$f_0(400\text{–}1200)$ 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. • • •				
$602 \pm 26 - i(196 \pm 27)$	[1] ISHIDA	97		$\pi\pi \to \pi\pi$
$537 \pm 20 - i(250 \pm 17)$	[2] KAMINSKI	97B	RVUE	$\pi\pi \to \pi\pi\ K\overline{K}4\pi$
$469.5 - i178.6$	[3] OLLER	97	RVUE	$\pi\pi \to \pi\pi\ ,\ K\overline{K}$
$470 - i250$	[4,5] TORNQVIST	96	RVUE	$\pi\pi \to \pi\pi,\ K\overline{K},\ K\pi,\ \eta\pi$
$\sim (1100 - i300)$	AMSLER	95B	CBAR	$\overline{p}p \to 3\pi^0$
$400 - i500$	[5,6] AMSLER	95D	CBAR	$\overline{p}p \to 3\pi^0$
$1100 - i137$	[5,7] AMSLER	95D	CBAR	$\overline{p}p \to 3\pi^0$
$387 - i305$	[5,8] JANSSEN	95	RVUE	$\pi\pi \to \pi\pi,\ K\overline{K}$
$525 - i269$	[9] ACHASOV	94	RVUE	$\pi\pi \to \pi\pi$
$370 - i356$	[10] ZOU	94B	RVUE	$\pi\pi \to \pi\pi,\ K\overline{K}$
$408 - i342$	[5,10] ZOU	93	RVUE	$\pi\pi \to \pi\pi,\ K\overline{K}$
$870 - i370$	[5,11] AU	87	RVUE	$\pi\pi \to \pi\pi,\ K\overline{K}$
$470 - i208$	BEVEREN	86	RVUE	$\pi\pi \to \pi\pi,\ K\overline{K}$
$750 \pm 50 - i(450 \pm 50)$	[12] ESTABROOKS	79	RVUE	$\pi\pi \to \pi\pi,\ K\overline{K}$
$660 \pm 100 - i(320 \pm 70)$	PROTOPOP...	73	HBC	$\pi\pi \to \pi\pi,\ K\overline{K}$
$650 - i370$	[13] BASDEVANT	72	RVUE	$\pi\pi \to \pi\pi$

[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 of KAMINSKI 97B 3-channel model.
[3] Coupled channel analysis combined with chiral perturbation theory.
[4] 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.
[5] Demonstrates explicitly that $f_0(400\text{–}1200)$ and $f_0(1370)$ are two different poles.
[6] Coupled channel analysis of $\overline{p}p \to 3\pi^0$, $\pi^0\eta\eta$ and $\pi^0\pi^0\eta$ on sheet II.
[7] Coupled channel analysis of $\overline{p}p \to 3\pi^0$, $\pi^0\eta\eta$ and $\pi^0\pi^0\eta$ on sheet III.
[8] Analysis of data from FALVARD 88.
[9] Analysis of data from OCHS 73, ESTABROOKS 75, ROSSELET 77, and MUKHIN 80.
[10] Analysis of data from OCHS 73, GRAYER 74, and ROSSELET 77.
[11] Analysis of data from OCHS 73, GRAYER 74, BECKER 79, and CASON 83.
[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. • • •				
780±30	ALDE	97	GAM2	450 $pp \to pp\pi^0\pi^0$
585±20	[14] ISHIDA	97		$\pi\pi \to \pi\pi$
761±12	[15] SVEC	96	RVUE	6–17 $\pi N_{\text{polar}} \to \pi^+\pi^- N$
∼ 860	[16] TORNQVIST	96	RVUE	$\pi\pi \to \pi\pi$, $K\overline{K}$, $K\pi$, $\eta\pi$
1165±50	[17,18] 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	[19] ACHASOV	94	RVUE	$\pi\pi \to \pi\pi$
506±10	KAMINSKI	94	RVUE	$\pi\pi \to \pi\pi$, $K\overline{K}$
414±20	[15] AUGUSTIN	89	DM2	

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

[15] 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).

[16] 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.

[17] 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.

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

[19] 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. • • •				
780±60	ALDE	97	GAM2	450 $pp \to pp\pi^0\pi^0$
385±70	[20] ISHIDA	97		$\pi\pi \to \pi\pi$
290±54	[21] SVEC	96	RVUE	6–17 $\pi N_{\text{polar}} \to \pi^+\pi^- N$
∼ 880	[22] TORNQVIST	96	RVUE	$\pi\pi \to \pi\pi$, $K\overline{K}$, $K\pi$, $\eta\pi$
460±40	[23,24] ANISOVICH	95	RVUE	$\pi^- p \to \pi^0\pi^0 n$, $\overline{p}p \to \pi^0\pi^0\pi^0$, $\pi^0\pi^0\eta$, $\pi^0\eta\eta$
∼ 3200	[25] ACHASOV	94	RVUE	$\pi\pi \to \pi\pi$
494± 5	KAMINSKI	94	RVUE	$\pi\pi \to \pi\pi$, $K\overline{K}$
494±58	[21] AUGUSTIN	89	DM2	

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

[21] 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).

[22] 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.

[23] 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.

