Citation: K. Hagiwara *et al.* (Particle Data Group), Phys. Rev. D **66**, 010001 (2002) and 2003 partial update for edition 2004 (URL: http://pdg.lbl.gov)

$\rho(770)$

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

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$\rho(770)$ MASS

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

MIXED CHARGES

VALUE (MeV)	*DOCUMENT ID*
775.0±1.0 OUR ESTIMATE	

775.9±0.5 OUR NEW AVERAGE Includes data from the datablock that follows this one.
[771.1 ± 0.9 MeV OUR 2002 AVERAGE Scale factor = 2.6]

MIXED CHARGES, τ DECAYS and e^+e^-

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
The data in this block is included in the average printed for a previous datablock.						
775.9 ±0.5 OUR AVERAGE						
775.8 ±0.9 ±2.0	500k	ACHASOV	02	SND	0	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
776.09±0.64±0.50	114k	[1] AKHMETSHIN	02	CMD2		$e^+e^- \to \pi^+\pi^-$
775.1 ±1.1 ±0.5	87k	[2,3] ANDERSON	00A	CLE2		$\tau^- \to \pi^-\pi^0\nu_\tau$
776.4 ±0.9 ±1.5		[3] BARATE	97M	ALEP		$\tau^- \to \pi^-\pi^0\nu_\tau$
775.9 ±1.1		[4] BARKOV	85	OLYA	0	$e^+e^- \to \pi^+\pi^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
774.5 ±0.7 ±1.5	500k	[5] ACHASOV	02	SND	±	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
775.0 ±0.6 ±1.1	500k	[6] ACHASOV	02	SND		1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
775.1 ±0.5		[7] PICH	01	RVUE		$\tau^- \to \pi^-\pi^0\nu_\tau$
775.1 ±0.7 ±5.3		[8] BENAYOUN	98	RVUE		$e^+e^- \to \pi^+\pi^-$, $\mu^+\mu^-$
770.5 ±1.9 ±5.1		[9] GARDNER	98	RVUE		0.28–0.92 $e^+e^- \to \pi^+\pi^-$
764.1 ±0.7		[10] O'CONNELL	97	RVUE		$e^+e^- \to \pi^+\pi^-$
757.5 ±1.5		[11] BERNICHA	94	RVUE		$e^+e^- \to \pi^+\pi^-$
768 ±1		[12] GESHKEN...	89	RVUE		$e^+e^- \to \pi^+\pi^-$

MIXED CHARGES, OTHER REACTIONS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
763.0±0.3±1.2	600k	[13] ABELE	99E	CBAR	0±	0.0 $\overline{p}p \to \pi^+\pi^-\pi^0$

CHARGED ONLY, HADROPRODUCED

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
766.5±1.1 OUR AVERAGE						
763.7±3.2		ABELE	97	CBAR		$\overline{p}n \rightarrow \pi^-\pi^0\pi^0$
768 ±9		AGUILAR-...	91	EHS		400 pp
767 ±3	2935	[14] CAPRARO	87	SPEC	−	200 π^- Cu → $\pi^-\pi^0$ Cu
761 ±5	967	[14] CAPRARO	87	SPEC	−	200 π^- Pb → $\pi^-\pi^0$ Pb
771 ±4		HUSTON	86	SPEC	+	202 π^+ A → $\pi^+\pi^0$ A
766 ±7	6500	[15] BYERLY	73	OSPK	−	5 π^-p
766.8±1.5	9650	[16] PISUT	68	RVUE	−	1.7–3.2 π^-p, t <10
767 ±6	900	[14] EISNER	67	HBC	−	4.2 π^-p, t <10

