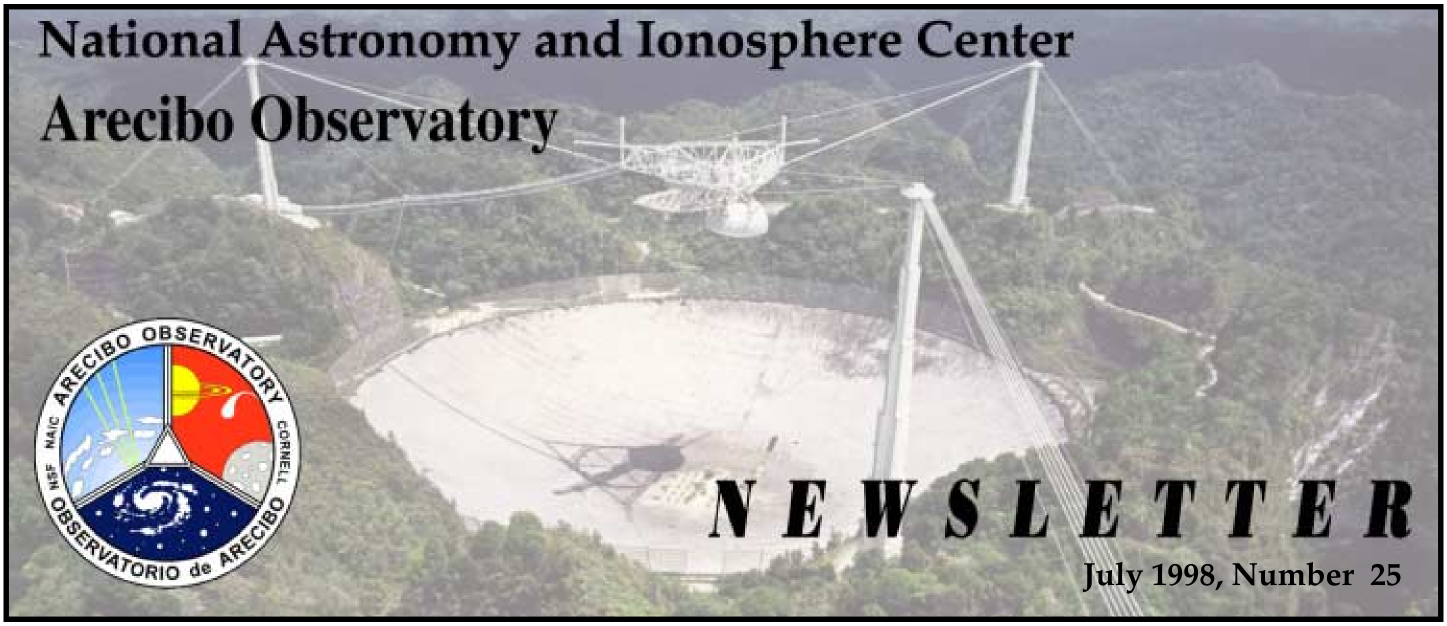


For a long time the front page of this newsletter has been dedicated to the progress of the upgrade. Now you might be expecting us to say that we have left those days behind us, and that the observatory is back to normal operations. Well, not quite. But we are confident enough that we now grace the cover and first pages with scientific results that say, for the first time in recent memory, "we are back in business."
– *The Editors*

Planetary Radar Astronomy

Don Campbell

The new S-band planetary radar system has been under test and development since "first light" of the upgraded 305m telescope in October, 1997. In late October as part of these tests, an attempt was made to detect Titan using the Arecibo antenna to transmit and the 70-m NASA/JPL Goldstone antenna to receive the echo. While unsuccessful, this attempt was a start in getting both the telescope and radar system operational. Unfortunately, Mercury and Venus, natural test targets for the radar system, are not observable with the telescope in winter so it was not until May 9 that a successful detection of a planetary body, Mercury, was obtained. Two weeks later on May 24 we made the first detection of the small near earth asteroid, 4183 Cuno and in June there were successful observations of another near earth asteroid, 1994 AH2 (see Fig. 1). The first ob-

First spatially-resolved post-upgrade S-band radar observation.

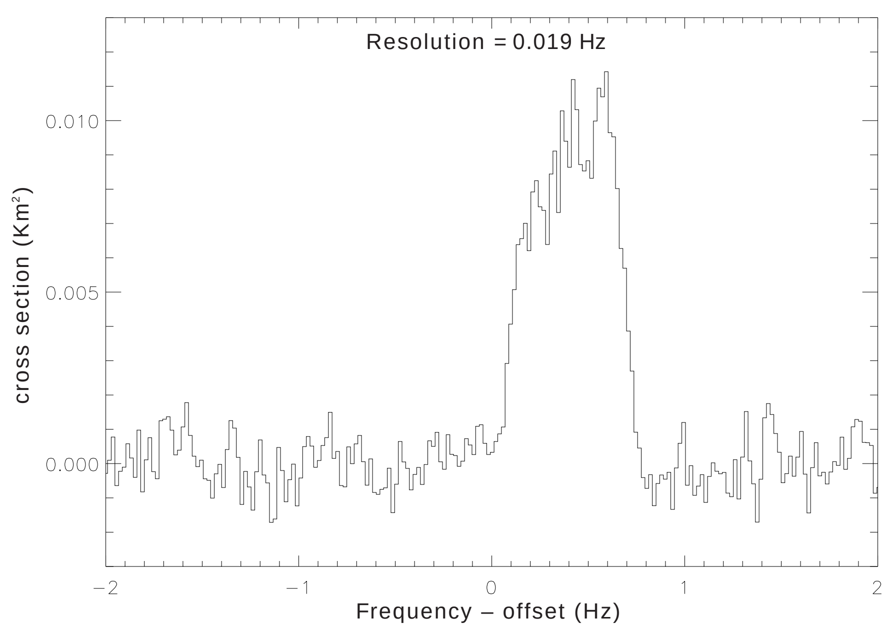


Fig. 1: The target, asteroid 1994 AH2, was believed to be about 2 km in diameter. The spectrum has a narrower-than-expected bandwidth, suggesting either a smaller, very reflective object, or that its pole was nearly pointed at us during this obsevation.

INDEX

The Mission of NAIC

Paul F. Goldsmith and Daniel R. Altschuler

Following the recommendations of the 1997 Arecibo Users and Scientific Advisory Committee (AUSAC) we have prepared the following:

<u>Mission Statement</u>

The National Astronomy and Ionosphere Center enables research in the areas of radio astronomy, solar system radar astronomy, and atmospheric sciences by providing unique capabilities and state-of-the-art instrumentation for data collection and analysis, together with logistical support to users.

NAIC initiates and supports progress in the above research areas by maintaining a scientific staff whose members develop individual research programs, provide assistance to visiting scientists, and extend available scientific opportunities by developing and implementing plans for future enhancements to NAIC facilities and instrumentation.

NAIC strengthens scientific and engineering research potential by supporting activities which provide undergraduate and graduate students with opportunities to further their education. NAIC contributes to the general understanding and appreciation of science by initiating and participating in public education and outreach programs.

Use of the Arecibo Observatory, operated by NAIC, 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, as ascertained by peer review of proposals by external referees.

servations with the new system of a comet, a newly discovered one, C/1998 K5, were made on June 12 and 14 with a weak detection being obtained on the 14th. Over the next few months there will be observations of at least one more near earth asteroid, 1987 OA, observations of Mercury aimed at a more detailed study of the probable ice deposits in the north polar region and observations of Titan, again in a bistatic mode with the 70-m NASA/JPL Goldstone antenna.

As of June, 1998 the new S-band radar system is operational, and about four times more sensitive than the old one, but it has not yet achieved it full design performance. The antenna gain at S-band (12.6 cm wavelength) is currently measured to be 72.0 db (7.3 K/Jy), approximately 1.5 db less than the design value. The gain decreases by the expected 1db out to the maximum zenith angle of 20°. Adjustments of the pitch and roll of the dome will result in improved focusing and, hence, gain. Reduction of the rms errors of the secondary and primary reflectors should then bring the gain to its design value. The system temperature of each of the two polarization channels is close to 30 K, 5 to 10 degrees above what can probably be achieved. This excess temperature is probably due to small contributions from a number of sources, tertiary spillover, radiation from the lifting hole in the center of the primary reflector and higher than expected receiver temperature. The new S-band transmitter is consistently putting out between 900 kW and 1,000 kW of power. However, some remedial work, such as better regulation of the klystron magnet power supplies, would improve operational ease and reliability.

