CCAT

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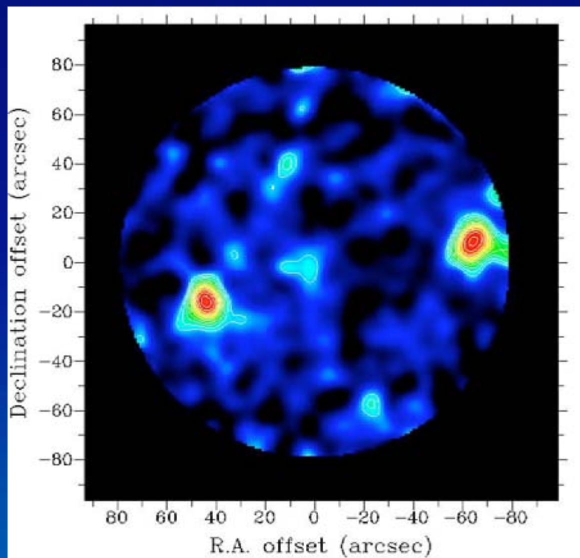
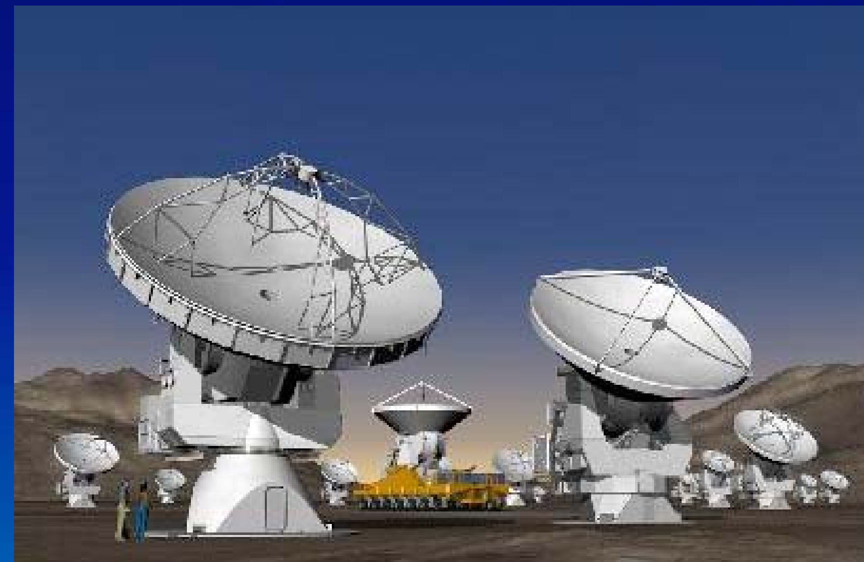
Why CCAT ?



Declination offset (arcsec)
R.A. offset (arcsec)
80
60
40
20
0
−20
−40
−60
−80

+



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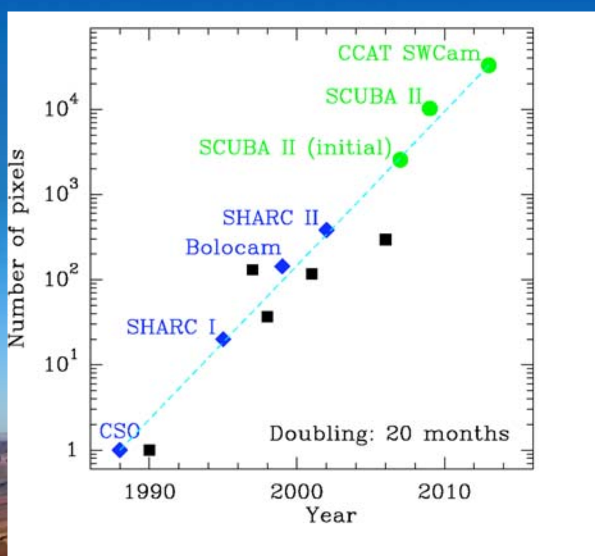


CCAT SWCam
SCUBA II
SCUBA II (initial)
SHARC II
Bolocam
SHARC I
CSO
Doubling: 20 months
Number of pixels
10^4
10^3
10^2
10^1
1
1990
2000
2010
Year

=

CCAT
25 m, 10 μm rms
Cerro Chajnantor

CCAT Overview

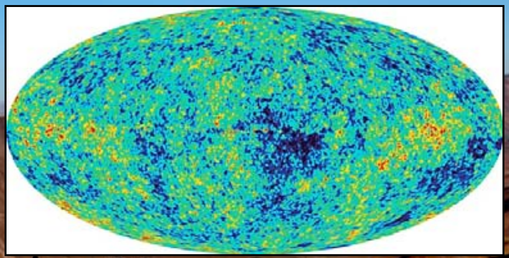
- Big: 25 m diameter submm telescope
  - high aperture efficiency at 200 µm
- Wide: Field of View > 15′
  - surveys and wide field imaging
  - large format bolometer array cameras
  - spectroscopy opportunities
- High: dry, tropical mountain site
  - 5600 m, median PVW < 1 mm
  - wide sky coverage
- Complement ALMA

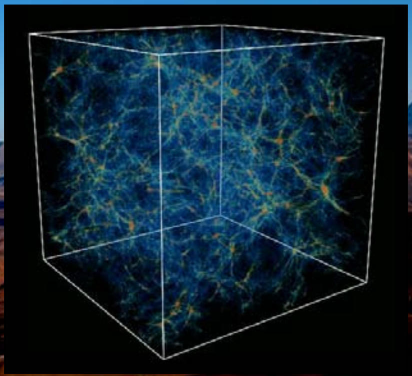
Motivation: Scientific Excellence

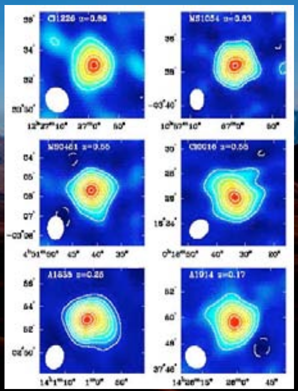
- Investigation of cosmic origins
- Planets to galaxies
  - Early Universe Cosmology
  - Galaxy Formation and Evolution
  - Disks, Star, and Planet Forming Regions
  - Cosmic Microwave Background, SZ Effect
  - Solar System Astrophysics
- at FIR/submm wavelengths

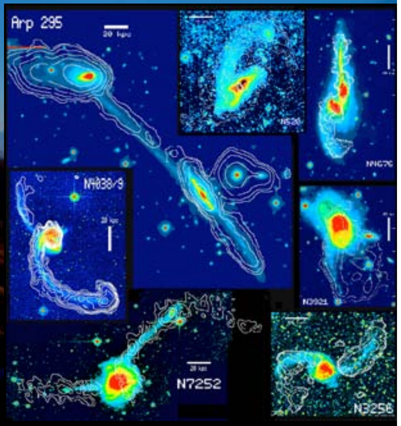
…to this?

