

## The Narrow Field InfraRed Adaptive Optics System (NFIRAOS)

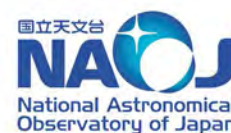
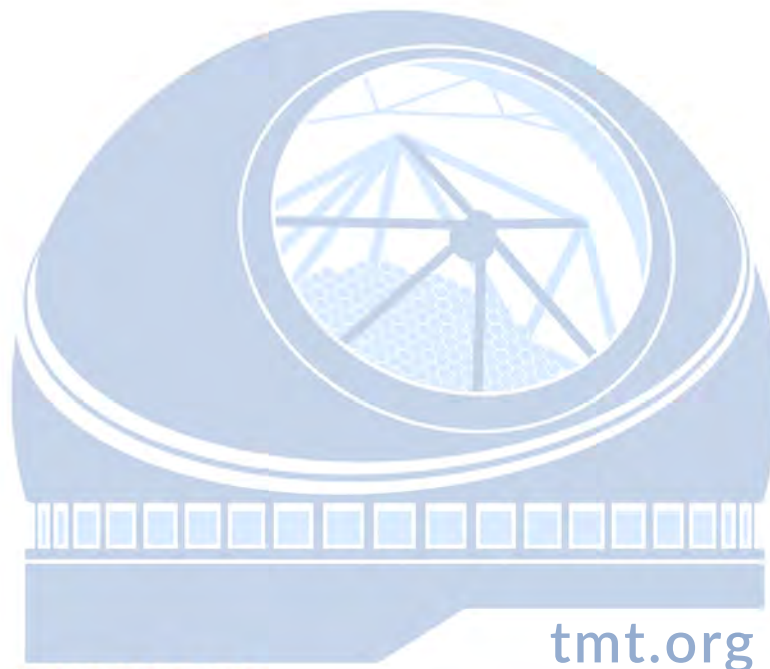
NFIRAOS is TMT's Adaptive Optics facility that will feed three science instruments, including TMT's first-light instruments IRIS and MODHIS. NFIRAOS uses 2 deformable mirrors and 6 laser guide star wavefront sensors to deliver diffraction-limited performance in J, H and K bands over a uniform 34 x 34 arcsec field of view.

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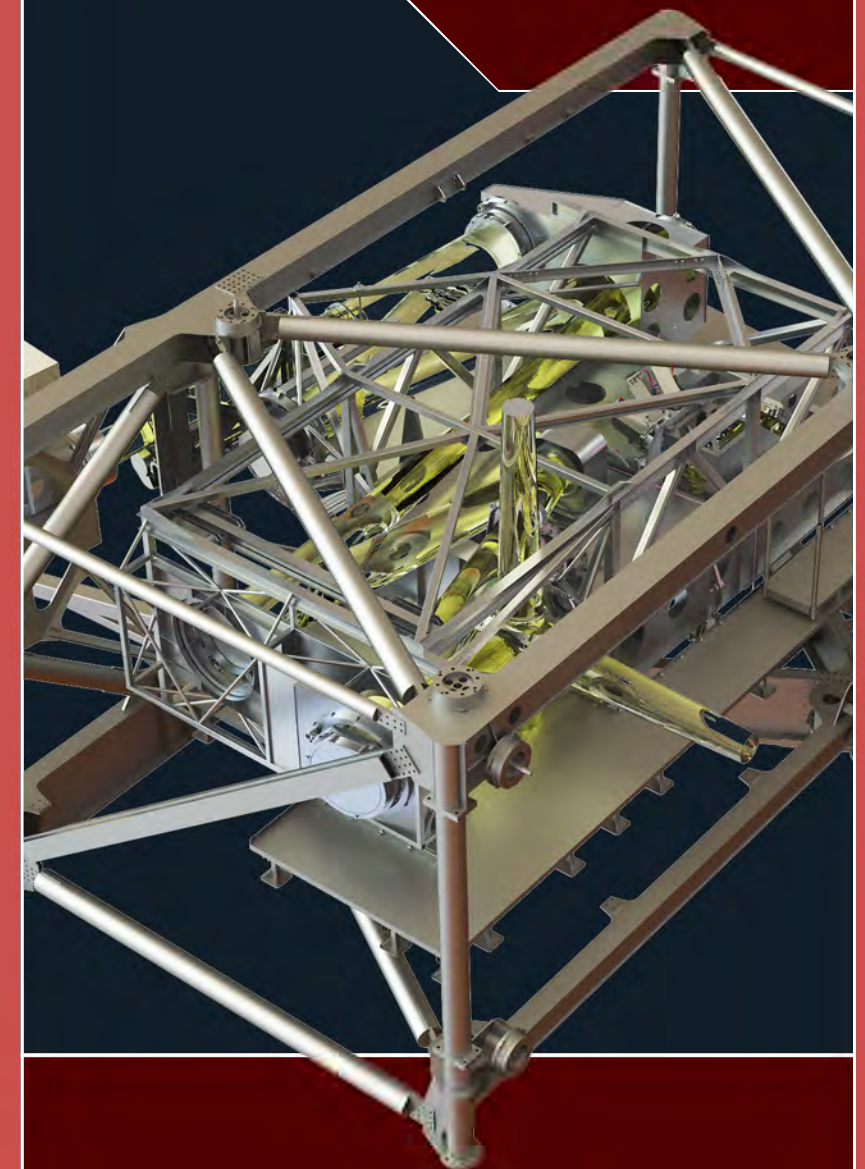
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## Notes



