$\rho(770)$

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

THE $\rho(770)$

Updated March 2000 by S. Eidelman (Novosibirsk).

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 by PISUT 68. Bose-Einstein correlations are another source of shifts in the $\rho(770)$ line shape, particularly in multiparticle final state systems (LAFFERTY 93).

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 (BENAYOUN 93, ABELE 97B). Recently, BENAYOUN 98 compared the predictions of different Vector Meson Dominance (VMD)-based models with the data on the $e^+e^- \to \pi^+\pi^-$ cross section below 1 GeV, as well as with the phase and near-threshold behavior of the time-like pion form factor. They showed that only the model based on hidden local symmetry (HLS) is able to account consistently for all low-energy information, if one also requires a point-like coupling $\gamma\pi^+\pi^-$, which is excluded by common VMD but predicted by HLS.

The cleanest determination of the $\rho(770)$ mass and width comes from the e^+e^- annihilation and τ-lepton decays. BARATE 97M showed that the charged $\rho(770)$ parameters measured

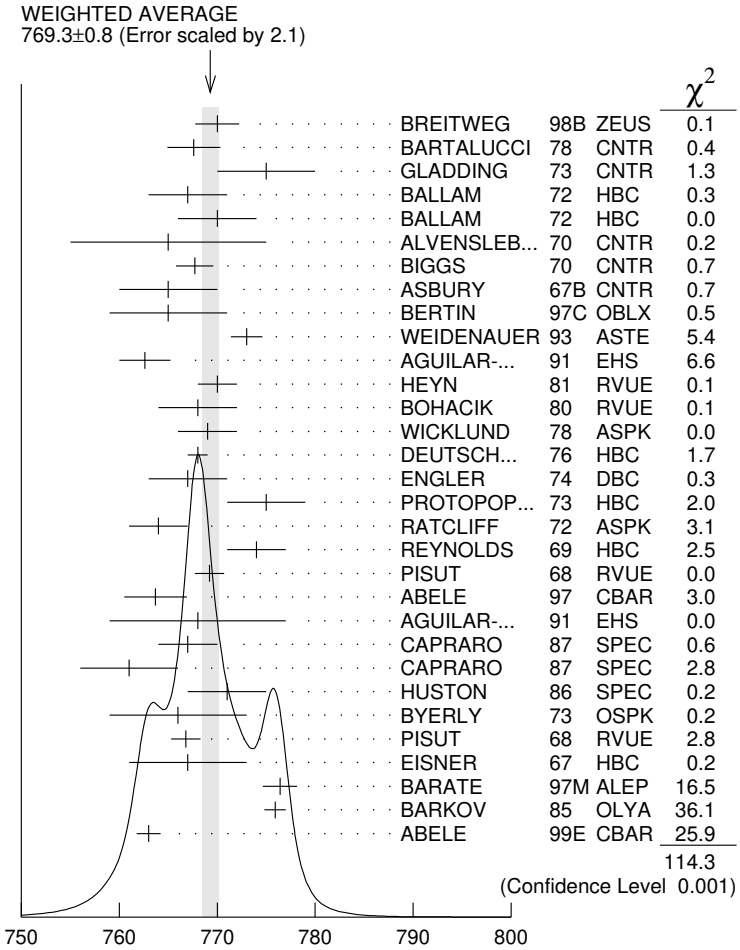
from τ-lepton decays are consistent with those of the neutral one determined from e^+e^- data of BARKOV 85. This conclusion is qualitatively supported by the high statistics study of ANDERSON 00. However, model-independent comparison of the two-pion mass spectrum in τ decays and the $e^+e^- \to \pi^+\pi^-$ cross section gives indications of discrepancies between the overall normalization: τ data are about 3% higher than e^+e^- data (ANDERSON 99, EIDELMAN 99). This effect is too big to be explained by isospin violation (ALEMANY 98).

$\rho(770)$ MASS

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

MIXED CHARGES

VALUE (MeV)	*DOCUMENT ID*
769.3±0.8 OUR AVERAGE	Includes data from the 5 datablocks that follow this one. Error includes scale factor of 2.1. See the ideogram below.



