

**$\rho(2150)$** 

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

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		<sup>1</sup> ABLIKIM	23BQ BES3	$e^+e^- \rightarrow a_2(1320)^+\pi^- +$ c.c. $\rightarrow \eta\pi^+\pi^-$
2095 ± 4		<sup>2</sup> ACHASOV	23A SND	$e^+e^- \rightarrow \omega\pi^0$
2034 ± 13 ± 9		<sup>3</sup> ABLIKIM	21A BES3	$e^+e^- \rightarrow \omega\pi^0$
2111 ± 43 ± 25		<sup>4</sup> ABLIKIM	21X BES3	$e^+e^- \rightarrow \eta'\pi^+\pi^-$
2255 $\begin{smallmatrix} +17 \\ -18 \end{smallmatrix}$ $\begin{smallmatrix} +50 \\ -41 \end{smallmatrix}$	1.8k	<sup>5</sup> ABLIKIM	20F BES3	$\psi(2S) \rightarrow K^+K^-\eta$
2201 ± 19		<sup>6</sup> LEES	20 BABR	$e^+e^- \rightarrow K^+K^-\gamma$
2227 ± 9 ± 9		<sup>7</sup> LEES	20 RVUE	$e^+e^- \rightarrow K^+K^-$
2039 ± 8 $\begin{smallmatrix} +36 \\ -18 \end{smallmatrix}$		<sup>8</sup> ABLIKIM	19AQ BES	$J/\psi \rightarrow K^+K^-\pi^0$
2239.2 ± 7.1 ± 11.3		<sup>9</sup> ABLIKIM	19L BES3	$e^+e^- \rightarrow K^+K^-$
2254 ± 22		<sup>10</sup> 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		<sup>11</sup> CLEGG	90 RVUE	$e^+e^- \rightarrow 3(\pi^+\pi^-),$ $2(\pi^+\pi^-\pi^0)$

<sup>1</sup> 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.

<sup>2</sup> 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.

<sup>3</sup> 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.

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

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

<sup>6</sup> 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  $3.5\sigma$ .

<sup>7</sup> 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.

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

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

- <sup>10</sup> 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.  
<sup>11</sup> 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	<sup>1</sup> OAKDEN	94	RVUE 0.36–1.55 $\bar{p}p \rightarrow \pi\pi$
~ 2170	<sup>2</sup> MARTIN	80B	RVUE
~ 2100	<sup>2</sup> MARTIN	80C	RVUE

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

<sup>2</sup>  $I(J^P) = 1(1^-)$  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	<sup>1</sup> ANISOVICH	02	SPEC 0.6–1.9 $p\bar{p} \rightarrow \omega\pi^0, \omega\eta\pi^0, \pi^+\pi^-$
~ 2190	<sup>2</sup> CUTTS	78B	CNTR 0.97–3 $\bar{p}p \rightarrow \bar{N}N$
2155 ± 15	<sup>2,3</sup> COUPLAND	77	CNTR 0.7–2.4 $\bar{p}p \rightarrow \bar{p}p$
2193 ± 2	<sup>2,4</sup> ALSPECTOR	73	CNTR $\bar{p}p$ S channel
2190 ± 10	<sup>5</sup> ABRAMS	70	CNTR S channel $\bar{p}N$

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

<sup>2</sup> Isospins 0 and 1 not separated.

<sup>3</sup> From a fit to the total elastic cross section.

<sup>4</sup> Referred to as  $T$  or  $T$  region by ALSPECTOR 73.

<sup>5</sup> 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		<sup>1</sup> ABLIKIM	23BQ	BES3 $e^+e^- \rightarrow a_2(1320)^+\pi^- +$ c.c. $\rightarrow \eta\pi^+\pi^-$
270 ± 3		<sup>2</sup> ACHASOV	23A	SND $e^+e^- \rightarrow \omega\pi^0$
234 ± 30 ± 25		<sup>3</sup> ABLIKIM	21A	BES3 $e^+e^- \rightarrow \omega\pi^0$
135 ± 34 ± 30		<sup>4</sup> ABLIKIM	21X	BES3 $e^+e^- \rightarrow \eta'\pi^+\pi^-$
460 + 54 + 160 - 48 - 90	1.8k	<sup>5</sup> ABLIKIM	20F	BES3 $\psi(2S) \rightarrow K^+K^-\eta$
70 ± 38		<sup>6</sup> LEES	20	BABR $e^+e^- \rightarrow K^+K^-\gamma$
127 ± 14 ± 4		<sup>7</sup> LEES	20	RVUE $e^+e^- \rightarrow K^+K^-$

