



You are here !

# Fizeau Interferometry on LBT: The LINC-NIRVANA Project

Tom Herbst, MPIA

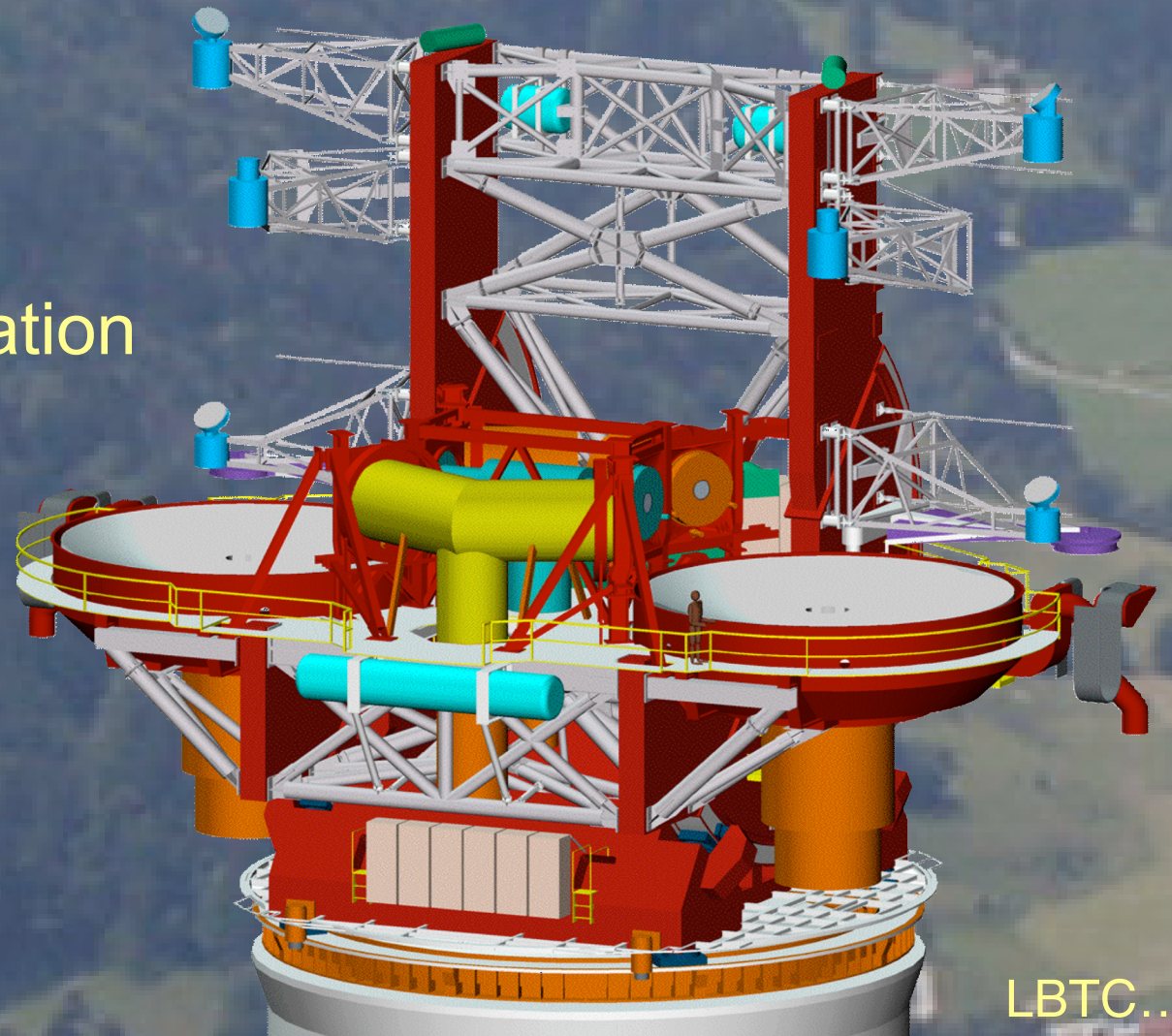
Outline: LBT Update  
Fizeau on LBT  
LINC-NIRVANA

- overview
- highlights
- project status
- LBT / L-N and the VLTI

LBT...

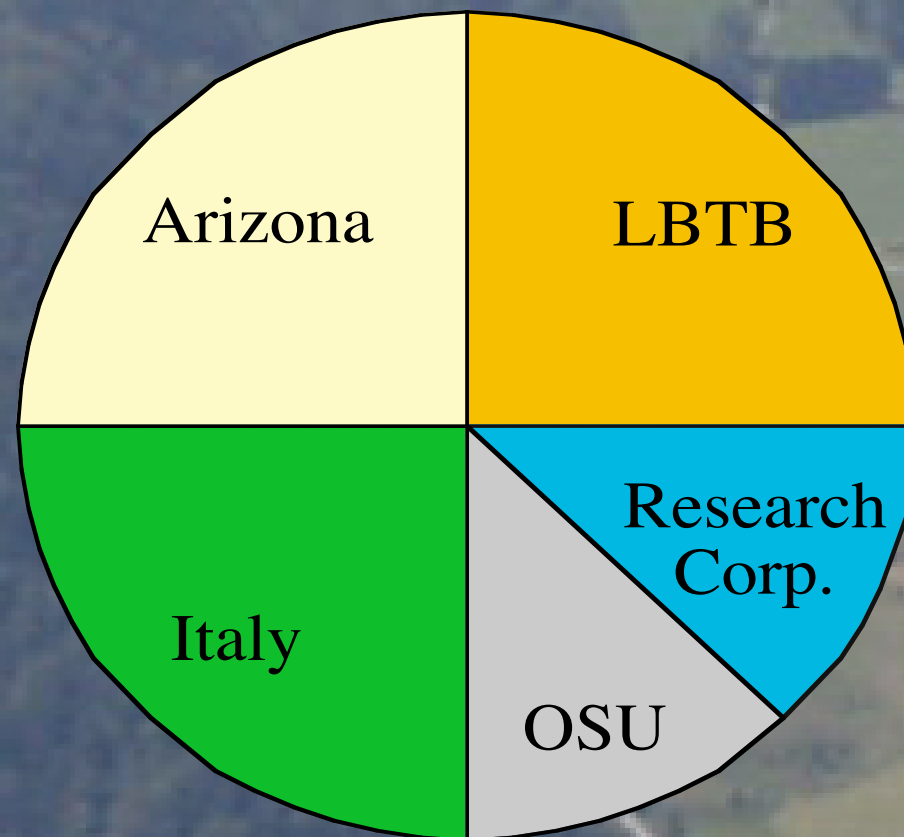
# The Large Binocular Telescope

- 2 x 8.4 m
- flexible configuration
- AO secondaries
- Gregorian
  
- 10 focal stations
  - 2 prime
  - 2 direct
  - 3 shared



LBTC...

# The LBT: A USA-European Collaboration



First Light - June 2004  
Second Light - September 2005

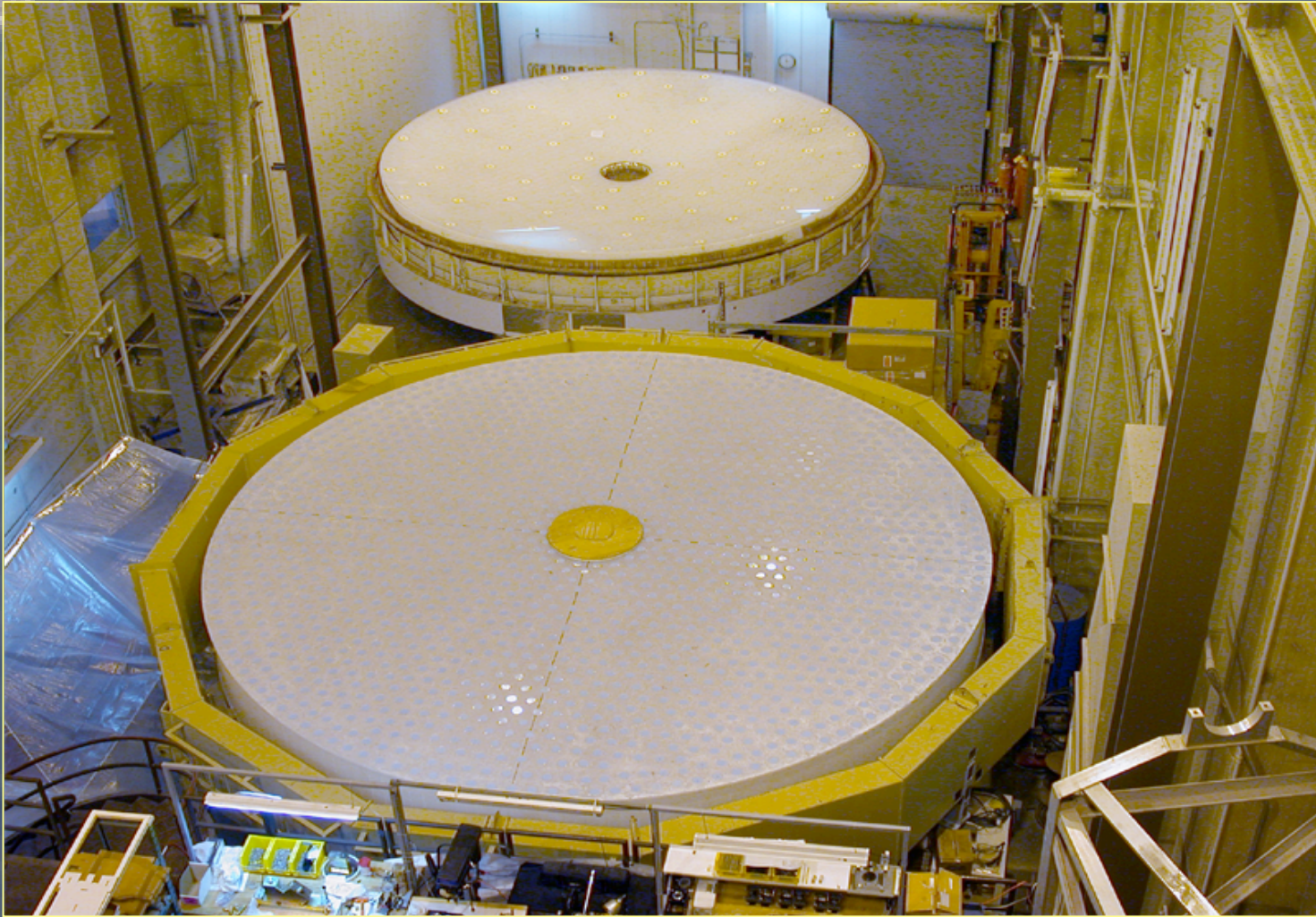
# Honeycomb Primaries



- 8.4 m diameter spin-cast
- f/1.14 parabola
- $\square$  ~20 minutes

LBT-2  
December 2000

# Primary Mirrors



Jan 2003

transport...

# Dummy Mirror Transport



26 August 2003



26 August 2003



27 August 2003



AOS...

