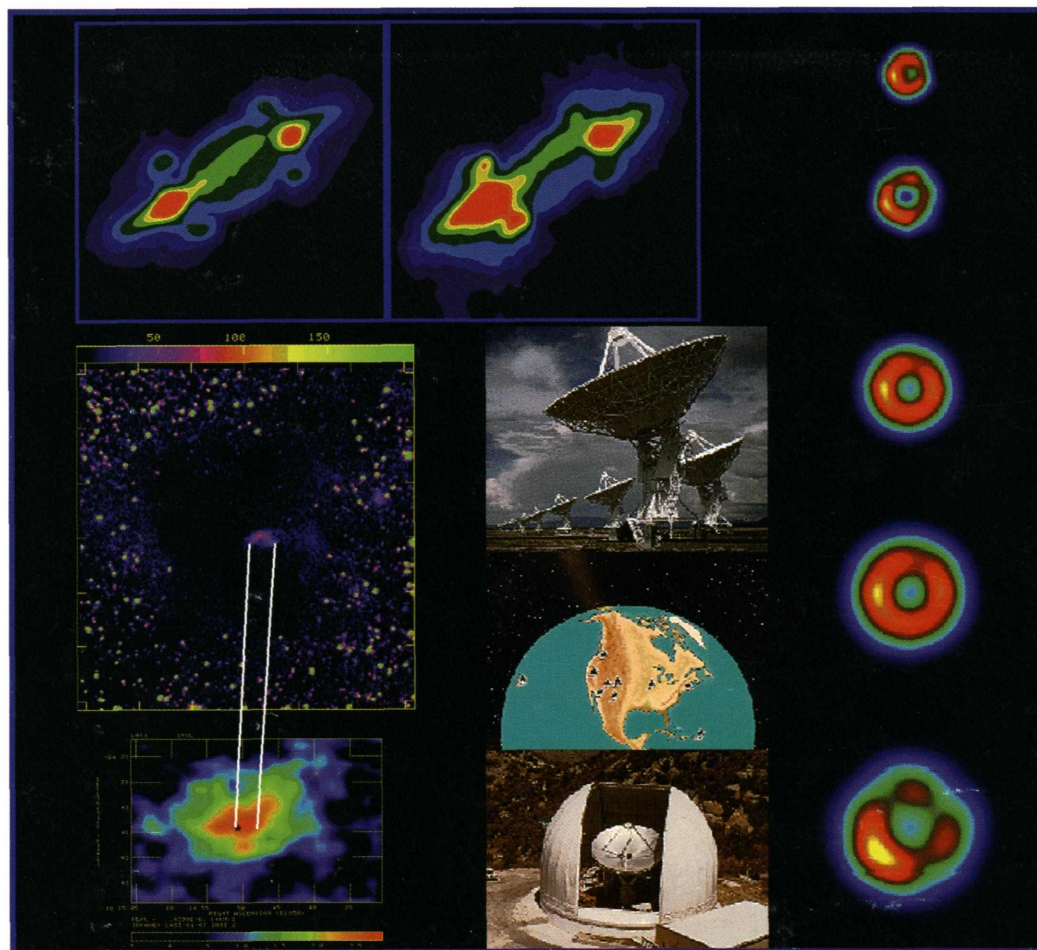


# NATIONAL RADIO

OBSERVING



SUMMARY

## ASTRONOMY OBSERVATORY



# 1996 STATISTICS

Cover Image, clockwise from upper left: VLA images of Jupiter before and after the impact on Jupiter of comet Shoemaker-Levy; sequential VLBA images of supernova 1993J in the galaxy M81; the 12-meter telescope on Kitt Peak, AZ; a 12m telescope on-the-fly image of the CO emission in the L183 dark cloud together with an optical image of that cloud. The two center panels show the VLA antennas and the VLBA station locations respectively.

# **NATIONAL RADIO ASTRONOMY OBSERVATORY**

## **Observing Summary — 1996 Statistics**



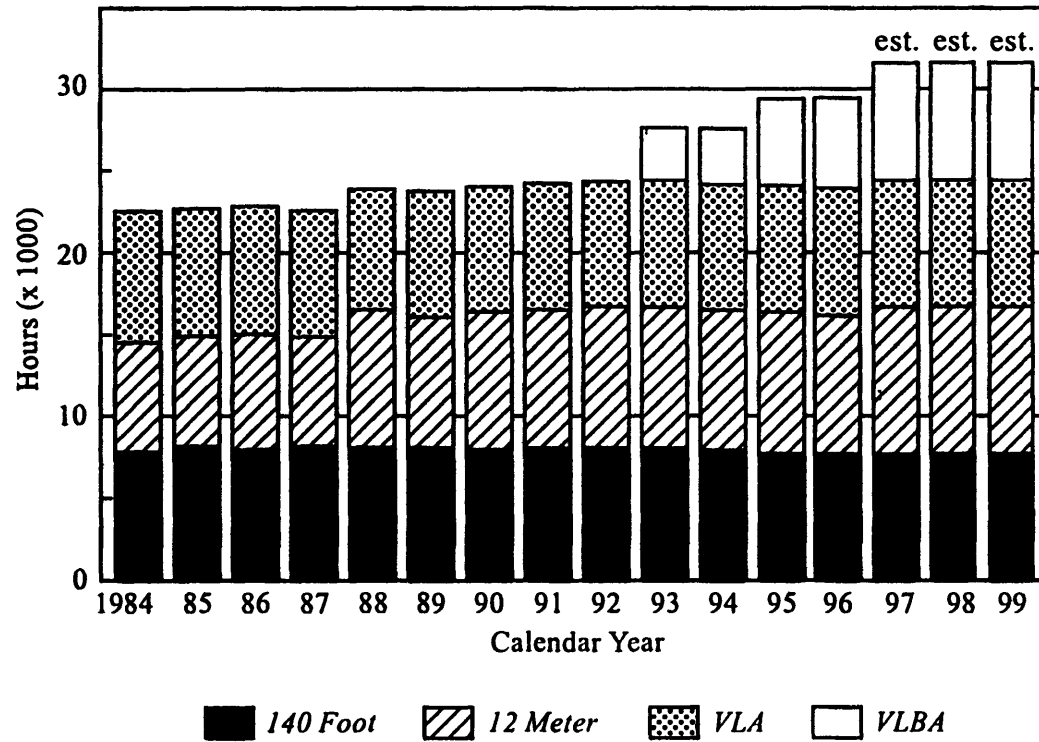
February 1997

## SOME HIGHLIGHTS OF THE 1996 RESEARCH PROGRAM

- The Very Large Array (VLA) observations have helped to confirm the existence of a “quasar cutoff”. Optical studies have indicated that the space density of quasars decreases rapidly at distances beyond redshift  $Z=3$ . This is not, however, an unambiguous result, because the optical cutoff could be caused by obscuration of more distant quasars by dust in intervening galaxies. A study of radio emission from quasars was undertaken with the VLA and the Australia Telescope to see if the decline in space density occurs when quasars are observed at wavelengths unaffected by dust. The result was similar to that of the optical studies, showing a strong decrease in quasars at redshifts greater than  $Z=3$ . The radio studies strengthen the case for the “cutoff” applying to all quasars. If this is the case, the observations provide a measure of the timescale for processes such as galaxy formation and interactions, thought to be associated with quasars.
- Comets Hyakutake (C/1996 B2) and Hale-Bopp (1995 OI) have been intensively studied at both the 12 Meter and 43 Meter NRAO Telescopes, as part of the international effort. The near-Earth passage of Hyakutake allowed measurements of  $\text{CH}_3\text{OH}$ ,  $\text{H}_2\text{CO}$ , HCN, and CO emission and hence the production rates of these species, which indicate that the HCN production rate is similar to that for CN, suggesting a direct link between these two species. The CO and  $\text{H}_2\text{CO}$  production rates, by contrast, indicate that  $\text{H}_2\text{CO}$  is not the main parent of the observed CO. Rather, CO and  $\text{H}_2\text{CO}$  are both parent species (species left over from the formation of the comet), while HCN is not a parent species. OCS was discovered in Hyakutake, allowing a new insight into sulfur chemistry in comets. Its production rate, compared to that of OH, agrees with theoretical prediction. Ammonia ( $\text{NH}_3$ ) has been detected toward Hyakutake and determines a kinetic temperature of 67 K for the cometary gas. The  $\text{NH}_3/\text{H}_2\text{O}$  ratio is  $\sim 0.003$ , five times less than the same ratio in comet Halley made with the Giotto space-craft. Comet Hale-Bopp has been the subject of a monitoring program to study the changes in the CO production rate. These results suggest that the comet is an object similar to Chiron, yet is presently a long-period comet that has evolved from an Oort Cloud quasi-parabolic trajectory. CO is thought to be the dominant outgassing agent in the comet.
- Precise analysis of pulse arrival times from pulsars shows that there are often perturbations in the apparent pulsar period. One source of this timing noise is variation in the pulsar's dispersion measure caused by its motion through the interstellar medium (ISM). Multifrequency timing observations on the 43 Meter Telescope show, however, that the perturbations do not scale with wavelength squared, as would be expected from dispersive changes, but rather as wavelength to the fourth power. This implies that, because of interstellar scattering, a different volume of the ISM is being sampled by pulses at different frequencies. Precision timing in the presence of this unstable “interstellar weather” is thus difficult, and requires multi-frequency observations at the highest possible frequencies.

