$\pi_2(1670)$

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

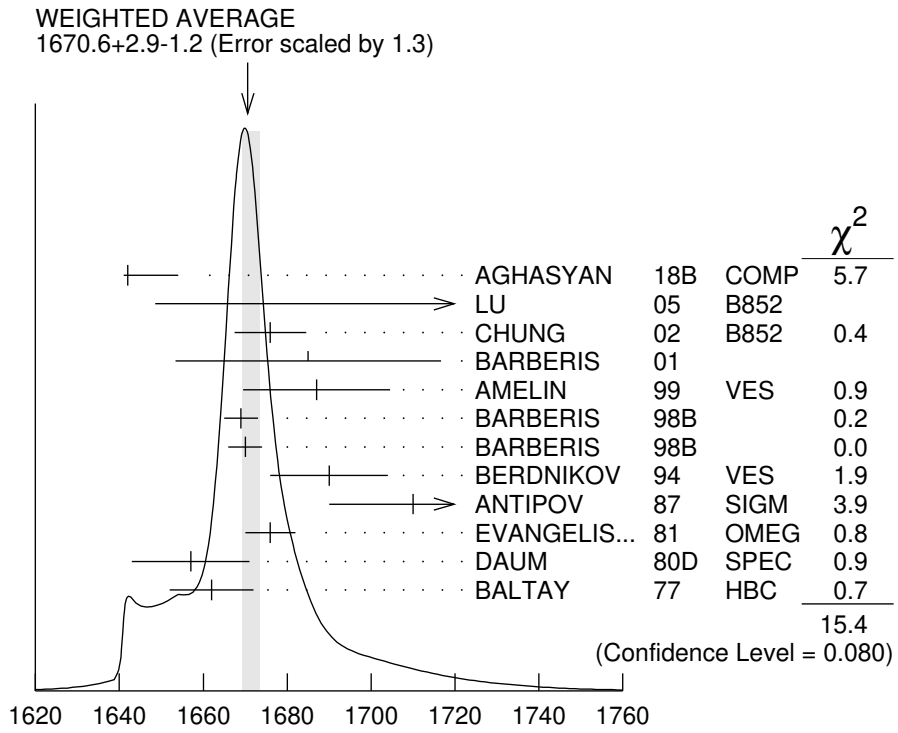
$\pi_2(1670)$ MASS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
$1670.6^{+\ 2.9}_{-\ 1.2}$ OUR AVERAGE Error includes scale factor of 1.3. See the ideogram below.						
$1642\ ^{+12}_{-\ 1}$	46M	[1] AGHASYAN	18B	COMP		190 $\pi^- p \to \pi^-\pi^+\pi^- p$
$1749 \pm 10 \pm 100$	145k	LU	05	B852		18 $\pi^- p \to \omega\pi^-\pi^0 p$
$1676 \pm 3 \pm 8$		[2] CHUNG	02	B852		18.3 $\pi^- p \to \pi^+\pi^-\pi^- p$
$1685 \pm 10 \pm 30$		BARBERIS	01			450 $pp \to p_f 3\pi^0 p_s$
$1687 \pm 9 \pm 15$		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 $pp \to p_f f_2(1270)\pi p_s$
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] EVANGELIS...	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. • • •						
$1658 \pm 3\ ^{+\ 24}_{-\ 8}$	420k	[5] ALEKSEEV	10	COMP		190 $\pi^- Pb \to \pi^-\pi^-\pi^+ Pb'$
1730 ± 20		[6] AMELIN	95B	VES		36 $\pi^- A \to \pi^+\pi^-\pi^- A$
$1742 \pm 31 \pm 49$		ANTREASYAN	90	CBAL		$e^+e^- \to e^+e^-\pi^0\pi^0\pi^0$
1624 ± 21		[2] BELLINI	85	SPEC		40 $\pi^- A \to \pi^-\pi^+\pi^- A$
1622 ± 35		[7] BELLINI	85	SPEC		40 $\pi^- A \to \pi^-\pi^+\pi^- A$
1693 ± 28		[8] BELLINI	85	SPEC		40 $\pi^- A \to \pi^-\pi^+\pi^- A$
1710 ± 20		[9] DAUM	81B	SPEC	$-$	63,94 $\pi^- p$
1660 ± 10		[3] ASCOLI	73	HBC	$-$	5–25 $\pi^- p \to p\pi_2$

[1] Statistical error negligible.
[2] From $f_2(1270)\pi$ decay.
[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[5] Superseded by AGHASYAN 2018B.
[6] J^{PC} ambiguous.
[7] From $\rho\pi$ decay.

