

$\rho(2150)$

$$I^G(J^{PC}) = 1^+(1^{--})$$

OMITTED FROM SUMMARY TABLE

This entry was previously called $T_1(2190)$. See the review on "Spectroscopy of Light Meson Resonances." **$\rho(2150)$ MASS** **e^+e^- PRODUCED**

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
2044 ± 31 ± 4		¹ ABLIKIM	23BQ BES3	$e^+e^- \rightarrow a_2(1320)^+\pi^- +$ c.c. $\rightarrow \eta\pi^+\pi^-$
2095 ± 4		² ACHASOV	23A SND	$e^+e^- \rightarrow \omega\pi^0$
2034 ± 13 ± 9		³ ABLIKIM	21A BES3	$e^+e^- \rightarrow \omega\pi^0$
2111 ± 43 ± 25		⁴ ABLIKIM	21X BES3	$e^+e^- \rightarrow \eta'\pi^+\pi^-$
2255 $\begin{smallmatrix} +17 & +50 \\ -18 & -41 \end{smallmatrix}$	1.8k	⁵ ABLIKIM	20F BES3	$\psi(2S) \rightarrow K^+K^-\eta$
2201 ± 19		⁶ LEES	20 BABR	$e^+e^- \rightarrow K^+K^-\gamma$
2227 ± 9 ± 9		⁷ LEES	20 RVUE	$e^+e^- \rightarrow K^+K^-$
2039 ± 8 $\begin{smallmatrix} +36 \\ -18 \end{smallmatrix}$		⁸ ABLIKIM	19AQ BES	$J/\psi \rightarrow K^+K^-\pi^0$
2239.2 ± 7.1 ± 11.3		⁹ ABLIKIM	19L BES3	$e^+e^- \rightarrow K^+K^-$
2254 ± 22		¹⁰ LEES	12G BABR	$e^+e^- \rightarrow \pi^+\pi^-\gamma$
2150 ± 40 ± 50		AUBERT	07AU BABR	10.6 $e^+e^- \rightarrow$ $f_1(1285)\pi^+\pi^-\gamma$
1990 ± 80		AUBERT	07AU BABR	10.6 $e^+e^- \rightarrow \eta'\pi^+\pi^-\gamma$
2153 ± 37		BIAGINI	91 RVUE	$e^+e^- \rightarrow \pi^+\pi^-, K^+K^-$
2110 ± 50		¹¹ CLEGG	90 RVUE	$e^+e^- \rightarrow 3(\pi^+\pi^-),$ $2(\pi^+\pi^-\pi^0)$

¹ From a fit to the cross section between 2.00 and 3.08 GeV with a coherent sum of a Breit-Wigner resonance and a non-resonant contribution. Could be another state.² From a vector dominance fit to the Born cross section between 1.05 and 2.0 GeV with $\rho(770)$, $\rho(1570)$, $\rho(1700)$, $\rho(2150)$. The fit also uses SND data from the VEPP-2M collider below 1.02 GeV and from LEES 17H and ABLIKIM 21A above 1.5 GeV.³ From a fit to the cross section between 2.00 and 3.08 GeV with a coherent sum of Breit-Wigner amplitudes, including contributions from $\rho(770)$, $\rho(1450)$ and $\rho(1700)$. Could be another state.⁴ From a Breit-Wigner fit to the Born cross section, including an s -dependent continuum amplitude.⁵ Seen in $\psi(2S)$ decay with branching ratio $\psi(2S) \rightarrow X\eta \rightarrow K^+K^-\eta = (21.7 \pm 1.9^{+7.7}_{-8.3}) \times 10^{-6}$.⁶ From the fit to the BABAR data of LEES 13Q assuming a coherent sum of a single Breit-Wigner resonance and a nonresonant contribution. The resonance significance is 3.5σ .⁷ From the fit to the BABAR data of LEES 13Q and BESIII data of ABLIKIM 19L assuming a coherent sum of a single Breit-Wigner resonance and a nonresonant contribution.⁸ Could also be another state. Seen in J/ψ decay with branching ratio $J/\psi \rightarrow X\pi^0 \rightarrow K^+K^-\pi^0 = (6.7 \pm 1.1^{+2.2}_{-1.8}) \times 10^{-6}$.⁹ The observed structure can be due to both the $\phi(2170)$ and $\rho(2150)$.

