THIRTY METER TELESCOPE

IRIS OIWFS Concept Study

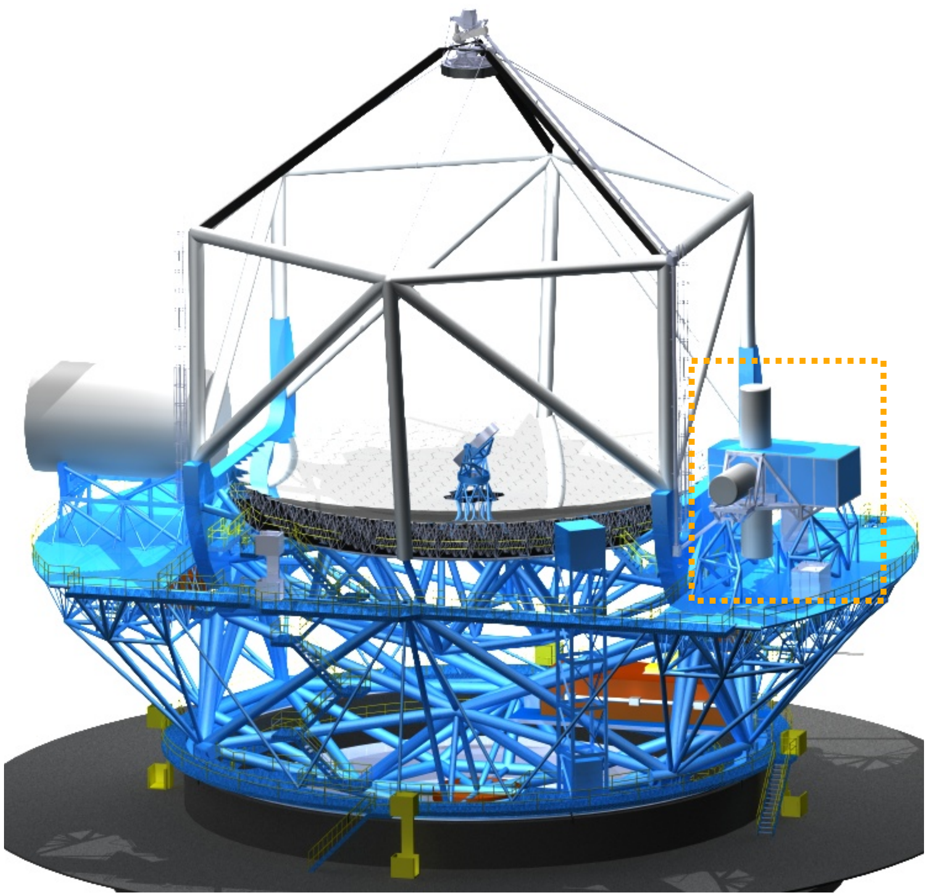
D. Loop[1], M. Fletcher[1], V. Reshetov[1], R. Wooff[1], J. Dunn[1],
A. Moore[2], R. Smith[2], D. Hale[2], R. Dekany[2],
L. Wang[3], B. Ellerbroek[3], L. Simard[3], D. Crampton[3]

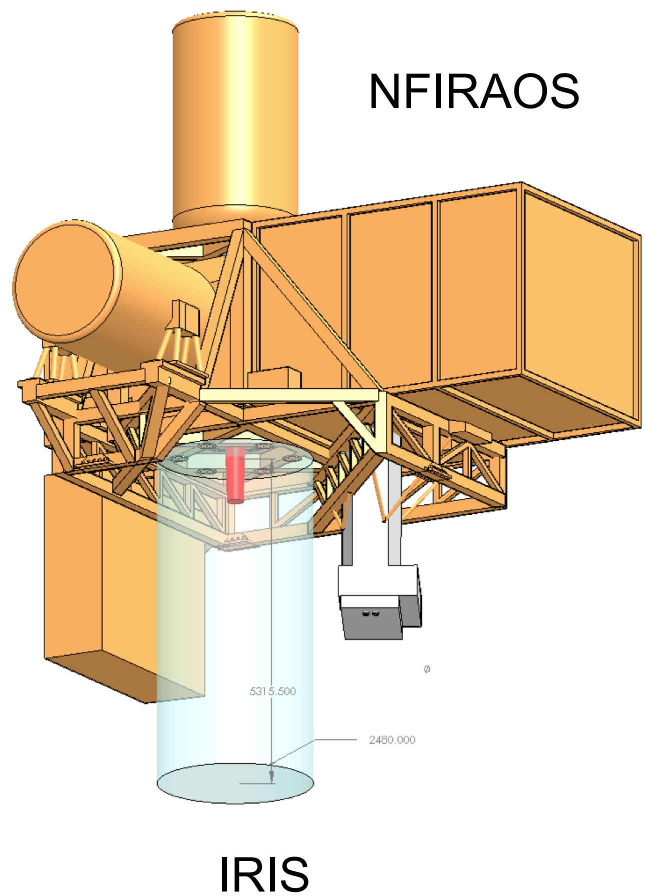
[1]NRC-Herzberg Institute of Astrophysics
[2]Caltech Optical Observatories
[3]TMT Observatory Corporation

Wavefront Sensor Meeting
Caltech, Dec 15, 2009

THIRTY METER TELESCOPE

IRIS on TMT

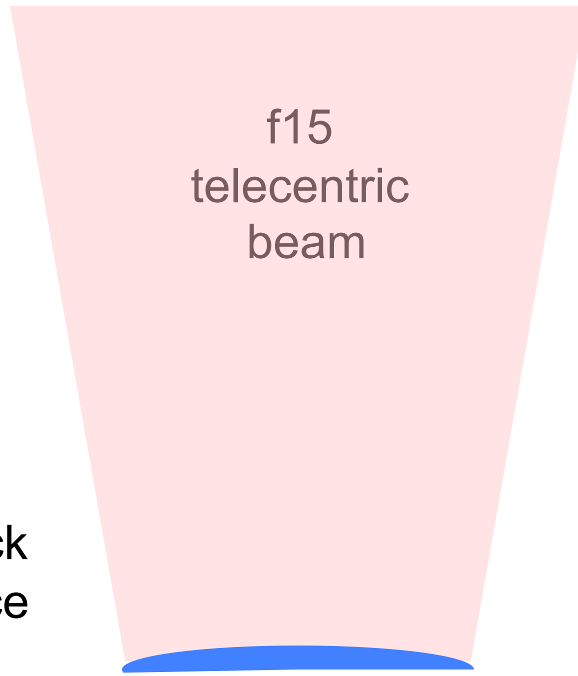




TMT
THIRTY METER TELESCOPE

Delivered Focal Plane

~780mm back
focal distance



2 arcmin focal plane
curved convex, r~7400mm
plate scale = 2.18 mm/arcsec

2 arcmin
Field of regard

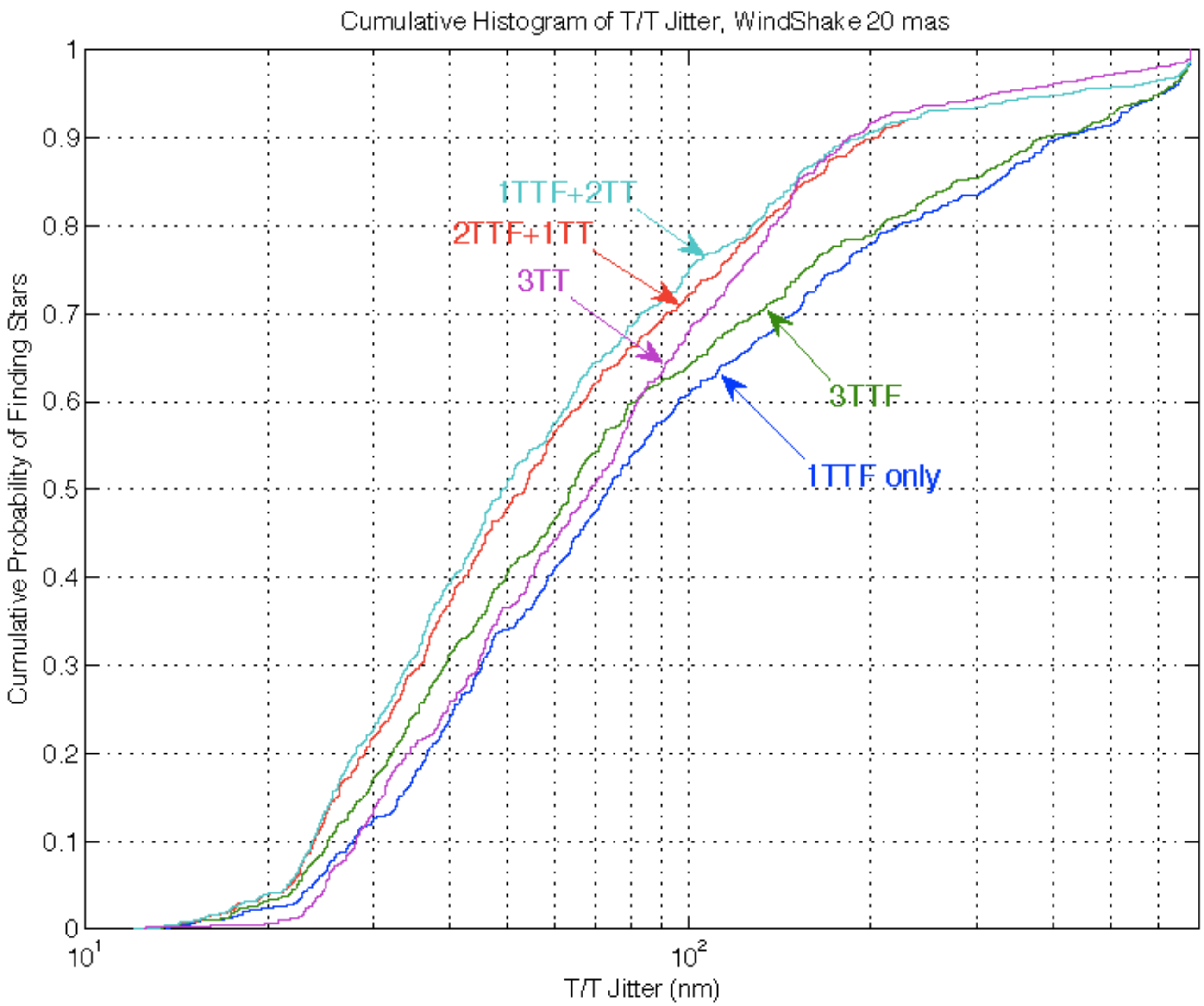
~25 arcsec
science field

Key OIWFS Requirements

- Instrument rotator & services wrap - alignment between NFIRAOS delivered beam and IRIS science instrument
  - Critical to IRIS image quality
- 2 tip/tilt and 1 tip/tilt/focus wavefront sensors
  - Fast guiding, focus and tilt anisoplanatism
- 2 mas positioning accuracy > 4.4 μm at focal plane
  - OIWFS are the positional reference for astrometric performance
- High sky coverage - < 2 mas tip/tilt jitter at galactic pole
  - Near infrared, 1.0 to 1.7 μm, sensing on ‘sharpened’ guide stars
- High acquisition probability = low acquisition time

Number & Type of Probes

(Lianqi Wang, Brent Ellerbroek, 2008)



