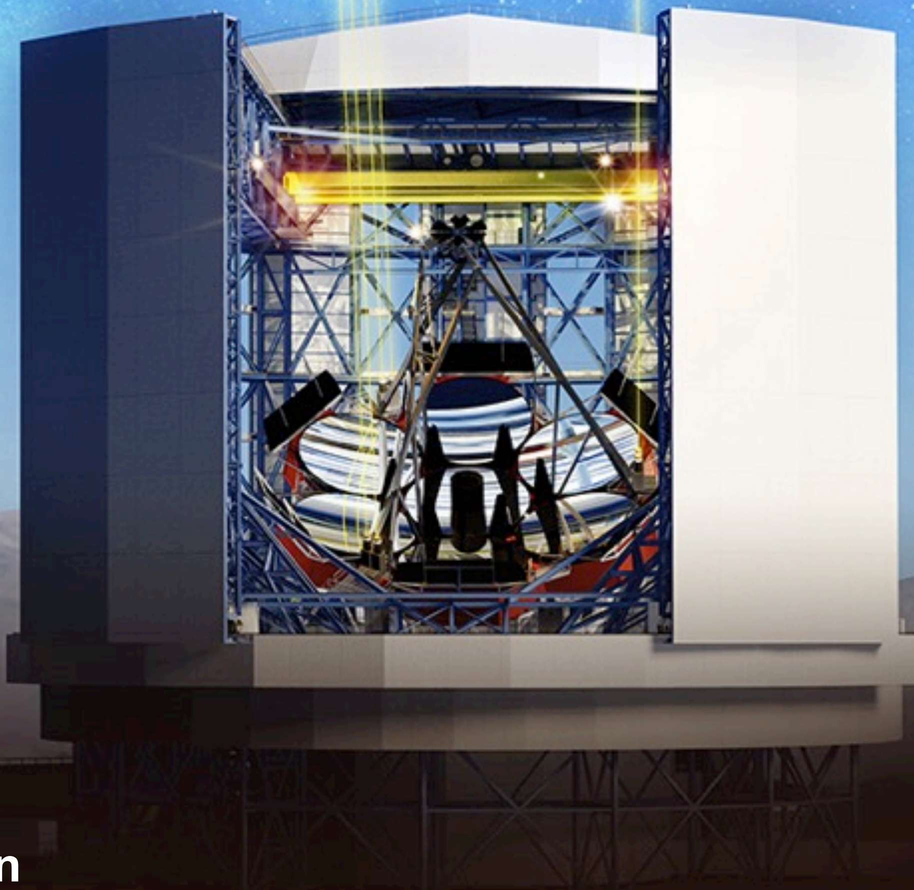
Giant Magellan Telescope Project

Overview and Relevance to LUVIOR



Patrick J. McCarthy
GMTO Director

Rebecca A. Bernstein
GMT Project Scientist

GIANT MAGELLAN TELESCOPE

GMT Founder Institutions

GMT

KASI
Korea

Astronomy Australia Ltd.

Smithsonian Institution

FAPESP
Sao Paulo, Brazil

HARVARD UNIVERSITY

Texas A&M

Australian National University

CARNEGIE SCIENCE

Arizona

THE UNIVERSITY OF TEXAS AT AUSTIN

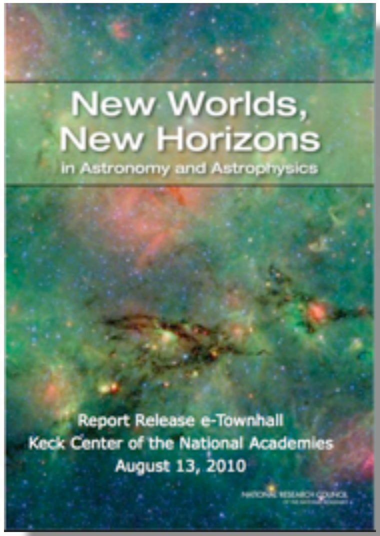
THE UNIVERSITY OF CHICAGO

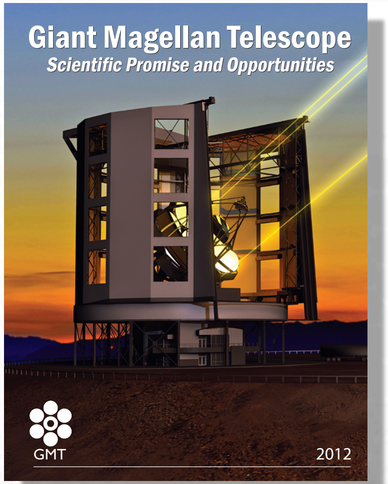
Science Goals

GMT

Top-Level Science Areas

- **Extra-solar planets**
- Stellar Populations and Chemistry
- Galaxy Building
- Black Hole Growth
- Cosmological Physics
- **First-Light & Reionization**



