamma(\eta_c(2S) \to K^+K^-\pi^+\pi^-\pi^0)/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma\eta_c(2S))/\Gamma_{total}$ $\Gamma_{12}/\Gamma \times \Gamma_{185}^{\psi(2S)}/\Gamma^{\psi(2S)}$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<43.0 × 10^{-6}	90	[1] CRONIN-HEN..10	CLEO	$\psi(2S) \to \gamma K^+K^-\pi^+\pi^-\pi^0$

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

$\Gamma(\eta_c(2S) \to K^+K^-2\pi^+2\pi^-)/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma\eta_c(2S))/\Gamma_{total}$ $\Gamma_{13}/\Gamma \times \Gamma_{185}^{\psi(2S)}/\Gamma^{\psi(2S)}$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<9.7 × 10^{-6}	90	[1] CRONIN-HEN..10	CLEO	$\psi(2S) \to \gamma K^+K^-2\pi^+2\pi^-$

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

$\Gamma(\eta_c(2S) \to K_S^0K^-2\pi^+\pi^- + \text{c.c.})/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma\eta_c(2S))/\Gamma_{total}$ $\Gamma_{14}/\Gamma \times \Gamma_{185}^{\psi(2S)}/\Gamma^{\psi(2S)}$

VALUE (units 10^{-6})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
7.9 ±1.8 OUR AVERAGE						
9.31±0.72±2.77		3140	ABLIKIM	24Q	BES3	$\psi(2S) \to \gamma K_S^0 K^- 2\pi^+\pi^-$ +c.c.
7.03±2.10±0.7		60	ABLIKIM	13K	BES3	$\psi(2S) \to \gamma K_S^0 K^- 2\pi^+\pi^-$ +c.c.
• • • We do not use the following data for averages, fits, limits, etc. • • •						
< 15.2	90		[1] CRONIN-HEN..10		CLEO	$\psi(2S) \to \gamma K_S^0 K^- 2\pi^+\pi^-$ +c.c.

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

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

$\Gamma_{19}/\Gamma \times \Gamma^{\psi(2S)}_{185}/\Gamma^{\psi(2S)}$

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

$\Gamma(\eta_c(2S) \to p\overline{p})/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma\eta_c(2S))/\Gamma_{total}$

$\Gamma_{20}/\Gamma \times \Gamma^{\psi(2S)}_{185}/\Gamma^{\psi(2S)}$

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

$\Gamma(\eta_c(2S) \to \gamma J/\psi(1S))/\Gamma_{total} \times \Gamma(\psi(2S) \to \gamma\eta_c(2S))/\Gamma_{total}$

$\Gamma_{23}/\Gamma \times \Gamma^{\psi(2S)}_{185}/\Gamma^{\psi(2S)}$

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$<9.7 \times 10^{-6}$	90	33	[1] ABLIKIM	17N	BES3	$\psi(2S) \to \gamma\gamma J/\psi$

[1] Uses B($J/\psi \to e^+e^-$) = (5.971 ± 0.032)% and B($J/\psi \to \mu^+\mu^-$) = (5.961 ± 0.033)%.

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

$\Gamma_{24}/\Gamma \times \Gamma^{\psi(2S)}_{185}/\Gamma^{\psi(2S)}$

VALUE (units 10^{-6})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
2.97±0.81±0.26		106	ABLIKIM	23Q	BES3	$\psi(2S) \to \gamma\pi^+\pi^-\eta$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<4.3	90		[1] CRONIN-HEN..10		CLEO	$\psi(2S) \to \gamma\pi^+\pi^-\eta$

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

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

$\Gamma_{25}/\Gamma \times \Gamma^{\psi(2S)}_{185}/\Gamma^{\psi(2S)}$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<14.2 \times 10^{-6}$	90	[1] CRONIN-HEN..10	CLEO	$\psi(2S) \to \gamma\pi^+\pi^-\eta'$

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

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

$\Gamma_{26}/\Gamma \times \Gamma^{\psi(2S)}_{185}/\Gamma^{\psi(2S)}$

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<2.21 \times 10^{-5}$	90	[1] ABLIKIM	24Q	BES3	$\psi(2S) \to \gamma\pi^+\pi^-\eta_c(1S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<1.7 \times 10^{-4}$	90	[2] CRONIN-HEN..10		CLEO	$\psi(2S) \to \gamma\pi^+\pi^-\eta_c(1S)$

[1] $\eta_c(1S)$ reconstructed in the final states $K^+K^-\pi^0$ and $K^0_S K^\pm \pi^\mp$.

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

$\eta_c(2S)$ REFERENCES

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ABLIKIM	24BW	PR D110 092003	M. Ablikim *et al.*	(BESIII Collab.)
ABLIKIM	24J	PR D109 032004	M. Ablikim *et al.*	(BESIII Collab.)
ABLIKIM	24Q	PR D109 072017	M. Ablikim *et al.*	(BESIII Collab.)
AAIJ	23AH	PR D108 032010	R. Aaij *et al.*	(LHCb Collab.)
ABLIKIM	23Q	PR D107 052007	M. Ablikim *et al.*	(BESIII Collab.)
ABLIKIM	22Q	PR D106 032014	M. Ablikim *et al.*	(BESIII Collab.)
CHILIKIN	19	PR D100 012001	K. Chilikin *et al.*	(BELLE Collab.)
XU	18	PR D98 072001	Q.N. Xu *et al.*	(BELLE Collab.)
AAIJ	17AD	PL B769 305	R. Aaij *et al.*	(LHCb Collab.)
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ABLIKIM	17N	PR D95 072004	M. Ablikim *et al.*	(BESIII Collab.)
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ASNER	04	PRL 92 142001	D.M. Asner *et al.*	(CLEO Collab.)
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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)
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