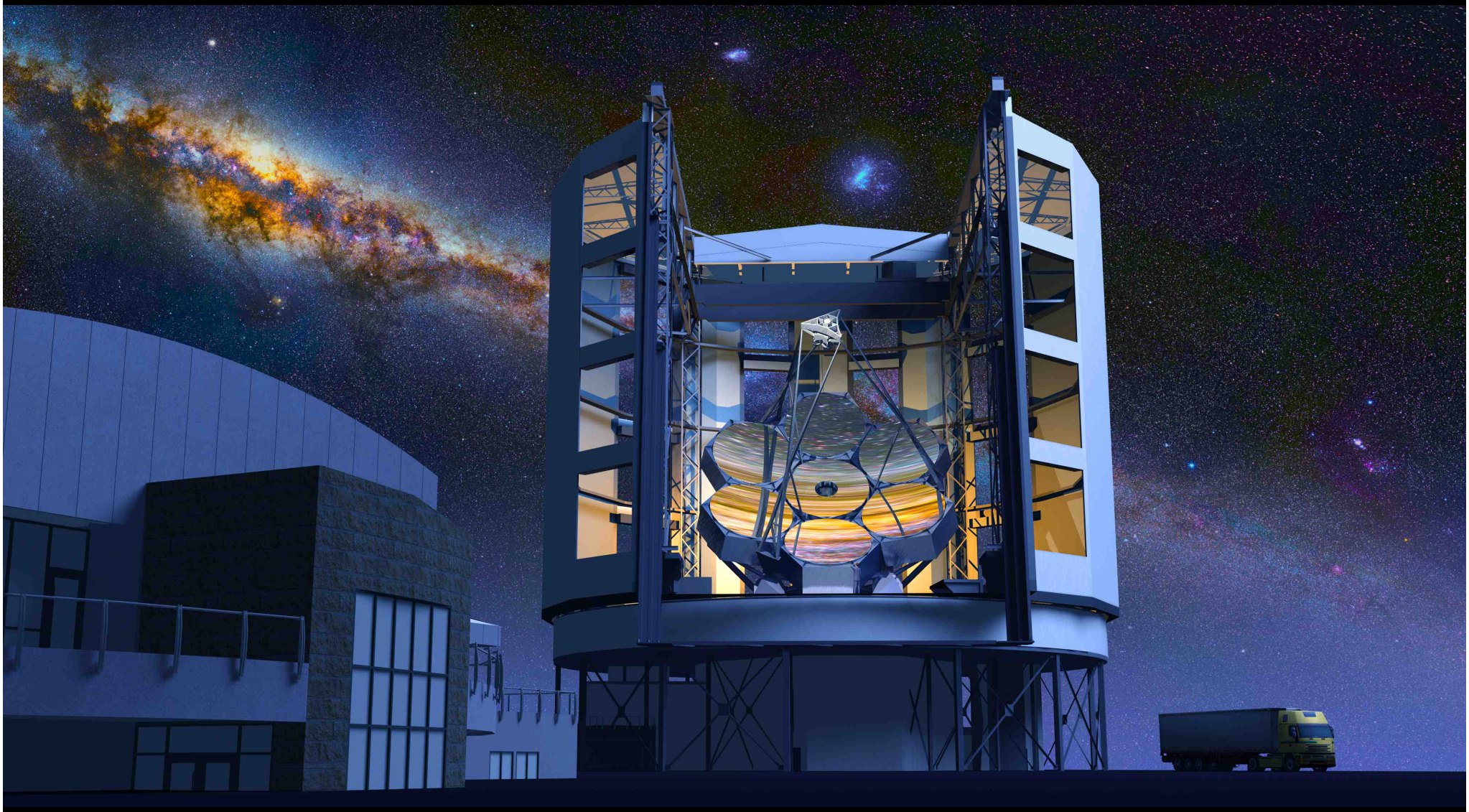
Instrumentation for The Giant Magellan Telescope

