

**$a_1(1260)$** 

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

**THE  $a_1(1260)$** 

Updated March 2000 by S. Eidelman (Novosibirsk).

The main experimental data on the  $a_1(1260)$  may be grouped into two classes:

**(1) Hadronic Production:** This comprises diffractive production with incident  $\pi^-$  (DAUM 80, 81B) and charge-exchange production with low-energy  $\pi^-$  (DANKOWYCH 81, ANDO 92). The 1980's experiments explain the  $I^G L J^P = 1^+ S 0^+$  data using a phenomenological amplitude consisting of a rescattered Deck amplitude, plus a direct resonance-production term. They agree on a mass of about 1270 MeV and a width of 300–380 MeV. ANDO 92 finds rather lower values for the mass (1121 MeV) and width (239 MeV), in a partial-wave analysis based on the isobar model of the  $\pi^+\pi^-\pi^0$  system. However, in this analysis, only Breit-Wigner terms were considered. Recently, BARBERIS 98B studied central production of the  $\pi^+\pi^-\pi^0$  system, and observed the  $a_1(1260)$  meson with a mass of 1240 MeV and a width of about 400 MeV.

**(2)  $\tau$  Decay:** Various experiments reported good data on  $\tau \rightarrow a_1(1260)\nu_\tau \rightarrow \rho\pi\nu_\tau$  (RUCKSTUHL 86, SCHMIDKE 86, ALBRECHT 86B, BAND 87, ACKERSTAFF 97R, ABREU 98G, and ASNER 00). They are somewhat inconsistent concerning the  $a_1(1260)$  mass, which can, however, be attributed to model-dependent systematic uncertainties (BOWLER 86, ALBRECHT 93C, ACKERSTAFF 97R). They all find a width greater than 400 MeV.

The discrepancies between the hadronic and  $\tau$  decay results have stimulated several reanalyses. BASDEVANT 77, 78 used

the early diffractive dissociation and  $\tau$ -decay data, and showed that they could be well reproduced with an  $a_1$  resonance mass of  $1180 \pm 50$  MeV and width of  $400 \pm 50$  MeV. Later, BOWLER 86, TORNQVIST 87, ISGUR 89, and IVANOV 91 have studied the process  $\tau \rightarrow 3\pi\nu_\tau$ . Despite quite different approaches, they all found a good overall description of the  $\tau$ -decay data with an  $a_1(1260)$  mass near 1230 MeV, consistent with the hadronic data. However, their widths remain significantly larger (400–600 MeV) than those extracted from diffractive-hadronic data. This is also the case with the later OPAL experiment (ACKERSTAFF 97R). In the high statistics analysis of ACKERSTAFF 97R, the models of ISGUR 89 and KUHN 90 are used to fit distributions of the  $3\pi$  invariant mass, as well as the  $2\pi$  invariant mass projections of the Dalitz plot. Neither model is found to provide a completely satisfactory description of the data. Another recent high statistics analysis of ABREU 98G obtains a good description of the  $\tau \rightarrow 3\pi$  data using the model of FEINDT 90, which includes the  $a'_1$  meson, a radial excitation of the  $a_1(1260)$  meson, with a mass of 1700 MeV and a width of 300 MeV. A similar signal has been observed by AMELIN 95B in the  $D$  and  $S$  waves of the  $\rho\pi$  state, as well as by GOUZ 92 in the  $f_1(1285)\pi$  state. The existence of such a resonance is also suggested by the very big data sample of ASNER 00, which shows an excess of events at high  $3\pi$  mass. Their data are better described by the  $a'_1$  contribution, though at a level below that reported by ABREU 98G. Since the statistical significance of the  $a'_1$  contribution is  $2\text{--}3\sigma$  only, they conclude that more data is needed to establish the existence of the  $a'_1$ .

ASNER 00 has also performed an analysis of the substructures in the Dalitz plot, and found significant contributions

of the  $a_1$  decay to  $\sigma\pi$ ,  $f_0(1370)\pi$ , and  $f_2(1270)\pi$ . The contribution of the  $a_1 \rightarrow \sigma\pi$  at a similar level has independently been observed in  $e^+e^- \rightarrow 4\pi$  annihilation (AKHMETSHIN 99E), where the  $2\pi^+2\pi^-$  final state was shown to be dominated by the  $a_1(1260)\pi$  mechanism. Note that the existence of isoscalar contributions to the two-pion state, in addition to the isovector one ( $\rho\pi$ ), will influence the ratio  $B(a_1^- \rightarrow \pi^-\pi^+\pi^-)/B(a_1^- \rightarrow \pi^-\pi^0\pi^0)$ , which should be equal to 1 for the pure  $\rho\pi$  state.

