NRAO NEWSLETTER

1983 October 1 No. 14

VLBI

THE VERY LONG BASELINE ARRAY

The NRAO has recently submitted to the NSF a 1984 VLBA Program Plan containing design schedules and detailed cost estimates for each element of the project. Major areas of work include: the antenna, front-end and feed system, prototype feed development, software development for the telescope monitor and control systems, the record system, and the processor system.

The adopted configuration for the ten antennas is based on an extensive computer analysis that maximizes uv plane coverage in terms of highest resolution (long baselines), large field of view (short baselines), maximum declination range, and high image quality (dynamic range). The following regions have been chosen to site VLBA antennas: Arizona, California, Hawaii, Iowa, Massachusetts, New Mexico (2), Puerto Rico, Texas, and Washington. Specific sites are now being investigated.

The location of the VLBA Control Center will be determined over the next several months. This determination will be reviewed by a site selection committee: B. Burke, A. Davidsen, R. Dicke, A. Hoag, D. Hogg, G. Preston, J. Taylor, and P. Vanden Bout, and by the AUI Board of Trustees.

M. S. Roberts

12-Meter

HOLOGRAPHIC MEASUREMENT OF THE 12-METER TELESCOPE SURFACE

The primary method which has been used to set and measure the telescope surface has been essentially mechanical. It has involved the use of a stable reference jig and a template carrying 12 precise electronic sensors. All data have been read directly into the Tucson computer and analyzed and mapped in Charlottesville (Findlay, J. W. and Payne, J. M. IEE Conference Publication No. 219, pp. 55-59, April 1983 (available as an NRAO reprint)).

Early in 1982, we decided to use the well-known holographic technique to measure the surface (a recent paper on the method is Mayer, C. E., Davis, J. H., Peters, W. L. and Vogel, W. J. IEEE Trans. Instrumentation and Measurement IM-32, pp. 102-109, March 1983.) This would give us an independent look at the surface shape; in particular it would test whether there were systematic errors in the mechanical measurements.

Craig Moore developed and built a suitable front end with which to observe the Lincoln Laboratory LES-8 satellite at 38 GHz. Ron Weimer designed the back end. Bob Freund did the interface to the PDP-11. Betty Stobie did the computing to track the satellite and raster

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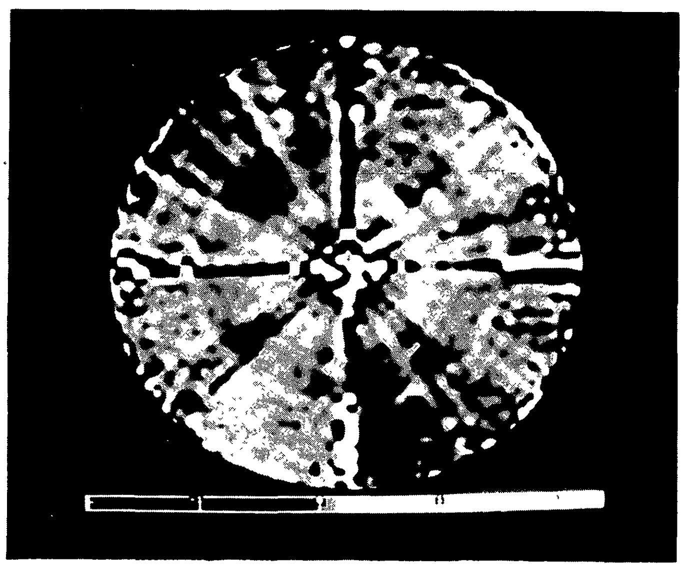
scans and to record the data. Dewey Ross assisted with the observations. Anthony Lasenby came from Jodrell Bank to Tucson in July 1983, and he has carried through the final tasks of deriving the surface maps from the original data, applying corrections, and getting the reduced data into Lee King's IBM programs and also into AIPS. John Payne has overseen the whole operation.

