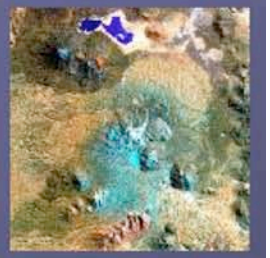
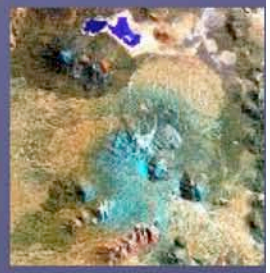


CCAT
Overview & Workshop Goals

Riccardo Giovanelli
Cornell University

Ithaca, 12-13 November 2010

What is CCAT:



- A 25meter submillimeter telescope that will operate at wavelengths as short as λ = 200 micron, an atmospheric limit.

Why 25m?
- Match ALMA sensitivity at submm regime
- Integration time to confusion at 350 um > 1 hr
- Better than 0.5" source positioning

- 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

Table 1. Telescope requirements

Parameter	Requirement [Goal]	Notes
Wavelength	350 to 1400 μm [200 to 3500 μm]	Primary science band is λ=350 μm
Aperture	25 m	1" positions for followup, exceeds ALMA sensitivity at $\lambda = 350$ μm, limited by cost
Field of view	20' [1°]	Limited to 1° by curvature of field
Emissivity	< 0.1 $\lambda \geq 300$ μm [< 0.05 $\lambda \geq 800$ μm] < 0.20 at $\lambda = 200$ μm	Small cf. atmospheric loss
Half wavefront error	< 12.5 μm rms [< 9.5 μm rms]	$< 1.5\times$ longer integration time
Blind pointing	2" rms [0.5" rms]	<1/2 FWHM beam at $\lambda = 350$ μm
Offset pointing	0.35" $\times \lambda/350$ μm rms	1/10th beam within 1° of last pointing measurement
Pointing stability	0.35" hr^{-1} $\times \lambda/350$ μm rms	1/10th beam change between pointing measurements every hour
Slow scan speed	$0.2°s^{-1}$ in EL, $0.4°s^{-1}$ in AZ	For $\lambda \leq 620$ μmm, 200 Hz in timestrean at $\lambda = 350$ μmm
Slow scan acceleration	$0.4°s^{-2}$	For $\lambda \leq 620$ μm, 1 s turn around time
Fast scan speed	$1°s^{-1}$ in EL, $2°s^{-1}$ in AZ	For $\lambda > 620$ μm, 200 Hz in timestrean at $\lambda = 2$ mm
Fast scan acceleration	$2°s^{-2}$	For $\lambda > 620$ μm, 1 s turn around time
Following error in scan	< 1.8" $\times (\lambda/350$ μm) rms	Half FWHM beamwidth
Pointing knowledge in scan	0.35" $\times (\lambda/350$ μm) rms	1/10th beam

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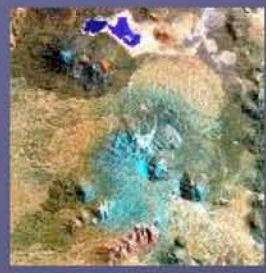

