

New Solar Telescope in Big Bear Solar Observatory

Philip R. Goode

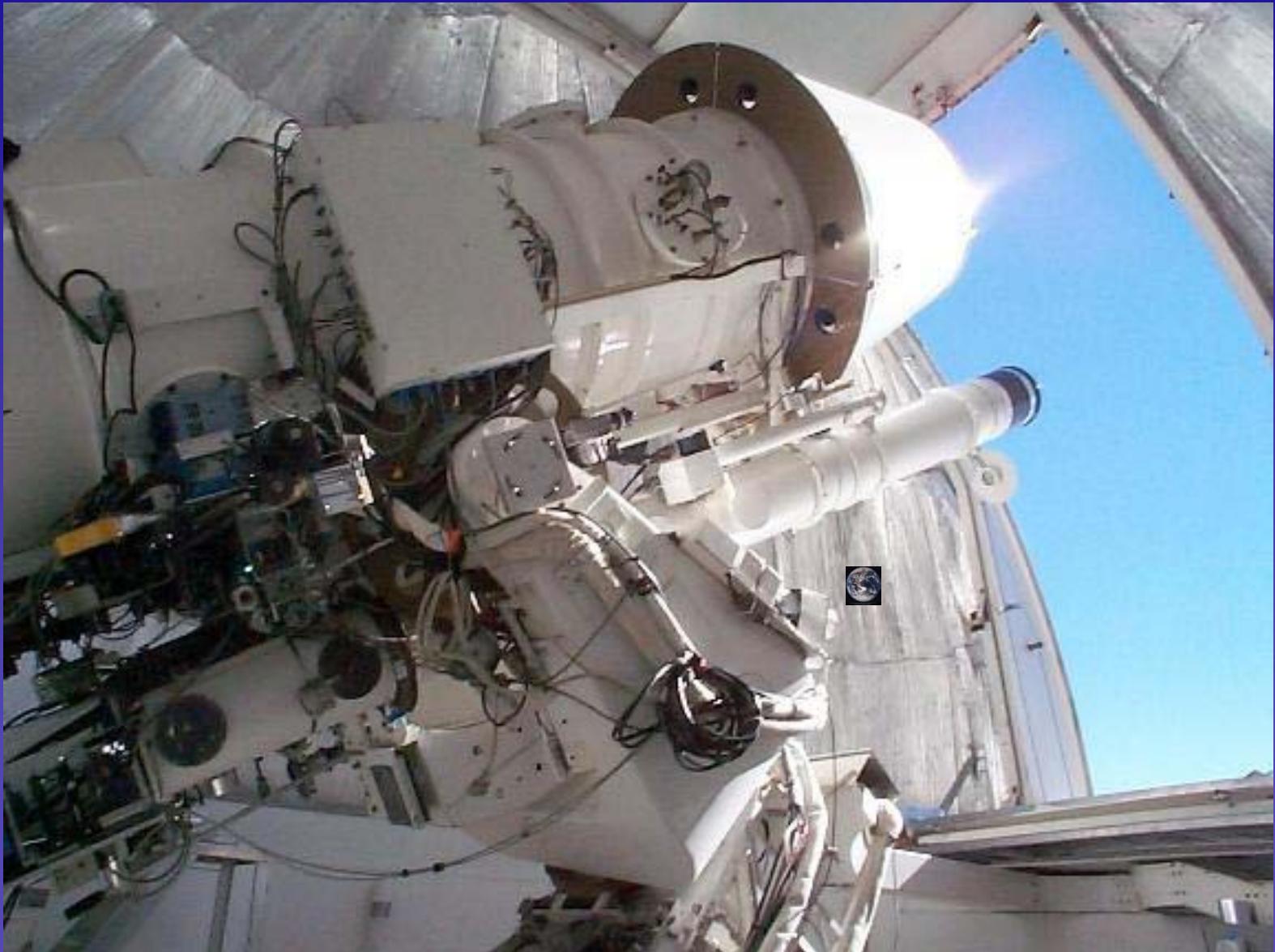
Big Bear Solar Observatory

Center for Solar-Terrestrial Research

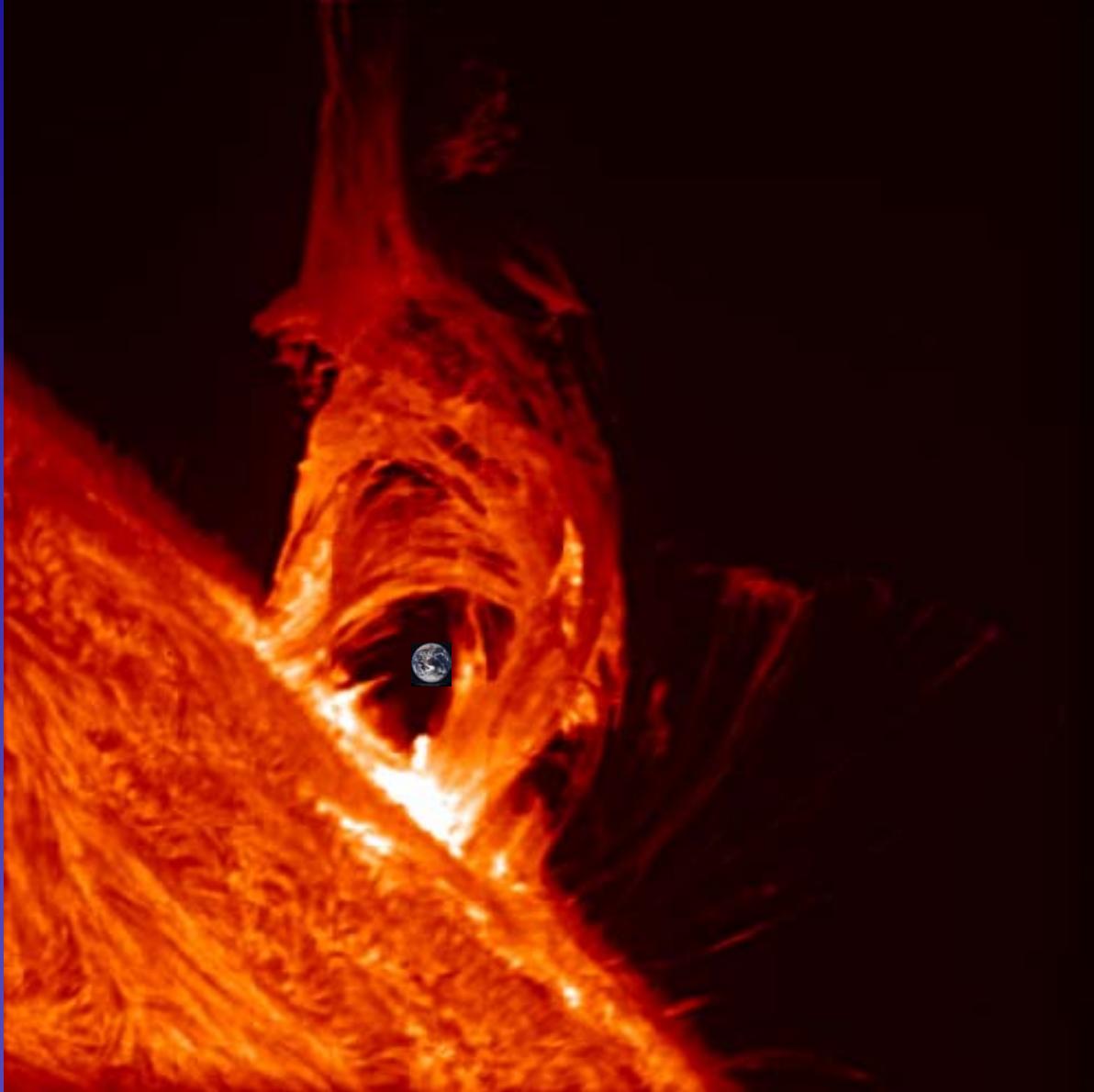
New Jersey Institute of Technology



Big Bear Solar Observatory

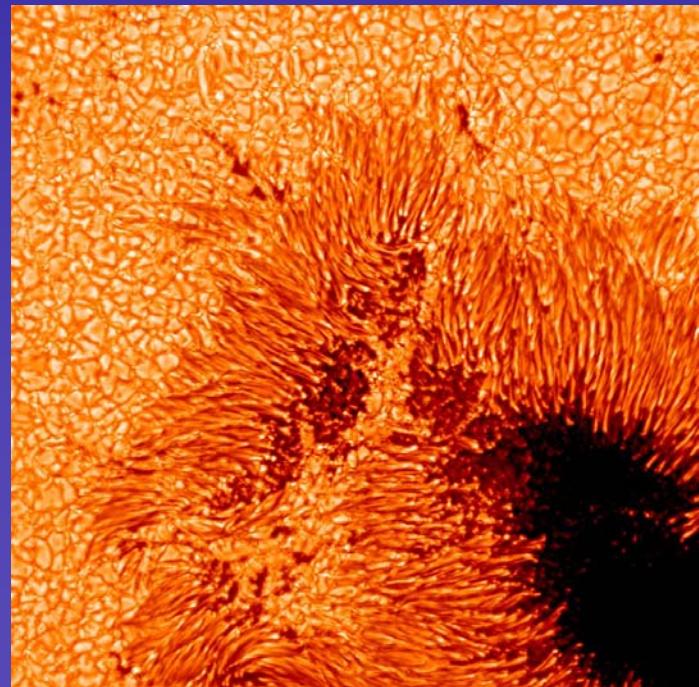
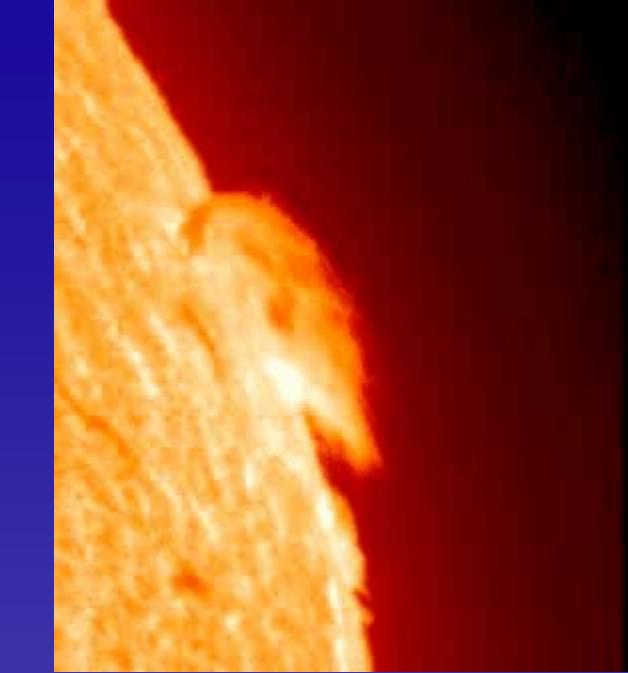


Big Bear Solar Observatory



Motivations for NST

- **Fundamental Scale of Solar Magnetism**
 - Solar magnetic field (bundled) fibers
 - Flares and CMEs origins
 - Satellite data a complement
- **Space Weather**
 - Solar storms can damage space assets and terrestrial telecommunications/power grid
- **Telescope Technology Challenges**
 - Off-axis Telescope
 - Adaptive Optics
 - Heat Stop



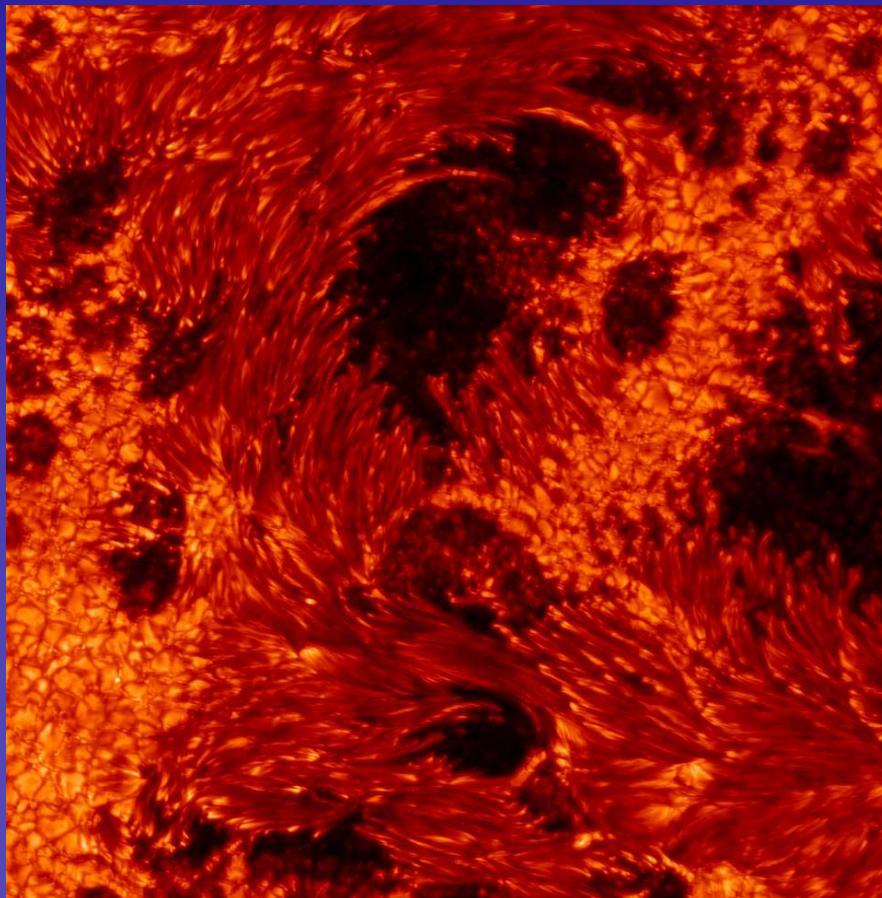
New Solar Telescope (NST)

