National Radio Astronomy Observatory

Newsletter

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The NVSS and the CMB: Evidence for a 280 Mpc Void?

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2008 Jansky Fellowship Program

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Cover: The Omega Nebula is found at the edge of a dark gas cloud in which new stars are being born. Optical (blue), infrared (green), and radio radiation (red) are emitted by the nebula. While much of the optical light is blocked by foreground dust clouds, the radio radiation streams through, allowing us to see all of the hot gas. Investigator(s): Frank Ghigo, Ron Maddalena, Glen Langston and Toney Minter (NRAO).

Fred K. Y. Lo, Director

It is October again, another new school year. When I was teaching, I used to view the beginning of a school year with mixed feelings. The unstructured summer when you can focus on research is over. And yet, I also remember feeling invigorated on seeing students back on the campus, full of energy and expectation.

For our users in the universities, there is another piece of good news to help you start the new academic year: the GBT track has now been successfully replaced by a brand new one. The preliminary results already indicate that the GBT pointing will be excellent. In the past five years, our colleagues at GB have done an outstanding job of managing the GBT track that was showing premature wear, deciphering the causes of the problem, maintaining the tracks to allow scientific observations to continue while detailed studies of how to improve the track were undertaken. With careful planning starting a year ago, our GB staff worked closely with the contractors to complete the very challenging task of replacing the GBT track on schedule and on budget. To put things in perspective, the GBT weigh 16.7 million pounds (7580 metric tons), reputedly the heaviest moving object on land. All that weight is carried via 16 wheels on the track. For more details, please consult the NRAO webpage at *www.nrao.edu*.

On the scientific side, the GBT is becoming very highly subscribed. This is of course an excellent testament to the scientific capabilities of the GBT. To continue optimizing the science impact of the GBT, the NRAO is now planning the next generation instrumentation for the GBT, including array receivers. Our users are welcome and encouraged to get involved in the planning, construction and commissioning of such instrumentation.

In preparing for this article to welcome everyone back to school, I reviewed published scientific results that depended on NRAO telescopes reported in 2007 so far. Examples include: the detection of C_8H^- on the GBT; a combined study of the mass losing envelope of S Ori with the VLT and VLBA; the identification of an intermediate mass black hole in a globular cluster of M31 from VLA observations; the surprising molten core of Mercury from measurements of a tiny variation in the planet's spin rate using the combination of Arecibo, NASA/JPL telescopes and the GBT; and the VLA detection of sporadic and periodic radio emission from two brown dwarf stars. Perhaps the most intriguing is the identification of a paucity of NRAO VLA Sky Survey (NVSS) radio sources in the direction of a region of temperature minimum in the CMB, suggesting that there is a giant (~140 Mpc) "hole in the Universe." The range of interesting results emerging from the NRAO telescopes is quite astounding.

To facilitate 10 micro-arcsecond accuracy astrometric measurements of stars, mega-masers and weak radio sources, the VLBA is undergoing upgrades by improving the λ1 cm receivers with the latest low noise amplifiers, and by new electronics to increase its recording bandwidth (1 Gbps or more by the end of 2008). The EVLA and ALMA projects are making steady progress and by 2010, early science opportunities with the two major new facilities will add even more dramatically to the scientific capabilities at the NRAO. To engage the community in preparing to harness these new capabilities, there will be an increasing number of scientific workshops organized by the NRAO in the near future.

Looking even further ahead, and to prepare for the upcoming Decadal Review, the AUI has sponsored a committee on the future of radio astronomy, chaired by Prof. Richard McCray of the University of Colorado, to consider the scientific outlook and needs of astronomy that can be answered by radio techniques. The committee deliberations will help to focus the science cases for any future facilities to be proposed to the Decadal survey. The details of the McCray committee deliberations are accessible via the web at *www.aui.edu* or *www.nrao.edu*.

Along with you, I look forward with enthusiasm to what the new academic year will bring.

SCIENCE

The NVSS and the CMB: Evidence for a 280 Mpc Void?

Thirty-three years ago, Ed Groth gave me some parting advice as I was leaving for a postdoc at NRAO, “You've measured your *Princeton zero*—now go out and do something real.” He was referring to my thesis work under David Wilkinson, an attempt to detect a diffuse ionized IGM by looking at the dispersion of short-timescale radio fluctuations. It was a null experiment, as were my attempts to make the first Sunyaev-Zeldovich detections using the 140 Foot telescope—only 1–2 orders of magnitude short in sensitivity! So I did “real work” for decades, but the “nothing” bug had bit me, along with a lingering Cosmick Microwave Background (CMB) fascination after building a radiometer for dipole component measurements as my Master’s project.

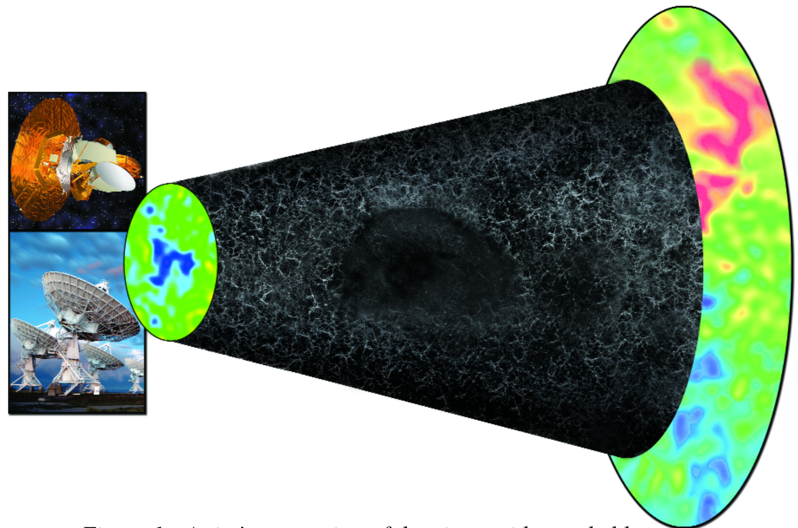

Figure 1. Artist’s conception of the giant void revealed by its effect on the CMB. Credit: Bill Saxton, NRAO/AUI/NSF.

These worlds converged this spring, largely by accident. I was frustrated one morning with trying to pull diffuse polarization signals out of the NRAO VLA Sky Survey (NVSS) (Condon et al. 1998). That project, with graduate student Shea Brown, is actually turning out to be extremely productive, with the discovery of emission in the environs of galaxy clusters, around HII regions and far beyond the known extent of radio galaxies. But that morning I decided to see what the convolved NVSS survey looked like in the direction of the CMB “cold spot” (Vielva et al. 2004), a region which appears to be too cold to be part of the normal Gaussian fluctuations from the early universe. Different exotic possibilities for explaining the cold spot as a feature of the early universe have been suggested (Jaffe et al. 2005). I found that the NVSS brightness (and later the source counts) in the cold spot region was abnormally low—so this was a special place in the NVSS survey as well. This is quite surprising, since most radio sources come from redshifts of <1, while the CMB originates at $z=1000$.

My immediate reaction was that the CMB cold spot must be due to a foreground correction problem, with the NVSS sources subtracted incorrectly. But the sign was wrong, and I was still really confused when Shea Brown walked in, looked at what I had found, and immediately pronounced it as the (late) Integrated Sachs-Wolfe (ISW) effect (Crittendon and Turok 1996). I had only a vague notion of what that was, but he and Liliya Williams, whom we recruited to do the calculations and get all the physics right, patiently explained it to me.

On scales of superclusters, gravitational collapse is linear even to the present epoch. Thus, in an $\Omega=1$ (Einstein-de Sitter) Universe model, the gravitational potential depth stays constant as the expansion of the universe counteracts the continuing collapse. If you now track a photon on its way to us from the CMB, it gains energy falling into the gravitational well, and loses the same energy on the way out, for a net change of zero. The situation changes when dark energy begins to accelerate the expansion, at redshifts of order 1. The wiggles in gravitational potential, positive and negative, are smoothed out by the acceleration, so the CMB photons undergo a bigger energy change going in than they do coming out. They thus experience a net gain in energy when they pass through a supercluster and a net loss when they pass through a void.

This ISW effect has already been detected statistically, by cross-correlating optical, radio and X-ray surveys against the microwave background (Pietrobon, Balbi & Marinucci 2006; Cabre et al. 2006; Boughn and Crittendon 2005). Further work on isolating the NVSS regions contributing most to the ISW signal was done by McEwen et al. (2007), who actually listed the cold spot in the table of strong ISW contributing regions, without noting its special significance. Their "blind" search actually provides important support for our study. Since we knew that the cold spot was interesting beforehand, and specifically looked there, we are placed in a bind when calculating the statistical significance of our results (the curse of "a posteriori" statistics). But combining the McEwen work and ours, we were able to argue that the ISW effect, and thus the role of dark energy, could now be seen to be operating on a specific region for the first time (Rudnick, Brown and Williams 2007).

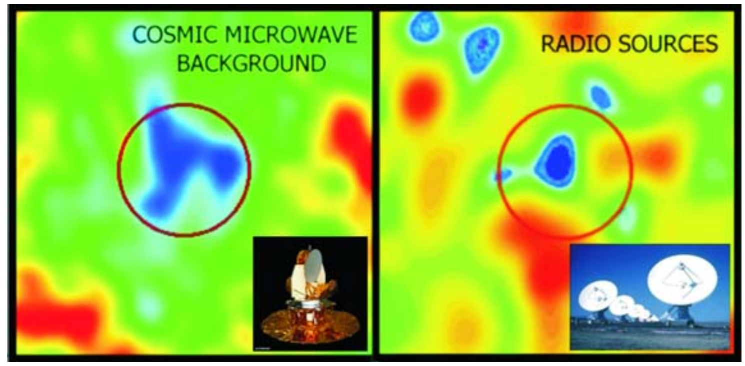

Figure 2. Left: A 25-degree region of the Cosmic Microwave Background emission around the region of the WMAP cold spot (circled). The colors represent very small variations (parts in 100,000) around the average temperature of 2.7 degrees above absolute zero, with blue colors being colder. Data are from NASA's WMAP satellite. Right: A heavily smoothed portion of the NRAO Very Large Array Sky Survey (NVSS) showing the blended emission from radio galaxies along each path. Blue colors represent brightnesses approximately 20 percent below the average.

Our calculations then yielded a self-consistent explanation, using the ISW effect, for the size and strength of the cold spot and the lack of NVSS sources, based on the existence of a void along the line of sight at a redshift ≤ 1. To calculate the minimum size void needed to create the observed ISW effect, we assumed that it was empty of all matter, including dark matter. Our derived radius for the void was 140 Mpc—seven times the radius, or over 300 times the volume, of the average void found in the 2dF Galaxy Redshift Survey (Hoyle and Vogeley, 2004). Some authors, such as Inoue and Silk (2006), have suggested that such large voids must exist, both to explain the cold spot and the related "axis of evil" (but that's another story). In any case, we're stuck with an extraordinary void that may or may not be consistent with our current understanding of structure formation—the growth of sheets, filaments, superclusters and clusters of galaxies. That will take deeper surveys and simulations of much larger volumes to sort out.

Could this whole picture be wrong? Sure. The cold spot could simply be an unusually large fluctuation in the early universe. The lack of NVSS sources could be a statistical fluke. NVSS sources might not be good tracers of the total matter density. There could be other exotic effects perturbing the CMB. So stay tuned—there are sure to be more surprises ahead!

Lawrence Rudnick
University of Minnesota

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GBT Discovery of the Largest Molecular Anion: C_8H^- toward IRC+10216 and TMC–1

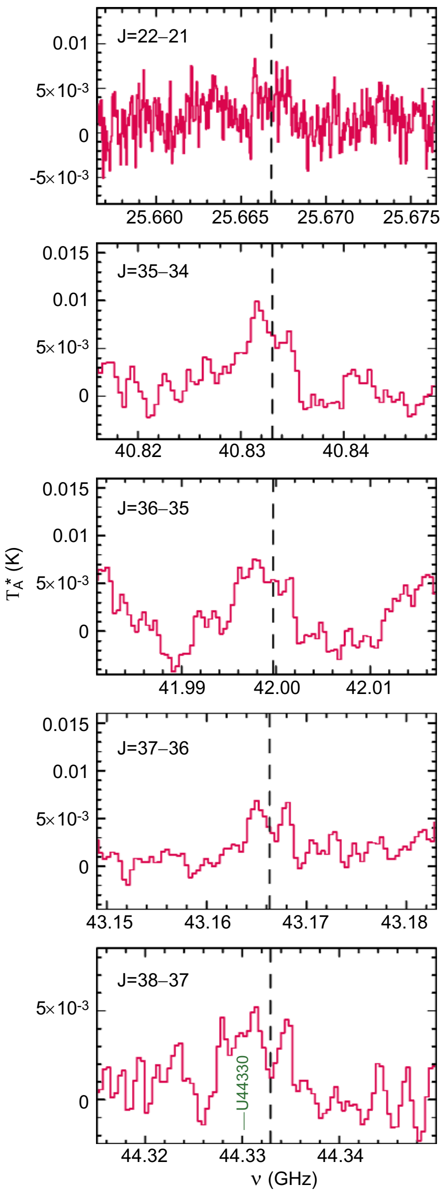

Figure 1. Octatetraynyl anion (C_8H^-) spectra toward IRC +10216.

