$\rho(770)$

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

THE $\rho(770)$

Updated September 2019 by S. Eidelman (Novosibirsk) and G. Venanzoni (Pisa).

The determination of the parameters of the $\rho(770)$ is beset with many difficulties because of its large width. In physical region fits, the line shape does not correspond to a relativistic Breit-Wigner function with a P-wave width, but requires some additional shape parameter. This dependence on parameterization was demonstrated long ago [1]. Bose-Einstein correlations are another source of shifts in the $\rho(770)$ line shape, particularly in multiparticle final-state systems [2].

The same model dependence afflicts any other source of resonance parameters, such as the energy dependence of the phase shift δ^1_1, or the pole position. It is, therefore, not surprising that a study of $\rho(770)$ dominance in the decays of the η and η' reveals the need for specific dynamical effects, in addition to the $\rho(770)$ pole [3,4].

The cleanest determination of the $\rho(770)$ mass and width comes from e^+e^- annihilation and τ-lepton decays. Analysis of ALEPH [5] showed that the charged $\rho(770)$ parameters measured from τ-lepton decays are consistent with those of the neutral one determined from e^+e^- data [6]. This conclusion is qualitatively supported by the later studies of CLEO [7] and Belle [8]. However, comparison of the two-pion mass spectrum in τ decays from OPAL [9], CLEO [7], and ALEPH [10,11], and the $e^+e^- \to \pi^+\pi^-$ cross section from CMD-2 [12,13], showed significant discrepancies between the two shapes which can be as high as 10% above the ρ meson [14,15]. This discrepancy remains after measurements of the two-pion cross section in e^+e^-

annihilation at KLOE [16,17,18,19], SND [20,21], BaBar [22] and, more recently BESIII [23] The effect is not accounted for by isospin breaking [24,25,26,27], but the accuracy of its calculation may be overestimated [28,29].

This problem seems to be solved after a recent analysis in [30] which showed that after correcting the τ data for the missing $\rho-\gamma$ mixing contribution, besides the other known isospin symmetry violating corrections, the $\pi\pi$ I=1 part of the hadronic vacuum polarization contribution to the muon g$-$2 is fully compatible between τ based and e^+e^- based evaluations. The global fit of the whole set of the ρ, ω, and ϕ decays, taking into account mixing effects in the hidden local symmetry model, also showed consistency of the data on τ decays to two pions and e^+e^- annihilation [31,32]. However, because of the progress in e^+e^- data, the τ input is now less precise and less reliable due to additional theoretical uncertainties [33] decreasing importance of τ versus e^+e^- comparison for the determination of $\rho(770)$ parameters and other applications, like, e.g., calculations of hadronic vacuum polarization.

References

1. J. Pisut and M. Roos, Nucl. Phys. **B6**, 325 (1968).
2. G.D. Lafferty, Z. Phys. **C60**, 659 (1993).
3. A. Abele *et al.*, Phys. Lett. **B402**, 195 (1997).
4. M. Benayoun *et al.*, Eur. Phys. J. **C31**, 525 (2003).
5. R. Barate *et al.*, Z. Phys. **C76**, 15 (1997).
6. L.M. Barkov *et al.*, Nucl. Phys. **B256**, 365 (1985).
7. S. Anderson *et al.*, Phys. Rev. **D61**, 112002 (2000).
8. M. Fujikawa *et al.*, Phys. Rev. **D78**, 072006 (2008).
9. K. Ackerstaff *et al.*, Eur. Phys. J. **C7**, 571 (1999).
10. M. Davier *et al.*, Nucl. Phys. (Proc. Supp.) **B123**, 47 (2003).

11. S. Schael *et al.*, Phys. Reports **421**, 191 (2005).
12. R.R. Akhmetshin *et al.*, Phys. Lett. **B527**, 161 (2002).
13. R.R. Akhmetshin *et al.*, Phys. Lett. **B578**, 285 (2004).
14. M. Davier *et al.*, Eur. Phys. J. **C27**, 497 (2003).
15. M. Davier *et al.*, Eur. Phys. J. **C31**, 503 (2003).
16. A. Aloisio *et al.*, Phys. Lett. **B606**, 12 (2005).
17. F. Ambrosino *et al.*, Phys. Lett. **B670**, 285 (2009).
18. F. Ambrosino *et al.*, Phys. Lett. **B700**, 102 (2011).
19. D. Babusci *et al.*, Phys. Lett. **B720**, 336 (2013).
20. M.N. Achasov *et al.*, Sov. Phys. JETP **101**, 1053 (2005).
21. M.N. Achasov *et al.*, Sov. Phys. JETP **103**, 380 (2006).
22. B. Aubert *et al.*, Phys. Rev. Lett. **103**, 231801 (2009).
23. M. Ablikim *et al.*, Phys. Lett. **B753**, 629 (2016).
24. R. Alemany *et al.*, Eur. Phys. J. **C2**, 123 (1998).
25. H. Czyz and J.J. Kuhn, Eur. Phys. J. **C18**, 497 (2001).
26. V. Cirigliano *et al.*, Phys. Lett. **B513**, 361 (2001).
27. V. Cirigliano *et al.*, Eur. Phys. J. **C23**, 121 (2002).
28. K. Maltman and C.E. Wolfe, Phys. Rev. **D73**, 013004 (2006).
29. C.E. Wolfe and K. Maltman, Phys. Rev. **D80**, 114024 (2009).
30. F. Jegerlehner and R. Szafron, Eur. Phys. J. **C71**, 1632 (2011).
31. M. Benayoun *et al.*, Eur. Phys. J. **C72**, 1848 (2012).
32. M. Benayoun *et al.*, Eur. Phys. J. **C73**, 2453 (2013).
33. M. Davier *et al.*, Eur. Phys. J. **C77**, 827 (2017).

$\rho(770)$ T-MATRIX POLE $\sqrt{s}$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$(761^{+4}_{-3}) - i(71.7^{+1.9}_{-2.3})$	[1] GARCIA-MAR..11		RVUE	Compilation
$(763.7^{+1.7}_{-1.5}) - i(73.2^{+1.0}_{-1.1})$	[2] GARCIA-MAR..11		RVUE	Compilation
$(754 \pm 18) - i(74 \pm 10)$	[3] PELAEZ	04A	RVUE	$\pi\pi \to \pi\pi$

[1] Reanalysis of the K_{e4} data of BATLEY 10C and the $\pi N \to \pi\pi N$ data of HYAMS 73, GRAYER 74, and PROTOPOPESCU 73 using Roy equations.
[2] Reanalysis of the K_{e4} data of BATLEY 10C and the $\pi N \to \pi\pi N$ data of HYAMS 73, GRAYER 74, and PROTOPOPESCU 73 using GKPY equations.
[3] Reanalysis of data from PROTOPOPESCU 73, ESTABROOKS 74, GRAYER 74, and COHEN 80 in the unitarized ChPT model.

ρ(770) MASS

We no longer list S-wave Breit-Wigner fits, or data with high combinatorial background.

NEUTRAL ONLY, e^+e^-

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
775.26±0.23 OUR AVERAGE					
775.3 ±0.5 ±0.6		[1] ACHASOV	21	SND	$e^+e^- \to \pi^+\pi^-$
775.02±0.35		[2] LEES	12G	BABR	$e^+e^- \to \pi^+\pi^-\gamma$
775.97±0.46±0.70	900k	[3] AKHMETSHIN	07		$e^+e^- \to \pi^+\pi^-$
774.6 ±0.4 ±0.5	800k	[4,5] ACHASOV	06	SND	$e^+e^- \to \pi^+\pi^-$
775.65±0.64±0.50	114k	[6,7] AKHMETSHIN	04	CMD2	$e^+e^- \to \pi^+\pi^-$
775.9 ±0.5 ±0.5	1.98M	[8] ALOISIO	03	KLOE	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
775.8 ±0.9 ±2.0	500k	[8] ACHASOV	02	SND	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
775.9 ±1.1		[9] BARKOV	85	OLYA	$e^+e^- \to \pi^+\pi^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
763.49±0.53		[10] BARTOS	17	RVUE	$e^+e^- \to \pi^+\pi^-$
758.23±0.46		[11] BARTOS	17A	RVUE	$e^+e^- \to \pi^+\pi^-$
775.8 ±0.5 ±0.3	1.98M	[12] ALOISIO	03	KLOE	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
775.9 ±0.6 ±0.5	1.98M	[13] ALOISIO	03	KLOE	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
775.0 ±0.6 ±1.1	500k	[14] ACHASOV	02	SND	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
775.1 ±0.7 ±5.3		[15] BENAYOUN	98	RVUE	$e^+e^- \to \pi^+\pi^-$, $\mu^+\mu^-$
770.5 ±1.9 ±5.1		[16] GARDNER	98	RVUE	0.28–0.92 $e^+e^- \to \pi^+\pi^-$
764.1 ±0.7		[17] O'CONNELL	97	RVUE	$e^+e^- \to \pi^+\pi^-$
757.5 ±1.5		[18] BERNICHA	94	RVUE	$e^+e^- \to \pi^+\pi^-$
768 ±1		[19] GESHKEN...	89	RVUE	$e^+e^- \to \pi^+\pi^-$

[1] From a fit of the cross section in the energy range 0.525 < $\sqrt{s}$ < 0.883 GeV parameterized by the sum of the Breit-Wigner amplitudes for the ρ(770), ω and ρ(1450) resonances.
[2] Using the GOUNARIS 68 parametrization with the complex phase of the $\rho-\omega$ interference and leaving the masses and widths of the ρ(1450), ρ(1700), and ρ(2150) resonances as free parameters of the fit.
[3] A combined fit of AKHMETSHIN 07, AULCHENKO 06, and AULCHENKO 05.
[4] Supersedes ACHASOV 05A.
[5] A fit of the SND data from 400 to 1000 MeV using parameters of the ρ(1450) and ρ(1700) from a fit of the data of BARKOV 85, BISELLO 89 and ANDERSON 00A.
[6] Using the GOUNARIS 68 parametrization with the complex phase of the ρ-ω interference.
[7] Update of AKHMETSHIN 02.
[8] Assuming $m_{\rho^+} = m_{\rho^-}$, $\Gamma_{\rho^+} = \Gamma_{\rho^-}$.
[9] From the GOUNARIS 68 parametrization of the pion form factor.
[10] Applies the Unitary & Analytic Model of the pion electromagnetic form factor of DUBNICKA 10 to analyze the data of LEES 12G and ABLIKIM 16C.

[11] 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.
[12] Assuming $m_{\rho^+} = m_{\rho^-} = m_{\rho^0}$, $\Gamma_{\rho^+} = \Gamma_{\rho^-} = \Gamma_{\rho^0}$.
[13] Without limitations on masses and widths.
[14] Assuming $m_{\rho^0} = m_{\rho^\pm}$, $g_{\rho^0 \pi\pi} = g_{\rho^\pm \pi\pi}$.
[15] Using the data of BARKOV 85 in the hidden local symmetry model.
[16] From the fit to $e^+ e^- \rightarrow \pi^+ \pi^-$ data from the compilations of HEYN 81 and BARKOV 85, including the GOUNARIS 68 parametrization of the pion form factor.
[17] A fit of BARKOV 85 data assuming the direct $\omega\pi\pi$ coupling.
[18] Applying the S-matrix formalism to the BARKOV 85 data.
[19] Includes BARKOV 85 data. Model-dependent width definition.