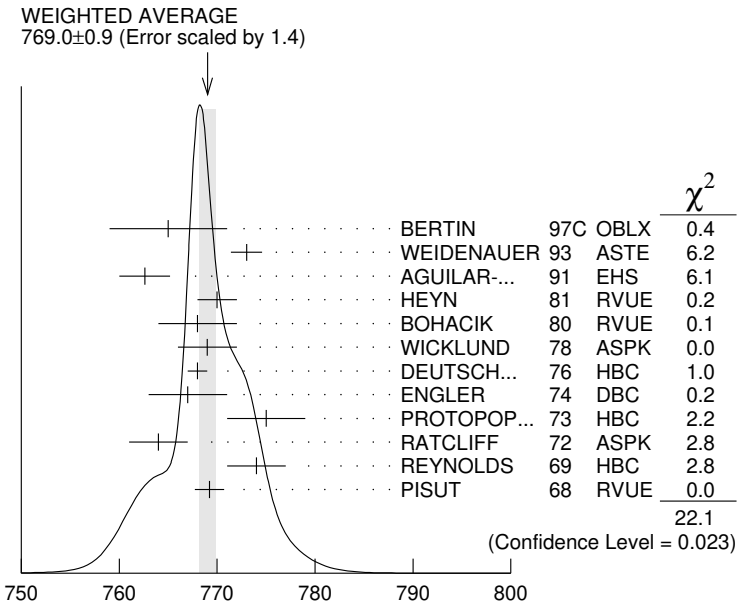
NEUTRAL ONLY, PHOTOPRODUCED

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
768.5± 1.1 OUR AVERAGE						
770 ± 2 ±1	79k	[17] BREITWEG	98B	ZEUS	0	50–100 γp
767.6± 2.7		BARTALUCCI	78	CNTR	0	$\gamma p \rightarrow e^+e^-p$
775 ± 5		GLADDING	73	CNTR	0	2.9–4.7 γp
767 ± 4	1930	BALLAM	72	HBC	0	2.8 γp
770 ± 4	2430	BALLAM	72	HBC	0	4.7 γp
765 ±10		ALVENSLEB...	70	CNTR	0	γ A, t <0.01
767.7± 1.9	140k	BIGGS	70	CNTR	0	<4.1 γ C → $\pi^+\pi^-$ C
765 ± 5	4000	ASBURY	67B	CNTR	0	γ + Pb
• • • We do not use the following data for averages, fits, limits, etc. • • •						
771 ± 2	79k	[18] BREITWEG	98B	ZEUS	0	50–100 γp

NEUTRAL ONLY, OTHER REACTIONS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*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 $\overline{p}p \rightarrow \pi^+\pi^-\pi^0$
773 ±1.6		WEIDENAUER	93	ASTE		$\overline{p}p \rightarrow \pi^+\pi^-\omega$
762.6±2.6		AGUILAR-...	91	EHS		400 pp
770 ±2		[19] HEYN	81	RVUE		Pion form factor
768 ±4		[20,21] BOHACIK	80	RVUE	0	
769 ±3		[15] WICKLUND	78	ASPK	0	3,4,6 $\pi^\pm N$
768 ±1	76000	DEUTSCH...	76	HBC	0	16 π^+p
767 ±4	4100	ENGLER	74	DBC	0	6 $\pi^+n \rightarrow \pi^+\pi^-p$
775 ±4	32000	[20] PROTOPOP...	73	HBC	0	7.1 π^+p, t <0.4
764 ±3	6800	RATCLIFF	72	ASPK	0	15 π^-p, t <0.3
774 ±3	1700	REYNOLDS	69	HBC	0	2.26 π^-p
769.2±1.5	13300	[22] PISUT	68	RVUE	0	1.7–3.2 π^-p, t <10
• • • We do not use the following data for averages, fits, limits, etc. • • •						
773.5±2.5		[23] COLANGELO	01	RVUE		$\pi\pi \rightarrow \pi\pi$
762.3±0.5±1.2	600k	[24] ABELE	99E	CBAR	0	0.0 $\overline{p}p \rightarrow \pi^+\pi^-\pi^0$
777 ±2	4943	[25] ADAMS	97	E665		470 $\mu p \rightarrow \mu XB$
770 ±2		[26] BOGOLYUB...	97	MIRA		32 $\overline{p}p \rightarrow \pi^+\pi^-$X
768 ±8		[26] BOGOLYUB...	97	MIRA		32 $pp \rightarrow \pi^+\pi^-$X

761.1±2.9			DUBNICKA	89	RVUE		π form factor
777.4±2.0		[27]	CHABAUD	83	ASPK	0	17 π^- p polarized
769.5±0.7		[20,21]	LANG	79	RVUE	0	
770 ±9		[21]	ESTABROOKS	74	RVUE	0	17 π^- $p \rightarrow$ $\pi^+\pi^-$ n
773.5±1.7	11200	[14]	JACOBS	72	HBC	0	2.8 π^- p
775 ±3	2250		HYAMS	68	OSPK	0	11.2 π^- p



$\rho(770)^0$ mass (MeV)

[1] Using the GOUNARIS 68 parameterization with the complex phase of the ρ-ω interference.

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

[3] 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.

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

[5] Not independent of ACHASOV 02 measurements of m_{ρ^0} and $m_{\rho^0} - m_{\rho^\pm}$.

[6] Assuming $m_{\rho^\pm} = m_{\rho^0}$.

[7] From a fit of the model-independent parameterization of the pion form factor to the data of BARATE 97M.

[8] Using the data of BARKOV 85 in the hidden local symmetry model.

[9] 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.

[10] A fit of BARKOV 85 data assuming the direct $\omega\pi\pi$ coupling.

