

N(1520) D_{13}

$$I(J^P) = \frac{1}{2}(\frac{3}{2}^-) \text{ Status: } ****$$

Most of the results published before 1975 were last included in our 1982 edition, Physics Letters **111B** 1 (1982). Some further obsolete results published before 1984 were last included in our 2006 edition, Journal of Physics, G **33** 1 (2006).

N(1520) BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1515 to 1525 (\approx 1520) OUR ESTIMATE			
1514.5 \pm 0.2	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1524 \pm 4	MANLEY	92	IPWA $\pi N \rightarrow \pi N \ \& \ N\pi\pi$
1525 \pm 10	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1519 \pm 4	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1520 \pm 10	THOMA	08	DPWA Multichannel
1516.3 \pm 0.8	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1509 \pm 1	PENNER	02C	DPWA Multichannel
1518 \pm 3	VRANA	00	DPWA Multichannel
1516 \pm 10	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
1515	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1526 \pm 18	BATINIC	95	DPWA $\pi N \rightarrow N\pi, N\eta$
1510	LI	93	IPWA $\gamma N \rightarrow \pi N$
1510	¹ LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
1520	² LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

N(1520) BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
100 to 125 (\approx 115) OUR ESTIMATE			
103.6 \pm 0.4	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
124 \pm 8	MANLEY	92	IPWA $\pi N \rightarrow \pi N \ \& \ N\pi\pi$
120 \pm 15	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
114 \pm 7	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
125 \pm 15	THOMA	08	DPWA Multichannel
98.6 \pm 2.6	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
100 \pm 2	PENNER	02C	DPWA Multichannel
124 \pm 4	VRANA	00	DPWA Multichannel
106 \pm 4	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
106	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
143 \pm 32	BATINIC	95	DPWA $\pi N \rightarrow N\pi, N\eta$
120	LI	93	IPWA $\gamma N \rightarrow \pi N$
110	¹ LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
150	² LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

N(1520) POLE POSITION

REAL PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1505 to 1515 (\approx 1510) OUR ESTIMATE			
1515	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1510	³ HOEHLER	93	ARGD $\pi N \rightarrow \pi N$
1510 \pm 5	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1509 \pm 7	THOMA	08	DPWA Multichannel
1514	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1504	VRANA	00	DPWA Multichannel
1515	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1511	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90
1514 or 1511	⁴ LONGACRE	78	IPWA $\pi N \rightarrow N\pi\pi$
1508 or 1505	¹ LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$

–2×IMAGINARY PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
105 to 120 (\approx 110) OUR ESTIMATE			
113	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
120	³ HOEHLER	93	ARGD $\pi N \rightarrow \pi N$
114 \pm 10	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
113 \pm 12	THOMA	08	DPWA Multichannel
102	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
112	VRANA	00	DPWA Multichannel
110	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
108	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90
146 or 137	⁴ LONGACRE	78	IPWA $\pi N \rightarrow N\pi\pi$
109 or 107	¹ LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$

N(1520) ELASTIC POLE RESIDUE

MODULUS $|r|$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
38	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
32	HOEHLER	93	ARGD $\pi N \rightarrow \pi N$
35 \pm 2	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
35	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
34	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
33	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

PHASE θ

<u>VALUE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
– 5	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
– 8	HOEHLER	93	ARGD $\pi N \rightarrow \pi N$
– 12 \pm 5	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

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

– 6	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
7	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
– 10	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

