$\pi_1(1600)$

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

Coupled channel analyses favor the existence of only one broad 1^{-+} isovector state consistent with $\pi_1(1600)$ in the 1400–1600 MeV region. Accordingly, the $\pi_1(1400)$ entries of the previous Reviews have been moved into this section. See the review on "Spectroscopy of Light Meson Resonances."

$\pi_1(1600)$ T-Matrix Pole $\sqrt{s}$

Note that $\Gamma = -2\ \mathrm{Im}(\sqrt{s})$.

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
(1480–1680) − i (150–300) OUR ESTIMATE				
$(1623 \pm 47^{+24}_{-75}) - i\,(228 \pm 44^{+72}_{-88})$	[1] KOPF	21	RVUE	0.9 $p\overline{p} \to \pi^0\pi^0\eta$, $\pi^0\eta\eta$, $\pi^0 K^+ K^-$ and 191 $\pi^- p \to \pi^-\pi^-\pi^+ p$
$(1564 \pm 24 \pm 86) - i\,(246 \pm 27 \pm 51)$	[2] RODAS	19	RVUE	191 $\pi^- p \to \eta^{(\prime)}\pi^- p$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$(1405 \pm 4^{+15}_{-18}) - i\,(314 \pm 14^{+18}_{-69})$	[3] ALBRECHT	20	RVUE	$\overline{p}p \to \pi^0\pi^0\eta$

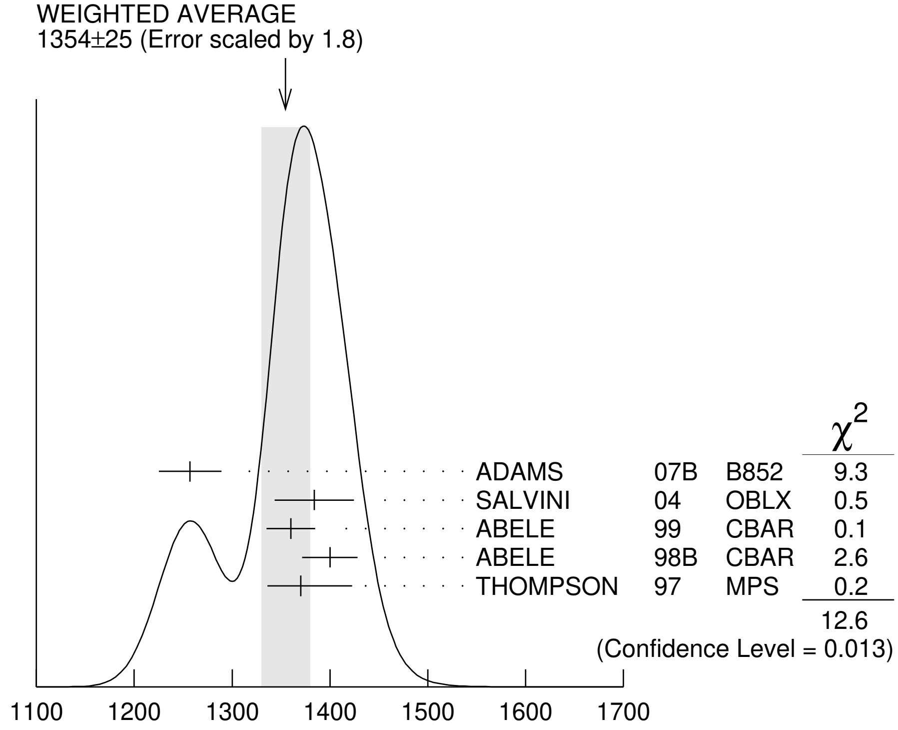
[1] From T-matrix pole based on combined fit of Crystal Barrel and $\pi\pi$ scattering data (ALBRECHT 20), and COMPASS data (ADOLPH 15), using a coupled-channel model of $\eta\pi$, $\eta'\pi$ and $K\overline{K}$ systems.
[2] The coupled-channel analysis of both the $\eta\pi$ and $\eta'\pi$ systems using ADOLPH 15 data.
[3] Superseded by KOPF 21.

$\pi_1(1600)$ MASS ($\eta\pi$ mode)

Not seen by PROKOSHKIN 95B, BUGG 94, APEL 81, BOUTEMEUR 90, and AGHASYAN 18B.

