

$\pi_2(1670)$

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

$\pi_2(1670)$ MASS

<u>VALUE (MeV)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
1672.2 ± 3.0 OUR AVERAGE		Error includes scale factor of 1.4. See the ideogram below.			
1658 ± 3 $\begin{smallmatrix} + \\ - \end{smallmatrix} \begin{smallmatrix} 24 \\ 8 \end{smallmatrix}$	420k	ALEKSEEV	10	COMP	190 $\pi^- Pb \rightarrow \pi^- \pi^- \pi^+ Pb'$
1749 ± 10 ± 100	145k	LU	05	B852	18 $\pi^- p \rightarrow \omega \pi^- \pi^0 p$
1676 ± 3 ± 8		1 CHUNG	02	B852	18.3 $\pi^- p \rightarrow \pi^+ \pi^- \pi^- p$
1685 ± 10 ± 30		2 BARBERIS	01		450 $p p \rightarrow p_f 3\pi^0 p_s$
1687 ± 9 ± 15		AMELIN	99	VES	37 $\pi^- A \rightarrow \omega \pi^- \pi^0 A^*$
1669 ± 4		BARBERIS	98B		450 $p p \rightarrow p_f \rho \pi p_s$
1670 ± 4		BARBERIS	98B		450 $p p \rightarrow p_f f_2(1270) \pi p_s$
1730 ± 20		3 AMELIN	95B	VES	36 $\pi^- A \rightarrow \pi^+ \pi^- \pi^- A$
1690 ± 14		4 BERDNIKOV	94	VES	37 $\pi^- A \rightarrow K^+ K^- \pi^- A$
1710 ± 20	700	ANTIPOV	87	SIGM -	50 $\pi^- Cu \rightarrow \mu^+ \mu^- \pi^- Cu$
1676 ± 6		4 EVANGELIS...	81	OMEG -	12 $\pi^- p \rightarrow 3\pi p$
1657 ± 14		4,5 DAUM	80D	SPEC -	63-94 $\pi p \rightarrow 3\pi X$
1662 ± 10	2000	4 BALTAY	77	HBC +	15 $\pi^+ p \rightarrow p 3\pi$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
1742 ± 31 ± 49		ANTREASYAN	90	CBAL	$e^+ e^- \rightarrow e^+ e^- \pi^0 \pi^0 \pi^0$
1624 ± 21		1 BELLINI	85	SPEC	40 $\pi^- A \rightarrow \pi^- \pi^+ \pi^- A$
1622 ± 35		6 BELLINI	85	SPEC	40 $\pi^- A \rightarrow \pi^- \pi^+ \pi^- A$
1693 ± 28		7 BELLINI	85	SPEC	40 $\pi^- A \rightarrow \pi^- \pi^+ \pi^- A$
1710 ± 20		8 DAUM	81B	SPEC -	63,94 $\pi^- p$
1660 ± 10		4 ASCOLI	73	HBC -	5-25 $\pi^- p \rightarrow p \pi_2$

¹ From $f_2(1270)\pi$ decay.

² From a fit to the invariant mass distribution.

³ From a fit to $J^{PC} = 2^-+ f_2(1270)\pi, f_0(1370)\pi$ waves.

⁴ From a fit to $J^P = 2^- S$ -wave $f_2(1270)\pi$ partial wave.

