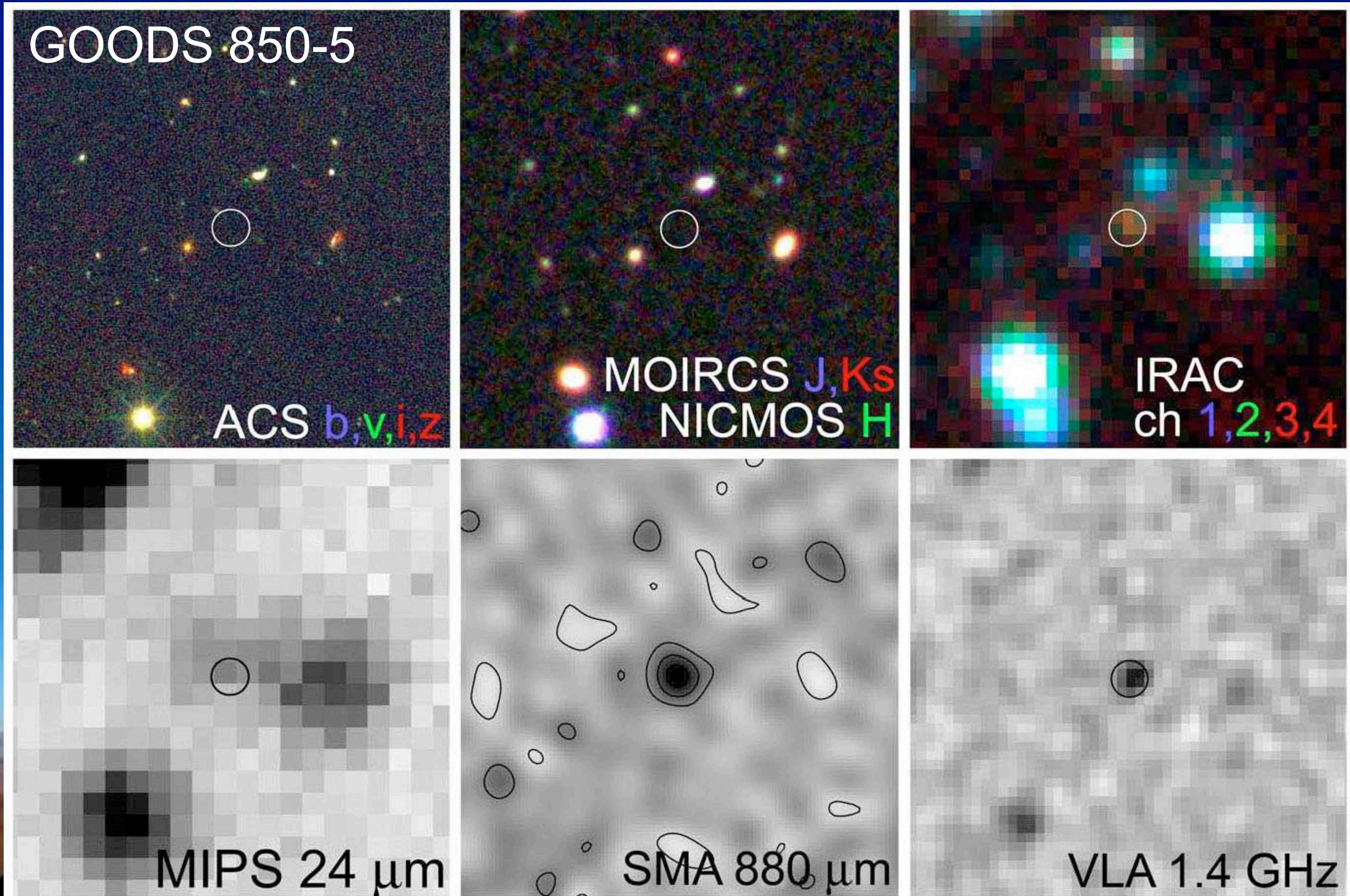
CCAT

2009 February 23

Simon Radford

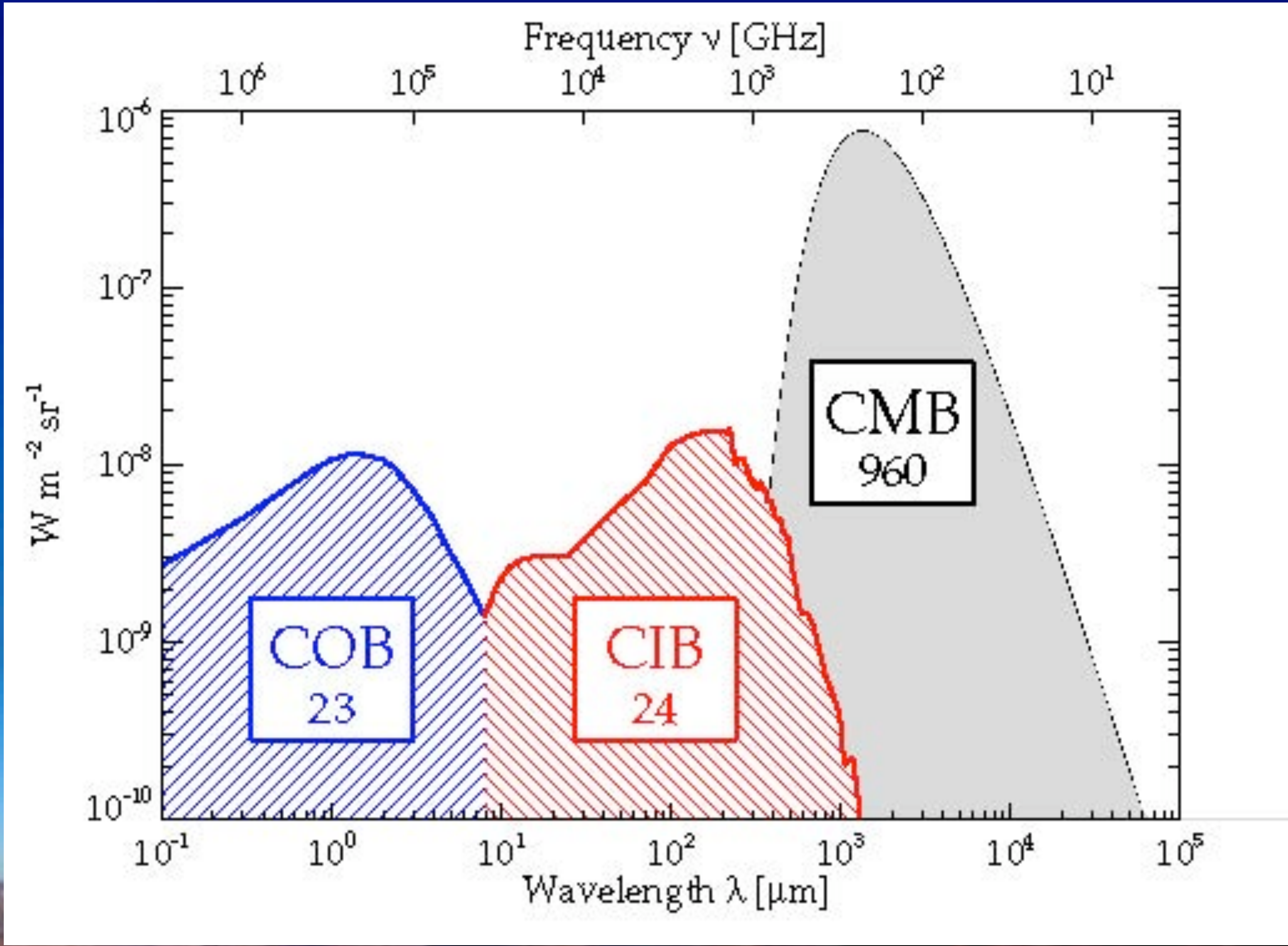
Riccardo Giovanelli, Tom Sebring, Jason Glenn, Gordon Stacey, Matt Bradford, Mark Halpern, Ian Robson, Jürgen Stutzki, Jonas Zmuidzinas, and others!