BOWLER 88 showed that good fits to both the hadronic and the  $\tau$ -decay data could be obtained with a width of about 400 MeV. However, applying the same type of analysis to the ANDO 92 data, the low mass and narrow width they obtained with the Breit-Wigner PWA do not change appreciably.

CONDO 93 found no evidence for charge-exchange photoproduction of the  $a_1(1260)$  (but found a clear signal of  $a_2(1320)$  photoproduction). They show that it is consistent with either an extremely large  $a_1(1260)$  hadronic width, or with a small radiative width to  $\pi\gamma$ , which could be accommodated if the  $a_1$  mass is somewhat below 1260 MeV.

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### **$a_1(1260)$ MASS**

<u>VALUE (MeV)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
<b>1230±40 OUR ESTIMATE</b>					
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
1331±10± 3	37k	<sup>1</sup> ASNER	00	CLE2	10.6 $e^+e^- \rightarrow \tau^+\tau^-, \tau^-\tau^+ \rightarrow \pi^-\pi^0\pi^0\nu_\tau$
1255± 7± 6	5904	<sup>2</sup> ABREU	98G	DLPH	$e^+e^-$
1207± 5± 8	5904	<sup>3</sup> ABREU	98G	DLPH	$e^+e^-$
1196± 4± 5	5904	<sup>4,5</sup> ABREU	98G	DLPH	$e^+e^-$

1240 ± 10	BARBERIS	98B	450 $pp \rightarrow$ $p_f \pi^+ \pi^- \pi^0 p_s$
1262 ± 9 ± 7	<sup>2,6</sup> ACKERSTAFF	97R OPAL	$E_{cm}^{ee} = 88-94,$ $\tau \rightarrow 3\pi\nu$
1210 ± 7 ± 2	<sup>3,6</sup> ACKERSTAFF	97R OPAL	$E_{cm}^{ee} = 88-94,$ $\tau \rightarrow 3\pi\nu$
1211 ± 7 <sup>+50</sup> <sub>-0</sub>	<sup>3</sup> ALBRECHT	93C ARG	$\tau^+ \rightarrow$ $\pi^+ \pi^+ \pi^- \nu$
1121 ± 8	<sup>7</sup> ANDO	92 SPEC	8 $\pi^- p \rightarrow$ $\pi^+ \pi^- \pi^0 n$
1242 ± 37	<sup>8</sup> IVANOV	91 RVUE	$\tau \rightarrow \pi^+ \pi^+ \pi^- \nu$
1260 ± 14	<sup>9</sup> IVANOV	91 RVUE	$\tau \rightarrow \pi^+ \pi^+ \pi^- \nu$
1250 ± 9	<sup>10</sup> IVANOV	91 RVUE	$\tau \rightarrow \pi^+ \pi^+ \pi^- \nu$
1208 ± 15	ARMSTRONG	90 OMEG 0	300.0 $pp \rightarrow$ $pp \pi^+ \pi^- \pi^0$
1220 ± 15	<sup>11</sup> ISGUR	89 RVUE	$\tau^+ \rightarrow$ $\pi^+ \pi^+ \pi^- \nu$
1260 ± 25	<sup>12</sup> BOWLER	88 RVUE	$\tau^+ \rightarrow$ $\pi^+ \pi^+ \pi^- \nu$
1166 ± 18 ± 11	BAND	87 MAC	$\tau^+ \rightarrow$ $\pi^+ \pi^0 \pi^0 \nu$
1164 ± 41 ± 23	BAND	87 MAC	$\tau^+ \rightarrow$ $\pi^+ \pi^+ \pi^- \nu$
1250 ± 40	<sup>11</sup> TORNQVIST	87 RVUE	$\tau^+ \rightarrow$ $\pi^+ \pi^+ \pi^- \nu$
1046 ± 11	ALBRECHT	86B ARG	$\tau^+ \rightarrow$ $\pi^+ \pi^+ \pi^- \nu$
1056 ± 20 ± 15	RUCKSTUHL	86 DLCO	$\tau^+ \rightarrow$ $\pi^+ \pi^+ \pi^- \nu$
1194 ± 14 ± 10	SCHMIDKE	86 MRK2	$\tau^+ \rightarrow$ $\pi^+ \pi^+ \pi^- \nu$
1255 ± 23	BELLINI	85 SPEC	40 $\pi^- A \rightarrow$ $\pi^- \pi^+ \pi^- A$
1240 ± 80	<sup>13</sup> DANKOWY...	81 SPEC 0	8.45 $\pi^- p \rightarrow$ $n3\pi$
1280 ± 30	<sup>13</sup> DAUM	81B CNTR	63,94 $\pi^- p \rightarrow$ $p3\pi$
1041 ± 13	<sup>14</sup> GAVILLET	77 HBC +	4.2 $K^- p \rightarrow$ $\Sigma 3\pi$

