NATIONAL RADIO ASTRONOMY OBSERVATORY

Newsletter

January 2005

Issue 102

ALMA Progress Update

ALMA, NRAO, and Astronomy in Chile

EVLA Project Progress Report

The GBT Finds a Low Cal Sugar: Glycolaldehyde

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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 result obtained using NRAO telescopes that could be featured in this section of the NRAO Newsletter, please contact Jim Condon at *jcondon@nrao.edu*. We particularly encourage Ph.D. students to describe their thesis work.

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Cover Image: ESO artist's concept of the Atacama Large Millimeter Array (ALMA).

ATACAMA LARGE MILLIMETER ARRAY (ALMA)

ALMA Gains Capabilities with Japan's Entry

Japan entered the ALMA Project with the signing of an Agreement Concerning the Construction of the Enhanced Atacama Large Millimeter/Submillimeter Array. The Agreement was signed by Arden L. Bement, Acting Director of NSF, Catherine Cesarsky, Director General of ESO, and Yoshiro Shimura, President of the National Institutes of Natural Science (NINS) of Japan. All parties had signed the document by September 14, 2004, making Japan an official partner in an Enhanced ALMA, to be known as the Atacama Large Millimeter/Submillimeter Array (same ALMA acronym). Final negotiations on an operations plan for Enhanced ALMA are expected to be concluded by the end of 2005. Japan will provide the Atacama Compact Array with its correlator, three receiver bands, and other components. The value assigned to the Japanese contribution to Enhanced ALMA is $180M USD (FY2000). Assuming all three partners are able to meet their commitments, the final project will be cost-shared 37.5 percent, 37.5 percent, 25 percent, between North America, Europe and Japan, respectively. The observing time, after a ten percent share for Chile, will be distributed accordingly.

The U.S. Congress has approved HR4818, the omnibus funding bill, making FY2005 the seventh year of funding for ALMA.

H. A. Wootten

ALMA Town Meeting at the American Astronomical Society

An ALMA Town Meeting will be held at the 205th American Astronomical Society (AAS) Meeting, which is being held January 9-13, 2005 in San Diego. The ALMA Town Meeting is scheduled for Tuesday, January 11, from 1:00 - 2:00 p.m., and is principally aimed at informing the North American astronomical community about the scientific capabilities and current status of the ALMA Project. The construction of ALMA has progressed rapidly; in Chile, North America, and Europe. Japan has entered into an Agreement as a new partner in ALMA; with its entry, ALMA construction activities involve Asia. The AAS ALMA Town Meeting will cover progress on all these fronts. Equally important, there will be a presentation of the North American ALMA Science Center (NAASC, *http://www.cv.nrao.edu/naasc/*). This center will be the main communication hub between North American astronomers and the Joint ALMA Observatory, and is being organized in Charlottesville, Virginia.

Following the presentations, there will be a discussion session where we will solicit comments from the user community, with a focus on the science user services to be provided by the NAASC. If you will be at the AAS Meeting, please plan to attend this Town Meeting. The tentative agenda for the Meeting is as follows:

Introduction	K. Y. Lo, NRAO Director
ALMA Science Examples	M. Yun, U. Massachusetts
Project Description, Status	M. Tarenghi, Director, Joint ALMA Office
North American ALMA Science Center	A. Wootten, ALMA/NA Project Scientist
Discussion (15 mins)	A. Wootten, Moderator

H. A. Wootten

ALMA Science Community Outreach

On October 4-8, 2004 the "Cool Universe: Observing Cosmic Dawn" conference was held in Valparaiso, Chile to introduce ALMA science to the Chilean astronomical community. The conference included several one-hour review talks on topics ranging from the CMB and cosmic reionization, to the ISM and star formation, plus numerous short contributions. The conference was well attended (about 100 participants), with the majority coming from the Chilean astronomical community, including good representation from CTIO, ESO, and the Chilean universities.

More than 230 potential ALMA and Herschel users gathered in Paris, France on October 27-29 for the "Dusty and Molecular Universe" conference, which focussed on the science the community expects to reap from ALMA and Herschel. Paul Vanden Bout spoke on the origins of ALMA, and Carlos de Breuck and John Richer presented the top-level ALMA science requirements from the newly approved Project Plan v2. A number of reviews of ALMA science capabilities were also given.

H. A. Wootten

North American ALMA Science Center

Access to ALMA science use by the North American astronomical community is through the North American ALMA Science Center (NAASC), based in the newly re-modeled NRAO headquarters in Charlottesville, Virginia. The Science Center is operated by NRAO in partnership with the National Research Council of Canada. It is one of at least two such regional support centers in the world. There will be an ALMA Town Meeting at the AAS Meeting in San Diego on Tuesday, January 11, where the structure and functionality of the NAASC will be presented to the North American astronomical community.

ALMA is designed so that very few astronomers will actually travel to Chile to obtain data. The ALMA data reduction pipeline will provide calibrated data and images to users, and an on-line archive will be maintained at the NAASC.

ALMA users can expect a wide range of support from the NAASC staff, such as: support for community participation in commissioning, science verification, and early science operations; information on ALMA observing modes and capabilities; support for the use of proposal submission and scheduling tools; validation of observers scheduling blocks; post-observation user support including detailed examination of images delivered to or produced by users; and verification of user-reported defects. The NAASC staff will also support user visits to the NAASC for data reduction, sponsor ALMA workshops and summer schools, and provide ALMA proposal guides and data reduction "cookbooks". Information on the NAASC is available at *http://www.cv.nrao.edu/naasc/*. The NAASC is currently being staffed, and we welcome user feedback.

P. A. Vanden Bout

New ALMA North America Project Manager

Dr. Adrian Russell

The NRAO is pleased to announce that Dr. Adrian Russell will join the Observatory's senior management team as the ALMA North America Project Manager in February 2005.

Adrian comes to the NRAO after nearly seven years as Director of the United Kingdom Astronomy Technology Centre (UK ATC) in Edinburgh, Scotland where he was responsible for the design and production of state-of-the-art astronomical instrumentation. Adrian's responsibilities at the UK ATC have included: SCUBA 2, a sub-millimeter bolometer array camera for the James Clerk Maxwell Telescope (JCMT); the Mid-Infrared Instrument (MIRI), an infrared camera and spectrometer for the future James Webb Space Telescope; and the Visible and Infrared Survey Telescope for Astronomy (VISTA), a wide-field 4m telescope now under development that will be sited at the Cerro Paranal Observatory in Chile.

Adrian graduated from the University of Sheffield in 1983 with a 1st Class Honours degree in Electrical and Electronic Engineering and received the IEE Prize and the Mappin Medal. In 1987 he joined the Royal Observatory, Edinburgh and accepted a three-year tour of duty as a JCMT support scientist in Hawaii. Adrian received a Ph.D. in Astronomy from the University of Cambridge (Mullard Radio Astronomy Observatory), working on millimeter-wave heterodyne instrumentation and molecular-line studies of outflows in star-formation regions.

During a 1990–1992 sabbatical with Reinhard Genzel at the Max Planck Institute for Extraterrestrial Physics in Garching, Germany, Adrian worked on sub-millimeter instrumentation for the JCMT. In 1992 he became the Head of the JCMT Instrumentation Programme at the Royal Observatory, Edinburgh.

Immediately prior to assuming his duties as the UK ATC Director, Adrian was Deputy Director of the Royal Observatory, Edinburgh and UK Project Manager for the Gemini 8m telescopes project (1995–2001).

The Atacama Large Millimeter Array is an essential and exciting component of the near-term future for the international astronomical community and the Observatory. Working with our ALMA partners in Europe and in Japan, Adrian Russell is an extraordinarily capable project manager whose vision and expertise will help bring the ALMA project to successful completion.

Fred K. Y. Lo

John Webber to be ALMA Front End IPT Leader

The NRAO is pleased to announce that Dr. John Webber has agreed to become the new ALMA Front End (FE) Integrated Product Team (IPT) Leader, replacing Charles Cunningham and reporting to the NA ALMA Project Manager. Charles will remain in the FE IPT as senior technical expert contributing to high-level design work. As ALMA FE IPT Leader, John will be responsible for coordinating the development and production of the ALMA Front Ends, which are a joint effort by several groups in North America and Europe. He will be directly supervising the NRAO activity in the Front End, including the Band 6 cartridges, local oscillators for all bands, and the integration and test of the completed Front End assemblies at the NRAO Technology Center in Charlottesville. This new assignment is effective October 1, 2004. John will also retain his position as ALMA Correlator IPT Leader.

Fred K. Y. Lo

Eduardo Donoso to be NA ALMA Site IPT Leader

The NRAO is also pleased to announce that Eduardo Donoso will become the new NA ALMA site IPT leader, a position formerly held by Simon Radford, who has now joined Caltech and the Cornell-Caltech 25m telescope project. Eduardo Donoso has been in charge of site construction activities in Chile since he joined ALMA in February 2004. He has prepared the bids for the construction of the NA ALMA deliverables, and for the outfitting of the Santiago ALMA Central Office and offices of the ALMA Executives.

Fred K. Y. Lo

ALMA Laboratory System Integration Tests

The first ALMA Laboratory System Integration tests have been taking place in Tucson. The setup consists of a pair of receiver simulators, receiving a coherent signal at 3mm from across the lab. A photonic system is used as the local oscillator (LO) for both receivers and is fed to the receivers along independent fibers. Fringes have been measured by mixing the IF outputs of the two receivers.

Figure 1. Lab System Integration test equipment.

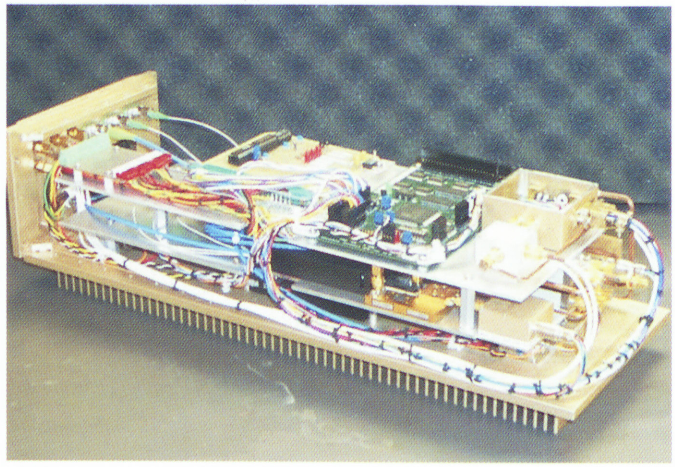

Figure 2. Laser Synthesizer electronics.

Tests to date have concentrated on checking the overall functionality of the LO system, with detailed phase noise measurements of the overall system and individual system components, including the Central Reference Generator and the Local Oscillator Reference Receiver (LORR). The performance of the first LO drivers and the overall system have been checked for phase noise at multiple frequencies within the 77-100 GHz band.

Measurements still to be made include long-term phase stability of the system and its components, and temperature dependencies. So far the measurements have included only short LO fiber transmission distances, but measurements will soon be extended to fiber lengths of several kilometers and will eventually include the fiber Line Length Corrector system. After these and other measurements, this front-end test system will be shipped to Socorro during the first quarter of 2005 for further testing in conjunction with back-end components. Later in the year the prototype system components will be moved to the Antenna Test Facility (ATF) for integrated testing as a working interferometer using the two ALMA prototype antennas.

The LO is supplied by a prototype ALMA Band 6 LO source, which includes a tunable YIG oscillator, Warm Multiplier Assembly, and first LO phase-lock-loop. The LO reference is supplied by a prototype ALMA Laser Synthesizer common to both receivers. The Laser Synthesizer provides two lightwaves whose difference frequency is phase-locked to a small offset from the required LO frequency and is tunable over the full LO range. A second laser synthesizer will soon be available for locking each receiver to a separate reference, allowing further analysis of the phase noise contributions of various parts of the LO system. The central LO racks also include an ALMA prototype Master Laser, two microwave synthesizers, and photonic distribution assemblies for splitting, amplifying, and routing the fibers.

Test and integration of ALMA IF components is performed in Socorro, in cooperation with testing in Tucson. The Data Transmission System (DTS) is a major focus, including testing with the prototype correlator. A sine-wave signal was passed to the Data Transmission System (DTS) formatter and transmitter, through fiber to the DTS receiver, and processed through the prototype correlator to yield sample statistics and spectra. This first end-to-end test of the digital system was successful.

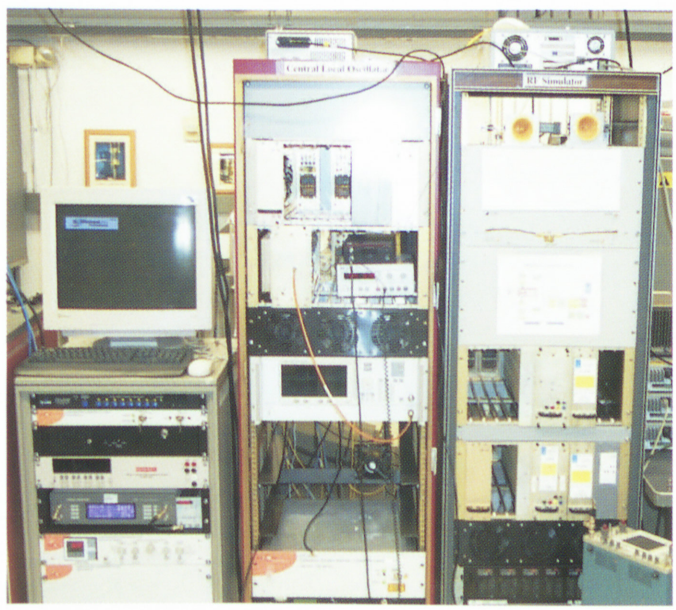

Figure 3. The Lab System Integration test setup. The left rack contains the master laser for the photonic LO. The center rack contains electronics intended for the central LO system, and the right rack simulates two antennas. Note the two feed horns at upper right, which are receiving a test signal transmitted from the other side of the lab.

Initial testing in Tucson suggested upgrades to the Central Reference Generator/Distributor to reduce phase noise. These upgrades are under way in Socorro.

Prototype antenna tests continue at the ALMA Test Facility at the VLA site. A conceptual design for a prototype Photonics LO fiber cable azimuth and elevation wrap has been devised and discussed. A prototype will be available for testing by January.

Construction of the ALMA front-ends, covering the four bands being built in the construction phase, continues. Performance tests of the 1.3mm cartridge continue at the NRAO Technology Center. The first cryostat, into which the cartridges will be inserted, has arrived and undergone initial testing.

Correlator construction is also proceeding at the NRAO Technology Center. The ALMA Correlator consists of four quadrants. Construction of the first quadrant of these has progressed very well and progress has also been made on the second quadrant.