CHARGED ONLY, τ DECAYS and $e^+ e^-$

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
775.11±0.34 OUR AVERAGE						
774.6 ±0.2 ±0.5	5.4M	[1,2] FUJIKAWA	08	BELL	±	$\tau^- \rightarrow \pi^- \pi^0 \nu_\tau$
775.5 ±0.7		[2,3] SCHAEL	05C	ALEP		$\tau^- \rightarrow \pi^- \pi^0 \nu_\tau$
775.5 ±0.5 ±0.4	1.98M	[4] ALOISIO	03	KLOE		1.02 $e^+ e^- \rightarrow \pi^+ \pi^- \pi^0$
775.1 ±1.1 ±0.5	87k	[5,6] ANDERSON	00A	CLE2		$\tau^- \rightarrow \pi^- \pi^0 \nu_\tau$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
761.60±0.95		[7] BARTOS	17A	RVUE		$\tau^- \rightarrow \pi^- \pi^0 \nu_\tau$
774.8 ±0.6 ±0.4	1.98M	[8] ALOISIO	03	KLOE	−	1.02 $e^+ e^- \rightarrow \pi^+ \pi^- \pi^0$
776.3 ±0.6 ±0.7	1.98M	[8] ALOISIO	03	KLOE	+	1.02 $e^+ e^- \rightarrow \pi^+ \pi^- \pi^0$
773.9 ±2.0 $^{+0.3}_{-1.0}$		[9] SANZ-CILLERO	03	RVUE		$\tau^- \rightarrow \pi^- \pi^0 \nu_\tau$
774.5 ±0.7 ±1.5	500k	[4] ACHASOV	02	SND	±	1.02 $e^+ e^- \rightarrow \pi^+ \pi^- \pi^0$
775.1 ±0.5		[10] PICH	01	RVUE		$\tau^- \rightarrow \pi^- \pi^0 \nu_\tau$

[1] $|F_\pi(0)|^2$ fixed to 1.
[2] From the GOUNARIS 68 parametrization of the pion form factor.
[3] The error combines statistical and systematic uncertainties. Supersedes BARATE 97M.
[4] Assuming $m_{\rho^+} = m_{\rho^-}$, $\Gamma_{\rho^+} = \Gamma_{\rho^-}$.
[5] $\rho(1700)$ mass and width fixed at 1700 MeV and 235 MeV respectively.
[6] From the GOUNARIS 68 parametrization of the pion form factor. The second error is a model error taking into account different parametrizations of the pion form factor.
[7] Applies the Unitary & Analytic Model of the pion electromagnetic form factor of DUBNICKA 10 to analyze the data of FUJIKAWA 08.
[8] Without limitations on masses and widths.
[9] Using the data of BARATE 97M and the effective chiral Lagrangian.
[10] From a fit of the model-independent parameterization of the pion form factor to the data of BARATE 97M.

MIXED CHARGES, OTHER REACTIONS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
763.0±0.3±1.2	600k	[1] ABELE	99E	CBAR	0±	0.0 $\overline{p} p \rightarrow \pi^+ \pi^- \pi^0$

[1] Assuming the equality of ρ^+ and ρ^- masses and widths.

CHARGED ONLY, HADROPRODUCED

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
766.5±1.1 OUR AVERAGE						
763.7±3.2		ABELE	97	CBAR		$\overline{p}n \to \pi^- \pi^0 \pi^0$
768 ±9		AGUILAR-...	91	EHS		400 pp
767 ±3	2935	[1] CAPRARO	87	SPEC	−	200 π^- Cu $\to \pi^- \pi^0$ Cu
761 ±5	967	[1] CAPRARO	87	SPEC	−	200 π^- Pb $\to \pi^- \pi^0$ Pb
771 ±4		HUSTON	86	SPEC	+	202 π^+ A $\to \pi^+ \pi^0$ A
766 ±7	6500	[2] BYERLY	73	OSPK	−	5 $\pi^- p$
766.8±1.5	9650	[3] PISUT	68	RVUE	−	1.7–3.2 $\pi^- p$, t <10
767 ±6	900	[1] EISNER	67	HBC	−	4.2 $\pi^- p$, t <10

[1] Mass errors enlarged by us to $\Gamma/\sqrt{N}$; see the note with the $K^*(892)$ mass.
[2] Phase shift analysis. Systematic errors added corresponding to spread of different fits.
[3] From fit of 3-parameter relativistic P-wave Breit-Wigner to total mass distribution. Includes BATON 68, MILLER 67B, ALFF-STEINBERGER 66, HAGOPIAN 66, HAGOPIAN 66B, JACOBS 66B, JAMES 66, WEST 66, BLIEDEN 65 and CARMONY 64.

NEUTRAL ONLY, PHOTOPRODUCED

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
769.2± 0.9 OUR AVERAGE					
770.8± 1.3$^{+2.3}_{-2.4}$	900k	ANDREEV	20	H1	$e p \to e \pi^+ \pi^- p$
771 ± 2 $^{+2}_{-1}$	63.5k	[1] ABRAMOWICZ	12	ZEUS	$e p \to e \pi^+ \pi^- p$
770 ± 2 ±1	79k	[2] BREITWEG	98B	ZEUS	50–100 γp
767.6± 2.7		BARTALUCCI	78	CNTR	$\gamma p \to e^+ e^- p$
775 ± 5		GLADDING	73	CNTR	2.9–4.7 γp
767 ± 4	1930	BALLAM	72	HBC	2.8 γp
770 ± 4	2430	BALLAM	72	HBC	4.7 γp
765 ±10		ALVENSLEB...	70	CNTR	γA, t <0.01
767.7± 1.9	140k	BIGGS	70	CNTR	<4.1 γC $\to \pi^+ \pi^-$ C
765 ± 5	4000	ASBURY	67B	CNTR	$\gamma +$ Pb
• • • We do not use the following data for averages, fits, limits, etc. • • •					
771 ± 2	79k	[3] BREITWEG	98B	ZEUS	50–100 γp

[1] Using the KUHN 90 parametrization of the pion form factor, neglecting ρ—ω interference.
[2] From the parametrization according to SOEDING 66.
[3] From the parametrization according to ROSS 66.

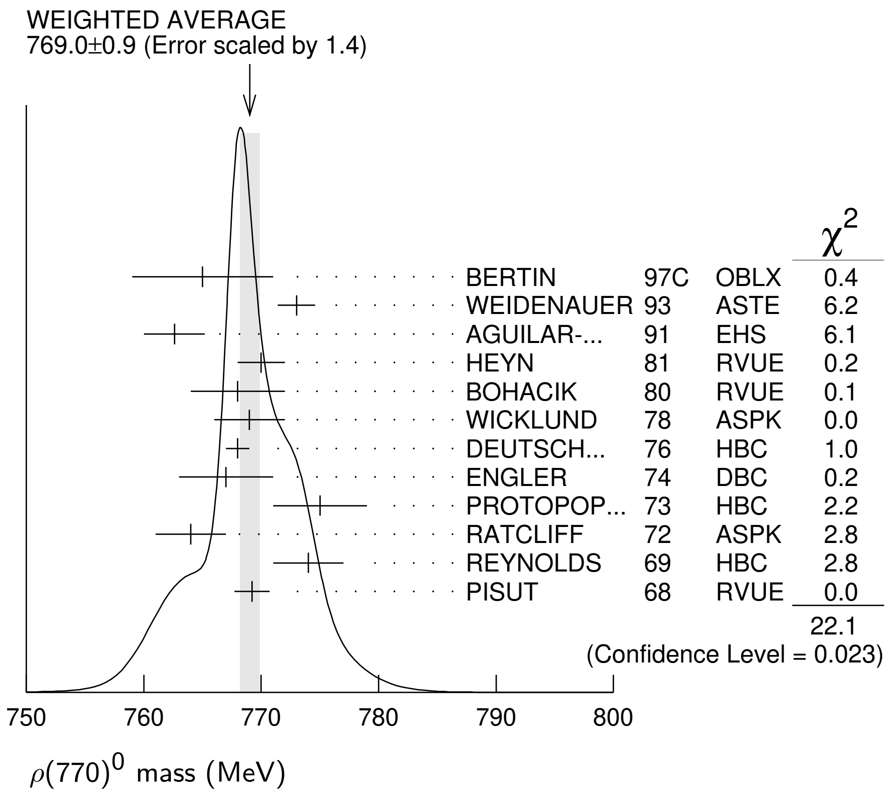
NEUTRAL ONLY, OTHER REACTIONS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
769.0 ±0.9 OUR AVERAGE	Error includes scale factor of 1.4. See the ideogram below.				
765 ±6		BERTIN	97C	OBLX	0.0 $\overline{p}p \to \pi^+ \pi^- \pi^0$
773 ±1.6		WEIDENAUER	93	ASTE	$\overline{p}p \to \pi^+ \pi^- \omega$
762.6 ±2.6		AGUILAR-...	91	EHS	400 pp
770 ±2		[1] HEYN	81	RVUE	Pion form factor
768 ±4		[2,3] BOHACIK	80	RVUE	
769 ±3		[4] WICKLUND	78	ASPK	3,4,6 $\pi^\pm N$
768 ±1	76k	DEUTSCH...	76	HBC	16 $\pi^+ p$
767 ±4	4100	ENGLER	74	DBC	6 $\pi^+ n \to \pi^+ \pi^- p$
775 ±4	32k	[2] PROTOPOP...	73	HBC	7.1 $\pi^+ p$, t <0.4
764 ±3	6.8k	[5] RATCLIFF	72	ASPK	15 $\pi^- p$, t <0.3

774	±3	1.7k		REYNOLDS	69	HBC	2.26 $\pi^- p$
769.2	±1.5	13.3k	[6]	PISUT	68	RVUE	1.7–3.2 $\pi^- p$, $t < 10$

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

774.34±0.18±0.35	970k	[7] ABLIKIM	18C	BES3	$\eta'(958) \to \gamma\pi^+\pi^-$
772.93±0.18±0.34	970k	[8] ABLIKIM	18C	BES3	$\eta'(958) \to \gamma\pi^+\pi^-$
773.5 ±2.5		[9] COLANGELO	01	RVUE	$\pi\pi \to \pi\pi$
762.3 ±0.5 ±1.2	600k	[10] ABELE	99E	CBAR	0.0 $\overline{p}p \to \pi^+\pi^-\pi^0$
777 ±2	4.9k	[11] ADAMS	97	E665	470 $\mu p \to \mu X B$
770 ±2		[12] BOGOLYUB...	97	MIRA	32 $\overline{p}p \to \pi^+\pi^- X$
768 ±8		[12] BOGOLYUB...	97	MIRA	32 $pp \to \pi^+\pi^- X$
761.1 ±2.9		DUBNICKA	89	RVUE	π form factor
777.4 ±2.0		[13] CHABAUD	83	ASPK	17 $\pi^- p$ polarized
769.5 ±0.7		[2,3] LANG	79	RVUE	
770 ±9		[3] ESTABROOKS	74	RVUE	17 $\pi^- p \to \pi^+\pi^- n$
773.5 ±1.7	11.2k	[14] JACOBS	72	HBC	2.8 $\pi^- p$
775 ±3	2.2k	[15] HYAMS	68	OSPK	11.2 $\pi^- p$



[1] HEYN 81 includes all spacelike and timelike F_π values until 1978.

[2] From pole extrapolation.

[3] From phase shift analysis of GRAYER 74 data.

[4] Phase shift analysis. Systematic errors added corresponding to spread of different fits.

[5] Published values contain misprints. Corrected by private communication RATCLIFF 74.

