

$\eta_c(1S)$

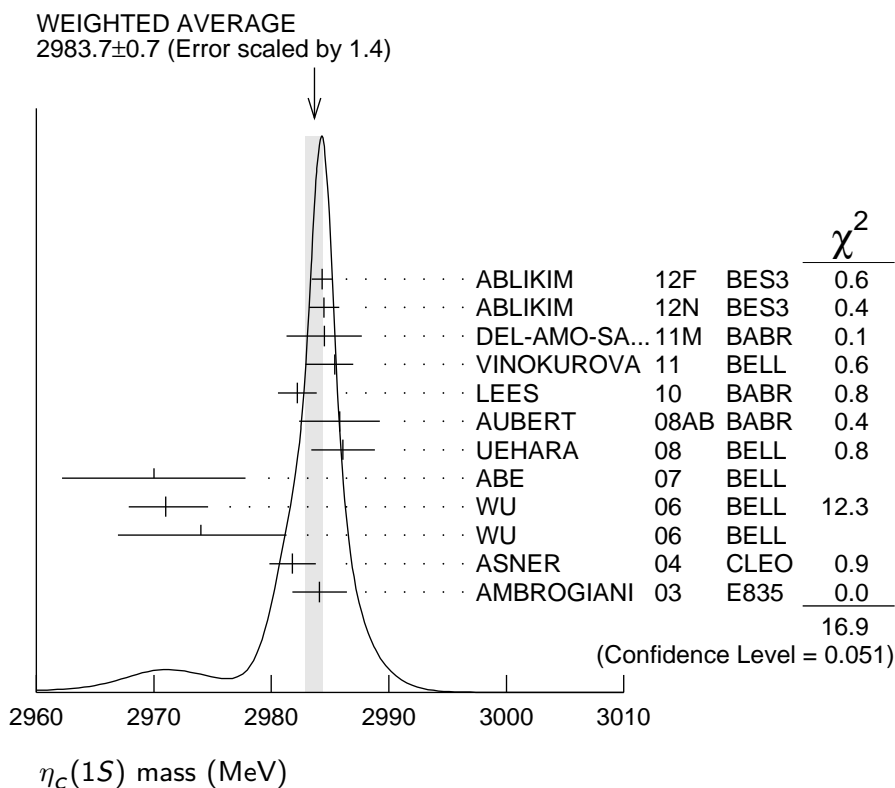
$$I^G(J^{PC}) = 0^+(0^{-+})$$

$\eta_c(1S)$  MASS

| VALUE (MeV)   | EVTS | DOCUMENT ID   | TECN | COMMENT  |
|---|------|---|------|--|
| <b>2983.7 ± 0.7 OUR AVERAGE</b>   |      | Error includes scale factor of 1.4. See the ideogram below. |      |  |
| 2984.3 ± 0.6 ± 0.6  |      | <sup>1,2</sup> ABLIKIM 12F                                  | BES3 | $\psi(2S) \rightarrow \gamma \eta_c$                                 |
| 2984.49 ± 1.16 ± 0.52   | 832  | <sup>3</sup> ABLIKIM 12N                                    | BES3 | $\psi(2S) \rightarrow \pi^0 \gamma$ hadrons                          |
| 2984.5 ± 0.8 ± 3.1  | 11k  | DEL-AMO-SA...11M  | BABR | $\gamma\gamma \rightarrow K^+ K^- \pi^+ \pi^- \pi^0$                 |
| 2985.4 ± 1.5 <sup>+0.5</sup> / <sub>-2.0</sub>                                | 920  | <sup>2</sup> VINOKUROVA 11                                  | BELL | $B^\pm \rightarrow K^\pm (K_S^0 K^\pm \pi^\mp)$                      |
| 2982.2 ± 0.4 ± 1.6  | 14k  | <sup>4</sup> LEES 10  | BABR | $10.6 e^+ e^- \rightarrow e^+ e^- K_S^0 K^\pm \pi^\mp$               |
| 2985.8 ± 1.5 ± 3.1  | 0.9k | AUBERT 08AB   | BABR | $B \rightarrow \eta_c(1S) K^{(*)} \rightarrow K \bar{K} \pi K^{(*)}$ |
| 2986.1 ± 1.0 ± 2.5  | 7.5k | UEHARA 08   | BELL | $\gamma\gamma \rightarrow \eta_c \rightarrow$ hadrons                |
| 2970 ± 5 ± 6  | 501  | <sup>5</sup> ABE 07   | BELL | $e^+ e^- \rightarrow J/\psi(c\bar{c})$                               |
| 2971 ± 3 <sup>+2</sup> / <sub>-1</sub>  | 195  | WU 06   | BELL | $B^+ \rightarrow p \bar{p} K^+$                                      |
| 2974 ± 7 <sup>+2</sup> / <sub>-1</sub>  | 20   | WU 06   | BELL | $B^+ \rightarrow \Lambda \bar{\Lambda} K^+$                          |
| 2981.8 ± 1.3 ± 1.5  | 592  | ASNER 04  | CLEO | $\gamma\gamma \rightarrow \eta_c \rightarrow K_S^0 K^\pm \pi^\mp$    |
| 2984.1 ± 2.1 ± 1.0  | 190  | <sup>6</sup> AMBROGIANI 03                                  | E835 | $\bar{p} p \rightarrow \eta_c \rightarrow \gamma\gamma$              |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● |      |   |      |  |
| 2982.5 ± 0.4 ± 1.4  | 12k  | <sup>7</sup> DEL-AMO-SA...11M                               | BABR | $\gamma\gamma \rightarrow K_S^0 K^\pm \pi^\mp$                       |
| 2982.2 ± 0.6  |      | <sup>8</sup> MITCHELL 09                                    | CLEO | $e^+ e^- \rightarrow \gamma X$                                       |
| 2982 ± 5  | 270  | <sup>9</sup> AUBERT 06E                                     | BABR | $B^\pm \rightarrow K^\pm X_{c\bar{c}}$                               |
| 2982.5 ± 1.1 ± 0.9  | 2.5k | <sup>10</sup> AUBERT 04D                                    | BABR | $\gamma\gamma \rightarrow \eta_c(1S) \rightarrow K \bar{K} \pi$      |
| 2977.5 ± 1.0 ± 1.2  |      | <sup>8,11</sup> BAI 03                                      | BES  | $J/\psi \rightarrow \gamma \eta_c$                                   |
| 2979.6 ± 2.3 ± 1.6  | 180  | <sup>12</sup> FANG 03                                       | BELL | $B \rightarrow \eta_c K$   |
| 2976.3 ± 2.3 ± 1.2  |      | <sup>8,13</sup> BAI 00F                                     | BES  | $J/\psi, \psi(2S) \rightarrow \gamma \eta_c$                         |
| 2976.6 ± 2.9 ± 1.3  | 140  | <sup>8,14</sup> BAI 00F                                     | BES  | $J/\psi \rightarrow \gamma \eta_c$                                   |
| 2980.4 ± 2.3 ± 0.6  |      | <sup>15</sup> BRANDENB... 00B                               | CLE2 | $\gamma\gamma \rightarrow \eta_c \rightarrow K^\pm K_S^0 \pi^\mp$    |
| 2975.8 ± 3.9 ± 1.2  |      | <sup>14</sup> BAI 99B                                       | BES  | Sup. by BAI 00F  |
| 2999 ± 8  | 25   | ABREU 980   | DLPH | $e^+ e^- \rightarrow e^+ e^- + \text{hadrons}$                       |
| 2988.3 <sup>+3.3</sup> / <sub>-3.1</sub>                                      |      | ARMSTRONG 95F   | E760 | $\bar{p} p \rightarrow \gamma\gamma$                                 |
| 2974.4 ± 1.9  |      | <sup>8,16</sup> BISELLO 91                                  | DM2  | $J/\psi \rightarrow \eta_c \gamma$                                   |
| 2969 ± 4 ± 4  | 80   | <sup>8</sup> BAI 90B  | MRK3 | $J/\psi \rightarrow \gamma K^+ K^- K^+ K^-$                          |
| 2956 ± 12 ± 12  |      | <sup>8</sup> BAI 90B  | MRK3 | $J/\psi \rightarrow \gamma K^+ K^- K_S^0 K_L^0$                      |

|        |                      |      |                |      |      |  |
|--------|----------------------|------|----------------|------|------|--|
| 2982.6 | $\pm 2.7$<br>$- 2.3$ | 12   | BAGLIN         | 87B  | SPEC | $\bar{p}p \rightarrow \gamma\gamma$                          |
| 2980.2 | $\pm 1.6$            | 8,16 | BALTRUSAIT..86 | MRK3 |      | $J/\psi \rightarrow \eta_c \gamma$                           |
| 2984   | $\pm 2.3 \pm 4.0$    | 8    | GAISER         | 86   | CBAL | $J/\psi \rightarrow \gamma X, \psi(2S) \rightarrow \gamma X$ |
| 2976   | $\pm 8$              | 8,17 | BALTRUSAIT..84 | MRK3 |      | $J/\psi \rightarrow 2\phi\gamma$                             |
| 2982   | $\pm 8$              | 18   | HIMEL          | 80B  | MRK2 | $e^+e^-$   |
| 2980   | $\pm 9$              | 18   | PARTRIDGE      | 80B  | CBAL | $e^+e^-$   |

- <sup>1</sup> From a simultaneous fit to six decay modes of the  $\eta_c$ .
- <sup>2</sup> Accounts for interference with non-resonant continuum.
- <sup>3</sup> With floating width.
- <sup>4</sup> Taking into account interference with the non-resonant  $J^P = 0^-$  amplitude.
- <sup>5</sup> From a fit of the  $J/\psi$  recoil mass spectrum. Supersedes ABE,K 02 and ABE 04G.
- <sup>6</sup> Using mass of  $\psi(2S) = 3686.00$  MeV.
- <sup>7</sup> Not independent from the measurements reported by LEES 10.
- <sup>8</sup> MITCHELL 09 observes a significant asymmetry in the lineshapes of  $\psi(2S) \rightarrow \gamma\eta_c$  and  $J/\psi \rightarrow \gamma\eta_c$  transitions. If ignored, this asymmetry could lead to significant bias whenever the mass and width are measured in  $\psi(2S)$  or  $J/\psi$  radiative decays.
- <sup>9</sup> From the fit of the kaon momentum spectrum. Systematic errors not evaluated.
- <sup>10</sup> Superseded by LEES 10.
- <sup>11</sup> From a simultaneous fit of five decay modes of the  $\eta_c$ .
- <sup>12</sup> Superseded by VINOKUROVA 11.
- <sup>13</sup> Weighted average of the  $\psi(2S)$  and  $J/\psi(1S)$  samples. Using an  $\eta_c$  width of 13.2 MeV.
- <sup>14</sup> Average of several decay modes. Using an  $\eta_c$  width of 13.2 MeV.
- <sup>15</sup> Superseded by ASNER 04.
- <sup>16</sup> Average of several decay modes.
- <sup>17</sup>  $\eta_c \rightarrow \phi\phi$ .
- <sup>18</sup> Mass adjusted by us to correspond to  $J/\psi(1S)$  mass = 3097 MeV.