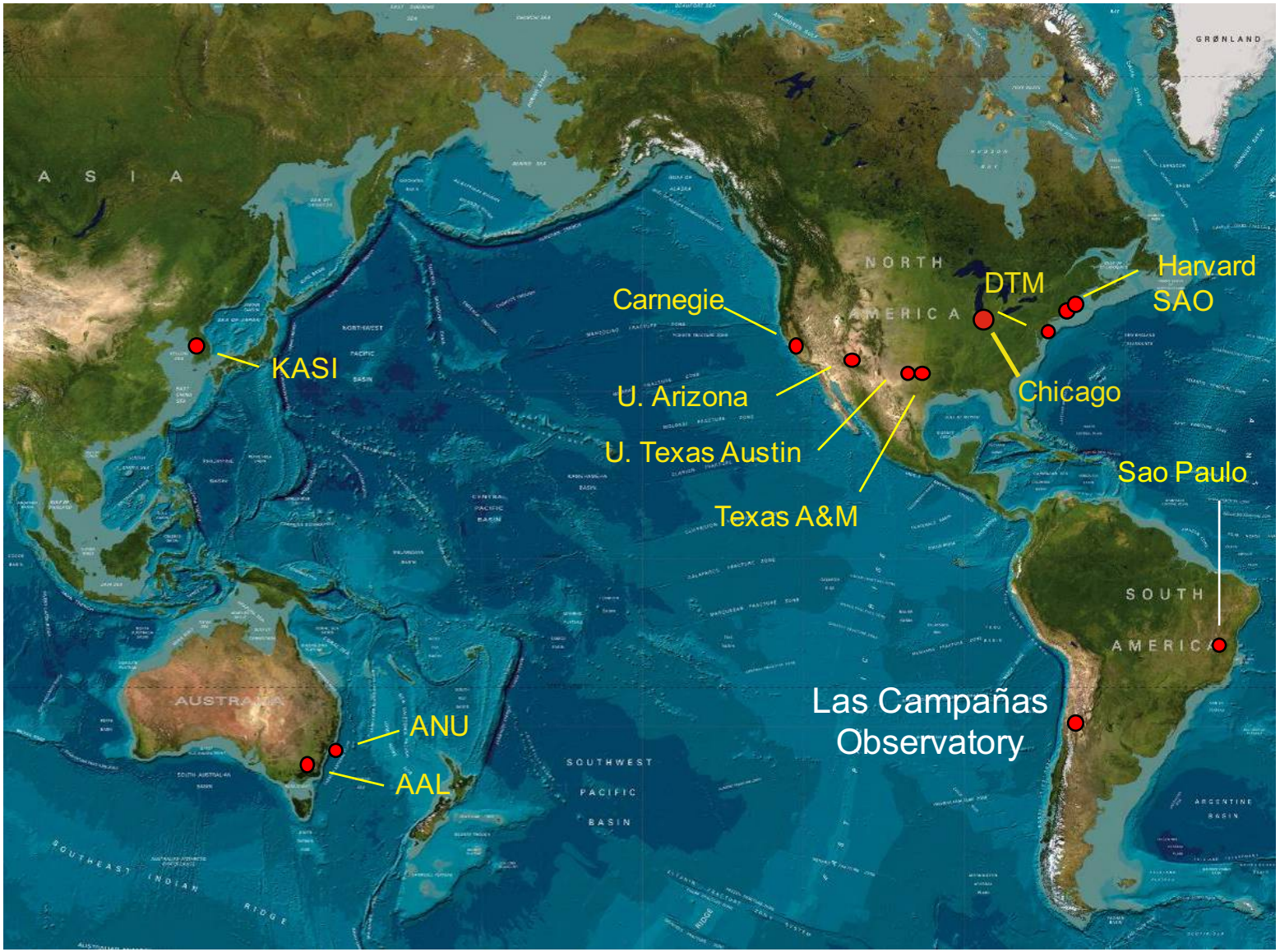


George Jacoby (GMTO/Carnegie) – GMT Instrumentation Scientist

Outline

- Overview / Status of the *Giant Magellan Telescope* project
- Science instrument suite
- Second generation instrument concepts
- Challenges and Opportunities for ELT instrument programs

Partner Institutions



The GMT Concept

7 – 8.36-m primary segments
25.4-m maximum diameter
21.9-m effective collecting area

