NATIONAL RADIO ASTRONOMY OBSERVATORY

Quarterly Report

January – March 2004

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Executive Summary

ALMA

The ALMA Management Advisory Committee (AMAC) met in Charlottesville, Virginia in mid-March and heard reports on IPT progress and definition of the management interfaces between the Executives and the Joint ALMA Office (JAO). The ALMA Board met in Socorro, New Mexico to consider Chilean office space options, and approve implementation of a Project Management Control System (PMCS).

The Mini-ALMA week attended by ~ 60 ALMA staff was held near Garmisch, Germany in early March. A two-day system design review was followed by detailed discussions on IPT status, operations planning, and potential Japanese contributions.

Technical discussions continued between the JAO and the Japanese, while formal negotiations were conducted by the Joint Negotiating Team, a committee of the ALMA Board. The JAO, Executive Project Manager, and IPT leads met in Japan to clarify deliverables and interfaces for potential Japanese ALMA contributions.

A fully-operational prototype Band 6 cartridge was successfully tested by the Charlottesville Front End group. This prototype meets the critical noise requirements. The first production unit will be completed and ready for Front End integration in October, 2004.

Proposals for the productions antennas are due from vendors at the end of April. Technical evaluation of the proposals will be conducted jointly with the European Southern Observatory (ESO) for all responsive proposals received by either Executive. Contract execution is expected to begin in September, 2004.

EVLA

Installation of the fiber optic cable along the Very Large Array (VLA) arms was completed February 26, several months ahead of schedule. On March 24, another major milestone was achieved when the first interferometric fringes were obtained between the EVLA test antenna and other VLA antennas using the existing VLA correlator. This demonstrates the correct functioning of most of the new EVLA equipment on the test antenna, which is now in routine use for interferometric testing. Construction of the structural components for the second EVLA antenna (VLA antenna #14) was initiated this quarter.

The Canadian EVLA partners received four bids in response to their Request for Proposal (RFP) for the new correlator chip, the key component for the new EVLA correlator. Completion of the full correlator remains on schedule for early 2009.

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Accelerated EVLA funding in FY 2004 has permitted a large procurement of critical electrical and mechanical components, mitigating possible future obsolescence problems and reducing costs due to economies of scale.

The NRAO proposal for Phase II of the EVLA project was completed and submission to the NSF FastLane system began at the end of the quarter.

Green Bank Telescope

The 26 - 40 GHz (Ka-Band) receiver and the associated millimeter-wave converter were both nearing completion at the end of March 2004. The Ka-Band receiver is a dual-beam, dual-polarization receiver with pseudo-correlation architecture – the first such receiver built for the GBT. This design should give very good performance for both continuum and spectral line applications, including measurements of faint continuum point sources, searches for highly redshifted molecular lines, and general spectroscopy. The millimeter-wave converter provides IF down-conversion of the broadband RF signal, and will be used for both the Ka-Band and future W-Band (3 mm) receiver.

The range of observing programs executed at the GBT continued to grow in variety and level of difficulty. Observing at K-Band (18 – 26 GHz), for example, has become routine. Final commissioning of the Q-Band (40 – 52 GHz) receiver was completed this quarter and the first astronomy programs using it were scheduled. The GBT Spectrometer Spigot Card (or Spigot system) is a new pulsar-search backend that has received additional use this quarter in the "expert operation" mode. This powerful system allows pulsar data to be dumped very rapidly with observing bandwidths as high as 800 MHz.

The azimuth track problems were successfully managed in the first quarter as the observatory's long-term mitigation efforts continued to make good progress. Two wear plates developed cracks through to the top surface; one was replaced and the other is being closely monitored. Intensive efforts to determine a permanent remedy to the GBT azimuth track deficiencies continued. The firm of Simpson, Gumpertz, and Heger completed 4 of their 6 models and made noteworthy progress on their three-dimensional, quasi-static model. This effort will continue into the early part of the second quarter. The planned internal and external review panels will convene by June.

The Precision Telescope Control System (PTCS) project made significant progress this quarter. Dynamic corrections to pointing and focus that compensate for thermal gradient effects are now in production use and are working well. Considerable documentation has been added to the PTCS web pages to assist observers in planning their observations. The PTCS project is pursuing an aggressive campaign to measure and improve GBT surface accuracy using two complementary surface measurement techniques: phase-coherent and out-of-focus (OOF) holography. Test time is scheduled in April to apply the holography results and measure the resulting gain improvement. Conceptual design is underway for instruments and methods to correct primary mirror distortions due to thermal effects and to derive an improved model for gravity effects.

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Drawings for the Penn Array detector box assembly were completed, submitted to the Green Bank machine shop, and the parts were completed and delivered to the University of Pennsylvania. A major milestone was achieved in operation of the multiplexing in the lab at Penn. At Goddard, significant progress was made on the firmware upgrade for the multiplexing readout electronics. The target for Penn Array engineering commissioning is early 2005.

Following the major re-organization of the Caltech Continuum Backend (CCB) project at the end of 2003, a project meeting was held in Green Bank in mid-January to settle key aspects of the design, and review schedule and strategy. The CCB project is moving towards a May 2004 review, with assembly occurring over the summer, and commissioning on the GBT in fall and winter.

The Green Bank software development team conducted reviews this quarter for the SDFITS export data format generator, the new Ka-Band receiver software, the new common Millimeter downconverter, and the standard interface to the M&C system, known as Grail. This group will automate much of its systems-level testing by the end of 2004, relieving resources from the often time-consuming process of manually running such tests.

The GBT interim raw data archive went on-line in February. This archive provides disaster-recovery backup and local access to GBT raw data back to December 2002, and is complementary to the externally available central NRAO data archive.

The Green Bank Science Center and dormitory projects are now complete. The contractors have been paid, and these facilities are in full use.

The "Sagittarius A* at 30" workshop was held March 25 – 26 in Green Bank, with approximately 50 X-ray, infrared, and radio astronomers participating. A plaque commemorating the Sag A* discovery observations by Robert Brown and Bruce Balick was installed on the 45-foot telescope.

Very Large Array & Very Long Baseline Array

A well-attended and successful four-day workshop on "X-ray and Radio Connections" was held in Santa Fe, New Mexico in early February. Scientific topics included massive star cluster outflows, colliding stellar winds, supernova remnants, pulsar wind nebulae, dissipation of jets and lobes, and galaxy cluster mergers.

Prototype concrete planks have been developed for the support of VLA rail intersections, and will reduce long-term VLA maintenance costs. The construction of a new office building is under way on the New Mexico Tech campus; this building will temporarily house 20 NRAO employees beginning summer 2004.

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The analog tachometers on the VLBA antennas at Pie Town and Hancock were replaced with new digital tachometers, improving reliability and reducing maintenance costs. The noisy signals produced by the analog tachometers routinely cause drive motor fuses to blow. Digital tachometers will be installed on three other VLBA antennas later this year, and operations costs should decrease as a result.

The VLBA operations group was re-organized to eliminate a layer of middle management and improve efficiency. The resultant cost savings will be used to initiate the implementation of Mark 5 data recording on two VLBA stations later this year.

VLBA staff has made significant progress in investigating the feasibility of using VLBA observations for spacecraft navigation. Using the total delay observable, systematic offsets between VLBA phase-referencing and JPL position measurements have been resolved, and now provide consistent results within the error level of 0.3 milli-arcseconds or less.

The Interferometry Software Division (ISD), formed in mid-2003, has responsibility for all interferometric post-processing software and for the development of end-to-end data flow software common to all NRAO telescopes. The ISD team made good progress this quarter towards providing a GBT proposal tool for fall 2004, then adding support for the VLA and VLBA during 2005. The proposal team is negotiating with the UK-based ALMA proposal team to ensure commonality between the NRAO proposal tool and ALMA's phase 1 proposal tool. Initial design for an NRAO-wide master database has been completed. The extensive Green Bank database will be adopted as the starting point for the requisite astronomical institute database, and the design of an NRAO-wide proposal database is underway.

The Science Software Group (SSG) continued its development of the legacy AIPS++ software for critical observatory needs, such as the ALMA Offline reduction requirements. A three-year plan for the development of all priority-1 ALMA Offline requirements was drafted. A detailed study of the performance of the AIPS++ imaging capabilities was conducted. Iterative software improvements implemented over the last three quarters have brought the AIPS++ imaging performance to approach that of the AIPS software employed for VLA and VLBA data.

The NRAO Archive has been operational since October 1, 2003, allowing community-wide access to all non-proprietary VLA data and some VLBA data. More than 250 users from 124 institutions have downloaded 4,400+ telescope data files in the archive's first four months of operation. The archive currently contains all VLA acquired from 1976 to the present, raw VLBA data taken since June 2002, and some calibrated VLBA data acquired from December 2002 to the present. The NRAO Archive's first development phase is now complete: users can access all VLA data and have been provided tools to identify and download the data of interest to them and their science. The next phase of archive development will further improve the user interface and will build automated data reduction pipelines for producing calibrated data and images.

Executive Summary

Central Development Laboratory

Four 1 - 2 GHz balanced amplifiers optimized for EVLA L-Band use were delivered to Socorro, and a prototype L-Band feed was successfully fabricated and tested. Work continued on the final design of the 2 – 4 GHz amplifier and a new version of the 40 – 50 GHz amplifier.

A prototype receiver cartridge for ALMA Band 6 was successfully fabricated and tested. The main components for the first eight cartridges have been ordered.

A prototype ALMA correlator was completed and installed in Socorro for system integration testing; orders were placed for most of the custom integrated circuits, printed circuit boards, and other parts for the 64-antenna correlator. A new computer floor, additional air conditioning, and a fire suppression system are being added to the NRAO Technology Center (NTC) correlator laboratory so that this facility can fully support continued ALMA correlator system construction.

Pre-production ALMA local oscillator assemblies were completed and successfully tested for Bands 3, 6, and 7; the complete LOs are not yet in final form for Band 9 due to the present low efficiency of the cooled frequency multipliers.

Beamlead HEB mixers for heterodyne THz biohazard detection were fabricated for the initial 600 - 720 GHz band and construction of a test receiver began.

Observations of the sun at 20 - 70 MHz began at Green Bank using the prototype antenna and receiver for the Green Bank Solar Radio Burst Spectrometer (GB/SRBS), and the results are available over the internet.

The move from the old Dynamics building on Ivy Road to the NRAO Technology Center was completed.

Computing and Information Services

As a result of focused attention on security, the NRAO continues to be almost completely spared from major virus outbreaks. All sites are now cautious about verifying operating-system patches and anti-virus protection on non-NRAO systems such as visitors' laptops, and the automated patching processes established by the Common Computing Environment (CCE) group for both Windows and Linux are functioning well.

The Common Computing Environment (CCE) group has as its goal to ensure that all sites provide a standard configuration of operating systems, network services, applications software availability, and user interfaces. A review of the project's substantial progress during the previous year was held in Green Bank in mid-March 2004, and future goals were identified.

Executive Summary

An LDAP-based server with data populated from the Human Resources database has been deployed as the basis for all online and printed NRAO phone book information.

With the completion of the documentation, the deployment of the network and telephony infrastructure in the NRAO Technical Center in Charlottesville is done. The next network infrastructure upgrade will be in the Edgemont Road Stone Hall building. Planning for this is well underway.

Education and Public Outreach

The NRAO Education and Public Outreach (EPO) staff from New Mexico, Green Bank, and Charlottesville convened for a two-day workshop in Charlottesville in mid-February to refine and update the NRAO EPO Strategic Plan, clarifying their goals, deliverables, and milestones.

NRAO EPO staff issued national press releases this quarter on the exciting SS443 data and imagery acquired at the VLBA, and on the interesting high-velocity neutral hydrogen clouds discovered by the GBT in the vicinity of the Andromeda Galaxy. EPO staff also initiated multiple local news stories in daily and weekly newspapers and on local television that featured ALMA science and technology, the NRAO Technology Center, the National Radio Quiet Zone, the Green Bank Telescope, and the Green Bank Science Center.

In February, the structure of the ALMA EPO Integrated Project Team (IPT) was finalized with appointments from NRAO and ESO. In March, at the mini-ALMA week meetings, NRAO and ESO EPO staff initiated the planning cycle for their future joint efforts, including the production of a new ALMA video and publications, and the revision of the existing ALMA web policy.

EPO staff represented the NRAO at the January American Astronomical Society (AAS) meeting in Atlanta. Public Information Officers Chuck Blue and Dave Finley assisted extensively in the AAS Press Room. Three press conferences featured data acquired at NRAO telescopes, and two of these press conferences included NRAO scientific staff.

NRAO personnel at Green Bank and Socorro were notified in February that their teacher workshop proposals to the NASA Initiative to Develop Education through Astronomy & Space Science (IDEAS) grant program had been funded: "Quiet Skies: Exploring Radio Astronomy and the Noisy World We Live In" will be hosted at Green Bank, while "Doing Dishes: Observational Radio Astronomy for Science Education" will be hosted at Socorro. Detailed planning and preparation for these programs is now underway.

The Science Center at Green Bank and the VLA Visitor Center continue to see increasing visitor attendance; and gift shop revenue at both sites continues outperform our original projections.

Executive Summary

Environment, Safety and Security

Environment, Safety, and Security (ES&S) personnel participated in an NRAO ALMA meeting to address environmental and safety issues associated with the operation and existence of NRAO/AUI in Chile. The hire of an ALMA Safety Officer for the Joint ALMA Office was initiated this period. A video safety program was initiated in Green Bank to provide safety reminders to maintenance and machine shop staff. A session for supervisors was presented and reviewed the legal responsibilities of supervisors with respect to ensuring employee safety on the jobsite. The NRAO Vehicle Safety program was finalized for NRAO Commercial Drivers in accordance with the Department of Transportation requirements. In Charlottesville, several video surveillance units were installed at the Edgemont Road facilities.

Science Highlights

Very Large Array

NVSS Provides Support for Dark Energy Model - The "dark energy" presumably responsible for the acceleration of the expansion of the Universe also is believed to affect the evolution of fluctuations in the density of matter. Researchers using the NRAO VLA Sky Survey data, along with all-sky X-ray maps, have found a correlation between large-scale structure in the Universe and fluctuations in the Cosmic Microwave Background as mapped with the WMAP satellite. This correlation is consistent with the predictions of the dark-energy model, and thus provides an important independent confirmation of that model.

Investigators: S. Boughn (Haverford College) and R. Crittenden (Institute of Cosmology and Gravitation, Portsmouth, UK).

Very Long Baseline Array

VLBA Makes First Size Measurement of Galactic-Center Radio Source - Using the VLBA, researchers have made the first direct size measurement of Sagittarius A*, the radio source at the dynamical center of the Milky Way. The source, as measured at 7mm wavelength, would fit neatly just inside the Earth's orbit. Both the measured size and the confirmation that the size diminishes as the observing wavelength becomes shorter, provide important constraints on models of the mechanisms responsible for accretion, outflow and emission in the vicinity of the black hole. The measurement also sets a new lower limit on the mass density in Sgr A*, a limit that rules out any cluster of objects with a dynamical lifetime longer than 1,000 years.

Investigators: G. Bower (Berkeley); H. Falcke (Westerbork); R. Herrnstein (Columbia); W.M. Goss (NRAO); and D. Backer (Berkeley).

Science Highlights

Green Bank

Observations of the Double Binary Pulsar J0737-3039 - Following the discovery at Parkes last year of the first double pulsar binary J0737-3039, the GBT has been used to significantly improve the physical characterization of the system. This short period system is the first example of a binary in which both stars are pulsars. It provides a unique laboratory for studies of general relativity and neutron star physics. Observations of this system were made with the GBT in late December 2003 and early January 2004. The GBT is able to observe the emission from both pulsars during most of the orbital period. A number of significant results were obtained in the initial observations. For example, it was found that that the eclipse profile of the faster pulsar, PSR J0737-3039A, by PSR J0737-3039B is significantly asymmetric and is independent of frequency. The size of the eclipsing region was determined to be 18,600 km. A number of proposals from several different observing teams requesting time to pursue various aspects of this unique system were approved at the last proposal review. Observations of this system will thus continue in the coming months.

Investigators: V. Kaspi (McGill), S. Ransom (McGill, MIT), D. Backer, R. Ramachandra, P. Demorest, J. Arons (UC-Berkeley), and A. Spitkovsky (UCB, Stanford).

ALMA

The official bimonthly reports to the NSF on the ALMA Project can be found on the NRAO web site at *http://www. alma.nrao.edu/news/*. A summary of significant items during the period of this report is given below.

Mini ALMA Week was held March 1-5 near Garmisch, Germany. Approximately sixty ALMA staff attended the week long meeting. A two day system design review was followed by detailed discussions on IPT status, Operations Planning, and potential Japanese contributions.

The ALMA Management Advisory Committee met on March 11 and 12 in Charlottesville, Virginia. The committee heard reports on progress of each of the IPTs as well as the management interfaces between the Executives and the JAO. The committee will submit a written report to the ALMA Board in April.

The ALMA Board met on March 30 and 31 in Socorro, New Mexico where it heard reports on project status, considered options for office space in Santiago and approved implementation of a Project Management Control System. The Board also visited the ATF to inspect the prototype antennas.

Discussions with the Japanese continue on two fronts. Technical discussions are being led by the JAO while formal negotiations are conducted by the Joint Negotiating Team (JNT), a committee of the ALMA Board. The JAO, together with the Executive Project Manager and IPT leads, met in Mitaka Japan to clarify deliverables and interfaces for potential Japanese contributions. This meeting was followed by a meeting of the JNT.

As described above, the ALMA Board approved the implementation of a Project Management Control System. The detailed requirements and implementation plan were developed during a phase one program. With the approval of the Board, implementation is underway. The necessary hardware and software will be installed in April. Additional staff, both new hires and contract staff, will work with the IPT staff to complete planning and populate the PMCS databases. While a fully operational PMCS system will require as much as nine months to complete, the results of detailed planning within and between the IPTs will benefit the project immediately.

Proposals from potential vendors for the production antennas are due at the end of April. Technical evaluation of the proposals will be conducted jointly with ESO for all responsive proposals received by either Executive. AUI/NRAO will separately conduct business due diligence on proposals it receives. An AUI/NRAO selection committee will consider the results of the business due diligence evaluation, the technical evaluation and the price proposals. Contract execution is expected to begin in September 2004.

ALMA

A fully operational prototype Band 6 cartridge was assembled and successfully tested by the Front End group in Charlottesville. The prototype meets the critical noise performance requirements with sufficient margin to suggest that production units will meet these demanding requirements. The first production unit will be completed and ready for Front End integration in October 2004.

Expanded Very Large Array

Expanded Very Large Array Highlights

The installation of the fiber optic cable along the arms of the VLA was completed in February, several months ahead of schedule. On 24 March, first interferometric fringes were obtained between the EVLA test antenna and other VLA antennas using the existing VLA correlator. This demonstrates the correct functioning of most of the new EVLA equipment on the test antenna. The new wideband feed for the 1-2 GHz band was completed and successfully tested. Four bids were received by the Canadian Partners for the new correlator chip, the key component for the new EVLA correlator. A design team for the top-level architecture of the EVLA software system is developing a design in progressively increasing detail, with a cycle of internal reviews held every four weeks.

Expanded Very Large Array Milestones

Milestones	Original Date	Revised Date	Date Completed
First internal software design review	01/05/04		01/05/04
Antenna vertex room HVAC system functioning	10/17/03	01/09/04	01/09/04
Band switches design & development plan	08/20/03	01/15/04	01/12/04
First digital transmission from antenna to Control Bldg	01/14/04		01/14/04
Bench test of samplers, DTS and D/As	11/03/03	01/22/04	01/16/04
Establish NRAO-NM VPN capability	06/30/03	01/21/04	01/21/04
Begin mechanical preparation for 2nd test antenna	01/26/04		01/26/04
Q-Band receiver ready for test antenna	12/01/03	01/20/04	01/26/04
Electronic hardware functional design freeze	01/30/04		01/30/04
GUI to correlator back-end	01/30/04		01/30/04
Test antenna module and rack assemblies complete	11/07/03	01/30/04	01/30/04
M301 converter interface prototype assembled	10/24/03	01/22/04	02/06/04
Control of test antenna azimuth & elevation movement	01/30/04		02/09/04
MIB software installed on L302 synthesizer	10/03/03	01/26/04	02/09/04
Control of test antenna RA, Dec	02/13/04		02/13/04
e2e observing scripts for test antenna observations	12/12/03	01/30/04	02/13/04
1.4 GHz transition receiver ready for test antenna	11/26/03	01/22/04	02/17/04
Array fiber burial complete	05/31/04	02/26/04	02/17/04

Expanded Very Large Array

Milestones	Original Date	Revised Date	Date Completed
1.4 GHz feed horn prototype assembled and ready for testing	12/04/03	02/22/04	02/22/04
Bench integration test rack complete	03/12/04		03/01/04
L302 synthesizer ready for test antenna	10/08/03	02/02/04	03/01/04
Antenna D/A tests of sampler/DTS	01/29/04		03/09/04
Develop production specifications document	03/11/04		03/11/04
1.4 GHz feed prototype tested	03/19/04		03/19/04
F317 FE controller prototype design	11/17/03	01/12/04	03/20/04
First fringes achieved at 8.6 GHz	03/15/04		03/24/04
U/X converter IC prototype design complete	02/13/04		03/30/04
Monitor data archive operational	03/30/04		03/30/04
2nd L351 module ready for software	03/19/04		03/31/04
2nd L350 module ready for software	03/30/04		03/31/04
Electronic hardware physical design freeze	03/31/04		03/31/04
Software requirements for real-time system	08/29/03	04/05/04	
M301 converter module ready for MIB	11/14/03	04/06/04	
Electrical power survey of test antenna	03/22/04	04/09/04	
30 GHz receiver design ready for drafting	11/14/03	04/15/04	
Start 2nd test antenna outfitting	03/22/04	04/15/04	
Install 1.4 GHz feed on ant 13	04/15/04		
75/328 MHz converter module ready for test antenna	10/24/03	04/16/04	
U/X converter ready for test antenna	11/14/03	04/16/04	
T302 L,S,C converter ready for test antenna	12/19/03	04/16/04	
C-Band OMT design/analysis	03/16/04	04/16/04	
F320 FE transition module w/MIB & ICD ready for software	12/09/04	04/16/04	
VLA Control Bldg. HVAC chiller replacement	04/16/04		
3 GHz feed assembled & laminated	04/16/04		
Power supply board layout for P301 & P302	12/19/03	04/20/04	
Internal software design review	04/22/04		
Master LO functional	02/25/04	04/23/04	
F317 prototype module board layout	04/26/04		
Vertex room mockup internal review	04/26/04		
WBS updates	04/29/04		
New Control Bldg chillers installed	04/30/04		
2nd L305 module ready for software	04/30/04		

Expanded Very Large Array

Milestones	Original Date	Revised Date	Date Completed
MIB slot identification software written	04/30/04		
Complete Part 1 hardware bench integration	03/03/03	04/30/04	
MIB software ready for FRM interface	01/26/04	04/30/04	
30 GHz feed tests complete	05/04/04		
New shielded room planning session	05/06/04		
LO/IF switches ready for test antenna	05/06/04		
Check for interference and bandpass shapes: 328MHz, 22 & 45 GHz	03/15/04	05/06/04	
Check for interference and bandpass shapes 8, 22 & 45 GHz	12/19/03	05/06/04	
Level 2 schedule reviews	05/07/04		
Bench integration test racks populated	05/07/04		
Preliminary design on non-blindmate module connector	05/07/04		
Receiver stability tests: 8, 22 and 45 GHz	12/19/03	05/10/04	
Routine test observing	05/13/04		
3 GHz feed tested	05/14/04		
Start 3 GHz receiver assembly	05/16/04		
LO, IF & Fiber Optic/DTS system CDR	03/03/04	05/21/04	
Verify linearity of RF designs – receiver to correlator	05/27/04		
EVLA Computing Overall Design	03/01/04	06/01/04	
Functional and technical overall EVLA M&C architectural design	03/01/04	06/01/04	
*Overall software design completion	06/08/04		
Cold storage building ready	06/18/04		

Management

During the quarter it became clear that an additional $4M in accelerated funding for the EVLA Phase I Project will be available in the FY 2004 budget. A plan was made to commit these funds on large orders of critical electronic and mechanical components. These procurements will solve problems of possible future obsolescence by allowing lifetime supplies of critical components to be made and they will reduce costs due to economies of scale.

By the end of the quarter a proposal for the EVLA Phase II Project was completed and was beginning to be submitted to the NSF via Fastlane.

Expanded Very Large Array

Systems Integration

Late in the quarter sufficient hardware and monitor and control software was integrated in the test antenna so that it was possible to obtain interferometric fringes between the test antenna and other VLA antennas using the existing correlator. Fringes were obtained on March 24, 2004. This is an important milestone for the project because the test demonstrates the correct functioning of most of the newly designed equipment on the antenna.

A redesign of the DC power supply started this quarter and the layout of the new circuit board is near completion. System tests of the local oscillator, intermediate frequency and digital transmission on the test antenna continued throughout the quarter. Assembly and testing of the digital to analog interface board is complete. This board interfaces the Module Interface Board (MIB) and the module analog signal to send data through the digital transmission system. A functional and physical freeze to the overall hardware system was established and production specifications are being written to place large quantities of components for several pieces of hardware.

Civil Construction

The project reached a key milestone with the installation of fiber-optic cable along the arms of the VLA finishing on February 26. This work was completed several months ahead of schedule. The hired HVAC contractor started its initial preparation to replace the VLA Control Building chillers. Preparation is underway toward relocation of the VLA Modcomp computers, the fiber optic and computer labs to clear an area in the VLA Control Building for the WIDAR correlator shielded room.

Antenna

The test antenna is now in routine use for interferometric testing. Construction of structural components for the second EVLA antenna (VLA antenna # 14) began.

Front End

The wafer run required to obtain all of the MMIC amplifiers needed for the production of the 60+ Q-Band post-amp modules was placed on order. The 1.4 GHz Ortho Mode Transducer (OMT) is essentially completed and the design of the 6 GHz OMT is undergoing final analysis. The 6 GHz receiver design is complete and is in drafting to produce drawings for ordering parts. The 33 GHz downconverter is in its second iteration of design. The EVLA modified 22 and 45 GHz receivers were installed on the test antenna. The 1.4 GHz transition receiver was completed. Assembly and lamination of the 1.4 GHz feed was completed and the feed was tested. The F-rack to hold all the front end control modules is assembled and ready to install on the test antenna. Fabrication of three 33 GHz prototype feeds was completed this quarter. Testing of the feeds will begin soon. The process to order production quantities of cryogenic compressors and cold heads started.

