# $\phi(1680)$

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

## $\phi(1680)$ MASS

### $e^+e^-$ PRODUCTION

| VALUE (MeV) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **1680±20 OUR ESTIMATE** | | | | | |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 1674±12± 6 | 6.2k | [1] LEES | 14H | BABR | $e^+e^- \to K^0_S K^0_L \gamma$ |
| 1733±10±10 | | [2] LEES | 12F | BABR | 10.6 $e^+e^- \to \phi\pi^+\pi^-\gamma$ |
| 1689± 7±10 | 4.8k | [3] SHEN | 09 | BELL | 10.6 $e^+e^- \to K^+K^-\pi^+\pi^-\gamma$ |
| 1709±20±43 | | [4] AUBERT | 08S | BABR | 10.6 $e^+e^- \to$ hadrons |
| 1623±20 | 948 | [5] AKHMETSHIN | 03 | CMD2 | 1.05–1.38 $e^+e^- \to K^0_L K^0_S$ |
| ∼ 1500 | | [6] ACHASOV | 98H | RVUE | $e^+e^- \to \pi^+\pi^-\pi^0$, $\omega\pi^+\pi^-$, $K^+K^-$ |
| ∼ 1900 | | [7] ACHASOV | 98H | RVUE | $e^+e^- \to K^0_S K^\pm\pi^\mp$ |
| 1700±20 | | [8] CLEGG | 94 | RVUE | $e^+e^- \to K^+K^-$, $K^0_S K\pi$ |
| 1657±27 | 367 | BISELLO | 91C | DM2 | $e^+e^- \to K^0_S K^\pm\pi^\mp$ |
| 1655±17 | | [9] BISELLO | 88B | DM2 | $e^+e^- \to K^+K^-$ |
| 1680±10 | | [10] BUON | 82 | DM1 | $e^+e^- \to$ hadrons |
| 1677±12 | | [11] MANE | 82 | DM1 | $e^+e^- \to K^0_S K\pi$ |

[1] Using a vector meson dominance model with contribution from $\phi(1020)$, $\phi(1680)$, and higher mass excitations of $\rho(770)$ and $\omega(782)$.

[2] Using events with $\pi\pi$ invariant mass less than 0.85 GeV.

[3] From a fit with two incoherent Breit-Wigners.

[4] From the simultaneous fit to the $K\overline{K}^*(892)+$ c.c. and $\phi\eta$ data from AUBERT 08S using the results of AUBERT 07AK.

[5] From the combined fit of AKHMETSHIN 03 and MANE 81 also including $\rho$, $\omega$, and $\phi$. Neither isospin nor flavor structure known.

[6] Using data from IVANOV 81, BARKOV 87, BISELLO 88B, DOLINSKY 91, and ANTONELLI 92.

[7] Using the data from BISELLO 91C.

[8] Using BISELLO 88B and MANE 82 data.

[9] From global fit including $\rho$, $\omega$, $\phi$ and $\rho(1700)$ assume mass 1570 MeV and width 510 MeV for $\rho$ radial excitation.

[10] From global fit of $\rho$, $\omega$, $\phi$ and their radial excitations to channels $\omega\pi^+\pi^-$, $K^+K^-$, $K^0_S K^0_L$, $K^0_S K^\pm\pi^\mp$. Assume mass 1570 MeV and width 510 MeV for $\rho$ radial excitations, mass 1570 and width 500 MeV for $\omega$ radial excitation.

[11] Fit to one channel only, neglecting interference with $\omega$, $\rho(1700)$.

### PHOTOPRODUCTION

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 1753± 3 | [12] LINK | 02K | FOCS | 20–160 $\gamma p \to K^+K^-p$ |
| 1726±22 | [12] BUSENITZ | 89 | TPS | $\gamma p \to K^+K^-X$ |
| 1760±20 | [12] ATKINSON | 85C | OMEG | 20–70 $\gamma p \to K\overline{K}X$ |
| 1690±10 | [12] ASTON | 81F | OMEG | 25–70 $\gamma p \to K^+K^-X$ |

[12] We list here a state decaying into $K^+K^-$ possibly different from $\phi(1680)$.

## $p\overline{p}$ ANNIHILATION

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 1700±8 | [13] AMSLER | 06 | CBAR | 0.9 $\overline{p}p \rightarrow K^+K^-\pi^0$ |

[13] Could also be $\rho(1700)$.

