The TolTEC Camera on the 50 meter LMT Telescope

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Optical System

The TolTEC optical design simultaneously couples a 4 arcminute diameter FOV onto its three single-band focal planes. The silicon lenses are AR-coated with diced sub-wavelength features (Datta et al. 2013)

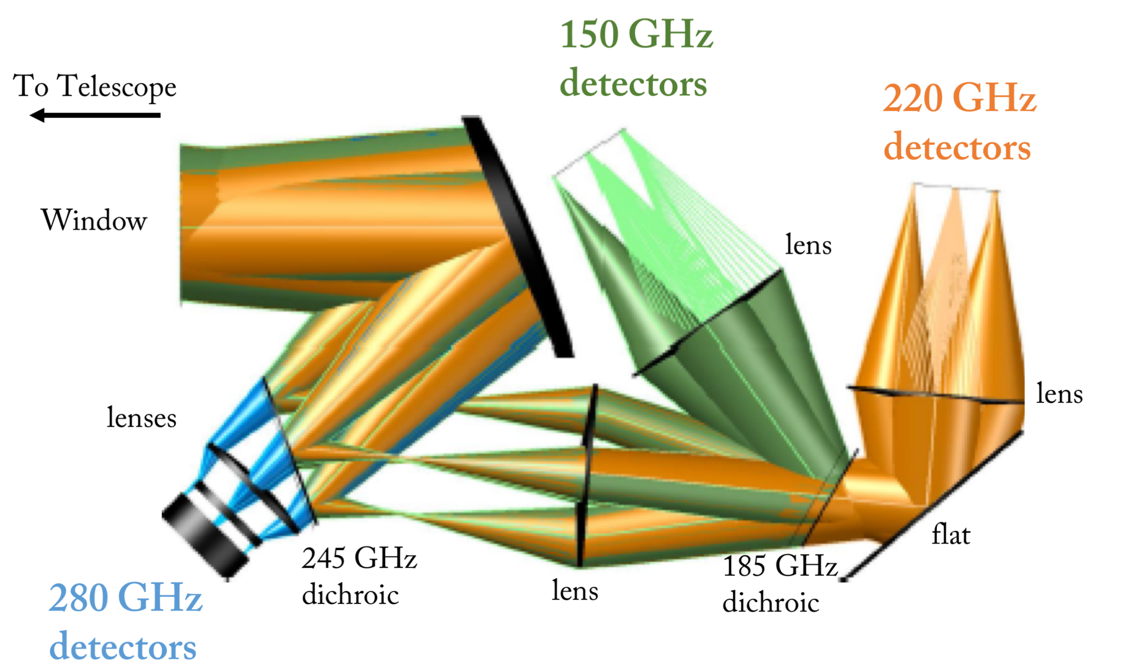


Figure 1: TolTEC cold optics layout, top schematic view.

A rapidly-rotating ambient-temperature metamaterial half-wave plate (Pisano et al. 2008) is attached to the cryostat just skyward of the vacuum window.

LEKID Detectors

The camera uses three arrays of single-band polarized LEKID detectors fabricated at NIST.

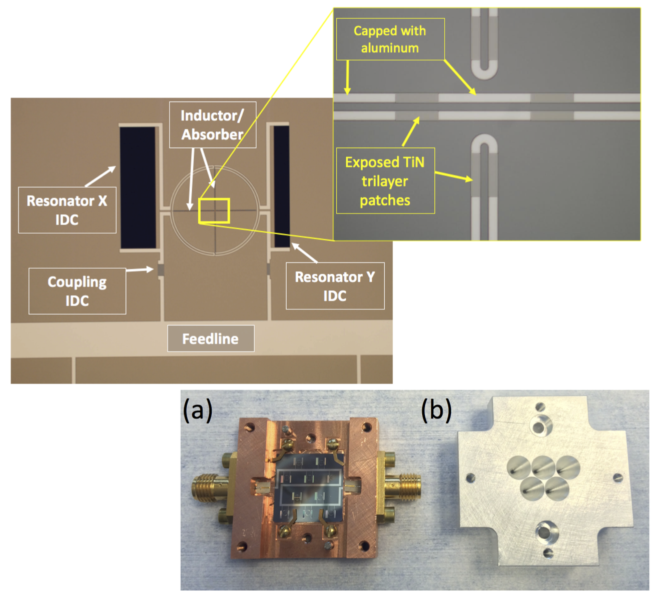


Figure 2: An individual LEKID detector (top) and a prototype detector and feedhorn array (bottom).

