National Astronomy and Ionosphere Center
Arecibo Observatory

NEWSLETTER

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Photo: Jonathan Friedman and John Toohey, 2002

NAIC Cooperative Agreement
Robert L. Brown

Following a competition that began in October of 2003, the NSF awarded to Cornell the Cooperative Agreement for a continuation of its management and operation of NAIC. The new Cooperative Agreement began on October 1, 2005 and continues for a period of 54 months to March 31, 2010.

We are very pleased with the recognition that NSF has given by means of this award to Cornell and with the entire staff of the NAIC for the exemplary way in which the Observatory serves its users and facilitates future scientific capabilities. The process by which the NSF evaluated competing proposals for the Cooperative Agreement involved extensive interviews with the Observatory staff; the pride expressed by the staff in the Observatory, and for their roles in its operation, contributed in a very significant way to the decision to award the Cooperative Agreement to Cornell. On behalf of the NAIC management, and all the users of the Observatory, I would like to express my sincere appreciation for that support.

The new Cooperative Agreement itself is innovative. The NSF Division of Contracts and Complex Agreements (DCCA) developed a template to be used for cooperative agreements with all NSF facilities. The template incorporates the provisions of the agreement by reference to web-based documents and text rather than including this material explicitly in the agreement. This reduces the length of the Cooperative Agreement from 50 or 60 pages to 5 or 6 pages. NAIC was the first NSF facility to negotiate a Cooperative Agreement based on this new template and the experience was educational both for us and for DCCA. It was also very interesting. I hope our efforts will ease the burden for the other NSF facilities.

Congratulations to all! With the new award we can plan aggressively, and confidently, for the future.

NSF Senior Review
Robert L. Brown

As I am sure everyone reading this Newsletter is aware, the NSF Division of Astronomical Sciences (AST) is in the process of assessing the scale of, and priorities for, the financial support it provides to its present facilities and programs. The assessment is being aided by a community-based panel of advisors established under the aegis of the NSF Mathematics and Physical Sciences Advisory Committee (MPSAC). The AST process is called the Senior Review.

According to the MPSAC charge to the senior review panel (see *http://www.nsf.gov/mps/ast/seniorreview/srcharge.pdf*).

> *This review is designed to examine the balance of the AST investments in the various facilities and selected other activities that we support. The primary goal of the review and the resultant adjustment of balance is to enable progress on the recommendations of the Decade Survey, including such things as operations funds for ALMA, and other priorities such as those recommended in "Connecting*

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The NAIC is operated by Cornell University under a Cooperative Agreement with the National Science Foundation.

Quarks with the Cosmos". At the same time AST seeks to preserve, indeed grow, a healthy core program of astronomical research. Possible reinvestment of some of the Division's resources in the highest priority components of the existing facilities and programs is therefore an important consideration. ...

The committee is asked to examine the impact and the gains that would result by redistributing ~$30M of annual spending from Division funds. These funds would be obtained by selective reductions in the operations of existing facilities and instrumentation development programs, possibly in combination with opportunities to deliver scientific knowledge at reduced cost to NSF or increased efficiency through new operating modes. Near-term needs for new investment lead us to conclude that we must try to generate the $30M in annual redistributed funding by the end of FY2011. The $30M (annual) would be used to bolster the highest priority components of existing facilities, to begin to cover ALMA operations costs, and as a source of support for implementation of Decade Survey recommendations.

AST is keeping an up-to-date summary on the web of the progress of the senior review process (see *http://www.nsf.gov/mps/ast/ast_senior_review/jsp*). On this website you can find the membership of the senior review panel, the schedule for Town Meetings the NSF staff is holding at sites across the U.S. to communicate the purpose and goals of the senior review with the astronomy community, and other important information. The material that NAIC, and all the other AST facilities, have provided to the senior review panel in response to requests from the NSF can also be accessed from that website.

On October 21, 2005, Joe Burns, Martha Haynes, Jim Cordes and I met in Washington for a question and answer session with the NSF Astronomy Senior Review Panel. We talked with the panel in an informal discussion format (no formal presentations were made), as scheduled, for somewhat more than 2 hours. The previous day the SR panel had met with representatives from NOAO, NSO, Gemini and NRAO, each institution also talking with the panel privately for 2 hours.

We had expected to receive a list of questions from the panel prior to our meeting, but several days earlier we were informed that the questioning instead would be done spontaneously at the meeting itself, and that is how the meeting progressed. Because the research experience of the panel members covered almost all of ground-based astronomy, yet only a few of the panel members had used or even visited the Arecibo Observatory, we welcomed the opportunity given us to describe for them the excellence of the multidisciplinary research program, and the staff, of the Observatory. We were also able to describe the uniqueness of the facility and the broad array of science that we accomplish. This was a very helpful dialog that allowed us to clarify a number of issues about how the Observatory functions and how it serves its user community.

At the outset, the SR panel chairman, Roger Blandford, emphasized that the focus of the panel interest, given the committee charge, was on ways by which significant operational savings could be made at all the national astronomy centers. It was clear that the panel was still very much in an information-gathering stage. We had a productive dialog on questions such as whether it was possible for NAIC to secure partial funding support for Observatory operations from agencies, institutions, or countries that presently make use of Observatory facilities in ways that would provide some funding relief to NSF astronomy. We also discussed with the committee plans for future facilities, and modes of operation, at the Observatory and how those plans might be realized in ways that lead to reductions in future funding requirements. The panel was particularly interested in learning more about our vision for Arecibo's future.

I believe the day was successful for us; it is clear that our message as set forth in the NAIC report to the senior review has been well conveyed and was well received. It is also clear that the senior review panel is engaged in a serious review that, if done well, will enhance the credibility of arguments the NSF Astronomy division will make to improve its present prospects. It does not seem likely that additional funds will be available for several years at least. In the meantime, the prospects for (and competition for) funding within NSF are bleak, and all the national observatories are being told to plan for some budget reduction. Our objective must be to plan for carefully and manage the available budget in order to assure the continued vitality of our program.

The senior review panel is meant to provide its conclusions and recommendations to the MPSAC at the April 2006 meeting of that committee. In the meantime, the panel is anxious to hear from as wide a segment of the astronomy community as possible. To this end, they have established an email address, *astsenior-review@nsf.gov* to receive community input. I strongly encourage everyone to contribute their comments to this email account. Even if all you say in your email is "Continued robust operational support for NAIC (or NRAO, or Gemini, or NOAO, or NSO) is important to my research and the research of my students," that is sufficient. But please, take the time to be heard. It is very important, not just to NAIC but to the continued health of U.S. astronomy.

I appreciate your support.

State of the Observatory

Robert L. Brown

In March 2005, the National Science Board approved the National Science Foundation (NSF) award of the Cooperative Agreement for management and operation of the National Astronomy and Ionosphere Center (NAIC) to Cornell University for the 5-year period FY2006–2010. The award, described elsewhere in this Newsletter, represents a strong endorsement by the NSF of the primary elements of the Cornell vision for NAIC, and the relation of NAIC to the community it serves, that are being vigorously pursued at NAIC. Additionally, it is a significant milestone that, having been achieved, positions us well to promote the NAIC program in the ongoing NSF Senior Review analysis of priorities for NSF astronomy. The Senior Review goals and process, as they affect NAIC, are also discussed elsewhere in this Newsletter.

In broad terms, NAIC exists to serve two communities, the U.S. community of academic researchers and, through their collaborations, the worldwide research community; and our Observatory neighbors, the people of Puerto Rico. In the past year, there has been significant progress to report in both these areas.

- *Support of Scientific Research.* In January 2005, we completed a major project to measure the shape of all the reflectors on the 305-m Arecibo telescope using photogrammetry and videogrammetry. All the panels making up all three telescope reflectors were re-adjusted to remove the errors uncovered in the measurement process. The Arecibo telescope optical system is now more precise, and the resulting telescope gain higher, than it has ever been in its 40-year history. The total root sum squared optical error is less than 2 mm. This provides extremely good optical performance up to 30 mm wavelength, the shortest wavelength at which the telescope is used.

Arecibo Telescope Astronomy Program FY 2005 Oversubscription		
Proposal Deadline	**Avg. Oversubscription (all LST)**	**Peak Oversubscrip-tion**
Oct 1, 2004	2.2	3.9
Feb 1, 2005	4.1	9.1
June 1, 2005	4.1	7.2

This marked improvement in telescope performance, together with the routine availability of the ALFA multibeam receiver for extremely large-scale sky surveys, has led to a dramatic increase in proposal pressure for observing time on the Arecibo telescope. The oversubscription rate of the Arecibo telescope astronomy program at the three proposal deadlines in FY2005, averaged over all LST intervals, and the oversubscription at the LST interval of greatest demand, are given in the table above .

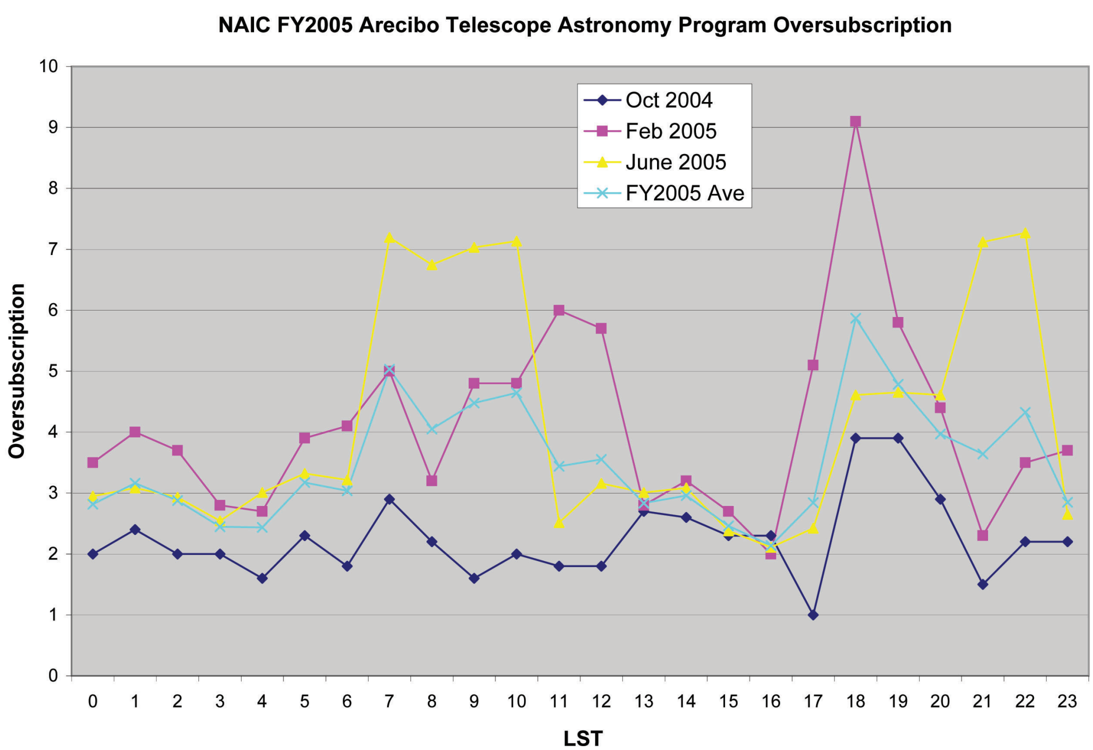


Figure 1. The FY2005 oversubscription of the astronomy program time on the Arecibo telescope as a function of interval of local sidereal time (LST). Data are plotted independently for proposals received at each of the three proposal deadlines in FY2005, viz. October 1, 2004, February 1, 2005 and June 1, 2005. Also shown is the average oversubscription for all of FY2005.

The above table does not include proposal requests for VLBI observations. Such requests go through the VLBA and EVN proposal review processes respectively.

The FY2005 over-subscription, in the average, makes the Arecibo telescope the most oversubscribed telescope funded by the NSF Division of Astronomical Sciences. The peak oversub-scription of the Arecibo telescope at the two most recent proposal

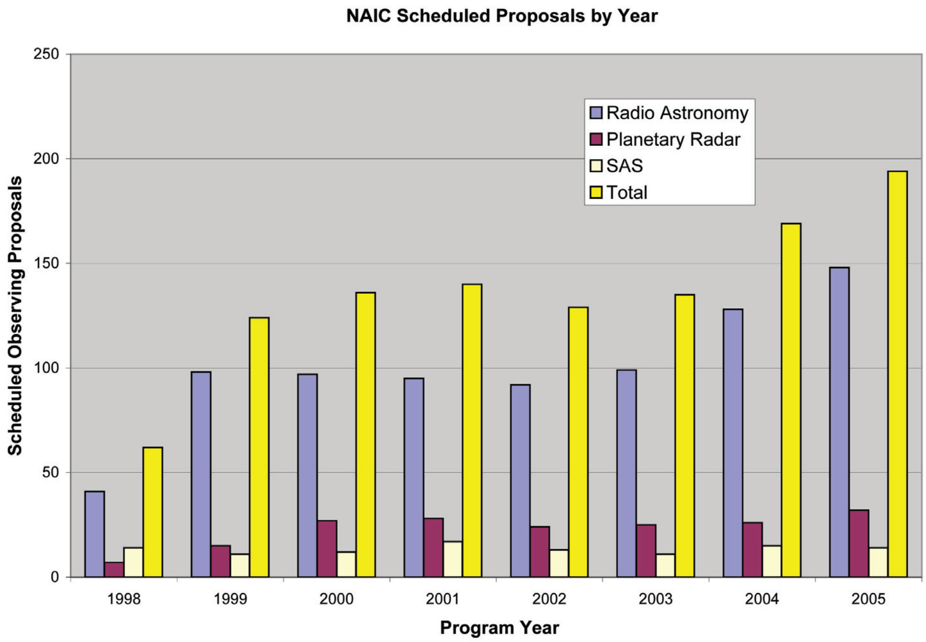


Figure 2. The number of scientific proposals scheduled on the Arecibo telescope as a function of year. Figures are shown separately for the three components of the NAIC scientific program at the Arecibo Observatory.

deadlines exceeds that of any telescope in astronomy, including that of the Hubble Space Telescope.

The NAIC Arecibo telescope is a semi-transit instrument located in Puerto Rico at a latitude of 18 degrees north. It can view celestial objects with declinations in the range 0 to +38 degrees, and can track a particular object for at most 2.5 hours (less time at the high and low declination limits). The Arecibo telescope thus has only a limited view of the disk of the Milky Way; the first quadrant of the galaxy can only be seen between 18 and 19 hours LST. Because studies of pulsars and galactic giant molecular clouds favor the inner galaxy, this LST range is the most oversubscribed. But not dramatically so, as the plot of the FY2005 Arecibo telescope oversubscription as a function of LST, Figure 1, illustrates.

The number of scientific proposals scheduled on the Arecibo telescope since the major Gregorian upgrade of the telescope was completed in 1999 is shown in Figure 2. This plot includes scheduled proposals in all three components of the NAIC scientific program at the Arecibo Observatory, astronomy, planetary radar astronomy, and space and atmospheric sciences (SAS).

The number of scientists using the NAIC Arecibo telescope annually and the number of institutions these scientists represent has grown consistently since the completion of the Gregorian upgrade of the telescope in 1999. The telescope user statistics are shown in Figure 3. Each person is counted individually and only once in a year, even in those cases where a person observes multiple times during the year and/or participates on several scheduled observing proposals. In the six year period since 1999 the annual number of users has grown by 64% (from 170 to 278).

NAIC provides encouragement by means of travel cost reimbursement for graduate students to become actively involved in their thesis research programs on the Arecibo telescope. Students are encouraged to get their (trained) hands on the equipment, to make modifications to the observing procedures, and to experiment with novel observing techniques and data processing algorithms. Largely for this reason, there is an active and growing group of Ph.D. students who make use of Arecibo observations as a component of their thesis research. Figure 4 summarizes the number of graduate students whose observations were scheduled on the Arecibo telescope. Again, for each year an individual

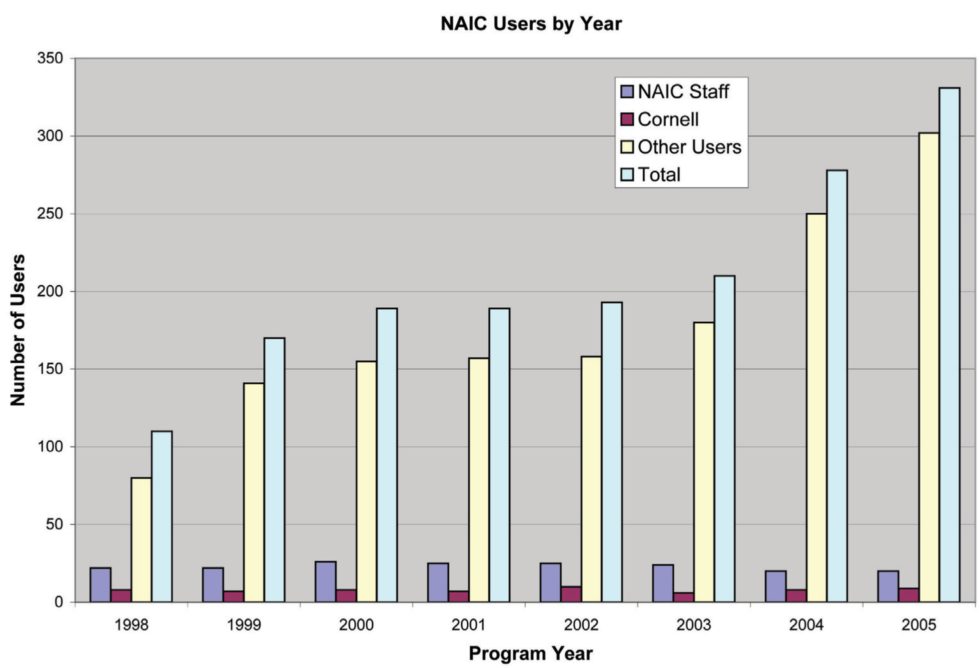


Figure 3. The number of users of the NAIC Arecibo telescope in the period since completion of the Gregorian upgrade.

graduate student was counted only once, even in those cases where the student observed multiple times or on multiple scheduled programs.

