MILLIMETER ARRAY
MEMO NO. 16

NATIONAL RADIO ASTRONOMY OBSERVATORY
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Report of the Millimeter Array Technical Advisory Committee

on their conclusions as a result of the meeting on March 1 and 2, 1984.

II Array Concept

1) Is it a good concept?

The present concept looks good, but it is hard for us to evaluate with our current knowledge. We feel that you must consider the science to be done with the instrument in some detail. Although we cannot know what measurements will be made with the array in the future, it would be desirable to simulate specific sources and the response of the instrument to them. VLA or Westerbork maps of 21cm emission would be a good starting point in some cases. Specific measurements which you might simulate are:

a) A measurement of the Sunyaev-Zel'dovich effect.
b) A one day CO observation of an NGC galaxy
c) A 1" Arc map of M101 in CO
d) Search for a proto-planetary system at 100pc
e) Map the CO absorption in Titan's atmosphere
f) Map various molecules in a giant molecular cloud in the Milky way or M31.
g) IRC+10216 or smaller stars in various lines
h) Any of the above in the J=2-1 line of CO.

The results of the simulations would hopefully show whether the UV coverage of the array is appropriate for such problems and give good publicity material for later use in selling the instrument.

2) Should we consider multibeaming?

Probably not. The number of correlators is already high and multibeaming could always be added later if it becomes easier.

III. Beam patterns

1) What types of calculations should we make in addition to those presented?

The simulations suggested above would be useful. It is important that the results be presented in map space so that members of the community who don't have much experience with interferometry will be able to understand them.

2) What are the important criteria?

Adequate dynamic range and sensitivity to low brightness regions. In the case of regions which are much larger than the primary beam, the problem of dealing with bright spots outside of the synthesized individual area of the mosaic must be faced.

IV. Mosaicing

1) Is mosaicing reasonable?

Yes - necessary. It will also be necessary to obtain the dc components for a large class of observations, either by using autocorrelations or observations with a single dish.

2) What tests, or calculations should be made?

This is a very critical area for the mm-array and needs more study. Some of the simulations suggested above require mosaicing and putting in the dc component. VLA measurements of extended regions should also be done to gain more experience with real data.

V. Sites

1) Should we even consider other sites than the VLA?

Yes, one must be prepared to answer questions which will certainly come up. The highest priority should be to establish whether the VLA site is acceptable. If it is, one would almost certainly use it.

2) New suggestions?

none.

3) South America?

This is not an attractive idea.

VI. Atmosphere, Site Testing

1) What site testing is necessary?

a) at the VLA?

Mm-wave atmospheric extinction measurements should be made in a variety of conditions. 22GHz radiometer measurements can probably be used for long term statistics.

Atmospheric phase stability must be established. From our present knowlege, mm-wave atmospheric seeing at the plains is marginal, so it is especially important to get more information. An interferometer measuring a microwave signal from a satellite might be a good, inexpensive way to do this. Joint work with Hat Creek, OVRO, and SAO may be desirable.

It seems worthwhile to explore correlations between readily measured atmospheric parameters and interferometer phase stability. The acoustic sounder that was mentioned is one possibility which should be pursued. This work has the advantage that the results would be useful at the VLA now. The VLA is potentially the best possible site testing tool. The cause of VLA phase instabilities should be investigated. Perhaps special instrumentation on a few antennas would allow one to measure phases more accurately on a few baselines. You should find out about antenna translation due to wind, as this must be separated from atmospheric effects of wind.

b) on other sites?

At this time there is no other site which is appealing enough to warrant full site testing. The Joint investigations mentioned above are all that we recommend.

VII. Numerical Techniques

1) What tests, or calculations should be made in this area?

This has been covered under II and III

VIII. Computers

1) We have not put a lot of work into this area. What should we be most concerned about?

It is appropriate that you not work much in this area. Computer hardware will change too much before the array is built. The best thing to do is to generate an algorithm for estimating the computing load that will be generated by proposed array relative to the existing predictions of VLA and VLBA needs. Considering the history of VLA computer needs, the estimates should be somewhat generous. These needs should be kept in mind in planning for NRAO's future computer needs.

