The Cornell Caltech Atacama Telescope (CCAT)

Presented by

David Woody

for

Simon Radford

Consortium

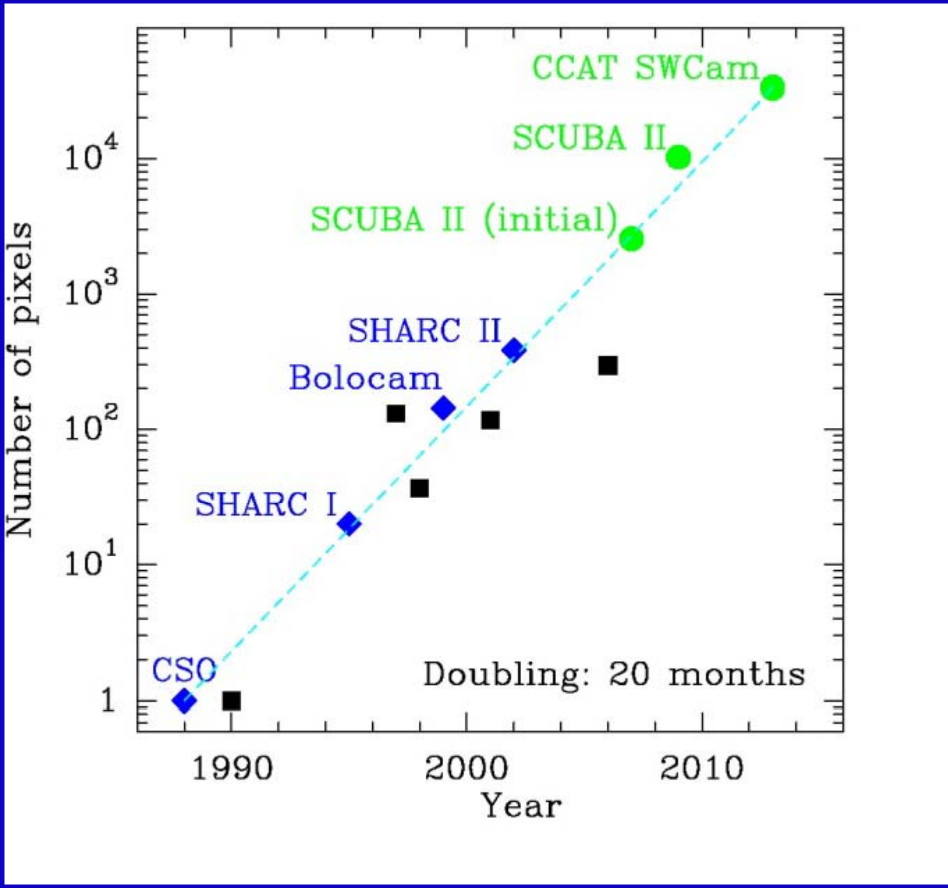
- Caltech
  - Includes JPL involvement
- Cornell University
- University of Colorado Boulder
- UK Astronomy Technology Centre (STFC)
- Canada (Univs. of BC & Waterloo)
- Germany (Univs. Cologne & Bonn)
- Other Institutions Interested

Interim Consortium Agreement Signed in 2007

Full Project Agreement Planned in 2008

Motivation

- High sensitivity observations and surveys at submillimeter wavelengths
- Enough angular resolution to have a low confusion limit
- Exploit the large focal plane arrays that are becoming available



