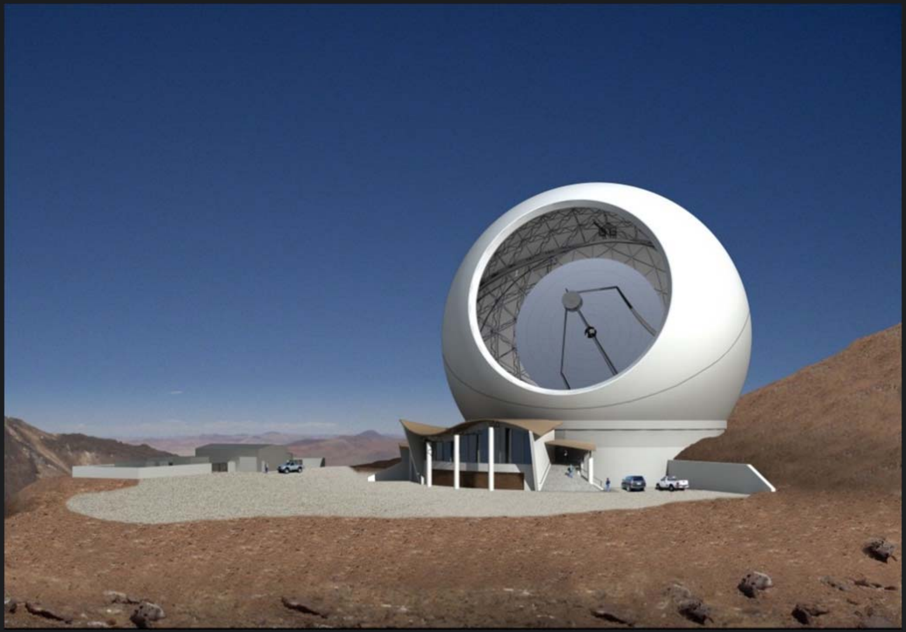
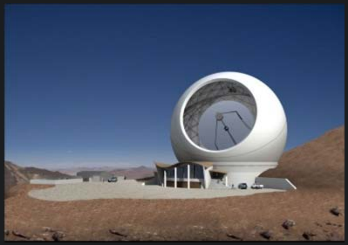


