# $\rho(1700)$

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

## THE $\rho(1450)$ AND THE $\rho(1700)$

Updated March 2000 by S. Eidelman (Novosibirsk) and J. Hernandez (Valencia).

In our 1988 edition, we replaced the $\rho(1600)$ entry with two new ones, the $\rho(1450)$ and the $\rho(1700)$, because there was emerging evidence that the 1600-MeV region actually contains two $\rho$-like resonances. ERKAL 86 had pointed out this possibility with a theoretical analysis on the consistency of $2\pi$ and $4\pi$ electromagnetic form factors and the $\pi\pi$ scattering length. DONNACHIE 87, with a full analysis of data on the $2\pi$ and $4\pi$ final states in $e^+e^-$ annihilation and photoproduction reactions, had also argued that in order to obtain a consistent picture, two resonances were necessary. The existence of $\rho(1450)$ was supported by the analysis of $\eta\rho^0$ mass spectra obtained in photoproduction and $e^+e^-$ annihilation (DONNACHIE 87B), as well as that of $e^+e^- \to \omega\pi$ (DONNACHIE 91).

The analysis of DONNACHIE 87 was further extended by CLEGG 88, 94 to include new data on $4\pi$ systems produced in $e^+e^-$ annihilation, and in $\tau$ decays ($\tau$ decays to $4\pi$ and $e^+e^-$ annihilation to $4\pi$ can be related by the Conserved Vector Current assumption). These systems were successfully analyzed using interfering contributions from two $\rho$-like states, and from the tail of the $\rho(770)$ decaying into two-body states. While specific conclusions on $\rho(1450) \to 4\pi$ were obtained, little could be said about the $\rho(1700)$.

An analysis by CLEGG 90 of $6\pi$ mass spectra from $e^+e^-$ annihilation and from diffractive photoproduction provides evidence for two $\rho$ mesons at about 2.1 and 1.8 GeV that decay strongly into $6\pi$ states. While the former is a candidate for a

new resonance ($\rho(2150)$), the latter could be a manifestation of the $\rho(1700)$ distorted by threshold effects.

Independent evidence for two $1^-$ states is provided by KILLIAN 80 in $4\pi$ electroproduction at $\langle Q^2 \rangle = 1$ (GeV/$c$)$^2$, and by FUKUI 88 in a high-statistics sample of the $\eta\pi\pi$ system in $\pi^- p$ charge exchange.

This scenario with two overlapping resonances is supported by other data. BISELLO 89 measured the pion form factor in the interval 1.35–2.4 GeV and observed a deep minimum around 1.6 GeV. The best fit was obtained with the hypothesis of $\rho$-like resonances at 1420 and 1770 MeV, with widths of about 250 MeV. ANTONELLI 88 found that the $e^+e^- \to \eta\,\pi^+\,\pi^-$ cross section is better fitted with two fully interfering Breit-Wigners, with parameters in fair agreement with those of DONNACHIE 87 and BISELLO 89. These results can be considered as a confirmation of the $\rho(1450)$.

Decisive evidence for the $\pi\pi$ decay mode of both $\rho(1450)$ and $\rho(1700)$ came from recent results in $\overline{p}p$ annihilation at rest (ABELE 97). It was shown that these resonances also possess a $K\overline{K}$ decay mode (ABELE 98, BERTIN 98B, ABELE 99D). High statistics studies of the decays $\tau \to \pi\pi\nu_\tau$ (BARATE 97M, URHEIM 97), and $\tau \to 4\pi\nu_\tau$ (EDWARDS 00), also require the $\rho(1450)$, but are not sensitive to the $\rho(1700)$, because it is too close to the $\tau$ mass.

The structure of these $\rho$ states is not yet completely clear. BARNES 97 and CLOSE 97C claim that $\rho(1450)$ has a mass consistent with radial $2S$, but its decays show characteristics of hybrids, and suggest that this state may be a $2S$-hybrid mixture. DONNACHIE 99 argues that hybrid states could have a $4\pi$ decay mode dominated by the $a_1\pi$. Such behavior has recently been observed by AKHMETSHIN 99E in $e^+e^- \to 4\pi$ in the energy range 1.05–1.38 GeV, and by EDWARDS 00 in

$\tau \to 4\pi$ decays. More data should be collected to clarify the nature of the $\rho$ states, particularly in the energy range above 1.6 GeV.

We also list under the $\rho(1450)$ the $\phi\pi$ state with $J^{PC} = 1^{--}$ or $C(1480)$ observed by BITYUKOV 87. While ACHASOV 96B shows that it may be a threshold effect, CLEGG 88 and LANDSBERG 92 suggest two independent vector states with this decay mode. Note, however, that $C(1480)$ in its $\phi\pi$ decay mode was not confirmed by $e^+e^-$ (DOLINSKY 91, BISELLO 91C) and $\overline{p}p$ (ABELE 97H) experiments.