[8] From $\sigma\pi$ decay.

[9] 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

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
$258^{+\ 8}_{-\ 9}$ OUR AVERAGE		Error includes scale factor of 1.2.				
$311^{+\ 12}_{-\ 23}$	46M	[10] AGHASYAN	18B	COMP		190 $\pi^- p \to \pi^-\pi^+\pi^- p$
$408\pm\ 60\pm 250$	145k	LU	05	B852		18 $\pi^- p \to\ \omega\pi^-\pi^0 p$
$254\pm\ \ 3\pm\ 31$		[11] CHUNG	02	B852		18.3 $\pi^- p \to \pi^+\pi^-\pi^- p$
$265\pm\ 30\pm\ 40$		BARBERIS	01			450 $pp \to\ p_f 3\pi^0 p_s$
$168\pm\ 43\pm\ 53$		AMELIN	99	VES		37 $\pi^- A \to \omega\pi^-\pi^0 A^*$
$268\pm\ 15$		BARBERIS	98B			450 $pp \to\ p_f \rho\pi p_s$
$256\pm\ 15$		BARBERIS	98B			450 $pp \to p_f f_2(1270)\pi p_s$
$190\pm\ 50$		[12] BERDNIKOV	94	VES		37 $\pi^- A \to K^+K^-\pi^- A$
$170\pm\ 80$	700	ANTIPOV	87	SIGM	−	50 π^- Cu $\to \mu^+\mu^-\pi^-$ Cu
$260\pm\ 20$		[12] EVANGELIS...	81	OMEG	−	12 $\pi^- p \to\ 3\pi p$
$219\pm\ 20$		[12,13] DAUM	80D	SPEC	−	63–94 $\pi p \to\ 3\pi$X
$285\pm\ 60$	2000	[12] BALTAY	77	HBC	+	15 $\pi^+ p \to\ p3\pi$

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

$271\pm\ 9^{+\ 22}_{-\ 24}$	420k	[14] ALEKSEEV	10	COMP		190 $\pi^- Pb \to \pi^-\pi^-\pi^+ Pb'$
$310\pm\ 20$		[15] AMELIN	95B	VES		36 $\pi^- A \to \pi^+\pi^-\pi^- A$
$236\pm\ 49\pm\ 36$		ANTREASYAN	90	CBAL		$e^+e^- \to e^+e^-\pi^0\pi^0\pi^0$
$304\pm\ 22$		[11] BELLINI	85	SPEC		40 $\pi^- A \to \pi^-\pi^+\pi^- A$
404 ± 108		[16] BELLINI	85	SPEC		40 $\pi^- A \to \pi^-\pi^+\pi^- A$
$330\pm\ 90$		[17] BELLINI	85	SPEC		40 $\pi^- A \to \pi^-\pi^+\pi^- A$
$312\pm\ 50$		[18] DAUM	81B	SPEC	–	63,94 $\pi^- p$
$270\pm\ 60$		[12] ASCOLI	73	HBC	–	5–25 $\pi^- p \to\ p\pi_2$

