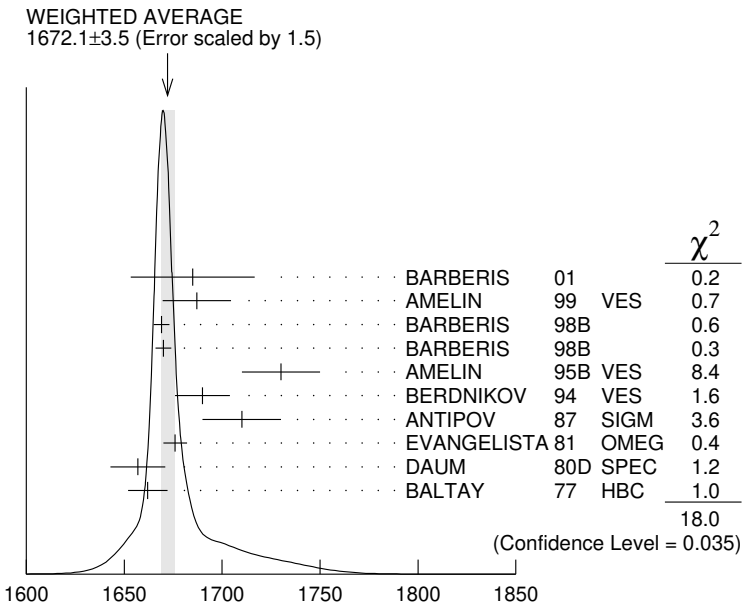
$\pi_2(1670)$

$I^G(J^{PC}) = 1^-(2^{-+})$

$\pi_2(1670)$ MASS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
1670 ±20 OUR ESTIMATE This is only an educated guess; the error given is larger than the error on the average of the published values.						
1672.1± 3.5 OUR AVERAGE Error includes scale factor of 1.5. See the ideogram below.						
1685 ±10 ±30		[1] BARBERIS	01			450 $pp \to p_f 3\pi^0 p_s$
1687 ± 9 ±15		AMELIN	99	VES		37 $\pi^- A \to \omega\pi^-\pi^0 A^*$
1669 ± 4		BARBERIS	98B			450 $pp \to p_f \rho\pi p_s$
1670 ± 4		BARBERIS	98B			450 $pp \to p_f f_2(1270)\pi p_s$
1730 ±20		[2] AMELIN	95B	VES		36 $\pi^- A \to \pi^+\pi^-\pi^- A$
1690 ±14		[3] BERDNIKOV	94	VES		37 $\pi^- A \to K^+K^-\pi^- A$
1710 ±20	700	ANTIPOV	87	SIGM	−	50 π^- Cu $\to \mu^+\mu^-\pi^-$ Cu
1676 ± 6		[3] EVANGELISTA	81	OMEG	−	12 $\pi^- p \to 3\pi p$
1657 ±14		[3,4] DAUM	80D	SPEC	−	63–94 $\pi p \to 3\pi$X
1662 ±10	2000	[3] BALTAY	77	HBC	+	15 $\pi^+ p \to p3\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
1742 ±31 ±49		ANTREASYAN	90	CBAL		$e^+e^- \to e^+e^-\pi^0\pi^0\pi^0$
1624 ±21		[5] BELLINI	85	SPEC		40 $\pi^- A \to \pi^-\pi^+\pi^- A$
1622 ±35		[6] BELLINI	85	SPEC		40 $\pi^- A \to \pi^-\pi^+\pi^- A$
1693 ±28		[7] BELLINI	85	SPEC		40 $\pi^- A \to \pi^-\pi^+\pi^- A$
1710 ±20		[8] DAUM	81B	SPEC	−	63,94 $\pi^- p$
1660 ±10		[3] ASCOLI	73	HBC	−	5–25 $\pi^- p \to p\pi_2$

