US/GR BK/

NATIONAL RADIO ASTRONOMY OBSERVATORY

QUARTERLY REPORT

October 1 – December 31, 1998

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A. TELESCOPE USAGE

The following telescopes have been scheduled for research and maintenance in the following manner during the fourth quarter of 1998.

	140 Foot	12 Meter	VLA	VLBA
Scheduled Observing (hrs)	1307.00	1706.25	1539.40	1131.00
Scheduled Maintenance and Equipment Changes	168.25	139.00	227.20	228.00
Scheduled Tests and Calibration	50.75	298.75	355.70	373.00
Time Lost	51.50	271.00	56.95	35.30
Actual Observing	1255.50	1435.25	1482.45	1095.70

B. 140 FOOT OBSERVING PROGRAMS

The following continuum programs were conducted during this quarter.

No.	Observer(s)	Program
C320	Churchwell, E. (Wisconsin)	Microwave emission from small spinning dust grains.
D195	de Pater, I. (UC, Berkeley) Millan, R. (UC, Berkeley) Maddalena, R.	Jupiter's radio spectrum from 74 MHz up to 8000 MHz.
G370	Guerra, E. J. (Princeton) Partridge, R. B. (Haverford College) Haarsma, D. B. (Haverford College)	K-band observations of FIRST/GB6 inverted-spectrum radio sources.

The following line programs were conducted during this quarter.

No.	Observer(s)	Programs
L31	Lockman, F. J.	21 cm HI mapping of the galactic plane.
N020	Normandeau, M. (UC, Berkeley)	Recombination lines observations of W5.
R270	Rood, R. (Virginia) Balser, D. Bania, T. (Boston)	^{3}He abundances in galactic neutral hydrogen clouds.
S430	Sato, F. (Tokyo Gakugei University)	HI gas in the upper Scorpium shell with the Lupus molecular clouds.
S434	Sato, F. (Tokyo Gakugei University)	HI in the Taurus-Perseus region.

No.	Observer(s)	Program
W398	Wootten, H. A. Claussen, M. Wilking, B. (Missouri)	Water maser monitoring of low-luminosity young stellar objects.
W417	Woodney, L. (Maryland) McMullin, J.	Water in comets: a target of opportunity proposal to observe cometary OH.

The following pulsar programs were conducted during this quarter.

No.	Observer(s)	Program
A118	Arzoumanian, Z. (Cornell) Nice, D. (Princeton) Taylor, J. (Princeton)	Bimonthly timing of 63 pulsars at 500 and 800 MHz.
A132	Arzoumanian, Z. (Cornell) Nice, D. (Princeton)	575 MHz monitoring of the evolution of the PSR B1957+20 eclipsing binary system.
A133	Arzoumanian, Z. (Cornell)	370 MHz observations of six binary pulsars to measure or constrain long-term relativistic effects.
B687	Backer, D. (UC, Berkeley) Somer, A. (UC, Berkeley) Sallmen, S. (UC, Berkeley) Foster, R. (NRL)	Pulsar timing array.
N018	Nice, D. (Princeton) Thorsett, S. (Princeton)	Monitoring the irregularities in the rotation and orbital motion of a binary pulsar B1744-24A.
N019	Nice, D. (Princeton)	Observations of three binary pulsars: mass and proper motion measurements.

The following very long baseline programs were conducted during this quarter.

No.	Observer(s)	Program
B673	Briggs, F. (Groningen/Kapteyn) Carilli, C. de Bruyn, A. G. (NFRA) Vermeulen, R. (NFRA) Moore, C. (Groningen/Kapteyn)	VLBI of HI 21 cm absorbers at z=0.7 and 0.25.
B679	Briggs, F. (Groningen/Kapteyn) Carilli, C. de Bruyn, A. G. (NFRA) Koopmans, L. (Groningen/Kapteyn) Vermeulen, R. (NFRA) Moore, C. (Groningen/Kapteyn) Chengalur, J. (NCRA, India)	Observations of HI and OH line absorbers at z=0.6 to 0.9.

No.	Observer(s)	Program
BS044	Satoh, S. (NAO, Japan), *et al.*	Monitoring of the continuum and H_2O maser emission in NGC 3079.
M424	Molotov, I. (Lebedev) Likhachev, S. (Lebedev) Churpriko, A. (Lebedev)	Low frequency VLBI observations for RadioAstron mission pre-fly survey.
VS06	Hirabayshi, H. (ISAS, Japan)	VSOP survey.

C. 12 METER OBSERVING PROGRAMS

The following line programs were conducted during this quarter.

No.	Observers	Programs
A135	Apponi, A. (CfA) Ziurys, L. (Arizona)	Evaluating the HCO^+/HOC^+ abundance ratio towards photon-dominated regions.
A139	Arce, H. (CfA) Goodman, A. (CfA)	Study of the interaction between giant Herbig-Haro flows and their surroundings.
A140	Aalto-Bergman, S. (Chalmers, Onsala) Radford, S. Johansson, L. (Chalmers, Onsala)	Study of gas temperatures in luminous mergers with compact CO distributions.
A141	Apponi, A. (CfA)	Study of H_2C_8.
B691	Butner, H. (Arizona) Lada, C. (CfA) Alves, J. (CfA) Lada, E. (Florida) Charnley, S. (NASA/Ames)	Tracing the density profile of starless cores: CS versus dust extinction.
B693	Butner, H. (Arizona) Charnley, S. (NASA/Ames) Yonekura, Y. (Osaka U)	Study of the density and velocity structure of the B1 core.
C322	Choi, M. (Maryland) Panis, J-F. (SA/IAA, Taiwan) Evans, N. (Texas)	Study of protostellar collapse candidates using the HCO^+ and the HCN 1-0 lines.
C323	Clancy, R. T. (SSI, Boulder) Sandor, B. (High Altitude Obs)	Mars and Venus temperature and water studies.
CB12	Bower, G. (MPIR, Bonn) Krichbaum, T. (MPIR, Bonn) Zensus, J. A. (MPIR, Bonn)	Do EGRET blazars differ from other flat-spectrum radio sources?
CC09	Colomer, F. (Yebes Obs) Cernicharo, J. (IEM-CSIC, Spain) Desmurs, J-F. (Yebes Obs) Baudry, A. (Bordeaux)	Study of high-velocity SiO maser emission from evolved stars.

No.	Observer(s)	Program
CD12	Doeleman, S. (Haystack) Lonsdale, C. (Haystack) Barvainis, R. (Haystack) Phillips, R. (Haystack) Greenhill, L. (CfA)	86 GHz imaging of the SiO masers in the Orion-KL nebula.
CD13	Doeleman, S. (Haystack) Boboltz, D. (Haystack) Lonsdale, C. (Haystack)	Imaging the v=1, J= 2→1 86-GHz SiO masers toward χ Cygni.
CK07	Krichbaum, T. (MPIR, Bonn) Britzen, S. (MPIR, Bonn) Bower, G. (MPIR, Bonn) Witzel, A. (MPIR, Bonn) Zensus, J. A. (MPIR, Bonn)	Broad-band variability and jet-bending in PKS 0528+134.
CL05	Lonsdale, C. (Haystack) Boboltz, D. (Haystack) Doeleman, S. (Haystack)	The statistical properties of 86 GHz SiO masers around evolved stars.
CL06	Lo, K. Y. (SA/IAA, Taiwan) Zhao, J. (CfA) Ho, P. (CfA) Shen, Z. (SA/IAA, Taiwan)	Mapping the intrinsic source structure of Sgr A* at 86 GHz.
CR08	Rantakyrö, F. (Bologna) Conway, J. (Chalmers, Onsala) Wehrle, A. (IPAC) Bååth, L. (Halmstad U.) Booth, R. (Chalmers, Onsala)	Continuing MM-VLBI monitoring of 3C273 and 3C279.
CR09	Rantakyrö, F. (Bologna) Valtaoja, E. (Turku) Tornikoski, M. (Helsinki) Wiik, K. (Helsinki) Bååth, L. (Halmstad U.)	Investigation of the rapid structural variability in CTA 102.
CW02	Wright, M. (UC, Berkeley) Bower, G. (UC, Berkeley) Backer, D. (UC, Berkeley) Emerson, D.	VLBI spectral imaging at millimeter wavelengths.
G372	Gordon, M. Moringello, S. (Vassar College) Strelnitski, V. (Maria Mitchell Obs)	Monitoring of MWC 349 in hydrogen recombination lines.
G373	Gensheimer, P. (Arizona) Ziurys, L. (Arizona)	Search for SiC_2 in Sgr B2.
H331	Habara, H. (Tokyo U.) Minowa, H. (Tokyo U.) Yamamoto, S. (Tokyo U.)	Search for a new sulfur-bearing radical, HCS.

No.	Observer(s)	Program
H334	Helfer, T. Thornley, M. Regan, M. (DTM/Carnegie) Sheth, K. (Maryland) Vogel, S. (Maryland) Harris, A. (Maryland) Wong, T. (UC, Berkeley) Blitz, L. (UC, Berkeley) Bock, D. (UC, Berkeley)	Update: zero-spacing data for BIMA survey of nearby galaxies.
K361	Kuan, Y. (SA/IAA, Taiwan) Snyder, L. (Illinois) Charnley, S. (NASA/Ames) Wilson, T. (MPIR, Bonn) Lovas, F. (JILA)	Study of interstellar glycine.
K362	Kalenskii, S. (Lebedev) Alakoz, A. (Lebedev)	Observations of the 8-7 CH_3CN lines.
L333	Lee, C. (CfA) Myers, P. (CfA)	An unbiased survey for infall motions in starless cores.
L336	Lim, J. (SA/IAA, Taiwan) Ho, P. (CfA)	Study of the kinematic structure of the molecular core around the isolated UC-HII region, ON 1.
M420	Minowa, H. (Tokyo U.) Yamamoto, S. (Tokyo U.)	Search for HDCS toward active star-forming regions.
M421	Magnani, L. (Georgia) LaRosa, T. (Kennesaw State) Shore, S. (Indiana)	A study of turbulence in MBM 40.
M422	Moore, T. (Liverpool JMU) Ridge, N. (Liverpool JMU) Chandler, C. (Cambridge) Collins, C. (Liverpool JMU)	The study of luminosity correlation for high-mass molecular outflows.
M423	Magnani, L. (Georgia) Onello, J. (SUNY)	HCO^+ observations of wings of MBM 16.
S437	Sage, L. (Maryland) Welch, G. (St. Mary's U.) Henkel, C. (MPIR, Bonn) Wiklind, T. (Chalmers, Onsala)	The interstellar medium of lenticular galaxies: a survey of an unbiased sample.
S438	Smith, B. (Colorado) Struck, C. (Iowa State)	Study of molecular gas in bridge/ring galaxy pairs.
S444	Shah, R. (Virginia) Wootten, H. A.	Study of protostellar chemistry.
T375	Turner, B. Steimle, T. (Arizona State)	A search for HCS.

No.	Observer(s)	Program
T376	Turner, B.	A study of pure hydrocarbon species in translucent clouds.
W412	Lee, C. (CfA) Myers, P. (CfA) Plume, R. (CfA)	Mapping of four starless cores with infall asymmetry.
W413	Womack, M. (St. Cloud State) Festou, M. (SWRI) Stern, S. A. (SWRI)	The search for chemical diversity in comets.
Z161	Ziurys, L. (Arizona) Savage, C. (Arizona) Apponi, A. (CfA)	Is IRC+10216 unique? Searches for metal-bearing species towards other AGB stars.
Z162	Ziurys, L. (Arizona) Savage, C. (Arizona) Apponi, A. (CfA)	Chemistry in PDR's: mapping of HOC^+ in the Orion Bar.

D. VERY LARGE ARRAY OBSERVING PROGRAMS

Fourth quarter, 1998, was spent in the following configurations: B configuration from October 1 to October 19; BnC configuration from October 19 to November 16; and C configuration from November 19 to December 31.

The following research programs were conducted with the VLA during this quarter.

No.	Observer(s)	Program
AA232	Aparicio, A. (Laguna) Dalcanton, J. (Mt. Wilson) Gallart, C. (Mt. Wilson) Martinez-Delgado, D. (Laguna) Skillman, E. (Minnesota)	Detailed HI study of Antlia Dwarf Galaxy. 20 cm line
AA233	Anantharamaiah, K. (Raman Institute) De Pree, C. (Agnes Scott College) Goss, W. M.	C92 α in W49A. 2, 3.6 cm line
AB856	Biretta, J. (STScI) Owen, F. Zhou, F. (NMIMT)	Monitoring of M87 jet at 15 GHz. 2 cm
AB860	Bietenholz, M. (York U.) Frail, D. Weiler, K. (NRL)	Low frequency observations of 3C58 and Vela X. 90 cm
AB875	Bennett, P. (Colorado/JILA) Harper, G. (Colorado/JILA) Brown, A. (Colorado/JILA) Bauer, W. (Wellesley College)	1997/98 eclipse of VV Cephei. 1.3, 2, 3.6, 6 cm
AB876	Bietenholz, M. (York U.) Frail, D. Hester, J. (Arizona)	Time-variability in the radio structure of the Crab nebula. 6 cm

No.	Observer(s)	Program
AB879	Becker, R. (UC, Davis) White, R. (STScI) Helfand, D. (Columbia)	FIRST survey. 20 cm
AB882	Butler, B. Stern, S. A. (SWRI)	Observations of Pluto/Charon. 0.7 cm
AB883	Beck, R. (MPIR, Bonn) Shoutenkov, V. (Lebedev) Shukurov, A. (Newcastle) Sokoloff, D. (Moscow)	Magnetic fields in barred galaxy NGC 1097. 3.6 cm
AB885	Bastian, T. Aschwanden, M. (Lockheed)	High spatial and temporal resolution studies of flares. 1.3, 2 cm
AB889	Barlow, T. (Caltech) Lonsdale, C. (Caltech) Xu, C. (Caltech) Hacking, P. (IPAC) Shupe, D. (Caltech) Condon, J.	Radio survey of WIRE mid-infrared fields. 20 cm
AB890	Bhatnagar, S. (NCRA, India) Anantharamaiah, K. (Raman Institute) Roshi, A. (NCRA, India) Rao, A. (NCRA, India)	Low density ionized gas in directions of galactic SNRs. 90 cm line
AC508	Cooray, A. (Chicago) Carlstrom, J. (Chicago) Holzapfel, W. (Chicago) Joy, M. (NASA/MSFC)	Radio sources in galaxy clusters. 2, 3.6, 6 cm
AC516	Cassaro, P. (Catania) Stanghellini, C. (Bologna) Dallacasa, D. (Bologna) Bondi, M. (Bologna) Zappala, R. (Catania)	Extended emission from gamma ray sources. 3.6, 20 cm
AC521	Cote, S. (DAO) Broadhurst, T. (UC, Berkeley) Carignan, C. (Montreal) Freeman, K. (Mt. Stromlo) Wyse, R. (Johns Hopkins)	Search for HI emission associated with very nearby Ly absorbers. 20 cm line
AD419	Dennett-Thorpe, J. (Lisbon) Barthel, P. (Groningen/Kapteyn) van Bemmel, I. (Groningen/Kapteyn) Corbett, E. (Hertfordshire)	Radio asymmetries in 3CR broadline radio galaxies. 20 cm