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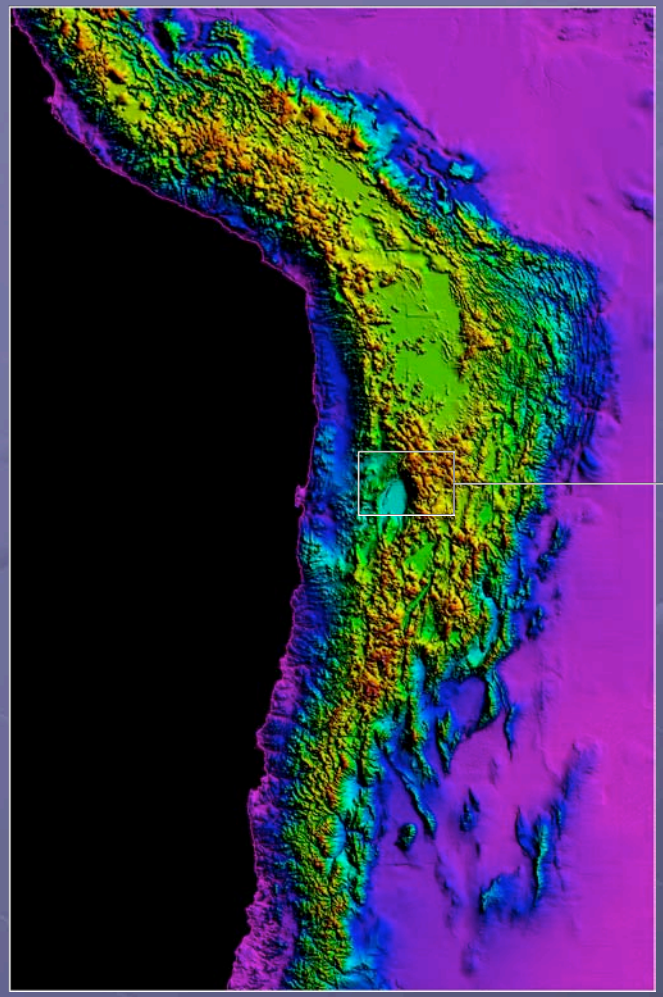
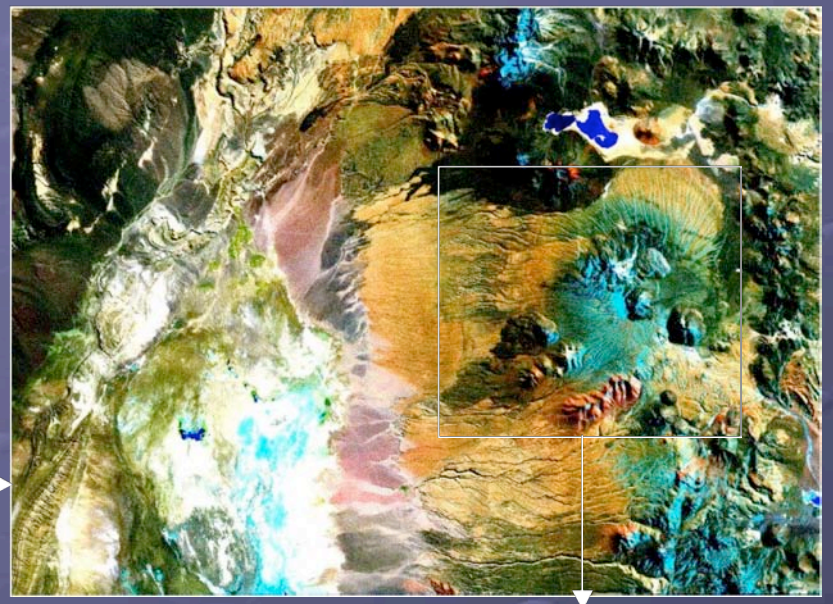