## $\eta_c(1S)$ WIDTH

| VALUE (MeV)   | EVTS | DOCUMENT ID                   | TECN | COMMENT   |
|---|------|-------------------------------|------|---|
| <b>32.0 ± 0.9 OUR FIT</b>   |      |                               |      |   |
| <b>32.2 ± 1.0 OUR AVERAGE</b>   |      |                               |      | Error includes scale factor of 1.2.   |
| 32.0 ± 1.2 ± 1.0  |      | <sup>1,2</sup> ABLIKIM 12F    | BES3 | $\psi(2S) \rightarrow \gamma \eta_c$  |
| 36.4 ± 3.2 ± 1.7  | 832  | <sup>3</sup> ABLIKIM 12N      | BES3 | $\psi(2S) \rightarrow \pi^0 \gamma$ hadrons                                 |
| 36.2 ± 2.8 ± 3.0  | 11k  | DEL-AMO-SA..11M               | BABR | $\gamma\gamma \rightarrow K^+ K^- \pi^+ \pi^- \pi^0$                        |
| 35.1 ± 3.1 <sup>+1.0</sup> <sub>-1.6</sub>                                    | 920  | <sup>2</sup> VINOKUROVA 11    | BELL | $B^\pm \rightarrow K^\pm (K_S^0 K^\pm \pi^\mp)$                             |
| 31.7 ± 1.2 ± 0.8  | 14k  | <sup>4</sup> LEES 10          | BABR | $10.6 e^+ e^- \rightarrow e^+ e^- K_S^0 K^\pm \pi^\mp$                      |
| 36.3 <sup>+3.7</sup> <sub>-3.6</sub> ± 4.4                                    | 0.9k | AUBERT 08AB                   | BABR | $B \rightarrow \eta_c(1S) K^{(*)} \rightarrow K \bar{K} \pi K^{(*)}$        |
| 28.1 ± 3.2 ± 2.2  | 7.5k | UEHARA 08                     | BELL | $\gamma\gamma \rightarrow \eta_c \rightarrow$ hadrons                       |
| 48 <sup>+8</sup> <sub>-7</sub> ± 5  | 195  | WU 06                         | BELL | $B^+ \rightarrow p \bar{p} K^+$   |
| 40 ± 19 ± 5   | 20   | WU 06                         | BELL | $B^+ \rightarrow \Lambda \bar{\Lambda} K^+$                                 |
| 24.8 ± 3.4 ± 3.5  | 592  | ASNER 04                      | CLEO | $\gamma\gamma \rightarrow \eta_c \rightarrow K_S^0 K^\pm \pi^\mp$           |
| 20.4 <sup>+7.7</sup> <sub>-6.7</sub> ± 2.0                                    | 190  | AMBROGIANI 03                 | E835 | $\bar{p} p \rightarrow \eta_c \rightarrow \gamma\gamma$                     |
| 23.9 <sup>+12.6</sup> <sub>-7.1</sub>   |      | ARMSTRONG 95F                 | E760 | $\bar{p} p \rightarrow \gamma\gamma$  |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● |      |                               |      |   |
| 32.1 ± 1.1 ± 1.3  | 12k  | <sup>5</sup> DEL-AMO-SA..11M  | BABR | $\gamma\gamma \rightarrow K_S^0 K^\pm \pi^\mp$                              |
| 34.3 ± 2.3 ± 0.9  | 2.5k | <sup>6</sup> AUBERT 04D       | BABR | $\gamma\gamma \rightarrow \eta_c(1S) \rightarrow K \bar{K} \pi$             |
| 17.0 ± 3.7 ± 7.4  |      | <sup>7</sup> BAI 03           | BES  | $J/\psi \rightarrow \gamma \eta_c$  |
| 29 ± 8 ± 6  | 180  | <sup>8</sup> FANG 03          | BELL | $B \rightarrow \eta_c K$  |
| 11.0 ± 8.1 ± 4.1  |      | <sup>9</sup> BAI 00F          | BES  | $J/\psi \rightarrow \gamma \eta_c$ and $\psi(2S) \rightarrow \gamma \eta_c$ |
| 27.0 ± 5.8 ± 1.4  |      | <sup>10</sup> BRANDENB... 00B | CLE2 | $\gamma\gamma \rightarrow \eta_c \rightarrow K^\pm K_S^0 \pi^\mp$           |
| 7.0 <sup>+7.5</sup> <sub>-7.0</sub>   | 12   | BAGLIN 87B                    | SPEC | $\bar{p} p \rightarrow \gamma\gamma$  |
| 10.1 <sup>+33.0</sup> <sub>-8.2</sub>   | 23   | <sup>11</sup> BALTRUSAIT..86  | MRK3 | $J/\psi \rightarrow \gamma p \bar{p}$                                       |
| 11.5 ± 4.5  |      | GAISER 86                     | CBAL | $J/\psi \rightarrow \gamma X, \psi(2S) \rightarrow \gamma X$                |
| < 40 90% CL   | 18   | HIMEL 80B                     | MRK2 | $e^+ e^-$   |
| < 20 90% CL   |      | PARTRIDGE 80B                 | CBAL | $e^+ e^-$   |

<sup>1</sup> From a simultaneous fit to six decay modes of the  $\eta_c$ .

<sup>2</sup> Accounts for interference with non-resonant continuum.

<sup>3</sup> With floating mass.

<sup>4</sup> Taking into account interference with the non-resonant  $J^P = 0^-$  amplitude.

<sup>5</sup> Not independent from the measurements reported by LEES 10.

<sup>6</sup> Superseded by LEES 10.

<sup>7</sup> From a simultaneous fit of five decay modes of the  $\eta_c$ .

<sup>8</sup> Superseded by VINOKUROVA 11.

<sup>9</sup> From a fit to the 4-prong invariant mass in  $\psi(2S) \rightarrow \gamma \eta_c$  and  $J/\psi(1S) \rightarrow \gamma \eta_c$  decays.

<sup>10</sup> Superseded by ASNER 04.

<sup>11</sup> Positive and negative errors correspond to 90% confidence level.

## $\eta_c(1S)$ DECAY MODES

| Mode  | Fraction ( $\Gamma_i/\Gamma$ )       | Confidence level |
|---|--------------------------------------|------------------|
| <b>Decays involving hadronic resonances</b>             |                                      |                  |
| $\Gamma_1$ $\eta'(958)\pi\pi$                           | ( 4.1 $\pm$ 1.7 ) %                  |                  |
| $\Gamma_2$ $\rho\rho$                                   | ( 1.8 $\pm$ 0.5 ) %                  |                  |
| $\Gamma_3$ $K^*(892)^0 K^- \pi^+ + \text{c.c.}$         | ( 2.0 $\pm$ 0.7 ) %                  |                  |
| $\Gamma_4$ $K^*(892)\bar{K}^*(892)$                     | ( 7.1 $\pm$ 1.3 ) $\times 10^{-3}$   |                  |
| $\Gamma_5$ $K^{*0}\bar{K}^{*0}\pi^+\pi^-$               | ( 1.1 $\pm$ 0.5 ) %                  |                  |
| $\Gamma_6$ $\phi K^+ K^-$                               | ( 2.9 $\pm$ 1.4 ) $\times 10^{-3}$   |                  |
| $\Gamma_7$ $\phi\phi$                                   | ( 1.76 $\pm$ 0.20 ) $\times 10^{-3}$ |                  |
| $\Gamma_8$ $\phi 2(\pi^+\pi^-)$                         | $< 3.5 \times 10^{-3}$               | 90%              |
| $\Gamma_9$ $a_0(980)\pi$                                | $< 2$ %                              | 90%              |
| $\Gamma_{10}$ $a_2(1320)\pi$                            | $< 2$ %                              | 90%              |
| $\Gamma_{11}$ $K^*(892)\bar{K} + \text{c.c.}$           | $< 1.28$ %                           | 90%              |
| $\Gamma_{12}$ $f_2(1270)\eta$                           | $< 1.1$ %                            | 90%              |
| $\Gamma_{13}$ $\omega\omega$                            | $< 3.1 \times 10^{-3}$               | 90%              |
| $\Gamma_{14}$ $\omega\phi$                              | $< 1.7 \times 10^{-3}$               | 90%              |
| $\Gamma_{15}$ $f_2(1270)f_2(1270)$                      | ( 9.8 $\pm$ 2.5 ) $\times 10^{-3}$   |                  |
| $\Gamma_{16}$ $f_2(1270)f_2'(1525)$                     | ( 9.7 $\pm$ 3.2 ) $\times 10^{-3}$   |                  |
| <b>Decays into stable hadrons</b>                       |                                      |                  |
| $\Gamma_{17}$ $K\bar{K}\pi$                             | ( 7.3 $\pm$ 0.5 ) %                  |                  |
| $\Gamma_{18}$ $\eta\pi^+\pi^-$                          | ( 1.7 $\pm$ 0.5 ) %                  |                  |
| $\Gamma_{19}$ $\eta 2(\pi^+\pi^-)$                      | ( 4.4 $\pm$ 1.3 ) %                  |                  |
| $\Gamma_{20}$ $K^+ K^- \pi^+ \pi^-$                     | ( 6.9 $\pm$ 1.1 ) $\times 10^{-3}$   |                  |
| $\Gamma_{21}$ $K^+ K^- \pi^+ \pi^- \pi^0$               | ( 3.5 $\pm$ 0.6 ) %                  |                  |
| $\Gamma_{22}$ $K^0 K^- \pi^+ \pi^- \pi^+ + \text{c.c.}$ | ( 5.6 $\pm$ 1.5 ) %                  |                  |
| $\Gamma_{23}$ $K^+ K^- 2(\pi^+\pi^-)$                   | ( 7.5 $\pm$ 2.4 ) $\times 10^{-3}$   |                  |
| $\Gamma_{24}$ $2(K^+ K^-)$                              | ( 1.47 $\pm$ 0.31 ) $\times 10^{-3}$ |                  |
| $\Gamma_{25}$ $\pi^+ \pi^- \pi^0 \pi^0$                 | ( 4.7 $\pm$ 1.0 ) %                  |                  |
| $\Gamma_{26}$ $2(\pi^+ \pi^-)$                          | ( 9.7 $\pm$ 1.2 ) $\times 10^{-3}$   |                  |
| $\Gamma_{27}$ $2(\pi^+ \pi^- \pi^0)$                    | ( 17.4 $\pm$ 3.3 ) %                 |                  |
| $\Gamma_{28}$ $3(\pi^+ \pi^-)$                          | ( 1.7 $\pm$ 0.4 ) %                  |                  |
| $\Gamma_{29}$ $\rho\bar{\rho}$                          | ( 1.51 $\pm$ 0.16 ) $\times 10^{-3}$ |                  |
| $\Gamma_{30}$ $\rho\bar{\rho}\pi^0$                     | ( 3.6 $\pm$ 1.3 ) $\times 10^{-3}$   |                  |
| $\Gamma_{31}$ $\Lambda\bar{\Lambda}$                    | ( 1.09 $\pm$ 0.24 ) $\times 10^{-3}$ |                  |
| $\Gamma_{32}$ $K\bar{K}\eta$                            | ( 10 $\pm$ 5 ) $\times 10^{-3}$      |                  |
| $\Gamma_{33}$ $\pi^+ \pi^- \rho\bar{\rho}$              | ( 5.3 $\pm$ 1.8 ) $\times 10^{-3}$   |                  |
| <b>Radiative decays</b>                                 |                                      |                  |
| $\Gamma_{34}$ $\gamma\gamma$                            | ( 1.57 $\pm$ 0.12 ) $\times 10^{-4}$ |                  |

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

|               |               |               |                  |     |
|---------------|---------------|---------------|------------------|-----|
| $\Gamma_{35}$ | $\pi^+ \pi^-$ | $P, CP < 1.1$ | $\times 10^{-4}$ | 90% |
| $\Gamma_{36}$ | $\pi^0 \pi^0$ | $P, CP < 3.5$ | $\times 10^{-5}$ | 90% |
| $\Gamma_{37}$ | $K^+ K^-$     | $P, CP < 6$   | $\times 10^{-4}$ | 90% |
| $\Gamma_{38}$ | $K_S^0 K_S^0$ | $P, CP < 3.1$ | $\times 10^{-4}$ | 90% |

**CONSTRAINED FIT INFORMATION**

An overall fit to the total width, 8 combinations of partial widths obtained from integrated cross section, and 17 branching ratios uses 79 measurements and one constraint to determine 12 parameters. The overall fit has a  $\chi^2 = 112.1$  for 68 degrees of freedom.

The following *off-diagonal* array elements are the correlation coefficients  $\langle \delta p_i \delta p_j \rangle / (\delta p_i \delta p_j)$ , in percent, from the fit to parameters  $p_i$ , including the branching fractions,  $x_i \equiv \Gamma_i / \Gamma_{\text{total}}$ . The fit constrains the  $x_i$  whose labels appear in this array to sum to one.

|          |       |       |          |          |          |          |          |          |          |          |
|----------|-------|-------|----------|----------|----------|----------|----------|----------|----------|----------|
| $x_7$    | 18    |       |          |          |          |          |          |          |          |          |
| $x_{15}$ | 3     | 6     |          |          |          |          |          |          |          |          |
| $x_{17}$ | 22    | 42    | 7        |          |          |          |          |          |          |          |
| $x_{20}$ | 11    | 21    | 4        | 25       |          |          |          |          |          |          |
| $x_{24}$ | 9     | 16    | 3        | 25       | 10       |          |          |          |          |          |
| $x_{26}$ | 14    | 25    | 5        | 31       | 16       | 12       |          |          |          |          |
| $x_{29}$ | 14    | 26    | 5        | 36       | 16       | 13       | 20       |          |          |          |
| $x_{31}$ | 3     | 6     | 1        | 9        | 4        | 3        | 5        | 25       |          |          |
| $x_{34}$ | -29   | -54   | -10      | -66      | -34      | -27      | -41      | -45      | -11      |          |
| $\Gamma$ | -2    | -3    | -1       | -4       | -2       | -2       | -2       | 7        | 2        | -29      |
|          | $x_4$ | $x_7$ | $x_{15}$ | $x_{17}$ | $x_{20}$ | $x_{24}$ | $x_{26}$ | $x_{29}$ | $x_{31}$ | $x_{34}$ |

|               | Mode                        | Rate (MeV)          |
|---------------|-----------------------------|---------------------|
| $\Gamma_4$    | $K^*(892) \bar{K}^*(892)$   | 0.23 $\pm$ 0.04     |
| $\Gamma_7$    | $\phi \phi$                 | 0.056 $\pm$ 0.007   |
| $\Gamma_{15}$ | $f_2(1270) \bar{f}_2(1270)$ | 0.31 $\pm$ 0.08     |
| $\Gamma_{17}$ | $K \bar{K} \pi$             | 2.35 $\pm$ 0.17     |
| $\Gamma_{20}$ | $K^+ K^- \pi^+ \pi^-$       | 0.222 $\pm$ 0.035   |
| $\Gamma_{24}$ | $2(K^+ K^-)$                | 0.047 $\pm$ 0.010   |
| $\Gamma_{26}$ | $2(\pi^+ \pi^-)$            | 0.31 $\pm$ 0.04     |
| $\Gamma_{29}$ | $\rho \bar{\rho}$           | 0.049 $\pm$ 0.005   |
| $\Gamma_{31}$ | $\Lambda \bar{\Lambda}$     | 0.035 $\pm$ 0.008   |
| $\Gamma_{34}$ | $\gamma \gamma$             | 0.0050 $\pm$ 0.0004 |

## $\eta_c(1S)$ PARTIAL WIDTHS

| $\Gamma(\gamma\gamma)$ |             |                    |             |                |  | $\Gamma_{34}$ |
|------------------------|-------------|--------------------|-------------|----------------|--|---------------|
| <u>VALUE (keV)</u>     | <u>EVTS</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |  |               |