No.	Observer(s)	Program
AE120	Eales, S. (U. College Cardiff) Lilly, S. (Toronto) Bond, D. (CITA) Gear, W. (Cambridge) Hammer, F. (Paris Obs) Le Fevre, O. (Marseille Obs)	Sources detected in a sub-millimeter survey. 20 cm
AE123	Eyres, S. (Keele) Richards, A. (Manchester) Evans, A. (Keele) Bode, M. (Liverpool JMU) Smalley, B. (Keele) Bains, I. (Manchester)	Planetary nebula associated with V4334 Sgr. 20 cm
AE125	Edge, A. (Durham) Allen, S. (Cambridge) Crawford, C. (Cambridge) Fabian, A. (Cambridge)	Radio properties of central galaxies in x-ray selected clusters. 2, 3.6, 6, 20 cm
AF337	Frail, D. Kulkarni, S. (Caltech) Vakil, D. (Caltech)	Late time radio emission from well localized gamma ray bursts. 3.6, 6, 20 cm
AF340	Fassnacht, C. Pearson, T. (Caltech) Readhead, A. (Caltech) Browne, I. (Manchester) Wilkinson, P. (Manchester) Myers, S. (Pennsylvania)	Monitoring of gravitational lens 1608+656. 3.6 cm
AF346	Fich, M. (Waterloo)	Structure of HII regions and measuring elemental abundances. 6, 20 cm
AF349	Feretti, L. (Bologna) Giovannini, G. (Bologna) Tordi, M. (Bologna)	Observations of new radio halos and relics from NVSS. 20 cm
AF350	Falcke, H. (MPIR, Bonn) Lobanov, A. (MPIR, Bonn) Wright, M. (UC, Berkeley) Bower, G. (MPIR, Bonn) Aller, M. (Michigan) Terasranta, H. (Helsinki) Patnaik, A. (MPIR, Bonn)	Monitoring extremely variable spiral III Zw 2. 1.3, 2, 3.6, 6, 20, 90 cm
AF352	Fabian, A. (Cambridge) DiMatteo, T. (Cambridge) Rees, M. (Cambridge) Carilli, C.	Radio emission from hot ion tori. 0.7, 1.3, 3.6 cm

No.	Observer(s)	Program
AF354	Furuya, R. (Nobeyama Obs) Wootten, H. A. Claussen, M. Saito, M. (CfA) Kitamura, Y. (ISAS, Japan) Marvel, K. (Caltech) Kawabe, R. (NAO, Japan)	Multi-epoch H_2O maser survey toward Class O/I protostars. 1.3 cm line
AG516	Gao, Y. (Illinois) Lo, K. Y. (Illinois) Gruendl, R. (Illinois) Hwang, C-Y. (SA/IAA, Taiwan)	Luminous IR galaxies in a merger sequence. 20 cm
AG539	Cruz-Gonzalez, I. (Mexico/UNAM) Salas, L. (Mexico/UNAM) Porras, A. (INAOE) Rodriguez, L. (Mexico/UNAM)	Exciting source of the curved molecular hydrogen jet near S187. 3.6 cm
AG546	Gaume, R. (USNO) Martin-Pintado, J. (Yebes Obs)	NH3 masers in Sgr B2? 1.3 cm
AG547	Gallimore, J. Thornley, M. Baum, S. (STScI) O'Dea, C. (STScI) Kukula, M. (STScI) Axon, D. (Manchester) Pedlar, A. (Manchester) Thean, A. (Manchester)	Star forming regions in active and normal spiral galaxies. 6 cm
AG548	van Gorkom, J. (Columbia) Szomoru, A. (UC, Santa Cruz) Verheijen, M. Schiminovich, D. (Caltech) Poggianti, B. (Cambridge)	Cluster evolution as probed in HI. 20 cm line
AH628	Hjellming, R. Mioduszewski, A. Rupen, M.	Radio and x-ray activity in galactic black holes. 2, 3.6, 6, 20 cm
AH639	Herrnstein, J. Greenhill, L. (CfA) Moran, J. (CfA) Blackman, E. (Cambridge) Diamond, P.	Polarimetry of the masers in NGC 4258. 1.3 cm line
AH648	Harris, D. (CfA) Leahy, J. P. (Manchester) Leighly, K. (Columbia)	X-ray emitting radio hotspot in 3C390. 0.7, 2 cm
AH656	Hoffman, G. (Lafayette College) van Gorkom, J. (Columbia) Salpeter, E. (Cornell)	High resolution HI study of DDO 154. 20 cm

No.	Observer(s)	Program
AH657	Han, J-L. (Beijing) Beck, R. (MPIR, Bonn) Berkhuijsen, E.M. (MPIR, Bonn)	Magnetic field in NGC 2997; coherent or not? 18, 22 cm
AH658	Hjellming, R. Rupen, M. Narayan, R. (CfA)	Quiescent radio emission of black hole binary V404 Cyg. 1.3, 2, 3.6, 6, 20 cm
AH659	Hoare, M. (Leeds) Hartquist, T. (Leeds) Dyson, J. (Leeds)	Probing the cometary tails in the Helix. 20 cm
AH660	Hankins, T. (NMIMT) Weatherall, J. (NMIMT) Kern, J. (NMIMT) Moffett, D. (Tasmania)	Bandwidth of the emission mechanism of Crab pulsar giant pulses. 2, 3.6, 6, 20, 90 cm
AJ267	Jauncey, D. (CSIRO) Kedziora-Chudczer, L. (Sydney) Reynolds, J. (CSIRO) Tzioumis, A. (CSIRO) Wieringa, M. (CSIRO) Perley, R. Nicolson, G. (HartRAO) Tingay, S. (JPL)	Target of Opportunity.
AK452	Koopmans, L. (Groningen/Kapteyn) de Bruyn, A. G. (NFRA) Jackson, N. (Manchester) Wilkinson, P. (Manchester) Fassnacht, C. Myers, S. (Pennsylvania)	Time delay monitoring of the CLASS gravitational lens B1600+434. 3.6 cm
AK453	Kassim, N. (NRL) Lazio, T. J. W. (NRL) Anantharamaiah, K. (Raman Institute) Goss, W. M. Falcke, H. (MPIR, Bonn)	74 MHz imaging of the galactic center. 90 cm
AK456	Kulkarni, S. (Caltech) Bloom, J. (Caltech) Djorgovski, S. (Caltech) Vakil, D. (Caltech) Frail, D.	Radio afterglows of gamma ray bursters. 2, 3.6, 6, 20 cm
AK461	Kassim, N. (NRL) Perley, R. Erickson, W. (Maryland) Lazio, T. J. W. (NRL) Feretti, L. (Bologna)	74 MHz observations of bright sources. 90 cm

No.	Observer(s)	Program
AK462	Kronberg, P. (Toronto) Ensslin, T. (MPIR, Bonn) Biermann, P. (MPIR, Bonn) Feretti, L. (Bologna) Giovannini, G. (Bologna) Perley, R. Hanish, R. (STScI)	The coma cluster at 74 MHz. 90 cm
AK466	Gopal Krishna (TIFR) Bhatnagar, S. (NCRA, India) Wisotzki, L. (Hamburg U.)	Search for radio continuum emission from QSOs in the Hamburg-ESO survey. 6 cm
AK469	Kameno, S. (NAO, Japan) Hamaguchi, K. (Kyoto) Umemoto, T. (NAO, Japan) Tsuboi, Y. (Kyoto) Koyama, K. (Kyoto) Fomalont, E.	Jet ejection from protostar R1 in R CrA star forming region. 3.6 cm
AK471	Kornreich, D. (Cornell) Haynes, M. (Cornell) van Zee, L. Lovelace, R. (Cornell)	Kinematic studies of optically asymmetric disk galaxies. 20 cm line
AK472	Kulkarni, S. (Caltech) Frail, D.	Radio counterpart to SGR 1900+14. 20, 90 cm
AK473	Krishnamurthi, A. (Colorado/JILA) Linsky, J. (Colorado/JILA) O'Neal, D. (Colorado/JILA)	Radio emission from very late M dwarfs and brown dwarfs. 3.6 cm
AK474	Knezek, P. (Johns Hopkins) Sembach, K. (Johns Hopkins) Gallagher, J. (Wisconsin)	Neutral gas content of "transition" dwarf galaxies. 20 cm line
AK475	Keto, E. (CfA) Ho, P. (CfA)	Disk or envelopes around Herbig Ae/Be stars. 0.7 cm
AK476	Kurtz, S. (Mexico/UNAM) Carral, P. (Guanajuato U.) Rodriguez, L. (Mexico/UNAM) Hofner, P. (NAIC) De Pree, C. (Agnes Scott College)	Possible hot core near NGC 6334F. 0.7, 3.6 cm
AK477	Kurtz, S. (Mexico/UNAM) Watson, A. (Mexico/UNAM) Hofner, P. (NAIC)	Extended emission near ultracompact HII regions. 3.6 cm
AL439	Leahy, J. P. (Manchester) Spencer, R. (Manchester) Garrington, S. (Manchester)	Prototype classical double 3C 295. 0.7, 1.3 cm

No.	Observer(s)	Program
AL441	Ludke, E. (UFSM, Brazil) Katz-Stone, D. (USNA)	Spectral analysis of CSS galaxies. 0.7, 1.3, 2, 6 cm
AL442	Lara, L. (IAA, Andalucia) Cotton, W. Feretti, L. (Bologna) Giovannini, G. (Bologna) Marcaide, J. (Valencia) Venturi, T. (Bologna)	New sample of large angular size radio sources. 6, 20 cm
AL451	Laine, S. (Hertfordshire) Gottesman, S. (Florida)	Anomalous radio continuum in NGC 7479. 20 cm
AL457	Lebron, M. (Mexico/UNAM) Rodriguez, L. (Mexico/UNAM) Lizano, S. (Mexico/UNAM)	Kinematical study of compact HII region G111.61+0.37. 3.6 cm
AL459	Lebron, M. (Mexico/UNAM) Gomez, Y. (Mexico/UNAM) Rodriguez, L. (Mexico/UNAM) Escalante, V. (Mexico/UNAM) Lizano, S. (Mexico/UNAM) Garay, G. (Chile)	Photo dissociated HI gas in GGD 12-15. 20 cm
AL460	Lacey, C. (Mexico/UNAM) Goss, W. M. Duric, N. (New Mexico) Pannuti, T. (New Mexico)	Supernova remnant search in M83. 6 cm
AL462	Lim, J. (SA/IAA, Taiwan) Ho, P. (CfA)	HI environment of low redshift quasars. 20 cm line
AL464	Leighly, K. (Columbia) van Gorkom, J. (Columbia) Harris, D. (CfA)	HI in a galaxy near BLRG 3C 390.3. 20 cm line
AL466	Law-Green, D. (Leicester) Zezas, A. (Leicester) Ward, M. (Leicester) Hirst, P. (Leicester)	Radio imaging of x-ray selected starbursts and composite galaxies. 3.6, 6, 20 cm
AL467	Lehar, J. (CfA) Falco, E. (CfA) Kochanek, C. (CfA) Munoz, J. (CfA) Mediavilla, E. (Laguna) Oscoz, A. (Laguna) Serra, M. (Laguna)	Redshift survey of faint, flat spectrum radio sources. 6 cm
AL470	Lee, S-W. (SA/IAA, Taiwan) Gao, Y. (Illinois) Lo, K. Y. (SA/IAA, Taiwan) Wang, W-H. (SA/IAA, Taiwan)	Early stage merging or pre-merging luminous IR galaxies. 20 cm line

No.	Observer(s)	Program
AL472	Lang, C. (UCLA) Morris, M. (UCLA) Goss, W. M.	H92 observations of unusual arched filaments. 3.6 cm line
AL473	Lang, C. (UCLA) Anantharamaiah, K. (Raman Institute)	Radio polarimetric study of filamentary source G359.8+0.2. 3.6, 6 cm
AM573	Miller, S. (Maryland) Veilleuz, S. (Maryland) Wilson, A. (Maryland)	Radio halos of edge-on spiral galaxies. 20 cm
AM585	Marti, J. (CNRS, France) Mirabel, I. F. (CNRS, France) Rodriguez, L. (Mexico/UNAM) Chaty, S. (CNRS, France)	Monitoring the radio outbursts of GX 354-00. 3.6, 6 cm
AM596	Menten, K. (MPIR, Bonn) Neuhauser, R. (MPIfEP, Garching) Preibisch, T. (Wurzburg)	Class I protostars in R CrA. 3.6 cm
AM601	Marcha, M. (Lisbon) Dennett-Thorpe, J. (Lisbon) Browne, I. (Manchester)	Extended emission in flat radio spectrum sources. 20 cm
AM602	Mirabel, I. F. (CNRS, France) Rodriguez, L. (Mexico/UNAM) Dhawan, V.	Radio, infrared and x-ray observations of microquasar 1915+105. 2, 3.6, 6 cm
AM604	Molnar, L. (Iowa) Dunn, D. (Iowa) Fix, J. (Iowa) de Pater, I. (UC, Berkeley) van der Tak, F. (UC, Berkeley)	Coordinated, multi-wavelength observations of Saturn near opposition. 3.6, 6, 20 cm
AM609	McLaughlin, M. (Cornell) Cordes, J. (Cornell) Lazio, T. J. W. (NRL) Iyudin, A. (MPIAP, Munich) Diehl, R. (MPIAP, Munich) Bennett, K. (Raman Institute) Schoenfelder, V. (MPIAP, Munich)	Search for radio emission from a young galactic SNR. 20, 90 cm
AN081	Mohan, R. N. (Raman Institute) Anantharamaiah, K. (Raman Institute) Goss, W. M.	Radio recombination lines from starburst galaxies. 3.6 cm line
AN083	Nindos, A. (Maryland) Kundu, M. (Maryland)	Search for microwave emission from solar Ellerman bombs. 2, 3.6, 6 cm
AO136	Owen, F.	330 MHz observations of M87. 90 cm

No.	Observer(s)	Program
AO139	Oosterloo, T. (Milano Obs) Morganti, R. (Bologna) Caldwell, N. (CfA) Vergani, D. (Bologna) van Moorsel, G.	Mass distribution in NGC 3108. 20 cm line
AP361	Pooley, G. (Cambridge) Alexander, P. (Cambridge) Gilbert, G. (Cambridge) Hardcastle, M. (Bristol, UK) Riley, J. (Cambridge)	Properties of Jets in FRII radio sources. 3.6 cm
AP375	Pedani, M. (Bologna) Grueff, G. (Bologna)	Observations of new and complete sample of ultra steep spectrum radio sources. 6 cm
AR386	Rudnick, L. (Minnesota) Treichel, K. (Minnesota) Mack, K. (Bologna) Klein, U. (Bonn U.) Katz-Stone, D. (USNA)	Electron populations and ages in radio galaxies. 6, 20, 90 cm
AR398	Roy, A. (MPIR, Bonn) Anantharamaiah, K. (Raman Institute) Verheijen, M.	Molecular absorption in two type-2 Seyfert galaxies. 20 cm line
AR399	Rector, T. (Colorado/JILA) Stocke, J. (Colorado/JILA)	Parsec and kpc-scale jets in x-ray selected BL Lac objects. 3.6, 20 cm
AR400	Roy, A. (MPIR, Bonn) Anantharamaiah, K. (Raman Institute) Goss, W. M.	Radio recombination lines from NGC 3256. 3.6 cm line
AR402	Rudnick, L. (Minnesota) Treichel, K. (Minnesota) Katz-Stone, D. (USNA) Giovannini, G. (Bologna)	Non-relativistic sheaths around extragalactic jets. 3.6, 6, 20 cm
AS568	Sramek, R. Weiler, K. (NRL) Van Dyk, S. (UCLA) Panagia, N. (STScI)	Properties of radio supernovae. 1.3, 2, 3.6, 6, 20 cm
AS632	Sahu, K. (STScI) Baum, S. (STScI) Kaiser, M. (NASA/GSFC) O'Dea, C. (STScI) Shaw, R. (STScI)	The most luminous x-ray cluster RXJ 1247.5-1145. 20 cm
AS638	Slysh, V. (Lebedev) Val'tts, I. (Lebedev) Kalensky, S. (Lebedev) Golubev, V. (Lebedev)	Methanol masers in star forming regions. 0.7 cm line

