

$\Delta(1232) P_{33}$ $I(J^P) = \frac{3}{2}(\frac{3}{2}^+)$ Status: ****

Most of the results published before 1977 are now obsolete and have been omitted. They may be found in our 1982 edition, Physics Letters **111B** (1982).

 $\Delta(1232)$ BREIT-WIGNER MASSES**MIXED CHARGES**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1230 to 1234 (\approx 1232) OUR ESTIMATE			
1231 \pm 1	MANLEY	92	IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$
1232 \pm 3	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1233 \pm 2	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1233	ARNDT	95	DPWA $\pi N \rightarrow N\pi$

 $\Delta(1232)^{++}$ MASS

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1230.5 \pm 0.2	ABAEV	95	IPWA $\pi N \rightarrow \pi N$
1230.9 \pm 0.3	KOCH	80B	IPWA $\pi N \rightarrow \pi N$
1231.1 \pm 0.2	PEDRONI	78	$\pi N \rightarrow \pi N$ 70–370 MeV

 $\Delta(1232)^+$ MASS

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1231.6	CRAWFORD	80	DPWA $\gamma N \rightarrow \pi N$
1234.9 \pm 1.4	MIROSHNIC...	79	Fit photoproduction
1231.2	BARBOUR	78	DPWA $\gamma N \rightarrow \pi N$
1231.8	BERENDS	75	IPWA $\gamma p \rightarrow \pi N$

 $\Delta(1232)^0$ MASS

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1233.1 \pm 0.3	ABAEV	95	IPWA $\pi N \rightarrow \pi N$
1233.6 \pm 0.5	KOCH	80B	IPWA $\pi N \rightarrow \pi N$
1233.8 \pm 0.2	PEDRONI	78	$\pi N \rightarrow \pi N$ 70–370 MeV

 $m_{\Delta^0} - m_{\Delta^{++}}$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
2.25 \pm 0.68	BERNICA	96	Fit to PEDRONI 78
2.6 \pm 0.4	ABAEV	95	IPWA $\pi N \rightarrow \pi N$
2.7 \pm 0.3	¹ PEDRONI	78	See the masses

$\Delta(1232)$ BREIT-WIGNER WIDTHS**MIXED CHARGES**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
115 to 125 (≈ 120) OUR ESTIMATE			
118 \pm 4	MANLEY	92	IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$
120 \pm 5	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
116 \pm 5	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
114	ARNDT	95	DPWA $\pi N \rightarrow N\pi$

 $\Delta(1232)^{++}$ WIDTH

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
111.0 \pm 1.0	KOCH	80B	IPWA $\pi N \rightarrow \pi N$
111.3 \pm 0.5	PEDRONI	78	$\pi N \rightarrow \pi N$ 70–370 MeV

 $\Delta(1232)^+$ WIDTH

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •			
111.2	CRAWFORD	80	DPWA $\gamma N \rightarrow \pi N$
131.1 \pm 2.4	MIROSHNIC...	79	Fit photoproduction
111.0	BARBOUR	78	DPWA $\gamma N \rightarrow \pi N$

 $\Delta(1232)^0$ WIDTH

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
113.0 \pm 1.5	KOCH	80B	IPWA $\pi N \rightarrow \pi N$
117.9 \pm 0.9	PEDRONI	78	$\pi N \rightarrow \pi N$ 70–370 MeV

 Δ^0 - Δ^{++} WIDTH DIFFERENCE

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •			
8.45 \pm 1.11	BERNICHIA	96	Fit to PEDRONI 78
5.1 \pm 1.0	ABAEV	95	IPWA $\pi N \rightarrow \pi N$
6.6 \pm 1.0	PEDRONI	78	See the widths

 $\Delta(1232)$ POLE POSITIONS**REAL PART, MIXED CHARGES**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1209 to 1211 (≈ 1210) OUR ESTIMATE			
1211	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1209	² HOEHLER	93	ARGD $\pi N \rightarrow \pi N$
1210 \pm 1	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1210	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

