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NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO
VERY LARGE ARRAY PROGRAM

VLA OBSERVATIONAL STATUS REPORT

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The capabilities of the VLA array vary with time because of the rapid changes during construction. This report is an attempt to communicate the current observational limitations of the VLA to both users and potential users.

The hardware configuration as well as the best estimates of the sensitivity of the VLA at the end of March are briefly outlined. More current estimates of the array status or information not covered in this report may be obtained directly from the VLA staff.

1.0 HARDWARE CONFIGURATIONS

Continuum observations at the four separate wavelengths 1.3 cm, 2 cm, 6 cm, and 20 cm are supported. Observations at three separate bandwidths, 50, 12 and 1.5 MHz, are possible. Circularly polarized feeds are used at all bands except 20 cm where linearly polarized feeds are in use.

There were a total of seventeen antennas operating at the close of the month. The location of these antennas from the array center are approximately 0.5, 1.6, 3.2, 5.2, 7.7, 13.6, 17.2 km along the West arm, .08, .09, .15, .5, .97, 1.6, 1.95 km along the East arm and 0.13 and 0.44 km along the North arm. The West arm is populated principally in the A configuration, the East arm in the B configuration and the North arm in the D configuration. The approximate minimum and maximum baselines are 0.04 and 18.3 km respectively.

There are three antennas assigned to the test array for testing purposes. Up to a maximum of 17 antennas may be usable for astronomical observations; however there are typically fewer antennas available.

2.0 OBSERVATIONAL LIMITATIONS

The best estimates of the sensitivity and resolution of the VLA are summarized in Table I. Unless otherwise stated, these parameters assume 15 antennas, a maximum baseline of 18 km and an observing bandwidth of 50 MHz. In general the parameter estimates are conservative.

Mapping of sources is restricted to small diameter sources. Sources with extended regions larger than 8', 3', 1', and 40" at 20, 6, 2, and 1.3 cm respectively, will be missing major fractions of flux density.

The large daytime single antenna pointing errors of 1 arcminute or more will influence observational strategy to the extent that synthesis observations at the high frequencies may necessitate several pointing checks during the run.

2.1 Dynamic Range

The dynamic range, loosely defined to be the ratio of the maximum source brightness to the minimum believable source brightness, is limited by phase stability. Many of the synthesized maps generated from VLA observations are limited by dynamic range and not noise.

2.2 Side Lobes

Since the array is populated only to 2 km along the East arm and to 18 km along the West arm the side lobe levels for sources at low declinations particularly near the equator can be greater than 20 percent. The clean algorithm is available to lessen the effects of the synthesized beam.

2.3 Interference

Externally and internally generated radio interference has had a variable influence on past observations taken in the 20 cm

TABLE I

VLA SENSITIVITY AND RESOLUTION *

Frequency (GHz) Wavelength (cm)	1.34 - 1.73 20	4.5 - 5.0 6	14.4 - 15.4 2	22.0 - 24.0 1.3
RMS Sensitivity (mJy) in 10 minutes (50 MHz bandwidth - 15 antennas)	0.9	0.6	6	9
RMS Sensitivity (mJy) in 12 hours (50 MHz bandwidth - 15 antennas)	0.1	0.08	1.4?	1.6 - 4?
Dynamic Range **	100	50	10 - 20?	10?
Synthesized Beam (arcseconds) (15 antennas - max. baseline:18 km)	2.2	0.67	0.26	0.13
Antenna Beam Size (FWHP - arcsecs)	1800	540	220	120
Undistorted Field-of-View (arcsecs) with 50 MHz bandwidth (max. baseline:18 km)	135	135	135	135
Brightest Source (mJy) Expected in Antenna Beam	100	2.3	<.1	<.01
Brightest Source (mJy) Expected in the undistorted Field-of-View with 50 MHz bandwidth with 18 km array	2.0	0.2	<.04	<.004

* Table entries are the best estimates as of March 31, 1979.

** Extremely dependent on declination, time of day, season, and frequency of calibration.

band. The amount of interference noticed in observational data has diminished recently.

2.4 Positions

Source position can be determined to approximately 0.10 arcseconds for sources in the north and about 0.3 arcseconds for sources south of 0 degrees declination.

2.5 Polarization

Circular polarization measurements are not presently possible because of the large circularly polarized side lobes.

Linear polarization observations are possible at 6 cm and 2 cm. The on-axis instrumental polarization can be determined to an accuracy of about 0.5 to 1.0 percent. This poor accuracy is partly a result of known pointing problems. Mapping the polarization of sources more than one arcminute away from the beam center may be subject to uncertainties greater than one percent because of the large linear polarized side lobes. Polarization observations in the 20 cm band are not currently supported and observations at the short wavelengths, particularly 1.3 cm, are severely hampered by pointing problems.

2.6 Spectral Line Capabilities

Not currently possible.

3.0 VLA CALIBRATORS

The general philosophy adopted by the VLA staff towards the measurement and compilation of "unresolved" radio sources used to calibrate the gain and phase of the VLA is to compile a list of sources which are sufficiently unresolved and unconfused to permit calibration at all bands to a few percent.

The list of phase and gain calibrators as of March 31 is presented in Table II. This list is by no means complete and will be updated at approximately three-month intervals. There exists a larger list of secondary calibrators which have a more limited use and can be used in conjunction with the primary calibrators. As the VLA staff collects more data, the primary list of calibrators will grow and become more complete.