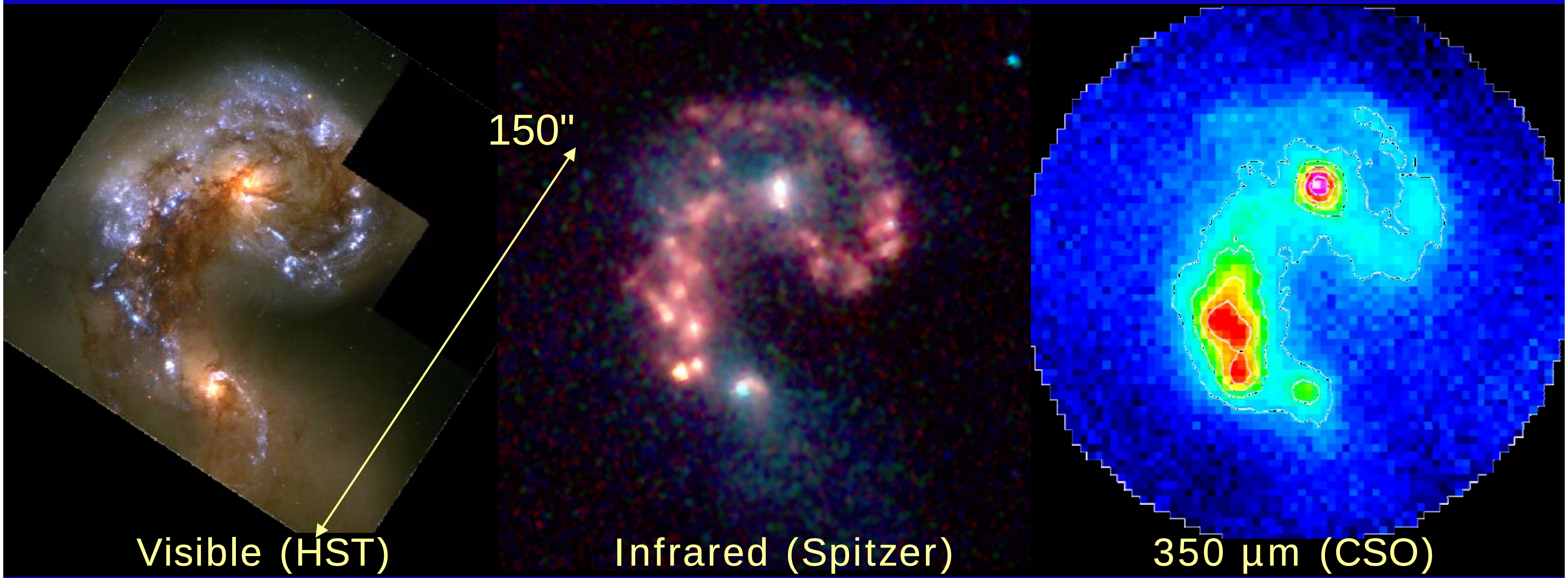
CCAT Technical Specifications

	Requirement	Goal	remark
Wavelength	350 – 1400	200 – 2500	μm
Aperture	25 m		
Field of view	10'	20'	
Half WFE	< 12.5 μm	< 9.5 μm	rms
Site condns.	< 1.0 mm	< 0.7 mm	median pwv

Science

Clusters (SZ), submm galaxies,
star-forming regions & cores,
debris disks, KBOs, and more

- Large detection rates and samples of submm galaxies
  ~150 × SCUBA2; ~300 × ALMA, 100-6000 per hour



Images of extended sources and large fields

Cerro Chajnantor 5612 m

(Atacama desert in Chile)

APEX CBI ALMA (5050 m) ASTE & NANTEN2 (4800 m)

