CCAT: Project Overview, Science & Instrumentation Plans

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What is CCAT?

•A 25meter FIR/submillimeter telescope that will operate at wavelengths as short as λ = 200 μm, an atmospheric limit

• To be located in a high (5617m environment

• It will take advantage of one of the now fastest-developing detector technologies of any spectral region, opening up for surveys one of the last, largely untapped frontiers of ground-based astronomical research

Beam size: λ[μm]/100 arcsec
e.g. 2" @ 200 μm

FoV: 1 sq. deg.

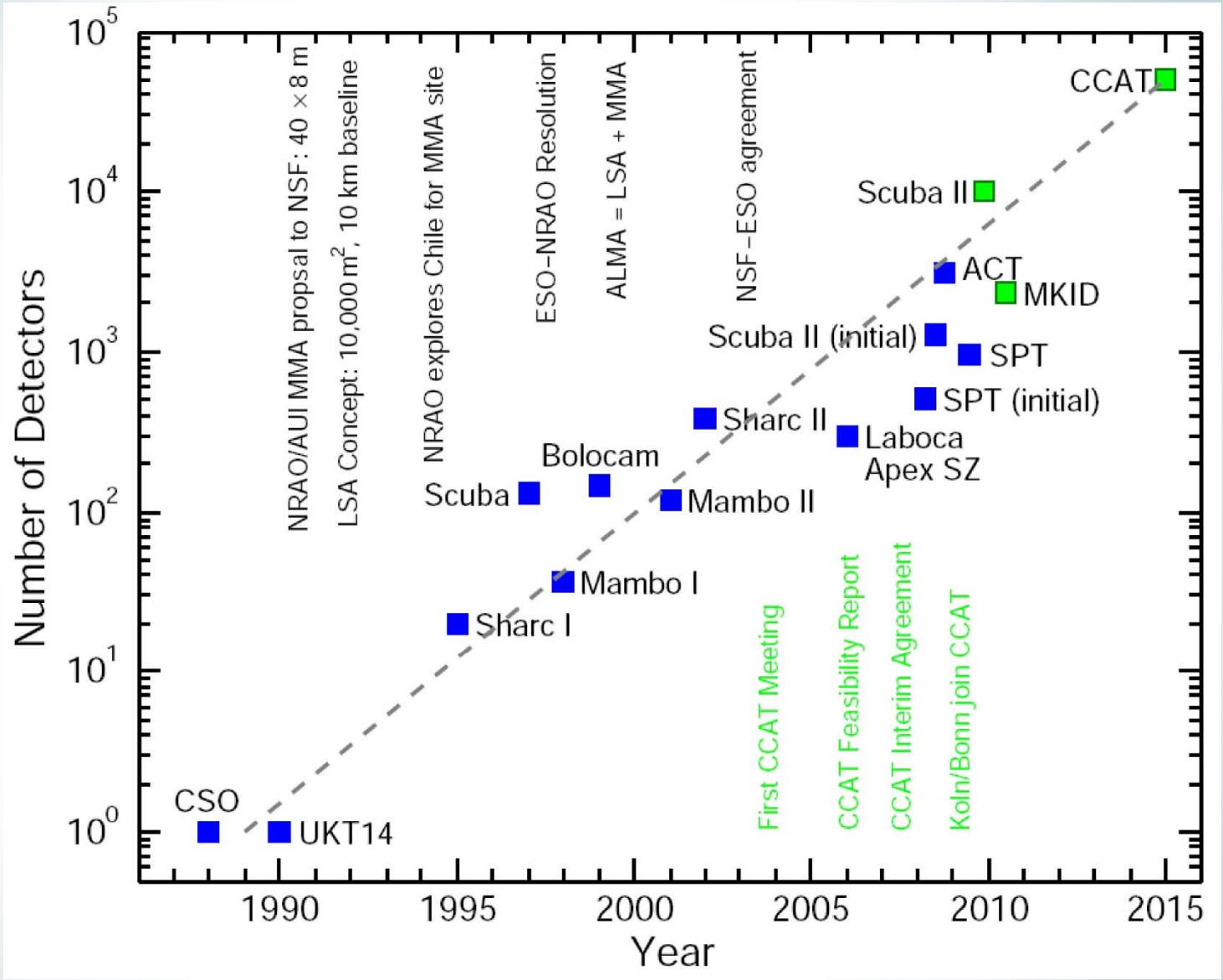
Why 25m?
- Match ALMA sensitivity in submm regime
- Integration time to confusion(?) at 350 um ~ 1 hr
  or to fully resolve the FIR/submm CBR
- Better than 0.5" source positioning

@ 350 μm

First-light
short λ camera: 50 kpix

Several instruments in Nasmith foci, some simultaneously accessible in very large FoV

CCAT


Number of Detectors
Year
10^0
10^1
10^2
10^3
10^4
10^5
1990
1995
2000
2005
2010
2015
CSO
UKT14
Sharc I
Mambo I
Scuba
Bolocam
Mambo II
Sharc II
Laboca
Apex SZ
Scuba II (initial)
SPT
SPT (initial)
ACT
MKID
Scuba II
CCAT
NRAO/AUI MMA propsal to NSF: 40 × 8 m
LSA Concept: 10,000 m², 10 km baseline
NRAO explores Chile for MMA site
ESO–NRAO Resolution
ALMA = LSA + MMA
NSF–ESO agreement
First CCAT Meeting
CCAT Feasibility Report
CCAT Interim Agreement
Koln/Bonn join CCAT

CCAT

What is CCAT?

CCAT is not intended to be a “national” observatory: a consortium of mostly academic partners, it is intended to be run – inasmuch as possible – as an academic facility, training ground for the instrumentalists, observers, telescope makers of tomorrow; nimble in rapidly responding to new discoveries as in testing new technologies; with “lean & mean” bureaucracy and eager to release its data with short “proprietary periods”, in order to maximize science fall-out.