In Figure 1, the left rack represents the central LO system, and the right rack represents the system at the antennas. Note the two feed horns at the top of the right-hand rack, simulating reception at two different antennas; the signal is received from a Gunn diode oscillator across the lab. The central LO rack and the Receiver Simulator rack are connected by short lengths of fiber carrying the photonic LO signals.

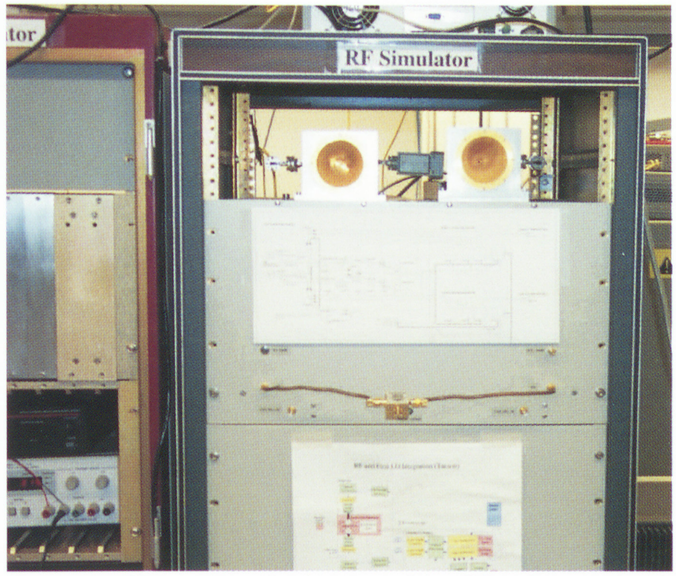

Figure 4. The receiver simulator, receiving LO reference signals along fiber from the central LO system, with the two feed horns, representing two antennas of an interferometer, receiving a signal transmitted from across the lab.

D. Emerson, R. A. Sramek, C. C. Janes, H. A. Wootten

CHILE

ALMA, NRAO, and Astronomy in Chile

It has been ten years since an NRAO expedition located what was destined to become the ALMA site. This place, an immense plateau in the Chilean Andes situated at 5000m above sea level, is known as "Chajnantor" from the indigenous Kuntza name meaning "starting place." And indeed the Chajnantor plateau, the best overall site for millimeter and sub-mm wave astronomy known in the world, is the place where a new era of discovery in the origins of cosmic structure, ranging from planets to galaxies, will start. This is a breathtaking place, and not only because of the lack of oxygen but, above all, for the pristine view of the surrounding mountains and the huge Atacama salt lake lying almost two miles below (Figure 1). At this altitude, the water vapor in the atmosphere that renders most other places unsuitable to mm-wave astronomy is low enough to make Chajnantor one of the driest locations known to man. And yet, this inhospitable place is of remarkably easy access. A modern commercial jetliner takes the visitor from Santiago to nearby Calama, world capital of the copper industry (Figure 2), in less than two hours. From there, it is an hour's drive along a modern paved

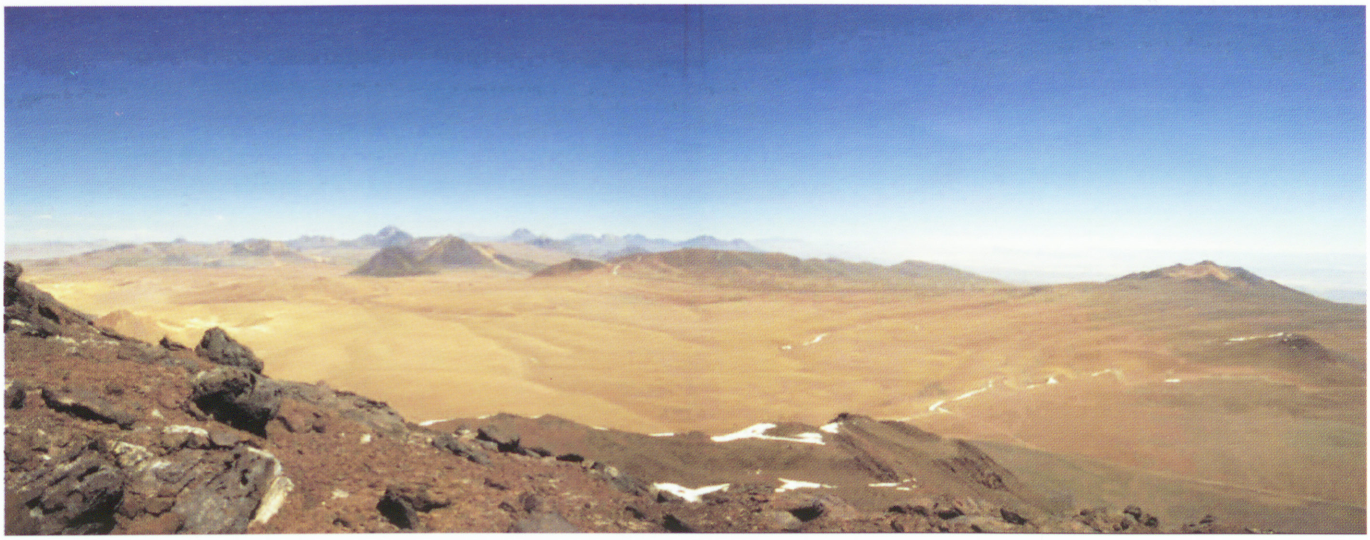

Figure 1: A panoramic view of the ALMA Site facing south-west. The Atacama salt lake 2.5 km below the Site is seen to the right of the picture.

highway to San Pedro, 55 km west of the ALMA site, which in turn can be reached in another hour and a half via the international paved highway connecting Chile with Argentina. All in all, it is possible to leave the capital of Chile in the morning, reach Chajnantor by noon and return to Santiago on the same day, thanks to the excellent transportation infrastructure Chile has to offer.

When completed in 2012, the ALMA interferometer will be the premier millimeter and sub-mm wave imaging instrument, and an unmatched example of world-wide scientific collaboration in Astronomy. Operating in this particular type of "light," ALMA will be able to see through the dust that shrouds the regions of the Universe where new stars are being formed and will bring information on the physical properties of these regions, including images with resolution superior to those obtained in visible light from space. But why Chile? In fact, when NRAO explored the North of Chile it was only unveiling the astronomical potential of the country for this particular form of radio astronomy. Its potential for more conventional visible and infrared astronomy had been known and exploited for some 40 years, to the point that today Chile is by far the main astronomical area in the southern hemisphere and is fast reaching the status of world capital of observational astronomy. Where other countries compete for one or just a few mountains of exceptional quality, Chile offers a thousand miles of potentially exceptional sites for optical astronomy.

Table 1. The International Observatories in Chile and their largest telescopes.

OBSERVATORY	ORGANIZATION	YEAR OF FIRST OPERATION	DIAMETER
Cerro Tololo	AURA-NOAO	1962	4m
La Silla	ESO	1969	2 × 3.6 m
Paranal VLA	ESO	1999	4 × 8.2 m
Las Campanas	Carnegie Inst. Wash.	1971	2 × 6.5 m
Pachón: Gemini S.	Gemini	2002	8.1 m
ALMA	AUI/NRAO-ESO-Japan	2012	~ 64 × 12 m

But good sites are not enough to bring the large investments and creative efforts required to build

Figure 2. Geographical location in Northern Chile of the International Observatories listed in Table 1.

a large world-class observatory such as ALMA and those that preceded it. Chile has shown through thick and thin, and for well over a generation, its commitment to stable and generous legislation in order to attract astronomy capital. The same willingness to help that allowed AUI-NRAO to establish itself in Chile and complete with its European counterpart, ESO, the delicate negotiations required to establish ALMA had already been shown by Chile to the many international observatories in its northern mountains (Table 1). In addition Chile possesses excellent engineering and manpower and an expanding astronomical community of international quality. This local community, in exchange for access to the best observing facilities in the world, lends its strong support to new initiatives. These astronomers like to point out that in the sixties when Chile's astronomical potential was still unknown, it was the U.S. astronomical community that took a bet

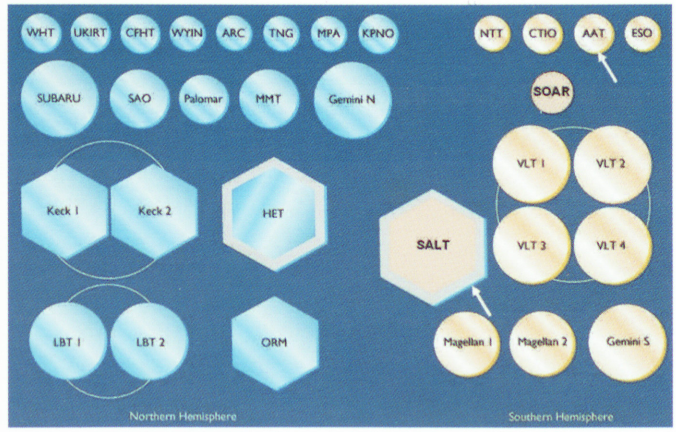

Figure 3. World's major telescope mirrors. With the exception of the two telescopes indicated with white arrows (the Anglo Australian Telescope and the 9m effective aperture South Africa Large Telescope all others are located in Chile (refer to Table 1 for diameters).

on the country, thus initiating the long road that is increasingly bringing new projects to Chilean sites.

E. J. Hardy

New ALMA and Executive Offices in Santiago

The last weeks of October were hectic in Santiago for ALMA and its Executives. A Board meeting was coming, the new offices were about to be finished and the happy event, always filled with surprises, of moving into new offices was about to take place.

On November 2 everything was ready for the ALMA Executive Meeting at the shiny, new ALMA offices, and the event was the right occasion to inaugurate the offices via a celebration that included the JAO and all the ALMA associates: NSF, AUI, NRAO, and ESO, as well as our new Japanese partners, who gave the celebration a special note by providing sake. Not to be outdone, the Joint ALMA Office Director, Massimo Tarenghi, uncorked an over-sized champagne bottle.

ALMA occupies the 18th floor of a modern building in Santiago's new business area, conveniently located

Figure 1. Through the door to the new AUI-NRAO offices.

near subway entrances and within walking distance of restaurants and hotels. From the new offices on a clear day one can see forever, in keeping with ALMA's mission of opening new horizons.

The new offices include 800 square meters and were outfitted in three months, on time and budget, starting from an empty floor, to obtain useful office space that serves as the landing place for ALMA, including the JAO and the Executives. This was a successful joint

Figure 2. ALMA main meeting room

Figure 3. Main reception area.

mission, with NRAO assuming responsibility for the construction contract and its administration.

After nearly four years in breathtaking Cerro Calán in the same building as the Astronomy Department of the University of Chile, AUI-NRAO has moved to the new headquarters occupying a distinct section of the floor, next to ESO. These are the offices of the representation, business and fiscal, with additional space for visitors.

We hope that our colleagues will find on this 18th floor a new home when visiting Santiago. Comfortable accommodations, a great view, and access to high speed communications are waiting for you!

E. J. Hardy, M. Pilleux

Living at the ALMA Camp

The ALMA Camp was finished in June 2004, and the European Site IPT team, consisting of the Site IPT leader, the supervisors, and the road construction team, moved in. The first experiences in Camp living were with pre-packaged food brought from nearby San Pedro de Atacama, since the kitchen was not yet finished. The dormitories were complete other than some exterior finish work.

By August 2004, the Camp was complete and the kitchen was operational. Approximately 15 people have been living in the Camp since then.

Figure 1. Dormitories.

Figure 2. Road construction team at lunch.

Life at the Camp is quiet, beginning with a short walk to the dining room for morning breakfast, and then to work. The office is just meters from the dining room, so commuting requires only a few minutes. The construction and site supervision teams, and the road construction crew move up the hills to continue their current labor: excavation, transport, and filling. Day after day the road from the Operations Support Facility (OSF) to the Array Operations Site (AOS) improves, days that are filled with sun, dust, and thirst.

Everybody gathers at the dining room for lunch in a pleasant environment. For the road team, lunch is soup, salad, main course, and dessert. Lunch ends with a short rest under the shade of the barbecue before the day's labor is renewed.

After lunch, work goes on until dusk, the most beautiful hour of the day. The desert landscape turns red with the last rays of the sun, giving the spectator a time for meditation and astonishment. After the early equatorial sunset, it is time for dinner, replenishing the energy spent during a hard day's work. There follows relaxation, satellite TV, music, sharing conversation, watching a soccer game or the daily news, or calling home to chat with the family.

Once in a while there is occasion for celebration. For National Holidays, the barbecue becomes the center of activity. We feel lucky to be present and have the opportunity to share these moments with the people on-site. The experience cements bonds and raises everyone's spirits.

Figure 3. The Bar(becue) is open!

Figure 4. National Holidays barbeque.

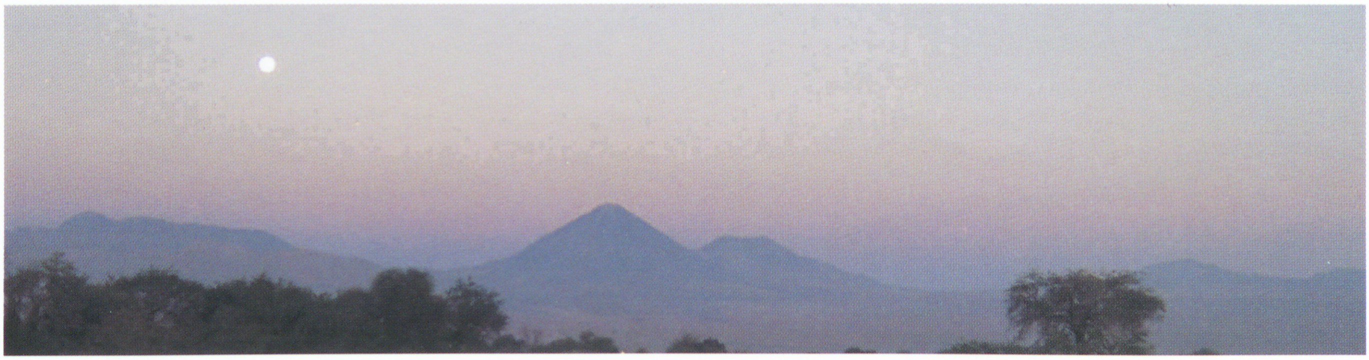

Figure 5. Desert moon.

The day ends, and it is time to rest in the desert silence far away from noise and traffic jams. Nights under the clearest skies invite one to enjoy star watching, perhaps to sight a shooting star, make three wishes, and bid all good night.