7 – 1.05-m secondary mirrors
Fast steering mirrors
Adaptive secondary mirrors

f/0.71 primary focal ratio

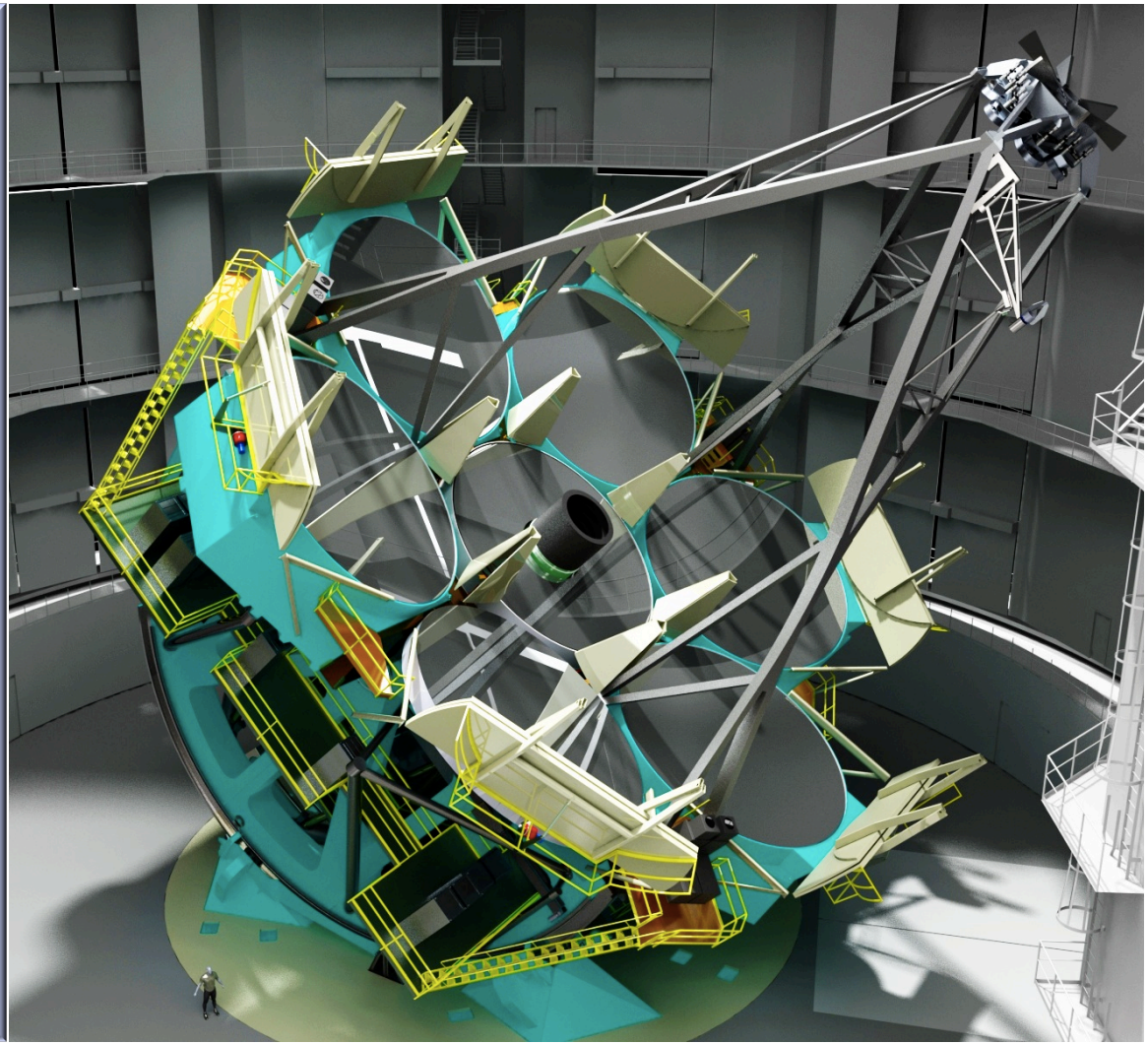
f/8.16-8.34 final focal ratio

Plate scale ~1.0 mm/arcsec

20 arcmin field of view

↓

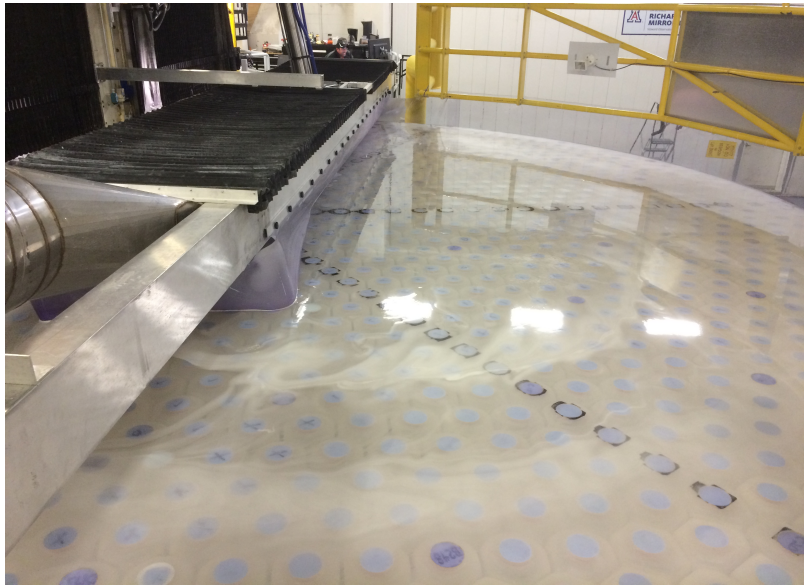
~1200 mm physical field



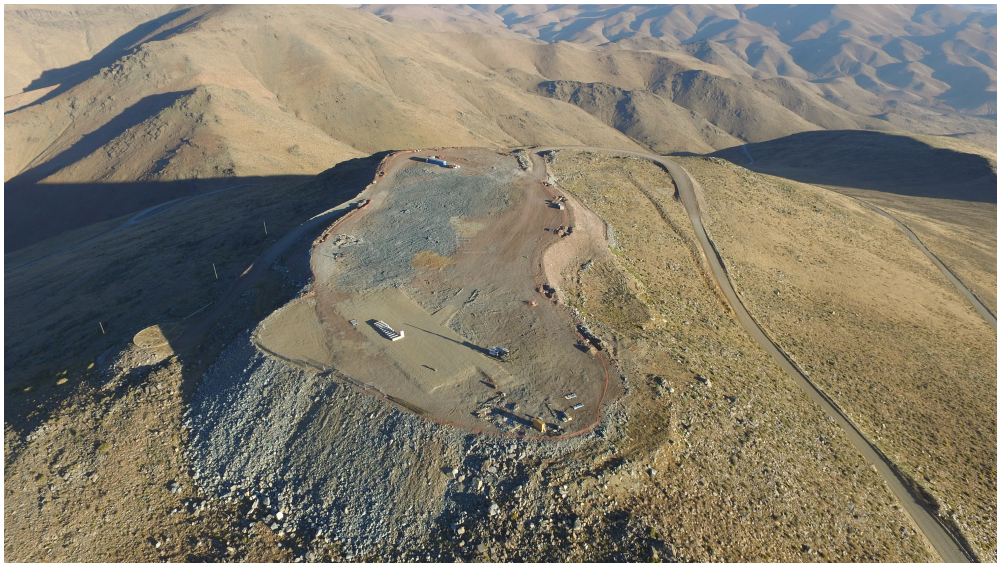
Primary Mirror Status

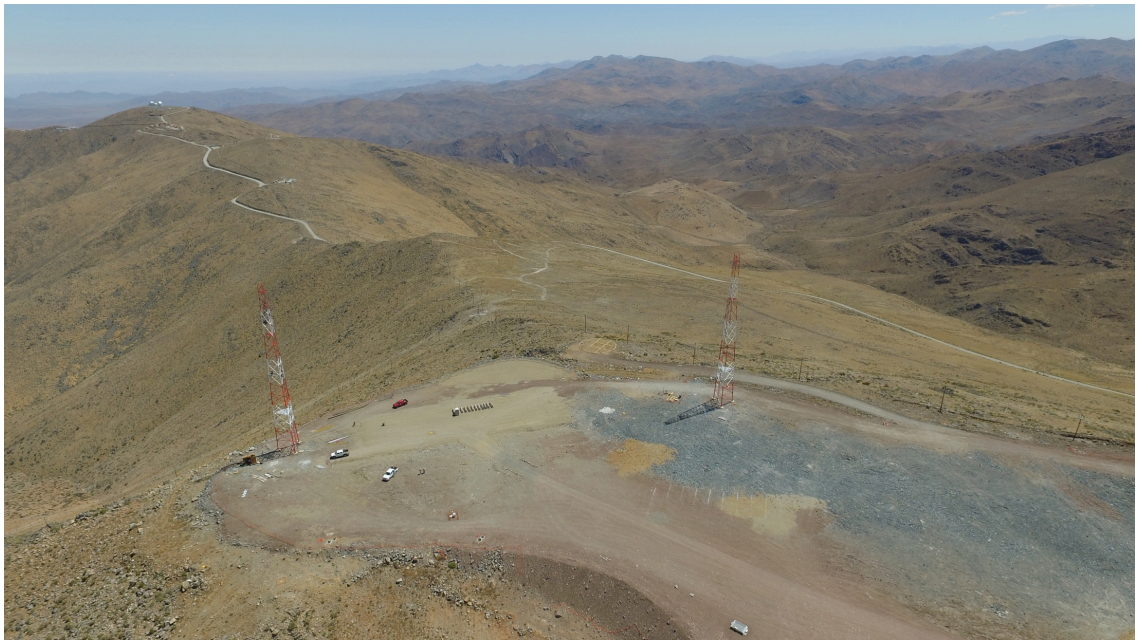
7 mirrors needed (plus 1)

- #1 is complete – first off-axis mirror
- #2 being ground and polished
- #3 (below left) having rear surface generated
- #4 (below right) is cast – the central mirror
- #5 to be cast late this year – glass delivered
- #6 glass purchase in progress



Las Campanas Observatory





Science – Key Areas & Sample Questions

Stars and Planets

What is the Origin of the IMF, binary stars, disks, and sub-stellar masses?

Exoplanets and Their Properties

How do formation mechanisms affect planet compositions and structure?

Stellar Populations

What is the metallicity distribution function of the most metal-poor stars?

Galaxy Assembly

How do the processes of feedback from stars, SNe, AGN winds, accretion, and star formation lead to the present day galaxy properties and diversity?