[11] Applying the S-matrix formalism to the BARKOV 85 data.

[12] Includes BARKOV 85 data. Model-dependent width definition.

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

[14] Mass errors enlarged by us to $\Gamma/\sqrt{N}$; see the note with the $K^*(892)$ mass.

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

[16] 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.
[17] From the parametrization according to SOEDING 66.
[18] From the parametrization according to ROSS 66.
[19] HEYN 81 includes all spacelike and timelike F_π values until 1978.
[20] From pole extrapolation.
[21] From phase shift analysis of GRAYER 74 data.
[22] 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.
[23] Breit-Wigner mass from a phase-shift analysis of HYAMS 73 and PROTOPOPESCU 73 data.
[24] Using relativistic Breit-Wigner and taking into account ρ-ω interference.
[25] Systematic errors not evaluated.
[26] Systematic effects not studied.
[27] From fit of 3-parameter relativistic Breit-Wigner to helicity-zero part of P-wave intensity. CHABAUD 83 includes data of GRAYER 74.

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

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
0.5±0.7 OUR AVERAGE						
1.3±1.1±2.0	500k	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 $\overline{p} p \to \pi^+ \pi^- \pi^0$
0.0±1.0		[30] BARATE	97M	ALEP		$\tau^- \to \pi^- \pi^0 \nu_\tau$
−4 ±4	3000	[28] REYNOLDS	69	HBC	−0	2.26 $\pi^- p$
−5 ±5	3600	[28] FOSTER	68	HBC	±0	0.0 $\overline{p} p$
2.4±2.1	22950	[29] PISUT	68	RVUE		$\pi N \to \rho N$

[28] From quoted masses of charged and neutral modes.
[29] 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.
[30] Using the compilation of $e^+ e^-$ data from BARKOV 85.

$\rho(770)$ 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*
$\mathbf{5.3^{+0.9}_{-0.7}}$	CHABAUD	83	ASPK	0	17 $\pi^- p$ polarized

$\rho(770)$ WIDTH

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

MIXED CHARGES

VALUE (MeV)	*DOCUMENT ID*
150.0±2.0 OUR ESTIMATE	
150.4±1.3 OUR NEW AVERAGE Includes data from the datablock that follows this one. [149.2 ± 0.7 MeV OUR 2002 AVERAGE Scale factor = 1.1]	

MIXED CHARGES, τ DECAYS and e^+e^-

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
The data in this block is included in the average printed for a previous datablock.						
150.4 ±1.3 OUR FIT						
150.4 ±1.3 OUR NEW AVERAGE [147.9 ± 1.3 MeV OUR 2002 AVERAGE Scale factor = 1.3]						
151.1 ±2.6 ±3.0	500k	ACHASOV	02	SND	0	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
149.9 ±2.3 ±2.0	500k	ACHASOV	02	SND	±	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
150.4 ±1.4 ±1.4	87k	[31,32] ANDERSON	00A	CLE2		$\tau^- \to \pi^-\pi^0\nu_\tau$
150.5 ±1.6 ±6.3		[32] BARATE	97M	ALEP		$\tau^- \to \pi^-\pi^0\nu_\tau$
150.5 ±3.0		[33] BARKOV	85	OLYA	0	$e^+e^- \to \pi^+\pi^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
149.8 ±2.2 ±2.0	500k	[34] ACHASOV	02	SND		1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
150.9 ±2.2 ±2.0	500k	[34] ACHASOV	02	SND		1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
144.46±1.33±0.80	114k	[35,36] AKHMETSHIN	02	CMD2		$e^+e^- \to \pi^+\pi^-$
147.9 ±1.5 ±7.5		[37] BENAYOUN	98	RVUE		$e^+e^- \to \pi^+\pi^-$, $\mu^+\mu^-$
153.5 ±1.3 ±4.6		[38] GARDNER	98	RVUE		0.28–0.92 $e^+e^- \to \pi^+\pi^-$
145.0 ±1.7		[39] O'CONNELL	97	RVUE		$e^+e^- \to \pi^+\pi^-$
142.5 ±3.5		[40] BERNICHA	94	RVUE		$e^+e^- \to \pi^+\pi^-$
138 ±1		[41] GESHKEN...	89	RVUE		$e^+e^- \to \pi^+\pi^-$

MIXED CHARGES, OTHER REACTIONS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
149.5±1.3	600k	[42] ABELE	99E	CBAR	0±	0.0 $\overline{p}p \to \pi^+\pi^-\pi^0$