¹⁰ Using the GOUNARIS 68 parametrization of the pion form factor leaving the masses and widths of the $\rho(1450)$, $\rho(1700)$, and $\rho(2150)$ resonances as free parameters of the fit.

¹¹ Includes ATKINSON 85.

$\bar{p}p \rightarrow \pi\pi$

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
~ 2191	HASAN	94	RVUE $\bar{p}p \rightarrow \pi\pi$
~ 2070	¹ OAKDEN	94	RVUE 0.36–1.55 $\bar{p}p \rightarrow \pi\pi$
~ 2170	² MARTIN	80B	RVUE
~ 2100	² MARTIN	80C	RVUE

¹ See however KLOET 96 who fit $\pi^+\pi^-$ only and find waves only up to $J = 3$ to be important but not significantly resonant.

² $I(J^P) = 1(1^-)$ from simultaneous analysis of $p\bar{p} \rightarrow \pi^-\pi^+$ and $\pi^0\pi^0$.

S-CHANNEL $\bar{N}N$

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
2110 ± 35	¹ ANISOVICH	02	SPEC 0.6–1.9 $p\bar{p} \rightarrow \omega\pi^0, \omega\eta\pi^0, \pi^+\pi^-$
~ 2190	² CUTTS	78B	CNTR 0.97–3 $\bar{p}p \rightarrow \bar{N}N$
2155 ± 15	^{2,3} COUPLAND	77	CNTR 0.7–2.4 $\bar{p}p \rightarrow \bar{p}p$
2193 ± 2	^{2,4} ALSPECTOR	73	CNTR $\bar{p}p$ S channel
2190 ± 10	⁵ ABRAMS	70	CNTR S channel $\bar{p}N$

¹ From the combined analysis of ANISOVICH 00J, ANISOVICH 01D, ANISOVICH 01E, and ANISOVICH 02.

² Isospins 0 and 1 not separated.

³ From a fit to the total elastic cross section.

⁴ Referred to as T or T region by ALSPECTOR 73.

⁵ Seen as bump in $l = 1$ state. See also COOPER 68. PEASLEE 75 confirm $\bar{p}p$ results of ABRAMS 70, no narrow structure.

$\pi^-p \rightarrow \omega\pi^0n$

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
2140 ± 30	ALDE	95	GAM2 38 $\pi^-p \rightarrow \omega\pi^0n$
2170 ± 30	ALDE	92C	GAM4 100 $\pi^-p \rightarrow \omega\pi^0n$

$\rho(2150)$ WIDTH

e^+e^- PRODUCED

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
163 ± 69 ± 24		¹ ABLIKIM	23BQ BES3	$e^+e^- \rightarrow a_2(1320)^+\pi^- +$ c.c. $\rightarrow \eta\pi^+\pi^-$
270 ± 3		² ACHASOV	23A SND	$e^+e^- \rightarrow \omega\pi^0$
234 ± 30 ± 25		³ ABLIKIM	21A BES3	$e^+e^- \rightarrow \omega\pi^0$
135 ± 34 ± 30		⁴ ABLIKIM	21X BES3	$e^+e^- \rightarrow \eta'\pi^+\pi^-$
460 + 54 + 160 - 48 - 90	1.8k	⁵ ABLIKIM	20F BES3	$\psi(2S) \rightarrow K^+K^-\eta$
70 ± 38		⁶ LEES	20 BABR	$e^+e^- \rightarrow K^+K^-\gamma$
127 ± 14 ± 4		⁷ LEES	20 RVUE	$e^+e^- \rightarrow K^+K^-$