No.	Observer(s)	Program
AS644	Scuderi, S. (Bologna) Stanghellini, C. (Bologna) Panagia, N. (STScI)	Survey of radio emission from O and B supergiants. 2, 3.6, 6 cm
AS645	Stanghellini, C. (Bologna) Dallacasa, D. (Bologna) Fanti, R. (Bologna) Centonza, M. (Bologna)	High frequency peakers at higher frequency. 1.3, 2, 3.6, 6, 20 cm
AS648	Shibata, K. (NAO, Japan) Satoh, S. (NAO, Japan)	HI absorption survey of megamaser sources. 20 cm line
AT210	Thorsett, S. (Princeton) Taylor, J. (Princeton) Nice, D. (Princeton) Briskin, W. (Princeton)	Timing fast pulsars. 6, 20, 90 cm
AT211	Taylor, G. Fabian, A. (Cambridge)	X-ray to radio correlations in cooling flow clusters. 6, 20 cm
AT220	Thornley, M.	Weak spiral density waves in flocculent spiral NGC 7331. 20 cm line
AT221	Taylor, G. Vermeulen, R. (NFRA)	Searching for HI in the CSOs 1826+796 and 2021+614. 20 cm line
AU076	Urbanik, M. (Jagellonian) Chyzy, K. (Jagellonian) Soida, M. (Jagellonian) Beck, R. (MPIR, Bonn)	Polarization in the perturbed face on spiral NGC 4254. 20 cm
AW362	White, S. (Maryland)	The stellar activity cycle on active stars. 3.6, 6, 20 cm
AW489	Wilner, D. (CfA) Ho, P. (CfA) Rodriguez, L. (Mexico/UNAM) Zhang, Q. (CfA)	Continuum studies of T-Tauri disks. 0.7 cm
AW498	Wilcots, E. (Wisconsin) Bershady, M. (Wisconsin) Jangren, A. (Penn State)	HI observations of a sample of compact, luminous star forming galaxies. 20 cm line
AW504	Wilson, T. (MPIR, Bonn) Gaume, R. (USNO) Megeath, S. (Haystack)	Observations of W3 IRS5. 0.7 cm
AX004	Xanthopoulos, E. (Manchester) Browne, I. (Manchester) Wilkinson, P. (Manchester) Patnaik, A. (MPIR, Bonn) Porcas, R. (MPIR, Bonn) King, L. (Manchester)	Monitoring the CLASS gravitational lenses B1030+074 and B1933+503. 3.6 cm

No.	Observer(s)	Program
AY085	Yun, M. Hibbard, J.	Tidal HI in IR luminous mergers. 20 cm
AY100	Yun, M. Carilli, C. Verheijen, M.	Search for new HI 21cm quasar absorption line systems. 20 cm line
AY105	Yun, M. Butler, B.	Stars of large angular size. 0.7 cm
AZ097	van Zee, L.	Gas distributions and kinematics of isolated irregular galaxies. 20 cm
AZ106	Zhang, Q. Hunter, T. (CfA) Sridharan, T. (CfA) Cesaroni, R. (Arcetri)	High mass protostar 2012ó+4104. 1.3 cm line
AZ107	van Zee, L. Salzer, J. (Wesleyan U.) Skillman, E. (Minnesota)	Kinematic constraints on BCD to dE evolutionary scenarios. 20 cm line
AZ108	van Zee, L. Haynes, M. (Cornell)	Testing closed-box chemical evolution: controlling the dark matter and neutral gas content. 20 cm line
AZ112	Zhu, M. (Toronto) Seaquist, E. (Toronto)	HI mapping of interacting galaxies. 20 cm line
AZ115	Zijlstra, A. (ESO) Dudziak, G. (ESO)	Planetary He^2-426 in the Sagittarius dwarf galaxy.
BA030	Attridge, J. (Brandeis) Roberts, D. (Brandeis) Wardle, J. (Brandeis)	Multi-frequency VLBA imaging of the blazar 1055+018. 18 cm
BD046	Diamond, P., *et al.*	Monitoring SiO masers through a cycle of Mira TX Cam. 0.7 cm single antenna VLBI
BG073	Gomez, J-L. (ESA, Spain), *et al.*	3C 120 rapid variations. 0.7, 1.3 cm
BM011	Mioduszewski, A. Hjellming, R. Rupen, M.	VLBI Observation of x-ray binary SS433 during a flare. 18 cm
GP019	Peck, A. (NMIMT) Taylor, G.	Observations of HI in absorption toward NGC 3894. 21 cm

E. VERY LONG BASELINE ARRAY OBSERVING PROGRAMS

Project	Observer(s)	Title
BA029	Alberdi, A. (ESA, Spain) Gomez, J-L. (ESA, Spain) Marcaide, J. (Valencia) Perez-Torres, M. (Valencia) Marscher, A. (Boston)	Superluminal source 4C39.25. 0.7, 1.3, 2 cm
BB101	Bower, G. (MPIR, Bonn) Backer, D. (UC, Berkeley)	Gamma ray blazar NRAO 530. 0.7, 1.3, 3.6 cm
BB103	Blundell, K. (Oxford) Close, L. (Oxford) Leahy, J. P. (Manchester)	Low frequency study of hotspots in powerful radio sources. 8, 90 cm
BC085	Charlot, P. (Bordeaux) Sol, H. (Paris Obs)	Multi-frequency monitoring of BL Lac object OJ287. 1.3, 3.6, 6 cm
BC086	Campbell, D. (Cornell) Black, G. Butler, B. Ostro, S. (JPL)	Radar observations of Asteroid 1996 FG3.
BC087	Carilli, C. Menten, K. (MPIR, Bonn) Reid, M. (CfA)	Imaging the HC_3N absorption in 1830-211. 1.3, 2 cm with phased VLA
BC088	Chatterjee, S. (Cornell) Cordes, J. (Cornell) Arzoumanian, Z. (Cornell) Goss, W. M. Beasley, A. Benson, J. Lazio, T. J . W. (NRL) Xilouris, K. (NAIC)	Neutron star kinematics: gated VLBA pulsar astrometry. 18 cm
BC089	Claussen, M. Wootten, H. A. Marvel, K. (Caltech) Wilking, B. (Missouri)	Proper motions of water masers in NGC 1333. 1.3 cm with VLA single antenna
BD046	Diamond, P. Kemball, A. Boboltz, D. (USNO)	Monitoring SiO masers through a cycle of Mira TX Cam. 0.7 cm
BD050	Diamond, P. Lonsdale, C. (Haystack) Lonsdale, C. (Caltech) Smith, H. (UC, San Diego)	Observations of two southern OH megamaser galaxies. 18 cm with phased VLA
BD053	Desai, K. Fey, A. (USNO)	Scatter broadened image of 2023+336. 2, 3.6, 6 cm

No.	Observer(s)	Program
BD054	Desai, K. Fey, A. (USNO)	Search for anisotropic scattering in the ISM. 6, 18 cm
BD055	Doeleman, S. (Haystack) Barvainis, R. (Haystack) Lonsdale, C. (Haystack) Greenhill, L. (CfA) Phillips, R. (Haystack)	SiO masers in Orion Nebula. 0.7 cm
BE017	Engels, D. (Hamburg U.) Winnberg, A. (Chalmers, Onsala) Yie, J. (Chalmers, Onsala)	Structure of H_2O masers in OH/IR stars. 1.3 cm with VLA single antenna
BF042	Faison, M. (Wisconsin) Goss, W. M. Diamond, P. Taylor, G.	Imaging small scale galactic HI structure. 18 cm with phased VLA
BF043	Fey, A. (USNO) Gaume, R. (USNO) Eubanks, T. M. (USNO) Johnston, K. (USNO) Ma, C. (NASA/GSFC)	Southern hemisphere astrometry for the celestial reference frame. 3.6 cm
BF044	Falcke, H. (MPIR, Bonn) Bower, G. (MPIR, Bonn) Zensus, J. A. (MPIR, Bonn) Aller, M. (Michigan) Aller, H. (Michigan) Terasranta, H. (Helsinki)	Extremely variable spiral galaxy III Zw 2. 0.7, 2 cm
BF046	Fomalont, E. Brisken, W. (Princeton) Benson, J. Beasley, A. Goss, W. M.	VLBA pulsar astrometry of B0950+08. 18 cm
BF047	Fiebig, D. (Heidelberg Obs) Diamond, P.	Polarization observations of circumstellar H_2O masers. 1.3 cm
BG073	Gomez, J-L. (IAA, Andalucia) Marscher, A. (Boston) Alberdi, A. (IAA, Andalucia)	3C 120 rapid variations. 0.7, 1.3 cm
BG077	Gurvits, L. (NFRA) Kellermann, K. Fomalont, E.	Resolution matching survey of VSOP survey sources. 2 cm
BG081	Gurvits, L. (NFRA) Schilizzi, R. (NFRA) Frey, S. (SGO, Hungary) Kellermann, K.	The most distant quasars. 6 cm

No.	Observer(s)	Program
BH050	Hirotani, K. (NAO, Japan) Wajima, K. (ISAS, Japan) Iguchi, S. (NAO, Japan) Satoh, S. (NAO, Japan) Kimura, M. (NAO, Japan) Imai, M. (NAO, Japan) Asaki, Y. (NAO, Japan) Fujisawa, K. (ISAS, Japan) Horiuchi, S. (NAO, Japan) Kameno, S. (NAO, Japan) Hirabayashi, H. (ISAS, Japan)	The pc scale jet of 2021+614. 1.3, 2, 3.6, 6, 18 cm
BH051	Hough, D. (Trinity U.) Vermeulen, R. (NFRA) Readhead, A. (Caltech)	Lobe-dominated quasars: 3C 9, 3C 14, 3C 432 and 4C16.49. 3.6 cm
BH052	Hough, D. (Trinity U.) Readhead, A. (Caltech)	Second epoch imaging of lobe dominated quasars 3C270.1 and 3C275.1. 2, 3.6 cm
BI010	Imai, H. (NAO, Japan) Sasao, T. (NAO, Japan) Kameya, O. (NAO, Japan) Miyoshi, M. (NAO, Japan) Horiuchi, S. (NAO, Japan) Asaki, Y. (NAO, Japan) Deguchi, S. (NAO, Japan)	Water masers in W3 IRS 5. 1.3 cm
BJ027	Johnston, K. (USNO) Fey, A. (USNO) Gaume, R. (USNO) Eubanks, T. M. (USNO) Kingham, K. (USNO) Clark, T. (NASA/GSFC) Ma, C. (NASA/GSFC) Ryan, J. (NASA/GSFC) Vandenberg, N. (Interferometrics) Himwich, E. (Interferometrics) Shaffer, D. (Radiometrics) Gordon, D. (NASA/GSFC) Fomalont, E. Walker, R. C.	VLBA geodesy/astrometry observations for 1998. 3.6 cm
BK052	Kellermann, K. Zensus, J. A. (MPIR, Bonn) Vermeulen, R. (NFRA) Cohen, M. (Caltech)	Kinematics of quasars and AGN. 2 cm
BK061	Kameno, S. (NAO, Japan) Wajima, K. (Ibaraki U.) Imai, M. (NAO, Japan) Inoue, M. (NAO, Japan)	Multi-frequency VSOP and VLBA survey for GPS sources. 2, 3.6 cm

No.	Observer(s)	Program
BK062	Kukula, M. (STScI) Ghosh, T. (NAIC) Pedlar, A. (Manchester) Baum, S. (STScI) O'Dea, C. (STScI) Xu, C. (Maryland)	Detailed study of the radio jets in Seyfert 2 galaxy Mrk 3. 3.6, 6, 18 cm with phased VLA
BL038	Lestrade, J-F. (Paris Obs) Phillips, R. (Haystack) Jones, D. (JPL) Preston, R. (JPL)	Search for extra solar planets by VLBI astrometry. 3.6 cm with phased VLA
BL066	Lobanov, A. (MPIR, Bonn) Krichbaum, T. (MPIR, Bonn) Kraus, A. (MPIR, Bonn) Witzel, A. (MPIR, Bonn) Otterbein, K. (Heidelberg Obs)	0836+710 jet kinematics related to the broad band activity. 0.7, 1.3, 3.6 cm
BL068	Lane, W. (Groningen/Kapteyn) Briggs, F. (Groningen/Kapteyn)	Two low redshift HI 21cm systems towards B0738+313. 18 cm
BL072	Lobanov, A. (MPIR, Bonn) Vermeulen, R. (NFRA) Kellermann, K. Zensus, J. A. (MPIR, Bonn)	Imaging the sub-parsec scale jets of NGC 1052. 0.7, 1.3, 3.6 cm
BM095	Marscher, A. (Boston) Cawthorne, T. (Lancashire) Gear, W. (Cambridge) Stevens, J. (Cambridge) Marchenko, S. (St. Petersburg) Yurchenko, A. (St. Petersburg) Gabuzda, D. (Lebedev) Lister, M. (Boston) Forster, J. (UC, Berkeley)	Monitoring bright AGNs. 0.7 cm
BM099	Miyoshi, M. (NAO, Japan) Imai, H. (NAO, Japan) Ukita, N. (NAO, Japan) Diamond, P. Hagiwara, Y. (Nobeyama Obs) Morimoto, M. (Kagoshima U.)	Astrometry with different transitions of SiO masers. 0.7 cm with VLA single antenna
BM104	Minier, V. (Chalmers, Onsala) Booth, R. (Chalmers, Onsala) Conway, J. (Chalmers, Onsala) Phillips, C. (NFRA)	12.2 GHz methanol masers in star forming regions. 2 cm
BM106	Mutel, R. (Iowa) Molnar, L. (Iowa)	Astrometric mapping of HR 1099: test of polar emission model. 3.6 cm with phased VLA

No.	Observer(s)	Program
BM107	Moscadelli, L. (MPIR, Bonn) Menten, K. (MPIR, Bonn) Patnaik, A. (MPIR, Bonn) Reid, M. (CfA)	Proper motion of 12 GHz methanol masers in W3 (OH). 2 cm
BM110	Mutel, R. (Iowa) Denn, G. (Iowa)	Monitoring BL Lac. 0.7, 1.3, 2 cm
BM112	Moran, J. (CfA) Greenhill, L. (CFA) Herrnstein, J. Diamond, P. Bragg, A. (CfA) Trotter, A. (CfA) Henkel, C. (MPIR, Bonn)	Next generation study of NGC 4258 accretion disk physics. 1.3 cm
BP048	Perlman, E. (STScI) Carilli, C. Minter, A. Langston, G. Ghigo, F. Stocke, J. (Colorado/JILA) Conway, J. (Chalmers, Onsala)	Monitoring PKS 1413+135. 0.7, 1.3, 2, 3.6 cm
BR052	Reid, M. (CfA) Eubanks, T. M. (USNO)	Trigonometric parallax to Sgr A*. 0.7 cm
BR057	Roberts, D. (Brandeis) Moellenbrock, G. (ISAS, Japan) Wardle, J. (Brandeis) Gabuzda, D. (Lebedev) Brown, L. (Connecticut)	Four 3C quasars with VSOP observations. 0.7, 1.3, 2, 3.6 cm
BR065	Rupen, M. Hjellming, R. Mioduszewski, A.	Observations of galactic jet source XTE 1748-288. 2 cm
BS044	Satoh, S. (NAO, Japan) Inoue, M. (NAO, Japan) Nakai, N. (NAO, Japan) Shibata, K. (NAO, Japan) Migenes, V. (Guanajuato U.) Kameno, S. (NAO, Japan) Fujisawa, K. (ISAS, Japan)	Monitoring of the continuum and H_2O maser emission in NGC 3079. 1.3, 2, 3.6 cm