# Adaptive Secondaries: Essential Components



RTC

Voice  
coils

Reference  
plate

Shell

Dedicated  
Italian



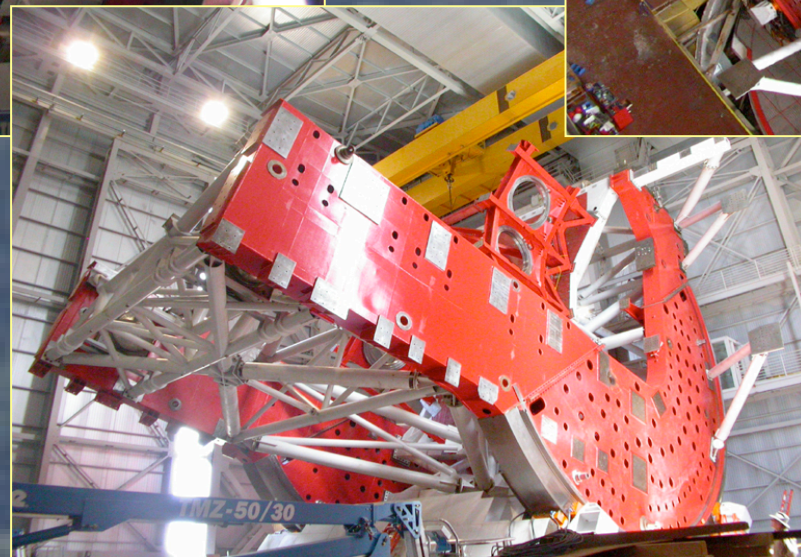
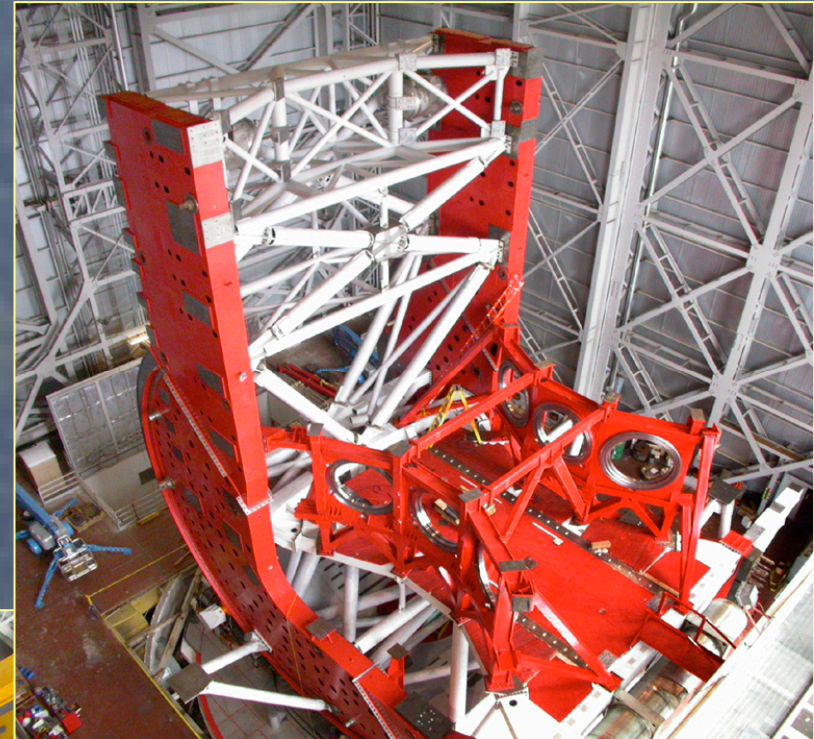
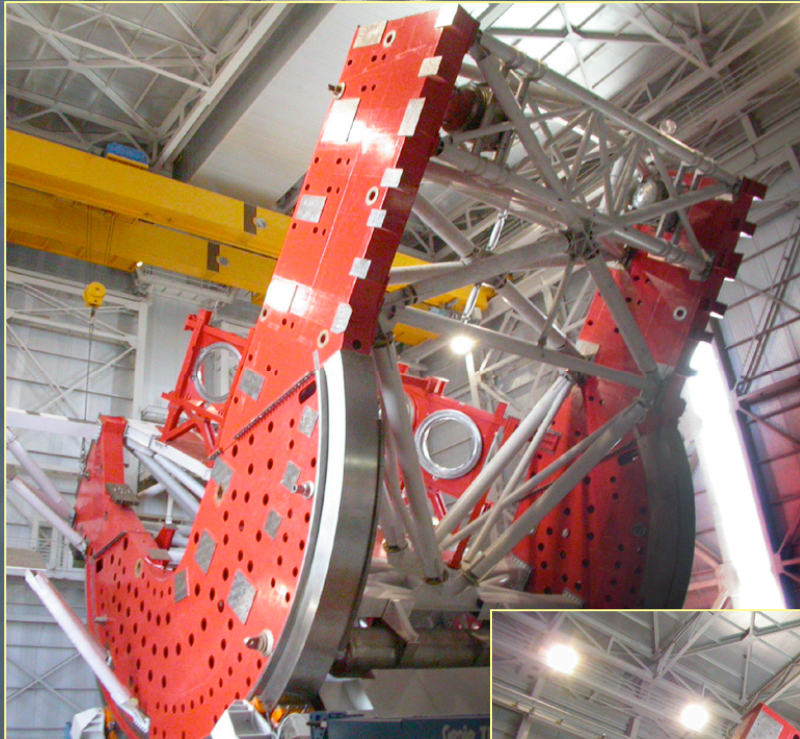
# LBT 672 Aspherization



May 2003

telescope...

# Telescope Assembly



August 2003

dome...

# LBT Enclosure on Mt. Graham



Jan 2003



3246 m

3192 m

how...

# LBT Enclosure on Mt. Graham



# LBT First Bite Image



July 2002

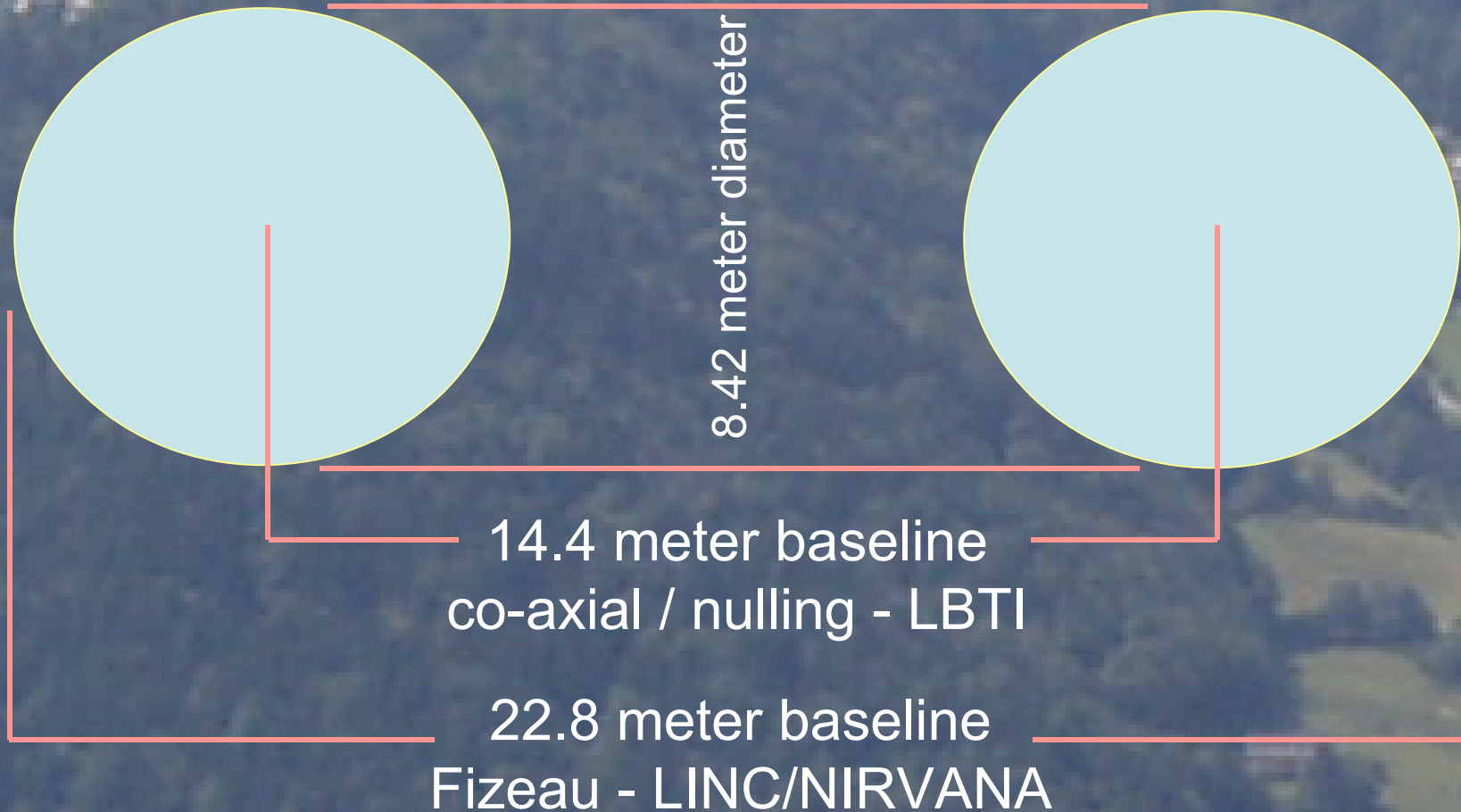
Pupil...

# LBT Pupil Geometry



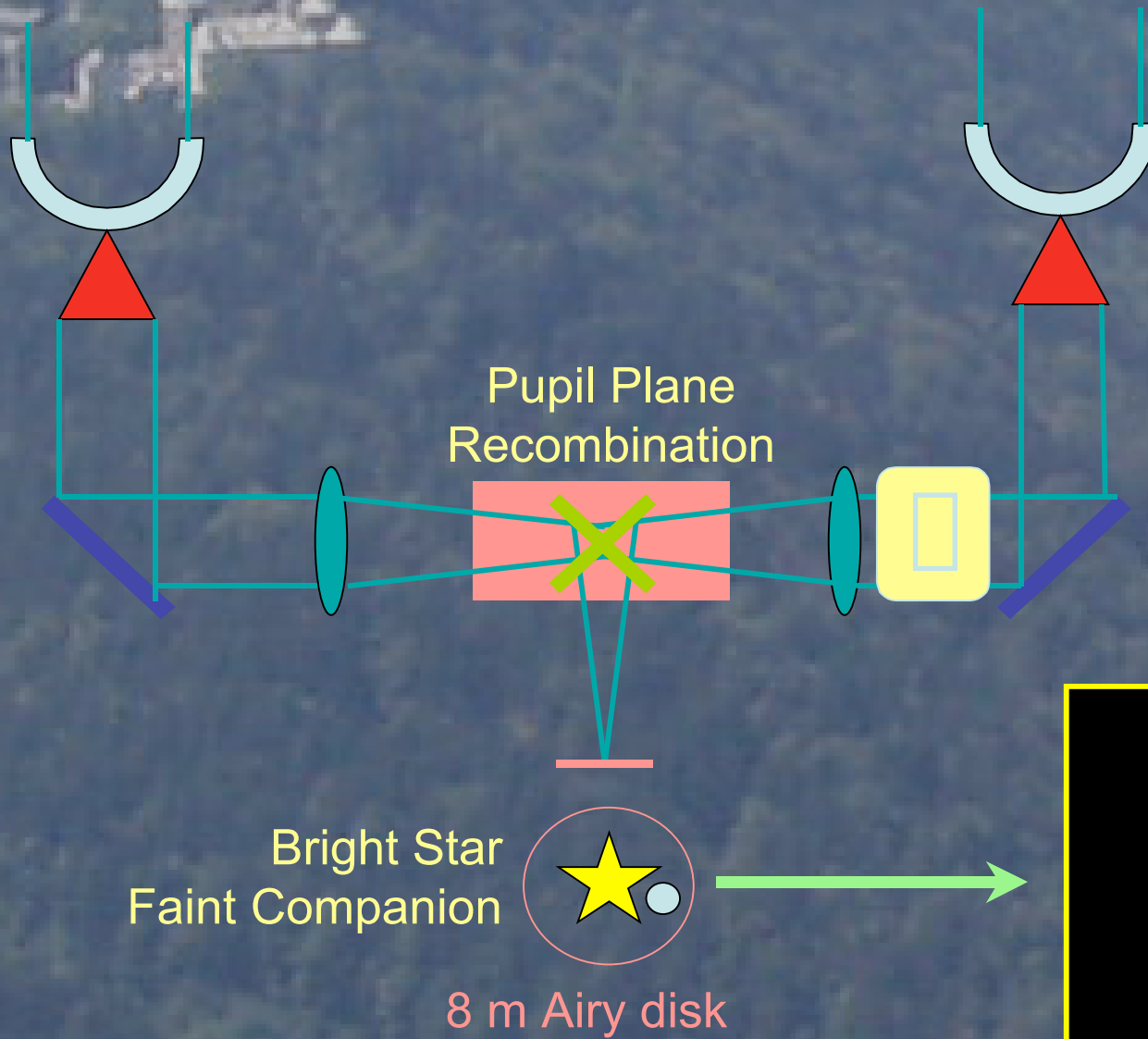
interferometry...

# LBT Pupil Geometry



coaxial...