196 ± 23 ⁺²⁵ / ₋₂₇	⁸ ABLIKIM	19AQ BES	$J/\psi \rightarrow K^+ K^- \pi^0$
139.8 ± 12.3 ± 20.6	⁹ ABLIKIM	19L BES3	$e^+ e^- \rightarrow K^+ K^-$
109 ± 76	¹⁰ LEES	12G BABR	$e^+ e^- \rightarrow \pi^+ \pi^- \gamma$
350 ± 40 ± 50	AUBERT	07AU BABR	$10.6 e^+ e^- \rightarrow f_1(1285) \pi^+ \pi^- \gamma$
310 ± 140	AUBERT	07AU BABR	$10.6 e^+ e^- \rightarrow \eta' \pi^+ \pi^- \gamma$
389 ± 79	BIAGINI	91 RVUE	$e^+ e^- \rightarrow \pi^+ \pi^-, K^+ K^-$
410 ± 100	¹¹ CLEGG	90 RVUE	$e^+ e^- \rightarrow 3(\pi^+ \pi^-), 2(\pi^+ \pi^- \pi^0)$

¹ From a fit to the cross section between 2.00 and 3.08 GeV with a coherent sum of a Breit-Wigner resonance and a non-resonant contribution. Could be another state.

² From a vector dominance fit to the Born cross section between 1.05 and 2.0 GeV with $\rho(770)$, $\rho(1570)$, $\rho(1700)$, $\rho(2150)$. The fit also uses SND data from the VEPP-2M collider below 1.02 GeV and from LEES 17H and ABLIKIM 21A above 1.5 GeV.

³ From a fit to the cross section between 2.00 and 3.08 GeV with a coherent sum of Breit-Wigner amplitudes, including contributions from $\rho(770)$, $\rho(1450)$ and $\rho(1700)$. Could be another state.

⁴ From a Breit-Wigner fit to the Born cross section, including an s -dependent continuum amplitude.

⁵ Seen in $\psi(2S)$ decay with branching ratio $\psi(2S) \rightarrow X \eta \rightarrow K^+ K^- \eta = (21.7 \pm 1.9^{+7.7}_{-8.3}) \times 10^{-6}$.

⁶ From the fit to the BABAR data of LEES 13Q assuming a coherent sum of a single Breit-Wigner resonance and a nonresonant contribution. The resonance significance is 3.5σ .

⁷ From the fit to the BABAR data of LEES 13Q and BESIII data of ABLIKIM 19L assuming a coherent sum of a single Breit-Wigner resonance and a nonresonant contribution.

⁸ Could also be another state. Seen in J/ψ decay with branching ratio $J/\psi \rightarrow X \pi^0 \rightarrow K^+ K^- \pi^0 = (6.7 \pm 1.1^{+2.2}_{-1.8}) \times 10^{-6}$.

⁹ The observed structure can be due to both the $\phi(2170)$ and $\rho(2150)$.

¹⁰ Using the GOUNARIS 68 parametrization of the pion form factor leaving the masses and widths of the $\rho(1450)$, $\rho(1700)$, and $\rho(2150)$ resonances as free parameters of the fit.

¹¹ Includes ATKINSON 85.

$\bar{p}p \rightarrow \pi\pi$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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••• We do not use the following data for averages, fits, limits, etc. •••

~ 296	HASAN	94	RVUE $\bar{p}p \rightarrow \pi\pi$
~ 40	¹ OAKDEN	94	RVUE $0.36\text{--}1.55 \bar{p}p \rightarrow \pi\pi$
~ 250	² MARTIN	80B	RVUE
~ 200	² MARTIN	80C	RVUE

¹ See however KLOET 96 who fit $\pi^+ \pi^-$ only and find waves only up to $J = 3$ to be important but not significantly resonant.

² $I(J^P) = 1(1^-)$ from simultaneous analysis of $p\bar{p} \rightarrow \pi^- \pi^+$ and $\pi^0 \pi^0$.