  
**TMT**  
THIRTY METER TELESCOPE



The Narrow Field InfraRed Adaptive Optics System (NFIRAOS)

**NFIRAOS is TMT's high performance Multi-Conjugate Adaptive Optics (MCAO) system. Its main specifications are:**

**Multi-Conjugate AO (MCAO):**

The combination of the 2 DM and 6 LGS will provide a corrected wavefront over a 2 arcmin field of view.

**High-order Deformable Mirrors:**

NFIRAOS will also be equipped with two high-order deformable mirrors (DM) for improved wavefront correction. The two DMs will be conjugated at 0 km and 11.8km altitude (63x63 and 76x76 actuators respectively) to provide high wavefront quality.

**Laser Guide Star (LGS):**

A Laser Guide Star (LGS) facility will ensure that NFIRAOS's sky coverage is at least 50% at the galactic poles.

**NGS Pyramid WFS:**

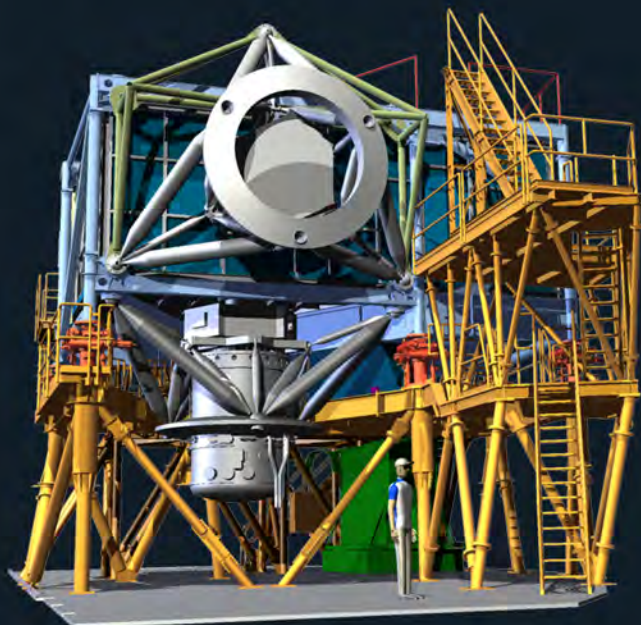
A pyramid wavefront sensor (WFS) will be used for on-axis Natural Guide Star (NGS) observations, and whenever high-contrast performance is required.

**Low thermal background:**

To reduce the thermal emission of its many optical components, and improve its sensitivity and performance, NFIRAOS will be cooled to -30°C.

**Near-Infrared tip-tilt and focus wavefront sensing within NFIRAOS science instruments:**

Up to three tip-tilt wavefront sensors will be available over a 2 arcmin field of view within each instrument. In addition, for IRIS, up to 4 guide regions on science detectors will be used to correct the residual tip/tilt and plate scale errors.



Rendering of NFIRAOS (blue) with the IRIS instrument (grey) attached below, on one of TMT's Nasmyth platform.