1 TTF + 2 TT probes

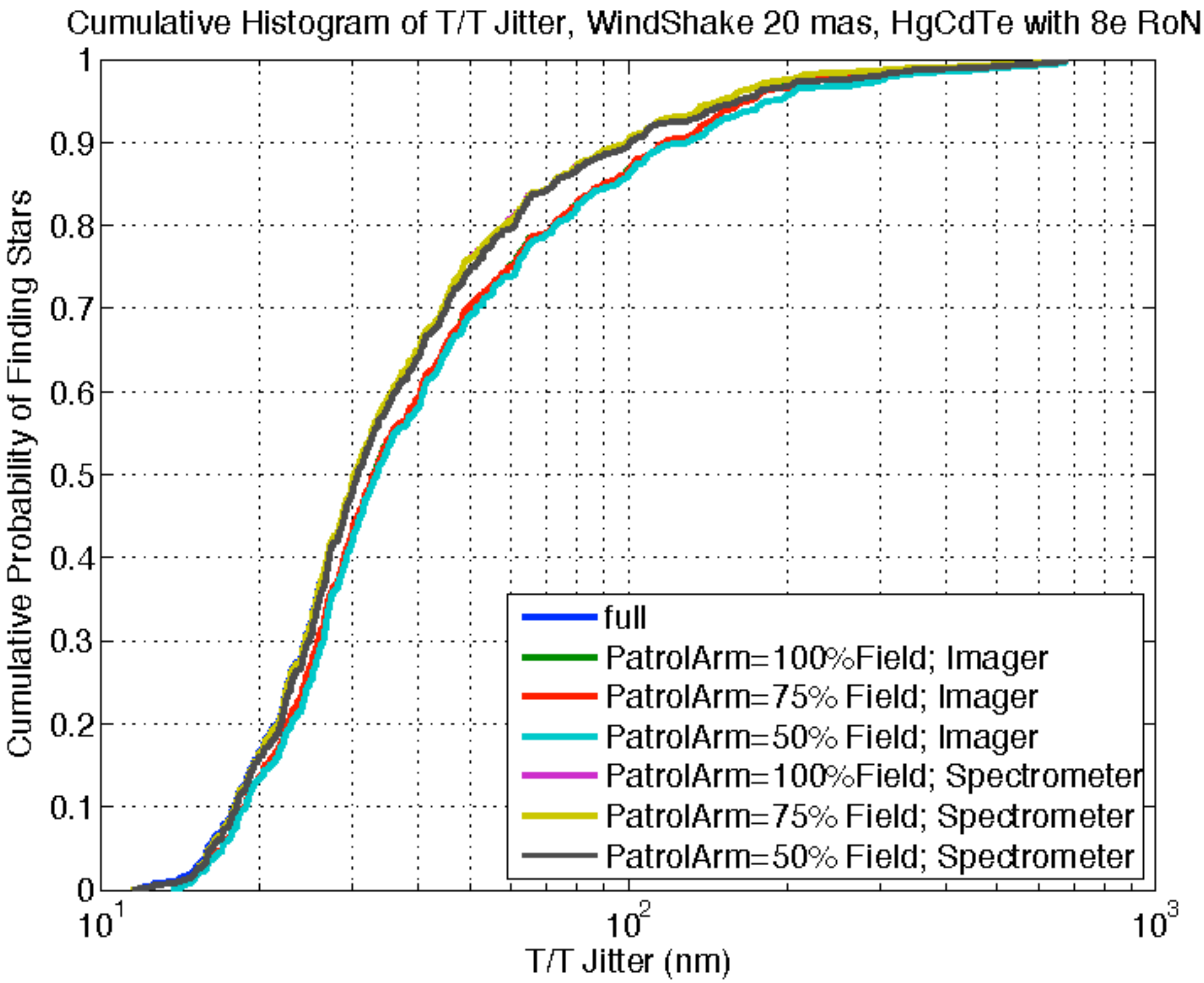
Object Selection Mechanism

- Object Select Mechanisms considered
  - Robot placed pickoff & pathlength mirrors (EAGLE concept)
  - Tip/tilt mirror tiling of focal plane (Caltech TIPI concept)
  - Theta-Phi, 2 rotation stages (Flamingos-2 OIWFS, etc)
  - Theta-R, 1 rotation + 1 linear stages (IRMOS, KMOS, etc)
- Requirements for positioning accuracy, dithering, and non-sidereal tracking
- Theta-R concept chosen for initial sky coverage analysis

- TT and TTF function change – versus - 2 probe planes

Patrol Geometry

(Lianqi Wang, Brent Ellerbroek, 2008)