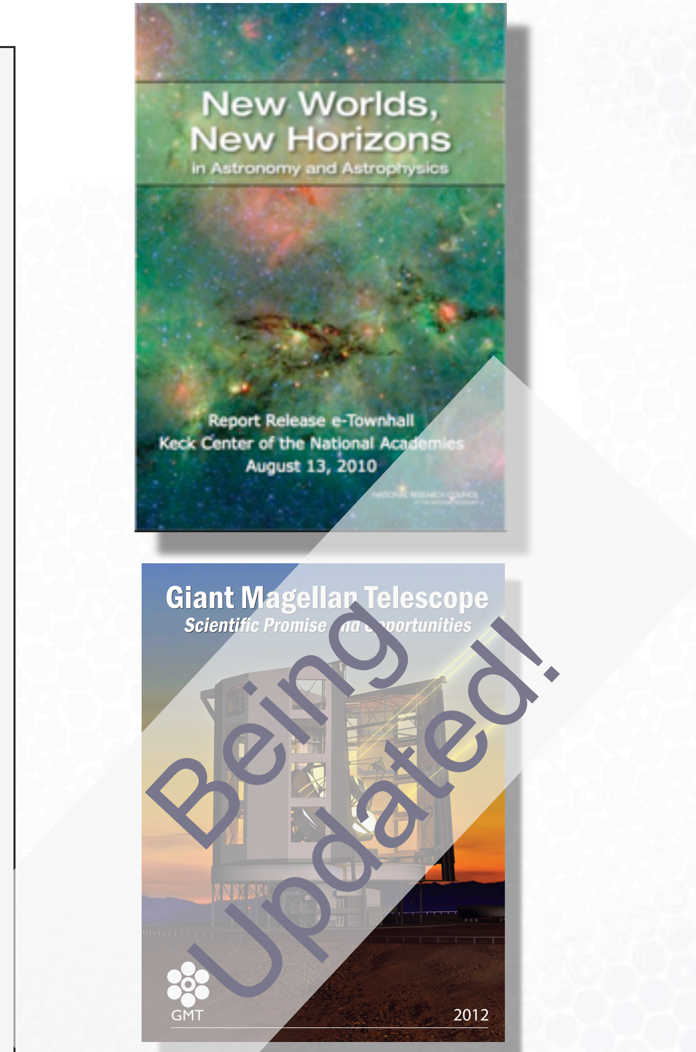


Science Goals

GMT

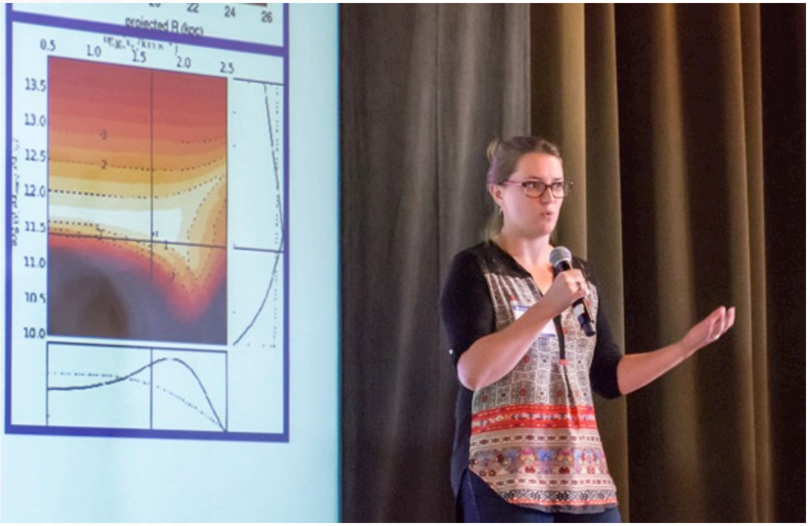
What's New?

- Earth-like planets, visible AO…
- 2000+ Exoplanets, TESS in 2018
- Stars with [Fe/H] < -7!
- Black holes with $M > 10^{10} M_{sun}$!
- FRBs and other new transients
- JWST 2 years away
- LSST to start in 2020+
- LUVOIR only 20 years away!