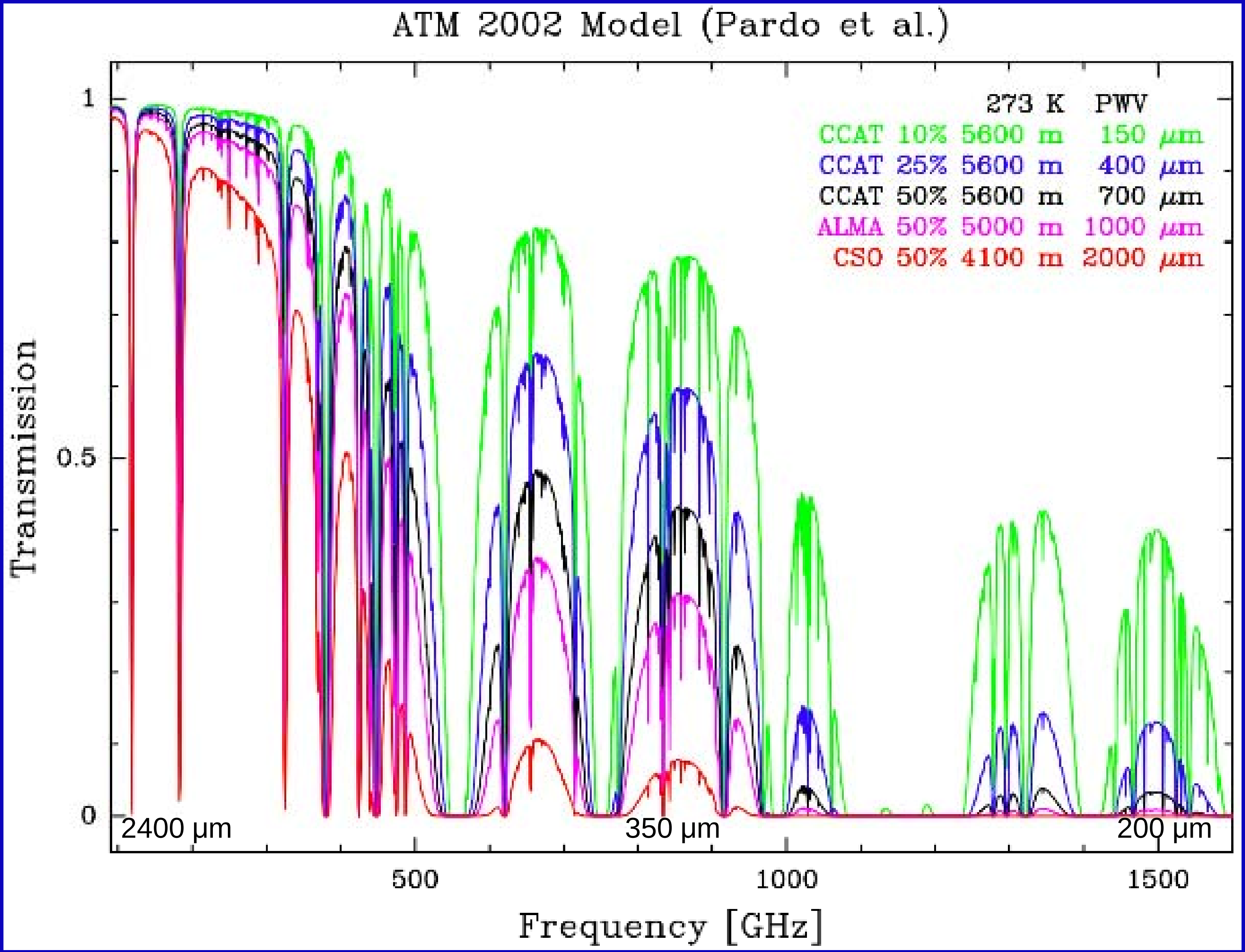
Google Earth

Cerro Chajnantor 5612 m

View SW from ASTE; access road constructed by U. Tokyo

Cerro Chajnantor 5612 m

Atmospheric Transmission

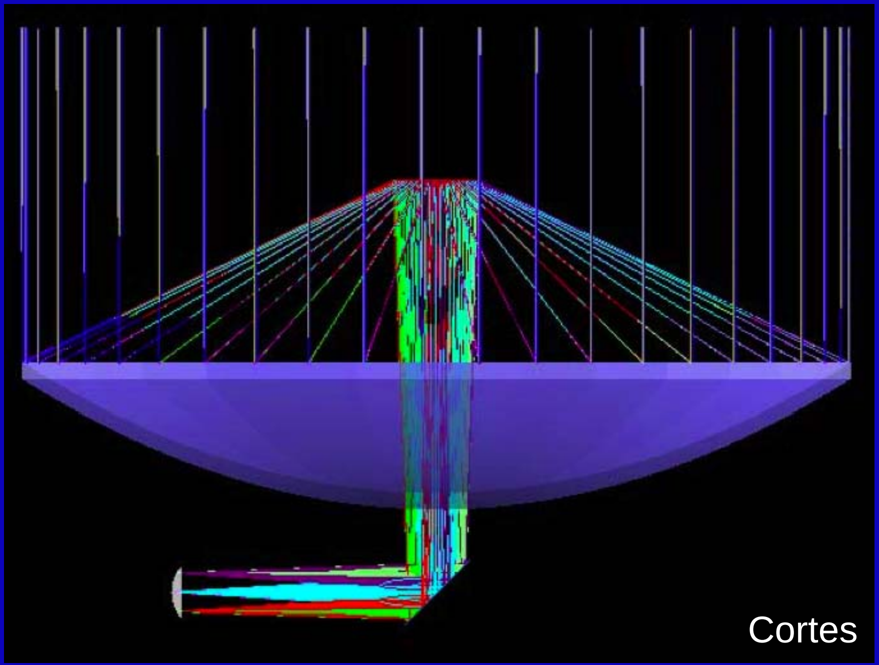


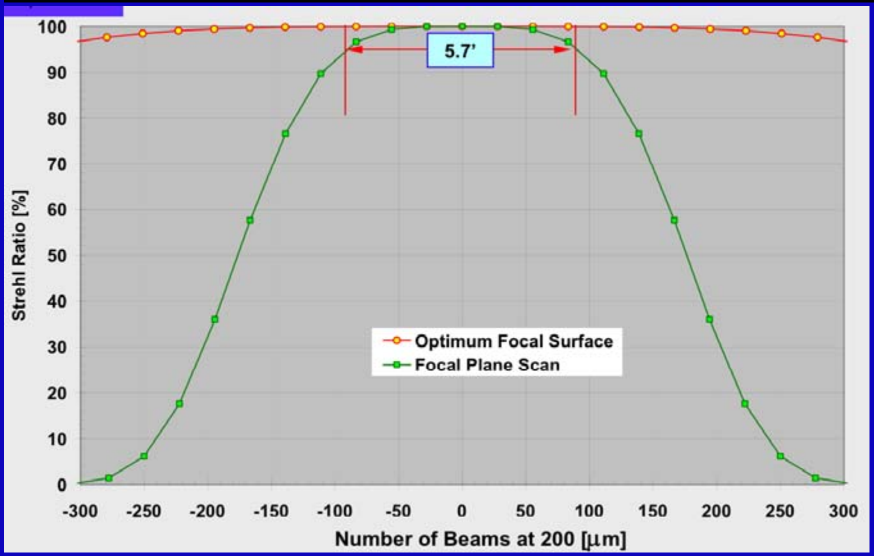
Facility Concept Design
M3 Engineering & Technology

- Summit Facility
  - Colotte dome
  - Support Operations
  - Oxygen Enrichment
  - Working Areas at Summit
- Base Facility
- Road and Site