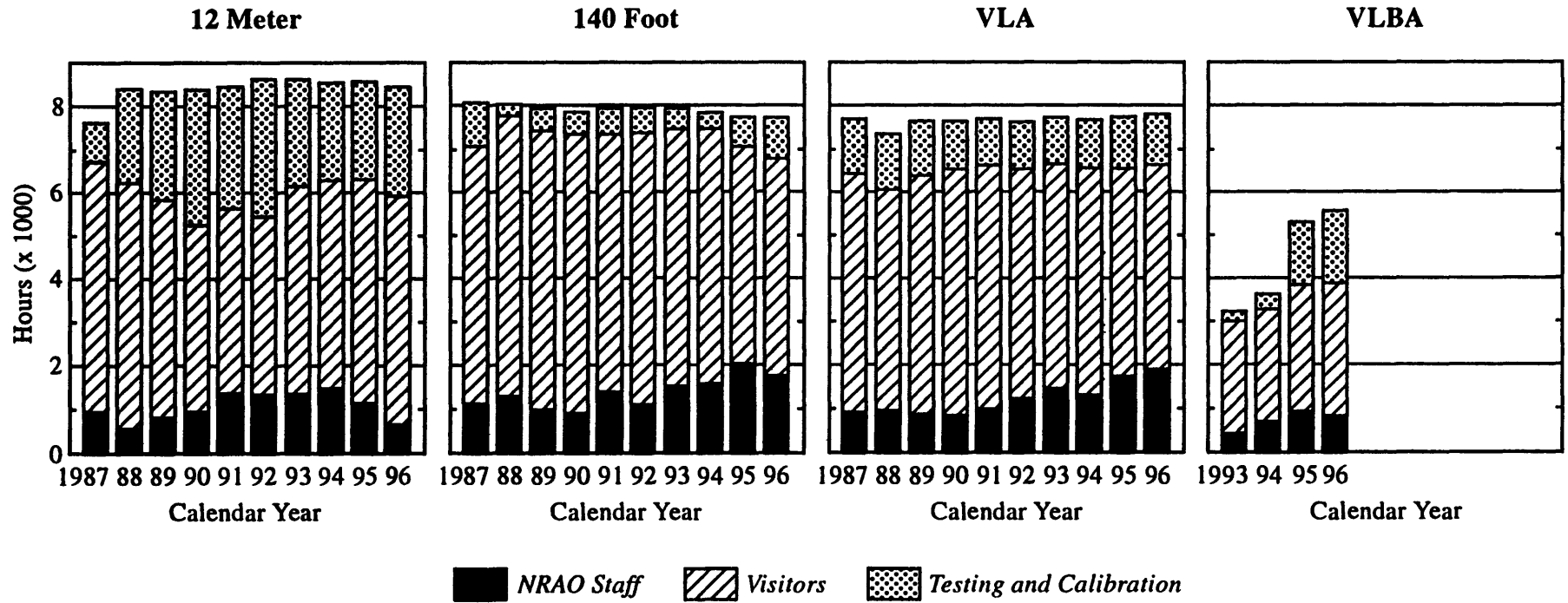
- NGC 4258 continued to provide impressive results during 1996. The same VLBA data sets that were used to provide the images of H<sub>2</sub>O masers in a Keplerian disk around the center of the galaxy were re-analyzed to demonstrate that weak continuum emission is also present. The strong H<sub>2</sub>O masers at the galaxy's systemic velocity were used as a phase-reference and revealed compact continuum emission with a flux density of about 3 mJy about 0.015 pc north of the dynamical center of the disk. The emission is presumably synchrotron radiation from the base of the jet. The jet-like structure lies almost exactly along the spin axis of the rotating disc of molecular gas. This is the first time that the relative position of the central engine with respect to the core (a stationary feature in the nozzle of the jet) of a relativistic outflow has been determined.
- Redshifted absorption lines have been detected in gravitational lens systems. VLA studies of the Einstein ring radio source PKS 1830-211, the brightest radio gravitational lens, have revealed redshifted absorption lines from eight different molecular species. These include a line of HCO<sup>+</sup>, redshifted from 89.2 to 47.3 GHz. The absorption occurs in only one of the two bright radio components of the lens. The size of the Einstein ring implies a massive lensing galaxy, which if assumed to be a giant elliptical, implies evidence for a giant molecular cloud in the ISM of a young giant elliptical galaxy at a galactocentric radius of about 5 kpc. Studies such as this provide the most direct means of learning about the neutral and molecular ISM in galaxies at cosmologically significant redshifts.
- An experimental observation using the VLA and an 85-ft telescope at Green Bank has provided information on the broadband spectrum of the giant pulses in the Crab pulsar. The phased VLA observed the Crab at 1400 MHz and the 85-ft telescope observed it at 610 MHz. A trigger pulse was sent from the VLA to Green Bank using a socket link on the Internet. The typical Internet delay of 200 ms was less than the dispersion delay between 1400 MHz and 610 MHz. The results showed high correlation of the events at both frequencies. The broad spectrum of the pulses supports models of a small radiating unit that delivers a nanosecond-wide pulse.
- Polarization maps made with the VLA show evidence for a large-scale, structured magnetic field surrounding a pair of colliding galaxies. The L-band observations of 4C 35.3, a pair of interacting elliptical galaxies, indicate a magnetic field larger than the size of either galaxy. The field is within the halo surrounding the galaxies, with two magnetic loops, each centered on one of the jets emitted by the nucleus of the larger galaxy. This raises the possibility that the halo surrounding the interacting pair may be formed from material emitted by the jets.

## OBSERVING HOURS



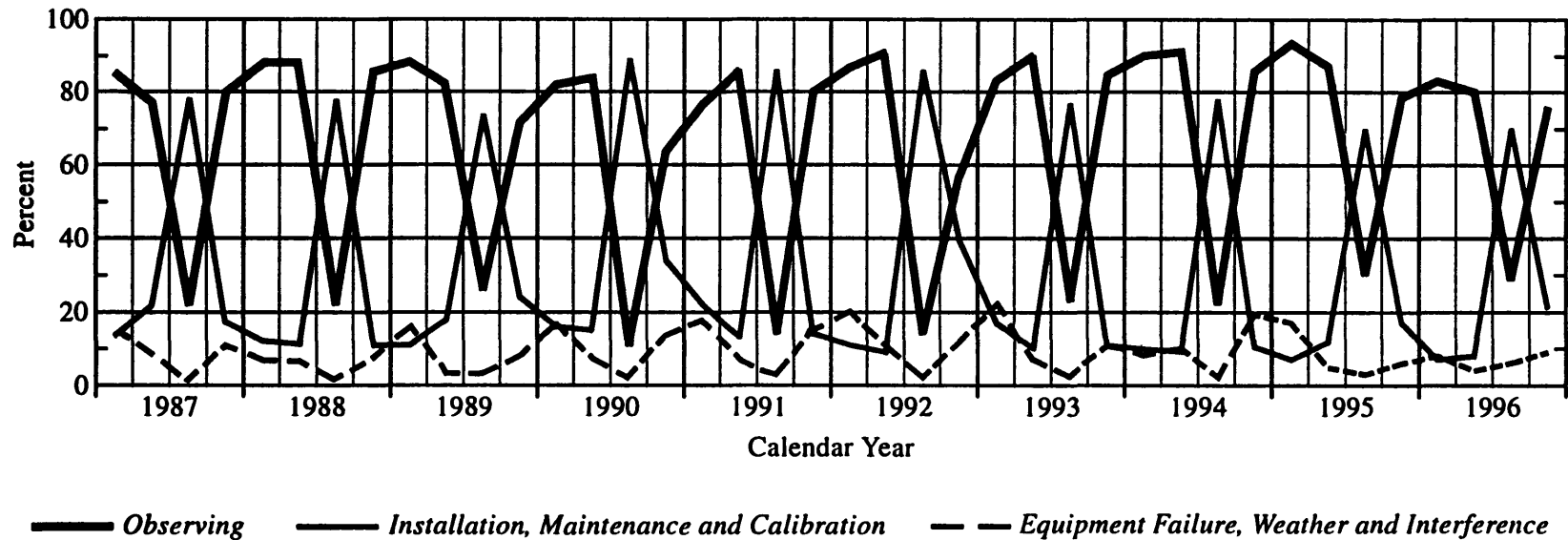
**Fig. 1.** This figure shows the hours scheduled for observing on each telescope during the last decade. Includes astronomical observing, testings, and calibration.