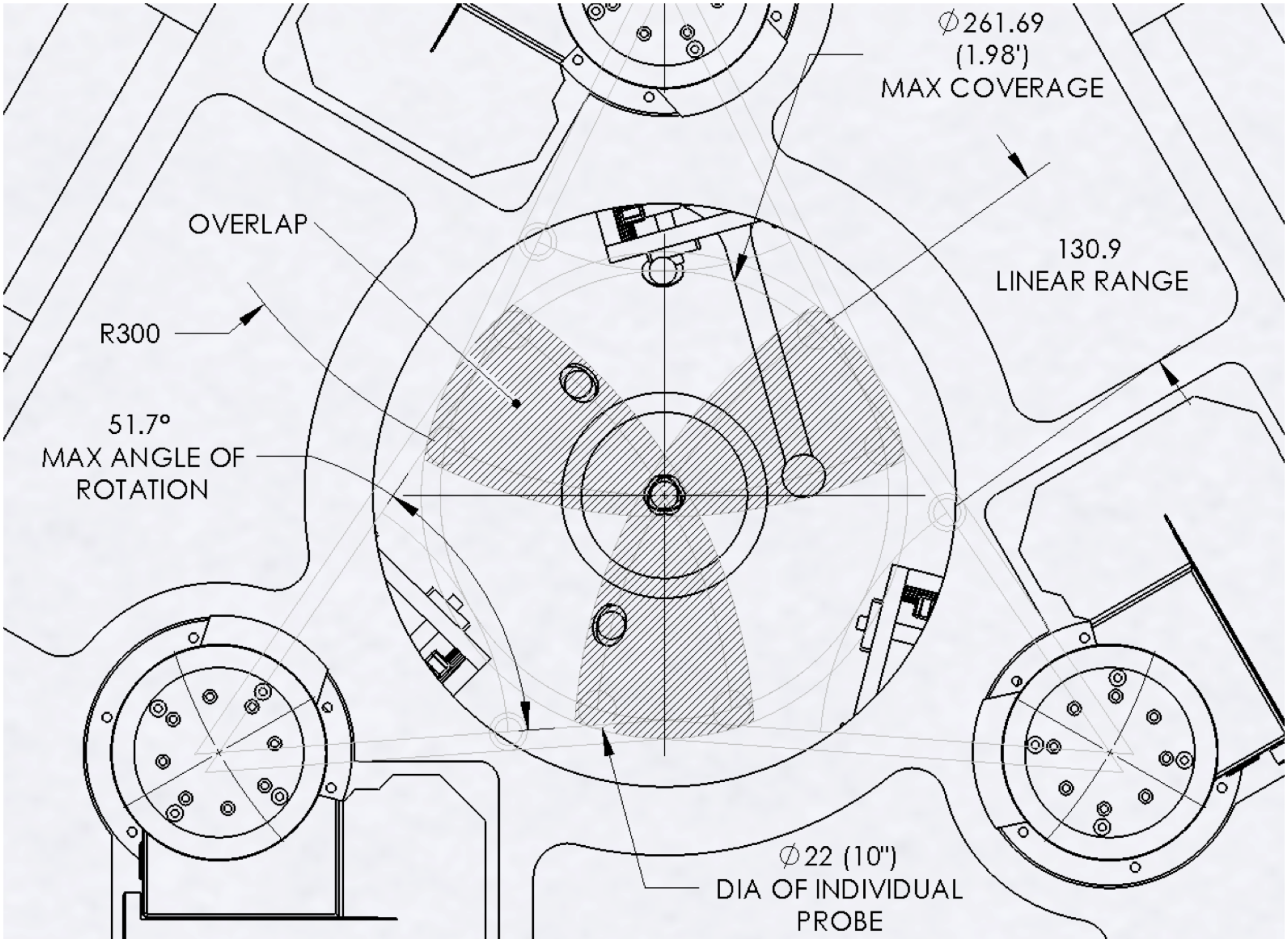


3 identical ‘theta-R’ probes at 120 degree spacing

Each probe capable of TT or TTF

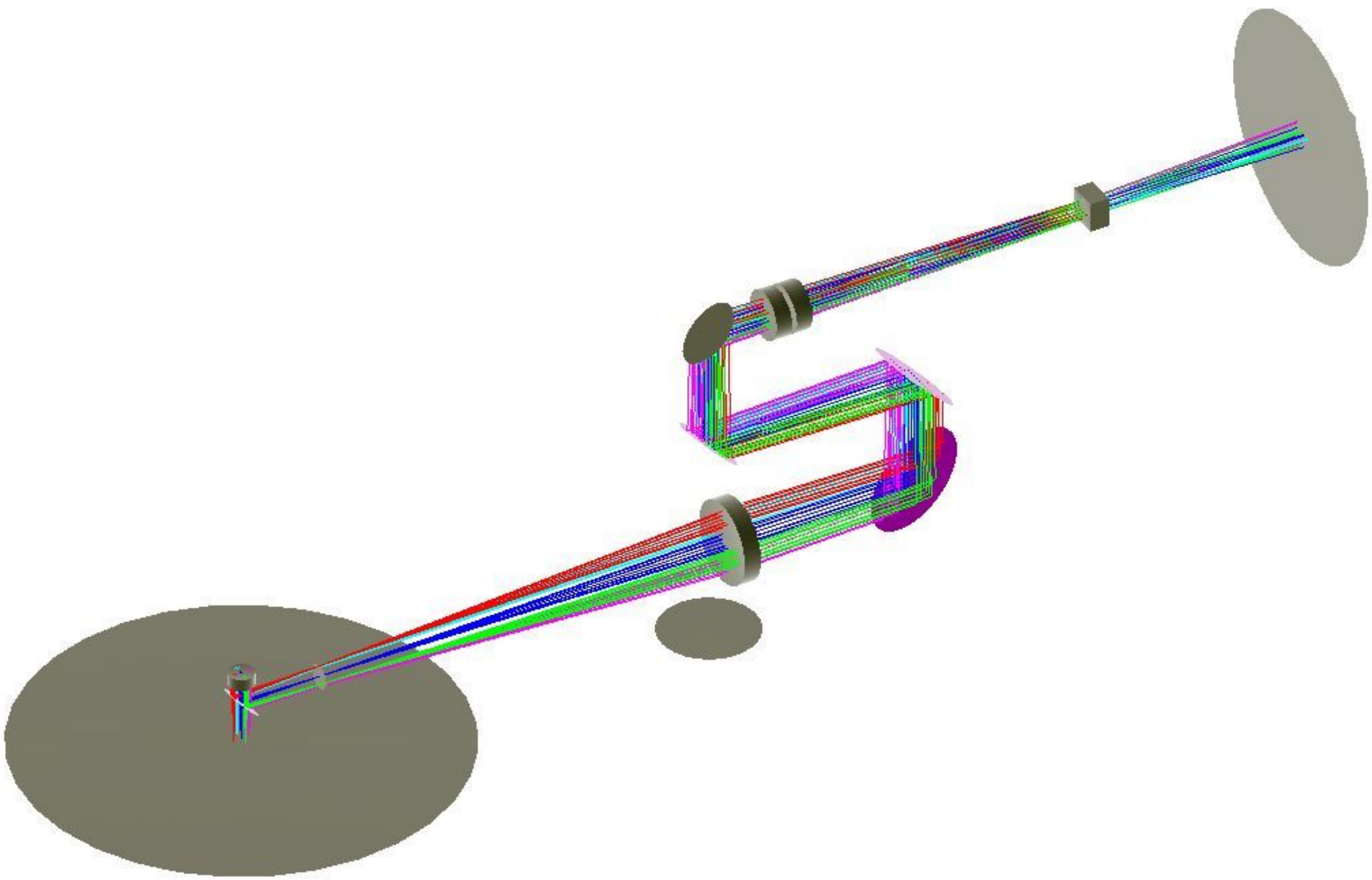
Only need to reach 50% across 2’ field

Theta-R Patrol Geometry

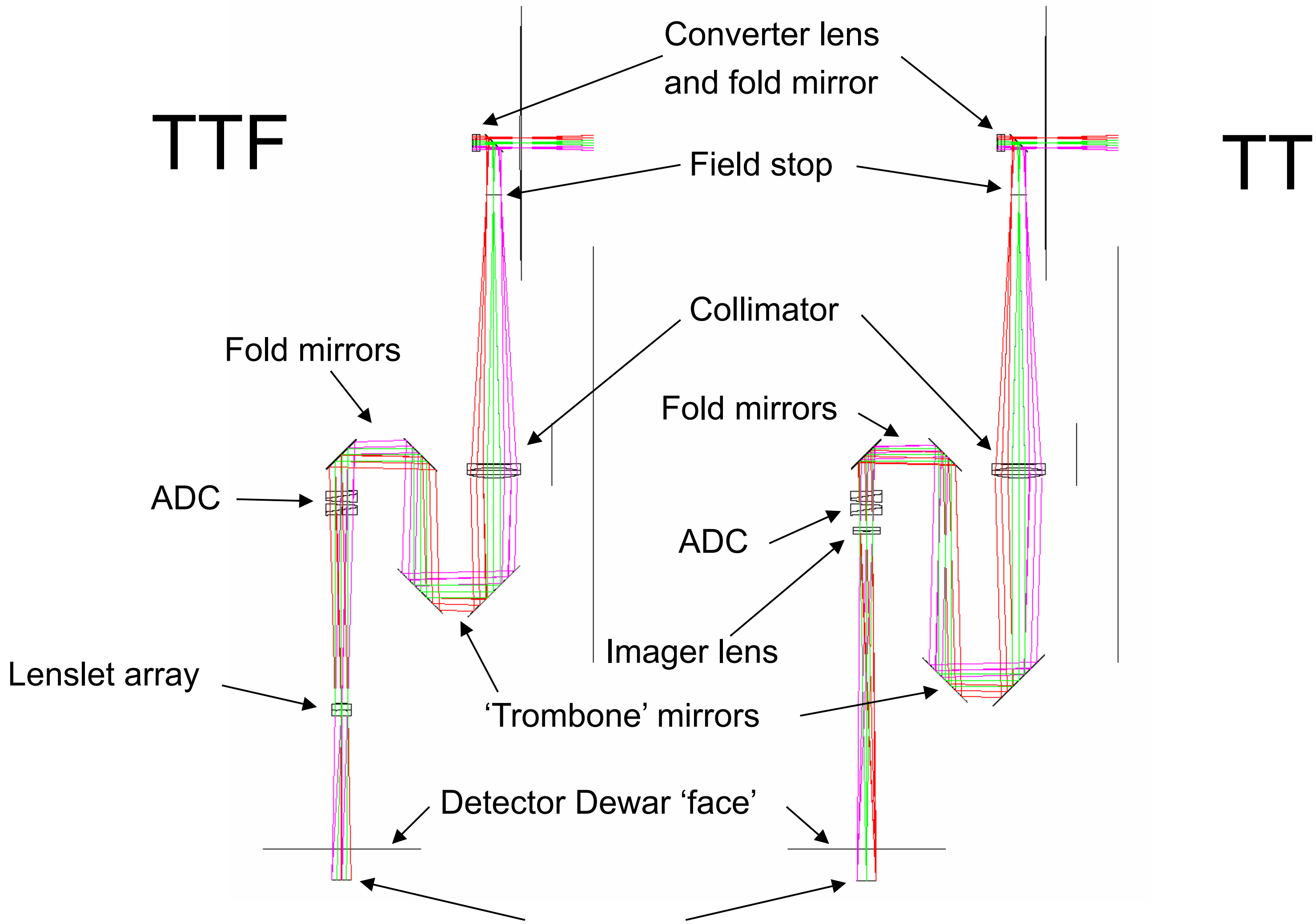


THIRTY METER TELESCOPE

Theta-R Probe Design

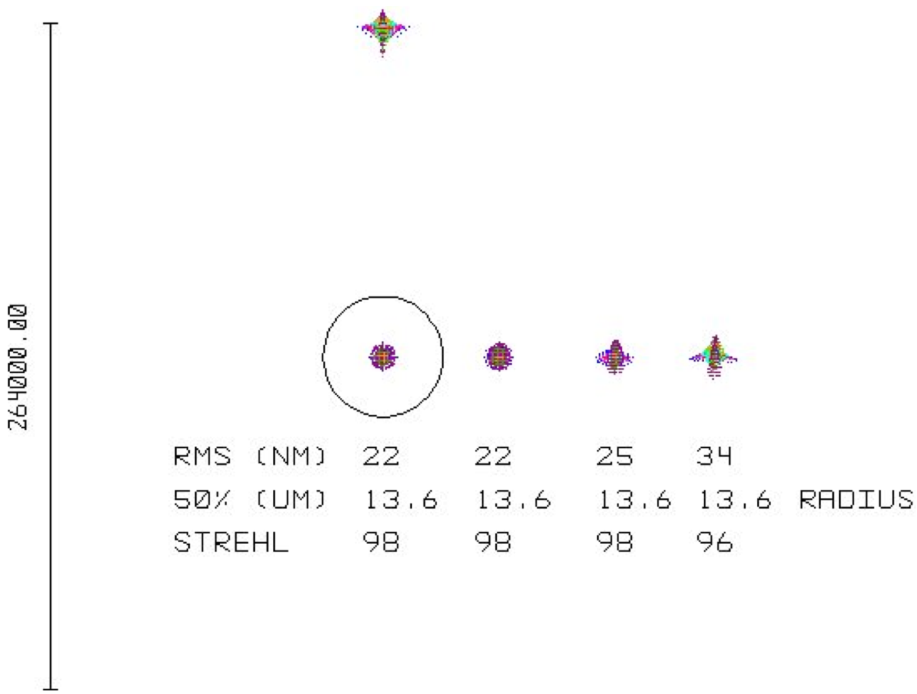


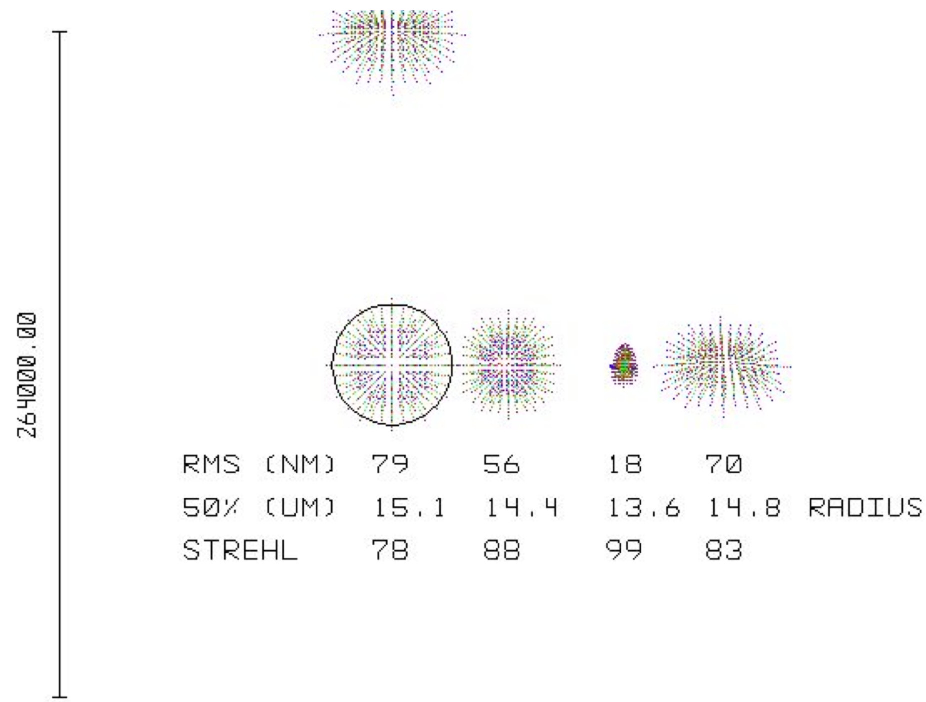
Theta-R Probe Optics



TMT
THIRTY METER TELESCOPE

Effect of Curved Focal Plane

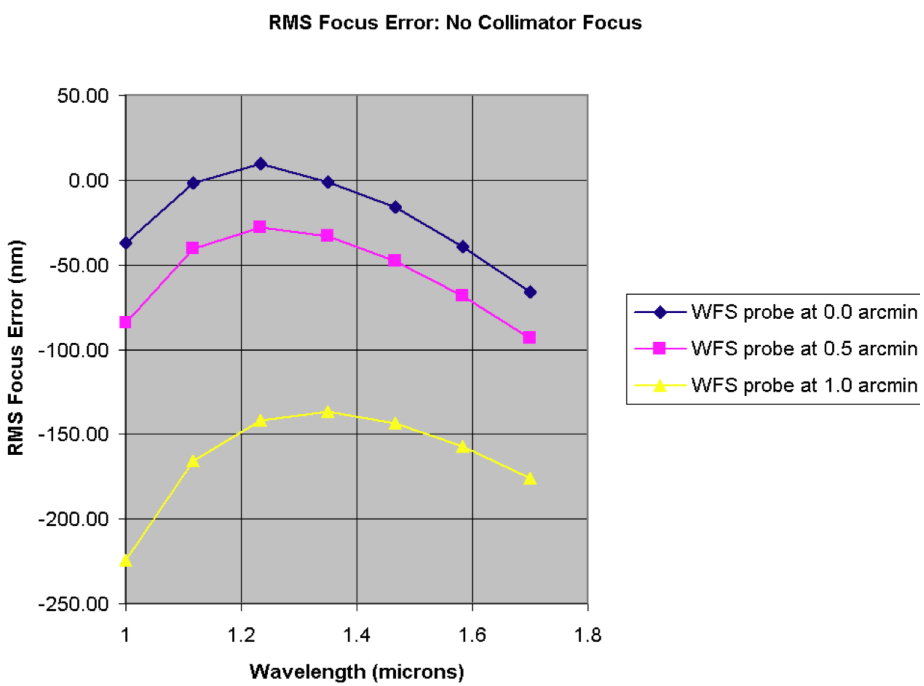


