
# IRIS: Infrared Imaging Spectrograph for the Thirty Meter Telescope (TMT)

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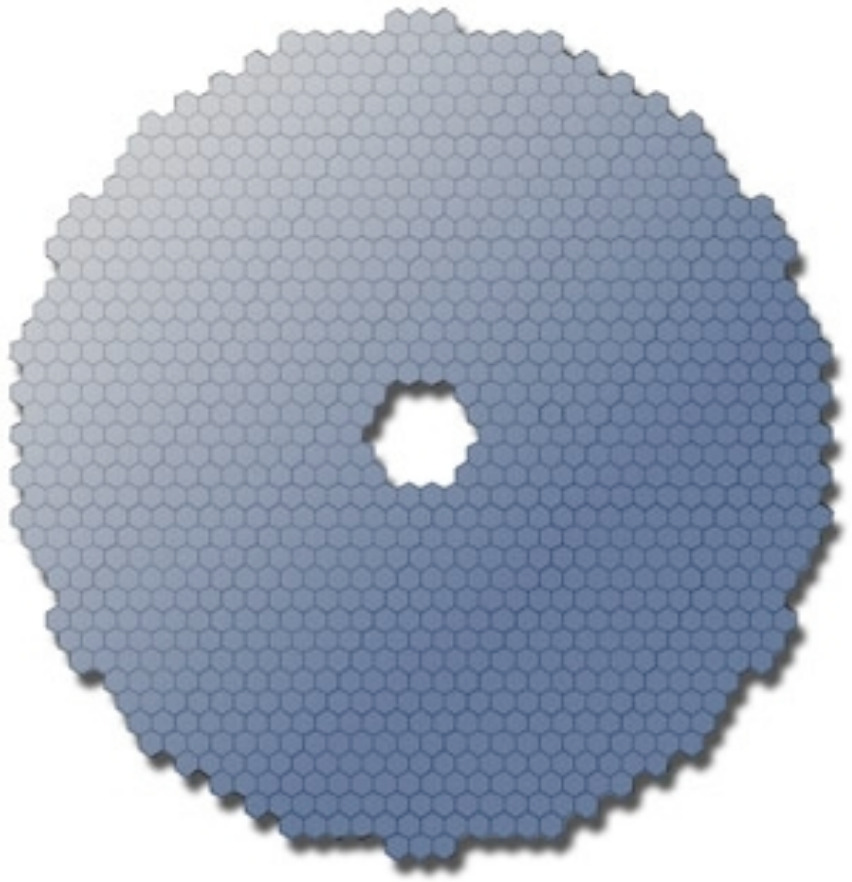
Dunlap Instrumentation Summer School - Toronto

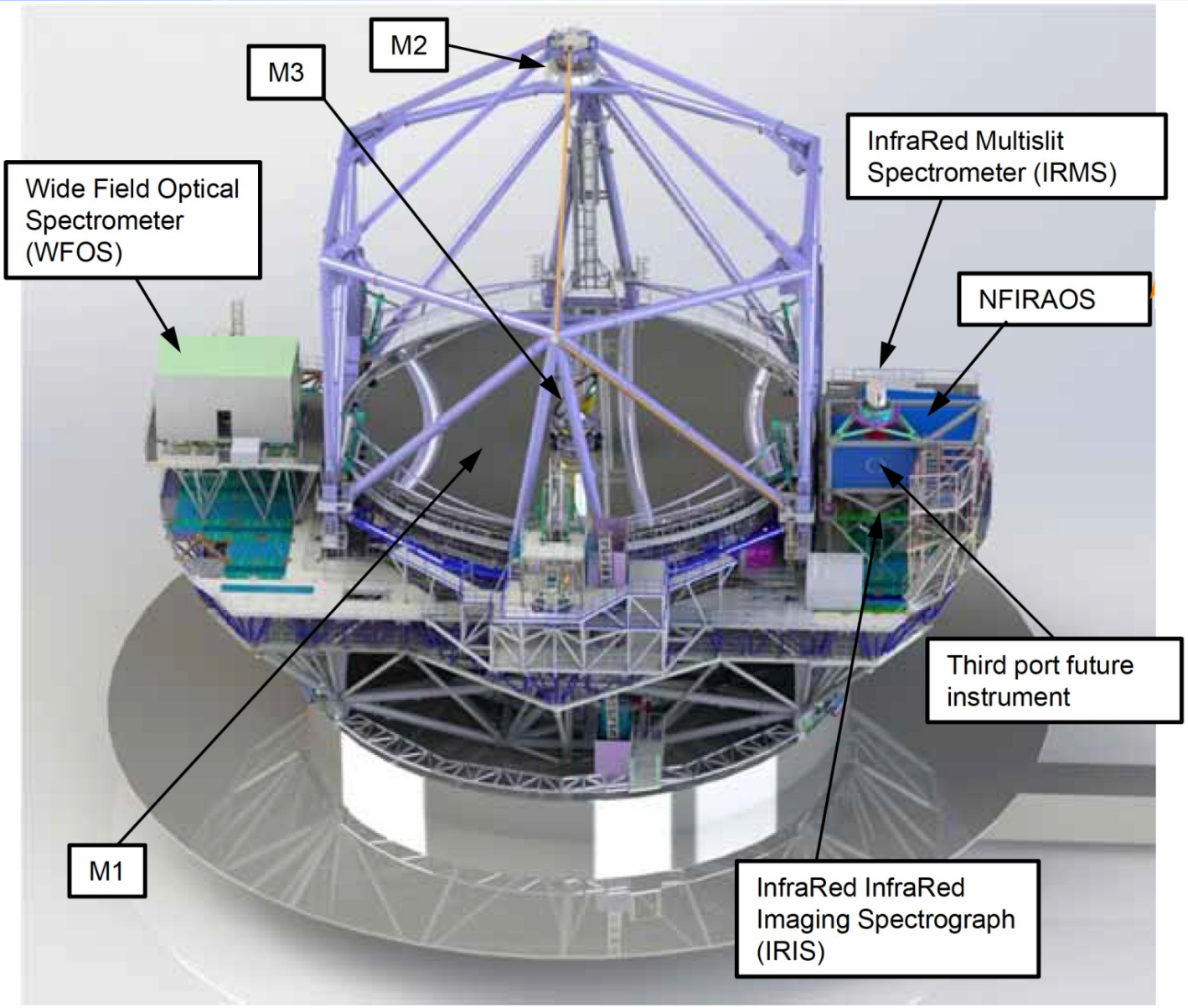
# Extremely Large Telescopes

Aperture Size ~ 76 $m^2$
Diffraction Limit (1 µm) ~ 0.025”



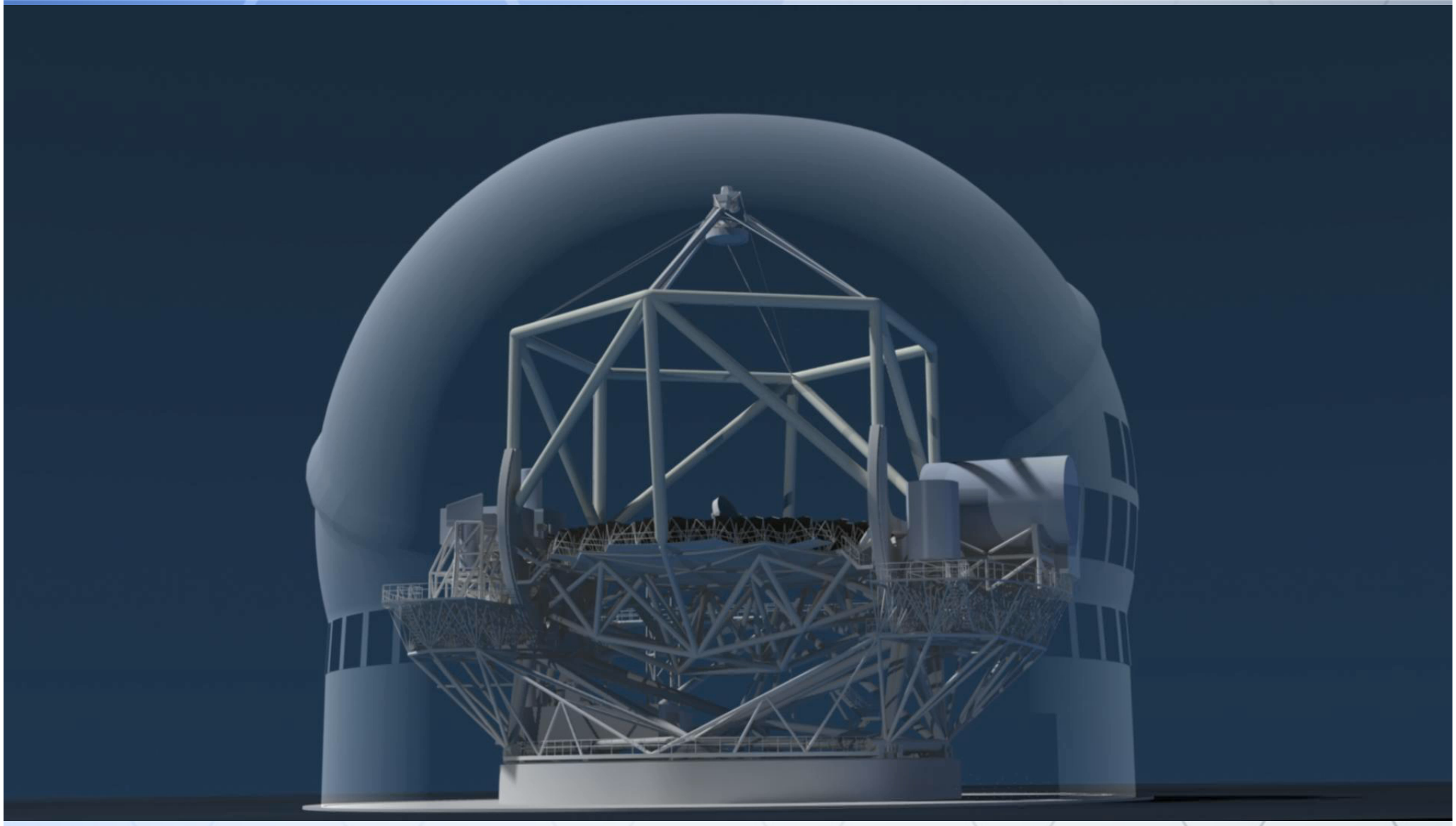
Aperture Size ~ 630 $m^2$
Diffraction Limit (1 µm) ~ 0.0083”

# Thirty Meter Telescope



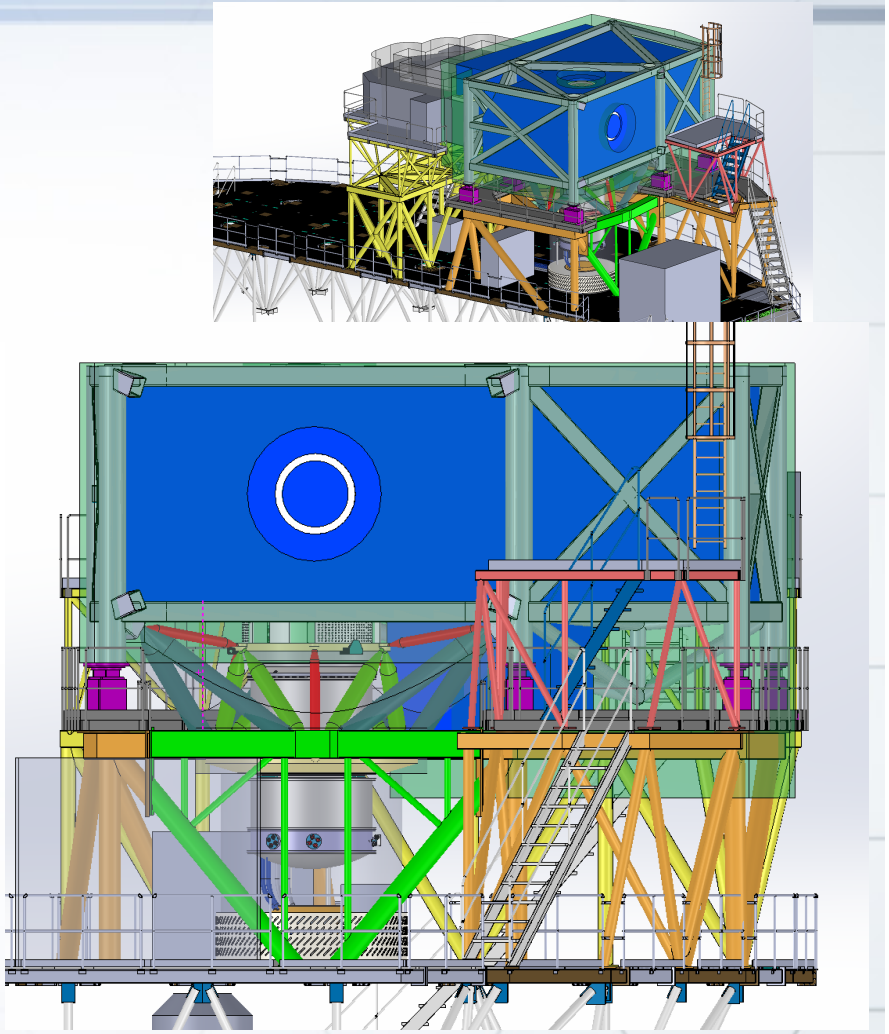

- Ritchey-Chrétien optical design
- 492 segments
- 30-m f/1 primary
- 3.1-m convex secondary
- 2.5 m x 3.5 m flat tertiary
- f/15 final focal ratio
- 20’ Field of view is 2.62m in diameter
- Science instruments mounted on Nasmyth platforms (fixed gravity vector)