S-CHANNEL $\bar{N}N$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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••• We do not use the following data for averages, fits, limits, etc. •••

230 ± 50	¹ ANISOVICH	02	SPEC $0.6\text{--}1.9 p\bar{p} \rightarrow \omega \pi^0, \omega \eta \pi^0, \pi^+ \pi^-$
135 ± 75	^{2,3} COUPLAND	77	CNTR $0.7\text{--}2.4 \bar{p}p \rightarrow \bar{p}p$
98 ± 8	³ ALSPECTOR	73	CNTR $\bar{p}p$ S channel
~ 85	⁴ ABRAMS	70	CNTR S channel $\bar{p}N$

- ¹From the combined analysis of ANISOVICH 00J, ANISOVICH 01D, ANISOVICH 01E, and ANISOVICH 02.
²From a fit to the total elastic cross section.
³Isospins 0 and 1 not separated.
⁴Seen as bump in $l = 1$ state. See also COOPER 68. PEASLEE 75 confirm $\bar{p}p$ results of ABRAMS 70, no narrow structure.

 $\pi^- p \rightarrow \omega \pi^0 n$

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
••• We do not use the following data for averages, fits, limits, etc. •••			
320 ± 70	ALDE	95	GAM2 38 $\pi^- p \rightarrow \omega \pi^0 n$
~ 300	ALDE	92C	GAM4 100 $\pi^- p \rightarrow \omega \pi^0 n$

 $\rho(2150)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)
Γ_1 $e^+ e^-$	
Γ_2 $\pi^+ \pi^-$	seen
Γ_3 $K^+ K^-$	seen
Γ_4 $3(\pi^+ \pi^-)$	seen
Γ_5 $2(\pi^+ \pi^- \pi^0)$	seen
Γ_6 $\eta' \pi^+ \pi^-$	seen
Γ_7 $f_1(1285) \pi^+ \pi^-$	seen
Γ_8 $\omega \pi^0$	seen
Γ_9 $\omega \pi^0 \eta$	seen
Γ_{10} $a_2(1320) \pi$	
Γ_{11} $p \bar{p}$	

 $\rho(2150) \Gamma(i) \Gamma(e^+ e^-) / \Gamma(\text{total})$

VALUE (eV)	DOCUMENT ID	TECN	COMMENT	$\Gamma_6 \Gamma_1 / \Gamma$
••• We do not use the following data for averages, fits, limits, etc. •••				
$23.3 \pm 5.3 \pm 3.3$	¹ ABLIKIM	21X	BES3 $e^+ e^- \rightarrow \eta' \pi^+ \pi^-$	

¹From a Breit-Wigner fit to the Born cross section interfering constructively with the continuum. For destructive interference the value is $0.64 \pm 0.49 \pm 0.42$ eV.

VALUE (eV)	DOCUMENT ID	TECN	COMMENT	$\Gamma_8 \Gamma_1 / \Gamma$
••• We do not use the following data for averages, fits, limits, etc. •••				
$34 \pm 11 \pm 16$	ABLIKIM	21A	BES3 $e^+ e^- \rightarrow \omega \pi^0$	

VALUE (eV)	DOCUMENT ID	TECN	COMMENT	$\Gamma_{10} \Gamma_1 / \Gamma$
••• We do not use the following data for averages, fits, limits, etc. •••				
$34.6 \pm 17.1 \pm 6.0$	¹ ABLIKIM	23BQ	BES3 $e^+ e^- \rightarrow a_2(1320)^+ \pi^- + \text{c.c.} \rightarrow \eta \pi^+ \pi^-$	

¹ From a solution of the fit to the cross section between 2.00 and 3.08 GeV using a coherent sum of a single Breit-Wigner resonance and a non-resonant contribution. $B(a_2(1320) \rightarrow \eta\pi) \times B(\eta \rightarrow \gamma\gamma)$ fixed to 0.057. Another solution with equal fit quality gives $137.1 \pm 73.3 \pm 2.1$ eV.

