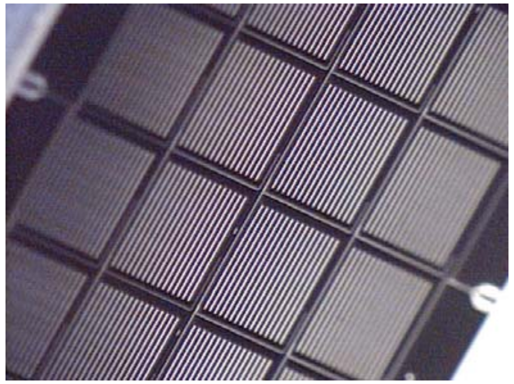
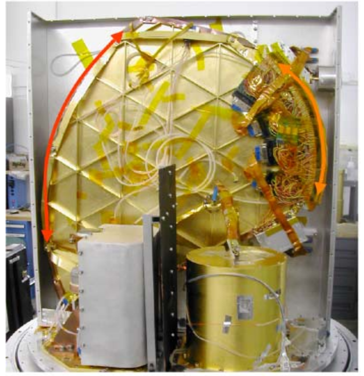
Novel Instrumentation

Advances in instrumentation enable astronomical discoveries. Achieving CCAT's scientific objectives will be possible because both the sensitivity of the basic detector elements and the size of submillimeter cameras continue to improve at an impressive rate. Furthermore, CCAT will provide a platform for deployment of novel instrumentation. Because CCAT is designed to provide a very wide field of view, emphasizing surveys and wide field imaging, the primary instrumentation will be large format cameras. In addition, there is considerable interest in spectroscopy and novel spectrometers will provide detailed information about the sources discovered in continuum surveys. Especially at the start of operations, existing instruments will be brought to CCAT to enhance the scientific return.

Antenna coupled focal plane. Each pixel is a 16 × 16 slot dipole array coupled through two color (1300 μm and 850 μm) microstrip filters to MKID resonators (Vayonakis).



Z-Spec grating spectrometer. To record a moderate resolution spectrum of the entire 200–300 GHz atmospheric window at one time, Z-Spec uses a Roland grating (red arc) in a plane parallel waveguide to illuminate an array of SiN micromesh bolometers (orange arc) (Bradford).



Performance Goals

Aperture	25 m diameter
Wavelength	200–2200 μm
Field of View	20 arcmin
Resolution (diffraction)	3.5" @ 350 μm
Pointing (offset)	0.2" rms
Half Wavefront Quality	< 10 μm rms
Site Altitude	5600 m
Atmospheric Water Vapor	< 1 mm (median)

Schedule

Feasibility/Concept Design	*Completed* 2006
Consortium Development	2006–2007
Technical Analysis	2006–2008
Engineering Design	2009–2011
Construction & Integration	2011–2014
Commissioning	2014–2015

Consortium

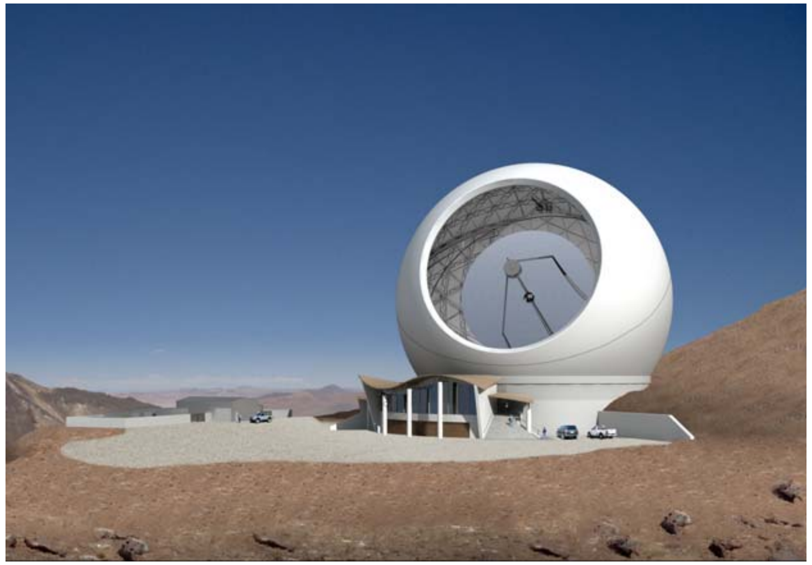
Cornell University
California Institute of Technology with Jet Propulsion Lab
University of Colorado
University of British Columbia for a Canadian consortium
UK Astronomy Technology Centre for the UK community
Universities of Cologne and Bonn

Information at:

http://www.submm.org

2009 January

Cornell Caltech Atacama Telescope



Both astronomical discoveries and technological innovations have positioned submillimeter astronomy for major advances in the coming decade. Star formation occurs in dense molecular clouds, readily observable in the submm but shrouded from view at shorter optical and IR wavelengths by interstellar dust. Galaxy collisions trigger giant bursts of star formation that cause entire galaxies to shine brilliantly in the submm but often to be inconspicuous or invisible in the optical and near IR. Collectively these galaxies produce the far IR and submm background, which equals the energy density of the optical background light.

Progress in detector and telescope technology now permits wide field imaging of the submm sky, enabling detection and characterization of large numbers of submm sources for the first time. A 25 m diameter telescope optimized for wide field submillimeter imaging, CCAT will have a survey speed many times higher than any other instrument, will complement ALMA, and will capitalize on continuous innovations in instrumentation to address a broad range of scientific opportunities.

