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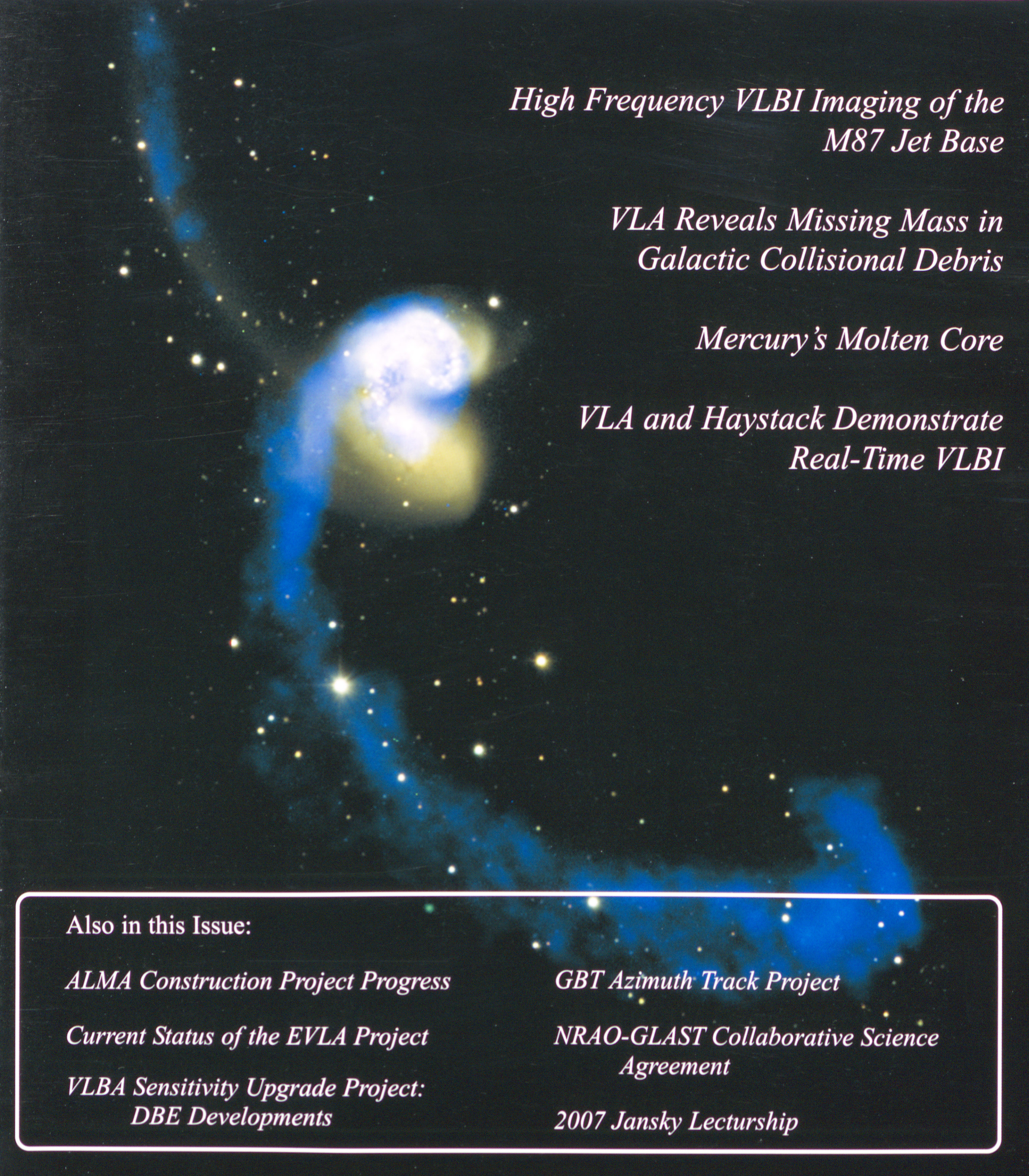

High Frequency VLBI Imaging of the M87 Jet Base

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Cover: Radio-optical composite image of the nearby merging galaxy, NGC 4038/9, also known as "The Antennae". Investigator(s): J. E.Hibbard, J. M. van der Hulst, J. E. Barnes & R. M. Rich.

Science

High Frequency VLBI Imaging of the M87 Jet Base

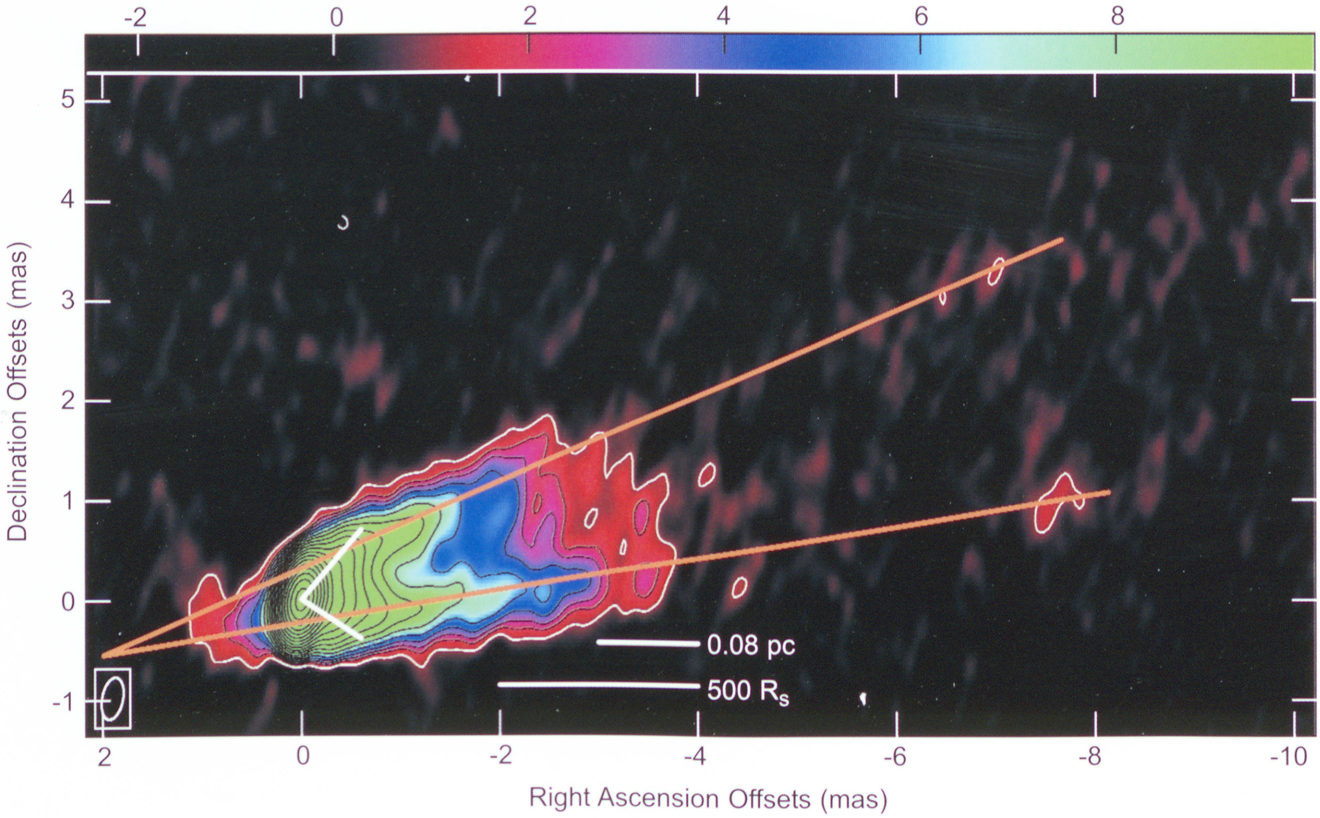

Figure 1. An averaged image from five 43 GHz observations. The orange lines follow the edge-brightened jet emission from 10 mas west of the core while the white lines represent the wide opening angle proposed by Junor, Biretta, & Livio (1999). The resolution is 0.43 mas × 0.21 mas. The color scale is from -2.5 to 10 mJy beam^{-1} with contour levels of -1, 1, 2, 2.8, 4, 5.7, 8, and multiples of √2 thereafter until 512 mJy beam^{-1}. Note that the apparent smoothness of the structure is an artifact of averaging images from multiple epochs and should not be taken as an indication that the structure of the jet is featureless.

Current capabilities of Very Long Baseline Interferometry (VLBI) have made it possible to probe extragalactic radio jets on sub-parsec scales, which provides a better understanding of how jets are accelerated and collimated close to a super-massive black hole. These observations can be used to test jet collimation theories and simulations. M87, a giant elliptical galaxy located at the center of the Virgo cluster, is the best candidate for the study of jet collimation because of its bright jet, massive black hole (3×10^9 $M_\odot$), and proximity (16 Mpc).

We report on five observations of M87 on 1999.17, 2000.27, 2001.78, 2002.42, and 2004.25 with VLBI at 43 GHz at a resolution of 0.43 milliarsec × 0.21 milliarsec. The 1999 and 2001 observations have been published in Junor, Biretta, & Livio (1999) and Ly, Walker, and Wrobel (2004), respectively. An average of all five epochs is shown above. This image nicely shows the edge-brightened structure, originally detected in the individual observation, extending out to about 4 mas. Such structure is consistent with previous numerical simulations that have found a sheath-like structure (Meier, Koide, and Uchida 2001). In addition, low-level emission from the jet is seen out to 10 mas, and the southern-half of the jet is detected about 1 mas (0.08 pc) further than the northern-half for the brighter inner regions. Following the bright edges of the jet back toward the brightest spot (orange lines in the figure), we find that the extrapolated point where they intersect is about 2 mas east (left) of the apparent start of the jet. Assuming that the brightest spot is the core—the location of the presumed black hole—these observations would indicate that the opening angle at the base of the jet is wider and collimation occurs further along the jet, confirming previous conclusions. An alternate possibility is that the jet does not light up immediately, and the black hole is located east of the brightest feature.

The counter-jet is believed to be detected east of the core. It was suggested to exist in the 2001 epoch by Ly, Walker, and Wrobel (2004), and is confirmed by the two most recent epochs where it appears to move away from the core. It is also detected in a 22 GHz observation, which is part of a multi-frequency project for the 2002 epoch. To test whether or not the counter-jet is a calibration artifact, several attempts were made to exclude it during the self-calibration and imaging process. After much effort, the counter-jet was still present, although reduced in intensity. The assumption that the emission to the east of the brightest spot is a counter-jet only holds if the brightest spot marks the location of the base of the jet. If the brightest spot is instead a shock occurring much further down the jet, then the presumed counter-jet would actually be part of the inner jet.

Assuming that the emission east of the brightest feature is a counter-jet, the jet and counter-jet apparent motions correspond to a deprojected jet speed of 0.3–0.5c with an orientation of 30–45° to the line-of-sight. Using this jet orientation angle, relativistic beaming would give the observed jet-to-counter-jet brightness ratio if the bulk flow is at 0.6–0.7c. Given the uncertainties in these arguments, these speeds are reasonably consistent. Other studies have found similar orientation angles in the 40–65° range. However, much smaller angles to the line-of-sight are required by the observation of superluminal motions in some features further from the core. This inconsistency still needs to be understood.

Future work currently in progress includes making a properly sampled movie of M87 at 43 GHz. This will provide kinematical information about the jet and counter-jet's components and help localize the core to determine the opening angle of the jet. In addition, if the counter-jet is real, it will help determine the motion of the jet and the angle to the line-of-sight with more accurate brightness ratios and proper motions. Polarization measurements from the extended structure, if possible, will provide a better understanding of the magnetic fields and help to further constrain jet-collimation models.

This project is partly funded by the NSF Research Experience for Undergraduates (REUs) and the NRAO Graduate Research Programs. A detailed account of this work has recently been published by Ly et al. (2007).

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and W. Junor (Los Alamos National Laboratory)

References:

Junor, W., Biretta, J. A., & Livio, M. 1999, Nature, 401, 891

Ly, C., Walker, R. C., & Wrobel, J. M. 2004, AJ, 127, 119

Ly, C., Walker, R. C., & Junor, W. 2007, ApJ 660, 200

Meier, D. L., Koide, S., & Uchida, Y. 2001, Science, 291, 84

VLA Reveals Missing Mass in Galactic Collisional Debris

Beginning with the work of Longmore et al. (1979), the large ring surrounding the galaxy NGC 5291 has been known to contain a huge amount of neutral hydrogen (5×10^{10} solar masses). Subsequently, Malphrus et al. (1997) performed the first VLA observations of this system, revealing a ring made up of debris expelled from a large spiral galaxy by a violent collision, from which self-gravitating condensations had formed, thereby producing "recycled" dwarf galaxies.

