

$\pi_1(1600)$

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

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 $\Gamma = -2 \text{Im}(\sqrt{s})$.

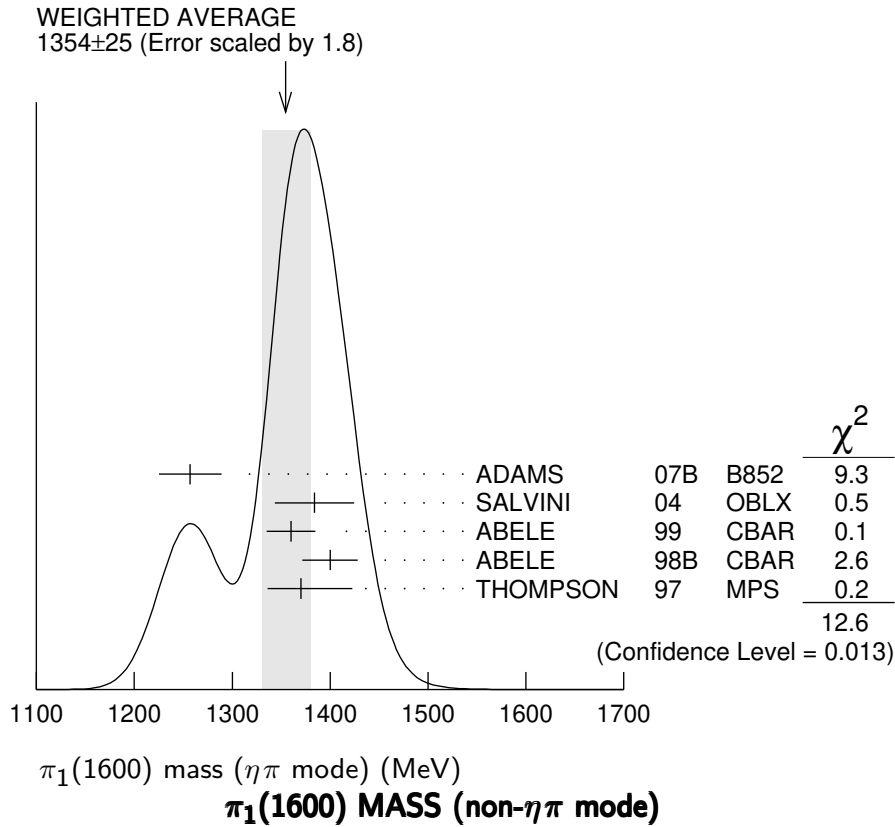
VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
(1480–1680) – i (150–300) OUR ESTIMATE			
$(1623 \pm 47^{+24}_{-75}) - i(228 \pm 44^{+72}_{-88})$	¹ KOPF	21	RVUE $0.9 \bar{p}p \rightarrow \pi^0 \pi^0 \eta,$ $\pi^0 \eta \eta, \pi^0 K^+ K^-$ and $191 \pi^- p \rightarrow$ $\pi^- \pi^- \pi^+ p$
$(1564 \pm 24 \pm 86) - i(246 \pm 27 \pm 51)$	² RODAS	19	RVUE $191 \pi^- p \rightarrow \eta^{(\prime)} \pi^- p$
● ● ● 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 $\bar{p}p \rightarrow \pi^0 \pi^0 \eta$
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 $K\bar{K}$ 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³ Superseded by KOPF 21.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.

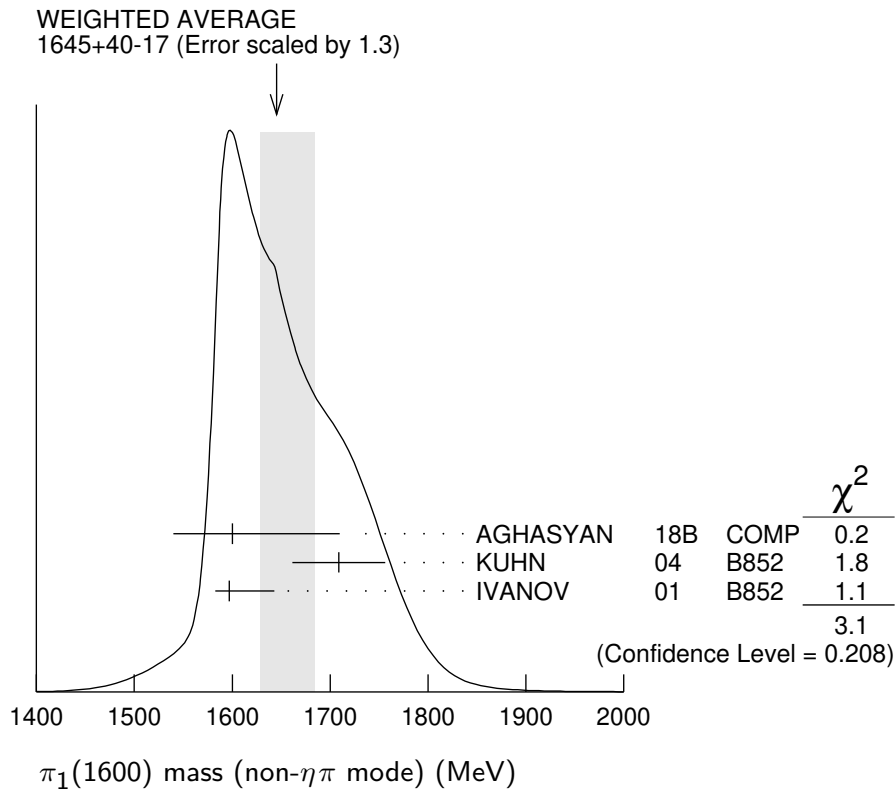
VALUE (MeV)	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
1354 ± 25	OUR AVERAGE	Error includes scale factor of 1.8. See the ideogram below.			
1257 ± 20 ± 25	23.5k	ADAMS	07B	B852	$18 \pi^- p \rightarrow \eta \pi^0 n$
1384 ± 20 ± 35	90k	SALVINI	04	OBLX	$\bar{p}p \rightarrow 2\pi^+ 2\pi^-$
1360 ± 25		ABELE	99	CBAR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