Expanded Very Large Array

Local Oscillator (LO)

The 10.8-14.8 GHz synthesizer running under MIB control was installed on the test antenna in preparation for first fringes. Assembly began on the second generation of both Local Oscillator (LO) synthesizers. Preliminary testing of IF path is underway. A second LO reference receiver module was built and made ready for MIB software development. Assembled copies of the master offset generator and central reference distributor modules are near to being ready for MIB software development. Testing of the LO system on the test antenna continued throughout the quarter.

Fiber Optics

Four Digital Transmission System (DTS) /sampler modules were assembled and bench tested. The deformatter firmware was written. Two of the five deformatter boards built and tested to date ran simultaneously. The digital to analog lab tests of the DTS/sampler confirmed that the digital link met specifications. The master LO transmitter module is complete with its MIB. The module was turned over to the software group for MIB software development. Two round trip phase monitoring (RTP) modules were completed. These RTP modules are being tested to determine the performance of the two-fiber approach. Phase stability performance tests of the fiber, both under the ground and in the antenna, will continue through the next quarter. In the VLA Control Building, fiber was run between the IF equipment racks in the old correlator room and the D racks outside the room.

Intermediate Frequency System

To simplify the control of the RF band switches, in addition to mechanical and electronic designs, the switches are being integrated into the U/X converter module housing eliminating a separate module package. The interface module (M301) controlling the switches and RF converters was assembled and bench tested. The M301 module was issued to the Monitor and Control software group to develop its MIB software. The integrated circuit design of the U/X converter module by an outside contractor is completed. In-house testing of the module has started. The assembly of an IF downconverter using integrated circuits continued with some of its circuit boards populated and tested. Four connectorized component downconverters have been assembled. A MIB was added to one of the downconverters and the module was sent to the M&C software group for software development.

Correlator

Correlator Progress Review Meeting was held at the facilities of the Canadian partner in Penticton, Canada. A detailed review of the schedule indicates that additional testing is required in the early stages of the project causing the date for first "shared risk" science with the first subset of the correlator to slip from June to December, 2007. However, completion of the full correlator is still on schedule for early 2009. Detailed design of all parts of the correlator is proceeding. Four bids were

received by the Canadian partners in response to their RFP for the new correlator chip which is the key component for the correlator.

Monitor and Control (M/C)

A production order of 70 MIBs was received from a commercial company. Some problems were found with fabrication problems in some of these units and it was decided that for future orders the company will be paid to both fabricate and test the devices so that problems can be found prior to shipping. Programming of the MIBs is proceeding well. Approximately 25% of the different MIB types have now been programmed.

With the antenna control software now working for first fringes, the next major goal will be to improve this software to the point where observations can be routinely scheduled so that the test antenna can be used for scientific observing with the rest of the VLA. This goal is scheduled for the third quarter of 2004.

Data Management and Computing

A design team tasked with defining the top-level architecture for the EVLA monitor and control and data management software is in place and worked throughout the quarter. Their work is reviewed every four weeks by an external review panel. The goal of the team is to have the top-level design complete by the end of the second quarter of 2004. A particular emphasis for the team is to determine which ALMA software can be efficiently re-used for the EVLA Project. With respect to this latter point, an NRAO-wide technical committee was established to oversee the End-to-End (e2e) software work being done by the various projects at NRAO. The goal of this committee is to provide uniformity to the e2e software for the various projects and to prevent duplication of effort. A member of the EVLA design team is the EVLA Project representative on the e2e committee.

At the end of the quarter the EVLA monitor database was placed in operation. This will allow easy access to monitor data from the test antenna and other EVLA antennas in the future.

Green Bank Telescope

Green Bank Telescope Highlights

The 26-40 GHz (Ka-Band) Receiver and the associated mmConverter were both nearing completion at the end of the first quarter. The Ka-Band Receiver is a dual-beam, dual-polarization receiver with pseudo-correlation architecture – the first such receiver built for the GBT. The design should give very good performance for both continuum and spectral line applications, including measurements of faint continuum point sources, searches for highly redshifted molecular lines, and general spectroscopy. The mmConverter provides IF down-conversion of the broadband RF signal, and will be used for both the Ka-Band and future W-Band (3 mm) receiver.

GBT Antenna & Operations Milestones

Milestones	Original Date	Revised Date	Date Completed
Complete Phase II of track analysis	10/31/03	04/31/04	
Complete development of new rail concepts	12/31/03	08/15/04	
Hold Panel Review Meeting	01/31/04	06/15/04	

GBT Electronics Milestones

Milestones	Original Date	Revised Date	Date Completed
Spectrometer Upgrades			
Spigot Card Expert Mode released	02/28/03	12/01/03	01/01/04
Cross-correlation/poln. test fixture designed	01/01/04	05/01/04	
Cross-correlation/poln. test fixture constructed	03/01/04	08/01/04	
Begin polarization mode checkouts	06/01/04	08/01/04	
LTA redesign (engineering only)	04/01/04	08/01/04	
Sampler distributor redesign (engineering)	08/01/04	12/01/04	
RFI Improvements			
Finish GBT receiver room HVAC suppresion	12/01/03	On Hold	

GBT Mechanical Engineering & Central Shop Milestones

Milestones	Original Date	Revised Date	Date Completed
Outdoor range rotator	04/15/04		
Prime focus test building adaptors	03/15/04		02/12/04
Receiver Turret Adapter	04/09/04		
Penn Array Optics Tower	04/09/04		
EVLA 5 Slot Bins (15)	06/26/04		

GBT Software & Computing Milestones

Milestones	Original Date	Revised Date	Date Completed
M&C v3.19	12/31/03	01/12/04	01/12/04
M&C v4.1	02/16/04	02/17/04	02/17/04
M&C v4.2	03/31/04		03/31/04
Deprecate IARDS	03/31/04	08/15/04	
First Scheduling Block Executed	03/31/04	06/30/04	
Complete GBT High-Level e2e Models	06/30/04		

GBT Project Milestones

Milestones	Original Date	Revised Date	Date Completed
PTCS			
Surface Efficiency Improvements	04/30/04		
Improved pointing based on compensation for wind effects	06/30/04		
Identify 1″ level contributors to pointing error	09/30/04		
Ready for prototype w-Band operation under benign conditions	10/01/04		
Ease of Use			
Beta Release of Observing API	02/16/04	06/30/04	
Production Release of Configuration API	12/30/03	03/31/04	03/31/04
Production Release of HLAPI's & Online Filler	03/31/04	06/30/04	
Beta Release of GO replacement	12/31/03	08/15/04	

Green Bank Telescope

Milestones	Original Date	Revised Date	Date Completed
Data Handling			
GBT/Class Interface	12/31/03	03/31/04	03/31/04
Generate requirements for imaging	12/31/03	03/31/04	
Analysis Conceptual Design Review (In-Progress Software Review)	02/09/04	TBD	
e2e-driven "pre-review" of GBT Software		03/31/04	03/31/04
Spectral Baselines			
Begin installation of IF fixes	01/01/04	06/01/04	
Ka-Band (1cm Rx)			
Complete assembly of common MM converter prototype and evaluate performance. Refine design if necessary.	01/01/04		03/22/04
Complete assembly of 1cm receiver	11/01/03	04/01/04	
Test 1cm receiver in laboratory, work out any problems	01/01/04	04/15/04	
Penn Array Receiver			
Detectors Delivered to Penn	5/17/04		
Full Lab integration at Penn	9/6/04		
GBT Commissioning	2/21/05		
3mm Receiver (POSTPONED)			
Restart Project	11/15/03	On Hold	
Revise Project Plan	12/01/03	On Hold	
Prepare Budget request for FY2004	12/31/03	On Hold	
Caltech Continuum Backend			
Hold CDR in Green Bank	12/15/03	05/14/04	
Construction and lab testing complete	27aug04	08/27/04	
Commission on GBT	06sep04	09/17/04	

GBT and Green Bank Overview

During the past quarter, observing at 18-26 GHz (K-Band) has become routine. The types of observing programs undertaken have grown in variety and level of difficulty. The GBT is now in full production use, and is having a significant impact on virtually every science area that it addresses.

This has been an active and productive quarter for both operations and project work. We limited our maintenance days to two per week during the winter to maximize time available for astronomy during the high transparency season. In addition, maintenance days are flexibly scheduled to allow the best days to be used for astronomy. During the fall, winter, and spring months, we are scheduling the

telescope dynamically, meaning that a decision is made daily as to whether the telescope will be used at low or high frequencies. Two telescope schedules are maintained, a primary and a backup schedule. The fraction of total telescope time used for astronomy was 69%, 57%, and 61% in January, February, and March, respectively.

Final commissioning of the 40-52 GHz (Q-Band) receiver was completed in the first quarter and the first astronomy programs using it were scheduled.

The azimuth track problems were successfully managed in the first quarter. Two wear plates developed cracks through to the top surface; one was replaced and the other is being closely monitored. Work on the project to determine a permanent remedy to azimuth track deficiencies is proceeding toward conclusion in the next quarter.

Our project teams made significant progress on the Precision Telescope Control System (PTCS), telescope Ease of Use, the Ka-Band Receiver, and the Penn Array Camera and the Caltech Continuum Backend. The PTCS project pursued two, complementary techniques for surface measurement – phase coherent and Out of Focus (OOF) holography—together with a program to measure tilts of the structure using inclinometry. The Ease of Use project continued to develop a new configuration tool that is already in successful use at the telescope. This tool will be part of the new Observing interface for both configuration and execution of observing procedure. The Ka-Band (26-40 GHz) receiver was nearing completion at the end of the quarter, and is expected on the telescope for first engineering tests in mid-April. The two University-Built instruments, the Penn Array and Caltech Continuum Backend, progressed well and included active participation by NRAO staff. Details on these and other activities follow.

Azimuth Track

Two wear plates developed cracks through their top surfaces during January and February. The first crack found was a previously detected crack on plate 35. The crack has changed very little since first detection, and is being monitored to determine growth rate. It will be replaced if it progresses. The crack in plate 42 was a previously undetected crack, and due to its length and direction, was replaced. We currently have 4 spares on hand, and are ordering 2 more made out of AISI 4340 material as a trial. Some of the gouging of the plates as the wheels pass over the joints is a little worse, and we will replace them when we need to do so to manage wheel tilts.

We have also ordered a replacement plate for the trial modification plate (plate 45). When we receive it, we will replace the existing plate and destructively examine it to determine the nature of the ultrasonic indications described in the previous quarterly report.

The firm of Simpson, Gumpertz, and Heger has completed 4 of 6 models and other analyses, and they continue to work on the three-dimensional, quasi-dynamic model. Some of the effects observed, such as the ultrasonic indications mentioned above have not been identified, and they are trying to resolve that issue. This effort will continue into the early part of the second quarter.

The efforts identified above had an impact on our schedule for the in-house effort review as well as the follow-up outside panel review. We expect to hold these by June.

GBT Operations and Maintenance

Telescope Operations Activities

After review, Modjeski and Masters and Dr. Peter Keating have recommended that we repair the shallow defects found on the elevation shaft assemblies. We will perform this work during our summer maintenance period. We will also be restoring joint grouting and using a surface protectant to minimize corrosion inside the structural joints. This will be accomplished as we paint this summer as well.

The trial for changing the azimuth wheel bearings lubricant from grease to oil continues to show favorable results, and we will move to oil in all of the bearings by the end of the summer maintenance period.

The modifications made to the rolling track covers described in last quarter's report were successful, and were replicated on all of the assemblies. We have not experienced any lost time since installation, so we consider this failure mode eliminated.

Green Bank Electronics

Green Bank Electronics provides support for all electronic systems at Green Bank, including telescope controls, backends, RF equipment, audio-visual equipment, network installation and maintenance, radio system work, and machine shop electronic repair. Specific activities of the three Groups are reported below

Digital Group Activities

Most of the digital group's time was spent on PTCS activities, GBT Servo support, Spectrometer support, and the Caltech Continuum Backend project.

About three FTE's were supplied to the PTCS project. Their tasks consisted of Air Temperature Sensor construction, installation, maintenance, and calibration work, along with active surface maintenance.

Green Bank Telescope

The GBT servo system work for this quarter consisted of repairs to motors, motor controllers, wiring, and tachometers. Two azimuth motor controllers and one elevation motor failed this quarter. The motor controllers were repaired by the servo group. The failed motor was taken to the vendor's motor shop and a failure analysis is being performed. All the other motors on the system have been inspected and several have shown problems. A service technician from Reliance was contracted to provide advice on inspection and maintenance of the motors.

Much of the spectrometer support rendered this quarter was for the purpose of developing and testing the Pulsar Spigot cards and associated modes. The spectrometer is in general fairly reliable, and except for producing scans with obviously bad data now and then, is behaving well. We continue to work on a Long Term Accumulator (LTA) card replacement to solve the data integrity problems, and the occasional DMA error problems. About two FTE's are provided to Spectrometer work.

The Digital Group is supplying engineering effort to the Caltech Continuum Backend project. We are designing the analog front end, including the receiver detector preamp, and consulting on the design of the digital sections of the backend. About one FTE is assigned to this task.

Other items that the Digital Group is involved in are reviving the 45 Foot Telescope for use by the Green Bank Solar Radio Burst Spectrometer project, repairing/maintaining printers, network cabling, and communications hardware on the GBT.

Microwave Group Activities

The Microwave group provides support for the GBT receivers, IF/LO systems, and the site radio, intercom, and GBT phone systems.

This quarter is the heart of the high frequency observing season and the microwave group devoted considerable resources to support of the high frequency receivers. The K-Band receiver was in use as the workhorse this season. The Q-Band receiver has been commissioned and used for astronomy projects.

The Ka-Band receiver construction is nearing completion and should be ready for initial commissioning tests on the GBT starting in mid-April. The Millimeter-wave converter, which will provide down-conversion of the broadband IF both for the Ka-Band and future W-Band (3 mm) receiver is also proceeding well.

The group continued to enhance the IF system this quarter. The system was tested and adjusted for best performance with the new modulators. New IF amplifiers are being designed and tested. A spurious signal near 300 kHz causing RFI in Spectrometer low bandwidth data is currently being addressed. Various module instabilities and failures were repaired, and efforts continue to improve gain stability with better temperature control and through other measures.

The outdoor antenna range upgrade is nearing completion. This will provide better positioners, instrumentation, and software for doing antenna measurements on the outdoor range. Work continues to outfit the indoor/outdoor building with mounts and hoists to allow us to test our GBT Gregorian receivers there.

More Microwave group activity is noted under the baseline investigation project.

RFI Group Activities

Direct Observer Support and Spectrum Monitoring:

In support of GBT01A-061, a brief shutdown of the channel 50 modulator at the Milestone Cable TV head end was requested and granted. This was done as a risk reduction measure as a deep integration near the frequency of that channel's video carrier was to be conducted. A request to shut down an amateur propagation beacon at 432.305 MHz was requested and granted in support of GBT02C-002.

Per an observer request, extensive spectrum monitoring and research of relevant allocations in the 125 - 200 MHz range was conducted. A meeting with the observer was held on March 23 to discuss our findings and identify additional RFI Group action items in preparation for a low frequency experiment to be conducted in June - July, 2004.

National Radio Quiet Zone (NRQZ) Administration:

Six requests for preliminary evaluation on 23 transmitter sites were completed. Twenty-two regular applications for 38 sites were also completed. ERPd restrictions were requested on two sites.

Community RFI Management:

Though considerable effort was required, both Cable TV and power line RFI were kept at bay to the extent that no related RFI problems were reported during the quarter. By the end of the quarter, all the major leaks in the Cable TV system had been eliminated and the suppression of the remaining minor leaks was underway.

An extensive effort to assess the RFI risk associated with the operation of IEEE-STD 802.11b wireless LAN devices in the vicinity of the Observatory was undertaken. Some anechoic chamber testing was conducted to facilitate this investigation.

Public Relations and Awareness:

A visit from one of US Cellular's lead engineers, Larry Leech, was hosted. Mr. Leech continues to be supportive of the Observatory and is voluntarily working with us to mitigate a RFI issue associated

with a Cellular tower on Muddy Creek Mountain outside the NRQZ. His visit was primarily a social call, but the problematic site was discussed. Some testing was conducted to follow up on some issues that were raised.

Some RFI Group members met with Jim Williams of Milestone Communications to advise him on power line RFI hunting and suppression. Power line RFI is problematic for two of their three over-the-air antenna sites in Pocahontas County.

Instrumentation Repair and Improvements:

Network based operation of the ICOM R9000 communications receiver at the RFI monitoring station was accomplished.

The effort to establish a GBT-based monitoring capability got underway during the quarter. The preliminary system design was completed and key cost drivers were identified.

On-Site RFI Management:

Four PTCS components were evaluated in the anechoic chamber. Two of them required minor modifications to suppress emissions.

RFI testing of the antenna positioner for the outdoor range indicated the need for three additional RFI filters. These were purchased and installed and were successful in suppressing problematic emissions.

Other:

Input on two FCC Notice of Proposed Rulemaking (NPRMs) was provided to the Observatory Spectrum Manager in Charlottesville.

The relatively strong 462.875 MHz signal in the PF1 450 band was tracked to a simulcast digital paging transmitter on Keeney Mountain in Alderson, WV outside the NRQZ.

Mechanical Engineering and Central Instrument Shop

The Mechanical Division continued working with the Telescope Operations Division, the Structural Engineer, and Simpson, Gumpertz & Heger on analysis of the GBT track. This quarter saw completion of the mechanical design work and part fabrication for the upgrade to the outdoor antenna test range. Installation is expected in the second quarter after the weather improves. Design work will continue on handling equipment for the testing and pre-installation checkout of smaller receivers in the Prime Focus Receiver test building.

The Central Instrument Shop began fabrication of the optics tower for Penn Array during this quarter and will complete it early in the second quarter. Work continued on the Ka-Band receiver and will carry into the second quarter. Work was completed on the three EVLA Ka-Band feeds. The test fixtures for these feeds will be completed in the second quarter. The shop also supported EVLA with 5 of a total order of 20five-slot bins. The end of next quarter will see delivery of the balance of 15 bins. The Shop will also see growing effort next quarter in support the GBT MM Converter.

Software Development

Software Continuing Maintenance and Enhancement

The SDD produced two regular releases of its key product, M&C, with v4.1 on February 17, 2004, and v4.2 which was released on March 31, 2004. Fixes and enhancements were made in many different areas. Much work was focused on the Spectrometer, which now aborts properly from all states. Also, serial line improvements were added to the Spectrometer to provide improved system reliability. A Spectrometer quadrant error was fixed, which caused the Spectrometer's start routine to be called twice under some circumstances. The number and severity of data interrupt errors has been significantly reduced; however, a final fix (requiring control library changes) is under development for release in M&C v4.3.

A key accomplishment during Q1 2004 was the completion of Phase 1 of the Linux Migration Project. After serious failures in late 2003, the Analog Filter Rack Manager and Converter Rack Manager (both previously resident on VxWorks machines) were both successfully migrated to Linux and run on the new host "wind". This involved five major steps: creating new SIB/MCB classes and an RPC Server, creating GPIB classes and RPC Server, porting the critical MCTime library to Linux, and completing an analysis and redesign/re-implementation of both the Converter Rack and Analog Filter Rack. Users should notice better responsiveness when manually configuring these devices. The biggest advantage to having these applications run on a Linux system is that there is better error handling, and system problems due to resource starvation (especially file handles) are significantly mitigated.

Code reviews were held this quarter for the SDFITS export data format generator, the new Ka-Band receiver software, the new Common Millimeter Downconverter, and the standard interface to the M&C system (called Grail). These sessions provided extremely valuable information regarding how to make applications more maintainable and reliable, as well as faster for users. Complete reports were written and are available from the GB.Software wiki web page at *http://wiki.gb.nrao.edu/*. Several of the changes have already been incorporated, and metrics are being gathered in April to determine the extent of the improvements. A separate meeting was held on March 17 to discuss, revise, and prioritize the list of most significant maintenance work that could be done to the telescope control system in the upcoming months. This meeting clearly outlined the top items requiring attention, so that more focused maintenance work can be conducted throughout the spring and summer.

Green Bank Telescope

Progress towards 2004 goals in software operations was continued during Q1 2004, primarily in the testing arena. As of this time, the group's approach to integration testing, astronomical regression testing, and a follow-up round of integration testing is now fully documented and is reproducible from cycle to cycle. This positions the group well for automating much of its testing by the end of the year, a key internal goal for 2004, which will relieve resources from the often time-consuming process of manually running systems-level tests.

In other areas, significant work was completed to support pre-commissioning tests of the Ka-Band receiver, which will commence in April. The encoder reading portion of the Tipper Manager was revised to support hardware changes. Calculations for wind speed on one of the weather stations was changed to support a new sensor. A proper error message is now provided when the LO1 is commanded out of range. Prior to v4.2, the LO2 frequencies as reported by the converter rack manager were potentially misleading. Now, the commanded frequency is now rounded to the nearest KHz, the rounded frequency is reported to the IFManager, and a message is displayed when significant rounding occurs. The active issue regarding the DCR missing its start tick, resulting in bad data, has finally been resolved this quarter. The antenna is also now being compiled with a properly configured STL library, which means that occasional antenna coordinator errors which were seen in previous M&C versions should no longer occur. Work on the software manager for the Caltech Continuum Backend (CCB) was started in January, and will be ready for testing in May.

Small, stopgap improvements were also made to other products, such as GO (which will be replaced by the Configuration & Observing APIs). For example, GO now correctly writes scan numbers to its log file. The GO procedures RaLongMap, DecLatMap, and PointMap now can all start from a position other then the beginning. The act of aborting a GO Table now functions properly.

Other Projects

Work on the Ease of Use Initiative and Data Handling Improvements, and support of the PTCS project is described in the "GBT Development Projects" section of this report.

Computing

Raw Data Archive

The GBT interim raw data archive went online in February. This provides disaster-recovery backup and local access to GBT raw data back to Dec 2002, and is complimentary to the externally available central NRAO archive. As well as science data, all test data and GBT logs are available. A full description of what is in the archive and how the data is organized at available *http://www.gb.nrao.edu/newgbarchive*. Updates to the archive will continue to be made on a monthly basis.

Green Bank Telescope

Sysadmin Workshop

In March, Green Bank hosted a system administrator's workshop that focused on the accelerated Common Computing Environment (CCE) project. This was held in the new visitors center and was very successful with several areas being identified for future improvements. As a result of this workshop the sysadmins will be having a close look at Macintosh OS/X with a view to making this a CCE supported operating system.

Web Server Upgrade

The experimental apache version 2 webserver is now being configured at Green Bank prior to it being deployed observatory wide.

Web Mail

As a result of user demand, we are developing a web mail service which will be of benefit to all, especially travelers. An experimental web mail interface has already been set up and is in the process of being tested in preparation for an observatory wide system being deployed. If anyone wishes to try this out they should contact Chris Clark.

Network Improvements

Two new switches have been deployed in the equipment room to provide extra connections. One of these is currently gigabit and the other will shortly be upgraded to gigabit. This upgrade will provide an increase in data transfer rates between machines and overall performance.

Software Packages

The Starlink software package was upgraded this quarter to the latest release.

PTCS

Pointing/Focus

Dynamic corrections to pointing and focus to compensate for the effects of thermal gradients are now in production use, and are generally working well. There have been some minor problems with the Antenna Characterization manager, which calculates the corrections and passes them to the Antenna; we believe these have now all been resolved. Progress to improve the robustness and functionality of the new peak/focus real-time fitting and display package (GFM) has been slow; this will need to be addressed in the second quarter. The hardware aspects of the system have been extremely reliable. Considerable

additional documentation has been added to the PTCS web pages to assist observers in planning their observations.

Work continues to further extend the capability of the dynamic corrections. We are developing a preliminary algorithm that corrects pointing for wind-induced errors. Pointing corrected with this algorithm shows no correlation with wind speeds or directions (at least under all conditions sampled by our existing dataset), hence we are optimistic that our 5 m/s wind speed goal can be reached. Algorithms under test now indicate one-sigma focus errors of 1.2mm and radial pointing errors of 3.6 arcsec when tested against our full pointing dataset and excluding daylight hours, and corresponding 1.4 mm and 4.0 arcsec errors over all time-of-day and wind conditions.

The next phase of pointing correction instruments and analysis is underway. The first set (of three) of inclinometers and accelerometers are on the GBT and are producing data. We will now undertake a set of targeted experiments including astronomical observation to investigate the effects of uneven azimuth track, wind, and main drive servo disturbances on pointing. In addition we will compare measured alidade tilts with thermal model predictions to develop additional confidence and insight into the thermal correction algorithms.

Surface Efficiency/Holography

A campaign to measure and improve the surface accuracy of the GBT using phase-coherent and out-of-focus (OOF) holography techniques is now underway. Phase-coherent holography is being performed at 12 GHz using a geo-stationary satellite at an elevation angle of about 42 degrees, near the so-called rigging angle of the telescope. The OOF technique is being tested at 12, 22 and 43 GHz, using astronomical methanol, water and SiO maser sources. The two techniques are complementary: phase-coherent holography provides higher spatial resolution, but our system is currently restricted to 12 GHz and a single elevation; the OOF technique provides lower spatial resolution, but can be performed over a range of elevations, and at higher frequencies. Fred Schwab from the Charlottesville staff is analyzing the phase-coherent holography data, while the OOF measurements are being analyzed by Claire Chandler from Socorro, in collaboration with Richard Hills, John Richer and Bojan Nikolic of Cambridge University. Preliminary inspection of the data looks promising, and detailed analysis is underway. It is now also possible to command the shape of the GBT active surface by inputting a series of Zernike polynomial coefficients; this provides a convenient and very quick (few seconds) method for trying different surface adjustments, and we will use this capability to input the results of the holography measurements. Test time is scheduled in April to apply the holography results, and measure the resulting improvement in gain.

Additional Future Work

The current refraction corrections in use at the GBT include a scaling factor which we now believe is incorrect by ~10% (corresponding to ~ 6″ at 45 degrees); this is currently being approximately

corrected for by the elevation terms in the traditional pointing model. Although not a limiting factor for current observers, as part of the general program to reduce all potential sources of pointing error, we plan in April to update the refraction model, re-deriving the traditional pointing model terms as required from existing data.

Conceptual designs are underway for instruments and methods to correct primary mirror distortions due to thermal effects as well as to derive an improved model of gravity effects. Laser rangefinder studies will begin at a low level in this coming quarter, focusing on the improvement of laser rangefinder pointing capability. These studies will determine whether simple improvements to the rangefinder hardware can provide robust pointing, the most significant practical problem encountered in our summer 2003 laser rangefinder experiments.