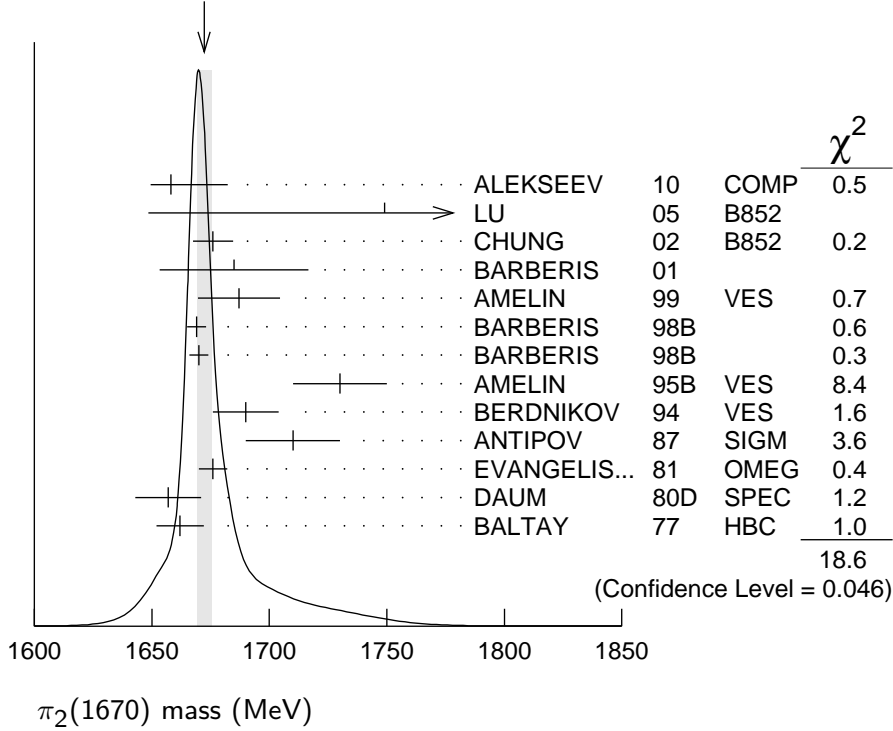
⁵ Clear phase rotation seen in $2^- S, 2^- P, 2^- D$ waves. We quote central value and spread of single-resonance fits to three channels.

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.

WEIGHTED AVERAGE
 1672.2 ± 3.0 (Error scaled by 1.4)



$\pi_2(1670)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
260 ± 9	OUR AVERAGE	Error includes scale factor of 1.2.			
$271 \pm 9^{+22}_{-24}$	420k	ALEKSEEV	10	COMP	190 $\pi^- Pb \rightarrow \pi^- \pi^- \pi^+ Pb'$
$408 \pm 60 \pm 250$	145k	LU	05	B852	18 $\pi^- p \rightarrow \omega \pi^- \pi^0 p$
$254 \pm 3 \pm 31$		⁹ CHUNG	02	B852	18.3 $\pi^- p \rightarrow \pi^+ \pi^- \pi^- p$
$265 \pm 30 \pm 40$		¹⁰ BARBERIS	01		450 $pp \rightarrow p_f 3\pi^0 p_s$
$168 \pm 43 \pm 53$		AMELIN	99	VES	37 $\pi^- A \rightarrow \omega \pi^- \pi^0 A^*$
268 ± 15		BARBERIS	98B		450 $pp \rightarrow p_f \rho \pi p_s$
256 ± 15		BARBERIS	98B		450 $pp \rightarrow p_f f_2(1270) \pi p_s$
310 ± 20		¹¹ AMELIN	95B	VES	36 $\pi^- A \rightarrow \pi^+ \pi^- \pi^- A$
190 ± 50		¹² BERDNIKOV	94	VES	37 $\pi^- A \rightarrow K^+ K^- \pi^- A$
170 ± 80	700	ANTIPOV	87	SIGM	- 50 $\pi^- Cu \rightarrow \mu^+ \mu^- \pi^- Cu$
260 ± 20		¹² EVANGELIS...	81	OMEG	- 12 $\pi^- p \rightarrow 3\pi p$
219 ± 20		^{12,13} DAUM	80D	SPEC	- 63-94 $\pi p \rightarrow 3\pi X$
285 ± 60	2000	¹² BALTAY	77	HBC	+ 15 $\pi^+ p \rightarrow p 3\pi$

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

236 ± 49 ± 36	ANTREASYAN 90	CBAL	$e^+e^- \rightarrow e^+e^-\pi^0\pi^0\pi^0$
304 ± 22	⁹ BELLINI	85 SPEC	40 $\pi^- A \rightarrow \pi^- \pi^+ \pi^- A$
404 ± 108	¹⁴ BELLINI	85 SPEC	40 $\pi^- A \rightarrow \pi^- \pi^+ \pi^- A$
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	¹² ASCOLI	73 HBC	5-25 $\pi^- p \rightarrow p\pi_2$

⁹ From $f_2(1270)\pi$ decay.