E. Donoso

Director's Office

Message from the Director

Fred K. Y. Lo

In the spring of 2003, I wrote an article for this Newsletter that described the experiences and impressions of my first six months as the NRAO Director. Now, twenty-one months later, as I am in my third year at the NRAO, this second installment of the Director's perspective is long overdue. My tenure as Director so far has been fascinating and always humbling. Owing to the remarkable range of responsibilities undertaken by the Observatory, my schedule continues to be extremely busy, but my enthusiasm for the bright future of astronomy and the NRAO remains very high.

The Atacama Large Millimeter Array (ALMA) is currently the world's largest ground-based astronomy facility construction project, especially now that our Japanese colleagues have joined Europe and North America in this international project. ALMA is also the NRAO's most visible project. Its success is essential for the future of ground-based radio astronomy and the long-term health of the astronomical community in the U.S. and the rest of the world. Civil construction at the Atacama site in Chile has started in earnest, and the complex antenna procurement process is in progress. Hardware and software subsystems are being prototyped, reviewed, and tested in the prototype system integration. ALMA demands much of the NRAO and its people, and the Observatory is responding to the challenges of this technically complex and high-profile international collaboration.

Planning is also underway for the North American ALMA Science Center (NAASC) that will be housed in the Observatory's recently renovated and expanded Charlottesville facilities. The NAASC will support the scientific use of the array by the North American (United States and Canada) astronomical community. NAASC staff will assist users in proposal preparation and submission, organize proposal reviews, prepare observing blocks and assure data acquisition, maintain pipeline data processing and the data archive, and also provide support in the analysis phases of ALMA observations. The NAASC personnel will also organize ALMA science meetings, workshops, and schools, sponsor pre-doctoral and post-doctoral programs, and conduct a range of other programs designed to optimize the astronomical community's scientific use of ALMA. The NAASC will also be responsible for carrying out research and development, as well as the implementation of software and hardware upgrades for ALMA on behalf of North America. We sincerely hope to see and hear from many of our colleagues at the ALMA Town Meeting that is scheduled for January 11, 2005 (1:00 - 2:00 p.m.) at the up-coming American Astronomical Society Meeting in San Diego.

The Expanded Very Large Array (EVLA) is another cornerstone of ground-based astronomy's future that brings powerful new capabilities to the community for research. Though it is built on the foundation and infrastructure of the Very Large Array (VLA), the EVLA is much more a new facility than simply an upgrade of an existing facility. Phase I of the EVLA Project, now in its fourth year, will improve the array's sensitivity by an order of magnitude, and the second phase of the project, when funded and built, will achieve an order of magnitude improvement in resolution. Phase I of the EVLA is making very good progress. "First light" was achieved on the first retro-fitted antenna last spring, and first fringes were achieved using this antenna as an element of the VLA last fall. The proposal for Phase II of the EVLA was submitted to the NSF in April 2004 and is currently undergoing peer-review.

As it builds for the future, the Observatory continues to enable forefront research for the astronomical community by operating and continually improving the Robert C. Byrd Green Bank Telescope (GBT) in West Virginia, the extraordinarily productive VLA in New Mexico, and the ten-element Very Long Baseline Array (VLBA).

To borrow a phrase from one of our colleagues, the GBT is "scientifically flourishing." Recent GBT scientific results include the detection of at least 17 new pulsars in one beam-pointing at the globular cluster Terzan 5, the detection of HCN at $z = 2.4$, and the identification of small-scale structure in the HI halo of the Milky Way. The GBT will also provide unique capabilities as its operation is extended to high frequencies up to ~115 GHz. It has already achieved very good efficiency at 43 GHz during the winter of 2003/2004, and new instrumentation is under construction to exploit the GBT's sensitivity and resolution at the higher frequencies. Also worth noting is that the Observatory's methodical analyses and tests of the GBT azimuth track has yielded a retrofit plan that we have high confidence will correct the premature wear problems.

The VLA, which was originally designed to work up to 22 GHz, detected and mapped the CO emission at 46 GHz from the highest known red-shift quasar J1148+5251. This feat of probing galaxies and quasars in the Epoch of Re-ionization was unimaginable only a few years ago. It also highlights the enormous scientific possibilities that will come with the completion of the EVLA. Through careful planning, the NRAO is aiming to operate the VLA continuously during the entire construction period of the EVLA. After the antennas have been retrofitted, they will be brought back continually as elements of the array until the EVLA is completed. Similarly, the new WIDAR correlator will be brought into operation in stages. After a subset of the new correlator is installed, early science done with the partial EVLA will already have significantly improved performance over the current VLA.

The VLBA is currently the only operating facility in the world dedicated full-time to VLBI. Last year, the Haystack Observatory and the NRAO jointly commissioned a study of future U.S. VLBI development. The resulting Taylor-Lonsdale Report provides a roadmap to guide future VLBA development. In response to this report, replacement of the VLBA tape-recording systems by Mark 5 hard-disk recorders has started and is scheduled to be complete by the end of 2005. Agreements with other observatories have also made available for VLBI proposals the High Sensitivity Array (HSA) which includes the VLBA, the Arecibo telescope, the Effelsberg 100 m telescope, the phased

VLA, and the GBT . The sensitivity of the HSA has generated a significant increase in the number of VLBA proposals. In addition, pipeline-processing for the more routine VLBA observations is now available.

A new application for the VLBA is its use in spacecraft navigation, providing high-precision angular tracking of spacecraft. In close collaboration with NASA and ESA, the VLBA's capabilities are being applied in a manner that benefits both astronomy and space science.

In the last two years, the Observatory has worked to enhance its interaction with university and other research organization. The new Division of Scientific and Academic Affairs serves as the focal point for such activities. The enhanced Jansky Fellowship Program, for example, now permits these fellowships to be held at any NRAO site, U.S. university or research organization, providing outstanding research opportunities for young astronomers, on par with those available through the Hubble, Chandra, and Spitzer Fellowship Programs. Another NRAO program supports astronomical research at the GBT by offering financial support for graduate and undergraduate students at U.S. universities, helping to train new generations of astronomers. The Observatory has seen excellent community response to this GBT program and hopes to initiate a similar program for the VLA and VLBA, funding permitting. The Observatory also encourages increased interaction of the astronomical community with NRAO scientific staff through its Visitors Program, which sponsors short- and long-term visits, summer visits, and sabbatical leaves.

The NRAO has also been actively pursuing collaboration with university and other research groups to build forefront instruments for use on NRAO telescopes. Current examples include the Caltech digital radiometer, the Penn/Goddard Bolometer Array Camera, and instruments being proposed for funding, including Zpectrometer (University of Maryland) and PAPER (UC Berkeley.) On a larger scale, NRAO staff members are working with university groups to develop a new consortium and a proposal to build the Frequency Agile Solar Radio-telescope (FASR). Directly or indirectly, many NRAO staff members are also involved in the planning and design studies for the Square Kilometre Array (SKA).

The remarkable range of activities undertaken by the Observatory is possible only because of the breadth and depth of the staff's expertise and their devotion to the NRAO missions and the astronomical community. I am impressed on a daily basis by the talent and dedication of the NRAO staff in West Virginia, New Mexico, Arizona, Virginia, Chile, and elsewhere. As I noted in the April 2003 Newsletter, a symphony makes great music only if all its musicians play well together and, similarly, the NRAO must function well as "one Observatory." In reviewing the past two years in my mind's eye, it is gratifying to see the concrete evidence of the positive change this approach has brought to the NRAO. Communication and coordination across the Observatory continue to improve among our far-flung staff and facilities.

This improvement has been especially noticeable in software development. Software development is now driven specifically by the needs of ALMA, EVLA, GBT, and the overall goal of end-to-end user support (from proposal submission to data archive). The Observatory has established mechanisms to ensure all these project-driven efforts are coordinated Observatory-wide to optimize efficiency and effectiveness. Close attention is required to assure the success of this very important and challenging effort within the NRAO.

There is, of course, a great deal more to do and the NRAO must continue to evolve to meet the challenges of the future. Over the past several years, the Observatory has been improving its management practices to deal with the significant increase in scope of its responsibilities. These efforts have included the establishment of the NRAO Program Management Office (PMO) to provide modern tools for project management, provide accurate cost and schedule data for our entire portfolio, and organize monthly Observatory-wide program reviews. Another important development has been the successful revision of the Scientific Staff Policy, clarifying the career paths and responsibilities of NRAO scientists, optimizing the impact of their expertise and experience on the Observatory's missions.

Assessing radio astronomy and the NRAO from the vantage point of January 2005, I see a bright future, but also complexity and challenges, including an uncertain and difficult funding environment. Not surprisingly, the U.S. federal deficit is creating political friction and financial pressures that seem certain to constrain budgetary growth for U.S. astronomy in the near-term future, especially in the National Science Foundation which funds the NRAO and ground-based astronomy. Nevertheless, despite these trials of the moment, this is an era of great opportunity, and there is much to celebrate in the astronomical community.

The NRAO staff is proud of what they have accomplished and welcome what will undoubtedly be an equally challenging future. They are forward-looking and continually striving to enable the broadest range of research for all astronomers.

Fred K. Y. Lo

Socorro

EVLA Project Progress Report

Recent Progress

Since the last Progress Report (April 2004) work has continued on installing and testing the prototype EVLA wide-bandwidth electronics system on the EVLA Test Antenna (VLA Antenna 13) and on the second EVLA antenna (VLA Antenna 14). We are pleased to report that the first interferometric fringes for an all-EVLA baseline (Antennas 13 with 14) were obtained on the afternoon of December 2, 2004, when the calibrator source 3C 345 was observed at X-Band (8447 MHz). Antenna 14 is the first "production-like" antenna, and contains the hardware we expect will be standard for the rest of the EVLA. (By comparison, Antenna 13 is the EVLA test antenna, and contains a wide variety of experimental systems). We are especially encouraged by how quickly Antenna 14 came on-line. It was made available for "first light" on the evening of December 1, and provided solid fringes with the VLA antennas by the afternoon of the following day. Indeed, most of the difficulties in getting fringes between it and Antenna 13 were with the latter antenna, with its non-standard hardware and software. The all-EVLA baseline shows gratifyingly flat phase across the bandpass, as shown in Figure 1.

The structural modifications on the third EVLA antenna (VLA Antenna 16) commenced in November, 2004. This antenna will be equipped with production electronics equipment during the first quarter of 2005. The overall goal for the project for the current fiscal year is to have five antennas equipped with EVLA equipment by September 2005.

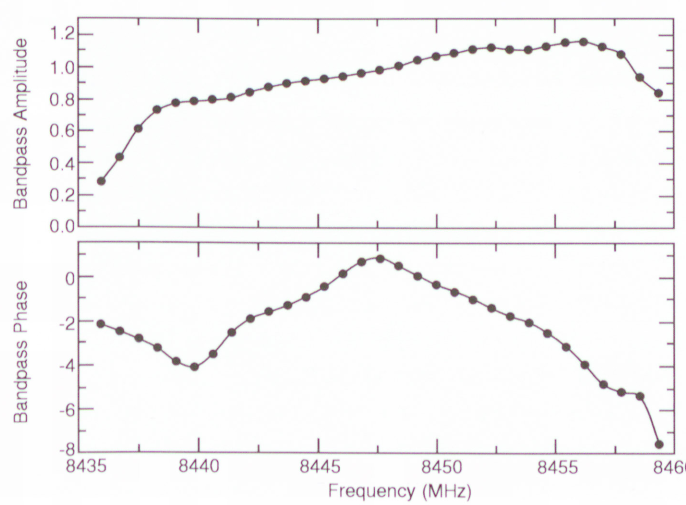

Figure 1. Bandpass response for the first interferometic fringes between a pair of EVLA antennas (Antenna 14 phase referenced to Antenna 13).

Detailed design of the EVLA correlator by the Canadian partner, Herzberg Institute for Astrophysics, is progressing well. It still appears possible to achieve all of the performance goals originally planned for the correlator. After initial bids for the new correlator chip were received early in 2004, study contracts were issued to two companies to investigate the optimum choice of chip technology. These studies were completed and final bids were received from four companies in November 2004. Contract award is planned for early 2005.

The project is now far enough along that we are beginning to pay considerable attention to the issue of scientific observing during the transition period. Considerable effort has recently been invested in planning and implementing a transition plan for operations as the modified antennas are returned to the existing array for ongoing scientific observations, and as the greatly expanded capabilities of the modified antennas become available for scientific use. Optimizing scientific capabilities during this transition phase is a complex problem. The impact of EVLA activities for on-going VLA observations can be found at the web-site *http://www.aoc.nrao.edu/evla/archive/transition/impact.html.*

Wideband Feed Testing

A demanding EVLA requirement is the ability to observe at any frequency between 1 and 50 GHz with optimal performance. The requirement will be met with eight wide-band feeds. The three lowest frequency bands (1 - 2 , 2 - 4, and 4 - 8 GHz) are the most difficult to design, as they each have a 2:1 Bandwidth Ratio. Designing a feed of fixed physical aperture and position to efficiently illuminate the subreflector over such a wide bandwidth is a daunting challenge. S. Srikanth of the NRAO Central Development Laboratory (CDL) has met this challenge with a "compact horn" design. Prototypes of his L- and C-Band designs were installed on the EVLA test antenna (#13) for testing by Rick Perley and Bob Hayward. (Despite the name of the design, the L-Band horn is hardly small. It is 4.1 meters high, with an aperture of almost 1.6 meters). Figure 2 illustrates how the feeds are arranged around the Cassegrain feed ring. The large horn is the L-Band feed, the next-largest aperture (currently unoccupied) is for the S-Band feed (2 - 4 GHz).

Figure 2. The new large L-Band feed installed in the EVLA feed system on the Test Antenna. The two-foot aperture between them, to the right of the L-Band feed, is the C-Band feed.

