$f_J(2220)$

$I^G(J^{PC}) = 0^+(2^{++} \text{ or } 4^{++})$

OMITTED FROM SUMMARY TABLE

Needs confirmation. See our mini-review in the 2004 edition of this *Review*, PDG 04.

$f_J(2220)$ MASS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
2231.1± 3.5 OUR AVERAGE					
2235 ± 4 ± 6	74	BAI	96B	BES	$e^+e^- \to J/\psi \to \gamma\pi^+\pi^-$
$2230\ ^{+\ 6}_{-\ 7}$ ±16	46	BAI	96B	BES	$e^+e^- \to J/\psi \to \gamma K^+K^-$
$2232\ ^{+\ 8}_{-\ 7}$ ±15	23	BAI	96B	BES	$e^+e^- \to J/\psi \to \gamma K^0_S K^0_S$
2235 ± 4 ± 5	32	BAI	96B	BES	$e^+e^- \to J/\psi \to \gamma p\overline{p}$
$2209\ ^{+17}_{-15}$ ±10		ASTON	88F	LASS	11 $K^-p \to K^+K^-\Lambda$
2230 ±20		BOLONKIN	88	SPEC	40 $\pi^-p \to K^0_S K^0_S n$
2220 ±10	41	[1] ALDE	86B	GA24	38–100 $\pi p \to n\eta\eta'$
2230 ± 6 ±14	93	BALTRUSAIT...	86D	MRK3	$e^+e^- \to \gamma K^+K^-$
2232 ± 7 ± 7	23	BALTRUSAIT...	86D	MRK3	$e^+e^- \to \gamma K^0_S K^0_S$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2223.9± 2.5		[2] VLADIMIRSK...	08	SPEC	40 $\pi^-p \to K^0_S K^0_S n$ +mπ^0
2246 ±36		BAI	98H	BES	$J/\psi \to \gamma\pi^0\pi^0$

[1] ALDE 86B uses data from both the GAMS-2000 and GAMS-4000 detectors.
[2] $J^{PC} = 2^{++}$. Systematic uncertainties not evaluated

$f_J(2220)$ WIDTH

VALUE (MeV)	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
$23^{+\ 8}_{-\ 7}$ OUR AVERAGE						
$19^{+\ 13}_{-\ 11}$ ±12		74	BAI	96B	BES	$e^+e^- \to J/\psi \to \gamma\pi^+\pi^-$
$20^{+\ 20}_{-\ 15}$ ±17		46	BAI	96B	BES	$e^+e^- \to J/\psi \to \gamma K^+K^-$
$20^{+\ 25}_{-\ 16}$ ±14		23	BAI	96B	BES	$e^+e^- \to J/\psi \to \gamma K^0_S K^0_S$
$15^{+\ 12}_{-\ 9}$ ± 9		32	BAI	96B	BES	$e^+e^- \to J/\psi \to \gamma p\overline{p}$
$60^{+107}_{-\ 57}$			ASTON	88F	LASS	11 $K^-p \to K^+K^-\Lambda$
80± 30			BOLONKIN	88	SPEC	40 $\pi^-p \to K^0_S K^0_S n$
$26^{+\ 20}_{-\ 16}$ ±17		93	BALTRUSAIT...	86D	MRK3	$e^+e^- \to \gamma K^+K^-$
$18^{+\ 23}_{-\ 15}$ ±10		23	BALTRUSAIT...	86D	MRK3	$e^+e^- \to \gamma K^0_S K^0_S$
• • • We do not use the following data for averages, fits, limits, etc. • • •						

8.6 ± 2.5	[1] VLADIMIRSK...08	SPEC	40 $\pi^- p \to K^0_S K^0_S n$ $+m\pi^0$		
<80	90	ALDE	87C	GAM2	38 $\pi^- p \to \eta' \eta n$

[1] $J^{PC} = 2^{++}$. Systematic uncertainties not evaluated

$f_J(2220)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$\pi\pi$	not seen
Γ_2	$\pi^+\pi^-$	not seen
Γ_3	$K\overline{K}$	not seen
Γ_4	$p\overline{p}$	not seen
Γ_5	$\gamma\gamma$	not seen
Γ_6	$\eta\eta'(958)$	seen
Γ_7	$\phi\phi$	not seen
Γ_8	$\eta\eta$	not seen

