MILLIMETER ARRAY NEWSLETTER

Number 6 March 1987

I. Millimeter Array Newsletter

This is the sixth 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. The newsletter is edited jointly by F.N. Owen, P.C. Crane, and L.E. Snyder. Comments, requests, and/or contributions should be sent to

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

II. Developments

The NRAO millimeter array project continues to work on the definition of the proposed instrument and related matters. Progress is steady but slow because of (1) the stretch-out of the construction of the VLBA project and (2) the poor funding situation at NRAO in 1986-87 (and for most of the rest of astronomy). However, there is a possibility that this situation will improve after 1987. First, it now seems more definite that the construction of the VLBA will be largely finished in 1991. This, at least, gives us a time scale for action. If the funding climate were to improve suddenly, we might be able to start sooner, but otherwise 1992 seems to be the first year when major construction could start. Second, the astronomy budget may improve somewhat in 1988 and thereafter.

In the meantime, we have some things we can do to get ready. One is site selection. Since the Science Workshop in Green Bank in October 1985 which discussed the science to be done with the array, the biggest conflict regarding the instrumental requirements has been between projects that benefit from a high, probably small, site with very dry conditions and those that require long baselines but can tolerate higher opacities.

We have not been able to resolve this problem, but one idea has come up which might, at least theoretically, do so. A site on South Baldy in the Magdelena Mountains would offer a site above 10,000 feet with baselines as long as two kilometers. Such a site would also be near enough to the center of the VLBA that an array there could be used as a central element in the VLBA at a wavelength of 3 mm, just as the VLA can be used as a central VLBA element at centimeter and meter wavelengths. Furthermore, it is not impossible that some antennas could be permanently located at 7,000 feet between South Baldy and the VLA or even transferred between the two locations. Thus, it might be possible to have a high site with baselines of moderate length as well as a nearby site providing longer baselines. At any rate, this possibility has increased our interest in South Baldy.

Since we have a few years before funding for a millimeter array is possible, we have begun testing the atmospheric opacities at some possible sites. We now have two 225-GHz tipping radiometers operating at two sites of interest, at the VLA and on South Baldy at 10,600 feet. In this issue of the Newsletter, Dave Hogg reports the initial results from these radiometers. In the next six months we hope to have additional radiometers operating on Mauna Kea and at the 12-meter radio telescope on Kitt Peak. The Kitt Peak radiometer will be used as an observing aid and as a reference point for a site with which many of you are familiar. In the future we may also test at the Grand Mesa in Colorado, but logistics there will be more difficult than at any of the other sites we are considering for testing. The Aquarius Plateau in Utah is impossible logistically as it has no regular access or power, and some years more than 20 feet of snow falls there.

We would like to make a site decision by 1989. The data from South Baldy already look very promising. However, as time passes, we will obtain better ideas of the conditions on each of the sites being tested.

A second area of progress is in the design of the array. We have been reconsidering our need for a central element, at least for the relatively complex designs we have been considering up to now. Tim Cornwell discusses the current thinking on the subject elsewhere in this Newsletter. More work needs to be done to answer this question and other questions concerning possible configurations on high sites. We hope to make progress in this area over the next year.

Another major question is the upper frequency limit of the instrument. We have found that South Baldy has some time with less than 0.5 mm of water vapor and a lot of time with 1 mm or less. (A zenith opacity of about 0.06 corresponds to 1 mm of water vapor based on most of the current modeling.) This raises the question of how high a frequency the millimeter array should operate at if we were to locate it on this or another high site. Certainly 345 GHz would be feasible. Operating at higher frequencies might depend on questions other than the atmosphere, such as the performance of individual antennas.

Discussions have begun with the Smithsonian Astrophysical Observatory about joint efforts toward our projects. (The SAO has proposed building an array that would operate at submillimeter wavelengths.) Cooperation could involve joint work in technical developments, locating the two instruments

on a common site, or even a joint instrument. So far the discussions have resulted in committees being formed to study common problems. The University of Massachusetts, through its agreement to work with the SAO on the submillimeter array, is also involved in these discussions.