- 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.



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 $\pi^- p \rightarrow \pi^- \pi^+ \pi^- p$
1709 ± 24 ± 41	69k	² KUHN	04	B852 18 $\pi^- p \rightarrow \eta \pi^+ \pi^- \pi^- p$
1597 ± 10 ⁺⁴⁵ ₋₁₀		² IVANOV	01	B852 18 $\pi^- p \rightarrow \eta' \pi^- p$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
1660 ± 10 ⁺⁰ ₋₆₄	420k	³ ALEKSEEV	10	COMP 190 $\pi^- Pb \rightarrow \pi^- \pi^- \pi^+ Pb'$
1664 ± 8 ± 10	145k	⁴ LU	05	B852 18 $\pi^- p \rightarrow \omega \pi^- \pi^0 p$
1593 ± 8 ⁺²⁹ ₋₄₇		^{2,5} ADAMS	98B	B852 18.3 $\pi^- p \rightarrow \pi^+ \pi^- \pi^- p$

- 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 $\pi^- p \rightarrow \pi^- \pi^- \pi^+ p$ and 3 M events of $\pi^- p \rightarrow \pi^- \pi^0 \pi^0 p$ of E852 data.



$\pi_1(1600)$ 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 $\pi^- p \rightarrow \eta\pi^0 n$
378 ± 50 ± 50	90k	SALVINI	04	OBLX	$\bar{p}p \rightarrow 2\pi^+ 2\pi^-$
220 ± 90		ABELE	99	CBAR	0.0 $\bar{p}p \rightarrow \pi^0\pi^0\eta$
310 ± 50 + 50 - 30		ABELE	98B	CBAR	0.0 $\bar{p}n \rightarrow \pi^- \pi^0\eta$
385 ± 40 + 65 - 105		¹ THOMPSON	97	MPS	18 $\pi^- p \rightarrow \eta\pi^- p$
• • •					We do not use the following data for averages, fits, limits, etc. • • •
143.2 ± 12.5		² AOYAGI	93	BKEI	$\pi^- p \rightarrow \eta\pi^- p$
180 ± 20		³ ALDE	88B	GAM4 0	100 $\pi^- p \rightarrow \eta\pi^0 n$

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
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370⁺⁵⁰₋₆₀ OUR AVERAGE

580 ⁺¹⁰⁰ ₋₂₃₀	46M	¹ AGHASYAN	18B	COMP	190 $\pi^- p \rightarrow \pi^- \pi^+ \pi^- p$
403 \pm 80 \pm 115	69k	² KUHN	04	B852	18 $\pi^- p \rightarrow \eta \pi^+ \pi^- \pi^- p$
340 \pm 40 \pm 50		² IVANOV	01	B852	18 $\pi^- p \rightarrow \eta' \pi^- p$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
269 \pm 21 ⁺⁴² ₋₆₄	420k	³ ALEKSEEV	10	COMP	190 $\pi^- Pb \rightarrow \pi^- \pi^- \pi^+ Pb'$
185 \pm 25 \pm 28	145k	⁴ LU	05	B852	18 $\pi^- p \rightarrow \omega \pi^- \pi^0 p$
168 \pm 20 ⁺¹⁵⁰ ₋₁₂		^{2,5} ADAMS	98B	B852	18.3 $\pi^- p \rightarrow \pi^+ \pi^- \pi^- p$

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 $\pi^- p \rightarrow \pi^- \pi^- \pi^+ p$ and 3 M events of $\pi^- p \rightarrow \pi^- \pi^0 \pi^0 p$ 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

