NRAO Newsletter

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AUI PRESIDENT GIACCONI RECEIVES NOBEL PRIZE IN PHYSICS AT CEREMONY IN STOCKHOLM

Riccardo Giacconi (left) receiving the Nobel Prize from His Majesty the King at the Stockholm Concert Hall.

Riccardo Giacconi, president of Associated Universities, Inc., received the Nobel Prize from His Majesty the King of Sweden at the Stockholm Concert Hall on December 8, 2002.

Giacconi received one half of the 2002 Prize in Physics "for pioneering contributions to astrophysics, which have led to the discovery of cosmic X-ray sources." The other half of the prize was shared by Raymond Davis, who did his pioneering work of detecting solar neutrinos while he was at Brookhaven National Lab, and Masatoshi Koshiba of the University of Tokyo, who headed the Kamiokande experiment in Japan that detected neutrinos from SN1987a in the Magellanic Clouds.

Professor Per Carlson, who is a member of the Royal Swedish Academy of Sciences and a member of the Nobel Committee for Physics delivered the presentation speech, saying: "Giacconi's achievements in X-ray astronomy have dramatically changed our view of the Universe. The Universe not only contains stars and star constellations in slow development but also hosts rapidly evolving compact objects which release enormous amounts of energy. Of particular interest is the possibility of indirectly detecting black holes."

Earlier in the day, Giacconi presented his Nobel Lecture, entitled "The Dawn of X-ray Astronomy" at the Aula Magna of Stockholm University.

Giacconi also will present a lecture entitled "The Development of X-ray Astronomy" in Charlottesville, on April 16 in the historic Rotunda of the University of Virginia.

"I am delighted that Riccardo Giacconi has received this recognition," said NRAO Director Fred Lo. "His pioneering work in the early '60s opened a new window on the Universe. He showed that certain astronomical bodies emit X-rays because of their high temperature, displaying high energy phenomena otherwise not evident if only viewed in the traditional optical observations. By the same token, radio astronomy has also provided an entirely new perspective on the Universe. By receiving the Nobel Prize, Dr. Giacconi has helped to showcase to the world the value and impact of multi-wavelength observations that enable us to gain a complete picture of what happens in the Universe. We are very proud of his association with the National Radio Astronomy Observatory."

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IN GENERAL

My First Six Months

Perhaps it comes as no surprise to anyone that I have been very busy during my first six months as the NRAO Director. I have visited all the sites (at least three times each by April 1), talked to as many of my colleagues (more than 500 and growing) as possible, and I have been reviewing all aspects of the NRAO operations. By most measures, the NRAO is doing very well, with a new GBT that is being commissioned, an effective operation of the VLA/VLBA, the first phase of upgrading of the VLA (EVLA1), and perhaps most importantly, the construction of the North American (NA = U.S. and Canada) half of ALMA.

Given the remarkable legacy of my predecessor, Paul Vanden Bout, my responsibility of seeing through the completion of all the major projects. The commissioning of the GBT for full-time science use, the EVLA1 and ALMA (NA) — in a funding environment that is inherently unstable, is a heavy one.

What makes my job possible are the remarkable breadth and depth of expertise and talent in the NRAO staff. My job is very much like that of a symphony conductor going through rehearsals with a group of excellent musicians in order to make the finest music possible. There is no doubt that the NRAO will give a great performance, but the rehearsals are a lot of work, requiring the continual dedication of all the staff. And, just as the different sections of an orchestra have to play as one body, the various components of the NRAO have to function as one Observatory.

To foster this "one Observatory" approach, I have been working to institute steps to increase coordination among all the sites on all that we do at the NRAO. I have set up an Observatory Technology Council and an Observatory Computing Council, composed of a cross section of the relevant experts from across the NRAO, to ensure inputs from and discussions among our colleagues with diverse viewpoints and experience, to advise me on policy and strategic issues. Both Councils were formed for an initial term of one year, so that we will have a chance to review how effective this approach is. So far so good. To coordinate the actual operations, both Councils have been asked to recommend how to reorganize the staff in both areas to achieve an even more effective approach to deal with the myriad of tasks confronting the NRAO.

February 25 marked a true milestone of the ALMA project. On that day, the Bilateral Agreement on ALMA was signed by NSF Director Rita Colwell and ESO Director General Catherine Cesarsky, formally launching the North American-Europe partnership to build the baseline ALMA project of sixty-four 12-meter telescopes in northern Chile.

Negotiations are underway with our Japanese colleagues who are seeking funding approval from their government to build the Atacama Compact Array (ACA = twelve 7-meter telescopes, plus four 12-meter telescopes for short-spacing data, three additional bands of receivers, and a second generation correlator). If all goes well, the Japanese funding will commence in the spring of 2004.

During the ten years of ALMA construction, it is essential to keep the university community involved in ALMA, in science preparation, in training students and young scientists, and in setting up the ALMA NA Science Support Center in Charlottesville, and all related issues. For this purpose, a representative group of astronomers has been appointed to the ANASAC (ALMA NA Science Advisory Committee) to advise the NRAO Director on such matters. One of the first activities of the ANASAC is likely the organization of an ALMA Science Workshop later this year.

AIPS++ has been a controversial effort for many years and has led to considerable division within the NRAO staff and in the user community. What complicates the matter is that AIPS++ is not an NRAO project but an international one. In order to identify the technical issues of AIPS++ that require attention, the AIPS++ Executive Committee (AEC) commissioned an independent Technical Review panel to make findings and recommendations on a list of charges that had been primarily prepared by a group of NRAO staff members with diverse opinions. The review took place on March 5-7 in Socorro, and a report is due by the end of March.

From my perspective as NRAO Director, the issue is not whether AIPS++ has problems, but what to do about those problems to make AIPS++ or some alternative approach fulfill the computing requirements of the future facilities such as the GBT, EVLA, and ALMA. The focus will be on finding the practical solutions, at the shortest possible time scales.

Another notable development is the announcement on February 18 that the Tucson group, dedicated to ALMA work in the last few years since the closing of the 12 Meter Telescope, will be consolidated with the other NRAO sites (mainly Charlottesville) by mid-2006. A small group of engineers will move during mid-2004, followed by a group of technicians during mid-2005, and the rest (roughly half) by mid-2006. This will enable the formation of a dedicated group in Charlottesville, working on the Front End and Local Oscillator tasks and subsystems of ALMA, which would make the operation more effective.

It has been a very interesting six months for me, and I am excited by the future prospects of the NRAO and radio astronomy. I aim to make another report to you at the end of the next six months.

K. Y. Lo

Robert Brown to Assume NAIC Directorship

Robert L. Brown deputy director of the National Radio Astronomy Observatory (NRAO) has been chosen to direct the National Astronomy and Ionosphere Center (NAIC), whose main facility is the Arecibo Observatory in Puerto Rico. NAIC is managed by Cornell University in Ithaca, New York, for the National Science Foundation (NSF).

Brown will take over this post on May 5, succeeding Paul Goldsmith, the J. A. Weeks Professor in the Physical Sciences at Cornell, who stepped down last month to return to full-time research and teaching.

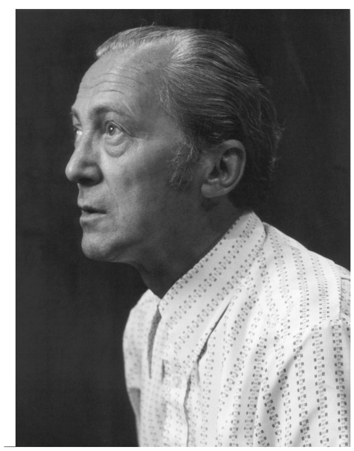
Brown came to the NRAO as a Research Associate (postdoc) in 1969. He has been both associate and deputy director of NRAO since 1985, spearheading not only the United States involvement in the Atacama Large Millimeter Array (ALMA) project, but also managing NRAO participation in NASA's Space Very Long Baseline Interferometry Project. From 1977 to 1980 he was assistant director of the NRAO operations in Green Bank, West Virginia, and from 1984 to 1985 he was assistant director of the NRAO operations in Tucson, Arizona. Associated Universities, Inc., tenure was granted in 1977. He received his bachelor's degree from the University of California, Berkeley, in 1965, and his master of science and doctorate degrees from the University of California, San Diego, both in 1969. All of his degrees are in physics. His scientific studies, both theoretical and observational, have focused on the interstellar medium, the galactic center, and distant galaxies.

"Bob Brown has been a leading figure at the NRAO and in the international astronomical community for many years," said NRAO Director Fred Lo. "His contributions at the NRAO, and particularly his outstanding work over many years on the planning and organization of ALMA, have helped to advance the science of radio astronomy. Though we are sorry to see Bob leave, the entire astronomical community will definitely benefit from his leadership at NAIC and at the Arecibo Observatory."

C. E. Blue

Sebastian von Hoerner (1919-2003)

Sebastian von Hoerner, astronomer, telescope designer, and former NRAO scientist, died January 7, 2003, in Esslingen Germany. His wife Lisa preceded him in death by about a year. He is survived by their children Gabriela, Hanna, and Roland, and Roland's wife Elvira. He was an outstanding scientist, colleague, and friend to all who knew him.