– 2×IMAGINARY PART, MIXED CHARGES

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
98 to 102 (≈ 100) OUR ESTIMATE			
100	ARNDT	95 DPWA	$\pi N \rightarrow N\pi$
100	² HOEHLER	93 ARGD	$\pi N \rightarrow \pi N$
100±2	CUTKOSKY	80 IPWA	$\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
100	ARNDT	91 DPWA	$\pi N \rightarrow \pi N$ Soln SM90

REAL PART, $\Delta(1232)^{++}$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>COMMENT</u>
1209.6±0.5	³ VASAN	76B Fit to CARTER 73
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●		
1210.5 to 1210.8	⁴ VASAN	76B Fit to CARTER 73

– 2×IMAGINARY PART, $\Delta(1232)^{++}$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>COMMENT</u>
100.8±1.0	³ VASAN	76B Fit to CARTER 73
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●		
99.8 to 100	⁴ VASAN	76B Fit to CARTER 73

REAL PART, $\Delta(1232)^+$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1208.0±2.0	CAMPBELL	76	Fit photoproduction
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1211 ±1 to 1212 ± 1	HANSTEIN	96 DPWA	$\gamma N \rightarrow \pi N$
1206.9±0.9 to 1210.5 ± 1.8	MIROSHNIC...	79	Fit photoproduction

– 2×IMAGINARY PART, $\Delta(1232)^+$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
106 ±4	CAMPBELL	76	Fit photoproduction
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
102 ±2 to 99 ± 2	HANSTEIN	96 DPWA	$\gamma N \rightarrow \pi N$
111.2±2.0 to 116.6 ± 2.2	MIROSHNIC...	79	Fit photoproduction

REAL PART, $\Delta(1232)^0$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>COMMENT</u>
1210.75±0.6	³ VASAN	76B Fit to CARTER 73
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●		
1210.2	⁴ VASAN	76B Fit to CARTER 73

– 2×IMAGINARY PART, $\Delta(1232)^0$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>COMMENT</u>
105.6±1.2	³ VASAN	76B Fit to CARTER 73
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●		
105.8 to 106.2	⁴ VASAN	76B Fit to CARTER 73

$\Delta(1232)$ ELASTIC POLE RESIDUES**ABSOLUTE VALUE, MIXED CHARGES**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
38	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
50	HOEHLER	93	ARGD $\pi N \rightarrow \pi N$
53 ± 2	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
52	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

PHASE, MIXED CHARGES

<u>VALUE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
−22	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
−48	HOEHLER	93	ARGD $\pi N \rightarrow \pi N$
−47 ± 1	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
−31	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

ABSOLUTE VALUE, $\Delta(1232)^{++}$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●		
52.4 to 53.2	³ VASAN	76B Fit to CARTER 73
52.1 to 52.4	⁴ VASAN	76B Fit to CARTER 73

PHASE, $\Delta(1232)^{++}$

<u>VALUE (rad)</u>	<u>DOCUMENT ID</u>	<u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●		
−0.822 to −0.833	³ VASAN	76B Fit to CARTER 73
−0.823 to −0.830	⁴ VASAN	76B Fit to CARTER 73

ABSOLUTE VALUE, $\Delta(1232)^0$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●		
54.8 to 55.0	³ VASAN	76B Fit to CARTER 73
55.2 to 55.3	⁴ VASAN	76B Fit to CARTER 73

PHASE, $\Delta(1232)^0$

<u>VALUE (rad)</u>	<u>DOCUMENT ID</u>	<u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●		
−0.840 to −0.847	³ VASAN	76B Fit to CARTER 73
−0.848 to −0.856	⁴ VASAN	76B Fit to CARTER 73

$\Delta(1232)$ DECAY MODES

The following branching fractions are our estimates, not fits or averages.