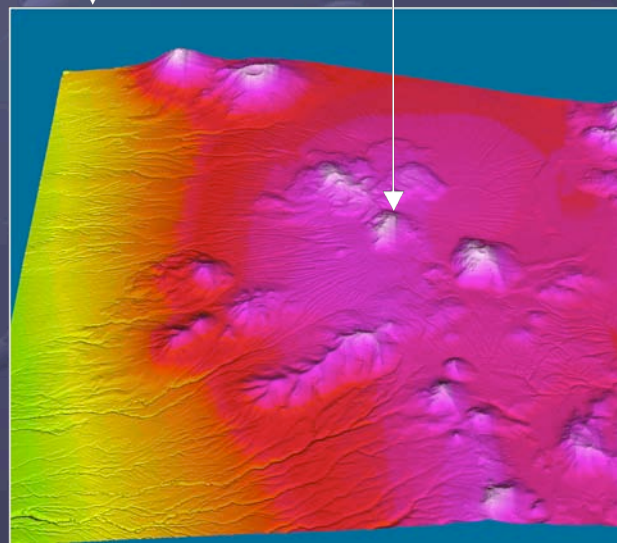
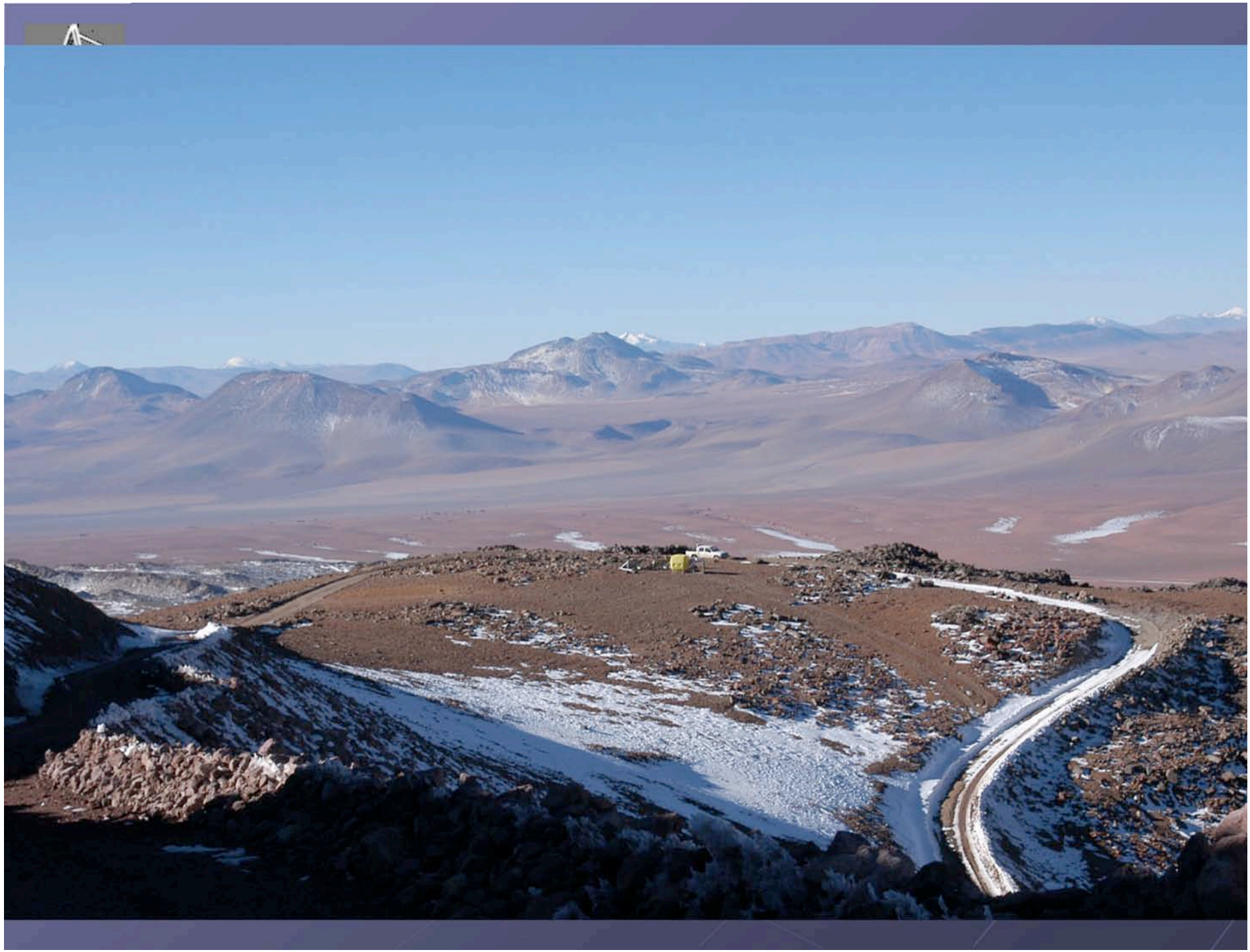
At the driest, high altitude site you can drive a truck to





