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$\rho(1450)$

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

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

Updated September 2019 by S. Eidelman (Novosibirsk), C. Hanhart (Juelich) and G. Venanzoni (Pisa).

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 ρ-like resonances. Erkal [1] had pointed out this possibility with a theoretical analysis on the consistency of 2π and 4π electromagnetic form factors and the $\pi\pi$ scattering length. Donnachie [2], with a full analysis of data on the 2π and 4π 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 [3], as well as that of $e^+e^- \to \omega\pi$ [4].

The analysis of [2] was further extended by [5,6] to include new data on 4π-systems produced in e^+e^- annihilation, and in τ-decays (τ decays to 4π, and e^+e^- annihilation to 4π can be related by the Conserved Vector Current assumption). These systems were successfully analyzed using interfering contributions from two ρ-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 $\rho(1700)$.

Independent evidence for two 1^- states is provided by [7] in 4π electroproduction at $\langle Q^2 \rangle = 1$ (GeV/c)^2, and by [8] in a high-statistics sample of the $\eta\pi\pi$ system in π^-p charge exchange.

This scenario with two overlapping resonances is supported by other data. Bisello [9] 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 ρ-like resonances at 1420 and 1770 MeV, with widths of about 250 MeV. Antonelli [10] 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 [2] and [9]. 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 $\rho(1700)$ comes from $\overline{p}p$ annihilation at rest [11]. It has been shown that these resonances also possess a $K\overline{K}$ decay mode [12–14]. . High-statistics studies of the decays $\tau \to \pi\pi\nu_\tau$ [15,16], and $\tau \to 4\pi\nu_\tau$ [17] also require the $\rho(1450)$, but are not sensitive to the $\rho(1700)$, because it is too close to the τ mass. A recent very-high-statistics study of the $\tau \to \pi\pi\nu_\tau$ decay performed at Belle [18] reports the first observation of both $\rho(1450)$ and $\rho(1700)$ in τ decays. A clear picture of the two $\pi^+\pi^-$ resonances interfering with the $\rho(770)$ in e^+e^- annihilation was also reported by BaBar using the ISR method [19].

The structure of these ρ states is not yet completely clear. Barnes [20] and Close [21] 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 [22] argues that hybrid states could have a 4π decay mode dominated by the $a_1\pi$. Such behavior has been observed by [23] in $e^+e^- \to 4\pi$ in the energy range 1.05–1.38 GeV, and by [17] in $\tau \to 4\pi$ decays. CLEO [24] and Belle [25] observe the $\rho(1450) \to \omega\pi$ decay mode in B-meson decays, however, do not find $\rho(1700) \to \omega\pi^0$. A similar conclusion is made by

[26,27], who studied the process $e^+e^- \to \omega\pi^0$ and do not observe a statistically significant signal of the $\rho(1700)$. Various decay modes of the $\rho(1450)$ and $\rho(1700)$ are observed in $\overline{p}n$ and $\overline{p}p$ annihilation [28,29], but no definite conclusions can be drawn. More data should be collected to clarify the nature of the ρ states, particularly in the energy range above 1.6 GeV.

We now list under a separate entry the $\rho(1570)$, the $\phi\pi$ state with $J^{PC} = 1^{--}$ earlier observed by [30] (referred to as $C(1480)$) and recently confirmed by [31]. While [32] shows that it may be a threshold effect, [5] and [33] suggest two independent vector states with this decay mode. The $C(1480)$ has not been seen in the $\overline{p}p$ [34] and e^+e^- [35,36] experiments. However, the sensitivity of the two latter is an order of magnitude lower than that of [31]. Note that [31] can not exclude that their observation is due to an OZI-suppressed decay mode of the $\rho(1700)$.

Several observations on the $\omega\pi$ system in the 1200-MeV region [37–43] mmay be interpreted in terms of either $J^P = 1^-$ $\rho(770) \to \omega\pi$ production [44], or $J^P = 1^+$ $b_1(1235)$ production [42,43]. We argue that no special entry for a $\rho(1250)$ is needed. The LASS amplitude analysis [45] showing evidence for $\rho(1270)$ is preliminary and needs confirmation. For completeness, the relevant observations are listed under the $\rho(1450)$.

Recently [46] reported a very broad 1^{--} resonance-like K^+K^- state in $J/\psi \to K^+K^-\pi^0$ decays. Its pole position corresponds to mass of 1576 MeV and width of 818 MeV. [47–49] ssuggest its exotic structure (molecular or multiquark), while [50] and [51] explain it by the interference between the $\rho(1450)$ and $\rho(1700)$. The latter statement is qualitatively supported by BaBar [52] and SND [53]. We quote [46] as $X(1575)$ in the section "Further States."

Evidence for ρ-like mesons decaying into 6π states was first noted by [54] in the analysis of 6π mass spectra from e^+e^- annihilation [55,56] and diffractive photoproduction [57]. Clegg [54] argued that two states at about 2.1 and 1.8 GeV exist: while the former is a candidate for the $\rho(2150)$, the latter could be a manifestation of the $\rho(1700)$ distorted by threshold effects. BaBar reported observations of the new decay modes of the $\rho(2150)$ in the channels $\eta'(958)\pi^+\pi^-$ and $f_1(1285)\pi^+\pi^-$ [58]. The relativistic quark model [59] predicts the 2^3D_1 state with $J^{PC} = 1^{--}$ at 2.15 GeV which can be identified with the $\rho(2150)$.

We no longer list under a separate particle $\rho(1900)$ various observations of irregular behavior of the cross sections near the $N\bar{N}$ threshold. Dips of various width around 1.9 GeV were reported by the E687 Collaboration (a narrow one in the $3\pi^+3\pi^-$ diffractive photoproduction [60,61]) , by the FENICE experiment (a narrow structure in the R value [62]) , by BaBar in ISR (a narrow structure in $e^+e^- \to \phi\pi$ final state [63], but much broader in $e^+e^- \to 3\pi^+3\pi^-$ and $e^+e^- \to 2(\pi^+\pi^-\pi^0)$ [64]) , by CMD-3 (also a rather broad dip in $e^+e^- \to 3\pi^+3\pi^-$ [65]) . A dedicated scan of the $N\bar{N}$-threshold region by CMD-3 confirms this effect in the $e^+e^- \to 3\pi^+3\pi^-$ and $e^+e^- \to K^+K^-\pi^+\pi^-$ final states, but does not see it in the cross section of $e^+e^- \to 2\pi^+2\pi^-$ [66]. Most probably, these structures emerge as a threshold effect due to the opening of the $N\bar{N}$ channel [67,68,69].