In the area of data acquisition hardware and software much has been achieved with some further work needed. One of the intentions for the new system was that it be highly automated to allow automatic switching back and forth between transmit and receive/data acquisition. This capability is especially important when the round trip light time to the object is less than one minute. Automation of the system has largely been achieved with coordinated control of the transmitter, the dome receiver room rotary floor, the receive horn protective shutter, Doppler shifting of the local oscillator and data acquisition. It works impressively well. CW runs, where a monochromatic wave is transmitted and the Doppler broadened echo from the object received, are now almost routine with the last requirement, frequency switching to improve baseline subtraction, about to be implemented. Ranging observations for delay-Doppler mapping and orbit determination are now possible for time resolutions of one microsecond or longer via direct sampling through the radar interface. Routines to analyze this data still need work. Higher time resolutions needed for the mapping of NEA's will require use of the new radar decoder. The hardware for this device is completed, but final testing and integration into the system still needs to be done.

Radio Astronomy Highlights

Chris Salter

During the first four months of 1998, alignment work on the 305-m telescope led to azimuth motion restrictions which severely limited the number of outside users that could be accommodated. However, at the beginning of June 1998, following a month of intensive commissioning, the telescope returned to scheduled-user operations during the prime night-time hours. The projects that represent the radio-astronomy observing since that date are reviewed here.

HI in Galaxies

A completely new auto/cross-correlation spectrometer has been built for post-upgrade operations. For each polarization, this can process four spectral slices, each of up to 50-MHz bandwidth, with 4096 channels and 3-level sampling. Alternatively, bandwidths decreasing by factors of two down to 195 kHz can be chosen. In addition, it is possible to select either 9-level sampling with bandwidths up to 25 MHz, or full-Stokes parameter observing with 3-level sampling and 25-MHz maximum bandwidth. One innovation is that the observing parameters of each spectral slice can be chosen independently. Despite the advanced features of its design, we note that this spectrometer will serve only as an "interim" backend and will be replaced in a year or so by a "next-generation" correlator.

In early June 1998, Riccardo Giovanelli (Cornell) observed nearby, inclined spiral galaxies for which I-band images already exist. The measured HI velocities are being used via the Tully-Fisher technique to estimate secondary distances, the local density field being reconstructed from the resultant peculiar velocities. He pronounced himself impressed with the post-upgrade L-band system, noting superb telescope pointing, and praising the exact repeatability between ON and OFF source conditions in position-switching schemes resulting in excellent spectral baseline stability. He notes that the correlator performed excellently, the 9-level sampling option allowing high dynamic range of input signal and making it very forgiving of strong in-band radio-frequency interference (RFI). He adds that, while the RFI environment has presumably worsened during the Upgrade hiatus, L-band observations are of overall better quality now than pre-upgrade, thanks to system improvements. Spectral baselines are extremely flat and separate subcorrelator spectra join seamlessly, with most spectra being usable without the need to subtract a polynomial baseline.

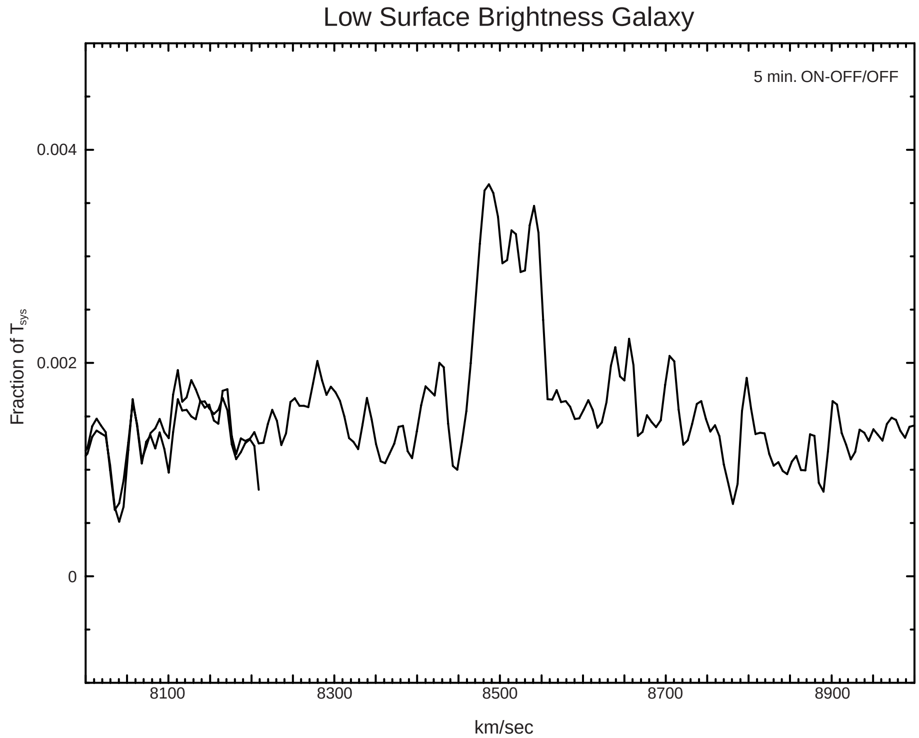


Fig. 2: This figure shows the HI spectrum of a low-surface brightness galaxy (J584-18-16). This is part of a search of extremely faint galaxies taken from the DPOSS. The double trace at the left-hand side of the plot is the region of overlap between two adjacent subcorrelators; no baseline has been removed. (Courtesy of Jim Schombert and JoAnn Eder.)

Low surface brightness (LSB) galaxies are both a significant contributor to the total galaxy mass and critical to understanding the distribution and formation of galaxy types. Over the past several years O'Neil, Bothun & Schombert (Oregon) have made a CCD survey for LSB galaxies lying primarily in the direction of the Pegasus and Cancer galaxy clusters. This is the first extensive multi-filter (Johnson/ Kron-Cousins U, B, V, & I) LSB galaxy survey, and they have found over 120 previously undetected galaxies with colors ranging from very blue through to the first discovery of very red LSB galaxies. Their Arecibo run in late June 1998 was the first attempt at determining the gas content and redshift of these galaxies. In 58.5 hr of observing, 27 galaxies were detected using 5-min ON/ OFF pairs. The detected galaxies have sizes in the range $10 < r_{27} < 47$ arcsec (or scale lengths between 3 and 20 arcsec), inclinations from 20° through 85° (determined photometrically), and central surface brightnesses in the range $22.0 < \mu_{B(0)} < 24.8$ mag·arcsec^{-2}. The individual galaxies were detected between 1372 and 1420 MHz, showing the identified objects to range from nearby dwarf galaxies to large, intrinsically fairly luminous galaxies. Additionally, the colors of the detected galaxies lie within $-0.9 < U{-}B < 1.0^m$, $0.2 < B{-}V < 1.7^m$, showing successful detections for galaxies covering the evolutionary LSB galaxy spectrum, and representing the first-ever radio detection of a red LSB galaxy. While most LSB galaxies are extremely blue and HI-rich, the class of red LSB galaxies might be the descendents of faded starburst systems which have exhausted their HI several Gyr ago. The HI mass of these systems will be critical in resolving their star formation histories. These observers also detected several new dwarf galaxies in the 6,000–10,000 kms^{-1} range, important to large scale structure mapping, as well as detecting a couple of low-redshift Malin objects.

In a related project, Jim Schombert (Oregon), JoAnn Eder (NAIC), George

Djorgovski and Steve Odewahn (Caltech) are determining the redshift and HI content of a test sample of new LSB galaxies identified from fields of the Caltech Digitized Second Palomar Sky Survey (DPOSS). During the few hours of observing assigned to date, 8 candidates were detected (see Fig. 2 for an example). These detections of extremely small (d ~15 arcsec), faint, gas-rich galaxies demonstrates that Arecibo observations will be critical for applying the anticipated large DPOSS LSB catalogs to tests of biased galaxy formation, LSB galaxy evolution and dwarf galaxy formation. The newly discovered objects would be too faint for efficient optical redshift measurement.

