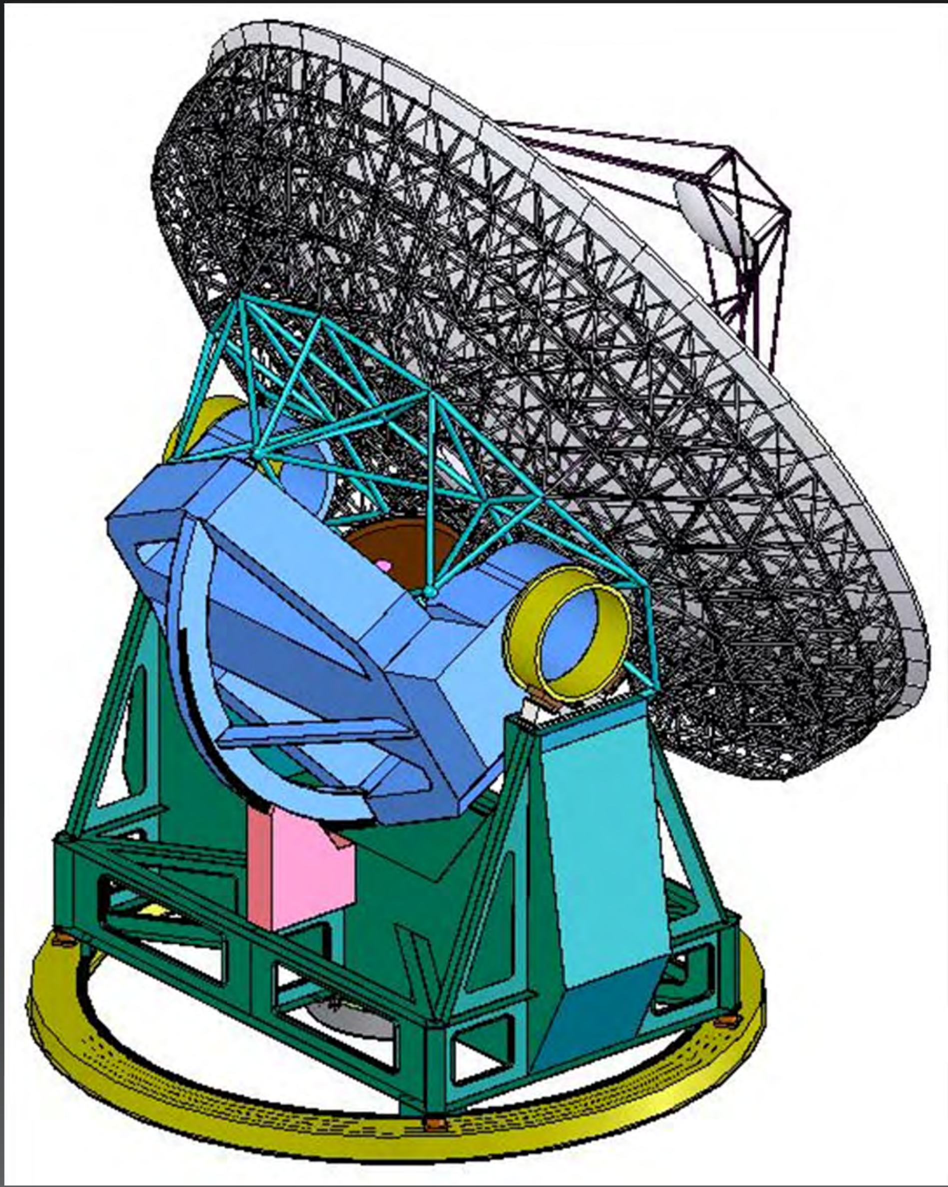
CCAT

Cornell University
California Institute of Technology &
NASA JPL
University of Cologne
University of Bonn
Canadian university consortium
British Columbia
Calgary
Dalhousie
McGill
McMaster
Toronto
Waterloo
Western Ontario
University of Colorado
Associated Universities, Inc.

