$a_1(1260)$

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

THE $a_1(1260)$

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

(1) Hadronic Production. This comprises diffractive production with incident π^- (DAUM 80, 81B) and charge-exchange production with low-energy π^- (DANKOWYCH 81, ANDO 92). The 1980's experiments explain the $I^G LJ^P = 1^+ S0^+$ data using a phenomenological amplitude consisting of a rescattered Deck amplitude plus a direct resonance-production term. They agree on an $a_1(1260)$ 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.

(2) τ decay. Five experiments reported good data on $\tau \to a_1(1260)\nu_\tau \to \rho\pi\nu_\tau$ (RUCKSTUHL 86, SCHMIDKE 86, ALBRECHT 86B, BAND 87, and ACKERSTAFF 97R). 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 τ-decay results have stimulated several reanalyses. BASDEVANT 77, 78 used the early diffractive dissociation and τ 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 τ-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 3π invariant mass as well as the 2π invariant mass projections of the Dalitz plot and neither model is found to provide a completely satisfactory description of the data. Another recent high statistics analysis of ABREU 98G obtains 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.

BOWLER 88 showed that good fits to both the hadronic and the τ-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.

$a_1(1260)$ MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
1230±40 OUR ESTIMATE					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1262± 9± 7	[1,2] ACKERSTAFF	97R	OPAL		E^{ee}_{cm}= 88–94, $\tau \rightarrow 3\pi\nu$
1210± 7± 2	[2,3] ACKERSTAFF	97R	OPAL		E^{ee}_{cm}= 88–94, $\tau \rightarrow 3\pi\nu$
1211± 7	ALBRECHT	93C	ARG		$\tau^+ \rightarrow \pi^+\pi^+\pi^-\nu$
1121± 8	[4] ANDO	92	SPEC		$8\ \pi^- p \rightarrow \pi^+\pi^-\pi^0 n$
1242±37	[5] IVANOV	91	RVUE		$\tau \rightarrow \pi^+\pi^+\pi^-\nu$
1260±14	[6] IVANOV	91	RVUE		$\tau \rightarrow \pi^+\pi^+\pi^-\nu$
1250± 9	[7] 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	[8] ISGUR	89	RVUE		$\tau^+ \rightarrow \pi^+\pi^+\pi^-\nu$
1260±25	[9] BOWLER	88	RVUE		
1166±18±11	BAND	87	MAC		$\tau^+ \rightarrow \pi^+\pi^+\pi^-\nu$
1164±41±23	BAND	87	MAC		$\tau^+ \rightarrow \pi^+\pi^0\pi^0\nu$
1250±40	[8] TORNQVIST	87	RVUE		
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		$\tau^+ \rightarrow \pi^+\pi^+\pi^-\nu$
1240±80	[10] DANKOWY...	81	SPEC	0	$8.45\ \pi^- p \rightarrow n 3\pi$
1280±30	[10] DAUM	81B	CNTR		$63,94\ \pi^- p \rightarrow p 3\pi$
1041±13	[11] GAVILLET	77	HBC	+	$4.2\ K^- p \rightarrow \Sigma 3\pi$

[1] Uses the model of KUHN 90.
[2] Supersedes AKERS 95P
[3] Uses the model of ISGUR 89.
[4] Average and spread of values using 2 variants of the model of BOWLER 75.
[5] Reanalysis of RUCKSTUHL 86.
[6] Reanalysis of SCHMIDKE 86.
[7] Reanalysis of ALBRECHT 86B.
[8] From a combined reanalysis of ALBRECHT 86B, SCHMIDKE 86, and RUCKSTUHL 86.
[9] From a combined reanalysis of ALBRECHT 86B and DAUM 81B.
[10] Uses the model of BOWLER 75.
[11] Produced in K^- backward scattering.