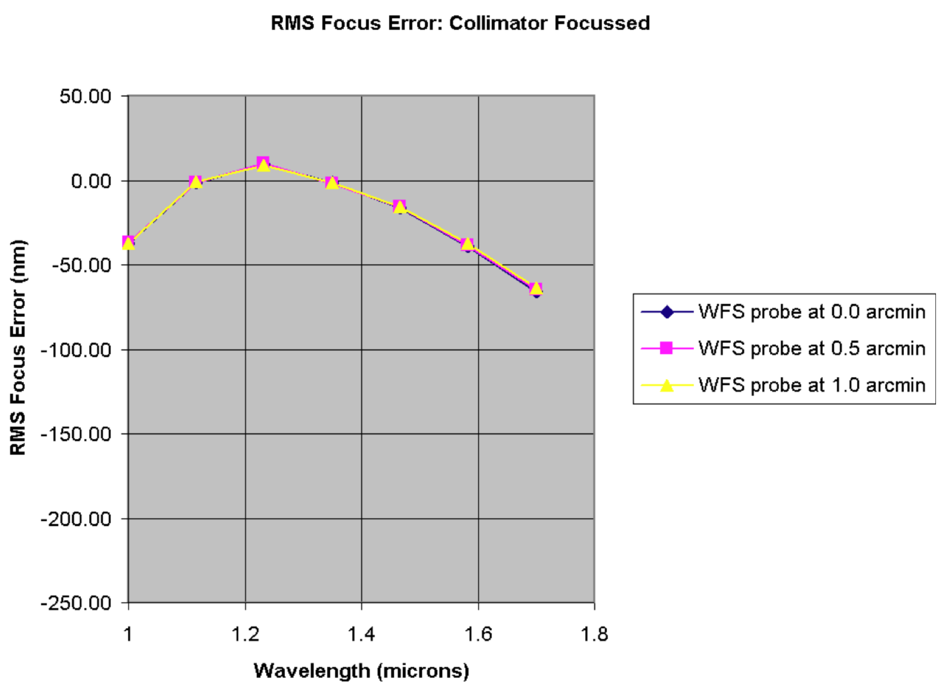


Results shown for 0, 0.3, 0.7, and 1.0 arcmin off axis

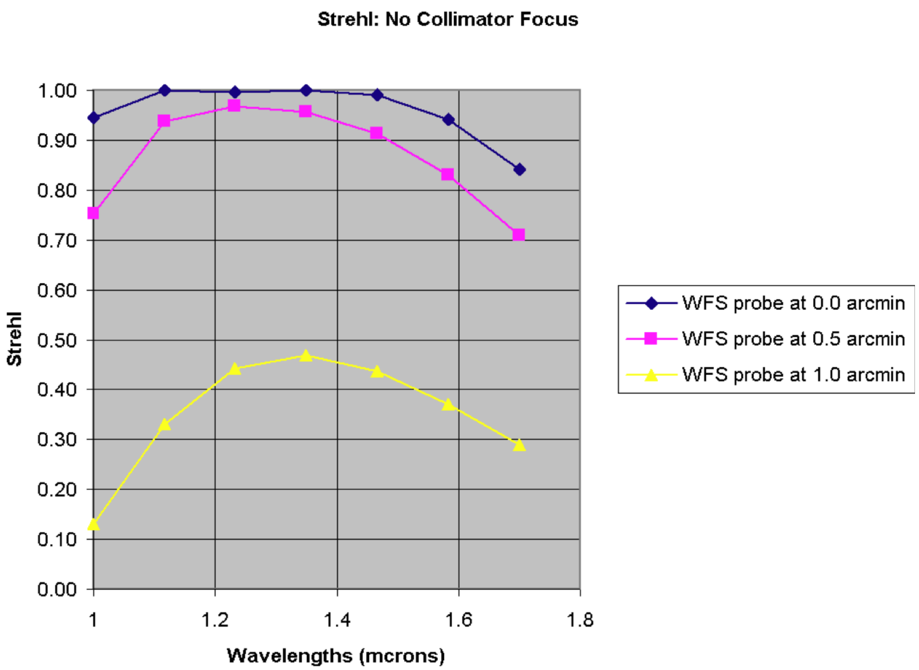
THIRTY METER TELESCOPE

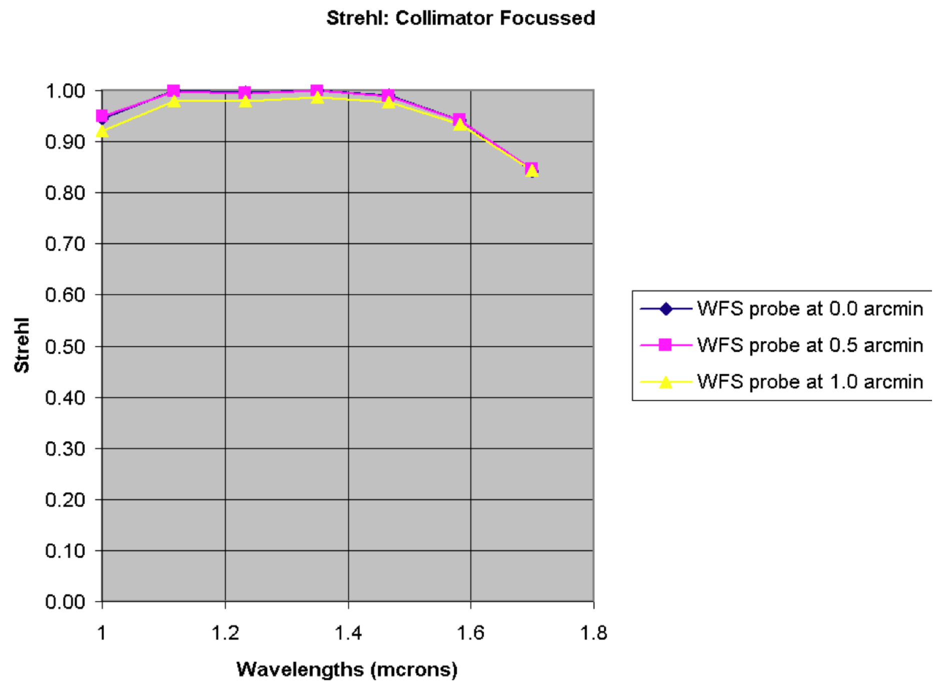
RMS Focus Error





Color Dependent Strehl





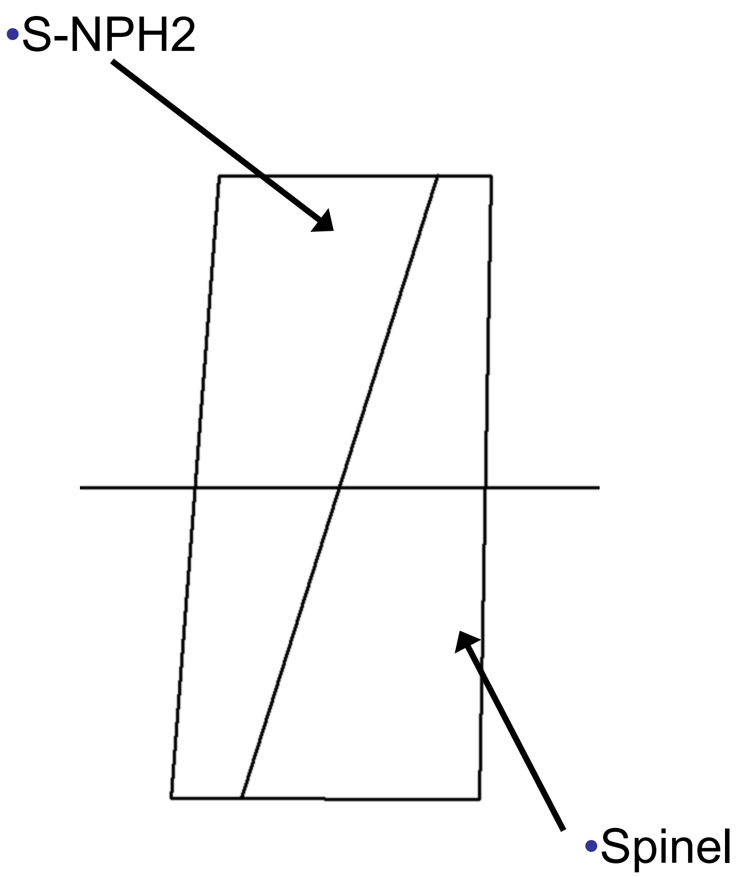
OIWFS ADC
Current Version

- The doublet prism pair.

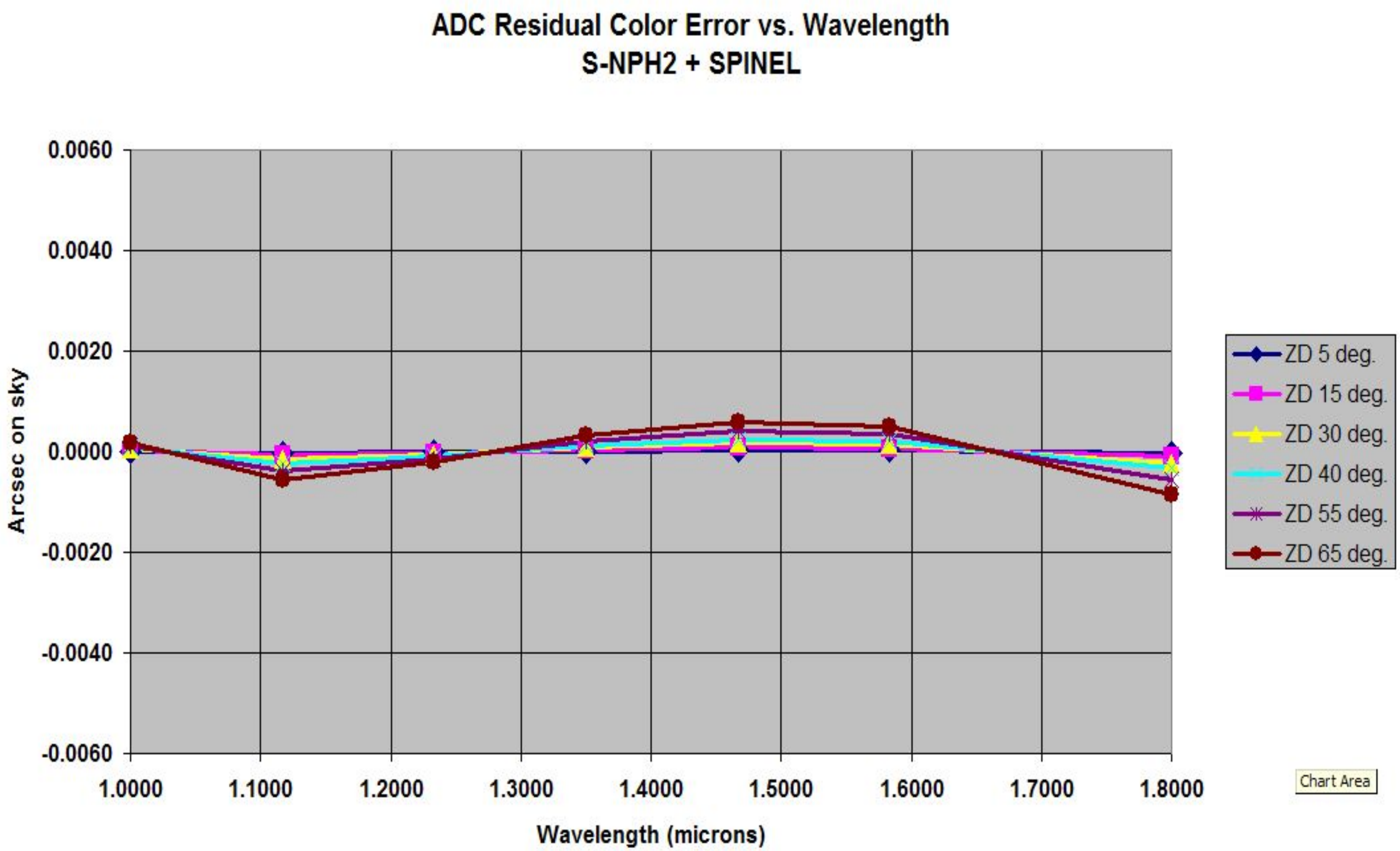
- Glass selection inspired by Drew Philips' glass-pair investigation.

- Diameter = 30 mm.
- Thickness of a doublet = 14 mm.
- Glasses are S-NPH2 and Spinel.