The feed provides an aperture efficiency of approximately 43 percent at 1.3 GHz, rising to about 54 percent at the upper frequency end of the band. The system temperature (using an old-style VLA receiver) is 27K at the zenith, approximately 5K better than the VLA. This improvement reflects the removal of the lossy polarizer and the microwave lens. Although the efficiency is a little lower than the current VLA (50 percent at 1425 MHz)—a price which has to be paid to obtain such wide-band performance in a limited space—the difference is more than made up by the greatly improved performance at low elevations. The existing VLA feed uses a microwave lens to avoid using a large horn (which we could not build in 1977). Besides the small attenuation of, and addition of noise from the lens, the metal components of the lens and its support scatters considerable ground radiation into the feed aperture at elevations below 50 degrees, resulting in greatly increased system temperatures at low elevations. The new design dispenses with the lens,

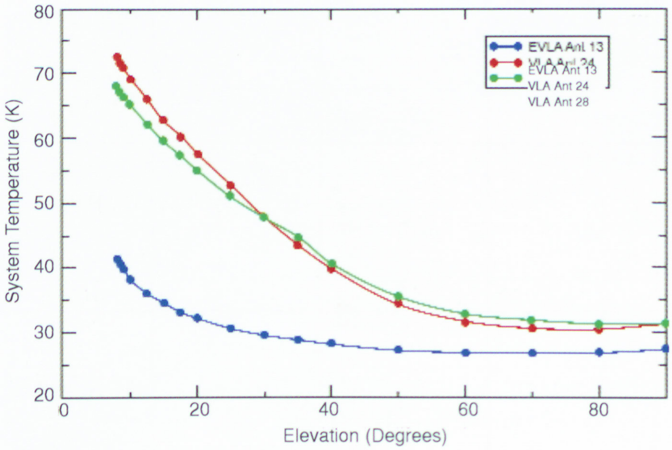

Figure 3. The variation in system temperature for the new EVLA L-Band feed (Antenna 13) and the old VLA feed (Antennas 24 and 28).

and the improvement in system temperature over all of the visible sky is dramatic, as shown in Figure 3.

The improvement with this new feed will be most noted for long integrations and for observations of southern objects. An estimate of the improvement is given in Figure 4, showing the SEFD (System Equivalent Flux Density) of the VLA and EVLA antennas as a function of declination. Meridian snapshots are in black; long integrations (defined as the duration the source is above ten degrees elevation for the given declination) are in red. The VLA performance is shown with dashed lines, the EVLA performance is shown with solid lines.

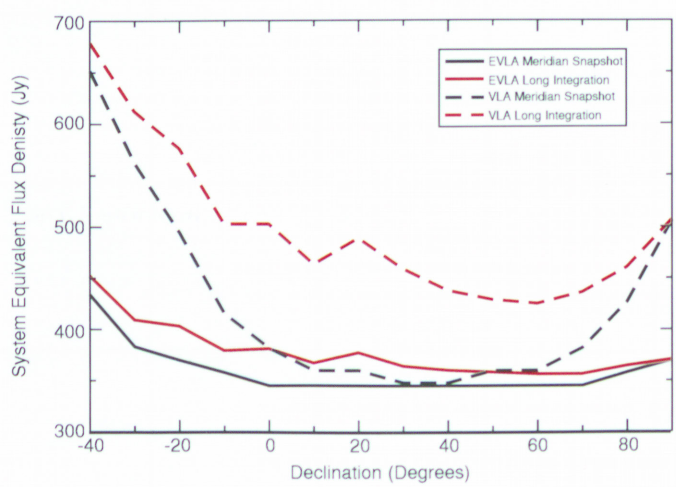

Figure 4. SEFD for the new (EVLA) and old (VLA) feeds.

Full details of the L-Band feed tests are in EVLA Memo #85 at *http://www.aoc.nrao.edu/evla/memolist.shtml.*

During the month of November, we have been performing similar tests of the prototype C-Band feed. Although these are still being reduced, it is clear that the efficiency of this feed is at least 60 percent from 4.0 to 8.0 GHz. Combined with the expected total system temperature of less than 30K (30 percent better than the VLA), we expect outstanding sensitivity. However, it is also evident that this new feed has higher over-illumination of the subreflector than the current C-Band feed, resulting in a higher ground radiation contribution at elevations below 15 degrees. The difference reaches about 10° K at the VLA's limiting elevation of 8 degrees—less than the anticipated difference in receiver temperatures between the VLA and EVLA. Hence, the EVLA will be more sensitive per unit bandwidth than the VLA at all elevations. The EVLA will have eight times the tuning bandwidth of the VLA and 40 times the instantaneous bandwidth. The result will be, as required, an order of magnitude improvement in C-Band continuum sensitivity.

Software Activities

The design for all EVLA software was successfully reviewed by the newly formed e2e (end-to-end) oversight committee in June 2004. This design satisfies the various observatory-wide models developed by this oversight committee, which is a necessary (but not sufficient) condition for sharing software between NRAO telescopes. Instead of immediately following this by a detailed design of the various subsystems, we are embarking first on a VLA - EVLA transition plan. This is driven by the need to be able to operate the VLA/EVLA without major outages during the transition. This 7-phase plan describes in detail how to transition from the pure VLA, through a period of several years of hybrid operations (when the array consists of both VLA antennas and upgraded EVLA antennas), to the eventual EVLA. The first phases of this plan will then be used to prototype the design of the various subsystems. Phase 1 of this plan, which aims to make upgraded EVLA antennas work with old VLA antennas and with each other, is expected to conclude early in 2005.

Through the summer, all AIPS++ application development was focused on ALMA, and benefited the EVLA was well. There is now one AIPS++ staff member dedicated to investigating EVLA specific problems, such as imaging wide fields and wide bandwidths. It is our intention for work on EVLA specific applications to further increase during 2005.

EVLA Advisory Committee

The EVLA Advisory Committee meets annually to review the progress of the project. The next meeting of this committee will be on December 14 and 15, 2004. The charges to this year's committee are to evaluate and advise the NRAO Director regarding:

(a) the EVLA Phase I project's technical progress and issues;

(b) the project's software development plan and resource requirements;

(c) the EVLA Phase I management plan, schedule, and cost, including strategies for the effective use of project contingency;

(d) the scope and maturity of the project's operations plan, including the resource requirements;

(e) the relative priority and scientific impact of options for change in project scope;

(f) the project's future evolution should the opportunity to begin Phase II arise.

The current members of the EVLA Advisory Committee are:

Mark Reid (Chair)	CfA	Tony Beasley	ALMA JAO
Marco de Vos	NFRA	Sean Dougherty	NRC/HIA
John Dreher	SETI	Gianni Raffi	ESO
Luis Rodriguez	UNAM	Alan Rogers	Haystack Obs.
Steve Scott	Caltech	Tom Soifer	Caltech
Steve Thorsett	UCSC	Jacqueline van Gorkom	
Sandy Weinreb	JPL		Columbia

EVLA Project personnel will review for the committee the progress of the project's hardware and software.

As stated in the committee's charge, the committee's report will go to the NRAO Director and is expected early in the spring of 2005.

EVLA Phase II Progress

The proposal for funding Phase II of the EVLA Project was submitted to the NSF on April 15, 2004. The proposal requests $117M (FY2003 dollars) over an eight-year project duration. The primary goal for this phase is to extend the array's dimensions by approximately a factor of ten through the addition of eight new 25-meter antennas which would be permanently sited at locations throughout southwest New Mexico. In addition to the new antennas, two existing VLBA antennas would be converted to EVLA electronics standards. All ten of these antennas would be connected by leased optical fiber to the correlator for full-bandwidth, real-time operation with the EVLA or disk-recorded operations with the VLBA. The approximate locations of these ten "New Mexico Array" antennas are shown in the accompanying figure.

Figure 5. A schematic layout for the antennas in the New Mexico Array.

To accommodate the added data flow, the Canadian-supplied WIDAR correlator would be modestly expanded to 40 stations (from the present Phase I plan for 32). The extremely flexible design of this correlator will allow it to accommodate both the EVLA real-time and VLBA disk-recorded data, with an essentially unbounded choice of number of subarrays and division of the 45 antennas (27 EVLA, 8 new NMA, and 10 VLBA) amongst the subarrays.

In addition to the array expansion, the proposal contains a request to build a super-compact "E"-configuration. However, the proposal does not contain a request to extend the continuous frequency coverage below 1 GHz, as considerable technical study and development is still needed to find the best way to cover this frequency range.

The EVLA Phase II proposal was sent out by the NSF for review in September, with the reviews expected back at the NSF in late 2004. We are awaiting plans for a site visit by an NSF-appointed committee.

G. van Moorsel, P. Napier, and R. Perley

Classic AIPS New Versions Now Available in Binary Form

By the time you read this, there will be a new development version of AIPS (called 31DEC05), the current active version (31DEC04) will have been frozen, and the current frozen release (31DEC03) will have disappeared. The development and frozen versions are available for download from the AIPS web site at *http://www.aoc.nrao.edu/aips* or via anonymous ftp. Full installation instructions are available from the web site. Installations of 31DEC05 will want to run the "Midnight Job" (MNJ) occasionally to remain current with the changes we make to that version. Sites which already have 31DEC04 may wish to update it one last time with the MNJ.

The most important change to 31DEC04 is the development of a binary installation and MNJ. This means that AIPS sites will not be required to have suitable Fortran and C compilers to have a working AIPS installation. We began this process because, on MacIntosh computers, the IBM xlf compiler produces binaries which run about 50 percent faster than those produced by the GNU g77/gcc compilers. The IBM compiler is rather expensive, but the license agreement does allow us to ship binaries and run-time libraries which means that our user sites do not need to incur this expense. A similar situation arises on SUN Solaris computers, where the SUNWspro compilers produce significantly better executables than those produced by the GNU compilers. By January 2005, we should have binary installation and MNJ setups for both SUL and MACPPC architectures.

There are reports that the latest Intel Fortran compilers are also significantly better than the GNU compilers. We will investigate and, if true, attempt to make binaries available for LINUX as well. This may be somewhat problematic, however, since there are now so many flavors of LINUX in the community.

E. W. Greisen

Transition of the VLBA to Mark 5 Recording

Introduction

The VLBA has begun a long-awaited transition to the modern Mark 5 disk-based recording system developed by Haystack Observatory. Mark 5 offers substantial future benefits to the VLBA once the transition is complete. Scientifically, it will make possible a root-8 increase in continuum sensitivity by supporting, eventually, continuous observing at a 1 Gbps aggregate data rate. Operational efficiency will be enhanced enormously by more flexible use of the recording media, without wasted tracks or rules forbidding frequent mode changes; by reliable reproduction of recorded data, with instantaneous synchronization in the correlator; and by a major reduction in the cost of maintaining the recording system.

Current Status

Three VLBA stations — Pie Town, Kitt Peak, and Los Alamos — are fully equipped for Mark 5 recording, and three corresponding Mark 5 units have replaced three tape playbacks at the VLBA correlator. Two of these six Mark 5 units were acquired through our partial sponsorship of Haystack's development effort; four additional units were procured last summer. The necessary upgrades to the control and support software for both the VLBA array and correlator were completed last fall, and tests were performed to verify correct operation in all supported modes.

We have assembled Mark 5 disk modules with a total capacity of 126 TB, equivalent to a 30-day, 3-station media pool for the 128-Mbps continuous operation that the VLBA has maintained throughout the last decade. Although the cost per bit of magnetic disk media for Mark 5 use has fallen to about 35 percent of our cost to acquire the original VLBA tapes, these media costs still represent a very large investment for a full-time VLBI instrument. Since we will continue to be limited to the 128-Mbps daily mean rate by the remaining tape recorders, we plan to procure only enough disk drives during the transition to maintain that rate on the Mark 5 equipped stations as well. Once the transition is complete, it will become possible to increase the mean rate substantially by expanding the pool of disk media, at prices expected to be significantly lower at that time.

As of November 24, 2004, these first three stations are still able to record on both tape and Mark 5 units. We attempt to record as much data as possible on Mark 5 for VLBA observations, but are still exploring the limitations imposed by the available module pool. We continue to record Global observations only on tape, under a long-standing agreement with the European VLBI Network, pending conclusion of a new agreement.

Scheduling Considerations

The transition should be transparent for nearly all users. The normal recording medium for each VLBA station is determined from an entry in the station catalog used by the VLBA Sched program. Short-term changes are handled in two different ways.

For the dynamically-scheduled observations that make up a large majority of our queue, we can exploit the normal re-run of Sched shortly before observation. VLBA Operations uses the latest version of Sched, and a continuously updated station catalog, as part of this process.

A different approach will be applied to future Global and other fixed-schedule observations. The station catalog distributed with Sched will cause the correct recording commands to be generated for most stations, but to accommodate changes in station recording equipment occurring between Sched updates, an automated script has been developed to edit the VLBA station control (*.crd) files as necessary. This process will leave the Sched summary file unchanged and thus incorrect with respect to some of the recording details, but will not risk overwriting any Sched output files. In particular, user-edited VLA "obs.y" files will not be changed.

In both cases, schedules developed using older versions of Sched are expected to yield satisfactory results, but users are strongly encouraged to use the latest distributed version.

Related Topics

Our Mark 5 implementation plan is a bootstrap process, depending heavily on a continuing decommissioning of the tape drives. A significant fraction of the funding for new Mark 5 units and media comes from a drastic curtailment of spending on maintenance of these drives, in particular, in procurement of replacements for consumable or short-lived parts. The ongoing decommissioning is planned so as to ensure a continuing supply of replacement parts.

The transition is beginning with the current Mark 5A system, which does not support some extreme narrow-band VLBA recording modes. However, a search of the more than 1700 observing schedules executed since January 1, 2002 found only six scientific observations for two proposals which used modes not supported by Mark 5A. The VLBA modes table, available on the NRAO website, has been revised to exclude those modes.

We intend to switch to the Mark 5B system, presently under development by Haystack Observatory, as soon as possible once it becomes available. Mark 5B will enable formatless recording, and thus the removal of two current bottlenecks in the VLBA signal path: the formatter, and the deformatting functions of the correlator's playback interface. This upgrade will raise the peak aggregate rate available on the VLBA to 1 Gbps for the first time.

Acknowledgments

Numerous NRAO personnel have contributed to this transition. Walter Brisken and Doug Gerrard were central to the effort, with substantial participation by Barry Clark, Juan Cordova, Bob McGoldrick, Paul Rhodes, Adrian Rascon, Bruce Rowen, Craig Walker, and the data analysts and VLBA operations groups.

J. D. Romney

VLA Configuration Schedule; VLA/VLBA Proposals

Configuration	Starting Date	Ending Date	Proposal Deadline
A(+PT)	17 Sep 2004	10 Jan 2005	1 Jun 2004
BnA	21 Jan 2005	14 Feb 2005	1 Oct 2004
B	18 Feb 2005	06 Jun 2005	1 Oct 2004
CnB	17 Jun 2005	05 Jul 2005	1 Feb 2005
C	08 Jul 2005	26 Sep 2005	1 Feb 2005
DnC	17 Oct 2005	24 Oct 2005	1 Jun 2005
D	28 Oct 2005	09 Jan 2006	1 Jun 2005
A-D (Large Proposals)	27 Jan 2006	07 May 2007	1 Jun 2005
A(+PT?)	27 Jan 2006	08 May 2006	3 Oct 2005
BnA	19 May 2006	05 Jun 2006	1 Feb 2006
B	09 Jun 2006	11 Sep 2006	1 Feb 2006
CnB	22 Sep 2006	09 Oct 2006	1 Jun 2006
C	13 Oct 2006	08 Jan 2007	1 Jun 2006

GENERAL: Please use the most recent proposal coversheets, which can be retrieved at *http://www.nrao.edu/administration/directors_office/tel-vla.shtml* for the VLA and at *http://www.nrao.edu/administration/directors_office/vlba-gvlbi.shtml* for the VLBA. Proposals in Adobe Postscript format may be sent to *propsoc@nrao.edu*. Please ensure that the Postscript files request U.S. standard letter paper. Proposals may also be sent by paper mail, as described at the web addresses given above. Fax submissions will not be accepted. Finally, VLA/VLBA referee reports are now distributed to proposers by e-mail only, so please provide current e-mail addresses for all proposal authors via the most recent LaTeX proposal coversheets.

