The Large Millimeter Telescope

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Abstract

A summary of the Large Millimeter Telescope Project and its present status is presented on behalf of the LMT Project Team. The Large Millimeter Telescope (LMT) is a joint project of the Instituto Nacional de Astrofísica, Óptica y Electrónica (INAOE) in Mexico and the University of Massachusetts (UMass) in the USA to build a 50m-diameter millimeter-wave telescope. The LMT is being built at an altitude of 4600 m atop Volcán Sierra Negra, an extinct volcanic peak in the state of Puebla, Mexico, approximately 100 km east of the city of Puebla. Construction of the antenna is nearly complete, with the basic structure in place since the end of 2005. Initial installation of the reflector surface panels for the inner 50% of the surface area was completed in 2006, which enabled a measurement of first light at centimeter-wavelengths at the dedication of the telescope in November 2006. Final installation of this portion of the reflector surface is now underway with the expectation that first light at millimeter wavelengths will occur in 2008.

1. Introduction

The Large Millimeter Telescope (LMT) is a 50m-diameter millimeter-wave radio-telescope. The LMT project is a bi-national collaboration between the USA and Mexico, led by the University of Massachusetts at Amherst and the Instituto Nacional de Astrofísica, Óptica y Electrónica (INAOE). The construction of the LMT at an altitude of 4600m on the summit of Sierra La Negra, an extinct volcano, in the Mexican state of Puebla has been a significant challenge, but the process is nearing completion. Full movement of the telescope, under computer control in both azimuth and elevation, has been achieved. First-light at centimeter wavelengths on astronomical sources was obtained in November 2006. Installation of the precision surface segments is underway. Following the adjustment of the primary surface, delivery and installation of the secondary and tertiary mirrors, the scientific commissioning of the telescope will begin in 2008. When finally completed and outfitted with its initial complement of scientific instruments, the LMT will be a world-leading scientific research facility for millimeter-wave astronomy.

The major LMT characteristics are summarized in Table 1. The LMT will be an ``open-air'' telescope with no radome or astrodome enclosure to obstruct its view. This configuration gives the optimum performance under the best observing conditions, particularly for measurements with sensitive, broadband continuum systems. Since the antenna is directly exposed to the wind and solar insolation, however, the telescope performance will degrade in some meteorological conditions and care must be taken to find methods to mitigate this. The LMT approach is to create an ``active'' telescope which measures properties of the antenna in real time and uses the predictions of finite element models of the structure to improve its performance.

Table 1 - LMT Summary	
Antenna Diameter	50 m
Primary Surface	180 panel segments under active control to correct for gravitational deformation and thermal distortion.
Surface Accuracy	75 microns RMS
Operating Wavelength	0.85-3.4 mm
Field of View	4 arcmin diameter
Resolution	5 – 18 arcsec
Pointing Accuracy	1 arcsec

2. LMT Site

The LMT site was selected in 1997 following radiometric testing at a number of potential mountain sites in Mexico. The location of the LMT at a latitude of 19 degrees was a significant factor in its selection, providing very good coverage of the southern sky, with the Galactic center culminating at an elevation of about 45 degrees. The high altitude of the LMT site (4600m) was found to be necessary in order to achieve the best millimeter-wavelength atmospheric opacities which, as measured by a 225 GHz tipping radiometer, are low for most of the year. The summer months, however, are relatively humid and cloudy so that the best high frequency observing conditions occur during the winter. Figure 1 shows the site opacity statistics for data obtained during 1999-2007. From October through May, the third quartile opacity at 1.3mm is <0.2, while the first quartile opacity falls below 0.1. Thus, the site has submillimeter qualities during a significant portion of the year, and even during the summer months, the site is good for observations in the 3mm window.

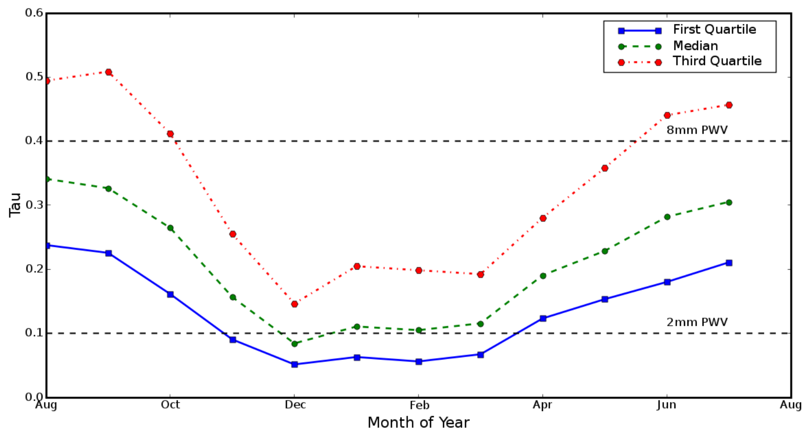

Figure 1: Plot of opacity derived from 225 GHz radiometer measurements at the LMT over the period of 1999-2007. The first, second (median) and third quartiles of the data are shown. The site allows for 3mm operation throughout the year, while 1mm wavelength operation is best done from October through May.

