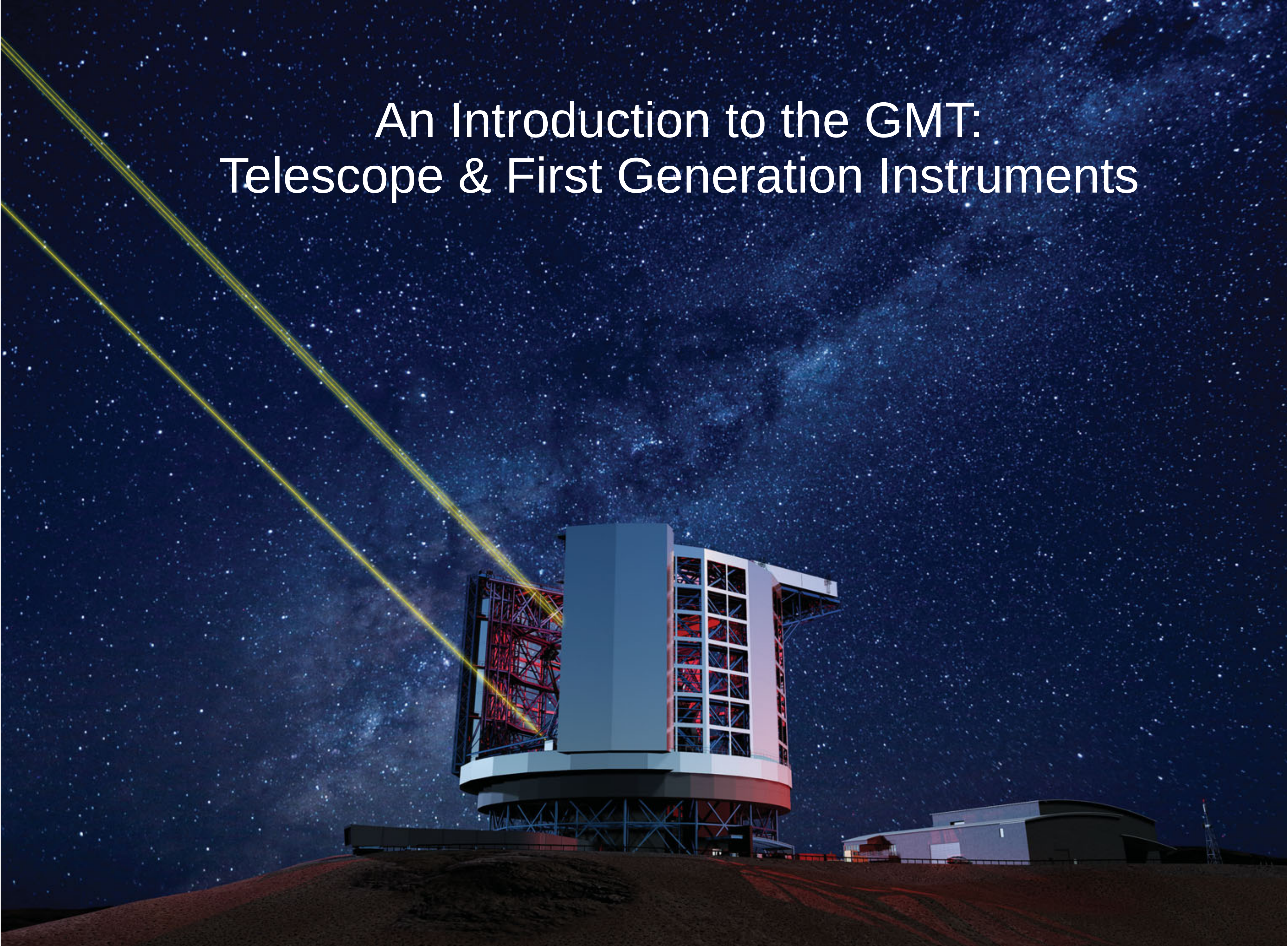
An Introduction to the GMT: Telescope & First Generation Instruments



Topics:

- Motivation: the science case for large telescopes
- Partnership & Site
- Telescope*
- Instruments*
- Enclosure & Site
- Status

* Key characteristics & how they enable science

Topics:

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* Key characteristics & how they enable science

Motivation: SENSITIVITY

6,000 stars in reach!

0.2 cm^2

Sensitivity = 1/(time) to get a given signal to noise ratio.

Motivation: SENSITIVITY

Motivation: first we need collecting area

Galileo's Telescope
(2.6 cm)

5.3 cm^2

Motivation: first we need collecting area

Yerkes 40 inch

(1m)

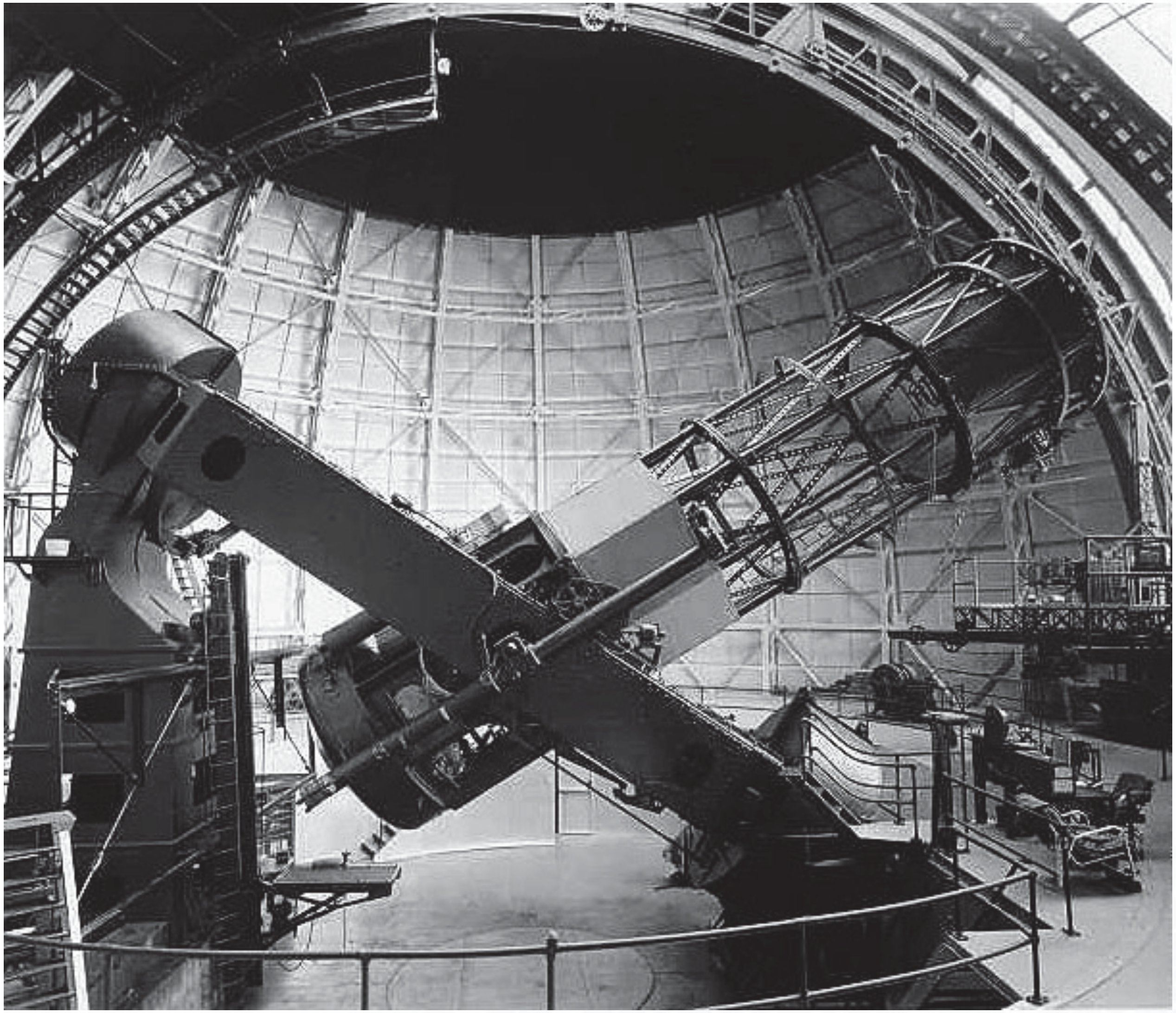
8,100 cm^2

Motivation: first we need collecting area

Hooker 100 inch

(2.5 meter)

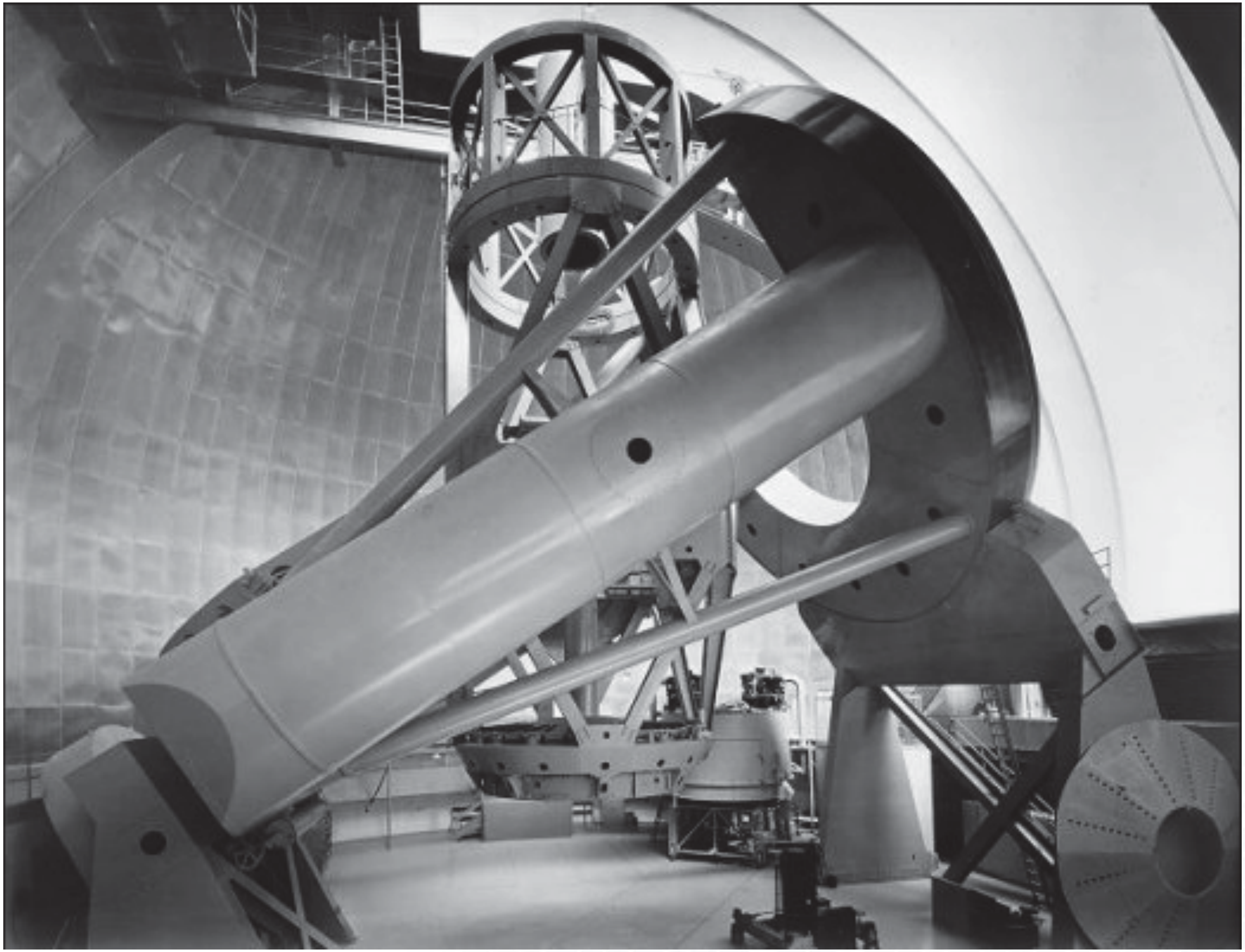
50,000 cm^2



Motivation: first we need collecting area

Hale 200 inch
(5 meter)

195,000 cm^2



Motivation: first we need collecting area

Gran Telescopio Canarias (10.4 meter)

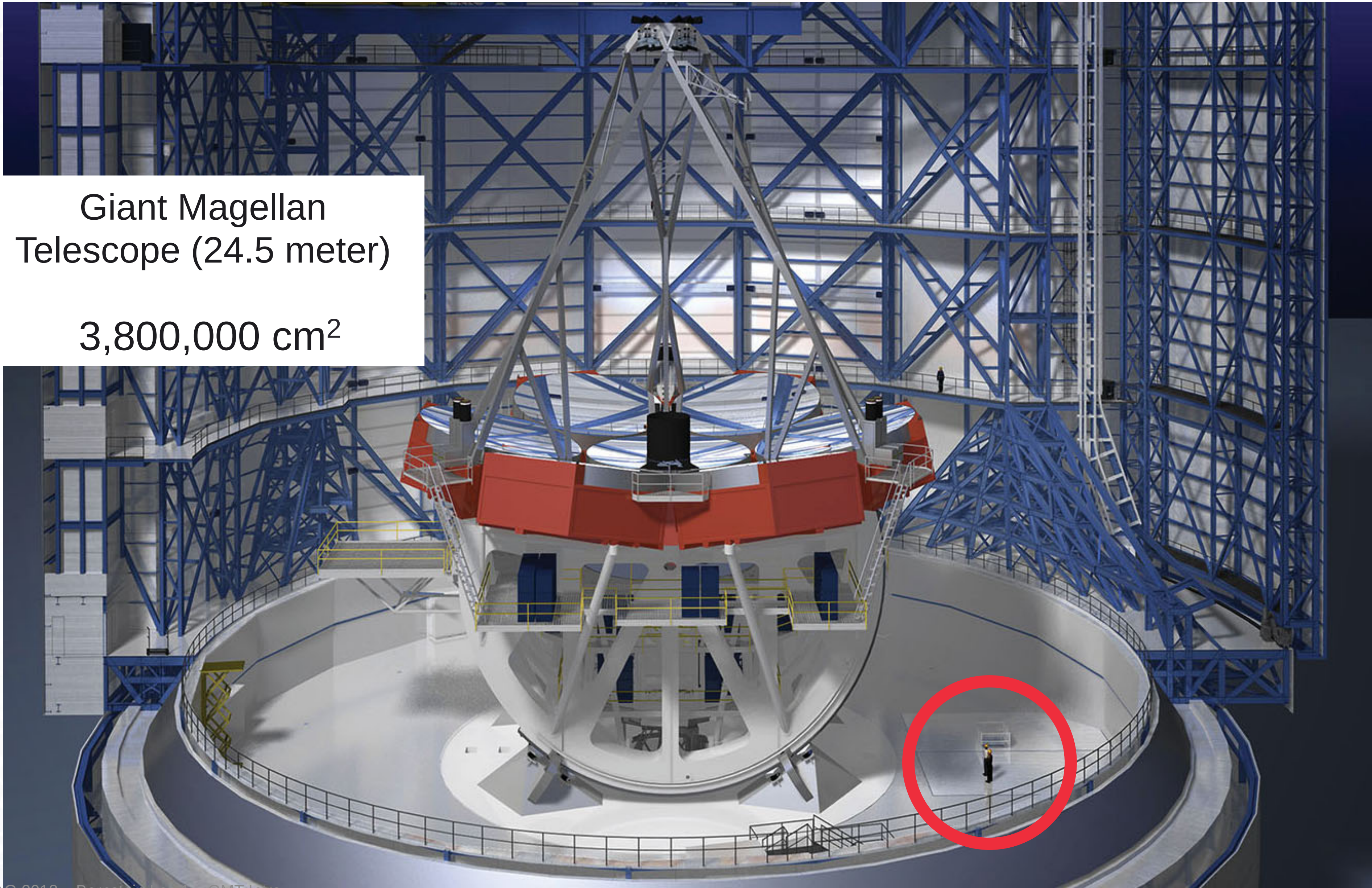
785,000 cm^2

Motivation: first we need collecting area

GMT

Giant Magellan Telescope (24.5 meter)

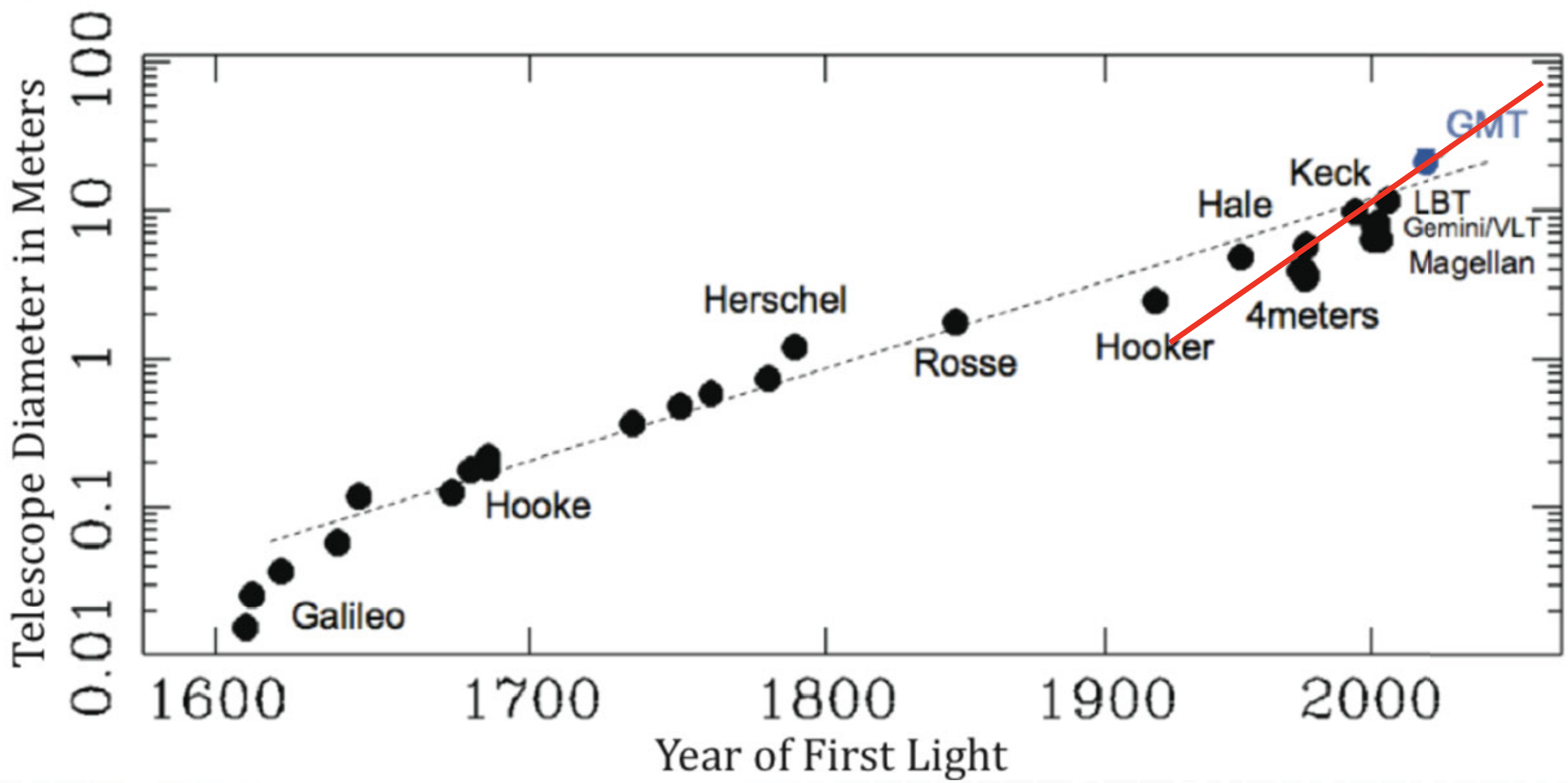
3,800,000 cm^2



History of telescope growth:

GMT

- Typical step size is about x2
- Factor of 1000 in diameter since Galileo (40 doublings)!
- Balance between technical limitations, scientific return and financial challenges



Motivation: sensitivity = D/ θ^2

GMT

Sensitivity ~ collecting area / image size

- Collecting area ~ D^2
- Image size ~ θ^2

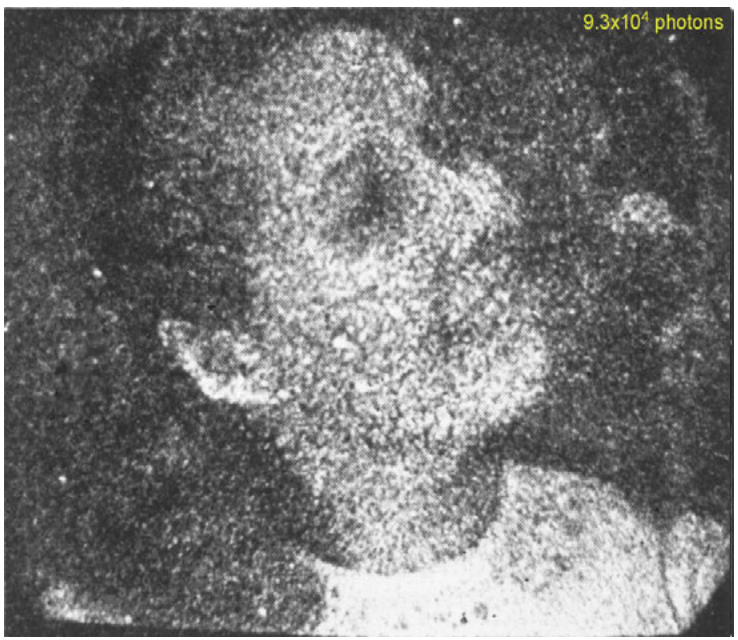
** Sensitivity = 1/(time) to get a given signal to noise ratio.

Motivation: sensitivity = D/θ^2

In the "seeing" limit:

FWHM = θ_{seeing} ~ D^2

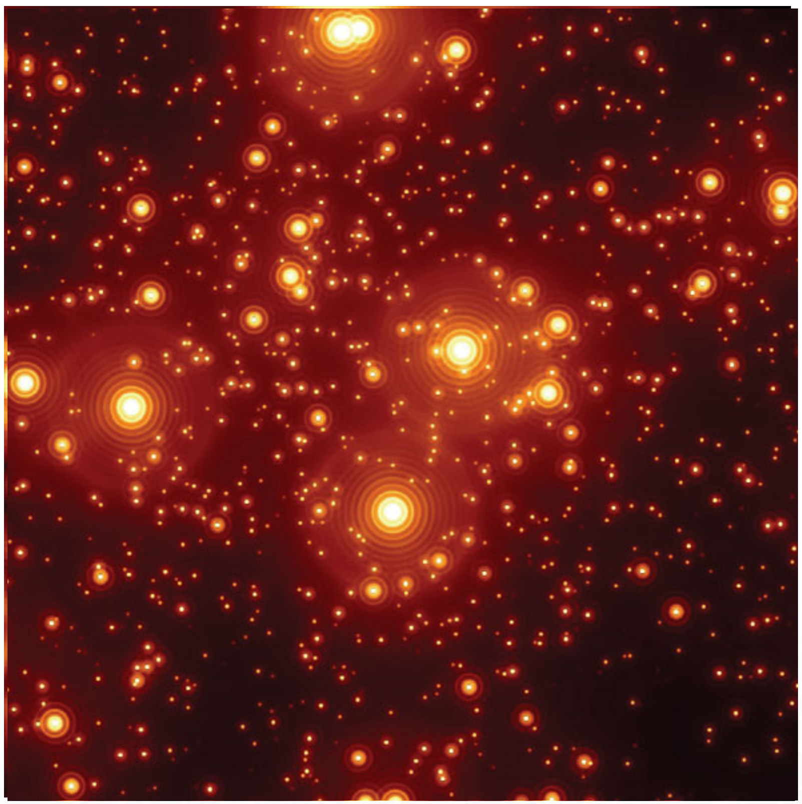
Sensitivity ~ D^2



In the diffraction limit:

FWHM ~ ($1.22\ \lambda/D$) ~ $1/D^2$

Sensitivity ~ D^4



(Credit: VLT)

Motivation: sensitivity = D/θ^2

In the "seeing" limit:

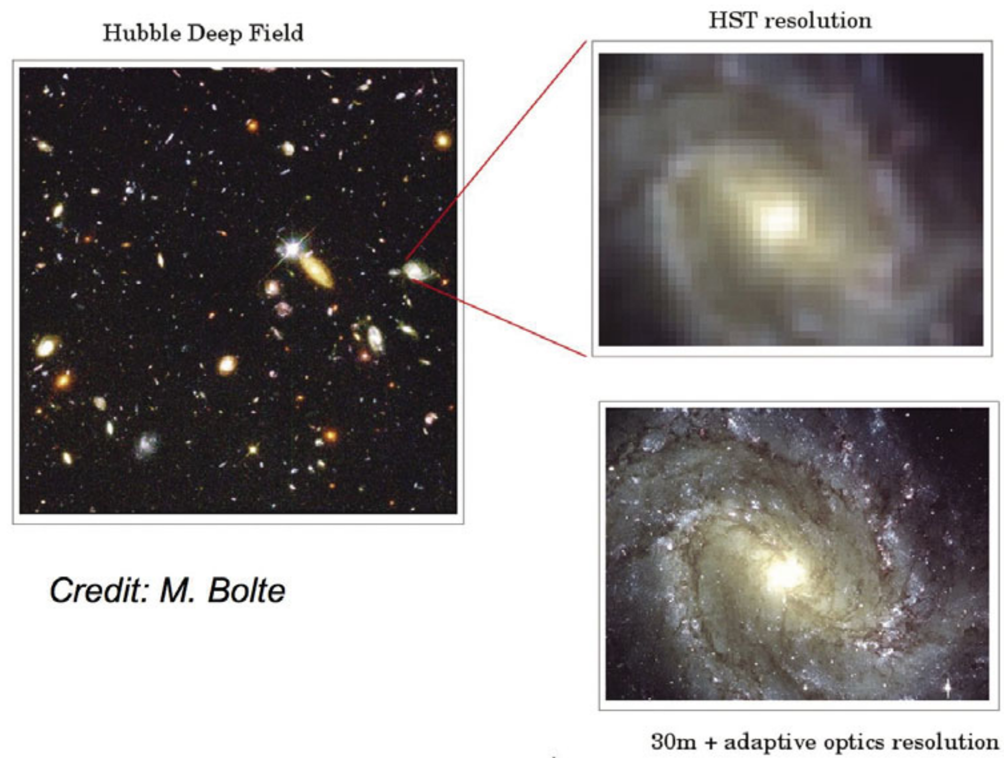
FWHM $=\theta_{seeing} \sim D^2$

Sensitivity $\sim D^2$

In the diffraction limit:

FWHM $\sim (1.22\,\lambda/D) \sim 1/D^2$

Sensitivity $\sim D^4$

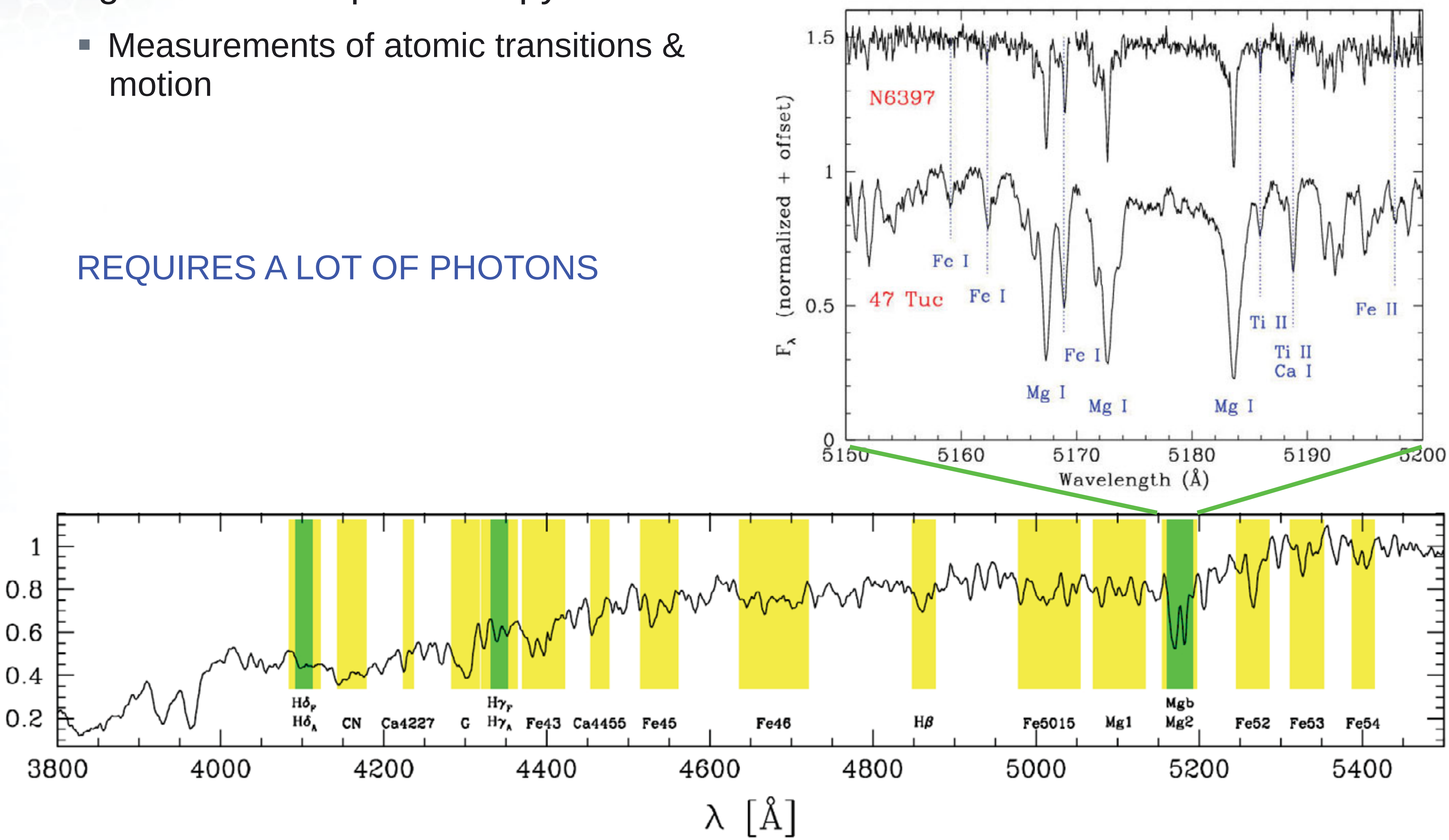


Credit: M. Bolte

Motivation: sensitivity → information

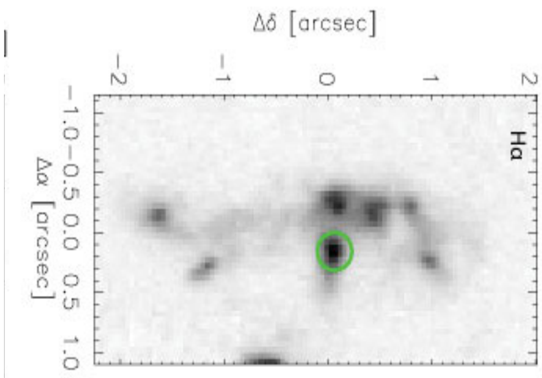
- High resolution spectroscopy:
  - Measurements of atomic transitions & motion

REQUIRES A LOT OF PHOTONS



Motivation: sensitivity → information

- High resolution spectroscopy:
  - Measurements of atomic transitions & motion
- High spatial resolution:
  - Resolving motion inside galaxies
  - Resolving planets

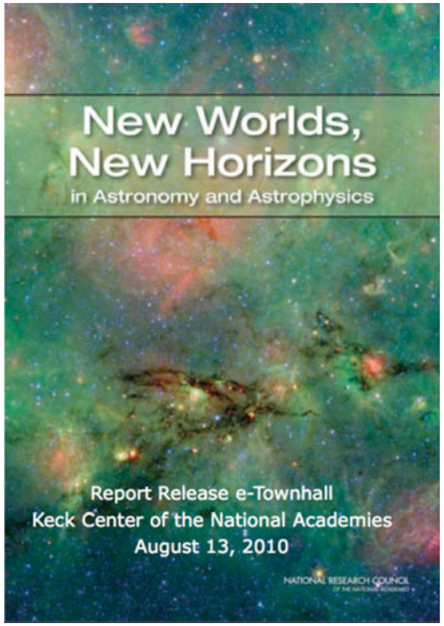


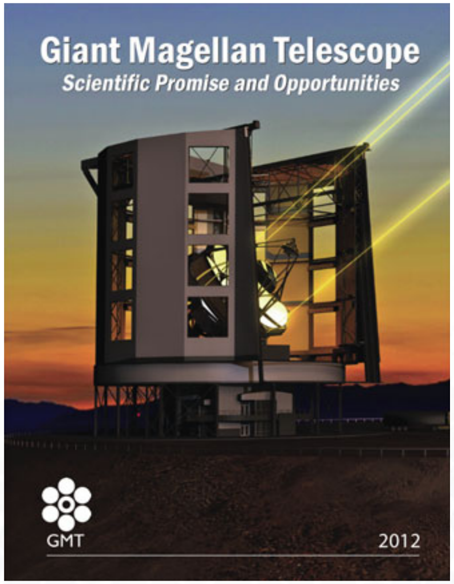
GMT Mission: 50 years of forefront science

GMT Science Book: science goals for the next decade

Top-Level Science Areas:

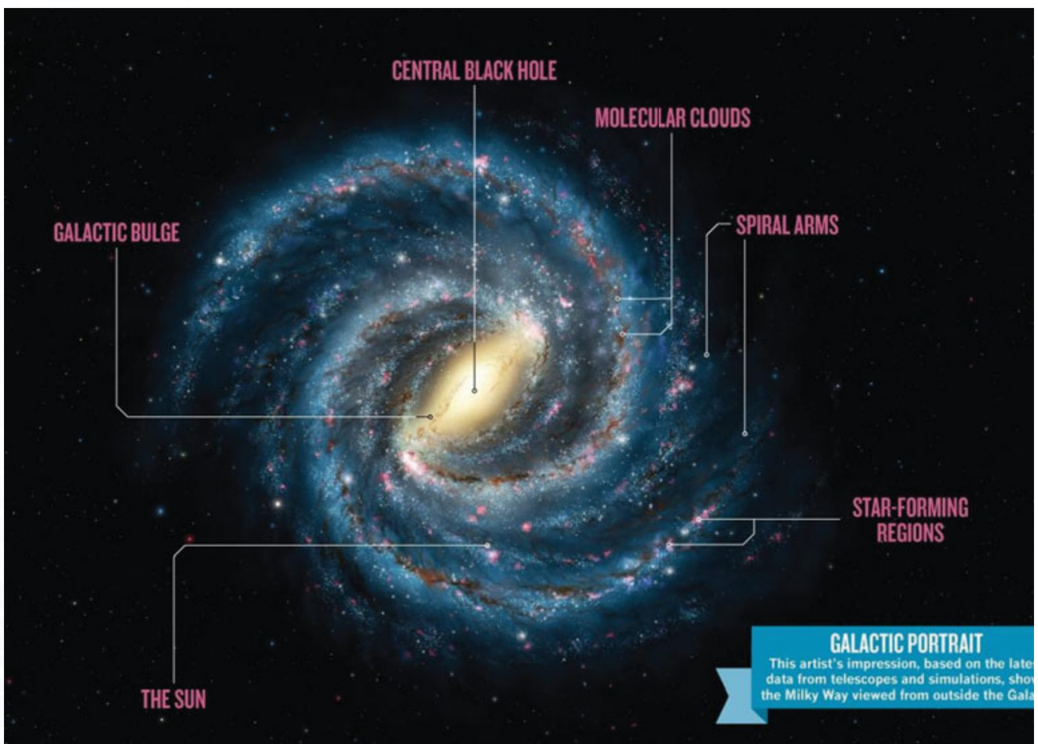
- Planets & Stars
- Stars & Galaxies
- Galaxies & Cosmology

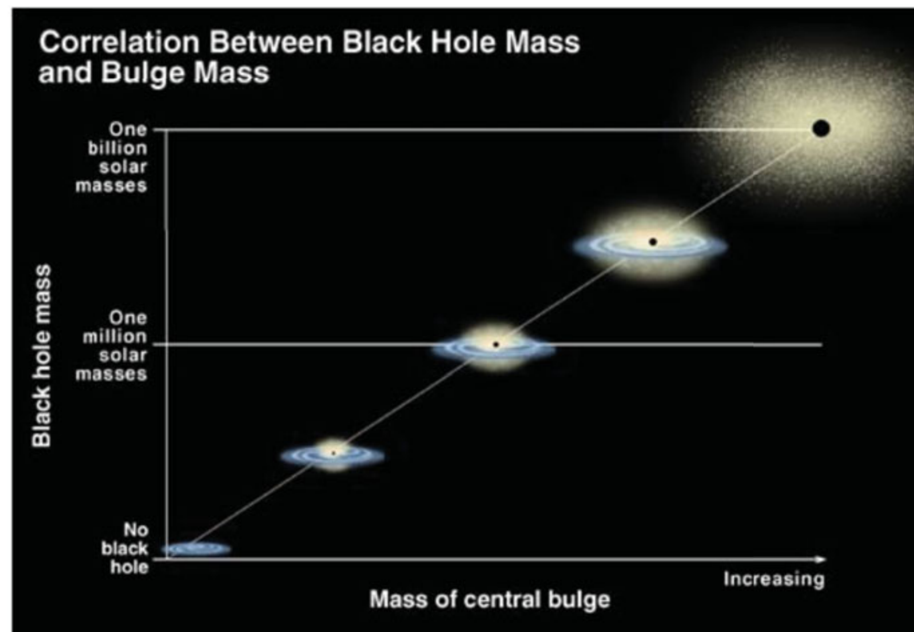




Science Case: a brief lesson from history

- The Black Hole at the center of our Galaxy
  → Coordinated evolution of black holes and galaxies