<sup>1</sup> From a fit to the  $3\pi$  mass spectrum including the  $K\bar{K}^*(892)$  threshold.

<sup>2</sup> Uses the model of KUHN 90.

<sup>3</sup> Uses the model of ISGUR 89.

<sup>4</sup> Includes the effect of a possible  $a_1'$  state.

<sup>5</sup> Uses the model of FEINDT 90.

<sup>6</sup> Supersedes AKERS 95P

<sup>7</sup> Average and spread of values using 2 variants of the model of BOWLER 75.

<sup>8</sup> Reanalysis of RUCKSTUHL 86.

<sup>9</sup> Reanalysis of SCHMIDKE 86.

<sup>10</sup> Reanalysis of ALBRECHT 86B.

<sup>11</sup> From a combined reanalysis of ALBRECHT 86B, SCHMIDKE 86, and RUCKSTUHL 86.

<sup>12</sup> From a combined reanalysis of ALBRECHT 86B and DAUM 81B.

<sup>13</sup> Uses the model of BOWLER 75.

<sup>14</sup> Produced in  $K^-$  backward scattering.

### $a_1(1260)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>250 to 600 OUR ESTIMATE</b>					
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
814 ± 36 ± 13	37k	15 ASNER	00	CLE2	10.6 $e^+e^- \rightarrow \tau^+\tau^-, \tau^- \rightarrow \pi^-\pi^0\pi^0\nu_\tau$
450 ± 50	22k	16 AKHMETSHIN 99E	CMD2		1.05–1.38 $e^+e^- \rightarrow \pi^+\pi^-\pi^0\pi^0$
570 ± 10		17 BONDAR	99	RVUE	$e^+e^- \rightarrow 4\pi, \tau \rightarrow 3\pi\nu_\tau$
587 ± 27 ± 21	5904	18 ABREU	98G	DLPH	$e^+e^-$
478 ± 3 ± 15	5904	19 ABREU	98G	DLPH	$e^+e^-$
425 ± 14 ± 8	5904	20,21 ABREU	98G	DLPH	$e^+e^-$
400 ± 35		BARBERIS	98B		450 $pp \rightarrow p_f\pi^+\pi^-\pi^0p_s$
621 ± 32 ± 58		18,22 ACKERSTAFF	97R	OPAL	$E_{cm}^{ee} = 88-94, \tau \rightarrow 3\pi\nu$
457 ± 15 ± 17		19,22 ACKERSTAFF	97R	OPAL	$E_{cm}^{ee} = 88-94, \tau \rightarrow 3\pi\nu$
446 ± 21 <sup>+140</sup> <sub>-0</sub>		19 ALBRECHT	93C	ARG	$\tau^+ \rightarrow \pi^+\pi^+\pi^-\nu$
239 ± 11		ANDO	92	SPEC	8 $\pi^-p \rightarrow \pi^+\pi^-\pi^0n$
266 ± 13 ± 4		23 ANDO	92	SPEC	8 $\pi^-p \rightarrow \pi^+\pi^-\pi^0n$
465 <sup>+228</sup> <sub>-143</sub>		24 IVANOV	91	RVUE	$\tau \rightarrow \pi^+\pi^+\pi^-\nu$
298 <sup>+40</sup> <sub>-34</sub>		25 IVANOV	91	RVUE	$\tau \rightarrow \pi^+\pi^+\pi^-\nu$
488 ± 32		26 IVANOV	91	RVUE	$\tau \rightarrow \pi^+\pi^+\pi^-\nu$
430 ± 50		ARMSTRONG	90	OMEG 0	300.0 $pp \rightarrow pp\pi^+\pi^-\pi^0$
420 ± 40		27 ISGUR	89	RVUE	$\tau^+ \rightarrow \pi^+\pi^+\pi^-\nu$
396 ± 43		28 BOWLER	88	RVUE	
405 ± 75 ± 25		BAND	87	MAC	$\tau^+ \rightarrow \pi^+\pi^+\pi^-\nu$
419 ± 108 ± 57		BAND	87	MAC	$\tau^+ \rightarrow \pi^+\pi^0\pi^0\nu$
521 ± 27		ALBRECHT	86B	ARG	$\tau^+ \rightarrow \pi^+\pi^+\pi^-\nu$
476 <sup>+132</sup> <sub>-120</sub> ± 54		RUCKSTUHL	86	DLCO	$\tau^+ \rightarrow \pi^+\pi^+\pi^-\nu$
462 ± 56 ± 30		SCHMIDKE	86	MRK2	$\tau^+ \rightarrow \pi^+\pi^+\pi^-\nu$
292 ± 40		BELLINI	85	SPEC	40 $\pi^-A \rightarrow \pi^-\pi^+\pi^-A$
380 ± 100		29 DANKOWY...	81	SPEC 0	8.45 $\pi^-p \rightarrow n3\pi$
300 ± 50		29 DAUM	81B	CNTR	63,94 $\pi^-p \rightarrow p3\pi$
230 ± 50		30 GAVILLET	77	HBC +	4.2 $K^-p \rightarrow \Sigma 3\pi$

