NATIONAL RADIO ASTRONOMY OBSERVATORY

Newsletter

January 2008 Issue 114

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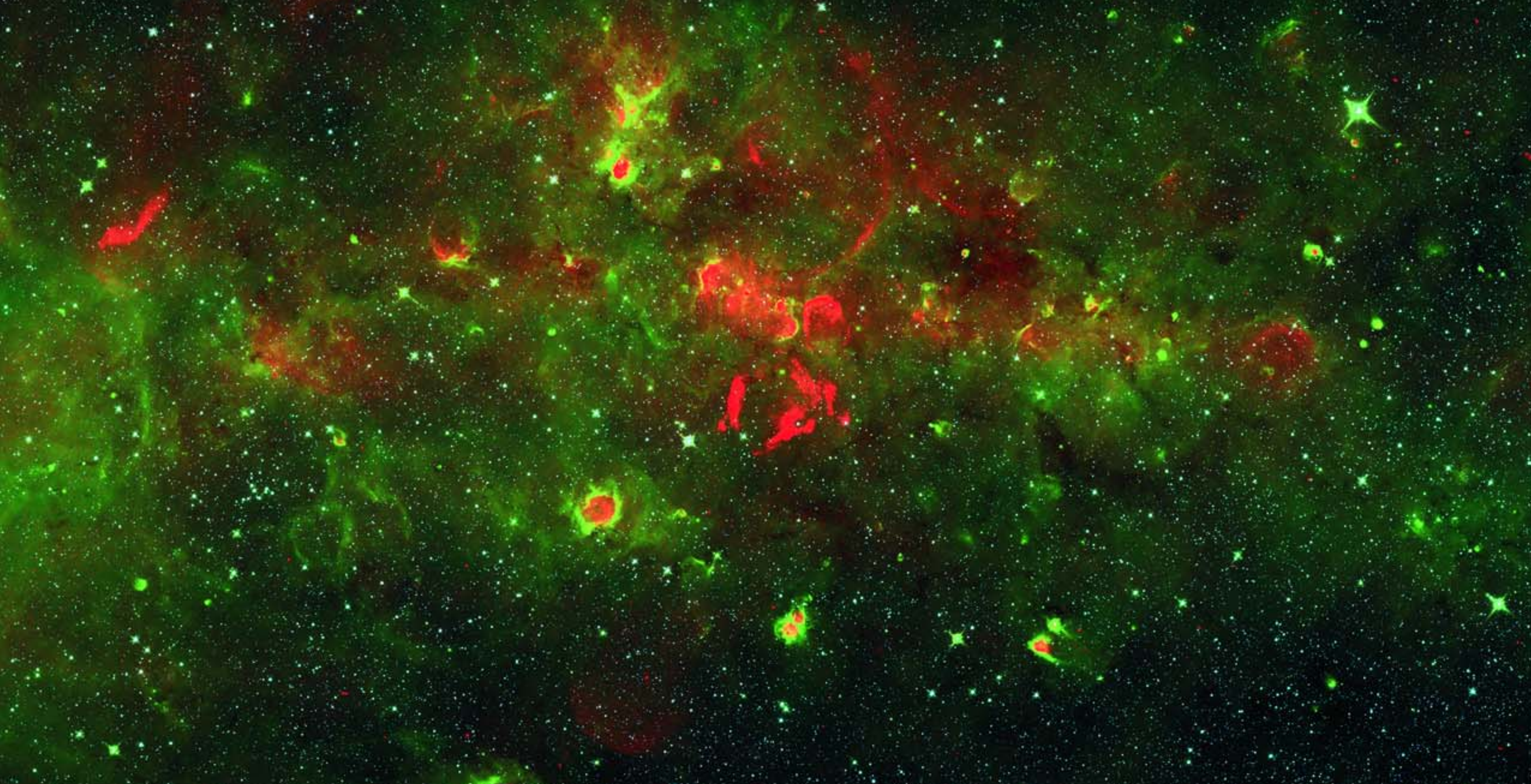

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Cover: This panorama of a section of the Milky Way in the constellations of Scutum and Aquila illustrates the dynamic interplay between the birth and death of massive stars in our Galaxy. The image is a composite of a radio data acquired with the NRAO's Very Large Array and mid-infrared observations from the Spitzer Space Telescope. Radio data shown in (red), mid-infrared (green), near-infrared composite (blue-white), and radio/infrared composite (yellow).

Investigators: David Helfand (Columbia), Bob Becker (UC Davis), and Rick White (STScI).

Science

The VLA Low-Frequency Sky Survey

The VLA Low-Frequency Sky Survey (VLSS) maps an area of 3π sr covering the entire sky above a declination of -30 degrees at a frequency of 74 MHz (4 meter wavelength). Survey images have 80" resolution and a 5σ detection limit of 0.5 Jy/beam on average. This represents an imaging capability that was unprecedented at such a low frequency until the development of the 74 MHz VLA system (Kassim 2007) and the algorithms necessary to correct ionospheric distortions (Cotton 2004, Cotton 2005). The survey is now 95 percent complete, with a catalog that numbers roughly 67,000 celestial sources (Figure 1). All data are publicly available on the VLSS website *http://lwa.nrl.navy.mil/VLSS*, which is also linked from the NRAO astronomers resource page. The VLSS Website provides a searchable source catalog, a postage stamp server, and a recently-added flux-density calculator for bright sources. Here we report recent progress on several fronts.

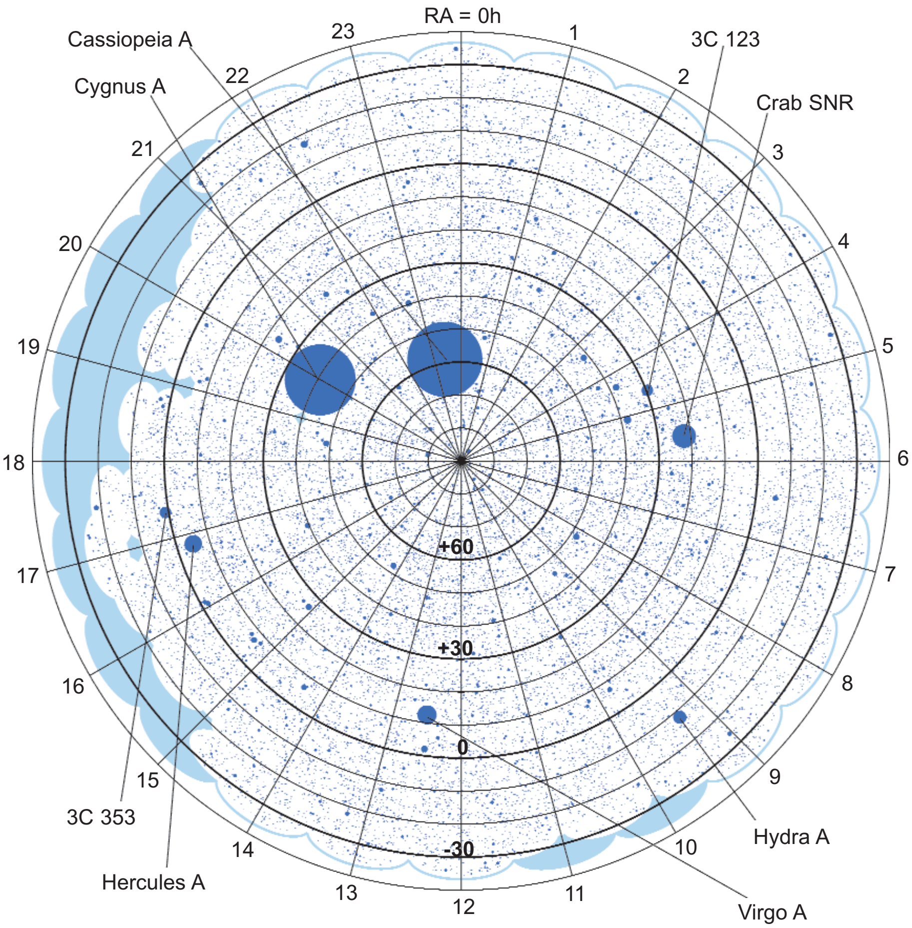

Figure 1. VLSS sky region now completed and available on our website in the form of images and source catalog. The dark blue dots represent all detected sources with peak intensities of at least 1 Jansky/beam, and the area of each dot is proportional to the flux density of that source. The eight strongest sources at 74 MHz are labeled. The light blue regions are not yet available, though most of this region has been observed and we are in the process of reducing and verifying this data before making it available to the public.

In September 2007, our first major VLSS paper was published in the Astronomical Journal (Cohen 2007). This provides a detailed description of the VLSS observing and data-processing methods. A complete analysis of the accuracy of position and flux-density measurements are presented to assist users of the survey data. The data have also now been incorporated into several online astronomical databases such as *Skyview* that make up the growing "virtual observatory" and convenient comparison with other surveys.

In October 2007 we completed observations for the remaining five percent of the survey region (see Figure 1). This region is the most challenging yet observed because it is at far southern declination and near the Galactic plane and Galactic Center. Not only are ionospheric phase effects compounded at low elevations, but the sky-noise dominated system temperature (and therefore system noise) is increased for observations towards the inner Galactic plane.

Following our standard policy for the VLSS, the most recently acquired survey data will be made available on the VLSS website as soon as they are reduced and verified. We anticipate that this will occur in the next few months.

We have compiled spectral data for the brightest VLSS sources to create the VLSS Bright Source Spectral Catalog (VBSSC; Helmboldt 2007). The VBSSC provides spectral data for the 388 sources with peak intensities above 15 Jy/beam at 74 MHz by combining the VLSS measurements with existing data from the literature and other catalogs and referencing all measurements to the same flux density scale. These data are available from our online search engine and flux density calculator which are also now on the VLSS website.

Additional scientific use of the VLSS data is proceeding in several areas. Although still relatively new, the VLSS has been used in 19 refereed publications on a range of topics including spectral aging of radio lobes, quasars, black hole accretion rates, and extra-solar planets. Various research groups are now studying astronomical objects that they have identified with the VLSS as potentially belonging to interesting classes of radio sources such as galaxy cluster halos and relics, high redshift radio galaxies, cluster cooling cores, giant radio galaxies, intra-cluster filaments and pulsars. The VLSS is also being used as a sky model by new low-frequency radio telescopes, including the Long Wavelength Array (LWA) and the Low Frequency Array (LOFAR), to simulate performance, to evaluate test data and to perform initial calibration of the instruments.

Aaron Cohen, Wendy Lane (NRL),
Bill Cotton, Rick Perley, Jim Condon (NRAO),
Namir Kassim, Joseph Lazio, Joseph Helmboldt (NRL),
and Bill Erickson (UMD)

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A New Distance to the Orion Nebula Cluster

As the nearest site of massive star formation in our Galaxy, the Orion Nebula Cluster (ONC) is the cornerstone of our understanding of this important process. At the heart of the Cluster lie the massive stars of the Trapezium whose intense radiation fields are responsible for disrupting the molecular gas out of which the Cluster formed and illuminating the well-known Orion Nebula. Surrounding the Trapezium are thousands of young stars, many still embedded in molecular gas. Most of the stars in our Galaxy are formed in OB associations like the ONC, so characterizing its stellar population is fundamental to our knowledge of star formation in general.

As is the case for any astronomical object, the measured physical properties of the ONC—stellar masses, luminosities and physical sizes—depend on the precision with which we know the Cluster's distance. Over the years, the distance to the ONC has been estimated using a variety of model-dependent techniques, resulting in distances ranging from 350 to 500 pc. Until recently the only fundamental distance measurement to the Cluster was the marginally detected parallax of HD 37061 by Hipparcos (Bertout et al. 1999). In 1981, Genzel et al. used VLBI measurements (though not with the VLBA) to determine the proper motions of H_20 masers in the BN/KL region. Combined with measurements of the radial velocities of the maser spots and a model of the source as an expanding shell, they determined a distance of 480 ± 80 pc to the Cluster. Since that time the Genzel et al. value has become the canonical distance to the ONC.

