$f_0(400\text{–}1200)$ or σ

$I^G(J^{PC}) = 0^+(0^{++})$

See "Note on scalar mesons" under $f_0(1370)$.

$f_0(400\text{–}1200)$ T-MATRIX POLE $\sqrt{s}$

Note that $\Gamma \approx 2\ \mathrm{Im}(\sqrt{s_{\mathrm{pole}}})$.

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
(400–1200)−*i*(300–500) OUR ESTIMATE				
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$445 - i235$	HANNAH	99	RVUE	π scalar form factor
$(523 \pm 12) - i(259 \pm 7)$	KAMINSKI	99	RVUE	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$, $\sigma\sigma$
$442 - i\ 227$	OLLER	99	RVUE	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$
$469 - i203$	OLLER	99B	RVUE	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$
$445 - i221$	OLLER	99C	RVUE	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$, $\eta\eta$
$(1530^{+90}_{-250}) - i(560 \pm 40)$	ANISOVICH	98B	RVUE	Compilation
$420 - i\ 212$	LOCHER	98	RVUE	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$
$(602 \pm 26) - i(196 \pm 27)$	[1] ISHIDA	97		$\pi\pi \rightarrow \pi\pi$
$(537 \pm 20) - i(250 \pm 17)$	[2] KAMINSKI	97B	RVUE	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$, 4π
$470 - i250$	[3,4] TORNQVIST	96	RVUE	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$, $K\pi$, $\eta\pi$
$\sim (1100 - i300)$	AMSLER	95B	CBAR	$\overline{p}p \rightarrow 3\pi^0$
$400 - i500$	[4,5] AMSLER	95D	CBAR	$\overline{p}p \rightarrow 3\pi^0$
$1100 - i137$	[4,6] AMSLER	95D	CBAR	$\overline{p}p \rightarrow 3\pi^0$
$387 - i305$	[4,7] JANSSEN	95	RVUE	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$
$525 - i269$	[8] ACHASOV	94	RVUE	$\pi\pi \rightarrow \pi\pi$
$(506 \pm 10) - i(247 \pm 3)$	KAMINSKI	94	RVUE	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$
$370 - i356$	[9] ZOU	94B	RVUE	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$
$408 - i342$	[4,9] ZOU	93	RVUE	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$
$870 - i370$	[4,10] AU	87	RVUE	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$
$470 - i208$	[11] BEVEREN	86	RVUE	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$, $\eta\eta$, ...
$(750 \pm 50) - i(450 \pm 50)$	[12] ESTABROOKS	79	RVUE	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$
$(660 \pm 100) - i(320 \pm 70)$	PROTOPOP...	73	HBC	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$
$650 - i370$	[13] BASDEVANT	72	RVUE	$\pi\pi \rightarrow \pi\pi$

[1] Reanalysis of data from HYAMS 73, GRAYER 74, SRINIVASAN 75, and ROSSELET 77 using the interfering amplitude method.

[2] Average and spread of 4 variants ("up" and "down") of KAMINSKI 97B 3-channel model.

[3] Uses data from BEIER 72B, OCHS 73, HYAMS 73, GRAYER 74, ROSSELET 77, CASON 83, ASTON 88, and ARMSTRONG 91B. Coupled channel analysis with flavor symmetry and all light two-pseudoscalars systems.

[4] Demonstrates explicitly that $f_0(400\text{–}1200)$ and $f_0(1370)$ are two different poles.

[5] Coupled channel analysis of $\overline{p}p \rightarrow 3\pi^0$, $\pi^0\eta\eta$ and $\pi^0\pi^0\eta$ on sheet II.

[6] Coupled channel analysis of $\overline{p}p \rightarrow 3\pi^0$, $\pi^0\eta\eta$ and $\pi^0\pi^0\eta$ on sheet III.

[7] Analysis of data from FALVARD 88.