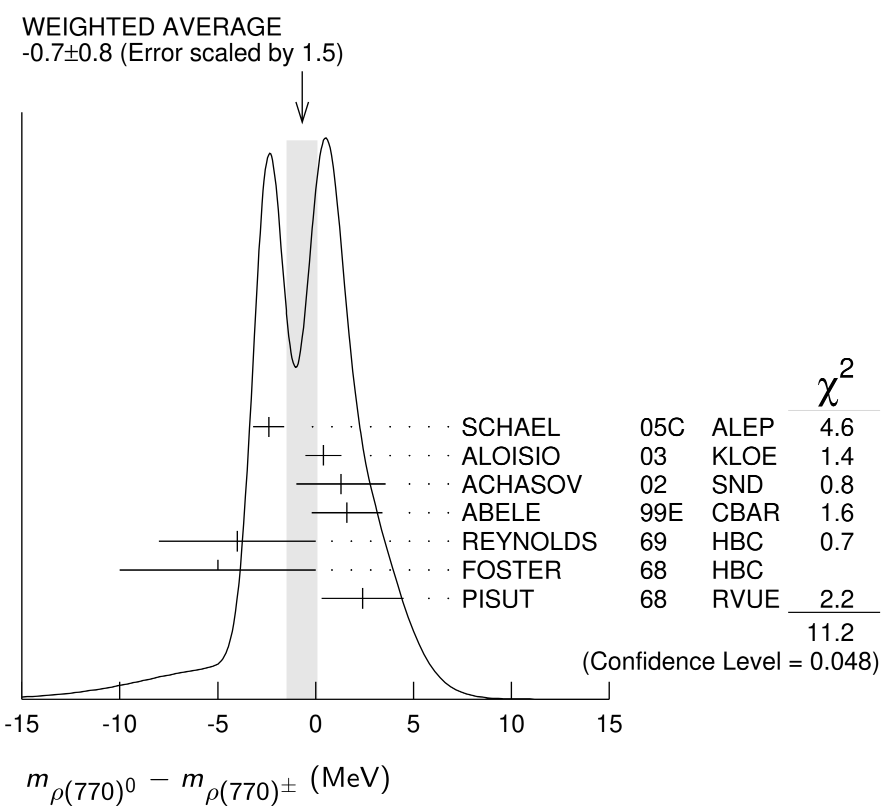
[6] Includes MALAMUD 69, ARMENISE 68, BACON 67, HUWE 67, MILLER 67B, ALFF-STEINBERGER 66, HAGOPIAN 66, HAGOPIAN 66B, JACOBS 66B, JAMES 66, WEST 66, GOLDHABER 64, ABOLINS 63.

[7] From a fit to $\pi^+\pi^-$ mass using $\rho(770)$ (parametrized with the Gounaris-Sakurai approach), $\omega(782)$, and box anomaly components.

[8] From a fit to $\pi^+\pi^-$ mass using $\rho(770)$ (parametrized with the Gounaris-Sakurai approach), $\omega(782)$, and $\rho(1450)$ components.
[9] Breit-Wigner mass from a phase-shift analysis of HYAMS 73 and PROTOPOPESCU 73 data.
[10] Using relativistic Breit-Wigner and taking into account ρ-ω interference.
[11] Systematic errors not evaluated.
[12] Systematic effects not studied.
[13] From fit of 3-parameter relativistic Breit-Wigner to helicity-zero part of P-wave intensity. CHABAUD 83 includes data of GRAYER 74.
[14] Mass errors enlarged by us to $\Gamma/\sqrt{N}$; see the note with the $K^*(892)$ mass.
[15] Of HYAMS 68 six parametrizations, this is theoretically soundest. MR

$m_{\rho(770)^0} - m_{\rho(770)^\pm}$

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
−0.7 ±0.8 OUR AVERAGE		Error includes scale factor of 1.5. See the ideogram below.				
−2.4 ±0.8		[1] SCHAEL	05C	ALEP		$\tau^- \to \pi^-\pi^0\nu_\tau$
0.4 ±0.7 ±0.6	1.98M	[2] ALOISIO	03	KLOE		$1.02\ e^+e^- \to \pi^+\pi^-\pi^0$
1.3 ±1.1 ±2.0	500k	[2] ACHASOV	02	SND		$1.02\ e^+e^- \to \pi^+\pi^-\pi^0$
1.6 ±0.6 ±1.7	600k	ABELE	99E	CBAR	±0	$0.0\ \overline{p}p \to \pi^+\pi^-\pi^0$
−4 ±4	3000	[3] REYNOLDS	69	HBC	−0	$2.26\ \pi^-p$
−5 ±5	3600	[3] FOSTER	68	HBC	±0	$0.0\ \overline{p}p$
2.4 ±2.1	22950	[4] PISUT	68	RVUE		$\pi N \to \rho N$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
−3.37±1.06		[5] BARTOS	17A	RVUE		$e^+e^- \to \pi^+\pi^-$, $\tau^- \to \pi^-\pi^0\nu_\tau$



[1] 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. Supersedes BARATE 97M.
[2] Assuming $m_{\rho^+} = m_{\rho^-}$, $\Gamma_{\rho^+} = \Gamma_{\rho^-}$.
[3] From quoted masses of charged and neutral modes.
[4] Includes MALAMUD 69, ARMENISE 68, BATON 68, BACON 67, HUWE 67, MILLER 67B, ALFF-STEINBERGER 66, HAGOPIAN 66, HAGOPIAN 66B, JACOBS 66B, JAMES 66, WEST 66, BLIEDEN 65, CARMONY 64, GOLDHABER 64, ABOLINS 63.
[5] 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.

$m_{\rho(770)^+} - m_{\rho(770)^-}$

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1.5±0.8±0.7	1.98M	[1] ALOISIO	03	KLOE	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$

[1] Without limitations on masses and widths.

ρ(770) RANGE PARAMETER

The range parameter R enters an energy-dependent correction to the width, of the form $(1 + q_r^2\ R^2)\ /\ (1 + q^2\ R^2)$, where q is the momentum of one of the pions in the $\pi\pi$ rest system. At resonance, $q = q_r$.

VALUE (GeV^{-1})	DOCUMENT ID		TECN	CHG	COMMENT
$5.3^{+0.9}_{-0.7}$	[1] CHABAUD	83	ASPK	0	17 $\pi^- p$ polarized

[1] The old PISUT 68 value, properly corrected, was 3.2 ± 0.6.

ρ(770) WIDTH

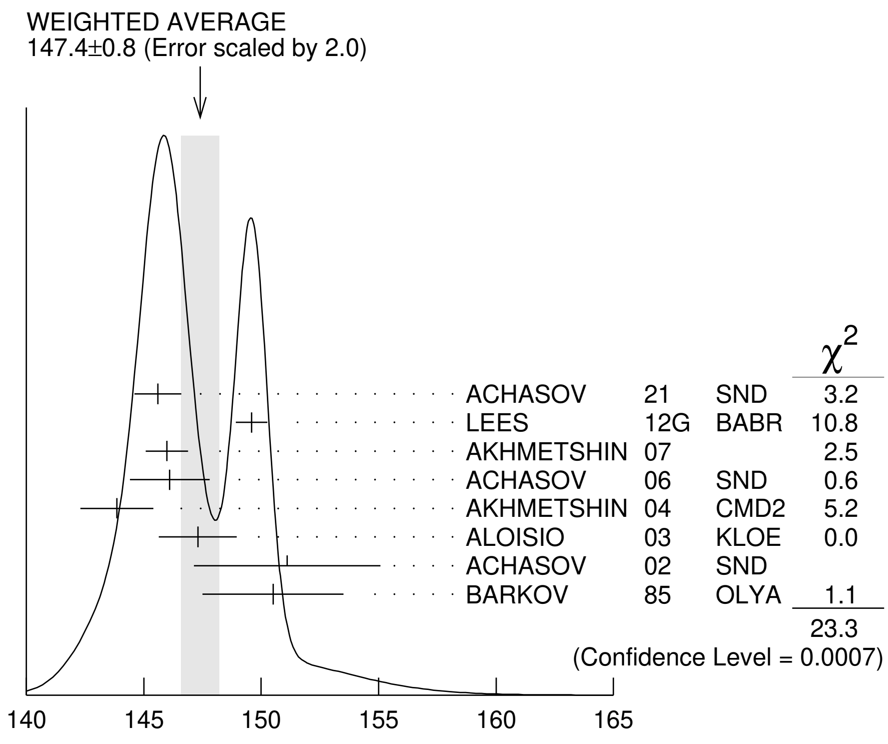
We no longer list S-wave Breit-Wigner fits, or data with high combinatorial background.

NEUTRAL ONLY, e^+e^-

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
147.4 ±0.8 OUR AVERAGE		Error includes scale factor of 2.0. See the ideogram below.			
145.6 ±0.6 ±0.8		[1] ACHASOV	21	SND	$e^+e^- \to \pi^+\pi^-$
149.59±0.67		[2] LEES	12G	BABR	$e^+e^- \to \pi^+\pi^-\gamma$
145.98±0.75±0.50	900k	[3] AKHMETSHIN	07		$e^+e^- \to \pi^+\pi^-$
146.1 ±0.8 ±1.5	800k	[4,5] ACHASOV	06	SND	$e^+e^- \to \pi^+\pi^-$
143.85±1.33±0.80	114k	[6,7] AKHMETSHIN	04	CMD2	$e^+e^- \to \pi^+\pi^-$
147.3 ±1.5 ±0.7	1.98M	[8] ALOISIO	03	KLOE	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
151.1 ±2.6 ±3.0	500k	[8] ACHASOV	02	SND	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
150.5 ±3.0		[9] BARKOV	85	OLYA	$e^+e^- \to \pi^+\pi^-$

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

144.06±0.85		[10] BARTOS	17	RVUE	$e^+e^- \to \pi^+\pi^-$
144.56±0.80		[11] BARTOS	17A	RVUE	$e^+e^- \to \pi^+\pi^-$
143.9 ±1.3 ±1.1	1.98M	[12] ALOISIO	03	KLOE	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
147.4 ±1.5 ±0.7	1.98M	[13] ALOISIO	03	KLOE	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
149.8 ±2.2 ±2.0	500k	[14] ACHASOV	02	SND	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
147.9 ±1.5 ±7.5		[15] BENAYOUN	98	RVUE	$e^+e^- \to \pi^+\pi^-$, $\mu^+\mu^-$
153.5 ±1.3 ±4.6		[16] GARDNER	98	RVUE	0.28–0.92 $e^+e^- \to \pi^+\pi^-$
145.0 ±1.7		[17] O'CONNELL	97	RVUE	$e^+e^- \to \pi^+\pi^-$
142.5 ±3.5		[18] BERNICHA	94	RVUE	$e^+e^- \to \pi^+\pi^-$
138 ±1		[19] GESHKEN...	89	RVUE	$e^+e^- \to \pi^+\pi^-$



Neutral only, e^+e^- (MeV)

[1] From a fit of the cross section in the energy range 0.525 < $\sqrt{s}$ < 0.883 GeV parameterized by the sum of the Breit-Wigner amplitudes for the $\rho(770)$, ω and $\rho(1450)$ resonances.

[2] Using the GOUNARIS 68 parametrization with the complex phase of the $\rho-\omega$ interference and leaving the masses and widths of the $\rho(1450)$, $\rho(1700)$, and $\rho(2150)$ resonances as free parameters of the fit.

[3] A combined fit of AKHMETSHIN 07, AULCHENKO 06, and AULCHENKO 05.

[4] Supersedes ACHASOV 05A.

[5] A fit of the SND data from 400 to 1000 MeV using parameters of the $\rho(1450)$ and $\rho(1700)$ from a fit of the data of BARKOV 85, BISELLO 89 and ANDERSON 00A.