Steve Schneider and Jessica Rosenberg (UMass) have scanned approximately 350 objects to derive more accurate declinations and flux densities for galaxies originally picked up in an Arecibo upgrade HI drift-scan survey. Whilst the telescope tracked the discovery right ascension of a galaxy, it also scanned through ±7.5 arcmin in declination in 3 min, with the correlator dumping independent spectra every 10 sec (see Fig. 3). This represents the first post-upgrade on-the-fly data acquisition, the measurements confirming over 65% of the observed sources.

Schneider, Rosenberg, John Huchra (CfA) and Eder have begun a survey of K-band identified galaxies from the near infrared 2MASS project and aim at testing the characteristics of galaxies in the near infra-red relative to their 21-cm HI emission. The interesting comparison here is that starlight suffers little extinction at K, and it is much less influenced by star-formation than optical bands. They used standard on-off observations to study galaxies with a range of colors, luminosities, and extragalactic environments.

Pulsars

During the upgrade years, observations for the upgrade drift-scan pulsar searches were taken whenever telescope motion was either not possible or restricted. However, completion of the track and trolley alignment work in early May 1998, and the subsequent return to fully pointed operations, means that the upgrade searches are no longer considered active. It is estimated that by this point the surveys cover some 70% of the Arecibo sky. However, the surveys will continue to have an impact on astronomy operations at the Observatory, with many good candidates awaiting confirmation in the months ahead. Significantly, we estimate that a total of 100 pulsars have been discovered through Arecibo drift-scan surveys since 1990 when Wolszczan (Penn State) used this technique to discover the two millisecond pulsars, PSR B1257+12 (that accompanied by its own planetary system), and PSR B1534+12 (potentially the best laboratory yet for research in relativistic physics).

Early in June 1998, Duncan Lorimer (MPIfR, Bonn) and Kiriaki Xilouris (NAIC) began a deep pulsar search in supernova remnants (SNRs). They acquired data at 20 positions, with an average integration time of 23 min on each. While most observations were made at 430 MHz using the Carriage House, they employed L-band from the Gregorian dome for two of the SNRs. Data reduction is underway at the Cornell Theory Center. Pulsars associated with SNRs are of great interest, and these observers are attempting to constrain the birth properties of neutron stars. In addition, they expect to address the question of what fraction of supernovae produce a neutron star.

A consortium of observers from Berkeley, Caltech, Jodrell Bank, MIT, NRL, Penn State, and Princeton continue their regular post-upgrade timing observation of standard millisecond pulsars. To date, 7 sessions have been observed, mainly at L-band, with some half a dozen targets being presently involved. Up to five independent pulsar backends can now collect simultaneous data by tapping off of the same I.F., a feature used by the

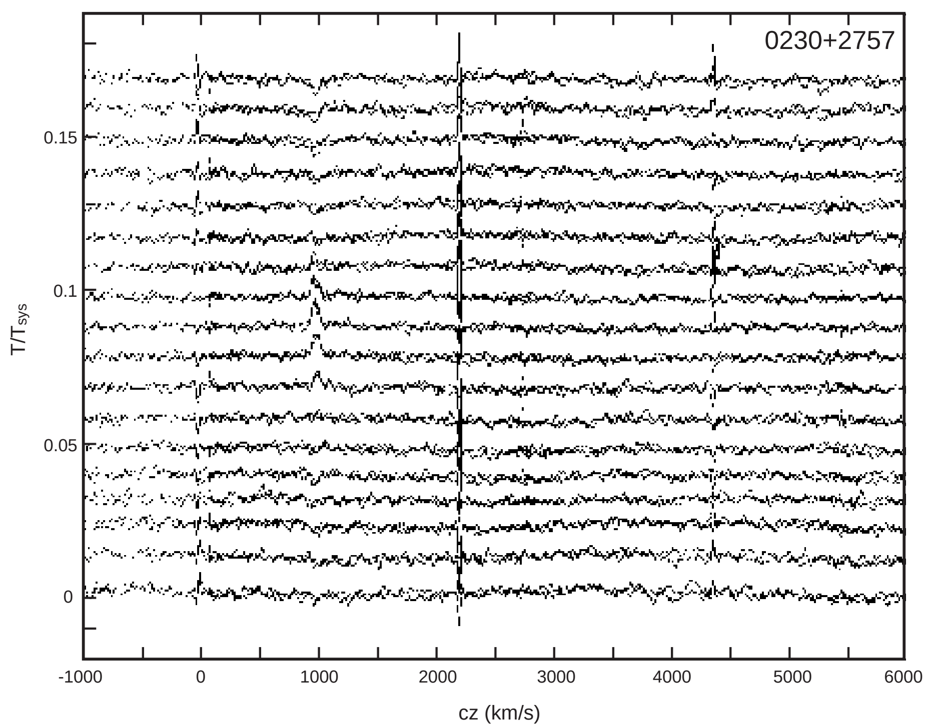


Fig. 3: The figure shows the eighteen 10-sec records for a galaxy detected in the UMass upgrade HI drift-scan survey. The present observing system has proved very stable and no baselines were removed from the spectra. The two polarizations are plotted on top of each other. This particular galaxy is located at 1013 kms^{-1} in the plot, and is one of this team's sources with no clear optical counterpart visible on the Palomar Sky Survey. The other prominent features in the plot are 1410 and 1400 MHz interference at 2200 and 4400 kms^{-1} and galactic HI at 0 kms^{-1}. (Courtesy Steve Schneider and Jessica Rosenberg.)

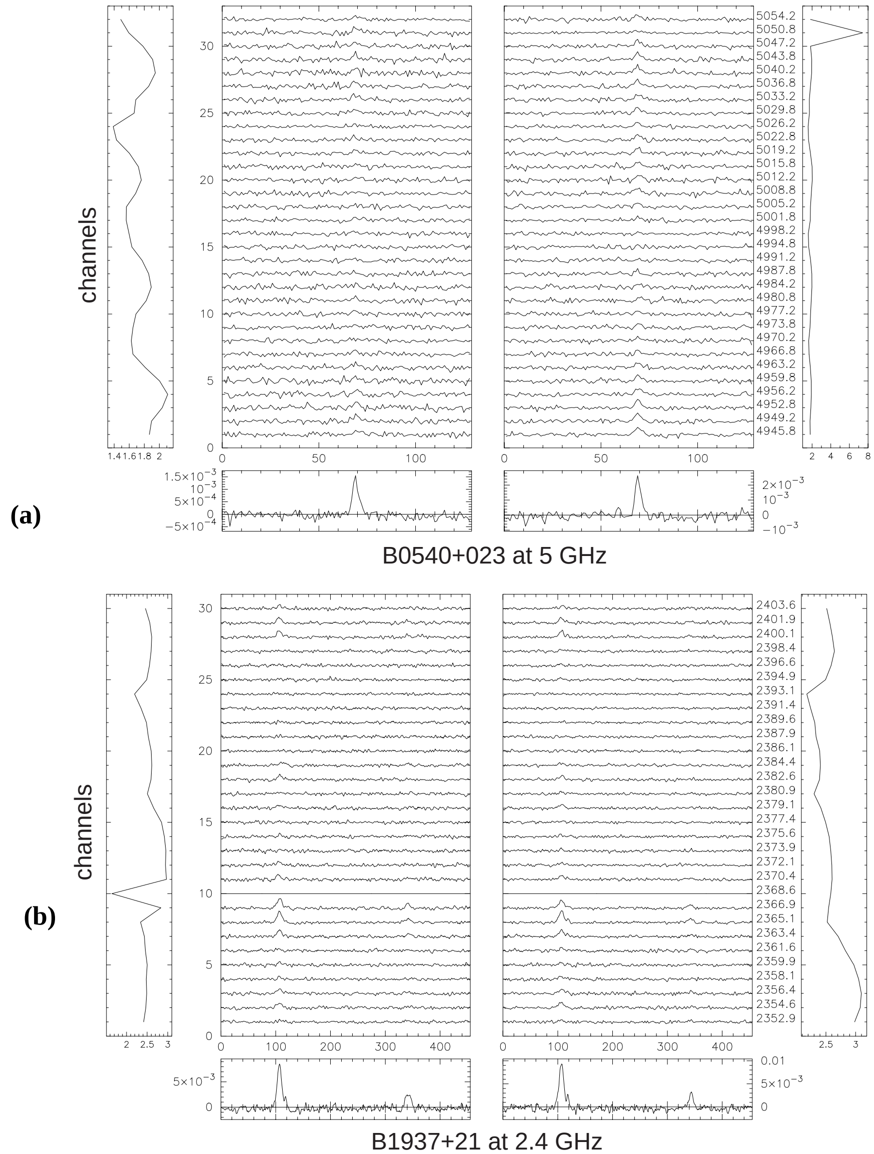


Fig. 4: These plots show the pulse profile of a) B0540+23 at 5 GHz and, b) B1937+21 at 2.38 GHz. The data were acquired through the Arecibo Berkeley Pulsar Processor (ABPP) on 21st June 1998. (Courtesy of Don Backer.)