Graphical representation of the black hole mass - galaxy bulge mass correlation [Credit: K. Cordes & S. Brown (STScI)]

Science Case: a brief lesson from history

- The existence of Dark Energy:
  - → accelerating expansion of the universe

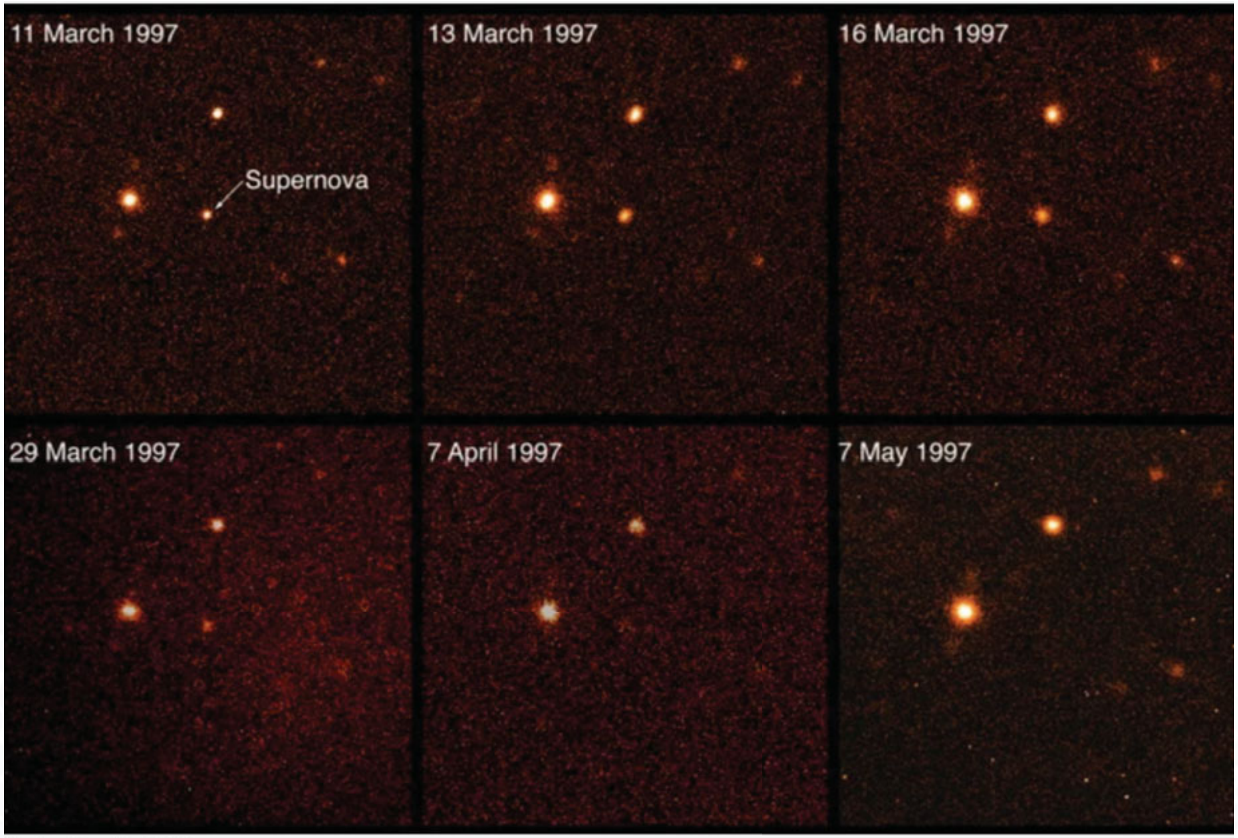
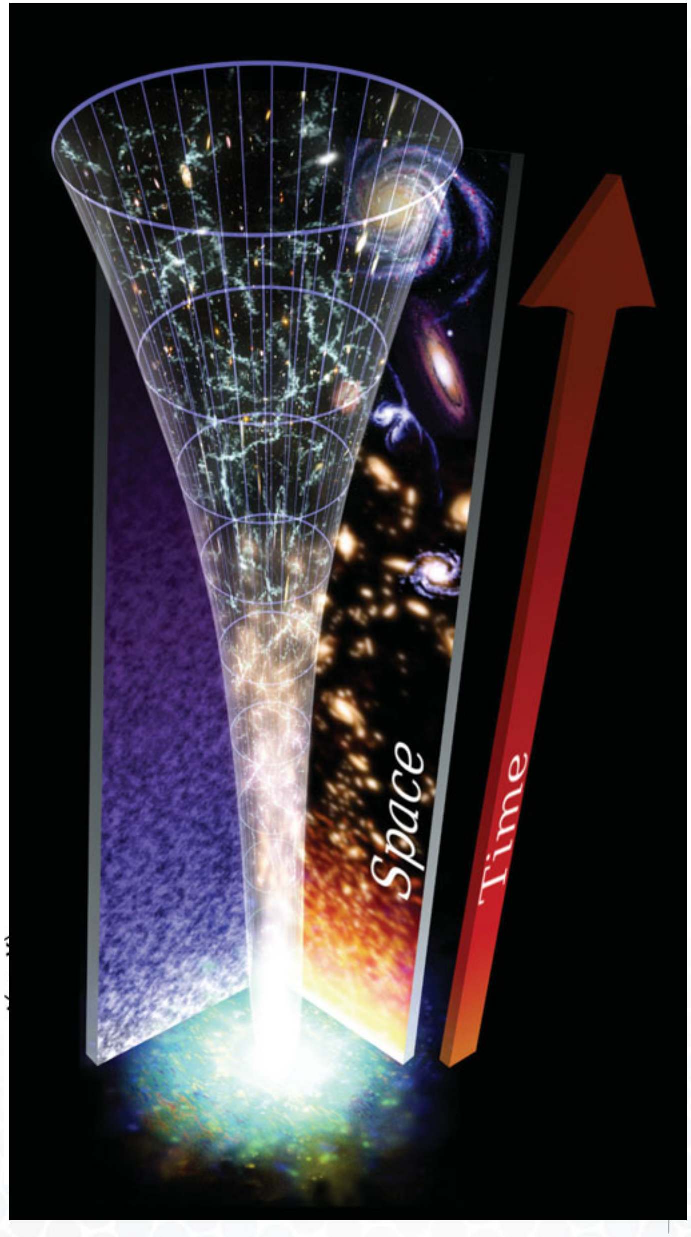


Photo Credit: ESO



Science Case: a brief lesson from history

- Gamma Ray Bursts (most energetic explosions seen) linked to Supernovae:
  - → Tests of general relativity (binary star interactions)
  - → Back-lighting for studying the chemistry of faint galaxies.
  - → "Heavy" chemical element factories (nucleosynthesis)

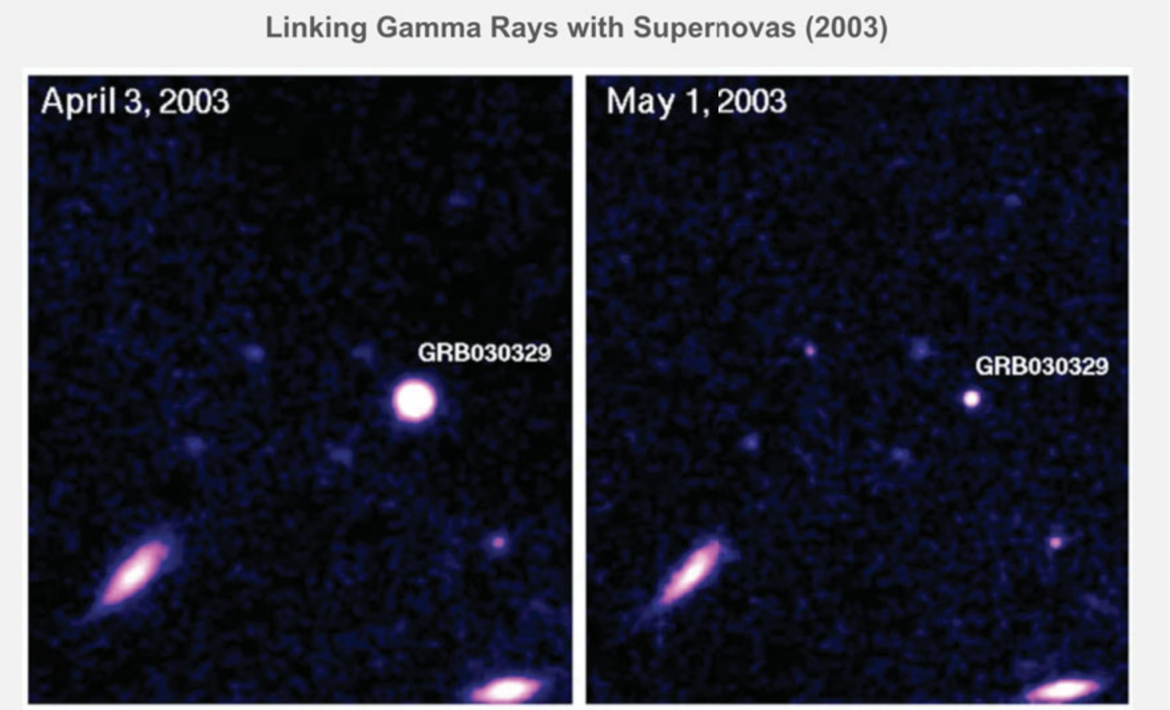


Photo Credit: ESO

Science Case: a brief lesson from history

- First direct images (and spectra!) of exoplanets

First Picture of Exoplanet System (2008)

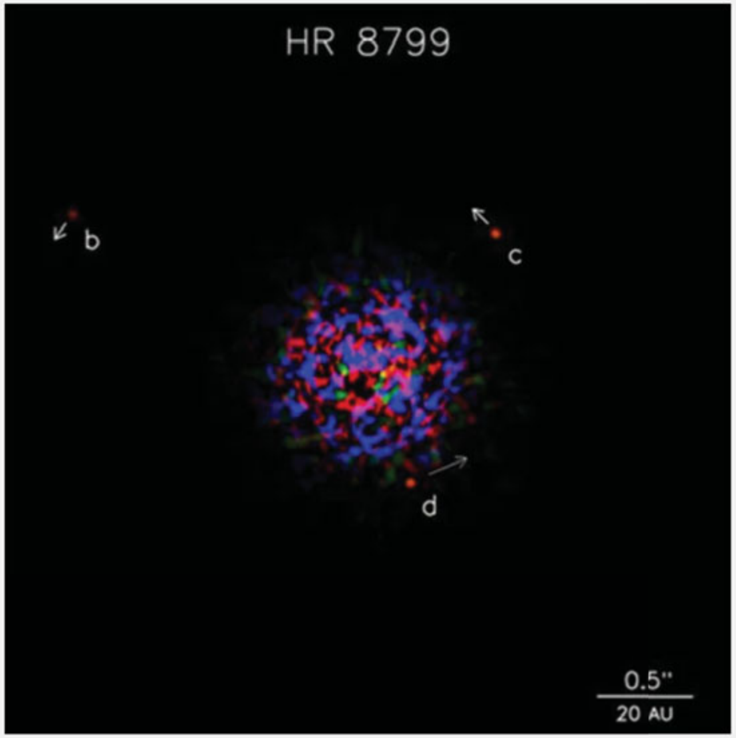


Photo Credit: Christian Marois and Bruce Macintosh

First Direct Spectrum of an Exoplanet (2010)

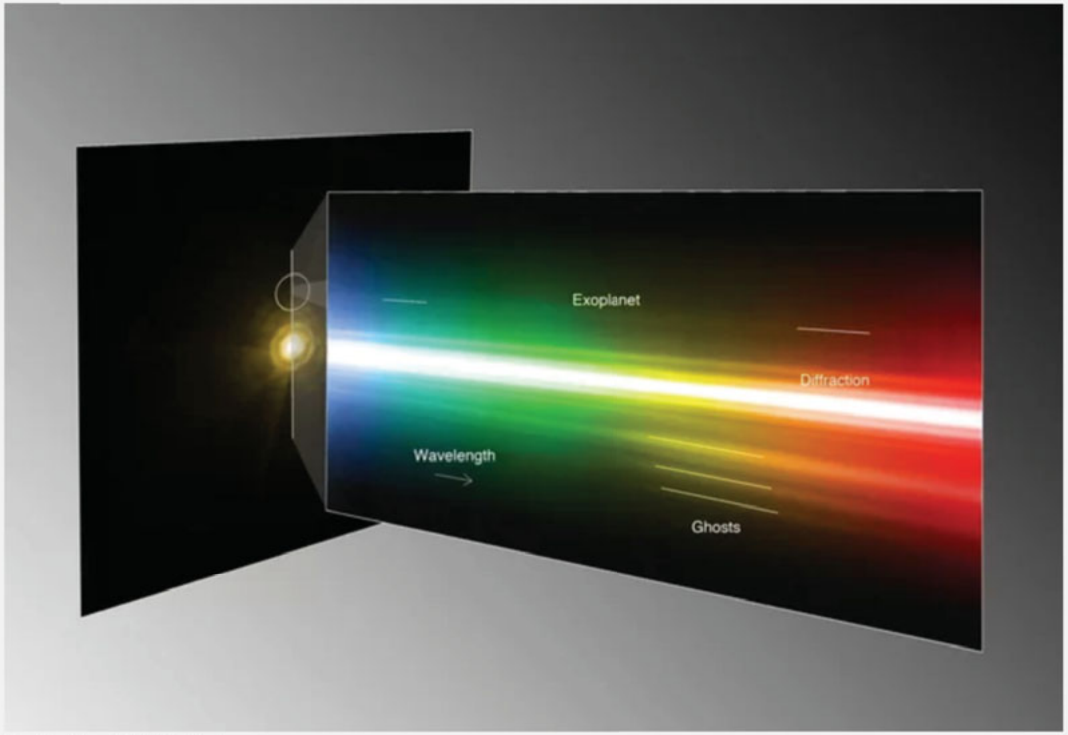


Photo Credit: ESO/M. Janson

GMT Mission: 50 years of forefront science

GMT Science Book: science goals for the next decade

- Planets & Stars
- Stars & Galaxies
- Galaxies & Cosmology

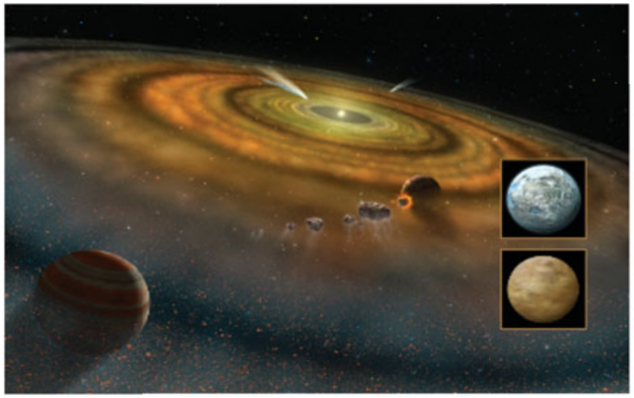
Top-Level Science Areas

For planning: think broadly

- what data is useful for what kinds of sources?
- what instruments provide that?
- what operational strategies are most effective?
- How can we enable a diverse instrument suite?

For instruments: think specifically

- what wavelength range?
- What pixel scale?
- What field size?



GMT Mission: 50 years of forefront science

GMT

GMT Science Book: science goals for the next decade

- Planets & Stars
- Stars & Galaxies
- Gal

Top-Level

For planni

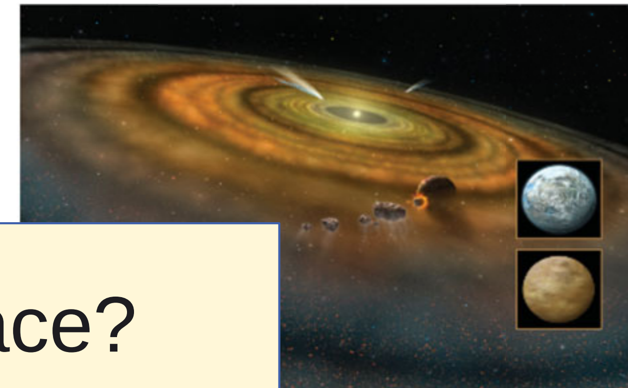
- wl
- wl
- wl
- H

Groundbased relative to space?

- They can be bigger! (better sensitivity: area + resolution)
- More modern instruments

For instruments: think specifically

- what wavelength range?
- What pixel scale?
- What field size?



Topics:

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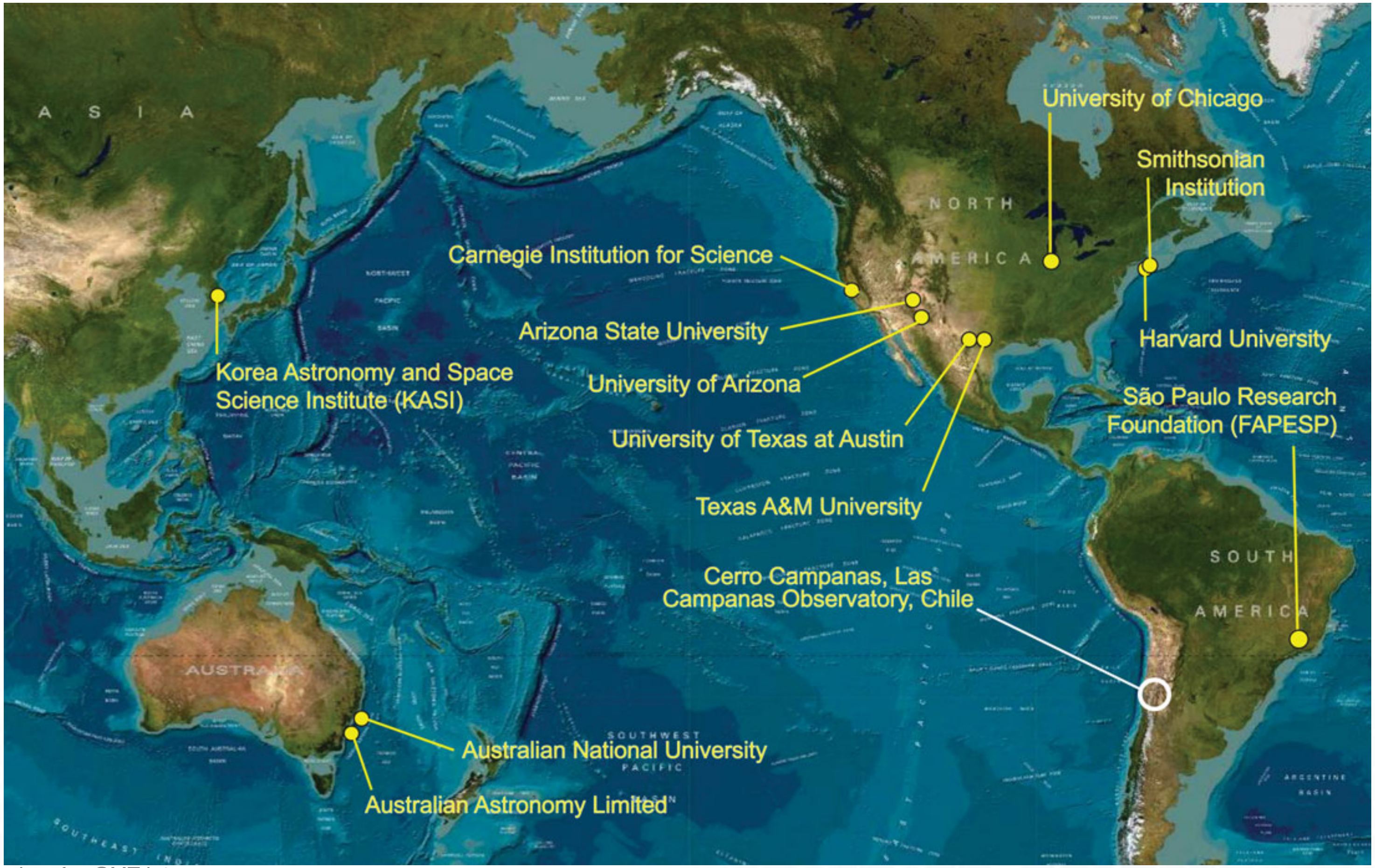
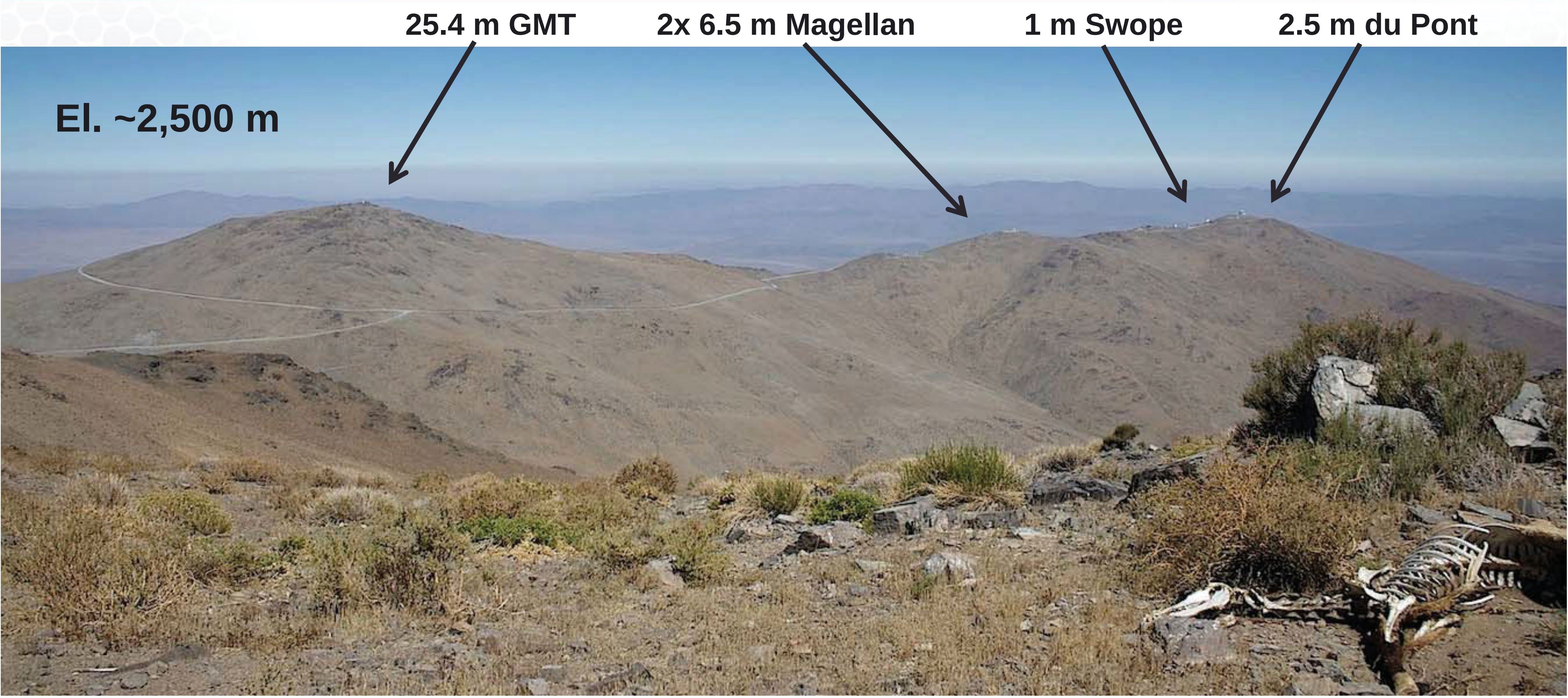
* Key characteristics & how they enable science

The GMT Partnership

- An international collaboration of academic and research institutions (not governments).
- GMTO Corporation formed in 2006. New partners welcome!



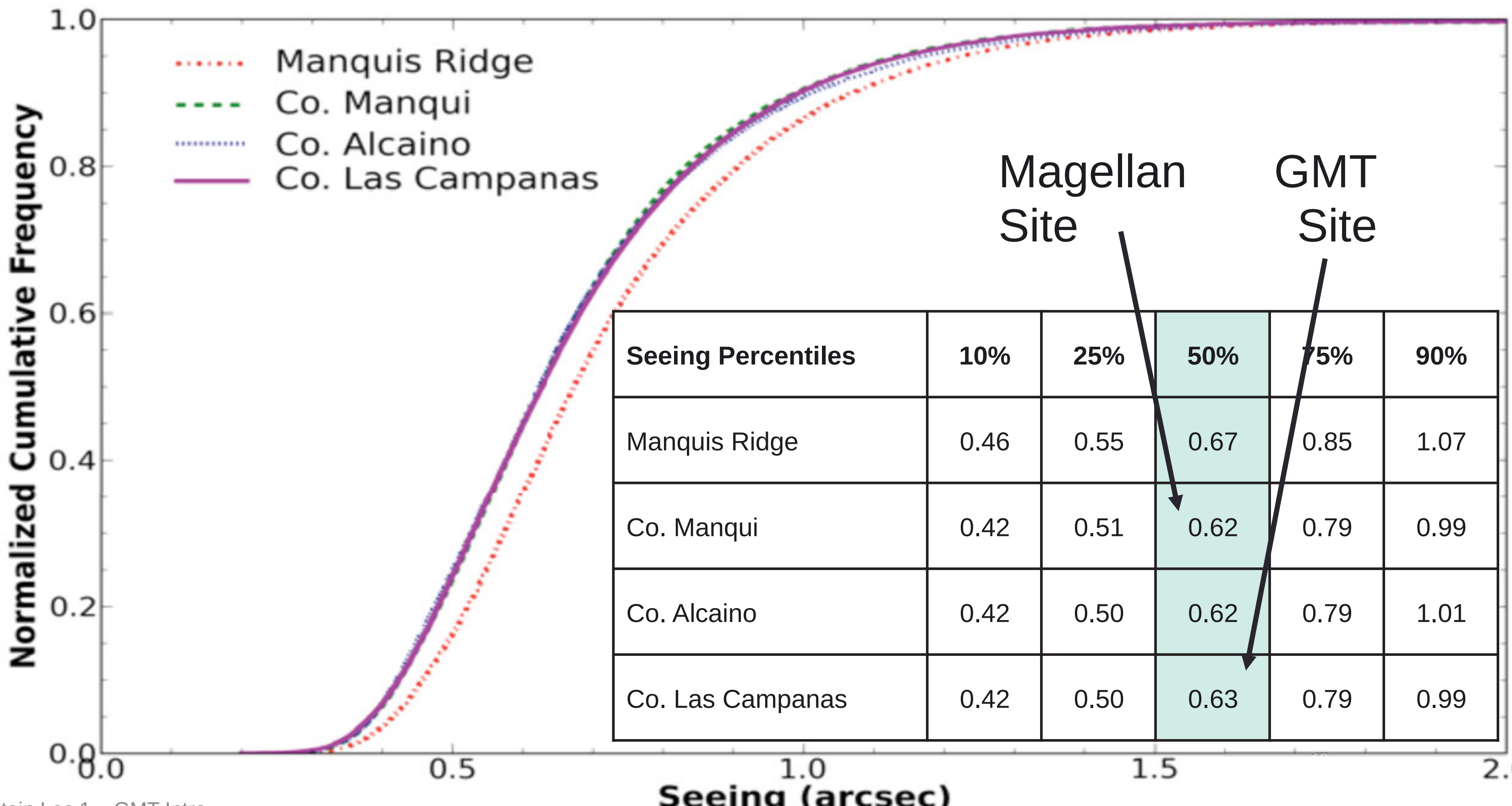
Site: Las Campanas Observatory (circa 2005)



- Excellent atmospheric stability (0.3-25 µm)
- Low water vapor
- Site owned by Carnegie Institution with a long term lease to GMTO

Site Characteristics – Seeing

- MASS/DIMM measurements (1990-95 and 2005-2010)
- Active observatory: no apparent evolution in performance over 25+ years
- Median seeing: 0.63 arcseconds in V-band



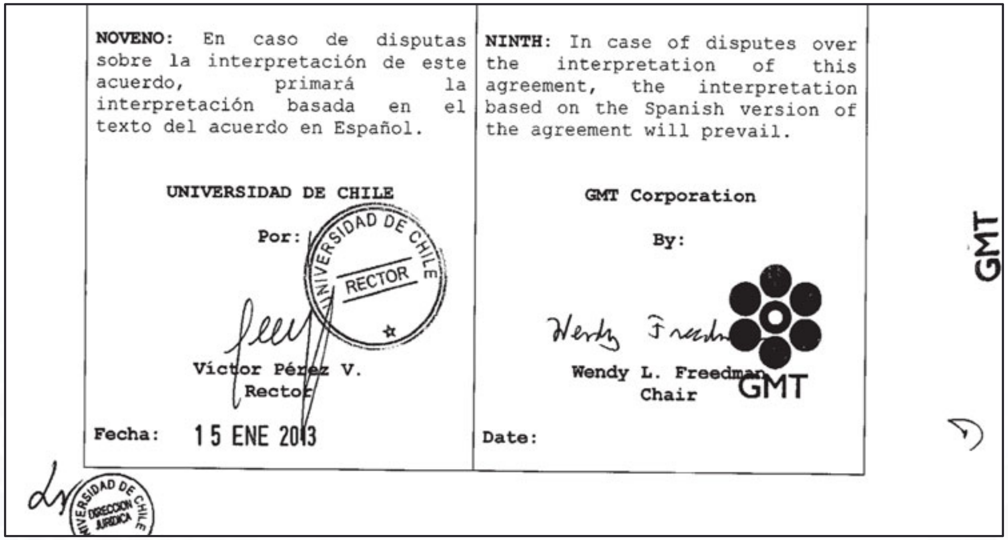
Seeing Percentiles	10%	25%	50%	75%	90%
Manquis Ridge	0.46	0.55	0.67	0.85	1.07
Co. Manqui	0.42	0.51	0.62	0.79	0.99
Co. Alcaino	0.42	0.50	0.62	0.79	1.01
Co. Las Campanas	0.42	0.50	0.63	0.79	0.99

Legal Standing in Chile

We operate in Chile under an agreement with the University of Chile

The agreement is recognized by the Foreign Ministry

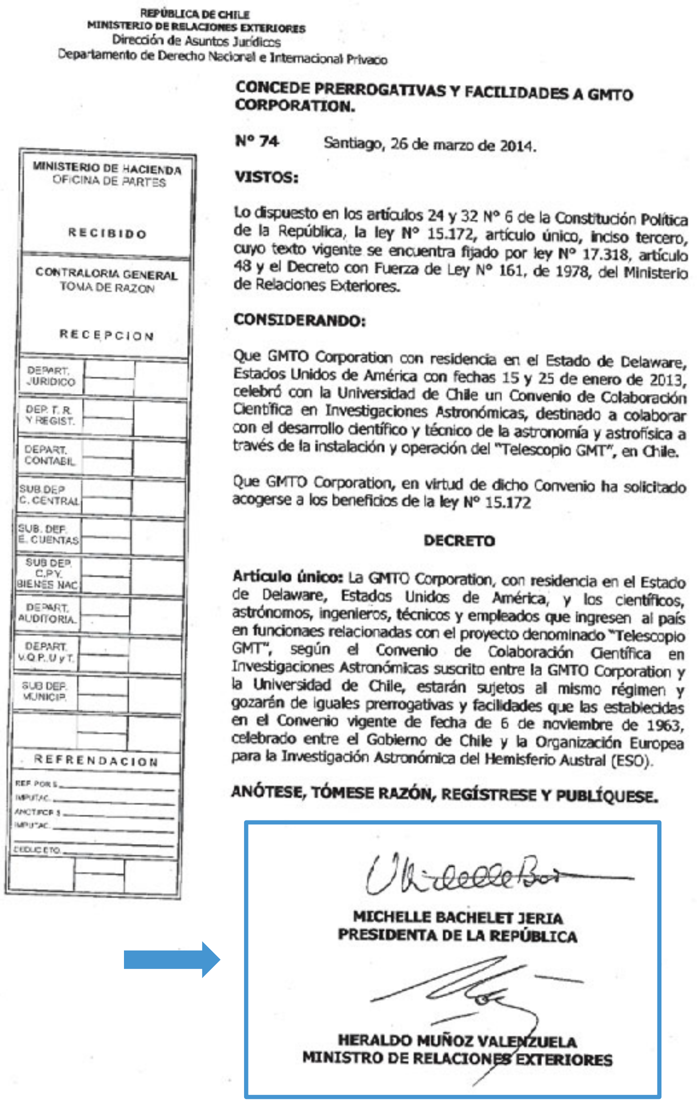
Chilean Astronomers get 10% of the observing time



NOVENO: En caso de disputas sobre la interpretación de este acuerdo, primará la interpretación basada en el texto del acuerdo en Español.

NINTH: In case of disputes over the interpretation of this agreement, the interpretation based on the Spanish version of the agreement will prevail.

UNIVERSIDAD DE CHILE	GMT Corporation
Por:	By:
Víctor Pérez V. Rector	Wendy L. Freedman Chair
Fecha: 15 ENE 2013	Date:



REPÚBLICA DE CHILE
MINISTERIO DE RELACIONES EXTERIORES
Dirección de Asuntos Jurídicos
Departamento de Derecho Nacional e Internacional Privado

CONCEDE PRERROGATIVAS Y FACILIDADES A GMTO CORPORATION.

Nº 74 Santiago, 26 de marzo de 2014.

MINISTERIO DE HACIENDA OFICINA DE PARTES — RECIBIDO
CONTRALORIA GENERAL TOMA DE RAZON — RECEPCION
REFRENDACION

VISTOS:

Lo dispuesto en los artículos 24 y 32 Nº 6 de la Constitución Política de la República, la ley Nº 15.172, artículo único, inciso tercero, cuyo texto vigente se encuentra fijado por ley Nº 17.318, artículo 48 y el Decreto con Fuerza de Ley Nº 161, de 1978, del Ministerio de Relaciones Exteriores.

CONSIDERANDO:

Que GMTO Corporation con residencia en el Estado de Delaware, Estados Unidos de América con fechas 15 y 25 de enero de 2013, celebró con la Universidad de Chile un Convenio de Colaboración Científica en Investigaciones Astronómicas, destinado a colaborar con el desarrollo científico y técnico de la astronomía y astrofísica a través de la instalación y operación del "Telescopio GMT", en Chile.

Que GMTO Corporation, en virtud de dicho Convenio ha solicitado acogerse a los beneficios de la ley Nº 15.172

DECRETO

Artículo único: La GMTO Corporation, con residencia en el Estado de Delaware, Estados Unidos de América, y los científicos, astrónomos, ingenieros, técnicos y empleados que ingresen al país en funcionaes relacionadas con el proyecto denominado "Telescopio GMT", según el Convenio de Colaboración Científica en Investigaciones Astronómicas suscrito entre la GMTO Corporation y la Universidad de Chile, estarán sujetos al mismo régimen y gozarán de iguales prerrogativas y facilidades que las establecidas en el Convenio vigente de fecha de 6 de noviembre de 1963, celebrado entre el Gobierno de Chile y la Organización Europea para la Investigación Astronómica del Hemisferio Austral (ESO).

ANÓTESE, TÓMESE RAZÓN, REGÍSTRESE Y PUBLÍQUESE.

MICHELLE BACHELET JERIA
PRESIDENTA DE LA REPÚBLICA

HERALDO MUÑOZ VALENZUELA
MINISTRO DE RELACIONES EXTERIORES

Presidential Decree

Location, Location, Location:

Synergy with southern hemisphere observatories and surveys:

complementarity capabilities!

Topics:

- Motivation
  - History
  - Science case for the large telescopes
- Partnership & Site
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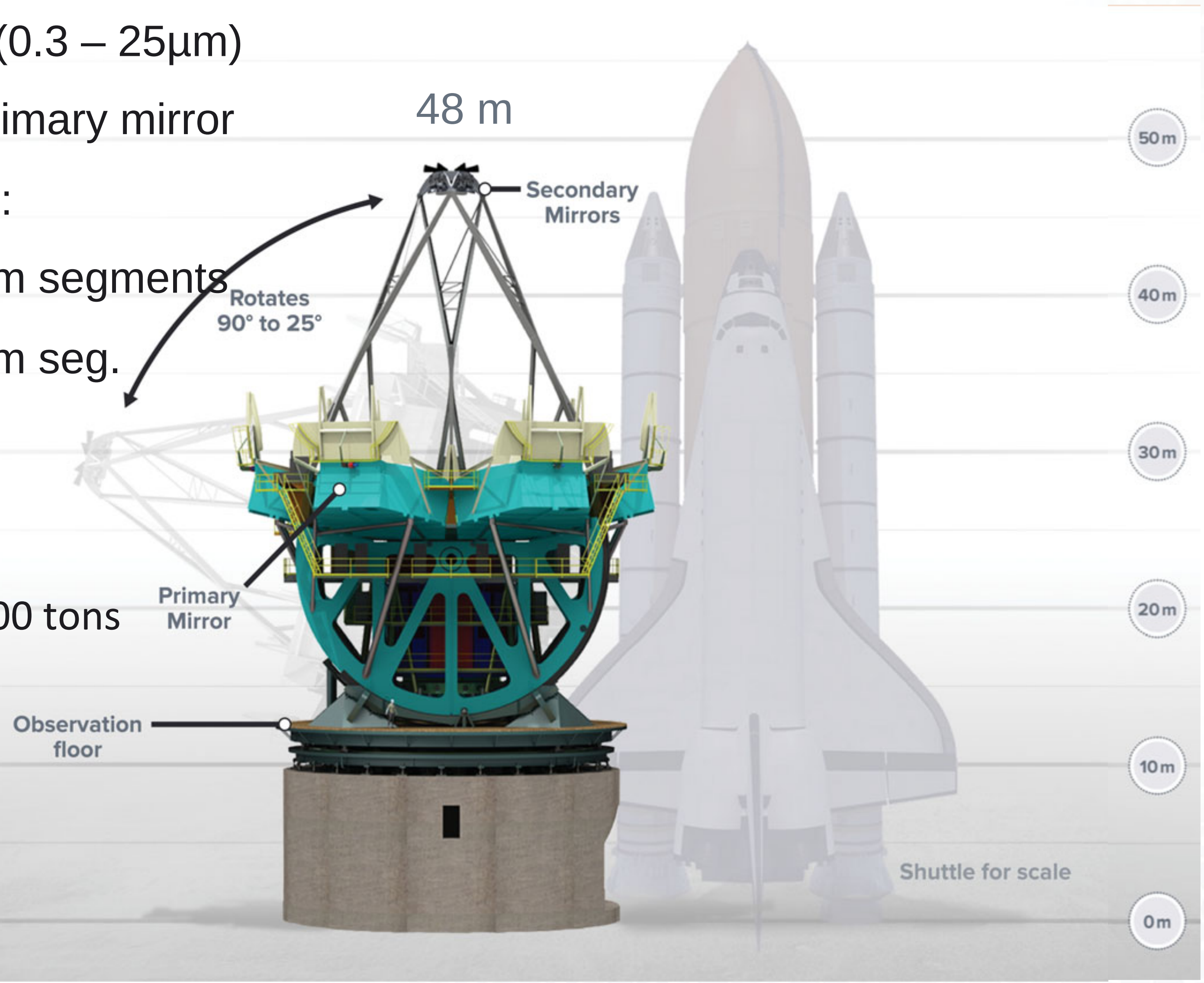
* Key characteristics & how they enable science

GMT design

- Optical to Infrared (0.3 – 25µm)
- 25.4 m diameter primary mirror
- Double segmented:
  - M1: seven 8.4m segments
  - M2: seven 1.1m seg.