**5.0 ± 0.4 OUR FIT**

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

|   |          |                            |          |   |  |  |
|---|----------|----------------------------|----------|---|--|--|
| 5.2 ± 1.2   | 273 ± 43 | <sup>1,2</sup> AUBERT      | 06E BABR | $B^\pm \rightarrow K^\pm X_{c\bar{c}}$                            |  |  |
| 5.5 ± 1.2 ± 1.8   | 157 ± 33 | <sup>3</sup> KUO           | 05 BELL  | $\gamma\gamma \rightarrow p\bar{p}$                               |  |  |
| 7.4 ± 0.4 ± 2.3   |          | <sup>4</sup> ASNER         | 04 CLEO  | $\gamma\gamma \rightarrow \eta_c \rightarrow K_S^0 K^\pm \pi^\mp$ |  |  |
| 13.9 ± 2.0 ± 3.0  | 41       | <sup>5</sup> ABDALLAH      | 03J DLPH | $\gamma\gamma \rightarrow \eta_c$                                 |  |  |
| 3.8 <sup>+</sup> <sub>-1.0</sub> 1.1 <sup>+</sup> <sub>-1.0</sub> | 190      | <sup>6</sup> AMBROGIANI    | 03 E835  | $\bar{p}p \rightarrow \eta_c \rightarrow \gamma\gamma$            |  |  |
| 7.6 ± 0.8 ± 2.3   |          | <sup>4,7</sup> BRANDENB... | 00B CLE2 | $\gamma\gamma \rightarrow \eta_c \rightarrow K^\pm K_S^0 \pi^\mp$ |  |  |
| 6.9 ± 1.7 ± 2.1   | 76       | <sup>8</sup> ACCIARRI      | 99T L3   | $e^+e^- \rightarrow e^+e^-\eta_c$                                 |  |  |
| 27 ± 16 ± 10  | 5        | <sup>4</sup> SHIRAI        | 98 AMY   | 58 $e^+e^-$   |  |  |
| 6.7 <sup>+</sup> <sub>-1.7</sub> 2.4 ± 2.3                        |          | <sup>3</sup> ARMSTRONG     | 95F E760 | $\bar{p}p \rightarrow \gamma\gamma$                               |  |  |
| 11.3 ± 4.2  |          | <sup>9</sup> ALBRECHT      | 94H ARG  | $e^+e^- \rightarrow e^+e^-\eta_c$                                 |  |  |
| 8.0 ± 2.3 ± 2.4   | 17       | <sup>10</sup> ADRIANI      | 93N L3   | $e^+e^- \rightarrow e^+e^-\eta_c$                                 |  |  |
| 5.9 <sup>+</sup> <sub>-1.8</sub> 2.1 ± 1.9                        |          | <sup>6</sup> CHEN          | 90B CLEO | $e^+e^- \rightarrow e^+e^-\eta_c$                                 |  |  |
| 6.4 <sup>+</sup> <sub>-3.4</sub> 5.0                              |          | <sup>11</sup> AIHARA       | 88D TPC  | $e^+e^- \rightarrow e^+e^-X$                                      |  |  |
| 4.3 <sup>+</sup> <sub>-3.7</sub> 3.4 ± 2.4                        |          | <sup>3</sup> BAGLIN        | 87B SPEC | $\bar{p}p \rightarrow \gamma\gamma$                               |  |  |
| 28 ± 15   |          | <sup>4,12</sup> BERGER     | 86 PLUT  | $\gamma\gamma \rightarrow K\bar{K}\pi$                            |  |  |

<sup>1</sup> Calculated by us using  $\Gamma(\eta_c \rightarrow K\bar{K}\pi) \times \Gamma(\eta_c \rightarrow \gamma\gamma) / \Gamma = 0.44 \pm 0.05$  keV from PDG 06 and  $B(\eta_c \rightarrow K\bar{K}\pi) = (8.5 \pm 1.8)\%$  from AUBERT 06E.

<sup>2</sup> Systematic errors not evaluated.

<sup>3</sup> Normalized to  $B(\eta_c \rightarrow p\bar{p}) = (1.3 \pm 0.4) \times 10^{-3}$ .

<sup>4</sup> Normalized to  $B(\eta_c \rightarrow K^\pm K_S^0 \pi^\mp)$ .

<sup>5</sup> Average of  $K_S^0 K^\pm \pi^\mp$ ,  $\pi^+ \pi^- K^+ K^-$ , and  $2(K^+ K^-)$  decay modes.

<sup>6</sup> Normalized to the sum of  $B(\eta_c \rightarrow K^\pm K_S^0 \pi^\mp)$ ,  $B(\eta_c \rightarrow K^+ K^- \pi^+ \pi^-)$ , and  $B(\eta_c \rightarrow 2\pi^+ 2\pi^-)$ .

<sup>7</sup> Superseded by ASNER 04.

<sup>8</sup> Normalized to the sum of 9 branching ratios.

<sup>9</sup> Normalized to the sum of  $B(\eta_c \rightarrow K^\pm K_S^0 \pi^\mp)$ ,  $B(\eta_c \rightarrow \phi\phi)$ ,  $B(\eta_c \rightarrow K^+ K^- \pi^+ \pi^-)$ , and  $B(\eta_c \rightarrow 2\pi^+ 2\pi^-)$ .

<sup>10</sup> Superseded by ACCIARRI 99T.

<sup>11</sup> Normalized to the sum of  $B(\eta_c \rightarrow K^\pm K_S^0 \pi^\mp)$ ,  $B(\eta_c \rightarrow 2K^+ 2K^-)$ ,  $B(\eta_c \rightarrow K^+ K^- \pi^+ \pi^-)$ , and  $B(\eta_c \rightarrow 2\pi^+ 2\pi^-)$ .

<sup>12</sup> Re-evaluated by AIHARA 88D.

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

| $\Gamma(\rho\rho) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ |            |             |                    |             |                | $\Gamma_2\Gamma_{34}/\Gamma$ |
|--|------------|-------------|--------------------|-------------|----------------|------------------------------|
| <u>VALUE (eV)</u>  | <u>CL%</u> | <u>EVTS</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |                              |

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

|     |    |        |        |         |   |  |
|-----|----|--------|--------|---------|---|--|
| <39 | 90 | < 1556 | UEHARA | 08 BELL | $\gamma\gamma \rightarrow 2(\pi^+ \pi^-)$ |  |
|-----|----|--------|--------|---------|---|--|

$\Gamma(K^*(892)\bar{K}^*(892)) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_4\Gamma_{34}/\Gamma$

| VALUE (eV)              | EVTS      | DOCUMENT ID | TECN    | COMMENT                                     |
|-------------------------|-----------|-------------|---------|---|
| <b>35 ± 6 OUR FIT</b>   |           |             |         |   |
| <b>32.4 ± 4.2 ± 5.8</b> | 882 ± 115 | UEHARA      | 08 BELL | $\gamma\gamma \rightarrow \pi^+\pi^-K^+K^-$ |

$\Gamma(\phi\phi) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_7\Gamma_{34}/\Gamma$

| VALUE (eV)   | EVTS     | DOCUMENT ID      | TECN     | COMMENT                              |
|--|----------|------------------|----------|--------------------------------------|
| <b>8.9 ± 0.8 OUR FIT</b>   |          |                  |          |                                      |
| <b>7.75 ± 0.66 ± 0.62</b>  | 386 ± 31 | <sup>1</sup> LIU | 12B BELL | $\gamma\gamma \rightarrow 2(K^+K^-)$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • •              |          |                  |          |                                      |
| 6.8 ± 1.2 ± 1.3  | 132 ± 23 | UEHARA           | 08 BELL  | $\gamma\gamma \rightarrow 2(K^+K^-)$ |
| <sup>1</sup> Supersedes UEHARA 08. Using $B(\phi \rightarrow K^+K^-) = (48.9 \pm 0.5)\%$ . |          |                  |          |                                      |

$\Gamma(\omega\omega) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_{13}\Gamma_{34}/\Gamma$

| VALUE (eV)  | EVTS    | DOCUMENT ID      | TECN     | COMMENT                                       |
|---|---------|------------------|----------|---|
| <b>8.67 ± 2.86 ± 0.96</b>   | 85 ± 29 | <sup>1</sup> LIU | 12B BELL | $\gamma\gamma \rightarrow 2(\pi^+\pi^-\pi^0)$ |
| <sup>1</sup> Using $B(\omega \rightarrow \pi^+\pi^-\pi^0) = (89.2 \pm 0.7)\%$ . |         |                  |          |   |

$\Gamma(\omega\phi) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_{14}\Gamma_{34}/\Gamma$

| VALUE (eV)  | CL% | DOCUMENT ID      | TECN     | COMMENT  |
|---|-----|------------------|----------|--|
| • • • We do not use the following data for averages, fits, limits, etc. • • •   |     |                  |          |  |
| <0.49   | 90  | <sup>1</sup> LIU | 12B BELL | $\gamma\gamma \rightarrow K^+K^-\pi^+\pi^-\pi^0$ |
| <sup>1</sup> Using $B(\phi \rightarrow K^+K^-) = (48.9 \pm 0.5)\%$ and $B(\omega \rightarrow \pi^+\pi^-\pi^0) = (89.2 \pm 0.7)\%$ . |     |                  |          |  |

$\Gamma(f_2(1270)f_2(1270)) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_{15}\Gamma_{34}/\Gamma$

| VALUE (eV)             | EVTS       | DOCUMENT ID | TECN    | COMMENT                                  |
|------------------------|------------|-------------|---------|--|
| <b>49 ± 13 OUR FIT</b> |            |             |         |  |
| <b>69 ± 17 ± 12</b>    | 3182 ± 766 | UEHARA      | 08 BELL | $\gamma\gamma \rightarrow 2(\pi^+\pi^-)$ |

$\Gamma(f_2(1270)f_2'(1525)) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_{16}\Gamma_{34}/\Gamma$

| VALUE (eV)         | EVTS       | DOCUMENT ID | TECN    | COMMENT                                     |
|--------------------|------------|-------------|---------|---|
| <b>49 ± 9 ± 13</b> | 1128 ± 206 | UEHARA      | 08 BELL | $\gamma\gamma \rightarrow \pi^+\pi^-K^+K^-$ |

$\Gamma(K\bar{K}\pi) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_{17}\Gamma_{34}/\Gamma$

| VALUE (keV)                      | CL% | EVTS | DOCUMENT ID              | TECN     | COMMENT  |
|----------------------------------|-----|------|--------------------------|----------|--|
| <b>0.369 ± 0.021 OUR FIT</b>     |     |      |                          |          |  |
| <b>0.407 ± 0.027 OUR AVERAGE</b> |     |      |                          |          | Error includes scale factor of 1.2.                              |
| 0.374 ± 0.009 ± 0.031            |     | 14k  | <sup>1</sup> LEES        | 10 BABR  | $10.6 e^+e^- \rightarrow e^+e^-K_S^0K^\pm\pi^\mp$                |
| 0.407 ± 0.022 ± 0.028            |     |      | <sup>2,3</sup> ASNER     | 04 CLEO  | $\gamma\gamma \rightarrow \eta_c \rightarrow K_S^0K^\pm\pi^\mp$  |
| 0.60 ± 0.12 ± 0.09               |     | 41   | <sup>3,4</sup> ABDALLAH  | 03J DLPH | $\gamma\gamma \rightarrow K_S^0K^\pm\pi^\mp$                     |
| 1.47 ± 0.87 ± 0.27               |     |      | <sup>3</sup> SHIRAI      | 98 AMY   | $\gamma\gamma \rightarrow \eta_c \rightarrow K^\pm K_S^0\pi^\mp$ |
| 0.84 ± 0.21                      |     |      | <sup>3</sup> ALBRECHT    | 94H ARG  | $\gamma\gamma \rightarrow K^\pm K_S^0\pi^\mp$                    |
| 0.60 +0.23 -0.20                 |     |      | <sup>3</sup> CHEN        | 90B CLEO | $\gamma\gamma \rightarrow \eta_c K^\pm K_S^0\pi^\mp$             |
| 1.06 ± 0.41 ± 0.27               |     | 11   | <sup>3</sup> BRAUNSCH... | 89 TASS  | $\gamma\gamma \rightarrow K\bar{K}\pi$                           |
| 1.5 +0.60 -0.45 ± 0.3            |     | 7    | <sup>3</sup> BERGER      | 86 PLUT  | $\gamma\gamma \rightarrow K\bar{K}\pi$                           |

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

|                             |     |                                     |   |
|-----------------------------|-----|-------------------------------------|---|
| $0.386 \pm 0.008 \pm 0.021$ | 12k | <sup>5</sup> DEL-AMO-SA..11M BABR   | $\gamma\gamma \rightarrow K_S^0 K^\pm \pi^\mp$                    |
| $0.418 \pm 0.044 \pm 0.022$ |     | <sup>3,6</sup> BRANDENB... 00B CLE2 | $\gamma\gamma \rightarrow \eta_c \rightarrow K^\pm K_S^0 \pi^\mp$ |
| $< 0.63$                    | 95  | <sup>3</sup> BEHREND 89 CELL        | $\gamma\gamma \rightarrow K_S^0 K^\pm \pi^\mp$                    |
| $< 4.4$                     | 95  | ALTHOFF 85B TASS                    | $\gamma\gamma \rightarrow K \bar{K} \pi$                          |

<sup>1</sup> From the corrected and unfolded mass spectrum.