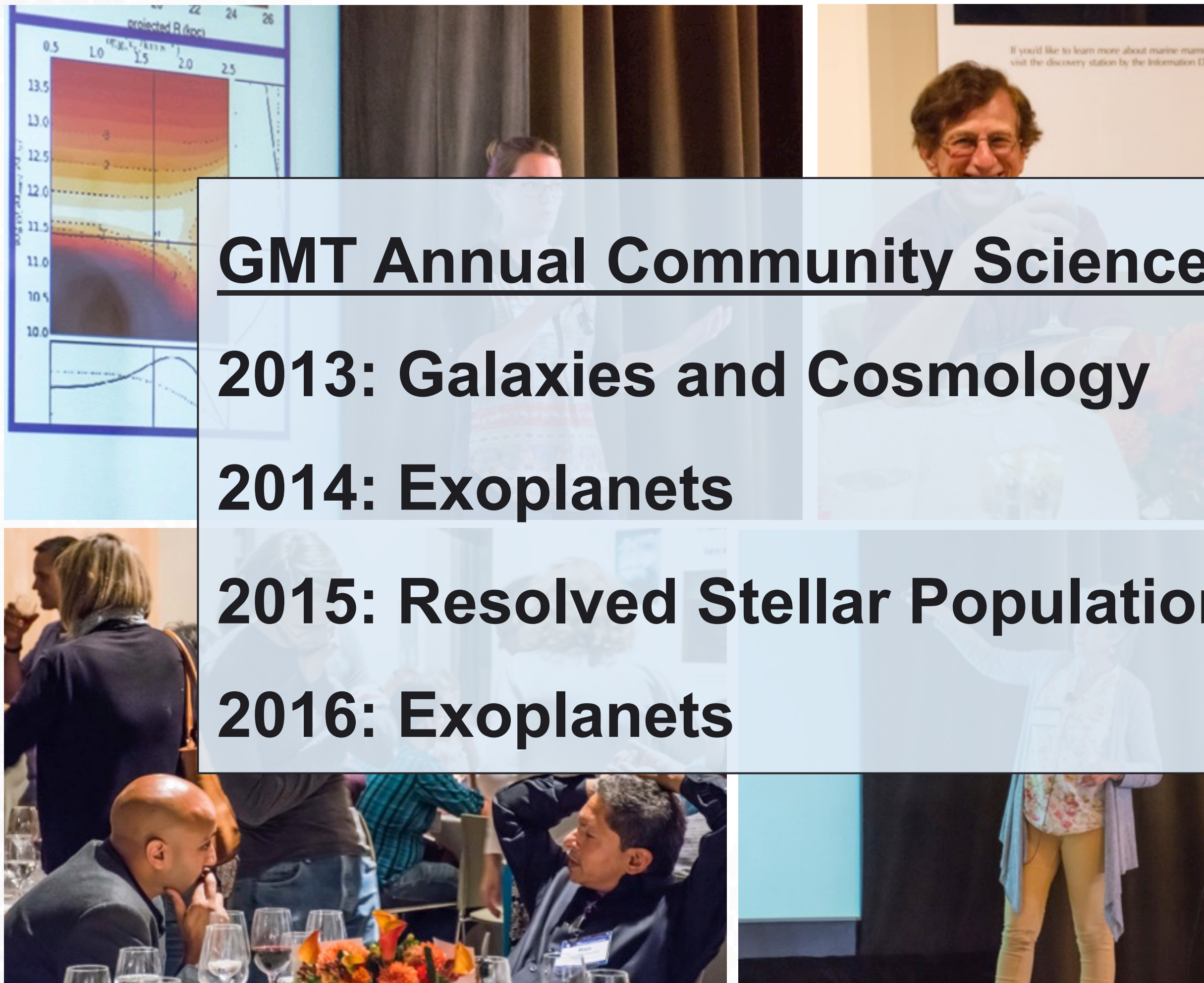
Community Science Meetings

Keeping the science mission current



Community Science Meetings

Keeping the science mission current



GMT Annual Community Science Meetings

2013: Galaxies and Cosmology

2014: Exoplanets

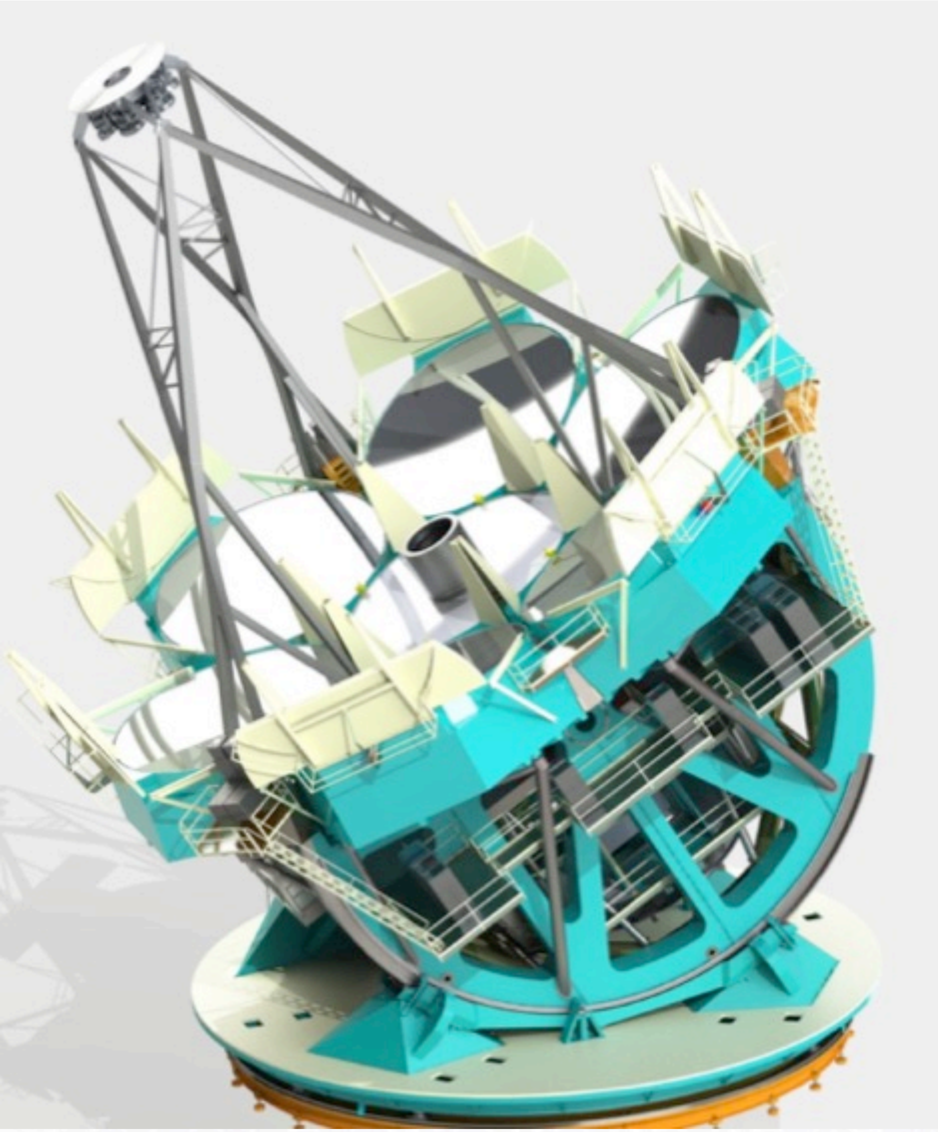
2015: Resolved Stellar Populations

2016: Exoplanets

Telescope Design Overview

GMT

- Doubly segmented
  - M1 – 8.4m segments
  - M2 – 1.1m segments
  - Aplanatic Gregorian configuration
  - M1:M2 segments are conjugate
  - f/0.7 primary
  - f/8 final focus – 1.0 mm/arcsec
- Compact structure
- Optimized for stiffness
- High throughput



GMT Primary Mirror Production

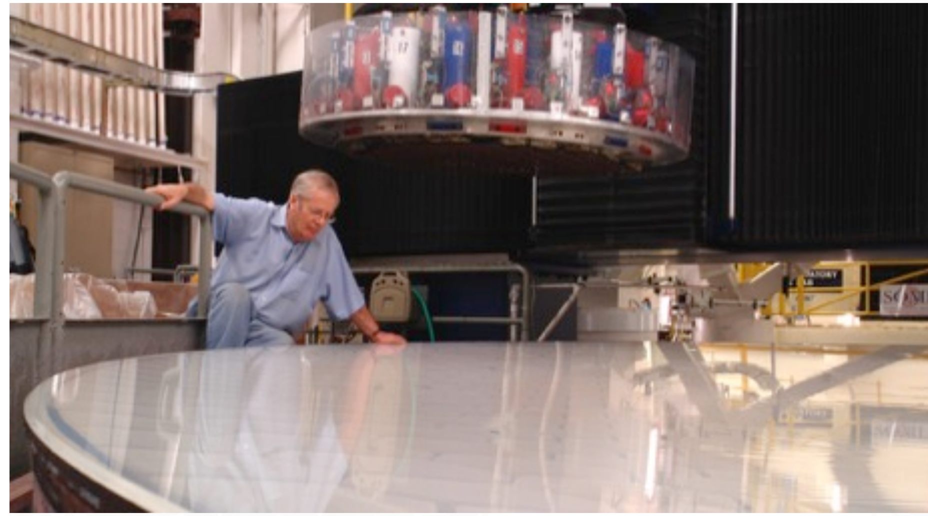
Segment #1:
Complete. Meets all specifications.

Segment #2:
Ready for front surface processing

Segment #3:
Rear surface complete.