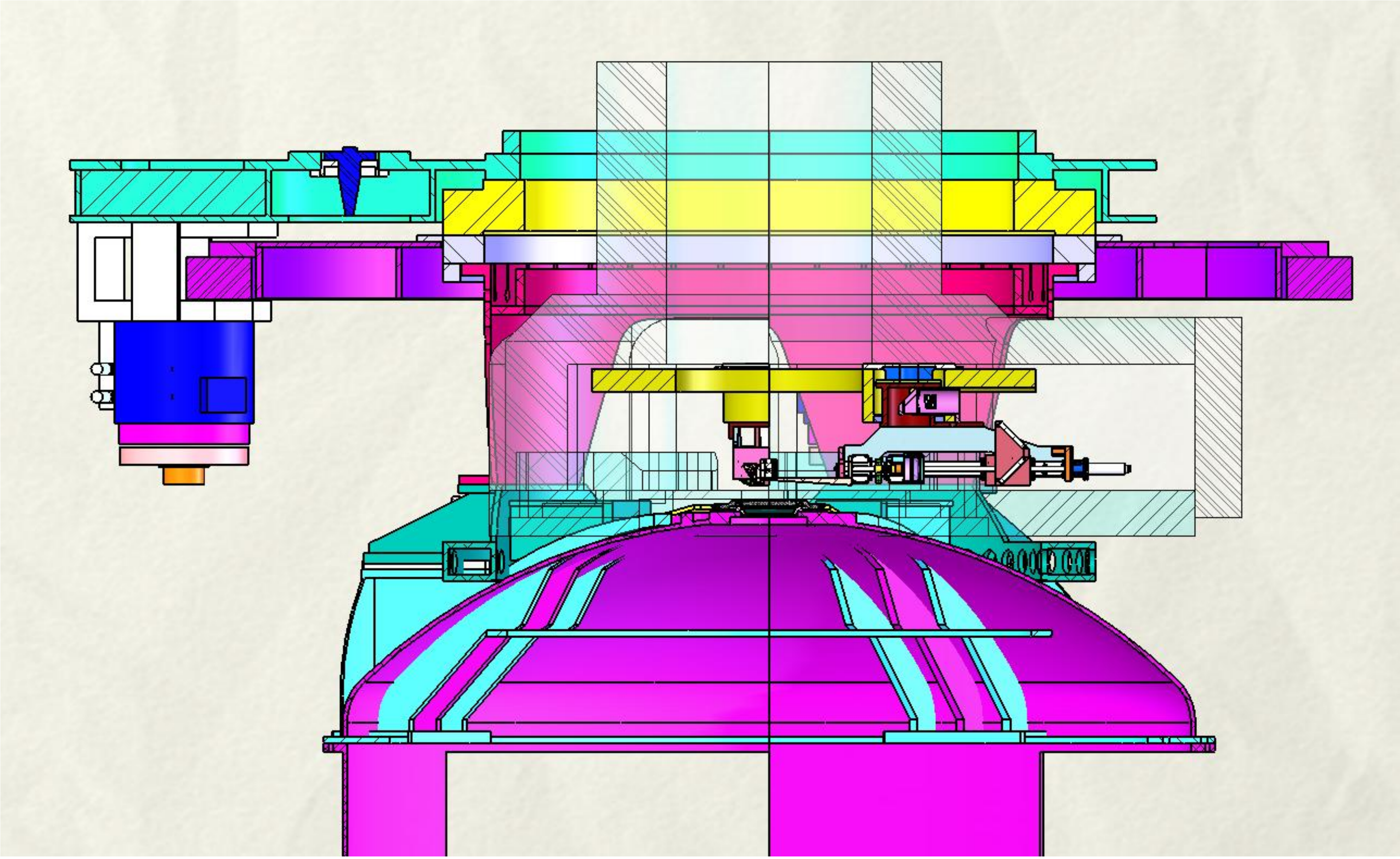
- It is quite well-behaved being in a collimated beam space.