$\Gamma(\rho^0 \pi^-)/\Gamma_{\text{total}}$	Γ_2/Γ
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VALUE	DOCUMENT ID	TECN	COMMENT
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seen ALEKSEEV 10 COMP 190 $\pi^- Pb \rightarrow \pi^- \pi^- \pi^+ Pb'$

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

not seen NOZAR 09 CLAS $\gamma p \rightarrow 2\pi^+ \pi^- n$

not seen ¹ DZIERBA 06 B852 18 $\pi^- p$

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

$\Gamma(f_2(1270)\pi^-)/\Gamma_{\text{total}}$ 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 $\pi^- p \rightarrow \pi^- \pi^- \pi^+ p$ and 3 M events of $\pi^- p \rightarrow \pi^- \pi^0 \pi^0 p$ of E852 data. Supersedes CHUNG 02.

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

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
seen	35280	¹ BAKER	03 SPEC	$\bar{p} p \rightarrow \omega \pi^+ \pi^- \pi^0$

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

seen	145k	LU	05 B852	18 $\pi^- p \rightarrow \omega \pi^- \pi^0 p$
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¹ $B((b_1\pi)_{D\text{-wave}})/B((b_1\pi)_{S\text{-wave}})=0.3 \pm 0.1$.

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

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

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

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			

$5.54 \pm 1.1^{+1.8}_{-0.27}$	¹ KOPF	21 RVUE	0.9 $p\bar{p} \rightarrow \pi^0 \pi^0 \eta, \pi^0 \eta \eta,$ $\pi^0 K^+ K^-$ and 191 $\pi^- p \rightarrow$ $\pi^- \pi^- \pi^+ p$
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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 $K\bar{K}$ 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 $\pi^- p \rightarrow \eta \pi^+ \pi^- \pi^- p$

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

$\pi_1(1600)$ REFERENCES

ALEXEEV	22	PR D105 012005	G.D. Alexeev <i>et al.</i>	(COMPASS Collab.)
KOPF	21	EPJ C81 1056	B. Kopf <i>et al.</i>	(BOCH)
ALBRECHT	20	EPJ C80 453	M. Albrecht <i>et al.</i>	(Crystal Barrel Collab.)
RODAS	19	PRL 122 042002	A. Rodas <i>et al.</i>	(JPAC Collab.)
AGHASYAN	18B	PR D98 092003	M. Aghasyan <i>et al.</i>	(COMPASS Collab.)
ADOLPH	15	PL B740 303	M. Adolph <i>et al.</i>	(COMPASS Collab.)
ALEKSEEV	10	PRL 104 241803	M.G. Alekseev <i>et al.</i>	(COMPASS Collab.)
NOZAR	09	PRL 102 102002	M. Nozar <i>et al.</i>	(JLab CLAS Collab.)
ADAMS	07B	PL B657 27	G.S. Adams <i>et al.</i>	(BNL E852 Collab.)
DZIERBA	06	PR D73 072001	A.R. Dzierba <i>et al.</i>	(BNL E852 Collab.)
LU	05	PRL 94 032002	M. Lu <i>et al.</i>	(BNL E852 Collab.)
KUHN	04	PL B595 109	J. Kuhn <i>et al.</i>	(BNL E852 Collab.)
SALVINI	04	EPJ C35 21	P. Salvini <i>et al.</i>	(OBELIX Collab.)
BAKER	03	PL B563 140	C.A. Baker <i>et al.</i>	
DZIERBA	03	PR D67 094015	A.R. Dzierba <i>et al.</i>	
CHUNG	02	PR D65 072001	S.U. Chung <i>et al.</i>	(BNL E852 Collab.)

IVANOV	01	PRL 86 3977	E.I. Ivanov <i>et al.</i>	(BNL E852 Collab.)
ABELE	99	PL B446 349	A. Abele <i>et al.</i>	(Crystal Barrel Collab.)
ABELE	98B	PL B423 175	A. Abele <i>et al.</i>	(Crystal Barrel Collab.)
ADAMS	98B	PRL 81 5760	G.S. Adams <i>et al.</i>	(BNL E852 Collab.)
THOMPSON	97	PRL 79 1630	D.R. Thompson <i>et al.</i>	(BNL E852 Collab.)
PROKOSHKIN	95B	PAN 58 606	Y.D. Prokoshkin, S.A. Sadovsky	(SERP)
		Translated from YAF 58 662.		
BUGG	94	PR D50 4412	D.V. Bugg <i>et al.</i>	(LOQM)
AOYAGI	93	PL B314 246	H. Aoyagi <i>et al.</i>	(BKEI Collab.)
BOUTEMEUR	90	Hadron 89 Conf. p 119	M. Boutemur, M. Poulet	(SERP, BELG, LANL+)
ALDE	88B	PL B205 397	D.M. Alde <i>et al.</i>	(SERP, BELG, LANL, LAPP)
APEL	81	NP B193 269	W.D. Apel <i>et al.</i>	(SERP, CERN)