$a_1(1260)$ WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	CHG	COMMENT
250 to 600 OUR ESTIMATE					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$621\pm 32\pm58$	[12,13] ACKERSTAFF	97R	OPAL		E^{ee}_{cm}= 88–94, $\tau \to 3\pi\nu$
$457\pm 15\pm17$	[13,14] ACKERSTAFF	97R	OPAL		E^{ee}_{cm}= 88–94, $\tau \to 3\pi\nu$
446 ± 21	ALBRECHT	93C	ARG		$\tau^+ \to \pi^+\pi^+\pi^-\nu$
239 ± 11	ANDO	92	SPEC		$8\ \pi^- p \to \pi^+\pi^-\pi^0 n$
$266\pm 13\pm 4$	[15] ANDO	92	SPEC		$8\ \pi^- p \to \pi^+\pi^-\pi^0 n$
465^{+228}_{-143}	[16] IVANOV	91	RVUE		$\tau \to \pi^+\pi^+\pi^-\nu$
298^{+40}_{-34}	[17] IVANOV	91	RVUE		$\tau \to \pi^+\pi^+\pi^-\nu$
488 ± 32	[18] IVANOV	91	RVUE		$\tau \to \pi^+\pi^+\pi^-\nu$
430 ± 50	ARMSTRONG	90	OMEG	0	$300.0 p p \to p p \pi^+\pi^-\pi^0$
420 ± 40	[19] ISGUR	89	RVUE		$\tau^+ \to \pi^+\pi^+\pi^-\nu$
396 ± 43	[20] BOWLER	88	RVUE		
$405\pm 75\pm25$	BAND	87	MAC		$\tau^+ \to \pi^+\pi^+\pi^-\nu$
$419\pm108\pm57$	BAND	87	MAC		$\tau^+ \to \pi^+\pi^0\pi^0\nu$
521 ± 27	ALBRECHT	86B	ARG		$\tau^+ \to \pi^+\pi^+\pi^-\nu$
$476^{+132}_{-120}\pm54$	RUCKSTUHL	86	DLCO		$\tau^+ \to \pi^+\pi^+\pi^-\nu$
$462\pm 56\pm30$	SCHMIDKE	86	MRK2		$\tau^+ \to \pi^+\pi^+\pi^-\nu$
380 ± 100	[21] DANKOWY...	81	SPEC	0	$8.45\ \pi^- p \to n 3\pi$
300 ± 50	[21] DAUM	81B	CNTR		$63{,}94\ \pi^- p \to p 3\pi$
230 ± 50	[22] GAVILLET	77	HBC	+	$4.2\ K^- p \to \Sigma 3\pi$

[12] Uses the model of KUHN 90.
[13] Supersedes AKERS 95P
[14] Uses the model of ISGUR 89.
[15] Average and spread of values using 2 variants of the model of BOWLER 75.
[16] Reanalysis of RUCKSTUHL 86.
[17] Reanalysis of SCHMIDKE 86.
[18] Reanalysis of ALBRECHT 86B.
[19] From a combined reanalysis of ALBRECHT 86B, SCHMIDKE 86, and RUCKSTUHL 86.
[20] From a combined reanalysis of ALBRECHT 86B and DAUM 81B.
[21] Uses the model of BOWLER 75.
[22] Produced in K^- backward scattering.

$a_1(1260)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$\rho\pi$	dominant
	[D/S amplitude ratio = -0.100 ± 0.028]	
Γ_2	$\pi\gamma$	seen
Γ_3	$\pi(\pi\pi)_{S\text{-wave}}$	possibly seen

$a_1(1260)$ PARTIAL WIDTHS

$\Gamma(\pi\gamma)$ Γ_2

VALUE (keV)	*DOCUMENT ID*		*TECN*	*COMMENT*
640±246	ZIELINSKI	84C	SPEC	200 $\pi^+ Z \to Z 3\pi$

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

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
−0.10 ±0.02 ±0.02	[23,24] ACKERSTAFF	97R	OPAL	E^{ee}_{cm}= 88–94, $\tau \to 3\pi\nu$

[23] Uses the model of ISGUR 89.
[24] Supersedes AKERS 95P

$a_1(1260)$ BRANCHING RATIOS

$\Gamma(\pi(\pi\pi)_{S\text{-wave}})/\Gamma(\rho\pi)$ Γ_3/Γ_1

VALUE	*DOCUMENT ID*		*TECN*
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.003±0.003	[25] LONGACRE	82	RVUE

[25] Uses multichannel Aitchison-Bowler model (BOWLER 75). Uses data from GAVILLET 77, DAUM 80, and DANKOWYCH 81.