Cerro Chajnantor (18,400 ft)



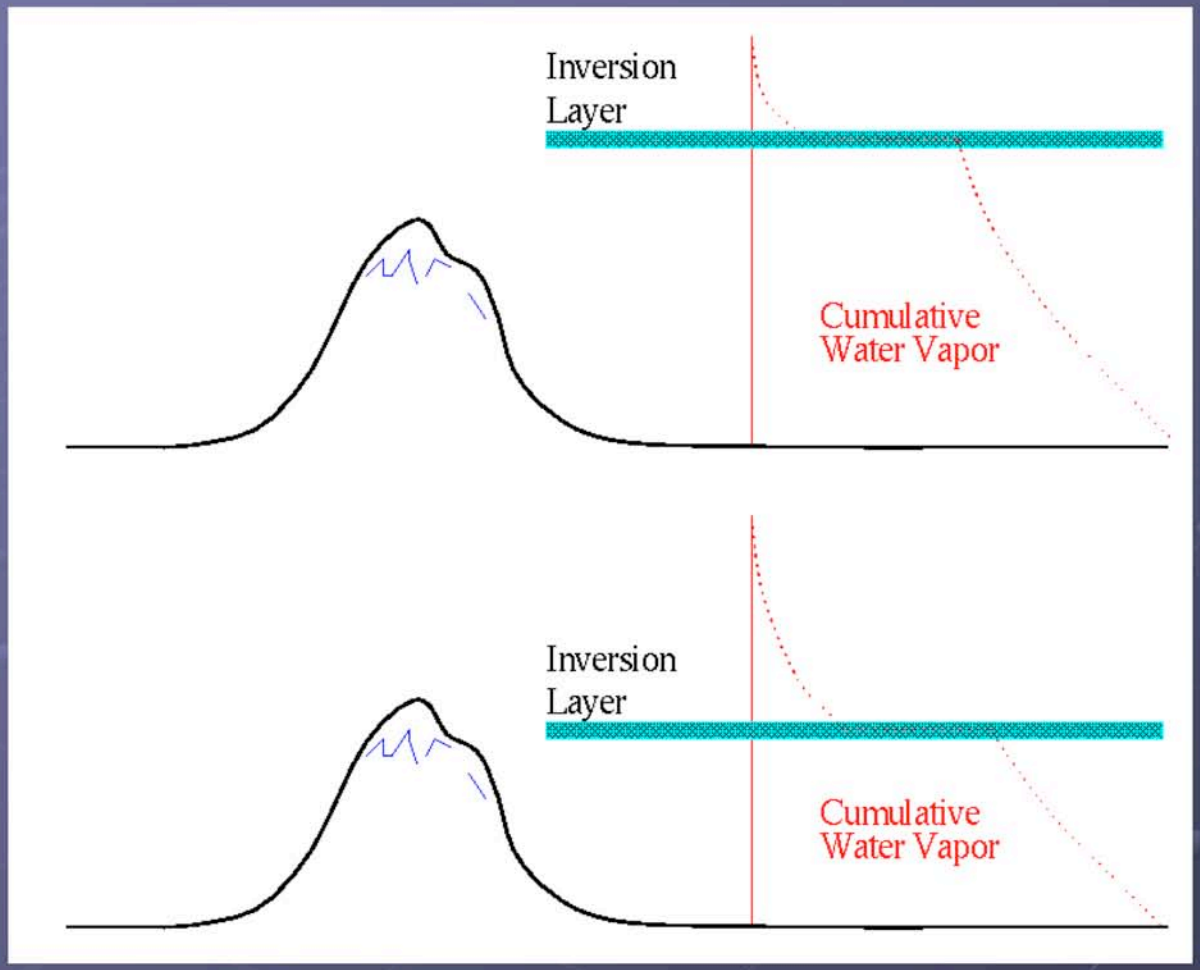


Is it really worth going just (!)
2000 ft (13%)
higher than ALMA?