Cosmology & Physics

What is the nature & distribution of dark matter in galaxies and clusters?

First Light & Reionization

What sources caused reionization; what is their distribution in time & space?

Transients, Surveys, and Synergies

LSST, DES, JWST, ALMA, SKA follow-up and collaborations

GMT Science Book is at: http://www.gmto.org/resources/

First Generation Instruments: Current Status

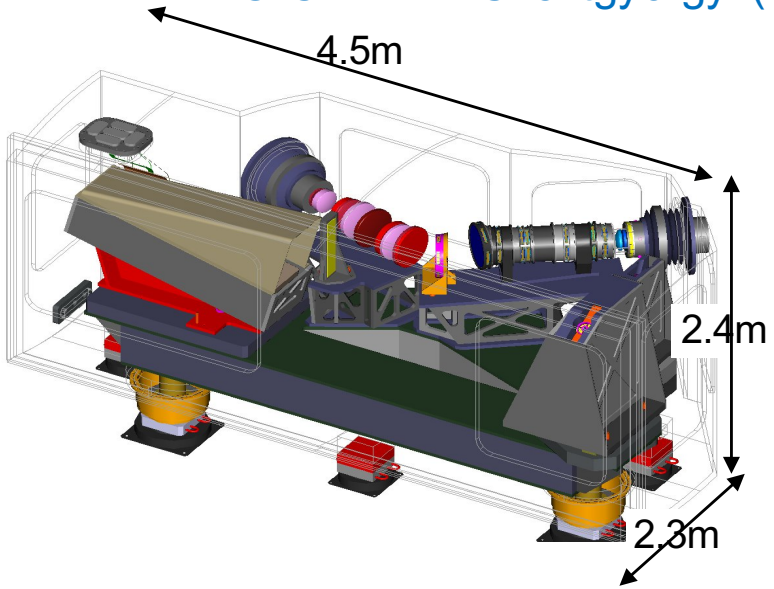
Instrument / Mode	Capabilities	λ Range, μm	Resolution	Field of View
G-CLEF / NS, GLAO, NGSAO	Optical High Resolution Spectrograph / PRV	0.35 – 0.95	20,000 – 105,000	7 x 0.7,1.2" fibers
GMTIFS / LTAO, NGSAO	NIR AO-fed IFS / Imager	0.9 – 2.5	5,000 & 10,000	10 / 400 arcsec^2
GMACS / NS, GLAO	Wide-Field Optical Multi-Object Spectrograph	0.37 – 1.0	1,500 – 4,000 (8K with MANIFEST)	40-60 arcmin^2
ComCam / NS, GLAO	Optical Imager	0.34 – 1.0	0.07 arcsec/pix	7.1 x 7.1 arcmin
GMTNIRS / NGSAO, LTAO	JHKLM AO-fed High Resolution Spectrograph	1.10 – 5.3	50,000 / 100,000 (JHK / LM)	1.2" long-slit
MANIFEST / NS, GLAO	Facility Robotic Fiber Feed	0.36 – 1.0		20' diameter