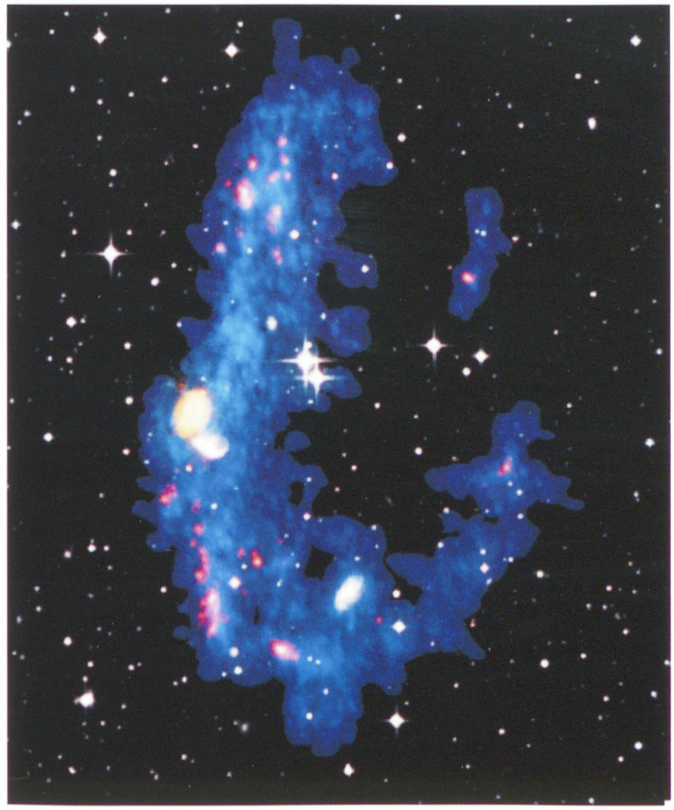

Figure 1. The VLA BnA image of the atomic gas ring (blue) superimposed on an optical image (showing the central galaxy NGC 5291 in orange) and a UV image from Galex, showing the star-forming regions in pink. The latter can be considered as recycled dwarf galaxies formed in the collisional debris, and it is there that the VLA data have revealed the unexpected presence of a "dark" massive component. © CEA-CNRS/NRAO-NASA/P-A. Duc.

Numerical simulations on supercomputers can reproduce the formation of the collisional ring and recycled dwarf galaxies in it, enabling the three-dimensional structure to be studied and the collision to be dated to 360 million years ago. But the simulations predict that, contrary to classical galaxies, these recycled dwarfs should be free of dark matter. This is because the debris from which they form came from the disk of a spiral galaxy: dark matter in spiral galaxies is believed to form a spheroidal halo surrounding the disk, not being in the disk itself, hence not participating in the collisional debris.

To test this prediction, Bournaud et al. (2007) have observed these recycled dwarf galaxies using the NRAO VLA in the high-resolution BnA configuration, in addition to data from lower-resolution configurations. The rotational velocities in these dwarf galaxies, revealed by the VLA data, are abnormally large compared to their visible mass. The visible mass has been

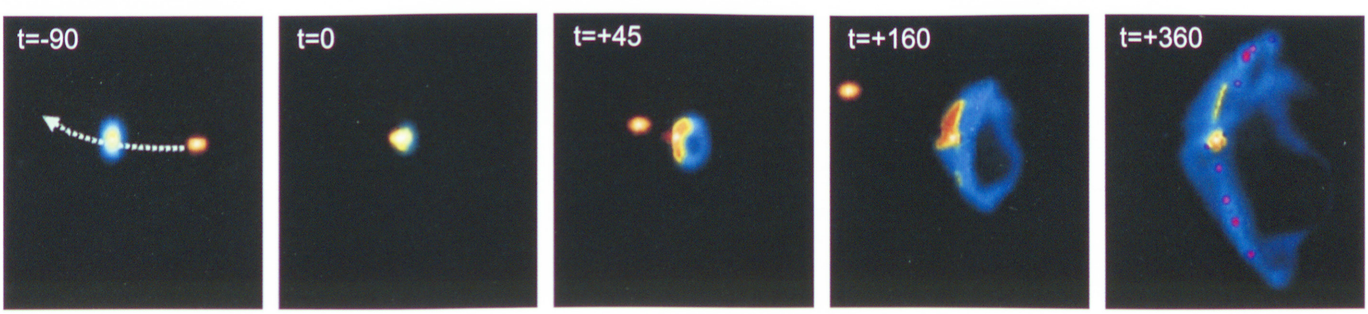

Figure 2. Numerical simulation of the formation of the NGC 5291 system. NGC 5291 was a spiral disk galaxy (similar to the Milky Way) when a head-on collision with a massive galaxy 360 million years ago expelled much of its disk material in a large ring of collisional debris. The model reproduces the formation of new dwarf galaxies in the ring, but predicts these galaxies to be free of dark matter, because the NGC 5291 spiral is assumed to have its dark mass in a spheroidal halo – not in its disk. Orange is for regions dominated by old stars, blue for gas-rich regions, and pink for regions forming new stars; time is in units of 1 million years. A movie of the simulation is available at http://www.uni-sw.gwdg.de/~paduc/N5291 © CEA-CCRT/F. Bournaud.

estimated from the same VLA data (for the atomic gas mass), CO data (tracing the molecular hydrogen mass), and optical data (to estimate the stellar mass). The recycled dwarf galaxies actually contain their own dark mass, amounting to about twice the mass of visible gas and stars. This does not rule out the existence of large dark matter halos around galaxies. But if recycled dwarf galaxies contain some dark matter, then the collisional debris from spiral disks should also, implying that some dark matter actually resides within the disks of spiral galaxies, directly influencing their dynamical evolution and the formation of stars.

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P. A. Duc (Laboratory AIM,CEA)
E. Brinks (Centre for Astrophysics Research)

References:

Bournaud, F., Duc, P. A., Brinks, E., Boquien, M., Amram, P., et al. 2007, Science 316, 1166

Malphrus, B. K., Simpson, C. E., Gottesman, S. T., & Hawarden, T. G. 1997, Astronom. J. 114, 1427

Longmore, A. J., Hawarden, T. G., Cannon, R. D., Allen, D. A., Mebold, U., et al. 1979, MNRAS 188, 285

Mercury's Molten Core

In 1974 and 1975 three flybys by the Mariner 10 spacecraft revealed astounding facts about Mercury, the smallest planet in the solar system. Acceleration of the spacecraft during close approach, as measured by the Doppler shift in its carrier signal, confirmed the surprisingly large mass (and correspondingly high bulk density) of Mercury. In familiar Earth units, the mass, radius, and bulk density of Mercury are 0.05, 0.38, and 0.98, respectively. The uncompressed density of Mercury suggests that its iron to silicate mass ratio is twice as large as that of the other three terrestrial planets, presumably requiring an enormous core extending perhaps 75–80 percent of the planetary radius. An even more surprising discovery enabled by Mariner 10 was the existence of a magnetic field of apparent internal origin, with a surface field strength about 1 percent that of Earth. Although the field is not well characterized or understood, the data are consistent with at least two possibilities: either the field is due to remnant magnetization of crustal rocks at temperatures below the Curie point, as observed on Mars, or the field is due to a planetary dynamo sustained by the convection of conducting fluid in the interior, as observed on Earth. Could such a small planet have maintained a partially liquid core over billions of years?

The question, which is fundamental to the understanding of terrestrial planets as a whole, prompted Stan Peale to propose an ingenious scheme to characterize the core of Mercury (Peale 1976). By measuring the response of the planet to gravitational torques from the Sun, it would be possible to distinguish between a molten or solid core. The torques exist because the mass distribution is asymmetric, and the planet responds in proportion to (B-A)/C, where (B-A) is the difference between the equatorial moments of inertia, known from Mariner 10, and C is the polar moment of inertia. Peale's brilliant insight was to realize that the moment of inertia of the mantle plus crust (Cm) is only about half that of the entire planet (i.e. Cm/C~0.5). With a molten core decoupling the mantle from the deep interior, the response to the gravitational torques would be about twice as large as it would be with a solid core. The year was 1976 and it was not clear how the amplitude of the so-called longitudinal libration would be measured. The tiny twists in the planet's orientation were expected to be 20 arcseconds for a solid core, and 40 arcseconds for a liquid core. The prevailing view was that a lander would be required.

But in the early 1990s Igor Holin, an expert in laser speckle theory, published papers describing the coherence properties of speckle patterns scattered from rotating solids illuminated by coherent light (Holin 1988, 1992). From his native Russia, he advocated using the "radar speckle displacement effect" to measure the spin states of planets. The idea that speckles observed at two separate receiving stations could be

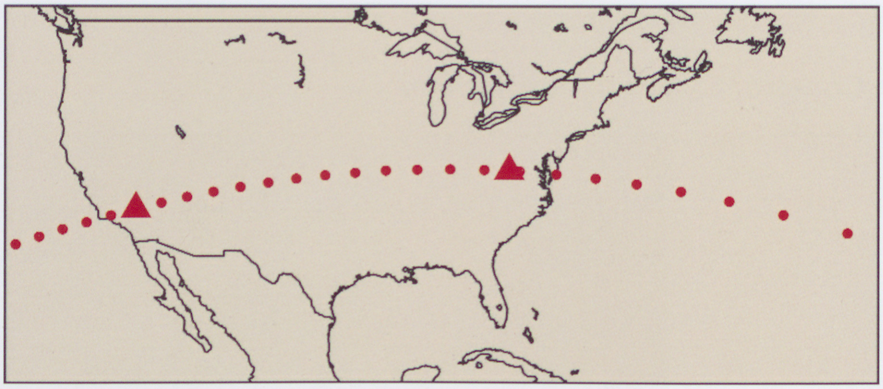

Figure 1. Illustration of the trajectory (circles, 1s timestep) of wavefront corrugations tied to the rotation of a planetary body as observed by two telescopes on Earth (triangles). The time delay for the pattern to reproduce at both stations is a direct measure of the planetary rotation rate.

used to measure planetary spin states had been promulgated by U.S. astronomer Paul Green in the 1960s (see e.g., Green, 1968) but the idea fell under the radar, until more prodding by Holin in 2001. At that time I examined the suggestion, found that it had merit, and designed a practical implementation involving the Goldstone Solar System Radar (GSSR) in California and the Green Bank Telescope (GBT). With a baseline of ~3200 km, it takes about ten seconds for the speckles tied to the rotation of Mercury to sweep from the GBT to GSSR (Figure 1). In practice one illuminates the planet with a monochromatic signal at 3.5 cm wavelength and records the echoes at the two receiving stations. Cross-correlations of the echo time-series yield precise (0.1 ms or 1 part in 10^5) estimates of the time lag, which is a direct measurement of the sidereal rotation rate.

The results of 21 measurements obtained from 2002–2006, some with an Arecibo-Goldstone configuration, show that Mercury's libration has been unambiguously detected (Figure 2). The amplitude of the libration, 36 ± 2 arcseconds, indicates that the mantle of Mercury is decoupled from a core that is at least partially molten. Measurements from NASA's MESSENGER spacecraft en route to Mercury will complete the picture, as many exciting questions remain. What is the size of the core? What is the origin of the magnetic field? What is the thermal history of the planet? How is interior cooling expressed on the surface? Was a lighter element such as sulfur required to maintain a liquid core over aeons? If so, how much radial mixing of planetesimals was required to bring sulfur to Mercury? The questions are fundamental to our understanding of the formation and evolution of planets like our own.

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(Cornell University)

References:

Green, P. E. 1968, in Radar Astronomy (J. Evans & T. Hagfors, eds), McGraw-Hill

Holin, I. V. 1988, Radiophys. Quant. Elec. 31, 371

Holin, I. V. 1992, Radiophys. Quant. Elec. 35, 433

Margot, J. L., Peale, S. J., Jurgens, R. F., Slade, M. A., & Holin, I.V. 2007, 316, 710

Peale, S. J. 1976, Nature 262, 765

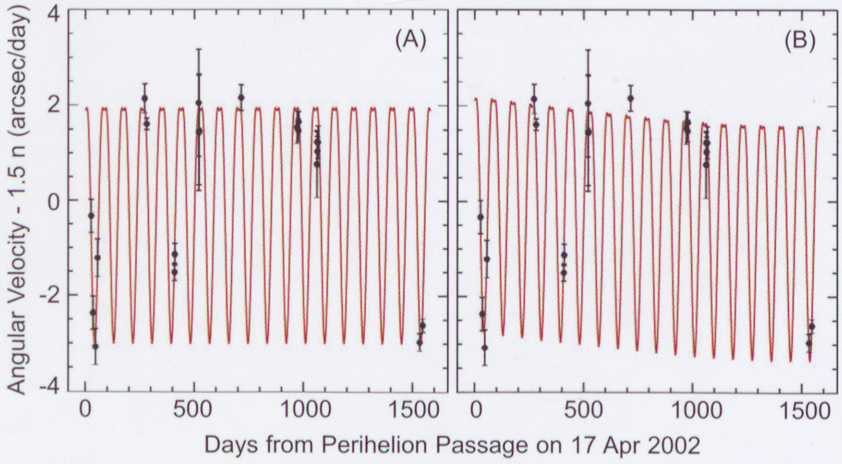

Figure 2. Mercury spin rate deviations from the resonant rate of 3/2 times the mean orbital frequency. Observed data points and their error bars are shown at their respective epochs. The solid line is a numerical integration of the torque equation, the phase of which is dictated by the time of pericenter passage. Panel A shows a one-parameter fit to the data (allowing for 88-day forced librations only) and panel B shows a three-parameter fit to the data (allowing for an additional libration component with ~12 year period).

