NODE=M164

$\pi_1(1600)$ $I^G(J^{PC}) = 1^-(1^{-+})$

NODE=M164

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 $\sqrt{s}$

NODE=M164TMP

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

NODE=M164TMP

NODE=M164TMP

→ UNCHECKED ←

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. NODE=M164TMP;LINKAGE=B

[2] The coupled-channel analysis of both the $\eta\pi$ and $\eta'\pi$ systems using ADOLPH 15 data. NODE=M164TMP;LINKAGE=A

[3] Superseded by KOPF 21. NODE=M164TMP;LINKAGE=AL

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

NODE=M164MEP

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

NODE=M164MEP

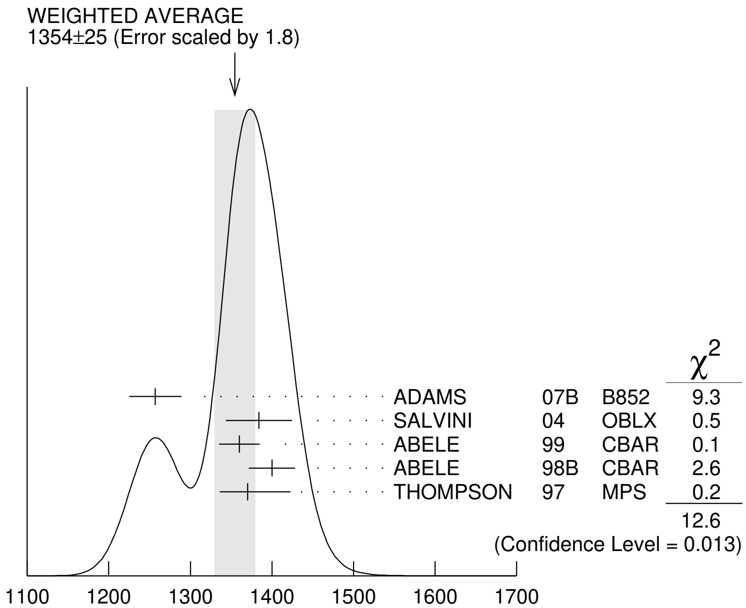
NODE=M164MEP

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	±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. NODE=M164MEP;LINKAGE=B

[2] Unnatural parity exchange. NODE=M164MEP;LINKAGE=C

[3] Seen in the P_0-wave intensity of the $\eta\pi^0$ system, unnatural parity exchange. NODE=M164MEP;LINKAGE=A



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

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

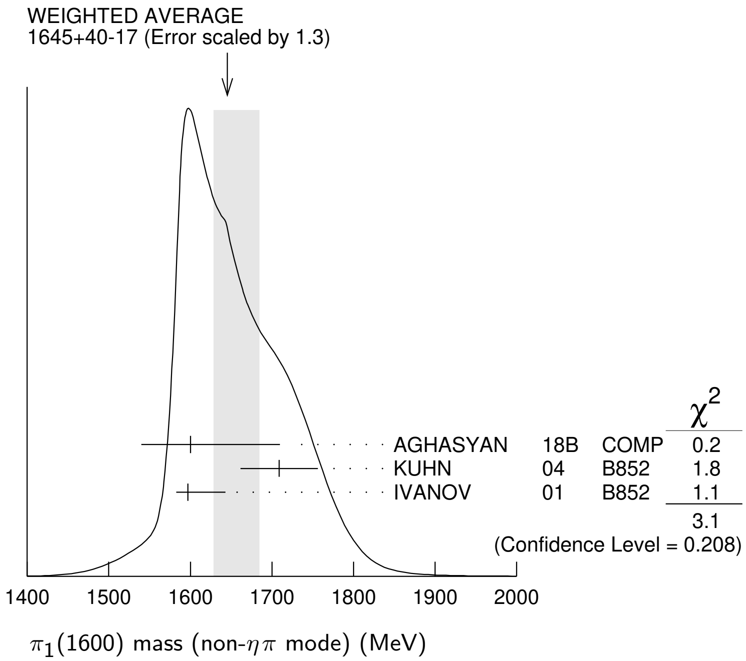
NODE=M164M

NODE=M164M

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

NODE=M164M;LINKAGE=B
NODE=M164M;LINKAGE=A
NODE=M164M;LINKAGE=C
NODE=M164M;LINKAGE=LU
NODE=M164M;LINKAGE=DZ



π_1(1600) WIDTH ($\eta\pi$ mode)

NODE=M164WEP

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

NODE=M164WEP

NODE=M164WEP

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. NODE=M164WEP;LINKAGE=QQ
[2] Unnatural parity exchange. NODE=M164WEP;LINKAGE=C
[3] Seen in the P_0-wave intensity of the $\eta\pi^0$ system, unnatural parity exchange. NODE=M164WEP;LINKAGE=A

π_1(1600) WIDTH (non-$\eta\pi$ mode)

