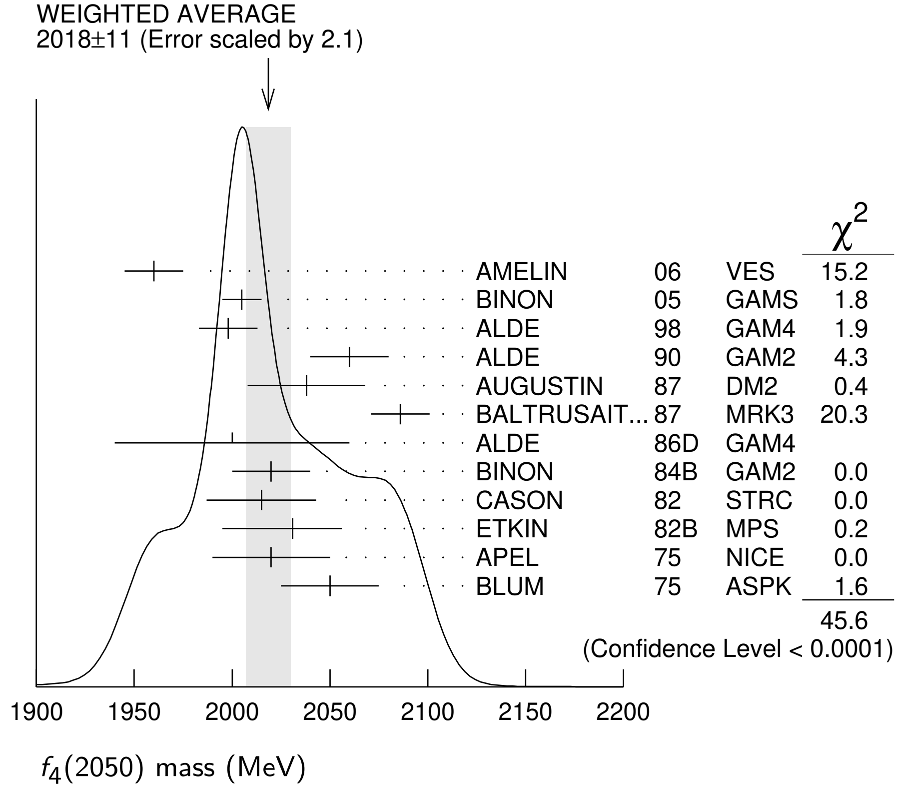
$f_4(2050)$

$I^G(J^{PC}) = 0^+(4^{++})$

$f_4(2050)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
2018±11 OUR AVERAGE		Error includes scale factor of 2.1. See the ideogram below.			
1960±15		AMELIN	06	VES	36 $\pi^- p \to \omega\omega n$
2005±10		[1] BINON	05	GAMS	33 $\pi^- p \to \eta\eta n$
1998±15		ALDE	98	GAM4	100 $\pi^- p \to \pi^0\pi^0 n$
2060±20		ALDE	90	GAM2	38 $\pi^- p \to \omega\omega n$
2038±30		AUGUSTIN	87	DM2	$J/\psi \to \gamma\pi^+\pi^-$
2086±15		BALTRUSAIT...	87	MRK3	$J/\psi \to \gamma\pi^+\pi^-$
2000±60		ALDE	86D	GAM4	100 $\pi^- p \to n2\eta$
2020±20	40k	[2] BINON	84B	GAM2	38 $\pi^- p \to n2\pi^0$
2015±28		[3] CASON	82	STRC	8 $\pi^+ p \to \Delta^{++}\pi^0\pi^0$
2031^{+25}_{-36}		ETKIN	82B	MPS	23 $\pi^- p \to n2K^0_S$
2020±30	700	APEL	75	NICE	40 $\pi^- p \to n2\pi^0$
2050±25		BLUM	75	ASPK	18.4 $\pi^- p \to nK^+K^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1966±25		[4] ANISOVICH	09	RVUE	0.0 $\overline{p}p$, πN
$1885^{+14}_{-13}{}^{+218}_{-25}$		[5] UEHARA	09	BELL	10.6 $e^+e^- \to e^+e^-\pi^0\pi^0$
2018± 6		ANISOVICH	00J	SPEC	2.0 $\overline{p}p \to \eta\pi^0\pi^0$, $\pi^0\pi^0$, $\eta\eta$, $\eta\eta'$, $\pi\pi$
∼ 2000		[6] MARTIN	98	RVUE	$N\overline{N} \to \pi\pi$
∼ 2010		[7] MARTIN	97	RVUE	$\overline{N}N \to \pi\pi$