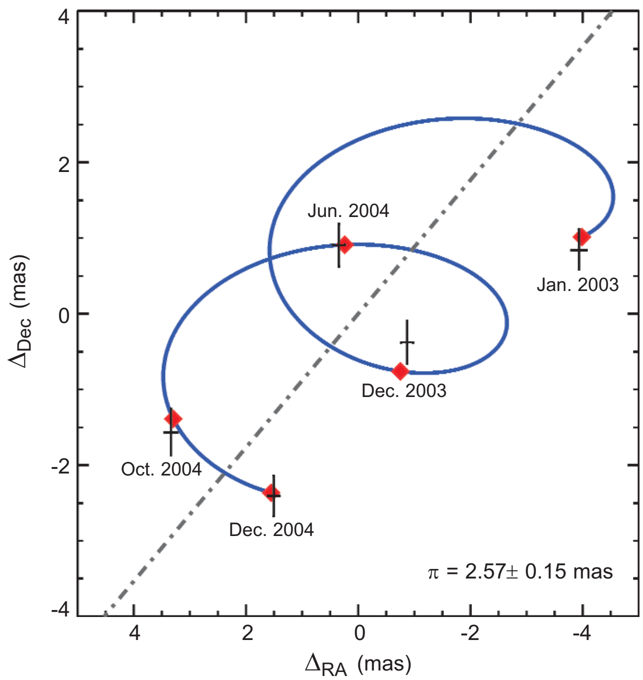

Figure 1. This figure shows the measured positions of GMR A with the best fit parallax and proper motion shown in blue. The red diamonds represent the predicted position of GMR A for each observation. The dashed line is the proper motion, with the parallactic motion subtracted.

In December of 2002, a serendipitous detection with the BIMA interferometer of a flaring episode from the T Tauri star GMR A prompted follow-up observations with the VLBA (Bower et al. 2003). Located 2 arcseconds from the Trapezium stars and still embedded in molecular gas, GMR A's membership in the ONC is well established. The VLBA observations showed it to be compact and bright enough for the purpose of precisely measuring its parallax with further observations spaced throughout a year. To that end we obtained five further epochs of VLBA observations between December 2003 and December 2004. We measured the position of GMR A relative to the quasar J0541-0541, located 1.6 degrees to the southeast of the target. We also observed a second quasar, J0529-0519, located a similar angular distance to the northwest of GMR A in order to remove phase gradients across the sky using the technique developed by Fomalont (2005).

The parallax of GMR A measured from the VLBA observations corresponds to a distance of 389^{+24}_{-21} pc, nearly 100 pc closer than the Genzel et al. (1981) value, though the measurements do agree within their one-sigma errors. One important consequence of our measurement is that the luminosities of stars in the ONC are 1.5 times lower at a distance of 389 pc than they are at 480 pc. Interestingly, a systematic offset between the temperatures and luminosities of the high mass ONC stars and the theoretical H-R diagram (see for instance, Palla & Stahler 1999) is greatly improved by decreasing the luminosities by a factor of 1.5. Decreasing their luminosity also has important implications for the ages of pre-main sequence stars in the ONC. For fully convective pre-main sequence stars, the proportionality of age and luminosity means that these stars are twice as old as previously assumed. However, pre-main sequence stars are not fully convective until they have contracted a significant amount, and thus younger stars, those near the stellar "birthline" (Palla & Stahler 1999), are not affected by the change in luminosity to the same degree. Therefore decreasing the luminosities a factor of 1.5 ages the entire pre-main sequence population, but not uniformly, increasing the age spread of the Cluster. For theoretical models that describe massive, clustered star formation, the age spread is a crucial parameter.

The VLBA is an important tool for astrometry, able to measure distances to objects outside the range of other astrometric techniques and with much higher precision. With its unique capabilities, future observations of active, pre-main sequence stars like GMR A could provide high precision, fundamental distance measurements to many nearby star-forming regions.

K. Sandstrom, J. E. G. Peek, G. Bower (U. C. Berkeley), A. Bolatto (U. Md.), and R. Plambeck (U. C. Berkeley)

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Monitoring Jets in Active Galactic Nuclei

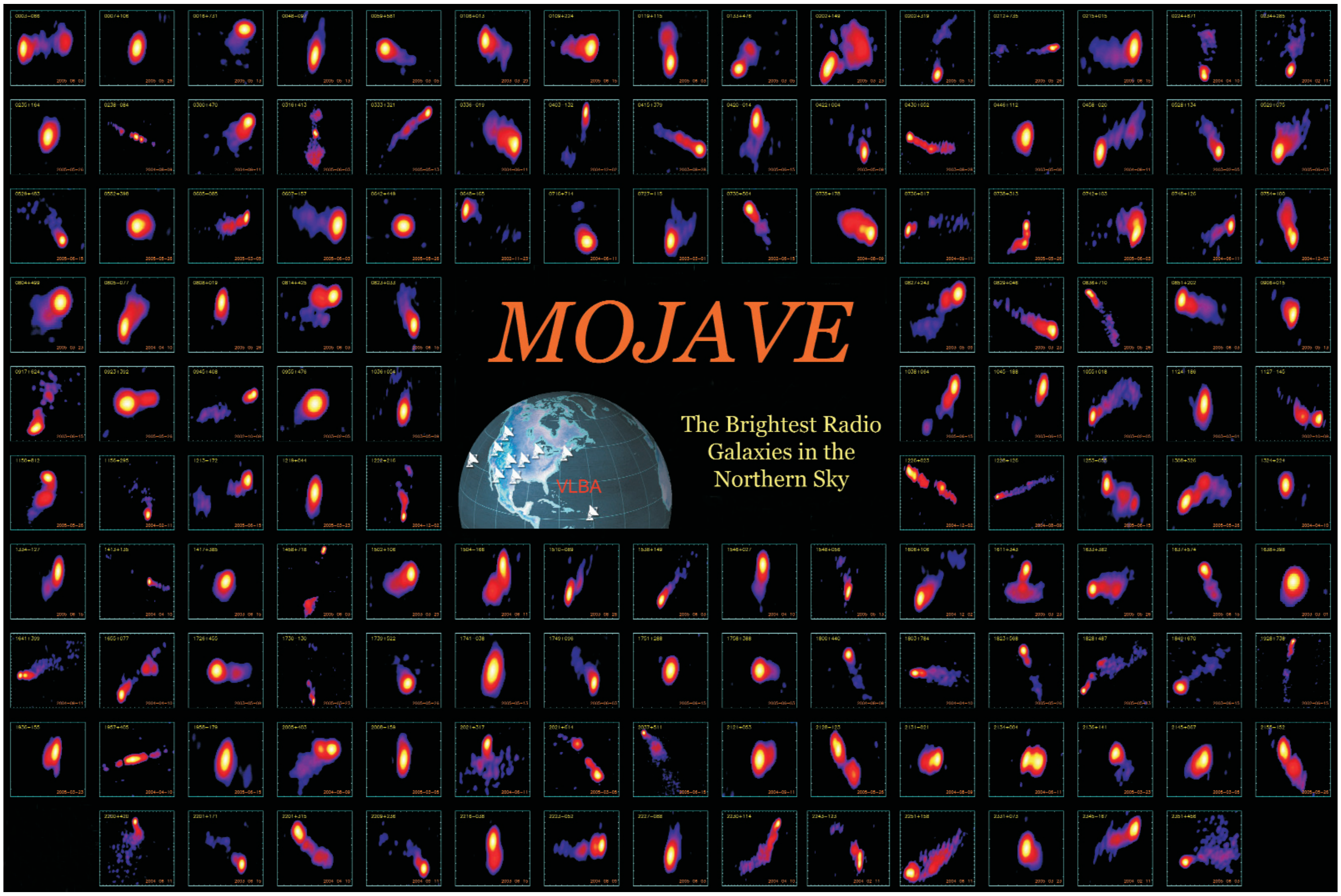

Figure 1. VLBA image montage of the 133 brightest, most compact AGN jets visible in the northern sky. These sources, plus 64 additional AGN of special interest, are currently being monitored by the MOJAVE program in support of the GLAST gamma-ray satellite mission.

Prior to the construction of the VLBA, progress in our understanding of relativistic outflows from powerful active galactic nuclei (AGN) was severely hindered by the absence of a facility which could provide high-quality, regularly spaced, full polarimetric images at milliarcsecond resolution. In meeting these requirements, the VLBA has become a premier facility for unprecedented study into the time evolution of astronomical phenomena out to large cosmic distances. One of the first studies to take advantage of the VLBA's versatile capabilities was the 2 cm VLBA Survey (Kellermann et al. 2004), which regularly imaged highly relativistic jets in nearly 200 AGN from 1994 to 2002. This survey established apparent superluminal motion as a ubiquitous property of AGN jets, which provides direct evidence of massive outflows travelling at near light-speed very close to the line of sight.

Since 2002, a successor program (MOJAVE: Monitoring Of Jets in Active galactic nuclei with VLBA Experiments) has been tracking a more complete sample of 200 jets, which includes all of the brightest AGN visible in the northern sky (Figure 1). The resulting full polarization images, which are taken at intervals appropriate to the evolution rate of each jet, have helped reveal important details of their magnetic field structure (Lister & Homan 2005). These include the presence of a strong transverse standing shock near the jet nozzle, and a distinct difference in the field structures of weak-emission-lined versus strong-lined AGN. The weak circularly polarized emission from the jets has also been useful for probing their matter content, as well as for reconstructing their three-dimensional magnetic field structure (Homan & Lister 2006). A follow-up multifrequency VLBA study led by Dan Homan of Denison University is currently investigating the origin of circular polarization that has been detected in 17 percent of the full MOJAVE sample.

The MOJAVE program has also made major contributions to our knowledge of relativistic jet kinematics. A recurring problem in AGN studies has been the presence of complex selection effects, which strongly bias the makeup of flux-limited samples toward highly beamed jets (i.e., blazars) that do not necessarily reflect the overall parent population. As a result, targeted studies of famous, yet potentially very rare AGN can severely bias our understanding of jet phenomena. Previous Monte Carlo studies by Lister and Marscher (1997) have shown that these selection effects can be modelled, however, given a sample that is large enough to overcome statistical fluctuations. To date, MOJAVE has measured over 300 speeds in a complete sample of AGN, which have been shown to directly reflect the underlying flow (Kellermann et al. 2004, Cohen et al. 2007, Homan et al. 2006). When modeled with Monte Carlo simulations, the overall apparent speed distribution indicates that most AGN jets in the Universe have only mild Lorentz factors (2–5), confirming that most well-known AGN jets are exceedingly rare. For example, for every highly beamed superluminal jet such as 3C 279, there must be at least ~1 million other jets with a slower apparent speed and beaming factor. The MOJAVE findings also imply that the majority of lower-luminosity AGN likely have intrinsically slow jet speeds, and are not merely highly beamed blazars pointed in the plane of the sky (Cohen et al. 2007).

In addition to providing speeds of moving jet features, the decade-long time baselines of the MOJAVE survey have revealed a variety of interesting kinematic behavior in individual jets. In many cases, successive features accelerate outward on curved trajectories that may be the result of helical instability modes (e.g., Hardee et al. 2005). On the other hand, nearly 15 percent of the sample display jet features that follow apparently ballistic trajectories at successively different position angles, as if launched from a precessing nozzle. In other cases where the jet is close enough to obtain excellent spatial resolution, some features are seen to break apart and form trailing shock structures (M. Kadler et al. 2007). All of these observations are currently providing excellent case studies for comparisons with detailed numerical jet simulations.

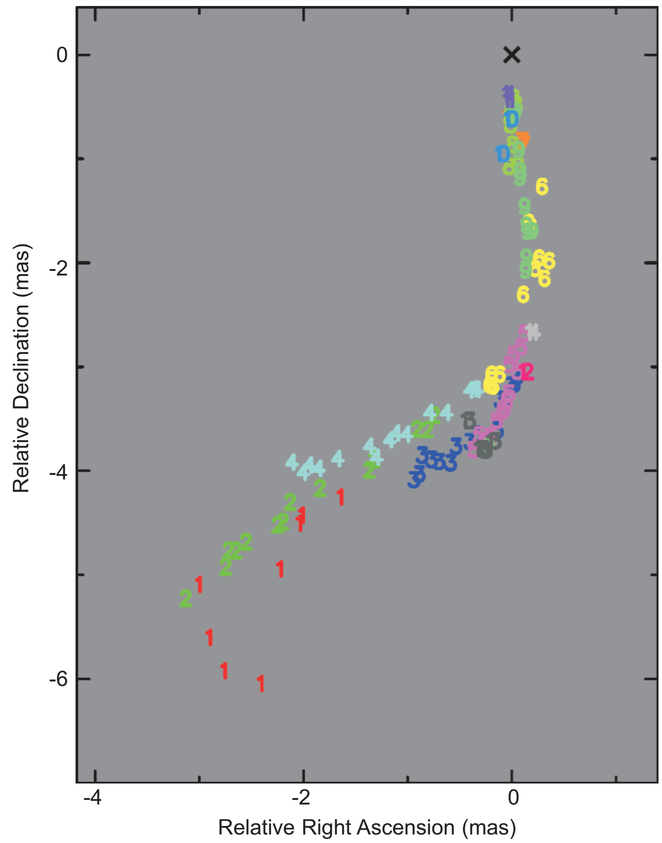

Figure 2. Positions of individual (numbered) jet features in the quasar 0738+313, showing their accelerating trajectories on the sky. The "X" indicates the position of the AGN.