How did we get from this



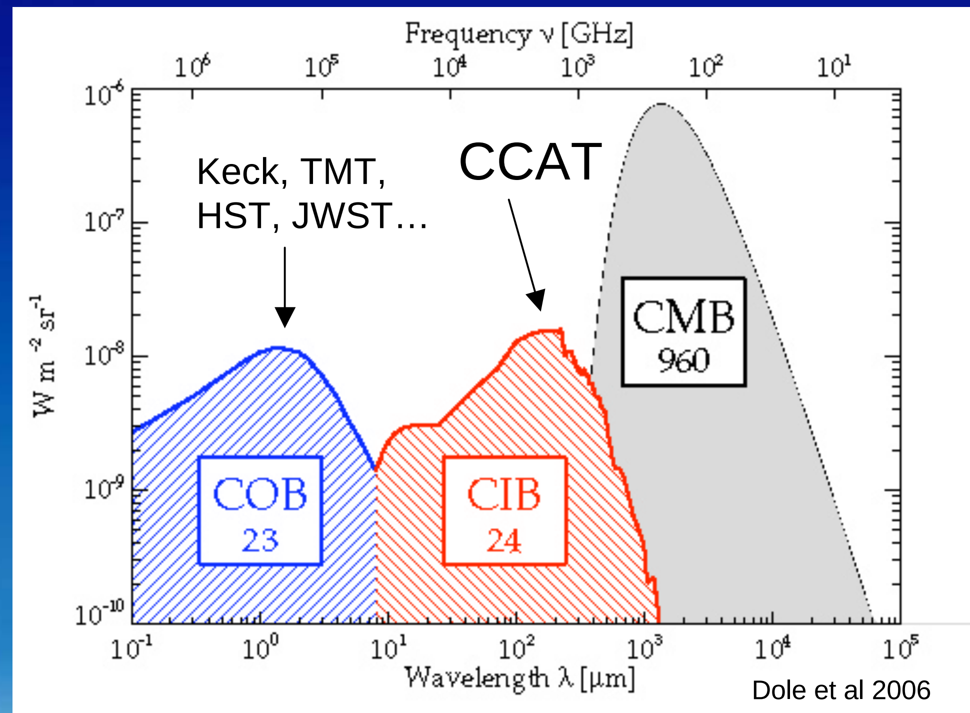




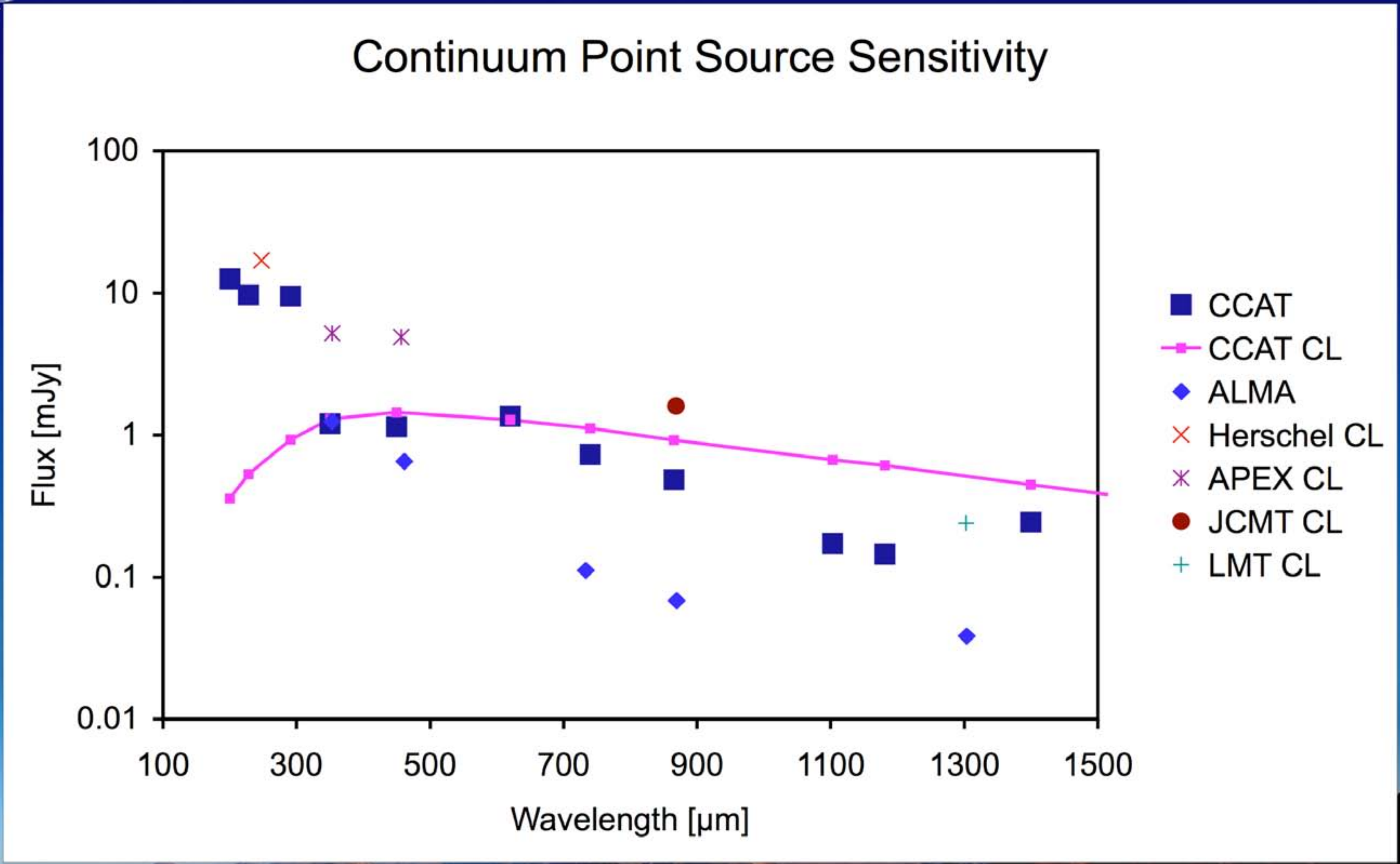


Why FIR/Submm?