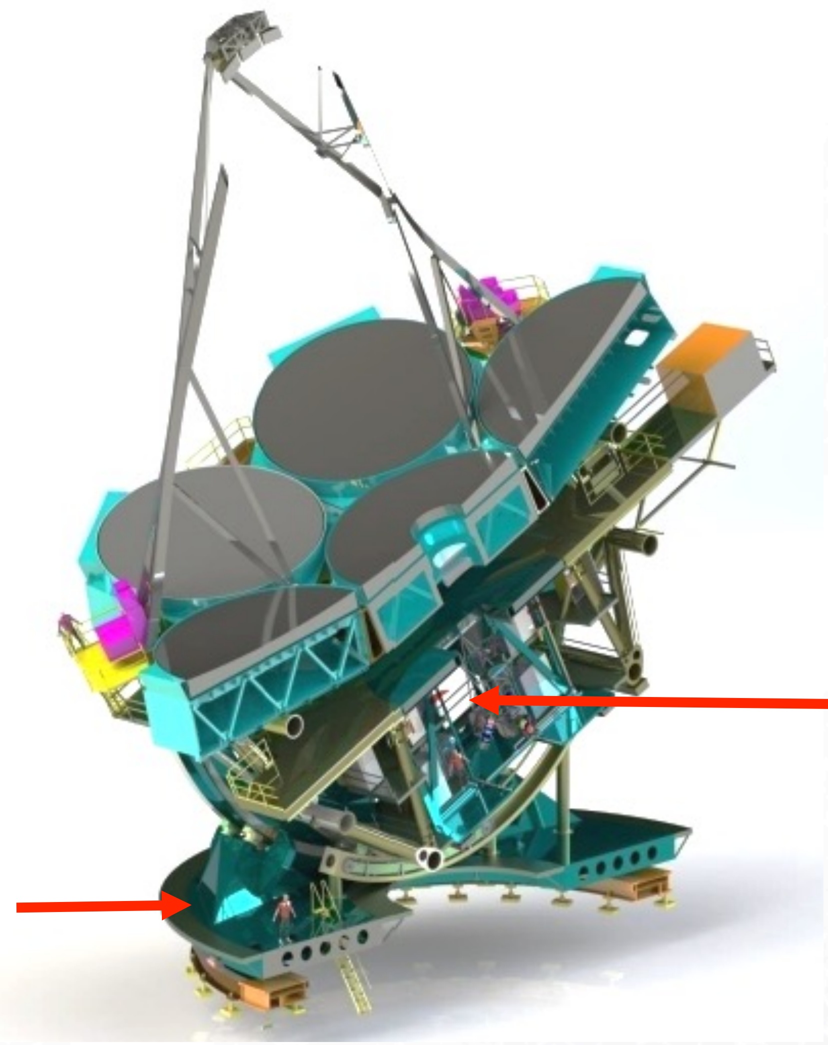
Segment #4:
Casting/cleanout complete.

Segments #5 & #6:
Materials purchased.