- Collaborators

- UHawaii
- UArizona
- KASI/SNU

- Federal Funding

- NSF
- AFOSR
- NASA
- KoSF



BBSO/NSTers



Roy Coulter



Nicolas Gorceix



Jeff Nenow



John Varsik



Sergey Shumko



Mark Vincent



Vlad Abramenko



Randy Fear

BBSOers



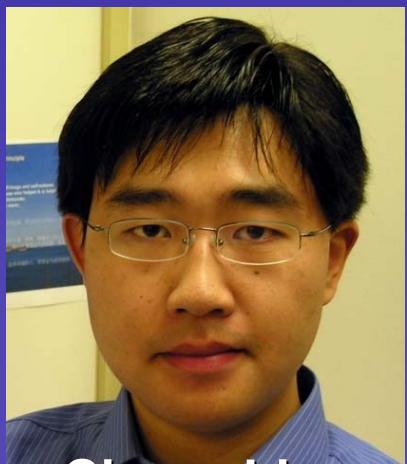
Erika Norro



Vasyl Yurchyshyn



Valentyna Abramenko



Chang Liu



Alla Shumko



Mark Klebba

Big Bear Solar Observatory



BBSO was built by Caltech in 1969. The dome sits at the end of a 1000 ft. causeway on Big Bear Lake's north shore at 6,750 foot elevation.

Observatory was transferred from Caltech to NJIT in July 1997.

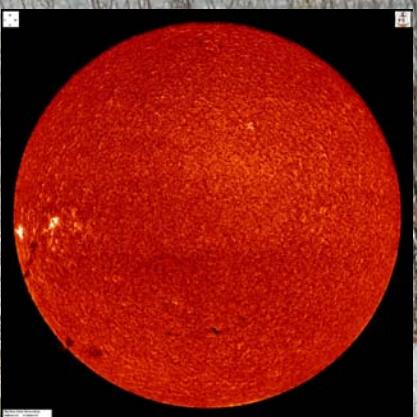
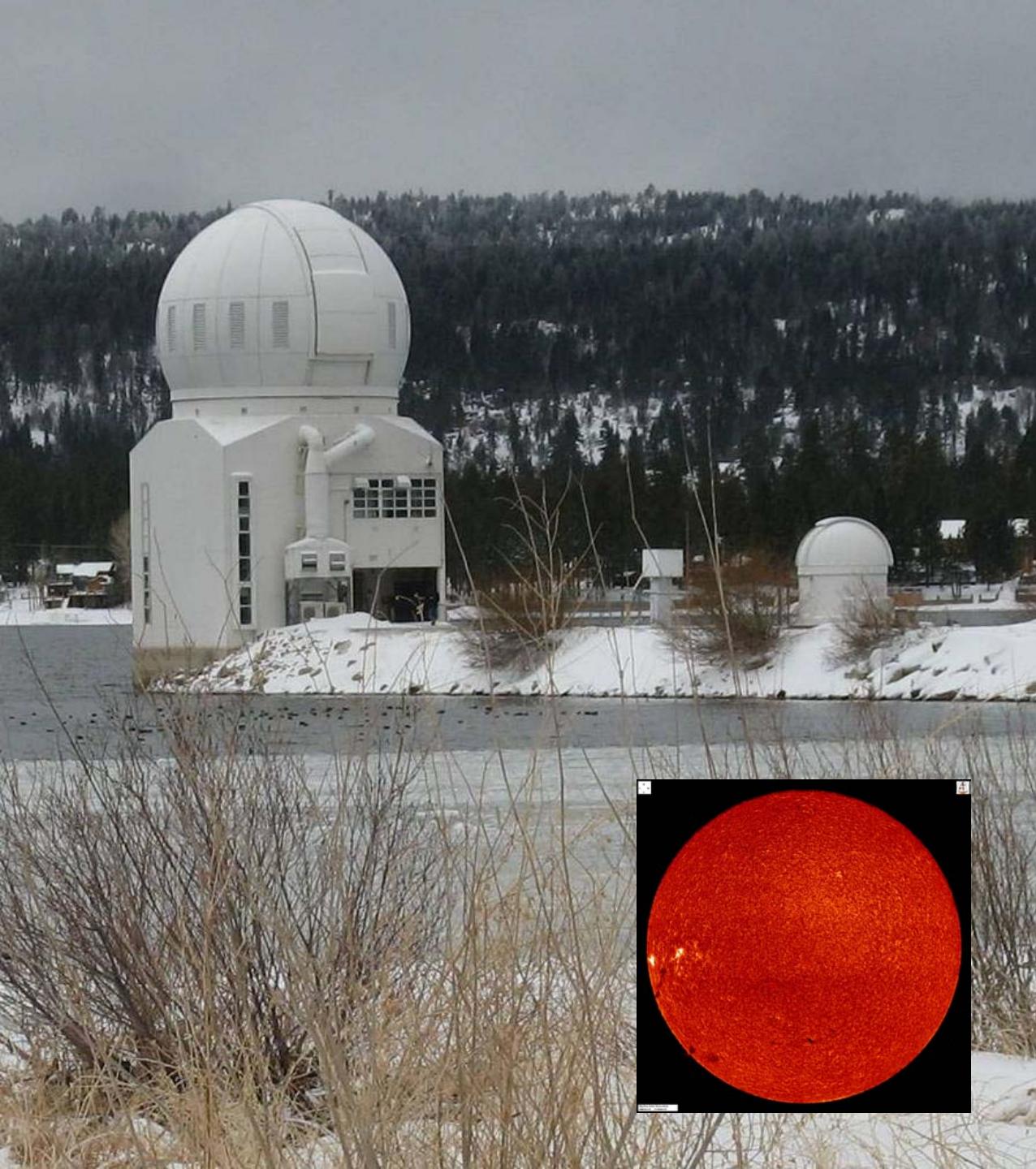
The surrounding waters of Big Bear Lake reduce ground level convection, and predominate winds bring smooth air flows across the flat surface of the lake providing superb conditions for solar observing.

Big Bear Solar Observatory

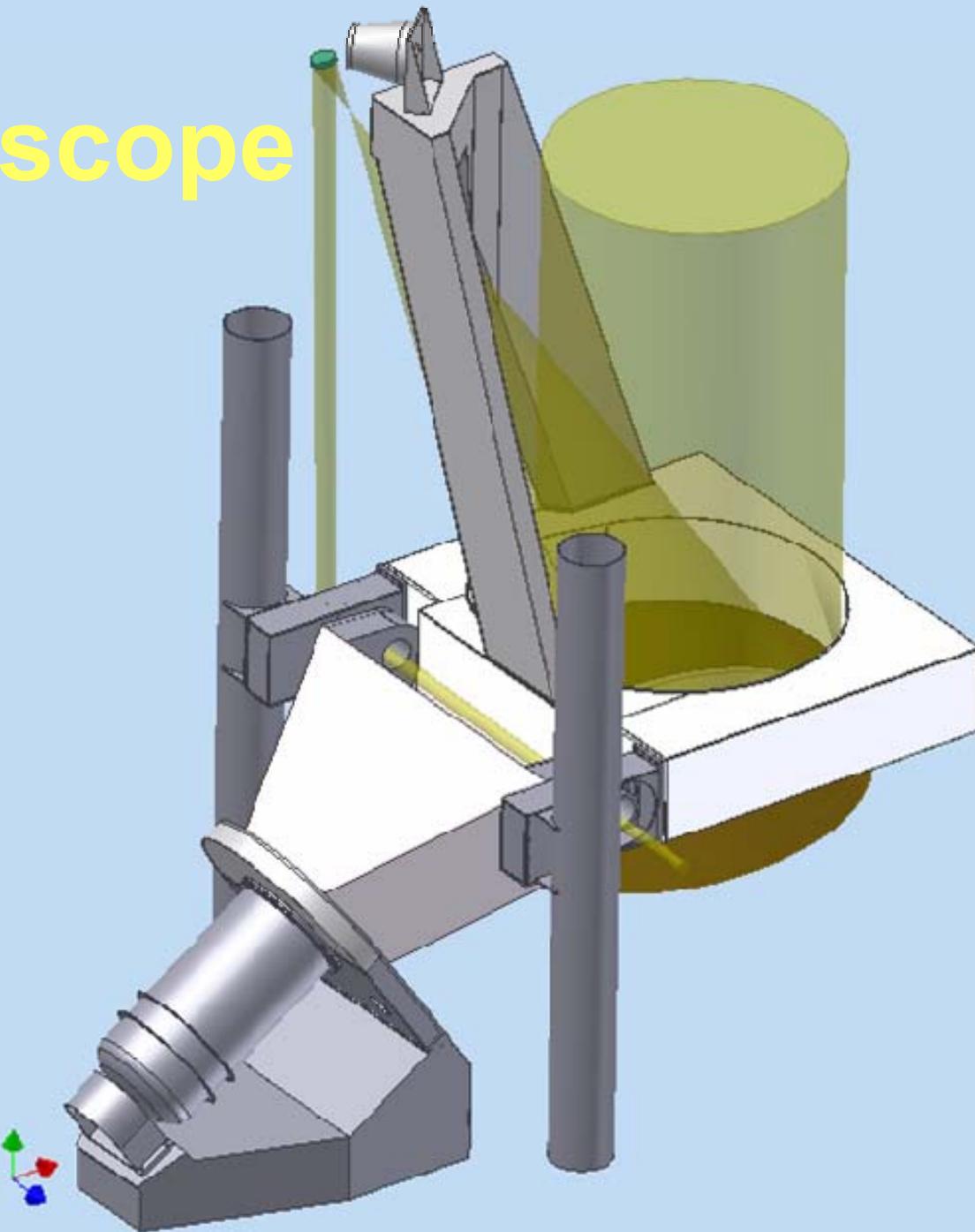
BBSO was built by Caltech in 1969. The dome sits at the end of a 1000 ft. causeway on Big Bear Lake's north shore at 6,750 foot elevation.

Observatory was transferred from Caltech to NJIT in July 1997.

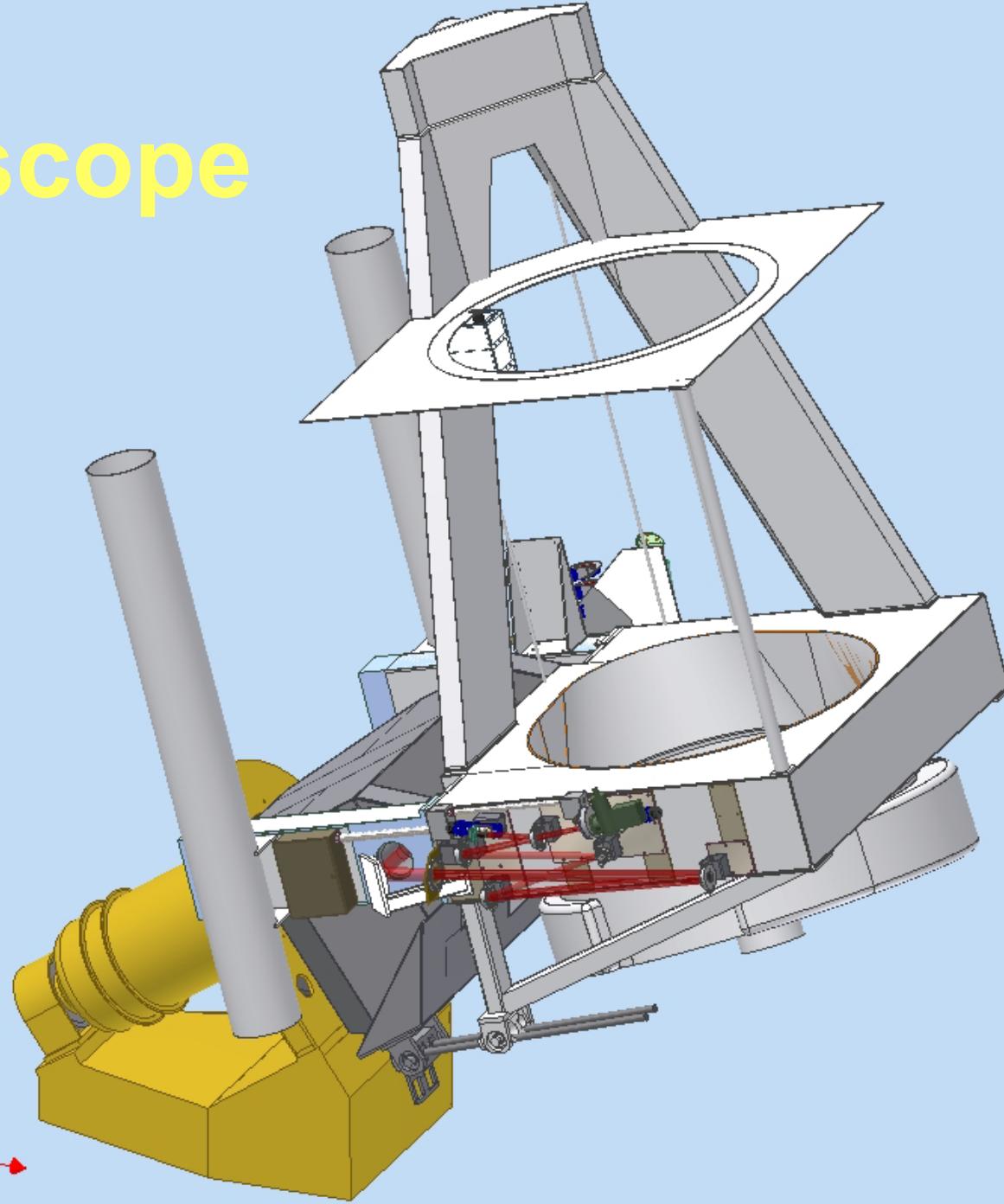
The surrounding waters of Big Bear Lake reduce ground level convection, and predominate winds bring smooth air flows across the flat surface of the lake providing superb conditions for solar observing.