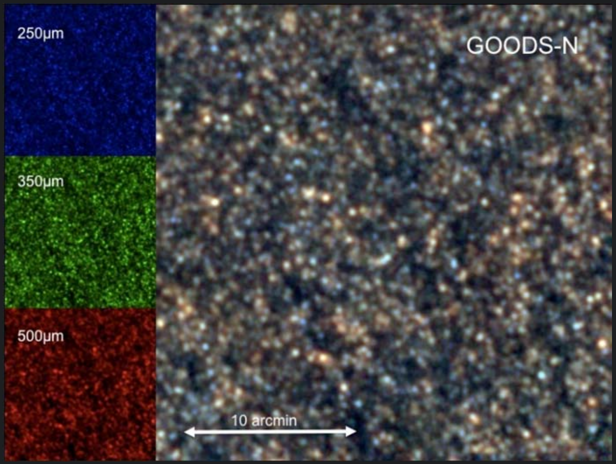
High-z Astrophysics with CCAT

Jason Glenn, University of Colorado, Boulder
On behalf of the CCAT consortium



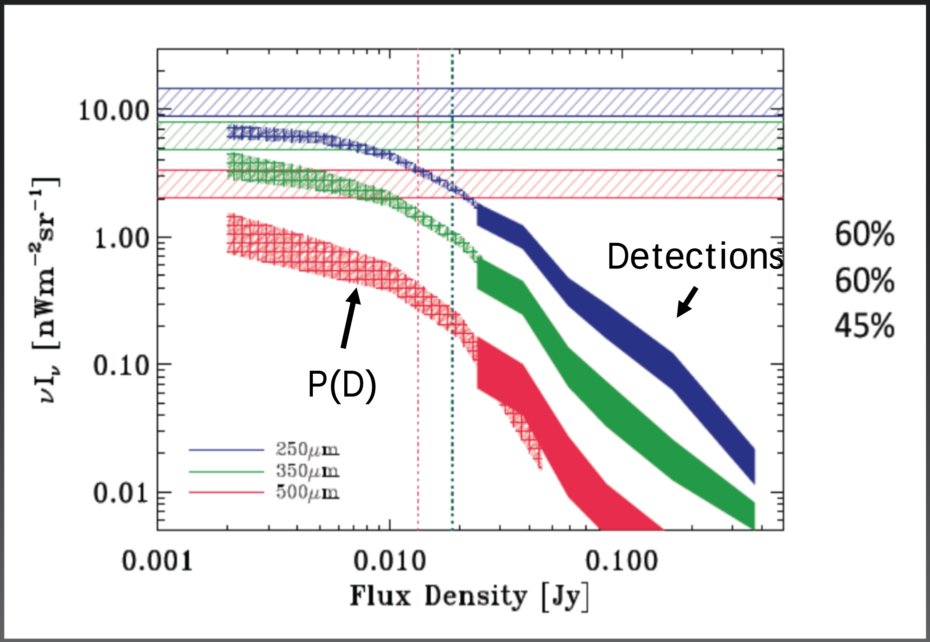
Galaxy Counts & the Cosmic FIRB at Submm Wavelengths

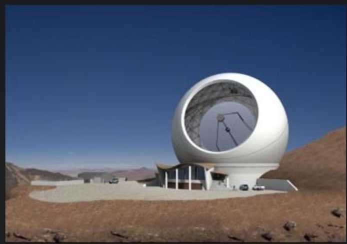
- 10% of CFIRB resolved directly with *Herschel*
- 50% resolved by P(D)
- ⇒ Parameterized number count models derived to a depth of 2 mJy/beam



HerMES Lockman Hole North

Oliver et al. (2010, 2011)

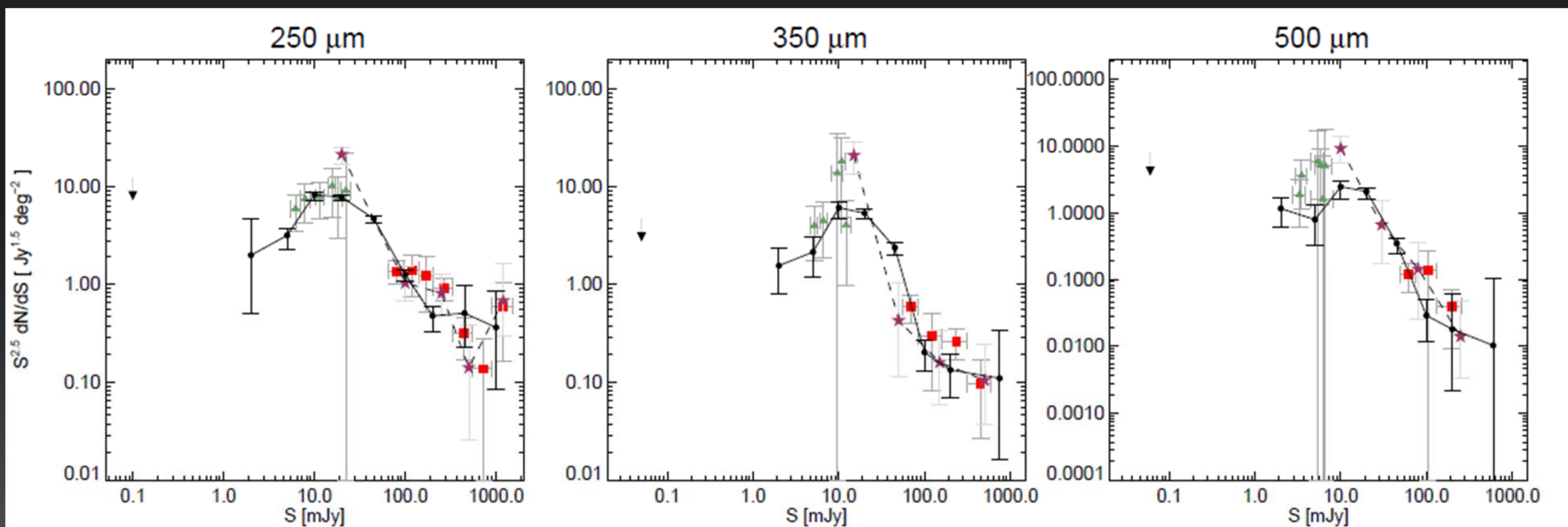




Galaxy Counts & the Cosmic FIRB at Submm Wavelengths

Models predict:

