# $\phi(1020)$

$I^G(J^{PC}) = 0^-(1^{--})$

## $\phi$(1020) MASS

We average mass and width values only when the systematic errors have been evaluated.

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **1019.413±0.008 OUR AVERAGE** | | | | |
| 1019.42 ±0.06 | 55600 | AKHMETSHIN 95 | CMD2 | $e^+e^- \to$ hadrons |
| 1019.7 ±0.3 | 2012 | DAVENPORT 86 | MPSF | 400 $pA \to 4KX$ |
| 1019.411±0.008 | 642k | [1] DIJKSTRA 86 | SPEC | 100–200 $\pi^\pm$, $\overline{p}$, $p$, $K^\pm$, on Be |
| 1019.7 ±0.1 ±0.1 | 5079 | ALBRECHT 85D | ARG | 10 $e^+e^- \to K^+K^-X$ |
| 1019.3 ±0.1 | 1500 | ARENTON 82 | AEMS | 11.8 polar. $pp \to KK$ |
| 1019.67 ±0.17 | 25080 | [2] PELLINEN 82 | RVUE | |
| 1019.52 ±0.13 | 3681 | BUKIN 78C | OLYA | $e^+e^- \to$ hadrons |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 1019.8 ±0.7 | | ARMSTRONG 86 | OMEG | 85 $\pi^+/pp \to \pi^+/p4Kp$ |
| 1020.1 ±0.11 | 5526 | [3] ATKINSON 86 | OMEG | 20–70 $\gamma p$ |
| 1019.7 ±1.0 | | BEBEK 86 | CLEO | $e^+e^- \to \Upsilon(4S)$ |
| 1020.9 ±0.2 | | [3] FRAME 86 | OMEG | 13 $K^+p \to \phi K^+p$ |
| 1021.0 ±0.2 | | [3] ARMSTRONG 83B | OMEG | 18.5 $K^-p \to K^-K^+\Lambda$ |
| 1020.0 ±0.5 | | [3] ARMSTRONG 83B | OMEG | 18.5 $K^-p \to K^-K^+\Lambda$ |
| 1019.7 ±0.3 | | [3] BARATE 83 | GOLI | 190 $\pi^-$ Be $\to 2\mu X$ |
| 1019.8 ±0.2 ±0.5 | 766 | IVANOV 81 | OLYA | 1–1.4 $e^+e^- \to K^+K^-$ |
| 1019.4 ±0.5 | 337 | COOPER 78B | HBC | 0.7–0.8 $\overline{p}p \to K^0_S K^0_L \pi^+\pi^-$ |
| 1020 ±1 | 383 | [3] BALDI 77 | CNTR | 10 $\pi^-p \to \pi^-\phi p$ |
| 1018.9 ±0.6 | 800 | COHEN 77 | ASPK | 6 $\pi^\pm N \to K^+K^-N$ |
| 1019.7 ±0.5 | 454 | KALBFLEISCH 76 | HBC | 2.18 $K^-p \to \Lambda K\overline{K}$ |
| 1019.4 ±0.8 | 984 | BESCH 74 | CNTR | 2 $\gamma p \to pK^+K^-$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1020.3 | ±0.4 | 100 | BALLAM | 73 | HBC | 2.8–9.3 $\gamma p$ |
| 1019.4 | ±0.7 | | BINNIE | 73B | CNTR | $\pi^- p \to \phi n$ |
| 1019.6 | ±0.5 | 120 | [4] AGUILAR-... | 72B | HBC | 3.9,4.6 $K^- p \to \Lambda K^+ K^-$ |
| 1019.9 | ±0.5 | 100 | [4] AGUILAR-... | 72B | HBC | 3.9,4.6 $K^- p \to K^- p K^+ K^-$ |
| 1020.4 | ±0.5 | 131 | COLLEY | 72 | HBC | 10 $K^+ p \to K^+ p \phi$ |
| 1019.9 | ±0.3 | 410 | STOTTLE... | 71 | HBC | 2.9 $K^- p \to \Sigma/\Lambda K \overline{K}$ |

[1] Weighted and scaled average of 12 measurements of DIJKSTRA 86.
[2] PELLINEN 82 review includes AKERLOF 77, DAUM 81, BALDI 77, AYRES 74, DEGROOT 74.
[3] Systematic errors not evaluated.
[4] Mass errors enlarged by us to $\Gamma/\sqrt{N}$; see the note with the $K^*(892)$ mass.

## $\phi$(1020) WIDTH

We average mass and width values only when the systematic errors have been evalutated.

