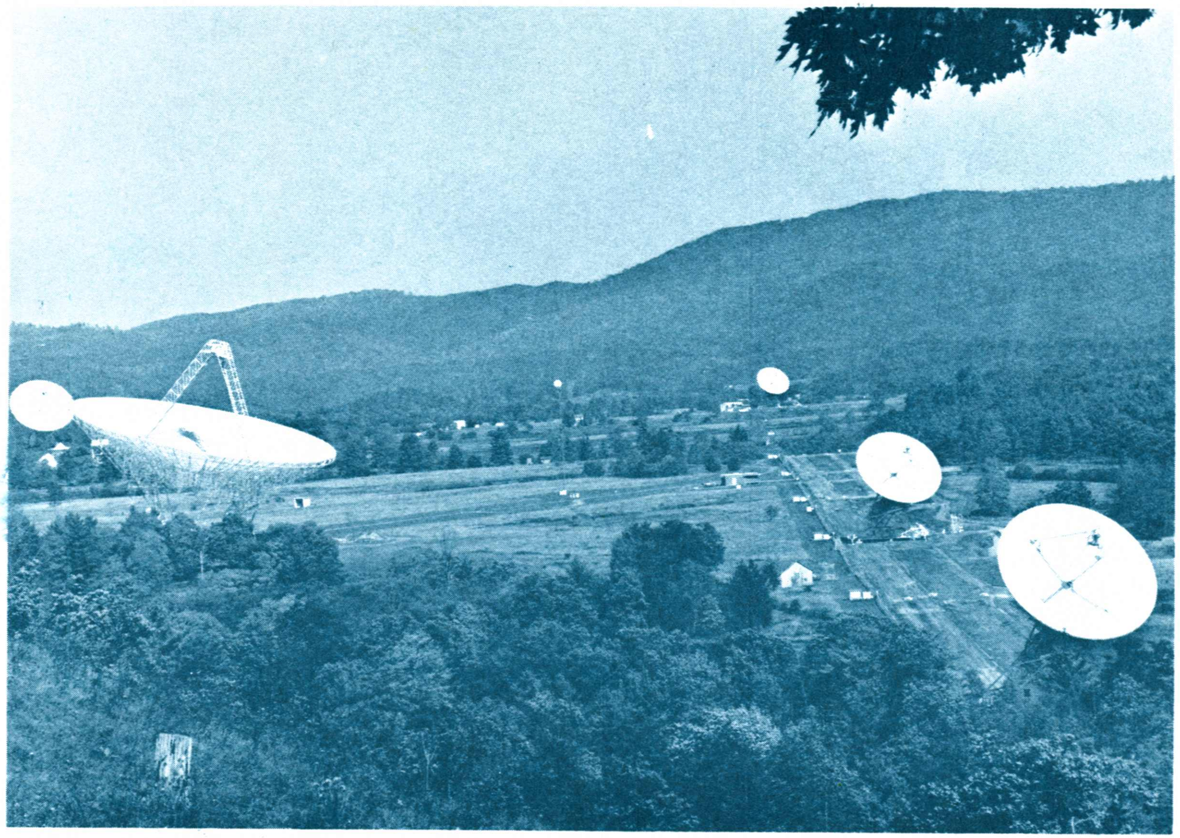
NATIONAL RADIO ASTRONOMY OBSERVATORY



1974

NATIONAL RADIO ASTRONOMY OBSERVATORY

1974

OBSERVING SUMMARY

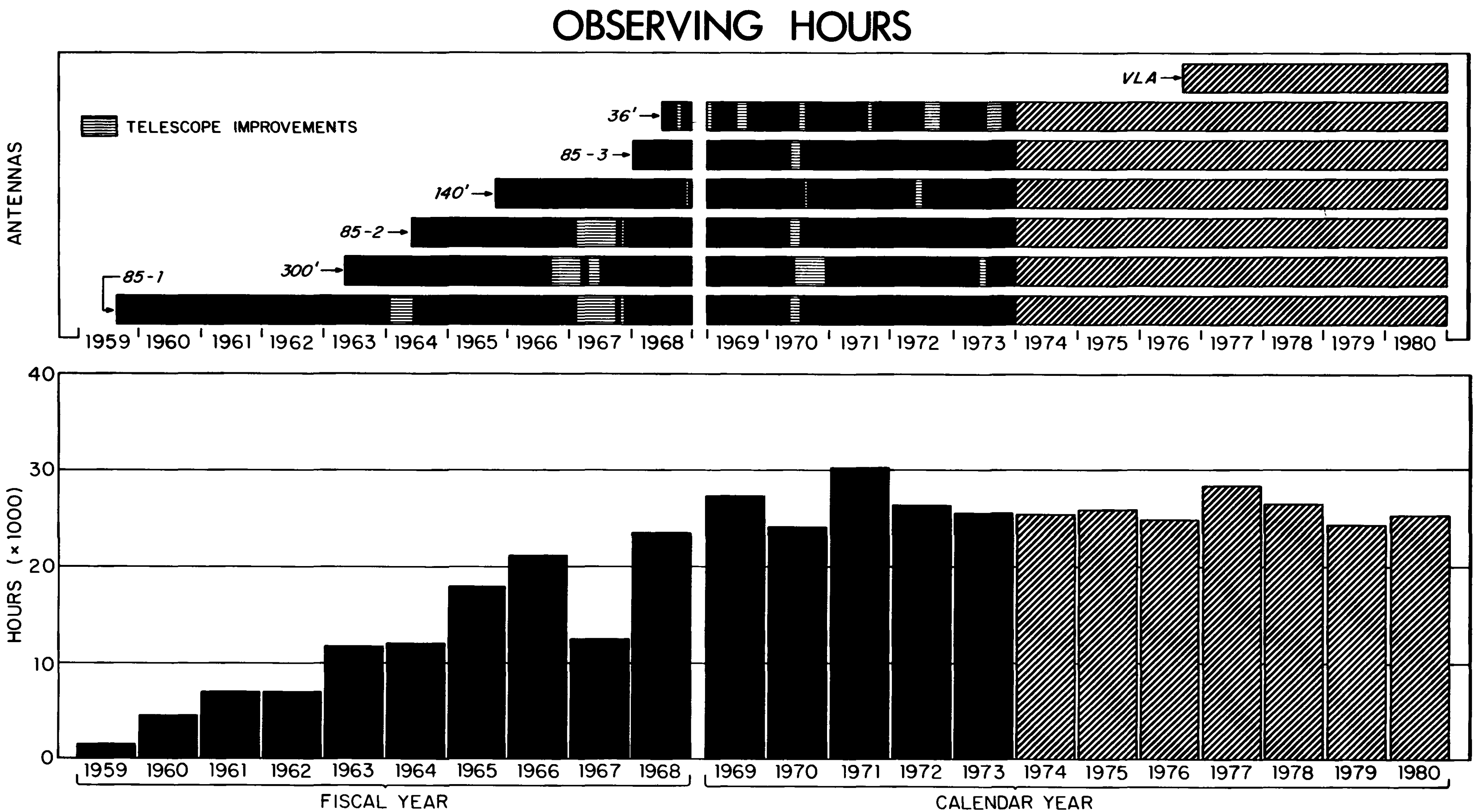


Fig. 1. The upper figure shows the year in which existing (black) or planned (shaded) telescope systems are incorporated into the NRAO observing program. The lower figure shows the total number of hours of observing time during each year.