N(1520) DECAY MODES

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

Mode	Fraction (Γ_i/Γ)
Γ_1 $N\pi$	0.55 to 0.65
Γ_2 $N\eta$	$(2.3 \pm 0.4) \times 10^{-3}$
Γ_3 $N\pi\pi$	40–50 %
Γ_4 $\Delta\pi$	15–25 %
Γ_5 $\Delta(1232)\pi$, <i>S</i> -wave	5–12 %
Γ_6 $\Delta(1232)\pi$, <i>D</i> -wave	10–14 %
Γ_7 $N\rho$	15–25 %
Γ_8 $N\rho$, <i>S</i> =1/2, <i>D</i> -wave	
Γ_9 $N\rho$, <i>S</i> =3/2, <i>S</i> -wave	
Γ_{10} $N\rho$, <i>S</i> =3/2, <i>D</i> -wave	
Γ_{11} $N(\pi\pi)_{S\text{-wave}}^{I=0}$	<8 %
Γ_{12} $p\gamma$	0.46–0.56 %
Γ_{13} $p\gamma$, helicity=1/2	0.001–0.034 %
Γ_{14} $p\gamma$, helicity=3/2	0.44–0.53 %
Γ_{15} $n\gamma$	0.30–0.53 %
Γ_{16} $n\gamma$, helicity=1/2	0.04–0.10 %
Γ_{17} $n\gamma$, helicity=3/2	0.25–0.45 %

N(1520) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$					Γ_1/Γ
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
0.55 to 0.65 OUR ESTIMATE					
0.632±0.001	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$	
0.59 ±0.03	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$	
0.58 ±0.03	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$	
0.54 ±0.03	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.58 ±0.08	THOMA	08	DPWA	Multichannel	
0.640±0.005	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$	
0.56 ±0.01	PENNER	02C	DPWA	Multichannel	
0.63 ±0.02	VRANA	00	DPWA	Multichannel	
0.61	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$	
0.46 ±0.06	BATINIC	95	DPWA	$\pi N \rightarrow N\pi, N\eta$	

$\Gamma(N\eta)/\Gamma_{\text{total}}$					Γ_2/Γ
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
0.0023±0.0004 OUR AVERAGE					
0.0023±0.0004	PENNER	02C	DPWA	Multichannel	
0.00 ± 0.01	VRANA	00	DPWA	Multichannel	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.002 ± 0.001	THOMA	08	DPWA	Multichannel	
0.0008 to 0.0012	ARNDT	05	DPWA	Multichannel	
0.0008±0.0001	TIATOR	99	DPWA	$\gamma p \rightarrow p\eta$	
0.001 ± 0.002	BATINIC	95	DPWA	$\pi N \rightarrow N\pi, N\eta$	

Note: Signs of couplings from $\pi N \rightarrow N\pi\pi$ analyses were changed in the 1986 edition to agree with the baryon-first convention; the overall phase ambiguity is resolved by choosing a negative sign for the $\Delta(1620) S_{31}$ coupling to $\Delta(1232)\pi$.

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow N(1520) \rightarrow \Delta(1232)\pi$, S-wave					$(\Gamma_1\Gamma_5)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
-0.26 to -0.20 OUR ESTIMATE					
-0.18±0.05	MANLEY	92	IPWA	$\pi N \rightarrow \pi N \& N\pi\pi$	
-0.26	^{1,5} LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$	
-0.24	² LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$	

$\Gamma(\Delta(1232)\pi, S\text{-wave})/\Gamma_{\text{total}}$					Γ_5/Γ
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
0.15±0.02	VRANA	00	DPWA	Multichannel	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.12±0.04	THOMA	08	DPWA	Multichannel	

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow N(1520) \rightarrow \Delta(1232)\pi$, D-wave					$(\Gamma_1\Gamma_6)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
-0.28 to -0.24 OUR ESTIMATE					
-0.29±0.03	MANLEY	92	IPWA	$\pi N \rightarrow \pi N \& N\pi\pi$	
-0.21	^{1,5} LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$	
-0.30	² LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$	

$\Gamma(\Delta(1232)\pi, D\text{-wave})/\Gamma_{\text{total}}$					Γ_6/Γ
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
0.11±0.02	VRANA	00	DPWA	Multichannel	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.14±0.05	THOMA	08	DPWA	Multichannel	

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow N(1520) \rightarrow N\rho, S=3/2, S\text{-wave}$					$(\Gamma_1\Gamma_9)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
-0.35 to -0.31 OUR ESTIMATE					
-0.35±0.03	MANLEY	92	IPWA	$\pi N \rightarrow \pi N \& N\pi\pi$	
-0.35	^{1,5} LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$	
-0.24	² LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$	