Sebastian was born in Görlitz, Germany in 1919. Like all young German men of that time he was conscripted into Hitler's army at age 18, and was in the Blitzkrieg of Poland in 1939. Two years later he was severely wounded during the siege of Leningrad and was therefore able to sit out the rest of the war in relative safety. The end of the war found Sebastian and his wife Lisa in the Soviet zone of occupied Germany. Sebastian left soon to attend the University of Göttingen. Over the next few years they had many harrowing experiences, sneaking across borders to visit each other, and finally getting Lisa and their children safely into the western zone.

Sebastian first came to the NRAO in 1960 on a one year visiting appointment, at the invitation of Otto Struve. He went back to Germany in 1961 but returned a year later, this time to the permanent staff. He remained in Green Bank, first as scientist, later as senior scientist, until he retired in 1983. Originally trained as a theoretical physicist under Carl von Weizsäcker, Sebastian's early astronomical interests included star formation, and turbulence and shocks in galaxies, and the interstellar medium. After coming to the NRAO he quickly became interested in the use of radio observations for cosmological studies, a topic which at that time was being fueled by controversies about the accuracy, interpretation and usefulness of radio source counts. The clear need for better data led Sebastian to consider possible designs for a new radio telescope. This in turn led ultimately to his development of the concepts of homologous deformations of steerable reflectors and the design (with Findlay and Wong) of a 65-meter telescope. Sadly, that telescope was never built, but Sebastian became recognized worldwide as an expert in telescope design.

Besides his interests in traditional astronomical subjects and telescope design he was an early advocate of SETI and made a number of highly original and thought provoking contributions to that area. He was also a talented musician and music theorist, and published several papers on musical theory in music journals. He played the flute and other conventional instruments, and also enjoyed coaxing music out of many commonplace objects, including bicycle pumps and saws.

A sampling of titles of von Hoerner's published papers illustrates the range of his interests: *Contributions to the Theory of Turbulence of Spiral Nebulae*; *The Internal Structure of Globular Clusters*; *The Origin of Stars Through the Condensation of Diffuse Matter*; *The Search for Signals from Other Civilizations*; *Requirements for Cosmological Studies in Radio Astronomy*; *Homologous Deformations of Tiltable Telescopes*; *The Definition of Major Scales, for Chromatic Scales of 12, 19, and 31 Divisions per Octave*; *The Derivative Tensor of the Stiffness Matrix as a Tool for Optimizations*; *Design Principals for Large Millimeter-Wave Telescopes*. His work in each of these fields was characterized by innovative ideas coupled with a concise logical development of the subject and strong mathematical analysis.

After retiring and returning to Germany, Sebastian continued to be active in telescope design, serving as consultant to the NRAO, Arecibo, and several other institutions. Most recently, he was a member of the GBT Advisory Committee and regularly attended meetings in Green Bank during its construction in the '90s.

I feel a special, personal loss at Sebastian's death. I offered him his permanent position at the NRAO in 1962; he gave the NRAO scientific credibility and me sound advice and support during the early difficult years at the NRAO; he and Lisa were good friends to my wife and me; Sebastian was a frequent sailing companion, sailing with me to Bermuda, the Bahamas, and the Virgin Islands. He was invariably cheerful, was a great story teller, had a lively sense of humor, a sharp and very analytical mind, and was simply a stimulating person to be with. His contributions to astronomy and to the NRAO were numerous and important and his impact on telescope design will live on.

David S. Heeschen
former Director, NRAO

ALMA

ALMA Officially Launched

Dr. Rita Colwell, director of the National Science Foundation (NSF), and Dr. Catherine Cesarsky, director general of the European Southern Observatory (ESO), signed a historic agreement jointly to construct and operate ALMA, the world's largest and most powerful radio telescope operating at millimeter and sub-millimeter wavelengths.

"With this agreement, we usher in a new age of research in astronomy," said Dr. Colwell. "By working together in this truly global partnership, the international astronomy community will be able to ensure the research capabilities needed to meet the long-term demands of our scientific enterprise, and we will be able to study and understand our Universe in ways that have previously been beyond our vision."

Dr. Cesarsky also commented, "This agreement signifies the start of a great project of contemporary astronomy and astrophysics. Representing Europe, and in collaboration with many laboratories and institutes on this continent, we together look forward to wonderful research projects. With ALMA, we may learn what the earliest galaxies in the Universe really looked like, to mention but one of the many eagerly awaited opportunities with this marvelous facility."

Chile, the host country for ALMA, has shown its support for the telescope by issuing a Presidential decree granting AUI permission to work on the ALMA project, and by signing an agreement between ESO and the government of the Republic of Chile. These actions by the government of Chile were necessary formal steps to secure the telescope site in that country.

By signing this agreement, ESO and the NSF give the green light for the joint construction of the ALMA telescope, which will cost approximately $552 million U.S. (in FY 2000 dollars). To oversee the construction and management of ALMA, a joint ALMA Board has been established by the partners. This board met for the first time on February 24-25, 2003, and witnessed the signing at the NSF headquarters in Arlington, Virginia.

Among the actions taken at its first meeting, the ALMA Board selected Massimo Tarenghi as the ALMA Director effective April 1, 2003. Dr. Tarenghi served as the interim ALMA Project Manager during the search for the permanent Joint ALMA Office (JAO) key staff. Selections for the remaining positions of the JAO are anticipated shortly.

While construction funding and the related activities for ALMA in the United States started last year and construction funding in Europe started this past January, these actions formalize the start of ALMA as an international project. With a well defined scope, schedule, funding, and governance, the ALMA project is now officially launched.

M. D. Rafal

ALMA VertexRSI prototype antenna at test facility in Socorro, New Mexico.

EVLA

The VLA Expansion Project

The EVLA Project is a joint enterprise involving the United States, Canada, and Mexico.

The Canadian portion of the project is to design, build, and deliver to the NRAO a modern digital correlator, with funding provided by Canada's National Research Council (NRC). This work is being done by the correlator design group at the Dominion Radio Astrophysical Observatory in Penticton, British Columbia. Despite uncertainty in obtaining a full funding commitment from the NRC, the design work has been continuing, and progress has been very good. On February 17, 2003, the Canadian federal government's budget for fiscal 2003 was presented. The Canadian Budget Plan includes the following statement under funding for the National Research Council (NRC):

"Budget 2003 also provides $10 million per year to the NRC to establish new regional innovation centers in Regina and Charlottetown and to secure Canada's participation in leading-edge astronomy projects, including the Extended Very Large Array project in New Mexico and the Atacama Large Millimeter Array project in Chile."

This is good news for both the EVLA and ALMA, as the language specifies support at the highest levels of government for Canada's participation in both projects. Thus we remain confident that construction of the WIDAR correlator will begin as scheduled in 2006 after prototype tests, and that first science will be possible with the first subset of the correlator in 2007. The full correlator is scheduled for completion in 2009.

Phase I Progress

The primary goals of the first phase are to vastly improve the frequency coverage, frequency resolution, sensitivity, and data processing capabilities of the VLA. This phase is now entering its third year of funding, with completion currently scheduled for 2012. In Phase I of the EVLA project we will replace most of the electronics and software systems at the VLA in order to obtain an order of magnitude or more improvement in sensitivity and spectroscopic capability. All hardware and software areas required for Phase I are now into the prototyping phase and laboratory testing of prototypes is beginning. The next major goal for the project is to begin installation of the prototype systems on an antenna for testing. Antenna 13 will become the EVLA Test Antenna when it enters the Antenna Assembly Building for its routine overhaul in mid-April. After completion of the overhaul work and the installation of the new EVLA Cassegrain feed support structure, installation of the prototype electronic systems will begin in late June. Although the new EVLA systems are compatible with the existing VLA electronic systems, it is not expected that Antenna 13 will be available for routine scientific observations before the first quarter of 2004. From July 2003 until the time that Antenna 13 returns to routine scientific observing, the VLA will become a 26-element array.

Installation crew at work on the west armof the VLA.

Installation of the fiber optic cable on the array by the six-person NRAO crew is proceeding well. Installation is currently occurring along the west arm where it has reached station AW6, a distance of about 10 km from the center of the array. Cable installation is scheduled for completion in 2005. The picture above shows the installation crew at work on the west arm.

As an aid to planning equipment layout in the receiver cabin, a mockup of the new Cassegrain focus feed structure and feed system were built and installed on a mockup of the receiver cabin. A picture of this assembly is shown on the following page.

Phase II (The Completion Phase)

Phase II, termed the "Completion Phase," will add three special capabilities to the VLA:

1) An increase in resolution by about a factor of ten, while maintaining the imaging fidelity of the VLA and the full sensitivity of the EVLA;

2) An extension of the continuous frequency coverage downward from 1.2 GHz to about 150 MHz;

A mockup of the new Cassegrain focus feed structure and feed system were built and installed on a mockup of the receiver cabin as an aid in planning equipment layout in the receiver cabin.

3) Construction of a new, compact configuration (E-config.) which, in combination with single-dish data, will give fast, accurate, and sensitive imaging on angular scales as large or larger than the primary beam of the individual antenna elements.

We are now finalizing the proposal for the Completion Phase II funding, with the goal of having it ready for delivery to the National Science Foundation by July of this year. The proposal will request funding for:

A) Eight new antennas, to be situated throughout New Mexico, and connected by fiber to the new Canadian correlator. A sketch of the planned antenna locations is shown in the accompanying figure. The correlator will be expanded from the Phase I 32-station capacity to 40 stations. Two VLBA stations (Pie Town and Los Alamos) will be upgraded to EVLA standards, and will become part of the EVLA for selected experiments while the VLA is in the A-configuration. For other configurations, the eight new stations will operate together with the VLBA, or as a stand-alone subarray, referred to as the New Mexico Array (NMA).