# Coaxial Interferometry

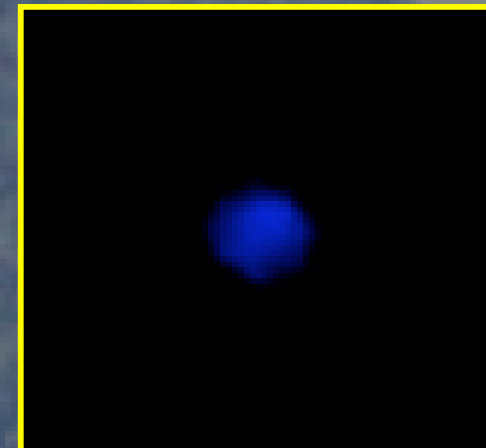


## Amplitude type

- fringes on sky
- LBTI, MIDI, Keck-I

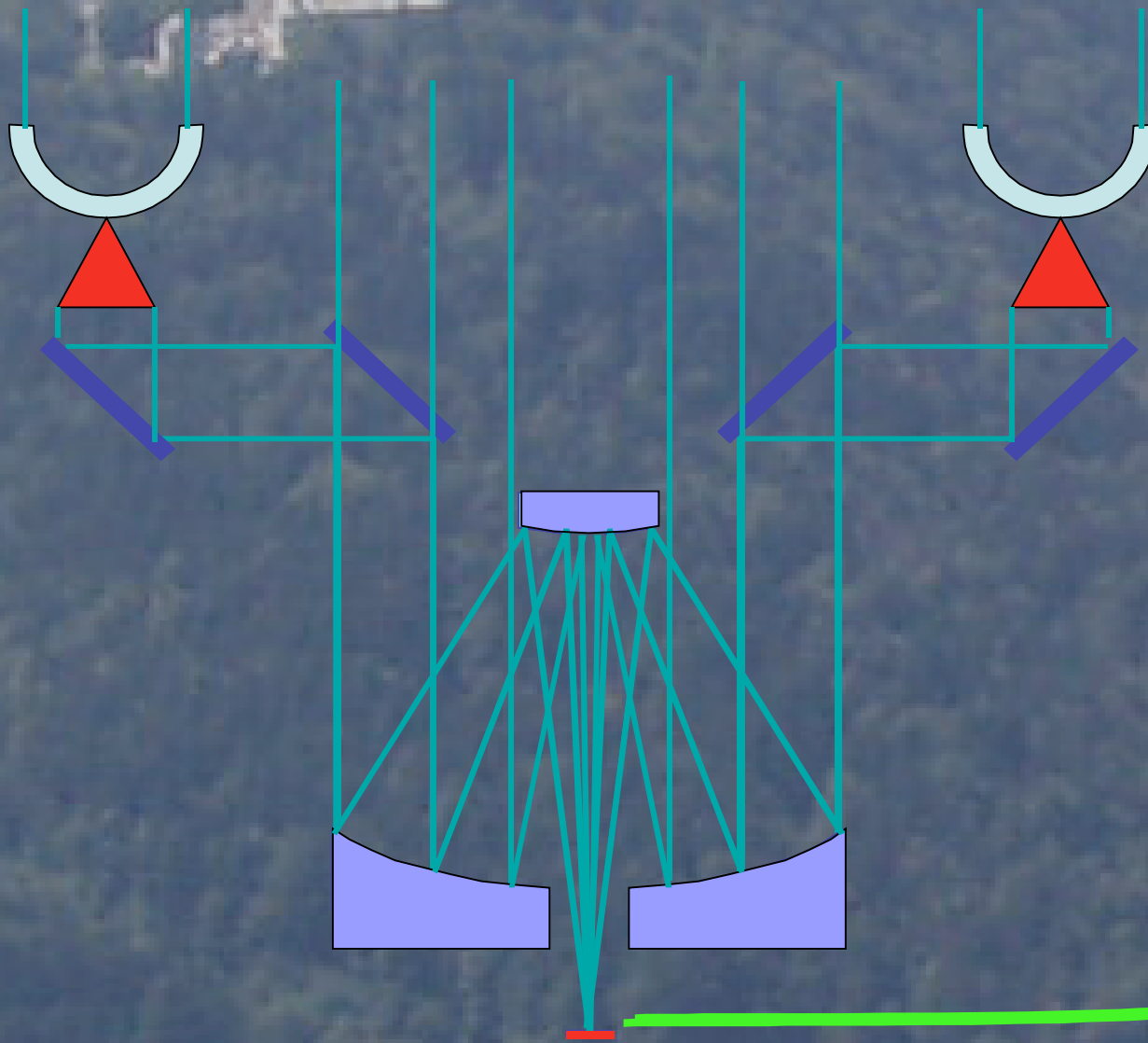
## Nulling type

- introduce  $\pi$  phase
- LBTI, Keck Nuller, GENIE





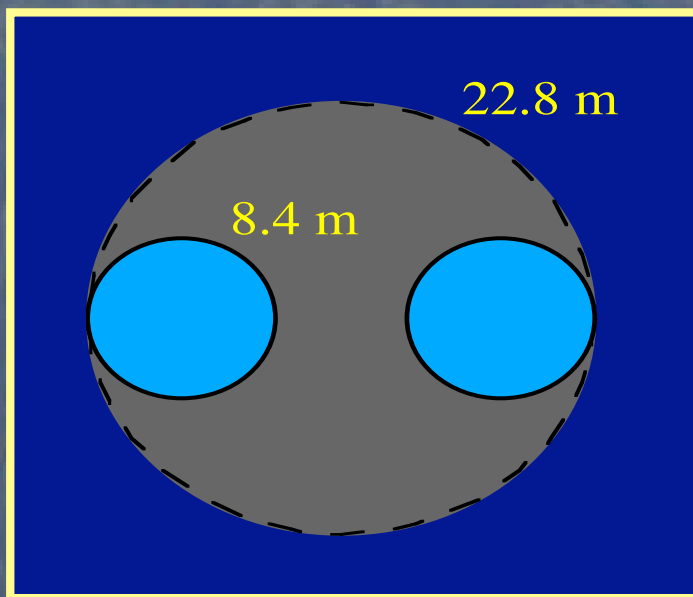
# Fizeau Interferometry



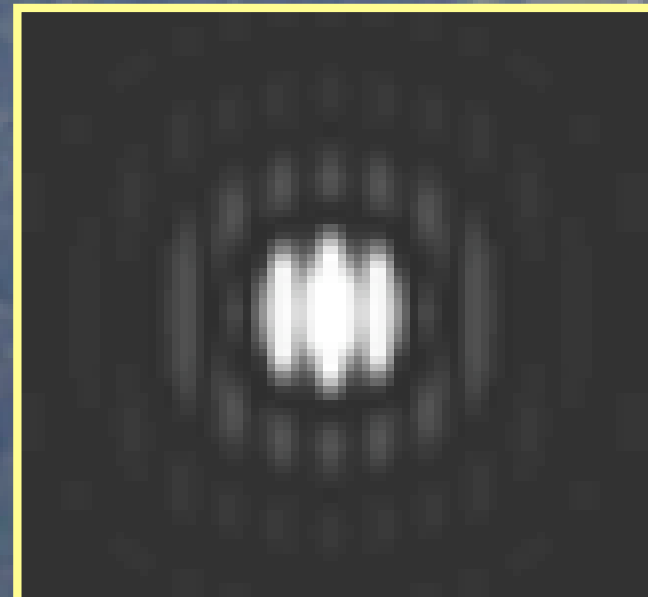
- The simplest  
Fizeau Interferometer  
Fizeau interferometer
- Images on detector, not sky
  - LINC-NIRVANA



# *Masked* ~~Large Binocular Telescope~~ (Fizeau configuration)



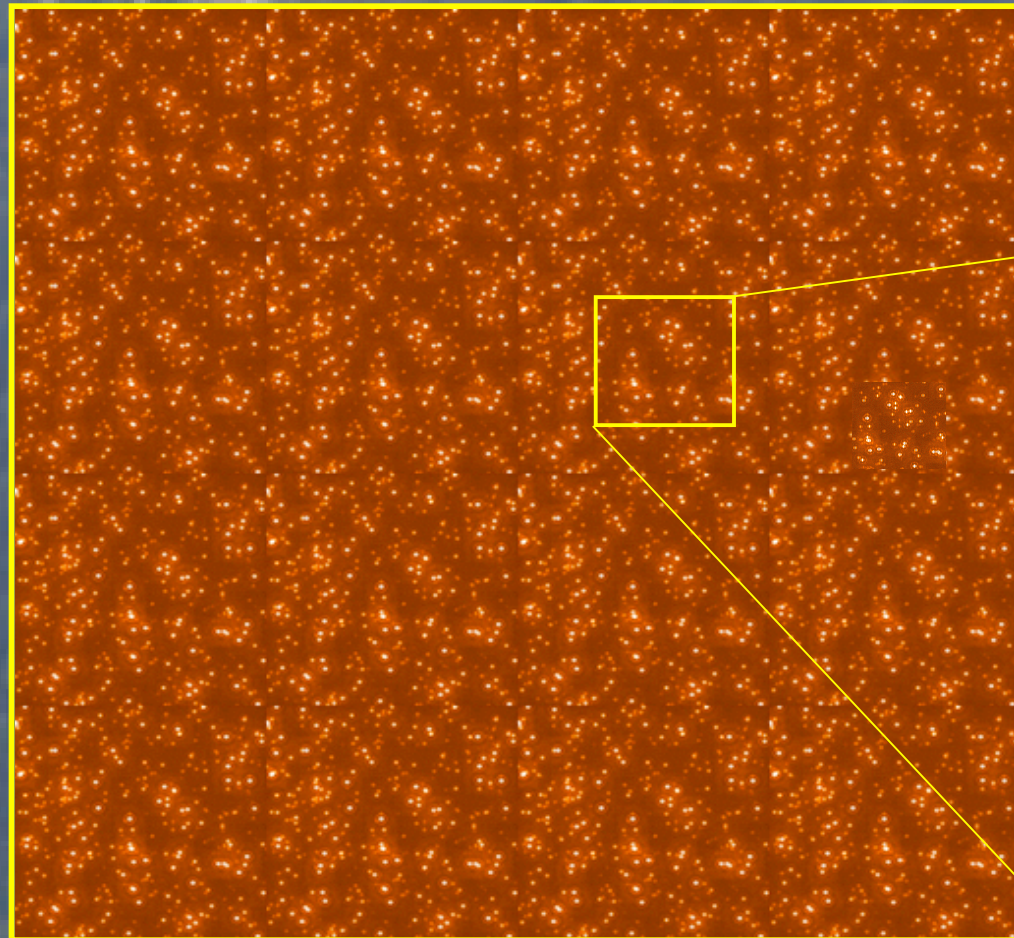
Pupil



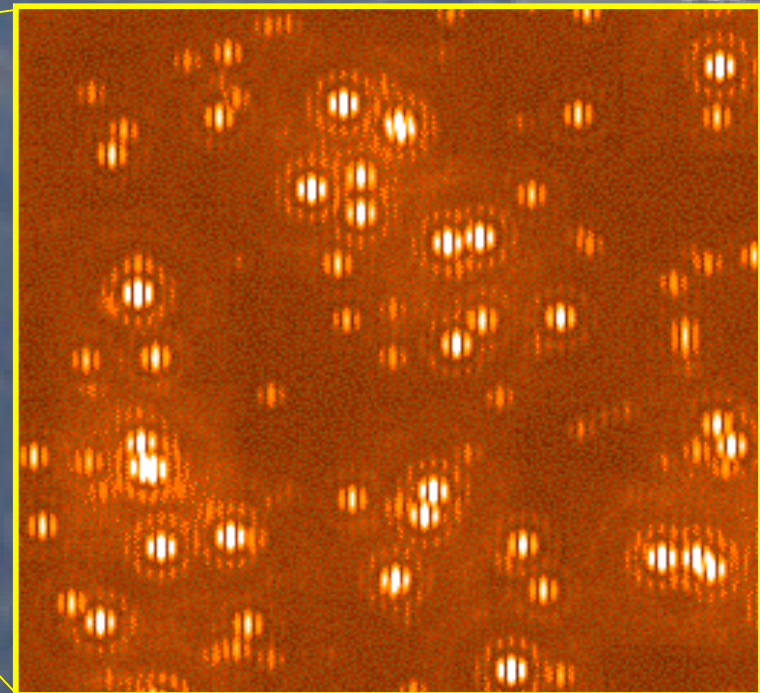
PSF

- True Imagery

# Simulated Star Cluster



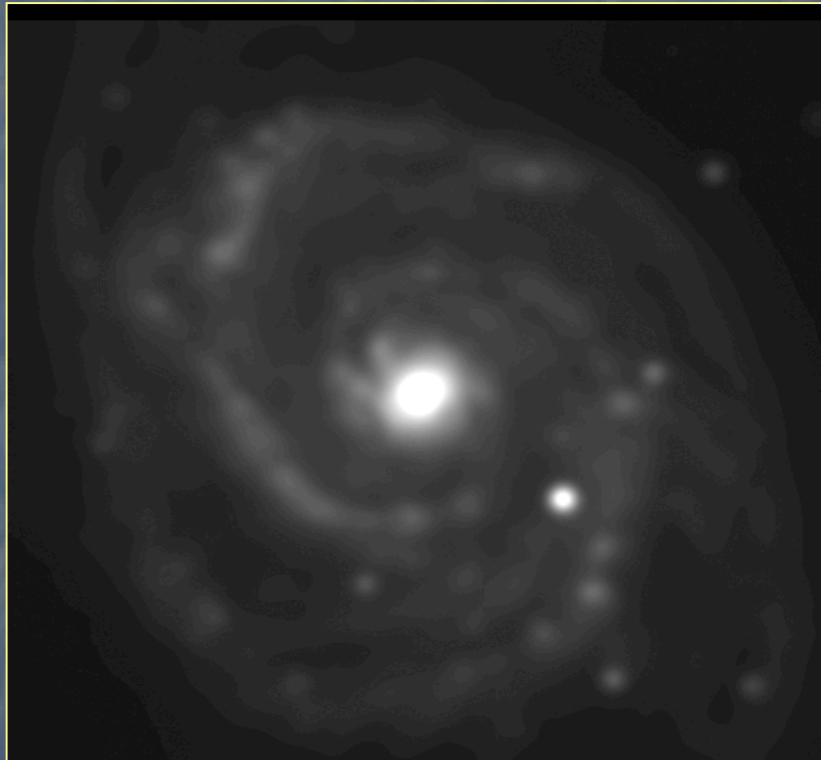
2048 x 2048 HAWAII-2  
11 x 11 arcsec FOV



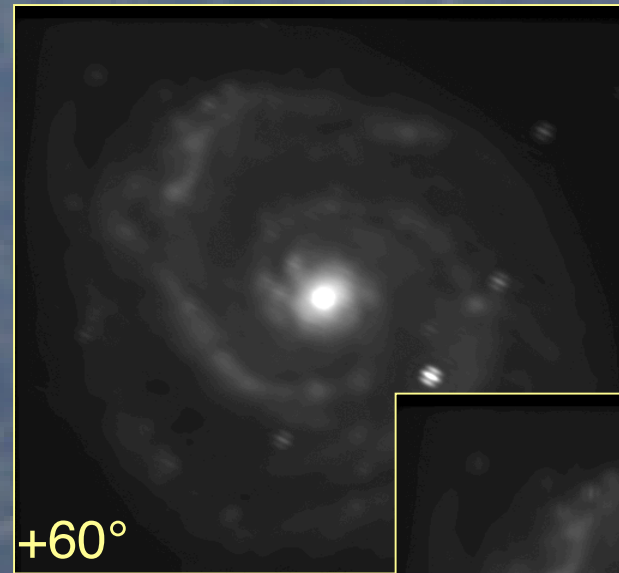
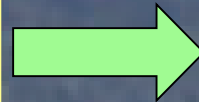
*M. Ollivier 2001*

(quite different)