The prototype 1.1 mm (280 GHz) array has promising sensitivity, passband, and polarimetric performance.

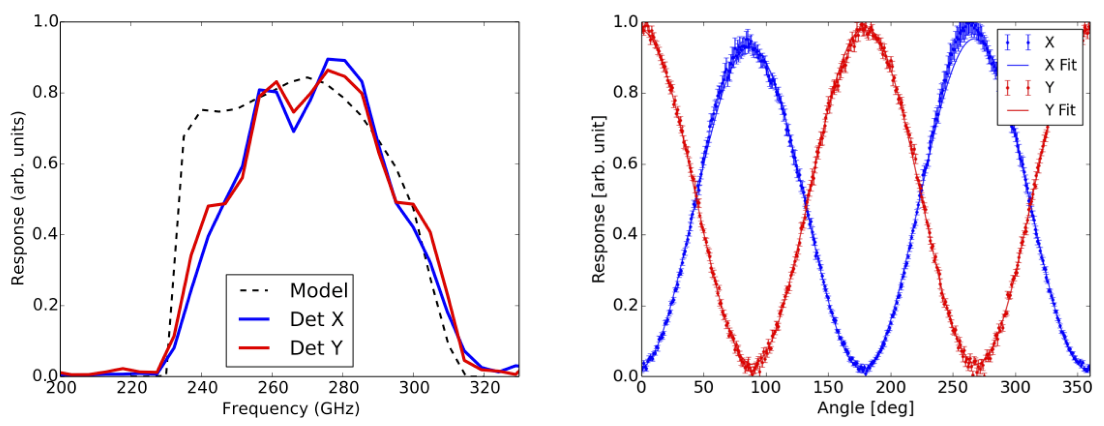
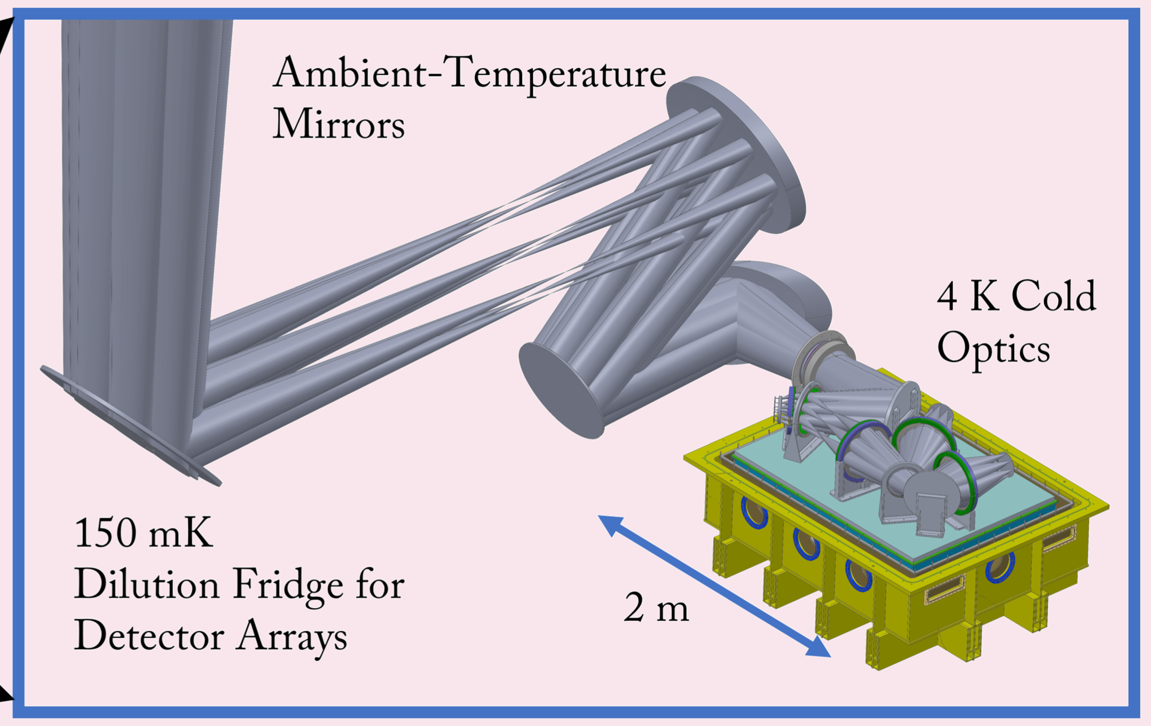