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **4.43±0.05 OUR AVERAGE** | | | | | |
| 4.44±0.09 | 55600 | AKHMETSHIN | 95 | CMD2 | $e^+ e^- \to$ hadrons |
| 4.45±0.06 | 271k | DIJKSTRA | 86 | SPEC | 100 $\pi^-$ Be |
| 4.5 ±0.7 | 1500 | ARENTON | 82 | AEMS | 11.8 polar. $p p \to K K$ |
| 4.2 ±0.6 | 766 | [5] IVANOV | 81 | OLYA | 1–1.4 $e^+ e^- \to K^+ K^-$ |
| 4.3 ±0.6 | | [5] CORDIER | 80 | WIRE | $e^+ e^- \to \pi^+ \pi^- \pi^0$ |
| 4.36±0.29 | 3681 | [5] BUKIN | 78C | OLYA | $e^+ e^- \to$ hadrons |
| 4.4 ±0.6 | 984 | [5] BESCH | 74 | CNTR | 2 $\gamma p \to p K^+ K^-$ |
| 4.67±0.72 | 681 | [5] BALAKIN | 71 | OSPK | $e^+ e^- \to$ hadrons |
| 4.09±0.29 | | BIZOT | 70 | OSPK | $e^+ e^- \to$ hadrons |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 3.6 ±0.8 | 337 | [5] COOPER | 78B | HBC | 0.7–0.8 $\overline{p} p \to K^0_S K^0_L \pi^+ \pi^-$ |
| 4.5 ±0.50 | 1300 | [5,6] AKERLOF | 77 | SPEC | 400 $p$A $\to K^+ K^-$ X |
| 4.5 ±0.8 | 500 | [5,6] AYRES | 74 | ASPK | 3–6 $\pi^- p \to K^+ K^- n$, $K^- p \to K^+ K^- \Lambda/\Sigma^0$ |
| 3.81±0.37 | | COSME | 74B | OSPK | $e^+ e^- \to K^0_L K^0_S$ |
| 3.8 ±0.7 | 454 | [5] BORENSTEIN | 72 | HBC | 2.18 $K^- p \to K \overline{K} n$ |

[5] Width errors enlarged by us to $4\Gamma/\sqrt{N}$; see the note with the $K^*(892)$ mass.
[6] Systematic errors not evaluated.

## $\phi(1020)$ DECAY MODES

| | Mode | Fraction ($\Gamma_i/\Gamma$) | Scale factor/ Confidence level |
|---|---|---|---|
| $\Gamma_1$ | $K^+K^-$ | $(49.1\ \pm0.8\ )\ \%$ | S=1.3 |
| $\Gamma_2$ | $K^0_L K^0_S$ | $(34.1\ \pm0.6\ )\ \%$ | S=1.2 |
| $\Gamma_3$ | $\rho\pi + \pi^+\pi^-\pi^0$ | $(15.5\ \pm0.7\ )\ \%$ | S=1.5 |
| $\Gamma_4$ | $\rho\pi$ | | |
| $\Gamma_5$ | $\pi^+\pi^-\pi^0$ | | |
| $\Gamma_6$ | $\eta\gamma$ | $(\ 1.26\pm0.06)\ \%$ | S=1.1 |
| $\Gamma_7$ | $\pi^0\gamma$ | $(\ 1.31\pm0.13) \times 10^{-3}$ | |
| $\Gamma_8$ | $e^+e^-$ | $(\ 2.99\pm0.08) \times 10^{-4}$ | S=1.2 |
| $\Gamma_9$ | $\mu^+\mu^-$ | $(\ 2.5\ \pm0.4\ ) \times 10^{-4}$ | |
| $\Gamma_{10}$ | $\eta e^+e^-$ | $(\ 1.3\ ^{+0.8}_{-0.6}\ ) \times 10^{-4}$ | |
| $\Gamma_{11}$ | $\pi^+\pi^-$ | $(\ 8\ ^{+5}_{-4}\ ) \times 10^{-5}$ | S=1.5 |
| $\Gamma_{12}$ | $\omega\gamma$ | $<\ 5\ \%$ | CL=84% |
| $\Gamma_{13}$ | $\rho\gamma$ | $<\ 7 \times 10^{-4}$ | CL=90% |
| $\Gamma_{14}$ | $\pi^+\pi^-\gamma$ | $<\ 3 \times 10^{-5}$ | CL=90% |
| $\Gamma_{15}$ | $f_0(980)\gamma$ | $<\ 1 \times 10^{-4}$ | CL=90% |
| $\Gamma_{16}$ | $\pi^0\pi^0\gamma$ | $<\ 1 \times 10^{-3}$ | CL=90% |
| $\Gamma_{17}$ | $\pi^+\pi^-\pi^+\pi^-$ | $<\ 8.7 \times 10^{-4}$ | CL=90% |
| $\Gamma_{18}$ | $\pi^+\pi^+\pi^-\pi^-\pi^0$ | $<\ 1.5 \times 10^{-4}$ | CL=95% |
| $\Gamma_{19}$ | $\pi^0 e^+e^-$ | $<\ 1.2 \times 10^{-4}$ | CL=90% |
| $\Gamma_{20}$ | $\pi^0\eta\gamma$ | $<\ 2.5 \times 10^{-3}$ | CL=90% |
| $\Gamma_{21}$ | $a_0(980)\gamma$ | $<\ 5 \times 10^{-3}$ | CL=90% |
| $\Gamma_{22}$ | $\eta'(958)\gamma$ | $(\ 1.2\ ^{+0.7}_{-0.5}\ ) \times 10^{-4}$ | |
| $\Gamma_{23}$ | $\mu^+\mu^-\gamma$ | $(\ 2.3\ \pm1.0\ ) \times 10^{-5}$ | |

