Optics Design and Optimizations of the Multi-Color TES Bolometer Camera for the ASTE Telescope

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Wideband mm/submm continuum observations provide great opportunities to explore the cosmic history of star-formation across the Hubble time via observations toward submm galaxies and nearby galaxies, as well as the clusters of galaxies through the Sunyaev-Zel'dovich effect. To promote such studies, a new TES (Transition Edge Sensor) bolometer camera for the ASTE 10-m telescope has been developed. The observing bands are carefully selected at 1100, 850, and 450 μm. In this study, we design the re-imaging optics to realize multi-pixel, wide field of view, and multi-color system under the limitation of the Cassegrain system of ASTE.

The optics is designed using the ray-trace method. Figure 1 and 2 show the designed cabin optics and cold optics. The optics has capabilities of the two-color observation and the 7.5 arcmin field of view. The pixel numbers are optimized to be 169, 271, and 919 for the 1100, 850, and 450 μm bands, respectively. The imaging qualities of the designed optics is enough better to achieve diffraction limit at the shortest wavelength.

The designed optics is simulated by physical optics to evaluate the influence of diffraction. The beam properties are calculated by tracing the propagations of the electro-magnetic wave radiated from conical horns. Consequently, the aperture efficiencies are ~35 %, 35 %, and 32 %, and the beam sizes (FWHM) are ~28″, 22″, and 12″ for the 1100, 850, and 450 μm bands, respectively. Thus we demonstrate the designed optics can achieve sufficient optical performance at the observing bands.

Based on the optics design, the bolometer camera were fabricated and evaluated. The first on-site installation was performed in May 2012. The upcoming scientific runs expected to create new scientific achievements for understandings of the formation history of the Universe.

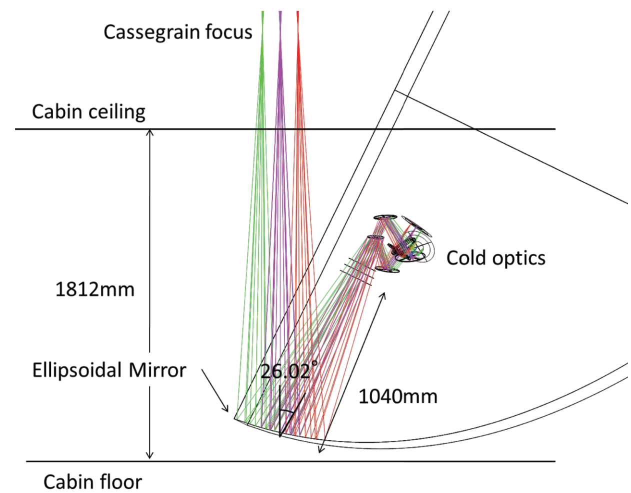

Figure 1: Receiver cabin optics. The rays reflected by the main- and sub-reflectors focus near the ceiling of the receiver cabin, and go into the receiver cabin. A modified ellipsoidal mirror optimized by adding fifth-ordered polynomials to reduce aberration is located near the bottom of the cabin to refocus the outspreading rays into the camera cryostat.

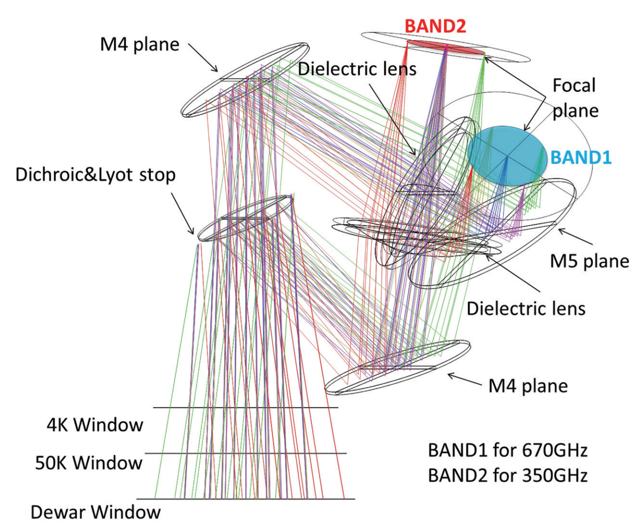

Figure 2: Cold optics. The rays reflected by the ellipsoidal mirror go through a cryostat window. The dichroic filter divides incoming rays into two bands. Each ray is focused at the focal plane after a flat mirror and a high density polyethylene lens, and couples with a conical horn.

Reference

[1] Takekoshi, T., et al.: 2012, *IEEE Trans. Terahertz Sci. Technol.*, **2**, 584.