NRAO NEWSLETTER

1988 October 1 No. 37

VLBA

SELECTED ITEMS

Operation - The U.S. VLBI Consortium, at its annual meeting, indicated that it would be advantageous to the Network to advance the operation date of the North Liberty, IA site to be as soon as possible. In response, site outfitting schedules are being changed to skip over the Fort Davis, TX site. The result is a new North Liberty scheduled operation date of November 1989 instead of the previous April 1990. Fort Davis operation is postponed one year, to November 1990. The currently projected operational date for both Kitt Peak and Los Alamos is unchanged: April 1989. The Brewster, WA operation date also remains unchanged: April 1990.

General - A first geodesy run with the NASA crustal dynamics network was done September 8/9 at Pie Town, using the VLBA recorder in Mk III mode. A Mk III phase cal system was installed for this and near future runs. It is being evaluated for possible installation at all VLBA sites.

With regard to the VLBA correlator, a major milestone was achieved in August with the selection of a vendor for the "FX chip." Final correlator circuit board design, hardware procurement, design of playback interfaces, and correlator control computer software development are underway.

Preparations for the September-October NUG run at 2.8, 1.3, and 3.6 cm at Pie Town are being made as of this writing. It is expected that this will be the first VLBA remote controlled, largely unattended NUG run. Operators, site technicians, and astronomers at the Socorro VLBA office now use a terminal office for communication with the Pie Town station computer.

Construction Status - Phase II mechanical and electronic outfitting, including installation of the focus/rotation mount and subreflector, are scheduled for the Kitt Peak site in October and the Los Alamos site in February. The Fort Davis antenna received its "punch list" acceptance inspection in early September. Antenna erection proceeds at North Liberty, IA and is scheduled for completion in November. At Brewster, WA and Owens Valley, CA the site preparations, antenna foundations, and control buildings are complete, awaiting antenna erection. The St. Croix, VI, Mauna Kea, HI, and Hancock, NH locations are in lease approval and pre-construction phases.

Ken Stetten

VLA

P-BAND CALIBRATION

Calibration at P-band (90 cm) is rather different than at other bands. In particular, observers should note that a separate list of calibration sources must be used, and that the effects of background objects are great, causing high "closure errors" to appear. I have written a special memo on this subject (VLA Scientific Memo #159) which contains the calibration list and hints on effective calibration. This memo was not put into general distribution, but is available on request from Alison Patrick at the VLA.

R. Perley

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SPECIAL PROBLEMS AT P-BAND

The sensitivity factor at P-band quoted above was measured in Stokes' parameters Q and U, and is very close to the expected value. In Stokes' parameter I, however, the noise was a factor of 10 higher. This result is a good example of the special problems in imaging VLA data at 90 cm. The basic problem is that the VLA is a non-coplanar array (except for short snapshots). Analysis shows that for arrays which sample a (u,v,w) volume, rather than a (u,v) plane, standard two-dimensional transformation of the visibilities results in distortions which worsen quadratically with distance from the image center. This would not be a problem if there were no sources outside the distortion-free region, but at P-band there are always hundreds of background objects whose total flux density is near 20 Jy in every field. These background objects cause sidelobe responses which cannot be properly removed in a two-dimensional image, and it is the summed response of these which give such a high apparent noise. Numerous tests show that the image noise is rarely lower than 5 mJy/beam. Somewhat better values might be expected for "A" configuration, where bandwidth smearing will be of some assistance. In no case should an observer expect noises less than 1 mJy/beam on any image produced by a two-dimensional transform.

There are many proposed ways to solve this problem. The simplest conceptually is to perform a three-dimensional transform on the data volume. This results in a three-dimensional map volume, which can be deconvolved in standard ways. The sky shows up on a sphere of unit radius within this volume; the rest of the volume is filled with sidelobe responses of the various objects. The number of horizontal planes required is given by the product of the longest spacing in the array with the wavelength, divided by the square of the antenna diameter (all quantities in the same units). Although simple in concept, the actual calculation, and especially the deconvolution of these image cubes, is very expensive computationally. Tim Cornwell has written special-purpose code to do these operations on the VLA CONVEX. These programs are available for data taken in the "C" and "D" configurations. We are looking at other approaches which might handle "B" configuration data. Full deconvolution of "A" configuration data lies outside the NRAO's computational resources.