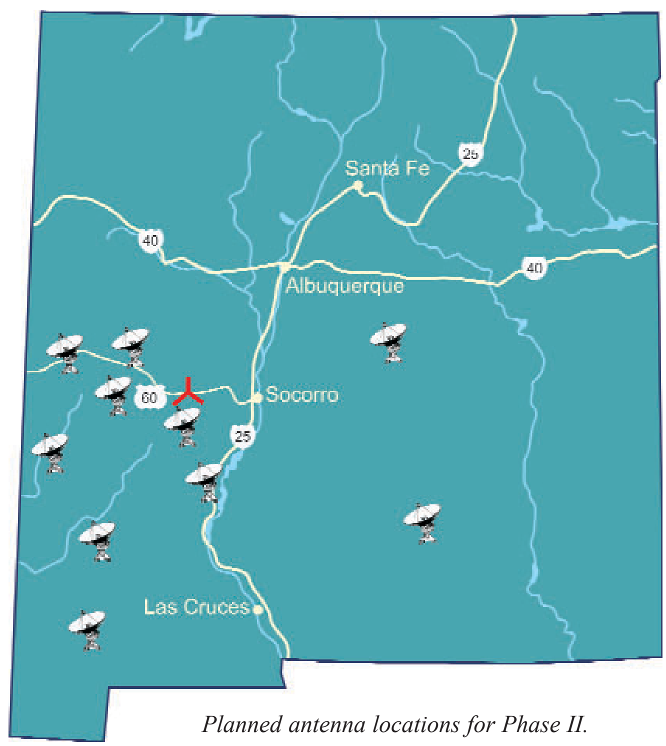
B) Mounting a prime-focus, low-frequency feed system. This will be either an off-axis phased array, an on-axis single feed, or a combination of the two. Studies of the performance of each system are ongoing.

C) Construction of 16 new VLA antenna stations, located near the center of the Y. The new stations will be combined with 11 existing D-configuration stations to define the new E-configuration.

The Canadian-designed correlator after expansion to 40-stations can process the data from all 45 antennas in a combined array (27 VLA, 8 new, and 10 VLBA) due to an innovative feature of its design. The correlator "station input" can process one input of 16 GHz bandwidth, or two inputs of 4 GHz bandwidth, or four inputs of 1 GHz bandwidth (bandwidths are the sums of both polarizations). This will permit, for example, definition of subarrays that can independently and simultaneously process the EVLA data input at full 16 GHz bandwidth and VLBA data input (either from disk input or in real-time) at 4 GHz bandwidth. Because of this capability, we plan to decommission both the existing VLBA and VLA correlators when the WIDAR correlator is fully operational in 2009. Operations for both arrays will then be combined, using the single correlator.

A final completion phase budget is now being estimated. Our goal is to complete Phase II of the EVLA at the same time as Phase I.

P. J. Napier & R. A. Perley



Planned antenna locations for Phase II.

GREEN BANK

The Green Bank Telescope

The GBT continues to move toward routine observing status. The percentage of total telescope time scheduled for observing programs was about 30 percent in the autumn, is up to 46 percent in March, and should grow through the spring. During the winter months, commissioning of the K-band (18-26.5 GHz) system was essentially completed. We are now checking out observing programs at K-band, and expect to schedule a number of these in late winter and spring. The priority, single-bank modes of the Spectrometer have now been confirmed and are available for use. Checkout of the multi-bank modes, which allow multiple IF inputs, is underway. We installed the Q-band (40-50 GHz) receiver in early March for initial engineering checkouts.

Over the past few months, significant telescope time, engineering, and scientific effort have gone into investigating spectral baseline shapes. The GBT is expected to have inherently good spectral baselines because of the unblocked optics that eliminate many of the usual sources of standing waves and reflections. The staff is working to ensure that electronic stability and other sources that affect baseline curvature match the performance of the optics over the wide spectral bandwidths available to GBT observers. The group studying baselines has made excellent progress in isolating many sources of baseline curvature. Detailed investigations continue, and they are now in the process of documenting their findings, implementing a number of improvements and mitigation schemes, and planning for further work.

Since K-band and Q-band observing depends on good weather, we have implemented a program of primary and backup observing. In this system, a block of several days is assigned during which high frequency observing and low frequency backup programs are scheduled. Since statistically, about half the days during the winter months are suitable for K-band observing, the potential K-band observing block is about twice the required time. Each day, based on the weather, a decision is made on whether to proceed with the high frequency or low frequency program. Once the required K-band time is satisfied, the remaining time will default to the lower frequency program or another K-band program. If the K-band observer falls well short of his allocated time at the end of the block, then additional time may be assigned at another date. This system increases the odds of success for the higher frequency program, while conserving total telescope time through use of approved, lower frequency programs. This is a manual method of dynamic scheduling. In the longer term, it is our intention to move to a more automated, queue-based form of dynamic scheduling.

In early February, the electronics staff completed RFI suppression modifications to the feed arm servo system. The feed arm servo, as originally installed, has been a major source of RFI at longer wavelengths. In addition, we are refitting the shielded windows of the GBT Control Room. Poor shielding by the windows, owing to dissimilar metal corrosion, meant that the Control Room was also a major source of RFI. This project will be completed in March. Together, these two projects should significantly improve the RFI environment at the GBT at L-band and lower frequencies. RFI is a serious challenge to radio astronomy, in general. At the GBT, we now have a group working full-time on RFI and Quiet Zone issues, and have significantly expanded overall resources devoted to this area.

One of the key development projects for the GBT is known as the Precision Telescope Control System (PTCS), which is the integrated system that will allow the GBT to operate at 3 mm wavelengths. This project is essential to achieve many of the scientific objectives of the GBT, and to support a suite of instrumentation that should be available in about two years. The project team has developed a proposed architecture for the system that was discussed, and well-received, in an open meeting with Green Bank scientific and technical staff in mid-January. They plan a formal conceptual design review in early April.

There have been new developments with the GBT azimuth track. On January 16, we discovered that one of the track wear plates had developed a significant crack on its end near the splice. Since then, we have removed and carefully inspected all 48 wear plates. Thirteen of the plates have cracks on their ends. Four of these are deemed serious, either because of the size of the crack or its direction of propagation. Only one plate — the first one detected — has a crack all the way through the plate, however. The cracks on the other nine plates are mostly hairline and are not serious at present, and can perhaps be repaired. The GBT remains in astronomical operation, but the cracks are being frequently and carefully monitored. In addition, we have restricted azimuth wheel movement over the most serious cracks and operations at low ambient temperatures, until the most seriously cracked plates are replaced.

The NRAO engineering staff has taken a number of steps to address these problems. As part of the process described above, all plates have been inspected for cracks both visually and with a magnetic particle machine. The lower edge of each plate end has been chamfered to reduce future crack initiation sites. Each plate has been shimmed to address the fretting wear problems described in previous news updates and, to provide better support at the ends. We have placed an expedited order for several replacement wear plates that should be received in early March. The three most seriously cracked plates will be replaced in-kind in March, and we will use some of the other plates for a trial modification of the track. When the cracked plates are removed, we will submit one to metallurgical analysis that should help us to understand the problem and to mitigate further cracking.

These new developments have increased the urgency of implementing the recommendations of the azimuth track review panel that met last November in Green Bank. As described in previous reports, the panel recommended a three-part program of analysis, trial retrofits and tests of the existing track, and development of concepts for a new track, should that be ultimately required. The program of analysis and trial retrofits has been expedited, and we hope to have the first trial retrofit installed by the end of April. This will consist of a reinforced and welded base plate with a bridging wear plate. Some of the new wear plates described above will be used for this purpose. This field trial will be thoroughly characterized and analyzed, and its performance will be closely examined while the telescope is in use over a period of 6-8 months. We also expect to complete the other elements of the program recommended by the panel by the end of 2003, and be ready for a decision on how to proceed at that time. In the meantime, the GBT will continue with astronomical operations.

P. R. Jewell

The Penn Array

Mark Devlin's group at the University of Pennsylvania is constructing the Penn Array Receiver, a 64-element array of transition-edge superconducting bolometers for the GBT. NRAO is providing funds for this development through the Universities Instrumentation Program. The work is a collaborative effort between the University of Pennsylvania, NRAO, Goddard Space Flight Center, the National Institute of Standards and Technology, and Cardiff University.

Over the summer the NRAO machine shop constructed and delivered a test cryogenic dewar to the University of Pennsylvania. In December 2002 and January of 2003 Simon Dicker of U. Penn led successful lab tests of the pulse tube cooler and cold-stage He3-He4 fridge to achieve detector temperatures of 300 mK. Penn also has an optics design, has obtained an 82-95 GHz filter from Cardiff for lab testing purposes, and is working with the Green Bank engineering team to finalize the receiver package design. The Goddard team has constructed 3x3 mechanical prototypes of the detectors; further work on the detectors is underway. The NRAO will develop the data analysis software for the Penn Array.

