Report to the GSMT Committee

P. McCarthy

GMT Science Working Group and GMT Board

- GMT Consortium Status
- Conceptual Design Review
- AO Systems
- GMT Instrument Candidates
  - Instrument properties
  - Potential scientific impact

GMT Consortium

- Carnegie Observatories
- Harvard College Observatory
- MIT
- Smithsonian Astrophysical Observatory
- Texas A&M University
- University of Arizona
- University of Michigan
- University of Texas at Austin
- Australian National University (as of 4/06)

Conceptual Design Review

Review held in Pasadena, Feb 10-12, 2006

Review Committee:

P. Osmer (OSU, Chair) J. Crocker (Lockheed), R. Davies (Oxford), H. Decker (ESO), R. Fugate (SOR), P. Gillingham (AAO), I. Hook (Oxford),P. Salinari (Arcetri), J. Spyromillo (ESO), E. Turner (Princeton), A. Walker (CTIO)

Observers from NSF, NOAO, Caltech, UC…

Review documents available on the web:

http://www.gmto.org/CoDRpublic

CoDR Committee Report

“*The science goals and case presented by the GMT Science Working Group do address the priorities of the Decadal Survey. They are broad enough to serve the needs of the GMT science community and the wider astronomical community.*”

“*The technical solution chosen is low risk for this class of telescope, and the work on the optics and telescope structure was highly regarded by the committee*.”

“*The committee does find the baseline design effort sufficient to advance to the Design and Development Phase. The committee strongly recommends that the project proceed as quickly as possible*”.

GMT Adaptive Optics

AO modes

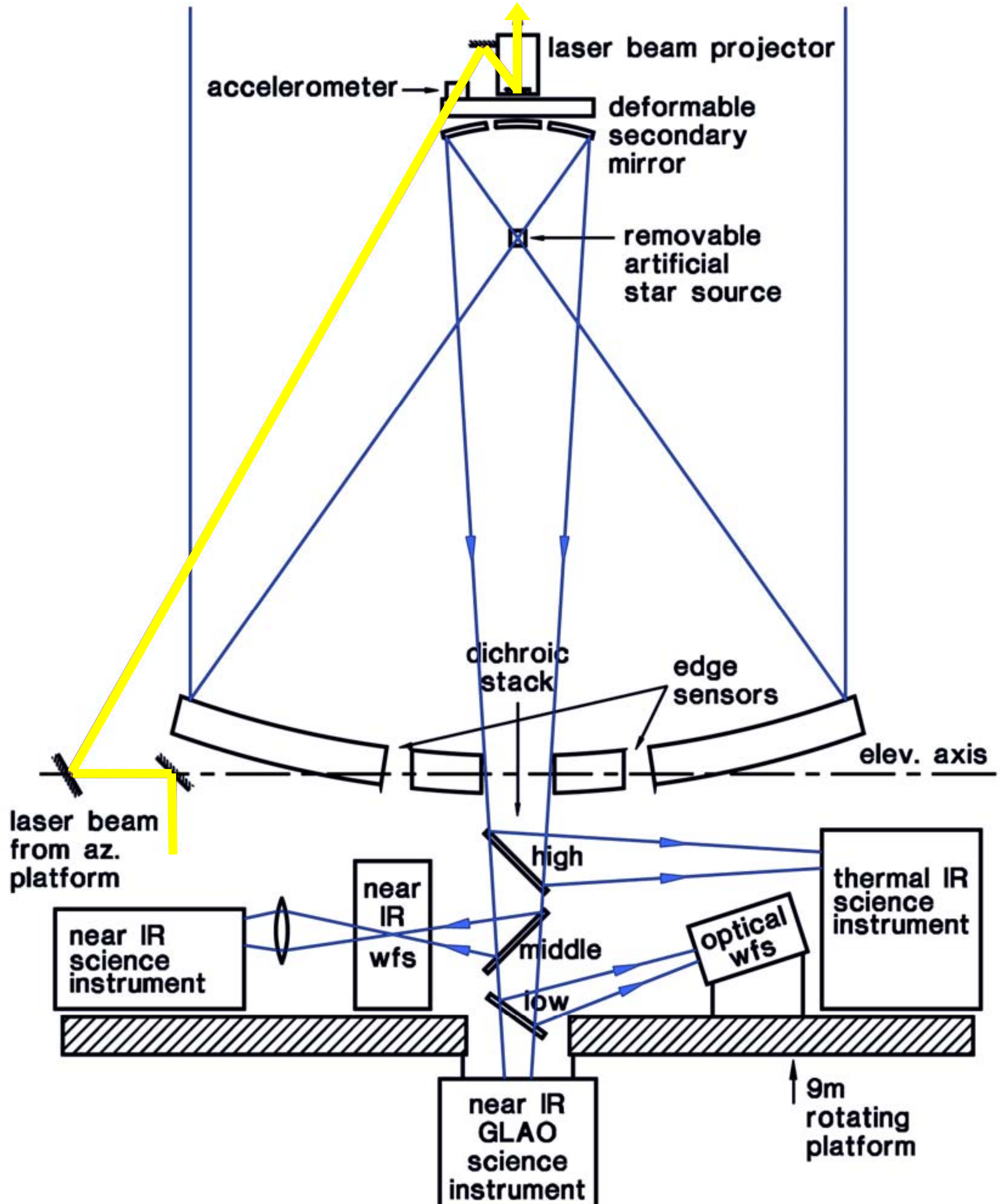
- Laser Tomography (high Strehl, modest field) AO (LTAO)
- Ground Layer AO (GLAO)
- Extreme AO

AO system components

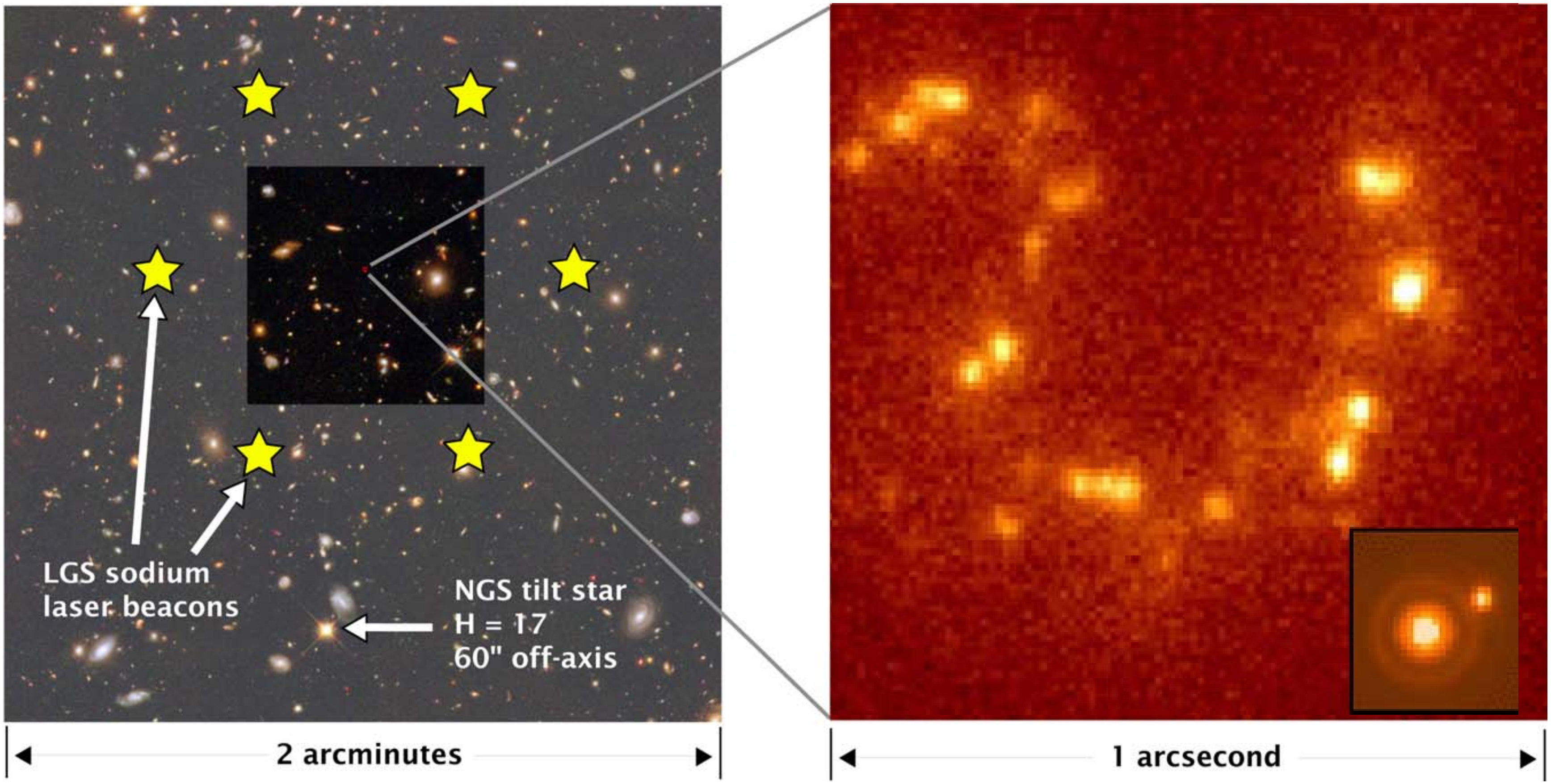
- AO secondary mirror
- Laser guide star system
- Optical Switch yard
- AO wavefront sensors
- Wavefront reconstructor(s)