Director – Riccardo Giovanelli
Project Manager – Jeff Zivick
Project Engineer – Steve Padin
Project Scientist – Jason Glenn

Jason Glenn, University of Colorado, Boulder
Formation and Development of Molecular Clouds
Cologne University, 5 Oct 2011

Telescope



Basics

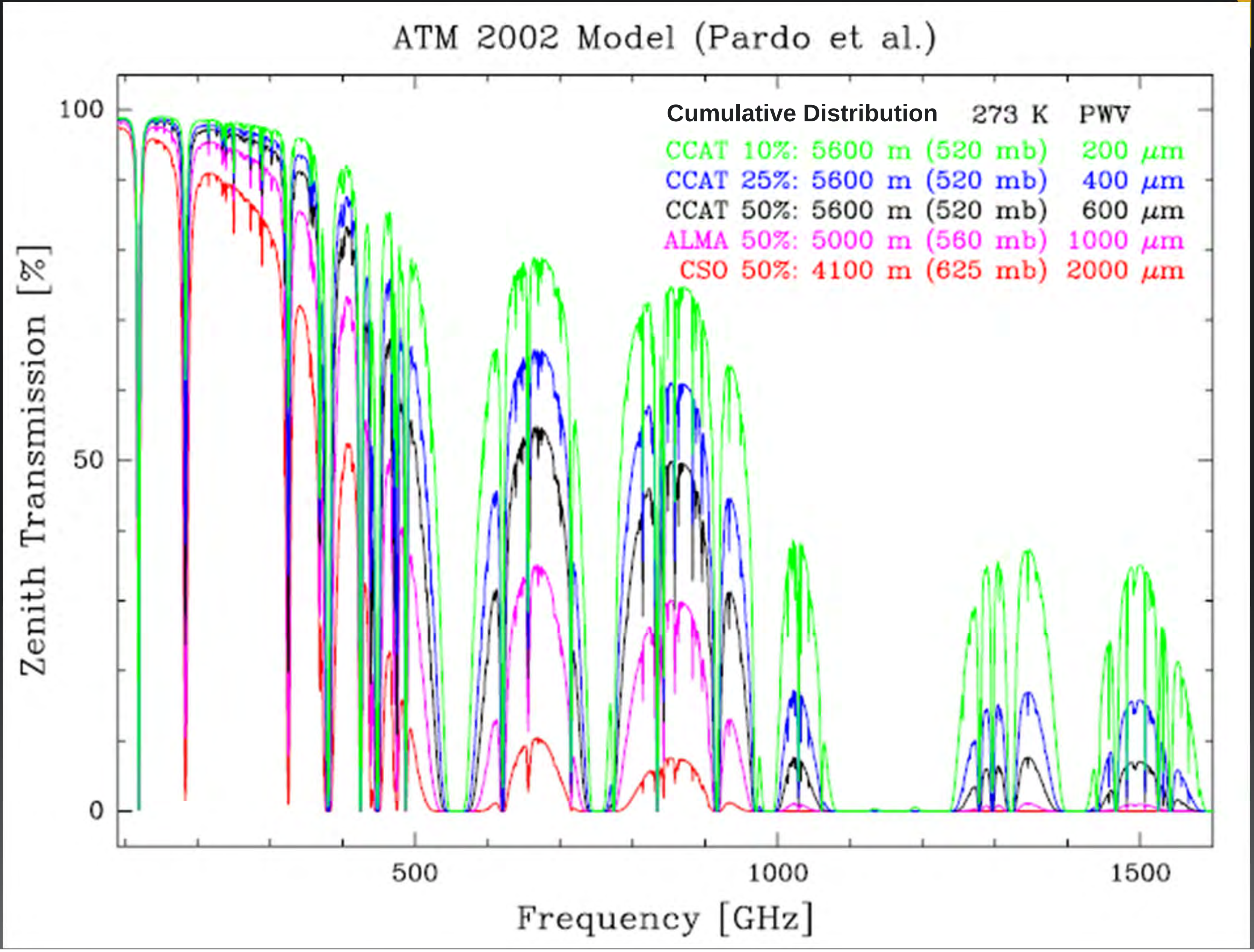
- Aperture: 25 m
- Angular Resolution: 3.5” beams @ 350 µm
- Wavelengths: 350 µm – 2.2 mm (200 µm goal)
- FOV: ≥ 20’ (1°)
- Surface: HWFE < 12.5 µm rms
- Cost: ~$110M U.S. (85€ million)

Construction

- Enclosed
- Alt/Az mount with Nasmyth foci
- Active surface with Al tiles and CFRP subframes
- CFRP truss
- Steel elevation structure

Atmospheric Transmission Cerro Chajnantor (5,600 m)

ALMA



Timeline

- 2004 MOU signed between Cornell and Caltech
- 2006 CCAT Feasibility/Concept Study completed
- 2007 Interim Consortium Agreement signed by, including Cornell, Caltech, UK ATC, Colorado
- 2010 U.S. Astro2010 Decadal Survey endorsement:

Recommendations for New Ground-Based Activities—Medium Project

Only one medium project is called out, because it is ranked most highly. Other projects in this category should be submitted to the Mid-Scale Innovations Program for competitive review.