- CCAT 5σ confusion limit 0.5 to 1.1 mJy (350 to 850 μm)
- Vast majority of the CFIRB will be resolved by CCAT

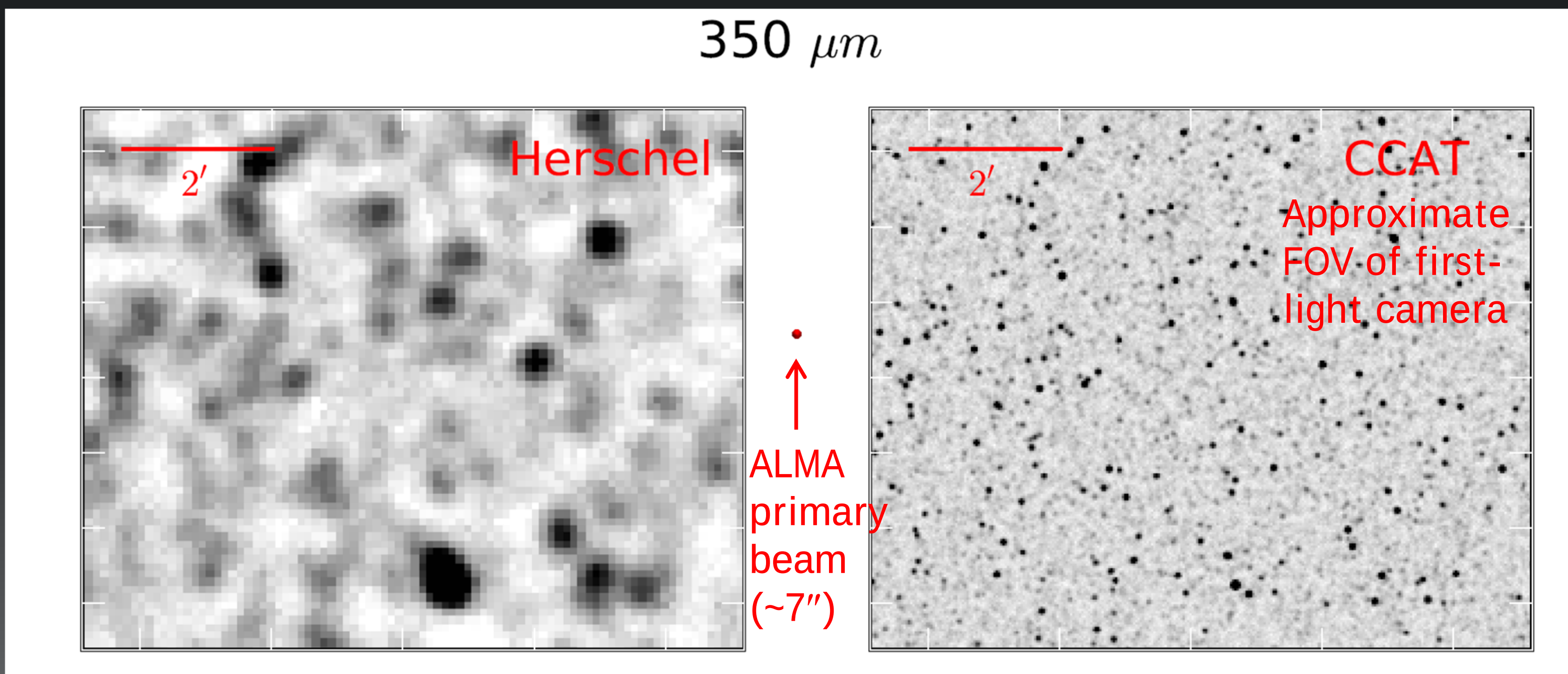


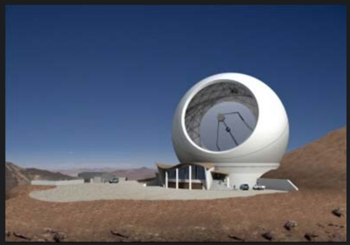
BLAST – purple stars (Patachon et al. 2009)
SPIRE stacking – green triangles (Bethermin et al. 2010)
SPIRE source extraction – red triangles