Recently, the laboratory and subsequent astronomical detection of the hexatriynyl anion (C_6H^-) toward the circumstellar envelope (CSE) of IRC+10216 and toward the dark cloud region TMC-1 by McCarthy et al. (2006) has sparked renewed interest in the detection, distribution and formation of molecular anions in astronomical environments. Although the existence of molecular anions in space had been postulated several decades ago (Dalgarno & McCray, 1973; Herbst, 1981), this first molecular anion, C_6H^-, was only detected last year.

Using the GBT, two independent teams have now discovered the largest molecular anion ever detected in astronomical environments, the octatetraynyl anion (C_8H^-). Anthony J. Remijan of the NRAO led the team who detected the newest and largest anion toward IRC+10216 (Remijan et al. 2007) and Sandra Brünken from the Harvard-Smithsonian Center for Astrophysics led the team who detected the anion toward TMC–1 (Brünken et al. 2007). The detection of now the largest molecular anion has opened up even more formation routes to the already complex formation chemistry of large molecules in astronomical environments.

Observations of the molecular anion transitions toward IRC+10216 were conducted at K-Band on March 4–29, 2004 and April 1, 2005. The Q-Band observations occurred in March–April 2005. Figure 1 shows the detections of C_8H^- toward IRC+10216. The spectra are displayed on the same velocity scale and each was Hanning-smoothed over three channels automatically during the data processing. Transition quantum numbers are shown in each panel. The rest frequency, assuming an LSR velocity of –26.0 km s^{-1} of the displayed transition, is shown by the dashed line.

The observations toward TMC–1 took place in 2007 April. Three successive transitions of C_8H^- that lie within the 12–15.4 GHz bandwidth of the Ku-Band receiver were observed simultaneously. A fourth line at 18.7 GHz was found in GBT archival data taken between 2004 and 2006. Figure 2 shows the observed lines of C_8H^- in TMC–1 and one of the HC_9N lines for comparison (bottom). The dashed line is at an LSR velocity of 5.8 km s^{-1}, the assumed source velocity. The spectra have been smoothed to a resolution of 6.1 kHz.

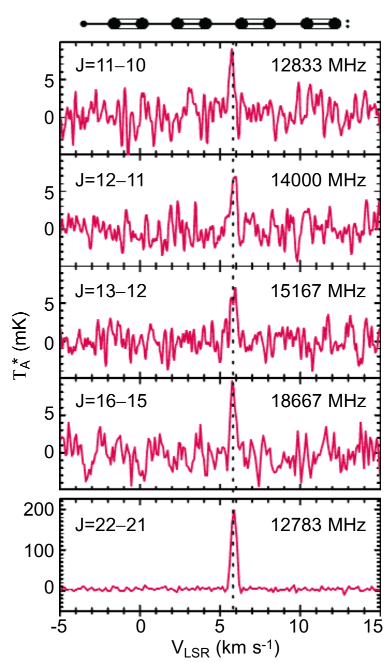

Figure 2. Octatetraynyl anion (C_8H^-) spectra toward TMC-1 and one HC_9N transition for comparison (bottom).

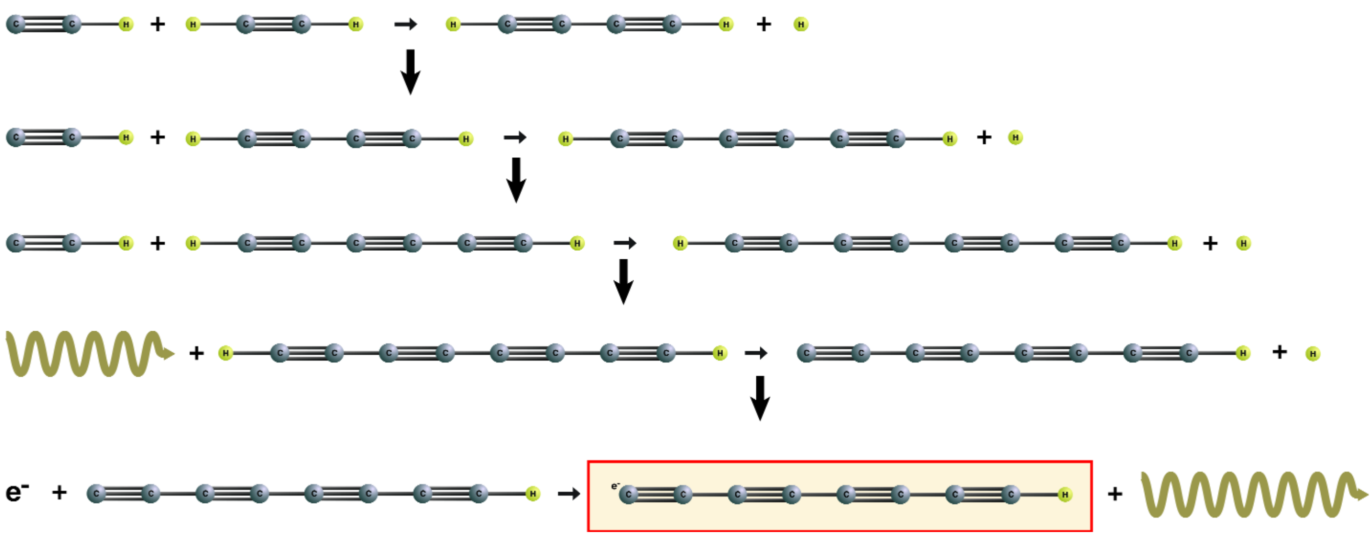

Figure 3: Illustration outlining the formation of the large C-chain molecular anion, C_8H^-. 1.) A molecule of C_2H (Ethynyl) attaches to a molecule of C_2H_2 (acetylene), producing a molecule of C_4H_2 (diacetylene) and a hydrogen atom. 2.) A molecule of C_2H attaches to a molecule of C_4H_2, producing a molecule of C_6H_2 (triacetylene) and a hydrogen atom. 3.) A molecule of C_2H attaches to a molecule of C_6H_2, producing a molecule of C_8H_2 and a hydrogen atom. 4.) Radiation (squiggly line) breaks one hydrogen atom from the C_8H_2 , leaving C_8H and a hydrogen atom. 5.) Finally, an electron attaches itself to the C_8H molecule, freeing a burst of radiation (squiggly line) and leaving the negatively-charged ion C_8H^-. The C_8H^- molecule is shown in the red box.. Credit: Bill Saxton, NRAO/AUI/NSF

Not only were these observations significant because they continue to illustrate the power of the GBT to detect new complex molecules, but they also gave new insight into the formation chemistry of large C-chains in the CSE of evolved stars and dark clouds. The current formation model of how large C-chains form, including molecular anions as large as C_8H^-, is shown in Figure 3. As illustrated, the formation of C_8H, and other large C-chains, is largely dependent on the initial C_2H_2 abundance since C-chain growth is dominated by the addition of C_2 units. Proceeding through the formation process, the high abundance of C_8H^-, as well as C_6H^-, with respect to their parent radicals suggest that in the end, the anions are formed by a simple and efficient mechanism. This likely process shown in the last panel of figure 3, is electron radiative attachment: $X + e^- \rightarrow X^- + h\nu$ which is favored by a large electron affinity of the parent neutral, and a high density of vibrational states which are available to dissipate the excess energy of formation.

This process has been used by Millar et al. 2007 to predict the column density of neutral and anions in photodissociation regions, the CSEs of evolved stars and in dark cloud regions. For specific cases extremely high anion abundances were predicted, in some cases comparable to their neutral counterparts. In the case of the C_8H^- detection toward TMC–1, the observed abundance of C_8H^- and C_6H^- was in good agreement with the formation models. However, toward IRC+10216, the model overestimates the column density by about a factor of 30 than what was observed. By lowering the initial C_2H_2 abundance in the formation model by a factor of five, the model more accurately predicts the measured column density of all detected anions and neutrals toward IRC+10 216 including C_6H, C_8H, C_6H^- and C_8H^-. Thus, the detections are able to constrain the formation models of these regions and give a better picture of the physical and chemical conditions which will lead to better predictions of more, and in some cases, more exotic, molecular species.

Finally, it is interesting to hypothesize what the detection of a new class of astronomical molecules can bring to the field of molecular astrophysics. It is quite clear that this discovery continues to add to the diversity and complexity that is already seen in the chemistry of interstellar space. However, it also adds to the number of paths available for making the complex organic molecules and other large molecular species that may be the precursors to life in the giant clouds from which stars and planets are formed. For years, ion-molecule chemistry has been the primary tool used to form large organic molecules in astronomical environments. Until recently, all the theoretical models of how chemical reactions evolve in interstellar space have ignored anions. This can no longer be the case, and this means that there are many more ways to build large organic molecules in these environments than have been previously explored. Furthermore, observations of molecular anions yields information about the ionization degree in astronomical objects.

Anthony J. Remijan

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The Distance to SS433 and W50

The measurement of distances in astronomy, be they extragalactic or within the Galaxy, is notoriously tricky. Two entirely independent methods of estimating the distance to the strikingly beautiful microquasar SS433 (Figure 1), giving two rather different answers were thus not without precedent. Since the discovery of SS433 in the late 1970s, a method to estimate its distance from us based on the light-travel time effects, due to the relativistic motion of the jet plasma that give rise to SS433's characteristic zig-zag/corkscrew appearance in the radio sky, has persistently given estimates of the distance of SS433 from Earth to be in excess of 5 kpc. Meanwhile, observations of HI seen in absorption against SS433, or against the W50 nebula in which it is embedded (Figure 2) gave a robust lower limit to the distance of 3 kpc. Blundell and Bowler (2004) used the VLA in its A-configuration to make a deep 4.85 GHz image of SS433 which revealed over two complete precession cycles in the zig-zag/corkscrew structure of this object and enabled them to determine the distance to SS433 as 5.5 ± 0.2 kpc—with the uncertainty in distance actually arising from fluctuations in the launch speed of SS433's jet plasma. With this refined distance determination, it seemed beneficial to re-

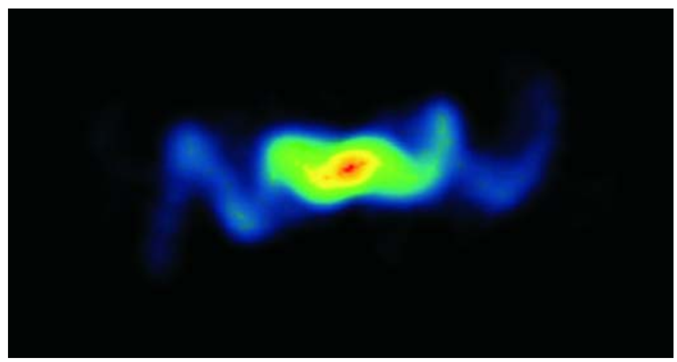

Figure 1. Total intensity image of SS433 at 4.85 GHz observed with the VLA in A configuration.

observe this system in neutral hydrogen with the newly commissioned GBT, in part to see if there was an absence of neutral hydrogen in the vicinity of SS433 (and hence whether the explanation for the lack of HI absorption observed against SS433's 21cm emission was simply because of a lack of hydrogen gas along the line of sight at the correct distance). In addition, we were motivated to search for secure evidence of HI in emission interacting with the nebula, which would give a direct distance measure, rather merely than a lower limit (which absorption observations give). A HI image over 25 square degrees around the

