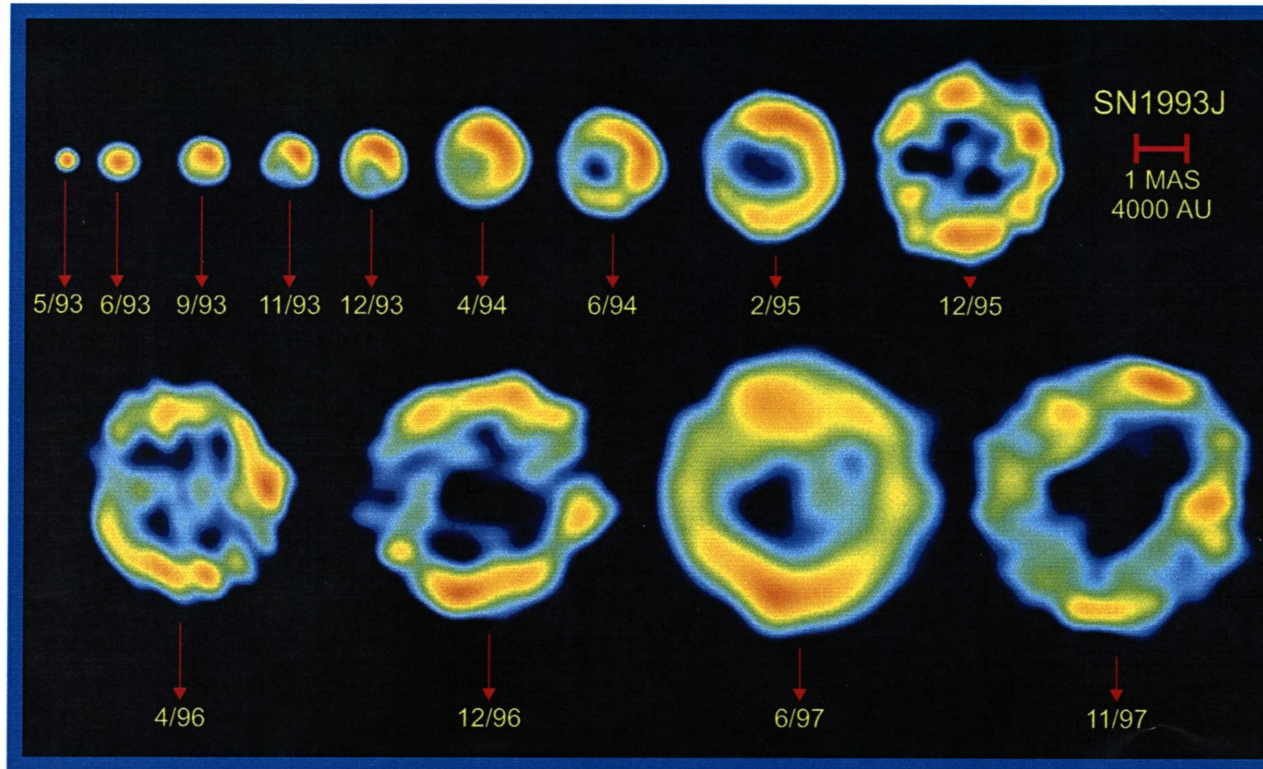


# NATIONAL RADIO

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## ASTRONOMY OBSERVATORY



## 1998 STATISTICS

Cover: A “movie” of the radio emission from the exploding star Supernova 1993J in the galaxy M81. This time-sequence of images was made at a wavelength of 3.6 cm (8.3 Ghz) with a global array of telescopes that included the VLBA and the VLA. The resolution, or clarity of image detail, is 4000 AU (about 20 light-days), hundreds of times finer than can be achieved by optical telescopes on such a distant object. Observers: M. Rupen, N. Bartel, M. Bietenholz, T. Beasley.