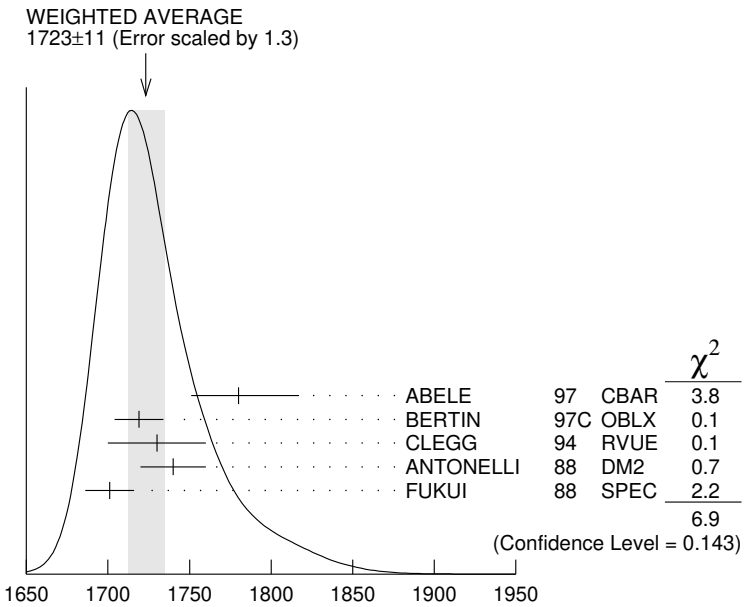
Several observations on the $\omega\pi$ system in the 1200-MeV region (FRENKIEL 72, COSME 76, BARBER 80C, ASTON 80C, ATKINSON 84C, BRAU 88, AMSLER 93B) may be interpreted in terms of either $J^P = 1^-$ $\rho(770) \to \omega\pi$ production (LAYSSAC 71), or $J^P = 1^+$ $b_1(1235)$ production (BRAU 88, AMSLER 93B). We argue that no special entry for a $\rho(1250)$ is needed. The LASS amplitude analysis (ASTON 91B) showing evidence for $\rho(1270)$ is preliminary and needs confirmation. For completeness, the relevant observations are listed under the $\rho(1450)$.

---

## $\rho(1700)$ MASS

### $\eta\rho^0$ AND $\pi^+\pi^-$ MODES

| *VALUE* (MeV) | *DOCUMENT ID* |
|---|---|
| **1700±20 OUR ESTIMATE** | |
| **1723±11 OUR AVERAGE** | Includes data from the 2 datablocks that follow this one. Error includes scale factor of 1.3. See the ideogram below. |




$\rho(1700)$ mass, $\eta\rho^0$ and $\pi^+\pi^-$ modes (MeV)

## $\eta\rho^0$ MODE

| *VALUE* (MeV) | | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| The data in this block is included in the average printed for a previous datablock. | | | | | |
| 1740 ± 20 | | ANTONELLI | 88 | DM2 | $e^+e^- \to \eta\pi^+\pi^-$ |
| 1701 ± 15 | | [2] FUKUI | 88 | SPEC | 8.95 $\pi^- p \to \eta\pi^+\pi^- n$ |

## $\pi\pi$ MODE

| *VALUE* (MeV) | | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| The data in this block is included in the average printed for a previous datablock. | | | | | |
| 1780 | $^{+37}_{-29}$ | [3] ABELE | 97 | CBAR | $\overline{p}n \to \pi^-\pi^0\pi^0$ |
| 1719 | ± 15 | [3] BERTIN | 97C | OBLX | 0.0 $\overline{p}p \to \pi^+\pi^-\pi^0$ |
| 1730 | ± 30 | CLEGG | 94 | RVUE | $e^+e^- \to \pi^+\pi^-$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 1768 | ± 21 | BISELLO | 89 | DM2 | $e^+e^- \to \pi^+\pi^-$ |
| 1745.7 | ± 91.9 | DUBNICKA | 89 | RVUE | $e^+e^- \to \pi^+\pi^-$ |
| 1546 | ± 26 | GESHKEN... | 89 | RVUE | |
| 1650 | | [4] ERKAL | 85 | RVUE | 20–70 $\gamma p \to \gamma\pi$ |
| 1550 | ± 70 | ABE | 84B | HYBR | 20 $\gamma p \to \pi^+\pi^- p$ |
| 1590 | ± 20 | [5] ASTON | 80 | OMEG | 20–70 $\gamma p \to p2\pi$ |
| 1600 | ± 10 | [6] ATIYA | 79B | SPEC | 50 $\gamma$ C $\to$ C2$\pi$ |
| 1598 | $^{+24}_{-22}$ | BECKER | 79 | ASPK | 17 $\pi^- p$ polarized |
| 1659 | ± 25 | [4] LANG | 79 | RVUE | |
| 1575 | | [4] MARTIN | 78C | RVUE | 17 $\pi^- p \to \pi^+\pi^- n$ |
| 1610 | ± 30 | [4] FROGGATT | 77 | RVUE | 17 $\pi^- p \to \pi^+\pi^- n$ |
| 1590 | ± 20 | [7] HYAMS | 73 | ASPK | 17 $\pi^- p \to \pi^+\pi^- n$ |

### $\pi\omega$ MODE

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $1710 \pm 90$ | ACHASOV | 97 | RVUE | $e^+ e^- \to \omega\pi^0$ |

### $K\overline{K}$ MODE

| VALUE (MeV) | EVTS | DOCUMENT ID | | TECN | CHG | COMMENT |
|---|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| $1740.8 \pm 22.2$ | 27k | [1] ABELE | 99D | CBAR | $\pm$ | 0.0 $\overline{p}p \to K^+ K^- \pi^0$ |
| $1582 \pm 36$ | 1600 | CLELAND | 82B | SPEC | $\pm$ | 50 $\pi p \to K^0_S K^\pm p$ |

[1] K-matrix pole. Isospin not determined, could be $\omega(1650)$ or $\phi(1680)$.