Ease of Use Project

The Ease of Use project is underway so that observers can more easily configure the telescope and perform observations with the GBT. It includes the ability to define observations in advance of observing, the ability to execute those observations, improved monitor and status information while observations are executed, and an improved real-time display. At the moment, Ease of Use work is focused on providing readiness for Scheduling-Block based operation, including completing APIs for Configuration, Observing and simplified Balancing which will be used by a Scheduling Block Executor.

Continued progress was also made on the Configuration API, which is now being used regularly by astronomers and is approaching maturity. Some issues remain, however, that will be addressed during Q2 before this API's official production release. Recent additions include allowing the user to specify the number of banks to be used in a Spectrometer configuration, allowing the user to set the IFRack analog power level to a desired value, supporting 3-window and 6-window spectrometer modes, and being able to configure some user-provided backends as well as the Ka-Band receiver.

Observing API beta development extended beyond the initial beta release goal of February 16, 2004. On-telescope testing by the scientific sponsor was initiated, however, during February and March. The Observing API encapsulates "building blocks" which can be used by observers who wish to write their own procedures, by pre-packaged observing procedures, and also by any graphical interface. By successfully slewing to a position in the sky and tracking, the team was able to validate its prototype approach in December 2003, and developed on this foundation throughout the quarter. By mid-February, the team had recreated most of the GBT's observing procedures, and assessments were underway to determine how easy it was for astronomers to create their own procedures with the toolkit, in addition to stringent testing on simulators and on the telescope. In March, the development team added knowledge of time- and coordinate-system sensitive actions, in preparation for a beta release late in the spring. The beta release has been delayed because there are still some open issues regarding how to implement the Configuration & Observing APIs in a Scheduling Block context, particularly how to best integrate

"global" keywords without duplication of software effort. However, out of 13 procedures (some with 2-4 variations), 9 have been written and tested, and 4 are in progress.

Data Handling Improvements Project

This project covers all aspects of observer-facing software that are encountered after an observation is successfully made, from data quality assessment and quick look capabilities through imaging. In Q1 2004, work focused on a) continued incremental improvements to the new real-time display, GBT FITS Monitor (GFM), b) improvements to the AIPS++ DISH single-dish reduction environment, including completely revised documentation which is accessible from the GB.Data wiki, and c) high-level strategy discussions including reengineering DISH in a more interoperable context, which was reviewed and evaluated within the newly launched E2E Architecture and Design Committee. Several adaptations are in progress to the GBT strategy to ensure that long-term needs are balanced with immediate user demands.

Accomplishments during Q1 included some items which were not available until shortly after the end of the period:

- Production Release of GBT FITS Monitor for limited continuum online and offline data processing (February 25)
- Fully updated DISH documentation on the GB wiki (January 16)
- Release of Phase 1 of DISH updates, including adding reduce.g to d.calib and other changes at DishRequests (March 31)
- GBT Informational Presentation to E2E Architecture & Oversight Committee (March 31)
- Beta Release of CLASS binary generator (April 6)

Penn Array

In Q1 2004 work at University of Pennsylvania proceeded along a number of fronts. A major priority was finalizing cable and flexline orders for the dewar; at the end of Q1 this was nearly complete. Substantial effort was also invested in tracking down a mysterious extra cryogenic load which appeared in the test dewar in late 2003, and tentative indications now point to a cold fault in one of the cables. Drawings for the detector box assembly were completed, submitted to the GB machine shop, and the parts completed and delivered to Penn. A major milestone was achieved in operation of the multiplexing in the lab at Penn. At Goddard, significant progress was made on the firmware upgrade for the multiplexing readout electronics, and specifications for a datastream parser were written. Some difficulties have been encountered in designing the absorbing layer of the detectors which unresolved would lead to limited frequency bandwidth and degrading optical performance over time—these issues are being investigated by GSFC personnel. A project meeting was held at Goddard in February, focusing on NASA's Instrument Remote Control (IRC) language and its interfaces. IRC will provide the framework for control of and acquisition of data from the Penn Array during engineering commissioning.

We determined that IRC can be interfaced to the GBT via Python since the GBT monitor and control system has a Python interface and IRC supports observing procedures written in python. The other crucial instrument interfaces to IRC are GPIB (an IRC interface layer to which will be written by GB) and PCI (which GSFC is working on).

Work on the analysis software at NRAO has continued, with improved fourier-series based filtering being incorporated into the iterative single-dish imaging package OBIT. Goddard has also passed on their IDL-based linear inversion imaging package, and work has begun applying it to simulated Penn Array data. Data taken late in December 2003 to prototype mapping scan patterns were analyzed; the results are encouraging, indicating that structural vibration modes are not significantly excited, although there are indications of measurable quasi-static distortions correlated with the antenna acceleration.

The target for Penn Array engineering commissioning is early 2005. While there is substantial schedule risk, particularly from the detector production, as a backup plan the PAR can be commissioned with existing individual bolometers. A June project meeting will assess the project's performance with respect to this target.

Caltech Continuum Backend

Following the major reorganization of the Caltech Continuum Backend (CCB) project in the fourth quarter of 2003, a project meeting was held on January 15 and 16 in Green Bank. The team reviewed and agreed upon the post-amplifier detector circuit design, reviewed the schedule and strategy to build the instrument, and brainstormed different FPGA choices, methods of communication with the master computer, and packaging options. Since the project meeting, Caltech has documented a detailed consideration of a range of FPGA architecture options and tested USB and parallel port communications interfaces. This work has led to a draft design for the main instrument board; Green Bank has reviewed this design and agreed to take it through to a final board layout. Green Bank staff have also assembled a prototype detector circuit board. Basic DC tests of the circuit give the expected results; dynamical characterization is a priority for early Q2, and will be performed as copies of the prototype circuit are fielded on the GBT for the spring commissioning of the Ka-Band receiver. The CCB YGOR manager architecture and scientific requirements have been mapped out and much of the manager has been written. Q2 will see tests of the manager with the CCB simulator Caltech provided in 2003. The project is moving towards a review in May 2004, an assembly phase over the summer, and commissioning on the GBT with the Ka-Band receiver in fall and winter 2004. Caltech and NRAO will share responsibility for assembly, test, and commissioning.

Green Bank Telescope

Green Bank Science Center & Dormitory

The Green Bank Science Center and Dormitory projects are complete, the contractors have been paid in full, and these facilities are now in routine and wide use. This will be the last report on these two construction projects.

Very Large Array and Very Long Baseline Array

Very Large Array Highlights

A workshop on "X-ray and Radio Connections" was held in Santa Fe, New Mexico, from February 3 through February 6. This meeting was hosted by NRAO and co-organized with Los Alamos National Laboratory and the Chandra X-ray Center. Approximately 110 scientists attended, including many observers who employ one or both of these electromagnetic bands and a number of attendees who are primarily theorists. Scientific topics included massive star cluster outflows, colliding stellar winds, supernova remnants, pulsar wind nebulae, dissipation of jets and lobes, and galaxy cluster mergers.

Prototype concrete planks have been developed for the support of VLA rail intersections. Since the concrete planks are less expensive and more robust than wood timbers, rail maintenance costs will be reduced by using planks instead of timbers.

The construction of a new office building is under way on the New Mexico Tech campus; this building will temporarily house 20 NRAO employees. The building will be ready for occupancy in early summer 2004.

Very Long Baseline Array Highlights

The analog tachometers on the VLBA antennas at Pie Town and Hancock were replaced with new digital tachometers. The noisy signals produced by the analog tachometers routinely cause drive motor fuses to blow. Digital tachometers will be installed on 3 more VLBA antennas this year, and operations costs should decrease as a result.

The VLBA operations group was reorganized to eliminate a layer of middle management and increase efficiency. Resulting savings will be used, among other things, to help fund the beginning of implementation of Mark 5 recording on two VLBA stations later this year.

VLBA staff have made significant progress in investigating the feasibility of using VLBA observations for spacecraft navigation. Using the total delay observable, systematic offsets between VLBA phase-referencing and JPL position measurements have been resolved, and now provide consistent results within the error level of 0.3 milliarcseconds or less.

Management and Scientific Services Milestones

Milestones	Original Date	Revised Date	Date Completed
VLBI Calibration Transfer for GBT Completed	10/15/03	05/31/04	12/31/03
Test Report on VLA Water Vapor Radiometer Prototypes	12/18/03	01/15/04	01/15/04
AIPS++ Stable Release 4	02/01/04	01/15/04	01/19/04
VLA Large Proposal Deadline	02/02/04		02/02/04
VLA/VLBA General Proposal Deadline	02/02/04		02/02/04
Santa Fe Workshop on Radio/X-ray Connections	03/31/04	02/06/04	02/06/04
VLBI Future Report Completed	09/30/03	02/15/04	02/13/04
Complete Tests of Resurfaced Subreflector at Pie Town	05/15/03	02/28/04	02/28/04
AIPS++ Stable Release 5	03/15/04		03/26/04
VLBI High Sensitivity Array Call for Proposals	04/01/04		
EVLA Phase 2 Proposal Submitted to NSF	02/28/04	04/09/04	
Global 3mm VLBI Session	04/21/04		
Large Proposal Review Committee Meeting	06/30/04	04/30/04	
Complete Project-Oriented Sci. Staff Reorganization	05/15/04		
AIPS++ Stable Release 6	05/15/04		
Temporary Office Space Occupied	05/10/03	06/01/04	
VLA/VLBA General Proposal Deadline	06/01/04		
Synthesis Imaging Summer School	06/30/04	06/22/04	
AIPS++ Stable Release 7	07/15/04		
Pie Town 3mm Test After Re-setting Panels	05/31/04	08/31/04	
Complete VLBA Pilot Program for S/C Navigation	01/30/04	08/31/04	
Initial Version of Proposal Submission Tool	09/01/04		
AIPS++ Stable Release 8	09/15/04		
VLA-Pie Town Link 4th Operational Session Begins	10/01/04		
VLA/VLBA General Proposal Deadline	10/01/04		
VLBI High Sensitivity Array—First Observations	11/01/04		
Implement Mark 5 Recorders on Two VLBA Stations	12/31/04		
AIPS Frozen Release of 31DEC04, Begin 31DEC05	12/31/04		

Computer Infrastructure Milestones

Milestones	Original Date	Revised Date	Date Completed
Increase archive to 8TB	11/01/03		11/30/03
Increase archive to 11TB	01/15/04		01/30/04
Phase 2 AOC Rewire	07/31/03		01/30/04
Upgrade to RedHat 9.0	09/30/03		01/30/04
Replace AOC Wireless Network	12/31/03		01/30/04
Configure/build Filehost replacement	11/30/03		02/15/04
Establish NRAO-NM VPN Capability	06/30/03		03/15/04
Install summer student systems	05/15/04		
Deploy MRO building network	06/01/04		
Examine OS/X support	09/30/04		
Replace all systems >6 years old	09/30/04		
Migration to Windows 2K domain (1)	07/31/03	10/01/04	
Phase 3 AOC Rewire	12/30/04		

Operations Software Support Milestones

Milestones	Original Date	Revised Date	Date Completed
Track program modifications for Mark 5	10/30/03	04/01/04	
Satellite tracking software mods	02/01/04	04/01/04	
VLA Op. logs on archive web page	01/01/04	05/01/04	
Online VLA recording to DAT	02/01/04	05/30/04	
Correlator controller transition plan	02/28/04	05/30/04	
Correlator controller changes to Modcomp	03/30/04	05/30/04	
Correlator controller bug fixes	03/31/04	05/30/04	
Transcribe VLA observe/system files	11/30/02	05/31/04	
Correlator controller integrate line/continuum	06/30/03	06/30/04	
Translate and copy stored VLA monitor data from 9-track to DAT	03/01/04	07/01/04	

Electronics Milestones

Milestones	Original Date	Revised Date	Date Completed
Pie Town Link (LO/IF)			
Pretest Pie Town Link hardware and software	08/13/04		
Complete construction & checkout of spare L6, F4, and Pie Town data sets. Develop a full system checkout procedure	09/30/04		
Lab Services			
Implement ESD procedures in assembly areas	07/30/04		
Receivers (FE)			
Install K-Band receivers #27 and #28 in the VLA	04/30/04		03/30/04
Install K-Band receivers #29 and #30 in the VLA	09/15/04		
Improvements			
Replace the maser at Brewster, WA	02/15/04		12/12/03
Repair the back-up maser (EFOS) at VLA	02/16/04		01/20/04
Develop Windows based QA tools for VLBA Base Band Converter (BBC) repair	03/05/04		03/05/04
Install digital tachometer system at Hancock, NH and at Pie Town, NM	07/30/04		03/19/04
Investigate the impact of XMSR and the 2.56 GHz Broadband Internet on Fort Davis, TX S-Band performance	06/15/04		
Replace the maser at Hancock, NH	07/30/04		
Upgrade the ACU power supply & backplane at Pie Town, NM	09/15/04		
Install digital tachometer system at Fort Davis, TX	09/30/04		

Engineering Services Milestones

Milestones	Original Date	Revised Date	Date Completed
Complete CnB array reconfiguration	01/30/04		01/22/04
Complete C array reconfiguration	02/20/04		02/20/04
Complete DnC array reconfiguration	05/28/04		
Complete D array reconfiguration	06/18/04		
Mechanical Group			
Pie Town maintenance visit	04/05/04		

Milestones	Original Date	Revised Date	Date Completed
Receive new azimuth bearings	04/30/04		
Adjust panels at Pie Town	05/15/04		
Replace Ant #14 AZ bearing	05/30/04		
Ft. Davis maintenance visit	06/10/04		
VLBA second drive wheel construction	06/30/04		
Brewster maintenance visit	08/09/04		
Mauna Kea azimuth rail repair	06/16/03	09/30/04	
Owens Valley maintenance visit	10/04/04		
Electrical Group			
CW7 transformer repair	01/30/04		01/07/04
VLA anemometer upgrade	04/01/04		
Site & Wye Group			
Complete track repairs between BN6-AN5	12/31/02	05/28/04	
ES Engineering Group			
Water tank repair	09/30/04		

AIPS

Key Developments

1. Changed the VLA data format translation task (FILLM) to handle a wider range of data as now provided by the archive. In particular, different configurations are recognized and kept separate.

2. Provided support for data-reduction pipeline and other procedures. Tasks that now return their results to allow procedures to use them include SETFC to set suitable image and cell sizes for imaging, IMFIT and JMFIT to fit Gaussians to images, and RLDIF (new) to measure the phase difference between the parallel polarizations in order to calibrate linear polarization.

3. Changed the basic calibration (CALIB) and fringe-fitting tasks (FRING) to allow for overlapping solution intervals, which should resolve phase ambiguities. CALIB also now allows for different calibrator fluxes in "RR" and "LL" polarizations in case the calibrator source has real circular polarization. This trick allows the Westerbork telescope to calibrate its linearly-polarized total intensity channels.

4. Added the concept of a read-only data area, thereby enabling the use of read-only DVD data devices for data transfer.

5. Changed handling of tape device assignments inside AIPS to allow for more devices without breaking other parts of the code. Unfortunately, this means that the 31DEC04 and previous versions of AIPS cannot share the remote tape daemons.

6. Improved the astrometric task DELZN to make delay and clock error and rate solutions available to other programs including AIPS' CLCOR.

7. Worked on documentation, completing all adverb help files, updating the cross-referencing files used by ABOUT and APROPOS, and making minor revisions to the CookBook. XHELP was made to work again; Charlottesville's web site no longer provided needed support. Its functioning was also corrected and improved.

8. A task to renumber sources (DSORC) was written.

9. In the first quarter of 2004, 93 sites downloaded the 31DEC03 (frozen) version of AIPS and 268 downloaded the 31DEC04 (development) version. A total of 297 different sites (separate IP addresses) made some use of the AIPS cvs facility, either during installation of 31DEC04 or running the "midnight job" to update their copy of 31DEC04.

Goals for the Second Quarter 2004

1. Continue user support and bug fixes, as the major portion of AIPS effort.

2. Complete update of CookBook including html and pdf forms with full cross-referencing.

3. Consider methods to include source models with AIPS distributions.

4. Continue the moderate-term project to explore improved troposphere calibration.

5. Provide support for pipeline data reduction, especially new automatic editing algorithms.

6. Investigate calibration by phase referencing with two calibration sources.

7. Add weight-based flagging to be able to use flag tables.

8. Begin investigations of new/improved imaging algorithms, including those dealing with spectral index and multiple pointings.

Very Large Array and Very Long Baseline Array

Interferometry Software Division

General

In mid-2003, a new matrix-managed Interferometry Software Division was formed. This Division has taken over responsibility for interferometry post-processing software and for development of end-to-end data flow software common for all NRAO telescopes. In the past several quarterly reports, we have gradually incorporated more milestones from this new organization within the Management and Scientific Services portion of the VLA/VLBA section. Below, we provide a discussion of the specific progress made in the Interferometry Software Division over the past year (excluding AIPS). In succeeding reports, we will provide more succinct summaries of progress on a quarterly basis.

The Interferometry Software Division (ISD) was formed to deliver software meeting the scientific requirements of the NRAO radio interferometers, both operating instruments and development projects; VLA, VLBA, ALMA, and EVLA. The key long-term goal is to meet the requirements of EVLA and ALMA, often using the VLA and VLBA as test beds. The key short-term goal is to produce software that delivers new capabilities to the scientific community currently using the NRAO telescopes.

The two primary areas of activity for the ISD are (1) all aspects of end-to-end (e2e) software, and (2) interferometry post-processing software. The aim is to develop, as much as possible, software and software systems that are common and/or compatible among the different instruments. (Monitor and control software generally is not included, since it is so closely linked to specific telescope hardware implementations.)

Since ALMA actually has more resources devoted to these activities ALMA systems are used as the baselines. Whenever possible, developments for other projects take advantage of ALMA developments, with re-use mandated whenever it improves efficiency in use of resources and/or in the systems presented to end users of the telescopes. When appropriate (e.g., proposal tools and archives) developments are carried out in which the GBT requirements are also incorporated, and common systems are being built for all NRAO telescopes.

The Interferometry Software Division is a matrix-managed division under the joint control of VLA/VLBA Operations and ALMA. Figure 1 shows a functional organization chart of the Division. The Division consists of a number of Integrated Product Teams (IPTs) and Groups, with membership drawn from the various operating telescopes and projects. (In theory, these teams may form and disband as products are delivered, but in practice, most of the activities are long-term and the current teams are likely to exist for quite some time.) Each team contains a lead or manager, as well as an IPT scientist who is responsible for coordinating scientific requirements. Membership in each team may be drawn from EVLA, ALMA, or VLA/VLBA Operations; the management of the team members' work (and a fraction of their time) is delegated to the team lead.

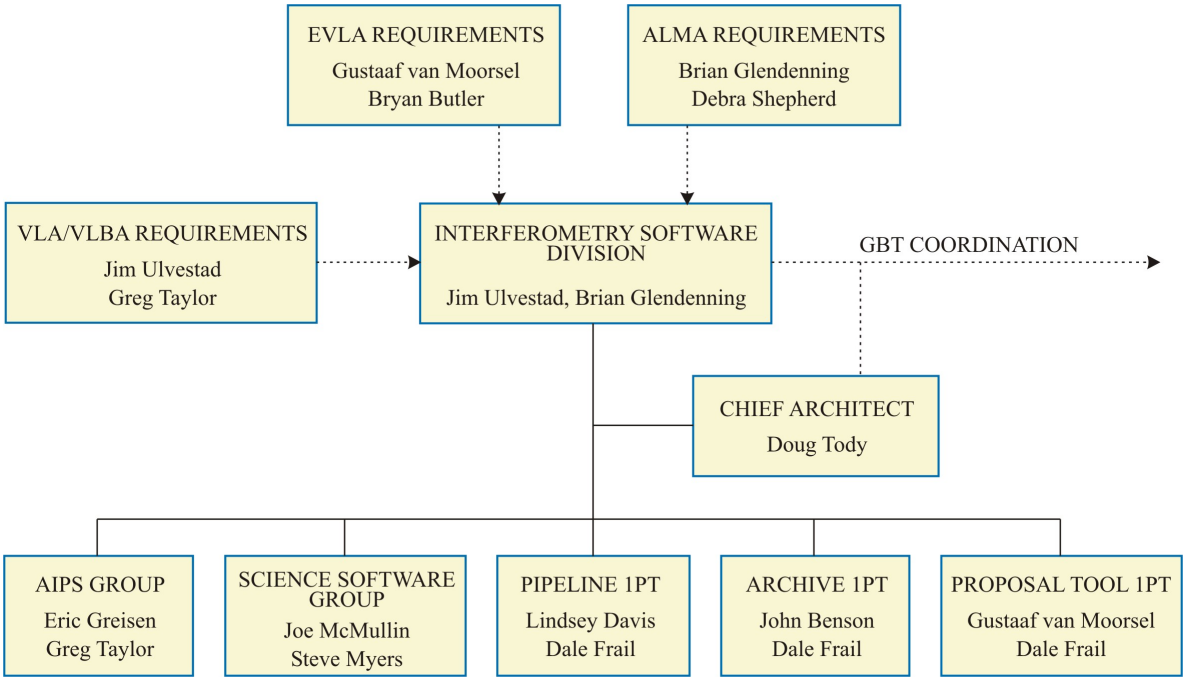

Figure 1. Functional Diagram of Interferometry Software Division.

The ISD contains a system architect, whose primary responsibilities are to ensure an overall coherent effort, a workable data-flow system architecture, consistency with standards and requirements for the National Virtual Observatory, and appropriate coordination between the interferometry group and the GBT personnel and requirements. Scientific requirements for the ISD flow from the projects and telescopes deliverables based on those requirements are negotiated between the projects and the IPTs, according to the resources allocated to each IPT. When conflicts arise over priority, lack of resources, and/or implementation, these conflicts are resolved by the system architect and the two ISD co-managers. Beginning in January 2004, the team leads and scientists, as well as the project software managers and scientists, have met semi-monthly (moving to monthly in April 2004) to exchange information and improve coordination.

AIPS++

The AIPS++ project and consortium were cancelled in April of 2003 by NRAO. The observatory then re-organized its computing efforts to reflect a strong, telescope-project focus. The SSG (Science Software Group) continues development of the legacy AIPS++ code base for specific NRAO purposes; currently it is principally driven by ALMA Offline reduction requirements.

The current SSG personnel within NRAO are 5.25 FTEs, comprising four astronomer developers (at 75%) and three computer scientists (at 50-100%); an additional NSF grant position outside the NRAO main budget makes available one FTE for visualization.

The accomplishments since inception (June 2003) are described below.

Benchmarking:

A detailed study of the performance of the code's imaging capabilities was performed. Significant progress in this area has brought the imaging steps to near-parity with comparable packages (such as AIPS, Gildas, MIRIAD). Initial identification and implementation of calibration improvements have also been underway. A use-case based, automated web publishing of benchmark results has been established to track the performance of the package, identifying potential problems in the code and demonstrating improvements with time.

Figure 2 displays successive improvements in AIPS++ imaging performance over the past year. The red curves are for the Cotton-Schwab (CS) Clean algorithm implementation in AIPS++ while the green curves are for improved versions of CS-Clean in AIPS++. Iterative improvements to the software performance have taken place over the last 9 months so that imaging speed now is approaching that of the AIPS software traditionally used for VLA and VLBA data.

ALMA Benchmark page:
http://shiraz.drao.nrc.ca:8080/AlmaDRPBenchmarks/

Scientific Completeness:

This is driven by the ALMA Science Software Requirements. Key developments include: uv-plane and imaging plane continuum subtraction, flexible interpolation of calibration solutions, scan-based calibration solutions, high frequency calibration support (specified zenith opacity), calibration gain curve corrections, data split and concatenate facility, visualization blinking, visualization data editing using statistics (mean, median, rms, difference). In addition, there are scheduled six month tests within ALMA for evaluation of the software. ALMA TST1 took place in January-February 2004; four datasets (2 VLA & 2 PdBI) were reduced and imaged by six testers with experience in interferometry. The full report can be found at the web site below; overall the test was passed and a significant decrease in "Inadequate" functionality was seen.

ALMA TST1 Page:
http://projectoffice.aips2.nrao.edu/almatst1/ALMA_TST1.html

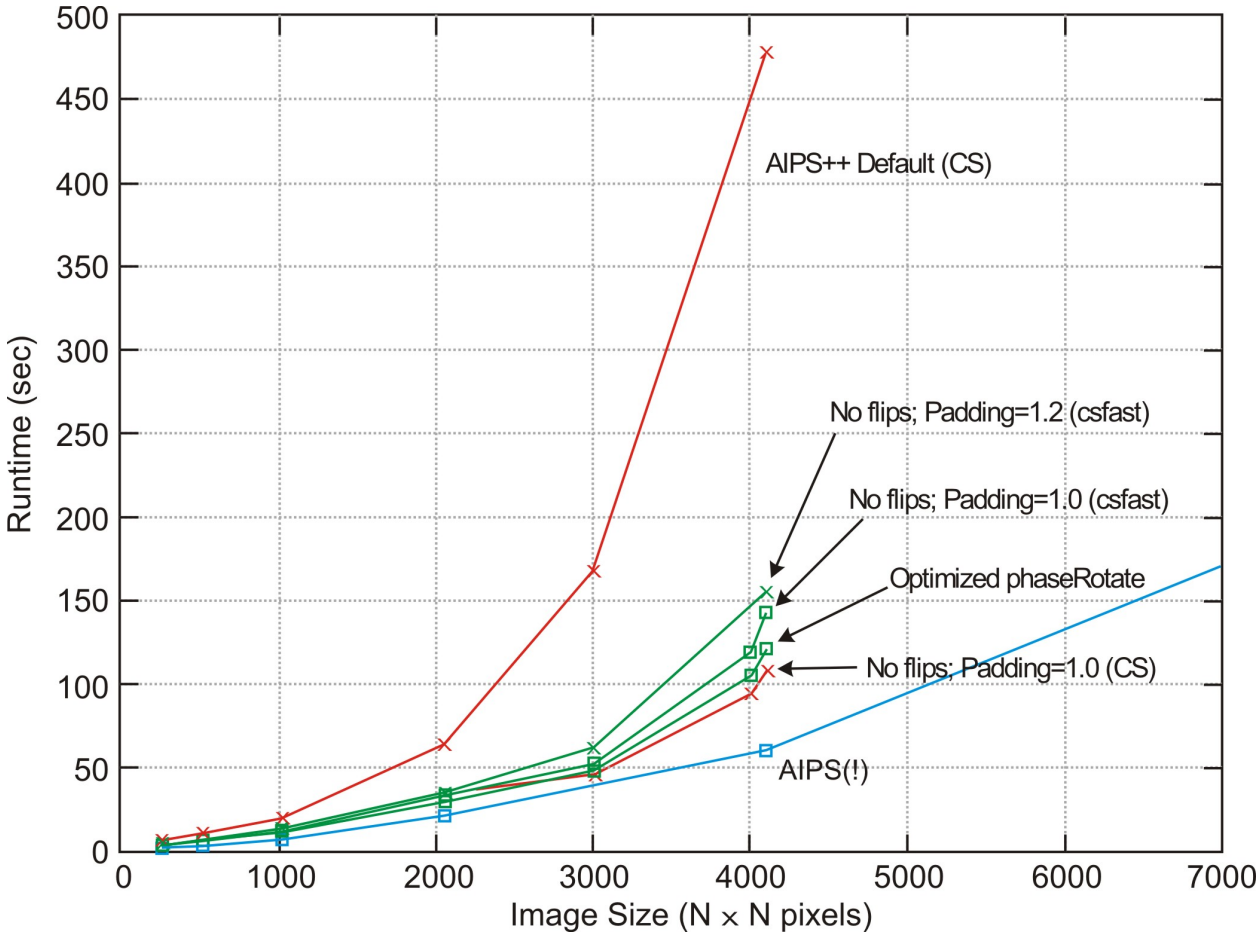

Figure 2. Wall-clock run time for interferometric imaging in AIPS and AIPS++. The horizontal axis is the number of pixels in each dimension, while the vertical axis is seconds of run time.