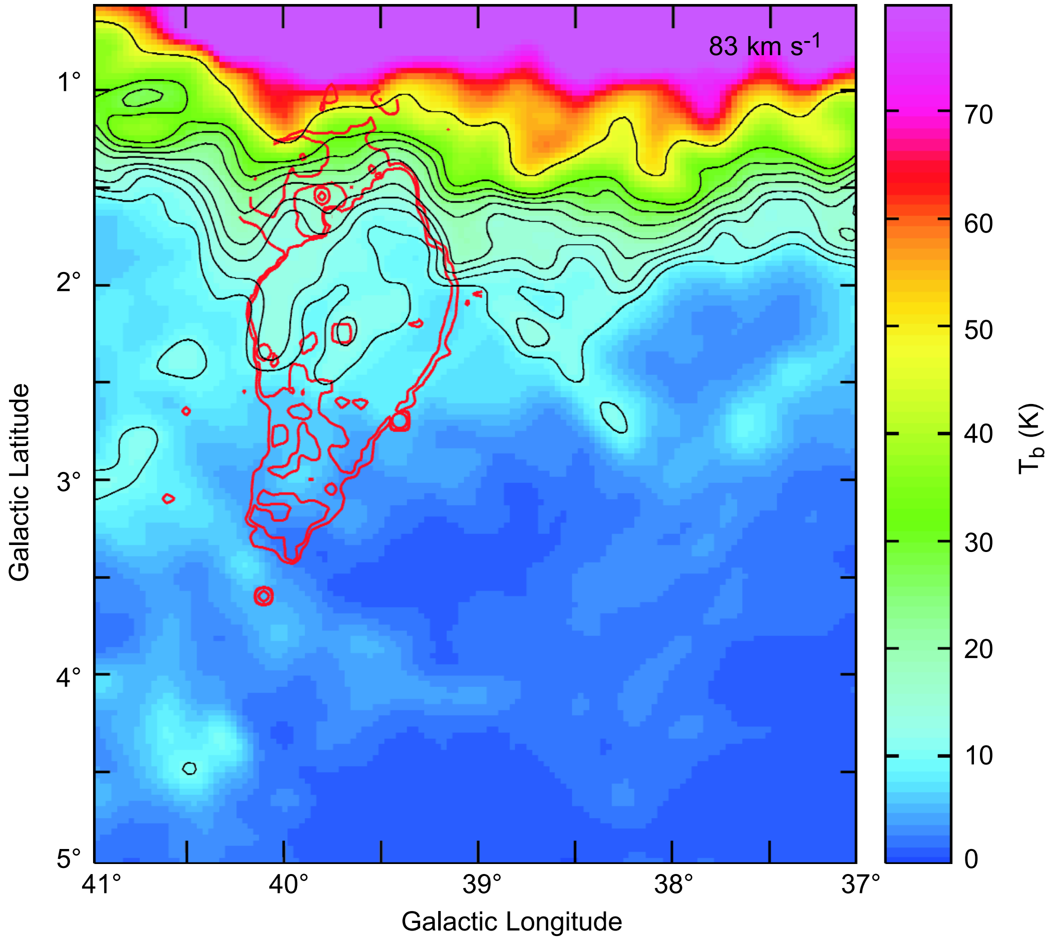

Figure 2. A GBT image of HI near 83 km s^{-1} with the radio continuum contours of the W50 remnant superimposed (red). SS433 is marked by the small contour near 39.75-2.25. There is evidence in the GBT data for interaction of the system with interstellar hydrogen at velocities appropriate for a system distance of 5.5 kpc, not nearer distances as had been claimed in some previous work.

SS433/W50 system was made with the GBT and even with integration times of only a few seconds per pixel a beautiful data cube resulted. These observations revealed evidence of many different interaction velocities of W50 with the surrounding Galactic hydrogen, all associated with velocities in the range corresponding to the higher distances of 5 kpc rather than the lower distance of 3 kpc. The clinching data in fact came from sensitive VLA spectral line observations at 21cm of SS433 itself, which revealed absorption at a velocity of 75 km s^{-1}. This, together with a model of the rotation of gas in the Galaxy, means that there is now a robust lower-limit to the distance of SS433 of 5.5 kpc and that there is no longer a discrepancy between the distances determined by these two very different methods. Indeed it could be argued that the determination of the distance of SS433 due to light-travel time effects can be used to confirm, if not calibrate, the rotation model for that part of our Galaxy. This work is described in detail by Lockman, Blundell, and Goss (2007), and will appear in the MNRAS.

K. Blundell (Oxford)and F. J. Lockman (NRAO)

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Atacama Large Millimeter/submillimeter Array

ALMA Project Progress

Figure 1. OSF Technical Facilities, showing the Warehouse (left), Antenna Assembly Building (rear left) and Technical Building (right).

Figure 2. The first ALMA production antenna at the OSF is being readied for handover to the ALMA construction project and acceptance tests.

On a normal day there are now nearly five hundred people living and working at the ALMA site in northern Chile, making it one of the largest "towns" in the area and a very busy place. Most of these people live at the 9600 foot elevation Operations Support Facility (OSF), and are housed and fed in camp facilities. Three fifths of these people work on construction of the technical building for the OSF, which is nearing completion. The first element to be finished will be the warehouse, which is needed to accommodate the influx of materials arriving at the site.

Among the new arrivals on the site are, of course, the ALMA antennas, the arrival of the first of which was reported in the previous *Newsletter*. The surface is now being installed on the first ALMA VertexRSI production antenna (Figures 2 and 3). A short video chronicling the antenna's trip to Chile was shown at the January 2007 American Astronomical Society meeting, and can be downloaded in high, medium and low resolution format from *http://www.nrao.edu/epo*.

Since the last *Newsletter*, three 12m antennas from the Mitsubishi Electric Company arrived on July 23, and the second VertexRSI antenna is poised to join the first on the site by mid-September. The third and fourth VertexRSI antennas are in various stages of construction.

By the end of the year, antenna testing will commence as part of the process of assembly, integration, and verification. The system integration science team in Chile will welcome NRAO's Joe McMullin to Santiago as lead test scientist. Dick Sramek, also of NRAO, will join Joe after extended visits to CARMA and the SMA.

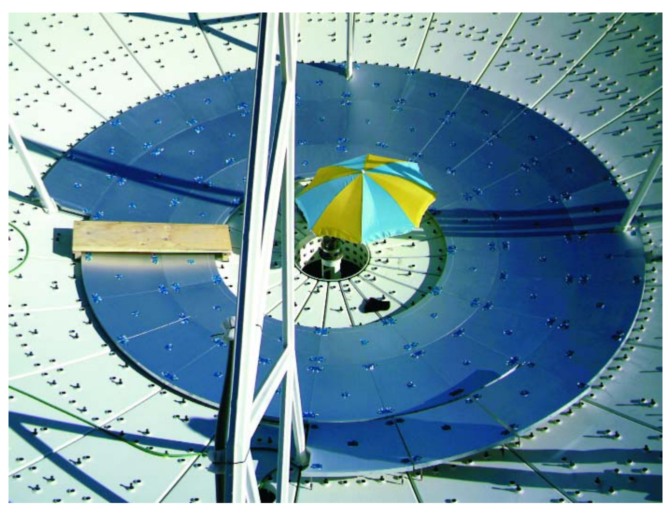

Figure 3. Tiers of panels are being assembled onto the support structure for the first VertexRSI antenna.

Figure 4. ALMA Camp element, ready for occupation.

Figure 5. The first of two ALMA antenna transporters has been completed and has passed its initial operational tests.

Other members of the test scientist team are being selected. The elements needed for the testing are being assembled at the OSF. The OSF weather station will provide data for the pointing models and will be installed shortly, as will the holography transmitter.

ALMA personnel on the OSF site live in the ALMA Camp, which was recently expanded to accommodate the three to four dozen ALMA personnel working there. Figure 4 shows an entry view to one of the elements of the camp.

The first of two ALMA antenna transporters has been completed and has passed its initial operational tests. These unique vehicles have been designed to move the precision ALMA antennas between the OSF and the Array Operations Site (AOS) at 16000 feet, and among the antenna stations at the AOS during reconfiguration of the array. These mammoth machines weigh 130 tons and sit on 28 wheels. They are designed to transport a 115 ton antenna and place it on its station with an accuracy of millimeters. The first vehicle will arrive at the OSF in late 2007; it leaves the factory in Germany in October.

At the AOS, the transporter will be housed in a hangar adjacent to the Technical Building. The hangar construction will commence shortly. In coordination with the celebration of NRAO's 50th birthday, the Technical Building at the Array Operations Site was linked to the other NRAO sites via video for a simulcast cake-cutting ceremony. The ALMA correlators will be stationed in the building early next year in preparation for integration into the ALMA system in approximately one year.

Space has been exhausted at the current Joint ALMA Observatory (JAO) offices in Santiago; nearby space has been leased as an annex. The design concept for the ALMA Santiago Central Office at Vitacura was selected. Design development and engineering has begun. An annual ALMA External Review was held in Santiago in September; eight reviewers assessed the progress of the project.

On September 1, 2007, the ALMA Test Facility in New Mexico underwent a transition in from Prototype System Integration, with an emphasis on demonstrating system connectivity and performance, to a phase in which the emphasis is on software testing under the Computing and Science IPTs. Static fringes on Mercury have been demonstrated with the new two-antenna correlator and pre-production backends using a radiometric pointing model developed by J. Mangum and D. Emerson.

The ALMA Board held the second of its 2007 meetings in Santiago. Two new members were welcomed from East Asia: Dr. P. T. P. Ho (Academia Sinica Institute of Astronomy and Astrophysics, Taiwan) and Dr. H. Kobayashi (Director of the VERA Project, Japan). The first ALMA Front End (receiver package and associated electronics) continues testing prior to shipment to Chile by the end of the year. This Front End incorporates the first four ALMA frequency bands. A first two-antenna correlator was delivered to the ATF; a second will be manufactured for shipment to the OSF.

The Proceedings of an ALMA Science Center Workshop held at the NAASC, From Z-Machines to ALMA: (Sub)Millimeter Spectroscopy of Galaxies, Volume 375 of the ASP Conference Series has been published, edited by A. J. Baker, J. Glenn, A. Harris, J. Mangum and Min S. Yun.

Mauricio Pilleux assumed the new post of Deputy Project Manager (Technical) for ALMA in North America. Chris Langley was appointed ALMA Back End IPT Lead.

Al Wootten

North American ALMA Science Center

The North American Science Center activities are ramping-up for support and training during ALMA commissioning and science verification (CSV) and early science. Two CSV-related scientific staff positions have been advertised, as well as a position for ALMA-related education and public outreach. NAASC staff are assisting and training at the ALMA Test Facility in Socorro, New Mexico.

NAASC staff have been involved with extensive ALMA software testing, including preparation for a limited Beta release of the CASA offline software system in the Fall, user documentation, as well as pipeline heuristics development. Details of the staged CASA Beta release plan can be found in the E2E article in this *Newsletter*. Crystal Brogan has taken over the duties of ALMA CASA subsystem scientist.

The ALMA North American Science Advisory committee held its annual face to face meeting in Charlottesville in August. The meeting was well attended, and a number of key issues were discussed, including: user grants and ALMA Board charges to the ASAC. Presentations were made by NAASC staff on project status and plans, as well as a practical demonstration of the CASA software. A report was submitted by the current Chair, Jonathan Williams (Hawaii) (See: *http://www.cv.nrao.edu/naasc/admin.shtml*). Andrew Baker (Rutgers) was selected as the new chair. Our sincere thanks to Jonathan for his excellent leadership of the ANASAC during these formative years, and we look forward to working with Andrew and the rest of the ANASAC on North American ALMA User-related issues.

Work continued on the Splatalogue spectral line database, including an extended visit by Frank Lovas in July 2007. The catalog now contains over 3.9 million transitions and a new database server has been purchased to support this effort. As part of the updates to Splatalogue, 229,221 new/updated molecular lines were added from Lovas' own line lists including the Spectral Line Atlas of Interstellar Molecules (SLAIM). The database has been reconciled for overlaps and a common way to display and designate each individual species was developed. In addition, Lovas/NIST recommended rest frequencies have been evaluated and assigned for 12,332 molecular lines. Finally, over 3000 frequencies from recombination lines from H, He and C were added calculated from the most recent value of the Rydberg constant. The new database and additional functionality (to be described in a future *Newsletter* article), will be made available in December 2007 at *www.splatalogue.net*.