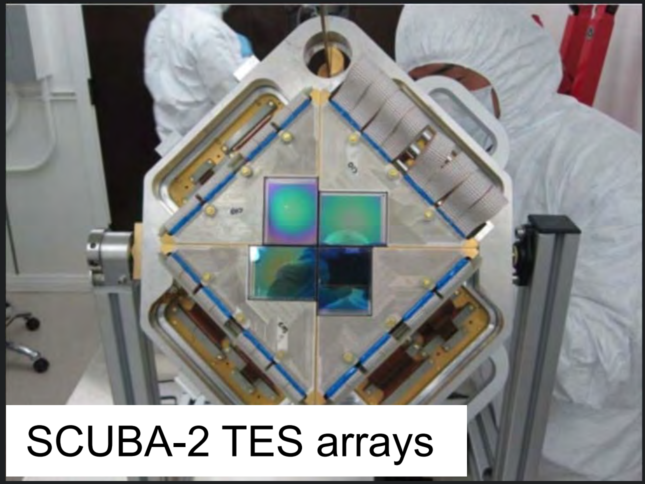
- 2011 CCAT partnership, corporation, and board of directors formed; Engineering Design Phase initiated
- 2013 Scheduled completion of EDP
- 2013 – 2017 Scheduled construction phase

First-Light Instrumentation

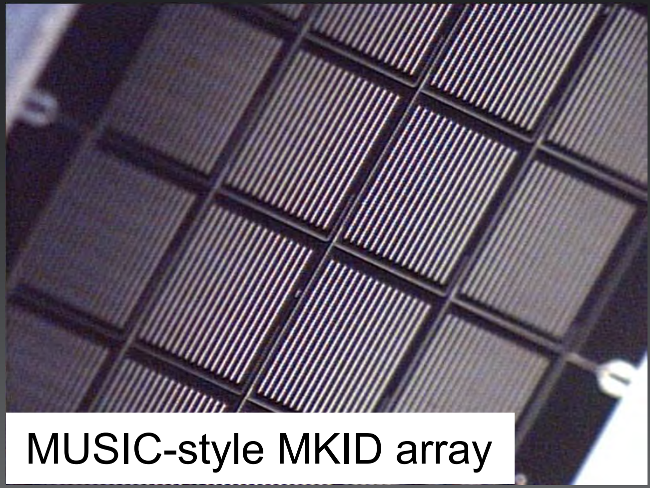
A call for proposals will be circulated to CCAT partners shortly for design studies for first-light instruments, with first-light instrument selection preceding the end of the EDP.

Instruments that have been discussed include

- SWCam: TES or FIR-KID arrays
  - (200), 350, 450, (620) μm bands
  - Possibly 50,000 0.5fλ pixels
- LWCam: MKID array
  - (750), 850, 1100, 1300, 2100 μm bands
  - Possibly 3k 4-color (1-2)fλ pixels
- Broadband, medium resolution multiobject spectrometer using ZEUS or Z-Spec technology
- Heterodyne spectrometer arrays