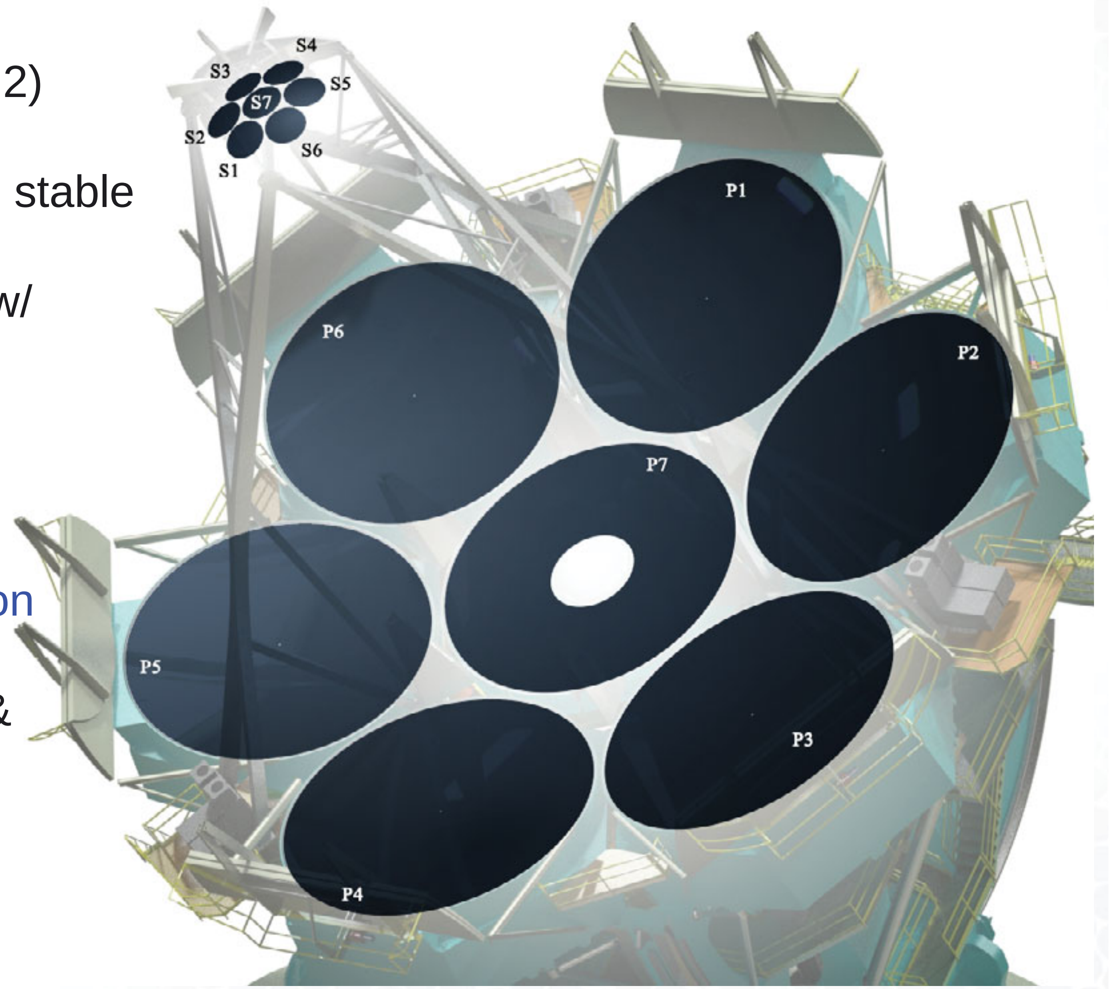


- Telescope mass: 1,400 tons

GMT design strengths

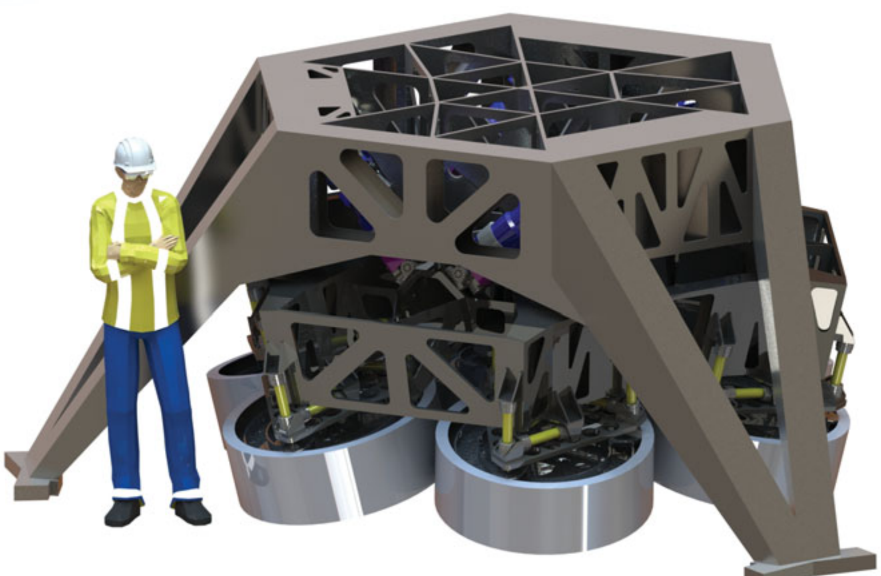
- Aplanatic Gregorian optical configuration
- Fast primary (f/0.7) & final f/ratio (f/8.2)
  - → Compact structure: cheaper, more stable
  - → Wide FOV: 10 arcmin (20 arcmin w/ corrector)
  - → Small plate scale: 1.0 mm/arcsec

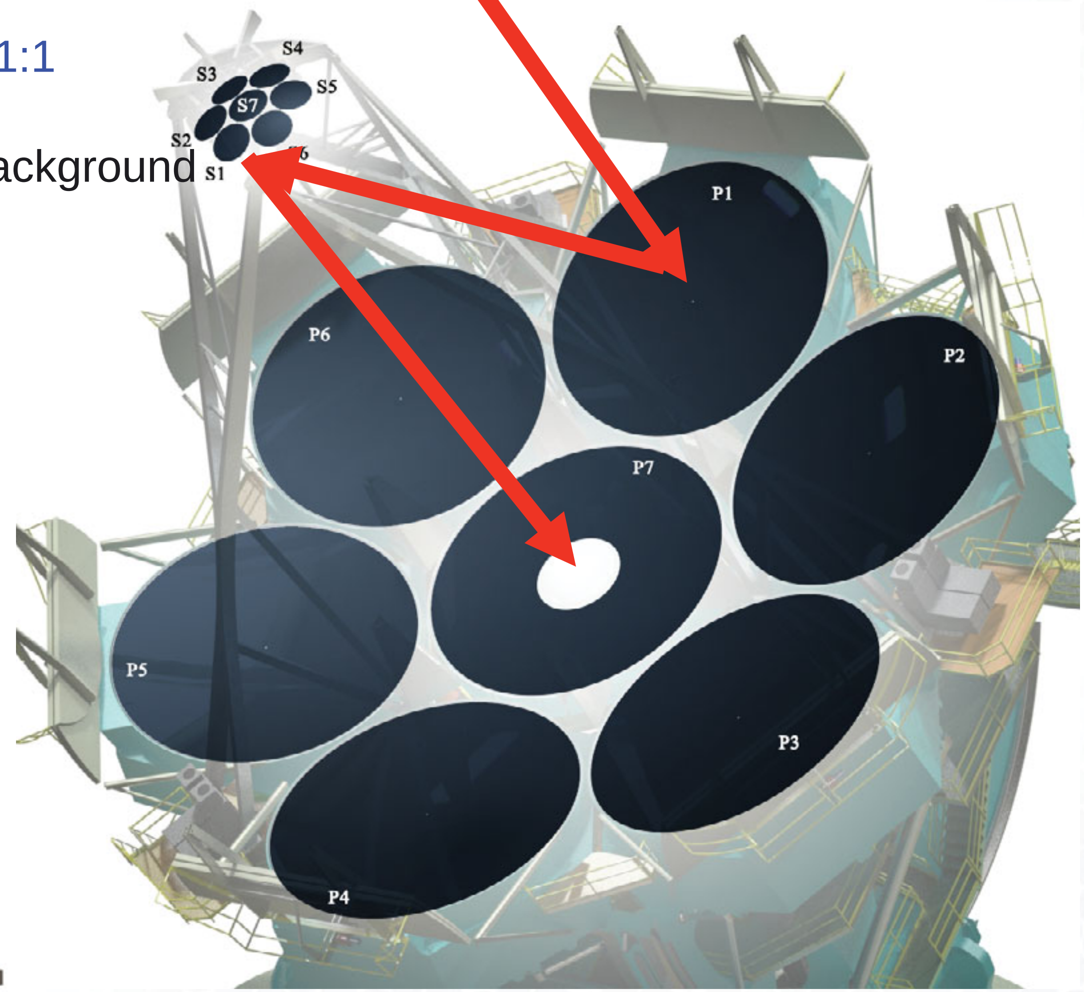
    facilitates wide field instrumentation
  - → Real primary focus for alignment & calibration



GMT design strengths

- Adaptive secondary mirrors for full time AO
  - → M1 & M2 segments are conjugate 1:1
  - → 2 reflections: high efficiency, low background
  - → GLAO enabled by M2 location





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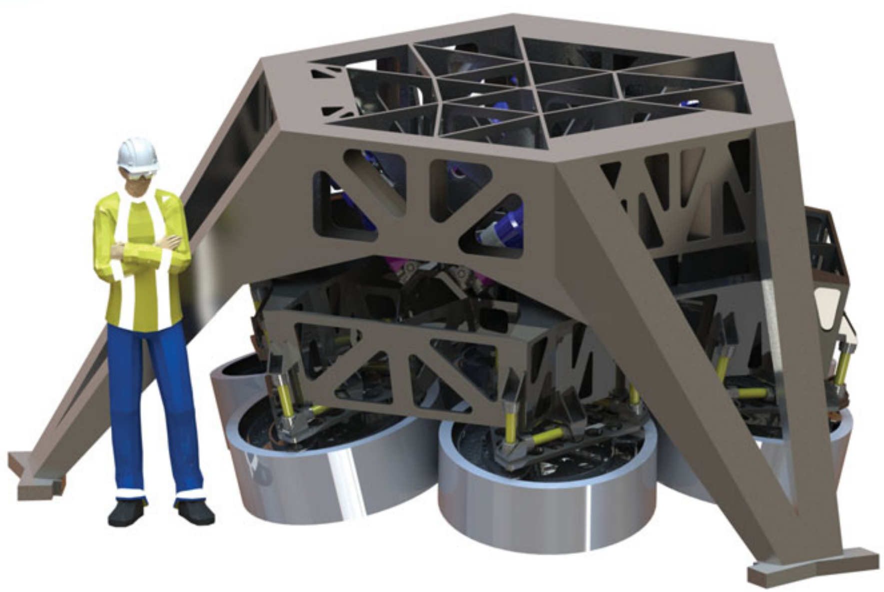
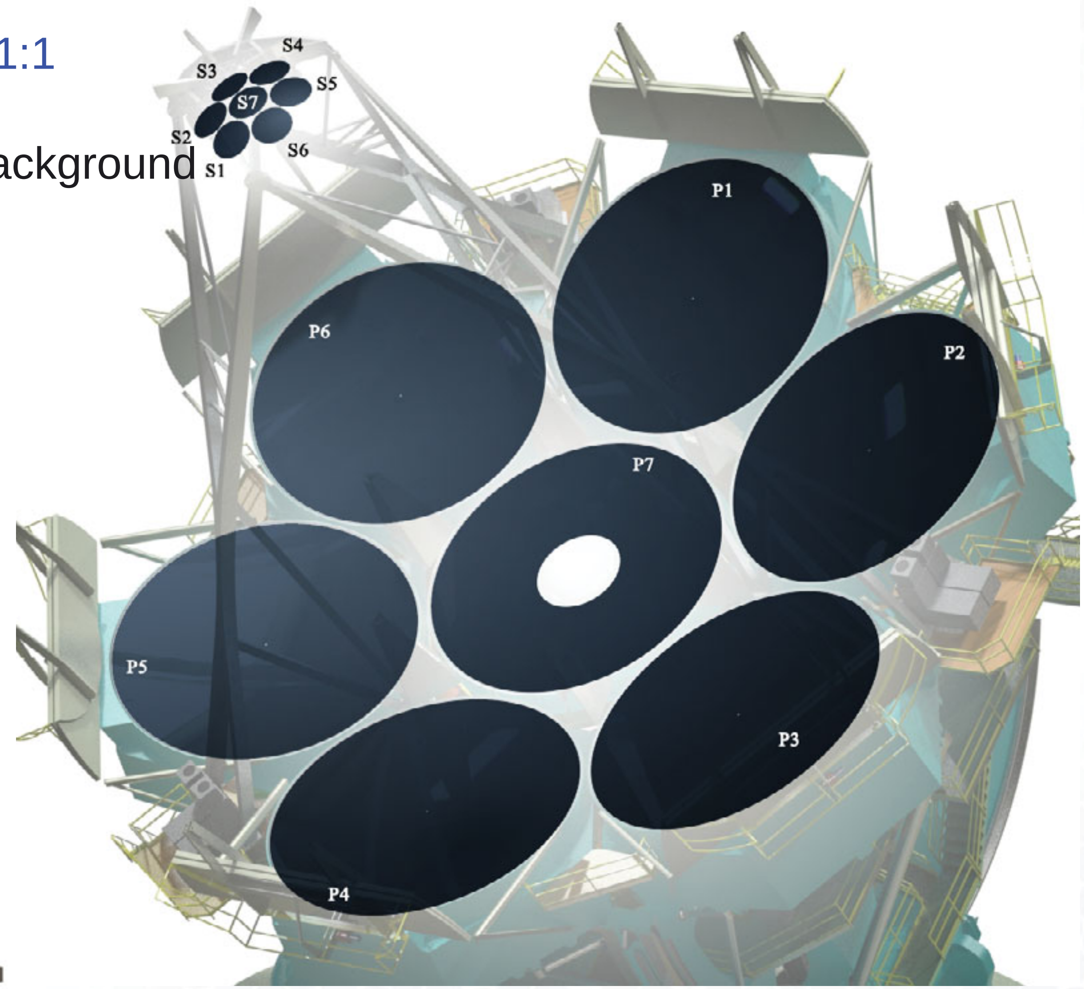
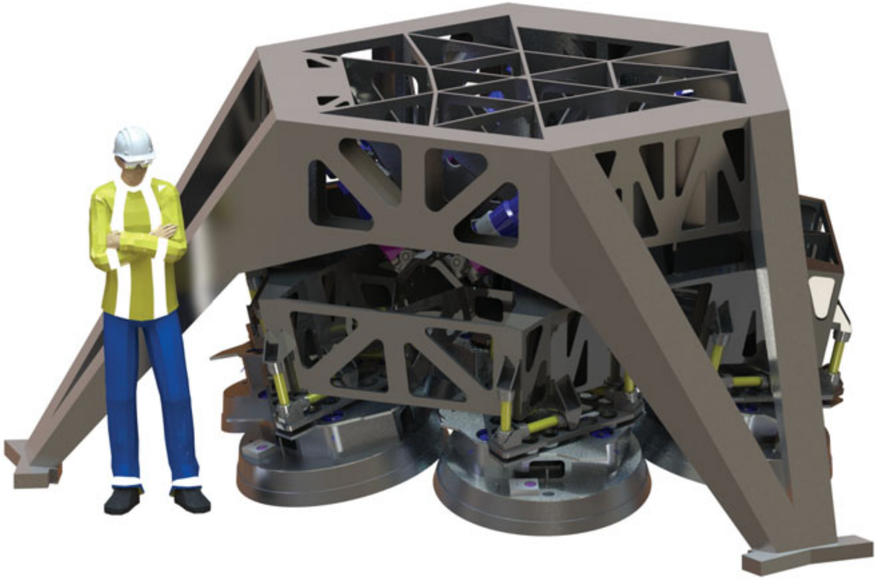
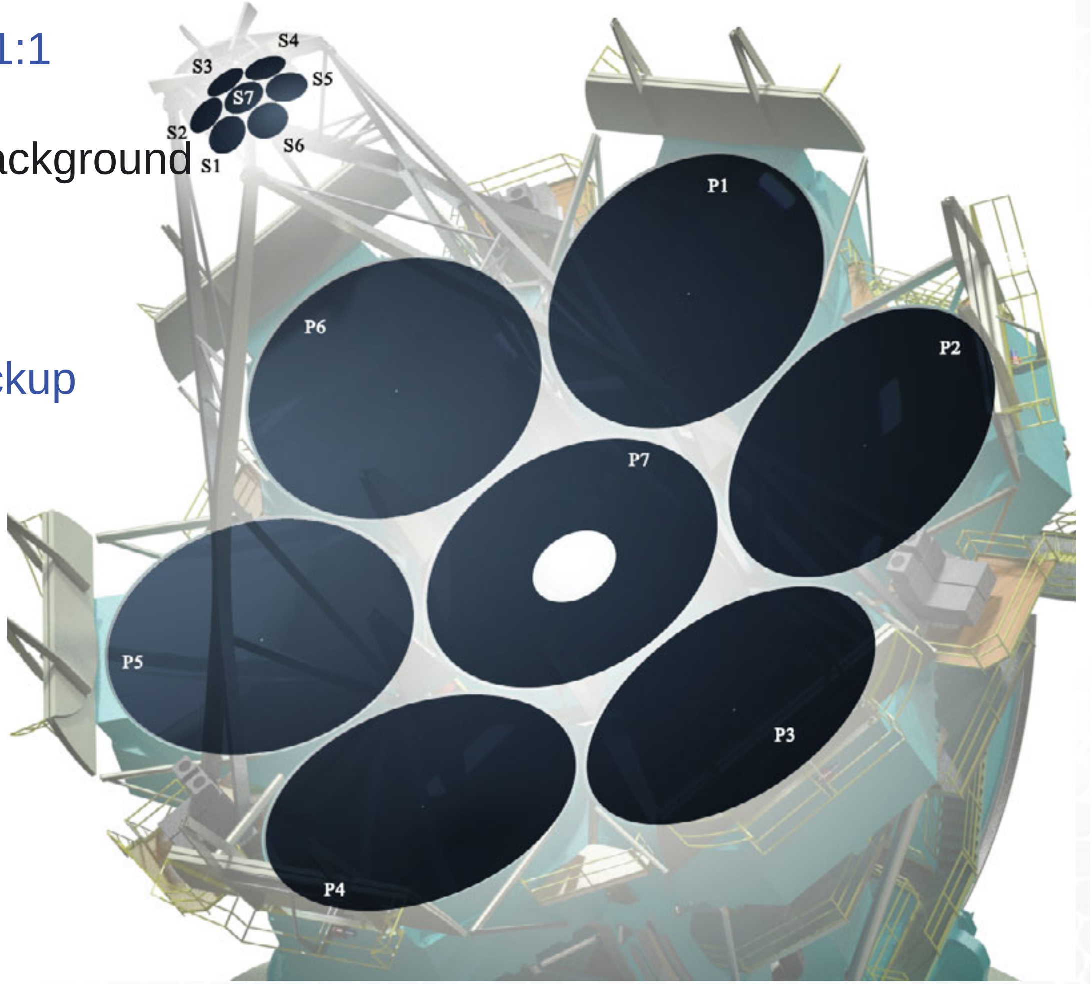




GMT design strengths

- Adaptive secondary mirrors for full time AO
  - → M1 & M2 segments are conjugate 1:1
  - → 2 reflections: high efficiency, low background
  - → GLAO enabled by M2 location
  - → Standard M2 system (FSM) for backup





ASMs provide full time AO: NGAO

Natural guide star AO (NGAO):

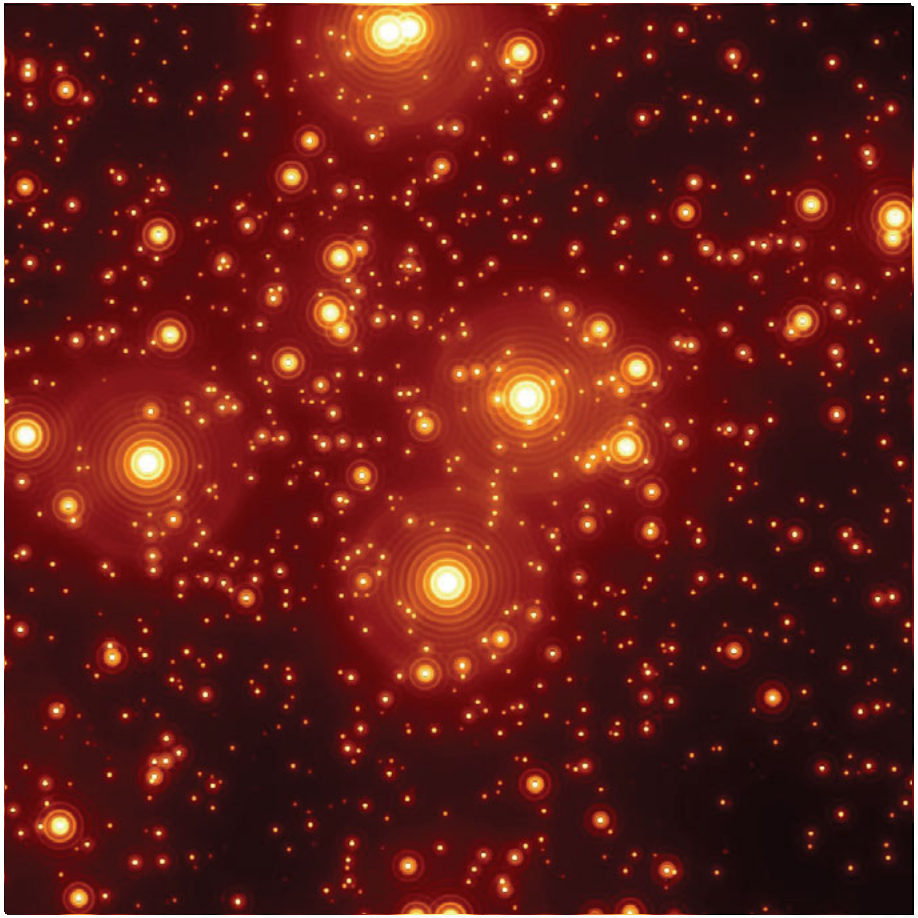
Atmospheric seeing limit:
$\theta_J \approx 0.5$ arcsec

Hubble Space Telescope
$\theta_J \approx 0.2$ arcsec

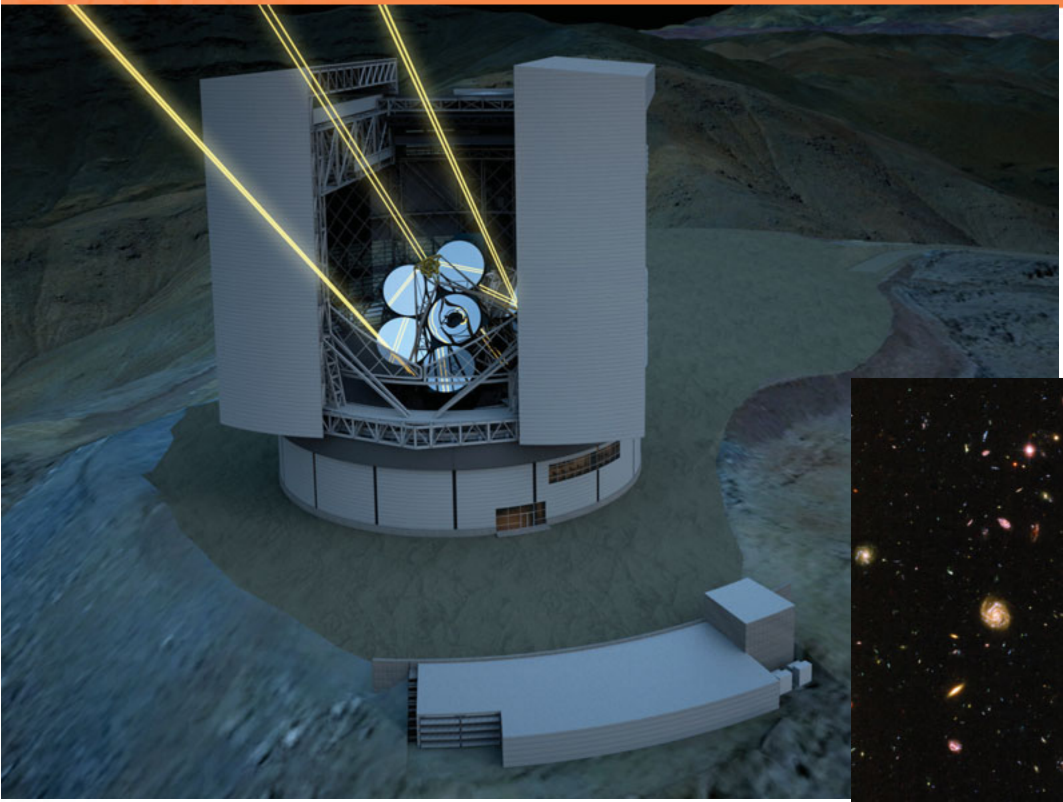
Webb Space Telescope
$\theta_J \approx 0.07$ arcsec

GMT with **NGAO**
$\theta_J \approx 0.02$ arcsec

10 – 30" (limited by isoplanatic patch)



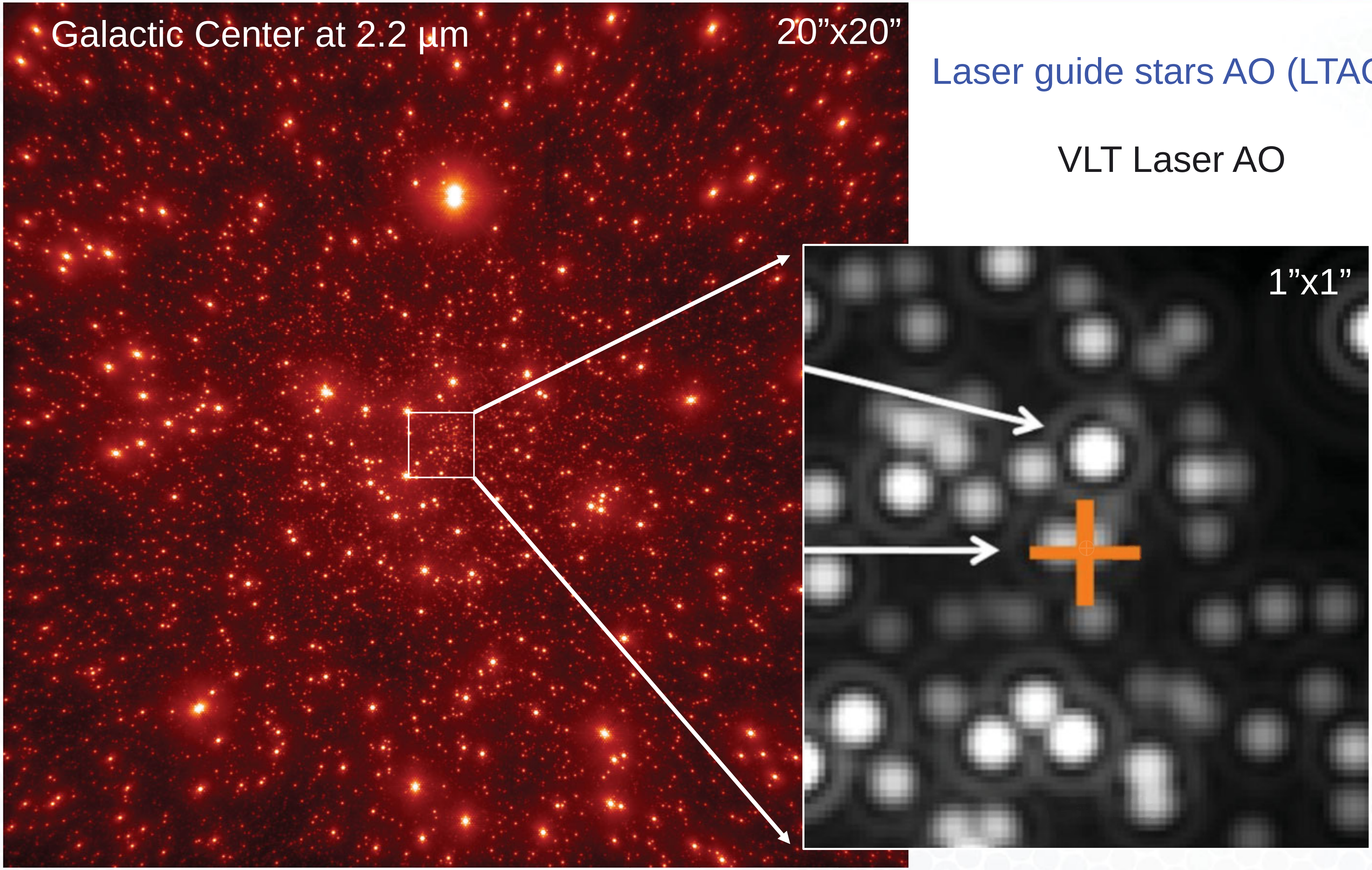
ASMs provide full time AO: LTAO



Laser guide stars AO (LTAO):

> 80% sky coverage

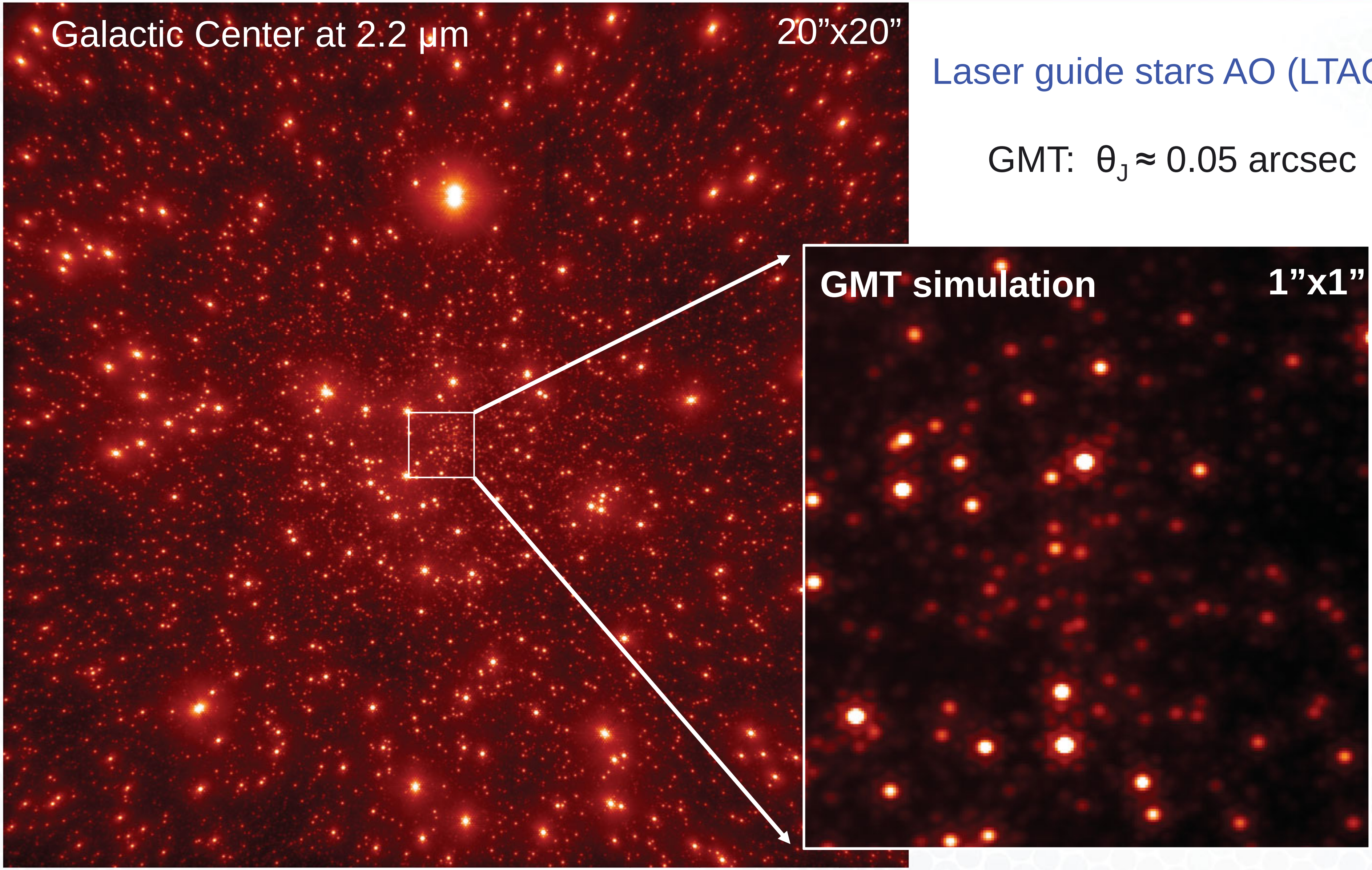
ASMs provide full time AO: LTAO



Laser guide stars AO (LTAO):

VLT Laser AO

ASMs provide full time AO: LTAO

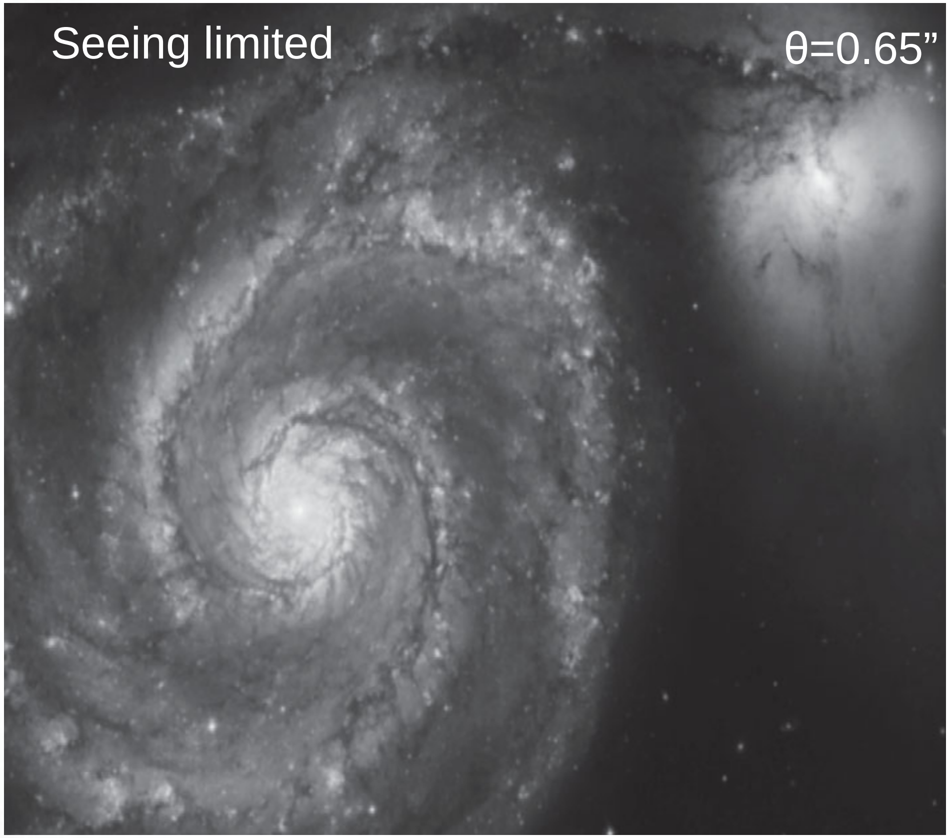


Laser guide stars AO (LTAO):

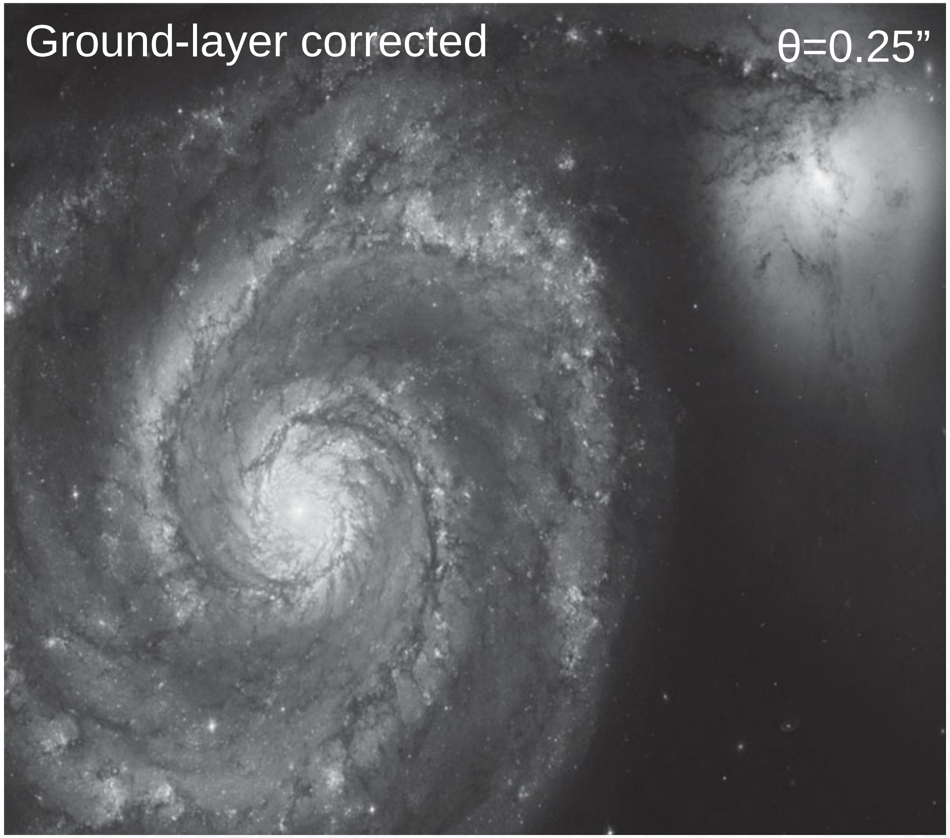
GMT: $\theta_J \approx 0.05$ arcsec

ASMs provide full time AO: GLAO

Ground layer AO: 30-50% improvement over natural seeing



$\theta_R \approx 0.25$ arcsec (75th percentile)

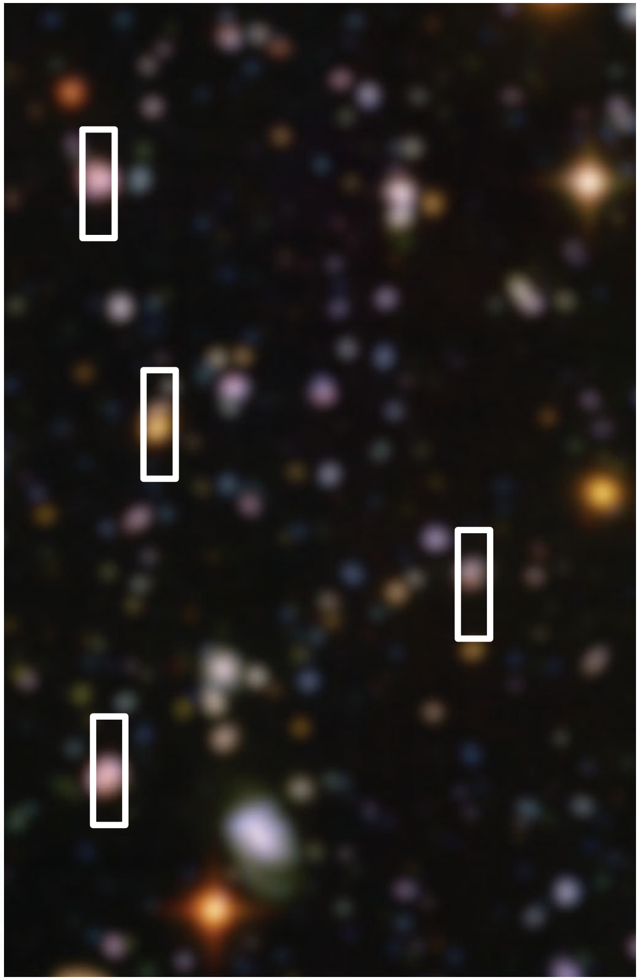


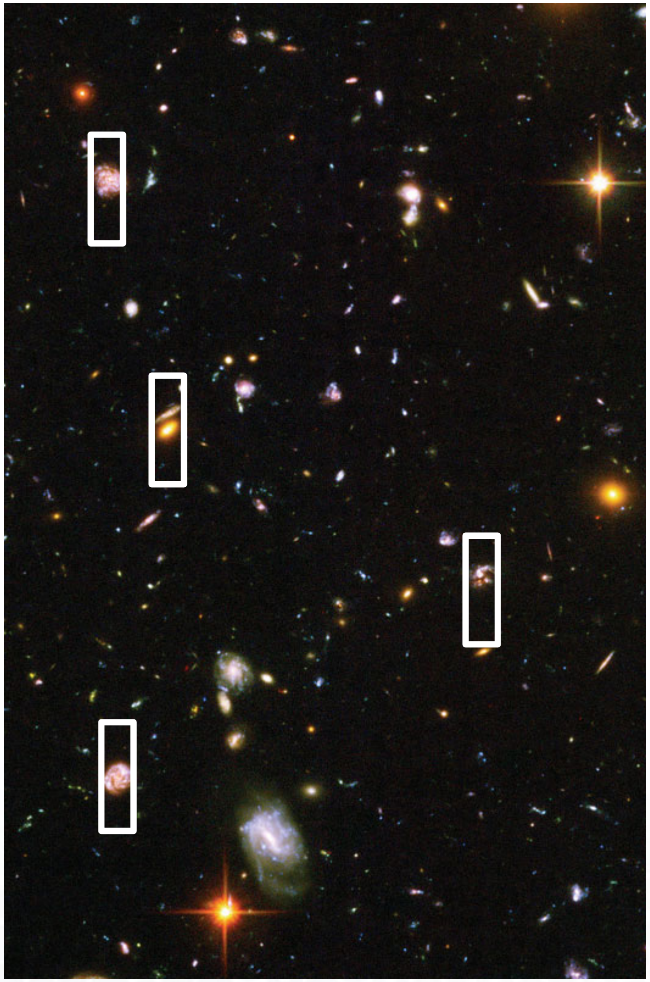
10 arcminute fields of view

ASMs provide full time AO: GLAO ---

Ground layer AO: 30-50% improvement over natural seeing

Factor of >1.5 more light into slits.