Atacama Large Millimeter/submillimeter Array

ALMA Construction Project Progress

Figure 1. The first VertexRSI pedestal assembly travels by truck across northern Chile to the ALMA Operations Support Facility.

Figure 2. The first ALMA production antenna at the OSF: the VertexRSI pedestal stands on its pad to the right of the partially assembled backup structure, and in front of the VertexRSI site erection facility.

Having already traveled thousands of miles by land and sea from Kilgore, Texas in the United States to the port of Antofagasta in northern Chile, the pedestal assembly of the first ALMA VertexRSI production antenna departed Antofagasta for the Operation Support Facility (OSF) on April 20, 2007, escorted by local police. Other elements of the telescope, including the backup structure and the invar cone that joins the pedestal assembly and the backup structure, had already arrived at the OSF.

At 03:15 p.m. on April 27 at the ALMA OSF, the crane hangers were removed and the first VertexRSI pedestal assembly stood atop its foundation adjacent to the Vertex hangar. That evening, the first southern hemisphere starlight fell upon an ALMA production antenna.

The second VertexRSI antenna is poised to follow as its pedestal is being assembled in Kilgore, Texas. This second antenna will be erected inside the recently completed VertexRSI site erection facility.

A trio of Mitsubishi antennas will arrive within the next few weeks in Antofagasta from Osaka, Japan. Their assembly will then begin at the Mitsubishi laydown area at the OSF.

The third type of antenna, from the AEM consortium, will be delivered to the OSF next year and assembled at the AEM laydown area. Work on construction of this facility has begun and will be completed by the end of June.

On March 10, 2007, a ceremony celebrated the completion of the roof structure on the OSF technical facility building. Held in the nascent OSF warehouse, the crowd of workers and others heard speeches from the Mayor of San Pedro de Atacama, Sandra Berna, and others. The facility, which will host about 100 people during operations, consists of three main buildings: the technical building, hosting the control center of the observatory; the antenna assembly building, including four antenna foundations for testing and maintenance purposes; and the warehouse building, including mechanical workshops. The warehouse should be available later this year, and the whole building is slated for completion by January 2008.

At the 16,400 foot elevation Array Operations Site, the Technical Building construction has been finished (Figure 4). The building now has temporary power and Internet connections and is being readied to receive the first quadrant of the ALMA correlator later this year.

Figure 3. During the celebration of the completion of the OSF warehouse roof, members of the local community joined ALMA and others as a pachamama or "payment to the Earth" ceremony was held, in which harmony is sought. Photo: R. Simon.

The design of the antenna array configuration (Figure 5), and the road and fiber network interconnecting the antenna foundations, has been completed, and bids to build this critical infrastructure have been received.

In Santiago, staff growth has exceeded the capacity of the Joint ALMA Observatory (JAO) headquarters in Las Condes. Plans are proceeding for construction of the permanent headquarters next to ESO in Vitacura. Temporary space has been secured at the University of Chile Department of Astronomy quarters at Cerro Calan.

The ALMA Board held its first meeting of the year in Tokyo at the National Center of Sciences of Japan. Dr. Yoshiro Shimura, President of the National Institute of Natural Sciences (NINS), welcomed the Board members to Tokyo with remarks on the bright future of ALMA. The Master Agreements for ALMA Goods and Services between North American partners and ESO, and the

Figure 4. The Technical Building at the Array Operations Site.

National Astronomical Observatories of Japan were signed in March and May, providing the detailed framework for construction of ALMA.

At the ALMA Test Facility (ATF), adjacent to the NRAO Very Large Array in New Mexico, equipment needed to test and verify performance of the ALMA production antennas has been proven. A holography system and an optical pointing telescope, items critical for the preparation of the antennas, were accepted and shipped to the OSF. During the coming months, the ATF will concentrate on radio pointing, installation of preproduction electronics and the two station correlator.

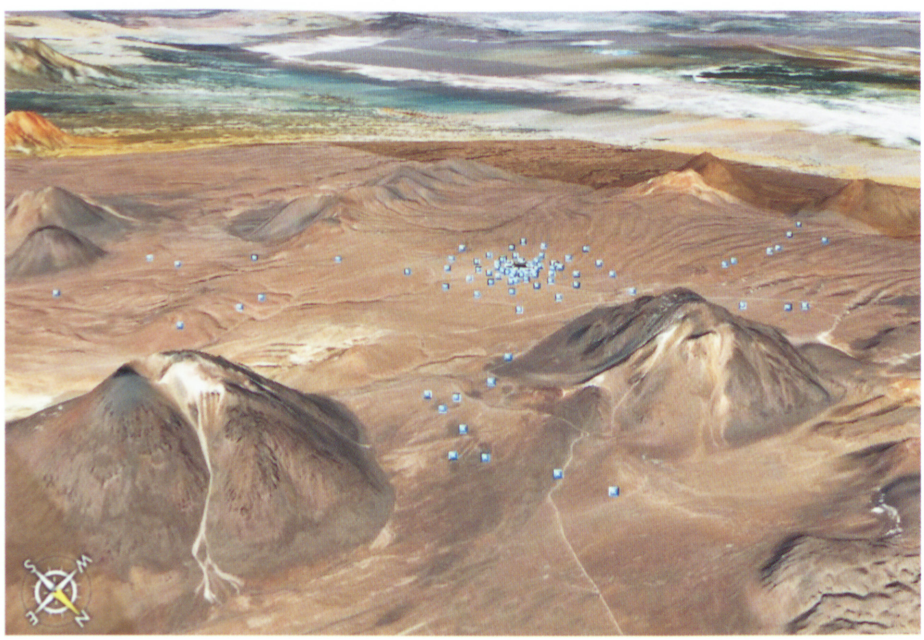

Figure 5. The ALMA array configuration stretches across the Array Operations Site.

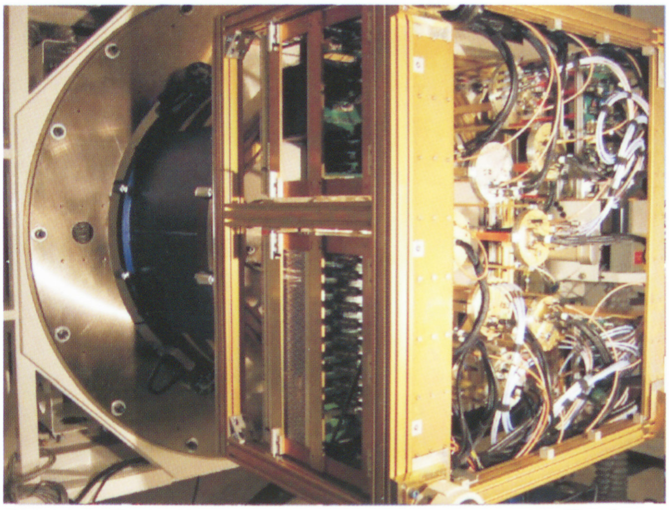

Figure 6. The ALMA Front End package, incorporating the dewar, receiver cartridges, and oscillators is now under test at the NTC. In this view, the panels are removed. This package will be installed on the first antenna at the OSF in fall 2007.

By late summer, interferometry will be a focus of efforts there.

The two-station correlator was built at the NRAO Technology Center (NTC) to replace the prototype correlator that has been in New Mexico for several years with a current design. At the Front End Integration Center at the NTC, the first ALMA Front End (receiver package and associated electronics) has undergone beam shape measurements for the first four ALMA frequency bands.

The Science group developed a new version (v2.0) of the Design Reference Science Plan (DRSP). The goal of the ALMA DRSP is to provide a prototype suite of high-priority projects that could be carried out in 3–4 years of full ALMA operations. The DRSP serves as a quantitative reference for developing the science operations plan, performing imaging simulations, software design, and other applications within the ALMA project. Since v1.1 was released, Japan has joined the project, enhancing ALMA's capabilities. DRSP v2.0 expands v1.1 to include science that takes advantage of these expanded features.

ALMA's role in the search for and study of exoplanets and planetary systems has been developed at a number of scientific conferences over the past years. In December 2006, the NSF-NASA-DOE Astronomy and Astrophysics Advisory Committee (AAAC) established an ExoPlanet Task Force (ExoPTF) as a subcommittee to advise NSF and NASA on the future of the ground-based and space-based search for and study of exoplanets, planetary systems, Earth-like planets, and habitable environments around other stars. A white paper describing ALMA's role in this endeavor was submitted to the ExoPTF. The ExoPTF will recommend a 15-year strategy to detect and characterize aspects of exoplanets and planetary systems. *ALMA Memo No. 475* addresses this topic.

A. Wootten and S. Cabezon

North American ALMA Science Center

The NSF and ALMA Board reviews of the North American ALMA Science Center and the ALMA operations plan are complete, and written reports from the review panels, as well as the response to these reports by NRAO/AUI, have been submitted to the NSF and the ALMA Board. For a summary of the overall findings of these panels, see the April 2007 NRAO *Newsletter*. The coming year will see the implementation of the operations plan, and the first positions for NAASC staff who will participate in ALMA commissioning and science verification will be advertised fall 2007.

The NAASC staff have also participated in ALMA software testing, including testing of the ALMA pipeline, the CASA-PY post-processing software, the CASA user interface. Software testing and documentation will be a major task for the NAASC in the coming two years, preparing for ALMA Early Science in 2010.

The ALMA North American Science Advisory committee held monthly telecons, with issues discussed including: the operations reviews, the potential for a ALMA Users Grants program, and the ASAC charges. The ANASAC is evolving toward a formal charge and response format, parallel to that of the ASAC.
The 2nd annual NAASC Science Workshop *Transformational Science with ALMA: Through Disks to Stars and Planets* was held in Charlottesville,

June 22–24, 2007 (see article on page 32). Community interest in attending the workshop has been very positive and we plan to hold an ALMA workshop with a different focus every year. Stay tuned for next year's topic!

NAASC staff visited the Spitzer Science Center and the Chandra X-ray Center to discuss Science Center operation and user support. Also, NAASC staff gave talks on the scientific potential and current status of ALMA at various institutions. If your institution is interested in having a NAASC staff member visit and discuss ALMA, please contact me at *ccarilli@nrao.edu*.

Finally, Frank Lovas (NIST) will spend a month in Charlottesville this summer, helping NAASC staff further develop a molecular spectral line database ("Spatalogue", see the April 2007 *Newsletter* article).

Chris Carilli

Expanded Very Large Array

Current Status of the EVLA Project

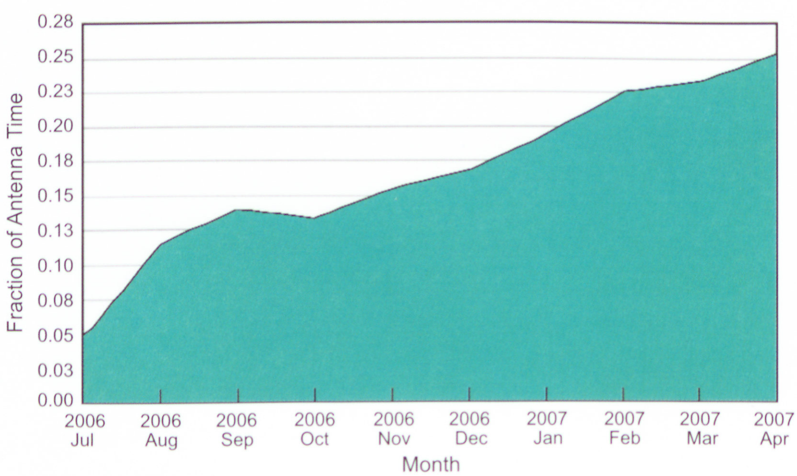

Figure 1. EVLA antenna hours as a fraction of total VLA antenna hours used in astronomical observations.

The retrofitting of VLA antennas to the EVLA design remains on schedule. Eleven antennas are in various stages of the retrofit. Ten of these antennas are used routinely for astronomical observations, and the mechanical outfitting of another antenna is well underway. As of April 2007, the EVLA antennas account for over 25 percent of the VLA antenna hours used in astronomical observations (Figure 1).

The -48 VDC power plant for the correlator was delivered to the VLA site in early March 2007, and site personnel completed its installation and startup in April. The power plant consists of two battery strings, each consisting of 12, 4-volt batteries wired in series, and a control panel (Figure 2). One battery string can provide the 3,500 amperes needed to power the correlator for a limited time, while the other battery string is a full-service backup.

The new shielded room for the correlator will be ready well in advance of the arrival of the prototype (Q2 2008) and production correlators (Q2 2009). Now that the power plant has been installed, the next step will be to begin work on the equipment racks and cabling for the correlator, networking, and back-end computing. At that time, control and alarm wiring will be installed from the air conditioning equipment, fire suppression system panel, and the operations area to the correlator's power control computer. Training on the operation of the HVAC system in the shielded room was completed in March 2007.

Figure 2. 48 VDC power plant for the WIDAR correlator.

The installation of an uninterruptible power supply (UPS) for the EVLA operations area was completed in May 2007. The installation of the UPS and the correlator power plant marks the completion of the civil construction element in the project's Work Breakdown Structure (WBS).