NODE=M164W

NODE=M164W

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± 80±115	69k	[2] KUHN	04	B852	18 $\pi^- p \to \eta\pi^+\pi^-\pi^- p$
340± 40± 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± 21 $^{+42}_{-64}$	420k	[3] ALEKSEEV	10	COMP	190 $\pi^- Pb \to \pi^-\pi^-\pi^+ Pb'$
185± 25± 28	145k	[4] LU	05	B852	18 $\pi^- p \to \omega\pi^-\pi^0 p$
168± 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. NODE=M164W;LINKAGE=B
[2] Natural parity exchange. NODE=M164W;LINKAGE=A
[3] Superseded by AGHASYAN 2018B. NODE=M164W;LINKAGE=C
[4] May be a different state: natural and unnatural parity exchanges. NODE=M164W;LINKAGE=LU
[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. NODE=M164W;LINKAGE=DZ

$\pi_1(1600)$ DECAY MODES

NODE=M164215;NODE=M164

	Mode	Fraction (Γ_i/Γ)	
Γ_1	$\pi\pi\pi$	seen	DESIG=1;OUR EST;→ UNCHECKED ←
Γ_2	$\rho^0\pi^-$	seen	DESIG=2
Γ_3	$f_2(1270)\pi^-$	not seen	DESIG=4
Γ_4	$b_1(1235)\pi$	seen	DESIG=5
Γ_5	$\eta'(958)\pi^-$	seen	DESIG=3
Γ_6	$\eta\pi$	seen	DESIG=7;OUR EST;→ UNCHECKED ←
Γ_7	$f_1(1285)\pi$	seen	DESIG=6;OUR EST;→ UNCHECKED ←

$\pi_1(1600)$ BRANCHING RATIOS

NODE=M164220

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

NODE=M164R1
NODE=M164R1

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.

NODE=M164R1;LINKAGE=DZ

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

NODE=M164R3
NODE=M164R3

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.

NODE=M164R3;LINKAGE=DZ

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

NODE=M164R4
NODE=M164R4

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

NODE=M164R;LINKAGE=RB

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

NODE=M164R2
NODE=M164R2

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

NODE=M164R00
NODE=M164R00

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.

NODE=M164R00;LINKAGE=A

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

NODE=M164R5
NODE=M164R5

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.

NODE=M164R;LINKAGE=KU

$\pi_1(1600)$ REFERENCES

NODE=M164

ALEXEEV	22	PR D105 012005	G.D. Alexeev *et al.*	(COMPASS Collab.)	REFID=61491
KOPF	21	EPJ C81 1056	B. Kopf *et al.*	(BOCH)	REFID=61470
ALBRECHT	20	EPJ C80 453	M. Albrecht *et al.*	(Crystal Barrel Collab.)	REFID=60439
RODAS	19	PRL 122 042002	A. Rodas *et al.*	(JPAC Collab.)	REFID=59554
AGHASYAN	18B	PR D98 092003	M. Aghasyan *et al.*	(COMPASS Collab.)	REFID=59471
ADOLPH	15	PL B740 303	M. Adolph *et al.*	(COMPASS Collab.)	REFID=56385
ALEKSEEV	10	PRL 104 241803	M.G. Alekseev *et al.*	(COMPASS Collab.)	REFID=53356
NOZAR	09	PRL 102 102002	M. Nozar *et al.*	(JLab CLAS Collab.)	REFID=52758
ADAMS	07B	PL B657 27	G.S. Adams *et al.*	(BNL E852 Collab.)	REFID=52048
DZIERBA	06	PR D73 072001	A.R. Dzierba *et al.*	(BNL E852 Collab.)	REFID=51077
LU	05	PRL 94 032002	M. Lu *et al.*	(BNL E852 Collab.)	REFID=50459
KUHN	04	PL B595 109	J. Kuhn *et al.*	(BNL E852 Collab.)	REFID=49773
SALVINI	04	EPJ C35 21	P. Salvini *et al.*	(OBELIX Collab.)	REFID=53226
BAKER	03	PL B563 140	C.A. Baker *et al.*		REFID=49414
DZIERBA	03	PR D67 094015	A.R. Dzierba *et al.*		REFID=49412
CHUNG	02	PR D65 072001	S.U. Chung *et al.*	(BNL E852 Collab.)	REFID=48837
IVANOV	01	PRL 86 3977	E.I. Ivanov *et al.*	(BNL E852 Collab.)	REFID=48317
ABELE	99	PL B446 349	A. Abele *et al.*	(Crystal Barrel Collab.)	REFID=46602
ABELE	98B	PL B423 175	A. Abele *et al.*	(Crystal Barrel Collab.)	REFID=45864
ADAMS	98B	PRL 81 5760	G.S. Adams *et al.*	(BNL E852 Collab.)	REFID=46610
THOMPSON	97	PRL 79 1630	D.R. Thompson *et al.*	(BNL E852 Collab.)	REFID=45584
PROKOSHKIN	95B	PAN 58 606	Y.D. Prokoshkin, S.A. Sadovsky	(SERP)	REFID=44619
		Translated from YAF 58 662.			
BUGG	94	PR D50 4412	D.V. Bugg *et al.*	(LOQM)	REFID=44078
AOYAGI	93	PL B314 246	H. Aoyagi *et al.*	(BKEI Collab.)	REFID=43599
BOUTEMEUR	90	Hadron 89 Conf. p 119	M. Boutemeur, M. Poulet	(SERP, BELG, LANL+)	REFID=41751
ALDE	88B	PL B205 397	D.M. Alde *et al.*	(SERP, BELG, LANL, LAPP)	REFID=40558
APEL	81	NP B193 269	W.D. Apel *et al.*	(SERP, CERN)	REFID=22913