Full time AO: NGAO, LTAO, & GLAO

Telescope + planned instrument field of view:

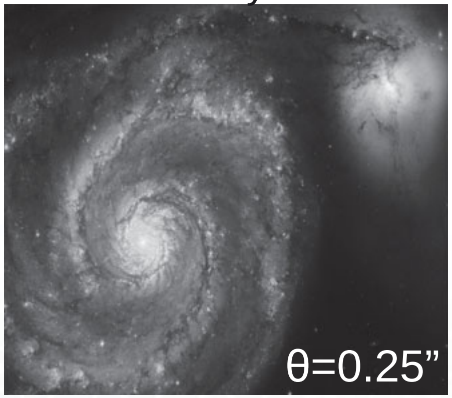
	Keck	GMT (2 mirrors)	GMT with GLAO	TMT (3 mirrors)	ELT (5 mirrors)
Aε	1	6	6	9	14
Ω	81	50	50	24	11
θ^2 **	(0.65")^2	(0.65")^2	**(0.25")^2**	(0.65")^2	**(0.25")^2**
$A\varepsilon\Omega/\theta^2$ (relative)	1	4	25	3	10

Metric for **wide field** science: $\mathbf{A\varepsilon\Omega/\theta^2}$

A = Area
ε = efficiency (0.8 – 0.9 per mirror)
Ω = Field of view
θ = image size (flux concentration)

**Typical 75th percentile, R-band seeing.

Ground Layer AO



Full time AO: NGAO, LTAO, & GLAO

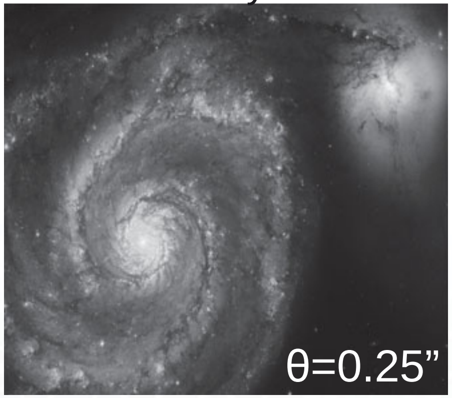
Telescope + planned instrument field of view:

	Keck	GMT (2 mirrors)	GMT with GLAO	TMT (3 mirrors)	ELT (5 mirrors)
Aε	1	6	6	9	14
Ω	81	50	50	24	11
θ^2 **	(0.65")^2	(0.65")^2	**(0.25")^2**	(0.65")^2	**(0.25")^2**
$A\varepsilon\Omega/\theta^2$ (relative)	1	4	25	3	10

Metric for **wide field** science: $\mathbf{A\varepsilon\Omega/\theta^2}$

A = Area
ε = efficiency (0.8 – 0.9 per mirror)
Ω = Field of view
θ = image size (flux concentration)

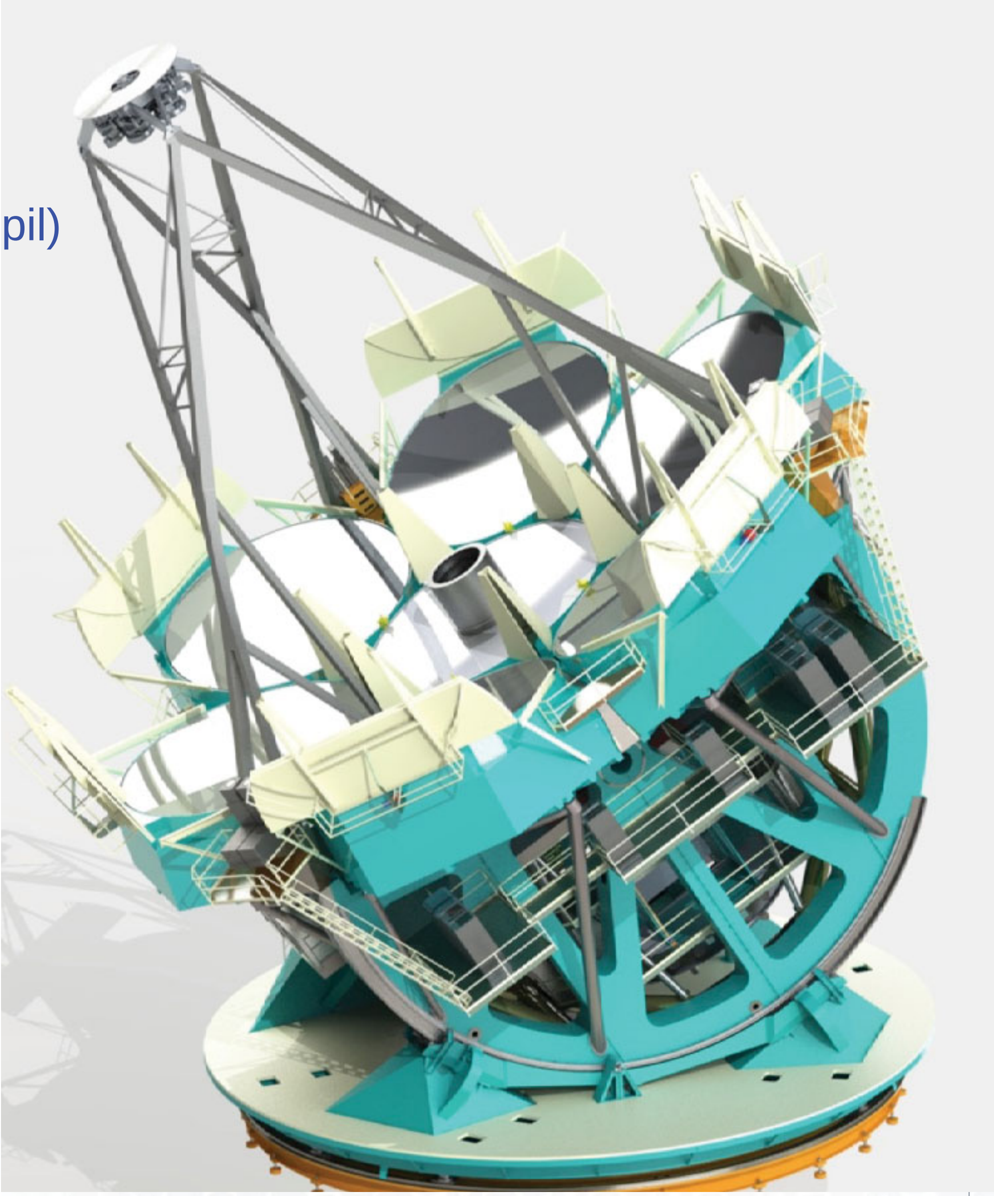
Ground Layer AO



**Typical 75th percentile, R-band seeing.

Structure: secondary mirror support

- Upper truss support:
  - Outer segments unobscured (clean pupil)
  - Facilitates high contrast AO



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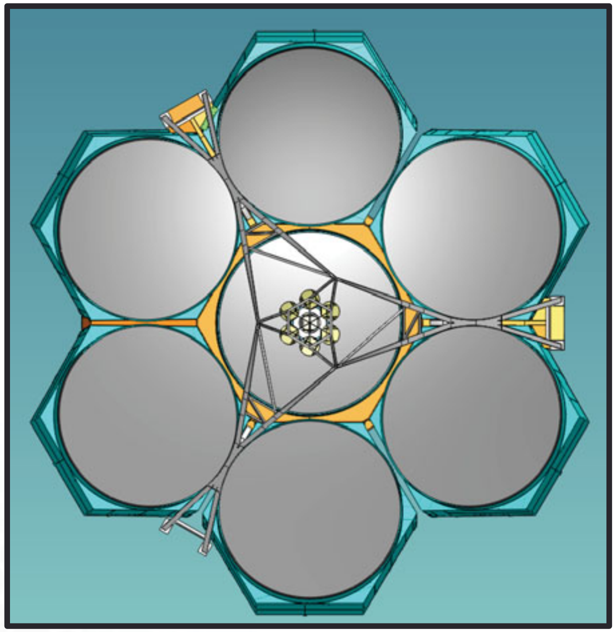
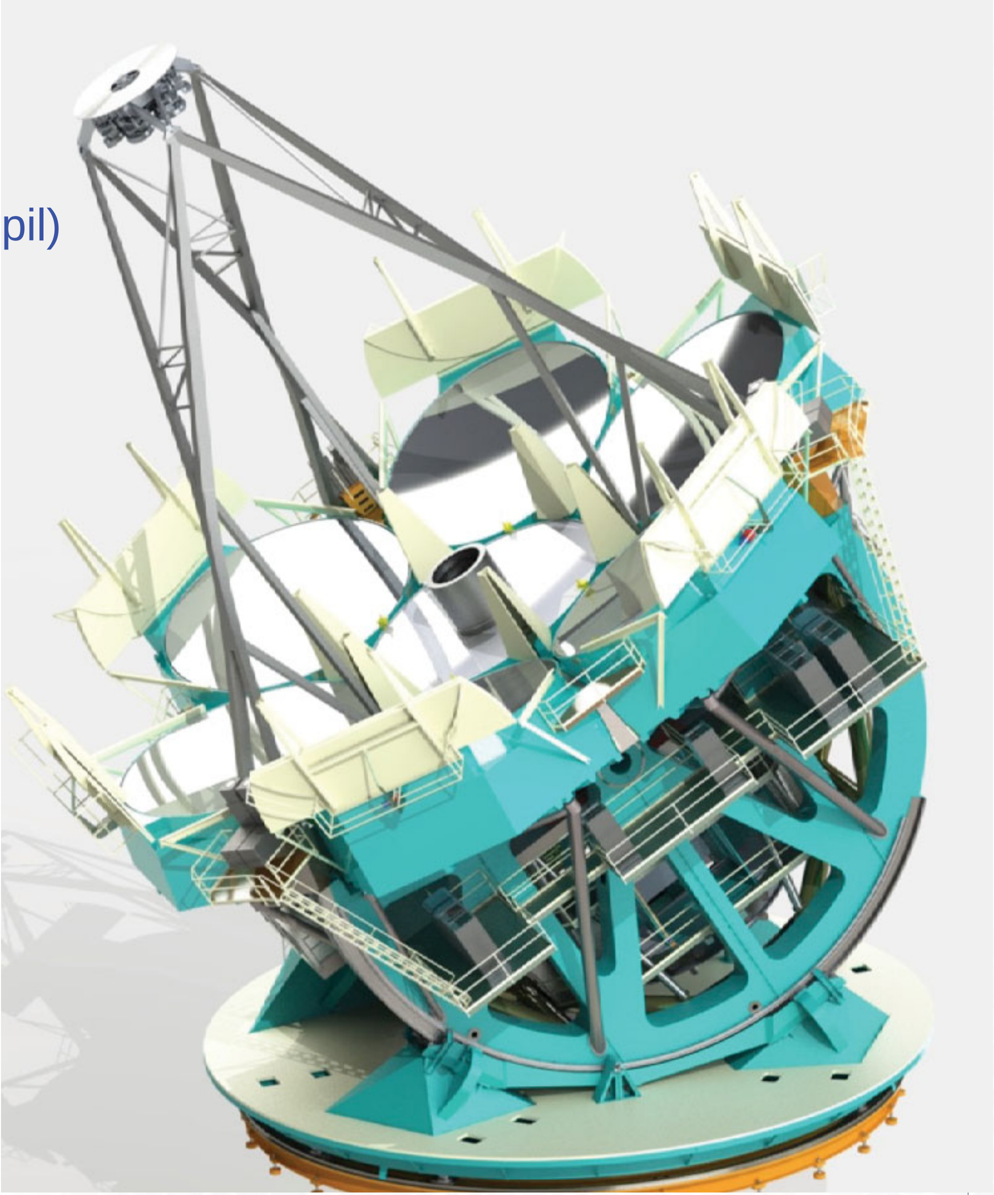
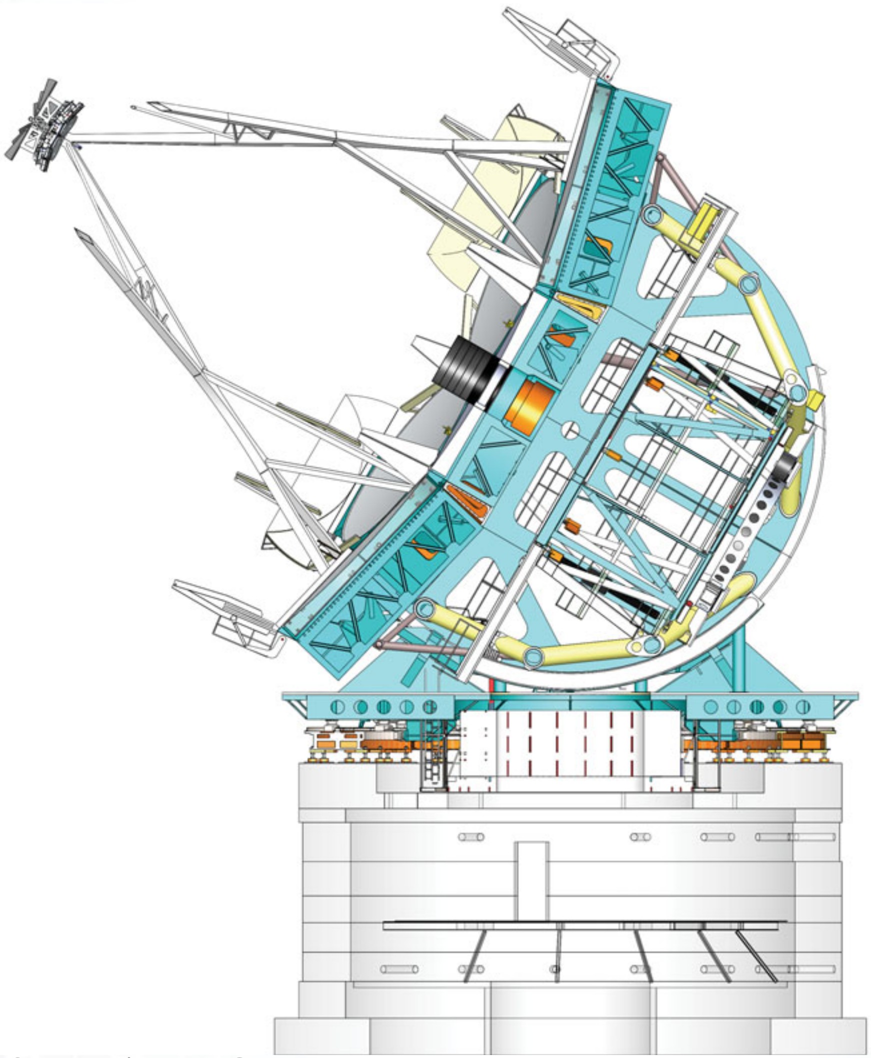
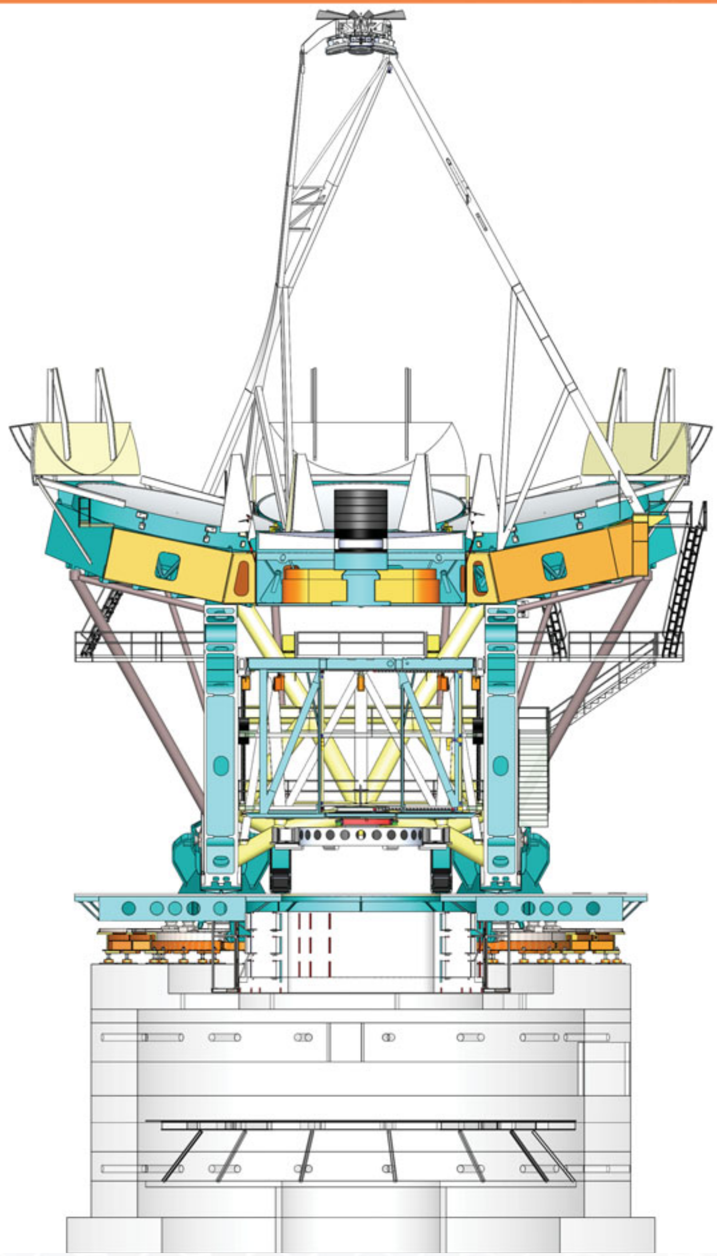




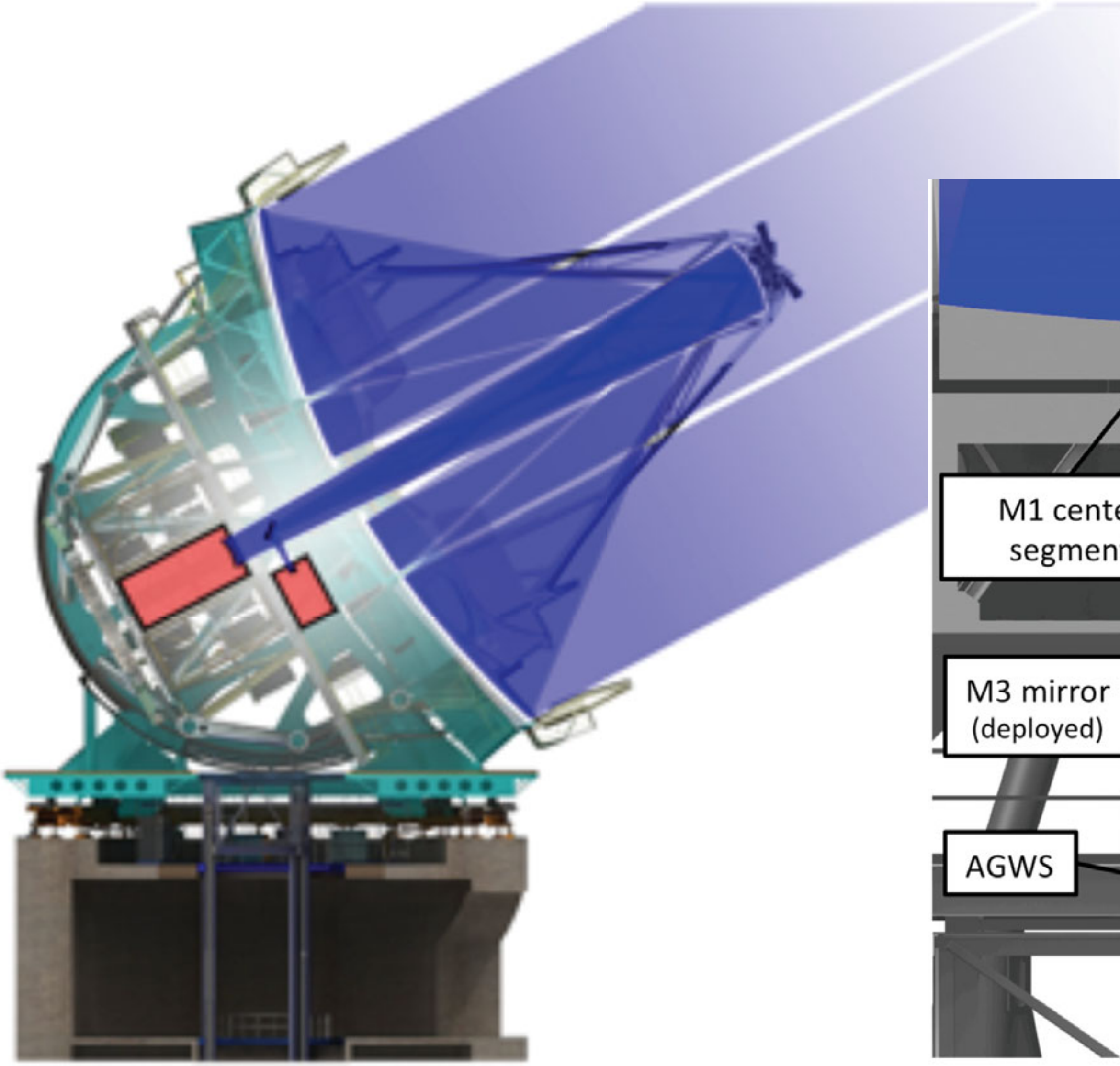
Structure: … notice anything strange?

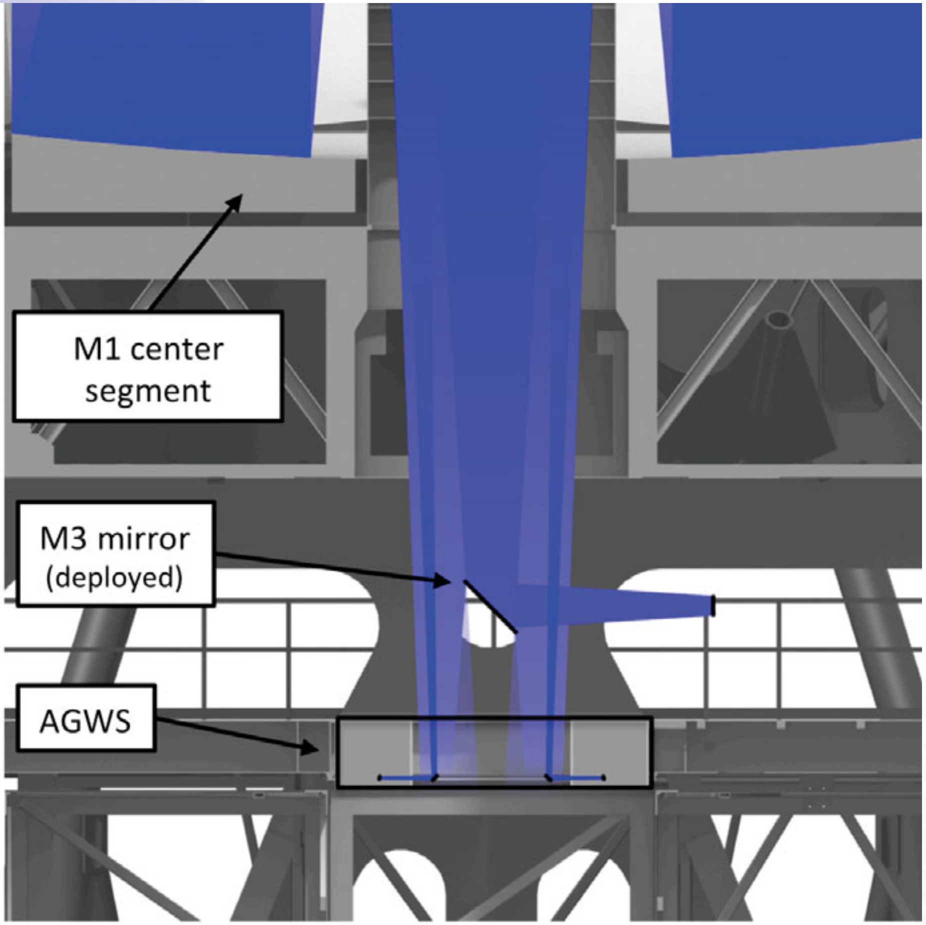
- low center of gravity, rigid





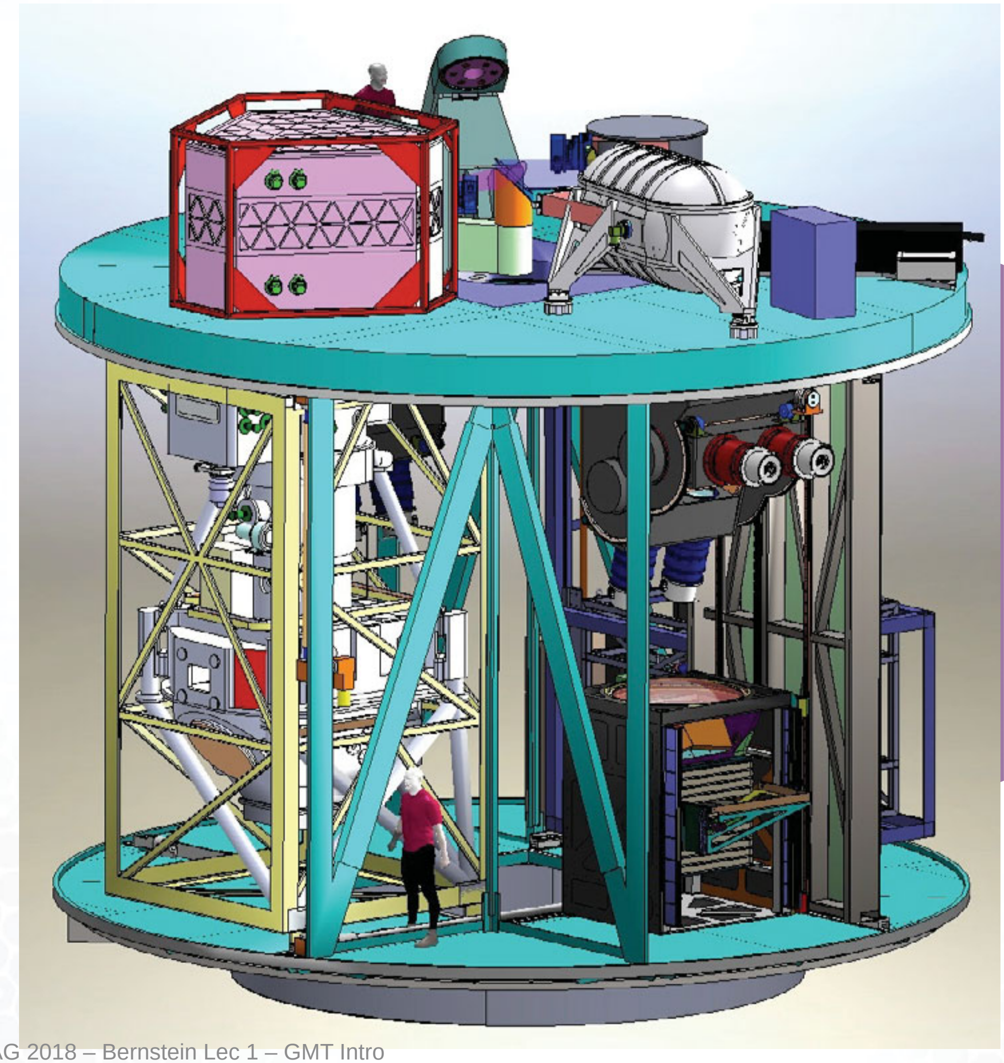
Instrument mounting locations:

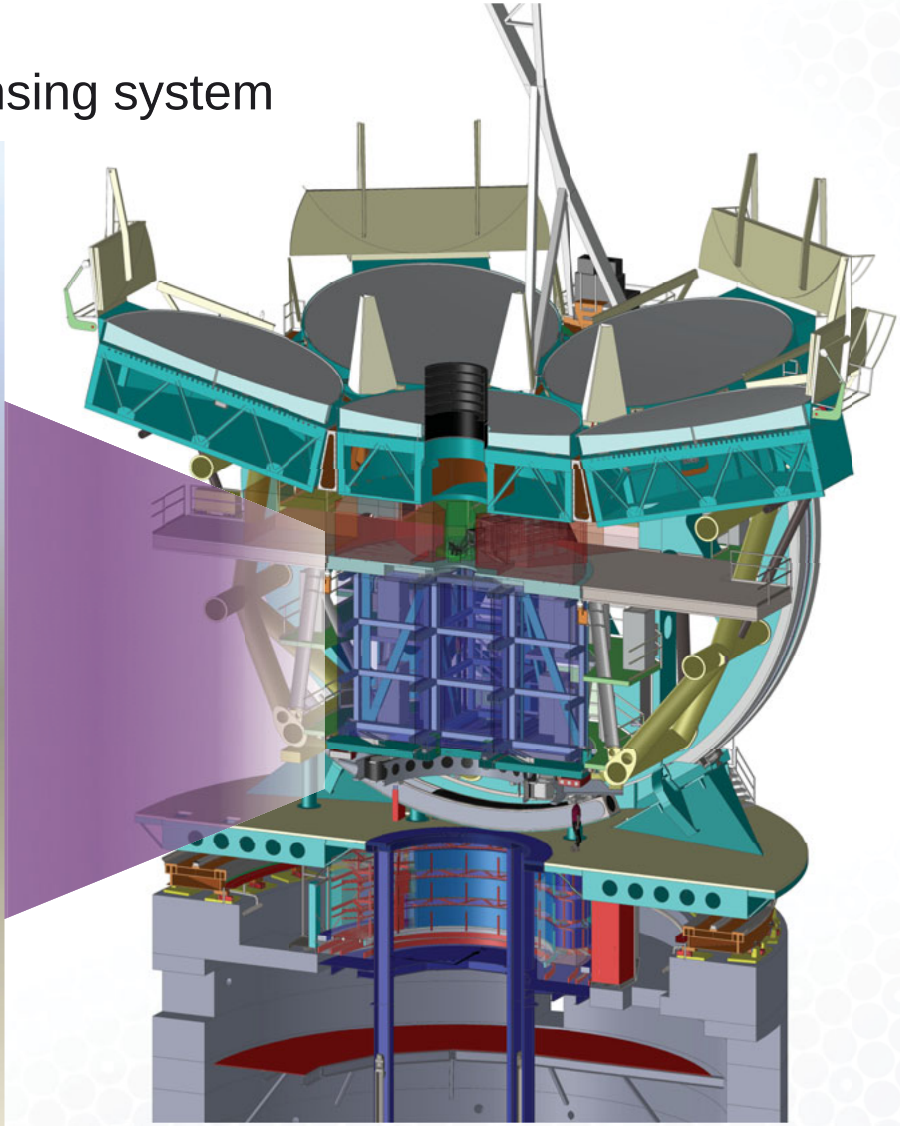




Gregorian Instrument Rotator (GIR)