<sup>2</sup> Calculated by us from the value reported in ASNER 04 that assumes  $B(\eta_c \rightarrow K \bar{K} \pi) = 5.5 \pm 1.7\%$

<sup>3</sup> We have multiplied  $K^\pm K_S^0 \pi^\mp$  measurement by 3 to obtain  $K \bar{K} \pi$ .

<sup>4</sup> Calculated by us from the value reported in ABDALLAH 03J, which uses  $B(\eta_c \rightarrow K_S^0 K^\pm \pi^\mp) = (1.5 \pm 0.4)\%$ .

<sup>5</sup> Not independent from the measurements reported by LEES 10.

<sup>6</sup> Superseded by ASNER 04.

$\Gamma(K^+ K^- \pi^+ \pi^-) \times \Gamma(\gamma\gamma) / \Gamma_{\text{total}}$   $\Gamma_{20} \Gamma_{34} / \Gamma$

| VALUE (eV)                | EVTS       | DOCUMENT ID                    | TECN | COMMENT  |
|---------------------------|------------|--------------------------------|------|--|
| <b>35 ± 5 OUR FIT</b>     |            |                                |      |  |
| <b>27 ± 6 OUR AVERAGE</b> |            |                                |      |  |
| 25.7 ± 3.2 ± 4.9          | 2019 ± 248 | UEHARA 08 BELL                 |      | $\gamma\gamma \rightarrow \pi^+ \pi^- K^+ K^-$ |
| 280 ± 100 ± 60            | 42         | <sup>1</sup> ABDALLAH 03J DLPH |      | $\gamma\gamma \rightarrow \pi^+ \pi^- K^+ K^-$ |
| 170 ± 80 ± 20             | 13.9 ± 6.6 | ALBRECHT 94H ARG               |      | $\gamma\gamma \rightarrow \pi^+ \pi^- K^+ K^-$ |

<sup>1</sup> Calculated by us from the value reported in ABDALLAH 03J, which uses  $B(\eta_c \rightarrow \pi^+ \pi^- K^+ K^-) = (2.0 \pm 0.7)\%$ .

$\Gamma(K^+ K^- \pi^+ \pi^- \pi^0) \times \Gamma(\gamma\gamma) / \Gamma_{\text{total}}$   $\Gamma_{21} \Gamma_{34} / \Gamma$

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

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

|                             |     |                                   |  |
|-----------------------------|-----|-----------------------------------|--|
| $0.190 \pm 0.006 \pm 0.028$ | 11k | <sup>1</sup> DEL-AMO-SA..11M BABR | $\gamma\gamma \rightarrow K^+ K^- \pi^+ \pi^- \pi^0$ |
|-----------------------------|-----|-----------------------------------|--|

<sup>1</sup> Not independent from other measurements reported in DEL-AMO-SANCHEZ 11M.

$\Gamma(2(K^+ K^-)) \times \Gamma(\gamma\gamma) / \Gamma_{\text{total}}$   $\Gamma_{24} \Gamma_{34} / \Gamma$

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

**7.4 ± 1.5 OUR FIT**

**5.8 ± 1.9 OUR AVERAGE**

|                 |           |                                |  |                                       |
|-----------------|-----------|--------------------------------|--|---------------------------------------|
| 5.6 ± 1.1 ± 1.6 | 216 ± 42  | UEHARA 08 BELL                 |  | $\gamma\gamma \rightarrow 2(K^+ K^-)$ |
| 350 ± 90 ± 60   | 46        | <sup>1</sup> ABDALLAH 03J DLPH |  | $\gamma\gamma \rightarrow 2(K^+ K^-)$ |
| 231 ± 90 ± 23   | 9.1 ± 3.3 | <sup>2</sup> ALBRECHT 94H ARG  |  | $\gamma\gamma \rightarrow 2(K^+ K^-)$ |

<sup>1</sup> Calculated by us from the value reported in ABDALLAH 03J, which uses  $B(\eta_c \rightarrow 2(K^+ K^-)) = (2.1 \pm 1.2)\%$ .

<sup>2</sup> Includes all topological modes except  $\eta_c \rightarrow \phi\phi$ .

$\Gamma(2(\pi^+ \pi^-)) \times \Gamma(\gamma\gamma) / \Gamma_{\text{total}}$   $\Gamma_{26} \Gamma_{34} / \Gamma$

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

**49 ± 6 OUR FIT**

**42 ± 6 OUR AVERAGE**

|                  |            |                  |  |   |
|------------------|------------|------------------|--|---|
| 40.7 ± 3.7 ± 5.3 | 5381 ± 492 | UEHARA 08 BELL   |  | $\gamma\gamma \rightarrow 2(\pi^+ \pi^-)$ |
| 180 ± 70 ± 20    | 21.4 ± 8.6 | ALBRECHT 94H ARG |  | $\gamma\gamma \rightarrow 2(\pi^+ \pi^-)$ |



| $\Gamma(p\bar{p}) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$                           |          |                         |          |                                     | $\Gamma_{29}\Gamma_{34}/\Gamma$ |
|--|----------|-------------------------|----------|-------------------------------------|---------------------------------|
| VALUE (eV)   | EVTS     | DOCUMENT ID             | TECN     | COMMENT                             |                                 |
| <b>7.6 ± 0.8 OUR FIT</b>   |          |                         |          |                                     |                                 |
| <b>7.20 ± 1.53<sup>+0.67</sup><sub>-0.75</sub></b>   | 157 ± 33 | <sup>1</sup> KUO        | 05 BELL  | $\gamma\gamma \rightarrow p\bar{p}$ |                                 |
| • • • We do not use the following data for averages, fits, limits, etc. • • •                  |          |                         |          |                                     |                                 |
| 4.6 <sup>+1.3</sup> <sub>-1.1</sub> ± 0.4  | 190      | <sup>1</sup> AMBROGIANI | 03 E835  | $\bar{p}p \rightarrow \gamma\gamma$ |                                 |
| 8.1 <sup>+2.9</sup> <sub>-2.0</sub>  |          | <sup>1</sup> ARMSTRONG  | 95F E760 | $\bar{p}p \rightarrow \gamma\gamma$ |                                 |
| <sup>1</sup> Not independent from the $\Gamma_{\gamma\gamma}$ reported by the same experiment. |          |                         |          |                                     |                                 |

## $\eta_c(1S)$ BRANCHING RATIOS

### HADRONIC DECAYS

| $\Gamma(\eta'(958)\pi\pi)/\Gamma_{\text{total}}$  |      |                             |      |                                   | $\Gamma_1/\Gamma$ |
|---|------|-----------------------------|------|-----------------------------------|-------------------|
| VALUE   | EVTS | DOCUMENT ID                 | TECN | COMMENT                           |                   |
| <b>0.041 ± 0.017</b>  | 14   | <sup>1</sup> BALTRUSAIT..86 | MRK3 | $J/\psi \rightarrow \eta_c\gamma$ |                   |
| <sup>1</sup> The quoted branching ratios use $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = 0.0127 \pm 0.0036$ . |      |                             |      |                                   |                   |

| $\Gamma(\rho\rho)/\Gamma_{\text{total}}$   |     |      |                             |          | $\Gamma_2/\Gamma$                               |
|--|-----|------|-----------------------------|----------|---|
| VALUE (units 10 <sup>-3</sup> )  | CL% | EVTS | DOCUMENT ID                 | TECN     | COMMENT   |
| <b>18 ± 5 OUR AVERAGE</b>  |     |      |                             |          |   |
| 12.6 ± 3.8 ± 5.1   |     | 72   | <sup>1</sup> ABLIKIM        | 05L BES2 | $J/\psi \rightarrow \pi^+\pi^-\pi^+\pi^-\gamma$ |
| 26.0 ± 2.4 ± 8.8   |     | 113  | <sup>1</sup> BISELLO        | 91 DM2   | $J/\psi \rightarrow \gamma\rho^0\rho^0$         |
| 23.6 ± 10.6 ± 8.2  |     | 32   | <sup>1</sup> BISELLO        | 91 DM2   | $J/\psi \rightarrow \gamma\rho^+\rho^-$         |
| • • • We do not use the following data for averages, fits, limits, etc. • • •  |     |      |                             |          |   |
| <14  | 90  |      | <sup>1</sup> BALTRUSAIT..86 | MRK3     | $J/\psi \rightarrow \eta_c\gamma$               |
| <sup>1</sup> The quoted branching ratios use $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = 0.0127 \pm 0.0036$ . Where relevant, the error in this branching ratio is treated as a common systematic in computing averages. |     |      |                             |          |   |

| $\Gamma(K^*(892)^0 K^- \pi^+ + \text{c.c.})/\Gamma_{\text{total}}$  |      |                               |      |                                   | $\Gamma_3/\Gamma$ |
|---|------|-------------------------------|------|-----------------------------------|-------------------|
| VALUE   | EVTS | DOCUMENT ID                   | TECN | COMMENT                           |                   |
| <b>0.02 ± 0.007</b>   | 63   | <sup>1,2</sup> BALTRUSAIT..86 | MRK3 | $J/\psi \rightarrow \eta_c\gamma$ |                   |
| <sup>1</sup> BALTRUSAITIS 86 has an error according to Partridge.   |      |                               |      |                                   |                   |
| <sup>2</sup> The quoted branching ratios use $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = 0.0127 \pm 0.0036$ . |      |                               |      |                                   |                   |

| $\Gamma(K^*(892)\bar{K}^*(892))/\Gamma_{\text{total}}$   |      |                             |          |  | $\Gamma_4/\Gamma$ |
|--|------|-----------------------------|----------|--|-------------------|
| VALUE (units 10 <sup>-4</sup> )  | EVTS | DOCUMENT ID                 | TECN     | COMMENT                                      |                   |
| <b>71 ± 13 OUR FIT</b>   |      |                             |          |  |                   |
| <b>91 ± 26 OUR AVERAGE</b>   |      |                             |          |  |                   |
| 108 ± 25 ± 44  | 60   | <sup>1</sup> ABLIKIM        | 05L BES2 | $J/\psi \rightarrow K^+K^-\pi^+\pi^-\gamma$  |                   |
| 82 ± 28 ± 27   | 14   | <sup>1</sup> BISELLO        | 91 DM2   | $e^+e^- \rightarrow \gamma K^+K^-\pi^+\pi^-$ |                   |
| 90 ± 50  | 9    | <sup>1</sup> BALTRUSAIT..86 | MRK3     | $J/\psi \rightarrow \eta_c\gamma$            |                   |
| <sup>1</sup> The quoted branching ratios use $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = 0.0127 \pm 0.0036$ . Where relevant, the error in this branching ratio is treated as a common systematic in computing averages. |      |                             |          |  |                   |

$\Gamma(K^*0\bar{K}^*0\pi^+\pi^-)/\Gamma_{\text{total}}$   $\Gamma_5/\Gamma$

| VALUE (units $10^{-4}$ ) | EVTS | DOCUMENT ID          | TECN     | COMMENT   |
|--------------------------|------|----------------------|----------|---|
| <b>112±47±25</b>         | 45   | <sup>1</sup> ABLIKIM | 06A BES2 | $J/\psi \rightarrow K^*0\bar{K}^*0\pi^+\pi^-\gamma$ |

<sup>1</sup> ABLIKIM 06A reports  $[\Gamma(\eta_c(1S) \rightarrow K^*0\bar{K}^*0\pi^+\pi^-)/\Gamma_{\text{total}}] \times [B(J/\psi(1S) \rightarrow \gamma\eta_c(1S))] = (1.91 \pm 0.64 \pm 0.48) \times 10^{-4}$  which we divide by our best value  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = (1.7 \pm 0.4) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(\phi K^+ K^-)/\Gamma_{\text{total}}$   $\Gamma_6/\Gamma$

| VALUE (units $10^{-3}$ )                     | EVTS                                 | DOCUMENT ID        | TECN    | COMMENT                              |
|--|--------------------------------------|--------------------|---------|--------------------------------------|
| <b>2.9<sup>+0.9</sup><sub>-0.8</sub>±1.1</b> | 14.1 <sup>+4.4</sup> <sub>-3.7</sub> | <sup>1</sup> HUANG | 03 BELL | $B^+ \rightarrow (\phi K^+ K^-) K^+$ |

<sup>1</sup> Using  $B(B^+ \rightarrow \eta_c K^+) = (1.25 \pm 0.12^{+0.10}_{-0.12}) \times 10^{-3}$  from FANG 03 and  $B(\eta_c \rightarrow K\bar{K}\pi) = (5.5 \pm 1.7) \times 10^{-2}$ .