Testing and debugging of the correlator's prototype station and baseline boards have been the primary focus of the correlator development team in Penticton and Socorro. The station boards provide delay tracking and digital filtering, while the baseline boards contain the correlator chips where the correlations are computed. Testing and debugging of the station boards have concentrated on ensuring that all of the high-speed data paths are working and have the desired signal integrity. These tests have been successful, and now effort is concentrated on testing station board functions and making the minor design changes required before the next prototype is fabricated. Debugging of the baseline board has concentrated on tests of the correlator chips. The socketing of this 672-pin ball grid array (BGA) chip on the board did not work as planned, so chips that passed standalone full-speed tests earlier this year were soldered on the board with some, but not complete, success. Nevertheless, the major functions on the board have been tested successfully, and the chip has passed significant and exhaustive, although not final, tests. Due to the inability to populate fully the first prototype board with correlator chips, final testing of the chips and the board must wait until the second stage prototypes on which the chips will be soldered instead of socketed. Tests of the correlator chips on a special test board also indicated that the random access memory (RAM) on some of the chips was not functioning properly. However, additional tests by the chip manufacturer and our Canadian colleagues revealed that the RAM problem was caused by a faulty chip initialization sequence when the test board was turned on. The delivery of the correlator would have been delayed significantly had the RAM problem been intrinsic to the chip.

Despite a staffing shortage in the receiver group, progress continues to be made in developing and fielding receivers for the EVLA antennas. The highest priorities in the group are the fielding of receivers in accordance with the antenna retrofitting schedule and the development of the prototype 26–40 GHz receiver and the 4–8 GHz orthomode transducer (OMT). The RF tree for the 26–40 GHz receiver was assembled (Figure 3), and the first cooled tests of this receiver will occur this summer. The fin spacing and probe length dimensions of the 4–8 GHz OMT were finalized, and laboratory tests show that the OMT meets its design specifications. The OMT will be placed in production soon. Problems with the machining and wire bonding of the 40–50 GHz post-amplifiers were overcome, and problems with the production design of the receiver card cages were resolved. Both sets of problems delayed the fielding of the 40–50 GHz and 4–8 GHz receivers on the EVLA antennas. The production version of the 1–2 GHz OMT consists primarily of an aluminum-cast housing and an electroformed throat section. The castings for the first two production units have been received from a contractor, and the NRAO will electroform the throat sections. Project contingency was allocated to the receiver group to address its staffing shortage.

Good progress continues on the fiberglass lamination of the L-Band (1–2 GHz) and S-Band (2–4 GHz) feed horns. The lamination of L-Band horns 1 through 19 is complete. The first S-Band horn was assembled, and its lamination completed, in June 2007.

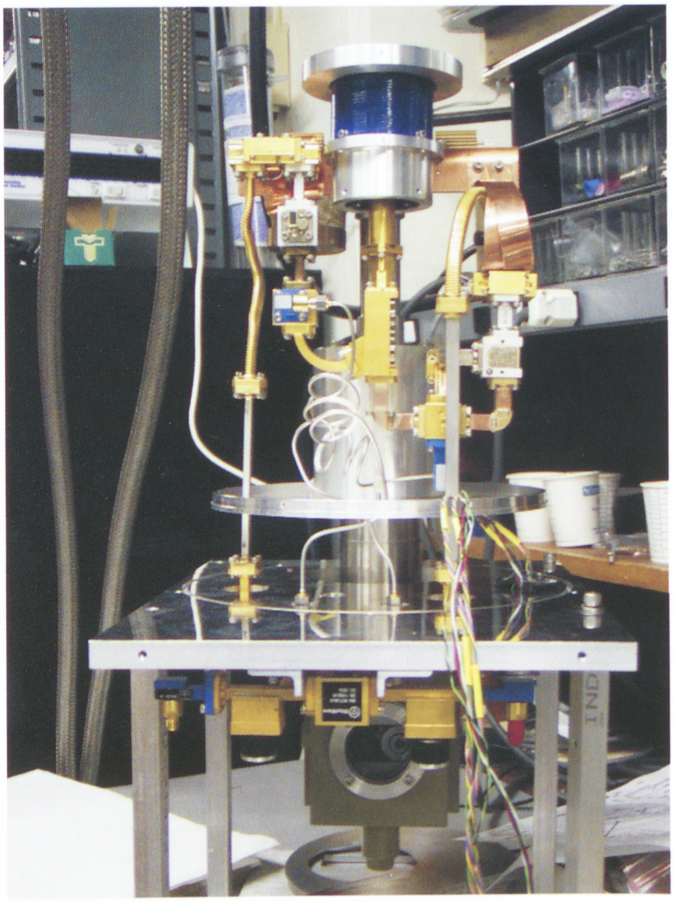

Figure 3. Assembled RF tree for the EVLA 26–40 GHz receiver.

The EVLA 3-bit, 4 Gsps samplers will consist of a custom circuit board designed around a commercially-available digitizer chip. Requests for quotation for the production order of the chip have been prepared, solicited, and received. The quotations are being evaluated now. The chip order will be placed in the next few months so that chip production and board fabrication can begin later this year.

The first set of 4P IF converters (T301s), the modules that upconvert the RF signals from the 327 MHz and 74 MHz receivers to a 1–8 GHz IF, was completed and installed on EVLA antennas. The production and installation of the T301s had been delayed due to more pressing priorities, but now their installation should keep pace with the antenna retrofitting schedule.

Junction boxes for optical fiber connections are needed at each antenna location so that an EVLA antenna can be connected to the optical fiber data transmission system. Of the 72 junction boxes on the array, 66 have been installed. The completion of the junction boxes allows more flexibility in locating the EVLA antennas in the array after their retrofit is complete.

The retirement of the VLA's Modcomp control computers is the main focus of the EVLA Monitor and Control (M&C) effort. A number of issues remain to be solved before operation of a Modcomp-free system becomes the rule rather than the exception. Handling of the VLA correlator is being refined, and while the system now writes valid archive records, it sometimes takes too long to get organized. However, exclusive operation of the VLA-EVLA hybrid array by the EVLA M&C System, with no assistance from the Modcomp-based VLA Control system, now occurs on a regular basis, with at least one day per week given over to the testing and debugging of the Modcomp-free system. Time and attention are also being given to the long list of tools and utilities that need to be in place when the Modcomp computers are retired. Prototypes have been demonstrated for several of the tools. Foundation level capabilities upon which other tools will be built are being put into place.

An item of rising prominence for the EVLA M&C System is the anticipated arrival of the prototype correlator in Q2 2008. Progress has been made in defining and implementing the output data format of the prototype correlator and in defining the format of the records that will be written to the archive.

An agreement among the ALMA and EVLA projects and the E2E Operations Division was made for the joint development of software tools for proposal submission, observation preparation, scheduling, data archive, and data processing. The primary objectives of the agreement are to provide common software tools for ALMA and EVLA users and to minimize long-term software development and maintenance costs. The agreement defines responsibilities for software development across the Observatory. Additional, detailed negotiations will be taking place over the next few months to ensure that short-term project needs and long-term Observatory objectives are adequately addressed by the agreement.

The responsibility for the Proposal Submission Tool (PST) was transferred to the E2E Operations Division for the June 2007 VLA proposal deadline. In preparation for the transfer, software contractors from Open Sky Software visited the Array Operations Center in Socorro, spending four days meeting with programmers and managers to get an idea of just how much work it would be for them to take over the maintenance and further development of the tool. A report was issued detailing their experience and their recommendations. They were impressed by the quality of the existing PST code and foresaw no problems in taking it over.

The software tool that manages catalogs of sources, including calibrator catalogs, was updated significantly and its interaction with the Observation Preparation Tool (OPT) was made seamless. This is a big improvement over previous implementations. Both the VLA and VLBA calibrator catalogs are now available in this tool with a variety of simple query functions. We will be extending the available catalogs to include high frequency catalogs and making the calibrator catalogs available to the astronomical community via standard web queries.

Mark McKinnon

New C-Band Capabilities with the EVLA

The interim C-Band receivers installed on EVLA antennas are sensitive over a far wider range of frequencies than the 4.5–5.0 GHz range of traditional VLA receivers. These receivers are "interim" in the sense that they comprise the new EVLA receivers with the orthomode transducers (OMTs) from the old C-Band receivers. They therefore exhibit good polarization properties only over the traditional tuning range of the VLA. However, good sensitivity over much of the EVLA C-Band (4–8 GHz) was observed during tests of the interim receivers in March 2007 (see Figures 1–3), even though the polarization purity is

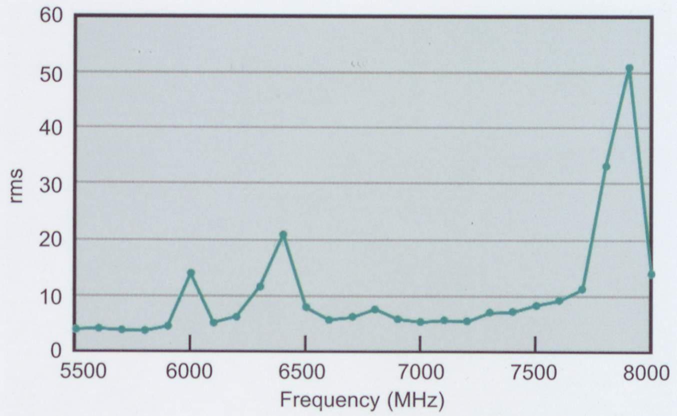

Figure 1. Rms (in arbitrary units) as a function of frequency from 5500 to 8000 MHz. Note that in between the few peaks of high rms there are many areas where good sensitivity can be expected. Between 4200 MHz and 5500 MHz (not shown) the behavior is very similar to the flat response from 5500–5900 MHz.

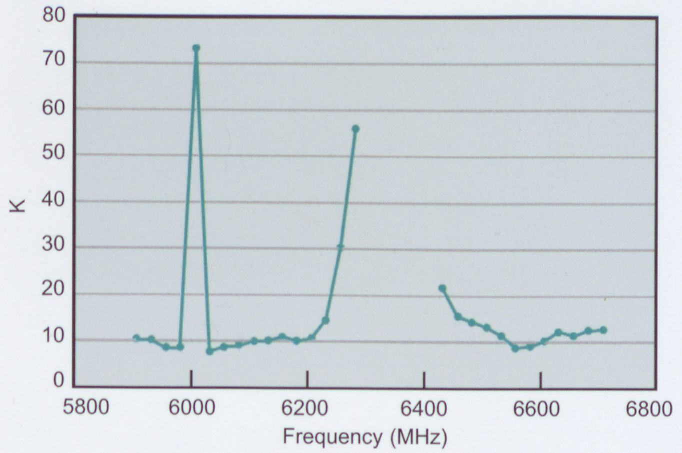

Figure 2. Frequency dependence of the interim EVLA C-Band receivers at higher frequency resolution than in Figure 1, and over the more limited range 5.9—6.7 GHz. A number of familiar emission lines are located in this tuning range. The y-axis shows the K number as defined in the "sensitivity" section of the VLA Observational Status Summary*; see http://www.vla.nrao.edu/astro/guides/vlas/2007-04-09/.*

poor for much of the band. There are also resonances at certain frequencies due to the old OMTs, which are responsible for the points of high noise or K value in Figures 1 and 2. Installation of new OMTs providing good performance across the entire 4–8 GHz is expected to begin later this year.

Because of the new tuning capabilities described above a special call for A and D configuration proposals to

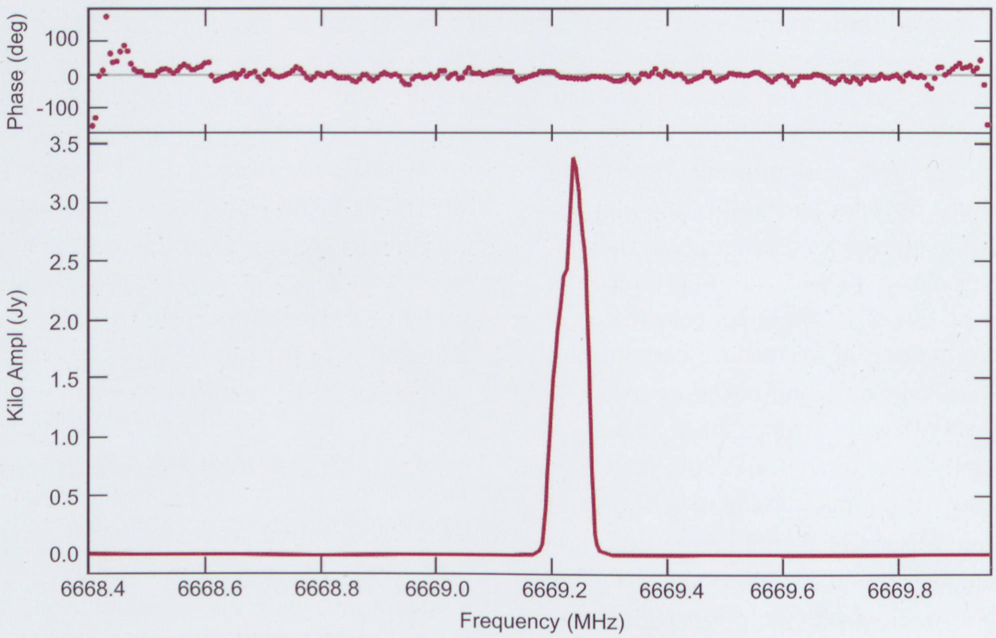

Figure 3. Shows the cross-power spectrum of W3(OH) in the 6668.6 MHz methanol line on one of the 15 EVLA-EVLA baselines available during the March 2007 tests. The flux scale is arbitrary.

exploit the expanded C-Band frequencies was announced at the end of March 2007. Eight proposals were received for D configuration, one for the move from D to A, and ten for A configuration. Three of the D configuration proposals also requested time in the A configuration in addition to the ten mentioned above. A total of five proposals were granted time for D configuration/D to A move, and six for A configuration. Observations for those projects allocated time have already begun.