AO System

- Single DM and common wavefront sensing system serves all GMT focal stations
- Gregorian secondary is DM
  - Avoids any loss of throughput or field, or increase in thermal background
- Laser system projects a constellation of 6 LGSs
- Guide stars and beacons separated by dichroics and by IR field probes:
  - Low only – GLAO
  - + middle – LTAO
  - + top – thermal



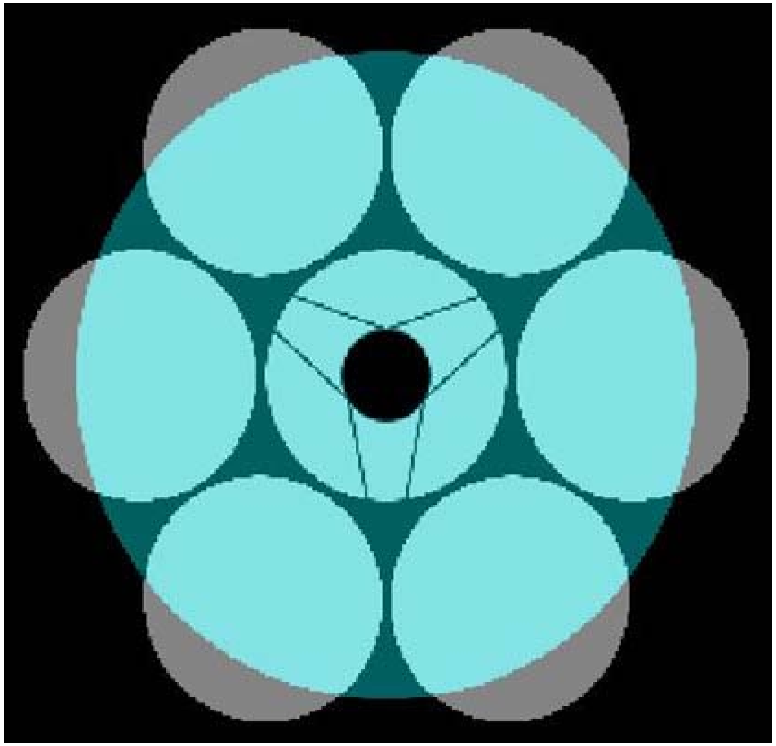
LTAO Laser Constellation

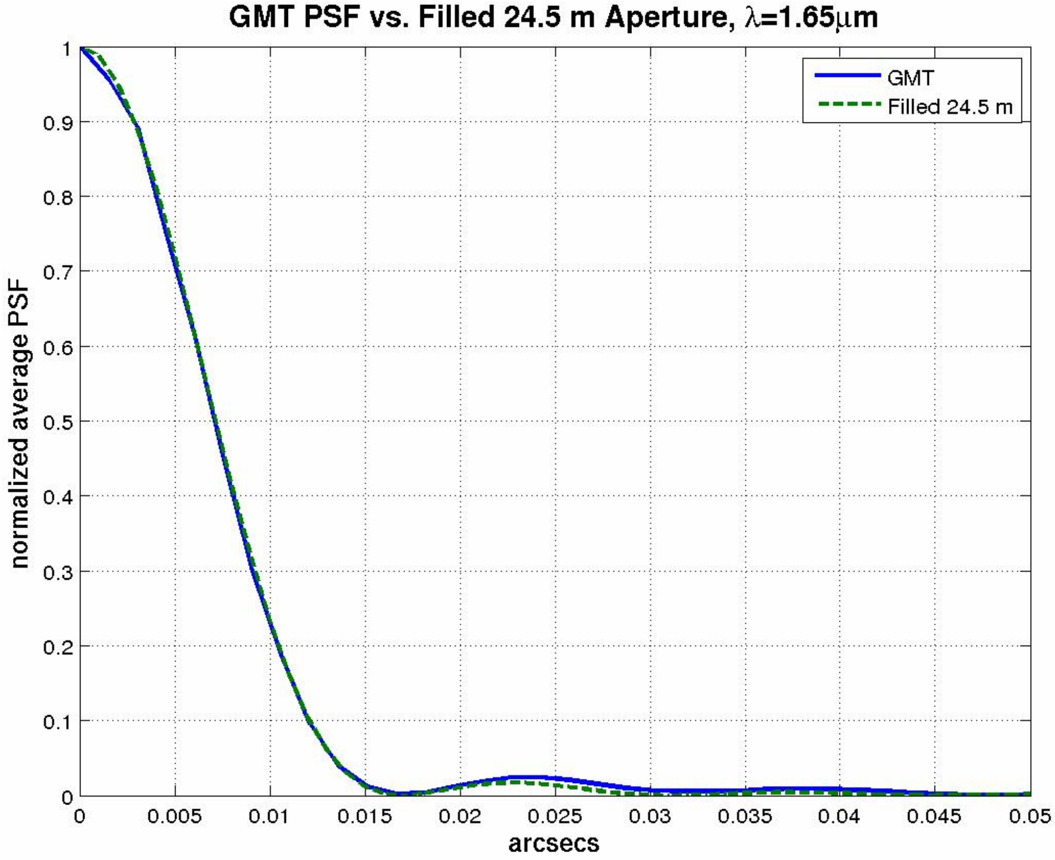


z = 1.4

Exposure: 1 hr

FAQ: How Big Is It?





Full Diameter: 25.4 m

Circular aperture 21.9 m

Diffraction limit 24.5 m

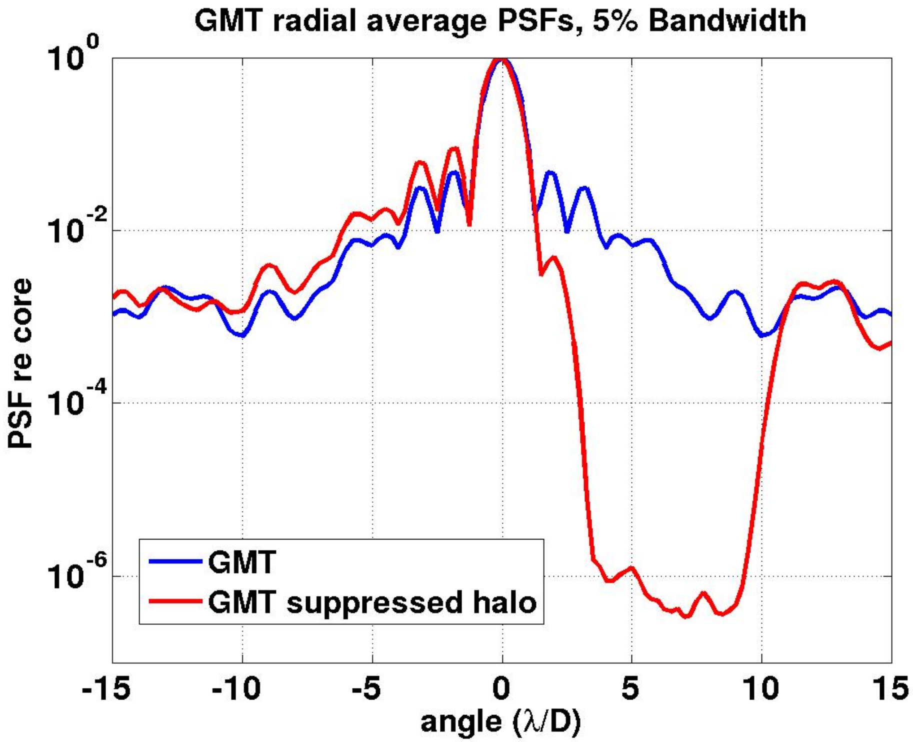
66% in central diffraction peak

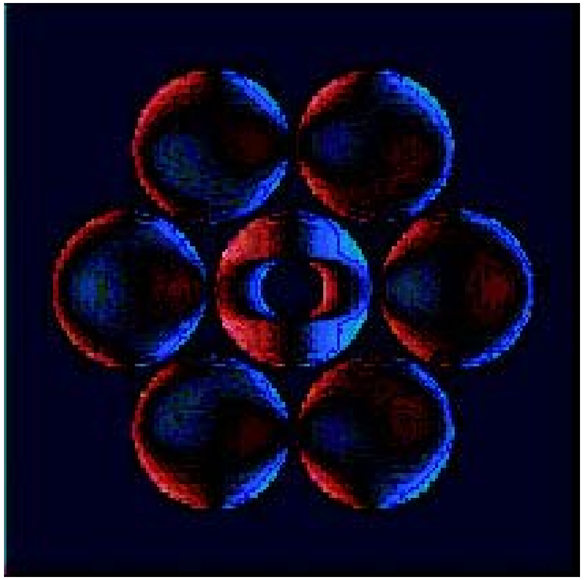
- (84% for perfect filled aperture)
- (72% for Hubble ST)