[6] Using the GOUNARIS 68 parametrization with the complex phase of the ρ-ω interference.

[7] From a fit in the energy range 0.61 to 0.96 GeV. Update of AKHMETSHIN 02.

[8] Assuming $m_{\rho^+} = m_{\rho^-}$, $\Gamma_{\rho^+} = \Gamma_{\rho^-}$.
[9] From the GOUNARIS 68 parametrization of the pion form factor.
[10] Applies the Unitary & Analytic Model of the pion electromagnetic form factor of DUBNICKA 10 to analyze the data of LEES 12G and ABLIKIM 16C.
[11] 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.
[12] Assuming $m_{\rho^+} = m_{\rho^-} = m_{\rho^0}$, $\Gamma_{\rho^+} = \Gamma_{\rho^-} = \Gamma_{\rho^0}$.
[13] Without limitations on masses and widths.
[14] Assuming $m_{\rho^0} = m_{\rho^\pm}$, $g_{\rho^0\pi\pi} = g_{\rho^\pm\pi\pi}$.
[15] Using the data of BARKOV 85 in the hidden local symmetry model.
[16] From the fit to $e^+e^- \to \pi^+\pi^-$ data from the compilations of HEYN 81 and BARKOV 85, including the GOUNARIS 68 parametrization of the pion form factor.
[17] A fit of BARKOV 85 data assuming the direct $\omega\pi\pi$ coupling.
[18] Applying the S-matrix formalism to the BARKOV 85 data.
[19] Includes BARKOV 85 data. Model-dependent width definition.

CHARGED ONLY, τ DECAYS and e^+e^-

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
149.1 ±0.8 OUR FIT						
149.1 ±0.8 OUR AVERAGE						
148.1 ±0.4 ±1.7	5.4M	[1,2] FUJIKAWA	08	BELL	±	$\tau^- \to \pi^-\pi^0\nu_\tau$
149.0 ±1.2		[2,3] SCHAEL	05C	ALEP		$\tau^- \to \pi^-\pi^0\nu_\tau$
149.9 ±2.3 ±2.0	500k	[4] ACHASOV	02	SND	±	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
150.4 ±1.4 ±1.4	87k	[5,6] ANDERSON	00A	CLE2		$\tau^- \to \pi^-\pi^0\nu_\tau$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
139.90±0.46		[7] BARTOS	17A	RVUE		$\tau^- \to \pi^-\pi^0\nu_\tau$
143.7 ±1.3 ±1.2	1.98M	[4] ALOISIO	03	KLOE	±	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
142.9 ±1.3 ±1.4	1.98M	[8] ALOISIO	03	KLOE	−	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
144.7 ±1.4 ±1.2	1.98M	[8] ALOISIO	03	KLOE	+	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
150.2 ±2.0 $^{+0.7}_{-1.6}$		[9] SANZ-CILLERO	03	RVUE		$\tau^- \to \pi^-\pi^0\nu_\tau$
150.9 ±2.2 ±2.0	500k	[10] ACHASOV	02	SND		1.02 $e^+e^- \to \pi^+\pi^-\pi^0$

[1] $|F_\pi(0)|^2$ fixed to 1.
[2] From the GOUNARIS 68 parametrization of the pion form factor.
[3] The error combines statistical and systematic uncertainties. Supersedes BARATE 97M.
[4] Assuming $m_{\rho^+} = m_{\rho^-}$, $\Gamma_{\rho^+} = \Gamma_{\rho^-}$.
[5] $\rho(1700)$ mass and width fixed at 1700 MeV and 235 MeV respectively.
[6] From the GOUNARIS 68 parametrization of the pion form factor. The second error is a model error taking into account different parametrizations of the pion form factor.
[7] Applies the Unitary & Analytic Model of the pion electromagnetic form factor of DUBNICKA 10 to analyze the data of FUJIKAWA 08.
[8] Without limitations on masses and widths.
[9] Using the data of BARATE 97M and the effective chiral Lagrangian.
[10] Assuming $m_{\rho^0} = m_{\rho^\pm}$, $g_{\rho^0\pi\pi} = g_{\rho^\pm\pi\pi}$.

MIXED CHARGES, OTHER REACTIONS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
149.5±1.3	600k	[1] ABELE	99E	CBAR	0±	0.0 $\overline{p}p \to \pi^+\pi^-\pi^0$

[1] Assuming the equality of ρ^+ and ρ^- masses and widths.

CHARGED ONLY, HADROPRODUCED

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
150.2± 2.4 OUR FIT						
150.2± 2.4 OUR AVERAGE						
152.8± 4.3		ABELE	97	CBAR		$\overline{p}n \to \pi^-\pi^0\pi^0$
155 ±11	2.9k	[1] CAPRARO	87	SPEC	−	200 π^- Cu $\to \pi^-\pi^0$ Cu
154 ±20	967	[1] CAPRARO	87	SPEC	−	200 π^- Pb $\to \pi^-\pi^0$ Pb
150 ± 5		HUSTON	86	SPEC	+	202 π^+ A $\to \pi^+\pi^0$ A
146 ±12	6.5k	[2] BYERLY	73	OSPK	−	5 $\pi^- p$
148.2± 4.1	9.6k	[3] PISUT	68	RVUE	−	1.7–3.2 $\pi^- p$, t <10
146 ±13	900	EISNER	67	HBC	−	4.2 $\pi^- p$, t <10
• • • We do not use the following data for averages, fits, limits, etc. • • •						
137.0± 0.4		[4] ABLIKIM	17	BES3		$J/\psi \to \gamma 3\pi$

[1] Width errors enlarged by us to $4\Gamma/\sqrt{N}$; see the note with the $K^*(892)$ mass.
[2] Phase shift analysis. Systematic errors added corresponding to spread of different fits.
[3] From fit of 3-parameter relativistic P-wave Breit-Wigner to total mass distribution. Includes BATON 68, MILLER 67B, ALFF-STEINBERGER 66, HAGOPIAN 66, HAGOPIAN 66B, JACOBS 66B, JAMES 66, WEST 66, BLIEDEN 65 and CARMONY 64.
[4] S-matrix pole at a fixed ρ meson mass of 775.49 MeV.

NEUTRAL ONLY, PHOTOPRODUCED

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
$151.5^{+1.9}_{-2.1}$ OUR AVERAGE					
$151.3\pm 2.2^{+1.6}_{-2.8}$	900k	ANDREEV	20	H1	$e p \to e \pi^+\pi^- p$
155 ± 5 ± 2	63.5k	[1] ABRAMOWICZ	12	ZEUS	$e p \to e \pi^+\pi^- p$
146 ± 3 ±13	79k	[2] BREITWEG	98B	ZEUS	50–100 γp
150.9± 3.0		BARTALUCCI	78	CNTR	$\gamma p \to e^+e^- p$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
138 ± 3	79k	[3] BREITWEG	98B	ZEUS	50–100 γp
147 ±11		GLADDING	73	CNTR	2.9–4.7 γp
155 ±12	2430	BALLAM	72	HBC	4.7 γp
145 ±13	1930	BALLAM	72	HBC	2.8 γp
140 ± 5		ALVENSLEB...	70	CNTR	γA, t <0.01
146.1± 2.9	140k	BIGGS	70	CNTR	<4.1 γC $\to \pi^+\pi^-$ C
160 ±10		LANZEROTTI	68	CNTR	γp
130 ± 5	4000	ASBURY	67B	CNTR	γ + Pb

[1] Using the KUHN 90 parametrization of the pion form factor, neglecting ρ−ω interference.
[2] From the parametrization according to SOEDING 66.
[3] From the parametrization according to ROSS 66.

NEUTRAL ONLY, OTHER REACTIONS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
150.9 ± 1.7 OUR AVERAGE		Error includes scale factor of 1.1.			
122 ±20		BERTIN	97C	OBLX	0.0 $\overline{p}p \rightarrow \pi^+\pi^-\pi^0$
145.7 ± 5.3		WEIDENAUER	93	ASTE	$\overline{p}p \rightarrow \pi^+\pi^-\omega$
144.9 ± 3.7		DUBNICKA	89	RVUE	π form factor
148 ± 6		[1,2] BOHACIK	80	RVUE	
152 ± 9		[3] WICKLUND	78	ASPK	3,4,6 $\pi^{\pm} p N$
154 ± 2	76k	DEUTSCH...	76	HBC	16 $\pi^+ p$
157 ± 8	6.8k	[4] RATCLIFF	72	ASPK	15 $\pi^- p$, t <0.3
143 ± 8	1.7k	REYNOLDS	69	HBC	2.26 $\pi^- p$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
150.85± 0.55±0.67	970k	[5] ABLIKIM	18C	BES3	$\eta'(958) \rightarrow \gamma\pi^+\pi^-$
150.18± 0.55±0.65	970k	[6] ABLIKIM	18C	BES3	$\eta'(958) \rightarrow \gamma\pi^+\pi^-$
147.0 ± 2.5	600k	[7] ABELE	99E	CBAR	0.0 $\overline{p}p \rightarrow \pi^+\pi^-\pi^0$
146 ± 3	4.9k	[8] ADAMS	97	E665	470 $\mu p \rightarrow \mu X B$
160.0 $^{+4.1}_{-4.0}$		[9] CHABAUD	83	ASPK	17 $\pi^- p$ polarized
155 ± 1		[10] HEYN	81	RVUE	π form factor
148.0 ± 1.3		[1,2] LANG	79	RVUE	
146 ±14	4.1k	ENGLER	74	DBC	6 $\pi^+ n \rightarrow \pi^+\pi^- p$
143 ±13		[2] ESTABROOKS	74	RVUE	17 $\pi^- p \rightarrow \pi^+\pi^- n$
160 ±10	32k	[1] PROTOPOP...	73	HBC	7.1 $\pi^+ p$, t <0.4
145 ±12	2.2k	[3,11] HYAMS	68	OSPK	11.2 $\pi^- p$
163 ±15	13.3k	[12] PISUT	68	RVUE	1.7–3.2 $\pi^- p$, t <10

[1] From pole extrapolation.
[2] From phase shift analysis of GRAYER 74 data.
[3] Width errors enlarged by us to $4\Gamma/\sqrt{N}$; see the note with the $K^*(892)$ mass.
[4] Published values contain misprints. Corrected by private communication RATCLIFF 74.
[5] From a fit to $\pi^+\pi^-$ mass using $\rho(770)$ (parametrized with the Gounaris-Sakurai approach), $\omega(782)$, and box anomaly components.
[6] From a fit to $\pi^+\pi^-$ mass using $\rho(770)$ (parametrized with the Gounaris-Sakurai approach), $\omega(782)$, and $\rho(1450)$ components.
[7] Using relativistic Breit-Wigner and taking into account ρ-ω interference.
[8] Systematic errors not evaluated.
[9] From fit of 3-parameter relativistic Breit-Wigner to helicity-zero part of P-wave intensity. CHABAUD 83 includes data of GRAYER 74.
[10] HEYN 81 includes all spacelike and timelike F_π values until 1978.
[11] Of HYAMS 68 six parametrizations this is theoretically soundest. MR
[12] Includes MALAMUD 69, ARMENISE 68, BACON 67, HUWE 67, MILLER 67B, ALFF-STEINBERGER 66, HAGOPIAN 66, HAGOPIAN 66B, JACOBS 66B, JAMES 66, WEST 66, GOLDHABER 64, ABOLINS 63.