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	2935	[43] CAPRARO	87	SPEC	−	200 π^- Cu → $\pi^-\pi^0$ Cu
154 ±20	967	[43] CAPRARO	87	SPEC	−	200 π^- Pb → $\pi^-\pi^0$ Pb
150 ± 5		HUSTON	86	SPEC	+	202 π^+ A → $\pi^+\pi^0$ A
146 ±12	6500	[44] BYERLY	73	OSPK	−	5 $\pi^- p$
148.2± 4.1	9650	[45] PISUT	68	RVUE	−	1.7–3.2 $\pi^- p$, t <10
146 ±13	900	EISNER	67	HBC	−	4.2 $\pi^- p$, t <10

NEUTRAL ONLY, PHOTOPRODUCED

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
150.7± 2.9 OUR AVERAGE						
146 ± 3 ±13	79k	[46] BREITWEG	98B	ZEUS	0	50–100 γp
150.9± 3.0		BARTALUCCI	78	CNTR	0	$\gamma p \rightarrow e^+ e^- p$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
138 ± 3	79k	[47] BREITWEG	98B	ZEUS	0	50–100 γp
147 ±11		GLADDING	73	CNTR	0	2.9–4.7 γp
155 ±12	2430	BALLAM	72	HBC	0	4.7 γp
145 ±13	1930	BALLAM	72	HBC	0	2.8 γp
140 ± 5		ALVENSLEB...	70	CNTR	0	γ A, t <0.01
146.1± 2.9	140k	BIGGS	70	CNTR	0	<4.1 γ C $\rightarrow \pi^+ \pi^-$ C
160 ±10		LANZEROTTI	68	CNTR	0	γp
130 ± 5	4000	ASBURY	67B	CNTR	0	γ + Pb

NEUTRAL ONLY, OTHER REACTIONS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*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		[48,49] BOHACIK	80	RVUE	0	
152 ± 9		[44] WICKLUND	78	ASPK	0	3,4,6 $\pi^\pm p N$
154 ± 2	76000	DEUTSCH...	76	HBC	0	16 $\pi^+ p$
157 ± 8	6800	RATCLIFF	72	ASPK	0	15 $\pi^- p$, t <0.3
143 ± 8	1700	REYNOLDS	69	HBC	0	2.26 $\pi^- p$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
147.0± 2.5	600k	[50] ABELE	99E	CBAR	0	0.0 $\overline{p} p \rightarrow \pi^+ \pi^- \pi^0$
146 ± 3	4943	[51] ADAMS	97	E665		470 $\mu p \rightarrow \mu X B$
$160.0^{+\ 4.1}_{-\ 4.0}$		[52] CHABAUD	83	ASPK	0	17 $\pi^- p$ polarized
155 ± 1		[53] HEYN	81	RVUE	0	π form factor
148.0± 1.3		[48,49] LANG	79	RVUE	0	
146 ±14	4100	ENGLER	74	DBC	0	6 $\pi^+ n \rightarrow \pi^+ \pi^- p$
143 ±13		[49] ESTABROOKS	74	RVUE	0	17 $\pi^- p \rightarrow \pi^+ \pi^- n$
160 ±10	32000	[48] PROTOPOP...	73	HBC	0	7.1 $\pi^+ p$, t <0.4
145 ±12	2250	[43] HYAMS	68	OSPK	0	11.2 $\pi^- p$
163 ±15	13300	[54] PISUT	68	RVUE	0	1.7–3.2 $\pi^- p$, t <10

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

[32] 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.

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

[34] Assuming $g_{\rho^0 \pi\pi} = g_{\rho^\pm \pi\pi}$.

[35] Using Gounaris-Sakurai parameterization with the complex phase of the ρ-ω interference.

[36] From a fit in the energy range 0.61 to 0.96 GeV.

[37] Using the data of BARKOV 85 in the hidden local symmetry model.

[38] 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.

[39] A fit of BARKOV 85 data assuming the direct $\omega\pi\pi$ coupling.

[40] Applying the S-matrix formalism to the BARKOV 85 data.

[41] Includes BARKOV 85 data. Model-dependent width definition.
[42] Assuming the equality of ρ^+ and ρ^- masses and widths.
[43] Width errors enlarged by us to $4\Gamma/\sqrt{N}$; see the note with the $K^*(892)$ mass.
[44] Phase shift analysis. Systematic errors added corresponding to spread of different fits.
[45] 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.
[46] From the parametrization according to SOEDING 66.
[47] From the parametrization according to ROSS 66.
[48] From pole extrapolation.
[49] From phase shift analysis of GRAYER 74 data.
[50] Using relativistic Breit-Wigner and taking into account ρ-ω interference.
[51] Systematic errors not evaluated.
[52] From fit of 3-parameter relativistic Breit-Wigner to helicity-zero part of P-wave intensity. CHABAUD 83 includes data of GRAYER 74.
[53] HEYN 81 includes all spacelike and timelike F_π values until 1978.
[54] 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	*DOCUMENT ID*		*TECN*	*COMMENT*
-0.1 ± 1.9	[55] BARATE	97M	ALEP	$\tau^- \to \pi^- \pi^0 \nu_\tau$

[55] Using the compilation of $e^+ e^-$ data from BARKOV 85.