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$\rho(1450)$ MASS

$\rho(1450)$ MASS

VALUE (MeV)	*DOCUMENT ID*

1465±25 OUR ESTIMATE This is only an educated guess; the error given is larger than the error on the average of the published values.

$\eta\rho^0$ MODE

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1506 ± 11	13.4k	[1] GRIBANOV	20	CMD3	1.1–2.0 $e^+e^- \rightarrow \eta\pi^+\pi^-$
1500 ± 10	7.4k	[2] ACHASOV	18	SND	1.22–2.00 $e^+e^- \rightarrow \eta\pi^+\pi^-$
1497 ± 14		[3] AKHMETSHIN	01B	CMD2	$e^+e^- \rightarrow \eta\gamma$
1421 ± 15		[4] AKHMETSHIN	00D	CMD2	$e^+e^- \rightarrow \eta\pi^+\pi^-$
1470 ± 20		ANTONELLI	88	DM2	$e^+e^- \rightarrow \eta\pi^+\pi^-$
1446 ± 10		FUKUI	88	SPEC	8.95 $\pi^- p \rightarrow \eta\pi^+\pi^- n$

[1] Mass and width of the $\rho(770)$ fixed at 775 and 149 MeV, respectively; solution 2 of model 2, $\eta \rightarrow \gamma\gamma$ decays used.

[2] From the combined fit of AULCHENKO 15 and ACHASOV 18 in the model with the interfering $\rho(1450)$, $\rho(1700)$ and $\rho(2150)$ with the parameters of the $\rho(1450)$ and $\rho(1700)$ floating and the mass and width of the $\rho(2150)$ fixed at 2155 MeV and 320 MeV, respectively. The phases of the resonances are π, 0 and π, respectively.

[3] Using the data of AKHMETSHIN 01B on $e^+e^- \rightarrow \eta\gamma$, AKHMETSHIN 00D and ANTONELLI 88 on $e^+e^- \rightarrow \eta\pi^+\pi^-$.

[4] Using the data of ANTONELLI 88, DOLINSKY 91, and AKHMETSHIN 00D. The energy-independent width of the $\rho(1450)$ and $\rho(1700)$ mesons assumed.

$\omega\pi$ MODE

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1510 ± 7	10.2k	[1] ACHASOV	16D	SND	1.05–2.00 $e^+e^- \rightarrow \pi^0\pi^0\gamma$
$1544 \pm 22 ^{+11}_{-46}$	821	[2] MATVIENKO	15	BELL	$\overline{B}^0 \rightarrow D^{*+}\omega\pi^-$
1491 ± 19	7815	[3] ACHASOV	13	SND	1.05–2.00 $e^+e^- \rightarrow \pi^0\pi^0\gamma$
$1582 \pm 17 \pm 25$	2382	[4] AKHMETSHIN	03B	CMD2	$e^+e \rightarrow \pi^0\pi^0\gamma$
$1349 \pm 25 ^{+10}_{-5}$	341	[5] ALEXANDER	01B	CLE2	$B \rightarrow D^{(*)}\omega\pi^-$
1523 ± 10		[6] EDWARDS	00A	CLE2	$\tau^- \rightarrow \omega\pi^-\nu_\tau$

1463 ± 25	[7] CLEGG 94	RVUE	
1250	[8] ASTON 80C	OMEG	20–70 $\gamma p \to \omega \pi^0 p$
1290 ± 40	[8] BARBER 80C	SPEC	3–5 $\gamma p \to \omega \pi^0 p$

[1] From a phenomenological model based on vector meson dominance with interfering $\rho(770)$, $\rho(1450)$, and $\rho(1700)$. The $\rho(1700)$ mass and width are fixed at 1720 MeV and 250 MeV, respectively. Systematic uncertainties not estimated. Supersedes ACHASOV 13.

[2] Using Breit-Wigner parameterization of the $\rho(1450)$ and assuming equal probabilities of the $\rho(1450) \to \pi\pi$ and $\rho(1450) \to \omega\pi$ decays.

[3] From a phenomenological model based on vector meson dominance with the interfering $\rho(1450)$ and $\rho(1700)$ and their widths fixed at 400 and 250 MeV, respectively. Systematic uncertainty not estimated.

[4] Using the data of AKHMETSHIN 03B and BISELLO 91B assuming the $\omega\pi^0$ and $\pi^+\pi^-$ mass dependence of the total width. $\rho(1700)$ mass and width fixed at 1700 MeV and 240 MeV, respectively.

[5] Using Breit-Wigner parameterization of the $\rho(1450)$ and assuming the $\omega\pi^-$ mass dependence for the total width.

[6] Mass-independent width parameterization. $\rho(1700)$ mass and width fixed at 1700 MeV and 235 MeV respectively.

[7] Using data from BISELLO 91B, DOLINSKY 86 and ALBRECHT 87L.

[8] Not separated from $b_1(1235)$, not pure $J^P = 1^-$ effect.

4π MODE

VALUE (MeV)	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1435 ± 40	ABELE 01B	CBAR	0.0 $\overline{p} n \to 2\pi^- 2\pi^0 \pi^+$
1350 ± 50	ACHASOV 97	RVUE	$e^+ e^- \to 2(\pi^+ \pi^-)$
1449 ± 4	[1] ARMSTRONG 89E	OMEG	300 $p p \to p p 2(\pi^+ \pi^-)$

[1] Not clear whether this observation has I=1 or 0.