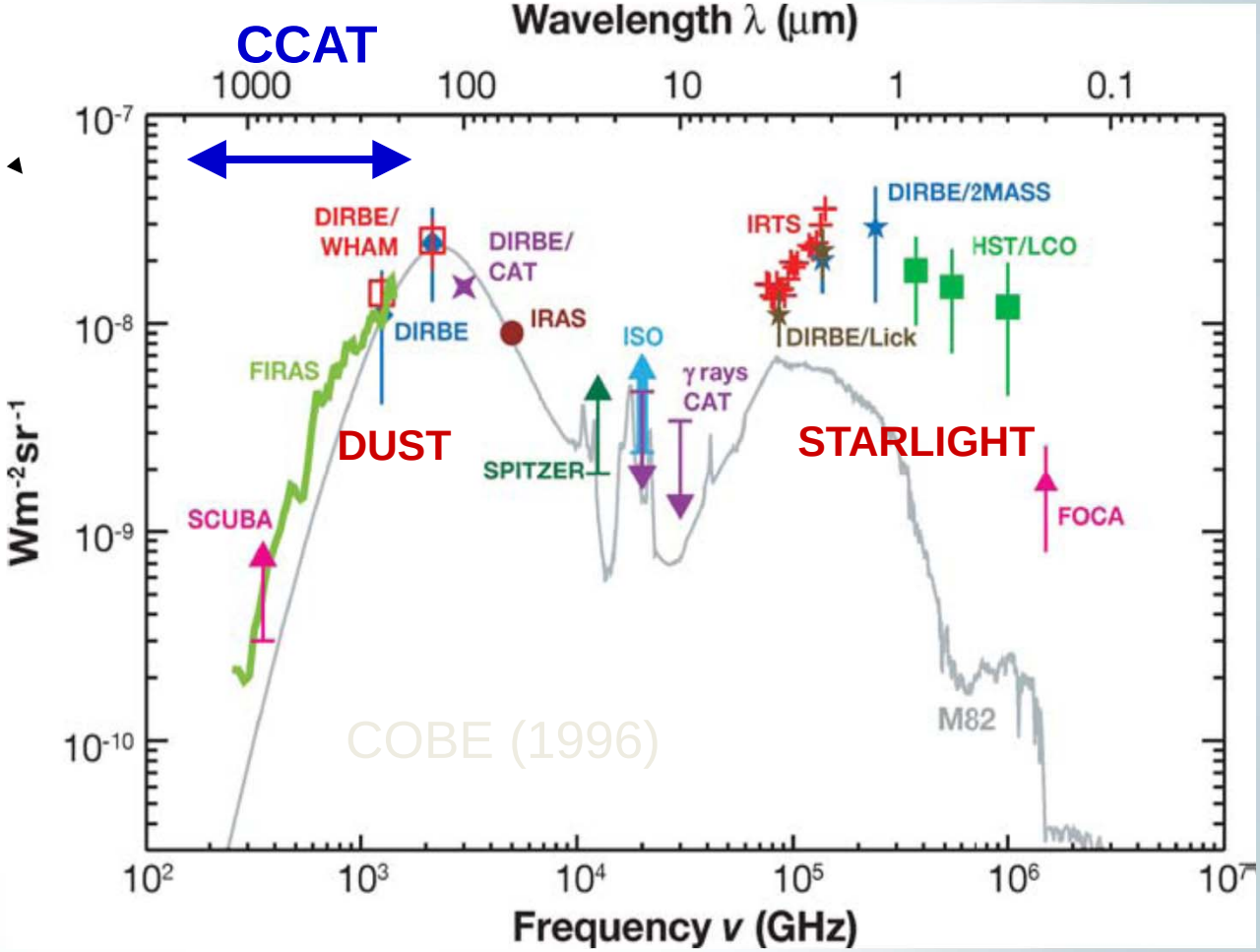
What's CCAT for?...

Main CCAT Science Themes

- Measuring the History of Star Formation in Galaxies from the Epoch of Reionization, Through the Peak of Activity, to today
- Advancing the Resolution of the Cosmic FIR Background Radiation Field
- Characterizing the Atomic, Molecular, and Solid-State Interstellar Media of Nearby Galaxies
- Probing the Formation of Galaxy Clusters with the Sunyaev-Zel'dovich Effect (*SZE*)
- Characterizing the Formation of Molecular Clouds and the Clump Mass Function

The Cosmic FIR Background Radiation Field

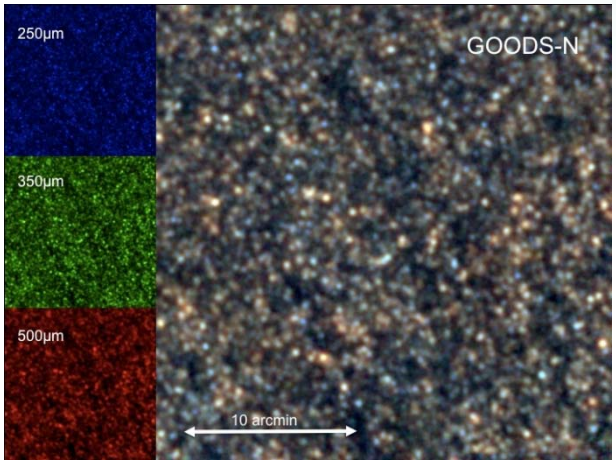
- Dust reprocesses starlight into FIR
- Cosmic expansion shifts light of early galaxies further into submm and mm bands