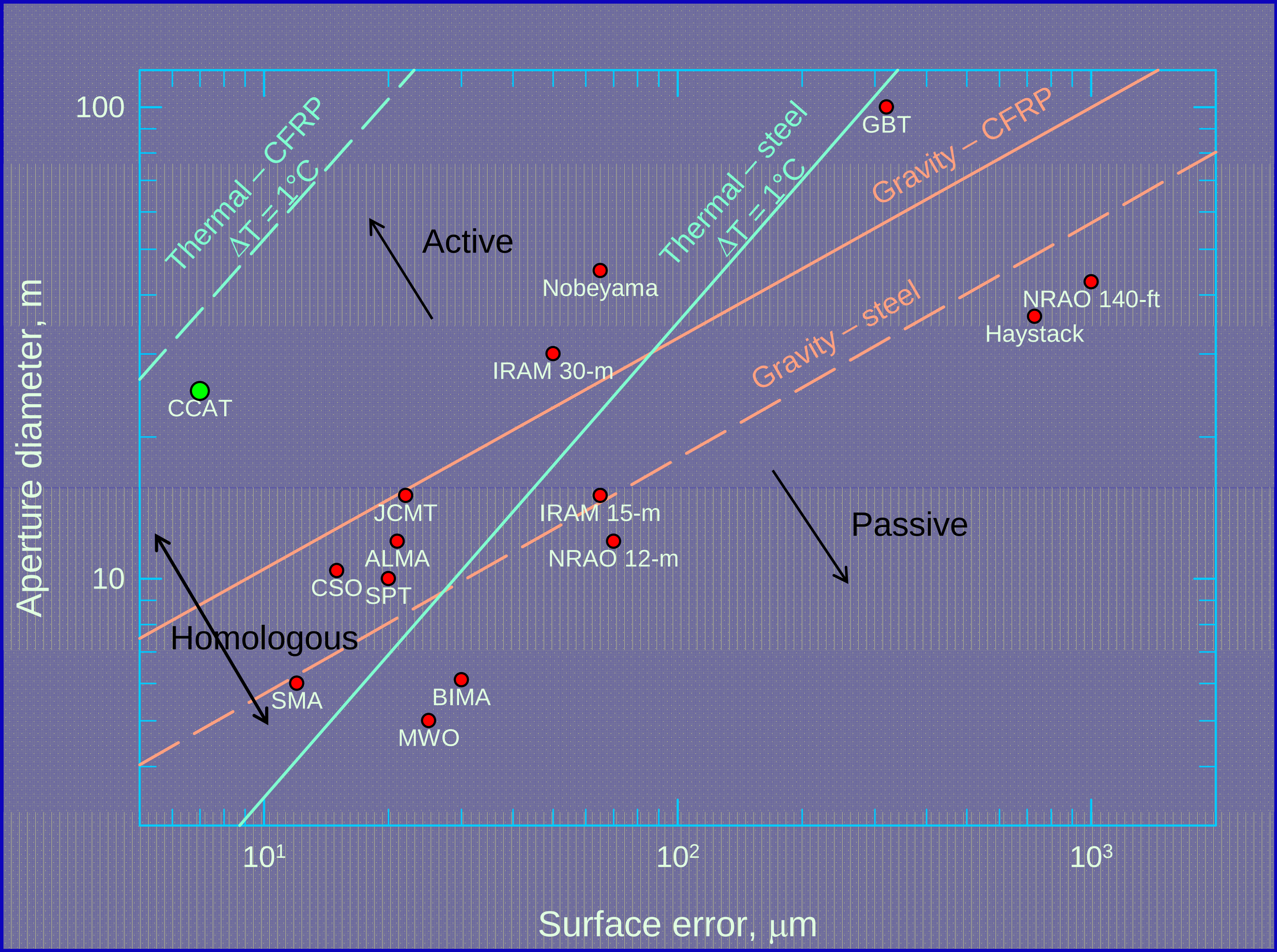
Optical Design

- Ritchey Chretién Layout
  - **Wide field of view**
  - High aperture efficiency
- *f* 0.4 Primary Focus
  - Compact telescope
  - Minimum dome
- *f* 8 Secondary Focus
  - Match instruments
- Rotating tertiary
  - Left and right Nasmyth Foci
    - Rapid instrument changes
    - Large cameras
  - Bent Cassegrain Foci





Natural Telescope Limits
(von Hoerner diagram)

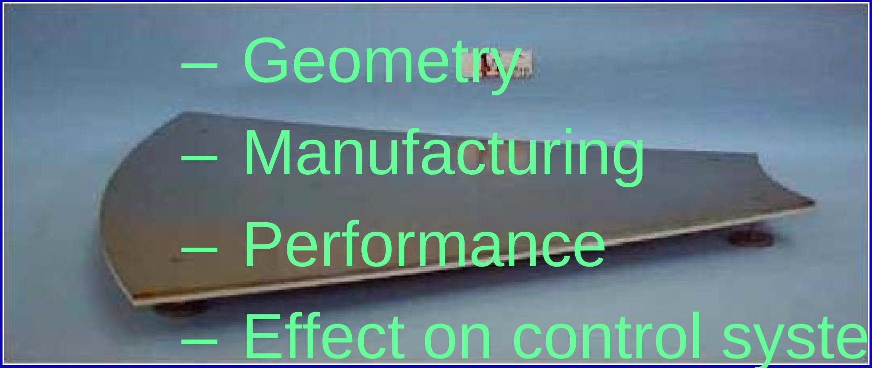


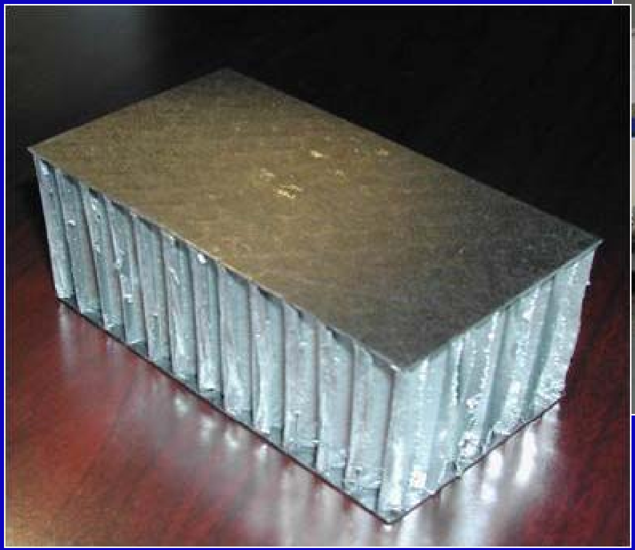
Panels are critical

- Top down error budget only leaves ~7 μm for the primary reflector
  - Panels
  - Surface maintenance system (active surface)
- Keck like system with edge sensors
  - Panels serve as the reference system for feedback to control system

Many types of panels to be evaluated

- Materials
- Size
- Geometry
- Manufacturing
- Performance
- Effect on control system
- ….