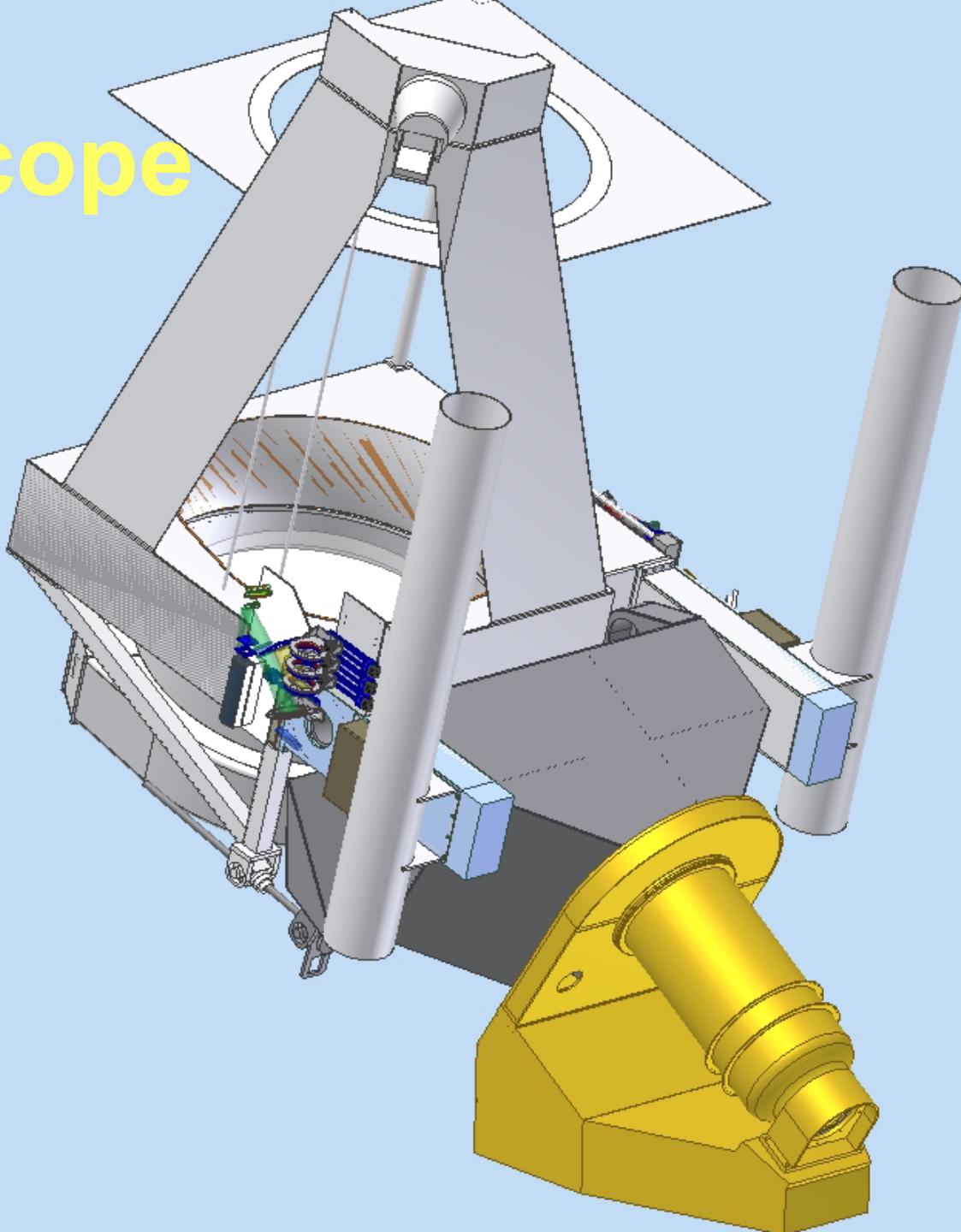
Telescope



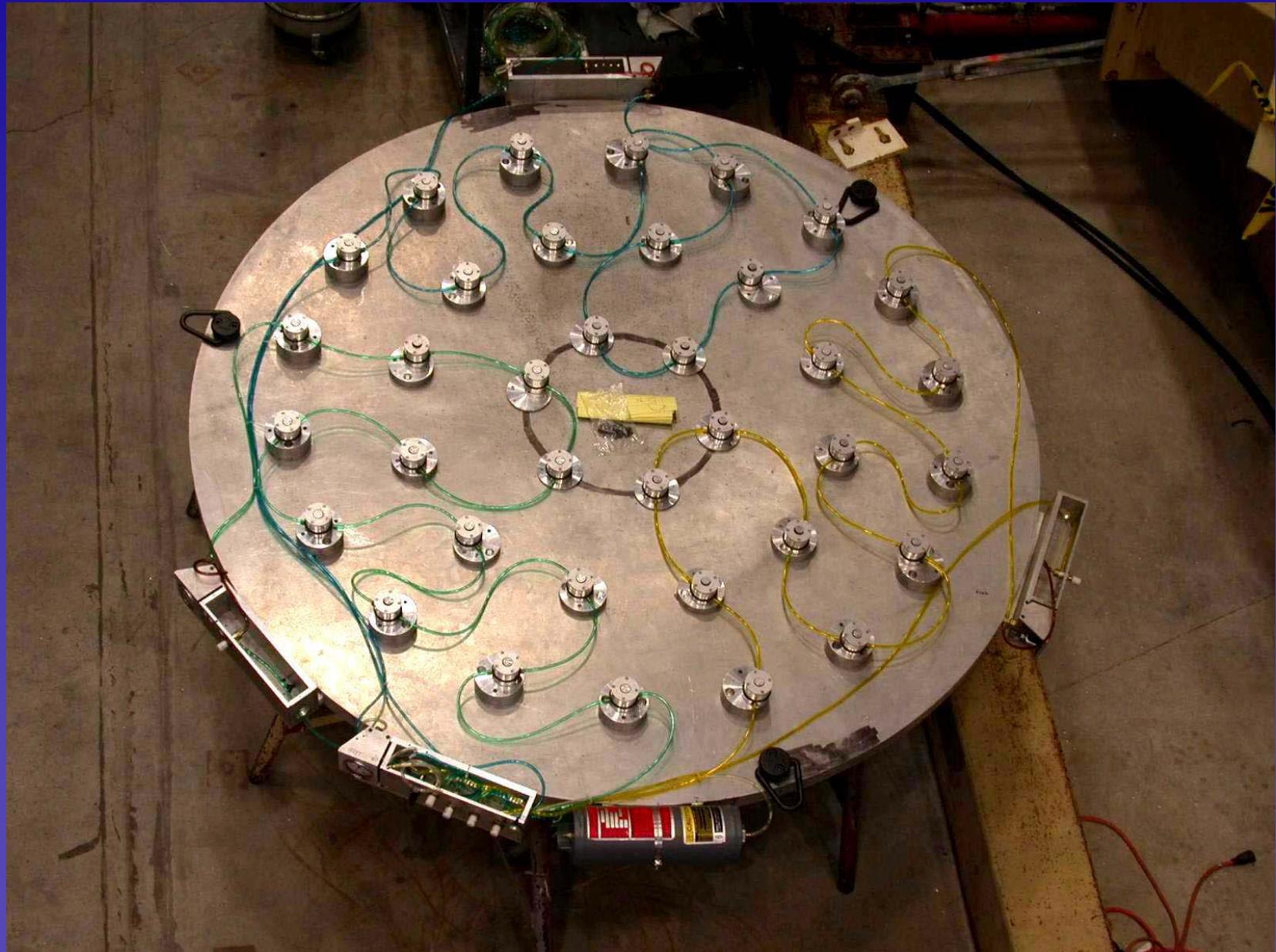
Telescope



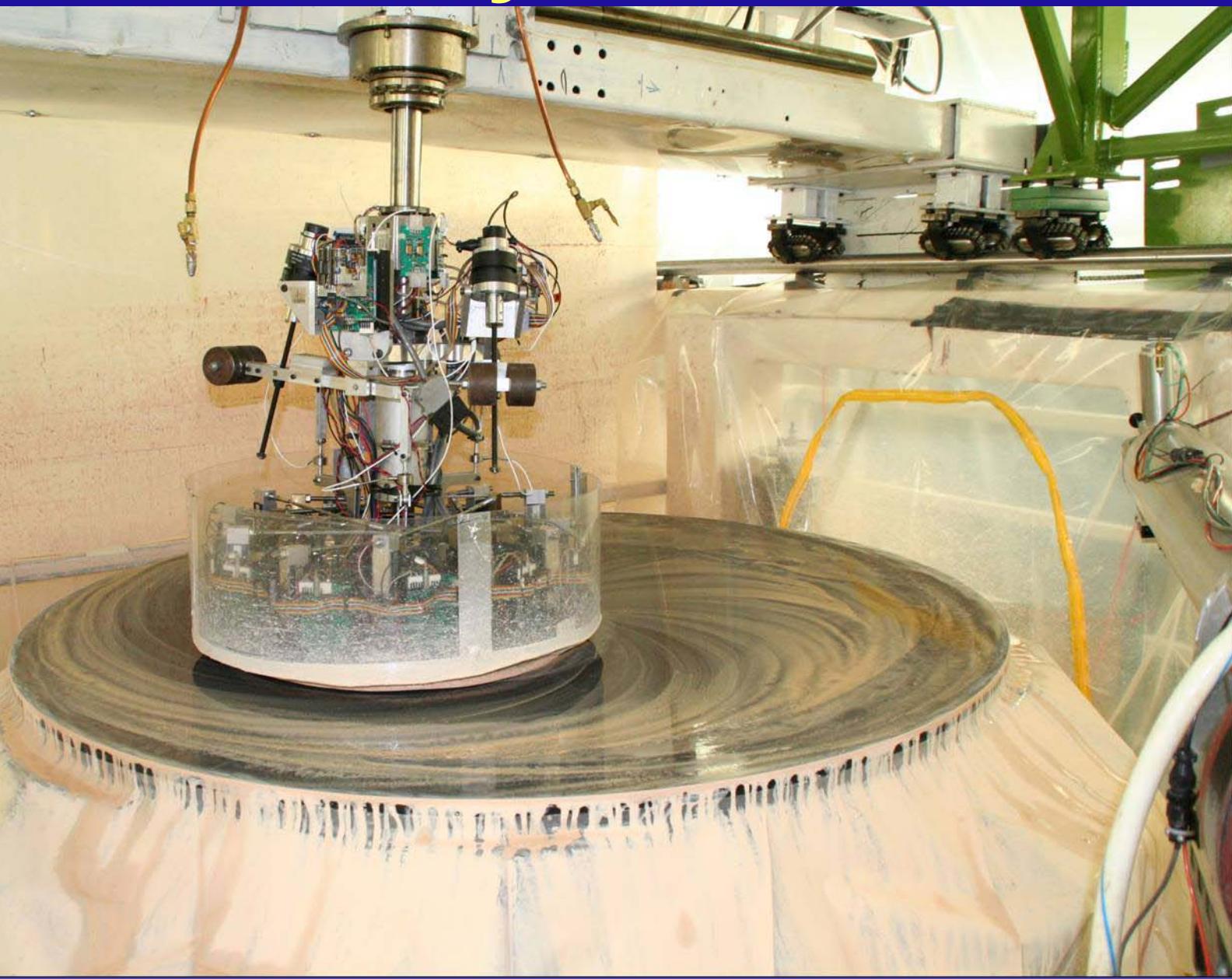
Telescope



Primary Mirror



Primary Mirror

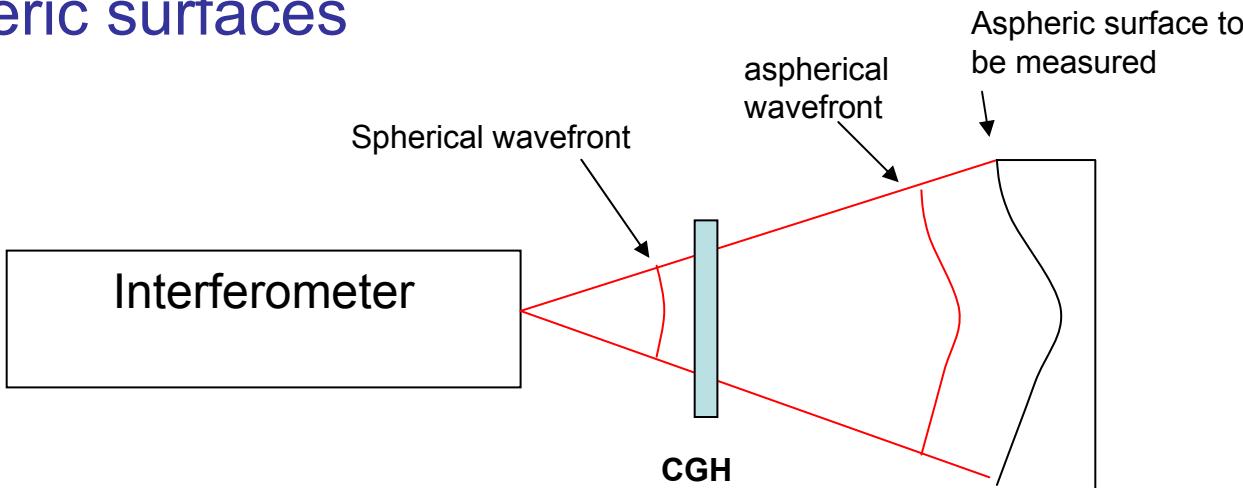


Primary Mirror



Optical testing : measuring aspheric surfaces

- Interferometers use light to measure to ~1 nm surface errors, for spherical or flat surfaces
- We need to measure aspheric (non-spherical) surfaces
- CGH can change spherical wavefronts to aspheric, allowing the use of interferometers for measuring aspheric surfaces



Test Tower

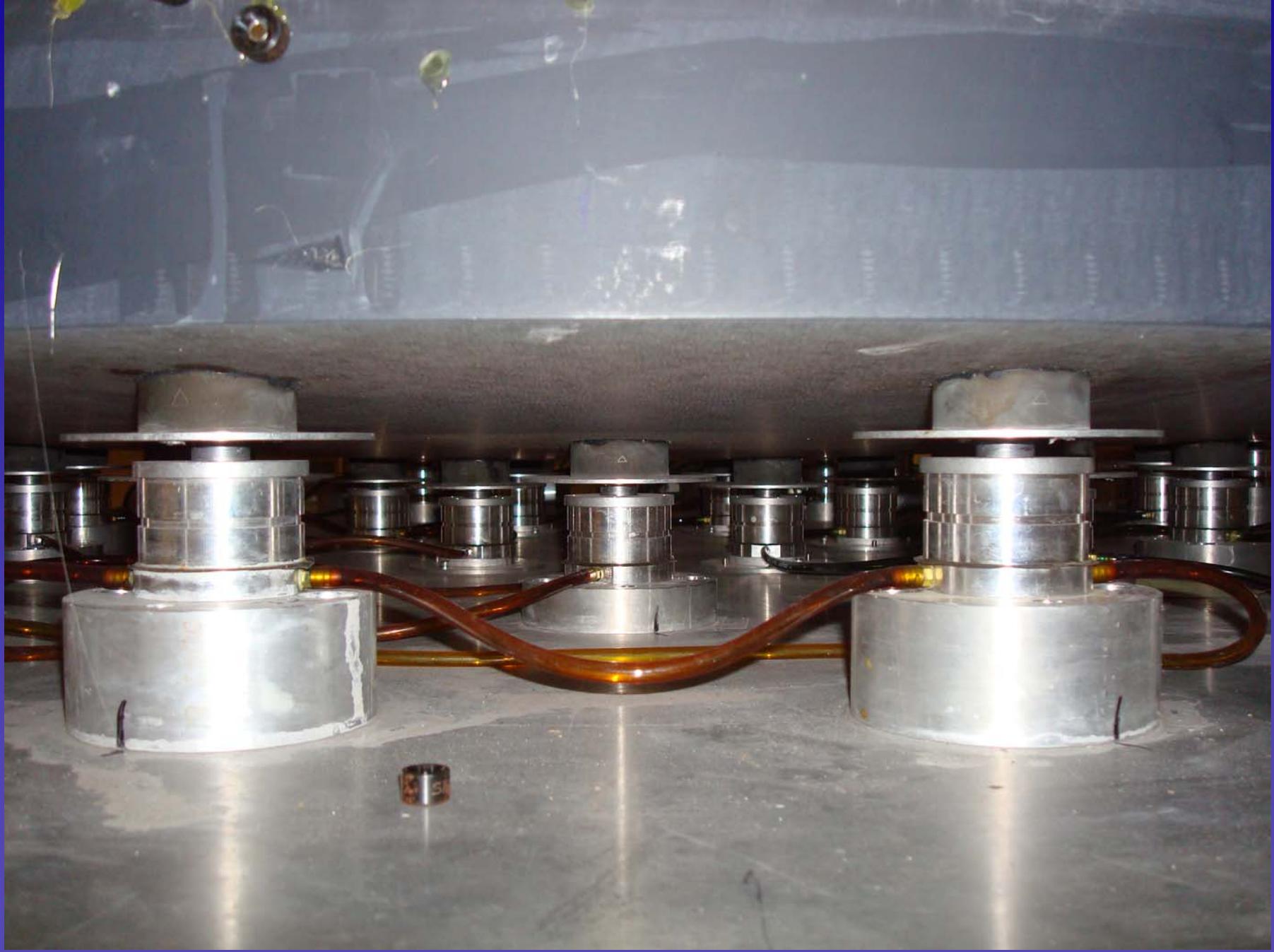


PM Final Figuring



PM Final Figuring





Primary Mirror (M1) Thermal Control

- Function:
Mitigate mirror seeing

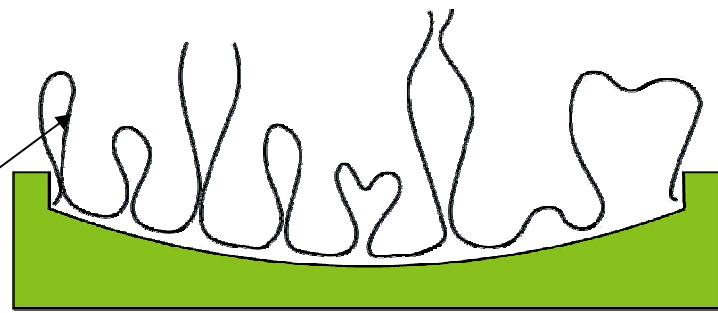
seeing

$$n_1 \approx -77.6 \cdot 10^{-6} \frac{P_{\text{mbar}}}{T_K}$$

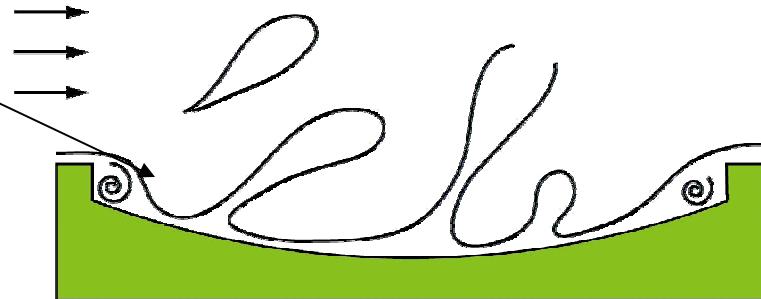
$$n_1 = \frac{\partial n_1}{\partial T} \Delta T + \frac{\partial n_1}{\partial P} \Delta P$$

$\uparrow \quad \uparrow$

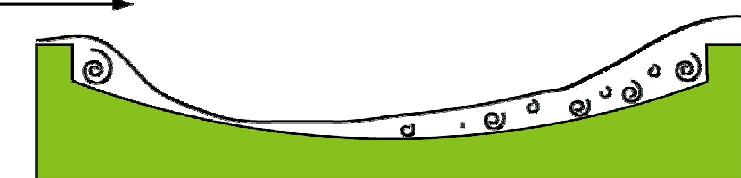
$-0.69 \times 10^{-6} \text{ K}^{-1} \quad 0.28 \times 10^{-6} \text{ mbar}^{-1}$



(a) Natural Convection



(b) Mixed Convection



(c) Forced Convection

Optical Support Structure





Big Bear Solar Obs

23 April 2008

Dome Removal



Dome Removal



New Dome



New Dome



New Dome



Old Telescope Removal





Big Bear Solar Obs

23 April 2008

Fly Away



Fork and Spectrograph, etc.