The receiver is scheduled to be ready to go on the telescope early in 2005. When completed, the Penn Array will enable astronomers to make sensitive, high-resolution images of the sky at a wavelength of 3 mm.

B. S. Mason

The Education Center

The interior of the new Green Bank education center is speeding toward substantial completion, although much work remains in exterior landscaping and paving. The auditorium is finished and outfitted with audio visual equipment. The education staff and work area staff have learned to operate and troubleshoot this system. We used the new VLA tour video as our test material, and the image was bright and crisp on the screen. The cafe equipment has been delivered, installed and tested.The gift shop and office space are also complete, as are the classrooms and computer lab. The exhibit hall and computer lab passed rigorous RFI testing. Of note are the entry "baffles" to the exhibit hall. These are essentially U-shaped corridors that lead into the exhibit hall. They are lined with copper, and RFI absorbent cones. Although this design is a first, it passed RFI mitigation criteria, much to the relief of the contractor and the NRAO.

The new education center at Green Bank, West Virginia.

The education center lobby.

Last week the exhibit hall flooring was laid and buffed. What remains? Mostly cleaning work, and there is plenty of that. Then of course there is the punch list, which will include the site work. The staff are eager to begin the 2003 tour season in this extraordinary new facility.

S. A. Heatherly

2nd NAIC-NRAO School on Single-Dish Radio Astronomy: 1st Announcement

The Green Bank (NRAO) and Arecibo (NAIC) observatories are organizing the second NAIC-NRAO School on Single-Dish Radio Astronomy. The summer school will take place from August 10-16, 2003 at the NRAO Observatory in Green Bank, West Virginia. It is intended for students, postdocs, and experts in other fields of astronomy who would like to explore emerging techniques and applications of single-dish radio astronomy.

The school will consist of an intensive series of lectures in conjunction with hands on projects for participants. The primary goals are:

- to provide participants with a strong grounding in fundamental elements of single-dish radio astronomy, and its relation to other observing techniques;
- to give an overview of current and emerging capabilities of single-dish radio telescopes;
- and to provide practical experience with a single-dish telescope, and familiarize participants with all phases of the observing and data reduction process.

Both lecturers and participants are invited to contribute posters describing research conducted with single dishes. Proceedings of the first Single Dish School in 2001 is published in the ASP Conference Series (Vol. 278) and will be provided to this year's participants as part of the registration fee.

The number of participants will be limited to approximately 55 people. A registration fee of $150 will include: travel to/from Dulles airport, the welcome reception, the social events, the school banquet, and a copy of the proceedings.

There is additional information on the web available at *http://www.gb.nrao.edu/sd03/* or *http://www.naic.edu/meeting.htm*.

K. L. O'Neil

GBT Student Support Program: Announcement of Awards

Two awards were made in December as part of the GBT Student Support Program. This program is designed to support GBT research by graduate or undergraduate students at U.S. universities, thereby strengthening the proactive role of the Observatory in training new generations of telescope users.

The December awards were in conjunction with approved observing proposals submitted at the October deadline. Awards were made for students J. Swift (UC Berkeley) in the amount of $4,000, and J. Martin (UVA) in the amount of $15,700. Swift's proposal is entitled "*Will L1551-C2S Form the Next Star in Taurus?*", and Martin's proposal is "*The HI Environment of Early-Type Galaxies with Anomalous Light Profiles*."

New applications to the program may be submitted along with new GBT observing proposals at any proposal deadline. For full details, restrictions, and procedures, please visit *http://www.gb.nrao.edu* then select "student support program." Questions on the program may be directed to Joan Wrobel (*jwrobel@nrao.edu*, phone 505-835-7392) in her role as GBT Student Support Coordinator.

J. M. Wrobel & P. R. Jewell

SOCORRO

VLA Configuration Schedule; VLA / VLBA Proposals

Configuration	Starting Date	Ending Date	Proposal Deadline
D	07 Feb 2003	12 May 2003	1 Oct 2002
A(+PT)	30 May 2003	08 Sep 2003	3 Feb 2003
BnA	19 Sep 2003	06 Oct 2003	2 Jun 2003
B	10 Oct 2003	05 Jan 2004	2 Jun 2003
CnB	16 Jan 2004	02 Feb 2004	1 Oct 2003
C	06 Feb 2004	10 May 2004	1 Oct 2003
DnC	21 May 2004	07 Jun 2004	2 Feb 2004
D	11 Jun 2004	13 Sep 2004	2 Feb 2004

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 also may be sent by mail, as described at the web addresses given above. FAX submissions will not be accepted. 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 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 400 cm and 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 (tropospheric phase variations, especially in summer). Proposers should defer such observations for a configuration cycle to avoid such problems. In 2003, the B configuration daytime will involve RAs between 12^h and 19^h. Current and past VLA schedules may be found at *http://www.aoc.nrao.edu/vla/schedules/this_dir.html*. EVLA construction will begin to impact VLA observers in 2003; for more information please see the web page at *http://www.aoc.nrao.edu/evla/archive/transition/impact.html.*

Approximate VLA Configuration Schedule

	Q1	Q2	Q3	Q4
2002	A	A,B	B	C
2003	D	D,A	A,B	B
2004	C	D	D,A	A
2005	B	B,C	C	D
2006	D,A	A	B	C

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. When the VLA-Pie Town link is in use during the VLA's A configuration, we will try to substitute a single VLA antenna for Pie Town in a concurrent VLBA dynamic program. Therefore, scheduling prospects will be enhanced for VLBA dynamic programs that can accommodate such a swap. 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. 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.

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

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:

Date	Bands	Proposals Due
22 May to 12 Jun 2003	18/21 cm, 6 cm, 5 cm ...	01 Feb 2003
23 Oct to 13 Nov 2003	90 cm, 18/21 cm, 6 cm ...	01 Jun 2003

Note that these deadlines are slightly earlier than the corresponding VLBA deadlines, due to different treatment of weekends. 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 JIVE correlator 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 also may be sent by 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 email only, so please provide current email addresses for all proposal authors via the most recent LaTeX proposal coversheet.

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

Installation of 1612 MHz Filters Complete

The installation of 1612 MHz filters at the front end of the 20 cm receivers at the VLA was completed on all antennas by the end of 2002. As reported in the October 2002 *Newsletter*, these filters were installed in order to mitigate strong radio frequency interference (RFI) from the Iridium constellation of satellites, and allow observations of galactic OH at the 1612.2 MHz line.

Tests of the filters have been carried out; the results will be published as a VLA Test Memo, which will be available by press time of this *Newsletter*. In general, the results of the tests show that the system works reasonably well to mitigate the effects of the Iridium RFI. Documentation will be made available from the VLA web page *http://www.aoc.nrao.edu/vla/html/vlahome/astronomer.html* on more specific results of the tests and how to control the insertion (and removal) of the filters from the observing file.

Users considering observing the 1612.2 MHz transition of OH should consult these documents and/or contact the undersigned (*mclausse@nrao.edu*) for further information.

M. J. Claussen

VLA Observations During Move Times

Periods of duration of one to three weeks are devoted to VLA antenna moves. During these periods, the array is being reconfigured from one standard configuration to another one. Astronomical observing can, and does, continue through these move periods, although the VLA is not in one of its standard configurations. In addition, a few antennas may be unavailable because they are being moved or because their system parameters (delays, pointing, etc.) have not yet been updated. Although many types of observations are still scientifically useful, requests for observations during these periods seem to be dwindling. We therefore wish to remind proposers that if their science goals require photometry, polarimetry, and/or astrometry of suitably compact sources, then they should consider either requesting just move time (e.g., move to B) or else listing move time as an acceptable alternative to a standard configuration (e.g., B or move to B).

J. S. Ulvestad, B. G. Clark, J. M. Wrobel

A New Calibrator Tool for the VLBA and VLA

A new web-based tool is available for searching the VLA and VLBA calibrator source databases. It was developed as part of NRAO's End-to-End initiative at the request of VLA/VLBA Array Operations. This tool allows a user to carry out a search for calibrators around a given position and then displays the results in a grid map and a table. Calibrators can be pre-selected and sorted on the basis of their frequency, flux density, and position accuracy. Information pages are also available to help a user determine whether a calibrator is suitable for his/her needs. This includes a flux history, a spectrum and (when available) visibility plots and images for each calibrator. A basic help capability is also provided.

This new calibrator tool is intended to replace a number of different packages that have been written in the past for accessing the VLA and VLBA calibrator databases. A link to the tool can be found on the web pages for the VLA (*http://www.aoc.nrao.edu/vla/html/vlahome/astronomer.html*) and VLBA (*http://www.aoc.nrao.edu/vlba/html/vlbahome/observer.html*) under "VLA Calibration" and "VLBA Source Lists and Surveys," respectively. As this is new, we welcome any comments, bugs, and suggestions for future improvements at *caltool@nrao.edu*. In the near future, the calibration source database for the GBT will be incorporated into this tool.

G. B. Taylor, H. Ye, D. A. Frail

NRAO-NM Computing Division

We retired our last remaining public Sparc running the Solaris operating system. All eight of our public machines are now high-end PCs running Linux.

The conversion from twisted pair ethernet cable to fiber optic cable at the AOC is progressing well. As reported, this involves pulling tubing from central communications closets to individual office jacks, after which the fiber is blown through the tubing with compressed nitrogen. Almost all tubing is in place, and we have started blowing actual fiber to a number of offices.