## DISTRIBUTION OF SCHEDULED OBSERVING TIME



**Fig. 2.** These graphs show the number of hours scheduled for testing and calibration, and for observing by the NRAO staff and by visitors on each telescope system.

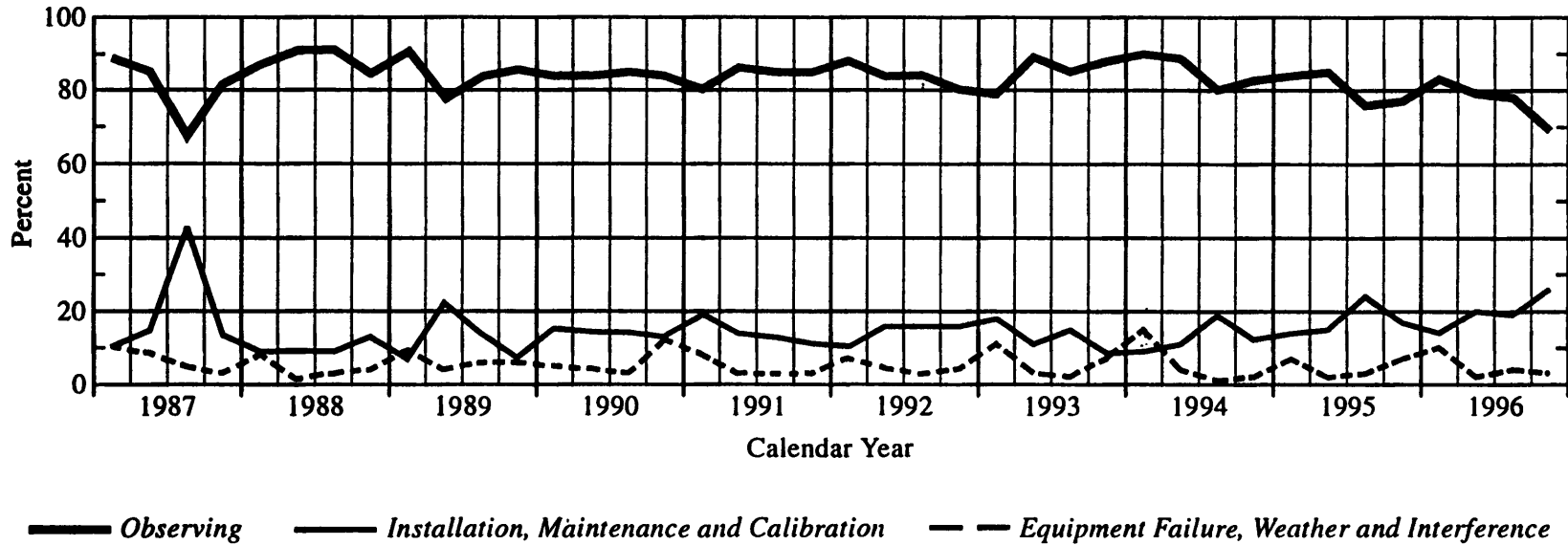
## 12 METER RADIO TELESCOPE SUMMARY



**Fig. 3.** This summary for each quarter of the calendar year shows the percentage of time the telescope was scheduled for observing; for routine calibration, maintenance, and installation of new experiments; and the percentage of time lost due to equipment failure, bad weather, and radio interference. The telescope is removed from service for a period of four to six weeks each summer during the wet season. This period is used for maintenance and upgrading of the instrument.