Lagache, Puget, & Dole 2005

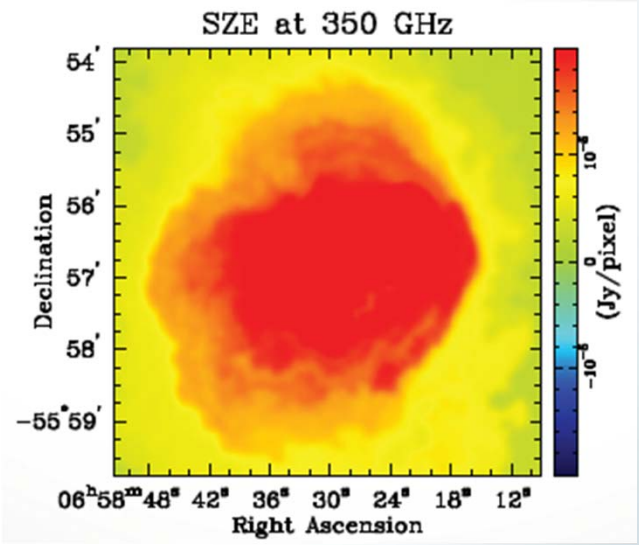
Galaxy Counts and the Cosmic FIRB at Submm Wavelengths

- ~10% of CFIRB resolved directly with *Herschel*
- ~50% inferred statistically, yielding estimated number count models to a depth of 2 mJy/beam
- CCAT will resolve (directly) sources to 0.5-1 mJy, likely resolving the totality of the CFIRB
- ➔ Large Scale surveys into the most active epoch of assembly of cosmic structures



HerMES Lockman Hole North

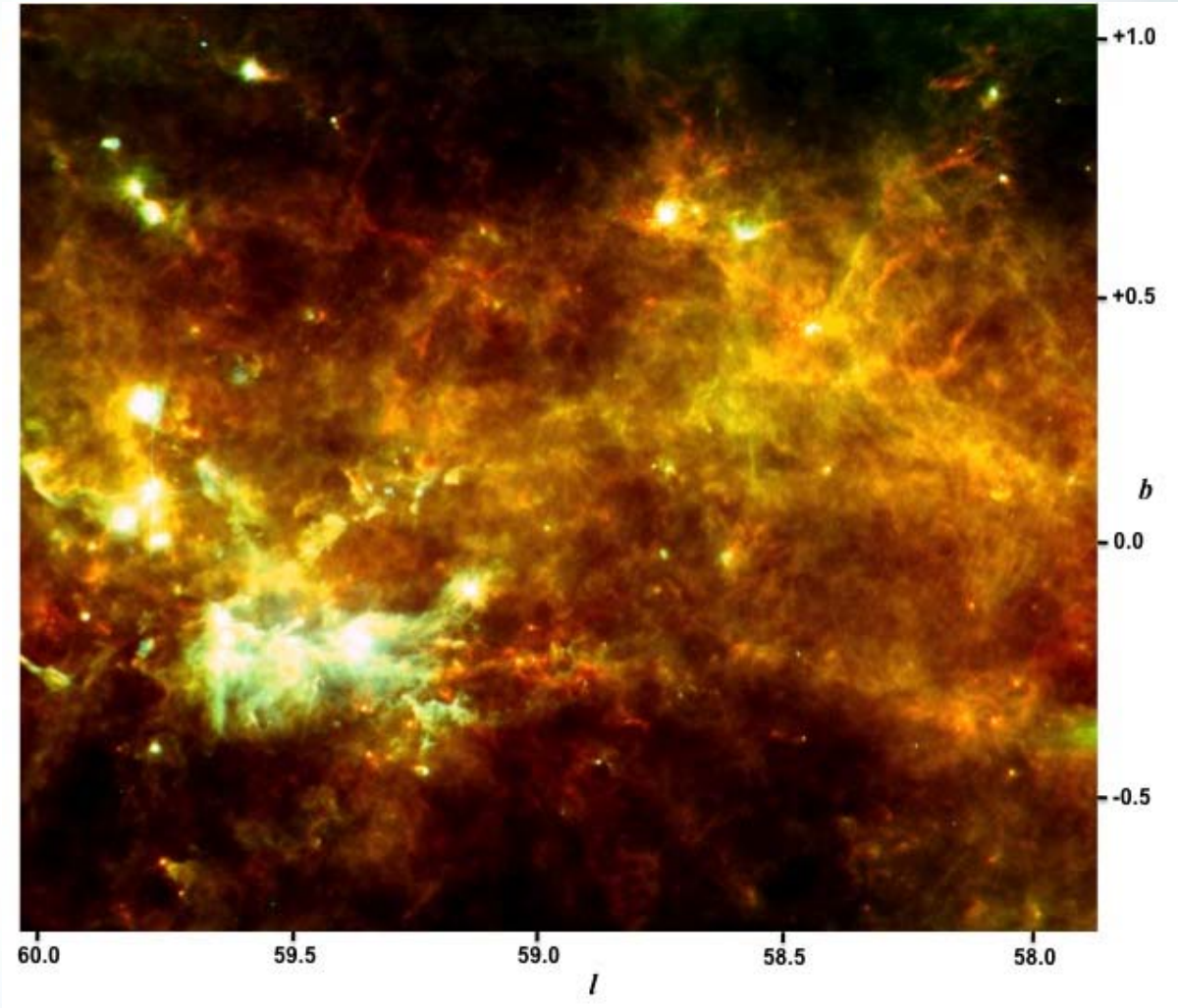
Oliver et al. (2010, 2011)



