Report of the Subcommittee on Millimeter Wave Facilities of the Advisory Committee for Astronomical Sciences

The Subcommittee met on July 16 and 17, 1979, in Washington, D.C., to advise the National Science Foundation on the following issues:

(1) From the material available, presentations made, and after deliberation on possible advantages and disadvantages of both the 25-meter fully steerable telescope and the 35-meter fixed spherical telescope, how should the NSF proceed with its funding plans for millimeter wave astronomy in the near future?

(2) In the event one of these two millimeter wave telescopes will soon be funded, at what site should it be located?

The committee heard presentations by the NRAO on their proposed 25-m fully steerable paraboloid to be located on Mauna Kea, Hawaii, and by the NAIC on their proposed 35-m fixed spherical telescope to be located on Angel Peak in southern Nevada. Consistent with the charge to the committee, the committee considered the two telescope projects without regard to their locations insofar as that was possible. However, since costs and scientific utility are determined in part by the sites, a complete separation of the two charges was impossible. Several sites in the general area of the Santa Catalina Mountains in the Coronado National Forest, northeast of Tucson, Arizona, were also actively considered by the committee.

Charge 1:

The committee is unanimous in recommending without reservation that the NSF fund immediately the 25-meter millimeter wave telescope, as proposed by the NRAO. The NRAO design is an excellent response to the needs of millimeter wavelength astronomy; it has been thoroughly studied, and realistic plans exist for the construction, management, operation, and maintenance of the instrument and facility. The NRAO is the best qualified institution in the country to carry out this program, with a long history of effective operation of comparable national facilities and a highly-qualified scientific, engineering, and technical staff.

It is the unanimous judgment of the committee that the 35-meter fixed spherical telescope advanced by the NAIC is not a realistic alternative to the 25-meter fully steerable telescope. Several fixed spherical telescopes would be required to obtain adequate sky coverage, equivalent to that of the 25-meter telescope. The

spherical telescope may have serious limitations as a spectroscopic instrument because of internal reflections, and it would not operate well at wavelengths below 1 millimeter with the radome currently envisioned. Engineering studies adequate to evaluate the feasibility, performance, and cost of the proposed fixed-mirror spherical telescope do not yet exist; in the judgment of the committee, these studies will take considerably longer and will cost far more than the NAIC suggests. Additional delay and expense may result from the fact that critical items, such as the complex two-mirror feed and feed support, have never before been constructed. It is the committee's opinion that the actual cost of constructing the 35-meter facility has been seriously underestimated by the NAIC. The NAIC staff also has relatively little experience in millimeter wave techniques and the committee finds this to be a serious shortcoming of the proposal. Nevertheless, the fixed spherical telescope, as exemplified by the Arecibo instrument, has proved a useful solution to obtaining a very large collecting area, and this may also be true in the millimeter wavelength range when the need arises for telescopes of very large diameter, perhaps 100 meters or more. Therefore, the committee feels that the NAIC may wish to consider studies of the feasibility of such a telescope, recognizing also that a large instrument of this type might be appropriate as an international project.

With regard to the NSF funding plans for millimeter wave astronomy, the committee felt it is absolutely necessary that the capital funds for this project should come from new money and not out of present National Center operating expenses or the University grants program. The unique capabilities of the 25-meter antenna in this exciting field which has been pioneered by astronomers in this country are important and timely for the continued strength of American astronomy and justify the expenditure of new funds.

The committee felt that operating expenses of the 25-meter telescope, above those of the present 11-meter antenna, should be obtained broadly from the NSF Astronomy Program so as not to place a special burden on the University Grants program. Since the 25-meter antenna will primarily be a user system, it would be counterproductive to reduce program funding to the very scientists involved in carrying out and interpreting the observations.

To summarize, this committee emphatically reaffirms the high priority for a large millimeter wave telescope as recommended by the Greenstein Committee and by subsequent NSF astronomy advisory groups. To implement this recommendation we believe the NSF should immediately support the 25-meter telescope proposed by the NRAO.

