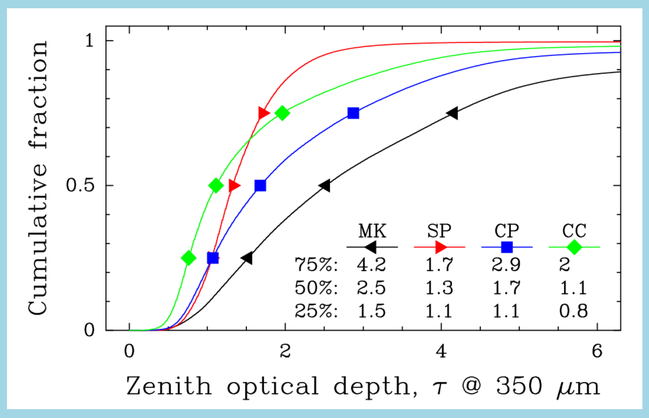
The CCAT-prime Project

The CCAT-prime (CCAT-p) project aims to construct a 6-meter diameter telescope with a surface accuracy of 7-10 µm at 5600 meter elevation on Cerro Chajnantor in Chile. Implementation of a novel crossed-Dragone optical design will deliver a high-throughput wide-field-of-view telescope capable of illuminating >10^5 millimeter wavelength detectors. The 5600 meter site enables routine access to the 350 µm window as well as improved performance at longer wavelengths and, under best conditions, access to the 200 µm window. CCAT-p is specifically designed to measure the kinematic Sunyaev-Zel'dovich effect of galaxy clusters, to trace the appearance of the first population of star-forming galaxies through intensity mapping of their [CII] emission in the epoch of reionization, and to probe multiple spectral line tracers of the ISM over a range of environments in the Milky Way, Magellanic Clouds and other nearby galaxies. It will also be a next-generation Cosmic Microwave Background observatory.

Superb observing site



Cerro Chajnantor offers better observing conditions than the South Pole, ALMA plateau, & Mauna Kea (Radford & Peterson, arXiv:1602.08795).

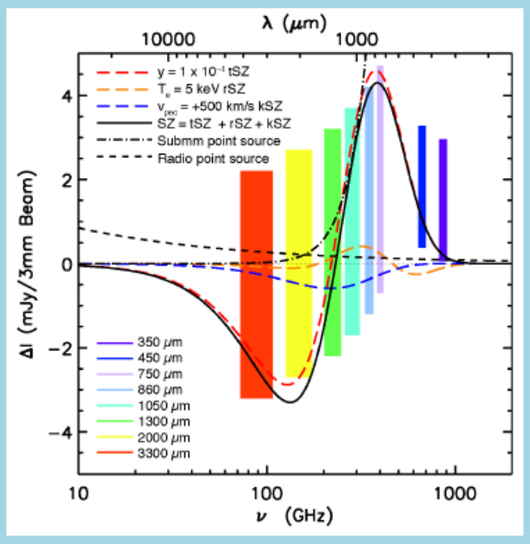
$$\mathrm{PWV\ [mm]} = 0.84\,\tau(350\,\mu\mathrm{m}) - 0.31$$

Water Vapor Scale Height

	$\tau(350\,\mu$m) Chaj. plateau	Cerro Chaj.	PWV [mm] Chaj. plateau	Cerro Chaj.	WV scl. ht. [m] *
75 %	2.7	1.9	2.0	1.3	1280
50 %	1.5	1.1	1.0	0.6	1080
25 %	1.0	0.7	0.53	0.28	860

* WV scale height = $550\,\mathrm{m}/\ln(\mathrm{PWV_{cp}}/\mathrm{PWV_{cc}})$

kSZ: Kinetic Sunyaev-Zel'dovich Effect



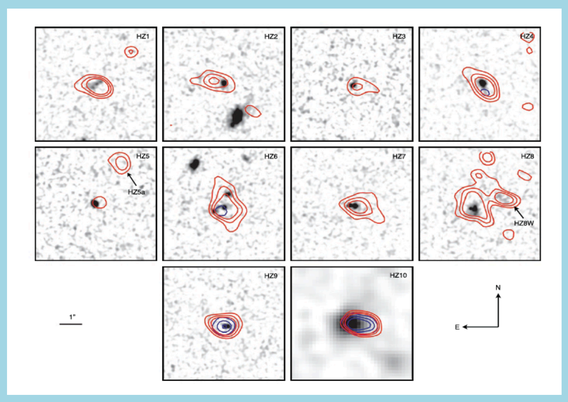
- **S-Z Effect:** Distortions in the Cosmic Microwave Background spectrum are seen when CMB photons travel through the hot intra-cluster medium of clusters of galaxies along the line of sight. Three kinds of distortions are predicted:

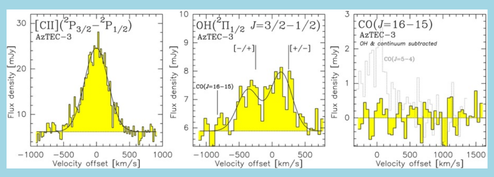
  tSZ (thermal): dashed **red**
  rSZ (relativistic): dashed **orange**
  kSZ (kinetic): dashed **blue**

- It is important to characterize and remove CMB, tSZ, bright submm galaxies and radio sources which CCAT-p does in the short submm bands.
  - CCAT-p can observe over wider range from submm to mm at once.
- Will yield improved constraints on models of dark energy and modified gravity based on measuring 1000 clusters with 100 km/s accuracy.
- Will also enable a measurement of the sum of neutrino masses, another important cosmological prediction.