- 15 From a fit to the  $3\pi$  mass spectrum including the  $K\bar{K}^*(892)$  threshold.
- 16 Using the  $a_1(1260)$  mass of 1230 MeV.
- 17 From AKHMETSHIN 99E and ASNER 00 data using the  $a_1(1260)$  mass of 1230 MeV.
- 18 Uses the model of KUHN 90.
- 19 Uses the model of ISGUR 89.
- 20 Includes the effect of a possible  $a_1'$  state.
- 21 Uses the model of FEINDT 90.
- 22 Supersedes AKERS 95P
- 23 Average and spread of values using 2 variants of the model of BOWLER 75.
- 24 Reanalysis of RUCKSTUHL 86.
- 25 Reanalysis of SCHMIDKE 86.
- 26 Reanalysis of ALBRECHT 86B.
- 27 From a combined reanalysis of ALBRECHT 86B, SCHMIDKE 86, and RUCKSTUHL 86.
- 28 From a combined reanalysis of ALBRECHT 86B and DAUM 81B.
- 29 Uses the model of BOWLER 75.
- 30 Produced in  $K^-$  backward scattering.

### $a_1(1260)$ DECAY MODES

Mode	Fraction ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ ( $\rho\pi$ ) $S$ -wave	seen
$\Gamma_2$ ( $\rho\pi$ ) $D$ -wave	seen
$\Gamma_3$ ( $\rho(1450)\pi$ ) $S$ -wave	seen
$\Gamma_4$ ( $\rho(1450)\pi$ ) $D$ -wave	seen
$\Gamma_5$ $\sigma\pi$	seen
$\Gamma_6$ $f_0(980)\pi$	not seen
$\Gamma_7$ $f_0(1370)\pi$	seen
$\Gamma_8$ $f_2(1270)\pi$	seen
$\Gamma_9$ $K\bar{K}^*(892) + c.c.$	seen
$\Gamma_{10}$ $\pi(1300)\pi$	not seen
$\Gamma_{11}$ $\pi\gamma$	seen

### $a_1(1260)$ PARTIAL WIDTHS

$\Gamma(\pi\gamma)$	$\Gamma_{11}$		
VALUE (keV)	DOCUMENT ID	TECN	COMMENT
<b><math>640 \pm 246</math></b>	ZIELINSKI	84C	SPEC 200 $\pi^+ Z \rightarrow Z 3\pi$