- Wavelengths where:
  - We see most of the Universe's early light produced after recombination
  - Radiation produced in star and planet forming regions emerges from the dust cocoons

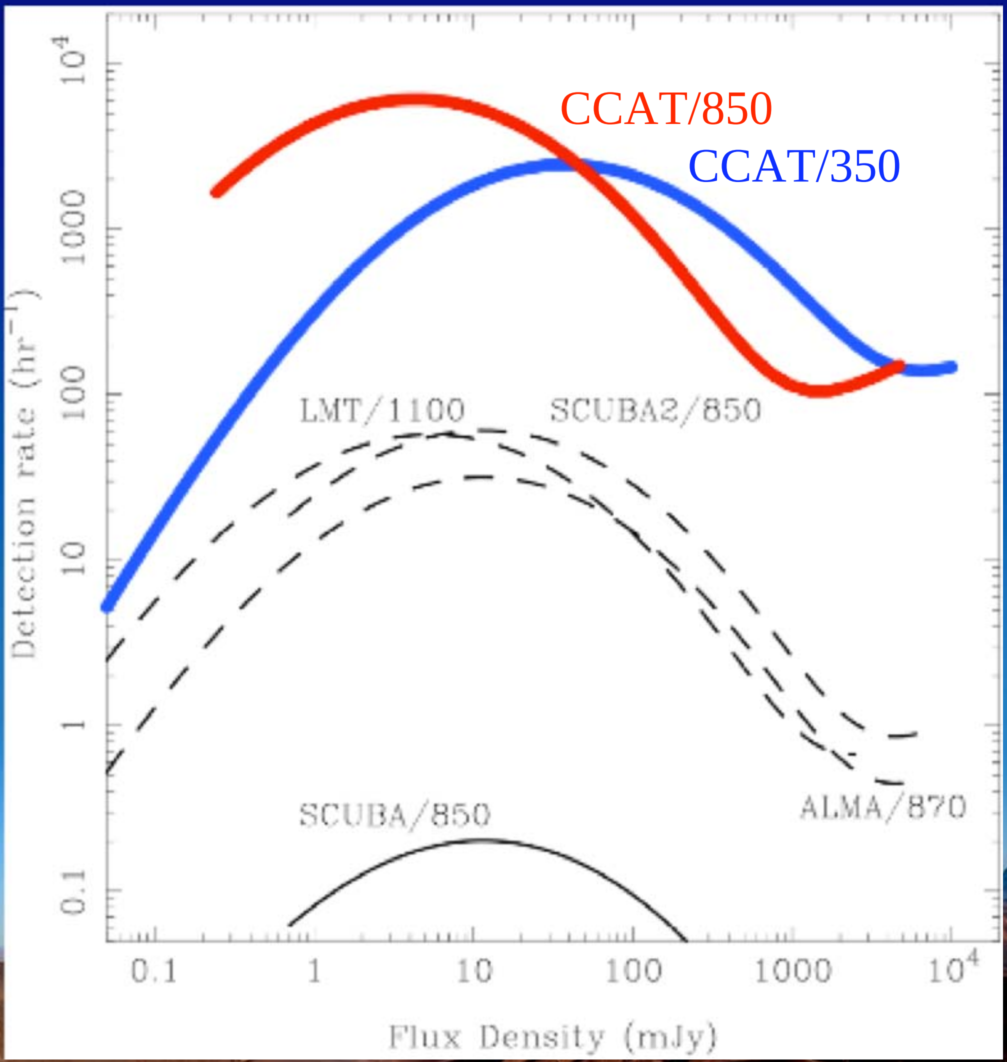


CCAT Sensitivity

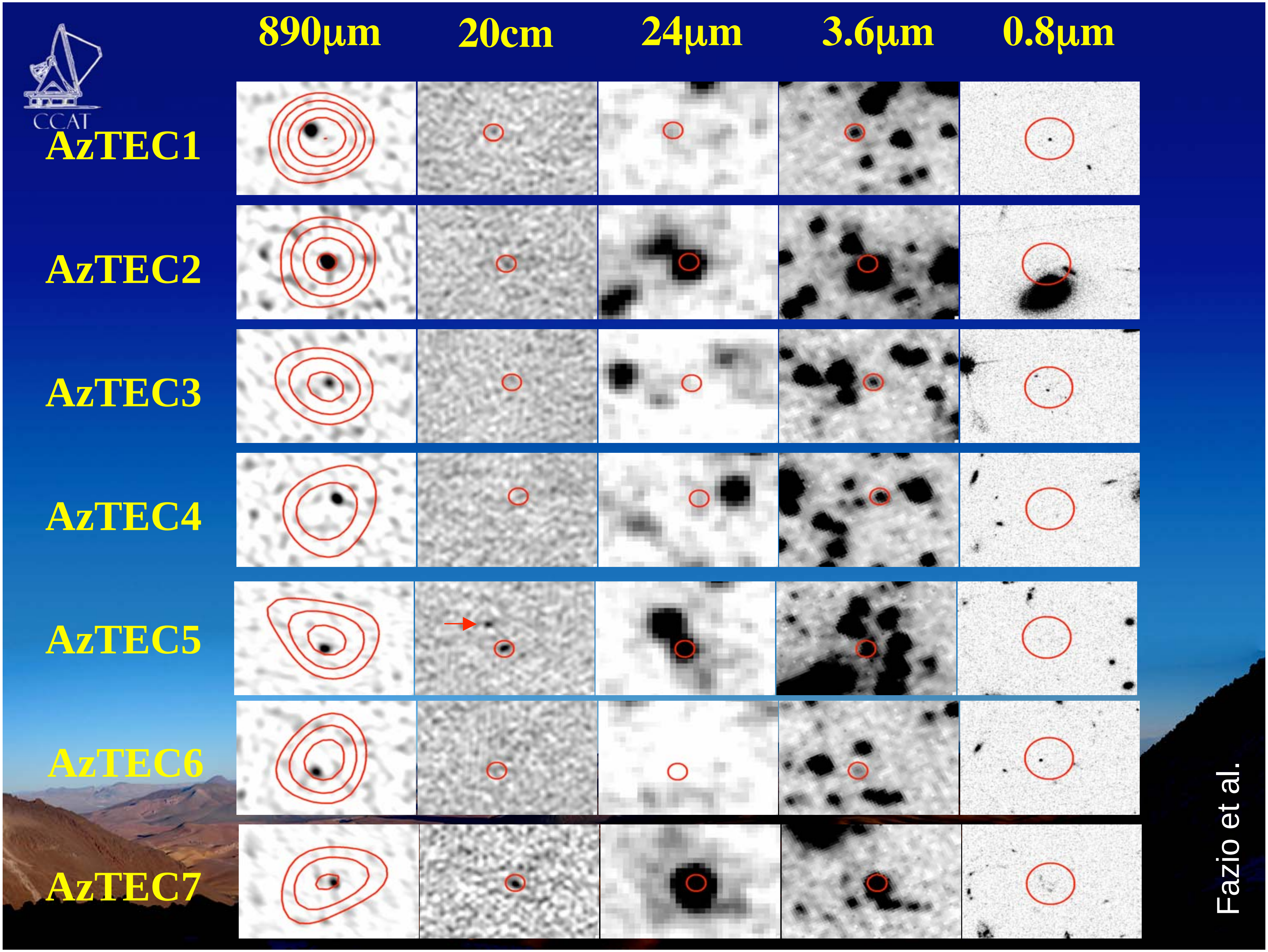


Continuum sensitivities of CCAT and other instruments (5 σ in 1 hour) with confusion limits (30 beams source^{-1}). CCAT sensitivities computed for precipitable water vapor appropriate to that band.

Submm Galaxy Detection Rate



- CCAT is an ultrafast mapper
- Assumptions