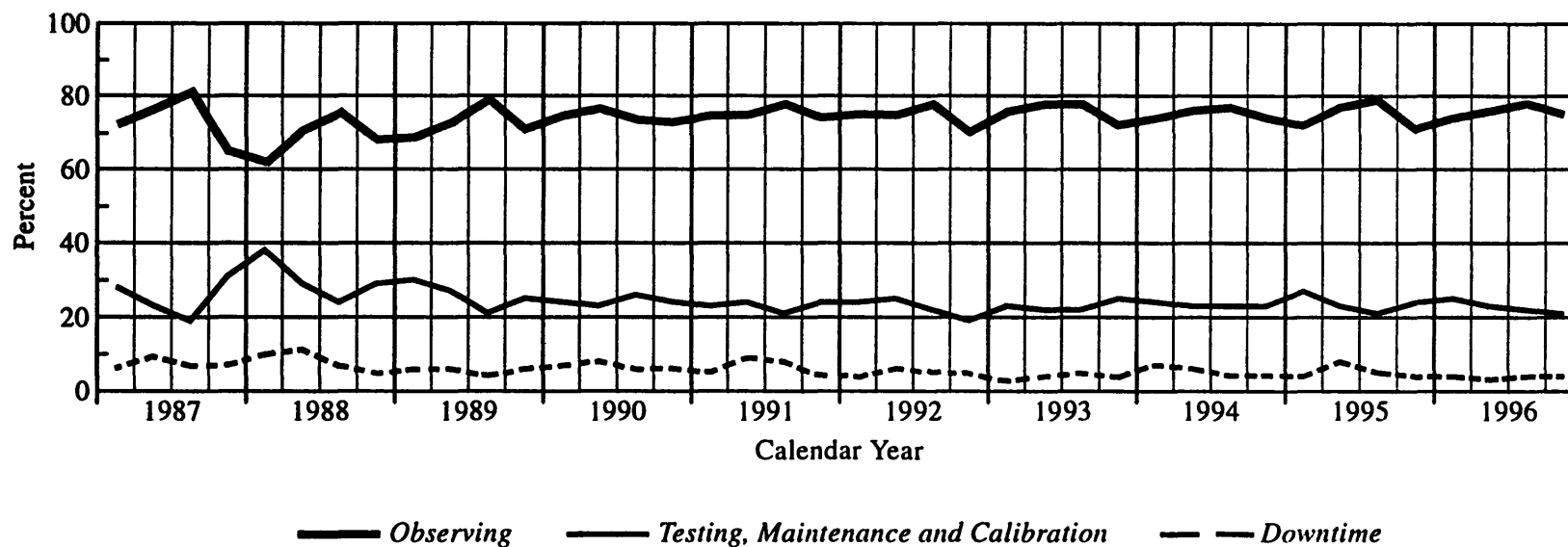


## 140 FOOT RADIO TELESCOPE SUMMARY



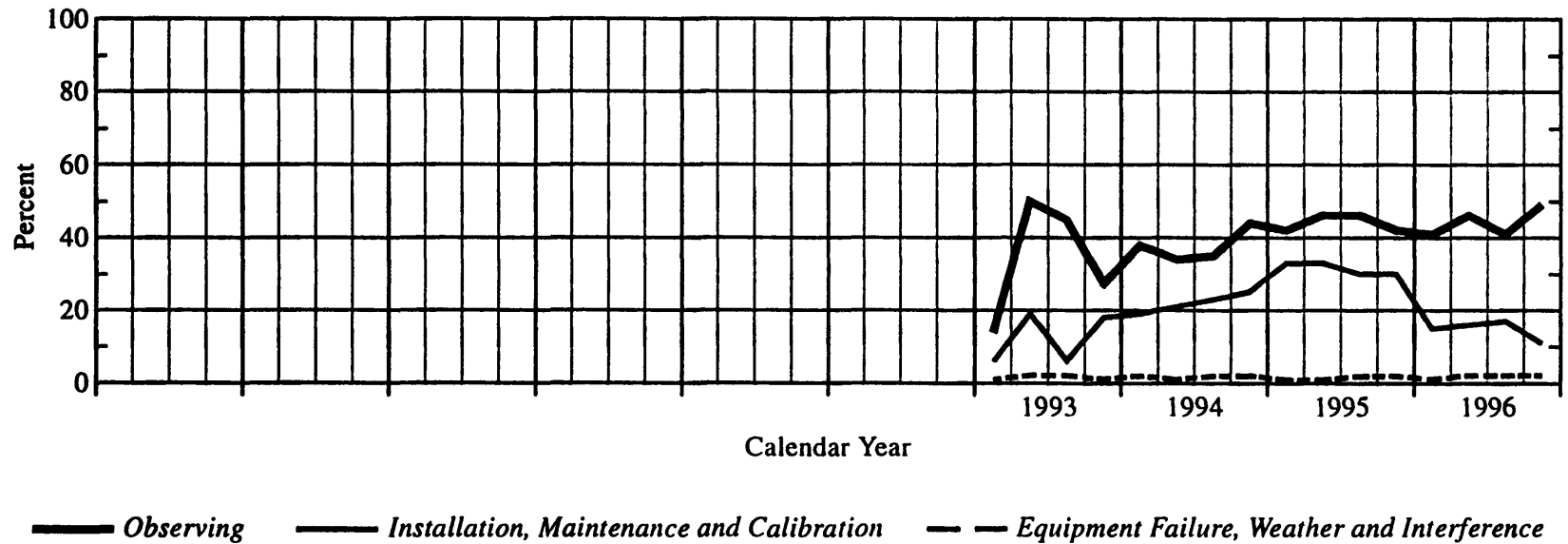
**Fig. 4.** This summary for each quarter of the calendar year shows the percentage of time the telescope was scheduled for observing; for routine calibration, maintenance, and installation of new experiments; and the percentage of time lost due to equipment failure, bad weather, and radio interference. Major improvements to the telescope system include holographic surface tests and panel readjustments in 1987.

## VERY LARGE ARRAY TELESCOPE SUMMARY



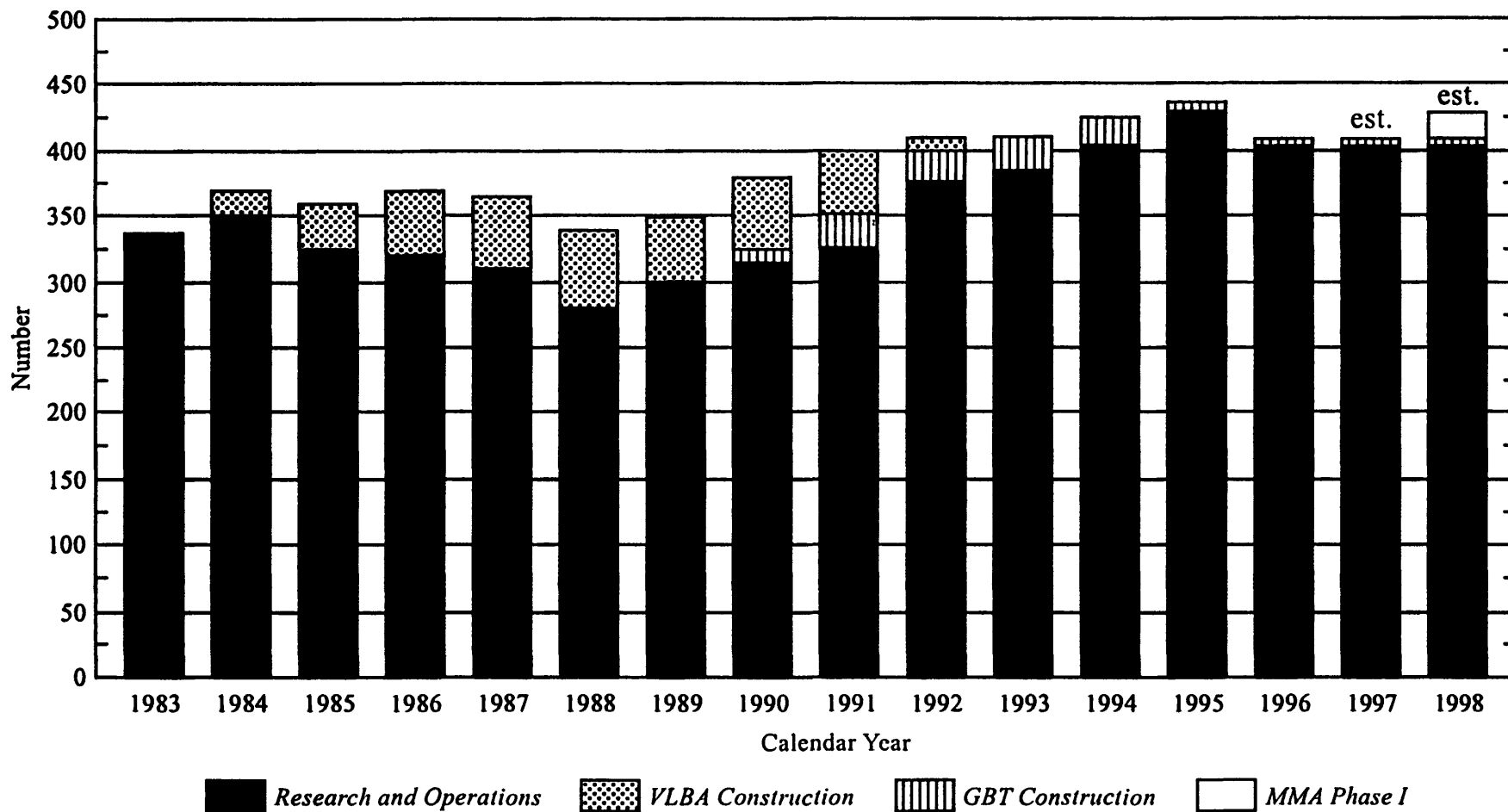
**Fig. 5.** This summary for each quarter of the calendar year shows the percentage of time the telescope was scheduled for observing; for routine system testing, maintenance, and calibration; and the percentage of time lost due to hardware or software failure, power failure, or bad weather.