Utilization of these programs has produced distortion-free images, with rms noises near 1 mJy/beam, a great improvement. However, we still have not reached expected thermal levels. The role of other factors (such as internally generated interference) is now being intensively explored.

R. Perley

SPECIAL PROBLEMS AT K-BAND

The K-band (1.3 cm) upgrade will be completed by April 1989. At the time of writing, 20 antennas have been outfitted with the new receivers, which have a sensitivity factor of 2.5 better than the old receivers. However, users of the K-band system should be aware that many factors can conspire to worsen the sensitivity from the values given above. In particular, observations in wet weather (causing high atmospheric emission and absorption), in sunny weather (which induces pointing offsets), in blustery weather (causing antenna deformations), or in snowy weather (which drastically changes the antenna's effective reflecting surface) will certainly result in poorer performance. Also note that the K-band sensitivity will be sharply frequency dependent, and somewhat elevation dependent (because the antenna efficiency is a function of elevation).

R. Perley

VLA CONFIGURATION SCHEDULE

Schedule of Reconfiguration Dates

From	To	Starting Date	Completion Date
D	A	03 October 1988	28 October 1988
A	A/B	06 February 1989	17 February 1989
A/B	B	06 March 1989	10 March 1989
B	B/C	01 May 1989	12 May 1989

Summary 1988/90

Period	Configuration	Antennas Available* 327 MHz	8.4 GHz	23 GHz	Proposal Deadline
1988 O,N,D,J	D→A, A	22	25	21	15 June 1988
1989 F,M,A,M	A/B,B,B/C	27	27	24	15 October 1988
1989 J,J,A,S	C,C/D	27	27	27	15 February 1989
1989 O,N,D,J	D	27	27	27	15 June 1989
1990 F,M,A,M	D A, A	27	27	27	15 October 1989
1990 J,J,A,S	A/B,B,B/C	27	27	27	15 February 1990

Maximum antenna separation for the four VLA configurations are: A-36 km, B-11 km, C-3 km, D-1 km. Further information is summarized in the "VLA Observational Status Report" available from Alison Patrick, NRAO, P. O. Box O, Socorro, NM 87801 (Telephone 505-772-4240).

* All 27 antennas are available at 1.4, 5, and 15 GHz. At 23 GHz the number given is the number of antennas with new receivers, approximately three times more sensitive than the older ones.

Approximate Long-Term Schedule

	01	02	03	04
1988	B	C	D	A
1989	A+#	B	C*	D
1990	D,A	A	B	C
1991	D	A	B	B,C
1992	C	D	A	A,B

\+ All antennas equipped for 8.4 GHz operation
\# All antennas equipped for 327 MHz operation
* Voyager-Neptune encounter 24 August 1989. Modified C array to minimize shadowing. All antennas equipped for 23 GHz operation.

B. G. Clark

RECENT VLA MEMORANDA

One VLA numbered memorandum has been issued since the last Newsletter: VLA Scientific Memorandum No. 159, "Calibration of P-band Data," R. Perley) September, 1988.

Note: This memo was not put into general circulation, but is available on request.

Copies of any VLA numbered memoranda or a copy of the listings of all VLA numbered memoranda are available from Alison Patrick at the VLA, P.O. Box O, Socorro, NM 87801 (505)772-4240.

Alison Patrick

INTERIM SPECTRAL LINE SUPPORT

With the online system update of August 2, 1988, support for some new spectral line modes using two IFs is available. The new correlator modes now supported are 2AC, 2AD, and 2CD. All other planned correlator modes which utilize the entire correlator, including full polarization, are not yet supported. All of the old correlator modes (2A, 2C, ...) which use only a fraction of the correlator will be phased out once the new modes are in place. This update is expected to occur by the last quarter of 1989. Ample warning will be given prior to the transition. In the meantime, all of the old modes as well as the three new modes will be supported.

During this interim period, we will support only a subset of the possibilities available with two IFs. In particular, the bandwidth and related quantities from the //DS card must be the same for both IFs. The sky frequencies may be different, subject to the restriction that A and C, just as B and D, cannot be set independently.