  - 32 x 32 (1024) pixel detector, Nyquist sampled, 350 µm & 850 µm
  - Observationally verified counts (good to factor 2)
  - Confusion and all sky limits
- 350 µm & 850 µm detection rates are compatible, but
- Confusion at 350 µm is deeper than at 850 µm
- Detection rates:
  - ~150 × SCUBA2; ~300 × ALMA
  - About 100-6000 per hour
  - Lifetime detection of order 10^{7-8} galaxies: ~1% of ALL galaxies!
- '1/3 sky survey': ~1000 deg^2 at 3 deg^2 hr^{-1} in 5000 hr

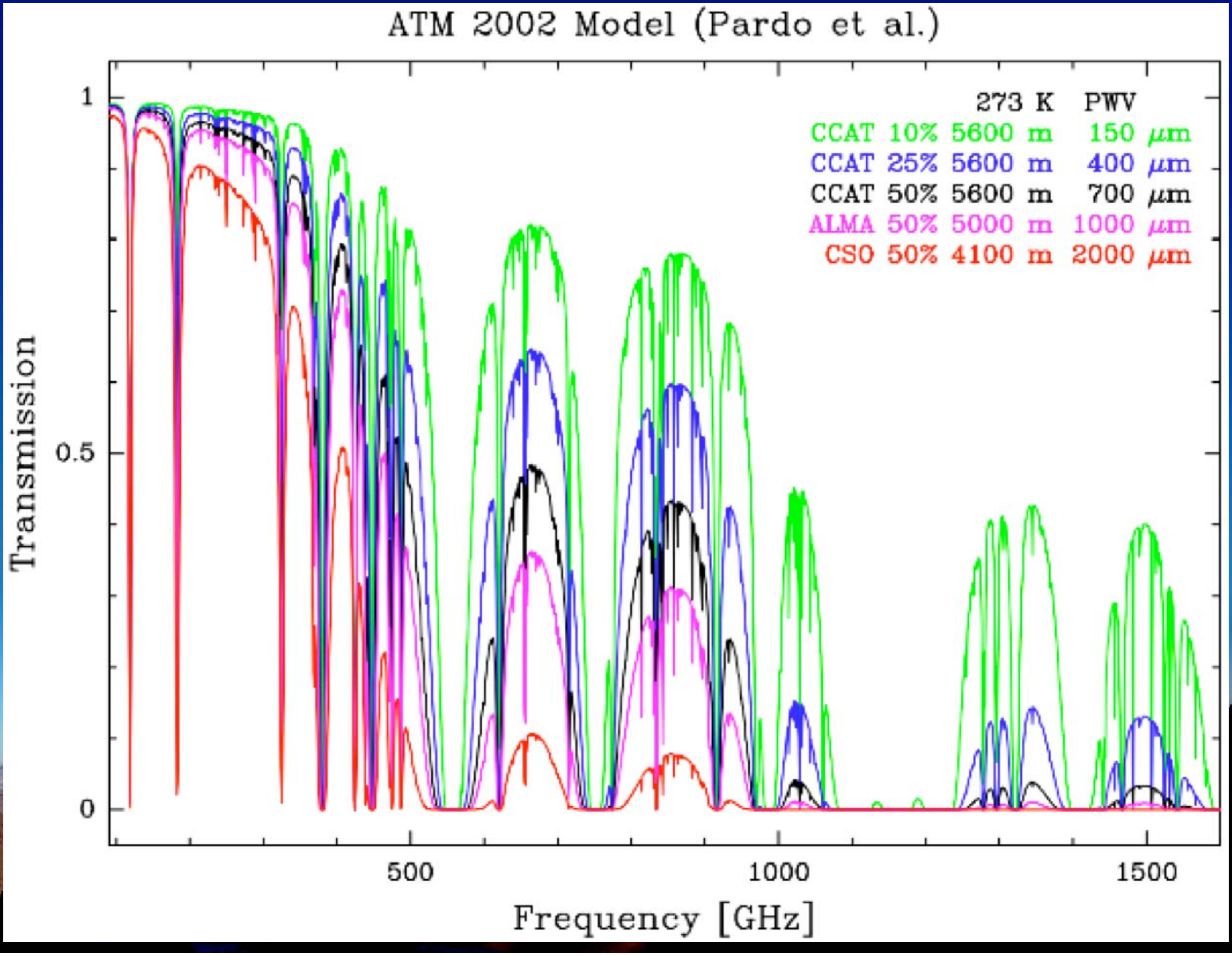

CCAT
890µm
20cm
24µm
3.6µm
0.8µm
AzTEC1
AzTEC2
AzTEC3
AzTEC4
AzTEC5
AzTEC6
AzTEC7
Fazio et al.