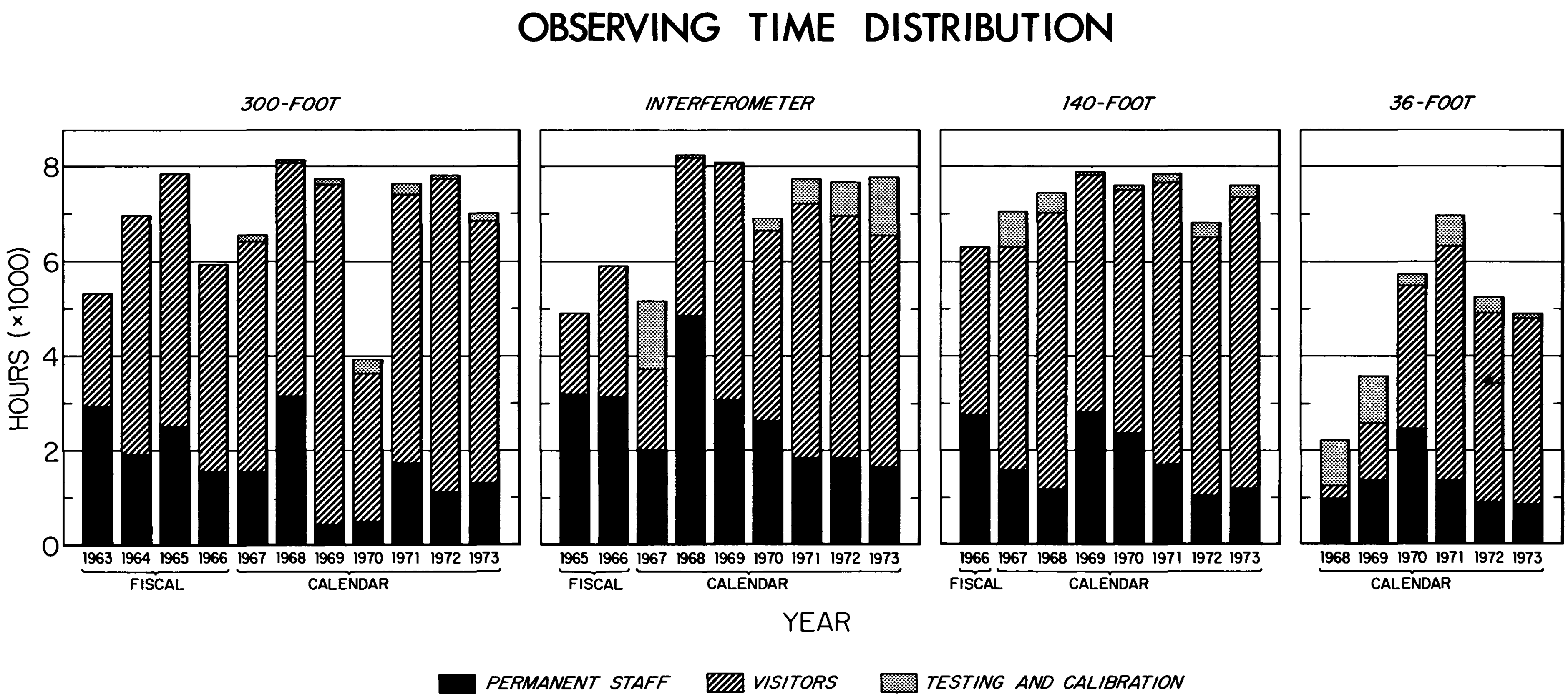


Fig. 2. These graphs show the number of hours devoted to calibration and testing and to observing by NRAO permanent staff members and by visitors on each telescope system during each year the telescope has been operative.

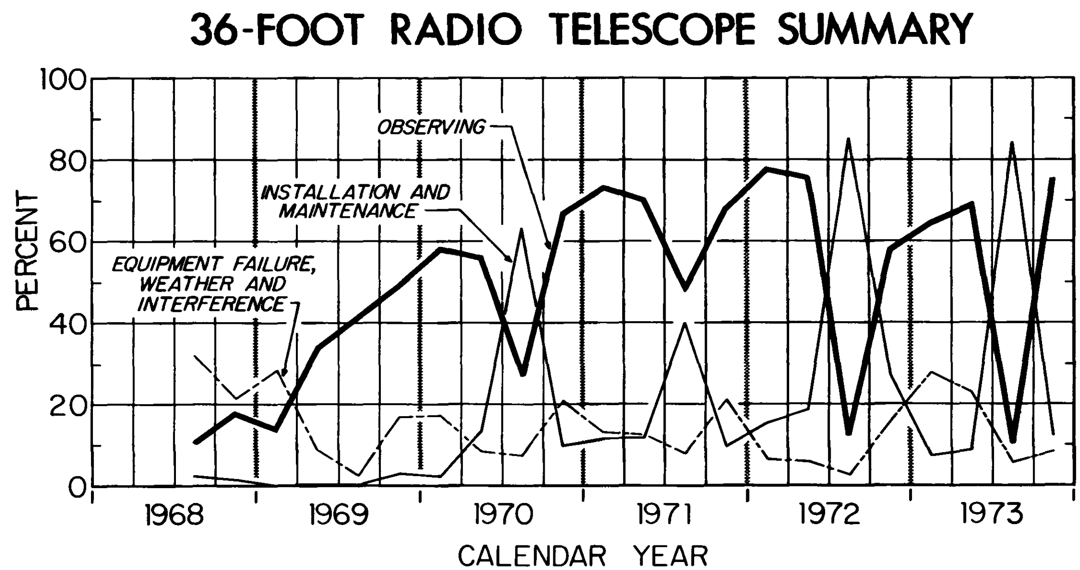


Fig. 3. This summary for each quarter of the calendar year shows the percentage of time the telescope was scheduled for observing, for routine maintenance and installation of new experiments, and the percentage of time lost due to equipment failure, bad weather, and radio interference.

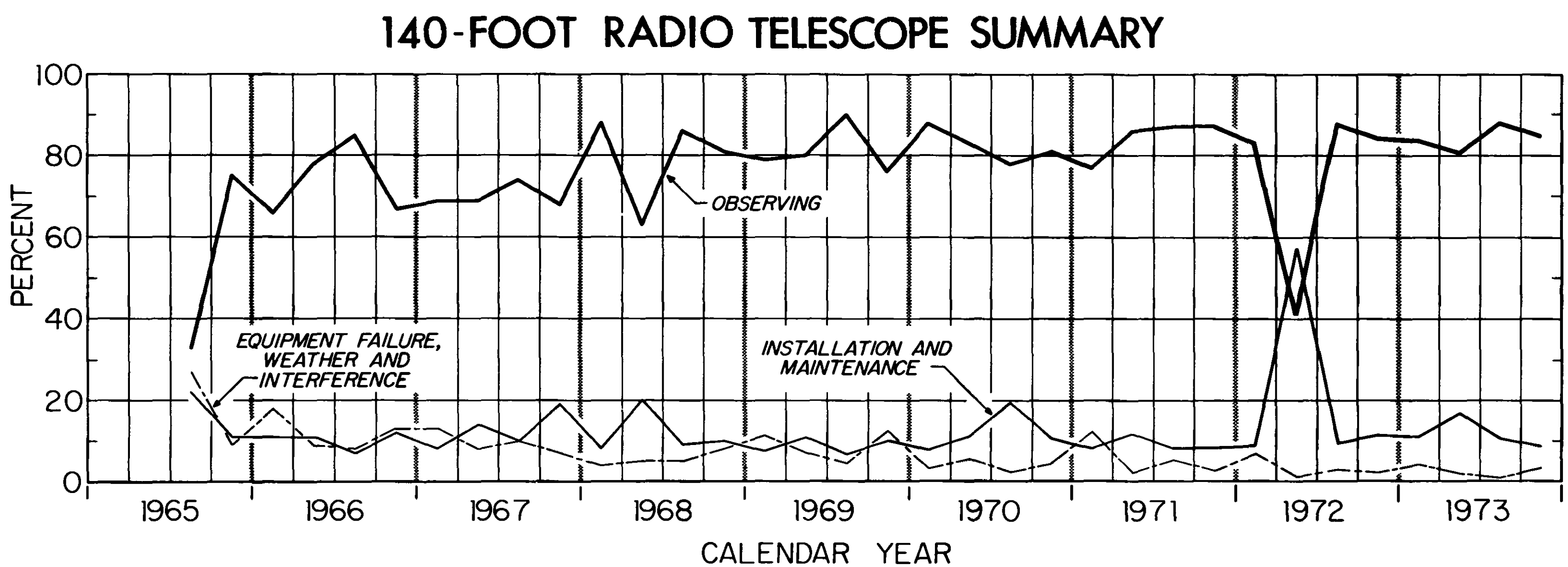


Fig. 4. This summary for each quarter of the calendar year shows the percentage of time the telescope was scheduled for observing, for routine maintenance and installation of new experiments, and the percentage of time lost due to equipment failure, bad weather, and radio interference.