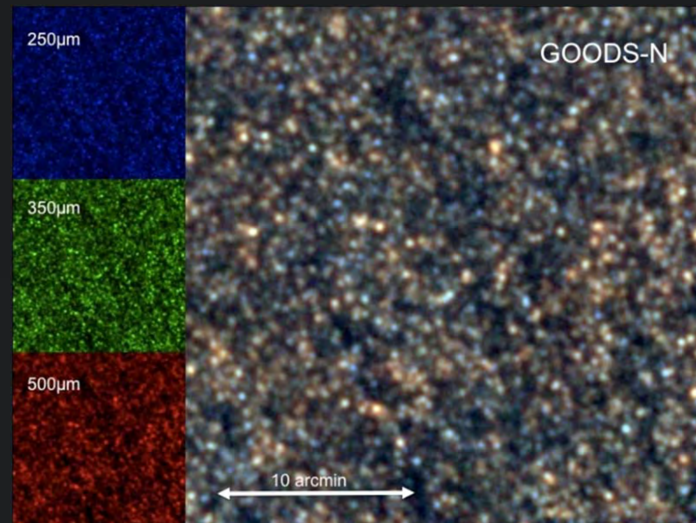


SCUBA-2 TES arrays



MUSIC-style MKID array

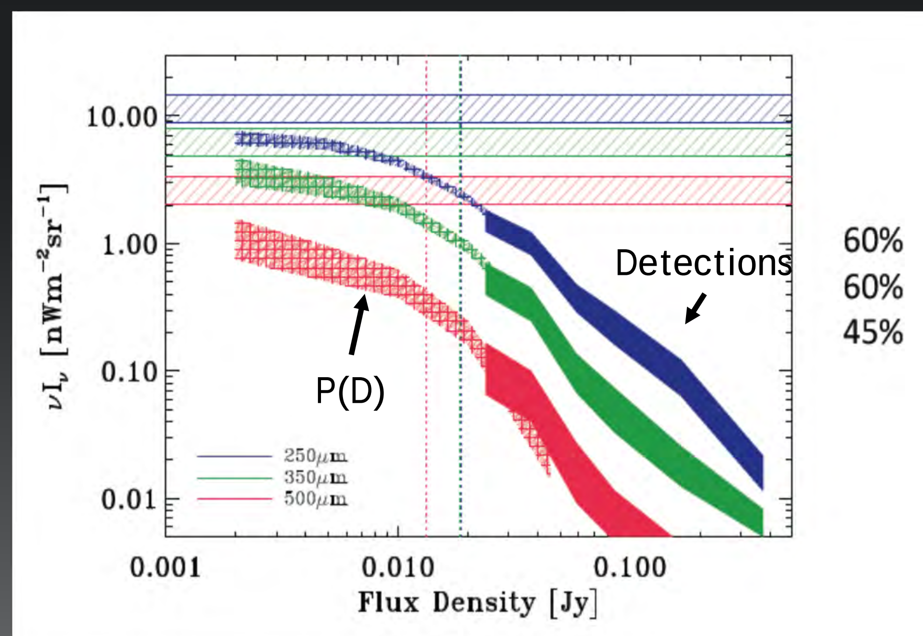
Galaxies & the Cosmic Far-Infrared Background at Submillimeter Wavelengths



HerMES Lockman Hole North

Oliver et al. (2010, 2011)

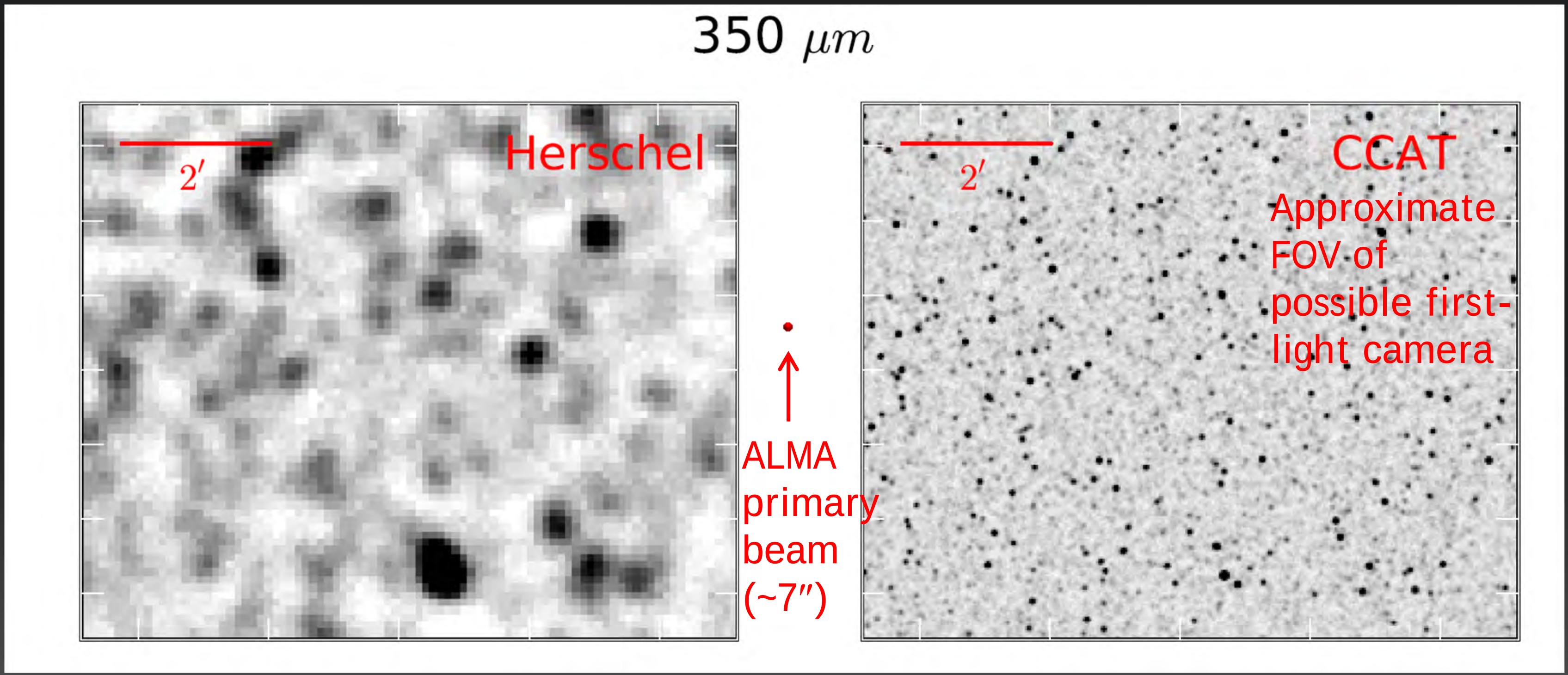
1. Submm observations are necessary to measure the bolometric luminosities of star-forming galaxies
2. Only the most luminous galaxies have been detected so far
   - 10% of CFIRB resolved directly with *Herschel*
   - 50% resolved by P(D)
   - ⇒ Parameterized number count models derived to a depth of 2 mJy/beam