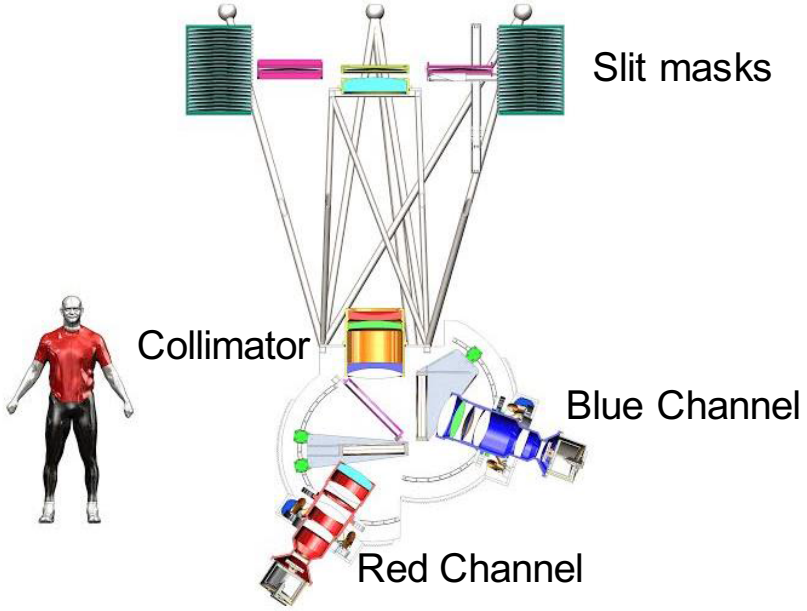
Current Phase	Next Phase
Final Design	Fabrication
Preliminary Design	Final Design
Conceptual Design	Preliminary Design
Silicon Grating Technology Development	Preliminary Design
Science demonstrator closeout	Concept Design

Detailed descriptions available in SPIE papers 2014, 2016

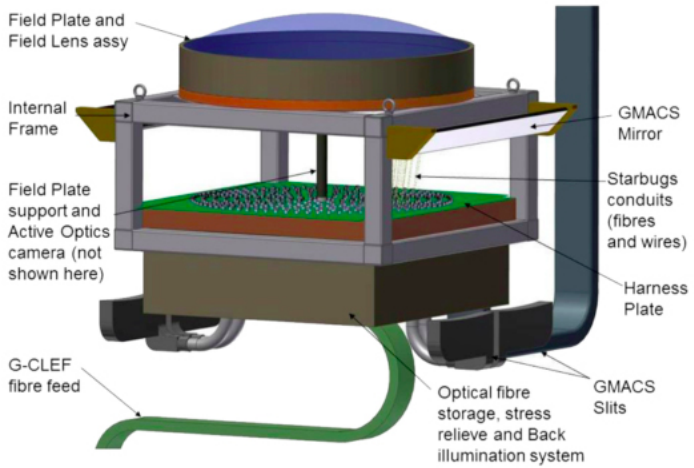
GMT's First Generation Instruments - 1

G-CLEF: A. Szentgyorgyi (SAO)





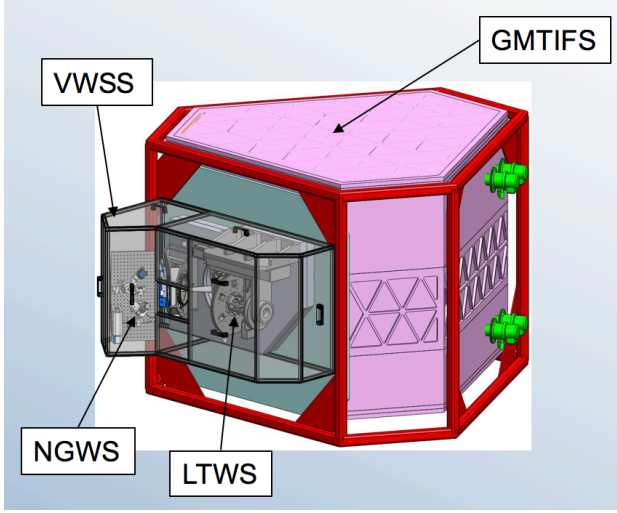
GMACS: D. DePoy (Texas A&M)



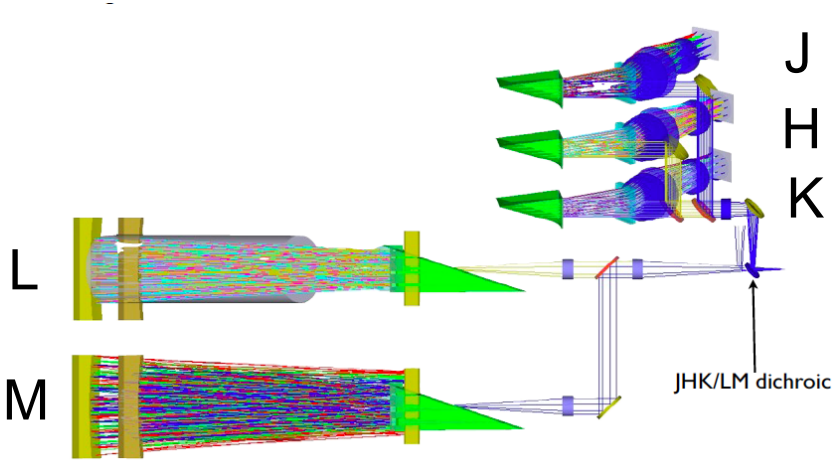
MANIFEST: J. Lawrence (AAO)

MANIFEST allows observations with 2 or more instruments simultaneously:
GMACS + G-CLEF + future IR-MOS