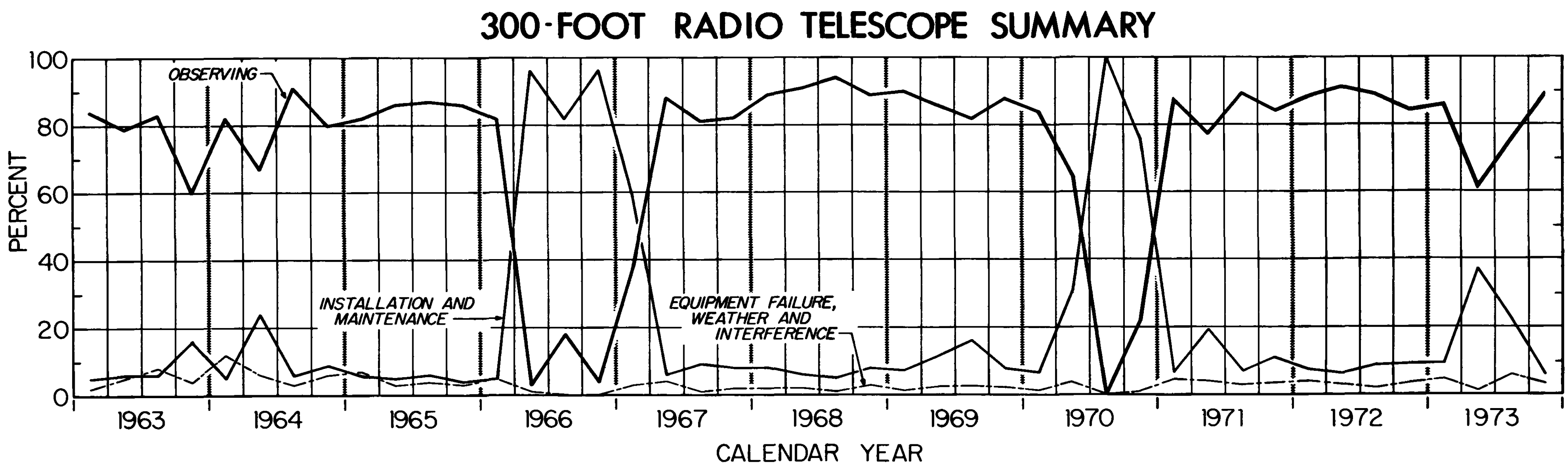


Fig. 5. This summary for each quarter of the calendar year shows the percentage of time the telescope was scheduled for observing, for routine maintenance and installation of new experiments, and the percentage of time lost due to equipment failure, bad weather, and radio interference.

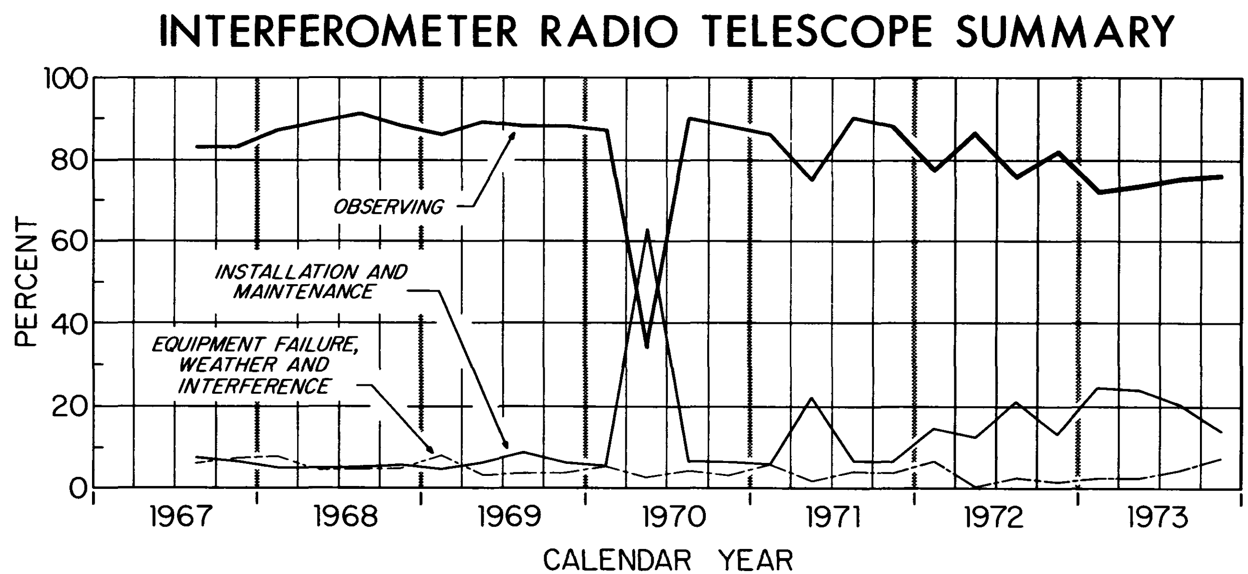


Fig. 6. This summary for each quarter of the calendar year shows the percentage of time the telescope was scheduled for observing, for routine maintenance and installation of new experiments, and the percentage of time lost due to equipment failure, bad weather, and radio interference.