¹⁰ From a fit to the invariant mass distribution.

¹¹ From a fit to $J^{PC} = 2^{-+} f_2(1270)\pi, f_0(1370)\pi$ waves.

¹² From a fit to $J^P = 2^- f_2(1270)\pi$ partial wave.

¹³ 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.

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.

$\pi_2(1670)$ 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 $f_2(1270)\pi$	(56.3 ± 3.2) %	
Γ_5 $\rho\pi$	(31 ± 4) %	
Γ_6 $\sigma\pi$	(10.9 ± 3.4) %	
Γ_7 $(\pi\pi)_S\text{-wave}$	(8.7 ± 3.4) %	
Γ_8 $K\bar{K}^*(892) + \text{c.c.}$	(4.2 ± 1.4) %	
Γ_9 $\omega\rho$	(2.7 ± 1.1) %	
Γ_{10} $\gamma\gamma$	< 2.8 × 10 ⁻⁷	90%
Γ_{11} $\eta\pi$		
Γ_{12} $\pi^\pm 2\pi^+ 2\pi^-$		
Γ_{13} $\rho(1450)\pi$	< 3.6 × 10 ⁻³	97.7%
Γ_{14} $b_1(1235)\pi$	< 1.9 × 10 ⁻³	97.7%
Γ_{15} $\eta 3\pi$		
Γ_{16} $f_1(1285)\pi$	possibly seen	
Γ_{17} $a_2(1320)\pi$	not seen	

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 $\langle \delta x_i \delta x_j \rangle / (\delta x_i \delta x_j)$, in percent, from the fit to the branching fractions, $x_i \equiv \Gamma_i / \Gamma_{\text{total}}$. 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}
<u>VALUE (keV)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>	
<0.072	90	17 ACCIARRI	97T L3		$e^+ e^- \rightarrow e^+ e^- \pi^+ \pi^- \pi^0$	
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
<0.19	90	17 ALBRECHT	97B ARG		$e^+ e^- \rightarrow e^+ e^- \pi^+ \pi^- \pi^0$	
1.41 $\pm 0.23 \pm 0.28$		ANTREASYAN 90	CBAL 0		$e^+ e^- \rightarrow e^+ e^- \pi^0 \pi^0 \pi^0$	
0.8 $\pm 0.3 \pm 0.12$		18 BEHREND	90C CELL 0		$e^+ e^- \rightarrow e^+ e^- \pi^+ \pi^- \pi^0$	
1.3 $\pm 0.3 \pm 0.2$		19 BEHREND	90C CELL 0		$e^+ e^- \rightarrow e^+ e^- \pi^+ \pi^- \pi^0$	

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.

$\pi_2(1670)$ $\Gamma(i)\Gamma(\gamma\gamma)/\Gamma(\text{total})$

$\Gamma(\pi^+ \pi^- \pi^0) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$					$\Gamma_2 \Gamma_{10} / \Gamma$
<u>VALUE (keV)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<0.1	95	20 SCHEGELSKY 06	RVUE	$\gamma\gamma \rightarrow \pi^+ \pi^- \pi^0$	

²⁰ From analysis of L3 data at 183–209 GeV.