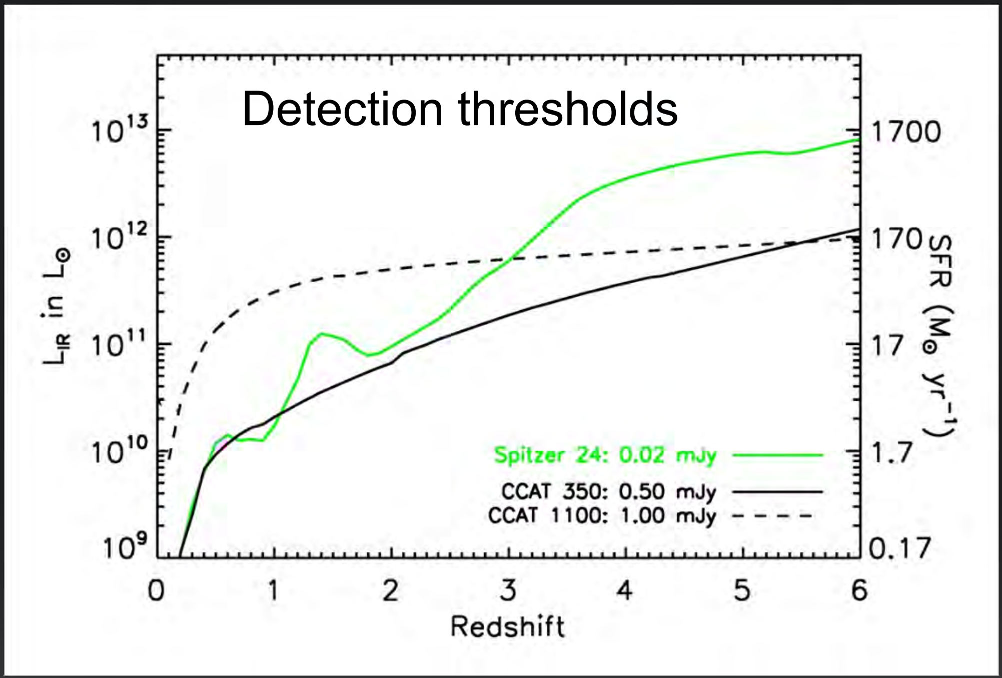
60%
60%
45%

The Importance of Mapping Speed and Angular Resolution

Simulated maps of the same patch of sky based on *Herschel* counts



Measuring the ULIRG Luminosity Function to $z \geq 5$

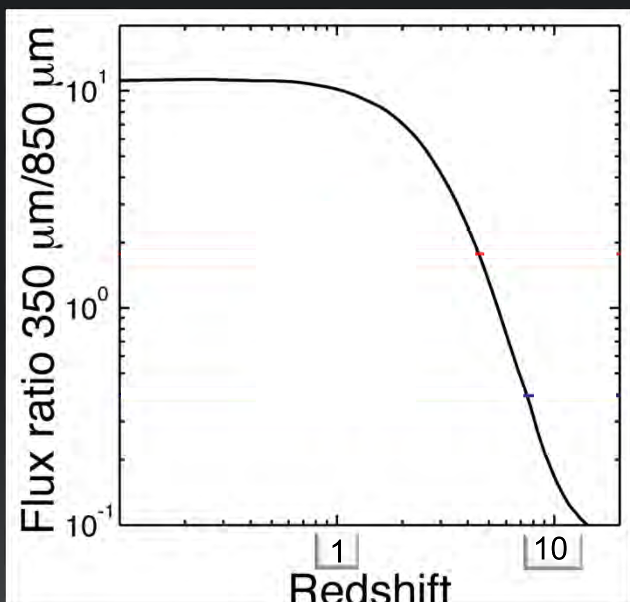


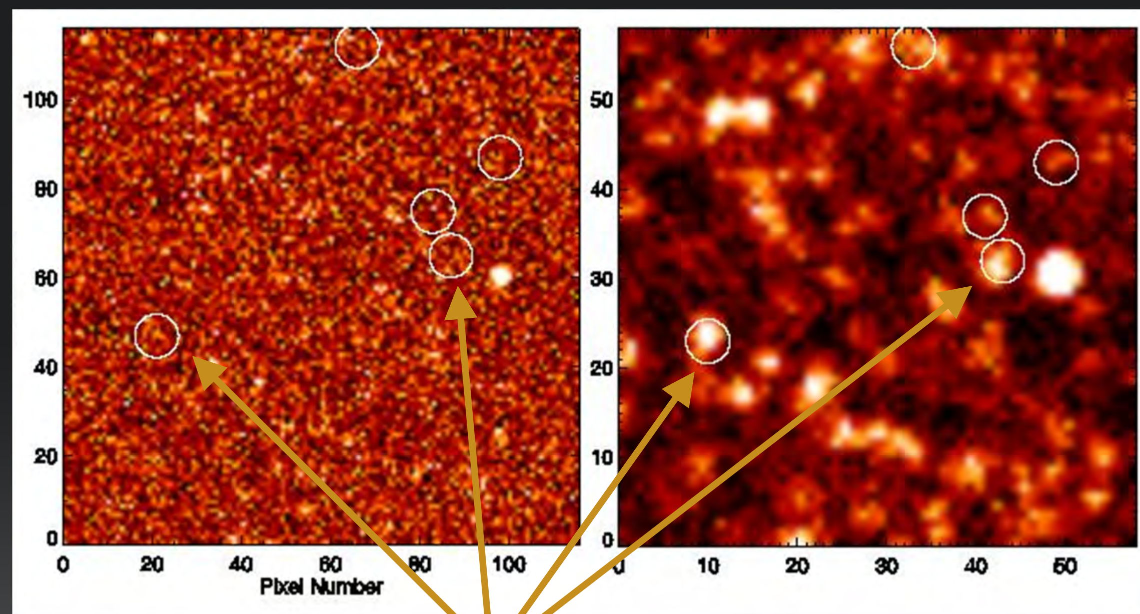
Courtesy R. Chary, based on Chary & Elbaz

- At $5\sigma_{conf}$ CCAT will detect ULIRGs to $z \approx 6.3$, 5.5, and 0.7, respectively, at λ = 350, 450, and 850 µm
- The deepest CCAT surveys will match *Spitzer* 24 µm for $z < 2$ and surpass for $z > 2$
- Halo masses can be measured via clustering of galaxies almost two orders of magnitude fainter than *Herschel* [$S_{250\mu m} > 30$ mJy reside in dark matter halos with $M > (5 \pm 4) \times 10^{12}\ M_{sun}$]

Identifying High-z Galaxy Candidates

High-z galaxies will have low 350 to 850 µm flux density ratios ("350 µm dropouts") and may enable us to probe the epoch of reionization