# **NATIONAL RADIO ASTRONOMY OBSERVATORY**

## **Observing Summary — 1998 Statistics**



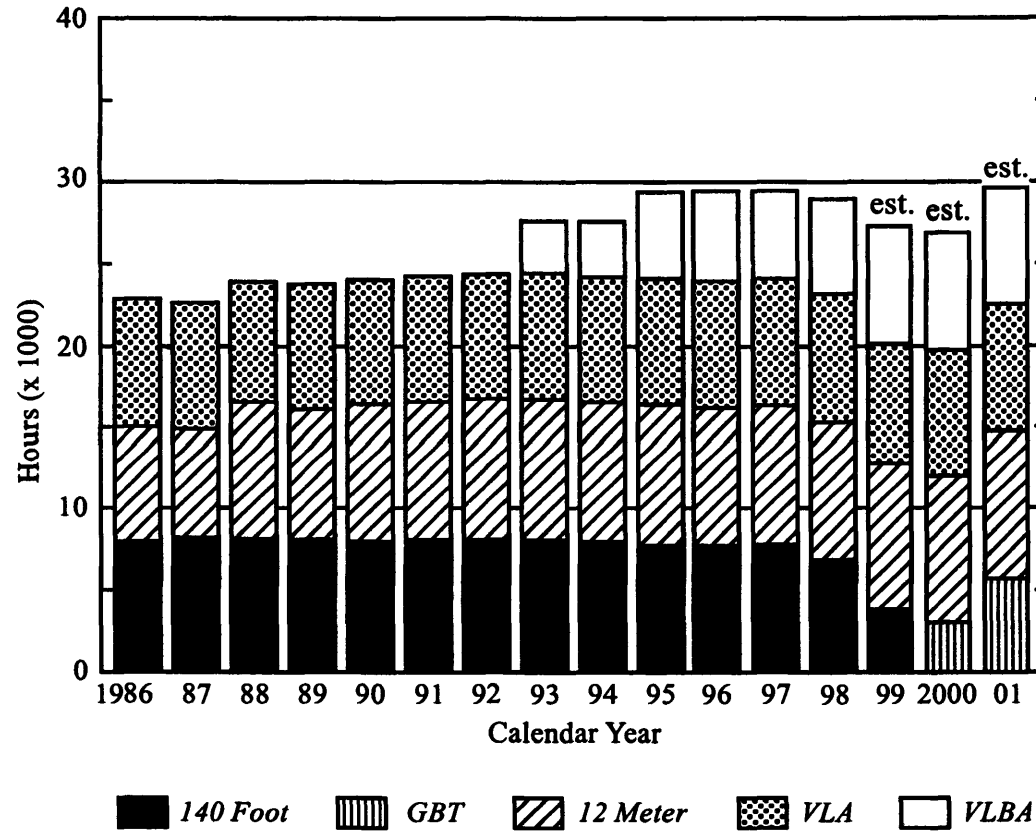
March 1999

## SCIENTIFIC HIGHLIGHTS

- **Positrons Found to be Prominent in Relativistic Quasar Jets:** The VLBA detection of circular polarization in the quasar 3C 279 and other compact radio sources has resolved the long standing question of whether an electron-proton or electron-positron composition maintains electrical neutrality of the relativistic plasma ejected from the nuclei of quasars and active galactic nuclei. The detection of circular polarization requires that the relativistic electron population extend to very low energies. This implies an electron-positron jet rather than an electron-proton composition which would carry more energy than is seen to be dissipated.
- **Discovery of the First Rhombic-Structured Interstellar Molecule:** A new carbon ring molecule, SiCCC, has been discovered in the interstellar medium with the 12 Meter Telescope. This species is remarkable in being the first 4-member cyclic compound (rhombic geometry). Four previous ring compounds have been detected in space, but they are all 3-member rings. Quantum chemists have predicted that cyclic hydrocarbon species of order higher than 3 exist; for example, in addition to the already detected linear forms,  $C_4H$  may have a rhombic structure, and  $C_6H$  may have a 6-member ring, but these remain undetected in space. It is notable that SiCCC should be the first higher-order cyclic compound found, because SiCC was the first cyclic compound detected in the 1980's. The present detection of SiCCC is based on 7 detected transitions in the circumstellar gas shell IRC10216.
- **Second GRB Radio Afterglow Supports "Hypernova" Model:** The detection of a second GRB radio afterglow supports the "Hypernova" model. Only one day after the Gamma Ray Burst of March 29, 1998 (GRB980239) a radio counterpart was observed with the VLA. Continued monitoring showed evidence of interstellar scintillation, indicating an angular diameter for the fireball of a few microarcseconds in the first two weeks after the burst. This GRB counterpart was much fainter at infrared and optical wavelengths than at radio wavelengths (optical observers found the counterpart only after they obtained the radio position and re-examined their images). This suggests extinction by dust. If so, the GRB's occurrence in a dusty environment, probably a star-forming region, supports the "hypernova" model for GRBs and is harder to explain with the merging neutron-star model.
- **New Method to Measure  $H_2$  Abundance in Molecular Clouds:** A major difficulty in understanding molecular clouds is that their main constituent is molecular hydrogen, which is usually impossible to observe directly. For over 20 years a canonical value of  $CO/H_2$  has been used to infer the  $H_2$  abundance from CO observations, even though it has been recognized that this ratio is highly unreliable, depending strongly on local physical conditions. Observations of CH, made at the 140 Foot Telescope, have shown that the amount of  $H_2$  can be inferred from the 9 cm transitions of CH, which although quite weak, are found to be more representative of the  $H_2$  abundance than the more easily observed CO. Observations of two high-latitude molecular clouds in CH show that the  $CO/H_2$  ratio varies by an order of magnitude from point to point across a cloud, and that the mean value varies by a factor of 3 between the two clouds. It appears that, at least in high-latitude molecular clouds, CO is a poor surrogate for  $H_2$ .

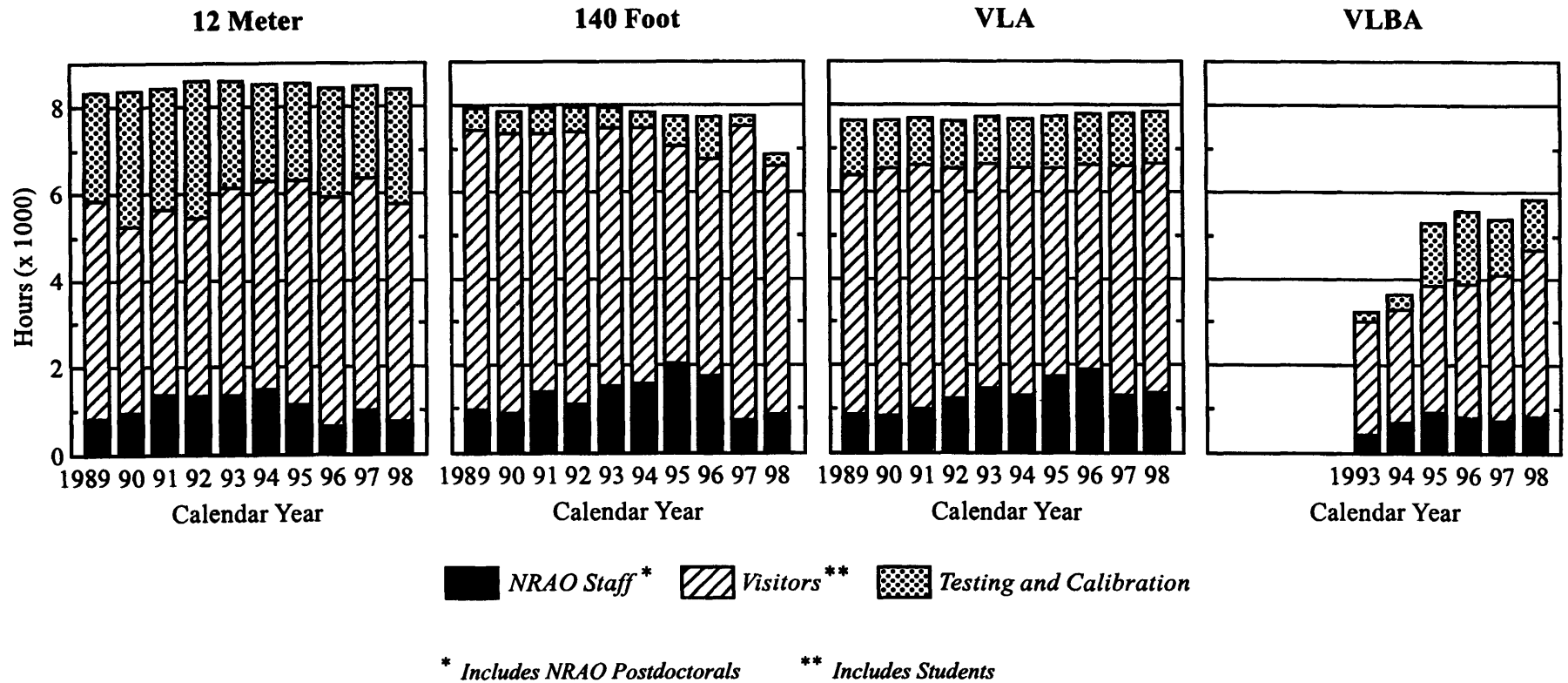
- **Accretion Disks Seen Around Black Holes in Seyfert Galaxy Nuclei:** VLBA observations of active galactic nuclei have revealed the nuclear torus or disk feeding the central massive black hole, showing both the patchiness of the gas structure and the gradual density falloff away from the nucleus. These parsec scale structures are seen in absorption from both the neutral hydrogen as well as the ionized gas which lies in front of some, but not all of the continuum radiation from the radio cores and jets. The measured density of the ionized gas as well as the neutral hydrogen gas within a parsec of the central mass is above  $10^5 \text{ cm}^{-3}$ , decreasing to  $10^3$  to  $10^4 \text{ cm}^{-3}$  on scales of 10 to 20 parsecs.
- **VLA Reveals Protoplanetary Disks in Close Binary Pair:** VLA observations at 7 mm wavelength have revealed a close pair of proto-planetary disks in the L1551 star-forming region. The protostars are only 45 AU apart. The disks are truncated at a radius of 10 AU, but each disk has a mass of 0.05 solar masses, more than enough to form a planetary system. This result indicates that planet formation may well be possible in such very close binary systems.
- **Translucent Clouds as Testbeds for Astrochemistry:** Small "translucent" molecular clouds provide a strong test of astrochemistry models. Their quiescent physical conditions are well characterized so they may be reliably modeled both physically and chemically. Some 38 molecular species have now been extensively observed in 3 dozen translucent objects, using both the 140 Foot Telescope (Green Bank) and the 12 Meter Telescope. Accurate abundances have been obtained using the detailed physical models of the translucent objects, and the chemistry has been modeled using a system of over 4000 reactions and over 400 species. Thirty of the 38 studied species are well explained by the "standard" gas-phase chemistry, including the dependence of the abundance upon extinction as one traverses the transition region between diffuse and dense clouds. The successful species include the basic hydrocarbon "backbone" species from which all other compounds are believed to form. The misfits are  $\text{H}_2\text{CO}$ ,  $\text{CH}_3\text{OH}$ ,  $\text{H}_2\text{S}$ , and four "complex" species containing 5 or more atoms, including nitrogen and oxygen. These species may mark the transition between gas-phase and grain chemistry.