JObserve 1.7.0 was released on February 11, 2003. It contains fixes to most bugs found in Version 1.6.5, and we strongly recommend that users upgrade to the new version. It is available for download at the JObserve web site (*http://www.aoc.nrao.edu/software/jobserve*). A comprehensive list of added features and fixed bugs can be found at *http://www.aoc.nrao.edu/software/jobserve/Release_Notes/1.7.0.*

G. A. van Moorsel

Classic AIPS Available for MacIntosh Computers

The *31DEC03* release of AIPS now supports the Apple MacIntosh OS X operating system. The port was relatively straightforward after C and Fortran compilers, XWindows, and readline libraries were obtained from Apple and Fink. Details are available from the AIPS web pages *http://www.aoc.nrao.edu/aips*. Performance on Macs, so far, has proved disappointing. Although the *31DEC03* release will remain under development throughout 2003, it may be obtained via the above web site at any time. Software tools to allow an AIPS site to remain current with the changing version — the so-called Midnight Job — are provided with the source code.

This release already has a few new items. There is a verb to compute the circular separation and position angle between two image pixels, which do not have to be in the same image. There is a procedure to select the pixels from the TV and invoke this verb. There is also a new task LAYER to display images combined via a color layering technique, along with a new task SCLIM to assist in the preparation of input images for LAYER. Users of the *31DEC02* release may want to apply the patches which have already been announced for bugs in that version. Again, see the AIPS web page.

E. W. Greisen

VLBA 10th Anniversary Meeting

"Future Directions in High Resolution Astronomy: A Celebration of the 10th Anniversary of the VLBA" will be held June 8 - 12, 2003, in Socorro. This meeting will commemorate the opening of the VLBA on August 20, 1993, and will include invited reviews of the subsequent exciting progress in VLBI science and technology in the astronomical, astrophysical, and geophysical fields to which VLBA observations have contributed. A major focus of the meeting will be the future frontiers for VLBI and other high resolution telescopes operating across the entire electromagnetic spectrum, both in new opportunities for scientific exploration, and in the technological developments that will be necessary to support these future directions. The meeting is sponsored by the NRAO and New Mexico Tech.

A Second Announcement was issued recently via several e-mail lists, including a list of confirmed invited speakers, which is reproduced below. In inviting these speakers, the SOC sought to emphasize participation by younger members of the community. Contributed talks and posters are solicited on any of the scientific topics.

Further information is available at the meeting website: *http://www.aoc.nrao.edu/events/VLBA10th/*.

Confirmed Invited Speakers

Opening Keynote Talk

Roger Blandford: *Challenges for High Resolution Astronomy*

AGN Jets

Heino Falcke: *AGN Jets*
Jose-Luis Gomez: *Real vs. Simulated Relativistic Jets*
Glenn Piner: *Blazars (VLBA & GLAST)*
Dan Homan: *Polarization of AGN Jets*

SMBHs, Accretion Disks, & H_2O Masers

Alison Peck: *The Atomic and Molecular Environment of AGNs*
Lincoln Greenhill: *H_2O Masers & Accretion Disks*
Geoff Bower: *SgrA**

OH Megamasers, Starbursts & Normal Galaxies

Jeremy Darling: *OH Megamasers*

Microquasars & Compact Stellar Systems

Marc Ribo: *Microquasars*

Supernovae & Pulsars

Michael Bietenholz: *Imaging of Radio Supernovae*

Masers: Star Formation & Evolved Stars

Dave Boboltz: *Masers from Circumstellar Envelopes*
Claire Chandler: *Masers and High Mass Stars*
Crystal Brogan: *OH Masers Associated with SNRs*

Interstellar Medium & Propagation Effects

Lucyna Kedziora-Chudczer: *Intra-day variability*
Joseph Lazio: *Galactic Interstellar Scattering*

Gravitational Lenses

Andy Biggs: *Gravitational Lenses*

Astrometry & Geodesy

Tom Herring: *Astrometry & Geodesy with VLBI*
Eduardo Ros: *High-Precision Differential Astrometry*
Walter Brisken: *Pulsar Proper Motions*

VLBI (and related) Projects & Future Instrumentation

H. Kobayashi: *The VERA Project*
Colin Lonsdale: *LOFAR*
Dick Ferris: *High-Speed Sampling and Digital Filtering*
Alan Whitney: *Disk Based Recording*
[Not Confirmed]: *e-VLBI (e-MERLIN, e-EVN, e-VLBA)*
Brent Carlson: *New Technologies for Future VLBI Correlators*

Science with High Resolution Telescopes Across the EM Spectrum

[Not Confirmed]: *The North American Array - EVLA/NMA/eVLBA*
Chris Carilli: *High Resolution Observations with the SKA*
Francesco Paresce: *Large Ground-Based Optical/IR* Interferometers
[Not Confirmed]: *Long Baseline Stellar Interferometry*
Webster Cash: *X-ray Interferometry*

Closing Keynote Talk

[Not Confirmed]: *The Future of High Resolution Astronomy*

J. D. Romney

Student Assistance for Data Reduction Visits to the AOC

Students visiting the Array Operation Center for the purposes of working on a VLA or VLBA observing program may be eligible to have their lodging expenses in the NRAO guest-house covered by the NRAO. To qualify, the student must be a graduate or undergraduate enrolled at a University in the United States, working on an approved observing program. These are the same qualifications as required for NRAO support of air travel costs (see *http://www.nrao.edu/administration/directors_office/nonemployee_observing_ travel.shtml*).

In addition, the duration of the visit should be between 5 and 30 days. Requests for support should be made at least four weeks in advance of the proposed visit to Greg Taylor (*gtaylor@nrao.edu*). If this is a first time visit then the student should be accompanied by a collaborator on the project, or alternatively an NRAO collaborator may be requested.

G. B. Taylor & J. S. Ulvestad

NEW RESULTS

VLA Observations of Massive Stars in the Galactic Center

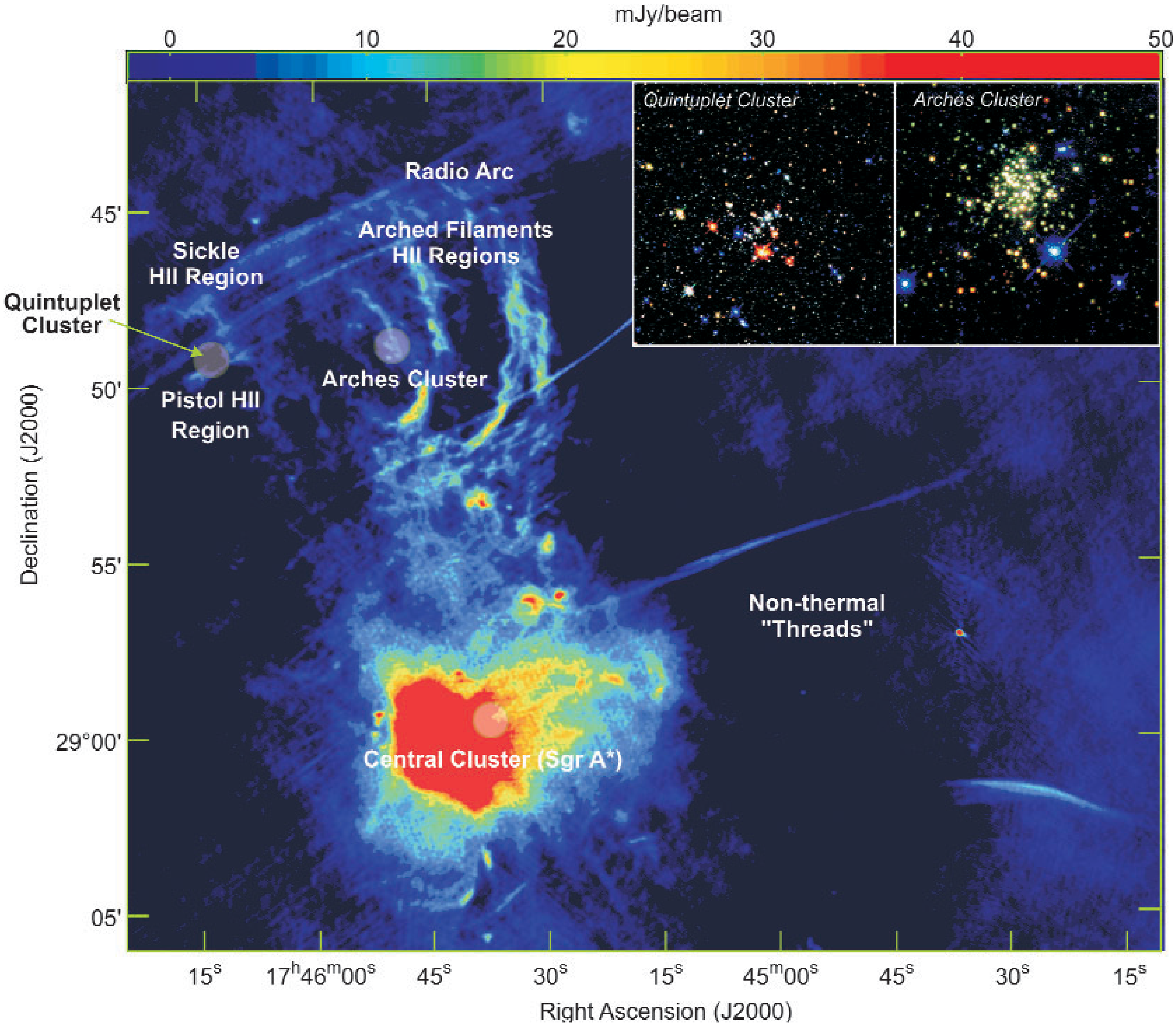


Figure 1. VLA 20 cm image of the central 50 pc of the Galactic Center, focusing on the sources in the Radio Arc region (Lang, Morris & Echevarria 1999b). The locations of the three extraordinary stellar clusters are also indicated in this figure, with near-IR images of the Arches and Quintuplet clusters from the Hubble Space Telescope/NICMOS camera detailed in the upper right-hand corner of the image (from Figer et al. 1999a).