$\Gamma(N\rho, S=3/2, S\text{-wave})/\Gamma_{\text{total}}$ Γ_9/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
0.09 ± 0.01	VRANA	00	DPWA Multichannel

$(\Gamma_i \Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow N(1520) \rightarrow N(\pi\pi)_{S\text{-wave}}^{I=0}$ $(\Gamma_1 \Gamma_{11})^{1/2}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
-0.22 to -0.06 OUR ESTIMATE			
-0.13	^{1,5} LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
-0.17	² LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

$\Gamma(N(\pi\pi)_{S\text{-wave}}^{I=0})/\Gamma_{\text{total}}$ Γ_{11}/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
0.01 ± 0.01	VRANA	00	DPWA Multichannel
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
<0.04	THOMA	08	DPWA Multichannel

N(1520) PHOTON DECAY AMPLITUDES

Papers on γN amplitudes predating 1981 may be found in our 2006 edition, Journal of Physics, G **33** 1 (2006).

$N(1520) \rightarrow p\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV ^{-1/2})	DOCUMENT ID	TECN	COMMENT
-0.024 ± 0.009 OUR ESTIMATE			
-0.028 ± 0.002	DUGGER	07	DPWA $\gamma N \rightarrow \pi N$
-0.038 ± 0.003	AHRENS	02	DPWA $\gamma N \rightarrow \pi N$
-0.020 ± 0.007	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
-0.028 ± 0.014	CRAWFORD	83	IPWA $\gamma N \rightarrow \pi N$
-0.007 ± 0.004	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
-0.027	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
-0.003	PENNER	02D	DPWA Multichannel
-0.052 ± 0.010 ± 0.007	⁶ MUKHOPAD...	98	$\gamma p \rightarrow \eta p$
-0.020 ± 0.002	LI	93	IPWA $\gamma N \rightarrow \pi N$
-0.012	WADA	84	DPWA Compton scattering

$N(1520) \rightarrow p\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE (GeV ^{-1/2})	DOCUMENT ID	TECN	COMMENT
+0.166 ± 0.005 OUR ESTIMATE			
0.143 ± 0.002	DUGGER	07	DPWA $\gamma N \rightarrow \pi N$
0.147 ± 0.010	AHRENS	02	DPWA $\gamma N \rightarrow \pi N$
0.167 ± 0.005	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
0.156 ± 0.022	CRAWFORD	83	IPWA $\gamma N \rightarrow \pi N$
0.168 ± 0.013	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.161	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
0.151	PENNER	02D	DPWA Multichannel
0.130 ± 0.020 ± 0.015	⁶ MUKHOPAD...	98	$\gamma p \rightarrow \eta p$
0.167 ± 0.002	LI	93	IPWA $\gamma N \rightarrow \pi N$
0.168	WADA	84	DPWA Compton scattering

$N(1520) \rightarrow n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($\text{GeV}^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
−0.059±0.009 OUR ESTIMATE			
−0.048±0.008	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
−0.066±0.013	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
−0.067±0.004	FUJII	81	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
−0.077	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
−0.084	PENNER	02D	DPWA Multichannel
−0.058±0.003	LI	93	IPWA $\gamma N \rightarrow \pi N$

$N(1520) \rightarrow n\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE ($\text{GeV}^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
−0.139±0.011 OUR ESTIMATE			
−0.140±0.010	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
−0.124±0.009	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
−0.158±0.003	FUJII	81	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
−0.154	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
−0.159	PENNER	02D	DPWA Multichannel
−0.131±0.003	LI	93	IPWA $\gamma N \rightarrow \pi N$

$N(1520)$ FOOTNOTES

- ¹ LONGACRE 77 pole positions are from a search for poles in the unitarized T-matrix; the first (second) value uses, in addition to $\pi N \rightarrow N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis. The other LONGACRE 77 values are from eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.
- ² From method II of LONGACRE 75: eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.
- ³ 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.
- ⁴ LONGACRE 78 values are from a search for poles in the unitarized T-matrix. The first (second) value uses, in addition to $\pi N \rightarrow N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis.
- ⁵ LONGACRE 77 considers this coupling to be well determined.
- ⁶ MUKHOPADHYAY 98 uses an effective Lagrangian approach to analyze η photoproduction data. The *ratio* of the $A_{3/2}$ and $A_{1/2}$ amplitudes is determined, with less model dependence than the amplitudes themselves, to be $A_{3/2}/A_{1/2} = -2.5 \pm 0.5 \pm 0.4$.