Glenn et al. (2010)

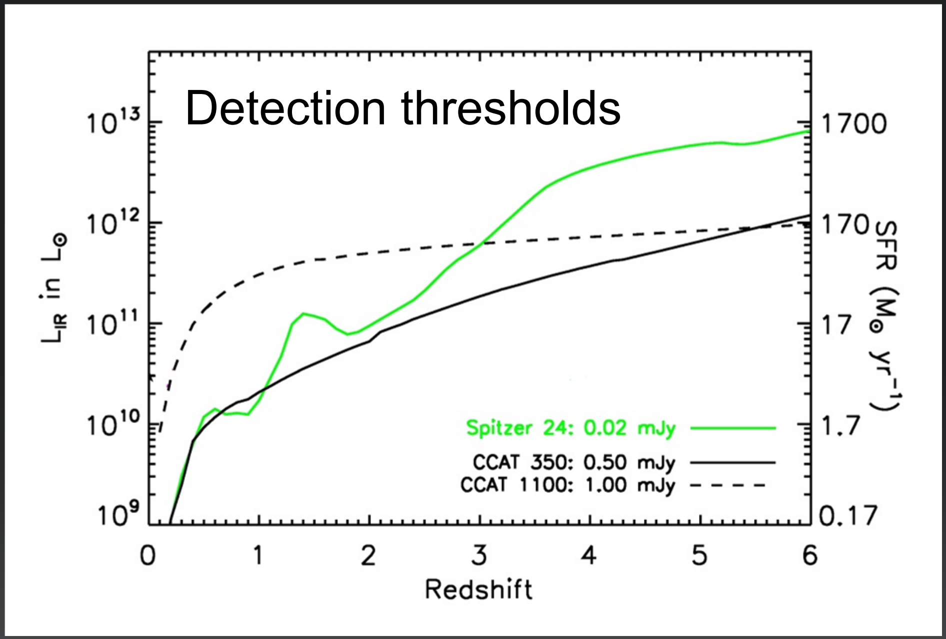
The Importance of Mapping Speed and Angular Resolution

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





Measuring the ULIRG LF to $z \geq 5$



Courtesy R. Chary, based on Chary & Elbaz

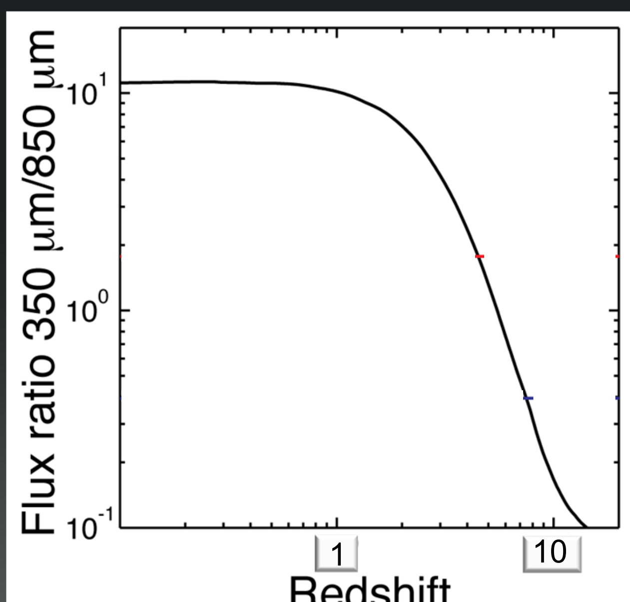
- Submm wavelengths are essential for measuring bolometric luminosities of star-forming galaxies
- At $5\sigma_{conf}$ CCAT will detect ULIRGs to $z \approx 6.3$, 5.5, and 0.7, respectively, at λ = 350, 450, and 850 μm (Bethermin, et al., 2010, models)
- The deepest surveys CCAT surveys will match *Spitzer* 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*