ππ MODE

VALUE (MeV)	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1326.35 ± 3.46		[1] BARTOS 17	RVUE	$e^+ e^- \to \pi^+ \pi^-$
1342.31 ± 46.62		[2] BARTOS 17A	RVUE	$e^+ e^- \to \pi^+ \pi^-$
1373.83 ± 11.37		[3] BARTOS 17A	RVUE	$\tau^- \to \pi^- \pi^0 \nu_\tau$
1429 ± 41	20k	[4] LEES 17C	BABR	$J/\psi \to \pi^+ \pi^- \pi^0$
$1350 \pm 20 {}^{+20}_{-30}$	63.5k	[5] ABRAMOWICZ 12	ZEUS	$e p \to e \pi^+ \pi^- p$
1493 ± 15		[6] LEES 12G	BABR	$e^+ e^- \to \pi^+ \pi^- \gamma$
$1446 \pm 7 \pm 28$	5.4M	[7,8] FUJIKAWA 08	BELL	$\tau^- \to \pi^- \pi^0 \nu_\tau$
1328 ± 15		[9] SCHAEL 05C	ALEP	$\tau^- \to \pi^- \pi^0 \nu_\tau$
1406 ± 15	87k	[7,10] ANDERSON 00A	CLE2	$\tau^- \to \pi^- \pi^0 \nu_\tau$
~ 1368		[11] ABELE 99C	CBAR	0.0 $\overline{p} d \to \pi^+ \pi^- \pi^- p$
1348 ± 33		BERTIN 98	OBLX	0.05–0.405 $\overline{n} p \to 2\pi^+ \pi^-$
1411 ± 14		[12] ABELE 97	CBAR	$\overline{p} n \to \pi^- \pi^0 \pi^0$
$1370 {}^{+90}_{-70}$		ACHASOV 97	RVUE	$e^+ e^- \to \pi^+ \pi^-$
1359 ± 40		[10] BERTIN 97C	OBLX	0.0 $\overline{p} p \to \pi^+ \pi^- \pi^0$
1282 ± 37		BERTIN 97D	OBLX	0.05 $\overline{p} p \to 2\pi^+ 2\pi^-$

1424 ±25	BISELLO	89	DM2	$e^+e^- \rightarrow \pi^+\pi^-$
1265.5 ±75.3	DUBNICKA	89	RVUE	$e^+e^- \rightarrow \pi^+\pi^-$
1292 ±17	[13] KURDADZE	83	OLYA	0.64–1.4 $e^+e^- \rightarrow \pi^+\pi^-$

[1] Applies the Unitary & Analytic Model of the pion electromagnetic form factor of DUBNICKA 10 to analyze the data of LEES 12G and ABLIKIM 16C.

[2] Applies the Unitary & Analytic Model of the pion electromagnetic form factor of DUBNICKA 10 to analyze the data of ACHASOV 06, AKHMETSHIN 07, AUBERT 09AS, and AMBROSINO 11A.

[3] Applies the Unitary & Analytic Model of the pion electromagnetic form factor of DUBNICKA 10 to analyze the data of FUJIKAWA 08.

[4] From a Dalitz plot analysis in an isobar model with $\rho(1450)$ and $\rho(1700)$ masses and widths floating.

[5] Using the KUHN 90 parametrization of the pion form factor, neglecting ρ—ω interference.

[6] Using the GOUNARIS 68 parametrization of the pion form factor leaving the masses and widths of the $\rho(1450)$, $\rho(1700)$, and $\rho(2150)$ resonances as free parameters of the fit.

[7] From the GOUNARIS 68 parametrization of the pion form factor.

[8] $|F_\pi(0)|^2$ fixed to 1.

[9] From the combined fit of the τ^- data from ANDERSON 00A and SCHAEL 05C and e^+e^- data from the compilation of BARKOV 85, AKHMETSHIN 04, and ALOISIO 05. $\rho(1700)$ mass and width fixed at 1713 MeV and 235 MeV, respectively. Supersedes BARATE 97M.

[10] $\rho(1700)$ mass and width fixed at 1700 MeV and 235 MeV, respectively.

[11] $\rho(1700)$ mass and width fixed at 1780 MeV and 275 MeV respectively.

[12] T-matrix pole.

[13] Using for $\rho(1700)$ mass and width 1600 ± 20 and 300 ± 10 MeV respectively.

$K\overline{K}$ MODE

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •						
1208 ±8 ±9	190k	[1] AAIJ	16N	LHCB		$D^0 \rightarrow K^0_S K^\pm \pi^\mp$
1422.8±6.5	27k	[2] ABELE	99D	CBAR	±	0.0 $\overline{p}p \rightarrow K^+K^-\pi^0$

[1] Using the GOUNARIS 68 parameterization with fixed width.

[2] K-matrix pole. Isospin not determined, could be $\omega(1420)$.

$K\overline{K}^*(892)$ + c.c. MODE

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1505±19±7	AUBERT	08S	BABR	10.6 $e^+e^- \rightarrow K\overline{K}^*(892)\gamma$

$m_{\rho(1450)^0} - m_{\rho(1450)^\pm}$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−31.53±47.99	[1] BARTOS	17A	RVUE	$e^+e^- \rightarrow \pi^+\pi^-$, $\tau^- \rightarrow \pi^-\pi^0\nu_\tau$

[1] Applies the Unitary & Analytic Model of the pion electromagnetic form factor of DUBNICKA 10 to analyze the data of ACHASOV 06, AKHMETSHIN 07, AUBERT 09AS, AMBROSINO 11A, and FUJIKAWA 08.

$\rho(1450)$ WIDTH

$\rho(1450)$ WIDTH

VALUE (MeV)	*DOCUMENT ID*	*TECN*	*COMMENT*
400± 60 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. • • •			
480 ± 180	[1] ACHASOV 10D	SND	1.075–2.0 $e^+ e^- \to \pi^0 \gamma$

[1] From a fit of a VMD model with two effective resonances with masses of 1450 MeV and 1700 MeV to describe the excited vector states $\omega(1420)$, $\rho(1450)$, $\omega(1650)$, and $\rho(1700)$. Systematic errors not evaluated.