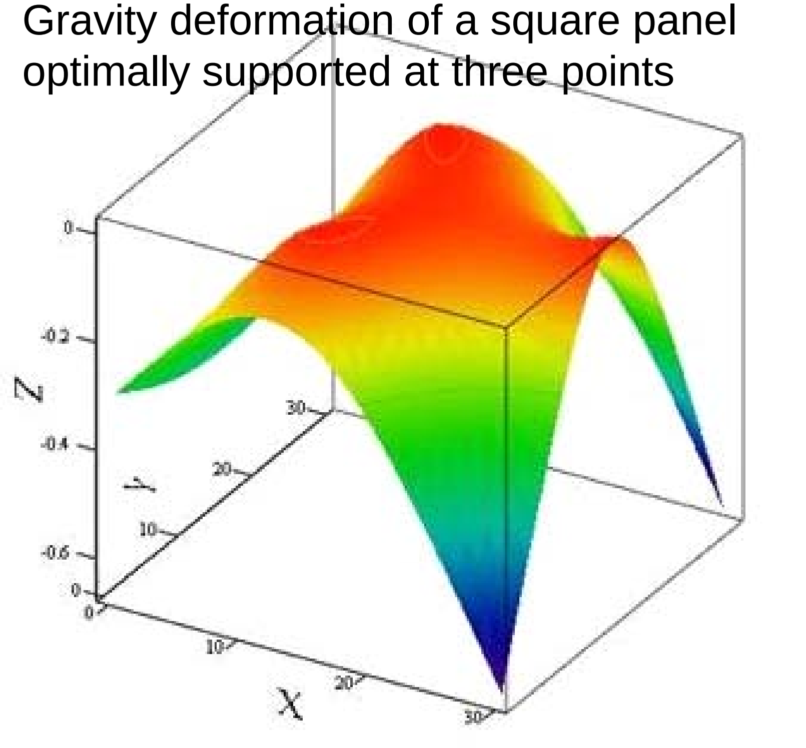
Reflector design

- Sources of surface error
  - Fabrication errors
  - Thermal distortion
  - Gravity deflection
  - Active control system
    - Sensors mounted on panels

- Have developed a generic panel model and spreadsheet to evaluate the many configurations and options