∼ 2040		[8] OAKDEN	94	RVUE	0.36–1.55 $\overline{p}p \to \pi\pi$
∼ 1990		[9] OAKDEN	94	RVUE	0.36–1.55 $\overline{p}p \to \pi\pi$
1978± 5		[10] ALPER	80	CNTR	62 $\pi^- p \to K^+K^- n$
2040±10		[10] ROZANSKA	80	SPRK	18 $\pi^- p \to p\overline{p}n$
1935±13		[10] CORDEN	79	OMEG	12–15 $\pi^- p \to n2\pi$
1988± 7		EVANGELIS...	79B	OMEG	10 $\pi^- p \to K^+K^- n$
1922±14		[11] ANTIPOV	77	CIBS	25 $\pi^- p \to p3\pi$

[1] From the first PWA solution.
[2] From a partial-wave analysis of the data.
[3] From an amplitude analysis of the reaction $\pi^+\pi^- \to 2\pi^0$.
[4] K matrix pole.
[5] Taking into account the $f_2(1950)$. Helicity-2 production favored.
[6] Energy-dependent analysis.
[7] Single energy analysis.
[8] From solution A of amplitude analysis of data on $\overline{p}p \to \pi\pi$. See however KLOET 96 who fit $\pi^+\pi^-$ only and find waves only up to $J = 3$ to be important but not significantly resonant.
[9] From solution B of amplitude analysis of data on $\overline{p}p \to \pi\pi$. See however KLOET 96 who fit $\pi^+\pi^-$ only and find waves only up to $J = 3$ to be important but not significantly resonant.
[10] $I(J^P) = 0(4^+)$ from amplitude analysis assuming one-pion exchange.
[11] Width errors enlarged by us to $4\Gamma/\sqrt{N}$; see the note with the $K^*(892)$ mass.