### $D$ -wave/ $S$ -wave AMPLITUDE RATIO IN DECAY OF $a_1(1260) \rightarrow \rho\pi$

VALUE	DOCUMENT ID	TECN	COMMENT
<b><math>-0.107 \pm 0.016</math> OUR AVERAGE</b>			
$-0.10 \pm 0.02 \pm 0.02$	<sup>31,32</sup> ACKERSTAFF	97R	OPAL $E_{cm}^{ee} = 88-94, \tau \rightarrow$
$-0.11 \pm 0.02$	<sup>31</sup> ALBRECHT	93C	ARG $\tau^+ \rightarrow \pi^+ \pi^+ \pi^- \nu$

- <sup>31</sup> Uses the model of ISGUR 89.
- <sup>32</sup> Supersedes AKERS 95P.

## $a_1(1260)$ BRANCHING RATIOS

### $\Gamma((\rho\pi)_{S\text{-wave}})/\Gamma_{\text{total}}$ $\Gamma_1/\Gamma$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

68.11	37k	<sup>34</sup> ASNER	00 CLE2	$10.6 e^+ e^- \rightarrow \tau^+ \tau^-$ , $\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu_\tau$
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### $\Gamma((\rho\pi)_{D\text{-wave}})/\Gamma_{\text{total}}$ $\Gamma_2/\Gamma$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$0.36 \pm 0.17 \pm 0.06$	37k	<sup>34</sup> ASNER	00 CLE2	$10.6 e^+ e^- \rightarrow \tau^+ \tau^-$ , $\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu_\tau$
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### $\Gamma((\rho(1450)\pi)_{S\text{-wave}})/\Gamma_{\text{total}}$ $\Gamma_3/\Gamma$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$0.30 \pm 0.64 \pm 0.17$	37k	<sup>34,35</sup> ASNER	00 CLE2	$10.6 e^+ e^- \rightarrow \tau^+ \tau^-$ , $\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu_\tau$
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### $\Gamma((\rho(1450)\pi)_{D\text{-wave}})/\Gamma_{\text{total}}$ $\Gamma_4/\Gamma$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$0.43 \pm 0.28 \pm 0.06$	37k	<sup>34,35</sup> ASNER	00 CLE2	$10.6 e^+ e^- \rightarrow \tau^+ \tau^-$ , $\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu_\tau$
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### $\Gamma(\sigma\pi)/\Gamma_{\text{total}}$ $\Gamma_5/\Gamma$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$16.18 \pm 3.85 \pm 1.28$	37k	<sup>34,36</sup> ASNER	00 CLE2	$10.6 e^+ e^- \rightarrow \tau^+ \tau^-$ , $\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu_\tau$
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### $\Gamma(f_0(980)\pi)/\Gamma_{\text{total}}$ $\Gamma_6/\Gamma$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

not seen	37k	ASNER	00 CLE2	$10.6 e^+ e^- \rightarrow \tau^+ \tau^-$ , $\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu_\tau$
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### $\Gamma(f_0(1370)\pi)/\Gamma_{\text{total}}$ $\Gamma_7/\Gamma$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$4.29 \pm 2.29 \pm 0.73$	37k	<sup>34,37</sup> ASNER	00 CLE2	$10.6 e^+ e^- \rightarrow \tau^+ \tau^-$ , $\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu_\tau$
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$\Gamma(f_2(1270)\pi)/\Gamma_{\text{total}}$   $\Gamma_8/\Gamma$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$0.14 \pm 0.06 \pm 0.02$	37k	<sup>34,38</sup> ASNER	00 CLE2	$10.6 e^+ e^- \rightarrow \tau^+ \tau^-$ , $\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu_\tau$

$\Gamma(K\bar{K}^*(892)+c.c.)/\Gamma_{\text{total}}$   $\Gamma_9/\Gamma$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$3.3 \pm 0.5 \pm 0.1$	37k	<sup>39</sup> ASNER	00 CLE2	$10.6 e^+ e^- \rightarrow \tau^+ \tau^-$ , $\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu_\tau$

