$\eta_c(1S)$

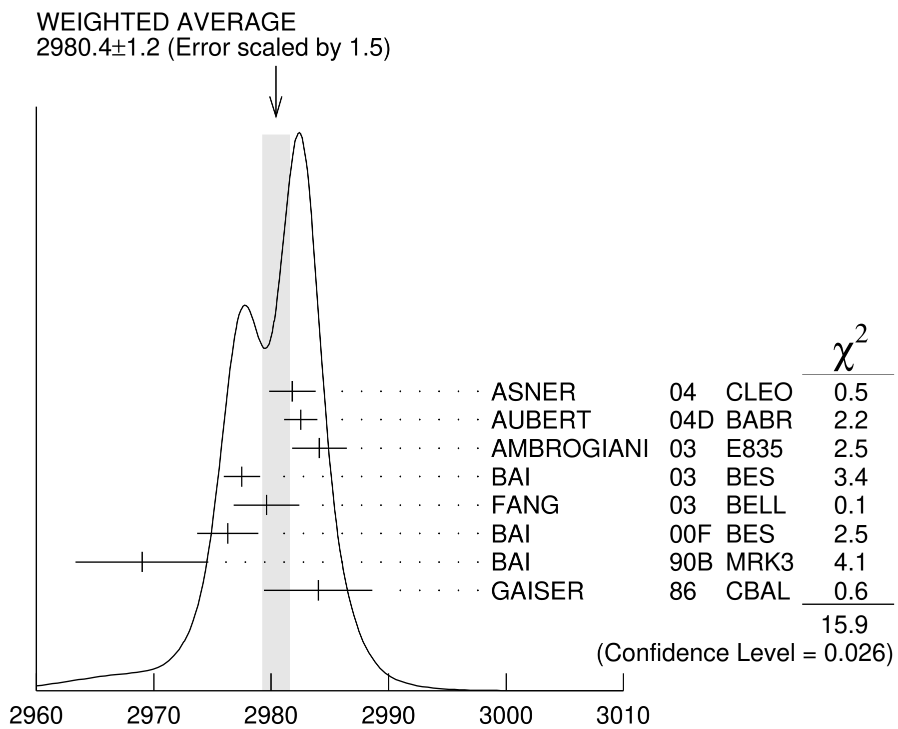
$I^G(J^{PC}) = 0^+(0^{-+})$

$\eta_c(1S)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
2980.4± 1.2 OUR AVERAGE	Error includes scale factor of 1.5. See the ideogram below.				
2981.8± 1.3± 1.5	592	ASNER	04	CLEO	$\gamma\gamma \to \eta_c \to K_S^0 K^\pm \pi^\mp$
2982.5± 1.1± 0.9	2547 ± 90	AUBERT	04D	BABR	$\gamma\gamma \to \eta_c(1S) \to K\overline{K}\pi$
2984.1± 2.1± 1.0	190	[1] AMBROGIANI	03	E835	$\overline{p}p \to \eta_c \to \gamma\gamma$
2977.5± 1.0± 1.2		[2] BAI	03	BES	$J/\psi \to \gamma\eta_c$
2979.6± 2.3± 1.6	182 ± 25	FANG	03	BELL	$B \to \eta_c K$
2976.3± 2.3± 1.2		[3,4,5] BAI	00F	BES	$J/\psi \to \gamma\eta_c$ and $\psi(2S) \to \gamma\eta_c$
2969 ± 4 ± 4	80	BAI	90B	MRK3	$J/\psi \to \gamma K^+ K^- K^+ K^-$
2984 ± 2.3± 4.0		GAISER	86	CBAL	$J/\psi \to \gamma X$, $\psi(2S) \to \gamma X$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2982 ± 5	273 ± 43	[6] AUBERT	06E	BABR	$B^\pm \to K^\pm X_{c\overline{c}}$
2972 ± 7	235	[7] ABE	04G	BELL	10.6 $e^+e^- \to J/\psi(c\overline{c})$
2976.6± 2.9± 1.3	140	[3,4] BAI	00F	BES	$J/\psi \to \gamma\eta_c$
2980.4± 2.3± 0.6		[8] BRANDENB...	00B	CLE2	$\gamma\gamma \to \eta_c \to K^\pm K_S^0 \pi^\mp$
2975.8± 3.9± 1.2		[3,4] BAI	99B	BES	Sup. by BAI 00F
2999 ± 8	25	ABREU	98O	DLPH	$e^+e^- \to e^+e^-$ +hadrons
$2988.3^{+3.3}_{-3.1}$		ARMSTRONG	95F	E760	$\overline{p}p \to \gamma\gamma$
2974.4± 1.9		[3] BISELLO	91	DM2	$J/\psi \to \eta_c\gamma$
2956 ±12 ±12		BAI	90B	MRK3	$J/\psi \to \gamma K^+ K^- K_S^0 K_L^0$
$2982.6^{+2.7}_{-2.3}$	12	BAGLIN	87B	SPEC	$\overline{p}p \to \gamma\gamma$
2980.2± 1.6		[3] BALTRUSAIT...	86	MRK3	$J/\psi \to \eta_c\gamma$
2976 ± 8		[9] BALTRUSAIT...	84	MRK3	$J/\psi \to 2\phi\gamma$
2982 ± 8	18	[10] HIMEL	80B	MRK2	e^+e^-
2980 ± 9		[10] PARTRIDGE	80B	CBAL	e^+e^-

[1] Using mass of $\psi(2S) = 3686.00$ MeV.
[2] From a simultaneous fit of five decay modes of the η_c.
[3] Average of several decay modes.
[4] Using an η_c width of 13.2 MeV.
[5] Weighted average of the $\psi(2S)$ and $J/\psi(1S)$ samples.
[6] From the fit of the kaon momentum spectrum. Systematic errors not evaluated.
[7] From a fit of the J/ψ recoil mass spectrum. Systematic errors not estimated.
[8] Superseded by ASNER 04.
[9] $\eta_c \to \phi\phi$.

[10] Mass adjusted by us to correspond to $J/\psi(1S)$ mass = 3097 MeV.