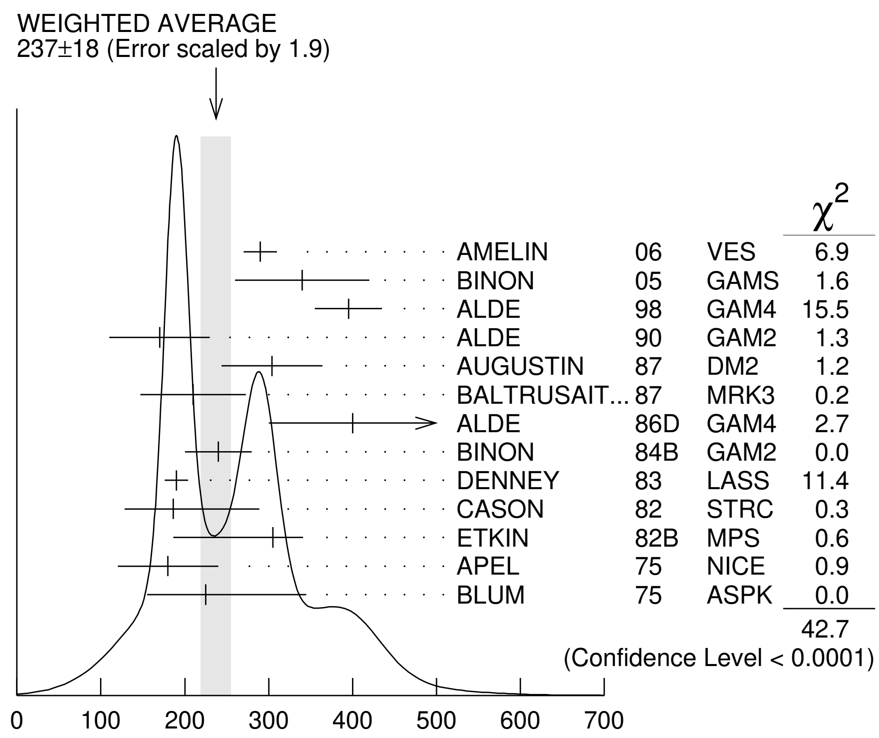


$f_4(2050)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
237± 18 OUR AVERAGE		Error includes scale factor of 1.9. See the ideogram below.			
290± 20		AMELIN	06	VES	36 $\pi^- p \to \omega\omega n$
340± 80		[12] BINON	05	GAMS	33 $\pi^- p \to \eta\eta n$
395± 40		ALDE	98	GAM4	100 $\pi^- p \to \pi^0\pi^0 n$
170± 60		ALDE	90	GAM2	38 $\pi^- p \to \omega\omega n$
304± 60		AUGUSTIN	87	DM2	$J/\psi \to \gamma\pi^+\pi^-$
210± 63		BALTRUSAIT...	87	MRK3	$J/\psi \to \gamma\pi^+\pi^-$
400±100		ALDE	86D	GAM4	100 $\pi^- p \to n2\eta$
240± 40	40k	[13] BINON	84B	GAM2	38 $\pi^- p \to n2\pi^0$
190± 14		DENNEY	83	LASS	10 $\pi^+ n/\pi^+ p$
186^{+103}_{-58}		[14] CASON	82	STRC	8 $\pi^+ p \to \Delta^{++}\pi^0\pi^0$
305^{+36}_{-119}		ETKIN	82B	MPS	23 $\pi^- p \to n2K^0_S$
180± 60	700	APEL	75	NICE	40 $\pi^- p \to n2\pi^0$
225^{+120}_{-70}		BLUM	75	ASPK	18.4 $\pi^- p \to nK^+K^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
260± 40		[15] ANISOVICH	09	RVUE	0.0 $\overline{p}p$, πN
$453\pm 20^{+31}_{-129}$		[16] UEHARA	09	BELL	10.6 $e^+e^- \to e^+e^-\pi^0\pi^0$
182± 7		ANISOVICH	00J	SPEC	2.0 $\overline{p}p \to \eta\pi^0\pi^0$, $\pi^0\pi^0$, $\eta\eta$, $\eta\eta'$, $\pi\pi$
$\sim$ 170		[17] MARTIN	98	RVUE	$N\overline{N} \to \pi\pi$

∼ 200	[18] MARTIN	97	RVUE	$\overline{N}N \to \pi\pi$
∼ 60	[19] OAKDEN	94	RVUE	0.36–1.55 $\overline{p}p \to \pi\pi$
∼ 80	[20] OAKDEN	94	RVUE	0.36–1.55 $\overline{p}p \to \pi\pi$
243±16	[21] ALPER	80	CNTR	62 $\pi^- p \to K^+ K^- n$
140±15	[21] ROZANSKA	80	SPRK	18 $\pi^- p \to p\overline{p}n$
263±57	[21] CORDEN	79	OMEG	12–15 $\pi^- p \to n2\pi$
100±28	EVANGELIS...	79B	OMEG	10 $\pi^- p \to K^+ K^- n$
107±56	[22] ANTIPOV	77	CIBS	25 $\pi^- p \to p3\pi$