The number of institutions from which the users of the Arecibo telescope come as a function of year is shown in Figure 5. Here the numbers are separated between institutions located in the U.S., and foreign institutions. In this plot, a particular institution is counted only once a year, even in those cases where several telescope users come from the same institution in that year.

• *Education and Outreach.* Puerto Rico is an island of more than 4 million U.S. citizens, the overwhelming majority of whom are Hispanic. With private funding, Cornell University built a Visitor Center for NAIC at the Arecibo Observatory to serve our community of neighbors and friends in Puerto Rico. Major support for the required capital funding was generously provided by the Ángel Ramos Foundation, one of the leading philanthropic foundations in Puerto Rico. Other funds came from various public and private institutions and individuals in Puerto Rico. The NSF Division of Informal Education provided funding for the displays.

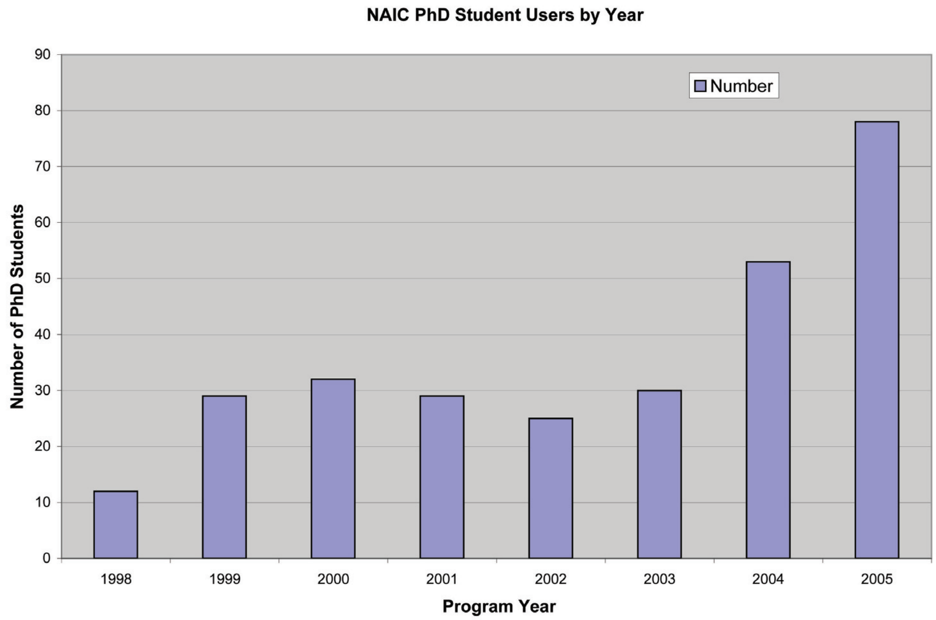


Figure 4. The number of graduate students conducting thesis research observations on the Arecibo telescope.

In the most recent year, more than 120,000 visitors purchased tickets for admission to the Ángel Ramos Visitor Center. This was an increase of approximately 8% over the average attendance of the previous five years.

The 120,000 annual visitors to the Arecibo Observatory is a number that exceeds the annual number of public visitors to all other NSF-supported observatories combined. Included in these statistics are school groups from both public and private institutions from around the island. Annually, approximately 525 individual school groups, each led by a teacher or school administrator, tour the observatory. The NAIC Ángel Ramos Visitor Center is a source of pride to the people of Puerto Rico as well as to all of us at NAIC.

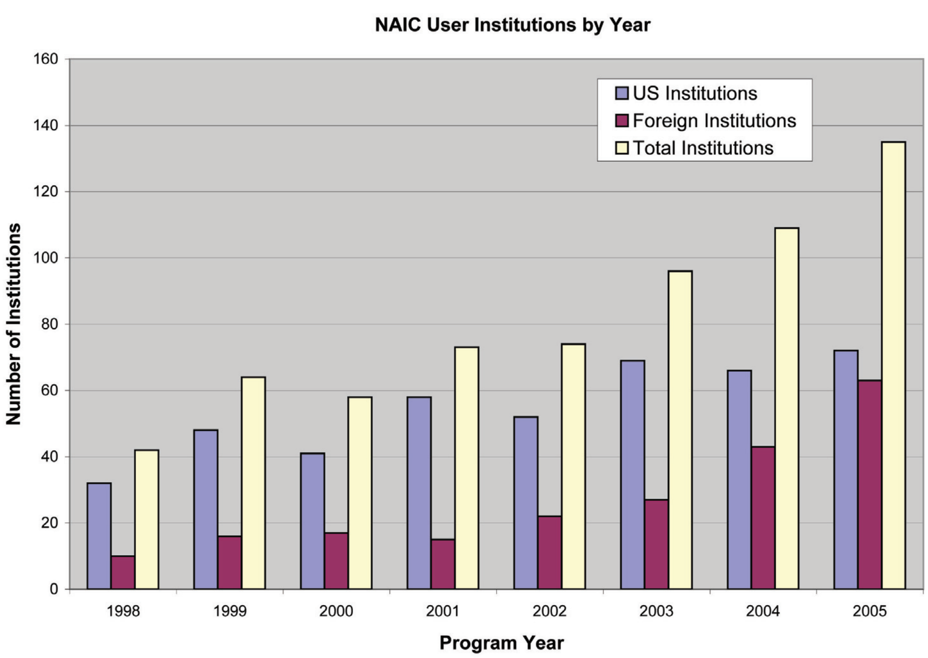


Figure 5. The number of institutions represented annually by scheduled users of the NAIC Arecibo telescope.

• *Summary.* The telescope, its instruments and ancillary facilities have reached their design capabilities with the result that the research opportunities at NAIC have never been so great. The efforts of the entire NAIC staff have led to an unprecedented demand for telescope time, the highest oversubscription rate for any NSF telescope, and to an unprecedented number of NAIC scientific users and students who are using the facilities for their PhD research endeavors.

In addition, over the past 18 months we have reaffirmed our programmatic support of the U.S. academic research community to facilitate, through partnerships, advances in

- Detector and digital signal processing technology;
- Computational capabilities and information sharing technology;
- Organizational structure of large-scale research teams working collaboratively on ambitious, problem-oriented, programs.

In so doing, NAIC strives to stimulate innovations at academic institutions and integrate them rapidly into capabilities at the national center. NSF funding of NAIC is then multiplexed to benefit both academic researchers and NAIC. The NAIC goal is to develop research initiatives with the community, not for the community. We are promoting collaboration, not competition, as a means to help insure that NSF astronomy research funds are used to greatest efficiency in the U.S. research community.

We believe these measures, priorities and emphases are helping us to establish a new relationship between the national center and the academic community it serves, a relation based on a partnership of efforts. With these measures, even in difficult financial times, or perhaps especially in difficult financial times, we can look ahead with confidence to a future of achievement.

Radio Astronomy Highlights

The extremely heavy proposal pressure on the astronomy time at Arecibo has resulted in many excellent proposals being scheduled and very interesting and exciting results being reported. Much of the work involves the initial ALFA Legacy Surveys; progress on the efforts of the three ALFA consortia is described in this section. However, we begin with a report of observations that benefit from the improved telescope performance resulting from the recently-completed adjustment of all three telescope reflectors.

Detection of Rotationally Excited OH Lines Toward the OH Megamaser Galaxy IIIZw35

Jeremy Darling (Univ. of Colorado, Boulder) and Christian Henkel (MPIfR)

Rotationally excited transitions of OH have been detected in absorption toward the OH Megamaser/Luminous IR galaxy IIIZw35 ($z = 0.02750$) (Fig. 6). All of the 6 cm (4.7 GHz) transitions and the two "main" 5 cm (6 GHz) transitions have been detected. The lines have similar widths and central velocities but differing optical depths. The excited state OH line widths and central velocities are in excellent agreement with those of the 1667 MHz OH megamaser emission line.

This work is part of a larger project underway at Arecibo to observe a sample of OH megamasers and OH absorbers in the lines of excited state OH; the goal is to probe the excitation of OH megamasers. The rotationally excited OH lines provide a critical diagnostic of the pumping mechanism that couples the infrared radiation field, which produces the excitation, to the OH megamaser emission. The OH absorption systems are included in the sample as a control used to identify properties distinguishing OH megamasers from simple OH absorption.

A tentative detection of formaldehyde (H_2CO) in emission at 4830 MHz will require further observations to confirm.

PALFA Legacy Survey: Progress Report

Jim Cordes (Cornell)

The PALFA Legacy Survey involves a massive search for radio pulsars in the Galactic Plane. It requires an end-to-end analysis of large volumes of survey data that leads to identification of new pulsars and to their characterization through follow-up timing (and other) observations. So far in 2005, we have worked on all aspects of this project. While we do not yet have all the pieces into place in final form, we have a system that has yielded new pulsars and we have two publications based on the data so far.

Key events and activities in 2005 include:

1. Commencement of data acquisition under program P2030, with observations beginning in March and continuing. Each observing run covers a 3-hour time block that covers the Galactic plane either in the inner Galaxy or in the outer Galaxy.
2. Temporary storage of PALFA data at the Arecibo Observatory until they have been shipped to and archived at the Cornell Theory Center (CTC). At the CTC, data are archived on a robotic tape system. Some of the data are processed at the CTC while other data are being processed, or will be processed, at other sites (NRAO, McGill, UBC, West Virginia University, NRL, Swinburne, Columbia). Data products from all processing sites will be consolidated at the CTC in a database system that uses MS SQL Server. The database is accessed through a web-based system. The CTC web site for the PALFA project may be found at *http://arecibo.tc.cornell.edu*.
3. Further development of a PALFA web site at Arecibo that includes observing-session reports, lists of confirmed new pulsars, and the status of disk packs used to ship data off-island.
4. Further development of a MySQL database at Arecibo that holds information on pointing positions that have been observed and it also includes the results of the real-time, "quick-look" data analysis.
5. Commencement of funding from the NSF for a joint proposal by Berkeley, Columbia and Cornell for conducting PALFA surveys over the next three years. Explicit funding for PALFA is also in place

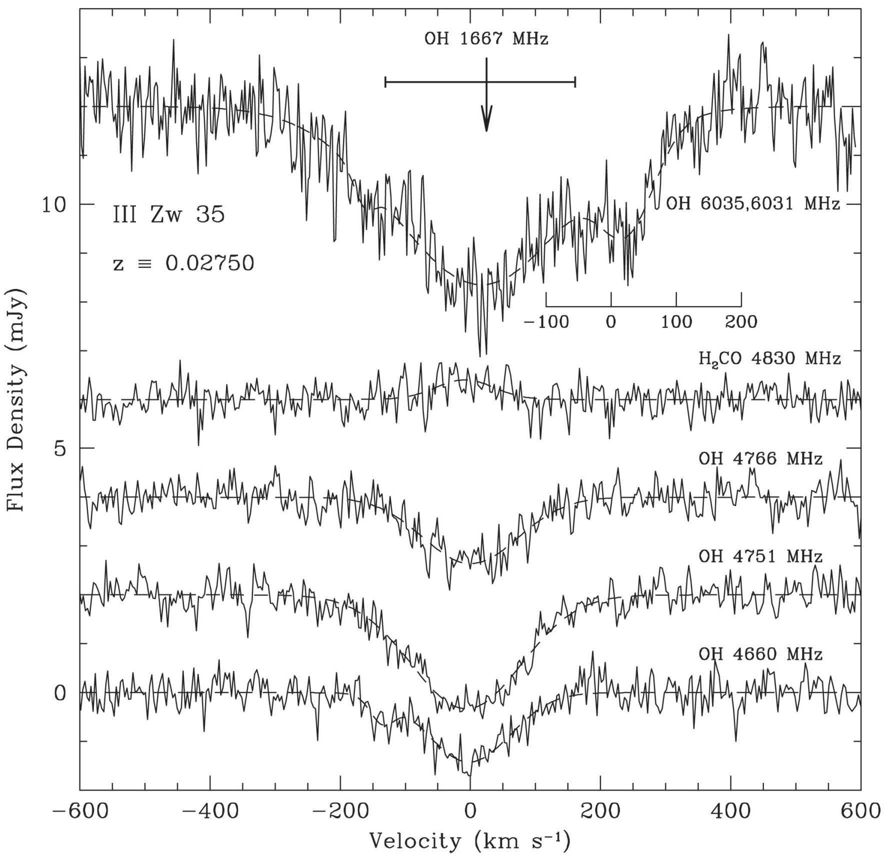


Figure 6. Rotationally excited OH lines and formaldehyde toward the OH megamaser galaxy IIIZw35. Zero rest frame heliocentric velocity refers to z = 0.02750. Spectra are offset vertically for clarity. The dashed lines show Gaussian fits to the line profiles. The arrow indicates the velocity of the 1667 MHz OH megamaser line in IIIZw35, and the error bars indicate the extent of the emission. The inset velocity scale corresponds to the 6031 MHz line which is blended with the 6035 MHz line.

at McGill and UBC.

6. Continued support from the NSF for the CISE division Research Infrastructure grant that supports hardware purchases at the CTC used by our project.
7. Preparation of two papers for the Astrophysical Journal: “Arecibo Pulsar Survey Using ALFA. I. Survey Strategy and First Discoveries,” 2006, ApJ, in press Jan 20 (astro-ph/0509732; *Cordes* et al.; 24 authors)
   “Arecibo Pulsar Survey Using ALFA. II. The Young, Highly Relativistic Binary Pulsar J1906+0746,” 2005, ApJ, submitted (*Lorimer* et al.; 36 authors)

   The first of these papers reports the survey goals and the initial 11 new pulsars that we have discovered. Of these 11, three have turned out to be of great interest:

   - PSR J1928+1746, a young 69 ms pulsar that, unlike most pulsars, has a very flat spectrum. Follow-up observations easily detected it at 9 GHz.
   - PSR J0628+09, an extremely sporadic pulsar with a spin period of 1.2 s. It was discovered through its strong individual pulses while it was undetected in the standard periodicity search.
   - PSR J1906+0746, a young 144 ms pulsar in a 3.98 hr orbit that has a massive companion, either a massive white dwarf or another neutron star. If the latter, then this object is similar to the recently discovered double pulsar except that we do not (yet) detect the older companion object as a pulsar. This object is important for estimating the merger rate of neutron stars that is of great interest for gravitational wave detection.

   The second of these papers reports the identification and initial followup on PSR J1906+0746.
8. The discovery of J1906+0746 underscores the importance of several aspects of our survey:
   (a) The short dwell time per sky position, which induces much smaller pulse smearing—and hence desensitization—from orbital motion;
   (b) Maintaining a database of intermediate data products from the processing pipeline; and
   (c)Archiving the raw survey data.
   Our original detection was made in spite of the orbital motion, which causes pulse smearing that scales as the square of the dwell time. By contrast, the 15 times longer dwell time of the Parkes Multibeam Survey led to an unbiased non-detection even though the pulsar position was observed. Data products from the Parkes analysis that included an acceleration search showed a strong detection that was discarded because of the presence of similar-frequency RFI signals. With our detection in hand, the Parkes data products indicated that the object was in a compact orbit, leading to follow-up observations that determined the orbital elements and quantified the more easily detected relativistic effects.

   In our most recent observing run (31 Oct – 6 Nov 2005), we discovered a short period pulsar with a 118 ms period that appears to be fairly distant (DM = 537 pc cm^{-3}). No followup has yet been conducted so we do not know if this is a young or a recycled object. Figure 7 shows the analysis page that emerges from our quicklook processing that led to the discovery.

Figure 8 is from the second paper and indicates that the pulse shape for PSR J1906_0746 has changed between the 7 years when it was observed in the Parkes Multibeam survey and when it was discovered in our ALFA survey. This evolution is almost certainly caused by General Relativistic geodetic precession, a spin-orbit effect that is significant in compact binary pulsars.

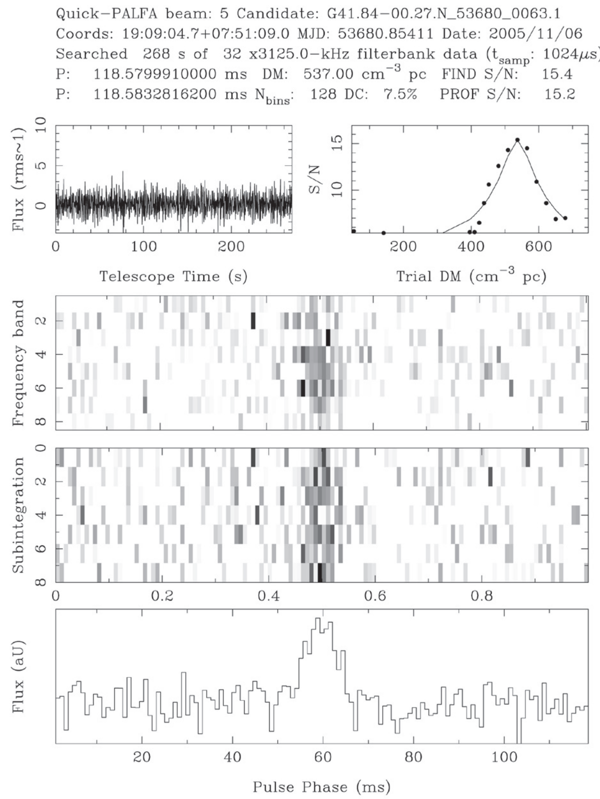


Figure 7. Sample periodicity search output from the quicklook analysis showing the discovery of the 69-ms pulsar PSR J1928+1746. Top left: a coarse version of the dedispersed time series used to assess basic data quality. Top right: S/N as a function of a trial DM. The points show detections in the periodicity search while the curve is the theoretically expected response given the system parameters and pulse width. Middle panels: gray scales showing pulse intensity as a function of sky frequency (quantized into frequency bands) and observing time (quantized into subintegrations). Bottom: folded pulse profile obtained by integrating over the whole pass band.