$\rho(770)$ DECAY MODES

	Mode		Fraction (Γ_i/Γ)		Scale factor/ Confidence level
Γ_1	$\pi\pi$		$\sim$ 100	%	
	$\rho(770)^\pm$ decays				
Γ_2	$\pi^\pm \pi^0$		$\sim$ 100	%	
Γ_3	$\pi^\pm \gamma$		(4.5 $\pm$0.5) $\times 10^{-4}$		S=2.2
Γ_4	$\pi^\pm \eta$		$<$ 6	$\times 10^{-3}$	CL=84%
Γ_5	$\pi^\pm \pi^+ \pi^- \pi^0$		$<$ 2.0	$\times 10^{-3}$	CL=84%
	$\rho(770)^0$ decays				
Γ_6	$\pi^+ \pi^-$		$\sim$ 100	%	
Γ_7	$\pi^+ \pi^- \gamma$		(9.9 $\pm$1.6) $\times 10^{-3}$		
Γ_8	$\pi^0 \gamma$		(6.2 $\pm$1.3) $\times 10^{-4}$		S=1.1
Γ_9	$\eta \gamma$		(3.1 $\pm$0.4) $\times 10^{-4}$		S=1.4
Γ_{10}	$\pi^0 \pi^0 \gamma$		(4.1 $\pm$1.0) $\times 10^{-5}$		
Γ_{11}	$\mu^+ \mu^-$	[a]	(4.60$\pm$0.28) $\times 10^{-5}$		
Γ_{12}	$e^+ e^-$	[a]	(4.48$\pm$0.21) $\times 10^{-5}$		
Γ_{13}	$\pi^+ \pi^- \pi^0$		$<$ 1.2	$\times 10^{-4}$	CL=90%
Γ_{14}	$\pi^+ \pi^- \pi^+ \pi^-$		(1.8 $\pm$0.9) $\times 10^{-5}$		
Γ_{15}	$\pi^+ \pi^- \pi^0 \pi^0$		$<$ 4	$\times 10^{-5}$	CL=90%

[*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 $\langle \delta p_i \delta p_j \rangle / (\delta p_i \cdot \delta p_j)$, in percent, from the fit to parameters p_i, including the branching fractions, $x_i \equiv \Gamma_i/\Gamma_{\rm total}$. The fit constrains the x_i whose labels appear in this array to sum to one.

x_3	−100		
Γ	15	−15	
	x_2	x_3	

	Mode	Rate (MeV)	Scale factor
Γ_2	$\pi^\pm\pi^0$	150.2 ±2.4	
Γ_3	$\pi^\pm\gamma$	0.068±0.007	2.3

CONSTRAINED FIT INFORMATION

An overall fit to the total width, a partial width, and 4 branching ratios uses 13 measurements and one constraint to determine 6 parameters. The overall fit has a $\chi^2 = 5.0$ for 8 degrees of freedom.

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

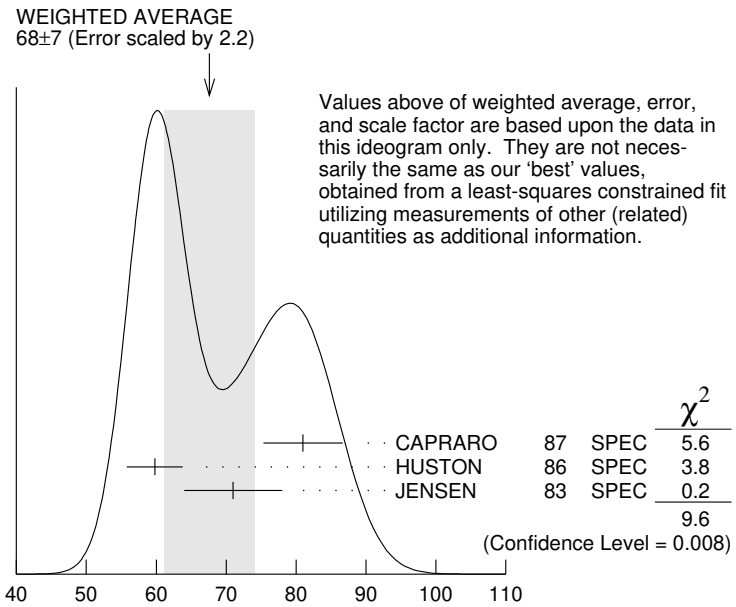
x_8	−96				
x_9	−35	8			
x_{11}	−2	0	0		
x_{12}	29	−22	−36	0	
Γ	−6	4	7	0	−19
	x_6	x_8	x_9	x_{11}	x_{12}