# TMT Optical Path



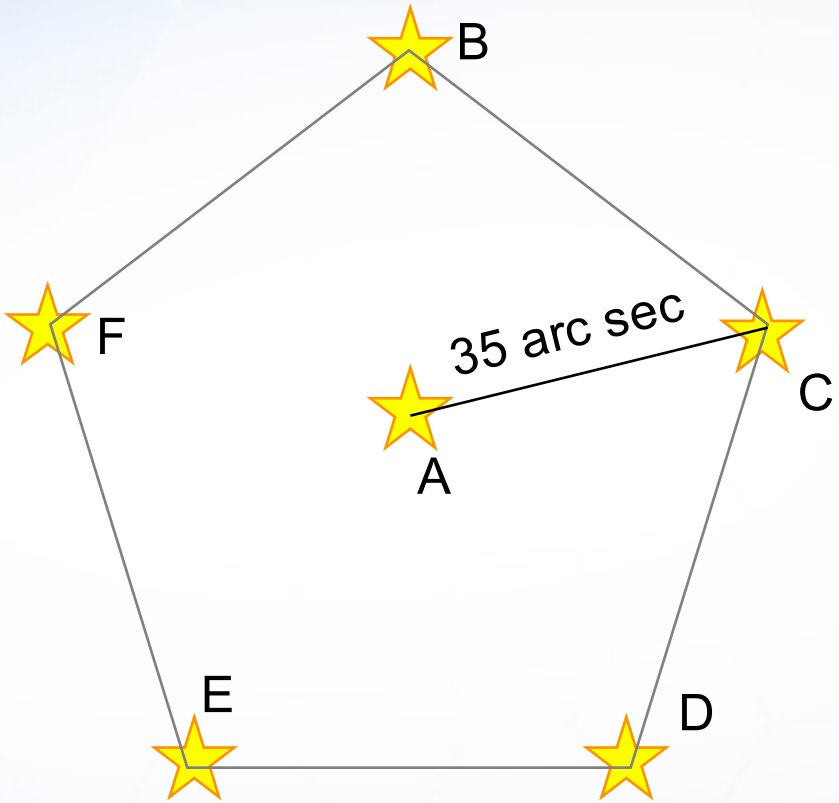
# NFIRAOS – Adaptive Optics System

- Multiconjugate Laser AO system
- Outputs 2 arcminute corrected field to three output ports
- 6 Laser WFSs with 60x60 spatial sampling at 800Hz sampling
- Two deformable mirrors
- Cooled to -30C for thermal background
- Client instruments have their own infrared wavefront sensors



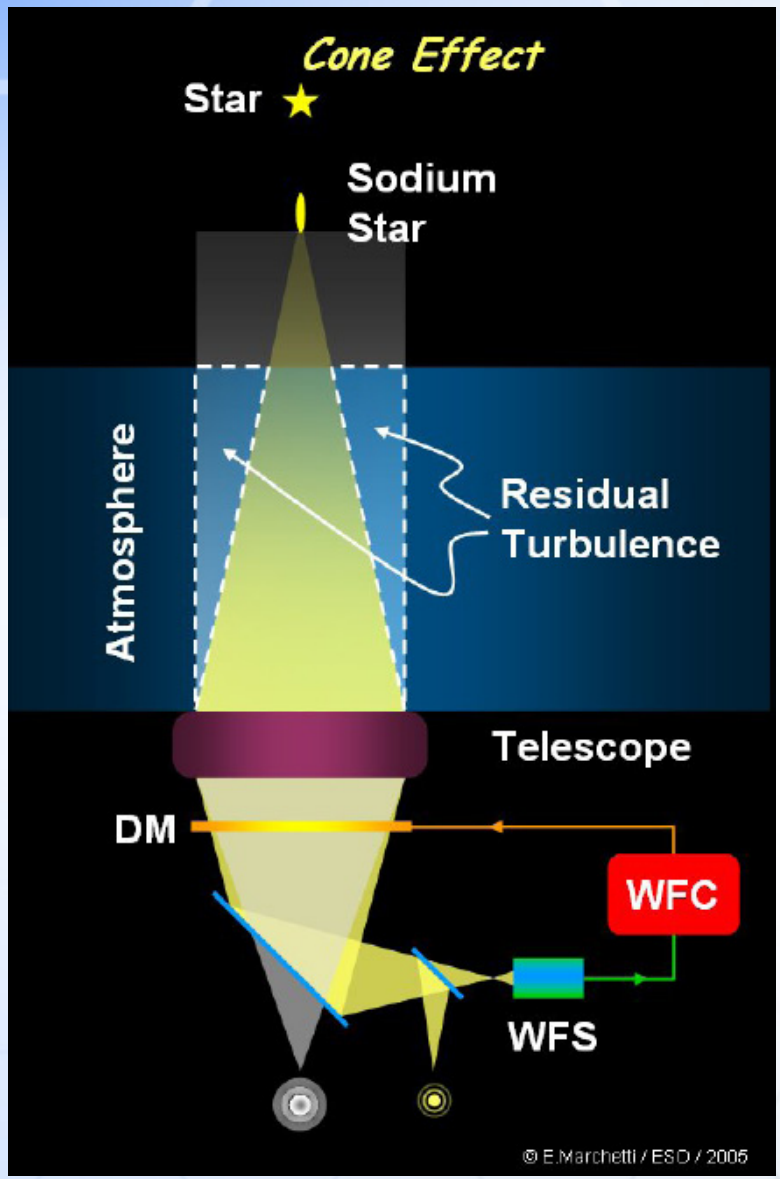
David Anderson
Adaptive Optics Lecture
Wavefront Sensor Lab