- Carries science instruments and acquisition, guide, & wavefront sensing system





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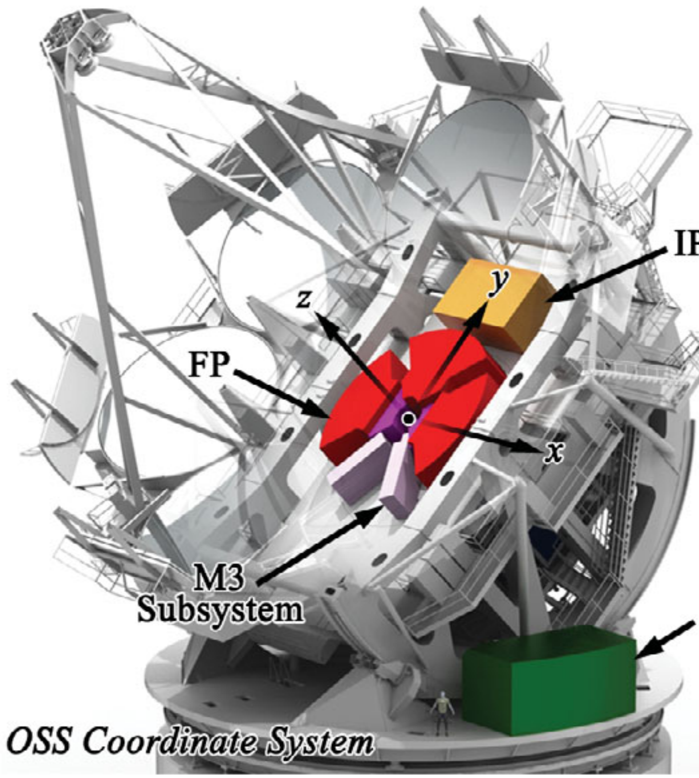
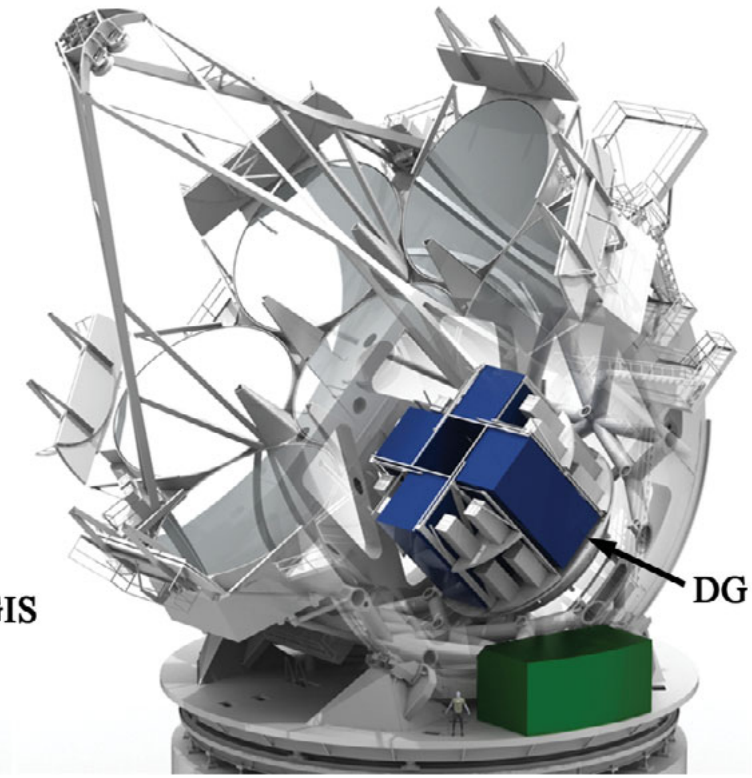
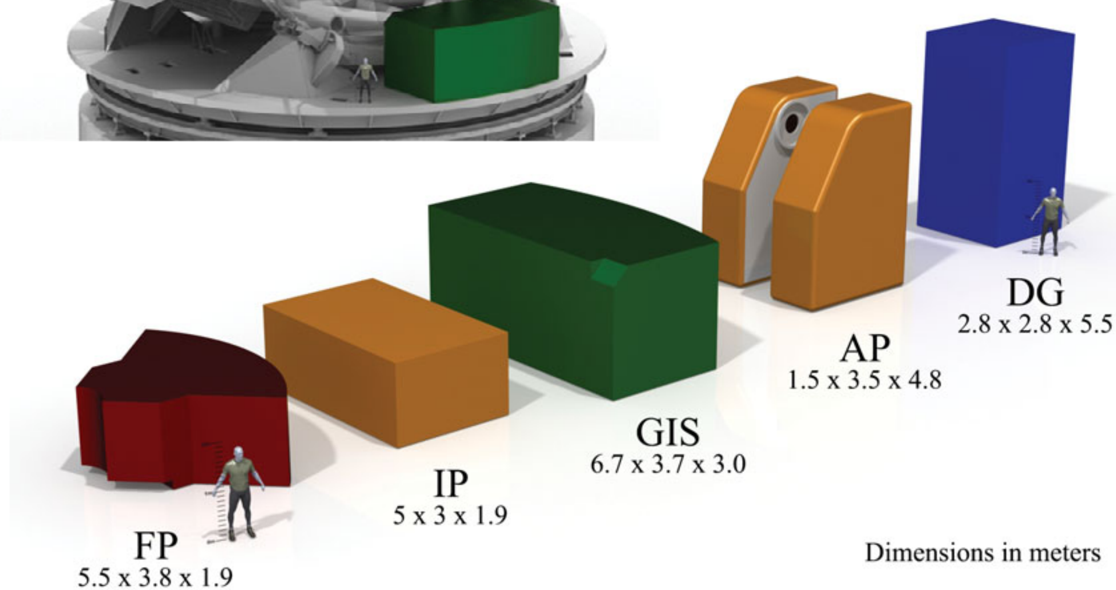


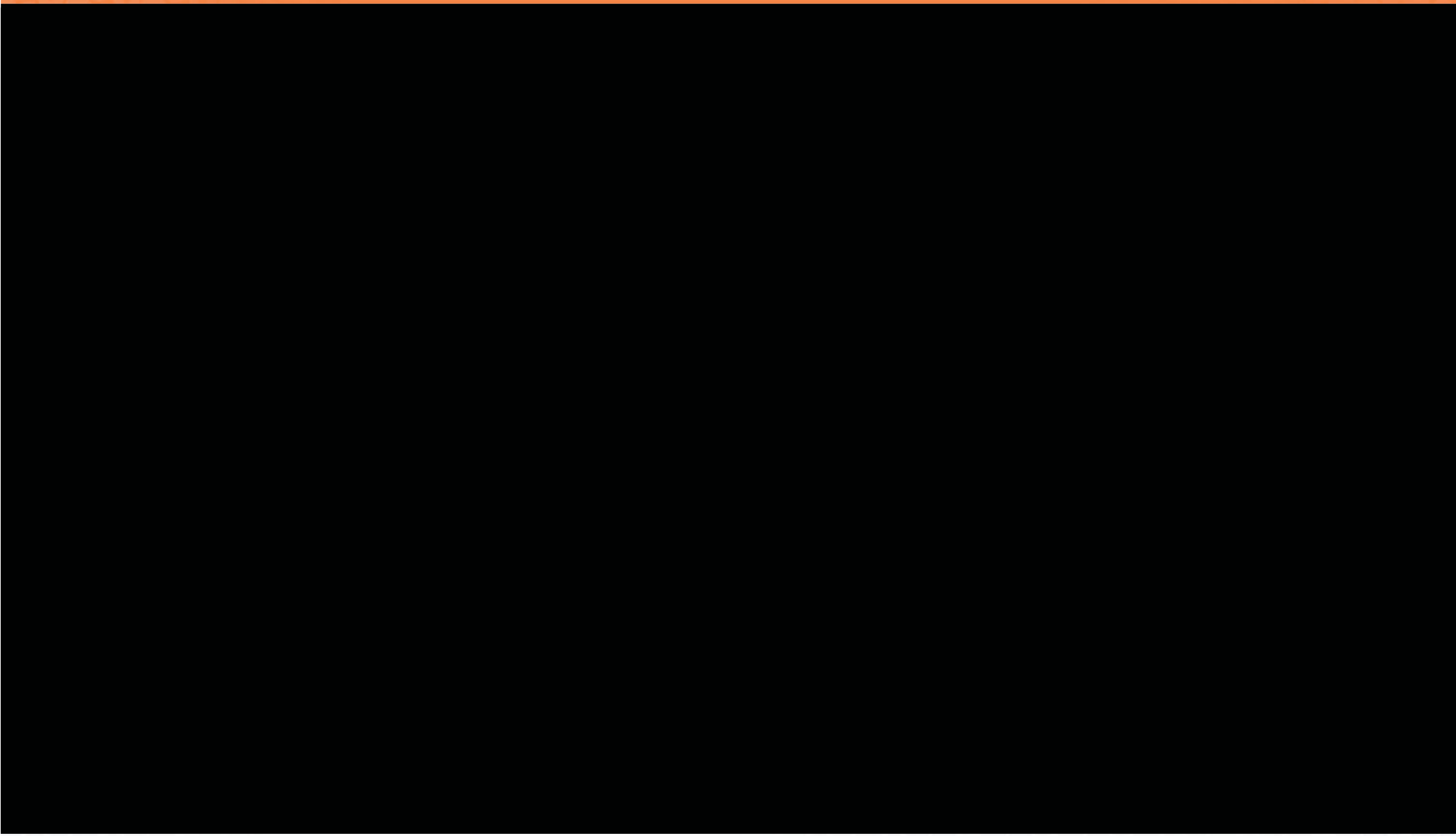


10 mounted instruments

- Folded Port (FP)
- Instrument Platform (IP)
- Gravity Invariant Station (GIS)
- Auxiliary Port (AP)
- Direct Gregorian (DG)



GMT tour:

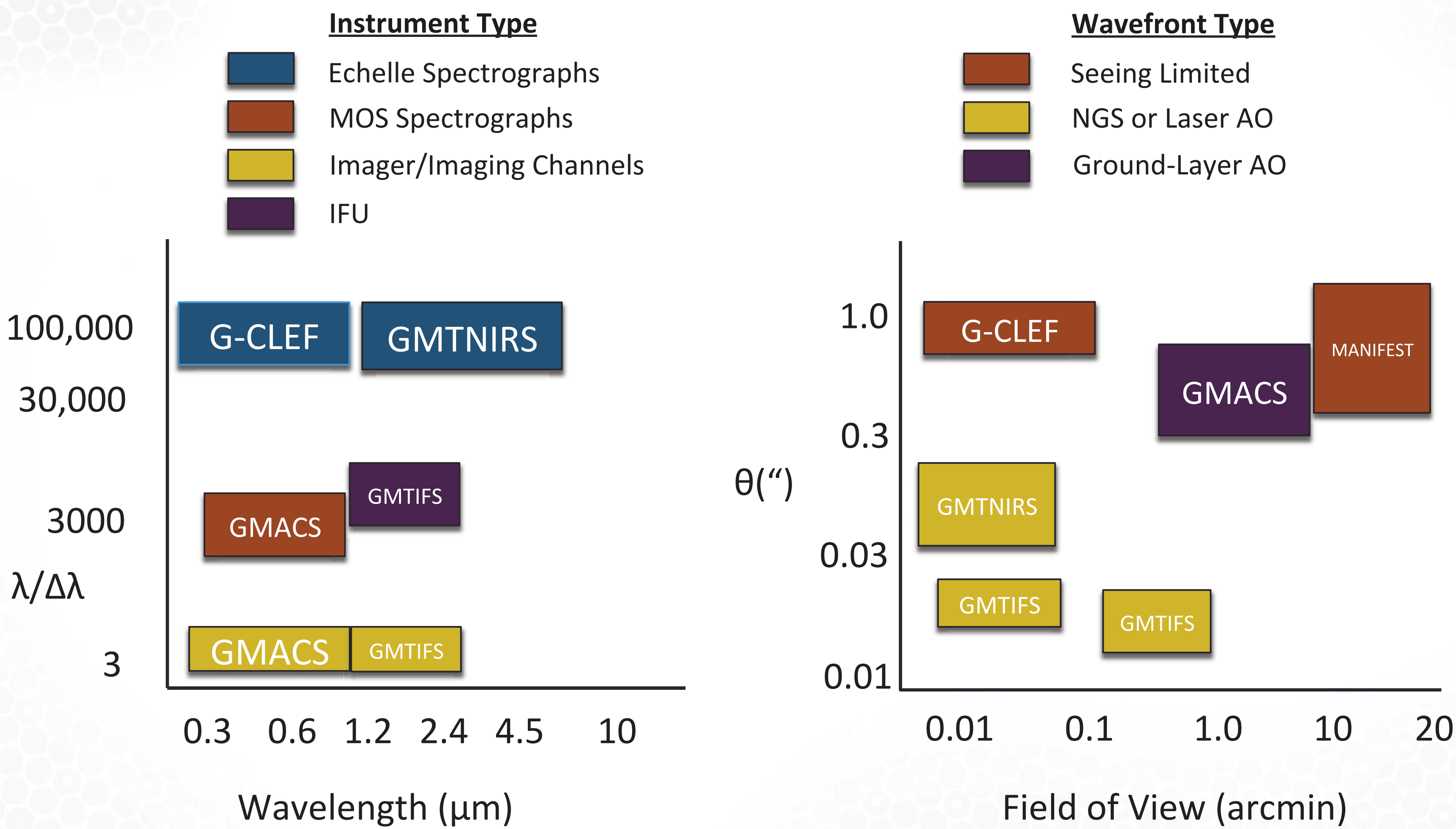


Topics:

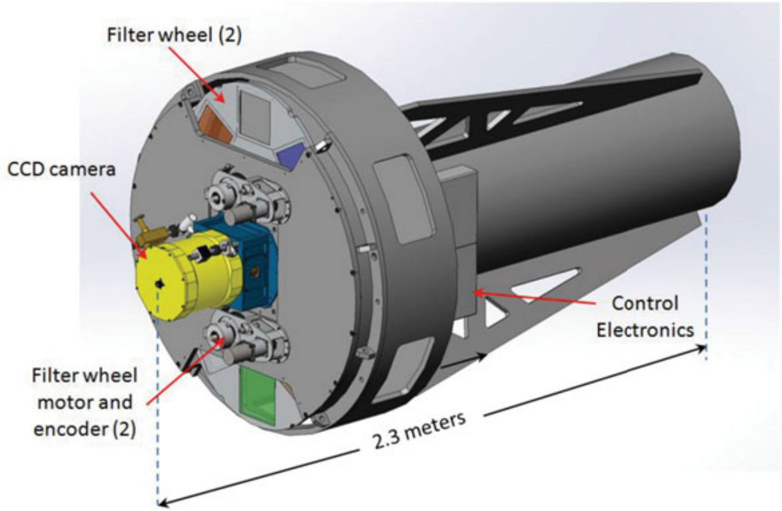
- Motivation
  - History
  - Science case for the large telescopes
- Partnership & Site
- Telescope*
- Instruments*
- Enclosure & Site
- Status

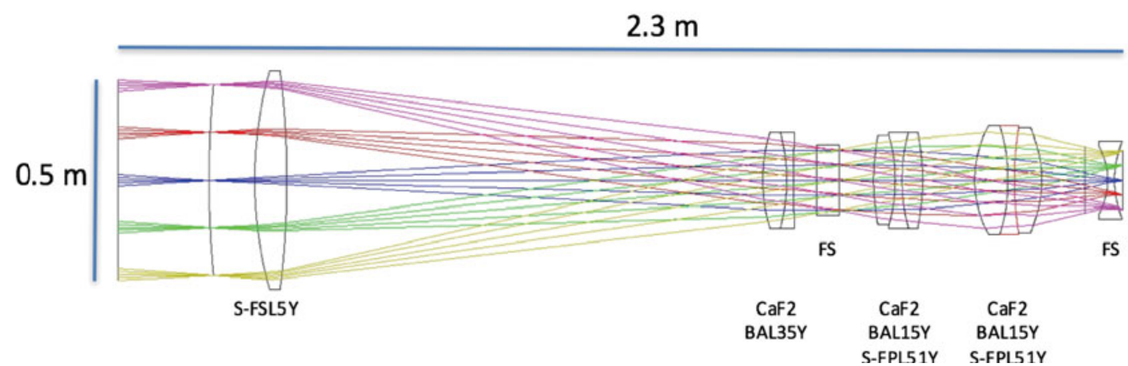
* Key characteristics & how they enable science

Science Instrument Parameter Space



First instrument: Commissioning Camera, Imager





Commissioning Camera
PI: J. Crane (Carnegie)

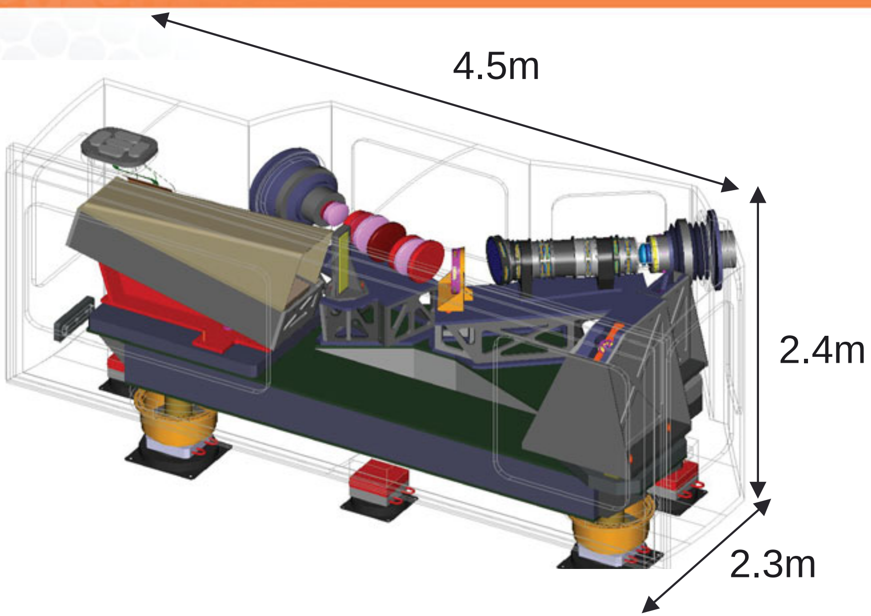
Engineering first light:

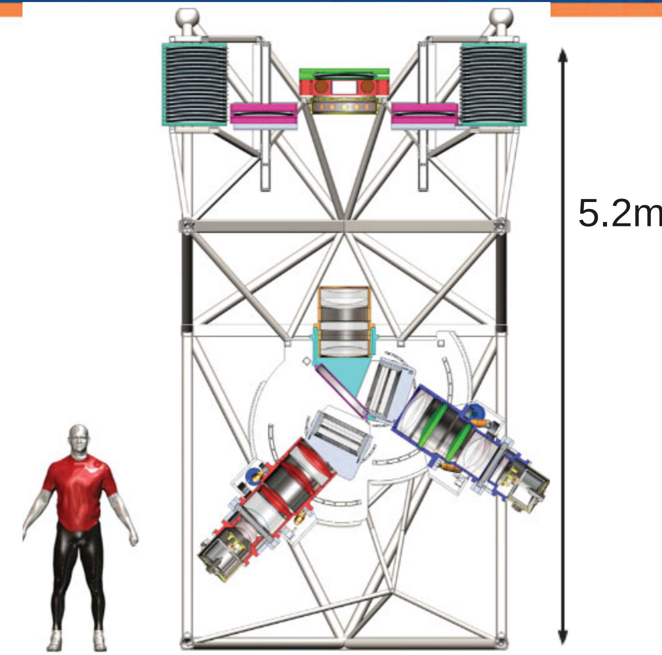
- Alignment & image quality, 6x6 arcmin field of view
- Simple, low cost, fast development cycle

Early Science: Narrow- and Wide-band imaging (10 filter slots)

- Stellar populations in nearby clusters and galaxies
- Nearby and distant emission line object studies (e.g., Narrow-Band)

Natural Seeing / GLAO Optical Spectrographs





G-CLEF
PI: Andrew Szentgyorgyi, CfA/SAO

Stabilized, fiber-fed, dual channel echelle

- R = $\lambda/\Delta\lambda$ =19,000 – 35,000 – 108,000
- Velocity accuracy: < 50 cm/s per observation

- **Abundances:** Planetary atmospheres, stars, transients, QSOs, absorption line systems
- **Dynamics:** planets, clusters, dwarf galaxies
- **Precision Radial Velocities:** exoplanets (<10 cm/s)

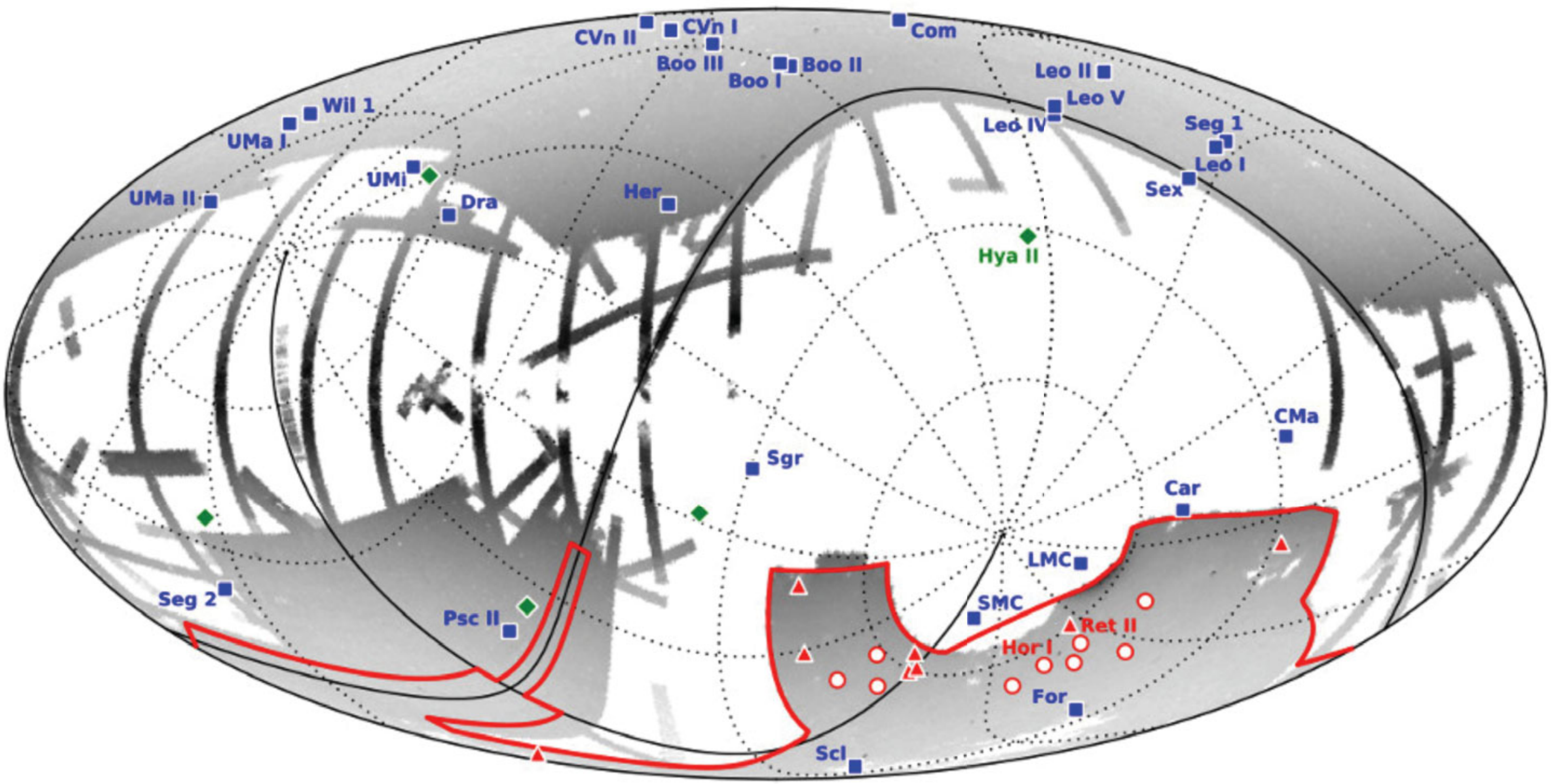
GMACS
PI: Darren DePoy, Texas A&M

Multi-object, slit-fed, red/blue channels

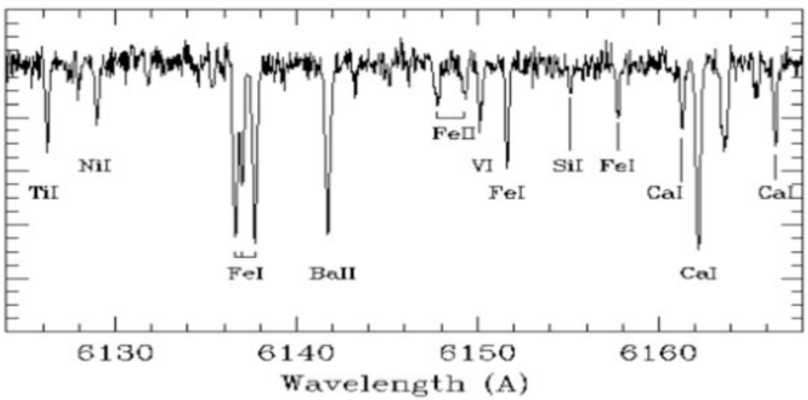
- R = $\lambda/\Delta\lambda$ = 1,000 – 6,000
- 7.5' diameter FoV spectroscopy / imager

- **Abundances:** stellar pops, galaxies, ISM, IGM, exoplanet atmospheres
- **Dynamics:** galaxies & clusters, Lyα systems, stellar systems

G-CLEF:
Chemical Enrichment & Dwarf Galaxies



G-CLEF:
Chemical Enrichment & Dwarf Galaxies



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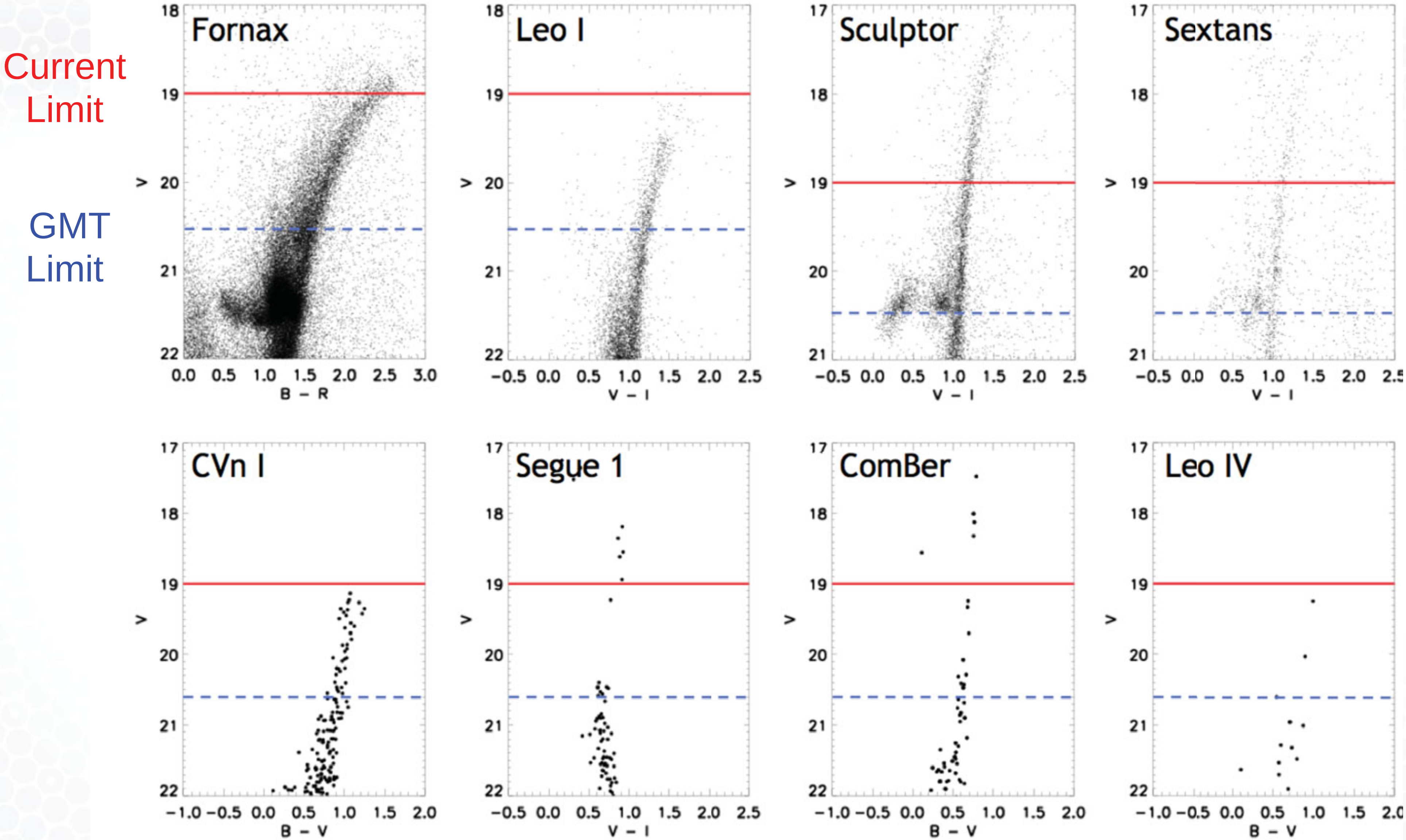
Chemical Enrichment & Dwarf Galaxies

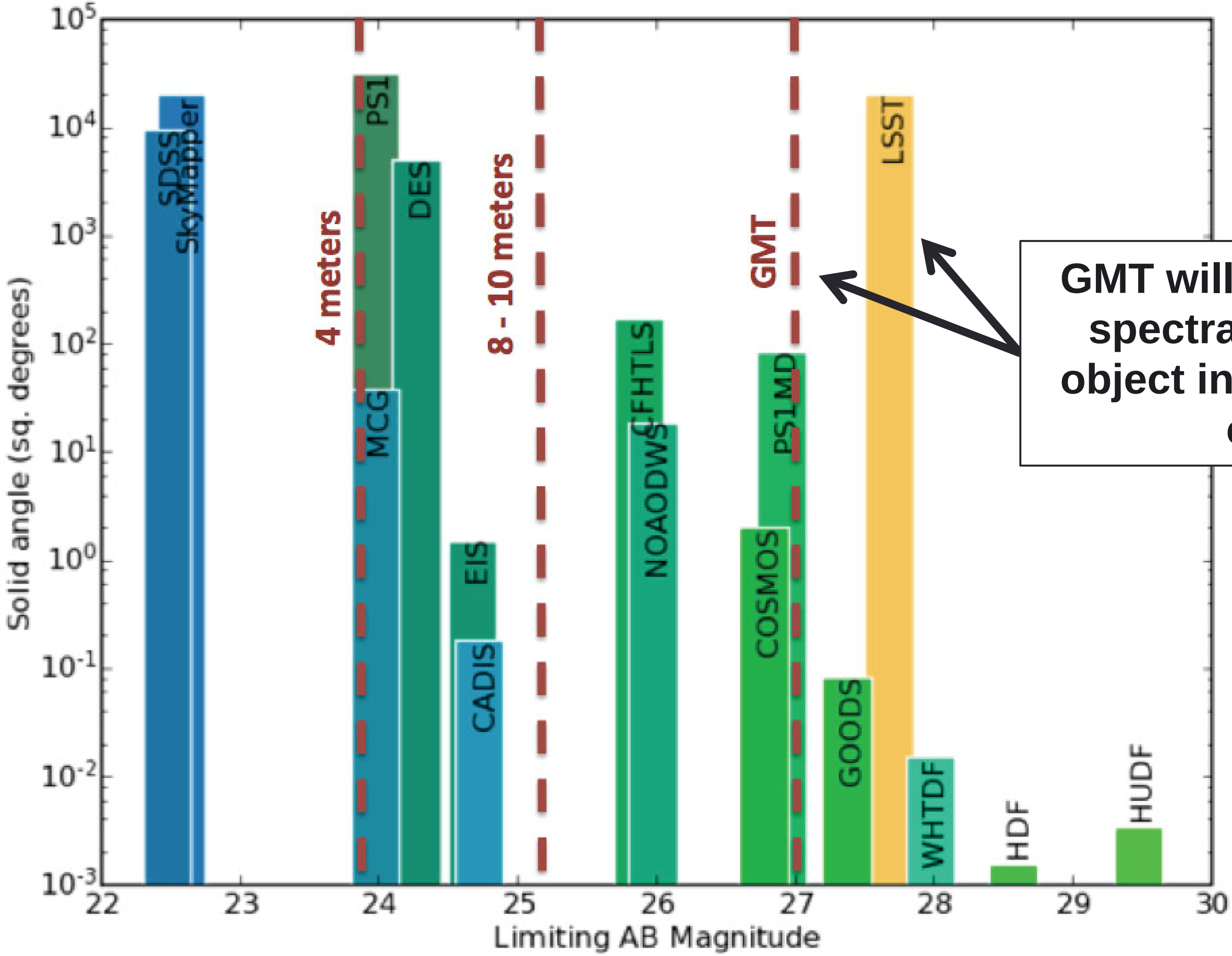


GMACS: **galaxy**, stars, planets

GMT

GMT, 8m, 4m spectroscopic limits (20hrs) at ~0.8µm

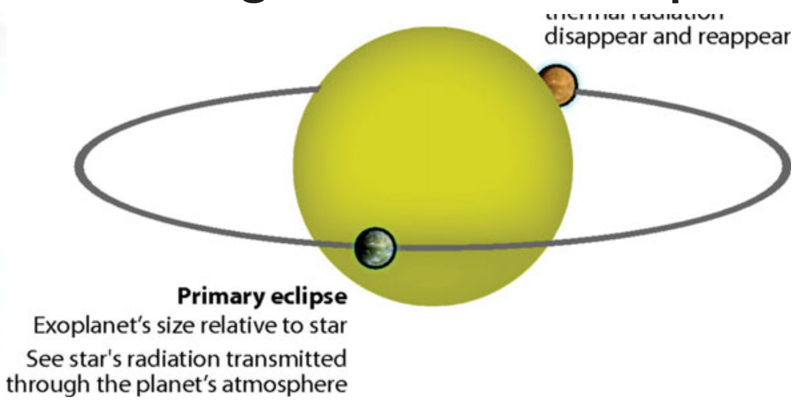
5σ detection limits for imaging surveys

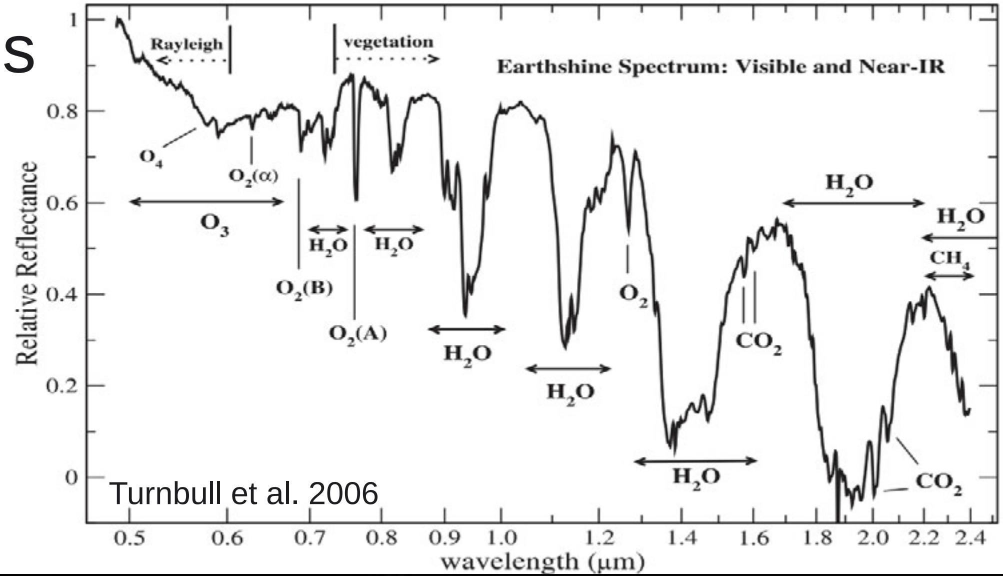


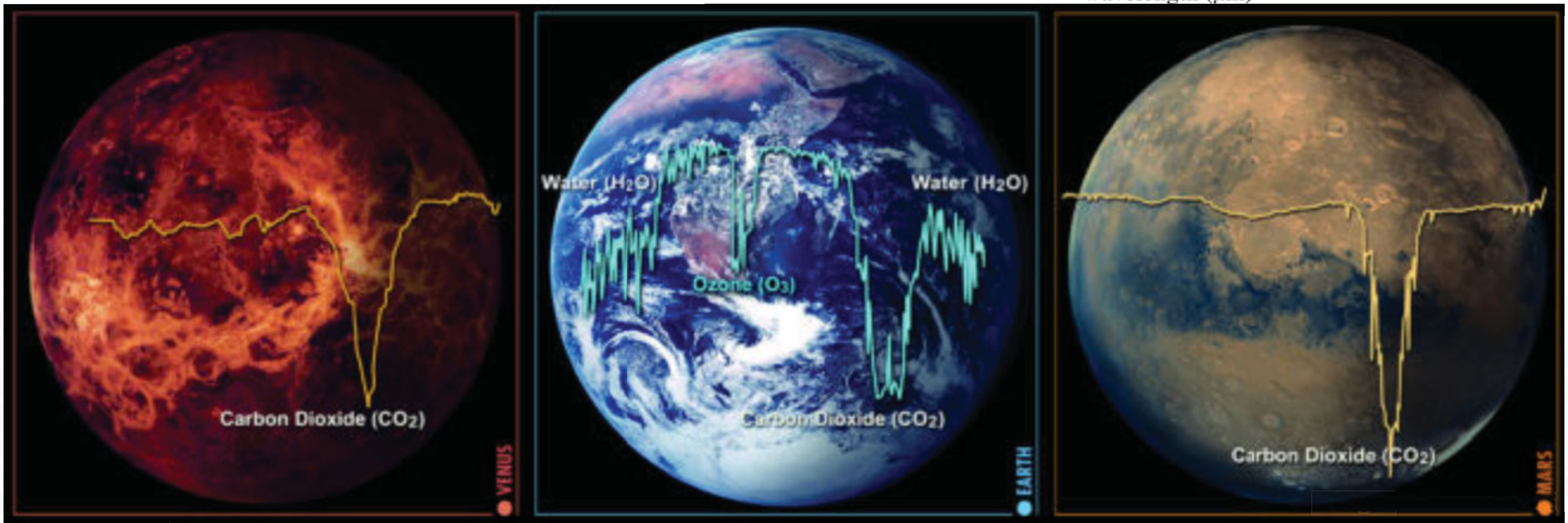
GMT will be able to take spectra of nearly any object in the LSST deep catalog

GMACS: galaxy, stars, **planets**

Detecting life — atmospheres

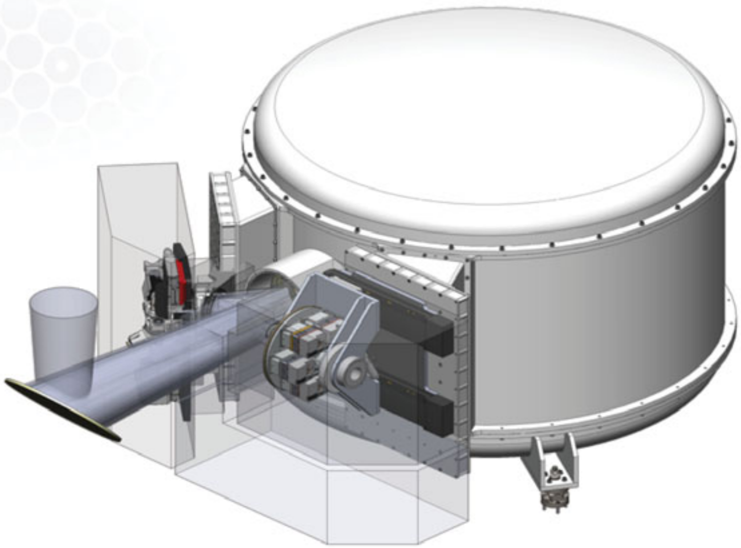


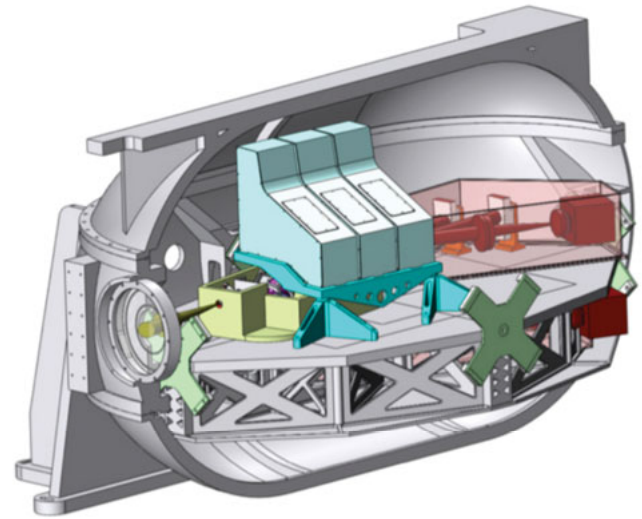




AO-Fed, near- and mid-IR Spectrographs

GMT





GMTIFS

PI: Rob Sharp, Australia National Univ.