The continuous long term coverage provided by the VLBA has also allowed us to witness long-duration events in AGN jets for the first time via time lapse movies, over 100 of which are available on the MOJAVE website: *http://www.physics.purdue.edu/MOJAVE*. A particularly dramatic example is the powerful radio galaxy 3C279, which emitted a bright feature in the early 1980s that moved on a straight path at an apparent speed of 8c for nearly 15 years. In mid-1998, this feature suddenly brightened, changed its polarization structure, and accelerated to 13c along a new direction that coincides with the overall kiloparsec scale jet as seen by the VLA. Homan et al. (2003)

interpreted this as a collimation event, which changed the direction of the flow by roughly 0.5 to 1 degrees at a distance ≥ 1 kiloparsec from the central engine.

As part of NRAO's large project policy, all of the reduced MOJAVE data are available on the project website within a few weeks of correlation, and the continuing observations are expected to be a primary source of structural information during the upcoming GLAST satellite mission. GLAST is anticipated to detect and monitor several thousand AGN at gamma-ray energies. By measuring the Doppler beaming factors and ejection dates of moving jet features, MOJAVE will address many lingering mysteries surrounding the origin and mechanisms of gamma-ray emission in AGN jets.

The MOJAVE program has successfully demonstrated the VLBA's ability to produce high quality, milliarc-second resolution images of AGN jets to the community in a timely manner. These data, when combined with ongoing complementary MOJAVE sample studies using the Swift and Chandra observatories in X-rays, the VLA on arcsecond scales, and the University of Michigan and RATAN observatories at cm wavelengths, are providing a rich and growing dataset with which to investigate many outstanding questions regarding powerful jets generated by supermassive black holes.

The author wishes to thank the members of the MOJAVE team whose work is reported here.

Matthew L. Lister (Purdue University)

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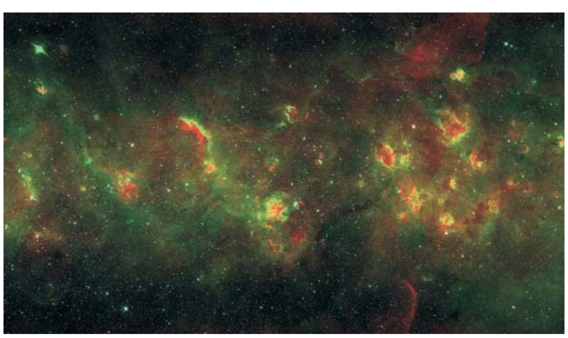
2007 AUI/NRAO Image Contest Prizes Awarded

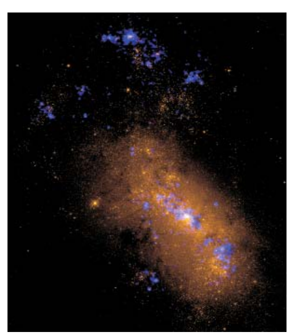
Associated Universities, Inc. and the National Radio Astronomy Observatory are pleased to announce and congratulate the prize recipients of the Third Annual Radio Astronomy Image Contest. A total of 14 images were submitted. AUI/NRAO wish to thank all of the participants in this Contest for their submissions. For further information on the contest visit our website at *http://www.nrao.edu/ imagegallery/image_contest/ image_contest_2007_prizes.shtml*.

First Prize



Birth and Death in the Milky Way
Investigators: D. Helfand (Columbia), R. Becker (UC Davis), and R. White (STScI). Image submitted by: R. White (STScI)

Second Prize



Emerging Super Star Clusters in NGC 4449
Investigators: A. Reines (UVA), K. E. Johnson (UVA/NRAO) M. Goss (NRAO). Image submitted by: A. Reines (UVA)

Third Prize

The Corpse of a Star
Investigators: D. Helfand (Columbia) R. Becker (UC Davis), R. White (STScI). Image submitted by: S. Croft (UC & LLNL)

Atacama Large Millimeter/submillimeter Array

ALMA Project Progress

Figure 1. Artist's conception of ALMA operating in an extended array. (Image courtesy of ALMA/ESO/NRAO/NAOJ)

ALMA's achievements in 2007 have poised the project to assemble the first complete production system in Chile during 2008. Laying the groundwork for this, the ALMA Test Facility (ATF) in New Mexico has brought together most of the pieces of the ALMA interferometer to demonstrate the operation of the system. In June 2007, a ceremony was held welcoming the Array Operations Site (AOS) Technical Building, the nerve center for the array at an altitude of 5000m, to the collection of NRAO facilities on the occasion of NRAO's 50th anniversary. During the first half of 2008, the correlators will occupy the building; the first correlator has arrived in Chile from Japan. From April 2007 through year's end, seven antennas have been delivered to Chile, and the first antenna from Mitsubishi Electric Co. (Melco) underwent holography and other tests during the final quarter. Shortly, ALMA is expected to begin to accept antennas from the contractors for testing, leading to installation of the ALMA receiver package, which is undergoing its readiness reviews as this is written. The ALMA transporters have been demonstrated in Germany and will embark on their journey to meet the antennas at the Operations Support Facility (OSF) by year's end. The plan for operating the Joint ALMA Observatory was reviewed by an international committee in February 2007, which led to the adoption by the ALMA Board of the ALMA Operations Plan, a blueprint for ALMA to produce its transformational science.

During 2008, a focus of the project will be demonstration of the production ALMA system at the OSF, where the Technical Building is nearing completion, and leading to demonstration at the AOS in the first part of 2009. Initially, with the delivery of antennas to the OSF well along, the focus will be on testing the antennas to ensure they meet the demanding ALMA specifications. Upon acceptance of the transporter, antennas will be delivered to the OSF area for incorporation into the two-antenna interferometer scheduled to operate there in the latter half of the year. Six additional antennas are scheduled for delivery to the OSF by the end of 2008.

At the North American Front End Integration Center (NA FEIC) located in the NRAO Technology Center (NTC) in Charlottesville, final tests and reviews are under way leading to the shipment of the first ALMA Front End, carrying the electronics associated with detecting the radio signals. That first Front End will arrive in Chile early in 2008. Also at the NTC, a second two-antenna correlator is reaching completion

Figure 2. Three Melco antennas under operation at the OSF. On the right is Melco unit-1, the most thoroughly tested of these antennas. Photo courtesy NAOJ.

and will be ready for shipment to Chile in January, where it will be installed at the OSF for the first interferometric tests of the production antennas later in the year. The first quadrant of the powerful ALMA correlator, which can accommodate 32 antennas, will be shipped to Chile for installation at the AOS in the second quarter of the year. ALMA will need two more Front End Integration Centers to supply its complement of receivers; a European installation at Rutherford Appleton Laboratories in England had a kickoff meeting in November. A third installation in Taiwan is approaching readiness. To assess the state of the production line for ALMA electronics, a Workshop was held in mid-November in Charlottesville.

Regular interferometry has continued at the ALMA Test Facility in New Mexico, where the assembled hardware has been linked by ALMA software and tested by scientists visiting the installation. The software drives the local oscillator (LO) fringe rate along with both coarse and fine delays. The system is phase stable over hours. Further tests are under way; interferometry will be used to fine-tune the antenna pointing solutions during the latter part of 2007.

Holography tests on the first of the three Melco antennas gave results that were repeatable to within four microns. The ALMA specification for the antenna surface accuracy is 25 microns. Optical pointing and control testing continues; a goal is that NAOJ might accept the antenna from the contractor shortly. The fourth 12 m antenna constructed by Melco arrived at port in Chile early in December.

The first of the VertexRSI antennas, a North American deliverable to ALMA, will undergo its testing early in 2008. The second antenna of this design is being assembled in the Site Erection Facility at the OSF, while the elements for the third antenna are in transit and should arrive in Chile in mid-December.

As components of ALMA flow toward the OSF, the Warehouse, part of the Technical Facility complex nearing completion, is ready to store them. Major components of the Back End, the signal distribution and processing portion of the ALMA system, arrive at the OSF in mid-December.

Figure 3. The first VertexRSI antenna was demonstrated at the ALMA Board meeting at the OSF on October 31, 2007.

The population of the Camps at the OSF reached over 500 people for construction activities. The balance of population will slowly shift from contractor personnel, now in the majority, to ALMA personnel as construction moves toward operations. One of the first elements of the operation of ALMA is managing the facilities; handover of this task occurs as construction of the facilities reaches completion during 2008. ALMA personnel are housed and fed in the ALMA camp, which is currently undergoing its final phases of expansion to accommodate the increased numbers.

At the 5000m elevation site, outfitting of the Technical Building with ALMA equipment has begun as the Atacama Compact Array (ACA) correlator is installed. Construction of a hangar for the antenna transporters has also begun and will complete in early 2008. Not

Figure 4. The Operations Support Facility Technical Building complex, seen from the holography tower in mid-October, is nearing completion. The warehouse is on the left, with offices and labs on the right. The transporter shelter can be seen in the background.

far to the south of the building, the central cluster of the array will stand. The first stage of readying the Chajnantor Plain for the cluster, involving substantial earthwork, will begin early in 2008.

A new ALMA outreach and education book was publicly presented to city officials of San Pedro de Atacama in Chile as part of the celebrations of the anniversary of the Andean village, a Sister City to Magdalena, NM. Entitled *Close to the Sky: Biological Heritage in the ALMA Area*, and edited in English and Spanish, the book collects unique on-site observations of the flora and fauna of the ALMA region performed by experts commissioned to investigate it and to provide key initiatives to protect it. Copies of this new book are available at *http://www.nrao.cl*.

In November 2006, an international ALMA conference was held in Madrid as a forum for astronomers interested in ALMA to exchange views, to plan preparatory observations looking forward to the interferometer's transformational science, and to obtain information needed to orient their scientific work to the best possible use of ALMA. The Proceedings of that conference will be available March 2008 as a special issue of *Astrophysics and Space Science* entitled *Science with the Atacama Large Millimeter Array: A New Era for Astrophysics*, edited by R. Bachiller, Rafael and J. Cernicharo. Many of the articles are available now at the journal's website.

During the last few months, the Santiago ALMA contingent has expanded to support the construction progress. In early November, Richard Hills assumed the post of Project Scientist; Joe McMullin took up his post as System Integration Lead; and Masato Ishiguro and Lewis Knee took up positions on the system integration team. To accommodate the burgeoning staff, additional space was obtained in the Alsacia building adjacent to the current offices at 40 El Golf.

Al Wootten

North American ALMA Science Center

Hiring at the NAASC is beginning in earnest. The NRAO recently announced two joint appointments with the University of Viriginia. Dr. Aaron Evans, formerly from the State University of New York at Stony Brook, and Dr. Remy Indebetouw, formerly a Spitzer Fellow at the University of Virginia, have joined the NAASC. There are four other NAASC positions currently advertised:

- Two Commissioning and Science Verification (CSV)-related scientific staff positions.
- A position for ALMA-related education and public outreach.
- A scientific programmer position for ALMA-related CASA development.

Closing dates are January 30, 2008. Please bring these positions to the attention of your colleagues. See: *http://www.nrao.edu/administration/personnel_office/careers.shtml.*

The ALMA North American Science Advisory committee is organizing the 2008 NAASC workshop. The topic will be massive star formation, and the co-chairs of the Scientific Organizing Committee (SOC) will be Andrew Baker (Rutgers) and Remy Indebetouw (NRAO/UVa). Details will be available in the next NRAO *Newsletter*. The ANASAC is also considering scientific community efforts in the ramp-up years to ALMA, preparing for early science in 2011.

A major milestone for the offline data reduction package for ALMA: Common Astronomy Software Applications (CASA) has been achieved with the first beta release in October (see *http://casa.nrao.edu/* for more information) and NAASC staff continue to be extensively involved in the testing and development of CASA. NAASC staff members and their counterparts worldwide participated in a CASA training workshop in October (in Socorro, NM) to train User Support Specialists who will provide user support to the wider community in the future. In addition to testing by ALMA and NRAO project members, the CASA beta has also been released to >20 representatives of ALMA and NRAO scientific advisory committees. Feedback from this initial beta users group will be used to improve CASA and the newly commissioned CASA helpdesk in preparation for a wider user base. Testing also continued on all ALMA software subsystems, including the pipeline, CASA ALMA simulator, Obstool, and archive.

The NAASC staff is assisting with, and training at, the ALMA Test Facility in Socorro, NM, in preparation for ALMA commissioning and science verification (CSV) and early science.

Work continued on the spectral line database in anticipation of its beta release on January 1, 2008 including the purchase of a dedicated database server to handle the expected number of queries. The database is currently a transition-resolved compilation of the JPL, CDMS, Lovas/NIST, and now Frank Lovas' (NIST) own Spectral Line Atlas of Interstellar Molecules (SLAIM) list. It currently contains 3,916,043 spectral lines in 865 chemical species including H, He and C recombination lines. Intelligent search filters have been added that allow the user to display the type of line strength (Aij, Sij, Sijmu2, Astronomical Intensity, JPL/CDMS intensity) or energy (K, cm^{-1}) preferred, what line list they want displayed, as well as upper limits to the errors on transitions. For a demonstration of all these new features, and more, visit *www.splatalogue.net*.