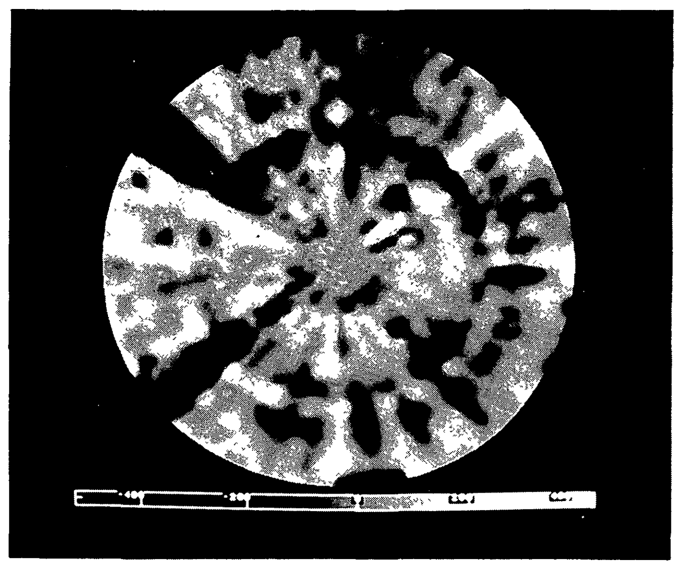
At present we have a good 64x64 holographic map of surface shape and illumination in AIPS, together with a recent (August 29) mechanical map, also in AIPS. They show a very satisfactory agreement, particularly in the areas of greatest departure from perfection, and they can be used for our next step in adjusting these areas to a better shape. These two maps are shown below.

We hope that this work will go smoothly; if so the telescope could be observing again before the end of November.

We should like to thank Lincoln Laboratories for their excellent help in providing the satellite transmissions, the ephemeris, and look-angle data to us.

John W. Findlay





Editor's Note: Shown are maps of the 12-meter surface, measured by holographic techniques (left) and by the mechanical (template) method (right). The scale on the mechanical map is in μm. The scale on the holographic map is in thousands of μm (i.e., mm). In the holographic method there is no data in the center position of the dish, and the map shows noise (maximum excursions) here. Shadowing of the feed legs is clearly seen. In the mechanical method, the shadowing of the feed legs does not show because no measurements were made in these regions.

On both maps, the individual panels can be seen, as well as the ring which separates the inner and outer panels. Some obvious mis-settings can be seen in both maps, which agree quite well. Work is continuing to improve these settings. The rms deviation from perfect paraboloid over the mechanical map is ~110 μm and over the holographic map is ~130 μm. The holographic method has better intrinsic resolution.

12-METER ANTENNA PERFORMANCE OVER FIRST OBSERVING PERIOD

Although the first scheduled observing period on the 12-meter was a short one (March 21 to June 30, 1983), it provided a good period to evaluate and measure the performance of the telescope.

Antenna Stability

The most dramatic improvement in the 12-meter over the 36-foot is the antenna's thermal stability. The improvement was seen in several areas.

(1) Pointing - The pointing of the antenna (with no direct sun on the feed legs or the dish) is repeatable (over the entire sky) to within 5 arc seconds for periods up to several weeks. Unlike the 36-foot, there are no pointing changes (to within 3-5 arc seconds) from night to day even when the ambient temperature has changed by 10-15°C. However, over the time period of one month to several months, the pointing changed from one region of the sky to another by 10-20 arc seconds (mainly in azimuth). This is exactly the way the 36-foot behaved, although the 36-foot saw these sort of changes in as short a period as a few days. The pointing of the 12-meter when in direct or partial sun can change by as much as 10 arc seconds. Most of this effect is accounted for by the differential heating of the feed legs. Measurements of pointing error versus feed leg temperature indicate that a 5°C difference between the east and west feed legs will produce about a 5 arc second azimuth pointing error. Although the pointing changes due to sun on the antenna, the gain does not seem to be affected by direct sun (at least at 3 mm).