### $2(\pi^+\pi^-)$ MODE

| VALUE (MeV) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $1851^{+27}_{-24}$ | | ACHASOV | 97 | RVUE | $e^+ e^- \to 2(\pi^+\pi^-)$ |
| $1570 \pm 20$ | | [8] CORDIER | 82 | DM1 | $e^+ e^- \to 2(\pi^+\pi^-)$ |
| $1520 \pm 30$ | | [5] ASTON | 81E | OMEG | 20–70 $\gamma p \to p4\pi$ |
| $1654 \pm 25$ | | [9] DIBIANCA | 81 | DBC | $\pi^+ d \to pp2(\pi^+\pi^-)$ |
| $1666 \pm 39$ | | [8] BACCI | 80 | FRAG | $e^+ e^- \to 2(\pi^+\pi^-)$ |
| 1780 | 34 | KILLIAN | 80 | SPEC | 11 $e^- p \to 2(\pi^+\pi^-)$ |
| 1500 | | [10] ATIYA | 79B | SPEC | 50 $\gamma$C $\to$ C$4\pi^\pm$ |
| $1570 \pm 60$ | 65 | [11] ALEXANDER | 75 | HBC | 7.5 $\gamma p \to p4\pi$ |
| $1550 \pm 60$ | | [5] CONVERSI | 74 | OSPK | $e^+ e^- \to 2(\pi^+\pi^-)$ |
| $1550 \pm 50$ | 160 | SCHACHT | 74 | STRC | 5.5–9 $\gamma p \to p4\pi$ |
| $1450 \pm 100$ | 340 | SCHACHT | 74 | STRC | 9–18 $\gamma p \to p4\pi$ |
| $1430 \pm 50$ | 400 | BINGHAM | 72B | HBC | 9.3 $\gamma p \to p4\pi$ |

### $\pi^+\pi^-\pi^0\pi^0$ MODE

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $1660 \pm 30$ | ATKINSON | 85B | OMEG | 20–70 $\gamma p$ |

### $3(\pi^+\pi^-)$ AND $2(\pi^+\pi^-\pi^0)$ MODES

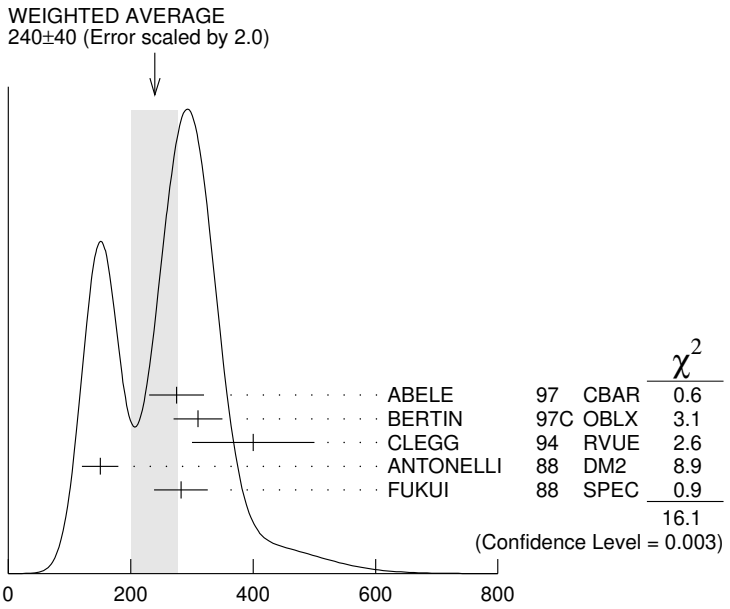
| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $1783 \pm 15$ | CLEGG | 90 | RVUE | $e^+ e^- \to 3(\pi^+\pi^-)2(\pi^+\pi^-\pi^0)$ |

[2] Assuming $\rho^+ f_0(1370)$ decay mode interferes with $a_1(1260)^+\pi$ background. From a two Breit-Wigner fit.
[3] T-matrix pole.
[4] From phase shift analysis of HYAMS 73 data.
[5] Simple relativistic Breit-Wigner fit with constant width.
[6] An additional 40 MeV uncertainty in both the mass and width is present due to the choice of the background shape.
[7] Included in BECKER 79 analysis.
[8] Simple relativistic Breit-Wigner fit with model dependent width.
[9] One peak fit result.
[10] Parameters roughly estimated, not from a fit.
[11] Skew mass distribution compensated by Ross-Stodolsky factor.