[10] Statistical error negligible.
[11] From $f_2(1270)\pi$ decay.
[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] Superseded by AGHASYAN 2018B.
[15] J^{PC} ambiguous.
[16] From $\rho\pi$ decay.
[17] From $\sigma\pi$ decay.
[18] 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 ±4) %	
Γ_7	$\pi(\pi\pi)_S$-wave	(8.7±3.4) %	
Γ_8	$\pi^\pm\pi^+\pi^-$	(53 ±4) %	
Γ_9	$K\overline{K}^*(892)+$ c.c.	(4.2±1.4) %	
Γ_{10}	$\omega\rho$	(2.7±1.1) %	
Γ_{11}	$\pi^\pm\gamma$	(7.0±1.2) $\times 10^{-4}$	
Γ_{12}	$\gamma\gamma$	$<$ 2.8 $\times 10^{-7}$	90%
Γ_{13}	$\eta\pi$	$<$ 5 %	
Γ_{14}	$\pi^\pm 2\pi^+ 2\pi^-$	$<$ 5 %	
Γ_{15}	$\rho(1450)\pi$	$<$ 3.6 $\times 10^{-3}$	97.7%
Γ_{16}	$b_1(1235)\pi$	$<$ 1.9 $\times 10^{-3}$	97.7%
Γ_{17}	$\eta 3\pi$		
Γ_{18}	$f_1(1285)\pi$	possibly seen	
Γ_{19}	$a_2(1320)\pi$	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 $\left\langle \delta x_i \delta x_j \right\rangle / (\delta x_i \cdot \delta x_j)$, in percent, from the fit to the branching fractions, $x_i \equiv \Gamma_i/\Gamma_{\text{total}}$. The fit constrains the x_i whose labels appear in this array to sum to one.

x_5	−53		
x_7	−29	−59	
x_9	−8	−21	−9
	x_4	x_5	x_7

$\pi_2(1670)$ PARTIAL WIDTHS

$\Gamma(\pi^\pm\gamma)$ Γ_{11}

VALUE (keV)	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
181±11±27	[19] ADOLPH	14	COMP	−	190 π^- Pb → $\pi^+\pi^-\pi^-$ Pb′

[19] Primakoff reaction. Assumes incoherent $f_2(1270)\pi$ contribution to 3π final state and uses B($\pi_2(1670) \to f_2\pi$) = 56%.

$\Gamma(\gamma\gamma)$ Γ_{12}

VALUE (keV)	*CL%*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
<0.072	90	[20] ACCIARRI	97T	L3		$e^+e^- \to e^+e^-\pi^+\pi^-\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<0.19	90	[20] ALBRECHT	97B	ARG		$e^+e^- \to e^+e^-\pi^+\pi^-\pi^0$
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		[21] BEHREND	90C	CELL	0	$e^+e^- \to e^+e^-\pi^+\pi^-\pi^0$
1.3 ±0.3 ±0.2		[22] BEHREND	90C	CELL	0	$e^+e^- \to e^+e^-\pi^+\pi^-\pi^0$

[20] Decaying into $f_2(1270)\pi$ and $\rho\pi$.
[21] Constructive interference between $f_2(1270)\pi$,$\rho\pi$ and background.
[22] Incoherent Ansatz.

$\pi_2(1670)$ Γ(i)$\Gamma(\gamma\gamma)/\Gamma$(total)

$\Gamma(\pi^+\pi^-\pi^0) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\Gamma_2\Gamma_{12}/\Gamma$

VALUE (keV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<0.1	95	[23] SCHEGELSKY	06	RVUE	$\gamma\gamma \to \pi^+\pi^-\pi^0$

[23] From analysis of L3 data at 183–209 GeV.

$\pi_2(1670)$ BRANCHING RATIOS

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

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	BARBERIS	01	450 $pp \to p_f 3\pi^0 p_s$

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

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

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

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.17±0.02±0.07	CHUNG	02	B852	18.3 $\pi^- p \to \pi^+\pi^-\pi^- p$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.24±0.10	[24,25] BAKER	99	SPEC	1.94 $\overline{p}p \to 4\pi^0$

$\frac{1}{2}\Gamma(\rho\pi)/\Gamma(\pi^\pm\pi^+\pi^-)$ $\frac{1}{2}\Gamma_5/\Gamma_8 = \frac{1}{2}\Gamma_5/(0.565\Gamma_4+\frac{1}{2}\Gamma_5+0.624\Gamma_7)$

VALUE	DOCUMENT ID		TECN	CHG	COMMENT
0.29±0.04 OUR FIT					
0.29±0.05	[26] 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 $\pi^+ p \to 3\pi p$

$0.565\Gamma(f_2(1270)\pi)/\Gamma(\pi^\pm\pi^+\pi^-)$ $0.565\Gamma_4/\Gamma_8 = 0.565\Gamma_4/(0.565\Gamma_4+\frac{1}{2}\Gamma_5+0.624\Gamma_7)$