[12] From the first PWA solution.
[13] From a partial-wave analysis of the data.
[14] From an amplitude analysis of the reaction $\pi^+\pi^- \to 2\pi^0$.
[15] K matrix pole.
[16] Taking into account the $f_2(1950)$. Helicity-2 production favored.
[17] Energy-dependent analysis.
[18] Single energy analysis.
[19] From solution A of amplitude analysis of data on $\overline{p}p \to \pi\pi$. See however KLOET 96 who fit $\pi^+\pi^-$ only and find waves only up to $J = 3$ to be important but not significantly resonant.
[20] From solution B of amplitude analysis of data on $\overline{p}p \to \pi\pi$. See however KLOET 96 who fit $\pi^+\pi^-$ only and find waves only up to $J = 3$ to be important but not significantly resonant.
[21] $I(J^P) = 0(4^+)$ from amplitude analysis assuming one-pion exchange.
[22] Width errors enlarged by us to $4\Gamma/\sqrt{N}$; see the note with the $K^*(892)$ mass.



$f_4(2050)$ width (MeV)

$f_4(2050)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$\omega\omega$	seen
Γ_2	$\pi\pi$	(17.0 ± 1.5) %
Γ_3	$K\overline{K}$	$(6.8^{+3.4}_{-1.8}) \times 10^{-3}$
Γ_4	$\eta\eta$	$(2.1\pm0.8) \times 10^{-3}$
Γ_5	$4\pi^0$	$<$ 1.2 %
Γ_6	$\gamma\gamma$	seen
Γ_7	$a_2(1320)\pi$	seen

$f_4(2050)$ $\Gamma(i)\Gamma(\gamma\gamma)/\Gamma(\text{total})$

$\Gamma(K\overline{K}) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ — $\Gamma_3\Gamma_6/\Gamma$

VALUE (keV)	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.29	95	ALTHOFF	85B	TASS	$\gamma\gamma \to K\overline{K}\pi$

$\Gamma(\pi\pi) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ — $\Gamma_2\Gamma_6/\Gamma$

VALUE (eV)	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$23.1^{+3.6}_{-3.3}{}^{+70.5}_{-15.6}$			[23] UEHARA	09	BELL	10.6 $e^+e^- \to e^+e^-\pi^0\pi^0$
<1100	95	13 ± 4	OEST	90	JADE	$e^+e^- \to e^+e^-\pi^0\pi^0$

[23] Taking into account the $f_2(1950)$. Helicity-2 production favored.

$f_4(2050)$ BRANCHING RATIOS

$\Gamma(\omega\omega)/\Gamma_{\text{total}}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	AMELIN	06	VES	36 $\pi^- p \to \omega\omega n$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	BARBERIS	00F		450 $pp \to p_f \omega\omega p_s$

$\Gamma(\omega\omega)/\Gamma(\pi\pi)$ — Γ_1/Γ_2

VALUE	DOCUMENT ID		TECN	COMMENT
1.5±0.3	ALDE	90	GAM2	38 $\pi^- p \to \omega\omega n$

$\Gamma(\pi\pi)/\Gamma_{\text{total}}$ — Γ_2/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.170±0.015 OUR AVERAGE				
0.18 ± 0.03	[24] BINON	83C	GAM2	38 $\pi^- p \to n 4\gamma$
0.16 ± 0.03	[24] CASON	82	STRC	8 $\pi^+ p \to \Delta^{++}\pi^0\pi^0$
0.17 ± 0.02	[24] CORDEN	79	OMEG	12–15 $\pi^- p \to n 2\pi$

[24] Assuming one pion exchange.

$\Gamma(K\overline{K})/\Gamma(\pi\pi)$ — Γ_3/Γ_2

VALUE	DOCUMENT ID		TECN	COMMENT
$0.04^{+0.02}_{-0.01}$	ETKIN	82B	MPS	23 $\pi^- p \to n 2K^0_S$

$\Gamma(\eta\eta)/\Gamma_{\text{total}}$ — Γ_4/Γ

VALUE (units 10^{-3})	DOCUMENT ID		TECN	COMMENT
2.1±0.8	ALDE	86D	GAM4	100 $\pi^- p \to n 4\gamma$