A word about bandwidths and channel widths is probably in order. The VLA correlator has enough correlator chips to produce 16 complex frequency channels at 50 MHz bandwidth. Halving the bandwidth allows the chips to be "timeshared" so that the number of channels is doubled. This can be continued to a maximum of 512 channels, at which point successive halvings of bandwidth leave the number of channels at 512. It is important to remember that these 16 channels must be split among both IFs. Thus, for example, if an observation is set up at 50 MHz with 2 IFs and no Hanning smoothing, there will be 8 channels (8 + 8 = 16 channels total) in each of the two spectra. The flexibility in channel width we once enjoyed through use of the "obsolescent" modes is no longer available if two IFs are used.

To ease the burden of understanding and using these new features, there is now available an updated version of Arnold Rots' "Short Guide to Spectral Line Observing." It describes what is currently possible and how to convince OBSERV to let you do it.

Restrictions still exist on the amount of data produced by the VLA if it is to be filled to an NRAO computer. The guideline in use is that the product of the number of baselines and the number of channels, divided by the integration time in seconds, must be less than 375. No such restriction is placed on data that will be taken away and never read by any NRAO computer.

K. Sowinski

K-BAND PROPOSALS

In the scheduling of the last two quarters (1988 Q2 and Q3), we have noticed many mistakes in both the correlator configurations and the sensitivity estimates.

Many proposals have errors of two to four in the calculations of the rms noise (after one hour). The system noise with the new K-band receivers is about 170 K (compared to 400-500 K for the old system). With 18 antennas (during the start of Quarter 3, 1988) outfitted with the new receivers, the rms noise can be calculated for a single IF using the equation in Section 2.1 (Sensitivities) of the "VLA Observational Status Report." For 48.8 kHz channels (a typical NH_3 frequency resolution), the rms noise is 13 mJy after one hour. We would urge users to use the natural weighting noise estimate and indicate that natural weighting has been used.

For the correlator configuration, users should consult Table III in the "VLA Observational Status Report" or Appendix C in the "Short Guide to VLA Spectral Line Observing" (otherwise known as the "Spectral Line Guide"). Some proposals in the recent past have used nonexistent bandwidths and numbers of channels (e.g., 64 channels for 25 MHz total bandwidth).

W. M. Goss

X-BAND PREPARATION FOR VOYAGER AT NEPTUNE

During 46 periods of about 9 hours each, in 1989, the VLA will be arrayed with the Goldstone 70 m and 34 m antennas to receive telemetry from Voyager 2 as it flies by Neptune and its moon Triton. Close-encounter will occur August 24/25, 1989. The additional collecting area and low-noise front ends (T_{sys} < 33 K at zenith) of the VLA allows the VLA-Goldstone Telemetry Array (VGTA) to nearly double the total data return from Voyager at Neptune over what would be possible without the VLA.

NASA funding has provided the VLA with X-band receiving systems on all 28 antennas, analog sums and switches for the four intermediate frequency channels, a backup on-line computer, and a diesel generator system capable of powering the entire VLA (with only one of the two generators). Nearly all the hardware is in place, functioning, and tested. The 25th antenna became operational at X-band in September. All 27 antennas in the array will operate at X-band by mid-December, and the 28th by mid-January.

Although not yet formally accepted, the generators have powered the VLA during several JPL tests of the VGTA and VLA stand-alone. Tests in July demonstrated a VGTA signal-to-noise ratio (SNR) of the Voyager telemetry which exceeded the design goal. The VGTA SNR design goal for Voyager at Neptune is only 2.6 dB at 21.6 kilobits/sec.

As more VLA antennas have become available at X-band, more science has been done within the 8.0 to 8.8 GHz tuning range. Observations have included surveys of spectral fluctuations, recombination lines, solar imaging, and spectral imaging of radar reflections from Saturn's rings and from Mars. See "Science News," Vol. 134, No. 11, September 10, 1988 for more details.

B. Brundage

VLA SENSITIVITY

Recent measurments of the VLA sensitivity have been made, and the results are given below. These are expressed in units of the "Sensitivity Factor," S, which is the rms noise per complex correlator measured on an image made with one hour of data and a bandwidth of 1 MHz. This quantity can be converted into a system temperature provided the feed efficiency is known. This conversion is also provided.