# $\phi(1680)$ WIDTH

## $e^+e^-$ PRODUCTION

| VALUE (MeV) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **150±50 OUR ESTIMATE** This is only an educated guess; the error given is larger than the error on the average of the published values. | | | | | |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 165±38± 70 | 6.2k | [14] LEES | 14H | BABR | $e^+e^- \rightarrow K^0_S K^0_L \gamma$ |
| 300±15± 37 | | [15] LEES | 12F | BABR | 10.6 $e^+e^- \rightarrow \phi\pi^+\pi^-\gamma$ |
| 211±14± 19 | 4.8k | [16] SHEN | 09 | BELL | 10.6 $e^+e^- \rightarrow K^+K^-\pi^+\pi^-\gamma$ |
| 322±77±160 | | [17] AUBERT | 08S | BABR | 10.6 $e^+e^- \rightarrow$ hadrons |
| 139±60 | 948 | [18] AKHMETSHIN | 03 | CMD2 | 1.05–1.38 $e^+e^- \rightarrow K^0_L K^0_S$ |
| 300±60 | | [19] CLEGG | 94 | RVUE | $e^+e^- \rightarrow K^+K^-$, $K^0_S K\pi$ |
| 146±55 | 367 | BISELLO | 91C | DM2 | $e^+e^- \rightarrow K^0_S K^\pm\pi^\mp$ |
| 207±45 | | [20] BISELLO | 88B | DM2 | $e^+e^- \rightarrow K^+K^-$ |
| 185±22 | | [21] BUON | 82 | DM1 | $e^+e^- \rightarrow$ hadrons |
| 102±36 | | [22] MANE | 82 | DM1 | $e^+e^- \rightarrow K^0_S K\pi$ |

[14] Using a vector meson dominance model with contribution from $\phi(1020)$, $\phi(1680)$, and higher mass excitations of $\rho(770)$ and $\omega(782)$.

[15] Using events with $\pi\pi$ invariant mass less than 0.85 GeV.

[16] From a fit with two incoherent Breit-Wigners.

[17] From the simultaneous fit to the $K\overline{K}^*(892)+$ c.c. and $\phi\eta$ data from AUBERT 08S using the results of AUBERT 07AK.

[18] From the combined fit of AKHMETSHIN 03 and MANE 81 also including $\rho$, $\omega$, and $\phi$. Neither isospin nor flavor structure known.

[19] Using BISELLO 88B and MANE 82 data.

[20] From global fit including $\rho$, $\omega$, $\phi$ and $\rho(1700)$

[21] From global fit of $\rho$, $\omega$, $\phi$ and their radial excitations to channels $\omega\pi^+\pi^-$, $K^+K^-$, $K^0_S K^0_L$, $K^0_S K^\pm\pi^\mp$. Assume mass 1570 MeV and width 510 MeV for $\rho$ radial excitations, mass 1570 and width 500 MeV for $\omega$ radial excitation.

[22] Fit to one channel only, neglecting interference with $\omega$, $\rho(1700)$.

## PHOTOPRODUCTION

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 122±63 | [23] LINK | 02K | FOCS | 20–160 $\gamma p \rightarrow K^+K^-p$ |
| 121±47 | [23] BUSENITZ | 89 | TPS | $\gamma p \rightarrow K^+K^-X$ |
| 80±40 | [23] ATKINSON | 85C | OMEG | 20–70 $\gamma p \rightarrow K\overline{K}X$ |
| 100±40 | [23] ASTON | 81F | OMEG | 25–70 $\gamma p \rightarrow K^+K^-X$ |

[23] We list here a state decaying into $K^+K^-$ possibly different from $\phi(1680)$.

### $p\overline{p}$ ANNIHILATION

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 143±24 | [24] AMSLER | 06 | CBAR | 0.9 $\overline{p}p \rightarrow K^+K^-\pi^0$ |

[24] Could also be $\rho(1700)$.

## $\phi(1680)$ DECAY MODES

| | Mode | Fraction ($\Gamma_i/\Gamma$) |
|---|---|---|
| $\Gamma_1$ | $K\overline{K}^*(892)+$ c.c. | dominant |
| $\Gamma_2$ | $K^0_S K\pi$ | seen |
| $\Gamma_3$ | $K\overline{K}$ | seen |
| $\Gamma_4$ | $K^0_L K^0_S$ | |
| $\Gamma_5$ | $e^+e^-$ | seen |
| $\Gamma_6$ | $\omega\pi\pi$ | not seen |
| $\Gamma_7$ | $\phi\pi\pi$ | |
| $\Gamma_8$ | $K^+K^-\pi^+\pi^-$ | seen |
| $\Gamma_9$ | $\eta\phi$ | seen |
| $\Gamma_{10}$ | $\eta\gamma$ | seen |
| $\Gamma_{11}$ | $K^+K^-\pi^0$ | |

## $\phi(1680)$ $\Gamma(i)\Gamma(e^+e^-)/\Gamma(\text{total})$

This combination of a partial width with the partial width into $e^+e^-$ and with the total width is obtained from the integrated cross section into channel (I) in $e^+e^-$ annihilation. We list only data that have not been used to determine the partial width $\Gamma(\text{I})$ or the branching ratio $\Gamma(\text{I})$/total.