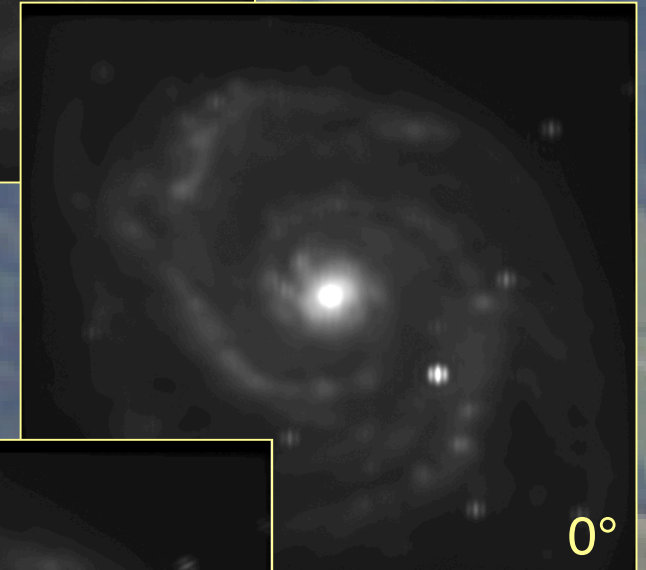
# Image Extraction



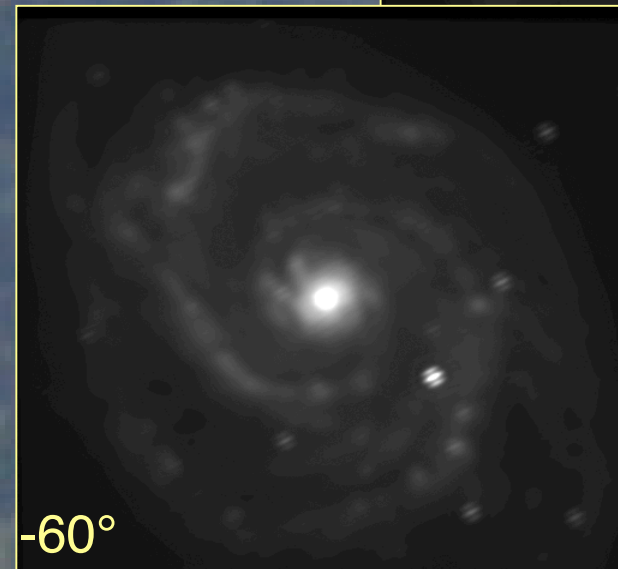
dev\$pix



+60°



0°



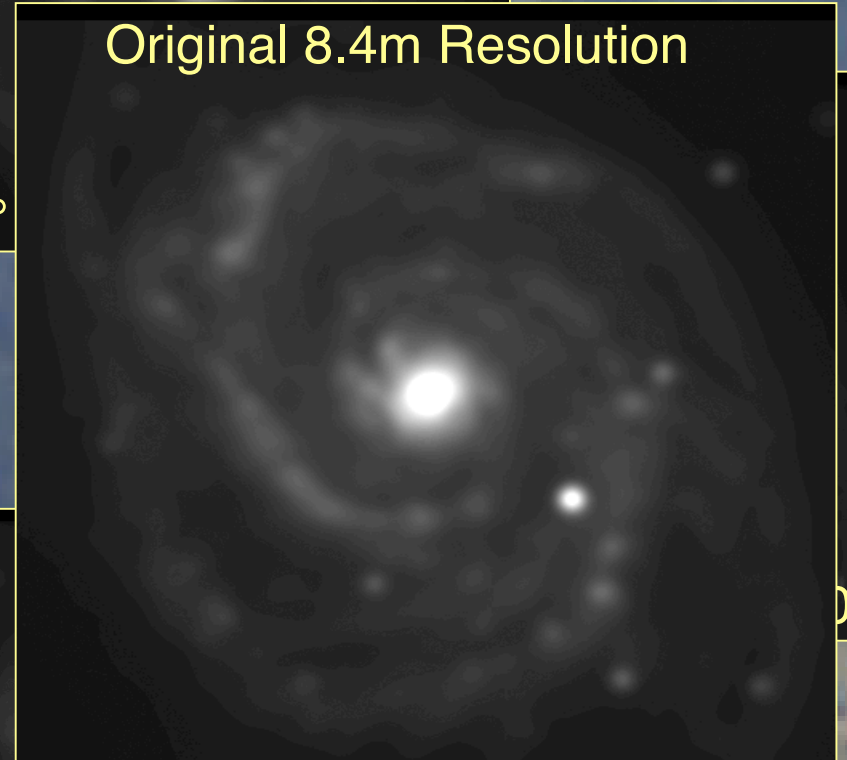
-60°

# Image Extraction

Reconstructed 23m Resolution



Original 8.4m Resolution



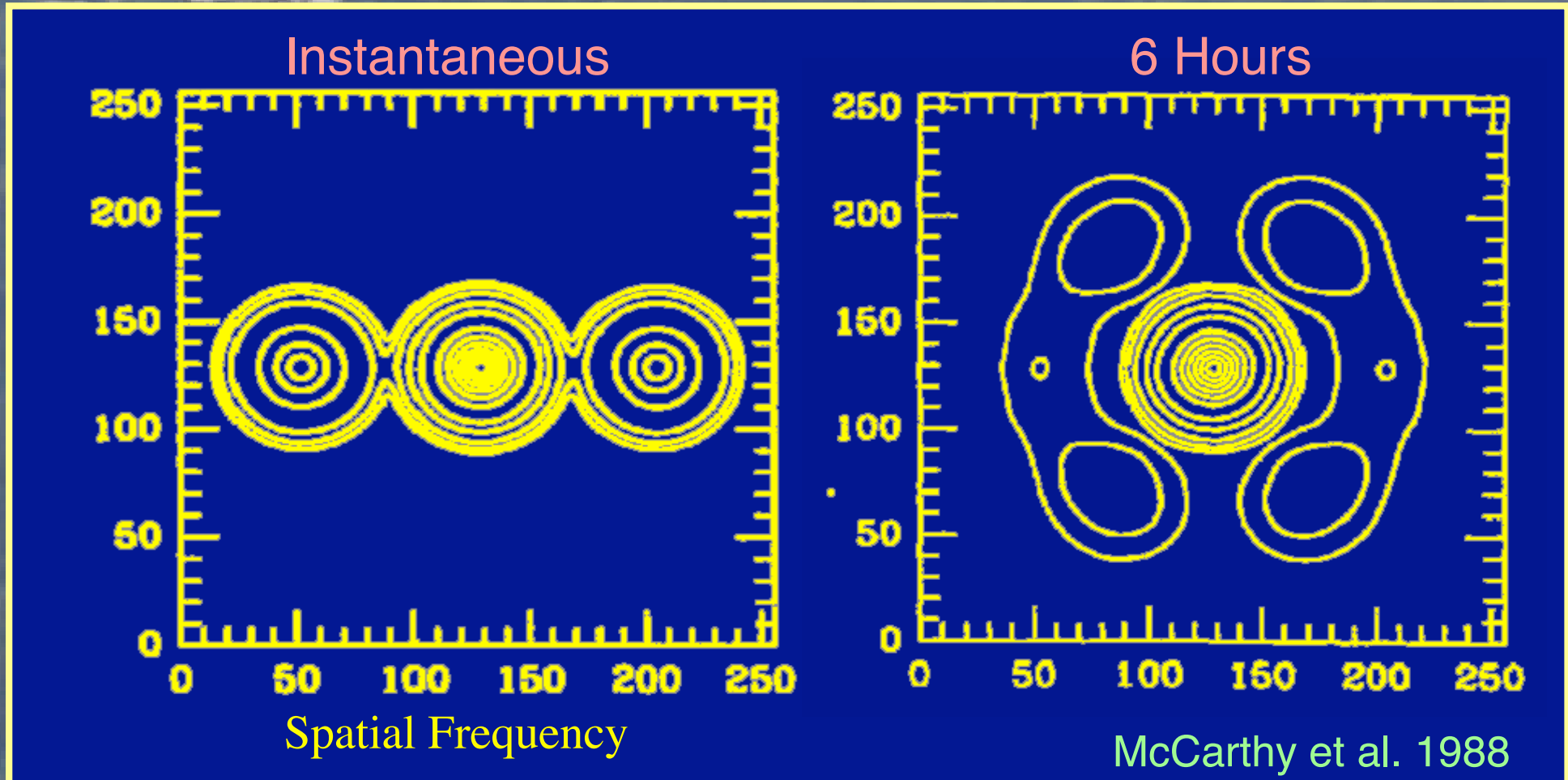
+60°

0°

-60°

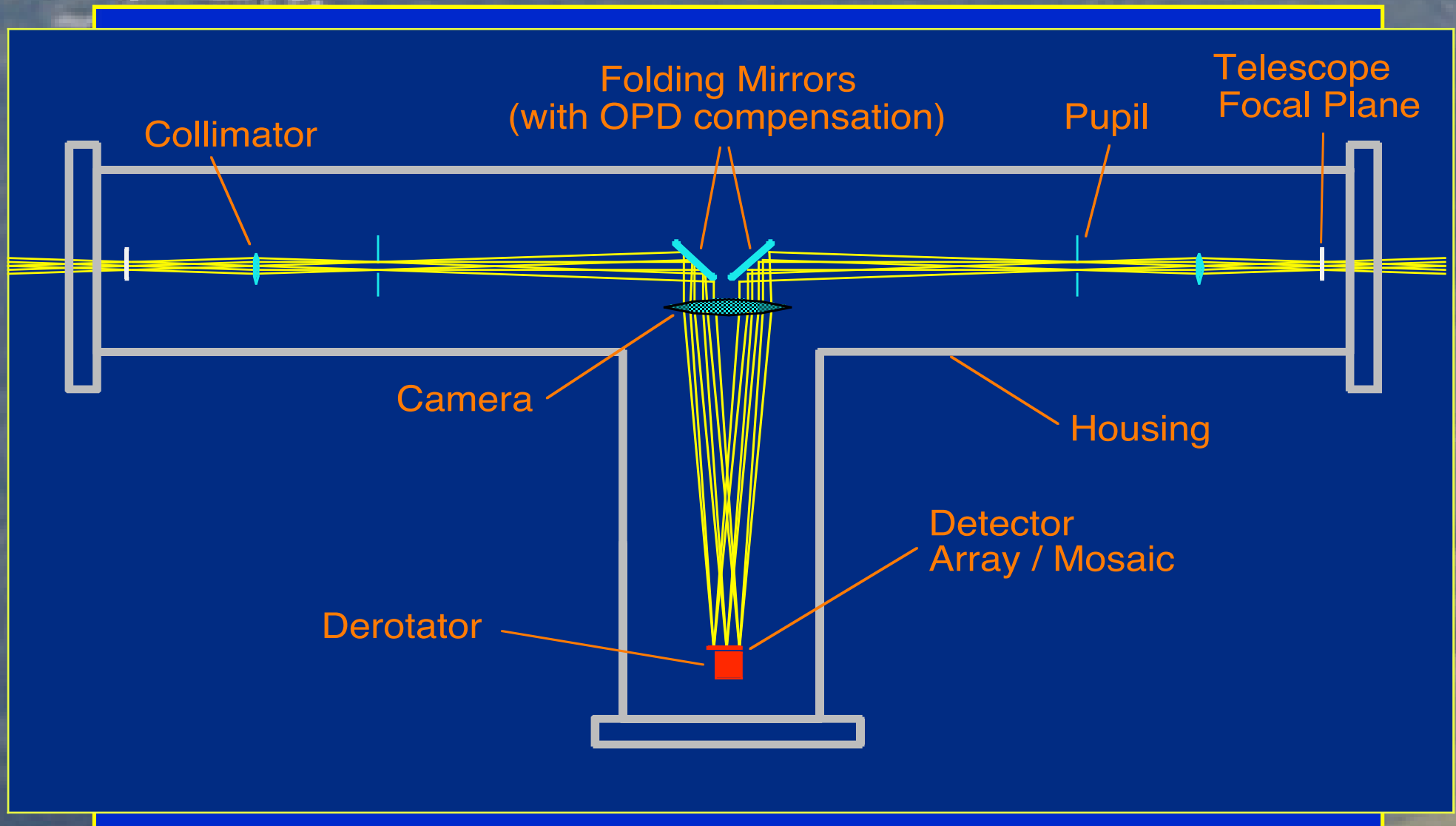
(u,v)...

# (u,v) Plane Coverage



- “Compact Array”:
- Avoids nulls in response
  - Complete (u,v) with  $\sim 3$  PA's
  - temporal coverage

# Fizeau on LBT (somewhat simplified)





# LINC - NIRVANA



MPIA, Arcetri, Köln, Bonn

## LINC

LBT

INterferometric

Camera

First implementation (single on-axis facility AO)

## NIRVANA

Near-IR / Visible

Adaptive

iNterferometer for

Astronomy

Final implementation (MCAO)

team...



# The Team



## Köln

Thomas Bertram\*  
Andreas Eckart  
Damian Moratschke  
Christian Straubmeier \*  
VbF 1  
VbF 2

## Bonn

Udo Beckmann  
Gerd Weigelt

## MPIA

Dave Andersen\*  
Harald Baumeister\*  
Hermann Böhnhardt\*  
Peter Bizenberger\*  
Bernhard Grimm  
Tom Herbst\*  
Werner Laun  
Christoph Leinert  
Hans-Walter Rix  
Ralf-Rainer Rohloff  
Florian Briegel\*  
Sebastiano Ligori  
Robert Weiss  
(SW Engineer)\*



## Paul Prize

Wolfgang Gaessler\*  
Roberto Ragazzoni\*  
Roberto Soci\*  
Robert Weiss\*  
Wenli Xu\*



## Arcetri

Carmelo Arcidiacona\*  
Carlo Baffa  
Emiliano Diolaiti\*  
Simone Esposito  
Jacopo Farinato\*  
Debora Ferruzzi  
Piero Salinari  
Elise Viard

\*50-100% committment

specs...