Modeling and Physical Characterization of Cluster Formation via the SZE

Structure of Molecular Clouds

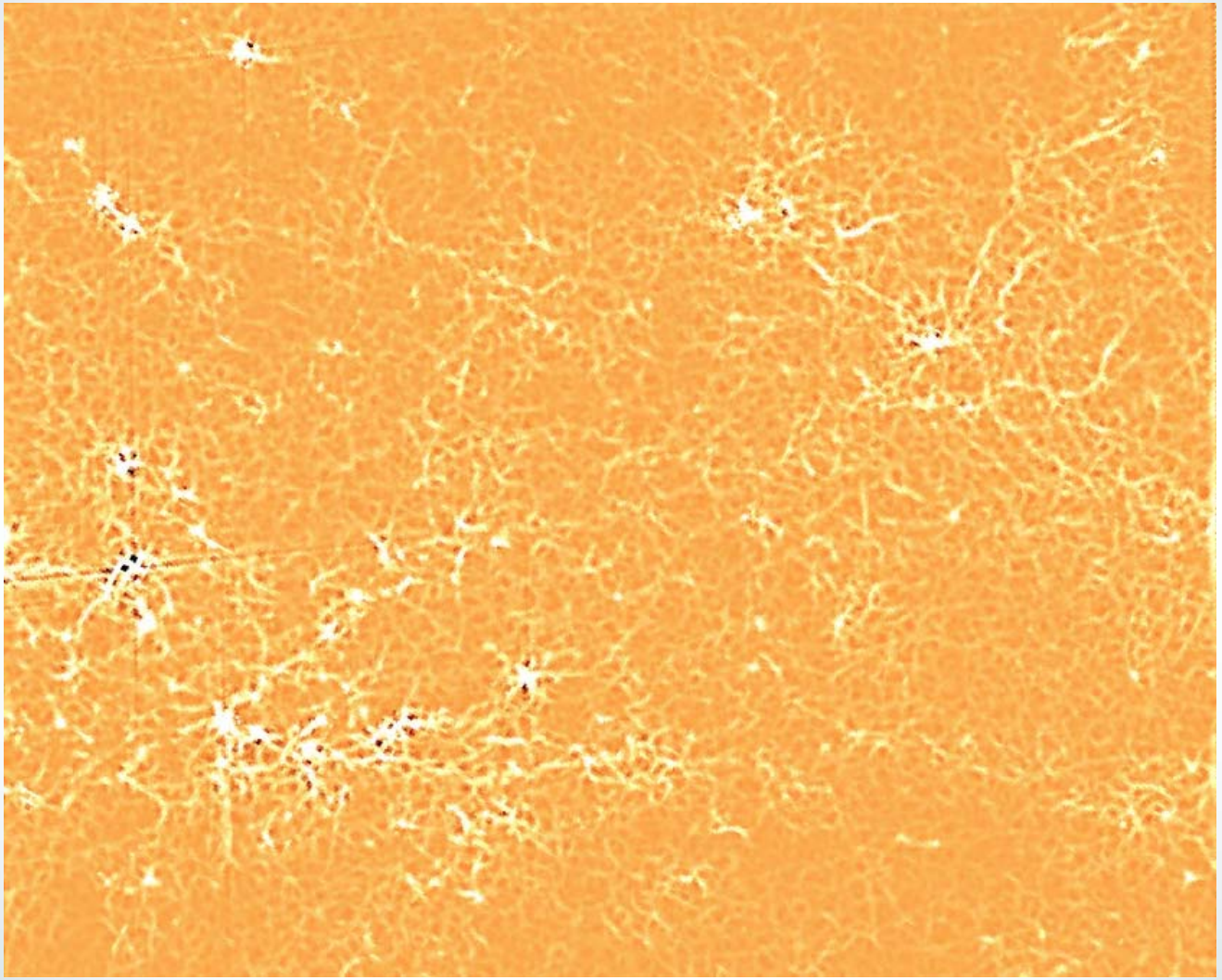
2 degrees



Molinari et al. 2010

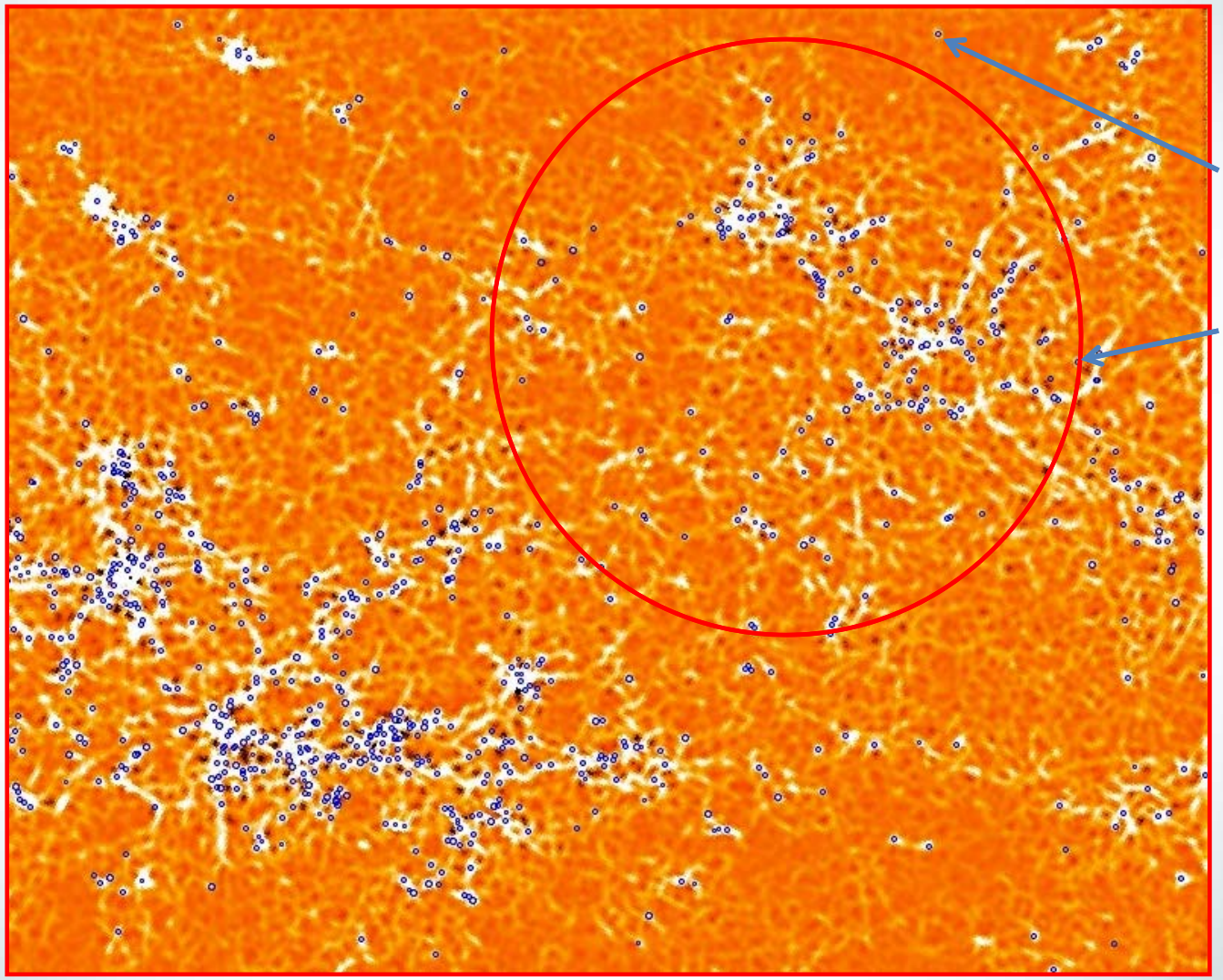
Herschel 70µm, 160µm, and 350µm image at longitude = 59°