One of the most prominent set of features in the central regions of our Milky Way — the Radio Arc — was first discovered with the VLA in the early 1980s (Yusef-Zadeh, Morris & Chance 1984). This region is located ~30 pc in projection from the dynamical center of the Galaxy, SgrA*, and is comprised of unusually-shaped thermal and non-thermal radio sources (Figure 1). The origin and energetics of these features have been the focus of numerous studies of this region. The non-thermal linear filamentary "threads" are thought to trace a poloidal magnetic field configuration in the Galactic Center (Yusef-Zadeh, Morris & Chance 1984; Morris 1994), whereas high-resolution VLA continuum and recombination line studies of the curved filaments and streamers of ionized gas in the Radio Arc suggest that these are HII regions ionized by large numbers of young, massive stars (Lang, Goss & Wood 1997; Lang, Goss & Morris 2001a).

However, until recently, detailed information on the spatial distribution and physical properties of the stellar component of the Radio Arc was not known, due to the 20-30 visual magnitudes of obscuration toward this part

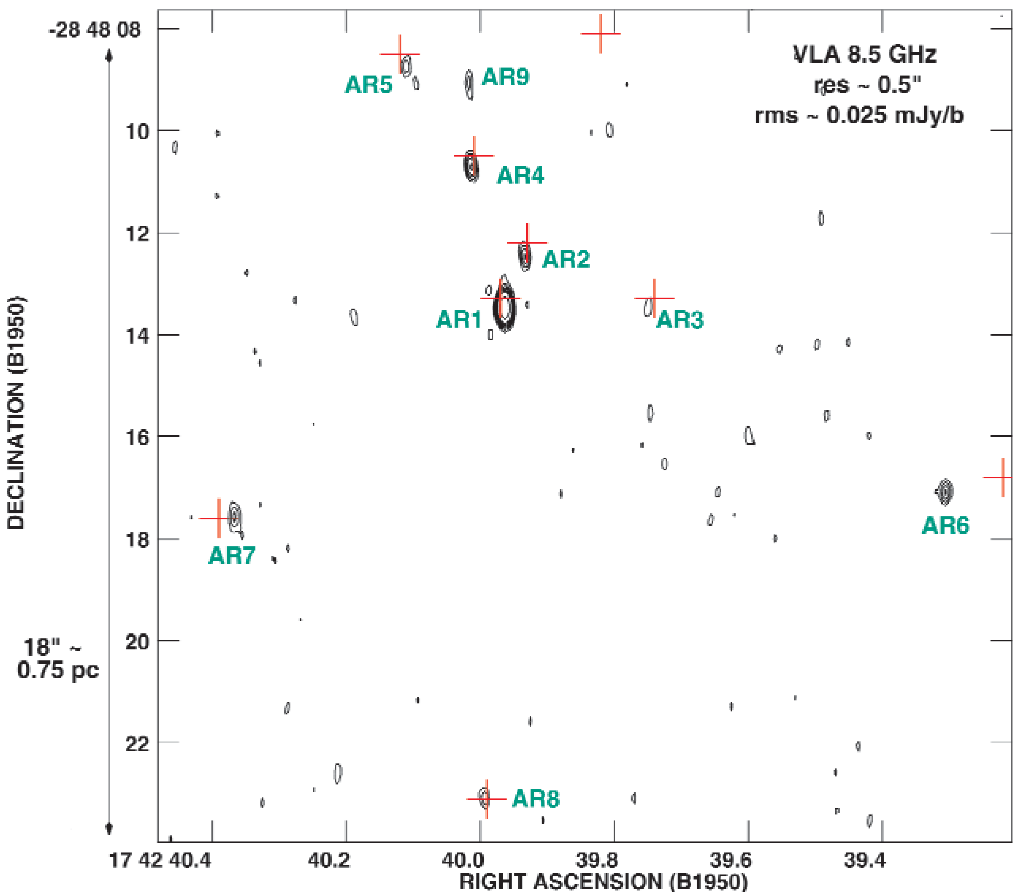


Figure 2. VLA 8.5 GHz continuum image of the inner 16″ (0.7 pc) of the Arches cluster, with a resolution of 0.41″ H 0.16″, PA=2.8°, combined from the 1999 and 2002 observations. Contours correspond to 0.075, 0.15, 0.25, 0.5, 1.0, 1.5, 1.75 mJy beam^{-1}, with an rms noise of 0.025 mJy beam^{-1}. Crosses in the image show the positions (0.5″ positional errors indicated by the cross sizes) of near-IR stellar sources that are known to be losing mass from their surfaces at high rates. Seven of the nine sources appear to have near-IR counterparts, whereas AR6 has a much larger offset from the nearby near-IR source and AR9 does not appear to have near-IR counterpart.

of the Galaxy. Over the last ten years, very high resolution near-IR observations have revealed (and resolved) several extraordinary clusters of stars within this region (Figer et al. 1999ab, 2002; see also review by Morris & Serabyn 1996). The Arches and Quintuplet clusters reside within the Radio Arc region and the Central cluster surrounds SgrA* (see Figure 1).

The stars in these clusters can be identified using near-IR spectroscopy. Many of the stars appear to have near-IR signatures of blue supergiants and late-type Wolf-Rayet stars (including WN, WC and WN9/Ofpe types) (Cotera et al. 1996; Figer et al. 1999ab, 2002). The Arches & Quintuplet clusters are believed to each contain more than 100 of such massive stars, with total cluster masses of more than 10^4 solar masses and some of the highest stellar densities in the Galaxy (Figer et al. 2002). These stars can now account for the ionization of the unusual thermal components of the Radio Arc (Lang, Goss & Morris 2001a). In addition, such luminous stars should have strong stellar winds, which can dramatically affect the surrounding interstellar environment, and may be responsible for the unique morphology of this region. The origin and nature of massive star formation in such close proximity to the Galactic center (with strong gravitational tidal effects, high densities and pressures of molecular clouds and turbulence) are intriguing and the subject of much current observational and theoretical work (see Morris & Serabyn 1996).

The stellar wind emission from these types of mass-losing stars should be detectable at centimeter wavelengths, based on the classic theory of Panagia & Felli (1975) and Wright & Barlow (1975). The spectrum of radio emission from a stellar wind should be proportional to $\nu^{+0.6}$ for a spherically symmetric, isothermal, stationary wind expanding at a constant velocity. The predicted rising spectral index is an important diagnostic of radio detections of stellar winds, and the radio flux density of the stellar wind emission can also be used to calculate the mass loss rate of the stellar wind. VLA surveys have been very successful in detecting radio continuum emission from individual OB supergiant and Wolf-Rayet stellar winds in the Galaxy (Bieging, Abbott & Churchwell 1989).

We have undertaken a project to detect stellar wind emission in the Quintuplet and Arches clusters using the VLA at several frequencies. We first found evidence for stellar wind emission in archival images of the HII regions near the Quintuplet cluster — the Sickle & Pistol HII regions. Several compact radio sources with inverted spectra were discovered, and three of these were spatially coincident with near-IR mass-losing stars, suggesting that these were detections of stellar winds (Lang et al. 1999a). Recently we have carried out a more complete multi-frequency, multi-epoch study of the two clusters using the VLA in the A and BnA configurations at 43.3 GHz, 8.3 GHz and 4.9 GHz.

The first epoch (1999) observations of the Arches cluster revealed eight compact sources with S/N ratios greater than five (AR1-8; see Figure 2; Lang et al. 2001b). The spectral indices of seven of these sources range from $\alpha = +0.3$ to $+0.9$, consistent with the theoretical predictions. One of these sources (AR6) has a non-thermal spectrum (-0.7), which is also consistent with the observed frequency of a non-thermal component in the stellar wind (~25% of all stellar wind detections; Bieging et al. 1989). Seven of these sources have firm near-IR counterparts, which have spectra consistent with late-type WN stars known to be losing mass at high rates (Cotera et al. 1996; Figer et al. 2002). The spectral indices of the Arches radio sources as well as their spatial correlation with near-IR counterparts solidifies the interpretation that these radio sources represent the stellar wind emission of the known massive stars. Mass loss rates calculated from the 8.5 GHz data vary between $(3-17) \times 10^{-5}$ $M_{\odot}$ yr^{-1}, which is typical for such massive stars (van der Hucht 2002), and provides further evidence that these stars are indeed very massive and can strongly influence their interstellar surroundings. Our second epoch 8.5 GHz observations (2002) produced one new source, AR9, and three of the sources (AR1, AR4, AR7) showed variations in their flux densities of $(10-35)$%. This modest variability may be indicative of the presence of a time-variable non-thermal component (due to shocks in the stellar wind) or variability in the mass-loss rate or wind velocity. Additional radio sources are likely to be present in the image; a simple overlay of the near-IR and radio images of the Arches cluster reveals a larger number of correlations (see Figer et al. 2002) which are currently being investigated in our images.