Mode	Fraction (Γ_i/Γ)
Γ_1 $N\pi$	>99 %
Γ_2 $N\gamma$	0.52–0.60 %
Γ_3 $N\gamma$, helicity=1/2	0.11–0.13 %
Γ_4 $N\gamma$, helicity=3/2	0.41–0.47 %

$\Delta(1232)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$				Γ_1/Γ
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
0.993 to 0.995 OUR ESTIMATE				
1.0	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
1.0	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
1.0	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
1.0	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$

$\Delta(1232)$ PHOTON DECAY AMPLITUDES

$\Delta(1232) \rightarrow N\gamma$, helicity-1/2 amplitude $A_{1/2}$

<u>VALUE ($\text{GeV}^{-1/2}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
–0.135 ±0.006 OUR ESTIMATE			
–0.135 ±0.005	ARNDT	97	IPWA $\gamma N \rightarrow \pi N$
–0.1278 ±0.0012	DAVIDSON	97	DPWA $\gamma N \rightarrow \pi N$
–0.132 ±0.002	TIATOR	97	DPWA $\gamma N \rightarrow \pi N$
–0.141 ±0.005	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
–0.135 ±0.016	DAVIDSON	91B	FIT $\gamma N \rightarrow \pi N$
–0.145 ±0.015	CRAWFORD	83	IPWA $\gamma N \rightarrow \pi N$
–0.138 ±0.004	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
–0.147 ±0.001	ARAI	80	DPWA $\gamma N \rightarrow \pi N$ (fit 1)
–0.145 ±0.001	ARAI	80	DPWA $\gamma N \rightarrow \pi N$ (fit 2)
–0.136 ±0.006	CRAWFORD	80	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
–0.143 ±0.004	LI	93	IPWA $\gamma N \rightarrow \pi N$
–0.140 ±0.007	DAVIDSON	90	FIT See DAVIDSON 91B
–0.142 ±0.007	BARBOUR	78	DPWA $\gamma N \rightarrow \pi N$
–0.140	⁵ NOELLE	78	$\gamma N \rightarrow \pi N$
–0.141 ±0.004	FELLER	76	DPWA $\gamma N \rightarrow \pi N$

$\Delta(1232) \rightarrow N\gamma$, helicity-3/2 amplitude $A_{3/2}$

<u>VALUE (GeV^{-1/2})</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-0.255 ±0.008 OUR ESTIMATE			
-0.250 ±0.008	ARNDT	97	IPWA $\gamma N \rightarrow \pi N$
-0.2524 ±0.0013	DAVIDSON	97	DPWA $\gamma N \rightarrow \pi N$
-0.253 ±0.003	TIATOR	97	DPWA $\gamma N \rightarrow \pi N$
-0.261 ±0.005	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
-0.251 ±0.033	DAVIDSON	91B	FIT $\gamma N \rightarrow \pi N$
-0.263 ±0.026	CRAWFORD	83	IPWA $\gamma N \rightarrow \pi N$
-0.259 ±0.006	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
-0.264 ±0.002	ARAI	80	DPWA $\gamma N \rightarrow \pi N$ (fit 1)
-0.261 ±0.002	ARAI	80	DPWA $\gamma N \rightarrow \pi N$ (fit 2)
-0.247 ±0.010	CRAWFORD	80	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
-0.262 ±0.004	LI	93	IPWA $\gamma N \rightarrow \pi N$
-0.254 ±0.011	DAVIDSON	90	FIT See DAVIDSON 91B
-0.271 ±0.010	BARBOUR	78	DPWA $\gamma N \rightarrow \pi N$
-0.247	⁵ NOELLE	78	$\gamma N \rightarrow \pi N$
-0.256 ±0.003	FELLER	76	DPWA $\gamma N \rightarrow \pi N$

 $\Delta(1232) \rightarrow N\gamma$, E_2/M_1 ratio

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-0.025 ±0.005 OUR ESTIMATE			
-0.015 ±0.005	⁶ ARNDT	97	IPWA $\gamma N \rightarrow \pi N$
-0.025 ±0.002 ±0.002	BECK	97	IPWA $\gamma N \rightarrow \pi N$
-0.030 ±0.003 ±0.002	BLANPIED	97	DPWA $\gamma N \rightarrow \pi N, \gamma N$
-0.0319 ±0.0024	DAVIDSON	97	DPWA $\gamma N \rightarrow \pi N$
-0.025 ±0.001	TIATOR	97	DPWA $\gamma N \rightarrow \pi N$
-0.015 ±0.005	WORKMAN	92	IPWA $\gamma N \rightarrow \pi N$
-0.0157 ±0.0072	DAVIDSON	91B	FIT $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
-0.027 ±0.003 ±0.001	KHANDAKER	95	DPWA $\gamma N \rightarrow \pi N$
-0.0107 ±0.0037	DAVIDSON	90	FIT $\gamma N \rightarrow \pi N$
-0.015 ±0.002	DAVIDSON	86	FIT $\gamma N \rightarrow \pi N$
+0.037 ±0.004	TANABE	85	FIT $\gamma N \rightarrow \pi N$