## $\rho(1700)$ WIDTH

### $\eta\rho^0$ AND $\pi^+\pi^-$ MODES

| *VALUE* (MeV) | *DOCUMENT ID* |
|---|---|
| **240±60 OUR ESTIMATE** | |
| **240±40 OUR AVERAGE** | Includes data from the 2 datablocks that follow this one. Error includes scale factor of 2.0. See the ideogram below. |




$\rho(1700)$ width, $\eta\rho^0$ and $\pi^+\pi^-$ modes (MeV)

### $\eta\rho^0$ MODE

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| The data in this block is included in the average printed for a previous datablock. | | | | |
| $150\pm30$ | ANTONELLI | 88 | DM2 | $e^+e^- \to \eta\pi^+\pi^-$ |
| $282\pm44$ | [13] FUKUI | 88 | SPEC | 8.95 $\pi^- p \to \eta\pi^+\pi^- n$ |

### $\pi\pi$ MODE

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| The data in this block is included in the average printed for a previous datablock. | | | | |
| 275 ± 45 | [14] ABELE | 97 | CBAR | $\overline{p}n \to \pi^-\pi^0\pi^0$ |
| 310 ± 40 | [14] BERTIN | 97C | OBLX | 0.0 $\overline{p}p \to \pi^+\pi^-\pi^0$ |
| 400 ±100 | CLEGG | 94 | RVUE | $e^+e^- \to \pi^+\pi^-$ |

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

| | | | | | |
|---|---|---|---|---|---|
| 224 ± 22 | BISELLO | 89 | DM2 | $e^+ e^- \to \pi^+ \pi^-$ | |
| 242.5 ± 163.0 | DUBNICKA | 89 | RVUE | $e^+ e^- \to \pi^+ \pi^-$ | |
| 620 ± 60 | GESHKEN... | 89 | RVUE | | |
| <315 | [15] ERKAL | 85 | RVUE | 20–70 $\gamma p \to \gamma\pi$ | |
| $280 \begin{smallmatrix}+30\\-80\end{smallmatrix}$ | ABE | 84B | HYBR | 20 $\gamma p \to \pi^+ \pi^- p$ | |
| 230 ± 80 | [16] ASTON | 80 | OMEG | 20–70 $\gamma p \to p 2\pi$ | |
| 283 ± 14 | [17] ATIYA | 79B | SPEC | 50 $\gamma$ C $\to$ C$2\pi$ | |
| $175 \begin{smallmatrix}+98\\-53\end{smallmatrix}$ | BECKER | 79 | ASPK | 17 $\pi^- p$ polarized | |
| 232 ± 34 | [15] LANG | 79 | RVUE | | |
| 340 | [15] MARTIN | 78C | RVUE | 17 $\pi^- p \to \pi^+ \pi^- n$ | |
| 300 ±100 | [15] FROGGATT | 77 | RVUE | 17 $\pi^- p \to \pi^+ \pi^- n$ | |
| 180 ± 50 | [18] HYAMS | 73 | ASPK | 17 $\pi^- p \to \pi^+ \pi^- n$ | |

## $K\overline{K}$ MODE

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | | *TECN* | *CHG* | *COMMENT* |
|---|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| 187.2± 26.7 | 27k | [12] ABELE | 99D | CBAR | ± | 0.0 $\overline{p} p \to K^+ K^- \pi^0$ |
| 265 ±120 | 1600 | CLELAND | 82B | SPEC | ± | 50 $\pi p \to K^0_S K^\pm p$ |

[12] K-matrix pole. Isospin not determined, could be $\omega(1650)$ or $\phi(1680)$.

## $2(\pi^+\pi^-)$ MODE

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 510± 40 | | [19] CORDIER | 82 | DM1 | $e^+ e^- \to 2(\pi^+ \pi^-)$ |
| 400± 50 | | [16] ASTON | 81E | OMEG | 20–70 $\gamma p \to p 4\pi$ |
| 400±146 | | [20] DIBIANCA | 81 | DBC | $\pi^+ d \to p p 2(\pi^+ \pi^-)$ |
| 700±160 | | [19] BACCI | 80 | FRAG | $e^+ e^- \to 2(\pi^+ \pi^-)$ |
| 100 | 34 | KILLIAN | 80 | SPEC | 11 $e^- p \to 2(\pi^+ \pi^-)$ |
| 600 | | [21] ATIYA | 79B | SPEC | 50 $\gamma$ C $\to$ C$4\pi^\pm$ |
| 340±160 | 65 | [22] ALEXANDER | 75 | HBC | 7.5 $\gamma p \to p 4\pi$ |
| 360±100 | | [16] CONVERSI | 74 | OSPK | $e^+ e^- \to 2(\pi^+ \pi^-)$ |
| 400±120 | 160 | [23] SCHACHT | 74 | STRC | 5.5–9 $\gamma p \to p 4\pi$ |
| 850±200 | 340 | [23] SCHACHT | 74 | STRC | 9–18 $\gamma p \to p 4\pi$ |
| 650±100 | 400 | BINGHAM | 72B | HBC | 9.3 $\gamma p \to p 4\pi$ |