[1] From a fit to the invariant mass distribution.
[2] From a fit to $J^{PC} = 2^{-+}$ $f_2(1270)\pi$, $f_0(1370)\pi$ waves.
[3] From a fit to $J^P = 2^-$ S-wave $f_2(1270)\pi$ partial wave.
[4] Clear phase rotation seen in 2^-S, 2^-P, 2^-D waves. We quote central value and spread of single-resonance fits to three channels.
[5] From $f_2(1270)\pi$ decay.
[6] From $\rho\pi$ decay.
[7] From $\sigma\pi$ decay.
[8] From a two-resonance fit to four 2^-0^+ waves. This should not be averaged with all the single resonance fits.



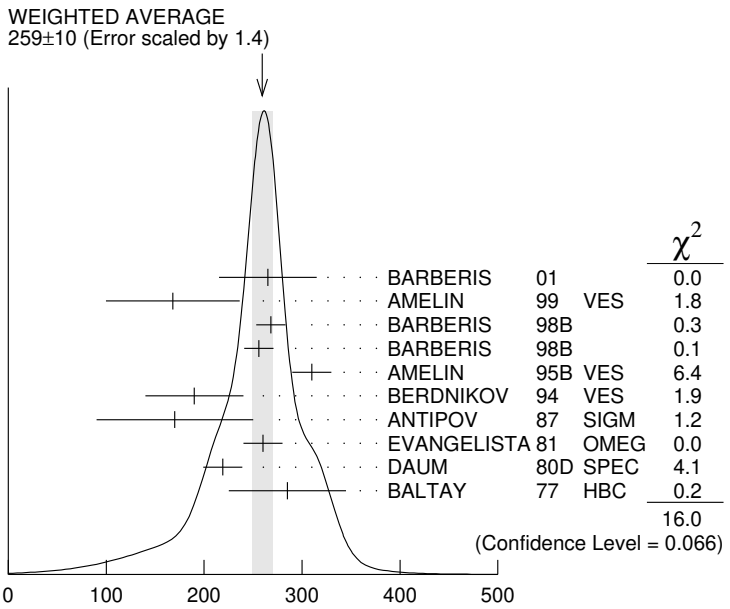
$\pi_2(1670)$ mass (MeV)

$\pi_2(1670)$ WIDTH

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
259± 10 OUR AVERAGE	Error includes scale factor of 1.4. See the ideogram below.					
265± 30±40		[9] BARBERIS	01			450 $pp \to p_f 3\pi^0 p_s$
168± 43±53		AMELIN	99	VES		37 $\pi^- A \to \omega\pi^-\pi^0 A^*$
268± 15		BARBERIS	98B			450 $pp \to p_f \rho\pi p_s$
256± 15		BARBERIS	98B			450 $pp \to p_f f_2(1270)\pi p_s$
310± 20		[10] AMELIN	95B	VES		36 $\pi^- A \to \pi^+\pi^-\pi^- A$
190± 50		[11] BERDNIKOV	94	VES		37 $\pi^- A \to K^+ K^-\pi^- A$
170± 80	700	ANTIPOV	87	SIGM	–	50 π^- Cu $\to \mu^+\mu^-\pi^-$ Cu
260± 20		[11] EVANGELISTA	81	OMEG	–	12 $\pi^- p \to 3\pi p$
219± 20		[11,12] DAUM	80D	SPEC	–	63–94 $\pi p \to 3\pi$X
285± 60	2000	[11] BALTAY	77	HBC	+	15 $\pi^+ p \to p3\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
236± 49±36		ANTREASYAN	90	CBAL		$e^+e^- \to e^+e^-\pi^0\pi^0\pi^0$
304± 22		[13] BELLINI	85	SPEC		40 $\pi^- A \to \pi^-\pi^+\pi^- A$
404±108		[14] BELLINI	85	SPEC		40 $\pi^- A \to \pi^-\pi^+\pi^- A$