### $\Gamma(K^0_L K^0_S) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ — $\Gamma_4\Gamma_5/\Gamma$

| VALUE (eV) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 14.3±2.4±6.2 | 6.2k | [25] LEES | 14H | BABR | $e^+e^- \rightarrow K^0_S K^0_L\gamma$ |

[25] Using a vector meson dominance model with contribution from $\phi(1020)$, $\phi(1680)$, and higher mass excitations of $\rho(770)$ and $\omega(782)$.

### $\Gamma(\phi\pi\pi) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ — $\Gamma_7\Gamma_5/\Gamma$

| VALUE ($10^{-2}$ keV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 4.2±0.2±0.3 | LEES | 12F | BABR | 10.6 $e^+e^- \rightarrow \phi\pi^+\pi^-\gamma$ |

## $\phi(1680)$ $\Gamma(i)\Gamma(e^+e^-)/\Gamma^2(\text{total})$

This combination of a branching ratio into channel ($i$) and branching ratio into $e^+e^-$ is directly measured and obtained from the cross section at the peak. We list only data that have not been used to determine the branching ratio into ($i$) or $e^+e^-$.

### $\Gamma(K^0_L K^0_S)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ — $\Gamma_4/\Gamma \times \Gamma_5/\Gamma$

| *VALUE* (units $10^{-6}$) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $0.131\pm0.059$ | 948 | [26] AKHMETSHIN | 03 | CMD2 | 1.05–1.38 $e^+e^- \to K^0_L K^0_S$ |

[26] From the combined fit of AKHMETSHIN 03 and MANE 81 also including $\rho$, $\omega$, and $\phi$. Neither isospin nor flavor structure known. Recalculated by us.

### $\Gamma(K\overline{K}^*(892)+\text{c.c.})/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ — $\Gamma_1/\Gamma \times \Gamma_5/\Gamma$

| *VALUE* (units $10^{-6}$) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $1.15\pm0.16\pm0.01$ | | [27] AUBERT | 08S | BABR | 10.6 $e^+e^- \to K\overline{K}^*(892)\gamma$ + c.c. |
| $3.29\pm1.57$ | 367 | [28] BISELLO | 91C | DM2 | 1.35–2.40 $e^+e^- \to K^0_S K^\pm \pi^\mp$ |

[27] From the simultaneous fit to the $K\overline{K}^*(892)$+ c.c. and $\phi\eta$ data from AUBERT 08S using the results of AUBERT 07AK.

[28] Recalculated by us with the published value of B($K\overline{K}^*(892)$ + c.c.) × $\Gamma(e^+e^-)$.

### $\Gamma(\phi\pi\pi)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ — $\Gamma_7/\Gamma \times \Gamma_5/\Gamma$

| *VALUE* (units $10^{-7}$) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $1.86\pm0.14\pm0.21$ | 4.8k | [29] SHEN | 09 | BELL | 10.6 $e^+e^- \to K^+K^-\pi^+\pi^-\gamma$ |

[29] Multiplied by 3/2 to take into account the $\phi\pi^0\pi^0$ mode. Using B($\phi \to K^+K^-$) = (49.2 ± 0.6)%.

### $\Gamma(\eta\phi)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ — $\Gamma_9/\Gamma \times \Gamma_5/\Gamma$

| *VALUE* (units $10^{-6}$) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $0.43\pm0.10\pm0.09$ | [30] AUBERT | 08S | BABR | 10.6 $e^+e^- \to \phi\eta\gamma$ |

[30] From the simultaneous fit to the $K\overline{K}^*(892)$+ c.c. and $\phi\eta$ data from AUBERT 08S using the results of AUBERT 07AK.