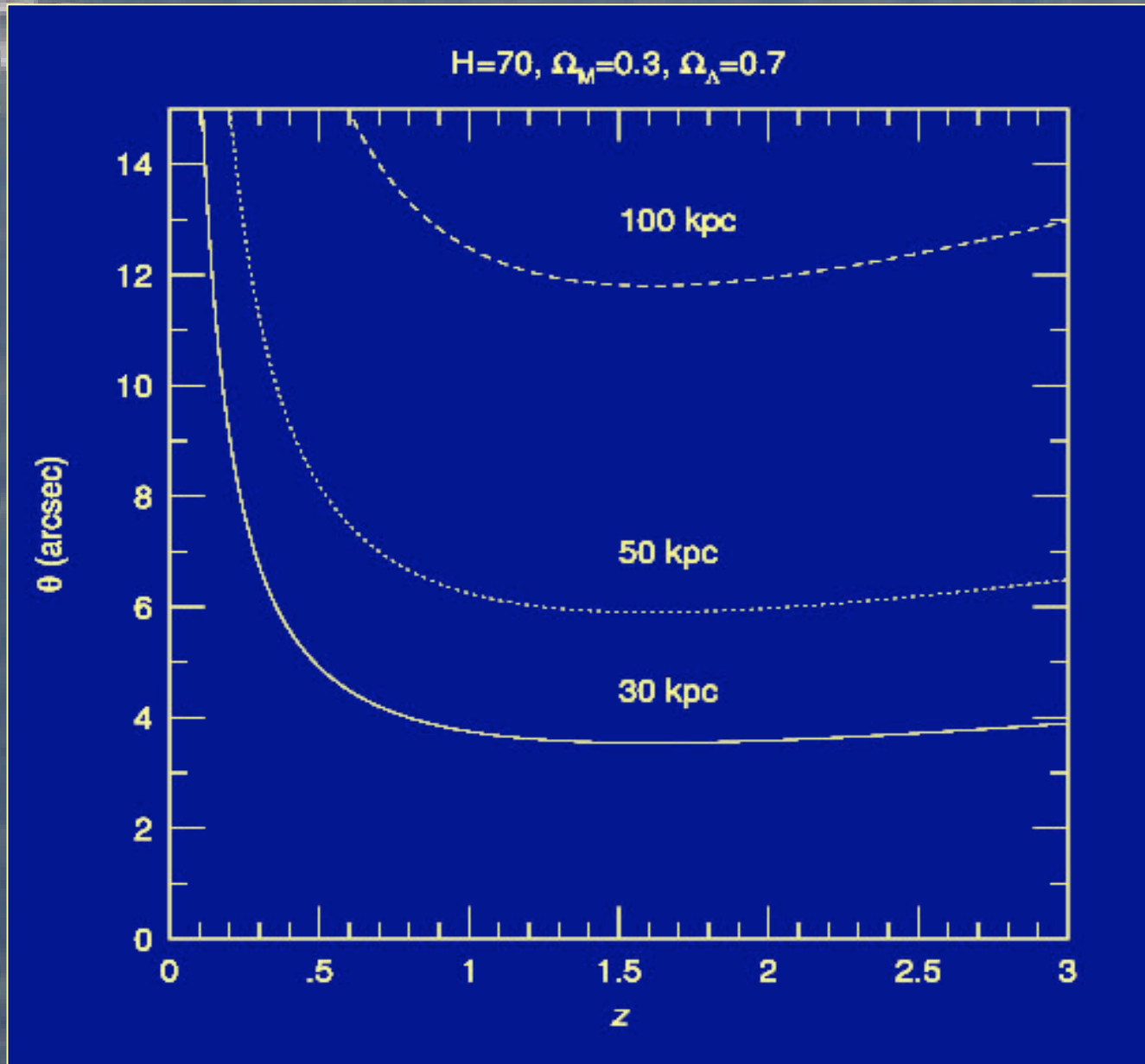
# LINC - NIRVANA Capabilities

- Operating Wavelength: • 0.8 - 2.5  $\mu\text{m}$
- Wide FOV: • 1-2 arcmin @K (det. lim.)
- Spatial Resolution: • 8 mas @Z - 20 mas @K
- Sensitivity: •  $m_K \sim 26$  (5 $\sigma$ /1hr on pt src)
- Sky Coverage (MCAO): • 0.86 ( $b=20^\circ$ )  
0.29 ( $b=50^\circ$ )  
0.12 (NGP)

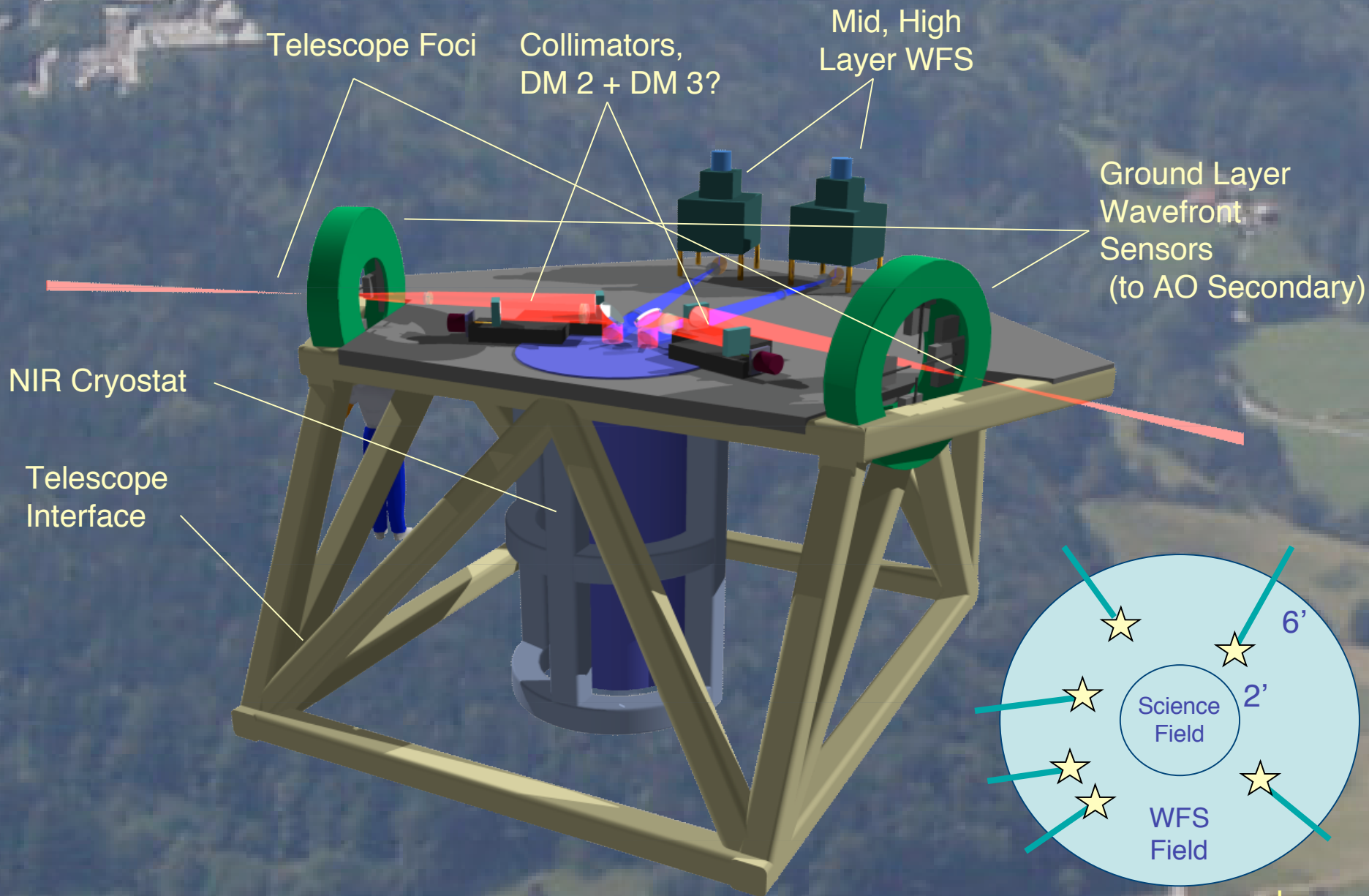
(i.e. standard wish list)

(i.e. standard astrophysics)