Operations in Chile is rapidly gearing-up for support of CSV using the first ALMA production antennas. Key hires have been made in leadership areas, such as the head of science operations (Lars-Ake Nyman) and head of administration (R. Smebak). In the coming year, ALMA Chilean operations will be hiring 84 staff, including several astronomers. The Science Operations team, including the managers of the three ALMA Regional Centers (North America, European, and East Asian) held their quarterly face-to-face meeting in September in Garching to discuss global ALMA operations plans and progress, especially preparations for CSV, near-term scientific hires, and plans for user support and software testing.

If your institution is interested in having an NRAO staff member visit and discuss ALMA, please contact *ccarilli@nrao.edu*.

Chris Carilli

Expanded Very Large Array

Current Status of the EVLA Project

The EVLA project is on track to complete its primary goal for the year of retrofitting a total of 12 antennas to the EVLA design by September 30, 2007. A total of 11 EVLA antennas are used routinely for astronomical observations and account for approximately 36 percent of VLA antenna hours. The mechanical overhaul of the twelfth EVLA antenna was completed in late August.

NRAO-New Mexico Operations and the EVLA project achieved a major milestone with the retirement of the VLA Modcomp control computers on June 27, 2007. The VLA-EVLA hybrid array has been operating "Modcomp-free" ever since. The effort to complete the milestone was impressive, requiring the replacement of an entire suite of array monitor and control (M&C) software, the development of a new correlator controller that allows the EVLA M&C system to command the correlator, the development of hardware and software for a "visibility pipeline" that provides access to correlator data by the EVLA M&C system, the development of data capture and format software that forms partial archive records of visibility data, and the development of the various tools and utilities that are needed to monitor the progress of an observation, ascertain the health of the array, and diagnose problems. The implications of the Modcomp retirement for astronomical observations are described elsewhere in this *Newsletter*.

Significant progress has been made on the EVLA correlator. The final testing of the correlator chip was completed and was reviewed in a production sign-off critical design review (CDR) in early June 2007. More tests were run at the direction of the CDR committee, and the sign-off for chip production was given in late June. The chip worked the first time it was tested, although it did take considerable time to come to this conclusion because of socketing problems on the chip's ball grid array, delays in the fabrication of printed circuit boards, some test environment bugs, and the amount of time it took to perform chip testing at the appropriate level of rigor.

Software development and testing has kept pace with the hardware debugging and testing required for the correlator's baseline and station boards. Real-time algorithms and code for delay tracking, phase model generation, and integration control signaling are under development. In the near future, focus in software development will be shifting to higher-level software mapping tasks and for software to support initial on-the-sky tests.

A new connectivity scheme for the EVLA correlator was proposed in early April and was formally reviewed in Socorro on July 31. The new scheme improves the processing capability of the correlator, improves reliability by reducing the number of modules, the number of racks, and the number of high speed interconnect cables, and frees up some project contingency for the Canadian partner. The changes to existing development are minimal, with the most extensive changes being to the baseline board which are already complete.

A new schedule has been proposed to improve on correlator delivery by combining some of the pre-production stages of the correlator project plan. This new schedule negates the need for an independent "prototype correlator", and replaces it with a more significant interim capability (ten antennas) that more seamlessly merges with the final software. If this goes well, according to the schedule, this pre-production system should be in place by mid-2008 for testing.

Considerable systems integration effort was devoted to the reconfiguration of the VLA into A-array during May and June. This is the first time EVLA antennas were moved out to the ends of the array arms. The reconfiguration required the evaluation and testing of antenna operation over long fiber runs. The system seems to be performing well. The only unexpected outcome was the requirement for erbium-doped fiber amplifiers on the IF fiber from antennas closer to the array center.

Planning is well underway for the relocation of the deformatter racks and networking equipment from the old correlator room to the new correlator room. This work involves extensive re-cabling of fiber and coaxial cables in the control building and will require that all EVLA antennas be taken out of array operations for approximately four days. The work is scheduled for the last week of September.

Excellent progress continues in the production of receiver feed horns. The RF performance of the first S-Band (2-4 GHz) feed horn was shown to meet project specifications, and the procurement and full production of the horn will commence in October 2007, approximately one year ahead of schedule. A total of 23 L-Band (1-2 GHz) feed horns have been fabricated. The designs for the Ku-Band (12-18 GHz) feed horn and its mounting tower were completed.

Overall, the production of modules for EVLA local oscillator, intermediate frequency, and data transmission systems are keeping pace with the antenna retrofits. The only module that is not in full production is the round trip phase module. Its design is being modified slightly to address some problems with module component noise.

The wideband (2 GHz) signal path, including the new gain slope equalizer in the IF downconverter module was tested and shown to meet project specifications. The gain slope equalizers will be incorporated in the downconverters soon.

A vendor was selected for the digitizer chip in the EVLA 3-bit 4 Gsps sampler. The chip procurement has been submitted to the National Science Foundation for approval.

All of the 72 junction boxes for optical fiber connections on the array have now been installed. The completion of this task allows more flexibility in locating the EVLA antennas in the array after their retrofit is complete.

The design and development of the EVLA S-Band (2-4 GHz) receiver is underway in Green Bank. The design of the new S-Band orthomode transducer (OMT) was recently completed. This effort involved the scaling in frequency of the current designs for the L and C-Band (4-8 GHz) OMTs. The completion of a prototype S-Band receiver is slated for spring 2008.

Work on the Archive Access Tool has focused on coming to an agreement with ALMA on a common definition for the format of the science archive data. The definition has two parts: the raw binary data itself (the so-called “Binary Data Format”, or BDF), and the descriptive meta-data (the so-called “Science Data Model”, or SDM). A document was written describing how the ALMA and EVLA BDFs differ, and several meetings were held to discuss how they could be reconciled. Discussions are proceeding well, and agreement on the BDF should be reached by fall 2007. Additionally, a meeting was held to discuss the ALMA SDM, and how it might need to be modified to support the EVLA. A joint SDM description should be agreed upon by the end of calendar year 2007. The BDF and SDM are needed in preparation for the arrival of the prototype correlator.

The inaugural meeting of the Science Advisory Group for the EVLA (SAGE) was held in Socorro on May 22– 23, 2007. The charges to the SAGE included defining high priority observing modes and first science cases and advertising the scientific capabilities of the EVLA to the astronomical community. The committee discussed how to involve members of the scientific community in EVLA commissioning, the importance of Legacy-type programs in the early stages of the project, practices in assigning telescope time, and the need for advanced algorithm development for data post processing. Topics to be discussed at future SAGE meetings include the shape of a commissioning program for “outside” scientists, correlator resource allocation rules for parallel science programs, optimal investment in pipeline processing, and a continuing discussion of potential first-light science programs.

M. M. McKinnon and the EVLA Project Team

EVLA News for VLA Observers: Retirement of the Modcomp Computers

A crucial step in the transition from VLA to EVLA was made in late June. The Modcomp computers, which for decades had been at the core of the VLA online system, were retired and replaced with a completely new system. This was the culmination of years of development and testing. Some components, such as the new correlator controller, had been deployed at an earlier date, but until June 27, 2007 the system still largely depended on the Modcomps. During the first few weeks after the change-over the Modcomps were kept on stand-by, in case a quick return to the old system should the required. This, however, has turned out not to be necessary.

Although extensive testing had taken place prior to the change there is no substitute for an actual operational environment. Therefore, local scientific staff were involved in scrutinizing all projects observed during the first five weeks of operation. A number of problems were found, and were fixed quickly thanks to continuing efforts of our computing and engineering staff.

The most significant problem found was an erroneous calculation of the u, v, and w coordinates, causing defects in the resulting images. Although the AIPS task UVFIX can fully correct for these faulty coordinates in the post-processing stage, the archival data have also been corrected to maintain the integrity of the VLA archive. Therefore, data taken with the new system (i.e., after June 27, 2007) and downloaded after August 10, 2007 do not require a coordinate recalculation during post-processing. All PIs affected by this problem have been notified by e-mail.

All "standard" observing modes, including pointing, fast switching, and mosaicing, are supported in the new online system. A small number of capabilities offered by the old system are not yet fully commissioned, and at the time of writing phased VLA and single-dish VLBI, planetary observing, multiple subarrays, and solar observations are not yet supported. Work in these areas is actively ongoing. For the current status, please refer to the EVLA returns web page at *http://www.vla.nrao.edu/astro/guides/evlareturn*.

Doppler tracking is now available for experiments using EVLA-only antennas (e.g., those using the expanded tuning ranges now available at C and K Bands). We still do not recommend Doppler tracking for the vast majority of projects that use VLA-EVLA baselines, since the Fluke synthesizers on the VLA introduce phase jumps with even the slightest frequency changes due to Doppler tracking. We expect this restriction to remain in effect as long as there are VLA antennas in the array.

G. van Moorsel and C. Chandler

Socorro

VLA Configuration Schedule

Configuration	Starting Date	Ending Date	Proposal Deadline
BnA	21 Sep 2007	15 Oct 2007	1 Jun 2007
B	19 Oct 2007	04 Feb 2008	1 Jun 2007
CnB	15 Feb 2008	03 Mar 2008	1 Oct 2007
C	07 Mar 2008	27 May 2008	1 Oct 2007
DnC	06 Jun 2008	23 Jun 2008	1 Feb 2008
D	27 Jun 2008	15 Sep 2008	1 Feb 2008

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 2cm and shorter wavelengths (tropospheric phase variations, especially in summer). In 2008, the D configuration daytime will involve RAs between 06^h and 11^h. Proposers and observers should be mindful of the impact of EVLA construction, as described at *http://www.vla.nrao.edu/astro/guides/news/*.

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/*. Observers should consult the "EVLA returns" page at *http://www.vla.nrao.edu/astro/guides/evlareturn/* for instructions on how to include EVLA antennas successfully.

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 email 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 ten-element VLBA must justify, quantitatively, 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.ubordeaux1.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. Proposers may access NorthStar at *http://proposal.jive.nl*.

Global cm VLBI scheduling occurs only on fixed dates.

J.M. Wrobel and B.G. Clark
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VLBA Sensitivity Upgrade Project

Software Correlator

This is the second in a series of articles focusing on individual development areas of the VLBA Sensitivity Upgrade Project. The July 2007 *Newsletter* detailed the new Digital Backend (DBE) which will increase the maximum data rate by a factor of eight or more. The new data recorder (Mark 5C) will be explored in a future article. In this article a software correlator, intended as a replacement for the VLBA correlator, will be discussed. Brief updates on other project areas are given at the end.

The current VLBA hardware correlator is capable of correlating 256 Mbps on up to 20 antennas in real-time. A special mode that was never implemented could have also allowed simultaneous correlation of 512 Mbps on up to ten antennas. Clearly this correlator is incapable of correlating the 4 Gbps that the sensitivity upgrade will provide. Historically the design and construction of a new correlator has been a significant effort, occupying many engineers for several years. Such an effort cannot be afforded for this upgrade project, especially if a working system is desired within a modest number of months, not years. Fortunately, traditional VLBI correlators, and their design practices, are likely things of the past.

Over the past few years several software correlator projects have reached maturity. Of particular interest is the DiFX correlator written at Swinburne University of Technology by graduate student Adam Deller. This software has a number of features that make it practical as an augmentation to, and possible replacement for, the VLBA correlator:

1. Runs on a cluster of commodity workstations running Linux;
2. It can correlate VLBA formatted data among other common VLBI formats;
3. It implements the FX algorithm which is much more efficient than XF architecture software correlators, especially for multi-element arrays and when producing a large number of spectral channels; and
4. It is freely available for use subject to some conditions.

In general, software correlators offer several advantages over hardware correlators. They can be relatively easily programmed to handle a wide variety of data formats. Fundamental parameters of the correlator such as maximum number of antenna inputs and maximum number of spectral channels are not fixed. Special processing modes, such as pulsar binning, can be implemented without special hardware. Even without a bandwidth expansion the software correlator would significantly improve capabilities when wide fields of view or high spectral resolution are required.

How many computers are needed for this? Is this effort affordable? In order to correlate 4 Gbps data rate (1 GHz bandwidth Nyquist sampled with 2-bit quantization) on ten stations in real-time, an estimated 4.3 TeraFLOPS of compute power is required (see VLBA Sensitivity Upgrade Memo #16). This is equivalent to about 500 of the fastest Intel CPUs available today. Full compute capacity will not be required until we have enough media for a 30 day turn-around period at 4 Gbps. The computer cluster will grow in time with the media pool as funding permits. Overall the computing infrastructure cost will be a fraction (about one quarter) of the media cost, and both continue to get cheaper with time.