ALFALFA: An Arecibo Extragalactic HI Legacy Survey

Riccardo Giovanelli

ALFALFA, the *Arecibo Legacy Fast ALFA Survey*, aims to cover 7074 deg² of the high galactic latitude sky between 0º and 36º in Declination (see Figure 9). The "fast" in the title obviously does not refer to the time it will take to complete the survey, but rather to the integration time per beam area, which is 48 sec. This HI line survey exploits the large collecting area of the Arecibo antenna and its relatively small beam size, to deliver a map of the local Universe which will be eight times more sensitive than HIPASS, with about four times better angular resolution. Furthermore, the WAPP spectral backends provide 3 times better spectral resolution (5.3 km s^{-1} at z = 0) over 1.4 times more bandwidth. In combination with a simple observing technique designed to maximize data quality and survey efficiency, new opportunities arise in the exploration of the extragalactic HI sky to unprecedented depth. Following acceptance by NAIC, ALFALFA started taking data in February 2005. In the practical context of time allocation at a widely used, multidisciplinary national facility such as NAIC, completion of the full survey is projected to require about 5 years. In accordance with the ALFA survey paradigm established by NAIC, ALFALFA is being conducted as an inclusive, open collaboration with strong emphasis on student involvement.

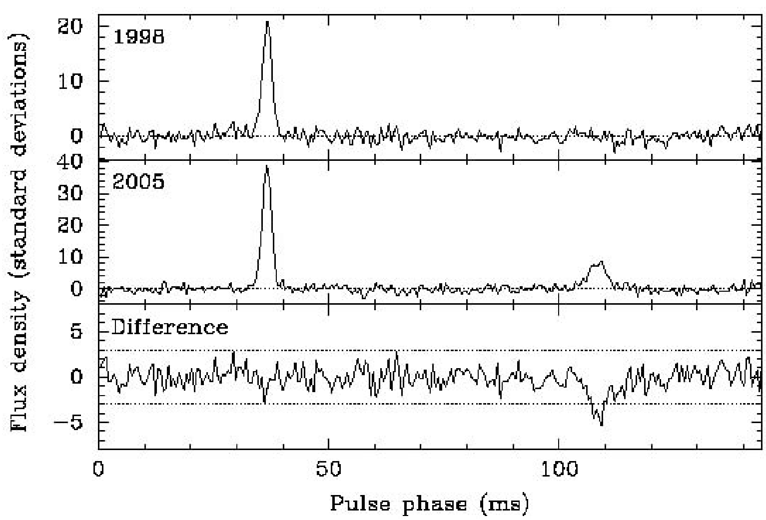


Figure 8. Integrated pulse profiles of PSR J1906+0746 showing 360° of rotational phase. The upper panel shows the detection at 1.374 GHz from the 35-min of PMPS data taken on 1998 August 3. The lower panel shows a 35-min observation with the same observing system taken on 2005 September 4. The lower panel shows the difference profile (i.e. 1998 minus 2005 data) after scaling both profiles to the area of the main pulse. The dashed horizontal lines show ±3 standard deviations computed from the off-pulse noise region. The limiting instrumental time resolution of both these profiles is 2.1 ms.

Plans for ALFALFA go back to the late 1980s, when design of the Gregorian upgrade were materializing. With the new subreflector system, the 305m telescope would finally get a *focal plane*, and with it, the potential to host feed arrays. The first design for ALFA was presented in a paper by *Kildal* et al. (1994), and the actual device (which looks very much like that early design) was commissioned 10 years later. With it, the opportunity for large-scale surveys arose, and several groups are now happily engaged in the early phases of such surveys.

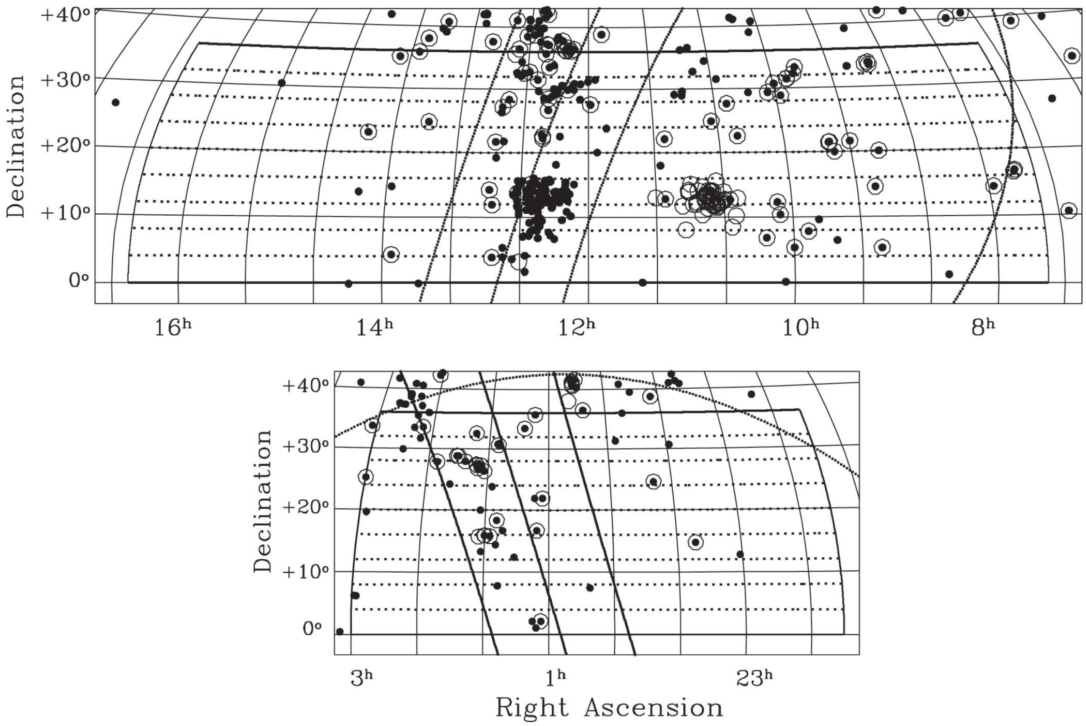


Figure 9. Proposed sky coverage of the ALFALFA survey, in the Virgo (upper) and anti-Virgo (lower) directions. In each panel, the thicker lines at constant RA or Dec. outline the proposed survey area. Dashed lines at constant Dec. mark the designated ALFALFA `tile' strip boundaries. The thick dotted curves to the right of the upper panel and top of the bottom panel mark b = +20°(upper) and -20°(lower) while the set of three thick lines crossing each panel top to bottom trace SGL = -10°, 0° and +10°. Filled circles mark galaxies with observed recessional velocities cz < 700 km s^{-1}, while open circles denote objects believed to lie within 10 Mpc (Karachentsev et al. 2004), based largely on primary distances. From Giovanelli et al. 2005a.

Based on extensive numerical simulations, now verified by preliminary results of precursor observations conducted during the ALFA commissioning phase (*Giovanelli* et al., 2005a,b), ALFALFA is expected to yield on the order of 20,000 HI line detections, from local, very low HI mass dwarfs to gas-rich massive galaxies seen to $z \sim 0.06$ (~ 250 Mpc). HI spectra provide redshifts, HI masses and rotational widths for normal gas-rich galaxies, trace the history of tidal events with high kinematical accuracy and provide quantitative measures of the potential for future star formation via comparative HI contents. As a blind HI survey, ALFALFA will not be biased towards the high surface brightness galaxies typically found in optical galaxy catalogs and moreover, in contrast to HIPASS and HIJASS, will have adequate angular and spectral resolution to be used on its own, generally without the need for higher resolution follow-up observations, to determine identifications, positions and, in many cases, HI sizes. The wide area coverage of ALFALFA overlaps with several other major surveys, most notably the Sloan Digital Sky Survey (SDSS), 2MASS and the NVSS. The catalog products of ALFALFA will be invaluable for a wide spectrum of multiwavelength purposes; a key element of our overall collaborative program is to provide broad application, legacy data products that will maximize the science fallout of the ALFALFA survey. The ALFALFA collaboration is composed of a diverse group of astronomers: veteran radio spectroscopists, astronomers specializing in observations at other wavelengths and experts in numerical simulations, assuring broad application and participation of talent. Education and training of students at both the undergraduate and graduate levels is a fundamental component of the survey program. Active ALFALFA websites are accessible at: *http://egg.astro.cornell.edu/alfalfa* and *http://www.naic.edu/~a2010/a2010_galaxy.html*.

The design of the survey relies on a few basic scaling relations, two of which are worth reviewing. First, the depth of a survey increases only as the integration time per beam area as $t_{int}^{1/4}$. With equality of back-ends, the time required to detect a given HI mass at a given distance increases as the 4th power of the reflector diameter. To achieve a sensitivity comparable to ALFALFA, the Parkes telescope would require integration times of ~30,000 sec per beam. Arecibo offers a tremendous advantage because of its huge collecting area. Second, for a fixed investment of telescope time, in order to map a given survey volume at any HI mass, it is more advantageous to maximize the surveyed solid angle than to increase t_{int}. These scaling relations provide, however, only general guidelines; other considerations play important roles in the survey strategy. For example, the growing impact of RFI on HI spectroscopy dictates increased attention to signal identification and corroboration, recommending a survey with more than a single pass over a given region of sky. The determination of specific properties of galaxies or systems may drive towards deeper surveys of narrow solid angle regions, as planned for other ALFA surveys, the goals and products of which will be complementary to ALFALFA.

The adopted ALFALFA strategy reflects both the practical limitations of the Arecibo telescope and the desire to achieve, as a main science goal, the undertaking of a robust census of low HI mass ($M_{HI} < 10^8$ $M_\odot$) extragalactic objects in regions of varying cosmic density. The survey strategy is strongly constrained by the dependence of telescope and feed performance (limited tracking capability, susceptibility to radio frequency interference, gain, system temperature, complex sidelobe structure) on observing configuration. ALFALFA minimizes the impact of these factors by observing in drift mode at fixed azimuth and feed rotation angle, as well as through minimum electronic intrusion (e.g. no tracking LO or "winking" cals). With no moving telescope parts, constant gain and nearly constant system temperature along a drift are obtained; standing waves change slowly, as driven by the sidereal rate; beam characteristics remain fixed; bandpass subtraction is optimized. Under normal conditions, ALFALFA observing efficiency is 97%.

Each region of sky is surveyed twice in drift mode, the second pass being preferably conducted some 3–9 months after the first, modulo 1 year, for maximal chance of separation between cosmic signals and spurious features. A second pass also allows a more even coverage in the Dec. direction, allows for the data to allow detection of continuum transients and minimizes the impact on sky coverage of possible hardware malfunctions. Spectra are recorded every second, with a bandwidth of 100 MHz, over 4096 lags. Each data record thus consists of 65,536 spectral samples. The generation of raw data by the survey is slightly over 1 GB per hour.

ALFALFA also serves as a vehicle for a galactic HI survey: TOGS. This survey "steals the IF signal" at whatever position ALFALFA may be pointing and commensally maps the distribution of HI in the Milky Way with a high resolution (0.1 km s^{-1}) spectrometer, making the investment of telescope time doubly as effective.

The scientific goals of ALFALFA are numerous. An important one is the accurate determination of the HI Mass Function (HIMF), which is quite poorly known at masses below 10^8 $M_\odot$. Perhaps the most important discrepancy between the CDM galaxy formation paradigm and observations consists in an apparent deficiency of observed counts of low mass haloes, in comparison with theory predictions. ALFALFA will allow us to verify whether the "missing" low mass halos are in the form of optically faint or inert, but baryon rich systems. ALFALFA will also investigate the variations in the HIMF with environment, and will provide a rich sample of low mass systems to investigate the spatial variations in metallicity which may have been seeded by pop III objects. ALFALFA will resolve the HI disks of ~500 gas-rich galaxies, allowing a quantitative measure of their HI sizes and the derivation of the HI diameter function. It will map several HVC complexes and detect new compact HVCs. The survey region contains thousands of sources suitable for the detection of HI lines in absorption out to $z \sim 0.06$. By combining HI emission and absorption data, ALFALFA will allow a robust estimate of the low z HI cross section, as well as a measure of its clustering correlation amplitude and scale. In addition, several dozen new OH Megamasers will be detected in the redshift interval 0.16–0.25, allowing a more robust determination of the low z OHM luminosity function than currently available.

Following NAIC guidelines, ALFALFA is being pursued as an open collaboration. Anyone with an interest in ALFALFA-related science and the willingness to contribute to the collective effort is welcome to join, propose a spin-off project and participate in the survey activities. Currently, 48 individuals from 11 countries and 32 different institutions have expressed such interest. The ALFALFA collaboration has organized its governance by forming a representative Oversight Committee and a number of Working Groups. A set of guidelines regulating the science project development, within and around ALFALFA, including criteria for authorship, has been adopted and posted (see *http://egg.astro.cornell.edu/alfalfa/joining.php*). Working groups coordinate the observations, bookkeeping, software development, data processing, follow-up work, public access to the data, research involvement of students and public outreach. Particular attention to the protection of student thesis projects has been given in the drafting of ALFALFA collaboration guidelines.

The software development for the processing of the data was fully developed at Cornell within the IDL environment, adopting templates for data structures set at Arecibo by Phil Perillat. Our software has been exported to, and operates successfully at Arecibo, Colgate, Lafayette, Union and Indiana. A "designated observer" member of the survey team is in charge of and monitors data taking during every observing session. Quality assessment of the data is done for each session by a single senior member of the team. NVO compliant web tools to allow examination, manipulation and statistical analysis of the ALFALFA dataset, as well as cross-correlation with other large survey datasets found anywhere on any VO node are in test phase. We anticipate a first data release by late Spring 2006. Through the efforts of Cornell graduate student Brian Kent, the results of the Fall 2004 ALFALFA precursor observations have been placed in a SQL database with a PHP interface for public access (see *http://egg.astro.cornell.edu/precursor/*). In addition, users have the option of downloading the catalog in a XML/VOTable format for use in their own client applications.

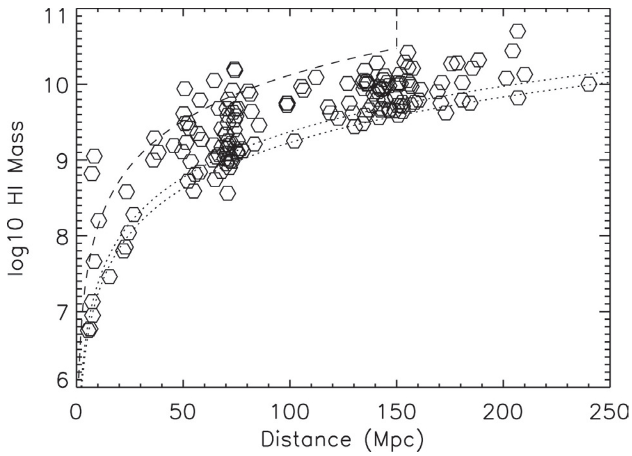


Figure 10. Distribution of HI mass as a function of distance for the ALFALFA precursor program detections. The highest of the two dotted lines corresponds to a line flux integral of 1.0 Jy km s^{-1}; the lower dotted line corresponds to 0.72 Jy km s^{-1}, the detection limit for a W = 200 km s^{-1} source with an effective integration of 30 seconds per map pixel. The dashed line corresponds to a flux integral of 5.6 Jy km s^{-1}, which corresponds to the HIPASS detection limit for a W = 200 km s^{-1} source. HIPASS could have detected only a handful of the objects detected in these ALFALFA precursor observations. From Giovanelli et al. 2005b.

As was the case for other survey teams, ALFALFA had early access to the ALFA array in 2004. We devoted most of the allocated telescope time to commissioning tasks, which have been documented through a number of publicly distributed memos. A fraction of this "precursor run" time did yield science grade data, which have already been published by our group (*Giovanelli* et al., 2005b). Those precursor observations were obtained towards a region of sky centered near RA=2^h, Dec=+26º, towards the nearest large-scale void in the cosmic tapestry and yielded 166 detections. Their distribution in a mass-distance diagram are shown in Fig. 10, clearly illustrating the power of ALFALFA in comparison with previous surveys. Most of the sky coverage of the precursor run observations was in "single-pass" rather than double-pass mode—the latter being the mode adopted for the full ALFALFA survey—and thus their sensitivity is inferior to that achieved by ALFALFA. In fact, the sensitivity of the precursor observations largely surpasses that of HIPASS, the detection limit of which is shown in Fig. 10 as a dashed line. A HIPASS-like survey of the same region mapped by the precursor observations would have detected only a few percent of the 166 objects we detected, and none of the scientifically critical ones with HI masses below 10^8 M$_\odot$.