	Mode		Rate (MeV)		Scale factor
Γ_6	$\pi^+ \pi^-$		150.3	±1.3	
Γ_8	$\pi^0 \gamma$		0.093	±0.020	1.1
Γ_9	$\eta \gamma$		0.046	±0.006	1.4
Γ_{11}	$\mu^+ \mu^-$	[a]	0.0069	±0.0004	
Γ_{12}	$e^+ e^-$	[a]	0.00674	±0.00032	

$\rho(770)$ PARTIAL WIDTHS

$\Gamma(\pi^\pm \gamma)$ Γ_3

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 ±4 ±4	CAPRARO	87	SPEC	−	200 π^- A → $\pi^- \pi^0$ A
59.8±4.0	HUSTON	86	SPEC	+	202 π^+ A → $\pi^+ \pi^0$ A
71 ±7	JENSEN	83	SPEC	−	156–260 π^- A → $\pi^- \pi^0$ A



$\Gamma\left(\pi^{\pm}\gamma\right)$ (keV)

$\Gamma\left(e^+e^-\right)$ Γ_{12}

VALUE (keV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
6.74±0.32 OUR NEW UNCHECKED FIT		[6.85 ± 0.11 keV OUR 2002 FIT]			
6.77±0.32 OUR NEW AVERAGE		[6.85 ± 0.11 keV OUR 2002 AVERAGE]			
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. • • •					
6.86±0.11±0.05	114k	[56,57] AKHMETSHIN	02	CMD2	$e^+e^- \to \pi^+\pi^-$
6.3 ±0.1		[58] BENAYOUN	98	RVUE	$e^+e^- \to \pi^+\pi^-$, $\mu^+\mu^-$

$\Gamma\left(\pi^0\gamma\right)$ Γ_8

VALUE (keV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
77±17±11	36500	[59] ACHASOV	03	SND	0.60–0.97 $e^+e^- \to \pi^0\gamma$
121±31		DOLINSKY	89	ND	$e^+e^- \to \pi^0\gamma$

$\Gamma\left(\eta\gamma\right)$ Γ_9

VALUE (keV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
62±17	[60] DOLINSKY	89	ND	$e^+e^- \to \eta\gamma$

$\Gamma(\pi^+\pi^-\pi^+\pi^-)$ Γ_{14}

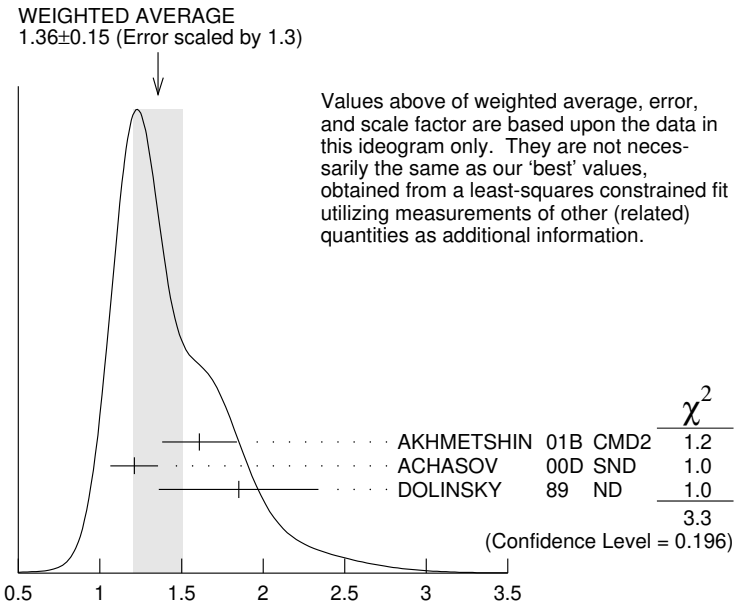
VALUE (keV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$2.8\pm1.4\pm0.5$	153	AKHMETSHIN	00	CMD2	0.6–0.97 $e^+e^- \to \pi^+\pi^-\pi^+\pi^-$

[56] Using Gounaris-Sakurai parameterization with the complex phase of the ρ-ω interference.
[57] From a fit in the energy range 0.61 to 0.96 GeV.
[58] Using the data of BARKOV 85 in the hidden local symmetry model.
[59] Using $\Gamma_{total} = 147.9 \pm 1.3$ MeV and B($\rho \to \pi^0\gamma$) from ACHASOV 03.
[60] Solution corresponding to constructive ω-ρ interference.