$\Gamma(\pi(1300)\pi)/\Gamma_{\text{total}}$   $\Gamma_{10}/\Gamma$

VALUE (units $10^{-2}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
<0.01	90	37k	<sup>40,41</sup> ASNER	00 CLE2	$10.6 e^+ e^- \rightarrow \tau^+ \tau^-$ , $\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu_\tau$
<0.019	90	37k	<sup>40,42</sup> ASNER	00 CLE2	$10.6 e^+ e^- \rightarrow \tau^+ \tau^-$ , $\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu_\tau$

$\Gamma(\sigma\pi)/\Gamma((\rho\pi)_{S\text{-wave}})$   $\Gamma_5/\Gamma_1$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$\sim 0.3$	28k	AKHMETSHIN 99E	CMD2	$1.05\text{--}1.38 e^+ e^- \rightarrow \pi^+ \pi^- \pi^+ \pi^-$
$0.003 \pm 0.003$		<sup>33</sup> LONGACRE	82 RVUE	

<sup>33</sup> Uses multichannel Aitchison-Bowler model (BOWLER 75). Uses data from GAVILLET 77, DAUM 80, and DANKOWYCH 81.

<sup>34</sup> From a fit to the Dalitz plot.

<sup>35</sup> Assuming for  $\rho(1450)$  mass and width of 1370 and 386 MeV respectively.

<sup>36</sup> Assuming for  $\sigma$  mass and width of 860 and 880 MeV respectively.

<sup>37</sup> Assuming for  $f_0(1370)$  mass and width of 1186 and 350 MeV respectively.

<sup>38</sup> Assuming for  $f_2(1270)$  mass and width of 1275 and 185 MeV respectively.

<sup>39</sup> From a fit to the  $3\pi$  mass spectrum including the  $K\bar{K}^*(892)$  threshold.

<sup>40</sup> Assuming for  $\pi(1300)$  mass and width of 1300 and 400 MeV respectively. From a fit to the Dalitz plot.

<sup>41</sup> Assuming  $\pi(1300) \rightarrow \rho\pi$  decay.

<sup>42</sup> Assuming  $\pi(1300) \rightarrow \sigma\pi$  decay.

## $a_1(1260)$ REFERENCES

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AKHMETSHIN	99E	PL B466 392	R.R. Akhmetshin <i>et al.</i>	(CMD2 Collab.)
BONDAR	99	PL B466 403	A.E. Bondar <i>et al.</i>	(CMD2 Collab.)
ABREU	98G	PL B426 411	P. Abreu <i>et al.</i>	(DELPHI Collab.)
BARBERIS	98B	PL B422 399	D. Barberis <i>et al.</i>	(WA102 Collab.)
ACKERSTAFF	97R	ZPHY C75 593	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)
AKERS	95P	ZPHY C67 45	R. Akers <i>et al.</i>	(OPAL Collab.)
ALBRECHT	93C	ZPHY C58 61	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
ANDO	92	PL B291 496	A. Ando <i>et al.</i>	(KEK, KYOT, NIRS, SAGA+)
IVANOV	91	ZPHY C49 563	Y.P. Ivanov, A.A. Osipov, M.K. Volkov	(JINR)
ARMSTRONG	90	ZPHY C48 213	T.A. Armstrong, M. Benayoun, W. Beusch	
FEINDT	90	ZPHY C48 681	M. Feindt	(HAMB)
KUHN	90	ZPHY C48 445	J.H. Kuhn <i>et al.</i>	(MPIM)
ISGUR	89	PR D39 1357	N. Isgur, C. Morningstar, C. Reader	(TNTO)
BOWLER	88	PL B209 99	M.G. Bowler	(OXF)
BAND	87	PL B198 297	H.R. Band <i>et al.</i>	(MAC Collab.)
TORNQVIST	87	ZPHY C36 695	N.A. Tornqvist	(HELS)
ALBRECHT	86B	ZPHY C33 7	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
RUCKSTUHL	86	PRL 56 2132	W. Ruckstuhl <i>et al.</i>	(DELCO Collab.)
SCHMIDKE	86	PRL 57 527	W.B. Schmidke <i>et al.</i>	(Mark II Collab.)
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LONGACRE	82	PR D26 83	R.S. Longacre	(BNL)
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GAVILLET	77	PL 69B 119	P. Gavillet <i>et al.</i>	(AMST, CERN, NIJM+ JP)
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## OTHER RELATED PAPERS

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