Special attention has been given by our group to the preparation of tools for the proper interpretation of the data, e.g.: an accurate description of the peculiar velocity field in the local Universe, based on our extensive surveys of *z*-independent distances over the last couple of decades (see Karen Masters' Ph.D. thesis, Cornell 2005 and *Masters, Giovanelli & Haynes,* 2004); the preparation of a digital archive of nearly 10,000 HI observations of galaxies, now publicly accessible through the web (*Springob* et al., 2005a) through robust access tools linked to the NVO; independent determinations of the HIMF based on optically selected samples (*Springob* et al., 2005b), etc. We have created an HI node compatible with NVO standards. Three of our graduate students attended the September 2004 Aspen NVO School, and one of them returned to the School in Sept. 2005. The results of that investment are very important. The way we now process data is very different from the way we had planned it before the "NVO exposure" took place. Our current data processing tools are now dynamically linked to the web through MySQL/PHP interfaces. Rather than comparing final catalogs of objects with those obtained at other wavelengths at the end of the data processing stages, our software now allows interaction with the full breadth of data available for a field (UV, optical, infrared, radio continuum maps) as the HI data is processed, influencing in very effective ways (calibration, resolution of blends, source identification etc.) the quality of our final product. Figure 11

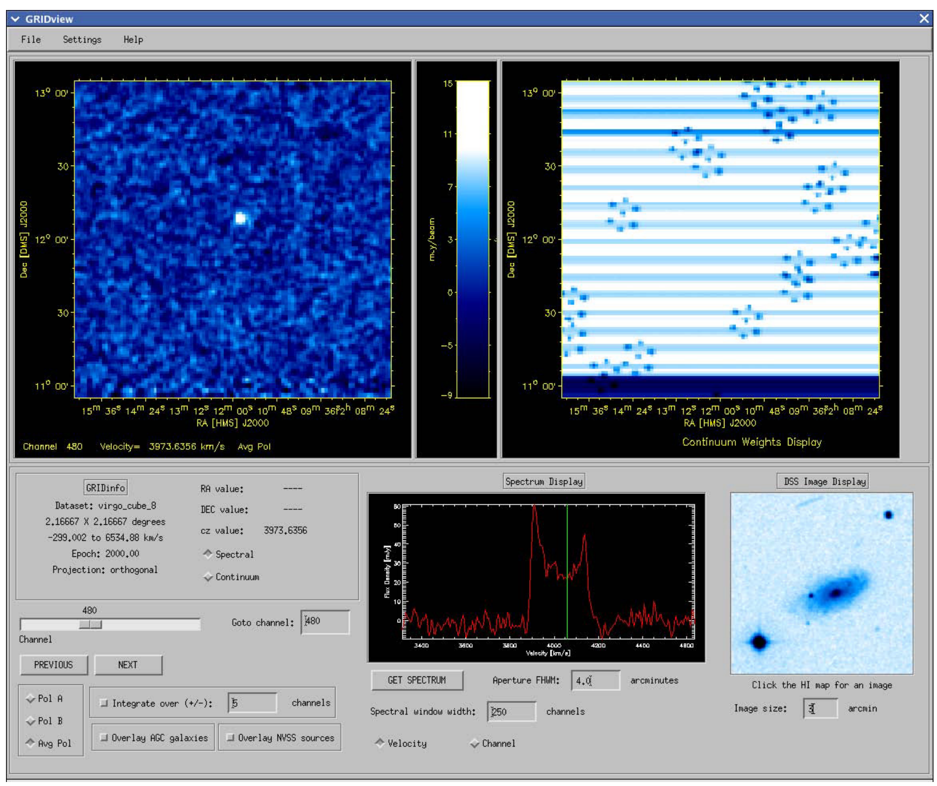


Figure 11. Graphical user interface of gridview, an IDL ALFALFA processing utility developed by our group. A moment 0 map extracted from a data cube is shown in the upper left, with a source near its center. The upper right display illustrates the current survey sky coverage of the same region. Below is a spectral profile of the source and an optical image of the field from SDSS. The IDL-based ALFALFA processing package including this utility has been successfully installed by users at other institutions including Arecibo, Colgate, Indiana, Lafayette, and Union.

shows an example of the GUI of an IDL procedure developed by graduate student Brian Kent, which allows simultaneous inspection and manipulation of many frequency planes of a data cube, *vis-a-vis* the sky sampling weights as available at the time the map was produced, a spectral display from either current or archival observations, and an image display from a large selection of possible archival multiwavelength sources.

The engagement of our collaboration demands both to accomplish the broad range of efforts required of ALFALFA's science goals and to fulfill the expectations of NAIC as a national center. In May and June 2005, we organized two separate workshops in Milan, Italy and in Ithaca, NY for members of the ALFALFA science team. Similar in intent, the workshops were designed to brief participants on the 2004 ALFALFA results and the status of the program at the time of the meeting and to engage them in discussions of science programs, coordination of followup and complementary observations, opportunities for individual participation and issues of survey governance. Attendance was 22 in Milan and 31 in Ithaca. We intend to hold similar workshops at least yearly to complement the more frequent electronic and web exchanges and coincidental meetings at scientific conferences. In collaboration with Rebecca Koopmann of Union College, we organized a workshop held at Union on July 6–7, 2005 (see Fig. 12). Participants included faculty from Union, Cornell, Colgate, Lafayette, St. Lawrence, U. of Puerto Rico and Wesleyan, two Cornell graduate students, and 14 undergraduates, as well as the Director of Arecibo's Ángel Ramos Visitor Center, Dr. José Alonso. Lectures were provided by faculty and graduate students. Science discussion and data analysis activities were organized, taking advantage of advanced, digital classroom facilities at Union. The highlight of the meeting was an ALFALFA observing session of 90 minutes using the Arecibo telescope, carried out remotely by the students and successfully processed by them on the following day. Following a suggestion by Bob Brown, before the meeting the students developed a proposal, interacting on email, for how they would use the allocated time, which they submitted to NAIC. Several of the students have now separately analyzed the data obtained during this single observing period and one of them (J. Ayala, UPR) will present the results at the January 2006 AAS meeting.

Finally, a morsel of preliminary results from ALFALFA. One of the goals of the study is that of verifying whether a significant population of optically faint, baryon rich, low mass systems exists. The preliminary ALFALFA results indicate that such systems are relatively abundant. While this statement is still based on very preliminary statistical grounds (the lowest S/N detections need still to be corroborated), it may be useful to note that ~10 nearby, extragalactic HI sources have been detected at encouragingly high S/N, which appear not to have optical counterparts, nor do they appear to be the result of recent tidal events. ALFALFA has easily detected the cloud VIRGOHI 21, reported by *Davies* et al. (2004). The more comprehensive and higher quality ALFALFA dataset shows a clear tidal stream associated with the galaxy NGC 4254 (*Phookun, Vogel & Mundy* 1993) and extending well beyond the boundary of the HI indicated by either the single pixel Arecibo (*Minchin* et al., 2005a) and more recent WSRT measurements (*Minchin* et al., 2005b). Additionally, a newly discovered, very widespread ALFALFA source (AHI 123026.0+092800; see Figure 13), also in the periphery of the Virgo cluster, has been confirmed by follow-up observations at Arecibo. Thanks to the NRAO rapid response proposal mode, a synthesis map of the central region of this feature has very recently been obtained with the VLA. As evident in Figure 13, the source consists of a complex of clouds stretching for some 250 kpc, if

Figure 12. Participants in the Summer 2005 ALFALFA Undergraduate Workshop.

located at the Virgo distance. The total mass of the system approaches 10^9 $M_\odot$, including a main component containing about half the mass in the system. No optical counterpart has been identified, and no ordered velocity field is apparent in the complex. The synthesis data of the largest cloud reveal a high degree of clumpiness. A very low surface brightness dwarf is offset 1.6′ (7.5 kpc) from one of the smaller clumps of gas. The clouds in the complex appear not to be gravitationally bound to one other, and may represent the remnant of an ancient episode of harassment. A paper on this discovery is currently in preparation.

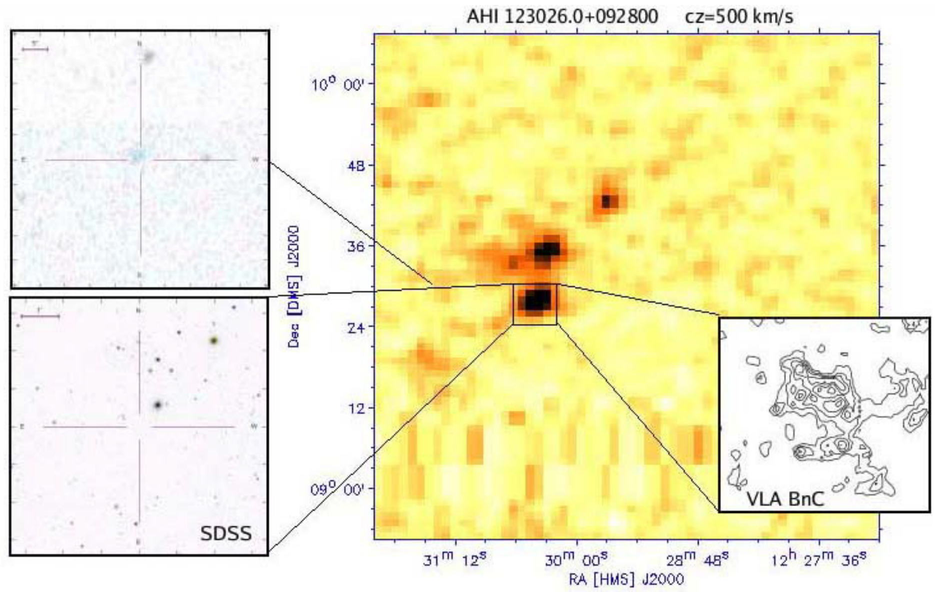


Figure 13. HI distribution in the vicinity of the newly discovered cloud AHI~123026.0+092800. The ALFALFA moment map 50 km s⁻¹ wide is shown in the center (lower part of the map affected by poor sky coverage), while the VLA-BnC moment 0 map is displayed to the right. SDSS images of (lower left) the HI detection field over a 6' ' 6' box and (upper left) of one centered on a low surface brightness dwarf nearest to the HI cloud complex are inset.

GALFA Highlights: What have we learned/discovered from GALFA observations to date?

Snezana Stanimirovic, J. Goldston, C. Heiles, E. Korpela, and K. Douglas (UC Berkeley), J.H. Kang and B.C. Koo (Seoul Nat'l Univ.), M. Putman (Univ. of Michigan), E. Muller (ATNF), M. Krco (Cornell), H. Arce (AMNH), and P. Goldsmith (JPL)

Since the beginning of this year several projects aiming at studying Galactic HI with ALFA have been undertaken or are in progress, a few smaller ones have even been completed. These projects address outstanding and diverse questions in the field of Galactic astronomy, cover regions of varying size, and are slowly building up the 'jigsaw puzzle' of the whole Galactic sky visible from Arecibo, at the angular resolution of about 3.4′. We summarize here several interesting scientific results that are already emerging from these studies.

What Drives the Forbidden-Velocity Wings?

Large-scale *(l,v)* diagrams of HI 21-cm line emission in the Galactic plane usually show small high-velocity bumps protruding from their surroundings. Since those wing-like features are at forbidden velocities, i.e., at velocities beyond the maximum or minimum values permitted by the Galactic rotation, we call them "Forbidden-velocity wings (FVWs)".

Figure 14 (a) is a *(l,v)* diagram at b = 4°. The wing-like feature at *l*~39 and [80 km s^{-1} $v_{LSR} \lesssim 130$ km s^{-1}] and the one at *l*~83 and [30 km s^{-1} $\lesssim v_{LSR} \lesssim 70$ km s^{-1}] in Fig. 14(a) are examples of FVWs. We suspect that they are the sites where Galactic dynamical events, for example, supernova explosions, stellar winds, or collisions of high-velocity clouds, which could accelerate their surrounding gas, have occurred. We have searched for the FVWs using the Leiden-Dwingeloo HI survey and the Southern Galactic Plane Survey data, and identified about 90 FVWs in the Galactic plane (|b| ≤ 13°) (*Kang,* 2004, *Kang* et al., 2004). We compared this catalog of FVWs with those of supernova remnants, high-velocity clouds, and nearby galaxies, and found that about 85% are not coincident with those known objects. The natures of most FVWs are not known yet.

During last January and February, for 15 days, we carried out commensal observations using the ALFA receiver covering areas including 3 FVWs in the inner Galaxy. Two of them showed shell-like features. FVW39.0+4.0 (Fig. 14b) is an ~ 1°-sized shell of $v_{exp} \gtrsim 55$ km s^{-1}. As it goes to higher velocities, it becomes fainter and finally disappears, so that its endcap is not seen. Its systematic velocity seems to be less than 73 km s^{-1}. Its distance from the Sun would be less than 5.0 kpc or greater than 8.3 kpc. If it is located in the Sagittarius-Carina arm, the kinetic energy of the HI shell would be ~ 1.2 × 10^{50} erg or ~ 1.0 × 10^{51} erg, depending on whether it is at close (~ 3.3 kpc) or distant (~ 9.8 kpc) part of the arm. It does not have any known OB type stars inside and could be an old supernova remnant. FVW40.0+0.5 (Fig. 14c) shows center-filled complex of filamentary structures. Since it shows a roughly circular shape, it could possibly be part of an endcap of a larger shell. FVW44.5−2.0 (Fig. 14d) shows a single clump-like structure from 110 km s^{-1} to 90 km s^{-1}, and then connects to a complicated filamentary structure at lower velocities. It seems to be similar to the halo cloud of Lockman (2002) in the sense that it exists near the tangent velocity and shows a clump-like structure. These are only three of 26 FVWs observable at Arecibo. The future ALFA survey of the Galactic plane will reveal the nature of FVWs.

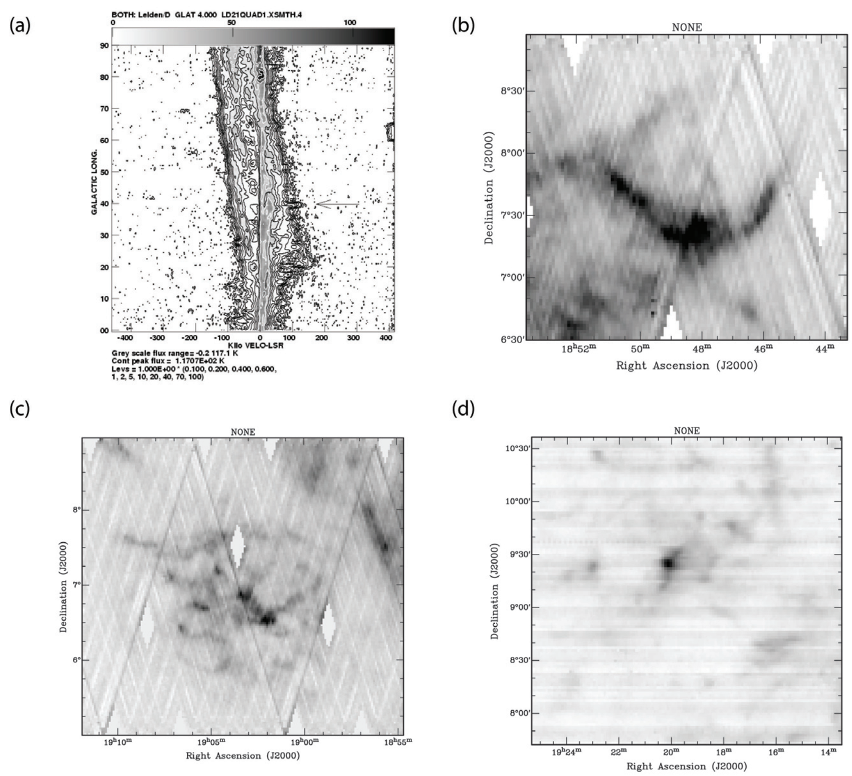


Figure 14. (a) Large-scale (l,v) diagram at b = + 4° using LD data. The arrow near the center indicates faint extended bump of FVW39.0+4.0. (b) Arecibo image of FVW39.0+4.0 integrated over velocities between v_{LSR} = 73 km s^{-1} and 130 km s^{-1}. (c) Image of FVW40.0+0.5 integrated from v_{LSR} = −79 km s^{-1} to −114 km s^{-1} (d) Image of FVW44.5−2.0 integrated from v_{LSR} = +90 km s^{-1} to +110 km s^{-1}. (Image courtesy: Ji-hyun Kang and Bon-Chul Koo (Seoul National University))

Halo HI Clouds in the Galactic Outback

One of the very first GALFA observations targeted the region of the Galactic Anti-center, which is well know to harbor a wealth of high velocity gas. The most striking feature in these observations is a large number of discrete, small HI clouds located at velocities distinctly separated from that of the bulk of HI gas in the Galactic disk, yet not very anomalous from the velocity range permitted by the Galactic rotation. An example of this phenomenon is shown in Figure 15 where 3 small HI clouds are easily noticeable in this Galactic longitude−velocity diagram, located at the velocity of about −20 km s^{-1}. The velocity profile shown at the bottom of this figure was obtained through the center of the cloud in the middle, at l = 187.07° and b = 18.00°. While we are still searching GALFA datasets for a more complete census of similar clouds, their typical properties are: an angular size of 5−10′, a velocity line-width of about 5 km s^{-1}, and a peak HI column density of 2 × 10^{19} cm^{-2}. Clearly, some of these clouds are very cold.

Clouds with similar properties have been discovered in the inner Galaxy with the Green Bank Telescope (*Lockman*, 2002), suggesting that most of the mass of the lower Galactic Halo could be in the form of small, discrete HI clouds. It is believed that these clouds are a result of the Galactic Fountain—buoyant outflows from the star forming regions that bring hot gas from the Galactic disk into the Halo. The hot gas eventually starts to cool and condense into small clouds, which then rain back into the disk. ALFA observations, together with the recent observations of several regions in the outer Galaxy obtained with the Effelsberg telescope (*Kalberla* et al., 2004), show that the clumpy Halo structure may not be restricted only to the inner Galaxy but could be a wide-spread phenomenon. The origin of the Halo clouds in the Galactic outback is harder to understand though. The effects of the Galactic Fountain in the outer Galaxy are expected to be more severe than in the inner Galaxy. Due to a larger rotation velocity clouds are expected to lag back significantly behind the bulk of the disk gas. Yet, we find that they still primarily follow the main disk features. Other mechanisms for the formation of these clouds clearly need to be considered.

