# MILLIMETER ARRAY

# NEWSLETTER

Volume I No. 1 January 1984

## I. Millimeter Array Newsletter

This is the first issue of a newsletter intended to keep the astronomical community up to date on progress toward construction of a synthesis array for millimeter wavelengths in the U.S. Initially, the newsletter will be edited by F. N. Owen. Comments, requests, and/or contributions (of text or money) should be sent to F. N. Owen, NRAO, P. O. Box O, Socorro, NM 87801.

We hope to publish an issue about every six months in order to report the progress toward this goal. This issue will probably be a bit longer than average due to the introduction included for those of you not familiar with the activity of the last year.

We invite contributions in the form of letters or articles. We also invite requests for additions to our mailing list.

## II. General Introduction to the Millimeter Array

As most of you know, over the last year and a half discussions have begun concerning the construction of a millimeter array by the U.S. Very generally the idea is to build an instrument which would fill the needs for high resolution millimeter work in the same manner that the VLA serves centimeter astronomy. This implies a large number of dishes (probably at least 15 and maybe as many as 30) with a fairly large total collecting area.

Discussions of such an array began informally inside NRAO in spring of 1982. A first conceptual report on such a project was presented at an internal NRAO workshop on future instrumention in September 1982. Later that year two groups were formed outside of NRAO to discuss the future of millimeter astronomy in light of the failure of the 25 meter millimeter telescope to be funded by the NSF. The first group met a Bell Labs in October and concluded that a millimeter array would be the best instrument for the U.S. The second group was a committee formed by the NSF and chaired by Al Barrett reported to the NSF in April of 1983. Their first priority recommendations included a design study for a millimeter array.

General requirements for the array include operation from 1 to 10 millimeter wavelength, 1000 to 2000 square meters of total collecting area and an angular resolution of at least one arcsecond at 2.6 mm. In addition it would be desirable to have as much low surface brightness sensitivity as possible, and to have at least a 1 GHz bandwidth. With 100 to 200 K system temperatures (which are now becoming possible), such an instrument would be able to reach an r.m.s noise of 0.1 mJy in eight hours for a point source in the continuum.

The science that such an instrument would do is well summarized (as of early 1983) by the Barrett committee report to the NSF. While the expertise of the committee lay mainly in galactic and extragalactic studies of molecular lines and star formation, the report shows the vast range of projects which such an instrument would be able to undertake. Important contributions would be made to cosmology through studies of the fluctations in the microwave background and the Sunyaev-Zeldovich effect. Valuable work would take place concerning particle acceleration and emission processes in quasars and radio galaxies. The array would also be the biggest single collecting area available in the U.S. for millimeter VLBI studies of the nuclei of these objects. As mentioned many studies would concentrate on star formation both in galactic and extragalactic objects including both continuum and spectral line work. Chemistry in stellar envelopes and in shock fronts would also be opened up as an important new area for detailed studies. Besides stars and stellar systems which are still forming, much work would be possible on mass loss from more evolved stars which is necessary fo a better understanding of the giant region of the H-R diagram. Solar system work would include studies of the upper atmospheres of the giant planets as well as studies of the surface properties of the satellites and asteriods through continuum spectra and the heating and cooling of the surface layers. Global and small scale studies of the sun at millimeter wavelengths promise to tell us about the chromosphere and the mechanics of particle acceleration in solar flares.

The list given above just barely scratches the surface of the contributions which would be possible with a millimeter array. Almost every area of astronomy has something major to gain from this project. For more details see the Barrett committee report.

## III. Array Location

The configuration and location of the millimeter array are still open questions. However, initial ideas have taken shape on both of these questions. At present, the VLA site seems to be the best possibility for the array. Its altitude of 7000 feet, the large flat area available and the existing facilities and operation on the site make it hard to match elsewhere. Also our ability to test other sites without existing interferometers may be quite limited. Phase stability is the biggest unknown. We are studying possible approaches to this problem.

In the meantime we are studying the properties of the VLA site. Atmospheric phase stability measurements were started at the beginning of 1983 and are continuing using the VLA at 23 GHz. Initial results suggest typical phase flucuations equivalent to 0.5 arcseconds are typical and conditions as good as 0.1 arcseconds occur. These results are very similar to Jack Welch's measurements at Hat Creek. Atmospheric transparency measurements should begin early in 1984 using a 230 GHz receiver to make tiping curves.