consortium to observe with four or five backends simultaneously. Initial results indicate that timing residuals achieved by the various backends are unprecedentedly small, the many innovations in data-taking hardware providing significant improvements over the pre-upgrade system.

On June 18 and 21, 1998, Don Backer (Berkeley) and collaborators observed the strong millisecond pulsars, J1713+0747 and B1937+21, simultaneously at Effelsberg and Arecibo, with B1937+21 being observed at Arecibo on all nights from June 18 to 21. The coordinated L-band observations were made through identical backends, and will be used to constrain the timing uncertainties due to propagation through the interstellar medium (ISM). The 1.4-GHz timing residuals for B1937+21 are excellent. There may be a 100–200-ns systematic hour angle effect and, if so, random-noise limited timing at 50 ns per 2-min integration is obtained. However, there are a few aberrant points at the 500-ns level which are not understood. The sensitivity to gain changes is negligible. The sensitivity to RF changes is very significant and not constant; this needs further investigation.

Xilouris, Shauna Sallmen (Berkeley), Backer, and Andrea Somer (Berkeley) have begun 430-MHz polarimetry of a large sample of millisecond pulsars. They have extensive calibration for gain and relative RCP/LCP phase and anticipate a quality result. This extends the work done already by Xilouris and Sallmen to lower frequencies and will be important in interpretation of the structure of millisecond pulsar magnetospheres.

Joel Weisberg (Carleton), Xilouris and collaborators have initiated L-band measurements of the HI absorption spectra of distant pulsars. To make these observations they used the new Caltech CBR backend. They will use their spectra together with a galactic rotation model to kinematically determine the pulsar distances, which will themselves be combined with the dispersion measures of the targets to derive the mean electron density along the line of sight. These latter values will be used to calibrate models of the galactic electron-density distribution.

In June 1998, Backer, Somer and Xilouris explored the performance of the telescope for high-frequency pulsar measurements. Their observations resulted in pulse profiles for the 1.5-ms pulsar, B1937+21, at 2.4 GHz, and for PSR B0540+23 at 5 GHz. Both profiles display excellent signal-to-noise ratios (Fig. 4 a-b).

VLBI

Arecibo has continued its support of the 8-m orbiting antenna, HALCA, of the Japanese VSOP (VLBI Space Observatory Programme) Project. An L-band run on the quasar J1602+334 took place on June 26, 1998, and fringes were detected over the entire tracking pass to Arecibo. The first Arecibo C-band observations with HALCA were made on the quasars, J2212+239 and J2139+143, on May 27 and 28, 1998. The NRAO 140-ft telescope at Green Bank also joined in. The data from the first of these runs has recently been correlated, and strong fringes were found on both recorded channels for all baselines. Although Arecibo C-band sensitivity is presently somewhat below its design target, the signal-to-noise ratios obtained were 1000:1 between Arecibo and the 140-ft, 100:1 between Arecibo and HALCA, and 20:1 between HALCA and the 140-ft. Correlation for J2139+143 is awaited. Two further C-band runs on J1824+107 and J1329+319 were made on July 7 and 8, 1998. The tapes have been sent for correlation. The first three of these C-band targets form part of the VSOP Survey of the 5-GHz continuum emission from all flat-spectrum extragalactic sources at b >10° with 5-GHz flux densities greater than 1 Jy.

Success in Space VLBI is not, however, the end of the good news in respect of VLBI and Arecibo. Early in 1997, NAIC submitted a consortium proposal (with NRAO as partner) to the NSF Major Research Instrumentation (MRI) program for the purchase of a VLBA-compatible system for Arecibo. Late in 1997, we received official confirmation that the proposal had been successful. The MRI program requires that cost sharing at the level of 30% be made by the proposing institution, meaning that of the total project costs of $502,000, about $150,000 will be provided by Cornell University. The equipment was ordered early in 1998 and, when in place in early 1999, will enable the 305-m telescope to join in a wide range of VLBI observations in conjunction with NRAO's Very Long Baseline Array (VLBA), the global VLBI network, future Space VLBI antennas, and ad-hoc arrays of the world's largest frequency-agile telescopes. In addition, Alan Rogers from Haystack Observatory has kindly supplied Arecibo with a phase calibration unit which will be used in all future VLBI runs.

Atmospheric Sciences

Jonathan Friedman

World Day campaigns dominated atmospheric sciences activity during the past three months. There were two notable successes during this period. The first was coordination of the display of observations over the world wide web with the other National Science Foundation's Incoherent Scatter Radar facilities. The second was the implementation, for the first time since the start of the upgrade, of beam swinging with the ISR.

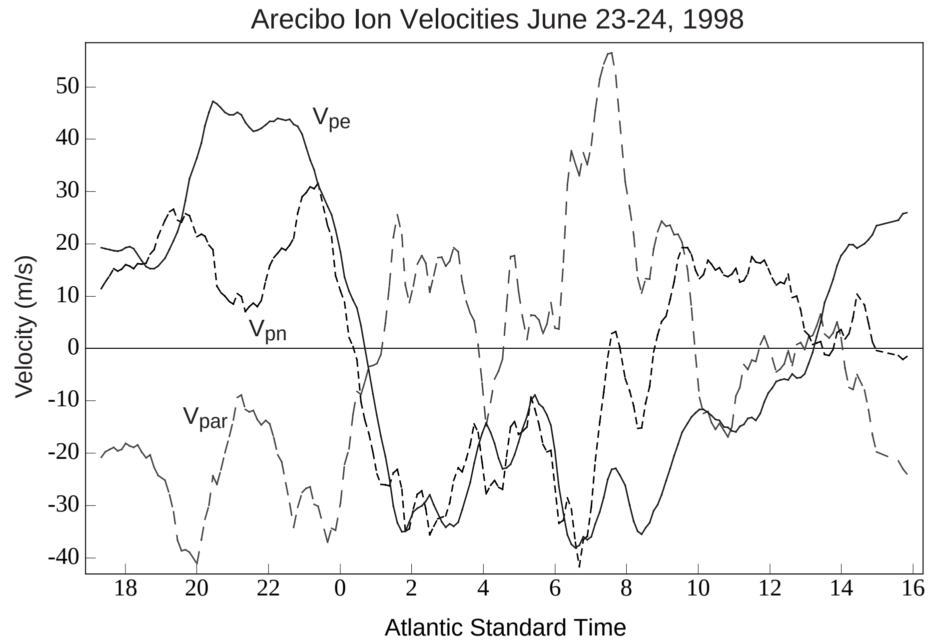


Fig. 5: Ion velocities from 23-24 June, 1998. The three components shown are the velocity parallel to the magnetic field (V_{par}), and the perpendicular north (V_{pn}) and east (V_{pe}) velocities. The velocities are in general agreement with typical summer values.

The first World Day campaign of this period was April 27–29. It was a UARC (Upper Atmosphere Research Collaboratory) campaign in which Sixto González participated in a demonstration at the NSF in Washington. This was the first time that data from all of the NSF's ISRs were available on the web simultaneously.