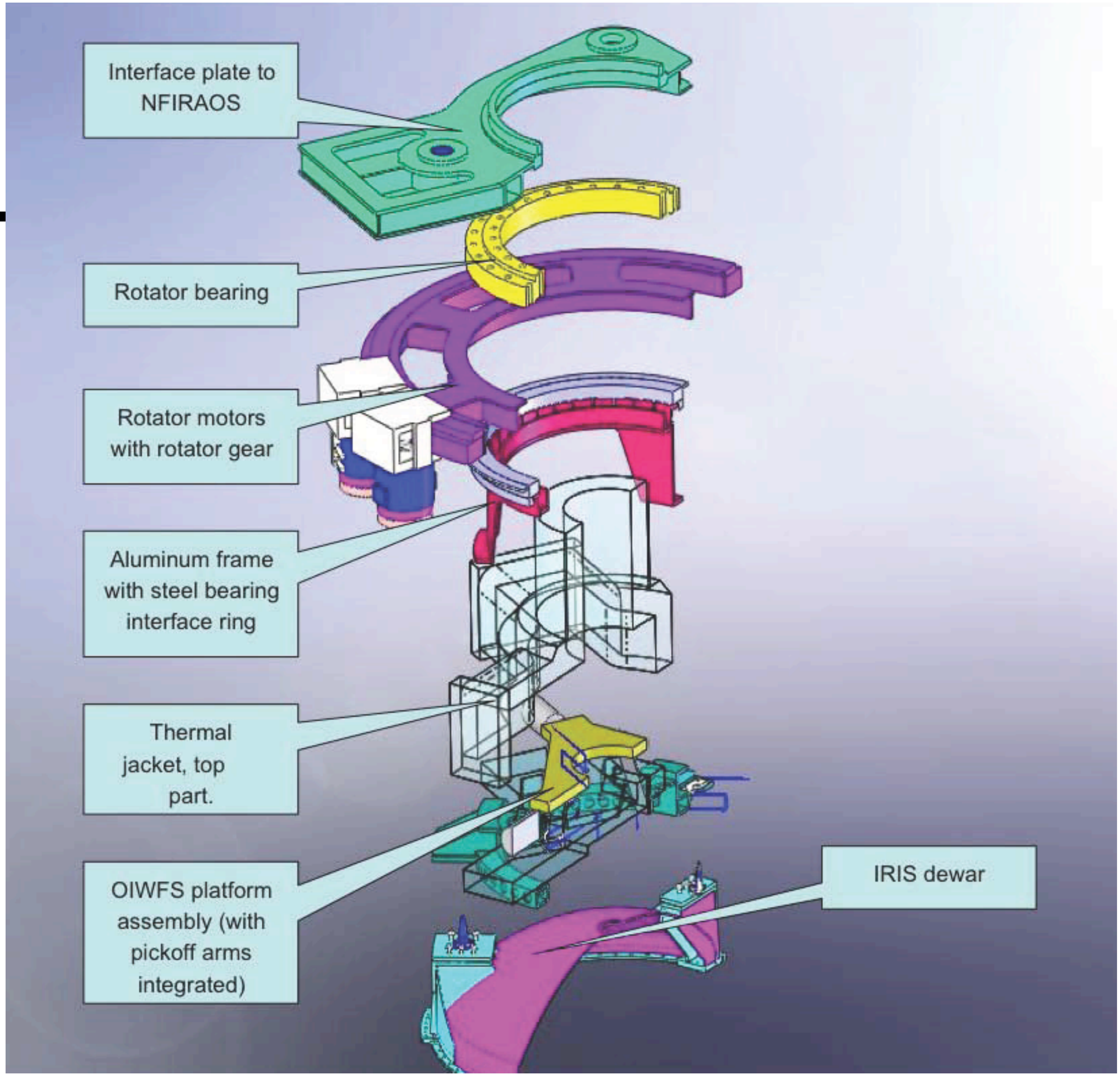
ADC Residual Color Errors



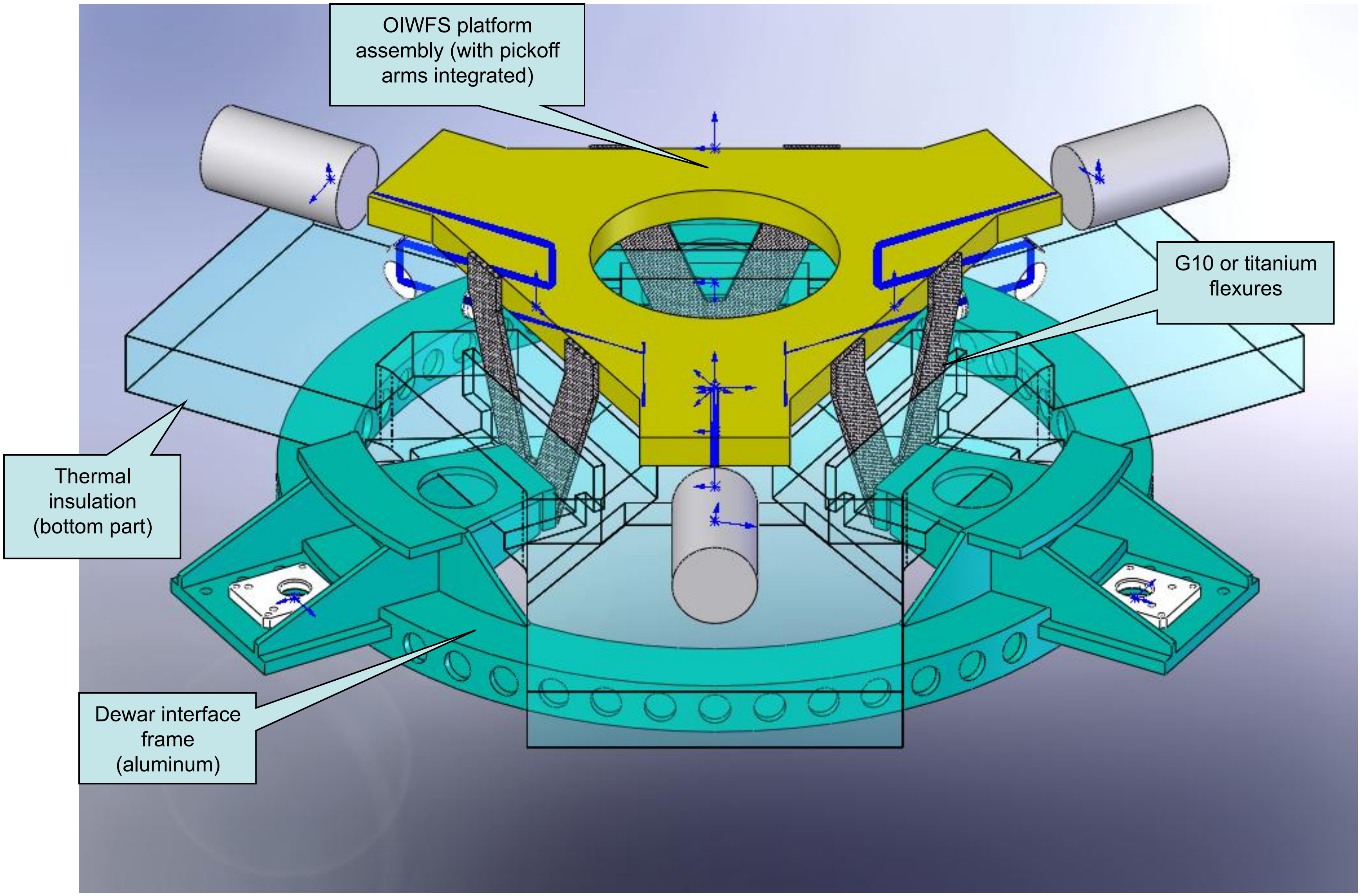
Macro Mechanics



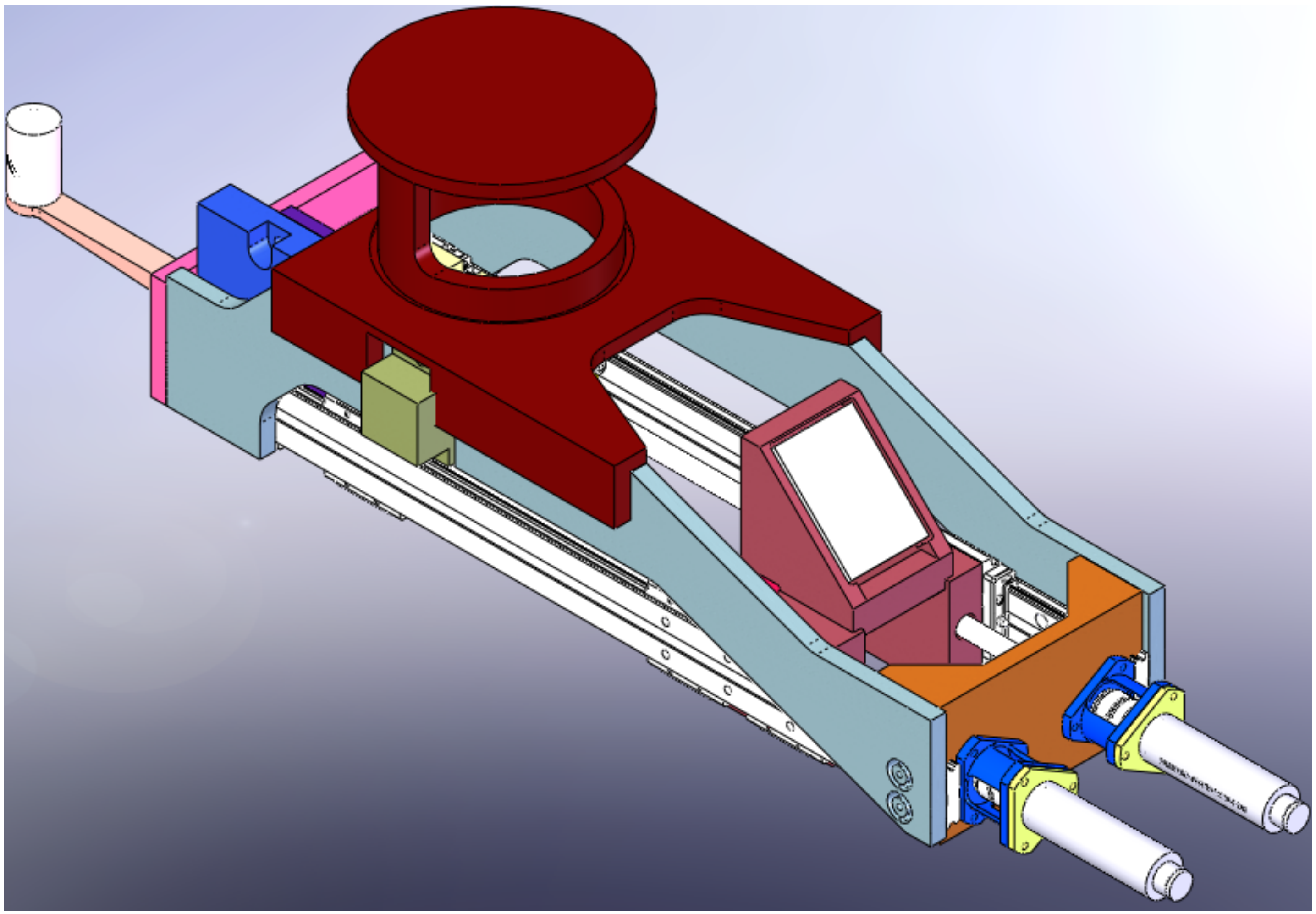
Exploded View



OIWFS Probe Platform

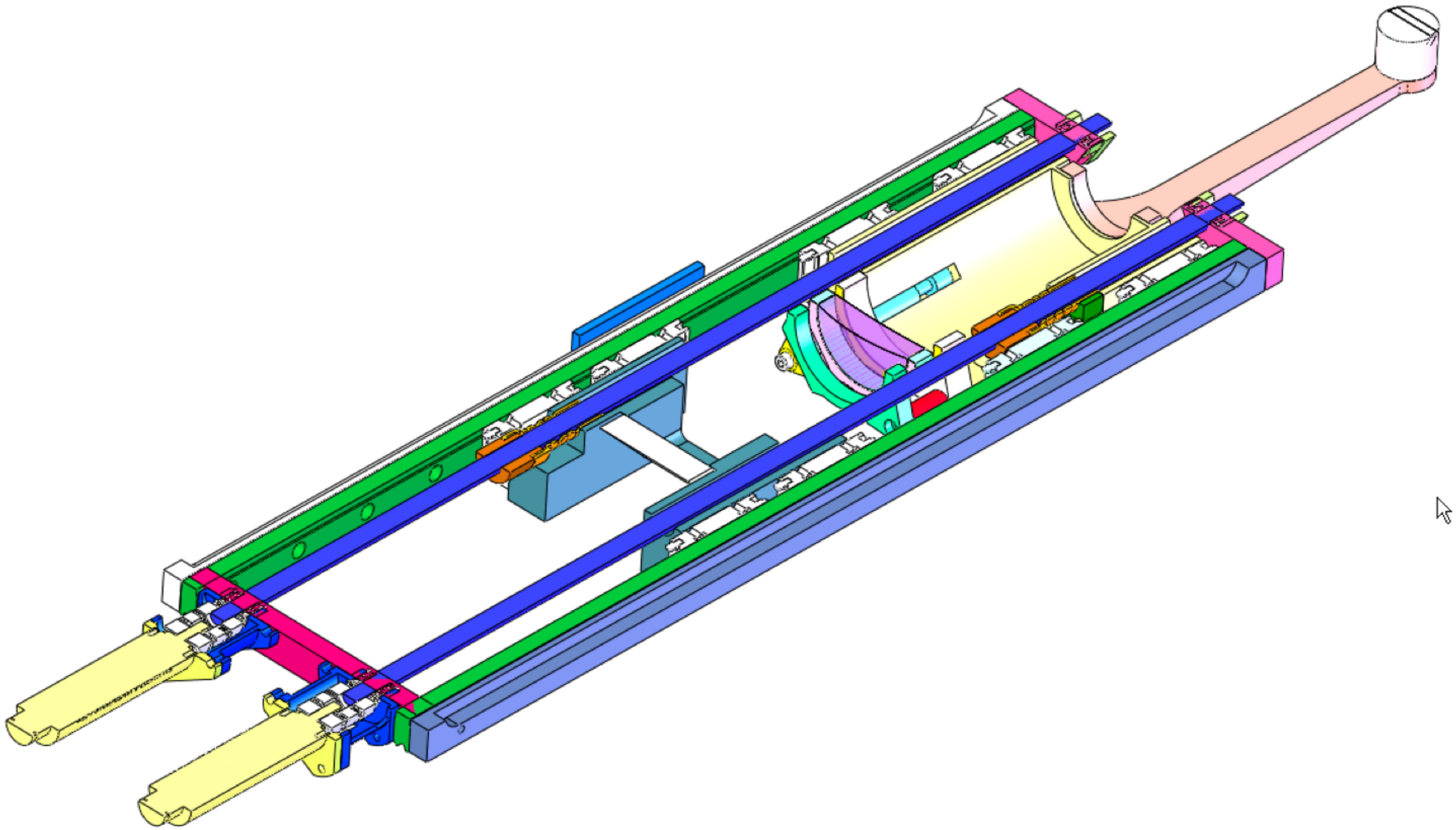


Theta-R Probe Mechanics

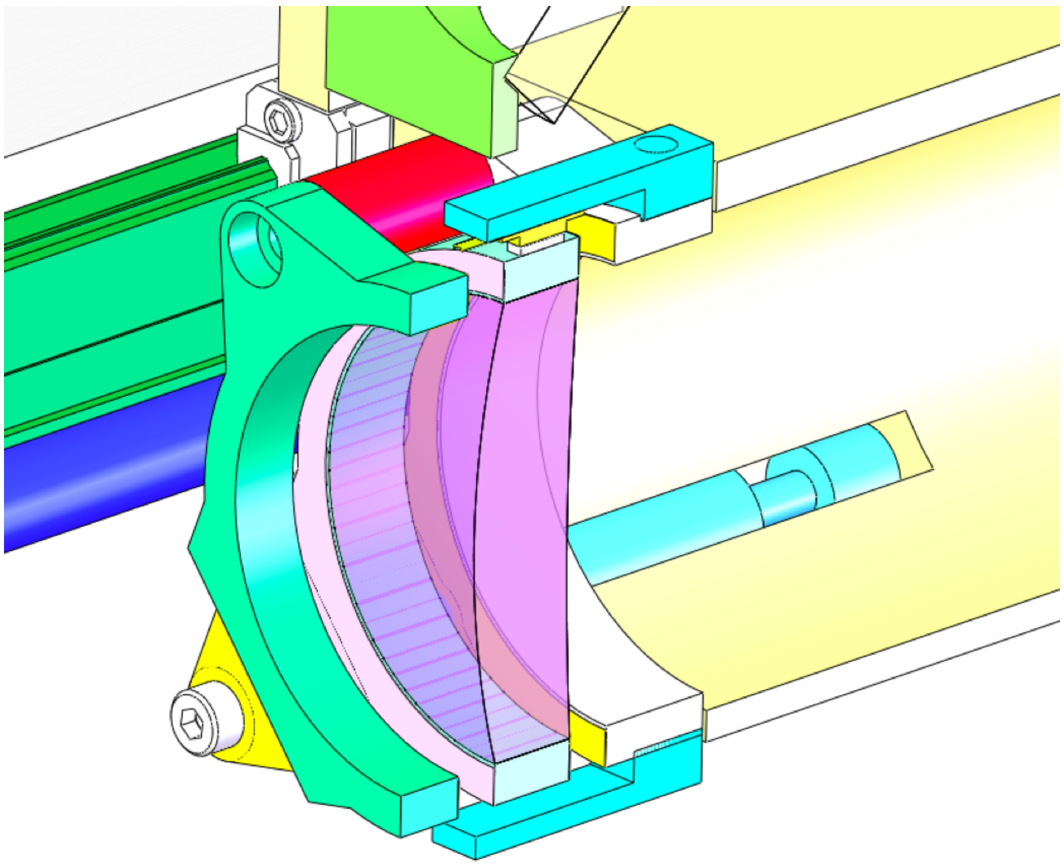


THIRTY METER TELESCOPE

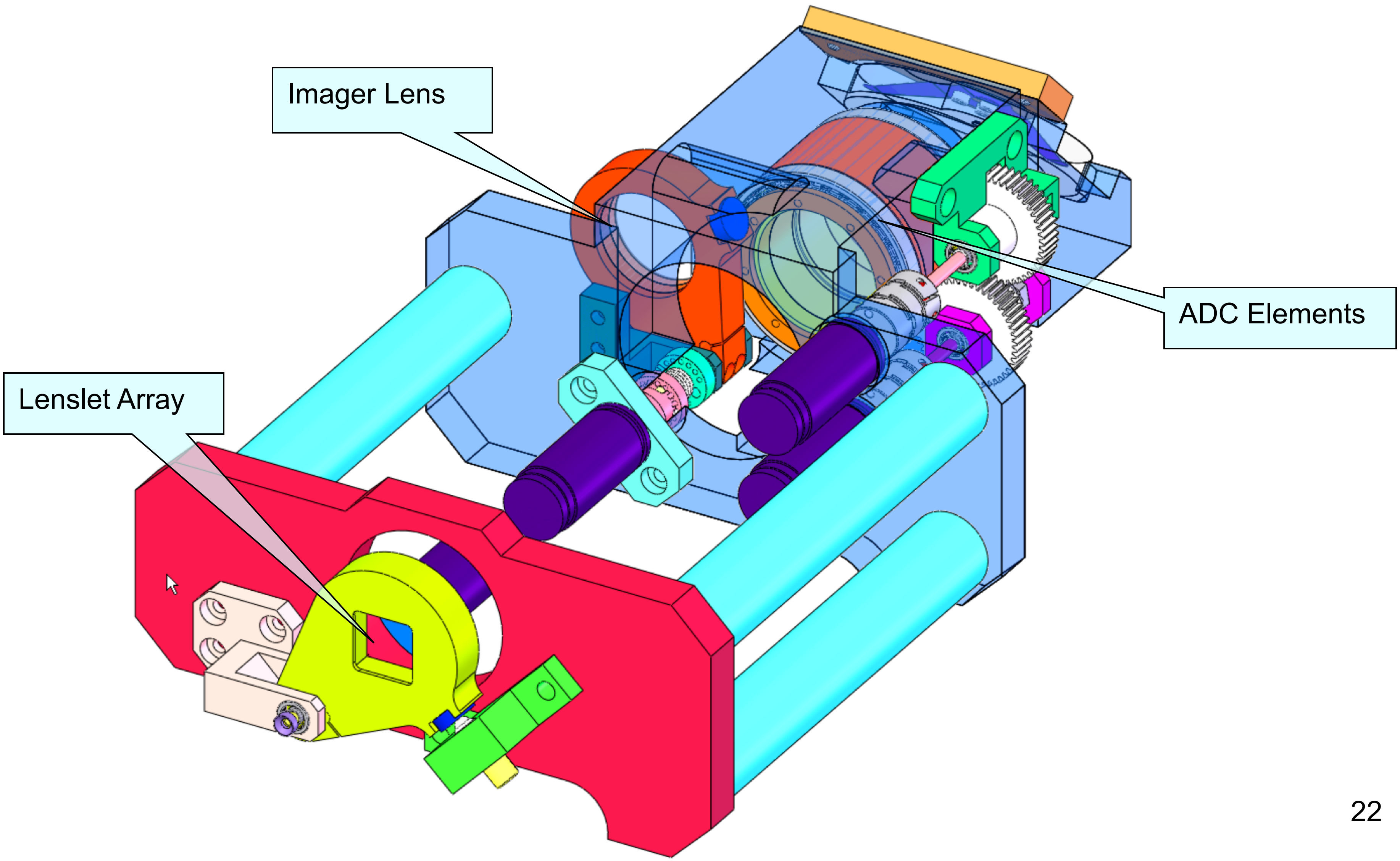
Custom Linear Stage



Collimator focus stage



Back end optics



TMT
THIRTY METER TELESCOPE

OIWFS Cameras

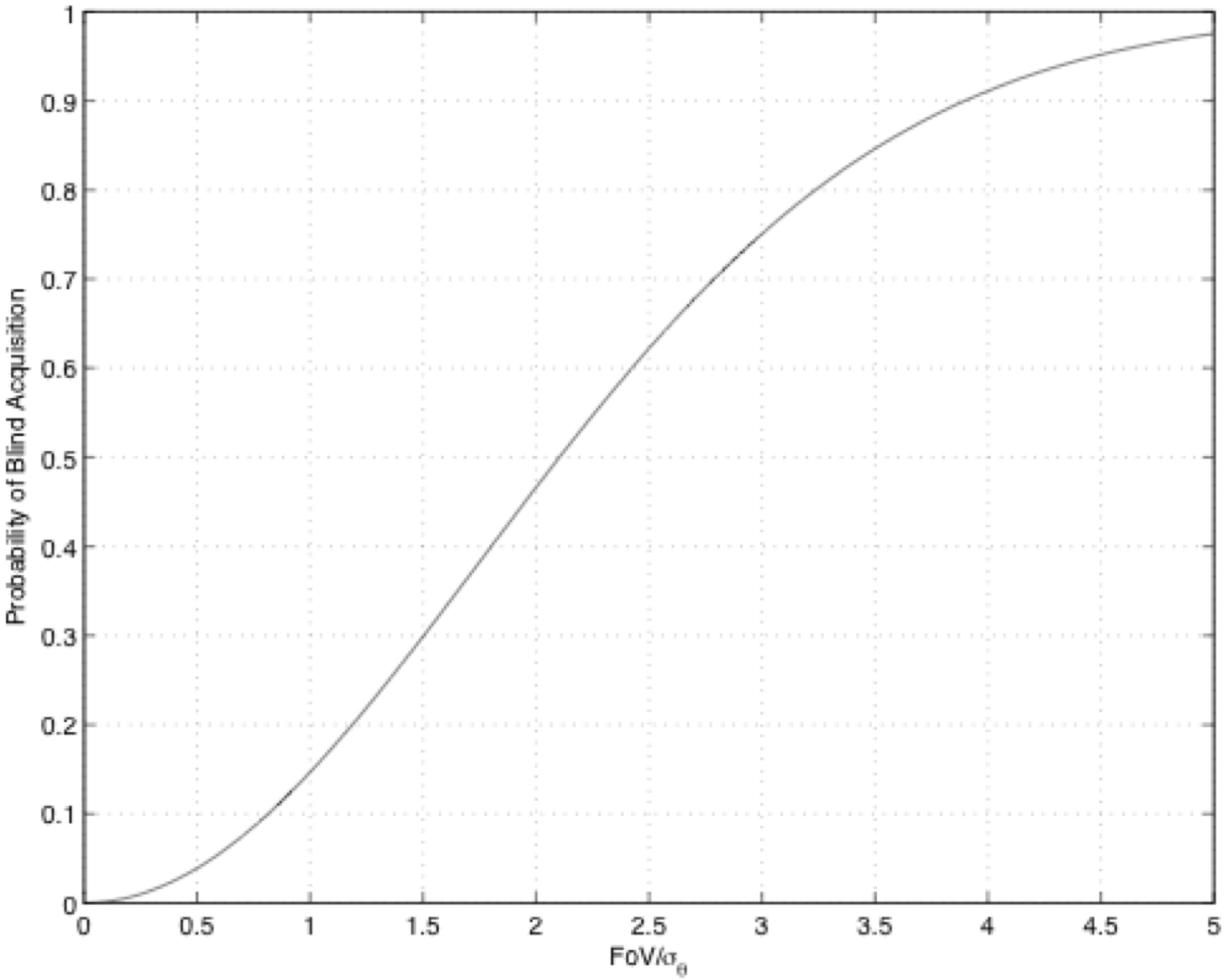
- TT pixel scale = $\lambda_H/2D$ = 5.67 mas/pixel
- TTF pixel scale = λ_H/D = 11.34 mas/pixel