There are currently a limited number of sources used for polarization calibration at 6 cm and 2 cm. The instrumental polarization can be calibrated using 0316+413, 0552+398, 0923+398, 1328+307, and 2005+403 at 6 cm and 0316+413 at 2 cm. 1328+307 is currently used to establish the absolute position angle. In long synthesis programs it is often possible to use the gain calibrator to calibrate the instrumental polarization. The list of polarization calibrators will be expanded in the near future.

4.0 SOFTWARE STATUS

The current on-site VLA software capabilities for converting raw visibility data into well-calibrated maps are best summarized by briefly listing the various tasks presently implemented at the different stages of data processing. No attempt is made to list the complete set of either the software options or its limitations.

The on-line computers, the Modcomps, automatically (a) change the LO phase to compensate for differential atmospheric refraction; and (b) correct the visibility phases for variations in the effective electrical length of the waveguide and some of the antenna LO paths (this latter correction is often termed the "round-trip phase correction"). In addition, gain variations caused by changes in the system temperature are corrected by using real time measured system temperatures. The latter correction may be turned on or off at the astronomer's option and by default is turned on at 6 cm and 20 cm only.

All further processing required to take the initially corrected visibility data from the Modcomps through calibration to the final

TABLE II

VLA CALIBRATORS

0007+171	XL,?UK	0605-085	XL,?UK	1245-197	
0016+731		0607-157		1252+119	
0056-001	?UK	0615+820		1253-055	XL,XC,?UK
0104-408	XL	0646+600		1311+678	?UK
0116+319	?UK	0707+476	XL,?UK	1313-333	XL,?UK
0134+329	XUK	0711+356		1323+799	
0150-334		0727-115		1328+254	
0153+744		0742+103		1328+307	
0201+113		0814+425	XUK	1334-127	
0202+149	XUK	0826-373		1357+769	
0212+735		0831+557	XUK	1402+660	XUK
0224+671	XL	0834-201	?UK	1404+286	?UK
0237-027		0836+710	XL	1418+546	?UK
0237-233		0851+202	?UK	1451-375	XC,XUK
0248+430	?UK	0917+624	XL	1458+718	XUK
0316+161	?UK	0917+449	XL,XUK	1502+106	?UK
0316+413		0919-260		1519-273	
0333+321	?UK	0923+392	XL,?UK	1538+149	
0336-019	XL,?UK	0945+408	XL,?UK	1555+001	?UK
0355+508	XL	0953+254	XL,?UK	1611+343	?UK
0406+121		1015-314	XUK	1622-297	
0420-014		1031+567	?UK	1633+382	
0426-380		1034-293		1634+628	XUK
0429+415	XUK	1055+018	XL,?UK	1637+575	XL
0430+052		1127-145		1637+826	
0438-436	XUK	1143-245		1638+398	?UK
0454+844		1144-379	XL,?UK	1641+399	XL
0518+165		1147+245		1717+178	?UK
0528+134		1150+812	XL	1726+455	
0529+075	XL,?UK	1155+251		1730-130	XL
0537-441	?UK	1216+487	XL	1741-038	?UK
0538+498	XUK	1222+037		1749+701	
0552+398	?UK	1226+023	XL,XC,?UK	1749+096	XL,?UK

1751+288	XL
1803+784	XL
1921-293	?UK
1928+738	
1958-179	XL
2005+403	
2007+776	
2021+614	
2128+123	?UK
2134+004	
2200+420	
2203-188	?UK
2230+114	?UK
2245-328	?UK
2331-240	XL
2345-167	?UK
2352+495	

All sources are phase calibrators. The position accuracies vary between .03 and 0.3 arcseconds.

All sources are unresolved over all frequencies and baselines unless otherwise indicated by:

XL, XC, XUK - do not use at 20 cm, 6 cm and 1 or 2 cm respectively,
?L, ?C, ?UK - not enough information at 20 cm, 6 cm and 1 or 2 cm respectively to know if they are good calibrators.

It should be noted that many of these sources are good calibrators over restricted baseline ranges and can be used as calibrators to obtain antenna solutions.

maps is accomplished using the DEC-10 general purpose computer. The software is quite extensive and employs an antenna-by-antenna calibration technique.

For the calibration of data there exist programs to (a) flag data good or bad, (b) correct phases for known source position errors, antenna position errors and time errors, and (c) correct amplitudes for general zenith angle dependent effects such as atmospheric absorption. First order antenna shadowing corrections and system temperature corrections for all bands utilizing the measured system temperature data are possible. The antenna gain, phase and polarization characteristics are calculated from calibrator source observations, interpolated in time and stored with the visibility data. It is possible to undo some of the corrections applied by the Modcomps; these currently include the round-trip phase corrections at all bands and the system temperature correction at 6 cm and 20 cm. There is additional software which allows the observers to calculate baseline and pointing errors from calibrator observations. The pointing and baseline parameters are regularly determined by the VLA staff.

The tasks for conversion of calibrated data to maps on the DEC-10 include sorting, gridding, fast Fourier transform, source subtraction in the u,v plane and the clean algorithm. Both u,v plane convolution (to aid in reducing the aliasing problems) and tapering are supported. Some limited mapping capabilities exist on the PDP-11/70. Map display formats include: character display on computer terminals and line printer output; contours with or without polarization on the Tektronix storage tube terminal and the Versatec dot matrix plotter; and gray scale and color images on the Comptal graphics terminal attached to the PDP-11/40.

Complete processing of VLA data from editing through calibration to mapping and cleaning is possible with the NRAO computer located in Charlottesville, Virginia. Any observers who plan to use this computer for processing VLA data should contact Ed Fomalont or Frazer Owen for more information. They will also be available for assistance in the use of the Charlottesville software.