Optically Invisible Distant Starburst



Wang et al 2008

Light in the Universe

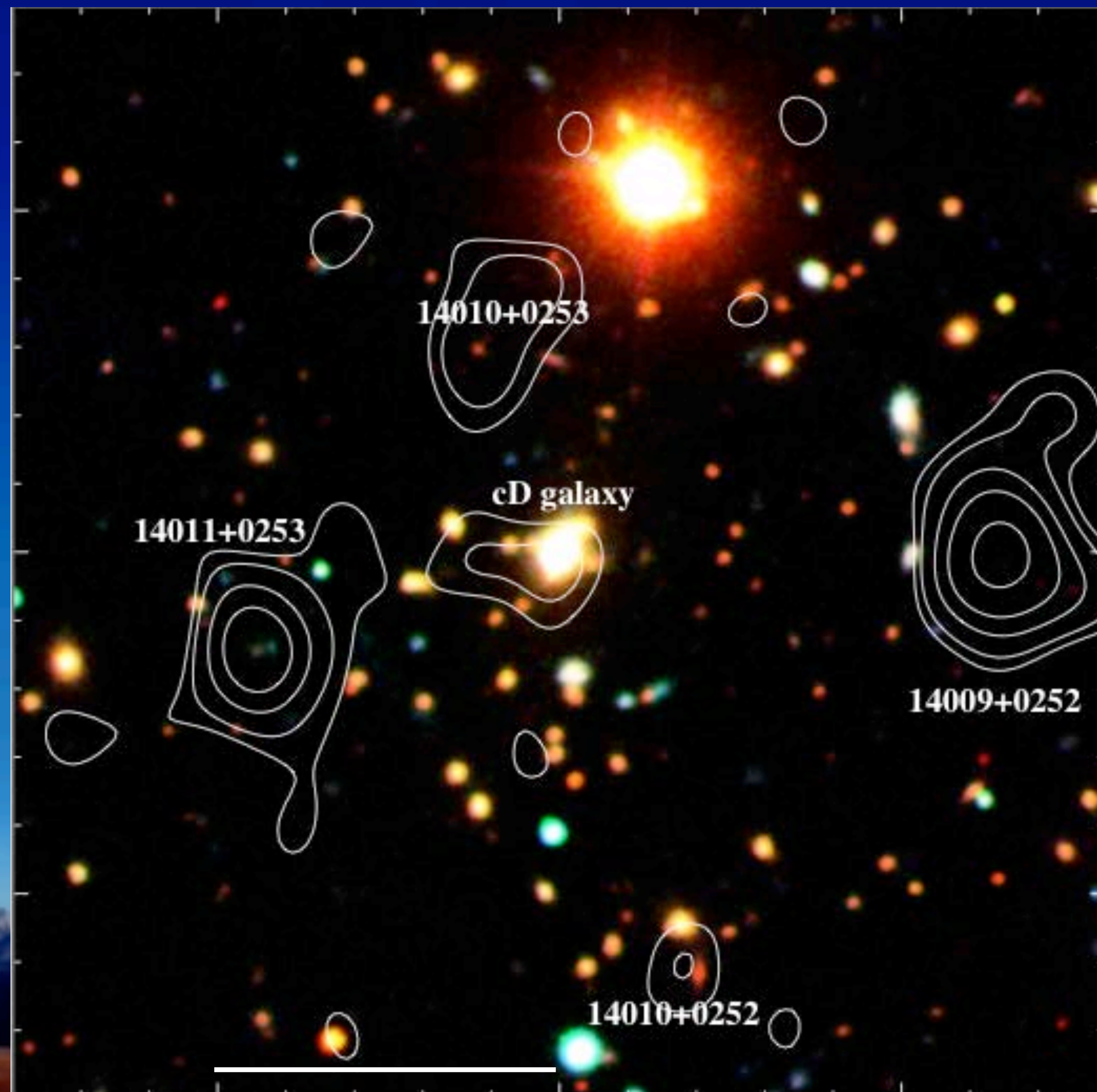


Half of starlight ends up in far infrared – how?

Dole et al 2006

Submm galaxies are hard to find

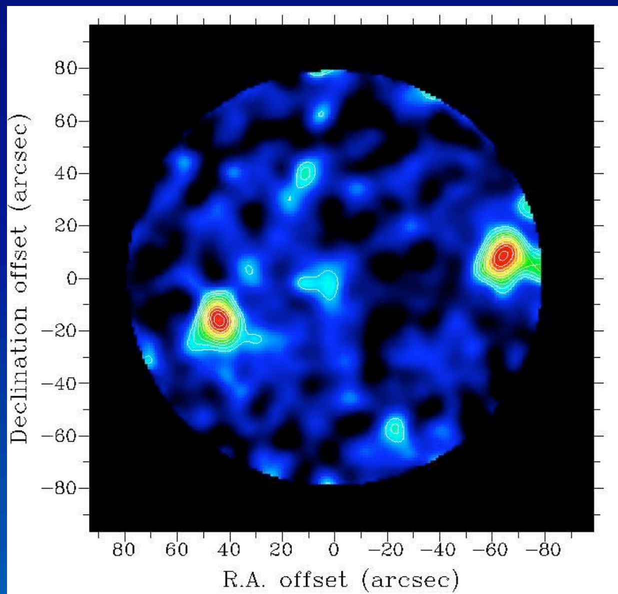
Detection rate at current telescopes is 1–2 per night



50"

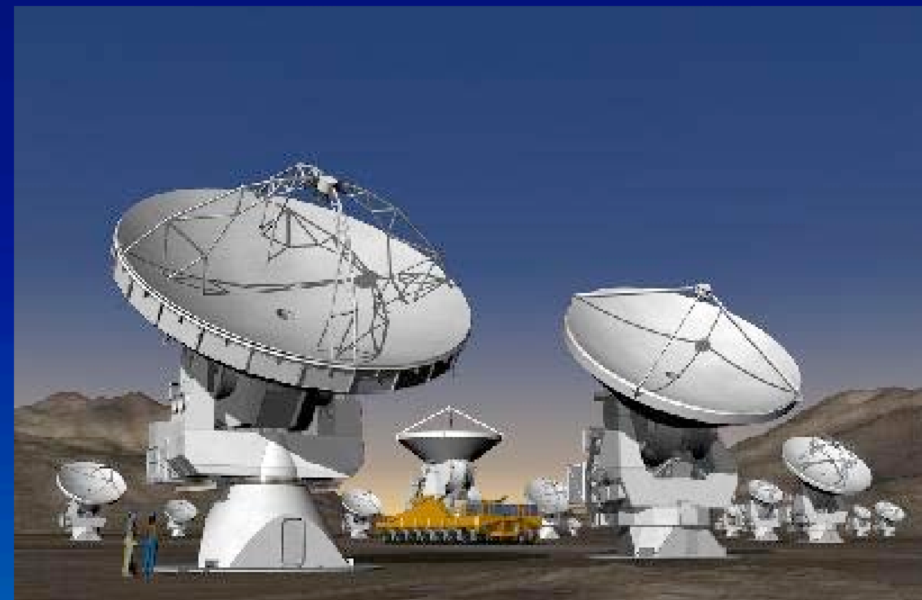
Abell 1835

Why CCAT ?