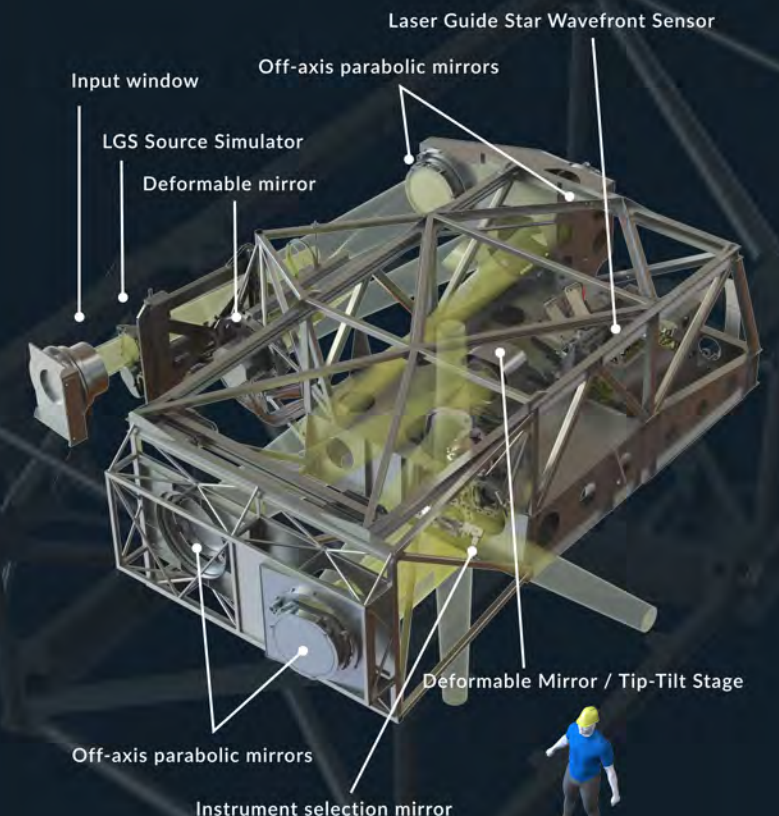
**NFIRAOS is TMT's first light AO facility**

**Requirements Values**

High throughput	>60% over 0.80-1 $\mu\text{m}$ >80% over 1-2.4 $\mu\text{m}$
Low Thermal emission	15% of ambient sky + telescope
Diffraction limited	Wavefront error of 193 nm RMS on axis or 207 nm RMS over a 34 arcsec x 34 arcsec field of view
High sky coverage	From 50% at galactic pole to 99% along galactic plane
High photometric accuracy	2% over 30 arcsec at 1 $\mu\text{m}$ for a 10 minute exposure
High astrometric accuracy	50 $\mu\text{arcsec}$ over 34 arcsec in H band for a 100 second exposure (10 $\mu\text{arcsec}$ systematic error)
High observing efficiency	No more than 5 min between AO observing sequences
Deformable mirrors	63x63 and 76x76 actuators at 5mm spacing, 10 $\mu\text{m}$ stroke, 15% hysteresis and operating at -30C
Tip/tilt stage	500 $\mu\text{rad}$ with 0.05 $\mu\text{rad}$ angular resolution, 80 Hz bandwidth
NGS WFS detectors	240x240 EMCCD, 96x96 virtual sub-apertures, >0.9 quantum efficiency, 1 electron read noise
LGS WFS detectors	CMOS with 75x75 sub-apertures with 11x11 pixels each, less than 3 electrons read noise and operating at up to 600 Hz
Real time controller	Solve 55k x 8k reconstruction problem at up to 800 Hz

**NFIRAOS Specifications**

**TMT's center-launched Laser Guide Star Facility (LGSF):**



The baseline asterism for NFIRAOS LGS will be the Multi-Conjugate Adaptive Optics mode (MCAO). Available at first-light, it consists of 6 LGS, one on-axis and 5 equally spaced on a circle of a 35 arcsec radius.

Other asterisms will be available to support future TMT instruments:

- MIRAO for mid-infrared adaptive optics observations
- MOAO to support multi-object AO observations with imaging spectrographs
- GLAO to improve the image quality produced by the lower atmospheric layers



**NFIRAOS and TMT's Laser Guide Star (LGS) system**