VLB ARRAY MEMO No. 489

Pie Town Test Procedures

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VLBA Test Memo No. 1

Subsequent to installation and preliminary check out of the individual instruments (i.e. receivers, control system, recorders, local oscillator, etc.), a variety of system tests and calibrations followed by short regular observing sessions in coordination with the VLB Network are anticipated.

Gain.

Table I summarizes the specified error budget of the VLBA antenna elements.

Table I

Antenna Error Budget

Contributions	Primary Reflector (mm)	Primary and Secondary (.004") Reflector (mm)	Primary and Secondary (.008") Reflector (mm)
Panels and setting	0.18	0.21	0.27
Panels, setting, wind, thermal	0.23	0.25	0.30
Panels, setting, wind, thermal, gravity	0.28	0.30	0.34

Under conditions of no wind, thermal equilibrium (e.g. quiet night), and no gravity deformation (zenith angle equal to optimum value) the surface error budget is equally divided between panel accuracy and setting accuracy (each 0.125 mm) so that accurate setting will be important to the final performance.

I presume that the setting of the panels will be checked by conventional mechanical methods, but it is not clear if this will be sufficient, to set the surface in a way so that this does not dominate the error budget.

The most complete test of antenna performance will be from direct rf tests which will be sensitive to the accuracy and figure of the primary and subreflector surfaces, as well as the geometry. However, if we get an antenna of the quality we anticipate, it will be necessary to do this measurement at a wavelength much less than 1 cm, in order to distinguish small errors in measuring the efficiency from surface error. 3.5 mm seems to be an optimum wavelength, as it is near the lambda/16 point where the measurements will be sensitive to surface errors, but where the beam will still be reasonably stable and the pointing manageable.

John Payne has indicated that it would be possible to prepare a 3.5 mm radiometer with a system temperature of 110 K (DSB) and 600 MHz bandwidth. This would give an rms noise equivalent of 0.2 Jy in 1 sec, which should be adequate. The strongest non-thermal sources in the sky at this wavelength are about 30 Jy, and there are several more available in the range 5-30 Jy. There are also several well known compact thermal sources in the range 5-15 Jy. The planet Jupiter will be very close to the sun in early 1987. Mars and Saturn will be reasonably favorably located, but do not reach elevation angles higher than 50 deg and 35 deg respectively.

I understand that the 12 m efficiency tests were made in a total power mode, but I am concerned about the effect of sky noise which could easily exceed receiver noise by a factor of 10 to 100, and I would be more comfortable with including a chopper wheel to beam switch. This would make many more sources available. An accurate thermal calibration will of course be necessary.

As a check on the optics it will be desirable to be able to install the radiometer in 3 or 4 positions on the feed ring. It will also be necessary to have remote control of the focus. If the 3.5 mm feed is mounted on an adjustable mount (in 3 dimensions) it will also be possible to verify the correct feed position.

The radiometer tests will of course only indicate deficiencies in the antenna efficiency, but it will be difficult to assess specific problems. This is best done with holographic techniques. Two options may be considered.

1) Building a self-contained holographic system either using an artificial source, if a suitable one still exists, or using cosmic radio sources. The former method has the advantage of greater sensitivity, while the latter allows the change in surface errors caused by gravity deformation (a major contribution to the error budget) to be determined.

2) VLBI holography will not require building any new equipment and will give flexibility in the choice of wavelength. Once procedures are established it will be easy to extend the tests to the other antennas, if desired. However, because it is necessary to make frequent "on axis" measurements to establish a

phase reference it is not clear if sufficient precision and resolution can be achieved in a single observing session of 1 to 2 hours.

Some rough estimates by Alan Rogers indicate that we could map the surface with an accuracy of say 60 microns and 1 meter resolution in one hour, but this is very uncertain. Should we explore this technique further at the VLA say under moderately poor sky conditions to simulate the expected phase stability on the longer baseline to Pie Town?

The use of VLBI holography will require the VLBA record system at Pie Town operating in the 200 Mbps mode, and an upgraded MKIII at the VLA, the full VLA may be required to obtain adequate sensitivity. 1.3 cm is probably the best band, so that strong H_2O maser sources can be used. Otherwise 15 GHz would be used.

Pointing.

Rough pointing can probably most easily be done at 2 cm which is the shortest wavelength where we have a good receiver and where the antenna is expected to perform well. Assuming clear sky conditions, a stable total power radiometer should be adequate, especially if it includes a NAR capability. But the continuum radiometer should cover the entire bandwidth of 500 MHz. A TRF receiver is suggested with the detector located in the Cassegrain house.

I anticipate that these rough pointing measurements which may take a few days will be most straightforwardly done in a closely interactive mode, and simple chart recording should be adequate. For this phase of the pointing measurements the control system needs to be capable of setting in a source position and quickly and easily setting in a variety of azimuth and elevation offsets. I anticipate that this would be done from the local station control.

Precision pointing will be best done in the interferometer mode at 6 or 2 cm, the choice of wavelength depending on the atmospheric phase stability. This will require a VLBI recording capability, and the use of one or more VLA antennas. MKII recordings will be the easiest to handle at NRAO, but the VLBA/MKIII sensitivity may be required for the best results. This will mean doing the initial reductions at Haystack (or Caltech).

The precision pointing measurements will probably be carried out for a period of, say a few weeks, and with a lowered duty cycle for an extended period to assess diurnal and seasonal influences. Thus these measurements and subsequent analysis should be as automated as possible. This means being able to set up positions and offsets for periods of 8-24 hours in advance, and is best done from the central computer. I suspect that these observations might be delayed until central computer control is operational.

Considering the inconvenience of VLBI recordings and data reductions, as well as tieing up one or more VLA antennas for an extended period, it may be better to carry out as much of the precision pointing as possible in the single dish mode. This will require a digital back end and either a recording device or on-line reduction system to derive pointing offsets from the measurements.

Specialized Equipment and Procedures Needed for Pie Town Tests

1) 3.5 mm (switched?) broadband radiometer to be mounted in 3 or 4 feed positions.

2) Digital back-end and data recording device?

3) Reduction program to analyze pointing offsets, and best fitting pointing constants.

4) Automated (preferably remote) control of antenna, including focus, to set in positions and offsets for observing sessions of 8-24 hours.

5) Holographic system of some sort.

6) VLBA record system.

7) MKII record system.

8) Upgraded MKIII at the VLA.

9) 1 to 27 VLA antennas.

<u>Staff requirements</u>: The need for special operating personnel will depend to a large extent on the level of automation available. If full remote control is available from Socorro or the VLA site, operating staff requirements should be small. I anticipate that one (local) scientist will be involved essentially full time for a period of about 6 months in observations, reduction, and documentation. Some considerable effort will also be required to adapt existing software or algorithms for deriving pointing offsets from the observations, and best fitting pointing constants from these offsets.

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