## CONSTRAINED FIT INFORMATION

An overall fit to 9 branching ratios uses 29 measurements and one constraint to determine 4 parameters. The overall fit has a $\chi^2 =$ 26.9 for 26 degrees of freedom.

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

| | | | |
|---|---|---|---|
| $x_2$ | −53 | | |
| $x_3$ | −60 | −36 | |
| $x_6$ | −3 | −3 | −2 |
| | $x_1$ | $x_2$ | $x_3$ |

# $\phi(1020)$ BRANCHING RATIOS

## $\Gamma(K^+K^-)/\Gamma_{total}$ — $\Gamma_1/\Gamma$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.491±0.008 OUR FIT** Error includes scale factor of 1.3. | | | | | |
| **0.493±0.010 OUR AVERAGE** | | | | | |
| 0.492±0.012 | 2913 | AKHMETSHIN | 95 | CMD2 | $e^+e^- \to K^+K^-$ |
| 0.44 ±0.05 | 321 | KALBFLEISCH | 76 | HBC | 2.18 $K^-p \to \Lambda K^+K^-$ |
| 0.49 ±0.06 | 270 | DEGROOT | 74 | HBC | 4.2 $K^-p \to \Lambda\phi$ |
| 0.540±0.034 | 565 | BALAKIN | 71 | OSPK | $e^+e^- \to K^+K^-$ |
| 0.48 ±0.04 | 252 | LINDSEY | 66 | HBC | 2.1–2.7 $K^-p \to \Lambda K^+K^-$ |

## $\Gamma(K^0_L K^0_S)/\Gamma_{total}$ — $\Gamma_2/\Gamma$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.341±0.006 OUR FIT** Error includes scale factor of 1.2. | | | | | |
| **0.331±0.009 OUR AVERAGE** | | | | | |
| 0.335±0.010 | 40644 | AKHMETSHIN | 95 | CMD2 | $e^+e^- \to K^0_L K^0_S$ |
| 0.326±0.035 | | DOLINSKY | 91 | ND | $e^+e^- \to K^0_L K^0_S$ |
| 0.310±0.024 | | DRUZHININ | 84 | ND | $e^+e^- \to K^0_L K^0_S$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.27 ±0.03 | 133 | KALBFLEISCH | 76 | HBC | 2.18 $K^-p \to \Lambda K^0_L K^0_S$ |
| 0.257±0.030 | 95 | BALAKIN | 71 | OSPK | $e^+e^- \to K^0_L K^0_S$ |
| 0.40 ±0.04 | 167 | LINDSEY | 66 | HBC | 2.1–2.7 $K^-p \to \Lambda K^0_L K^0_S$ |

## $[\Gamma(\rho\pi) + \Gamma(\pi^+\pi^-\pi^0)]/\Gamma_{total}$ — $\Gamma_3/\Gamma$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.155±0.007 OUR FIT** Error includes scale factor of 1.5. | | | | | |
| **0.151±0.009 OUR AVERAGE** Error includes scale factor of 1.7. | | | | | |
| 0.161±0.008 | 11761 | AKHMETSHIN | 95 | CMD2 | $e^+e^- \to \pi^+\pi^-\pi^0$ |
| 0.143±0.007 | | DOLINSKY | 91 | ND | $e^+e^- \to \pi^+\pi^-\pi^0$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.139±0.007 | | [7] PARROUR | 76B | OSPK | $e^+e^-$ |

[7] Using total width 4.1 MeV. The $\rho\pi$ to $3\pi$ mode is more than 80%. at the 90% confidence level.