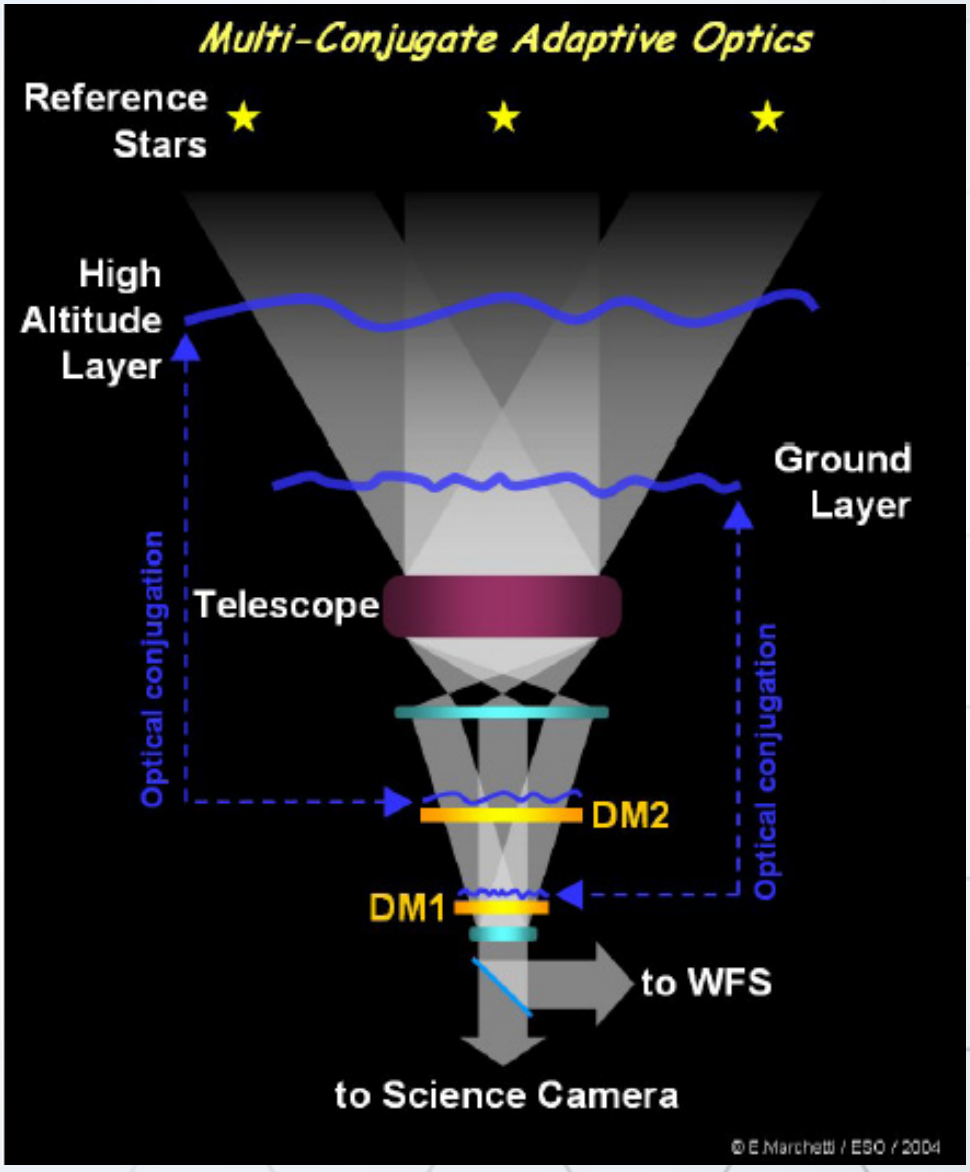
# LGS Asterism



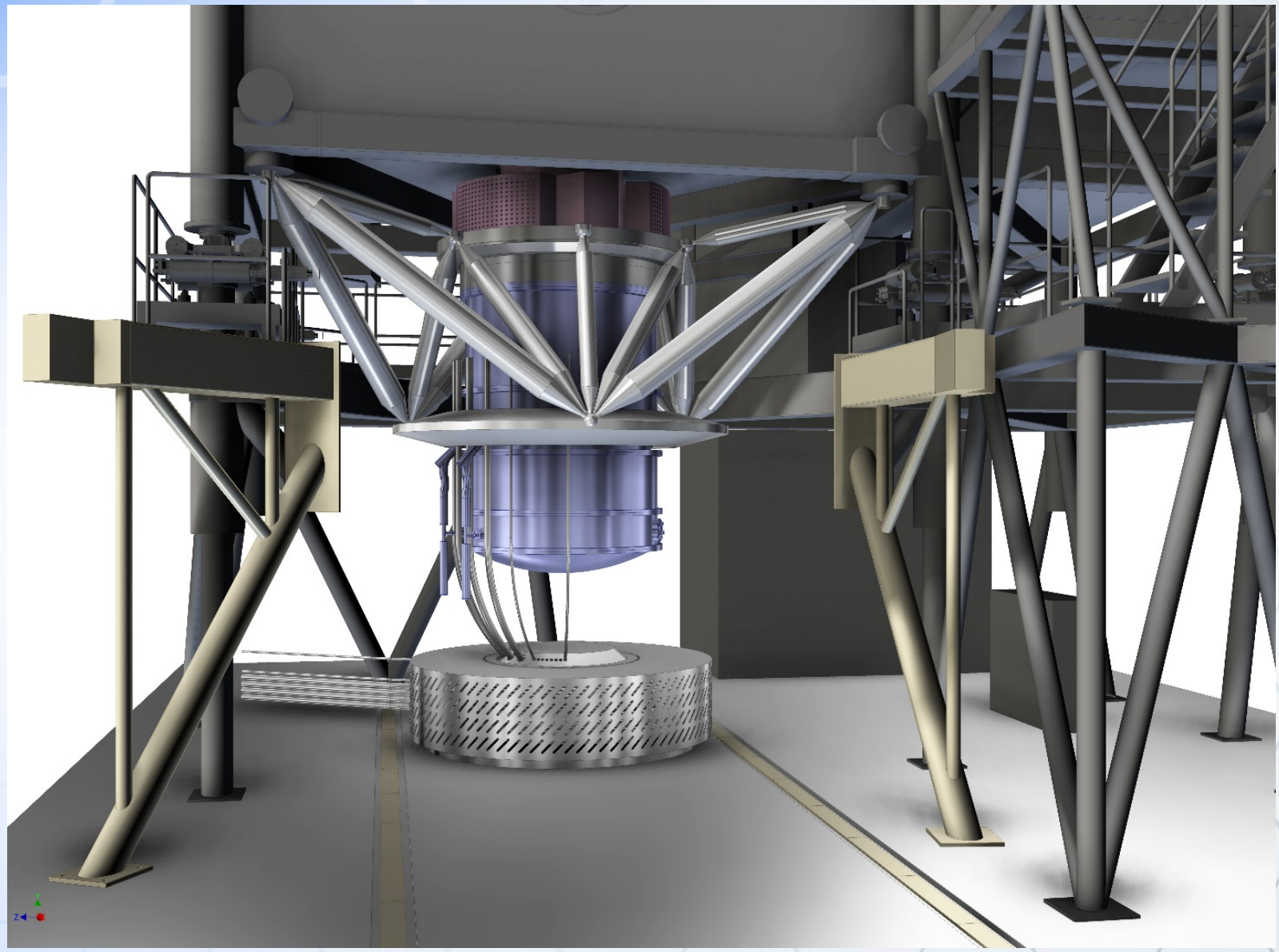

Axis of symmetry

# Multi-conjugate adaptive optics



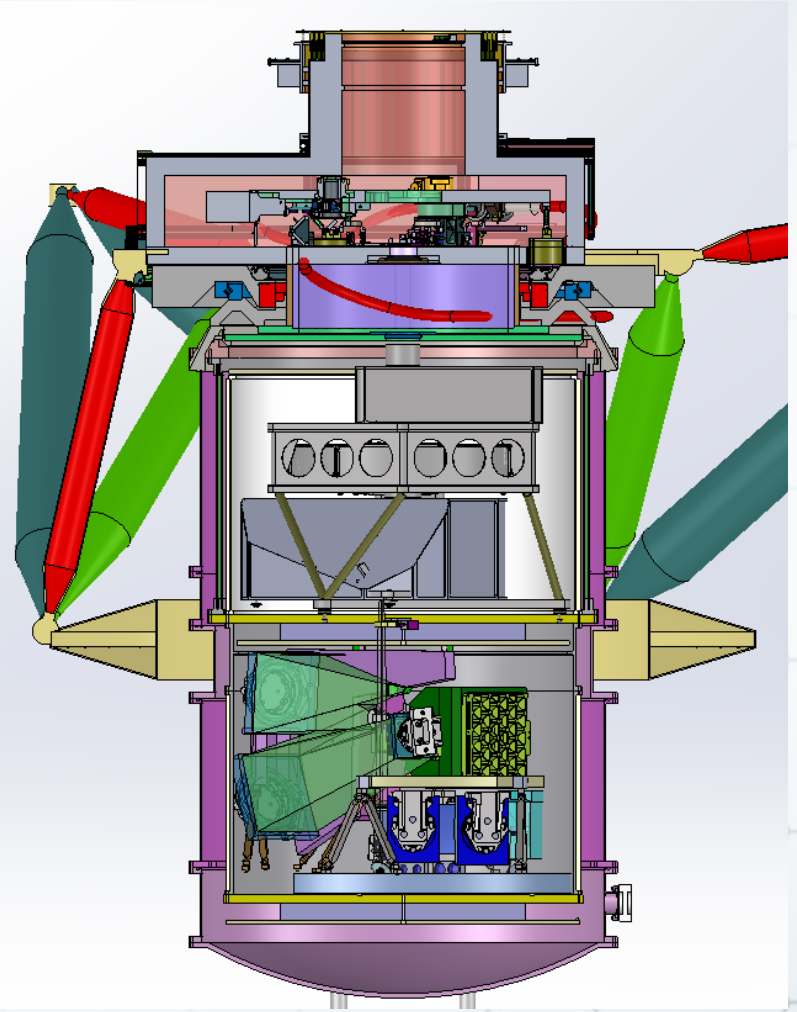



# IRIS designed to operate at TMT diffraction-limit



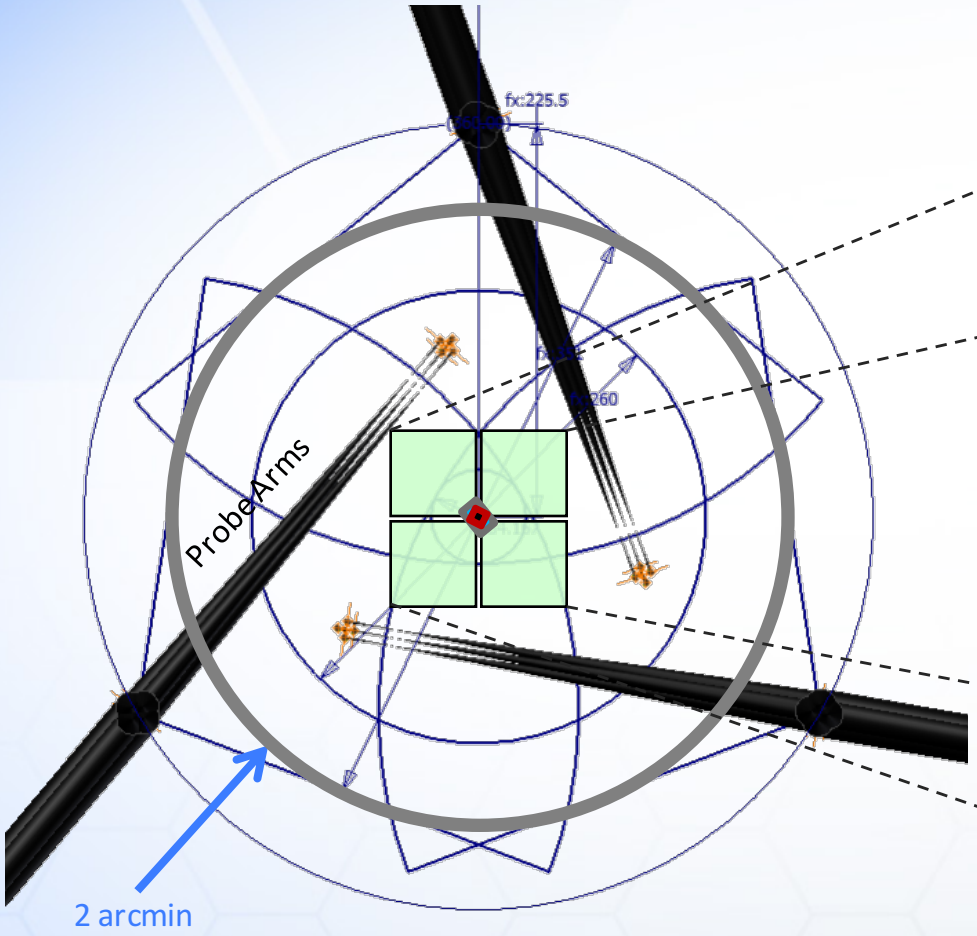
# IRIS Capabilities

- **Diffraction limited spectrograph and imager to work with NFIRAOS**
  - Wavelength Range 0.84 - 2.4 microns
- **On-Instrument deployable wavefront sensors (OIWFS)**
  - Three sensors to measure tip/tilt, focus and distortion across field.
- **Imager**
  - 34 arcsec field of view
  - 0.004 " per pixel
  - Parallel observations with IFS
- **Integral Field Spectrograph**
  - R=4000, 8000, 10000
  - Four Plate Scales: 0.004, 0.009, 0.025, 0.050 arcsec per sample

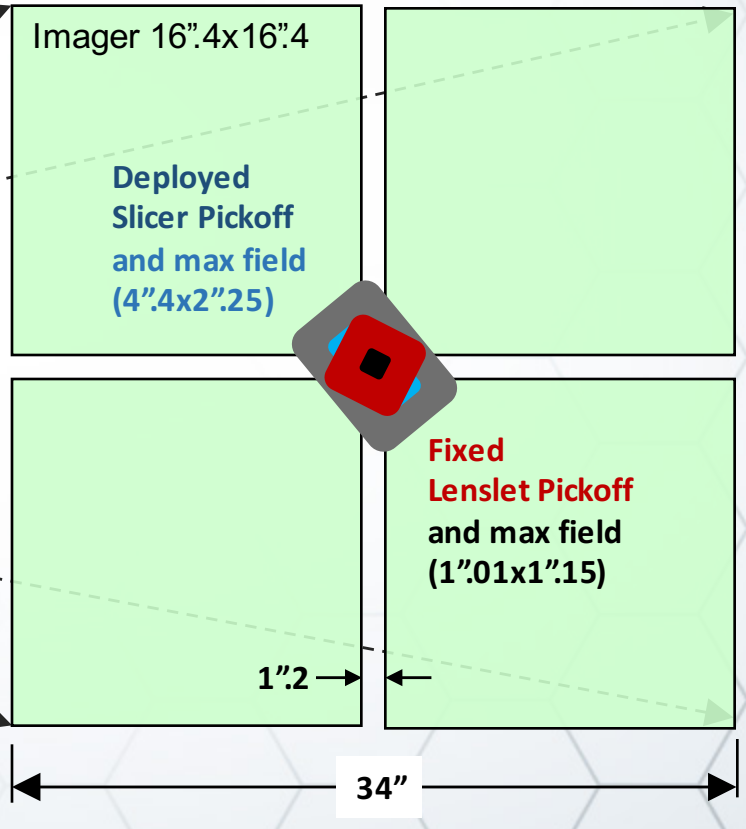


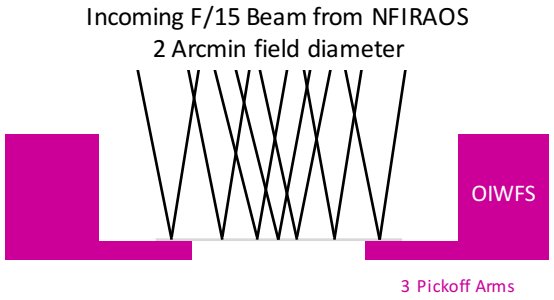
# IRIS Focal Plane

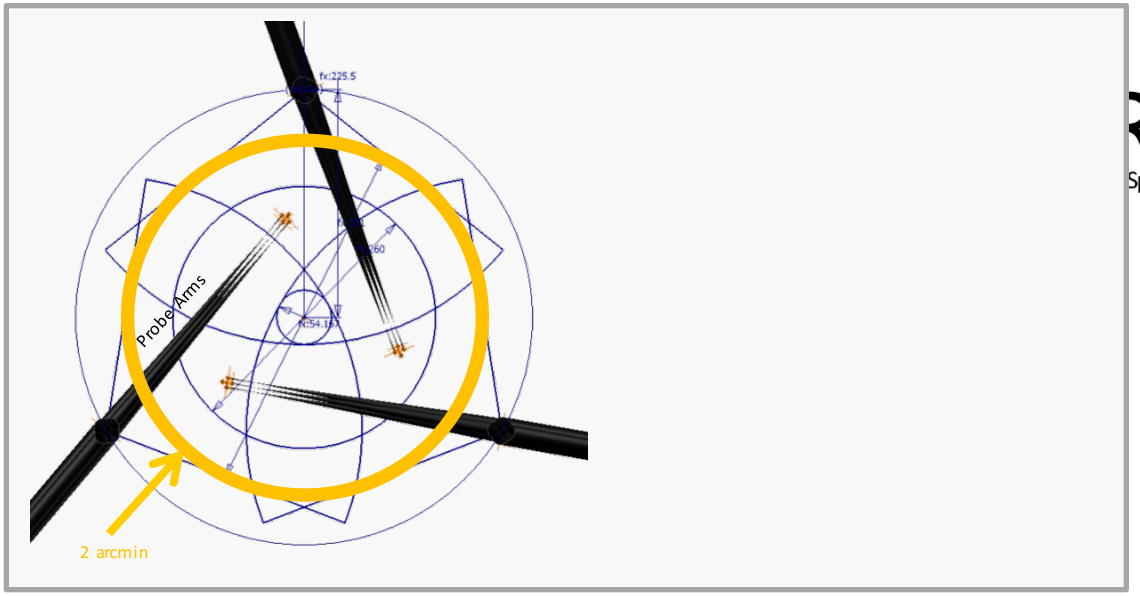
On-instrument wavefront sensors (OIWFS)