$\Gamma_{\rho(770)^0} - \Gamma_{\rho(770)^\pm}$

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
0.3 ±1.3 OUR AVERAGE		Error includes scale factor of 1.4.			
−0.2 ±1.0		[1] SCHAEL	05C	ALEP	$\tau^- \rightarrow \pi^-\pi^0\nu_\tau$
3.6 ±1.8 ±1.7	1.98M	[2] ALOISIO	03	KLOE	1.02 $e^+e^- \rightarrow \pi^+\pi^-\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
4.66±0.85		[3] BARTOS	17A	RVUE	$e^+e^- \rightarrow \pi^+\pi^-$, $\tau^- \rightarrow \pi^-\pi^0\nu_\tau$

[1] 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. Supersedes BARATE 97M.

[2] Assuming $m_{\rho^+} = m_{\rho^-}$, $\Gamma_{\rho^+} = \Gamma_{\rho^-}$.

[3] 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.

$\Gamma_{\rho(770)^+} - \Gamma_{\rho(770)^-}$

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
1.8±2.0±0.5	1.98M	[1] ALOISIO	03	KLOE	1.02 $e^+ e^- \to \pi^+ \pi^- \pi^0$

[1] Without limitations on masses and widths.

ρ(770) DECAY MODES

	Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level
Γ_1	$\pi\pi$		$\sim$ 100 %	
Γ_2	$K\overline{K}$			
	$\rho(770)^\pm$ decays			
Γ_3	$\pi^\pm \pi^0$		$\sim$ 100 %	
Γ_4	$\pi^\pm \gamma$		$(4.5 \pm 0.5) \times 10^{-4}$	S=2.2
Γ_5	$\pi^\pm \eta$		$< 6 \times 10^{-3}$	CL=84%
Γ_6	$\pi^\pm \pi^+ \pi^- \pi^0$		$< 2.0 \times 10^{-3}$	CL=84%
	$\rho(770)^0$ decays			
Γ_7	$\pi^+ \pi^-$		$\sim$ 100 %	
Γ_8	$\pi^+ \pi^- \gamma$		$(9.9 \pm 1.6) \times 10^{-3}$	
Γ_9	$\pi^0 \gamma$		$(4.7 \pm 0.8) \times 10^{-4}$	S=1.7
Γ_{10}	$\eta \gamma$		$(3.00 \pm 0.21) \times 10^{-4}$	
Γ_{11}	$\pi^0 \pi^0 \gamma$		$(4.5 \pm 0.8) \times 10^{-5}$	
Γ_{12}	$\mu^+ \mu^-$	[a]	$(4.55 \pm 0.28) \times 10^{-5}$	
Γ_{13}	$e^+ e^-$	[a]	$(4.72 \pm 0.05) \times 10^{-5}$	
Γ_{14}	$\pi^+ \pi^- \pi^0$		$(1.01^{+0.54}_{-0.36} \pm 0.34) \times 10^{-4}$	
Γ_{15}	$\pi^+ \pi^- \pi^+ \pi^-$		$(1.8 \pm 0.9) \times 10^{-5}$	
Γ_{16}	$\pi^+ \pi^- \pi^0 \pi^0$		$(1.6 \pm 0.8) \times 10^{-5}$	
Γ_{17}	$\pi^0 e^+ e^-$		$< 1.2 \times 10^{-5}$	CL=90%
Γ_{18}	$\eta e^+ e^-$			

[a] The $\omega\rho$ interference is then due to $\omega\rho$ mixing only, and is expected to be small. If $e\mu$ universality holds, $\Gamma(\rho^0 \to \mu^+ \mu^-) = \Gamma(\rho^0 \to e^+ e^-) \times 0.99785$.

CONSTRAINED FIT INFORMATION

An overall fit to the total width and a partial width uses 10 measurements and one constraint to determine 3 parameters. The overall fit has a $\chi^2 = 10.7$ for 8 degrees of freedom.

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

x_4	−100	
Γ	15	−15
	x_3	x_4

	Mode	Rate (MeV)	Scale factor
Γ_3	$\pi^\pm\pi^0$	150.2 ±2.4	
Γ_4	$\pi^\pm\gamma$	0.068±0.007	2.3

CONSTRAINED FIT INFORMATION

An overall fit to the total width, a partial width, and 7 branching ratios uses 21 measurements and one constraint to determine 9 parameters. The overall fit has a $\chi^2 = 9.5$ for 13 degrees of freedom.

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

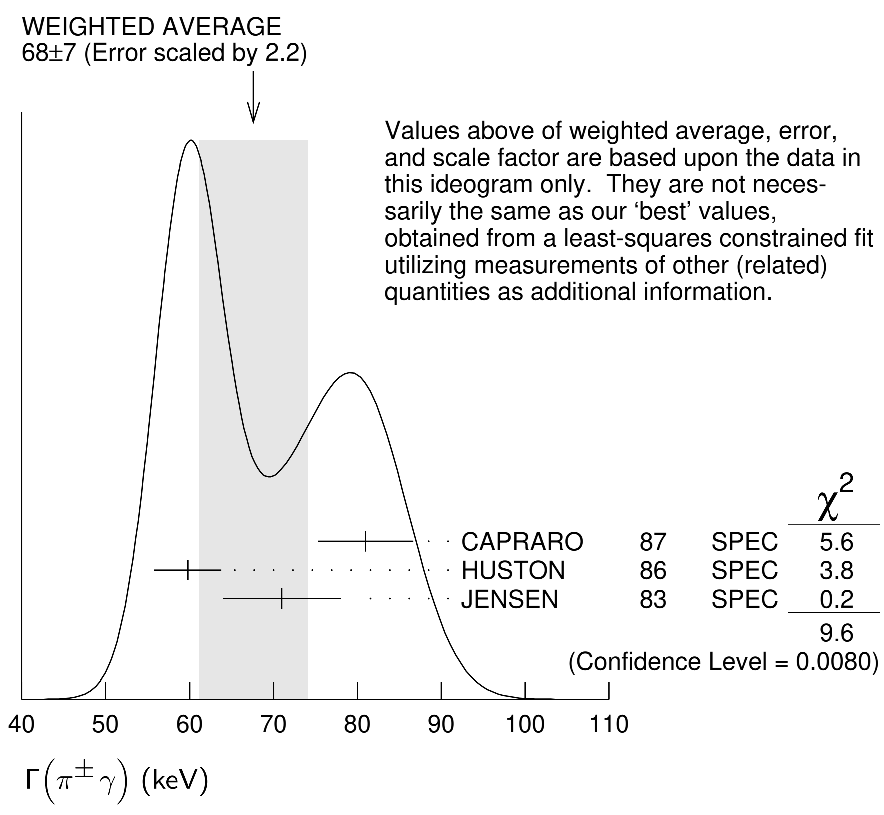
x_8	−100							
x_9	−5	0						
x_{10}	−1	0	1					
x_{11}	−1	0	0	0				
x_{12}	2	−3	0	0	0			
x_{13}	0	0	−6	−9	0	0		
x_{15}	−1	0	0	0	0	0	0	
Γ	0	0	3	5	0	0	−54	0
	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{15}

	Mode		Rate (MeV)	Scale factor
Γ_7	$\pi^+\pi^-$		147.5 $\pm$0.9	
Γ_8	$\pi^+\pi^-\gamma$		1.48 $\pm$0.24	
Γ_9	$\pi^0\gamma$		0.070 $\pm$0.012	1.7
Γ_{10}	$\eta\gamma$		0.0447 $\pm$0.0032	
Γ_{11}	$\pi^0\pi^0\gamma$		0.0066 $\pm$0.0012	
Γ_{12}	$\mu^+\mu^-$	[a]	0.0068 $\pm$0.0004	
Γ_{13}	e^+e^-	[a]	0.00704$\pm$0.00006	
Γ_{15}	$\pi^+\pi^-\pi^+\pi^-$		0.0027 $\pm$0.0014	

ρ(770) PARTIAL WIDTHS

$\Gamma(\pi^\pm\gamma)$ Γ_4

VALUE (keV)	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
68 ±7 OUR FIT Error includes scale factor of 2.3.					
68 ±7 OUR AVERAGE Error includes scale factor of 2.2. See the ideogram below.					
81 $\pm$4 $\pm$4	CAPRARO	87	SPEC	$-$	200 π^- A $\rightarrow$ $\pi^-\pi^0$ A
59.8$\pm$4.0	HUSTON	86	SPEC	$+$	202 π^+ A $\rightarrow$ $\pi^+\pi^0$ A
71 $\pm$7	JENSEN	83	SPEC	$-$	156–260 π^- A $\rightarrow$ $\pi^-\pi^0$ A



$\Gamma(\pi^0\gamma)$ Γ_9

VALUE (keV)	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
77±17±11	36500	[1] ACHASOV	03	SND	0.60–0.97 $e^+e^- \to \pi^0\gamma$
121±31		DOLINSKY	89	ND	$e^+e^- \to \pi^0\gamma$

[1] Using Γ_{total}= 147.9 ± 1.3 MeV and B($\rho \to \pi^0\gamma$) from ACHASOV 03.

$\Gamma(\eta\gamma)$ Γ_{10}

VALUE (keV)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
62±17	[1] DOLINSKY	89	ND	$e^+e^- \to \eta\gamma$

[1] Solution corresponding to constructive ω-ρ interference.

$\Gamma(e^+e^-)$ Γ_{13}

VALUE (keV)	EVTS	DOCUMENT ID		TECN	COMMENT
7.04 ±0.06 OUR FIT					
7.04 ±0.06 OUR AVERAGE					
7.048±0.057±0.050	900k	[1] AKHMETSHIN	07		$e^+e^- \to \pi^+\pi^-$
7.06 ±0.11 ±0.05	114k	[2,3] AKHMETSHIN	04	CMD2	$e^+e^- \to \pi^+\pi^-$
6.77 ±0.10 ±0.30		BARKOV	85	OLYA	$e^+e^- \to \pi^+\pi^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
7.12 ±0.02 ±0.11	800k	[4] ACHASOV	06	SND	$e^+e^- \to \pi^+\pi^-$
6.3 ±0.1		[5] BENAYOUN	98	RVUE	$e^+e^- \to \pi^+\pi^-$, $\mu^+\mu^-$

[1] A combined fit of AKHMETSHIN 07, AULCHENKO 06, and AULCHENKO 05.
[2] Using the GOUNARIS 68 parametrization with the complex phase of the ρ-ω interference.
[3] From a fit in the energy range 0.61 to 0.96 GeV. Update of AKHMETSHIN 02.
[4] Supersedes ACHASOV 05A.
[5] Using the data of BARKOV 85 in the hidden local symmetry model.

$\Gamma(\pi^+\pi^-\pi^+\pi^-)$ Γ_{15}

VALUE (keV)	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2.8±1.4±0.5	153	AKHMETSHIN	00	CMD2	0.6–0.97 $e^+e^- \to \pi^+\pi^-\pi^+\pi^-$

$\rho(770)$ $\Gamma(e^+e^-)\Gamma(i)/\Gamma^2(\text{total})$

$\Gamma(e^+e^-)/\Gamma_{total} \times \Gamma(\pi^+\pi^-)/\Gamma_{total}$ $\Gamma_{13}/\Gamma \times \Gamma_7/\Gamma$

VALUE (units 10^{-5})	EVTS	DOCUMENT ID		TECN	COMMENT
4.89 ±0.04 OUR AVERAGE					
4.889±0.015±0.039		[1] ACHASOV	21	SND	$e^+e^- \to \pi^+\pi^-$
4.876±0.023±0.064	800k	[2,3] ACHASOV	06	SND	$e^+e^- \to \pi^+\pi^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
4.72 ±0.02		[4] BENAYOUN	10	RVUE	0.4–1.05 e^+e^-

[1] From a fit of the cross section in the energy range $0.525 < \sqrt{s} < 0.883$ GeV parameterized by the sum of the Breit-Wigner amplitudes for the $\rho(770)$, ω and $\rho(1450)$ resonances.
[2] Supersedes ACHASOV 05A.
[3] A fit of the SND data from 400 to 1000 MeV using parameters of the $\rho(1450)$ and $\rho(1700)$ from a fit of the data of BARKOV 85, BISELLO 89 and ANDERSON 00A.
[4] A simultaneous fit of $e^+e^- \to \pi^+\pi^-$, $\pi^+\pi^-\pi^0$, $\pi^0\gamma$, $\eta\gamma$ data.