## $\pi^+\pi^-\pi^0\pi^0$ MODE

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 300±50 | ATKINSON | 85B | OMEG | 20–70 $\gamma p$ |

### $3(\pi^+\pi^-)$ AND $2(\pi^+\pi^-\pi^0)$ MODES

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $285\pm20$ | CLEGG | 90 | RVUE | $e^+e^- \to 3(\pi^+\pi^-)2(\pi^+\pi^-\pi^0)$ |

[13] Assuming $\rho^+ f_0(1370)$ decay mode interferes with $a_1(1260)^+\pi$ background. From a two Breit-Wigner fit.
[14] T-matrix pole.
[15] From phase shift analysis of HYAMS 73 data.
[16] Simple relativistic Breit-Wigner fit with constant width.
[17] An additional 40 MeV uncertainty in both the mass and width is present due to the choice of the background shape.
[18] Included in BECKER 79 analysis.
[19] Simple relativistic Breit-Wigner fit with model-dependent width.
[20] One peak fit result.
[21] Parameters roughly estimated, not from a fit.
[22] Skew mass distribution compensated by Ross-Stodolsky factor.
[23] Width errors enlarged by us to $4\Gamma/\sqrt{N}$; see the note with the $K^*(892)$ mass.

## $\rho(1700)$ DECAY MODES

| | Mode | Fraction ($\Gamma_i/\Gamma$) |
|---|---|---|
| $\Gamma_1$ | $\rho\pi\pi$ | dominant |
| $\Gamma_2$ | $\rho^0\pi^+\pi^-$ | large |
| $\Gamma_3$ | $\rho^0\pi^0\pi^0$ | |
| $\Gamma_4$ | $\rho^\pm\pi^\mp\pi^0$ | large |
| $\Gamma_5$ | $2(\pi^+\pi^-)$ | large |
| $\Gamma_6$ | $\pi^+\pi^-$ | seen |
| $\Gamma_7$ | $\pi^-\pi^0$ | seen |
| $\Gamma_8$ | $K\overline{K}^*(892)+$ c.c. | seen |
| $\Gamma_9$ | $\eta\rho$ | seen |
| $\Gamma_{10}$ | $a_2(1320)\pi$ | not seen |
| $\Gamma_{11}$ | $K\overline{K}$ | seen |
| $\Gamma_{12}$ | $e^+e^-$ | seen |
| $\Gamma_{13}$ | $\pi^0\omega$ | seen |

## $\rho(1700)$ $\Gamma(i)\Gamma(e^+e^-)/\Gamma(total)$

This combination of a partial width with the partial width into $e^+e^-$ and with the total width is obtained from the cross-section into channel$_i$ in $e^+e^-$ annihilation.

### $\Gamma(2(\pi^+\pi^-)) \times \Gamma(e^+e^-)/\Gamma_{total}$ $\Gamma_5\Gamma_{12}/\Gamma$

| *VALUE* (keV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **2.83±0.42** | BACCI | 80 | FRAG | $e^+e^- \to 2(\pi^+\pi^-)$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 2.6 ±0.2 | DELCOURT | 81B | DM1 | $e^+e^- \to 2(\pi^+\pi^-)$ |

### $\Gamma(\pi^+\pi^-) \times \Gamma(e^+e^-)/\Gamma_{total}$ $\Gamma_6\Gamma_{12}/\Gamma$

| *VALUE* (keV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 0.13 | [24] DIEKMAN | 88 | RVUE | $e^+e^- \to \pi^+\pi^-$ |
| $0.029^{+0.016}_{-0.012}$ | KURDADZE | 83 | OLYA | 0.64–1.4 $e^+e^- \to \pi^+\pi^-$ |

[24] Using total width = 220 MeV.

### $\Gamma(K\overline{K}^*(892)+\text{c.c.}) \times \Gamma(e^+e^-)/\Gamma_{total}$ $\Gamma_8\Gamma_{12}/\Gamma$

| *VALUE* (keV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $0.305 \pm 0.071$ | [25] BIZOT | 80 | DM1 | $e^+e^-$ |

### $\Gamma(\eta\rho) \times \Gamma(e^+e^-)/\Gamma_{total}$ $\Gamma_9\Gamma_{12}/\Gamma$

| *VALUE* (eV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **7 ±3** | ANTONELLI | 88 | DM2 | $e^+e^- \to \eta\pi^+\pi^-$ |

### $\Gamma(K\overline{K}) \times \Gamma(e^+e^-)/\Gamma_{total}$ $\Gamma_{11}\Gamma_{12}/\Gamma$

| *VALUE* (keV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $0.035 \pm 0.029$ | [25] BIZOT | 80 | DM1 | $e^+e^-$ |

### $\Gamma(\rho\pi\pi) \times \Gamma(e^+e^-)/\Gamma_{total}$ $\Gamma_1\Gamma_{12}/\Gamma$

| *VALUE* (keV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $3.510 \pm 0.090$ | [25] BIZOT | 80 | DM1 | $e^+e^-$ |

[25] Model dependent.