To convert the sensitivity factor into a predicted noise on an image, divide by the number of antennas, and again by the square root of the product of the observing bandwidth (or channel width) in megahertz, with the observing time in hours. If the image to be made utilizes only one IF, multiply the sensitivity factor by $\sqrt{2}$. If uniform weighting is employed, multiply by 1.25 (this factor is somewhat uncertain).

Band	S	η	T_{sys}
90	31	0.40	150
20	10	0.51	62
6	7.4	0.65	59
3.6	5.2	0.62	39
2	19	0.52	120
1.3	40	0.43	210

R. A. Perley

CREDIT CARDS NOW ACCEPTED AT VLA

Visiting scientists to the VLA will now have the added convenience of paying for their lodging and meals with Visa or Mastercard credit cards before leaving the VLA site. In order to reduce the NRAO overhead for billing and collection, each visitor is expected to settle their accounts with the NRAO administration during normal working hours prior to departure. Please come prepared with either cash, personal check, travellers checks, or approved credit card.

R. J. Havlen

ARRAY OPERATIONS CENTER AND VISITING OBSERVERS

The current schedule predicts that NRAO will take possession of the new building in Socorro sometime during November. The move of the staff and computers from the VLA site into the new building will take place over a period of several weeks. During this time some of the computers (e.g., the CONVEX and the two VAX 11/780s) will be down and inaccessible for various periods. In addition, our staff will be occupied with the move and normal user support will most likely be less than normal.

Visitors would be advised to plan their trips to NRAO in New Mexico carefully and as much in advance as possible. Since the move date cannot be fixed at this time with any certainty, visitors planning trips to NRAO/New Mexico who want to use our computers (especially the CONVEX and VAXes) or who will need or expect extensive support should contact us to get the latest information.

R. C. Bignell

12-METER

SUMMER SHUTDOWN REPORT

A productive Summer Shutdown was concluded on September 16 and the telescope is back on the air for another season. Here is a summary of the changes and new features that observers will see at the telescope; more details are available on request.

I. Software Changes

Source Catalog Entry. A new capability for creating and editing source catalogs has been developed. Observers can now bring their source catalogs on IBM PC-compatible floppy disk or 1600 bpi magnetic tape and load them into the control system via an IBM PC. The source catalog can be brought in free format and a utility on the PC will parse the records and reformat them for control system input. With this new capability, the old card reader has now been retired, and punched card catalog entry will no longer be supported in any form. All existing source cards at the telescope have been converted into floppy disk format. This new system is described in detailed in a memo by Chris Biemesderfer that is available upon request.

Beam Throw Parameter. The way in which pointing offsets, reference positions, and subreflector beam throws are entered has been changed substantially. The AZ/EL pointing offsets, which are used to make corrections to the basic telescope pointing model, are now separate and distinct from the subreflector beam positions. This new convention offers several advantages over the old method. Telescope offsets are calculated automatically according to the current observing technique, and there is no longer any need for the mental arithmetic in sexagesimal that has been responsible for numerous observing errors in the past.

Spectral Line Mapping Procedures. A new spectral-line mapping procedure, PSM, has been installed. PSM is a position-switched RA-DEC grid map that uses relative, not absolute, offset positions. The offset position can be specified in either the AZ-EL or RA-DEC frames. The map is made on a rectangular grid that can have different X and Y cell sizes. A subset of the originally specified map can be observed, if desired. An old mapping procedure (PS-MAP) is now called by a new name, APM. APM stands for "absolute position-switched mapping." This is the catalog generation method of mapping that is described in the User's Manual and the Operator's Manual. A total power observing mode also exists that allows for multiple ONs per OFF.

Continuum Observing Procedures. The command words for several continuum observing procedures were changed over the summer. DBMAP is the dual-beam mapping procedure available at the 12-m for some years. SBMAP is essentially the same procedure except that the map is centered on the main beam instead of the mid-point of the main and reference beams. Two things have changed about DBMAP: first,

the command words have been changed to agree with spectral line mapping (the old GRID, ACELL, AROW, etc., have been replaced); second, the map is now centered automatically by the beam throw parameters. Because of a vocabulary conflict, the continuum commands SON, SOFF, and SON-OFF have been changed to DON, DOFF, and DON-OFF.