## OBSERVING HOURS



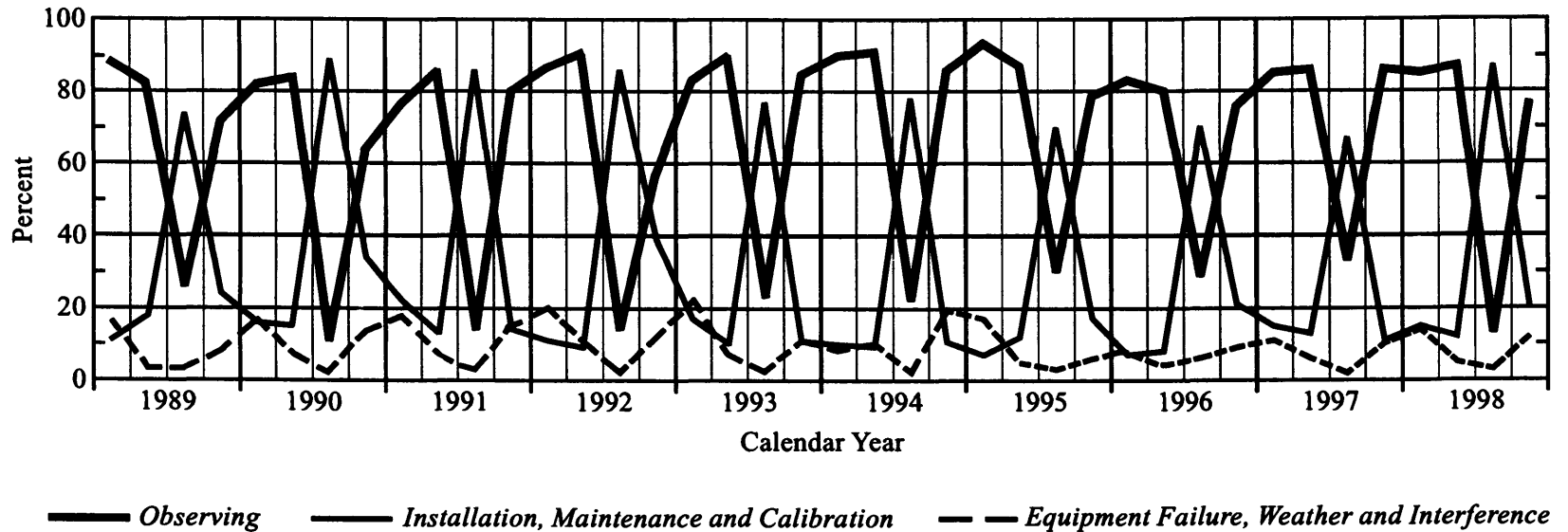
**Figure 1.** This figure shows the hours for observing on each telescope during the last decade. Includes astronomical observing, testing, and calibration. The 140 Foot Telescope closes July 1, 1999, and the GBT is expected to begin operations in January, 2000.

## DISTRIBUTION OF SCHEDULED OBSERVING TIME



**Figure 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.

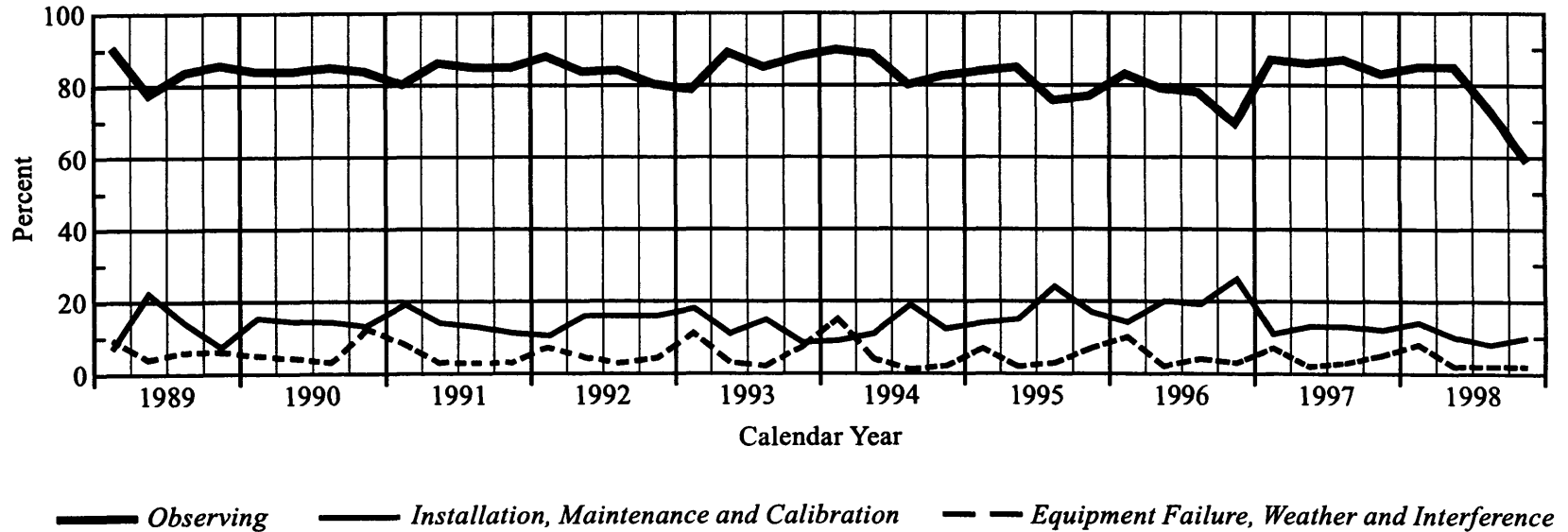
## 12 METER RADIO TELESCOPE SUMMARY



**Figure 3.** This summary for each quarter of the calendar year shows the percentage of the total time in the year (8760 hours) that 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.