## $\Gamma(K^0_L K^0_S)/\Gamma(K\overline{K})$ — $\Gamma_2/(\Gamma_1+\Gamma_2)$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.410±0.007 OUR FIT** Error includes scale factor of 1.2. | | | | | |
| **0.45 ±0.04 OUR AVERAGE** | | | | | |
| 0.44 ±0.07 | | LONDON | 66 | HBC | 2.24 $K^-p \to \Lambda K\overline{K}$ |
| 0.48 ±0.07 | 52 | BADIER | 65B | HBC | 3 $K^-p$ |
| 0.40 ±0.10 | 34 | SCHLEIN | 63 | HBC | 1.95 $K^-p \to \Lambda K\overline{K}$ |

### $[\Gamma(\rho\pi) + \Gamma(\pi^+\pi^-\pi^0)]/\Gamma(K\overline{K})$ $\Gamma_3/(\Gamma_1+\Gamma_2)$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **0.187±0.010 OUR FIT** Error includes scale factor of 1.5. | | | | |
| **0.24 ±0.04 OUR AVERAGE** | | | | |
| 0.237±0.039 | CERRADA | 77B | HBC | 4.2 $K^- p \to \Lambda 3\pi$ |
| 0.30 ±0.15 | LONDON | 66 | HBC | 2.24 $K^- p \to \Lambda\pi^+\pi^-\pi^0$ |

### $[\Gamma(\rho\pi) + \Gamma(\pi^+\pi^-\pi^0)]/\Gamma(K^0_L K^0_S)$ $\Gamma_3/\Gamma_2$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.456±0.025 OUR FIT** Error includes scale factor of 1.5. | | | | | |
| **0.51 ±0.05 OUR AVERAGE** | | | | | |
| 0.56 ±0.07 | 3681 | BUKIN | 78C | OLYA | $e^+e^- \to K^0_L K^0_S, \pi^+\pi^-\pi^0$ |
| 0.47 ±0.06 | 516 | COSME | 74 | OSPK | $e^+e^- \to \pi^+\pi^-\pi^0$ |

### $\Gamma(\mu^+\mu^-)/\Gamma_{total}$ $\Gamma_9/\Gamma$

| VALUE (units $10^{-4}$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **2.5 ±0.4 OUR AVERAGE** | | | | |
| 2.69±0.46 | [8] HAYES | 71 | CNTR | 8.3,9.8 $\gamma C \to \mu^+\mu^- X$ |
| 2.17±0.60 | [8] EARLES | 70 | CNTR | 6.0 $\gamma C \to \mu^+\mu^- X$ |

[8] Neglecting interference between resonance and continuum.

### $\Gamma(\eta\gamma)/\Gamma_{total}$ $\Gamma_6/\Gamma$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.0126±0.0006 OUR FIT** Error includes scale factor of 1.1. | | | | | |
| **0.0126±0.0005 OUR AVERAGE** Error includes scale factor of 1.1. | | | | | |
| 0.0118±0.0011 | 279 | [9] AKHMETSHIN | 95 | CMD2 | $e^+e^- \to \pi^+\pi^- 3\gamma$ |
| 0.0130±0.0006 | | [10] DRUZHININ | 84 | ND | $e^+e^- \to 3\gamma$ |
| 0.014 ±0.002 | | [11] DRUZHININ | 84 | ND | $e^+e^- \to 6\gamma$ |
| 0.0088±0.0020 | 290 | KURDADZE | 83C | OLYA | $e^+e^- \to 3\gamma$ |
| 0.0135±0.0029 | | ANDREWS | 77 | CNTR | 6.7–10 $\gamma$ Cu |
| 0.015 ±0.004 | 54 | [10] COSME | 76 | OSPK | $e^+e^-$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.0121±0.0007 | | [12] BENAYOUN | 96 | RVUE | 0.54-1.04 $e^+e^- \to \eta\gamma$ |

[9] From $\pi^+\pi^-\pi^0$ decay mode of $\eta$.
[10] From $2\gamma$ decay mode of $\eta$.
[11] From $3\pi^0$ decay mode of $\eta$.
[12] Reanalysis of DRUZHININ 84, DOLINSKY 89, and DOLINSKY 91 taking into account a triangle anomaly contribution.