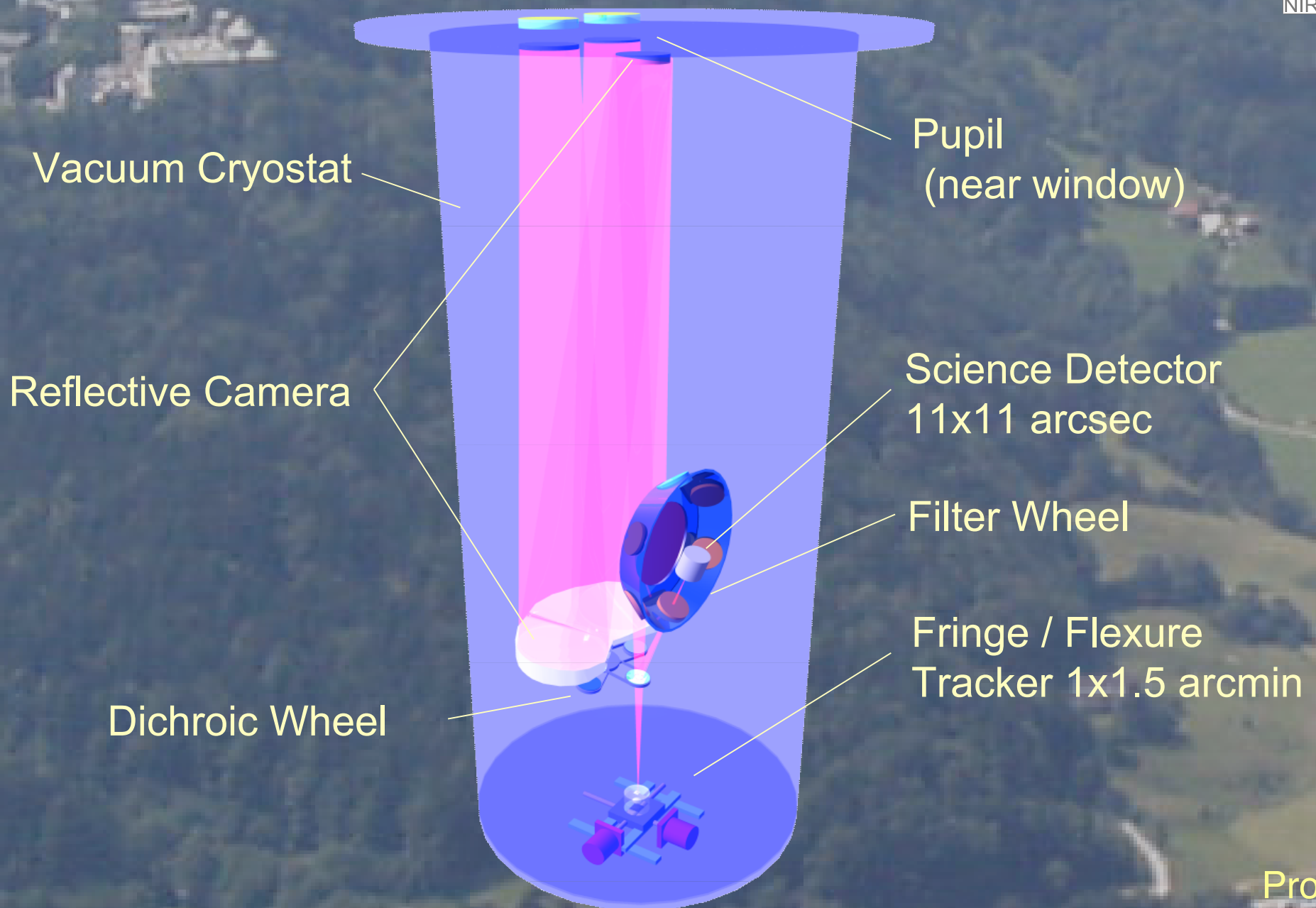
# 11" Field of View



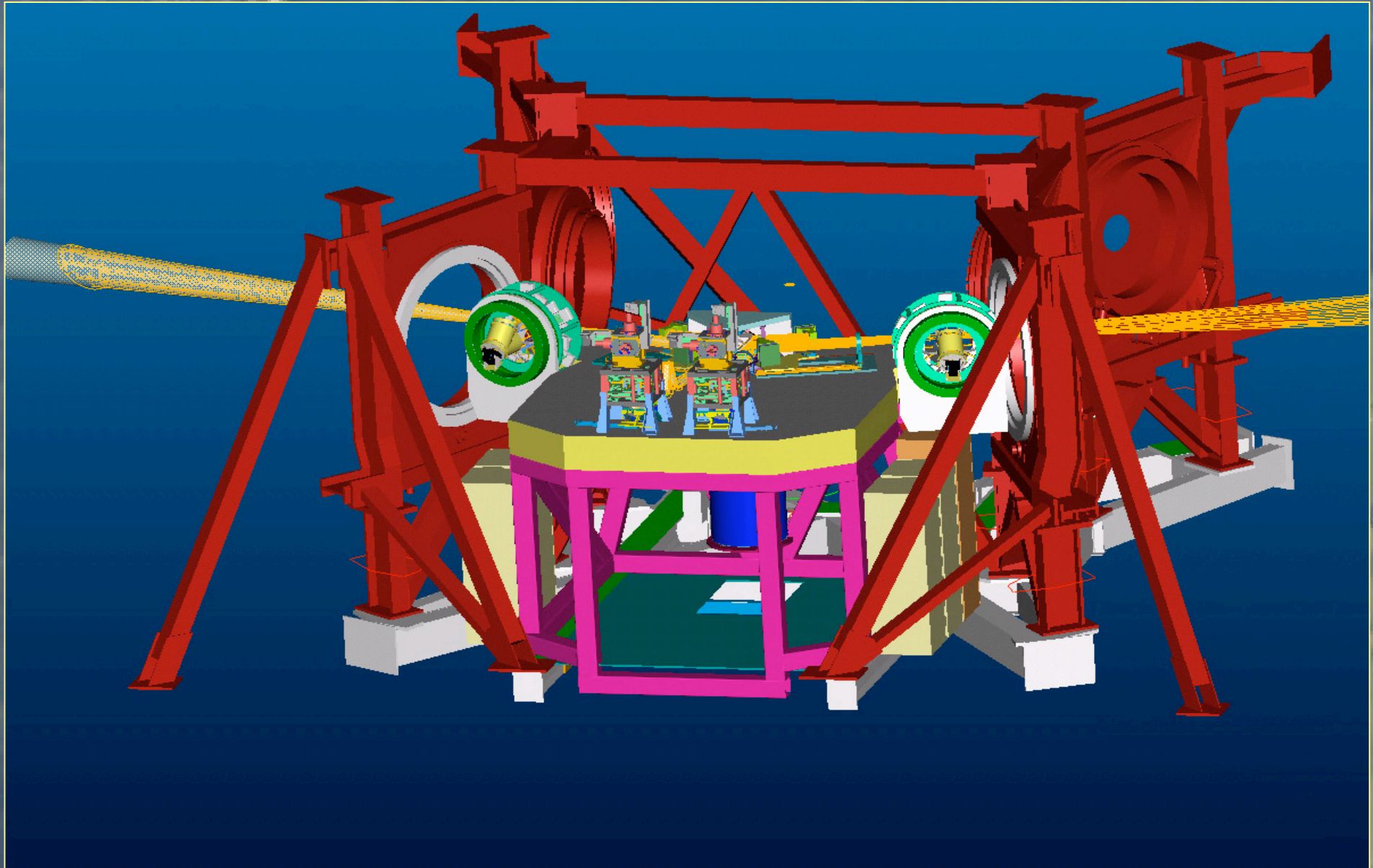
# LINC-NIRVANA Layout



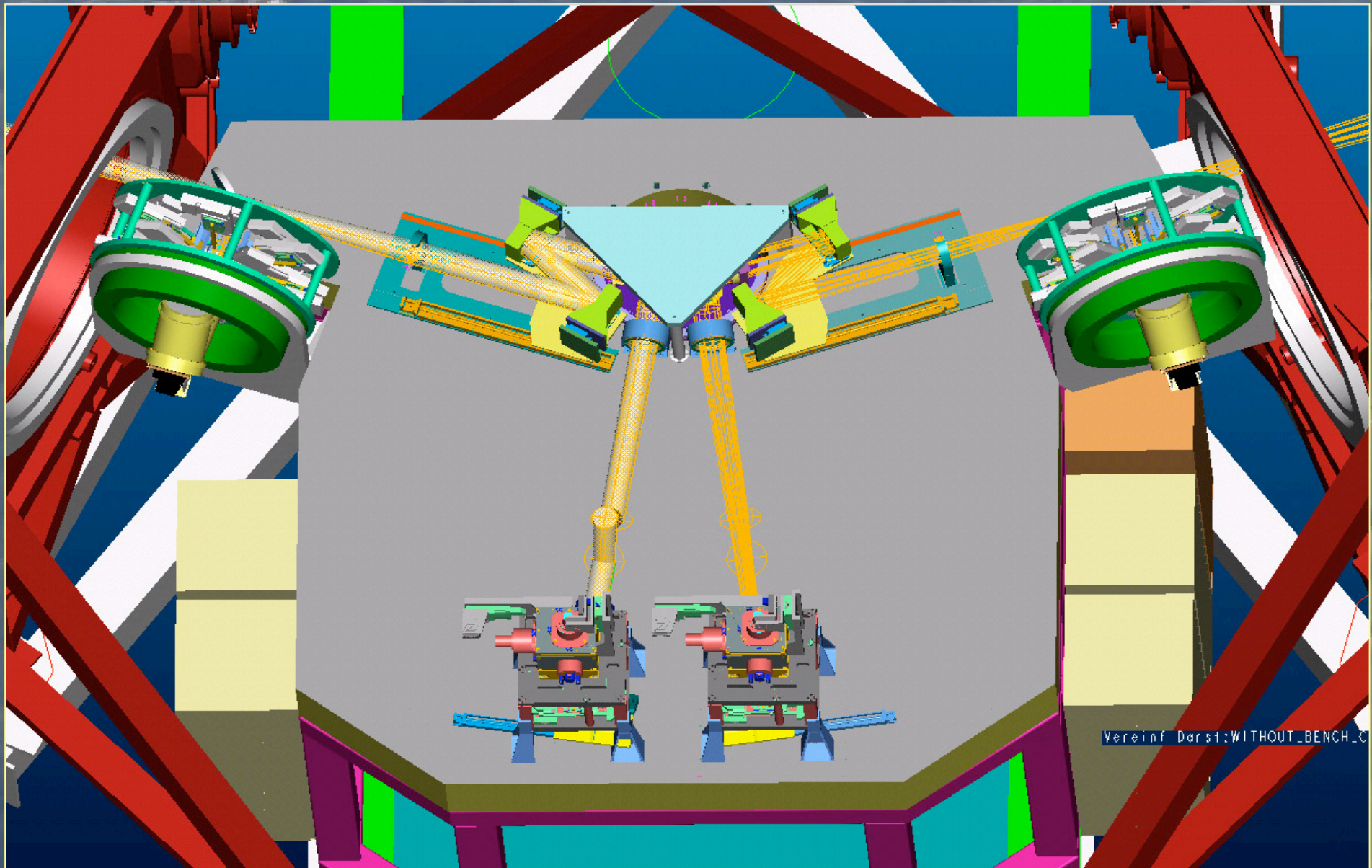
and in the cold...