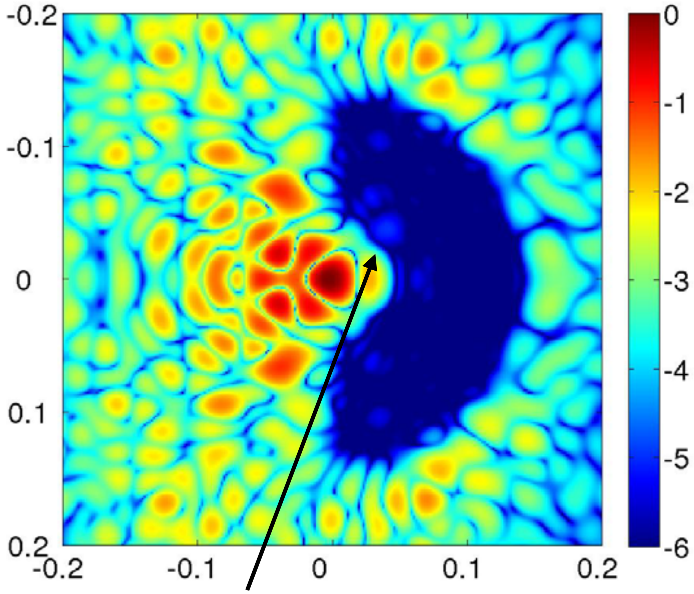
GMT PSF with phase apodization

1.65 μm, 5% band. Diffraction only, no wavefront error

10^{-6} suppression at 4 λ/D, 56 mas





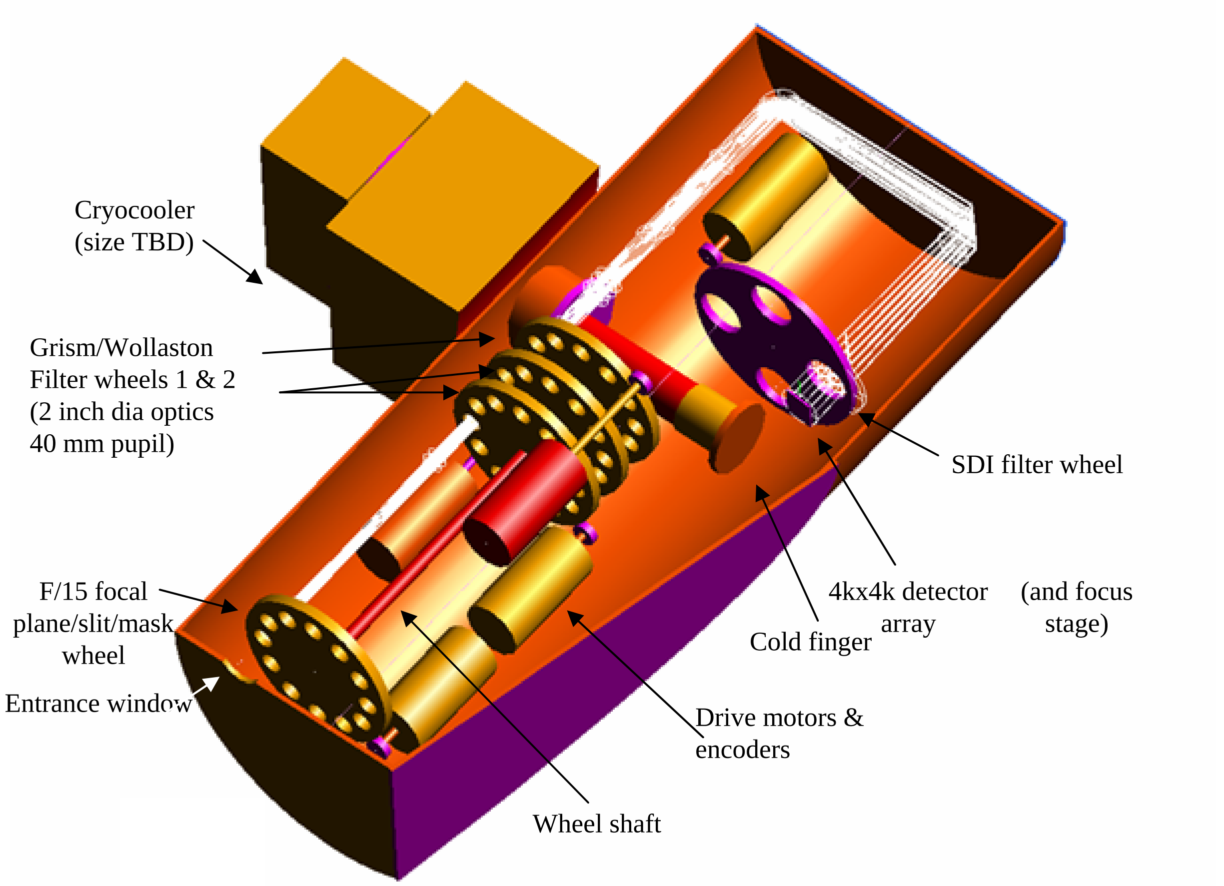


10^{-5} companion

Instrument Concept Studies

Instrument	λ range (microns)	Resolution	FOV	P.I.
Optical Multi-Object Spectrometer	0.35-1.0	250-4000	9 x 18 (18 x 18)	Shectman
Near-IR Multi-Object Spectrometer	1.0-2.5	Up to ~4000	7 x 7	Fabricant
Optical High Resolution Spectrometer	0.4-0.95	30K for 1" slit	Single obj fibre option	MacQueen
Mid-IR Imaging Spectrometer	3.0-25.0	1500	30"	Hinz
Near-IR High-Resolution Spectrometer	1.2- 5.0	20K-200K	Single obj	Jaffe
Near-IR AO Imager	0.9-5.0	5-5000	30"	Close