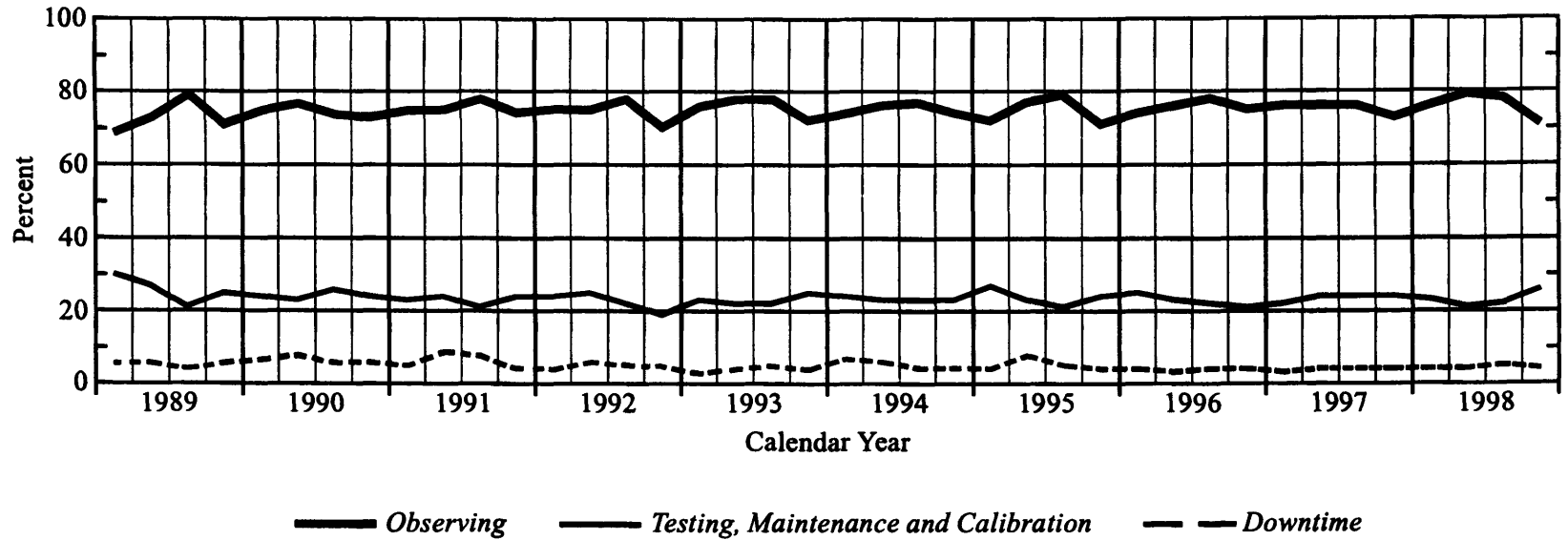


## 140 FOOT RADIO TELESCOPE SUMMARY



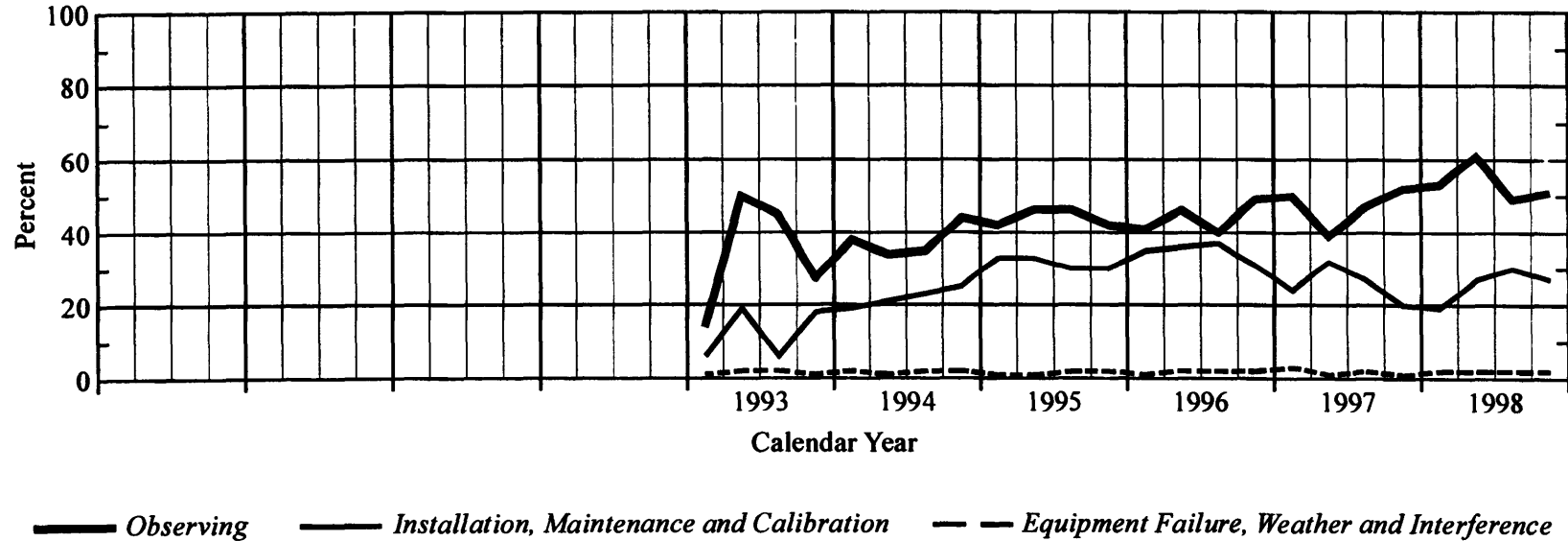
**Figure 4.** This summary for each quarter of the calendar year shows the percentage of the total time in the year (8760 hours) that the telescope was scheduled for observing; for routine calibration, maintenance, and installation of new experiments; and the percentage of time lost due to equipment failure, bad weather, and radio interference.