[8] Analysis of data from OCHS 73, ESTABROOKS 75, ROSSELET 77, and MUKHIN 80.

[9] Analysis of data from OCHS 73, GRAYER 74, and ROSSELET 77.

[10] Analysis of data from OCHS 73, GRAYER 74, BECKER 79, and CASON 83.

[11] Uses data from PROTOPOPESCU 73, HYAMS 73, HYAMS 75, GRAYER 74, ESTABROOKS 74, ESTABROOKS 75, FROGGATT 77, CORDEN 79, BISWAS 81.
[12] Analysis of data from APEL 73, GRAYER 74, CASON 76, PAWLICKI 77. Includes spread and errors of 4 solutions.
[13] Analysis of data from BATON 70, BENSINGER 71, COLTON 71, BAILLON 72,PROTOPOPESCU 73, and WALKER 67.

f_0(400–1200) BREIT-WIGNER MASS OR K-MATRIX POLE PARAMETERS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
(400–1200) OUR ESTIMATE				
• • • We do not use the following data for averages, fits, limits, etc. • • •				
750± 4	ALEKSEEV	99	SPEC	1.78 $\pi^- p_{\text{polar}} \to \pi^- \pi^+ n$
744± 5	ALEKSEEV	98	SPEC	1.78 $\pi^- p_{\text{polar}} \to \pi^- \pi^+ n$
759± 5	[14] TROYAN	98		5.2 $n p \to n p \pi^+ \pi^-$
780±30	ALDE	97	GAM2	450 $p p \to p p \pi^0 \pi^0$
585±20	[15] ISHIDA	97		$\pi\pi \to \pi\pi$
761±12	[16] SVEC	96	RVUE	6–17 $\pi N_{\text{polar}} \to \pi^+ \pi^- N$
∼ 860	[17] TORNQVIST	96	RVUE	$\pi\pi \to \pi\pi$, $K\overline{K}$, $K\pi$, $\eta\pi$
1165±50	[18,19] ANISOVICH	95	RVUE	$\pi^- p \to \pi^0 \pi^0 n$, $\overline{p} p \to \pi^0 \pi^0 \pi^0$, $\pi^0 \pi^0 \eta$, $\pi^0 \eta\eta$
∼ 1000	[20] ACHASOV	94	RVUE	$\pi\pi \to \pi\pi$
414±20	[16] AUGUSTIN	89	DM2	

[14] 6σ effect, no PWA.
[15] Reanalysis of data from HYAMS 73, GRAYER 74, SRINIVASAN 75, and ROSSELET 77 using the interfering amplitude method.
[16] Breit-Wigner fit to S-wave intensity measured in $\pi N \to \pi^- \pi^+ N$ on polarized targets. The fit does not include $f_0(980)$.
[17] Uses data from ASTON 88, OCHS 73, HYAMS 73, ARMSTRONG 91B, GRAYER 74, CASON 83, ROSSELET 77, and BEIER 72B. Coupled channel analysis with flavor symmetry and all light two-pseudoscalars systems.
[18] Uses $\pi^0 \pi^0$ data from ANISOVICH 94, AMSLER 94D, and ALDE 95B, $\pi^+ \pi^-$ data from OCHS 73, GRAYER 74 and ROSSELET 77, and $\eta\eta$ data fromANISOVICH 94.
[19] The pole is on Sheet III. Demonstrates explicitly that f_0(400–1200) and $f_0(1370)$ are two different poles.
[20] Analysis of data from OCHS 73, ESTABROOKS 75, ROSSELET 77, and MUKHIN 80.

f_0(400–1200) BREIT-WIGNER WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
(600–1000) OUR ESTIMATE				
• • • We do not use the following data for averages, fits, limits, etc. • • •				
119±13	ALEKSEEV	99	SPEC	1.78 $\pi^- p_{\text{polar}} \to \pi^- \pi^+ n$
77±22	ALEKSEEV	98	SPEC	1.78 $\pi^- p_{\text{polar}} \to \pi^- \pi^+ n$
35±12	[21] TROYAN	98		5.2 $n p \to n p \pi^+ \pi^-$
780±60	ALDE	97	GAM2	450 $p p \to p p \pi^0 \pi^0$