Operations staff in Chile is undergoing extensive training as part of AIV/CSV activities. The ALMA operations plan version D has been approved by the ALMA Board. Special thanks go the ALMA operations working group on their extensive efforts in preparing the revised operations plan. In the coming year, ALMA Chilean operations will be hiring a significant number of operations staff, including astronomers. See: *http://www.alma.cl/jobops/*.

Heads of the ALMA Regional Centers continue to hold regular telecons and quarterly face-to-face meeting to discuss global ALMA operations plans and progress. The next meeting is in Santiago in December, where main topics will be the ALMA Science Operations Plan, the ALMA helpdesk, regional recruitment activities, and planning the ARC mirror archives. 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 Advisory Committee met in Socorro on September 7–8, 2007. The committee found that the project was responsive to its previous recommendations and was impressed by the overall progress. The primary recommendations of the committee include: examine the correlator integration schedule for schedule recovery; and develop detailed, science-driven, task schedules for the commissioning and start-of-science phases of the project.

Figure 1. EVLA deformatter racks in the new shielded correlator room.

The primary goal of the EVLA project in FY 2007 was the retrofitting of 12 antennas to the EVLA design by September 30, 2007. This goal was achieved on September 21, nine days ahead of schedule, when antenna 25 was returned to array operations for astronomical observing. The 12 EVLA antennas now account for 43.3 percent of all antenna hours used for routine scientific observations. The electronics outfitting of Antenna 13 has begun, and the mechanical overhaul of Antenna 14 is underway.

Another project goal was completed on September 26, 2007 when the EVLA deformatter racks were relocated to the new correlator room (Figure 1). The rack relocation was necessary prior to the completion of the EVLA Antenna 13, which could not be supported in the existing correlator room due to space limitations. The rack relocation required the removal and reinstallation of all the racks and networking, fiber optics and coaxial cables supporting the 12 operational EVLA antennas. At the same time, cables were installed to support the Antenna 13. An additional rack and all of the fiber required to support the next set of 12 EVLA antennas has since been installed.

The development of wideband orthomode transducers (OMTs) for EVLA receivers continues to progress. Cryogenic testing of the C-Band OMT prototypes shows excellent sensitivity across the full 4–8 GHz frequency range, with the receiver temperature across most of the band being less than 10K. Earlier results had been less than satisfactory due to large bumps in the frequency response above 6 GHz. This degradation in sensitivity was traced to the commercial calibration couplers used in front of the low noise amplifiers. The couplers developed a high insertion loss when cooled. The prototype OMTs do show some smaller variability in sensitivity when cooled. Tests are underway to improve the thermal stability before moving on to the production phase of this unit. The RF design of the new S-Band (2–4 GHz) OMT was completed in Green Bank. The mechanical drawings of this OMT have also been completed, and a prototype will be fabricated for tests starting in December. The top level design of a new L-Band cryogenic dewar for cooling the large 1–2 GHz OMT was completed. A prototype dewar will be fabricated once the full set of mechanical drawings is complete.

The designs for the Ku-Band (12–18 GHz) feed horn and its mounting tower were completed.

Large procurements of production components have been initiated over the last three months. The new 26–40 GHz Ka-Band receiver was assembled and successfully tested, and requisitions were issued for the receiver's production components. Requests for quotation have been submitted for the production of the S-Band feed horn. Orders were placed for the gain slope equalizer in the IF downconverter module. The NSF approved the vendor selection for the 3-bit, 4Gsps samplers, and a contract was awarded to the successful vendor.

The testing of the L352 round trip phase module is nearing completion. The full scale production of the L352 modules will begin as soon as testing verifies that its performance specifications are being met.

Progress continues with the Wideband Digital Interferometric Architecture (WIDAR) correlator. The correlator chip is now in full production. The correlator group in Penticton is working with the chip contractor on developing and putting into place an appropriate production screen to minimize the possibility of chip failures on boards. Many of the components for the correlator racks have now arrived in Penticton, and the assembly of the racks has begun. The new connectivity scheme for the EVLA correlator was formally reviewed and accepted at a review in July. The new scheme improves the processing capability of the correlator and improves reliability by reducing the number of modules, racks, and high speed interconnect cables. The minor changes to the circuit boards resulting from the scheme and from initial prototype testing have been implemented. Work packages for the manufacture of the baseline and station boards have been distributed to prospective vendors.

The rollover to the EVLA Monitor and Control (M&C) Transition System took place during the last week of June 2007. The Transition System has been used continuously, with no fallback to the old VLA control system. The M&C group has focused on validating the Transition System, eliminating bugs found during its operational use, and developing and expanding its capabilities. Validation was done by examining the results of every observation conducted during the first months of operation of the array by the system. Problems were found and corrected. The need to scrutinize every result produced by the system is no longer present.

The Observation Preparation Tool (OPT) now has two component tools that work both inside the OPT and as independent applications. These are the Source Catalog Tool (SCT) and the Resource Catalog Tool (RCT). The SCT presents users with standard calibrator catalogs and also allows them to maintain their own catalogs of calibrators and observational sources. The RCT will give observers similar capabilities with respect to instrument configurations.

M. M. McKinnon and the EVLA Project Team

Socorro

VLA Configuration Schedule

Configuration	Starting Date	Ending Date	Proposal Deadline
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
A	03 Oct 2008	12 Jan 2009	2 Jun 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 2 cm and shorter wavelengths (tropospheric phase variations, especially in summer). In 2008, the D configuration daytime will involve RAs between 06^h and 11^h, and the A configuration daytime will involve RAs between 12^h and 20^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 (page 12) 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. Access NorthStar at *http://proposal.jive.nl*.

Global cm VLBI scheduling occurs only on fixed dates.

J. M. Wrobel and B. G. Clark

Observing with the VLA/EVLA Transition Array

As of the end of November 2007, there are 12 fully equipped EVLA antennas in the array, with a new EVLA antenna being added approximately every two months. As the total fraction of baselines involving EVLA antennas steadily grows, we are continually increasing the number of modes supported and improving the quality and reliability of the data. During the third quarter of 2007 we added support for multiple subarrays, phased VLA, and single-dish VLBI. Although good progress was made with planetary observing, full support for this mode is not expected until the fourth quarter of 2007. A number of problems remain, however, and users need to be aware of them in preparing proposals and observe files.

Closure errors due to the mismatched bandpasses of the VLA and EVLA antennas will remain as long as both types of antenna are in the transition array, and affect all continuum data and "channel 0" data created prior to bandpass calibration. Modified post-processing procedures are needed to deal with both continuum and spectral line data as described at *http://www.vla.nrao.edu/astro/guides/evlareturn*, and these procedures work very well.

Doppler tracking is not recommended for observations using both VLA and EVLA antennas. The fine tuning synthesizers on the VLA cause phase jumps on the VLA-EVLA baselines at the slightest change of frequency, which for Doppler tracking means that every scan will have a phase jump that cannot be calibrated. We therefore advise that all observations using VLA and EVLA antennas be carried out in fixed-frequency mode, and that Doppler tracking corrections be carried out during post-processing. Observations using subarrays of VLA-only or EVLA-only antennas can be successfully used with online Doppler tracking.

There is a DC correlator offset present in 25 MHz bandwidth spectral line data that causes a weak fictitious source at the phase center, and shows up after a couple of hours or more of integration. It has probably been present since the deployment of the new correlator controller on September 26, 2006. We have now conclusively shown that the problem goes away by turning off the correlator self-test, and as of November 12, 2007, the self-test is automatically turned off for all programs using 25 MHz spectral line mode. All users therefore need to inspect their data very carefully, and as soon as possible after the observations are completed. For observations taken prior to November 12, the effects of the offset can be mitigated to some extent during post-processing.

A filter that converts the digital EVLA signals into analog signals to be fed into the VLA correlator is causing the lowest ~0.7 MHz of baseband to suffer from aliasing. The aliased signal only correlates on EVLA-EVLA baselines; VLA-EVLA and VLA-VLA baselines are unaffected. For most narrow-band spectral line observations any line emission can be recovered by applying the AIPS task UVLSF, which has been adapted especially for this purpose. However, continuum emission cannot be reliably recovered for these narrow bandwidths, and attempts to stitch together two overlapping IFs for broader velocity coverage of spectral lines are also compromised.

All the above problems are likely to remain as long as the array continues to operate a combination of VLA and EVLA hardware, although the issues with closure errors and Doppler tracking will go away when all the antennas are converted to EVLA antennas. The remaining problems are related to the continued use of the VLA correlator. However, all but the aliasing problem have good solutions or work-arounds, and overall the array is producing very high quality data. For the latest news on these and other items, please consult our "EVLA returns" web page at *http://www.vla.nrao.edu/astro/guides/evlareturn*.

G. van Moorsel and C. Chandler

Rust Proofing of the St. Croix VLBA Antenna

Figure 1. (Left) corrosion of the bolted connections on the St Croix dish backup structure. (Right) examples of corroded nuts from the St. Croix antenna compared with an uncorroded original.

The St. Croix VLBA Antenna is situated in the "atmospheric corrosion zone" near the coast. In this zone the corrosion rate of unprotected steel is typically 8–20 mills per year. For comparison, most steel structures placed inland are situated in zones where the corrosion rate is only 1–2 mills per year. A corrosion rate of 20 mills per year means that a 1/4" thick steel plate is 50 percent consumed in just three years. Because of the high corrosion rate, steel structures near the ocean require a high quality coating system for protection.

The St. Croix Antenna was initially protected with a three part paint system that consisted of an inorganic, zinc-rich primer, and two coats of high quality epoxy paint. This type of paint system has a typical service life of approximately 14 years. Since the VLBA antenna was assembled in 1992, we have exceeded this lifetime and are beginning to see severe corrosion where the paint system has failed. This corrosion is most apparent at the bolted connections on the dish backup structure (Figure 1). The severely corroded nuts shown at right in Figure 1 were removed from the St. Croix Antenna.

The corrosion is most severe at the bolted connections because of crevice corrosion. Crevice corrosion occurs in the pockets that form when pieces of metal are held together in a lap joint, under washers, or between a bolt and a nut. Corrosion occurs when corrosive elements inside the crevice, such as salts and moisture, create a build-up of corrosion products. The interior of the crevice becomes a cathode and the exterior of the crevice shows severe corrosion because it becomes the anode.

The steel at the nuts and bolts swells, disintegrates, and flakes off in layers. This is a form of layer corrosion that starts at the edge, and proceeds within the body of the material in paths parallel to the rolling direction of the steel. The corrosion formed is greater in volume than the metal it replaced, and the layers of steel are forced apart.

Because of this corrosion, the St Croix antenna was removed from service from September through December 2007 to facilitate corrosion remediation efforts. Several hundred pounds of bolts and nuts were removed and replaced. The antenna structure was then prepared and repainted using a procedure similar to the ones developed for the maintenance coating of offshore drilling rigs.

Ultra high pressure (42,000 psi) waterjetting was used to remove all of the rust and loosely adhered original paint. UHP waterjetting was chosen over the more traditional abrasive blasting primarily because it does not require abrasives that could damage bearings and other sensitive equipment, and it also does an excellent job of removing the soluble salts that accumulate in a marine environment.

UHP waterjetting was used to remove almost all of the original coating from the dish backup structure (Figure 2). The bare metal was then coated with a zinc-rich organic epoxy primer. The remaining antenna structure was sweep blasted using the UHP waterjets. Sweep blasting removes all contaminates and loosely adhered coatings. The entire structure was then painted with aluminum flake filled, surface tolerant epoxy, and topcoated with acrylic polysiloxane paint. The aluminum flakes are platelet-like pigments that are added to the epoxy resin to create a labyrinth-like path through

Figure 2. Ultra high pressure waterjets were used to remove the original coating from the St. Croix dish backup structure.

the epoxy thereby increasing its barrier properties. The topcoat is needed to protect the epoxy undercoats from UV radiation degradation. This treatment provides an expected lifetime of 12 years, with routine maintenance.

Jon Thunborg

Green Bank

Characterization of the New GBT Azimuth Track and Pointing Model

Following the completion of the mechanical aspect of the azimuth track refurbishment project (described in the October 2007 *Newsletter*), it was necessary to characterize the performance of the new track and implement a new pointing model prior to the resumption of scheduled operations. The Precision Telescope Control System (PTCS) team was responsible for this effort, which required significant planning and development beginning a year ago in January 2007. Although there was high confidence that the refurbishment would yield a flatter and more resilient track, the possibility of remaining low-level features spurred the team to develop a robust technique for measuring track features prior to the April 30 shutdown. A key component in this effort was the suite of PTCS instruments that had been deployed on the GBT during the past few years.