Imager and spectrograph FoV

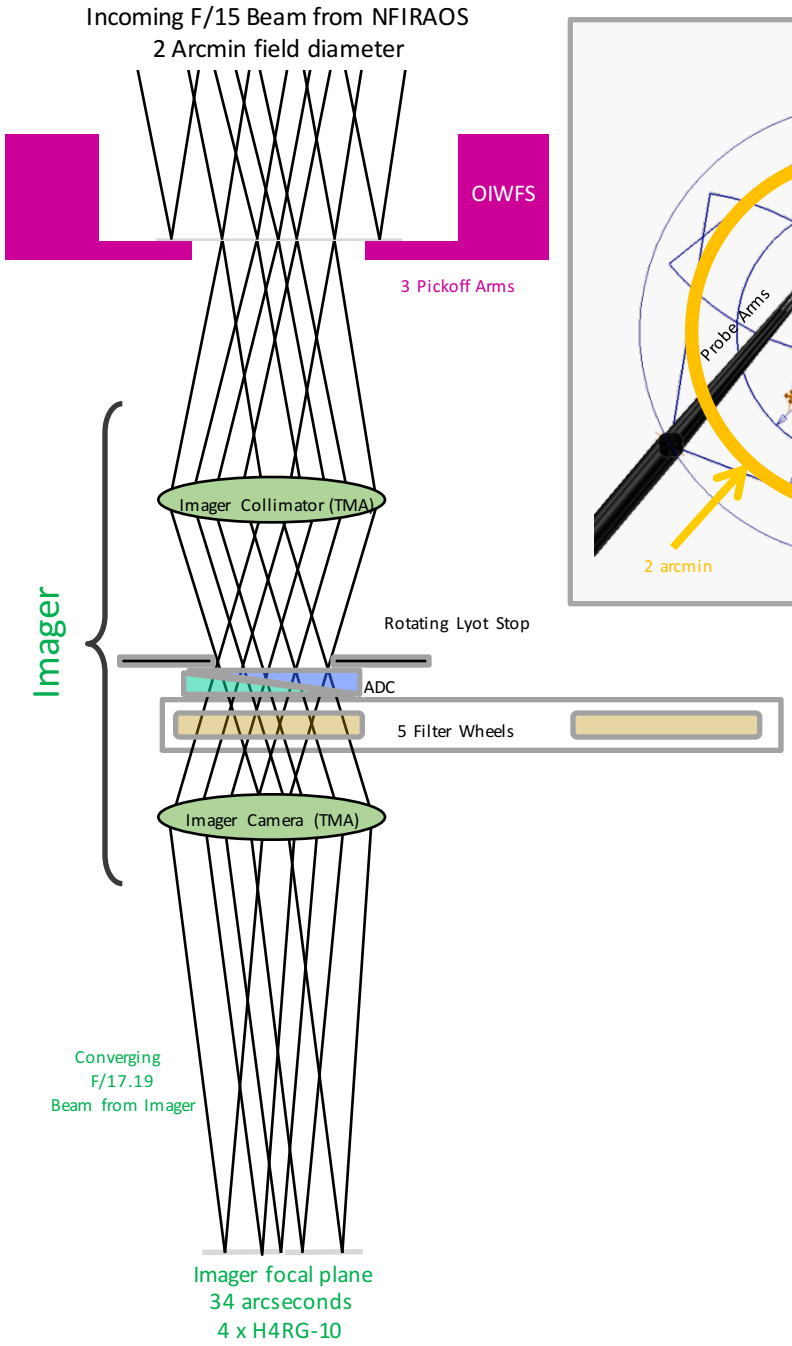


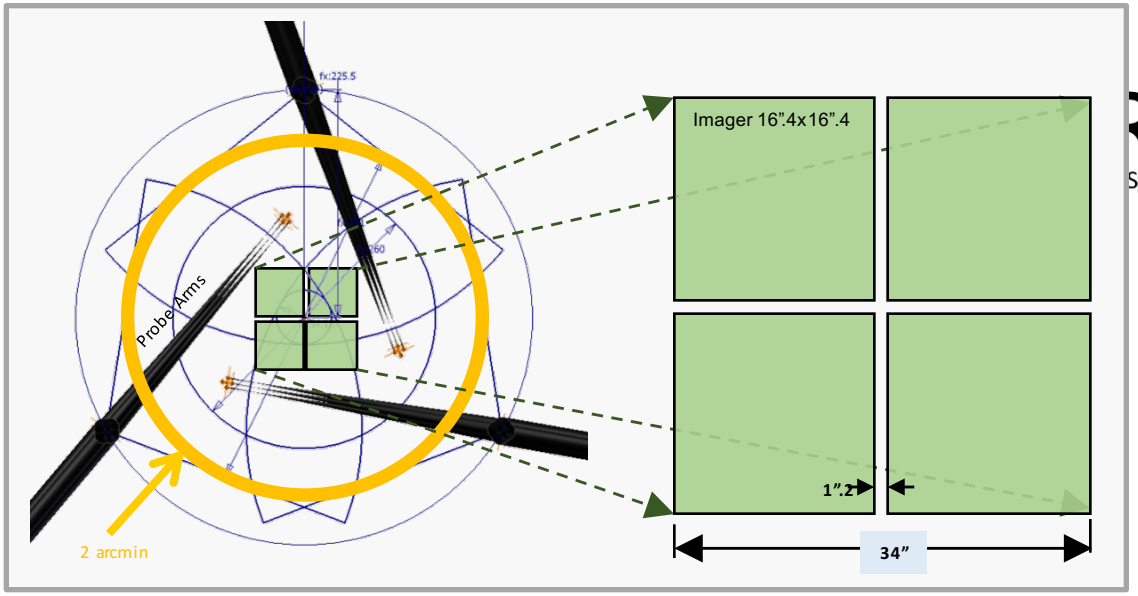



RIS
Spectrograph

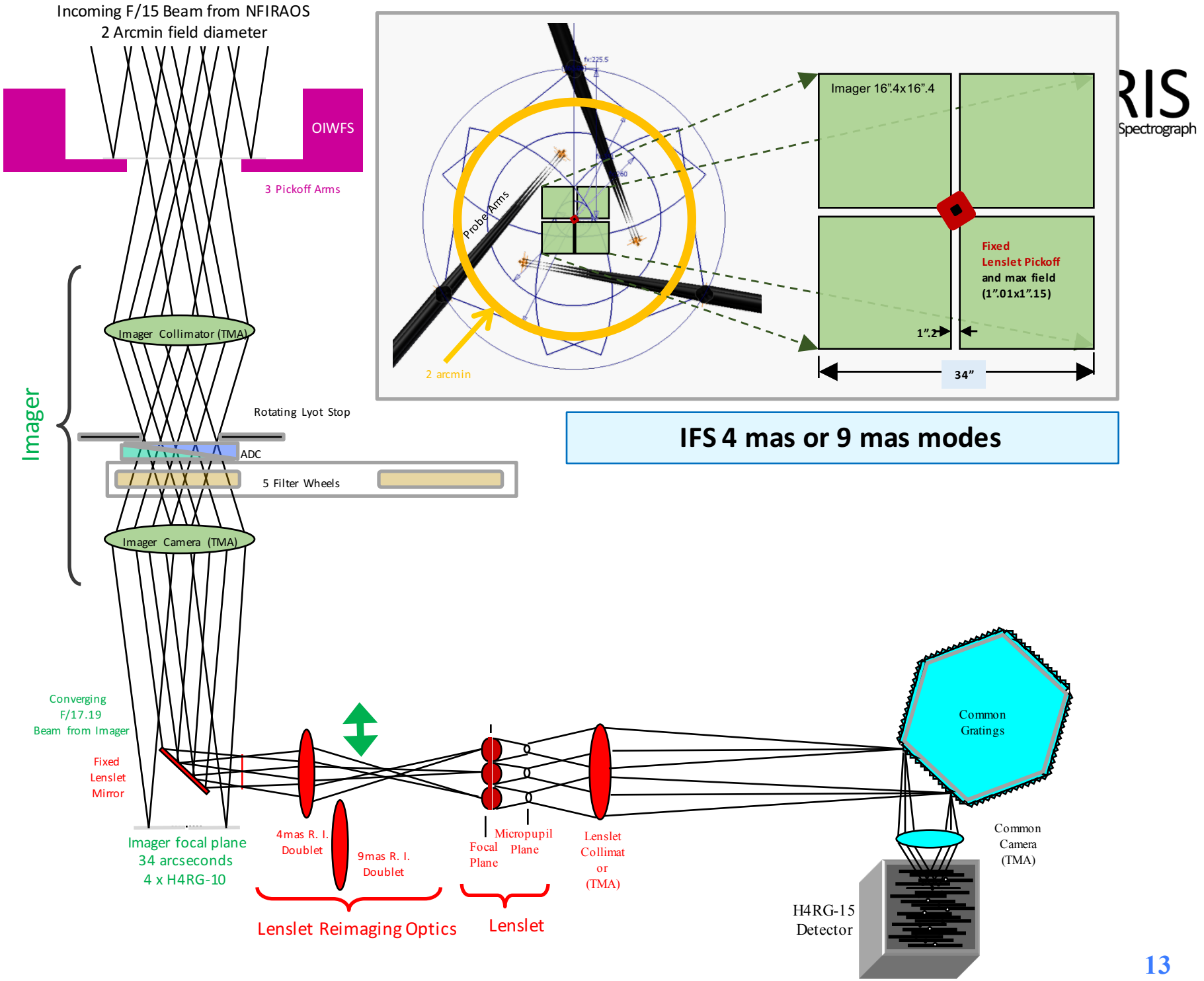
**Three OIWFS Arms patrol 2 arcminute NFIRAOS output field.**