II. **Other Changes in Telescope Systems**

Several other projects were completed during shutdown. Many of these will not have an immediate effect on the way we take data, but should have long-term benefit to the Observatory.

Pointing Improvements. Because of the increasing emphasis on observation at higher frequencies with the 12-m telescope, we have started a major program to improve the pointing characteristics of the telescope:

New Insulation and Fans on the Feedlegs. Air circulation fans and new insulation were installed on the feedlegs. We expect these additions to make the telescope pointing much more stable, particularly during the daytime.

Optical Pointing Telescope. An optical pointing telescope and measurement system was completed over the summer. We expect this system to allow us to monitor and adjust the telescope pointing model more frequently and more accurately than ever before.

Laser Quadrant Detector. A laser measurement system was installed that will allow us to monitor movements in the apex of the telescope with respect to the vertex. This system allows us to monitor and, eventually, to correct for any pointing excursions caused by thermal expansion and contraction of the feedlegs.

Improved Focus-Translation (Sterling) Mount. The Sterling Mount was rebuilt to improve its positioning tolerances. This should provide more accurate focus and subreflector positioning for high-frequency observations.

Miscellaneous Project:
New Service Platform. A big job for the summer was the replacement of the old lower service platform with one about three times as big. This platform will make it easier to service our receivers and I.F. boxes and will give us a place to mount new chasses and cryogenic compressors.

Improved Cryogenic Monitoring. A new digital cryogenic monitoring system was completed. This system has readouts in the control room and will make it easier for the staff to spot cryogenic problems before they become critical.

New Work Areas for Observers. New work tables have been installed in the breezeway adjacent to the control room and in the observer's work room. These tables make more efficient use of the available work space. A light-table has also been installed in the breezeway.

D. T. Emerson and P. R. Jewell

FORTH BINARY TAPE

Because of the many software changes, it has been necessary to expand the FORTH header from 128 to 192 words. A description of the new format is available. This is only important to observers who use raw data from the FORTH binary tape at their home institution. ASCII FORTH tapes will no longer be available (and in fact have not been requested for a number of years). Both raw and processed data are available in ASCII FITS format.

D. T. Emerson

GREEN BANK

140-FT CASSEGRAIN SYSTEM MAJOR IMPROVEMENTS

Users of the 140-ft Cassegrain system have endured a gradual decline in performance of the B receiver maser. The entire 5 to 25 GHz frequency range has been affected. The most serious problem was an abnormally high ripple in instantaneous gain response over most of the tuning range. Tuning was difficult, and when observing frequency coincided with a gain null (usually the case), the result was high noise temperature, often 50 percent or higher than for A receiver. There was also a tendency to oscillate. The receiver was removed from the telescope in July 1988 and the following problems identified.

1. Two of the four rubies were nearly identically phased instead of being staggered. The waveguide structure may have relaxed over time causing this. A different mix of rubies in their waveguides and a slight lapping of one of them resulted in near perfect staggered phasing.

2. In the circulator assembly, it was found that the cement holding the ferrite discs was flexible enough so that eight of the ten ferrites mounted on the center plate were being displaced on application of the ferrite magnetic field thus changing the air gap and affecting the match. The entire assembly was stripped of ferrites and aluminum matching blocks and rebuilt to the original design by Carl Chestnut.

3. The permanent magnets for the circulator ferrites had weakened so that the average flux density was low by about 15 percent. These were replaced with new magnets.

4. Thermal resistance had increased between the top liquid helium heat exchanger and maser structure. The rubies were then at a slightly elevated temperature and overall maser gain was suppressed by about 3 dB.

5. The waveguide for pumping the rubies had cracked, and the loss was measured at 1 to 10 dB, depending on force applied to the waveguide. This lowered the maser gain-bandwidth product and contributed to instability.

6. The superconducting magnet current loop had a defective weld causing a drifting field, failure to lock up, and difficulty in tuning.

All of these problems have been corrected and the receiver has been reinstalled on the telescope. It appears that, on average, bandwidth and noise temperature are now somewhat better than for A receiver over most of the tuning range. Maser frequency range can be taken to be 18.0 to 25.16 GHz. There are narrow band (typically 40 MHz) responses below 18 GHz; the high end frequency limit is firm. Users are reminded that many observing constraints imposed by past performance will no longer apply.

