

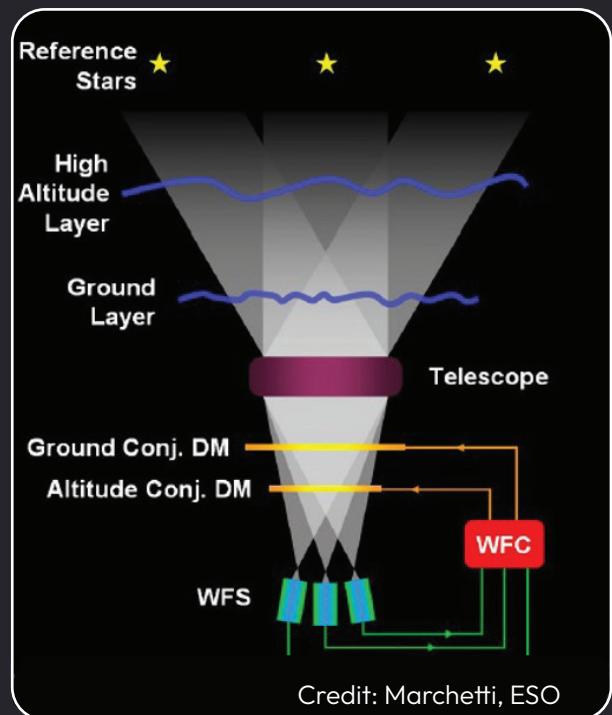
# NFIRAOS

## Multiconjugate Adaptive Optics

### Narrow Field InfraRed Adaptive Optics System

NFIRAOS is TMT's Adaptive Optics facility that will feed three science instruments, including TMT's first-light instruments, the **InfraRed Imaging Spectrograph (IRIS)** and the **Multi-Objective High Dispersion Infrared Spectograph (MODHIS)**.

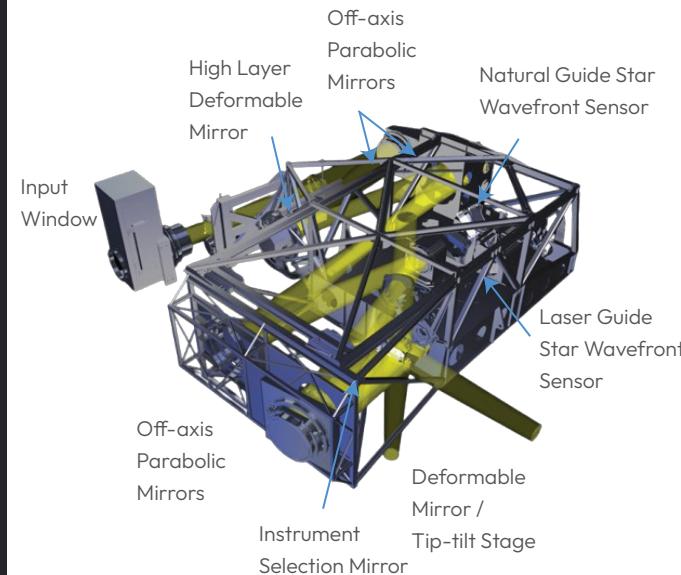
NFIRAOS is a Multi-Conjugate Adaptive Optics (MCAO) system that uses 2 deformable mirrors and 6 laser guide star wavefront sensors to deliver diffraction-limited performance in J, H, and K-bands over a uniform 34 x 34 arcsecond field of view.



# NFIRAOS

## Ready for Fabrication

NFIRAOS design has been led by NRC HAA with contributions from industrial partners. NFIRAOS completed its Final Design Review in 2018. Cilas is manufacturing the deformable mirrors. NRC is ready to start NFIRAOS fabrication.