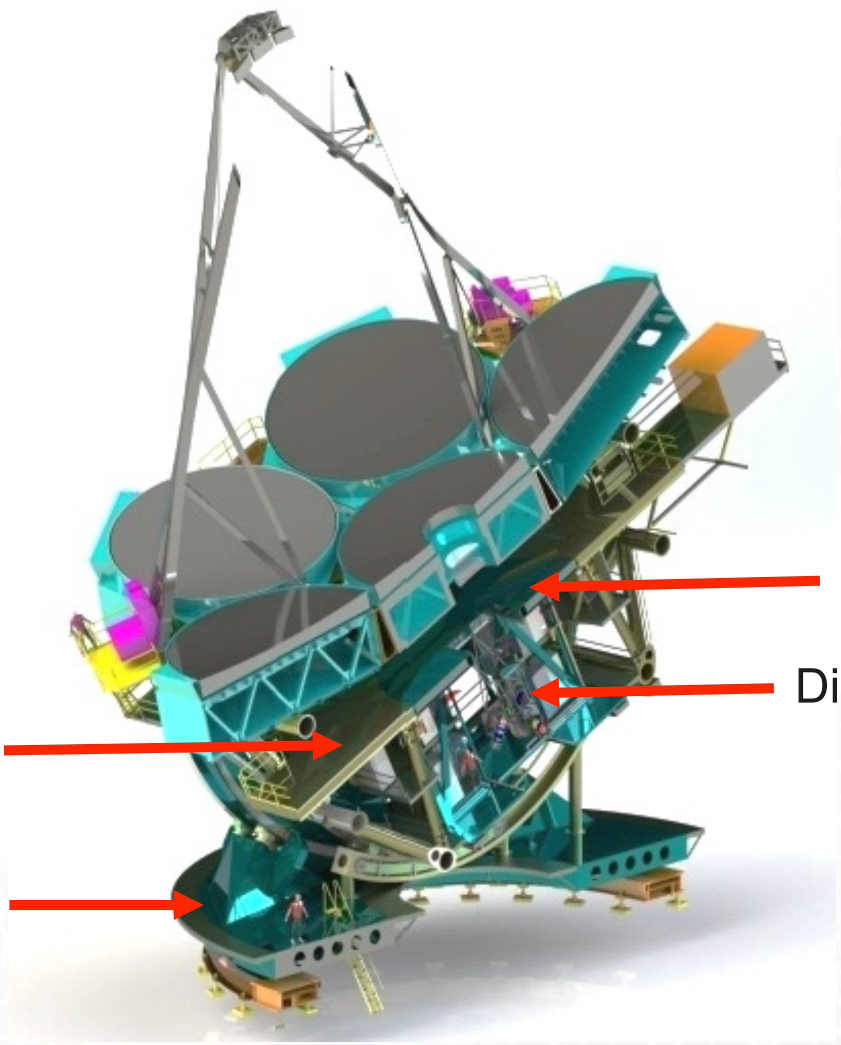


GMT Site Development Well Underway

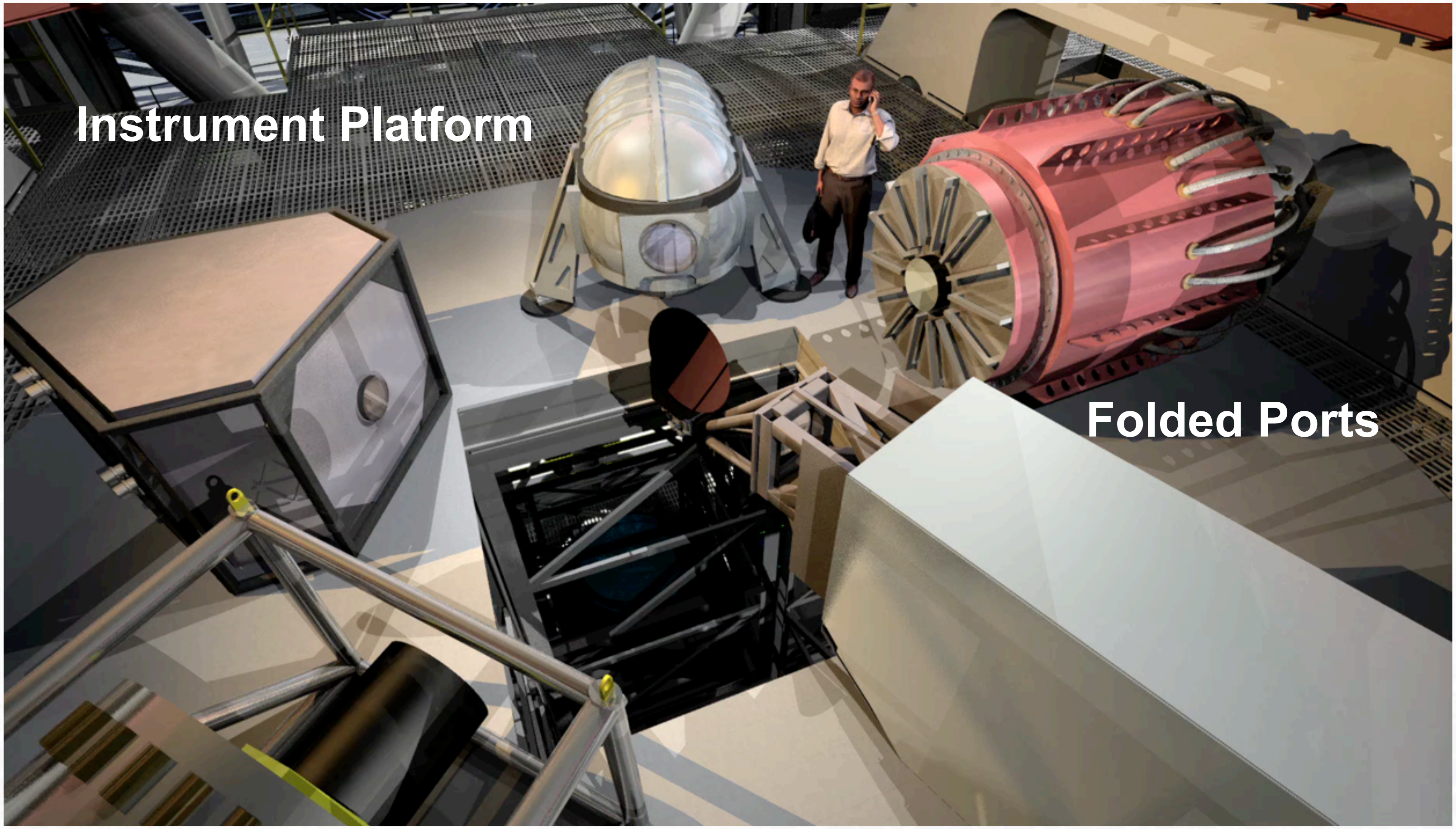
Instrument Mount Locations



Instrument Mount Locations



Instrument Mount Locations



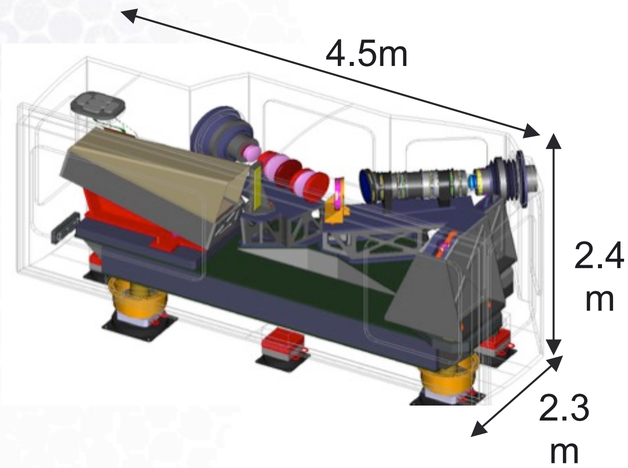
First Generation Instrument Status

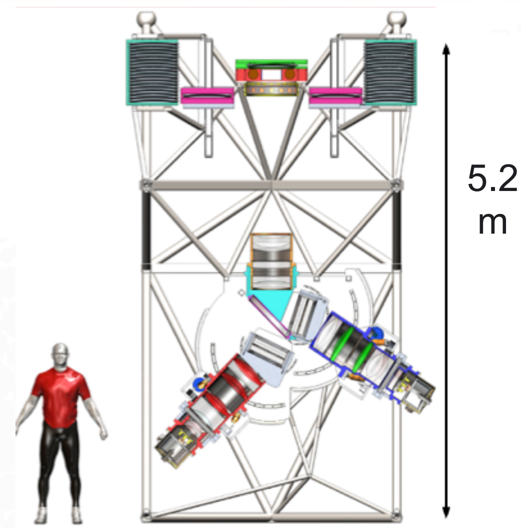
GMT

Instrument / Mode	Capabilities	λ Range, μm	Resolution	Field of View
G-CLEF / NS, GLAO, NGSAO	Optical High Resolution Spectrograph / PRV	0.35 – 0.95	19,000 – 108,000	7 x 0.7,1.2” fibers
GMTIFS / LTAO, NGSAO	NIR AO-fed IFS / Imager	0.95 – 2.5	5,000 & 10,000	10 / 400 $arcsec^2$
GMACS / NS, GLAO	Wide-Field Optical Multi-Object Spectrograph	0.35 – 0.95	1,000 – 6,000 (8K with MANIFEST)	7.5’ diameter
ComCam / NS, GLAO	Optical Imager	0.34 – 1.0	0.06 arcsec/pix	6 x 6 arcmin
GMTNIRS / NGSAO, LTAO	JHKLM AO-fed High Resolution Spectrograph	1.1 – 5.3	50,000 / 75,000 (JHK / LM)	1.2” long-slit
MANIFEST / NS, GLAO	Facility Robotic Fiber Feed	0.36 – 1.0		20’ diameter

Current Phase	Next Phase
Final Design	Fabrication
Preliminary Design	Final Design
Conceptual Design	Preliminary Design
Silicon Grating Technology Development	Preliminary Design
Science demonstrator closeout	Concept Design