Filaments are pervasive ...



Filtered Herschel 250um image Molinari et al. 2010

... and are where stars form



Molinari et al. 2010

Synergy with ALMA

ALMA will deliver very high spatial resolution, but only over a very small Field of View:

➔ Will reveal fine detail, ONE SOURCE AT A TIME

CCAT will not match ALMA in angular resolution (beam 2”-5” will not yield morphological info); it will however match it in continuum sensitivity and will have a Field of View 30,000 times larger

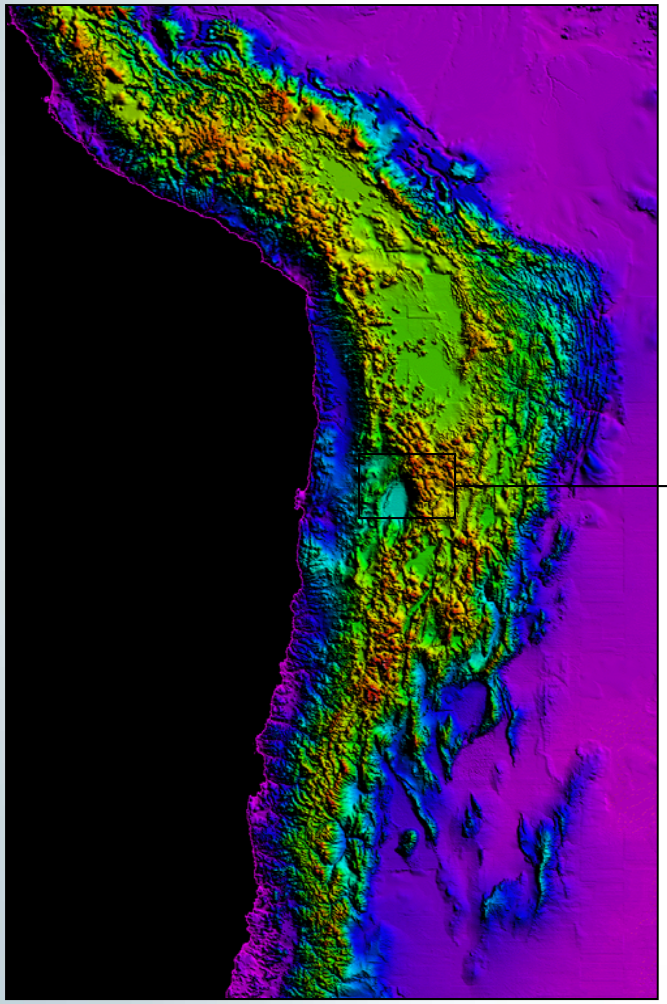
➔ FAST SURVEYOR (many objects at a time)