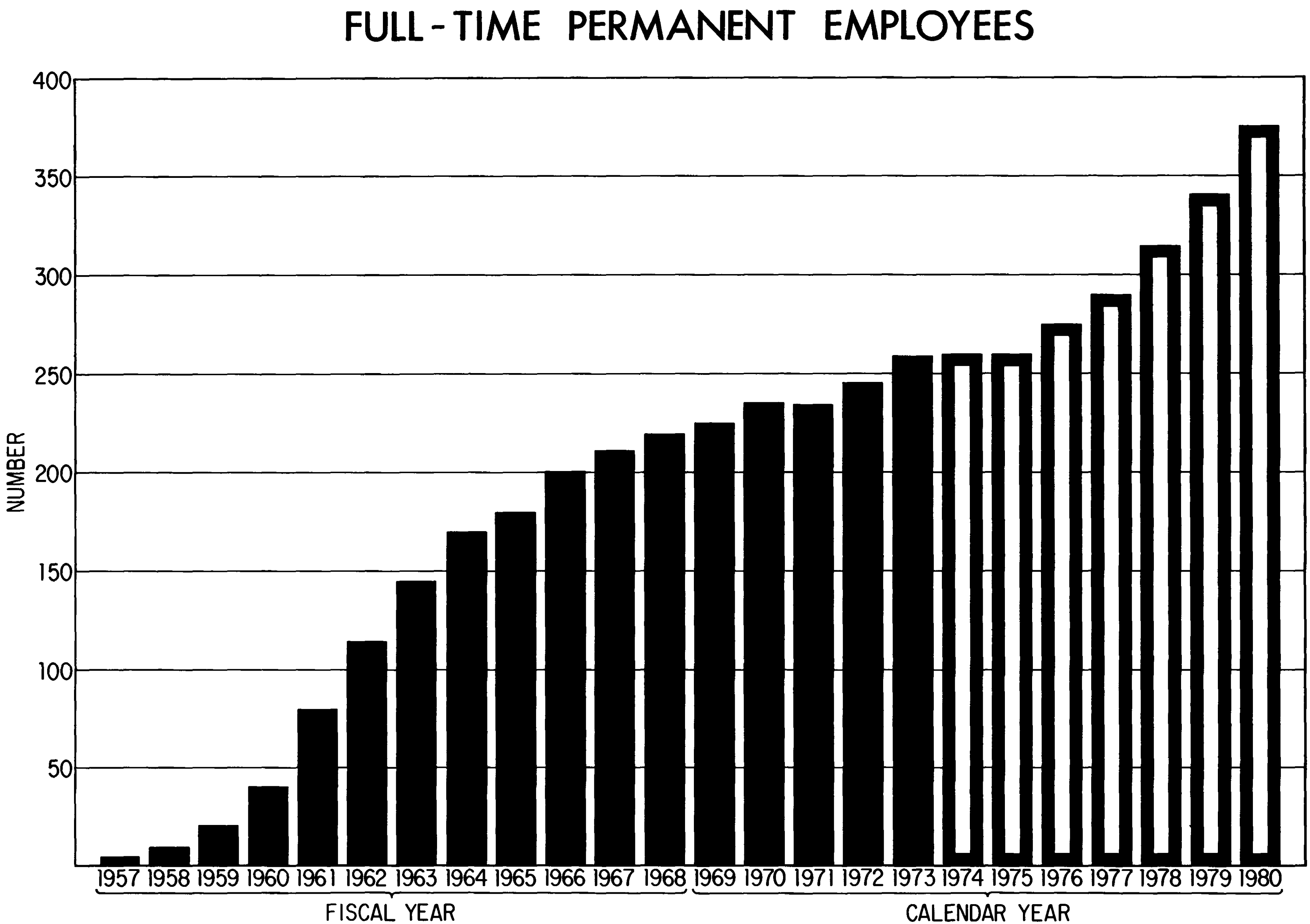


Fig. 7. This figure shows the total number of NRAO full-time, permanent employees at the end of each year, projected into the future.

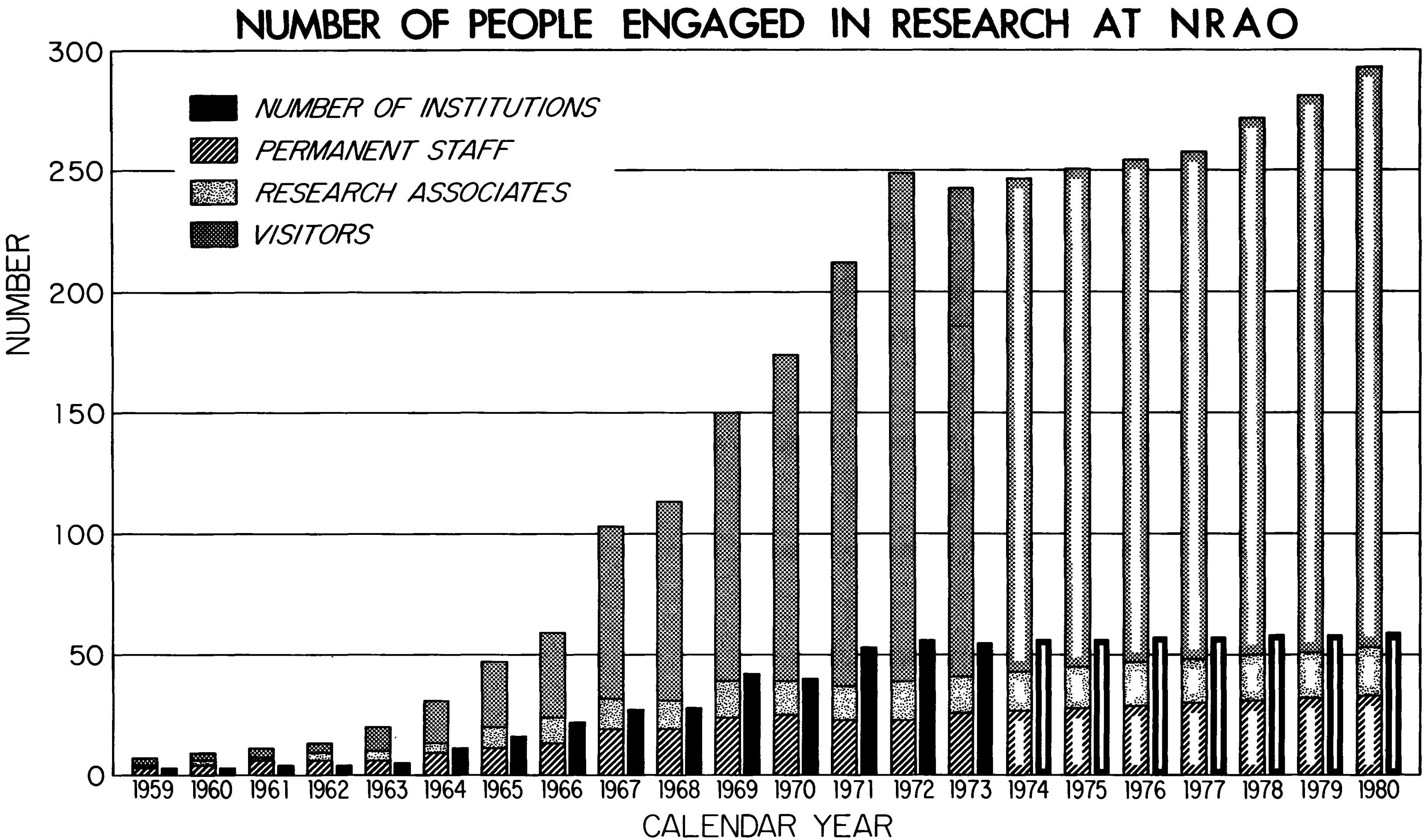


Fig. 8. This bar chart shows for each calendar year the size of the NRAO permanent research staff and the number of research associates on one or two year appointments. In addition it shows the total number of visitor-users of NRAO telescopes and the number of institutions from which the NRAO visitors come.

Distribution of Scheduled Telescope Time by Per Cent

	140-ft	300-ft	36-ft	Interferometer	1973 Summary
Visitors	54%	40%	61%	42%	49
Students	18	14	13	13	15
Permanent Staff	16	19	18	21	19
Research Associates	8	24	7	8	12
Test Time	3	3	2	16	6

INSTITUTIONS FROM WHICH VISITORS CAME TO USE NRAO TELESCOPES DURING 1973

		Telescope			
		36-foot	Interferometer	140-foot	300-foot
1.	Aerospace Corp.	X			
2.	Bell Telephone Laboratories	X		X	
3.	Berkeley	X		X	X
4.	Brandeis		X		
5.	Byurakan Ap. Obs., USSR		X		
6.	Calif. Inst. of Tech.		X	X	
7.	Canterbury, Kent, England	X			
8.	Cerro Tololo, Chile			X	
9.	Chalmers Inst. Tech., Sweden			X	
10.	Chicago	X	X	X	X
11.	CSIRO, Australia	X			
12.	Cornell		X		X
13.	Dept. Terrestr. Magnetism, Carnegie		X		X
14.	Florida		X	X	
15.	Freie Univ. Berlin, W. Germany			X	
16.	Harvard	X		X	
17.	Haystack Facility			X	
18.	Illinois	X		X	
19.	Indiana			X	
20.	Jodrell Bank, England		X		
21.	Kitt Peak National Observatory	X		X	
22.	Lab de Physique Stell. et Planet., France	X			
23.	Lockheed Corp.	X			
24.	Los Alamos Sci. Lab	X			
25.	Lulejian Associates	X			