During May 26–27 we had a successful one day topside experiment. On June 23–24 an important milestone in the commissioning of the upgraded telescope was reached as we carried out the first beam-swinging experiment since the upgrade began. We did one 24 hour run swinging the azimuth at half slew-rate (0.2 deg/s). The vector velocities obtained from this run are shown in Figure 5. The three components shown are the velocity parallel to the magnetic field (V_{par}), and the perpendicular north (V_{pn}) and east (V_{pe}) velocities. Although this period was moderately disturbed, the velocities are in general agreement with typical summer values, in particular the velocity parallel to the magnetic field (V_{par}) shows the usual post sunset collapse and large morning upward flow that are two standard features of the summer ionosphere over Arecibo. In addition, Mike Kelley from Cornell University had two 5 hour observations during the next two nights (see below) at full azimuth scan rate 0.4 deg/s or about 15 minutes per scan). The second of these nights was quite disturbed (K_p=6+) and the measurements show spectacular storm effects on the ionosphere: increased temperatures around midnight and large irregularities in the density profiles. After these succesful experiments we can safely say that we are "back in business".

Optical observations were made during all of the World Day observations. In April, nine nights of observations from the 21st through May 2 were carried out. Photometers recorded 78 hours of 630.0 nm and 557.7 nm emissions along with 65 hours of Fabry-Perot wind and temperature measurements from the same emissions. The spectrometer operated

80 hours in the red part of the spectrum recording OH and O_2 emissions for mesospheric temperatures. Nine nights of data were also taken during the period from May 19-21, although bad weather and power outages caused some minor problems. Finally, the airglow facility operated for ten nights during the June World Day period. Each instrument logged 80 hours. All of these data are awaiting analysis. During these periods the resonance lidar systems were idle, awaiting repairs of critical parts.

As mentioned above, the June World Day was extended to include 10 additional hours of observing, this in support of two field operations. One involved coherent scatter observations made by the University of Illinois (Erhan Kudeki and Julio Urbina) and by Cornell University (Wes Swartz) which were dedicated to sporadic E plasma instability studies. The other was a tomography campaign using the chain of stations on Puerto Rico (Gary Bust, Robert McCoy, Paul Bernhardt, and Daniel Meléndez) and an all-sky imager/GPS station set up by Cornell students (Francisco Garcia, Lymari Castro, and John Makela). Castro is a former REU summer student at the Observatory. She enrolled in the graduate program at Cornell this summer.

The first publication to come out of the Coqui Dos rocket campaign was just submitted to Geophysical Research Letters by University of New Hampshire graduate student Lynette Gelinas. It is entitled “First observation of meteoritic charged dust in the tropical mesosphere” and co-authored by Kristina Lynch of UNH, Mike Kelley, Steve Collins, and Steve Baker of Cornell University, and Qihou Zhou and Jonathan Friedman from the Arecibo Observatory. The study provides the first observations of the earth’s mesopause dust layer using instruments on Mike Kelley's Sudden Atom Layer rocket. This paper compared the dust observation with simultaneously observed sporadic E and enhanced sodium layers. These data were recorded with Arecibo's incoherent scatter radar and sodium resonance lidar. Steve Collins is compiling a CD with all the sodium lidar and ISR data taken in the campaign. This will form a large part of his thesis after he returns to Cornell in the fall.

At the annual CEDAR meeting in Boulder, CO, June 7-12, Arecibo atmospheric science staff members played important roles in three workshops. Jonathan Friedman worked with Richard Collins (University of Alaska, Fairbanks) and C. Y. (Joe) She (Colorado State University) to put together the two-part lidar workshop on Monday afternoon. This workshop was modelled on the 1997 CEDAR ISR facilities workshop. The first two hours was a plenary tutorial in which Jonathan gave the opening talk on the application of lidars to middle and upper atmospheric research. The second two hour session consisted of reports from the various facilities. Steve Collins reported on progress in lidar work at Arecibo.

In another of the CEDAR workshops, Sixto González collaborated with Phil Erickson (Millstone Hill) and Bob Kerr (Scientific Solutions) to convene a topside workshop. The highlights (besides the premium time slot at 3:30 on Friday afternoon) were Mike Sulzer’s talk on the effect of electron collisions on the ISR spectrum and Bryan Macpherson’s brief presentation on observations during the February 1998 solar eclipse. In addition, there was discussion on having a topside workshop that may be hosted at Arecibo.

At the Upper Atmospheric Facilities workshop on Thursday, Craig Tepley gave an overview of atmospheric work during the last year at Arecibo. This talk was highlighted by results from the Coqui Dos sounding rocket campaign and progress on the upgrade. Of particular interest was the upcoming World Day which, as we now know, was able to incorporate beam swinging for the first time since the upgrade began.

Finally, in another CEDAR presentation Steve Collins combined with Brent Grime, a former Arecibo REU summer student and now graduate student at Penn State, on a poster giving results of lidar observations of atomic layer enhancements observed during the Coqui Dos campaign. The study of these ALEs will form important parts of Steve’s dissertation and Brent's Masters’ thesis.

Ionospheric Interactions News

Brett Isham

Collaboration with EISCAT

Brett Isham was principal scientific coordinator in a heating experiment carried out between June 5 and 15 at the EISCAT facility located near Tromso in northern Norway. The principal objectives of the experiment were the study of the microphysics of Langmuir turbulence during the first 100 ms after the turn on of the HF electromagnetic pump wave and the physics of irregularities produced during the heating process. EISCAT is a unique location for Langmuir turbulence experiments due to the high HF effective radiated power (up to 1.2 MW ERP), two incoherent scatter wave vectors (at 224 and 931 MHz), and the near-field-aligned geometry (between 0 and 13 degrees from parallel to the geomagnetic field), all of which complement very well similar experiments performed at Arecibo. Simultaneous radio beacon scintillation and stimulated electromagnetic emission observations were also performed and provided valuable diagnostics on the background spectrum of plasma irregularities. During half of the heating observations the HF duty cycle was increased and the irregularities became the primary topic of study, with the EISCAT radars providing valuable incoherent scatter support not yet available at other high latitude heating facilities.

This was the second EISCAT heating experiment to be coordinated with support from Brett’s NSF/ONR Ionospheric Interactions Initiative grant. Time on the EISCAT radars was contributed by Tor Hagfors of the Max-Planck-Institute in Lindau, Germany, César La Hoz of the University of Tromso in Norway, and Wlodek Kofman of CEPHAG at Domaine University in Grenoble, France. The Max-Planck-Institute also contributed financial support, which helped to enable participation by Frank Djuth and John Elder of Geospace Research, Inc., whose work was supported by the Air Force Research Lab. Frank and John brought and operated their raw data-taking system, which allowed two raw data channels on each EISCAT radar. The Air Force Research Lab also actively participated by performing radio beacon scintillation and stimulated electromagnetic emission observations at a remote field site -- Keith Groves, Bob Livingston, and Jake Quinn were responsible for those measurements. HF radar support during the first part of the campaign was provided by the British CUTLASS SuperDARN radars in Iceland and Finland, operated by Terry Robinson and Darren Wright of Leicester University in the UK. The timing of the experiment was fortunate in that Pekka Hiitola of the Geophysical Institute in Sodankyla, Finland, offered to test a new raw data taking system at the EISCAT 931 MHz remote receiving antenna in Finland, where the angle to the geomagnetic field is about 30 degrees, much closer to the 45° angle at Arecibo and potentially very interesting for an EISCAT/Arecibo comparison. Mike Rietveld, jointly of EISCAT and the Max-Planck-Institute, was invaluable in coordinating many of the details and through his operation of the heating facility and assistance in operating the radars.

As noted above, the primary experimental objectives were Langmuir turbulence and irregularities. However, conditions in the auroral ionosphere vary markedly from day to day, and not all days were suited to the principal objectives. As a result, sufficient time was available for several backup experiments, including natural plasma line observations, support of satellite overpasses in the hope of measuring auroral precipitation events, and meteor observations.

Specific results are not yet available as the raw data has not been processed, but it is clear that, during the low duty cycle (100 ms on every 30 seconds) Langmuir turbulence experiment, the 224 MHz (VHF) radar saw strong enhancements looking 13 degrees away from field-aligned, whereas the 931 MHz (UHF) radar saw only occasional very weak enhancements at 13 degrees and saw much stronger and consistent enhancments at the field-aligned position, in agreement with past results. It is a mystery as to why the UHF behaves in this fashion, and we expect the new data to be of significant help in finding the explanation.