IX. Antennas

1) General comments on our proposed antennas and plan of attack

We have an uneasy feeling about antennas. What has gone wrong with the 12 meter antenna? Although adequate antennas could be made by scaling conventional designs, modern techniques should

be investigated more carefully before making such a decision. A preliminary set of antenna specifications should be developed soon so that they can be discussed. The requirements for the multiple mirror structure seem especially unclear. Clustering of feeds should be considered for reducing the cost of refrigerators on the multiple mirror telescope.

2) Carbon Fibers?

Carbon fibers have obvious advantages, but being unproven, have more risk. Since the price of the fibers is decreasing and their advantages very appealing, they should be considered carefully.

3) Does the cost estimate seem reasonable?

The estimated cost seems acceptable, but in the light of the above and their preliminary nature cannot be taken very seriously.

X. Transporters

1) Any comments and suggestions

No.

XI. Electronics

A) Receivers

1) Is SIS the only way to go?

SIS is the most promising way to build a receiver now. SIS development should be supported both for the array and the 12-m antenna. Final decisions about receivers can and should be delayed.

2) Do cost estimates seem reasonable?

Several receivers should be put on one refrigerator, so that the cost of the refrigerator does not overwhelm receiver cost. The final optical design of the multiple mirror telescope will control the maximum number of receivers in one dewar. Receivers should cost about the same as the VLA receivers.

B) IF-LO

1) Seems clear cut; do you agree?

Yes. The existing study seems adequate for current planning.

C) Correlators

1) How many channels, total bandwidth?

The proposed bandwidth of 1 GHz is very desirable. It is not so clear that 1000 channels are required, especially if non-contiguous groups of channels could be provided. The array complexity and field of view will be limited by the cost of correlators; a trade between number of frequency channels and number of antennas will have to be considered. Flexible assignment of correlator channels is very desirable. How many channels would be needed to do the example observations mentioned under II?

2) Is the filter band/digital scheme clearly the correct solution?

The arguments for it are persuasive and it should be pursued. We will continue to watch the development of other techniques.

XII. Competition

1) Do we have any?

Yes, other mm-wave arrays and other techniques for doing the same or similar astronomy.

2) How should competition affect our plans?

We have to be sure that our proposed instrument is clearly superior to existing instruments which could make the same observations and that it opens the study of a significant range of astronomical phenomena which cannot be properly studied by other techniques. Competitive mm-wave instruments could be compared with the proposed array using the same simulations suggested above. The project should not be delayed overlong, or the United States will lose its radio astronomical pre-eminence. This project is clearly on the leading edge of radio astronomical technique.

XIII Technical Plan

1) What changes should be made in our plan?

Our most radical suggestion for changing the plan is to drop the construction of a full prototype interferometer. This is based on the relatively high cost of that project and the assumption that the benefits of such an effort can be largely

obtained in other ways. The OVRO and Hat Creek interferometer can be used as test beds for most interferometer related purposes except proving the Plains as a site. NRAO should consider having scientists and engineers make extended visits to these observatories to encourage that use. The 12-m can be used as a receiver test bed.

The proposed multibeam optics study addresses a general need in radio astronomy and should be done for that reason. It will probably not influence the initial development of the mm-array.

Hiring a post-doc to help with the array configuration studies is a desirable next step.

XIV What Next?

1) When should we submit a proposal?

A preliminary proposal should be prepared in 1-2 years.

2) What should people outside NRAO be doing?

We suggest that a small Scientific Committee be formed including a broad range of astronomical rather than technical people. Their charge would be to prepare the detailed scientific justification of the mm-array within a year. Starting with the Barrett report they should show how the array would solve specific problems better than any other method (and, of course, be flexible enough to discover numerous unexpected things). The simulation studies recommended in II should be coordinated to give them very specific examples. They would prepare the justification part of a conceptual proposal (like the VLBA Design Study) and aim it at the general astronomical and physics community.

Members of the technical advisory committee and other outsiders should be available to work on specific technical problems for which help is needed.