Process:

A 3-year plan for the development of all Priority 1 ALMA Offline requirements was drafted, along with key gains in performance and robustness. A project office page was constructed for tracking of progress and for coordination with projects and internal scientists. We have completed six, 2-month development cycles within one week of schedule. There is also a strong feedback loop with internal NRAO scientists through the Project Scientist (Myers) and the NRAO AIPS++ Users (NAUG) group. They provide reviews on proposed implementation ideas and verification of application developments.

SSG Project Office page:
http://projectoffice.aips2.nrao.edu

Very Large Array and Very Long Baseline Array

Infrastructure:

A migration of the code management system to CVS (from RCS) was done to facilitate a more open development and to better coordinate with the overall ALMA computing which uses this system. A requirements document for a revised data reduction framework were drafted in line with the Technical Review committee recommendations of 2003. Effort in this area continues with a design scheduled for 2004 and a staged implementation through mid-2007.

SSG Change proposals:
http://aips2.nrao.edu/daily/docs/project/change-proposals/change-proposals.html

Archive

The NRAO Data Archive has been operational since 1 Oct 2003. It allows everyone access to all non-proprietary VLA data and some VLBA data (*http://archive.nrao.edu/archive*). Two hundred-fifty users from 124 institutions downloaded over 4400 telescope data files in the first four months of operation. Data files over 18 months old (changing to one year for recent observations) are in the public domain (see URL below for details) and accounted for 75% of the downloads. The data files reside on a hard disk array and allow the archive users fast access and downloads via FTP and secure channels.

Currently the archive contains all VLA data going back to 1976, raw VLBA data going back to June 2002, and some calibrated VLBA data going back to December 2002. Efforts to fill the VLBA archive back to 1992 are under way. There is a small amount of GBT data available now from 2002 and 2003. We intend to begin archiving GBT data and making it available in the near future. The GBT archiving depends on the GBT writing data in its new single FITS file format.

The data archive occupies ~8 TBytes currently and will expand to nearly 20 TBytes as historical VLBA data are copied to disk. We have an arrangement with NCSA where they will provide 30 TBytes of archive capacity to NRAO to maintain a mirror-site. The NCSA mirror-site will also allow users to download data from there. Data transfer to NCSA is just now beginning. A 1 TByte shippable disk array (showbox) will be used to move data to NCSA in stages.

A new NRAO-wide data archive policy has been written and may be found at *http://www.nrao.edu/administration/directors_office/dataarchive.shtml*. The new policy shortens the proprietary period from 18 to 12 months, beginning with the start of VLA C-array observations in February 2004. The 12 month period is consistent with proprietary periods at other major observatories.

The development of the NRAO Archive is proceeding in phases. The first phase is essentially complete: we now provide users with access to all VLA data and tools to identify and download the data they require. The next phase makes the archive scientifically more useful to a wider range of astronomers, especially non-radio astronomers. To that end, a group is discussing several issues: improvements to the user interface, more descriptive display tables, and automated data reduction pipelines that will produce

calibrated data and useful images. We are just beginning to design a pilot project here that will experiment with various ways to accomplish pipeline calibration and imaging.

Through the NRAO Newsletter, we are encouraging people to use the archive, experiment with it, and send comments and suggestions back to the developers in Socorro. The web-page at *http://e2e.aoc.nrao.edu/archive/archivefuture.html* contains an outline of the highest priorities for development in the near future.

Pipeline

The pipeline IPT in the ISD is tasked with developing infrastructure for the ALMA pipeline. This infrastructure will then be reused in EVLA pipeline developments. The heuristics (decision logic) for the ALMA pipeline will be further developed in Europe.

Pipeline development to date has concentrated in two areas. First an interface to the overall ALMA software system was developed. This interface responds to the other ALMA software subsystems as defined in the overall ALMA design, for example it accepts events to initiate processing as sent by the scheduling subsystem. However behind this subsystem the actual processing is only "stubbed." This development is to allow the whole ALMA software subsystem to be incrementally developed without missing pieces.

The major pipeline development to date has been the development of a prototype pipeline. First native AIPS++/C++ processing engines have been connected to the ALMA Common Software, totally replacing the underlying AIPS++ tasking system. This makes the processing engines interface compatible with ALMA and enables the Python scripting language to be utilized as required by ALMA. This technology development went fairly well, although there were some problems related to file locking in a multi-threaded environment that took some time to resolve. With the prototype technology development largely completed, work is now (March 2004) proceeding on the development of some heuristics to process a set of VLA X-Band Gamma Ray Burst data and a IRAM mm synthesis data set. The whole prototype pipeline will then be tested in an external user test set to conclude in May 2004.

After this prototyping phase, the next major task will involve bringing further pipeline developments together with the ALMA software system interfaces, working through developing heuristics for ALMA specific observing modes. It is also intended that a very simple prototype of a quick-look pipeline be deployed at the ALMA Test Facility (ATF) at the VLA site late in 2004.

Very Large Array and Very Long Baseline Array

Proposal Tool

The ISD proposal tool team was formed in late 2003, and includes programmers and scientists who represent the individual NRAO instruments and projects. The goal is to create a common proposal tool for all NRAO telescopes and projects. The initial goal is a GBT proposal tool for fall 2004, adding support for VLA and VLBA during 2005, and for the EVLA and ALMA at a later date.

To start collaborations with ALMA before their efforts have diverged too much from the EVLA effort, the proposal team is currently negotiating with the UK-based ALMA proposal team to ensure commonality between the NRAO proposal tool and ALMA's phase 1 proposal tool. First indications are that these negotiations are successful and that agreement on common architectural principles and implementation can be reached.

Basic requirements for the proposal tool were formulated late 2003, and a first Strategy and Architecture document was added early 2004. The interface will initially be a Web-based form on which the user will fill out instrument-independent fields first. After selecting the telescope this is followed by one or more pages of instrument-dependent fields. A general description of the instrument-independent fields has been agreed upon among representatives of NRAO's telescopes.

Development of important databases for the proposal tool is progressing. Initial design for an NRAO-wide master address database has been agreed upon; we expect a final iteration of this design shortly. New users establish their own entry in this database by creating an account and signing in; they can edit their information at a later date. For a database of Astronomical Institutes we will use the contents of an extensive database Green Bank has developed. Finally, design of an NRAO-wide proposal database is under way.

National Virtual Observatory (NVO)

NRAO is a partner in both the US National Virtual Observatory (NVO) and in the International Virtual Observatory Alliance (IVOA). NRAO is active in VO development on three fronts: 1) participation in research and development of the international VO framework, 2) providing radio data and services to the VO, most notably for data produced by the NRAO telescopes, and 3) coordination of NRAO end-to-end data management and science data post-processing software development with the standards and technology being developed by the VO community.

Development of the international VO framework is currently being done by both the IVOA, which is primarily a standards body, and the individual VO projects such as NVO in the US, which are implementing the VO framework. NRAO leads the effort to develop the "data access layer", which is the VO technology required to write multiwavelength data analysis and data mining applications to access distributed astronomical data and data access services via the VO. Data analysis applications which previously ran on the astronomer's desktop will become distributed applications which remotely access

massive data archives, with parts of the computation running remotely, close to the data being processed. Other working groups are developing related standards for data models and astronomical metadata. Current work is focused on describing data provenance, uniform data characterization, and access to image, spectral, and time series data.

The main NRAO contribution in the past year towards providing radio data to the VO was the commissioning of the NRAO online digital archive. Despite being merely a raw visibility data archive now, the archive has been very successful for VO data mining, with access to nonproprietary (older) archival data running 3: 1 with respect to retrieval of new observations. An effort is currently getting under way to produce reference images and spectral data cubes for subsets of the archive, which would greatly increase the usability of the archive for multiwavelength data mining via the VO. An effort is underway to replicate the entire NRAO archive to NCSA to provide the user community with higher bandwidth access to NRAO data, and ultimately enable large scale processing of NRAO radio data on the Teragrid and its successors.

Coordination of NRAO software development with VO is occurring on many fronts. This includes engineering the end-to-end dataflow for each NRAO telescope so that observational data is fully described when acquired, allowing data to be automatically pipeline processed, adequately characterized in the archive to enable automated data mining, and ultimately referenced back to the original observational proposals and subsequent publications. As data is captured at the telescope it will be reformatted to a formal science data model and export data format conformant to VO standards. All observations will be tagged with a globally unique VO dataset identifier to uniquely identify data within the VO and reference datasets or derived products back to the NRAO archive.

Central Development Laboratory

Central Development Laboratory Highlights

The move to the NRAO Technology Center was completed. Four 1-2 GHz balanced amplifiers optimized for EVLA L-Band use were delivered to Socorro, and a prototype L-Band feed was successfully fabricated and tested. A prototype receiver cartridge for ALMA Band 6 was successfully fabricated and tested. A prototype ALMA correlator was completed and installed in Socorro for system integration testing; orders were placed for most of the custom integrated circuits, printed circuit boards, and other parts for the 64-antenna correlator. Pre-production ALMA local oscillator assemblies were completed and successfully tested for Bands 3, 6, and 7; the complete LOs are not yet in final form for Band 9 due to the present low efficiency of the cooled frequency multipliers. Beamlead HEB mixers for heterodyne THz biohazard detection were fabricated for the initial 600-720 GHz band and construction of a test receiver began. Observations of the sun at 20-70 MHz began at Green Bank using the prototype antenna and receiver for the Green Bank Solar Radio Burst Spectrometer (GB/SRBS), and the results are available via the internet.

Major Development Milestones

Milestone	Original Date	Revised Date	Date Completed
Amplifier Design & Development:			
Evaluation of TRW Cryo-3 devices from the point of noise, signal and dc properties at cryogenic temperatures	04-01-04	10-01-04	
Design/redesign of cryogenic amplifiers using Cryo-3 TRW devices for EVLA, VLBA, GBT and ALMA covering frequency range from 1 to 120 GHz	04-01-04	4-01-05	
Superconducting Millimeter-Wave Mixer Development:			
Freeze Band 6 cartridge design	12-31-03	01-31-04	01-31-04
Test Band 6 cartridge with production LO and bias supply	07-30-04		
Electromagnetic Support:			
GBT L-Band pattern simulations	03-31-03	01-31-04	02-28-04
Testing of EVLA C-Band prototype feed horn	09-30-03	06-30-04	
Testing of EVLA L-Band feed horn	12-31-03	04-30-04	03-31-04
Design of EVLA X-Band feed horn	12-31-03	06-30-04	
Testing of EVLA Ka-Band feed horn	12-31-03	06-30-04	

Central Development Laboratory

Milestone	Original Date	Revised Date	Date Completed
ALMA Correlator:			
Complete VLBA data recording project	12-31-02	12-31-04	
Release RFQ for motherboards	12-31-03		02-27-04
Ship the prototype ALMA correlator to Socorro	03-31-04		02-12-04
Support system testing at the AOC as far as the correlator is concerned	03-31-04	ongoing	
Update the PCB layout of the station and correlator motherboards	03-31-04		02-27-04
Release RFQ for motherboard assembly	03-31-04		02-27-04
Place order for the remaining printed circuit card assembly	03-31-04		03-31-04
Begin testing of assembled circuit cards for the first correlator Quadrant	06-30-04		
Complete all correlator lab construction work	06-30-04		
Place orders for all station and correlator bins	06-30-04		
Place order for signal cables	06-30-04		
Start testing of prototype data interface card	06-30-04		
Place order for 6U power card assembly	06-30-04		
ALMA Frequency Multipliers:			
Complete Band 6 frequency tripler evaluation set with actual driver amplifiers	12-15-03	06-30-04	
Complete Band 7 frequency tripler evaluation set with actual driver amplifiers	12-15-03	06-30-04	
Complete evaluation of four Band 6 frequency triplers for immediate cartridge work	10-15-03		10-23-03
Order Band 6 and Band 7 frequency triplers for ALMA production	11-14-03		03-04-04
Finalize action plan for Band 9 frequency quintupler	11-14-03		03-04-04
Complete evaluation of two Band 7 frequency triplers for immediate cartridge work	12-31-03		12-29-03
Band 6:			
Fabrication run (2 wafers, 50 devices each)	05-01-04		
Verify sample devices in existing frequency tripler blocks	06-30-04		
Delivery of production waveguide blocks from machine shop	07-01-04		
First batch of 25 units delivered to NRAO (Subsequently, 25 units each month until all of the 139 units are delivered.)	07-31-04		
Band 7:			
Finalize the layout and fabricate the mask-set	04-30-04		

Central Development Laboratory

Milestone	Original Date	Revised Date	Date Completed
Fabrication run (2 wafers, 50 devices each)	05-31-04		
Verify sample devices in existing frequency tripler blocks	06-30-04		
Delivery of production waveguide blocks from machine shop	07-01-04		
First batch of 25 units delivered to NRAO (Subsequently, 25 units each month until all of the 139 units are delivered.)	07-31-04		
ALMA LO Source:			
Delivery of the first LO driver	12-31-03	02-28-04	03-06-04

Amplifier Design and Development

Work continued on the development of amplifiers using devices from JPL/TRW Cryo-3 wafers. Testing of the prototype 1-2 GHz balanced amplifier has been completed. Three additional units have been built and tested. The amplifiers exhibit average noise of less than 4.5 K with minimum about 3 K and average gain of about 19 dB. These units also possess excellent input and output return losses of better than 15 dB (typically about 20 dB).

In the course of discussions with the Socorro team, it has been determined that the RFI mitigation at L-Band could be greatly enhanced by the development of a cryogenic amplifier with respectable noise but with possibly the largest output power at 1 dB gain compression point. This amplifier, also of the balanced type, would use commercial pseudo-morphic HFET's and would provide a second stage of cryogenic amplification in the L-Band EVLA receiver. Work has started on the design and development of such an amplifier.

Work on the final design of the 2-4 GHz amplifier and a new version of the 40-50 GHz amplifier continued.

Amplifier Production

Amplifier production and development activities resumed during the first quarter, even as out-fitting of the NTC facility continued. Production of standard amplifiers included six K-Band units and two Ka-Band LNAs. There were also six LNA repairs or Cryo-3 upgrades during the quarter. The group continued to provide support to ALMA in production of various MMIC amplifier designs. One new technician was added to the group on a temporary basis, replacing a 2003 retiree. The "new hire" was brought in as a temporary employee due to the hiring freeze and has been training for several weeks in amplifier micro-assembly.

Other Projects

The new chemistry lab became fully operational by the end of the quarter, with total production of 400 gold-plated components. Lab outfitting is essentially complete at this point, with much of the aged equipment from the CDL having been either refurbished or replaced.

Superconducting Millimeter-Wave Mixer Development

ALMA Receiver Development

Following delivery of the first Band 6 orthomode transducer this quarter, the prototype Band 6 cartridge is now complete except for the rear module which contains the local oscillator and bias circuits. Nevertheless, initial measurements have been made using an interim LO and laboratory bias supplies for the mixers and preamplifiers. Figure 1 shows the SSB receiver noise temperature, gain, and image rejection as functions of signal frequency for the prototype dual-polarization cartridge. In each plot, data are given for both sidebands with the LO adjusted in 10 GHz steps.

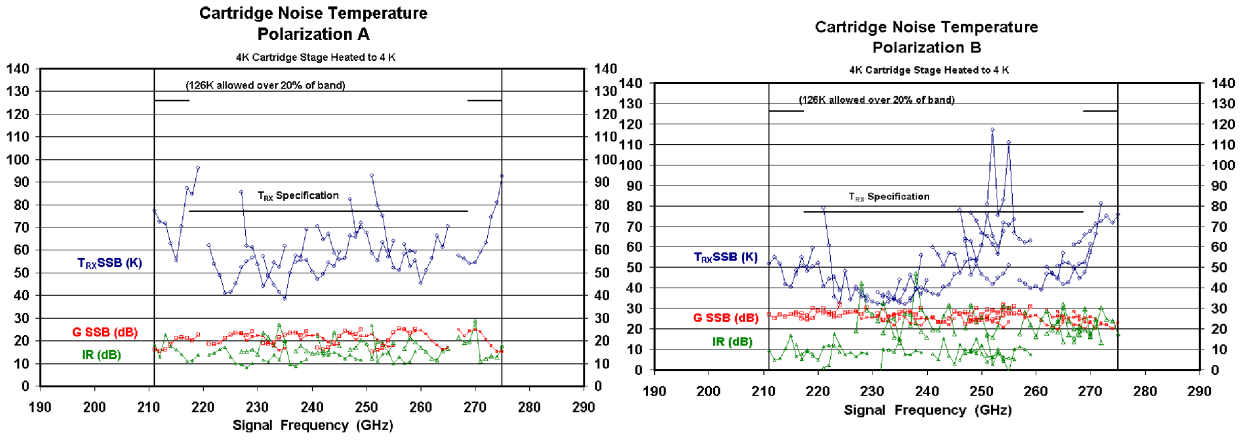

Figure 1. Prototype ALMA Band 6 cartridge performance.

The poor image rejection observed in polarization B was not present when the mixer-preamp was tested individually and has been determined to be caused by a loose IF connector inside the dewar.

Preliminary measurement of the cartridge beam pattern agrees with the earlier measurements made on the optical components at IRAM.

Assembly and maintenance of the cartridge was complicated by the one-piece G-10 shell between the 90 K and 300 K plates. By changing to a split shell, one half of which could be removed without disassembling the whole cartridge, it would be possible to change components located between the 300 K

and 90 K plates without removing the components on the other stages. A prototype split shell has been produced for evaluation.

The main components for the first eight cartridges have been ordered, including 4 K IF attenuators which reduce gain ripples due to component mismatch. Tests of Narda coaxial attenuators indicate that they perform adequately at 4 K. Drawings for the mechanical components will be released shortly for quotes from outside machine shops.

Band 6 Mixer-Preamp Production

The first Band 6 mixer chips were fabricated on a 30-mm wafer. After verifying their performance, the first 50-mm wafer was made. This had noticeable magnetic field dependent hysteresis loops in the junction I(V) curves at high bias currents which, on further investigation, were also found in the mixers from the earlier 30-mm wafer. The hysteresis did not appear to affect the mixer performance, but it was decided to modify the fabrication process slightly to eliminate the junction vias responsible for this effect and to replace them with full vias. The modified design was fabricated on a 30-mm wafer with excellent results, and a new 50-mm wafer has been fabricated and is now under test.

So far, of the six mixer-preamps tested, two have achieved acceptable performance and are being used in the prototype cartridge. This is better than the anticipated 25% acceptance rate.

An RFQ has been issued for fabrication of the mixer blocks for the first eight cartridges. The magnetic circuit components (superconducting coils, pole pieces, and aide arms) have been machined and are awaiting nickel plating.

The mixer-preamp test set is now in operation, but it still has a manually-tuned Gunn LO and the sideband generator is not always available, as it is being shared with the cartridge test set. The components for the automated LO and sideband source are on order and the sources should be operational next quarter.

The preamplifiers, quite stable when operated with the standard laboratory bias supply, were found to oscillate when mounted in the prototype cartridge with the temporary cartridge bias supply and ESD protection circuits. These bias circuit oscillations were suppressed by adding 100-nF capacitors in the amplifiers on the bias lines (the bias supplies are of the standard NRAO servo type).

An RFQ has been issued for the construction of 24 additional amplifiers which, with the amplifiers already in hand, will be sufficient for the first 8 cartridges. Bids have been received from two companies and are being evaluated.

Preamplifier production has been delayed by the availability of the necessary InP transistors from JPL. This quarter a tentative agreement was made with the JPL DSN group to supply the devices. If the agreement is confirmed, we will receive sufficient transistors for the 256 amplifiers required for Band 6.

Software Development

The Labview-based data acquisition software has undergone significant revision this quarter. The current version is compatible with both the cartridge test system and the mixer test system. Measured data are written to an Excel spreadsheet template by the data acquisition program. The noise temperature, gain, and image rejection can then be plotted directly within Excel.

Non-ALMA SIS Mixer Development

385-500 GHz SIS Mixer: Two different mixer circuits are being developed for this band. One uses the 50-micron quartz substrate and the other has a 7-micron SOI (Silicon on Insulator) wafer developed at the University of Virginia (UVA). Design of the broadband suspended-substrate stripline-to-waveguide transducer for both types of circuits is complete. Several different mixer tuning approaches are currently being evaluated and optimized using the microwave circuit design simulator Microwave Office. The tuning circuits will be finalized in the next quarter. This is a joint R&D project between NRAO and UVA, and is supported mainly by an NSF grant to UVA.

New SIS Mixer Bias Supply: The CDL's standard SIS mixer bias supply has several mechanical switches which make it unsuitable for automated measurements. The new design is based on the old one but replaces the mechanical switches with reed relays driven by a basic stamp chip integrated into the bias supply circuit. The basic stamp chip sequences the switches in response either to inputs from push buttons on the front panel or to serial commands from a computer. The circuit has been designed and is ready to be translated to a PC board.

Electromagnetic Support

EVLA

A wide band, rectangular-to-circular stepped transition was designed for testing the C-Band (4-8 GHz) feed. It is expected to have return loss better than -25 dB in the given band.

A prototype of the L-Band (1-2 GHz) feed was fabricated and measured. Near-field (at the distance of the VLA antenna subreflector) and far-field patterns of the feed were measured. The feed has an average illumination taper of -10.5 dB at the edge of the subreflector in the 1.2-2.0 GHz range and agrees well with theory and patterns of a scale model (at 4-8 GHz) feed measured earlier. The cross-polar patterns in the 45 degree plane are below -24 dB level. Return loss of the feed is better than -20 dB above 1.03 GHz.

Central Development Laboratory

GBT

A study to compare the beam efficiency of the GBT, illuminating it using either a prime focus feed or a secondary focus feed, was completed. For the prime focus case, the illumination taper was varied from -11 to -18 dB. The beam efficiency calculated at the half-power point is optimum for -14 dB taper prime focus illumination and is higher by about 3.5 % compared to the secondary focus case.

Spectrometers/Correlators

ALMA Correlator

During this quarter, the prototype ALMA correlator was shipped to Socorro and installed there for integrated testing.

A design review of the ALMA system was held in Germany in March, and the current correlator design was presented. A revised correlator system specification, reflecting the tunable filter card enhancement being proposed for the correlator, was released just prior to the design review.

PCB layout modifications to all printed circuit cards and motherboards were completed during the quarter with the exception of the data interface card.

Designs for the station and correlator bins were completed, and prototype units of both bins ordered.

Contracts for all parts, plus spares, needed to build the complete ALMA correlator are now in place with the exception of the system cables, the 6U power card, the data interface card, the final adder card, and the station and correlator bins. The 6U power card is out for price bid and the bins are being prototyped.

A purchase requisition to modify the correlator laboratory for system construction was issued. This requisition covers a computer floor, air conditioning, and a fire suppression system for the lab.

ALMA Frequency Multipliers

The purpose of this project is to develop millimeter- and submillimeter-wave frequency multipliers for use in laboratory experiments and receiver systems associated with ALMA. A series of multipliers using varactor and varistor circuits operating in the 50 to 950 GHz range are currently being developed and evaluated. The status of the cooled frequency multipliers for the ALMA frequency bands in the baseline plan is described, followed by an outline of other frequency multiplier development efforts.

Central Development Laboratory

A brief summary of the activity in this quarter is given, and reference to detailed reports provided as appropriate.

Band 3: No cooled frequency multiplier stage is required for this ALMA band.

Band 6 and Band 7: Subsequent to their prototypes meeting specifications, four Band 6 and two Band 7 pre-production frequency triplers were ordered and received from Virginia Diodes, Inc. (VDI) to satisfy laboratory requirements as well as for integration into the first receiver cartridges. These were evaluated both at room temperature and at 77 K and delivered to the project. The test reports are available as ALMA EDM document numbers FEND-40.10.00.00-012-A-REP (Band 6) and FEND-40.10.00.00-017-A-REP (Band 7). Delivery of another batch of two Band 7 pre-production frequency triplers is expected shortly.

Concurrently, formal "Specifications and Requirements" and "Statement of Work" documents were finalized for ordering the Band 6 and Band 7 frequency triplers to meet the full ALMA first LO requirement (for all 64 antennas, including 10% spare units). The $651k order was placed after obtaining NSF, as well as the Observatory Director's approval, earlier in this quarter.

Band-9: The five prototype frequency quintuplers delivered by VDI did not meet the output power specification. As described in an earlier quarterly report, they need to be driven with 40 mW of RF power to be able to generate the LO power required to meet the ALMA Band 9 receiver requirements. The Band 9 LO driver is designed to generate only 15–20 mW of pump power.

VDI was awarded a contract for demonstration of an improved version of the existing quintupler design that would meet the output power specification with a drive level of 20 mW and supply NRAO/NTC with three units based on this improved design. The contract calls for re-optimization of the existing design based on the earlier results and/or design and fabrication of the quintuplers on InGaAs (which has a smaller barrier height than GaAs) to reduce the input drive power requirement. A wafer run for the first of the two approaches failed to produce usable devices. The fabrication issues that resulted in the failure of this GaAs-on-quartz wafer containing the new Band 9 quintupler design are being studied. After satisfactory resolution, another wafer run is planned. However, frequency quintuplers based on these devices are not expected earlier than the next 2–3 months. A design and fabrication run with the reduced barrier height InGaAs is being planned. The material issues related to the InGaAs wafers have been resolved, and the wafers have been ordered. This fabrication process is not expected to present difficulties encountered in the GaAs-on-Quartz process. A no-cost extension is being considered for the contract.