	Institution	36-foot	Interferometer	140-foot	300-foot
		Telescope			
25.	Marseille, France			X	X
26.	Maryland	X	X	X	X
27.	Massachusetts	X	X	X	X
28.	Mass. Inst. of Tech.	X	X	X	X
29.	Max Planck Inst., Germany			X	
30.	Meudon, France	X			
31.	Minnesota	X		X	
32.	NASA-Goddard (Greenbelt)	X	X	X	X
33.	NASA Inst. Space Stud. (NYC)	X		X	
34.	National Astronomy and Ionosphere Ctr.	X	X	X	X
35.	National Bureau of Standards			X	
36.	National Res. Council, Canada		X	X	
37.	Naval Research Lab	X	X	X	X
38.	Northern Iowa				X
39.	Ozarks			X	
40.	Princeton	X	X	X	
41.	Queen Mary, England	X			
42.	Queens, Canada		X		X
43.	Santa Cruz		X	X	
44.	Smithsonian Astrophys. Obs.	X		X	
45.	Southern Illinois	X			
46.	SUNY, Albany		X		X
47.	Tata Institute, India				X
48.	Texas		X		
49.	Tokyo Astr. Obs., Japan			X	
50.	Toronto, Canada		X	X	X

	Institution	Telescope 36-foot	Interferometer	140-foot	300-foot
51.	Unaffiliated Scientists			X	X
52.	Virginia	X	X	X	
53.	Yale			X	
54.	York, Canada		X		

		36-foot	Interferometer	140-foot	300-foot
No. Institutions	:	27	23	34	17
No. Visitors	:	57	41	78	25
No. Students	:	15	11	31	15
No. Research Associates	:	3	6	9	5
No. Permanent Staff	:	11	13	11	7
Total Observers	:	86	71	129	52

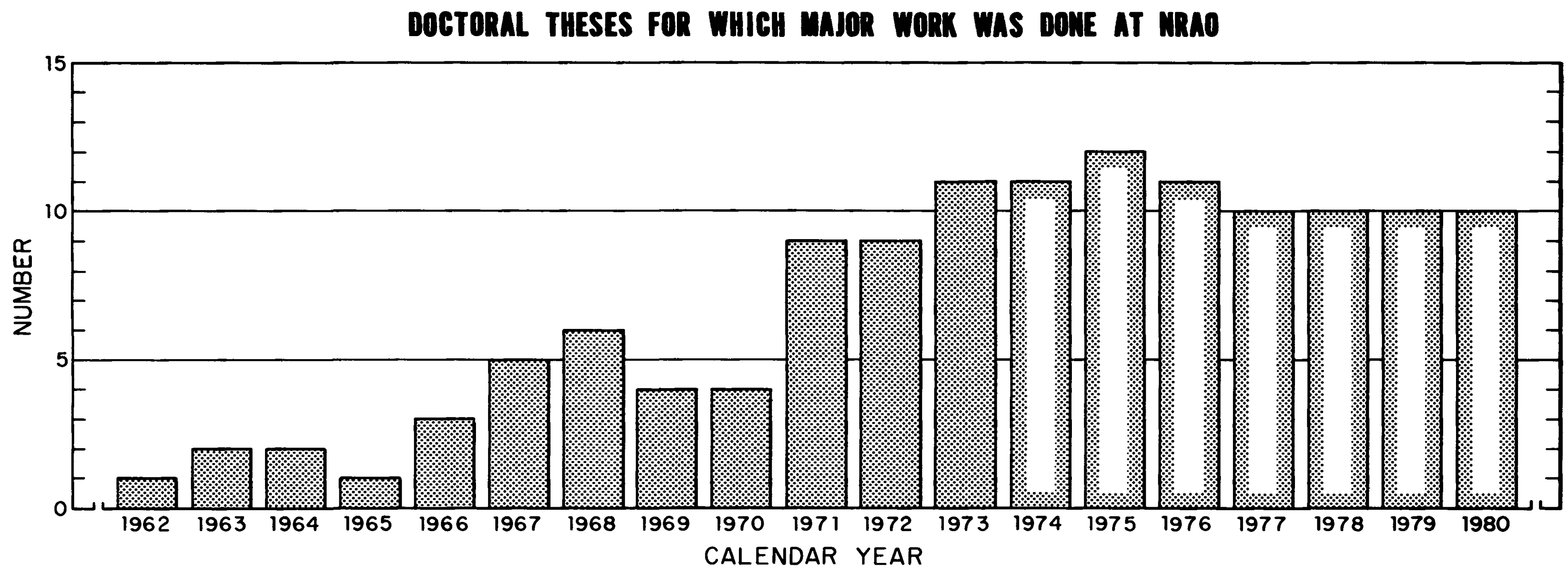


Fig. 9. This bar chart shows the number of doctoral dissertations produced each calendar year by Ph.D. students where the major work on the theses was done at the NRAO.