Natural Seeing Optical (350-950 nm) Spectrographs





G-CLEF

PI: Andrew Szentgyorgyi, Smithsonian

Stabilized, fiber-fed, dual channel echelle
R = $\lambda/\Delta\lambda$ =19,000 – 35,000 – 108,000
< 50 cm/s per observation

- Exoplanets PRV (<10 cm/s) & chemistry
- Stellar abundances, esp. [Fe/H] < -4
- Dark matter distribution in dwarf galaxies

GMACS

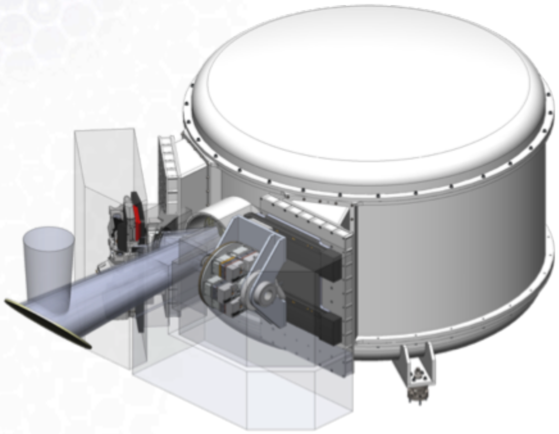
PI: Darren DePoy, Texas A&M

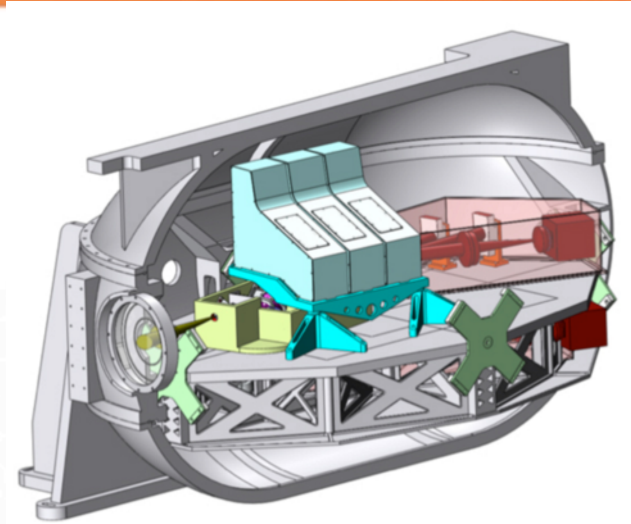
Multi-object, dual channel
R = $\lambda/\Delta\lambda$ = 1,000 – 6,000
7.5' diameter FoV spectroscopy / imager

- Stellar evolution & abundances
- ISM & IGM abundances
- Galaxy chemical evolution, Lyα systems

AO-Fed Spectrographs

GMT





GMTIFS

Rob Sharp

Diffraction-limited yJHK IFU / imager (20.4”)
R = $\lambda/\Delta\lambda$ = 5,000 or 10,000
Spaxels: 6, 12, 25, or 50 mas

- Galaxy chemical enrichment history
- First galaxy structure and assembly
- Black hole masses
- IGM at high redshift

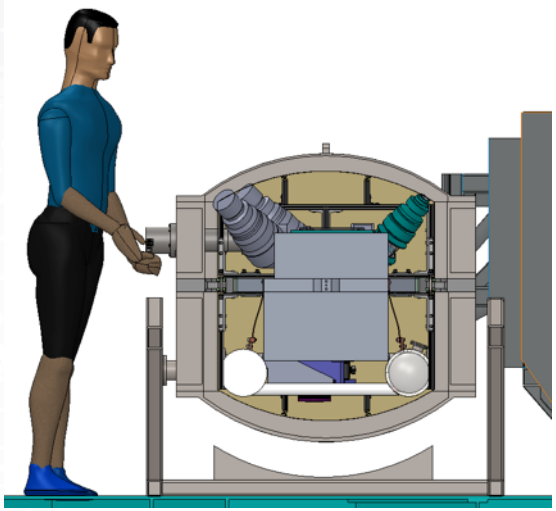
GMTNIRS

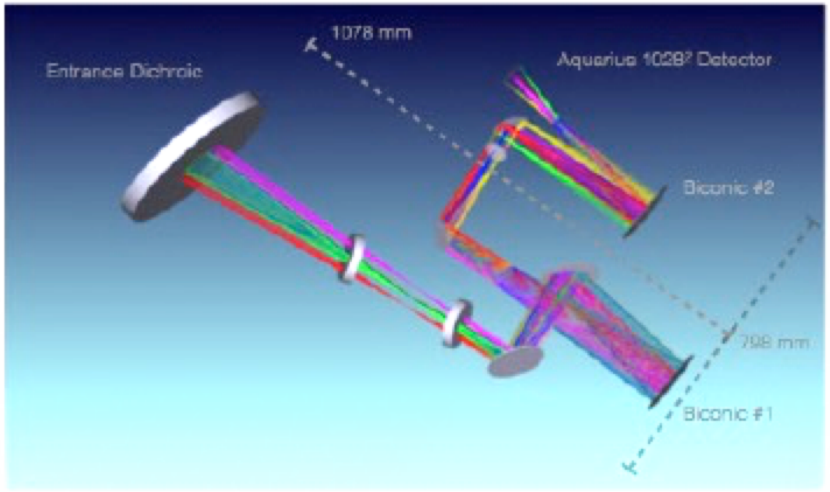
Dan Jaffe

Near-diffraction limited JHKLM echelle
Full 5 band coverage simultaneously
R = $\lambda/\Delta\lambda$ = 50,000 (JHK) – 75,000 (LM)

- Exoplanet structure and atmospheres
- Star and planet formation
- Composition of stars & nebulae
- Galaxy chemical evolution history

Future Instruments SuperFIRE & TIGER





Super FIRE

Rob Simcoe

IR echelle spectrograph
3-channel JHK simultaneous
R = $\lambda/\Delta\lambda$ ~ 6,000
8" slit length

Derives from FIRE on Magellan

TIGER

Phil Hinz

Dual channel ExAO imager
1.5-5 μm; 7-14 μm
R = $\lambda/\Delta\lambda$ ~ 300; Spatial ~ 7 mas / pixel
30" Field of view
Contrast: ~10^{-6} in L band @ 3 λ/D