GALFA Discovers Massive Ultra-high Velocity Cloud

The GALFA consortium has begun mapping and imaging various regions of the Galactic sky. Fortuitously, one of these regions contained an unexpected and uncataloged high-velocity cloud

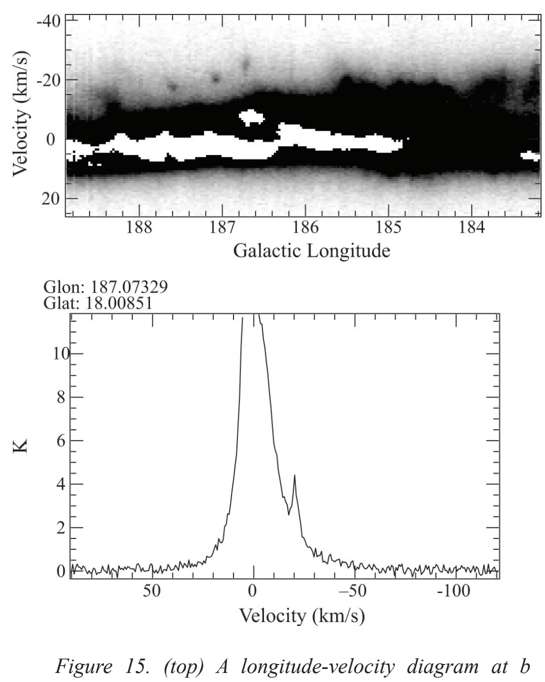


Figure 15. (top) A longitude-velocity diagram at b = 18° from the recent GALFA observations. Three small Halo clouds, at l ~ 187° are noticeable with the LSR velocity of about −20 km s^{-1}. All pixels with the brightness temperature higher than 10 K have been masked out to enhance weaker features in the figure. (Bottom) An HI spectrum through the center of the small cloud at l = 187° and v = −20 km s^{-1}. (Image courtesy: Snezana Stanimirovic (UC Berkeley) and Mary Putman (Michigan University))

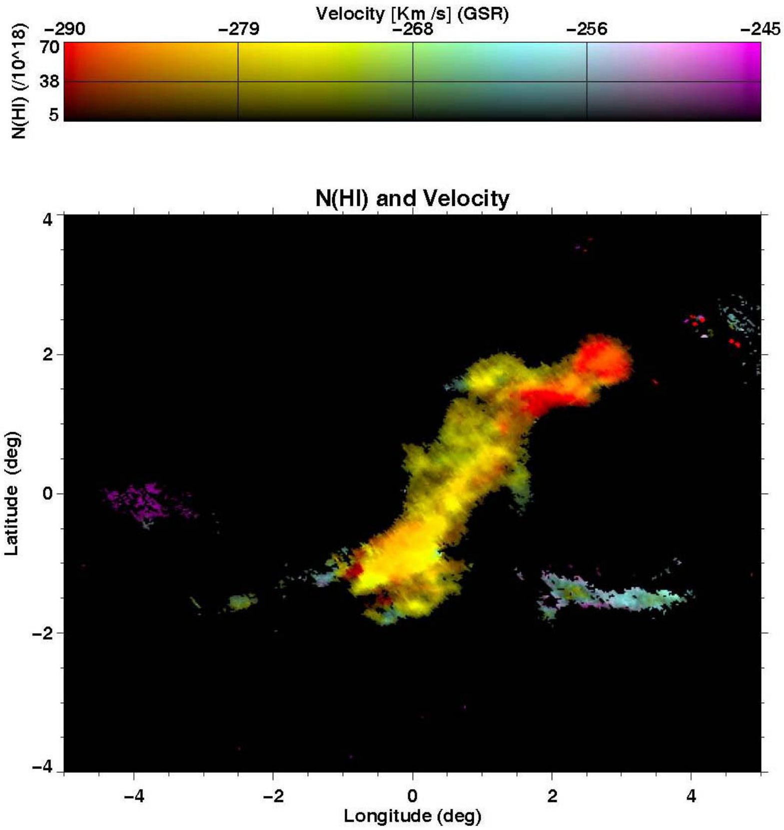


Figure 16. The HI column density distribution and the velocity field of the massive HVC at the extreme negative velocity end of the range 'allowed' for HVCs. (Image courtesy: Josh Goldston and Carl Heiles (UC Berkeley)).

(HVC). This, though, is no ordinary HVC. With Galactic standard of rest (GSR) velocities approaching −300 km s^{-1} and a mass of ~ 2000 $M_\odot$ $(D_{kpc})^2$, this is very nearly the fastest HVC ever seen, and dwarfs all other known clouds in this ultra-high velocity range.

Figure 16 shows the HI column density and the velocity field of this cloud. The morphology is very suggestive of an infalling cloud. The cloud has shredded streamers at reduced velocities pulling off the main body of the cloud, perhaps having been sheared off by interaction with ambient halo gas (i.e. ram pressure stripping). The cloud also has a somewhat 'head-tail' or even cometary shape, suggestive of infall, towards the galactic plane (up, in the plot, Fig. 16).

A cloud with these characteristics puts stiff constraints on models of HVC origin. A compact, low-mass cloud at this velocity could be explained by chance kinetic interactions, but a coherent cloud of this scale requires a robust explanation. Were this cloud to be falling directly onto the plane, it would have an infall velocity of nearly 450 km s^{-1}. Since this number is comparable to the escape speed from the solar neighborhood, any model that proposes to generate HVC velocity by infall, whether it be an accretion model or a fountain model, must contend with a massive body entering the galaxy at free-fall, even as we see it being ablated (and therefore presumably arrested) by ambient gas.

It seems that Milky Way gravity alone cannot account for this monster HVC.

Large Shell in the Galactic Anti-center

Prior to the installation of ALFA, the SETHI survey, consisting of Arecibo L-band data originally taken for SETI@home, had been scanning the Arecibo sky since 1999. With the SETHI data, *Korpela* et al., 2004 detected what appears to be a series of interlocking shells in a region close to the Galactic plane, near the anticenter [(l,b) = (192,6)]. This region was recently mapped with ALFA. Figure 17 shows a huge shell structure, at the velocity of −18 km s^{-1}, having a diameter of almost 4°. These observations were made using a "modified basketweave" technique, because of the region's declination being close to 18 degrees, making transit observations unfavourable. A technique was devised where the region would be scanned at an hour angle of 1 hr, and the azimuth of the Gregorian would be wagged while keeping the zenith angle constant, instead of the usual method which reverses the roles of these angles. Furthermore, test observations prior to the observing run showed that beam rotation occurs during modified basketweave runs, so the region was split into two adjacent strips in an effort to limit beam rotation by covering a smaller declination range.

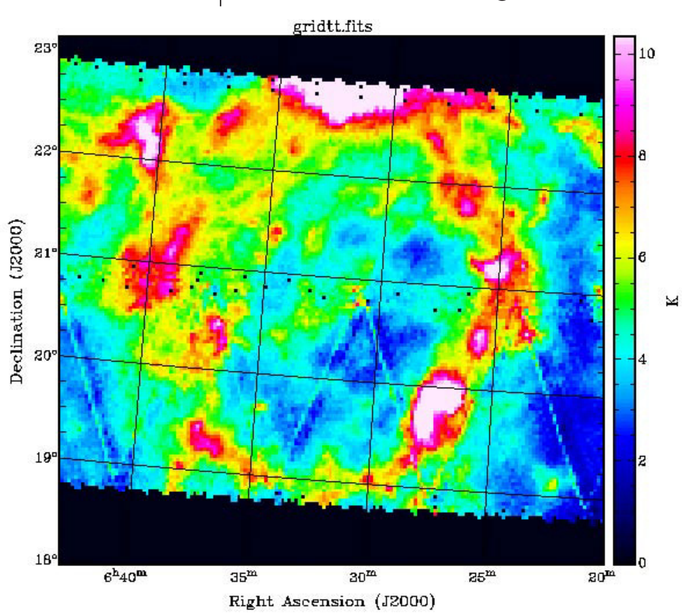


Figure 17. A large shell in the Galactic Anti-center recently mapped with ALFA. (Image courtesy: Kevin Douglas (UC Berkeley))

Small-Scale HI Structure of Galactic Clouds

Several Galactic HI clouds, previously observed with the Green Bank Telescope (GBT), have been recently observed with ALFA. Figure 18 shows an HI image of one of the target clouds. While being unresolved at the GBT's angular resolution of 9′, with Arecibo's resolution of 3′ the cloud breaks into several HI clumps, which are embedded in a more diffuse emission. A more technical aim of this project is to compare HI images obtained with ALFA with the images obtained with the GBT and and the Very Large Array to study the influence of the ALFA sidelobes on the mapped power distribution. In addition, as this project employs a drift-and-chase mode, it is suceptable to effects resulting from the elongation of the beams on the sky, which would otherwise impose a directional structure bias in all maps of the extended emission. A secondary objective for this project is to investigate the benefits to be gained from artificially defocusing the beam shape, to force it to return to a circular shape and thereby removing any directional biases, albeit at the expense of spatial resolution. This project was one of the very first ones to employ commensal observing capabilities with two independent back-end systems, the GALFA spectrometer and the more traditional WAPP system.

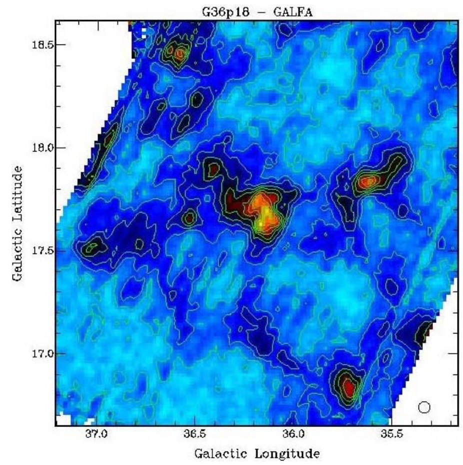


Figure 18. The HI column density image of the Galactic cloud G36.18 obtained with ALFA. (Image courtesy: Erik Muller (ATNF))

How Do Molecular Clouds Form?

All stars are formed deep inside molecular clouds. One of the current enigmas lies in the formation and evolution of molecular clouds, specifically the conversion from atomic to molecular gas. Until recently, studies of the relationship between the atomic and molecular gas were limited to observations of individual small clouds. The enhanced capabilities of ALFA currently allows the observation of the neutral hydrogen in and surrounding large molecular clouds spanning several hundreds of square degrees on the sky. In July of 2005 GALFA mapped about 300 deg^2 of the Taurus Molecular Cloud (TMC) complex yielding the largest high-resolution 21cm map of a star forming region, while using less than 40 hours of observing time. This map provides clues that will allow us to tackle long standing questions in star formation theory.

Figure 19 shows an integrated intensity HI map of our region over a velocity range of 0–10 km s^{-1}. The overlaid contours represent the borders of significant ^{13}CO emission obtained from a recent FCRAO map. The HI Narrow Self-Absorption (HINSA) feature allows us to measure the HI content of individual dense clumps in the cloud, and, in combination with molecular line data, allows us to determine the chemical ages of the clumps. Most of the dark regions in the map which correspond with significant CO emission exhibit HINSA features. This will yield significant insight into the formation mechanisms of the TMC and similar star forming regions. Studying the warm, externally heated, HI in the molecular cloud halo will allow us to better understand the physical and chemical conditions of the transition region between the neutral and molecular gas. A cursory look at the HI

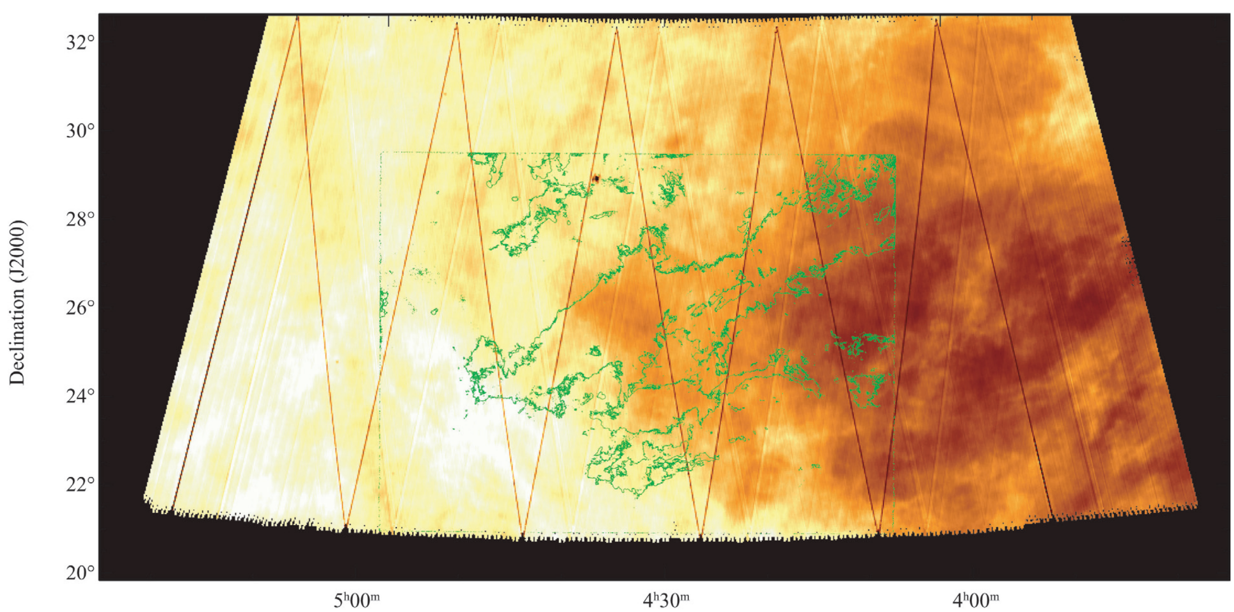


Figure 19. The HI column density image of the Taurus molecular cloud obtained recently with ALFA. (Image courtesy: Marko Krčo (Cornell University), Héctor Arce (AMNH) and Paul Goldsmith(JPL))

distribution in this region immediately shows us a wide variety of environments ranging from diffuse gas, and pre-stellar dark clouds, to newly formed stars. This shows us that the different portions of the TMC complex are in various stages of evolution. In short, we now have our first complete high-resolution, high-sensitivity head-to-toe guide to star formation in a giant molecular cloud complex.

Radar Astronomy

Mike Nolan

In October 2005, Mars came into the Arecibo sky for the first time since the upgrade. There are three projects to obeserve it this fall, the first of which (*Harmon* (NAIC) et al.) has produced roughness maps of the Tharsis region at 10 times finer resolution than the pre-upgrade images.

Don Campbell (Cornell) et al. have also been mapping the Moon using a bistatic AO-GBT program to produce dual-polarization maps at 15-m resolution. Bruce Campbell (NASM) has a related program to produce dual polarization maps at 70-cm wavelength. The resolution is about a factor of 30 lower, due to the narrower bandwidth of the 70-cm transmitter, which was not designed for planetary work.

Benner (JPL) et al. obtained a radar range of the potentially hazardous asteroid (99942) Apophis, AKA 2005 MN4, which has a non-zero probability of impacting the Earth in 2036. This radar observation dramatically improved our knowledge of the orbit of Apophis, and ruled out an impact in 2024, but the possibility of impact in 2036 still remains. Further radar observations in 2013 provide the best chance to rule out an impact.

Chris Magri (Univ. of Maine) visited the observatory in the summer of 2005, to continue development of shape-modelling software originally written by Scott Hudson (Washington State Univ.). As a result, REU students Sarah Scoles and Casey Dreier derived shape models of asteroids 2005 EU2 and 2002 HK12 that were presented at the 2005 DPS meeting in Cambridge, UK.

Space and Atmospheric Sciences

Sixto González

From August 11–20, 2004, we hosted the Polar Aeronomy and Radio Science (PARS) summer school. Students and their advisors carried out many observing programs involving aeronomy, radar techniques, and plasma physics; two have resulted in additional work. First, studies by M. C. Lee and students (MIT) of sporadic E, and spread F. They returned in December 2004 to continue this observing program. Second, Elizabeth Gherkin (SRI) and Asti Bhatt (Cornell) studied the weak gyro line of incoherent scatter during dawn and verified that it becomes visible at the same time as the plasma line. Additional studies of its temporal behavior are scheduled for December 2005.

In the second half of 2004 we carried out a number of observations in support of the international World Day program, these taking place in June, September, November and December. In 2005, World Day observations were performed in March, June, and July, twice in the September world month, and again in October.

In 2004, we encountered a number of major technical problems with the 430 MHz transmitter, which have now been overcome, thanks to the hard work of Jon Hagen, Víctor Iguina, Joe Greene and others. The major problems were the failure of high-voltage insulators in the modulator oil tank, or a consequence of these failures. It was necessary to replace nearly all of these insulators. We suggest that other NSF radar facilities may want to look for low-level electrical corona, which is a sign of the initial problems. Many other long-term issues with the transmitter were addressed, and currently it is operating with remarkably high reliability at or near its rated power. Work by the receiver group in the electronics department has resulted in high reliability cooled receivers in both the line feed and Gregorian systems.

We have had a number of frequent visitors in the past twelve months. John Mathews and his group at Penn State came in June and December 2004, and then again in March, August and September 2005. Johannes Wiig and Paloma Gutiérrez, who are in that group, arrived in January 2005 and expect to stay for two years working on projects related to the new Echotek digital receivers and the Penn State all-sky imager.

Other long-term visitors include Ryan Seal (Univ. Arkansas, Little Rock), who in Summer 2004 worked on the Echotek digital receiver (his advisor, Julio Urbina, visited for a month in June 2005) and Xinzhao Chu (University of Illinois—UIUC, now at University of Colorado—CU) who was here in March–April 2005 to work on mesospheric science and lidar technologies with NAIC staff scientist Jonathan Friedman.

Lara Waldrop (UIUC) visited in December 2004, and then again in January, March and October 2005 to continue her studies of H and He in the exosphere. As part of that project, John Noto (SSI) is upgrading one of our Fabry-Perot interferometers (FPI) to use a modern CCD detector. Lara has published her first project that dealt with metastable helium and gave a very nice talk about her current work on H^+–O charge exchange equilibrium at last summer's CEDAR workshop.

Frank Djuth (Geospace Research, Inc.) visited in June 2004 and July 2005 and is using high-resolution E-region measurements to study gravity waves. His observations have served as a benchmark in the progress of work on the radar system. We achieved dual beam high-resolution coded long pulse plasma line observations with good quality in both the F and E regions, thus showing the radar is indeed working very well.

Diego Janches (Colorado Research Associates—CoRA) has visited several times to continue his meteor work and most recently used the dual beam in collaboration with Dave Fritts and Dennis Riggin (both of CoRA) to study momentum flux. This work has resulted in the submission of two papers within two months of the first observations. He also returned for 10 weeks this summer to help mentor the REU students.

An expansion of the airglow lab added 50% to its workspace, and our first 'tenant' was John Meriwether's (Clemson) 'Mini-me' instrument, a transportable FPI. M.C. Lee (MIT) deploys his all-sky camera in the new wing for his E/F region observations (see above) as well.

Romina Nikoukar continues to work on her Ph.D. thesis at UIUC. Her work is concerned with new codes and inversion techniques for optimal inversion of radar signals into geophysical parameters. We used these techniques to obtain very accurate nighttime temperature measurements for comparison with results from Mini-me.