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

[25] 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	[26] 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	$e^+e^- \rightarrow \pi^+\pi^-e^+e^-$

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

f_0(400–1200) REFERENCES

ALDE	97	PL B397 350	+Bellazzini, Binon+	(GAMS Collab.)
ISHIDA	97	PTP 98 1005	S. Ishida+	(NIHON, TOKY, MIYA, KEK)
KAMINSKI	97B	PL B413 130	R. Kaminski+	(CRAC, IPN)
OLLER	97	NP A620 438	J.A. Oller+	(VALE)
SVEC	96	PR D53 2343		(MCGI)
TORNQVIST	96	PRL 76 1575	+Roos	(HELS)
ALDE	95B	ZPHY C66 375	+Binon, Boutemeur+	(GAMS Collab.)
AMSLER	95B	PL B342 433	+Armstrong, Brose+	(Crystal Barrel Collab.)
AMSLER	95D	PL B355 425	+Armstrong, Spanier+	(Crystal Barrel Collab.)
ANISOVICH	95	PL B355 363	+Kondashov+	(PNPI, SERP)
JANSSEN	95	PR D52 2690	+Pearce, Holinde, Speth	(STON, ADLD, JULI)
ACHASOV	94	PR D49 5779	+Shestakov	(NOVM)
AMSLER	94D	PL B333 277	+Anisovich, Spanier+	(Crystal Barrel Collab.)
ANISOVICH	94	PL B323 233	+Armstrong+	(Crystal Barrel Collab.)
KAMINSKI	94	PR D50 3145	R. Kaminski+	(CRAC, IPN)
ZOU	94B	PR D50 591	+Bugg	(LOQM)
ZOU	93	PR D48 R3948	+Bugg	(LOQM)
ARMSTRONG	91B	ZPHY C52 389	+Barnes+	(ATHU, BARI, BIRM, CERN, CDEF)
BOYER	90	PR D42 1350	+Butler+	(Mark II Collab.)
MARSISKE	90	PR D41 3324	+Antreasyan+	(Crystal Ball Collab.)
MORGAN	90	ZPHY C48 623	+Pennington	(RAL, DURH)
AUGUSTIN	89	NP B320 1	+Cosme	(DM2 Collab.)
ASTON	88	NP B296 493	+Awaji, Bienz, Bird+	(SLAC, NAGO, CINC, INUS)
FALVARD	88	PR D38 2706	+Ajaltouni+	(CLER, FRAS, LALO, PADO)
AU	87	PR D35 1633	+Morgan, Pennington	(DURH, RAL)
BEVEREN	86	ZPHY C30 615	E. van Beveren+	(NIJM, BIEL)
COURAU	86	NP B271 1	+Falvard, Haissinski, Jousset, Michel+	(CLER, LALO)
CASON	83	PR D28 1586	+Cannata, Baumbaugh, Bishop+	(NDAM, ANL)
MUKHIN	80	JETPL 32 601	+Patarakin+	(KIAE)
		Translated from ZETFP 32 616.		

BECKER	79	NP B151 46	+Blanar, Blum+	(MPIM, CERN, ZEEM, CRAC)
ESTABROOKS	79	PR D19 2678		(CARL)
PAWLICKI	77	PR D15 3196	+Ayres, Cohen, Diebold, Kramer, Wicklund	(ANL) IJ
ROSSELET	77	PR D15 574	+Extermann, Fischer, Guisan+	(GEVA, SACL)
CASON	76	PRL 36 1485	+Polychronakos, Bishop, Biswas+	(NDAM, ANL) IJ
ESTABROOKS	75	NP B95 322	+Martin	(DURH)
SRINIVASAN	75	PR D12 681	+Helland, Lennox, Klem+	(NDAM, ANL)
GRAYER	74	NP B75 189	+Hyams, Blum, Dietl+	(CERN, MPIM)
APEL	73	PL 41B 542	+Auslander, Muller+	(KARL, PISA)
HYAMS	73	NP B64 134	+Jones, Weilhammer, Blum, Dietl+	(CERN, MPIM)
OCHS	73	Thesis		(MPIM, MUNI)
PROTOPOP...	73	PR D7 1279	Protopopescu, Alston-Garnjost, Galtieri, Flatte+	(LBL)
BAILLON	72	PL 38B 555	+Carnegie, Kluge, Leith, Lynch, Ratcliff+	(SLAC)
BASDEVANT	72	PL 41B 178	+Froggatt, Petersen	(CERN)
BEIER	72B	PRL 29 511	+Buchholtz, Mann+	(PENN)
BENSINGER	71	PL 36B 134	+Erwin, Thompson, Walker	(WISC)
COLTON	71	PR D3 2028	+Malamud, Schlein+	(LBL, FNAL, UCLA, HAWA)
BATON	70	PL 33B 528	+Laurens, Reignier	(SACL)
WALKER	67	RMP 39 695		(WISC)