## VERY LONG BASELINE ARRAY TELESCOPE SUMMARY



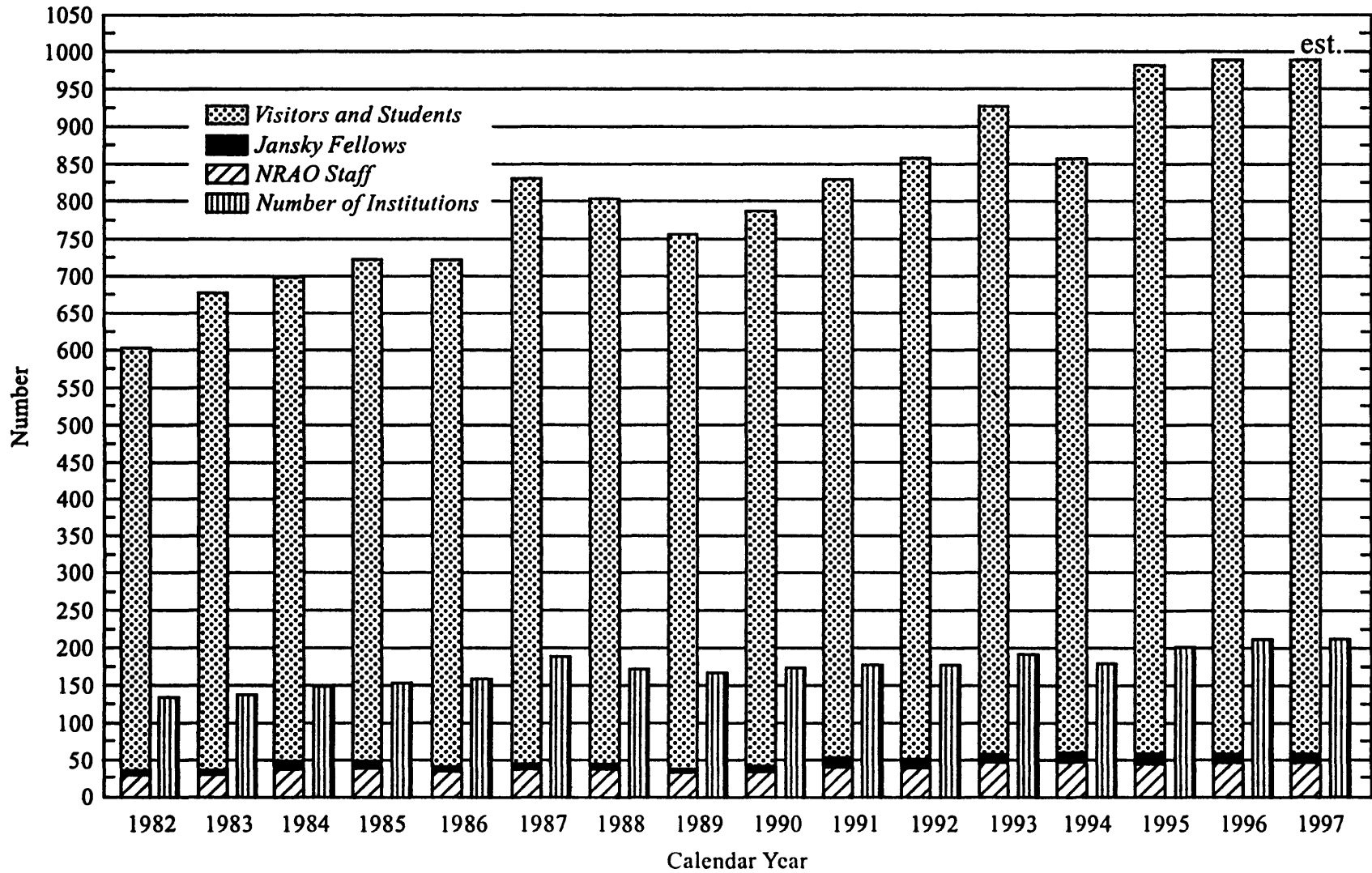
**Fig. 6.** This summary for each quarter of the calendar year shows the percentage of time the telescope was scheduled for observing; for routine calibration, maintenance, and installation of new experiments; and the percentage of time lost due to equipment failure, bad weather, and radio interference.

## FULL-TIME EMPLOYEES



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

## NUMBER OF PEOPLE OBSERVING WITH NRAO TELESCOPES



**Fig. 8.** This bar chart shows for each calendar year the number of NRAO research staff and the number of NRAO postdoctorals (Jansky Postdoctorals) who used the telescopes. In addition, it shows the total number of visitor-users of NRAO telescopes and the number of institutions from which the NRAO visitors came.

**DISTRIBUTION OF SCHEDULED OBSERVING PROGRAMS  
IN VARIOUS RESEARCH AREAS, BY PERCENT**

	12 Meter	140 Foot	VLA	VLBA	Overall
<b>I. SOLAR SYSTEM —</b>					
Sun, Planet, Satellites, and Comets	17%	9%	6%	3%	9%
<b>II. STELLAR —</b>					
Pulsars, X-ray Sources, Planetary Nebulae, Circumstellar Shells, Supernova Remnants, Masers, Novae, Supernovae, and Stars	8%	27%	26%	21%	21%
<b>III. GALACTIC —</b>					
Galactic Structure, Center, Molecular Clouds, HII Regions, Star Formation, Molecules, and Interstellar Medium	44%	45%	23%	10%	25%
<b>IV. EXTRAGALACTIC —</b>					
Normal and Active Galaxies, Radio Galaxies, Clusters, Quasars, VLBA Studies, Extragalactic Molecules, and Cosmology	31%	19%	45%	66%	45%

**DISTRIBUTION OF TELESCOPE TIME BY PERCENT**

	12 Meter	140 Foot	VLA	VLBA	1996 Summary
Visitors	48%	46%	47%	31%	43%
Students	12%	11%	8%	4%	9%
NRAO Staff	6%	12%	20%	7%	11%
Jansky Postdoctorals	1%	8%	1%	2%	3%
Test and Calibration	29%	11%	13%	19%	18%
Maintenance and Installation	3%	9%	10%	16%	9%
Holidays and Unscheduled	1%	3%	1%	21%	7%

**INSTITUTIONS FROM WHICH VISITORS CAME TO USE NRAO TELESCOPES DURING 1996**

	<b>Institute</b>	<b>140 Foot</b>	<b>12 Meter</b>	<b>VLA</b>	<b>VLBA</b>
1	Agnes Scott College (GA)			X	
2	Alabama, University of			X	
3	American Assoc. Variable Star Observers (MA)			X	
4	Amsterdam, University of - Astronomy Institute			X	
5	Applied Research Corporation				X
6	Arcetri Astrophysical Observatory (Italy)			X	
7	AFIPI (Russia)				X
8	Arizona, University of - Steward, LPL, SMTO	X	X	X	X
9	Arizona State University		X	X	
10	Astrophysical Institute, Potsdam (Germany)			X	
11	Athens, University of (Greece)			X	
12	Barcelona, University of (Spain)			X	X
13	Birmingham, University of (UK)			X	
14	Bochum, University of (Germany)			X	
15	Bologna, University of (Italy)			X	X
16	Bonn University (Germany)		X	X	
17	Bordeaux Observatory (France)	X		X	X
18	Boston University (MA)	X	X	X	X
19	Brandeis University (MA)		X	X	X
20	Brera Osservatorio (Italy)		X		



	Institute	140 Foot	12 Meter	VLA	VLBA
21	Bristol - Cantock Close (UK)				X
22	Byurakan Astrophysical Observatory (Armenia)			X	
23	Calgary, University of (Canada)			X	
24	California, University of, Davis	X		X	
25	California, University of, Berkeley	X	X	X	X
26	California, University of, Los Angeles	X	X	X	X
27	California, University of, Riverside - IGPP		X	X	
28	California, University of, San Diego				X
29	California, University of, Santa Cruz - Lick			X	
30	California, University of, Santa Barbara			X	X
31	Caltech - OVR, Palomar, Big Bear Solar Obs.	X	X	X	X
32	Cambridge Univ. - Cavendish, MRAO, IOA (UK)			X	X
33	Canadian Military College			X	
34	Cantabria, University of (Spain)			X	
35	Catania University (Italy)			X	
36	CFA - Harvard, SAO (MA)	X	X	X	X
37	CNRS, France (CEN, Saclay)			X	X
38	Chalmers-Onsala Space Observatory (Sweden)	X	X	X	X
39	Chicago, University of - Yerkes Obs. (IL)	X		X	
40	Chile, University of (Chile)			X	

	Institute	140 Foot	12 Meter	VLA	VLBA
41	Chungnam National University (Korea)		x		
42	Cologne, University of (Germany)			x	
43	Colorado, University of - JILA, LASP, CASA		x	x	x
44	Columbia University (NY)			x	
45	Connecticut College		x		
46	Cornell University (NY)	x		x	x
47	CSIRO - ATNF, Parkes Obs. (Australia)	x		x	x
48	DRAO (Dominion Radio Astrophys. Obs.) (Canada)			x	x
49	DTM/Carnegie Inst. (DC) - Las Campanas (Chile)		x	x	
50	Durham, University of (UK)			x	
51	ESA (European Space Agency) Spain				x
52	ESO (European Southern Obs.) Chile, Germany			x	
53	ESTEC/ESA/EXOSAT (Netherlands)				x
54	Florence, University of (Italy)			x	
55	Florida International University			x	
56	Florida, University of			x	
57	Genova University (Italy)			x	
58	Georgia Institute of Technology			x	
59	George Mason University (VA)				x
60	Gray Data Consultants (Chicago, IL)			x	

	Institute	140 Foot	12 Meter	VLA	VLBA
61	Groningen, University of - Kapteyn Lab.			x	x
62	Guanajuato, Universidad de (Mexico)			x	
63	Hamburger Sternwarte (Germany)			x	
64	Hampden-Sydney College (VA)			x	
65	Hanscom Air Force Base - AFGL (MA)	x			
66	Haverford College (PA)			x	
67	Hawaii, University of - IOA		x	x	x
68	Haystack Observatory - NEROC (MA)		x	x	x
69	Helsinki, Univ. of - METSAHOVI, HUT (Finland)				x
70	Heidelberg Observatory (Germany)			x	x
71	Hitotsubashi University (Japan)			x	
72	Hofstra University (NY)			x	
73	Ibaraki University (Japan)			x	
74	IBM - J.T. Watson Research Center (NY)			x	
75	IAFE - Buenos Aires (Argentina)	x		x	
76	Illinois, University of - Vermillion Obs.		x	x	
77	Imperial College (London)			x	
78	Institute of Astrophysics (Granada)				x
79	Institute of Astrophysics (Paris)	x		x	
80	Institute for A & A (Andalucia)		x	x	x