  - Same detectors can be used for TT and TTF functions
- Analysis of tip/tilt jitter & image wander during acquisition shows worst case of ~250 mas
  - at 4σ and 5.67 mas/pixel > minimum of ~180x180 pixels
  - Acquisition probability > larger probe FoV > more pixels
- Hawaii HxRG 1024x1024 HgCdTe detector w/new MBE material testing underway – read noise, dynamics
- HgCdTe e-APDs and InGaAs emerging technologies

TMT

THIRTY METER TELESCOPE

Acquisition Probability

(Corinne Boyer, Luc Simard, 2008)



1024x1024 pixels

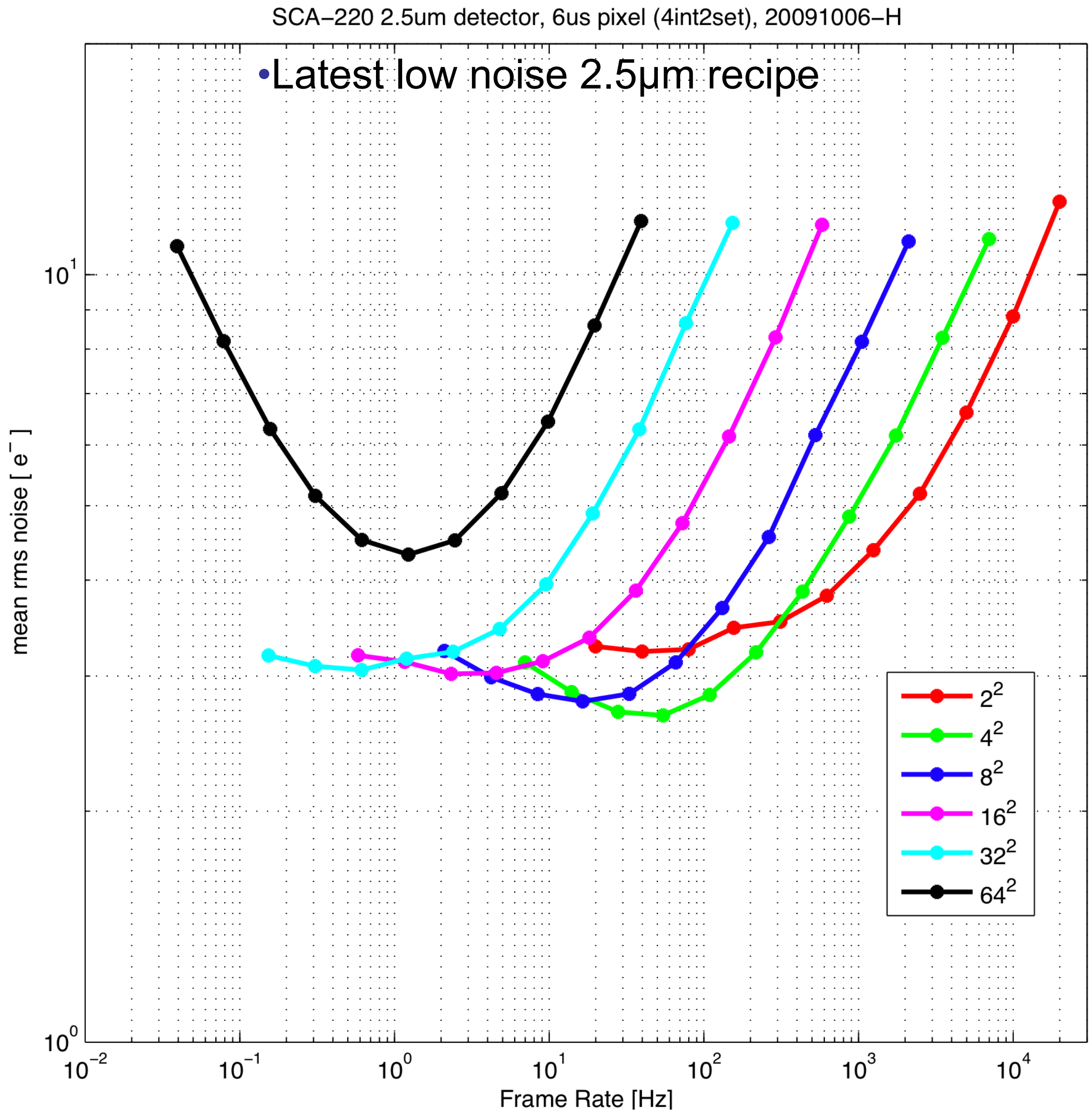
5.8’ probe FoV

1’ Telescope pointing σ_θ (worse at 1st light)

provide on-chip small dithering capability (2-3’)