To characterize the track, the centerpiece instrument is a pair of two-axis gas-damped capacitive-readout incli-

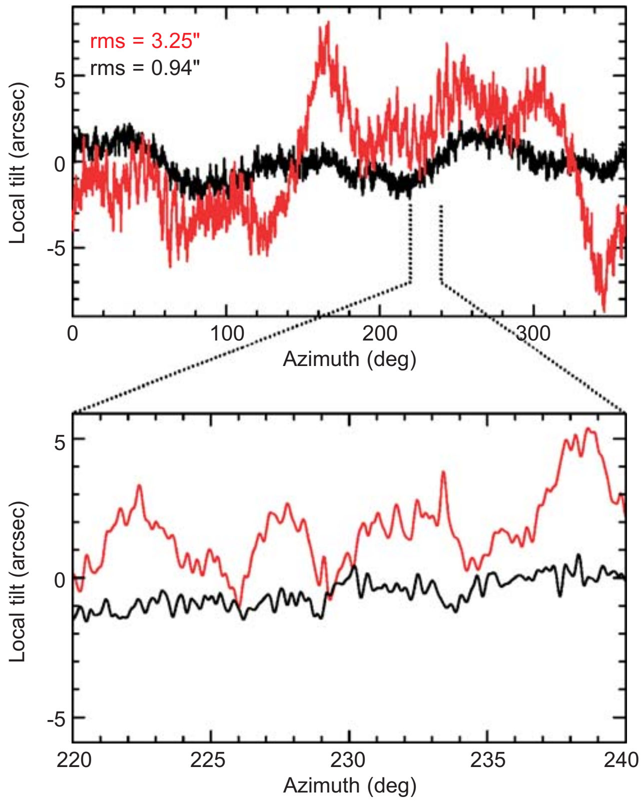


Figure 1. The local tilt as a function of azimuth in the old track (red) compared to the new track (black), as estimated by the average of the X-axis inclinometers. Top panel: the full track. Bottom panel: an enlargement of the section from 220 to 240 degrees.

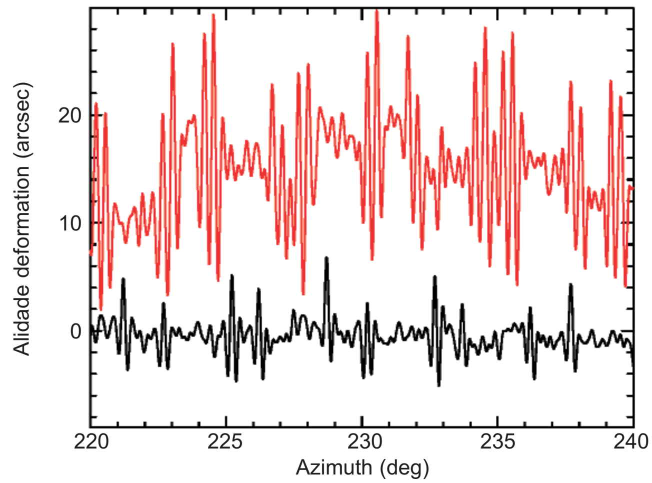


Figure 2. Magnitude of the difference signal between the two X-axis inclinometers for the old track (red) and new track (black).

nometers (from Wyler Zeromatic) mounted on the ends of the elevation axle. During early spring, the PTCS team performed two slow azimuth scans (0 to 360 degrees and back again over five hours) at a constant angular rate (approximately ten times sidereal). The inclinometer data streams from these scans were compared with the 3-axis accelerometers (co-located with the inclinometers) as well as the derivatives of the azimuth encoder. Data processing and filtering techniques were explored to remove the horizontal accelerations sensed by the inclinometers. The filtered results were examined for repeatability, proper orthogonality between the axes, and correlation with track splices. The application of a zero-phase shift, low-pass digital FIR filter to the data removes most of the unwanted signal while preserving the signature due to irregularities of the track level.

Irregularities in the track lead to pointing shifts via two primary effects: local tilt, and deformation (“twist”) of the alidade. The functional relation between a static track map and the corresponding az/el pointing shifts can be expressed geometrically and included in the pointing model. However, the coefficients for the magnitude of alidade distortion must be fit to the astronomical pointing data simultaneously with the rest of the traditional terms (gravitational and thermal). This exercise was successfully performed for the old track using pointing data from fall through spring 2007, leading to a noticeable improvement. An additional term was added to account for a small (~1") amount of hysteresis evident in the cross-scan fit results that is plausibly attributed to a velocity-independent windup of the encoder back shafts. The implementation of the new model required a modification of the antenna Monitor & Control (M&C) software which was completed and validated during the summer.

As soon as the new track was declared usable on September 3, 2007 (Labor Day), we immediately began observations. We spent the first night repeating the full azimuth scans we had done in April. These results quickly demonstrated that the new track shows a marked improvement in performance. Figure 1 shows the local tilt as a function of azimuth in the old track compared to the new track, as estimated by the average of the X-axis inclinometers. Both the large scale (tens of degrees) and small scale structure has been greatly reduced, with an rms of 0.94 arcseconds (equivalent to 5.7 thousandths of an inch at the track radius). A repeated measurement of the new track over the timescale of a week has shown the remaining features to be stable, but it will be monitored occasionally during the coming year. A further demonstration of the high quality of the new track can be seen in the reduced level of alidade distortion, visible as the magnitude of the difference signal between the X-axis inclinometers (Figure 2). There appears to be significantly less vibrational energy dissipated into the structure during azimuth motion.

Following the azimuth track scans, we obtained 90 hours of all-sky X-Band pointing scans, approximately equally distributed between day and night. These data were used along with the inclinometer data to produce a new pointing model fit. In addition to coefficients, the model produces lookup tables to account for track effects as a function of azimuth. The tables have a resolution of 0.1 degrees (equivalent to 5.6 cm along the track circumference). Of course, due to the high quality of the new track, the values in these tables are small. The new pointing and focus model (PFM5) was installed on September 26 and tested for about 24 hours before science observations resumed. In 200 nighttime measurements (10PM–8AM) scattered about the sky from elevations of 10 to 83 degrees, the blind pointing performance shows a standard deviation of 3.4" in cross-elevation, 3.7" in elevation, and 2.0 mm in focus. These rms values are improved by about 1" in elevation and 1 mm in focus over the previous model when compared under the same conditions in fall 2006 and spring 2007. For daytime performance, where residual thermal effects dominate, the current blind pointing values are 4.3", 6.5", and 6.8 mm. Future pointing runs will be done with the Ka-Band (26–40 GHz) receiver with the Caltech Continuum Backend. We hope to quantify the offset pointing performance with this setup in the near future.

Finally, another testament to the track quality is the total power stability recorded when tracking a bright source at the half-power point. During the September re-commissioning period, we obtained about 12 hours of these data under wind conditions ranging from 0–5 m/s. In the limit of no wind, the rms of the two-dimensional variable component of the tracking error is 1.5", matching the value measured when the old track was in a less degraded condition. As expected, the effect of wind still contributes an additive term equal to 0.15" times the square of the wind speed in m/s. The zero-wind performance is presently limited by the servo, which the PTCS team is working to address through a program of servo improvements.

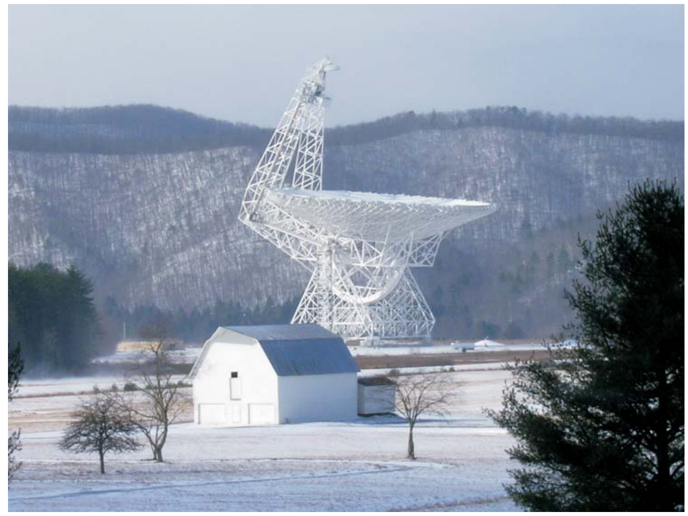
T. R. Hunter, K. T. Constantikes, F. Ghigo, J. Brandt, and R. Grider

The GBT Dynamic Scheduling System

The GBT spans a larger range of frequencies than other comparable single-dish telescopes, and is located in a continental, mid-latitude region where weather is dominated by water vapor and small-scale effects. As a result, the observing efficiency of the GBT can be enhanced significantly by dynamically scheduling observations best matched to weather conditions.

To date, the GBT has employed a simple form of dynamic scheduling in which two projects, one high-frequency and one low-frequency, are scheduled together in two sessions (spaced typically by two days). The high-frequency observer is allowed to choose which of the sessions he or she would like to use. The second is used by the low-frequency observer. This scheme often results in high-frequency observers receiving little or no time if they wait for truly high-frequency weather, which compromises the ability to discharge these projects, and could delay completion of low-frequency projects if high-frequency observers choose substandard conditions to execute their observations. Additionally, not all high-frequency programs require the same weather—conditions which may be ideal for 26 GHz observations are not necessarily the best for 48 GHz, and vice-versa. The new Dynamic Scheduling System (DSS) will allow observers to optimally match their desired weather conditions to their observations, resulting in considerably increased observing efficiency.

An improved scheme, and the accompanying software and hardware, for dynamically scheduling science on the GBT is required to make the most efficient use of telescope time, which is in high demand. This must be delivered however in a way which minimizes the burden on the GBT observer. These are the two primary goals of the GBT Dynamic Scheduling System (DSS). A successful implementation of the DSS should increase the average observing efficiency at high frequencies with the GBT by approximately 50 percent while ensuring that the flexibility and ease of use of the GBT is fully retained, and the data quality of observations is not adversely affected.



A photograph of the GBT taken in December 2007 by Dave Finley.

One of the primary benefits of single-dish radio observations is the ease with which observers can make on-the-fly decisions regarding their data and observing process. Additionally, the GBT was built with the flexibility to allow users to bring in their own hardware for observations, an idea which has proven to be highly successful. As these instruments are often not fully integrated into the GBT monitor and control software system, users need to be able to interact with their hardware in real time during observations.

The flexibility of the GBT—the ability to observe from 0.300–90 GHz, observer-created observing routines and telescope patterns and a large number of observatory supported front and back-ends—means that data quality assurance is a formidable issue. To date the issue has been dealt with by requiring project investigators to acquire the data for their project in real time and so be responsible for the data quality of their own projects. Any move away from this scheme, e.g. to a queue-based system wherein Green Bank staff run an observing project, would require both GB staff having a detailed understanding of the scientific requirements of every project and a data reduction pipeline for all queue based projects (to allow the staff to assess the data quality).

The GBT DSS team is implementing a dynamic scheduling system that schedules observing sessions, not individual observations, unlike the standard queue-based system that other telescopes use. At the start of a trimester, observers will be asked to indicate when they will be available to observe. Within the time periods observers themselves specify, they will be notified well in advance if their project is likely to be run. Then every 24 hours the DSS will create a schedule for the GBT from the pool of available projects. A minimum of 24 hours before their observations start, the relevant observers will be notified that their observations have been placed on the schedule. The weather will then be monitored by the DSS in real time. If at any point the weather has deteriorated such that the scheduled project cannot be run, a back-up project (which has been pre-approved and can be run in the available weather) will be run in its place. The back-up project may be run with the GBT support staff running the experiment and monitoring the data quality, or it may be run by a project investigator who has agreed to be notified at the last minute, depending on the wishes of the project investigators and the complexity of the project.

One of the components of the GBT DSS which will both improve the ease of use of the GBT and make the DSS plans feasible is the implementation of an observer's availability calendar for each project. With this calendar each observer can note the times he or she cannot be available for observing, blocking anything from an hour to months. The exciting part of this system is that any observer can update it at any time and that information will be immediately and automatically fed into the scheduling software. As a result it will be extremely easy for observers to make sure that GBT observing does not conflict with any other commitment. The DSS team is looking into the best method for notifying observers of the probability of their projects being scheduled over a ~1 week period, which will aid observers in knowing when they may be scheduled on the telescope.

There are, of course, many other details to the GBT DSS, such as the ability to schedule monitoring and fixed time observations, a ranking scheme for scheduling the projects, etc.