## $\phi(1680)$ BRANCHING RATIOS

### $\Gamma(K\overline{K}^*(892)+\text{c.c.})/\Gamma(K^0_S K\pi)$ — $\Gamma_1/\Gamma_2$

| *VALUE* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| dominant | MANE | 82 | DM1 | $e^+e^- \to K^0_S K^\pm\pi^\mp$ |

### $\Gamma(K\overline{K})/\Gamma(K\overline{K}^*(892)+\text{c.c.})$ — $\Gamma_3/\Gamma_1$

| *VALUE* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $0.07\pm0.01$ | BUON | 82 | DM1 | $e^+e^-$ |

### $\Gamma(\omega\pi\pi)/\Gamma(K\overline{K}^*(892)+\text{c.c.})$ — $\Gamma_6/\Gamma_1$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **<0.10** | BUON | 82 | DM1 | $e^+e^-$ |

### $\Gamma(\eta\phi)/\Gamma_{\text{total}}$ — $\Gamma_9/\Gamma$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **seen** | 35 | [31] ACHASOV | 14 | SND | 1.15–2.00 $e^+e^- \rightarrow \eta\gamma$ |

[31] From a phenomenological model based on vector meson dominance with $\rho(1450)$ and $\phi(1680)$ masses and widths from the PDG 12.

### $\Gamma(\eta\phi)/\Gamma(K\overline{K}^*(892)+\text{c.c.})$ — $\Gamma_9/\Gamma_1$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $\approx$ 0.37 | [32] AUBERT | 08S | BABR | 10.6 $e^+e^- \rightarrow$ hadrons |

[32] From the fit including data from AUBERT 07AK.

### $\Gamma(\eta\gamma)/\Gamma_{\text{total}}$ — $\Gamma_{10}/\Gamma$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **seen** | 35 | [33] ACHASOV | 14 | SND | 1.15–2.00 $e^+e^- \rightarrow \eta\gamma$ |

[33] From a phenomenological model based on vector meson dominance with $\rho(1450)$ and $\phi(1680)$ masses and widths from the PDG 12.

## $\phi(1680)$ REFERENCES


| | | | | |
|---|---|---|---|---|
| ACHASOV | 14 | PR D90 032002 | M.N. Achasov *et al.* | (SND Collab.) |
| LEES | 14H | PR D89 092002 | J.P. Lees *et al.* | (BABAR Collab) |
| LEES | 12F | PR D86 012008 | J.P. Lees *et al.* | (BABAR Collab.) |
| PDG | 12 | PR D86 010001 | J. Beringer *et al.* | (PDG Collab.) |
| SHEN | 09 | PR D80 031101 | C.P. Shen *et al.* | (BELLE Collab.) |
| AUBERT | 08S | PR D77 092002 | B. Aubert *et al.* | (BABAR Collab.) |
| AUBERT | 07AK | PR D76 012008 | B. Aubert *et al.* | (BABAR Collab.) |
| AMSLER | 06 | PL B639 165 | C. Amsler *et al.* | (CBAR Collab.) |
| AKHMETSHIN | 03 | PL B551 27 | R.R. Akhmetshin *et al.* | (Novosibirsk CMD-2 Collab.) |
| Also | | PAN 65 1222 | E.V. Anashkin, V.M. Aulchenko, R.R. Akhmetshin | |
| | | Translated from YAF 65 1255. | | |
| LINK | 02K | PL B545 50 | J.M. Link *et al.* | (FNAL FOCUS Collab.) |
| ACHASOV | 98H | PR D57 4334 | N.N. Achasov, A.A. Kozhevnikov | |
| CLEGG | 94 | ZPHY C62 455 | A.B. Clegg, A. Donnachie | (LANC, MCHS) |
| ANTONELLI | 92 | ZPHY C56 15 | A. Antonelli *et al.* | (DM2 Collab.) |
| BISELLO | 91C | ZPHY C52 227 | D. Bisello *et al.* | (DM2 Collab.) |
| DOLINSKY | 91 | PRPL 202 99 | S.I. Dolinsky *et al.* | (NOVO) |
| BUSENITZ | 89 | PR D40 1 | J.K. Busenitz *et al.* | (ILL, FNAL) |
| BISELLO | 88B | ZPHY C39 13 | D. Bisello *et al.* | (PADO, CLER, FRAS+) |
| BARKOV | 87 | JETPL 46 164 | L.M. Barkov *et al.* | (NOVO) |
| | | Translated from ZETFP 46 132. | | |
| ATKINSON | 85C | ZPHY C27 233 | M. Atkinson *et al.* | (BONN, CERN, GLAS+) |
| BUON | 82 | PL 118B 221 | J. Buon *et al.* | (LALO, MONP) |
| MANE | 82 | PL 112B 178 | F. Mane *et al.* | (LALO) |
| ASTON | 81F | PL 104B 231 | D. Aston | (BONN, CERN, EPOL, GLAS, LANC+) |
| IVANOV | 81 | PL 107B 297 | P.M. Ivanov *et al.* | (NOVO) |
| MANE | 81 | PL 99B 261 | F. Mane *et al.* | (ORSAY) |