Rubén Delgado (UPR-Río Piedras) continues to visit for one week every dark moon period to assist with lidar observations. He has developed a model, based on the work of John Plane (UK) and including ab initio calculations of the thermochemistry, to explain the steady-state characteristics of the mesospheric K layer, and he is using it as the basis for a model describing dynamic chemical processes, particularly those involving sporadic atom layers.

We have welcomed two new staff members. José Fernández arrived last fall from the University of Nebraska to assume a post-doc position at NAIC, and has been busy using genetic algorithms to invert our ISR data. Hien Vo is a new scientific staff member from the University of Wales and began work here in February primarily focusing on Space Weather projects with Jan Sojka (Utah State—USU) and Vince Eccles (Space Environment Center—SEC). Observations of the ionosphere enhanced by X rays from the X class solar flare during the September 2005 World Day have provided an unexpected start to this collaboration.

In staff activities, we have had a number of successes. Néstor Aponte published a very nice dual beam result on instantaneous electric field measurements in the F-region and is now working on developing a technique to use the plasma line together with the ion line to obtain accurate temperature estimates in the lower F-region.

Shikha Raizada spent a year as a Humboldt Fellow at the Leibniz Institute for Atmospheric Physics (IAP) in Germany. She studied mesospheric dust and its role in the formation of ice particles that are observed as Polar Mesospheric Summer Echoes (PMSE) and Noctilucent Clouds (NLC). Shikha returned to Arecibo in August.

Craig Tepley presented at the Spring 2005 AGU meeting preliminary results from his investigation of the use of a Fabry-Perot interferometer in a lidar receiver to make sodium lidar temperature measurements, with a potential to measure the winds as well. The idea is to provide a method for the many existing broadband Na lidars to convert to Doppler lidars without replacing their transmitters. Craig has also been busy overhauling the datataking software for the airglow systems to run on Windows PCs. The transfer of this system from the PDP-11/83 micro-computer is a major project and will greatly modernize the airglow datataking and increase its capability and flexibility.

Mike Sulzer has recently been involved in preparing a proposal to re-establish HF capabilities for ionospheric modification work at Arecibo. He also published a description of the method that we now use to obtain vector velocities from our ISR line of sight measurements.

Finally, Mike Nicolls (Cornell) did several Arecibo-related projects that resulted in publications and has finished a manuscript where the O–O^+ energy balance and associated 'Burnside' factor are revisited. With his help Sixto González was able to finish two projects, one relating to solar cycle variations in the He^+ abundances, and the other describing a novel heating experiment that was carried out in what turned out to be the final campaign of the now defunct Islote HF facility.

With about 30 Arecibo-related publications in 2004 (*http://www.naic.edu/aisr/bibproj/bibproj.html/*), nearly that many already this year and 12 Arecibo-related presentations at this Fall AGU meeting, things have been exciting on site. Although the oversubscription rate continues to increase, we have managed to accommodate most requests by combining proposals that have compatible observing modes with the result where in most cases we can grant time not only to A but also to large fraction the B-rated proposals.

Electronics Department Highlights

Ganesan Rajagopalan

The electronics department has been busy maintaining and improving our transmitters and receivers. What follows is a review of that activity.

Transmitters:

- ***430 MHz radar returned to full power operation in August 2005.***

After several weeks of hard work and perseverance, the transmitter team led by Joe Greene and guided by Jon Hagen (both NAIC) successfully restored the 430 MHz klystrons to full power operations in August 2005. Further improvements to ensure reliable performance are underway.

• S-band radar will be back to full power in early 2006.

The planetary radar system at 2380 MHz has been operating at half power with only one klystron since May 2005. The final testing of the two spare klystron tubes is ongoing at press time in CPI (formerly Varian), and we expect the system restored to full power operation in early 2006.

Receivers:

• C-band system temperature drops below 30 K with Indium Phosphide Amplifiers.

In May 2005, the receiver group carried out an upgrade of the C-band 4–6 GHz receiver, with the installation of ~ 2 K In P-based low noise amplifiers. This completes the upgrade of all three high frequency receivers with system temperature improvements across the band up to 10 GHz. The SEFD (System Equivalent Flux Density) of the C-band receiver improved over 25% with Tsys ~25K and Gain ~8K/Jy. Arecibo now exhibits unmatched sensitivity from 4–10 GHz. More details on the System performance at *http://www.naic.edu/~phil/sysperf/sysperf.html*

• New Filter bank for ALFA: radar-free 100 MHz band centered at 1440 MHz.

In March 2005, a switchable filter bank was installed upstairs, enabling an easy switch between the full band (300 MHz) low pass filters and 1665 MHz bandpass filters that extended ALFA beyond the normal 1225–1525 MHz coverage.

Ellen Howell (NAIC) et al. used the 1665 MHz filters to map OH from Comet Temple 1 before and after NASA's Deep Impact spacecraft mission. In December 2005, these were replaced by another set of bandpass filters centered at 1440 MHz. The new filters render an (almost) radar-free ~100 MHz band for PALFA and other Galactic HI observations. FAA and other radar-induced intermods have largely been removed.

• Notch filter solution enables sensitive continuum observations with the 430 MHz receiver.

In January 2005, ultra low loss cavity filters with a novel combination of a bandpass filter and four filters to notch out the TV station carrier frequencies were placed in front of the cooled receiver. While adding only ~3 K to the system temperature, this combination eliminated the TV station intermods inside the passband. Phil Kronberg (Los Alamos Nat'l Lab) and Chris Salter (NAIC) have since used the 430 MHz receiver for sensitive continuum observations.

• Sterling cycle compact dewar houses a high dynamic range cooled receiver.

Dual beam 430 MHz radar observations received a big boost in September 2005 with the addition of a very high dynamic range and low-noise cooled receiver inside a compact dewar. This Sterling cycle cryopump is operating near 60 K ambient temperature, reducing the system temperature from 110 K to 70 K for radar runs. This increase in sensitivity enabled the success of many dual beam experiments. This dewar is under test before being deployed for the 327 MHz receiver. Another compact receiver will be built in 2006 to cater to the radar observations.

Spectrometers:

• 300 MHz PALFA/EALFA spectrometers

The 100 MHz WAPP (Wideband Arecibo Pulsar Processor) is being used with great success for ALFA multi-beam and other single pixel receiver observations. An upgrade to cover the full 300 MHz bandwidth with an FPGA-based spectrometer is planned for this fiscal year. Jeff Mock (independent entrepreneur who collaborates with UC Berkeley) who had collaborated with UC Berkeley group to deliver the GALFA spectrometer will be producing the new PALFA/EALFA spectrometer under contract to NAIC. The analog front-end will be designed and built in house with installation expected in Fall 2006.

• Digital receiver for Aeronomy

APC-based completely digital receiver is under development by Ryan Seal (Univ. Arkansas at Little Rock) for Aeronomy projects. Original first generation data acquisition system design began July 2005. The system uses commercial digital receivers combined with a general purpose computer. Development of second generation system is under way with many improvements to the initial design in terms of efficiency and flexibility. A more detailed report will follow in a future newsletter.

2005 Summer Student Projects

Diego Janches (Colorado Research Associates—CoRA)

Supported by NSF REU Funds:

Evan J. Anzalone (Univ. of Louisiana, Baton Rouge,)—a third-year student majoring in Physics. He worked under the supervision of Ganesh Rajagopalan on Noise Characterization of Cryogenic Amplifiers under LabVIEW Environment. The noise level of a receiver's amplifier sets the sensitivity limit of the whole receiver system.

As new semiconductor materials and improved engineering methods are applied to high frequency transistor technology, significant decreases in inherent noise have been achieved. NAIC possesses a system to measure the whole receiver using the hot load and cold sky/cold load method. This data is very useful for the implementation and characterization of new receivers. But an accurate, dependable, and very low uncertainty system to directly measure the contribution of the amplifier itself was not available.

The methods in use at NRAO, JPL, Caltech, and other laboratories were researched through the published reports/papers. The majority of these systems are based on the Cryogenic Attenuator (CAT) Method, which employs a Noise Figure Analyzer/noise diode measurement with a cryogenically cooled attenuator before the amplifier to minimize uncertainty of error, and isolator and low noise amplifier on the output of the cryogenic chamber to reduce the noise of the measurement system. This method is shown to produce very accurate measurements of Effective Temperature within an uncertainty limit of ± 0.7 K repeatedly. The main goal of the summer project is to create a similar system for the NAIC Electronics Dept. A parallel goal of the research is to automate the measurement process with GPIB using National Instruments LabVIEW software.

Fonda Day (Univ. of Colorado at Boulder)—a fourth-year undergraduate student majoring in Astronomy. She worked with Dr. Emmanuel Momjian on two projects. The first was an HI emission search for low surface brightness (LSB) galaxies. Lyman alpha absorption has been detected along the sightline to the active galaxy Ton 28. She looked at HI line emission data of this sightline, which was taken in 2003, to search for LSB galaxies that may be associated with the Lyman alpha absorption system. No galaxies were found along the sightline, but an optical study on the system will be pursued.

The second project was to analyze the impact of adding the Arecibo telescope to the VLBA observations. Fonda used data from 2003 observations of NGC 2623 to conduct the study. She found that with natural weighting applied to the images, Arecibo increases the sensitivity from a factor of 2 to a factor of 4, depending on the integration time, just as theoretical calculations predicted.

Rhea C. George (Univ. of California at Berkeley)—a third-year undergraduate student majoring in Computer Science and Planetary Science. She worked under the supervision of Mike Sulzer and Diego Janches on retrieving meteor information from data collected from incoherent scatter for ionospheric studies.

At Arecibo the 430 MHz radar transmits in many different modes. Rhea searched for meteors using the coded-long pulse (CLP), power (PWR), and Multiple Radar Auto-Correlation Function (MRACF) modes that are used primarily for studying the E and F regions of the ionosphere. For the latter two modes, Rhea was to determine whether or not the meteor parameters such as velocities and heights could be calculated from the signal return of a meteor.

She wrote programs in ASP to do this. Processing the PWR mode was successful, but using another algorithm or fitting technique would be beneficial to increase the frequency resolution. The processing program Rhea wrote for the MRACF mode worked well for strong signal return meteors, but did not always correctly obtain meteor information from weaker meteors where ambiguous situations occurred.

Talia Kohen (Cornell University)—a third-year student majoring in Electrical Engineering. She worked with Dr. Néstor Aponte comparing the trend of the meridional neutral wind obtained by the Fabry Perot Interferometry (FPI) techniques, with the corresponding trend extracted from ion velocities measured by the Arecibo Incoherent Scatter Radar (1985–2003). The purpose of the study was to verify the conclusions reached by Robles et al. who measured meridional and zonal neutral winds obtained by Arecibo FPI over the years 1980–2002 and concluded that the horizontal neutral wind vector rotated from southeast to eastward over those years. This change is mostly due to a change in the meridional (north-south) component of the neutral wind. Initial results of ISR monthly and yearly averages supported the magnitudes of the FPI data, as well as the overall trend of the FPI measured winds.

Laura Kushner (Univ. of Washington, Seattle)—a third-year undergraduate student majoring in Physics and Astronomy, with a minor in Spanish. She worked under the supervision of Chris Salter and Tapasi Ghosh conducting a blind survey of a large sample of known compact radio sources with $z > 0.3$ to determine how many low-redshift Damped Lyman-alpha (DLA) absorption systems could be found. A damped Lyman-alpha system, in most general terms, consists of a thick absorbing cloud of neutral hydrogen (HI) along the line of sight between ourselves and an active galactic nucleus.

Arecibo observations were made using the Wideband Arecibo Pulsar Processor (WAPP) and the L-band wide receiver between January 2004 and July 2005, recording the radio spectrum over the frequency range of 1420 to 1100 MHz. The data were taken and reduced using the method of double position switching (DPS), a means to remove the effects of standing waves resulting from the continuum flux density of a source. DPS consists of on- and off-source measurements on a target and a reference source. The off-source observation tracks across the same part of the telescope as does the on phase. By taking the ratio of the differences of the on and off phases, [(on_target – off_target)/(on_reference - off_reference)], one can eliminate the standing waves imposed on the source radiation by the telescope. On the final ratio spectrum, a DLA absorption in the target source appears as a dip, with one in the reference source appearing as a peak.

Iain Mansfield (Univ. of Cambridge, UK)—a third-year undergraduate student majoring in Physics. He worked with Dr. Avinash Deshpande on Gamma Ray Bursts (GRBs) and Scintillation Radio observations of GRBs. These scintillations (i.e. intensity fluctuations) get quenched later as the so-called “fireball” expands rapidly.

Iain’s project aimed to model and simulate this situation to study scintillation depth and its evolution in time as a function of radio frequency, source size and source shape. To do this, Iain used C to model the progression of the wavefront, step by step, as it propagated through the interstellar medium after having scattered off a cloud of gas. By choosing the wavelength, screen size and other such parameters correctly, Iain was able to study both refractive and diffractive effects. A number of trends of how properties of the wavefront ˜ for example, rms intensity as a function of time ˜ altered as the wavelength and source size changes were observed.

Sarah Scoles (Agnes Scott College) – a third-year undergraduate student majoring in Astronomy. Sarah worked with Drs. Mike Nolan and Ellen Howell on modeling radar observations of the near-Earth asteroid 2005 EU2 obtained at the Arecibo Observatory on March 26–27, 2005. Both continuous wave (CW) and delay-Doppler images were used to estimate the shape of 2005 EU2 using the method of Hudson (1993).

Sarah was able to create a three-dimensional asteroid model, which provides new information about the rotation and size characteristics of 2005 EU2. The ephemerides and estimates of rotation rate, rotation poles, spin states, diameters, and scattering law parameters were estimated in order to provide initial model parameters.

2005 EU2 was found to have approximately a period of 3.07 ± 0.20 hours. The asteroid appears to be an elongated object with principal axes of 211 m by 167 m ± 15.0 km. These observations cover only one hemisphere of the asteroid. All calculations were done assuming equatorial view and principal axis rotation.

Preliminary results for another near-Earth asteroid, 2002 HK12 indicate a double-lobed object with a rotation period of approximately 13 hours and a diameter of approximately 690 m. The SC/OC ratio (the ratio of same circular polarization to opposite circular polarization) is approximately 1, which, compared to the typical 0.1–0.2 ratio, indicates possible unusual surface material and scattering properties.

Teacher in Residence:

Roberto Nieves—a science teacher from the Domingo Aponte High School in Lares, Puerto Rico. Mr. Nieves participated of the "Teacher in Residence Program", a summer internship at the Arecibo Observatory for qualified high school science teachers.

A large fraction of Mr. Nieves effort was devoted to his role as an instructor in the Geoscience Workshop (June 5–17). Mr. Nieves provided a series of hands-on activities and lectures related to the geology of Puerto Rico to a group of 24 participants. He also organized a field trip to the karst region in which participants collected rocks and fossils. He also provided training in the use of the GPS and map and compass.

As part of his duties, Mr. Nieves assembled a collection of Puerto Rican rocks and fossils (properly classified) that will be part of a new exhibit at the Visitor Center depicting the Geology of Puerto Rico.

Supported by Other Funds:

Two students were supported with NAIC funds:

Anthony Salvagno (SUNY-Albany)— a third-year undergraduate student majoring in Physics. He was supervised by Murray Lewis. His project involved exploring a new method for distinguishing OH/IR Stars from proto planetary nebulae (PPN).

He was expected to model the circumstances that lead to the observed red limit on the (25–12) micron color range of high-latitude OH/IR stars using the public-domain radiative-transfer code DUSTY. Models of the spectral energy distribution were expected to set limits on the duration of a constant mass-loss rate into a circumstellar shell, and show that the observed color limit could not be generated by a prolonged, more or less constant dM/dt. The few rare OH/IR stars with smaller than average expansion velocities lying beyond the red limit are expected to be PPN. Their NIR colors ought to reflect this fact, and their IRAS variability flags should show a low probability of their being MIR variables.

Anthony extracted from Murray's databases in the first instance all of the Arecibo sky OH/IR stars, and, in the second instance, all of those from the rest of the sky, and pulled together their IRAS, 2MASS & MSX characteristics to test this expectation.

Casey Dreier (Oberlin College)— a May 2005 graduate**,** Physics major. Casey worked with Drs. Mike Nolan and Ellen Howell on modeling the near-Earth asteroid (7753) 1988 XB, which made a close approach to Earth during the Fall of 2004.

Each day during the period of November 22–26, the Arecibo Observatory Planetary Radar made continuous wave and delay-Doppler imaging measurements at 7.5-meter resolution. Immediately apparent from the delay-Doppler maps was that 1988 XB is an irregularly shaped object with a relatively slow rotation period. The data are consistent with principal axis rotation with a period of 28 ± 1 hours. The apparent diameter varied between 1.3 and 2.0 km, which reflects the elongated shape of the object.

Casey used Hudson's (1993) "Shape" software to form a plausible physical model of the asteroid. The properties mentioned above were used with the 1- D and 2-D radar data to define a starting model. Preliminary results show a large outcropping of rock, which defines 1988 XB's irregular radar echo. Multiple starting conditions were used to test the uniqueness of this solution. Other preliminary results suggest a sub-radar latitude of approximately 60 degrees and a major-axis diameter of (1.7 ± 0.2) km, which are consistent with initial measurements. Further results will be presented by Casey at the DPS meeting in Cambridge, UK in September 2005.

Adam Mott (University of Arizona)—second-year graduate student and former REU student at Arecibo during Summer 2003. Adam worked at the Observatory for six weeks under the supervision of Paulo Freire towards high precision timing of the binary millisecond pulsar 1741+1351.

This 3.7-millisecond pulsar was found in a survey by Jacoby et al. of high galactic latitudes using the Parkes radio telescope at 1.4 GHz (L-band). It is in a nearly circular 16-day orbit with a companion star that is almost certainly a white dwarf. However, only a rough determination of the pulsar's orbit was possible from the pulse times of arrival in the Parkes data. The likely cause of this difficulty was the high degree of scintillation (variations in intensity), which this pulsar exhibits.