$\rho(770)$ MASS MIXED CHARGES

MIXED CHARGES, τ DECAYS and $e^+ e^-$

VALUE (MeV)	DOCUMENT ID		TECN	CHG	COMMENT
The data in this block is included in the average printed for a previous datablock.					
776.0±0.9 OUR AVERAGE					
776.4±0.9±1.5	[1] BARATE	97M	ALEP		$\tau^- \to \pi^- \pi^0 \nu_\tau$
775.9±1.1	[2] BARKOV	85	OLYA	0	$e^+ e^- \to \pi^+ \pi^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
775.1±0.7±5.3	[3] BENAYOUN	98	RVUE		$e^+ e^- \to \pi^+ \pi^-, \mu^+ \mu^-$
770.5±1.9±5.1	[4] GARDNER	98	RVUE		0.28–0.92 $e^+ e^- \to \pi^+ \pi^-$
764.1±0.7	[5] O'CONNELL	97	RVUE		$e^+ e^- \to \pi^+ \pi^-$
757.5±1.5	[6] BERNICHA	94	RVUE		$e^+ e^- \to \pi^+ \pi^-$
768 ±1	[7] GESHKEN...	89	RVUE		$e^+ e^- \to \pi^+ \pi^-$

MIXED CHARGES, OTHER REACTIONS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
The data in this block is included in the average printed for a previous datablock.						
763.0±0.3±1.2	600k	[8] 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
The data in this block is included in the average printed for a previous datablock.						
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	[9] CAPRARO	87	SPEC	−	200 π^- Cu $\to \pi^-\pi^0$ Cu
761 ±5	967	[9] 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	[10] BYERLY	73	OSPK	−	5 π^-p
766.8±1.5	9650	[11] PISUT	68	RVUE	−	1.7–3.2 π^-p, t <10
767 ±6	900	[9] EISNER	67	HBC	−	4.2 π^-p, t <10

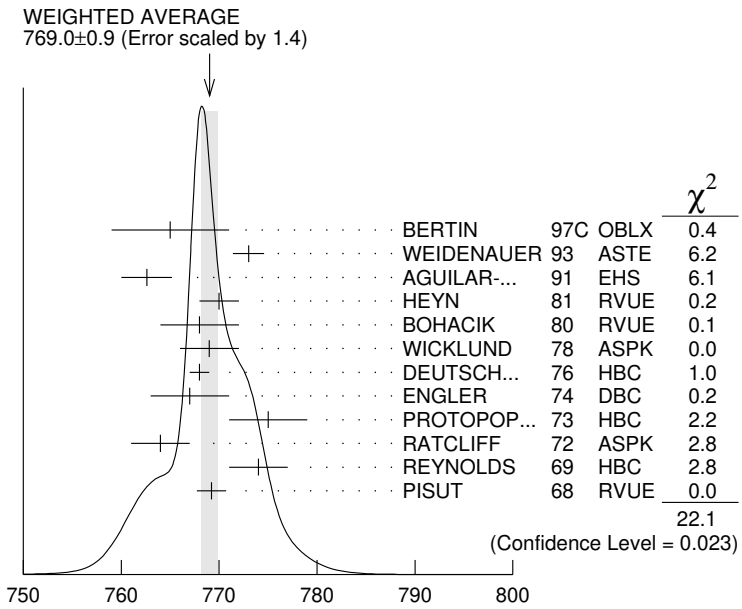
NEUTRAL ONLY, PHOTOPRODUCED

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
The data in this block is included in the average printed for a previous datablock.						
768.5± 1.1 OUR AVERAGE						
770 ± 2 ±1	79k	[12] BREITWEG	98B	ZEUS	0	50–100 γp
767.6± 2.7		BARTALUCCI	78	CNTR	0	$\gamma p \to e^+e^-p$
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	γA, t <0.01
767.7± 1.9	140k	BIGGS	70	CNTR	0	<4.1 γC $\to \pi^+\pi^-$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	[13] BREITWEG	98B	ZEUS	0	50–100 γp

NEUTRAL ONLY, OTHER REACTIONS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
The data in this block is included in the average printed for a previous datablock.						
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		[14] HEYN	81	RVUE		Pion form factor
768 ±4		[15,16] BOHACIK	80	RVUE	0	
769 ±3		[10] WICKLUND	78	ASPK	0	3,4,6 $\pi^\pm N$