“Empty” Dome



Ala Saadeghvaziri

New Pier



New Pier



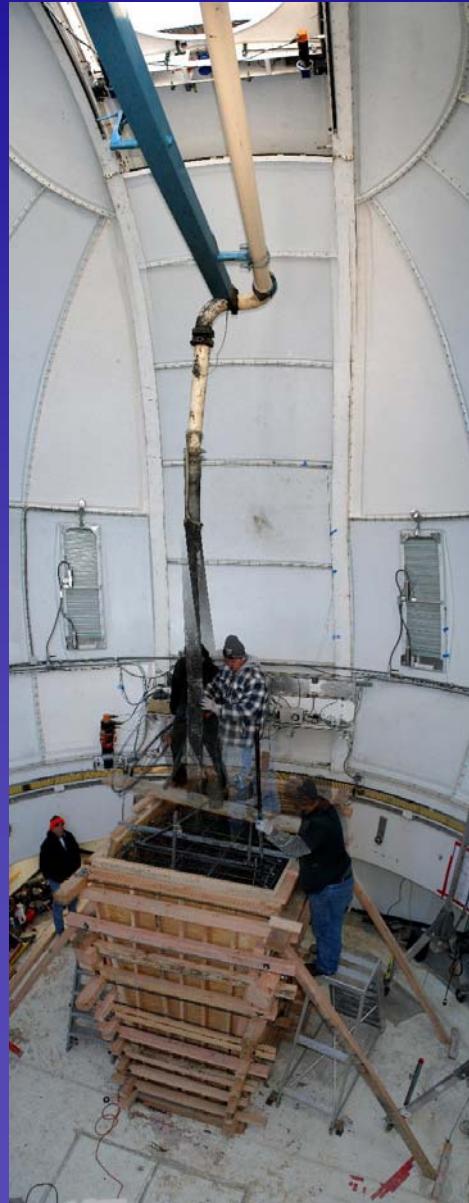
New Pier



New Pier



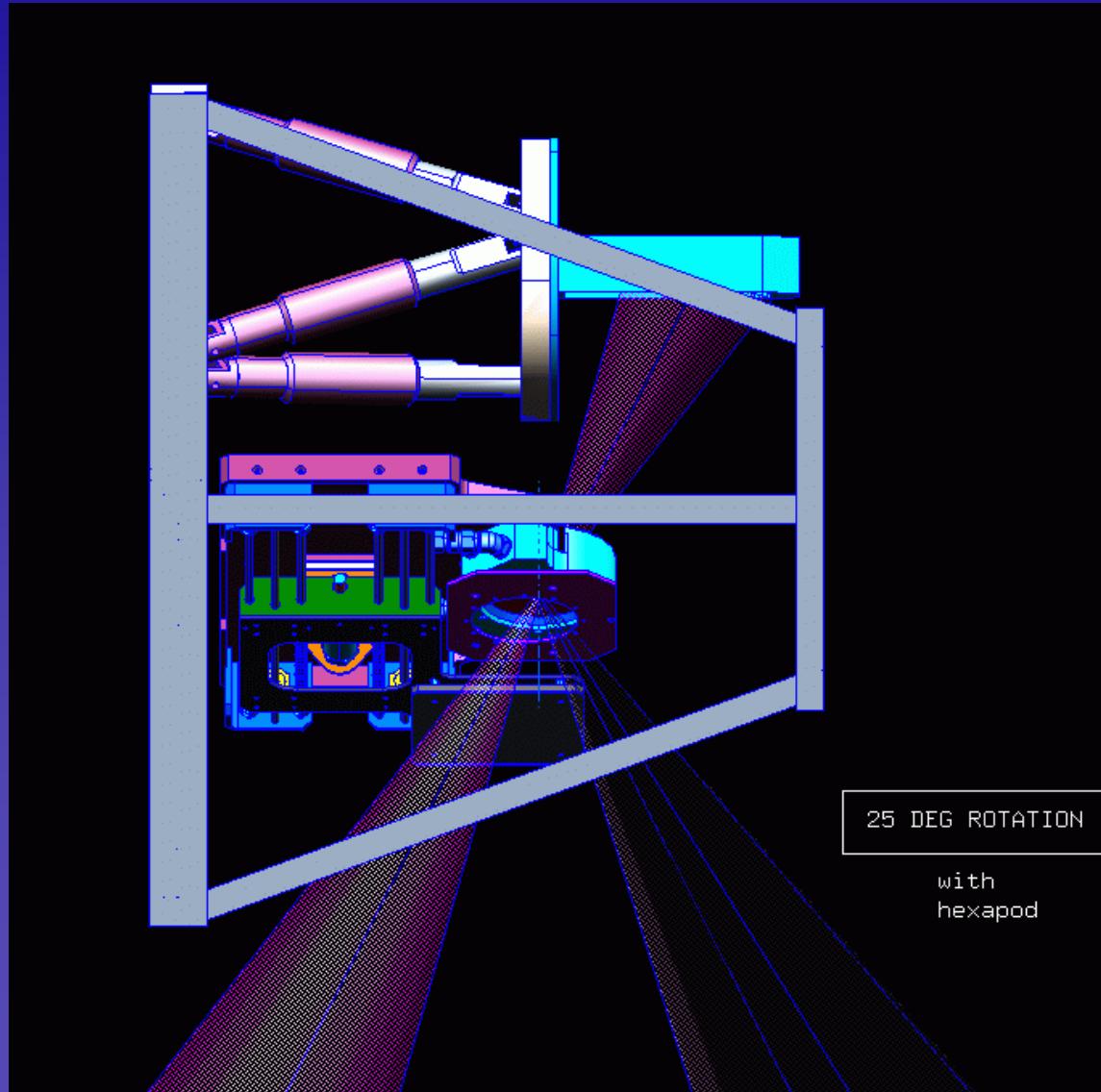
New Pier



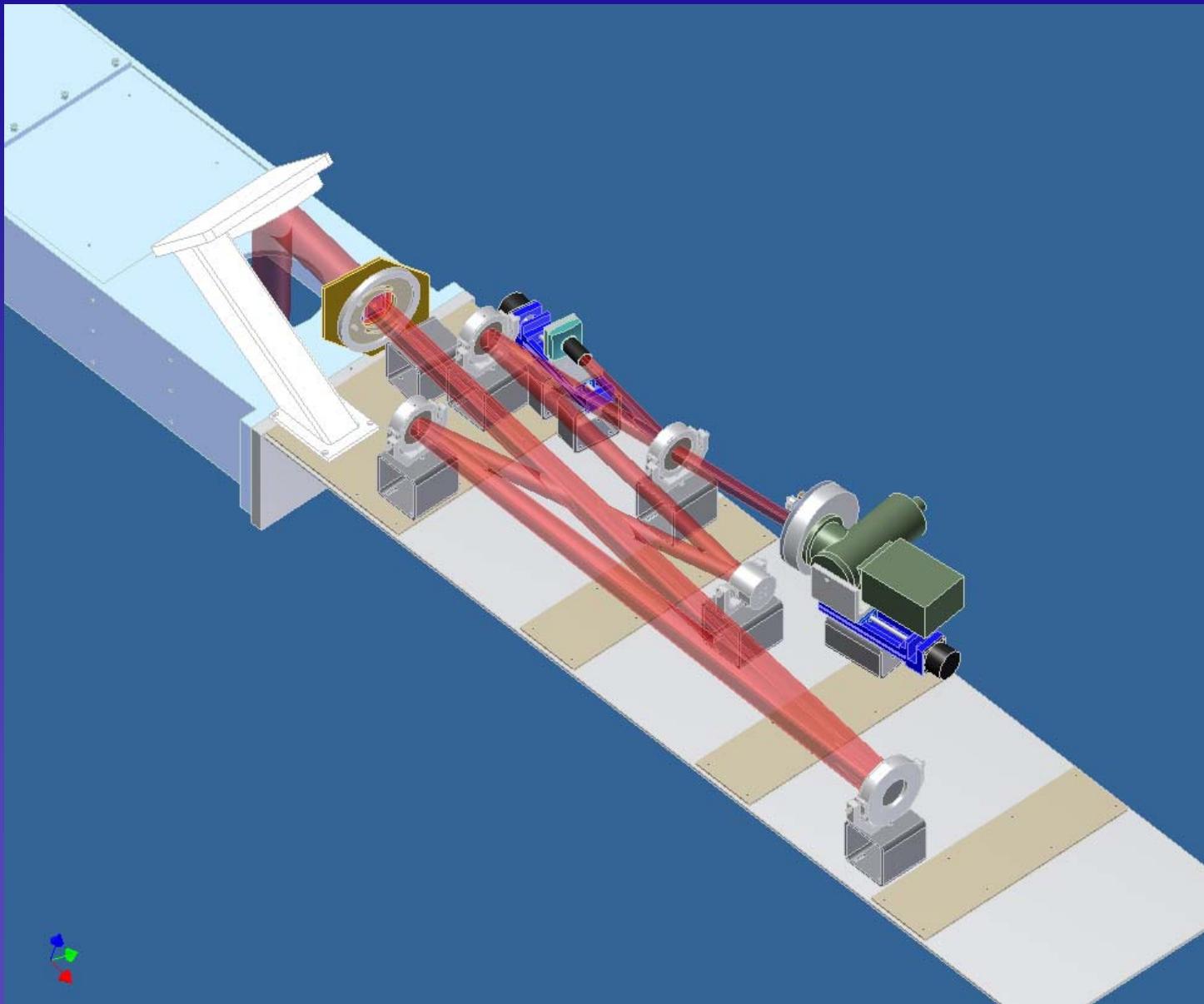
New Pier



Prime Focus

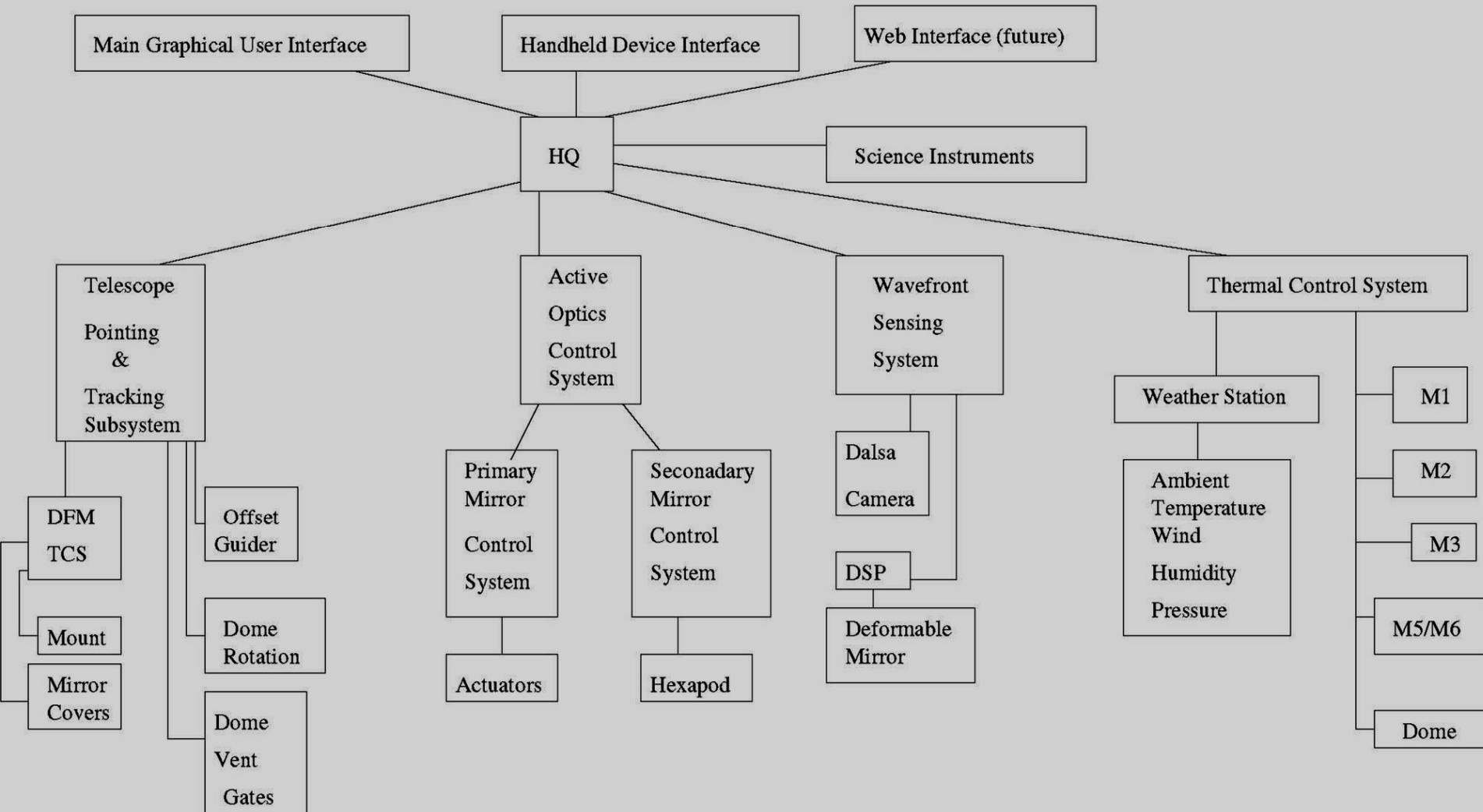


Nasmyth Focus



Telescope Control System

TCS Schematic 2005-06-14 JRV

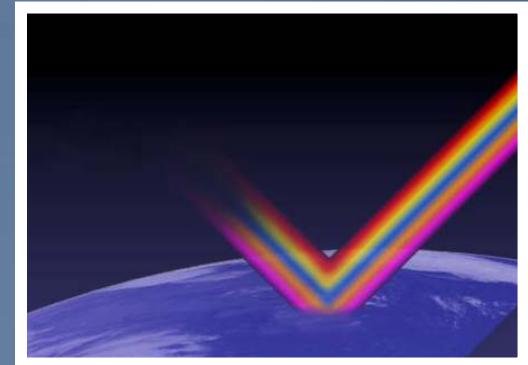


Timeline



Dome complete – Mar. 2008
OSS Delivery – May 2008
PM Delivery – Apr 2008
Telescope Installation – June 2008
First Light - June 2008
Full operation – Spring 2009

Sun's Direct and Indirect Roles in Climate Change

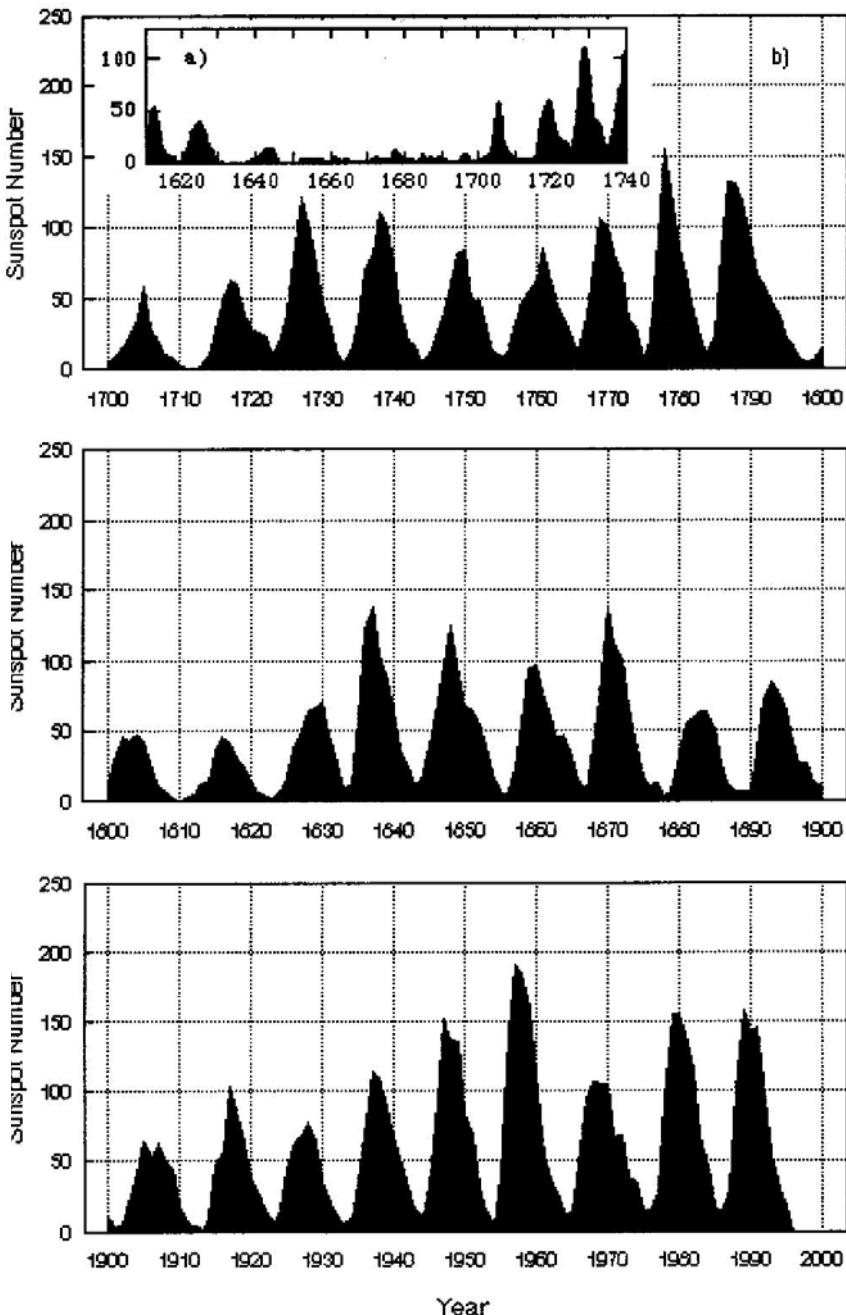
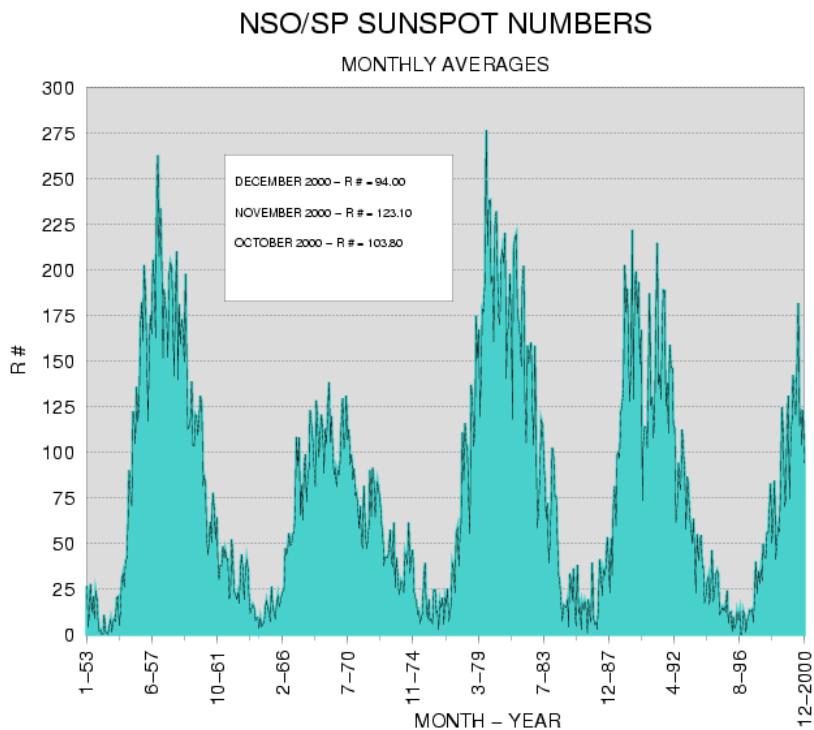