Work also continues on the conceptual proposal. A draft version has been circulated to the technical advisory committee. As a result of their comments and some of the points mentioned above, some more work is necessary before we can send it to community and to the NSF.

As usual, comments either to Frazer Owen or Paul Vanden Bout are welcomed on any of these subjects.

F.N. Owen

III. Thoughts on Short Spacings

The MMA design group has some new thoughts about methods of collecting short-spacing data for the array. If the array is to image objects larger than about a few arcminutes, measurements at short spacings in the range between an antenna diameter and a small fraction thereof must be obtained. Our previous solutions to this problem were to supplement the basic array of say 10m antennas either with an array of smaller antennas (perhaps 4m in diameter) or with a larger (perhaps 25m in diameter) single antenna using a focal-plane array for fast imaging. These two solutions differ little scientifically, but the former is more conservative since the technology of focal-plane arrays is just being developed.

Given these two solutions, one unanswered question concerns the optimum ratio of antenna sizes. The general wisdom is that this should be about 2.5 to 3 to minimize the effects of the poorly known illumination of the larger antenna and of any errors introduced in total-power measurements. However, the design group now believes that a third solution may be feasible - a solution that theoretically may allow a ratio of unity and the use of the basic array to measure all spacings. The idea is to scan or point the entire array over the region of interest at intervals much smaller than the primary beamwidth of the individual antennas; the overlapping measurements allow the estimation of the data for all spatial frequencies of interest.

We plan to pursue this possibility both by theoretical analysis and by observations with existing telescopes. The latter is particularly attractive since it may allow a considerable enhancement in the imaging capabilities of telescopes such as the VLA. In our theoretical analysis, we plan to look at the effects of errors in the assumed illumination, systematic errors in the observations, crosstalk between receivers, correlated atmospheric emission, etc. We welcome comments on this scheme from anyone but particularly from people with experience in the combination of single-antenna and interferometer data. Please contact either Tim Cornwell, Bob Hjellming, or Frazer Owen.

T.J. Cornwell

IV. Site Testing

As part of the design effort for the Millimeter Array, we have begun a program to evaluate a number of possible sites for the array. The first tipping radiometer began operation on South Baldy on November 8, 1986. A second system was placed in operation at the VLA on December 30, 1986. Two more radiometers will be completed in the next several months and will be placed at other sites of interest. Although only a limited amount of data from the first two radiometers is as yet available, we thought that a progress report would be appropriate.

Each of the tipping radiometers operates at a frequency of 225 GHz with a bandwidth of 1 GHz. The calibration of the temperature scale is made with reference to internal thermal loads. Observations are made every ten minutes by rotating a mirror to direct the beam of the radiometer in a series of steps between the zenith and the horizon. The opacity is calculated from the calibrated tipping curve. A rough check on the procedure is obtained by comparing the measured zenith temperature and that predicted from the measurement of zenith opacity; the consistency has been excellent.

The ten-minute samples have been binned into hourly intervals, and the median for each hour is computed. The hourly medians form the data base used in the subsequent analysis. The data collected so far are summarized in the table and are shown in the three figures:

1. A plot showing the fraction of the time the zenith opacity measured on South Baldy is less than the specified value (for those hours that the radiometer was working).

2. A similar plot of the data measured at the VLA.

3. A plot of the ratio of the opacity measured on South Baldy to that measured at the VLA as a function of the opacity at the VLA (when simultaneous measurements are available).

It is too early to draw any detailed conclusions from the data. However, it is clear that during the winter months there are many hours when the zenith opacity on South Baldy is less than 0.1 at 225 GHz. It is also apparent that the opacity at the VLA is typically higher, by a factor of about 2.2. This factor is approximately what one expects simply from the altitude difference between the two sites (10,600 ft vs 7,000 ft); for a scale height of 1.8 km the factor should be 1.9.