$a_1(1260)$ REFERENCES

ACKERSTAFF	97R	ZPHY C75 593	K. Ackerstaff+	(OPAL Collab.)
AKERS	95P	ZPHY C67 45	+Alexander, Allison, Ametewee+	(OPAL Collab.)
ALBRECHT	93C	ZPHY C58 61	+Ehrlichmann, Hamacher+	(ARGUS Collab.)
ANDO	92	PL B291 496	+Imai+	(KEK, KYOT, NIRS, SAGA, INUS, AKIT)
IVANOV	91	ZPHY C49 563	+Osipov, Volkov	(JINR)
ARMSTRONG	90	ZPHY C48 213	+Benayoun, Beusch	(WA76 Collab.)
KUHN	90	ZPHY C48 445	J.H. Kuhn, Santamaria+	(MPIM)
ISGUR	89	PR D39 1357	+Morningstar, Reader	(TNTO)
BOWLER	88	PL B209 99		(OXF)
BAND	87	PL B198 297	+Camporesi, Chadwick, Delfino+	(MAC Collab.)
TORNQVIST	87	ZPHY C36 695		(HELS)
ALBRECHT	86B	ZPHY C33 7	+Donker, Gabriel, Edwards+	(ARGUS Collab.)
RUCKSTUHL	86	PRL 56 2132	+Stroynowski, Atwood, Barish+	(DELCO Collab.)
SCHMIDKE	86	PRL 57 527	+Abrams, Matteuzzi, Amidei+	(Mark II Collab.)
ZIELINSKI	84C	PRL 52 1195	+Berg, Chandlee, Cihangir+	(ROCH, MINN, FNAL)
LONGACRE	82	PR D26 83		(BNL)
DANKOWY...	81	PRL 46 580	Dankowych+	(TNTO, BNL, CARL, MCGI, OHIO)
DAUM	81B	NP B182 269	+Hertzberger+	(AMST, CERN, CRAC, MPIM, OXF+)
DAUM	80	PL 89B 281	+Hertzberger+	(AMST, CERN, CRAC, MPIM, OXF+) JP
GAVILLET	77	PL 69B 119	+Blockzijl, Engelen+	(AMST, CERN, NIJM, OXF) JP
BOWLER	75	NP B97 227	+Game, Aitchison, Dainton	(OXFTP, DARE)

OTHER RELATED PAPERS

ABREU	98G	PL B (to be publ.)	P. Abreu+	(DELPHI Collab.)
CERN-EP/98-14				
BOLONKIN	95	PAN 58 1535	+Vladimirskii, Erofeeva+	(ITEP)
		Translated from YAF 58 1628.		
WINGATE	95	PRL 74 4596	+De Grand	(COLO, FSU)
CONDO	93	PR D48 3045	+Handler, Bugg+	(SLAC Hybrid Collab.)
FEINDT	90	ZPHY C48 681	M. Feindt	(HAMB)
IIZUKA	89	PR D39 3357	+Koibuchi, Masuda	(NAGO, IBAR, TSUK)
TORNQVIST	87	ZPHY C36 695		(HELS)
BOWLER	86	PL B182 400		(OXF)
BASDEVANT	78	PRL 40 994	+Berger	(FNAL, ANL) JP
BASDEVANT	77	PR D16 657	+Berger	(FNAL, ANL) JP
ADERHOLZ	64	PL 10 226	+	(AACH3, BERL, BIRM, BONN, DESY, HAMB+)
GOLDHABER	64	PRL 12 336	+Brown, Kadyk, Shen+	(LRL, UCB)
LANDER	64	PRL 13 346A	+Abolins, Carmony, Hendricks, Xuong+	(UCSD) JP
BELLINI	63	NC 29 896	+Fiorini, Herz, Negri, Ratti	(MILA)