GMT's First Generation Instruments - 2

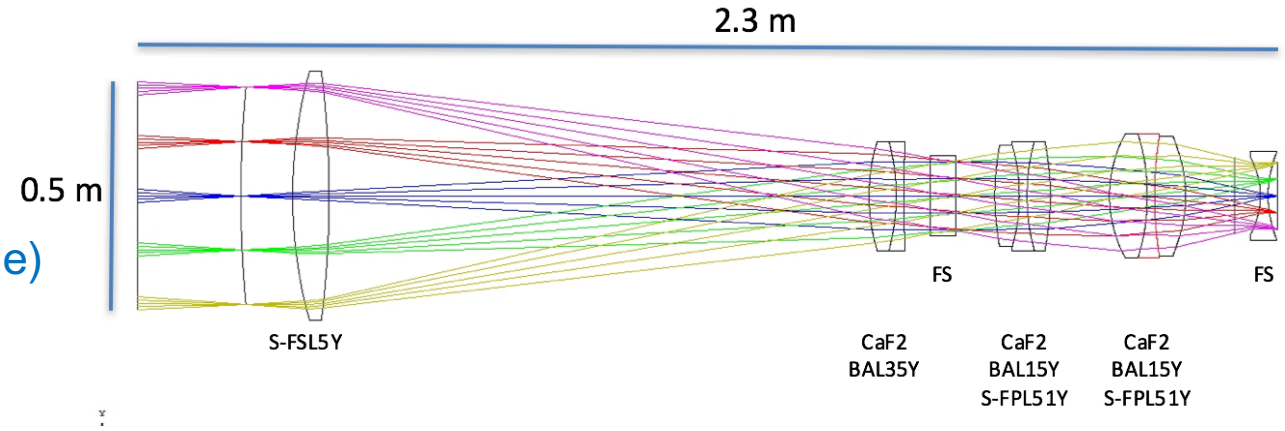


R. Sharp (ANU)

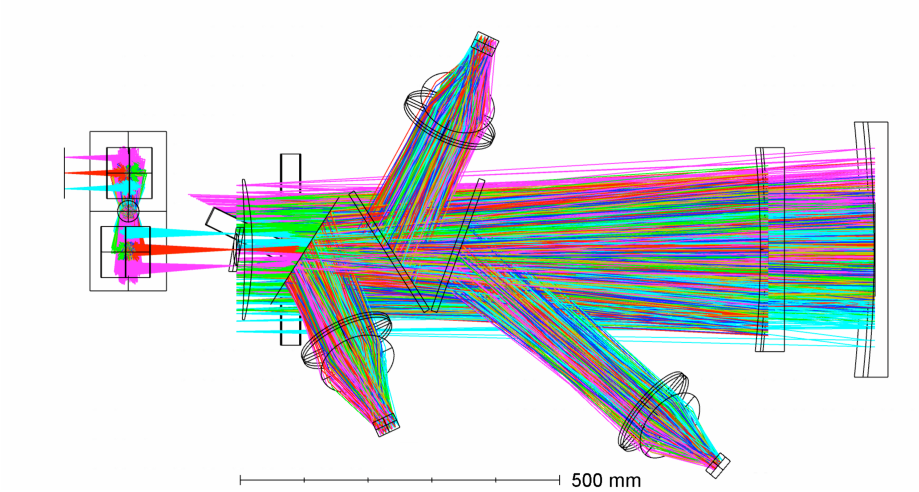


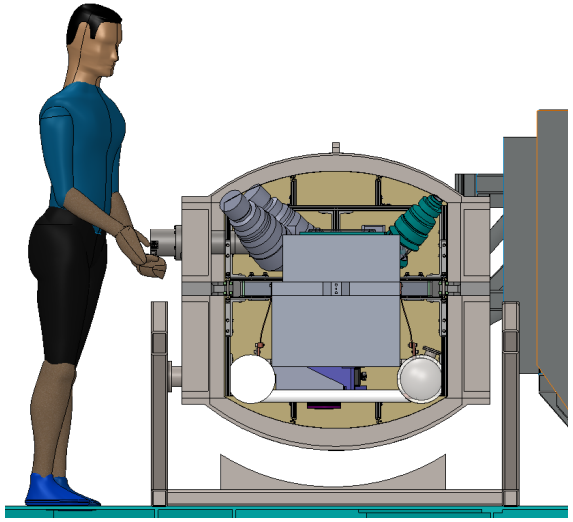
GMTNIRS: D. Jaffe (Univ Texas)

ComCam:
J. Crane (Carnegie)



Second Generation Instruments - 1
YJHK Spectrograph: Rob Simcoe (MIT)