G. van Moorsel and C. Chandler

Socorro

VLA Configuration Schedule

Configuration	Starting Date	Ending Date	Proposal Deadline
A	01 Jun 2007	10 Sep 2007	1 Feb 2007
BnA	21 Sep 2007	08 Oct 2007	1 Jun 2007
B	12 Oct 2007	14 Jan 2008	1 Jun 2007
CnB	25 Jan 2008	11 Feb 2008	1 Oct 2007
C	15 Feb 2008	12 May 2008	1 Oct 2007

VLA Proposals

Use of the web-based NRAO Proposal Submission Tool is required for all VLA proposal submissions; please see *http://www.vla.nrao.edu/astro/prop/vlapst/*. The maximum antenna separations for the four VLA configurations are A-36 km, B-11 km, C-3 km, and D-1 km. The BnA, CnB, and DnC configurations are the hybrid configurations with the long north arm, which produce a circular beam for sources south of about -15 degree declination and for sources north of about 80 degree declination. Some types of VLA observations are significantly more difficult in daytime than at night. These include observations at 90 cm (solar and other interference; disturbed ionosphere, especially at dawn), deep 20 cm observations (solar interference), line observations at 18 and 21 cm (solar interference), polarization measurements at L-Band (uncertainty in ionospheric rotation measure), and observations at 2 cm and shorter wavelengths (tropospheric phase variations, especially in summer). In 2008, the C configuration daytime will involve RAs between 21^h and 04^h. Proposers and observers should be mindful of the impact of EVLA construction, as described at *http://www.vla.nrao.edu/astro/guides/evlareturn/impact.html*. They should also consult the "EVLA returns" page for instructions on how to include EVLA antennas successfully in their observations, at *http://www.vla.nrao.edu/astro/guides/evlareturn/*.

VLA Scheduling

VLA scheduling takes two forms, fixed date and dynamic. Some approved proposals will be scheduled on fixed dates. Other approved proposals will be accepted for insertion into the VLA dynamic scheduling queue. A guide to VLA dynamic scheduling is available at *http://www.aoc.nrao.edu/~schedsoc/dynvla.shtml*. Current and past VLA schedules may be found at *http://www.vla.nrao.edu/astro/prop/schedules/old/*.

VLBA and HSA Proposals

Please use the most recent LaTeX template at *http://www.nrao.edu/administration/directors_office/vlba-gvlbi.shtml*. VLA/VLBA referee reports are distributed to proposers by e-mail only, so please provide current e-mail addresses for all proposal authors. Time will be allocated for the VLBA on intervals approximately corresponding to the VLA configurations (see above), from those proposals in hand at the corresponding VLA proposal deadline.

VLBA proposals requesting antennas beyond the 10-element VLBA must quantitatively justify the benefits of the additional antennas. Proposals for the VLBA [alone or with affiliate(s)] or for the High Sensitivity Array (*http://www.nrao.edu/HSA/*) should be prepared using the LaTeX template and then submitted via e-mail to *propsoc@nrao.edu*. Global 3 mm VLBI proposals, VLBA+Effelsberg proposals, and requests for using the Bonn correlator should also be sent to *propvlbi@mpifr-bonn.mpg.de*. Any proposal requesting NRAO antennas and antennas from two or more institutions affiliated with the European VLBI Network (EVN) is a Global cm VLBI proposal (see below).

VLBA and HSA Scheduling

VLBA scheduling takes two forms, dynamic and fixed date. Some approved proposals will be accepted for insertion into the VLBA dynamic scheduling queue; for such proposals, information about proposal priorities, plus the preparation and submission of observe files, may be found at *http://www.aoc.nrao.edu/~schedsoc/dynamic-memo.shtml*. A list of dynamic programs which are currently in the queue or were recently observed may be found at *http://www.vlba.nrao.edu/astro/schedules/*. Other approved proposals will be scheduled on fixed dates. Any proposal requesting a non-VLBA antenna is ineligible for dynamic scheduling. For example, HSA scheduling occurs only on fixed dates. Current and past VLBA schedules may be found at *http://www.vlba.nrao.edu/astro/schedules/*.

Global cm VLBI Proposals

Proposals for Global VLBI Network observing at centimeter wavelengths are handled by the NRAO. There are three Global sessions per year, with up to three weeks allowed per session. Plans for these sessions are posted at *http://www.obs.u-bordeaux1.fr/vlbi/EVN/call.html*. Any proposal requesting NRAO antennas and antennas from two or more institutions affiliated with the EVN is a Global cm proposal. For all classes of proposals involving the EVN, only the on-line tool *NorthStar* should be used to prepare and submit proposals. Access *NorthStar* at *http://proposal.jive.nl*. Global cm VLBI scheduling occurs only on fixed dates.

J. M. Wrobel and B. G. Clark
schedsoc@nrao.edu

VLA/VLBA Proposal Selection Committee

The VLA/VLBA Proposal Selection Committee was expanded at its April meeting to include five external members in addition to the five NRAO members. The external members were nominally assigned to review galactic or extragalactic proposals, but were encouraged to comment on and discuss all the proposals. The committee members at the April meeting are listed below. For the NRAO members with official scheduling duties, those duties are listed in parentheses:

NRAO:

Jim Ulvestad (Site Director, Committee Chair)
Barry Clark (Scheduling Officer)
Joan Wrobel (Scheduling Officer)
Mark Claussen (referee selection and assignment)
Harvey Liszt

External:

Bob Becker (University of California - Davis)
Alex Brown (University of Colorado)
James Di Francesco (National Research Council of Canada)
Martin Elvis (Smithsonian Astrophysical Observatory)
Nicole Vogt (New Mexico State University)

The external members participated fully in the discussions and also made several suggestions for improvement of the entire process. A key recommendation that we hope to implement by the end of the year is expansion of the non-NRAO membership to eight to ten individuals. A number of other suggestions from the new members were discussed with the NRAO Users Committee at its meeting in May, and we await recommendations from that group before moving forward.

In the past, the NRAO-dominated committee has tended to follow the initial grades from our external referees very carefully, in order to avoid having too strong an influence over the proposal selection process. A Proposal Selection Committee with more external members leads to a more varied discussion of the referee grades and reports, which occasionally results in a proposal rating being incremented or decremented relative to the original referee recommendations; this makes the process more similar to an NSF or NASA review panel.

On the whole, we found the new committee makeup to be an improvement, and we greatly appreciate the participation of our new members in helping us to develop a better process, and in taking the time to provide a careful evaluation of over 150 proposals.

Jim Ulvestad

VLBA Sensitivity Upgrade Project: DBE Developments

With this issue of the *Newsletter*, we are initiating a series of focused articles, each concentrating on recent progress in one of the several VLBA development areas outlined in last quarter's issue. At the end of each article, there will also be brief summaries of progress in other project areas.

This article focuses on the Digital Backend (DBE), which will replace the existing baseband converters and samplers. Currently, the preliminary specifications include two separate, program-selectable operating modes: a maximum of eight tunable digital down-converter (DDC) sub-bands (four per IF input), with bandwidth ranging from 0.5 to 256 MHz in binary steps, and output sample precision up to 8 bits; and a polyphase filterbank (PFB) with up to 32 channels spanning the entire passband of each of the two IFs. Each mode is subject to an overall maximum throughput of 8 Gbps. (The overdesign relative to the 4 Gbps goal is partly to allow for future expansion of the upstream equipment, and partly to accommodate the requirements of the VLBI-2010 geodetic project.) The principal change, relative both to the specs described in the previous article, and to the existing system, is the reduction in the total number of DDC sub-bands; we believe that the larger number of channels often used currently can be obtained satisfactorily using the PFB mode.

Major developments in the DBE involve the platforms to be used for development and implementation of the device. Instead of the specially-designed board originally planned, we have joined a collaboration led by the CASPER group at UC Berkeley, and including the South African KAT effort, and others, to complete the development of a new iBOB-2 board. This further development of the very successful iBOB includes, among the features most essential for the VLBA, a higher-capacity FPGA and an integrated 10G Ethernet output interface. NRAO will work with KAT engineers to complete the schematic, and will handle the board layout. An intermediate iBOB-1.5 prototype is already complete, which will save time in prototyping NRAO's FPGA code.

A primary advantage of the iBOB-2 platform is that it allows NRAO and Haystack Observatory to standardize on a common platform suitable for both the applications that we still plan to share. Under a more specific division of effort agreed upon recently, NRAO will develop the DDC-based FPGA personality described above, which for clarity we have termed the "VDBE". Haystack will produce a PFB-based "DBE2" personality, an extension of their original DBE that was developed in collaboration with UC Berkeley. The common iBOB-2 platform will simplify maintaining compatibility despite using different design techniques. NRAO still plans to adopt a traditional approach for the VDBE, so as to exploit the expertise developed at NRAO for the EVLA project, where quite similar equipment has already been implemented. The change to the iBOB-2 implies several related changes in modularization. The high-speed sampler will be moved to a separate input board, and some secondary output formatter-translator functions will also be moved off-board. The latter include the Mark 5A/B outputs necessary during transition to the new Mark 5C, and the OC-192 output used for the Pie Town - VLA link.

Internal NRAO funds have been allocated to deploy the new DBE devices at NRAO's twelve VLBI stations once the design is complete. Funding for other VLBA Sensitivity Upgrade Project areas will be discussed in the detailed articles we are planning for future *Newsletter* issues.

In other project areas: LNAs were upgraded in three additional 1 cm receivers, and these were installed at Los Alamos, Kitt Peak and Fort Davis. Measurements with the Los Alamos system showed excellent results, similar to those reported for the first receiver at Pie Town, as reported in the previous issue. Lab bench tests suggest that similar performance will be achieved with the two newest receivers. The Mark 5C 4-Gbps recording system will be based on Conduant Corporation's "Amazon" interface to the disk array, already used in the Mark 5B+ system. Mark 5C's input will be matched to the DBE's 10G Ethernet output, so that the special-purpose VLBI interfaces used in Mark 5A/B will not be necessary. Peripheral software to interface the DiFX software to the VLBA's current operational system is nearly complete, and procurements are under way for the rudimentary cluster on which it will be operated initially. We anticipate an article in the next issue of the Newsletter that will include details on both these software correlator developments, and preliminary test results as well.

Jonathan Romney

VLA and Haystack Demonstrate Real-Time VLBI

A successful test on May 21 marked NRAO's first demonstration of real-time VLBI, or eVLBI, as a single VLA antenna was used along with Haystack Observatory's Westford telescope. The VLA data were sent to the Haystack correlator through the Internet2 research network, and the signals from both antennas were correlated in real time.

During a two hour session, the telescopes observed the quasar 3C454.3. The VLA signals were sent to the correlator at a continuous rate of 32 Megabits per second, providing an observing bandwidth of 8 MHz. To achieve real-time correlation, the data streams from the two telescopes had to be synchronized to within one microsecond. During the observing session, a total of

230 Gigabits of data were transmitted, enough to fill eight movie DVDs.

Real-time VLBI offers important advantages, such as quicker availability of results, over the traditional VLBI techniques that involve recording the data from individual antennas on magnetic media and shipping the media to the correlator. Applications of eVLBI could include the observation of rapidly-evolving transient astronomical events and use of VLBI for spacecraft navigation and guidance.

A long-term goal is to produce the capability to make real-time eVLBI observations using tens of telescopes on intercontinental baselines with data rates upwards of 8 Gigabits per second.

Steve Durand

End to End Operations

End to End Communications

Over the past year, the NRAO End to End Operations division has been working on initiatives related to archive development, pipelines, proposal management, data processing, and broadening access to NRAO facilities in general to the user community. There are many exciting efforts underway, including work on the VLA pipeline, continuous generation of images and data products for the archive, and work on an improved, streamlined user interface for archive searching. To date, there has been no channel for communicating the details of this division's ongoing activities. But starting in July, *http://e2e.nrao.edu* will be used to provide information about what's under development and when new capabilities will be available to the user community. Please visit this updated web site to get a sense of the new capabilities NRAO is working to provide the user community as *One Observatory*.

Nicole Radziwill

VLA Pipeline Update

The VLA Pipeline team, led by NRAO Scientist Lorant Sjouwerman (with John Benson and Jared Crossley) continues its production of images and calibrated data from the VLA archive, at a rate of 1000 images and 100 archive days processed per month. Over 30,000 images covering over 6,000 sky positions have now been processed. For the VLA, automatic scripts to produce Level 2 images (which will incorporate further editing and self-calibration to improve the final product) are now being developed. This new collection of images will be published to the *Virtual Observatory* later this year, to coincide with the release of new archive interfaces to make finding the images much easier. NRAO has also started bringing together scientists and software engineers working on pipeline development to ensure that heuristics are effectively applied for all NRAO telescopes.