A project to assess DiFX began at NRAO in early March. Integration of DiFX into VLBA operations is currently ongoing. To simplify the initial transition to DiFX, software is being developed to make DiFX behave like the VLBA correlator. A program that converts job scripts allows DiFX to be controlled. A second program converts the output of DiFX into standard FITS-IDI format. Additional software will be needed for resource management. The core of DiFX has been augmented with code that allows it to read data directly off Mark 5 units.

Instead of immediately buying a stand-alone computer cluster for DiFX, the motherboards and CPUs of the Mark 5 playback units attached to the hardware correlator are being upgraded to become an evaluation cluster. The Mark 5 compute resources can be used even when the hardware correlator is in operation, although the two correlators require independent sets of Mark 5 units for data playback. It is expected that the upgraded Mark 5 units will allow for correlation at 128 Mbps bandwidth on ten stations in real-time—already a significant fraction of the old correlator's capability. There is still a lot of work to be done to support all observing modes but we expect that the future of the VLBA will include software correlation.

In other areas of the VLBA Sensitivity Upgrade project, development continues on the iBOB-2 board upon which the VLBA Digital Backend will be based, as described in Issue 112. Functional iBOB-2 prototypes are anticipated by the end of the year. Development of the new Mark 5C recording system draws on the extensive experience of Haystack Observatory and Conduant Corporation in disc-based recording. Primary goals include sustainable data transmission at 4 Gbps, a 10 Gigabit Ethernet interface from the DBE, and direct access to the recorded data from a software correlator, via the playback unit's bus. Draft Mark 5C specifications are given in VLBA Sensitivity Upgrade Memos #12 and #13. These, and Memo #16 on software correlation, are available at the memo series index page, *http://www.vlba.nrao.edu/memos/sensi*.

W. Brisken, J. Romney

Upgraded Receivers at 22 GHz on the VLBA

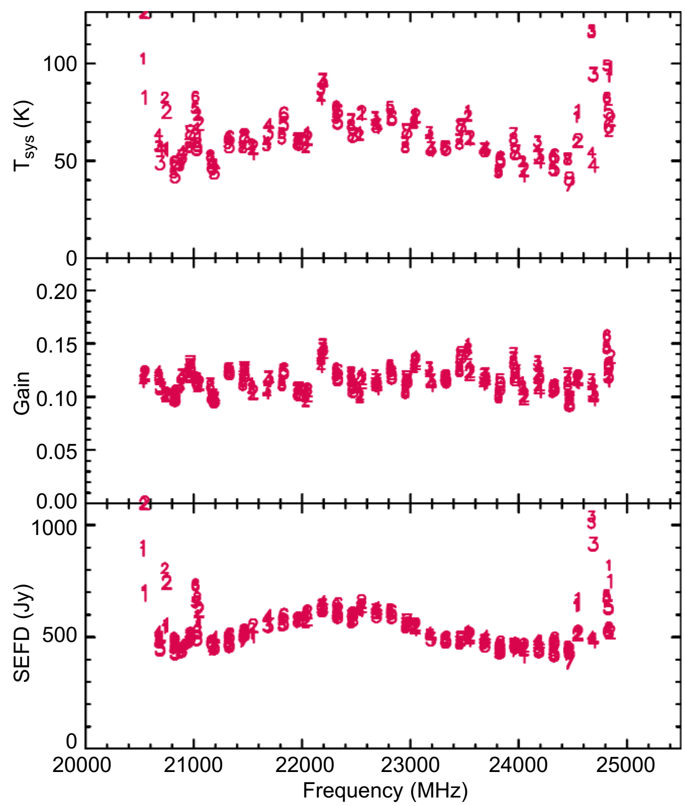


Figure 1. Tsys, Gain, and SEFD for Pie Town at 1 cm.

The installation of upgraded receivers at 22 GHz on the VLBA, as described in the April 2007 *Newsletter*, is proceeding at a good pace. Typical increases in sensitivity are 30 percent or more, but a full understanding of the improvements will have to await better observing conditions next winter. As of August 2007, six receivers have been installed and are already benefiting 22 GHz observations. The project should be complete by late January 2008.

Testing of the upgraded antennas has made it clear that there is a significant benefit for continuum projects in shifting to a frequency near 24 GHz. With the old receivers, the atmospheric water line at 22.2 GHz was not especially obvious in measurements of the performance over a wide range of frequencies. The new receivers have better and cleaner performance over the full range of frequencies allowed by other parts of the system such as the polarizers. The water line is now obvious and it is clear that the system temperature is about 20 percent better near 24 GHz than at the current standard observing frequency of 22.2 GHz, at least at the time of the measurements in June. The gains are essentially the same at both frequencies. As an example, the system temperature, gain, and SEFD (Tsys/gain) measured at Pie Town are shown as a function of frequency in Figure 1.

The higher scatter in the Tsys and gain plots than in SEFD (Figure 1) indicates that there are issues with the cal temperature measurements, something that will be addressed later. The cal temperature divides out in the SEFD.

There is a radio astronomy frequency allocation between 23.6 and 24.0 GHz, so a new standard observing frequency will be established centered at 23.8 GHz. This band will be added to the standard bands available in SCHED and to the frequencies at which regular gain measurements are made. Also the polarization properties will be tested to make sure they are not significantly worse than at 22.2 GHz.

Craig Walker

Saint Croix Downtime

The Saint Croix VLBA antenna will be unavailable between September 10 and approximately December 10, while it undergoes major maintenance for rust and corrosion control.

Claire Chandler

End to End Operations

Beta Release for Common Astronomy Software Applications (CASA)

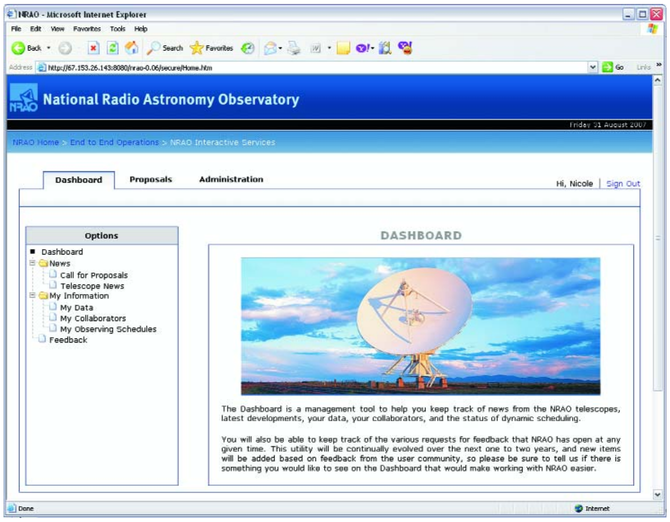
This October, there will be a staged release of the Common Astronomy Software Applications (CASA) data reduction package under development for ALMA and EVLA. A staged release will allow the operations staff of ALMA and the EVLA to gain experience and training in providing high quality, responsive user support, while ensuring that CASA development staff can continue to make progress to complete the suite of basic functionality and pursue advanced algorithm development. In October, training sessions will be conducted in Socorro and Japan for the project staff members that will become trainers or provide user support. In November and December, a subset of NRAO's science advisory committees will begin to provide a wider community assessment of the package, and strategic guidance to direct upcoming activities, to ensure that the package meets expectations.

The date for the first full public release of CASA has not yet been determined, but we anticipate that this will occur in late 2008 or early 2009. In the meantime, there will be regular updates to the beta release. At these times, NRAO will assess the satisfaction of the users with the support process, and reassess organizational capacity to provide additional user support, so that the support can be gradually extended to a larger user base.

C. Brogan, E. Fomalont, J. McMullin, S. Myers, N. Radziwill, and M. Rupen

Introducing NRAO Interactive Services

In mid-September, NRAO unveiled its new Interactive Services Portal at *http://my.nrao.edu*. This provides a single web location for astronomers and other scientists in the field to find all of the information and services they need to work with NRAO facilities. This portal will be a resource for science operations for the VLA, VLBA, EVLA, GBT, and the North American ALMA Science Center (NAASC), and will be continually grown and expanded based on feedback from the user community. Initially, NRAO Interactive Services will contain resources for proposal preparation and adminis-



tering your user profile. This fall, additional resources will be integrated for archive access and visitor services.

N. Radziwill, J. Hibbard, C. Chandler, and R. Maddalena

An Enhanced NRAO Archive

In October, several new improvements will be evident at the NRAO archive, which can be accessed from *http://archive.nrao.edu*. First and foremost, over 50,000 images representing over 9,000 sky positions have been generated using the VLA pipeline. This pipeline has been developed and refined by NRAO scientist Lorant Sjouwerman, with support from Jared Crossley who has been systematically running the pipeline on the VLA archive for the past year. In addition to being accessible as a Virtual Observatory (VO) collection, the thumbnail images will be available using the NRAO archive search. The new products are complemented by a simple, Google-like search interface and an updated advanced search, with results that have been interlinked for easier browsing and data file retrieval. Additional improvements will be continually made over the upcoming year.

N. Radziwill and J. Benson

Green Bank

Green Bank Telescope Azimuth Track Project

After four months of intense and demanding work, the GBT Azimuth Track Replacement Project was completed at the end of August. This represents the conclusion of a major stage of GBT development. We are now looking forward to many years of reliable and precision performance from the track after this extensive refurbishment.

As regular readers of the *Newsletter* will know, premature deterioration of the track components was first found during the early commissioning phase of the telescope. The basic cause of the deterioration was the high wheel load—over one million pounds per wheel of dead load; the highest loading of any wheel on rail application known. After many months of investigation, modeling and failure analysis, the best course determined to correct the deterioration was a complete redesign and replacement of every component between the concrete foundation and the wheels. Both the general approach and specific details were thoroughly reviewed by an independent expert panel. The goal of the replacement was to restore the 20 year service life of the components.

The replacement entailed the following:

- New, higher strength base plates, made from bridge steel. Each base plate was welded to the next, and also to the splice plates below each joint.
- New, tougher wear plates. These plates have higher impact and fatigue strengths, and are over 50 percent thicker than the old plates. The wear plates overlap the joints of the base plates below them. The wear plates are also as wide as the base plates

beneath them, and have a v-shaped joint instead of the 45 degree mitered joint used previously.

- A layer of bronze/Teflon/molybdenum is now sandwiched between the wear plates and the base plates to prevent the chance of fretting wear.

- The plates are held together by studs that go all the way through both the wear plates and base plates. These replace the bolts that previously threaded only a short distance into the base plates. The studs are also located further away from the wheel path to reduce fatigue stresses on them. The design of these studs allowed them to be tensioned by stretching them with hydraulic tensioners, rather than the less reliable method of torqueing.

- The cement grout that filled the void between the base plates and the top of the concrete has been replaced by a high strength, two part epoxy grout. The old grout was packed into the void by hand, whereas the new grout was poured in and allowed to completely fill the void.

Preparation of the materials began more than a year ago, with raw steel fabrication processed through two different steel mills, one in Pennsylvania and one in Ohio. The raw material was sent to machining and fabrication shops in Georgia and Alabama, where the base plates and wear plates were machined to strict tolerances by Continental Field Systems, Inc. (CFS) and Gadsden Tool, respectively. FEMCO Machine Co. in Pennsylvania was awarded a contract to manufacture the two inch diameter steel studs to NRAO specifications, and General Dynamics-SATCOM Technologies was awarded the demolition and installation contract. Despite concerns over the aggressive schedule for getting a place in line with the steel mills, all components were delivered on site as planned, one month ahead of the start of the outage.

The actual field work commenced on April 30, 2007. Interestingly enough, all of this work was done with the telescope still resting on the track, so work was done in the octants between the wheel sets. Once the first four octants were complete, special transition

NRAO's John Shelton checks track level with General Dynamics employees. John spent many weeks on night shift.

plates were installed so that the telescope could be rotated 45 degrees into position over the new sections. All the work was completed in four months, to specification, and on budget. The work took rather longer than the originally estimated schedule, but was still completed within the time we had allowed for a potential over-run.