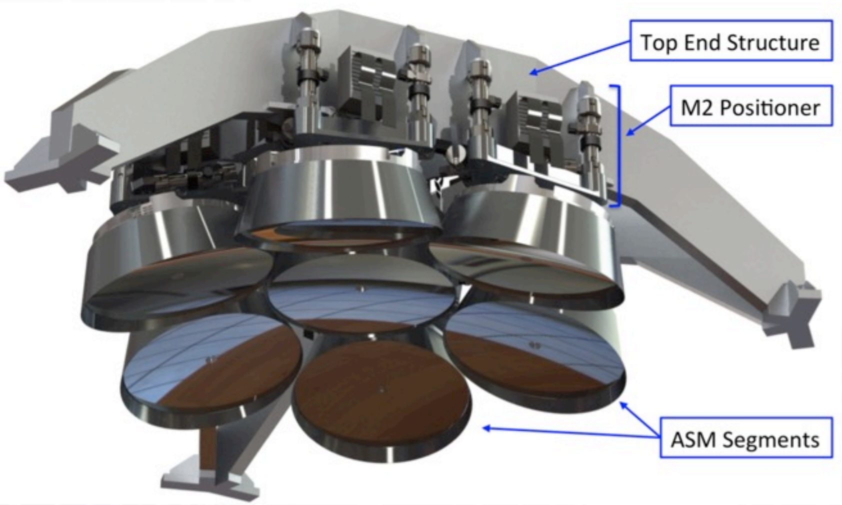
Adaptive Optics with the GMT

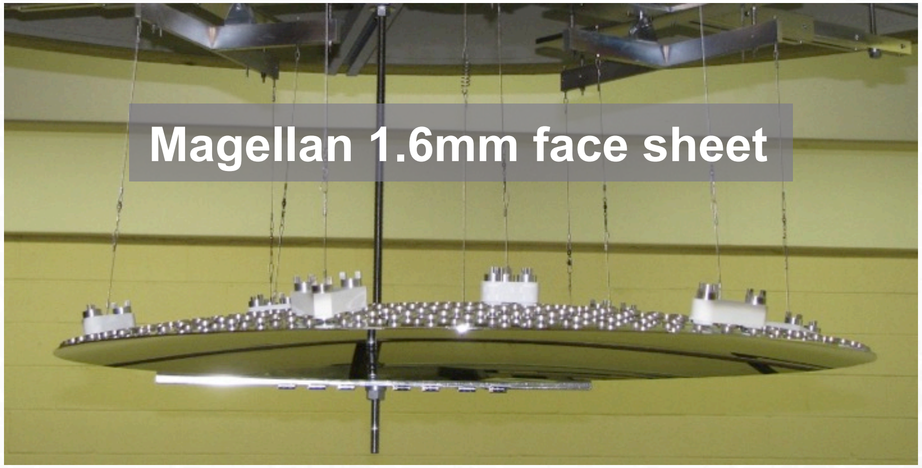
GMT uses a segmented Adaptive Secondary Mirror with a direct-feed architecture

Builds on success of LBT, Magellan and VLT systems

Low background, 10 mas resolution at 1 micron

4700 actuators



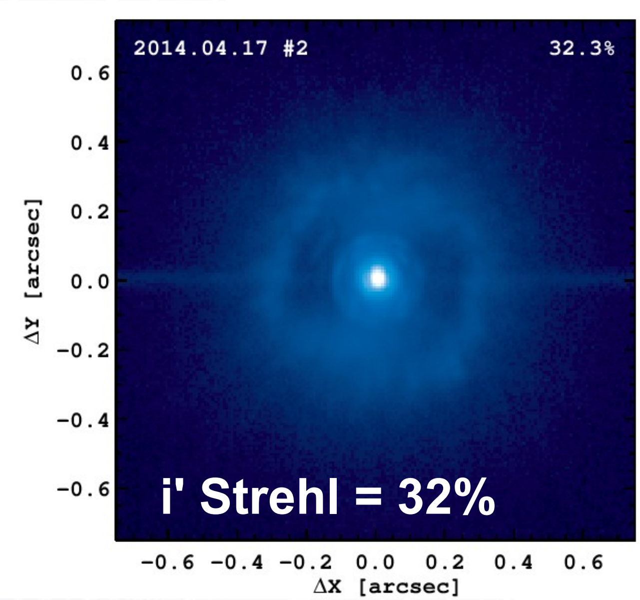


Adaptive Optics with the GMT

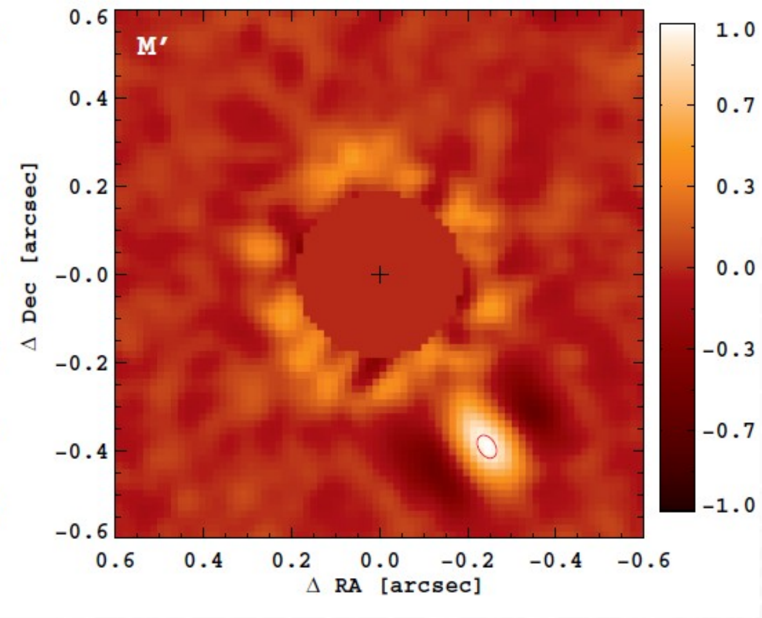
Magellan AO system achieves 32% Strehl in the i-band
Has reached 40% in R-band (at Hα)!

