THE LARGE MILLIMETER-WAVE TELESCOPE

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1. Introduction

The Large Millimeter-wave Telescope (LMT) is a joint project of the United States and Mexico. The project goal is to construct and operate a 50m diameter millimeter-wave antenna. The antenna, shown schematically in Figure 1, will be built on a mountain site in Mexico and will have the highest gain and the highest overall sensitivity of any millimeter-wave antenna ever constructed. The total construction cost is estimated to be approximately 46 million dollars, with completion of the telescope in the year 2000. Initial instrumentation for the antenna will emphasize focal plane arrays for spectroscopy and continuum observations in the 1.3mm wavelength region. Key scientific projects to be carried out with the LMT include studies of: (1) molecular ISM in high redshift systems; (2) spiral structure in external galaxies; (3) chemistry and structure of molecular clouds and star forming cores; and (4) chemistry and physical properties of primitive objects in the solar system.

2. LMT Technical Goals and Approach

The technical goals of the LMT are ambitious. The 50m diameter of LMT provides a total collecting area of ~ 2000 m^2 which must have sufficient precision to operate from 4mm wavelength to less than 1mm wavelength. Moreover, the large diameter implies a small beam which must be pointed to high precision. For the important 230 GHz frequency window, the requirement for $\lambda/20$ optics leads to an overall error budget of $\leq$70 microns rms. At this frequency, the half power beam width of the antenna is 6 arcsec, so the desirable rms pointing accuracy is about 0.6 arcsec, corresponding to one-tenth of the HPBW.

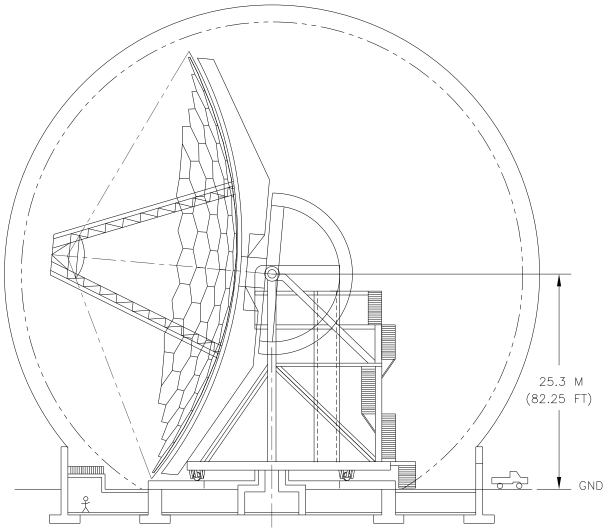

Figure 1. Schematic Drawing of the Large Millimeter Telescope.

The LMT will achieve its technical goals tΞhrough the use of active control systems to maintain the precise optical alignments that are required. This approach has several advantages over a more traditional approach where the accuracy of the structure is obtained through the use of a stiff structure and precision manufacturing. However, for this program, the principal advantage is that it enables construction of a large precise structure at an affordable cost.

The active systems currently planned for the LMT include: (1) an active primary surface following the approach used for the Keck 10m optical telescope; (2) a laser metrology system to sense the alignment of the major optical elements; (3) an active secondary for fine pointing and tracking adjustments; and (4) a wavefront sensing system for correcting pointing shifts due to atmospheric propagation effects. In the following sections, we describe our basic approach for the active surface and the antenna pointing.

3. LMT Active Surface System

The LMT will be a "fully active" antenna with a surface that is designed to be controlled at relatively high bandwidth ($\sim$ 1-10 Hz). The basic approach follows the scheme developed for the successful Keck optical telescope and divides the primary surface into 126 hexagonal segments. Each segment consists of a set of precision surface panels mounted on a stiff "subframe". The segment dimension is approximately 5m.

Figure 2 presents a conceptual block diagram of the active surface sys-

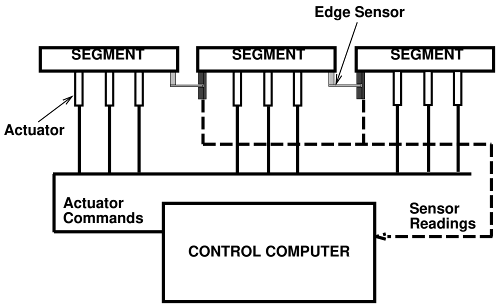

Figure 2. Conceptual Block Diagram of LMT Active Surface

tem. Each segment is attached to the backstructure by 3 actuators which permit 3 degrees of freedom per segment to be controlled. These degrees of freedom correspond to tilt of the segment and translation perpendicular to the antenna surface. There are a total of 378 actuators — or 378 controlled degrees of freedom — in the structure. The positions of the segments are sensed by measuring the relative positions of the *edges* of the segments. With two sensors at each segment boundary, there will be 684 total sensor measurements to provide the information required to adjust the 378 actuators. The current error budget for the antenna optics including the active surface system is 69 microns rms.

4. LMT Pointing Control System

Sub-arcsecond pointing of a structure the size of the LMT is clearly a major challenge. The antenna must be pointed blind, and preliminary structural studies have indicated that "non-repeatable" pointing errors of approximately 2-3 arcsec are likely. Thus, an approach to dealing with these sources of error is required.

The LMT approach to pointing involves: (1) the active surface system itself, which removes many pointing difficulties associated with surface deformation; and (2) enclosure of the telescope within a radome to protect it from the wind. In addition to these factors, a study by Kaman Aerospace has proposed a system to measure the alignment and spacing of the major optical elements in order to correct the telescope pointing. The budget for mechanical pointing errors with the Kaman system is 0.84 arcsec. Thus, although this approach comes close to the desired level of 0.6 arcsec rms, the problem will require continued study. Moreover, an important point is that the atmospheric "seeing" errors themselves are likely to be comparable contributors to the overall pointing errors, and ideas for actively sensing these errors during observations are now being evaluated.