$N(1520)$ REFERENCES

For early references, see Physics Letters **111B** 1 (1982). For very early references, see Reviews of Modern Physics **37** 633 (1965).

THOMA	08	PL B659 87	U. Thoma <i>et al.</i>	(CB-ELSA Collab.)
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)
DUGGER	07	PR C76 025211	M. Dugger <i>et al.</i>	(Jefferson Lab CLAS Collab.)
ARNDT	06	PR C74 045205	R.A. Arndt <i>et al.</i>	(GWU)
PDG	06	JPG 33 1	W.-M. Yao <i>et al.</i>	(PDG Collab.)
ARNDT	05	PR C72 045202	R.A. Arndt <i>et al.</i>	(GWU, PNPI)
ARNDT	04	PR C69 035213	R.A. Arndt <i>et al.</i>	(GWU, TRIU)
AHRENS	02	PRL 88 232002	J. Ahrens <i>et al.</i>	(Mainz MAMI GDH/A2 Collab.)

PENNER	02C	PR C66 055211	G. Penner, U. Mosel	(GIES)
PENNER	02D	PR C66 055212	G. Penner, U. Mosel	(GIES)
VRANA	00	PRPL 328 181	T.P. Vrana, S.A. Dytman,, T.-S.H. Lee	(PITT+)
TIATOR	99	PR C60 035210	L. Tiator <i>et al.</i>	
MUKHOPAD...	98	PL B444 7	N.C. Mukhopadhyay, N. Mathur	
ARNDT	96	PR C53 430	R.A. Arndt, I.I. Strakovsky, R.L. Workman	(VPI)
ARNDT	95	PR C52 2120	R.A. Arndt <i>et al.</i>	(VPI, BRCO)
BATINIC	95	PR C51 2310	M. Batinic <i>et al.</i>	(BOSK, UCLA)
Also		PR C57 1004 (erratum)	M. Batinic <i>et al.</i>	
HOEHLER	93	πN Newsletter 9 1	G. Hohler	(KARL)
LI	93	PR C47 2759	Z.J. Li <i>et al.</i>	(VPI)
MANLEY	92	PR D45 4002	D.M. Manley, E.M. Saleski	(KENT) IJP
Also		PR D30 904	D.M. Manley <i>et al.</i>	(VPI)
ARNDT	91	PR D43 2131	R.A. Arndt <i>et al.</i>	(VPI, TELE) IJP
WADA	84	NP B247 313	Y. Wada <i>et al.</i>	(INUS)
CRAWFORD	83	NP B211 1	R.L. Crawford, W.T. Morton	(GLAS)
PDG	82	PL 111B 1	M. Roos <i>et al.</i>	(HELS, CIT, CERN)
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)
Also		NP B197 365	K. Fujii <i>et al.</i>	(NAGO)
FUJII	81	NP B187 53	K. Fujii <i>et al.</i>	(NAGO, OSAK)
CUTKOSKY	80	Toronto Conf. 19	R.E. Cutkosky <i>et al.</i>	(CMU, LBL) IJP
Also		PR D20 2839	R.E. Cutkosky <i>et al.</i>	(CMU, LBL) IJP
HOEHLER	79	PDAT 12-1	G. Hohler <i>et al.</i>	(KARLT) IJP
Also		Toronto Conf. 3	R. Koch	(KARLT) IJP
LONGACRE	78	PR D17 1795	R.S. Longacre <i>et al.</i>	(LBL, SLAC)
LONGACRE	77	NP B122 493	R.S. Longacre, J. Dolbeau	(SACL) IJP
Also		NP B108 365	J. Dolbeau <i>et al.</i>	(SACL) IJP
LONGACRE	75	PL 55B 415	R.S. Longacre <i>et al.</i>	(LBL, SLAC) IJP