$\pi_2(1670)$ BRANCHING RATIOS

$\Gamma(3\pi)/\Gamma_{\text{total}}$	$\Gamma_1/\Gamma = (\Gamma_4 + \Gamma_5 + \Gamma_7)/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>
0.958 \pm 0.014 OUR FIT	

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

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
0.29±0.03±0.05	21 BARBERIS	01		450 $pp \rightarrow p_f 3\pi^0 p_s$

$\Gamma(\rho\pi)/0.565\Gamma(f_2(1270)\pi)$ $\Gamma_5/0.565\Gamma_4$

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

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
0.97±0.09 OUR AVERAGE	Error includes scale factor of 1.9.			
0.76±0.07±0.10	CHUNG	02	B852	18.3 $\pi^- p \rightarrow \pi^+\pi^-\pi^- p$
1.01±0.05	BARBERIS	98B		450 $pp \rightarrow p_f \pi^+\pi^-\pi^0 p_s$

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

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
0.19±0.06 OUR AVERAGE				
0.17±0.02±0.07	CHUNG	02	B852	18.3 $\pi^- p \rightarrow \pi^+\pi^-\pi^- p$
0.24±0.10	22,23 BAKER	99	SPEC	1.94 $\bar{p}p \rightarrow 4\pi^0$

$\frac{1}{2}\Gamma(\rho\pi)/\Gamma(\pi^\pm\pi^+\pi^-)$ $\frac{1}{2}\Gamma_5/(0.565\Gamma_4+\frac{1}{2}\Gamma_5+0.624\Gamma_7)$

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
0.29±0.04 OUR FIT				
0.29±0.05	24 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 $\pi^+ p \rightarrow 3\pi p$

$0.565\Gamma(f_2(1270)\pi)/\Gamma(\pi^\pm\pi^+\pi^-)$ $0.565\Gamma_4/(0.565\Gamma_4+\frac{1}{2}\Gamma_5+0.624\Gamma_7)$

(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.			
0.61 ±0.04	24 DAUM	81B	SPEC	63,94 $\pi^- p$
0.76 ^{+0.24} _{-0.34}	ARMENISE	69	DBC +	5.1 $\pi^+ d \rightarrow d 3\pi$
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 $\pi^+ p \rightarrow 3\pi p$

$0.624\Gamma((\pi\pi)_{S\text{-wave}})/\Gamma(\pi^\pm\pi^+\pi^-)$ $0.624\Gamma_7/(0.565\Gamma_4+\frac{1}{2}\Gamma_5+0.624\Gamma_7)$

(With $(\pi\pi)_{S\text{-wave}} \rightarrow \pi^+\pi^-$.)

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
0.10±0.04 OUR FIT				
0.10±0.05	24 DAUM	81B	SPEC	63,94 $\pi^- p$

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

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
0.075±0.025 OUR FIT				
0.075±0.025	25 ARMSTRONG	82B	OMEG -	16 $\pi^- p \rightarrow K^+ K^- \pi^- p$

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

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
0.027±0.004±0.010	26 AMELIN	99	VES	37 $\pi^- A \rightarrow \omega\pi^-\pi^0 A^*$

$\Gamma(\eta\pi)/\Gamma(\pi^\pm\pi^+\pi^-)$ **$\Gamma_{11}/(0.565\Gamma_4+\frac{1}{2}\Gamma_5+0.624\Gamma_7)$**
 (All η decays.)

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

$\Gamma(\pi^\pm 2\pi^+ 2\pi^-)/\Gamma(\pi^\pm\pi^+\pi^-)$ **$\Gamma_{12}/(0.565\Gamma_4+\frac{1}{2}\Gamma_5+0.624\Gamma_7)$**

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

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

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

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

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

$\Gamma(f_1(1285)\pi)/\Gamma_{\text{total}}$ **Γ_{16}/Γ**

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT	
possibly seen	69k	KUHN	04	B852	18 $\pi^-p \rightarrow \eta\pi^+\pi^-\pi^-p$