	Institute	140 Foot	12 Meter	VLA	VLBA
81	Institute Applied Physics (Bonn, Germany)		x		
82	Interferometrics, Inc. - NVI			x	
83	Inst. Space & Aeronautical Sciences (Japan)			x	x
84	Iowa, University of (IA)				x
85	Iowa State University (IA)			x	
86	IPAC - Infrared Processing/Analysis Ctr (CA)		x	x	x
87	IRAM (France, Spain)	x	x		
88	Jagellonian University (Poland)			x	
89	Jena Universitat (Germany)			x	
90	Johns Hopkins University (MD)	x		x	
91	JPL - Goldstone (CA)	x	x	x	x
92	Katholieke University (Netherlands)		x		
93	Keele, University of (UK)			x	
94	Kent, University of (UK)			x	
95	Kentucky, University of			x	
96	Kiev University (Ukraine)	x			
97	Krakow, University of (Poland)		x		
98	Kyoto University (Japan)			x	
99	KPNO/NOAO (National Optical Astronomy Obs.)		x	x	
100	Laguna, University of - Canarias (Spain)			x	

	<b>Institute</b>	<b>140 Foot</b>	<b>12 Meter</b>	<b>VLA</b>	<b>VLBA</b>
101	Lancashire, University of Central (UK)			x	x
102	Lawrence Livermore National Laboratory (CA)	x		x	x
103	Lebedev Physics Institute - ASC (Russia)	x		x	x
104	Leeds, University of (UK)			x	
105	Leiden, University of - Huygens (Netherlands)	x	x	x	x
106	Liverpool Johns Moores University (UK)			x	
107	Lisbon, University of (Portugal)			x	
108	Lockheed Research Laboratory (CA)			x	
109	Lowell Observatory (AZ)		x	x	
110	Madrid Observatory - OAN (Spain)			x	x
111	Manchester, University of - Jodrell, NRAL (UK)			x	x
112	Marseille Observatory (France)		x	x	
113	Maryland, University of - Clark Lake (CA)	x	x	x	x
114	Massachusetts, University of - FCRAO	x	x	x	
115	McMaster University (Canada)		x	x	
116	Meudon Observatory (France)	x		x	x
117	Mexico, University of - UNAM (Mexico)			x	x
118	Michigan State University			x	
119	Michigan, University of	x		x	x
120	Midi-Pyrenees Observatoire (France)		x		

	<b>Institute</b>	<b>140 Foot</b>	<b>12 Meter</b>	<b>VLA</b>	<b>VLBA</b>
121	Minnesota, University of	x	x	x	
122	Missouri, University of		x	x	x
123	Mizusawa Observatory (Japan)			x	x
124	MIT - Lincoln Laboratories (MA)	x		x	x
125	Moscow State U. - Sternberg State AI (Russia)			x	
126	MPIA (Heidelberg, Germany)			x	
127	MPIR (Bonn, Germany)	x	x	x	x
128	MPIEP, Garching (Germany)		x	x	
129	Mt. Stromlo Observatory - ANU (Australia)			x	x
130	Mt. Wilson - Hale Observatory (CA)			x	
131	NAIC - Arecibo Observatory (NY, PR)	x			x
132	National Astronomical Observatory (Japan)			x	x
133	NASA/Ames Research Center (CA)		x		
134	NASA/Goddard Space Flight Center (MD)		x	x	x
135	National Centre Radio Astrophysics (India)			x	x
136	NFRA - JIVE, Dwingeloo, Zwiggelte, Westerbork		x	x	x
137	NMIMT - New Mexico Inst. of Mining Technology	x		x	x
138	New Mexico, University of		x		x
139	New Mexico State University			x	x
140	New South Wales, University of (Australia)	x			

	<b>Institute</b>	<b>140 Foot</b>	<b>12 Meter</b>	<b>VLA</b>	<b>VLBA</b>
141	Nobeyama Observatory (Japan)		x	x	x
142	Northwestern University (IL)		x	x	
143	NRC Herzberg - Algonquin Obs. (Canada)	x			
144	NRL - Naval Research Laboratory (DC)	x		x	
145	Oberlin College (OH)	x		x	
146	Ohio State University		x	x	
147	Oklahoma, University of			x	
148	Oxford University (UK)			x	x
149	Padova Observatory (Italy)			x	
150	Paris Observatory (France)	x	x	x	x
151	Penn State University	x	x	x	x
152	Pennsylvania, University of			x	x
153	Pittsburgh, University of - Allegheny Obs			x	
154	Pomona College (CA)				x
155	Princeton Univ. - Inst. Advanced Studies (NJ)	x		x	x
156	Puerto Rico University (PR)	x			
157	Purdue University (IN)	x		x	
158	Purple Mountain Observatory (China)	x			
159	Queen Mary College (UK)		x	x	
160	Queens University of Belfast (N. Ireland)			x	

	<b>Institute</b>	<b>140 Foot</b>	<b>12 Meter</b>	<b>VLA</b>	<b>VLBA</b>
161	Queensland, University of (Australia)			x	
162	Radiometrics Incorporated (NV)				x
163	Raman Research Institute (India)			x	x
164	Rochester, University of (NY)			x	x
165	Royal Greenwich Observatory (UK)			x	
166	Royal Observatory - UKIRT, JCMT (Scotland)		x	x	
167	Rutgers University (NJ)			x	
168	Sao Paulo, University of - IAG (Brazil)				x
169	SERC, Rutherford Appleton Laboratories (UK)			x	
170	Seoul National University (Korea)		x		
171	SETI Institute (CA)	x		x	
172	Sheffield, University of (UK)			x	
173	Sinica Academia, IAA (Taiwan)			x	
174	Southampton, University of (UK)				x
175	Southwest Research Institute (TX)		x		
176	Space Telescope Science Institute (MD)	x	x	x	x
177	St. Lawrence University (NY)			x	
178	St. Mary's University (Canada)		x		
179	Stockholm Observatory (Sweden)			x	
180	SUNY (all campi)			x	