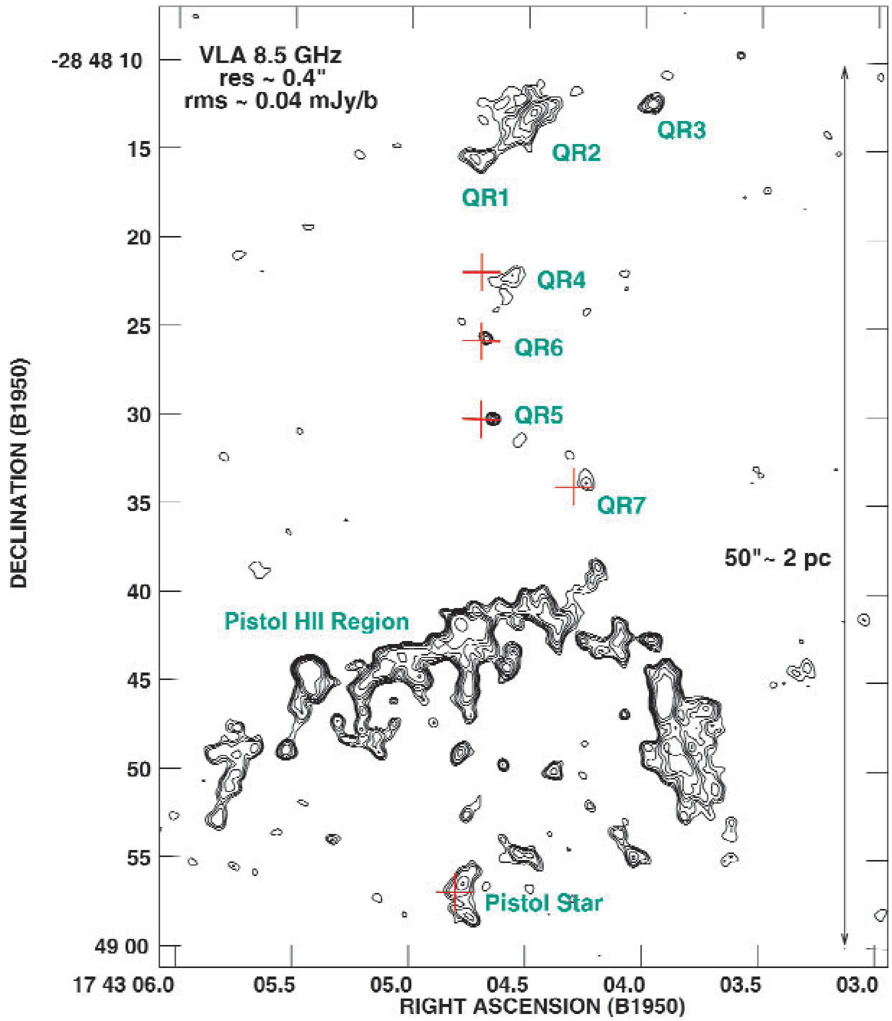


Figure 3. VLA 8.5 GHz continuum image of the Pistol HII region and Quintuplet cluster, with a resolution of 1.15" × 0.94" PA=65.4° from the June 1, 2002 observation. Contours correspond to 0.12, 0.2, 0.28, 0.36, 0.48, 0.64, 1.3 & 1.9 mJy beam^{-1}, with an rms noise level of 0.04 mJy beam^{-1}. Crosses in the image show the positions of the near-IR sources from Figer et al. (1999b), which correspond well to QR4-7 and the Pistol Star. QR1-3 do not appear to have near-IR counterparts.

Recent VLA observations of the Quintuplet cluster have also revealed eight compact radio sources QR1-8 (Figure 3), which have spectral indices in the range of $\alpha = +0.2$ to $+0.7$, consistent with the interpretation that these sources are also detections of stellar wind emission. Considerable extended radio emission surrounds the massive Pistol star at all frequencies, which prevents an accurate spectral index and mass-loss estimate in the current A- and BnA-array data. Five of the eight radio sources (including the Pistol Star source) correspond in position to known members of the Quintuplet cluster which have been identified as a mix of peculiar O-type and late-type WR stars (Figer et al. 1999b). The derived mass-loss rates for the Quintuplet radio sources range from $(6-13) \times 10^{-5}$ $M_{\odot}$ yr^{-1}, similar to those in the Arches cluster and consistent with the expected rates from late-type WR star winds (van der Hucht 2002). Three of the Quintuplet radio sources exhibit the characteristic positive spectral index signature; however, do not have near-IR counterparts. It is possible that such sources represent enshrouded massive stars in the process of forming (i.e. UC HII regions), in which case, such stars would be bright in the mid-IR and observations at the Gemini North Observatory are currently scheduled for spring 2003.

Exploratory A-array observations at 7 mm were also made of the Central Cluster region, directly surrounding SgrA*. Detections of stellar wind emission in such close proximity to the central supermassive black hole, SgrA*, would be extremely interesting to shed light on massive star formation in this region. However, the dynamic range required to detect a stellar wind source (~0.2 mJy) in the vicinity of the bright SgrA* source, is more than 10,000 and beyond the sensitivity of even a four hour integration.

The detection of stellar wind emission and such high mass-loss rates in the Arches and Quintuplet clusters, coupled with the large ionizing fluxes of the clusters and the size of the associated HII nebulae, makes these clusters comparable to the Galactic starburst region NGC 3603 and the 30 Doradus complex in the LMC. Because of the densely-packed nature of these clusters, especially in the Arches cluster (where the stellar density may exceed 5×10^5 $M_\odot$ pc^{-3}), collisions between the expanding stellar winds may occur. Such collisions are thought to produce shocks, which may create gas with temperatures as high as 10^7 K (Cantó et al. 2000). The first high-resolution (1″) X-ray observations of the Arches cluster with *Chandra* reveal it to be one of the brightest X-ray sources in the Galactic Center (Yusef-Zadeh et al. 2002; Wang, Gotthelf & Lang 2002). Several point-like sources in the cluster with $L_x \sim 10^{35}$ erg s^{-1} may represent colliding wind binaries of extremely massive stars.

The VLA detections of stellar winds in the Galactic Center represent some of the first detections of winds from multiple sources in such extraordinary clusters of stars. The synthesis of radio, near-IR and X-ray data allow a much more complete understanding of the importance of massive star activities in the Galactic Center. In fact, the presence of strong diffuse X-ray emission from the central 50 pc of the Galactic Center which has a spectrum consistent with 10^7 K gas, indicates that much of the energetic activity in this region is driven by massive star formation activity (Wang, Gotthelf & Lang 2002).

C. C. Lang, University of Iowa
W.M. Goss, NRAO
L.F. Rodríguez, UNAM
K. E. Johnson, NRAO and University of Wisconsin

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GBT Observations of Extragalactic HI toward M31 and M33

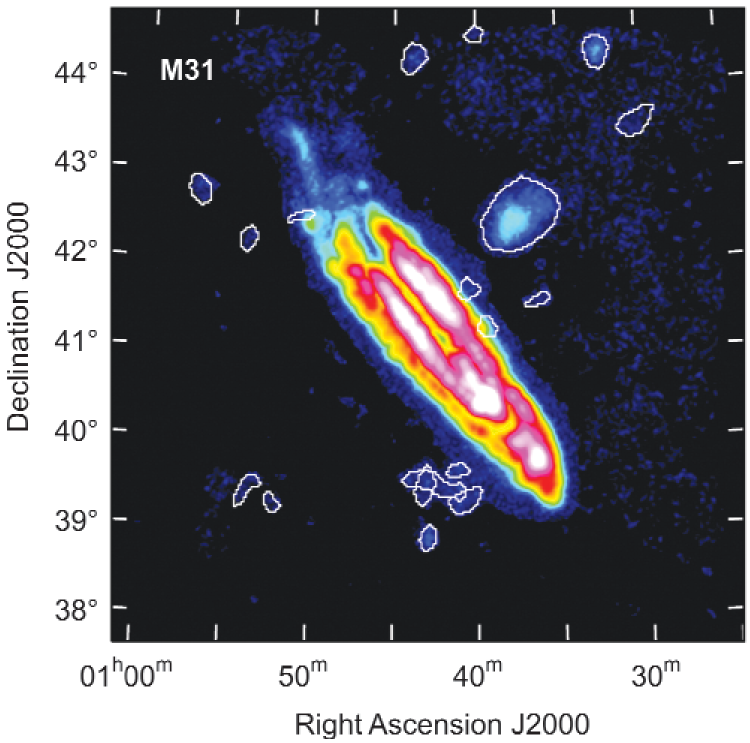

Figure 1. HI peak brightness temperature toward M31, as measured by the GBT. Due to the substantial overlap in velocity space between Andromeda and the Galaxy, the Milky Way contributes some of the structure seen on the righthand side of the figure. Nevertheless, many of the CHVCs associated with M31 are evident in this image. Other significant detections are buried in the disk or too faint to be seen except in channel maps or after velocity smoothing. We plot contours showing the approximate extent of confirmed CHVCs. Davies's Cloud is the large detection to the NW of M31. The CHVCs situated immediately south of the disk could be related to the "Andromeda stream" of Ferguson et al.(2002), although the HI clouds are somewhat offset from the stream's metal rich stars.