- Systems Engineer: Glen Herriot
- Project Manager: Scott Roberts
- Lead AO Scientist: Jean-Pierre Véran
- Real Time Controller Lead: Jennifer Dunn
- AO Work Package Manager: Corinne Boyer
- AO Simulations: Lianqi Wang



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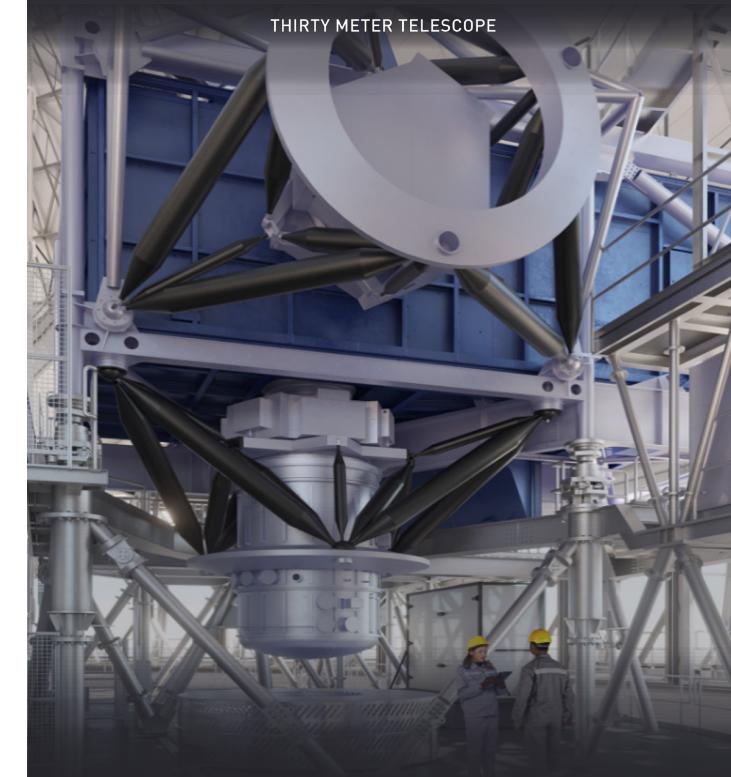
ABB

TMT

Quantum Technology

Cilas  
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**TMT**  
THIRTY METER TELESCOPE



# NFIRAOS

**Sharper, Clearer, Deeper –**  
NFIRAOS Is At The Cutting Edge

Canada  
**NRC-CRC**

UNIVERSITY  
OF  
CALIFORNIA

Department of  
Science &  
Technology,  
Government of  
India  
संस्कृत जगत

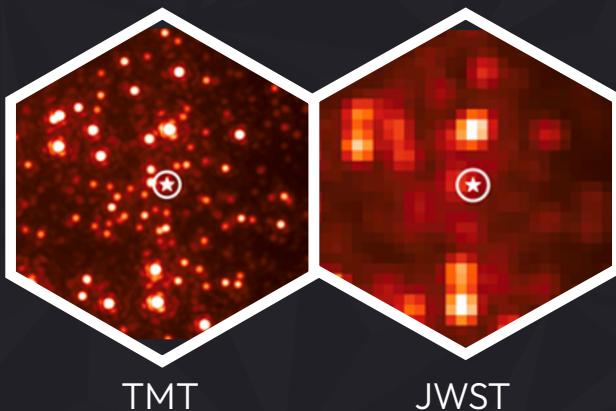
**NINS**  
National Institutes of Natural Sciences  
自然科学研究機構

**Caltech**

# NFIRAOS

## Science Highlights

- Images with NFIRAOS will be **4.5x sharper than JWST!**
- More sensitive than JWST for compact targets, especially in crowded fields. And more than **150x as sensitive as current 10- meter-class telescopes.**