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
1354 ±25 OUR AVERAGE	Error includes scale factor of 1.8. See the ideogram below.					
1257 ±20 ±25	23.5k	ADAMS	07B	B852		18 $\pi^- p \to \eta\pi^0 n$
1384 ±20 ±35	90k	SALVINI	04	OBLX		$\overline{p}p \to 2\pi^+ 2\pi^-$
1360 ±25		ABELE	99	CBAR		0.0 $\overline{p}p \to \pi^0\pi^0\eta$
1400 ±20 ±20		ABELE	98B	CBAR		0.0 $\overline{p}n \to \pi^-\pi^0\eta$
$1370 \pm 16\ ^{+50}_{-30}$		[1] THOMPSON	97	MPS		18 $\pi^- p \to \eta\pi^- p$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
1323.1± 4.6		[2] AOYAGI	93	BKEI		$\pi^- p \to \eta\pi^- p$
1406 ±20		[3] ALDE	88B	GAM4	0	100 $\pi^- p \to \eta\pi^0 n$

[1] Natural parity exchange, questioned by DZIERBA 03.
[2] Unnatural parity exchange.
[3] Seen in the P_0-wave intensity of the $\eta\pi^0$ system, unnatural parity exchange.

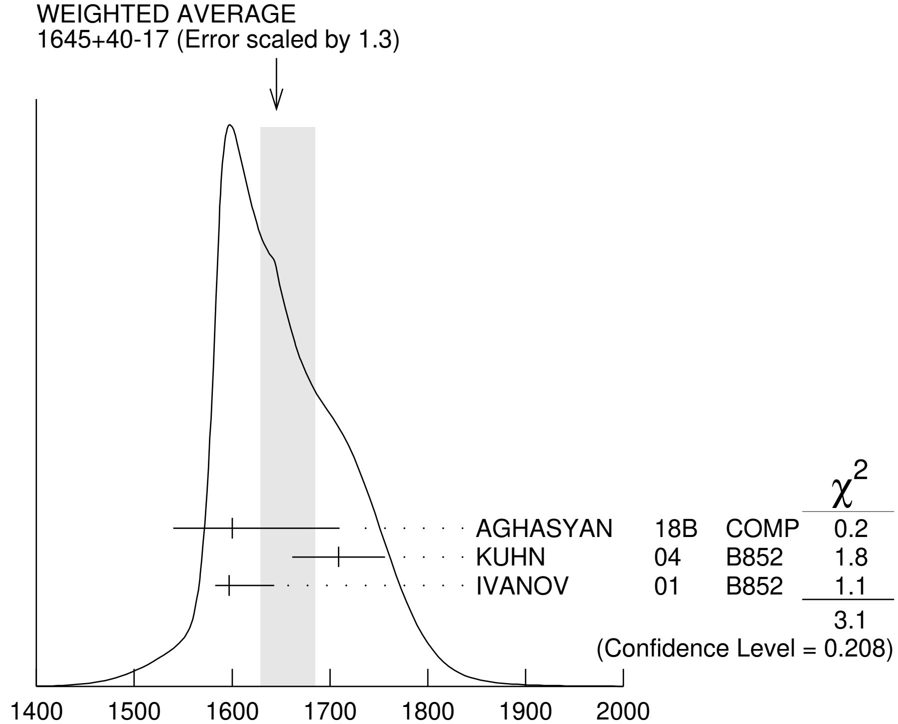


$\pi_1(1600)$ mass ($\eta\pi$ mode) (MeV)

π_1(1600) MASS (non-$\eta\pi$ mode)

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
1645^{+40}_{-17} OUR AVERAGE		Error includes scale factor of 1.3. See the ideogram below.		
1600^{+110}_{-60}	46M	[1] AGHASYAN	18B	COMP	$190\ \pi^- p \to \pi^-\pi^+\pi^- p$
$1709 \pm 24 \pm 41$	69k	[2] KUHN	04	B852	$18\ \pi^- p \to \eta\pi^+\pi^-\pi^- p$
$1597 \pm 10^{+45}_{-10}$		[2] IVANOV	01	B852	$18\ \pi^- p \to \eta'\pi^- p$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$1660 \pm 10^{+0}_{-64}$	420k	[3] ALEKSEEV	10	COMP	$190\ \pi^- Pb \to \pi^-\pi^-\pi^+ Pb'$
$1664 \pm 8 \pm 10$	145k	[4] LU	05	B852	$18\ \pi^- p \to \omega\pi^-\pi^0 p$
$1593 \pm 8^{+29}_{-47}$		[2,5] ADAMS	98B	B852	$18.3\ \pi^- p \to \pi^+\pi^-\pi^- p$

[1] Statistical error negligible. See also the review ALEXEEV 22.
[2] Natural parity exchange.
[3] Superseded by AGHASYAN 2018B.
[4] May be a different state: natural and unnatural parity exchanges.
[5] Superseded by DZIERBA 06 excluding this state in a more refined PWA analysis, with 2.6 M events of $\pi^- p \to \pi^-\pi^-\pi^+ p$ and 3 M events of $\pi^- p \to \pi^-\pi^0\pi^0 p$ of E852 data.