$\eta_c(1S)$ mass (MeV)

$\eta_c(1S)$ WIDTH

VALUE (MeV)	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
25.5± 3.4 OUR AVERAGE			Error includes scale factor of 2.0. See the ideogram below.			
24.8± 3.4±3.5		592	ASNER	04	CLEO	$\gamma\gamma \to \eta_c \to K^0_S K^{\pm} \pi^{\mp}$
34.3± 2.3±0.9		2547 ± 90	AUBERT	04D	BABR	$\gamma\gamma \to \eta_c(1S) \to K \overline{K} \pi$
$20.4^{+7.7}_{-6.7}\pm2.0$		190	AMBROGIANI	03	E835	$\overline{p}p \to \eta_c \to \gamma\gamma$
17.0± 3.7±7.4			[11] BAI	03	BES	$J/\psi \to \gamma\eta_c$
29 ± 8 ±6		182 ± 25	FANG	03	BELL	$B \to \eta_c K$
11.0± 8.1±4.1			[14] BAI	00F	BES	$J/\psi \to \gamma\eta_c$ and $\psi(2S) \to \gamma\eta_c$
$23.9^{+12.6}_{-7.1}$			ARMSTRONG	95F	E760	$\overline{p}p \to \gamma\gamma$
$7.0^{+7.5}_{-7.0}$		12	BAGLIN	87B	SPEC	$\overline{p}p \to \gamma\gamma$
$10.1^{+33.0}_{-8.2}$		23	[12] BALTRUSAIT...	86	MRK3	$J/\psi \to \gamma p\overline{p}$
11.5± 4.5			GAISER	86	CBAL	$J/\psi \to \gamma X$, $\psi(2S) \to \gamma X$

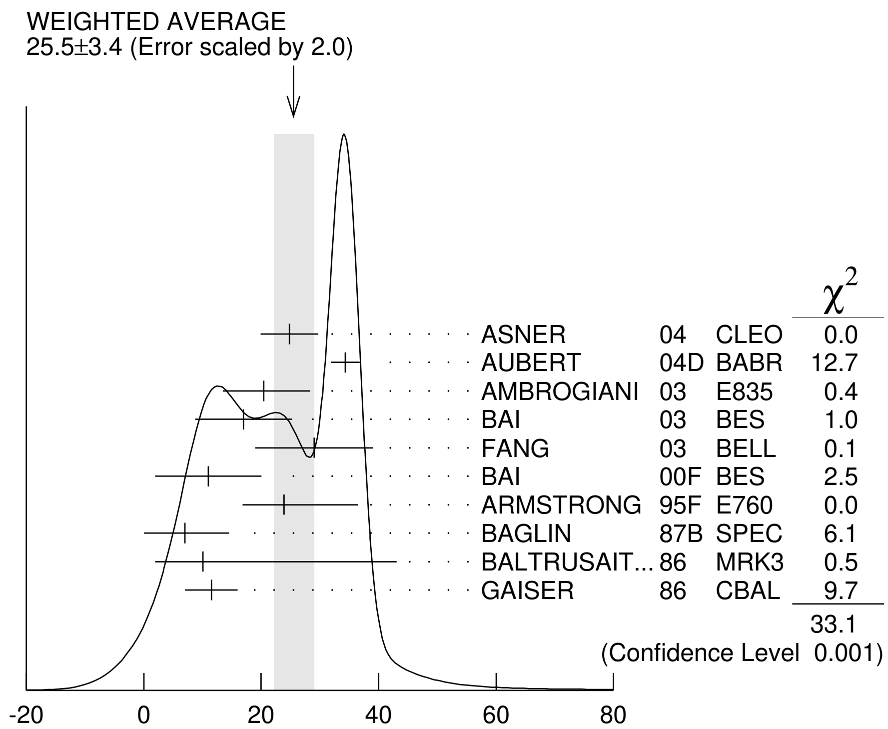
• • • We do not use the following data for averages, fits, limits, etc. • • •

$27.0 \pm 5.8 \pm 1.4$			[13] BRANDENB...	00B	CLE2	$\gamma\gamma \to \eta_c \to K^{\pm} K^0_S \pi^{\mp}$
< 40	90	18	HIMEL	80B	MRK2	$e^+ e^-$
< 20	90		PARTRIDGE	80B	CBAL	$e^+ e^-$

[11] From a simultaneous fit of five decay modes of the η_c.

[12] Positive and negative errors correspond to 90% confidence level.

[13] Superseded by ASNER 04.



$\eta_c(1S)$ WIDTH

[14] From a fit to the 4-prong invariant mass in $\psi(2S) \to \gamma\eta_c$ and $J/\psi(1S) \to \gamma\eta_c$ decays.

$\eta_c(1S)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)	Confidence level
	Decays involving hadronic resonances		
Γ_1	$\eta'(958)\pi\pi$	(4.1 ± 1.7) %	
Γ_2	$\rho\rho$	(2.0 ± 0.7) %	
Γ_3	$K^*(892)^0 K^- \pi^+ +$ c.c.	(2.0 ± 0.7) %	
Γ_4	$K^*(892)\overline{K}^*(892)$	$(9.2 \pm 3.4) \times 10^{-3}$	
Γ_5	$K^{*0}\overline{K}^{*0}\pi^+\pi^-$	(1.5 ± 0.8) %	
Γ_6	$\phi K^+ K^-$	$(2.9 \pm 1.4) \times 10^{-3}$	
Γ_7	$\phi\phi$	$(2.7 \pm 0.9) \times 10^{-3}$	

Γ_{8}	$\phi 2(\pi^+\pi^-)$		$<$ 4.7	$\times 10^{-3}$	90%
Γ_{9}	$a_0(980)\pi$		$<$ 2	%	90%
Γ_{10}	$a_2(1320)\pi$		$<$ 2	%	90%
Γ_{11}	$K^*(892)\overline{K}+$ c.c.		$<$ 1.28	%	90%
Γ_{12}	$f_2(1270)\eta$		$<$ 1.1	%	90%
Γ_{13}	$\omega\omega$		$<$ 3.1	$\times 10^{-3}$	90%
Γ_{14}	$\omega\phi$		$<$ 1.7	$\times 10^{-3}$	90%
Γ_{15}	$f_2(1270) f_2(1270)$		$(1.0\ ^{+0.4}_{-0.5})$ %		