Changes in Earth's Climate

- In the most basic sense, it depends on changes in
 - The Sun's output
 - The Earth's reflectivity
 - Atmospheric Greenhouse gasses
- Earthshine provides a global measure of reflectivity and greenhouse gasses
 - Precise, cheap and global
 - Satellites are expensive, degrade and can fail

Sunspot Number

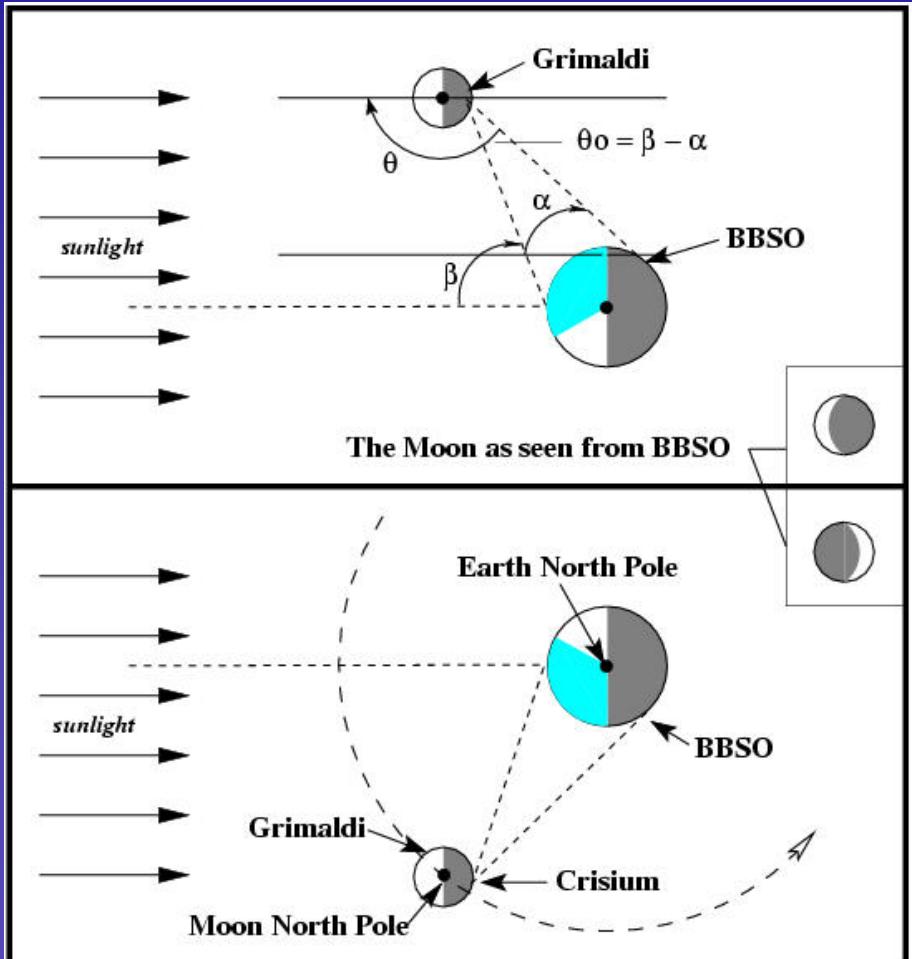
- Sunspot number
1620 –2000



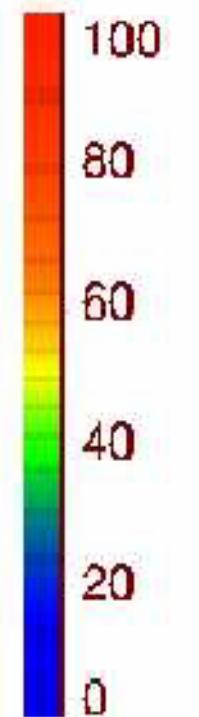
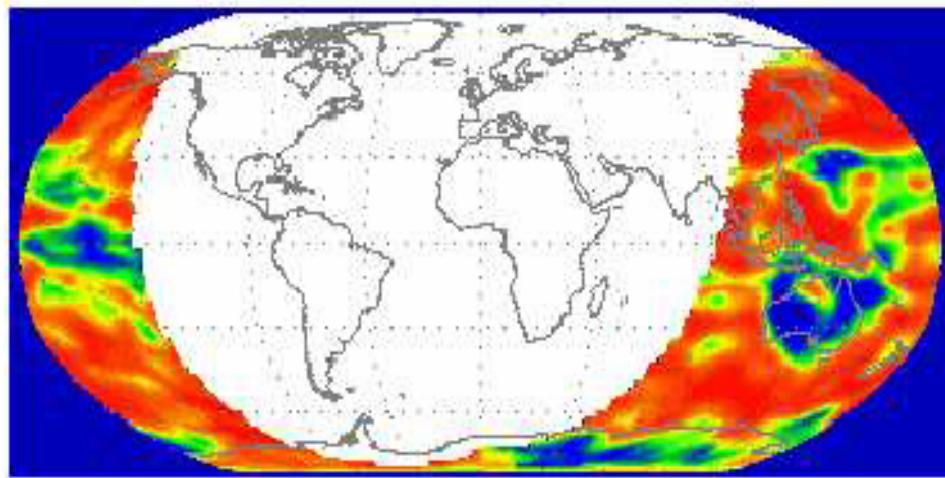
Earthshine Measurements of the Earth's Large-scale Reflectance

- The Earthshine is the ghostly glow on the dark side of the Moon
- Origin of Earthshine first explained by Leonardo da Vinci
- First measured by Danjon beginning in 1927-34 and by Dubois 1940-60.
- $ES/MS = \text{albedo} (+ \text{geometry and moon properties})$