C. Brockway

300-FT FRIEND OF THE OBSERVER

I have taken over the position of the "friend of the telescope"--I would rather call it "friend of the observer"--at the 300-ft telescope. Observers can reach me with their questions at (304) 456-2210 or via electronic mail under 'wbatrla@nrao'.

I am a novice to the instrument, which could turn out to be an advantage for my new task to improve the user interface of the instrument. While scouting the system myself, I would like to encourage all users who had a chance to use and digest the new operating system during the past two years to give me their comments on the features they liked or disliked.

Wolfgang Batrla

NEW FRIEND OF THE INTERFEROMETER

Frank Ghigo has joined the Green Bank staff to handle scientific and software aspects of the interferometer operation. This will include instrumenting 85-3 for VLBI operation and pulsar monitoring and upgrades to the two-element interferometer for source flux density monitoring. Frank comes to us from the University of Minnesota where he developed extensive software for the automatic plate scanner. He can be reached at (304) 456-2208.

R. Fisher

INTERACTIVE 300-FT CONTROL SYSTEM

The 300-ft telescope can now be controlled interactively from the operator's terminal using the same commands as in programmed control. The transit instrument interactive commands are of limited use, but they are helpful for quick receiver checks on other tests. We have received several very constructive suggestions for simplifying the use of the command language on which we are working. Also, work continues on the menu-type setup system.

R. Fisher

IN GENERAL

PAGE CHARGE SUPPORT AT THE NRAO

Users of the NRAO telescopes and facilities are encouraged to publish their scientific results in a timely manner. To this end the NRAO provides partial page charge support to scientists at U. S. educational and scientific institutions.

In the past the fraction of the page charges that the NRAO would pay was predicated on the fraction of telescopes used that were operated by NRAO. This was cumbersome in the era of VLBI and inappropriate in the era of VLBA. The trend toward a multi-telescope, multi-wavelength, research similarly argues for a restatement of the page charge support formula. Therefore, beginning January 1, 1989 and thereafter the NRAO will support page charges with a reimbursement which does not depend on the fraction of authors eligible for support nor does it depend on the number of telescopes involved. The following applies whenever any one author is eligible and whenever at least one of the telescopes involved in the work reported is operated by NRAO.

When requested, the NRAO will pay the larger of the following:

(1) one third (33%) of the page charges of papers reporting original observations made with NRAO instruments when at least one of the authors is eligible for such support
(2) 100% of the page charges prorated by the fraction of authors who are NRAO staff members.

Two caveats. First, the intent of this support, clearly, is to assist users in getting their observations into print. The radio observations should, therefore, make a substantive contribution to the paper. Second, no page charge support is provided for publication of color plates. We hope to be able to relax this restriction in the future if the cost of color plates in the journals ever retreats from its currently outrageous position ($1600/page in the Ap. J.). As before, requests for page charge support should be made with the NRAO librarian in Charlottesville prior to publication. Four preprint copies of the paper must accompany the request. The familiar footnote reference to the source of funding and operation of the NRAO must appear ("The National Radio Astronomy Observatory is operated by Associated Universities., Inc. under contract with the National Science Foundation"). A convenient way to handle the latter is for users to footnote their institutional affiliation on the title page with "NRAO Visiting Astronomer. The NRAO is operated by ...."

R. L. Brown

NSF SUPPORTS LONG-TERM RESEARCH VISITS TO JAPAN

Members of the NRAO user community interested in a 6 - 18 month research visit to Japan should investigate a new NSF program. There is no proposal deadline, but six months should be allowed for proposal review and decision. For information contact:

Division of International Programs
Room 1208, National Science Foundation
1800 G. Street NW, Washington, D.C. 20550
Telephone: (202) 357-9558
e-mail: cwallace@note.nsf.gov

Paul Vanden Bout

NRAO LEAVING FTS NETWORK

Effective October 1, 1988, all NRAO locations will be disconnected from the Federal Telecommunications System. Callers may continue to reach all NRAO locations through their respective commerical telephone numbers. The main numbers are given here.

Charlottesville.....804 296-0211
Green Bank.....304 456-2011
Tucson.....602 882-8250
Socorro.....505 835-5690
VLA Site.....505 772-4011
AOC - Socorro.....505 835-7000

J. P. Lagoyda

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