Using the greater sensitivity of the Arecibo radio telescope, Adam and Paulo undertook observations of this pulsar on ten evenings from 16 July to 7 August 2005 using the L-wide receiver with all four Wideband Arecibo Pulsar Processor (WAPP) backends, each with 128 frequency channels spread across 50 MHz of bandwidth. Since each WAPP was set to a different center frequency, they were able to improve the accuracy of the previously known dispersion measure (DM) by comparing the pulse times of arrival (TOAs) obtained from the four WAPPs. The TOAs also allowed for a much-improved determination of the pulsar's rotational period and orbit, giving us a phase-connected timing solution for all of our Arecibo observations. They then were able to use this timing solution to make sense of the earlier Parkes TOAs provided by Brian Jacoby and, in so doing, further improve the accuracy of the determined parameters for the pulsar.

This pulsar has excellent timing characteristics due to its very sharply peaked main pulse, and the average (root-mean-square) difference between the observed pulse times of arrival and our timing model is ~450 nanoseconds. We have high hopes that this pulsar may yield a measurement of the Shapiro delay (a relativistic delay in the observed pulse period caused by the signal passing nearby the companion star on its way to Earth). This would allow for a determination of the inclination angle of the binary system and the masses of the pulsar and its companion star. To facilitate this measurement, future Arecibo observations are already planned for 22 August to 6 September 2005 to cover one complete orbit at a rate of one observation per day.

Three students from the University of Puerto Rico-Mayagüez, were funded through the NASA Space Grant:

Igneris Franco—a fourth-year undergraduate student majoring in Electrical Engineering. She worked under the supervision of Jose Rosado. Her project involved correlation studies of sporadic E layer dual beam height differences and F region ion drifts. MATLAB was the software used.

The routines used to obtain the electron velocity and calibration were Nestor Aponte's programs defvvels m, vvels.m, readall.m, readerrors.m. During the process, Igneris wrote some matlab programs, one of which calculated the correlation between the modulation of heights at the sporadic E layers and the variations in the electric field at the F region. The other program drew the electron density of the sporadic ionosphere layers (90–120 km) and calculated the difference between the data obtained from the gregorian and the linefeed for the days of observation.

Israel González Pérez—a seventh-year undergraduate student majoring in Electrical Engineering. Israel worked with Jonathan Friedman in making accurate daytime temperature measurements with the Arecibo potassium lidar.

For this purpose, an ultra-narrow bandwidth filter is required to reduce the solar background light. This filter is a Faraday Anomalous Dispersion Optical Filter (FADOF), which has been previously constructed and is already in use at Arecibo. The filter has to be calibrated regularly, and in order to do this a test bed was constructed. Using existing parts, Israel constructed a filter function measurement test station. This station uses a tunable single-mode CW diode laser to record the spectral pass band of the filter to get precise measurements of the laser's wavelength as it is tuned.

The project was a combination of two parts. First, a Doppler-free fluorescence measurement system that uses fluorescence in a potassium vapor cell in a "Doppler-free" configuration. This gives specific frequency markers to a very high degree of accuracy. Second, in order to verify the linearity of the laser scan, a low-finesse small Free Spectral Range Fabry-Perot etalon was put in place.

Due to time constraints no tests of the equipment or its application have been performed as of yet, however, Israel will continue working with Jonathan and participate in measurements when the equipment is tested and operational.

Alex J. Rivera Irizarry—a third-year undergraduate student majoring in Computer and Electrical Engineering. He worked under the supervision of Craig Tepley on a lidar optical configuration for tropospheric aerosol measurements in a multiangle profile. The goal of this project was to determine and map the aerosol optical parameters over Puerto Rico (PR) and some regions of the Caribbean. The retrieval of aerosol optical parameters requires the use of an Nd:YAG laser in a LIDAR with fundamental and harmonics wavelengths of 1064nm, 532 nm, and 355 nm.

It is known from recent work that at least three wavelengths and the nitrogen Raman channels (387 and 607 nm) are needed in order to extract the extinction and backscattering coefficients that are important in the determination of aerosol optical parameters. Because a multi-wavelength LIDAR of the Arecibo Observatory currently only measures a vertical profile, in this work an optical configuration has been done to assure a multi-angle profile that can extend the measurements to cover PR. Although, some problems were encountered during the development and testing of the optical setup whereby only one wavelength (532 nm) was transmitted to the atmosphere. Nevertheless, some measurements were taken with the wavelength mentioned that showed aerosol layers at low altitudes.

NAIC-NRAO School on Single-Dish Radio Astronomy

Robert L. Brown

In the week of July 10–17, 2005 the third in the bi-annual NAIC-NRAO School on Single Dish Radio Astronomy was held at the Arecibo Observatory. The school is oriented to the needs of undergraduate students, graduate students and professionals in astronomy and related fields with a professional interest in using the NSF radio telescopes in Arecibo, PR and Green Bank, WV for their research projects.

In 2005, 54 students participated in the summer school. These students were selected from among more than 80 applicants using criteria that, in order of priority, included the following: Current graduate students who are beginning their thesis research in radio astronomy; Postdocs in radio astronomy seeking to broaden their professional experience or observational skills; junior astronomy faculty with a desire to understand radio astronomy more fully so as to enrich their classroom lectures; undergraduate students with a demonstrated interest in observational radio astronomy. The student participants came from around the world, and this extremely broad base of experience allowed the students to learn as much from each other as from the organized lectures and projects.

The school included an intensive lecture course providing the necessary background, and overview of current single-dish capabilities in respect of both hardware and software, and it detailed state-of-the-art applications to specific research fields. Twenty-seven lectures were presented at the school in five days. Copies of the presentations from each of these lectures is available on-line at *http://www2.naic.edu/~astro/School/*.

An important part of the "full immersion" experience given the student participants was the requirement that each student participate in one of the nine Hands-on Projects. Telescope time was reserved at both the Arecibo telescope and the GBT for the use of the summer student participants, and the nine project teams. These were led by a supervising scientist from NAIC or NRAO. At the conclusion of the school, each of the nine teams made an oral report of their research project, its scientific goals, methodology and results, at a meeting of the entire school. Certificates of Accomplishment were awarded.

The school was an extremely rewarding and enjoyable experience for students, speakers and mentors alike. The diversity of the student population stimulated lively discussion on a wide range of topics; friendships were made that are likely to last a very long time. We look forward to seeing these students among the prominent users of the GBT and the Arecibo telescope in future years. And we look forward to the next Single Dish Radio Astronomy school to be held in the summer of 2007 at the NRAO Green Bank, WV observatory.

First Teacher Workshop on Science and Pseudoscience

Daniel R. Altschuler and José Alonso

Twenty-four science teachers from Puerto Rico, selected from among 130 applicants, met at the Learning Center between October 12 and 14, to participate in a new workshop entitled *¿Realidad o Fantasía? – Ciencia y Pseudociencia en el Salón de Clase y en la Sociedad* (Reality or Fantasy? Science and Pseudocience in the Classroom and in Society). The workshop was developed based on the recent publication of the text: *Ciencia Pseudociencia y Educación*, by D. Altschuler, J. Medín and E. Núñez (Fig. 20). José Alonso presented the Observatory to the teachers, while the three authors gave a series of lectures and activities designed for the workshop.

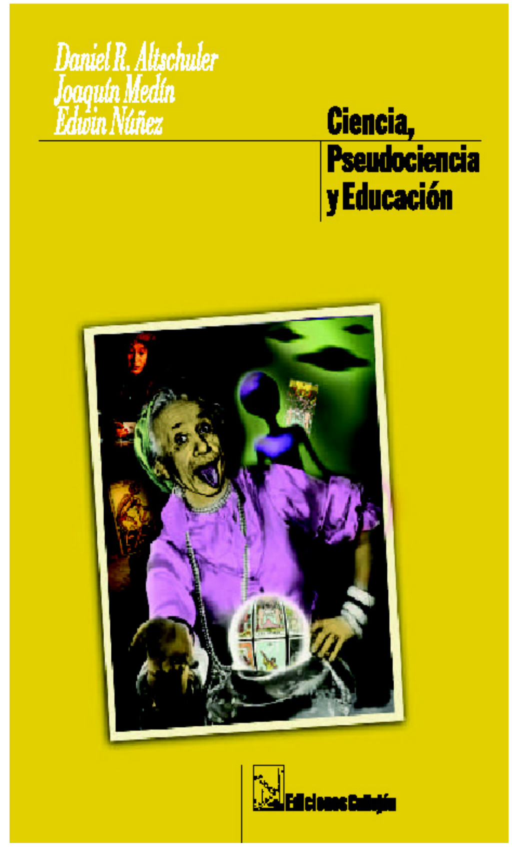


Figure 20. The cover of Ciencia, Pseudociencia y Educación*, by Daniel Altschuler, Joaquín Medín, and Edwin Núñez, published by Ediciones Callejón, 2005.*

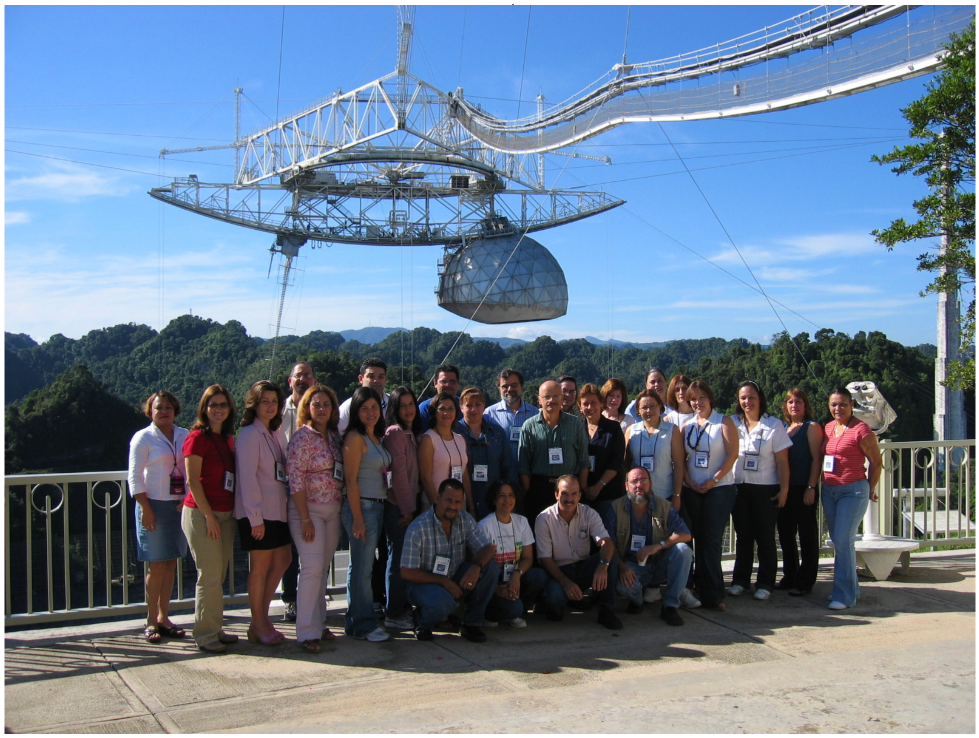
Daniel Altschuler and one of the participants.

An ambitious program covered topics which ranged from a discussion of the differences between Science and Pseudocience, Astronomy and Astrology, passing through ESP, extraterrestrials and life in the Universe. A presentation by Professor Lizzette Velázquez, from the school of education of the UPR summarized the workshop and highlighted the need to help teachers with sometimes difficult and confusing issues.

The participants expressed their appreciation of the workshop, commenting that it should have been longer. We agree, and will run a second workshop early next year adding one more day. We also plan to offer a short—one day—version of the workshop for journalists.

From comparisons of pre and post evaluations it is clear that the teachers improved their understanding of several issues. The distribution of scores is shown on the accompanying graph (Fig. 21) where the score is the number of correct answers on 28 questions.

This workshop was sponsored in part by the Puerto Rico Space Grant Consortium.



Group photo of the attendees of the Teachers' Workshop.

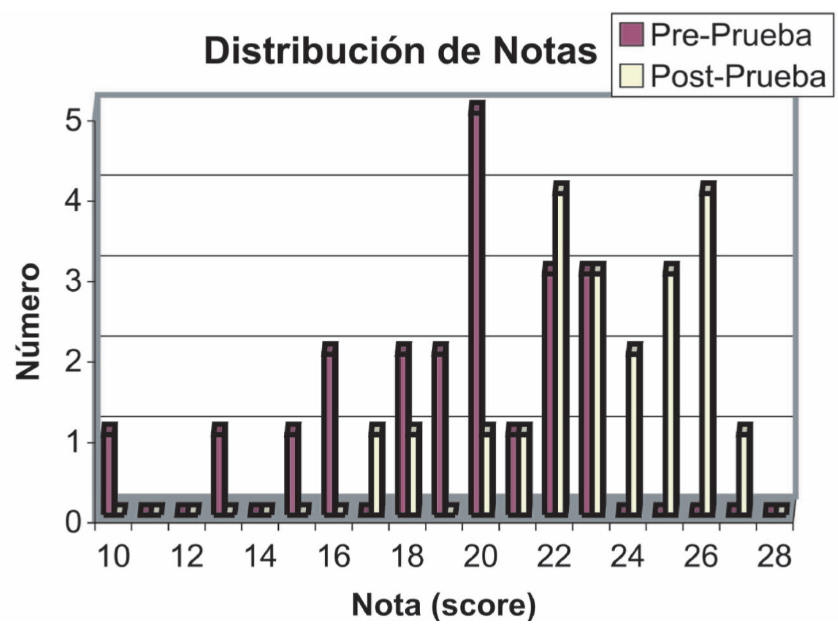


Figure 21. Comparison of the workshop participants' understanding of science vs. pseudoscience, before and after the workshop.

Workshop on Inter-Hemispheric Collaboration in Atmospheric Science

In FY2005 members of the NAIC atmospheric sciences staff began discussions with colleagues at the Universidad Nacional de La Plata in Argentina on the development of next generation research facilities for atmospheric science. There was a common recognition of the exciting scientific potential of studying phenomena in the upper atmosphere from mid-latitude sites that provide a complementary northern hemisphere/ southern hemisphere view of the earth's geomagnetic field. Moreover, recent advancements in the technology of incoherent scatter radar systems stimulated by the AMISR project have the potential to provide a cost-effective ISR capability that will uniquely complement the ISR facilities at the Arecibo Observatory in the southern hemisphere. It was agreed that these ideas need to be developed further in a broader community of researchers; to this end, a workshop is being organized at the Observatory in the second quarter of 2006.

The workshop is still in the planning stage with an agenda and participation built around the draft Memorandum of Understanding being circulated among interested institutions in South America and Europe. In addition to the Universidad Nacional de La Plata and NAIC, these institutions include the Universidad Nacional de Tucumán, the

Centro Astronómico El Leoncito, the Instituto Argentino de Física del Espacio, and the ICTP in Italy. The workshop agenda will include the following:

- Review of existing research capabilities in South and North America;
- Discussion of new technology and new technology facilities (e.g. AMISR, HF, optical, GPS);
- Discussion of the scientific potential of an atmospheric facility at the Arecibo conjugate point in the southern hemisphere;
- Organization of science working groups to develop the science arguments for a southern hemisphere research facility.

Further information on the workshop will be distributed as it becomes available.

Comings and Goings

Jon Hagen Retires

Don Campbell

Jon Hagen has retired!

After a thirty-four year association with the Observatory, Jon Hagen has retired. The good news is that Jon will continue to consult for NAIC and the Observatory from his new home in Brooklyn (as in New York) so we can expect to see him occasionally in both Ithaca and Arecibo.

Since first arriving at the Observatory in June 1971 as a Cornell graduate student working with Don Farley, Jon has had a major impact on all of the Observatory's research areas. His PhD thesis research included building a specialized digital data acquisition device, the hybrid correlator intended for studies of the Earth's protonosphere, which sparked his interest in the issue of the quantization of digital data. Jon, in collaboration with Don Farley, published a very elegant paper in 1973 outlining the signal-to-noise penalty for correlation quantization schemes, a paper that I still hand out to students taking the graduate radio astronomy techniques class at Cornell. After finishing his PhD, Jon joined the Observatory's scientific staff as a research associate in the atmospheric sciences group. Working with Rich Behnke, he was the first to detect the electron component for the incoherent scatter of radio waves by the ionosphere. This was the period of the first upgrading of the telescope, which allowed observations of the 21 cm line of neutral hydrogen. However, the Observatory did not have a modern digital spectrometer to take advantage of this capability so Jon turned his attention to building a 1008-channel autocorrelation spectrometer—I still wonder why 1008 channels and not 1024 but Jon can explain it to me once again—which was completed in 1976. This was a forefront instru-ment that became the workhorse of radio astronomy spectrometry at the Observatory until it was finally replaced during the second upgrading of the telescope in the 1990s.

In the late 1970s, Jon felt the allure of hi-tech industry so in 1979 he, his wife Freddie, their daughter Lorna and newly arrived son Ronald, moved to the Boston area where Jon joined the Raytheon Corporation. However, Jon's contacts with his colleagues at the Observatory and Freddie's with her family in Arecibo, combined with the frustrations of corporate life made Jon very receptive when I called him in 1983 to ask if he would take over as head of the electronics department from Miguel Feyjoo, the department's highly respected head since the mid-1960s. Jon, Freddie, Lorna and Ron returned to Arecibo.

For the next five years, Jon and his engineers and technicians kept the electronics side of the observatory humming along. In 1988, Jon decided it was time for another change so he moved his family to Ithaca and took up a new position as Laboratory Director at NAIC's Maple Avenue electronics laboratory. There he worked on developing low noise receiver systems for Arecibo and was involved in many aspects of the second upgrading of the telescope. He designed and oversaw the construction of the high-powered rotary waveguide coupler for the S-band transmitter and the Gregorian rotary floor cable wrap system. Jon also taught a course in Cornell's Electrical Engineering Department, which formed the basis for his book, Radio Frequency Electronics, published in 1996. At the same time he became involved with VLSI chip development via a fortuitous meeting with John Canaris, a student at the University of Idaho who was working on the design of a correlator chip and needed an application. Jon provided the application and worked with Canaris to tailor the chip to the needs of radio astronomy. Thus was born the NAIC Correlator Chip, which was widely used by radio astronomical observatories around the world and is the heart of Arecibo's current spectrometers.