- Critical parameters
  - Fabrication materials => CFRP
  - Panel size => 1-2 m

Gravity deformation of a square panel optimally supported at three points

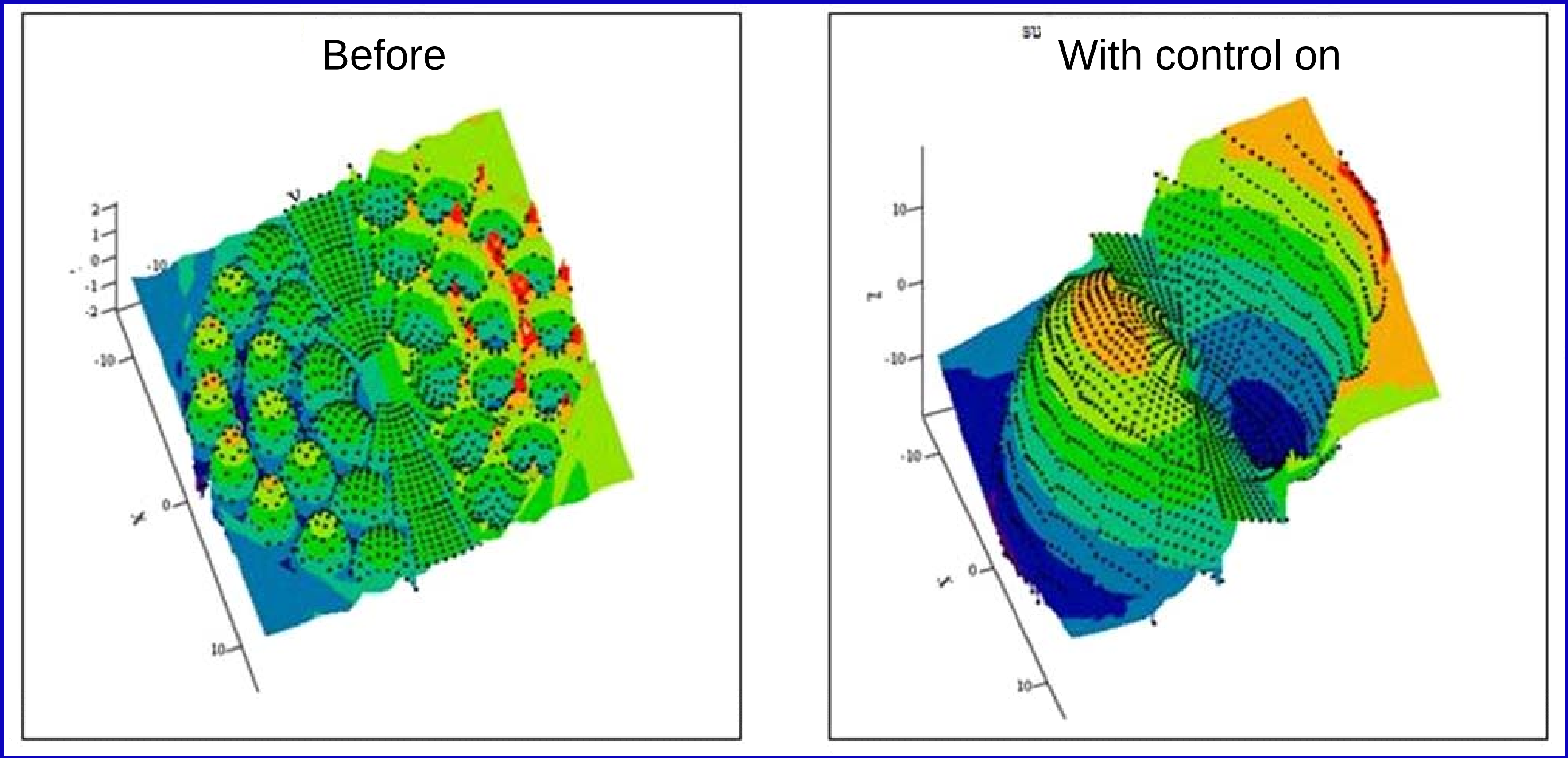


Fabrication errors

- No polishing
  - Replication
  - or Direct machining
- Most sources of manufacturing errors are the same nature as the load distortions experienced by the panel
  - Gravity
  - Thermal
  - Stress relaxation
- All errors scale at least as d^2

  Therefore it is reasonable to assume that the fabrication will also scale as d^2
  - Specify fabrication errors for 1 m size panel and scale as d^2

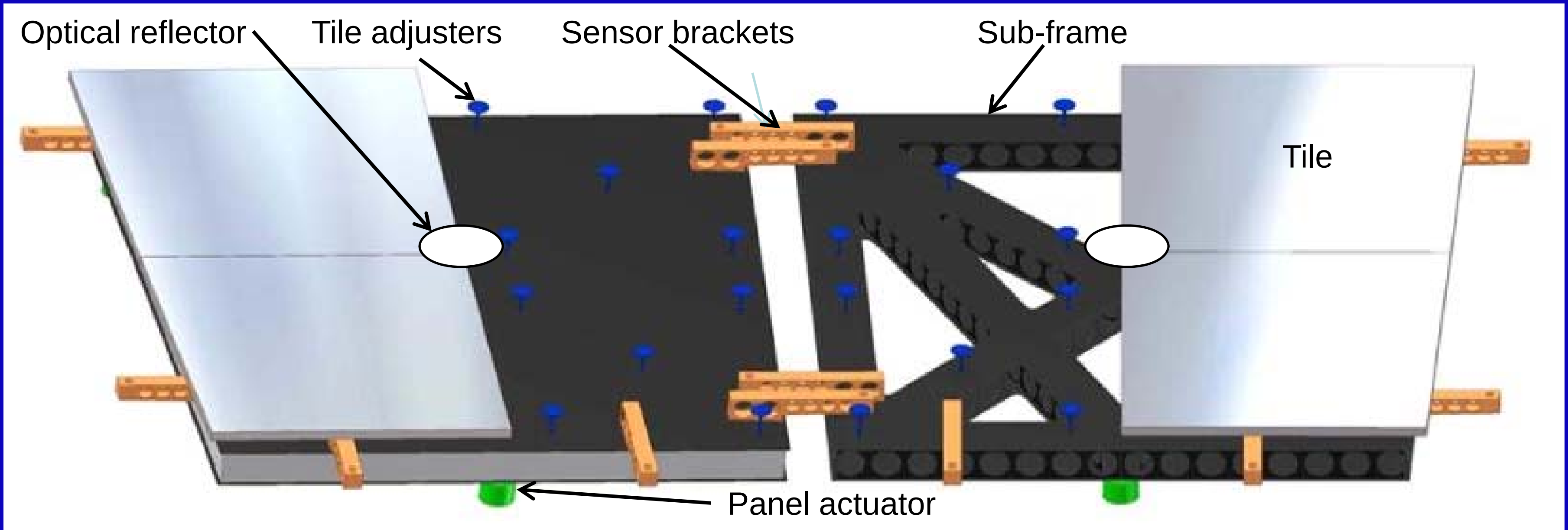
Effect of thermal cupping on surface control system



Control system tries to keep continuity of surface and slope across panel boundaries.
Telescope surface HWFE ~10 x individual panel error.
This type of mode needs to be minimized and/or additional types of sensors used.

Compound panel

Separate the functions of providing the accurate reflecting surface from providing the structural strength and stability



Four (or more) reflecting tiles (1mx1m) attached to a sub-frame (2mx2m) at five points. Adjusted at the factory to the required accuracy.

The sub-frames are encased in foam insulation to minimize ΔT.

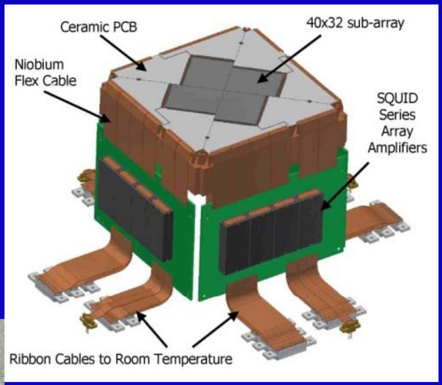
The tile errors are small because of five point support but more error terms from the manual adjusters, etc.