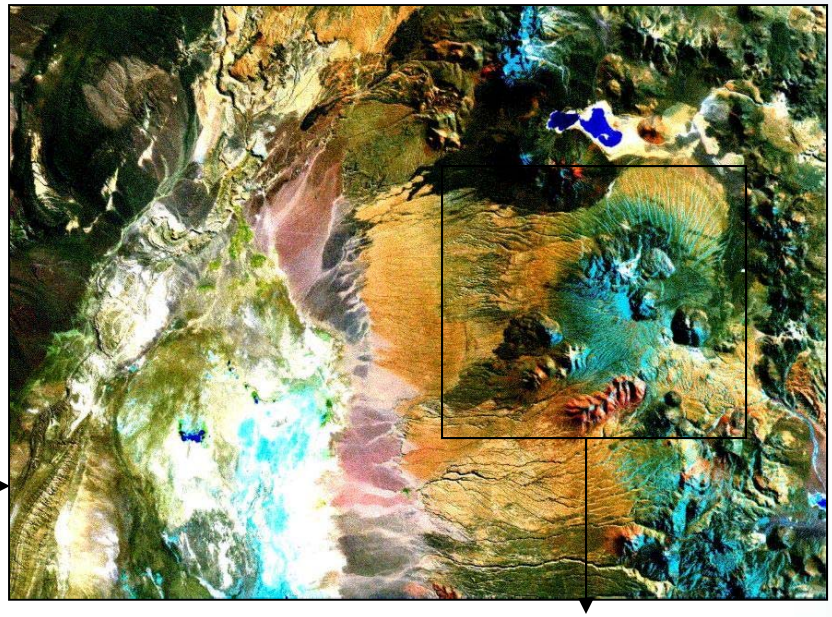
ALMA
ATACAMA LARGE MILLIMETER ARRAY

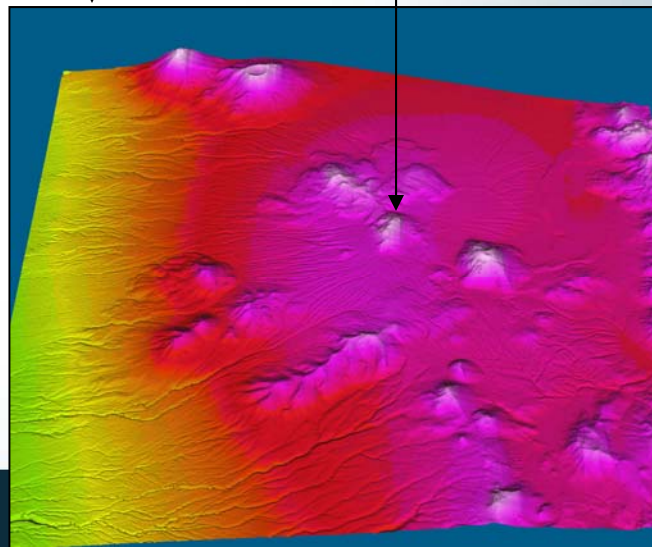
Ideal Complementarity

Where CCAT ?...

At the driest, high altitude site you can drive a truck to….



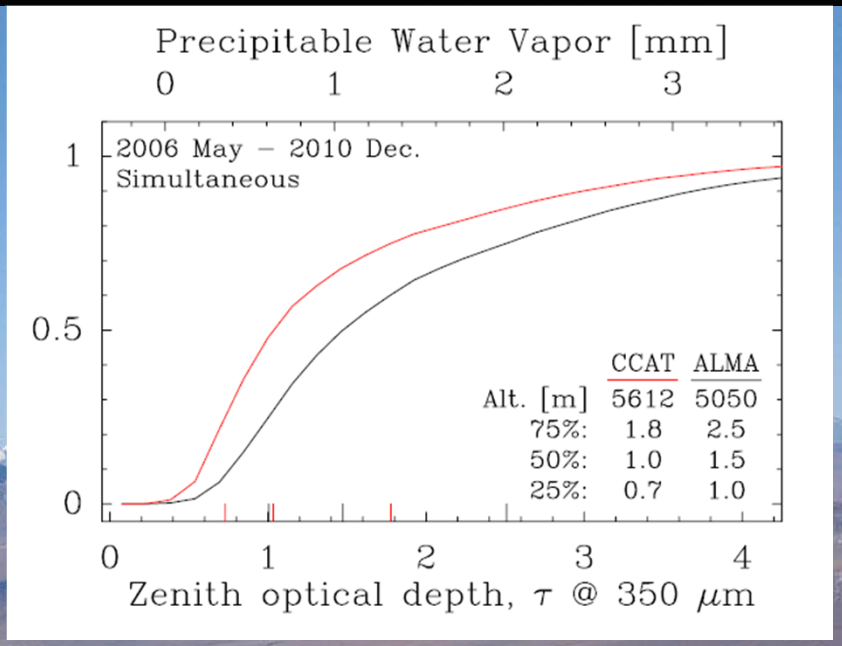




Cerro Chajnantor (18,500 ft)


27
27
27
27
27
Map
Photos
2 mi
2 km

Median 350 μm atm. Transparency
At CCAT site is 1.64x higher than at
ALMA Plateau

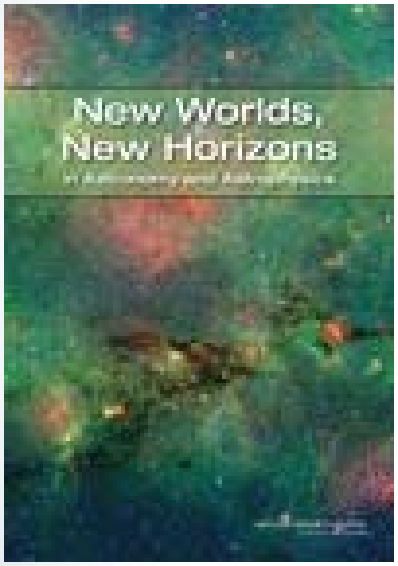


Who is CCAT?

- Cornell University (*)
- California Institute of Technology(*)/Jet Propulsion Laboratory
- University of Colorado(*)
- University of Cologne(*) + University of Bonn
- Canadian consortium(**):
  - U. of Waterloo, U. of British Columbia, U. of Toronto, Dalhousie U., McGill U., of Western Ontario, McMaster U. and U. of Calgary
- Associated Universities, Inc.
- U.S. National Science Foundation

(*) Signers of CCAT Consortium Agreement and members of CCAT Corp.
(**) Members of Canada Corp., which is in process of joining CCAT Corp.