$\pi_1(1600)$ mass (non-$\eta\pi$ mode) (MeV)

$\pi_1(1600)$ WIDTH ($\eta\pi$ mode)

Not seen by PROKOSHKIN 95B, BUGG 94, APEL 81, BOUTEMEUR 90, and AGHASYAN 18B.

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
330 ±35 OUR AVERAGE						
354 ±64 ± 58	23.5k	ADAMS	07B	B852		18 $\pi^- p \to \eta\pi^0 n$
378 ±50 ± 50	90k	SALVINI	04	OBLX		$\overline{p}p \to 2\pi^+ 2\pi^-$
220 ±90		ABELE	99	CBAR		0.0 $\overline{p}p \to \pi^0\pi^0\eta$
310 ±50 $^{+50}_{-30}$		ABELE	98B	CBAR		0.0 $\overline{p}n \to \pi^-\pi^0\eta$
385 ±40 $^{+65}_{-105}$		[1] THOMPSON	97	MPS		18 $\pi^- p \to \eta\pi^- p$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
143.2±12.5		[2] AOYAGI	93	BKEI		$\pi^- p \to \eta\pi^- p$
180 ±20		[3] ALDE	88B	GAM4	0	100 $\pi^- p \to \eta\pi^0 n$

[1] Resolution is not unfolded, natural parity exchange, questioned by DZIERBA 03.
[2] Unnatural parity exchange.
[3] Seen in the P_0-wave intensity of the $\eta\pi^0$ system, unnatural parity exchange.

$\pi_1(1600)$ WIDTH (non-$\eta\pi$ mode)

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
370^{+50}_{-60} OUR AVERAGE					
580^{+100}_{-230}	46M	[1] AGHASYAN	18B	COMP	190 $\pi^- p \to \pi^-\pi^+\pi^- p$

$403 \pm 80 \pm 115$	69k	[2] KUHN	04	B852	$18\ \pi^- p \to \eta\pi^+\pi^-\pi^- p$
$340 \pm 40 \pm 50$		[2] IVANOV	01	B852	$18\ \pi^- p \to \eta'\pi^- p$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$269 \pm 21^{+42}_{-64}$	420k	[3] ALEKSEEV	10	COMP	$190\ \pi^- Pb \to \pi^-\pi^-\pi^+ Pb'$
$185 \pm 25 \pm 28$	145k	[4] LU	05	B852	$18\ \pi^- p \to \omega\pi^-\pi^0 p$
$168 \pm 20^{+150}_{-12}$		[2,5] ADAMS	98B	B852	$18.3\ \pi^- p \to \pi^+\pi^-\pi^- p$

[1] Statistical error negligible. See also the review ALEXEEV 22.
[2] Natural parity exchange.
[3] Superseded by AGHASYAN 2018B.
[4] May be a different state: natural and unnatural parity exchanges.
[5] Superseded by DZIERBA 06 excluding this state in a more refined PWA analysis, with 2.6 M events of $\pi^- p \to \pi^-\pi^-\pi^+ p$ and 3 M events of $\pi^- p \to \pi^-\pi^0\pi^0 p$ of E852 data.

$\pi_1(1600)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$\pi\pi\pi$	seen
Γ_2	$\rho^0\pi^-$	seen
Γ_3	$f_2(1270)\pi^-$	not seen
Γ_4	$b_1(1235)\pi$	seen
Γ_5	$\eta'(958)\pi^-$	seen
Γ_6	$\eta\pi$	seen
Γ_7	$f_1(1285)\pi$	seen

$\pi_1(1600)$ BRANCHING RATIOS

$\Gamma(\rho^0\pi^-)/\Gamma_{total}$ Γ_2/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	ALEKSEEV	10	COMP	$190\ \pi^- Pb \to \pi^-\pi^-\pi^+ Pb'$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	NOZAR	09	CLAS	$\gamma p \to 2\pi^+\pi^- n$
not seen	[1] DZIERBA	06	B852	$18\ \pi^- p$

[1] From the PWA analysis of 2.6 M $\pi^- p \to \pi^-\pi^-\pi^+ p$ and 3 M events of $\pi^- p \to \pi^-\pi^0\pi^0 p$ of E852 data. Supersedes ADAMS 98B.

$\Gamma(f_2(1270)\pi^-)/\Gamma_{total}$ Γ_3/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
not seen	[1] DZIERBA	06	B852	$18\ \pi^- p$

[1] From the PWA analysis of 2.6 M $\pi^- p \to \pi^-\pi^-\pi^+ p$ and 3 M events of $\pi^- p \to \pi^-\pi^0\pi^0 p$ of E852 data. Supersedes CHUNG 02.