## VERY LARGE ARRAY TELESCOPE SUMMARY



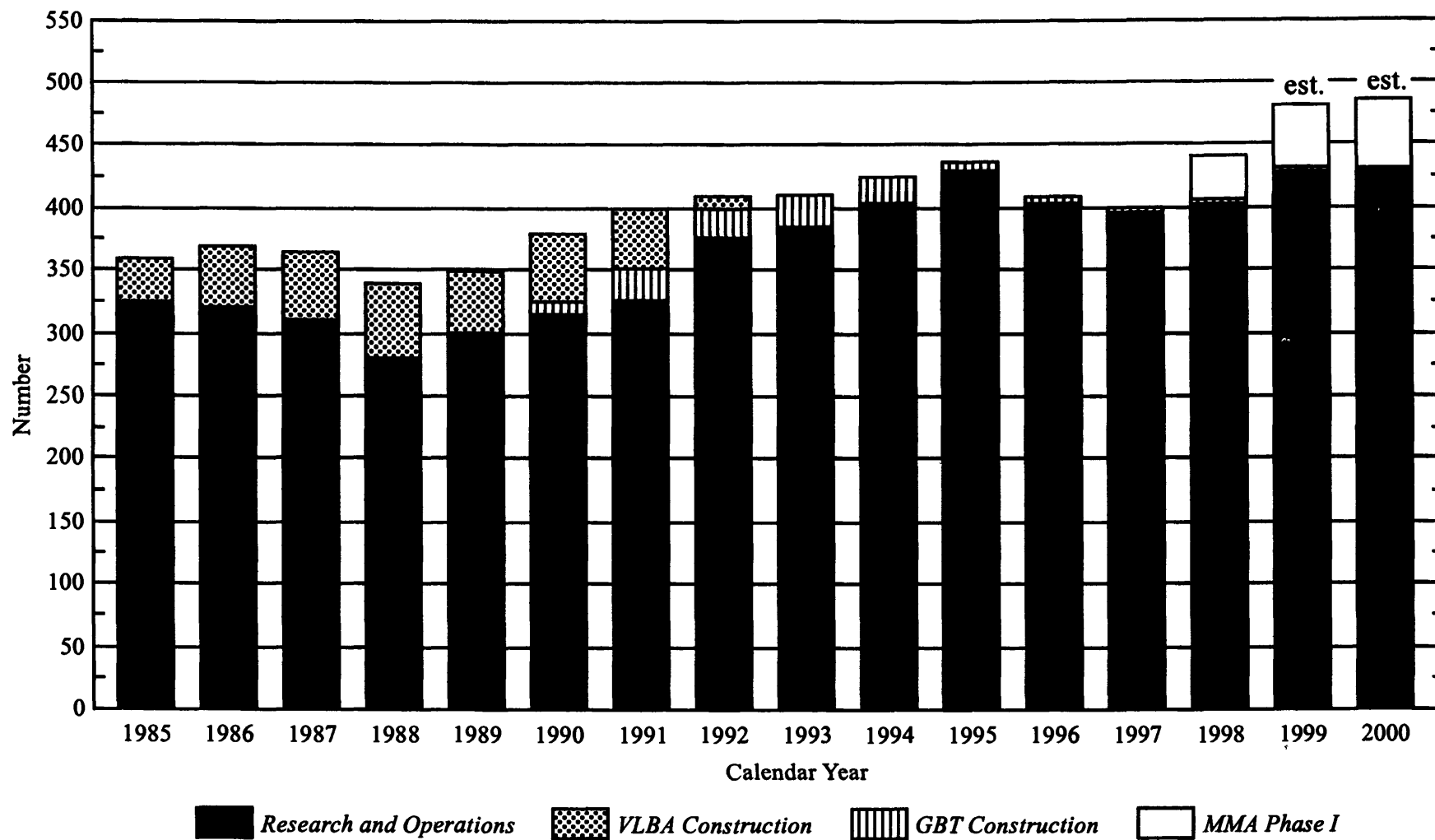
**Figure 5.** This summary for each quarter of the calendar year shows the percentage of the total time in the year (8760 hours) that the telescope was scheduled for observing; for routine system testing, maintenance, and calibration; and the percentage of time lost due to hardware or software failure, power failure, or bad weather.

## VERY LONG BASELINE ARRAY TELESCOPE SUMMARY



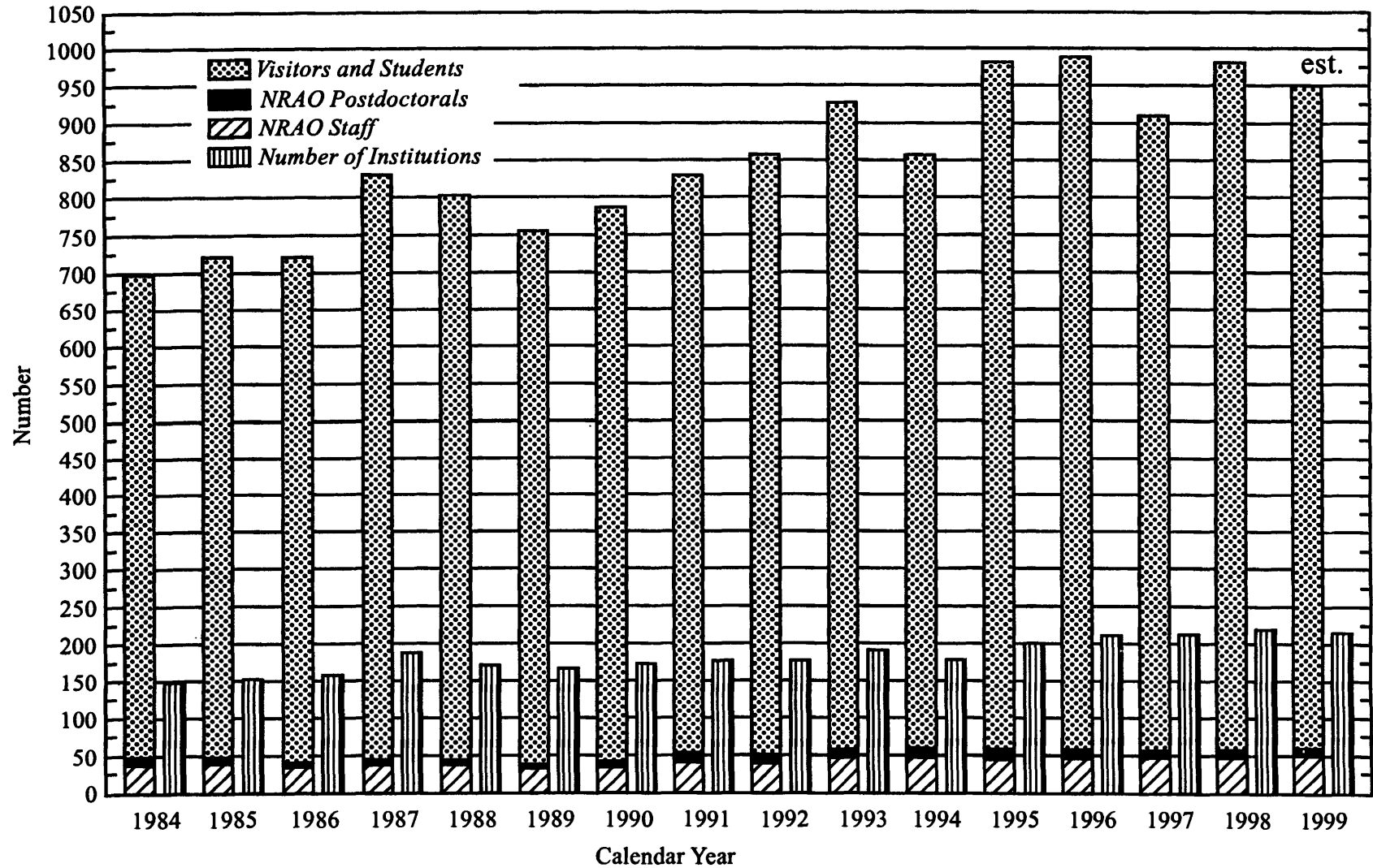
**Figure 6.** This summary for each quarter of the calendar year shows the percentage of the total time in the year (8760 hours) that the telescope was scheduled for observing; for routine calibration, maintenance, and installation of new experiments; and the percentage of time lost due to equipment failure, bad weather, and radio interference. It should be noted that about 15 percent of the time cannot be scheduled as it results from the time difference across the array; this is reflected as a difference in the time between the end of one program and the start of the next.