To meet the immediate Band 9 LO requirement, a cascade of a frequency doubler followed by a frequency tripler driven by a Band 7 LO driver has been evaluated at NRAO/NTC. However, these measurements were made with a low input drive power (from an existing Band 7 LO driver) and are scheduled to be repeated once the assembly of a power-combined Band 7 power amplifier is complete.

Phase-Noise Test Station for Evaluation of ALMA First LO Driver Assemblies

A test station to measure the phase noise of the completed LO driver assemblies has been configured; this allows measurements to be made on the final completed assemblies prior to their delivery to the respective cartridge assembly groups. The LO assemblies can be controlled either directly from the computer via I/O interface modules or through the LO M&C subsystem over the CAN-bus. The necessary software to automatically acquire phase-lock to the selected sideband (above or below the reference) is in place. Figure 2 shows the measured phase noise of the Band 6 LO driver assembly at 86.4 GHz, prior to its delivery for system integration tests (see FEND-40.10.00.00-022-B-REP for further details). Figures 3 and 4 have a view of the phase noise test station described above and used to make this measurement.

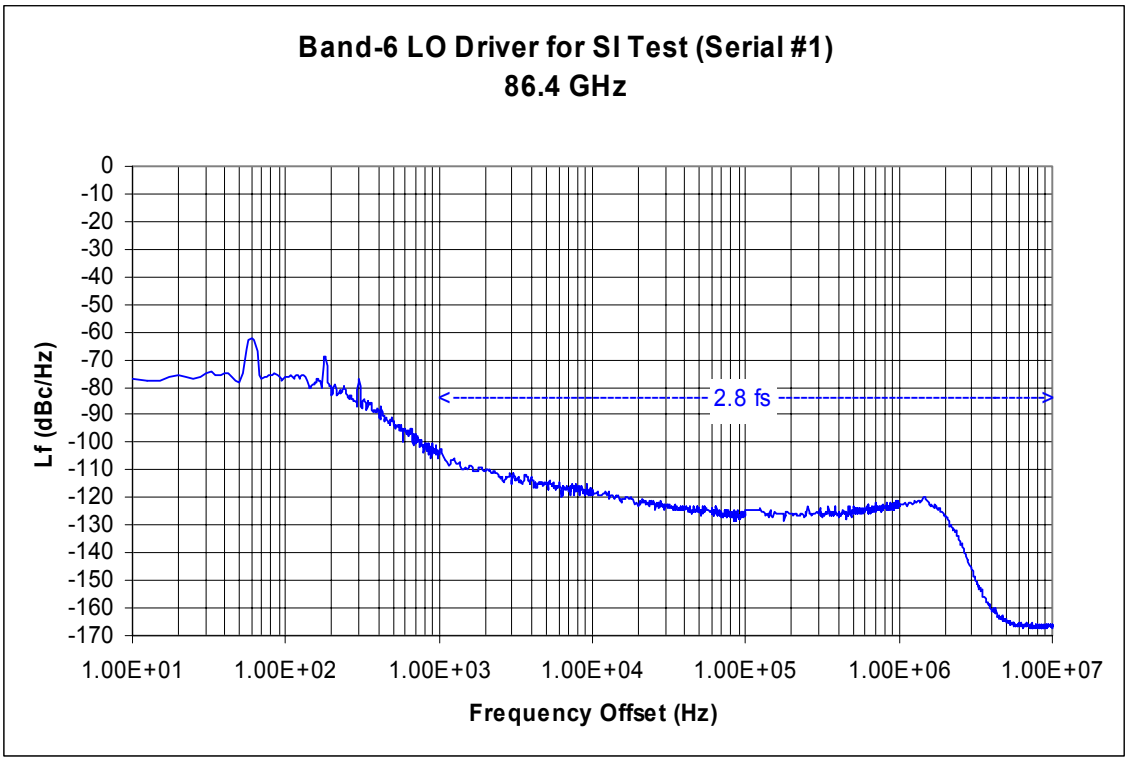

Figure 2. A sample plot of the measured phase noise of the Band 6 LO driver assembly prior to its delivery for system integration tests. The total phase jitter was 2.8 fs (integrated from 1 kHz to 10 MHz).

Figure 3. The phase noise test station used to measure the phase noise performance of completed LO driver assemblies prior to their delivery to the respective cartridge assembly groups.

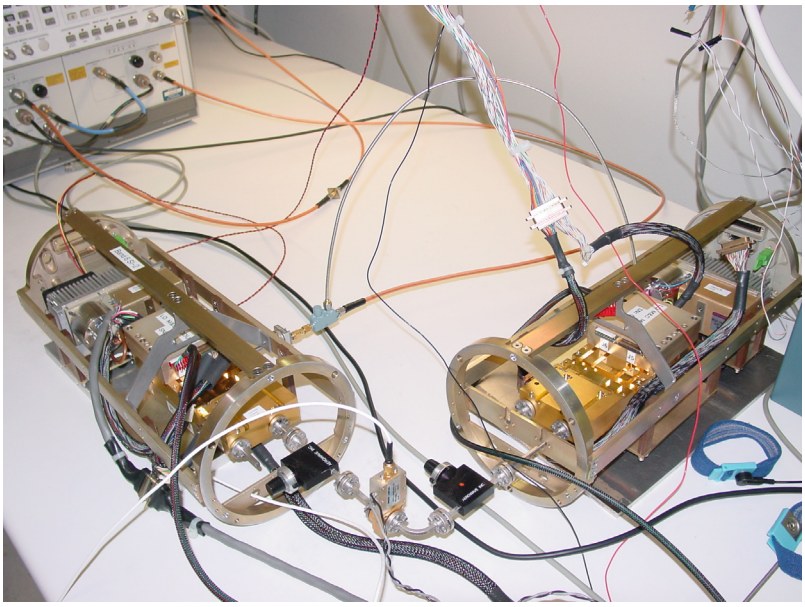

Figure 4. A close-up view of two Band 6 LO driver assemblies being evaluated for their phase noise performance.

ALMA LO Source

The purpose of this project is to develop a series of electronically-tunable, phase-locked sources operating near 100 GHz. These sources will be used to drive millimeter- and submillimeter-wave frequency multipliers that produce the first LO signal for the ALMA receivers.

During this quarter, pre-production versions of the Band 3, 6, and 7 active multiplier chains (AMCs), as well as pre-production Band 6, 7, and 9 power amplifiers, were fabricated, assembled, and tested.

The first pre-production Band 3, 6, and 7 warm cartridge assemblies (WCAs) are being prepared to be shipped to the respective cartridge manufacturers. These assemblies contain all the warm components of the first LO, including the YIG oscillator, AMC (multipliers and amplifiers up to 140 GHz), millimeter-wave power amplifier, PLL, and LO M/C module. A Band 6 WCA has already been delivered to the systems group for system integration tests; a second will be delivered shortly. Figure 5 shows a photograph of the Band 3 and 7 WCAs. The two Band 6 WCAs are currently being used together for phase stability measurements. Figure 6 shows output power measurements of the three Band 6 WCAs produced so far. Note the flatness and repeatability of the output power over the passband. Power leveling measurements were also performed on one of the Band 6 WCAs. These results indicate that at the power amplifier output, < 0.1 dB step size can be achieved over a 6 dB dynamic range.

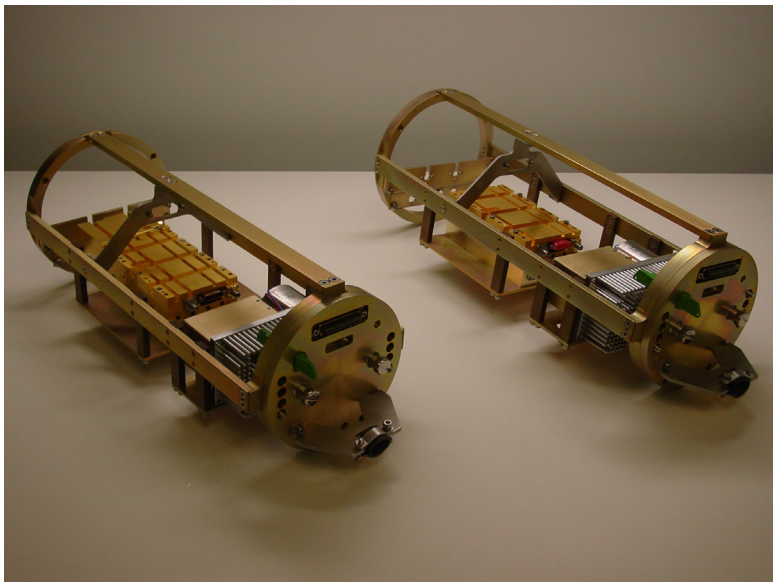

Figure 5. Photograph of the Band 3 and 7 warm cartridge assemblies. Not shown are cables and M/C module.

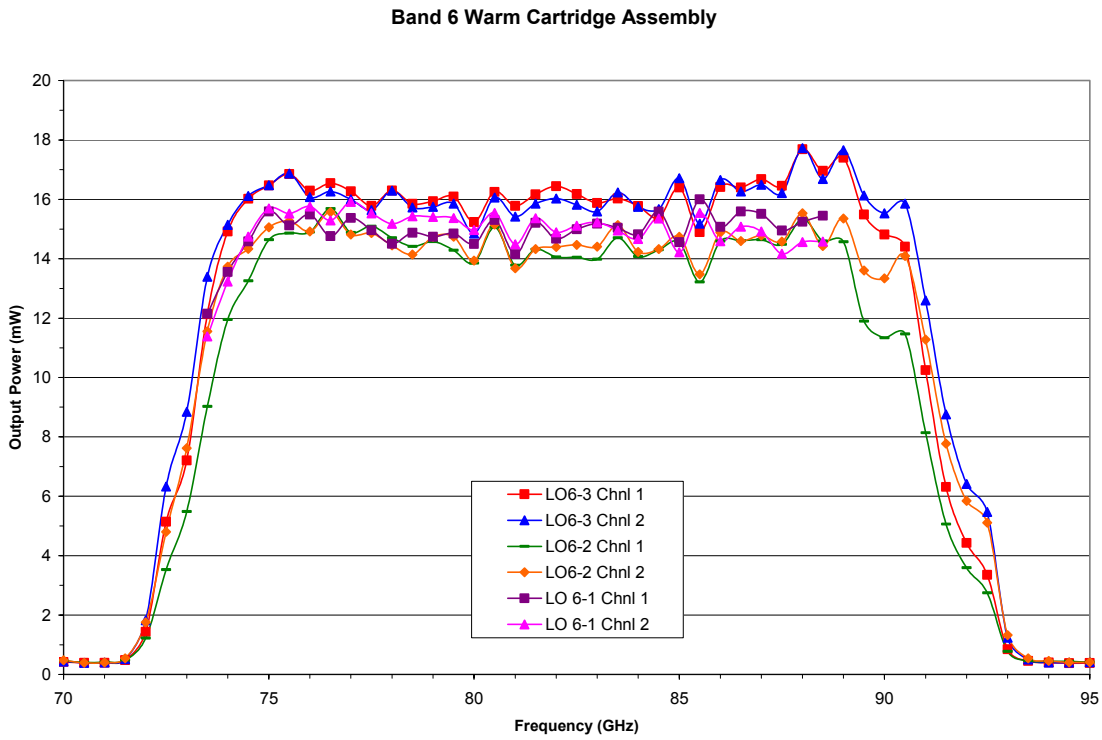

Figure 6. Output power measurements of the first three pre-production Band 6 warm cartridge assemblies. The required frequency range for ALMA is 74.3 to 87.7 GHz.

One of the Band 6 WCAs was used in the Band 6 cartridge measurements system to drive the first pre-production cartridge. These tests showed that the sideband noise contributed by the LO was equal to or better than a Gunn LO (the "gold standard") over the entire specified band. HIA used a pre-production Band 3 AMC to drive their mixer and also found that the LO contributed no more sideband noise than a Gunn LO.

For Band 9, the backup solution for the power amplifier problem was to power-combine two of the original broadband MMIC amplifier designs. Unfortunately, this is still not enough power and the effort by Virginia Diodes to improve the quintupler efficiency at lower input power has not yet been successful. The proposed interim solution is to use a doubler plus tripler in place of the quintupler. The AMC required for this scheme is exactly the same as the Band 7 AMC. The power amplifier will power-combine two of the new successful Band 7 MMIC amplifiers. Preliminary results using one of the Band 7 power amplifier MMICs to drive a warm doubler-tripler chain were very encouraging. Increased drive power from power-combining plus cooling the multipliers should result in an output greater than the specified 50 μW over the required band.

Central Development Laboratory

Investigation of Beamlead HEB Mixers for Heterodyne THz Biohazard Detection

This is a SGER (Small Grant for Exploratory Research) awarded by the NSF under the ACT (Approaches to Combat Terrorism) program. This is a one-year grant to build, measure, and compare different types of HEB mixers in a 600-720 GHz receiver using existing NRAO equipment. Custom Microwave has delivered the mixer blocks. Both phonon-cooled and diffusion-cooled HEB mixer circuits have been fabricated on thinned Si. The phonon-cooled HEB mixer has been assembled and is currently undergoing cooled I-V measurements. The next step is to perform receiver noise measurements using this mixer. This will be done first at UVA using a feed mirror external to the dewar and, as an LO, a Gunn oscillator and quintupler. These will be preliminary measurements at a single IF (1.8 GHz). Meanwhile, we will be assembling a receiver test set at NRAO for more comprehensive measurements using the ALMA Band 9 LO when it is available. This receiver will use a feed mirror inside the dewar and a Mylar beamsplitter to inject the LO. The optics design is under way. A summer student will be assisting with these measurements.

Green Bank Solar Radio Burst Spectrometer (GB/SRBS)

In June 2003, the NRAO received an NSF MRI grant to develop a high-performance instrument to receive solar radio emissions with adequate temporal and spectral resolution to probe a wide variety of active solar phenomena from the base of the corona, including energy released from flares, particle acceleration, and escape, coronal shocks, and electron beams. The instrument consists of two radio spectrometers that will together provide frequency coverage from 10-3000 MHz. This instrument provides a basic research tool in solar radiophysics for use by the wider community, remedies the lack of an important component of the U.S. space weather effort, and provides a platform for research and development work on broadband antennas, feeds, and receivers needed for the upcoming Frequency Agile Solar Radiotelescope (FASR) project. A significant portion of the development work will be performed at the NRAO Technology Center (NTC) in Charlottesville.

Phase I of the GB/SRBS has been monitoring solar activity on a daily basis for more then 97% of the time since its deployment in Green Bank on January 7, 2004. This system consists of a single polarization inverted-V style antenna, a high dynamic range low-noise amplifier, and a specially developed sweep frequency spectrometer covering the 20-70 MHz band. The frequency and temporal resolution are 30 kHz and 1 sec, respectively. A spectrogram from GB/SRBS on January 19 is shown in Figure 7. This spectrogram was obtained through application of a rudimentary post-acquisition procedure for excising only narrow-band radio frequency interference (RFI) from these data, and thus clearly illustrates the value of the National Radio Quiet Zone. Intermodulation distortion products are nearly absent from the spectrogram, indicating excellent receiver linearity and low RFI levels. Unprocessed data and data products from GB/SRBS are currently being archived at the University of Maryland, but, in the near future, they will be located on a new dedicated server at NRAO in Charlottesville. Web access to these data has already been developed (temporarily, see website *http://www.astro.umd.edu/~white/gb/*).

Central Development Laboratory

The upgrade path for GB/SRBS was changed this quarter to extend the lower cutoff frequency to 10 MHz to overlap with current and future space-borne missions. As a result, GB/SRBS will now consist of three sub-systems designated as GB/SRBS-L (10-30 MHz), GB/SRBS-M (25-350 MHz), and GB/SRBS-H (300-3000 MHz). Sub-systems L and M will share a common spectrometer via an RF diplexing approach and the target date for deployment in Green Bank is August 2004. GB/SRBS-H will make use of the 45-foot radio telescope and is scheduled to begin operation this fall. Work this quarter is summarized below.

GB/SRBS-L: The antenna style was chosen and the dimensions optimized through the use of electromagnetic simulation software to operate with appropriate beam quality over the 10-30 MHz band. A preliminary design of a non-reflection-type diplexer was performed and optimized for a cross-over frequency of 27 MHz.

GB/SRBS-M: A prototype high-dynamic range, low-noise amplifier was designed, fabricated and evaluated. This amplifier was based on a configuration developed by the graduate student visiting our laboratory last quarter. It consists of two bipolar junction transistors (BJTs) in a common-base configuration. Extensive circuit modeling was performed this quarter to yield a design having a forward gain of 13 dB, gain flatness of ± 0.5 dB over the 20-350 MHz band, noise temperature better than 250 K, an acceptable input and output match to 125 and 50 ohms, respectively, unconditional stability, and high dynamic range. These performance goals have been demonstrated for the prototype. A push-pull version, followed by a single-ended third stage (all in one package), is being constructed for field use in Green Bank.

The antenna for this band will be a dual-polarization, trapezoidal element, log-periodic design in the form of a pyramid. The antenna is being prototyped as part of the feed development for GB/SRBS-H.

GB/SRBS-H: The motor drive control units for the 45-foot radio telescope in Green Bank are being upgraded to improve reliability for GB/SRBS. The initial version of the broadband feed will be a dual-polarization, trapezoidal element log-periodic configuration. A prototype of this feed has been designed and is currently being constructed. The terminal impedance and power pattern versus frequency will be evaluated early next quarter.

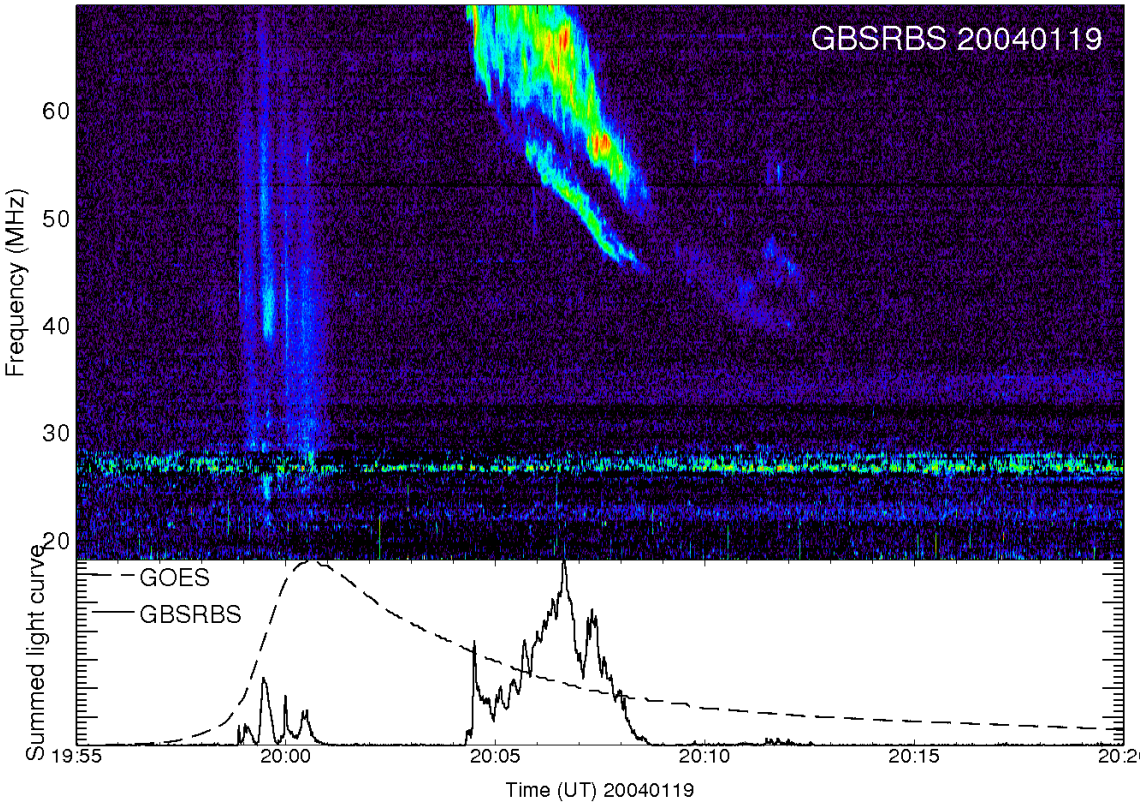

Figure 7. A radio spectrogram from GB/SRBS on January 19, 2004 covering the 20-70 MHz band over a period of 25 minutes. The false-color radio intensity plot clearly shows several Type-III bursts and a Type-II burst that are associated with a classic X-ray flare. The integrated radio intensity curve along with the GOES X-ray flux data are shown below the spectrogram.

Computing and Information Services

Computing and Information Services Highlights

As a result of focused attention on security, the NRAO continues to be almost completely spared from major virus outbreaks. All sites are now cautious about verifying operating-system patches and anti-virus protection on non-NRAO systems such as visitors' laptops, and the automated patching processes established by the Common Computing Environment (CCE) group for both Windows and Linux are functioning well.

The CCE group has as its goal to ensure that all sites provide a standard configuration of operating systems, network services, applications software availability, and user interfaces. A review of the project's progress during the previous year was held in Green Bank in March 2004, and future goals were identified.

An LDAP-based server with data populated from the Human Resources database has been deployed as the basis for all online and printed NRAO phone book information.

With the completion of the documentation, the deployment of the network and telephony infrastructure in the NRAO Technical Center in Charlottesville is done. The next network infrastructure upgrade will be in the Edgemont Road Stone Hall building. Planning for this is well underway.

Central Computing Services Milestones

Milestone	Original Deadline	Revised Deadline	Date Completed
Update Computing Security Policy	02/05/01	05/31/04	
VPN deployed (NM)	06/30/03	01/31/04	03/01/04
VPN policy fully implemented for both concentrators	04/30/04		03/01/04
Personal firewall on all Linux systems	03/31/04	06/30/04	
Personal firewall on all Windows systems	05/31/04	09/30/04	
CCE: Linux add-on package management deployed	04/30/03		
CCE: end AD domain full testing	09/15/03	05/31/03	
CCE: begin AD production client migration	09/30/03	06/30/04	
CCE: Accelerated-phase Project Review Meeting	03/31/04		03/16/04
CCE: Determine future Linux plans	06/30/04		

Computing and Information Services

Security

Our Internet router filters, vigilant anti-virus maintenance, focused patching efforts, and the watchfulness of our computer users continue to permit the NRAO to be almost completely spared from major virus outbreaks and other computer security problems. Laptops infected at other locations and subsequently connected to the internal NRAO network show up occasionally and are cleaned up quickly. All sites are cautious about verifying operating-system patches and anti-virus protection on non-NRAO systems, and the automated patching processes established by the CCE groups for both Windows and Linux are functioning well. In addition, 'personal firewall' software will be automatically installed on all NRAO computers to reduce the chance of compromise through services that do not need to be open, whether the computer is on an NRAO network or connected elsewhere. This effort is already underway for Linux, and will be done for Windows systems later in the year. The growing volume of rapidly-spreading new viruses also prompted us to change our approach to attached files in email: we no longer permit machine-runnable binary files to be transmitted this way.

Virtual Private Networking (VPN) is needed for employees who are required to work frequently or for extended periods of time at non-NRAO locations, and to support telecommuters during construction at Edgemont Road in Charlottesville. VPN service in Charlottesville was made available to users in May 2003. Identical hardware for Socorro was delivered in mid-2003, and became available to users at the beginning of March 2004.

The Computing Security Committee has begun work to define different levels of access control which will be enforced for different types of systems on 'internal' NRAO networks. In the past, the distinction was based almost exclusively on 'internal' versus 'external' IP addresses. The new controls will be finer-grained within NRAO's own networks. This is consistent with a growing dependence upon the NRAO Web for conducting internal business functions, which the Program Office plans to expand significantly. It is also required to control VPN access and internal wireless networks (which are limited to office environments in Charlottesville and at the AOC because of RFI concerns).

Common Computing Environment (CCE)

The Computing and Information Services group of the former Data Management Division was given a mandate by the NRAO Director to substantially complete the CCE project by the end of 2003. Significant changes to project management were implemented following the face-to-face CCE workshop for all NRAO system administration staff that was held in Socorro March 13-15, 2003.

A CCE Project Review Meeting was held March 15-16, 2004 in Green Bank, with all NRAO system administration staff attending. Prior to the meeting, a checklist to assess the implementation status of agreed-upon standards was completed by the four computer division heads, and the results were tabulated to show where deficiencies remained. Approximately 90% of the targets set by the project members had been met by the end of 2003, and most of the rest were completed by the time of the review.

Computing and Information Services

Except for a few longer-term objectives, most of the remaining work from last year's goals involves completing documentation and final implementation of a few details at one or another of the sites. During discussions at the meeting, new goals were identified, primarily related to application software availability, Unix laptop issues, Windows domain deployment, and centralized authentication for all platforms. The technology to achieve the latter is, for practical purposes, still in its infancy, but preliminary steps have been taken with the introduction of an LDAP database server by the CIS Information Infrastructure group (see report below).

During the past quarter, the Unix group deployed a third-party software management tool at three of the four sites. In addition, RedHat 9 upgrades have been largely or entirely completed across the Observatory. Last fall, RedHat announced changes to its Linux offerings which leave us with several options of varying cost and suitability. By the end of the coming quarter, the CCE group will need to decide, in consultation with other divisions at the NRAO and external organizations similar to ours, what path to take for future Linux installations. This is a decision facing all organizations which have depended on RedHat Linux, and some NRAO testing of alternative Linux distributions began in early 2004.

The Windows administrators have moved selected users into the Active Directory domain for testing on everyday use, along with the Business Division staff in Charlottesville who are involved in a software pilot project for the NRAO Program Office. Few problems have been encountered so far, all minor; this is largely a result of time-consuming investigation and testing of techniques to painlessly migrate users' profiles. During discussions at the Project Review Meeting, the group decided to delay production domain migration for approximately two months so that all servers in the new domain can be upgraded to Microsoft's current operating system version, Windows Server 2003. This change, and its timing, is dictated in part by the requirements of the Program Office, which is now the highest priority for support resources.

Continued effort and vigilance will be required in future to ensure that the sites' environments do not diverge, and to integrate new technology and software. Regular meetings will therefore continue, with tasks assigned to specific individuals. Project management will be moved to a more collaborative environment – specifically, a 'Wiki' server, which is a popular and useful tool for collaboration in similar projects such as software development.