CCAT Technical Goals

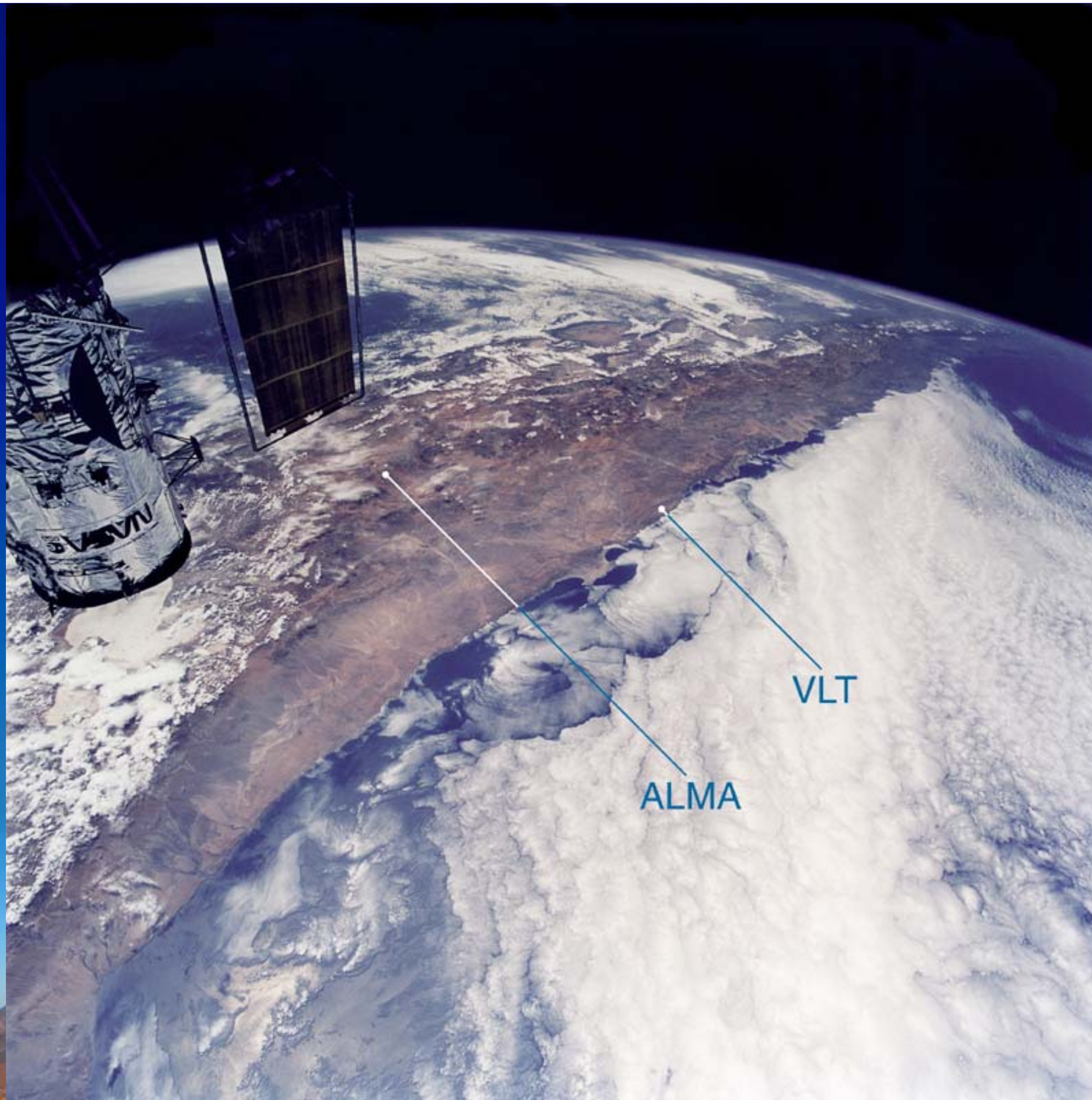
	Requirement	Goal	remark
Wavelength	350 – 1400	200 – 2500	μm
Aperture	25 m		
Field of view	10'	20'	
Half WFE	< 12.5 μm	< 9.5 μm	rms
Site condns.	< 1.0 mm	< 0.7 mm	median pwv

These Goals and Advanced Bolometer Arrays Will Make CCAT a Revolutionary New Observatory

Atmospheric Transmission



CCAT



View of Northern Chile (NASA Space Shuttle)

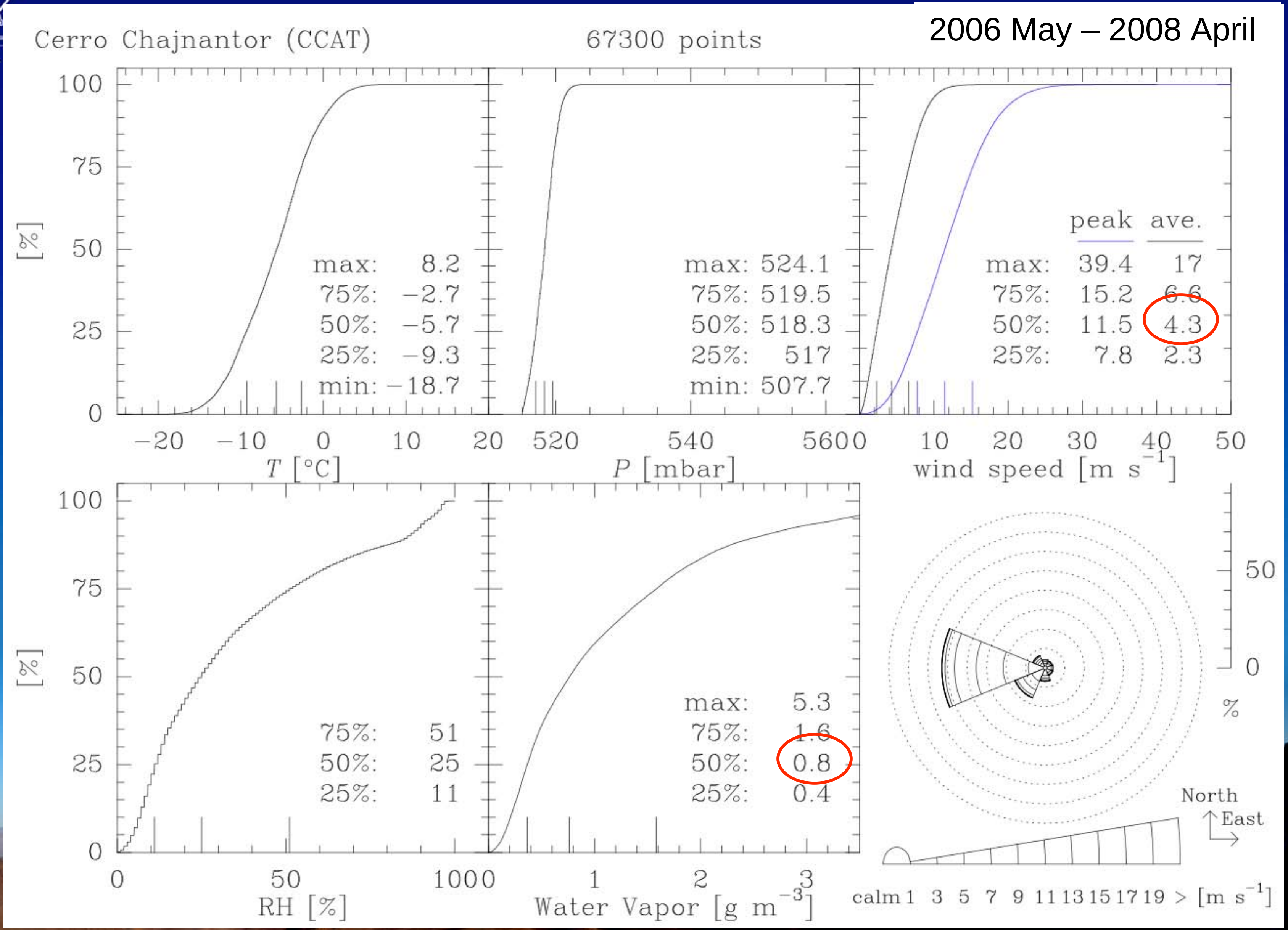
ESO PR Photo 24b/99 (8 June 1999)