3. Telescope Status

A view of the LMT at the Sierra Negra site is presented in Figure 2. The telescope structure is complete, and the main remaining work involves completion of the reflector surface and optics.

Figure 2: Large Millimeter Telescope

The LMT is a bent Cassegrain optical system. The secondary mirror is being fabricated at INAOE. The secondary positioner and tertiary mirror system are being fabricated at CIATEQ, another technical institute in Mexico. Figure 3 shows the secondary and tertiary subsystems. An initial secondary mirror is shown with its positioning system. A final version of the secondary mirror is in fabrication and due to be completed this year. The tertiary mirror system is also nearing completion and due to be completed this year.

Figure 3: Left: Secondary mirror with hexapod positioner and mount. Right: Tertiary mirror with positioner.

The inner 50% of the reflector surface was installed for the LMT dedication in November 2006, and first light was obtained at a wavelength of 3 cm. Following this initial installation, the segments of the inner portion of the surface have undergone a major internal realignment and reinstallation in order to enable millimeter-wave work. Figure 4 shows results of measurements of one of the segments installed on the telescope during the realignment and reinstallation process. The measurements show an rms of 30 microns, which indicates that the system requirements for the segments can be achieved through careful work.

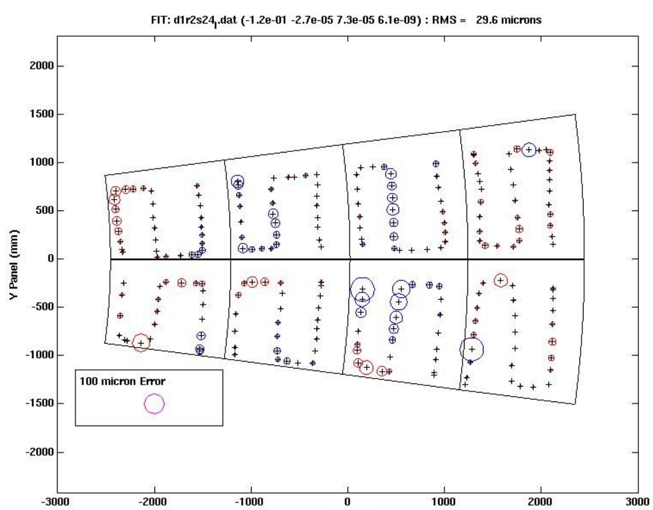

Figure 4: Laser tracker measurements of an LMT segment installed on the antenna.

Following the completion of the inner 50% of the antenna's reflector surface, expected in 2008, the antenna will be aligned and used to demonstrate the basic system performance. The components for the remaining 50% are presently being acquired and will be assembled and installed over the approximately one year following initial demonstration of the system with the inner 50% of the area.

4. Instrumentation Status

The initial complement of LMT instruments is summarized in Table 2. The development and fabrication of the first generation LMT/GTM instruments has proceeded in parallel with the construction of the telescope. Several of these instruments have been fully commissioned and placed on existing telescopes to carry out fundamental millimeter research and pathfinder science for the LMT/GTM.

Table 2 – LMT Instrument Summary

Instrument	***Status***	***Description***
SEQUOIA	COMPLETE; deployed on UMass 14m antenna.	32 pixel heterodyne focal plane array for 85-115 GHz
AZTEC	COMPLETE; deployed on JCMT and ASTE telescopes.	144 pixel bolometer focal plane array; Si-Ni spider-web bolometers; Operating bands 1.1 and 2.1mm
Redshift Search Receiver	IN FINAL TESTING at UMass 14m telescope.	Dual pixel, dual polarization ultra-wideband receiver for 75-111 GHz
SPEED	UNDER DEVELOPMENT	4 pixel x 4 frequency array; Frequency Selected Bolometers at wavelengths 0.85, 1.1, 1.4, and 2.1 mm.
1mm Heterodyne Receiver	UNDER DEVELOPMENT	Single pixel, dual polarization, SIS, heterodyne receiver for 210-275 GHz; 8 GHz bandwidth in each sideband.