

$\pi_2(1670)$

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

$\pi_2(1670)$ 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 $\pi^- p \rightarrow \pi^- \pi^+ \pi^- p$
1749 ±10 ±100	145k	LU	05	B852	18 $\pi^- p \rightarrow \omega \pi^- \pi^0 p$
1676 ± 3 ± 8		2 CHUNG	02	B852	18.3 $\pi^- p \rightarrow \pi^+ \pi^- \pi^- p$
1685 ±10 ± 30		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 $p p \rightarrow p_f f_2(1270) \pi p_s$
1690 ±14		3 BERDNIKOV	94	VES	37 $\pi^- A \rightarrow K^+ K^- \pi^- A$
1710 ±20	700	ANTIPOV	87	SIGM -	50 $\pi^- \text{Cu} \rightarrow \mu^+ \mu^- \pi^- \text{Cu}$
1676 ± 6		3 EVANGELIS...	81	OMEG -	12 $\pi^- p \rightarrow 3\pi p$
1657 ±14		3,4 DAUM	80D	SPEC -	63-94 $\pi p \rightarrow 3\pi X$
1662 ±10	2000	3 BALTAY	77	HBC +	15 $\pi^+ p \rightarrow p 3\pi$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
1658 ± 3 ⁺²⁴ ₋₈	420k	5 ALEKSEEV	10	COMP	190 $\pi^- Pb \rightarrow \pi^- \pi^- \pi^+ Pb'$
1730 ±20		6 AMELIN	95B	VES	36 $\pi^- A \rightarrow \pi^+ \pi^- \pi^- A$
1742 ±31 ± 49		ANTREASYAN	90	CBAL	$e^+ e^- \rightarrow e^+ e^- \pi^0 \pi^0 \pi^0$
1624 ±21		2 BELLINI	85	SPEC	40 $\pi^- A \rightarrow \pi^- \pi^+ \pi^- A$
1622 ±35		7 BELLINI	85	SPEC	40 $\pi^- A \rightarrow \pi^- \pi^+ \pi^- A$
1693 ±28		8 BELLINI	85	SPEC	40 $\pi^- A \rightarrow \pi^- \pi^+ \pi^- A$
1710 ±20		9 DAUM	81B	SPEC -	63,94 $\pi^- p$
1660 ±10		3 ASCOLI	73	HBC -	5-25 $\pi^- p \rightarrow p \pi_2$

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.

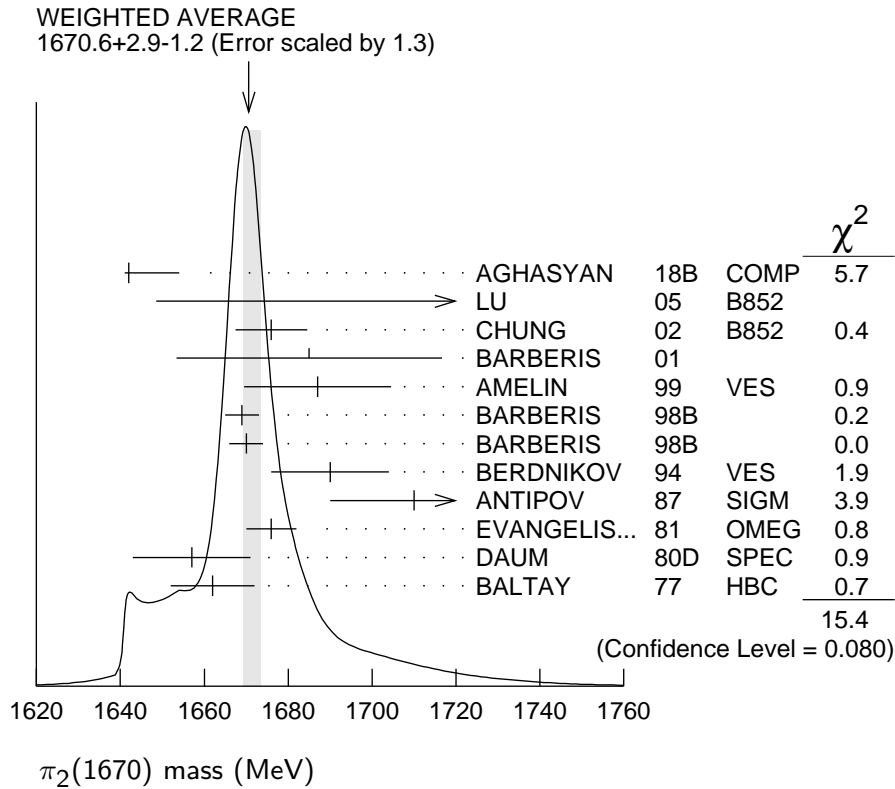
⁵ Superseded by AGHASYAN 2018B.