In addition to improving the observing efficiencies for high-frequency observers, the DSS will allow for more flexible use of the GBT. This will benefit both high and low-frequency observers in many ways, including:

- Observations affected by transient RFI can be halted and seamlessly rescheduled;
- System faults (both in hardware and software) will be easier to work around, and to schedule fixes, making the running of the GBT smoother and more efficient;
- Any "make-up time" needed for a project will be easily rescheduled, allowing the observations to be completed within the requested trimester;
- Rapid Response Proposals will be scheduled without disrupting another observer's scheduled time;
- Observers will be able to state when they wish to travel to Green Bank for observations, rather than being told by the telescope scheduler when to arrive;
- Observers will be able to change their availability for observing even as the trimester progresses rather than only a few months before a trimester begins;
- Observers will be able to block out many small amounts of available time (e.g. when teaching classes) rather than needing to schedule classes around the pre-existing schedule;
- Observers will have the ability to observe a small part of their allotted time and then request a few days (or more) to analyze the data before using more telescope time;
- Complicated monitoring programs will be easily handled by the DSS;
- The GBT scheduling process will be transparent, allowing users to discern the likelihood of attaining telescope time as the trimester progresses.

The main deliverable of the DSS project is the complete adoption of an easy to use, significantly improved and more efficient dynamic scheduling system for all GBT telescope time. This includes delivery of all the tools necessary to make dynamic scheduling possible. While developing these deliverables, we will strive to keep ease of use high for observers, investigators, and support staff.

Release of the DSS is not planned until late 2009. However, a prototype of the new DSS will be tested during the GBT's 08B trimester (beginning June 1, 2008). All observers taking part in the test will be encouraged to provide feedback on their experience. This feedback will allow the DSS team to insure that when the system is fully deployed it is a system all GBT observers can readily use. As a result of the planned tests, all observers applying for time at the February 1, 2008 proposal deadline should be prepared to participate in this exercise.

The DSS tests will result in no change to the proposal preparation and submission process. Once the refereeing process is complete, all information available from the proposal submission tool (PST) and pertinent for the DSS will be transferred from the successful proposals. At this point project investigators will be contacted regarding how to modify the information brought over from the PST to insure all information in the DSS database is correct and to make any modifications to that data which is desired. This will allow for accurate and efficient scheduling of the accepted projects.

GBT staff will, as always, be available to help observers both in working with the observing information in the DSS database and also with understanding the new dynamic scheduling scheme. It should be noted that the DSS alters only the scheduling process for the GBT and will not affect the observing interface (e.g. Astrid) in any way.

Further information on the new GBT Dynamic Scheduling System can be found online at *http://www.gb.nrao.edu/DSS*.

Karen O'Neil

Ka-Band Commissioning Results with the GBT Spectrometer

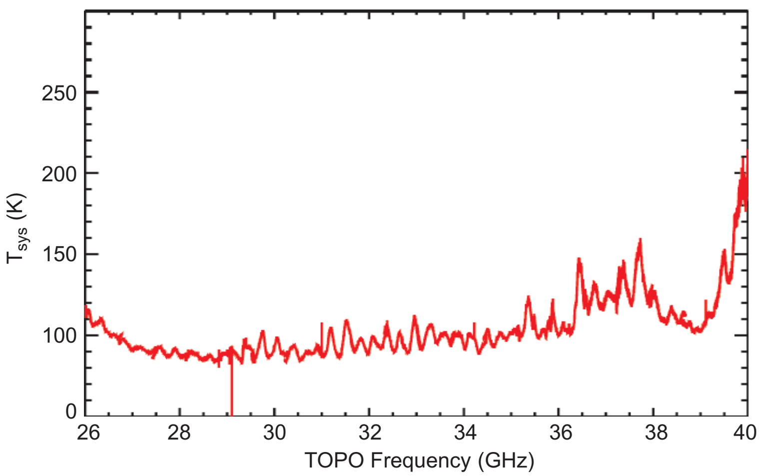


Figure 1. Ka-Band system temperature for channel R1.

In the previous *Newsletter*, we described the new single channel, dual feed configuration of the Ka-Band (26–40 GHz) receiver. This new configuration was implemented to improve system temperatures and baseline structure that inhibited broad line spectroscopic measurements with the receiver. The receiver was installed on the telescope in September, and we have conducted a number of on-sky tests with the GBT Spectrometer utilizing the new subreflector nodding modes. The results of these tests are summarized here; further details are available in the GBT memo series *http://wiki.gb.nrao.edu/bin/view/Knowledge/ GBTMemos*.

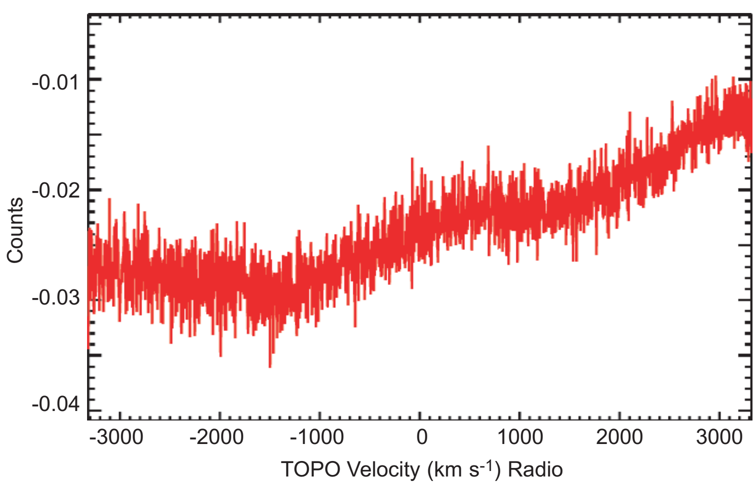


Figure 2. Spectrum of blank sky around 34.5 GHz in units of antenna temperature after 7.5 hours of observing. This spectrum has not had a baseline removed.

We measured the noise diode and total receiver system temperatures across the entire bandwidth by observing 3C48 and 3C286 in better than median weather conditions. The system temperatures (shown for one channel in Figure 1) have dropped to 35–60 K (down from 50–100 K) across most of the band. This is an improvement of ~25 percent over most of the band, and is much more at the high frequency end. Between 35–37 GHz the system temperatures are comparable to the old configuration. There is a 300 MHz ripple visible in Figure 1 that is smoother and broader than the structure previously seen with this receiver.

Figure 2 shows an average spectrum from 7.5 hrs of observing at 34.5GHz. The residual ripple is predominantly a ghost of the ripple in the system response, and should be removable by appropriately applying a vector temperature calibration, a procedure which is currently being developed at Green Bank. Since expected line widths (500 km s^{-1}) are much narrower than the ripple period, this structure will not compromise most experiments. Overall, this spectrum represents a dramatic improvement over the previous configuration of the receiver.

Users of the refurbished Ka-Band receiver will also benefit from the newly developed subreflector nodding observing mode in Astrid. The "SubBeamNod" command will nod the subreflector between the two beams of the Ka-Band receiver with the user providing a half-cycle time and a scan length. Half-cycle times are limited to be greater than 4.4 seconds or three integrations of the Spectrometer, but longer cycle times can be used and will reduce observing overhead. Subreflector nodding can be done for no more than 45 minutes before a Focus observation should be made to limit wear on the actuators. Note that subreflector nodding is currently limited to the Ka-Band receiver only. Tasks to automatically process this data in GBTIDL will be available shortly. Finally, there are a number of changes in how the receiver is configured and how GFM deals with pointing data. Observers should consult their support person for details on using the new system.

D. J. Pisano, R. Maddalena, G. Watts, and K. O'Neil

Zpectrometer Commissioning Results

The Zpectrometer, described in detail in the October 2007 *Newsletter*, resumed observations with the modified Ka-Band receiver in early October 2007. Figure 1 is a first-light spectrum of the W51 HII region divided by Jupiter's spectrum. Different colors in the spectrum denote the Zpectrometer's four sub-bands, which line up well without correction of any kind. The overall slope shows the spectral index ratio of W51 to Jupiter. Fine-scale ripples across the spectrum are a residual of the receiver's noise power spectrum left after observations of a strong continuum source. The lower frequency scale shows the Zpectrometer's instantaneous band, from 24 to 36 GHz; this band corresponds to z of 2 to 3.5 for the redshifted CO J=1-0 line, as shown on the top scale.

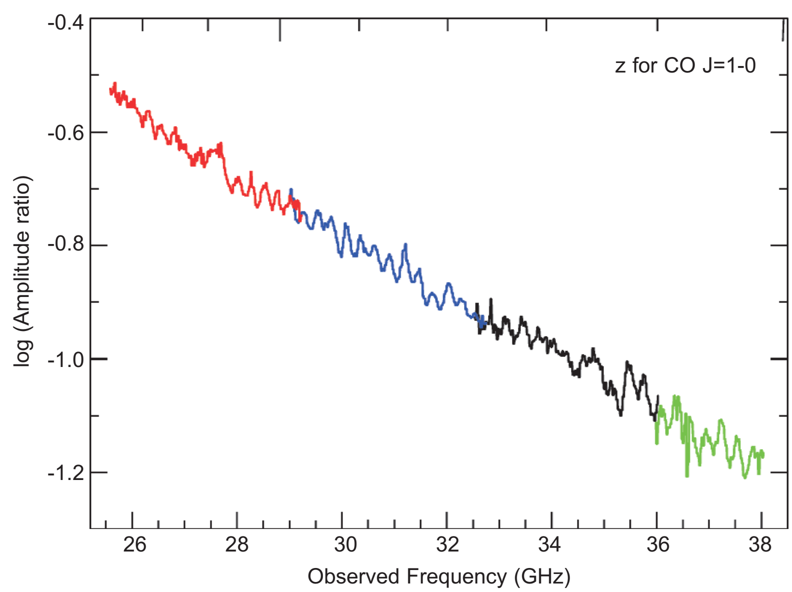


Figure 1. First light spectrum from Zpectrometer; W 51 divided by Jupiter - October 8, 2007.

Science observations of dusty galaxies with high but imprecisely known (or unknown) redshifts are now underway; detecting CO lines from such sources was the principal purpose of building the ultra wideband Zpectrometer. A combination of position switching between nearby sources and fast nodding has proved necessary to cancel a small offset left by fast nodding alone. Such simultaneous searching for lines in two sources is only possible because the Zpectrometer observes the entire receiver band at once, with no retuning between sources required. With this observing pattern, the spectral baselines are generally reasonably flat to the mJy level.

A. Harris, S. Zonak, and A. Baker

Configurable Instrument Collection for Agile Data Acquisition (CICADA)

CICADA, a development program to design and build instruments for data collection and processing using off-the-shelf hardware, has been very active. We have several concurrent projects underway, including a new Pulsar Processor, Graphical Processing Unit (GPU) cluster research, and Spectrometer design work.

After beginning the program in collaboration with the University of Cincinnati, the first hardware project to be completed under this program is the event capture system developed by Glen Langston and West Virginia University students for deployment on the NRAO 43 meter telescope. The system was built with FPGA technology from the CASPER group at UC Berkeley to capture dual polarization, 1 GHz bandwidth bursts of data using a triggering algorithm to identify short duration events. The project design and initial tests are documented at *https://wikio.nrao.edu/bin/CICADA/CicadaNotes*.

In collaboration with the NRAO Office of End to End Operations, our next project to be deployed will be the Green Bank Ultimate Pulsar Processing instrument (GUPPi). GUPPi will also be built with FPGA technology from the CASPER group at UC Berkeley. Plans are to deploy the first version of GUPPi in January 2008 as a spigot replacement, with coherent dedispersion over 800 MHz of bandwidth available in a second version to be available in June. Both of these instruments will begin life as expert user instruments until software development resources become available to complete the integration into the GBT system. We expect this to occur in FY 2009. The GUPPi project held a workshop in late October to get the design team together with students and scientists from West Virginia University, the University of California at Berkeley, and Cal Tech. Work is underway in Green Bank, Charlottesville, and West Virginia University on the hardware, software, and gateware.

With the NRAO Office of End to End Operations, work is underway in Green Bank and Charlottesville on research into acceleration of numerical computation using GPUs. In contrast to general purpose CPUs, GPUs are optimized for fast parallel computation as is needed for computer graphics applications. Utilizing these GPUs holds the promise of 10 to 100 times speedup for certain numerically intensive algorithms often employed in radio astronomy, along with greatly reduced power consumption per GFLOP. We have assembled a cluster of eight GPU cards in four computers, all tied together with multiple Gigabit Ethernets. A ten Gigabit Ethernet connection is also available for use by each of these cluster machines. Several members of the team from both Green Bank and Charlottesville attended the AstroGPU conference in Princeton, NJ, as well as the IEEE/ACM Supercomputing ’07 conference, to become more familiar with leading edge scientific computing.