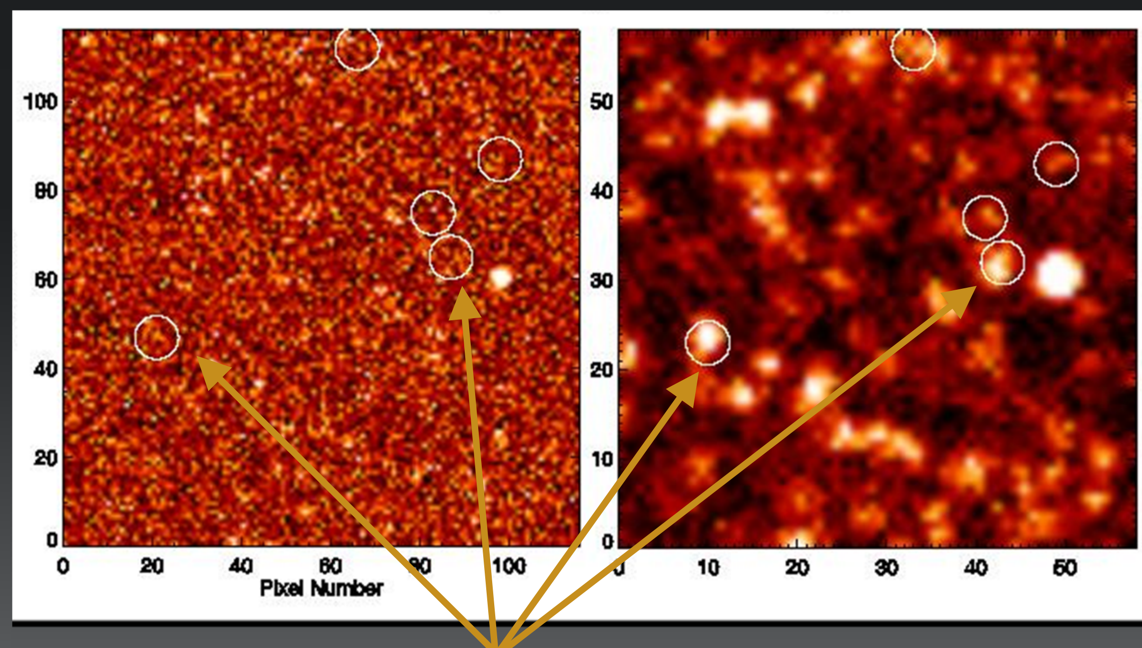
Minimum Luminosity Function Survey

- Require ~1,000 galaxies per
  - $\Delta z = 0.25$ for $1 < z < 2$
  - $\Delta z = 0.50$ for $2 < z < 5$
  - in the luminosity range $10^{11.5}\ L_{sun} < L_{IR} < 10^{12.5}\ L_{sun}$
  - of order 10,000 galaxies total $\Rightarrow$ 1 sq. deg.
- ~1,000 galaxies per Δz allows for ~10 bins within $10^{11.5}\ L_{sun} < L_{IR} < 10^{12.5}\ L_{sun}$ (of unequal ΔLog(L)) not limited by Poisson statistics
- Anticipated first light camera: 6.5' FOV
- NEFD = 14 mJy $s^{1/2}$
- Integration to $\sigma_{conf,850\mu m}$ = 0.2 mJy (1.3 hours, including overheads)
- $\Rightarrow$ ~1 sq. deg., 2.5 weeks of dedicated time