1999 Arecibo Heating Campaigns

Mike Sulzer

In calendar year 1999 Arecibo intends to conduct two ionospheric interactions campaigns. The first of these will take place in the January/February time frame and the second in the mid to late summer period. A decision has been made to appoint a campaign scientist who will help coordinate the efforts by working with Mike Sulzer and John Harmon of the Arecibo Observatory and with the user community. For the winter campaign Dr. Herbert Carlson will be the campaign scientist and for the summer campaign Dr. Keith Groves will take on these duties.

In the Active Experiments Newsletter it was announced that new proposals must be tendered for review to the Observatory by August 1, 1998. We are extending this deadline to August 15. Emphasis will be placed on those experiments which can benefit most from winter ionospheric conditions and airglow observations. There is a possibility that the scientists involved will be asked to relinquish time to a CEDAR/Wide Latitude Studies substorm campaign, should such an event occur during the heating campaign. As part of the campaign planning we will incorporate contingency plans for replacing hours lost due to magnetic activity.

New proposals for the Summer 1999 Campaign can be submitted at the same time but must be submitted by October 1, 1998. Emphasis will be placed on experiments which can benefit from simultaneous coherent scatter radar observations from Guadeloupe and/or summertime ionospheric weather conditions.

Photo by Tony Acevedo

The Project Pheonix Mobile Research Facility was recently located outside the transmitter room.

Project Phoenix comes to Arecibo

Chris Salter

Under a long-term commitment, Project Phoenix of the SETI Institute will recommence observing at Arecibo from September 1998. In late 1992, as NASA's High Resolution Microwave Survey, they used 200 hours on the telescope, observing portions of the band between 1 and 3 GHz on a number of Sun-like stars. No Extra Terrestrial Intelligence (ETI) signals were detected. In each of the next five years they will observe biannually for 12 hr per day and 20 days per session. With this observing time they will search for ETI signals from a large number of nearby solar-type stars.

Project Phoenix's future observing technique will be very different to the pure single-dish approach employed pre-upgrade. Apart from doubling the bandwidth, they will now supplement the Targeted Search System (TSS) at Arecibo with two Follow-Up Detection Devices (FUDDs) operating pseudo-interferometrically at Arecibo and Jodrell Bank. For a narrow-band signal, the differential Doppler shift and drift between these two sites pointing at the same celestial position can be used as a filter to reject terrestrial or near-Earth RFI. A recent 16-week long campaign between the Parkes and Mopra antennas proved the system, though no potential ETI signals were detected. Observations are also being made using the NRAO 140-ft antenna and the Woodbury, GA, 30-m dish. Using Arecibo with 300-sec integrations, this team can gain a factor of 20 in sensitivity over Parkes and Green Bank.

Because of limitations at Jodrell Bank at S-band, they will begin measurements at L-band. However, S-band observations are also required for detection of the beacon on the Pioneer 6 spacecraft, used to check and calibrate the performance of the FUDDs. Up to the year 2000, Project Phoenix will operate in the band 1.2 to 1.75 GHz, and the search will then be continued in the 1.75 to 3 GHz range.

The SETI search activity uses a Mobile Research Facility (MRF), a 30-ft by 8-ft portable electronics shelter. The MRF arrived at Arecibo recently, and is now installed adjacent to the telescope control room. It houses the necessary back-end processing electronic equipment to support the project. In addition, the project's own RF/IF up/down converter is now installed in the observing turret of the Gregorian Dome. Recently, SETI Institute staff have been on-site at Arecibo preparing for the re-launch of their observations which will occur in two month's time.

Gregorian Pointing

Mike Davis

The last shim bolt was tightened down on the azimuth rails in late April. Vertical alignment was improved from 3.6 to 1.4 mm rms, the radial alignment is now within 1.8 mm rms, and the average radius is within 0.6 mm of its design value.

These improvements set the stage for new pointing measurements, which were carried out in May. All measurements were done at night, using the 2 arcminute S-Band (2380 MHz) beam. Over 1,000 "turret scans" were made of 23 unresolved sources with very well known positions, spaced approximately every two degrees in declination. A turret scan allows the massive feed arm to track smoothly while the feed turret executes a sinusoidal motion with a period of 15 seconds and amplitude of about 6 arcminutes, see Fig. 6. The turret moves the feed and receiver back and forth across the focal point to shift the beam on the sky in the azimuth direction. At the same time the Gregorian Dome scans 10 arcminutes in zenith angle. Each scan lasts two minutes, and provides an independent measurement of the azimuth and zenith angle pointing errors, source strength, beam width in both coordinates, and relative system temperature.

Phil Perillat wrote the data acquisition, processing and model fitting software. Mike Nolan contributed to the

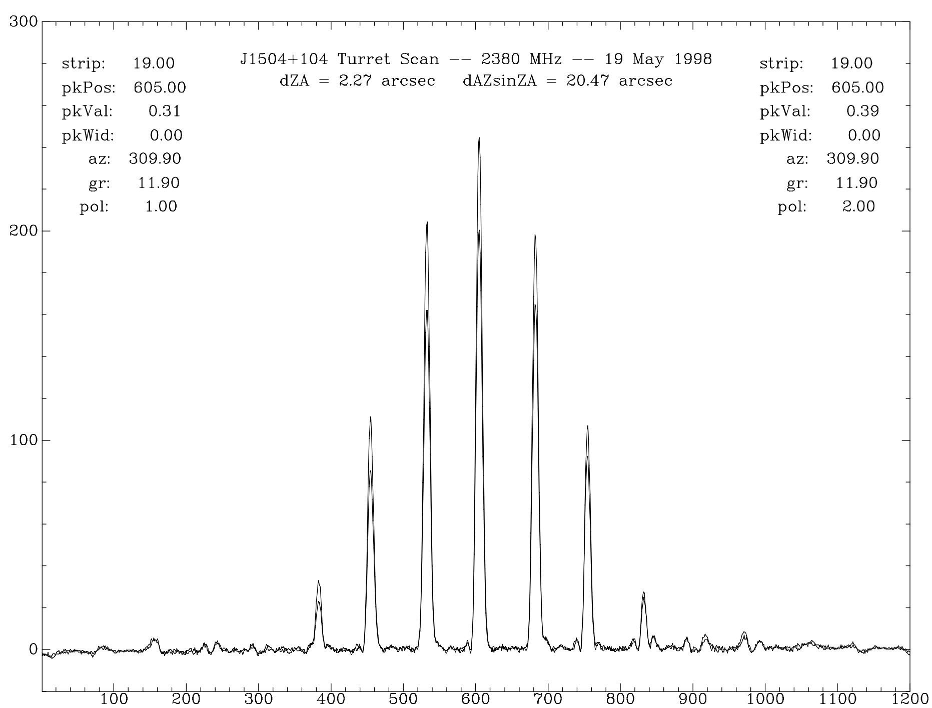


Fig. 6: Turret Scan used to determine pointing corrections for the Arecibo telescope. While the massive feed arm tracks the nominal source azimuth and the Gregorian dome scans slowly through 10 arcminutes in zenith angle, the antenna beam cuts through the source azimuth 16 times using 12 arcminute peak-to-peak sinusoidal motion of the feed turret. Abscissa: Time, in tenths of seconds. Ordinate: Intensity (arbitrary units). Both polarizations are plotted.

development of the pointing model, which uses 13 free parameters in each coordinate. In addition, an ‘encoder function’ tabulated every half degree provides an empirical fit to irregularities in the elevation rail rack girder. The model’s zero points are adjusted for each feed, to allow for small differences in mounting location, using turret scans made for that purpose.