Decays into stable hadrons

Γ_{16}	$K\overline{K}\pi$		$(7.0\ \pm 1.2)$ %		
Γ_{17}	$\eta\pi\pi$		$(4.9\ \pm 1.8)$ %		
Γ_{18}	$\pi^+\pi^- K^+ K^-$		$(1.5\ \pm 0.6)$ %		
Γ_{19}	$K^+ K^- 2(\pi^+\pi^-)$		$(10\ \pm 4)\times 10^{-3}$		
Γ_{20}	$2(K^+ K^-)$		$(1.5\ \pm 0.7)\times 10^{-3}$		
Γ_{21}	$2(\pi^+\pi^-)$		(1.20 ± 0.30) %		
Γ_{22}	$3(\pi^+\pi^-)$		$(2.0\ \pm 0.7)$ %		
Γ_{23}	$p\overline{p}$		$(1.3\ \pm 0.4)\times 10^{-3}$		
Γ_{24}	$K\overline{K}\eta$		$<$ 3.1	%	90%
Γ_{25}	$\pi^+\pi^- p\overline{p}$		$<$ 1.2	%	90%
Γ_{26}	$\Lambda\overline{\Lambda}$		$<$ 2	$\times 10^{-3}$	90%

Radiative decays

Γ_{27}	$\gamma\gamma$		$(2.8\ \pm 0.9)\times 10^{-4}$		

Charge conjugation (C), Parity (P), Lepton family number (LF) violating modes

Γ_{28}	$\pi^+\pi^-$	P,CP	$<$ 8.7	$\times 10^{-4}$	90%
Γ_{29}	$\pi^0\pi^0$	P,CP	$<$ 5.6	$\times 10^{-4}$	90%
Γ_{30}	$K^+ K^-$	P,CP	$<$ 7.6	$\times 10^{-4}$	90%
Γ_{31}	$K^0_S K^0_S$	P,CP	$<$ 4.2	$\times 10^{-4}$	90%

$\eta_c(1S)$ PARTIAL WIDTHS

$\Gamma(\gamma\gamma)$ Γ_{27}

VALUE (keV)	EVTS	DOCUMENT ID		TECN	COMMENT
7.2± 0.7± 2.0 OUR EVALUATION Error includes scale factor of 1.3. Treating systematic errors as correlated.					
$6.7^{+0.9}_{-0.8}$ OUR AVERAGE					
5.5± 1.2± 1.8	157 ± 33	[15] KUO	05	BELL	$\gamma\gamma \rightarrow p\overline{p}$
7.4± 0.4± 2.3		[16] ASNER	04	CLEO	$\gamma\gamma \rightarrow \eta_c \rightarrow K^0_S K^\pm\pi^\mp$
13.9± 2.0± 3.0	41	[17] ABDALLAH	03J	DLPH	$\gamma\gamma \rightarrow \eta_c$
$3.8^{+1.1+1.9}_{-1.0-1.0}$	190	[18] AMBROGIANI	03	E835	$\overline{p}p \rightarrow \eta_c \rightarrow \gamma\gamma$
6.9± 1.7± 2.1	76	[19] ACCIARRI	99T	L3	$e^+e^- \rightarrow e^+e^-\eta_c$
27 ±16 ±10	5	[16] SHIRAI	98	AMY	58 e^+e^-

$6.7^{+2.4}_{-1.7} \pm 2.3$		[15] ARMSTRONG	95F	E760	$\overline{p}p \to \gamma\gamma$
11.3 ± 4.2		[20] ALBRECHT	94H	ARG	$e^+e^- \to e^+e^-\eta_c$
$5.9^{+2.1}_{-1.8} \pm 1.9$		[18] CHEN	90B	CLEO	$e^+e^- \to e^+e^-\eta_c$
$6.4^{+5.0}_{-3.4}$		[21] AIHARA	88D	TPC	$e^+e^- \to e^+e^-X$
$4.3^{+3.4}_{-3.7} \pm 2.4$		[15] BAGLIN	87B	SPEC	$\overline{p}p \to \gamma\gamma$
28 ± 15		[16,22] BERGER	86	PLUT	$\gamma\gamma \to K\overline{K}\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
5.2 ± 1.2	273 ± 43	[23,24] AUBERT	06E	BABR	$B^\pm \to K^\pm X_{c\overline{c}}$
$7.6 \pm 0.8 \pm 2.3$		[16,25] BRANDENB...	00B	CLE2	$\gamma\gamma \to \eta_c \to K^\pm K^0_S\pi^\mp$
$8.0 \pm 2.3 \pm 2.4$	17	[26] ADRIANI	93N	L3	$e^+e^- \to e^+e^-\eta_c$

[15] Normalized to B($\eta_c \to p\overline{p}$)= $(1.3 \pm 0.4) \times 10^{-3}$.

[16] Normalized to B($\eta_c \to K^\pm K^0_S\pi^\mp$).

[17] Average of $K^0_S K^\pm\pi^\mp$, $\pi^+\pi^-K^+K^-$, and $2(K^+K^-)$ decay modes.

[18] Normalized to the sum of B($\eta_c \to K^\pm K^0_S\pi^\mp$), B($\eta_c \to K^+K^-\pi^+\pi^-$), and B($\eta_c \to 2\pi^+2\pi^-$).

[19] Normalized to the sum of 9 branching ratios.

[20] Normalized to the sum of B($\eta_c \to K^\pm K^0_S\pi^\mp$), B($\eta_c \to \phi\phi$), B($\eta_c \to K^+K^-\pi^+\pi^-$), and B($\eta_c \to 2\pi^+2\pi^-$).

[21] Normalized to the sum of B($\eta_c \to K^\pm K^0_S\pi^\mp$), B($\eta_c \to 2K^+2K^-$), B($\eta_c \to K^+K^-\pi^+\pi^-$), and B($\eta_c \to 2\pi^+2\pi^-$).

[22] Re-evaluated by AIHARA 88D.

[23] Calculated by us using $\Gamma(\eta_c \to K\overline{K}\pi) \times \Gamma(\eta_c \to \gamma\gamma) / \Gamma = 0.44 \pm 0.05$ keV from PDG 06 and B($\eta_c \to K\overline{K}\pi$) = (8.5 ± 1.8)% from AUBERT 06E.

[24] Systematic errors not evaluated.

[25] Superseded by ASNER 04.

[26] Superseded by ACCIARRI 99T.