$f_J(2220)$ Γ(i)$\Gamma(\gamma\gamma)/\Gamma$(total)

$\Gamma(K\overline{K}) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\quad \Gamma_3\Gamma_5/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID		TECN	COMMENT
$<$ 1.4	95	[1] ACCIARRI	01H	L3	$\gamma\gamma \to K^0_S K^0_S$, $E^{ee}_{\text{cm}}=$ 91, 183–209 GeV

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

$<$ 5.6	95	[1] GODANG	97	CLE2	$\gamma\gamma \to K^0_S K^0_S$
$<$ 86	95	[1] ALBRECHT	90G	ARG	$\gamma\gamma \to K^+ K^-$
$<$1000	95	[2] ALTHOFF	85B	TASS	$\gamma\gamma$, $K\overline{K}\pi$

$\Gamma(\pi\pi) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\quad \Gamma_1\Gamma_5/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID		TECN	COMMENT
<2.5	95	ALAM	98C	CLE2	$\gamma\gamma \to \pi^+\pi^-$

[1] Assuming $J^P = 2^+$.
[2] True for $J^P = 0^+$ and $J^P = 2^+$.

$f_J(2220)$ Γ(i)$\Gamma(p\overline{p})/\Gamma^2$(total)

$\Gamma(p\overline{p})/\Gamma_{\text{total}} \times \Gamma(\pi\pi)/\Gamma_{\text{total}}$ $\quad \Gamma_4/\Gamma \times \Gamma_1/\Gamma$

VALUE (units 10^{-5})	CL%	DOCUMENT ID		TECN	COMMENT
<18	95	[1] AMSLER	01	CBAR	1.4–1.5 $p\overline{p} \to \pi^0\pi^0$

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

$<$(11–42)	99	[2] HASAN	96	SPEC	1.35–1.55 $p\overline{p} \to$ $\pi^+\pi^-$

$\Gamma(p\overline{p})/\Gamma_{\text{total}} \times \Gamma(\phi\phi)/\Gamma_{\text{total}}$ $\quad \Gamma_4/\Gamma \times \Gamma_7/\Gamma$

VALUE (units 10^{-5})	CL%	DOCUMENT ID		TECN	COMMENT
<6	95	[3] EVANGELIS...	98	SPEC	1.1-2.0 $p\overline{p} \to \phi\phi$

$\Gamma(p\overline{p})/\Gamma_{total} \times \Gamma(\eta\eta)/\Gamma_{total}$ $\Gamma_4/\Gamma \times \Gamma_8/\Gamma$

VALUE (units 10^{-5})	CL%	DOCUMENT ID		TECN	COMMENT
<4	95	[1] AMSLER	01	CBAR	1.4–1.5 $p\overline{p} \rightarrow \eta\eta$

[1] For $J^P = 2^+$ in the mass range 2222–2240 MeV and the total width between 10 and 20 MeV.
[2] For $J^P = 2^+$ and $J^P = 4^+$ in the mass range 2220–2245 MeV and the total width of 15 MeV.
[3] For $J^P = 2^+$, the mass of 2235 MeV and the total width of 15 MeV.

$f_J(2220)$ BRANCHING RATIOS

$\Gamma(\pi\pi)/\Gamma_{total}$ Γ_1/Γ

VALUE	DOCUMENT ID		COMMENT
not seen	[1] DOBBS	15	$J/\psi \rightarrow \gamma\pi\pi$
not seen	[1] DOBBS	15	$\psi(2S) \rightarrow \gamma\pi\pi$

[1] Using CLEO-c data but not authored by the CLEO Collaboration.

$\Gamma(K\overline{K})/\Gamma_{total}$ Γ_3/Γ

VALUE	DOCUMENT ID		COMMENT
not seen	[1] DOBBS	15	$J/\psi \rightarrow \gamma K\overline{K}$
not seen	[1] DOBBS	15	$\psi(2S) \rightarrow \gamma K\overline{K}$

[1] Using CLEO-c data but not authored by the CLEO Collaboration.