Figure 3: Measured spectrum and polarization efficiency.

A New View of the Millimeter-Wave Sky

15,030 feet (4,580 m) on
Volcán Sierra Negra, Puebla, Mexico

- 6,300 Polarized LEKID Detectors
- 2.1 mm, 1.4 mm, 1.1 mm bands (150 GHz, 220 GHz, 280 GHz)
- 5-10 arcsecond Angular Resolution



- 4x 100 hour surveys with science goals already chosen
  - Large Scale Structure Survey, Ultra Deep Star-Forming Galaxies Survey
  - Clouds-in-Cores Survey, Fields-in-Filaments Survey
- 6x 100 hour survey periods dedicated for the community

High-Redshift Galaxies

TolTEC on the LMT will conduct a wide 100 deg^2 and an ultradeep 1 deg^2 survey to detect a large number of high-redshift dusty star-forming galaxies, and characterize their star formation rates.

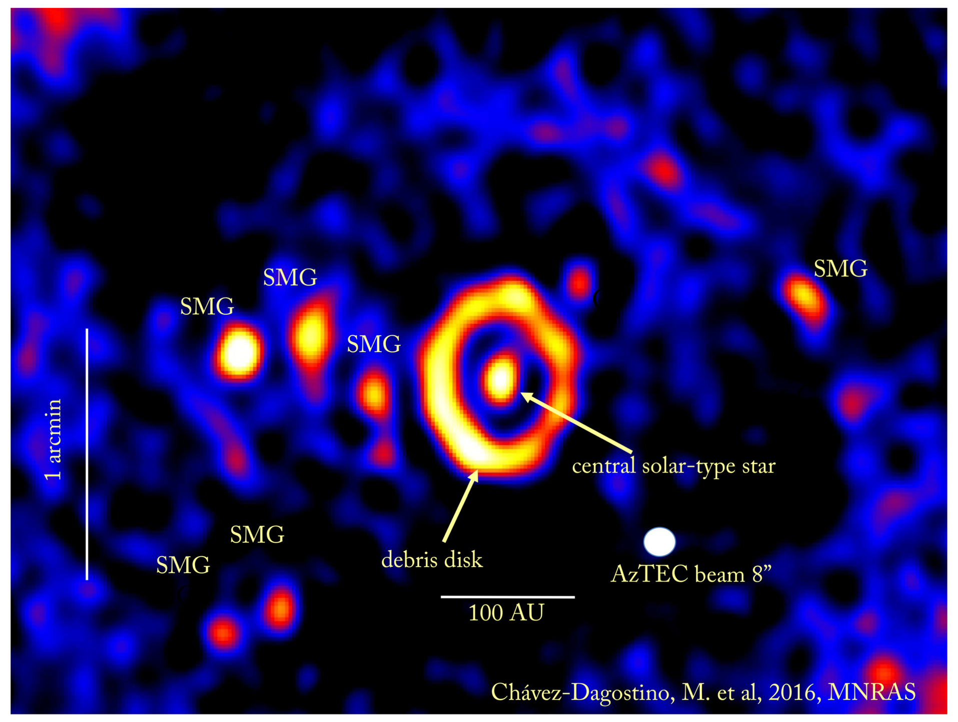


Figure 4: 1.1 mm map made with the LMT and AzTEC towards Epsilon Erdani. This image shows the debris disk around the star, as well as several distant dusty sub-millimeter galaxies (SMGs). TolTEC will make dramatically deeper and wider field maps for new surveys of SMGs.