(2) Focus - The focus of the antenna is nearly independent of temperature. The relative position of the secondary (to focus the antenna) as a function of dome ambient temperature was measured using the 3-mm Cassegrain system. The best fit linear equation for the focus is:

$$\mathrm{FOCUS(mm)} = (39.52 \pm 0.21\ \mathrm{mm}) - (0.033 \pm 0.02\ \mathrm{mm/°C}) \times T_{AMB}(\mathrm{°C})$$

(3) Spectral line data - Spectral line observations were made with the 3-mm Cassegrain receiver (plus path length modulator) using the standard vane calibration scheme. Since the antenna coupling efficiency to the sky, the secondary solid angle and the illumination taper are all the same as for the 36-foot, the standard TC (DSB) value of 800 K at all frequencies except ^{12}CO and ^{13}CO can be adopted. Standard line strengths are about 25% stronger than those for the 36-foot. The standard sources used were IRC+10216, W3(OH), S146 and M17SW (^{13}CO only). Assuming that the calibration is correct, this means that the source coupling efficiency to these standards has increased by 25%. For very extended sources, the observed line strengths are about the same as for the 36-foot, as expected. All observers found that the baselines are flatter than those with the 36-foot. This was true even when using both 1-MHz filter banks. Integrations as long as 850 minutes produced flat baselines over 256 MHz, gave a T_A^* (RMS) of 7.5 mK, and showed that the noise is going down as $T^{-1/2}$.

(4) Continuum data - There are two significant improvements in 3-mm continuum observing. One is that in the normal beam switching/position switching mode (on-on scheme), the sky or background cancellation has improved by a factor of at least 10. The 36-foot produced "ghost detections" and large systematic elevation offsets that made it very difficult to believe detections less than 0.5 Jy. Plots of the observed antenna temperature for scans of 360 seconds integration versus source elevation for two sources (both about 0.1 Jy) show no systematic offsets to within ± 1 mK. Observation on 1704 + 608 for a total of 288 minutes showed that the noise continued to go down as $T^{-1/2}$, reaching a final RMS of 30 mJy.

Antenna Parameters

The aperture efficiencies and half-power beam widths that have been measured since the setting of the panels in February 1983 are listed below.

Wavelength	Configuration	Aperture Efficiency (%)	HPBW (arc sec)	Comments
3.3 mm	Prime Focus	39±2	72±2	Measured before final panel setting
3.3 mm	Cassegrain	30±1	78±2	Average over March - July 1983
1.33 mm	Prime Focus	15±3	29±2	
1.33 mm	Cassegrain	10±3	36±2	July 1983

The efficiencies at 1 mm are not well determined because of high receiver temperatures at prime focus and marginal weather conditions with the new Cassegrain receiver in July. The Cassegrain HPBW's (both at 1 mm and 3 mm) are broader than theoretical, and in fact the 3-mm HPBW is the same as the 36-foot.

A map of the beam (on Jupiter) at 3.3 mm using the Cassegrain receiver (10 dB taper) shows sidelobe features are about 8 dB lower than those for the 36-foot.

At 1.4 mm, both the bolometer (2 dB taper) and the coherent Cassegrain receiver (11 dB taper) show asymmetries in the beam at levels as high as 3 dB for the bolometer and 8 dB for the coherent receiver. Figure 4 is a map of the beam (on Jupiter) at 1.4 mm using the He_3 bolometer system.

R. J. Howard

VLA

MORE DIAL-IN CAPABILITY FOR THE DEC-10

The VLA has added a second dial-in line to the DEC-10 computer. The new line has the capability to communicate with Bell 103 (300 baud), Bell 212 (300 + 1200 baud) and Racal Vadic (1200 baud) modems and will automatically choose the correct modem protocal and speed. The new line is telephone number (505) 772-4362. The existing dial-in line, (505) 772-4346, continues to support Racal-Vadic compatible modems at 1200 baud only.

Observers are encouraged to use the dial-in lines to prepare observing files with the OBSERV program; general use of the lines for data reduction is not permitted.

Observers wishing to use the dial-in lines may telephone the VLA switchboard operator, who will call back via FTS and then switch you over to the computer.