385±70	[22] ISHIDA	97		$\pi\pi \rightarrow \pi\pi$
290±54	[23] SVEC	96	RVUE	6–17 $\pi N_{\mathrm{polar}} \rightarrow \pi^+\pi^- N$
∼ 880	[24] TORNQVIST	96	RVUE	$\pi\pi \rightarrow \pi\pi$, $K\overline{K}$, $K\pi$, $\eta\pi$
460±40	[25,26] ANISOVICH	95	RVUE	$\pi^- p \rightarrow \pi^0\pi^0 n$, $\overline{p}p \rightarrow \pi^0\pi^0\pi^0$, $\pi^0\pi^0\eta$, $\pi^0\eta\eta$
∼ 3200	[27] ACHASOV	94	RVUE	$\pi\pi \rightarrow \pi\pi$
494±58	[23] AUGUSTIN	89	DM2	

[21] 6σ effect, no PWA.

[22] Reanalysis of data from HYAMS 73, GRAYER 74, SRINIVASAN 75, and ROSSELET 77 using the interfering amplitude method.

[23] Breit-Wigner fit to S-wave intensity measured in $\pi N \rightarrow \pi^-\pi^+ N$ on polarized targets. The fit does not include $f_0(980)$.

[24] Uses data from ASTON 88, OCHS 73, HYAMS 73, ARMSTRONG 91B, GRAYER 74, CASON 83, ROSSELET 77, and BEIER 72B. Coupled channel analysis with flavor symmetry and all light two-pseudoscalars systems.

[25] Uses $\pi^0\pi^0$ data from ANISOVICH 94, AMSLER 94D, and ALDE 95B, $\pi^+\pi^-$ data from OCHS 73, GRAYER 74 and ROSSELET 77, and $\eta\eta$ data fromANISOVICH 94.

[26] The pole is on Sheet III. Demonstrates explicitly that f_0(400–1200) and f_0(1370) are two different poles.

[27] Analysis of data from OCHS 73, ESTABROOKS 75, ROSSELET 77, and MUKHIN 80.

f_0(400–1200) DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$\pi\pi$	dominant
Γ_2	$\gamma\gamma$	seen

f_0(400–1200) PARTIAL WIDTHS

$\Gamma(\gamma\gamma)$ — Γ_2

VALUE (keV)	*DOCUMENT ID*		*TECN*	*COMMENT*
seen	[28] MORGAN	90	RVUE	$\gamma\gamma \rightarrow \pi^+\pi^-$, $\pi^0\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
10±6	COURAU	86	DM1	$e^+e^- \rightarrow \pi^+\pi^- e^+e^-$

[28] Analysis of data from BOYER 90 and MARSISKE 90.