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

+



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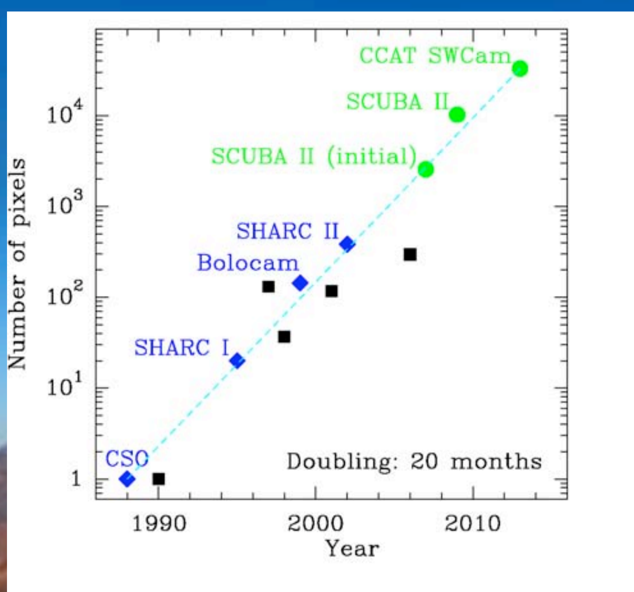
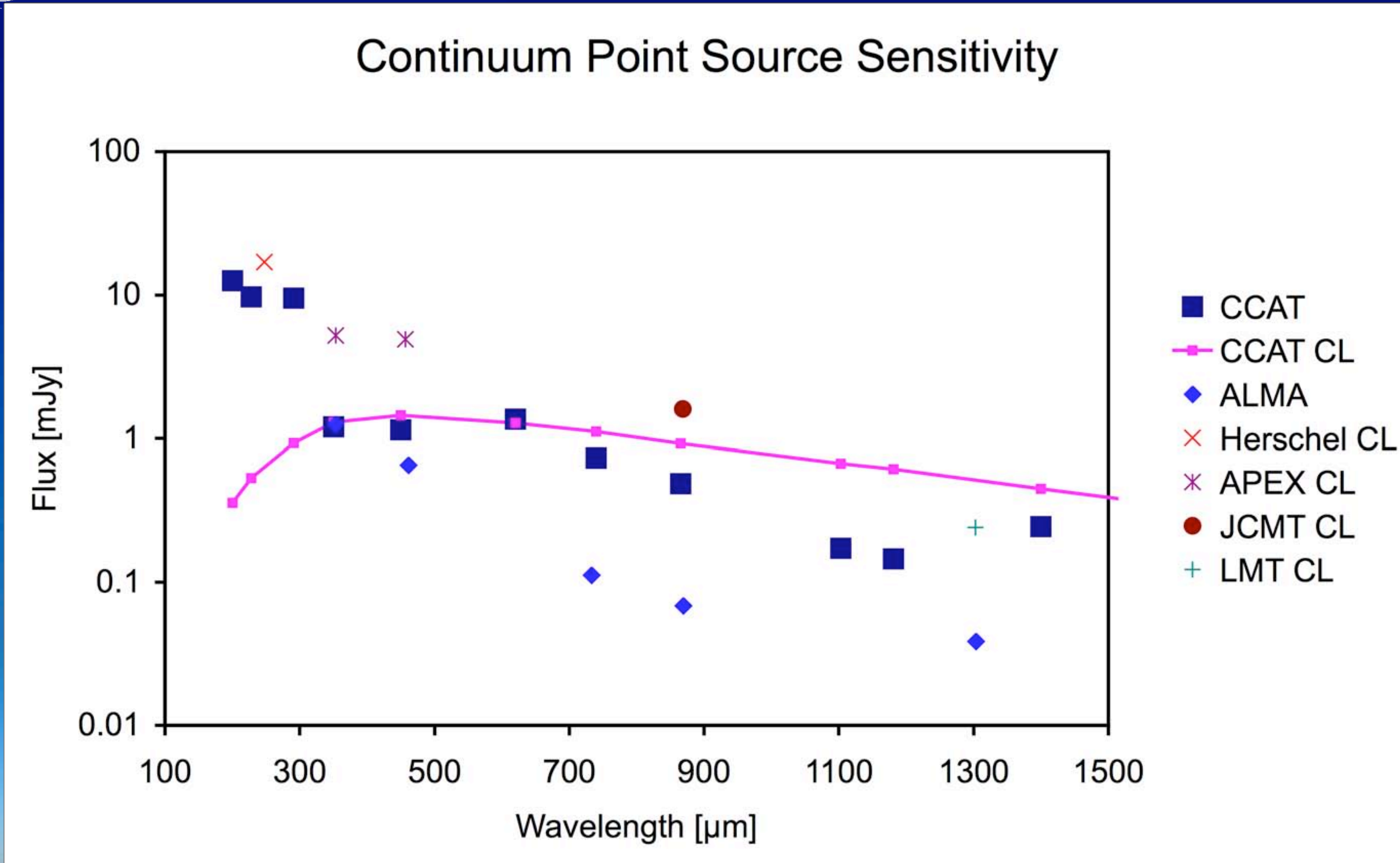


Number of pixels
10^4
10^3
10^2
10^1
1
1990
2000
2010
Year
CCAT SWCam
SCUBA II
SCUBA II (initial)
SHARC II
Bolocam
SHARC I
CSO
Doubling: 20 months

