$N(1535)$ S_{11}

$I(J^P) = \frac{1}{2}(\frac{1}{2}^-)$ 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(1535) BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1525 to 1545 (≈ 1535) OUR ESTIMATE				
1547.0±0.7	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
1534 ±7	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
1550 ±40	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1526 ±7	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1548 ±15	THOMA	08	DPWA	Multichannel
1546.7±2.2	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
1526 ±2	PENNER	02C	DPWA	Multichannel
1530 ±10	BAI	01B	BES	$J/\psi \to p\overline{p}\eta$
1522 ±11	THOMPSON	01	CLAS	$\gamma^* p \to p\eta$
1542 ±3	VRANA	00	DPWA	Multichannel
1532 ±5	ARMSTRONG	99B	DPWA	$\gamma^* p \to p\eta$
1549.0±2.1	ABAEV	96	DPWA	$\pi^- p \to \eta n$
1525 ±10	ARNDT	96	IPWA	$\gamma N \to \pi N$
1535	ARNDT	95	DPWA	$\pi N \to N\pi$
1542 ±6	BATINIC	95	DPWA	$\pi N \to N\pi, N\eta$
1537	BATINIC	95B	DPWA	$\pi N \to N\pi, N\eta$
1544 ±13	KRUSCHE	95	DPWA	$\gamma p \to p\eta$
1518	LI	93	IPWA	$\gamma N \to \pi N$
1520	[1] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
1510	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

N(1535) BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
125 to 175 (≈ 150) OUR ESTIMATE				
188.4±3.8	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
148.2±8.1	GREEN	97	DPWA	$\pi N \to \pi N, \eta N$
151 ±27	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
240 ±80	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
120 ±20	HOEHLER	79	IPWA	$\pi N \to \pi N$

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

170 ±20	THOMA	08	DPWA	Multichannel
178.0±11.6	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
129 ± 8	PENNER	02C	DPWA	Multichannel
95 ±25	BAI	01B	BES	$J/\psi \to p\overline{p}\eta$
143 ±18	THOMPSON	01	CLAS	$\gamma^* p \to p\eta$
112 ±19	VRANA	00	DPWA	Multichannel
154 ±20	ARMSTRONG	99B	DPWA	$\gamma^* p \to p\eta$
212 ±20	[3] KRUSCHE	97	DPWA	$\gamma N \to \eta N$
168.8±11.6	ABAEV	96	DPWA	$\pi^- p \to \eta n$
103 ± 5	ARNDT	96	IPWA	$\gamma N \to \pi N$
66	ARNDT	95	DPWA	$\pi N \to N\pi$
150 ±15	BATINIC	95	DPWA	$\pi N \to N\pi$, $N\eta$
145	BATINIC	95B	DPWA	$\pi N \to N\pi$, $N\eta$
200 ±40	KRUSCHE	95	DPWA	$\gamma p \to p\eta$
84	LI	93	IPWA	$\gamma N \to \pi N$
135	[1] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
100	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

N(1535) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1490 to 1530 (≈ 1510) OUR ESTIMATE				
1502	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
1487	[4] HOEHLER	93	SPED	$\pi N \to \pi N$
1510±50	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1508^{+10}_{-30}	THOMA	08	DPWA	Multichannel
1526	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
1525	VRANA	00	DPWA	Multichannel
1510±10	[5] ARNDT	98	DPWA	$\pi N \to \pi N$, ηN
1501	ARNDT	95	DPWA	$\pi N \to N\pi$
1499	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
1496 or 1499	[6] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$
1525 or 1527	[1] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
90 to 250 (≈ 170) OUR ESTIMATE				
95	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
260±80	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
165±15	THOMA	08	DPWA	Multichannel
130	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
102	VRANA	00	DPWA	Multichannel
170±30	[5] ARNDT	98	DPWA	$\pi N \to \pi N$, ηN

124	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
110	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
103 or 105	[6] LONGACRE	78	IPWA	$\pi N \rightarrow N\pi\pi$
135 or 123	[1] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