VLA: 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 in B and A configurations (trophospheric phase variations, especially in summer). Proposers should defer such observations for a configuration cycle to avoid such problems. In 2005, the B configuration daytime will involve RAs between 21^h and 05^h; and the C configuration daytime will involve RAs between 06^h and 12^h. Current and past VLA schedules may be found at *http://www.vla.nrao.edu/astro/prop/schedules/old/*. EVLA construction will continue to impact VLA observers; please see the web page at *http://www.aoc.nrao.edu/evla/archive/transition/impact.html*.

Approximate VLA Configuration Schedule

Year	Q1	Q2	Q3	Q4
2004	C	D	D,A	A
2005	A,B	B,C	C	D
2006	A	A,B	B,C	C
2007	D	D,A	A	A,B

VLBA: Time will be allocated for the VLBA, on intervals approximately corresponding to the VLA configurations, from those proposals in-hand at the corresponding VLA proposal deadline. VLBA proposals requesting antennas beyond the 10-element VLBA must justify, quantitatively, the benefits of the additional antennas. Any proposal requesting a non-VLBA antenna is ineligible for dynamic scheduling, and fixed date scheduling of the VLBA currently amounts to only about one quarter of observing time. Adverse weather increases the scheduling prospects for dynamics requesting frequencies below about 10 GHz. See *http://www.aoc.nrao.edu/vlba/schedules/this_dir.html* for a list of dynamic programs which are currently in the queue or were recently observed. VLBA proposals requesting the GBT, the VLA, and/or Arecibo need to be sent only to the NRAO. Note also the possibility to propose for the High Sensitivity Array, discussed further in previous Newsletter articles (April 2004 and October 2004).

Any proposal requesting NRAO antennas and antennas from two or more institutions affiliated with the European VLBI Network (EVN) is a Global proposal, and must reach *both* the EVN scheduler and the NRAO on or before the proposal deadline. VLBA proposals requesting only one EVN antenna, or requesting unaffiliated antennas, are handled on a bilateral basis; the proposal should be sent both to the NRAO and to the operating institution of the other antenna requested. Coordination of observations with non-NRAO antennas, other than members of the EVN and the DSN, is the responsibility of the proposer.

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VLBI Global Network Call for Proposals

Proposals for VLBI Global Network observing are handled by the NRAO. There are three Global Network sessions per year, with up to three weeks allowed per session. The Global Network sessions currently planned are:

Start Date	End Date	Proposals Due
17 Feb 2005	10 Mar 2005	01 Oct 2004
02 Jun 2005	20 Jun 2005	01 Feb 2005
20 Oct 2005	10 Nov 2005	01 Jun 2005

Any proposal requesting NRAO antennas and antennas from two or more institutions affiliated with the European VLBI Network (EVN) is a Global proposal, and must reach *both* the EVN scheduler and the NRAO on or before the proposal deadline. Fax submissions of Global proposals will not be accepted. A few EVN-only observations may be processed by the Socorro correlator if they require features of the EVN correlator at JIVE which are not yet implemented. Other proposals (not in EVN sessions) that request the use of the Socorro correlator must be sent to NRAO, even if they do not request the use of NRAO antennas. Similarly, proposals that request the use of the EVN correlator at JIVE must be sent to the EVN, even if they do not request the use of any EVN antennas. All requests for use of the Bonn correlator must be sent to the MPIfR.

Please use the most recent proposal coversheet, which can be retrieved at *http://www.nrao.edu/administration/directors_office/vlba-gvlbi.shtml.* Proposals may be submitted electronically in Adobe Postscript format. For Global proposals, those to the EVN alone, or those requiring the Bonn correlator, send proposals to *proposevn@hp.mpifr-bonn.mpg.de*. For Global proposals that include requests for NRAO resources, send proposals to propsoc@nrao.edu. Please ensure that the Postscript files sent to the latter address request U.S. standard letter paper. Proposals may also be sent by paper mail, as described at the web address given. Only black-and-white reproductions of proposal figures will be forwarded to VLA/VLBA referees. Finally, VLA/VLBA referee reports are now distributed to proposers by e-mail only, so please provide current e-mail addresses for all proposal authors via the most recent LaTeX proposal coversheet.

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EVLA Impact Forecast on VLA Observations

During the entire Expanded VLA (EVLA) project we are committed to keeping the VLA observing and producing forefront science. It is expected that there will be some periods when the amount of observing time is reduced, and the average number of antennas available may be less than for the nominal VLA. We have created an e-mail list of observers to which we have begun sending brief announcements about the current impact of the EVLA project on timescales shorter than the quarterly Newsletter. This information will also be posted at the same time on the EVLA impact forecast web page: *http://www.aoc.nrao.edu/evla/archive/transition/impact.html.*

The first e-mail message about the impact forecast was sent in mid-September 2004. If you did not receive that message, and would like to be added to the observers' e-mail list, please contact Lori Appel at *lappel@nrao.edu.*

M. J. Claussen, F. Owen

A New Joint Proposal Policy

Beginning with the February 2005 deadline we will have a system in place to manage proposals that request the use of multiple NRAO telescopes. The criterion for a valid joint proposal is that it must require more than one telescope to successfully accomplish its scientific goals. A common example of a joint proposal would be one that requires VLA and GBT observations to combine short and long spacings to synthesize a filled aperture. Another example could be a project that requests VLA observations of a sample of sources and then follows up selected candidates with VLBA observations. Such projects are now submitted as separate proposals for each telescope with each proposal reviewed and scheduled independently. This results in a "double jeopardy" situation, where a single science project is evaluated more than once.

To create a joint proposal you must fill in the cover sheets for each telescope but attach the identical scientific justification. Since we expect that most joint proposals are likely to use the VLA, please use the newest VLA proposal form, dated October 2004, and check the appropriate "Joint Proposal" box. The new VLA form is available at *http://www.nrao.edu/administration/directors_office/tel-vla.shtml.* These proposals are then submitted to each telescope independently but they will be reviewed and scheduled as joint proposals. In the near future a new system should make it possible to submit a single cover sheet and scientific justification for multiple NRAO telescopes.

VLBI proposals that request either the GBT or VLA (one antenna or phased array) as part of a VLBI array need not be submitted as joint proposals, but should continue to be submitted as a single VLBI proposal with the appropriate telescopes indicated on the cover page.

P. R. Jewell, J. S. Ulvestad

Green Bank

The Green Bank Telescope

With the return of cooler temperatures and clear, autumn skies, the GBT has resumed observations at higher frequencies. To optimize science throughput, we maintain a form of dynamic scheduling in which parallel high-frequency and low-frequency schedules are maintained. Decisions regarding which schedule to execute for the following twenty-four hour period are made by the high-frequency observer at noon each day. In the longer term, we plan to move to a more automated, queue-based dynamic scheduling system.

To aid observers in forecasting observing conditions including atmospheric opacity and surface winds, Ron Maddalena of the GBT scientific staff has developed prediction tools based on Weather Service vertical profile data. The information is posted on the web at *http://www.gb.nrao.edu/~rmaddale/Weather/* and is updated automatically. Zenith opacity predictions at a number of frequencies from 3 to 43 GHz are plotted. Spot comparisons of these predictions with actual GBT tipping scan data have shown very good agreement.

The new Ka-Band (26-40 GHz) receiver is being commissioned this fall and winter (2004/05). This receiver has a pseudo-correlation architecture, the first such receiver built for the GBT. It is specifically designed to suppress excess 1/f-type noise to yield very high continuum sensitivity, as well as excellent spectral line performance. Commissioning is still underway, but initial results look promising. We expect this receiver to be released for first science this winter. This receiver will have many scientific uses, but should be particularly valuable for high-redshift molecular-line observations and for high-sensitivity continuum point source observations. The Caltech Continuum Backend, a Caltech-NRAO collaboration, is being developed to exploit the continuum performance of the Ka-Band and future W-Band receivers.

As part of the high frequency instrumentation program, the Q-Band (40-50 GHz) receiver was refurbished last summer in an effort to remove some bandpass frequency resonances and to make other improvements. The receiver is being re-commissioned at present, but preliminary data also look promising. Work on the new W-Band (68-92 GHz) receiver has also resumed. This receiver will be another pseudo-correlation system with high continuum and spectral line sensitivity. Work on the Penn Array camera, a collaborative project of the University of Pennsylvania, NASA-Goddard, NIST, Cardiff University, and NRAO, continues to proceed well. We are hopeful that first telescope engineering checks of this 64-pixel, 3 mm bolometer camera can be made in the spring of 2005.

A small workshop on the development of the IDL-based data analysis package for the GBT was hosted on October 15 in Green Bank. In addition to NRAO software and science staff, several members of the community with extensive IDL expertise and keen interest in this project attended. These included Tom Bania (Boston Univ.), Ed Murphy (Univ. Virginia), Tim Robishaw (UC-Berkeley), and Tapasi Ghosh and Chris Salter (Arecibo Obs.). The project staff benefited from the discussion, and the project has been proceeding very well. The objective of the project to produce a basic spectral line and continuum package similar in functionality to the old Unipops system, but easily extensible by any GBT observer familiar with the IDL product. The package will be available for near real-time reduction of data at the telescope, or for off-line post-processing. The IDL development process is also being used to generate critical components for long-term data analysis software development, such as a science data model and detailed requirements. The project team expects to have a beta version of the package available for internal testing by the end of 2004, and a first release for general users in the spring of 2005.

A pulsar observers workshop was held on November 12-13 in Green Bank. The workshop was organized by Scott Ransom of the NRAO scientific staff and was attended by about 20 of the most active users of the GBT for pulsar observing. A wide range of topics was discussed, including scheduling and observing, data handling infrastructure, current and future pulsar instrumentation, large proposals, and data archiving. The workshop was extremely productive and produced excellent discussion and recommendations, which have been documented in a report to the NRAO. We are presently evaluating the recommendations and hope that most, if not all, can be incorporated into NRAO operational and development plans.

A progress review for the GBT azimuth track project was held in Green Bank on December 7-8. The review covered the status of investigations and analyses of the track, the performance of the trial retrofit of one section of the track, and the plans for a full retrofit to remedy the performance problems experienced since late 2001. The conclusions of the review will be described in the next Newsletter.

P. R. Jewell

In General

Joint Spitzer/NRAO Proposals

Proposers interested in making use of the VLA and/or the GBT with the Spitzer Space Telescope may submit a single proposal in response to the Spitzer Space Telescope Cycle-2 Call for Proposals (see page 23 of *http://ssc.spitzer.caltech.edu/documents/calls/cp2.pdf*). The proposal deadline is February 12, 2005. The award of NRAO time will be made to highly-ranked Spitzer proposals and will be subject to approval by the NRAO Director. The primary criterion for the award of NRAO time is that both Spitzer and NRAO datasets are essential to meet the scientific objectives of the proposal. The NRAO plans to make up to 200 hours of observing time on each of the VLA and the GBT available for this opportunity, with a maximum of 75 hours in any configuration/scheduling trimester during an 18 month period close to the Spitzer Cycle-2 such that all VLA configurations are available. The first trimester in which observations could be executed is October 2005 to January 2006. For specific questions about the VLA or GBT aspects of this joint proposal process, please contact Joan Wrobel at *jwrobel@nrao.edu* or Carl Bignell at *cbignell@nrao.edu*.

J. J. Condon

Powerful 94 GHz Cloud-Mapping Radar Scheduled for Low-Earth Orbit

In April 2005 NASA will launch a cloud-mapping experiment called CloudSat. Orbiting at 705 km altitude with a 99-minute period, CloudSat will carry a pulsed, 1.8 kW, narrow-band, 94.05 GHz radar feeding a nadir-pointing, high-gain antenna. CloudSat will fly over most of the world's observatories: just which ones fall under it during a given few-week period will change slightly with time and will only be known in detail after launch.

Power levels of the radar are such that an SiS-junction deployed on a typical radio telescope could be burned out if CloudSat crosses the main beam while it passes overhead. Moreover, an SiS receiver will probably saturate during an overflight no matter where the telescope is pointed, and similarly-strong signal levels would be received if a telescope points at or near CloudSat whenever it is above the horizon. Depending on (increasing with) site latitude, CloudSat will be visible for one-two hours per day during its 13-15 minute-long passes, most of which culminate well below the zenith.

Observatories working at or near 94 GHz will have to formulate a response to CloudSat based on their own particular situation. To assist in this, links to a wide variety of pertinent information have been collected at *http://www.iucaf.org/CloudSat*. This site contains detailed technical information on CloudSat and its nominal orbit, as well as links to 3rd-party satellite tracking tools and an ALMA memo which should serve as a template for understanding the impact on everyday telescope operations. JPL has promised additional tools which were not available at the time of writing of this article.

H. S. Liszt, D. Emerson

2005 Radio and Submillimeter Astronomy Planning Group

As many readers will be aware, the Astronomy Division at the National Science Foundation (NSF) plans to hold a senior review of its portfolio in Spring 2005 as part of its mid- and long-range planning activities. The NSF has asked NOAO and AUI to sponsor broad-based activities to provide input to this senior review in the areas of optical/infrared and radio/submillimeter astronomy, respectively. Since the principal objective of this exercise is to review the current status of progress towards implementation of the recommendations of the 2000 Astronomy and Astrophysics Survey Committee, AUI has called upon the same individuals who participated in the NRC 2000 AASC panel on radio and submillimeter astronomy and were authors of its report. At present, this 2005 Radio and Submillimeter Astronomy Planning Group is beginning its work to develop such an implementation plan, which will serve as input to the NSF AST senior review, on behalf of the U.S. radio and submillimeter astronomy community.

Regular updates of Planning Group activities are posted on-line at *http://www.astro.cornell.edu/~haynes/radiosmm*. Comments and input from the community to any members of the Planning Group would be most welcome.