$\Gamma(\phi\phi)/\Gamma_{\text{total}}$   $\Gamma_7/\Gamma$

| VALUE (units $10^{-4}$ )              | EVTS     | DOCUMENT ID          | TECN     | COMMENT   |
|---------------------------------------|----------|----------------------|----------|---|
| <b>17.6± 2.0 OUR FIT</b>              |          |                      |          |   |
| <b>30 ± 5 OUR AVERAGE</b>             |          |                      |          |   |
| 25.3± 5.1± 9.1                        | 72       | <sup>1</sup> ABLIKIM | 05L BES2 | $J/\psi \rightarrow K^+ K^- K^+ K^- \gamma$     |
| 26 ± 9                                | 357 ± 64 | <sup>1</sup> BAI     | 04 BES   | $J/\psi \rightarrow \gamma K^+ K^- K^+ K^-$     |
| 31 ± 7 ± 10                           | 19       | <sup>1</sup> BISELLO | 91 DM2   | $J/\psi \rightarrow \gamma K^+ K^- K^+ K^-$     |
| 30 <sup>+18</sup> <sub>-12</sub> ± 10 | 5        | <sup>1</sup> BISELLO | 91 DM2   | $J/\psi \rightarrow \gamma K^+ K^- K_S^0 K_L^0$ |
| 74 ± 18 ± 24                          | 80       | <sup>1</sup> BAI     | 90B MRK3 | $J/\psi \rightarrow \gamma K^+ K^- K^+ K^-$     |
| 67 ± 21 ± 24                          |          | <sup>1</sup> BAI     | 90B MRK3 | $J/\psi \rightarrow \gamma K^+ K^- K_S^0 K_L^0$ |

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

|                                    |                                     |                    |         |                                  |
|------------------------------------|-------------------------------------|--------------------|---------|----------------------------------|
| 18 <sup>+8</sup> <sub>-6</sub> ± 7 | 7.0 <sup>+3.0</sup> <sub>-2.3</sub> | <sup>2</sup> HUANG | 03 BELL | $B^+ \rightarrow (\phi\phi) K^+$ |
|------------------------------------|-------------------------------------|--------------------|---------|----------------------------------|

<sup>1</sup> The quoted branching ratios use  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = 0.0127 \pm 0.0036$ . Where relevant, the error in this branching ratio is treated as a common systematic in computing averages.

<sup>2</sup> Using  $B(B^+ \rightarrow \eta_c K^+) = (1.25 \pm 0.12^{+0.10}_{-0.12}) \times 10^{-3}$  from FANG 03 and  $B(\eta_c \rightarrow K\bar{K}\pi) = (5.5 \pm 1.7) \times 10^{-2}$ .

$\Gamma(\phi\phi)/\Gamma(K\bar{K}\pi)$   $\Gamma_7/\Gamma_{17}$

| VALUE   | EVTS | DOCUMENT ID | TECN | COMMENT |
|---|------|-------------|------|---------|
| <b>0.0240±0.0026 OUR FIT</b>                                |      |             |      |         |
| <b>0.044 <sup>+0.012</sup><sub>-0.010</sub> OUR AVERAGE</b> |      |             |      |         |

|   |   |                    |          |                                    |
|---|---|--------------------|----------|------------------------------------|
| 0.055 ± 0.014 ± 0.005                             |   | AUBERT,B           | 04B BABR | $B^\pm \rightarrow K^\pm \eta_c$   |
| 0.032 <sup>+0.014</sup> <sub>-0.010</sub> ± 0.009 | 7 | <sup>1</sup> HUANG | 03 BELL  | $B^\pm \rightarrow K^\pm \phi\phi$ |

<sup>1</sup> Using  $B(B^+ \rightarrow \eta_c K^+) = (1.25 \pm 0.12^{+0.10}_{-0.12}) \times 10^{-3}$  from FANG 03 and  $B(\eta_c \rightarrow K\bar{K}\pi) = (5.5 \pm 1.7) \times 10^{-2}$ .

**$\Gamma(\phi 2(\pi^+ \pi^-))/\Gamma_{\text{total}}$**   **$\Gamma_8/\Gamma$**

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

|               |    |                          |      |   |
|---------------|----|--------------------------|------|---|
| <b>&lt;35</b> | 90 | <sup>1</sup> ABLIKIM 06A | BES2 | $J/\psi \rightarrow \phi 2(\pi^+ \pi^-) \gamma$ |
|---------------|----|--------------------------|------|---|

<sup>1</sup> ABLIKIM 06A reports  $[\Gamma(\eta_c(1S) \rightarrow \phi 2(\pi^+ \pi^-))/\Gamma_{\text{total}}] \times [B(J/\psi(1S) \rightarrow \gamma \eta_c(1S))] < 0.603 \times 10^{-4}$  which we divide by our best value  $B(J/\psi(1S) \rightarrow \gamma \eta_c(1S)) = 1.7 \times 10^{-2}$ .

**$\Gamma(a_0(980)\pi)/\Gamma_{\text{total}}$**   **$\Gamma_9/\Gamma$**

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

|                 |    |                               |      |                                    |
|-----------------|----|-------------------------------|------|------------------------------------|
| <b>&lt;0.02</b> | 90 | <sup>1,2</sup> BALTRUSAIT..86 | MRK3 | $J/\psi \rightarrow \eta_c \gamma$ |
|-----------------|----|-------------------------------|------|------------------------------------|

<sup>1</sup> The quoted branching ratios use  $B(J/\psi(1S) \rightarrow \gamma \eta_c(1S)) = 0.0127 \pm 0.0036$ .

<sup>2</sup> We are assuming  $B(a_0(980) \rightarrow \eta \pi) > 0.5$ .

**$\Gamma(a_2(1320)\pi)/\Gamma_{\text{total}}$**   **$\Gamma_{10}/\Gamma$**

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

|                 |    |                             |      |                                    |
|-----------------|----|-----------------------------|------|------------------------------------|
| <b>&lt;0.02</b> | 90 | <sup>1</sup> BALTRUSAIT..86 | MRK3 | $J/\psi \rightarrow \eta_c \gamma$ |
|-----------------|----|-----------------------------|------|------------------------------------|

<sup>1</sup> The quoted branching ratios use  $B(J/\psi(1S) \rightarrow \gamma \eta_c(1S)) = 0.0127 \pm 0.0036$ .

**$\Gamma(K^*(892)\bar{K} + \text{c.c.})/\Gamma_{\text{total}}$**   **$\Gamma_{11}/\Gamma$**

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

|                   |    |            |     |   |
|-------------------|----|------------|-----|---|
| <b>&lt;0.0128</b> | 90 | BISELLO 91 | DM2 | $J/\psi \rightarrow \gamma K_S^0 K^\pm \pi^\mp$ |
|-------------------|----|------------|-----|---|

|         |    |                         |     |   |
|---------|----|-------------------------|-----|---|
| <0.0132 | 90 | <sup>1</sup> BISELLO 91 | DM2 | $J/\psi \rightarrow \gamma K^+ K^- \pi^0$ |
|---------|----|-------------------------|-----|---|

<sup>1</sup> The quoted branching ratios use  $B(J/\psi(1S) \rightarrow \gamma \eta_c(1S)) = 0.0127 \pm 0.0036$ .

**$\Gamma(f_2(1270)\eta)/\Gamma_{\text{total}}$**   **$\Gamma_{12}/\Gamma$**

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

|                  |    |                             |      |                                    |
|------------------|----|-----------------------------|------|------------------------------------|
| <b>&lt;0.011</b> | 90 | <sup>1</sup> BALTRUSAIT..86 | MRK3 | $J/\psi \rightarrow \eta_c \gamma$ |
|------------------|----|-----------------------------|------|------------------------------------|

<sup>1</sup> The quoted branching ratios use  $B(J/\psi(1S) \rightarrow \gamma \eta_c(1S)) = 0.0127 \pm 0.0036$ .

**$\Gamma(\omega\omega)/\Gamma_{\text{total}}$**   **$\Gamma_{13}/\Gamma$**

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

|                   |    |                             |      |                                    |
|-------------------|----|-----------------------------|------|------------------------------------|
| <b>&lt;0.0031</b> | 90 | <sup>1</sup> BALTRUSAIT..86 | MRK3 | $J/\psi \rightarrow \eta_c \gamma$ |
|-------------------|----|-----------------------------|------|------------------------------------|

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

|         |    |                          |      |   |
|---------|----|--------------------------|------|---|
| <0.0063 | 90 | <sup>1</sup> ABLIKIM 05L | BES2 | $J/\psi \rightarrow \pi^+ \pi^- \pi^0 \pi^+ \pi^- \pi^0 \gamma$ |
|---------|----|--------------------------|------|---|

|         |  |                         |     |   |
|---------|--|-------------------------|-----|---|
| <0.0063 |  | <sup>1</sup> BISELLO 91 | DM2 | $J/\psi \rightarrow \gamma \omega \omega$ |
|---------|--|-------------------------|-----|---|

<sup>1</sup> The quoted branching ratios use  $B(J/\psi(1S) \rightarrow \gamma \eta_c(1S)) = 0.0127 \pm 0.0036$ . Where relevant, the error in this branching ratio is treated as a common systematic in computing averages.

**$\Gamma(\omega\phi)/\Gamma_{\text{total}}$**   **$\Gamma_{14}/\Gamma$**

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

|                   |    |                          |      |   |
|-------------------|----|--------------------------|------|---|
| <b>&lt;0.0017</b> | 90 | <sup>1</sup> ABLIKIM 05L | BES2 | $J/\psi \rightarrow \pi^+ \pi^- \pi^0 K^+ K^- \gamma$ |
|-------------------|----|--------------------------|------|---|

<sup>1</sup> The quoted branching ratios use  $B(J/\psi(1S) \rightarrow \gamma \eta_c(1S)) = 0.0127 \pm 0.0036$ .

$\Gamma(f_2(1270)f_2(1270))/\Gamma_{\text{total}}$   $\Gamma_{15}/\Gamma$

| VALUE (units $10^{-2}$ )                           | EVTS        | DOCUMENT ID          | TECN    | COMMENT                                   |
|--|-------------|----------------------|---------|---|
| <b>0.98 ± 0.25 OUR FIT</b>                         |             |                      |         |   |
| <b>0.77<sup>+0.25</sup><sub>-0.29</sub> ± 0.17</b> | 91.2 ± 19.8 | <sup>1</sup> ABLIKIM | 04M BES | $J/\psi \rightarrow \gamma 2\pi^+ 2\pi^-$ |

<sup>1</sup> ABLIKIM 04M reports  $[\Gamma(\eta_c(1S) \rightarrow f_2(1270)f_2(1270))/\Gamma_{\text{total}}] \times [B(J/\psi(1S) \rightarrow \gamma\eta_c(1S))] = (1.3 \pm 0.3^{+0.3}_{-0.4}) \times 10^{-4}$  which we divide by our best value  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = (1.7 \pm 0.4) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(K\bar{K}\pi)/\Gamma_{\text{total}}$   $\Gamma_{17}/\Gamma$

| VALUE (units $10^{-2}$ )             | EVTS | DOCUMENT ID                   | TECN     | COMMENT   |
|--------------------------------------|------|-------------------------------|----------|---|
| <b>7.3 ± 0.5 OUR FIT</b>             |      |                               |          |   |
| <b>6.5 ± 0.6 OUR AVERAGE</b>         |      |                               |          |   |
| 6.3 ± 1.3 ± 0.6                      | 55   | <sup>1,2</sup> ABLIKIM        | 12N BES3 | $\psi(2S) \rightarrow \pi^0 \gamma K^+ K^- \pi^0$       |
| 7.9 ± 1.4 ± 0.7                      | 107  | <sup>3,4</sup> ABLIKIM        | 12N BES3 | $\psi(2S) \rightarrow \pi^0 \gamma K_S^0 K^\mp \pi^\pm$ |
| 8.5 ± 1.8                            |      | <sup>5</sup> AUBERT           | 06E BABR | $B^\pm \rightarrow K^\pm X_{c\bar{c}}$                  |
| 5.1 ± 2.1                            | 0.6k | <sup>6</sup> BAI              | 04 BES   | $J/\psi \rightarrow \gamma K^\pm \pi^\mp K_S^0$         |
| 6.90 ± 1.42 ± 1.32                   | 33   | <sup>6</sup> BISELLO          | 91 DM2   | $J/\psi \rightarrow \gamma K^+ K^- \pi^0$               |
| 5.43 ± 0.94 ± 0.94                   | 68   | <sup>6</sup> BISELLO          | 91 DM2   | $J/\psi \rightarrow \gamma K^\pm \pi^\mp K_S^0$         |
| 4.8 ± 1.7                            | 95   | <sup>6,7</sup> BALTRUSAIT..86 | MRK3     | $J/\psi \rightarrow \eta_c \gamma$                      |
| 16.1 <sup>+9.2</sup> <sub>-7.3</sub> |      | <sup>8,9</sup> HIMEL          | 80B MRK2 | $\psi(2S) \rightarrow \eta_c \gamma$                    |

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

< 10.7 90% CL <sup>6,10</sup> PARTRIDGE 80B CBAL  $J/\psi \rightarrow \eta_c \gamma$

<sup>1</sup> ABLIKIM 12N quotes  $B(\psi(2S) \rightarrow \pi^0 h_c) \cdot B(h_c \rightarrow \gamma \eta_c) \cdot B(\eta_c \rightarrow K^+ K^- \pi^0) = (4.54 \pm 0.76 \pm 0.48) \times 10^{-6}$  which we multiply by 6 to account for isospin symmetry.

<sup>2</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow K\bar{K}\pi)/\Gamma_{\text{total}}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}}] = (27.24 \pm 4.56 \pm 2.88) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>3</sup> ABLIKIM 12N quotes  $B(\psi(2S) \rightarrow \pi^0 h_c) \cdot B(h_c \rightarrow \gamma \eta_c) \cdot B(\eta_c \rightarrow K_S^0 K^\pm \pi^\mp) = (11.35 \pm 1.25 \pm 1.50) \times 10^{-6}$  which we multiply by 3 to account for isospin symmetry.

<sup>4</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow K\bar{K}\pi)/\Gamma_{\text{total}}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}}] = (34.05 \pm 3.75 \pm 4.50) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>5</sup> Determined from the ratio of  $B(B^\pm \rightarrow K^\pm \eta_c) B(\eta_c \rightarrow K\bar{K}\pi) = (7.4 \pm 0.5 \pm 0.7) \times 10^{-5}$  reported in AUBERT, B 04B and  $B(B^\pm \rightarrow K^\pm \eta_c) = (8.7 \pm 1.5) \times 10^{-3}$  reported in AUBERT 06E.

