

November 19, 1962

Dr. Geoffrey Keller
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National Science Foundation
Washington 25, D. C.

Dear Geoff:

I will try here to give you a little more information about our proposed antenna project.

We believe that the next major development the NRAO should undertake is that of an antenna system with a resolution of the order of 10 seconds of arc. The desirable characteristics of such an instrument are roughly as follows:

- a) 10 seconds of arc resolution at some centimeter wavelength;
- b) ability to map a small region of sky -- five to ten minutes of arc in diameter -- to the above resolution in a reasonable time. "Reasonable time" is perhaps a few days, but this is a direct case where time required is a function of the money spent;
- c) considerable declination coverage;
- d) sufficient sensitivity to study several hundred sources;
- e) low side lobe levels, and no troubles due to grating lobes;
- f) ability to change operating wavelength over 10 to 1 range -- say 10 cm to 100 cm -- without great difficulty;
- g) antenna system should be expandable, so that by later addition of elements greater resolution could be obtained -- or perhaps do same thing by moving the elements.

The most feasible arrangement for such a system seems to be an array of moderate size elements, of 80 to 150-ft. diameter. The number of elements would determine the cost and would also set, along with some other factors, the time required to map a given region or source. It might be desirable that some of the elements be movable, on tracks for example, or that all of the elements be steerable in hour angle in order to utilize the changing orientation and effective baseline as a source is tracked across the sky, or both.

Among the many questions that need investigating are the following:

1) What would be the most advantageous configuration for the elements to obtain the greatest information per day from a given number of elements? Different configurations might be desirable for different programs. C. M. Wade and I. Pauliny-Toth are studying this problem now, and determining the characteristics of various possible configurations.

2) What is the optimum size of an individual element? Is it better to move elements, steer elements, or add more elements to get the required number of Fourier components? Questions of array sensitivity, cost, and time required for an observation enter here. J. W. Findlay, C. M. Wade, and others are studying this now. We also hope to have some antenna studies (of an individual element) made outside the NRAO to help provide information about this and some of the following questions.

3) What is the best wavelength?

4) Over how large a baseline can observations be made, before phase coherence deteriorates too much? We don't think the answer to this is known, and we think it can only be answered by an experiment. M. Vinokur has been investigating this, and we hope to start an experiment this year to help answer this question.

5) How should the elements be tied together (electronically) to maintain good phase stability? This involves transmittal of a phase stable local oscillator signal, or some phase reference signal, to each element of the array. M. Vinokur and several people in the electronics group are now studying various possibilities, both theoretically and experimentally.

6) What is the effect of the atmosphere on amplitude of the incoming wave, and on stability of a radiometer baseline? Are fluctuations in atmospheric emission serious at Green Bank (or at some other site) at 6 cm? at 10 cm? V. R. Venugopal is now conducting observations to investigate this at Green Bank -- later in the year we hope to move the experiment to some other site in order to get a comparison.

7) Is Green Bank a good site for this instrument, or should it be somewhere else?

8) How should phasing the array be accomplished?

9) How should the signals from individual elements be combined and recorded? There are many possibilities.

10) What are the general problems of data handling, reduction, etc.?

Many of these questions are interrelated, of course. There are also other electronic problems. I have indicated some of the things we are now doing. Other investigations of some of the above problems are also now in progress. Four scientists (Wade, Venugopal, Vinokur, Pauliny-Toth) and two

or three technicians are working more than half-time on these various questions. We will soon have two electronic engineers (Bringe, Keen) working full-time on them also. In addition, Pleasants and the engineering group are working on some of the mechanical and structural questions. And most of the other scientists on the staff are involved in various ways.

We hope to be fairly clear on the configuration of the array, operating wavelengths, size of individual elements, etc. before the end of FY 1963. We also expect to have narrowed down many of the questions of phasing, phase references, data handling, and so on. To this end we plan to spend some of the FY 63 antenna design study budget as follows:

- 1) Contract with two or three firms for studies of cost of an element as a function of size, operating wavelength, sky coverage, steerability.
- 2) Set up experiments to study phase coherence and phase reference problems over long baselines.
- 3) Investigate in the laboratory some of the other electronic problems.

In FY 1964 the planning should be far enough along that it will be possible and desirable to prove out many of the components and ideas by various further experiments. It is difficult to specify their exact nature at this time. It is probable that we will want to design and build one or two elements, full size, to test the design and performance, and get really good cost data. These elements would then be used to test various electronic schemes, observing procedures, etc.

The combined effort for FY 1963 and 64 of what we call Phase I in the development of a large antenna system is outlined in our budget submittal of October 4, 1962. To carry out the program described there and amplified (and I hope clarified) here, we have received about \$300,000 in FY 1963 and are requesting \$1.5 million in FY 1964. Our original request for FY 1964 was \$3 million, but when the total budget figure was reduced from \$10 million to \$7 million, we had to cut it.

I hope all this will help to give a better idea of our plans. Some time in the next few months we will have available reports which describe some of the work we have already done, and explain the reasons for the conclusions that have been reached thus far.

Sincerely yours,

D. S. Heeschen