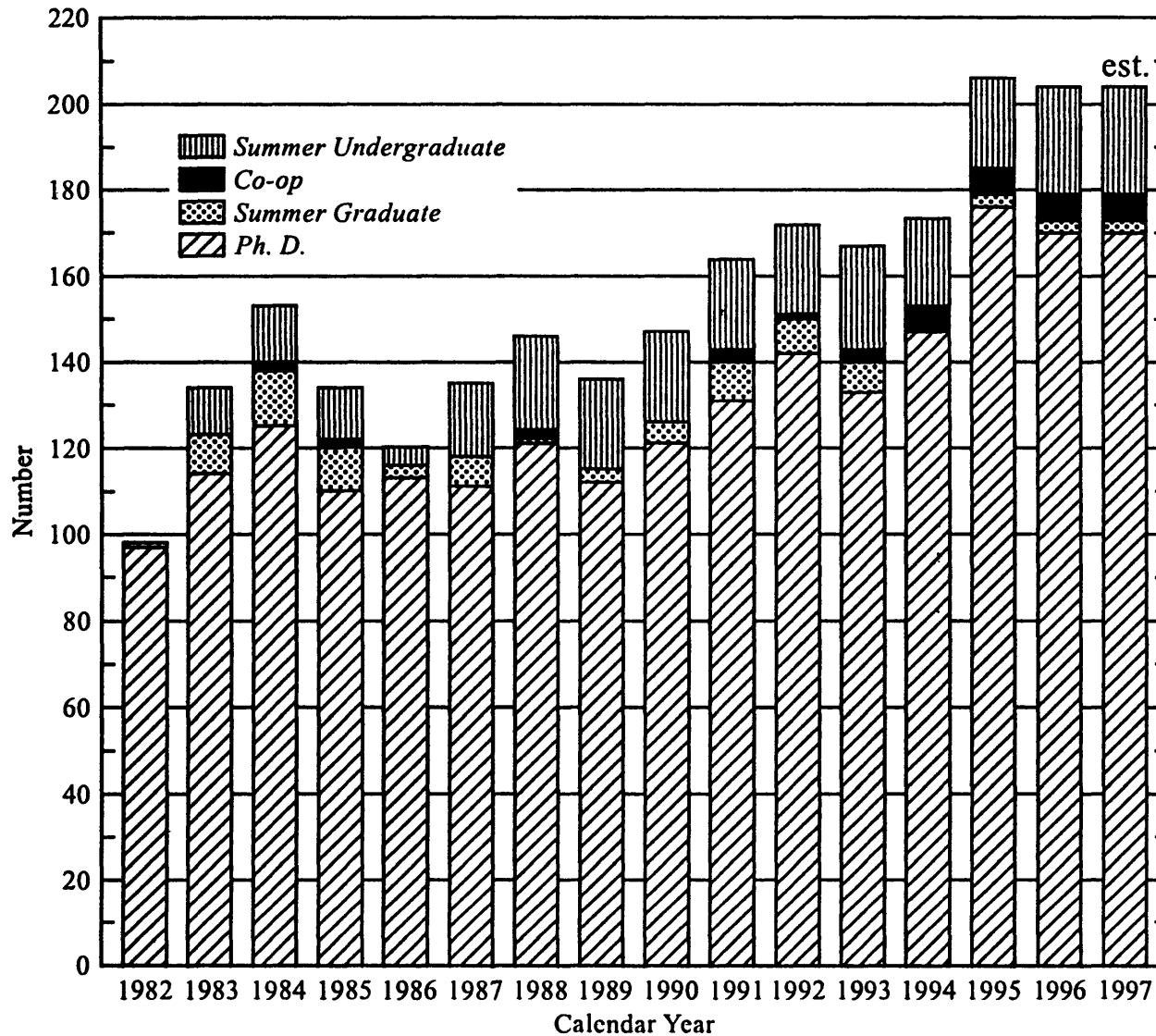


	Institute	140 Foot	12 Meter	VLA	VLBA
181	SFIT, ETH - Swiss Federal Institute of Tech.			x	x
182	Sydney, University of (Australia)			x	
183	Tasmania, University of (Australia)				x
184	Tata Inst. Fundamental Res. - RAC, GMRT (India)			x	x
185	Tel-Aviv University - Wise Obs. (Israel)			x	
186	TESRE, Bologna (Italy)			x	
187	Texas, University of - McDonald Observatory		x	x	
188	Tokyo Univ. - Tokyo Astronomical Obs. (Japan)			x	
189	Torino University (Italy)			x	
190	Toronto, Univ. of - Dunlap Obs. (Canada)		x	x	
191	Trieste Astronomical Obs. - ISAS (Italy)			x	
192	Trinity College (TX)			x	x
193	Tufts University (MA)			x	
194	Union College (NY)				x
195	University College Cardiff (UK)			x	
196	University College Dublin (Ireland)			x	
197	USNO - United States Naval Observatory (DC)			x	x
198	Utrecht, University of (Netherlands)			x	
199	Valencia, University of (Spain)			x	x
200	Villanova University (PA)			x	

	<b>Institute</b>	<b>140 Foot</b>	<b>12 Meter</b>	<b>VLA</b>	<b>VLBA</b>
201	Virginia, University of	x	x	x	
202	Virginia Polytechnic Institute & State U.	x			x
203	Washington State University			x	
204	Washington, University of			x	
205	Waterloo, University of (Canada)		x		
206	Wesleyan University (CT)			x	
207	Western Australia, University of (Australia)				x
208	Wisconsin, University of - Washburn Obs.		x	x	
209	Yale University (CT)			x	
210	Yebees Observatory - CAY, OAN (Spain)			x	x
211	York University (Canada)				x
<b>Number of Institutions</b>		<b>45</b>	<b>58</b>	<b>172</b>	<b>82</b>
<b>Number of Visitors</b>		<b>84</b>	<b>135</b>	<b>515</b>	<b>214</b>
<b>Number of Students</b>		<b>16</b>	<b>31</b>	<b>108</b>	<b>40</b>
<b>Number of Research Associates</b>		<b>8</b>	<b>3</b>	<b>7</b>	<b>3</b>
<b>Number of Permanent Staff</b>		<b>17</b>	<b>12</b>	<b>32</b>	<b>24</b>
<b>Total Observers</b>		<b>125</b>	<b>181</b>	<b>662</b>	<b>281</b>

All told, 930 visitors, including 173 students from 211 institutions.

## NRAO STUDENT PROGRAM



**Fig. 9.** This figure shows for each calendar year the number of PhD students (salaried at NRAO and non-salaried), co-op students, and summer undergraduate and graduate students who observed or worked at the NRAO during that year. Beginning in 1987 the majority of the undergraduate summer students were funded by a separate NSF Grant for Research Experience for Undergraduates.

# NRAO FRONT-END STATUS 140 FOOT TELESCOPE

JANUARY 1997

TECHNICAL DATA SHEET NO. 12

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RECEIVER NAME	FREQUENCY (GHz)	AMPLIFIER TYPE	SYSTEM TEMPERATURE (KELVIN)	3 dB BANDWIDTH (MHz)	FEED TYPE	POLARIZATION	CALIBRATION VALUE	SWITCHING SYSTEM	REMARKS	PERSON(S) IN CHARGE
50-500 MHz Rx	50-88 MHz	HIGH DYNAMIC RANGE TRANSISTOR DUAL CHANNEL	300 + Tsky	38	OPEN SLEEVE CROSSED DIPOLE	ORTHOGONAL LINEAR OR REMOVABLE QUAD HYBRID AT FEED FOR RCP AND LCP	ADJUSTABLE 2 TO 2500K	DICKE SWITCH: REFERENCE TEMPERATURE ADJUSTABLE FROM 100 TO 100,000K	FEED CHANGES FROM 50-88 MHz TO 110-240 MHz OR TO 450-500 MHz REQUIRE TWO HOURS.	NORROD (SHANK)
	110-240 MHz			130	BROADBAND CROSSED DIPOLE			FREQUENCY SWITCH		
	450-500 MHz	FET AMP	50-80	50	CAVITY BACKED CROSSED DIPOLE	RCP AND LCP		FREQUENCY SWITCH	450-500 MHz AMP IN 50-250 MHz Rx	
300-1000 MHz Rx	300-350 MHz	COOLED GASFET AMP DUAL CHANNEL	60-100	70	280-350 350-410 CAVITY BACKED CROSSED DIPOLES	DUAL ORTHOGONAL LINEAR  RF HYBRID FOR RCP AND LCP	5K	FREQUENCY SWITCHING	ONE OF THE FIVE FEEDS 280-350 MHz 350-410 MHz 500-750 MHz 750-850 MHz OR 750-1000 MHz  CAN BE USED. TO CHANGE FEEDS REQUIRES TWO HOURS.	NORROD (SHANK)
	350-410 MHz			80						
	500-750 MHz	50-70	80	500-750 SCALAR WITH CROSSED DIPOLES						
	750-950 MHz	45-50	80	750-850 CAVITY OR 750-1000 SCALAR						
	750-1000 MHz	50-70	80	750-1000 SCALAR WITH CROSSED DIPOLES						
6/25 CM Rx	1.00-1.45 (25 CM)	COOLED GASFET DUAL CHANNEL	35-40	450	SINGLE BEAM SCALAR	ORTHOGONAL LINEAR	4K TO 6K	FREQUENCY SWITCHING NOISE ADDING	FEED CHANGE REQUIRED TO SWITCH BANDS TAKES TWO HOURS.	NORROD (SHANK)
	4.47-5.05 (6 CM)	COOLED GASFET DUAL CHANNEL	50-60	580	SINGLE BEAM DUAL BEAM OFFSET 3 HPBW	ORTH CIRCULAR OR ORTH LINEAR IDENTICAL OR ORTH CIRCULAR OR IDENTICAL LINEAR	1.4K OR 12.8K	OTHER POLARIZATION BEAM SWITCHING		

