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FUTURE MM-VLBI ARRAYS

M.C.H. Wright & G.C.Bower
Radio Astronomy laboratory, University of California, Berkeley, CA, 94720

ABSTRACT

VLBI observations at short millimeter wavelengths are required to resolve the compact radio components associated with active galactic nuclei. These components are optically thick at longer wavelengths, or obscured by scattering, as in the case of SgrA*. Large new telescopes planned for completion in the next 10 years provide a powerful new platform for millimeter and submillimeter VLBI. The atmospheric phase correction required for successful operation of millimeter arrays on baselines of several km also enable phase coherent VLBI observation with 20μarcsec resolution. This is sufficient to resolve structure on the scale of an accretion disk around a massive black hole in the nearest quasars. The new telescopes can be outfitted for VLBI at modest cost and should be planned with this capability in mind.

1. New Telescopes

The distribution of large mm/sub-mm antennas being planned around the Pacific rim show a striking resemblance to the optimum array configurations being discussed for the MMA. The possible large millimeter telescopes for a future Millimeter VLB Array are listed in Table 1. New telescopes included here are the NRAO Millimeter Array (MMA), the Japanese Large Millimeter-Submillimeter Array (LMSA), the European Large Millimeter Array (LMA), the Large Millimeter Telescope (LMT) which is collaboration of the University of Massachusetts and Mexico's National Institute of Astrophysics, Optics and Engineering, the California Array (CCA) which is the proposed merger of the BIMA and OVRO arrays and the Smithsonian Astrophysical Observatory Submillimeter Array (SMA).

We show in Figure 1 the *uv* tracks for 3C 273 for this new millimeter VLBI array (MMVLBA) at a wavelength 1.3 mm. The array will provide significantly better *uv* coverage for low declination and southern sources. The beam has a size of 20 μarcsec at 1.3 mm and is roughly circular for both northern and southern sources.

The geometric mean equivalent diameter is 35 m. Since all these telescopes are being built on good high sites with low antenna noise, it is reasonable to assume that a system temperature around 100 K will be obtained at 1 to 3 mm wavelength. Assuming a 256 MHz bandwidth which

Table 1: Locations and effective diameters for currently existing and proposed millimeter and submillimeter observatories.

Name	Location	Latitude	Longitude	Effective Diameter (m)
IRAM	France	44.6	-5.9	33
Pico Veleta	Spain	36.9	3.4	30
MMA	Chile	-23	68	50
LMSA	Chile	-25	69	70
LSA	Chile	-25	69	110
SEST	Chile	-29.1	70.7	10
LMT	Mexico	19.0	97.3	50
CCA	California	37	118	30
SMA	Hawaii	19.7	155.5	19
NOBEYAMA	Japan	35.8	-138.5	25

should become standard by the time these telescopes are built, the rms sensitivity is about 0.5 mJy in 1 min. This is about 20 times better than currently obtained with a system temperature of 200 K, an average diameter of 15 m and a bandwidth of 64 MHz. The brightness sensitivity is about 10^7 K at 1 mm.

2. Phase coherent Millimeter VLBI

The path length fluctuations due to atmospheric water vapor cause a serious loss of coherence in VLBI experiments. For the new millimeter array telescopes, it is anticipated that a combination of fast switching between source and calibrator, and phase correction from water-vapor measurements will be able to correct for atmospheric phase fluctuations, so that phase coherent aperture synthesis images can be obtained using baselines of several km. The new millimeter arrays are being designed to include this capability. If these corrections are successful, then the same techniques at each telescope, or phased array, in the proposed MMVLBA will provide phase coherent aperture synthesis images with a resolution of 20 μarcsec at 1.3 mm. Of course, most of the calibrators will themselves be resolved, so that self-calibration will be required to obtain the structure of the calibrators. The calibrator with it's known structure, and correction for the atmospheric phase can then be used as a phase reference for the unknown source.

3. Design Considerations

An ideal VLBI system would include a hydrogen maser, phase stable electronics in the LO chain and a recording device like the MK IV system. A test tone generator would also be nice. The

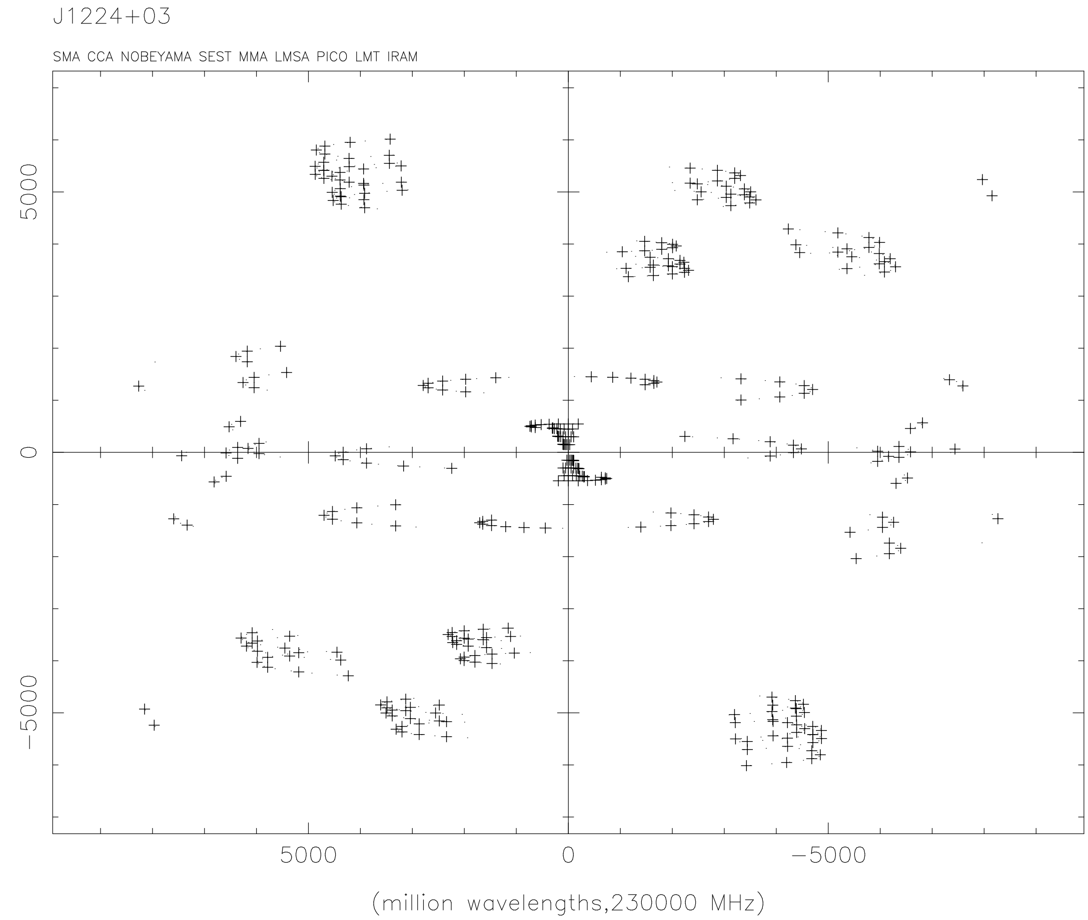

Fig. 1.— *uv* tracks for 3C 273 ($\delta = +03^o$) for the hypothetical millimeter VLBI array at 230 GHz.

cost of providing 256 MHz VLB recorders and maser time standards is about 1% of the MMA. Observing modes should include array phasing, dual polarization and rapid switching from local to VLBI modes.