768 ±1	76000		DEUTSCH...	76	HBC	0	16 $\pi^+ p$
767 ±4	4100		ENGLER	74	DBC	0	6 $\pi^+ n \rightarrow \pi^+ \pi^- p$
775 ±4	32000	[15]	PROTOPOP...	73	HBC	0	7.1 $\pi^+ p$, t <0.4
764 ±3	6800		RATCLIFF	72	ASPK	0	15 $\pi^- p$, t <0.3
774 ±3	1700		REYNOLDS	69	HBC	0	2.26 $\pi^- p$
769.2±1.5	13300	[17]	PISUT	68	RVUE	0	1.7–3.2 $\pi^- p$, t <10
• • • We do not use the following data for averages, fits, limits, etc. • • •							
762.3±0.5±1.2	600k	[18]	ABELE	99E	CBAR	0	0.0 $\overline{p} p \rightarrow \pi^+ \pi^- \pi^0$
777 ±2	4943	[19]	ADAMS	97	E665		470 $\mu p \rightarrow \mu X B$
770 ±2		[20]	BOGOLYUB...	97	MIRA		32 $\overline{p} p \rightarrow \pi^+ \pi^- X$
768 ±8		[20]	BOGOLYUB...	97	MIRA		32 $p p \rightarrow \pi^+ \pi^- X$
761.1±2.9			DUBNICKA	89	RVUE		π form factor
777.4±2.0		[21]	CHABAUD	83	ASPK	0	17 $\pi^- p$ polarized
769.5±0.7		[15,16]	LANG	79	RVUE	0	
770 ±9		[16]	ESTABROOKS	74	RVUE	0	17 $\pi^- p \rightarrow \pi^+ \pi^- n$
773.5±1.7	11200	[9]	JACOBS	72	HBC	0	2.8 $\pi^- p$
775 ±3	2250		HYAMS	68	OSPK	0	11.2 $\pi^- p$



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

[1] From the Gounaris-Sakurai parametrization of the pion form factor. The second error is a model error taking into account different parametrizations of the pion form factor.

[2] From the Gounaris-Sakurai parametrization of the pion form factor.

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

[4] From the fit to $e^+ e^- \rightarrow \pi^+ \pi^-$ data from the compilations of HEYN 81 and BARKOV 85, including the Gounaris-Sakurai parametrization of the pion form factor.

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

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

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

[8] Assuming the equality of ρ^+ and ρ^- masses and widths.
[9] Mass errors enlarged by us to $\Gamma/\sqrt{N}$; see the note with the $K^*(892)$ mass.
[10] Phase shift analysis. Systematic errors added corresponding to spread of different fits.
[11] 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.
[12] From the parametrization according to SOEDING 66.
[13] From the parametrization according to ROSS 66.
[14] HEYN 81 includes all spacelike and timelike F_π values until 1978.
[15] From pole extrapolation.
[16] From phase shift analysis of GRAYER 74 data.
[17] 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.
[18] Using relativistic Breit-Wigner and taking into account ρ-ω interference.
[19] Systematic errors not evaluated.
[20] Systematic effects not studied.
[21] 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*
0.4±0.8 OUR AVERAGE						
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		[22] BARATE	97M	ALEP		$\tau^- \to \pi^-\pi^0\nu_\tau$
−4 ±4	3000	[23] REYNOLDS	69	HBC	−0	2.26 $\pi^- p$
−5 ±5	3600	[23] FOSTER	68	HBC	±0	0.0 $\overline{p}p$
2.4±2.1	22950	[24] PISUT	68	RVUE		$\pi N \to \rho N$

[22] Using the compilation of e^+e^- data from BARKOV 85.
[23] From quoted masses of charged and neutral modes.
[24] 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.

$\rho(770)$ 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
150.2±0.8 OUR AVERAGE	Includes data from the 5 datablocks that follow this one.