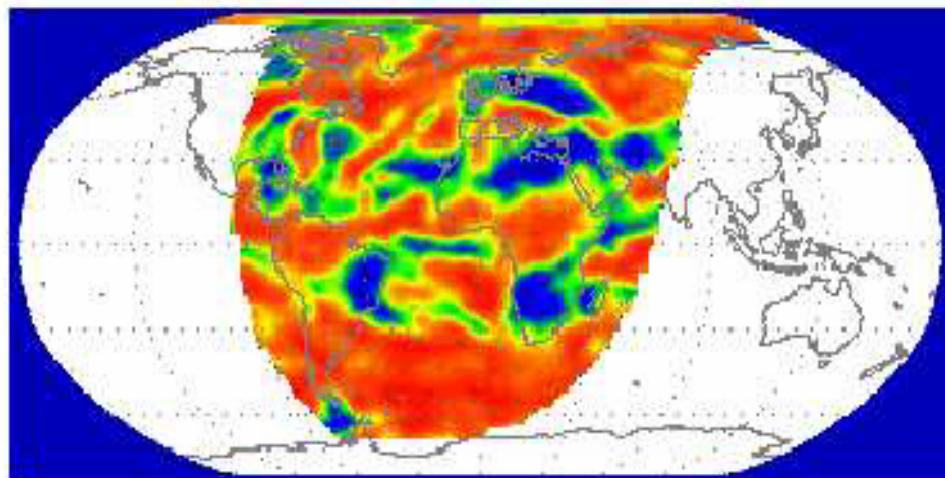
Waning / morning



Coverage during One Night



15/10/99
Phase = -116

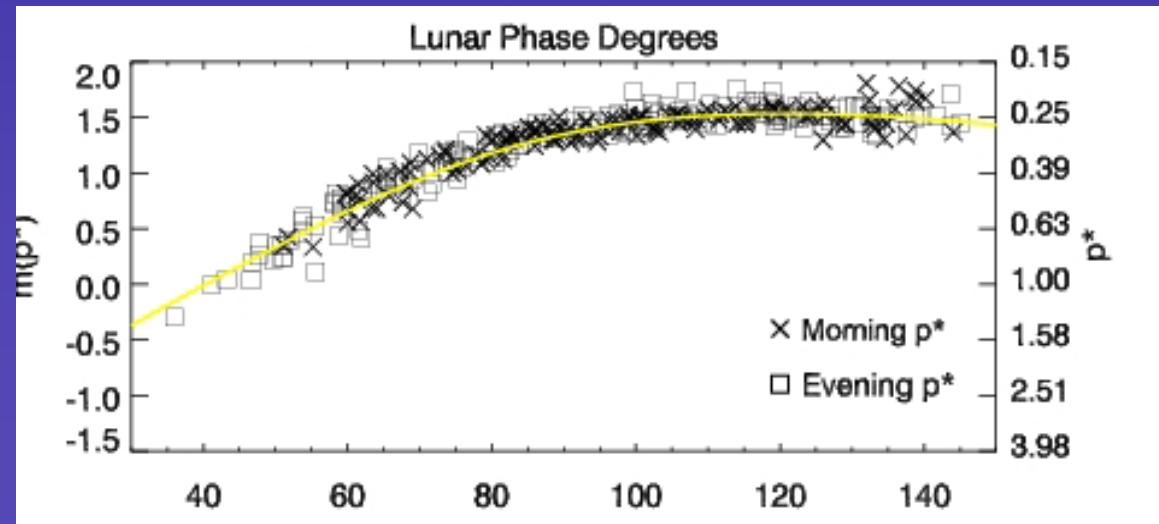


04/09/99
Phase = +110

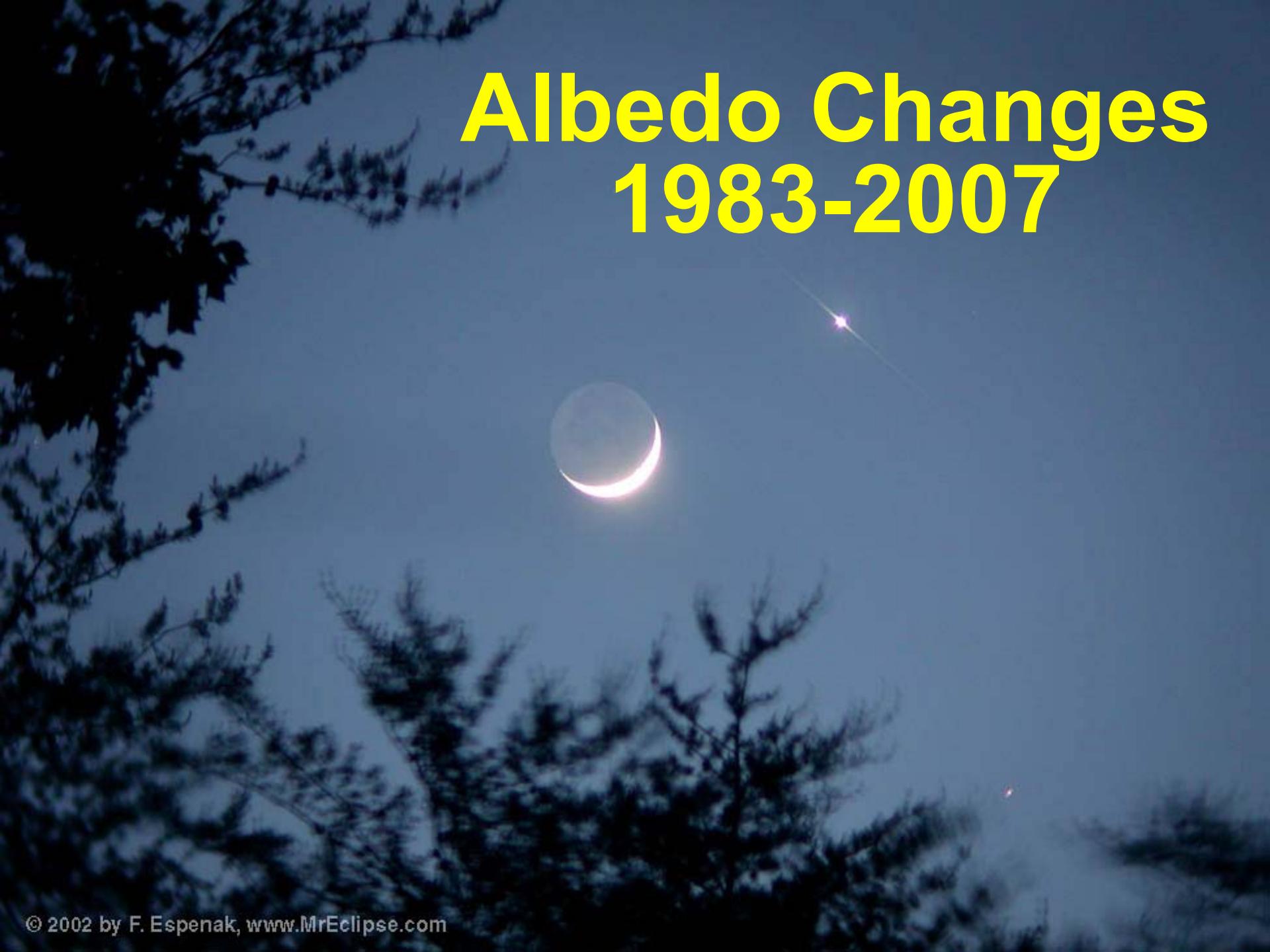
The Effective and Bond Albedos

- On any one night, we measure p^* , the effective (or apparent) albedo (one direction - different Sun-Earth-Moon reflection angle).
- To obtain the Bond albedo, A , we integrate over all phases of the moon at monthly/yearly time scales

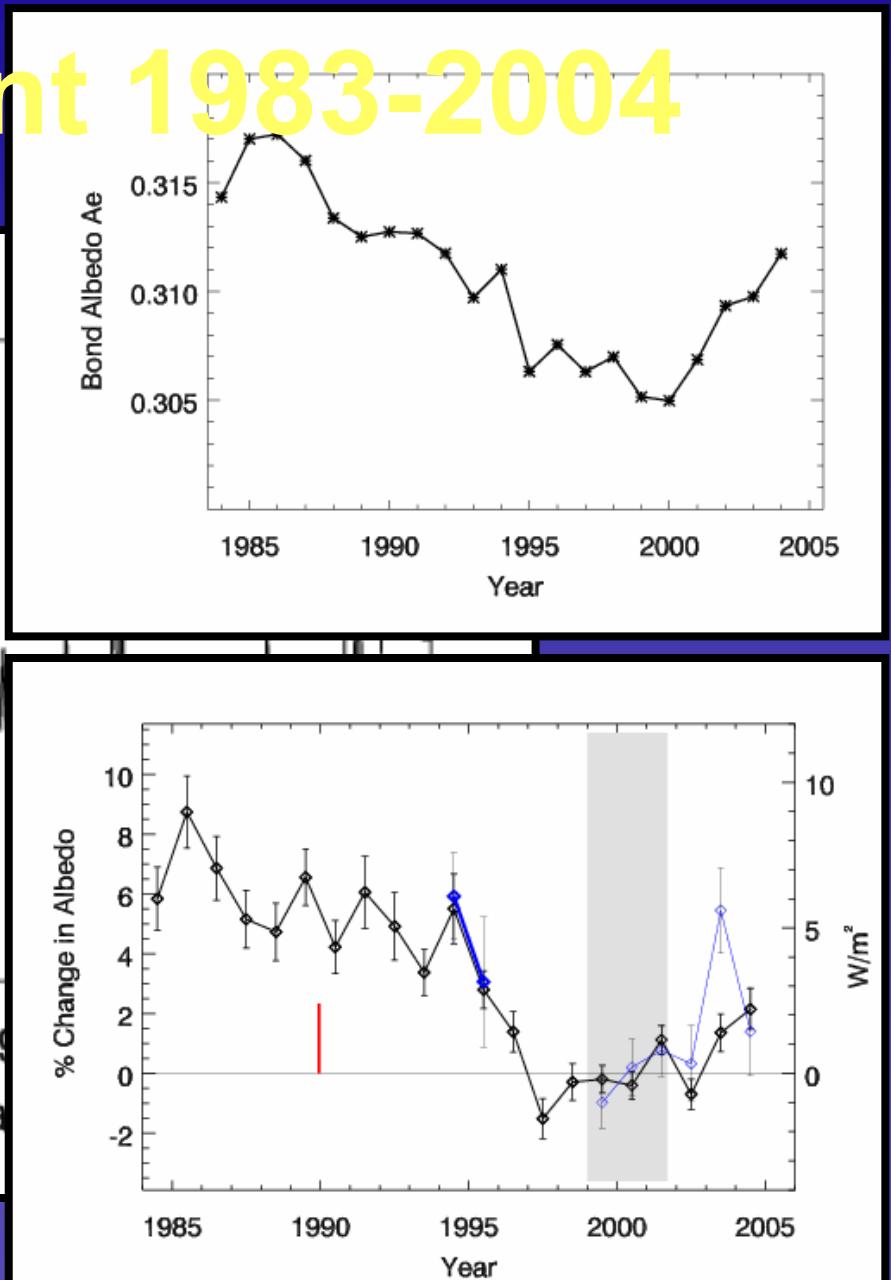
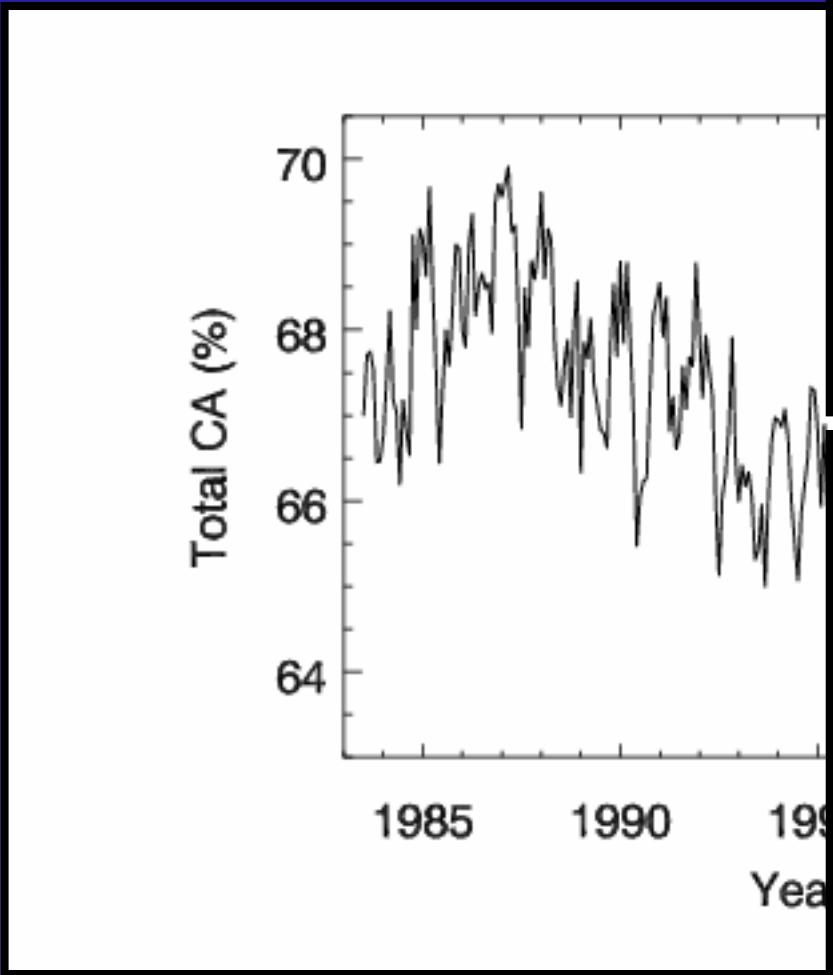
$$A = \frac{2}{3} \int p^* f_L(\theta) \sin(\theta) d\theta$$