=

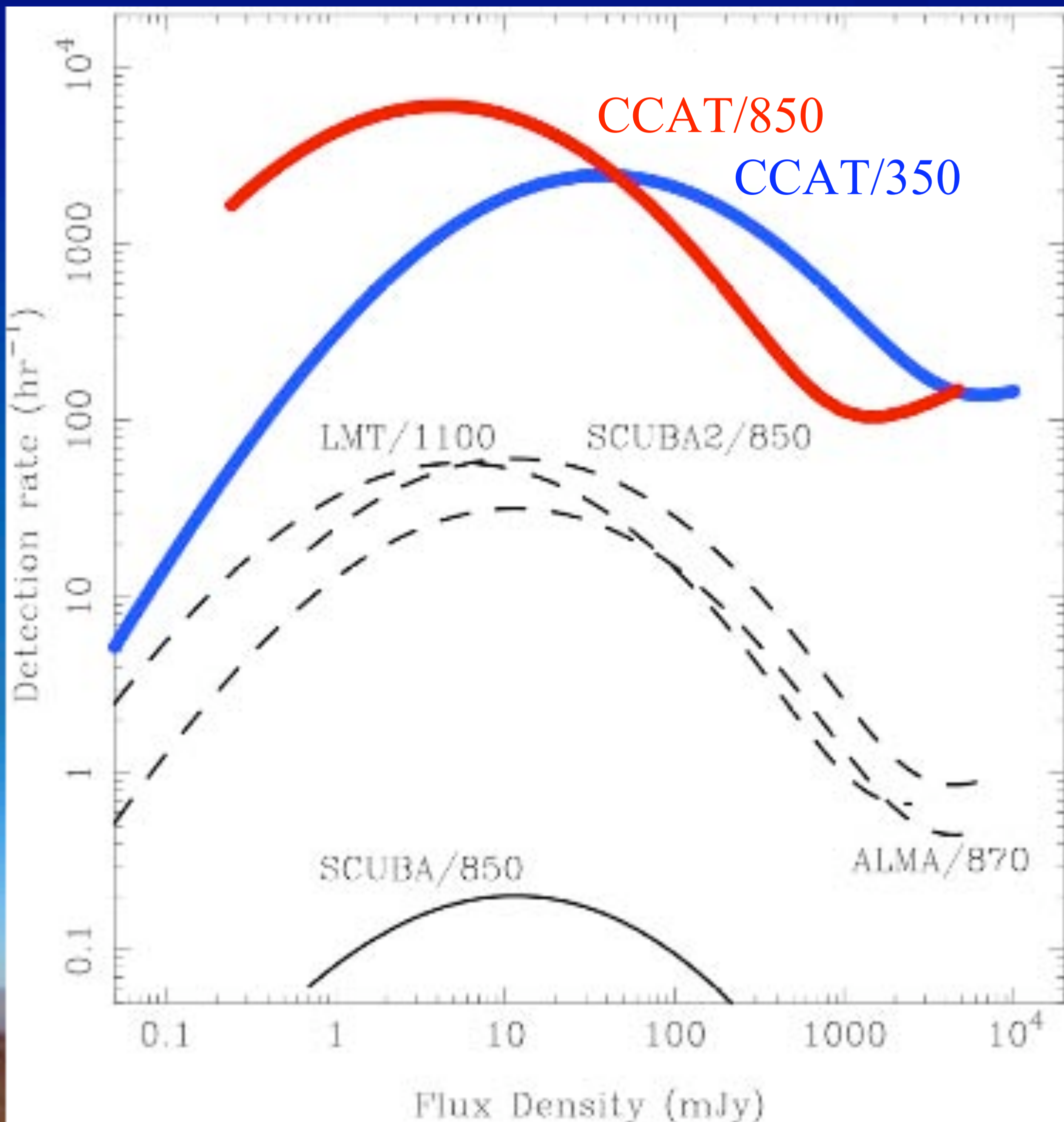
CCAT
25 m, 10 µm rms
Cerro Chajnantor

CCAT Sensitivity



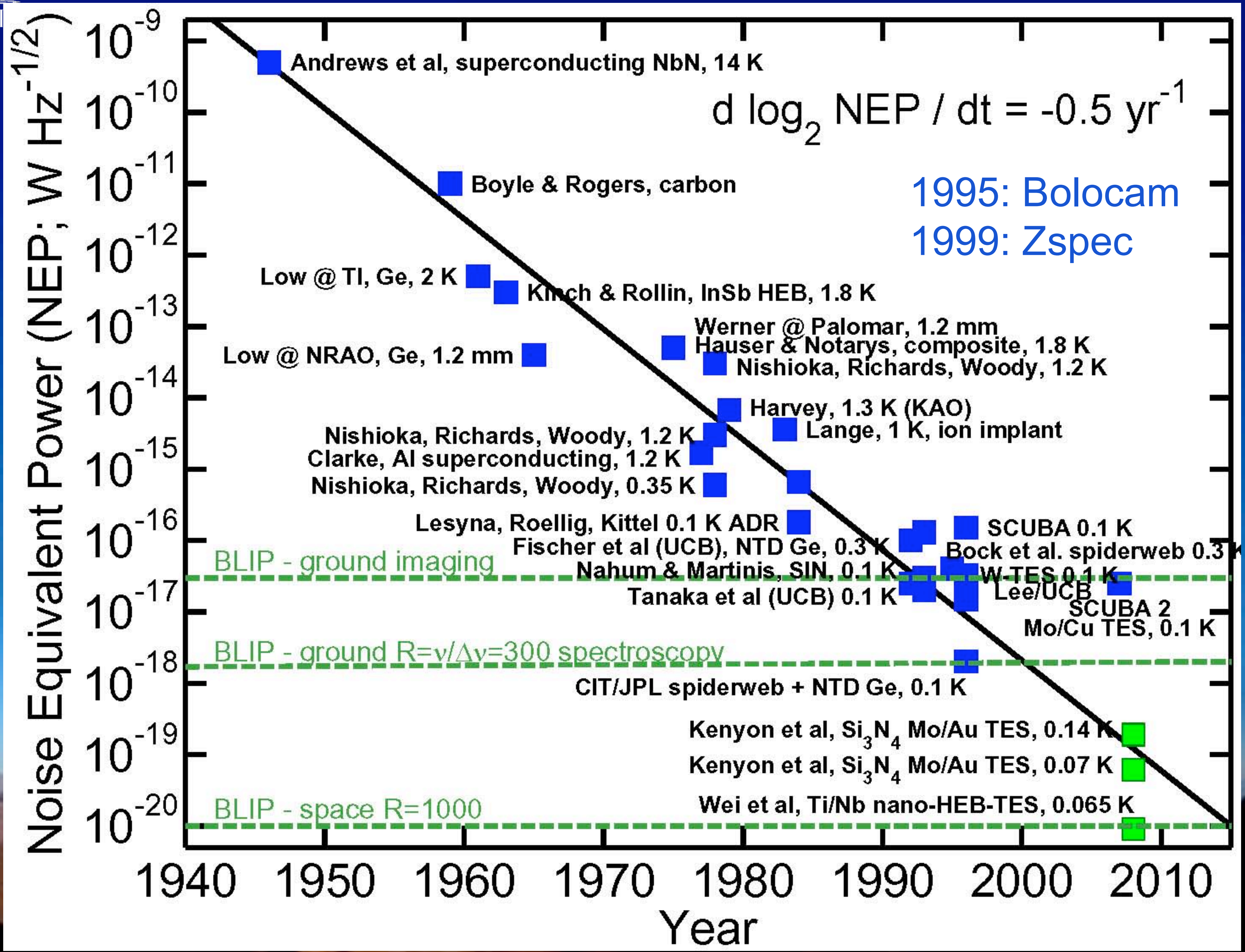
Continuum sensitivities per pixel of CCAT and other instruments (5 σ in 1 hour) with confusion limits (30 beams source^{-1}). CCAT sensitivities computed for precipitable water vapor appropriate to that band.