The experience with the radiometers has so far been fairly good. They appear to be measuring the opacities reliably, and the basic electronics have worked quite well. Storage of the data on a hard disk on South Baldy has proven troublesome, and steps are being taken to correct this situation. However, because of the remoteness of the site, it has not been possible to check the radiometer frequently, and so the storage problem has cost us an unsatisfactory (about 25%) fraction of the data. The radiometer at the VLA has worked well, and measurements are being made continuously.

Figure 1

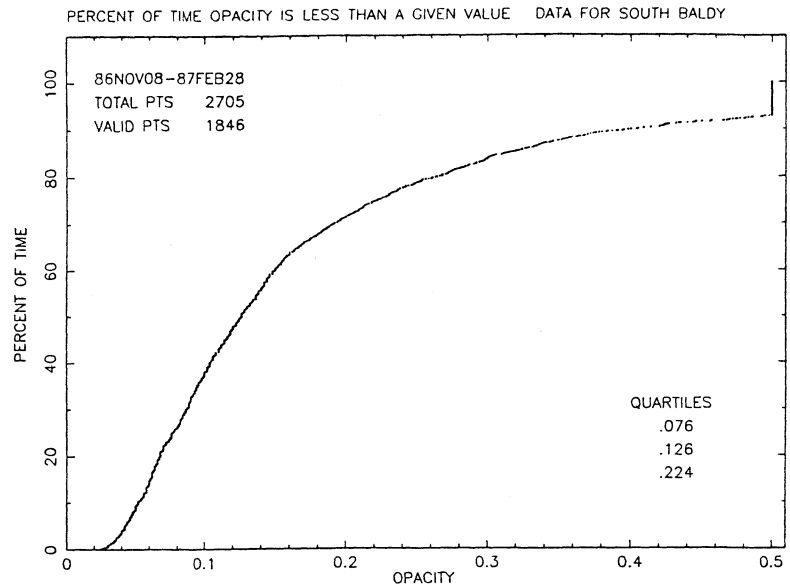


Figure 2

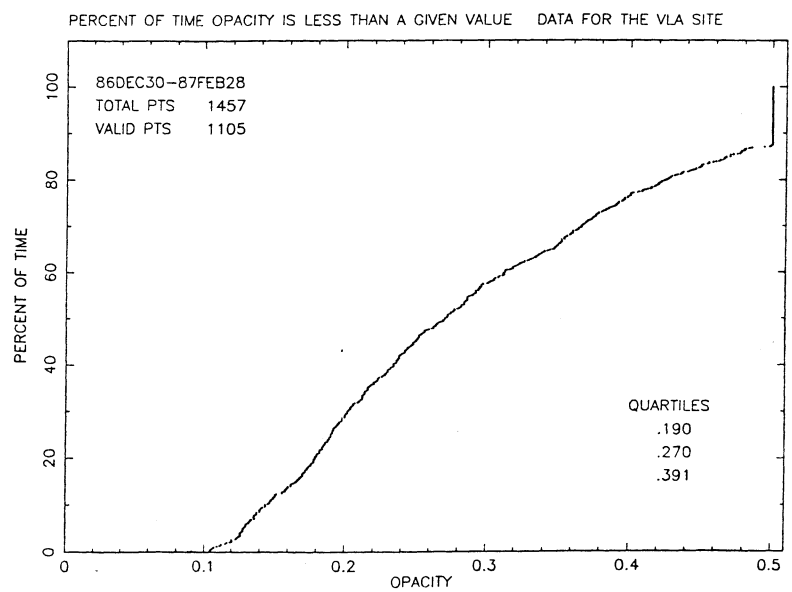
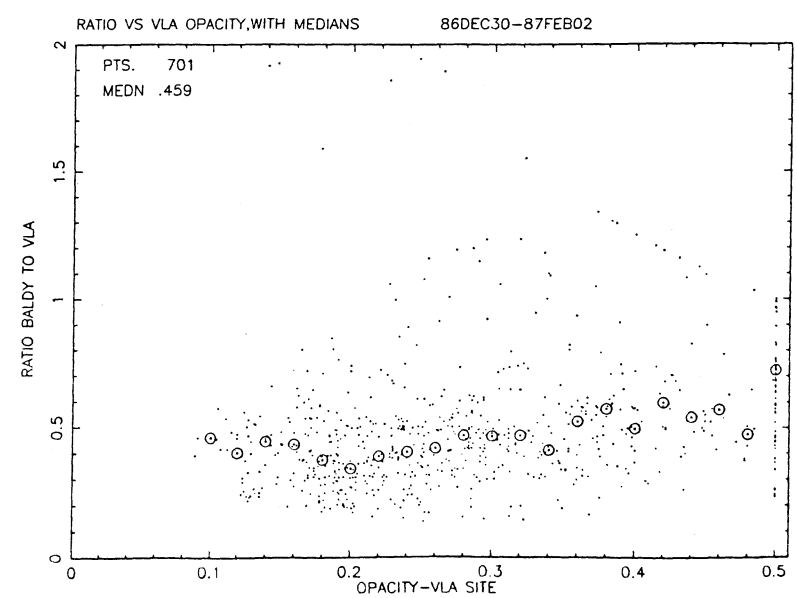


