A joint project of Cornell University, the California Institute of Technology and the Jet Propulsion Laboratory, the University of Colorado, the Universities of Waterloo & British Columbia, the Universities of Bonn & Koeln, and Associated Universities, Inc.
What is **CCAT:**

- A 25 meter Far Infrared/submillimeter telescope that will operate at wavelengths as short as $\lambda = 200$ micron, an atmospheric limit.

- It will be located in a desert environment, at very high elevation (5600m, or 18400 ft)

- Designed for maximal synergy with ALMA

- It will take advantage of the fastest-developing detector technology of any spectral range, opening up the last, largely untapped frontier of ground-based astronomical research

**Why 25m?**
- Match ALMA sensitivity at submm regime
- Integration time to confusion at 350 um $> 1$ hr
- Better than 0.5” source positioning
- Good fraction of time with PWV $< 0.5$mm
At a very high site

Access to Far Infrared/submm

Photospheric light
Reprocessed by dust

Microwave Background

Photospheric light from stars

Chajnantor Plateau, view from N
ALMA as a z-machine

Hubble DF
Rich in nearby galaxies
(z < 3)
93%

Galaxies z<1.5

ALMA DF
Poor in nearby galaxies
(z < 1.5)
20%

Hubble DF
Poor in distant galaxies
(z > 3)
7%

Galaxies z>1.5

ALMA DF
Rich in distant galaxies
(z > 1.5)
80%
CCAT Continuum Sensitivity: $5\sigma$, 1 hr
Confusion limit at 350 um is $\sim 0.5$ mJy $\Rightarrow 10^5$ sources per sq. deg.

1 sq.deg. $\Rightarrow \sim 1.06 \times 10^6$ CCAT beams. $0.24 \times 10^6$ ALMA FoVs

First light, 40Kpix camera will map a $\sim 6' \times 6''$ patch $\Rightarrow \sim 2400$ faster surveyor than ALMA

Second generation camera ($\sim 4$ Mpix) will populate full FoV $\Rightarrow 240,000$ faster than ALMA

Spectroscopic (redshift) survey on coat tails of imaging survey with MOS

Allocate $\sim 50\%$ of telescope time to surveys
CCAT & ALMA

CCAT’s instantaneous field of view (350 μm, 40 kpix 1st light camera)
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 spatial resolution; it will however match it in sensitivity and will have a Field of View > 240,000 times larger

- Fast Surveyor (MANY objects at a time)

Large scale projects coordinated between the two facilities.
The revolution in detector array technology
Colors of Detected Sources

- Different colors preferentially detect different redshifts as the far-IR emission peak redshifts through the bands ⇒ photometric redshifts

- Typically $z \sim 0.5$ to 3
  - Provides a deep census of galaxies from the epoch of galaxy formation and assembly: 10-12 billion years ago.

- CCAT also probes the earliest bursts of dusty star formation as far back as $z \sim 10$ -- less than 500 million years after the Big Bang or when the Universe was $\sim 4\%$ of its current age.

Estimated redshift distribution of galaxies that will be detected by CCAT at 1 mJy for 200 (blue), 350 (green), and 850 (red) $\mu$m.
But… these photo-z results will be only very rough, not at all good for individual sources.

To get precise redshifts and investigate the physical properties of the gas and stellar radiation fields, we need follow-up spectroscopy.

Why not with ALMA? – Larger collecting area (12:1) cancelled by requirement to scan many bandwidth intervals (1:10)

Multi-object Spectrometer (10-50 spectra at a time)
CCAT REDSHIFT METHODS

- **CO rotational ladder:** $\Delta v = 115 \text{ GHz}/(1+z)$
  - Direct redshift indicator – ladder constrains the physical conditions of the molecular ISM – molecular gas mass, excitation

- **[CII] line:** Bright! 50-200 times brighter than mid-J CO lines
  - At $z \sim 1$ to 2 mid-J CO receivers 5 to 10 times more sensitive, but [CII] is still easier to detect (same telescope, at a good submm site)
  - Indirect redshift indicator – but not too bad since...
    - Next comparable brightness shorter wavelength lines are [OIII] (88 and 52 $\mu$m) $\Rightarrow$ very high $z$
    - Next comparable brightness longer wavelength lines would be [NII] – then check for [CII] or nearby mid-J CO – optically distinguishable.

- Insights on strength of far-UV field, extent of starburst

- **Best is a combination of the line tracers**

Slide credit: G. Stacey