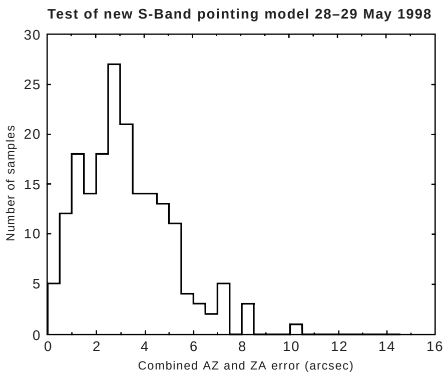


Fig. 7: Distribution of measured pointing residuals, following installation of the new pointing model. The standard deviation is 3.7 arcseconds, with a 95th percentile value of 7.7 arcseconds.

Figure 7 shows the results of test measurements following installation of the new pointing model. All of the effort which went into precise alignment of the rails has paid off. These residuals have an rms error of 3.7 arcseconds overall, 2.2 in zenith angle and 3.4 in azimuth. This is significantly better than the specification of 5 arcseconds rms in each coordinate, and somewhat better than the residuals from the model fit of 2.4 and 3.8 arcsec rms in zenith angle and azimuth, for a total of 4.5 arcsec.

A few cautions: these results obviously apply only at night, and may degrade with time. They do not yet take advantage of the improved platform stability which will be provided by the tiedowns when we activate their computer control. Nevertheless, the present results are significantly better than expected, and are a tribute to the careful alignment work being carried out by Jose Maldonado and his staff in the Maintenance department.

Proposal Status

Daniel R. Altschuler and John K. Harmon

With a total current time request since Feb 1, 1997 of over 10,000 hours distributed over 170 proposals we are currently heavily oversubscribed. Only a small fraction of all proposals will receive telescope time during 1998, considering also that a significant fraction of time is being used for commissioning activities and adjustments to the telescope to improve performance.

We have extended the validity of current proposals as explained in the previous newsletter so that proposals submitted for the 1997 deadlines **(numbered from 1000 to 1114)** are valid for scheduling until Dec. 15, 1998. If not scheduled by then they will no longer be considered. You will need to resubmit proposals to keep them active.

All proposals submitted for 1998 deadlines will be treated according to our standard procedures. If a proposal does not get scheduled in the first four-month period because of lack of available telescope time, it will remain in the active-proposal category for the next period (unless the proposer withdraws the proposal). It will compete with all new proposals received by the next deadline. If a proposal fails to be scheduled after the second try, it will not be considered further. Proposers might then wish to submit a revised version for a new deadline.

We will soon have the schedules posted on the web so that you may be better informed.

Policy for Large Proposals

Daniel R. Altschuler

Our policy for Large Proposals follows the recommendations of the report of the NRAO large proposals committee. Your comments are welcome at this time.

The narrative of a large proposal can be up to 12 pages long. All proposals that ask for more observing time than 300–400 hours and, at the Director's discretion, some proposals requesting less time than this, will initially be evaluated by an expanded “skeptical review” panel of five or more referees. The panel will be drawn from the normal pool of proposal referees for the telescope, augmented if necessary by others who have recently been proposal referees. The panel will be roughly balanced between “experts” in the sub-discipline addressed by the large proposal, and cross-disciplinary “skeptics”.

The panel will assess:

- the scientific priority for the proposal in competition with all other science that is being done at the telescope,
- whether the telescope is well suited to the proposal,
- whether the total duration proposed for the project is well-defined and commensurate with the scientific priority,
- whether there should be any proprietary “holding time” for the data, and, if so, for how long,
- whether the proposal is suitable for use as a backup project in a dynamic scheduling strategy for the telescope.

The panel will provide the Director with a recommended course of action and a summary of its deliberations.

Volunteering for Skeptical Review

Proposers of “moderate-sized” (below-threshold) projects may also volunteer for expanded “skeptical review” of their proposals. This option provides a way to obtain a stronger guarantee of observing time for moderate-sized projects whose science could clearly be advanced by receiving such guarantees, in return for submitting them to a more demanding initial review. We emphasize that we see this as an option to be used rarely, and only in exceptional cases where the science would suffer if the project was done piecemeal through the regular proposal process.

Ongoing "Expert Review"

The skeptical review panel for a large proposal should also advise the Director whether any further "expert" review of the proposal is needed in any of the following four areas:

- scientific issues of observing strategy,
- technical issues of observing strategy and data acquisition,
- ongoing review of project progress, and
- public availability of the data products.

Not all large proposals will require further review in all of these areas, and many may not require further review at all. If a highly-rated large proposal is of sufficient scope or technical complexity to warrant ongoing review, the NAIC will make every effort to achieve this without over-burdening either the proposers or the expert referees. The arrangements for any ongoing "expert review" would be made at the discretion of the Director on a case-by-case basis.

If several large proposals are highly rated by the skeptical review panels, the Director will seek advice from a cross-disciplinary subset of the regular proposal referees about upper limits to the fraction of all observing time that should be devoted to them.

First Teacher Workshop takes place at Arecibo

Daniel R. Altschuler

One of the stated objectives of the Angel Ramos Foundation Visitor and Educational Facility was to "help to improve science teaching in the public and private schools of Puerto Rico." Toward this end a proposal was successfully written to the Puerto Rico Department of Education to provide funds for teacher workshops. This summer two one-week long workshops led by José Alonso were held for a total of fifty teachers from the north-central area of Puerto Rico. The workshops provided hands-on activities in the areas of weather, the moon, our solar system and the constellations. It also included a tour of the observatory, a "star party", and a talk by one of our scientists.

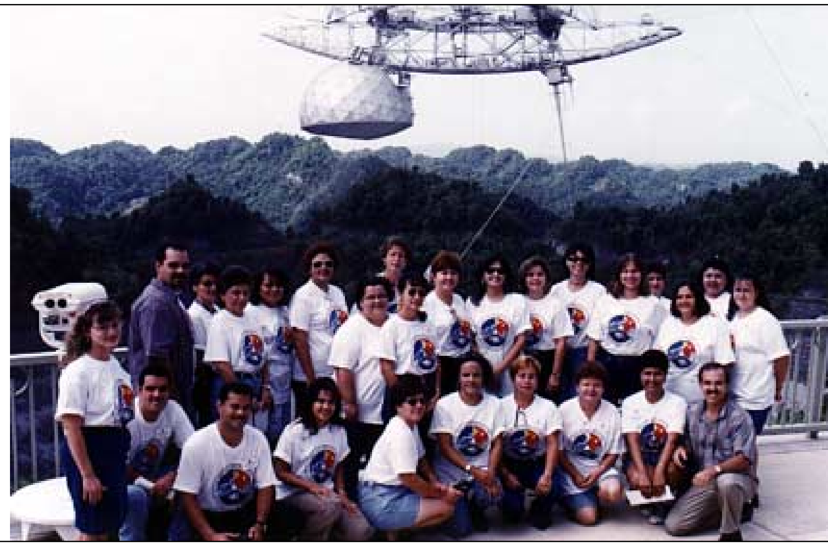


Photo by José Alonso

Participants in the 1998 AOVEF Teachers' Workshop.

We hope to extend this program to teachers from all of Puerto Rico once we have a larger VSQ.

Summer Student Program for 1998

JoAnn Eder

The Observatory is hosting ten students from universities in Puerto Rico and the mainland for ten weeks of research and study. This summer, the Arecibo Summer Student Program also includes a teacher from a local middle school who is working on developing classroom materials in Spanish at the Visitor Center. She and the other summer students are busily preparing for their own observing time with the new Gregorian system. The students have designed four very interesting research programs which include observations of radio continuum sources, spiral galaxies, OH/IR stars (evolved stars with circumstellar shells) and regions of star formation. In addition, the students are working on research projects in radar and radio astronomy and atmospheric physics with their advisers.

Photo by Tony Acevedo

The 1998 Arecibo Observatory Summer Students.