330± 90	[15] BELLINI	85	SPEC		40 $\pi^- A \rightarrow \pi^- \pi^+ \pi^- A$
312± 50	[16] DAUM	81B	SPEC	–	63,94 $\pi^- p$
270± 60	[11] ASCOLI	73	HBC	–	5–25 $\pi^- p \rightarrow p \pi_2$

[9] From a fit to the invariant mass distribution.
[10] From a fit to $J^{PC} = 2^{-+}$ $f_2(1270)\pi$, $f_0(1370)\pi$ waves.
[11] From a fit to $J^P = 2^-$ $f_2(1270)\pi$ partial wave.
[12] Clear phase rotation seen in 2^-S, 2^-P, 2^-D waves. We quote central value and spread of single-resonance fits to three channels.
[13] From $f_2(1270)\pi$ decay.
[14] From $\rho\pi$ decay.
[15] From $\sigma\pi$ decay.
[16] From a two-resonance fit to four 2^-0^+ waves. This should not be averaged with all the single resonance fits.



$\pi_2(1670)$ width (MeV)

$\pi_2(1670)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)	Confidence level
Γ_1	3π	(95.8±1.4) %	
Γ_2	$\pi^+\pi^-\pi^0$		
Γ_3	$\pi^0\pi^0\pi^0$		
Γ_4	$f_2(1270)\pi$	(56.2±3.2) %	
Γ_5	$\rho\pi$	(31 ±4) %	
Γ_6	$\sigma\pi$	(13 ±6) %	
Γ_7	$f_0(1370)\pi$	(8.7±3.4) %	

Γ_8	$K\overline{K}^*(892)+$ c.c.	(4.2±1.4) %			
Γ_9	$\omega\rho$	(2.7±1.1) %			
Γ_{10}	$\gamma\gamma$				
Γ_{11}	$\eta\pi$				
Γ_{12}	$\pi^\pm 2\pi^+ 2\pi^-$				
Γ_{13}	$\rho(1450)\pi$	< 3.6	$\times 10^{-3}$		97.7%
Γ_{14}	$b_1(1235)\pi$	< 1.9	$\times 10^{-3}$		97.7%

CONSTRAINED FIT INFORMATION

An overall fit to 4 branching ratios uses 6 measurements and one constraint to determine 4 parameters. The overall fit has a $\chi^2 =$ 1.9 for 3 degrees of freedom.

The following *off-diagonal* array elements are the correlation coefficients $\left\langle \delta x_i \delta x_j \right\rangle / (\delta x_i \cdot \delta x_j)$, in percent, from the fit to the branching fractions, $x_i \equiv \Gamma_i/\Gamma_{\rm total}$. The fit constrains the x_i whose labels appear in this array to sum to one.

x_5	−53		
x_7	−29	−59	
x_8	−8	−21	−9
	x_4	x_5	x_7

$\pi_2(1670)$ PARTIAL WIDTHS

$\Gamma(\gamma\gamma)$ Γ_{10}

VALUE (keV)	CL%	DOCUMENT ID		TECN	CHG	COMMENT
<0.072	90	[17] ACCIARRI	97T	L3		$e^+e^- \to e^+e^-\pi^+\pi^-\pi^0$
<0.19	90	[17] ALBRECHT	97B	ARG		$e^+e^- \to e^+e^-\pi^+\pi^-\pi^0$

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

1.41 ±0.23±0.28		ANTREASYAN	90	CBAL	0	$e^+e^- \to e^+e^-\pi^0\pi^0\pi^0$
0.8 ±0.3 ±0.12	[18]	BEHREND	90C	CELL	0	$e^+e^- \to e^+e^-\pi^+\pi^-\pi^0$
1.3 ±0.3 ±0.2	[19]	BEHREND	90C	CELL	0	$e^+e^- \to e^+e^-\pi^+\pi^-\pi^0$

[17] Decaying into $f_2(1270)\pi$ and $\rho\pi$.
[18] Constructive interference between $f_2(1270)\pi$, $\rho\pi$ and background.
[19] Incoherent Ansatz.