### $\Gamma(\pi^+\pi^-\gamma)/\Gamma_{total}$ $\Gamma_{14}/\Gamma$

| VALUE (units $10^{-4}$) | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **< 0.3** | 90 | [13] AKHMETSHIN | 97C | CMD2 | $e^+e^- \to \pi^+\pi^-\gamma$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <600 | 90 | KALBFLEISCH | 75 | HBC | 2.18 $K^- p \to \Lambda\pi^+\pi^-\gamma$ |
| < 70 | 90 | COSME | 74 | OSPK | $e^+e^- \to \pi^+\pi^-\gamma$ |
| <400 | 90 | LINDSEY | 65 | HBC | 2.1–2.7 $K^- p \to \Lambda\pi^+\pi^-$ neutrals |

[13] For $E_\gamma > 20$ MeV and assuming that B($\phi(1020) \to f_0(980)\gamma$) is negligible.

### $\Gamma(\omega\gamma)/\Gamma_{total}$ — $\Gamma_{12}/\Gamma$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.05** | 84 | LINDSEY | 66 | HBC | 2.1–2.7 $K^- p \to \Lambda \pi^+ \pi^-$ neutrals |

### $\Gamma(\rho\gamma)/\Gamma_{total}$ — $\Gamma_{13}/\Gamma$

| VALUE (units $10^{-4}$) | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **< 7** | 90 | AKHMETSHIN | 97C | CMD2 | $e^+ e^- \to \pi^+ \pi^- \gamma$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <200 | 84 | LINDSEY | 66 | HBC | 2.1–2.7 $K^- p \to \Lambda \pi^+ \pi^-$ neutrals |

### $\Gamma(e^+ e^-)/\Gamma_{total}$ — $\Gamma_8/\Gamma$

| VALUE (units $10^{-4}$) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **2.99±0.08 OUR AVERAGE** Error includes scale factor of 1.2. | | | | | |
| 2.88±0.09 | 55600 | AKHMETSHIN | 95 | CMD2 | $e^+ e^- \to$ hadrons |
| 3.00±0.21 | 3681 | BUKIN | 78C | OLYA | $e^+ e^- \to$ hadrons |
| 3.10±0.14 | | [14] PARROUR | 76 | OSPK | $e^+ e^-$ |
| 3.3 ±0.3 | | COSME | 74 | OSPK | $e^+ e^- \to$ hadrons |
| 2.81±0.25 | 681 | BALAKIN | 71 | OSPK | $e^+ e^- \to$ hadrons |
| 3.50±0.27 | | CHATELUS | 71 | OSPK | $e^+ e^-$ |

[14] Using total width 4.2 MeV. They detect $3\pi$ mode and observe significant interference with $\omega$ tail. This is accounted for in the result quoted above.

### $\Gamma(\pi^0\gamma)/\Gamma_{total}$ — $\Gamma_7/\Gamma$

| VALUE (units $10^{-3}$) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **1.31±0.13 OUR AVERAGE** | | | | | |
| 1.30±0.13 | | DRUZHININ | 84 | ND | $e^+ e^- \to 3\gamma$ |
| 1.4 ±0.5 | 32 | COSME | 76 | OSPK | $e^+ e^-$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 1.26±0.17 | | [12] BENAYOUN | 96 | RVUE | 0.54–1.04 $e^+ e^- \to \pi^0 \gamma$ |

### $\Gamma(\pi^+\pi^-)/\Gamma_{total}$ — $\Gamma_{11}/\Gamma$

| VALUE (units $10^{-4}$) | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$0.8^{+0.5}_{-0.4}$ OUR AVERAGE** Error includes scale factor of 1.5. | | | | | |
| $0.63^{+0.37}_{-0.28}$ | | [15] GOLUBEV | 86 | ND | $e^+ e^- \to \pi^+ \pi^-$ |
| $1.94^{+1.03}_{-0.81}$ | | [15] VASSERMAN | 81 | OLYA | $e^+ e^-$ |
| <6.6 | 95 | BUKIN | 78B | OLYA | $e^+ e^- \to \pi^+ \pi^-$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <2.7 | 95 | ALVENSLEB... | 72 | CNTR | 6.7 $\gamma C \to C \pi^+ \pi^-$ |

[15] Using $\Gamma(e^+ e^-)/\Gamma_{total} = 3.1 \times 10^{-4}$.