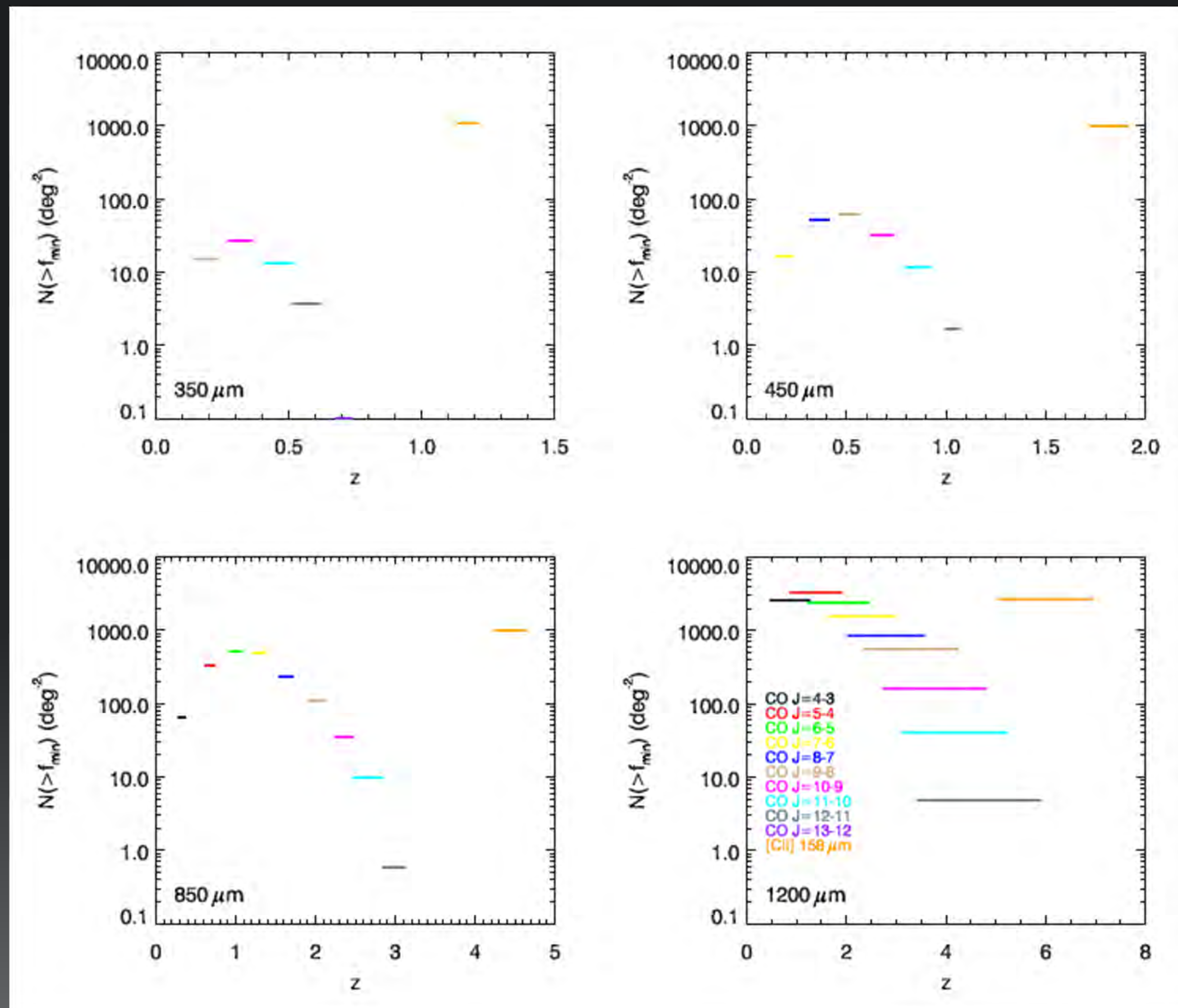


>5σ 850 µm detection, 350 µm nondetections

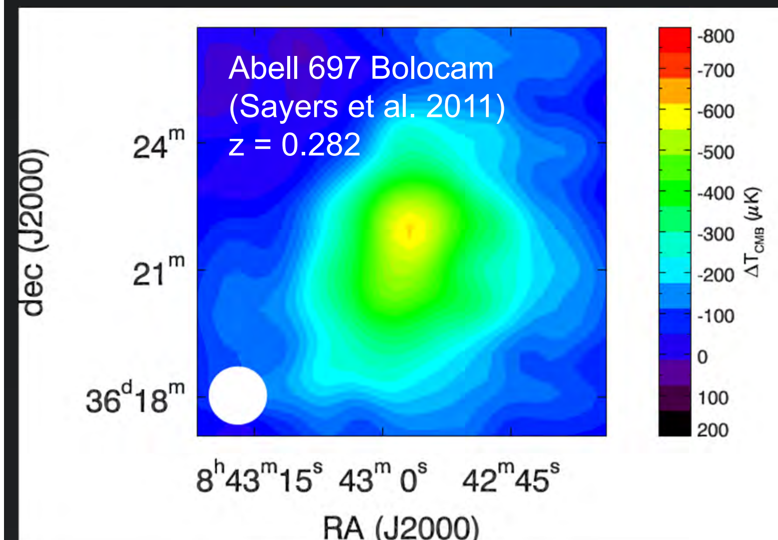
Spectroscopy: Redshifts and ISM Astro-physics