D. S. Retallack

LINEAR POLARIZATION CALIBRATION

The absolute position angles of linear polarization are measured by adopting the values for 3C 286 or 3C 138. We have recently discovered that the value we have adopted for 3C 138 in the past has been wrong at 2 cm by 6 degrees. The correct value is -18° instead of the -12° we have been advertising.

R. C. Bignell

VLA COMPUTER MAINTENANCE SCHEDULES

As the Pipeline processing system comes into more general use, regular maintenance of the interconnected computers and peripherals can no longer be done on separate days without taking down the whole Pipeline on those days. To impact the data reduction the least, we will in future perform maintenance on the Pipeline computers and the DEC-10 on electronics/maintenance days (usually Wednesdays unless VLBI schedules conflict) when no observing is done. The Pipeline computers--the four PDP-11's, SORTER, GRIDDER, WORKER and DISPLAY, will not be available from 0900 to 1600 Mountain time on those days. The DEC-10 will not be available between 0900 and 1400 on alternate electronics/maintenance days. The two VAX's at the VLA site will be maintained between 0900 and 1300 on alternate Tuesdays.

Details of computer maintenance at the VLA for the current month can be obtained by typing HELP SCHED on any asynchronous VLA computer.

D. S. Retallack

Green Bank

NEW L-BAND SYSTEM: PERFORMANCE AT OH FREQUENCIES

The new L-band system underwent extensive tests on the 140-foot telescope during the period 25-30 August.

The receiver is a dual-channel, broad-band, cooled FET 2-stage amplifier covering the range 1300-1800 MHz. The first stage, cooled to 4.3 K, runs at 30 dB gain at 1666 MHz. The second-stage FET is uncooled. The receiver was built by Roger Norrod.

To reduce spillover losses and optimize efficiency, more than one specialized feed will be used with the broad-band receiver. For the 1600-1730 MHz range, the feed, designed by Rick Fisher, employs dual hybrid modes (HE_{11}, HE_{12}) simultaneously so as to provide a more uniform illumination pattern than is the case for the usual one-mode feeds. The illumination pattern is maximum at $>$ 20° from axis, is slightly reduced in the center of the dish, and has very sharp skirts at the edge of the dish. It has been designed to optimize the ratio of gain to system temperature. The contribution of spillover and scatter (off feed legs, etc.) is reduced by ~5 K from that of conventional illumination patterns when the aperture efficiency is 0.53.

The total system temperature in each channel, at 50° elevation on clear (but humid) sky, was 24 ± 1 K. The contributions are: sky (background 3 K, atmosphere 2 K, galactic background 1 K) = 6 K; feed loss = 4 K; receiver = 8 K; spillover and scatter = 6 K. These values are unchanged from 1612 to 1720 MHz, within 1 K.

Feed polarization is orthogonal linear. Beam maps reveal expected four-eared patterns, elongated somewhat in declination for receiver 1, and in R.A. for receiver 2. For channel 1, one of the sidelobes is -16 dB down from the central beam (offset ~1.5 degrees in both coordinates, north and west); the others are down by ~24 dB.

The feed gain was optimized at 1666 MHz and degrades slightly at 1600 and 1730 MHz. When the telescope and feed are focused specifically at 1612, 1666, and 1720 MHz in turn, the measured aperture efficiencies are 0.55, 0.57, 0.54, respectively, ± 0.01 for each. When the telescope is focused at 1666 MHz, the efficiency at 1612 MHz decreases slightly, to 0.54, while at 1720 MHz it decreases even less (0.005). Thus all four OH lines may be observed simultaneously with no significant loss of performance for any of the lines.

Tests of stability yielded excellent results for integrations up to four hours. Noise decreased as $\tau^{-1/2}$, and baselines were excellent under normal frequency switching and total power observing techniques, with or without MODFOCUS, and for bandwidths up to 10 MHz. At a bandwidth of 1.25 MHz, suitable for galactic work in general, the baselines were stable for many days--that is, a single reference scan could be used for several days without appreciable deterioration of the baselines.