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RECEIVER NAME	FREQUENCY (GHz)	AMPLIFIER TYPE	SYSTEM TEMPERATURE (KELVIN)	3 dB BANDWIDTH (MHz)	FEED TYPE	POLARIZATION	CALIBRATION VALUE	SWITCHING SYSTEM	REMARKS	PERSON(S) IN CHARGE
1.3-1.8 GHz Rx	1.30-1.80	DUAL CHANNEL COOLED HFET	19-25	UP TO 120 FEED LIMITED	THREE 2HE SINGLE BEAM 1.30-1.36 1.36-1.43 1.60-1.72 ZEEMAN 1.36-1.43 ZEEMAN 1.6-1.72	ORTHOGONAL LINEAR OR CIRCULAR	2K AND 200K	FREQUENCY OR POLARIZATION SWITCHING OR NOISE ADDING	EITHER CIRCULAR OR LINEAR POLARIZATIONS ARE SELECTABLE. CIRCULAR POLARIZATION REQUIRES ADJUSTMENTS FROM THE CONTROL ROOM. BAND CHANGE REQUIRES 2 TO 3 HOURS. OBSERVATIONS OUTSIDE STATED FEED BANDS POSSIBLE AT REDUCED EFFICIENCIES.	NORROD (SIMMONS)
2-5 GHz Rx	2.9-3.4	DUAL CHANNEL COOLED FET	38±4	UP TO 250 FEED LIMITED	TWO 2HE SINGLE BEAM 2.90-3.1 3.20-3.4	ORTHOGONAL LINEAR	APPROX 1.6K AND 150K	FREQUENCY SWITCHING NOISE ADDING	BAND CHANGE REQUIRES FEED CHANGE. THIS TAKES 2-3 HOURS. FREQUENCY SWITCHING REQUIRES 50 MS BLANKING TIME.	BEHRENS (HALL)
	4.6-5.0	DUAL CHANNEL COOLED HFET	28±5	UP TO 200 FEED LIMITED	ONE 2HE SINGLE BEAM 4.6-4.8	CIRCULAR	3K AND 150K		RECEIVER BAND LIMITED BY 4.6-4.8 GHz FEED. FREQUENCY SWITCHING REQUIRES 50 MS BLANKING TIME.	
6 CM, 7-FEED Rx	4.6-5.1	COOLED HFET FOURTEEN CHANNEL	35-45	500	7 CORRUGATED HORNS 3 HPBW APART	DUAL CIRCULAR	4K	NONE	CONTINUUM USE ONLY. TOTAL POWER RF DETECTION.	BEHRENS (HALL)
CASSEGRAIN RECEIVERS	8-10	COOLED HFET	28-34	500	CASSEGRAIN	DUAL CIRCULAR	2-4K	FREQUENCY OR NUTATOR BEAM		STENNES (DUNBRACK)
	12-15.4	COOLED HFET	25-32	500	CASSEGRAIN	DUAL CIRCULAR	2-4K	FREQUENCY OR NUTATOR BEAM		
	18.0-26.5	COOLED HFET	30-60	500	CASSEGRAIN	DUAL CIRCULAR	3-7K	FREQUENCY OR NUTATOR BEAM	TWO BANDS: 18.0-22.5, 22.0-26.5 4 HOURS TO SWITCH BANDS	
	26-36	COOLED HFET	80-100	500	CASSEGRAIN	SINGLE FIXED LINEAR	7-14K	FREQUENCY OR NUTATOR BEAM	SHARES DEWAR WITH 12-15.4 Rx 4 HOURS TO INSTALL 26-36 FEED 26-36 IS COVERED IN TWO BANDS 30 MINUTES TO CHANGE BANDS	
									BEAM SHIFT = 0-18 ARC MIN.	

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FREQUENCY (GHz)	AMPLIFIER TYPE	RECEIVER TEMPERATURE (KELVIN)	CONTINUUM SENSITIVITY (JANSKY $\sqrt{\text{SEC}}$ )	3 dB BANDWIDTH (MHz)	FEED TYPE	POLARIZATION	CALIBRATION VALUE	SWITCHING SYSTEM	REMARKS	PERSON(S) IN CHARGE
65-118	SIS MIXER	60-100 SSB	1.0	600	COOLED HORN-LENS + OFFSET PARABOLA	DUAL LINEAR	6 K	NUTATING SUBREFLECTOR	SINGLE-SIDEBAND MIXERS	PERFETTO
70-115	SIS MIXER	30 DSB	NOT MEASURED	600	8 CHANNEL	DUAL POLARIZATION 4 BEAMS	6 K	NUTATING SUBREFLECTOR	UNDER CONSTRUCTION COMPLETED DECEMBER 97	SHILLUE
130-170	SIS MIXER	100-180 SSB	NOT MEASURED	600	COOLED HORN-LENS + OFFSET PARABOLA	DUAL LINEAR	-	NUTATING SUBREFLECTOR	SINGLE-SIDEBAND MIXERS	PERFETTO
200-300	SIS MIXER	150-400 SSB	NOT MEASURED	600	COOLED HORN-LENS	DUAL LINEAR	-	NUTATING SUBREFLECTOR	SINGLE-SIDEBAND FILTER IMAGE TERMINATED IN COLD LOAD	PERFETTO
220-250	SIS MIXER	100 DSB	NOT MEASURED	600	8 FEEDS	LINEAR	-	NUTATING SUBREFLECTOR	8 BEAM RECEIVER	SHILLUE

# NRAO FRONT-END STATUS VERY LARGE ARRAY

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FREQUENCY (MHz)	AMPLIFIER TYPE	SYSTEM TEMPERATURE (KELVIN)	3 dB BANDWIDTH (MHz)	FEED TYPE	POLARIZATION	CALIBRATION VALUE	SWITCHING SYSTEM	REMARKS	PERSON(S) IN CHARGE
74	UNCOOLED FET	~ 1200	0.8	PRIME	DUAL ORTHOGONAL CIRCULAR	120	NOISE INJECTION, 9.6 Hz, 50 PERCENT CYCLE.	ANTENNAS 3, 6, 7, 11, 15, 19, 21 & 26	LILIE
308-343	UNCOOLED FET	150	3 MHz (LIMITED BY INTERFERENCE)	PRIME FOCUS	DUAL ORTHOGONAL CIRCULAR	10	NOISE INJECTION, 9.6 Hz, 50 PERCENT CYCLE.		LILIE
1340-1730	COOLED HFET	35	55	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	4	NOISE INJECTION, 9.6 Hz, 50 PERCENT CYCLE.		LILIE
4500-5000	COOLED HFET	60	55	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	4	NOISE INJECTION, 9.6 Hz, 50 PERCENT CYCLE.		LILIE
8000-8800	COOLED HFET	35	55	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	4	NOISE INJECTION, 9.6 Hz, 50 PERCENT CYCLE.		LILIE
14400-15400	COOLED FET	110	55	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	7	NOISE INJECTION, 9.6 Hz, 50 PERCENT CYCLE.		LILIE
22000-24000	COOLED HFET	130	55	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	10	NOISE INJECTION, 9.6 Hz, 50 PERCENT CYCLE.		LILIE
40000-50000	COOLED HFET	110	55	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	7	NOISE INJECTION, 9.6 Hz, 50 PERCENT CYCLE.	13 ANTENNAS: 3, 4, 6, 8, 11, 12, 13, 14, 16, 20, 22, 25 & 27 EFFICIENCY LOW, DEPENDS ON FREQUENCY	LILIE

# NRAO FRONT-END STATUS VERY LONG BASELINE ARRAY

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FREQUENCY (MHz)	AMPLIFIER TYPE	SYSTEM TEMPERATURE (KELVIN)	3 dB BANDWIDTH (MHz)	FEED TYPE	POLARIZATION	CALIBRATION VALUE	SWITCHING SYSTEM	REMARKS	PERSON(S) IN CHARGE
312-342	WARM FET	200	30	PRIME FOCUS	DUAL ORTHOGONAL CIRCULAR	10	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJLIE
596-622	WARM FET	200	30 OR 4	PRIME FOCUS	DUAL ORTHOGONAL CIRCULAR	5	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJLIE
1350-1750	COOLED HFET	30	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	2	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJLIE
2150-2350	COOLED HFET	35	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	2	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJLIE
4600-5100	COOLED HFET	40	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	2	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJLIE
8000-8800	COOLED HFET	37	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	3	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJLIE
12000-15400	COOLED HFET	60	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	4	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJLIE
21700-24100	COOLED HFET	100	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	5	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJLIE
41000-45000	COOLED HFET	120	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	8	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJLIE
82000-89000	COOLED HFET	140	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	50	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.	PIE TOWN NOW, LOS ALAMOS APRIL 1997	LJLIE



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