<sup>6</sup> The quoted branching ratios use  $B(J/\psi(1S) \rightarrow \gamma \eta_c(1S)) = 0.0127 \pm 0.0036$ . Where relevant, the error in this branching ratio is treated as a common systematic in computing averages.

<sup>7</sup> Average from  $K^+ K^- \pi^0$  and  $K^\pm K_S^0 \pi^\mp$  decay channels.

<sup>8</sup>  $K^\pm K_S^0 \pi^\mp$  corrected to  $K\bar{K}\pi$  by factor 3. KS, MR.

<sup>9</sup> Estimated using  $B(\psi(2S) \rightarrow \gamma \eta_c(1S)) = 0.0028 \pm 0.0006$ .

<sup>10</sup>  $K^+ K^- \pi^0$  corrected to  $K\bar{K}\pi$  by factor 6. KS, MR

### $\Gamma(\phi K^+ K^-)/\Gamma(K\bar{K}\pi)$

$\Gamma_6/\Gamma_{17}$

| VALUE                               | EVTS | DOCUMENT ID        | TECN | COMMENT                             |
|-------------------------------------|------|--------------------|------|-------------------------------------|
| $0.052^{+0.016}_{-0.014} \pm 0.014$ | 7    | <sup>1</sup> HUANG | 03   | BELL $B^\pm \rightarrow K^\pm \phi$ |

<sup>1</sup> Using  $B(B^+ \rightarrow \eta_c K^+) = (1.25 \pm 0.12^{+0.10}_{-0.12}) \times 10^{-3}$  from FANG 03 and  $B(\eta_c \rightarrow K\bar{K}\pi) = (5.5 \pm 1.7) \times 10^{-2}$ .

### $\Gamma(\eta\pi^+\pi^-)/\Gamma_{\text{total}}$

$\Gamma_{18}/\Gamma$

| VALUE (units $10^{-2}$ ) | EVTS | DOCUMENT ID                 | TECN | COMMENT   |
|--------------------------|------|-----------------------------|------|---|
| $1.7 \pm 0.4 \pm 0.1$    | 33   | <sup>1</sup> ABLIKIM        | 12N  | BES3 $\psi(2S) \rightarrow \pi^0 \gamma \eta \pi^+ \pi^-$ |
| $5.4 \pm 2.0$            | 75   | <sup>2</sup> BALTRUSAIT..86 | MRK3 | $J/\psi \rightarrow \eta_c \gamma$                        |
| $3.7 \pm 1.3 \pm 2.0$    | 18   | <sup>2</sup> PARTRIDGE      | 80B  | CBAL $J/\psi \rightarrow \eta \pi^+ \pi^- \gamma$         |

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

<sup>1</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow \eta \pi^+ \pi^-)/\Gamma_{\text{total}}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}}] = (7.22 \pm 1.47 \pm 1.11) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>2</sup> The quoted branching ratios use  $B(J/\psi(1S) \rightarrow \gamma \eta_c(1S)) = 0.0127 \pm 0.0036$ . Where relevant, the error in this branching ratio is treated as a common systematic in computing averages.

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

$\Gamma_{19}/\Gamma$

| VALUE (units $10^{-2}$ ) | EVTS | DOCUMENT ID          | TECN | COMMENT   |
|--------------------------|------|----------------------|------|---|
| $4.4 \pm 1.2 \pm 0.4$    | 39   | <sup>1</sup> ABLIKIM | 12N  | BES3 $\psi(2S) \rightarrow \pi^0 \gamma \eta 2(\pi^+\pi^-)$ |

<sup>1</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow \eta 2(\pi^+\pi^-))/\Gamma_{\text{total}}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}}] = (19.17 \pm 3.77 \pm 3.72) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

$\Gamma_{20}/\Gamma$

| VALUE (units $10^{-3}$ )                     | EVTS | DOCUMENT ID                 | TECN | COMMENT  |
|--|------|-----------------------------|------|--|
| <b><math>6.9 \pm 1.1</math> OUR FIT</b>      |      |                             |      |  |
| <b><math>11.2 \pm 1.9</math> OUR AVERAGE</b> |      |                             |      |  |
| $9.7 \pm 2.2 \pm 0.9$                        | 38   | <sup>1</sup> ABLIKIM        | 12N  | BES3 $\psi(2S) \rightarrow \pi^0 \gamma K^+ K^- \pi^+ \pi^-$ |
| $12 \pm 4$                                   | 0.4k | <sup>2</sup> BAI            | 04   | BES $J/\psi \rightarrow \gamma K^+ K^- \pi^+ \pi^-$          |
| $21 \pm 7$                                   | 110  | <sup>2</sup> BALTRUSAIT..86 | MRK3 | $J/\psi \rightarrow \eta_c \gamma$                           |
| $14^{+22}_{-9}$                              |      | <sup>3</sup> HIMEL          | 80B  | MRK2 $\psi(2S) \rightarrow \eta_c \gamma$                    |

<sup>1</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow K^+ K^- \pi^+ \pi^-)/\Gamma_{\text{total}}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}}] = (4.16 \pm 0.76 \pm 0.59) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>2</sup> The quoted branching ratios use  $B(J/\psi(1S) \rightarrow \gamma \eta_c(1S)) = 0.0127 \pm 0.0036$ . Where relevant, the error in this branching ratio is treated as a common systematic in computing averages.

<sup>3</sup> Estimated using  $B(\psi(2S) \rightarrow \gamma \eta_c(1S)) = 0.0028 \pm 0.0006$ .

$\Gamma(K^+ K^- \pi^+ \pi^- \pi^0)/\Gamma(K \bar{K} \pi)$   $\Gamma_{21}/\Gamma_{17}$

| VALUE                    | EVTS | DOCUMENT ID                  | TECN | COMMENT  |
|--------------------------|------|------------------------------|------|--|
| <b>0.477±0.017±0.070</b> | 11k  | <sup>1</sup> DEL-AMO-SA..11M | BABR | $\gamma\gamma \rightarrow K^+ K^- \pi^+ \pi^- \pi^0$ |

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

$\Gamma(K^0 K^- \pi^+ \pi^- \pi^+ +c.c.)/\Gamma_{total}$   $\Gamma_{22}/\Gamma$

| VALUE (units 10 <sup>-2</sup> ) | EVTS | DOCUMENT ID            | TECN     | COMMENT  |
|---------------------------------|------|------------------------|----------|--|
| <b>5.6±1.4±0.5</b>              | 43   | <sup>1,2</sup> ABLIKIM | 12N BES3 | $\psi(2S) \rightarrow \pi^0 \gamma K_S^0 K^\mp \pi^\mp 2\pi^\pm$ |

<sup>1</sup> ABLIKIM 12N quotes  $B(\psi(2S) \rightarrow \pi^0 h_c) \cdot B(h_c \rightarrow \gamma \eta_c) \cdot B(\eta_c \rightarrow K_S^0 K^- \pi^- 2\pi^+)$  =  $(12.01 \pm 2.22 \pm 2.04) \times 10^{-6}$  which we multiply by 2 to take c.c. into account.

<sup>2</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow K^0 K^- \pi^+ \pi^- \pi^+ +c.c.)/\Gamma_{total}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{total} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{total}] = (24.02 \pm 4.44 \pm 4.08) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{total} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{total} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(K^+ K^- 2(\pi^+ \pi^-))/\Gamma_{total}$   $\Gamma_{23}/\Gamma$

| VALUE (units 10 <sup>-3</sup> ) | EVTS | DOCUMENT ID | TECN | COMMENT |
|---------------------------------|------|-------------|------|---------|
| <b>7.5±2.4 OUR AVERAGE</b>      |      |             |      |         |

|             |     |                      |          |  |
|-------------|-----|----------------------|----------|--|
| 8 ±4 ±1     | 10  | <sup>1</sup> ABLIKIM | 12N BES3 | $\psi(2S) \rightarrow \pi^0 \gamma K^+ K^- 2(\pi^+ \pi^-)$ |
| 7.1±2.4±1.6 | 100 | <sup>2</sup> ABLIKIM | 06A BES2 | $J/\psi \rightarrow K^+ K^- 2(\pi^+ \pi^-) \gamma$         |

<sup>1</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow K^+ K^- 2(\pi^+ \pi^-))/\Gamma_{total}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{total} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{total}] = (3.60 \pm 1.71 \pm 0.64) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{total} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{total} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>2</sup> ABLIKIM 06A reports  $[\Gamma(\eta_c(1S) \rightarrow K^+ K^- 2(\pi^+ \pi^-))/\Gamma_{total}] \times [B(J/\psi(1S) \rightarrow \gamma \eta_c(1S))] = (1.21 \pm 0.32 \pm 0.24) \times 10^{-4}$  which we divide by our best value  $B(J/\psi(1S) \rightarrow \gamma \eta_c(1S)) = (1.7 \pm 0.4) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2(K^+ K^-))/\Gamma_{total}$   $\Gamma_{24}/\Gamma$

| VALUE (units 10 <sup>-3</sup> ) | EVTS | DOCUMENT ID | TECN | COMMENT |
|---------------------------------|------|-------------|------|---------|
| <b>1.47± 0.31 OUR FIT</b>       |      |             |      |         |

|                       |   |                      |          |  |
|-----------------------|---|----------------------|----------|--|
| <b>2.2 ± 0.9 ±0.2</b> | 7 | <sup>1</sup> ABLIKIM | 12N BES3 | $\psi(2S) \rightarrow \pi^0 \gamma 2(K^+ K^-)$ |
|-----------------------|---|----------------------|----------|--|

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

|  |  |                       |         |  |
|--|--|-----------------------|---------|--|
| 1.4 <sup>+0.5</sup> / <sub>-0.4</sub> ±0.6 | 14.5 <sup>+4.6</sup> / <sub>-3.0</sub> | <sup>2</sup> HUANG    | 03 BELL | $B^+ \rightarrow 2(K^+ K^-) K^+$           |
| 21 ±10 ±6                                  |  | <sup>3</sup> ALBRECHT | 94H ARG | $\gamma\gamma \rightarrow K^+ K^- K^+ K^-$ |

<sup>1</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow 2(K^+ K^-))/\Gamma_{total}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{total} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{total}] = (0.94 \pm 0.37 \pm 0.14) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{total} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{total} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>2</sup> Using  $B(B^+ \rightarrow \eta_c K^+) = (1.25 \pm 0.12_{-0.12}^{+0.10}) \times 10^{-3}$  from FANG 03 and  $B(\eta_c \rightarrow K \bar{K} \pi) = (5.5 \pm 1.7) \times 10^{-2}$ .

<sup>3</sup> Normalized to the sum of  $B(\eta_c \rightarrow K^\pm K_S^0 \pi^\mp)$ ,  $B(\eta_c \rightarrow \phi \phi)$ ,  $B(\eta_c \rightarrow K^+ K^- \pi^+ \pi^-)$ , and  $B(\eta_c \rightarrow 2\pi^+ 2\pi^-)$ .

### $\Gamma(2(K^+ K^-))/\Gamma(K \bar{K} \pi)$

$\Gamma_{24}/\Gamma_{17}$

| VALUE   | EVTS | DOCUMENT ID        | TECN | COMMENT                                    |
|---|------|--------------------|------|--|
| <b>0.020 ± 0.004 OUR FIT</b>                      |      |                    |      |  |
| <b>0.024 ± 0.007 OUR AVERAGE</b>                  |      |                    |      |  |
| 0.023 ± 0.007 ± 0.006                             |      | AUBERT,B           | 04B  | BABR $B^\pm \rightarrow K^\pm \eta_c$      |
| 0.026 <sup>+0.009</sup> <sub>-0.007</sub> ± 0.007 | 15   | <sup>1</sup> HUANG | 03   | BELL $B^\pm \rightarrow K^\pm (2K^+ 2K^-)$ |

<sup>1</sup> Using  $B(B^+ \rightarrow \eta_c K^+) = (1.25 \pm 0.12_{-0.12}^{+0.10}) \times 10^{-3}$  from FANG 03 and  $B(\eta_c \rightarrow K \bar{K} \pi) = (5.5 \pm 1.7) \times 10^{-2}$ .