Submm Galaxy Detection Rate

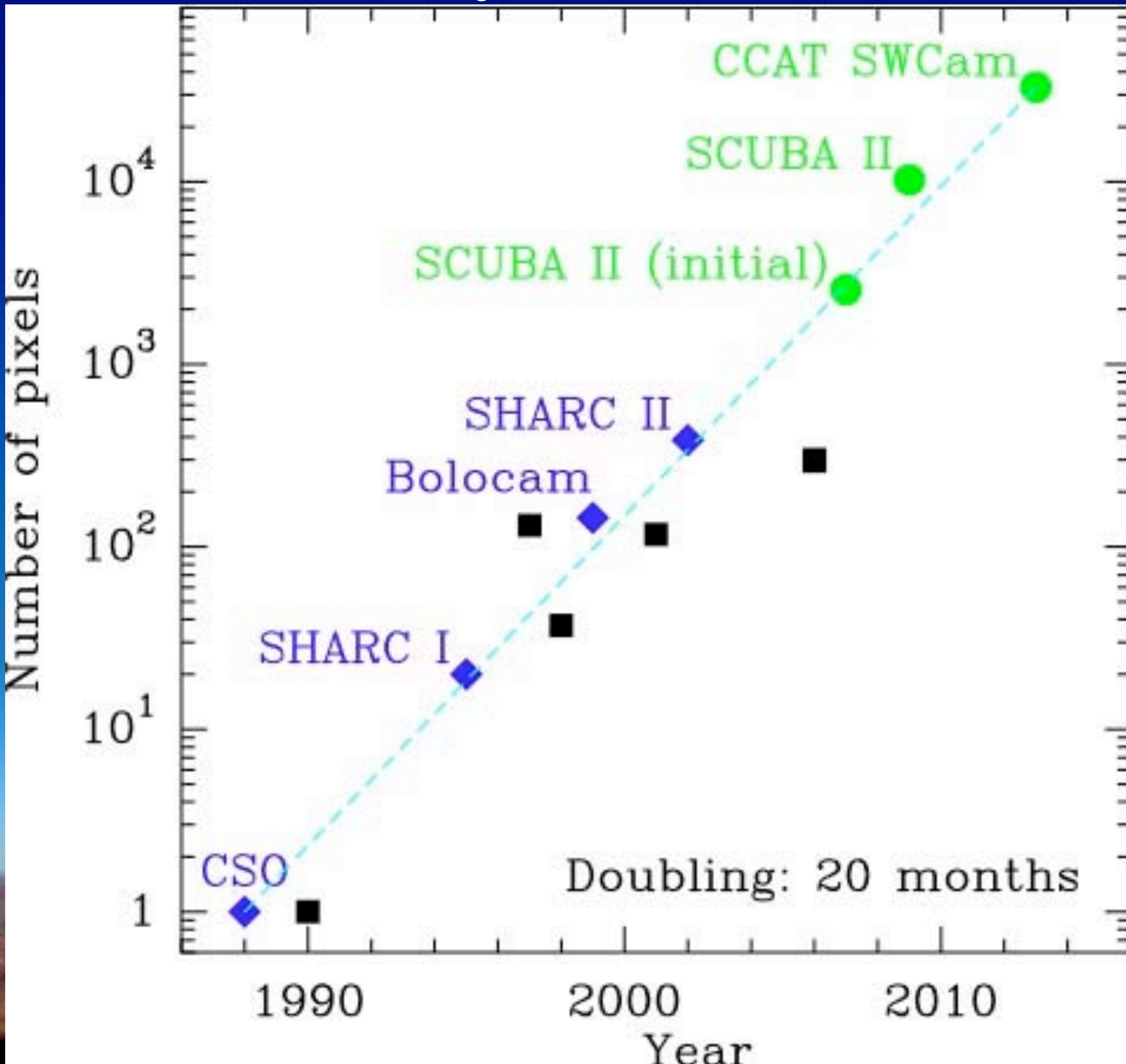


- CCAT is an ultrafast mapper
- Assumptions
  - 32 x 32 (1024) pixel detector, Nyquist sampled, 350 μm & 850 μm
  - Observationally verified counts (good to factor 2)
  - Confusion and all sky limits
- 350 μm & 850 μm detection rates are compatible, but
- Confusion at 350 μm is deeper than at 850 μm
- 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