No.	Observer(s)	Program
BS067	Schilizzi, R. (NFRA) de Bruyn, A. G. (NFRA) Snellen, I. (Cambridge) Tschager, W. (Leiden) Miley, G. (Leiden) Rottgering, H. (Leiden) van Langevelde, H. (NFRA) Fanti, C. (Bologna) Fanti, R. (Bologna)	GPS galaxies and quasars: matched beam observations of HALCA objects. 2 cm
BT038	Tingay, S. (JPL) Preston, R. (JPL) Jones, D. (JPL) Murphy, D. (JPL) Meier, D. (JPL) Jauncey, D. (CSIRO) Tzioumis, A. (CSIRO) Reynolds, J. (CSIRO)	Monitoring of Centaurus A, the closest active radio galaxy. 3.6 cm
BW041	Wilson, A. (Maryland) Ulvestad, J. Mundell, C. (Maryland) Roy, A. (MPIR, Bonn)	Free-free absorption in megamaser galaxies. 2, 6, 18 cm
BW042	White, S. (Maryland) Beasley, A. Lim, J. (SA/IAA, Taiwan)	An active giant star: λ Andromedae. 3.6 cm
GB031	Browne, I. (Manchester) Jackson, N. (Manchester) Wilkinson, P. (Manchester) Marlow, D. (Manchester) Garrett, M. (NFRA) Fassnacht, C. de Bruyn, A. G. (NFRA) Koopmans, L. (Groningen/Kapteyn) Myers, S. (Pennsylvania)	Structure of gravitational lens system 1933+503. 18 cm
GB033	Bartel, N. (York U.) Rupen, M. Bietenholz, M. (York U.) Beasley, A. Conway, J. (Chalmers, Onsala) Altunin, V. (JPL) Graham, D. (MPIR, Bonn) Venturi, T. (Bologna) Umana, G. (Bologna)	VLBI imaging of supernova 1993J in M81. 3.6, 6, 18 cm

No.	Observer(s)	Program
GC021	Campbell, R. (NFRA) de Bruyn, A. G. (NFRA) Vermeulen, R. (NFRA) Galama, T. (Amsterdam) van den Heuvel, E. (Amsterdam) Verbunt, F. (Utrecht) Lestrade, J-F. (Paris Obs) Schilizzi, R. (NFRA)	Pulsar parallax and proper motion determination. 18 cm
GG038	Giovannini, G. (Bologna) Feretti, L. (Bologna) Venturi, T. (Bologna) Cotton, W. Lara, L. (IAA, Andalucia) Taylor, G.	Symmetrically expanding FRI radio galaxy 3C338. 2, 3.6 cm with phased VLA
GM035	Marcaide, J. (Valencia) Perez-Torres, M. (Valencia) Guirado, J. (Valencia) Alberdi, A. (ESA, Spain) Ros, E. (MPIR, Bonn) Diamond, P. Shapiro, I. (CfA) Preston, R. (JPL) Schilizzi, R. (NFRA) Mantovani, F. (Bologna) Trigilio, C. (Bologna) Van Dyk, S. (UCLA) Weiler, K. (NRL) Sramek, R. Whitney, A. (Haystack)	Monitoring of the expansion of SN 1993J. 6, 18 cm
GP018	Pedlar, A. (Manchester) Muxlow, T. (Manchester) Wills, K. (Manchester) Diamond, P. Wilkinson, P. (Manchester) Garrett, M. (NFRA) Alef, W. (MPIR, Bonn)	Global VLBI observations of compact supernova remnants in M82. 6, 18 cm
V026	Walker, R. C.	3C120 structure from 0.1 to 250 pc. 6, 18 cm
V032	Guirado, J. (Valencia)	Quasar phase-reference mapping and astrometry with VSOP: 1342+662. 6 cm
V053	Witzel, A. (MPIR, Bonn)	Polarization variability of intraday variable sources: 0954+658. 6 cm
V063	Bartel, N. (York U.)	Core-jet in the nearby spiral galaxy M81. 6, 18 cm
V078	Charlot, P. (Bordeaux)	Monitoring of the BL Lac object OJ287. 18 cm with phased VLA

No.	Observer(s)	Program
W014	Ulvestad, J. Vestrand, W. T. (New Hampshire) Stacy, J. (New Hampshire) Biretta, J. (STScI)	Flaring CGRO blazar 2255-282. 6 cm
W041	Alberdi, A. (ESA, Spain) Gomez, J-L. (ESA, Spain) Marcaide, J. (Valencia) Perez-Torres, M. (Valencia) Marscher, A. (Boston) Lobanov, A. (MPIR, Bonn)	Polarimetric observations of 4C39.25. 6 cm with phased VLA
W058	King, E. (CSIRO) Jauncey, D. (CSIRO) Reynolds, J. (CSIRO) Tzioumis, A. (CSIRO) McCulloch, P. (Tasmania) Costa, M. (Tasmania) Lovell, J. (ISAS, Japan) Preston, R. (JPL) Murphy, D. (JPL)	Imaging of strong GPS sources: J2136+00. 6 cm

F. SCIENCE HIGHLIGHTS

Socorro

VLA Reveals Close Pair of Protoplanetary Disks - VLA observations at 7 mm showed a pair of protoplanetary 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.

Investigators: L. F. Rodriguez, P. D. Alessio, S. Curiel, Y. Gomez, S. Lizano, J. Canto, and A.C. Raga (UNAM); D. J. Wilner and P. Ho, (CfA); and J. M. Torrelles (Granada).

HI Images Indicate Nearby Quasars Result From Galactic Encounters - VLA HI images of three relatively nearby quasars indicate that the gas in all three host galaxies has been disrupted by galactic interactions. Optical images of only one of these host galaxies showed evidence of interaction. This indicates that the evidence for interactions probably is longer-lived in the gas component than the stellar component. In addition, these observations also tend to support the current model that nearer quasars are "turned on" by galactic mergers.

Investigators: J Lim (Academia Sinica, Taiwan) and P. Ho (CfA).

Green Bank

The galactic intersteller abundances of lithium and Boron provide important information about big bang nucleosynthesis, galactic chemical evolution, stellar evolution, and cosmic-ray spallation reactions. Because these two elements are destroyed in stellar interiors, significant abundances of Li and B can exist only in regions of explosive nucleosynthesis or in the cool interstellar medium. Most of the Li and Bin interstellar gas must be of galactic origin.

A search was made, for the first time, for the ground-state hyperfine-structure transitions of Li and B using the 140 Foot Telescope. Lines were not detected in observations toward the Galactic Center, allowing strict limits to be placed on any possible enhancement of abundances caused by activity in the galactic nucleus. Comparing the results to models of AGN, it appears that the Galactic Center has not had an extended period of AGN activity with a large cosmic-ray flux, a large, low-energy cosmic ray flux, or a large gamma-ray flux in the last 10^8 to 10^9 years. Furthermore, since the Li and B abundances are sensitive to the abundance of Deuterium, these observations

make it possible to conclude that there have been no sources of Deuterium in the galaxy, and all must have originated from infall of primordial matter.

Investigators: D. A. Lubowich (Hofstra University), B. E. Turner, and L. M. Hobbs (Univ. Chicago).

G. PUBLICATIONS

Attached as Appendix A is a listing of all preprints received in the NRAO Charlottesville library during the reporting period authored by NRAO staff or based on observations on NRAO telescopes.

H. CHARLOTTESVILLE ELECTRONICS

Amplifier Development, Design, and Production

Construction of the last MAP amplifiers was completed. The last of the 90 GHz units were sent to Goddard Space Flight Center (GSFC) for vibration testing just before the end of 1998, with final post-vibration tests scheduled for completion by mid-January 1999. The complete build spread over five frequencies consisted of 80 flight amplifiers, 20 spares, and about 40 pre-prototypes, prototypes, and additional units. No further work on MAP is expected beyond the end of these deliveries unless there is a failure before the scheduled launch in September 2000.

The extreme ruggedness of the new amplifiers was proven following an accident at GSFC. The first 90 GHz radiometer was undergoing final vibration testing prior to permanent installation in the spacecraft instrument section when a bracket holding various units together broke. This left the amplifiers to vibrate at the ends of long waveguide arms— rather like the tips of a tuning fork. Dave Wilkinson of Princeton University noted that one of the four abused amplifiers looked as if it had been attacked with a ball peen hammer. Nevertheless, all four amplifiers still worked!

Production has now begun for K- and Q-band amplifiers for the VLA. The first K-band units are due to be ready before the end of January 1999. A comprehensive inventory of components was undertaken and, as a result, major purchases of such items as quartz wafers and commercial capacitors have begun.

Marian Pospieszalski completed the design of a new version of the 90 GHz amplifier which is optimized for 80–95 GHz, the band desired by the VLBA. In early 1999, a prototype of this amplifier will be built and evaluated, with production units to follow later in the year for retrofit to the four existing VLBA W-band receivers.

A total of nine balanced amplifiers were fabricated this quarter: two 350 MHz, two 450 MHz, and five 800 MHz. Richard Bradley has completed the design of a balanced amplifier for the 1.2–2.4 GHz band and fabrication of the prototype will begin next quarter.

Superconducting (SIS) Millimeter-Wave Mixer Development

SIS Fabrication for the MMA - We received proposals for Nb SIS mixer fabrication from JPL and SUNY/Stony Brook. After a careful review and detailed discussions with both groups, we selected SUNY to fabricate Nb circuits during the MMA's development phase. The SUNY Nb foundry is not widely known in millimeter astronomy circles, so a brief description might be of interest to the reader. The Nb foundry at SUNY/Stony Brook was set up by Prof. J. Lukens in the 1970's for physics research on superconductors. Lukens was probably the first to use electron-beam lithography for Nb circuits, and they now routinely use a combination of e-beam-lithography for junction definition and photo-lithography for the less critical parts of the circuit. They use a "planarization" process, developed by IBM for IC production, which allows fabrication of very small SIS junctions without using a lift-off procedure or creation of via-holes through an insulator layer. An impressive aspect of the SUNY foundry is their emphasis on process monitoring and quality control—unusual in a university laboratory—which has been driven largely by their work on large array oscillators in which uniformity of junction parameters across a wafer is critical. They produce excellent I-V curves for junctions as small as 0.5 um x 0.5 um (0.25 um^2) with critical current densities up to 100,000 A/cm^2. Because most of the SUNY Nb work has been on Si substrates, we asked them to do a pilot study to confirm their ability to make high quality SIS junctions on fused quartz substrates. They produced excellent junctions of area 1 um^2 with J_c = 8000 A/cm^2. There appears to be no difference in the quality of their junctions on quartz *vs.* silicon.

SIS Mixer Design - Analysis of the input circuit of our 200–300 GHz mixers using the QuickWave electromagnetic simulator revealed a resonance in the suspended stripline when the substrate was slightly off center in its channel. A small change of channel dimensions moved the resonance out of the band. The revised dimensions will be used for all future mixer blocks. This applies to single-ended, balanced, and sideband-separating mixers.

Analysis of cavity and substrate modes in MMIC's with dimensions greater than one wavelength—our balanced and sideband-separating SIS mixers—indicates that input-to-output coupling through unwanted mode resonances can be suppressed without

adding appreciable loss in the desired mode by using appropriately placed absorbing material. A difficulty is the lack of data on absorbers such as Eccosorb at high frequencies and low temperatures. We have sent samples of Eccosorb MF112 to Dr. Harvey Moseley at GSFC who has kindly offered to perform FTS measurements at room temperature and 4 K.

Photomixer Development at UCLA - We found that the CPS-to-microstrip-to-waveguide transition proposed by UCLA for the photomixer LO had undesired resonances in the operating band. UCLA is now exploring a symmetrical CPS-to-waveguide transition which appears to have acceptable performance over a full waveguide band.

Vacuum Window Development - Work continues on a low-loss, low-leakage, 100 GHz quasi-optical vacuum window for the VLBA—this is also a prototype for a possible MMA design. The earlier problem with gas bubbles between the PTFE and quartz due to out-gasing of the epoxy has been solved by using a pneumatic press instead of a vacuum frame. The first of these windows has been installed on a VLBA receiver.

Because the three-layer vacuum window only covers approximately 70 percent of a waveguide band with loss < 0.1 dB, we have started work on a five-layer design for use with the MMA receivers. It appears that with five layers it should be possible at 100 GHz to obtain less than 0.08 dB loss over a full waveguide band.

4–12 GHz IF Test Equipment - For the MMA receivers an IF of 4–12 GHz is (tentatively) planned. All our present receiver measuring equipment uses a 1–2 GHz IF, so we have begun building test equipment for the higher band.

In testing SIS mixers, a switch at 4 K between mixer and IF amplifier allows accurate calibration of the IF gain and noise temperature. Conventional microwave switches generate enough static electricity to damage SIS junctions, and for this reason we modify commercial switches to include static-suppressing resistors. The old static suppressor design is acceptable below 2 GHz, but is unacceptable at higher frequencies. Two years ago, in collaboration with microwave switch consultant Dr. P. Novak, we developed a static suppression circuit suitable for operation to 12 GHz. About a year ago Dynatech Microwave Technology agreed to collaborate with us in developing a new product based on this static suppressor. Subsequent progress was delayed by illness and retirement of the two DMT engineers with whom we were working, but we have now initiated a new round of discussions with DMT. Meanwhile, a new microwave switch has been announced by the Radiall Company of France, which we believe should be inherently static-free. It is not clear whether this switch will operate at 4 K. We have ordered one of the new switches to evaluate.

The room temperature part of the 4–12 GHz IF system is essentially complete. It has an instantaneous bandwidth of ~45 MHz defined by a YIG filter which is digitally tunable across the band.

Automated SIS Receiver Measurements - Hitherto, measurements of SIS mixers in the Central Development Lab have been done manually, frequency by frequency, and the data entered by hand into a computer. To produce mixers at the rate required for the MMA, mixer testing will have to be automated to a high degree. Preliminary software has been written to measure mixer noise temperature, gain, and impedance data automatically. We have also designed and tested prototype user and database interfaces: computer-controlled mixer measurements are recorded into a database, from which results can be queried and graphed using a spreadsheet to access data. Construction has begun of several chassis to interface computer controls with Dewar elements such as coax switches, hot loads, etc.

New Positions - Considerable time this quarter was taken up with recruiting new engineering staff for MMA work.

Publications - We have proposed revised definitions of the standard noise quantities (noise temperature, noise figure, etc.) in a paper entitled "Suggestions for Revised Definitions of Noise Quantities, Including Quantum Effects," which has been accepted by *IEEE Trans. MTT*, and is also available as MMA Memo No. 236. The current IEEE standard definitions are inconsistent and ambiguous when used outside the Rayleigh-Jeans regime ($hf << kT$). The revised definitions require minimal changes in current engineering procedures from RF to optical frequencies.