$\eta_c(1S)$ $\Gamma(i)\Gamma(\gamma\gamma)/\Gamma(\text{total})$

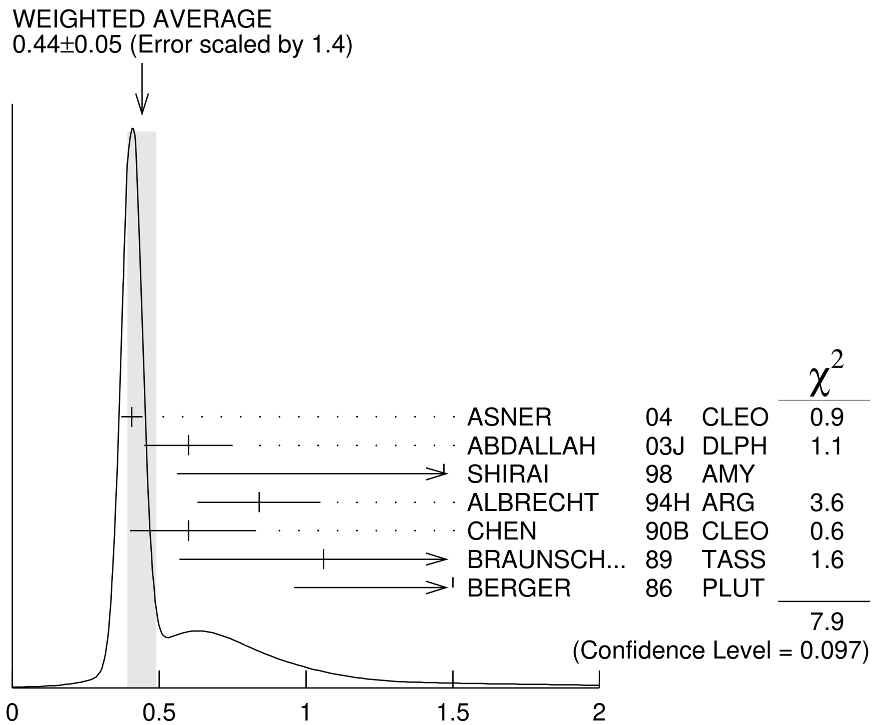
$\Gamma(K\overline{K}\pi) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ — $\Gamma_{16}\Gamma_{27}/\Gamma$

VALUE (keV)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
0.44 ±0.05 OUR AVERAGE Error includes scale factor of 1.4. See the ideogram below.					
$0.407 \pm 0.022 \pm 0.028$			[27,28] ASNER	04 CLEO	$\gamma\gamma \to \eta_c \to K^0_S K^\pm\pi^\mp$
$0.60 \pm 0.12 \pm 0.09$		41	[28,29] ABDALLAH	03J DLPH	$\gamma\gamma \to K^0_S K^\pm\pi^\mp$
$1.47 \pm 0.87 \pm 0.27$			[28] SHIRAI	98 AMY	$\gamma\gamma \to \eta_c \to K^\pm K^0_S\pi^\mp$
0.84 ± 0.21			[28] ALBRECHT	94H ARG	$\gamma\gamma \to K^\pm K^0_S\pi^\mp$
$0.60^{+0.23}_{-0.20}$			[28] CHEN	90B CLEO	$\gamma\gamma \to \eta_c K^\pm K^0_S\pi^\mp$
$1.06 \pm 0.41 \pm 0.27$		11	[28] BRAUNSCH...	89 TASS	$\gamma\gamma \to K\overline{K}\pi$
$1.5^{+0.60}_{-0.45} \pm 0.3$		7	[28] BERGER	86 PLUT	$\gamma\gamma \to K\overline{K}\pi$

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

$0.418 \pm 0.044 \pm 0.022$		[28,30] BRANDENB...	00B	CLE2	$\gamma\gamma \rightarrow \eta_c \rightarrow K^{\pm} K^0_S \pi^{\mp}$
<0.63	95	[28] BEHREND	89	CELL	$\gamma\gamma \rightarrow K^0_S K^{\pm} \pi^{\mp}$
<4.4	95	ALTHOFF	85B	TASS	$\gamma\gamma \rightarrow K\overline{K}\pi$

[27] Calculated by us from the value reported in ASNER 04 that assumes B($\eta_c \rightarrow K\overline{K}\pi$) = 5.5 ± 1.7%



$\Gamma\big(K\overline{K}\pi\big) \times \Gamma\big(\gamma\gamma\big)/\Gamma_{\text{total}}$ $\Gamma_{16}\Gamma_{27}/\Gamma$

$\Gamma\big(\pi^+\pi^- K^+ K^-\big) \times \Gamma\big(\gamma\gamma\big)/\Gamma_{\text{total}}$ $\Gamma_{18}\Gamma_{27}/\Gamma$

VALUE (keV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.21±0.07 OUR AVERAGE					
$0.28 \pm 0.10 \pm 0.06$	42	[31] ABDALLAH	03J	DLPH	$\gamma\gamma \rightarrow \pi^+\pi^- K^+ K^-$
$0.17 \pm 0.08 \pm 0.02$	13.9 ± 6.6	ALBRECHT	94H	ARG	$\gamma\gamma \rightarrow \pi^+\pi^- K^+ K^-$

$\Gamma\big(2(K^+ K^-)\big) \times \Gamma\big(\gamma\gamma\big)/\Gamma_{\text{total}}$ $\Gamma_{20}\Gamma_{27}/\Gamma$

VALUE (keV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.28 ±0.07 OUR AVERAGE					
$0.35 \pm 0.09 \pm 0.06$	46	[32] ABDALLAH	03J	DLPH	$\gamma\gamma \rightarrow 2(K^+ K^-)$
$0.231 \pm 0.090 \pm 0.023$	9.1 ± 3.3	[33] ALBRECHT	94H	ARG	$\gamma\gamma \rightarrow 2(K^+ K^-)$

$\Gamma\big(2(\pi^+\pi^-)\big) \times \Gamma\big(\gamma\gamma\big)/\Gamma_{\text{total}}$ $\Gamma_{21}\Gamma_{27}/\Gamma$

VALUE (keV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.18±0.07±0.02	21.4 ± 8.6	ALBRECHT	94H	ARG	$\gamma\gamma \rightarrow 2(\pi^+\pi^-)$

$\Gamma(p\overline{p}) \times \Gamma(\gamma\gamma)/\Gamma_{total}$ $\Gamma_{23}\Gamma_{27}/\Gamma$

VALUE (eV)	EVTS	DOCUMENT ID		TECN	COMMENT
$6.2^{+1.1}_{-1.0}$ OUR AVERAGE	Error includes scale factor of 1.1.				
$7.20\pm1.53^{+0.67}_{-0.75}$	157 ± 33	[34] KUO	05	BELL	$\gamma\gamma \to p\overline{p}$
$4.6^{+1.3}_{-1.1}\pm0.4$	190	[34] AMBROGIANI	03	E835	$\overline{p}p \to \gamma\gamma$
$8.1^{+2.9}_{-2.0}$		[34] ARMSTRONG	95F	E760	$\overline{p}p \to \gamma\gamma$

[28] We have multiplied $K^\pm K^0_S \pi^\mp$ measurement by 3 to obtain $K\overline{K}\pi$.