Bolometer Performance: Sensitivity Improves



While Array Size Increases

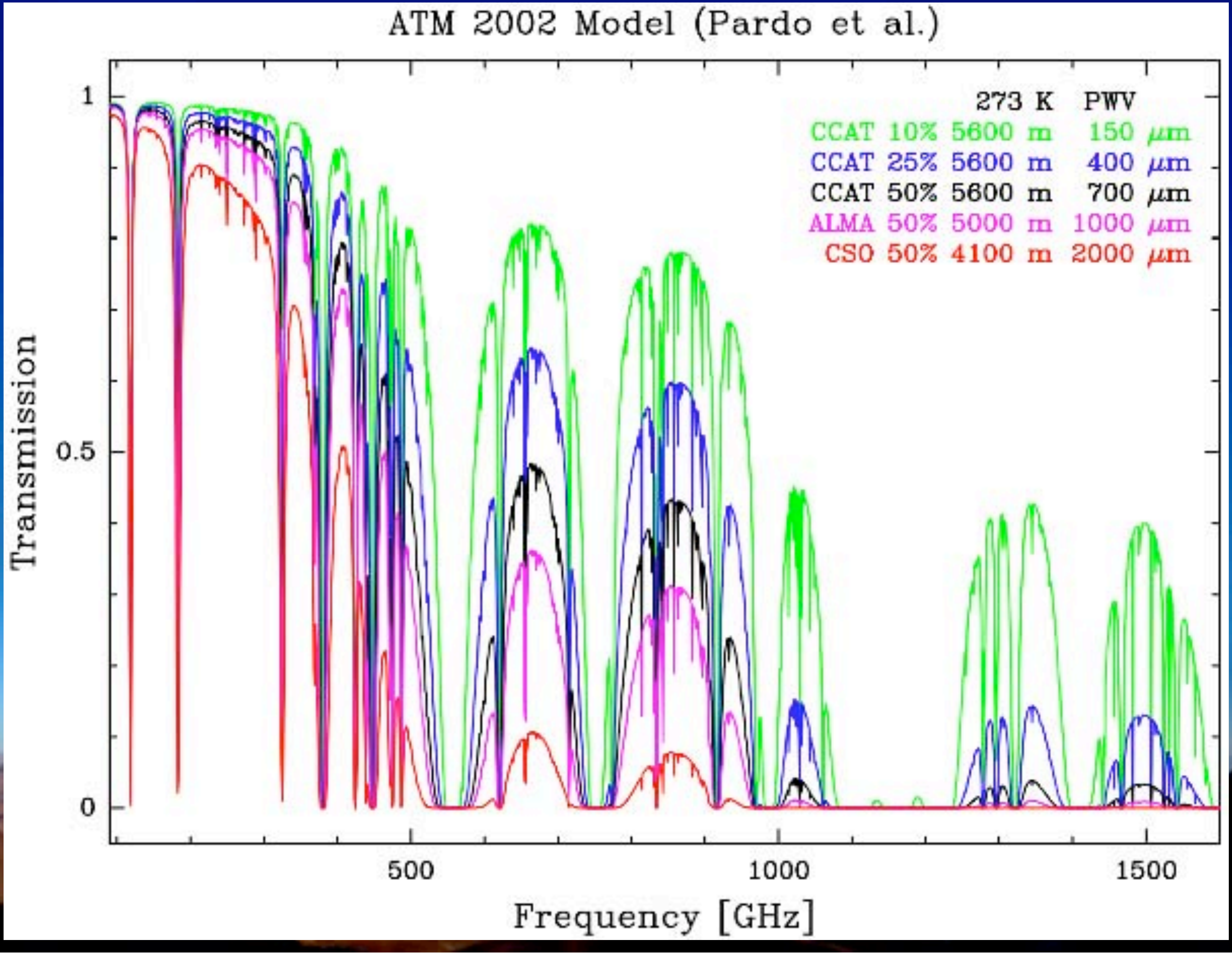


CCAT Performance Goals

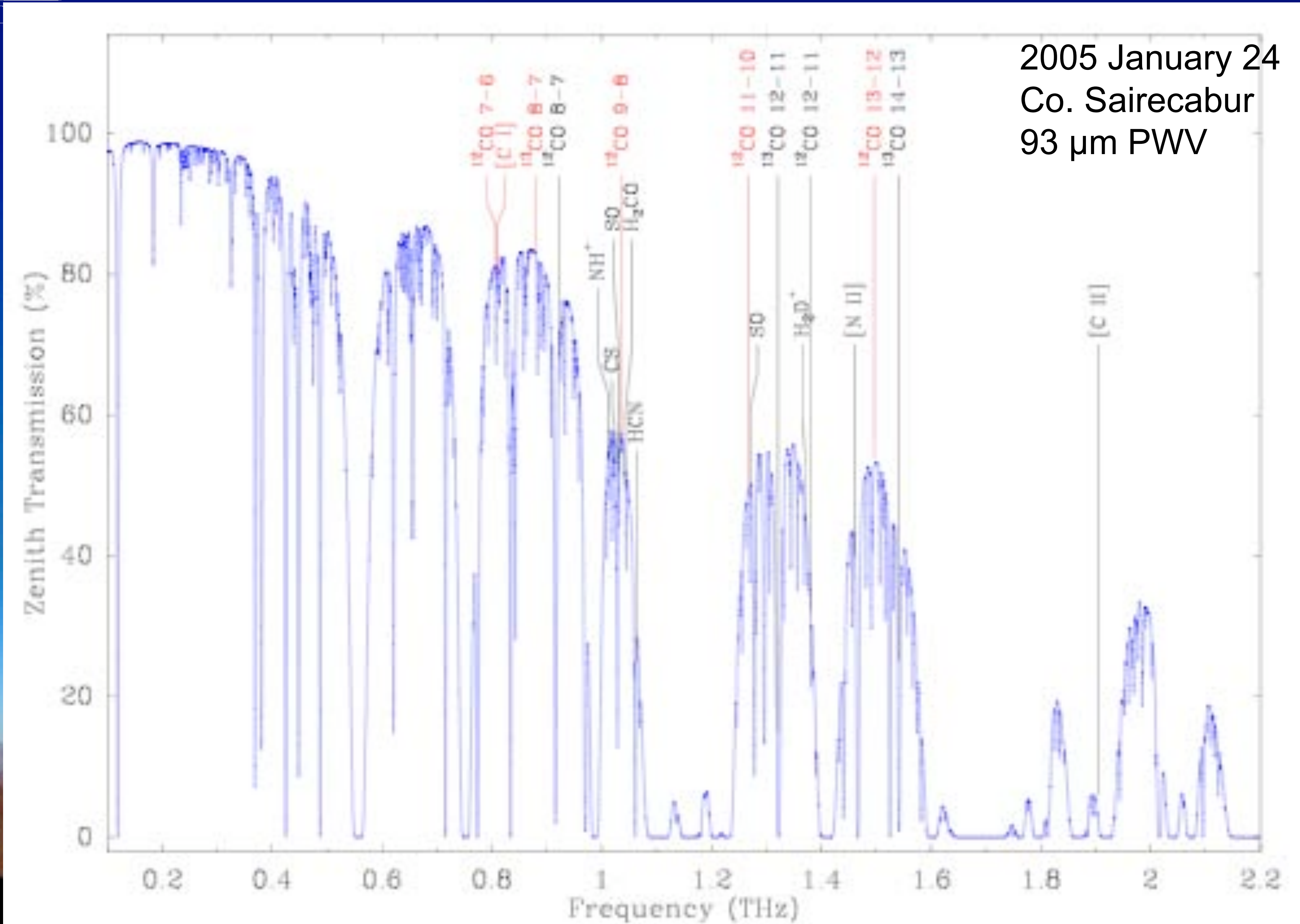
	Requirement	Goal	remark
Wavelength	350 – 1400	200 – 2500	μm
Aperture	25 m		
Field of view	10'	20'	
Half WFE	< 12.5 μm	< 9.5 μm	rms
Site condns.	< 1.0 mm	< 0.7 mm	median pwv

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

Atmospheric Transmission (model)



Atmospheric Transmission (observed)



Marrone et al. 2005

Cerro Chajnantor 5612 m

Cerro Chajnantor 5612 m

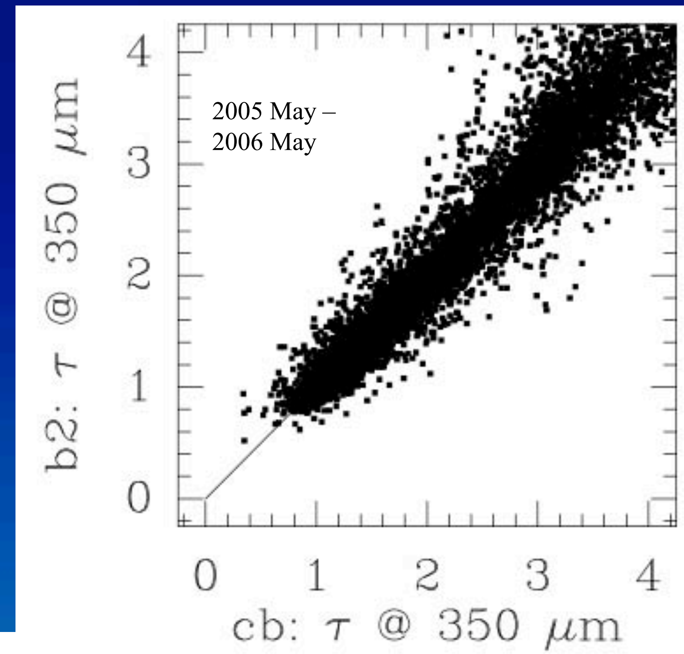
View SW from ASTE; access road constructed by U. Tokyo