The Editor

300-FOOT SURFACE BOLT REPAIR

This summer about 170 surface-mounting studs on the 300-foot were found to be broken, and two surface panels on the north lip of the dish were bent. The broken studs have been replaced and the bent panels have been straightened and reinstalled. Samples of the broken studs are being analyzed by a metals testing firm to determine the cause of breakage, and, if the results of these tests indicate the potential for more widespread breakage, a procedure will be devised for sampling and testing of the unbroken studs.

Rick Fisher

In General

PENZIAS AND WILSON RECEIVE JANSKY AWARDS

The NRAO is pleased to announce the award of the 1983 and 1984 Karl G. Jansky Lectureships to Drs. Arno Penzias and Robert Wilson, both of Bell Laboratories. Well known in the astronomical world as discoverers of evidence of the relic radiation predicted by the "big bang" theory of the origin of the universe, they shared the 1978 Nobel Prize for Physics.

The Eighteenth Jansky Lecture will be given by Dr. Penzias in Charlottesville on November 10, 1983. The lecture, entitled "The Astronomical Origin of the Earth's Materials", will be delivered at 8:30 P.M. in Gilmer Hall, on the Grounds of the University of Virginia. All friends of radio astronomy are cordially invited to attend the lecture and reception which will follow immediately thereafter at the Edgemont Road office of the NRAO. Under the auspices of Associated Universities, Inc., the Jansky Lectureship annually recognizes outstanding achievement in astronomy or a related field.

R. J. Havlen

THE SECOND GREEN BANK WORKSHOP ON FUTURE INSTRUMENTATION

Scientists and staff from all of the NRAO sites met in Green Bank on 20 September for the second Green Bank workshop on future instrumentation in radio astronomy. Among the topics discussed were the following:

A low-frequency (75 or 150 MHz) array of 27 banks of antennas located near the VLA A-array stations was discussed. It would yield 20 arcsec resolution and 3 mJy rms noise at 75 MHz and cost about $1M. The array design itself is not a problem, but phase calibration in the presence of the ionosphere may be difficult. Self-calibration on background sources present in the low-frequency maps might be sufficient, and this method can be tested with data from the 327 MHz system under construction at the VLA.

The largest proposal under discussion is for a millimeter-wavelength array consisting of about 15, 10-meter dishes in a Y array whose arms are up to 1 km in length, plus a central array of perhaps 30, 3-meter dishes closely packed on a single steerable backup structure. The central array has a large field of view and good sensitivity to low-brightness structures; the outer array attains ~1 arcsec resolution on bright, compact sources. This is a technically demanding project, so preliminary design studies of critical components (a wide-bandwidth correlator, for example) are already being made. Site testing has also begun, with atmospheric phase-stability measurements at λ = 13 mm indicating that the VLA site is usable for observations at λ = 3 mm on baselines up to 1 km for perhaps 50% of the time.

Three additional 25-meter telescopes in New Mexico were suggested to fill the gap between the longest spacing available on the VLA (35 km) and the shortest on the VLBA (200 km). They would be useful for mapping with 0.1-arcsec resolution and would allow "scaled array" spectral-index maps to be made over wide ranges of frequency and angular resolution. Design, construction, and operation of these telescopes should be straightforward; the main obstacle is that $10M is required.

The VLA performance is currently limited by both its synchronous (on-line) and asynchronous (off-line) computer systems, so upgrading both is being considered, at a total cost ranging up to $10M. The computing power needed is difficult to estimate because some observations are far more computer intensive than most.

In addition to hardware proposals, it was suggested that two study groups be formed. An image construction group would develop methods of cleaning, self-calibration, etc., in order to improve both their mathematical foundations and practical implementation. A future instrumentation group would study ideas which require basic research before they can be implemented (e.g., array feeds for single-dish telescopes).

Jim Condon

PROCEEDINGS OF THE WORKSHOP ON SYNTHESIS MAPPING

Proceedings of the Workshop on Synthesis Mapping have been reprinted and are now available. Request copies from:

National Radio Astronomy Observatory
P.O. Box 2
Green Bank, WV 24944
Attention: Berdeen O'Brien

Proceedings have been mailed by library rate and surface mail to persons whose requests were held in anticipation of the reprinting.

Ellen Bouton

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