## $\Gamma(K^0_L K^0_S)/\Gamma(K^+K^-)$ — $\Gamma_2/\Gamma_1$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.695±0.021 OUR FIT** | Error includes scale factor of 1.2. | | | | |
| **0.740±0.031 OUR AVERAGE** | | | | | |
| 0.70 ±0.06 | 2732 | BUKIN | 78C | OLYA | $e^+e^- \to K^0_L K^0_S$ |
| 0.82 ±0.08 | | LOSTY | 78 | HBC | 4.2 $K^- p \to \phi$hyperon |
| 0.71 ±0.05 | | LAVEN | 77 | HBC | 10 $K^- p \to K^+K^-\Lambda$ |
| 0.71 ±0.08 | | LYONS | 77 | HBC | 3–4 $K^- p \to \Lambda\phi$ |
| 0.89 ±0.10 | 144 | AGUILAR-... | 72B | HBC | 3.9,4.6 $K^- p$ |

## $[\Gamma(\rho\pi) + \Gamma(\pi^+\pi^-\pi^0)]/\Gamma(K^+K^-)$ — $\Gamma_3/\Gamma_1$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.317±0.017 OUR FIT** | Error includes scale factor of 1.5. | | | | |
| **0.28 ±0.09** | 34 | AGUILAR-... | 72B | HBC | 3.9,4.6 $K^- p$ |

## $\Gamma(\eta e^+e^-)/\Gamma_{total}$ — $\Gamma_{10}/\Gamma$

| VALUE (units $10^{-4}$) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$1.3^{+0.8}_{-0.6}$** | 7 | GOLUBEV | 85 | ND | $e^+e^- \to \gamma\gamma e^+e^-$ |

## $\Gamma(\eta'(958)\gamma)/\Gamma_{total}$ — $\Gamma_{22}/\Gamma$

| VALUE (units $10^{-4}$) | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| $1.2^{+0.7}_{-0.5}\pm0.2$ | | 6 | [16] AKHMETSHIN | 97B | CMD2 | $e^+e^- \to \pi^+\pi^- 3\gamma$ |
| $<4.1$ | 90 | | DRUZHININ | 87 | ND | $e^+e^- \to \gamma\eta\pi^+\pi^-$ |

[16] Using the value $B(\phi \to \eta\gamma) = (1.26 \pm 0.06) \times 10^{-2}$

## $\Gamma(\pi^0\pi^0\gamma)/\Gamma_{total}$ — $\Gamma_{16}/\Gamma$

| VALUE (units $10^{-3}$) | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<1** | 90 | DRUZHININ | 87 | ND | $e^+e^- \to 5\gamma$ |

## $\Gamma(\pi^+\pi^+\pi^-\pi^-\pi^0)/\Gamma_{total}$ — $\Gamma_{18}/\Gamma$

| VALUE (units $10^{-4}$) | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<1.5** | 95 | BARKOV | 88 | CMD | $e^+e^- \to \pi^+\pi^-\pi^+\pi^-\pi^0$ |

## $\Gamma(\pi^+\pi^-\pi^+\pi^-)/\Gamma_{total}$ — $\Gamma_{17}/\Gamma$

| VALUE (units $10^{-4}$) | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<8.7** | 90 | CORDIER | 79 | WIRE | $e^+e^- \to 4\pi$ |

## $\Gamma(f_0(980)\gamma)/\Gamma_{total}$ — $\Gamma_{15}/\Gamma$

| VALUE (units $10^{-4}$) | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **< 1** | 90 | [17] AKHMETSHIN | 97C | CMD2 | $e^+e^- \to \pi^+\pi^-\gamma$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| < 7 | 90 | [18] AKHMETSHIN | 97C | CMD2 | $e^+e^- \to \pi^+\pi^-\gamma$ |
| <20 | 90 | DRUZHININ | 87 | ND | $e^+e^- \to \pi^0\pi^0\gamma$ |

[17] For destructive interference with the Bremsstrahlung process
[18] For constructive interference with the Bremsstrahlung process

### $\Gamma(\pi^0 e^+ e^-)/\Gamma_{total}$ — $\Gamma_{19}/\Gamma$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$<1.2 \times 10^{-4}$** | 90 | DOLINSKY | 88 | ND | $e^+ e^- \to \pi^0 e^+ e^-$ |

### $\Gamma(\pi^0 \eta\gamma)/\Gamma_{total}$ — $\Gamma_{20}/\Gamma$

| VALUE (units $10^{-3}$) | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<2.5** | 90 | DOLINSKY | 91 | ND | $e^+ e^- \to \pi^0 \eta\gamma$ |

### $\Gamma(a_0(980)\gamma)/\Gamma_{total}$ — $\Gamma_{21}/\Gamma$

| VALUE (units $10^{-3}$) | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<5** | 90 | DOLINSKY | 91 | ND | $e^+ e^- \to \pi^0 \eta\gamma$ |

### $\Gamma(\eta'(958)\gamma)/\Gamma(\eta\gamma)$ — $\Gamma_{22}/\Gamma_6$

| VALUE (units $10^{-3}$) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$9.5^{+5.2}_{-4.0}\pm1.4$** | 6 | AKHMETSHIN | 97B | CMD2 | $e^+ e^- \to \pi^+ \pi^- 3\gamma$ |

### $\Gamma(\mu^+ \mu^- \gamma)/\Gamma_{total}$ — $\Gamma_{23}/\Gamma$

| VALUE (units $10^{-5}$) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **2.3±1.0** | 824±33 | [19] AKHMETSHIN | 97C | CMD2 | $e^+ e^- \to \mu^+ \mu^- \gamma$ |

[19] For $E_\gamma > 20$ MeV.