## FULL-TIME EMPLOYEES



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

## NUMBER OF PEOPLE OBSERVING WITH NRAO TELESCOPES



**Figure 8.** The bar chart shows for each calendar year the number of NRAO research staff and the number of NRAO 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	6%	7%	5%	3%	5%
<b>II. STELLAR —</b>					
Pulsars, X-ray Sources, Planetary Nebulae, Circumstellar Shells, Supernova Remnants, Masers, Novae, Supernovae, and Stars	8%	24%	29%	24%	24%
<b>III. GALACTIC —</b>					
Galactic Structure, Center, Molecular Clouds, HII Regions, Star Formation, Molecules, and Interstellar Medium	56%	37%	20%	11%	23%
<b>IV. EXTRAGALACTIC —</b>					
Normal and Active Galaxies, Radio Galaxies, Clusters, Quasars, VLBA Studies, Extragalactic Molecules, and Cosmology	30%	32%	46%	62%	48%

**DISTRIBUTION OF TELESCOPE TIME BY PERCENT**

	12 Meter	140 Foot	VLA	VLBA	1998 Summary
Visitors	50%	60%	53%	41%	51%
Students	7%	6%	8%	3%	6%
NRAO Staff	8%	9%	13%	8%	10%
Jansky Postdoctorals	1%	1%	2%	2%	1%
Test and Calibration	30%	3%	13%	13%	15%
Maintenance and Installation	3%	7%	10%	13%	8%
Holidays and Unscheduled	1%	14%	1%	20%	9%

**INSTITUTIONS FROM WHICH VISITORS CAME TO USE NRAO TELESCOPES DURING 1998**

	<b>140 FOOT</b>	<b>12 METER</b>	<b>VLA</b>	<b>VLBA</b>
1. Anglo Australian Observatory - UKSTU (Schmidt)			X	
2. Agnes Scott College (GA)			X	X
3. Alabama, University of			X	
4. Amsterdam, University of - Astronomy Institute			X	X
5. Arcetri Astrophysical Observatory (Italy)		X	X	
6. Argentine Radio Astronomy Institute (IAR)		X		
7. Arizona, University of - Steward, LPL, SMTO	X	X	X	
8. Astrophysical Institute, Potsdam (Germany)			X	
9. Barcelona, University of (Spain)			X	
10. Beijing Astronomical Observatory (China)		X	X	
11. Bologna, University of (Italy)		X	X	X
12. Bordeaux Observatory (France)		X		X
13. Boston University (MA)	X		X	X
14. Brandeis University (MA)		X		X
15. Bristol - Cantock Close (UK)			X	
16. British Columbia, University of (Canada)			X	
17. Calgary, University of (Canada)			X	
18. California, University of, Davis			X	X
19. California, University of, Berkeley	X	X	X	X
20. California, University of, Irvine	X			



	140 FOOT	12 METER	VLA	VLBA
21. California, University of, Los Angeles	x	x	x	x
22. California, University of, San Diego				x
23. California, University of, Santa Cruz - Lick Obs.		x	x	
24. California, University of, Santa Barbara			x	x
25. Caltech - OVRA, Palomar, Big Bear Solar Obs.	x	x	x	x
26. Cambridge Univ. - Cavendish, MRAO, IOA (UK)		x	x	x
27. Canadian Military College			x	
28. Catania University (Italy)			x	
29. Catholic University of America (DC)			x	
30. CfA - Harvard, SAO (MA)	x	x	x	x
31. CNRS, France (CEN, Saclay)	x	x	x	x
32. Chalmers-Onsala Space Observatory (Sweden)		x	x	x
33. Chicago, University of - Yerkes Obs. (IL)			x	
34. Chile, University of (Chile)			x	
35. CITA - Canadian Inst. Theoretical Astrophysics			x	
36. Colorado, University of - JILA, LASP, CASA		x	x	x
37. Columbia University (NY)			x	x
38. Connecticut College		x		x
39. Copernicus University - Torun Obs. (Poland)	x		x	x
40. Cornell University (NY)	x		x	x

	140 FOOT	12 METER	VLA	VLBA
41. CSIRO - ATNF, Parkes Obs. (Australia)			x	x
42. DAO (Dominion Astrophysical Obs.) (Canada)			x	
43. DRAO (Dominion Radio Astrophys. Obs.) (Canada)			x	
44. Dublin Institute for Advanced Studies			x	
45. Drake University (IA)			x	
46. DTM/Carnegie Inst. (DC) - Las Campanas (Chile)		x	x	
47. Durham, University of (UK)			x	
48. Ecole Polytechnique, Palaiseau, France				x
49. Edinburgh, University of (Scotland)	x		x	
50. ESO (European Southern Obs.) Chile, Germany			x	
51. ESTEC/ESA/EXOSAT (Netherlands)			x	
52. Fermi National Accelerator Lab (IL)				x
53. Florence, University of (Italy)			x	
54. Florida, University of		x	x	
55. Frankfurt University (Germany)	x			
56. Furman University (SC)			x	
57. Georgia, University of		x		
58. Georgia State University			x	
59. George Mason University (VA)			x	x
60. Granada, Universidad de (Spain)			x	

	140 FOOT	12 METER	VLA	VLBA
61. Grenoble, Univ/Observatory (France)			X	
62. Groningen, University of - Kapteyn Lab.	X		X	X
63. Guanajuato, Universidad de (Mexico)			X	X
64. Halmstad University (Sweden)		X		X
65. Hamburger Sternwarte (Germany)			X	X
66. Hanscom Air Force Base - AFGL (MA)		X		
67. Hartebeesthoek Radio Astronomy Observatory				X
68. Haverford College (PA)	X		X	
69. Haystack Observatory - NEROC (MA)		X	X	X
70. Helsinki, Univ. of - METSAHOVI, HUT (Finland)		X	X	X
71. Heidelberg Observatory (Germany)			X	X
72. Herfordshire, University of (UK)			X	
73. High Altitude Observatory - NCAR (CO)		X		
74. Ibaraki University (Japan)				X
75. IAFE - Buenos Aires (Argentina)	X	X		
76. IAS-Frascati (Italy)			X	
77. Illinois, University of - Vermillion Obs.	X	X	X	X
78. Indiana, University of		X		
79. Indian Institute of Science (India)			X	X
80. Institute of Astrophysics (Granada)			X	X

	140 FOOT	12 METER	VLA	VLBA
81. Institute of Astrophysics (Paris)	x			
82. Institute for Advanced Studies (NJ)	x		x	
83. Institute for A & A (Andalucia)			x	x
84. Institute of Physical & Chemical Res. (Japan)			x	
85. Inst. Space & Aeronautical Sciences (Japan)	x		x	x
86. Iowa, University of			x	x
87. Iowa State University		x	x	
88. IPAC - Infrared Processing/Analysis Ctr (CA)		x	x	x
89. IRAM (France, Spain)		x	x	
90. IUCAA (India)			x	
91. Johns Hopkins University (MD)	x		x	
92. JPL - Goldstone (CA)		x	x	x
93. Kagoshima University (Japan)				x
94. Keele, University of (UK)			x	
95. Kennesaw State College (GA)		x		
96. Kent, University of (UK)			x	
97. Kentucky, University of			x	
98. Keyano College (Canada)			x	
99. Koln, University of (Germany)			x	
100. Kyoto University (Japan)			x	