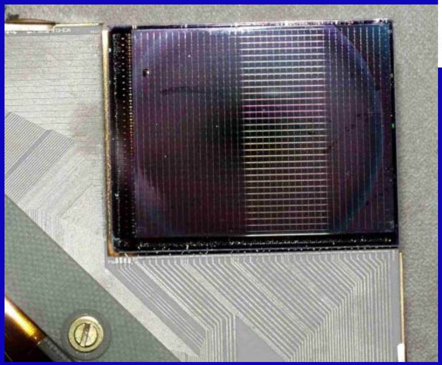
Projected net primary surface error is ~6 μm

Direct Illumination Cameras

- SCUBA2 (UK ATC, Can., NIST)
  - NIST TES silicon bolometers
  - Simultaneous 450 µm and 850 µm
  - Each color: 4 x 1280 pixels
  - At JCMT

- CCAT SW Camera (concept)
  - 200 µm, <u>350 µm</u>, 450 µm, 620 µm
  - Single color with filter wheel
  - NIST TES silicon bolometers
  - Total: 32 000 pixels
  - 5' field of view @ 350 µm

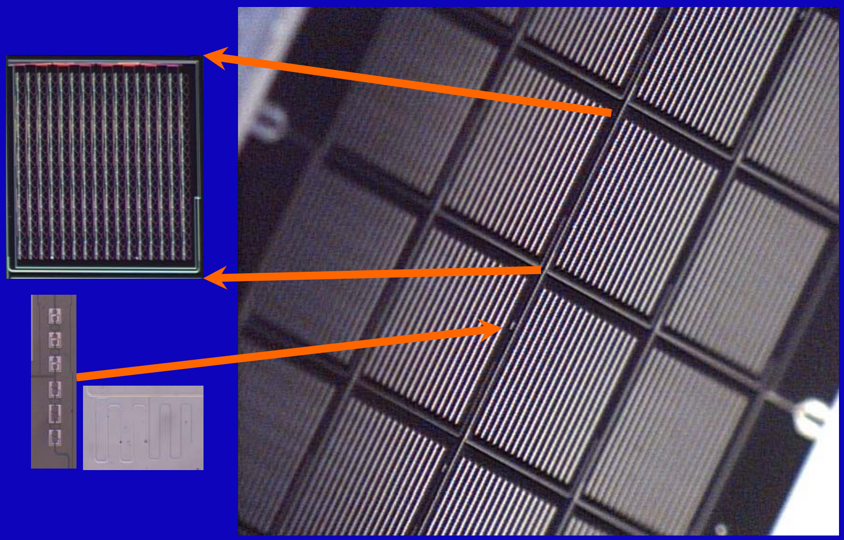




Antenna Coupled Camera

- Demo camera (CIT, Colorado)
  - MKID Detectors
  - Two color microstrip filters
  - 16 Slot Dipole Antennae pixels
  - To go on CSO
- CCAT LW Camera (concept)
  - 750–2000 µm
  - Total: 45 000 pixels
  - Up to 20' x 20' Field of View

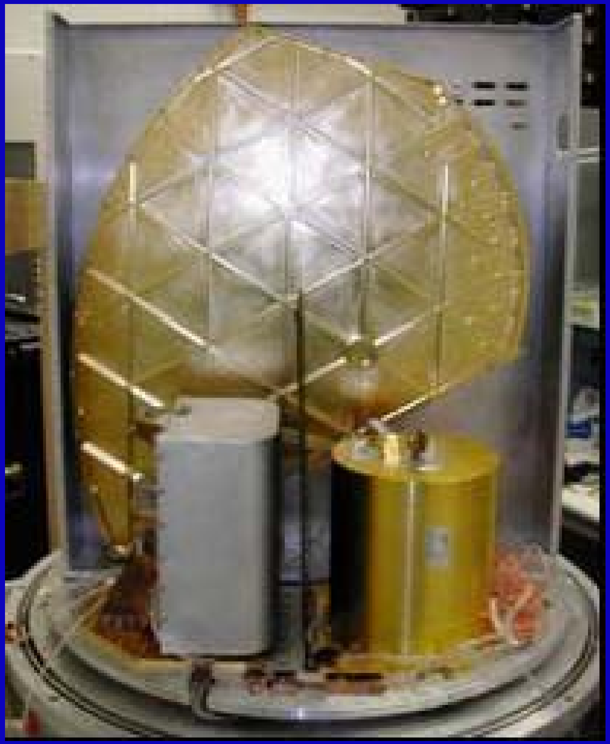
Antenna coupled array
1300 & 850 µm

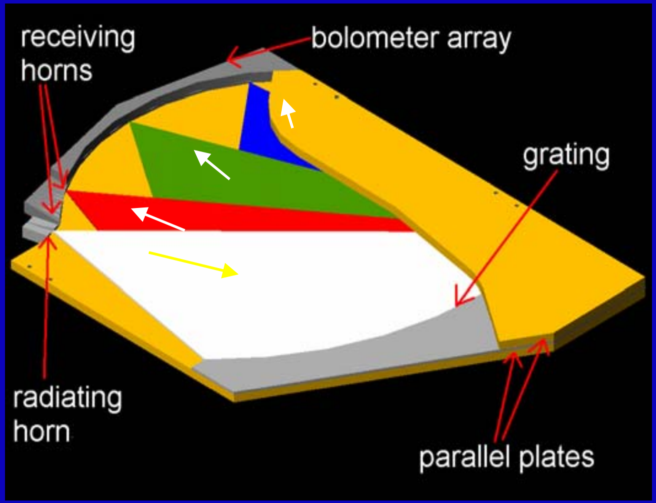


Spectrometers

- Zeus (Cornell)
  - Long slit echelle grating
  - 350, 450, 610 µm, R ~ 1000
  - Already to CSO
- Z-Spec (CIT, JPL, Colorado)
  - Parallel plate grating cavity
  - 190–310 GHz, R ~ 250 to 400
  - Already to CSO (2005 June)
- Multiobject
  - Flexible dielectric waveguide
  - Laboratory studies