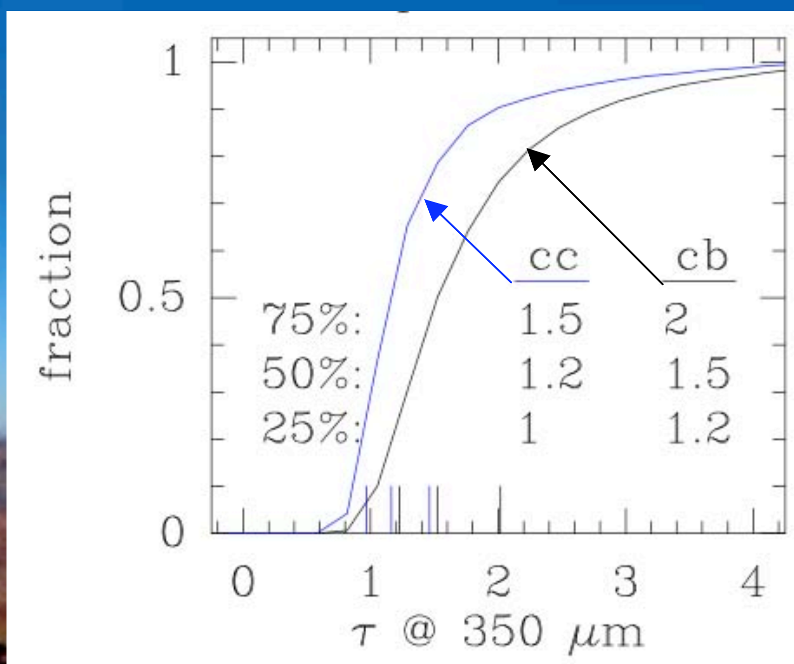
Cerro Chajnantor 5612 m

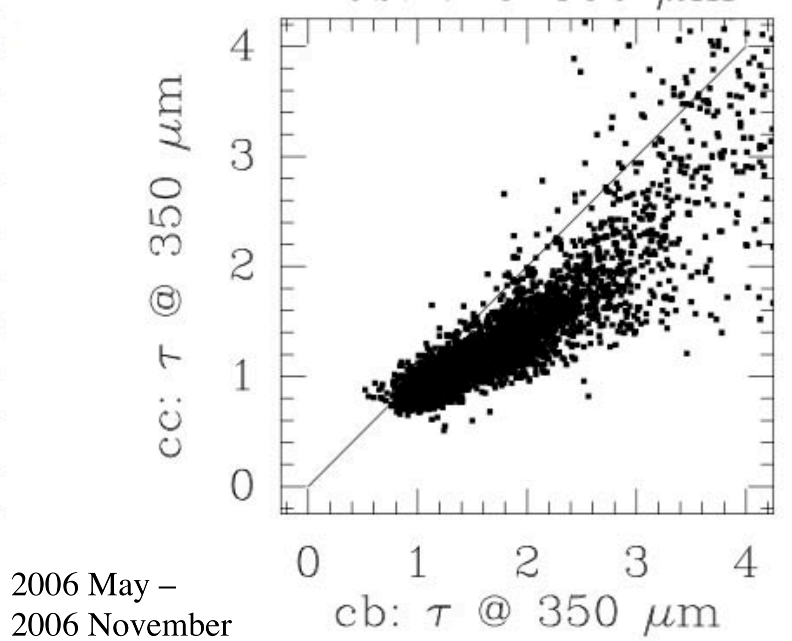
CCAT equipment overlooking ASTE & NANTEN2 @ 4800 m

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)
- Corroborated by humidity measurements



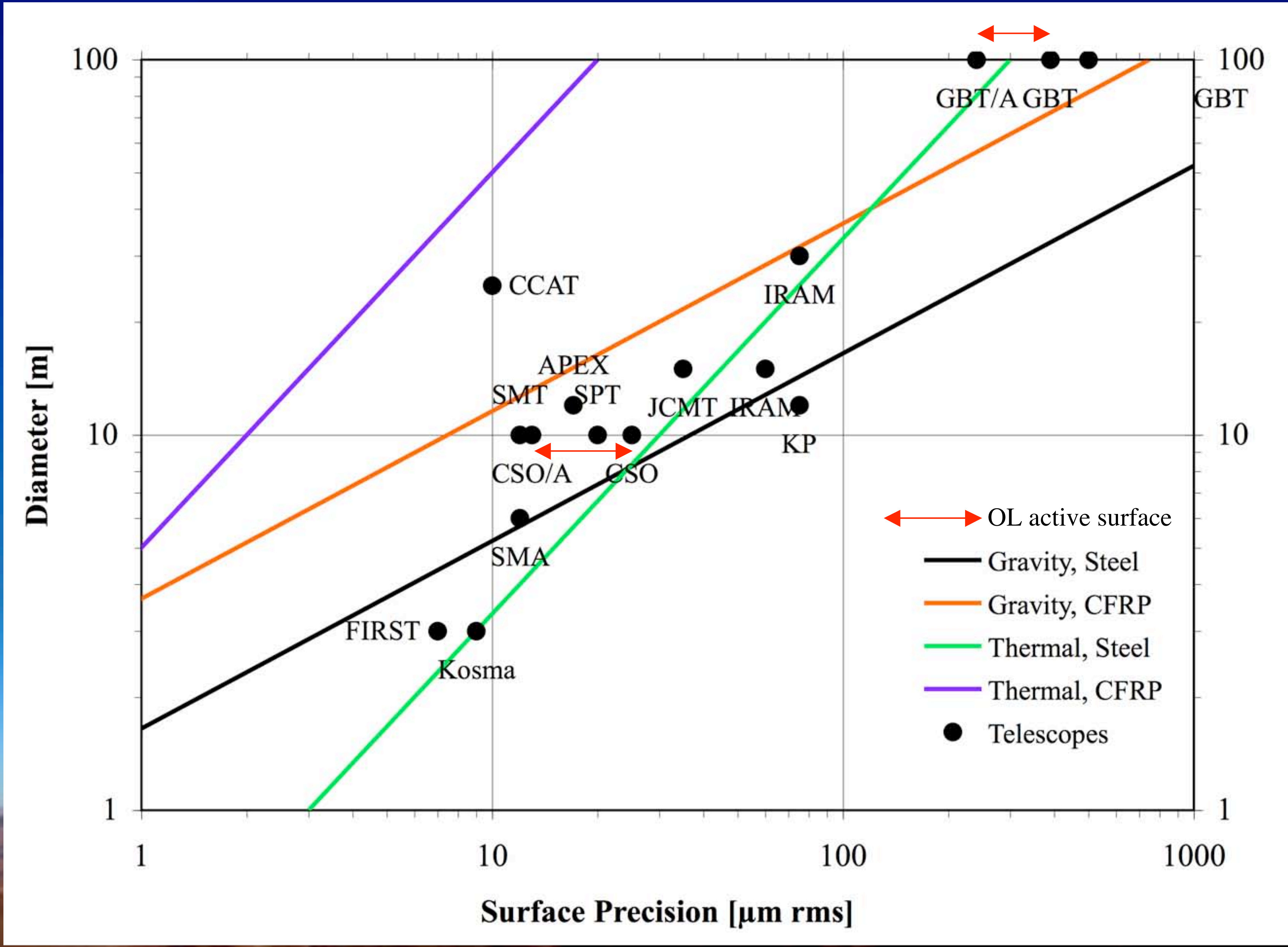




CCAT Concept Design

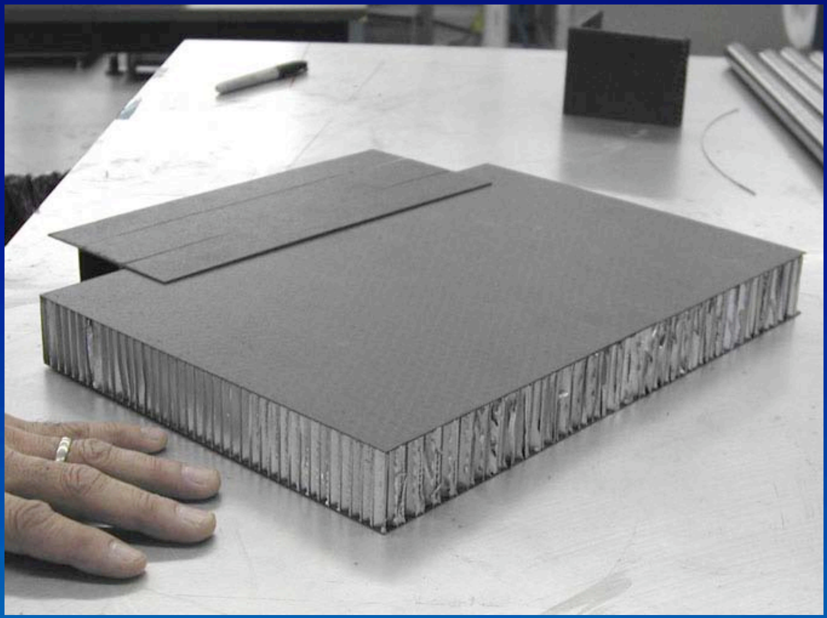
- RC Optics, Nasmyth Foci
- Calotte Dome
  - Internal storm shutter
- High Performance Mount
  - Precise pointing, 0.3" rms
  - Agile scanning motions
- Active Primary Surface
  - Kinematic panel supports
  - Closed loop control
  - Holography alignment
- Cerro Chajnantor, 5612 m
  - Instrument prep. & ops. areas
  - Oxygen enrichment in rooms
- Base Facility near San Pedro