 $\Delta(1232) \rightarrow N\gamma$, absolute value of E_2/M_1 ratio at pole

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
-0.065 ±0.007	ARNDT	97	DPWA $\gamma N \rightarrow \pi N$
-0.058	HANSTEIN	96	DPWA $\gamma N \rightarrow \pi N$

 $\Delta(1232) \rightarrow N\gamma$, phase of E_2/M_1 ratio at pole

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
-122 ±5	ARNDT	97	DPWA $\gamma N \rightarrow \pi N$
-127.2	HANSTEIN	96	DPWA $\gamma N \rightarrow \pi N$

$\Delta(1232)^{++}$ MAGNETIC MOMENT

The values are extracted from UCLA and SIN data on $\pi^+ p$ bremsstrahlung using a variety of different theoretical approximations and methods. Our estimate is *only* a rough guess of the range we expect the moment to lie within.

VALUE (μ_N)	DOCUMENT ID	COMMENT
3.7 to 7.5 OUR ESTIMATE		
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●		
$4.52 \pm 0.50 \pm 0.45$	BOSSHARD 91	$\pi^+ p \rightarrow \pi^+ p \gamma$ (SIN data)
3.7 to 4.2	LIN 91B	$\pi^+ p \rightarrow \pi^+ p \gamma$ (from UCLA data)
4.6 to 4.9	LIN 91B	$\pi^+ p \rightarrow \pi^+ p \gamma$ (from SIN data)
5.6 to 7.5	WITTMAN 88	$\pi^+ p \rightarrow \pi^+ p \gamma$ (from UCLA data)
6.9 to 9.8	HELLER 87	$\pi^+ p \rightarrow \pi^+ p \gamma$ (from UCLA data)
4.7 to 6.7	NEFKENS 78	$\pi^+ p \rightarrow \pi^+ p \gamma$ (UCLA data)

 $\Delta(1232)$ FOOTNOTES

- ¹ Using $\pi^\pm d$ as well, PEDRONI 78 determine $(M^- - M^{++}) + (M^0 - M^+)/3 = 4.6 \pm 0.2$ MeV.
- ² See HOEHLER 93 for a detailed discussion of the evidence for and the pole parameters of N and Δ resonances as determined from Argand diagrams of πN elastic partial-wave amplitudes and from plots of the speeds with which the amplitudes traverse the diagrams.
- ³ This VASAN 76B value is from fits to the coulomb-barrier-corrected CARTER 73 phase shift.
- ⁴ This VASAN 76B value is from fits to the CARTER 73 nuclear phase shift without coulomb barrier corrections.
- ⁵ Converted to our conventions using $M = 1232$ MeV, $\Gamma = 110$ MeV from NOELLE 78.
- ⁶ This ARNDT 97 value is very sensitive to the database being fitted. The result is from a fit to the full pion photoproduction database, apart from the BLANPIED 97 cross-section measurements.

 $\Delta(1232)$ REFERENCES

For early references, see Physics Letters **111B** 70 (1982).