## $\phi$(1020) REFERENCES


AKHMETSHIN 97B PL B415 445 R.R. Akhmetshin, Anashkin+ (NOVO, BOST, PITT, YALE)
AKHMETSHIN 97C PL B415 452 +Aksenov+ (NOVO, BOST, PITT, YALE)
BENAYOUN 96 ZPHY C72 221 M. Benayoun+ (IPNP, NOVO)
AKHMETSHIN 95 PL B364 199 +Akesnov+ (NOVO, BOST, PITT, MINN, YALE)
DOLINSKY 91 PRPL 202 99 +Druzhinin, Dubrovin+ (NOVO)
DOLINSKY 89 ZPHY C42 511 +Druzhinin, Dubrovin, Golubev+ (NOVO)
BARKOV 88 SJNP 47 248 +Vasserman, Vorobyev, Ivanov+ (NOVO)
Translated from YAF 47 393.
DOLINSKY 88 SJNP 48 277 +Druzhinin, Dubrovin, Golubev+ (NOVO)
Translated from YAF 48 442.
DRUZHININ 87 ZPHY C37 1 +Dubrovin, Eidelman, Golubev+ (NOVO)
ARMSTRONG 86 PL 166B 245 +Bloodworth, Carney+ (ATHU, BARI, BIRM, CERN)
ATKINSON 86 ZPHY C30 521 + (BONN, CERN, GLAS, LANC, MCHS, CURIN+)
BEBEK 86 PRL 56 1893 +Berkelman, Blucher, Cassel+ (CLEO Collab.)
DAVENPORT 86 PR 33 2519 (TUFTS, ARIZ, FNAL, FSU, NDAM, VAND)
DIJKSTRA 86 ZPHY C31 375 +Bailey+ (ANIK, BRIS, CERN, CRAC, MPIM, RAL)
FRAME 86 NP B276 667 +Hughes, Lynch, Minto, McFadzean+ (GLAS)
GOLUBEV 86 SJNP 44 409 +Druzhinin, Ivanchenko, Perevedentsev+ (NOVO)
Translated from YAF 44 633.
ALBRECHT 85D PL 153B 343 +Drescher, Binder, Drews+ (ARGUS Collab.)
GOLUBEV 85 SJNP 41 756 +Druzhinin, Ivanchenko, Peryshkin+ (NOVO)
Translated from YAF 41 1183.
DRUZHININ 84 PL 144B 136 +Golubev, Ivanchenko, Peryshkin+ (NOVO)
ARMSTRONG 83B NP B224 193 + (BARI, BIRM, CERN, MILA, CURIN+)
BARATE 83 PL 121B 449 +Bareyre, Bonamy+ (SACL, LOIC, SHMP, IND)
KURDADZE 83C JETPL 38 366 +Lelchuk, Root+ (NOVO)
Translated from ZETFP 38 306.