Cerro Chajnantor 5612 m

View SW from ASTE; access road constructed by U. Tokyo

Cerro Chajnantor 5612 m

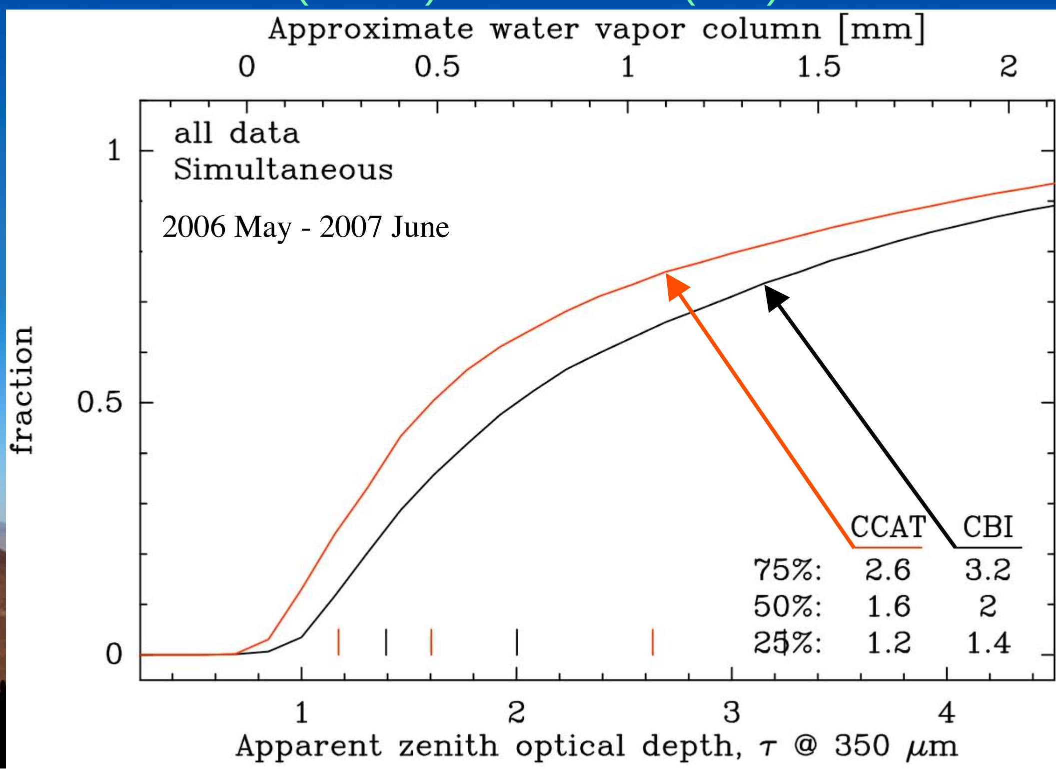
CCAT equipment overlooking ASTE & NANTEN2 @ 4800 m

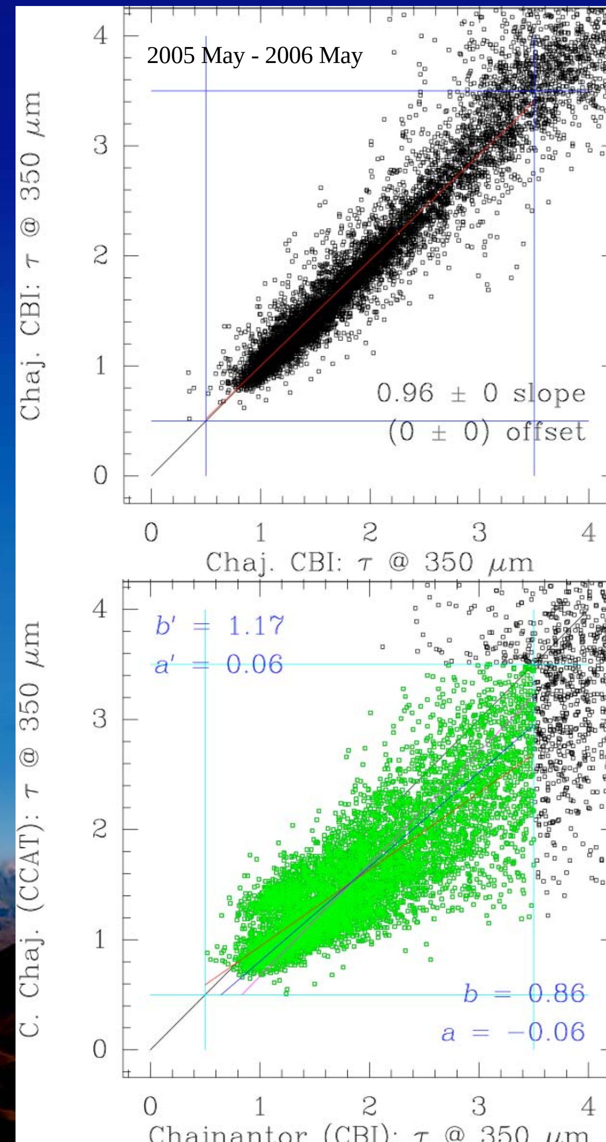


2006 May – 2008 April
Cerro Chajnantor (CCAT)
67300 points
max: 8.2
75%: −2.7
50%: −5.7
25%: −9.3
min: −18.7
T [°C]
max: 524.1
75%: 519.5
50%: 518.3
25%: 517
min: 507.7
P [mbar]
peak ave.
max: 39.4 17
75%: 15.2 6.6
50%: 11.5 4.3
25%: 7.8 2.3
wind speed [m s−1]
75%: 51
50%: 25
25%: 11
RH [%]
max: 5.3
75%: 1.6
50%: 0.8
25%: 0.4
Water Vapor [g m−3]
North
East
calm 1 3 5 7 9 11 13 15 17 19 > [m s−1]