$\eta\rho^0$ MODE

VALUE (MeV)	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
321 ± 27	13.4k	[1] GRIBANOV 20	CMD3	1.1–2.0 $e^+ e^- \to \eta\pi^+\pi^-$
280 ± 20	7.4k	[2] ACHASOV 18	SND	1.22–2.00 $e^+ e^- \to \eta\pi^+\pi^-$
226 ± 44		[3] AKHMETSHIN 01B	CMD2	$e^+ e^- \to \eta\gamma$
211 ± 31		[4] AKHMETSHIN 00D	CMD2	$e^+ e^- \to \eta\pi^+\pi^-$
230 ± 30		ANTONELLI 88	DM2	$e^+ e^- \to \eta\pi^+\pi^-$
60 ± 15		FUKUI 88	SPEC	8.95 $\pi^- p \to \eta\pi^+\pi^- n$

[1] Mass and width of the $\rho(770)$ fixed at 775 and 149 MeV, respectively; solution 2 of model 2, $\eta \to \gamma\gamma$ decays used.

[2] From the combined fit of AULCHENKO 15 and ACHASOV 18 in the model with the interfering $\rho(1450)$, $\rho(1700)$ and $\rho(2150)$ with the parameters of the $\rho(1450)$ and $\rho(1700)$ floating and the mass and width of the $\rho(2150)$ fixed at 2155 MeV and 320 MeV, respectively. The phases of the resonances are π, 0 and π, respectively.

[3] Using the data of AKHMETSHIN 01B on $e^+ e^- \to \eta\gamma$, AKHMETSHIN 00D and ANTONELLI 88 on $e^+ e^- \to \eta\pi^+\pi^-$.

[4] Using the data of ANTONELLI 88, DOLINSKY 91, and AKHMETSHIN 00D. The energy-independent width of the $\rho(1450)$ and $\rho(1700)$ mesons assumed.

$\omega\pi$ MODE

VALUE (MeV)	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
440 ± 40	10.2k	[1] ACHASOV 16D	SND	1.05–2.00 $e^+ e^- \to \pi^0\pi^0\gamma$
303^{+31+69}_{-52-7}	821	[2] MATVIENKO 15	BELL	$\overline{B}^0 \to D^{*+}\omega\pi^-$
$429 \pm 42 \pm 10$	2382	[3] AKHMETSHIN 03B	CMD2	$e^+ e \to \pi^0\pi^0\gamma$
$547 \pm 86^{+46}_{-45}$	341	[4] ALEXANDER 01B	CLE2	$B \to D^{(*)}\omega\pi^-$
400 ± 35		[5] EDWARDS 00A	CLE2	$\tau^- \to \omega\pi^-\nu_\tau$
311 ± 62		[6] CLEGG 94	RVUE	
300		[7] ASTON 80C	OMEG	20–70 $\gamma p \to \omega\pi^0 p$
320 ± 100		[7] BARBER 80C	SPEC	3–5 $\gamma p \to \omega\pi^0 p$

[1] From a phenomenological model based on vector meson dominance with interfering $\rho(770)$, $\rho(1450)$, and $\rho(1700)$. The $\rho(1700)$ mass and width are fixed at 1720 MeV and 250 MeV, respectively. Systematic uncertainties not estimated. Supersedes ACHASOV 13.

[2] Using Breit-Wigner parameterization of the $\rho(1450)$ and assuming equal probabilities of the $\rho(1450) \to \pi\pi$ and $\rho(1450) \to \omega\pi$ decays.

[3] Using the data of AKHMETSHIN 03B and BISELLO 91B assuming the $\omega\pi^0$ and $\pi^+\pi^-$ mass dependence of the total width. $\rho(1700)$ mass and width fixed at 1700 MeV and 240 MeV, respectively.

[4] Using Breit-Wigner parameterization of the $\rho(1450)$ and assuming the $\omega\pi^-$ mass dependence for the total width.

[5] Mass-independent width parameterization. $\rho(1700)$ mass and width fixed at 1700 MeV and 235 MeV respectively.

[6] Using data from BISELLO 91B, DOLINSKY 86 and ALBRECHT 87L.

[7] Not separated from $b_1(1235)$, not pure $J^P = 1^-$ effect.

4π MODE

VALUE (MeV)	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •			
325±100	ABELE 01B	CBAR	0.0 $\bar{p}n \to 2\pi^-2\pi^0\pi^+$

$\pi\pi$ MODE

VALUE (MeV)	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
324.13± 12.01		[1] BARTOS 17	RVUE	$e^+e^- \to \pi^+\pi^-$
492.17±138.38		[2] BARTOS 17A	RVUE	$e^+e^- \to \pi^+\pi^-$
340.87± 23.84		[3] BARTOS 17A	RVUE	$\tau^- \to \pi^-\pi^0\nu_\tau$
576 ± 29	20k	[4] LEES 17C	BABR	$J/\psi \to \pi^+\pi^-\pi^0$
$460 \pm 30 \, {}^{+40}_{-45}$	63.5k	[5] ABRAMOWICZ 12	ZEUS	$e p \to e \pi^+\pi^- p$
427 ± 31		[6] LEES 12G	BABR	$e^+e^- \to \pi^+\pi^-\gamma$
434 ± 16 ±60	5.4M	[7,8] FUJIKAWA 08	BELL	$\tau^- \to \pi^-\pi^0\nu_\tau$
468 ± 41		[9] SCHAEL 05C	ALEP	$\tau^- \to \pi^-\pi^0\nu_\tau$
455 ± 41	87k	[7,10] ANDERSON 00A	CLE2	$\tau^- \to \pi^-\pi^0\nu_\tau$
∼ 374		[11] ABELE 99C	CBAR	0.0 $\bar{p}d \to \pi^+\pi^-\pi^- p$
275 ± 10		BERTIN 98	OBLX	0.05–0.405 $\bar{n}p \to \pi^+\pi^+\pi^-$
343 ± 20		[12] ABELE 97	CBAR	$\bar{p}n \to \pi^-\pi^0\pi^0$
310 ± 40		[10] BERTIN 97C	OBLX	0.0 $\bar{p}p \to \pi^+\pi^-\pi^0$
236 ± 36		BERTIN 97D	OBLX	0.05 $\bar{p}p \to 2\pi^+2\pi^-$
269 ± 31		BISELLO 89	DM2	$e^+e^- \to \pi^+\pi^-$
391 ± 70		DUBNICKA 89	RVUE	$e^+e^- \to \pi^+\pi^-$
218 ± 46		[13] KURDADZE 83	OLYA	0.64–1.4 $e^+e^- \to \pi^+\pi^-$

[1] Applies the Unitary & Analytic Model of the pion electromagnetic form factor of DUBNICKA 10 to analyze the data of LEES 12G and ABLIKIM 16C.