Since the base plates in this design are fully welded around the perimeter of the track, and in order to minimize this welding in the field, the base plate sections were welded together in pairs at the shops of CFS in Savannah, GA. Each double plate when welded

Other NRAO employees who have been deeply involved throughout the project are (left to right) Dennis Egan, Bob Anderson, Harry Morton, Art Symmes and Jeff Cromer (not pictured).

together weighs 23,000 pounds. During the original trials of this welding process, it was found that the end of each plate would rise, or gullwing, about 1-1/8" due to shrinkage of the weld metal as it solidified and cooled—the actual weld is only applied on the top three inches of the nine inch thick plate. In order to compensate for this effect, the two plates were raised at the weld joint by 1-1/8"; the resulting process flattens the plates to the tolerance required. This process was continued in the field and proved to be very efficient. However the final tolerances required of the track in the field demanded exacting surveying processes to set these weldments and align the pieces. This required the use of two laser trackers and optical levels, many times all at the same time. The entire track was leveled to within ± 0.005".

The last sections of track being formed for grouting on August 30.

The final four welds were a difficult proposition, however, as they could not be raised as the others due to the final installation process. Since these joints were welded flat, buckling of the material resulted, with hills and valleys as much as 0.066 inches from flat. In order to provide the specified 0.005 inch flatness, CFS supplied a "portable" milling head machine and milled the plates to within ± 0.005 inch of level. This required many long nights of level surveying on the part of Green Bank staff so that thermal factors could be eliminated from the data and approximately 200 hours of machining on the base plates.

Although the telescope was largely stationary in azimuth throughout the course of the project, it has by no means been sitting idle. Rather, as described in the previous Newsletter, we have used the time to perform an extensive 350 MHz pulsar drift scan survey. By the end of the refurbishment work, this program received ~1400 hours of observing time, and collected ~140 TB of data, all of which is archived. This is a fantastic scientific resource. In addition, we were able to perform educational observing projects for both the NRAO/NAIC Single Dish Summer School and the West Virginia Governor's School for Math and Sciences, a two week residential program for 8th graders.

At the time of writing this article, we are mid-way through the recommissioning of the antenna. Results to date look extremely promising, and we expect this work to be essentially complete by the time the *Newsletter* is published. The latest performance is available from the "News" link off the main Green Bank web page *http://www.gb.nrao.edu/*.

Throughout this project, many members of the Green Bank staff provided many long and industrious hours on the job alongside the contractors' workers. Employees from the Green Bank Machine Shop and the Telescope Operations Division provided the labor to cut, grind, and modify the existing splice plates for reuse and modified the track wipers and ground brush fixtures to fit the new track. They also moved components from storage to preparation areas, provided electrical service for the contractors, assisted with many aspects of the civil engineering work, and moved the telescope as needed. The senior team members supplied oversight for quality assurance purposes and coordination among the contractors. We had planned throughout the design of the project for Observatory personnel to play a crucial role during construction, and their dedication and commitment to the project was outstanding. We also appreciate the patience of the observers waiting for the results. The end result is a truly spectacular product, worthy of one of the finest radio telescopes on the planet.

B. Anderson, M. Holstine, and R. Prestage

Ka-Band Receiver and the Zpectrometer

The combination of the GBT 26-40 GHz Receiver and the University of Maryland's Zpectrometer, a spectrometer to cover the entire Ka-Band at modest resolution, showed limited results when installed on the GBT in October 2006. Demonstration observations of strong sources were achieved but systematic instrumental effects precluded deep spectral integrations. These effects not only preclude observations with the Zpectrometer but also affect observations with the GBT Spectrometer.

Work with the Zpectrometer resumed at the end of the high-frequency observing season with a series of laboratory experiments with the Ka-Band receiver. The experiments demonstrated that asymmetries in the receiver's input circuit were the principal causes of receiver imbalance that caused non-ideal spectral structure and degraded sky noise rejection, and that the remainder of the receiver was fundamentally very stable. With the receiver warm and the cryostat open the circuitry before the first hybrid was disassembled part by part. The loss differential was measured as each component down to and including the first hybrid was removed from the circuit or exchanged with its matching piece in the other beam with the goal of determining the cause of the loss differential. With over half a dozen components each contributing to the differential many effects were discovered including a contribution of the dewar and radiation shield to the differential. The greatest contribution was from the polarizers and ortho-mode transducers (OMTs) that separate the two circular polarizations out of each beam.

The asymmetry of the receiver circuitry before the first hybrid is unavoidable due to the physical geometry of the OMTs, the pseudo-correlation architecture, and the desire to keep losses to a minimum before the low noise amplifiers. Something had to give and it was decided to forgo the second polarization from each beam and to forgo circular polarization entirely. This allowed building a simpler and symmetrical circuit that takes two orthogonal, linear polarizations and combines them in the first hybrid which, it should be noted, is before the low noise amplifiers. The 50K radiation shield was lined with RF absorber in an effort to reduce the impact of moding of the cryostat cavity on the baseline stability. Mechanically the receiver will have the same feed location and beam spacing as before. This was achieved by in-house fabrication of specific radius, 90 degree E-plane waveguide bends. In addition to receiver work, the monitor and control points in the Zpectrometer's power supply have been added to the instrument's system monitoring, and the calibration signal levels have been optimized for the new receiver configuration.

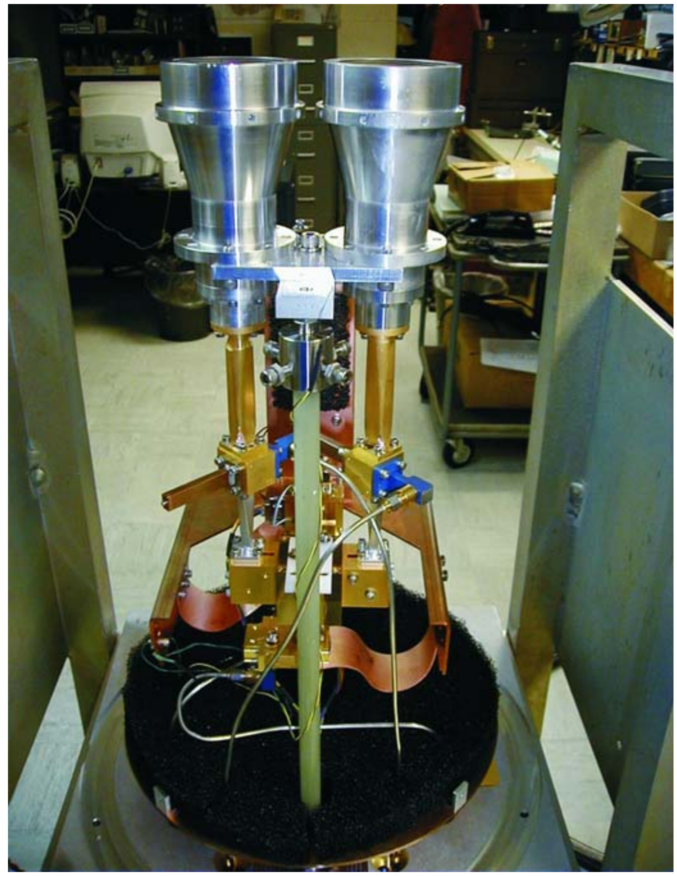


Figure 1. View inside the dewar of the modified Ka-Band receiver.

The testing in May and June culminated in a full prototype assembled from surplus components. The cryostat was open and warm, the beam spacing was wider than what would normally be used on the GBT and the polarizations were parallel but as a proof of concept the results were quite promising. In early August the proposed modifications were complete (Figure 1) and tests with the receiver in a symmetrical, dual beam, single-channel configuration and with absorber in the cryostat showed a substantial increase in stability. Allan variance measurements show white noise longer than 50 seconds most but not all of the time (compared with 3–5 seconds of stability found previously), as well as considerably smaller systematic spectral structure. The decrease in baseline structure indicates an improvement in common-mode signal rejection that should provide better rejection of sky brightness temperature fluctuations, possibly allowing observations in worse weather than before. On-sky tests of the new configuration are scheduled for Fall 2007.

The Cal Tech Continuum Backend (CCB) had previously shown excellent on-sky and in-lab noise performance in spite of the imperfect symmetry of the inputs. Noise levels for most channels are within 30 percent of those predicted by the radiometer equation, and continue to integrate down for many minutes. The improved balance may reduce the sensitivity of the CCB data to imperfect photometric conditions. The loss of one polarization results in only half the CCB channels being usable, which will reduce the sensitivity by somewhat less than the ideal $\sqrt{2}$—probably about 20 percent, though a precise determination on the sky has yet to be established.

The new configuration of the Ka-Band receiver should result in improved baseline structure and reduced system temperatures that will benefit GBT Spectrometer observers. Since the new configuration only has a single polarization per beam, this will result in longer integration times to obtain similar theoretical sensitivities to a dual polarization, dual beam system, but it will hopefully not be a full factor of two longer. The full implications of the modified Ka-Band receiver for GBT Spectrometer observing will not be known until on-sky tests are completed this October. We are currently working to implement nodding of the subreflector within Astrid. This will allow for more rapid switching than is possible with standard nodding, and should reduce overheads. Observers should note that this is still an experimental observing mode. It will not be released for general use until after commissioning tests have been conducted and it will initially only be available for Ka-Band observing.

More detailed information regarding this project is available in GBT Memos 245, 246, 248, 249 and Electronics Division Internal Report 318.

B. Mason, D. J. Pisano, K. O'Neil, G. Watts, and A. Harris

Dynamic Scheduling Update

The plans for testing the new Dynamic Scheduling System (DSS) for the GBT in the Fall of 2007 have been delayed due to the need for the majority of the DSS team members to work on preparations for the high frequency season. This delay has allowed for further refinement of the DSS plans. In particular, the team has been working on determining how much advance notification observers will be able to receive under the DSS. The results are extremely encouraging, and a memo describing the advance notification possibilities will be released before this Newsletter hits the press. Full details of the plans for Dynamic Scheduling, as well as all memos relating to the DSS, can be found at *http://www.gb.nrao.edu/DSS*.

Karen O'Neil

GBT Proposal Pressure for 2007–2008

The GBT is experiencing a tremendous growth in capabilities as we open up higher frequencies, add new instruments and start to schedule large, key science projects. This is evidenced in the call for new GBT proposals for the 07C observing trimester (October 2007–January 2008) which yielded a high demand (more than 3400 hours in 92 proposals) for what turned out to be a relatively small amount of available time. The vast majority of the requested time requires good weather, and nearly one-third of the proposals requested use of more than one receiver.

The available time in trimester 07C was affected by several factors: a large backlog of experiments, mainly at frequencies >18 GHz (especially Ka-Band), which could not be scheduled previously; the need to allocate time for commissioning of new instruments, in particular the MUSTANG bolometer array and the

Zpectrometer; and finally, the allocation of telescope time for the six "large proposals" accepted from last year's call. The overall over-subscription factor for good-weather proposals (generally those desiring frequencies >8 GHz) in 07C was greater than 6 (for Ka-Band alone it was about 14). Galactic Center time was also in high demand at all frequencies. The LST range 17–22 hours was oversubscribed by a factor of nearly four.

Looking ahead to 2008 and beyond, it is likely that pressure for observing time on the GBT will remain high. During trimester 08A, large proposals will take a somewhat larger fraction of the time and reduction of the backlog a somewhat smaller fraction than in the upcoming trimester. However, as both the large proposals and the backlog are dominated by high-frequency projects, trimester 08A promises to be as competitive for new high frequency proposals as 07C has been.

We absolutely encourage submission of proposals for high-quality research and we will do our best to get them on the GBT. It is important to recognize however that certain resources, like night-time, inner-Galaxy LSTs, or the best weather, are in high demand but limited supply. If any or all parts of a project can be done in arbitrary weather conditions it is important to clearly indicate that fact in the proposal so that we can better match the available resources to the astronomical demand. Also, there is a somewhat reduced level of competition for right ascensions outside of the inner-Galaxy range, so a judicious choice of targets may improve the odds of a proposal being scheduled.

We continue to work on ways to make most efficient use of the best weather conditions through improved dynamic scheduling, and to improve telescope performance so that the need for night-only observations is reduced. We are also working on enhancing tools to allow our users to better judge the resources (integration time, weather conditions) necessary for a successful experiment.

D. Frail, C. Bignell, F. J. Lockman, and R.M. Prestage

Education and Public Outreach

Sister Cities: An Exchange Across Hemispheres

A Sister Cities program was initiated by the NRAO and AUI in 2006, creating a mutually beneficial educational and cultural exchange between the communities of Magdalena, New Mexico in the United States, and San Pedro de Atacama, Region II, in Chile. Both communities responded enthusiastically to this AUI/NRAO initiative, and the Sister Cities program has brought the teachers and students of these communities together for new learning opportunities in culture, language, and science.