[29] Calculated by us from the value reported in ABDALLAH 03J, which uses B($\eta_c \to K^0_S K^\pm \pi^\mp$) = $(1.5 \pm 0.4)\%$.

[30] Superseded by ASNER 04.

[31] Calculated by us from the value reported in ABDALLAH 03J, which uses B($\eta_c \to \pi^+\pi^-K^+K^-$) = $(2.0 \pm 0.7)\%$.

[32] Calculated by us from the value reported in ABDALLAH 03J, which uses B($\eta_c \to$) $2(K^+K^-)$ = $(2.1 \pm 1.2)\%$.

[33] Incudes all topological modes except $\eta_c \to \phi\phi$.

[34] Not independent from the $\Gamma_{\gamma\gamma}$ reported by the same experiment.

$\eta_c(1S)$ BRANCHING RATIOS

HADRONIC DECAYS

$\Gamma(\eta'(958)\pi\pi)/\Gamma_{total}$ Γ_1/Γ

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.041±0.017	14	[35] BALTRUSAIT..86	MRK3	$J/\psi \to \eta_c\gamma$

$\Gamma(\rho\rho)/\Gamma_{total}$ Γ_2/Γ

VALUE (units 10^{-3})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
20 ± 7 OUR EVALUATION	(Treating systematicerrors as correlated.)					
18 ± 5 OUR AVERAGE						
$12.6\pm\ 3.8\pm5.1$		72	[35] ABLIKIM	05L	BES2	$J/\psi \to \pi^+\pi^-\pi^+\pi^-\gamma$
$26.0\pm\ 2.4\pm8.8$		113	[35] BISELLO	91	DM2	$J/\psi \to \gamma\rho^0\rho^0$
$23.6\pm10.6\pm8.2$		32	[35] BISELLO	91	DM2	$J/\psi \to \gamma\rho^+\rho^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<14	90		[35] BALTRUSAIT..86		MRK3	$J/\psi \to \eta_c\gamma$

$\Gamma(K^*(892)^0K^-\pi^+ + c.c.)/\Gamma_{total}$ Γ_3/Γ

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.02±0.007	63	[35] BALTRUSAIT..86	MRK3	$J/\psi \to \eta_c\gamma$

$\Gamma(K^*(892)\overline{K}^*(892))/\Gamma_{total}$ Γ_4/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
92±34 OUR EVALUATION	(Treating systematicerrors as correlated.)				
91±26 OUR AVERAGE					
$108\pm25\pm44$	60	[35] ABLIKIM	05L	BES2	$J/\psi \to K^+K^-\pi^+\pi^-\gamma$
$82\pm28\pm27$	14	[35] BISELLO	91	DM2	$e^+e^- \to \gamma K^+K^-\pi^+\pi^-$
90 ± 50	9	[35] BALTRUSAIT..86		MRK3	$J/\psi \to \eta_c\gamma$

$\Gamma(K^*(892)\overline{K}+\text{c.c.})/\Gamma_{\text{total}}$ — Γ_{11}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.0128	90	BISELLO	91	DM2	$J/\psi \to \gamma K^0_S K^\pm \pi^\mp$
<0.0132	90	[35] BISELLO	91	DM2	$J/\psi \to \gamma K^+ K^- \pi^0$

$\Gamma(K^{*0}\overline{K}^{*0}\pi^+\pi^-)/\Gamma_{\text{total}}$ — Γ_5/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
150.±63.±43.	45	[36] ABLIKIM	06A	BES2	$J/\psi \to K^{*0}\overline{K}^{*0}\pi^+\pi^-\gamma$

$\Gamma(\phi K^+ K^-)/\Gamma_{\text{total}}$ — Γ_6/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
$2.9^{+0.9}_{-0.8}\pm1.1$	$14.1^{+4.4}_{-3.7}$	[37] HUANG	03	BELL	$B^+ \to (\phi K^+ K^-) K^+$

$\Gamma(\phi 2(\pi^+\pi^-))/\Gamma_{\text{total}}$ — Γ_8/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<50	90	[38] ABLIKIM	06A	BES2	$J/\psi \to \phi 2(\pi^+\pi^-)\gamma$

$\Gamma(\phi\phi)/\Gamma_{\text{total}}$ — Γ_7/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
27 ± 9 OUR EVALUATION		(Treating systematic errors as correlated.)			
27 ± 5 OUR AVERAGE					
25.3± 5.1± 9.1	72	[35] ABLIKIM	05L	BES2	$J/\psi \to K^+K^-K^+K^-\gamma$
26 ± 9	357 ± 64	[35] BAI	04	BES	$J/\psi \to \gamma K^+K^-K^+K^-$
$18\ ^{+\ 8}_{-\ 6} \pm 7$	$7.0^{+3.0}_{-2.3}$	[37] HUANG	03	BELL	$B^+ \to (\phi\phi) K^+$
31 ± 7 ±10	19	[35] BISELLO	91	DM2	$J/\psi \to \gamma K^+K^-K^+K^-$
$30\ ^{+18}_{-12} \pm10$	5	[35] BISELLO	91	DM2	$J/\psi \to \gamma K^+K^- K^0_S K^0_L$
74 ±18 ±24	80	[35] BAI	90B	MRK3	$J/\psi \to \gamma K^+K^-K^+K^-$
67 ±21 ±24		[35] BAI	90B	MRK3	$J/\psi \to \gamma K^+K^- K^0_S K^0_L$

$\Gamma(\phi\phi)/\Gamma(K\overline{K}\pi)$ — Γ_7/Γ_{16}

VALUE	DOCUMENT ID		TECN	COMMENT
0.055±0.014±0.005	AUBERT,B	04B	BABR	$B^\pm \to K^\pm \eta_c$

$\Gamma(a_0(980)\pi)/\Gamma_{\text{total}}$ — Γ_9/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.02	90	[35,39] BALTRUSAIT...86	MRK3	$J/\psi \to \eta_c\gamma$

$\Gamma(a_2(1320)\pi)/\Gamma_{\text{total}}$ — Γ_{10}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.02	90	[35] BALTRUSAIT...86	MRK3	$J/\psi \to \eta_c\gamma$

$\Gamma(f_2(1270)\eta)/\Gamma_{\text{total}}$ — Γ_{12}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.011	90	[35] BALTRUSAIT...86	MRK3	$J/\psi \to \eta_c\gamma$