$\Gamma(e^+e^-)/\Gamma_{total} \times \Gamma(\eta\gamma)/\Gamma_{total}$ — $\Gamma_{13}/\Gamma \times \Gamma_{10}/\Gamma$

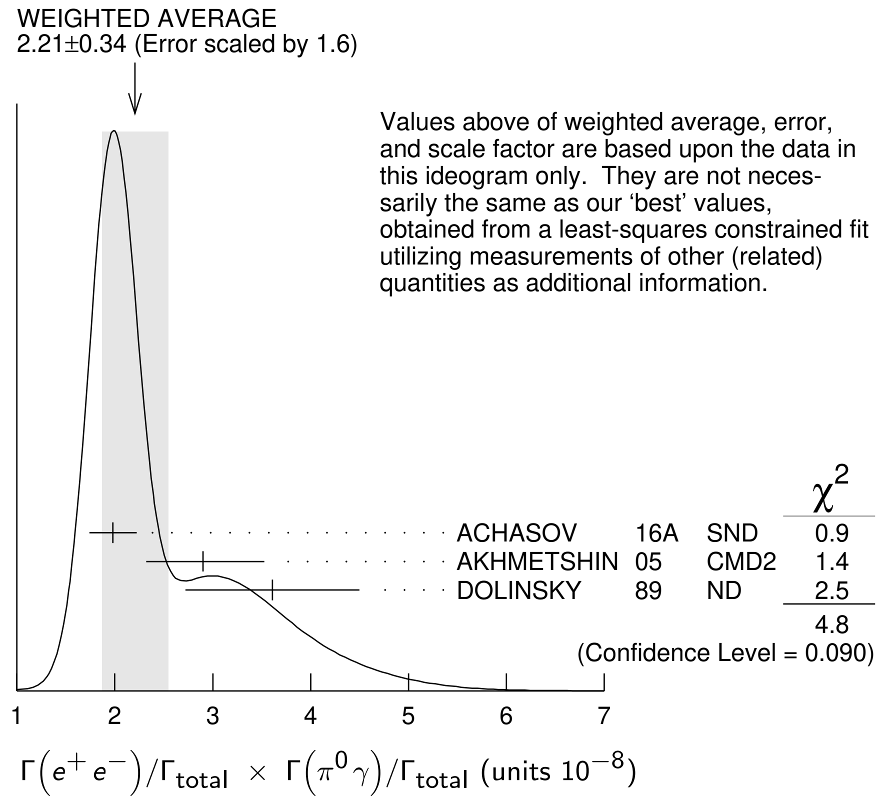
VALUE (units 10^{-8})	EVTS	DOCUMENT ID		TECN	COMMENT
1.42±0.10 OUR FIT					
1.45±0.12 OUR AVERAGE					
1.32±0.14±0.08	33k	[1] ACHASOV	07B	SND	0.6–1.38 $e^+e^- \to \eta\gamma$
1.50±0.65±0.09	17.4k	[2] AKHMETSHIN	05	CMD2	0.60-1.38 $e^+e^- \to \eta\gamma$
1.61±0.20±0.11	23k	[3,4] AKHMETSHIN	01B	CMD2	$e^+e^- \to \eta\gamma$
1.85±0.49		[5] DOLINSKY	89	ND	$e^+e^- \to \eta\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1.05±0.02		[6] BENAYOUN	10	RVUE	0.4–1.05 e^+e^-

[1] From a combined fit of $\sigma(e^+e^- \to \eta\gamma)$ with $\eta \to 3\pi^0$ and $\eta \to \pi^+\pi^-\pi^0$, and fixing B($\eta \to 3\pi^0$) / B($\eta \to \pi^+\pi^-\pi^0$) = 1.44 ± 0.04. Recalculated by us from the cross section at the peak. Supersedes ACHASOV 00D and ACHASOV 06A.
[2] From the $\eta \to 2\gamma$ decay and using B($\eta \to \gamma\gamma$)= 39.43 ± 0.26%.
[3] From the $\eta \to 3\pi^0$ decay and using B($\eta \to 3\pi^0$)= $(32.24 \pm 0.29) \times 10^{-2}$.
[4] The combined fit from 600 to 1380 MeV taking into account $\rho(770)$, $\omega(782)$, $\phi(1020)$, and $\rho(1450)$ (mass and width fixed at 1450 MeV and 310 MeV respectively).
[5] Recalculated by us from the cross section in the peak.
[6] A simultaneous fit of $e^+e^- \to \pi^+\pi^-$, $\pi^+\pi^-\pi^0$, $\pi^0\gamma$, $\eta\gamma$ data.

$\Gamma(e^+e^-)/\Gamma_{total} \times \Gamma(\pi^0\gamma)/\Gamma_{total}$ — $\Gamma_{13}/\Gamma \times \Gamma_9/\Gamma$

VALUE (units 10^{-8})	EVTS	DOCUMENT ID		TECN	COMMENT
2.2 ±0.4 OUR FIT Error includes scale factor of 1.7.					
2.21 ±0.34 OUR AVERAGE Error includes scale factor of 1.6. See the ideogram below.					
1.98 ±0.22 ±0.10		[1] ACHASOV	16A	SND	0.60-1.38 $e^+e^- \to \pi^0\gamma$
2.90 $^{+0.60}_{-0.55}$ ±0.18	18k	AKHMETSHIN	05	CMD2	0.60-1.38 $e^+e^- \to \pi^0\gamma$
3.61 ±0.74 ±0.49	10k	[2] DOLINSKY	89	ND	$e^+e^- \to \pi^0\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1.875±0.026		[3] BENAYOUN	10	RVUE	0.4–1.05 e^+e^-
2.37 ±0.53 ±0.33	36k	[4] ACHASOV	03	SND	0.60–0.97 $e^+e^- \to \pi^0\gamma$

[1] From the VMD model with the prho(770), $\omega(782)$, $\phi(1020)$ resonances, and an additional resonance describing the total contribution of the $\rho(1450)$ and $\omega(1420)$ states. Supersedes ACHASOV 03.
[2] Recalculated by us from the cross section in the peak.
[3] A simultaneous fit of $e^+e^- \to \pi^+\pi^-$, $\pi^+\pi^-\pi^0$, $\pi^0\gamma$, $\eta\gamma$ data.
[4] Using $\sigma_{\phi \to \pi^0\gamma}$ from ACHASOV 00 and m_ρ = 775.97 MeV in the model with the energy-independent phase of ρ-ω interferenceequal to $(-10.2 \pm 7.0)^\circ$.



$\Gamma(e^+e^-)/\Gamma_{total} \times \Gamma(\pi^+\pi^-\pi^0)/\Gamma_{total}$ — $\Gamma_{13}/\Gamma \times \Gamma_{14}/\Gamma$

VALUE (units 10^{-9})	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.903 ± 0.076		[1] BENAYOUN	10	RVUE	0.4–1.05 e^+e^-
$4.58\ ^{+2.46}_{-1.64} \pm 1.56$	1.2M	[2] ACHASOV	03D	RVUE	0.44–2.00 $e^+e^- \to \pi^+\pi^-\pi^0$

[1] A simultaneous fit of $e^+e^- \to \pi^+\pi^-$, $\pi^+\pi^-\pi^0$, $\pi^0\gamma$, $\eta\gamma$ data.
[2] Statistical significance is less than 3σ.

$\rho(770)$ BRANCHING RATIOS

$\Gamma(\pi^\pm\eta)/\Gamma(\pi\pi)$ — Γ_5/Γ_1

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	CHG	COMMENT
<60	84	FERBEL	66	HBC	±	$\pi^\pm p$ above 2.5

$\Gamma(\pi^\pm\pi^+\pi^-\pi^0)/\Gamma(\pi\pi)$ — Γ_6/Γ_1

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	CHG	COMMENT
<20	84	FERBEL	66	HBC	±	$\pi^\pm p$ above 2.5
• • • We do not use the following data for averages, fits, limits, etc. • • •						
35 ± 40		JAMES	66	HBC	+	2.1 $\pi^+ p$

$\Gamma(\pi^+\pi^-\gamma)/\Gamma_{total}$ Γ_8/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
0.0099±0.0016 OUR FIT					
0.0099±0.0016		[1] DOLINSKY	91	ND	$e^+e^- \rightarrow \pi^+\pi^-\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.0111±0.0014		[2] VASSERMAN	88	ND	$e^+e^- \rightarrow \pi^+\pi^-\gamma$
<0.005	90	[3] VASSERMAN	88	ND	$e^+e^- \rightarrow \pi^+\pi^-\gamma$

[1] Bremsstrahlung from a decay pion and for photon energy above 50 MeV.
[2] Superseded by DOLINSKY 91.
[3] Structure radiation due to quark rearrangement in the decay.

$\Gamma(\pi^0\gamma)/\Gamma_{total}$ Γ_9/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
4.20±0.52		[1] ACHASOV	16A	SND	0.60–1.38 $e^+e^- \rightarrow \pi^0\gamma$
$6.21^{+1.28}_{-1.18}\pm0.39$	18k	[2,3] AKHMETSHIN	05	CMD2	0.60-1.38 $e^+e^- \rightarrow \pi^0\gamma$
5.22±1.17±0.75	36k	[3,4] ACHASOV	03	SND	0.60–0.97 $e^+e^- \rightarrow \pi^0\gamma$
6.8 ±1.7		[5] BENAYOUN	96	RVUE	0.54-1.04 $e^+e^- \rightarrow \pi^0\gamma$
7.9 ±2.0		[3] DOLINSKY	89	ND	$e^+e^- \rightarrow \pi^0\gamma$

[1] Using B($\rho \rightarrow e^+e^-$) from PDG 15. Supersedes ACHASOV 03.
[2] Using B($\rho \rightarrow e^+e^-$) = (4.67 ± 0.09) × 10^{-5}.
[3] Not independent of the corresponding $\Gamma(e^+e^-) \times \Gamma(\pi^0\gamma)/\Gamma^2_{total}$.
[4] Using B($\rho \rightarrow e^+e^-$) = (4.54 ± 0.10) × 10^{-5}.
[5] Reanalysis of DRUZHININ 84, DOLINSKY 89, and DOLINSKY 91 taking into account a triangle anomaly contribution.