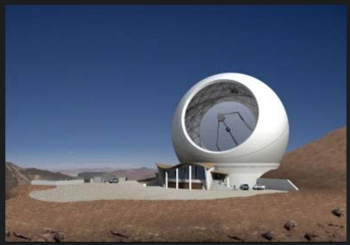
Identifying High-z Galaxy Candidates

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



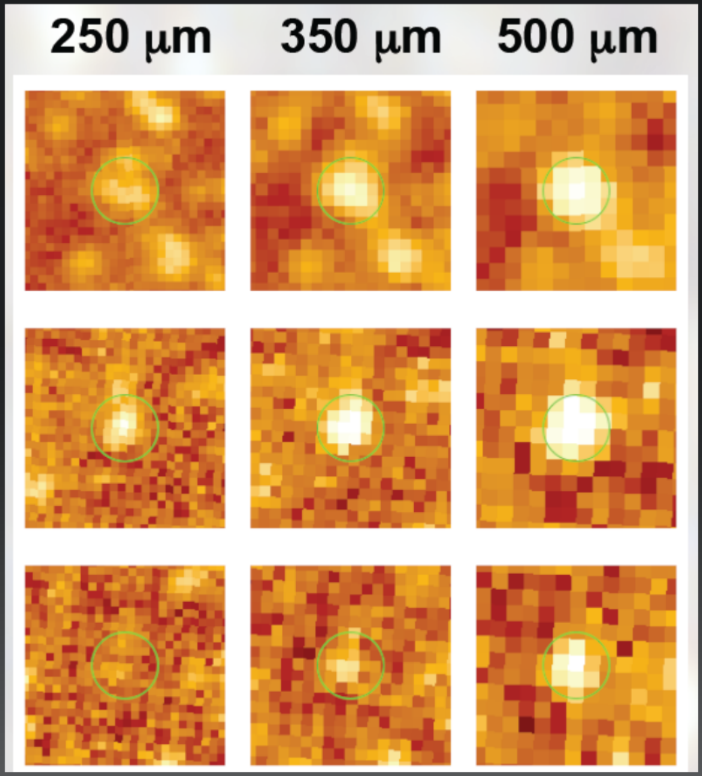


>5σ 850 μm detection, 350 μm nondetections



Identifying High-z Galaxy Candidates

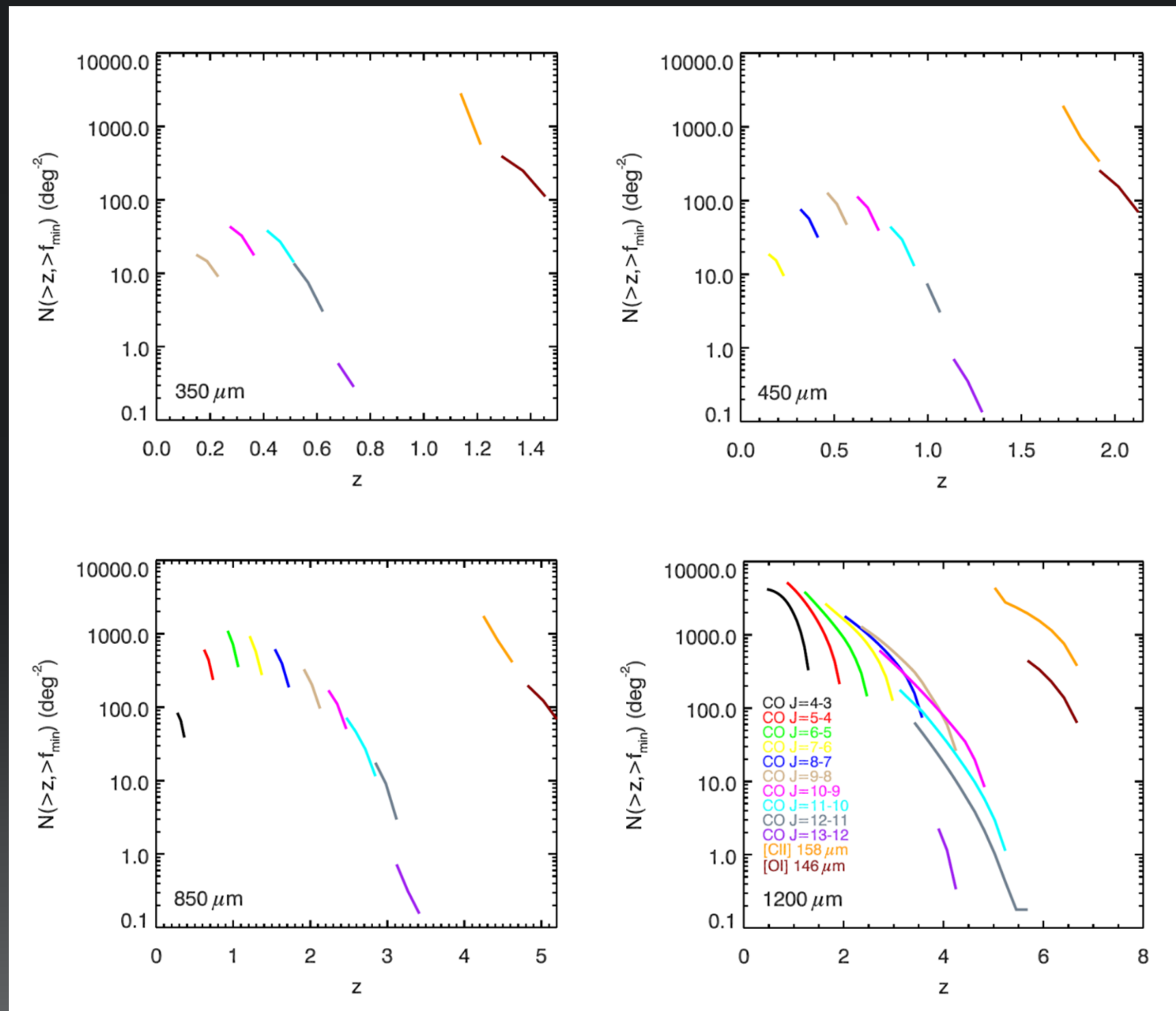
Three *Herschel* examples (Dowell et al. 2011)



