$a_1(1260)$

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

THE $a_1(1260)$

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 have 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 AKERS 95P). They are somewhat inconsistent concerning the $a_1(1260)$ mass, which can, however, be attributed to model-dependent systematic uncertainties (BOWLER 86, ALBRECHT 93C, AKERS 95P). They all find a width greater than 400 MeV.

The discrepancies between the early hadronic and τ decay results have stimulated several reanalyses. BOWLER 86, TORNQVIST 87, ISGUR 89, and IVANOV 91 have studied the process $\tau \to 3\pi\nu_\tau$. 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 higher (400-600 MeV) than those extracted from diffractive-hadronic data. This is also the case with the later OPAL experiment (AKERS 95P).

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 this 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. • • •					
$1266 \pm 14^{+12}_{-2}$	[1] AKERS	95P	OPAL		E^{ee}_{cm}= 88–94
$1202 \pm 9^{+9}_{-1}$	[2] AKERS	95P	OPAL		E^{ee}_{cm}= 88–94
1211± 7	ALBRECHT	93C	ARG		$\tau^+ \to \pi^+\pi^+\pi^-\nu$
1121± 8	[3] ANDO	92	SPEC		$8\ \pi^- p \to \pi^+\pi^-\pi^0 n$
1242±37	[4] IVANOV	91	RVUE		$\tau \to \pi^+\pi^+\pi^-\nu$
1260±14	[5] IVANOV	91	RVUE		$\tau \to \pi^+\pi^+\pi^-\nu$
1250± 9	[6] IVANOV	91	RVUE		$\tau \to \pi^+\pi^+\pi^-\nu$
1208±15	ARMSTRONG	90	OMEG	0	$300.0 pp \to pp\pi^+\pi^-\pi^0$
1220±15	[7] ISGUR	89	RVUE		$\tau^+ \to \pi^+\pi^+\pi^-\nu$
1260±25	[8] BOWLER	88	RVUE		
1166±18±11	BAND	87	MAC		$\tau^+ \to \pi^+\pi^+\pi^-\nu$
1164±41±23	BAND	87	MAC		$\tau^+ \to \pi^+\pi^0\pi^0\nu$
1250±40	[7] TORNQVIST	87	RVUE		
1046±11	ALBRECHT	86B	ARG		$\tau^+ \to \pi^+\pi^+\pi^-\nu$
1056±20±15	RUCKSTUHL	86	DLCO		$\tau^+ \to \pi^+\pi^+\pi^-\nu$
1194±14±10	SCHMIDKE	86	MRK2		$\tau^+ \to \pi^+\pi^+\pi^-\nu$
1240±80	[9] DANKOWY...	81	SPEC	0	$8.45\ \pi^- p \to n 3\pi$
1280±30	[9] DAUM	81B	CNTR		$63,94\ \pi^- p \to p 3\pi$
1041±13	[10] GAVILLET	77	HBC	+	$4.2\ K^- p \to \Sigma 3\pi$

[1] Uses the model of Kuhn and Santamaria.
[2] Uses the model of Isgur, Morningstar, and Reader.
[3] Average and spread of values using 2 variants of the model of BOWLER 75.
[4] Reanalysis of RUCKSTUHL 86.
[5] Reanalysis of SCHMIDKE 86.
[6] Reanalysis of ALBRECHT 86B.
[7] From a combined reanalysis of ALBRECHT 86B, SCHMIDKE 86, and RUCKSTUHL 86.
[8] From a combined reanalysis of ALBRECHT 86B and DAUM 81B.
[9] Uses the model of BOWLER 75.
[10] Produced in K^- backward scattering.

a_1(1260) WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
~ 400 OUR ESTIMATE					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$610 \pm 49^{+53}_{-19}$	[11] AKERS	95P	OPAL		E^{ee}_{cm}= 88–94
$422 \pm 23^{+33}_{-4}$	[12] AKERS	95P	OPAL		E^{ee}_{cm}= 88–94
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± 13± 4	[13] ANDO	92	SPEC		$8\ \pi^- p \to \pi^+\pi^-\pi^0 n$
465^{+228}_{-143}	[14] IVANOV	91	RVUE		$\tau \to \pi^+\pi^+\pi^-\nu$
298^{+40}_{-34}	[15] IVANOV	91	RVUE		$\tau \to \pi^+\pi^+\pi^-\nu$
488± 32	[16] IVANOV	91	RVUE		$\tau \to \pi^+\pi^+\pi^-\nu$
430± 50	ARMSTRONG	90	OMEG	0	$300.0 pp \to pp\pi^+\pi^-\pi^0$

420± 40	[17] ISGUR	89	RVUE		$\tau^+ \to \pi^+ \pi^+ \pi^- \nu$
396± 43	[18] BOWLER	88	RVUE		
405± 75±25	BAND	87	MAC		$\tau^+ \to \pi^+ \pi^+ \pi^- \nu$
419±108±57	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}±54	RUCKSTUHL	86	DLCO		$\tau^+ \to \pi^+ \pi^+ \pi^- \nu$
462± 56±30	SCHMIDKE	86	MRK2		$\tau^+ \to \pi^+ \pi^+ \pi^- \nu$
380±100	[19] DANKOWY...	81	SPEC	0	8.45 $\pi^- p \to n 3\pi$
300± 50	[19] DAUM	81B	CNTR		63,94 $\pi^- p \to p 3\pi$
230± 50	[20] GAVILLET	77	HBC	+	4.2 $K^- p \to \Sigma 3\pi$

[11] Uses the model of Kuhn and Santamaria.
[12] Uses the model of Isgur, Morningstar, and Reader.
[13] Average and spread of values using 2 variants of the model of BOWLER 75.
[14] Reanalysis of RUCKSTUHL 86.
[15] Reanalysis of SCHMIDKE 86.
[16] Reanalysis of ALBRECHT 86B.
[17] From a combined reanalysis of ALBRECHT 86B, SCHMIDKE 86, and RUCKSTUHL 86.
[18] From a combined reanalysis of ALBRECHT 86B and DAUM 81B.
[19] Uses the model of BOWLER 75.
[20] Produced in K^- backward scattering.

$a_1(1260)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$\rho\pi$	dominant
Γ_2	$\pi\gamma$	seen
Γ_3	$\pi(\pi\pi)_{S\text{-wave}}$	
Γ_4	$K\overline{K}^*(892)$	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*
−0.09 ±0.03 ±0.01	[21] AKERS	95P	OPAL	E^{ee}_{cm}= 88–94

[21] Uses the model of Isgur, Morningstar, and Reader.

$a_1(1260)$ 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	[22] LONGACRE	82	RVUE

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

$a_1(1260)$ REFERENCES

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.)
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

BOLONKIN	95	PAN 58 1535 Translated from YAF 58 1628.	+Vladimirskii, Erofeeva+	(ITEP)
WINGATE	95	PRL 74 4596	+De Grand	(COLO, FSU)
IIZUKA	89	PR D39 3357	+Koibuchi, Masuda	(NAGO, IBAR, TSUK)
TORNQVIST	87	ZPHY C36 695		(HELS)
BOWLER	86	PL B182 400		(OXF)
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)