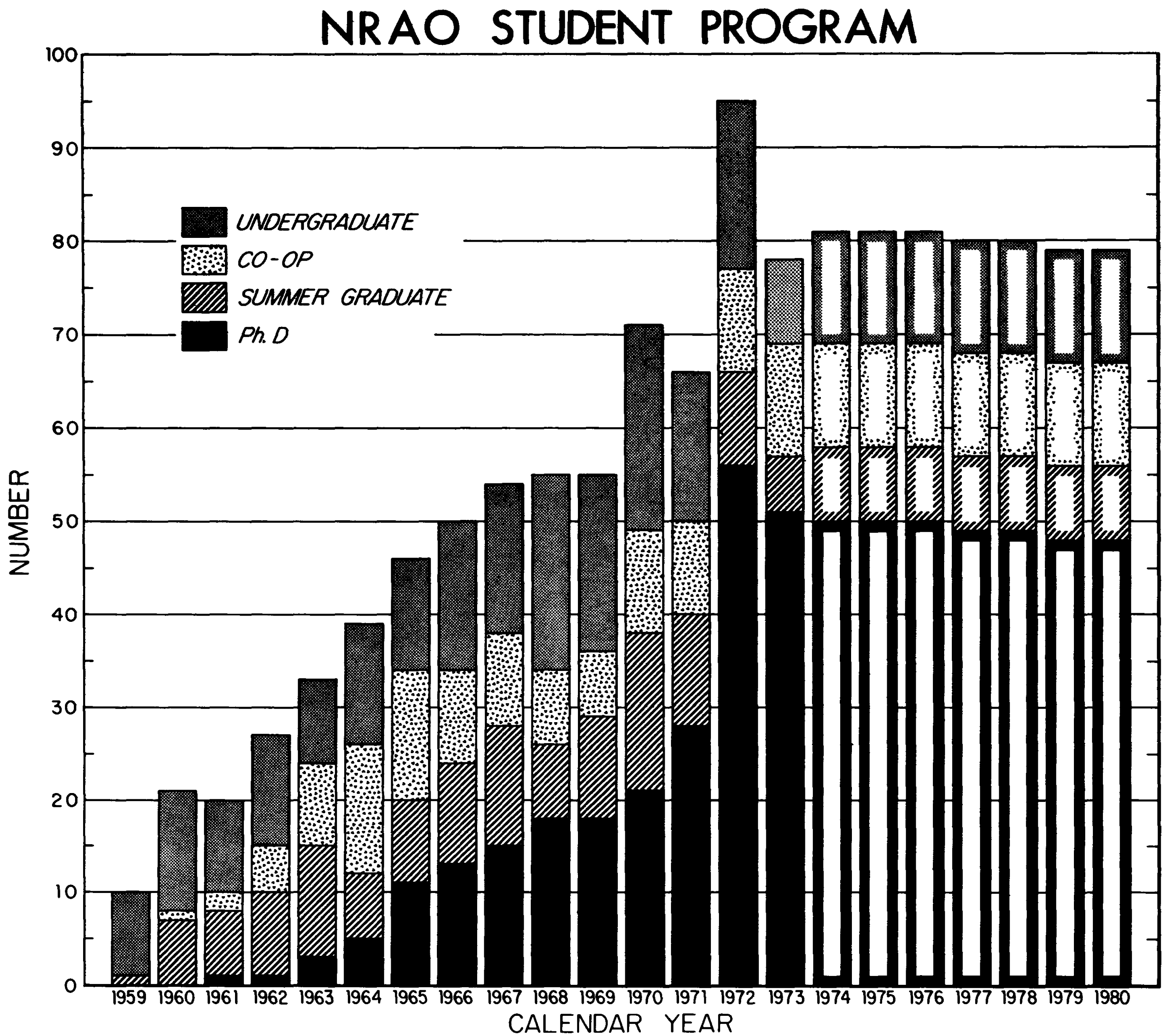
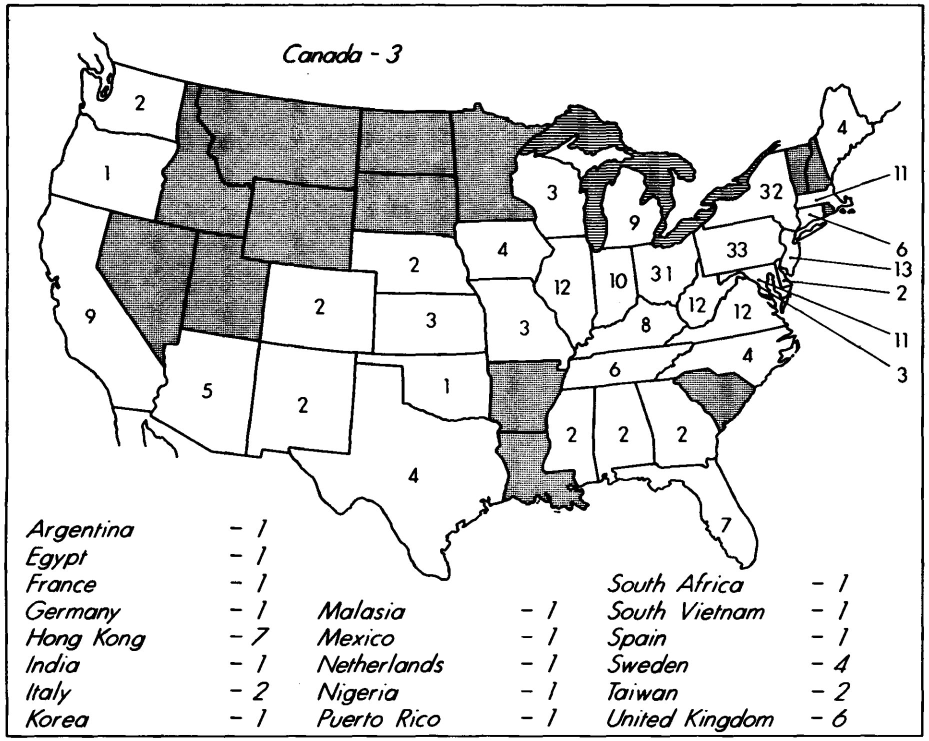
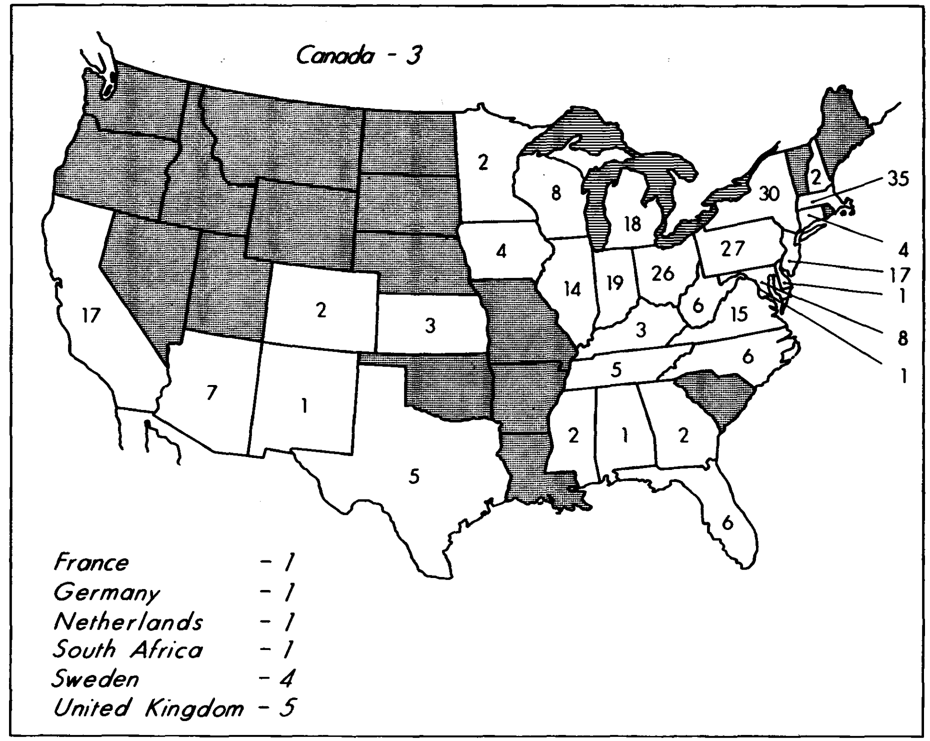


Fig. 10. This figure shows for each calendar year the number of Ph.D. students (salaried and non-salaried), co-op students, and summer undergraduate and graduate students who observed or worked at the NRAO during that year.

NRAO SUMMER STUDENT PROGRAM



Home States



College-University Affiliation

Fig. 11. This figure shows the total number of graduate and undergraduate students by home state or country and by college location who did summer work at the NRAO since the beginning of the summer student program in 1959.

Telescopes and Receiver Systems

λ cm	T_{system} (°K)	Bandwidth	36-ft	140-ft	300-ft	Interf.
0.125	30000	100 GHz	X			
0.25 - 0.375	400	500 MHz	(X)			
0.26	1500	100 MHz	X			
0.35	1500	1 GHz	X			
0.3 - 0.40 (line)	4000	100 MHz	X			
0.60 - 0.90	1500	100 MHz	X			
0.65	150	500 MHz	(X)			
0.95	1500	400 MHz	X	[X]		
1.35 (line)	600	50 MHz	X			
1.7 - 2.5 (line)	1500	200 MHz		X		
1.95	1200	2 GHz	X	X		
2.05	100	500 MHz		X		
3 - 6 (line)	400	50 MHz		X		
3	75	300 MHz		X		
3 and 11	100	30 MHz				X
6	90	200 MHz		X		
6	70	300 MHz		X		
11	50	250 MHz		(X)	(X)	
11 (3 beam)	120	50 MHz			X	
7.5 - 30 (line)	100-300	45 MHz		X	X	
18	70	50 MHz		X	X	
21 (line)	120	60 MHz				X
21 (4 beam)	150	60 MHz			X	
21	50	50 MHz		X	X	
30 - 60	170	20 MHz		X	X	
40	500	90 MHz		[X]	X	
50	170	4 MHz		X	X	
75	400	8 MHz		[X]	X	
60 - 150	400	300 MHz			X	
120	400	3 MHz		X	X	
200	400	100 MHz			X	
300 - 30	300-600	Octave		X		