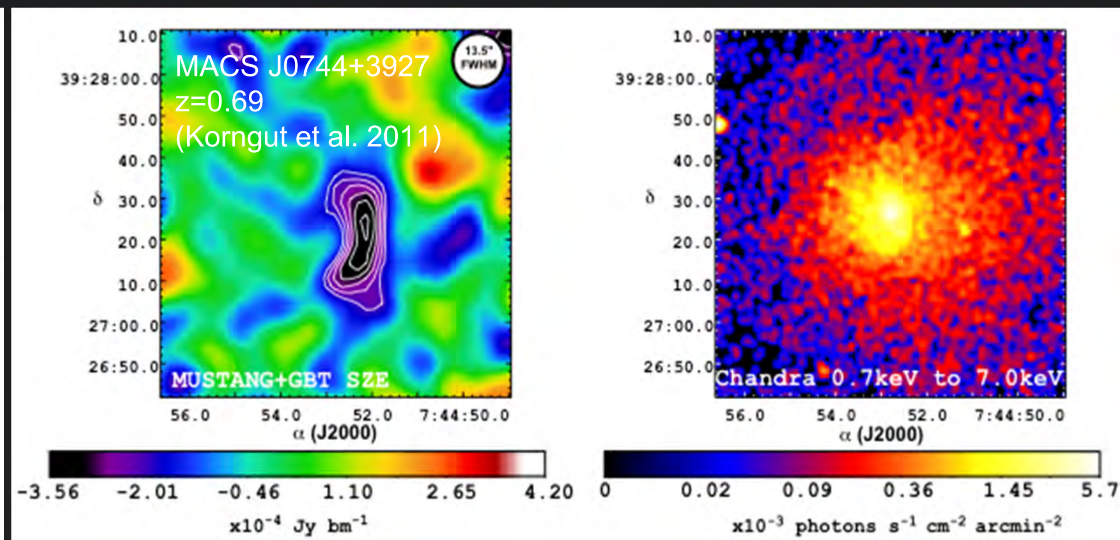
CCAT

- Thousands of galaxies will be detectable per sq. deg. spectroscopically
- Broadband MOS capability required
- Atomic fine-structure lines, line-continuum ratios, and CO ladder will measure
  - Redshifts
  - Gas mass reservoirs
  - Gas cooling rate
  - Gas excitation mechanisms



The SZ Effect: Resolving Cluster Astrophysics





- CCAT will resolve clusters better than 10 m class telescopes while not resolving out diffuse signal
- Broad submm-to-mm spectral coverage and good angular resolution will enable separation of thermal SZ, kinetic SZ, dusty galaxies, and CMB
- N(M, z) help constrain cosmological parameters, such as w_0
- Comparison to simulations will improve scaling relations for mass estimates

Questions to Consider

- What spectral lines are most important for mapping?
- What priority should be assigned to the bands?

Assumed Sensitivities

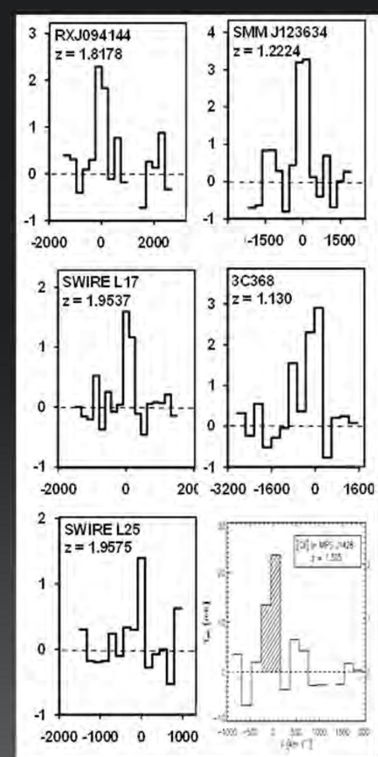
Continuum sensitivities from Table 4.3 of the CCAT Feasibility/Concept Design Study (2006)

λ (μm)	PWV (mm)	NEFD (mJy $s^{1/2}$)
200	0.3	150
350	0.4	14
450	0.5	14
620	0.5	16
740	0.7	8.7
865	1.0	5.8
1.18	1.0	1.7
1.4	1.5	2.9
2.0	1.5	2.3

Measuring Redshifts and Characterizing Interstellar Media

Atomic fine-structure and molecular lines enable z to be measured and T, n, M_{gas}, and G to be measured and source of excitation to be identified

- G: 400- 5,000
- n: $10^3 – 10^4$ cm^{-3}
- Starburst-dominated to AGN-dominated $L_{[CII]}/L_{FIR}$ ~ 8



Flux Density (10^{-18} W / m^2 / bin)

v (km/sec)

ZEUS CSO Stacey and Hailey-Dunsheath, et al.