Martha Haynes, Co-Chair
2005 Radio and Submillimeter Astronomy Planning Group

2004 NRAO Summer Program Presentations at Winter AAS Meeting

Thirteen NRAO summer program participants, including eleven students and two teachers, will travel to San Diego, CA, to attend the 205th Meeting of the American Astronomical Society, January 9-13, 2005. Below are the abstract numbers, titles, and authors of the posters that will describe the results of their summer research.

[11.01] ***Radio Observations of Brown Dwarfs***, L. C. Quick (NC A&T State University), R. Osten, T. Bastian (NRAO), S. Hawley (University of Washington).

[68.07] ***Short and Long Term Radio Transient Searches,*** S. A. Scoles (Agnes Scott College), G. I. Langston (NRAO).

[69.07] ***The Hubble Constant Derived from the Sunyaev-Zel'dovich Effect***, A.M. Stilp (University of Wisconsin-Madison/NRAO), S.T. Myers (NRAO).

[96.04] ***Monitoring Radio Frequency Interference: The Quiet Skies Project***, S. Rapp (Linwood Holton Governor's School), C. Gear (Elkins High School), R.J. Maddalena, S.A. Heatherly (NRAO).

[98.09] ***High Resolution Imaging of Three Starless Cores Using N2H+***, J.M. Grcevich (University of Wisconsin - Madison/ NRAO), Y.L. Shirley (NRAO).

[104.01] ***Exploring the Jet Proper Motions of SS433***, K. Schillemat (Clarkson University and NRAO), A. Mioduszewski, V. Dhawan, M. Rupen (NRAO).

[106.11] ***The Proper Motion of PSR B1951+32 and Its Interaction with CTB80***, B. Zeiger (Willamette University, NRAO), W. F. Brisken (NRAO), S. Chatterjee (NRAO, CfA).

[110.01] ***High Frequency VLBA/VLBI Imaging of M87***, C. Ly (UCLA), R. C. Walker (NRAO), W. Junor (LANL).

[110.12] ***Dating COINS: Kinematic Ages for Compact Symmetric Objects***, N. E. Gugliucci (Lycoming College), G. B. Taylor (NRAO), A. B. Peck (Harvard-Smithsonian CfA), M. Giroletti (Istituto do Radioastronomia del CNR).

[136.01] ***Motions of Water Masers toward Class I Protostar YLW16A***, C. M. Simpson (Wellesley College and NRAO), M. J. Claussen (NRAO), B. A. Wilking (Univ. of Missouri-St. Louis), H. A. Wootten (NRAO), K. B. Marvel (AAS).

[141.11] ***Cataloging Radio Point Sources in the Center of M31***, K. M. Hess (Department of Physics, Cornell University).

[153.05] ***A Pipeline for VLA Data Reduction***, P. B. Cameron (Caltech).

[153.13] ***Pseudo-Real-Time Signal Visualization during Pulsar Observations on the Green Bank Telescope***, C.J. Kelly, K O'Neil (NRAO).

If you plan on attending the AAS meeting, we encourage you to stop by these presentations to judge for yourself the fine work accomplished by our summer program participants. Travel support for the participants is provided by the NSF through the Research Experience for Undergraduates and Teachers (REU/RET) program.

J. Hibbard

Opportunities for Undergraduate Students, Graduating Seniors, and Graduate Students

Applications are now being accepted for the 2005 NRAO Summer Student Research Assistantships. Each summer student conducts research under the supervision of an NRAO staff member at one of the Observatory's 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 Observatory. On their application, students may request to work with a specific staff member, to work on a specific scientific topic, or to work at a specific site.

The program runs 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. These projects often 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. Each is described below.

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 seniors who are citizens or permanent residents of the United States or its possessions or who are eligible for a Curriculum Practical Training (CPT) from an accredited U.S. Undergraduate Program. This program primarily supports students or research projects which do not meet the REU guidelines, such as graduating seniors, some foreign undergraduate students, or projects involving pure engineering or computer programming.

The NRAO Graduate Summer Student Research Assistantship program is for first- or second-year graduate students who are citizens or permanent residents of the United States or its possessions or who are eligible for a Curriculum Practical Training (CPT) from an accredited U.S. Graduate Program.

The stipends for the 2005 Summer Student Program are $460 per week for undergraduates, and $490 per week for graduating seniors and 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 24, 2005.

J. Hibbard

Dynamic Spectra from Green Bank Solar Radio Burst Spectrometer (SRBS)

We are pleased to announce the availability of dynamic (i.e., time-varying) spectra from the Green Bank Solar Radio Burst Spectrometer (SRBS). SRBS was built and tested over the past year for two purposes: (1) to provide high quality spectroscopic data to the solar, heliospheric, and space weather communities for research and programmatic purposes; and (2) to serve as a development platform for ultra-wideband antennas, feeds, and receivers in anticipation of the Frequency Agile Solar Radiotelescope (FASR). Dynamic spectroscopy is a powerful tool for detecting, identifying, and characterizing several types of energetic phenomena in the Sun's corona. These include fast-frequency-drift type III bursts, which trace the path of electron beams through the Sun's atmosphere, and slower-drift type II radio bursts, due to shocks in the corona produced by eruptive phenomena. Type II radio bursts are highly correlated with coronal mass ejections and solar energetic particle events and are therefore of great interest to the coronal physics, heliospheric physics, and space weather communities. Other phenomena detected by SRBS include solar noise storms, radio bursts of type IV and V, radio continua, and a variety of ionospheric effects such as short-wave fade outs, ionospheric refraction, and sporadic E layer ionization.

At present, the instrument produces swept-frequency spectra between 18-70 MHz once per second with a resolution of 30 kHz, sufficient to identify and excise most interfering signals. Since Green Bank is within the National Radio Quiet Zone, the radio frequency interference environment is relatively benign. The instrument operates every day during local daylight hours, roughly 12-24 UT. It has been in operation since January 2004. The data can accessed through the web at *http:// www.nrao.edu/astrores/gbsrbs*.

At present, data are available in image form only. Examples of all phenomena mentioned above are available on the web site. Users will soon be able to select and download data from specific dates and times in a variety of formats (e.g., FITS files or IDL save sets). Users will also be able to view the data in near-real time in the near future. An example of a type II radio burst observed by SRBS is shown in Figure 1.

A major upgrade of the instrument is planned for December 2004 to January 2005. A frequency-agile

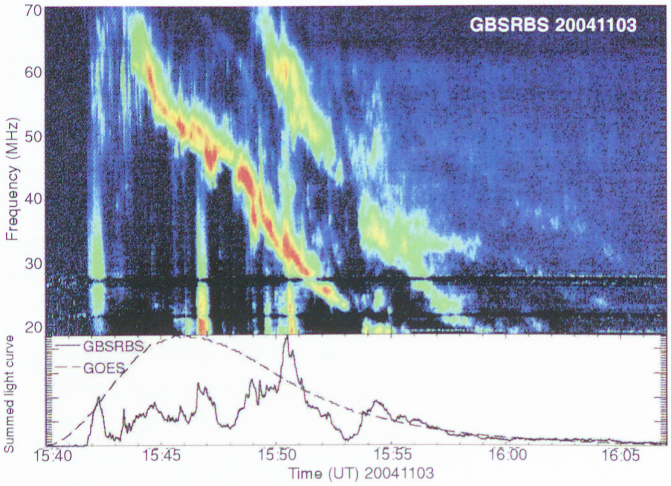


Figure 1. An example of a complex type II radio burst from a coronal shock produced by a GOES class M6 flare on November 3, 2004. The type II shows two bright lanes of emission slowly drifting to lower frequencies with time. The emission is due to plasma radiation at the fundamental and harmonic of the the local plasma frequency. The frequency drift is the result of the mean density gradient in the solar corona. As the shock propagates to greater heights in the corona, the density and hence, the frequency, declines. Also seen in the dynamic spectrum are type III bursts (fast drift bursts) and a type IV burst (diffuse continuum following the type II burst). The associated soft X-ray emission is shown below.

spectrometer (Callisto), designed and fabricated by the Swiss Federal Institute of Technology (ETH/Zurich), will be deployed on the 45 ft telescope at Green Bank. Callisto will provide spectra from 80-800 MHz. A series of future upgrades are planned for 2005-2006 that will ultimately replace Callisto and the low-frequency system with an all digital configuration. These will provide frequency coverage from 10-3000 MHz.

The instrument is the result of a collaboration between the NRAO, the University of Maryland, the Naval Research Lab, and the Swiss Federal Institute of Technology (ETH). The work is funded by an MRI grant from the Atmospheric Sciences Division, Geosciences Directorate, of the National Science Foundation.

T. Bastian, R. Bradley
S. White (University of Maryland)

Portable Array to Probe the Epoch of Reionization (PAPER)

In the early Universe the decoupling of hot, ionized matter from radiation at a redshift around 1000 was followed by the combination of hydrogen and trace amounts of other elements to neutral states. Feeble density fluctuations existed as shown by structures imposed on the microwave background radiation. These fluctuations continued to collapse under gravity during a long, hundreds of millions of years, dark age in the evolution of the Universe. Ultimately the first objects—stars, stellar systems and massive black holes —formed at redshifts around 20. The ultraviolet emission from stars excited the "spin" temperature of the 21cm line in hydrogen above the ambient kinetic and radiation temperature such that it began to appear in emission. This emission continued for a given line-of-sight until full ionization occured at the "epoch of reionization."

A number of authors, including Shaver et al. (1999 A&A, 345, 380), have discussed the amplitude and structure of this redshifted spectrum of hydrogen, and how it might be detected. During the last five years many have written on this topic: theory, simulations, approaches and impediments to detection. The reionization epoch is now bounded by WMAP detection of linear polarization that is interpreted as evidence for partial ionization at a redshift around 15, and the Gunn-Peterson absorption troughs at redshifts in the range 6 to 6.5 that tell us the ionization becomes complete during this interval. The predicted signal amplitudes are in the range of 1 to 10's of mK in this range of redshifts that corresponds to radio frequencies from 190 MHz to 90 MHz, and angular scales above 10 arcseconds are relevant. Several experimental approaches to detection of these faint HI emission signals are being pursued. Some groups seek to measure the global spectrum of the sky with steradian resolution. Others are looking for halos around the first quasars. Several groups are pursuing spectral imaging with varying angular resolution. Foregrounds of galactic synchrotron, extragalactic point sources, galactic recombination lines, and terrestrial interference

Figure 1. One of two broad band PAPER dipoles being installed at Green Bank.

all provide serious impediments to detection. A pioneering experiment by Bebbington (1986, MNRAS, 128, 577) placed a weak limit of 1200 mK on potential HI emission at 150 MHz.

In late August 2004, we placed two broadband dipoles (Figure 1) on a 200m baseline in Green Bank just north of the old 85-1 lab, and linked them with an FX correlator to launch our epoch of reionization experiment. R. Bradley designed the dipoles that were constructed in the Green Bank shop. He, D. Boyd, and University of Virginia student I. Biswas constructed and installed the active balun and low-loss cables. Principle design criteria are smooth dependences on angle and frequency to allow differential measurements at a high level of subtraction that will be essential to reach the mK level.

The initial one-baseline correlator is based on the Green Bank Astronomical Signal Processor (GASP). Frequency division to the 4 MHz level in a FPGA-based spectrometer, built by A. Parsons, D. Werthimer, and J. Mock, is followed by software FX correlation. Figure 2 shows a real-time display of fringe amplitude and phase from Cygnus during the August observations. University of Sydney student A. Chippendale has provided an FX algorithm for the FPGA which provides wider bandwidth and 100 percent measurement duty cycle. R. Bradley has improved the amplifier chain and installed a 140 MHz high-pass filter that suppresses the strong aircraft navigation signals below this frequency.

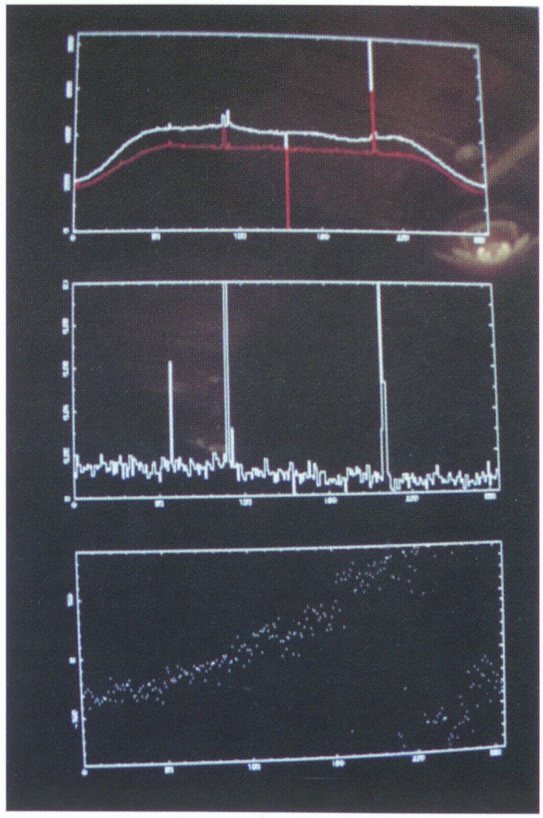


Figure 2. Real-time fringe amplitude and phase display. The top plot shows the receiver bandpass while the middle and lower plots show the magnitude and phase of the cross-correlation, respectively.

In December 2004 we will: (a) upgrade the correlator to a 4-station design by making use of a copy of the prototype correlator developed for the Allen Telescope Array (ATA) under an NSF MRI grant by L. Blitz, L. Urry, and D. McMahon; and (b) deploy two more dipoles to feed this 6-baseline, single polarization, 50 MHz correlator. This will provide significant multi-frequency synthesis capability to image the sky overhead. Our initial goal is to explore stability of the system while developing wide-field imaging capability. The next stage will be to expand to 32-elements with full Stokes parameter sampling. Six of these elements have already been fabricated by NRAO research assistant E. Mastrantonio and D. Boyd with support from the Green Bank shop. The first generation ATA correlator will be replicated. All elements will be on equal-length cables to allow us to repeat measurements of the sky with dithered, or even completely reconfigured, element locations. The array is highly portable, and negotiations are underway to transport PAPER-32 to a low human interference environment such as Western Australia in late 2005.