Mixer Production - During this quarter the CDL assembled and tested four SIS mixers using Nb circuits fabricated at UVA.

Electromagnetic Support

GBT - The short-backfire antenna feed for the 385–520 MHz range was modified to make it mechanically stronger. Supports made of G10 were introduced to hold the two small reflectors and the sleeves for the dipoles. Far-field patterns of this antenna were measured and were found to be the same as for the earlier version. However, using these G10 supports, with the same size plates as before for the sleeves, resulted in a poorer input return loss. A different set of plates resulted in return loss better than -12.7 dB.

General - Four K_a-band phase shifters were measured and the absolute value of the phase shift varied by about 10 degrees. The difference is attributed to machining tolerances. It appears that while tighter tolerances are required on the phase shifters, no design change is required.

VLA - Design of a prime focus feed for the 0.7–1.1 GHz range is in progress. Computation of aperture efficiency and spillover temperature with this feed is in progress.

GBT Spectrometer

Most of this quarter was spent programming modes of operation for the GBT and Tucson spectrometers. As of this date, all modes for both machines have been completed with about one-half of the Tucson modes having been successfully tested already. Only a small number of GBT modes have been tested.

Support for both systems took up a small percentage of the quarter, requiring several trips to Green Bank and one trip to Tucson.

Except for support and the Tucson system manual, all Charlottesville work on the two spectrometers has now been completed.

Some work was done on the MMA correlator. Some system definitions work was done, as well as simulation of the proposed MMA digital FIR filter. A specification for the correlator chip to be used in the MMA correlator was started and largely completed during December.

Frequency Coordination

Dick Thompson attended a meeting of ITU Working Party 7D in Geneva, September 28–October 5. A major part of the time was spent on preparation for the World Radiocommunication Conference of year 2000, at which allocations to passive services at frequencies above 72 GHz will be reviewed, with a possibility of making some adjustments. Documents outlining the requirements of radio astronomy in this part of the spectrum, and possible improvements in coverage of bands of importance to radio astronomy, are in final stages of drafting as input to the Conference Preparatory Meeting in 1999. Other subjects of work in Geneva included specification of the percentage of time that interference can be accepted, which is a basic input parameter for Monte-Carlo model studies of coordination zones around radio observatories to protect against uplinks of mobile communications services. A study of the possibility of downlinks in the 1429–1432 MHz band for a little LEO satellite system, and numerous other items also received attention. A meeting of U.S. Working Party 7D, chaired by Dick Thompson, was held on November 10 at the National Science Foundation building in Arlington as part of the continuing preparation for further international meetings in March of 1999.

I. GREEN BANK ELECTRONICS

GBT Spectrometer

Not much progress was made on programming the spectrometer. Other activities occupied the time of the people assigned to this project

The cooling problem is being addressed with the addition of an additional cooling stage in the supplied air. It is anticipated that a further 10 degrees C will be gained by pre-cooling the air. This mod should be installed during February, 1999.

Work to convert the sampler modules to use 15 volts instead of 12 was begun and mostly finished. The sampler module problem was first found in the Tucson spectrometer.

GBT Fiber IF System

Two channels of the production prototype are being manufactured. These should be finished by February. Plans call for these to be tested and when these tests pass, the additional seven channels will be built.

GBT Servo System

The 30-day reliability test was run, and the system seemed to work very well. Analyzing the data revealed some unsettling encoder jumps in the electronics. These jumps are too large to be actual position errors, so they are in fact electronic readout errors. Investigations are on-going in this matter. The Prime Focus mount and Feed Turret were not exercised in this test, as they were out of commission.

A meeting is held regularly between NRAO, COMSAT, and RSi/PCD to address the current Servo issues.

GBT Active Surface

All the actuator cables are installed. Work on cutting them to length and dressing them continues. About 50 percent of the cables are cut and dressed. Much progress is being made on the active surface software. An apparent bug has been found in the intelligent I/O Processors used to communicate with the actuators. The vendor is working on isolating the problem.

GBT Mockup

The Mockup has been used over the past quarter to help integrate the electronics for the GBT with the M&C software. This testbed has proven to be very beneficial. A stable version of the M&C software is available for system tests, and a test version of the software is available for the M&C group to test new software features. The Prime Focus receiver was tested in the Mockup for the first time this quarter.

Quadrant Detector

Work on linearity improvements continues. The new power supply from the vendor has eliminated the problems seen with the original supply. Improvements in the optics and mounting details are being worked out.

Holography

The new LO modules are installed and are being tested. The phase stability measurements showed that the original LO modules did not meet the required long-term stability required for holography. A test of the holography system is planned for first or second quarter of 1999 at the 140 Foot Telescope.

Equipment Room

The site timing center was moved into the GBT equipment room this quarter. The timing center consists of the hydrogen maser and electronics to buffer, transmit, and monitor the maser signals. It also supplies IRIG time code signals to the GBT and 140 Foot Telescope. The 1 PPS signal generated by the timing center is used to sync up all the GBT equipment, along with other equipment on site that needs to sync up to the 1 PPS signal.

GBT Receiver Systems

Prime Focus Receiver - The IF conditioner was completed in August. The low-band dewar is undergoing extensive tests. Some of the amplifiers were sent back to the CDL for repair. The PF1 receiver (Bands 1 through 4) was assembled and tested in the Mockup. some problems were found, necessitating some re-work of the dewar assembly, and some electronics were found to be inoperative.

C-Band Receiver - The C-band receiver still has significant cooling problems. The receiver is still in use at the 140 Foot. Improvements were made in the vacuum on the system.

Q-Band Receiver - The mechanical design of the fixturing to test the prototype Q-band RF assembly in a lab test dewar is still in progress. Outfitting of the test dewar with electronics and cabling is underway. Results of the first tests should be available next quarter.

S-Band Receiver - Many of the parts for this receiver are still awaiting shop time. All electronics are purchased and waiting for machine shop parts to become available.

GBT Cryogenics

A significant problem was discovered in the planned installation of cryogenic tubing for the GBT. The 6000 ft. of tubing that we planned to use is incompatible with the compression fittings we planned to use, due to the wall-thickness of the tubing. A decision was made to abandon the compression fittings and use a fully-welded cryogenic tubing system on the GBT. This will give the GBT a much more reliable cryogenic gas supply system at an affordable cost.

Site Operations

OVLBI - Overall, the station is in good shape. Work was done to move the operations from the trailer into the new control room in the Jansky Lab. Work is underway to replace the antenna control system with more modern, more reliable, components.

Interference Protection Group - Electronics is an integral part of the Interference Protection Group. Four engineers and a technician work part-time on this program, along with staff scientists. Over the past quarter we have tested and re-tested many subsystems, identifying sources of RFI in each subsystem. Work was completed on a data acquisition system for the anechoic chamber. Work has begun on an interference monitoring station for the GB site.

Telescope Support - Work to move operations into the new control rooms in the Jansky Lab Addition for the USNO 20 Meter, OVLBI, Green Bank Interferometer, and 85-3 were started. All but the OVLBI and Interferometer moves were completed. The Interferometer move cannot take place until the DDC-116 and the old Digital Delay Rack are replaced.

Maintenance, repair, and installation support was supplied to the 140 Foot, USNO 20 Meter and the OVLBI earth-station telescopes. This includes electronic maintenance, electronic design projects to assist users for special projects, and cryogenic support for virtually every receiver in Green Bank. Normal day-to-day support of UNIX workstations, weather station, time systems, and local area networks is also provided.

J. TUCSON ELECTRONICS

1-mm Array, 220-250 GHz Receiver

This receiver is now in routine use. Several early operational problems have been identified and solved. We have identified two faults in this system which may be the source of the problems with baseline stability which sometimes affects wide-bandwidth measurements.

The 8-Channel, 4-Beam, 3-mm System

A commercially available frequency tripler for the LO has been tested and works well at 4 K. This validates the concept of using coaxial lines to input the LO to the dewar at one third of the LO frequency. The dewar has been built and awaits testing. The design of the basic receiver insert has been completed and fabrication has begun. A crossed-grid polarization diplexer designed to operate at 4 K has been constructed and tested. A prototype 2-channel system is currently being tested.

Planned Wide-band Continuum Receiver

The availability of HEMT amplifiers covering the frequency range from 70–90 GHz raises the possibility of building a continuum receiver with a sensitivity of around 50 mJy per root sec; the extraordinarily high sensitivity comes from the very wide bandwidths. The major problem to be overcome is the 1/f noise which has been reported from early experiments. Although not necessarily worse in this system than in other HEMT amplifiers, the extremely large (bandwidth times integration time) product means that much lower levels of 1/f gain modulation can dominate the residual noise in the detected output from the receiver. Progress with this project is dependent on available manpower, and has been given lower priority than the multi-beam systems mentioned above.

New Phase Lock Control

One of the most efficient observing modes, generally applicable to relatively narrow bandwidth observations, is frequency switching. Unlike other switching schemes, in this observing mode the object of interest is in the telescope beam and in the spectrometer passband for 100 percent of the time. At present, we are limited in our ability to frequency switch, in both switching rate and in total frequency throw, by the analog phase lock system. We have designed, tested, and installed a digital phase lock system into our 2/3 mm receiver that combines both frequency and phase control and provides faster, reliable switching over a broader frequency range. We can now routinely switch by as much as ±35 MHz, making frequency switching useable for a wide variety of research projects. We are currently producing digital phase lock systems for all of our receivers.

Another capability which will become practical thanks to the enhanced digital phase lock is "sideband smear" operation. This is a powerful technique of reducing confusion in spectral line observations from features appearing in the unwanted sideband. The principles have been established during some ad hoc test observations performed at the 12 Meter Telescope, and have been described in conference proceedings. The practical implementation of a usable system at the 12 Meter has been hampered by the performance of the phase lock system; fast switching times over a relatively large bandwidth are required. The digital phase lock should solve these problems.

Receiver Component Servo Systems

Given the importance of the accuracy and reliability of the servo drivers for the components of the 12 Meter receivers, we have investigated these aspects on our 1 mm Array system. By implementing a periodic test and maintenance procedure for all of the mechanical systems in these servo drivers, we have dramatically improved the accuracy, reliability, and repeatability of these systems. This will have direct impact on our ability to quickly and automatically tune all of the 12 Meter receivers.

Cryogenics

All receivers on the 12 Meter Telescope rely heavily on reliable operation of cryogenic systems. A new cryogenic compressor system has been developed for our closed-cycle 4 K refrigerator. The individual compressor units for the Gifford-McMahon refrigerator and the Joule Thomson expansion valve have been combined into a single unit, resulting in a smaller installation with lower power consumption. All four of these units have been fabricated, tested, and installed on the telescope.

Quadrant Detector and Thermal Sensors

One of the main contributions to pointing changes on the 12 Meter Telescope is lateral movement of the subreflector, with respect to the main telescope surface. This is caused by unbalanced thermal effects on the subreflector support structure. We have installed a system on the 12 Meter to sense these changes; we have a laser quadrant detector to measure the lateral motion of the subreflector mount, with respect to the telescope central hub structure, and we have thermistors continuously monitoring the temperature of the feed legs and other parts of the telescope structure. We are currently trying to gather statistics to enable us to understand the detailed relationship between the thermal distribution of the telescope and telescope pointing offsets. At a later date we hope to incorporate the thermal data into our telescope pointing model to give real time pointing corrections.

New Digital Spectrometer

A new digital spectrometer, called the Millimeter Auto Correlator (MAC), has been installed at the 12 Meter Telescope. The MAC, which is a GBT correlator clone, has twice the instantaneous bandwidth currently available for our multibeam systems, and uses a single wideband sampler for each IF channel. This new design should avoid the persistent platforming problems experienced with our now decommissioned hybrid correlator spectrometer. The MAC will support the existing 1.3 mm and 3 mm, and any future, multi-beam systems on the telescope. The MAC currently functions with all of its available bandwidth modes, and is in routine operation at the telescope.

Software

Continuum On-The-Fly Analysis - Eric Greisen has added tasks to the AIPS package which allow the analysis of continuum on-the-fly (OTF) data. By employing the Emerson, Klein, Haslam deconvolution algorithm, these analysis tasks add greatly to our complement of OTF analysis software. This development has also expanded the scientific capabilities of the 12 Meter by adding continuum OTF to its complement of observing modes.

K. SOCORRO ELECTRONICS

VLA-Pie Town Link

Testing of the Pie Town link equipment proceeded through November and December. First real-time single IF fringes were obtained at X-band on December 3. Subsequently fringes were obtained on all seven common VLA/VLBA bands 327 MHz to 43 GHz. Progress is approximately following the Gantt schedules as detailed in early 1998.

Efforts now continue on the following:

1. Implementation of a round-trip phase measurement system in order to separate differential Maser drifts from the 104 km transmission line effects. The VLA Maser has poor long term characteristics.
2. Implementation of the bi-directional analog and digital wavelength division multiplexing on a single fiber.
3. Increasing the launched CW laser power to accommodate the 4 IF system.
4. Manufacturing and modifying the 200+ piggy-backed expanded delay cards.
5. Development of robust and friendly control software. The "final" system should be in place by June 1999 in readiness for the A array.

Further details can be found at http://www.nrao.edu/~julvesta/vla_pt.html

VLBA Power Supply Upgrade

The P103 5-volt power supply in the VLBA D-rack is near its current limit when eight Base Band Converters are present. This supply is being upgraded to a P107 5-volt supply capable of supplying enough current for 12 BBCs. Currently, nine VLBA sites have been retrofitted. Mauna Kea and the VLA are scheduled to be completed the first quarter of 1999, which will finish this project.

VLA Final LO Replacement

We have been informed that Fluke will no longer support the 6061 Fluke Synthesizers by the year 2000. These synthesizers are used as the final LO in the back end at the VLA. We are currently working on plans to do an in-house design to replace these synthesizers. Preliminary design studies are ongoing and the design will start in the first quarter 1999.

New VLA Servo Encoder

The DCS group will continue to advise the Servo Group with this effort. The bulk of this effort will be done within the Servo Group.

Wye-Com Phone Replacement

When the wye-monitor system was installed a couple of years ago it made available enough pairs on the wye-com cable to allow installation of regular telephones in the antennas. We are currently testing the spare pairs to see if telephones can be viably installed. We have been able to talk over the lines as far as A7 without the use of line extenders. This project will be a joint effort between electronics personnel and New Mexico Tech.

Analog Sum Fiber Link

Efforts are under way to study the feasibility of linking the analog sum outputs of the correlator with the VLA VLBI equipment. This link is an effort to eliminate spurious 60 Hz components which are caused by ground loops between the correlator screen room and the VLBI equipment. These 60 Hz components are most prevalent in pulsar observations.

GPS Receivers

Eight of the Truetime model XL-AK-600 GPS receivers that have been chosen to replace the Odetics 325 are in the field and working well. Four additional receivers will be procured in the first quarter of 1999 to complete the VLBA sites. A dual-frequency GPS receiver has been procured and will be installed at the VLA in the first quarter for ionospheric monitoring.

VLBA Masers

Maser # 11 was returned from the North Liberty VLBA site to the AOC for diagnosis of an excessive IF degradation problem. Efforts to restore Maser # 04 at the AOC have failed and the maser will have to be returned to the Sigma Tau factory for repair.

VLA K-Band Front-End

Front-ends #3 and #4, along with prototype H_2O vapor radiometer sub-systems, have been installed on Antennas 26 and 28. The front-ends are performing as expected while the H_2O sub-system is under going further testing.