| | | | | |
|---|---|---|---|---|
| ARENTON | 82 | PR D25 2241 | +Ayres, Diebold, May, Swallow+ | (ANL, ILL) |
| PELLINEN | 82 | PS 25 599 | +Roos | (HELS) |
| DAUM | 81 | PL 100B 439 | +Bardsley+ | (AMST, BRIS, CERN, CRAC, MPIM+) |
| IVANOV | 81 | PL 107B 297 | +Kurdadze, Lelchuk, Sidorov, Skrinsky+ | (NOVO) |
| Also | 82 | Private Comm. | Eidelman | (NOVO) |
| VASSERMAN | 81 | PL 99B 62 | +Kurdadze, Sidorov, Skrinsky+ | (NOVO) |
| CORDIER | 80 | NP B172 13 | +Delcourt, Eschstruth, Fulda+ | (LALO) |
| CORDIER | 79 | PL 81B 389 | +Delcourt, Eschstruth, Fulda+ | (LALO) |
| BUKIN | 78B | SJNP 27 521 | +Kurdadze, Sidorov, Skrinsky+ | (NOVO) |
| | | Translated from YAF 27 985. | | |
| BUKIN | 78C | SJNP 27 516 | +Kurdadze, Serednyakov, Sidorov+ | (NOVO) |
| | | Translated from YAF 27 976. | | |
| COOPER | 78B | NP B146 1 | +Ganguli+ | (TATA, CERN, CDEF, MADR) |
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| ANDREWS | 77 | PRL 38 198 | +Fukushima, Harvey, Lobkowicz, May+ | (ROCH) |
| BALDI | 77 | PL 68B 381 | +Bohringer, Dorsaz, Hungerbuhler+ | (GEVA) |
| CERRADA | 77B | NP B126 241 | +Blockzijl, Heinen+ | (AMST, CERN, NIJM, OXF) |
| COHEN | 77 | PRL 38 269 | +Ayres, Diebold, Kramer, Pawlicki, Wicklund | (ANL) |
| LAVEN | 77 | NP B127 43 | +Otter, Klein+ | (AACH3, BERL, CERN, LOIC, WIEN) |
| LYONS | 77 | NP B125 207 | +Cooper, Clark | (OXF) |
| COSME | 76 | PL 63B 352 | +Courau, Dudelzak, Grelaud, Jean-Marie+ | (ORSAY) |
| KALBFLEISCH | 76 | PR D13 22 | +Strand, Chapman | (BNL, MICH) |
| PARROUR | 76 | PL 63B 357 | +Grelaud, Cosme, Courau, Dudelzak+ | (ORSAY) |
| PARROUR | 76B | PL 63B 362 | +Grelaud, Cosme, Courau, Dudelzak+ | (ORSAY) |
| KALBFLEISCH | 75 | PR D11 987 | +Strand, Chapman | (BNL, MICH) |
| AYRES | 74 | PRL 32 1463 | +Diebold, Greene, Kramer, Levine+ | (ANL) |
| BESCH | 74 | NP B70 257 | +Hartmann, Kose, Krautschneider, Paul+ | (BONN) |
| COSME | 74 | PL 48B 155 | +Jean-Marie, Jullian, Laplanche+ | (ORSAY) |
| COSME | 74B | PL 48B 159 | +Jean-Marie, Jullian, Laplanche+ | (ORSAY) |
| DEGROOT | 74 | NP B74 77 | +Hoogland, Jongejans, Metzger+ | (AMST, NIJM) |
| BALLAM | 73 | PR D7 3150 | +Chadwick, Eisenberg, Bingham+ | (SLAC, LBL) |
| BINNIE | 73B | PR D8 2789 | +Carr, Debenham, Duane+ | (LOIC, SHMP) |
| AGUILAR-... | 72B | PR D6 29 | Aguilar-Benitez, Chung, Eisner, Samios | (BNL) |
| ALVENSLEB... | 72 | PRL 28 66 | Alvensleben, Becker, Biggs, Binkley+ | (MIT, DESY) |
| BORENSTEIN | 72 | PR D5 1559 | +Danburg, Kalbfleisch+ | (BNL, MICH) |
| COLLEY | 72 | NP B50 1 | +Jobes, Riddiford, Griffiths+ | (BIRM, GLAS) |
| BALAKIN | 71 | PL 34B 328 | +Budker, Pakhtusova, Sidorov, Skrinsky+ | (NOVO) |
| CHATELUS | 71 | Thesis LAL 1247 | | (STRB) |
| Also | 70 | PL 32 416 | Bizot, Buon, Chatelus, Jeanjean+ | (ORSAY) |
| HAYES | 71 | PR D4 899 | +Imlay, Joseph, Keizer, Stein | (CORN) |
| STOTTLE... | 71 | Thesis ORO 2504 170 | Stottlemyer | (UMD) |
| BIZOT | 70 | PL 32 416 | +Buon, Chatelus, Jeanjean+ | (ORSAY) |
| Also | 69 | Liverpool Sym. 69 | Perez-y-Jorba | |
| EARLES | 70 | PRL 25 1312 | +Faissler, Gettner, Lutz, Moy, Tang+ | (NEAS) |
| LINDSEY | 66 | PR 147 913 | +Smith | (LRL) |
| LONDON | 66 | PR 143 1034 | +Rau, Goldberg, Lichtman+ | (BNL, SYRA) IGJPC |
| BADIER | 65B | PL 17 337 | +Demoulin, Barloutaud+ | (EPOL, SACL, AMST) |
| LINDSEY | 65 | PRL 15 221 | +Smith | (LRL) |
| LINDSEY 65 data included in LINDSEY 66. | | | | |
| SCHLEIN | 63 | PRL 10 368 | +Slater, Smith, Stork, Ticho | (UCLA) IGJP |


## OTHER RELATED PAPERS


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