## $\rho(1700)$ BRANCHING RATIOS

### $\Gamma(\pi^+\pi^-)/\Gamma_{total}$ $\Gamma_6/\Gamma$

| *VALUE* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $0.287^{+0.043}_{-0.042}$ | BECKER | 79 | ASPK | 17 $\pi^- p$ polarized |
| 0.15 to 0.30 | [26] MARTIN | 78C | RVUE | 17 $\pi^- p \to \pi^+\pi^- n$ |
| <0.20 | [27] COSTA... | 77B | RVUE | $e^+e^- \to 2\pi, 4\pi$ |
| 0.30 ±0.05 | [26] FROGGATT | 77 | RVUE | 17 $\pi^- p \to \pi^+\pi^- n$ |
| <0.15 | [28] EISENBERG | 73 | HBC | 5 $\pi^+ p \to \Delta^{++}2\pi$ |
| 0.25 ±0.05 | [29] HYAMS | 73 | ASPK | 17 $\pi^- p \to \pi^+\pi^- n$ |

[26] From phase shift analysis of HYAMS 73 data.
[27] Estimate using unitarity, time reversal invariance, Breit-Wigner.
[28] Estimated using one-pion-exchange model.
[29] Included in BECKER 79 analysis.

## $\Gamma(\pi^+\pi^-)/\Gamma(2(\pi^+\pi^-))$ $\Gamma_6/\Gamma_5$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $0.13\pm0.05$ | ASTON | 80 | OMEG | 20–70 $\gamma p \rightarrow p 2\pi$ |
| $<0.14$ | [30] DAVIER | 73 | STRC | 6–18 $\gamma p \rightarrow p 4\pi$ |
| $<0.2$ | [31] BINGHAM | 72B | HBC | 9.3 $\gamma p \rightarrow p 2\pi$ |

[30] Upper limit is estimate.
[31] $2\sigma$ upper limit.

## $\Gamma(K\overline{K}^*(892)+\text{c.c.})/\Gamma(2(\pi^+\pi^-))$ $\Gamma_8/\Gamma_5$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $0.15\pm0.03$ | [32] DELCOURT | 81B | DM1 | $e^+e^- \rightarrow \overline{K}K\pi$ |

[32] Assuming $\rho(1700)$ and $\omega$ radial excitations to be degenerate in mass.

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

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.04** | | DONNACHIE | 87B | RVUE | |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $<0.02$ | 58 | ATKINSON | 86B | OMEG | 20–70 $\gamma p$ |

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

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| not seen | AMELIN | 00 | VES | 37 $\pi^- p \rightarrow \eta\pi^+\pi^- n$ |

## $\Gamma(\eta\rho)/\Gamma(2(\pi^+\pi^-))$ $\Gamma_9/\Gamma_5$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $0.123\pm0.027$ | DELCOURT | 82 | DM1 | $e^+e^- \rightarrow \pi^+\pi^-$ MM |
| $\sim 0.1$ | ASTON | 80 | OMEG | 20–70 $\gamma p$ |

## $\Gamma(\pi^+\pi^-\text{neutrals})/\Gamma(2(\pi^+\pi^-))$ $(\Gamma_3+\Gamma_4+0.714\Gamma_9)/\Gamma_5$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $2.6\pm0.4$ | [33] BALLAM | 74 | HBC | 9.3 $\gamma p$ |

[33] Upper limit. Background not subtracted.

## $\Gamma(\pi^0\omega)/\Gamma_{\text{total}}$ $\Gamma_{13}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| seen | ACHASOV | 97 | RVUE | $e^+e^- \rightarrow \omega\pi^0$ |

## $\Gamma(K\overline{K})/\Gamma(2(\pi^+\pi^-))$ $\Gamma_{11}/\Gamma_5$

| VALUE | CL% | DOCUMENT ID | | TECN | CHG | COMMENT |
|---|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| $0.015 \pm 0.010$ | | [34] DELCOURT | 81B | DM1 | | $e^+e^- \to \overline{K}K$ |
| $<0.04$ | 95 | BINGHAM | 72B | HBC | 0 | 9.3 $\gamma p$ |

[34] Assuming $\rho(1700)$ and $\omega$ radial excitations to be degenerate in mass.

## $\Gamma(K\overline{K})/\Gamma(K\overline{K}^*(892)+\text{c.c.})$ $\Gamma_{11}/\Gamma_8$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $0.052 \pm 0.026$ | BUON | 82 | DM1 | $e^+e^- \to$ hadrons |

## $\Gamma(\rho^0\pi^+\pi^-)/\Gamma(2(\pi^+\pi^-))$ $\Gamma_2/\Gamma_5$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $\sim 1.0$ | | DELCOURT | 81B | DM1 | $e^+e^- \to 2(\pi^+\pi^-)$ |
| $0.7 \pm 0.1$ | 500 | SCHACHT | 74 | STRC | 5.5–18 $\gamma p \to p4\pi$ |
| 0.80 | | [35] BINGHAM | 72B | HBC | 9.3 $\gamma p \to p4\pi$ |

[35] The $\pi\pi$ system is in $S$-wave.