$\pi_2(1670)$ BRANCHING RATIOS

$\Gamma(3\pi)/\Gamma_{\rm total}$ $\Gamma_1/\Gamma = (\Gamma_4+\Gamma_5+\Gamma_7)/\Gamma$

VALUE	DOCUMENT ID
0.958±0.014 OUR FIT	

$\Gamma(\pi^0\pi^0\pi^0)/\Gamma(\pi^+\pi^-\pi^0)$ Γ_3/Γ_2

VALUE	DOCUMENT ID		COMMENT
0.29±0.03±0.05	[20] BARBERIS	01	450 $pp \rightarrow p_f 3\pi^0 p_s$

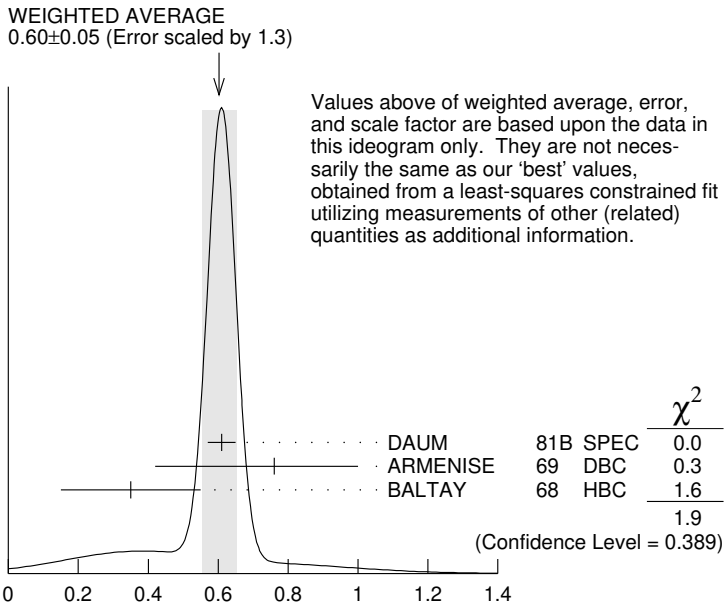
$\Gamma(\rho\pi)/\Gamma(\pi^\pm\pi^+\pi^-)$ $\frac{1}{2}\Gamma_5/(0.567\Gamma_4+\frac{1}{2}\Gamma_5+0.624\Gamma_7)$

VALUE	DOCUMENT ID		TECN	CHG	COMMENT
0.29±0.04 OUR FIT					
0.29±0.05	[21] DAUM	81B	SPEC		63,94 $\pi^- p$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.3	BARTSCH	68	HBC	+	8 $\pi^+ p \rightarrow 3\pi p$

$\Gamma(f_2(1270)\pi)/\Gamma(\pi^\pm\pi^+\pi^-)$ $0.567\Gamma_4/(0.567\Gamma_4+\frac{1}{2}\Gamma_5+0.624\Gamma_7)$

(With $f_2(1270) \rightarrow \pi^+\pi^-$.)

VALUE	DOCUMENT ID		TECN	CHG	COMMENT
0.604±0.035 OUR FIT					
0.60 ±0.05 OUR AVERAGE Error includes scale factor of 1.3. See the ideogram below.					
0.61 ±0.04	[21] DAUM	81B	SPEC		63,94 $\pi^- p$
$0.76\ ^{+0.24}_{-0.34}$	ARMENISE	69	DBC	+	5.1 $\pi^+ d \rightarrow d3\pi$
0.35 ±0.20	BALTAY	68	HBC	+	7–8.5 $\pi^+ p$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.59	BARTSCH	68	HBC	+	8 $\pi^+ p \rightarrow 3\pi p$



$\Gamma(f_2(1270)\pi)/\Gamma(\pi^\pm\pi^+\pi^-)$

$\Gamma(\rho\pi)/\Gamma(f_2(1270)\pi)$ $\Gamma_5/0.564\Gamma_4$

(With $f_2(1270) \to \pi^+\pi^-$.)