OTHER RELATED PAPERS

ABELE	98	PR D57 3860	A. Abele, Adomeit, Amsler+	(Crystal Barrel Collab.)
ANISOVICH	97	PL B395 123	+Sarantsev	(PNPI)
ANISOVICH	97B	ZPHY A357 123	A.V. Anisovich+	(PNPI)
ANISOVICH	97C	PL B413 137		
ANISOVICH	97D	ZPHY A359 173		
CLOSE	97B	PR D55 5749	F. Close+	(RAL, RUTG, BEIJT)
KAMINSKI	97	ZPHY C74 79	R. Kaminski+	(CRAC)
MALTMAN	97	PL B393 19	K. Maltman, Wolfe	(YORKC)
OLLER	97	NP A620 438	J.A. Oller+	(VALE)
SVEC	97	PR D55 4355	M. Svec	
SVEC	97B	PR D55 5727	M. Svec	(MCGI)
ABELE	96	PL B380 453	+Adomeit, Amsler+	(Crystal Barrel Collab.)
AMSLER	96	PR D53 295	+Close	(ZURI, RAL)
BIJNENS	96	PL B374 210	J. Bijnens, Colangelo, Ecker+	(NORD, BERN, WIEN, HELS)
BONUTTI	96	PRL 77 603	+Amerini, Fragiacomo+	(TRSTI, TRSTT, TRIU)
BUGG	96	NP B471 59	+Sarantsev, Zou	(LOQM, PNPI)
HARADA	96	PR D54 1991	M. Harasa+	(SYRA)
ISHIDA	96	PTP 95 745	S. Ishida+	(TOKY, MIYA, KEK)
AMSLER	95C	PL B353 571	+Armstrong, Hackman+	(Crystal Barrel Collab.)
AMSLER	95F	PL B358 389	+Armstrong, Urner+	(Crystal Barrel Collab.)
ANTINORI	95	PL B353 589	+Barberis, Bayes+	(ATHU, BARI, BIRM, CERN, JINR)
BUGG	95	PL B353 378	+Scott, Zoli+	(LOQM, PNPI, WASH)
GASPERO	95	NP A588 861		(ROMA)
TORNQVIST	95	ZPHY C68 647		(HELS)
AMSLER	94	PL B322 431	+Armstrong, Meyer+	(Crystal Barrel Collab.)
BUGG	94	PR D50 4412	+Anisovich+	(LOQM)
KAMINSKI	94	PR D50 3145	R. Kaminski+	(CRAC, IPN)
ADAMO	93	NP A558 13C	+Agnello+	(OBELIX Collab.)
GASPERO	93	NP A562 407		(ROMAI)
MORGAN	93	PR D48 1185	+Pennington	(RAL, DURH)
Also	93C	NC A Conf. Suppl.	Morgan	(RAL)
BOLTON	92B	PRL 69 1328	+Brown, Bunnell+	(Mark III Collab.)
SVEC	92	PR D45 55	+de Lesquen, van Rossum	(MCGI, SACL)
SVEC	92B	PR D45 1518	+de Lesquen, van Rossum	(MCGI, SACL)
SVEC	92C	PR D46 949	+de Lesquen, van Rossum	(MCGI, SACL)
RIGGENBACH	91	PR D43 127	C. Riggenbach, Gasser+	(BERN, CERN, MASA)
BAI	90C	PRL 65 2507	+Blaylock+	(Mark III Collab.)
WEINSTEIN	90	PR D41 2236	+Isgur	(TNTO)
WEINSTEIN	89	UTPT 89 03	+Isgur	(TNTO)
ASTON	88D	NP B301 525	+Awaji, Bienz+	(SLAC, NAGO, CINC, INUS)
BEVEREN	86	ZPHY C30 615	E. van Beveren+	(NIJM, BIEL)
LONGACRE	86	PL B177 223	+Etkin+	(BNL, BRAN, CUNY, DUKE, NDAM)
ACHASOV	84	ZPHY C22 53	+Devyanin, Shestakov	(NOVM)

GASSER	84	ANP 158 142		
BINON	83	NC 78A 313	+Donskov, Duteil+	(BELG, LAPP, SERP, CERN)
ETKIN	82B	PR D25 1786	+Foley, Lai+	(BNL, CUNY, TUFTS, VAND)
TORNQVIST	82	PRL 49 624		(HELS)
COHEN	80	PR D22 2595	+Ayres, Diebold, Kramer, Pawlicki+	(ANL) IJP
COSTA	80	NP B175 402	G. Costa+(BARI, BONN, CERN, GLAS, LIVP, MILA, WIEN)	
BECKER	79B	NP B150 301	+Blanar, Blum+	(MPIM, CERN, ZEEM, CRAC)
NAGELS	79	PR D20 1633	+Rijken, Deswart	(NIJM)
POLYCHRO...	79	PR D19 1317	Polychronakos, Cason, Bishop+	(NDAM, ANL) IJP
CORDEN	78	NP B144 253	+Corbett, Alexander+	(BIRM, RHEL, TELA, LOWC)
JAFFE	77	PR D15 267,281		(MIT)
FLATTE	76	PL 63B 224		(CERN)
WETZEL	76	NP B115 208	+Freudenreich, Beusch+	(ETH, CERN, LOIC)
DEFOIX	72	NP B44 125	+Nascimento, Bizzarri+	(CDEF, CERN)