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

$\Gamma(e^+e^-) \times \Gamma(\eta\gamma)/\Gamma^2_{total}$ $\Gamma_{12}\Gamma_9/\Gamma^2$

VALUE (units 10^{-8})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1.38 ± 0.17 OUR FIT Error includes scale factor of 1.5.					
1.36 ± 0.15 OUR NEW AVERAGE Error includes scale factor of 1.3. See the ideogram below. [$(1.33 \pm 0.18) \times 10^{-8}$ OUR 2002 AVERAGE Scale factor = 1.5]					
$1.61\pm0.20\pm0.11$	23k	[62,63] AKHMETSHIN	01B	CMD2	$e^+e^- \to \eta\gamma$
$1.21\pm0.14\pm0.04$	312	[64] ACHASOV	00D	SND	$e^+e^- \to \eta\gamma$
1.85 ± 0.49		[65] DOLINSKY	89	ND	$e^+e^- \to \eta\gamma$



$\Gamma(e^+e^-) \times \Gamma(\eta\gamma)/\Gamma^2_{total}$ $\Gamma_{12}\Gamma_9/\Gamma^2$

$\Gamma(e^+e^-) \times \Gamma(\pi^0\gamma)/\Gamma^2_{\text{total}}$ $\Gamma_{12}\Gamma_8/\Gamma^2$

VALUE (units 10^{-8})	EVTS	DOCUMENT ID		TECN	COMMENT
2.8 ±0.6 OUR FIT Error includes scale factor of 1.1.					
2.8 ±0.6 OUR AVERAGE Error includes scale factor of 1.1.					
2.37±0.53±0.33	36500	[61] ACHASOV	03	SND	0.60–0.97 $e^+e^- \to \pi^0\gamma$
3.61±0.74±0.49	10625	[65] DOLINSKY	89	ND	$e^+e^- \to \pi^0\gamma$

[61] 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 ϕ-ω interference equal to $(-10.2 \pm 7.0)^\circ$.

[62] From the $\eta \to 3\pi^0$ decay and using B($\eta \to 3\pi^0$)= $(32.24 \pm 0.29) \times 10^{-2}$.

[63] 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).

[64] From the $\eta \to 3\pi^0$ decay and using B($\eta \to 3\pi^0$)= $(32.2 \pm 0.4) \times 10^{-2}$.

[65] Recalculated by us from the cross section in the peak.

$\rho(770)$ BRANCHING RATIOS

$\Gamma(\pi^\pm\eta)/\Gamma(\pi\pi)$ Γ_4/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_5/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 $\pi^+ p$

$\Gamma(\mu^+\mu^-)/\Gamma(\pi^+\pi^-)$ Γ_{11}/Γ_6

VALUE (units 10^{-5})	DOCUMENT ID		TECN	COMMENT
4.60±0.28 OUR FIT				
4.6 ±0.2 ±0.2	ANTIPOV	89	SIGM	π^- Cu $\to \mu^+\mu^-\pi^-$ Cu
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$8.2\ ^{+1.6}_{-3.6}$	[66] ROTHWELL	69	CNTR	Photoproduction
5.6 ±1.5	[67] WEHMANN	69	OSPK	12 π^- C, Fe
$9.7\ ^{+3.1}_{-3.3}$	[68] HYAMS	67	OSPK	11 π^- Li, H

$\Gamma(e^+e^-)/\Gamma(\pi\pi)$ Γ_{12}/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	[69] BENAKSAS	72	OSPK	$e^+e^- \to \pi^+\pi^-$

$\Gamma(\eta\gamma)/\Gamma_{total}$ Γ_9/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
3.1 ±0.4 OUR FIT	Error includes scale factor of 1.4.					
3.6 ±0.9 OUR NEW AVERAGE	[(3.8 ± 0.7) × 10^{-4} OUR 2002 AVERAGE]					
3.6 ±0.9		[70] ANDREWS	77	CNTR	0	6.7–10 γ Cu
• • • We do not use the following data for averages, fits, limits, etc. • • •						
3.39±0.42±0.23		[70,71,72] AKHMETSHIN	01B	CMD2		$e^+e^- \to \eta\gamma$
2.69±0.32±0.16	312	[73] ACHASOV	00D	SND		$e^+e^- \to \eta\gamma$
$1.9\ ^{+0.6}_{-0.8}$		[74] BENAYOUN	96	RVUE		0.54-1.04 $e^+e^- \to \eta\gamma$
4.0 ±1.1		[70,75] DOLINSKY	89	ND		$e^+e^- \to \eta\gamma$

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

VALUE (units 10^{-5})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
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_{14}/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 $\pi^+ p$