[2] Applies the Unitary & Analytic Model of the pion electromagnetic form factor of DUBNICKA 10 to analyze the data of ACHASOV 06, AKHMETSHIN 07, AUBERT 09AS, and AMBROSINO 11A.

[3] Applies the Unitary & Analytic Model of the pion electromagnetic form factor of DUBNICKA 10 to analyze the data of FUJIKAWA 08.

[4] From a Dalitz plot analysis in an isobar model with $\rho(1450)$ and $\rho(1700)$ masses and widths floating.

[5] Using the KUHN 90 parametrization of the pion form factor, neglecting ρ—ω interference.

[6] Using the GOUNARIS 68 parametrization of the pion form factor leaving the masses and widths of the $\rho(1450)$, $\rho(1700)$, and $\rho(2150)$ resonances as free parameters of the fit.

[7] From the GOUNARIS 68 parametrization of the pion form factor.

[8] $|F_\pi(0)|^2$ fixed to 1.

[9] From the combined fit of the τ^- data from ANDERSON 00A and SCHAEL 05C and e^+e^- data from the compilation of BARKOV 85, AKHMETSHIN 04, and ALOISIO 05. $\rho(1700)$ mass and width fixed at 1713 MeV and 235 MeV, respectively. Supersedes BARATE 97M.
[10] $\rho(1700)$ mass and width fixed at 1700 MeV and 235 MeV, respectively.
[11] $\rho(1700)$ mass and width fixed at 1780 MeV and 275 MeV respectively.
[12] T-matrix pole.
[13] Using for $\rho(1700)$ mass and width 1600 ± 20 and 300 ± 10 MeV respectively.

$K\overline{K}$ MODE

VALUE (MeV)	*EVTS*	*DOCUMENT ID*	*TECN*	*CHG*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
410 ±19 ±35	190k	[1] AAIJ 16N	LHCB		$D^0 \to K^0_S K^\pm \pi^\mp$
146.5±10.5	27k	[2] ABELE 99D	CBAR	±	0.0 $\overline{p}p \to K^+K^-\pi^0$

[1] Using the GOUNARIS 68 parameterization with fixed mass.
[2] K-matrix pole. Isospin not determined, could be $\omega(1420)$.

$K\overline{K}^*(892)$ + c.c. MODE

VALUE (MeV)	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •			
418±25±4	AUBERT 08S	BABR	10.6 $e^+e^- \to K\overline{K}^*(892)\gamma$

$\Gamma_{\rho(1450)^0} - \Gamma_{\rho(1450)^\pm}$

VALUE (MeV)	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •			
151.30±140.42	[1] BARTOS 17A	RVUE	$e^+e^- \to \pi^+\pi^-$, $\tau^- \to \pi^-\pi^0\nu_\tau$

[1] Applies the Unitary & Analytic Model of the pion electromagnetic form factor of DUBNICKA 10 to analyze the data of ACHASOV 06, AKHMETSHIN 07, AUBERT 09AS, AMBROSINO 11A, and FUJIKAWA 08.

$\rho(1450)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$\pi\pi$	seen
Γ_2	$\pi^+\pi^-$	seen
Γ_3	4π	seen
Γ_4	$\omega\pi$	
Γ_5	$a_1(1260)\pi$	
Γ_6	$h_1(1170)\pi$	
Γ_7	$\pi(1300)\pi$	
Γ_8	$\rho\rho$	
Γ_9	$\rho(\pi\pi)_{S\text{-wave}}$	
Γ_{10}	e^+e^-	seen
Γ_{11}	$\eta\rho$	seen
Γ_{12}	$a_2(1320)\pi$	not seen

Γ_{13}	$K\overline{K}$	seen
Γ_{14}	K^+K^-	seen
Γ_{15}	$K\overline{K}^*(892)+$ c.c.	possibly seen
Γ_{16}	$\pi^0\gamma$	
Γ_{17}	$\eta\gamma$	seen
Γ_{18}	$f_0(500)\gamma$	not seen
Γ_{19}	$f_0(980)\gamma$	not seen
Γ_{20}	$f_0(1370)\gamma$	not seen
Γ_{21}	$f_2(1270)\gamma$	not seen

ρ(1450) Γ(i)Γ(e^+e^-)/Γ(total)

$\Gamma(\pi\pi) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_1\Gamma_{10}/\Gamma$

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

VALUE (keV)	*DOCUMENT ID*		*TECN*	*COMMENT*
0.12	[1] DIEKMAN	88	RVUE	$e^+e^- \rightarrow \pi^+\pi^-$
$0.027^{+0.015}_{-0.010}$	[2] KURDADZE	83	OLYA	0.64–1.4 $e^+e^- \rightarrow \pi^+\pi^-$

[1] Using total width = 235 MeV.

[2] Using for ρ(1700) mass and width 1600 ± 20 and 300 ± 10 MeV respectively.

$\Gamma(\eta\rho) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_{11}\Gamma_{10}/\Gamma$

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

VALUE (eV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
335±27±20	13.4k	[1] GRIBANOV	20	CMD3	1.1–2.0 $e^+e^- \rightarrow \eta\pi^+\pi^-$
210±24±10		[2] LEES	18	BABR	$e^+e^- \rightarrow \eta\pi^+\pi^-$
74±20		[3] AKHMETSHIN	00D	CMD2	$e^+e^- \rightarrow \eta\pi^+\pi^-$
91±19		ANTONELLI	88	DM2	$e^+e^- \rightarrow \eta\pi^+\pi^-$

[1] Mass and width of the ρ(770) fixed at 775 and 149 MeV, respectively; solution 2 of model 2, $\eta \rightarrow \gamma\gamma$ decays used.

[2] Includes non-resonant contribution. The selected fit model includes three ρ excited states. Model uncertainty is 20%.

[3] Using the data of ANTONELLI 88, DOLINSKY 91, and AKHMETSHIN 00D. The energy-independent width of the ρ(1450) and ρ(1700) mesons assumed.