### $\Gamma(\pi^+ \pi^- \pi^0 \pi^0)/\Gamma_{\text{total}}$

$\Gamma_{25}/\Gamma$

| VALUE (units $10^{-2}$ ) | EVTS | DOCUMENT ID          | TECN | COMMENT   |
|--------------------------|------|----------------------|------|---|
| <b>4.7 ± 0.9 ± 0.4</b>   | 118  | <sup>1</sup> ABLIKIM | 12N  | BES3 $\psi(2S) \rightarrow \pi^0 \gamma \pi^+ \pi^- 2\pi^0$ |

<sup>1</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow \pi^+ \pi^- \pi^0 \pi^0)/\Gamma_{\text{total}}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S) \gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}}] = (20.31 \pm 2.20 \pm 3.33) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S) \gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

$\Gamma_{26}/\Gamma$

| VALUE (units $10^{-2}$ )            | EVTS     | DOCUMENT ID                 | TECN | COMMENT   |
|-------------------------------------|----------|-----------------------------|------|---|
| <b>0.97 ± 0.12 OUR FIT</b>          |          |                             |      |   |
| <b>1.35 ± 0.21 OUR AVERAGE</b>      |          |                             |      |   |
| 1.74 ± 0.32 ± 0.15                  | 100      | <sup>1</sup> ABLIKIM        | 12N  | BES3 $\psi(2S) \rightarrow \pi^0 \gamma 2(\pi^+ \pi^-)$ |
| 1.0 ± 0.5                           | 542 ± 75 | <sup>2</sup> BAI            | 04   | BES $J/\psi \rightarrow \gamma 2(\pi^+ \pi^-)$          |
| 1.05 ± 0.17 ± 0.34                  | 137      | <sup>2</sup> BISELLO        | 91   | DM2 $J/\psi \rightarrow \gamma 2\pi^+ 2\pi^-$           |
| 1.3 ± 0.6                           | 25       | <sup>2</sup> BALTRUSAIT..86 | MRK3 | $J/\psi \rightarrow \eta_c \gamma$                      |
| 2.0 <sup>+1.5</sup> <sub>-1.0</sub> |          | <sup>3</sup> HIMEL          | 80B  | MRK2 $\psi(2S) \rightarrow \eta_c \gamma$               |

<sup>1</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow 2(\pi^+ \pi^-))/\Gamma_{\text{total}}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S) \gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}}] = (7.51 \pm 0.85 \pm 1.11) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S) \gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>2</sup> The quoted branching ratios use  $B(J/\psi(1S) \rightarrow \gamma \eta_c(1S)) = 0.0127 \pm 0.0036$ . Where relevant, the error in this branching ratio is treated as a common systematic in computing averages.

<sup>3</sup> Estimated using  $B(\psi(2S) \rightarrow \gamma \eta_c(1S)) = 0.0028 \pm 0.0006$ .

**$\Gamma(2(\pi^+\pi^-\pi^0))/\Gamma_{\text{total}}$**   **$\Gamma_{27}/\Gamma$**

| VALUE (units $10^{-2}$ ) | EVTS | DOCUMENT ID          | TECN     | COMMENT  |
|--------------------------|------|----------------------|----------|--|
| <b>17.4 ± 2.9 ± 1.5</b>  | 175  | <sup>1</sup> ABLIKIM | 12N BES3 | $\psi(2S) \rightarrow \pi^0 \gamma 2(\pi^+\pi^-\pi^0)$ |

<sup>1</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow 2(\pi^+\pi^-\pi^0))/\Gamma_{\text{total}}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}}] = (75.13 \pm 7.42 \pm 9.99) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

**$\Gamma(3(\pi^+\pi^-))/\Gamma_{\text{total}}$**   **$\Gamma_{28}/\Gamma$**

| VALUE (units $10^{-3}$ )  | EVTS | DOCUMENT ID          | TECN     | COMMENT   |
|---------------------------|------|----------------------|----------|---|
| <b>17 ± 4 OUR AVERAGE</b> |      |                      |          |   |
| 20 ± 5 ± 2                | 51   | <sup>1</sup> ABLIKIM | 12N BES3 | $\psi(2S) \rightarrow \pi^0 \gamma 3(\pi^+\pi^-)$ |
| 15.2 ± 3.3 ± 3.4          | 479  | <sup>2</sup> ABLIKIM | 06A BES2 | $J/\psi \rightarrow 3(\pi^+\pi^-)\gamma$          |

<sup>1</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow 3(\pi^+\pi^-))/\Gamma_{\text{total}}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}}] = (8.82 \pm 1.57 \pm 1.59) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>2</sup> ABLIKIM 06A reports  $[\Gamma(\eta_c(1S) \rightarrow 3(\pi^+\pi^-))/\Gamma_{\text{total}}] \times [B(J/\psi(1S) \rightarrow \gamma\eta_c(1S))] = (2.59 \pm 0.32 \pm 0.47) \times 10^{-4}$  which we divide by our best value  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = (1.7 \pm 0.4) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

**$\Gamma(p\bar{p})/\Gamma_{\text{total}}$**   **$\Gamma_{29}/\Gamma$**

| VALUE (units $10^{-4}$ )      | EVTS     | DOCUMENT ID                 | TECN     | COMMENT                                      |
|-------------------------------|----------|-----------------------------|----------|--|
| <b>15.1 ± 1.6 OUR FIT</b>     |          |                             |          |  |
| <b>13.2 ± 2.7 OUR AVERAGE</b> |          |                             |          |  |
| 15 ± 5 ± 1                    | 15       | <sup>1</sup> ABLIKIM        | 12N BES3 | $\psi(2S) \rightarrow \pi^0 \gamma p\bar{p}$ |
| 15 ± 6                        | 213 ± 33 | <sup>2</sup> BAI            | 04 BES   | $J/\psi \rightarrow \gamma p\bar{p}$         |
| 10 ± 3 ± 4                    | 18       | <sup>2</sup> BISELLO        | 91 DM2   | $J/\psi \rightarrow \gamma p\bar{p}$         |
| 11 ± 6                        | 23       | <sup>2</sup> BALTRUSAIT..86 | MRK3     | $J/\psi \rightarrow \eta_c \gamma$           |
| 29 +29<br>-15                 |          | <sup>3</sup> HIMEL          | 80B MRK2 | $\psi(2S) \rightarrow \eta_c \gamma$         |

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

|   |     |                 |         |                               |
|---|-----|-----------------|---------|-------------------------------|
| 14.8 <sup>+</sup> <sub>-</sub> 2.0 <sup>+</sup> <sub>-</sub> 1.7<br>2.4 - 1.8 | 195 | <sup>4</sup> WU | 06 BELL | $B^+ \rightarrow p\bar{p}K^+$ |
|---|-----|-----------------|---------|-------------------------------|

<sup>1</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow p\bar{p})/\Gamma_{\text{total}}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}}] = (0.65 \pm 0.19 \pm 0.10) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>2</sup> The quoted branching ratios use  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = 0.0127 \pm 0.0036$ . Where relevant, the error in this branching ratio is treated as a common systematic in computing averages.

<sup>3</sup> Estimated using  $B(\psi(2S) \rightarrow \gamma\eta_c(1S)) = 0.0028 \pm 0.0006$ .

<sup>4</sup> WU 06 reports  $[\Gamma(\eta_c(1S) \rightarrow p\bar{p})/\Gamma_{\text{total}}] \times [B(B^+ \rightarrow \eta_c K^+)] = (1.42 \pm 0.11^{+0.16}_{-0.20}) \times 10^{-6}$  which we divide by our best value  $B(B^+ \rightarrow \eta_c K^+) = (9.6 \pm 1.1) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.



| $\Gamma(p\bar{p})/\Gamma(K\bar{K}\pi)$ |                                |             |                 |         | $\Gamma_{29}/\Gamma_{17}$ |                                    |
|--|--------------------------------|-------------|-----------------|---------|---------------------------|------------------------------------|
| VALUE                                  | EVTS                           | DOCUMENT ID | TECN            | COMMENT |                           |                                    |
| <b>0.0206 ± 0.0021 OUR FIT</b>         |                                |             |                 |         |                           |                                    |
| <b>0.021 ± 0.002</b>                   | <b>+0.004</b><br><b>-0.006</b> | 195         | <sup>1</sup> WU | 06      | BELL                      | $B^\pm \rightarrow K^\pm p\bar{p}$ |

<sup>1</sup> Using  $B(B^+ \rightarrow \eta_c K^+) = (1.25 \pm 0.12^{+0.10}_{-0.12}) \times 10^{-3}$  from FANG 03 and  $B(\eta_c \rightarrow K\bar{K}\pi) = (5.5 \pm 1.7) \times 10^{-2}$ .

| $\Gamma(p\bar{p})/\Gamma_{\text{total}} \times \Gamma(\phi\phi)/\Gamma_{\text{total}}$ |                            |        |         |      | $\Gamma_{29}/\Gamma \times \Gamma_7/\Gamma$ |  |
|--|----------------------------|--------|---------|------|---|--|
| VALUE (units $10^{-5}$ )   | DOCUMENT ID                | TECN   | COMMENT |      |   |  |
| <b>0.27 ± 0.05 OUR FIT</b>   |                            |        |         |      |   |  |
| <b>4.0</b>   | <b>+3.5</b><br><b>-3.2</b> | BAGLIN | 89      | SPEC |   | $\bar{p}p \rightarrow K^+ K^- K^+ K^-$ |

| $\Gamma(p\bar{p}\pi^0)/\Gamma_{\text{total}}$ |      |                      |      |         | $\Gamma_{30}/\Gamma$ |   |
|---|------|----------------------|------|---------|----------------------|---|
| VALUE (units $10^{-2}$ )                      | EVTS | DOCUMENT ID          | TECN | COMMENT |                      |   |
| <b>0.36 ± 0.13 ± 0.03</b>                     |      |                      |      |         |                      |   |
|   | 14   | <sup>1</sup> ABLIKIM | 12N  | BES3    |                      | $\psi(2S) \rightarrow \pi^0 \gamma p\bar{p}\pi^0$ |

<sup>1</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow p\bar{p}\pi^0)/\Gamma_{\text{total}}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}}] = (1.53 \pm 0.49 \pm 0.23) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

| $\Gamma(\Lambda\bar{\Lambda})/\Gamma_{\text{total}}$ |     |      |                      |      | $\Gamma_{31}/\Gamma$ |  |
|--|-----|------|----------------------|------|----------------------|--|
| VALUE (units $10^{-4}$ )                             | CL% | EVTS | DOCUMENT ID          | TECN | COMMENT              |  |
| <b>10.9 ± 2.4 OUR FIT</b>                            |     |      |                      |      |                      |  |
| <b>11.7 ± 2.3 ± 2.6</b>                              |     |      | <sup>1</sup> ABLIKIM | 12B  | BES3                 |  |

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

|                             |    |                      |    |      |   |
|-----------------------------|----|----------------------|----|------|---|
| $9.9^{+2.7}_{-2.6} \pm 1.2$ | 20 | <sup>2</sup> WU      | 06 | BELL | $B^+ \rightarrow \Lambda\bar{\Lambda}K^+$       |
| <20                         | 90 | <sup>3</sup> BISELLO | 91 | DM2  | $e^+e^- \rightarrow \gamma\Lambda\bar{\Lambda}$ |

<sup>1</sup> ABLIKIM 12B reports  $[\Gamma(\eta_c(1S) \rightarrow \Lambda\bar{\Lambda})/\Gamma_{\text{total}}] \times [B(J/\psi(1S) \rightarrow \gamma\eta_c(1S))] = (0.198 \pm 0.021 \pm 0.032) \times 10^{-4}$  which we divide by our best value  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = (1.7 \pm 0.4) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>2</sup> WU 06 reports  $[\Gamma(\eta_c(1S) \rightarrow \Lambda\bar{\Lambda})/\Gamma_{\text{total}}] \times [B(B^+ \rightarrow \eta_c K^+)] = (0.95^{+0.25+0.08}_{-0.22-0.11}) \times 10^{-6}$  which we divide by our best value  $B(B^+ \rightarrow \eta_c K^+) = (9.6 \pm 1.1) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>3</sup> The quoted branching ratios use  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = 0.0127 \pm 0.0036$ .

| $\Gamma(\Lambda\bar{\Lambda})/\Gamma(p\bar{p})$ |                              |                 |         |      | $\Gamma_{31}/\Gamma_{29}$                              |  |
|---|------------------------------|-----------------|---------|------|--|--|
| VALUE   | DOCUMENT ID                  | TECN            | COMMENT |      |  |  |
| <b>0.72 ± 0.16 OUR FIT</b>                      |                              |                 |         |      |  |  |
| <b>0.67</b>                                     | <b>+0.19</b><br><b>-0.16</b> | <sup>1</sup> WU | 06      | BELL | $B^+ \rightarrow p\bar{p}K^+, \Lambda\bar{\Lambda}K^+$ |  |

<sup>1</sup> Not independent from other  $\eta_c \rightarrow \Lambda\bar{\Lambda}, p\bar{p}$  branching ratios reported by WU 06.

$\Gamma(K\bar{K}\eta)/\Gamma_{\text{total}}$   $\Gamma_{32}/\Gamma$

| VALUE (units $10^{-2}$ ) | CL% | EVTS | DOCUMENT ID | TECN | COMMENT |
|--------------------------|-----|------|-------------|------|---------|
|--------------------------|-----|------|-------------|------|---------|

|                    |  |   |                        |          |  |
|--------------------|--|---|------------------------|----------|--|
| <b>1.0±0.5±0.1</b> |  | 7 | <sup>1,2</sup> ABLIKIM | 12N BES3 | $\psi(2S) \rightarrow \pi^0 \gamma \eta K^+ K^-$ |
|--------------------|--|---|------------------------|----------|--|

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

|      |    |  |                             |      |                                    |
|------|----|--|-----------------------------|------|------------------------------------|
| <3.1 | 90 |  | <sup>3</sup> BALTRUSAIT..86 | MRK3 | $J/\psi \rightarrow \eta_c \gamma$ |
|------|----|--|-----------------------------|------|------------------------------------|

<sup>1</sup> ABLIKIM 12N quotes  $B(\psi(2S) \rightarrow \pi^0 h_c) \cdot B(h_c \rightarrow \gamma \eta_c) \cdot B(\eta_c \rightarrow K^+ K^- \eta) = (12.01 \pm 2.22 \pm 2.04) \times 10^{-6}$  which we multiply by 2 to account for isospin symmetry.

<sup>2</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow K\bar{K}\eta)/\Gamma_{\text{total}}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}}] = (4.22 \pm 2.02 \pm 0.64) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>3</sup> The quoted branching ratios use  $B(J/\psi(1S) \rightarrow \gamma \eta_c(1S)) = 0.0127 \pm 0.0036$ .