## $\Gamma(\rho^0\pi^0\pi^0)/\Gamma(\rho^\pm\pi^\mp\pi^0)$ $\Gamma_3/\Gamma_4$

| VALUE | DOCUMENT ID | | TECN | CHG | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $<0.10$ | ATKINSON | 85B | OMEG | | 20–70 $\gamma p$ |
| $<0.15$ | ATKINSON | 82 | OMEG | 0 | 20–70 $\gamma p \to p4\pi$ |

## $\rho(1700)$ REFERENCES


| | | | | |
|---|---|---|---|---|
| AMELIN | 00 | NP B668 83 | D. Amelin *et al.* | (VES Collab.) |
| ABELE | 99D | PL B468 178 | A. Abele *et al.* | (Crystal Barrel Collab.) |
| ABELE | 97 | PL B391 191 | A. Abele *et al.* | (Crystal Barrel Collab.) |
| ACHASOV | 97 | PR D55 2663 | N.N. Achasov *et al.* | (NOVM) |
| BERTIN | 97C | PL B408 476 | A. Bertin *et al.* | (OBELIX Collab.) |
| CLEGG | 94 | ZPHY C62 455 | A.B. Clegg, A. Donnachie | (LANC, MCHS) |
| CLEGG | 90 | ZPHY C45 677 | A.B. Clegg, A. Donnachie | (LANC, MCHS) |
| BISELLO | 89 | PL B220 321 | D. Bisello *et al.* | (DM2 Collab.) |
| DUBNICKA | 89 | JPG 15 1349 | S. Dubnicka *et al.* | (JINR, SLOV) |
| GESHKEN... | 89 | ZPHY 45 351 | B.V. Geshkenbein | (ITEP) |
| ANTONELLI | 88 | PL B212 133 | A. Antonelli *et al.* | (DM2 Collab.) |
| DIEKMAN | 88 | PRPL 159 101 | B. Diekmann | (BONN) |
| FUKUI | 88 | PL B202 441 | S. Fukui *et al.* | (SUGI, NAGO, KEK, KYOT+) |
| DONNACHIE | 87B | ZPHY C34 257 | A. Donnachie, A.B. Clegg | (MCHS, LANC) |
| ATKINSON | 86B | ZPHY C30 531 | M. Atkinson *et al.* | (BONN, CERN, GLAS+) |
| ATKINSON | 85B | ZPHY C26 499 | M. Atkinson *et al.* | (BONN, CERN, GLAS+) |
| ERKAL | 85 | ZPHY C29 485 | C. Erkal, M.G. Olsson | (WISC) |
| ABE | 84B | PRL 53 751 | K. Abe *et al.* | |
| KURDADZE | 83 | JETPL 37 733<br>Translated from ZETFP 37 613. | L.M. Kurdadze *et al.* | (NOVO) |

| | | | | |
|---|---|---|---|---|
| ATKINSON | 82 | PL 108B 55 | M. Atkinson *et al.* | (BONN, CERN, GLAS+) |
| BUON | 82 | PL 118B 221 | J. Buon *et al.* | (LALO, MONP) |
| CLELAND | 82B | NP B208 228 | W.E. Cleland *et al.* | (DURH, GEVA, LAUS+) |
| CORDIER | 82 | PL 109B 129 | A. Cordier *et al.* | (LALO) |
| DELCOURT | 82 | PL 113B 93 | B. Delcourt *et al.* | (LALO) |
| ASTON | 81E | NP B189 15 | D. Aston | (BONN, CERN, EPOL, GLAS, LANC+) |
| DELCOURT | 81B | Bonn Conf. 205 | B. Delcourt | (ORSAY) |
| Also | 82 | PL 109B 129 | A. Cordier *et al.* | (LALO) |
| DIBIANCA | 81 | PR D23 595 | F.A. di Bianca *et al.* | (CASE, CMU) |
| ASTON | 80 | PL 92B 215 | D. Aston | (BONN, CERN, EPOL, GLAS, LANC+) |
| BACCI | 80 | PL 95B 139 | C. Bacci *et al.* | (ROMA, FRAS) |
| BIZOT | 80 | Madison Conf. 546 | J.C. Bizot *et al.* | (LALO, MONP) |
| KILLIAN | 80 | PR D21 3005 | T.J. Killian *et al.* | (CORN) |
| ATIYA | 79B | PRL 43 1691 | M.S. Atiya *et al.* | (COLU, ILL, FNAL) |
| BECKER | 79 | NP B151 46 | H. Becker *et al.* | (MPIM, CERN, ZEEM, CRAC) |
| LANG | 79 | PR D19 956 | C.B. Lang, A. Mas-Parareda | (GRAZ) |
| MARTIN | 78C | ANP 114 1 | A.D. Martin, M.R. Pennington | (CERN) |
| COSTA... | 77B | PL 71B 345 | B. Costa de Beauregard, B. Pire, T.N. Truong | (EPOL) |
| FROGGATT | 77 | NP B129 89 | C.D. Froggatt, J.L. Petersen | (GLAS, NORD) |
| ALEXANDER | 75 | PL 57B 487 | G. Alexander *et al.* | (TELA) |
| BALLAM | 74 | NP B76 375 | J. Ballam *et al.* | (SLAC, LBL, MPIM) |
| CONVERSI | 74 | PL 52B 493 | M. Conversi *et al.* | (ROMA, FRAS) |
| SCHACHT | 74 | NP B81 205 | P. Schacht *et al.* | (MPIM) |
| DAVIER | 73 | NP B58 31 | M. Davier *et al.* | (SLAC) |
| EISENBERG | 73 | PL 43B 149 | Y. Eisenberg *et al.* | (REHO) |
| HYAMS | 73 | NP B64 134 | B.D. Hyams *et al.* | (CERN, MPIM) |
| BINGHAM | 72B | PL 41B 635 | H.H. Bingham *et al.* | (LBL, UCB, SLAC) IGJP |