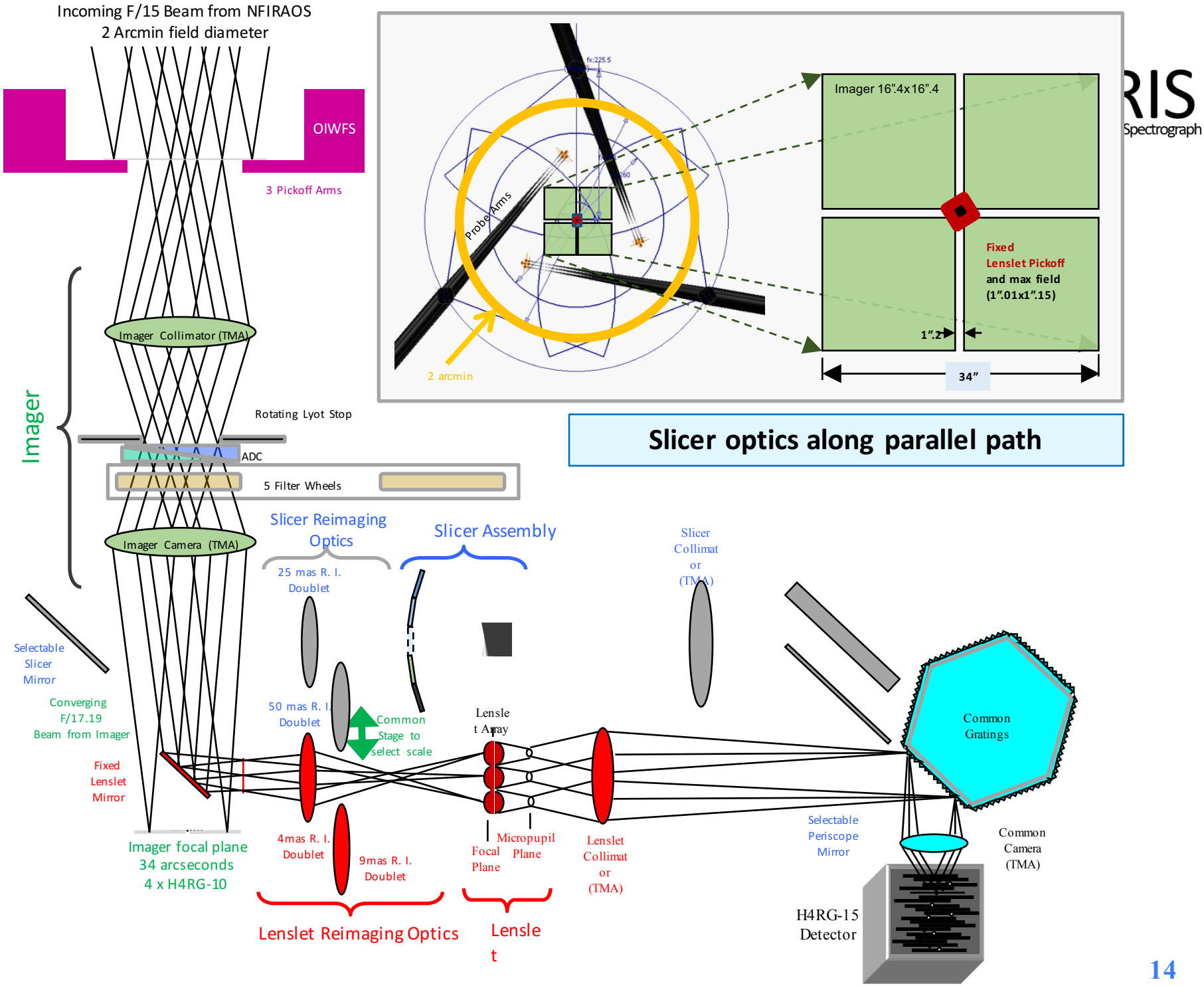


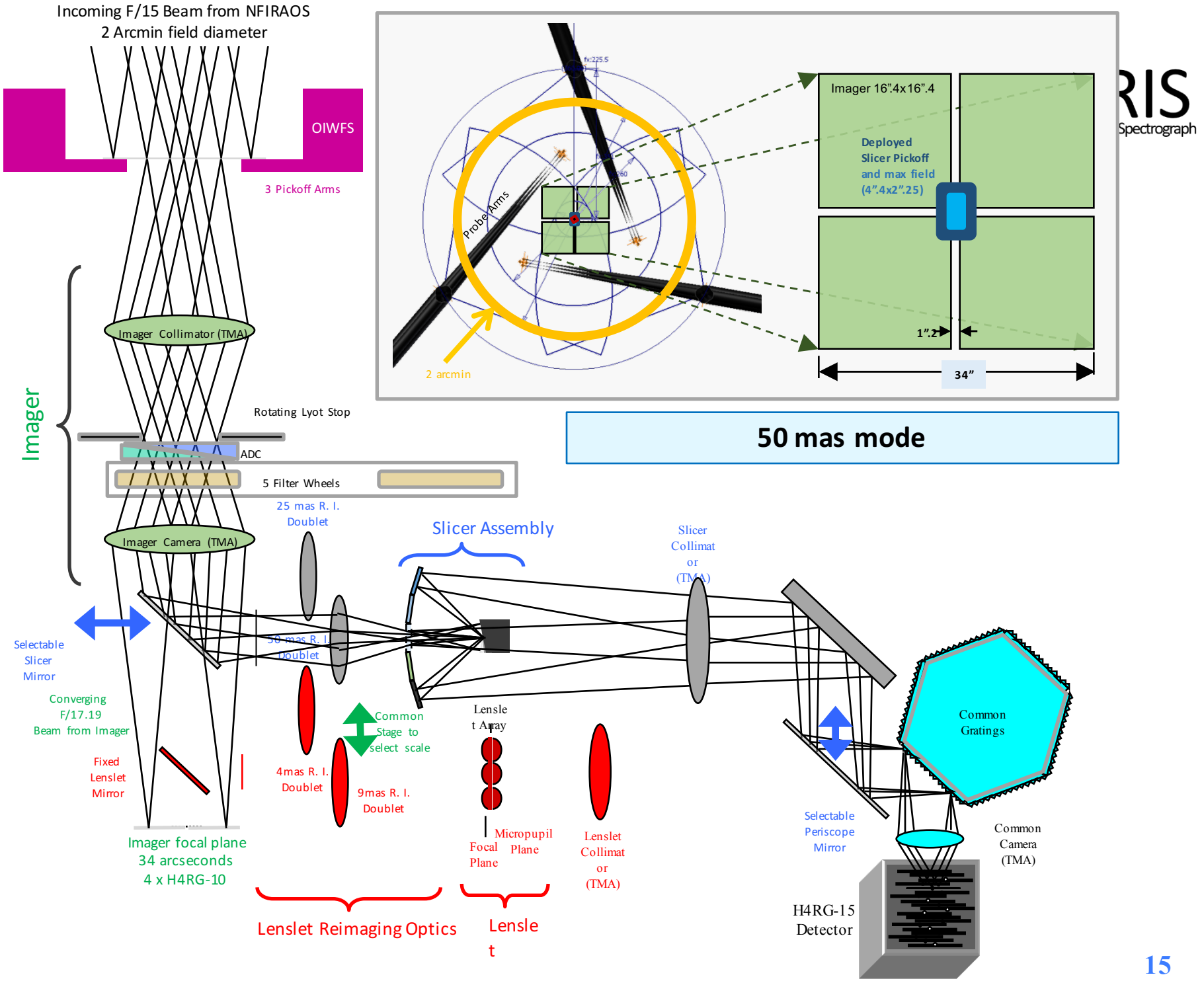



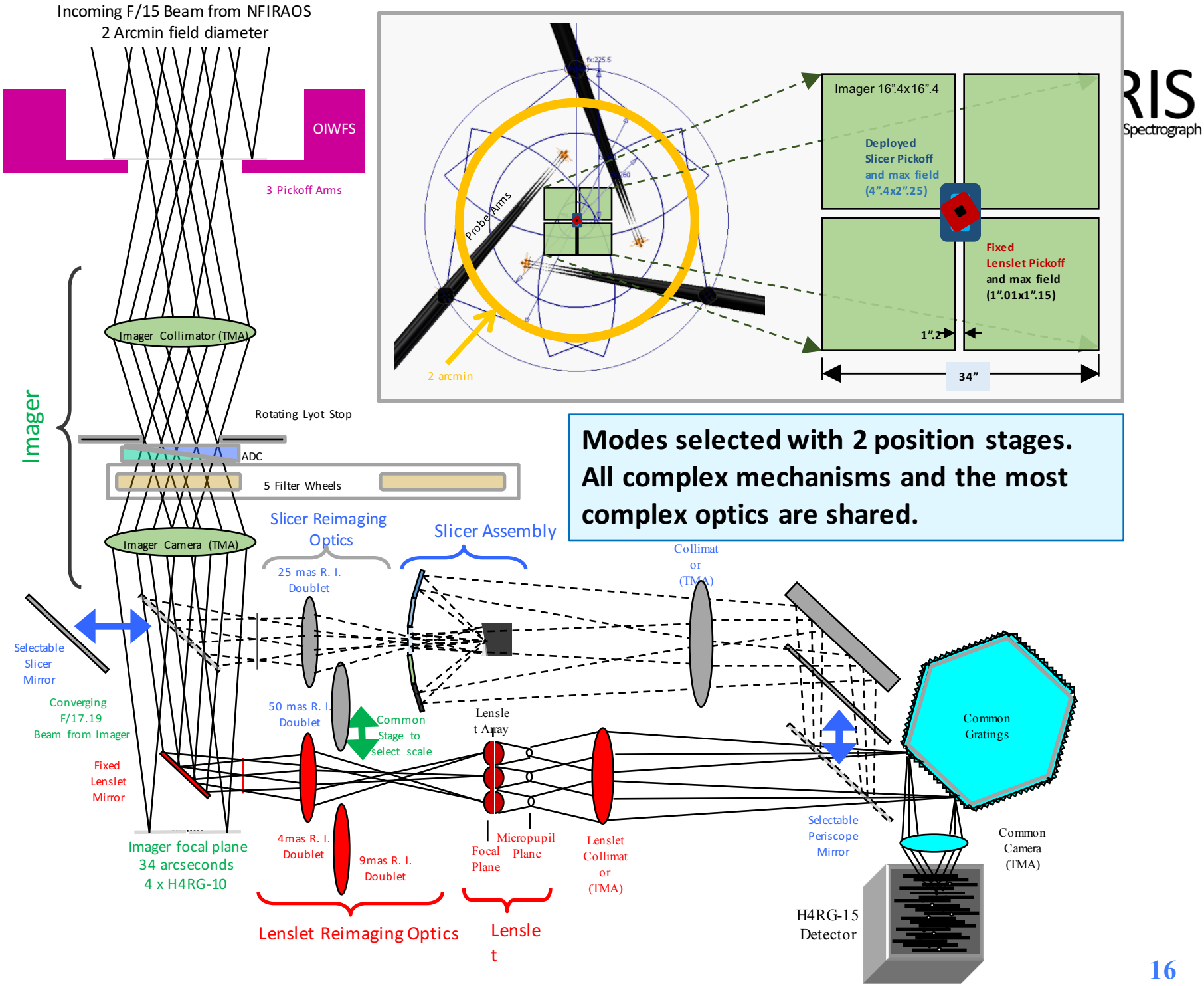

RIS
Spectrograph

**Imager with 4mas pixels**
**~34 arcsec field.**


Incoming F/15 Beam from NFIRAOS
2 Arcmin field diameter
OIWFS
3 Pickoff Arms
Imager
Imager Collimator (TMA)
Rotating Lyot Stop
ADC
5 Filter Wheels
Imager Camera (TMA)
Converging
F/17.19
Beam from Imager
Fixed
Lenslet
Mirror
Imager focal plane
34 arcseconds
4 x H4RG-10
4mas R. I.
Doublet
9mas R. I.
Doublet
Lenslet Reimaging Optics
Focal
Plane
Micropupil
Plane
Lenslet
Collimat
or
(TMA)
Lenslet
Common
Gratings
Common
Camera
(TMA)
H4RG-15
Detector
Probe Arms
2 arcmin
Imager 16".4x16".4
Fixed
Lenslet Pickoff
and max field
(1".01x1".15)
1".2
34"
IFS 4 mas or 9 mas modes


Incoming F/15 Beam from NFIRAOS
2 Arcmin field diameter
OIWFS
3 Pickoff Arms
Imager
Imager Collimator (TMA)
Rotating Lyot Stop
ADC
5 Filter Wheels
Imager Camera (TMA)
Slicer Reimaging Optics
Slicer Assembly
25 mas R. I. Doublet
Slicer Collimator (TMA)
Selectable Slicer Mirror
Converging F/17.19 Beam from Imager
50 mas R. I. Doublet
Common Stage to select scale
Lenslet Array
Common Gratings
Fixed Lenslet Mirror
4mas R. I. Doublet
9mas R. I. Doublet
Micropupil Plane
Focal Plane
Lenslet Collimator (TMA)
Selectable Periscope Mirror
Common Camera (TMA)
Imager focal plane
34 arcseconds
4 x H4RG-10
Lenslet Reimaging Optics
Lenslet
H4RG-15 Detector
Probe Arms
2 arcmin
Imager 16".4x16".4
Fixed Lenslet Pickoff and max field (1".01x1".15)
1".2
34"
Slicer optics along parallel path


Incoming F/15 Beam from NFIRAOS
2 Arcmin field diameter
OIWFS
3 Pickoff Arms
Imager
Imager Collimator (TMA)
Rotating Lyot Stop
ADC
5 Filter Wheels
25 mas R. I. Doublet
Imager Camera (TMA)
Slicer Assembly
Slicer Collimat or (TMA)
Selectable Slicer Mirror
50 mas R. I. Doublet
Converging F/17.19 Beam from Imager
Fixed Lenslet Mirror
Common Stage to select scale
4mas R. I. Doublet
9mas R. I. Doublet
Lensle t Array
Micropupil Plane
Focal Plane
Lenslet Collimat or (TMA)
Common Gratings
Selectable Periscope Mirror
Common Camera (TMA)
H4RG-15 Detector
Imager focal plane
34 arcseconds
4 x H4RG-10
Lenslet Reimaging Optics
Lensle t
Probe Arms
2 arcmin
Imager 16".4x16".4
Deployed Slicer Pickoff and max field (4".4x2".25)
1".2
34"
50 mas mode



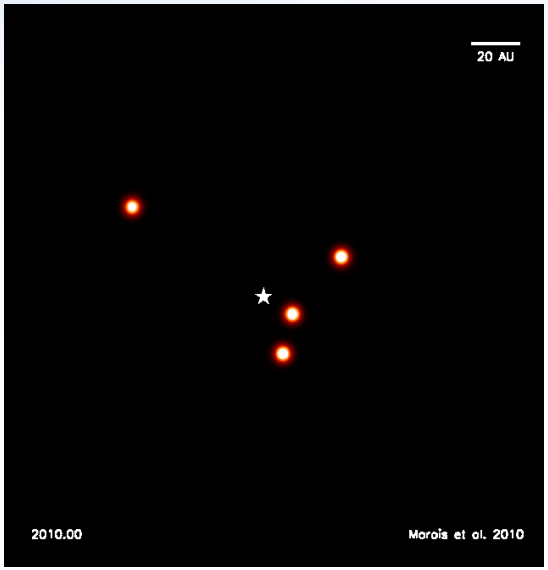

**Modes selected with 2 position stages. All complex mechanisms and the most complex optics are shared.**

RIS Spectrograph

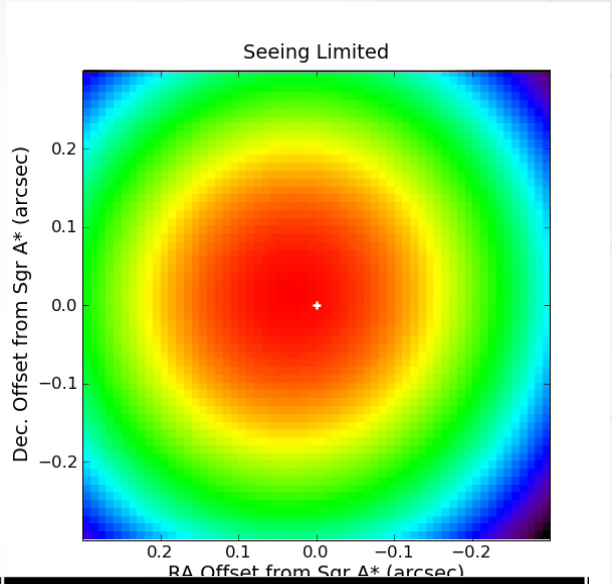
# IRIS is versatile and covers a broad range of science goals