VALUE	DOCUMENT ID		COMMENT
1.01±0.05	BARBERIS	98B	450 $pp \to p_f \pi^+\pi^-\pi^0 p_s$

$\Gamma(\eta\pi)/\Gamma(\pi^\pm\pi^+\pi^-)$ $\Gamma_{11}/(0.567\Gamma_4+\frac{1}{2}\Gamma_5+0.624\Gamma_7)$

(All η decays.)

VALUE	DOCUMENT ID		TECN	CHG	COMMENT
<0.09	BALTAY	68	HBC	+	7–8.5 $\pi^+ p$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.10	CRENNELL	70	HBC	−	6 $\pi^- p \to f_2 \pi^- N$

$\Gamma(\pi^\pm 2\pi^+ 2\pi^-)/\Gamma(\pi^\pm\pi^+\pi^-)$ $\Gamma_{12}/(0.567\Gamma_4+\frac{1}{2}\Gamma_5+0.624\Gamma_7)$

VALUE	DOCUMENT ID		TECN	CHG	COMMENT
<0.10	CRENNELL	70	HBC	−	6 $\pi^- p \to f_2 \pi^- N$
<0.1	BALTAY	68	HBC	+	7,8.5 $\pi^+ p$

$\Gamma(\rho(1450)\pi)/\Gamma_{total}$ Γ_{13}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.0036	97.7	AMELIN	99	VES	37 $\pi^- A \to \omega\pi^-\pi^0 A^*$

$\Gamma(b_1(1235)\pi)/\Gamma_{total}$ Γ_{14}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.0019	97.7	AMELIN	99	VES	37 $\pi^- A \to \omega\pi^-\pi^0 A^*$

$\Gamma(f_0(1370)\pi)/\Gamma(\pi^\pm\pi^+\pi^-)$ $0.624\Gamma_7/(0.567\Gamma_4+\frac{1}{2}\Gamma_5+0.624\Gamma_7)$

(With $f_0(1370) \to \pi^+\pi^-$.)

VALUE		DOCUMENT ID		TECN	COMMENT
0.10±0.04 OUR FIT					
0.10±0.05	[21]	DAUM	81B	SPEC	63,94 $\pi^- p$

$\Gamma(K\overline{K}^*(892)+\text{c.c.})/\Gamma(f_2(1270)\pi)$ Γ_8/Γ_4

VALUE		DOCUMENT ID		TECN	CHG	COMMENT
0.075±0.025 OUR FIT						
0.075±0.025	[22]	ARMSTRONG	82B	OMEG	−	16 $\pi^- p \to K^+K^-\pi^- p$

$\Gamma(\omega\rho)/\Gamma_{total}$ Γ_9/Γ

VALUE		DOCUMENT ID		TECN	COMMENT
0.027±0.004±0.010	[23]	AMELIN	99	VES	37 $\pi^- A \to \omega\pi^-\pi^0 A^*$

$\Gamma(\sigma\pi)/\Gamma(f_2(1270)\pi)$ Γ_6/Γ_4

VALUE		DOCUMENT ID		TECN	COMMENT
0.24±0.10	[24,25]	BAKER	99	SPEC	1.94 $\overline{p}p \to 4\pi^0$

D-wave/*S*-wave RATIO FOR $\pi_2(1670) \rightarrow f_2(1270)\pi$

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
-0.18 ± 0.06	[24] BAKER	99	SPEC	1.94 $\overline{p}p \rightarrow 4\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.22 ± 0.10	[21] DAUM	81B	SPEC	63,94 $\pi^- p$

[20] Using BARBERIS 98B.
[21] From a two-resonance fit to four 2^-0^+ waves.
[22] From a partial-wave analysis of $K^+K^-\pi^-$ system.
[23] Normalized to the B($\pi_2(1670) \rightarrow f_2\pi$).
[24] Using preliminary CBAR data.
[25] With the $\sigma\pi$ in L=2 and the $f_2(1270)\pi$ in L=0.