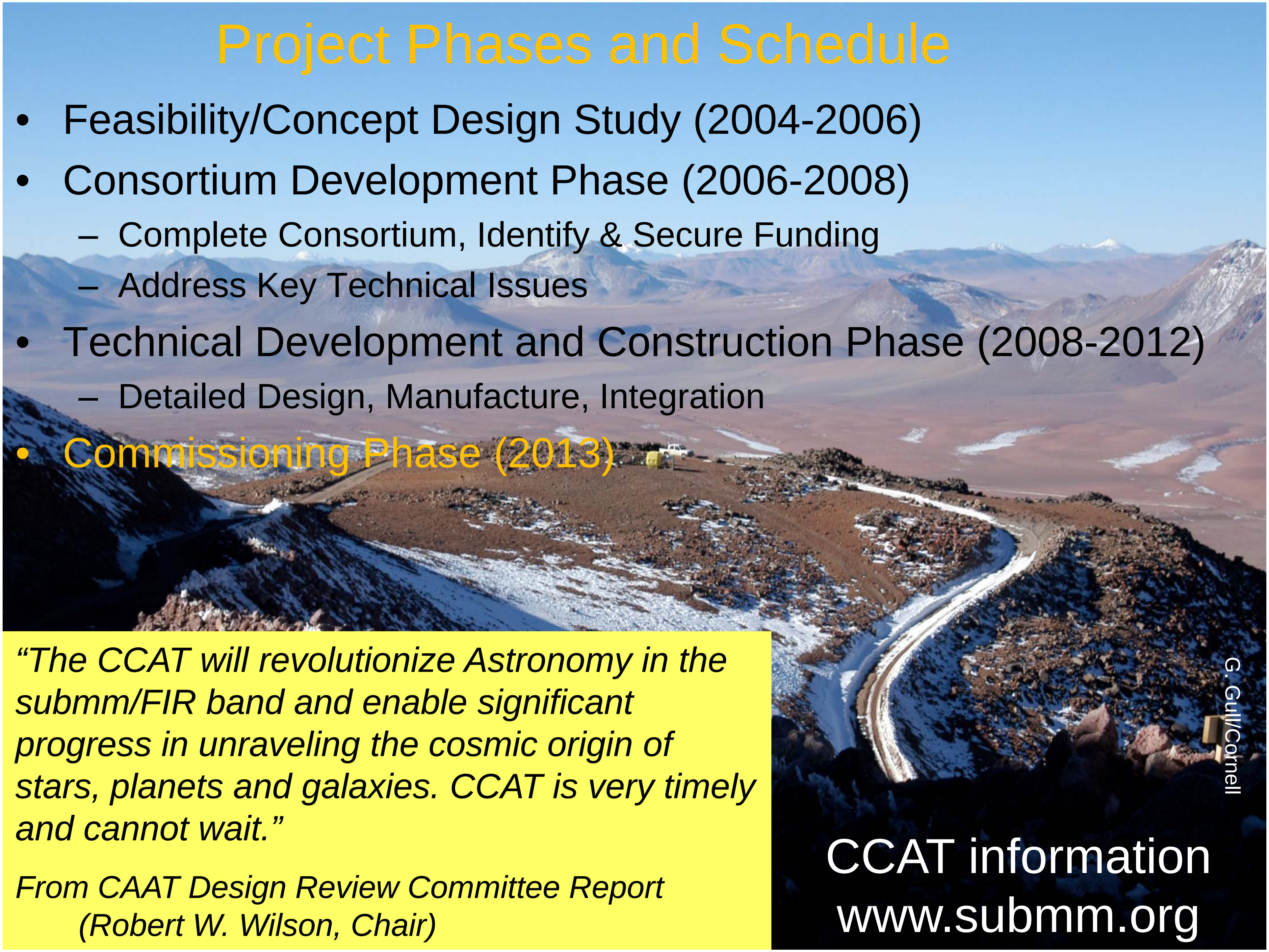
- Will also have heterodyne arrays





Project Phases and Schedule

- Feasibility/Concept Design Study (2004-2006)
- Consortium Development Phase (2006-2008)
  - Complete Consortium, Identify & Secure Funding
  - Address Key Technical Issues
- Technical Development and Construction Phase (2008-2012)
  - Detailed Design, Manufacture, Integration
- Commissioning Phase (2013)



"The CCAT will revolutionize Astronomy in the submm/FIR band and enable significant progress in unraveling the cosmic origin of stars, planets and galaxies. CCAT is very timely and cannot wait."

From CAAT Design Review Committee Report (Robert W. Wilson, Chair)

CCAT information
www.submm.org