Charge 2:

The Committee considered at great length the choice of site for the telescope. This choice quickly narrowed to one between Mauna Kea, Hawaii, and a site in the Santa Catalina Mountains near Tucson, Arizona. In discussing these sites the committee could not ignore the thorny problem of costs, both initial capital outlay and subsequent operating costs, as they depend upon the site. While the group was unanimous in the view that, purely scientifically, Mauna Kea appears to be, by a considerable margin, the best site in the United States for the instrument, a majority also considered that the scientific return might be greater over the short term if a more accessible, and hence less expensive, mainland site were chosen. Indeed, a significant minority believed that the negative factors related to the remoteness of Mauna Kea from the NRAO electronics laboratories and the physiological problems of working at extreme high altitudes might conceivably act to reduce the quantitative amount of useful scientific output for Mauna Kea to less than what could be expected from a well-situated mainland site, especially in the short term. However, the qualitative breadth of scientific results would almost certainly be greater from Mauna Kea, and this factor might well grow to be more important over the longer term as technology at short millimeter and submillimeter wavelengths improves. The importance of not foreclosing this possibility led the committee to choose Mauna Kea as the preferred site.

The advantages of the Mauna Kea site can be summarized as follows:

(1) Mauna Kea is 12° lower in latitude than any suitable mainland site, thus providing the best possible sky coverage. In particular, the entire galactic plane is visible from Mauna Kea and the important galactic center region is available at substantially lower air mass than from continental sites.

(2) The annual average amount of precipitable water vapor over Mauna Kea is lower than at any other U.S. site with reasonable access. For example, comparison with sites in the Santa Catalina Mountains of Arizona shows that these sites have comparable but slightly more water vapor than Mauna Kea for nine months of the year but significantly more water vapor, perhaps by a factor of 3 to 5, during the summer months. Low water vapor is essential for operation at submillimeter wavelengths.

(3) Mauna Kea is free from locally-generated radio frequency interference and appears likely to remain so.

(4) The relatively constant climate at Mauna Kea will ease the problems of scheduling the observing programs of the large number of visiting astronomers who will use the facility.

(5) There is a possibility for some fixed-baseline interferometry at millimeter and submillimeter wavelengths using a smaller, university-built, submillimeter telescope which may be erected on Mauna Kea.

(6) Mauna Kea can accommodate only a limited number of facilities. Sites on Mauna Kea for major new installations will not be available indefinitely, and it is important that the major U.S. millimeter-wave facility not be denied access to this excellent site. Foreign-based astronomers are presently located on Mauna Kea and others are making inquiries.

A site in the Santa Catalina Mountains of Arizona has several advantages over the Mauna Kea site. These can be summarized as follows:

(1) Capital construction costs and operating costs appear to be significantly less at a mainland site. This fact alone weighed heavily on the committee.

(2) The task of recruiting a permanent professional staff to maintain the sophisticated electronic equipment would undoubtedly be simplified at a mainland site.

(3) The efficiency of those personnel who must work at the site would likely be improved by virture of working at a lower elevation, typically 2700 meters in the Santa Catalina Mountains versus 4200 meters at Mauna Kea. This most probably will have an impact on the quality of operations and equipment maintenance.

The committee was informed that construction costs at Mauna Kea can be significantly lowered, from $27M to $22.85M, by funding the NRAO project on a two-year rather than a four-year time scale. Not only is this a major dollar saving, but it brings the telescope "on line" two years sooner, a situation of great scientific importance in such a rapidly moving field.

The various factors which were considered to favor one site or the other have been enumerated above. The committee feels that if the increased costs of construction and operation of the 25-meter telescope on Mauna Kea were to jeopardize the entire project, then the same instrument should be funded by the NSF for

construction and operation at a site in the Santa Catalina Mountains of Arizona. However, even though the factors favoring one site over another are difficult to quantify, these factors do point to Mauna Kea as the scientifically superior site. Therefore, the committee strongly recommends the NSF fund immediately the construction and operation of the 25-meter telescope on Mauna Kea.

Submitted by:

SIGNED

Alan H. Barrett
Chairman

Committee Members:

Dr. Alan Barrett (Chairman)
Dr. Robert Gehrz
Dr. Carl B. Heiles
Dr. Richard Huguenin
Dr. Donald R. Johnson
Dr. Robert B. Leighton
Dr. Alan T. Moffet
Dr. Donald E. Osterbrock
Dr. John Ruze
Dr. Philip Solomon
Dr. Lewis E. Snyder
Dr. Patrick Thaddeus
Dr. Charles H. Townes
Dr. Paul A. Vanden Bout
Dr. Robert W. Wilson