D. Backer (UC-Berkeley),
R. Bradley, D. Boyd (NRAO), I. Biswas (UVa),
P. Demorest, K. Peek (UC Berkeley),
A. Parsons (NASA),
D. Werthimer, J. Mock (UC Berkeley),
A. Chippendale (ATNF), E. Mastrantonio (NRAO)

Announcement from the NRAO Archives

We are pleased to announce the availability of the Finding Aid to the Papers of Grote Reber, *http://www.nrao.edu/archives/Reber/reber.shtml.*

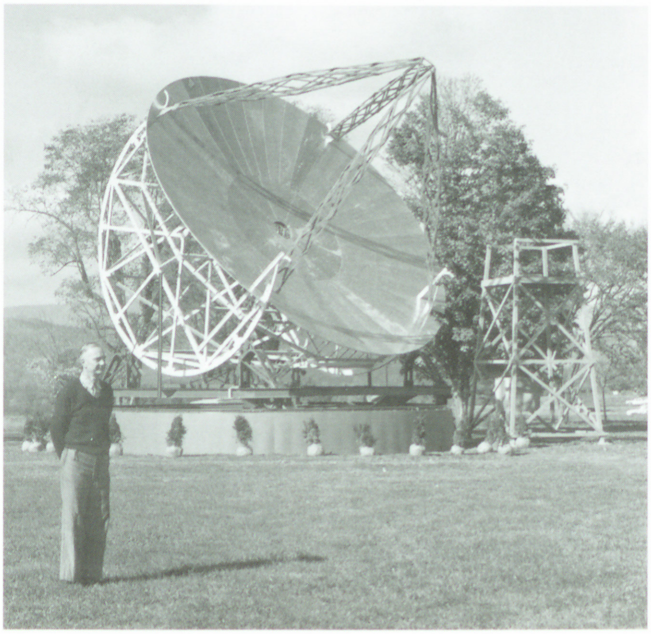


Figure 1. Grote Reber and his restored telescope in Green Bank, 1960.

These papers document the career, research, and personal life of Grote Reber, who designed and built the world's first radio telescope in Wheaton, Illinois in 1937 and established radio astronomy as a key sub-discipline of astronomy. His interest and research in radio astronomy and in other fields, including archeology, botany, electronics, and meteorology, continued nearly until the time of his death in 2002. The papers consist of correspondence, technical and research materials on radio astronomy and a wide variety of other topics, manuscripts and published papers, speeches, ham radio materials, newspaper and magazine clippings, photographs, and other miscellaneous materials. The collection currently includes material dated 1924-1999.

A complete bibliography of Reber's published papers, 1935-1995, may be found at *http://www.nrao.edu/archives/Reber/reber_publist.shtml.*

The NRAO is the repository for Reber's papers and his Wheaton equipment. The papers are in the NRAO Archives in Charlottesville, and the equipment is archived at NRAO's Green Bank Science Center.

E. N. Bouton

Figure 2. Reber in his electric car, Pixie. (Image courtesy of Reber Estate).

New Results

Starburst-Driven Thermal and Nonthermal Structures in the Galactic Center Region

Two large-scale radio components near the Galactic Center have been recognized for more than 20 years: the striking nonthermal filaments and the puzzling "Galactic Center Lobe." The filaments are found only within 2 degrees of the Galactic Center and have transverse dimensions that are roughly a fraction of a pc, whereas their lengths are tens of parsecs. The Galactic Center Lobe consists of two "columns" of continuum emission with a degree scale (~150 pc) rising in the direction away from the Galactic plane. Within the region where both the Lobe and the nonthermal filaments are found, there is a considerable amount of thermal ionized gas and dust emission associated with star-forming regions.

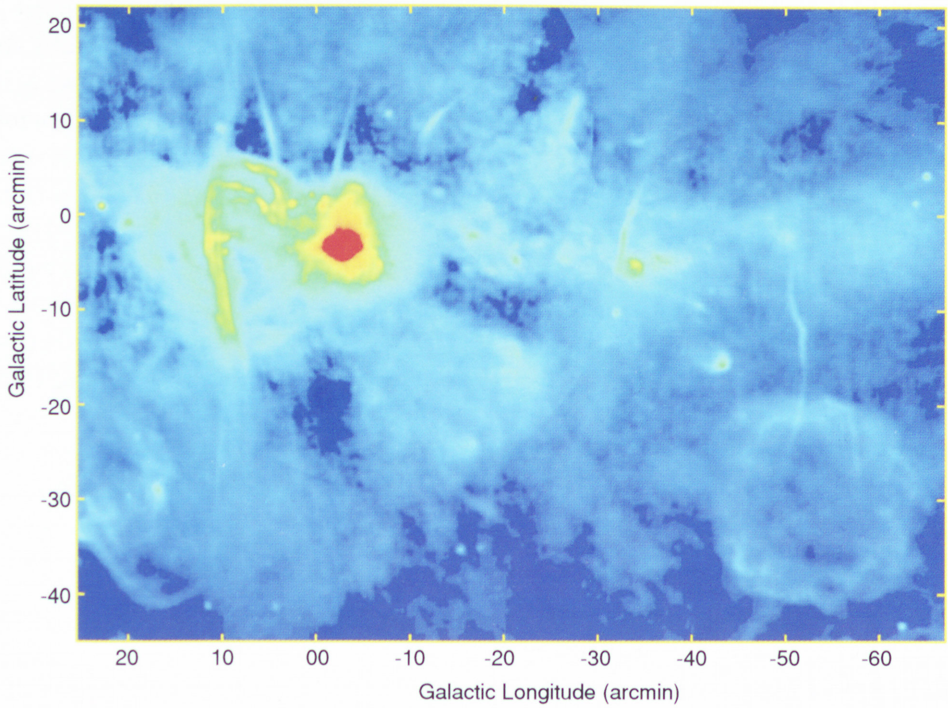
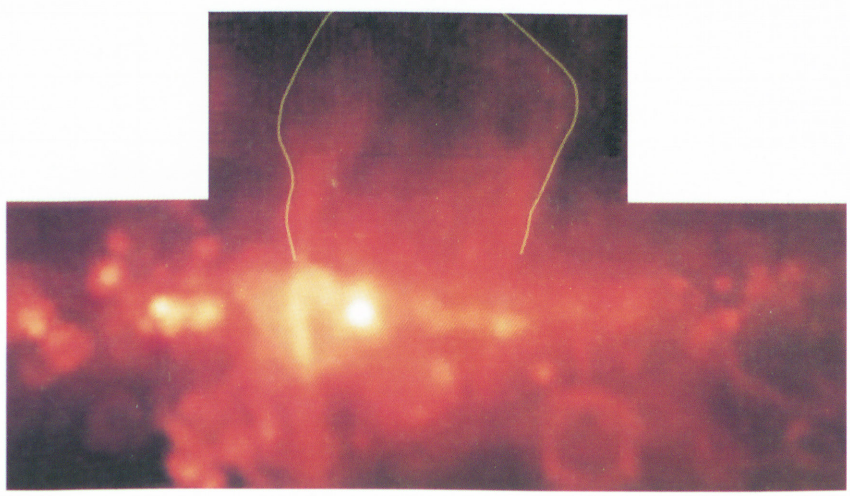


Figure 1. A combined 20 cm image from the VLA and GBT with a resolution of 30". The features near the top are some of the nonthermal radio filaments. Some of the known supernova remnants and HII regions are also visible.

In order to get a better understanding of the Lobe and the filaments and their relationship to star-forming regions, we recently carried out multi-configuration VLA and multi-wavelength GBT observations spanning several degrees near the Galactic center. We used wide-field imaging techniques to correct non-coplanar effects at 1.4 GHz in 40 overlapping VLA pointings. Figure 1 shows a segment of the survey image based on combining the VLA and GBT data at 1.4 GHz. Figure 2 shows a portion of the 5 GHz GBT image containing the Galactic Center Lobe.

Figure 2. A 6 cm image of the Galactic center region based on GBT observation with a resolution of 3'. The outline of the Galactic Center Lobe is drawn. The Galactic plane runs horizontally.



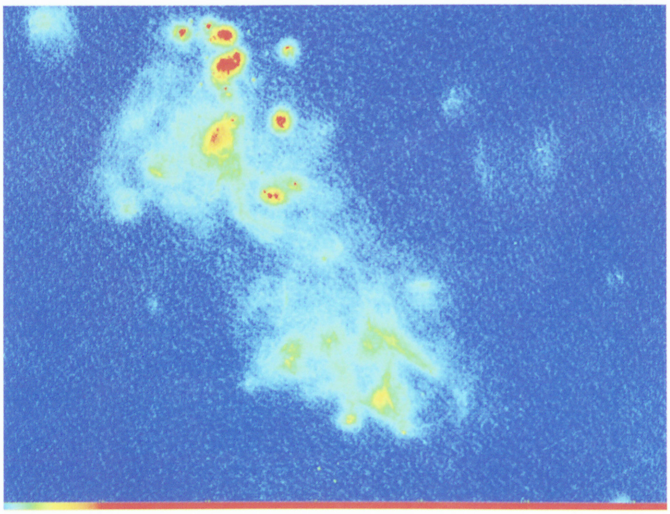


Figure 3: A 20 cm image of the Sgr B complex region with a resolution of 2.5″ × 1.7″. Sgr B2 and Sgr B1 lie to the northeast and southwest, respectively. The Galactic plane runs diagonally.

This study produced several lines of evidence suggesting that the inner few hundred parsecs of the Galaxy went through a burst of star-forming activity less than 10 million years ago. One is the number of young star clusters with similar ages, a few million years, distributed in this region. Hallmarks of an intense episode of star formation are the luminous, compact, young star clusters. Star-cluster formation has also been considered an important mode of star formation in a high-pressure environment in starburst galaxies. Numerical simulations of the evolution of massive star clusters predict that the inner 200 pc of the Galaxy could harbor some 10 to 50 young star clusters similar to the Arches and the Quintuplet clusters (Portegies Zwart et al. 2002). However, the high visual extinction and source confusion will make it difficult to disentangle the hidden star clusters in this region (Law & Yusef-Zadeh 2004). One highly obscured region in which star clusters may be hidden is the Sgr B complex. This complex consists of the evolved, extended HII region Sgr B1 and the young Sgr B2 source whose emission is dominated by compact, bright continuum HII regions. Sgr B2 may be the most spectacular on-going star forming region in the Galaxy, containing more than 50 compact HII regions, many of which are excited by young massive stars. In the context of the starburst model for the Galactic center, Sgr B is an example of a starburst that took place a few million years ago. However, because of its dense and massive molecular environment, expanding HII regions have induced star formation until the present. Figure 3 shows a 1.4 GHz continuum image of the Sgr B complex.

Our 20 cm survey has found a large fraction of the filaments showing jet-like morphology and a wide range of orientations with respect to the Galactic plane. Figure 4 is a schematic diagram of the distribution of more than 80 filaments. The longest filaments run roughly perpendicular to the Galactic plane, whereas the short filaments do not show a preferred orientation. It is not a coincidence that the largest concentrations of filaments are in star-forming regions and are found only within 2 degrees of the Galactic center. These observations suggest the origin of the magnetic fields tracing the filaments is local rather than global (LaRosa et al. 2004; Yusef-Zadeh 2003). Specifically, the filaments may be the emission from nonthermal particles generated in the colliding winds of Wolf-

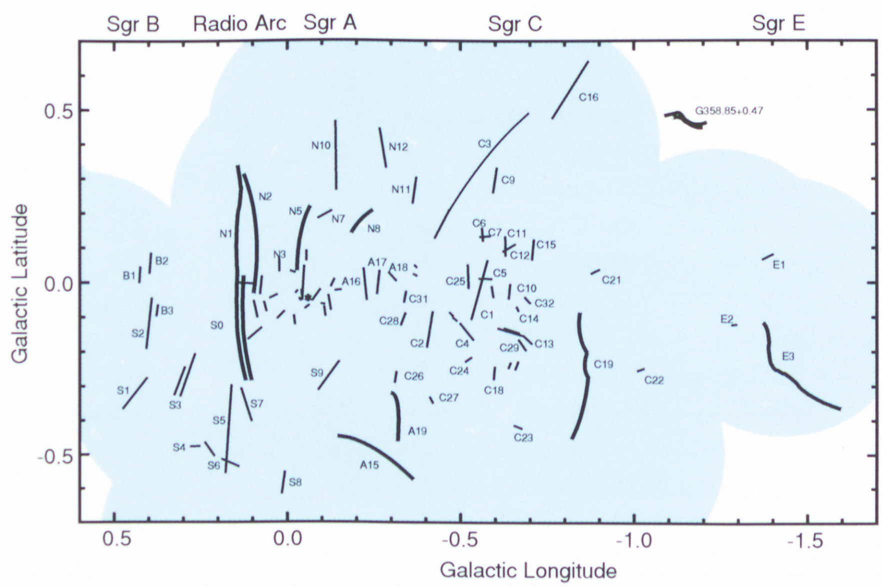


Figure 4: A schematic diagram of all the identified radio filaments. The position of Sgr A is indicated by a star. The blue background circles show the extent of the surveyed region.*

Rayet and OB stars. In addition, the same WR-OB binary systems can be responsible for much of the dust formation found in the Lobe. Another speculation for the origin of the filaments is that black holes, formed within massive young clusters as a result of runaway merging, are responsible for launching narrow filaments.

Other independent studies of the interstellar medium (ISM) in the Galactic center region support a similar picture of starburst activity (Bland-Hawthorn & Cohen 2003; Rodriguez-Fernandez & Martin-Pintado 2004). In particular, recent ISO observations of ionized gas in this region show excitation and ionization parameters that are similar to those of some low-excitation starburst galaxies. We believe the unusual collection of remarkable thermal and nonthermal components found in the Galactic center region can be viewed as a manifestation of winds from massive stars affecting their surrounding ISM during a starburst episode. In particular, a WR-type phenomenon may be the thread that connects the material accreting onto the Sgr A* black hole, young stellar clusters, the nonthermal filaments, and the Galactic Center Lobe. Future study of this region can help our understanding of more energetic WR phenomena in distant galaxies, and, conversely, studying distant galaxies can aid our understanding of energetic WR phenomena in our Galaxy.

F. Yusef-Zadeh (Northwestern U.), W. Cotton (NRAO), J. Hewitt, C. Law (Northwestern U.), R. Maddalena (NRAO), D. A. Roberts (Northwestern U.)