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 $\pi^- p \rightarrow \pi^- \pi^+ \pi^- p$
408 ± 60 ± 250	145k	LU	05	B852	18 $\pi^- p \rightarrow \omega \pi^- \pi^0 p$
254 ± 3 ± 31		¹¹ CHUNG	02	B852	18.3 $\pi^- p \rightarrow \pi^+ \pi^- \pi^- p$
265 ± 30 ± 40		BARBERIS	01		450 $pp \rightarrow p_f 3\pi^0 p_s$
168 ± 43 ± 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 $pp \rightarrow p_f f_2(1270) \pi p_s$
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. • • •

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

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 $K\bar{K}^*(892) + c.c.$	(4.2 ± 1.4) %	
Γ_{10} $\omega\rho$	(2.7 ± 1.1) %	
Γ_{11} $\pi^\pm \gamma$	(7.0 ± 1.2) × 10 ⁻⁴	
Γ_{12} $\gamma\gamma$	< 2.8 × 10 ⁻⁷	90%
Γ_{13} $\eta\pi$	< 5 %	
Γ_{14} $\pi^\pm 2\pi^+ 2\pi^-$	< 5 %	
Γ_{15} $\rho(1450)\pi$	< 3.6 × 10 ⁻³	97.7%
Γ_{16} $b_1(1235)\pi$	< 1.9 × 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 $\langle \delta x_i \delta x_j \rangle / (\delta x_i \delta x_j)$, 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_9	-8	-21	-9
	x_4	x_5	x_7

$\pi_2(1670)$ PARTIAL WIDTHS

$\Gamma(\pi^\pm \gamma)$						Γ_{11}
<u>VALUE (keV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>		
$181 \pm 11 \pm 27$	¹⁹ ADOLPH	14	COMP	-	190 $\pi^- \text{Pb} \rightarrow \pi^+ \pi^- \pi^- \text{Pb}'$	
¹⁹ Primakoff reaction. Assumes incoherent $f_2(1270)\pi$ contribution to 3π final state and uses $B(\pi_2(1670) \rightarrow f_2 \pi) = 56\%$.						

$\Gamma(\gamma\gamma)$						Γ_{12}
<u>VALUE (keV)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>	
<0.072	90	²⁰ 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	²⁰ ALBRECHT	97B	ARG	$e^+ e^- \rightarrow e^+ e^- \pi^+ \pi^- \pi^0$	
$1.41 \pm 0.23 \pm 0.28$		ANTREASYAN	90	CBAL	0 $e^+ e^- \rightarrow e^+ e^- \pi^0 \pi^0 \pi^0$	
$0.8 \pm 0.3 \pm 0.12$		²¹ BEHREND	90C	CELL	0 $e^+ e^- \rightarrow e^+ e^- \pi^+ \pi^- \pi^0$	
$1.3 \pm 0.3 \pm 0.2$		²² BEHREND	90C	CELL	0 $e^+ e^- \rightarrow e^+ e^- \pi^+ \pi^- \pi^0$	

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.