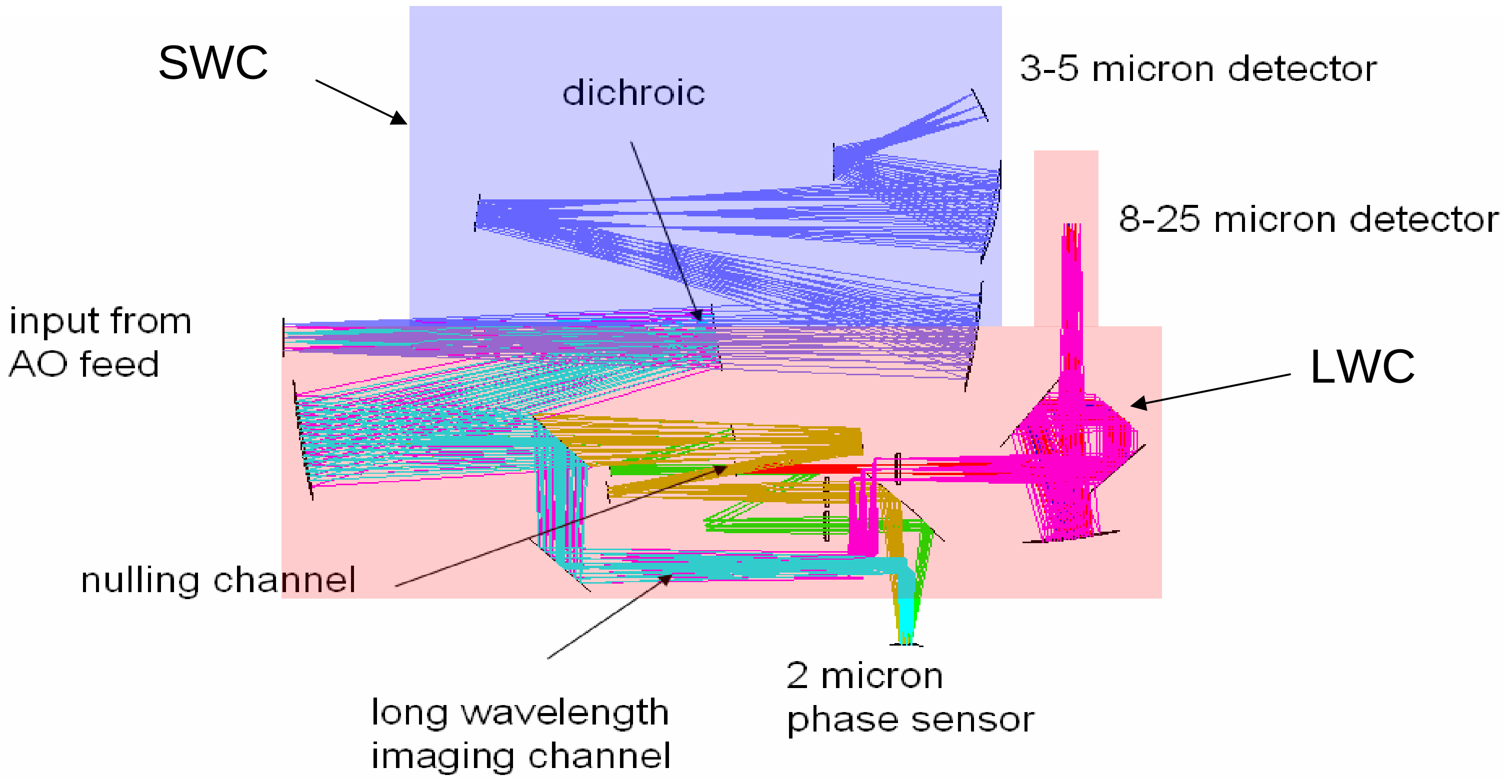
HRCAM F/46 Camera



Mid-IR Imaging Spectrometer

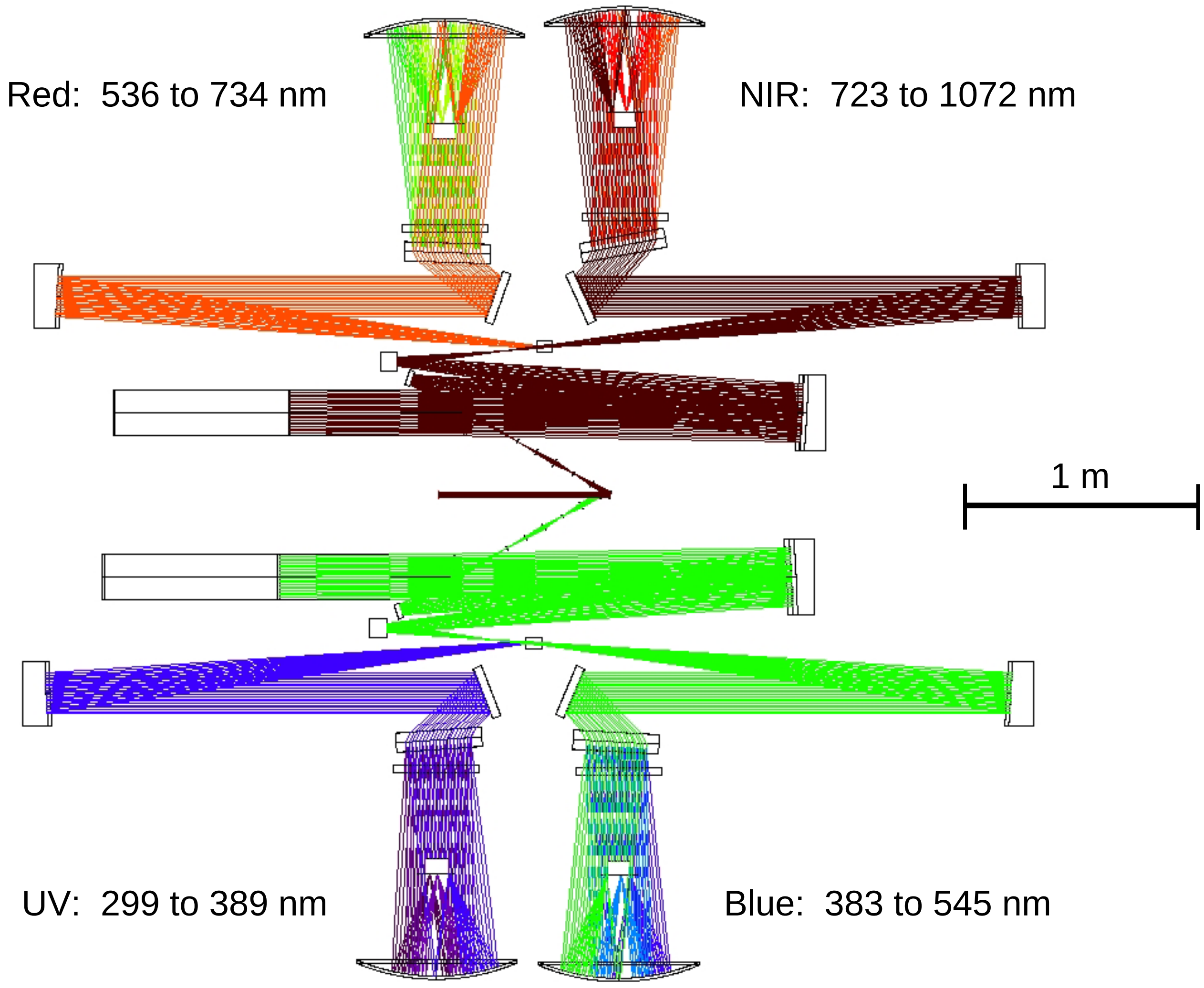
3-25μm imaging with coronography, nulling and spectroscopy