N. Radziwill and E. Fomalont

Green Bank

Green Bank Telescope Azimuth Track Project

Figure 1. Removal of old welds.

Figure 3. Setting of the first new base plate onto the foundation.

Phase I of the track demolition and erection work began April 30 with lots of dust, noise, and activity. Wear plates were removed from the first "octants" on the first day, followed by the base plates and splice plates later in the week. As the base plates and splice plates were removed, the extent of the rapid deterioration of the steel pieces and the underlying cement grout became apparent. If this project had not occurred now, the telescope would have to have been taken out of service for a period this summer to replace large sections of the grout. The good news is that the concrete foundation itself appears to be in very good shape, with only minor damage at the outside surfaces. These areas will be corrected with a fast setting, high strength concrete material and high strength epoxy grout.

Approximately 40 contract employees and NRAO staff have been involved in the work over the past month, performing direct work as well as supporting modifications and refurbishment of pieces to be reused. The crews have had to work through some unforeseen problems and have adapted their methods to

Figure 2. Modification of an original base plate to be used as a transition piece for driving the telescope onto the new track section. NRAO employees Mike Hedrick (left) and Harry Morton (right) are inspecting the piece.

Figure 4. First three base plates and wear plates being placed in position.

accommodate them. The Project is slightly behind the fair weather, "everything goes right" baseline schedule. The first successful weld joint was completed in late May; twenty-three more will be completed this summer. Only a few afternoons in May were lost to thunderstorms; and only one full day (May 18) has been lost to a combination of rain, sleet, and snow.

Bob Anderson

Pulsar Survey During Track Refurbishment

A very large fraction of the time during the GBT track repair has been scheduled for a 350 MHz pulsar driftscan survey (PIs: Lorimer, McLaughlin, and Ransom). Using a newly-commissioned 2048-lag 8-bit Spigot mode, the survey will cover almost 1/4 of the sky and should discover scores of new pulsars (including several or even tens of new millisecond pulsars). It is one of the most sensitive large-scale pulsar surveys ever conducted—at relatively high Galactic latitudes it is more sensitive to millisecond pulsars than any of the surveys undertaken with Arecibo, for instance.

Data are currently being taken at a rate of 1–2 TBs per day, and as of June 1, over 40 TB of data had been recorded. The total survey will encompass over 100 TB of data, which will be archived by NRAO, the Observatory's first large scale archiving of pulsar data. Non-pulsar uses of the data will include searching for high redshift HI absorption and for transient radio emission from flare stars. Once all the data are recorded, the fun will be just beginning: it will likely take more than a CPU century to process!

Scott Ransom

MUSTANG/PTCS Update

As reported in the January newsletter, the GBT achieved first light at 3 mm in a fall 2006 engineering run with MUSTANG, a 64-pixel TES-bolometer array developed by Mark Devlin's group at the University of Pennsylvania, in collaboration with NASA-GSFC and NRAO. In brief, the receiver functioned smoothly, and the GBT proved an excellent and reliable platform for test observations. At the time, the two principal obstacles to doing first-class science with MUSTANG on the GBT were the telescope's aperture efficiency (about ten percent), and a mysterious source of excess noise in the receiver itself.

In spring 2007, extensive laboratory investigations by Simon Dicker (UPenn) and Phil Korngut (NRAO/UPenn) showed that the excess noise was a strange form of microphonic vibration, uncorrelated between individual bolometers, and excited by the pulse tube cooler. The pulse tube was vibrationally isolated from the focal plane, dramatically improving the sensitivity of the receiver. Currently more than 50 of the 64 detectors are functioning well. A second commissioning run will take place this coming fall/winter (2007/2008), and for this run we expect a sensitivity increase of 50 or greater.

Over the summer, the cryogenic robustness of the receiver will be improved, increasing hold times, and reducing the susceptibility of the system to dramatic tipping in elevation. In Green Bank, work will commence for producing an YGOR-native control and data acquisition system that will replace the software NASA provided for commissioning observations. NRAO aims to make the instrument available in a limited shared-risk mode in 2008/2009, contingent on sufficient progress with systems integration and antenna improvements.

The PTCS team has also been investigating prospects for improving the GBT surface efficiency, with encouraging results to date. Measurements of the faint sidelobes of the telescope, conducted by performing 2 degree scans across the moon with the Q-Band (43 GHz) receiver, have been interpreted within the framework of a realistic mathematical model of surface errors. The results suggest that corner-setting error does not dominate over actuator error as a contributor to the small-scale surface errors. This is good news since actuator errors are much easier to correct than corner-setting errors. Furthermore, simulations of traditional holographic measurements which include pointing errors indicate that realistic pointing errors should not be a showstopper in measuring the surface. While timelines are not yet firm for this work, there is solid ground for optimism.

B. Mason and T. Hunter

Advanced Digital Backend Project

In September of last year at the GBT Future Instrumentation Workshop, Dan Werthimer gave a presentation on the Berkeley Center for Astronomy Signal Processing and Electronics Research (CASPER) group's efforts to build standardized hardware and software platforms for signal processing in radio astronomy. At the same workshop, Scott Ransom listed the desired characteristics of the next generation pulsar backend. Ron DuPlain, a Green Bank co-op student from the University of Cincinnati (UC) also attended the workshop. These events resulted in a group of UC students proposing as their senior project the preliminary design work on the pulsar backend, using the CASPER tools.

The UC effort is finished, with designs and simulations submitted to NRAO for review. Two interns are working with NRAO staff over the summer to further develop and test these designs with actual astronomical signals, and to implement the data collection. We have on order and should soon receive the hardware needed to implement the pulsar backend, which consists of a Berkeley Emulation Engine (BEE2), two analog-to-digital converters (iADCs), and two Infiniband Breakout Boards (iBOBs). Plans are in the works for the computers to collect and process the data from the pulsar machine. Another group from West Virginia University is collaborating with this group to produce another pulsar machine to be deployed at the 43 meter telescope for testing.

We will also investigate the use of the same hardware and software technology for the construction of new spectral line backends. We are beginning investigation of replacement of the GBT specrometer with a newer instrument with higher resolution at wide bandwidths. We also are interested in the scalability of this technology, since we are planning to begin building array feeds, and so we will need correspondingly greater numbers of IF inputs and spectral channels.

John Ford

Dynamic Scheduling Update

The plans for implementing a new dynamic scheduling system (DSS) for the GBT have progressed significantly over the last quarter. The DSS has gone through a number of reviews in the last few months, including two by the local staff, a presentation to the NRAO Users Committee, and an external Conceptual Design Review. The feedback from the reviews has been incorporated into the plans and policies for the DSS. Currently the team is working on the software and other information needed for a planned test of the DSS in September 2007. The results of the September tests will be made publicly available. Full details of the plans for Dynamic Scheduling are at: *http://wiki.gb.nrao.edu/bin/view/Dynamic/WebHome*

Karen O'Neil

GBT Documentation and Web Pages

Over the last few months, we have been engaged in a campaign to revise the user documentation for the GBT. We have concentrated our efforts on the documentation that our users have found most lacking. The released documents include:

Observing with the Green Bank Telescope
http://www.gb.nrao.edu/gbtprops/obsman/GBTog/GBTog_tf.html.

This document, authored by Toney Minter, is a complete rewrite of our old manual and puts in one place much of the user documentation that was scattered across our website.

GBTIDL User's Guide
http://www.gb.nrao.edu/GBT/DA/gbtidl/users_guide/.

This document was authored by Kristen Thomas, Jim Braatz, and Bob Garwood. It combines in a single place much of our data analysis documentation.

Calibration of GBT Spectral Line Data in GBTIDL v2.1
http://wwwlocal.gb.nrao.edu/GBT/DA/gbtidl/gbtidl_calibration.pdf.

Authored by Jim Braatz, this describes the standard calibration algorithms used by the various GBTIDL commands, plus the limitations of the algorithms.

The Proposer's Guide for the Green Bank Telescope
http://www.gb.nrao.edu/gbtprops/man/GBTpg/GBTpg_tf.html.

This document is revised by Toney Minter before each call for proposal.

Observers have also told us that they were having difficulty finding information on our web site. Recently, we consolidated onto a single page (*http://www.gb.nrao.edu/astronomers.shtml*) the set of links that observers use the most. The new page replaces the "Astronomers" page that is a link off of the Green Bank home page (*http://www.gb.nrao.edu/*). The new astronomers' page is the first step in a much larger effort to reorganize and prune our web site.

In parallel with the effort to reorganize the content of our website, we have begun revising the style as well. The new style improves the look of our pages, makes them more accessible, and reduces maintenance costs. Reorganizing a website as complicated as that in Green Bank will take some planning, effort and time. Visitors should see over the next year a steady stream of improvement in both the content and look of our web site. Those most involved in planning the web work are Paul Ruffle, Chris Clark, and Sue Ann Heatherly.

We will announce future releases of manuals and changes to our documentation on the GBT News e-mail exploder. Please go to: *http://listmgr.cv.nrao.edu/mailman/listinfo/gbtnews* if you would like to subscribe to the exploder.

Ronald Maddalena

Education and Public Outreach

The NRAO and AUI at the American Astronomical Society Meeting in Hawaii

The 210th meeting of the American Astronomical Society (AAS) convened at the spacious Hawaii Convention Center in Honolulu, Hawaii from Sunday, May 27 through Thursday, May 31, 2007. More than 1,200 scientists, teachers, students, journalists, and other professionals attended. This attendance is significantly higher than recent summer meetings, indicating the quality of the meeting and the attractiveness of the venue.

A portion of the joint AUI/NRAO exhibit at the May 2007 American Astronomical Society meeting in Honolulu, Hawaii.

Associated Universities, Inc. (AUI), NRAO's parent organization, joined the Observatory as an exhibitor, with President Ethan Schreier and Assistant Vice President Cynthia Allen representing AUI. Numerous AAS attendees visited the AUI/NRAO exhibits to seek information about our research facilities and project status, to converse with AUI and NRAO staff, and to pick up the latest brochures and other materials. AUI debuted a full-color brochure at this meeting. NRAO distributed updated ALMA and EVLA brochures, GBT and VLBA updates, and our full-color Observatory-wide brochure. Pins celebrating ALMA and the NRAO 50th anniversary were popular with meeting attendees, as were memory sticks branded with the NRAO 50th anniversary logo. Two new full-color posters were also featured: a radio-optical composite of the Whirlpool Galaxy (Messier 51) created by EPO Scientist Juan Uson; and the 2006 AUI/NRAO Image Contest First Prize image, a VLA – MSX composite created by Jayanne English (University of Manitoba). A short, high definition video trailer produced to celebrate the delivery of the first VertexRSI production antenna to Chile in late April helped attract visitors to the NRAO ALMA exhibit.

A new NRAO press release was distributed in conjunction with this AAS meeting. This release described recent research by James Ulvestad (NRAO), Jenny Greene (Princeton University), and Luis Ho (Carnegie Institute). This team of astronomers used the VLA to greatly strengthen the case that supermassive black holes at the cores of galaxies may have formed through mergers of smaller black holes, demonstrating that a globular star cluster in the Andromeda Galaxy, M31, probably has a black hole with 20,000 times the mass of the Sun at its core.

EPO personnel Sue Ann Heatherly and Mark Adams staffed and managed the NRAO exhibits. Members of the Observatory's scientific staff and management team assisted, including Deputy Director Phil Jewell, New Mexico Site Director Jim Ulvestad, and scientists Ken Kellermann and Paul Vanden Bout. We are also grateful to Alison Peck, Deputy Project Scientist for the Joint ALMA Observatory, who spent considerable time assisting and talking with visitors to the NRAO ALMA exhibit.

The NRAO looks forward to visiting with the astronomy community at the January 8 – 12, 2008 AAS meeting in Austin, Texas, where the NRAO will also host an hour-long Town Hall. We hope to see everyone there!

Mark Adams

Summer Students Assist with NRAO Summer Tours

Five of the Socorro-based, 2007 NRAO summer students: (left to right) Rosa Torres (UNAM), Jennifer van Saders (Rutgers), Nick Lee (UC Berkeley), Karen Mogren (NAU), and Diana Grijalva (NMT).

As part of their service to the observatory, each of the Socorro-based summer students provides much appreciated assistance with the Observatory's New Mexico based Education and Public Outreach program by leading tours of the Very Large Array. These tours are conducted by the NRAO summer students for the general public on each Saturday from mid-June through the first weekend of August. Through their participation in these popular weekly tours, NRAO summer students gain valuable experience in public outreach and learn a great deal about explaining the science, technology, and value of NRAO and the modern research enterprise to members of the general public.

Robyn Harrison

In General

NRAO-GLAST Collaborative Science Agreement

NRAO and the Gamma-ray Large Area Space Telescope (GLAST) have concluded an agreement for collaborative science. This agreement will maximize the science output from both GLAST and NRAO's unique radio telescopes by providing both radio-telescope observing time and funding for multi-wavelength investigations.