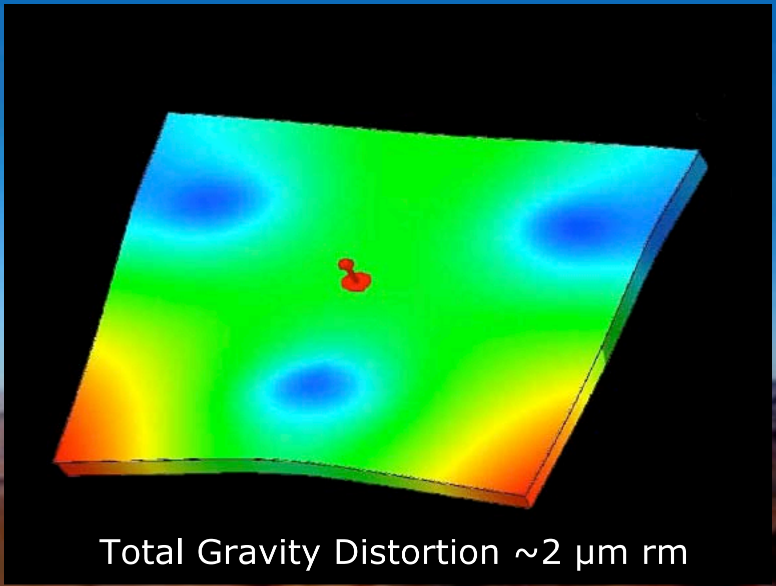
Passive Telescope Limits



Primary Mirror Panels

- Possible Panel Tech.
  - CFRP/Al Sandwich
- ~8 kg m^{-2} Areal Density
- ~5 μm rms <u>Total</u> Error
- Combine two functions
  - support structure
  - optical surface

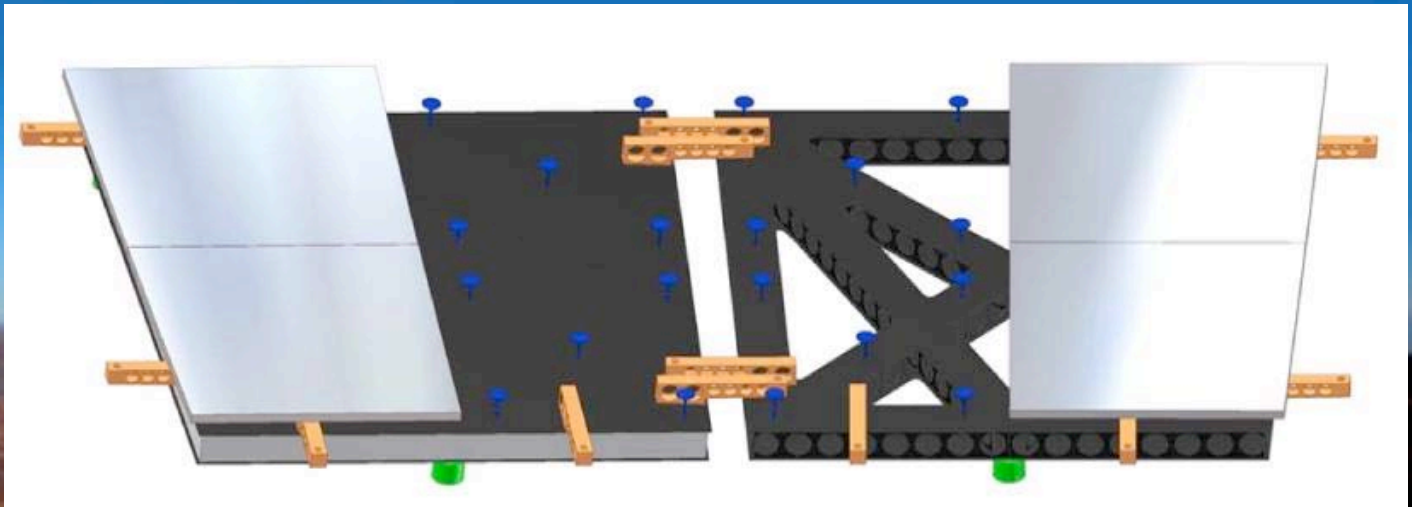




- Thermal stability?
- Manufacturing tolerance?
- SBIR program
  - Vanguard Composites
  - JPL, Cornell

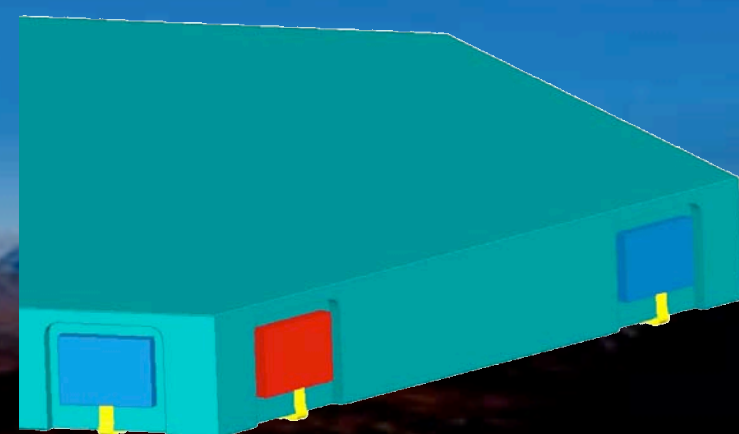
Hybrid Panels

- Separate functions: support and optical surface
- CFRP sub-frames provide stiff, thermally stable platform
  - Exploit excellent thermal & structural properties of CFRP
  - Sensors mounted to frames
- Precision reflecting tiles mounted on sub frame (similar to LMT)
  - Better manufacturing and performance of small panels
  - Tiles aligned with high precision measuring machine
- Extra layer of structure
  - Weight, complexity
- Development effort: NRW.hitech Köln, Bonn, and Vertex AT



Active Surface Alignment

- Sensing and Control Model
  - D. MacDonald (JPL), D. Woody (OVRO)
  - Sensor response to segment motions, modal analysis
  - Closed loop control to maintain surface
  - Low sensor sensitivity to global modes, i. e., focus, tilt, astig.
  - Thermal and gravity segment distortions disrupt control
- “Edge” Sensors
  - Displacement and dihedral information at segment borders
  - Necessary but not sufficient



CCAT Consortium

- Caltech
  - Includes JPL involvement
- Cornell University
- University of Colorado Boulder
- UK Astronomy Technology Centre (STFC)
- Canada (Univs. of BC & Waterloo)
- Germany (Univs. Köln & Bonn)
- Other Institutions Interested

Interim Consortium Agreement Signed in 2007

Full Project Agreement Anticipated

Project Phases and Schedule

- Feasibility/Concept Design Study
  - 2004 – 2006
  - Cornell, Caltech, & JPL: Develop Baseline Concept, Assess Feasibility, Initial Cost Estimate
- Consortium Development
  - 2006 – 2009
  - Expand Consortium, Develop Funding
  - Address Key Technical Issues
- Technical Development
  - 2009 – 2013
  - Detailed Design, Manufacture, Integration
- Commissioning Phase
  - 2014
  - Optimize Performance & Handover to Operations

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)