MIXED CHARGES, τ DECAYS and $e^+ e^-$

VALUE (MeV)	DOCUMENT ID		TECN	CHG	COMMENT
The data in this block is included in the average printed for a previous datablock.					
150.5±2.7 OUR AVERAGE					
150.5±1.6±6.3	[25] BARATE	97M	ALEP		$\tau^- \to \pi^- \pi^0 \nu_\tau$
150.5±3.0	[26] BARKOV	85	OLYA	0	$e^+ e^- \to \pi^+ \pi^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
147.9±1.5±7.5	[27] BENAYOUN	98	RVUE		$e^+ e^- \to \pi^+ \pi^-, \mu^+ \mu^-$
153.5±1.3±4.6	[28] GARDNER	98	RVUE		0.28–0.92 $e^+ e^- \to \pi^+ \pi^-$
145.0±1.7	[29] O'CONNELL	97	RVUE		$e^+ e^- \to \pi^+ \pi^-$
142.5±3.5	[30] BERNICHA	94	RVUE		$e^+ e^- \to \pi^+ \pi^-$
138 ±1	[31] GESHKEN...	89	RVUE		$e^+ e^- \to \pi^+ \pi^-$

MIXED CHARGES, OTHER REACTIONS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
The data in this block is included in the average printed for a previous datablock.						
149.5±1.3	600k	[32] 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
The data in this block is included in the average printed for a previous datablock.						
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	[33] CAPRARO	87	SPEC	−	200 π^- Cu $\to \pi^- \pi^0$ Cu
154 ±20	967	[33] 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	6500	[34] BYERLY	73	OSPK	−	5 $\pi^- p$
148.2± 4.1	9650	[35] 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
The data in this block is included in the average printed for a previous datablock.						
150.7± 2.9 OUR AVERAGE						
146 ± 3 ±13	79k	[36] BREITWEG	98B	ZEUS	0	50–100 γp
150.9± 3.0		BARTALUCCI	78	CNTR	0	$\gamma p \to e^+ e^- p$

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

138 ± 3	79k	[37] 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*

The data in this block is included in the average printed for a previous datablock.

150.9± 2.0 OUR FIT Error includes scale factor of 1.3.
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	[38,39]	BOHACIK	80	RVUE	0	
152 ± 9	[34]	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	[40] ABELE	99E	CBAR	0	0.0 $\overline{p}p \rightarrow \pi^+ \pi^- \pi^0$
146 ± 3	4943	[41] ADAMS	97	E665		470 $\mu p \rightarrow \mu X B$
$160.0^{+4.1}_{-4.0}$		[42] CHABAUD	83	ASPK	0	17 $\pi^- p$ polarized
155 ± 1		[43] HEYN	81	RVUE	0	π form factor
148.0± 1.3	[38,39]	LANG	79	RVUE	0	
146 ±14	4100	ENGLER	74	DBC	0	6 $\pi^+ n \rightarrow \pi^+ \pi^- p$
143 ±13		[39] ESTABROOKS	74	RVUE	0	17 $\pi^- p \rightarrow \pi^+ \pi^- n$
160 ±10	32000	[38] PROTOPOP...	73	HBC	0	7.1 $\pi^+ p$, t <0.4
145 ±12	2250	[33] HYAMS	68	OSPK	0	11.2 $\pi^- p$
163 ±15	13300	[44] PISUT	68	RVUE	0	1.7–3.2 $\pi^- p$, t <10

[25] From the Gounaris-Sakurai parametrization of the pion form factor. The second error is a model error taking into account different parametrizations of the pion form factor.
[26] From the Gounaris-Sakurai parametrization of the pion form factor.
[27] Using the data of BARKOV 85 in the hidden local symmetry model.
[28] From the fit to $e^+ e^- \rightarrow \pi^+ \pi^-$ data from the compilations of HEYN 81 and BARKOV 85, including the Gounaris-Sakurai parametrization of the pion form factor.
[29] A fit of BARKOV 85 data assuming the direct $\omega \pi \pi$ coupling.
[30] Applying the S-matrix formalism to the BARKOV 85 data.
[31] Includes BARKOV 85 data. Model-dependent width definition.
[32] Assuming the equality of ρ^+ and ρ^- masses and widths.
[33] Width errors enlarged by us to $4\Gamma/\sqrt{N}$; see the note with the $K^*(892)$ mass.
[34] Phase shift analysis. Systematic errors added corresponding to spread of different fits.
[35] 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.