$\rho(2150) \Gamma(i)\Gamma(e^+e^-)/\Gamma^2(\text{total})$

$$\Gamma(f_1(1285)\pi^+\pi^-)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}} \quad \Gamma_7/\Gamma \times \Gamma_1/\Gamma$$

VALUE (units 10^{-7})	DOCUMENT ID	TECN	COMMENT
$3.1 \pm 0.6 \pm 0.5$	¹ AUBERT	07AU BABR	$10.6 e^+e^- \rightarrow f_1(1285)\pi^+\pi^-\gamma$

¹ Calculated by us from the reported value of cross section at the peak.

$$\Gamma(\eta'\pi^+\pi^-)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}} \quad \Gamma_6/\Gamma \times \Gamma_1/\Gamma$$

VALUE (units 10^{-8})	DOCUMENT ID	TECN	COMMENT
4.9 ± 1.9	¹ AUBERT	07AU BABR	$10.6 e^+e^- \rightarrow \eta'\pi^+\pi^-\gamma$

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

¹ Calculated by us from the reported value of cross section at the peak.

$\rho(2150)$ REFERENCES

ABLIKIM	23BQ	PR D108 L111101	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ACHASOV	23A	PR D108 092012	M.N. Achasov <i>et al.</i>	(SND Collab.)
ABLIKIM	21A	PL B813 136059	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	21X	PR D103 072007	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	20F	PR D101 032008	M. Ablikim <i>et al.</i>	(BESIII Collab.)
LEES	20	PR D101 012011	J.P. Lees <i>et al.</i>	(BESIII Collab.)
ABLIKIM	19AQ	PR D100 032004	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	19L	PR D99 032001	M. Ablikim <i>et al.</i>	(BESIII Collab.)
LEES	17H	PR D96 092009	J.P. Lees <i>et al.</i>	(BABAR Collab.)
LEES	13Q	PR D88 032013	J.P. Lees <i>et al.</i>	(BABAR Collab.)
LEES	12G	PR D86 032013	J.P. Lees <i>et al.</i>	(BABAR Collab.)
AUBERT	07AU	PR D76 092005	B. Aubert <i>et al.</i>	(BABAR Collab.)
ANISOVICH	02	PL B542 8	A.V. Anisovich <i>et al.</i>	
ANISOVICH	01D	PL B508 6	A.V. Anisovich <i>et al.</i>	
ANISOVICH	01E	PL B513 281	A.V. Anisovich <i>et al.</i>	
ANISOVICH	00J	PL B491 47	A.V. Anisovich <i>et al.</i>	(RAL, LOQM, PNPI+)
KLOET	96	PR D53 6120	W.M. Kloet, F. Myhrer	(RUTG, NORD)
ALDE	95	ZPHY C66 379	D.M. Alde <i>et al.</i>	(GAMS Collab.) JP
HASAN	94	PL B334 215	A. Hasan, D.V. Bugg	(LOQM)
OAKDEN	94	NP A574 731	M.N. Oakden, M.R. Pennington	(DURH)
ALDE	92C	ZPHY C54 553	D.M. Alde <i>et al.</i>	(BELG, SERP, KEK, LANL+)
BIAGINI	91	NC 104A 363	M.E. Biagini <i>et al.</i>	(FRAS, PRAG)
CLEGG	90	ZPHY C45 677	A.B. Clegg, A. Donnachie	(LANC, MCHS)
ATKINSON	85	ZPHY C29 333	M. Atkinson <i>et al.</i>	(BONN, CERN, GLAS+)
MARTIN	80B	NP B176 355	B.R. Martin, D. Morgan	(LOUC, RHEL) JP
MARTIN	80C	NP B169 216	A.D. Martin, M.R. Pennington	(DURH) JP
CUTTS	78B	PR D17 16	D. Cutts <i>et al.</i>	(STON, WISC)
COUPLAND	77	PL 71B 460	M. Coupland <i>et al.</i>	(LOQM, RHEL)
PEASLEE	75	PL 57B 189	D.C. Peaslee <i>et al.</i>	(CANB, BARI, BROW+)
ALSPECTOR	73	PRL 30 511	J. Alspector <i>et al.</i>	(RUTG, UPNJ)
ABRAMS	70	PR D1 1917	R.J. Abrams <i>et al.</i>	(BNL)
COOPER	68	PRL 20 1059	W.A. Cooper <i>et al.</i>	(ANL)
GOUNARIS	68	PRL 21 244	G.J. Gounaris, J.J. Sakurai	