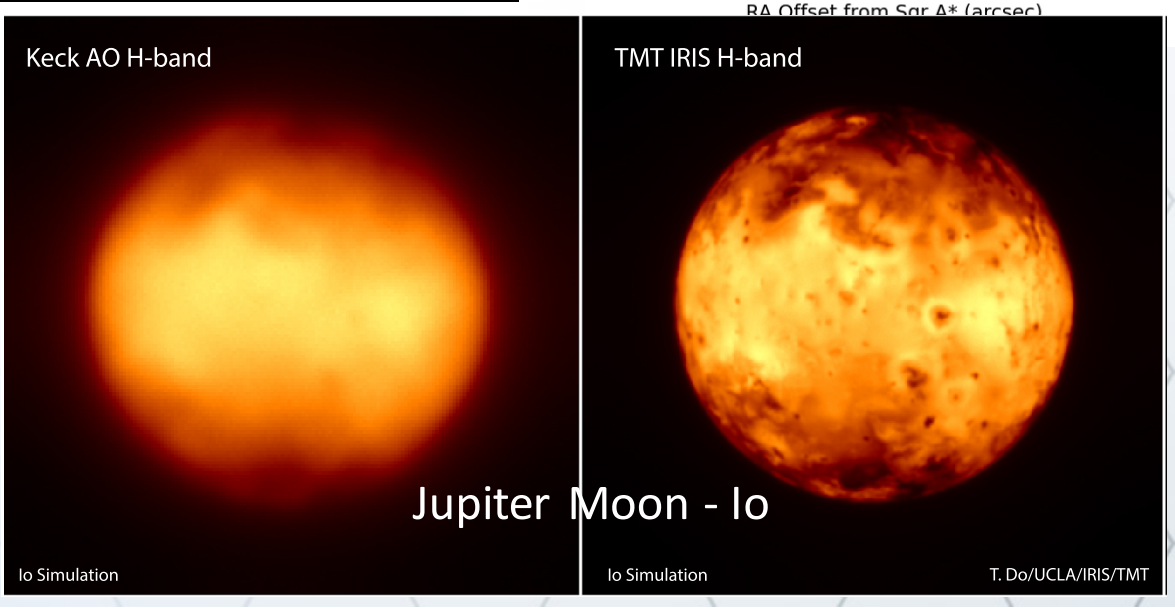
- Solar system
- Extrasolar planets
- Stellar structure & evolution (Microlensing)
- Star formation
- Galactic Center
- Nearby galaxies and stellar populations
- Supermassive black holes
- High-redshift galaxies
- First light galaxies