Jason Glenn, Unveiling the Far-IR and Sub-mm Extragalactic Universe

Spectroscopy: Redshifts and ISM Astro-physics

- 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 probe
    - Redshifts
    - Gas mass reservoirs
    - Gas cooling
    - Gas excitation mechanisms



Synergy: ALMA, LMT, SPICA, SOFIA

Survey Methodology

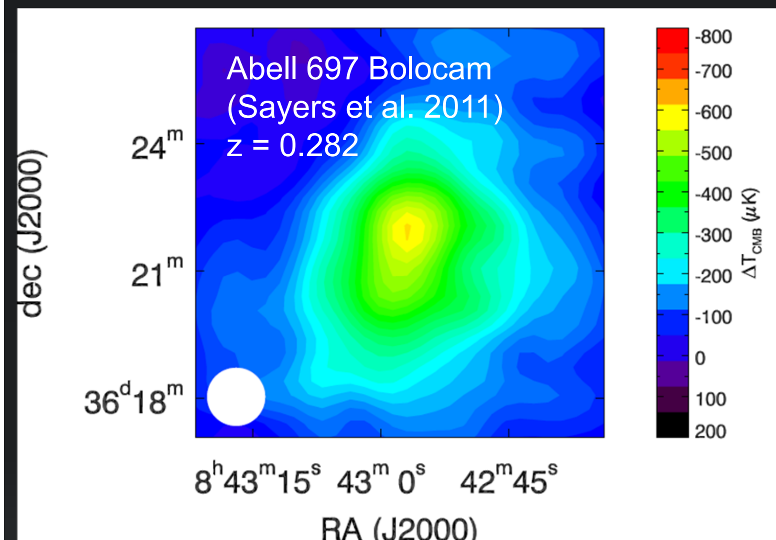
1. CCAT surveys, source catalogs
2. CCAT redshifts for subsets
3. Identify candidates for ALMA observations based on
   a. Brightness
   b. Colors
   c. Redshift
   d. Lensing
4. ALMA observations
   a. Morphology
   b. Spectroscopy of resolved lines: dynamics
   c. Lensing studies (enabling studies of intrinsically faint sources, enhanced angular resolution)