GLAST presently is scheduled for launch in December 2007. Its primary mission will be to perform an all-sky survey for gamma-ray sources, with an expectation that 5,000–10,000 discrete gamma-ray sources will be detected, compared to approximately 300 confirmed sources known from the Compton Gamma-Ray Observatory.

The NRAO-GLAST agreement will enable researchers to propose peer-reviewed multiwavelength investigations for funding from the GLAST mission; if their proposals pass the GLAST peer review and require radio observations with NRAO telescopes, NRAO will grant observing time based on the peer review from GLAST without requiring any separate proposal submission. NRAO will make available a maximum of up to 450–600 hours per telescope (roughly ten percent of the scientific observing time) on the VLA, VLBA, and GBT for Cycle 1 of the GLAST Guest Investigator Program.

A press release describing the collaborative science program is at *http://www.nrao.edu/pr/2007/glast/*. Optional Notices of Intent for the GLAST Cycle 1 program may be submitted by July 13, 2007, and proposals are due on September 7, 2007.

For further information about the GLAST Guest Investigator program, see the web site of the GLAST Science Support Center at *http://glast.gsfc.nasa.gov/ssc/*.

Jim Ulvestad

Professor Karl Menten Selected for the 2007 Jansky Lectureship

Karl M. Menten

Associated Universities, Inc. and the National Radio Astronomy Observatory are pleased to announce that the 42nd annual Karl G. Jansky Lecture will be given by Professor Karl M. Menten of the Max-Planck-Institut für Radioastronomie in Bonn, Germany.

Professor Menten studied physics and astronomy at the University of Bonn, Germany, completing his dissertation on *Interstellar Methanol towards Galactic HII Regions* and his doctoral degree in 1987. He then joined the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, where he was a Postdoctoral Fellow and a Research Associate for several years. From 1992 through 1996, Professor Menten continued to conduct research as a Radio Astronomer, then Senior Radio Astronomer, at the CfA. He then became the Director for Millimeter and Submillimeter Astronomy at the Max-Planck-Institut für Radioastronomie in Bonn in 1996, a position he still holds. Since 2001, he has also been a Professor for Experimental Astrophysics at the University of Bonn.

Professor Menten is an extraordinarily productive scientist whose research has improved our fundamental understanding of molecular clouds, astrochemistry, star formation in the Milky Way and in the early Universe, and circumstellar envelopes around stars in the late stages of their evolution. In particular he has used cosmic masers as observational probes for many astronomical environments. Professor Menten is particularly interested in the dense, hot regions around forming and recently formed high-mass stars. Since the stupendous energy production of these stars, which are much heavier than our Sun, profoundly influences interstellar matter on a galactic scale, it is important to investigate their origins.

Using the NRAO 140 Foot Telescope at Green Bank in 1991, he discovered very strong methanol maser emission in galactic star-forming regions, a discovery that he developed into a powerful tool for studying massive star formation (A maser is the radio-wavelength equivalent of the shorter-wavelength laser). In interstellar clouds maser radiation is produced by natural action from newly formed stars and intense maser beams guide astronomers to stellar birthplaces. Because maser emission is very bright and arises from compact regions it can be observed with ultra-high resolution by combining telescopes thousands of miles apart. Professor Menten pioneered the first such Very Long Baseline Interferometry of methanol masers soon after their discovery and currently is co-leading a large-scale project that uses the NRAO Very Long Baseline Array for high precision maser observations to probe the structure, size, and dynamics of the Milky Way.

Professor Menten has observed emission from interstellar molecules at wavelengths as long as many centimeters. However, the variety of molecular emission is much greater at shorter wavelengths of a millimeter or less. To create a platform for research in submillimeter astronomy, Professor Menten initiated the Atacama Pathfinder Experiment (APEX), a 12 meter diameter telescope on the high elevation Chajnantor site in Chile's Atacama Desert, where the Atacama Large Millimeter Array (ALMA) is now under construction. True to its name, APEX has pioneered submillimeter science on the Atacama plateau and proved the quality of the site for astronomical research at millimeter and submillimeter wavelengths.

The dates and locations for Professor Menten's 2007 Jansky Lectures titled *Tuning in to the Molecular Universe*, will be announced later this summer.

Fred K Y. Lo

Support for PhD Dissertations Using NRAO Facilities

Students planning to use an NRAO telescope for their PhD dissertation (particularly if more than one proposal will be required) should submit a "Plan of Dissertation Research" of no more than 1000 words with their first proposal. This plan can be referred to in later proposals. At a minimum it should contain a thesis timeline and an estimate of the level of NRAO telescope resources needed. The plan provides some assurance against a dissertation being impaired by adverse referee comments on one proposal, when the referees do not see the full scope of the project. This requirement applies to all three of the NRAO major instruments: VLA, VLBA and GBT. Shortly after the submission of the first proposal, please e-mail your research plan to Carl Bignell (*cbignell@nrao.edu*) for the GBT and Joan Wrobel (*jwrobel@nrao.edu*) for the VLA, VLBA and HSA. In the near future, we expect to make changes to the NRAO Proposal Submission Tool that will allow the research plan to be submitted with the proposal.

D. Frail, J. Wrobel, C. Bignell, and N. Radziwill

The Expanded Student Observing Support Program

In the October 2006 *Newsletter* we announced the expansion of this popular GBT program, increasing both the funding and the eligibility. Financial support is now available for U.S. students who submit regular proposals to use the GBT and the VLBA. In addition, support is available for Large proposals that request the use of GBT, VLBA, or the VLA. For more details on this program and the application process, please see the webpage of the Science and Academic Affairs linked from the main NRAO webpage under *Information for Astronomers*.

A total of nine new awards have been made since the start of the expanded program. Three awards were for Large proposals while six were for Regular proposals. Six awards were made for programs on the GBT, while three were for the VLBA. The awards were made to the following students:

- D. Ludovici (West Virginia University) in the amount of $8,000 for the proposal *Continued Radio Timing Observations of RRAT Sources.*
- J. Boyles (West Virginia University) in the amount of $16,000 for the proposal *A 350 MHz Drift Scan Survey for pulsars with the GBT.*
- H. Kuchibhotla (Purdue University) in the amount of $28,509 for the Large Proposal *The VLBA 2cm MOJAVE/GLAST Program.*
- N. Hakobian (University of Illinois) in the amount of $35,000 for the Large Proposal *A Definitive Test of Star Formation.*
- D'Arcangelo (Boston University) in the amount of $34,000 for the Large Proposal *Probing Blazars through Multiwaveband Variability of Flux, Polarization, and Structure.*
- C. Cyganowski (University of Wisconsin) in the amount of $3,000 for the proposal *Kinematics of Ionized and Molecular Gas Associated with IR Dust Bubbles.*
- H. Gupta (Harvard University) in the amount of $16,000 for the proposal *Search of anions C4H- and C8H- in TMC-1 and additional observations of C6H-.*
- S. Tremblay (University of New Mexico) in the amount of $23,000 for the proposal *Evolution of Burgeoning Active Galactic Nuclei.*
- B. Zeiger (University of Colorado) in the amount of $15,400 for the proposal *Formaldehyde Absorption in the Gravitational Lens PKS 1830-211.*

D. Frail, D. Nice (Bryn Mawr),
K. Johnson (U. Virginia),
J. Wrobel, C. Bignell

The Eleventh Synthesis Imaging Workshop

The Eleventh Synthesis Imaging Workshop will be held at NRAO and New Mexico Institute of Mining and Technology, in Socorro, New Mexico, from June 10–17, 2008. In addition to lectures on introductory and advanced radio synthesis topics, the workshop will feature hands-on data reduction tutorials and tours of NRAO telescopes and facilities.

Amy Mioduszewski

2007 NRAO Summer Students

By the time this *Newsletter* is published, the 2007 summer student class will have reported to their assigned NRAO sites. The 2007 class consists of twenty-two students: fifteen undergraduate students supported by the National Science Foundation *Research Experience for Undergraduates (REU)* program; and seven graduating seniors or graduate students supported by the NRAO Graduate or Undergraduate Summer Student program. Seven students are assigned to Socorro, ten to Charlottesville, and five to Green Bank. These 22 students were chosen from 118 applications.

During their 10–12 week summer internship, the students will work with a staff mentor on a project in the mentor's area of expertise. In addition to their summer research projects, the students will attend a lecture series, local science conferences, and field trips to other observatories. Students assigned to Socorro will collaborate on a VLA or VLBA observational project, while students assigned to Green Bank or Charlottesville will conduct observing projects with the GBT.

The accompanying table lists the names and schools of the 2007 summer students, together with their mentor, site, and project title. Details on these and all NRAO student programs are available at *http://www.nrao.edu/students/.*

Jeff Mangum

2007 NRAO Summer Students

Paula Aguirre	Universidad Católica de Chile	*HI Observations of the Edge-On Spiral Galaxy UGC10043*	Juan Uson	CV
Alan Aversa	Univ. of Arizona	*Searching for the Youngest Star Clusters*	Kelsey Johnson	CV
Heidi Brooks	Reed College	*Radio Emission from Interplanetary Shocks*	Tim Bastian	CV
Sophia Brunner	Bennington College	*Dust and Gas in the Southern Milky Way*	Jay Lockman	GB
Michael Carilli	Univ. of Notre Dame	*Galaxy Formation at (sub)mm Wavelengths*	Jeff Wagg	SOC
Courtney Epstein	Oberlin College	*WVU, NRAO, Cornell GBT Pulsar Drift Search Survey*	Maura McLaughlin, Dunc Lorimar, Vlad Kondratiev	GB
Michael Freed	Newport News Shipyard Apprentice School	*Saturns Satellites at True Opposition*	Anne Verbiscer	CV
Diana Grijalva	New Mexico Tech	*Exploring Frequency-Dependent Recombination Line Effects in ON 1*	David Meier Vincent Fish	SOC
A. J. Heroux	Univ. of Wisconsin - Whitewater	*Formaldehyde Densitometry of External Galaxies*	Jeff Mangum	CV
Danielle Holstine	Wheeling Jesuit Univ.	*RFI Visualization for the GBT*	Carla Beaudet Amy Shelton	GB
Steven Janowiecki	Case Western Reserve Univ.	*Dust and Gas in the Southern Milky Way*	D. J. Pisano	GB
Benjamin Jewell	Ohio Univ.	*Refinement of the ALMA 12-Meter Antenna Wind Load Predictions*	Art Symmes	CV
Matthew Klimek	Rutgers Univ.	*Low Frequency Spectra of MicroJy Radio Sources*	Frazer Owen	SOC
Jonathan Landon	Brigham Young Univ.	*An Array Receiver for the GB 20 Meter Telescope*	Roger Norrod Rick Fisher	GB
Nicholas Lee	Univ. of California, Berkeley	*A Search for HCN 1-0 Emission from the Galaxy J1635+6612*	Chris Carilli	SOC
Diane Leigh	Univ. of Virginia	*Investigating the Physical and Chemical Environments of Hot Cores in the Interstellar Medium*	Anthony Remijan	CV
Karen Mogren	Northern Arizona Univ.	*Radar Reflectivity of Mars*	Bryan Butler	SOC
Timothy Pennucci	Columbia Univ., Columbia College	*Pulsars*	Scott Ransom	CV
Charles Romero	Univ. Colorado	*How Long Will the SKAs Baselines Need To Be?*	Robert Reid	CV
Rosa Torres	Centro de Radioastronomia y Astrofisica - UNAM	*Astrometry of PMS Stars*	Amy Mioduszewski	SOC
Jennifer Van Saders	Rutgers Univ.	*Faint Submillimeter Sources Lensed* by Clusters	Wei-Hao Wang	SOC
Mary Wilkins	James Madison Univ.	*A Caltech Submillimeter Observatory Study of Three Promising Zeeman Molecules*	Crystal Brogan	CV

Production and Impact of Radio Telescopes 2001-2005

USED PRIMARILY FOR COSMOLOGY AND CMB STUDIES					
Facility	Papers		Citations		C/P Total
	2001	2002	2002-04	2003-05	
COBE	14.65	10.6	227	196	16.8
Boomerang	5.6	6.8	136	474	49.2
Maxima	5.6	2.7	456	114	68.7
3C, 6C, 7C	6.8	9.8	134	95	13.8
DASI	---	5.7	---	607	106.5
Other CMB etc.	12.4	4.6	223	142	21.5
TOTALS	45.0	40.1	1176	1628	32.9

MILLIMETER AND SUBMILLMETER FACILITIES					
Facility	Papers		Citations		C/P Total
	2001	2002	2002-04	2003-05	
NRAO 12-m	16.5	8.7	189	111	11.9
CSO	9.4	9.9	128	145	14.2
FCRAO	10.3	11.0	164	144	14.5
OVRO	21.1	21.6	282	190	11.0
BIMA	23.3	15.9	302	264	14.4
SWAS	8.3	6.3	120	50	11.6
JCMT	46.9	55.3	988	963	19.1
IRAM 30-m	31.6	41.4	467	641	15.2
IRAM Interf.	10.7	14.0	212	149	14.6
SEST	20.0	15.9	169	136	6.9
H. Hertz	5.0	5.1	37	28	6.4
Antarc. Submm	5.3	---	40	---	7.6
Nagoya 4-m	16.1	---	84	---	5.2
Nobeyama 45-m	19.2	14.8	128	71	5.9
Nobeyama Int.	6.6	6.3	34	38	5.6
Other mm/ submm	18.1	7.3	260	82	13.4
TOTALS	268.6	241.0	3604	2435	11.85

The use of paper and citation counts for evaluation of astronomical facilities was pioneered by Abt (1981), whose goal was to determine whether the publicly owned and operated telescopes at KPNO and CTIO were comparable with the privately owned Lick and Palomar facilities. The answer was (and is) yes. Trimble (1995, 1996) expanded the investigation, first, to all large American optical telescopes and then to telescopes of two meters or more anywhere in the world. The numbers presented here come from the first and second years of a further expansion to include all astronomical observing facilities of any size, operating at any wavelength, sited anywhere on earth or on devices that started on earth. The full two-year data set (Trimble & Ceja 2007) is being submitted for collective publication. This is an advance copy of some of the radio data. The numbers have been shared privately with colleagues involved in reviews of several different American and European facilities, but the data collection was not in any way motivated by these reviews.