$\Gamma(\eta\gamma) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_{17}\Gamma_{10}/\Gamma$

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

VALUE (eV)	*DOCUMENT ID*		*TECN*	*COMMENT*
<16.4	[1] AKHMETSHIN	05	CMD2	0.60-1.38 $e^+e^- \rightarrow \eta\gamma$
2.2±0.5±0.3	[2] AKHMETSHIN	01B	CMD2	$e^+e^- \rightarrow \eta\gamma$

[1] From 2γ decay mode of η using 1465 MeV and 310 MeV for the ρ(1450) mass and width. Recalculated by us.

[2] Using the data of AKHMETSHIN 01B on $e^+e^- \rightarrow \eta\gamma$, AKHMETSHIN 00D and ANTONELLI 88 on $e^+e^- \rightarrow \eta\pi^+\pi^-$. Recalculated by us using width of 226 MeV.

$\Gamma(K\overline{K}^*(892)+\text{c.c.}) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_{15}\Gamma_{10}/\Gamma$

VALUE (eV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$127 \pm 15 \pm 6$	AUBERT	08S	BABR	10.6 $e^+e^- \to K\overline{K}^*(892)\gamma$

$\rho(1450)$ $\Gamma(i)/\Gamma(\text{total}) \times \Gamma(e^+e^-)/\Gamma(\text{total})$

$\Gamma(\omega\pi)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_4/\Gamma \times \Gamma_{10}/\Gamma$

VALUE (units 10^{-6})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2.1 ± 0.4	10.2k	[1] ACHASOV	16D	SND	1.05–2.00 $e^+e^- \to \pi^0\pi^0\gamma$
5.3 ± 0.4	7815	[2] ACHASOV	13	SND	1.05–2.00 $e^+e^- \to \pi^0\pi^0\gamma$

[1] From a phenomenological model based on vector meson dominance with interfering $\rho(770)$, $\rho(1450)$, and $\rho(1700)$. The $\rho(1700)$ mass and width are fixed at 1720 MeV and 250 MeV, respectively. Systematic uncertainties not estimated. Supersedes ACHASOV 13.

[2] From a phenomenological model based on vector meson dominance with the interfering $\rho(1450)$ and $\rho(1700)$ and their widths fixed at 400 and 250 MeV, respectively. Systematic uncertainty not estimated.

$\Gamma(\eta\rho)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_{11}/\Gamma \times \Gamma_{10}/\Gamma$

VALUE (units 10^{-7})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
7.3 ± 0.3	7.4k	[1] ACHASOV	18	SND	1.22–2.00 $e^+e^- \to \eta\pi^+\pi^-$
$4.3^{+1.1}_{-0.9} \pm 0.2$	4.9k	[2] AULCHENKO	15	SND	1.22–2.00 $e^+e^- \to \eta\pi^+\pi^-$

[1] From the combined fit of AULCHENKO 15 and ACHASOV 18 in the model with the interfering $\rho(1450)$, $\rho(1700)$ and $\rho(2150)$ with the parameters of the $\rho(1450)$ and $\rho(1700)$ floating and the mass and width of the $\rho(2150)$ fixed at 2155 MeV and 320 MeV, respectively. The phases of the resonances are π, 0 and π, respectively.

[2] From a fit to the $e^+e^- \to \eta\pi^+\pi^-$ cross section with vector meson dominance model including $\rho(770)$, $\rho(1450)$, and $\rho(1700)$ decaying exclusively via $\eta\rho(770)$. Masses and widths of vector states are fixed to PDG 14. Coupling constants are assumed to be real.

$\Gamma(f_0(500)\gamma)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_{18}/\Gamma \times \Gamma_{10}/\Gamma$

VALUE (units 10^{-9})	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<4.0	90	ACHASOV	11	SND	$e^+e^- \to \pi^0\pi^0\gamma$

$\Gamma(\pi^0\gamma)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_{16}/\Gamma \times \Gamma_{10}/\Gamma$

VALUE (units 10^{-9})	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
2.3 ± 1.4	[1] ACHASOV	10D	SND	1.075–2.0 $e^+e^- \to \pi^0\gamma$

[1] From a fit of a VMD model with two effective resonances with masses of 1450 MeV and 1700 MeV to describe the excited vector states $\omega(1420)$, $\rho(1450)$, $\omega(1650)$, and $\rho(1700)$. Systematic errors not evaluated.

$\Gamma(f_0(980)\gamma)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_{19}/\Gamma \times \Gamma_{10}/\Gamma$

VALUE (units 10^{-9})	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<2.6	90	ACHASOV	11	SND	$e^+e^- \to \pi^0\pi^0\gamma$

$\Gamma(f_0(1370)\gamma)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_{20}/\Gamma \times \Gamma_{10}/\Gamma$

VALUE (units 10^{-9})	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<3.5	90	ACHASOV	11	SND	$e^+e^- \to \pi^0\pi^0\gamma$

$\Gamma(f_2(1270)\gamma)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_{21}/\Gamma \times \Gamma_{10}/\Gamma$

VALUE (units 10^{-9})	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<0.8	90	[1] ACHASOV	11	SND	$e^+e^- \to \pi^0\pi^0\gamma$

[1] Using Breit-Wigner parametrization of the $\rho(1450)$ with mass and width of 1465 MeV and 400 MeV, respectively.

$\rho(1450)$ BRANCHING RATIOS

$\Gamma(\pi\pi)/\Gamma(4\pi)$ Γ_1/Γ_3

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.37±0.10	[1,2] ABELE	01B	CBAR	0.0 $\bar{p}n \to 5\pi$

[1] $\omega\pi$ not included.

[2] Using ABELE 97.

$\Gamma(K^+K^-)/\Gamma(\pi^+\pi^-)$ Γ_{14}/Γ_2

VALUE (%)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
30.7±8.4±8.2	20k	[1] LEES	17C	BABR	$J/\psi \to h^+h^-\pi^0$

[1] From Dalitz plot analyses in isobar models.

$\Gamma(\omega\pi)/\Gamma_{\text{total}}$ Γ_4/Γ

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
seen	821	[1] MATVIENKO	15	BELL	$\overline{B}^0 \to D^{*+}\omega\pi^-$
seen	1.6k	ACHASOV	12	SND	$e^+e^- \to \pi^0\pi^0\gamma$
~ 0.21		CLEGG	94	RVUE	

[1] Using Breit-Wigner parameterization of the $\rho(1450)$ and assuming equal probabilities of the $\rho(1450) \to \pi\pi$ and $\rho(1450) \to \omega\pi$ decays.