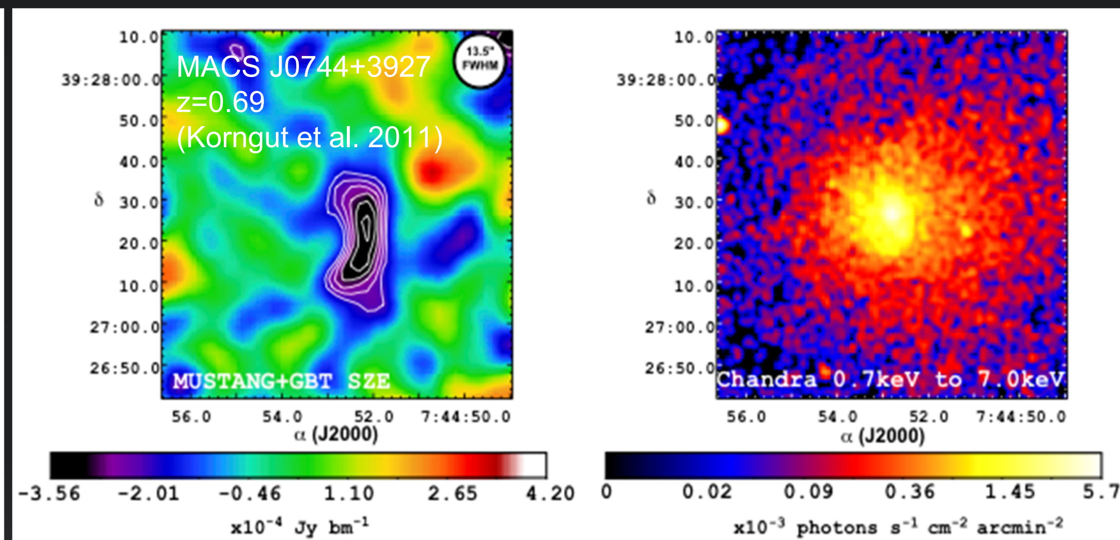
LMT: Significant sky overlap allows for coordinated observations

SPICA: Warm dust, atomic fine-structure lines, & redshifted PAHs to characterize star-formation environments

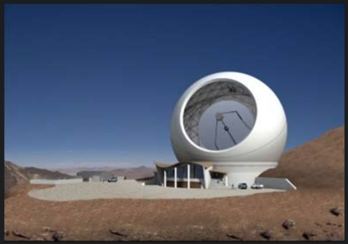
SOFIA: Detailed FIR studies of low-z galaxies

The SZ Effect: Resolving Cluster Astrophysics





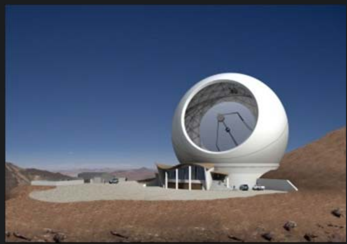
- CCAT will resolve clusters better than 10 m class telescopes while not resolving out diffuse signal
- Broad submm-to-mm spectral coverage and good angular resolution will enable separation of thermal SZ, kinetic SZ, dusty galaxies, and CMB
- N(M, z) help constrain cosmological parameters, such as w_0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



Conclusions and Future Work

High-z science with CCAT

- The history of obscured star formation and the assembly of galaxies:
  - Measure the LF, star formation activity, and gas reservoirs in galaxies to high redshifts
  - Overcome confusion noise to resolve the CFIRB into galaxies with statistically relevant sample sizes
  - Halo occupations: measure the clustering to sub-ULIRG luminosities
- Galaxy clusters: Simultaneously measure the structure and integrated mass in the intracluster medium



Conclusions and Future Work

Workshops to engage the community in CCAT science planning

First up: October 5 – 7, Cologne University, Germany:

“Formation and Development of Molecular Clouds – Prospects for High-Resolution Spectroscopy with CCAT”

https://www.astro.uni-koeln.de/FormationAndDevelopmentOfMolecularCloudsWithCCAT