Web Infrastructure Milestones

Milestones	Original Date	Revised Date	Date Completed
Purchase proxy servers for VLA, CDL	06/05/03	04/30/04	
Plan Web Server upgrade to RedHat 9	03/01/04	04/30/04	
Evaluate additional Groupware	04/01/04	05/15/04	

Computing and Information Services

Milestones	Original Date	Revised Date	Date Completed
Provide secure webmail for NRAO staff	05/01/04		
Provide collaborative 'wiki' for NRAO	05/01/04		

The web server hardware upgrade mentioned in the previous quarter's report (disk space) was held up by lack of vital parts; this has been rectified, though the delay has set back planning for the operating system upgrade on the servers. Also, the test machine ('sparerib') was moved from Charlottesville to Green Bank, to permit staff there to more easily test and build the latest operating systems and web server software thereon.

The secure servers in Charlottesville and Green Bank are being leveraged for two separate but vital facilities: a secure webmail portal, and a 'wiki' collaborative framework. Both operate on secure (SSL) web servers, and while by its nature the webmail interface is accessible from anywhere on the internet, the wiki is only accessible within the NRAO's intranet.

The webmail portal will permit NRAO staff to access their mail (for staff at all four main NRAO sites) with the only requirement being a web server. The employee simply points the browser at webmail.nrao.edu; no special java applet is needed, and the webmail interface works well with the vast majority of current internet browsers. A pull-down menu on the greeting screen permits the user to select their NRAO site. Testing has shown that a small investment in time by the system administrators at the user's home site can effectively make the webmail interface very easy to use and transparent for the end user.

The wiki is traditionally used in software development environments, and in fact some groups within NRAO were already using wiki sites (one in Green Bank, one at ESO for ALMA software development). Given its capabilities, however, even the beta testing reveals many uses for it outside the narrow scope of software development. In its most general form, the wiki can be—and is—used for any collaborative effort that requires document and information sharing. Both of these facilities leverage NRAO's existing web infrastructure to provide valuable services with a relative minimum of effort on the part of the computer support staff. While both are also in use in a 'beta' phase at the time of writing, we fully anticipate ending this phase and rolling out the services for general NRAO use in the timeframe indicated above.

To a large extent, work on the evaluation of other 'groupware' products was halted, so that the few person-hours available for web work was available for the wiki and webmail efforts described above. The work being carried out by (and on behalf of) the Program Office may provide some level of NRAO-wide calendar support, but in the event that cross-platform issues arise, the WebAdmin group will once again look at possible solutions.

Computing and Information Services

Information Infrastructure Milestones

Milestones	Original Date	Revised Date	Date Completed
Start using LDAP data for phonebook	03/01/04	03/17/04	03/17/04
Test LDAP server for authentication	04/01/04	06/30/04	

A major milestone was realized on March 17, with the rollout of the OpenLDAP server as the basis for all online and printed NRAO phone book information. The effort required to minimize the differences, and set up mechanisms for information correction, was far more than anticipated. This was mainly due to a myriad of differences in the way data had been entered in the two sources of information (the old 'flat file' phonebook and the Human Resources database).

The use of the LDAP server for authentication has been postponed, mainly due to resource starvation. The few people involved in this Information Infrastructure project are currently performing tasks for other projects. We intend to focus on issues of security and replication as our next main tasks.

Charlottesville Computing Milestones

Milestones	Original Date	Revised Date	Date Completed
Upgrade Linux clients to RedHat 9	03/31/03	04/30/04	
Upgrade Linux servers to RedHat 9	04/30/04	05/31/04	
Upgrade Windows systems to Windows XP	06/30/03		
Populate TrackIt database	05/15/04		
Migrate Tacacs authentication	06/30/04		

The task of upgrading all client Linux machines to Red Hat 9 is nearing completion; there should not be any issues with meeting the revised milestone dates for clients and servers. The Windows systems, because of increased effort required for operating system upgrades on this platform, are taking longer to do. The large support load, and the needs of the Program Office for Windows support from the division, will likely delay the Windows XP milestone significantly.

As part of the effort to maintain the viability of our installed base of hardware, a complete inventory was taken of all Windows, Linux, and Solaris systems at NRAO/Charlottesville. The resulting spreadsheet will be uploaded to the AOC-based Track-it database (for Linux and Solaris systems), and a Track-it client will be used on all Windows systems to inventory and audit them and their installed base of proprietary, licensed software.

Finally, the 'tacacs' authentication service used by the bank of dial-in modems at NRAO/CV is being migrated off a rapidly aging Sun workstation, and onto our main internal (Linux based) server. Because of attrition, this milestone may have to slip to significantly later in the calendar year.

Observatory-wide Communication Milestones

Milestones	Original Date	Revised Date	Date Completed
Completion of NTC wiring diagram	02/15/04		02/15/04
Completion of NTC cable labeling	02/15/04		02/15/04
Update network traffic analysis tools	03/01/04		03/01/04
Network plan for Stone Hall extension	04/01/04		04/01/04
Upgrade network services to VLBA BR, HN, OV antennas	04/01/04	04/30/04	
Upgrade network service to VLBA KP antenna	12/31/02	05/31/04	

The major effort at the end of 2003 was the completion of the networking and telephone infrastructure for the migration of the CDL staff from the Dynamics Building to the new NRAO Technology Center (NTC). The work was completed as planned, but two items were finished after the fact – a complete network wiring diagram for the two NTC buildings and labeling of the cables.

We have finished the preparatory design and costing for the local area network upgrade to the Edgemont Road Stone Hall building, which will be needed when construction nears completion at the end of 2004. A budget has been submitted for approval. Depending upon the contractor's progress, installation may start as early as next quarter, but we do not yet have an estimated date.

The upgrade of the network service to the VLBA Kitt Peak antenna was yet again delayed, this time due to a staff termination. We will attempt to work it into our plans for the coming quarter. As a result of lower costs for our intranet contract with AT&T, we have decided to upgrade the service at three other VLBA sites. A two-month delay was incurred due to a problem in the AT&T order processing. However, we still hope that the net delay will be just one month. When this is complete, five of the six VLBA locations that connect via the frame relay intranet will have full T1 connections.

The network traffic analysis tools, previously in place, have been updated to reflect new router equipment and network configuration. The procedure to gather the statistics was also upgraded significantly, resulting in increased performance.

Computing and Information Services

The NRAO video system is now routinely used to relay scientific and technical colloquia throughout the Observatory. The biggest remaining deficiency for interactive multi-site video between the auditoria is the auditorium sound systems. This will be addressed on a best-effort basis over the next few months. However, this project has also been significantly delayed because of the effort being re-assigned to the building projects.

Education and Public Outreach

Education and Public Outreach Highlights

NRAO sites at Green Bank and Socorro were notified in February that their proposals for NASA IDEAS grants for teacher workshops had been accepted and detailed planning and preparation for those programs has commenced. Also in February, the NRAO EPO staff held a two-day all hands workshop to refine and update the NRAO EPO Strategic Plan. The Science Center at Green Bank and the VLA Visitor Center both show increasing attendance and in concert with that the revenue of the gift shops at both sites continue to outperform original projections.

During two days in February, eight members of the EPO staff (including three from WV and two from NM) gathered in Charlottesville for a meeting to review, examine, and redefine the Strategic Plan for EPO that had been established a little more than two years earlier. Many of the initial goals had been reached or at least approached while others were still awaiting fulfillment. A new emphasis on promoting awareness of the National Radio Astronomy as the premier radio astronomy observatory in the world, seeking more dynamic radio images, and re-iterating the theme of one-observatory were incorporated into other goals in education and outreach along with an intent to establish a specific list of deliverables and a timeline on which they would arrive. The meeting was productive and many ideas were generated. The final draft is still in preparation even as some of the newly created goals are already being achieved.

Informal Education

Attendance at the Science Center at Green Bank during this quarter was lower than other quarters due to winter weather. Attendance at the VLA was nearly double that at Green Bank, though on an annual basis, attendance at Green Bank has generally recorded higher numbers. The attendance at the VLA Visitor Center is up by nearly 40% over the same quarter from last year and up by over 35% for the first half of the fiscal year compared to the last. It appears that the increased promotion of the Visitor Center has had a positive impact.

Site	January	February	March	Quarterly Total
Green Bank	834	720	834	2,388
VLA	1,295	1,236	1,958	4,489

There has been some additional work done on the Science Center basement in Green Bank. The basement was left unfinished with the premise that it would be available for future expansion. There have now been some upgrades so that it may be used for multipurpose special activities, though it is not ready for daily use. The area has been cleaned up and sees some use as gift shop storage.

Education and Public Outreach

There are continuing upgrades and additions in the exhibit area. Steve Hicks, museum technician, has made repairs to a number of the exhibits and the malfunction frequency has been drastically reduced. An exhibit demonstrating laser range finding called "2000 Points of Light" is now running; there are now 20 exhibits in the hall. Steve is also proceeding with improvements to the operation of the GBT model. Work is in progress on another new exhibit called the Galaxy Guessing Game. Sue Ann Heatherly (Education Officer) is developing a web-based "Who's Using the Telescopes" exhibit.

Figure 1. Teacher demonstrating how the dish functions.
(The mirror is focused on a ceiling mounted heat lamp.)

Robyn Harrison (Socorro Education Officer) is making the SRT (small radio telescope) at the VLA Visitor Center more user-friendly. Robyn is also working with the two-element interferometer for use with the summer NASA IDEAS workshop and the Masters of Science Teaching classes.

The new Green Bank and VLA gift shops continue to perform well with increasing revenue . The generated revenue covers the cost of operating each shop, and helps support ongoing education and outreach activities at both sites.

Gift Shop	January –March, 2004	January-March, 2003
Green Bank	$11,349	$667
VLA	$24,931	$6,077

Café revenue at the Science Center at Green Bank per capita has increased. This improvement lends support that Café revenue will achieve original projections.

Figure 2. Sleeping quarters of the student bunkhouse at Green Bank.

The dorm/bunkhouse was completed and furnished and now can house student, youth, and other educational groups during visits to the Observatory. Through this first quarter of operation, the bunkhouse was occupied for six nights for four groups with a total of seven chaperone nights and 64 student nights.

Formal Education

Both Green Bank and Socorro were awarded NASA IDEAS grants last quarter.

The Socorro program "Doing Dishes: Observational Radio Astronomy for Science Education" will enlist teachers in a week-long project, working with NRAO and New Mexico Tech staff to develop content and structure for a two-week radio astronomy course for teachers. This course will be available through the New Mexico Tech Master of Science Teaching program.

The Green Bank program, "Quiet Skies: Exploring Radio Astronomy and the Noisy World We Live In," will develop instrumentation and curriculum for 7-12 grade students to investigate radio frequency interference (RFI). The NRAO staff will design and build the initial Quiet Skies detectors. The NRAO will then collaborate with teacher-interns to test, calibrate and modify the instruments and to develop a curriculum. A larger group of teachers will field-test "Quiet Skies" with their students. The program will then be expanded statewide in West Virginia and eventually nationally.

Education and Public Outreach

Groups using the 40-foot telescope this quarter included Radford University, Ohio University, Woodrow Wilson High School, Rockingham County (VA) High School, the Oil Region Astronomical Society, and Lycoming College.

There were 26 applicants from 15 states for NRAO Research Experience for Teachers (RET) positions this summer. Offers were made to three applicants and two accepted. One will work with the RFI workshop, researching RFI detection, mitigation, and the National Radio Quiet Zone; the other RET will design analysis tools for understanding pulsar data.

To encourage school group visitation, direct mailings of the Green Bank Science Center Tour brochure and a cover letter were sent to all West Virginia schools and to all Virginia schools within a two-hour drive of Green Bank.

Special activities at Green Bank included behind-the-scenes High Tech tours, Friday Films, Star Parties, and Exhibit Hall Scavenger Hunts. At the VLA the January Quarterly public tour was successful.

Community Relations

The beginning of the year is Science Fair time, and the NRAO had considerable involvement at the local, regional, and state level. In West Virginia, one NRAO Green Bank employee served as a judge at the WV State Science & Engineering Fair in Huntington and was the only engineer among the 50 judges. In Charlottesville, the NRAO provided monetary support for the Piedmont (VA) Regional Science Fair. Next year we hope to recruit more NRAO judges for both of these Science Fairs. However, the sizeable effort, as it has been for many years, was in New Mexico where support for science fairs was provided at the local, regional, and state level. More than a dozen NRAO employees in New Mexico assisted with judging at science fairs at elementary, middle, and high schools in Socorro and Magdalena while the NRAO also provided judges for the regional fair. The NRAO sponsored prizes for selected winners at the middle and high school fairs.

In New Mexico, the NRAO again participated in the local tourism council. Another NRAO employee gave a presentation at a Career Fair at Piedmont Virginia Community College for 10th graders from Fluvanna and Greene counties. In New Mexico, every State House and Senate member received the NRAO calendar as did the Socorro Town Council, Mayor, and Chamber of Commerce. An NRAO display and staff distributing materials were on hand for a day in the Capitol Rotunda in Santa Fe. In Charlottesville, the calendar went to the regional public libraries and the media centers of each of the Charlottesville City and Albemarle County schools. For the second year in a row, NRAO participated in the DOE's Science Safari in Washington, DC doing presentations for area school children on one day and having a display in the Library of Congress for congressional staff on the second day.

Education and Public Outreach

Three observing sessions were held this quarter in Charlottesville to take advantage of the current planetary groupings. Sessions were held in two neighborhoods, for which the weather was only minimally cooperative, and at one elementary school.

Astronomy Community

The "Sagittarius A* at 30" Workshop was held on March 25-26 in Green Bank. EPO staff assisted with preparation, promotion, and documentation. The two days of presentations dealt with the history of the discovery, what has been learned, and the future. A plaque commemorating the discovery by Robert Brown and Bruce Balick was installed on the 45 Foot Telescope that was the critical addition to the existing three element Green Bank interferometer which made the discovery possible. Approximately 50 radio, X-ray, and infrared astronomers participated in the meeting.

Figure 3. Installing the plaque commemorating the 30th anniversary of the discovery of Sgr A*.

Significant NRAO staff supported the AAS Meeting in Atlanta in January. Public Information Officers, Chuck Blue and Dave Finley, assisted in the AAS Press Room with press conferences, aided the presenters, and provided reporters with accurate information about astronomy and NRAO activities. Three press conferences featured data from NRAO telescopes and at two of them NRAO scientists were on the panels speaking. The 20-foot long NRAO display booth was regularly manned by NRAO employees including scientists, EPO staff, and administrators. The three RET teachers from 2003 presented posters, highlighting what they had accomplished at the NRAO the previous summer. Assistance was also provided for the ALMA Town Meeting.

Figure 4. Agnes Scott College astronomer Chris De Pree talking to RET John Ciccarelli of George Washington Carver HS of Science & Engineering about his AAS poster and his experience at the NRAO.

In February, the structure of the ALMA EPO IPT (integrated project team) was finalized with appointments from NRAO EPO and ESO EPO. In March, at the Mini-ALMA Meeting, NRAO and ESO EPO leaders had their first face-to-face discussion and began planning efforts. In addition to producing new versions of ALMA video, publications, and web sites, they also received the assignment of revising the existing ALMA web policy.

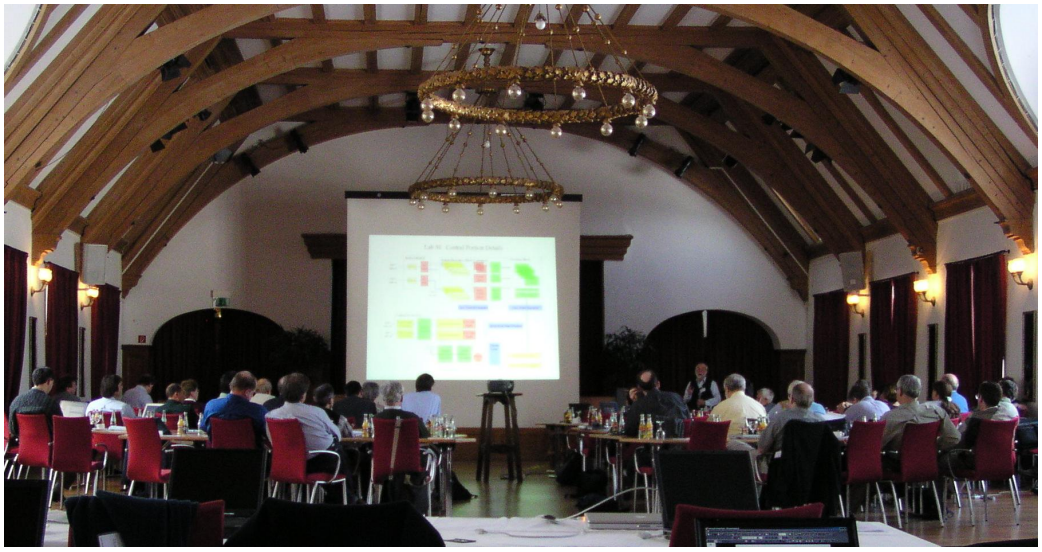

Figure 5. Mini-ALMA Week, Schloss Elmau, Germany.

Education and Public Outreach

To meet the continuing needs of the Observatory, significant EPO staff effort was provided for producing the spring Newsletter; the Quarterly Report; the annual Observing Summary; the Point Source; posters, figures, and images for presentations by scientists and engineers; and printed materials for Human Resources and observatory operations.

Media Relations

NRAO issued national press releases on the SS443 movie generated from VLBA data and on the neutral hydrogen clouds in the vicinity of the Andromeda galaxy studied with the GBT. Both stories generated extensive national and local coverage. There were also local news stories in daily and weekly newspapers and on local television on a variety of stories including the National Radio Quiet Zone, the unique electronics being produced for the ALMA telescopes, the opening of the NRAO Technology Center (NTC) in Charlottesville, and about the existence of the GBT and the Science Center in Green Bank (both stories and outside agency tourism publications).

In February, Green Bank hosted a Charleston, WV television station for a Saturday children's show titled "KidsNewz" which airs in Charleston and Beckley areas. This taping involved about 40 student "extras" recruited from the Green Bank School in addition to NRAO employees. The NRAO in Green Bank is one of the nine prime links across the top of the Pocahontas County, WV website (*http://www.pocahontas.org/home.aspx*) while a search of the West Virginia Tourism site (*http://www.westvirginia.com/*) quickly brings up the National Radio Astronomy Observatory. Similarly, the VLA is featured in a video on the New Mexico Tourism website (*http://www.newmexico.org/*).

Environment, Safety and Security

Environment, Safety and Security Highlights

Environment, Safety, and Security (ES&S) participated in an NRAO ALMA meeting to address environmental and safety issues associated with the operation and existence of NRAO/AUI in Chile. The hire of an ALMA Safety Officer for the Joint ALMA Office was initiated this period. A video safety program was initiated in GB to provide safety reminders to maintenance and machine shop staff. A session for supervisors was presented and reviewed the legal responsibilities of supervisors with respect to ensuring employee safety on the jobsite. The NRAO Vehicle Safety program was finalized for NRAO Commercial Drivers in accordance with the Department of Transportation requirements. In Charlottesville, several video surveillance units were installed at the Edgemont Road site.

ALMA

Environment, Safety, and Security (ES&S) participated in an NRAO ALMA Meeting at the AUI headquarters in Washington, DC. The purpose of the meeting was to address administrative issues associated with the operation and existence of NRAO/AUI in Chile. The significant safety issues addressed included environmental compliance with the Environmental Impact Statement developed for the ALMA site and the implementation of safety at the ALMA project site.

ES&S participated in the mini-ALMA week held near Garching, Germany. This meeting provided a full overview of the system design requirements and included reporting from each of the project teams. The hire of an ALMA Safety Officer for the Joint ALMA Office was initiated this period.

At the ATF, ES&S participated in "Critical Lift" tests for the AEC antenna using the newly installed jib hoist. This resulted in written procedures that are now available for the use of this hoist when lifting items into or out of the AEC Antenna receiver cabin.

NRAO-New Mexico

The Emergency Preparedness Plan was modified to include emergency evacuation routes and emergency contacts for both the AOC and the VLA sites. The programs under development included the preparation of first aid inventories, emergency lighting inventories as well as a update to the hazardous chemical inventory for the VLA site. The annual audiogram hearing tests were completed for 60 affected employees from the VLA site. During this quarter ES&S oversaw the final portion of the annual inspection and testing for the VLA site fire protection system.

ES&S received notice from the FAA that the New Mexico Air National Guard had filed a request to lower their operational floor for the CATO Military Operations Area (MOA), directly above the VLA, down to 500 ft. AGL (above ground level). This MOA is used for aerial combat training (dog fighting). With Socorro management, ES&S assisted in developing a response to the FAA objecting to the plan. Negotiations are ongoing.

NRAO-Green Bank

The Green Bank high angle rescue team held several practice sessions this quarter to prepare the team for any emergency event on the antennas. Bloodborne pathogen safety training was provided to designated staff that could potentially be exposed to pathogens as a result of occupational exposure. In addition, a video safety program was initiated in GB this period to provide frequent safety reminders to maintenance and machine shop staff. The video series is designed to increase safety awareness among employees most likely impacted to specific workplace hazards. The series has included information on electrical safety, and manual materials handling safety.

Liberty Mutual provided a session for Supervisory Safety requirements. The session reviewed the legal responsibilities of supervisors with respect to ensuring employee safety on the jobsite. The security surveillance cameras were installed at the GB site and coverage provided to common area entrances. The cameras are in sporadic use pending final RFI resolution.

NRAO-Charlottesville

The NRAO Vehicle Safety program was reviewed and discussed at length with Human Resources and Observatory Administration. Issues included potential liability for unauthorized drivers. Meetings were held with the insurer to determine the appropriate requirements for such a program. The final resolution is that the NRAO will maintain a fully compliant Vehicle Safety Program for Commercial Drivers. This program is currently implemented and in accordance with the Department of Transportation requirements.

The NTC was toured and inspected for final safety requirements associated with the relocation. The inspection focused on life and fire safety requirements including exits, fire extinguishers and the placement of warning signs as well as first aid kits.

The initial video surveillance units were installed at the Edgemont Road site. Due to construction considerations, only three (3) units were installed. As construction progresses, the remaining units will be deployed.

Designated staff from the NTC were provided forklift awareness training. This session was an introduction to the safe operation of forklifts and was primarily for anticipated use of mechanical lifting equipment.

Telescope Usage

The NRAO telescopes were scheduled for research and maintenance during the first quarter of 2004 as described in the table below. Note that time lost and actual observing for the arrays are computed as fractions of the total antenna arrays. For example, losing 27 VLA antennas for one hour counts as 1.0 hour of time lost, while losing one out of ten VLBA antennas for one hour counts as 0.1 hours of time lost. Also note that in the case of the GBT, Test and Calibrations occasionally require less time than is scheduled for them, and the excess time is then allocated to refereed backup science programs.

Activity	**VLA** (hrs)	**VLBA** (hrs)	**GBT** (hrs)
Scheduled Observing	1670.7	1022.6	1450
Scheduled Maintenance and Equipment Changes	233.0	204.0	220
Scheduled Tests and Calibration	228.0	314.8	510
Time Lost	85.3	31.7	221
Actual Observing	1585.4	990.9	1230

GBT Observing Programs

The following research programs were conducted with the GBT during this quarter:

No.	Observer(s)	Programs
BS131	Shen, Z. (ASIAA) Lo, F.K. Y. Ho, P. T. P. (SAO) Miyoshi, M. (National Astro. Obs)	VLBA observations of Sgr A * at 3 and 7 mm
GBT01A-054	Langston, G. I. Bastian, T. S.	Search for cyclotron emission from known extra-solar planets. 90 cm
GBT01A-058	Briggs, F. H. (ANU) de Bruyn, A. G. (NFRA) Chengalur, J. (NCRA (TIFR)) Kanekar, N. (Kapteyn Astro. Institute) Lane, W.M. (NRL) Vermeulen, R. (Stichting ASTRON) Little, B. (Australian National U.)	High redshift damped Lyman-alpha systems against background radio galaxies. 90 cm
GBT01A-061	Lane, W.M. (NRL) Briggs, F. H. (ANU) Chengalur, J. (NCRA (TIFR) Kanekar, N. (Kapteyn Astro. Institute) Kassim, N. E. (NRL)	A blind search for redshifted HI 21 cm absorption. 70 cm
GBT02A-025	Hollis, J. M. (NASA/GSFC) Jewell, P. R. Lovas, F. J. (National Institute of Standards and Technology) Mollendal, H. (U. of Oslo)	A search for the next interstellar aldehyde sugar glyceraldehyde. 1.3, 2 cm
GBT02A-028	Braatz, J. A. Langston, G. I. McMullin, J. Garwood, R.)	Exploring the radio spectrum of Orion A and W51 21. 1.3, 2 cm
GBT02A-031	Lockman, F. J.	Galactic HI mapping of X-Ray, UV, and optical deep fields. 21 cm

GBT Observing Programs

No.	Observer(s)	Programs
GBT02A-046	Braatz, J. A. Henkel, C. (MPIR) Wilson, A. S. (Maryland)	Monitoring a maser disk in Mrk 1419. 1.3 cm
GBT02A-063	Claussen, M. J. Wootten, H. A.) Marvel, K. (AAS) Wilking, B. A. (Missouri)	Water maser monitoring of low and intermediate mass young stellar objects. 1.3 cm
GBT02A-065	Greenhill, L. J. (Harvard-Smithsonian) Kondratko, P.T. (Harvard) Braatz, J. A. Moran, J. M. (CfA)	Detection of AGN in apparently "normal" galaxies. 1.3 cm
GBT02A-069	Fisher, R.	Galaxy survey of HI emission. 21 cm
GBT02B-016	Solomon, P. (SUNY, Stony Brook) Vanden Bout, P. A.	Dense molecular gas and star formation in the high redshift universe (HCN). 1.3 cm
GBT02C-002	Carilli, C. L. Stocke, J. T. (Colorado) Menten, K. M. (MPIR) Langston, G. I. Rector, T.A. Dwarakanath, K. S.	Redshifted HI 21 cm absorption towards red gravitational lenses (J0134-0931, J1004+1229). 70 cm
GBT02C-008	Darling, J. (Carnegie Institute) Giovanelli, R. (Cornell) Haynes, M. P. (Cornell)	A blind HI survey for damped Lyman-alpha absorbers. 38 cm
GBT02C-012	Hollis, J. M. (NASA/GSFC) Lovas, F. J. (National Institute of Standards and Technology) Jewell, P. R. Kisiel, Z. (Polish Academy of Sciences)	A search for the first nucleic acid base biomarker interstellar pyrimidine. 1.3, 2 cm