Slit & IFU spectrograph & imager (0.3” - 20x20”)

- λ = yJHK
- R = $\lambda/\Delta\lambda$ = 5,000 or 10,000
- Pixel scales: 6, 12, 25, or 50 mas

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

GMTNIRS

PI: Dan Jaffe, UTexas, Austin

High resolution, high throughput IR echelle

- λ = JHKLM (simultaneously!)
- R = $\lambda/\Delta\lambda$ = 50,000 (JHK) – 100,000(LM)
- Efficiency: x10,000 gain over current best

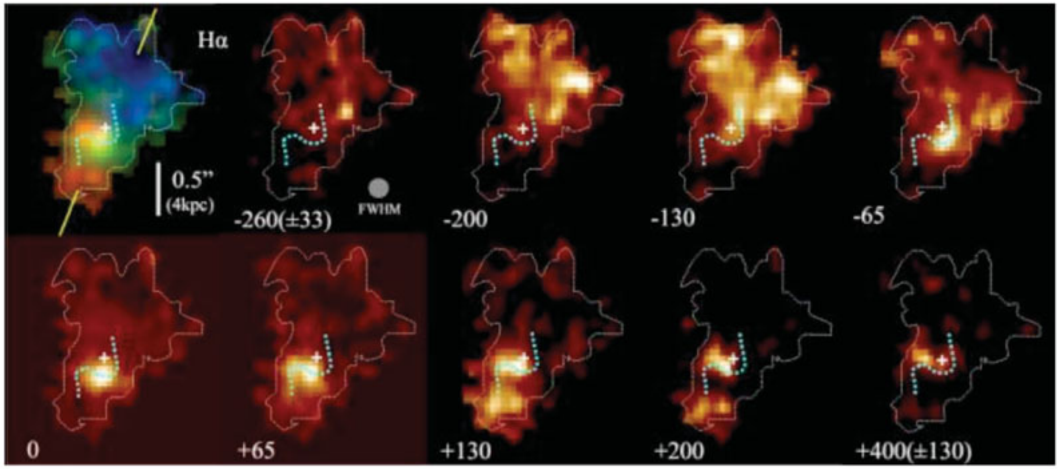
- **Composition of stars & nebulae**
- **Galaxy chemical evolution history**
- **Exoplanet structure and atmospheres**
- **Star and planet formation**

Galaxy assembly, evolution, & chemistry

Targets: M* galaxies at z~2, peak galaxy formation

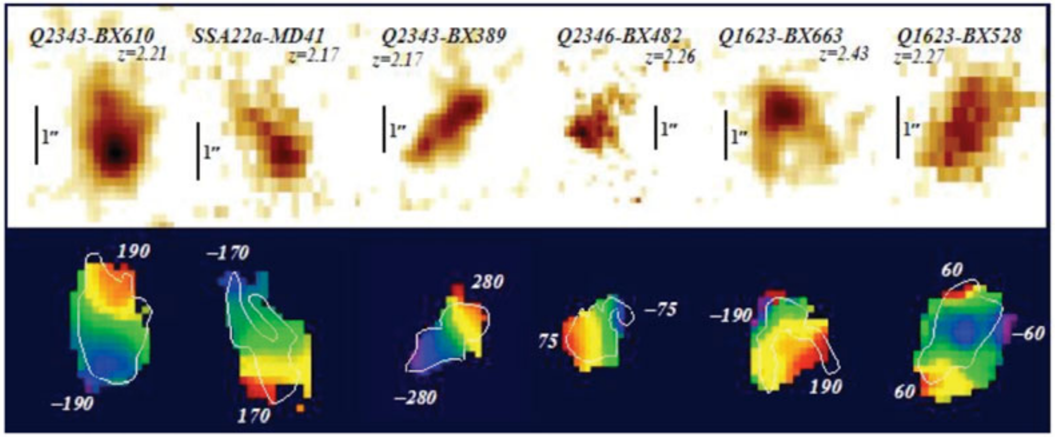
Method: Velocity channel maps (IFU spectroscopy)

VLT+SINFONI, with AO
(Genzel et al.)



5L*

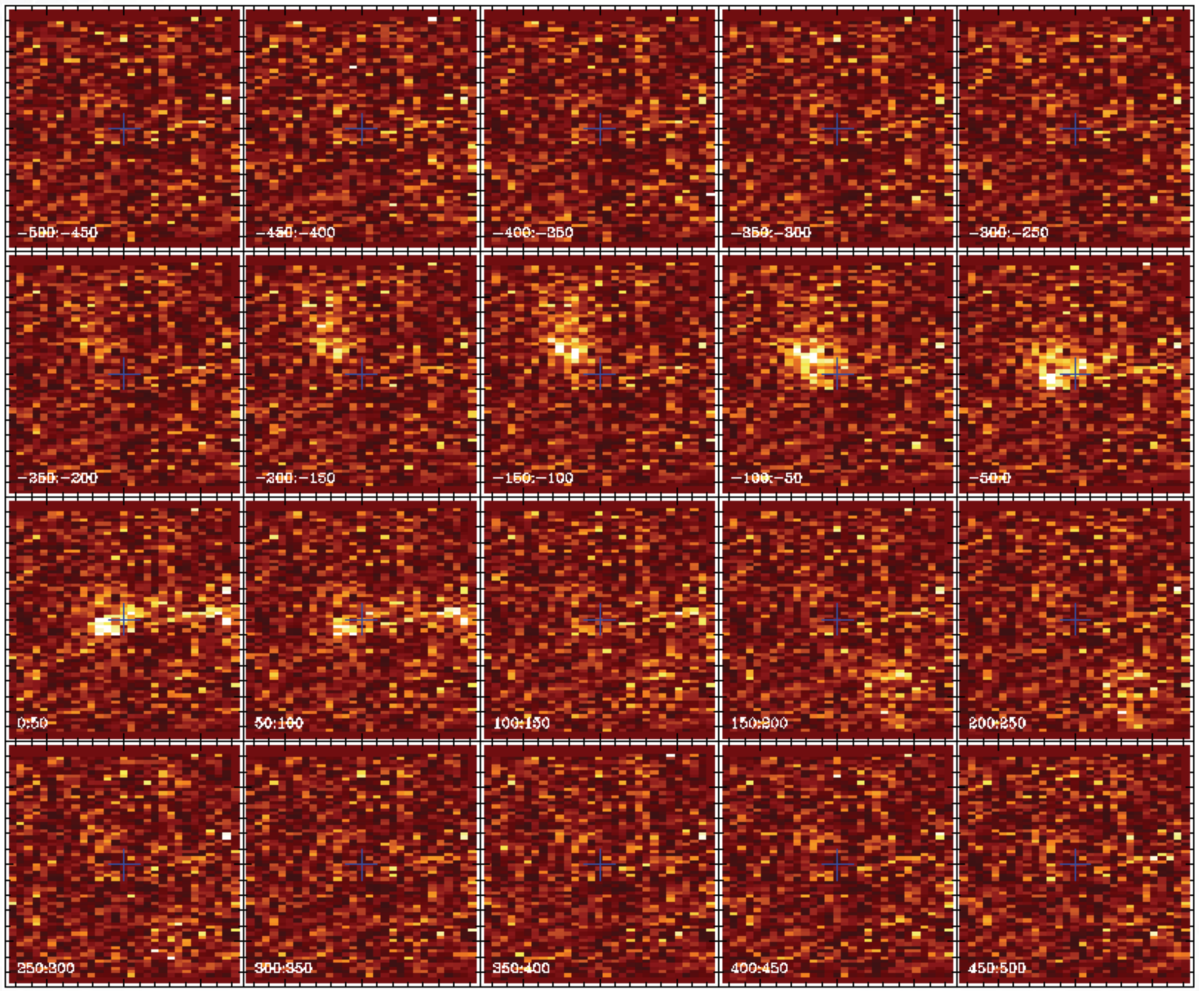
VLT+SINFONI, w/o AO
(Förster-Schreiber et al.)



Only massive galaxies are within detection limits of 8m telescopes

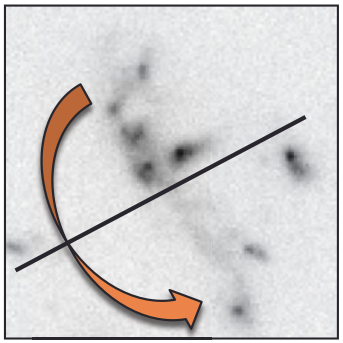
Galaxy assembly, evolution, & chemistry

Milky Way size galaxy, 10 hr integration

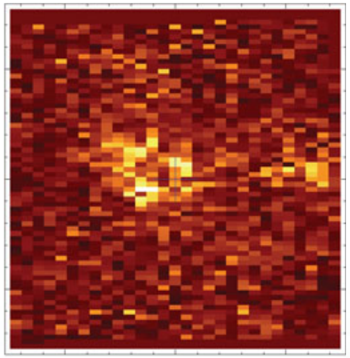


Simulation: Gemini 8m IFU Spectrograph

HUDF - i



NIFS - Sum

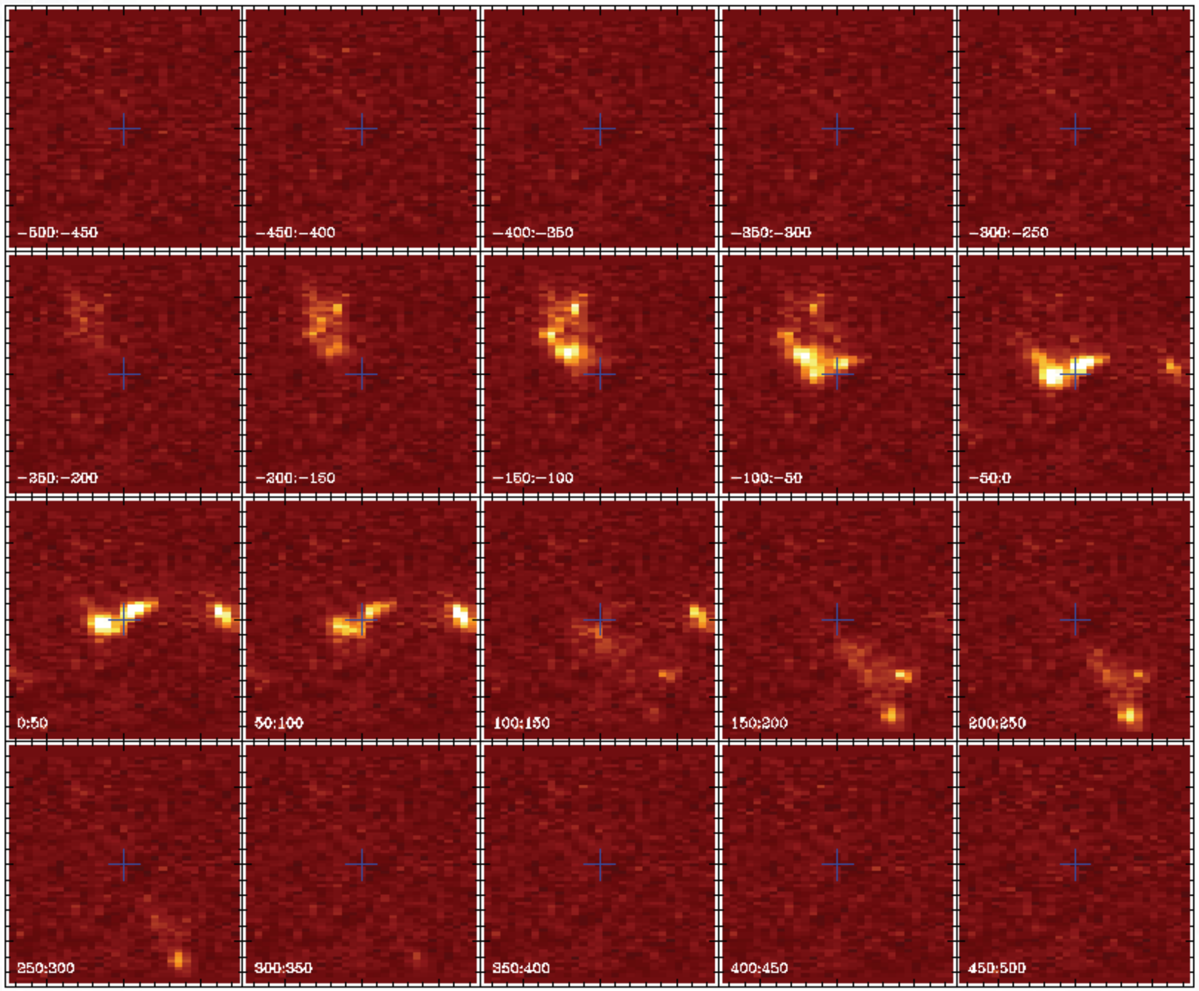


Clump cluster

Galaxy assembly, evolution, & chemistry

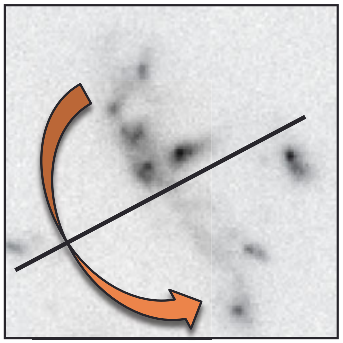
GMT

Milky Way size galaxy, 10 hr integration



Simulation: GMT simulation

HUDF - i



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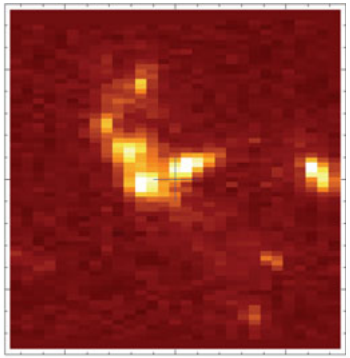
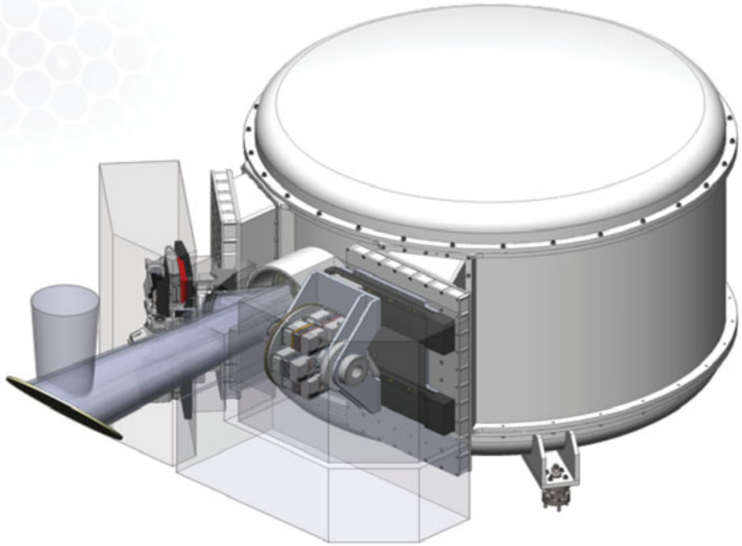
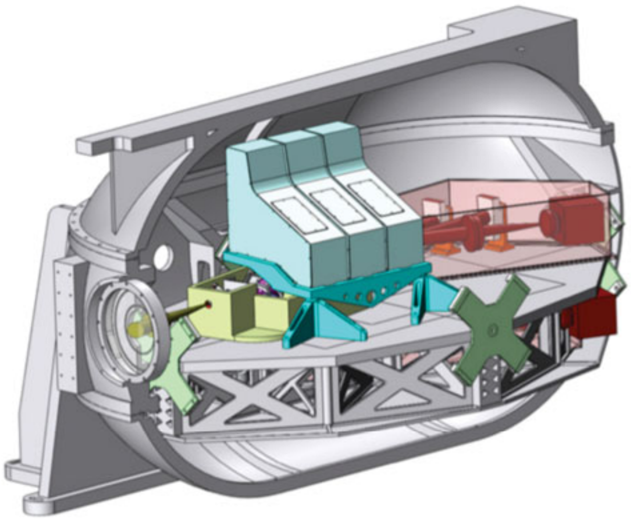


Clump cluster

AO-Fed, near- and mid-IR Spectrographs





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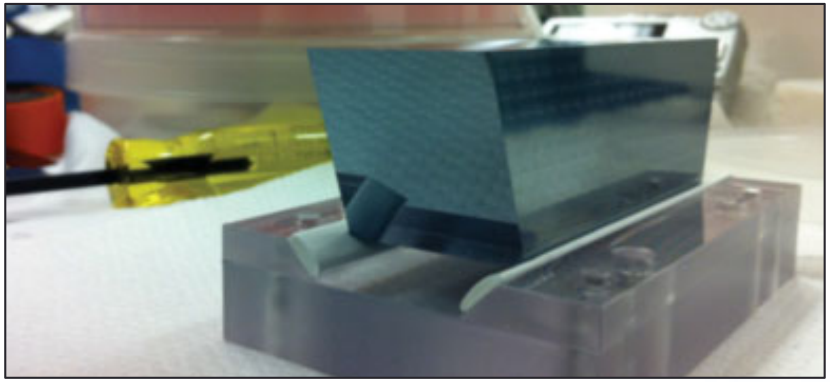
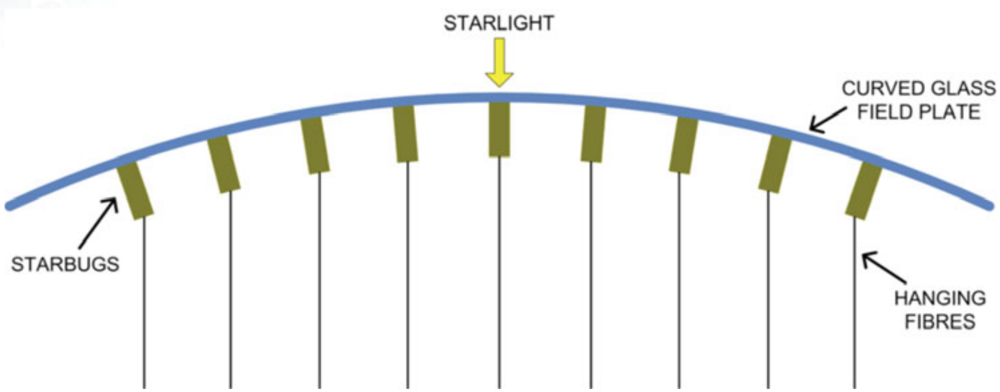


Silicon immersion gratings + Bigger telescope + 1 exposure vs 200

= 5,000-20,000 times more efficient

Facility robotic fiber feed to multiple instruments:



MANIFEST

Jon Lawrence (AAO) / Matthew Colless (ANU)

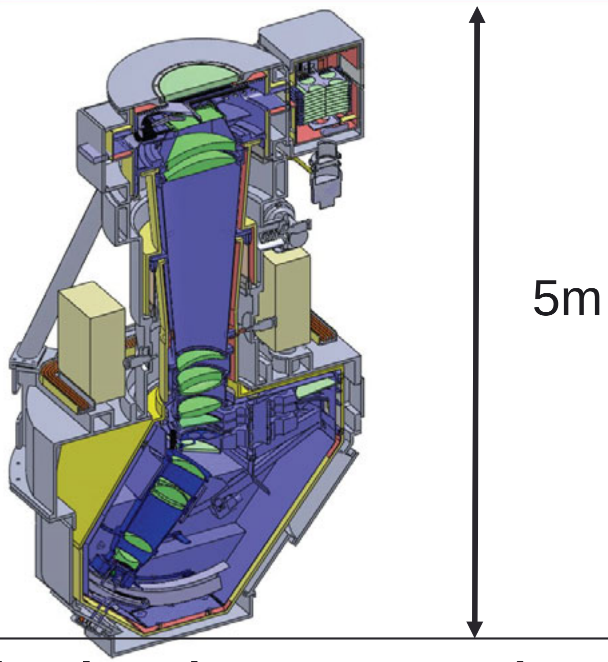
Characteristics:

- 2-3 min configuration time
- Single fibers, IFUs, Image slicers
- Extendable to thousands of fibers

G-CLEF
GMACS
Future IR MOS

- **Extends/Adds multi-object capability over 20’ FoV**
- **Enables very high AΩ survey science (stellar abundances, galaxy surveys)**
- **Allows simultaneous observing with multiple instrument (“parallels”)**

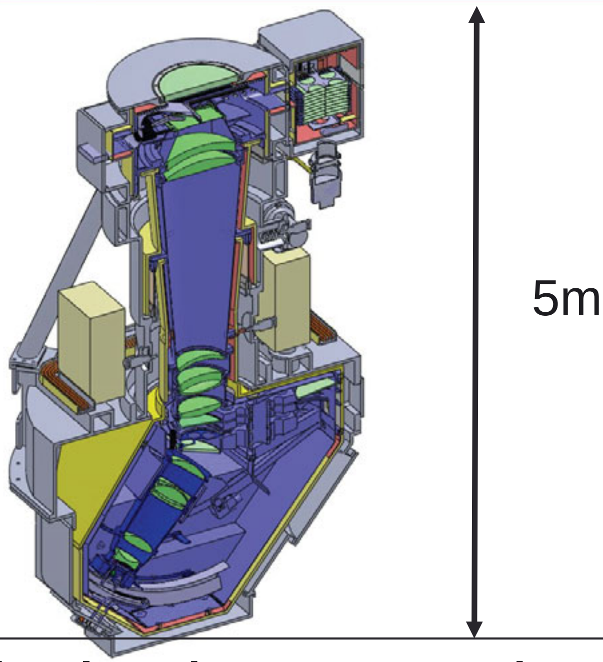
Deferred 1st generation: NIRMOS

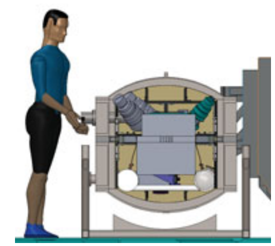


NIRMOS (developed to CoDR, 2011)
PI: Dan Fabricant, CfA/Harvard

Multi-Object, wide field near-IR spectrograph
λ = yJHK
R = $\lambda/\Delta\lambda$ ~ 3,000
Field of view: 6.5’x6.5’
Slit-fed or MANIFEST (J-band)

Addition 1st generation: SuperFIRE





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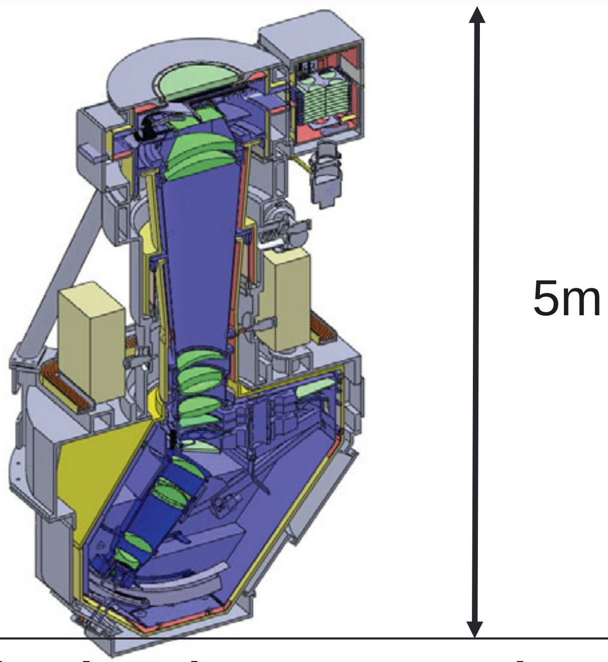
Field of view: 6.5'x6.5'
Slit-fed or MANIFEST (J-band)

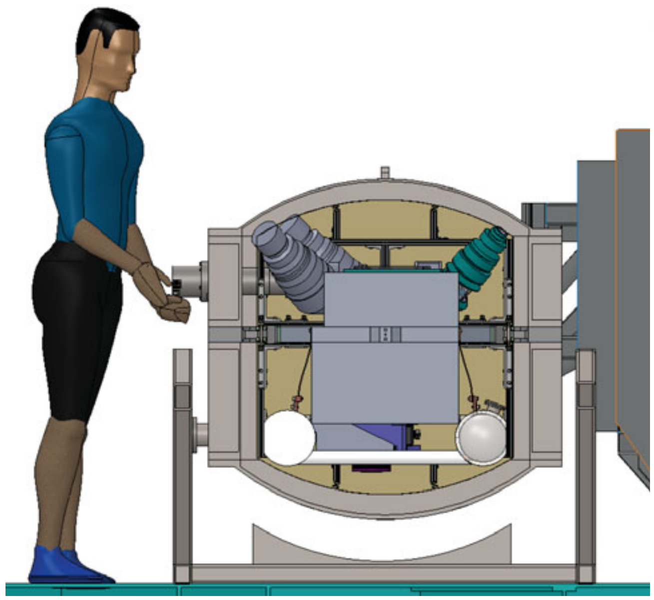
Super FIRE (prelim. studies)
PI: Rob Simcoe, MIT

Single object, near-IR echellette
λ = JHK (simultaneous)
R = $\lambda/\Delta\lambda$ ~ 6,000
Slit fed: 8" slit length
Heritage: FIRE on Magellan

First light targets (z>7), galaxy evolution z~2, Galactic Center, near field cosmology, planets…

Addition 1st generation: SuperFIRE





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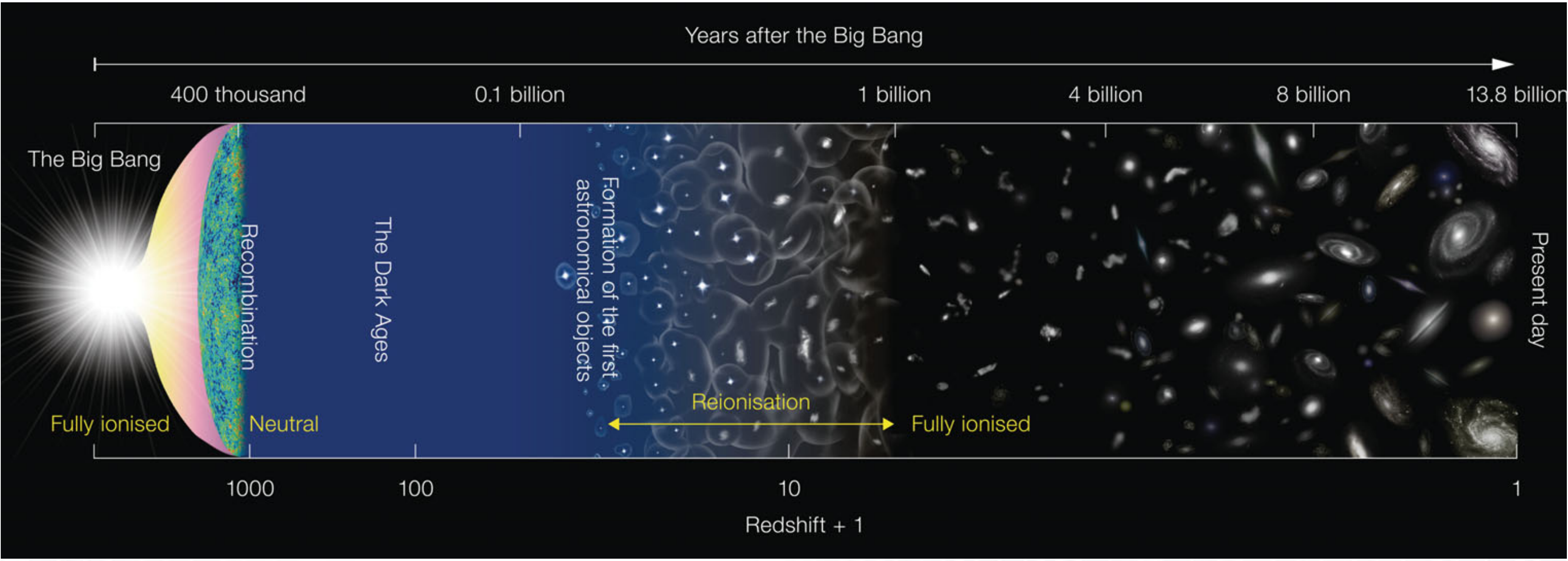
Distant: Formation and Evolution of Galaxies

- When did the first galaxies form?
- When and how did re-ionization begin?
- How do galaxies assemble and evolve throughout cosmic time?
- How do black holes and galaxies co-evolve?



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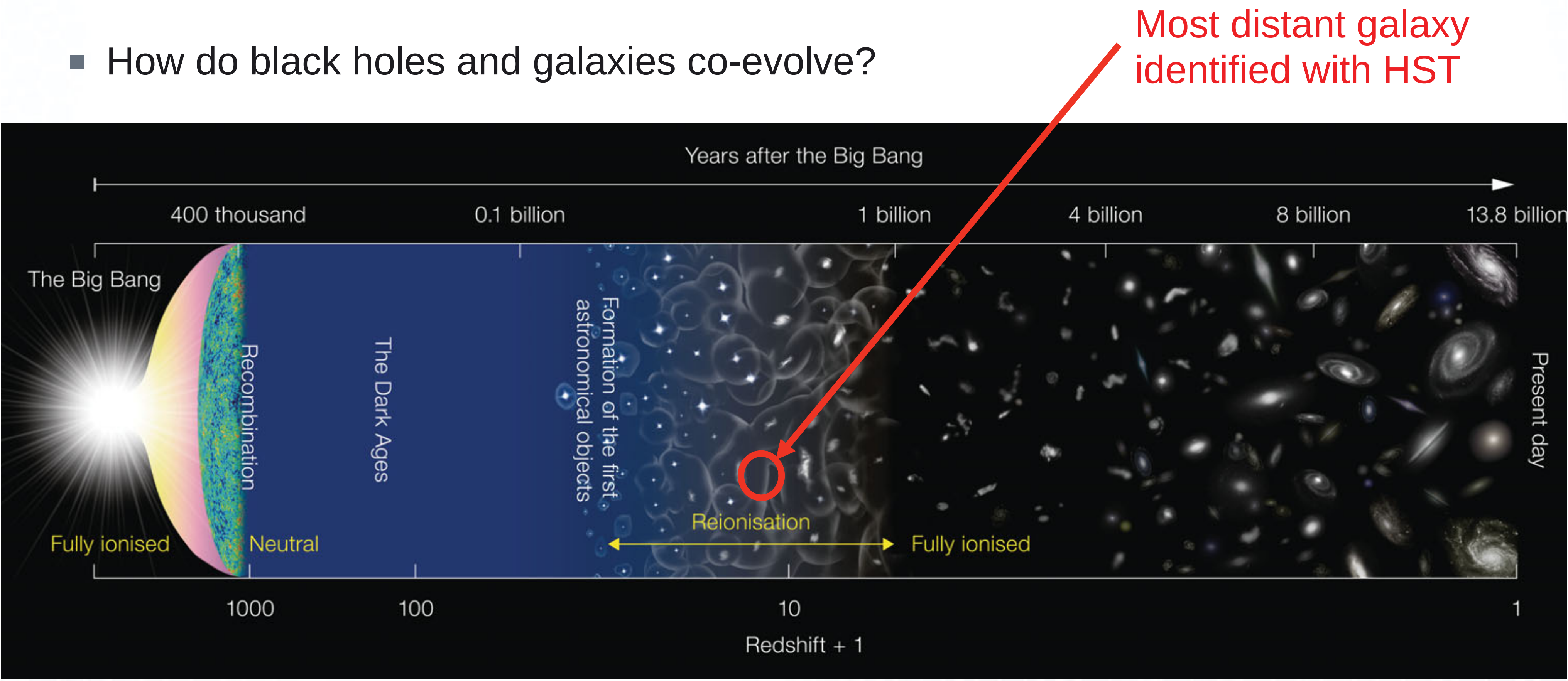
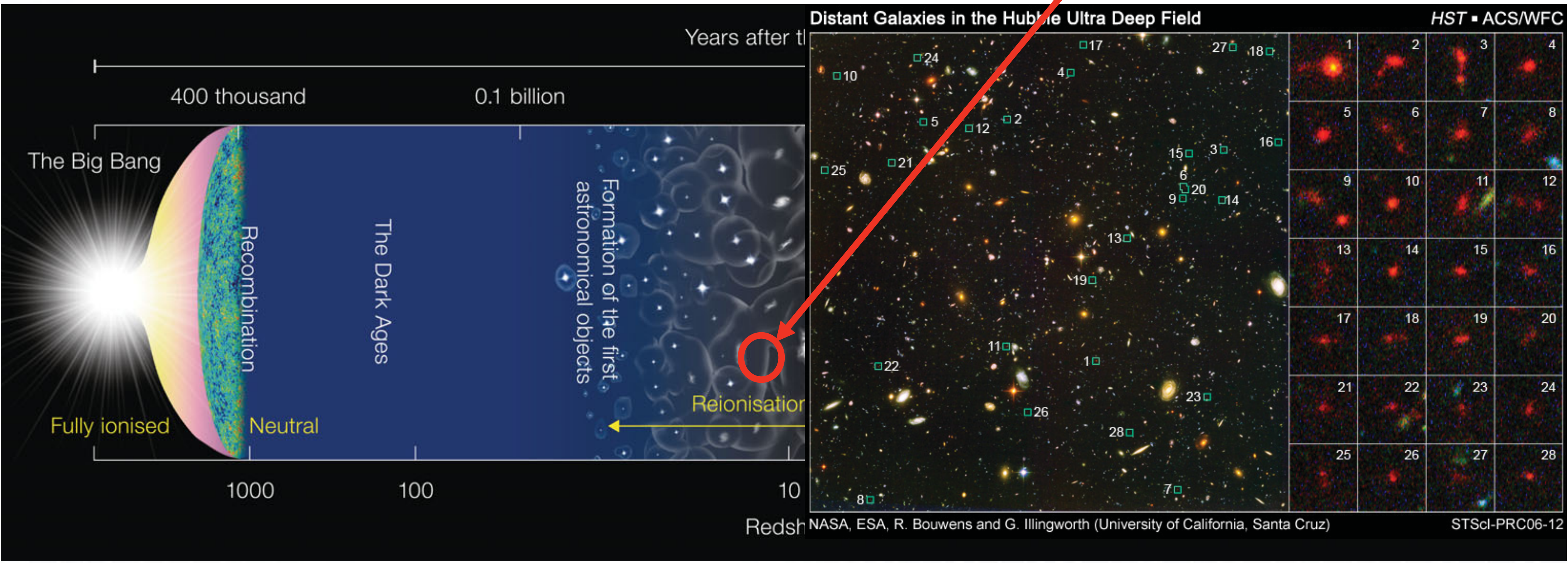


Distant: Formation and Evolution of Galaxies

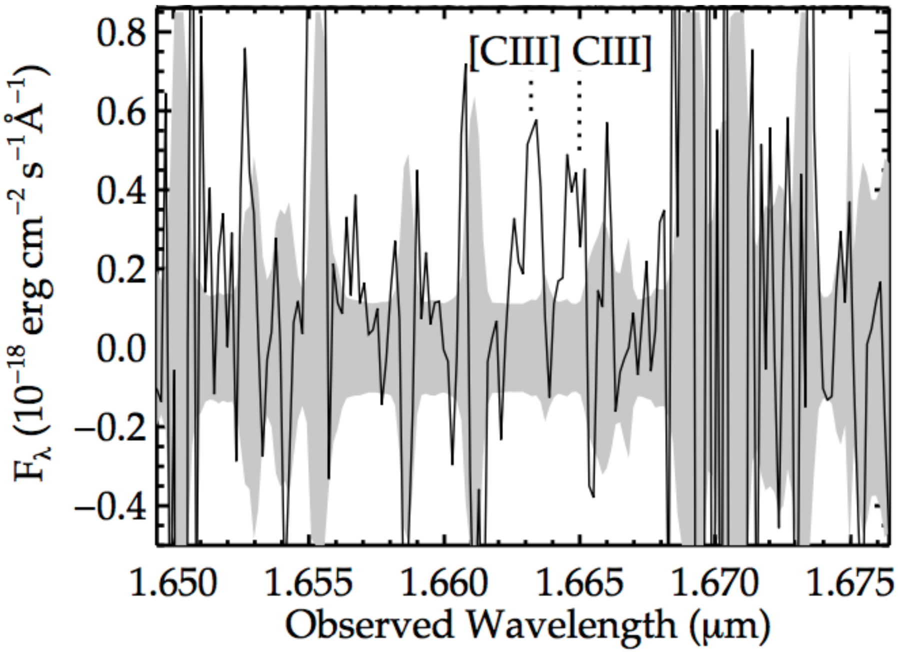
Methods:

- Surveys provide candidate targets — WFIRST satellite!
- Follow-up spectra: distances, chemistry, dynamics (mass, dynamics, content)