f_0(400–1200) REFERENCES

ALEKSEEV	99	NP B541 3	I.G. Alekseev *et al.*	
HANNAH	99	PR D60 017502	T. Hannah	
KAMINSKI	99	EPJ C9 141	R. Kaminski, L. Lesniak, B. Loiseau	
OLLER	99	PR D60 099906	J.A. Oller *et al.*	
OLLER	99B	NP A652 407	J.A. Oller, E. Oset	
OLLER	99C	PR D60 074023	J.A. Oller, E. Oset	
ALEKSEEV	98	PAN 61 174	I.G. Alekseev *et al.*	
ANISOVICH	98B	UFN 41 419	V.V. Anisovich *et al.*	
LOCHER	98	EPJ C4 317	M.P. Locher *et al.*	(PSI)
TROYAN	98	JINRRC 5 33	Yu. Troyan *et al.*	
ALDE	97	PL B397 350	D.M. Alde *et al.*	(GAMS Collab.)
ISHIDA	97	PTP 98 1005	S. Ishida *et al.*	(TOKY, MIYA, KEK)
KAMINSKI	97B	PL B413 130	R. Kaminski *et al.*	(CRAC, IPN)
Also	96	PTP 95 745	S. Ishida *et al.*	(TOKY, MIYA, KEK)
SVEC	96	PR D53 2343	M. Svec	(MCGI)
TORNQVIST	96	PRL 76 1575	N.A. Tornqvist, M. Roos	(HELS)
ALDE	95B	ZPHY C66 375	D.M. Alde *et al.*	(GAMS Collab.)
AMSLER	95B	PL B342 433	C. Amsler *et al.*	(Crystal Barrel Collab.)
AMSLER	95D	PL B355 425	C. Amsler *et al.*	(Crystal Barrel Collab.)
ANISOVICH	95	PL B355 363	V.V. Anisovich *et al.*	(PNPI, SERP)
JANSSEN	95	PR D52 2690	G. Janssen *et al.*	(STON, ADLD, JULI)
ACHASOV	94	PR D49 5779	N.N. Achasov, G.N. Shestakov	(NOVM)
AMSLER	94D	PL B333 277	C. Amsler *et al.*	(Crystal Barrel Collab.)
ANISOVICH	94	PL B323 233	V.V. Anisovich *et al.*	
KAMINSKI	94	PR D50 3145	R. Kaminski *et al.*	(CRAC, IPN)
ZOU	94B	PR D50 591	B.S. Zou, D.V. Bugg	(LOQM)
ZOU	93	PR D48 R3948	B.S. Zou, D.V. Bugg	(LOQM)
ARMSTRONG	91B	ZPHY C52 389	T.A. Armstrong *et al.*	(ATHU, BARI, BIRM+)
BOYER	90	PR D42 1350	J. Boyer *et al.*	(Mark II Collab.)
MARSISKE	90	PR D41 3324	H. Marsiske *et al.*	(Crystal Ball Collab.)
MORGAN	90	ZPHY C48 623	D. Morgan, M.R. Pennington	(RAL, DURH)
AUGUSTIN	89	NP B320 1	J.E. Augustin, G. Cosme	(DM2 Collab.)