N(1535) ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
16	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
120±40	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
33	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
31	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
23	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

PHASE θ

VALUE (°)	*DOCUMENT ID*		*TECN*	*COMMENT*
−16	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
+15±45	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
14	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
−12	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
−13	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

N(1535) DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	35–55 %
Γ_2	$N\eta$	45–60 %
Γ_3	$N\pi\pi$	1–10 %
Γ_4	$\Delta\pi$	<1 %
Γ_5	$\Delta(1232)\pi$, *D*-wave	
Γ_6	$N\rho$	<4 %
Γ_7	$N\rho$, S=1/2, *S*-wave	
Γ_8	$N\rho$, S=3/2, *D*-wave	
Γ_9	$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<3 %
Γ_{10}	$N(1440)\pi$	<7 %
Γ_{11}	$p\gamma$	0.15–0.35 %
Γ_{12}	$p\gamma$, helicity=1/2	0.15–0.35 %
Γ_{13}	$n\gamma$	0.004–0.29 %
Γ_{14}	$n\gamma$, helicity=1/2	0.004–0.29 %

N(1535) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.35 to 0.55 OUR ESTIMATE				
0.355±0.002	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
0.394±0.009	GREEN	97	DPWA	$\pi N \rightarrow \pi N, \eta N$
0.51 ±0.05	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
0.50 ±0.10	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
0.38 ±0.04	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.37 ±0.09	THOMA	08	DPWA	Multichannel
0.360±0.009	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
0.36 ±0.01	PENNER	02C	DPWA	Multichannel
0.35 ±0.08	VRANA	00	DPWA	Multichannel
0.330±0.011	ABAEV	96	DPWA	$\pi^- p \rightarrow \eta n$
0.31	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
0.34 ±0.09	BATINIC	95	DPWA	$\pi N \rightarrow N\pi, N\eta$

$\Gamma(N\eta)/\Gamma_{total}$ — Γ_2/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
+0.45–0.60 OUR ESTIMATE					
0.529±0.010 OUR AVERAGE					
0.53 ±0.01		PENNER	02C	DPWA	Multichannel
0.51 ±0.05		VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.40 ±0.10		THOMA	08	DPWA	Multichannel
>0.45	95	[7] ARMSTRONG	99B	DPWA	$p(e,e'p)\eta$
0.568±0.011		GREEN	97	DPWA	$\pi N \rightarrow \pi N, \eta N$
0.591±0.017		ABAEV	96	DPWA	$\pi^- p \rightarrow \eta n$
0.63 ±0.07		BATINIC	95	DPWA	$\pi N \rightarrow N\pi, N\eta$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(1535) \rightarrow N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.44 to +0.50 OUR ESTIMATE				
+0.47±0.02	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$

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 $\Delta(1232)\pi$.

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(1535) \rightarrow \Delta(1232)\pi$, D-wave — $(\Gamma_1\Gamma_5)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.04 to +0.06 OUR ESTIMATE				
+0.00±0.04	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
0.00	[1] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
+0.06	[2] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

$\Gamma(\Delta(1232)\pi\,,\ D\text{-wave})/\Gamma_{total}$ — Γ_5/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. • • •				
0.23±0.08	THOMA	08	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1535) \to N\rho$, S=1/2, S-wave — $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.14 to −0.06 OUR ESTIMATE				
−0.10±0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
−0.10	[1] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
−0.09	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$\Gamma(N\rho$, S=1/2, S-wave$)/\Gamma_{total}$ — Γ_7/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.02±0.01	VRANA	00	DPWA	Multichannel

$\Gamma(N\rho$, S=3/2, D-wave$)/\Gamma_{total}$ — Γ_8/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.00±0.01	VRANA	00	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1535) \to N(\pi\pi)^{I=0}_{S\text{-wave}}$ — $(\Gamma_1\Gamma_9)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.03 to +0.13 OUR ESTIMATE				
+0.07±0.04	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
+0.08	[1] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.09	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$\Gamma(N(\pi\pi)^{I=0}_{S\text{-wave}})/\Gamma_{total}$ — Γ_9/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.02±0.01	VRANA	00	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1535) \to N(1440)\pi$ — $(\Gamma_1\Gamma_{10})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.10±0.05	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