Key: X Available
(X) On order or planned
[X] Available, not optimum

Dec. 1973

Technical Data Sheet
November 1973

No. 12

Applicable Telescope	Frequency (MHz)	Amplifier Type	System Temperature (Kelvin)	Bandwidth (MHz)	Feed Type	Polarization	Calibration Value	Switching System	Remarks	Person in Charge
300' Fixed on Traveling Feed 140' Clip-On	50-80	Transistor	≥ 450 K ≥ 500 K with Dicke switch.	5	≈ 10% Band-width. Tunable Crossed-Dipole	Simultaneous 0°, 45°, 90°, 135° Linear, RCP and LCP. Removable quad hybrid at feed for CP.	Adjustable 30 K to 30000 K	Removable diode Dicke switch.	Designed for pulsar, continuum, and line work. 110-500 MHz feeds can be rotated 45° and 90° for polarization work. Usable with 4-channel multi-bandwidth receiver and all NRAO line receivers. About 2 hours to change Dicke switch and feed hybrid. Frequency switching not available.	Brundage
	110-250		≥ 200 K ≥ 260 K with Dicke switch.	140	Broadband Crossed-Dipole		Adjustable 8 K to 8000 K			
	250-500		≥ 320 K ≥ 220 K with removable 330-450 MHz amplifiers. Additional 50 K with Dicke swtich.	250	Broadband Crossed-Dipole		Adjustable 1.5 K to 1500 K.			
300' Fixed on Traveling Feed 140' Clip-On	500-610	Paramp Ch X	≥ 150	20 to 40	Broadband Crossed-Dipole	Single linear or circular with removable quad hybrid. Dual polarization at 610 MHz.	5 K or 50 K	Frequency switching. Removable Dicke switch.	Traveling feed box for 300' can be used on 140' as clip on. Available 1974. Multiple polarization with IF polarizer on 300' at 610 MHz. About 4 hours to change hybrid and Dicke switch. Feed can be rotated 45° and 90°.	Brundage
	610-740	Paramp Ch Y								
300' Fixed on Traveling Feed 140' Clip-On	740-880	Paramp Ch X	≥ 150	20 to 40	Broadband Crossed-Dipole	Single linear or circular with removable quad hybrid. Dual polarization at 835 MHz.	5 K or 50 K	Frequency switching. Removable Dicke switch.	Traveling feed box for 300' can be used on 140' as clip on. Multiple polarization with IF polarizer on 300' at 835 MHz. About 4 hours to change hybrid and Dicke switch. Feed can be rotated 45° and 90°.	Brundage
	835-1000	Paramp Ch Y								
140'	100 to 1000	Transistor	300 to 500	Limited by feed to 5%	Tunable Dipole	Dual Linear	≈ 50 K	Frequency.	Line and VLB. Can be used on 140' as clip on.	Moore
300/140'	1400 x 4	Paramp	150	60	4 Horns Scalar	Linear Dual Linear	4 K and 15 K	300 K load,polarization, or frequency switching.	Line or continuum from control room.	Fleming
140/300'	1410 Dual Channel	Cooled Paramp	50	25	Scalar	Dual Linear	4 K	Frequency switching. Total power.	Can be remotely tuned anywhere in frequency range 1375-1435 MHz. Two channels can be used simultaneously at different frequencies. Six polarizations are available simultaneously with IF polarimeter. Will tune 1370-1440 MHz with higher noise temperature outside range 1375-1435 MHz.	Fleming
140/300'	1610-1720 Dual Channel	Cooled Paramp	60	30	Scalar	Dual Linear	4 K	Normally frequency switched. Can be polarization switched.	Can be remotely tuned anywhere in frequency range 1610-1720 MHz. Two channels can be used simultaneously at different frequencies. Six polarizations are available simultaneously with IF polarimeter. Will tune 1540-1780 with higher noise temperature outside range 1610-1720 MHz.	Moore
140/300'	1000 to 2000	Paramp	270	30	1-2 GHz Scalar	Linear	10 K	300 K load or frequency switching.	Set of seven tunable paramps in two receiver boxes. Paramp change 2 hours. Receiver change 4 hours. Rx 1: 1.0-1.15, 1.16-1.3, 1.3 -1.7, 1.62-2.0 Rx 2: 2.0-2.54, 2.5 -3.15, 3.15-4.0 Paramps 2.1-2.4, 2.6 -3.1, 3.3 -3.9 LO Multipliers	Dunbrack
140/300'	2000 to 4000	Paramp	270 to 500	30	2-4 GHz Scalar	Linear	10 K	300 K load or frequency switching.		Dunbrack
Any	2295	Paramp	100	50	Horn	Circular	10 K	None.	Packaged in small temperature-stabilized box. Can be installed on other telescopes with little effort.	Grove
140/300'	2695 x 4	Degenerate Paramp	120	100 DSB	3 Horns	Dual Circular or Dual Linear	4 K	300 K load or polarization.	Continuum receiver. On-axis horn has paramps on both polarizations. Four hours to change polarization.	Fleming

NRAO FRONT-END BOX STATUS

Technical Data Sheet
November 1973

No. 12
Page 2 of 3

Applicable Telescope	Frequency (MHz)	Amplifier Type	System Temperature (Kelvin)	Bandwidth (MHz)	Feed Type	Polarization	Calibration Value	Switching System	Remarks	Person in Charge
140/300'	2695	Paramp	200	40	TRG Scalar	Dual Linear	3 K	300 K load or other polarization.	Choice of switching system from control room.	Behrens
140'/300'	4750-5100	AIL Cooled Paramp	90 line 135 cont.	225	TRG Scalar or 2 Horns	Dual Linear Orth. Linear	4 K	Other polarization, other beam, or 50 K load.	Feed change requires 3 hours. Dual horns are used for beam switching. A horn can be mounted off-axis to scalar feed, but beam spacing is high, approximately 30'. Two hours for switch change.	Behrens
140'	4500-5200	TRG Cooled Paramp	70 line 100 cont.	250	2 Horns or Scalar	Orth. Linear Dual Linear	≈ 5 K	Other polarization, other beam, or 25 K load.	Two feed arrangements are available: (1) Scalar and (2) dual horns for beam switching. Bandwidth and noise varies with center frequency.	Behrens
Any	4600-5100	Paramp	150	20	Horn	Linear	≈ 10 K	None.	Packaged in small temperature-controlled box. Can be installed on other telescopes with little effort.	Grove
140'	7.7—8.0 GHz	Cooled Paramp	100 line 125 cont.	120	Conical Horn	Linear/ Circular	----- ≈ 9 K	Frequency or beam.	Two hours to change switch; 1/2 hour to change polarization.	Brockway
140'	5.2—10.4 GHz	Paramps	300 to 400	40	Horn	Linear	≈ 20 K	Frequency switching.	Set of 7 tunable paramps in 2 bands about 7 GHz. Paramp change 1 1/2 hour. Band change 3 hours. Band 1: 5.2-5.8, 5.8-6.4, 6.4-7.0 Band 2: 7.0-7.8, 7.8-8.6, 8.6-9.5, 9.5-10.4.	Brockway
Any	10,695	Paramp	250	20	Horn	Linear	≈ 10 K	None.	Packaged in small temperature-controlled box. Can be installed on other telescopes with little effort.	Grove
140'	10,300 — 11,000	TRG Cooled Paramp	100	300	2 Horns or Scalar	Dual Linear Orth. Linear	≈ 7 K	Other polarization, other beam, or 25 K load.	Two feed arrangements available: (1) Scalar, and (2) dual horns for beam switching. Bandwidth and noise varies with center frequency. Two hours to change switch.	Behrens
140'	14.4—14.9 Dual Ch.	Cooled Paramp	100-150	500	2 Horns or Scalar	Orth. Linear/ Circular Dual Circular/ Linear	≈ 20 K	Frequency, beam, or polarization switching.	Two feeds available — two off-axis horns or dual polarization scalar.	Moore
140'	15,400-5000	TDA TDA	1100 1100	3 GHz 400	Horns Horns	Linear Linear	17 K 8 K	Beam or load switching.	Can be installed on 140' telescope in front of existing box in 2 hours. Box may be removed in a similar time, allowing lower frequency programs to continue when weather is too bad for 15 GHz observations.	Dolan
36'	15,375	TDA	1600	2 GHz	2 Horns	Parallel Linear	5 K	Other beam or sky horn.	Original 2 cm receiver repackaged in 36' box.	Dolan
140'	12.4—18 GHz	TDA's	1000 to 1300	50	Horn	Orth. Linear	≈ 10 K	Off-axis beam or frequency switching.	Contains LO system tunable 12.4—18 GHz. Three TDA's to cover the band: 12.4—14.5, 14.5—16.0, 16.0—18.0.	Brockway
36'	22—24 GHz	Degenerate Paramp	300 DSB	100 DSB	Horn	Linear	≈ 20 K	Load, beam, or frequency.	Stabilized LO system.	Cochran
36'	31—50 GHz	Mixer	1500 SSB	100	Horn	Linear	250 K	Chopper wheel or frequency.	Line receiver.	Ross
36'	31.4 GHz	Mixer	1100 DSB	400	2 Horns	Variable	28 K	Other beam or load.		Ross
36'	45.6 GHz	Degenerate Paramp	150 DSB	1000 DSB	Horn	Linear	10 K	Beam, load.	Under development. Estimate completion December 1973.	Weinreb
36'	85 GHz	Mixer	2000 DSB	1 GHz	2 Horns	Variable	28 K	Other beam or load.	Single horn mechanically position-modulated or ferrite switch. Continuum only.	Ross
36'	67—101 GHz	Mixers	4000 SSB	100	Beam Switch	Linear	30 K	Beam or frequency.	Stabilized LO for line work. Component channels required to tune over the 67-101 GHz range.	Ross