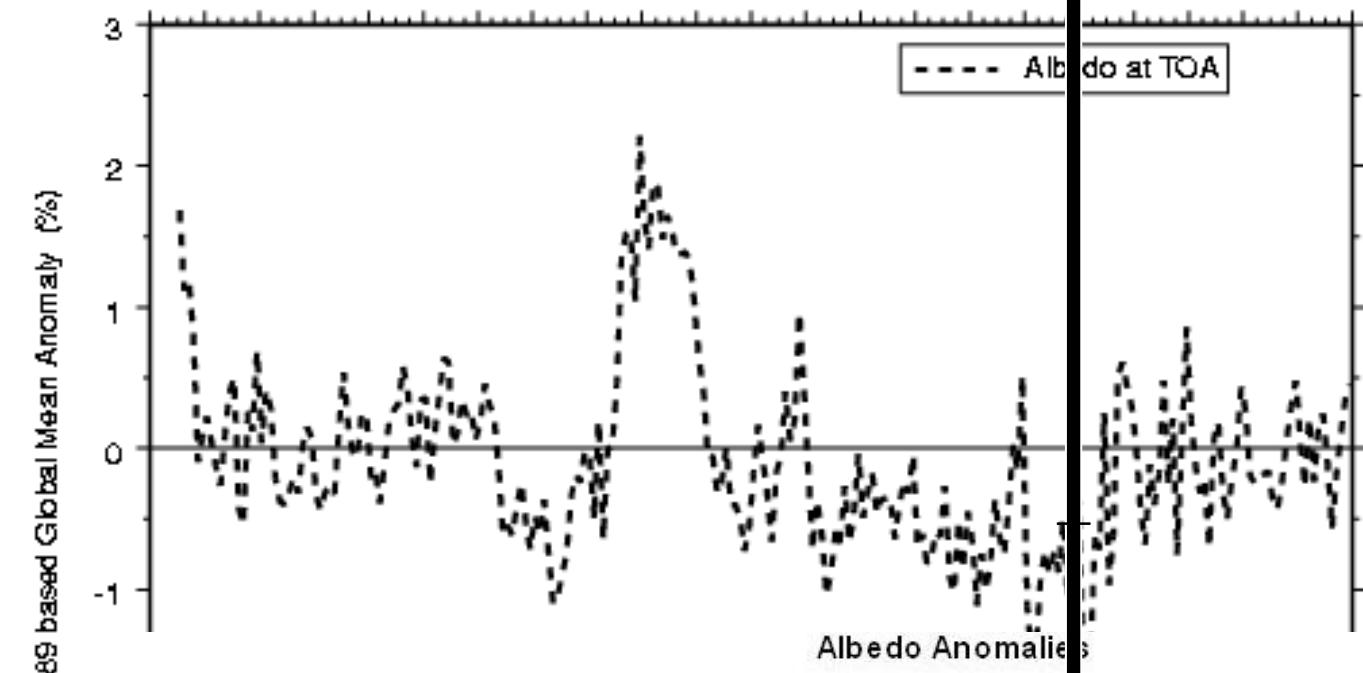


Albedo Changes 1983-2007



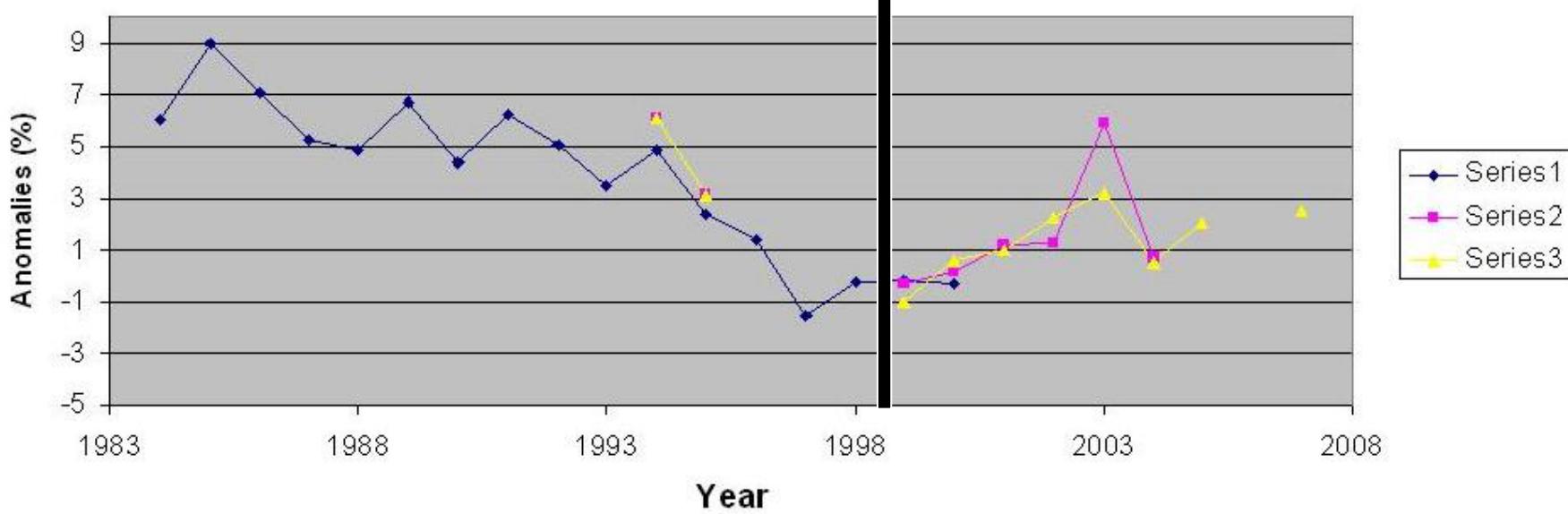
Cloud Amount 1983-2004



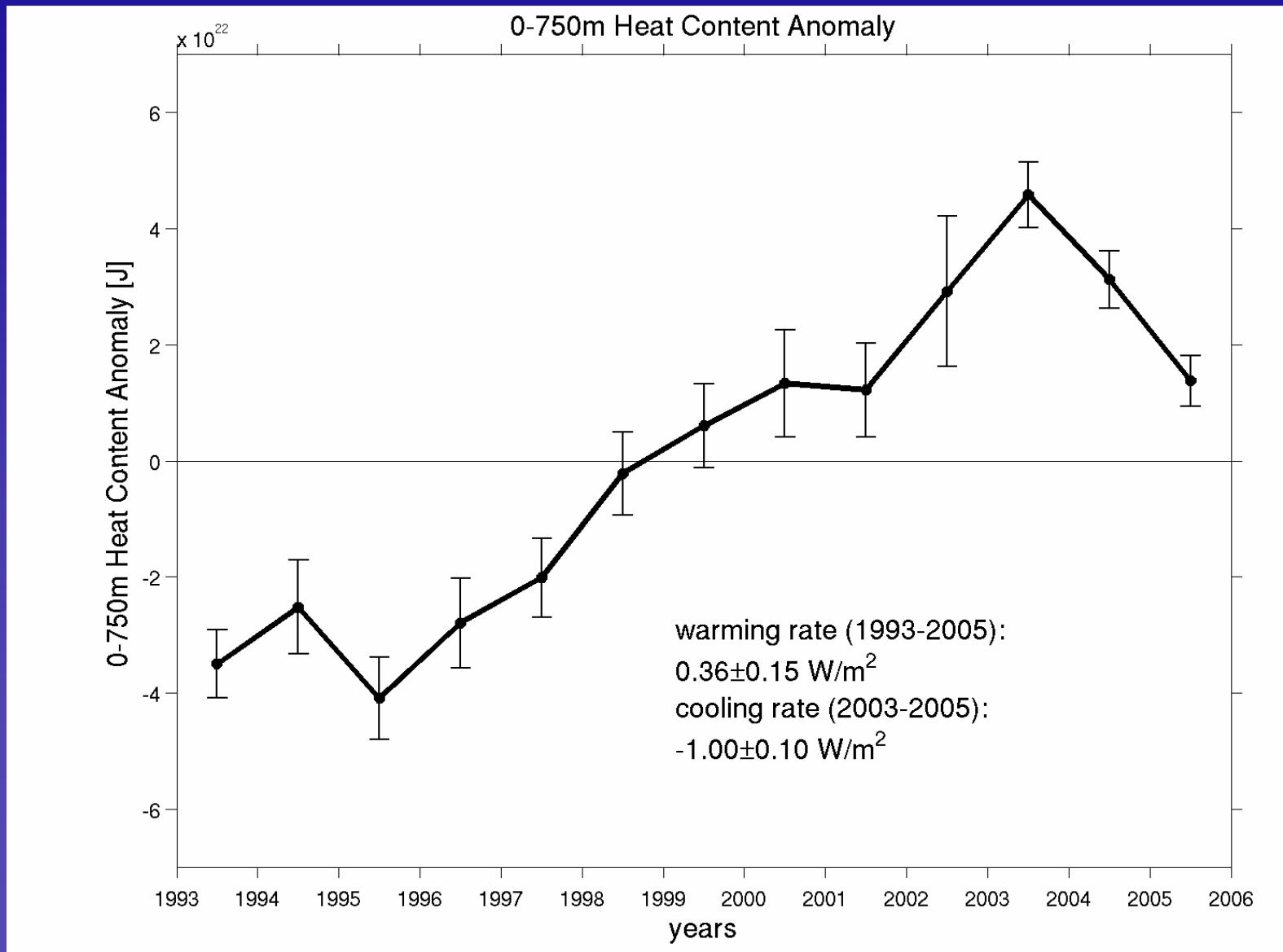


— ISCCP Recons
- ES data (old)
- ES data (new)

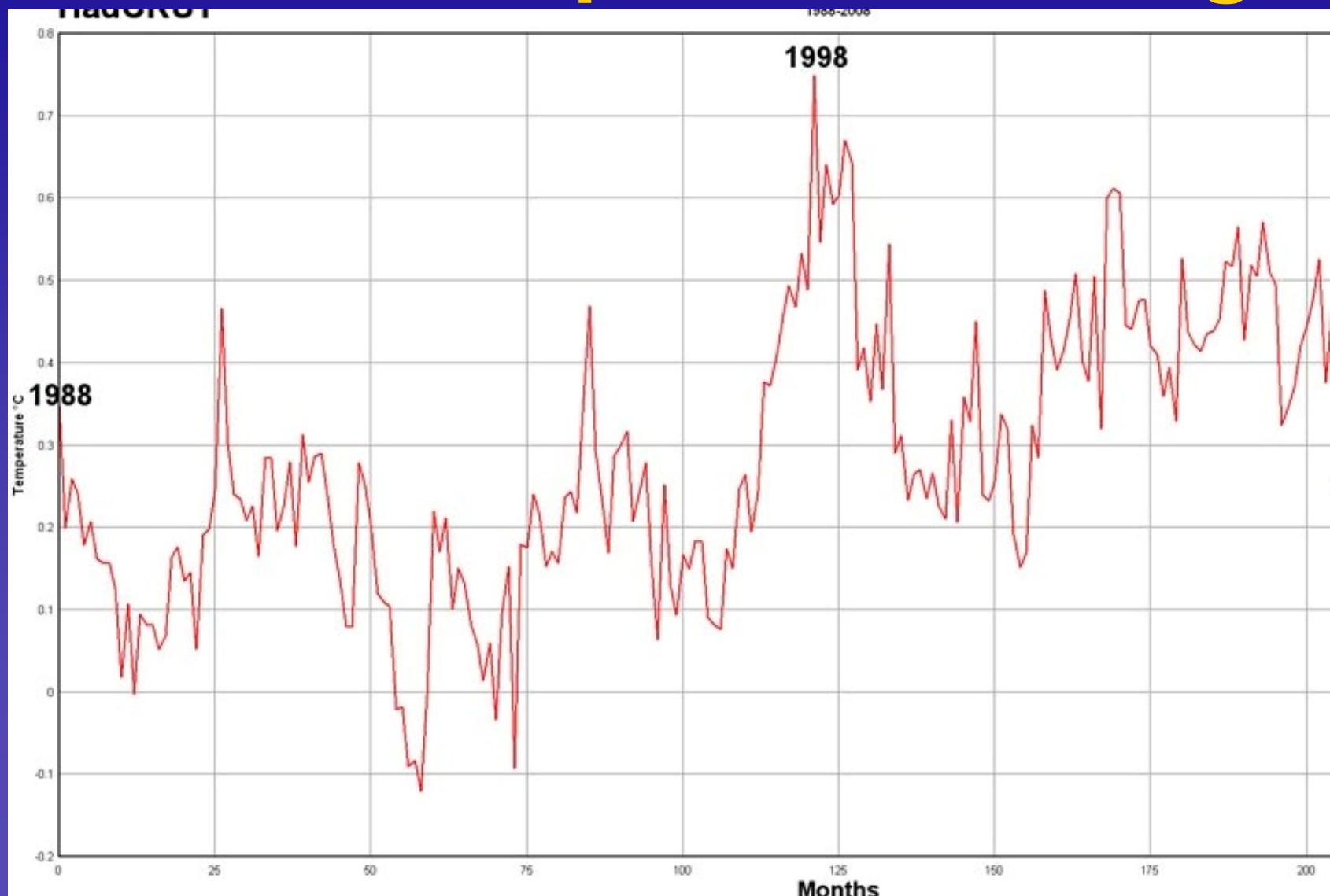
23 April 2008



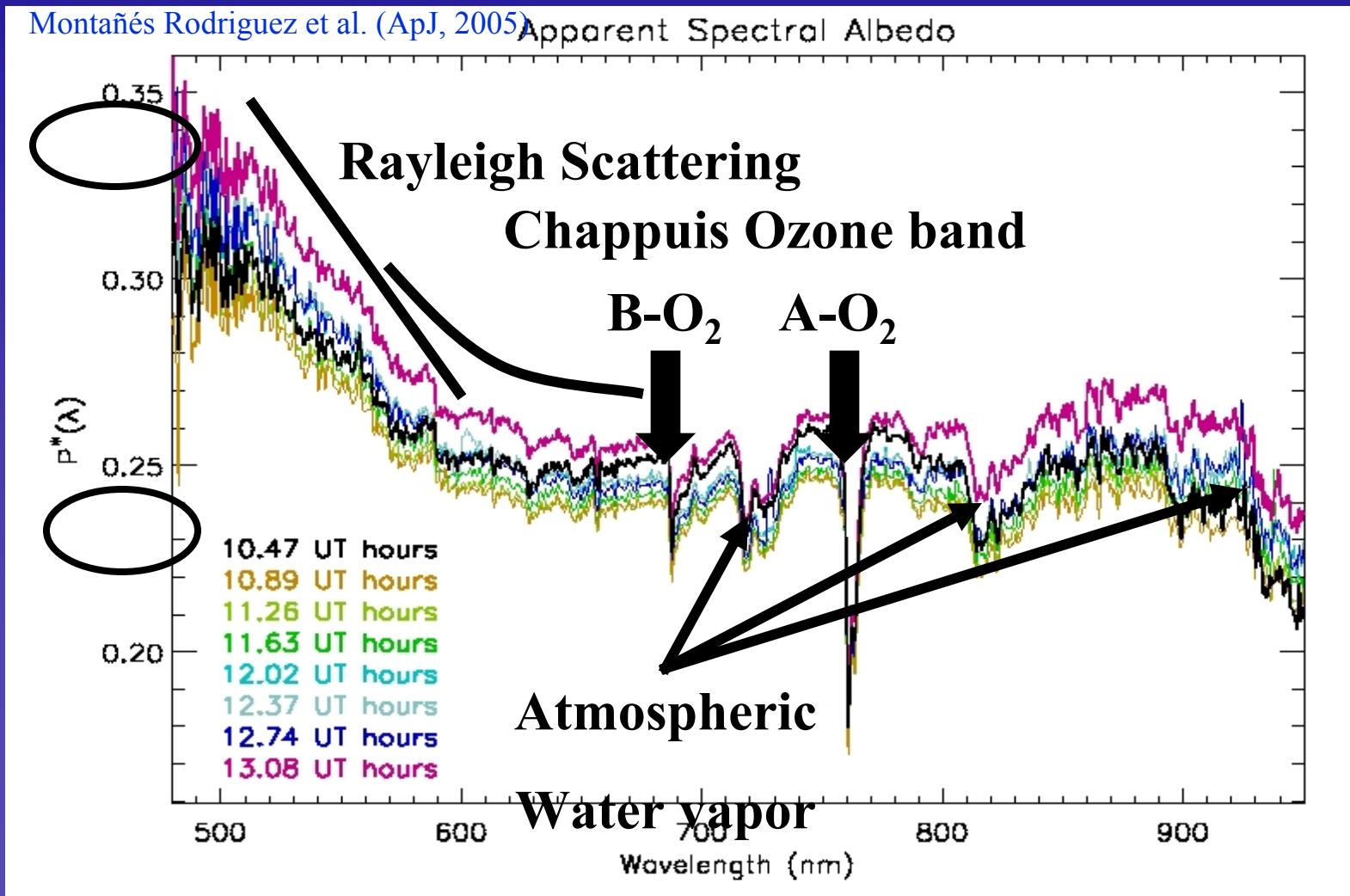
Ocean Warming – Lyman, Willis & Johnson



Global Temperature Change



Earth's *apparent* spectral albedo for a single night (11/19/2003) as Sun rises over South America



Thanks!



The End