A little gain in PWV by going to summit

PWV=precipitable water vapor

B most PWV below summit; great gain by going to summit



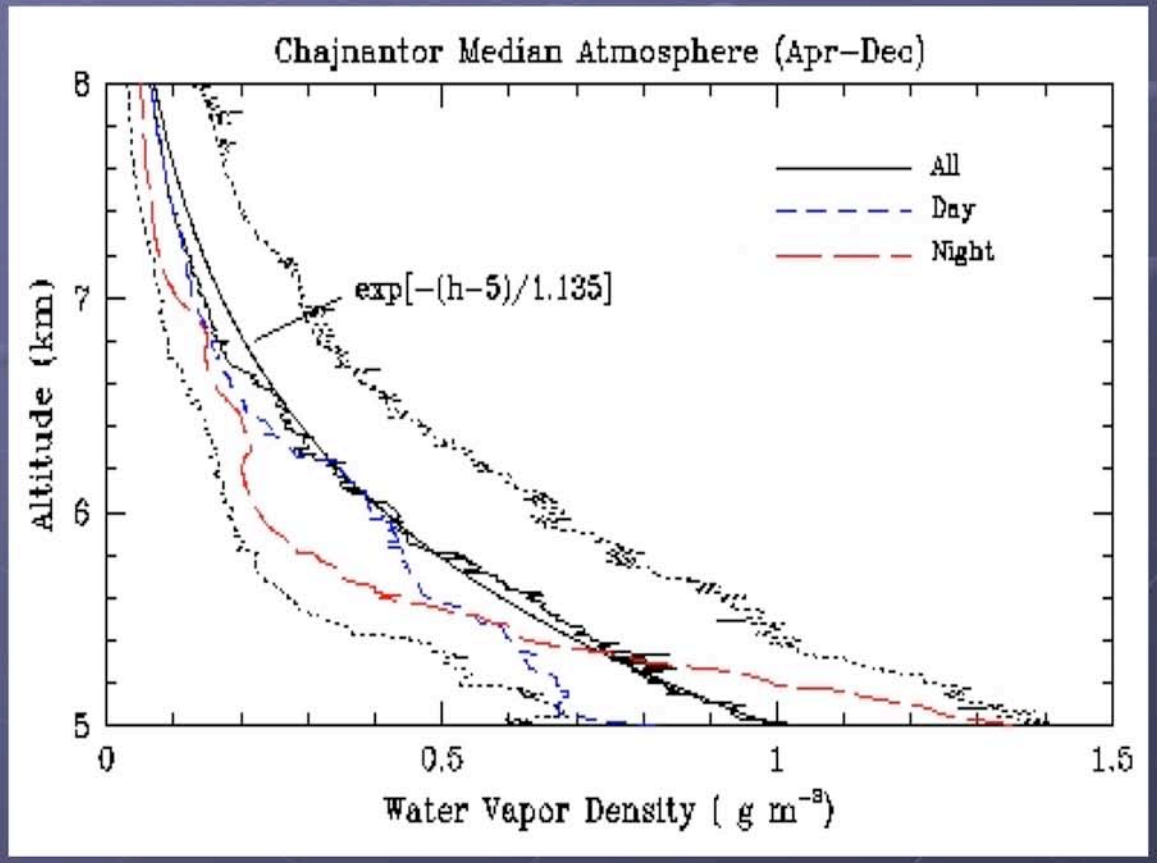
T-inversion layers form above extended plateaus. Much of the PWV gets trapped under them.
Is it worth focusing on surrounding summits?
YES! if case B occurs a fair fraction of the time.

Median WV Distribution over Chajnantor

From radiosondes:

The median WV scale height
Is h=1.135 km

However, it becomes
shallower at night…



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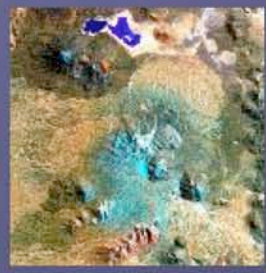

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- Wide FoV; fast surveyor

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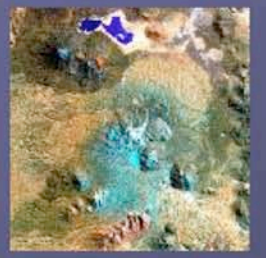


Who is CCAT?

A joint project of Cornell University,
the California Institute of Technology
the University of Colorado,
the Universities of Waterloo & British Columbia,
the Universities of Bonn & Cologne,
and Associated Universities, Inc.
…

Brief Timeline-1

- 2003 : Cornell invites Caltech to dance, Workshop in Pasadena
- 2004: MOU signed by Caltech and Cornell, Project Office established, Feasibility Study
- 2006: Feasibility Study Review

Feasibility Study Review

Review Panel:

- Robert Wilson (Harvard-Smithsonian, Chair)
- Mark Devlin (Penn)
- Fred Lo (NRAO)
- Matt Mountain (STScI)
- Peter Napier (NRAO)
- Jerry Nelson (UCSC)
- Adrian Russell (ALMA, NA)

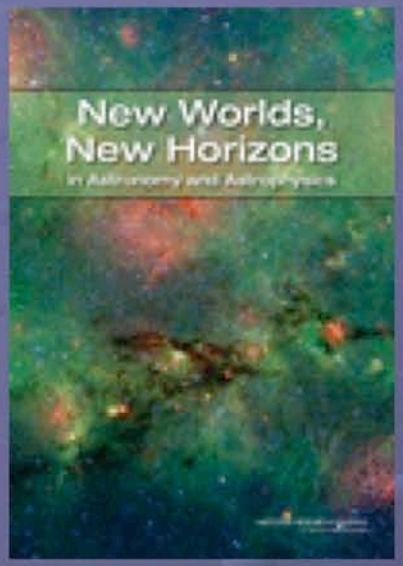
"CCAT is an important and timely project that will make fundamental contributions to our understanding of the processes of galaxy, star and planetary formation, both on its own and through its connection with ALMA. It should not wait."