$\Gamma(N(1440)\pi)/\Gamma_{total}$ — Γ_{10}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.08±0.02	[8] STAROSTIN	03		$\pi^- p \to n 3\pi^0$
0.10±0.09	VRANA	00	DPWA	Multichannel

N(1535) PHOTON DECAY AMPLITUDES

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

N(1535) → $p\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($GeV^{-1/2}$)	*DOCUMENT ID*		*TECN*	*COMMENT*
+0.090±0.030 OUR ESTIMATE				
0.091±0.002	DUGGER	07	DPWA	$\gamma N \rightarrow \pi N$
0.120±0.011±0.015	[3] KRUSCHE	97	DPWA	$\gamma N \rightarrow \eta N$
0.060±0.015	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
0.097±0.006	BENMERROU..	95	DPWA	$\gamma N \rightarrow N\eta$
0.095±0.011	[9] BENMERROU..	91		$\gamma p \rightarrow p\eta$
0.053±0.015	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
0.077±0.021	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.066	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$
0.090	PENNER	02D	DPWA	Multichannel
0.110 to 0.140	KRUSCHE	95	DPWA	$\gamma p \rightarrow p\eta$
0.125±0.025	KRUSCHE	95C	IPWA	$\gamma d \rightarrow \eta N(N)$
0.061±0.003	LI	93	IPWA	$\gamma N \rightarrow \pi N$
0.055	WADA	84	DPWA	Compton scattering

N(1535) → $n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($GeV^{-1/2}$)	*DOCUMENT ID*		*TECN*	*COMMENT*
−0.046±0.027 OUR ESTIMATE				
−0.020±0.035	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
0.035±0.014	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.062±0.003	FUJII	81	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.051	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$
−0.024	PENNER	02D	DPWA	Multichannel
−0.100±0.030	KRUSCHE	95C	IPWA	$\gamma d \rightarrow \eta N(N)$
−0.046±0.005	LI	93	IPWA	$\gamma N \rightarrow \pi N$

N(1535) → $N\gamma$, ratio $A^n_{1/2}/A^p_{1/2}$

VALUE ($GeV^{-1/2}$)	*DOCUMENT ID*		*TECN*
• • • We do not use the following data for averages, fits, limits, etc. • • •			
−0.84±0.15	MUKHOPAD...	95B	IPWA

N(1535) 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] KRUSCHE 97 fits with the mass fixed at 1544 MeV.

[4] 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.

[5] ARNDT 98 also lists pole residues, which display more model dependence than do the associated pole positions.

[6] 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.

[7] The best value ARMSTRONG 99B obtains is $\simeq$ 0.55; this assumes S_{11} dominance in the reaction $p(e, e'p)\,\eta$ at Q^2= 4 (GeV/c)^2.

[8] This STAROSTIN 03 value is an estimate made using simplest assumptions.

[9] BENMERROUCHE 91 uses an effective Lagrangian approach to analyze η photoproduction data.

N(1535) REFERENCES

For early references, see Physics Letters **111B** 1 (1982).