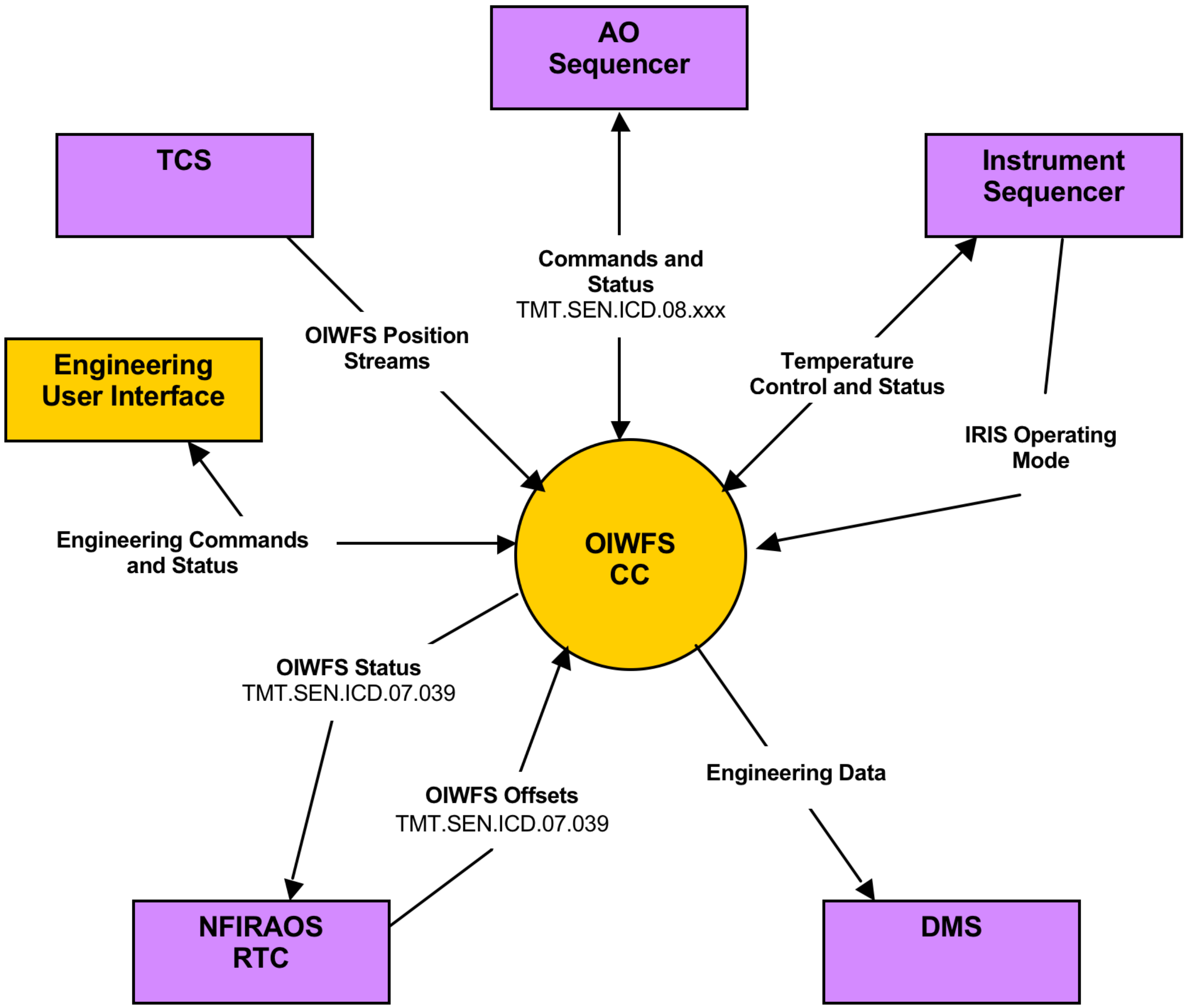
Noise vs. Frame Rate

measured for various frame sizes

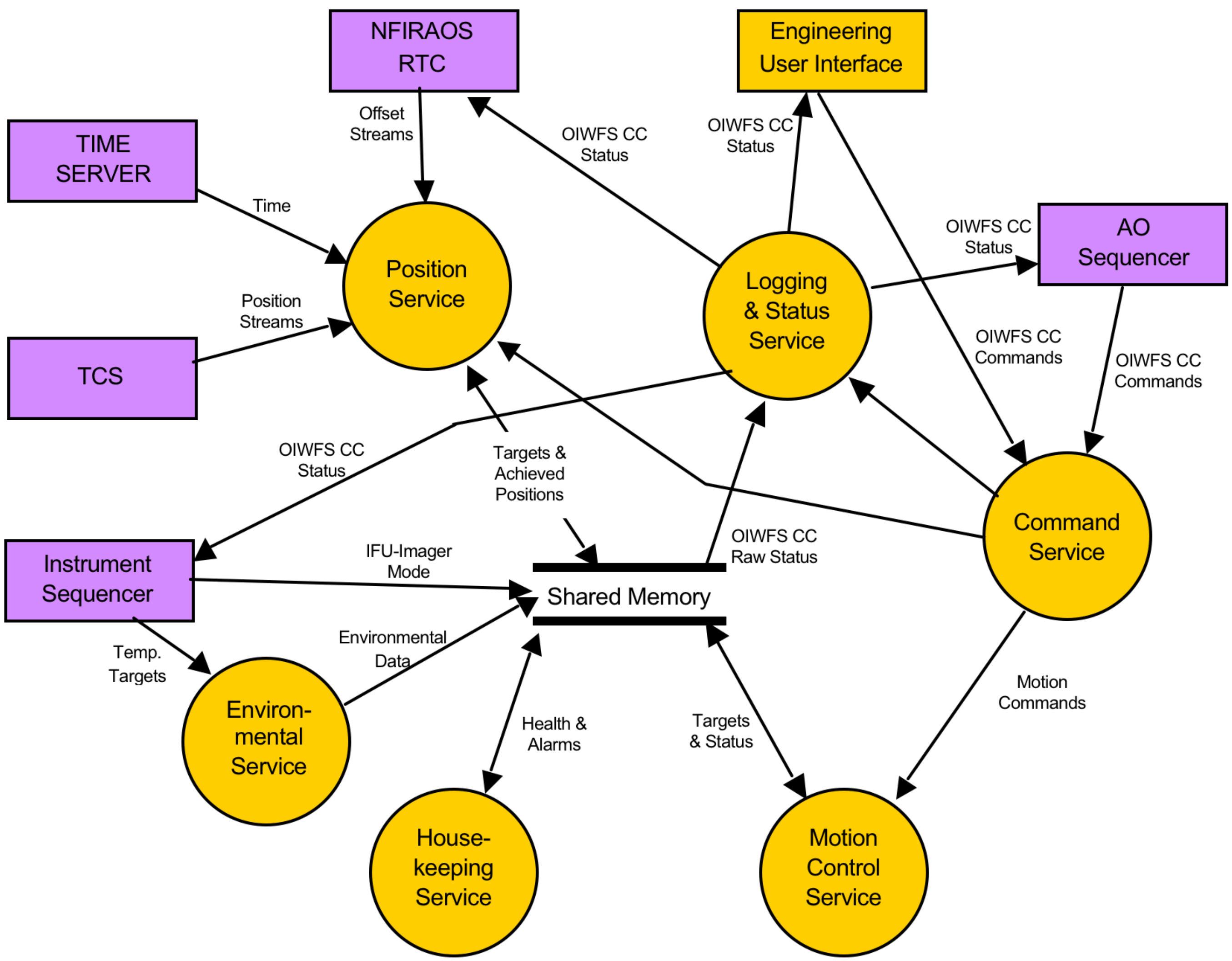


DfA Garching 2009-10-14

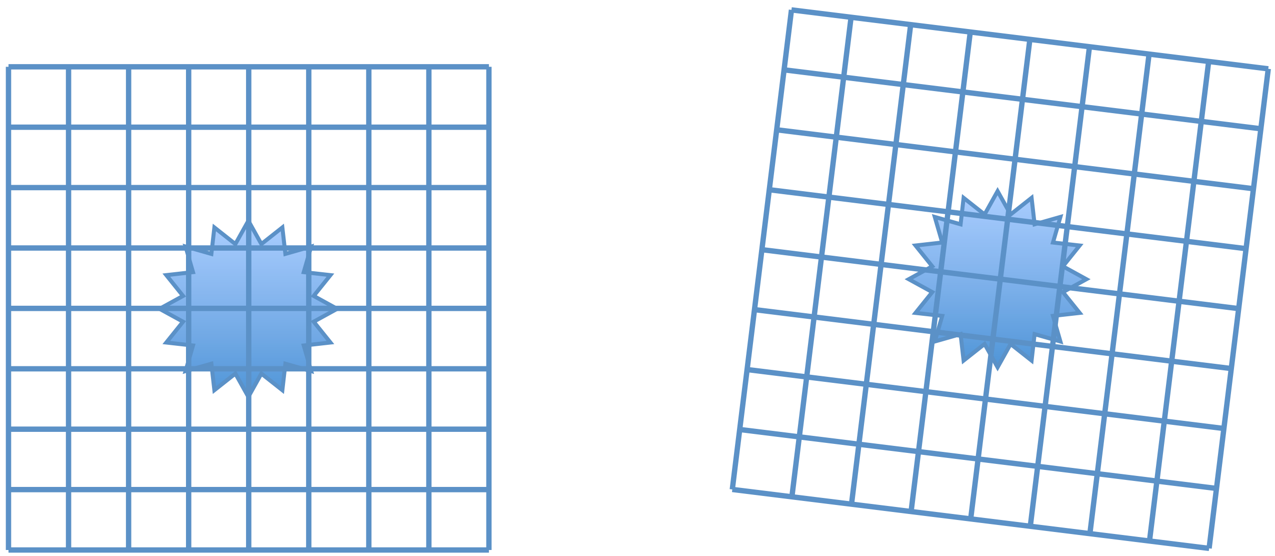
OIWFS Component Controller



CC Software Decomposition

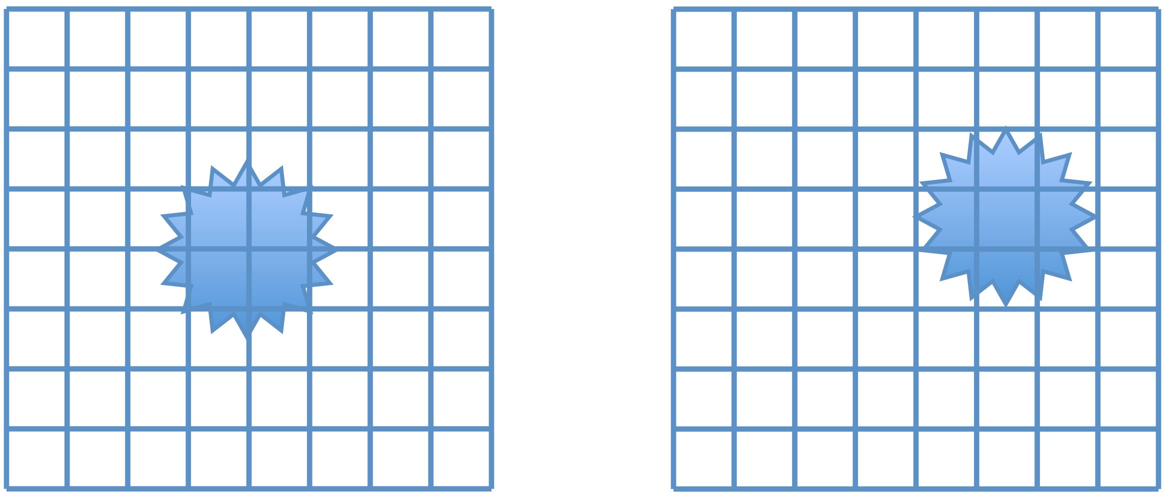


Opto-mechanical follow



THIRTY METER TELESCOPE

On-chip follow



Sky Coverage Update

(Lianqi Wang, Brent Ellerbroek, Jean-Pierre Veran, 2009)

- NGS mode errors combined with LGS mode errors of 178 nm RMS
- Overall on-axis budget of 187 nm RMS met at <u>45%</u> sky coverage
- Shortfall (in quadrature) of ~28 nm RMS at 50%
- System optimization still underway
  - Detector performance
  - “Fitting field” for LGS modes
  - Optimal choice of NGS modes and reconstructor