Brief Timeline-2

- 2003 : Cornell invites Caltech to dance, Workshop in Pasadena
- 2004: MOU signed by Caltech and Cornell, Project Office established, Feasibility Study
- 2006: Feasibility Study Review
- 2006-2010: Expand partnership, finalize site selection, review high risk issues, initiate engineering design, consolidate consortium, Astro2010

- 2010-2013: Engineering Design Phase, Critical Design Rev.
- 2013-2017: Construction → First light

Friday the 13th of August brings good news from Astro2010



New Worlds, New Horizons in Astronomy and Astrophysics

Committee for a Decadal Survey of Astronomy and Astrophysics

National Research Council

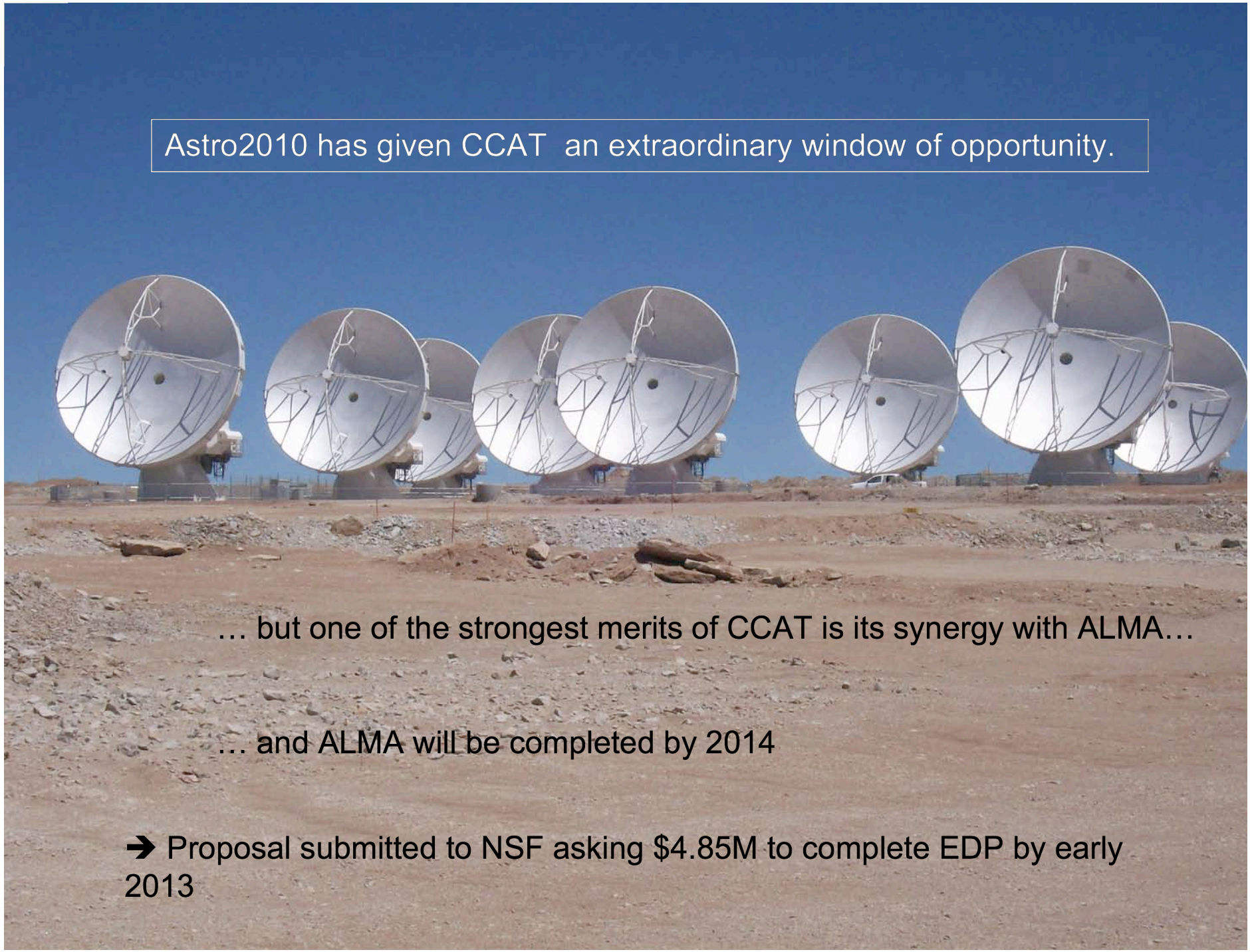
Quoting Astro2010:

The Section Recommendations for New Ground-Based Activities - Medium
Projects, page 7-37, starts with:

"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."