By 1998, with both Lorna and Ron having finished high school and gone off to college, Freddie and Jon decided it was time to return to Arecibo once again. Jon was given the official title of Senior Staff Engineer working with Eddie Castro, then head of the electronics department, but his de facto title was "electronics guru". He turned his attention to any problem that came along. Many of those problems involved the 430 MHz transmitter. Jon spent never ending hours working to upgrade it and improve its performance. However, probably his favorite project was working with Lynn Baker and José Maldonado to design and implement a hydraulic damper "safety brake" system for the Gregorian Dome and Carriage House.

In 2003, Jon took on the newly-created position of Assistant Director for Technical Services in which he played a critical role in setting the direction and priorities for technical projects at the Observatory. In so doing, Jon's legacy at Arecibo will continue for many years.

This long list of accomplishments gives some idea of Jon's many contributions to the success of the Observatory but they miss much of the real impact of his presence in Arecibo and Ithaca. Jon was the person you always went to with a technical problem partly because you knew that he would inevitably have suggestions for a solution but also because Jon's interest and generosity with his ideas always made it a rewarding experience even if a solution was not immediately evident. One great aspect of your continuing to consult for NAIC, Jon, is that we can still come to you for advice even if it is by phone to Brooklyn.

Edgar Castro

Daniel Altschuler

In January 2005, Edgar Castro (Eddie) retired after 39 years of service to the Observatory. Eddie joined the electronics staff in 1966 and spent the years 1975-1977 working in Ithaca. He spent a good fraction of his early years working with our receivers.

His dedication to the Observatory was exemplary, and I am certain the many readers of this newsletter remember being rescued from failure by the presence of Eddie at three in the morning.

In 1994, I had the privilege of appointing him to head the electronics department. One of his first initiatives was to remodel the electronics laboratories, which in 1990 looked like it was 1960. During the Gregorian Upgrade he designed and built the new IF-LO system worked closely with the design, calibration and installation of all our new receivers. The IF electronics associated with the ALFA receiver were also his work.

Edgar also supervised and gave support to the needs of our growing infrastructure working on the expanding telephone and computer network to provide connectivity to these new facilities (Lidar Laboratory, North VSQ, Visitor and Learning Center, etc.) and bringing the existing systems up to date.

Edgar distinguished himself by his efforts to establish working relationships with other institutions. This led in particular to an enhancement of our REU summer student program, which accepted students to work in engineering. Several students from UPR Mayagüez participated. His relationships with persons from the PR telephone company led to the placement of optical fiber to the Observatory.

We shall miss Eddie, both as a colleague and friend, and wish him all the best in his new life.

Lisa Wray

Ganesan Rajagopalan

Lisa came to Arecibo in 2000 from Canada via South Africa! She was a key member of AO Receiver group until she left in March 2005 for NRAO to join the EVLA team.

She was a receiver engineer par excellence. As the group embarked on the mission to complete the full frequency coverage upgrade, she contributed enormously to the successful commissioning of more than 5 new receivers, including the multibeam ALFA in 2004.

With her unlimited energy and enthusiasm, she carried out several other projects, including web page design, preparing beautiful posters for presentation, and organizing the receiver lab. She was also a popular speaker at the annual REU student seminars and once a coordinator of social activities of REU students. Not a weekend passed that summer without the students having a good time in and around this "Isla del encanto".

She was always a "hands on" person and made very good friends among the staff and visitors. Everyone loved to work with Lisa. We all miss her and her favorite song " la la la"! We wish Lisa and James all the very best and never may you need to say "socorro" in Socorro!

Desh returns to India after three memorable years

Chris Salter

Professor Avinash Deshpande has returned to the Raman Research Institute in Bangalore, India, following a most productive three years spent with us at the Arecibo Observatory. Desh arrived in Puerto Rico in September 2002, and proceeded to set new records for "burning the midnight oil". Morning greetings of, "My, you're in early this morning?" were invariably answered with, "I'm afraid that I haven't got home from yesterday yet"!

Desh contributed to just about every aspect of operations at Arecibo. His astronomical interests saw him observing pulsars, spectral lines of many varieties, and indulging in full-Stokes continuum imaging. He also contributed highly original approaches to advancing the "War on RFI." Each summer at Arecibo, Desh supervised undergraduate students in our NSF Research Experience for Undergraduates (REU) program. During the summer of 2003, Desh mentored three such students single-handedly.

Apart from his other many and varied astronomical contributions, Desh spent much of his time with NAIC serving as ALFA (Arecibo L-band Feed Array) Project Scientist, working closely with ALFA Project Manager, Steve Torchinsky. Desh performed many of the ALFA system commissioning calibrations personally, involving many other members of the astronomy department in other calibration tasks. He is also a member of a number of ALFA consortia, having especially contributed to the GALFA continuum and recombination-line sub-consortia.

Desh was joined in Arecibo for the majority of his stay by his wife, Ranjana, and his daughter, Akshaya, who completed her school career at the nearby *Colegio Nuestra Señora del Carmen* in Hatillo. Apart from his scientific and technical achievements, he and his family were valued most highly for their contributions to the social life of many of us. As well as memorable gatherings at "Casa Deshpande" over the years, quite a number of us owe a debt of gratitude to Desh (and to Jeff Hagen and Diego Janches) for keeping us "Happy" for much more than an hour on Friday evenings.

Desh, Ranjana and Akshaya, we thank you for your company and friendship over the past three years. We wish Desh and Ranjana all happiness and fulfillment in Bangalore, not forgetting all the best to Akshaya for her undergraduate studies of geology in Mumbai.

Erik sets sail for the South Seas

Chris Salter

On February 23, 2005, Dr. Erik Muller left NAIC where he had been a post-doctoral research associate for almost 2 years. Erik returned to his native Australia, where in April he took up a prestigious Bolton Fellowship with ATNF at Epping, (and is also in charge of the sheep dip!). At ATNF, Erik is advancing his studies of the neutral hydrogen and molecular gas in the Magellanic Clouds and Bridge.

Erik certainly made his mark at Arecibo. Not only did he play his part in the commissioning of the ALFA multi-beam receiver, contribute immensely to the design of local data formats, and produce a data-reduction pipeline for spectral-line data, but also flew the Jolly Roger over annual celebrations to mark "International Pirate Day". Astronomically, he used the 305-m telescope to study the interstellar medium of perturbed galaxies, and to investigate high velocity clouds.

With the indomitable Aussie characteristics of working hard and playing hard, Erik is much missed by us all at NAIC. It will be an age before the nouns "kite, Paris and Erik", coupled together, will cease to send shivers down our spines! So, "Belay there, Ye Old Seadog", and all the best to you "Darn-under".

Bienvenida Barbara Catinella!

Barbara Catinella joined us in September 2004 as a post-doctoral fellow in radio astronomy after a year at Arecibo as predoctoral fellow. She completed her Ph.D. at Cornell University, working with Martha Haynes, on "Internal Kinematics of Disk Galaxies in the Local Universe." Since Barbara came to Arecibo she has been working on HI emission from low redshift galaxies. She is an active member of the extragalactic ALFA team, being involved in several of their projects. Barbara has also been organizing departmental colloquia and journal clubs. We want to wish her a happy and long stay at the observatory.

Welcome to Robert and Helen Minchin!

Robert Minchin joined the AO in September 2005, as a postdoctoral fellow in radio astronomy. He did an M.S. in Physics at the University of Durham (1997), followed by a Ph.D. at Cardiff University (2001) on the HIDEEP survey using the L-band multibeam receiver at Parkes. He went on to do a post-doc at Cardiff, continuing to work on neutral hydrogen surveys with the Parkes multibeam and with a similar multibeam receiver at Jodrell Bank. With that background, it is probably no surprise that he is here at Arecibo to work on neutral hydrogen surveys with ALFA. He is an active member of the EALFA group. Robert and his wife Helen are well settled in Arecibo. We welcome them here and wish them all the best.

Welcome Steve Gibson!

Steven Gibson joined the AO staff as a new research associate in September 2005. He came from the University of Calgary, where he spent many years working in support of the Canadian Galactic Plane Survey (CGPS), a large-scale project using the Synthesis Telescope at the Dominion Radio Astrophysical Observatory. His recent research involves cold hydrogen gas traced by 21cm-line HI self-absorption (HISA) against warmer background HI emission, including the relationship between HISA features, molecular clouds, and Galactic spiral structure. To complement and extend his CGPS work, Steven has now joined several Galactic ALFA projects to map both continuum and HI line emission over the entire Arecibo sky. Prior to his stint in Calgary, he did his Ph.D. at the University of Wisconsin, using ultraviolet, optical, infrared, and radio observations to constrain the gas distribution and dust properties of the Pleiades reflection nebula. We wish Steve a long, and happy stay at Arecibo

Goodbye Jeff Hagen

Steve Torchinsky & Arun Venkataraman

Jeff Hagen left us in October 2004 to return to Tucson, Arizona where he has joined the staff of the Steward Observatory. Jeff came to Arecibo in 2000 and immediately began working with Bill Sisk to develop the Wideband Arecibo Pulsar Processor. The WAPP quickly became the pulsar workhorse at Arecibo, and over the years has been the most popular and reliable pulsar machine on site. The WAPP started doing double duty towards the end of 2003, working not only on pulsar observing, but also on spectral line observing.

By the time of the arrival of ALFA at Arecibo, the WAPP was upgraded and working as the backend on both pulsar and spectral line projects with ALFA. The quick success of ALFA with very early science results was due in a large part to the enormous effort by Jeff to make the WAPP into a viable backend for ALFA.

In addition to the WAPP, Jeff was also largely responsible for CIMA, the Control Interface Module for Arecibo. This graphical user interface made easy the setting-up, and the manipulation of experiments at Arecibo. With its ease of use, new users can quickly become familiar with CIMA, and run their own experiments. Thanks to Jeff and CIMA, Arecibo has become accessible to a wider community.

Additionally, Jeff worked on interfacing the windspeed meter for Electronics using a standalone singleboard computer running embedded Linux. Jeff may be said to have brought Linux (and Linux thinking) to the Observatory.

We are very sad that Jeff has left Arecibo, but we wish him all the best at the Steward Observatory. Thanks Jeff for all your hard work at Arecibo!

Welcome José Fernández

José Fernández joined the Arecibo Observatory in November 2004 as a post-doctoral fellow in Space and Atmospheric Sciences. He completed his Ph.D. at the University of Nebraska-Lincoln, working with Robert Palmer, on the topic of interferometric studies of Polar Mesospheric Summer Echoes using the EISCAT radar. He joins us with his wife, Cecilia, and their four children, José, Pablo, María, and newborn Sarah. We express our warmest welcome to José and his family.

Welcome Hien Vo

Hien Vo joined the Arecibo Observatory scientific staff as a Research Associate in the Space and Atmospheric Sciences Department in March. He arrives from the University of Wales, where he served as a lecturer. Hien completed his Ph.D. at the University of Calgary, where he used auroral imaging for the study of magnetospheric physics under the tutelage of J. S. Murphee. He stayed on as a post-doc, and later he served in post-doctoral positions at Millstone Hill with John Foster and UC Berkeley with S. Mende. We wish Hien welcome and hope to see him have a long and successful stay at Arecibo.

Adios Diego!

Diego Janches left the observatory in January 2003 following 2½ years as a post-doc and research associate. Our neglect in including Diego's departure in the last newsletter is rectified here, but let it be said that the oversight was not intentional, but rather a not unexpected brain cramp caused by the overwhelming task of writing up the 40th anniversary. Perhaps we still heard his voice echoing in the halls 5 months after his departure. Diego is now a Research Scientist at Colorado Research Associates (CoRA) in Boulder, CO. We wish him all the best.

Felicidades a Wilfredo Rosado

Ganesan Rajagopalan

Wilfredo retired from the Electronics Department in December 2005 after 35 years of service.

He started in 1962 as a mechanic with the contractor during construction, working in all areas including the electrical installations on the platform. He later became a regular staff member in 1969.

During the pre-upgrade period, he passionately maintained telescope control system, answering many "calls" (usually by a guard driving down to his home) at all odd hours. As a skilled machinist, he built beautiful pieces of equipment for all groups at the Observatory. Over the years, he became a much sought-after "master craftsman" of AO!

He won the Employee of the Year award in 2004 for his many contributions and to ALFA in particular, for the construction of 14 channel RF-to-Fiber down converter modules and the famous "snaik" cable wrap.

We wish Wilfredo "Fello" Rosado all the very best and happy times with his grand children and his favorite hobby of tinkering with motorcycles!

Other Arrivals

Edgardo Cruz – Telescope Operator
Paloma Farías Gutiérrez – Programmer (Penn State)
Johannes Wiig – Programmer (Penn State)
Rey Vélez – RFI Technician (returned from retirement)
Elga Neris – Executive Secretary / Administrative Assistant
María Judith Rodríguez – Human Resources Manager
José Cordero – Business Manager
Ryan Seal – Graduate Student, University of Arkansas, Little Rock

Other Departures

Miguel Boggiano – Telescope Operator
Ángel Davíd Rodríguez – Telescope Operator / Programmer
Héctor Jiménez – Guard (after 40 years service!)

NAIC retiree Héctor Cruz leads the staff in calisthenics prior to setting off on the "Turkey Walk' — an activity aimed at improving the health of the staff and takes place just before Thanksgiving. About 50 staff members participated in the one mile walk beginning at the front gate circling the dish, and finishing at the flag poles..

EMPLOYMENT OPPORTUNITIES

The Arecibo Observatory is recruiting the following positions to support the electronics section:

DIGITAL ENGINEER

(one position)

Research Supp Spec I, Posting # 04765

The digital engineer will have the education and experience in hardware and software engineering to design moderately complex systems that acquire analog signals and digitize, process, and store, or pipe-line, data to networked computers. In addition, will design suitable modules to interface user equipment to observatory equipment for optimal functioning. Will identify the appropriate components needed, procure those that are available, and design any systems that are not available. Must be available 24/7 to respond to emergencies.

Requirements: Bachelor of Science in Electronics Engineering. Two to three years experience in high-speed digital design, digital signal processing, motion and control systems. Good report writing and computer skills. Ability to work effectively in a team environment. Ability to work on the suspended antenna platform, 500 feet above ground. Communication skills in English and Spanish required.

DIGITAL ENGINEER, SECTION HEAD

(one position)

Research Supp Spec II, Posting # 04776

Direct the work of the junior engineers and technicians working in the digital group. Collaborate with users and scientists to adapt equipment to fit specific research requirements and develop new techniques and instruments. Design complex systems that acquire analog signals and digitize, process, and store, or pipe-line, data to networked computers. Work with staff to design suitable modules to interface user equipment to observatory equipment for optimal functioning. Develop quality standards for all systems and maintain quality. Must be available 24/7 to respond to emergencies. Requirements: Bachelor of Science in Electronics Engineering. Three to five years experience in high-speed digital design, digital signal processing, motion and control systems. Good report writing and communication skills. Proven leadership skills and ability to work effectively in a team environment. Ability to work on the suspended antenna platform, 500 feet above ground. Communication skills in English and Spanish required.

MICROWAVE RECEIVER ENGINEER

(two positions)

Research Supp Spec II, Posting # 04777

Work with cryogenically-cooled low-noise microwave receivers used in radio astronomy. This position involves more maintenance than design, but requires a strong engineering background to specify, characterize, and calibrate amplifiers, feed horns, and filters used in the 12+ receivers installed on the telescope. This engineer may supervise a junior engineer and up to two technicians.

Requirements: Master of Science in Electronics Engineering, Physics and 3 to 5 years experience in microwave theory and practice, or equivalent combination. Good writing and computer skills. Experience with and cryogenic and/or vacuum equipment. Ability to work on the suspended antenna platform. Communication skills in English and Spanish required.

The successful candidates will be employees of Cornell University and eligible for all applicable Cornell benefits offered to Observatory staff. Relocation assistance is available for these position. Cornell University is an affirmative action/equal employment opportunity employer. You must apply online at *http://www.cornell.edu/jobs* to be considered. (No facsimiles or hard copies, please.) Enter posting numbers listed above to view the positions and current status.

Proposal Deadline

The next deadline for proposal submission will be 1 February 2006 (although proposals may be submitted at any time). Submission for a given deadline implies that the observations are requested to be initially scheduled during the four-month period which starts four months after that deadline. Proposals have a validity of two four-month cycles. If a proposal has not been scheduled after this second period, it will not be considered further unless it is resubmitted.

A complete list of receivers available for this deadline can be seen at *http://www.naic.edu/~astro/RXstatus*.

Use of the Arecibo Observatory is available on an equal, competitive basis to all scientists from throughout the world to pursue research in radio astronomy, radar astronomy and atmospheric sciences. Observing time is granted on the basis of the most promising research. Potential users of the telescope should submit a proposal to the Observatory Director describing their desired observations and the scientific justification for these. The procedures for submitting proposals, the mechanics of evaluation and the life-cycle of these proposals, are outlined at *http://www.naic.edu/~astro/proposals*.

Notes to Observers

1. We would like to remind our readers that when you publish a paper using observations made with the Arecibo Observatory, please provide us with a reprint of your article. Reprints should be sent to: Librarian, Arecibo Observatory, HC3 Box 53995, Arecibo, PR 00612. Or, if you do not order reprints, please send publication information to csegarra@naic.edu.

2. Additionally, any publication that makes use of Arecibo data should include the following acknowledgement: *"The Arecibo Observatory is part of the National Astronomy and Ionosphere Center, which is operated by Cornell University under a cooperative agreement with the National Science Foundation."*

Editors' Note

We wish to thank Willie Portalatín, who provided welcome input for our departure note for Rey Vélez in the last newsletter. Rey's return has certainly not lessened the value of Willie's contribution. Thanks!

HAPPY NEW YEAR TO ALL!

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