Magnetic Fields & Star Formation

To study the role of magnetic fields in star formation, TolTEC will conduct polarimetric surveys at intermediate angular scales between the all-sky coverage of Planck and the sub-arcsecond resolution of ALMA.

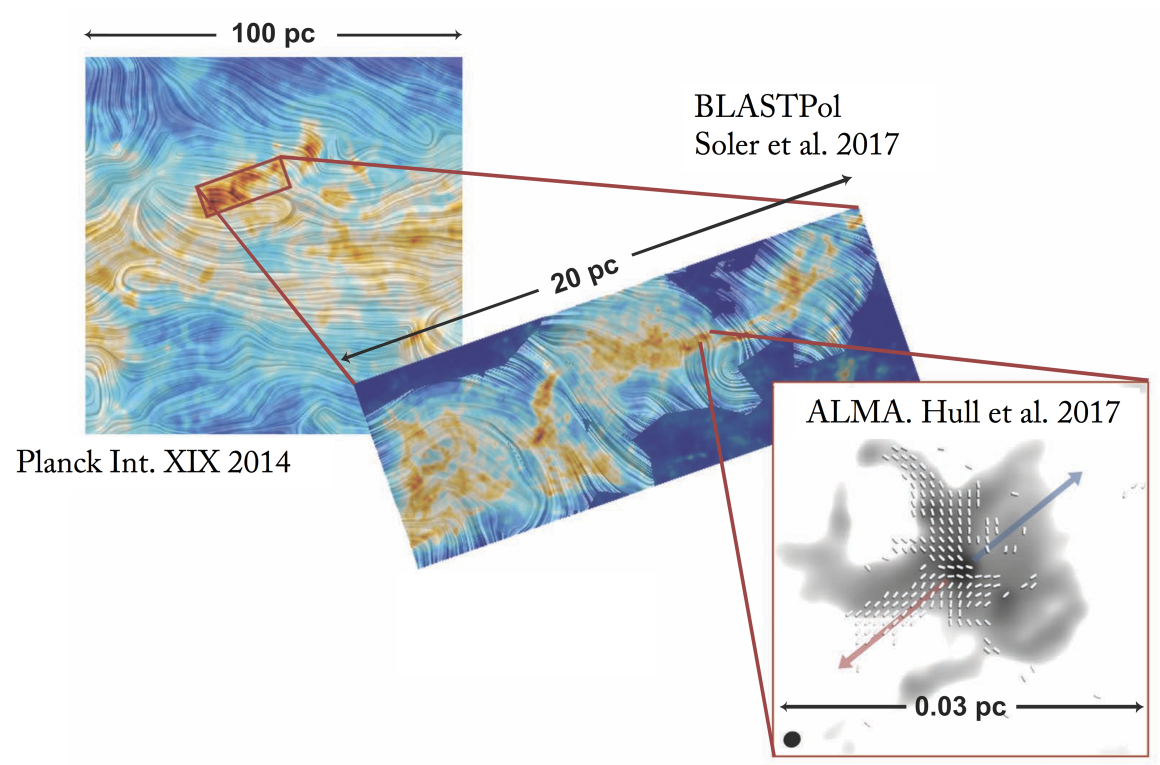


Figure 5: Millimeter-wave maps of magnetic fields and dust on all-sky (Planck), intermediate (TolTEC and BLAST), and sub-arcsecond (ALMA) scales.

Mapping Speed Forecasting

Table 1: Calculated instrument performance for TolTEC on the LMT during a median weather day from December to February.