$\Gamma(\pi\pi)/\Gamma(\omega\pi)$ Γ_1/Γ_4

VALUE	*DOCUMENT ID*		*TECN*
• • • We do not use the following data for averages, fits, limits, etc. • • •			
~ 0.32	CLEGG	94	RVUE

$\Gamma(\omega\pi)/\Gamma(4\pi)$ Γ_4/Γ_3

VALUE	*DOCUMENT ID*		*TECN*
• • • We do not use the following data for averages, fits, limits, etc. • • •			
<0.14	CLEGG	88	RVUE

$\Gamma(a_1(1260)\pi)/\Gamma(4\pi)$ Γ_5/Γ_3

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.27±0.08	[1] ABELE	01B	CBAR	0.0 $\bar{p}n \to 5\pi$

[1] $\omega\pi$ not included.

$\Gamma(h_1(1170)\pi)/\Gamma(4\pi)$ Γ_6/Γ_3

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.08 ± 0.04	[1] ABELE	01B	CBAR	0.0 $\overline{p}n \rightarrow 5\pi$

[1] $\omega\pi$ not included.

$\Gamma(\pi(1300)\pi)/\Gamma(4\pi)$ Γ_7/Γ_3

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.37 ± 0.13	[1] ABELE	01B	CBAR	0.0 $\overline{p}n \rightarrow 5\pi$

[1] $\omega\pi$ not included.

$\Gamma(\rho\rho)/\Gamma(4\pi)$ Γ_8/Γ_3

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.11 ± 0.05	[1] ABELE	01B	CBAR	0.0 $\overline{p}n \rightarrow 5\pi$

[1] $\omega\pi$ not included.

$\Gamma(\rho(\pi\pi)_{S\text{-wave}})/\Gamma(4\pi)$ Γ_9/Γ_3

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.17 ± 0.09	[1] ABELE	01B	CBAR	0.0 $\overline{p}n \rightarrow 5\pi$

[1] $\omega\pi$ not included.

$\Gamma(\eta\rho)/\Gamma_{\text{total}}$ Γ_{11}/Γ

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
seen	35	[1] ACHASOV	14	SND	1.15–2.00 $e^+e^- \rightarrow \eta\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.04		DONNACHIE	87B	RVUE	

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

$\Gamma(\eta\rho)/\Gamma(\omega\pi)$ Γ_{11}/Γ_4

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.081 ± 0.020	[1,2] AULCHENKO	15	SND	1.22–2.00 $e^+e^- \rightarrow \eta\pi^+\pi^-$
~ 0.24	[3] DONNACHIE	91	RVUE	
>2	FUKUI	91	SPEC	8.95 $\pi^-p \rightarrow \omega\pi^0 n$

[1] From a fit to the $e^+e^- \rightarrow \eta\pi^+\pi^-$ cross section with vector meson dominance model including $\rho(770)$, $\rho(1450)$, and $\rho(1700)$ decaying exclusively via $\eta\rho(770)$. Masses and widths of vector states are fixed to PDG 14. Coupling constants are assumed to be real.

[2] Reports the inverse of the quoted value as 12.3 ± 3.1.

[3] Using data from BISELLO 91B, DOLINSKY 86 and ALBRECHT 87L.

$\Gamma(\pi\pi)/\Gamma(\eta\rho)$ Γ_1/Γ_{11}

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1.3 ± 0.4	[1] AULCHENKO	15	SND	1.22–2.00 $e^+e^- \rightarrow \eta\pi^+\pi^-$

[1] From a fit to the $e^+e^- \rightarrow \eta\pi^+\pi^-$ cross section with vector meson dominance model including $\rho(770)$, $\rho(1450)$, and $\rho(1700)$ decaying exclusively via $\eta\rho(770)$. Masses and widths of vector states are fixed to PDG 14. Coupling constants are assumed to be real.

$\Gamma(a_2(1320)\pi)/\Gamma_{\text{total}}$ Γ_{12}/Γ

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

$\Gamma(K\overline{K})/\Gamma(\omega\pi)$ Γ_{13}/Γ_4

VALUE	*DOCUMENT ID*		*TECN*
• • • We do not use the following data for averages, fits, limits, etc. • • •			
<0.08	[1] DONNACHIE	91	RVUE

[1] Using data from BISELLO 91B, DOLINSKY 86 and ALBRECHT 87L.

$\Gamma(K\overline{K}^*(892)+\text{c.c.})/\Gamma_{\text{total}}$ Γ_{15}/Γ

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
possibly seen	COAN	04	CLEO	$\tau^- \rightarrow K^-\pi^-K^+\nu_\tau$

$\Gamma(\eta\gamma)/\Gamma_{\text{total}}$ Γ_{17}/Γ

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
seen	35	[1] ACHASOV	14	SND	1.15–2.00 $e^+e^- \rightarrow \eta\gamma$