$\Gamma(a_2(1320)\pi)/\Gamma_{\text{total}}$ **Γ_{17}/Γ**

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT	
not seen	69k	KUHN	04	B852	18 $\pi^-p \rightarrow \eta\pi^+\pi^-\pi^-p$

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

VALUE	DOCUMENT ID	TECN	COMMENT
-0.18±0.06	22 BAKER	99	SPEC 1.94 $\bar{p}p \rightarrow 4\pi^0$
0.22±0.10	24 DAUM	81B	SPEC 63,94 π^-p

F-wave/P-wave RATIO FOR $\pi_2(1670) \rightarrow \rho\pi$

VALUE	DOCUMENT ID	TECN	COMMENT
-0.72±0.07±0.14	CHUNG	02	B852 18.3 $\pi^-p \rightarrow \pi^+\pi^-\pi^-p$

²¹ Using BARBERIS 98B.

²² Using preliminary CBAR data.

²³ With the $\sigma\pi$ in $L=2$ and the $f_2(1270)\pi$ in $L=0$.

²⁴ From a two-resonance fit to four 2^-0^+ waves.

²⁵ From a partial-wave analysis of $K^+K^-\pi^-$ system.

²⁶ Normalized to the $B(\pi_2(1670) \rightarrow f_2\pi)$.

$\pi_2(1670)$ REFERENCES

ALEKSEEV	10	PRL 104 241803	M.G. Alekseev <i>et al.</i>	(COMPASS Collab.)
SCHEGELSKY	06	EPJ A27 199	V.A. Schegelsky <i>et al.</i>	
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.)
CHUNG	02	PR D65 072001	S.U. Chung <i>et al.</i>	(BNL E852 Collab.)
BARBERIS	01	PL B507 14	D. Barberis <i>et al.</i>	
AMELIN	99	PAN 62 445	D.V. Amelin <i>et al.</i>	(VES Collab.)
BAKER	99	Translated from YAF 62 487. PL B449 114	C.A. Baker <i>et al.</i>	
BARBERIS	98B	PL B422 399	D. Barberis <i>et al.</i>	(WA 102 Collab.)
ACCIARRI	97T	PL B413 147	M. Acciarri <i>et al.</i>	(L3 Collab.)
ALBRECHT	97B	ZPHY C74 469	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
AMELIN	95B	PL B356 595	D.V. Amelin <i>et al.</i>	(SERP, TBIL)
BERDNIKOV	94	PL B337 219	E.B. Berdnikov <i>et al.</i>	(SERP, TBIL)
ANTREASYAN	90	ZPHY C48 561	D. Antreasyan <i>et al.</i>	(Crystal Ball Collab.)
BEHREND	90C	ZPHY C46 583	H.J. Behrend <i>et al.</i>	(CELLO Collab.)
ANTIPOV	87	EPL 4 403	Y.M. Antipov <i>et al.</i>	(SERP, JINR, INRM+)
BELLINI	85	SJNP 41 781	D. Bellini <i>et al.</i>	
ARMSTRONG	82B	Translated from YAF 41 1223. NP B202 1	T.A. Armstrong, B. Baccari	(AACH3, BARI, BONN+)
DAUM	81B	NP B182 269	C. Daum <i>et al.</i>	(AMST, CERN, CRAC, MPIM+)
EVANGELIS...	81	NP B178 197	C. Evangelista <i>et al.</i>	(BARI, BONN, CERN+)
Also		NP B186 594	C. Evangelista	
DAUM	80D	PL 89B 285	C. Daum <i>et al.</i>	(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
CRENNELL	70	PRL 24 781	D.J. Crennell <i>et al.</i>	(BNL)
ARMENISE	69	LNC 2 501	N. Armenise <i>et al.</i>	(BARI, BGNA, FIRZ)
BALTAY	68	PRL 20 887	C. Baltay <i>et al.</i>	(COLU, ROCH, RUTG, YALE) I
BARTSCH	68	NP B7 345	J. Bartsch <i>et al.</i>	(AACH, BERL, CERN) JP