Figure 3



SUMMARY OF MEDIAN DATA

	BALDY	QUARTILES			VLA	QUARTILES		
MTH	PTS	Q1	Q2	Q3	PTS	Q1	Q2	Q3
NOV	426	0.089	0.144	0.222				
DEC	619	0.065	0.117	0.286	35	0.123	0.130	0.144
JAN	480	0.088	0.128	0.195	495	0.189	0.268	0.349
FEB	321	0.064	0.106	0.252	575	0.200	0.295	0.444
ALL	1846	0.076	0.126	0.244	1105	0.190	0.270	0.391

D.E. Hogg

V. More Thoughts on Mosaicking

From the Oxford English Dictionary, which notes that usage of "mosaic" as a verb is rare:

"A cottage ... embosomed, or rather matted and mosaicked, by roses and honeysuckles." - Tait's Mag. VI, (1839) 255.

"Its walks were mosaicked with small stones of various colours." - Arab. Nts., (Rtlg. ca. 1850) 239.

"It also wants William the Bad to mosaic the walls." - Freeman in W.R.W. Stephens, Life & Lett., (1890).

"A boy with a face mosaiced out in different squares of colour like a clown." - Mrs. A. C. Wilson, 5 Years India, (1895) 294.

"Prussia ... is new, and an artificial patchwork, without natural coherence, mosaiced out of bought, stolen, and plundered provinces." - Mottley, Corr., (Nov. 18, 1841).

"After all the rest of the world had been created the best bits were neatly cut out and mosaicked, so as to form Arcachon." - Even. Stand. 13, (July 3, 1867).

"They have mosaiced a hundred of his pithy apophthegms into our daily conversation." - W. S. Gilbert, Fogerty's Fairy, (1892) 331.

F.R. Schwab

VI. Millimeter Array Scientific Memorandum Series

The reports of the scientific working groups at the Millimeter Array Science Workshop are being released as Millimeter Array Scientific Memoranda. The last five reports have been released as Memoranda 5 through 9.

We encourage the radio-astronomy community to contribute to the Millimeter Array Scientific Memorandum series. Contributions should address specific scientific issues and their relation to the design of the array - for example, issues raised in the reports from the Science Workshop.

Contributions should be sent to

A. Wootten
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We invite requests for additions to our mailing list, which is identical to the mailing list for the Millimeter Array Newsletter.

The following five memoranda have been released since the last newsletter:

5	Low-Z Extragalactic Working Group Report 860825	L. Blitz et al.
6	Circumstellar Shells and Evolved Stars Working Group 860825	P. Schwartz et al.
7	Molecular Clouds Working Group Report 860825	N. Evans et al.
8	High Redshift Extragalactic Working Group Report 860825	B. Partridge et al.
9	Astrochemistry Working Group Report 860825	L. Snyder et al.

V. Millimeter Array Memorandum Series

One Millimeter Array Memorandum has been released since the last newsletter:

38	Crystalline Antenna Arrays 861210	T.J. Cornwell

Copies of individual memoranda may be obtained by writing to

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