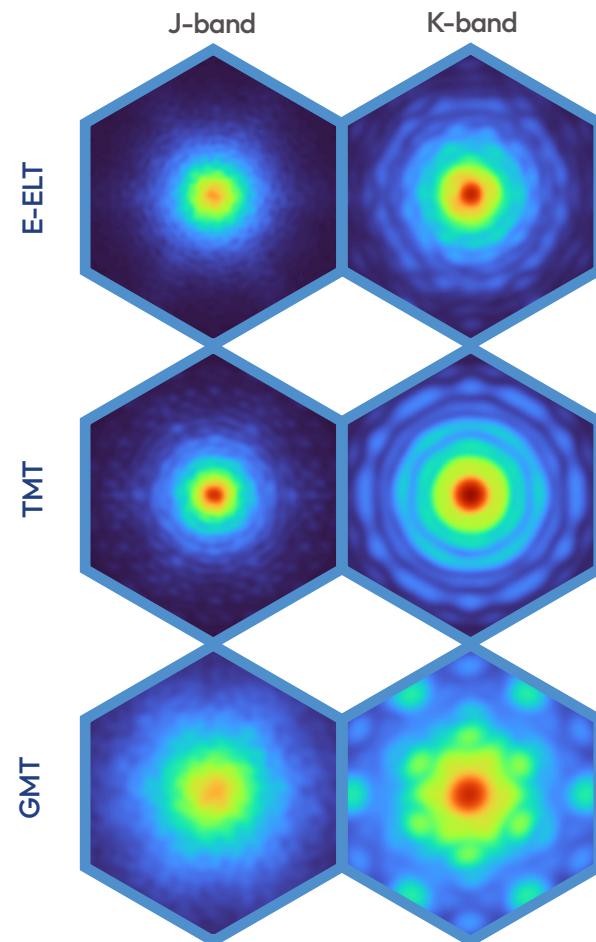
Simulations of NFIRAOS + IRIS (left) and JWST (right) images of the central one arcsecond of the Milky Way, centered on the supermassive black hole, Sgr A\* showing the power of NFIRAOS when making observations in crowded regions. Credit: UCLA Galactic Center Group

- NFIRAOS will deliver this performance with **>50% sky coverage at the North Galactic Pole** and **>99% sky coverage** near the Galactic Plane.
- NFIRAOS will be able to make astrometric measurements with a noise floor of **15  $\mu$ as**, allowing TMT to observe the orbits of stars in nearby galaxies!

# NFIRAOS

## Performance

NFIRAOS has been co-designed with the telescope to ensure that no design decisions compromise adaptive optics (AO) performance. Its performance is well understood, supported by an error budget that accounts for over 20 contributing terms. As a result, NFIRAOS is expected to deliver best-in-class AO performance.



Comparison of the point spread functions from E-ELT, TMT and GMT in J and K-bands. E-ELT and GMT performance based on latest published works.

# NFIRAOS

## Driving Requirements

Throughput	>60% (0.80-1 $\mu$ m) >80% (1-2.4 $\mu$ m)
Low Thermal Emission	NFIRAOS cooled To -30° C.
Diffraction Limited	227 nm RMS Wavefront Error over 34"x34" Field Of View
Sky Coverage	50% Sky Coverage at North Galactic Pole
Photometric Accuracy	2% over 34"x34" Field Of View
Astrometric Accuracy	50 $\mu$ as Over 34"x34" Field Of View in 100 sec exposure (15 $\mu$ as Systematic Error)
Observing Efficiency	<5 minutes between AO observing sequences
Deformable Mirrors	63x63 And 76x76 actuators with 5 mm spacing, 10 $\mu$ m stroke 15% hysteresis.
Tip-tilt Stage	500 $\mu$ rad with 0.05 $\mu$ rad angular resolution, 80 Hz bandwidth
NGS WFS	Pyramid Wavefront Sensor, 240x240 EMCCD, 96x96 Virtual subapertures, >90% QE 1 electron Read Noise
LGW WFS	CMOS With 75x75 subapertures 11x11 pixels per subaperture <3 electrons Read Noise Operating at up to 600 Hz
Real Time Controller	Solve 55k X 8k Reconstruction at 800 Hz.