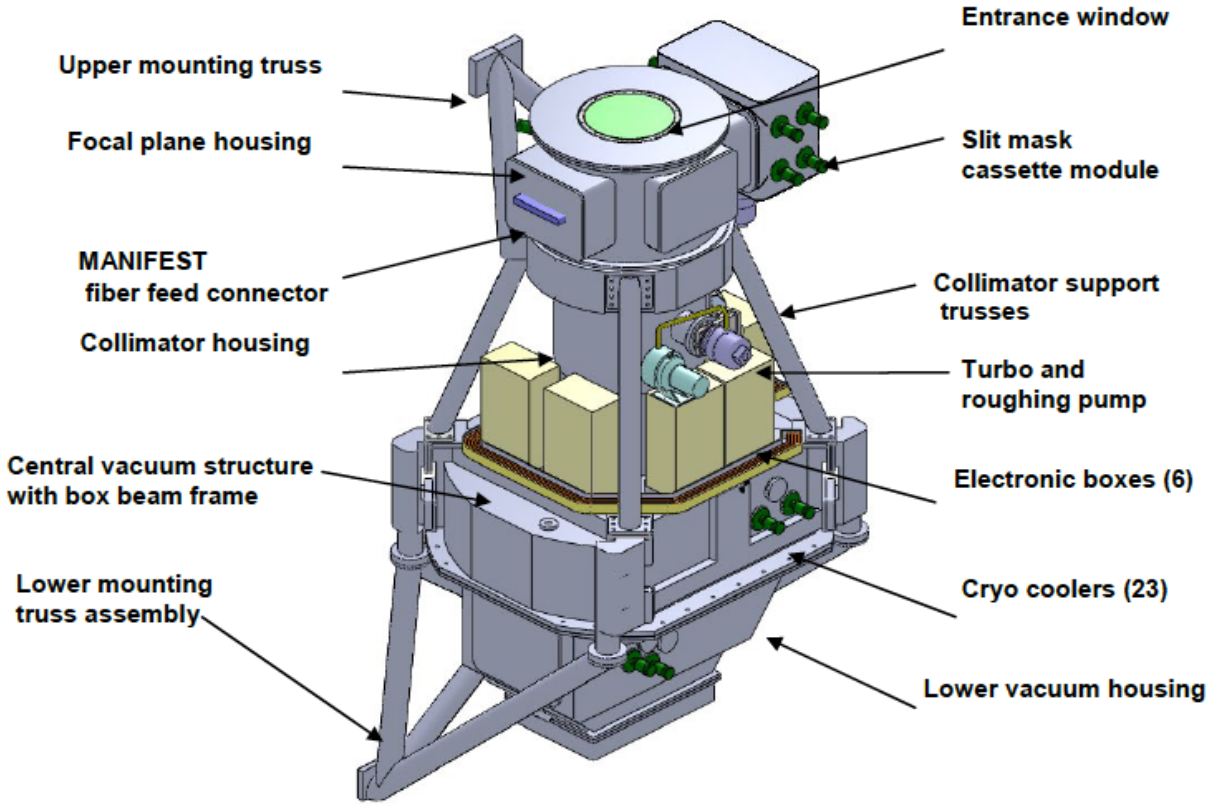


- 3-channel single object IR Spectrograph
- 8” slit length
- 0.9 – 2.5 μm
- Resolution ~ 6,000
- H2RG detectors (3)
- Derived from FIRE at Magellan
- Small, relatively inexpensive

Second Generation Instruments - 2
NIR Multi-Object Spectrograph: Dan Fabricant (SAO)

For IRMOS-like science

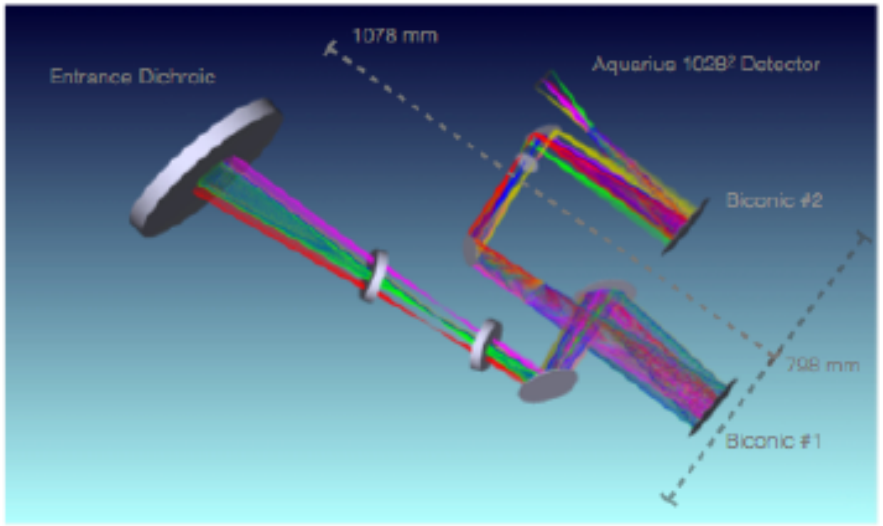
- Originally explored as GMT "NIRMOS"
- Multi-object slitlet IR Spectrograph
- 0.9 – 2.5 μm
- Resolution > 4,000
- 5' x 5' Field of view
- H4RG detector(s)



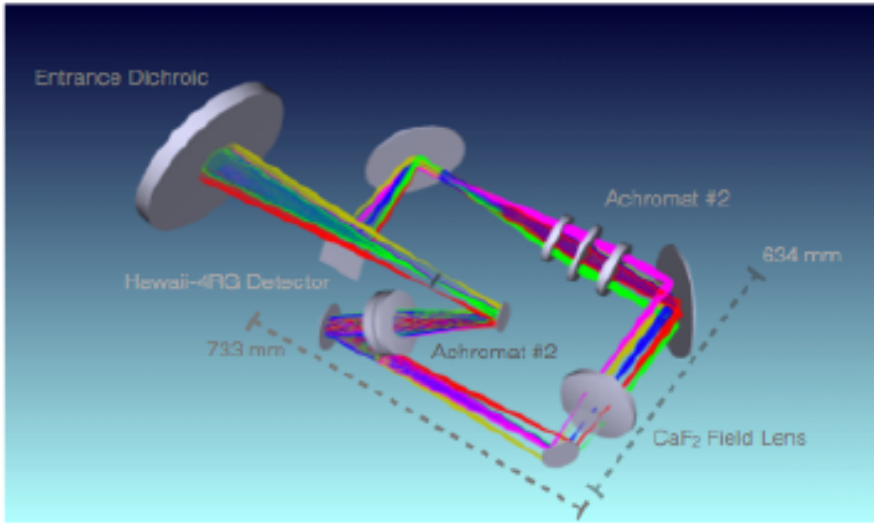
Second Generation Instruments - 3
High Contrast AO Mid-IR: Phil Hinz (Arizona)