Characterizing Exoplants

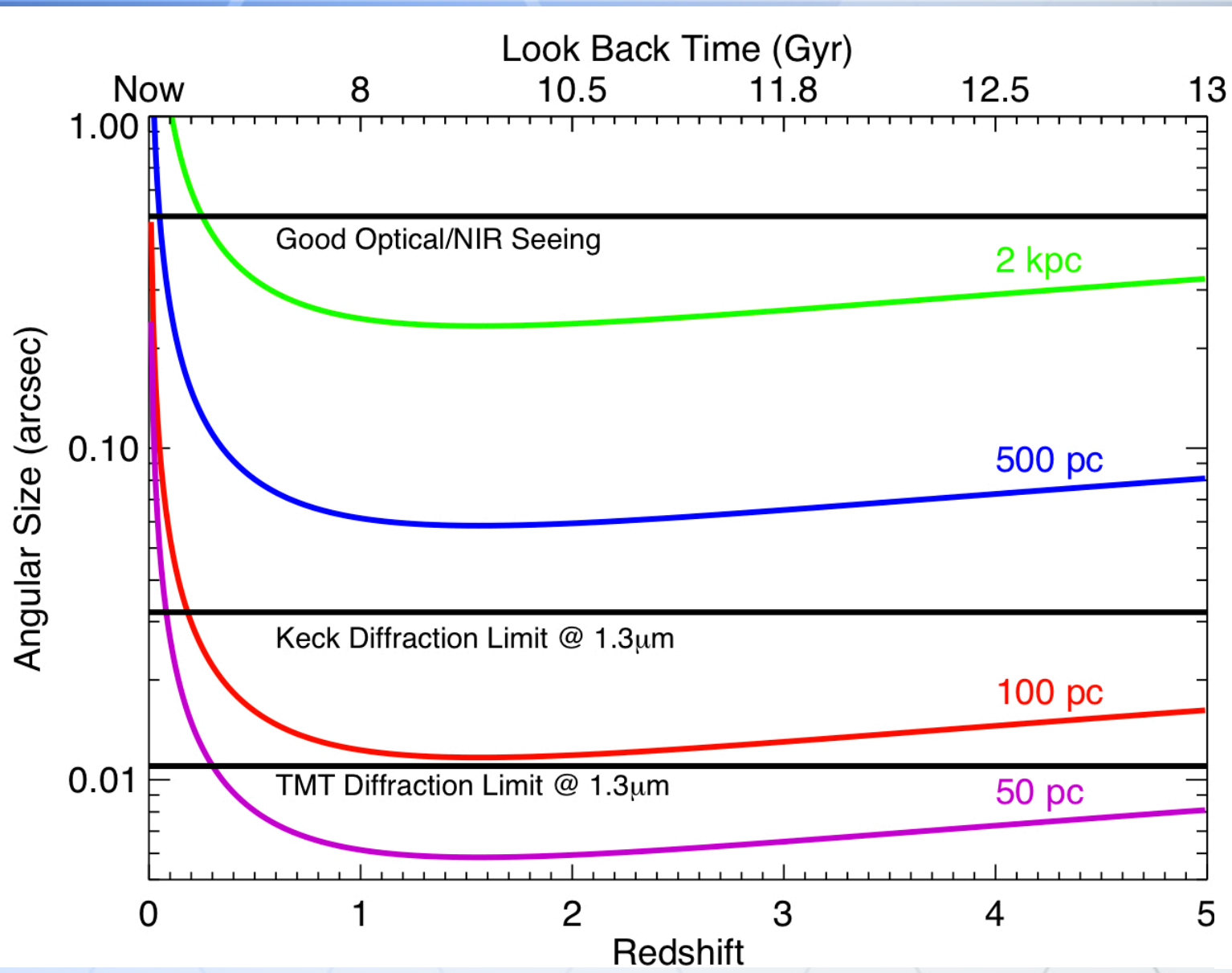


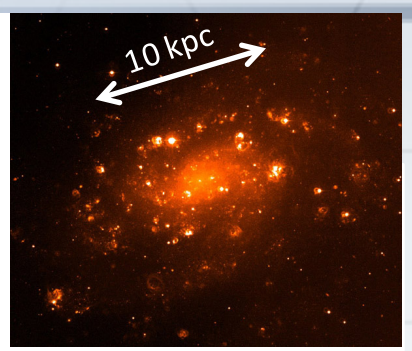

Testing GR at the Galactic Center



# TMT will be able to resolve Giant Molecular Clouds at high-redshift




Thick disk scale height

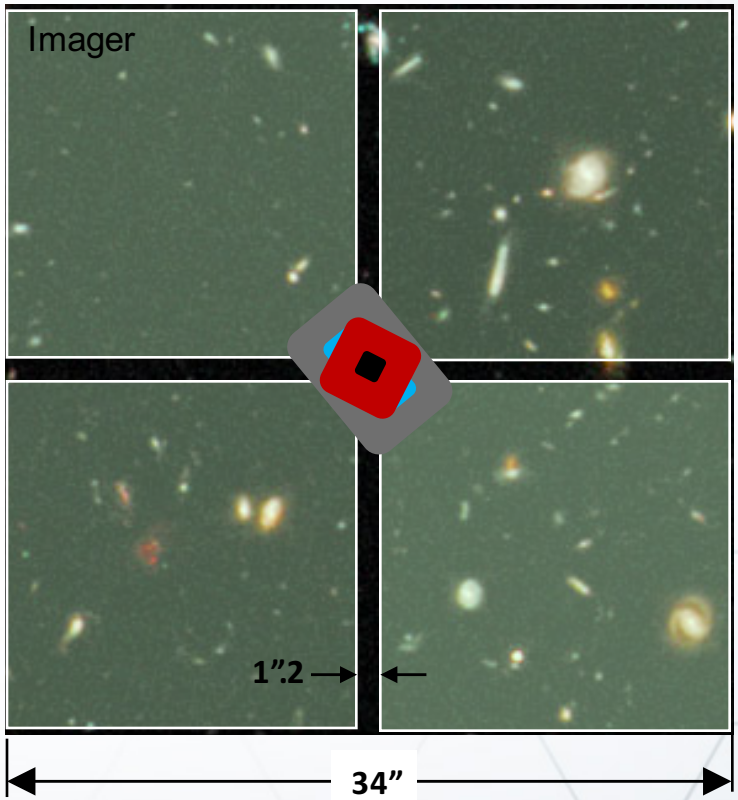
Galaxy Bulge

Giant Molecular Clouds

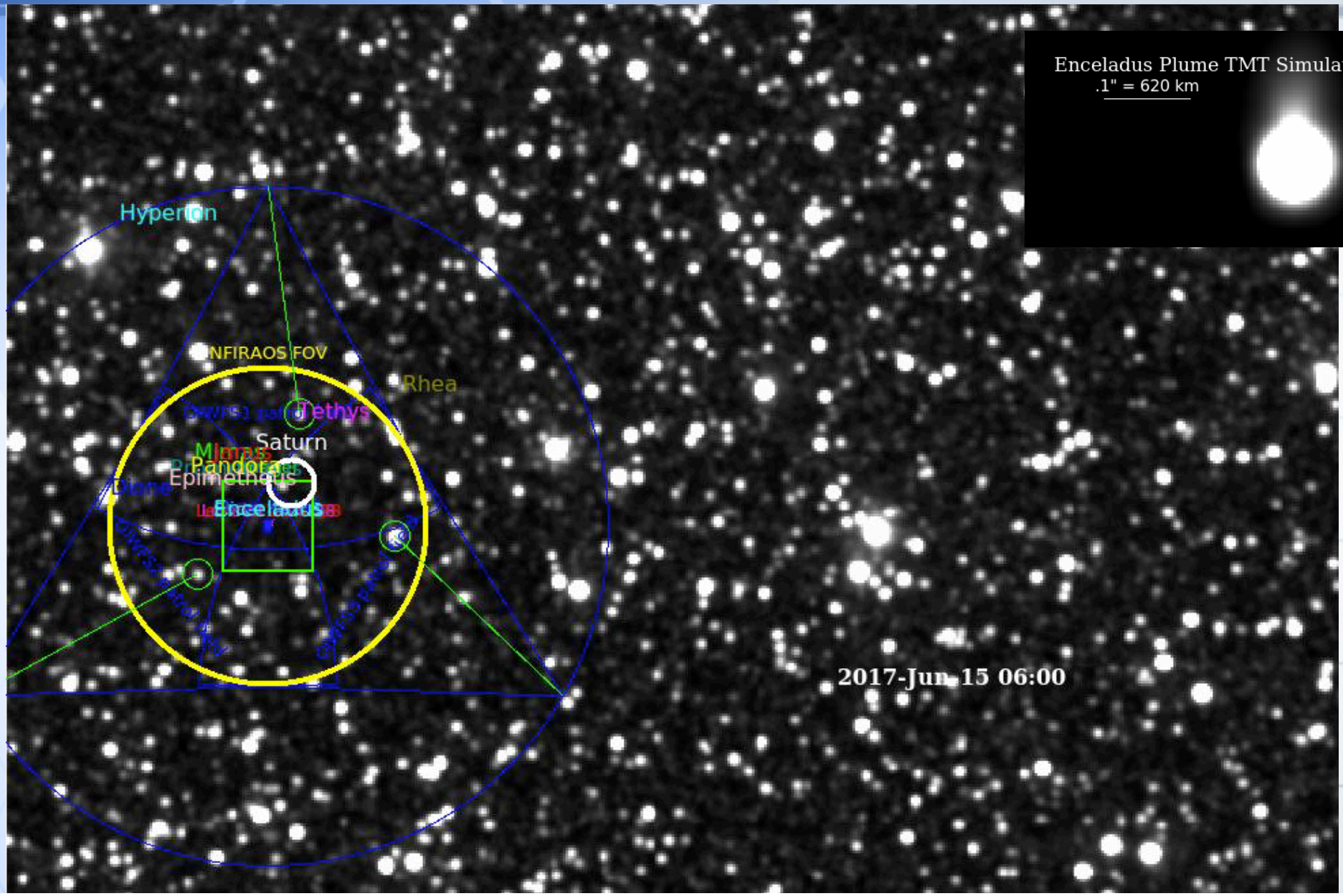
Molecular Clouds

# Advantages of IRIS parallel imaging and spectroscopy

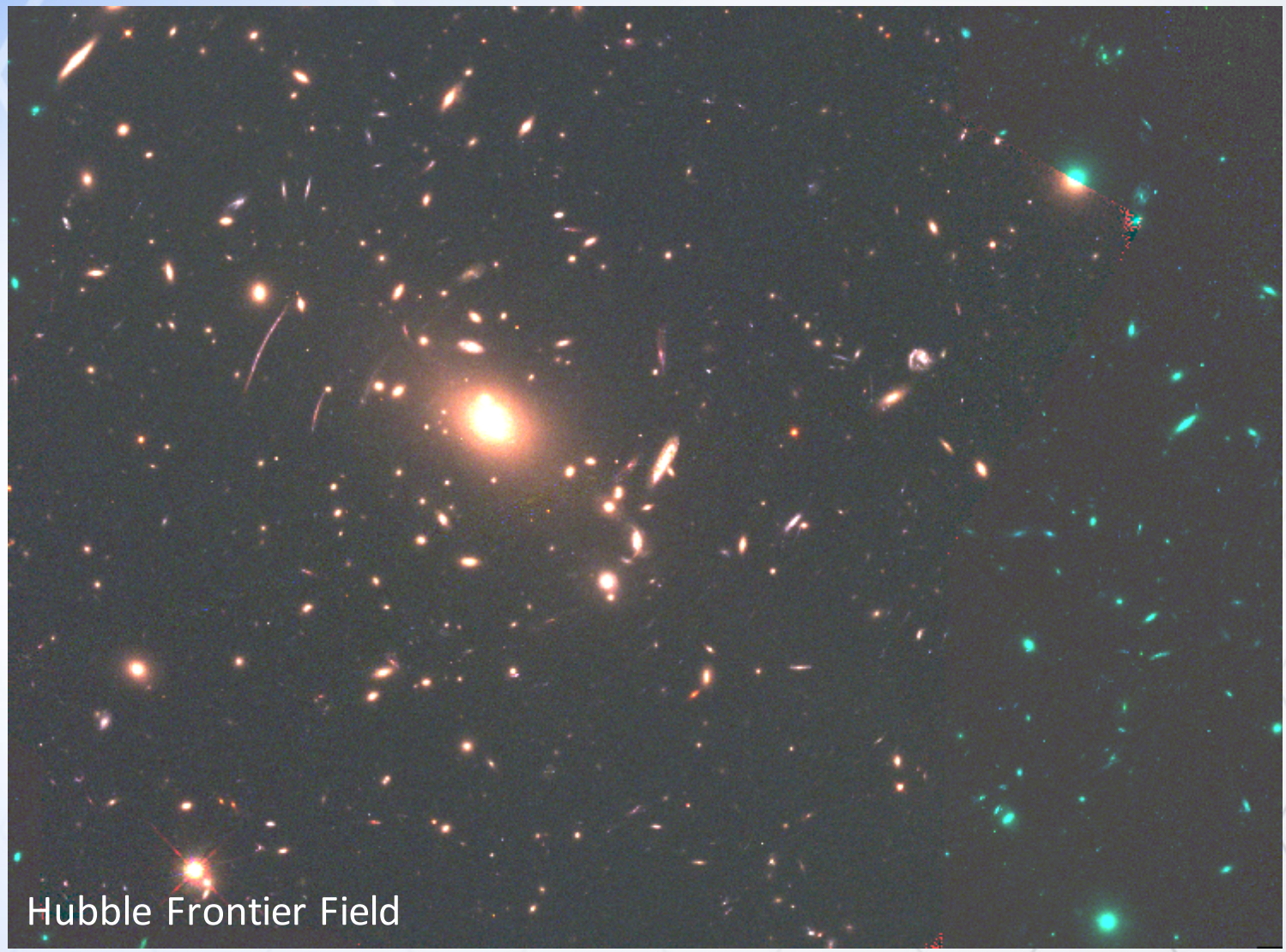
- Sensitivity provided by TMT means that almost any “dark sky” will contain thousands of objects.
- Deep HST quality-observations can be achieved on the order of ~20 minutes!
- RIGHT: HDF (to scale) with spectroscopy on one source while imaging field



