

**$f_J(2220)$** 

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

OMITTED FROM SUMMARY TABLE

See our mini-review in the 2004 edition of this *Review*, PDG 04. **$f_J(2220)$  MASS**

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

<sup>1</sup>ALDE 86B uses data from both the GAMS-2000 and GAMS-4000 detectors.<sup>2</sup> $J^{PC} = 2^{++}$ . Systematic uncertainties not evaluated **$f_J(2220)$  WIDTH**

VALUE (MeV)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
<b>23 <math>^{+8}_{-7}</math> OUR AVERAGE</b>					
19 $^{+13}_{-11}$ ± 12		74	BAI	96B BES	$e^+e^- \rightarrow J/\psi \rightarrow \gamma\pi^+\pi^-$
20 $^{+20}_{-15}$ ± 17		46	BAI	96B BES	$e^+e^- \rightarrow J/\psi \rightarrow \gamma K^+K^-$
20 $^{+25}_{-16}$ ± 14		23	BAI	96B BES	$e^+e^- \rightarrow J/\psi \rightarrow \gamma K_S^0 K_S^0$
15 $^{+12}_{-9}$ ± 9		32	BAI	96B BES	$e^+e^- \rightarrow J/\psi \rightarrow \gamma p\bar{p}$
60 $^{+107}_{-57}$			ASTON	88F LASS	11 $K^-p \rightarrow K^+K^-\Lambda$
80 ± 30			BOLONKIN	88 SPEC	40 $\pi^-p \rightarrow K_S^0 K_S^0 n$
26 $^{+20}_{-16}$ ± 17		93	BALTRUSAIT..86D	MRK3	$e^+e^- \rightarrow \gamma K^+K^-$
18 $^{+23}_{-15}$ ± 10		23	BALTRUSAIT..86D	MRK3	$e^+e^- \rightarrow \gamma K_S^0 K_S^0$

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

$8.6 \pm 2.5$		<sup>1</sup> VLADIMIRSK...08	SPEC	40	$\pi^- p \rightarrow K_S^0 K_S^0 n$
					$+m\pi^0$
<80	90	ALDE	87C	GAM2	$38 \pi^- p \rightarrow \eta' \eta n$

<sup>1</sup>  $J^{PC} = 2^{++}$ . Systematic uncertainties not evaluated

### $f_J(2220)$ DECAY MODES

Mode	Fraction ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $\pi\pi$	not seen
$\Gamma_2$ $\pi^+\pi^-$	not seen
$\Gamma_3$ $K\bar{K}$	not seen
$\Gamma_4$ $p\bar{p}$	not seen
$\Gamma_5$ $\gamma\gamma$	not seen
$\Gamma_6$ $\eta\eta'(958)$	seen
$\Gamma_7$ $\phi\phi$	not seen
$\Gamma_8$ $\eta\eta$	not seen

### $f_J(2220) \Gamma(i)\Gamma(\gamma\gamma)/\Gamma(\text{total})$

$\Gamma(K\bar{K}) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$					$\Gamma_3\Gamma_5/\Gamma$
VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT	
< 1.4	95	<sup>1</sup> ACCIARRI 01H L3		$\gamma\gamma \rightarrow K_S^0 K_S^0, E_{\text{cm}}^{\text{ee}} = 91, 183\text{--}209 \text{ GeV}$	

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

< 5.6	95	<sup>1</sup> GODANG 97 CLE2	$\gamma\gamma \rightarrow K_S^0 K_S^0$
< 86	95	<sup>1</sup> ALBRECHT 90G ARG	$\gamma\gamma \rightarrow K^+ K^-$
<1000	95	<sup>2</sup> ALTHOFF 85B TASS	$\gamma\gamma, K\bar{K}\pi$

$\Gamma(\pi\pi) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$					$\Gamma_1\Gamma_5/\Gamma$
VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT	
<2.5	95	ALAM 98C CLE2		$\gamma\gamma \rightarrow \pi^+\pi^-$	

<sup>1</sup> Assuming  $J^P = 2^+$ .

<sup>2</sup> True for  $J^P = 0^+$  and  $J^P = 2^+$ .