High spatial resolution Exoplanet imaging over a wide range of wavelengths

0.8 microns



4.6 microns

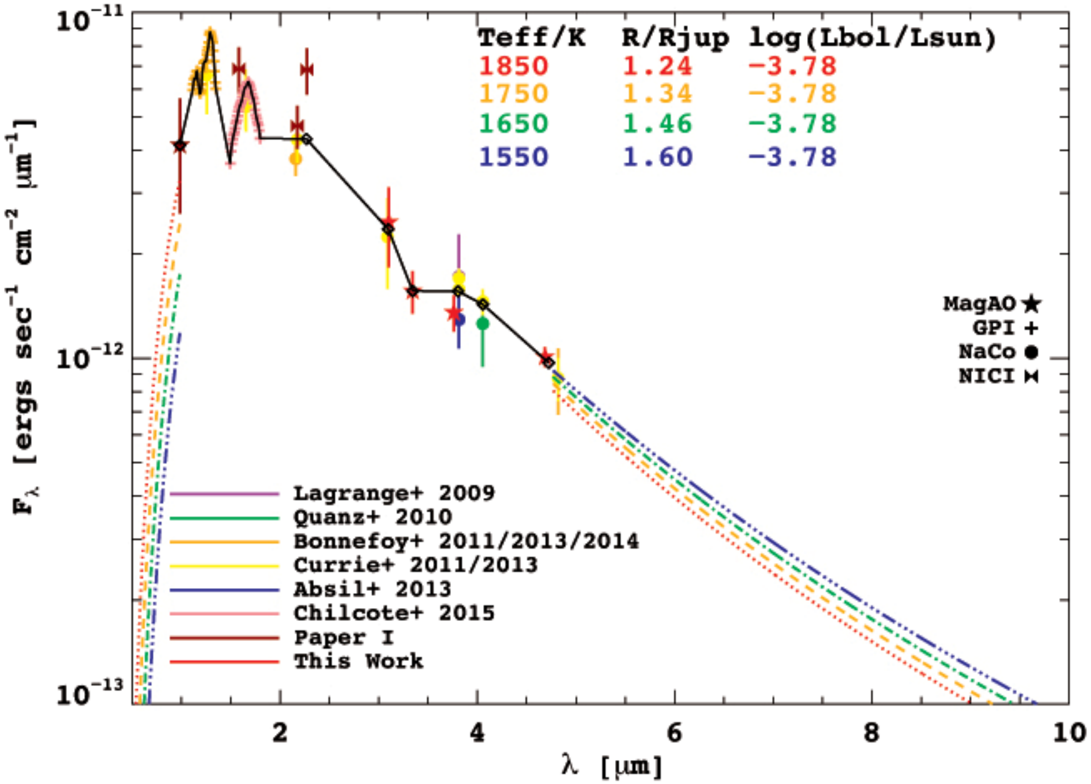


Adaptive Optics with the GMT

High spatial resolution Exoplanet imaging over a wide range of wavelengths

GPI, MagAO, and other systems are enabling physical studies of exoplanets

These are forerunners of the ELT AO systems

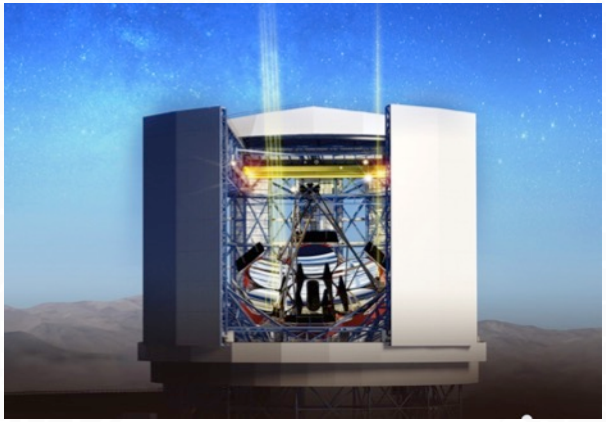
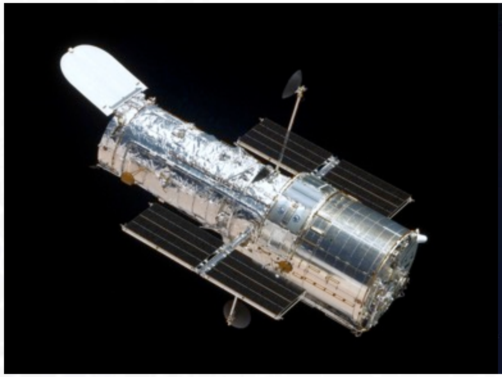
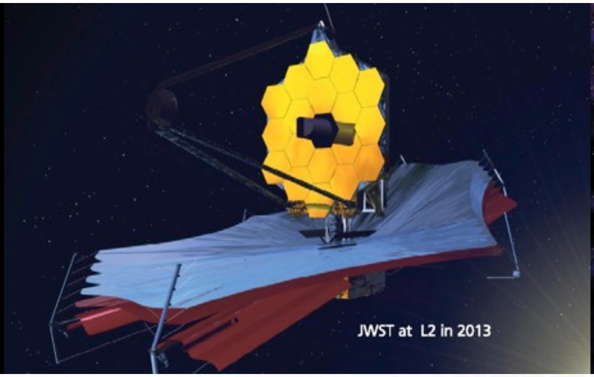


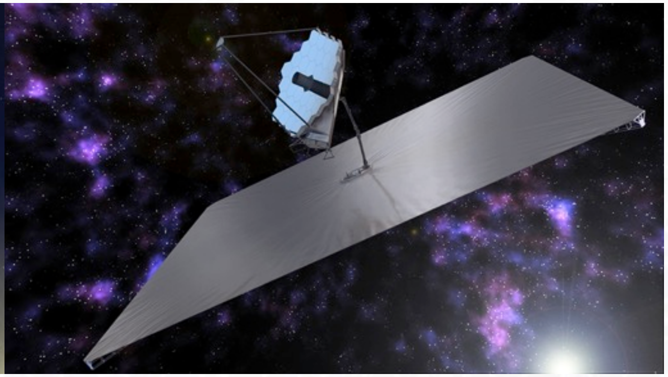
The ELTs and LUVOIR

The ELTs are the next generation ground-based observatories
Analogous to JWST and LUVOIR in the evolution of space telescopes

The ELTs will reach their zenith in the period between JWST and LUVOIR





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- Characterization of habitable planets
    - Atmospheric chemistry, orbits and masses, direct imaging
- Exploration of Cosmic Dawn
    - Spectroscopy, abundances, dynamics, clustering
- New Discovery Space
    - The unknown!