ASTON	88	NP B296 493	D. Aston *et al.*	(SLAC, NAGO, CINC, INUS)
FALVARD	88	PR D38 2706	A. Falvard *et al.*	(CLER, FRAS, LALO+)
AU	87	PR D35 1633	K.L. Au, D. Morgan, M.R. Pennington	(DURH, RAL)
BEVEREN	86	ZPHY C30 615	E. van Beveren *et al.*	(NIJM, BIEL)
COURAU	86	NP B271 1	A. Courau *et al.*	(CLER, LALO)
CASON	83	PR D28 1586	N.M. Cason *et al.*	(NDAM, ANL)
BISWAS	81	PRL 47 1378	N.N. Biswas *et al.*	(NDAM, ANL)
MUKHIN	80	JETPL 32 601	K.N. Mukhin *et al.*	(KIAE)
		Translated from ZETFP 32 616.		
BECKER	79	NP B151 46	H. Becker *et al.*	(MPIM, CERN, ZEEM, CRAC)
CORDEN	79	NP B157 250	M.J. Corden *et al.*	(BIRM, RHEL, TELA+) JP
ESTABROOKS	79	PR D19 2678	P. Estabrooks	(CARL)
FROGGATT	77	NP B129 89	C.D. Froggatt, J.L. Petersen	(GLAS, NORD)
PAWLICKI	77	PR D15 3196	A.J. Pawlicki *et al.*	(ANL) IJ
ROSSELET	77	PR D15 574	L. Rosselet *et al.*	(GEVA, SACL)
CASON	76	PRL 36 1485	N.M. Cason *et al.*	(NDAM, ANL) IJ
ESTABROOKS	75	NP B95 322	P.G. Estabrooks, A.D. Martin	(DURH)
HYAMS	75	NP B100 205	B.D. Hyams *et al.*	(CERN, MPIM)
SRINIVASAN	75	PR D12 681	V. Srinivasan *et al.*	(NDAM, ANL)
ESTABROOKS	74	NP B79 301	P.G. Estabrooks, A.D. Martin	(DURH)
GRAYER	74	NP B75 189	G. Grayer *et al.*	(CERN, MPIM)
APEL	73	PL 41B 542	W.D. Apel *et al.*	(KARL, PISA)
HYAMS	73	NP B64 134	B.D. Hyams *et al.*	(CERN, MPIM)
OCHS	73	Thesis	W. Ochs	(MPIM, MUNI)
PROTOPOP...	73	PR D7 1279	S.D. Protopopescu *et al.*	(LBL)
BAILLON	72	PL 38B 555	P.H. Baillon *et al.*	(SLAC)
BASDEVANT	72	PL 41B 178	J.L. Basdevant, C.D. Froggatt, J.L. Petersen	(CERN)
BEIER	72B	PRL 29 511	E.W. Beier *et al.*	(PENN)
BENSINGER	71	PL 36B 134	J.R. Bensinger *et al.*	(WISC)
COLTON	71	PR D3 2028	E.P. Colton *et al.*	(LBL, FNAL, UCLA+)
BATON	70	PL 33B 528	J.P. Baton, G. Laurens, J. Reignier	(SACL)
WALKER	67	RMP 39 695	W.D. Walker	(WISC)