For science of exoplanets, disks, star formation

- Originally explored as GMT “TIGER”
- Dual channel imager and spectrograph: 1.5-5 μm; 7-14 μm
- Spectral resolution ~ 300
- Spatial resolution ~ 7 mas / pixel
- 30” Field of view
- Contrast to 10^{-6} in L band @ 3 λ/D



Short wavelength channel

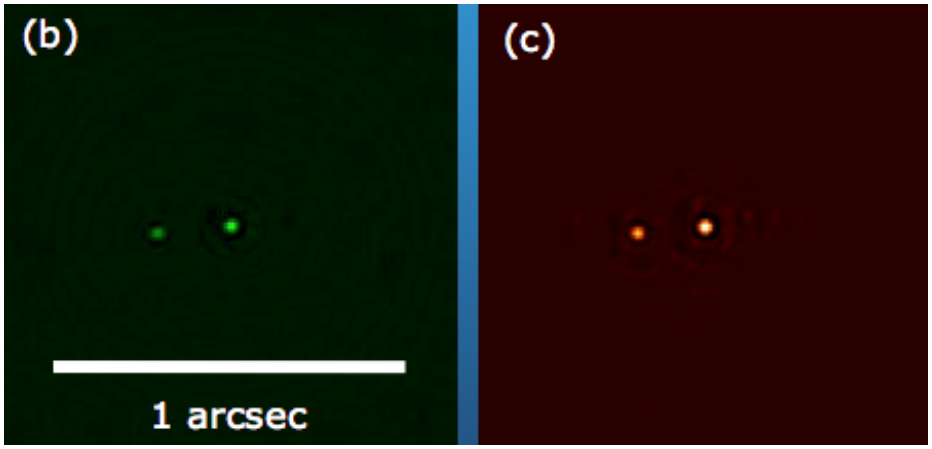


Long wavelength channel

Second Generation Instruments - 4
Speckle: Howell (Ames) & Horch (S. Conn. St. Univ)

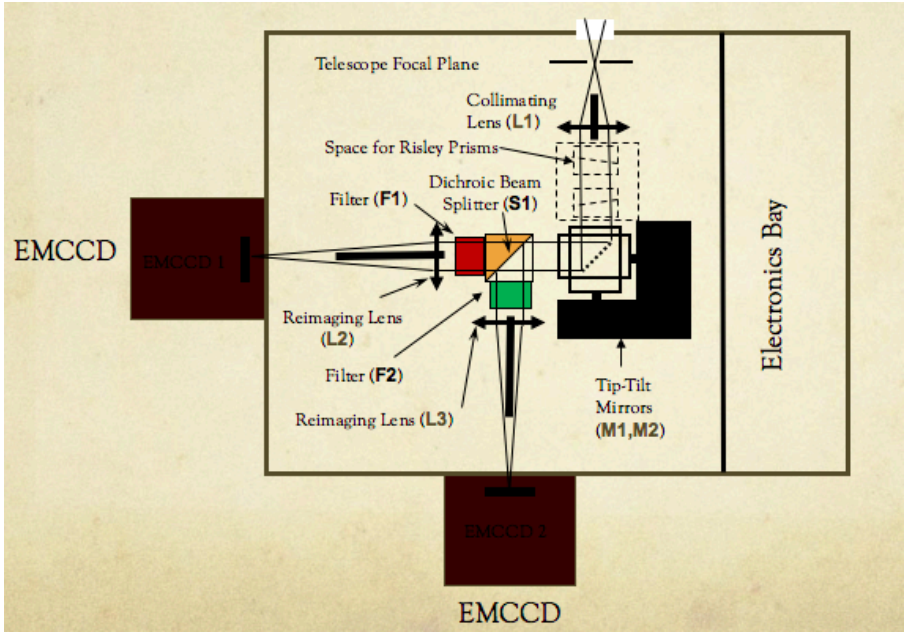
For early diffraction-limited imaging: binaries, exoplanets, Solar System

- Like DSSI at Gemini and WIYN: Fast dual channel visible imaging
- Enables GMT high resolution imaging (< 20 mas) before ASMs
- Inexpensive and simple design



562 nm 692 nm

Gemini



ELT Instrumentation is Challenging

- Long development period – 15 years or more
  - Science drivers change
  - Telescope is not stable
  - Key personnel on instrument teams leave
  - Vendors disappear
  - Technology evolves
- Expensive
  - Unreliable funding sources – instruments go first in tight budgets
  - Limited number of instruments, so …
- Complex
  - Tend to have many modes
  - Diffraction limit demands unprecedented tolerances and accuracy
- High Expectations
  - Demanding performance specifications (e.g., throughput, resolution)

ELT Instrumentation can be more Collaborative

- All 3 projects face similar challenges
- Opportunities for collaboration
- Example: *ELT Detector Workshop – October 2015*



- Possible additional areas for collaboration
  - Gratings, e.g., VPH
  - Optical coatings
  - Software, especially data pipelines and archives

Summary

- Six instruments under development at GMT
- Four future instruments being discussed informally

- GMT instruments advancing for deliveries in 2021-2024
- Schedule is more constrained by cash flow than technical issues
- Budget forcing additional funding strategies
  - Federal funding: MSIP and MRI
  - Institutionally funded ("in-kind" contributions)
  - Donor funded

- *Recommend:* that all ELT groups work more collaboratively
- *Recommend:* time trades for lacking capabilities
- *Recommend:* that future instruments be less ambitious