Better 350 μm Transparency

- Two Tippers: CCAT (5600 m) & CBI (5050 m)
- Side-by-Side at CBI: Same Values
- Better Transparency at CCAT
- Less Water Vapor at CCAT
  - $\tau_{off} \approx 0.5$
  - Slope ∝ PVW
  - PWV(CCAT) ≤ 70% PWV(CBI)





Motivation: Institutional Strengths

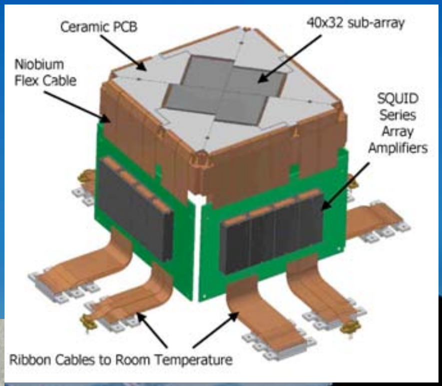
- CCAT emphasizes our institutions' strengths:
- Operation of major observatories
  - NAIC, CSO, JCMT, Kosma
- Instrument construction
  - SHARC, Bolocam, SCUBA I & II, ZEUS, Z-Spec, many heterodyne receivers
- Development of forefront technologies
  - SIS, MKIDs

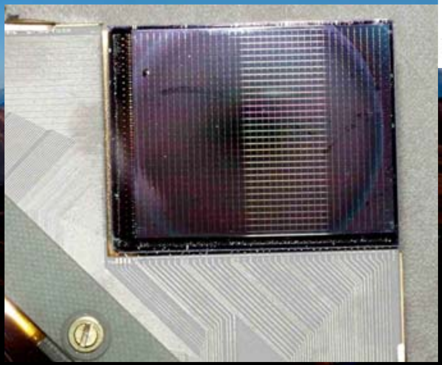
CCAT Instruments

- Direct Illumination Cameras
  - SCUBA2: 450 & 850 μm
  - SWCam: 200–620 μm
- Antenna Coupled Camera
  - LWCam: 700–2000 μm
- Spectrometers
  - Multiobject gratings
- Heterodyne Receivers
  - Array cameras
  - ALMA receiver, connect to ALMA, VLBI
- Legacy Instrumentation

Direct Illumination Cameras

- SCUBA2 (UK ATC, Canada)
  - To JCMT in 2007
  - On CCAT, would be:
    Proven first light instrument
    2.7' at 450 μm, 5' at 850 μm
- CCAT SW Camera (concept)
  - 200 μm, 350 μm, 450 μm, 620 μm
  - Single color with filter wheel
  - NIST TES silicon bolometers
  - Total: 32 000 pixels
  - 5' field of view @ 350 μm