ARNDT 97	PR C56 577	+Strakovsky, Workman	(VPI)
BECK 97	PRL 78 606	+Krahn+	(MANZ, SACL, PAVI, GLAS)
Also 97B	PRL 79 4510	Beck, Krahn	(MANZ)
Also 97C	PRL 79 4512	Beck, Krahn	(MANZ)
Also 97D	PRL 79 4515 (erratum)	Beck, Krahn+	(MANZ, SACL, PAVI, GLAS)
BLANPIED 97	PRL 79 4337	+Blecher, Caracappa+	(LEGS Collab.)
DAVIDSON 97	PRL 79 4509	+Mukhopadhyay	(RPI)
TIATOR 97	πN Newsletter 13, 127		(MANZ)
ARNDT 96	PR C53 430	+Strakovsky, Workman	(VPI)
BERNICHIA 96	NP A597 623	+Lopez Castro, Pestieau	(LOUV, CINV)
HANSTEIN 96	PL B385 45	+Drechsel, Tiator	(MANZ)
ABAEV 95	ZPHY A352 85	+Kruglov	(PNPI)
ARNDT 95	PR C52 2120	+Strakovsky, Workman, Pavan	(VPI, BRCO)
KHANDAKER 95	PR D51 3966	+Sandorfi	(BNL, VPI)
HOEHLER 93	πN Newsletter 9 1		(KARL)
LI 93	PR C47 2759	+Arndt, Roper, Workman	(VPI)
MANLEY 92	PR D45 4002	+Saleski	(KENT IJP)
Also 84	PR D30 904	Manley, Arndt, Goradia, Teplitz	(VPI)
WORKMAN 92	PR C46 1546	+Arndt, Li	(VPI)
ARNDT 91	PR D43 2131	+Li, Roper, Workman, Ford	(VPI, TELE) IJP
BOSSHARD 91	PR D44 1962	+Amsler+ (ZURI, LBL, VILL, LAUS, UCLA, CATH)	
Also 90	PRL 64 2619	Bosshard+ (CATH, LAUS, LBL, VILL, UCLA, ZURI)	
DAVIDSON 91B	PR D43 71	+Mukhopadhyay, Wittman	(RPI)

LIN	91B	PR C44 1819	+Liou, Ding	(CUNY, CSOK)
Also	91	PR C43 R930	Lin, Liou	(CUNY)
DAVIDSON	90	PR D42 20	+Mukhopadhyay	(RPI)
WITTMAN	88	PR C37 2075		(TRIU)
HELLER	87	PR C35 718	+Kumano, Martinez, Moniz	(LANL, MIT, ILL)
DAVIDSON	86	PRL 56 804	+Mukhopadhyay, Wittman	(RPI)
TANABE	85	PR C31 1876	+Ohta	(KOMAB)
CRAWFORD	83	NP B211 1	+Morton	(GLAS)
PDG	82	PL 111B	Roos, Porter, Aguilar-Benitez+	(HELS, CIT, CERN)
AWAJI	81	Bonn Conf. 352	+Kajikawa	(NAGO)
Also	82	NP B197 365	Fujii, Hayashii, Iwata, Kajikawa+	(NAGO)
ARAI	80	Toronto Conf. 93		(INUS)
Also	82	NP B194 251	Arai, Fujii	(INUS)
CRAWFORD	80	Toronto Conf. 107		(GLAS)
CUTKOSKY	80	Toronto Conf. 19	+Forsyth, Babcock, Kelly, Hendrick	(CMU, LBL) IJP
Also	79	PR D20 2839	Cutkosky, Forsyth, Hendrick, Kelly	(CMU, LBL)
KOCH	80B	NP A336 331	+Pietarinen	(KARLT) IJP
HOEHLER	79	PDAT 12-1	+Kaiser, Koch, Pietarinen	(KARLT) IJP
Also	80	Toronto Conf. 3	Koch	(KARLT) IJP
MIROSHNIC...	79	SJNP 29 94	Miroshnichenko, Nikiforov, Sanin+	(KFTI) IJP
		Translated from YAF 29 188.		
BARBOUR	78	NP B141 253	+Crawford, Parsons	(GLAS)
NEFKENS	78	PR D18 3911	+Arman, Ballagh, Glodis, Haddock+	(UCLA, CATH) IJP
NOELLE	78	PTP 60 778		(NAGO)
PEDRONI	78	NP A300 321	+Gabathuler, Domingo, Hirt+	(SIN, ISNG, KARLE+) IJP
CAMPBELL	76	PR D14 2431	+Shaw, Ball	(BOIS, UCI, UTAH) IJP
FELLER	76	NP B104 219	+Fukushima, Horikawa, Kajikawa+	(NAGO, OSAK) IJP
VASAN	76B	NP B106 535		(CMU) IJP
Also	76	NP B106 526	Vasan	(CMU) IJP
BERENDS	75	NP B84 342	+Donnachie	(LEID, MCHS)
CARTER	73	NP B58 378	+Bugg, Carter	(CAVE, LOQM) IJP