	140 FOOT	12 METER	VLA	VLBA
101. KPNO/NOAO (National Optical Astronomy Obs.)			X	
102. Lafayette College (PA)			X	
103. Laguna, University of - Canarias (Spain)			X	
104. Lancashire, University of Central (UK)				X
105. Lawrence Livermore National Laboratory (CA)			X	X
106. Lebedev Physics Institute - ASC (Russia)	X	X	X	X
107. Leeds, University of (UK)			X	
108. Leicester, University of (UK)			X	
109. Leiden, University of - Huygens (Netherlands)			X	X
110. Liverpool Johns Moores University (UK)		X	X	
111. Lisbon, University of (Portugal)			X	X
112. Lockheed Research Laboratory (CA)			X	
113. Lowell Observatory (AZ)		X		
114. Manchester, University of - Jodrell, NRAL (UK)			X	X
115. Maria Mitchell Observatory (MA)		X		
116. Marseille Observatory (France)			X	
117. Maryland, University of - Clark Lake (CA)	X	X	X	X
118. Massachusetts, University of - FCRAO		X	X	
119. Meudon Observatory (France)			X	X
120. Mexico, University of - UNAM (Mexico)			X	X

	140 FOOT	12 METER	VLA	VLBA
121. Michigan, University of			x	x
122. Milano Observatory (Italy)			x	
123. Minnesota, University of	x	x	x	
124. Missouri, University of	x		x	
125. Mizusawa Observatory (Japan)				x
126. MIT - Lincoln Laboratories (MA)			x	
127. Monash University (Australia)		x		
128. Montreal, University of (Canada)			x	
129. Moscow State U. - Sternberg State AI (Russia)			x	
130. MPIA (Heidelberg, Germany)			x	
131. MPIAP (Munich, Germany)			x	
132. MPIR (Bonn, Germany)	x	x	x	x
133. MPIfEP, Garching (Germany)		x	x	x
134. Mt. Stromlo Observatory - ANU (Australia)			x	
135. NAIC - Arecibo Observatory (NY, PR)			x	x
136. National Astronomical Observatory (Japan)			x	x
137. NASA/Ames Research Center (CA)		x		
138. NASA/Goddard Space Flight Center (MD)			x	x
139. NASA/Marshall Space Flight Center (AL)			x	
140. National Centre Radio Astrophysics (India)	x		x	

	140 FOOT	12 METER	VLA	VLBA
141. Newcastle, University of (UK)			X	
142. New Hampshire, University of				X
143. NJIT - New Jersey Institute of Technology			X	
144. NFRA - JIVE, Dwingeloo, Zwiggelte, Westerbork	X		X	X
145. NMIMT - New Mexico Inst. of Mining Technology			X	X
146. New Mexico, University of			X	X
147. New Mexico State University	X		X	
148. New South Wales, University of (Australia)	X			
149. Nobeyama Observatory (Japan)		X	X	X
150. Northwestern University (IL)			X	
151. NRL - Naval Research Laboratory (DC)	X		X	X
152. NSF - National Science Foundation (DC)			X	
153. Oberlin College (OH)		X		
154. Open University (UK)				X
155. Osaka, University of (Japan)		X		
156. Oxford University (UK)			X	X
157. Palermo, University of (Italy)			X	
158. Paris Observatory (France)			X	X
159. Penn State University	X	X	X	
160. Pennsylvania, University of			X	X

	140 FOOT	12 METER	VLA	VLBA
161. Princeton University (NJ)	x		x	x
162. Puerto Rico University (PR)	x		x	
163. Puget Sound University (WA)		x		
164. Queens University (Canada)			x	
165. Queensland, University of (Australia)			x	
166. Raman Research Institute (India)			x	x
167. Royal Greenwich Observatory (UK)			x	x
168. Royal Observatory - UKIRT, JCMT (Scotland)	x		x	
169. Ruhr University - Astro. Inst. (Germany)		x		
170. Rutgers University (NJ)			x	
171. Satellite Geodetic Observatory (Hungary)				x
172. SETI Institute (CA)	x		x	
173. Sheffield, University of (UK)			x	
174. Sinica Academia, IAA (Taiwan)	x	x	x	x
175. Southwest Research Institute (TX)		x	x	
176. Space Science Institute (Boulder, CO)		x		
177. Space Telescope Science Institute (MD)	x	x	x	x
178. St. Cloud State University (MN)		x		
179. St. Mary's University (Canada)		x		
180. St. Petersburg State University (Russia)				x