[36] From the parametrization according to SOEDING 66.
[37] From the parametrization according to ROSS 66.
[38] From pole extrapolation.
[39] From phase shift analysis of GRAYER 74 data.
[40] Using relativistic Breit-Wigner and taking into account ρ-ω interference.
[41] Systematic errors not evaluated.
[42] From fit of 3-parameter relativistic Breit-Wigner to helicity-zero part of P-wave intensity. CHABAUD 83 includes data of GRAYER 74.
[43] HEYN 81 includes all spacelike and timelike F_π values until 1978.
[44] 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	[45] BARATE	97M	ALEP	$\tau^- \to \pi^- \pi^0 \nu_\tau$

[45] 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	$\pi\pi$	~ 100 %	
	$\rho(770)^\pm$ decays		
Γ_2	$\pi^\pm \pi^0$	~ 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	$\pi^+ \pi^-$	~ 100 %	
Γ_7	$\pi^+ \pi^- \gamma$	$(9.9 \pm 1.6) \times 10^{-3}$	
Γ_8	$\pi^0 \gamma$	$(6.8 \pm 1.7) \times 10^{-4}$	
Γ_9	$\eta \gamma$	$(2.4 {}^{+0.8}_{-0.9}) \times 10^{-4}$	S=1.6
Γ_{10}	$\mu^+ \mu^-$	[a] $(4.60 \pm 0.28) \times 10^{-5}$	
Γ_{11}	$e^+ e^-$	[a] $(4.49 \pm 0.22) \times 10^{-5}$	
Γ_{12}	$\pi^+ \pi^- \pi^0$	$< 1.2 \times 10^{-4}$	CL=90%
Γ_{13}	$\pi^+ \pi^- \pi^+ \pi^-$	$(1.8 \pm 0.9) \times 10^{-5}$	
Γ_{14}	$\pi^+ \pi^- \pi^0 \pi^0$	$< 4 \times 10^{-5}$	CL=90%

[a] The $e^+ e^-$ branching fraction is from $e^+ e^- \to \pi^+ \pi^-$ experiments only. 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, $x_i \equiv \Gamma_i / \Gamma_{\text{total}}$. 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 a branching ratio uses 10 measurements and one constraint to determine 4 parameters. The overall fit has a $\chi^2 = 9.9$ for 7 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.

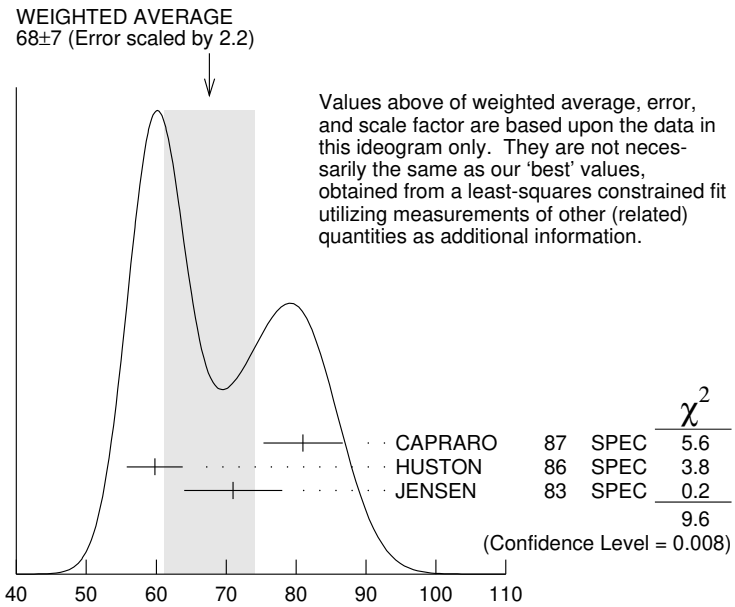
x_{10}	−79		
x_{11}	−61	0	
Γ	16	0	−27
	x_6	x_{10}	x_{11}