$\Gamma(\omega\omega)/\Gamma_{total}$ — Γ_{13}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.0031	90	[35] BALTRUSAIT...	86	MRK3	$J/\psi \to \eta_c\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.0063	90	[35] ABLIKIM	05L	BES2	$J/\psi \to \pi^+\pi^-\pi^0\pi^+\pi^-\pi^0\gamma$
<0.0063		[35] BISELLO	91	DM2	$J/\psi \to \gamma\omega\omega$

$\Gamma(\omega\phi)/\Gamma_{total}$ — Γ_{14}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.0017	90	[35] ABLIKIM	05L	BES2	$J/\psi \to \pi^+\pi^-\pi^0K^+K^-\gamma$

$\Gamma(f_2(1270)f_2(1270))/\Gamma_{total}$ — Γ_{15}/Γ

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN	COMMENT
$\mathbf{1.02^{+0.33}_{-0.39}\pm0.29}$	91.2 ± 19.8	[40] ABLIKIM	04M	BES	$J/\psi \to \gamma 2\pi^+2\pi^-$

$\Gamma(K\overline{K}\pi)/\Gamma_{total}$ — Γ_{16}/Γ

VALUE (units 10^{-2})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
7.0 ±1.2 OUR EVALUATION (Treating systematic errors as correlated.)						
6.1 ±0.8 OUR AVERAGE						
8.5 ±1.8			[41] AUBERT	06E	BABR	$B^\pm \to K^\pm X_{c\overline{c}}$
5.1 ±2.1		609 ± 71	[35] BAI	04	BES	$J/\psi \to \gamma K^\pm\pi^\mp K^0_S$
6.90±1.42±1.32		33	[35] BISELLO	91	DM2	$J/\psi \to \gamma K^+K^-\pi^0$
5.43±0.94±0.94		68	[35] BISELLO	91	DM2	$J/\psi \to \gamma K^\pm\pi^\mp K^0_S$
4.8 ±1.7		95	[35,42] BALTRUSAIT...	86	MRK3	$J/\psi \to \eta_c\gamma$
$16.1\ ^{+9.2}_{-7.3}$			[43] HIMEL	80B	MRK2	$\psi(2S) \to \eta_c\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
< 10.7	90		[35] PARTRIDGE	80B	CBAL	$J/\psi \to \eta_c\gamma$

$\Gamma(\eta\pi\pi)/\Gamma_{total}$ — Γ_{17}/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.049±0.018 OUR EVALUATION					
0.047±0.015 OUR AVERAGE					
0.054±0.020	75	[35] BALTRUSAIT...	86	MRK3	$J/\psi \to \eta_c\gamma$
0.037±0.013±0.020	18	[35] PARTRIDGE	80B	CBAL	$J/\psi \to \eta\pi^+\pi^-\gamma$

$\Gamma(\pi^+\pi^-K^+K^-)/\Gamma_{total}$ — Γ_{18}/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.015 ±0.006 OUR EVALUATION					
0.0142±0.0033 OUR AVERAGE					
0.012 ±0.004	413 ± 54	[35] BAI	04	BES	$J/\psi \to \gamma K^+K^-\pi^+\pi^-$
0.021 ±0.007	110	[35] BALTRUSAIT...	86	MRK3	$J/\psi \to \eta_c\gamma$
$0.014\ ^{+0.022}_{-0.009}$		[43] HIMEL	80B	MRK2	$\psi(2S) \to \eta_c\gamma$

$\Gamma(2(\pi^+\pi^-))/\Gamma_{total}$ Γ_{21}/Γ

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN	COMMENT
1.2 ±0.3 OUR EVALUATION					
1.15±0.26 OUR AVERAGE					
1.0 ±0.5	542 ± 75	[35] BAI	04	BES	$J/\psi \to \gamma\, 2(\pi^+\pi^-)$
1.05±0.17±0.34	137	[35] BISELLO	91	DM2	$J/\psi \to \gamma 2\pi^+ 2\pi^-$
1.3 ±0.6	25	[35] BALTRUSAIT...	86	MRK3	$J/\psi \to \eta_c \gamma$
$2.0\ ^{+1.5}_{-1.0}$		[43] HIMEL	80B	MRK2	$\psi(2S) \to \eta_c \gamma$

$\Gamma(3(\pi^+\pi^-))/\Gamma_{total}$ Γ_{22}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
204.±45.±58.	479	[44] ABLIKIM	06A	BES2	$J/\psi \to 3(\pi^+\pi^-)\gamma$

$\Gamma(K^+K^-2(\pi^+\pi^-))/\Gamma_{total}$ Γ_{19}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
95.±31.±27.	100	[45] ABLIKIM	06A	BES2	$J/\psi \to K^+K^-2(\pi^+\pi^-)\gamma$

$\Gamma(2(K^+K^-))/\Gamma_{total}$ Γ_{20}/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.0015±0.0007 OUR AVERAGE					
$0.0014^{+0.0005}_{-0.0004}\pm0.0006$	$14.5^{+4.6}_{-3.0}$	[37] HUANG	03	BELL	$B^+ \to 2(K^+K^-)K^+$
0.021 ±0.010 ±0.006		[46] ALBRECHT	94H	ARG	$\gamma\gamma \to K^+K^-K^+K^-$

$\Gamma(2(K^+K^-))/\Gamma(K\overline{K}\pi)$ Γ_{20}/Γ_{16}

VALUE	DOCUMENT ID		TECN	COMMENT
0.023±0.007±0.006	AUBERT,B	04B	BABR	$B^\pm \to K^\pm \eta_c$

$\Gamma(p\overline{p})/\Gamma_{total}$ Γ_{23}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
13 ± 4 OUR EVALUATION		(Treating systematic errors as correlated.)			
12.5± 3.2 OUR AVERAGE					
15 ± 6	213 ± 33	[35] BAI	04	BES	$J/\psi \to \gamma p\overline{p}$
10 ± 3 ±4	18	[35] BISELLO	91	DM2	$J/\psi \to \gamma p\overline{p}$
11 ± 6	23	[35] BALTRUSAIT...	86	MRK3	$J/\psi \to \eta_c \gamma$
$29\ ^{+29}_{-15}$		[43] HIMEL	80B	MRK2	$\psi(2S) \to \eta_c \gamma$

$\Gamma(K\overline{K}\eta)/\Gamma_{total}$ Γ_{24}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.031	90	[35] BALTRUSAIT...	86	MRK3	$J/\psi \to \eta_c \gamma$