$\Gamma(\eta\gamma)/\Gamma_{total}$ Γ_{10}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
3.00±0.21 OUR FIT						
2.90±0.32 OUR AVERAGE						
2.79±0.34±0.03	33k	[1] ACHASOV	07B	SND		0.6–1.38 $e^+e^- \rightarrow \eta\gamma$
3.6 ±0.9		[2] ANDREWS	77	CNTR	0	6.7–10 γCu
• • • We do not use the following data for averages, fits, limits, etc. • • •						
3.21±1.39±0.20	17.4k	[3,4] AKHMETSHIN	05	CMD2		0.60-1.38 $e^+e^- \rightarrow \eta\gamma$
3.39±0.42±0.23		[2,5,6] AKHMETSHIN	01B	CMD2		$e^+e^- \rightarrow \eta\gamma$
$1.9\ ^{+0.6}_{-0.8}$		[7] BENAYOUN	96	RVUE		0.54-1.04 $e^+e^- \rightarrow \eta\gamma$
4.0 ±1.1		[2,4] DOLINSKY	89	ND		$e^+e^- \rightarrow \eta\gamma$

[1] ACHASOV 07B reports [$\Gamma(\rho(770) \rightarrow \eta\gamma)/\Gamma_{total}$] × [B($\rho(770) \rightarrow e^+e^-$)] = (1.32 ± 0.14 ± 0.08) × 10^{-8} which we divide by our best value B($\rho(770) \rightarrow e^+e^-$) = (4.72 ± 0.05) × 10^{-5}. Our first error is their experiment's error and our second error is the systematic error from using our best value. Supersedes ACHASOV 00D and ACHASOV 06A.
[2] Solution corresponding to constructive ω-ρ interference.
[3] Using B($\rho \rightarrow e^+e^-$) = (4.67 ± 0.09) × 10^{-5} and B($\eta \rightarrow \gamma\gamma$) = 39.43 ± 0.26%.
[4] Not independent of the corresponding $\Gamma(e^+e^-) \times \Gamma(\eta\gamma)/\Gamma^2_{total}$.
[5] The combined fit from 600 to 1380 MeV taking into account $\rho(770)$, $\omega(782)$, $\phi(1020)$, and $\rho(1450)$ (mass and width fixed at 1450 MeV and 310 MeV respectively).

[6] Using B($\rho \to e^+ e^-$) = $(4.75 \pm 0.10) \times 10^{-5}$ from AKHMETSHIN 02 and B($\eta \to 3\pi^0$) = $(32.24 \pm 0.29) \times 10^{-2}$.
[7] Reanalysis of DRUZHININ 84, DOLINSKY 89, and DOLINSKY 91 taking into account a triangle anomaly contribution. Constructive ρ-ω interference solution.

$\Gamma(\pi^0 \pi^0 \gamma)/\Gamma_{total}$ — Γ_{11}/Γ

VALUE (units 10^{-5})	EVTS	DOCUMENT ID		TECN	COMMENT
4.5±0.8 OUR FIT					
$4.5^{+0.9}_{-0.8}$ OUR AVERAGE					
$5.2^{+1.5}_{-1.3} \pm 0.6$	190	[1] AKHMETSHIN	04B	CMD2	0.6–0.97 $e^+ e^- \to \pi^0 \pi^0 \gamma$
$4.1^{+1.0}_{-0.9} \pm 0.3$	295	[2] ACHASOV	02F	SND	0.36–0.97 $e^+ e^- \to \pi^0 \pi^0 \gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$4.8^{+3.4}_{-1.8} \pm 0.5$	63	[3] ACHASOV	00G	SND	$e^+ e^- \to \pi^0 \pi^0 \gamma$

[1] This branching ratio includes the conventional VMD mechanism $\rho \to \omega \pi^0$, $\omega \to \pi^0 \gamma$, and the new decay mode $\rho \to f_0(500)\gamma$, $f_0(500) \to \pi^0 \pi^0$ with a branching ratio $(2.0^{+1.1}_{-0.9} \pm 0.3) \times 10^{-5}$ differing from zero by 2.0 standard deviations.
[2] This branching ratio includes the conventional VMD mechanism $\rho \to \omega \pi^0$, $\omega \to \pi^0 \gamma$ and the new decay mode $\rho \to f_0(500)\gamma$, $f_0(500) \to \pi^0 \pi^0$ with a branching ratio $(1.9^{+0.9}_{-0.8} \pm 0.4) \times 10^{-5}$ differing from zero by 2.4 standard deviations. Supersedes ACHASOV 00G.
[3] Superseded by ACHASOV 02F.

$\Gamma(\mu^+ \mu^-)/\Gamma(\pi^+ \pi^-)$ — Γ_{12}/Γ_7

VALUE (units 10^{-5})	DOCUMENT ID		TECN	COMMENT
4.60±0.28 OUR FIT				
4.6 ±0.2 ±0.2	ANTIPOV	89	SIGM	$\pi^- \text{Cu} \to \mu^+ \mu^- \pi^- \text{Cu}$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$8.2\ ^{+1.6}_{-3.6}$	[1] ROTHWELL	69	CNTR	Photoproduction
5.6 ±1.5	[2] WEHMANN	69	OSPK	12 π^- C, Fe
$9.7\ ^{+3.1}_{-3.3}$	[3,4] HYAMS	67	OSPK	11 π^- Li, H

[1] Possibly large ρ-ω interference leads us to increase the minus error.
[2] Result contains 11 ± 11% correction using SU(3) for central value. The error on the correction takes account of possible ρ-ω interference and the upper limit agrees with the upper limit of $\omega \to \mu^+ \mu^-$ from this experiment.
[3] But he even enlarges his error to take residual ω contamination into account. Since his value is high, seems the other experiments also can't have too many ω's. But maybe Hyams has additional μ's from $\rho \to \pi\pi$, decaying π's.
[4] HYAMS 67's mass resolution is 20 MeV. The ω region was excluded.

$\Gamma(e^+ e^-)/\Gamma(\pi\pi)$ — Γ_{13}/Γ_1

VALUE (units 10^{-4})	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.40±0.05	[1,2] BENAKSAS	72	OSPK	$e^+ e^- \to \pi^+ \pi^-$

[1] The ρ' contribution is not taken into account.
[2] Barkov excludes Auslender and Benaksas for large statistical and systematic errors.

$\Gamma(\pi^+\pi^-\pi^0)/\Gamma_{total}$ — Γ_{14}/Γ

VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$1.01^{+0.54}_{-0.36}\pm0.34$		1.2M	[1] ACHASOV	03D	RVUE	0.44–2.00 $e^+e^- \to \pi^+\pi^-\pi^0$
<1.2	90		VASSERMAN	88B	ND	$e^+e^- \to \pi^+\pi^-\pi^0$

[1] Statistical significance is less than 3σ.

$\Gamma(\pi^+\pi^-\pi^0)/\Gamma(\pi\pi)$ — Γ_{14}/Γ_1

VALUE	CL%	DOCUMENT ID		TECN	CHG	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •						
~ 0.01		BRAMON	86	RVUE	0	$J/\psi \to \omega\pi^0$
<0.01	84	[1] ABRAMS	71	HBC	0	3.7 $\pi^+ p$

[1] Model dependent, assumes I = 1, 2, or 3 for the 3π system.

$\Gamma(\pi^+\pi^-\pi^+\pi^-)/\Gamma_{total}$ — Γ_{15}/Γ

VALUE (units 10^{-5})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
1.8±0.9 OUR FIT						
1.8±0.9±0.3		153	AKHMETSHIN	00	CMD2	0.6–0.97 $e^+e^- \to \pi^+\pi^-\pi^+\pi^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<20	90		KURDADZE	88	OLYA	$e^+e^- \to \pi^+\pi^-\pi^+\pi^-$

$\Gamma(\pi^+\pi^-\pi^+\pi^-)/\Gamma(\pi\pi)$ — Γ_{15}/Γ_1

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	CHG	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<15	90	ERBE	69	HBC	0	2.5–5.8 γp
<20		CHUNG	68	HBC	0	3.2,4.2 $\pi^- p$
<20	90	HUSON	68	HLBC	0	16.0 $\pi^- p$
<80		JAMES	66	HBC	0	2.1 $\pi^+ p$

$\Gamma(\pi^+\pi^-\pi^0\pi^0)/\Gamma_{total}$ — Γ_{16}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID		TECN	COMMENT
1.60±0.74±0.18		[1] ACHASOV	09A	SND	$e^+e^- \to \pi^+\pi^-\pi^0\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<4	90	AULCHENKO	87C	ND	$e^+e^- \to \pi^+\pi^-\pi^0\pi^0$
<20	90	KURDADZE	86	OLYA	$e^+e^- \to \pi^+\pi^-\pi^0\pi^0$

[1] Assuming no interference between the ρ and ω contributions.

$\Gamma(\pi^0 e^+ e^-)/\Gamma_{total}$ — Γ_{17}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID		TECN	COMMENT
<1.2	90	ACHASOV	08	SND	0.36–0.97 $e^+e^- \to \pi^0 e^+e^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<1.6		AKHMETSHIN	05A	CMD2	0.72-0.84 e^+e^-

$\Gamma(\eta e^+ e^-)/\Gamma_{total}$ — Γ_{18}/Γ

VALUE (units 10^{-5})	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
<0.7	AKHMETSHIN 05A	CMD2	0.72-0.84 $e^+ e^-$