Components for eight more K-band front-ends are being purchased and drawings for another eight K-band dewars are in the VLA machine shop. We will start fabrication of these new front-ends early in the first quarter of 1999. The DCS Group will assemble and test eight F14 modules in order to support the FE K-band effort.

Q-Band Front-Ends

Components for six more Q-band front-ends are in purchasing and drawings for six more Q-Bands dewars are in the VLA machine shop. We will start fabrication of these new front-ends late in the first quarter of 1999.

VLBA 3-mm Front-Ends

Front-end #3 was installed on the Mauna Kea VLBA Antenna. Front-end #4 was assembled and is under going lab testing. A noise diode and a mixer were found not to be operating properly and were returned to the manufacturer for repair. When these components are returned early during first quarter of 1999, testing will continue.

Amplitude Equalizers for the VLA

The average passband for the VLA antennas has a large slope across the 50 MHz bandwidth. This affects the observing center frequency during continuum observations. We plan to implement a simple equalizer circuit to correct bandpass shapes after the bandwidth has been expanded to 70 MHz.

Increasing the VLA Continuum Bandwidth

Work on increasing the VLA continuum bandwidth on all four IFs continues. The parts for 27 antennas have been received to increase the bandwidth to 70 MHz. The 240 IF filters needed in the F7 and F8 front-end modules will be fabricated by the VLA machine shop. Because of the work load in the machine shop it is expected that these filters may not be completed until the fourth quarter of 1999. The 70 MHz low-pass filters in the screen room are in the process of being retuned as necessary to match group delay. Modifications to T3 Image Reject Mixer modules has started.

VLA Correlator

Over one-third of the 234 VLA delay line cards now have been modified to accept the extended delay range piggyback board required for the Pie Town to VLA connection. The control logic for the piggyback board has been transferred from a Cypress chip to a Xilinx chip in order to try to fix the hot swap problem, where the piggyback board does not always work properly when hot swapped with the Cypress chip.

The errors previously detected in testing the new Serial I/O interface for the new VLA Correlator System Controller have been eliminated. Additional work is now being done to speed up the operation of sending delay values to the delay cards, after testing of the VME code indicated some improvement is necessary.

The four new power supply assemblies for the VLA Analog Sums have now all been installed.

VLBA Correlator

The track recovery sync detect algorithm was modified to handle the case where the auxiliary field byte preceding the sync word does not meet the VLBA requirement of being BCD, resulting in the inability to sync up on a tape. As long as a perfect sync is detected in the correct position, the auxiliary field byte contents will no longer disrupt playback. This change still needs to be tested by operations before officially being installed.

A second spare FFT control card was assembled and tested, providing additional backup.

VLBA Data Acquisition and Playback

NRAO has loaned a set of VLBA read electronics and a thin tape upgrade to Spin Physics, which enables them to test headstacks adequately and verify that they meet the specification. The other headstack manufacturer, Metrum, has had this capability for some time.

It is planned to outfit the rest of the VLBA tape drives with dry air kits in 1999. Six acquisition drives and two playback drives have been outfitted with the kits so far. The formatter expansion project is expected to continue in 1999. So far, four VLBA sites have the expansion.

VLA Archive

A major milestone in the VLA rearchiving project was reached on October 1st. The last old data (from 1987) still residing on 9-track tape were reformatted and transferred to Exabyte tape. This concludes a project which was started at the beginning of this decade. This also means that the catalog of VLA data, which is accessible from the NRAO home page, finally is complete. We are currently in the process of redoing a small fraction of the older spectral line data in which we discovered a problem for some correlator modes. We expect to finish this in the course of 1999.

Hardware

After gaining experience with a small number of 400MHz PCs running Linux, we have ordered and received 14 further systems. We expect to install these in the course of January 1999.

The computer floor at the VLA is undergoing profound changes. Originally designed with large mainframes in mind, a large portion has now been vacated to create new office space. The various computing servers, which formerly where spread out across the computer floor, have now been concentrated on several racks in the rear area adjacent to the VLBA correlator. Several old pieces of hardware, which were no longer on maintenance but still saw occasional use, had to be removed in the process. These include the line printer, the microvax, and the IBM RS6000 workstations. The laser printers are now located in the area where the line printer used to be.

The AOC's new file server, a Network Appliance Filer720, has arrived and has been installed. This new server, filehost, will be taking over file service from both Arana and Zia. Arana will be retired later next year after all of its services have been moved to other machines. Filehost is currently serving a handful of accounts as well as binaries for the Linux systems.

Software

OBSERVE, the software currently used for detailed scheduling of VLA observations, is built around a VT100 terminal interface. The archaic nature of this interface is causing a growing number of portability and maintenance problems. A replacement, JObserve, has been written by Bill Cotton (NRAO-CV), using the Java language for portability and a modern GUI interface. JObserve supports essentially all features of OBSERVE. JObserve Version 1.0 is now available in Socorro and Charlottesville, and release to the user community is expected in the first quarter of 1999.

The AOC is completing testing of the printing system. The new printing system is based on an older BSD style printing system instead of the newer Sys-V printing system. Both systems were developed by Sun for Solaris. Sun decided to revert to the older system due to problems with the newer Sys-V release. When completed, the new printing system should provide greater flexibility in file types sent to the printer as well as a wider range in printing options. Most importantly, the new system should prove more stable than the current one. Transfer to the new system should occur soon after the new year. A discussion is ongoing about the scope of the VLA online system rewrite project. Originally started to duplicate the current capabilities using state-of-the-art real-time hardware and software, the current topic of discussion is if, and to what extent, this rewrite should also support the planned VLA upgrade. The result of these discussions will have deep implications for the time scale of completing this project.

Personnel

The System Manager position that opened up when Vic Kiff resigned earlier this year is proving to be very difficult to fill. We have had four candidates turn us down. It has become exceedingly difficult to compete with the corporate sector in attracting skilled professionals. The location of Socorro does not help either. Good news is that we have had an acceptance to the vacancy that was created when Ron Heald moved to the MMA project; the new hire will start in January 1999.

L. COMPUTING AND AIPS

Observatory-Wide Computing

Planning - As part of the planning process, during the last quarter of 1998 the members of the NRAO Observatory-Wide Computing Council, including the computing division heads at the four major sites, produced a prioritized list of items to be covered in the 1999 Observatory-wide computing budget. During 1999, further, more detailed discussions with staff members will take place, to obtain a clearer picture of the directions our in-house users see their computing requirements taking over the next few years. This will permit further refinement of the future directions in the Long-Range Computing Plan.

Hardware - One of the chronic problems in radio astronomy, which has been steadily worsening over the past few years, is the time required to load and back up large datasets (i.e., up to tens of gigabytes). We are beginning to see more experiments, particularly VLBI, with individual files which exceed the storage capacity of a single high-density Exabyte tape; these files therefore cannot be backed up on traditional media. NRAO has now evaluated both Digital Linear Tape (DLT) and Exabyte Mammoth drives. Both appear to be able to meet our needs well, although only long-term use will indicate robustness and reliability. A third technology, Sony AIT, is also a viable contender; while we have not yet tested it in-house, we can see no reason why it would not also be a reasonable choice. The difficulty here is not technical, but a question of how widely available any of these models will be to NRAO's user community at their home locations. Communication with other institutions suggests that very few have made a decision on this issue, so it is unclear where

the bulk of our future investment should be made. It may be necessary either to wait for this situation to resolve itself, with a small number of different types of high-capacity tape available in the meantime, or else for NRAO to select a preferred medium and set the direction for our user community to follow.

The final 30 of 1998's approximately 50 replacements for aging Sun workstations were purchased during the last quarter, and have either been installed or will be shortly. These systems use PC hardware but will run the Linux operating system (a version of UNIX), and will primarily be used by in-house scientific and computing staff as their desktops.

Much of the equipment purchased for the initial steps of the network upgrade at Edgemont Road in Charlottesville has now been installed. The items necessary to lay a fiber network throughout the Jansky Lab in Green Bank have been ordered and will be installed in early 1999. A replacement for the obsolete network router in Green Bank has also been ordered. In addition, a sophisticated package was purchased to monitor use of the NRAO Intranet; the same package can also be used to gather information about the local-area network at any NRAO site as desired. This tool will assist in analyzing traffic patterns and determining where bandwidth adjustments would be beneficial, as well as in diagnosing problems which are due to non-trivial causes.

AIPS

Personnel - There are approximately 4.5 full-time equivalent employees in the AIPS group.

15OCT98 - The 15OCT98 version of AIPS has been distributed to over 152 sites, running Solaris, Linux, DEC Alpha, HP, and SGI versions. The overall number of AIPS installations has grown over the last two years; 15APR98 was one of the most widely-distributed versions ever.

The majority of AIPS distributions are now received via ftp, although the CD-ROM distribution is rapidly growing in demand. One attractive feature of the CD ROM is the ability to use the binaries directly from the CD, keeping only data and a small footprint (10MB) on the processing machine. This is particularly attractive for laptop computers.

The TST version of AIPS (15APR99) is currently distributed nightly to 26 sites throughout the U.S., Europe, and Japan (22 automatically, four on request). Full support for SVLBI processing has been available since 15APR98.

Hardware - AIPS running on Linux PCs continue to show impressive absolute and cost-relative performance. The best AIPSMARK so far is 14.5 when a 450 MHz Pentium II system is configured with 256 MB of memory. A new bench marking suite will need to be produced within a year or two to more adequately measure the performance (current suite now completes in under five minutes, which may be too short to be representative).

Documentation - The AIPS Cookbook has been translated from Tex to LaTex, enabling conversion of the master Cookbook text to HTML (to begin Q1 1999). We are considering placing the entire AIPS documentation system (Cookbook and all help documentation) on-line with full indexing and cross-referencing during 1999. Tasks to manipulate AIPS help files within browsers are now available in 15APR99.

General Developments -

Calibration transfer - The VLBA correlator can now automatically attach flagging, system temperature, weather, gain curve, and phase cal information to VLBA data sets. Detailed revision of the definition of the data tables and of the reader routines in FITLD was required to enable in-house testing of this capability. The format definition for FITS interferometry data (previously VLBA memo #108) has been re-released as AIPS memo #102.

The accuracy of SNR estimates for fringe-fitting in the tasks FRING and KRING have been improved by Ketan Desai, as described in AIPS memo #101.

A bug involving INTEGER*2 arithmetic in a number of subroutines when compiled with the Linux EGCS g77 compiler (Version 1.1 and above) was found. This bug silently corrupts data when writing out FITS files using Linux. These routines have been modified in 15APR99.

Hanning smoothing of cross-correlation spectra was added to minimize the effects of errors seen in the case of CVEL shifting of strong narrow spectral lines in narrow-bandwidth data.

A new task TECOR performs ionospheric Faraday rotation and dispersive delay corrections using maps of the free electron content of the ionosphere received in standard IONEX format. Full support for dispersive delay corrections into the calibration routines has been added.

All table headers keywords within AIPS are now stored/written as REAL*8 variables to avoid precision loss.

Image sizes throughout AIPS are now fully parameterized; the system can now deal with images of 16384 pixels on a side.

A new verb to show the TAPE definitions for any AIPS session has been added. Eventually this verb will inform the user if tape drives on remote machines are available.

The new task UVCON will generate a u-v database for an interferometric array whose configuration is specified by the user. Visibilities corresponding to a specified model, and Gaussian noise appropriate for the specified antenna characteristics are calculated

for each visibility. The array geometry can be specified in three different coordinate systems: equatorial, local horizon, and geodetic. There is an option of using set of different frequencies to improve UV coverage.

A serious bug affecting the w-term correction of visibilities when imaging fields distant from the phase center was fixed. This bug occurred if the first channel of a u-v dataset being imaged was not at the reference frequency of the file. A more complete description of this error can be found in the upcoming NRAO newsletter. A patch for 15OCT98 will be produced. Note, this bug was introduced sometime before 1990.

Software

PCs - Upgrades of several major PC software packages were purchased Observatory-wide to ensure compatibility across sites. This is particularly important due to the frequent need to exchange files between staff members, especially for distributed projects such as the MMA. The packages include Microsoft Office, Corel Office Suite, and the mechanical-engineering program AutoCAD, as well as tools related to maintaining the servers and services provided in the NRAO-wide NT domain; many of the technical details involved in configuring the domain have now been agreed upon by the sites, and considerable progress has been made.

NCSA - Poster papers and a demonstration of results were presented at the Astronomical Data Analysis Software and Systems (ADASS) meeting in November. Implementation efforts continue to progress on several fronts, including spectral-line imaging, UV-data gridding, image mosaicing, and performance tuning using the SGI/Cray Scientific Library parallel FFT routines, which in testing produced an increase in speed of approximately 50 percent over existing AIPS++ code.

The frame-relay connection between NRAO in Socorro and the University of Illinois at Urbana-Champaign (UIUC) campus became operational in early October. This permits simple and reliable network access both to NCSA's facilities and to our collaborators in the UIUC Department of Astronomy; the normal Internet connections do not provide acceptable performance. Although the bandwidth will be adequate for the mostly-interactive work required during the current phase of the project, much higher bandwidth will be needed to make the facilities useful for production work. This will be part of the fiscal 1999 efforts.

Year 2000 Issues

General - A number of improvements and updates have been made to the NRAO Y2K web pages (available at the URL http://www.cv.nrao.edu/y2k). These pages contain a section—accessible only from within the NRAO—that will be used to track compliance information on software and on outside providers important to the operation of the Observatory.

Financial Systems - All software and hardware for NRAO's financial systems has been upgraded to versions certified by their manufacturers to be Y2K-compliant. Although NRAO's own customizations to these systems had been tested and verified as compliant, the vendors recommended against full testing using production systems. However, as a result of recent reorganization within the Fiscal Division, there is now a spare system running the same software, which could be used to verify Y2K compliance of NRAO's data. Such tests are now being discussed and will be scheduled as appropriate.

Telescope Operations - Y2K compliance testing of the software used to operate the VLBA is scheduled for February 1999. The control software has already been reviewed and tested as much as possible in advance, so it is expected to be compliant. Assessment of the control software for the Green Bank 140 Foot Telescope has been completed; if it proves necessary to operate the 140 Foot beyond the end of 1999, we believe that the changes needed could be made in a short period of time.

Software - Mission-critical software was identified in 1997 and its compliance has already been addressed. Software areas still to be assessed are programs that may be used regularly by a few users, but which will not seriously affect fundamental Observatory operations should they malfunction. We are now beginning to determine which of the third-party software packages available on NRAO computers are most important to the daily work of staff. We will obtain and evaluate compliance information from vendors for as many of these as possible. In-house scripts and utilities running on UNIX systems will also be evaluated.

We plan to set up two UNIX systems during the first half of 1999 with their dates advanced to the year 2000. These will be used to test date-aware third-party packages whose compliance remains in doubt, or which are sufficiently specialized that their compliance can be evaluated only by knowledgeable in-house users.

NRAO staff have recently evaluated Y2K issues that affect spreadsheet packages used at the Observatory. These packages support a variety of date formats, including user-specified customization, so date-aware spreadsheets must be examined individually for Y2K compliance. Information will be provided to individual users to help them determine the compliance of any date-aware spreadsheets that they maintain.

While no major problems are anticipated, the date fields in large NRAO databases, such as that used for telescope maintenance tracking, will be inspected in early 1999 for any compliance issues.

Outside Services - We are continuing efforts to obtain Y2K compliance status information from outside providers (such as utilities, communications, and financial institutions) at all NRAO sites.

M. AIPS++ PROJECT

The main theme in the work of this quarter has been the integration of applications to operate together, along with continuing refinement of the user interfaces.

