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

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SINGLE-DISH APERTURE EFFICIENCIES AT 1.3 cm WAVELENGTH

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1.0 METHOD

All measurements have used Jupiter as the primary calibrator. In several cases they have been confirmed on Venus, when its configuration in the sky was favorable.

The initial check of pointing and focus performance was done at 6 cm on a strong calibrator, whenever the frequency was available, or more often at K-Band, on the Sun, with an absorber installed over the reference horn.

The resolution factor due to the finite angular size of Jupiter, has been taken equal to 97% (semidiameter 20"). An atmospheric absorption factor of 4.5% at the zenith has been adopted. The measurements are quoted for Jupiter very near transit with an altitude close to 50^{o}, in the period of October 1975 to January 1977. The calibration signal was measured with an ambient temperature hot load, and a liquid nitrogen cold load, installed over the primary feed shortly before or after the measurements on Jupiter. The bandwidth used was 50 MHz, the wavelength 1.34 cm, and the polarization circular.

Starting with antenna 7, not every antenna is single-dish tested, on account of the manpower effort involved. Some antennas are picked for a quality control check, whose objective is to verify quickly that the efficiency exceeds 40%.[1]

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[1] Some of these quality control measurements have used Cyg-A as a calibrator. This source is partially resolved at 1.3 cm, but the resolution factor has been carefully calibrated on several antennas, against Jupiter. Measurements in antennas 1-6 were conducted in a beam switching configuration, with two K-Band feeds, one occupying the position normally taken by the U-Band feed. The quality control measurements were done load switching against a room temperature load.

Interferometric system efficiency tests, of all antennas at all bands, are conducted periodically and will be described in the future.

2.0 EXAMPLE

On January 25, 1977, Jupiter was observed with antenna 6. The ON-OFF deflection was 81 units on the chart recorder. The CAL amplitude was 201 units, and the injected noise temperature was 13.2°K. The polar semidiameter was 19.7".

Then:

$$\text{EFF} = \frac{\text{SOURCE} \times T_{\text{CAL}}}{\text{CAL}} \times \frac{2k}{AS} \times KR \times KA$$

$$S = \frac{2kT\Omega}{\lambda^2}$$

where:

EFF - aperture efficiency

SOURCE - ON-OFF deflection on the source

T_{CAL} - injected noise temperature

Ω - solid angle subtended by Jupiter

T - brightness temperature of Jupiter, assumed 145°K

k - Boltzmann constant 1.38×10^{-23} JK^{-1}

A - antenna area : 490.6 m^2

KR - correction to account for the partial resolution of Jupiter, estimated to be 1.03

KA - correction to account for atmospheric absorption, estimated to be 1.06

S - radiation flux

λ - wavelength : 1.34 cm

then:

$$\text{EFF} = \frac{\text{SOURCE} \times T_{\text{CAL}} \times KR \times KA \times 0.0134^2}{\text{CAL} \times SD^2 \times \frac{98.47}{91.91} \times 490.6 \times 145 \times \frac{\pi^3}{(180 \times 60 \times 60)^2}}$$

where:

SD - polar semidiameter in arcseconds

$\frac{98.47}{91.91}$ - ratio of equatorial to polar diameters

or:

$$EFF = \frac{SOURCE \times T_{CAL}}{CAL \times SD^2} \times 3483 \quad \text{(in \%)}$$

finally:

$$EFF = \frac{81 \times 13.2}{201 \times 19.7^2} \times 3483 = 47\%$$

3.0 RESULTS

Antenna #	Aperture Efficiency %	Date
1	45	12/75
2	43	4/76
3	42	6/76
4	35	10/76
5	47	12/76
6	47	1/77
10	>40	11/77