J. Ford and A. Shelton

Beam-Forming Array and RFI Mitigation Trials at Green Bank

Jonathan Landon, one of the Green Bank summer students, had a busy time assembling a 19-element focal plane array and data acquisition system for installation on the 20-meter telescope. He and his faculty and student colleagues at Brigham Young University returned in November for more than a week of extensive measurements to test beam-forming and RFI canceling algorithms under realistic observing conditions. Professors Brian Jeffs and Karl Warnick from BYU have been collaborating with NRAO staff members Fisher, Bradley, and Norrod on RFI and feed array research for the past six years. Jonathan is one of about a half dozen students who have been involved in this work as part of their graduate research.

The BYU effort has been funded through NSF ATI grants and has concentrated on algorithm development, modeling, and signal processing. By the end of 2006 they had their 19-element, room-temperature, L-Band focal plane array running on one of their 3-meter antennas on top of the BYU Electrical Engineering building. The next step was to put this array on a larger antenna so in early 2007 they proposed to bring

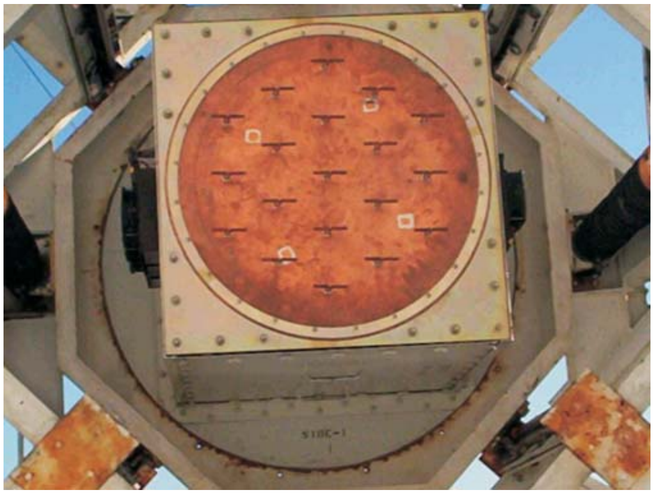


Figure 1. The array receiver on the 20-meter telescope.

their array receiver to Green Bank and install it on the 20-meter antenna. After initial inspections of the mothballed 20-meter antenna showed it could be reactivated with reasonable effort, support for the idea in Green Bank was enthusiastic.

The 20-meter antenna was constructed in 1994, funded by the USNO to be part of the National Earth Orientation Service telescope network. The 20-meter operated successfully in this network until June 2000, when budget cutbacks at USNO led to the end of 20-meter participation, and the antenna had been unused since then. After the GBT track replacement project was finished the Green Bank Electronics and Telescope Operations divisions set about the tasks of cleaning and making minor repairs to the 20-meter drive system and installing cables for the array. By mid-October the telescope was ready, so Jonathan returned with another BYU student, David Jones, to finish installing their receiver in a surplus NRAO front-end box and putting their computers in a shielded rack.

Initial results from the 10-day observing session in early November were very encouraging. One of the challenges of an array is to optimize the beam-forming weights for best sensitivity (effective aperture divided by system temperature). Within a few hours of the observation of a strong radio source, Karl had worked his matrix algebra magic to demonstrate a 36 percent increase in signal-to-noise ratio between single-element and combined multi-element array outputs. The results are shown in Figure 2. Using system receiver temperatures measured in the lab before installation on the 20-meter, calculated aperture efficiencies were close to expected values.

Beam-forming arrays offer the potential for reducing interference to radio astronomy observations by placing nulls in the directions of RFI sources in the beam-forming process. The challenge here is to steer and track the nulls on the RFI without modifying the gain and shape of the main telescope beam and without changing the system noise within the severe tolerances of radio astronomy. In simulations and field tests with small reflectors on the BYU campus, Brian has shown that constraints can be placed on the nulling algorithms to stabilize the telescope beam and spillover noise. He now has gigabytes of data on disk to test his ideas on weak celestial radio source observations. Initial results from his signal processing of 20-meter data are shown in Figure 3.

The two open-ended frontiers in radio telescopes are collecting area and field of view. Beam-forming arrays are a form of radio camera aimed at expanding our field of view by as much as 100 times or more. This will open up new areas of science, such as transient radio sources and pulsar-black hole binaries, and allow astronomers to expand the inventory of rare and interesting objects.

Beam-forming arrays are being vigorously developed at a number of observatories around the world, most notably in Australia, Holland, and Canada in connection with the SKA project. Their scientific goals require arrays with quite wide bandwidths, which present some challenging design problems. We have

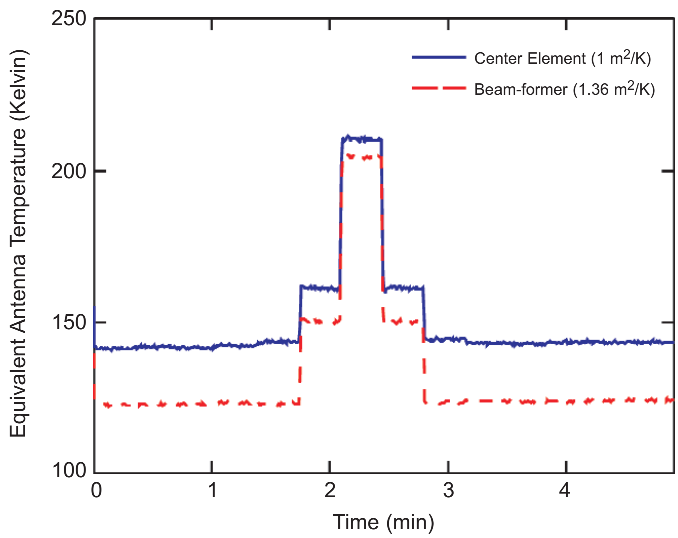


Figure 2. Telescope measurements on the radio source Cygnus A. Each 20-second section of data is a different telescope pointing with the highest values in the center when Cyg A was in the beam center and the two plateaus on either side when the beam was offset by about 1/4 beamwidth. Note the higher deflection on Cyg A, the lower system noise power (some spillover noise cancelled), and the lower sidelobe levels when the array elements are properly combined in the beam-former.

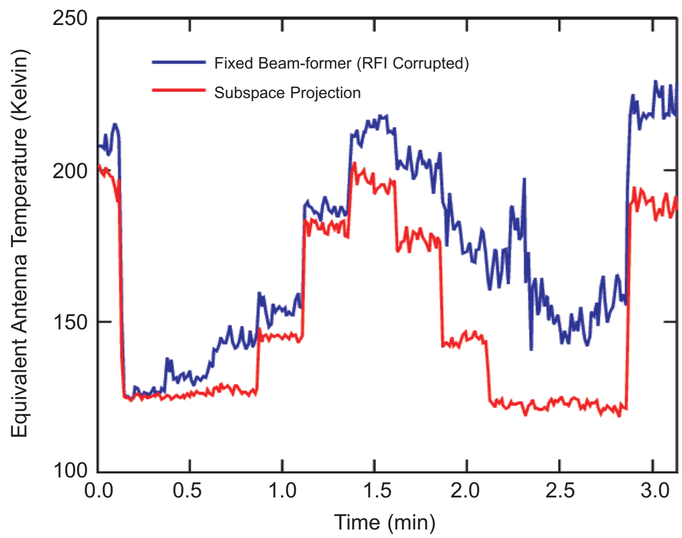


Figure 3. Another scan of the telecope through Cyg A, this type with a moderately strong interference source in the receiver bandpass. The red curve shows the result of processing of the array signals to null the interference seen in the blue curve using the same data.

chosen a complementary approach that emphasizes very low system temperatures (as good as current single beam receivers) in more modest bandwidths. In the end we all want very low noise and wide bandwidth arrays so there is much to be learned from one another. There is a lot of engineering R&D yet to be done to make array system temperature competitive with our best single-beam receivers.

More information about the BYU-20 meter experiment project is available at: *http://wiki.gb.nrao.edu/bin/view/Electronics/ByuFpa.*

R. J. Fisher and R. D. Norrod

Education and Public Outreach

New NSF-Funded Project to Involve High School Students in Cutting-Edge Research

You know that good idea relegated to the back drawer because it's not quite practical, or ready? It can sit there dormant and then suddenly burst forth into a project whose time has come. Such is the case with a new project involving the NRAO and West Virginia University: *The Pulsar Search Collaboratory*.

The idea—to involve high school students in the search for new pulsars—was hatched during a casual conversation with board members of West Virginia Experimental Program to Stimulate Competitive Research (EPSCoR) back in 2001. At that time, the brand new Green Bank Telescope was making a splash in the news. We wondered how GBT data might be used in a project similar to the popular distributed computing program called *SETI@home*, but we wanted the project to be more interactive with more learning taking place, and with a real chance of discovery.

Searching for pulsars immediately came to mind. But the idea ended up in the "back drawer" for several reasons:

- People/time constraints–Green Bank staff were consumed with GBT commissioning duties;
- Technical Limitations–the smallest useful "work-units" of raw pulsar data were still too large to distribute over the internet;
- Data Collection–how would we gather and store data for the project without compromising the normal scientific use of the telescope? Developing a piggy-back system (like the SERINDIP project) with which to acquire data would require significant funds, and we had none.

And then, one year ago, the idea resurfaced and we knew the time was right:

- Two new physics faculty at WVU just happened to be pulsar astronomers (Maura McLaughlin and Duncan Lorimer);
- Plans to replace the GBT track had precipitated a large proposal to conduct a 350 MHz drift survey for the purpose of searching for new pulsars. This survey would amass over 100 terabytes of data;
- The State of West Virginia had just launched a new ambitious agenda to improve "21st Century skills" in its K-12 students.

A group of NRAO staff met with faculty in the physics and engineering departments at WVU last December and decided in short order to seek NSF funds to train West Virginia high school teachers and students, and to submit an educational proposal to NRAO to secure additional drift survey data that would belong to students.

The result of our intense activity over last spring was the excellent news from the NSF in September—an $892,838 grant to NRAO and WVU to conduct a three-year program called the Pulsar Search Collaboratory (PSC). The project will involve 60 teachers and some 600 students in helping astronomers analyze data from 1500 hours of observing time on the GBT last summer. The 120 terabytes of data produced by 70,000 individual pointings of the telescope is expected to reveal dozens of previously-unknown pulsars. Of the 1500 hours of GBT observing data in the project, about 300 hours are reserved for analysis by the student teams.

Each year, the PSC program will include summer training for West Virginia teachers and high school students at Green Bank. During the following academic year, student teams will analyze parcels of data from the GBT to discover pulsars. To do so, they will learn to use analysis software and to recognize man-made radio interference that contaminates the data. Each portion of the data will be analyzed by multiple teams, who will share their findings with each other through an online collaboration site called the "Collaboratory," operated by Northwestern University. The capstone event for each year is a three-day scientific seminar at WVU where all students and professional astronomers will present their research.

The project is now inviting applications for a postdoctoral appointment, which will be split 50 percent independent research and 50 percent as Project Director for the PSC. Working closely with the PSC team, the Project Director will lead the development of this exciting and innovative project. For more information, visit AAS Job Register posting # 24187. You can also contact project PI Sue Ann Heatherly at *sheather@nrao.edu*, and Co-Is Maura McLaughlin at *maura.mclaughlin@mail.wvu.edu*, and Duncan Lorimer at *duncan.lorimer@mail.wvu.edu*

Sue Ann Heatherly

New Radio Show to Begin Airing in January

The NRAO and Allegheny Mountain Radio are pleased to announce the launch of a new radio show designed to bring the space-age science of radio astronomy down to earth. We call it *Cosmic Radio*. The short programs (there are 26) cover a wide range of topics, from notable events in the history of radio astronomy to fundamental concepts, to recent and exciting discoveries.

Within the next couple of weeks we will be distributing the complete Cosmic Radio series on CD to over 500 NPR affiliated stations. We have also developed a website which will be updated weekly with a new program. Check it out and listen to our first show at *http://www.nrao.edu/cosmicradio/.*

Funding for *Cosmic Radio* was provided to Allegheny Mountain Radio by the Corporation for Public Broadcasting. The concept is modeled after the venerable *StarDate* program, with the exception that it will be broadcast weekly rather than daily.

Our goal is to increase public awareness of radio astronomy, and the NRAO, and we hope it is a huge success! You can help, by making radio stations in your area aware of the series. Contact your favorite radio station and tell them you want *Cosmic Radio* on the air. Although we are targeting NPR affiliates, commercial stations are also welcome to run the program on a sustaining basis, but can not sell advertising sponsorship. And, it's free! Station managers can contact us through the website.