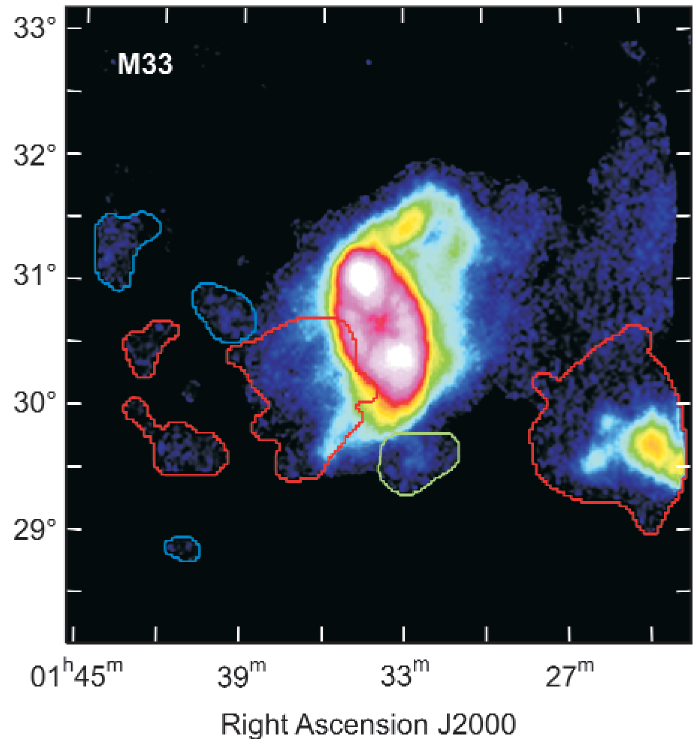

Figure 2. HI peak brightness temperature toward M33, as measured by the GBT. This OTF map includes the eastern tip of Wright's Cloud (lower right). Note the highly irregular appearance of M33's outer disk. Extensions of the disk toward the WNW and ESE may be additional gas belonging to M33's prodigious warp (most prominent to the NW and SE), but located at larger radii. We present contours showing the observed extent of Wright's Cloud and all CHVCs distributed throughout the field. The red-contoured CHVCs located east of the galaxy are sub-clumps which jointly constitute the larger M33 CHVC discussed by Thilker et al. (2002). One of the brightest sources belonging to the M33 CHVC population is found essentially due south of galaxy and appears to be interacting with M33.

Over the past several months, we have used the GBT to acquire On-The-Fly (OTF) maps of the HI distribution toward M31 and M33. These sensitive 21cm observations, obtained with the Spectral Processor, constitute the first extragalactic imaging survey conducted on the GBT. Our data bring to light exciting new information about compact high-velocity clouds (CHVCs, Braun & Burton 1999) and low column density gas associated with the outer parts of our galactic neighbors.

Even for otherwise familiar Local Group spirals like Andromeda and M33, outermost radii and the immediate intergalactic environment harbor significant potential for new discoveries. Cosmological models of hierarchical galaxy formation (Klypin et al. 1999, Moore et al. 1999) predict the continuing infall and accretion of numerous small dark matter haloes. Others have discussed the similarity between rarified, low-metallicity outer disks and physical conditions characteristic of the early universe (eg. Ferguson 2002). With this in mind, we surveyed a deliberately large region centered on each target. For the case of M31, we mapped a $\sim 7^\circ \times 7^\circ$ area. Toward M33, a smaller region of $\sim 5^\circ \times 5^\circ$ was used. The 8.7′ GBT beam projects to 1.9 kpc at the distance of Andromeda, and 2.1 kpc for M33. Such scales are optimally suited to the detection of clouds and tidal debris participating in the process of galaxy formation.

The GBT M31 and M33 OTF maps were obtained using a fast-scanning strategy, in which we moved the antenna as quickly as possible given the upper limit set by Nyquist sampling and the backend data rate. Our motivation was two-fold: (1) to maximize confidence in faint sources, by providing internal redundancy through multiply-repeated scans; and (2) to reduce the possible influence of unpredictable events such as RFI, shifts in the bandpass shape, or other calibration-related changes over the duration of each OTF pass. The telescope allocation for this project permitted six complete OTF passes per galaxy, totaling about 24 and 14 hours on source for M31 and M33, respectively.

For both maps, the GBT's Spectral Processor was configured to produce 1023 channels over 5 MHz total bandwidth, resulting in 1 km/s channel separation. Flux calibration was linked directly to the NRAO VLA Sky Survey (NVSS, Condon et al. 1998). Bandpass calibration was accomplished by iteratively determining a set of line-free spectra in each OTF database, then taking the median of these off-source scans as a reference observation. The bandpass response function evaluated in this manner usually remained constant on timescales greater than an hour. An independent bandpass solution was applied during each of these epochs.

Figures 1 and 2 show images of total HI peak brightness temperature for M31 and M33, evaluated at full spatial and velocity resolution. Our sensitivity in velocity-smoothed representations approaches 3×10^{17} cm^{-2} at 20 km/s resolution. In both targets, the observed velocity extent of detected emission overlaps with HI from the Milky Way, leading to some contamination in the apparent distribution of extragalactic emission. We limited the velocity range for these figures in an attempt to minimize such extraneous HI, yet retain as much of M31 and M33 as possible.

Although analysis of the new data is still underway, the GBT observations have revealed: (i) significant irregularity in the warped outer disks of both M31 and M33, plus (ii) a notable population of faint CHVCs apparently shepherding each galaxy. The warps in these Local Group spirals have long been recognized (Roberts 1965, Wright et al. 1972), but the degree of detail recovered at low column densities and extreme radii will contribute substantially to the characterization of the dark matter halo in both galaxies.

Our CHVC detections (shown with contours on Figures 1 and 2) are important for several reasons. First, the number of new clouds is surprisingly high. Based on a best-fit model for CHVCs as tracers of dark matter minihalos in the Local Group, de Heij et al. (2002b) predicted 250 faint CHVCs in a 60×60 degree region centered on Andromeda (detectable with HIPASS sensitivity). Considering only the M31 GBT map, we observe at least a dozen new CHVCs in a much smaller solid angle, suggesting either three times the predicted surface density or increased concentration at small galaxy-cloud separations. Secondly, the median angular size of CHVCs detected in our M31 survey is smaller than amidst the general population of CHVCs (Braun & Burton 1999, Putman et al. 2002). This observation is consistent with the assumption that they are truly affiliated with the Andromeda galaxy. Adopting a distance of 770 kpc, these exceptionally compact clouds have HI masses in the range $(0.2\text{-}2) \times 10^6$ $M_\odot$. The lower limit of this range is not bounded by our sensitivity, but rather appears consistent with the prediction that less massive clouds should be fully ionized (Sternberg, McKee & Wolfire 2002). Finally, several of the newly detected CHVCs appear to be interacting with M31 and M33. Some such present day interaction of CHVCs with the disk is to be expected. The existence of a metal-rich "Andromeda Stream" (Ibata et al. 2001, Irwin et al. 2002, Ferguson et al. 2002) of stellar debris likely originating from M32 or NGC205 has clearly shown that M31 is still in the process of forming. In a hierarchical framework, interactions directly preceeding accretion should be even more common for less massive companions, such as the CHVCs.

The discovery of CHVCs unambiguously associated with M31 revives the issue of how Davies's Cloud (Davies 1975) might fit into this picture. De Heij et al. (2002a) presented WSRT interferometry and NRAO 140 Foot observations of Davies's Cloud suggesting that it is rather atypical of the overall CHVC population. In particular, condensations of cool neutral medium (CNM) in the object exhibit broad line profiles, having 25-30 km/s FWHM. These CNM clumps are furthermore arranged along the periphery of Davies's Cloud projected nearest to M31, suggesting an interaction-based origin. Our GBT survey adds to the string of evidence tying Davies's Cloud to M31. In particular, the GBT HI imaging shows a clear extension of Andromeda's disk at low column densities in the direction of Davies's Cloud. It seems likely that Davies's cloud represents the most massive object (13×10^6 $M_\odot$ in HI) of the M31-centered CHVC population, with peak columndensity just below the star formation threshold. Interestingly, de Heij et al. (2002a) described how Davies's Cloud would resemble both HVC Complexes A and C if viewed from the center of M31.

In summary, our new GBT observations bear witness to the continued formation of Andromeda, M33, and the Local Group as a whole. We suggest that the CHVCs detected in the immediate vicinity of our neighbor spirals are the likely analogs of some HVCs and most CHVCs distributed about the Milky Way.

D. Thilker, Johns Hopkins University
R. Braun, ASTRON, The Netherlands
R. Walterbos, New Mexico State University
E. Corbelli, Osservatorio Astronomico di Arcetri , Italy
J. Lockman & R. Maddalena, NRAO
E. Murphy, University of Virginia

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Editor: Barry Turner *(bturner@nrao.edu)*
Science Editor: Juan Uson *(juson@nrao.edu)*
Assistant Editor: Sheila Marks
Layout and Design: Patricia Smiley

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