The one project is CCAT.

In pages 1-12 and 7-38: *"CCAT is called out to progress promptly [. . .] because of its strong science case, its importance to ALMA and its readiness."*



Astro2010 has given CCAT an extraordinary window of opportunity.

… but one of the strongest merits of CCAT is its synergy with ALMA…

… and ALMA will be completed by 2014

➔ Proposal submitted to NSF asking $4.85M to complete EDP by early 2013

CCAT Cost

CCAT was asked to provide Astro2010 detailed information to be used for the CATE process carried out by the Aerospace Corp.

Their estimates of the cost and time to completion of construction were higher than the project team's:

- ➔ $140M vs. $110M
- ➔ 2020 vs. 2017

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- ➔ 2020 vs. 2017

Engineering Design Phase goal: reduce error in estimate

Over last 5 yr the CCAT project $ burn rate has been $1-2M/yr, adding up to > $6.7M, fully funded by partners.

Goals for this Workshop:

1. Refresh CCAT science vis-à-vis Herschel, SCUBA-2, etc.
2. Consolidate instrumentation priorities for first light
3. Start a dialogue with the astronomical community
4. Surveys: how wide, how deep, how many
5. Surveys: coordination with ALMA?
6. Surveys: who's in, how to weigh participation, public access rules…

CCAT will be an ultrafast Cosmic Surveyor

Confusion limit at 350 um will be ~0.5 mJy ➔ ~10^5 sources per sq. deg.
(Herschel resolves ~10% of CFIRB – CCAT will resolve >90%)

1 sq.deg. ➔ ~1.06×10^6 CCAT beams. 0.24×10^6 ALMA FoVs

First light, 48Kpix camera will map a 6'x6' patch
➔ ~2400 faster surveyor than ALMA

Second generation camera (~4 Mpix) will populate full FoV
➔ 240,000 faster than ALMA

MOS (redshift) survey on coat tails of high z imaging survey

Allocate ~50% of telescope time to surveys

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 angular 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)

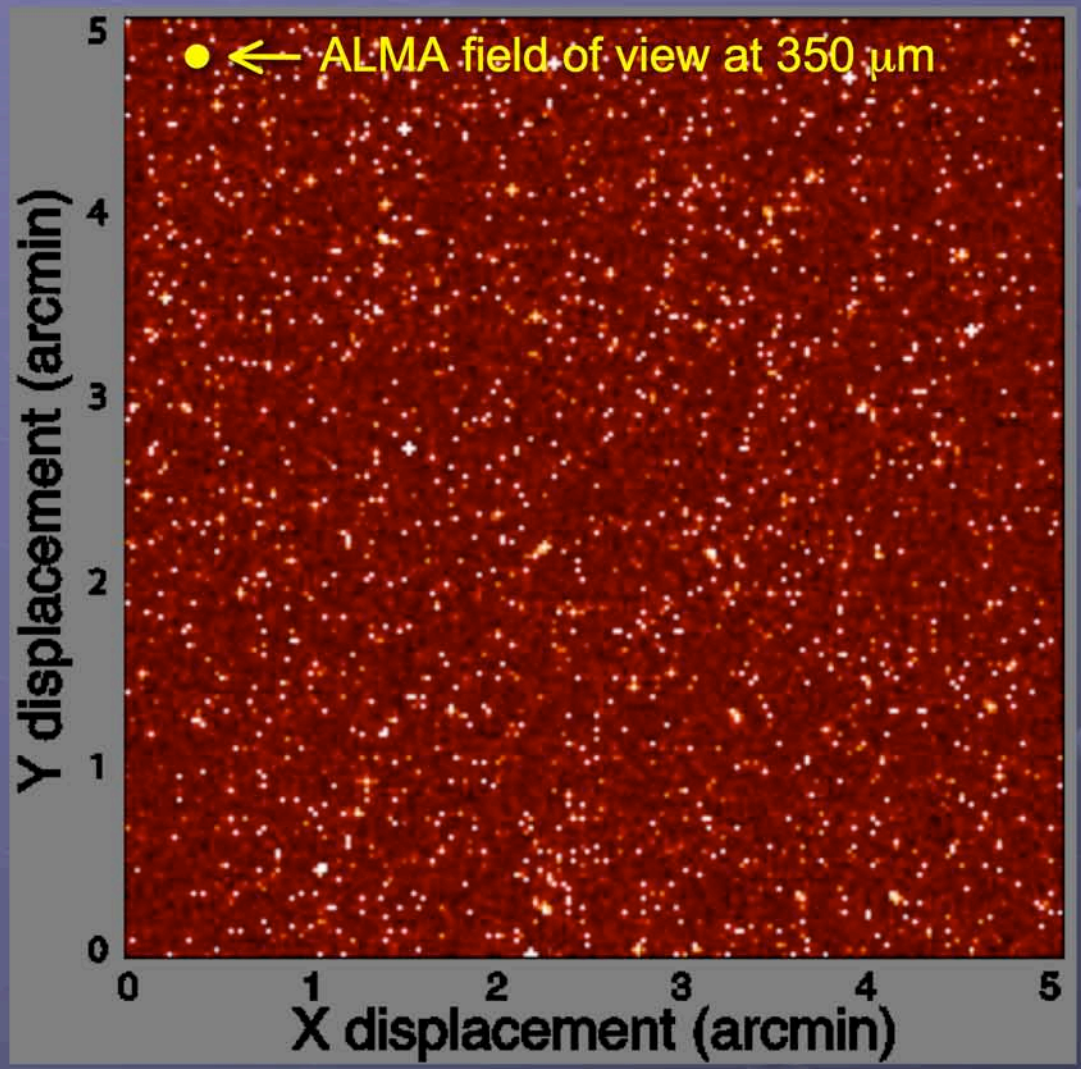
Large scale projects coordinated between the two facilities?

