MILLIMETER ARRAY
MEMO NO. 28

National Radio Astronomy Observatory
Charlottesville, Virginia

26 Nov. 1984

To: MM Array Project

From: R. C. Walker

Subject: Longer Baselines

So far the longest baselines under discussion for the MM Array are 1 km. Meanwhile, with great effort, VLBI experiments are being done at 3 mm. Is 1 km really the longest baseline of interest? Consider the following table of brightness sensitivities as a function of maximum spacing on the array. Equation 6 (multiplied by 2.5 to correct for an error pointed out to me by Owen) from MM Array Memo 21 has been used with Tsys = 100K, Dm = 10 m, bandwidth = 1 GHz, time and number of stations as shown in the table header.

Max Baseline km	Resolution at 1mm arc sec	Tb rms for 1 baseline 100 sec deg K	Tb rms for 351 baseline 12 hr. deg K
1	0.2	7.3	0.019
3 (VLA C)	0.07	65	0.17
11 (VLA B)	0.02	880	2.3
35 (VLA A)	0.006	8900	23.

The brightnesses given correspond to about 30 mJy rms noise on a single baseline in 100 sec or about 0.08 mJy on the full array in 12 hr. The longer baselines would surely depend on self-cal for calibration. Self-cal depends on detection of some signal from the source with the data to each antenna during a coherence time. The coherence time of the 3.4mm VLBI experiments has been as high as 700 sec, although lower values are typical (Rogers, Moffet, Backer, and Moran 1984, submitted to Radio Science). Since the atmospheric effects must be worse for VLBI than for baselines like those on the VLA, 100 seconds represents a conservative estimate of the coherence time that might be achieved.

The third column in the table gives the rms brightness sensitivity in 100 seconds for 1 baseline and is about 5 times the rms sensitivity of the sum of all baselines to each antenna in a 27 element array. Therefore, if a source of that brightness is in the field of view, it should be possible to self-cal and eventually reach the sensitivity of the fouth column. I am ignoring details such as the fact that the longest baselines of a configuration actually resolve sources of the size of the beam and that larger sources of the required brightness may be resolved and difficult to use. However all

antennas are connected to others by relatively short baselines which allows the use of less bright sources for the self-cal. These details, if included, should not seriously change the conclusions.

Is there much worth observing for which calibration is possible on the longer baselines? That is a question for the community as a whole and is, of course, one that is hard to really answer without actually trying observations. However there are some possibilities. If there are any HII regions that are still optically thick at these frequencies (there are at 1cm), they could be used for self cal on at least the B array. The resolution of 0.02 arc seconds corresponds to 20 a.u. at 1kpc. Very high angular resolution studies of the thermal gas in star formation regions might be possible. Are there other thermal sources that might be observed?

It will certainly be possible to study the cores of extragalactic sources, but it is not clear if they will be resolved (eg provide interesting structure to study) on these baselines. It is interesting to note that the resolution at 1mm wavelength in the A array is within a factor of about 2 of the resolution of intercontinental VLBI at 18 cm! One implication is that, if features can be seen, superluminal motions in souces such as 3C120 (0.0025 arc seconds per year) could be measured easily.

Are there any masers at the frequencies of the mm array? The SiO masers at 43 GHz would certainly be observable since they are often observed with VLBI. If there are any high brightness lines, they could provide yet another probe of the fine structure of star formation regions and of regions about stars undergoing mass loss.

If the MM Array is built at the VLA site, it should be possible to use at least the VLA track, if not parts of the rest of the system, to keep the cost of the long baselines down. Also note that the nearby VLBA antenna at Pie Town will have useful capabilities at 4 mm and can be used to extend the resolution of the A configuration. This could be especially useful for extragalactic studies.

In summary, the possibility of providing configurations for the MM Array as large as those of the VLA should be seriously considered.