# Guide star planning: solar system

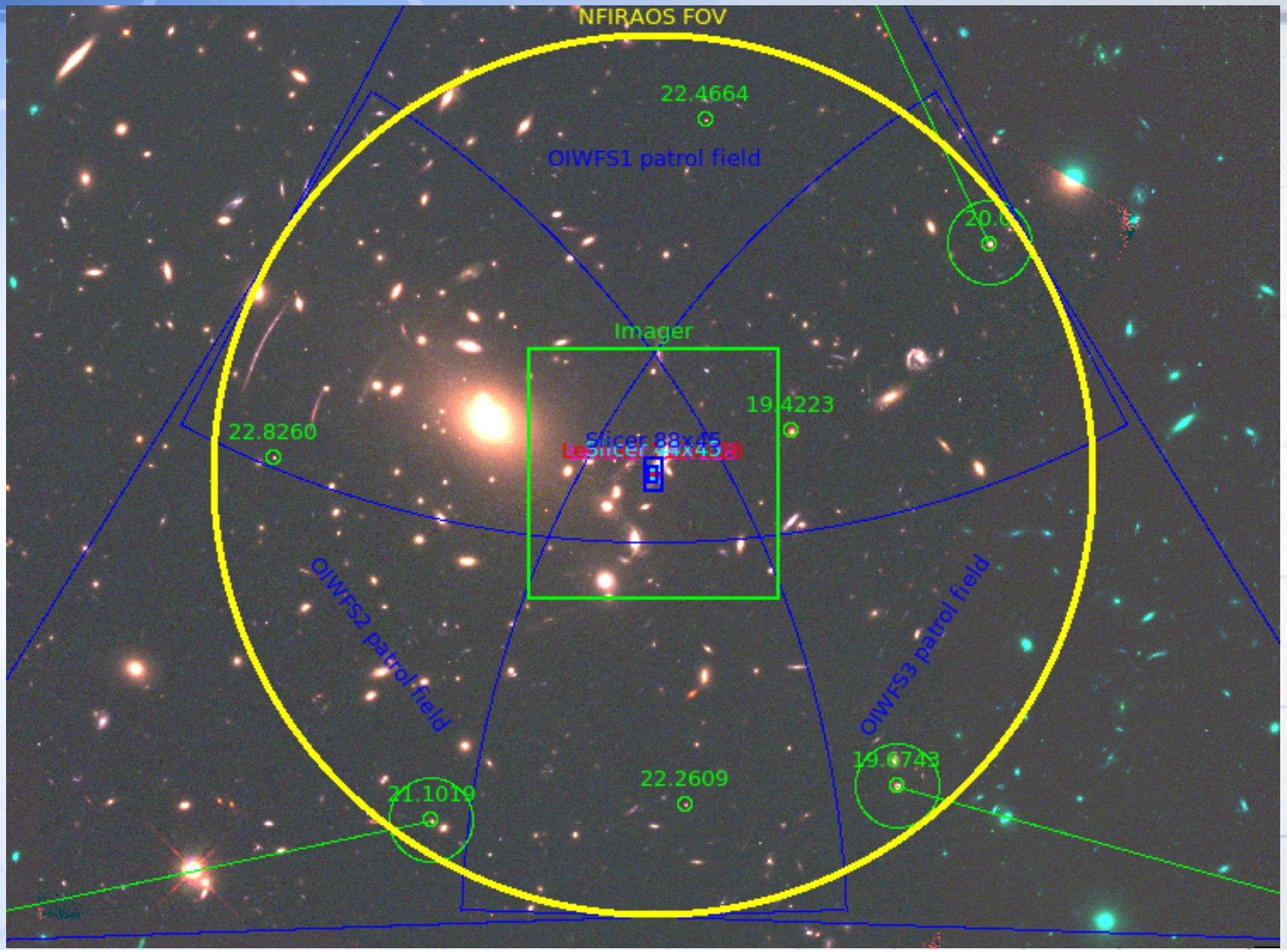


# Observational planning on gravitationally-lensed galaxies

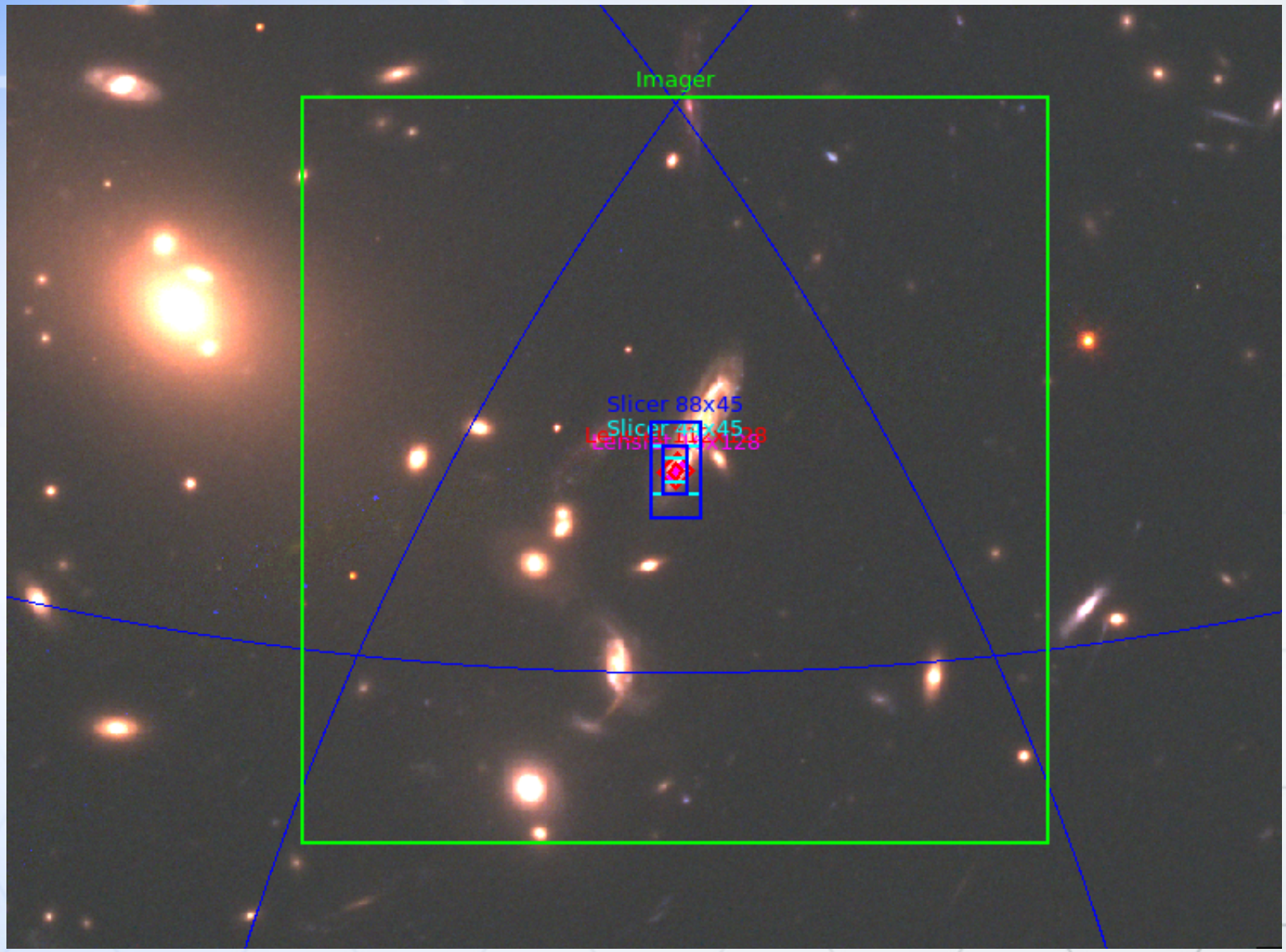


Hubble Frontier Field

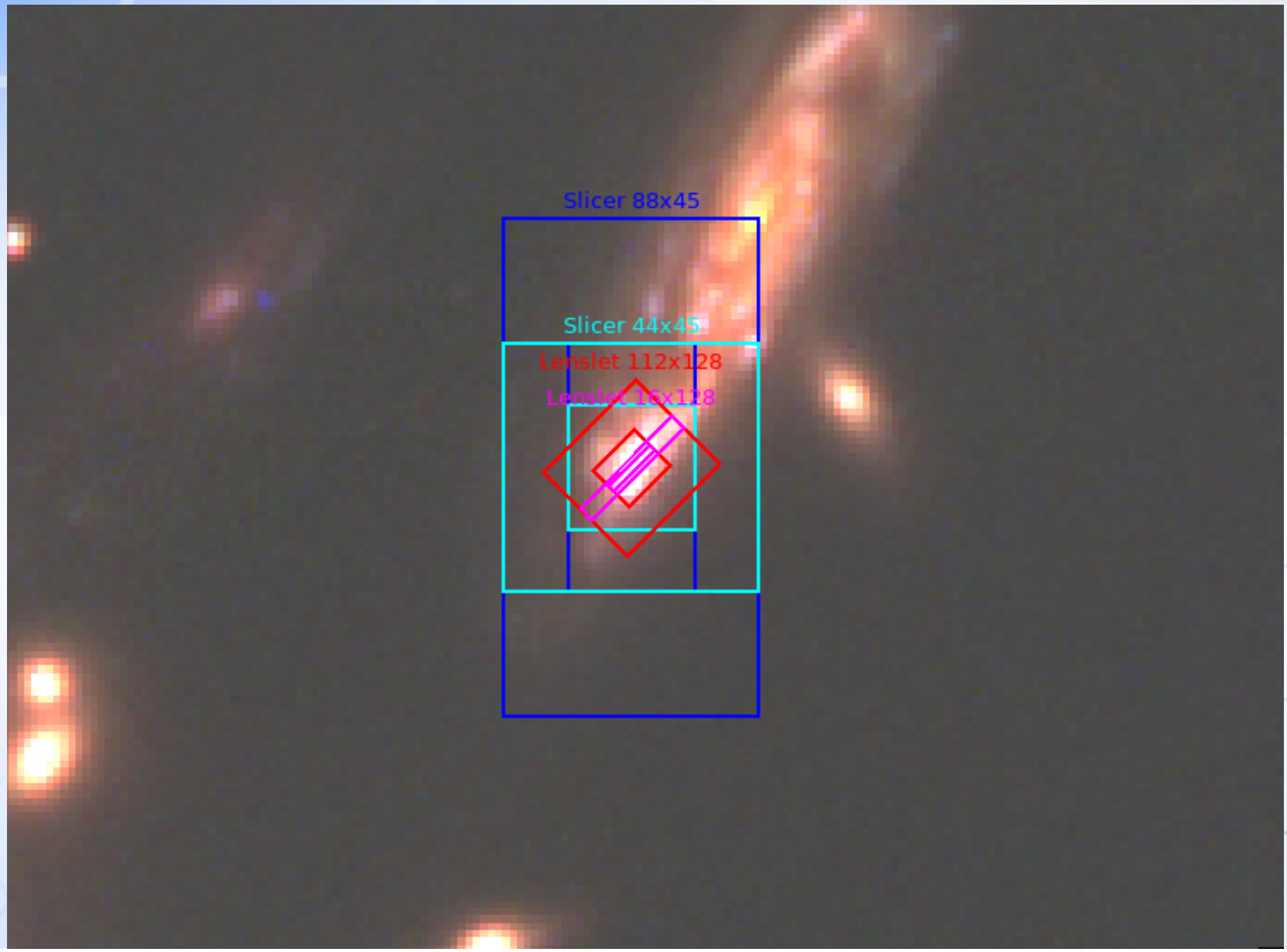
# NFIRAOS and OIWFS field of view



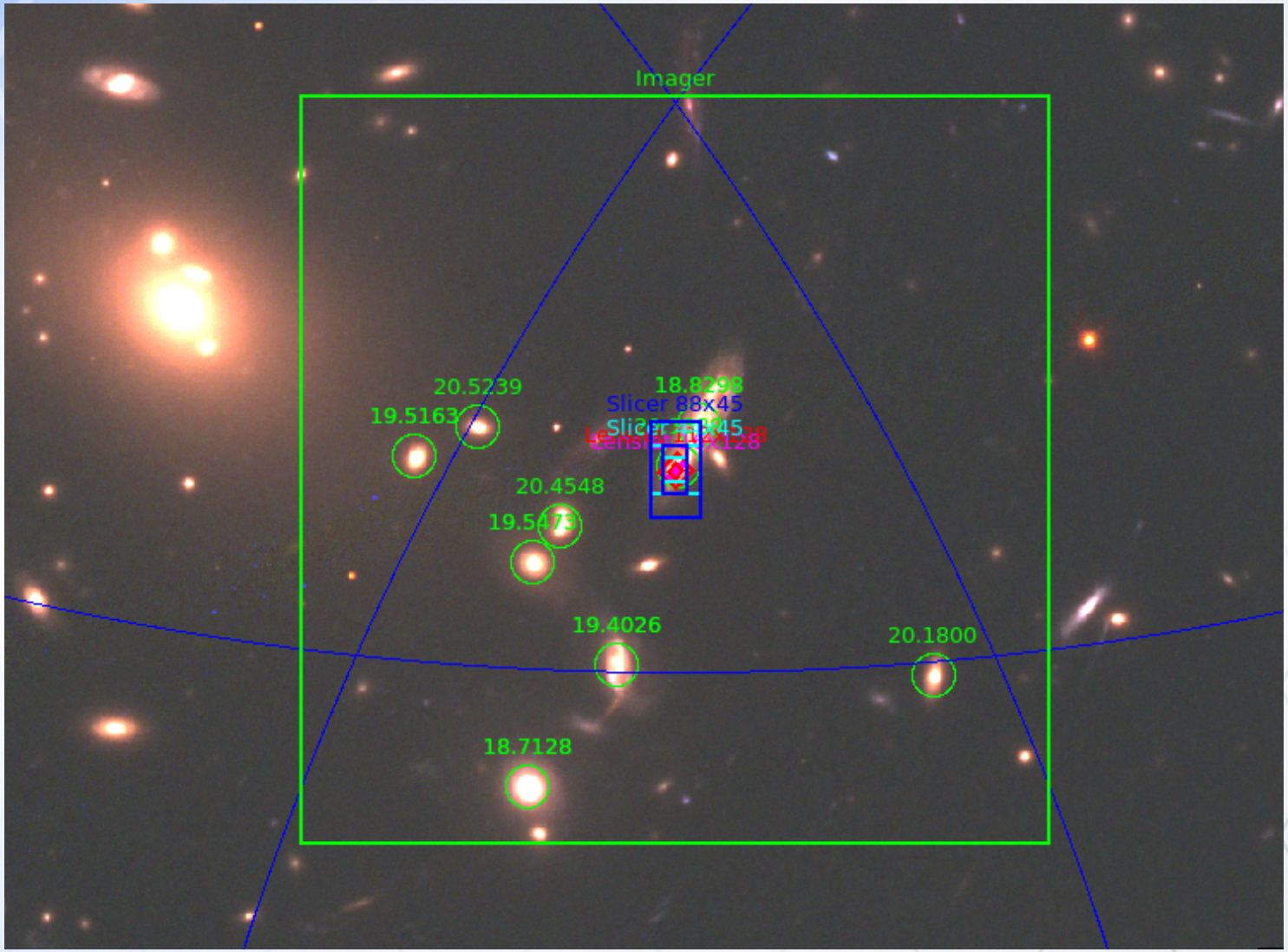
# IRIS imager and IFS field of view



# IRIS IFS field of view



# Issues of saturation: IRIS imager 60 second integrations



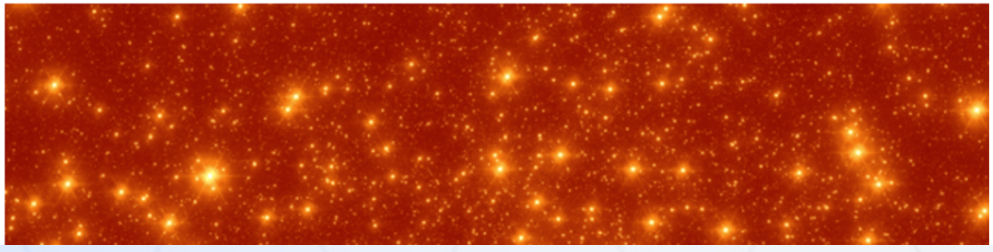

All green highlighted sources will saturate

# IRIS science simulations posted online

- http://oirlab.ucsd.edu/IRIS_sims.html


### Pluto

Simulated IRIS three color (J, H, and K) image of Pluto and Charon, with a single 100 second integration time. In comparison, HST observations only a sample ~10s pixels across Pluto and need to perform extensive deconvolution routines on multiple phases of observations. In this single observation, the IRIS imager at the 4 mas scale will resolve a spatial scale of ~82 km on both Pluto and Charon. See Wright et al. (2016).

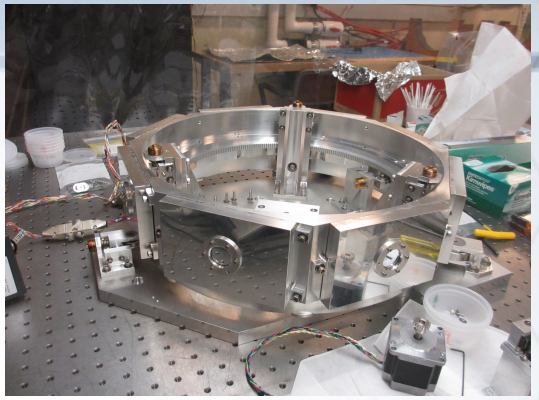


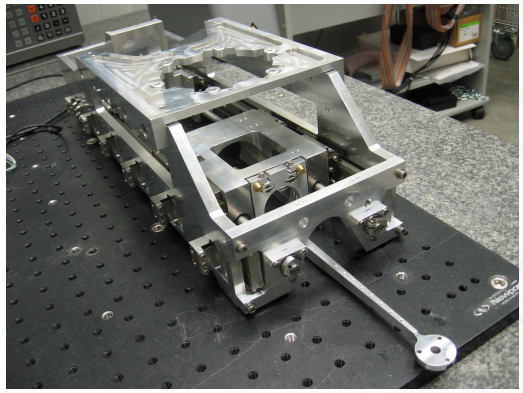
### Galactic Center

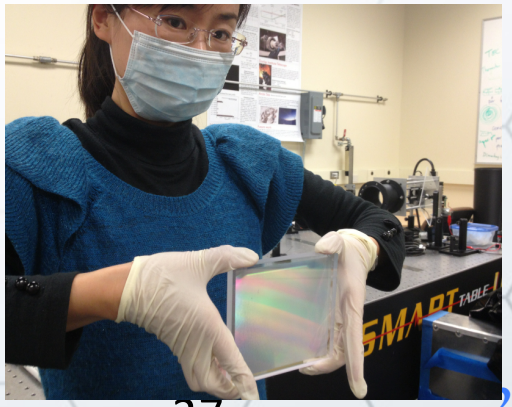
Simulation of an IRIS imager observation using K (2.2 µm) broadband of the Galactic Center with the expanded field of view of 32.8" x 32.8". In a single shot using the 0.004"

# IRIS status and prototyping

- Passed Preliminary Design Review November 2016
- PDR software/electronics review September 2017
- Key technical design issues to accomplish:
  - Imager and Spectrograph configuration
  - Grating Turret Wheel
  - Grating selection (OIR Dunlap)
  - Atmospheric Distortion Correction (ADC)
  - High-contrast imaging capabilities
  - Wavefront sensor probe arms
  - Pipeline software development (OIR Dunlap)
- Key science issues to accomplish by IRIS Science team:
  - Astrometric and photometric accuracies
  - High contrast imaging case
  - Filter and grating selections
  - Imager and spectrograph configuration
  - Finalizing Design Requirements





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