$\Gamma(b_1(1235)\pi)/\Gamma_{total}$ — Γ_4/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
seen	35280	[1] BAKER	03	SPEC	$\overline{p}p \to \omega\pi^+\pi^-\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
seen	145k	LU	05	B852	$18\ \pi^- p \to \omega\pi^-\pi^0 p$

[1] $B((b_1\pi)_{D-wave})/B((b_1\pi)_{S\text{-wave}})=0.3 \pm 0.1$.

$\Gamma(\eta'(958)\pi^-)/\Gamma_{total}$ — Γ_5/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	IVANOV	01	B852	$18\ \pi^- p \to \eta'\pi^- p$

$\Gamma(\eta'(958)\pi^-)/\Gamma(\eta\pi)$ — Γ_5/Γ_6

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$5.54\pm1.1^{+1.8}_{-0.27}$	[1] KOPF	21	RVUE	$0.9\ p\overline{p} \to \pi^0\pi^0\eta$, $\pi^0\eta\eta$, $\pi^0 K^+ K^-$ and $191\ \pi^- p \to \pi^-\pi^-\pi^+ p$

[1] From T-matrix pole based on combined fit of Crystal Barrel and $\pi\pi$ scattering data (ALBRECHT 20), and COMPASS data (ADOLPH 15), using a coupled-channel model of $\eta\pi$, $\eta'\pi$ and $K\overline{K}$ systems.

$\Gamma(f_1(1285)\pi)/\Gamma(\eta'(958)\pi^-)$ — Γ_7/Γ_5

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
3.80±0.78	69k	[1] KUHN	04	B852	$18\ \pi^- p \to \eta\pi^+\pi^-\pi^- p$

[1] Using $\eta'(958)\pi$ data from IVANOV 01.

$\pi_1(1600)$ REFERENCES

ALEXEEV	22	PR D105 012005	G.D. Alexeev et al.	(COMPASS Collab.)
KOPF	21	EPJ C81 1056	B. Kopf et al.	(BOCH)
ALBRECHT	20	EPJ C80 453	M. Albrecht et al.	(Crystal Barrel Collab.)
RODAS	19	PRL 122 042002	A. Rodas et al.	(JPAC Collab.)
AGHASYAN	18B	PR D98 092003	M. Aghasyan et al.	(COMPASS Collab.)
ADOLPH	15	PL B740 303	M. Adolph et al.	(COMPASS Collab.)
ALEKSEEV	10	PRL 104 241803	M.G. Alekseev et al.	(COMPASS Collab.)
NOZAR	09	PRL 102 102002	M. Nozar et al.	(JLab CLAS Collab.)
ADAMS	07B	PL B657 27	G.S. Adams et al.	(BNL E852 Collab.)
DZIERBA	06	PR D73 072001	A.R. Dzierba et al.	(BNL E852 Collab.)
LU	05	PRL 94 032002	M. Lu et al.	(BNL E852 Collab.)
KUHN	04	PL B595 109	J. Kuhn et al.	(BNL E852 Collab.)
SALVINI	04	EPJ C35 21	P. Salvini et al.	(OBELIX Collab.)
BAKER	03	PL B563 140	C.A. Baker et al.	
DZIERBA	03	PR D67 094015	A.R. Dzierba et al.	
CHUNG	02	PR D65 072001	S.U. Chung et al.	(BNL E852 Collab.)
IVANOV	01	PRL 86 3977	E.I. Ivanov et al.	(BNL E852 Collab.)
ABELE	99	PL B446 349	A. Abele et al.	(Crystal Barrel Collab.)
ABELE	98B	PL B423 175	A. Abele et al.	(Crystal Barrel Collab.)
ADAMS	98B	PRL 81 5760	G.S. Adams et al.	(BNL E852 Collab.)
THOMPSON	97	PRL 79 1630	D.R. Thompson et al.	(BNL E852 Collab.)
PROKOSHKIN	95B	PAN 58 606 (Translated from YAF 58 662.)	Y.D. Prokoshkin, S.A. Sadovsky	(SERP)
BUGG	94	PR D50 4412	D.V. Bugg et al.	(LOQM)
AOYAGI	93	PL B314 246	H. Aoyagi et al.	(BKEI Collab.)
BOUTEMEUR	90	Hadron 89 Conf. p 119	M. Boutemeur, M. Poulet	(SERP, BELG, LANL+)
ALDE	88B	PL B205 397	D.M. Alde et al.	(SERP, BELG, LANL, LAPP)
APEL	81	NP B193 269	W.D. Apel et al.	(SERP, CERN)