two channels: 3-5μm and 8-25μm



GMT HROS

- 4-Channels
- R4 Echelle
- VP Gratings &
- Schmidt Cameras

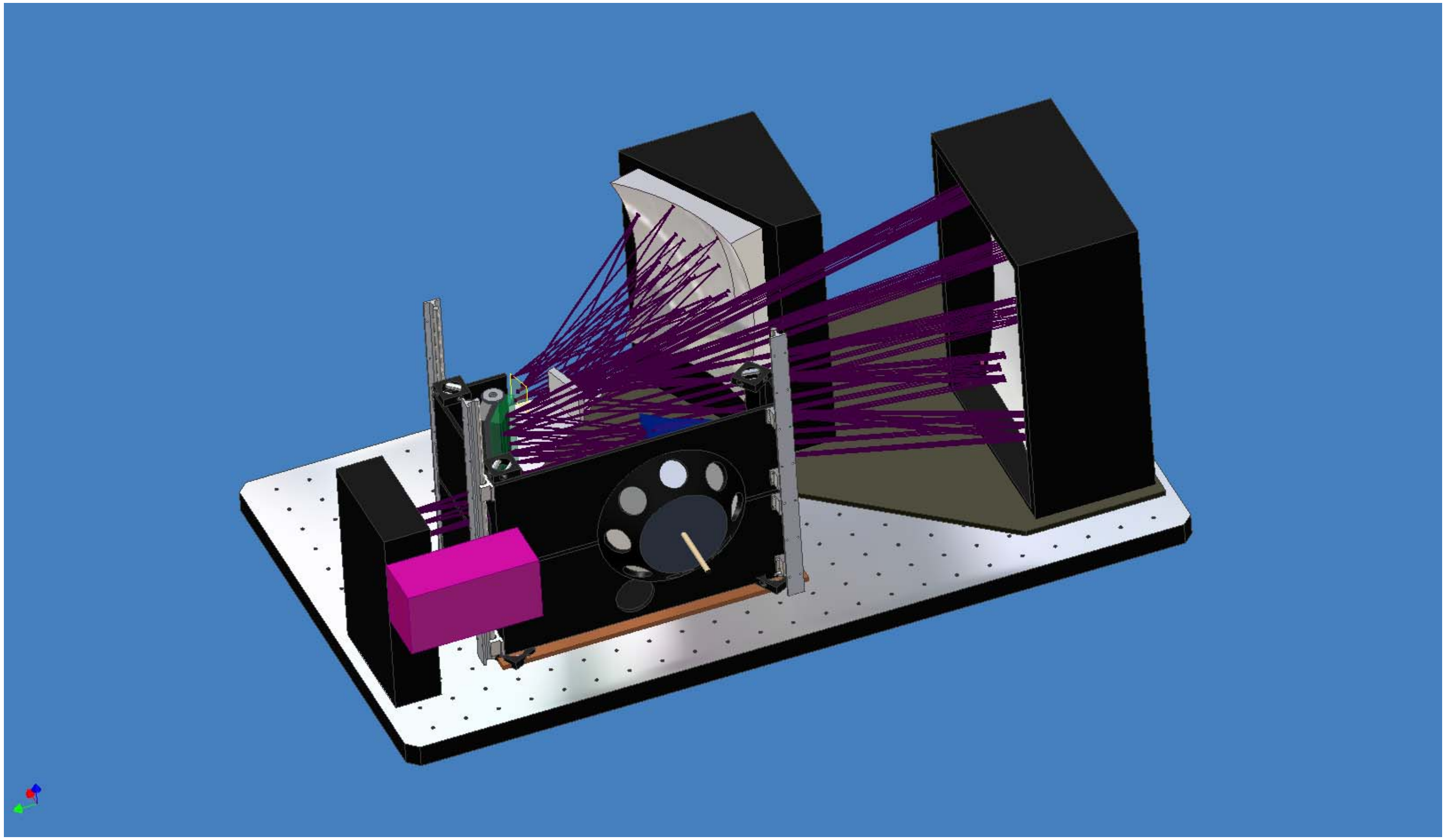


- Rφ = 30,000 arcseconds
- High throughput from optimization of each arm

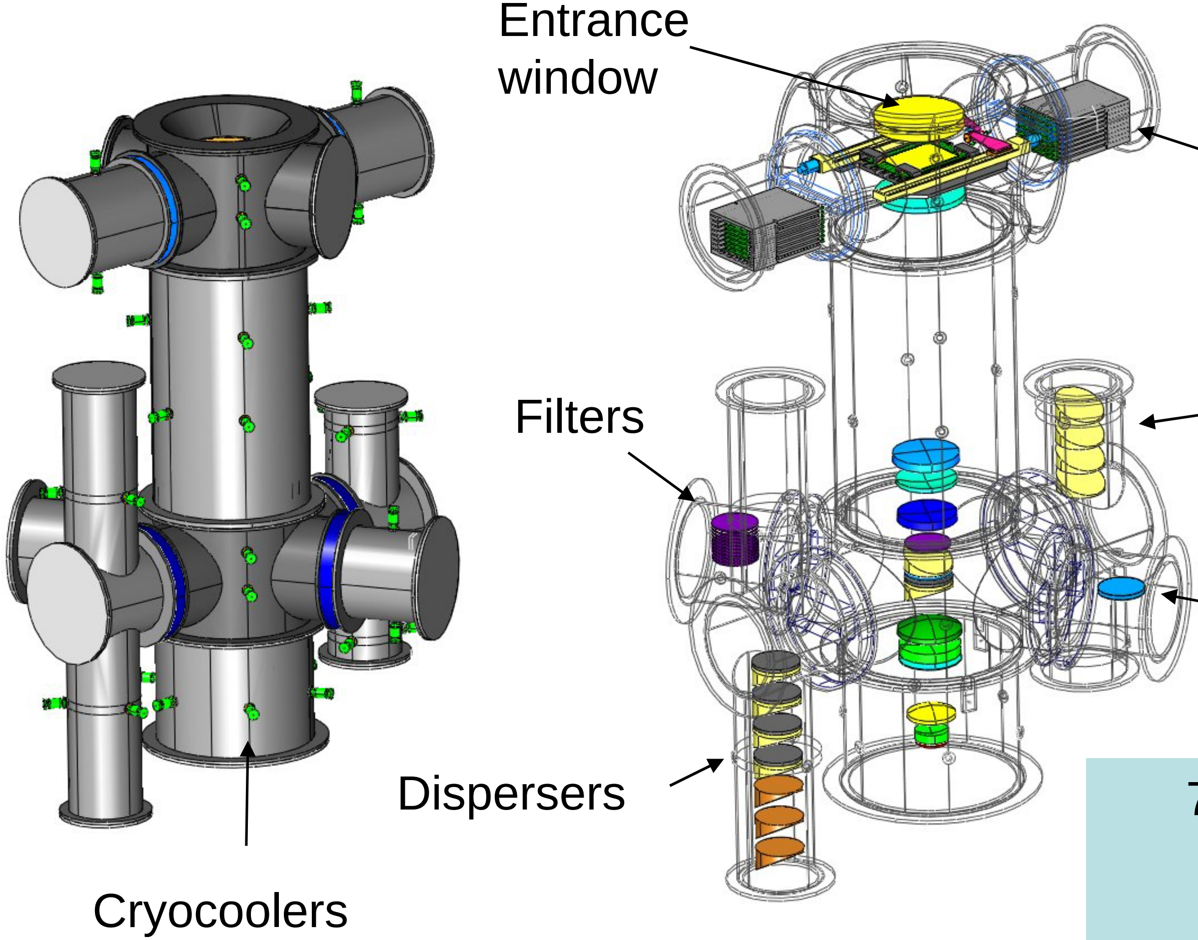
GMT NIRS

Two channels 1-2.5 μm and 3-5 μm

R = 50K (short)   R = 120K (long)