	2.1 mm	1.4 mm	1.1 mm	
Passband	128-170	195-245	245-310	GHz
$d\nu/\nu$ Bandwidth	28%	23%	23%	
At-det. Loading	4.8	7.2	10.7	pW
At-det. NEP	50	72	95	$\mathrm{aW}/\sqrt{\mathrm{Hz}}$
$\mathrm{NET_{CMB}}$	646	1979	4466	$\mu\mathrm{K}\sqrt{\mathrm{s}}$
NEFD	0.59	1.01	1.46	$\mathrm{mJy}\sqrt{\mathrm{s}}$
Detector Count	900	1800	3600	
Total $\mathrm{NET_{CMB}}$	18.5	46.7	74.4	$\mu\mathrm{K}\sqrt{\mathrm{s}}$
Total NEFD	19.5	23.8	24.3	$\mu\mathrm{Jy}\sqrt{\mathrm{s}}$
Mapping Speed	74.4	22.0	13.4	$\mathrm{deg}^2/\mathrm{mJy}^2/\mathrm{hr}$
Mapping Speed *Scaled by AzTEC Atm.*	**10.5**	**3.1**	**1.9**	$\mathbf{deg^2/mJy^2/hr}$

We incorporated detector performance, optics, filters, and atmospheric conditions to forecast the mapping speed of TolTEC on the LMT. After atmospheric common-mode subtraction, AzTEC achieved a mapping speed 7 times slower than indicated by its white noise level. We apply this same factor in our noise model.

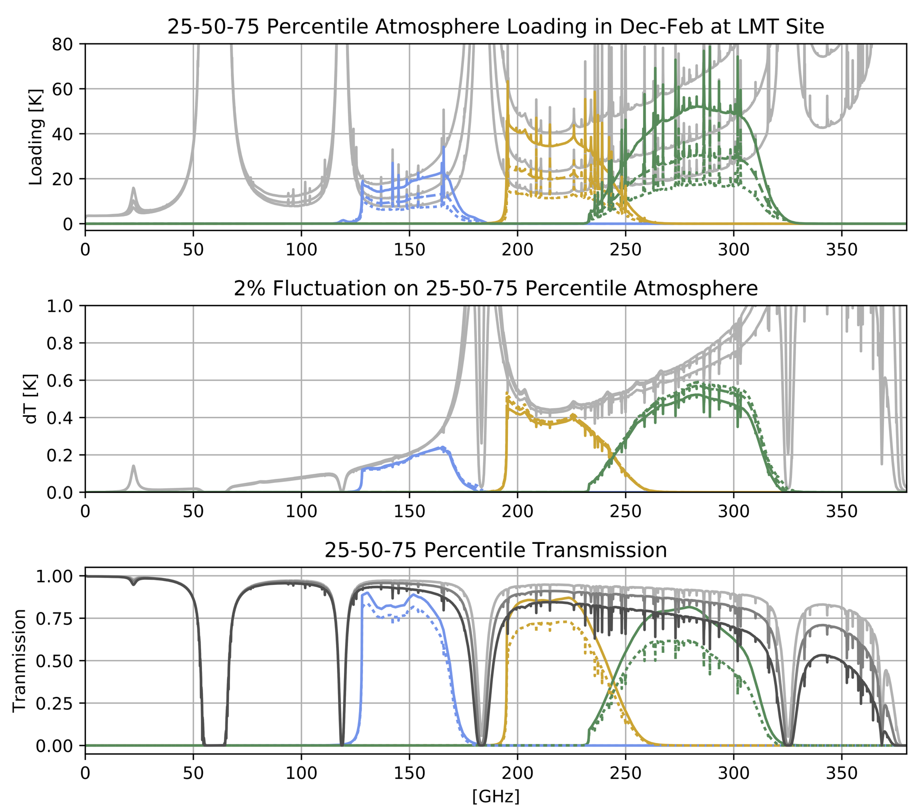


Figure 6: Passbands and Atmospheric Model

More Information

TolTEC Website: toltec.astro.umass.edu
Sign up on the website for science working groups!

TolTEC Detector Development

Austermann et al., JLTP, Submitted (2017)

Polarized LEKID Detectors

Dober et al., JLTP 184, 173-179 (2016)
Hubmayr et al., APL 106, 073505 (2015)
Bryan et al., ISSTT 2015, arXiv/1503.04684