$\Gamma(\pi^+\pi^-p\overline{p})/\Gamma_{total}$ Γ_{25}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.012	90	HIMEL	80B	MRK2	$\psi(2S) \to \eta_c \gamma$

$\Gamma(\Lambda\overline{\Lambda})/\Gamma_{\text{total}}$ Γ_{26}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.002	90	[35] BISELLO	91	DM2	$e^+e^- \to \gamma\Lambda\overline{\Lambda}$

$\Gamma(p\overline{p}) \times \Gamma(\phi\phi)/\Gamma^2_{\text{total}}$ $\Gamma_{23}\Gamma_7/\Gamma^2$

VALUE (units 10^{-5})	DOCUMENT ID		TECN	COMMENT
$\mathbf{4.0^{+3.5}_{-3.2}}$	BAGLIN	89	SPEC	$\overline{p}p \to K^+K^-K^+K^-$

[35] The quoted branching ratios use B($J/\psi(1S) \to \gamma\eta_c(1S)$) = 0.0127 ± 0.0036. Where relevant, the error in this branching ratio is treated as a common systematic in computing averages.

[36] ABLIKIM 06A reports [B($\eta_c(1S) \to K^{*0}\overline{K}^{*0}\pi^+\pi^-$) × B($J/\psi(1S) \to \gamma\eta_c(1S)$)] = $(1.91 \pm 0.64 \pm 0.48) \times 10^{-4}$. We divide by our best value B($J/\psi(1S) \to \gamma\eta_c(1S)$) = $(1.3 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

[37] Using B($B^+ \to \eta_c K^+$) = $(1.25 \pm 0.12^{+0.10}_{-0.12}) \times 10^{-3}$ from FANG 03 and B($\eta_c \to K\overline{K}\pi$) = $(5.5 \pm 1.7) \times 10^{-2}$.

[38] ABLIKIM 06A reports [B($\eta_c(1S) \to \phi 2(\pi^+\pi^-)$) × B($J/\psi(1S) \to \gamma\eta_c(1S)$)] = $< 0.603 \times 10^{-4}$. We divide by our best value B($J/\psi(1S) \to \gamma\eta_c(1S)$) = 0.013.

[39] We are assuming B($a_0(980) \to \eta\pi$) >0.5.

[40] ABLIKIM 04M reports [B($\eta_c(1S) \to f_2(1270) f_2(1270)$) × B($J/\psi(1S) \to \gamma\eta_c(1S)$)] = $(1.3 \pm 0.3^{+0.3}_{-0.4}) \times 10^{-4}$. We divide by our best value B($J/\psi(1S) \to \gamma\eta_c(1S)$) = $(1.3 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

[41] Determined from the ratio of B($B^\pm \to K^\pm\eta_c$) B($\eta_c \to K\overline{K}\pi$) = $(7.4 \pm 0.5 \pm 0.7) \times 10^{-5}$ reported in AUBERT,B 04B and B($B^\pm \to K^\pm\eta_c$) = $(8.7 \pm 1.5) \times 10^{-3}$ reported in AUBERT 06E.

[42] Average from $K^+K^-\pi^0$ and $K^\pm K^0_S\pi^\mp$ decay channels.

[43] Estimated using B($\psi(2S) \to \gamma\eta_c(1S)$) = 0.0028 ± 0.0006.

[44] ABLIKIM 06A reports [B($\eta_c(1S) \to 3(\pi^+\pi^-)$) × B($J/\psi(1S) \to \gamma\eta_c(1S)$)] = $(2.59 \pm 0.32 \pm 0.47) \times 10^{-4}$. We divide by our best value B($J/\psi(1S) \to \gamma\eta_c(1S)$) = $(1.3 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

[45] ABLIKIM 06A reports [B($\eta_c(1S) \to K^+K^- 2(\pi^+\pi^-)$) × B($J/\psi(1S) \to \gamma\eta_c(1S)$)] = $(1.21 \pm 0.32 \pm 0.24) \times 10^{-4}$. We divide by our best value B($J/\psi(1S) \to \gamma\eta_c(1S)$) = $(1.3 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

[46] Normalized to the sum of B($\eta_c \to K^\pm K^0_S\pi^\mp$), B($\eta_c \to \phi\phi$), B($\eta_c \to K^+K^-\pi^+\pi^-$), and B($\eta_c \to 2\pi^+2\pi^-$).

RADIATIVE DECAYS

$\Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ Γ_{27}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT

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

$2.80^{+0.67}_{-0.58} \pm 1.0$		[47] ARMSTRONG	95F	E760	$\overline{p}p \to \gamma\gamma$
< 9	90	[35] BISELLO	91	DM2	$J/\psi \to \gamma\gamma\gamma$
$6 \; {}^{+4}_{-3} \; \pm 4$		[47] BAGLIN	87B	SPEC	$\overline{p}p \to \gamma\gamma$
<18	90	[48] BLOOM	83	CBAL	$J/\psi \to \eta_c \gamma$

[47] Not independent from the values of the total and two-photon width quoted by the same experiment.

[48] Using $B(J/\psi(1S) \to \gamma\eta_c(1S)) = 0.0127 \pm 0.0036$.

$\Gamma(p\overline{p}) \times \Gamma(\gamma\gamma)/\Gamma^2_{\text{total}}$ $\Gamma_{23}\Gamma_{27}/\Gamma^2$

VALUE (units 10^{-6})	EVTS	DOCUMENT ID		TECN	COMMENT
0.26 ±0.05 OUR AVERAGE	Error includes scale factor of 1.4.				
$0.224^{+0.038}_{-0.037} \pm 0.020$	190	AMBROGIANI	03	E835	$\overline{p}p \to \eta_c \to \gamma\gamma$
$0.336^{+0.080}_{-0.070}$		ARMSTRONG	95F	E760	$\overline{p}p \to \gamma\gamma$
$0.68 \; {}^{+0.42}_{-0.31}$	12	BAGLIN	87B	SPEC	$\overline{p}p \to \gamma\gamma$

Charge conjugation (C), Parity (P), Lepton family number (LF) violating modes

$\Gamma(\pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_{28}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID		TECN	COMMENT
<90	90	[49] ABLIKIM	06B	BES2	$J/\psi \to \pi^+\pi^-\gamma$

[49] ABLIKIM 06B reports $[B(\eta_c(1S) \to \pi^+\pi^-) \times B(J/\psi(1S) \to \gamma\eta_c(1S))] = < 1.1 \times 10^{-5}$. We divide by our best value $B(J/\psi(1S) \to \gamma\eta_c(1S)) = 0.013$.