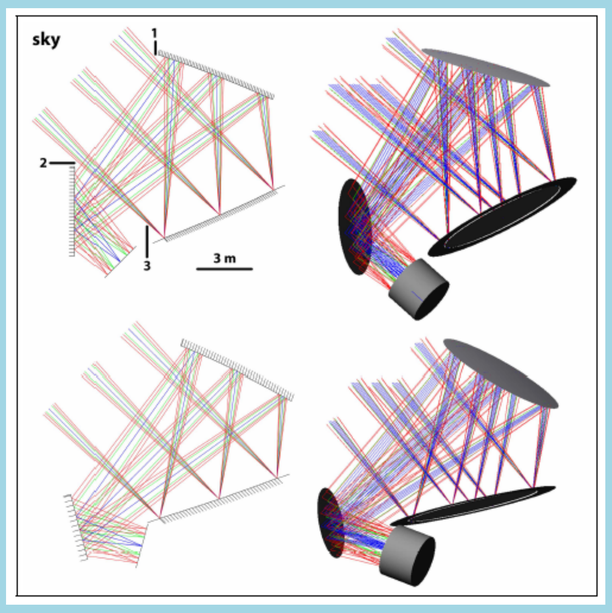
IM/EOR: Intensity Mapping of [CII] from the EOR

- Detect aggregate clustering signal of faint galaxies in the epoch of reionization (EOR) via redshifted [CII] 158 µm line.
- Directly traces sources of reionization (star forming galaxies) over the time interval of "Cosmic Dawn".
  - Recent ALMA detection of [CII] in "normal" galaxies at z = 5-6 (e.g. Cornell Professor Dominik Riechers+ 2014, ApJ 796, 84).
  - Enhanced [CII] to dust continuum compared to lower redshifts → strong signal.



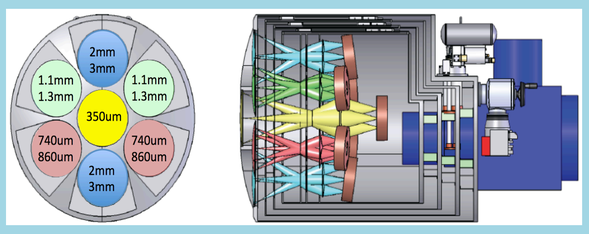


Crossed-Dragone Telescope Design



CCAT-p will use a novel telescope design pioneered by Cornell Professor Mike Niemack.

- High throughput
- Wide field-of-view
- Flat focal plane
- Accommodate > 10^5 detectors at longer wavelengths and even more at shorter.

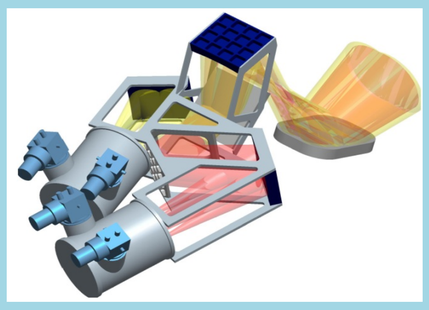


Niemack 2016 astro-ph/1511.04506
Applied Optics 15, 1688

Layout of CCAT-p camera designed by Cornell Professor Gordon Stacey.

GEco: Galactic Ecology of the Dynamic ISM

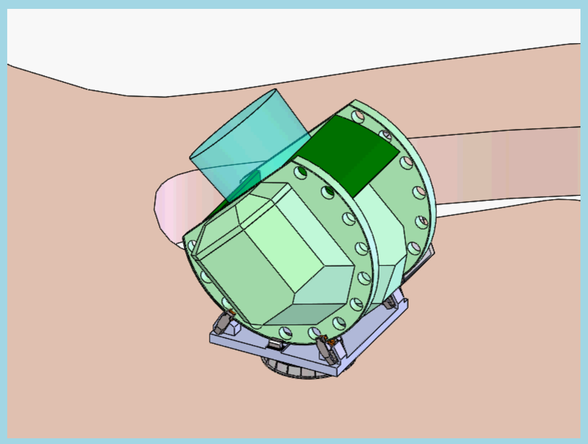
- Spectral mapping of fine structure and mid-/high-excitation CO lines as diagnostics of physical conditions and motions of interstellar clouds
  - Lines trace coolants in range environments where stars and planets form.
  - Maps at (15"× λ/350µm) resolution over degree scales of Milky Way including Galactic Center and Magellanic Clouds (low metallicity).
  - High site provides unique access to shortest wavelength.
  - Builds on SOFIA (2.5m) with better resolution, much more observing time.



Layout of CHAI instrument being built at University of Cologne led by Professor Juergen Stutzki.

Stage IV CMB platform

- Could map the CMB at 10 times the speed of current telescopes.
- Submm coverage will provide galactic foreground removal for other CMB efforts.
- Many synergies with planned Simons Observatory.
- Cornell become a leading player in CMB science.



Canadian Consortium

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