THOMA	08	PL B659 87	U. Thoma *et al.*	(CB-ELSA Collab.)	
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)	
DUGGER	07	PR C76 025211	M. Dugger *et al.*	(Jefferson Lab CLAS Collab.)	
ARNDT	06	PR C74 045205	R.A. Arndt *et al.*	(GWU)	
PDG	06	JPG 33 1	W.-M. Yao *et al.*	(PDG Collab.)	
ARNDT	04	PR C69 035213	R.A. Arndt *et al.*	(GWU, TRIU)	
STAROSTIN	03	PR C67 068201	A. Starostin *et al.*	(BNL Crystal Ball Collab.)	
PENNER	02C	PR C66 055211	G. Penner, U. Mosel	(GIES)	
PENNER	02D	PR C66 055212	G. Penner, U. Mosel	(GIES)	
BAI	01B	PL B510 75	J.Z. Bai *et al.*	(BES Collab.)	
THOMPSON	01	PRL 86 1702	R. Thompson *et al.*	(Jefferson CLAS Collab.)	
VRANA	00	PRPL 328 181	T.P. Vrana, S.A. Dytman,, T.-S.H. Lee	(PITT+)	
ARMSTRONG	99B	PR D60 052004	C.S. Armstrong *et al.*		
ARNDT	98	PR C58 3636	R.A. Arndt *et al.*		
GREEN	97	PR C55 R2167	A.M. Green, S. Wycech	(HELS, WINR)	
KRUSCHE	97	PL B397 171	B. Krusche *et al.*	(GIES, RPI, SASK)	
ABAEV	96	PR C53 385	V.V. Abaev, B.M.K. Nefkens	(UCLA)	
ARNDT	96	PR C53 430	R.A. Arndt, I.I. Strakovsky, R.L. Workman	(VPI)	
ARNDT	95	PR C52 2120	R.A. Arndt *et al.*	(VPI, BRCO)	
BATINIC	95	PR C51 2310	M. Batinic *et al.*	(BOSK, UCLA)	
Also		PR C57 1004 (erratum)	M. Batinic *et al.*		
BATINIC	95B	PR C52 2188	M. Batinic, I. Slaus, A. Svarc	(BOSK)	
BENMERROU...	95	PR D51 3237	M. Benmerrouche, N.C. Mukhopadhyay, J.F. Zhang		
KRUSCHE	95	PRL 74 3736	B. Krusche *et al.*	(GIES, MANZ, GLAS+)	
KRUSCHE	95C	PL B358 40	B. Krusche *et al.*	(GIES, MANZ, GLAS+)	
MUKHOPAD...	95B	PL B364 1	N.C. Mukhopadhyay, J.F. Zhang, M. Benmerrouche		
HOEHLER	93	πN Newsletter 9 1	G. Hohler	(KARL)	
LI	93	PR C47 2759	Z.J. Li *et al.*	(VPI)	
MANLEY	92	PR D45 4002	D.M. Manley, E.M. Saleski	(KENT)	IJP
Also		PR D30 904	D.M. Manley *et al.*	(VPI)	
ARNDT	91	PR D43 2131	R.A. Arndt *et al.*	(VPI, TELE)	IJP
BENMERROU...	91	PRL 67 1070	M. Benmerrouche, N.C. Mukhopadhyay	(RPI)	
WADA	84	NP B247 313	Y. Wada *et al.*	(INUS)	
CRAWFORD	83	NP B211 1	R.L. Crawford, W.T. Morton	(GLAS)	
PDG	82	PL 111B 1	M. Roos *et al.*	(HELS, CIT, CERN)	
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)	
Also		NP B197 365	K. Fujii *et al.*	(NAGO)	
FUJII	81	NP B187 53	K. Fujii *et al.*	(NAGO, OSAK)	
CUTKOSKY	80	Toronto Conf. 19	R.E. Cutkosky *et al.*	(CMU, LBL)	IJP
Also		PR D20 2839	R.E. Cutkosky *et al.*	(CMU, LBL)	IJP
HOEHLER	79	PDAT 12-1	G. Hohler *et al.*	(KARLT)	IJP
Also		Toronto Conf. 3	R. Koch	(KARLT)	IJP
LONGACRE	78	PR D17 1795	R.S. Longacre *et al.*	(LBL, SLAC)	
LONGACRE	77	NP B122 493	R.S. Longacre, J. Dolbeau	(SACL)	IJP
Also		NP B108 365	J. Dolbeau *et al.*	(SACL)	IJP
LONGACRE	75	PL 55B 415	R.S. Longacre *et al.*	(LBL, SLAC)	IJP