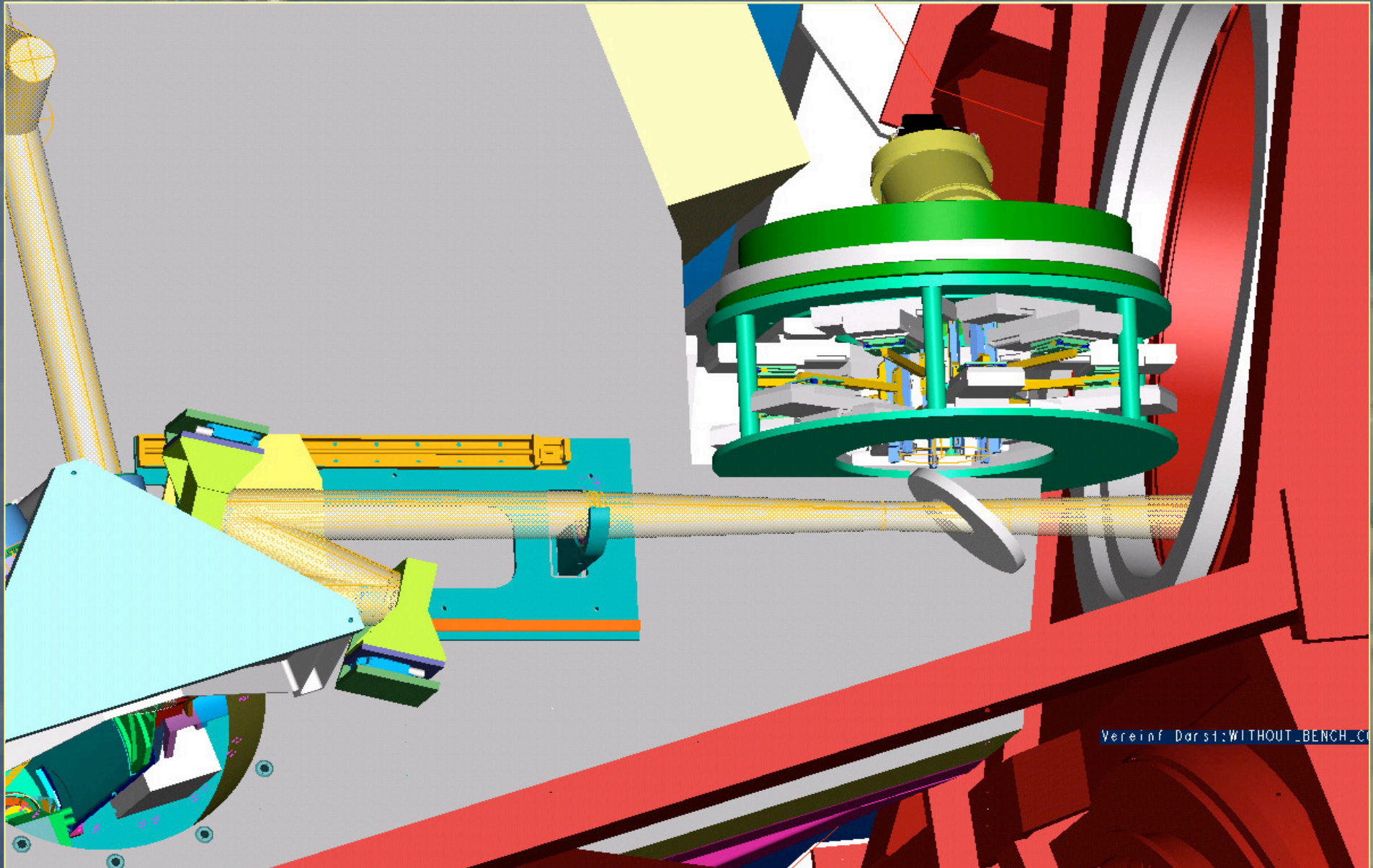
# Engineering Design



# Engineering Design

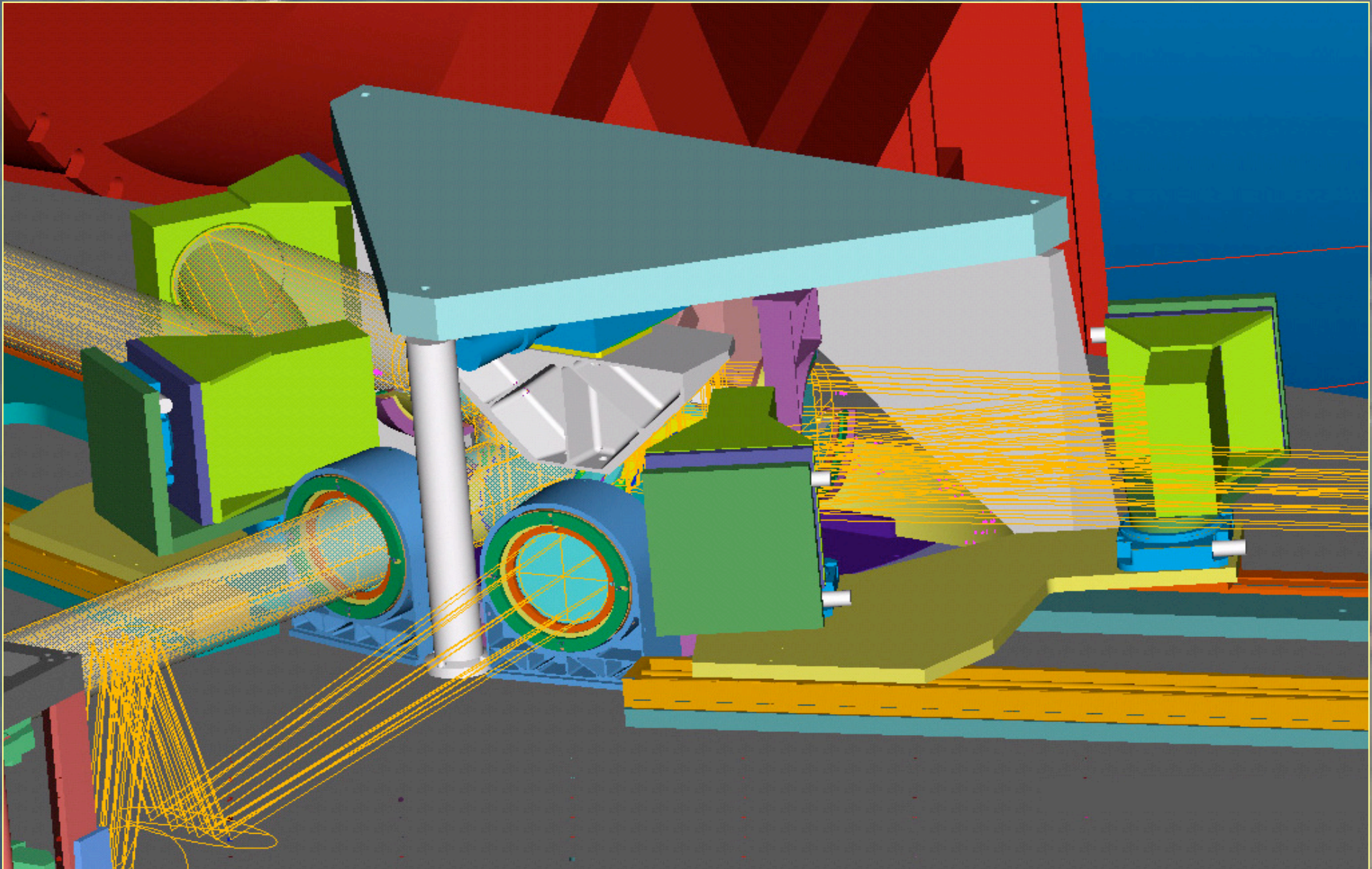


# Engineering Design

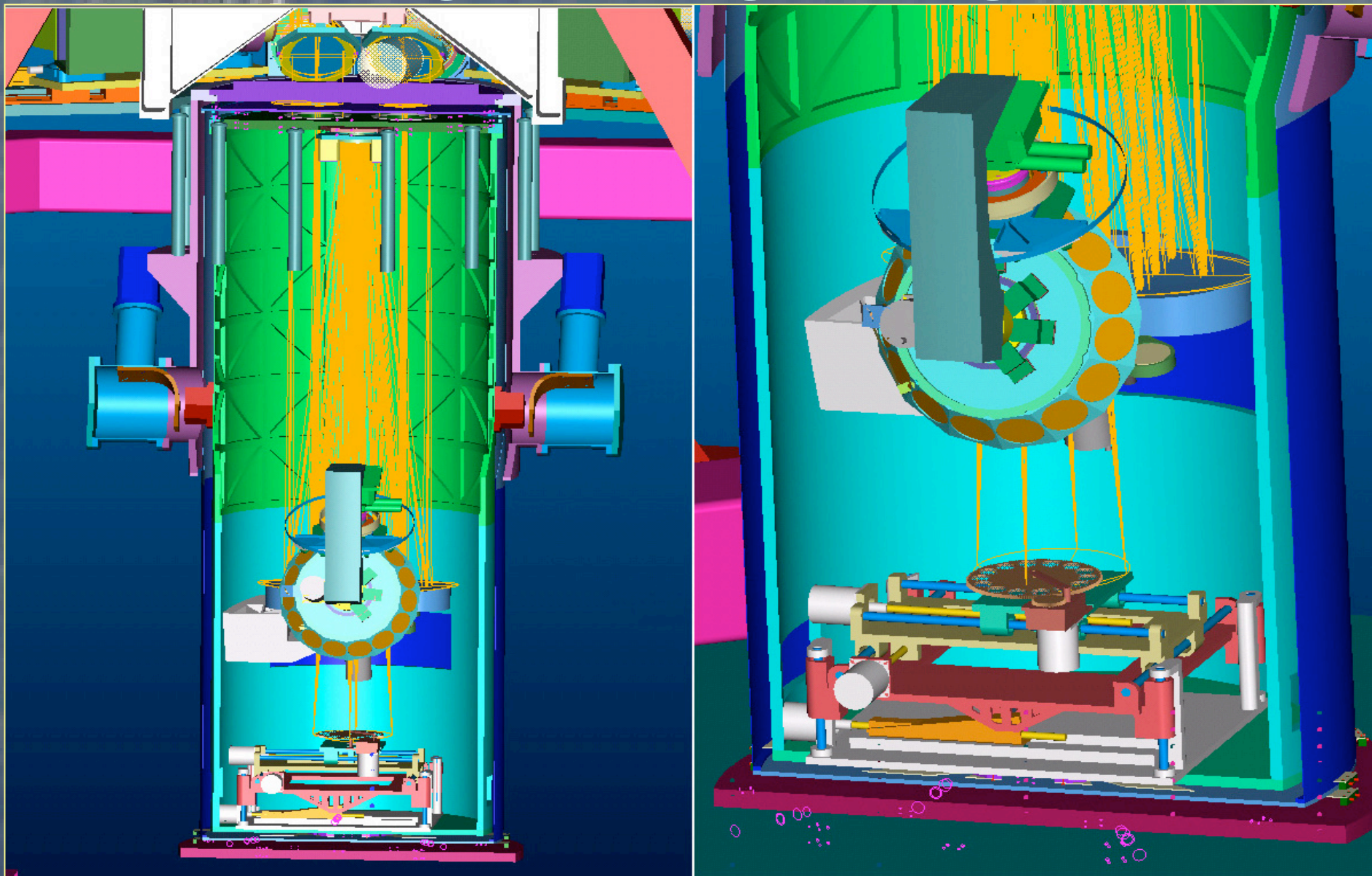




# Engineering Design

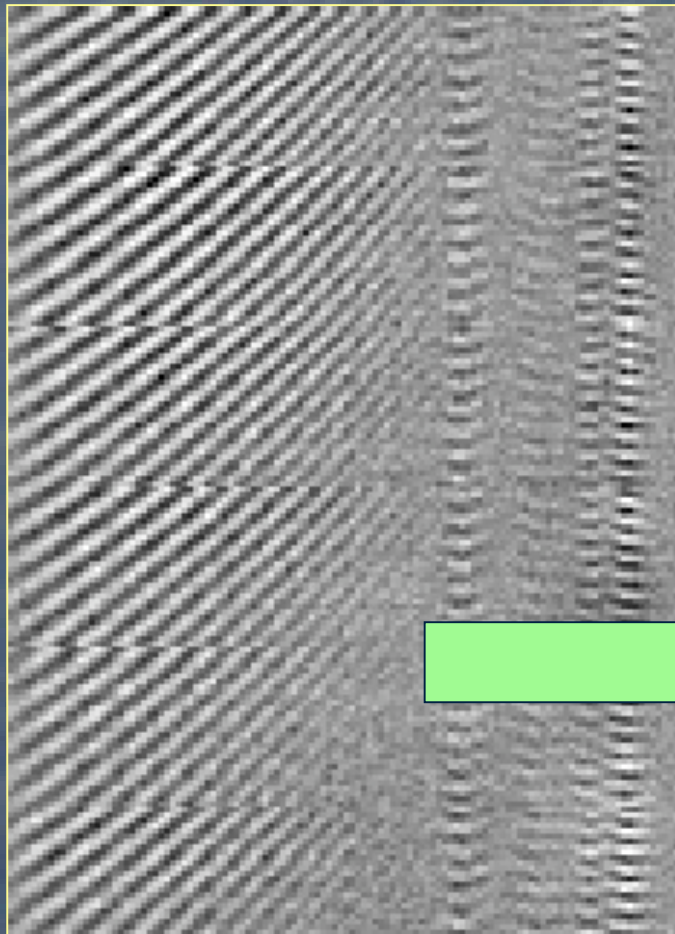


# Engineering Design



# Piston Control

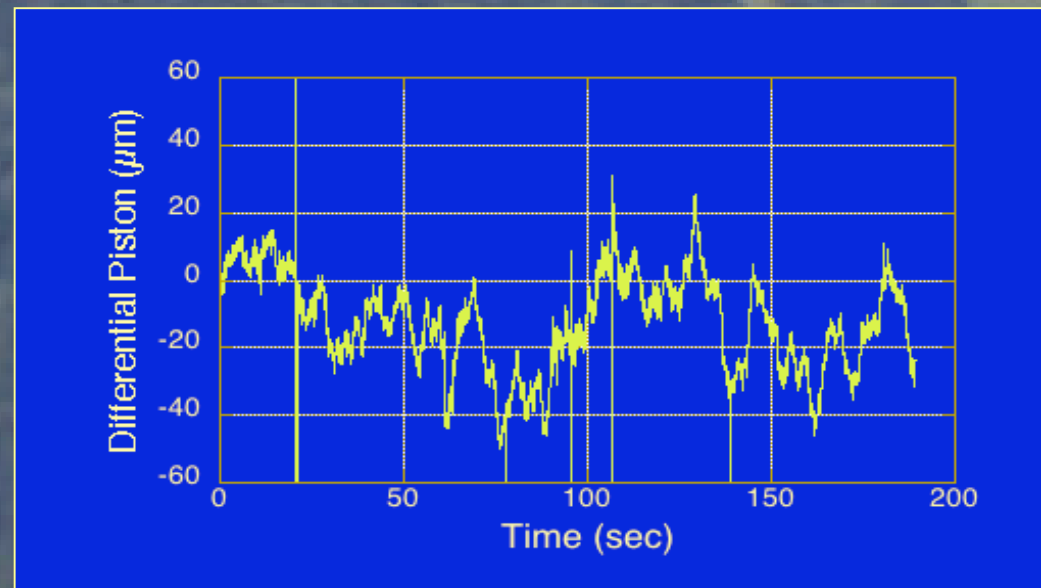
MCAO should ensure flat wavefronts, but...



MIDI, courtesy W. Jaffe

Estimate with:

- in-situ measurements
- other measurements
- modeling



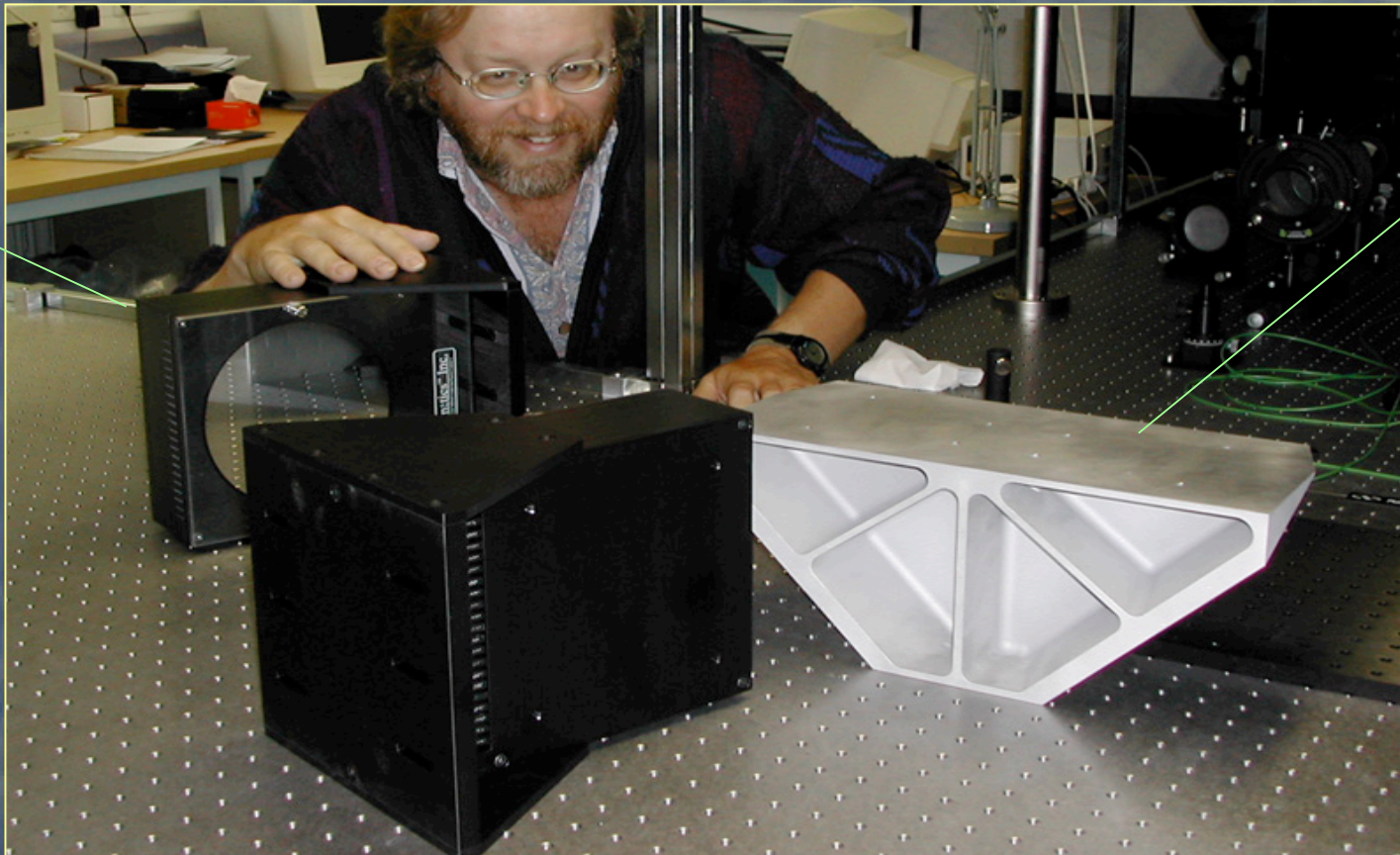
correcting...

# Correcting Piston

- Need:
- tens of  $\mu\text{m}$  slow
  - few  $\mu\text{m}$  fast

- Have:
- adaptive secondaries
  - piston mirror
  - DMs

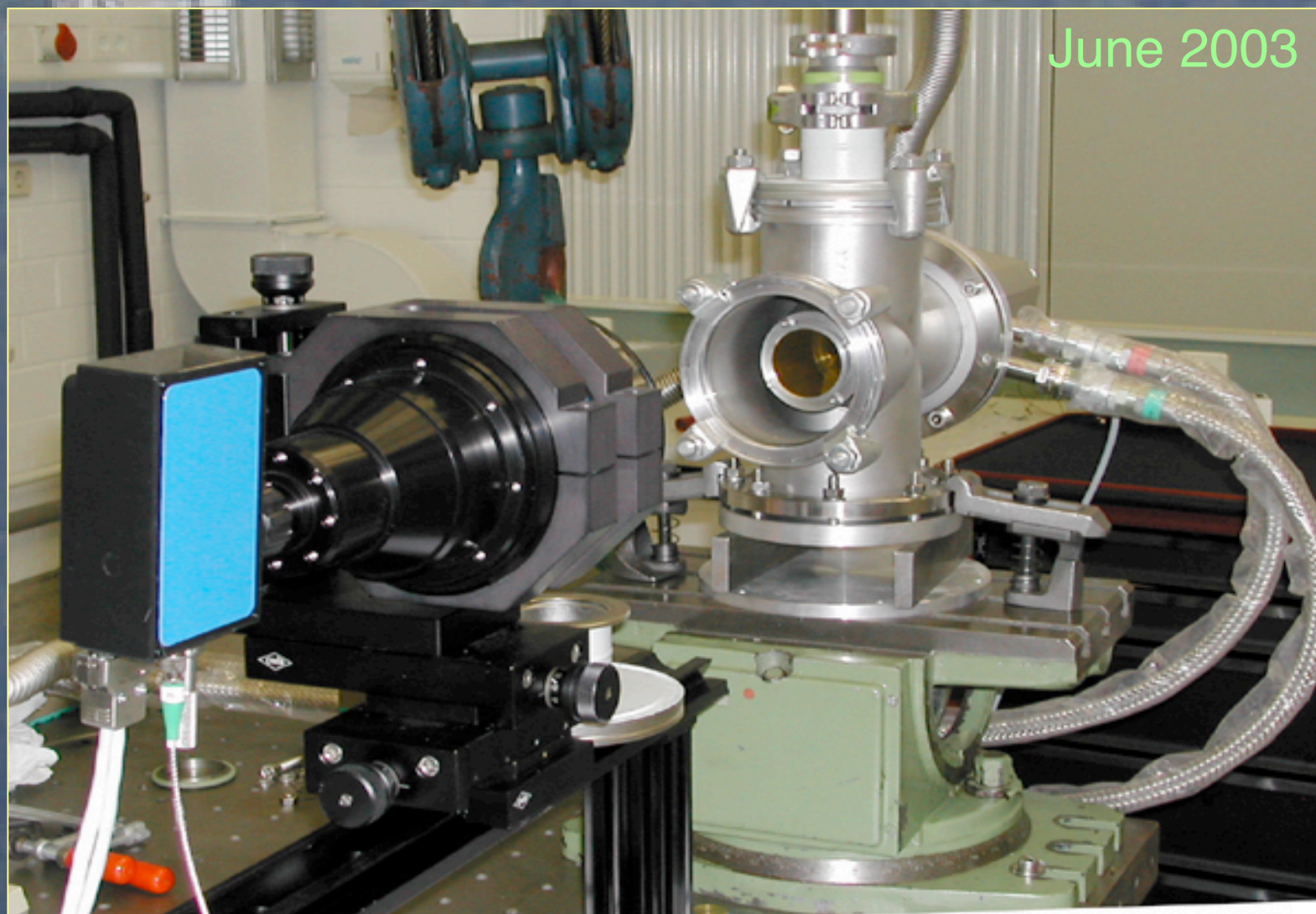
DM



Piston  
Mirror  
(test)

cooling...