What does a rural village in New Mexico (population 900, elevation 6500 feet) have in common with a rural village in northern Chile (population 3000, elevation 7000 feet)? Both are home to world-class radio astronomy observatories: the NRAO Very Large Array and the Atacama Large Millimeter/submillimeter Array (ALMA), respectively.

In September 2006, Magdalena Mayor James Wolfe and the town's Village Council officially proclaimed San Pedro de Atacama as their Sister City. In December 2006, San Pedro Alcaldesa Sandra Berna proclaimed the same of Magdalena in a ceremony that included the U.S. Ambassador to Chile.

Myriam Rivera, director of Liceo Likan Antai (San Pedro high school), tourism teacher Gabriela Rodriguez, and Alcaldesa Berna visited the Magdalena community and schools for two weeks in late January and early

Sandra Berna and Jim Sauer with a fourth grade class in Toconao, a village south of San Pedro. The students wear uniforms to school; the two students in costume performed a traditional dance.

February 2007. The Chilean teachers and San Pedro Alcaldesa visited classrooms and participated in educational programs at the Magdalena elementary, middle and high schools; joined school field trips and community events; presented a program describing life in San Pedro; and discussed employing the Internet for periodic educational and cultural programs.

In July 2007, two Magdalena teachers traveled south across the equator to Chile. Magdalena 5th grade teacher Jim Sauer and 2nd grade teacher Sandra Montoya visited San Pedro for two weeks in July 2007 accompanied by Socorro-based NRAO Education Officer Robyn Harrison. While in Chile, the teachers and Robyn attended classrooms in both San Pedro (Escuelas Básicas and Liceo Likan Antai) and the rural elementary school in Toconao. They collaborated with teachers and administration at each site, comparing education strategies and obstacles to instruction. They also worked with the students from Liceo tourism program and in the English classes. The tourism students practiced their skills as tour guides to some of the local natural and archaeological sites.

Having established close ties between these communities via this AUI/NRAO-sponsored Sister Cities program, we will continue to sponsor and conduct periodic educational and cultural exchange programs via teleconference, video-conference, and the Internet. A student exchange has also been proposed. This program would send two students to San Pedro and Magdalena for a semester each school year beginning in the northern hemisphere fall in 2008. The students for this program would be chosen through an application process supervised by both school and community personnel, with host families solicited and approved by each school. English-language training is also a critical community need in San Pedro de Atacama. Hence, an English Institute has been proposed that would provide language instruction for two months during the southern hemisphere summer to students, parents, and tourism industry workers in San Pedro.

M. Adams, S. Cabezon, E. Hardy, and R. Harrison

The 2007 Ruta Inka Students Explore the Night Sky of San Pedro de Atacama

The Ruta Inka was initiated in 2000 as a cultural program under the guardianship of Machu Picchu and other towns of the Sacred Valley of the Inkas. Sponsored by the National Assembly of University Presidents within the framework of the International Decade of Indigenous People, the Ruta Inka program's objective is to promote knowledge and awareness of the Inka road network and the pre-Hispanic cultures developed in the ancient Tawantinsuyo. Ruta Inka participants rediscover the geographical, historical, archaeological, anthropological and cultural dimensions of the Inka civilization, tracing the Inka legacy in Peru, Bolivia, and Chile. The 2007 Ruta Inka involved 150 university students from Latin America, the USA and Europe.

The municipality of San Pedro de Atacama, in collaboration with the European Southern Observatory (ESO) and Associated Universities Inc. (AUI) / National Radio Astronomy Observatory (NRAO), invited the 2007 Ruta Inka participants to a special celebration of the zone's extraordinary nighttime skies. This celebration took place at Parque Juvenil Likan Antai in San Pedro de Atacama on July 3, and was led by astronomy

2007 Ruta Inka involved 150 university students from Latin America, the USA and Europe.

students from the Universidad Católica del Norte (UCN). The centerpiece event of this celebration was a nighttime “star party.” The UCN students operated telescopes for the Inka Ruta students, showcasing the region’s extraordinarily dark, clear skies and introducing the students to astronomical objects such as the planets, star clusters, nebulae, and galaxies. The UCN students also pointed out the southern sky’s constellations and other naked eye astronomical objects of interest, such as the Southern Cross, the Coal Sack, α and β Centauri.

San Pedro de Atacama has been known as the “Archeological and Tourism Capital of Chile” for many years. With the arrival of the Atacama Large Millimeter Array, ALMA, this region is also becoming the “Astronomical Capital of Chile.” We enjoyed this opportunity to share the beauty and the purity of the Likan Antai sky with the young trekkers on the 2007 Ruta Inka. With our partners at ESO and the municipality of San Pedro de Atacama, we look forward to making this an annual outreach event in Chile’s Region II.

S. Cabezon and E. Hardy

Bicycle Donations for the NRAO Green Bank Site

Members of the Central Appalachian Astronomy Club delivered a dozen new bicycles to the National Radio Astronomy Observatory in Green Bank, West Virginia in August. The bicycles are used by visitors and staff to ride down range to view the many radio telescopes on site.

Pictured above are all CAAC club members with the new bicycles donated to the NRAO Green Bank site.

The Central Appalachian Astronomy Club and the Kanawha Valley Astronomical Society co-host the Green Bank Star Quest each year with the NRAO. The bicycle donation was the idea of Caitlin Ahrens, daughter of CAAC club members Steve and Connie Ahrens, who wanted to show appreciation for this past year's Star Quest, and the clubs voted to use some of the Star Quest proceeds for this effort.

Sue Ann Heatherly

In General

New NRAO Assistant Director for New Mexico Operations

Dr. Robert L. Dickman

We are very pleased to announce that Dr. Robert L. Dickman will be the new Assistant Director for New Mexico Operations beginning September 26, 2007. He was selected as the top choice after a comprehensive international search process.

Bob brings a wealth of experience to the NRAO, as he has had a distinguished career in radio astronomy and in the National Science Foundation (NSF) Astronomy Division. After earning both his undergraduate and graduate degrees in Physics from Columbia University, he was on the staff of the Five College Radio Astronomy Observatory (14m telescope) for 11 years. Subsequently, he moved to the NSF Astronomy Division, where over the past 15 years, he held a number of key positions, including Coordinator of the Radio Astronomy Facilities Unit and ALMA Program Manager. He served on the ALMA Board for five years and for a year was its Chair.

In the past year, Bob has been on sabbatical at the University of Virginia and Caltech. His scientific interests are in molecular cloud astrophysics, and most recently, in a method for testing the MOND theory of gravitation. Bob has had a long association with the NRAO and is very familiar with the Observatory. The NRAO is fortunate to have a leader of such wide experience as Bob to be the new Assistant Director for New Mexico Operations.

Bob takes over from Jim Ulvestad, who has been an outstanding Assistant Director for New Mexico Operations for the past six years. Under Jim's leadership, the EVLA project became a reality, and scientific research on the VLA and VLBA has flourished. Jim has been an excellent representative for New Mexico staff and operations internally and of the NRAO in the astronomy community. He has also been an invaluable member of the Observatory senior management team. Since last November, Jim has taken on new responsibilities as Assistant Director for the New Initiatives Office (NIO), representing the Observatory in the U.S. and international communities to help plan for the next generation centimeter and meter wave facilities in the SKA Program, and to help secure non-NSF funding for operation of the VLBA. We thank Jim for his outstanding contributions to New Mexico Operations and NRAO as a whole, and look forward to continuing to work with him in his new capacity.

The Observatory has been fortunate to have such able leaders in New Mexico, a tradition that will continue with the arrival of Bob Dickman. We welcome Bob to the NRAO.

K.Y. Lo and P. Jewell

2008 Jansky Fellowship Program

The National Radio Astronomy Observatory (NRAO) announces the 2008 postdoctoral Jansky Fellowship program that provides outstanding opportunities for research in astronomy. Jansky Fellows formulate and carry out investigations either independently or in collaboration with others within the wide framework of interests of the Observatory.

Prior radio experience is not required and multi-wavelength projects leading to a synergy with NRAO instruments are encouraged. The NRAO also encourages applications from candidates with interest in radio astronomy instrumentation, computation, and theory.

Up to three appointments will be made for positions at any of the NRAO sites (Socorro, New Mexico; Green Bank, West Virginia; and Charlottesville, Virginia). In the coming years, as ALMA commissioning activities get underway, we expect that there will also be positions available in Chile. Jansky Fellows are encouraged to spend time at universities working with collaborators during the course of their fellowship. In addition to appointments at NRAO sites, up to three non-resident Jansky Fellowship appointments will be offered for positions that may be located at a U.S. university. Frequent and/or long term visits to NRAO sites are encouraged. Split Fellowships with time spent at NRAO and at a U.S. university are allowed.

The starting salary will be $57,000 per year with an appointment duration of two years and possible renewal for a third year. There is a research budget of up to $10,000 provided per year for travel and computing requirements. Fellows are eligible for page charge support, vacation accrual, health insurance coverage, and a moving allowance. In addition, up to $3,000 per year is provided to defray local institutional costs for non-resident Jansky Fellows.

Note that the match between the host university and the candidate's research program is an important factor in the selection process. Also, appointments of more than one Jansky Fellow at a single external institution at a given time are discouraged. The blocked institutions for 2008 are California Institute of Technology and University of Chicago.

The NRAO web site provides a description of the application process and other relevant details: *http://www.nrao.edu/administration/directors_office/jansky-postdocs.shtml.*

Candidates must receive their Ph.D. prior to beginning a Jansky Fellowship appointment.

The deadline for both applications and letters of recommendation is November 16, 2007. The NRAO is an equal opportunity employer (M/F/H/V).

Award offers will be made by February 15, 2008, with the Fellowships expected to begin in September 2008.

M. Goss and B. Orahood

Opportunities for Undergraduate Students, Graduating Seniors, and Graduate Students

Later this fall NRAO will begin to accept applications for the *2008 NRAO Summer Student Research Assistantships* program. Each NRAO summer student conducts research under the supervision of an NRAO staff member at one of the NRAO sites, on a project in the supervisors area of expertise. The project may involve any aspect of astronomy, including original research, instrumentation, telescope design, or astronomical software development. Examples of past summer student research projects are available on the Summer Student website at *http://www.nrao.edu/students/NRAOstudents_summer.shtml*.

Supervisors choose their own student candidates from all applications received, and the site to which a summer student is assigned depends on the location of the NRAO supervisor who chose them. Students are encouraged to review the webpages of NRAO staff for an idea of the types of research being conducted at the NRAO. On their application, students may request to work with a specific staff member or to work on a specific scientific topic, or to work at a specific site.

The program runs from 10–12 weeks over the summer, from early June through early August. At the end of the summer, participants present their research results in a student seminar and submit a written report. Often, these projects result in publications in scientific journals. Financial support is available for students to present their summer research at a meeting of the American Astronomical Society, generally at the winter meeting following their appointment.

Besides their research, students take part in other activities, including a number of social events and excursions, as well as an extensive summer lecture series which covers various aspects of radio astronomy and astronomical research. Students also collaborate on their own observational projects using the VLA, VLBA and/or GBT.

There are three types of Summer Student programs available at the NRAO:

- *The NRAO Research Experiences for Undergraduates (REU)* program is for undergraduates who are citizens or permanent residents of the United States or its possessions, and is funded by the National Science Foundation (NSF)'s Research Experiences for Undergraduates (REU) program.
- The *NRAO Undergraduate Summer Student Research Assistantship* program is for undergraduate students or graduating college seniors who are citizens, are from an accredited U.S. Undergraduate Program, or otherwise eligible to work in the United States. This program primarily supports students or research projects which do not meet the REU guidelines, such as graduating college seniors, some foreign undergraduate students, or projects involving pure engineering or computer programming.
- The *NRAO Graduate Summer Student Research Assistantship* program is for graduate students who are citizens or permanent residents of the United States or its possessions, enrolled in an accredited U.S. Graduate Program, or otherwise eligible to work in the United States.

The stipends for the 2008 Summer Student Program are $490 per week for undergraduates and graduating seniors, and $525 per week for graduate students. These stipends include an allowance for housing, since housing is not provided.

Students who are interested in Astronomy and have a background in Astronomy, Physics, Engineering, Computer Science, and/or Math are preferred. The same application form and application process is used for all three programs, and may be accessed at *http://www.nrao.edu/students/summer-students.shtml*. Required application materials include an on-line application form (including a statement of interest), official transcripts, and three letters of recommendation. The deadline for receipt of application materials is **Monday, January 28, 2008**.