NIRMOS Imaging Spectrograph

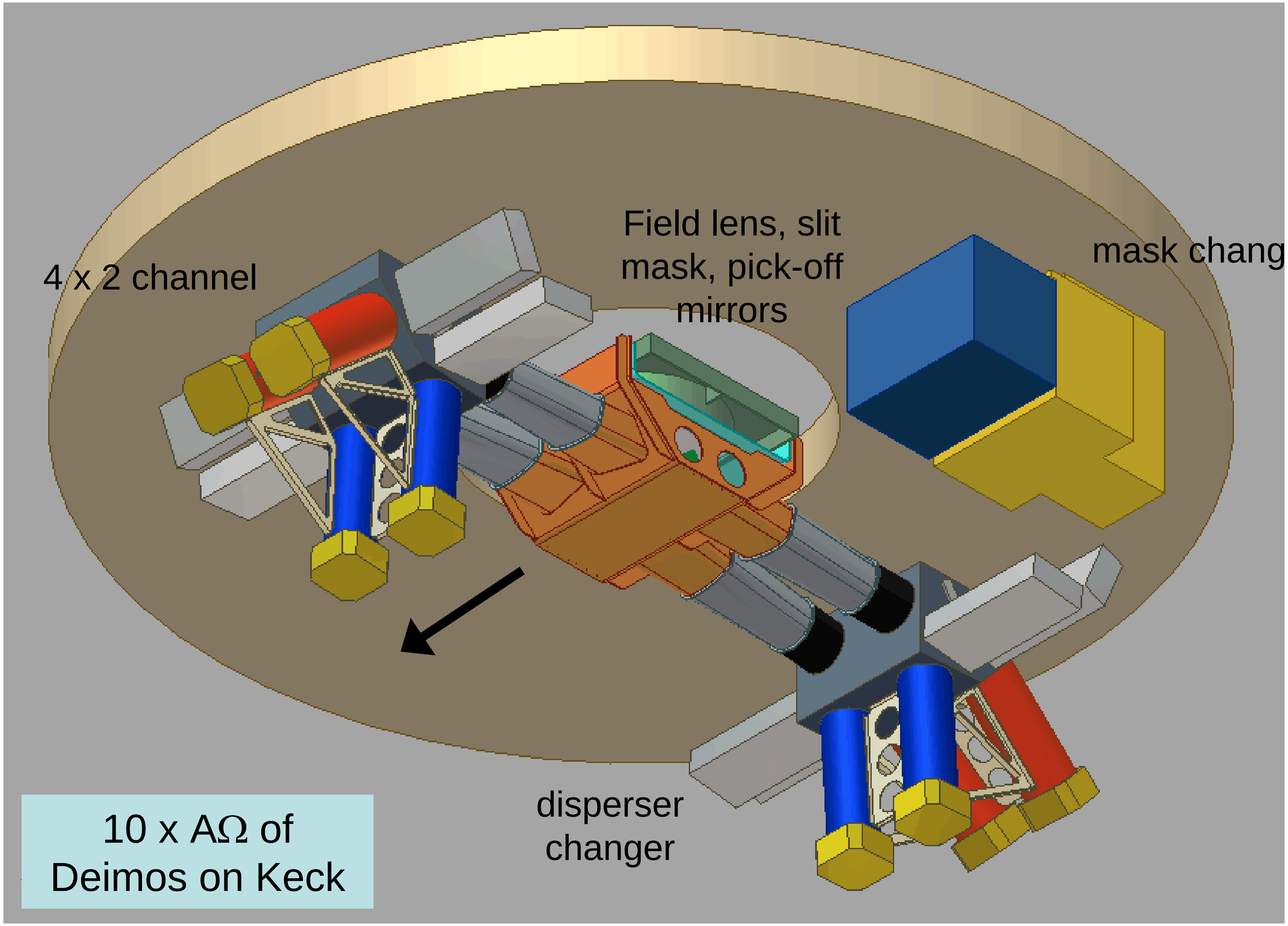


7′ x 7′ field of view

R ~ 4000

~100 objects per mask

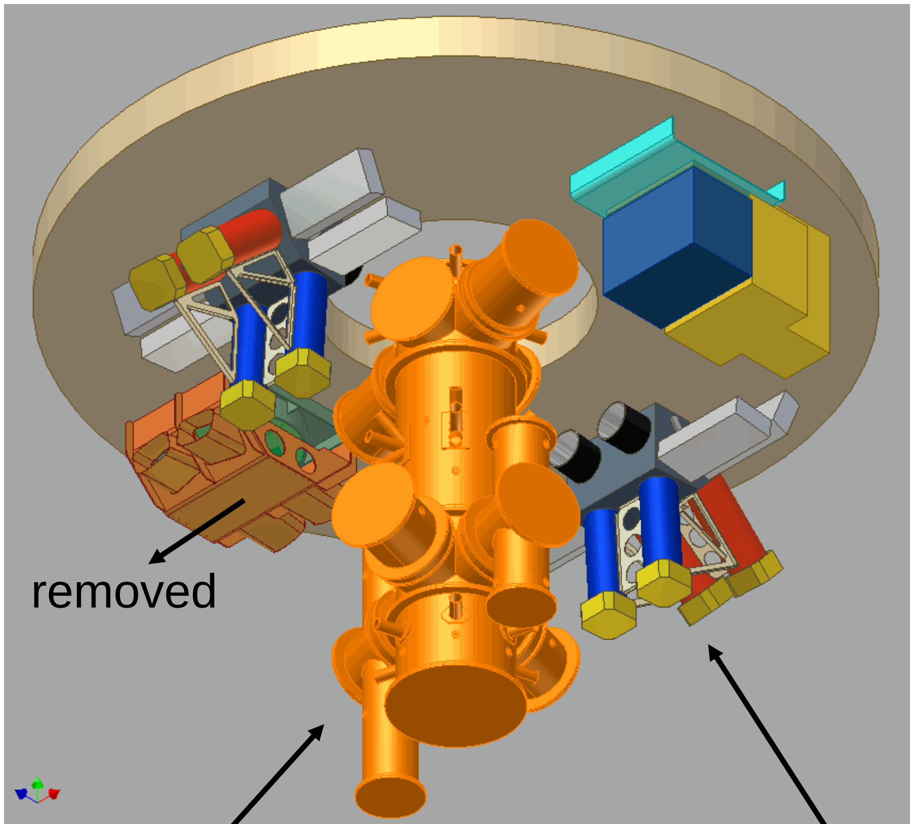
GMACS

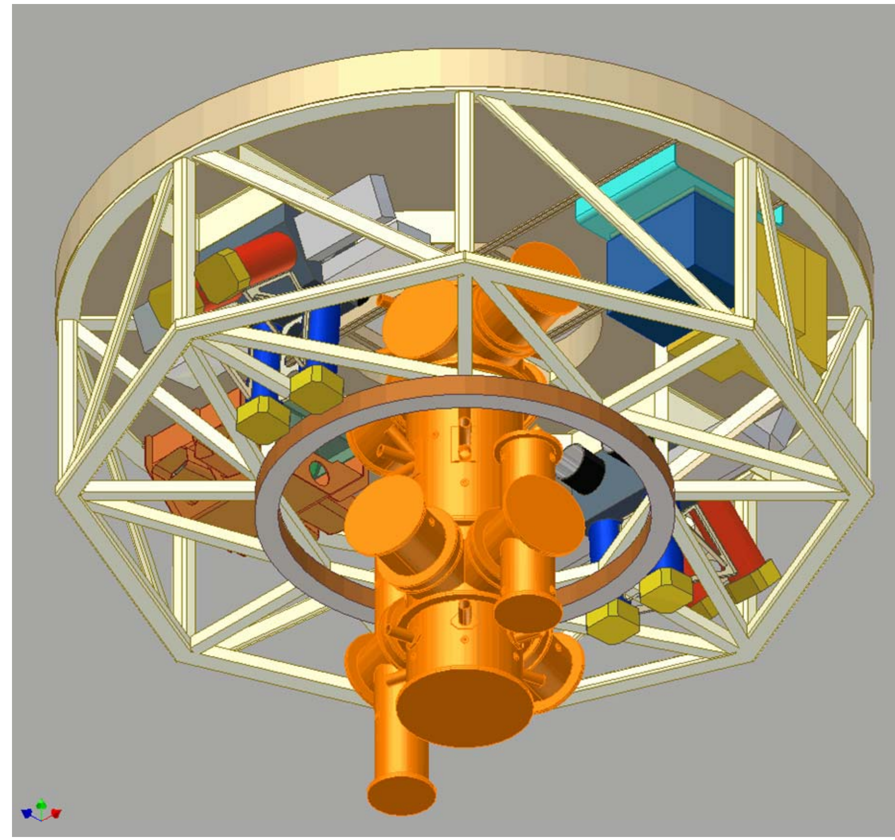


10 x AΩ of
Deimos on Keck

GMT

Multiple Instruments at Gregorian Focus



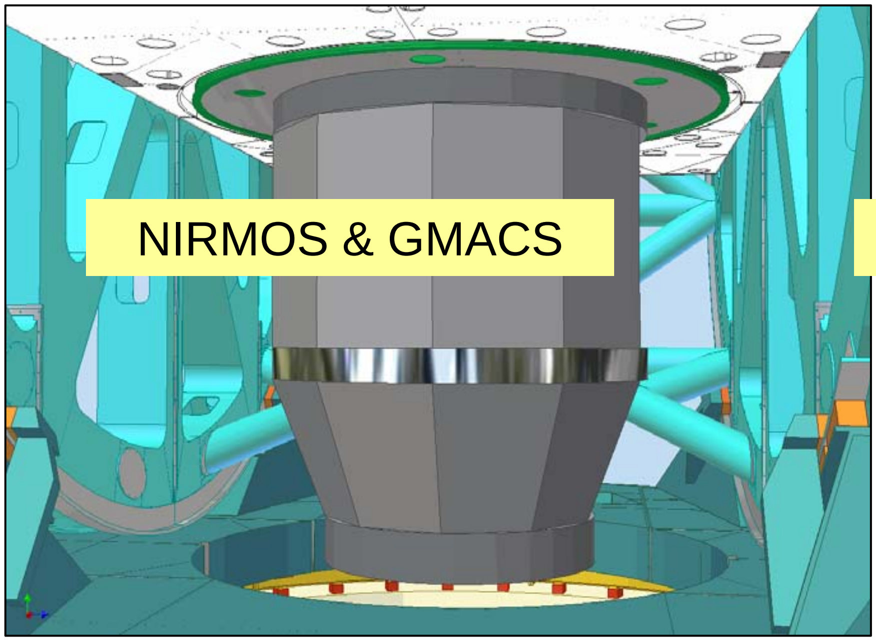


NIRMOS

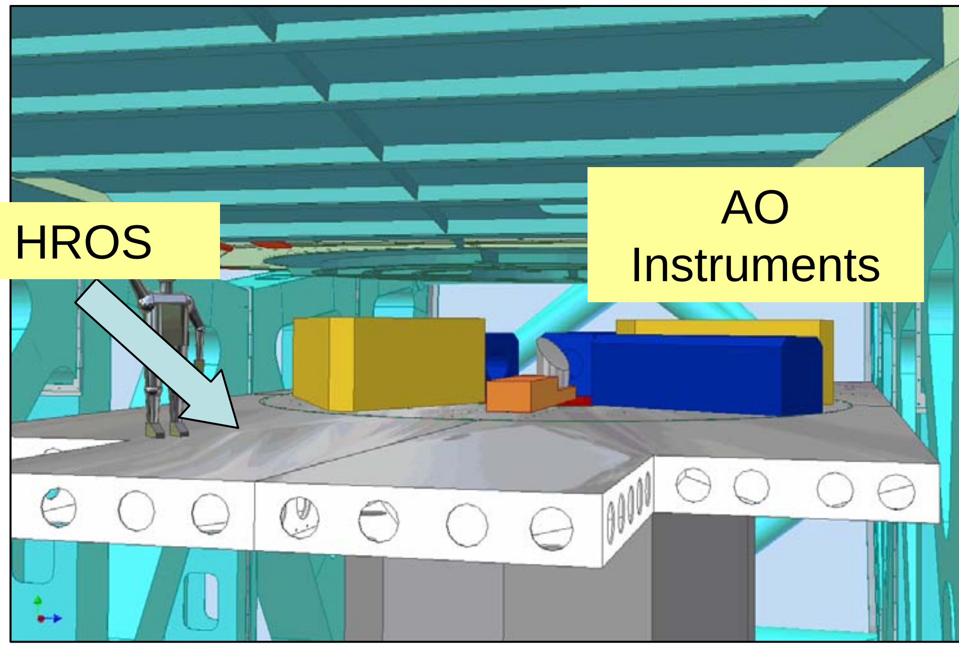
GMACS

Instrument Mounting

Straight Gregorian



Folded Ports



Instrument Capacity

6.4 m Diameter x 7.6 m High

25 ton

The Power of GMT Instruments

Origin of Large Scale Structure in the Universe

Powerful combination of wide-field seeing-limited and high performance diffraction-limited instruments

- GMACS and NIRMOS provide *order-of-magnitude* gains in survey speed and high spectral resolution for diagnostic studies