ρ(770) REFERENCES

ACHASOV	21	JHEP 2101 113	M.N. Achasov et al.	(SND Collab.)
ANDREEV	20	EPJ C80 1189	V. Andreev et al.	(H1 Collab.)
ABLIKIM	18C	PRL 120 242003	M. Ablikim et al.	(BESIII Collab.)
ABLIKIM	17	PRL 118 012001	M. Ablikim et al.	(BESIII Collab.)
BARTOS	17	PR D96 113004	E. Bartos et al.	
BARTOS	17A	IJMP A32 1750154	E. Bartos et al.	
ABLIKIM	16C	PL B753 629	M. Ablikim et al.	(BESIII Collab.)
ACHASOV	16A	PR D93 092001	M.N. Achasov et al.	(SND Collab.)
PDG	15	RPP 2015 at pdg.lbl.gov		(PDG Collab.)
ABRAMOWICZ	12	EPJ C72 1869	H. Abramowicz et al.	(ZEUS Collab.)
LEES	12G	PR D86 032013	J.P. Lees et al.	(BABAR Collab.)
AMBROSINO	11A	PL B700 102	F. Ambrosino et al.	(KLOE Collab.)
GARCIA-MAR...	11	PRL 107 072001	R. Garcia-Martin et al.	(MADR, CRAC)
BATLEY	10C	EPJ C70 635	J.R. Batley et al.	(CERN NA48/2 Collab.)
BENAYOUN	10	EPJ C65 211	M. Benayoun et al.	
DUBNICKA	10	APS 60 1	S. Dubnicka, A.Z. Dubnickova	
ACHASOV	09A	JETP 109 379	M.N. Achasov et al.	(SND Collab.)
		Translated from ZETF 136 442.		
AUBERT	09AS	PRL 103 231801	B. Aubert et al.	(BABAR Collab.)
ACHASOV	08	JETP 107 61	M.N. Achasov et al.	(SND Collab.)
		Translated from ZETF 134 80.		
FUJIKAWA	08	PR D78 072006	M. Fujikawa et al.	(BELLE Collab.)
ACHASOV	07B	PR D76 077101	M.N. Achasov et al.	(SND Collab.)
AKHMETSHIN	07	PL B648 28	R.R. Akhmetshin et al.	(Novosibirsk CMD-2 Collab.)
ACHASOV	06	JETP 103 380	M.N. Achasov et al.	(Novosibirsk SND Collab.)
		Translated from ZETF 130 437.		
ACHASOV	06A	PR D74 014016	M.N. Achasov et al.	(SND Collab.)
AULCHENKO	06	JETPL 84 413	V.M. Aulchenko et al.	(Novosibirsk CMD-2 Collab.)
		Translated from ZETFP 84 491.		
ACHASOV	05A	JETP 101 1053	M.N. Achasov et al.	(Novosibirsk SND Collab.)
		Translated from ZETF 128 1201.		
AKHMETSHIN	05	PL B605 26	R.R. Akhmetshin et al.	(Novosibirsk CMD-2 Collab.)
AKHMETSHIN	05A	PL B613 29	R.R. Akhmetshin et al.	(Novosibirsk CMD-2 Collab.)
ALOISIO	05	PL B606 12	A. Aloisio et al.	(KLOE Collab.)
AULCHENKO	05	JETPL 82 743	V.M. Aulchenko et al.	(Novosibirsk CMD-2 Collab.)
		Translated from ZETFP 82 841.		
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.)
AKHMETSHIN	04B	PL B580 119	R.R. Akhmetshin et al.	(Novosibirsk CMD-2 Collab.)
PELAEZ	04A	MPL A19 2879	J.R. Pelaez	(MADU)
ACHASOV	03	PL B559 171	M.N. Achasov et al.	(Novosibirsk SND Collab.)
ACHASOV	03D	PR D68 052006	M.N. Achasov et al.	(Novosibirsk SND Collab.)
ALOISIO	03	PL B561 55	A. Aloisio et al.	(KLOE Collab.)
SANZ-CILLERO	03	EPJ C27 587	J.J. Sanz-Cillero, A. Pich	
ACHASOV	02	PR D65 032002	M.N. Achasov et al.	(Novosibirsk SND Collab.)
ACHASOV	02F	PL B537 201	M.N. Achasov et al.	(Novosibirsk SND Collab.)
AKHMETSHIN	02	PL B527 161	R.R. Akhmetshin et al.	(Novosibirsk CMD-2 Collab.)
AKHMETSHIN	01B	PL B509 217	R.R. Akhmetshin et al.	(Novosibirsk CMD-2 Collab.)
COLANGELO	01	NP B603 125	G. Colangelo, J. Gasser, H. Leytwyler	
PICH	01	PR D63 093005	A. Pich, J. Portoles	
ACHASOV	00	EPJ C12 25	M.N. Achasov et al.	(Novosibirsk SND Collab.)
ACHASOV	00D	JETPL 72 282	M.N. Achasov et al.	(Novosibirsk SND Collab.)
		Translated from ZETFP 72 411.		
ACHASOV	00G	JETPL 71 355	M.N. Achasov et al.	(Novosibirsk SND Collab.)
		Translated from ZETFP 71 519.		
AKHMETSHIN	00	PL B475 190	R.R. Akhmetshin et al.	(Novosibirsk CMD-2 Collab.)
ANDERSON	00A	PR D61 112002	S. Anderson et al.	(CLEO Collab.)
ABELE	99E	PL B469 270	A. Abele et al.	(Crystal Barrel Collab.)
BENAYOUN	98	EPJ C2 269	M. Benayoun et al.	(IPNP, NOVO, ADLD+)
BREITWEG	98B	EPJ C2 247	J. Breitweg et al.	(ZEUS Collab.)
GARDNER	98	PR D57 2716	S. Gardner, H.B. O'Connell	
Also		PR D62 019903 (errat.)	S. Gardner, H.B. O'Connell	

ABELE	97	PL B391 191	A. Abele *et al.*	(Crystal Barrel Collab.)
ADAMS	97	ZPHY C74 237	M.R. Adams *et al.*	(E665 Collab.)
BARATE	97M	ZPHY C76 15	R. Barate *et al.*	(ALEPH Collab.)
BERTIN	97C	PL B408 476	A. Bertin *et al.*	(OBELIX Collab.)
BOGOLYUB...	97	PAN 60 46	M.Y. Bogolyubsky *et al.*	(MOSU, SERP)
		Translated from YAF 60 53.		
O'CONNELL	97	NP A623 559	H.B. O'Connell *et al.*	(ADLD)
BENAYOUN	96	ZPHY C72 221	M. Benayoun *et al.*	(IPNP, NOVO)
BERNICHA	94	PR D50 4454	A. Bernicha, G. Lopez Castro, J. Pestieau	(LOUV+)
WEIDENAUER	93	ZPHY C59 387	P. Weidenauer *et al.*	(ASTERIX Collab.)
AGUILAR-...	91	ZPHY C50 405	M. Aguilar-Benitez *et al.*	(LEBC-EHS Collab.)
DOLINSKY	91	PRPL 202 99	S.I. Dolinsky *et al.*	(NOVO)
KUHN	90	ZPHY C48 445	J.H. Kuhn *et al.*	(MPIM)
ANTIPOV	89	ZPHY C42 185	Y.M. Antipov *et al.*	(SERP, JINR, BGNA+)
BISELLO	89	PL B220 321	D. Bisello *et al.*	(DM2 Collab.)
DOLINSKY	89	ZPHY C42 511	S.I. Dolinsky *et al.*	(NOVO)
DUBNICKA	89	JP G15 1349	S. Dubnicka *et al.*	(JINR, SLOV)
GESHKEN...	89	ZPHY C45 351	B.V. Geshkenbein	(ITEP)
KURDADZE	88	JETPL 47 512	L.M. Kurdadze *et al.*	(NOVO)
		Translated from ZETFP 47 432.		
VASSERMAN	88	SJNP 47 1035	I.B. Vasserman *et al.*	(NOVO)
		Translated from YAF 47 1635.		
VASSERMAN	88B	SJNP 48 480	I.B. Vasserman *et al.*	(NOVO)
		Translated from YAF 48 753.		
AULCHENKO	87C	IYF 87-90 Preprint	V.M. Aulchenko *et al.*	(NOVO)
CAPRARO	87	NP B288 659	L. Capraro *et al.*	(CLER, FRAS, MILA+)
BRAMON	86	PL B173 97	A. Bramon, J. Casulleras	(BARC)
HUSTON	86	PR D33 3199	J. Huston *et al.*	(ROCH, FNAL, MINN)
KURDADZE	86	JETPL 43 643	L.M. Kurdadze *et al.*	(NOVO)
		Translated from ZETFP 43 497.		
BARKOV	85	NP B256 365	L.M. Barkov *et al.*	(NOVO)
DRUZHININ	84	PL 144B 136	V.P. Druzhinin *et al.*	(NOVO)
CHABAUD	83	NP B223 1	V. Chabaud *et al.*	(CERN, CRAC, MPIM)
JENSEN	83	PR D27 26	T. Jensen *et al.*	(ROCH, FNAL, MINN)
HEYN	81	ZPHY C7 169	M.F. Heyn, C.B. Lang	(GRAZ)
BOHACIK	80	PR D21 1342	J. Bohacik, H. Kuhnelt	(SLOV, WIEN)
COHEN	80	PR D22 2595	D. Cohen *et al.*	(ANL)
LANG	79	PR D19 956	C.B. Lang, A. Mas-Parareda	(GRAZ)
BARTALUCCI	78	NC 44A 587	S. Bartalucci *et al.*	(DESY, FRAS)
WICKLUND	78	PR D17 1197	A.B. Wicklund *et al.*	(ANL)
ANDREWS	77	PRL 38 198	D.E. Andrews *et al.*	(ROCH)
DEUTSCH...	76	NP B103 426	M. Deutschmann *et al.*	(AACH3, BERL, BONN+)
ENGLER	74	PR D10 2070	A. Engler *et al.*	(CMU, CASE)
ESTABROOKS	74	NP B79 301	P.G. Estabrooks, A.D. Martin	(DURH)
GRAYER	74	NP B75 189	G. Grayer *et al.*	(CERN, MPIM)
RATCLIFF	74	Private Comm.		
BYERLY	73	PR D7 637	W.L. Byerly *et al.*	(MICH)
GLADDING	73	PR D8 3721	G.E. Gladding *et al.*	(HARV)
HYAMS	73	NP B64 134	B.D. Hyams *et al.*	(CERN, MPIM)
PROTOPOP...	73	PR D7 1279	S.D. Protopopescu *et al.*	(LBL)
BALLAM	72	PR D5 545	J. Ballam *et al.*	(SLAC, LBL, TUFTS)
BENAKSAS	72	PL 39B 289	D. Benaksas *et al.*	(ORSAY)
JACOBS	72	PR D6 1291	L.D. Jacobs	(SACL)
RATCLIFF	72	PL 38B 345	B.N. Ratcliff *et al.*	(SLAC)
ABRAMS	71	PR D4 653	G.S. Abrams *et al.*	(LBL)
ALVENSLEB...	70	PRL 24 786	H. Alvensleben *et al.*	(DESY)
BIGGS	70	PRL 24 1197	P.J. Biggs *et al.*	(DARE)
ERBE	69	PR 188 2060	R. Erbe *et al.*	(German Bubble Chamber Collab.)
MALAMUD	69	Argonne Conf. 93	E.I. Malamud, P.E. Schlein	(UCLA)
REYNOLDS	69	PR 184 1424	B.G. Reynolds *et al.*	(FSU)
ROTHWELL	69	PRL 23 1521	P.L. Rothwell *et al.*	(NEAS)
WEHMANN	69	PR 178 2095	A.A. Wehmann *et al.*	(HARV, CASE, SLAC+)
ARMENISE	68	NC 54A 999	N. Armenise *et al.*	(BARI, BGNA, FIRZ+)
BATON	68	PR 176 1574	J.P. Baton, G. Laurens	(SACL)
CHUNG	68	PR 165 1491	S.U. Chung *et al.*	(LRL)
FOSTER	68	NP B6 107	M. Foster *et al.*	(CERN, CDEF)
GOUNARIS	68	PRL 21 244	G.J. Gounaris, J.J. Sakurai	
HUSON	68	PL 28B 208	R. Huson *et al.*	(ORSAY, MILA, UCLA)
HYAMS	68	NP B7 1	B.D. Hyams *et al.*	(CERN, MPIM)
LANZEROTTI	68	PR 166 1365	L.J. Lanzerotti *et al.*	(HARV)
PISUT	68	NP B6 325	J. Pisut, M. Roos	(CERN)

ASBURY	67B	PRL 19 865	J.G. Asbury *et al.*	(DESY, COLU)
BACON	67	PR 157 1263	T.C. Bacon *et al.*	(BNL)
EISNER	67	PR 164 1699	R.L. Eisner *et al.*	(PURD)
HUWE	67	PL 24B 252	D.O. Huwe *et al.*	(COLU)
HYAMS	67	PL 24B 634	B.D. Hyams *et al.*	(CERN, MPIM)
MILLER	67B	PR 153 1423	D.H. Miller *et al.*	(PURD)
ALFF-...	66	PR 145 1072	C. Alff-Steinberger *et al.*	(COLU, RUTG)
FERBEL	66	PL 21 111	T. Ferbel	(ROCH)
HAGOPIAN	66	PR 145 1128	V. Hagopian *et al.*	(PENN, SACL)
HAGOPIAN	66B	PR 152 1183	V. Hagopian, Y.L. Pan	(PENN, LRL)
JACOBS	66B	UCRL 16877	L.D. Jacobs	(LRL)
JAMES	66	PR 142 896	F.E. James, H.L. Kraybill	(YALE, BNL)
ROSS	66	PR 149 1172	M. Ross, L. Stodolsky	
SOEDING	66	PL B19 702	P. Soeding	
WEST	66	PR 149 1089	E. West *et al.*	(WISC)
BLIEDEN	65	PL 19 444	H.R. Blieden *et al.*	(CERN MMS Collab.)
CARMONY	64	PRL 12 254	D.D. Carmony *et al.*	(UCB)
GOLDHABER	64	PRL 12 336	G. Goldhaber *et al.*	(LRL, UCB)
ABOLINS	63	PRL 11 381	M.A. Abolins *et al.*	(UCSD)