GBT Observing Programs

No.	Observer(s)	Programs
GBT02C-020	Henkel, C. (MPIR) Balser, D. Desmurs, J. F. (Obs. Astronomico Nacio) Braatz, J. A.	A 6 GHz survey of extra-galactic OH megamasers. 6 cm
GBT02C-030	Lo, F.K. Y. Liang, M. C. (Caltech) Trung, D. (Academia Sinica)	GBT search for very luminous H_2O megamasers. 1.3 cm
GBT02C-038	Gibson, S. (Calgary) Knee, L.B.G. (Dominion Radio Astrophysical Observatory)	Interstellar matter in the vicinity of Cassiopeia A (HI) 70. 21 cm
GBT02C-052	McGary, R.S. (Harvard) Ho, P. T. P. (SAO)	Ammonia in the central 10 pc of the Galaxy. 1.3 cm
GBT02C-054	Braatz, J. A. Henkel, C. (MPIR) Wilson, A. S. (Maryland) Greenhill, L. J. (Harvard-Smithsonian) Moran, J. M. (CfA)	Measuring nuclear disks in NGC 1386 and IC 2560 (H_2O). 1.3 cm
GBT02C-065	Braatz, J. A. Henkel, C. (MPIR) Wilson, A. S. (Maryland)	A search for cosmologically interesting H_2O megamasers. 1.3 cm
GBT03A-002	Kardashev, N. S. (Lebedev Physical Institute) Soglasnov, V. (Astro Space Center) Kovalev, Jr., Y. Langston, G. I.	Search for extreme Faraday rotation in AGN 21. 3.5 cm

GBT Observing Programs

No.	Observer(s)	Programs
GBT03A-006	Kronberg, P. P. (Los Alamos Labs) Perley, R. A. Giovannini, G. (Istituto di Radioastronomia) Ensslin, T. (MPIR) Kassim, N. E. (NRL)	Proposal to search for diffuse low frequency synchrotron-radiating extensions of the Coma Cluster. 90 cm
GBT03A-014	Lockman, F. J.	Halo HI clouds: distribution and properties. 21 cm
GBT03A-015	Lane, W.M. (NRL) Kanekar, N. (Kapteyn Astro. Institute) Ellison, S.E. (ESO) Chengalur, J. (NCRA - TIFR)	A search for 21cm absorption in high redshift damped Lyman-alpha absorbers. 70 cm
GBT03A-016	Stairs, I. (British Columbia) Manchester, D.R. N. (Australia Telescope) Lyne, A. G. (NRAL)	The physics of a massive pulsar system. 21 cm
GBT03A-019	Swift, J (UC, Berkeley) Welch, W. J. (UC, Berkeley) Di Francesco, J. (NRC, Canada)	Possible pre-stellar core in L1551. 1.3 cm
GBT03A-023	Stairs, I. (British Columbia) Thorsett, S. (UC, Santa Cruz) Arzoumanian, Z. (NASA/GSFC)	Timing binary pulsars at the GBT. 21 cm
GBT03B-011	Widicus, S. (Caltech) Blake, G. (Caltech) Braakman, R. (Caltech)	A search for sugars in hot cores. 1.3 cm
GBT03B-013	Yun, M. (Massachusetts) Schneider, S. E. (Massachusetts) Brinks, E. (INAOE) Bravo-Alfaro, H. (Universidad de Guanajuato, Mexico)	An unbiased HI survey of the Coma cluster and beyond. 21 cm

GBT Observing Programs

No.	Observer(s)	Programs
GBT03B-015	Ransom, S. (McGill) Stairs, I. (British Columbia) Kaspi, V. (McGill) Hessels, J. W. T. (McGill) Backer, D. C. (UC, Berkeley)	Timing the pulsars in the globular cluster M30. 11, 21 cm
GBT03B-016	Walsh, A.J. (Harvard-Smithsonian) Myers, P. C. (CfA) Zhang, Q. (Harvard-Smithsonian) Di Francesco, J. (NRC, Canada) Bourke, T. (CfA) Wilner, D. (CfA)	A complete picture of cluster formation in NGC 1333. 1.3 cm
GBT03B-019	Li, D. (Harvard-Smithsonian) Goodman, A. A. (CfA) Goldsmith, P. F. (Cornell) Schnee, S. (Harvard)	The GBT HI narrow self-absorption survey of star-forming regions. 21 cm
GBT03B-026	Roberts, M. (McGill) Hessels, J. W. T. (McGill) Ransom, S. (McGill) Kaspi, V. (McGill) Tam, C.R. (McGill) Livingstone, M. (McGill) Backer, D. C. (UC, Berkeley) Crawford, F. (Haverford College)	Timing of a millisecond pulsar discovered in a survey of mid-latitude EGRET error boxes. 21, 38 cm
GBT03B-027	Butner, H. M. (Arizona Radio Obs.) Charnley, S.B. (NASA/Ames Research Center) Kuan, Y. J. (Academia Sinica) Ehrenfreund, P. (Leiden) Botta, O. (Leiden) Kisiel, Z. (Polish Academy of Sciences) Despois, D. (Universite de Bordeaux)	K-Band search for quinoline and isoquinoline. 1.3 cm

GBT Observing Programs

No.	Observer(s)	Programs
GBT03B-030	Benjamin, R.A. (Wisconsin, Whitewater) Lockman, F. J.	High velocity clouds interacting with the Milky Way? 21 cm
GBT03C-006	Bergin, E. (CfA) Wilner, D. (CfA)	A search for ammonia in proto-planetary disks. 1.3 cm
GBT03C-007	Roberts, M. (McGill) Ransom, S. (McGill) Camilo, F. (Columbia) Kaspi, V. (McGill) Romani, R. W. (Stanford)	Deep pulsation searches of two galactic gamma-ray sources. 21 cm
GBT03C-009	Darling, J. (Carnegie Institute)	A direct measurement of fine structure "constant" evolution from OH and HI absorption lines. 90 cm
GBT03C-012	Braatz, J. A. Henkel, C. (MPIR)	Follow-up observations of extragalactic H_2O masers discovered with the GBT. 1.3 cm
GBT03C-018	Mayo, E. (Kentucky) Troland, T. H. (Kentucky) Crutcher, R. M. (Illinois)	A critical test of magnetic effects in star formation. 21 cm
GBT03C-024	Troland, T. H. (Kentucky) Benjamin, R.A. (Wisconsin, Whitewater)	The magnetic field in high-velocity HI clouds. 21 cm
GBT03C-031	Jacoby, B. (Caltech) Anderson, S. (Caltech) Kulkarni, S. R. (Caltech) Kaplan, D.L. (Caltech) Backer, D. C. (UC, Berkeley)	Timing the pulsars in M62, NGC 6544, and NGC 6624 and search for ultra-fast pulsars. 21, 38 cm

GBT Observing Programs

No.	Observer(s)	Programs
GBT03C-041	Ransom, S. (McGill) Ramachandran, R. (UC, Berkeley) Kaspi, V. (McGill) Demorest, P. (UC, Berkeley) Backer, D. C. (UC, Berkeley) Arons, J. (UC, Berkeley)	RRS observations of the double binary pulsar J0737-3039. 70, 21. 11 cm
GBT04A-002	Camilo, F. (Columbia)	Measurement of scattering timescales at 800 MHz for a sample of "Parkes multibeam pulsars." 38 cm
GBT04A-016	Donovan, J. (Columbia) Camilo, F. (Columbia)	Deep searches for young pulsars in "shell" supernova remnants. 38 cm
GBT04A-025	Liszt, H. Lockman, F. J. Rupen, M. P. Pidopryhora, Y. (Ohio)	Physical properties of halo HI clouds. 21 cm
GBT04A-026	Pidopryhora, Y. (Ohio) Shields, J. (Ohio) Lockman, F. J.	Mapping the galactic halo HI: correlated halo clouds and an HI plume. 21 cm
GBT04A-030	Stairs, I. (British Columbia) Thorsett, S. (UC, Santa Cruz) Arzoumanian, Z. (NASA/GSFC) Ferdman, R. (British Columbia)	High-precision timing of binary pulsars at the GBT. 21 cm
GBT04A-041	Margot, J.L. (Caltech) Peale, S. (UC, Santa Barbara) Slade, M. (JPL)	The interiors of Mercury and Venus from their spin dynamics. 3.5 cm

GBT Observing Programs

No.	Observer(s)	Programs
GBT04A-045	Roberts, M. (McGill) Hessels, J. W. T. (McGill) Ransom, S. (McGill) Kaspi, V. (McGill) Tam, C.R. (McGill) Livingstone, M. (McGill) Backer, D. C. (UC, Berkeley) Crawford, F. (Haverford College) Kaplan, D.L. (Caltech)	Timing of three binary pulsars discovered in a survey of mid-latitude EGRET error boxes. 21, 38 cm
GG053	Garrett, M. (JIVE) Garrington, S. T. (NRAL) Muxlow, T. W. B. (NRAL)	High resolution radio observations of the Hubble Deep Field region. 21 cm

VLA Observing Programs

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

No.	Observer(s)	Programs
AB1099	Brookes, M. Best, P. (Royal Obs) Rottgering, H. (Leiden) Peacock, J. (Edinburgh) Dunlop, J. (Edinburgh)	Spectral indices of sources from EIS-NVSS survey. 90 cm
AB1108	Berger, E. (Caltech) Kulkarni, S. (Caltech) Frail, D.	Gamma-ray burst host galaxies. 20 cm
AB1112	Becker, R. (UC, Davis) Helfand, D. (Columbia) White, R. (STScI) Giveon, U. (UC, Davis)	Completing a Milky Way survey. 6 cm
AB1115	Butler, B. Perley, R. Gurwell, M. (Caltech) Readhead, T. (Caltech)	The effective bulk dielectric constant of Mars. 3.6, 6 cm
AB1117	Bergman, P. (Chalmers, Onsala) Kerschbaum, F. (Vienna) Olofsson, H. (Stockholm Obs)	Circumstellar envelopes of RV Boo and X Her. 0.7 cm
AB1122	Birkinshaw, M. (Bristol, UK) Worrall, D. (Bristol, UK) Wilkes, B. (CfA) Green, P. (CfA)	Radio counterparts to X-ray sources. 3.6 cm
AB1123	Brisken, W. Thorsett, S. (UC, Santa Cruz)	Calibrator search for merging binary pulsar. 3.6, 20 cm
AC666	Choi, M. (SA/IAA, Taiwan) Ho, P. (CfA) Takakuwa, S. (CfA)	Density structure of the inner envelope of Class O protostars. 0.7 cm
AC681	Cannon, J. (Minnesota) Skillman, E. (Minnesota)	Continuum emission in the low-metallicity galaxy I Zw 18. 3.6, 20 cm

VLA Observing Programs

No.	Observer(s)	Programs
AC682	Clarke, T. (Virginia) Kempner, J. (Virginia)	Radio X-ray power relation for cluster radio halos. 90 cm
AC696	Clarke, T. (Virginia) Kempner, J. (Virginia)	Radio halos in clusters of galaxies. 20 cm
AC697	Cirasuolo, M. (SISSA-Trieste) Magliocchetti, M. (SISSA-Trieste) Celotti, A. (Brera Obs) Danese, L. (SISSA-Trieste) Cristiani, S. (Padova)	Highest-redshift complete quasar sample. 20 cm
AC702	Cannon, J. (Minnesota) Skillman, E. (Minnesota)	Continuum emission in dwarf starburst galaxies: NGC 625. 3.6, 6 cm
AC705	Carilli, C. Walter, F. Bertoldi, F. (MPIR, Bonn) Menten, K. (MPIR, Bonn) Lewis, G. (AAO) Cox, P. (IAP, Paris) Beelen, A. (IAP, Paris) Yun, M. (Massachusetts) Omont, A. (IAP, Paris)	CO emission from most distant lensed quasar. 0.7 cm
AC707	Codella, C. (CNR/IRA-Frascati) Beltran, M. (CfA) Cesaroni, R. (Arcetri) Furuya, R. (Arcetri) Testi, L. (Arcetri)	Ammonia toward water masers in high-mass star-forming regions. 1.3 cm
AC712	Croston, J. (Bristol, UK) Hardcastle, M. (Bristol, UK) Birkinshaw, M. (Bristol, UK) Worrall, D. (Bristol, UK)	Structure of FR-I radio galaxy NGC 1044. 20 cm
AC713	Chen, Y. (CfA) Zhang, Q. (CfA)	Ammonia toward high-mass star-forming regions. 1.3 cm

VLA Observing Programs

No.	Observer(s)	Programs
AC714	Choi, M. (SA/IAA, Taiwan) Ho, P. (CfA) Takakuwa, S. (CfA)	Structure of inner envelope of Class O protostars. 0.7 cm
AC715	Choi, M. (SA/IAA, Taiwan) Tatematsu, K. (Ibaraki U.)	SiO and ammonia in protostellar outflow NGC 1333 IRAS 4A. 0.7, 1.3 cm
AC717	Chyzy, K. (Jagellonian) Bomans, D. (Ruhr U.) Beck, R. (MPIR, Bonn)	Polarimetry of blue compact dwarf IC 10. 20 cm
AC719	Claussen, M. Healy, K. (Arizona State) Hester, J. (Arizona State)	VLBI calibrator search toward the Eagle Nebula. 1.3, 3.6 cm
AC724	Chambers, K. (Hawaii) McGrath, E. (Hawaii)	Structure and spectra of FIRST sources. 3.6 cm
AC728	Cheung, T. (Brandeis) Wardle, J. (Brandeis)	Spectrum of X-ray "jet" in quasar GB 1508+5714. 3.6, 6 cm
AC738	Claussen, M. Wootten, A. Shirley, Y. Marvel, K. (AAS)	New nebula in Orion. 1.3, 3.6, 6, 20 cm
AC762	Carilli, C. Bertoldi, F. (MPIR, Bonn) Menten, K. (MPIR, Bonn) Walter, F. Cox, P. (IAP, Paris) Omont, A. (IAP, Paris) Fan, X. (Princeton) Strauss, M. (Princeton)	Continuum from QSO J1048+4637 at z=6.23. 20 cm
AD477	Dubner, G. (IAFE) Castelletti, G. (IAFE) Reynoso, E. (IAFE) Goss, W.M.	SNR Puppis A. 20 cm

VLA Observing Programs

No.	Observer(s)	Programs
AD493	Dahlem, M. (ESO) Ehle, M. (ESA, Spain) Lisenfeld, U. (IAA)	Structure of radio halo in edge-on galaxy NGC 4700. 20 cm
AD494	Dallacasa, D. (Bologna) Stanghellini, C. (Bologna) Tinti, S. (Brera Obs)	Spectra, polarization and structure of high-frequency peakers. 0.7, 1.3, 2, 3.6, 6, 20 cm
AD496	Decin, L. (Katholieke) Blommaert, J. (Katholieke) Groenewegen, M. (MPIA, Heidelberg) Butler, B.	Observations of 5 normal late-type stars at 7mm. 0.7 cm
AD497	Dalcanton, J. (Washington) Rosolowsky, E. (UC, Berkeley) Tavarez, M. (Michigan) Hibbard, J.	HI structure and kinematics of edge-on late-type disk galaxies. 20 cm
AD499	Drake, S. (NASA/GSFC) Bastian, T. Linsky, J. (Colorado/JILA) Osten, R. Wade, G. (RMCC)	Coordinated radio, X-ray measurements of MCP star 56 Tau. 2, 3.6, 6, 20 cm
AD500	DeLaney, T. (Minnesota) Rudnick, L. (Minnesota)	Spectral-index imaging of Cassiopeia A. 6, 20 cm
AE151	Emonts, B. (Groningen/Kapteyn) Morganti, R. (NFRA) vanderHulst, J. (Groningen/Kapteyn) Oosterloo, T. (NFRA) Tadhunter, C. (Sheffield) vanMoorsel, G.	HI observations of radio galaxies. 20 cm
AF405	Feretti, L. (Bologna) Orru, E. (Bologna) Brunetti, G. (Bologna) Giovannini, G. (Bologna) Girardi, M. (Trieste) Govoni, F. (Bologna)	Spectral indices of radio halos in clusters A2219 and A2744. 90 cm

VLA Observing Programs

AF406	Feretti, L. (Bologna) Orru, E. (Bologna) Giovannini, G. (Bologna) Lane, W. (NRL) Kassim, N. (NRL) Perley, R.	Spectral indices of giant radio galaxies 3C35 and 3C326. 90 cm
AF410	Fender, R. (Amsterdam) Gallo, E. (Amsterdam) Merloni, A. (Amsterdam) Rupen, M.	Counterpart to ultraluminous X-ray source in NGC 4244. 3.6 cm
AG657	Goto, T. (Johns Hopkins)	E+A galaxies uniformly selected from SDSS. 20 cm
AG659	deGregorio, I. (IAA, Andalucia) Gomez, J. (IAA, Andalucia)	Water masers in Bok globules. 1.3 cm
AG668	Goss, W.M.. Dubner, G. (IAFE) Giacani, E. (IAFE) Decourchelle, A. (Saclay) Cassam-Chenai, G . (Saclay)	OH masers toward SNR G347.3-0.5. 20 cm
AH811	Helfand, D. (Columbia) Becker, R. (UC, Davis) White, R. (STScI) Warwick, R. (Leicester)	A multi-wavelength image of Milky Way. 20 cm
AH831	Hardcastle, M. (Bristol, UK)	Spectral index variations in microquasar GRS 1758-258. 20 cm
AH833	Hunter, T. (CfA) Zhang, Q. (CfA) Sridharan, T. (CfA)	Locating the water masers in protocluster IRAS 18317-0757. 1.3 cm
AH837	Henning, P. (New Mexico) Massey, P. (Lowell Obs.)	HI structure and kinematics in dwarf irregular HIZSS 3. 20 cm
AH841	Hibbard, J.	HI structure and kinematics in merging

VLA Observing Programs

		systems. 20 cm
AI111	Impey, C. (Arizona) Miller, L. (Oxford) Lopes, A. (Oxford)	Potential new wide-separation gravitational lenses. 3.6 cm
AJ299	Johnson, K. (Wisconsin) Plante, S. (Laval)	Star cluster formation at low metallicities: SBS0335-052. 1.3, 2 cm
AJ309	Jetha, N. (Birmingham) Hardcastle, M. (Bristol, UK) Sakelliou, I. (Birmingham)	Structures of jets in wide angle tail radio sources. 3.6 cm
AK550	Kulkarni, S. (Caltech) Berger, E. (Caltech) Soderberg, A. (Caltech) Chevalier, R. (Virginia)	Type Ibc supernovae. 1.3, 3.6, 6, 20 cm
AK560	Keto, E. (CfA)	Continuing accretion in massive star formation. 0.7, 1.3 cm
AK563	Kenney, J. (Yale) van Gorkom, J. (Columbia) Vollmer, B. (MPIR, Bonn)	Virgo cluster, a laboratory for studying galaxy evolution. 20 cm
AK573	Kulkarni, S. (Caltech) Berger, E. (Caltech) Frail, D. Soderberg, A. (Caltech)	Radio afterglows of GRBs. 0.7, 1.3, 2, 3.6, 6, 20 cm
AK575	Kulkarni, S. (Caltech) Senko, S. (Caltech) Frail, D. Harrison, F. (Caltech) Fox, D. (MIT) Soderberg, A. (Caltech)	Triggered observations of GRB afterglows. 0.7, 1.3, 2, 3.6, 6, 20 cm
AK576	Kellermann, K. Kelly, J. (Virginia) Fomalont, E. Shaver, P. (ESO)	Deep imaging of Chandra DFS, including HST UDF. 20 cm

VLA Observing Programs

	Rosati, P. (MPIfEP, Garching)	
AK577	Kurtz, S. (Mexico/UNAM) Hofner, P. (NMIMT) Araya, E. (Puerto Rico) Cesaroni, R. (Arcetri) Olmi, L. (Puerto Rico)	Kinematics of molecules in G31.41 hot core. 0.7 cm
AK578	Kannappan, S. (Texas) Matthews, L. Bash, F. (Texas)	HI imaging of SO disks and their environments. 20 cm
AK579	Kondratko, P. (CfA) Greenhill, L. (CfA) Moran, J. (CfA)	Water maser emission in 5 distant AGN. 1.3 cm
AL604	Laing, R. (Oxford) Parma, P. (Bologna) Bridle, A. Fanti, R. (Bologna)	Depolarization asymmetry in extragalactic radio sources. 6 cm
AL609	Lang, C. (Iowa) Johnson, K. (Wisconsin) Goss, W.M.. Rodriguez, L. (Mexico/UNAM)	Stellar wind sources in galactic center clusters. 1.3, 3.6 cm
AL613	Lim, J. (SA/IAA, Taiwan) Hirano, N. (Hitotsubashi) Ohashi, N. (CfA) Takakuwa, S. (CfA)	Dust distribution in binary/multiple protostellar systems. 0.7 cm
AL617	Law, C. (Northwestern) Yusef-Zadeh, F. (Northwestern) Cotton, W. Maddalena, R. Roberts, D. (Northwestern)	The galactic center lobe. 6, 20 cm
AL618	Leone, F. (Catania) Umana, G. (Bologna) Trigilio, C. (Bologna) Leto, P. (Bologna)	Radio spectra of magnetic chemically peculiar stars. 0.7, 1.3, 2, 6, 20 cm

VLA Observing Programs

AL619	Lee, C. (CfA) Gyulbudaghian, A. (Byurakan Obs) Anglada, G. (IAA, Andalucia)	Continuum emission from optical/IR YSO candidates. 3.6 cm
AL620	Levy, L. (UNC) Rose, J. (UNC) vanGorkom, J (Columbia)	HI structure and kinematics of galaxies in Pegasus I cluster. 20 cm
AM766	Monnier, J. (CFA) Greenhill, L. (CFA) Tuthill, P. (Sydney) Danchi, W. (NASA/GSFC)	Monitoring colliding wind binary WR112. 3.6 cm
AM772	Mack, K-H. (NFRA) Prieto, M. (ESO) Brunetti, G. (Bologna	Optically detected radio galaxy hot spots. 3.6, 6, 20 cm
AM777	Murgia, M. (Bologna) Parma, P. (Bologna) deRuiter, H. (Bologna) Mack, K-H. (NFRA) Fanti, R. (Bologna)	Spectral index imaging of fossil radio galaxies. 3.6, 6, 20 cm
AM786	Massi, F. (Arcetri) Felli, M. (Arcetri) Cesaroni, R. (Arcetri)	Thermal radio jet in S235 A-B. 1.3, 3.6, 6 cm
AM788	Mundell, C. (Liverpool JMU) Wilson, A. (Maryland) Schinnerer, E. Wilcots, E. (Wisconsin) Ulvestad, J.	HI imaging survey of Seyfert galaxies. 20 cm
AN107	Neff, S. (NASA/GSFC) Ulvestad, J.	High resolution imaging of the young merger NGC 3395/6. 3.6, 6 cm

VLA Observing Programs

AN119	Nakanishi, H. (Tokyo) Sofue, Y. (Tokyo) Onodera, S. (Tokyo) Namba, T. (Tokyo) Egusa, F. (Tokyo) Kohno, K. (Tokyo) Kuno, N. (NAO, Japan) Sato, N. (NAO, Japan)	HI in Virgo cluster spirals with CO observations. 20 cm
AO175	Owen, F. Morrison, G. (IPAC) Lonsdale, C. (Caltech) Smith, G. (Calif., San Diego) Xu, K. (Caltech)	Observations of the SWIRE deep field. 20 cm
AP477	Perley, R. Vigotti, M. (Bologna) Benn, C. (RGO-La Palma) Mack, K. (NFRA)	BAL QSS J1624+38 at z=3.4. 2, 3.6 cm
AR523	Rupen, M. Dhawan, V. Mioduszewski, A. Ribo, M. (Barcelona)	X-ray binaries, transients and related sources. 0.7, 1.3, 2, 3.6, 6, 20 cm
AR535	Ribo, M. (Barcelona) Mirabel, I. (CNRS, France) Rodriguez, J (ISDC, Switzerland) Hannikainen, D. (Helsinki)	VLA/INTEGRAL/RXTE monitoring of GRS1915+105. 3.6, 20 cm
AR536	Rudnick, L. (Minnesota) Delain, K. (Minnesota)	Structures and spectral indices of WISH sources. 90 cm
AR537	Rodriguez, L. (Mexico/UNAM) Loinard, L. (Mexico/UNAM) D'Alessio, P. (Mexico/UNAM)	Compact protoplanetary disks around Class O proto stars. 0.7 cm
AR540	Ribo, M. (Barcelona) Mirabel, I. (CNRS, France)	Jet in galactic X-ray source 4U 1755-338. 6, 20 cm

VLA Observing Programs

AR541	Roussel, H. (CNRS, France) Condon, J. Beck, R. (MPIR, Bonn) Helou, G. (IPAC)	Imaging candidate and confirmed nascent starbursts. 3.6, 6, 20 cm
AR542	Roberts, D. (Northwestern) Yusef-Zadeh, F. (Northwestern) Bower, G. (Calif., Berkeley) Goldwurm, A. (Service d'Astrophys.)	Coordinated study of time variability of Sgr A*. 0.7, 1.3, 3.6 cm
AS762	Sokoloski, J. (Southampton) Mioduszewski, A. Brocksopp, C. (MSSL) Rupen, M.	Monitoring symbiotic binaries during outburst. 3.6, 6, 20 cm
AS773	Suarez, O. (ESA-LAEFF) Gomez, J. (IAA, Andalucia)	Continuum and H92a study of PN IRAS 17395-0841. 3.6 cm
AS777	Schinnerer, E. Goss, W.M. Turner, J. (UCLA) Johnson, K	Star formation in central 300 pc of IC 342. 3.6, 6 cm
AS778	Stockdale, C. (NRL) Maddox, L. (Oklahoma) Cowan, J. (Oklahoma) Pannuti, T. (MIT) Prestwich, A. (CFA) Kilgard, R.(CFA)	Spectral-index study of nearby spiral galaxies. 6 cm
AS780	Schinnerer, E. Rupen, M.Kennicutt, R. (Arizona)	Spectral-index study of M51 on 100-pc scale. 6, 20 cm
AS782	Sewilo, M. (Wisconsin) Churchwell, E. (Wisconsin) Goss, M. Kurtz, S. (Mexico/UNAM) Hofner, P. (Puerto Rico)	Broad radio recombination lines from hypercompact HII regions. 0.7 cm