OTHER RELATED PAPERS

BLACK	99	PR D59 074026	D. Black *et al.*	
IGI	99	PR D59 034005	K. Igi, K. Hikasa	
MINKOWSKI	99	EPJ C9 283	P. Minkowski, W. Ochs	
SCADRON	99	EPJ C6 141	M. Scadron	
TAKAMATSU	99	PAN 62 435	K. Takamatsu	
ABELE	98	PR D57 3860	A. Abele *et al.*	(Crystal Barrel Collab.)
ANISOVICH	98	PL B437 209	V.V. Anisovich *et al.*	
DELBOURGO	98	IJMP A13 657	R. Delbourgo *et al.*	
OLLER	98	PRL 80 3452	J.A. Oller *et al.*	
ANISOVICH	97	PL B395 123	A.V. Anisovich, A.V. Sarantsev	(PNPI)
ANISOVICH	97B	ZPHY A357 123	A.V. Anisovich *et al.*	(PNPI)
ANISOVICH	97C	PL B413 137		
ANISOVICH	97D	ZPHY A359 173		
CLOSE	97B	PR D55 5749	F. Close *et al.*	(RAL, RUTG, BEIJT)
MALTMAN	97	PL B393 19	K. Maltman, C.E. Wolfe	(YORKC)
OLLER	97	NP A620 438	J.A. Oller *et al.*	(VALE)
SVEC	97	PR D55 4355	M. Svec	
SVEC	97B	PR D55 5727	M. Svec	(MCGI)
ABELE	96	PL B380 453	A. Abele *et al.*	(Crystal Barrel Collab.)
AMSLER	96	PR D53 295	C. Amsler, F.E. Close	(ZURI, RAL)
BIJNENS	96	PL B374 210	J. Bijnens *et al.*	(NORD, BERN, WIEN+)
BONUTTI	96	PRL 77 603	F. Bonutti *et al.*	(TRSTI, TRSTT, TRIU)
BUGG	96	NP B471 59	D.V. Bugg, A.V. Sarantsev, B.S. Zou	(LOQM, PNPI)
HARADA	96	PR D54 1991	M. Harasa *et al.*	(SYRA)
ISHIDA	96	PTP 95 745	S. Ishida *et al.*	(TOKY, MIYA, KEK)
AMSLER	95C	PL B353 571	C. Amsler *et al.*	(Crystal Barrel Collab.)
AMSLER	95F	PL B358 389	C. Amsler *et al.*	(Crystal Barrel Collab.)
ANTINORI	95	PL B353 589	F. Antinori *et al.*	(ATHU, BARI, BIRM+)
BUGG	95	PL B353 378	D.V. Bugg *et al.*	(LOQM, PNPI, WASH)
GASPERO	95	NP A588 861	M. Gaspero	(ROMA)
TORNQVIST	95	ZPHY C68 647	N.A. Tornqvist	(HELS)
AMSLER	94	PL B322 431	C. Amsler *et al.*	(Crystal Barrel Collab.)
BUGG	94	PR D50 4412	D.V. Bugg *et al.*	(LOQM)
KAMINSKI	94	PR D50 3145	R. Kaminski *et al.*	(CRAC, IPN)
ADAMO	93	NP A558 13C	A. Adamo *et al.*	(OBELIX Collab.)
GASPERO	93	NP A562 407	M. Gaspero	(ROMAI)
MORGAN	93	PR D48 1185	D. Morgan, M.R. Pennington	(RAL, DURH)
Also	93C	NC A Conf. Suppl.	D. Morgan	(RAL)
BOLTON	92B	PRL 69 1328	T. Bolton *et al.*	(Mark III Collab.)
SVEC	92	PR D45 55	M. Svec, A. de Lesquen, L. van Rossum	(MCGI+)
SVEC	92B	PR D45 1518	M. Svec, A. de Lesquen, L. van Rossum	(MCGI+)
SVEC	92C	PR D46 949	M. Svec, A. de Lesquen, L. van Rossum	(MCGI+)
RIGGENBACH	91	PR D43 127	C. Riggenbach *et al.*	(BERN, CERN, MASA)
BAI	90C	PRL 65 2507	Z. Bai *et al.*	(Mark III Collab.)
WEINSTEIN	90	PR D41 2236	J. Weinstein, N. Isgur	(TNTO)
WEINSTEIN	89	UTPT 89 03	J. Weinstein, N. Isgur	(TNTO)
ASTON	88D	NP B301 525	D. Aston *et al.*	(SLAC, NAGO, CINC, INUS)
LONGACRE	86	PL B177 223	R.S. Longacre *et al.*	(BNL, BRAN, CUNY+)
ACHASOV	84	ZPHY C22 53	N.N. Achasov, S.A. Devyanin, G.N. Shestakov	(NOVM)
GASSER	84	ANP 158 142		
BINON	83	NC 78A 313	F.G. Binon *et al.*	(BELG, LAPP, SERP+)
ETKIN	82B	PR D25 1786	A. Etkin *et al.*	(BNL, CUNY, TUFTS, VAND)
TORNQVIST	82	PRL 49 624	N.A. Tornqvist	(HELS)
COHEN	80	PR D22 2595	D. Cohen *et al.*	(ANL) IJP
COSTA	80	NP B175 402	G. Costa *et al.*	(BARI, BONN, CERN, GLAS+)
BECKER	79B	NP B150 301	H. Becker *et al.*	(MPIM, CERN, ZEEM, CRAC)
NAGELS	79	PR D20 1633	M.M. Nagels, T.A. Rijken, J.J. de Swart	(NIJM)
POLYCHRO...	79	PR D19 1317	V.A. Polychronakos *et al.*	(NDAM, ANL) IJP
CORDEN	78	NP B144 253	M.J. Corden *et al.*	(BIRM, RHEL, TELA+)
JAFFE	77	PR D15 267,281	R. Jaffe	(MIT)
FLATTE	76	PL 63B 224	S.M. Flatte	(CERN)
WETZEL	76	NP B115 208	W. Wetzel *et al.*	(ETH, CERN, LOIC)
DEFOIX	72	NP B44 125	C. Defoix *et al.*	(CDEF, CERN)