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

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	[26] DAUM	81B	SPEC		63,94 $\pi^- p$
$0.76\ ^{+0.24}_{-0.34}$	ARMENISE	69	DBC	+	5.1 $\pi^+ d \to d3\pi$
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 $\pi^+ p \to 3\pi p$

$0.624\Gamma(\pi(\pi\pi)_{S\text{-wave}})/\Gamma(\pi^\pm\pi^+\pi^-)$ $0.624\Gamma_7/\Gamma_8 = 0.624\Gamma_7/(0.565\Gamma_4+\frac{1}{2}\Gamma_5+0.624\Gamma_7)$

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.10±0.04 OUR FIT				
0.10±0.05	[26] DAUM	81B	SPEC	63,94 $\pi^- p$

$\Gamma(K\overline{K}^*(892)+\text{c.c.})/\Gamma(f_2(1270)\pi)$ Γ_9/Γ_4

VALUE	DOCUMENT ID		TECN	CHG	COMMENT
0.075±0.025 OUR FIT					
0.075±0.025	[27] ARMSTRONG	82B	OMEG	−	16 $\pi^- p \to K^+ K^- \pi^- p$

$\Gamma(\omega\rho)/\Gamma_{\text{total}}$ Γ_{10}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.027±0.004±0.010	[28] AMELIN	99	VES	37 $\pi^- A \to \omega\pi^-\pi^0 A^*$

$\Gamma(\eta\pi)/\Gamma(\pi^\pm\pi^+\pi^-)$ $\Gamma_{13}/\Gamma_8 = \Gamma_{13}/(0.565\Gamma_4+\frac{1}{2}\Gamma_5+0.624\Gamma_7)$

(All η decays.)

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

$\Gamma(\pi^\pm 2\pi^+ 2\pi^-)/\Gamma(\pi^\pm\pi^+\pi^-)$ $\Gamma_{14}/\Gamma_8 = \Gamma_{14}/(0.565\Gamma_4+\frac{1}{2}\Gamma_5+0.624\Gamma_7)$

VALUE	DOCUMENT ID		TECN	CHG	COMMENT
<0.10	CRENNELL	70	HBC	−	6 $\pi^- p \to f_2 \pi^- N$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.1	BALTAY	68	HBC	+	7,8.5 $\pi^+ p$

$\Gamma(\rho(1450)\pi)/\Gamma_{\text{total}}$ Γ_{15}/Γ

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

$\Gamma(b_1(1235)\pi)/\Gamma_{\text{total}}$ Γ_{16}/Γ

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

$\Gamma(f_1(1285)\pi)/\Gamma_{\text{total}}$ Γ_{18}/Γ

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

$\Gamma(a_2(1320)\pi)/\Gamma_{\text{total}}$ Γ_{19}/Γ

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

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

VALUE	DOCUMENT ID		TECN	COMMENT
−0.18±0.06	[24] BAKER	99	SPEC	1.94 $\overline{p}p \to 4\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.22±0.10	[26] DAUM	81B	SPEC	63,94 $\pi^- p$

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

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
$-0.72\pm0.07\pm0.14$	CHUNG	02	B852	18.3 $\pi^- p \rightarrow \pi^+\pi^-\pi^- p$

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

$\pi_2(1670)$ REFERENCES

AGHASYAN	18B	PR D98 092003	M. Aghasyan *et al.*	(COMPASS Collab.)
ADOLPH	14	EPJ A50 79	C. Adolph *et al.*	(COMPASS Collab.)
ALEKSEEV	10	PRL 104 241803	M.G. Alekseev *et al.*	(COMPASS Collab.)
SCHEGELSKY	06	EPJ A27 199	V.A. Schegelsky *et al.*	
LU	05	PRL 94 032002	M. Lu *et al.*	(BNL E852 Collab.)
KUHN	04	PL B595 109	J. Kuhn *et al.*	(BNL E852 Collab.)
CHUNG	02	PR D65 072001	S.U. Chung *et al.*	(BNL E852 Collab.)
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+)
EVANGELIS...	81	NP B178 197	C. Evangelista *et al.*	(BARI, BONN, CERN+)
Also		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
CRENNELL	70	PRL 24 781	D.J. Crennell *et al.*	(BNL)
ARMENISE	69	LNC 2 501	N. Armenise *et al.*	(BARI, BGNA, FIRZ)
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