We have also begun looking for other sites. Hat Creek and Owens Valley will be studied since they have existing instruments. Besides these two we are trying to identify potential sites above 9000 feet with moderately flat land extending at least two kilometers in two perpendicular directions. We have isolated four such sites in the southwest and west south of 38 degrees latitude. Suggestions for possible sites are welcomed.

## IV. Array Configuration

Much of the success of the VLA is the result of the excellent sensitivity and image quality at all accessable declinations (even for snapshots) provided by the large number of antennas arranged in a two dimensional array. It seems likely that we wish to follow the same principle in designing the millimeter array.

The sizes of the dishes for the millimeter array present a more difficult conceptual problem. First sensitivity to low surface brightness, and field of view push one toward small elements. However, point source sensitivity, high resolution, and calibration considerations suggest large antennas. As a result we are thinking in terms of a compound array. For high resolution work and point source detections an array of moveable ten meter dishes seems the best size. For low surface brightness sources, an array of smaller dishes, possibly 3 meters in diameter, would be better. Initially, it was suggested that we have two arrays, one of 10 meter dishes and one of three meter dishes. However, with such a configuration, there would still be problems of shadowing in the most compact configurations. Ron Ekers then pointed out that this could be avoided if the whole array could be tilted as one does with a single dish. From this point,the idea of a multi-element telescope as the central antenna in the array grew. However, instead of several mirrors focused on one detector as is the case in the MMT, the millimeter wave version would consist of many dishes, each with its own receivers and pointing.

The multi-element telescope would be used in several different modes.

1) The instrument could be used as an array of independent 3 meter dishes. Each would be correlated with all the rest. In this mode, assuming 24 three meter antennas, one would get the field of view of a 3 meter, the resolution of a 25 meter (or less by tapering) and the collecting area of a 15 meter antenna.

2) For detection and calibration, the IF's from all the 3 meter dishes would be summed and then correlated with each of the ten meter antennas in order to provide a more sensitive baseline to each of the ten meter antennas and to maximize collecting area for detection of small sources.

3) The multi-element telescope could also be used as a single dish by summing the IFs as in 2) and either beam switching or frequency switching.

4) A superwide field, low resolution mode would be possible by pointing each of the 3 meter dishes in slightly different directions.

5) A compound mode might be useful in which groups of 4 three meter dishes are correlated with each of the ten meter antennas.

In modes 1), 3) and 4), the ten meter dishes could be working on some other project.

Thus as shown in the figure (a conceptual picture only), we now are thinking in terms of a compound array with 21(+/-6) ten meter antennas and a multi-element telescope with 24 (or perhaps 36) three meter antennas (each with its own receivers and pointing).

## V. Millimeter Array Technical Advisory Committee

A technical advisory committee has been appointed to aid NRAO in preparations for building the array. The first meeting will take place on March 1 and 2 at the VLA. The members of the committee are

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| Paul Goldsmith | U Mass |
| Alan Moffett | Caltech |
| Pat Palmer | Chicago |
| Tom Phillips | Caltech |
| Larry Rudnick | U Minn |
| Tony Stark | Bell Labs |
| Bobby Ulich | Arizona |
| Jack Welch | Berkeley |
| Bob Wilson | Bell Labs |

Bob Wilson will serve as chairman of the committee.

VI. What Next ?

The next major event in our process toward actually building an array will be the advisory meeting on March 1 and 2. Sandy Weinreb has drawn up a proposed plan of action for the next four years of work on the project at NRAO. The plan tries to lay out an active program of development for the millimeter array while taking into account NRAO's existing commitment to the VLBA project. Of course, this means that the project will not advance as rapidly as it might if NRAO had no other commitments. However, even if we could move along at maximum speed, the fact still exists that the NSF is probably committed to building the VLBA in the next few years and thus if all goes ahead as planned with that project, a millimeter array could not start major construction in the next few years anyway.

While all this may be true, a combination of factors is delaying the start of construction until the late eighties at best. Maybe we should move ahead faster, somehow. On the other hand, Sandy's plan requires quite a commitment inside NRAO and must fight against other priorities as well as budget limitations over the period outlined. At any rate, we expect the advisory committee to give general as well as detailed advice on these matters.

We will review the entire project as a result of this meeting. We will let you know in the next issue of this newsletter more about a long term plan. Until then comments are welcome to especially addressed to Frazer Owen at NRAO or Bob Wilson at Bell Labs.