$\Gamma(\pi^+\pi^-\pi^0)/\Gamma_{total}$ Γ_{13}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<1.2	90	VASSERMAN	88B	ND	$e^+e^- \to \pi^+\pi^-\pi^0$

$\Gamma(\pi^+\pi^-\pi^0)/\Gamma(\pi\pi)$ Γ_{13}/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	[76] ABRAMS	71	HBC	0	3.7 $\pi^+ p$

$\Gamma(\pi^+\pi^-\pi^0\pi^0)/\Gamma_{total}$ Γ_{15}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	CHG	COMMENT
<0.4	90	AULCHENKO	87C	ND	0	$e^+e^- \to \pi^+\pi^-\pi^0\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<2	90	KURDADZE	86	OLYA	0	$e^+e^- \to \pi^+\pi^-\pi^0\pi^0$

$\Gamma(\pi^+\pi^-\gamma)/\Gamma_{total}$ Γ_7/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
0.0099±0.0016		[77] DOLINSKY	91	ND	$e^+e^- \to \pi^+\pi^-\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.0111±0.0014		[78] VASSERMAN	88	ND	$e^+e^- \to \pi^+\pi^-\gamma$
<0.005	90	[79] VASSERMAN	88	ND	$e^+e^- \to \pi^+\pi^-\gamma$

$\Gamma(\pi^0\gamma)/\Gamma_{total}$ Γ_8/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
5.22±1.17±0.75	36500	[80,81] ACHASOV	03	SND	0.60–0.97 $e^+e^- \to \pi^0\gamma$
6.8 ±1.7		[82] BENAYOUN	96	RVUE	0.54-1.04 $e^+e^- \to \pi^0\gamma$
7.9 ±2.0		[81] DOLINSKY	89	ND	$e^+e^- \to \pi^0\gamma$

$\Gamma(\pi^0\pi^0\gamma)/\Gamma_{total}$ Γ_{10}/Γ

VALUE (units 10^{-5})	EVTS	DOCUMENT ID		TECN	COMMENT
4.1±1.0 OUR NEW AVERAGE		[$(4.8^{+3.4}_{-1.9})\times10^{-5}$ OUR 2002 AVERAGE]			
$4.1^{+1.0}_{-0.9}\pm0.3$	295	[83] 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. • • •					
$4.8^{+3.4}_{-1.8}\pm0.5$	63	[84] ACHASOV	00G	SND	$e^+e^- \to \pi^0\pi^0\gamma$

[66] Possibly large ρ-ω interference leads us to increase the minus error.
[67] 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.
[68] HYAMS 67's mass resolution is 20 MeV. The ω region was excluded.
[69] The ρ' contribution is not taken into account.
[70] Solution corresponding to constructive ω-ρ interference.
[71] 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).
[72] Using $B(\rho \to e^+e^-) = (4.75 \pm 0.10)\times10^{-5}$ from AKHMETSHIN 02 and $B(\eta \to 3\pi^0) = (32.24 \pm 0.29)\times10^{-2}$.
[73] Using $B(\rho \to e^+e^-) = (4.49\pm0.22)\times10^{-5}$ and $B(\eta \to 3\pi^0) = (32.2\pm0.4)\times10^{-2}$.
[74] Reanalysis of DRUZHININ 84, DOLINSKY 89, and DOLINSKY 91 taking into account a triangle anomaly contribution. Constructive ρ-ω interference solution.
[75] Not independent of the corresponding $\Gamma(e^+e^-)\times\Gamma(\eta\gamma)/\Gamma^2_{total}$.
[76] Model dependent, assumes I = 1, 2, or 3 for the 3π system.
[77] Bremsstrahlung from a decay pion and for photon energy above 50 MeV.
[78] Superseded by DOLINSKY 91.
[79] Structure radiation due to quark rearrangement in the decay.
[80] Using $B(\rho \to e^+e^-) = (4.54 \pm 0.10)\times10^{-5}$.
[81] Not independent of the corresponding $\Gamma(e^+e^-)\times\Gamma(\pi^0\gamma)/\Gamma^2_{total}$.
[82] Reanalysis of DRUZHININ 84, DOLINSKY 89, and DOLINSKY 91 taking into account a triangle anomaly contribution.
[83] This branching ratio includes the conventional VMD mechanism $\rho \to \omega\pi^0$, $\omega \to \pi^0\gamma$ and the new decay mode $\rho \to f_0(600)\gamma$, $f_0(600) \to \pi^0\pi^0$ with a branching ratio $(1.9^{+0.9}_{-0.8} \pm 0.4)\times10^{-5}$ differring from zero by 2.4 standard deviations.
[84] Superseded by ACHASOV 02F.

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