$\Gamma(\pi\pi)/\Gamma(K\overline{K})$ Γ_1/Γ_3

VALUE	DOCUMENT ID		TECN	COMMENT
1.0±0.5	BAI	96B	BES	$e^+e^- \rightarrow J/\psi \rightarrow \gamma 2\pi, K\overline{K}$

$\Gamma(p\overline{p})/\Gamma_{total}$ Γ_4/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
not seen		[1] AUBERT	07AV	BABR	$B \rightarrow p\overline{p}K^{(*)}$
not seen		WANG	05A	BELL	$B^+ \rightarrow \overline{p}pK^+$
<3.0	95	[2] EVANGELIS...	97	SPEC	1.96-2.40 $\overline{p}p \rightarrow K^0_S K^0_S$
<1.1	99.7	[3] BARNES	93	SPEC	1.3-1.57 $\overline{p}p \rightarrow K^0_S K^0_S$
<2.6	99.7	[3] BARDIN	87	CNTR	1.3-1.5 $\overline{p}p \rightarrow K^+K^-$
<3.6	99.7	[3] SCULLI	87	CNTR	1.29-1.55 $\overline{p}p \rightarrow K^+K^-$

[1] Assuming $\Gamma < 30$ MeV.
[2] Assuming $\Gamma \sim 20$ MeV, $J^P = 2^+$ and B($f_J(2220) \rightarrow K\overline{K}$) = 100%.
[3] Assuming Γ = 30-35 MeV, $J^P = 2^+$ and B($f_J(2220) \rightarrow K\overline{K}$) = 100%.

$\Gamma(p\overline{p})/\Gamma(K\overline{K})$ Γ_4/Γ_3

VALUE	DOCUMENT ID		TECN	COMMENT
0.17±0.09	BAI	96B	BES	$e^+e^- \rightarrow J/\psi \rightarrow \gamma p\overline{p}, K\overline{K}$

$f_J(2220)$ REFERENCES

DOBBS	15	PR D91 052006	S. Dobbs *et al.*	(NWES)
VLADIMIRSK...	08	PAN 71 2129	V.V. Vladimirsky *et al.*	(ITEP)
		Translated from YAF 71 2166.		
AUBERT	07AV	PR D76 092004	B. Aubert *et al.*	(BABAR Collab.)
WANG	05A	PL B617 141	M.-Z. Wang *et al.*	(BELLE Collab.)
PDG	04	PL B592 1	S. Eidelman *et al.*	(PDG Collab.)
ACCIARRI	01H	PL B501 173	M. Acciarri *et al.*	(L3 Collab.)
AMSLER	01	PL B520 175	C. Amsler *et al.*	(Crystal Barrel Collab.)
ALAM	98C	PRL 81 3328	M.S. Alam *et al.*	(CLEO Collab.)
BAI	98H	PRL 81 1179	J.Z. Bai *et al.*	(BES Collab.)
EVANGELIS...	98	PR D57 5370	C. Evangelista *et al.*	(JETSET Collab.)
EVANGELIS...	97	PR D56 3803	C. Evangelista *et al.*	(LEAR Collab.)
GODANG	97	PRL 79 3829	R. Godang *et al.*	(CLEO Collab.)
BAI	96B	PRL 76 3502	J.Z. Bai *et al.*	(BES Collab.)
HASAN	96	PL B388 376	A. Hasan, D.V. Bugg	(BRUN, LOQM)
BARNES	93	PL B309 469	P.D. Barnes *et al.*	(PS185 Collab.)
ALBRECHT	90G	ZPHY C48 183	H. Albrecht *et al.*	(ARGUS Collab.)
ASTON	88F	PL B215 199	D. Aston *et al.*	(SLAC, NAGO, CINC, INUS) JP
BOLONKIN	88	NP B309 426	B.V. Bolonkin *et al.*	(ITEP, SERP)
ALDE	87C	SJNP 45 255	D. Alde *et al.*	
		Translated from YAF 45 405.		
BARDIN	87	PL B195 292	G. Bardin *et al.*	(SACL, FERR, CERN, PADO+)
SCULLI	87	PRL 58 1715	J. Sculli *et al.*	(NYU, BNL)
ALDE	86B	PL B177 120	D.M. Alde *et al.*	(SERP, BELG, LANL, LAPP)
BALTRUSAIT...	86D	PRL 56 107	R.M. Baltrusaitis	(CIT, UCSC, ILL, SLAC+)
ALTHOFF	85B	ZPHY C29 189	M. Althoff *et al.*	(TASSO Collab.)

OTHER RELATED PAPERS

DEL-AMO-SA...	10O	PRL 105 172001	P. del Amo Sanchez *et al.*	(BABAR Collab.)