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Supernovae Mark the Violent Deaths of Massive Stars

Six years ago a peculiar ultra-energetic supernova explosion rocked the astronomical community. For the first time, a short burst of high energy gamma-ray photons was observed in conjunction with the visible light from a supernova (SN), marking SN 1998bw as the most powerful event of its kind and 20 times more energetic than any other known supernova. In the years that followed, astronomers proposed a number of hypotheses to explain the tremendous energy output of SN 1998bw. Particularly intriguing was the idea that the event was better described as a gamma-ray burst (GRB), based on the observed gamma-ray photons released at the time of the supernova explosion. As the most luminous events in the Universe, producing a few times 10^{51} ergs in ultra-relativistic energy, GRBs and their origin have been a puzzle to astronomers since their discovery in the 1960's. If SN 1998bw was also a gamma-ray burst, then supernovae and gamma-ray bursts are linked — thereby identifying massive stellar death as the origin of GRBs. The debate over the nature of SN 1998bw led the Caltech/NRAO GRB group to search for other examples of SN 1998bw-like cosmic explosions. After six long years, they have finally discovered an analogue to this peculiar event. On December 3, 2003 a weak gamma-ray burst was discovered with the European INTEGRAL satellite. Together with Dale Frail (NRAO, Socorro), Caltech graduate student Alicia Soderberg turned the Very Large Array antennas in the direction of the burst and detected a weak radio "afterglow" from the stellar explosion. By comparing these data with optical observations taken with the Carnegie Observatory Magellan telescope in Chile, it was clear that the radio source was associated with a nearby supernova (SN 2003lw) at a distance of "only" 1 billion light-years, making this burst the nearest GRB with the exception of SN 1998bw. This distance implies that the true luminosity of the gamma-ray and radio emission was 20 times fainter than typical GRBs and yet comparable with that of SN1998bw. GRB 031203 (and its associated SN 2003lw) were effectively a cosmic analogue to SN 1998bw (see figure). One of the most exciting implications of this discovery is the possible existence of a significant population of low-luminosity GRBs at small distances. Following the successful launch of the Swift satellite on November 20, 2004, the GRB/SN community anticipates detecting many more events like SN 1998bw and GRB 031203 thanks to the improved sensitivity of the Swift satellite to intrinsically faint gamma-ray bursts lurking in the nearby Universe.

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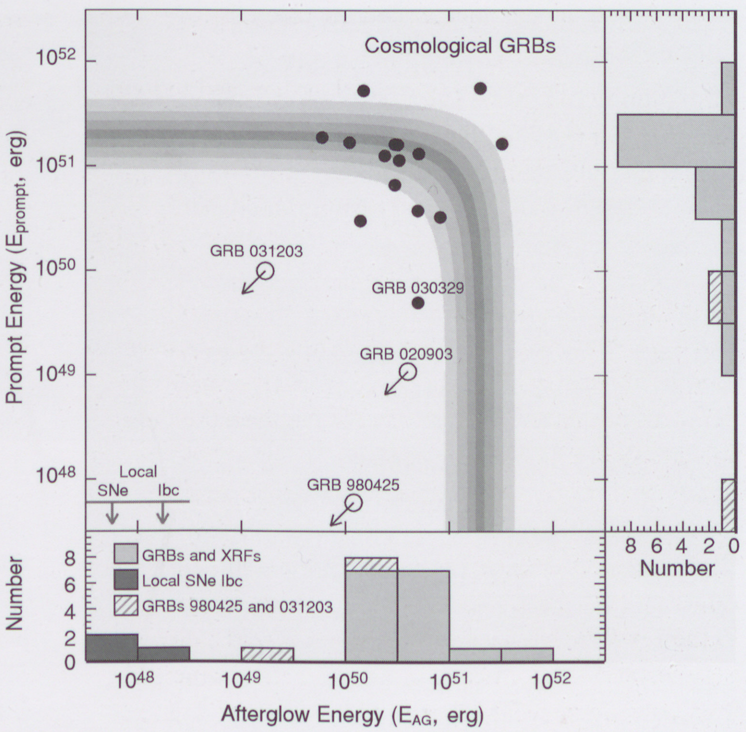
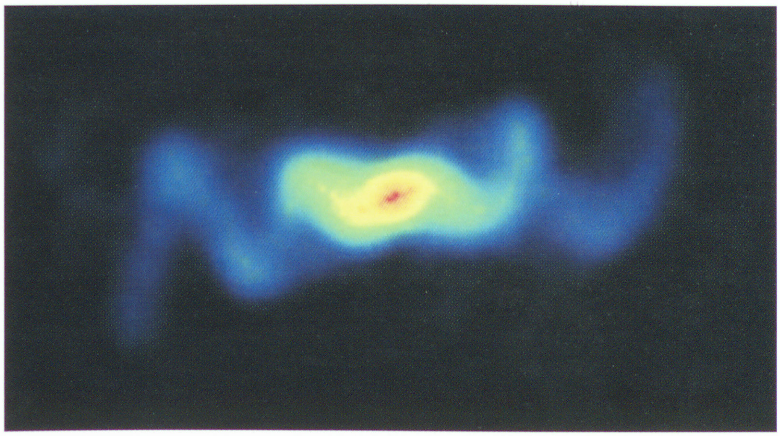


Figure. Two-dimensional energy plot for cosmic explosions. We plot the energy in the prompt gamma-ray emission as a fucntion of the energy in the broadband afterglow emission for all well-studied GRBs. Each point has been corrected for the jet collimation except in the cases of GRB 980425, XRF 020903, and GRB 031203, all of which appear to have isotropic emission and are therefore plotted as arrows (upper limits on both axes). Comological GRBs tend to cluster around a total (prompt plus afterglow) energy ~ 2 x 10^{51} ergs indicated by the shaded arc. However, GRBs 031203 and 980425, the nearest two bursts in the sample, are clearly sub-energetic GRBs, falling a factor of about 20 below the constant-energy arc. Histograms of afterglow and prompt energies are shown in the bottom and side panels, respectively, for cosmological GRBs and local Ibc SNe. The striped energy bins show the locations of sub-energetic GRB 980425 and its cosmic analogue, GRB 031203.

SS433's Zig-Zag/Corkscrew

SS433 has fascinated astronomers and physicists for over a quarter of a century. Successive optical spectra reveal pairs of moving hydrogen lines which behave as though the emitting gas is ejected in narrow opposite jets at about a quarter of the speed of light. The line of these jets is offset from the spin axis of the underlying source, just as the Earth's magnetic poles are away from the geographic polar axis, and so the direction of the jets rotates, with a period of 162 days. This bizarre object also attracted examination at radio wavelengths: the late, and much missed, Bob Hjellming pioneered many such studies to image SS433's oppositely directed radio jets, especially using the VLA. His early radio images eliminated ambiguities in the analysis of the optical data. In July 2003 the VLA in its A-configuration was used to make the deepest ever image of SS433 (Blundell & Bowler 2004). We were able to image more of SS433's zig-zag/corkscrew structure than had ever been seen before, revealing over two complete precession cycles of the axis along which the jets emanate (see figure on next page). Straightforward analysis of the radio image, taken at a wavelength of

6 cm (shown in the figure - which is half a light year across), showed the distance to SS433 to be 5.5 ± 0.2 kpc from Earth. Because the speed of light is not infinite and the radio-emitting matter is moving at a substantial fraction of the speed of light, matter in the receding jet is viewed at an earlier epoch than matter in the approaching jet. This observational asymmetry yields the speed directly (~0.26c). This speed, taken together with the angular periodicity over arcsecond scales revealed in the VLA image, is what determines the distance. Detailed analysis of the 6 cm image, using techniques in image analysis more often used in the medical community, revealed something rather unexpected: the jet speed, presumed for many years to be a constant 0.26c, varies between 0.24 c and 0.28 c. What is remarkable about this is that whatever variation is seen in one jet is also seen symmetrically in the opposite jet. This led us to a re-investigation of the archive of optical data which has been accumulated over the last quarter century. We find these data to be entirely consistent with the velocity variations, and our new treatment has uncovered phenomena previously unsuspected... but that is another story. This deep VLA image of SS433 may herald a new era of investigation and learning about SS433.



VLA 6 cm image of microquasar SS 433

Katherine Blundell and Michael Bowler (Oxford)

Reference:

Blundell, K. M., & Bowler, M. G. 2004, ApJ, 616, L159

The GBT Finds a Low-Cal Sugar: Glycolaldehyde toward Sgr B2(N)

The Robert C. Byrd Green Bank Telescope (GBT) made the news again this summer with the detection of a very cold source of the simplest possible aldehyde sugar toward the giant molecular cloud Sgr B2(N) (Hollis et al. 2004a). The GBT was also used this spring to detect two new interstellar aldehydes: propenal (CH_2CHCHO) and propanal (CH_3CH_2CHO). This time using the 100 m telescope, we detected four transitions of the 8-atom molecule glycolaldehyde (CH_2OHCHO - see figure 1.). From the observations, we determined that glycolaldehyde exists in at least two distinct temperature regions toward Sgr B2(N) which may imply a shock formation mechanism.

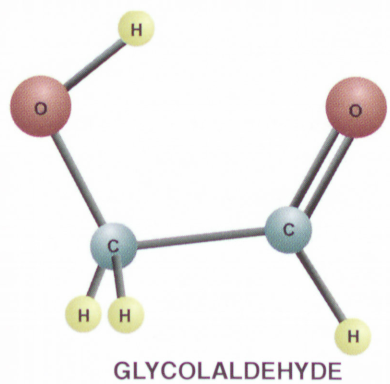


Figure 1: Diagram of the 8-atom molecule glycolaldehyde (CH_2OHCHO).

The observations of glycolaldehyde were made in 2004, February 29 - March 29. Figure 2 shows the GBT spectra of glycolaldehyde. It has now been well established that aldehydes are widespread and distributed on the order of arcminutes toward Sgr B2(N). The evidence comes from observations of acetaldehyde (Chengalur & Kanekar 2003) and propenal and propanal (Hollis et al. 2004b). Furthermore, we also see the competing effects of emission and absorption taking place for a given transition. Compared to emission, the effects of absorption increase as beamwidths decrease. We interpret this as evidence that the smaller beam is coupling better to the Sgr B2(N) continuum source(s), which thereby minimizes the response to the more extended gas in emission. Except in the lowest-energy transition, we see a strong absorption component near the LSR velocity of +64 km s^{-1}. However, also seen are a weaker absorption component at +82 km s^{-1} and a self-absorbed component at +74 km s^{-1}.

In addition to detecting new transitions of glycolaldehyde toward Sgr B2(N), we were also able to obtain an estimate of the temperature of the emitting region. To determine the temperature of the glycolaldehyde observed by the GBT, we made three key assumptions: (1) the distribution function over all molecular levels can be characterized by a single state temperature (T_S), (2) the continuum sources dominate the smallest beam of the transition seen entirely in absorption, and (3) the largest beam of the transition seen entirely in emission is dominated by the gas that is much more extended than the Sgr B2(N) continuum sources. We found that $T_S \sim 8$ K yields the same total column density of $N_T \sim 3.5 \times 10^{14}$ cm^{-2} for both the single emission component of the lowest energy transition seen entirely in emission and the sum of the two absorption components of the highest energy transition. So indeed, we have detected a very low-calorie sugar!

The original detection of glycolaldehyde was made with the NRAO 12 Meter (Hollis et al. 2000). From those observations, a rotational temperature diagram indicated a state temperature closer to 50 K. Thus, there is no doubt that the GBT glycolaldehyde emission and absorption observations are sampling a much colder gas than the glycolaldehyde emission environment sampled by the 12 Meter. The implication is that the ambient molecular medium toward Sgr B2(N) has a significant temperature gradient on a large spatial scale. Such conditions are consistent with the presence of large-scale shocks, and furthermore, the shocks may not only be responsible for the extended distribution of

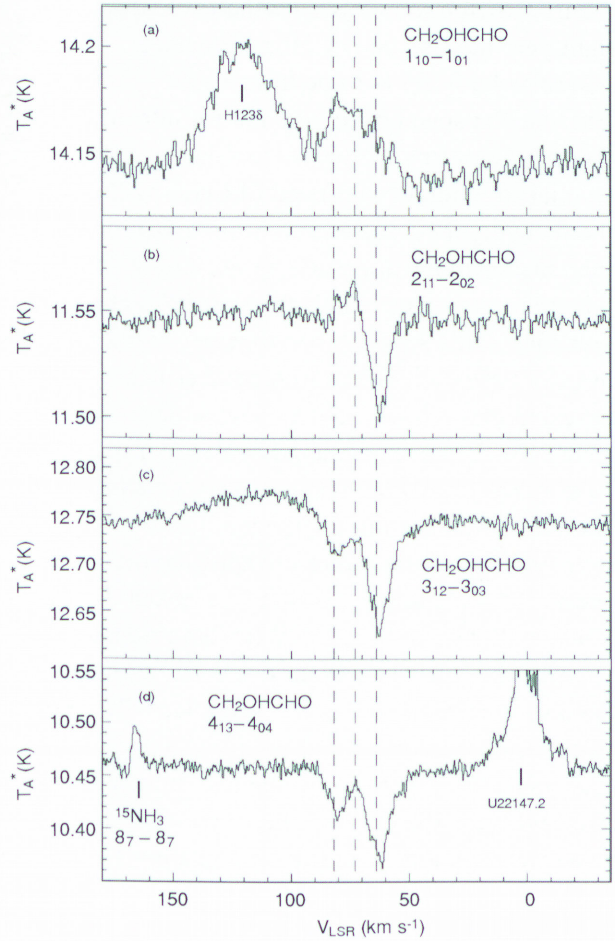


Figure 2. GBT spectra of glycolaldehyde.

glycolaldehyde but also for its formation on dust grains. Additional observations and formation models are needed to confirm this hypothesis.

What is clearly apparent from the new glycolaldehyde observations is that there exist at least two regions at two different temperatures toward the Sgr B2(N) region. A possible model for the two-temperature regions of glycolaldehyde is that a compact source, which contains a weak concentration of glycolaldehyde (Hollis et al. 2001), is surrounded by a warm ($T_S \sim 50$ K) extended glycolaldehyde envelope that is in turn surrounded but a cold ($T_S \sim 8$ K) glycolaldehyde halo. The warm envelope is characterized by a narrow range of LSR velocities from +71 to +75 km s^{-1} and may be shock-heated and/or located in proximity to a continuum source. The cold halo contains two clouds that are characterized by LSR velocities of +64 and +82 km s^{-1}.

These two clouds must lie in front of a distant continuum source to account for the glycolaldehyde absorption. However, further observations will be necessary to determine the details of the model.

In summary, we have detected unexpectedly strong lines of glycolaldehyde toward the high-mass star-forming region Sgr B2(N). The analysis of the four transitions detected with the GBT indicates that glycolaldehyde exists in a very cold region (T_s ~ 8 K) of the interstellar medium. Using the results from the previous detection, we find a two-temperature model may explain the glycolaldehyde emission toward Sgr B2(N). The model consists of a compact region surrounded by a warm (50 K) extended glycolaldehyde envelope, which is in turn surrounded by a cold (8 K) glycolaldehyde halo.

A complete report of the glycolaldehyde detection appears in the September 20, 2004 issue of ApJ Letters.

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