Jeff Mangum

Fourth NRAO/NAIC Single Dish Summer School

The fourth NRAO/NAIC Single Dish Summer School recently took place in Green Bank from July 8–15. The school focused upon advanced topics in single dish radio astronomy and was aimed at astronomers who are still in the early stages of their careers or are moving into radio astronomy from other fields.

The school was well attended with over 60 students from many different countries. The level was varied, ranging from students in the first year of their Ph.D. studies through to university faculty. The course was not limited to experts in astronomy. Kathryn Denning, Assistant Professor in Anthropology from York University in Canada, also attended as part of her own research program. Her aim was to better understand radio astronomers, how they think about their science, and how they actually use the telescopes and instruments to carry out their work. This is part of her larger project on observatories as places with multiple meanings (for scientists and the public), and on SETI science as a part of radio astronomy. Kathryn reports that she left delighted to have renewed her acquaintance with the wonderfully hospitable people at Green Bank, to have met so many remarkable students at the School, and to have learned so much about radio astronomy. She also reports that joining radio astronomers in the ritual climb up the GBT, and in the ancient practice of square-dancing under a starry West Virginia sky, are two of the highlights of her anthropological career.

Lectures on the many varied aspects of radio astronomy were delivered by NRAO and NAIC experts, as well as outside specialists. Topics covered all aspects of single dish radio astronomy, from what can be seen in the radio sky, receiver and antenna design, how to write a good observing proposal, and what to look for in the future of radio astronomy. In addition to the lectures, each school participant had the opportunity to observe using both the 40 Foot Educational Telescope and the GBT. The restrictions imposed by the stationary status of the GBT during this summer's track replacement program did not prevent the school's organizers from successfully completing a variety of "hands-on" projects.

The school was wrapped up with a talk by Frank Ghigo on the history of the Green Bank site, followed by a banquet and a dance with music performed by local musicians and square-dancing led by NRAO's own Sue Ann Heatherly. The following day found the participants of the school on a hike from the Green Bank site to Cass, a local historical railway and logging town, a distance of seven miles away.

The school was a resounding success, and our thanks go out to all the folks on the local staff who worked hard to keep the school running smoothly. Additionally, we would like to thank the many lecturers who took time out of their schedules to come and help train what will hopefully be the next generation of Arecibo and GBT users. The program from the school as well as photographs taken by the organizers and participants may be found at *http://www.gb.nrao.edu/sdss07/*.

Larry Morgan

NRAO Telescope Proposals to Observe the LCROSS Lunar Impact

(Proposal Deadline June 1, 2008)

The Lunar Crater and Observation Sensing Satellite (LCROSS) will provide a unique opportunity for the astronomical community to observe two lunar impact plumes and their aftermath to obtain data regarding the lunar regolith, impact dynamics, and the presence or absence of water ice near the lunar poles. The mission, which is a co-manifested payload launching with the Lunar Reconnaissance Orbiter in October 2008, will use the Earth departure upper stage (EDUS) of the launch vehicle as a kinetic impactor near the lunar South Pole. The impact will create an ejecta plume whose properties will be observed by a shepherding spacecraft (S-S/C) plus Earth and space-based telescopes. Following a similar trajectory of the EDUS, the S-S/C will fly through the EDUS impact plume and then the S-S/C will also impact the Moon. The S-S/C impact will likely also be observable to ground-based and space-based telescopes. The expected date of impact is mid-February 2009, although that date obviously depends on the actual launch date.

The mass of the EDUS is ~2000 kg and the mass of the S-S/C is ~700 kg. The EDUS and S-S/C will impact at a relatively high impact angle (>60 degrees) with an impact velocity of ~2.5 km s^{-1}. Both of these impact events are hundreds of times larger than that of Lunar Prospector which was 1) a smaller spacecraft, 2) traveling more slowly than LCROSS, and 3) impacted obliquely.

There are a variety of ground-based and orbital observatories that can observe the dust and water plumes plus a possible resultant OH exosphere caused by the LCROSS impacts. The LCROSS team encourages astronomers and planetary scientists to observe the impacts to support the scientific and exploration objectives of this mission.

The LCROSS project is committed to working with the observational scientists to provide mission information that is critical to the planning and proposal of observations. In this way the LCROSS project aims to develop a coordinated observation campaign utilizing ground-based and space-based observational assets.

The LCROSS Team is planning to host a workshop in early 2008 for astronomers interested in observing the LCROSS impacts. The idea is to have the astronomy community interact with the LCROSS team such that the astronomers can have access to and ask questions about the information they need to write successful proposals to the observatories to secure observing time.

Astronomers who are interested in using NRAO telescopes to observe this event should plan to submit a regular NRAO proposal in the normal way. These proposals will be peer-reviewed, ranked and awarded telescope time on the basis of scientific merit according to the standard NRAO proposal selection process. The one exception is that, to allow successful proposers time to apply for financial assistance we plan to accept LCROSS-related proposals at the June 1, 2008 proposal deadline.

Funding support for successful proposals may be available through a LASER (Lunar Advanced Science and Exploration Research) grant. This grant can support astronomer time for observation acquisition and data analysis as well as travel to telescope facilities. LASER is a new Research and Analysis element of NASA's ROSES (Research Opportunities in Space and Earth Sciences) program. Dr. Jennifer Heldmann (NASA Ames Research Center, LCROSS Observation Campaign Coordinator) will be coordinating one proposal next year (2008) covering all astronomers that have successfully secured telescope time to observe the impacts.

For additional information on all aspects of the LCROSS Observation Campaign, please contact Dr. Jennifer Heldmann at NASA Ames Research Center (*jheldmann@mail.arc.nasa.gov*, 650-604-5530). Additional information regarding the LCROSS mission can also be found on the website at *http://lcross.arc.nasa.gov*.

D. Frail, J. Heldmann, and R. Prestage

Green Bank student picture: Left to right are Jonathan Landon, Danielle Holstine, Ilene Mitchell, Steven Janowiecki, Courtney Epstein, Katie Chynoweth and Sophia Brunner.

Conclusion of 2007 NRAO Summer Student Research Programs

August brought to a close the 48th year of the NRAO Summer Student program. The student participants included undergraduate students, graduating seniors, and graduate students supported by various NRAO student programs (see accompanying article and *http://www.nrao.edu/students/*). The 25 student projects are listed in the July edition of the Newsletter (see *http://www.nrao.edu/news/newsletters/nraonews112.pdf*. On-line summaries of these projects are available at *http://www.nrao.edu/ students/archive/projects.php*.

J. Mangum and A. Bridle

Charlottesville student picture: Left to right are Diane Leigh, Charles Romero, A.J. Heroux, Mary Wilkins, Heidi Brooks, Paula Aguirre, Michael Freed, Alan Aversa, Tim Pennucci, and Ben Jewell.

Socorro student picture: Left to right are Rosa Torres, Jennifer van Saders, Nick Lee, Karen Mogren, and Diana Grijalva. Not shown are Michael Carilli and Matt Klimek.

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 NM 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. See *http://www.aoc.nrao.edu/events/synthesis/2008/* for more information on scheduled lectures and events. If you are interested in receiving more information about the workshop, please pre-register on the same web page.

Amy Mioduszewski

New Reservation System for NRAO Visitors

For many years the Business Offices of Green Bank and Socorro have aided visitors to the respective sites in making reservations for lodging, travel, etc., with each site utilizing its own in-house custom software package. With the desire for a common experience for users of all NRAO telescopes, and the requirements of financial reporting in the Business Offices, it was decided that a standardized package was needed across the Observatory for reservations, invoicing and coordination of requirements. Commercial software packages were reviewed for adoption, but none contained the specialized data accumulation and manipulation that was required by the Business Offices. In late 2005, the Green Bank Software Development division started a project to create a customized software solution to produce a superior package to meet the requirements of the entire Observatory.

The Green Bank Software Development division worked closely with representative product sponsors from each Business Office, who were chosen based upon various areas of expertise. The culmination of the partnership will occur on October 1, 2007 with the release of the Business Office System (BOS). Beginning October 1, 2007, all visitors to Green Bank and New Mexico are required to use the new online reservation system, accessible through the web page for the respective sites.

The software allows visitors to input all of their reservation information, including arrival and departure dates and times, mode of travel, special travel requirements for each of the sites, and any special needs while at the sites. Behind the scenes the software will then notify the traveler by email that the reservation was received, and then will allow the reservationist in Socorro (Natti Gonzales) or the Business Office in Green Bank (Becky Warner) to perform the coordination of the reservation for lodging, meals, special travel requirements, and special needs. Each site can then confirm the reservation and the system will then compile the information it needs to provide prompt and correct invoicing for the traveler, with the necessary inputs to ensure that the data is processed through the J.D. Edwards accounting system. Additionally, the software will allow on-the-fly additions to the reservation, for example, on-site sales for phone cards, postage, etc.

As this is the initial release, there will undoubtedly be enhancements which can aid in the flow of the program, and they will be addressed in future releases. The Business Offices would appreciate your constructive feedback and will use that feedback to make the system even better.

A. Shelton, M. Holstine, C. Chandler, and S. Lagoyda

E2E Welcomes Two New Employees

NRAO End to End Operations has two new employees this season.

Ron DuPlain started as a Software and Systems Engineer in August 2007. Ron received a Bachelor of Science degree in Computer Engineering from the University of Cincinnati, with minors in Mathematics and Very Large Scale Integration (VLSI) Engineering. He first joined the NRAO in June 2004 as a co-op student with the Green Bank Software Development Division. Beyond co-op, Ron recruited and led his classmates in a nine-month undergraduate capstone project to assist the Green Bank Electronics Division in initiating development for the FPGA-based next generation pulsar backend for the GBT. Ron will be working on high-performance computing issues, the NRAO archive, and EVLA development related to these areas.

Jared Crossley joined NRAO End to End Operations in October 2007 as a Scientific Associate. As a part-time contractor for NRAO since September 2006, Jared has helped to build the NRAO VLA Archive Survey (NVAS) and refine the NVAS pipeline system under the guidance of Lorant Sjouwerman and Ed Fomalont. Jared is a graduate of New Mexico Tech. He brings with him experience in radio astronomical research and computer programming acquired during his graduate studies under Timothy Hankins and Jean Eilek, and as a former NRAO summer student under the direction of Michael Rupen.

Welcome to Ron and Jared!

Nicole Radziwill

Online Catalog for Searching NRAO Archives

In addition to the finding aids found at *http://www.nrao.edu/archives/*, the NRAO Archives now has an online catalog to assist you in searching for Archives materials. The catalog includes records for groups of material (e.g., NRAO Director's office files on the annual Jansky Lectureships), as well as many individual item records (e.g., Grote Reber's correspondence; documents and correspondence on NRAO's founding). The catalog database will grow steadily, since we add new records as we process materials. We will also be adding links to digitized documents and to images. The URL for the catalog is *http://jump.cv.nrao.edu/textbase/archivesearch.htm.*

We currently have considerably more unprocessed than processed material in the Archives, particularly for the extensive records of NRAO and for the papers of John Kraus. Thus, if you do not find what you are seeking in the Archives online catalog or finding aids, you should contact Ellen Bouton for help (1-434-296-0203, *archivist@nrao.edu*).

Ellen Bouton

Please Complete the NRAO Newsletter Survey

To help us better satisfy your needs with regard to the NRAO Newsletter, we are asking that you complete a brief survey. The information provided will be kept confidential and your feedback will enable us to improve the newsletter content, format, and distribution. After submitting the survey online, you will be entered into a drawing to receive a 256 GB NRAO memory stick (a total of ten will be sent). The survey is available online via the following link: *http://www.nrao.edu/surveys/news*.

M. Adams and N. Radziwill

NRAO Library Corner

We have updated the NRAO Library Web Page with "Quick Links" for easy access to the NRAOcat, Electronic Journals, Page Charges, and the NRAO Bibliographic DB, RAPs.

Authors: Your response to requests for Proposal/ Project Numbers has doubled the number of papers that now have Proposal/Project Numbers. Thank you for your response. We really appreciate the time and effort you take to respond to the requests!

The NRAO Library has saved almost 50 percent on our OCLC invoice due to credits we have received for:

- Lending items to other libraries
- Creating new catalog records
- Deleting holdings (due to loss or weeding)

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

Marsha J. Bishop

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.vlba.nrao.edu/astro*
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: Ellen Bouton; Layout and Design: Patricia Smiley

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