In Single Dish support, Dish itself remained largely unchanged after the beta release during this quarter. A revised dish plotter has been designed. Dish was demonstrated at the GBT Advisory Committee meeting in October. Garwood and McMullin each presented poster papers at ADASS in November. Garwood attended the AIPS++ integration meeting at the AOC following ADASS.

Both Bob Garwood and Joe McMullin continue to be involved in supporting the GBT. This includes regular two- to three-day visits by at least one of them to Green Bank for most weeks during the quarter. The AIPS++ position in Green Bank remains unfilled.

The dish plotter and results manager were incorporated into the GBT continuum commissioning tools. Several options for pointing solutions for the GBT were examined. It is likely that we will use the TPOINT software for this task. The GBT filler are being rewritten.

In Synthesis support, the development strategy outlined in the previous quarterly report for synthesis imaging and calibration has been continued in this quarter, with primary emphasis on the expansion of the scientific capabilities and usefulness of the package. Development on a broad front has continued in calibration and imaging, but resources have also been allocated to the "thin-path" capability in the area of data fillers and uv-data visualization, consistent with the overall strategy discussed in earlier reports.

As previously agreed, work on the implementation of the second version of the MeasurementSet format was scheduled in this quarter. This has included a formal change proposal required by the project software engineering guidelines. Work on the implementation has been undertaken by Mark Wieringa (ATNF), and will be well in place before the public release, as previously planned.

Peter Barnes, who joined the project in the preceding quarter, has assumed responsibility for the development of uv-data visualization components compatible with the current Display Library. This is a cooperative effort with Athol Kemball and David Barnes (ATNF). A revised MeasurementSet summary format, and data lister has been completed, and an initial layout of display components had been completed along with a plan for their incorporation in the Display Library. This work will continue actively in this quarter.

Work on the VLA filler has been undertaken by Ralph Marson, with current efforts focused on tape support and MODCOMP format translators. This target will proceed actively in the next quarter.

Calibration capabilities have been expanded this quarter, with the adoption of the revised and extended calibration table format, and the implementation of basic cross-calibration capabilities. Current efforts in this area involve the extension of interpolation and data selection options. A new initiative in integrating single-dish and interferometry calibration has been undertaken in an initial group comprising Athol Kemball, Tim Cornwell, Joe McMullin, and Bob Garwood, with outside expertise provided by Rick Fisher. Two meetings have been held in this regard and the resulting note will be forwarded more widely once it is complete for broader discussion. The aim of this work is to standardize calibration models and data formats between single-dish and interferometric calibration development within the project, to allow joint calibration or calibration transfer.

Jan Noordam (NFRA) has continued work on supporting TMS and WSRT commissioning using customized Glish scripts to assess data quality. Details of this work can be found in the NFRA section of the report.

In imaging, the significant effort in mosaicing started by Mark Holdaway in the last quarter has continued. This has included the expansion of primary beam models supported in the imaging system and their representation. He has also nearly completed the early implementation of the Cornwell-Evans MEM algorithm, as required for subsequent planned development in mosaicing. Tim Cornwell has taken over 3-D wide-field imaging, and has successfully demonstrated a prototype capability in this area. In addition, he has implemented a multiscale CLEAN deconvolution algorithm, which has shown significant improvements in imaging performance in early trials. General refinements to imager developments have continued during this quarter, including the development of image-plane-only deconvolution capabilities in support of the MEM and multi-scale clean developments.

A summary of work on the parallelization of synthesis code can be found in the NCSA section. A primary emphasis in this area has been the demonstration of a scientifically useful capability in the area of embarrassingly parallel problems. An implementation of this type for spectral line deconvolution has been demonstrated in early imaging of a four-pointing, multi-configuration VLA dataset taken towards M33, which cannot easily be imaged using existing packages.

Athol Kemball presented a talk on calibration at the ADASS'98 meeting in November. Tim Cornwell provided a demonstration of AIPS++ at the same meeting.

The NCSA funded position at NRAO for parallel synthesis development has been filled, with a current starting date of 1 April 1999. There are no other outstanding positions in synthesis at this time.

In Glish, the past quarter has been one of consolidation. The graphical widgets were tentatively moved to a client for testing during the second quarter. At that time, while the default behavior of the widgets was unchanged, the new widget client was made available for testing. This quarter the new client-based widgets became the default widgets. This change revealed a number of problems both in Glish and in the client-based widgets. Fixing these and other problems, as well as adding a few new features were the primary Glish activity of the quarter.

A significant amount of time was spent working on memory leaks arising from self referential records. As a result of records containing functions, these sorts of records are often created. While a solution was found, more work is required to make it efficient before incorporating it into the distributed version of Glish. Other bug fixes included:

- timer client event scheduling problems were discovered and fixed
- problems with is_const() and is_defined() for certain values were discovered and fixed
- site-wide .glishrc file was created to fix startup problems
- many TCL/Tk widget bugs were fixed in the widget client

In addition to fixing bugs, a few new features were added during the quarter. These new features include:

- removal of the last blocking I/O in the Glish interpreter
- pgplot is available for creating PostScript without a GUI
- several improvements to subsequences
- new function, as_evalstr(), was added to create strings which can be passed to eval()

In Measures, only limited changes were made:

- changed Unit interface to not use Constants anymore for physical factors
- added virtual 'Type' interface to Measures, and made available in Glish
- no work done on new Measures features. Worked only on bugs and requests (like formatting options and the like)

In AIPS++ Infrastructure, two major additions have been made to the Table system:

- It is now possible to store records in table columns (internally they are stored as vectors of uChar). Other software (like TableRow, Glish table client, TaQL) has been changed to cope with records in columns. Although TaQL (Table Query Language) accepts column record fields in its syntax, it cannot handle them yet (an exception is thrown when they are used).
- The ColumnsIndex class has been created. It builds (in memory) an index on top of one or more columns to make it possible to do (fast) key lookups. For instance, given a time (or time range) it can find the appropriate row(s) in a weather subtable. This class has not been code-copped yet, so it is not checked in.

A few small bugs have been fixed and some small additions have been done.

A group of 14 Lattices classes has been submitted for review. Their documentation and test programs have been upgraded considerably. It is expected that the review will be finished by the end of January after which they can be moved from trial to AIPS.

The Lattice and Image region classes have been finished. The LC classes define a region in pixel coordinates. They are used by the Lattice classes (e.g. to create a SubLattice). An LC region consists of a (minimal) bounding box and optionally a mask. The mask tells which pixels in the bounding box belong to the region. The basic classes can be used to define a box, ellipsoid, or polygon. The compound classes make it possible to make the union, difference, complement, etc. of regions. The WC classes define a region in world coordinates. They can also be (partly) defined in pixel or fractional coordinates. When a WC region is used on an Image, it is first converted to an LC region. In this process axes are permutated as needed, so the order of the region axes matches the order of the image axes. Similar to the LC classes there are basic and compound WC region classes.

The LEL (Lattice Expression Language) classes have been changed to handle masked lattices (e.g. a sublattice formed by a circle) correctly. They even handle a lattice without any valid element correctly. Note that LEL is optimized such that no extra tests are done when a lattice has no mask. The LEL grammar has been extended with functions complex (forming a complex from two reals) and length (get length of given axes) and with the [] operator. This operator makes it possible to mask a lattice with a condition (e.g. lattice[lattice>5 && lattice<10]).

It appeared that egcs1.0 compiled some code using LatticeExprNode in a strange way (it invoked the Lattice copy constructor). By making that constructor protected, such cases were caught. It looks as if egcs1.1.1 is handling this better.

The class TempImage has been created to make temporary images (in memory or on disk depending on the size). To avoid having too many open files, functionality has been added (also to TempLattice) to temporarily close such an image when on disk. The reopen is done transparently.

In Display work, work proceeded on a number of fronts all aimed at developing the library and producing some initial applications:

- Implementing the "final" design of the Glish/Tk Display Library widgets/agents—pixelcanvas, worldcanvas, displaydata, colormap, animator—in a separate module to the gtk client: it is now ready for dynamic loading whenever AIPS++ is ready.
- Addition of PgPlot functionality to the WorldCanvas to display contour maps and axis labels as promised! Completed a second DisplayData: LatticeAsContour, for displaying contour maps of AIPS++ Images and Arrays. Work is still required to improve the axis labeling style, but the basic functionality is there.
- The design and implementation of an option-passing technique to allow glish records to be forwarded on to DisplayDatas, whose various parent classes simply pull out fields of the record that are relevant to them.
- The design of a prototype application—*aipseye*—to replace the functionality of aipsview. This application has been written in Glish using the Glish/Tk Display Library widgets/agents. At the November Applications Integration Meeting, it was accepted as a good model for the First Release Display Library application, which will be called the "viewer."

- As part of *aipseye*, the design of an autogui, which builds and manages automatic forms for setting options on DisplayDatas, or in fact anything that takes the record format specified for the options passing (described above). This will be checked into the system and used in other areas of AIPS++.
- The provision of GUI widgets to unify the look and feel of AIPS++. The widgetserver provides standard flavour buttons, entry boxes, etc., according to user settings in .aipsrc. The rollup widget provides a handy real-estate saving device. The tapedeck can be used to control stepping through data for example.

In the System area, we continued some minor work on compilers. In an effort to evaluate the egcs compiler, egcs1.1.1 has been installed on a few machines. In general it seems to work fine, but alas Solaris 2.4 has a bug which prevents it from building shared libraries. It means we cannot switch to egcs1.1.1 until all sites have moved to Solaris2.5 or higher. The strong points of egcs are that it supports almost the full C++ standard and that its exception handling is multi-thread safe. Egcs1.1.1 is stricter than gcc, so the code had to be changed in a few places. A few small tests indicated that code compiled with egcs seems to perform at the same level as code compiled with gcc.

A few general changes have been made to adhere the new C++ standard in a better way:

- The -fno-for-scope switch has been removed from all makedefs. Several source files had to be changed to get rid of the warnings generated by that change.
- Bool has been changed from an enum to a typedef as bool. Some code had to be changed, in particular because a conversion from const Char* to Bool now preceeds a conversion to String.
- The keyword explicit is now fully supported. It proved to be very useful, because the compiler showed a few errors in the code.
- The keyword mutable is supported by all compilers. It is advocated to use it when appropriate. The coding and code-copping guidelines have been changed accordingly.

Towards the end of the quarter building the documentation seemed to be quite stable. The aipsinit.sh file has been changed such that, in general, it can set up the environment such that an aipshosts file is not needed. This change has not been put into the system yet. because aipsinit files for other shells have to be changed too. Furthermore it'll be tried to cope with setting LD_LIBRARY_PATH as good as possible.

The assay script has been changed. It supports .run files and automatics check-out of .in* files.

In the area of Parallelization, the major push of the last quarter was a demonstration of the parallel AIPS++ system at the ADASS'98 conference in Urbana the first week of November. Wes Young and Doug Roberts presented a demonstration of the parallel capabilities of the AIPS++ system. Wes Young has implemented a parallel algorithm applicator in the AIPS++ system. This applicator class can be used for algorithms that can carry out significant work across multiple processors with little or no communication between the processors. This demonstration showed the first use of this class to deconvolve a large spectral line cube within AIPS++. The demonstration ran remotely on one of the NCSA Origin2000 systems. The implementation of parallel processing is with the Message Passing Interface (MPI). MPI is a portable system that allows data and instructions to be sent to remote processors (either on the same machine or on different machines).

In addition to the work put into the parallel algorithm applicator which was put into the imager application (and subsequently renamed pimager) significant effort was put into the user interface. Doug Roberts and Wes Young have worked on the user interface to allow users to access the batch systems at NCSA. The NCSA policy is to allow interactive systems for short cpu times (15 minute limit); all other jobs must be submitted to the batch manager lsbatch, which is a load-sharing batch system built on top of the Load Sharing Facility (LSF) system. The interface additions to the object manager allowed the users choices in the GUI to be written to a Glish script file. The Glish script could be submitted to the batch system with an additional click in the GUI.

The NCSA enabling technology (ET) team responsible for high performance computing has been involved in an effort to obtain I/O statistics of the AIPS++ code. The Pablo group at the University of Illinois Computer Science department has developed an I/O library that records the I/O usage during the execution of an application. The group also provides a set of tools to analyze the I/O data in the recorded file. The tools can be used to create statistics in several forms, from a table to a 3-D output that can be visualized on an immersive display. Doug Roberts and Wes Young have been involved in assisting Pablo group get a stable AIPS++ installation and linking in the instrumented I/O libraries. The changes to the code have been checked into the AIPS++ system to allow easy instrumentation of code running on other machines. Just before Christmas, we saw the first output from an "imagertest." Additional testing using larger data sets will be required before making conclusions on the I/O performance of the AIPS++ system.

Athol Kemball, the head of the parallelization project, circulated a plan for the next two quarters of the parallel project. It includes plans for a small exploration of OpenMP for fine-grain parallelization of gridding, continued work on the algorithm applicator class to extend it to additional processing (beyond Clark CLEAN that is currently parallelized). The group will assist in taking two large datasets (a VLA HI mosaic and a VLBA monitoring experiment) through the parallel AIPS++ system.

In Management, in this quarter, a special emphasis has been placed on the integration and standardization of applications development in preparation for the public release in early 1999. A directed meeting to address these objectives was held in Socorro in November and was attended by project members from all consortium sites. A key objective of this initiative is to standardize the framework for AIPS++ applications and to ensure as uniform a user interface as practical. The successful discussions at the meeting in

Socorro have been followed-up by weekly integration meetings to ensure that the identified items are addressed in the preparations for the public release. Planning in all areas was also reviewed at the time of the integration meeting in November, in preparation for the release.

N. GREEN BANK TELESCOPE

Antenna

With the completion, on the ground, of the BUS in July of 1998 the next task was the erection of the BUS on the box girder. Seventeen temporary support points were located atop the box, duplicating the 17 points used in building the BUS on the ground. The BUS was disassembled into its 22 modules and these units were sequentially repositioned so that they could be individually lifted and installed upon the box using highly qualified S70 tower derricks. With the BUS solidly in place on the box girder, installation of the permanent supports began. These members are made up of sixteen large weldments attached to the back of the BUS and a like number installed at various elevations on the top and sides of the box girder. Most of the two sets of weldments accommodate multiple beams as there are 30 large beams carrying structural loads from the BUS to the box. When the permanents are in place, the temporary supports on the top of the box will be removed.

Permanent Supports

As reported earlier, it was discovered that problems in the design and fabrication of the permanents required that they be reworked. Most of the rework has now been completed. A significant milestone was achieved during the week of December 6, 1998, when the rework of the large permanent supports attached to the BUS was completed. In the middle of December the work on the permanents attached to the box was estimated to be 88 percent complete. Fourteen of the 30 supporting beams have been installed between the permanent supports. The installation of the remaining beams will be completed by February.

Vertical Feed Arm

The Vertical Feed Arm (VFA) rises from the end of the Horizontal Feed Arm, the installation of which was completed in June 1997, past the vertex of the dish, and on past the prime focal point to the region of the secondary focus. The tip of the VFA, the Upper Feed Arm, carries the Gregorian mirror. When the secondary optics is in use, the radio signal, at frequencies above approximately 1 GHz, is reflected into a suitable feed on the roof of the Feed/Receiver Room mounted on the VFA. When the GBT operates at lower frequencies the signal is received by a prime focus radiometer mounted on a movable boom which is raised into a position in front of the Gregorian mirror. The boom is also carried by the Upper Feed Arm.