NRAO FRONT-END BOX STATUS

Technical Data Sheet
November 1973

No. 12

Applicable Telescope	Frequency (MHz)	Amplifier Type	System Temperature (Kelvin)	Bandwidth (MHz)	Feed Type	Polarization	Calibration Value	Switching System	Remarks	Person in Charge
36'	85 GHz	Mixer	1500 DSB	1 GHz	Cassegrain Horn & Lens	Dual Linear	≤ 10 K	Nutating subreflector.	Cassegrain system. Continuum use only.	Ross
36'	85—95 GHz	Mixer	1500 SSB	100	Horn	Linear	---	Chopper wheel or frequency.	Line receiver.	Ross
36'	108—116 GHz	Mixer	1400 SSB	100	Horn	Linear	---	Chopper wheel or frequency.	Line receiver.	Ross
36'	80—120 GHz	Cooled Mixer	400 SSB* per channel	500 MHz*	Cassegrain Horn & Lens	Dual Linear	≤ 10 K	Nutating subreflector or frequency.	Line or continuum.* Two channels receive orthogonal linear polarizations. The second LO in one channel is variable, allowing channels to be separated by up to 500 MHz.	Kerr
36'	250 GHz	Cooled "3-part" Bolometer	30 000	100 GHz limited by filters and atmosphere	Optical Single or Dual Beam	Unpolarized	Special procedure.	Other beam or load.	Scandium-Germanium bolometer. Reaches approximately 4 Jansky RMS in 1 hour under dry weather conditions. NEP = 2×10^{-13}.	Payne
36'	250 GHz	I_nSb Bolometer	160 000	100 GHz limited by filters and atmosphere	Optical Single or Dual Beam	Unpolarized	Special procedure.	Other beam or load.	Kinch-Rollin detector. Gain very stable. NEP ~ = 10^{-12}	Payne

VLA PERFORMANCE DATA

The VLA performance given in Table I is based on an array consisting of 27 antenna elements, each 25 m diameter, distributed along three arms of a wye. Each arm of the wye is 21 km long. The distribution of antenna elements is not symmetric, nor is the distance between elements equal. The positions of the antenna elements have been optimized for best performance (low sidelobes) over the sky above -15° declination.

The basic VLA operates at 4.75 GHz (6.3 cm) with both circular polarizations available.

Additional equipment will extend this capability to other frequencies. Then one polarization at each of two frequencies, or both polarizations at one of the frequencies, will be available simultaneously.

Table I shows the basic performance specifications for the VLA. The resolution and the fields of view given in the table correspond to the maximum resolution available with 21 km arms. There will be a total of 100 station available which will permit operation at a total of 4 different resolutions.

TABLE I

f (GHz)	λ (cm)	Resolution (arc sec)	Field of View at Maximum Resolution (arc sec)	Maximum Side-lobe Within Field of View (dB)[1]	Mean Distant Sidelobe (dB)	System Temperature (°K)	IF Bandwidth (MHz)	Sensitivity 12-hour Track[2] ($W\ m^{-2}\ Hz^{-1}$)
1.50	20.0	2	240	-15	-30	35	75	$6x10^{-31}$
4.75	6.3	0.6	72	-15	-30	40	75	$7x10^{-31}$
14.90	2.0	0.2	24	-15	-30	200	75	$4x10^{-30}$
22.50	1.3	0.13	15	-15	-30	250	75	$5x10^{-30}$

[1] At declinations above 15°

[2] About 5 times the rms noise level

Very Large Array (VLA) Construction Program

CY 1973 (First Year)

Procure and Design Antenna System

Procure Transporter

Develop Electronics and Computer

Acquire Central VLA Site

CY 1974 (Second Year)

Build Prototype Antennas

Design Site Facilities

Fabricate Prototype Electronics

Construct 0.7 Miles of Track

CY 1975 (Third Year)

Procure 4 Antenna Systems

Construct Site Facilities

Construct 2.9 Miles of Track (3.6 Total)

CY 1976 (Fourth Year)

Add 4 Antenna Systems (10 Total)

Add 2.6 Miles of Track (6.2 Total)

Start Partial Operations

CY 1977 (Fifth Year)

Add 5 Antenna Systems (15 Total)

Add 5.3 Miles of Track (11.5 Total)

CY 1978 (Sixth Year)

Add 5 Antenna Systems (20 Total)

Add 5.2 Miles of Track (16.7 Total)

CY 1979 (Seventh Year)

Add 5 Antenna Systems (25 Total)

Add 6.0 Miles of Track (22.7 Total)

CY 1980 (Eighth Year)

Add 3 Antenna Systems (28 Total)

Add 8.0 Miles of Track (30.7 Total)

CY 1981 (Ninth Year)

Add 8.5 Miles of Track (39.2 Total)

Full Operations

NRAO - STAFF AND VISITOR PUBLICATIONS 1973

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Backer, D.C., "Pulsar Fluctuation Spectra and the Generalized Drifting Subpulse Phenomenon", Astrophys. J., 182, 245-276, 1973.

Backer, D.C., Boriakoff, V., and Manchester, R.N., "Wide Integrated Pulse Profiles of Pulsars", Nature-Phys. Sci., 243, 77-78, 1973. (B407)

Bates, R.H.T., Gough, P.T., and Napier, P.J., "Speckle Interferometry Gives Holograms of Multiple Star Systems", Astron. & Astrophys., 22, 319-320, 1973. (A277)

Baker, P.L., "Small Scale Individual Features in the Local Neutral Hydrogen", Astron. & Astrophys., 26, 203-214, 1973. (A295)

Baker, P.L., "A Statistical Investigation of Neutral Hydrogen Line Profiles", Astron. & Astrophys., 23, 81-92, 1973. (A278)

Baker, P.L., and Diadiuk, V., "The Temperature of the Turbulent Intercloud Medium", Astrophys. Letters, 13, 199-203, 1973. (A289)

Balick, B., Bignell, C., and Terzian, Y., "Fine Structure in NGC 7027", Astrophys. J., 182, L117-L120, 1973. (B392)

Becker, R.H., and Kundu, M.R., "Interferometric Measurements of the Compact Source 2048+31", Nature-Phys. Sci., 244, 138-139, 1973

Becklin, E.E., Fomalont, E.B., and Neugebauer, G., "Infrared and Radio Observations of the Nucleus of NGC 253", Astrophys. J., 181, L27-L31, 1973. (B383)

Bignell, R.C., "A Radio Recombination Line in the Spectrum of W44", Astrophys.J., 186, 889-898, 1973.

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