Scientific Objectives

Combining high sensitivity, a wide field of view, and a broad wavelength range, CCAT will have an unprecedented capability to make deep, large area multiwavelength submillimeter surveys that address a large variety of astrophysical problems. Highlights include:

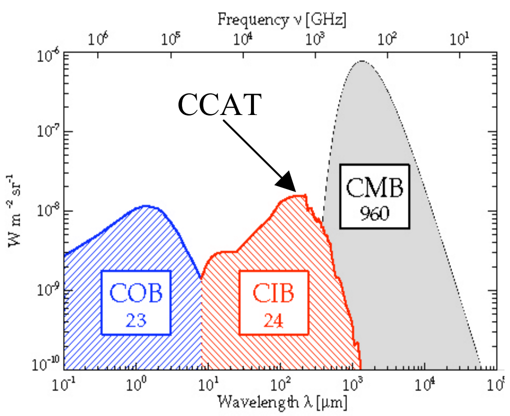
Galaxy formation and evolution: CCAT will detect hundreds of thousands of high redshift submillimeter starburst galaxies, allowing investigation of the star formation history of the early universe and of the evolution of the population, the luminosity distribution, and the clustering of these galaxies.

Dark Matter and dark energy: CCAT's high resolution images of the Sunyaev-Zel'dovich effect in hundreds of clusters of galaxies will illustrate in detail how clusters form and evolve, aiding the determination of the dark energy equation of state and other cosmological parameters from SZ survey catalogs.

Star Formation: CCAT will provide the first complete census of cold, dense Galactic molecular cores that collapse to form stars. In nearby clouds, CCAT will detect 0.08 $M_\odot$ cores, smaller than the lowest mass stars.

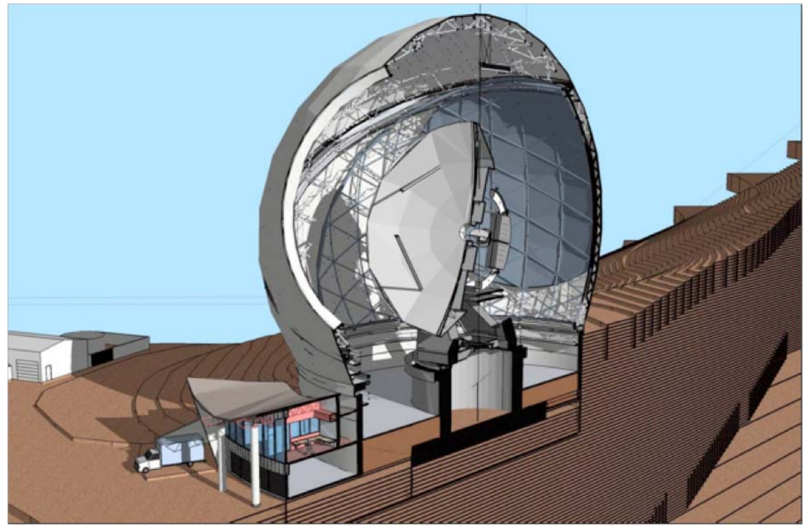
Protoplanetary and debris disks: CCAT will survey nearby young star clusters to determine the prevalence and evolution of protoplanetary and debris disks, identifying targets for high-resolution imaging with ALMA.

The Kuiper belt: CCAT will determine basic physical data – sizes and albedos – for hundreds of Kuiper belt objects.



All the Light in the Universe. CCAT surveys will catalog distant dusty starburst galaxies that emit the reprocessed starlight making up the FIR – submm background (Dole et al. 2006).

Concept Design



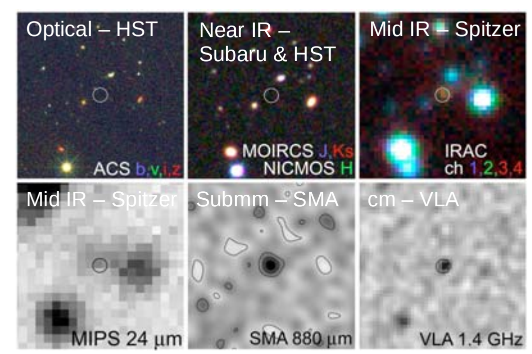
During the CCAT's scientific lifetime, bolometer arrays will become available that are many times larger than present instruments. To accommodate these large format cameras, the Ritchey-Chrétien optical design is optimized for a wide field of view. The telescope has an azimuth-elevation mount enclosed in a calotte style dome. Two Nasmyth foci outboard of the elevation bearings provide ample space for instruments. To achieve high aperture efficiency for short wavelength (200 μm) observations, an active surface adjustment system will be used with closed loop positioning of the primary mirror panels. The mirror surface will be measured with holographic observations of planets. Edge sensors and optical angle and distance metrology are among the techniques under consideration for maintaining the panel alignment.

The CCAT concept design was elaborated during a Feasibility Concept Design Study that developed the technical specifications of the telescope and evaluated possible technological approaches. An external committee reviewing the Study report concluded, *"The CCAT will revolutionize Astronomy in the submm/FIR band and enable significant progress in unraveling the cosmic origin of stars, planets, and galaxies. CCAT is very timely and cannot wait."*

— R. W. Wilson, Chair

Site: Cerro Chajnantor, Chile

Consistently superb observing conditions are crucial for achieving the CCAT's scientific objectives. Submillimeter radiation is strongly absorbed by atmospheric water vapor, precluding observations at most locations. The high Andes near of San Pedro de Atacama in northern Chile are one of the driest places on Earth. The candidate CCAT site at 5612 m near the summit of Cerro Chajnantor is about 600 m above and 5 km NNE of ALMA. Measurements since 2006 May demonstrate excellent observing conditions with median PWV about 700 μm during the winter.



Obscured starburst. Invisible in the optical and near infrared, this is the second brightest submm source in the Goods field. Likely a starburst at $z > 4$, it is among the most luminous galaxies known (Wang et al. 2008). CCAT will discover many of these rare objects with sufficient angular resolution for identification and follow up.