196 ± 23 $\begin{smallmatrix} + \\ - \end{smallmatrix} \begin{smallmatrix} 25 \\ 27 \end{smallmatrix}$	<sup>8</sup> ABLIKIM	19AQ BES	$J/\psi \rightarrow K^+ K^- \pi^0$
139.8 ± 12.3 ± 20.6	<sup>9</sup> ABLIKIM	19L BES3	$e^+ e^- \rightarrow K^+ K^-$
109 ± 76	<sup>10</sup> 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	<sup>11</sup> CLEGG	90 RVUE	$e^+ e^- \rightarrow 3(\pi^+ \pi^-), 2(\pi^+ \pi^- \pi^0)$

<sup>1</sup> 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.

<sup>2</sup> 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.

<sup>3</sup> 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.

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

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

<sup>6</sup> 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  $3.5 \sigma$ .

<sup>7</sup> 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.

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

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

<sup>10</sup> 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.

<sup>11</sup> Includes ATKINSON 85.

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

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
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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	<sup>1</sup> OAKDEN	94	RVUE 0.36–1.55 $\bar{p}p \rightarrow \pi\pi$
~ 250	<sup>2</sup> MARTIN	80B	RVUE
~ 200	<sup>2</sup> MARTIN	80C	RVUE

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

<sup>2</sup>  $I(J^P) = 1(1^-)$  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
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••• We do not use the following data for averages, fits, limits, etc. •••

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

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

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

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

**$\rho(2150)$  DECAY MODES**

Mode	Fraction ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $e^+ e^-$	
$\Gamma_2$ $\pi^+ \pi^-$	seen
$\Gamma_3$ $K^+ K^-$	seen
$\Gamma_4$ $3(\pi^+ \pi^-)$	seen
$\Gamma_5$ $2(\pi^+ \pi^- \pi^0)$	seen
$\Gamma_6$ $\eta' \pi^+ \pi^-$	seen
$\Gamma_7$ $f_1(1285) \pi^+ \pi^-$	seen
$\Gamma_8$ $\omega \pi^0$	seen
$\Gamma_9$ $\omega \pi^0 \eta$	seen
$\Gamma_{10}$ $a_2(1320) \pi$	
$\Gamma_{11}$ $\rho \bar{p}$	

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

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

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

**$\Gamma(\omega \pi^0) \times \Gamma(e^+ e^-)/\Gamma_{\text{total}}$   $\Gamma_8 \Gamma_1/\Gamma$**

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

**$\Gamma(a_2(1320) \pi) \times \Gamma(e^+ e^-)/\Gamma_{\text{total}}$   $\Gamma_{10} \Gamma_1/\Gamma$**

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

<sup>1</sup> 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.

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

$\Gamma(f_1(1285)\pi^+\pi^-)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$	$\Gamma_7/\Gamma \times \Gamma_1/\Gamma$		
VALUE (units $10^{-7}$ )	DOCUMENT ID	TECN	COMMENT
<b><math>3.1 \pm 0.6 \pm 0.5</math></b>	<sup>1</sup> AUBERT	07AU BABR	$10.6 e^+e^- \rightarrow f_1(1285)\pi^+\pi^-\gamma$

<sup>1</sup> Calculated by us from the reported value of cross section at the peak.

$\Gamma(\eta'\pi^+\pi^-)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$	$\Gamma_6/\Gamma \times \Gamma_1/\Gamma$		
VALUE (units $10^{-8}$ )	DOCUMENT ID	TECN	COMMENT

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

$4.9 \pm 1.9$	<sup>1</sup> AUBERT	07AU BABR	$10.6 e^+e^- \rightarrow \eta'\pi^+\pi^-\gamma$
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<sup>1</sup> 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	