- LTAO Instruments offer x 3 gain in resolution and two orders-of-magnitude gains in speed and sensitivity for studies of internal structure and dynamics

The Power of GMT Instruments

Building the MW and Other Galaxies

High performance diffraction-limited instruments and high resolution spectrographs

- LTAO Instruments offer x 3 gain in resolution and two orders-of-magnitude gains in speed and sensitivity for studies of internal structure and dynamics
- HROS provides ~ x 10 gain in speed over MIKE and similar spectrographs

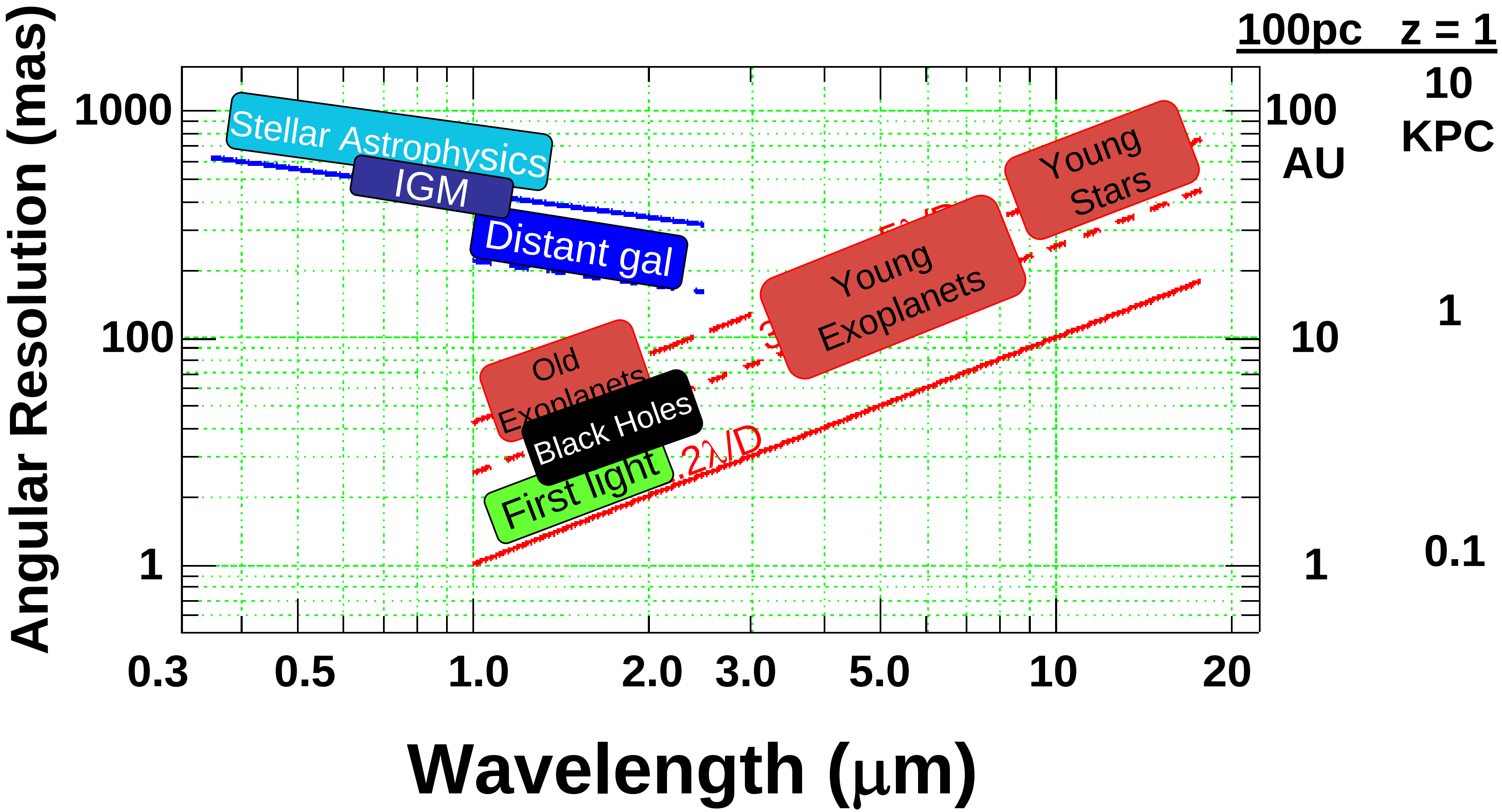
The Power of GMT Instruments

Exploring Other Solar Systems

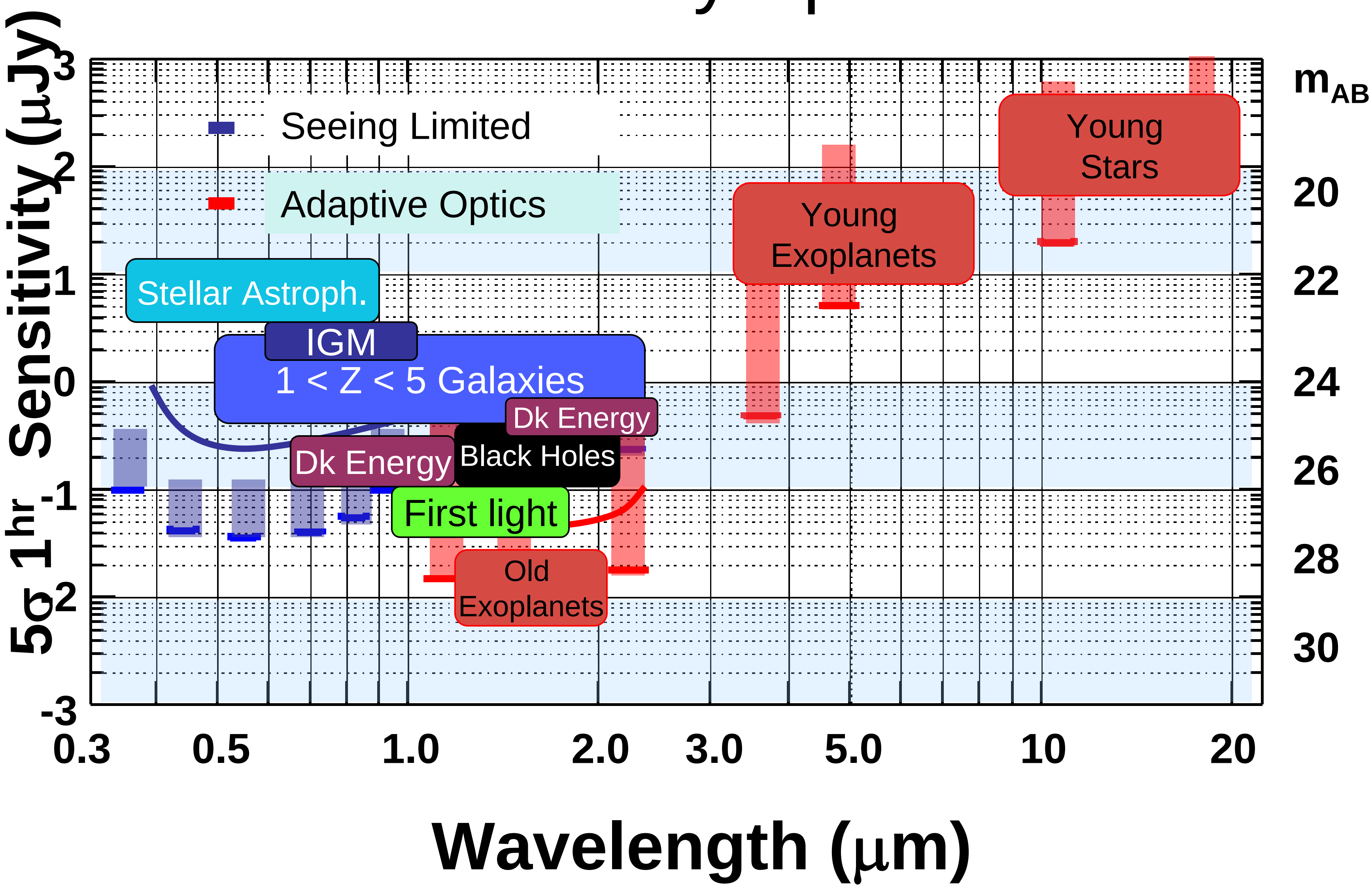
Low-background AO with nulling, and adaptive phase manipulation provide new tools for exoplanet studies