$\Gamma(\pi^0\pi^0)/\Gamma_{\text{total}}$ Γ_{29}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID		TECN	COMMENT
<60	90	[50] ABLIKIM	06B	BES2	$J/\psi \to \pi^0\pi^0\gamma$

[50] ABLIKIM 06B reports $[B(\eta_c(1S) \to \pi^0\pi^0) \times B(J/\psi(1S) \to \gamma\eta_c(1S))] = < 0.71 \times 10^{-5}$. We divide by our best value $B(J/\psi(1S) \to \gamma\eta_c(1S)) = 0.013$.

$\Gamma(K^+K^-)/\Gamma_{\text{total}}$ Γ_{30}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID		TECN	COMMENT
<80	90	[51] ABLIKIM	06B	BES2	$J/\psi \to K^+K^-\gamma$

[51] ABLIKIM 06B reports $[B(\eta_c(1S) \to K^+K^-) \times B(J/\psi(1S) \to \gamma\eta_c(1S))] = < 0.96 \times 10^{-5}$. We divide by our best value $B(J/\psi(1S) \to \gamma\eta_c(1S)) = 0.013$.

$\Gamma(K^0_S K^0_S)/\Gamma_{\text{total}}$ Γ_{31}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID		TECN	COMMENT
<40	90	[52] ABLIKIM	06B	BES2	$J/\psi \to K^0_S K^0_S \gamma$

[52] ABLIKIM 06B reports $[B(\eta_c(1S) \to K^0_S K^0_S) \times B(J/\psi(1S) \to \gamma\eta_c(1S))] = < 0.53 \times 10^{-5}$. We divide by our best value $B(J/\psi(1S) \to \gamma\eta_c(1S)) = 0.013$.

$\eta_c(1S)$ REFERENCES

ABLIKIM	06A	PL B633 19	M. Ablikim *et al.*	(BES Collab.)
ABLIKIM	06B	EPJ C45 337	M. Ablikim *et al.*	(BES Collab.)
AUBERT	06E	PRL 96 052002	B. Aubert *et al.*	(BABAR Collab.)
PDG	06	JPG 33 1	W.-M. Yao *et al.*	(PDG Collab.)
ABLIKIM	05L	PR D72 072005	M. Ablikim *et al.*	(BES Collab.)
KUO	05	PL B621 41	C.C. Kuo *et al.*	(BELLE Collab.)
ABE	04G	PR D70 071102	K. Abe *et al.*	(BELLE Collab.)
ABLIKIM	04M	PR D70 112008	M. Ablikim *et al.*	(BES Collab.)
ASNER	04	PRL 92 142001	D.M. Asner *et al.*	(CLEO Collab.)
AUBERT	04D	PRL 92 142002	B. Aubert *et al.*	(BABAR Collab.)
AUBERT,B	04B	PR D70 011101R	B. Aubert *et al.*	(BABAR Collab.)
BAI	04	PL B578 16	J.Z. Bai *et al.*	(BES Collab.)
ABDALLAH	03J	EPJ C31 481	J. Abdallah *et al.*	(DELPHI Collab.)
AMBROGIANI	03	PL B566 45	M. Ambrogiani *et al.*	(FNAL E835 Collab.)
BAI	03	PL B555 174	J.Z. Bai *et al.*	(BES Collab.)
FANG	03	PRL 90 071801	F. Fang *et al.*	(BELLE Collab.)
HUANG	03	PRL 91 241802	H.-C. Huang *et al.*	(BELLE Collab.)
BAI	00F	PR D62 072001	J.Z. Bai *et al.*	(BES Collab.)
BRANDENB...	00B	PRL 85 3095	G. Brandenburg *et al.*	(CLEO Collab.)
ACCIARRI	99T	PL B461 155	M. Acciarri *et al.*	(L3 Collab.)
BAI	99B	PR D60 072001	J.Z. Bai *et al.*	(BES Collab.)
ABREU	98O	PL B441 479	P. Abreu *et al.*	(DELPHI Collab.)
SHIRAI	98	PL B424 405	M. Shirai *et al.*	(AMY Collab.)
ARMSTRONG	95F	PR D52 4839	T.A. Armstrong *et al.*	(FNAL, FERR, GENO+)
ALBRECHT	94H	PL B338 390	H. Albrecht *et al.*	(ARGUS Collab.)
ADRIANI	93N	PL B318 575	O. Adriani *et al.*	(L3 Collab.)
BISELLO	91	NP B350 1	D. Bisello *et al.*	(DM2 Collab.)
BAI	90B	PRL 65 1309	Z. Bai *et al.*	(Mark III Collab.)
CHEN	90B	PL B243 169	W.Y. Chen *et al.*	(CLEO Collab.)
BAGLIN	89	PL B231 557	C. Baglin, S. Baird, G. Bassompierre	(R704 Collab.)
BEHREND	89	ZPHY C42 367	H.J. Behrend *et al.*	(CELLO Collab.)
BRAUNSCH...	89	ZPHY C41 533	W. Braunschweig *et al.*	(TASSO Collab.)
AIHARA	88D	PRL 60 2355	H. Aihara *et al.*	(TPC Collab.)
BAGLIN	87B	PL B187 191	C. Baglin *et al.*	(R704 Collab.)
BALTRUSAIT...	86	PR D33 629	R.M. Baltrusaitis *et al.*	(Mark III Collab.)
BERGER	86	PL 167B 120	C. Berger *et al.*	(PLUTO Collab.)
GAISER	86	PR D34 711	J. Gaiser *et al.*	(Crystal Ball Collab.)
ALTHOFF	85B	ZPHY C29 189	M. Althoff *et al.*	(TASSO Collab.)
BALTRUSAIT...	84	PRL 52 2126	R.M. Baltrusaitis *et al.*	(CIT, UCSC+) JP
BLOOM	83	ARNS 33 143	E.D. Bloom, C. Peck	(SLAC, CIT)
HIMEL	80B	PRL 45 1146	T.M. Himel *et al.*	(SLAC, LBL, UCB)
PARTRIDGE	80B	PRL 45 1150	R. Partridge *et al.*	(CIT, HARV, PRIN+)

OTHER RELATED PAPERS

ARMSTRONG	89	PL B221 216	T.A. Armstrong *et al.*	(CERN, CDEF, BIRM+)