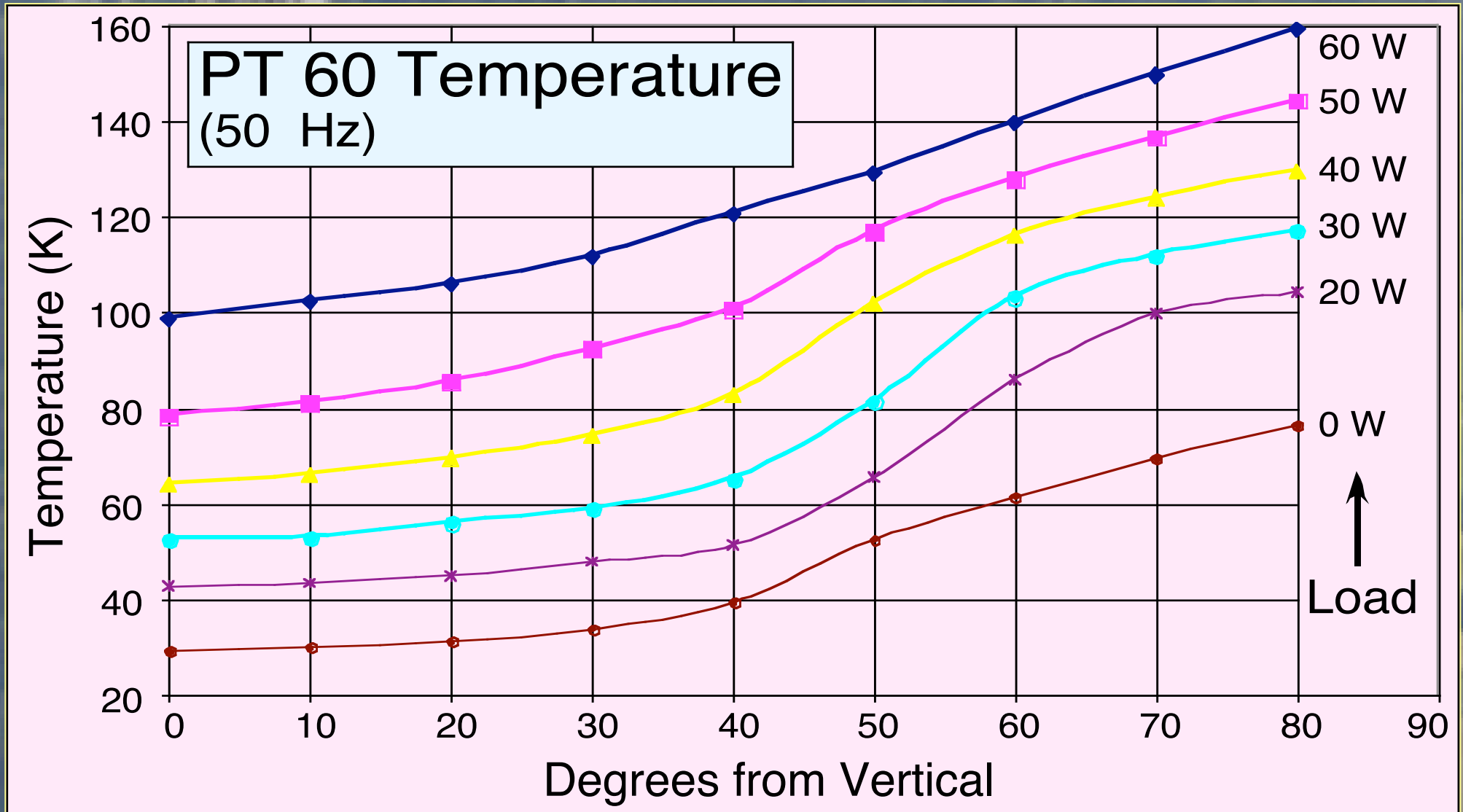
# Cooling the Cryostat



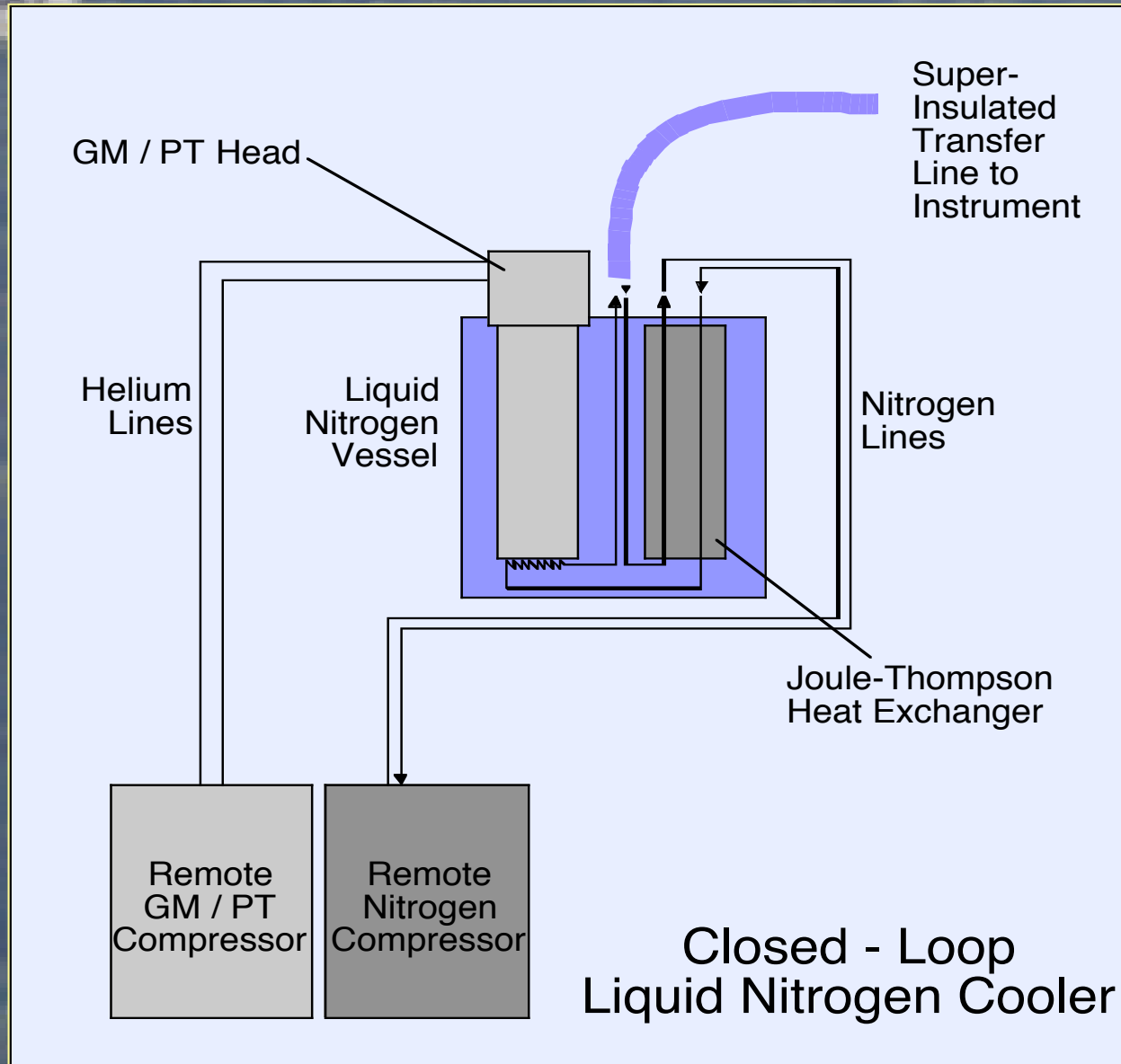
Excellent vibration performance (except compressor)

but...

# Tilt Problem



# A Solution ?



# Implementation Plan

(managing complexity)

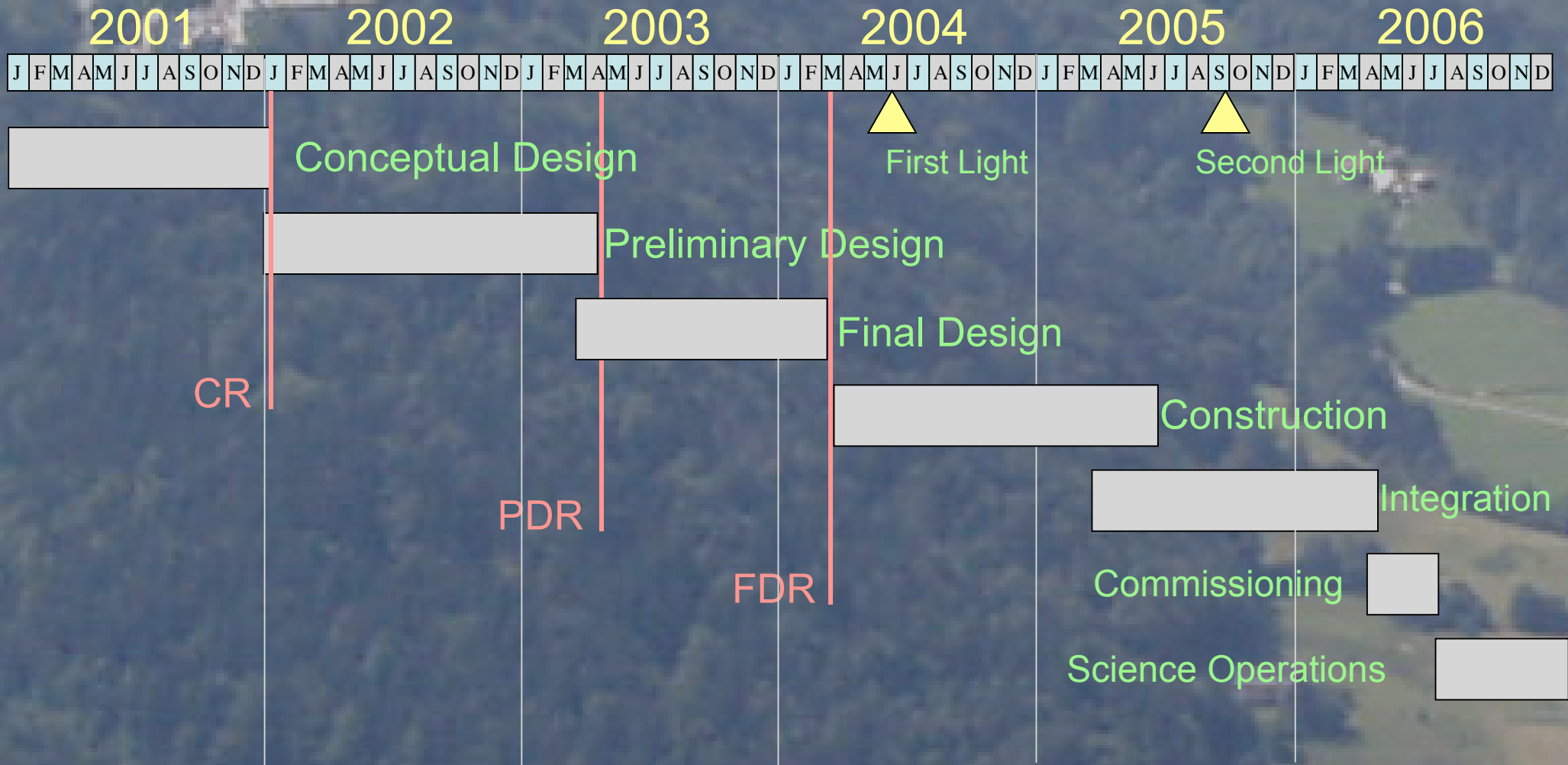


- Interferometric Imaging with Single Guide Star AO (LINC mode)  
--> scientifically useful fringes soon
- GWS Driving Secondaries  
--> best effort for interferometry
- MCAO on Single Telescope  
--> simultaneous Ground - Mid - High layers
- Full MCAO Interferometry  
--> NIRVANA attained, scientific exploitation

schedule...



# LINC-NIRVANA Schedule



# To Learn More

<http://www.mpia.de/LINC>