Construction on the Control Room extension. Photo by Tony Acevedo

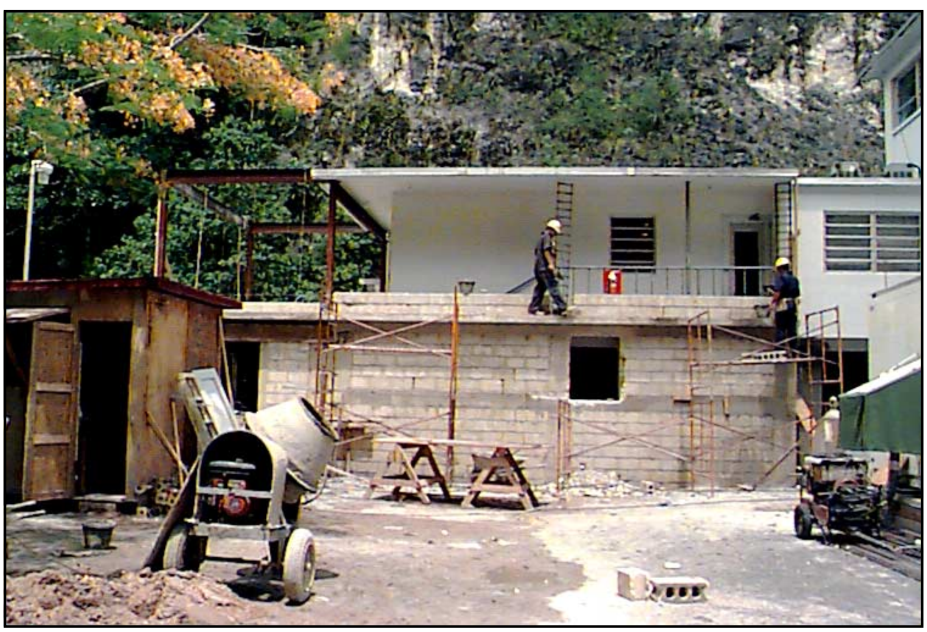
The 1998 NAIC summer students are: Angel Alejandro (UPR -Humacao), Monique Aller (Wellesley), Yira Cordero (UPR -Humacao), Ingrid Daubar (Cornell), Simon DeDeo (Harvard), David Kaplan (Cornell), Dale Kocevski (U. of Michigan), Myriam López (Morovis Middle School), Felix Mercado (U. Metropolitana), Benjamin Oppenheimer (Harvard), and Celia Salmerón (U. of Houston).

The Passage to Nowhere Goes Somewhere

Daniel R. Altschuler

As reported in the February 1996 Newsletter, the new hallway to the control room area was inaugurated as "phase one" of the control room modification project with a lot of fanfare in January 1996. Until recently however this hallway was a passage to nowhere, since as sometimes happens, "phase two" had to be delayed until we found the resources to do it. I am pleased that we are now more than half-way into completion of the control room expansion which we expect to be ready by early September.

The new addition will provide room for user instrumentation, office space for telescope operations and RFI coordination work, office space for the maintenance department and a control room annex with a small kitchenette.



Another angle on the Control Room construction. Photo by Tony Acevedo

Comings and Goings

New Astronomy Postdocs

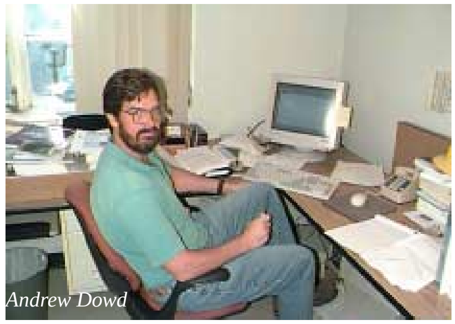
NAIC have recently awarded post-doctoral research associateships to two young radio astronomers. The Cornell University post-doctoral position at Arecibo will be filled by Duncan Lorimer from the MPIfR, Bonn. Karen O'Neil from the University of Oregon will also be joining us at Arecibo as a post-doc. They will both be arriving in Puerto Rico this October.

Duncan Lorimer hails from Darlington in the north of England. After studying undergraduate astrophysics at the University of Wales, Cardiff, he moved to Manchester University, and the Nuffield Radio Astronomy Labs, Jodrell Bank, to pursue his post-graduate studies. There he obtained his Ph.D. in 1994, having written a thesis entitled, "The Galactic Population of Millisecond and Normal Pulsars" under the supervision of Andrew Lyne, Dick Manchester and Matthew Bailes. For part of this time, he used the Parkes telescope intensively as a member of the Parkes Southern Sky Pulsar Survey team. From late 1995, Duncan has worked in the pulsar group at the MPIfR, Bonn, continuing his work on pulsar statistics and pulsar search, as well as being involved in a number of collaborative projects as part of the *European Pulsar Network* (EPN). The latter includes the simultaneous observation of individual pulses at a variety of frequencies. Duncan came to Puerto Rico for the first time this June to participate in a pulsar search project with Kiriaki Xilouris (see the Radio Astronomy Highlights). He admits to enjoying hiking, golf, cricket, music and learning languages. We look forward greatly to him joining us in 3 months time, and hope that he will find the island to his taste — We can provide the hiking, golf, and music, Duncan, with Spanish there to be learned; I guess it's not too far to Antigua, Trinidad and Jamaica for the cricket either!

Karen O'Neil was also here at Arecibo for the first time recently, observing low surface brightness (LSB) galaxies with Jim Schombert (again, see Radio Astronomy Highlights). Karen pursued her undergraduate studies at Marlboro College, before moving to the University of Oregon where she completed her Ph.D. in 1997 under Greg Bothun. Her thesis had the intriguing title of, "Faint Fuzzy Stuff: The Missing Baryons?" That faint fuzzy stuff was LSB galaxies, and in her work she focused on discovering and classifying these extremely faint objects, and investigating their composition and evolution. In particular, she used the McDonald Observatory 0.8-m optical telescope with a 2048 x 2048 CCD camera to search the local universe for LSB galaxies, cataloging over 120, mostly new discoveries. Among these are the first very red LSB galaxies, the final proof that LSB galaxies cover the entire range of galaxy development. On her recent trip to Arecibo, Karen made her presence felt quickly as one of the first post-upgrade HI observers. She even left us a very full and useful set of notes on observing with the post-upgrade spectral-line system. When she returns in October, we trust that she will enjoy her time here as much as we will enjoy having her as a colleague.

New Electronics Engineer

Andrew Dowd has joined the electronics department of the Arecibo Observatory. Having worked previously at NRAO, the University of Arizona, and SAO he comes with vast experience working with signal processing systems, and a very good understanding of our instrumentation and requirements.



Andrew Dowd

Andrew grew up near Cornell University, where much of his family still resides. He arrived in Puerto Rico with his wife, Zoe. Their interests include Scuba Diving, Sailing and Hiking, all of which they intent to pursue actively in Puerto Rico. They also enjoy snow skiing, which means they will need to return state-side for occasional visits to colder climes. We are very pleased to count Andy as a member of our Staff.

Gerson Ortíz

New Telescope Operator

Gerson Ortíz Ortíz joins the telescope operations group as Operations Technician. He obtained a Bachelors degree in Physics and Applied Electronics from the University of Puerto Rico, Humacao campus. He took their astronomy course and worked as an assistant at their observatory. In college he also did research work on Pentium processors. After graduation Gerson worked for one year at Elizabeth Arden in the area of Management Information Systems. Gerson enjoys water sports and physical fitness activities. We are pleased to welcome Gerson to the Observatory.

New Transmitter Technician

Victor Negrón

Victor Negrón Dávila, also with a Bachelors degree in Physics and Applied Electronics from the University of Puerto Rico, Humacao campus has joined our staff as an S-band technician. At Humacao he participated in the NASA sponsored Solar Moon Buggy project which won third place in last year's national competition held in Huntsville, Alabama. Victor practices Judo and Olympic Wrestling and was Judo champion of the LAI (Inter-university Athletic League of Puerto Rico) for the last four years and wrestling LAI champion last year. We welcome Victor to our staff.

Adiós Ray González

Although Ray was less than three years "old" at the Observatory, he became a grandfather last year (congratulations Ray!). As a devoted head of the family, he and wife Deborah decided that much as they liked Puerto Rico and the Observatory, they preferred to live closer to their children. So it was time to move on. We are happy that Ray could take up a software analyst position at NASA Goddard Space Flight Center with special responsibilities for the X-Ray orbiting telescope, only a short drive away from his family. Visitors to the Control Room can see Ray's mark on the AO monitor displays, the S2 (VLBI) recorder system, and the ARTS user interface. We wish Ray and family all the best.

You can find the electronic version (PDF) of this newsletter at http://www.naic.edu/about/newslett/aonews.html

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***address correction requested**

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