- Adaptive secondary provides low background high strehl AO
- Large segments provide clean wave-front and naturally lend themselves to nulling and phase modulation.

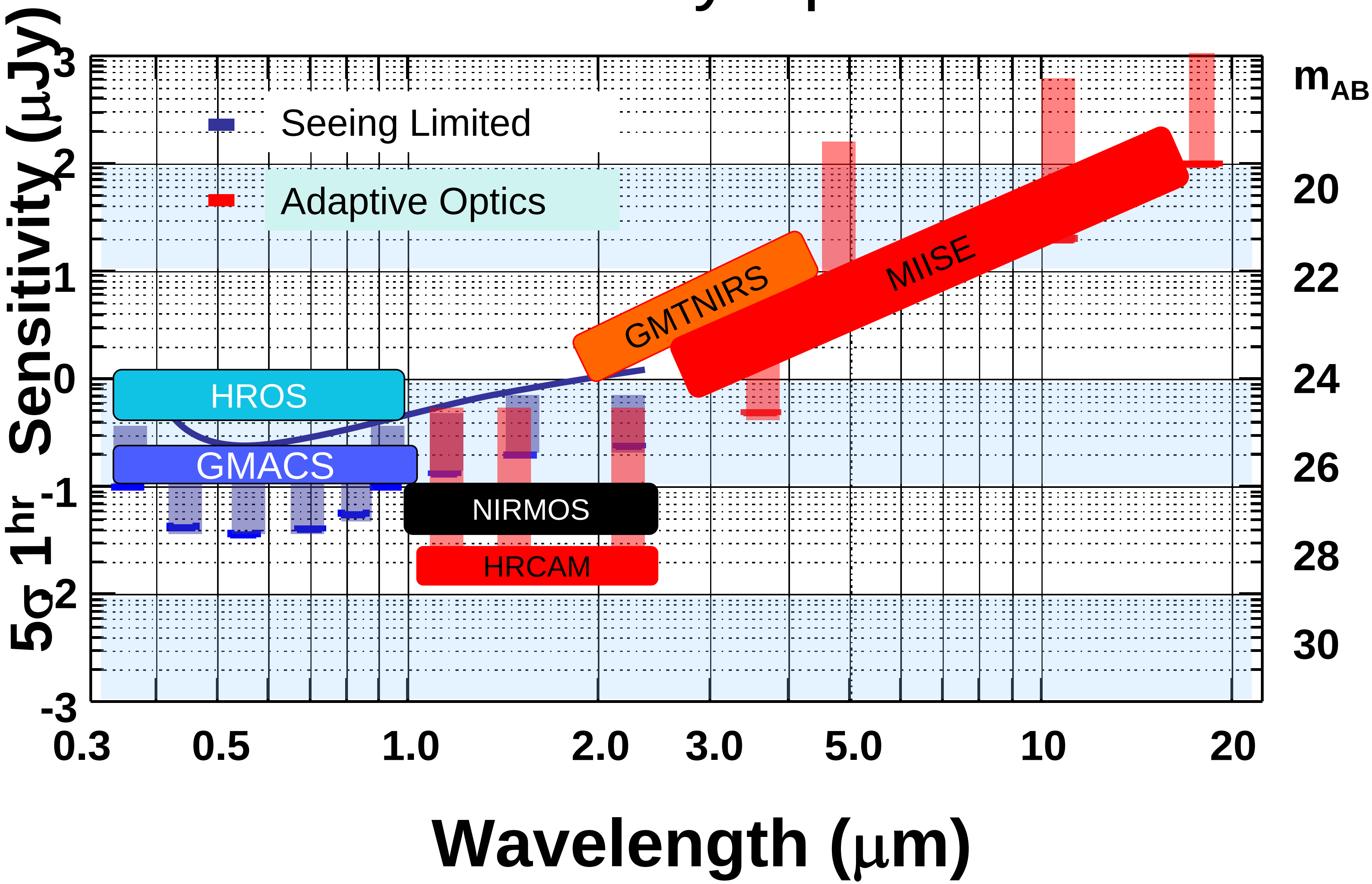
Discovery Space



Discovery Space



Discovery Space



Next Step for GMT Instruments

- Review of concepts and approach

GMT instrument workshops*:*

Spectrographs: October

AO systems & instruments: December

- Advance ~ 6 concepts to CoDR
- Select first generation instruments in late 2007

MIISE

MID-IR Imaging Spectrometer

PI: Phil Hinz - *Arizona*

Primary Science*: Young Exoplanets, Debris Disks*

Short Wavelength Channel

- 3-5μm
- 40″ x 40″ field of view
- 10 mas per pixel
- 4k x 4k detector array
- coronagraphy
- spectroscopy

Long Wavelength Channel

- 8-25μm
- 30″ x 30″ field of view
- 30 mas per pixel
- 2048 x 2048 detector
- nulling interferometry
- spectroscopy

HRCAM

Near-IR AO Imager & Spectrograph

PI: Laird Close - *Arizona*

Primary Science*: Exoplanets, Stellar Populations, Galaxy Evolution*

“Wide-Field” Mode

- f/15 Offner relay & camera
- 10 mas pixels
- 40′′ x 40′′ field of view
- 4K x 4K detector array
- IFU Mode

High Definition Mode

- f/46 camera
- 3.3 mas pixels
- 13′′ x 13′′ field of view
- 4K x 4K detector
- Spectral Difference imaging

GMTNIRS

Near-IR High Resolution Spectrograph

PI: Dan Jaffe - *U. Texas at Austin*

Primary Science*: Star formation, stellar evolution*

Short Wavelength Channel

- 1-2.5μm
- Natural Seeing
- f/2.2 three mirror anastigmat
- Si immersion gratings
- 4k x 4k detector array
- R = 50K for 0.15” slit

Long Wavelength Channel

- 2-5μm
- AO optimized
- f/8 TMA
- Si immersion grating
- 2048 x 2048 detector
- R = 100K for 2λ/D slit

GMACS

Optical Multi-Object Spectrograph

PI: *Steven Shectman - Carnegie*

Primary Science*: Galaxy evolution, IGM tomography*

Four Channel "Fly's Eye"

Each Module:

- Blue (3200Å - 7000Å) & Red (7000Å - 1μm) arms
- 4′ x 9′ field of view - *total is 8′ x 18′ !*
- R = 1200 (blue) 1750 (red) *high dispersions possible*
- VPH gratings
- 4K x 4K detector array

AΩ Light Grasp 10 x DEIMOS

NIRMOS

Near-IR Multi-object Spectrograph

PI: *Dan Fabricant - Smithsonian*

Primary Science*: Galaxy formation and evolution*

- 1 - 2.5μm wavelength coverage
- All refractive camera-collimator combination
- 5′ x 7′ field (imaging)   5′ x 5′ field (spectroscopy)
- R = 3500 (single band) 1500 (JH or HK)
- Removable cold slit masks
- VPH gratings
- IFU mode
- 6K x 10K detector array