	Mode	Rate (MeV)	Scale factor
Γ_6	$\pi^+ \pi^-$	150.8 ±2.0	1.3
Γ_{10}	$\mu^+ \mu^-$	[a] 0.0069 ±0.0004	
Γ_{11}	$e^+ e^-$	[a] 0.00677±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 $\pi^- A \to \pi^- \pi^0 A$
59.8±4.0	HUSTON	86	SPEC	+	202 $\pi^+ A \to \pi^+ \pi^0 A$
71 ±7	JENSEN	83	SPEC	−	156–260 $\pi^- A \to \pi^- \pi^0 A$



$\Gamma(e^+ e^-)$ — Γ_{11}

VALUE (keV)	DOCUMENT ID		TECN	COMMENT
6.77±0.32 OUR FIT				
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. • • •				
6.3 ±0.1	[46] BENAYOUN	98	RVUE	$e^+ e^- \to \pi^+ \pi^-$, $\mu^+ \mu^-$

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

$\Gamma(\pi^0\gamma)$ — Γ_8

VALUE (keV)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
121±31	DOLINSKY	89	ND	$e^+ e^- \to \pi^0 \gamma$

$\Gamma(\eta\gamma)$ — Γ_9

VALUE (keV)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
62 ± 17	[47] DOLINSKY	89	ND	$e^+e^- \to \eta\gamma$

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

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

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 $e^+e^- \to \pi^+\pi^-\pi^+\pi^-$

$\rho(770)$ 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	$\pm$	$\pi^\pm p$ 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	$\pm$	$\pi^\pm p$ 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_{10}/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. • • •				
$8.2\ ^{+1.6}_{-3.6}$	[48] ROTHWELL	69	CNTR	Photoproduction
$5.6\ \pm1.5$	[49] WEHMANN	69	OSPK	12 π^- C, Fe
$9.7\ ^{+3.1}_{-3.3}$	[50] HYAMS	67	OSPK	11 π^- Li, H

[48] Possibly large ρ-ω interference leads us to increase the minus error.
[49] 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.
[50] HYAMS 67's mass resolution is 20 MeV. The ω region was excluded.

$\Gamma(e^+e^-)/\Gamma(\pi\pi)$ — Γ_{11}/Γ_1

VALUE (units 10^{-4})	DOCUMENT ID		TECN	COMMENT
0.41±0.05	BENAKSAS	72	OSPK	e^+e^-

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

VALUE (units 10^{-4})	DOCUMENT ID		TECN	CHG	COMMENT
$2.4^{+0.8}_{-0.9}$ OUR AVERAGE Error includes scale factor of 1.6.					
$1.9^{+0.6}_{-0.8}$	[51] BENAYOUN	96	RVUE		0.54-1.04 $e^+e^- \to \eta\gamma$
3.6 ± 0.9	[52] ANDREWS	77	CNTR	0	6.7–10 γ Cu
• • • We do not use the following data for averages, fits, limits, etc. • • •					
4.0 ± 1.1	[52] DOLINSKY	89	ND		$e^+e^- \to \eta\gamma$

[51] Reanalysis of DRUZHININ 84, DOLINSKY 89, and DOLINSKY 91 taking into account a triangle anomaly contribution. Constructive ρ-ω interference solution.
[52] Solution corresponding to constructive ω-ρ interference.

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

VALUE (units 10^{-5})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$1.8 \pm 0.9 \pm 0.3$		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_{13}/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_{12}/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_{12}/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	[53] ABRAMS	71	HBC	0	3.7 $\pi^+ p$

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

$\Gamma(\pi^+\pi^-\pi^0\pi^0)/\Gamma_{total}$ — Γ_{14}/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		[54] 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		[55] VASSERMAN	88	ND	$e^+e^- \to \pi^+\pi^-\gamma$
<0.005	90	[56] VASSERMAN	88	ND	$e^+e^- \to \pi^+\pi^-\gamma$

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

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

VALUE (units 10^{-4})	DOCUMENT ID		TECN	COMMENT
6.8±1.7	[57] BENAYOUN	96	RVUE	0.54-1.04 $e^+e^- \to \pi^0\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
7.9±2.0	DOLINSKY	89	ND	$e^+e^- \to \pi^0\gamma$

[57] Reanalysis of DRUZHININ 84, DOLINSKY 89, and DOLINSKY 91 taking into account a triangle anomaly contribution.

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