## OTHER RELATED PAPERS


| | | | | |
|---|---|---|---|---|
| EDWARDS | 00 | PR D61 072003 | K.W. Edwards *et al.* | (CLEO Collab.) |
| ABELE | 99C | PL B450 275 | A. Abele *et al.* | (Crystal Barrel Collab.) |
| DONNACHIE | 99 | PR D60 114011 | A. Donnachie, Yu.S. Kalashnikova | |
| KULZINGER | 99 | EPJ C7 73 | G. Kulzinger *et al.* | |
| BELOZEROVA | 98 | PPN 29 63 | T.S. Belozerova, V.K. Henner | |
| | | Translated from FECAY 29 148. | | |
| BARNES | 97 | PR D55 4157 | T. Barnes *et al.* | (ORNL, RAL, MCHS) |
| CLOSE | 97C | PR D56 1584 | F.E. Close *et al.* | (RAL, MCHS) |
| URHEIM | 97 | NPBPS 55C 359 | J. Urheim | (CLEO Collab.) |
| ACHASOV | 96B | PAN 59 1262 | N.N. Achasov, G.N. Shestakov | (NOVM) |
| | | Translated from YAF 59 1319. | | |
| AMSLER | 93B | PL B311 362 | C. Amsler *et al.* | (Crystal Barrel Collab.) |
| LANDSBERG | 92 | SJNP 55 1051 | | (SERP) |
| | | Translated from YAF 55 1896. | | |
| ASTON | 91B | NPBPS 21 105 | D. Aston *et al.* | (LASS Collab.) |
| DONNACHIE | 91 | ZPHY C51 689 | A. Donnachie, A.B. Clegg | (MCHS, LANC) |
| ACHASOV | 88C | PL B209 373 | N.N. Achasov, A.A. Kozhevnikov | (NOVM) |
| BRAU | 88 | PR D37 2379 | J.E. Brau *et al.* | JP |
| CLEGG | 88 | ZPHY C40 313 | A.B. Clegg, A. Donnachie | (MCHS, LANC) |
| ASTON | 87 | NP B292 693 | D. Aston *et al.* | (SLAC, NAGO, CINC, INUS) |
| ERKAL | 86 | ZPHY C31 615 | C. Erkal, M.G. Olsson | (WISC) |
| BARKOV | 85 | NP B256 365 | L.M. Barkov *et al.* | (NOVO) |
| ATKINSON | 84C | NP B243 1 | M. Atkinson *et al.* | (BONN, CERN, GLAS+) JP |
| ATKINSON | 83B | PL 127B 132 | M. Atkinson *et al.* | (BONN, CERN, GLAS+) |
| ATKINSON | 83C | NP B229 269 | M. Atkinson *et al.* | (BONN, CERN, GLAS+) |
| AUGUSTIN | 83 | LAL 83-21 | J.E. Augustin *et al.* | (LALO, PADO, FRAS) |
| SHAMBROOM | 82 | PR D26 1 | W.D. Shambroom *et al.* | (HARV, EFI, ILL+) |
| ASTON | 80C | PL 92B 211 | D. Aston | (BONN, CERN, EPOL, GLAS, LANC+) |
| BARBER | 80C | ZPHY C4 169 | D.P. Barber *et al.* | (DARE, LANC, SHEF) |
| KILLIAN | 80 | PR D21 3005 | T.J. Killian *et al.* | (CORN) |
| COSME | 76 | PL 63B 352 | G. Cosme *et al.* | (ORSAY) |
| FRENKIEL | 72 | NP B47 61 | P. Frenkiel *et al.* | (CDEF, CERN) |
| ALVENSLEB... | 71 | PRL 26 273 | H. Alvensleben *et al.* | (DESY, MIT) G |
| BRAUN | 71 | NP B30 213 | H.M. Braun *et al.* | (STRB) G |
| BULOS | 71 | PRL 26 149 | F. Bulos *et al.* | (SLAC, UMD, IBM, LBL) G |
| LAYSSAC | 71 | NC 6A 134 | J. Layssac, F.M. Renard | (MONP) |