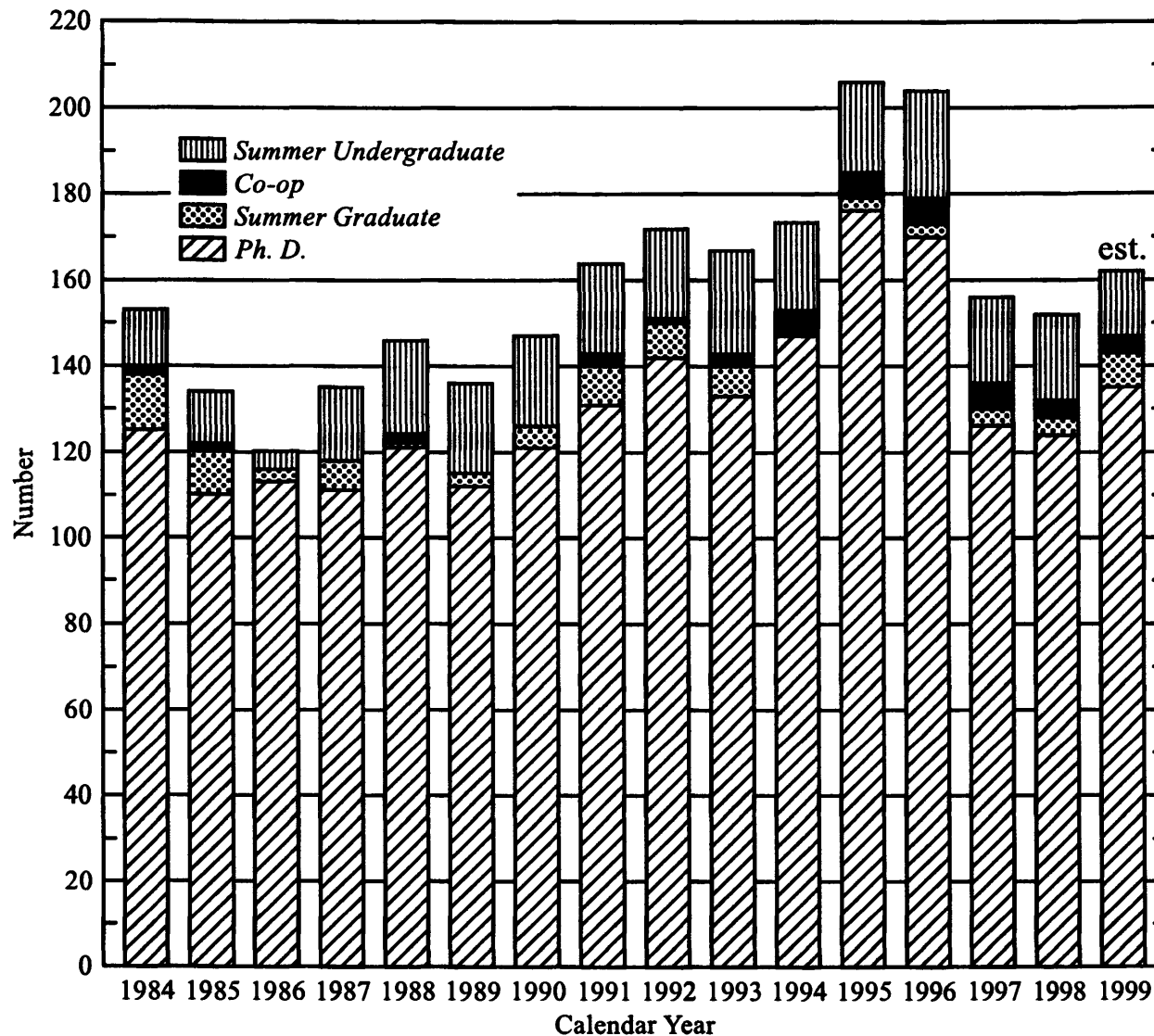
	140 FOOT	12 METER	VLA	VLBA
181. Stockholm Observatory (Sweden)		X		
182. SUNY (all campi)		X		
183. Sussex, University of (UK)				X
184. SFIT, ETH - Swiss Federal Institute of Tech.			X	
185. Sydney, University of (Australia)			X	X
186. Tasmania, University of (Australia)			X	X
187. Tata Institute Fund. Res. - RAC, GMRT (India)			X	X
188. Tel-Aviv University - Wise Obs. (Israel)			X	
189. Texas, University of - McDonald Observatory		X	X	X
190. Tohoku University (Japan)				X
191. Tokyo Univ. - Tokyo Astronomical Obs. (Japan)	X	X		
192. Toronto, Univ. of - Dunlap Obs. (Canada)		X	X	
193. Toulouse Observatory (France)			X	
194. Trieste Astronomical Obs. - ISAS (Italy)			X	
195. Trinity College (TX)				X
196. Tufts University (MA)			X	
197. Turku, University of - Tuorla Obs. (Finland)				X
198. Universidad Federal Rio Grande de Sul (Brazil)			X	
199. Universidad Federal de Santa Maria (Brazil)			X	X
200. University College Cardiff (UK)			X	

	140 FOOT	12 METER	VLA	VLBA
201. Uppsala Astronomical Observatory (Sweden)		X		
202. USNA - United States Naval Academy (MD)			X	
203. USNO - United States Naval Observatory (DC)			X	X
204. Universities Space Research Association (DC)			X	
205. Utrecht, University of (Netherlands)				X
206. Valencia, University of (Spain)			X	X
207. Vassar College (NY)		X		
208. Vermont, University of			X	
209. Victoria, University of (Canada)			X	
210. Virginia, University of	X	X	X	
211. Washington, University of			X	
212. Waterloo, University of (Canada)			X	
213. Wellesley College (MA)		X	X	
214. Wesleyan University (CT)		X	X	
215. Wisconsin, University of - Washburn Obs.	X		X	X
216. Wurzburg University (Germany)			X	
217. Yebes Observatory - CAY, OAN Spain)		X	X	X
218. Yekatarinburg University (Russia)		X		
219. York University (Canada)			X	X

	<b>140 FOOT</b>	<b>12 METER</b>	<b>VLA</b>	<b>VLBA</b>
<b>NUMBER OF INSTITUTIONS</b>	40	68	170	91
<b>NUMBER OF VISITORS</b>	68	149	529	258
<b>NUMBER OF STUDENTS</b>	9	18	74	44
<b>NUMBER OF NRAO POSTDOCTORALS</b>	2	4	11	4
<b>NUMBER OF PERMANENT STAFF</b>	10	15	26	26
<b>TOTAL OBSERVERS</b>	89	186	640	332

All told, 922 visitors, including 124 students, from 219 institutions.

## NRAO STUDENT PROGRAM



**Figure 9.** This figure shows for each calendar year the number of Ph.D. 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**

TECHNICAL DATA SHEET NO. 12

PAGE 1 OF 5

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 + Taky	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 OR FREQUENCY SWITCH	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					
	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			60						
	500-750 MHz	COOLED GASFET AMP DUAL CHANNEL	50-70	80	500-750 SCALAR WITH CROSSED DIPOLES					
	750-950 MHz	COOLED HFET DUAL CHANNEL	45-50	80	750-850 CAVITY OR 750-1000 SCALAR					
	750-1000 MHz	COOLED GASFET AMP DUAL CHANNEL	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		

**NRAO FRONT-END STATUS  
140 FOOT TELESCOPE**

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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.	ANDERSON (SIMMONS)
	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.	ANDERSON (SIMMONS)
CASSEGRAIN RECEIVERS	3.95-5.85	COOLED HFET	25K	300	CASSEGRAIN	DUAL LINEAR DUAL CIRCULAR	2-2.5K	FREQUENCY OR NUTATOR BEAM	FIXED 7 GHz LO FREQ; FEED LIMITS LOWER FREQ. OPERATION TO 4.7 GHz	NORROD (SIMON)
	8-10	COOLED HFET	30-35	300	CASSEGRAIN	DUAL CIRCULAR	2-4K	FREQUENCY OR NUTATOR BEAM		STENNES (DUNBRACK)
	18.0-26.5	COOLED HFET	30-60	300	CASSEGRAIN	DUAL CIRCULAR	3-7K	FREQUENCY OR NUTATOR BEAM	TWO BANDS: 18.0-22.5, 22.0-26.5 4 HOURS TO SWITCH BANDS	STENNES (DUNBRACK)
									BEAM SHIFT = 0-8 ARC MIN.	

**NRAO FRONT-END STATUS  
12 METER TELESCOPE**

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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.	OFF RE-INSTALL FOR A-ARRAY	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.	50K Taps ON ANT 5, 9, 26, 28	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.		LJIE
596-622	WARM FET	200	30 OR 4	PRIME FOCUS	DUAL ORTHOGONAL CIRCULAR	5	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJIE
1350-1750	COOLED HFET	30	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	2	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJIE
2150-2350	COOLED HFET	35	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	2	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJIE
4600-5100	COOLED HFET	40	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	2	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJIE
8000-8800	COOLED HFET	37	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	3	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJIE
12000-15400	COOLED HFET	60	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	4	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJIE
21700-24100	COOLED HFET	100	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	5	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJIE
41000-45000	COOLED HFET	120	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	8	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.		LJIE
82000-89000	COOLED HFET	140	128	CASSEGRAIN	DUAL ORTHOGONAL CIRCULAR	50	NOISE INJECTION, 80 Hz, 50 PERCENT CYCLE.	PT, LA, MK	LJIE

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