### $f_J(2220) \Gamma(i)\Gamma(p\bar{p})/\Gamma^2(\text{total})$

$\Gamma(p\bar{p})/\Gamma_{\text{total}} \times \Gamma(\pi\pi)/\Gamma_{\text{total}}$					$\Gamma_4/\Gamma \times \Gamma_1/\Gamma$
VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT	
<18	95	<sup>1</sup> AMSLER 01 CBAR		$1.4\text{--}1.5 p\bar{p} \rightarrow \pi^0\pi^0$	

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

<(11-42)	99	<sup>2</sup> HASAN 96 SPEC	$1.35\text{--}1.55 p\bar{p} \rightarrow \pi^+\pi^-$
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$$\Gamma(p\bar{p})/\Gamma_{\text{total}} \times \Gamma(\phi\phi)/\Gamma_{\text{total}} \qquad \Gamma_4/\Gamma \times \Gamma_7/\Gamma$$

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<6	95	<sup>3</sup> EVANGELIS... 98	SPEC	1.1-2.0 $p\bar{p} \rightarrow \phi\phi$

$$\Gamma(p\bar{p})/\Gamma_{\text{total}} \times \Gamma(\eta\eta)/\Gamma_{\text{total}} \qquad \Gamma_4/\Gamma \times \Gamma_8/\Gamma$$

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<4	95	<sup>1</sup> AMSLER 01	CBAR	1.4-1.5 $p\bar{p} \rightarrow \eta\eta$

<sup>1</sup> For  $J^P = 2^+$  in the mass range 2222–2240 MeV and the total width between 10 and 20 MeV.

<sup>2</sup> For  $J^P = 2^+$  and  $J^P = 4^+$  in the mass range 2220–2245 MeV and the total width of 15 MeV.

<sup>3</sup> For  $J^P = 2^+$ , the mass of 2235 MeV and the total width of 15 MeV.

## $f_J(2220)$ BRANCHING RATIOS

$$\Gamma(\pi\pi)/\Gamma_{\text{total}} \qquad \Gamma_1/\Gamma$$

VALUE	DOCUMENT ID	TECN	COMMENT
not seen	<sup>1</sup> DOBBS 15		$J/\psi \rightarrow \gamma\pi\pi$
not seen	<sup>1</sup> DOBBS 15		$\psi(2S) \rightarrow \gamma\pi\pi$

<sup>1</sup> Using CLEO-c data but not authored by the CLEO Collaboration.

$$\Gamma(K\bar{K})/\Gamma_{\text{total}} \qquad \Gamma_3/\Gamma$$

VALUE	DOCUMENT ID	TECN	COMMENT
not seen	<sup>1</sup> DOBBS 15		$J/\psi \rightarrow \gamma K\bar{K}$
not seen	<sup>1</sup> DOBBS 15		$\psi(2S) \rightarrow \gamma K\bar{K}$

<sup>1</sup> Using CLEO-c data but not authored by the CLEO Collaboration.

$$\Gamma(\pi\pi)/\Gamma(K\bar{K}) \qquad \Gamma_1/\Gamma_3$$

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

$$\Gamma(p\bar{p})/\Gamma_{\text{total}} \qquad \Gamma_4/\Gamma$$

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

not seen		<sup>1</sup> AUBERT 07AV	BABR	$B \rightarrow p\bar{p}K^{(*)}$
not seen		WANG 05A	BELL	$B^+ \rightarrow \bar{p}pK^+$
<3.0	95	<sup>2</sup> EVANGELIS... 97	SPEC	1.96-2.40 $\bar{p}p \rightarrow K_S^0 K_S^0$
<1.1	99.7	<sup>3</sup> BARNES 93	SPEC	1.3-1.57 $\bar{p}p \rightarrow K_S^0 K_S^0$
<2.6	99.7	<sup>3</sup> BARDIN 87	CNTR	1.3-1.5 $\bar{p}p \rightarrow K^+ K^-$
<3.6	99.7	<sup>3</sup> SCULLI 87	CNTR	1.29-1.55 $\bar{p}p \rightarrow K^+ K^-$

<sup>1</sup> Assuming  $\Gamma < 30$  MeV.

<sup>2</sup> Assuming  $\Gamma \sim 20$  MeV,  $J^P = 2^+$  and  $B(f_J(2220) \rightarrow K\bar{K}) = 100\%$ .

<sup>3</sup> Assuming  $\Gamma = 30-35$  MeV,  $J^P = 2^+$  and  $B(f_J(2220) \rightarrow K\bar{K}) = 100\%$ .

$$\Gamma(p\bar{p})/\Gamma(K\bar{K}) \qquad \Gamma_4/\Gamma_3$$

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

**$f_J(2220)$  REFERENCES**

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

**OTHER RELATED PAPERS**

DEL-AMO-SA...	100	PRL 105 172001	P. del Amo Sanchez <i>et al.</i>	(BABAR Collab.)
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