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

ρ(1450) REFERENCES

GRIBANOV	20	JHEP 2001 112	S.S. Gribanov *et al.*	(CMD-3 Collab.)
ACHASOV	18	PR D97 012008	M.N. Achasov *et al.*	(SND Collab.)
LEES	18	PR D97 052007	J.P. Lees *et al.*	(BABAR Collab.)
BARTOS	17	PR D96 113004	E. Bartos *et al.*	
BARTOS	17A	IJMP A32 1750154	E. Bartos *et al.*	
LEES	17C	PR D95 072007	J.P. Lees *et al.*	(BABAR Collab.)
AAIJ	16N	PR D93 052018	R. Aaij *et al.*	(LHCb Collab.)
ABLIKIM	16C	PL B753 629	M. Ablikim *et al.*	(BESIII Collab.)
ACHASOV	16D	PR D94 112001	M.N. Achasov *et al.*	(SND Collab.)
AULCHENKO	15	PR D91 052013	V.M. Aulchenko *et al.*	(SND Collab.)
MATVIENKO	15	PR D92 012013	D. Matvienko *et al.*	(BELLE Collab.)
ACHASOV	14	PR D90 032002	M.N. Achasov *et al.*	(SND Collab.)
PDG	14	CP C38 070001	K. Olive *et al.*	(PDG Collab.)
ACHASOV	13	PR D88 054013	M.N. Achasov *et al.*	(SND Collab.)
ABRAMOWICZ	12	EPJ C72 1869	H. Abramowicz *et al.*	(ZEUS Collab.)
ACHASOV	12	JETPL 94 734 Translated from ZETFP 94 796.	M.N. Achasov *et al.*	
LEES	12G	PR D86 032013	J.P. Lees *et al.*	(BABAR Collab.)
PDG	12	PR D86 010001	J. Beringer *et al.*	(PDG Collab.)
ACHASOV	11	JETP 113 75 Translated from ZETF 140 87.	M.N. Achasov *et al.*	(SND Collab.)
AMBROSINO	11A	PL B700 102	F. Ambrosino *et al.*	(KLOE Collab.)
ACHASOV	10D	PR D98 112001	M.N. Achasov *et al.*	(SND Collab.)
DUBNICKA	10	APS 60 1	S. Dubnicka, A.Z. Dubnickova	
AUBERT	09AS	PRL 103 231801	B. Aubert *et al.*	(BABAR Collab.)
AUBERT	08S	PR D77 092002	B. Aubert *et al.*	(BABAR Collab.)
FUJIKAWA	08	PR D78 072006	M. Fujikawa *et al.*	(BELLE Collab.)
AKHMETSHIN	07	PL B648 28	R.R. Akhmetshin *et al.*	(Novosibirsk CMD-2 Collab.)
ACHASOV	06	JETP 103 380 Translated from ZETF 130 437.	M.N. Achasov *et al.*	(Novosibirsk SND Collab.)

AKHMETSHIN	05	PL B605 26	R.R. Akhmetshin *et al.*	(Novosibirsk CMD-2 Collab.)
ALOISIO	05	PL B606 12	A. Aloisio *et al.*	(KLOE Collab.)
SCHAEL	05C	PRPL 421 191	S. Schael *et al.*	(ALEPH Collab.)
AKHMETSHIN	04	PL B578 285	R.R. Akhmetshin *et al.*	(Novosibirsk CMD-2 Collab.)
COAN	04	PRL 92 232001	T.E. Coan *et al.*	(CLEO Collab.)
AKHMETSHIN	03B	PL B562 173	R.R. Akhmetshin *et al.*	(Novosibirsk CMD-2 Collab.)
ABELE	01B	EPJ C21 261	A. Abele *et al.*	(Crystal Barrel Collab.)
AKHMETSHIN	01B	PL B509 217	R.R. Akhmetshin *et al.*	(Novosibirsk CMD-2 Collab.)
ALEXANDER	01B	PR D64 092001	J.P. Alexander *et al.*	(CLEO Collab.)
AKHMETSHIN	00D	PL B489 125	R.R. Akhmetshin *et al.*	(Novosibirsk CMD-2 Collab.)
AMELIN	00	NP A668 83	D. Amelin *et al.*	(VES Collab.)
ANDERSON	00A	PR D61 112002	S. Anderson *et al.*	(CLEO Collab.)
EDWARDS	00A	PR D61 072003	K.W. Edwards *et al.*	(CLEO Collab.)
ABELE	99C	PL B450 275	A. Abele *et al.*	(Crystal Barrel Collab.)
ABELE	99D	PL B468 178	A. Abele *et al.*	(Crystal Barrel Collab.)
BERTIN	98	PR D57 55	A. Bertin *et al.*	(OBELIX Collab.)
ABELE	97	PL B391 191	A. Abele *et al.*	(Crystal Barrel Collab.)
ACHASOV	97	PR D55 2663	N.N. Achasov *et al.*	(NOVM)
BARATE	97M	ZPHY C76 15	R. Barate *et al.*	(ALEPH Collab.)
BERTIN	97C	PL B408 476	A. Bertin *et al.*	(OBELIX Collab.)
BERTIN	97D	PL B414 220	A. Bertin *et al.*	(OBELIX Collab.)
CLEGG	94	ZPHY C62 455	A.B. Clegg, A. Donnachie	(LANC, MCHS)
BISELLO	91B	NPBPS B21 111	D. Bisello	(DM2 Collab.)
DOLINSKY	91	PRPL 202 99	S.I. Dolinsky *et al.*	(NOVO)
DONNACHIE	91	ZPHY C51 689	A. Donnachie, A.B. Clegg	(MCHS, LANC)
FUKUI	91	PL B257 241	S. Fukui *et al.*	(SUGI, NAGO, KEK, KYOT+)
KUHN	90	ZPHY C48 445	J.H. Kuhn *et al.*	(MPIM)
ARMSTRONG	89E	PL B228 536	T.A. Armstrong, M. Benayoun	(ATHU, BARI, BIRM+)
BISELLO	89	PL B220 321	D. Bisello *et al.*	(DM2 Collab.)
DUBNICKA	89	JP G15 1349	S. Dubnicka *et al.*	(JINR, SLOV)
ANTONELLI	88	PL B212 133	A. Antonelli *et al.*	(DM2 Collab.)
CLEGG	88	ZPHY C40 313	A.B. Clegg, A. Donnachie	(MCHS, LANC)
DIEKMAN	88	PRPL 159 99	B. Diekmann	(BONN)
FUKUI	88	PL B202 441	S. Fukui *et al.*	(SUGI, NAGO, KEK, KYOT+)
ALBRECHT	87L	PL B185 223	H. Albrecht *et al.*	(ARGUS Collab.)
DONNACHIE	87B	ZPHY C34 257	A. Donnachie, A.B. Clegg	(MCHS, LANC)
DOLINSKY	86	PL B174 453	S.I. Dolinsky *et al.*	(NOVO)
BARKOV	85	NP B256 365	L.M. Barkov *et al.*	(NOVO)
KURDADZE	83	JETPL 37 733	L.M. Kurdadze *et al.*	(NOVO)
		Translated from ZETFP 37 613.		
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)
GOUNARIS	68	PRL 21 244	G.J. Gounaris, J.J. Sakurai	