In 2001 and 2002 there appeared 1676 papers, in 18 journals, reporting observations from slightly more than 100 radio telescopes (out of a total of 7768 astronomical papers in 20 journals from more than 550 telescopes, including space-based facilities). These radio papers, some of which also include optical and/or space-based data, were cited 21,216 times in the three years after publication (that is 2002-04 for 2001 papers and 2003-05 for 2002 papers) for an average of 12.66 citations per paper or 4.22 citations per paper per year. Optical and space-based averages are slightly higher, but not enough to motivate career changes.

The 2001 data were published in a series of three short papers (Trimble, Zaich, & Bosler 2005; Trimble & Zaich 2006; Trimble, Zaich, & Bosler 2006). We present here a preliminary look at the second year of radio data. The methodology was basic bean counting: the first author went through all the pages of all the journals (from the Astrophysical Journal down to some that publish only a dozen or so papers per year) and recorded all the facilities used for each. In the "radio" data base (which includes millimeter and submillimeter wavelengths, from both the ground and space) credit for a paper was divided equally among all contributing facilities. The other author(s) of this work then went to Web of Science/ Science Citation Index and recorded the number of times each relevant paper was cited in the next three years. The citations were then also divided equally among the facilities used. Notice that this can only just now be done for papers published in 2003 because the citations from 2006 are only just recently completely recorded.

INTERFEROMETERS, PARTS USED SEPARATELY, AND SINGLE DISHES

Facility	Papers 2001	Papers 2002	Citations 2002-04	Citations 2003-05	C/P Total
VLA	181.4	199.5	3003	2631	14.8
VLBA + dishes	38.3	31.6	482	327	13.5
Arecibo	28.0	28.4	366	270	11.3
Green Bank	8.9	16.7	118	190	12.0
Other W. Hem.	6.3	12.2	53	28	4.4
DRAO	8.6	5.6	60	28	6.2
ATCA	46.8	42.8	525	437	10.7
Parkes	38.3	29.8	786	378	17.1
Aust. Other + DSN	11.4	10.8	94	54	6.7
Merlin	18.6	19.4	194	132	8.6
EVN	12.2	7.1	106	44	7.8
Jodrell	10.5	4.0	112	41	10.5
Ryle	---	6.5	---	49	7.5
Westerbork	14.1	23.1	181	266	12.0
Effelsberg	21.0	17.7	183	172	9.2
Puschina	7.0	5.3	24	12	2.9
RATAN 600	6.0	6.2	6	20	2.1
Other Euro	23.6	21.9	156	113	5.7
GMRT+Ooty	12.0	12.0	50	48	4.3
Other Asian	6.3	12.2	53	28	6.2
VLBI other	5.1	7.5	38	31	5.5
HALCA	3.4	0.6	26	3	7.3
TOTALS	504.3	558.0	6552	5821	11.65

Numbers are available for papers and citation rates per journal, by subject matter, and by telescope used. The tables show this last set of data, with the telescopes arranged in order from standard dishes and interferometers to facilities used primarily for study of the microwave background and large scale structure to millimeter and submillimeter antennas, etc. Some numbers change a good deal between years: the Ryle telescope and DASI do not appear in 2001 but do in 2002; the NRAO 12-meter went down and came up again under different ownership; Westerbork and Green Bank were in the process of recovery from various problems; and so forth. A separate entry in the table implies a minimum of 5.0 papers in one year (except that Nancay hit 6.2 in 2001 and Onsala 6.9 in 2002 but are included with "European – other"). HALCA (the Japanese VLBI satellite) did not reach that minimum but is shown anyhow. Component dishes of the VLBA used separately are included with the VLBA total. American facilities are listed first. And, finally, you may well have seen larger numbers for some of these telescopes and observatories, compiled by the institutions themselves. The secret is (and HST, the VLT, XMM, and everybody else does much the same) that the telescope being featured is given full credit for every paper that used some of its data, rather than the shared credit adopted here.

Contributed by:
Virginia Trimble (University of California)
Jose Ceja (Las Cumbres Observatory)

References:

Abt, H.A. 1981. PASP 93, 207

Trimble, V. 1995. PASP 107, 977

Trimble, V. 1996. Scientometrics 36, 237

Trimble, V. and Ceja, J. 2007. To be submitted to Astron. Nach.

Help NRAO Track Your Publications

In the adjacent Library Corner artjicle, a link is provided to the NRAO library catalog database. Among other things, this database keeps track of scientific publications utilizing data from NRAO instruments. We currently are able to collect proposal codes from authors only when they contact us directly to request page charge support. In the future, NRAO will provide cross-referencing between historical datasets, pipeline products, proposal information and publications through the NRAO archive. To do this, we need to know your past proposal codes and the publications that resulted from these observations. Please send an e-mail to *Library@nrao.edu* at any time to update the NRAO library staff with this information.

N. Radziwill, D. Frail, M. Bishop

NRAO Library Corner

As an author, you have probably noticed that the NRAO Library asks for Proposal Numbers on all papers using NRAO instruments. However, did you realize this is for past, present, and future authors? See: *http://69.63.217.22/N10017Staff/ OPAC/Index.asp?database=4663327* to search for author(s), instrument(s), or Proposal Number(s).

We only have a few hundred papers showing Proposal Numbers, but with your help, this will become tens of thousands.

Thank you for providing the Proposal Numbers!

Let us know what you think by sending your comments to: *Library@nrao.edu*

Marsha J. Bishop

AUI President Ethan Schreier (left), NRAO Director Fred K.Y. Lo (center), and AUI Board President H. Warren Moos (right) cut the NRAO 50th anniversary cake at an all-staff celebration on June 14. This Observatory-wide event also celebrated the completion of the ALMA Array Operations Site Technical Building (AOS TB) in Chile, a North American Executive responsibility. For this all-inclusive event, the Observatory's northern hemisphere staff in Virginia, West Virginia, New Mexico, and Arizona were joined via video-conference with our Chilean colleagues, each of whom braved the southern hemisphere, high-elevation winter to join the festivities from the AOS TB.

NRAO 50th Anniversary Symposium

A science symposium celebrating the 50th anniversary of the founding of the National Radio Astronomy Observatory by Associated Universities, Inc. and the National Science Foundation, and 75 years of radio astronomy discoveries, was held in Charlottesville, VA from June 18–21. Titled *Frontiers of Astrophysics*, this symposium commemorated major contributions to astronomy enabled by NRAO instruments, and brought together leading scientists to review recent discoveries and the key issues that will guide future radio observations.

Nearly 200 scientists from around the world heard presentations about the frontiers of astrophysics and how the challenges at those frontiers will be met. Over the symposium's four days, the scientific topics included the Cosmic Microwave Background, Dark Energy and Dark Matter, the origin of cosmic structure and galaxy evolution, extreme gravity, astroparticle physics, the Dark Ages and the Epoch of Reionization, and more.

In addition to the presentations, meeting participants enjoyed an in-depth tour of the NRAO Technology Center, where the observatory is developing and building state-of-the-art electronics for radio astronomy. Two Town Hall meetings were also held to obtain community input to the Committee on the *Future of U.S. Radio Astronomy* sponsored by AUI.

The success of this NRAO 50th anniversary symposium was made possible by the wide and active participation of our scientific community, the hard work of the Scientific and Local Organizing committees, and the numerous NRAO staff who contributed their energy and time.

Fred K.Y. Lo
Jim Condon (SOC Chair)
Laurie Clark (LOC Chair)

NRAO 50th Anniversary Symposium

From left to right: Current NRAO Director Fred K.Y. Lo, and former directors Paul Vanden Bout (1985-2002), Morton Roberts (1978-1984), and David Heeschen (1962-1978).

Each of these NRAO 50th anniversary science conference attendees participated in one or more NRAO summer student programs in their career.

2nd Annual North American ALMA Science Center Workshop

The 2nd Annual North American ALMA Science Center Workshop was held June 22-24, 2007 at the National Radio Astronomy Observatory headquarters in Charlottesville, VA, USA on the topic of *Transformational Science with ALMA: Through Disks to Stars and Planets*. Eighty participants from around the world attended, including a number of graduate students and post-docs. A wide range of excellent disk-related presentations were made, kicked off by an inspiring keynote talk by Anneila Sargent (Caltech) who discussed the importance of both "evolution" (expanding and refining what we currently know) and "revolution" (completely new techniques and ideas) to advance the field. The workshop engendered many productive and insightful discussions of the opportunities to both evolve and revolutionize the fields of protostellar, protoplanetary, and debris disks that will be afforded by the unprecedented angular resolution and sensitivity of ALMA. The workshop included a reception sponsored by the NRAO Director at the NRAO Technology Center (NTC), tours of the North American ALMA Front End Integration Center, and a workshop dinner hosted by the University of Virginia Astronomy Department.

The workshop presentations, notes from the discussions, program, and list of participants are posted at the workshop website *http://www.cv.nrao.edu/naasc/disk07/*.

For the success of this workshop we are greatly indebted to all of the NRAO headquarters and NTC staff who helped with the preparations and tours, as well as the Local and Scientific Organizing Committees.

Crystal Brogan

FURTHER INFORMATION

Visit the NRAO web site at: *http://www.nrao.edu*

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Las Condes
Santiago de Chile
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Tucson Site
Tucson, Arizona
(520) 882-8250

NRAO Results

For more information on recent scientific research with NRAO telescopes:

NRAO Press Releases: *http://www.nrao.edu/pr*
Discoveries with the GBT: *http://www.gb.nrao.edu/epo/GBT/data.html*
VLA Observation Highlights: *http://www.vla.nrao.edu/genpub/current_obs/*

NRAO Data and Products

NRAO Data Archive System: *http://e2e.nrao.edu/archive/*
VLA NVSS Survey (VLA D-array 20 cm continuum): *http://www.cv.nrao.edu/nvss/*
VLA FIRST Survey (VLA B-array 20 cm continuum): *http://www.cv.nrao.edu/first/*
Galactic Plane "A" Survey: *http://www.gb.nrao.edu/~glangsto/GPA/*
Green Bank Solar Radio Burst Spectrometer (SRBS): *http://www.nrao.edu/astrores/gbsrbs/*
Essential Radio Astronomy (web-based radio astronomy course):
http://www.cv.nrao.edu/course/astr534/ERA.shtml

Observing Information

VLA: *http://www.vla.nrao.edu/astro*
VLBA: *http://www.aoc.nrao.edu/vlba/html/vlbahome/observer.html*
GBT: *http://www.gb.nrao.edu/astronomers.shtml*
Information on proposal templates, instructions, and deadlines can be found at:
http://www.nrao.edu/administration/directors_office/

Publicizing NRAO Results

If you have a new research result obtained using an NRAO telescope that might be of interest to a wider audience, please write a 2-3 sentence description of the result and email it to one or more of the persons listed below. Your information could result in a press release, an article in this Newsletter, and/or inclusion of your image in the NRAO Image Gallery.

Press release contact: Dave Finley, Public Information Officer (*dfinley@nrao.edu*)
Newsletter contact: Mark Adams, Editor (*mtadams@nrao.edu*)
Image Gallery contact: Patricia Smiley, Information Services Coordinator (*psmiley@nrao.edu*)

NRAO Page Charge Policy

It is NRAO policy to pay a portion of the page charges for articles reporting original observations made with NRAO instruments or utilizing NRAO archival data. For more information and for details of the policy requirements, please see: *http://www.nrao.edu/library/page_charges.shtml*.

The NRAO Graphics Department will be happy to assist you in the production of images for your article as well as for your research papers. Contact Patricia Smiley (*psmiley@nrao.edu*) with your request.

If you have an interesting new research result obtained using NRAO telescopes that could be featured in the NRAO *Newsletter*, please contact Tim Bastian at *tbastian@nrao.edu*. We particularly encourage Ph.D. students to describe their thesis work.

Editor: Mark T. Adams (*mtadams@nrao.edu*); Science Editor: Tim Bastian (*tbastian@nrao.edu*); Assistant Editor: Sheila Marks; Layout and Design: Patricia Smiley

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