Sue Ann Heatherly

Green Bank Celebrates 50th Anniversary with Open House

In celebration of 50 years of great science in a great community, the NRAO-Green Bank held an open house on October 21. At 11 AM, about 80 Green Bank staff, family members and volunteers donned their pumpkin colored t-shirts, took their places and waited for the first visitors to appear. And appear they did! Based on bus tickets issued for tours of the GBT, we estimate that over 600 people participated in the event.

The event was an eclectic mix of science demonstrations, lectures, make-and-take activities and behind the scenes tours of the electronics lab, machine shop, GBT control room and of course the GBT itself. As the public visited various locations they learned about RFI, controlled a simulated GBT with NRAO software and

Open House attendees watched the GBT move rapidly as it completed pointing tests.

watched the GBT move rapidly as it completed pointing tests. Our machinists operated a CNC milling machine to make NRAO key fobs which were handed out to the admiring crowds. And of course, being an NRAO event, there was plenty of liquid nitrogen on hand to wow the young and old. As the public wandered about they completed a scavenger hunt consisting of 20 questions which entitled them to enter their names into a drawing for prizes, including a 6-inch dobsonian telescope. The Pritts family of Roanoke Virginia were the happy winners.

In addition to all of the family members of Green Bank staff who helped host the open house, we'd like to thank Central Appalachian Astronomy Club members who volunteered their time (and traveled two hours to do so), treating visitors to views of solar flares through a variety of H-alpha telescopes, Bob Rood of UVA and Dale Frail who joined our local scientific staff in

Open House attendees had an eclectic mix of make-and-take activities.

giving astronomy talks, Mark Adams, who assisted in a variety of ways, and members of the Pocahontas County High School Spanish Club who grilled hundreds of hot dogs.

The public was as enthusiastic as we were, leading us to the realization that we shouldn't wait 50 years for the next open house event!

Sue Ann Heatherly

Chile Celebrates Its First International Astronomy Seminar

The first International Astronomy Seminar in Chile, organized by the Chilean Ministry of Foreign Affairs, was celebrated December 4–6, 2007. The minister of Foreign Affairs, representatives of public institutions, international astronomical observatories in the country, and local scientific organizations were in attendance at this event.

The international character of this event was due to the participation of foreign institutions located in Chile, such as NRAO, which are in charge of important astronomical projects in different regions of the country. These international institutions were invited to participate in this seminar by the ministry.

In addition to the aforementioned participants, public representatives, such as the National Council of Scientific and Technological Investigation (CONCYT), the Chilean Astronomical Society (SOCHIAS), and different local universities that offer a career in Astronomy, were also invited.

The goal of the Ministry of Foreign Affairs was to demonstrate how the scientific projects developed by different international institutions are strengthening the growth of astronomy in Chile, and also how they are consolidating worldwide the position of the country as a leading nation in this scientific area.

The Atacama Large Millimeter/submillimiter Array (ALMA), the Very Large Array (VLA), the Green Bank Telescope (GBT), and the Very Long Baseline Array (VLBA), among others observatories, were presented to the public attending this event, that also included a presentation by Eduardo Hardy, Representative in Chile, Associated Universities Inc. and National Radio Astronomy Observatory.

This event was the opportunity for not only showing the local situation of this discipline to astronomers and the scientific community, but to also present astronomy to secondary education students who are interested in astronomy as a possible career. First, the latter group attended an educational speech supported by audiovisual material on different aspects of astronomy. Then they visited interactive stands which detailed different themes associated with the observatories in Chile today and those projected for the future.

Also, the organizer and participants decided to offer various presentations to cover the most important astronomical developments in Chile. These conferences were given by representatives from most of the participating institutions, in order to give the attendees a global vision of astronomy.

This event presented astronomy with all of its potential to different audiences, establishing this science as an area of interest for the whole local community.

Sergio Cabezón

Magdalena Book Fair Benefits Sister City

When the library at the Magdalena schools had its book fair in 2007, it came with an extra twist. The students were given the opportunity to purchase books,

NM students deliver books to the librarian.

not only for themselves, but for students in Magdalena's Sister City of San Pedro de Atacama in northern Chile. The students' efforts resulted in a shipment of eight boxes of books to Chile in December.

Magdalena and San Pedro embarked on a Sister City relationship a year ago, building on their commonalities of population, interest in tourism and nearness to a world class radio telescope. In February 2007, Myriam Rivera, Gabriela Rodriguez and Sandra Bernal, San Pedro High School's Principal, Tourism Teacher and the mayor of San Pedro respectively, traveled to Magdalena for a two week visit. In July 2007, Magdalena teachers Sandra Montoya and Jim Sauer made a reciprocal visit to Chile.

Sauer and Montoya visited the San Pedro elementary school. It was an old building, scheduled for replacement this summer—December to February in the southern hemisphere. Across the street is a brand new library that serves both the school and the general public. The Magdalena teachers opted to spend a portion of the proceeds from the Book Fair on new books for the San Pedro school and library, as well as donating some of Magdalena Elementary School's beginning readers in Spanish.

Associated Universities, Inc. funded the teacher exchange and the shipping charges for the books.

Robyn Harrison

In General

2008 Jansky Lectureship

The National Radio Astronomy Observatory invites nominations for the 2008 Jansky Lectureship *http://www.nrao.edu/jansky/janskyprize.shtml*.

The Karl G. Jansky Lectureship is an honor established by the trustees of Associated Universities, Inc. to recognize outstanding contributions to the advancement of radio astronomy. First awarded in 1966, it is named in honor of Karl G. Jansky who, in 1932, first detected radio waves from a cosmic source.

Please send nominations, including no more than <u>one</u> supporting paragraph, by COB February 15, 2008, to *borahood@nrao.edu* or Office of Science and Academic Affairs, National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville, VA, 22903-2475.

Billie M. Orahood

Opportunities for Undergraduate Students, Graduating Seniors, and Graduate Students

The NRAO is accepting applications for the 2008 NRAO Summer Student Research Assistantships program through January 28, 2008. 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 supervisor's 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.

Toney Minter

NRAO Student Observing Support Program

NRAO maintains a program to support research by students, both graduate and undergraduate, at U.S. universities and colleges. This program is intended to strengthen the proactive role of the Observatory in training new generations of telescope users. At the current time, regular proposals submitted for the Green Bank Telescope (GBT), the Very Long Baseline Array (VLBA) and the High Sensitivity Array (HSA) are eligible for funding, while regular VLA proposals are not. Large proposals for the VLBA, GBT, HSA, VLA, and any combination thereof, are also eligible.

Since the July 2007 NRAO *Newsletter*, seven awards were offered for Large Proposals. Six were on the GBT and one was for the VLBA.

For more details on this program and the application process, please visit *http://wiki.gb.nrao.edu/bin/view/Observing/NRAOStudentSupportProgram*.

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

Awards for Large Proposals

STUDENT	INSTITUTION	PROPOSAL TITLE	NUMBER	AWARD
T. Robishaw	UC Berkeley	The New Extragalactic Magnetometer: Zeeman Splitting in OH Megamasers	BR125	$23,000
B. Zeiger	U of Colorado	Formaldehyde in the Gravitational Lens PKS 1830-211	GBT07C-056	$15,400
J. Jun	U of Michigan	The Detection of Redshifted Hot Baryons with the NVII Line	GBT07C-030	$11,000
J. Boyles	U of W Virginia	Continued Radio Timing Observations of RRAT Sources	GBT07C-044	$6,500
S. Brown	U of Minnesota	Probing Magnetic Fields on the Largest Scales	GBT07C-045	$18,500
A. Kepley	U of Wisconsin	Magnetic Fields in Irregular Galaxies	GBT07C-029	$35,000
D. Watson	Vanderbilt U	Angular Momentum and Chemical Evolution of Pre-Stellar Cores in Ophiuchus	GBT07C-014	$19,000
L. Weintraub	Caltech	Investigating the Radio-Source Environment of Clusters in the OCRA SZ Samples	GBT07A-040	$35,000

First Announcement of the Eleventh Synthesis Imaging Workshop

The Eleventh Synthesis Imaging Workshop will be held at the NRAO and the New Mexico Institute of Mining and Technology in Socorro, NM, on June 10–17, 2008. In addition to introductory lectures on radio interferometry, advanced topics will cover a selection of new synthesis instruments, including the Atacama Large Millimeter/submillimeter Array (ALMA), the Expanded VLA (EVLA) and the Long Wavelength Array. The workshop will also feature hands-on data reduction tutorials, and tours of the VLA and the Array Operations Center. Attendance at the Synthesis Imaging Workshop will be limited to 150 people. 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 at the same web page. Full registration will open February 1, and will be on a first-come-first-served basis. There will be a registration fee of $150, which includes a copy of ASP Conf. Ser. Vol. 180, *Synthesis Imaging in Radio Astronomy II*. There will be support available for participants from selected New Mexico institutions, please contact Amy Mioduszewski (*amiodusz@nrao.edu*) for further information.

Information for participants outside the U.S.: it is our understanding of current U.S. policy that attending a scientific workshop in the U.S. should only require a visitor visa. Should you find you need a letter of invitation, please contact Amy Mioduszewski. Due to processing delays we strongly encourage you to start paperwork early.

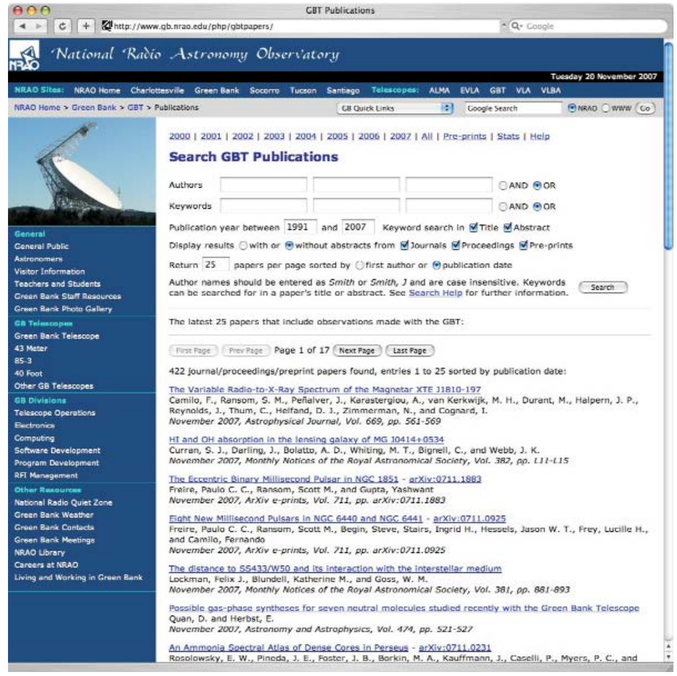
The Synthesis Imaging Workshop is sponsored by the National Radio Astronomy Observatory, the New Mexico Institute of Mining and Technology, the University of New Mexico and the New Mexico Consortium's Institute for Advanced Studies.

Amy Mioduszewski

A New GBT Publications Database

The new GBT Publications Database contains abstracts of published papers that include astronomical observations made with the GBT or technical reviews of the GBT and its associated systems. In the majority of cases these abstracts have been obtained from ADS in order to showcase the capabilities of the GBT to the astronomical community. The database can be searched via a PHP driven web page, publicly available at *http://www.gb.nrao.edu/php/gbtpapers*, where the default behavior is to display the latest 25 GBT related papers. The GBT Publications search form is very simple, and not intended as a replacement to the sophistication provided by ADS. However, the user can locate GBT related papers quickly (with or without full abstracts), and distinguish between peer reviewed papers, conference proceedings or preprints. Search options include author names, keywords and publication year. Quick links are also provided at the top of the page for individual years, preprints and publication statistics. The title of each paper listed is normally a link to the paper's ADS entry, with preprints also having an arXiv link. There is also a Help page which explains how to use the search form, and the logic employed when the MySQL database is queried.

An *Add Abstracts* tool allows NRAO staff to add papers to the database by ADS bibcode, journal/year/volume/page, or by searching for the strings "GBT" and "Green Bank Telescope" in recent journal titles



and abstracts. The tool checks for existing database entries and also recognises when a paper changes from a preprint to a published article. The system also maintains a list of bibcodes, which ADS harvest for their new GBT group search filter.

So that GBT papers can be easily identified, GBT users are encouraged to always mention the GBT in the abstract of their papers. If you are aware of a paper that should be included in the GBT Publications Database, please email *gbtpubs@nrao.edu*, quoting either the ADS bibcode or the journal, year, volume and page number.

Paul Ruffle

NRAO Library Corner

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PUBLISHERS AND PAGE CHARGES:

As most of you are aware, IOP is now publishing Astronomical Journal (and will be publishing ApJ in 2009). The page charge method for IOP is quite a bit different than UCP, so please let the Observatory Librarian know about papers and send the new IOP form to me at *library@nrao.edu* or 434 296-0278.

Marsha J. Bishop

Further Information

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

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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.

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