$\pi_2(1670)$ REFERENCES

BARBERIS	01	PL B507 14	D. Barberis *et al.*	
AMELIN	99	PAN 62 445	D.V. Amelin *et al.*	(VES Collab.)
		Translated from YAF 62 487.		
BAKER	99	PL B449 114	C.A. Baker *et al.*	
BARBERIS	98B	PL B422 399	D. Barberis *et al.*	(WA 102 Collab.)
ACCIARRI	97T	PL B413 147	M. Acciarri *et al.*	(L3 Collab.)
ALBRECHT	97B	ZPHY C74 469	H. Albrecht *et al.*	(ARGUS Collab.)
AMELIN	95B	PL B356 595	D.V. Amelin *et al.*	(SERP, TBIL)
BERDNIKOV	94	PL B337 219	E.B. Berdnikov *et al.*	(SERP, TBIL)
ANTREASYAN	90	ZPHY C48 561	D. Antreasyan *et al.*	(Crystal Ball Collab.)
BEHREND	90C	ZPHY C46 583	H.J. Behrend *et al.*	(CELLO Collab.)
ANTIPOV	87	EPL 4 403	Y.M. Antipov *et al.*	(SERP, JINR, INRM+)
BELLINI	85	SJNP 41 781	D. Bellini *et al.*	
		Translated from YAF 41 1223.		
ARMSTRONG	82B	NP B202 1	T.A. Armstrong, B. Baccari	(AACH3, BARI, BONN+)
DAUM	81B	NP B182 269	C. Daum *et al.*	(AMST, CERN, CRAC, MPIM+)
EVANGELISTA	81	NP B178 197	C. Evangelista *et al.*	(BARI, BONN, CERN+)
Also	81B	NP B186 594	C. Evangelista	
DAUM	80D	PL 89B 285	C. Daum *et al.*	(AMST, CERN, CRAC, MPIM+) JP
BALTAY	77	PRL 39 591	C. Baltay, C.V. Cautis, M. Kalelkar	(COLU) JP
ASCOLI	73	PR D7 669	G. Ascoli	(ILL, TNTO, GENO, HAMB, MILA+) JP
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BALTAY	68	PRL 20 887	C. Baltay *et al.*	(COLU, ROCH, RUTG, YALE) I
BARTSCH	68	NP B7 345	J. Bartsch *et al.*	(AACH, BERL, CERN) JP

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		Translated from SJPN 30 5.		
ABELE	96	PL B380 453	A. Abele *et al.*	(Crystal Barrel Collab.)
CHEN	83B	PR D28 2304	T.Y. Chen *et al.*	(ARIZ, FNAL, FLOR, NDAM+)
LEEDOM	83	PR D27 1426	I.D. Leedom *et al.*	(PURD, TNTO)
BELLINI	82B	NP B199 1	G. Bellini *et al.*	(CERN, MILA, JINR+)
DAUM	81B	NP B182 269	C. Daum *et al.*	(AMST, CERN, CRAC, MPIM+)
PERNEGR	78	NP B134 436	J. Pernegr *et al.*	(ETH, CERN, LOIC+)
FOCACCI	66	PRL 17 890	M.N. Focacci *et al.*	(CERN)
LEVRAT	66	PL 22 714	B. Levrat *et al.*	
VETLITSKY	66	PL 21 579	I.A. Vetlitsky *et al.*	(ITEP)
FORINO	65B	PL 19 68	A. Forino *et al.*	(BGNA, BARI, FIRZ, ORSAY+)