$\Gamma(4\pi^0)/\Gamma_{\text{total}}$ — Γ_5/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
<0.012	ALDE	87	GAM4	100 $\pi^- p \to 4\pi^0 n$

$\Gamma(a_2(1320)\pi)/\Gamma_{\text{total}}$ — Γ_7/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	AMELIN	00	VES	37 $\pi^- p \to \eta\pi^+\pi^- n$

$f_4(2050)$ REFERENCES

ANISOVICH	09	IJMP A24 2481	V.V. Anisovich, A.V. Sarantsev	(PNPI)	
UEHARA	09	PR D79 052009	S. Uehara et al.	(BELLE Collab.)	
AMELIN	06	PAN 69 690	D.V. Amelin et al.	(VES Collab.)	
		Translated from YAF 69 715.			
BINON	05	PAN 68 960	F. Binon et al.		
		Translated from YAF 68 998.			
AMELIN	00	NP A668 83	D. Amelin et al.	(VES Collab.)	
ANISOVICH	00J	PL B491 47	A.V. Anisovich et al.	(RAL, LOQM, PNPI+)	
BARBERIS	00F	PL B484 198	D. Barberis et al.	(WA 102 Collab.)	
ALDE	98	EPJ A3 361	D. Alde et al.	(GAM4 Collab.)	
Also		PAN 62 405	D. Alde et al.	(GAMS Collab.)	
		Translated from YAF 62 446.			
MARTIN	98	PR C57 3492	B.R. Martin et al.		
MARTIN	97	PR C56 1114	B.R. Martin, G.C. Oades	(LOUC, AARH)	
KLOET	96	PR D53 6120	W.M. Kloet, F. Myhrer	(RUTG, NORD)	
OAKDEN	94	NP A574 731	M.N. Oakden, M.R. Pennington	(DURH)	
ALDE	90	PL B241 600	D.M. Alde et al.	(SERP, BELG, LANL, LAPP+)	
OEST	90	ZPHY C47 343	T. Oest et al.	(JADE Collab.)	
ALDE	87	PL B198 286	D.M. Alde et al.	(LANL, BRUX, SERP, LAPP)	
AUGUSTIN	87	ZPHY C36 369	J.E. Augustin et al.	(LALO, CLER, FRAS+)	
BALTRUSAIT...	87	PR D35 2077	R.M. Baltrusaitis et al.	(Mark III Collab.)	
ALDE	86D	NP B269 485	D.M. Alde et al.	(BELG, LAPP, SERP, CERN+)	
ALTHOFF	85B	ZPHY C29 189	M. Althoff et al.	(TASSO Collab.)	
BINON	84B	LNC 39 41	F.G. Binon et al.	(SERP, BELG, LAPP)	
BINON	83C	SJNP 38 723	F.G. Binon et al.	(SERP, BRUX+)	
		Translated from YAF 38 1199.			
DENNEY	83	PR D28 2726	D.L. Denney et al.	(IOWA, MICH)	
CASON	82	PRL 48 1316	N.M. Cason et al.	(NDAM, ANL)	
ETKIN	82B	PR D25 1786	A. Etkin et al.	(BNL, CUNY, TUFTS, VAND)	
ALPER	80	PL 94B 422	B. Alper et al.	(AMST, CERN, CRAC, MPIM+)	
ROZANSKA	80	NP B162 505	M. Rozanska et al.	(MPIM, CERN)	
CORDEN	79	NP B157 250	M.J. Corden et al.	(BIRM, RHEL, TELA+)	JP
EVANGELIS...	79B	NP B154 381	C. Evangelista et al.	(BARI, BONN, CERN+)	
ANTIPOV	77	NP B119 45	Y.M. Antipov et al.	(SERP, GEVA)	
APEL	75	PL 57B 398	W.D. Apel et al.	(KARLK, KARLE, PISA, SERP+)	JP
BLUM	75	PL 57B 403	W. Blum et al.	(CERN, MPIM)	JP