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

$\Gamma(\pi^+ \pi^- \pi^0) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$						$\Gamma_2 \Gamma_{12}/\Gamma$
<u>VALUE (keV)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
<0.1	95	²³ SCHEGELSKY	06	RVUE	$\gamma\gamma \rightarrow \pi^+ \pi^- \pi^0$	
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 $p p \rightarrow p_f 3\pi^0 p_s$

$\Gamma(\rho\pi)/0.565\Gamma(f_2(1270)\pi)$ $\Gamma_5/0.565\Gamma_4$
 (With $f_2(1270) \rightarrow \pi^+ \pi^-$.)
VALUE DOCUMENT ID TECN 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 $p p \rightarrow p_f \pi^+ \pi^- \pi^0 p_s$

$\Gamma(\sigma\pi)/\Gamma(f_2(1270)\pi)$ Γ_6/Γ_4
VALUE DOCUMENT ID TECN COMMENT
0.17 ± 0.02 ± 0.07 CHUNG 02 B852 18.3 $\pi^- p \rightarrow \pi^+ \pi^- \pi^- p$
 • • • We do not use the following data for averages, fits, limits, etc. • • •
 0.24 ± 0.10 24,25 BAKER 99 SPEC 1.94 $\bar{p} p \rightarrow 4\pi^0$

$\frac{1}{2}\Gamma(\rho\pi)/\Gamma(\pi^\pm \pi^+ \pi^-)$ $\frac{1}{2}\Gamma_5/\Gamma_8 = \frac{1}{2}\Gamma_5/(0.565\Gamma_4 + \frac{1}{2}\Gamma_5 + 0.624\Gamma_7)$
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 $\pi^+ p \rightarrow 3\pi p$

$0.565\Gamma(f_2(1270)\pi)/\Gamma(\pi^\pm \pi^+ \pi^-)$ $0.565\Gamma_4/\Gamma_8 = 0.565\Gamma_4/(0.565\Gamma_4 + \frac{1}{2}\Gamma_5 + 0.624\Gamma_7)$
 (With $f_2(1270) \rightarrow \pi^+ \pi^-$.)
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 26 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 $\pi^+ p \rightarrow 3\pi p$

$0.624\Gamma(\pi(\pi\pi)_{S\text{-wave}})/\Gamma(\pi^\pm \pi^+ \pi^-)$ $0.624\Gamma_7/\Gamma_8 = 0.624\Gamma_7/(0.565\Gamma_4 + \frac{1}{2}\Gamma_5 + 0.624\Gamma_7)$
 (With $(\pi\pi)_{S\text{-wave}} \rightarrow \pi^+ \pi^-$.)
VALUE DOCUMENT ID TECN COMMENT
0.10 ± 0.04 OUR FIT
0.10 ± 0.05 26 DAUM 81B SPEC 63,94 $\pi^- p$

$\Gamma(K\bar{K}^*(892)+c.c.)/\Gamma(f_2(1270)\pi)$ 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 $\pi^- p \rightarrow K^+ K^- \pi^- p$

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

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

$\Gamma(\eta\pi)/\Gamma(\pi^\pm\pi^+\pi^-)$ $\Gamma_{13}/\Gamma_8 = \Gamma_{13}/(0.565\Gamma_4 + \frac{1}{2}\Gamma_5 + 0.624\Gamma_7)$
(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 $\pi^- p \rightarrow f_2 \pi^- N$

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

VALUE	DOCUMENT ID	TECN	CHG	COMMENT	
<0.10	CRENNELL	70	HBC	-	6 $\pi^- p \rightarrow f_2 \pi^- N$
••• 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 $\pi^- A \rightarrow \omega \pi^- \pi^0 A^*$

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

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

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

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

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

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

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

VALUE	DOCUMENT ID	TECN	COMMENT	
-0.18±0.06	24 BAKER	99	SPEC	1.94 $\bar{p} p \rightarrow 4\pi^0$
••• 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 $\pi_2(1670) \rightarrow \rho\pi$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$-0.72 \pm 0.07 \pm 0.14$	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 <i>et al.</i>	(COMPASS Collab.)
ADOLPH	14	EPJ A50 79	C. Adolph <i>et al.</i>	(COMPASS Collab.)
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.)
		Translated from YAF 62 487.		
BAKER	99	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>	
		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 <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