Friday the 13th of August 2010 brings good news from Astro2010



New Worlds, New Horizons in Astronomy and Astrophysics

Committee for a Decadal Survey of Astronomy and Astrophysics
(a.k.a. “Astro2010”)

National Research Council

Project Timeline

- October 2003: Partnership Workshop in Pasadena
- Feb 2004: MOU signed by Caltech, JPL and Cornell
- 2006-2010: Feasibility Study Review, Consortium consolidation, Site selection completed
- 2010: First-ranked mid-scale project by Astro2010
- 2011 Jun: NSF Award of $4.5M toward CCAT Engineering Design, UKoeln/Bonn awarded $9M by German Research Foundation
- 2011-2013: Detailed Engineering Design (EDP) underway
- mid-2013: Design Review
- 2013-2017: Construction and First Light

"Patience, n. A minor form of despair, disguised as a virtue." Ambrose Bierce

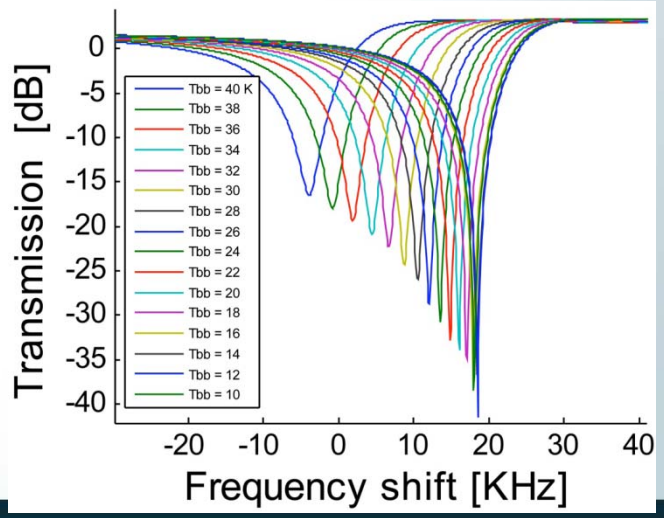
Instrumentation Plans

Four instruments are in preliminary design phase, all multi-institutional :

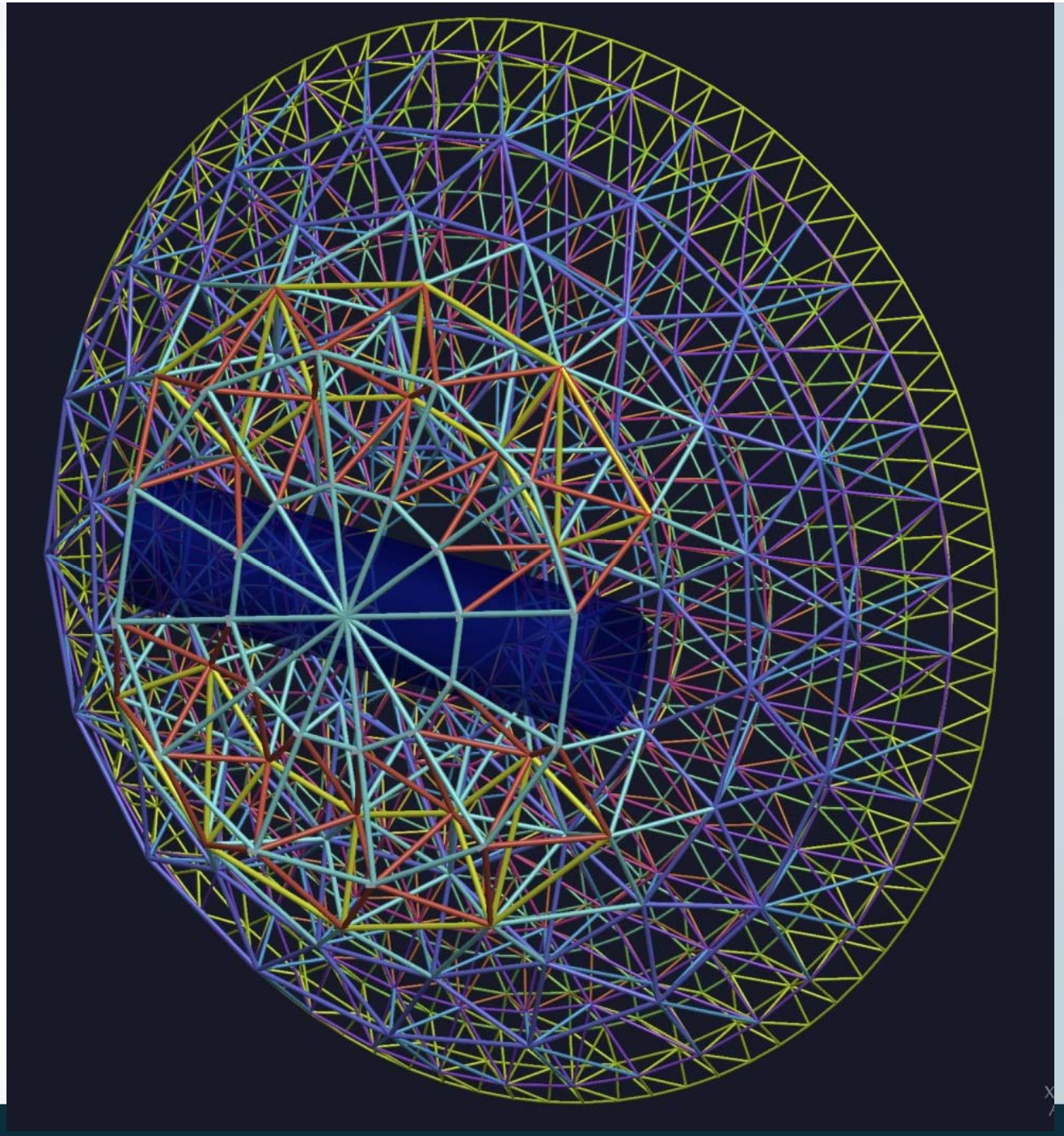
- Short Wavelength Camera (PI: G. Stacey, Cornell) (*)
- Long Wavelength Camera (PI: S. Golwala, Caltech) (*)
- Direct Detection MOS (PI: M. Bradford, JPL) (*)
- Heterodyne Feed Array (PI: J. Stutzki, Koeln)