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AS784	Swaters, R. (Johns Hopkins) Verheijen, M. (Wisconsin) Bershady, M. (Wisconsin) Andersen, D. (MPIA)	Kinematics of low surface brightness galaxy DDO 39. 20 cm
AS786	Scuderi, S. (Bologna) Markova, N. (Bulgary) Puls, J. (Sternwarte) Stanghellini, C. (Bologna)	Spectra of thermal winds from O stars. 0.7, 2, 3.6, 6 cm
AS787	Schinnerer, E. Mundell, C. (Liverpool JMU) Garcia-Burillo, S. (Obs. National) Combes, F. (Paris Obs) Ulvestad, J	Further HI imaging of CO selected galaxies. 20 cm
AS788	Solomon, P. (SUNY) VandenBout, P. Carilli, C.	HCN in SCUBA source SMM14011+02 at z=2.6. 1.3 cm
AS795	Sandell, G. (NASA-ARC) Wright, M. (Calif., Berkeley) Goss, W.M.	Dust emission from accretion disk of protostar NGC 7538 S. 1.3 cm
AS796	Soderberg, A. (Caltech) Kulkarni, S. (Caltech) Frail, D. Chevalier, R. (Virginia)	Triggering on further type Ibc SNe. 1.3, 3.6, 6, 20 cm
AS797	Sewilo, M. (Wisconsin) Churchwell, E. (Wisconsin) Goss, W.M. Kurtz, S. (Mexico/UNAM) Hofner, P. (NMIMT)	RRL spectroscopy of hypercompact HII regions. 1.3, 2, 3.6 cm
AT296	Tarchi, A. (MPIR, Bonn) Brunthaler, A. (MPIR, Bonn) Menten, K. (MPIR, Bonn)	Phase reference sources for water megamaser in 3C 403. 1.3 cm

VLA Observing Programs

AU096	Ulvestad, J. Mathur, S. (Ohio State) Fields, D. (Ohio State)	Narrow-line Seyfert 1 galaxies selected from SDSS. 3.6 cm
AV269	VanTrung, D. (SA/IAA, Taiwan) Lim, J. (SA/IAA, Taiwan)	Structure and spectral indices in Egg Nebula. 0.7, 1.3 cm
AW599	Whysong, D. (UC, Santa Barbara) Antonucci, R. (UC, Santa Barbara) Geller, R. (UC, Santa Barbara)	Search for Thompson scattering in the intergalactic medium. 20 cm
AW605	Walter, F. Brinks, E. (Guanajuato) de Blok, E. (Cardiff) Thornley, M. (Bucknell) Kennicutt, R. (Arizona)	HI structures of nearby galaxies. 20 cm
AW607	Winn, J. (CfA) Rusin, D. (CfA) Kochanek, C. (CfA) Lovell, J. (CSIRO) Fassnacht, C. (UC, Davis) Koopmans, L. (Caltech)	Gravitational lens monitoring. 3.6 cm
AW608	Weiler, K. (NRL) Stockdale, C. (NRL) Sramek, R. Van Dyk, S. (IPAC) Panagia, N. (STScI) Marcaide, J. (Valencia) Lewin, W. (MIT) Pooley, D. (MIT) Immler, S. (Massachusetts)	ToO observations of supernovae. 1.3, 2, 3.6, 6, 20, 90 cm
AW616	Wang, J. (Peking Obs) Zhang, Q. (CfA) Wang, Z. (CfA)	Atomic gas in galaxy-galaxy merger NGC 6090. 20 cm

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AW617	Weiler, K. (NRL) Stockdale, C. (NRL) Sramek, R. VanDyk, S. (UCLA) Panagia, N. (STScI) Marcaide, J. (Valencia) Lewin, W. (MIT) Pooley, D. (MIT) Immler, S. (Massachusetts)	Long-term monitoring of radio supernovae. 1.3, 2, 3.6, 6, 20 cm
AW619	Wilcots, E. (Wisconsin) Sanders, W. (Wisconsin) Doane, N. (Wisconsin)	Continuum and HI imaging of NGC 4395. 20 cm
AW620	Walter, F. Carilli, C. Lo, K.Y. Menten, K. (MPIR, Bonn) Cox, P. (IAP, Paris) Fan, X. (Princeton) Omont, A. (IAP, Paris) Strauss, M. (Princeton)	Resolving CO disk in J1148+5251 at z=6.42. 0.7 cm
AW622	Walter, F. Carilli, C. Lo, K. (SA/IAA, Taiwan) Bertoldi, F. (MPIR, Bonn) Menten, K. (MPIR, Bonn) Fan, X. (Princeton) Omont, A. (IAP, Paris)	Search for molecular gas in quasars at z > 6. 0.7 cm
AW624	Weiler, K. (NRL) Stockdale, C. (NRL) Sramek, R. VanDyk, S. (UCLA) Panagia, N. (STScI) Marcaide, J. (Valencia) Lewin, W. (MIT) Pooley, D. (MIT) Immler, S. (Massachusetts) Ryder, S. (AAO)	Triggered observations of type II SNe. 0.7, 1.3, 2, 3.6, 90 cm

VLA Observing Programs

AW626	Wilkin, F. (Mexico/UNAM) Loinard, L. (Mexico/UNAM)	SiO in the NGC1333 IRAS 2A protostellar outflow. 0.7 cm
AW628	Willson, R. (Tufts) Holman, G. (NASA/GSFC)	Observations of Solar flares and microflares. 3.6, 6 cm
AW629	Willson, R. (Tufts)	Observations of trans-equatorial loops on the Sun. 20, 90 cm
AY147	Yusef-Zadeh, F. (Northwestern) Cotton, W.D. Law, C. (Northwestern)	Continuum survey of Galactic center region. 20 cm
AY148	Young, L. (NMIMT) Skillman, E. (Minnesota)	HI structure and kinematics of the Phoenix dwarf galaxy. 20 cm
AY149	Yusef-Zadeh, F. (Northwestern) Wardle, M. (MacQuarie) Pound, M. (Maryland) Roberts, D. (Northwestern) Cotton, W. D.	Polarimetry of nonthermal features Sgr A-E and F. 2, 3.6 cm
AZ143	Zhao, J. (CfA) Herrnstein, R. (CfA) Goss, W.M. Bower, G. (UC, Berkeley) Pegg, J. (CfA)	Monitoring quasi-periodic oscillations of SgrA*. 0.7, 1.3, 2 cm
AZ148	Zijlstra, A (Manchester) Kerber, F. (ESO) vanHoof, P. (Queens) Pollacco, D. (RGO) Evans, A. (Keele) Eyres, S. (Central Lancashire)	Radio evolution of Sakurai's object. 3.6, 6 cm
BB184	Braatz, J. Greenhill, L. (CfA) Henkel, C. (MPIR, Bonn) Moran, J. (CfA) Wilson, A. (Maryland)	Imaging nuclear H_2O masers in NGC 4388, NGC 5728 and NGC 6323. 1.3 cm

VLBA Observing Programs

The following research programs were conducted with the VLBA during this quarter:

No.	Observer(s)	Programs
BB168	Bartel, N. (York) Bietenholz, M. (York) Lebach, D. (CfA) Ratner, M. (CfA) Shapiro, I. (CfA)	Proper motion of the "core" of the quasar 3C345. 0.7, 2 cm
BB172	Brunthaler, A. (MPIR, Bonn) Falcke, H. (MPIR, Bonn) Greenhill, L. CfA) Henkel, C. (MPIR, Bonn) Reid, M. (CfA)	Proper motions in the Local Group. 1 cm
BB176	Boboltz, D. (USNO) Marvel, K (AAS)	An overlooked water fountain? 20 cm
BB177	Bolton, R. (Cambridge) Chandler, C. Cotter, G. (Cambridge) Pearson, T. (Caltech) Pooley, G. (Cambridge) Readhead, T. (Caltech) Riley, J. (Cambridge) Waldram, E. (Cambridge)	VLBI Mapping of compact radio sources selected at 15 GHz. 6 cm
BB178	Bower, G. (UC, Berkeley) Anderson, J. (NMIMT)	Trigonometric parallax of radio stars in Pleiades open cluster. 4 cm

VLBA Observing Programs

No.	Observer(s)	Programs
BC120	Chatterjee, S. Backer, D. (UC, Berkeley) Benson, J. Brisken, W. Cordes, J. (Cornell) Ellis, R. (UC, Santa Cruz) Fomalont, E. Golden, A. (Ireland) Goss, W.M. Kramer, M. (Manchester) Lazio, T. (NRL) Lyne, A. (Manchester) McKinnon, M. Thorsett, S. (UC, Santa Cruz) Wong, D (Cornell)	Pulsar astrometry with the VLBA. 20 cm
BC127	Cawthorne, T. (Central Lancashire) Gabuzda, D. (Cork) Jorstad, S. (Boston) Marscher, A. (Boston) Stirling, A. (Central Lancashire)	Precessing jet in BL Lacertae? 0.7, 1, 2, 4 cm
BC128	Claussen, M. Marvel, K. (AAS) Wilking, B. (UMSL) Wootten, H.A.	Monitoring of water masers around low and intermediate luminosity young stellar objects. 1 cm
BC137	Cesaroni, R. (Arcetri) Beltran, M. (Arcetri) Codella, C. (Firenze) Furuya, R. (Arcetri) Mosadelli, L. (Cagliari) Testi, L (Arcetri)	Study of H_20 and OH masers tracing two bipolar outflows in the high-mass cluster G24.78+0.08. 1 cm
BC138	Cheung, T. (Brandeis) Taylor, G. Wardle, J (Brandeis)	Three lobe-dominated quasars with radio/optical hotspots. 90 cm

VLBA Observing Programs

No.	Observer(s)	Programs
BC142	Claussen, M. Morris, M. (UCLA) Sahai, R. (JPL) Sanchez-Contreras, C. (OVRO)	Water masers in newly discovered protoplanetary nebulae. 1 cm
BD087	Dhawan, V. Fomalont, E. Lestrade, J. (Obs. de Paris) Mioduszewski, A. Rupen, M	Astrometry of X-ray binaries. 0.7, 2, 4 cm
BE030	Edwards, P. (ISAS) Holder, J. (Leeds) Piner, B (Whittier College)	Puzzling parsec-scale structure of the TeV gamma-ray source 1ES1956+650. 1, 2 cm
BE033	Edwards, P. (ISAS) Kataoka, J. (Tokyo Inst. Technology) Murphy, D (JPL)	Radio/optical X-ray jet source 3C15. 2, 4, 6, 13, 20 cm
BF072	Fassnacht, C. (UC, Davis) Taylor, G. Fomalont, E. Gehrels, N. (NASA) Michelson, P. (NASA) Myers, S. Pearson, T. (Caltech) Readhead, T. (Caltech) Sjouwerman, L. Ulvestad, J. Walker, R. C. Wrobel, J.	VLBA imaging and polarimetry survey. 2, 6 cm
BG139	Gabuzda, D. (Cork) Murray, E. (Cork) Reynolds, C. (JIVE) Virtrischak, V (Moscow State)	Magnetic fields of the extended jets of BL Lac objects. 20 cm
BG140	Goddi, C. (Cagliari) Moscadelli, L. (Cagliari)	22.2 GHz maser observations to test the circumstellar disk/jet model toward the high-mass YSO in AFGL 5142. 1 cm

VLBA Observing Programs

No.	Observer(s)	Programs
BG144	Gabuzda, D. (Cork) Cronin, P. (Cork) Murray, E (Cork)	Investigating the toridal B fields of BL Lac object jets. 2, 4, 6 cm
BG145	Greenhill, L. (CFA) Argon, A. (CFA) Humphreys, E. (CFA) Moran, J. (CFA) Reid, M. (CFA)	Something interesting is happening in NGC 4258. 1 cm
BH116	Homan, D. (Dennison University) Cheung, T. (Brandeis) Wardle, J. (Brandeis)	Jet structure in 180-deg misaligned blazar PKS 1510-089. 90 cm
BI028	Imai, H. (JIVE) Morris, M. (UCLA) Sahai, R (JPL)	Kinematics of collimated molecular jets in evolved stars: case of IRAS 19134+2131. 1 cm
BJ045	Junor, B. (LANL)	Deep 3mm observations of Virgo A core. 0.3, 0.7 cm
BJ046	Junor, B. (LANL) Eilek, J. (NMIMT) Hardee, P. (Alabama) Owen, F. Walker, R.C.	M87 Jet at 25 mass resolution. 90 cm
BJ048	Johnston, K. (USNO) Fey, A. (USNO) Ma, C. (NASA/GSFC) Gordon, D. (NASA/GSFC) Boboltz, D. (USNO) Kingham, K. (USNO) Vandenberg, N. (Interferometrics) Himwich, E. (Interferometrics) MacMillan, D. (Interferometrics) Petrov, L. (NASA/GSFC) Fomalont, E. Walker, R. C.	Geodesy/astrometry observations for 2004. 3.6 cm

VLBA Observing Programs

No.	Observer(s)	Programs
BJ049	Jackson, N. (Manchester) Browne, I. (Manchester) Todorovic, M. (Manchester) Wilkinson, P. (Manchester)	Follow-up of possible small separation lenses in the CLASS survey. 6 cm
BK107	Krichbaum, T. (MPIR, Bonn) Sohn, B. (MPIR, Bonn) Agudo, I. (IAA, Andalucia) Witzel, A. (MPIR, Bonn) Zensus, J. A. (MPIR, Bonn) Ungerechts, H. (Massachusetts) Terasranta, H. (Helsinki)	Polarimetric monitoring of blazar 1633+382 after major flare. 0.7, 1 cm
BK108	Kunert, M. (TRAO) DeBreuck, C. (ESO) Marecki, A. (TRAO)	Looking for restarted small scale radio sources. 20 cm
BL104	Lobanov, A. (MPIR, Bonn) Roland, J. (IAP) Ros, E. (MPIR, Bonn) Zensus, J. A. (MPIR, Bonn)	Cross-Band monitoring of a flare in the VLBI core of 3C345. 0.7, 1, 2 cm
BL111	Lister, M. Aller, F. (Michigan) Aller, H. (Michigan) Cohen, M. (Caltech) Homan, D. Kadler, M. (MPIR, Bonn) Kellermann, K. Kovalev, Y. (Lebedev) Lobanov, A. (MPIR, Bonn) Ros, E. (MPIR, Bonn) Vermeulen, R. (NFRA) Zensus, J. A. (MPIR, Bonn)	MOJAVE program. 2 cm

VLBA Observing Programs

No.	Observer(s)	Programs
BL115	Lanyi, G. (JPL) Boboltz, D. (USNO) Charlot, P. (Bordeaux) Fey, A. (USNO) Fomalont, E. Gordon, D. (NASA/GSFC) Ma, C. (NASA/GSFC) Sovers, O. (NASA/Remote Sensing) Taylor, G. Ulvestad, J.	High precision K/Q-Band astrometry. 4, 1, 13 cm
BL118	Loinard, L. (Mexico/UNAM) Mioduszewski, A. Rodriguez, L. (Mexico/UNAM)	Astrometric study of T Tau Sb. 4 cm
BM191	Marscher, A. (Boston) Aller, M. (Michigan) Gomez, J. (IAA) Jorstad, S. (Boston) McHardy, I. (Southampton)	Relationship between X-ray events and superluminal ejections. 0.7, 1 cm
BM198	Massi, M. (MPIR, Bonn) Menten, K. (MPIR, Bonn) Ros, E. (MPIR, Bonn)	Polarimetry of young binary system V773 Tau A. 4 cm
BN019	Nagar, N. (Kapteyn Institute) Falcke, H. (MPIR, Bonn) Wilson, A. (Maryland)	Parsec-scale radio cores in low luminosity AGN. 6 cm
BN021	Nagar, N. (Kapteyn Institute) Falcke, H. (MPIR, Bonn) Maoz, D. (Tel Aviv) Wilson, A. (MPIR, Bonn)	Accretion in low-luminosity AGN: A radio, UV and X-ray variability study. 6 cm
BR091	Romani, R. (Stanford) Brisken, W. Dodson, R. (ISAS) Manchester, R. (CSIRO)	PSR B1706-44 origin and kick from an astrometric proper motion. 20 cm

VLBA Observing Programs

No.	Observer(s)	Programs
BR092	Ratner, M. (CfA) Bartel, N. (York U. U.) Bietenholz, M. (York U. U.) Lebach, D. (CfA) Lederman, J. (York U.) Lestrade, J. (Paris Obs) Ransom, R. (York U.) Shapiro, I. (CfA)	Astrometric monitoring of HR 8703 for GP-B mission. 4 cm
BR093	Romani, R. (Stanford) Greenhill, L. (CfA) Sowards-Emmerd, D. (Stanford)	Exploratory imaging of Q0906+6930. 2 cm
BR094	Rupen, M. Dhawan, V. Mioduszewski, A.	Observations of possible microquasar J1628-4152. 4, 13 cm
BS131	Shen, Z. (ISAS, Japan) Lo, K. (SA/IAA, Taiwan) Ho, P. (CfA) Miyoshi, M. (NAO, Japan)	VLBA observations of Sgr A*. 0.7 cm
BS133	Savolainen, T. (Tuorla Obs.) Raiteri, C. (Torino) Takalo, L. (Tuorla Obs.) Villata, M. (Torino) Wiik, K. (Tuorla Obs.)	Multi-frequency properties of the blazar 3C 66A. 0.3, 0.7, 1,4,6,13 cm
BS135	Stanghellini, C. (IRA-CNR) Cassaro, P. (IRA-CNR) Dallacasa, D. (Bologna) Tao, A. (Shanghai) Venturi, T. (IRA-CNR) Xiang, L. (Urumqi Obs.) Xiaoyu, H. (Shanghai Obs.)	VLBI monitoring of four CSOs. 4 cm
BT072	Thorsett, S. (UC, Santa Cruz) Brisken, W.	Parallax observations of a merging binary pulsar. 20 cm

VLBA Observing Programs

No.	Observer(s)	Programs
BV053	Vlemmings, W. (Cornell) Chatterjee, S. Diamond, P. (Manchester) van Langevelde, H. (JIVE)	Parallax and proper motions of late-type stars OH maser VLBA astrometry with in-beam calibrators. 20 cm
BW069	Wiik, K. (ISAS) Raiteri, C. (Torino) Savolainen, T. (Tuorla) Takalo, L. (Tuorla) Villata, M. (Torino) Wiik, K. (Tuorla)	Multi-wavelength monitoring of a highly active blazar: BL Lac object AO 0235+16 during an outburst. 0.7, 1, 2, 4, 6, 13 cm
BW072	Wiik, K. (Tuorla) Savolainen, T. (Tuorla) Tornikoski, M. (Metsahovi) Valtaoja, E. (Tuorla)	Multi-wavelength monitoring of an intraday variable blazar. 0.7, 1, 6, 20 cm
BW074	Wrobel, J. Condon, J.J. Garrett, M. (JIVE) Morganti, R. (ASTRON)	Calibrator search in the SIRTF First-Look survey. 20 cm
BX005	Xu, Y. (Nanjing) Greenhill, L. (CFA) Menten, K. (MPIR, Bonn) Moscadelli, L. (Cagliari) Reid, M. (CFA) Zheng, X. (Nanjing)	Distance to the Perseus spiral arm. 2 cm
BZ031	Zhang, H. (NAOC) Gabuzda, D. (Cork) Gurvits, L. (JIVE) Jin, C. (NAOC) Nan, R. (NAOC) Reynolds, L. (JIVE)	Search for parsec-scale rotation. 4, 6 cm
GG053	Garrett, M. (JIVE) Garrington, S. (NRAL) Muxlow, T. (Manchester)	Deep imaging of the Hubble Deep Field region. 20 cm

VLBA Observing Programs

No.	Observer(s)	Programs
GM052	Mantovani, F. (Bologna) Junor, W. (New Mexico) Saikia, D. (TIFR) Salter, C. (NAIC)	Imaging the jet and counter-jet in quasar B1524-136. 4 cm

Personnel

NEW HIRES

Adams, Mark	Assistant to the Director	01/28/2004
Bhatty, Azmat	Engineering Associate, Junior	01/05/2004
Caviggia, Kurt	Electronics Engineer III	01/12/2004
Ford, Ephraim	Electronics Engineer III	01/12/2004
McCarney, Benjamin	Engineering Associate, Junior	01/02/2004
Pidopryhora, Yurii	Research Associate, Junior	01/01/2004
Powers, William	Software Engineer II	01/19/2004
Verdugo, John	Software Engineer II	01/28/2004
Ye, Jason	Research Assistant	01/05/2004

TERMINATIONS

Verdugo, John	Software Engineer II	04/02/2004
Ye, Jason	Research Assistant	01/16/2004
Zavala, Robert	Research Associate	01/30/2004

PROMOTIONS

Gasho, Victor	Antenna Division Head	03/15/2004
Grammer, Wes	Electronics Engineer, Sr.	01/01/2004
Moeser, Richard	Software Engineer I	01/01/2004
Perfetto, Antonio	Deputy Division Head	01/01/2004
Rowen, Bruce	Software Engineer I	01/01/2004
Ryan, Kevin	Software Engineer I	01/01/2004
Shillue, William	Electronics Engineer, Sr.	01/01/2004
Strong, Bradley	Accounting Assistant	01/26/2004

Publications

The following preprints were received in the NRAO Charlottesville library during this reporting period authored by the NRAO staff or based on observations on an NRAO telescope.

BRAVO-ALFARO, H.; BRINKS, E.; BAKER, A.J.; WALTER, F.; KUNTH, D. HI and CO in Blue Compact Dwarf Galaxies: Haro 2 And Haro 4.

CANNON, J.M.; SKILLMAN, E.D.; KUNTH, D.; LEITHERER, C.; MAS-HESSE, M.; OSTLIN, G.; PETROSIAN, A. Extended Tidal Structure In Two Lyman alpha-Emitting Starburst Galaxies.

CHANDRA, P.; RAY, A.; BHATNAGAR, S. Synchrotron Aging and the Radio Spectrum of SN 1993J.

CID FERNANDES, R.; GONZALEZ DELGADO, R.M; SCHMITT, H.; STORCHI-BERGMANN, T.; MARTINS, L.P.; PEREZ, E.; HECKMAN, T.; LEITHERER, C.; SCHAERER, D. Stellar Populations of Low-Luminosity Active Galactic Nuclei. I. Ground-based Observations.

GAO, Y.; SOLOMON, P.M. HCN Survey of Normal Spiral, Infrared-Luminous and Ultraluminous Galaxies.

GAO, Y.; SOLOMON, P.M. The Star Formation Rate and Dense Molecular Gas in Galaxies.

HOMAN, D.C.; WARDLE, J.F.C. High Levels of Circularly Polarized Emission from the Radio Jet in NGC 1275 (3C 84)

HUNT, L.K.; DYER, K.K.; THUAN, T.X.; ULVESTAD, J.S. The Radio Continuum of the Metal-Deficient Blue Compact Dwarf Galaxy SBS0335-052.

HUNTER, T.R.; ZHANG, Q.; SRIDHARAN, T.K. IRAS 18317-0705: A Cluster of Embedded Massive Stars and Protostars.

KELLERMANN, K.I.; LISTER, M.L.; HOMAN, D.C.; VERMEULEN, R.C.; COHEN, M.H.; ROS, E.; KADLER, M.; ZENSUS, J.A.; KOVALEV, Y.Y. Sub-milliarcsecond Imaging of Quasars and Active Galactic Nuclei III. Kinematics of Parsec-Scale Radio Jets.

KENNEY, J.D.P.; VAN GORKOM, J.H.; VOLLMER, B. VLA HI Observations of Gas Stripping in the Virgo Cluster Spiral NGC 4522.

KOTHES, R.; LANDECKER, T.L.; WOLLEBEN, M. H I Absorption of Polarized Emission: A New Technique for Determining Kinematic Distances to Galactic Supernova Remnants.

LAROSA, T.N.; NORD, M.E.; LAZIO, T.J.W.; KASSIM, N.E. New Nonthermal Filaments at the Galactic Center: Are They Tracing a Globally Ordered Magnetic Field?

LEONG, B.; SASLAW, W.C. Gravitational Binding, Virialization and the Peculiar Velocity Distribution of the Galaxies.

MCKINNON, M.M. On the Excess Dispersion in the Polarization Position Angle of Pulsar Radio Emission.

Publications

MOMJIAN, E.; PETRIC, A.O.; CARILLI, C.L. VLBA Observations of z > 4 Radio-Loud Quasars.

PARKER, D.H. Multidirectional Retroreflector Assembly with a Common Virtual Reflection Point using Four-Mirror Retroreflectors.

PARKER, D.H.; ANDERSON, R.; EGAN, D.; FAKES, T.; RADCLIFF, B.; SHELTON, J.W. Weighting the World's Heaviest Telescope at Eight Points with Corrections for Lifting Perturbations.

PARKER, D.H.; GOLDMAN, M.A.; RADCLIFF, B.; SHELTON, J.W. Attenuated Retroreflectors for Electronic Distance Measurement.

PARKER, D.H; SHELTON, J.W. Calibration of Kelvin Clamp Euler Angles for Absolute Instrument Orientation.

SEWILO, M.; CHURCHWELL, E.; KURTZ, S.; GOSS, M.; HOFNER, P. Broad Radio Recombination Lines from Hypercompact H II Regions.

SJOUWERMAN, L.O.; MESSINEO, M.; HABING, H.J. 43 GHz SiO Maser and Astrometry with VERA in the Galactic Center.

SODERBERG, A.M.; KULKARNI, S.R.; BERGER, E.; FOX, D.B.; PRICE, P.A.; YOST, S.; HUNT, M.; FRAIL, D.A.; WALKER, C.; HAMUY, M.; SHECTMAN, S.; HALPERN, J.; MIRABAL, N. A Redshift Determination for XRF 020903: First Spectroscopic Observations of an X-ray Flash.

SU, Y.-N.; ZHANG, Q.; LIM, J. Bipolar Molecular Outflows from High-Mass Protostars.

TSUJIMOTO, M.; KOYAMA, K.; KOBAYASHI, N.; SAITO, M.; TSUBOI, Y.; CHANDLER, C.J. A High-Resolution Very Large Array Observation of a Protostar in OMC-3: Shock-Induced X-ray Emission by a Protostellar Jet.

TURNER, J.L.; BECK, S.C. Birth of a Super-Star Cluster: NGC 5253.

VAN DUYNE, J.; BECKERMAN, E.; SALZER, J.; GRONWALL, C.; THUAN, T.; CONDON, J.; FRATTARE, L. Radio Continuum Emission at 1.4 GHz from KISS Emission-Line Galaxies.

VOLLMER, B.; BECK, R.; KENNEY, J.D.P.; VAN GORKOM, J.H. Radio Continuum Observations of the Virgo Cluster Spiral NGC 4522 - The Signature of Ram Pressure.

WALTER, F.; DAHLEM, M.; LISENFELD, U. The Superwind Galaxy NGC 4666: Gravitational Interactions and the Influence of the Resulting Starburst on the ISM.

ZHAO, J.-H.; HERRNSTEIN, R.M.; BOWER, G.C.; GOSS, W.M.; LIU, S.M. A Radio Outburst Nearly Coincident with the Large X-Ray Flare from Sagittarius A* on October 3, 2002.