Desiderata for high z galaxy survey(s):

1. Wide area coverage (>100 sq. deg.) to overcome cosmic variance
2. Few arcsec resolution to overcome confusion, resolve CFIRB and identify source counterparts at other wavelengths
3. Multiwavelength submm imaging to identify the highest z candidates
4. Comprehensive submm spectroscopic follow-up, to measure z and characterize sources' physical conditions

CCAT & ALMA

CCAT's instantaneous field of view (350 μm, 48 kpix 1st light camera)



Desiderata for Galactic survey:

1. Sensitive to clumps capable of forming a 0.01 Msun dwarf *
2. Angular resolution <5” to resolve 0.05 pc clump to 1 kpc distance
3. Multicolor submm imaging to get dust T and mass
4. Follow-up spectroscopic survey in molecular lines to probe dynamics
5. Coverage of many fields - tens of sq deg wide - sampling different environments

A Strawman's Proposal for Public Participation in CCAT

(Response to request by RMS PPP of Astro2010)

1. Assume a US public contribution of 1/3 of capital cost
2. Assume 50% of telescope allocated to surveys
3. Assume US share of - "basic ops" cost (2/3)x$6M/yr

   - instrument dev. & upgrades $4M/yr (*)
   - survey execn. & delivery $3.6M/yr (*)

(*) through competitive proposals

… resulting in:

- US share of surveys (public) (1/2)xT
- US public GO time (1/6)xT
- US CCAT partners GO time (1/3)xT

(where T is the total amount of telescope time to US)

-CCAT will be a university(ies) observatory, not a national one

-Astro2010 asked us to provide a strawman proposal for US community participation in CCAT: we did, but the proposal was put together internally, NOT in consultation with the community, hence of limited value

-One of the goals of this workshop is to establish a dialog with the community, on the assumption that NSF funding will be a sizable fraction of CCAT capital & operations' costs

- We intend to hold a series of workshops such as this, on an annual basis and – as/if NSF materializes – get members of the community involved

- Today, we are here to start listening

Some Thorny issues:

-Suppose 50% of telescope time is allocated to *various* surveys

-How is participation in surveys to be weighed?

-Should partners (CCAT founders , US and other national communities, Chile 10%...) be asked to contribute 50% of their time to surveys?

-Should the observatory have common criteria for delivery of survey products to community for all surveys/all national communities?

-What is the fair balance in term of GO time to partners' early commitment and continued investment, to instrument builders and to national communities?

- Should some surveys be coordinated with ALMA, e.g. seeking ALMA guaranteed follow-up time?