Upper Feed Arm

The Upper Feed Arm has been fully assembled for some time, and extensive field tests of the Upper Feed Arm servo systems have been performed. On November 16 an intensive 30- day test began, in which the servos that control the position of the Gregorian subreflector were exercised around the clock in a simulation of actual observing modes. The test was completed successfully with no mechanical failures. The position transducers occasionally gave erroneous outputs, and this situation will be examined. Tests of the Prime Focus system were not possible, because of failures in the original motors. Tests will be made of the Prime Focus servos in January after new motors have been installed. The goal is to complete all testing of the Upper Feed Arm by the beginning of February, at which time the Upper Feed Arm assembly will be moved from its current location near the road to a position adjacent to the large derrick crane. The VFA consists of 12 modules, six on each of the two arms, and the Upper Feed Arm. The lower module's G & H left and G & H right are now in position and the welding of the structures is in progress. Next, modules K-L left and right will be lifted into place and modules J left and right will be created by welding interconnecting members into place. Then the Upper Feed Arm will be raised and attached. The installation of the Upper Feed Arm is currently scheduled to begin in April 1999.

Actuators

One of the important features of the GBT is that it will have an active primary surface. The telescope structure is so large that gravitational deflections will cause the primary mirror to deviate from the desired parabolic shape. To compensate, the surface panels will be mounted on a total of 2,209 remotely controlled actuators, so that the shape can be altered to improve the efficiency with which the telescope focuses radiation, especially at the higher frequencies where surface irregularities are more important.

All of the actuators are now mounted on the BUS. In order to gain time in the schedule, a program was started to align the actuators using a total station theodolite. As of November 15, 1998, 849 actuators had been set in this way. This program will be suspended for the winter, in part because of the difficulty in doing this precision work during winter weather and in part because of concern that the outlying actuators, those lying well beyond the Box, might shift when the load of the BUS is transferred from the temporary to the permanent supports. Such a shift would require a more extensive second stage of alignment than is anticipated for those over the Box.

It was originally planned to install the actuator cable in the spring of 1999, in order that the cabling not be in the way of actuator installation and welding. However, COMSAT developed a procedure for installing the actuator cables in cable trays in such a way that the cable is out of the way and protected until it is needed, at which time it can be spooled out and connected to the appropriate actuator. All of the cable is now in place, and one end of each cable has been passed through the bulkhead in the Actuator Control Room. In the Room the cables have been cut to approximate length and work will soon begin to prepare the cable ends for connection to the controllers.

Surface Panels

The primary reflector is made up of 2,004 panels, the largest of which are approximately 2.5 meters on a side. In order that the GBT be effective at high frequencies the panels themselves must be precise, with a smoothness of a surface of 5 mils, and they must be carefully installed and aligned. The status of the panels is unchanged from the previous reports; approximately 1,400 have been manufactured, and installation tests involving several panels were made in the summer of 1998. The actual panel installation will occur after the Upper Feed Arm is in place, in the late spring of 1999, and will continue through September. The accurate alignment will employ photogrammetry, and will begin late in 1999.

GBT Servo

(Progress on the GBT Servo is addressed in the Green Bank Electronics section of this report.)

GBT Spectrometer

(Progress on the GBT Spectrometer is addressed in the Charlottesville and Green Bank Electronics sections of this report.)

GBT Metrology

Ground laser monuments ZY107-ZY109 (the last three of 12) were poured. A COMSAT trailer was moved and a conduit was extended south of the road to pick up existing monuments ZY105 and ZY106, as well as connecting the conduit ring to the new manhole which will tie to the GBT pintle room. When the control panels are installed, this will increase the number of active instruments from seven to nine (ZY107-ZY109 will be wired after the receiver room is moved). Framework for the ZY114 access platform on module H of the left feed arm was installed before it went up. The engineering was done for the crosswalk between the existing vertex walkway and the left feed arm (to access ZY114) and material was purchased for the crosswalk, ladder to ZY114, and decking for the platforms for ZY113 and ZY114. Framework for access under the elevation bearings was fabricated and painted and awaits installation by COMSAT. Three of the four control panels used for the 140 Foot Telescope experiments were removed and will be reconditioned for installation at the GBT. One instrument (ZY10) will remain in service to measure motions of the feed arm towers and do refractive index measurements. The panel setting tool project was handed off to Tim Weadon. The prototype triplet retroreflector is 90 percent complete. The GeoSAR project, a $361,000 contract to build a laser system for JPL, was completed. Payne and Parker visited McDonald Observatory to advise them on the feasibility of using a GBT laser ranging instrument for the Hobby-Eberly Telescope mirror piston adjustment. It looks like a slightly modified instrument would solve the problem. Emphasis was given to completing the last four of 20 GBT instruments, repairs, and building an inventory of spare components.

An interesting experiment was conducted on the deflection of the feed arm in conjunction with the AUI Trustees tour, as reported in L0485. These results demonstrate the capability of the metrology system to measure small deflections due to forces of approximately 3000 pounds. Accelerometer data, taken by operations while the telescope was being rotated on October 21, was given a preliminary analysis, but better tools will have to be developed to make the data readily screened for interesting events and patterns—preferably near real-time in order to associate the data with events. Ideas being explored include time compressing the low frequency (<20 Hz) vibrational data into pseudoaudio data which could be played and edited using consumer digital music software, and converting the low frequency data into modulated white noise. Electronics installed additional accelerometers near the retroreflector on node 31020. This data will be recorded, along with laser range data, when the retroreflector on the GBT is rotated back into view by some of the existing lasers. Significant progress was made on packaging the hydrostatic level control electronics and the well/probe mechanical design. Report L0486 documents some extraordinary experimental results of a test of the control system and water level detection probes, with a precision at the 1 micron range. A stand-alone meteorology instrument system has been assembled which uses the dew point sensor,

pressure sensor, and three temperature probes. This will be used in conjunction with field experiments to calibrate refractometer paths at the GBT.

Software development focused on automating the ZY-to-ZY measurements (a specific experimental recommendation made by the GBT Advisory Committee) and code to compute clear lines of sight between instruments and retroreflectors as a function of azimuth and elevation. The ZY-to-ZY software was field tested. The retroreflector directing algorithm and mirror pointing algorithms worked well. The scheduling, handshaking, and data handling should be ready to test in January, 1999. A poster presentation was made at the ADASS meeting. Weekly GBT pointing meetings, which started in September, continue. After long years of debate, a position report (L0494) on the reasons why the subreflector differential position measurements should rely on the transducers, instead of the lasers was generated for McKinnon to make the decision. A document on scheduling range measurements is in draft form.

Todd Wright accepted a permanent position in Plant Maintenance (he was temporary in metrology), which leaves us short on manpower. This will become more acute next spring when we resume outdoor work at the GBT. Both co-op students completed their work sessions and returned to school for the winter. Since the co-op program is being phased out, we will not have a student this winter.

GBT Software - General

The GBT Advisory Committee was basically in agreement with our software priorities and was happy with our progress in the last year. The major item that they were concerned about was the integration of Metrology into the operational system. They were pleased to hear that we have already begun a series of weekly meetings, led by Mark McKinnon, towards this goal. The live demonstrations by Ron Maddalena (engineering screens), Joe McMullin (commissioning software using AIPS++), and Bob Garwood (spectral line data processing in AIPS++ using real data) were well received.

Several people from NRAO associated with the GBT (Clark, Creager, Garwood, Granados, Hunt, McMullin, Wells) attended the Eighth Annual Conference on Astronomical Data Analysis Software and Systems (ADASS98) in Champaign, Illinois.

Monitor and Control

As feared, the Spectral Processor control software upgrade was not completed in time for inclusion in release 2.8 of the M&C system, but this was the only major omission. Unfortunately, but not surprisingly, it was subsequently necessary to dedicate quite an amount of effort to address the bugs in 2.8 exposed by the ongoing engineering system tests. Although the bugs decreased in frequency, it still took effort away from the other software efforts. In addition, the computer system administrator left. Although he will be replaced as soon as possible, this vacancy will impact the M&C development, since the people in this group must pick up most of the system administration duties.

One of the major priorities in the M&C system is the integration of the Spectrometer. It's priority was confirmed by the recent GBT Science Workshop. The firmware for all of the modes of the spectrometer is now complete; there are, in total, 780 individual modes, many of which can be used in combination with others! After a careful look at the existing software, we now have a development outline which includes breaking up and assigning the software effort. Unfortunately, for reasons given above, actual progress has been regrettably slow.

After careful analysis, a memo detailing some GBT servo software issues was forwarded to the contractor (Precision Controls - PCD). In addition, a comprehensive bug list from the operational testing of the subreflector was forwarded to PCD. The 30-day, 24hrs/day, testing of the subreflector otherwise went smoothly.

The maximum time allotted for inter-device communication to determine the start time of a scan was reduced five seconds to one second. In addition, a couple of long-standing timing problems have been addressed. This leads to a faster response time of the whole system at the start of an observation (scan).

The software to control the Monitor and Control Bus (MCB) is being completely redesigned. The Standard Interface Board (SIB) low-level device driver is complete, and work has started on the MCB software layer.

O. MILLIMETER ARRAY PROJECT

In the last quarter of 1998, the Millimeter Array Project concentrated its efforts on implementing the suggestions of the NSF Millimeter Array Oversight Committee (MMAOC) that were made at the committee's August meeting. These suggestions included the following:

- *Complete the Project Book by including a clear statement of the project baseline description.* This recommendation is addressed to what the committee saw as a need to eliminate options that had been part of the initial version of the Project Book and instead, to establish a firm project description that could have decision points at which options could be substituted for that baseline description. In the last quarter the Project Book was completely revised in accord with this recommendation and such a baseline established. A procedure for modifying the baseline was also introduced as a formal management structure in the project. The

Project Book is maintained in electronic form so that everyone can have access to it and the version they access via the WWW is the latest version. Darrel Emerson, the MMA Project System Engineer is the editor of the Project Book. It is available at http://www.tuc.nrao.edu/~demerson/project_book/.

- *Secure the partnership with the interested European groups without delaying the U.S.-only part of the project.* Meetings were held both by the NRAO MMA Project team with technical groups in Europe and by the NSF with their counterpart agencies in Europe. Tangible progress was made by both groups. The MMA and European technical teams identified specific tasks for a common Design and Development program that could be shared effectively between the two. The specifics are still in flux as the European project team becomes established. Discussions among the agency personnel in the U.S. and Europe lead to a common understanding that a merger between the MMA and the European Large Southern Array (LSA) project was not only feasible but could be adopted as a goal for both sides. Again, further discussions were planned to outline the arrangements by which this could come to pass.
- *Maintain the procurement schedule for the initial MMA prototype antenna.* The prospect of a merger with the European project has the potential to cause a hiatus in the work being done in the U.S. while the European group gets established and functioning smoothly. The MMAOC recommendation addresses this potential problem for the U.S. project and strongly encourages the MMA project to find a mechanism by which the antenna schedule is kept–delivery of the prototype in June 2001–but at the same time the European group is involved in the effort. A plan was established to this end and reviewed with the MMAOC at the next committee meeting that was held in December 1998.

The report of the August 1998 MMAOC meeting is available at http://www.mma.nrao.edu/library/mmaocreport.html.

In November, the Millimeter Array Advisory Committee (MAC) met for its annual meeting. The MAC meets with the MMA Project Scientist monthly by telephone; once a year they get together in person, this year the meeting was held at the Hilton Hotel at the Chicago O'Hare airport. The committee heard presentations from many of the MMA Division Heads on progress being made in their respective areas and decisions that they were facing. The MAC was very concerned about the effect that the prospective merger with the European LSA project would have on the schedule for the MMA. They were eager to secure the merger, the prospect for an array having many more antennas than had been planned for the MMA alone, and the increase in net collecting area that this brings, was an attractive prospect for the MAC. At the 1998 meeting, as was the case also for the 1997 meeting, the MAC strongly endorsed the merger.

The principal scientific issue separating the U.S. and European groups was the antenna diameter. The U.S. community, for more than a decade, has emphasized that the MMA must be a complete imaging instrument. This means that it must have enough antennas so that it can create excellent *snapshot* images that can be stitched together as mosaics to cover a region of the sky very much larger than the primary beam of one of the individual antennas. It also means that those antennas must point exceptionally well so that one or a few *rogue* antennas with poor performance characteristics do not degrade the mosaic images. Controlling the performance of antennas, particularly antennas exposed to environmental effects such as wind and solar heating, is made easier as the antenna diameter is smaller. The European group, on the other hand, has as its key scientific interest long spectroscopic observations of small objects, particularly cosmologically distant galaxies. For this purpose one wants all the collecting area possible and leads to a desire for large antenna diameters. This difference in emphasis between the U.S. and European groups presented an impasse.

Prior to the MAC meeting an ad hoc committee composed of members of the MMA project, members of the Millimeter Array Development Consortium (MDC) university groups, and members of the MAC met to analyze the scientific implications of a choice of the antenna diameter favored by the U.S. group, 10 meters, and the antenna diameter favored by the European group, 12 meters. This committee wrote a report (MMA Memo 243), a draft of which was given to each member of the MAC and the conclusions of the report were presented orally at the meeting. The ad hoc committee's recommendation was that an array of 10 meter or 12 meter antennas could meet the scientific goals of the MMA as long as those antennas met the precision specifications established by the MMA to facilitate mosaic observations. The MAC endorsed this recommendation and encouraged the MMA to find a way to resolve the antenna diameter issue quickly with the European group.

The report of the MAC 1998 meeting is available at http://www.mma.nrao.edu/news/.

Given the recommendation of the MAC that either 10 m diameter antennas or 12 m diameter antennas would be scientifically acceptable, and the recommendation of the MMAOC that procurement of the initial MMA prototype antenna should not be delayed, the MMA Project management decided to adopt 12 m as the diameter of the antenna to be procured as the initial MMA prototype. This decision provides the opportunity for the MMA/LSA merger to occur without acrimony, it does not compromise the scientific goals set for the MMA, and it permits procurement of that prototype antenna to occur on the schedule set for the MMA project. The decision was announced to the community in the MMA electronic newsletter, http://www.mma.nrao.edu/news/jan99/jan99.pdf

Eight new MMA Memos, Memos 231 to 238, were distributed in the quarter. These memos may be found in the MMA Memo series available at http://www.mma.nrao.edu/memos/

P. PERSONNEL

New Hires

Bower, G.	Research Associate	12/02/98
Cortes, P.	Junior Engineering Associate	11/23/98
Fassnacht, C.	Research Associate	11/02/98
Gallimore, J.	Research Associate	10/01/98
Lewis, A.	Senior Personnel Representative	10/26/98
Norville, R.	Senior Personnel Representative	10/26/98
Sandell, G.	Visiting Associate Scientist	11/02/98
Stauffer, F.	Scientific Programmer Analyst	11/16/98
Thornley, M.	Research Associate	10/01/98
Welty, D.	Chief Accountant	10/05/98

Terminations

Barnes, M.	Senior Personnel Representative	12/31/98
Millner, R.	Systems Analyst	11/20/98
Morrison, G.	Junior Research Associate	11/30/98
Payne, R.	Sr Scientific Programmer Analyst	12/11/98

Promotions

Holstine, M.	to Business Manager, Green Bank	10/01/98

Other

D'Addario, L.	transfer from Charlottesville to Tucson	12/04/98
Grammar, W.	transfer from Green Bank to Tucson	12/14/98
Langston, G.	to Leave for Professional Advancement	10/26/98
Ross, D.	to Regular Part-time Eligible	12/18/98

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