$\Gamma(\pi^+ \pi^- \rho\bar{\rho})/\Gamma_{\text{total}}$   $\Gamma_{33}/\Gamma$

| VALUE (units $10^{-3}$ ) | CL% | EVTS | DOCUMENT ID | TECN | COMMENT |
|--------------------------|-----|------|-------------|------|---------|
|--------------------------|-----|------|-------------|------|---------|

|                    |  |    |                      |          |  |
|--------------------|--|----|----------------------|----------|--|
| <b>5.3±1.7±0.5</b> |  | 19 | <sup>1</sup> ABLIKIM | 12N BES3 | $\psi(2S) \rightarrow \pi^0 \gamma \rho\bar{\rho} \pi^+ \pi^-$ |
|--------------------|--|----|----------------------|----------|--|

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

|     |    |  |       |          |                                      |
|-----|----|--|-------|----------|--------------------------------------|
| <12 | 90 |  | HIMEL | 80B MRK2 | $\psi(2S) \rightarrow \eta_c \gamma$ |
|-----|----|--|-------|----------|--------------------------------------|

<sup>1</sup> ABLIKIM 12N reports  $[\Gamma(\eta_c(1S) \rightarrow \pi^+ \pi^- \rho\bar{\rho})/\Gamma_{\text{total}}] \times [\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}}] = (2.30 \pm 0.65 \pm 0.36) \times 10^{-6}$  which we divide by our best value  $\Gamma(h_c(1P) \rightarrow \eta_c(1S)\gamma)/\Gamma_{\text{total}} \times \Gamma(\psi(2S) \rightarrow \pi^0 h_c(1P))/\Gamma_{\text{total}} = (4.3 \pm 0.4) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

————— RADIATIVE DECAYS —————

$\Gamma(\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_{34}/\Gamma$

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

**1.57±0.12 OUR FIT**

**1.9  $\begin{smallmatrix} +0.7 \\ -0.6 \end{smallmatrix}$  OUR AVERAGE**

|               |  |  |                      |          |  |
|---------------|--|--|----------------------|----------|--|
| 2.6 ±0.8 ±0.6 |  |  | <sup>1</sup> ABLIKIM | 13I BES3 |  |
|---------------|--|--|----------------------|----------|--|

|   |  |  |                    |         |   |
|---|--|--|--------------------|---------|---|
| 1.4 $\begin{smallmatrix} +0.7 \\ -0.5 \end{smallmatrix}$ ±0.3 |  | 1.2 $\begin{smallmatrix} +2.8 \\ -1.1 \end{smallmatrix}$ | <sup>2</sup> ADAMS | 08 CLEO | $\psi(2S) \rightarrow \pi^+ \pi^- J/\psi$ |
|---|--|--|--------------------|---------|---|

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

|   |  |    |                    |         |   |
|---|--|----|--------------------|---------|---|
| 2.3 $\begin{smallmatrix} +1.0 \\ -0.8 \end{smallmatrix}$ ±0.3 |  | 13 | <sup>3</sup> WICHT | 08 BELL | $B^\pm \rightarrow K^\pm \gamma \gamma$ |
|---|--|----|--------------------|---------|---|

|  |  |  |                        |          |                                      |
|--|--|--|------------------------|----------|--------------------------------------|
| 2.80 $\begin{smallmatrix} +0.67 \\ -0.58 \end{smallmatrix}$ ±1.0 |  |  | <sup>4</sup> ARMSTRONG | 95F E760 | $\bar{p}p \rightarrow \gamma \gamma$ |
|--|--|--|------------------------|----------|--------------------------------------|

|     |    |  |                      |        |   |
|-----|----|--|----------------------|--------|---|
| < 9 | 90 |  | <sup>5</sup> BISELLO | 91 DM2 | $J/\psi \rightarrow \gamma \gamma \gamma$ |
|-----|----|--|----------------------|--------|---|

|   |  |  |                     |          |                                      |
|---|--|--|---------------------|----------|--------------------------------------|
| 6 $\begin{smallmatrix} +4 \\ -3 \end{smallmatrix}$ ±4 |  |  | <sup>4</sup> BAGLIN | 87B SPEC | $\bar{p}p \rightarrow \gamma \gamma$ |
|---|--|--|---------------------|----------|--------------------------------------|

|      |    |  |                    |         |                                    |
|------|----|--|--------------------|---------|------------------------------------|
| < 18 | 90 |  | <sup>6</sup> BLOOM | 83 CBAL | $J/\psi \rightarrow \eta_c \gamma$ |
|------|----|--|--------------------|---------|------------------------------------|

<sup>1</sup> ABLIKIM 13I reports  $[\Gamma(\eta_c(1S) \rightarrow \gamma\gamma)/\Gamma_{\text{total}}] \times [B(J/\psi(1S) \rightarrow \gamma\eta_c(1S))] = (4.5 \pm 1.2 \pm 0.6) \times 10^{-6}$  which we divide by our best value  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = (1.7 \pm 0.4) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>2</sup> ADAMS 08 reports  $[\Gamma(\eta_c(1S) \rightarrow \gamma\gamma)/\Gamma_{\text{total}}] \times [B(J/\psi(1S) \rightarrow \gamma\eta_c(1S))] = (2.4^{+1.1}_{-0.8} \pm 0.3) \times 10^{-6}$  which we divide by our best value  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = (1.7 \pm 0.4) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>3</sup> WICHT 08 reports  $[\Gamma(\eta_c(1S) \rightarrow \gamma\gamma)/\Gamma_{\text{total}}] \times [B(B^+ \rightarrow \eta_c K^+)] = (2.2^{+0.9+0.4}_{-0.7-0.2}) \times 10^{-7}$  which we divide by our best value  $B(B^+ \rightarrow \eta_c K^+) = (9.6 \pm 1.1) \times 10^{-4}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>4</sup> Not independent from the values of the total and two-photon width quoted by the same experiment.

<sup>5</sup> The quoted branching ratios use  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = 0.0127 \pm 0.0036$ .

<sup>6</sup> Using  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = 0.0127 \pm 0.0036$ .

### $\Gamma(\gamma\gamma)/\Gamma(K\bar{K}\pi)$ $\Gamma_{34}/\Gamma_{17}$

| <u>VALUE (units <math>10^{-3}</math>)</u>                          | <u>EVTS</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u>                         |
|--|-------------|--------------------|-------------|--|
| <b>2.14 ± 0.29 OUR FIT</b>   |             |                    |             |  |
| <b>3.2 <math>^{+1.3}_{-1.0}</math> <math>^{+0.8}_{-0.6}</math></b> | 13          | <sup>1</sup> WICHT | 08 BELL     | $B^\pm \rightarrow K^\pm \gamma\gamma$ |

<sup>1</sup> Using  $B(B^+ \rightarrow \eta_c K^+) = (1.25 \pm 0.12^{+0.10}_{-0.12}) \times 10^{-3}$  from FANG 03 and  $B(\eta_c \rightarrow K\bar{K}\pi) = (5.5 \pm 1.7) \times 10^{-2}$ .

### $\Gamma(p\bar{p})/\Gamma_{\text{total}} \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\Gamma_{29}/\Gamma \times \Gamma_{34}/\Gamma$

| <u>VALUE (units <math>10^{-6}</math>)</u> | <u>EVTS</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u>   |
|---|-------------|--------------------|-------------|--|
| <b>0.238 ± 0.024 OUR FIT</b>              |             |                    |             |  |
| <b>0.26 ± 0.05 OUR AVERAGE</b>            |             |                    |             | Error includes scale factor of 1.4.                    |
| 0.224 $^{+0.038}_{-0.037} \pm 0.020$      | 190         | AMBROGIANI 03      | E835        | $\bar{p}p \rightarrow \eta_c \rightarrow \gamma\gamma$ |
| 0.336 $^{+0.080}_{-0.070}$                |             | ARMSTRONG 95F      | E760        | $\bar{p}p \rightarrow \gamma\gamma$                    |
| 0.68 $^{+0.42}_{-0.31}$                   | 12          | BAGLIN             | 87B SPEC    | $\bar{p}p \rightarrow \gamma\gamma$                    |

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

### $\Gamma(\pi^+ \pi^-)/\Gamma_{\text{total}}$ $\Gamma_{35}/\Gamma$

| <u>VALUE (units <math>10^{-5}</math>)</u> | <u>CL%</u> | <u>DOCUMENT ID</u>   | <u>TECN</u> | <u>COMMENT</u>  |
|---|------------|----------------------|-------------|---|
| <b>&lt;11</b>                             | 90         | <sup>1</sup> ABLIKIM | 11G BES3    | $J/\psi \rightarrow \gamma\pi^+\pi^-$                                 |
| •••                                       |            |                      |             | We do not use the following data for averages, fits, limits, etc. ••• |
| <60                                       | 90         | <sup>2</sup> ABLIKIM | 06B BES2    | $J/\psi \rightarrow \pi^+\pi^-\gamma$                                 |

<sup>1</sup> ABLIKIM 11G reports  $[\Gamma(\eta_c(1S) \rightarrow \pi^+\pi^-)/\Gamma_{\text{total}}] \times [B(J/\psi(1S) \rightarrow \gamma\eta_c(1S))] < 1.82 \times 10^{-6}$  which we divide by our best value  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = 1.7 \times 10^{-2}$ .

<sup>2</sup> ABLIKIM 06B reports  $[\Gamma(\eta_c(1S) \rightarrow \pi^+\pi^-)/\Gamma_{\text{total}}] \times [B(J/\psi(1S) \rightarrow \gamma\eta_c(1S))] < 1.1 \times 10^{-5}$  which we divide by our best value  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = 1.7 \times 10^{-2}$ .

$\Gamma(\pi^0\pi^0)/\Gamma_{\text{total}}$   $\Gamma_{36}/\Gamma$

| VALUE (units $10^{-5}$ ) | CL% | DOCUMENT ID | TECN | COMMENT |
|--------------------------|-----|-------------|------|---------|
|--------------------------|-----|-------------|------|---------|

|                 |    |                      |          |                                       |
|-----------------|----|----------------------|----------|---------------------------------------|
| <b>&lt; 3.5</b> | 90 | <sup>1</sup> ABLIKIM | 11G BES3 | $J/\psi \rightarrow \gamma\pi^0\pi^0$ |
|-----------------|----|----------------------|----------|---------------------------------------|

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

|     |    |                      |          |                                       |
|-----|----|----------------------|----------|---------------------------------------|
| <40 | 90 | <sup>2</sup> ABLIKIM | 06B BES2 | $J/\psi \rightarrow \pi^0\pi^0\gamma$ |
|-----|----|----------------------|----------|---------------------------------------|

<sup>1</sup> ABLIKIM 11G reports  $[\Gamma(\eta_c(1S) \rightarrow \pi^0\pi^0)/\Gamma_{\text{total}}] \times [B(J/\psi(1S) \rightarrow \gamma\eta_c(1S))] < 6.0 \times 10^{-7}$  which we divide by our best value  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = 1.7 \times 10^{-2}$ .

<sup>2</sup> ABLIKIM 06B reports  $[\Gamma(\eta_c(1S) \rightarrow \pi^0\pi^0)/\Gamma_{\text{total}}] \times [B(J/\psi(1S) \rightarrow \gamma\eta_c(1S))] < 0.71 \times 10^{-5}$  which we divide by our best value  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = 1.7 \times 10^{-2}$ .

$\Gamma(K^+K^-)/\Gamma_{\text{total}}$   $\Gamma_{37}/\Gamma$

| VALUE (units $10^{-5}$ ) | CL% | DOCUMENT ID | TECN | COMMENT |
|--------------------------|-----|-------------|------|---------|
|--------------------------|-----|-------------|------|---------|

|               |    |                      |          |                                   |
|---------------|----|----------------------|----------|-----------------------------------|
| <b>&lt;60</b> | 90 | <sup>1</sup> ABLIKIM | 06B BES2 | $J/\psi \rightarrow K^+K^-\gamma$ |
|---------------|----|----------------------|----------|-----------------------------------|

<sup>1</sup> ABLIKIM 06B reports  $[\Gamma(\eta_c(1S) \rightarrow K^+K^-)/\Gamma_{\text{total}}] \times [B(J/\psi(1S) \rightarrow \gamma\eta_c(1S))] < 0.96 \times 10^{-5}$  which we divide by our best value  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = 1.7 \times 10^{-2}$ .

$\Gamma(K_S^0K_S^0)/\Gamma_{\text{total}}$   $\Gamma_{38}/\Gamma$

| VALUE (units $10^{-5}$ ) | CL% | DOCUMENT ID | TECN | COMMENT |
|--------------------------|-----|-------------|------|---------|
|--------------------------|-----|-------------|------|---------|

|               |    |                      |          |                                       |
|---------------|----|----------------------|----------|---------------------------------------|
| <b>&lt;31</b> | 90 | <sup>1</sup> ABLIKIM | 06B BES2 | $J/\psi \rightarrow K_S^0K_S^0\gamma$ |
|---------------|----|----------------------|----------|---------------------------------------|

<sup>1</sup> ABLIKIM 06B reports  $[\Gamma(\eta_c(1S) \rightarrow K_S^0K_S^0)/\Gamma_{\text{total}}] \times [B(J/\psi(1S) \rightarrow \gamma\eta_c(1S))] < 0.53 \times 10^{-5}$  which we divide by our best value  $B(J/\psi(1S) \rightarrow \gamma\eta_c(1S)) = 1.7 \times 10^{-2}$ .

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