Instrument prioritization w.r.t. first light will be decided in mid-2013

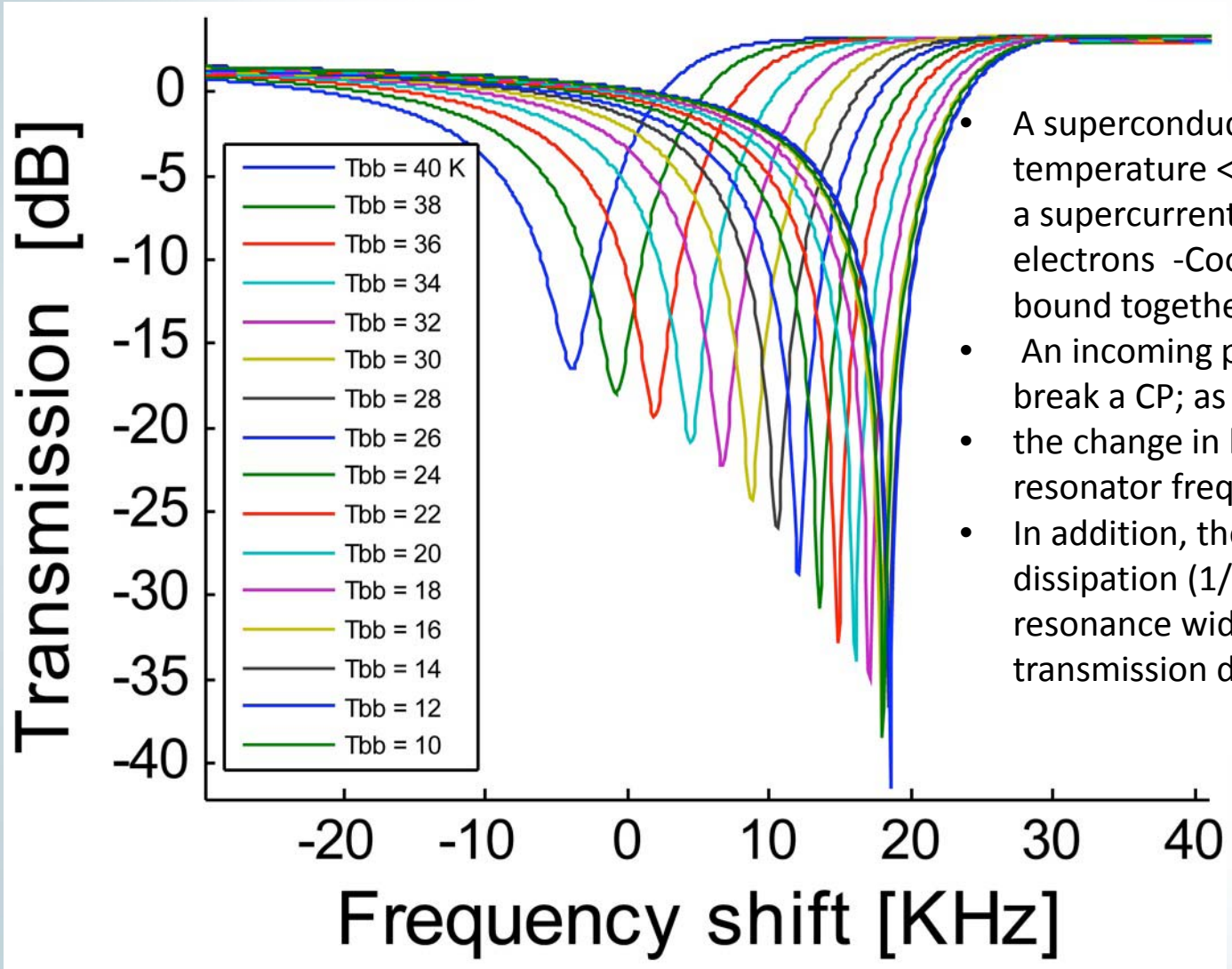
(*) Direct detection instruments MKIDs are technology of choice: they are intrinsically multiplexable, and can be implemented into large format arrays with relatively simple readout electronics.



Back view of the Carbon Fiber Reinforced Plastic (CFRP) Truss



Short Wavelength Camera (SWC) : MKIDs



- A superconducting resonator at temperature < than the critical one T_c has a supercurrent carried by pairs of electrons -Cooper Pairs (CP) -, which are bound together by an energy $\Delta = k_B T_c$.
- An incoming photon of energy $> \Delta$ can break a CP; as a result
- the change in kinetic inductance shifts the resonator frequency
- In addition, the resonator internal dissipation (1/Q) increases, causing the resonance width to increase and the transmission depth to decrease

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ABOUT CCAT OBSERVATORY SCIENCE EVENTS MULTIMEDIA DOCUMENTS

PURPOSE

CCAT is a groundbreaking submillimeter telescope that w
located at 5600 m altitude on
Cerro Chajnantor in the Andes
mountains of northern Chile. CCAT
will combine high sensitivity, a
wide field of view, and a broad
wavelength range to provide an
unprecedented capability for deep,
large area multicolor submillimeter
surveys. Science objectives
include galaxy formation and
evolution throughout the history of
the Universe; the hot gas
pervading clusters of galaxies; star
formation, protoplanetary disks,

ccatobservatory.org

FACTS & FEATURES

NEWS & EVENTS

NEWS

see all news

CCAT awards contract to A.D.S. International s.r.l.

CCAT recently awarded a contract for the design and fabrication of prototype actuator...

Read more...

CCAT awards contract to Lightworks LLC

CCAT has awarded a development contract to Lightworks LLC for the design and ...

Read more...

EVENTS

see all events

APR 30 - MAY 01, 2012
CCAT Board Meeting - Ontario, Canada

Done

CCAT