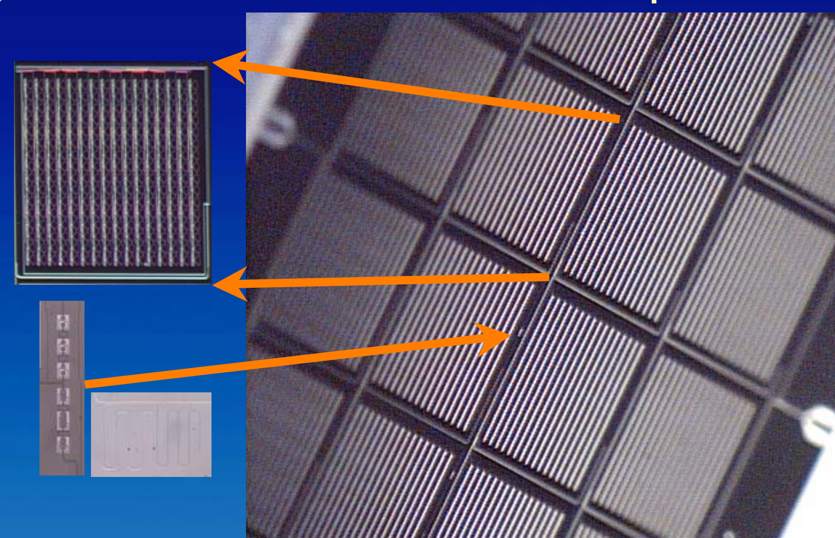


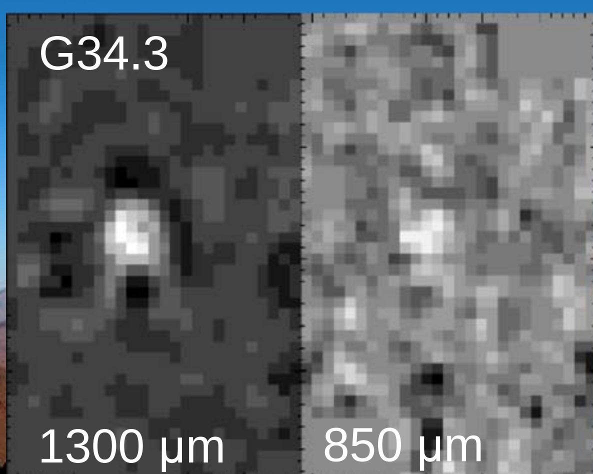


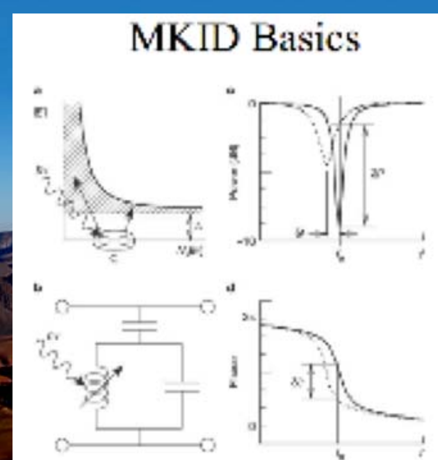
Antenna Coupled MKID Camera

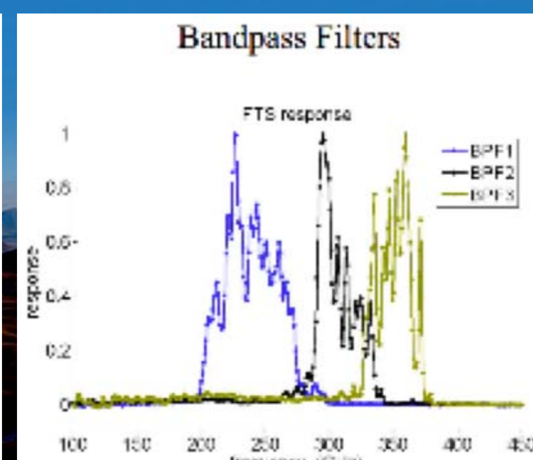
- CSO camera (CIT, Colorado)
  - DemoCam, 4x4 pixels, two colors
  - CSO observations in 2007 April
  - Successor funded, NSF ATI
  - 24x24 pix, 4 color 750-1300 µm
- CCAT LW Camera (concept)
  - 750–2000 µm, 45 000 pixels
  - Up to 20' x 20' Field of View

Antenna coupled array
1300 & 850 µm



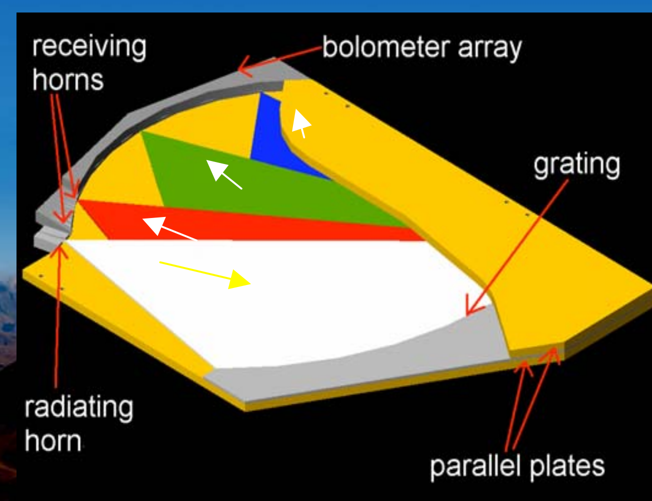






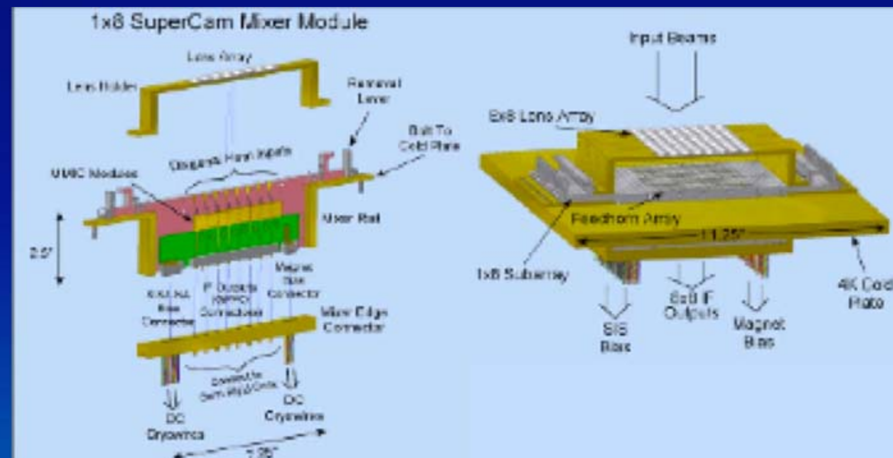
Spectrometers

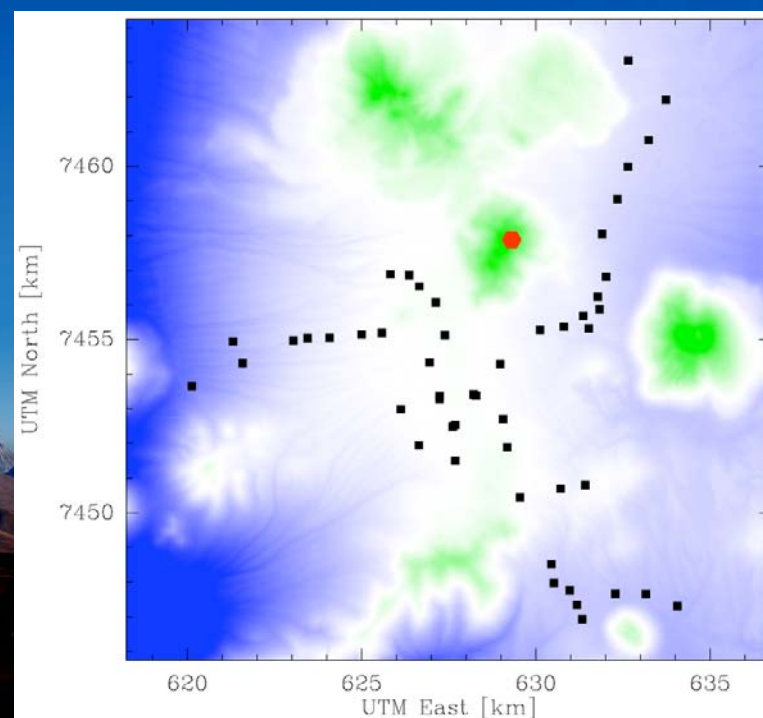
- Zeus (Cornell)
  - Long slit echelle grating
  - 350, 450, 610 μm, R ~ 1000
  - Already to CSO
- Z-Spec (CIT, JPL, Colorado)
  - Parallel plate grating cavity
  - 190–310 GHz, R ~ 250 to 400
  - Already to CSO (2005 June)
- Multiobject
  - Flexible dielectric waveguide
  - Optical relays
  - Laboratory studies



Heterodyne Receivers

- Super Cam (Arizona)
  - 64 pixels, 330–360 GHz
  - FPGA spectrometers
  - 1 GHz IF BW
  - Under development
- CHARM (concept)
  - 64–128 pixels, 650–700 GHz
  - 2–4 GHz IF BW
  - Digital spectrometers
- ALMA Receivers
  - Anchor for long baselines
  - At 350 μm, add 14% sens.
  - Improve dirty sidelobe levels
    - 9% ⇒ 7% (Holdaway)
  - Also VLBI





CCAT information
www.submm.org

"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."

From CAAT Design Review Committee Report
(Robert W. Wilson, Chair)