Most distant galaxy identified with HST



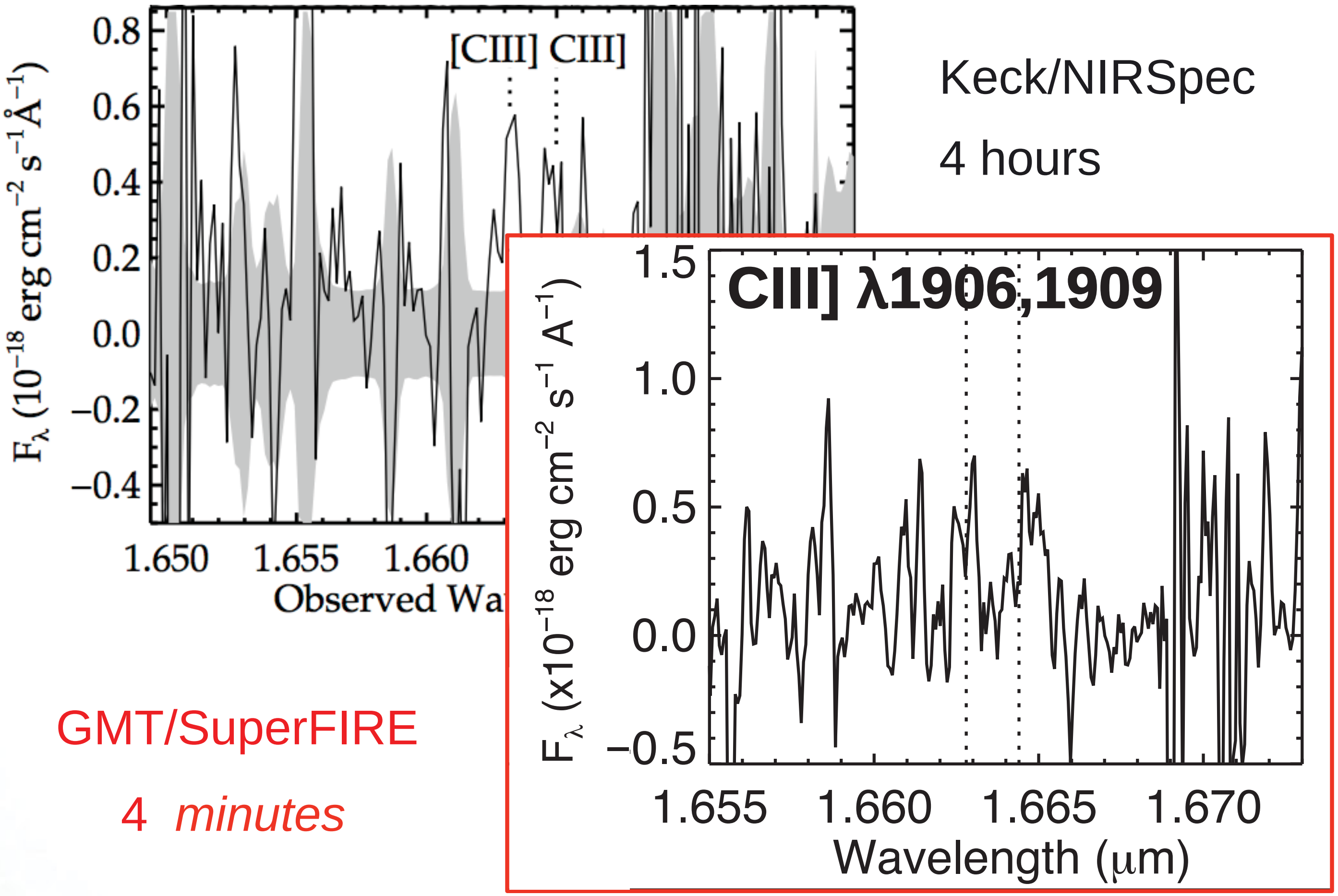
Distant: Formation and Evolution of Galaxies



Keck/NIRSpec

4 hours

Distant: Formation and Evolution of Galaxies



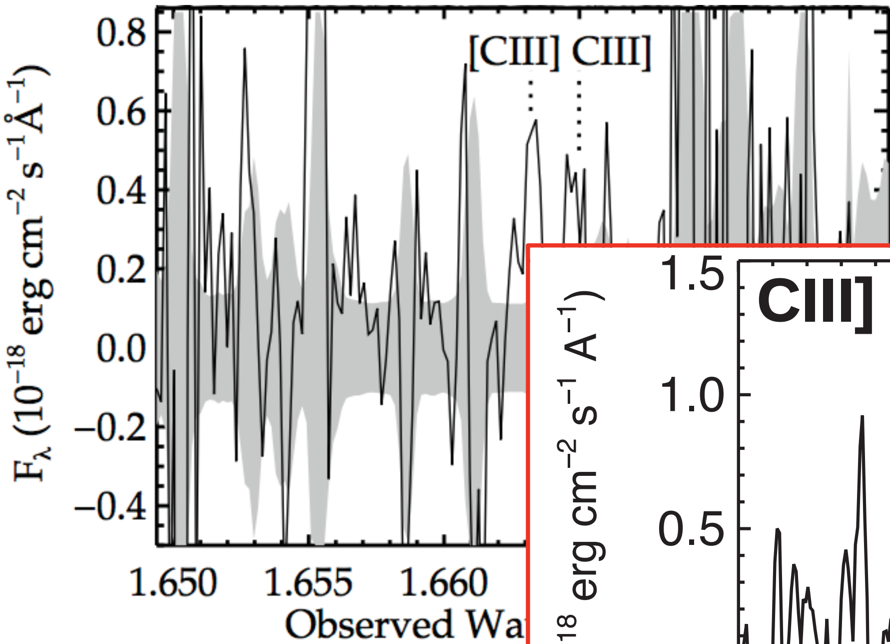
Keck/NIRSpec

4 hours

GMT/SuperFIRE

4 *minutes*

Distant: Formation and Evolution of Galaxies



Keck/NIRSpec

4 hours

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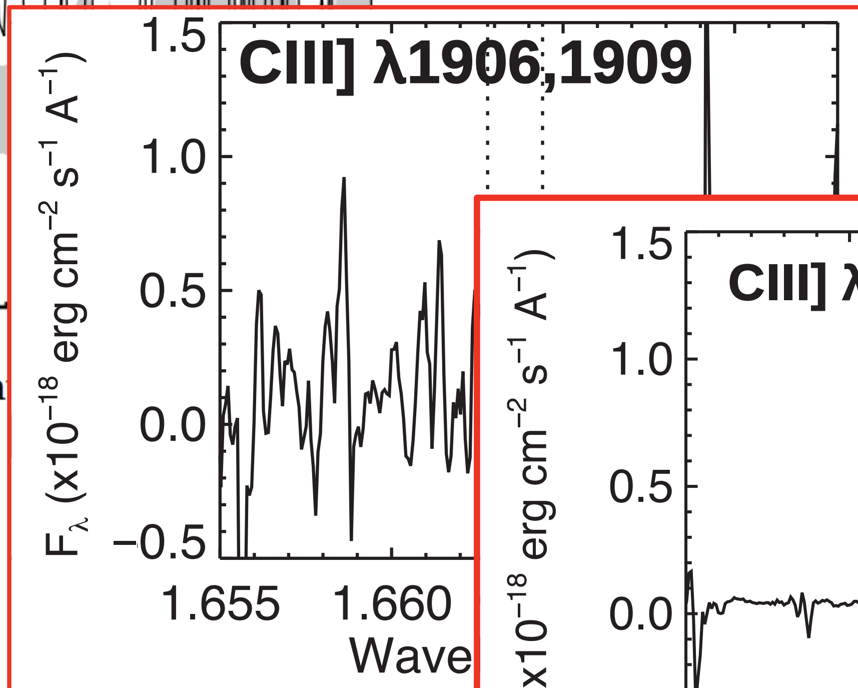
4 minutes



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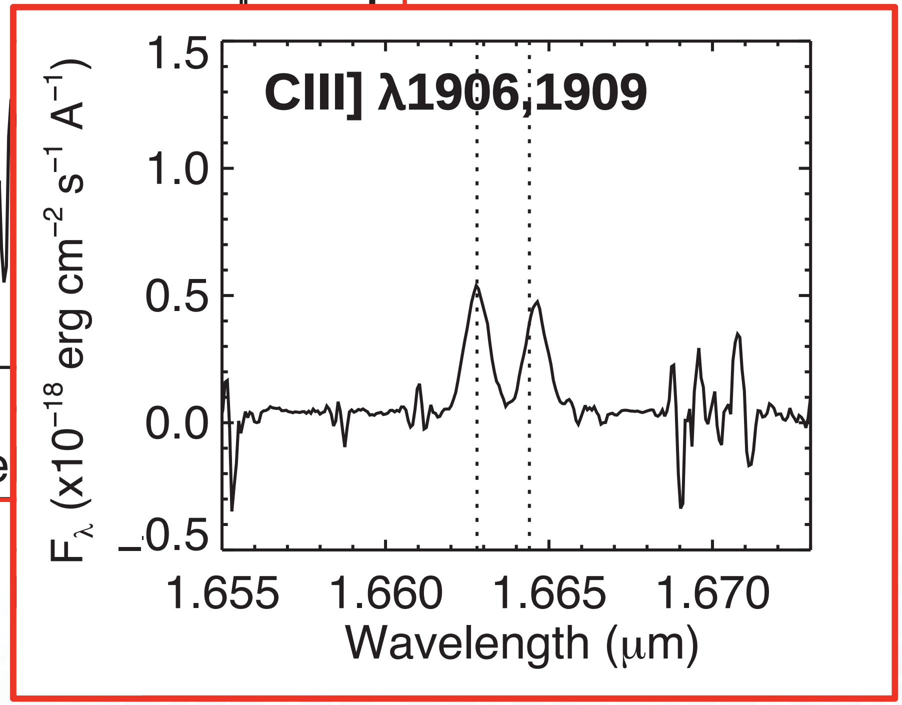
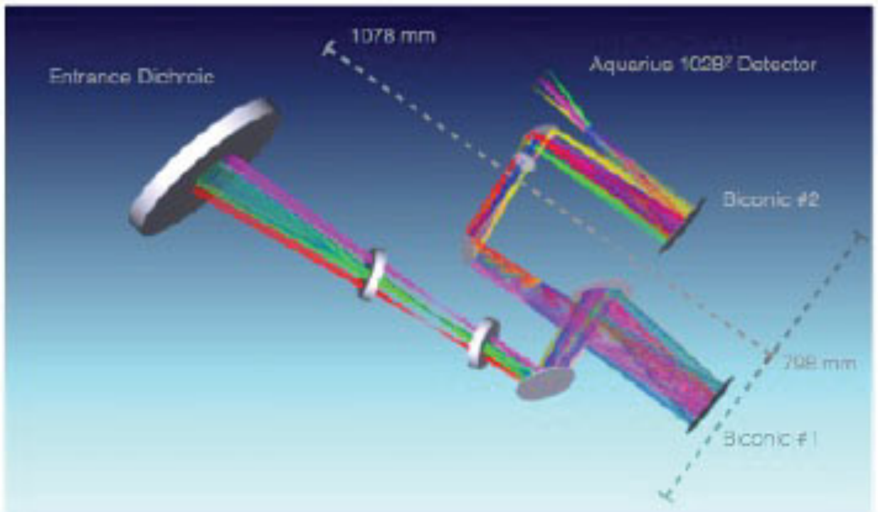
4 hours



Credit: S. Finkelstein (UT), R. Simcoe (MIT)

Deferred 1st generation: TIGER



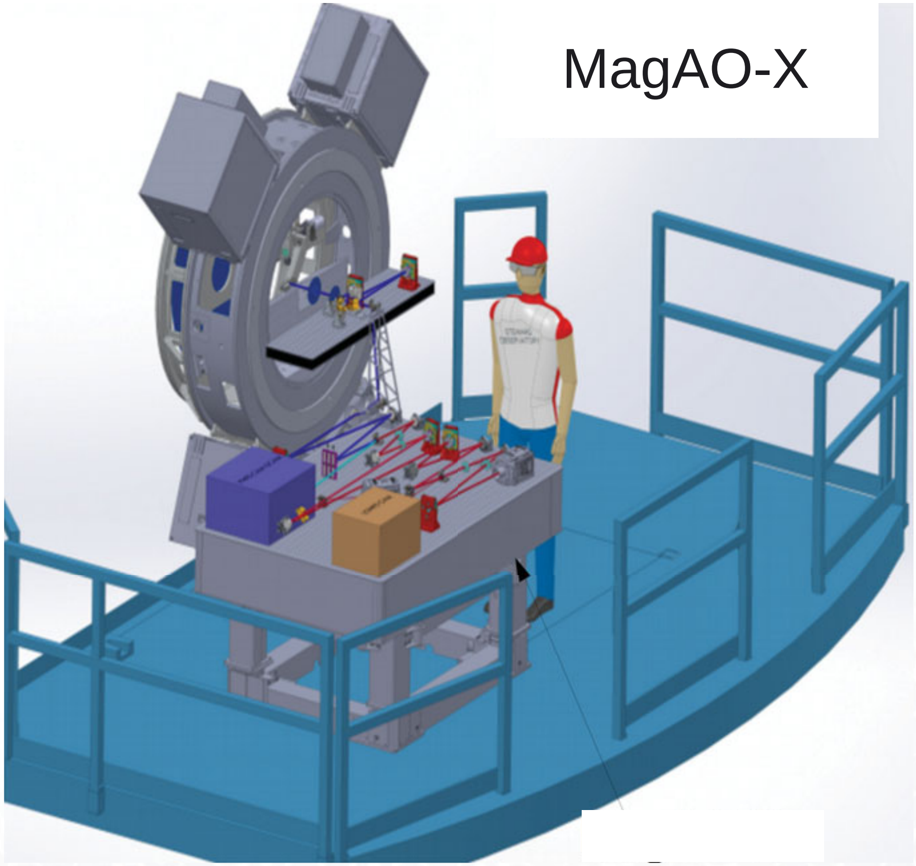
TIGER
Phil Hinz (Univ Arizona)

Dual channel imager and spectrograph
λ = 1.5-5 µm; 7-14 µm
R ~ 300; Spatial ~ 7 mas / pixel
Field of view: 30 arcseconds
Contrast to 10^{-6} in L band @ 3 λ/D

Addition 1st generation: ***before*** the ASMs

G-MagAO-X (Co-Is: Laird Close, Jared Males, UA)

- Technology being developed at Magellan (NSF funded)
- Visible and near-IR Exoplanet Imaging
  - Internal deformable mirrors
  - State of the art coronagraphy



Exoplanet imaging in first year!

Direct imaging:

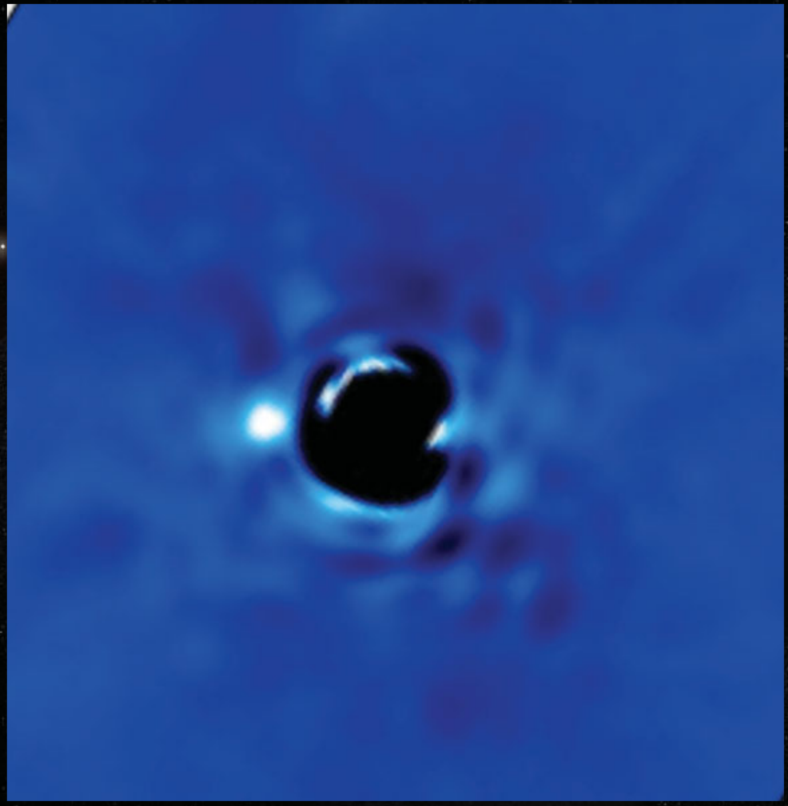
Proxima Centauri b: 0.38 arcsec angular separation

- 8m telescope: 1.2 λ/D … Hard!
- GMT: 3.8 λ/D … Easy!
- Contrast needed: 5,000,000:1

Current capabilities:

Beta Pic: 10 M_{jup}

VLT/AO at 3.5μm
Angular Differential Imaging and apodizing coronagraphy



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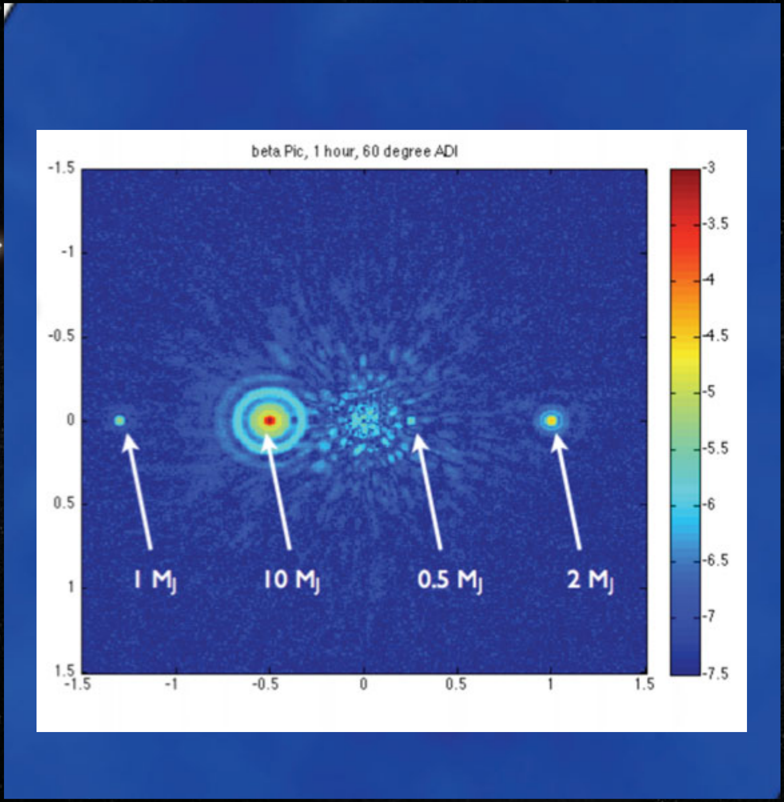
Proxima Centauri b: 0.38 arcsec angular separation

- 8m telescope: 1.2 λ/D … Hard!
- GMT: 3.8 λ/D … Easy!
- Contrast needed: 5,000,000:1

GMT simulation:

1 hr total integration
ADI, apodizing coronagraph

Planets detectable at 0.5-10 M_{Jup}



Topics:

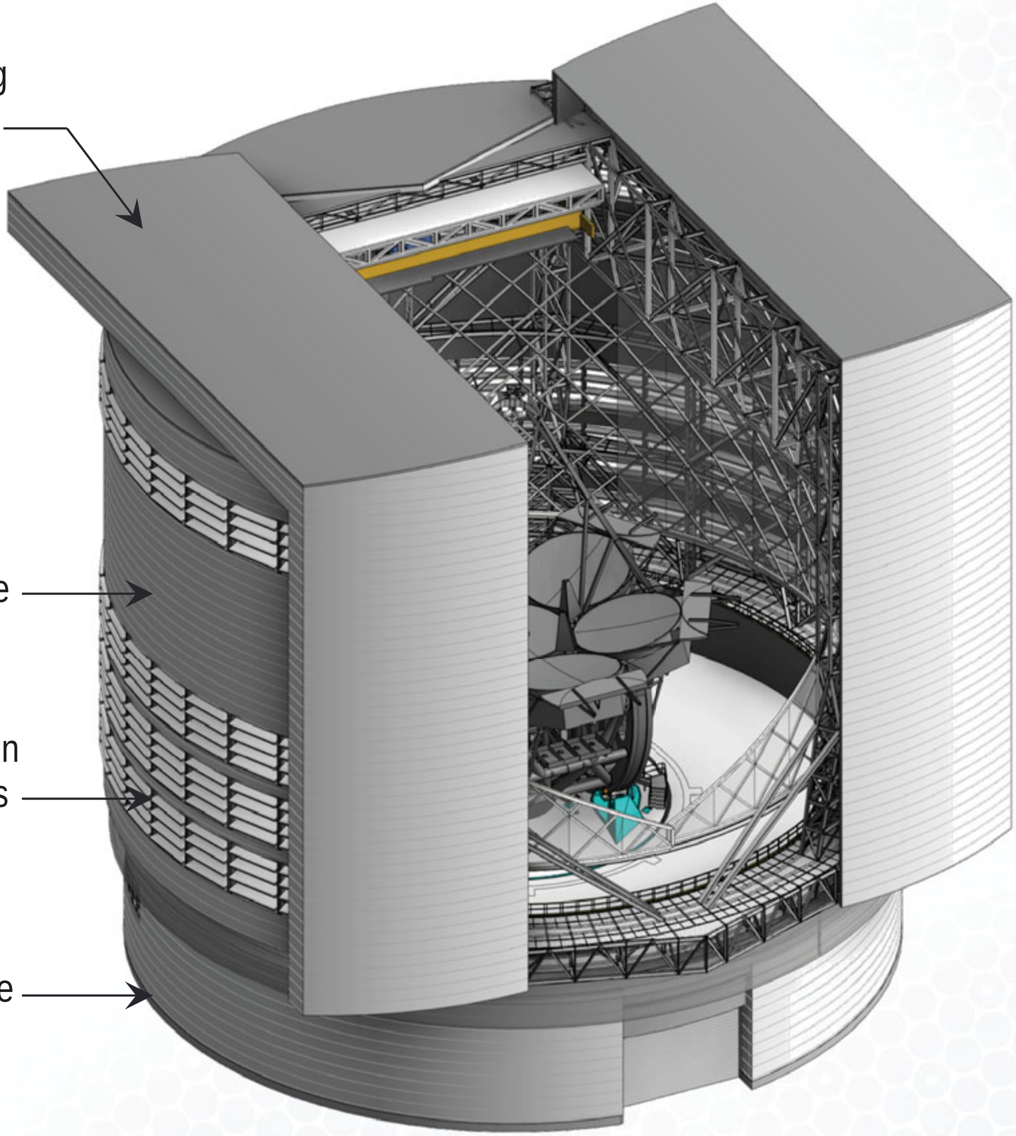
- Motivation
  - History
  - Science case for the large telescopes
- Partnership & Site
- Telescope*
- Instruments*
- Enclosure & Site
- Status

* Key characteristics & how they enable science

Enclosure Development

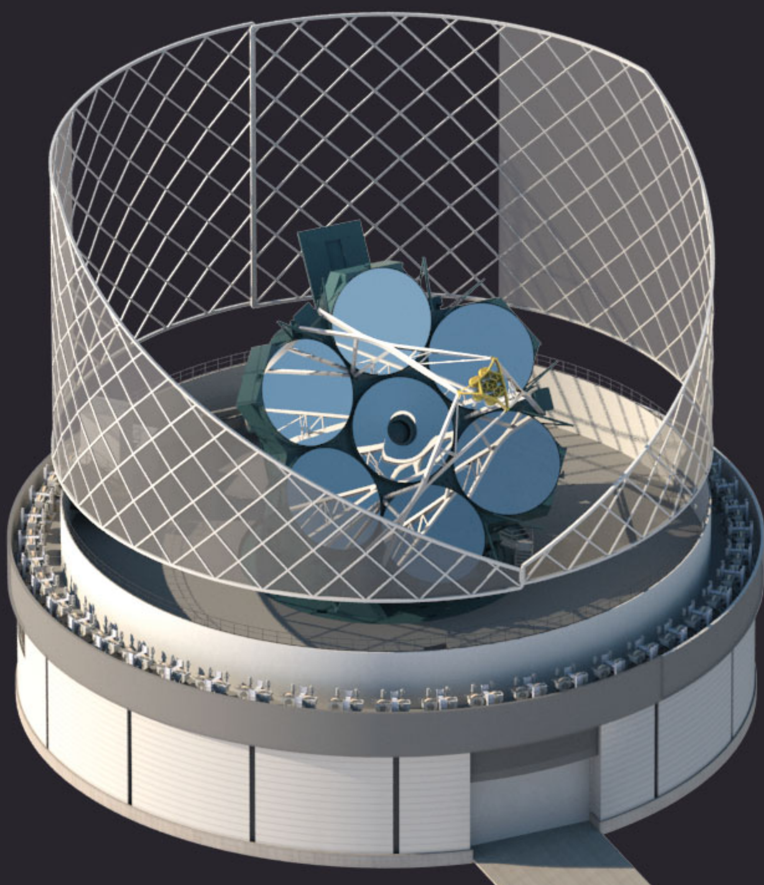
A moving 65m tall building:

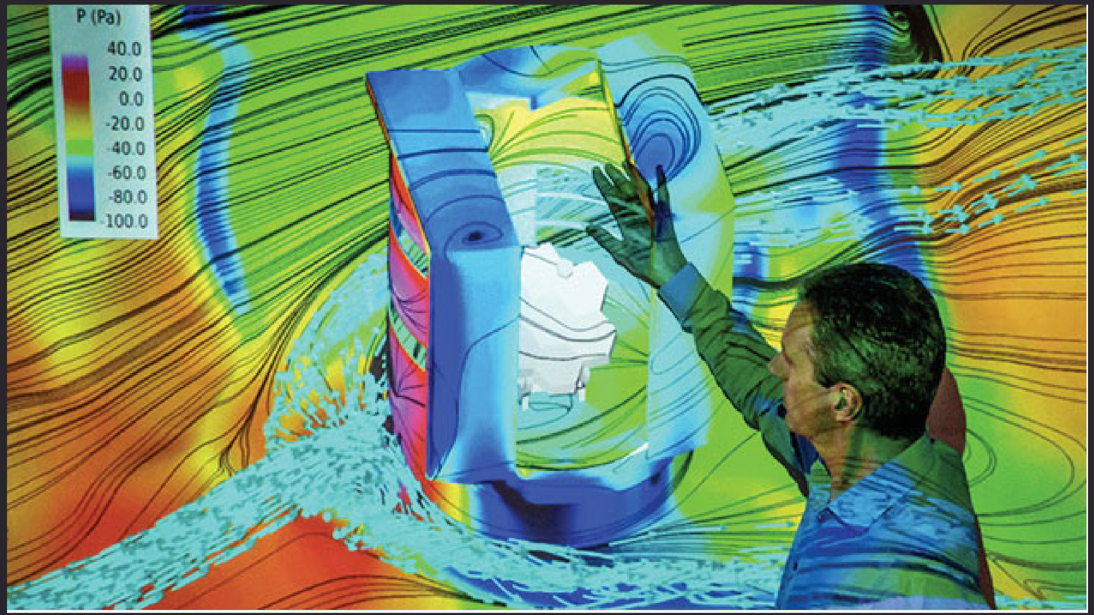
- Follows telescope pointing
- Reduce wind load
- Allow rapid thermal equilibration
- Provide adequate work space (instrument labs. mirror coating facilities.)
- Support assembly and maintenance activities



Enclosure

- Ideally the Enclosure would disappear during operations



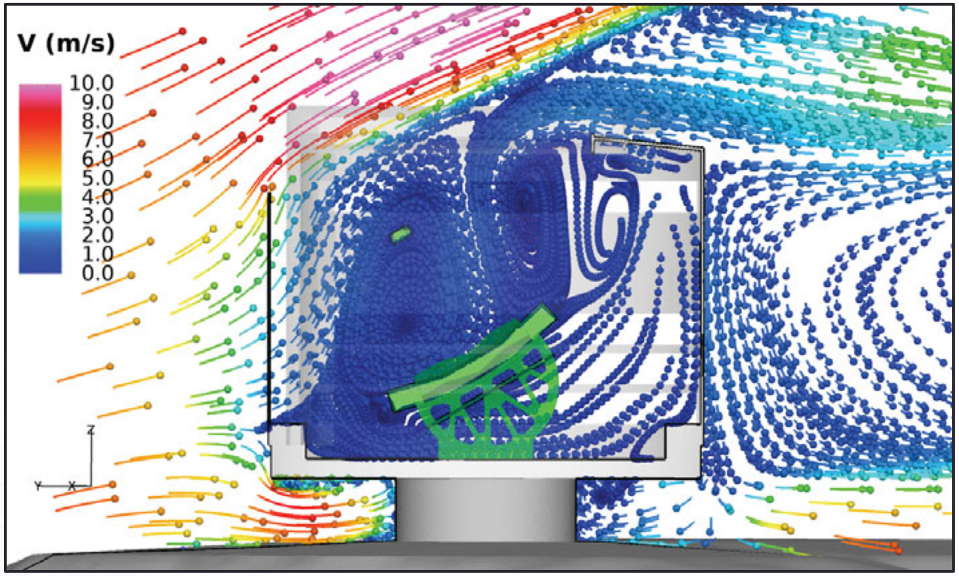


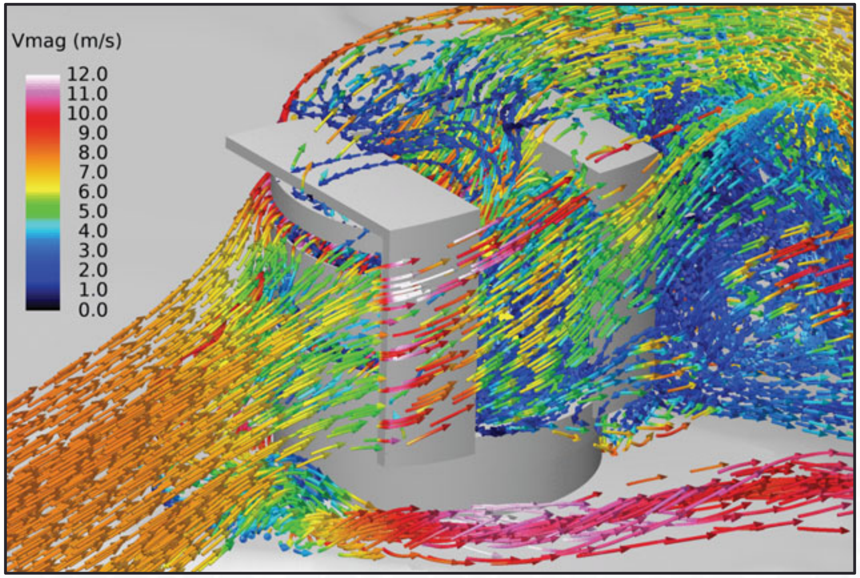
- Finalizing design to minimize impact on image quality based on computational fluid dynamics modeling

Enclosure Airflow

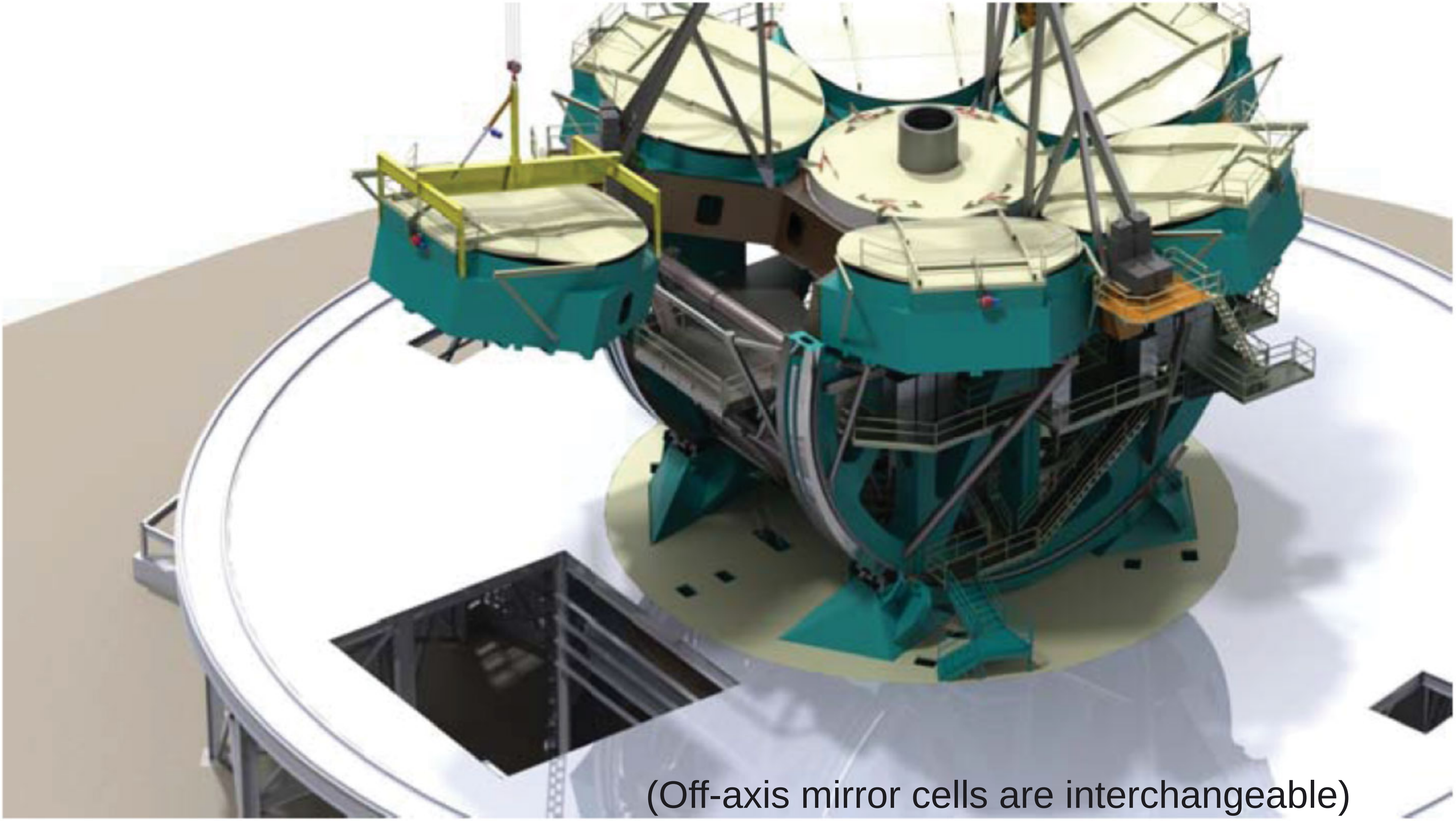
Boeing CFD Group modeling of airflow around and thru the enclosure

- Optimizing:
  - Enclosure Placement on the Summit
  - Lower Structure
  - Wind Screen Design





Enclosure crane: critical to build and maintain the telescope



(Off-axis mirror cells are interchangeable)

Topics:

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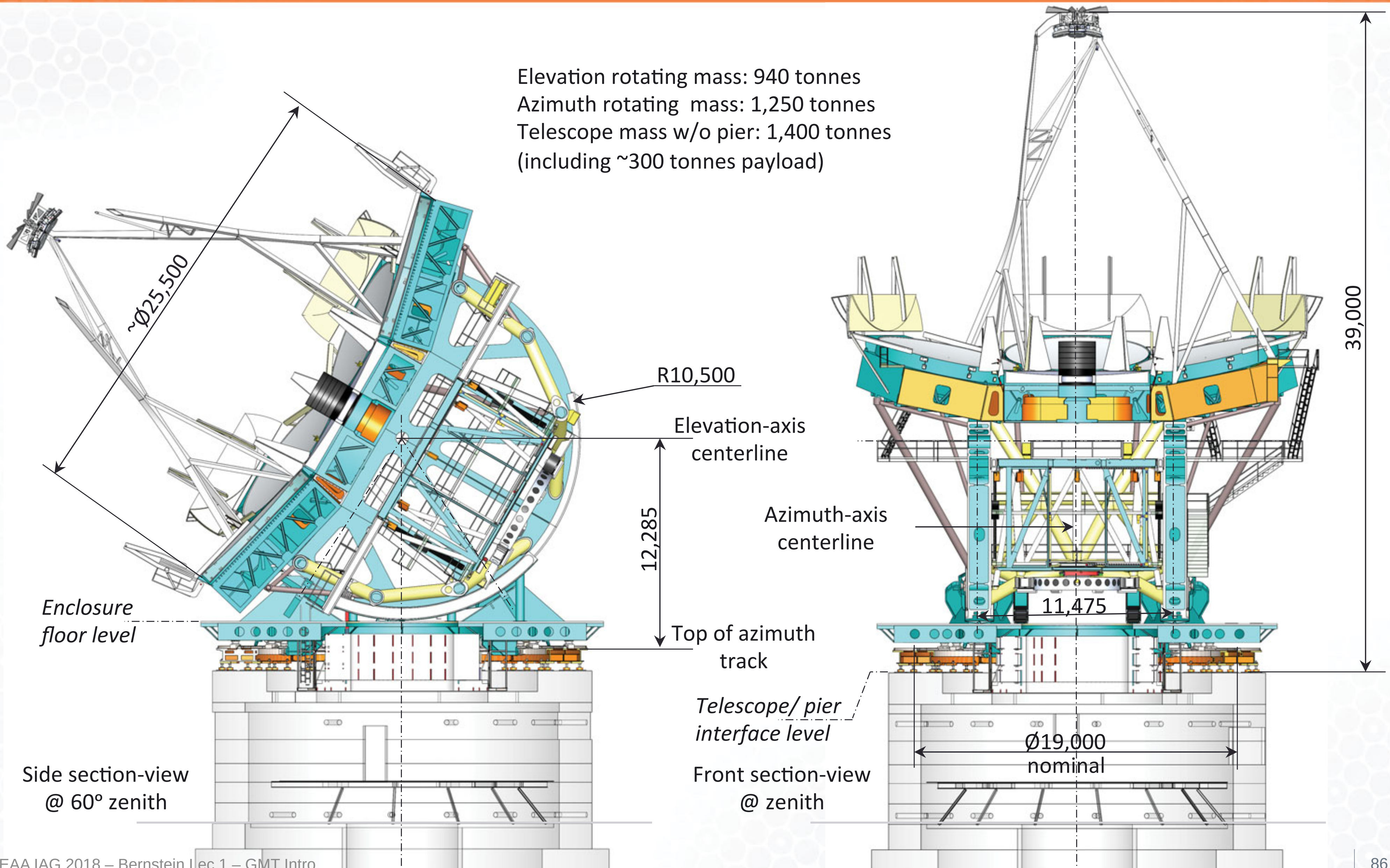
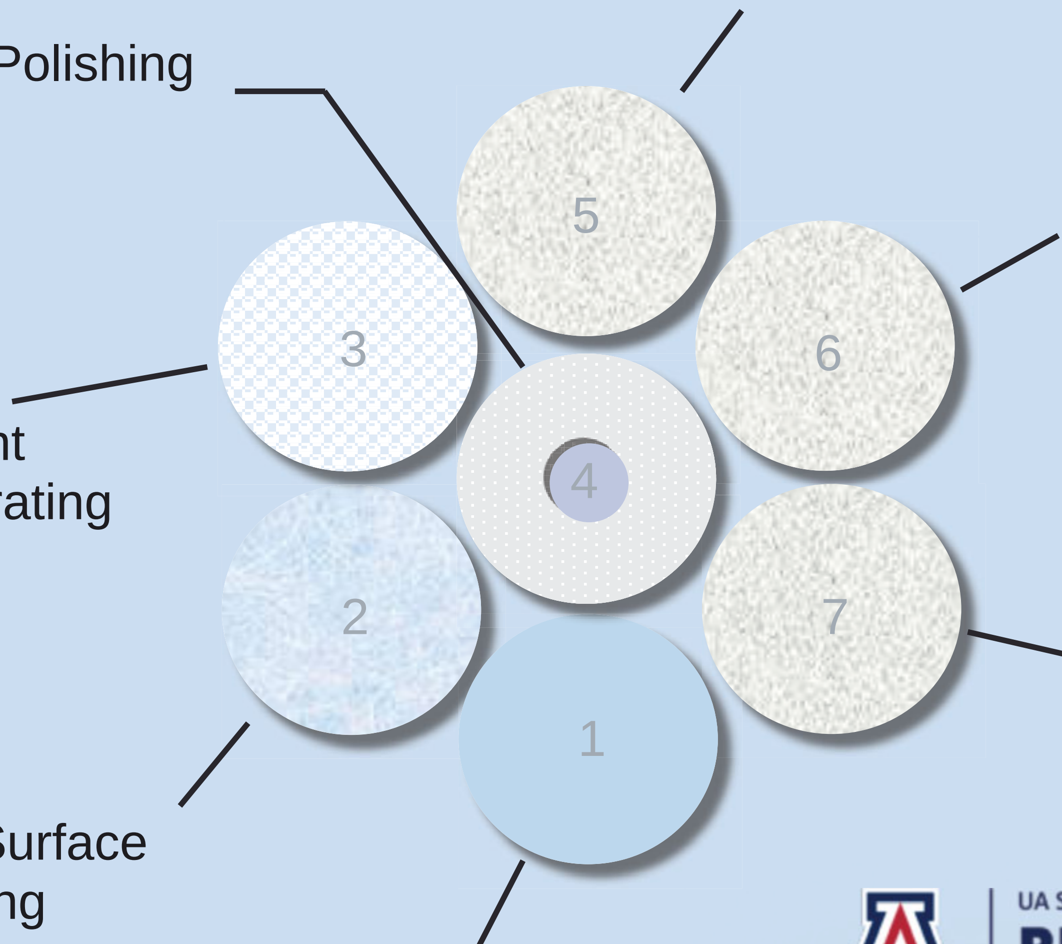
Telescope design: vendors on contract to complete final design

Elevation rotating mass: 940 tonnes
Azimuth rotating mass: 1,250 tonnes
Telescope mass w/o pier: 1,400 tonnes
(including ~300 tonnes payload)



Primary Mirror Production



UA SCIENCE
RICHARD F. CARIS
MIRROR LAB
Steward Observatory

Primary Mirror Production

2012: Site Cleared and Leveled, Road Graded

Construction progress: support sites

Construction progress: summit

Construction progress: summit

Site: Las Campanas Observatory (circa 2025)

Rendering of GMT at Las Campanas Site

Rendering of GMT at Las Campanas Site

Timeline to early science and operations:

Final Procurements

- **Telescope: Full performance**
- **Instrument**: Widest field of view (20 arcmin)

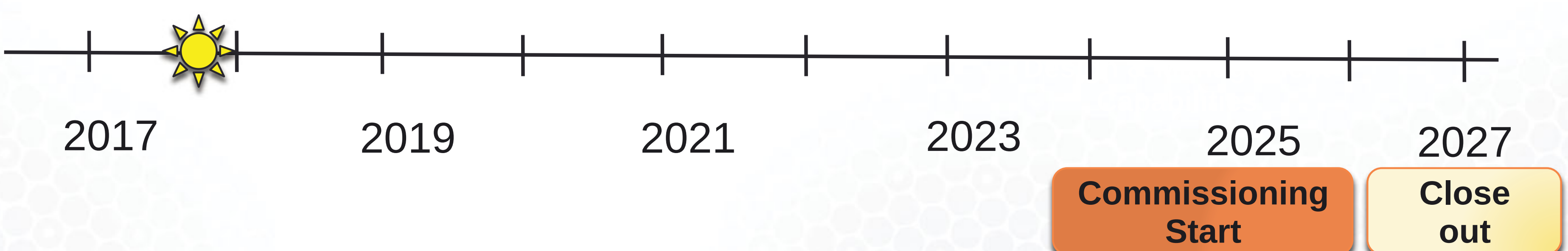
Intermediate Procurements

- **Telescope**: **7 M1+M2 segments, Adaptive M2s**
- Start AO
- **Instrument**: AO-fed IR spectrographs

Early Procurements

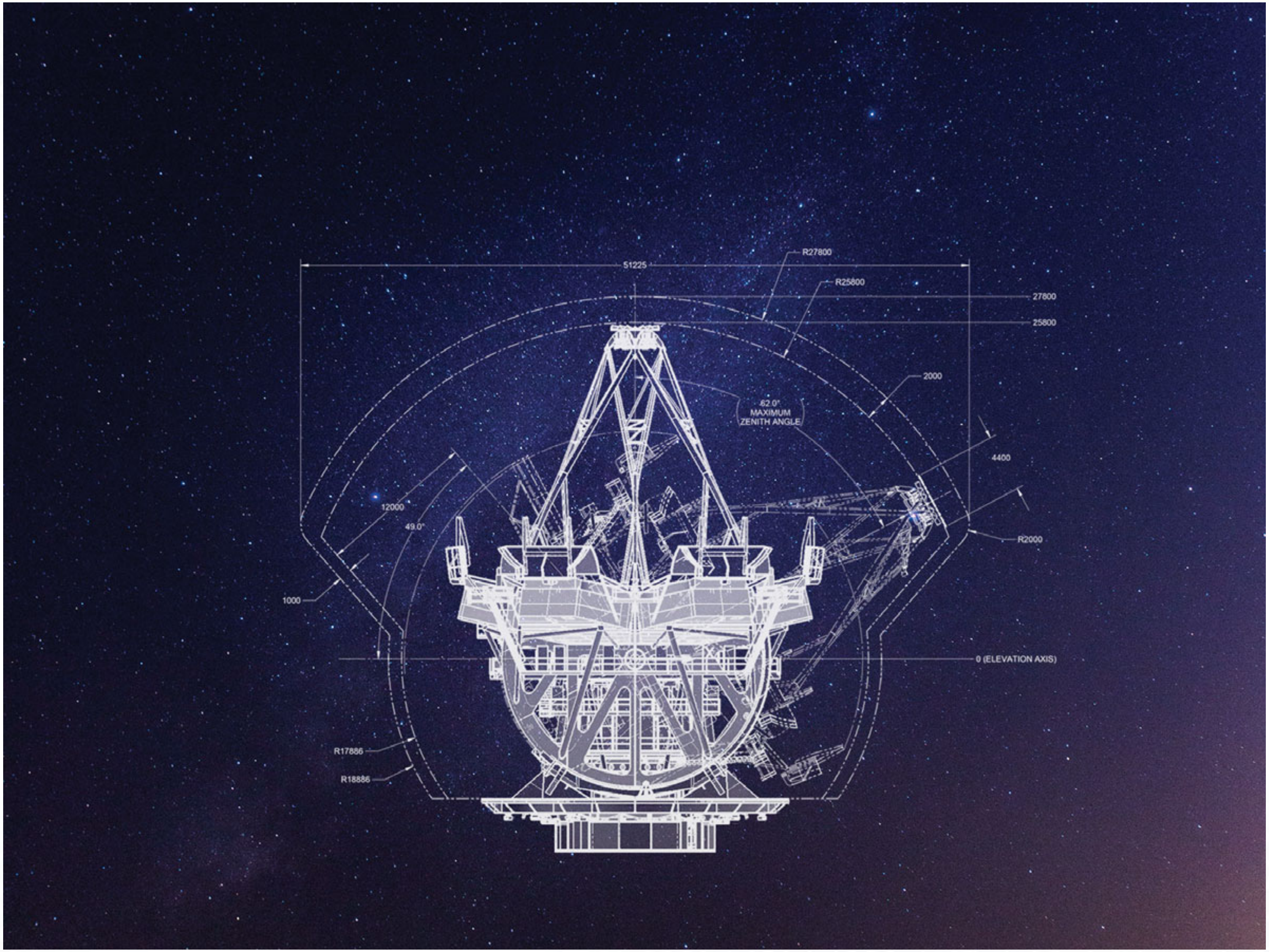
- Essential infrastructure
- Enclosure, Telescope Mount
- Summit Support Building

- **Telescope**: **4 M1+M2 segments**
- **Instruments**: Imaging, non-AO spec



The Vision

The Giant Magellan Telescope: Science & Status



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- Introduction – Project and Science Case
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Science nearby: Exoplanets

- How do planetary systems form?
- How common are systems like ours?
- Are there other Earths?
- Can we detect life?

Methods:

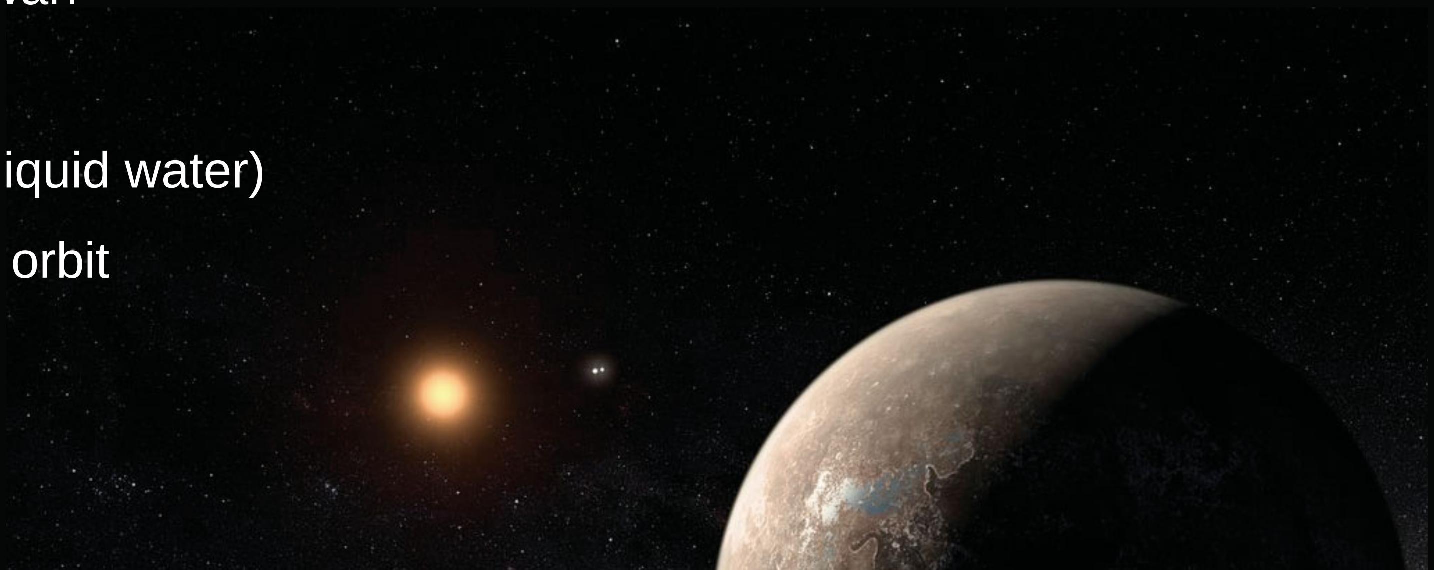
- Measuring Masses
- Direct Imaging
- Detecting atmospheres

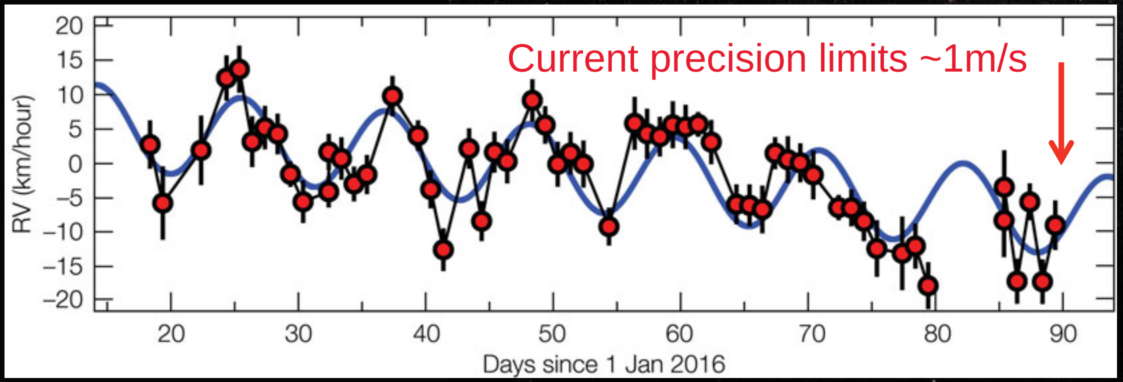
Measuring masses of Earth-sized planets

GMT

Proxima Centauri b:

- parent star: red dwarf
- 1.3 M_E planet
- “habitable” zone (liquid water)
- 0.05 AU, 11.5 day orbit





Measuring masses of Earth-sized planets

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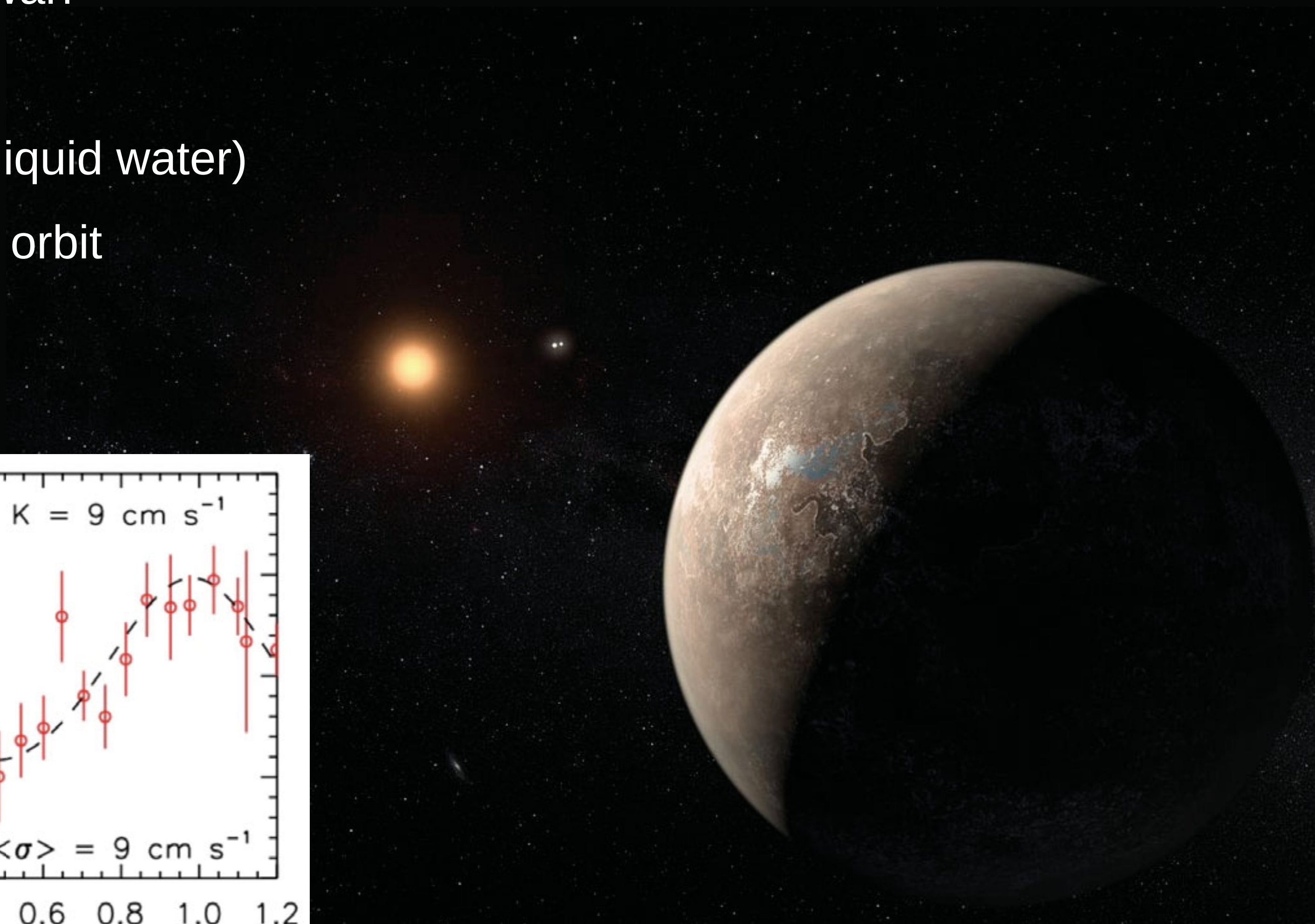

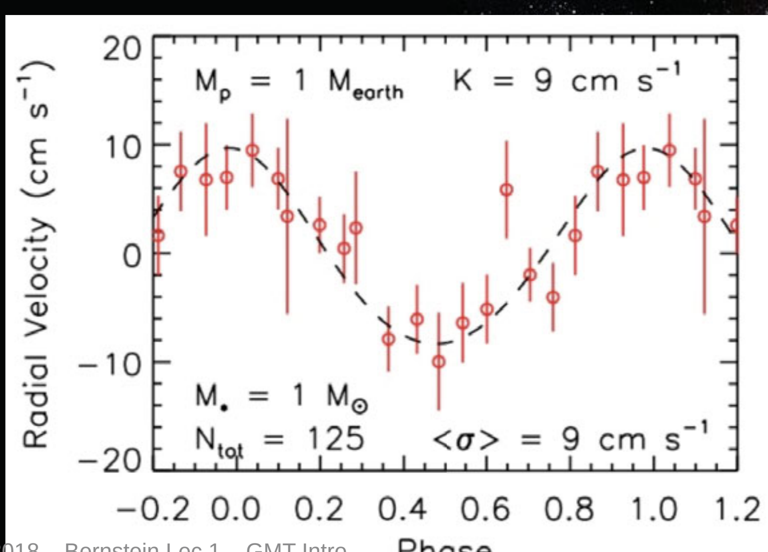

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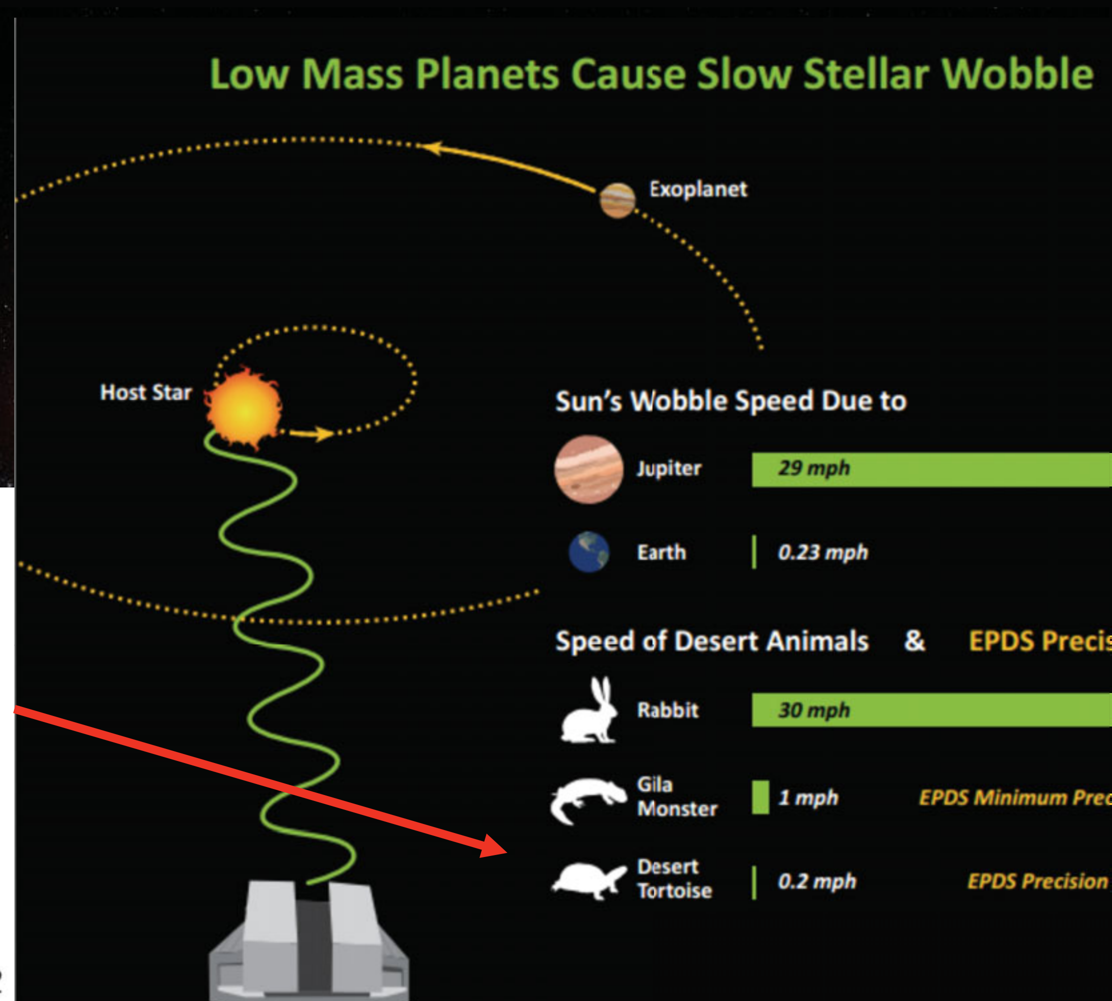

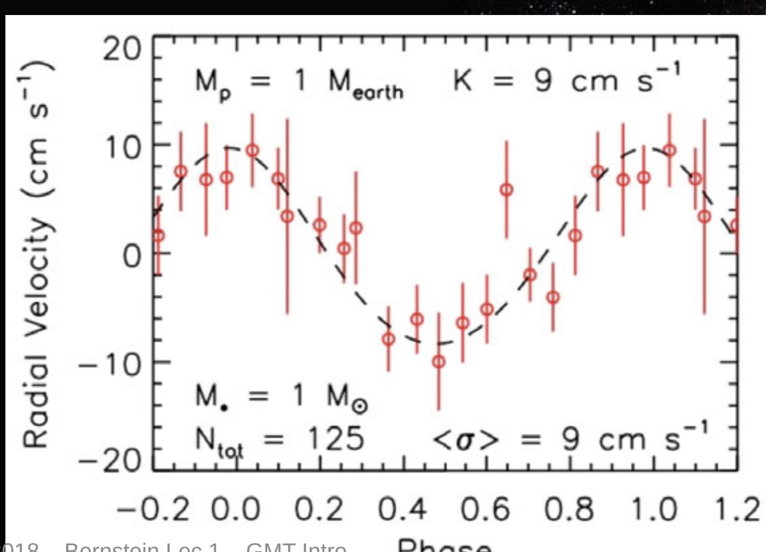

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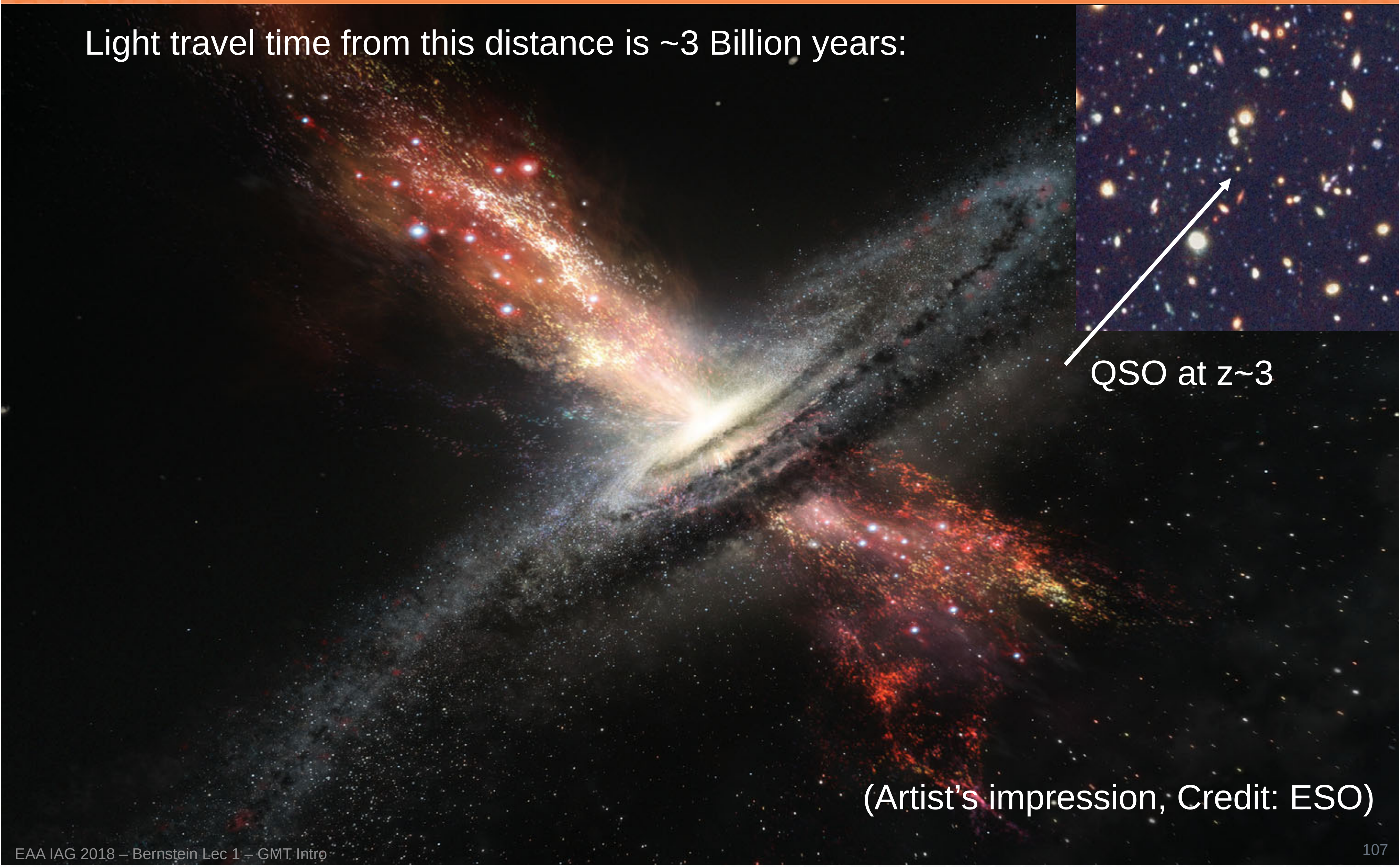
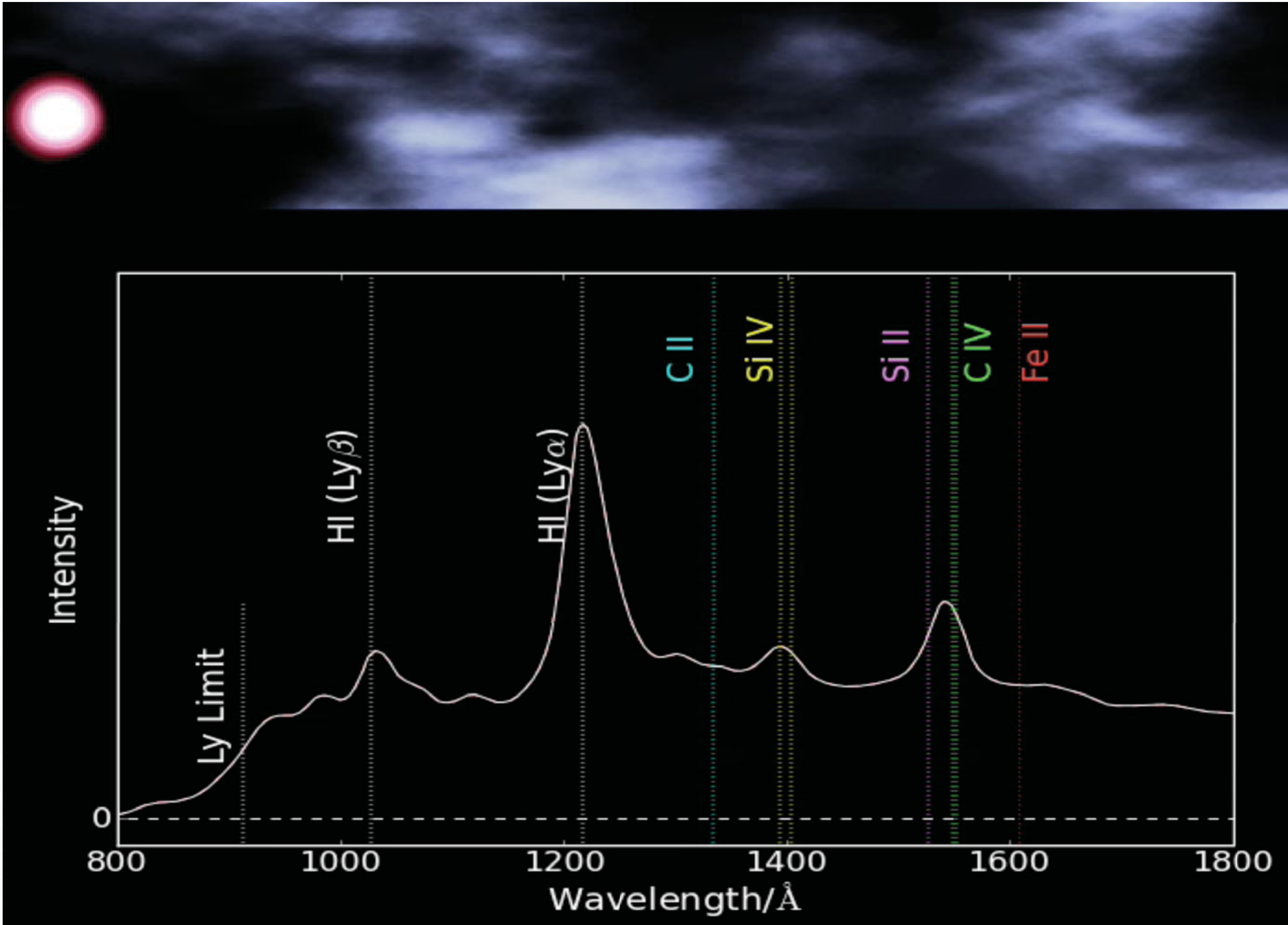
Quasars & the intervening absorption line systems:

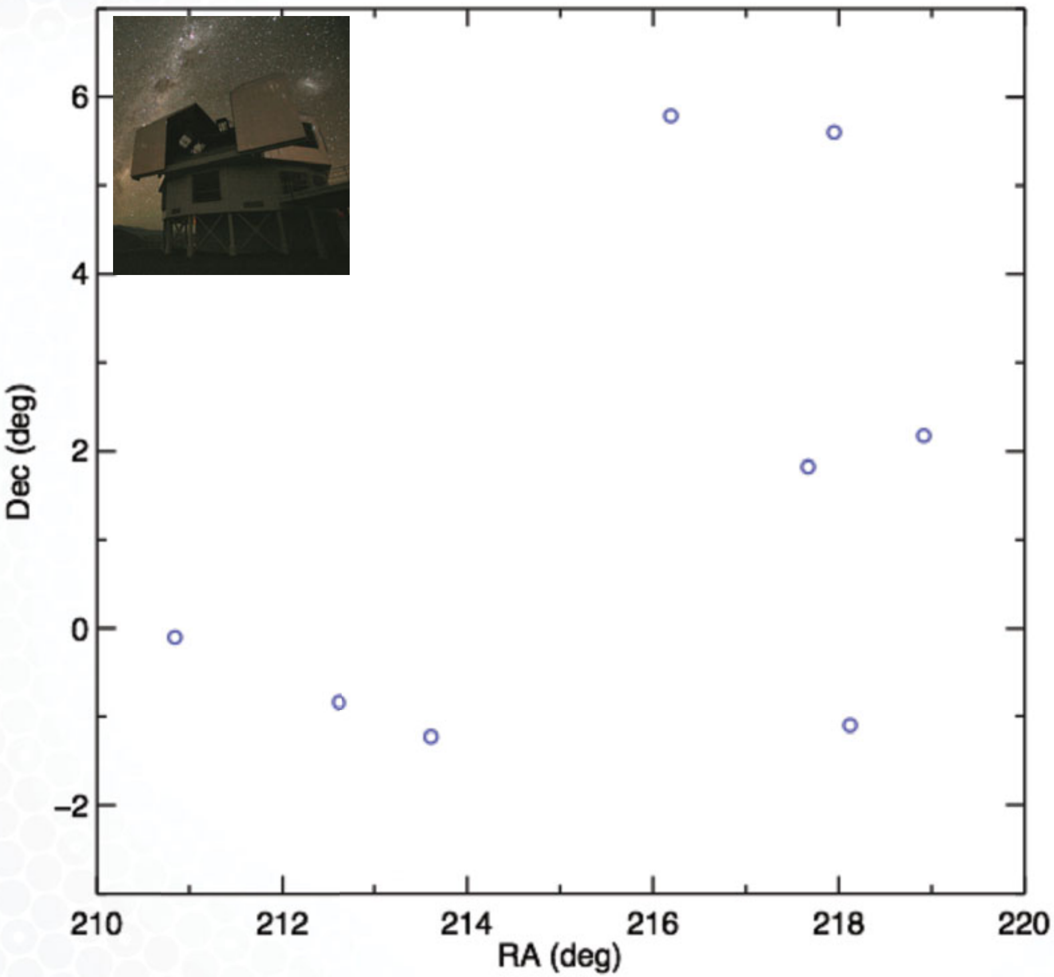
Light travel time from this distance is ~3 Billion years:

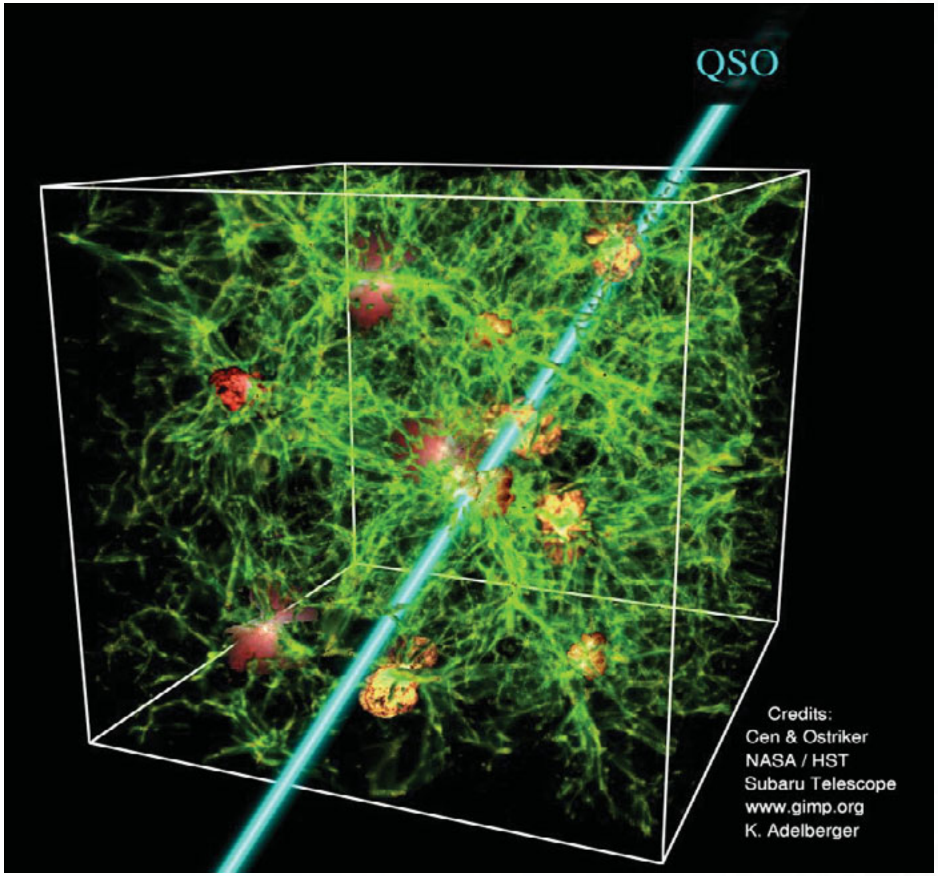



Intensity
Ly Limit
HI (Lyβ)
HI (Lyα)
C II
Si IV
Si II
C IV
Fe II
0
800
1000
1200
1400
1600
1800
Wavelength/Å

Quasars w/in reach at z=2:

8 Quasars ($m_r < 18$)





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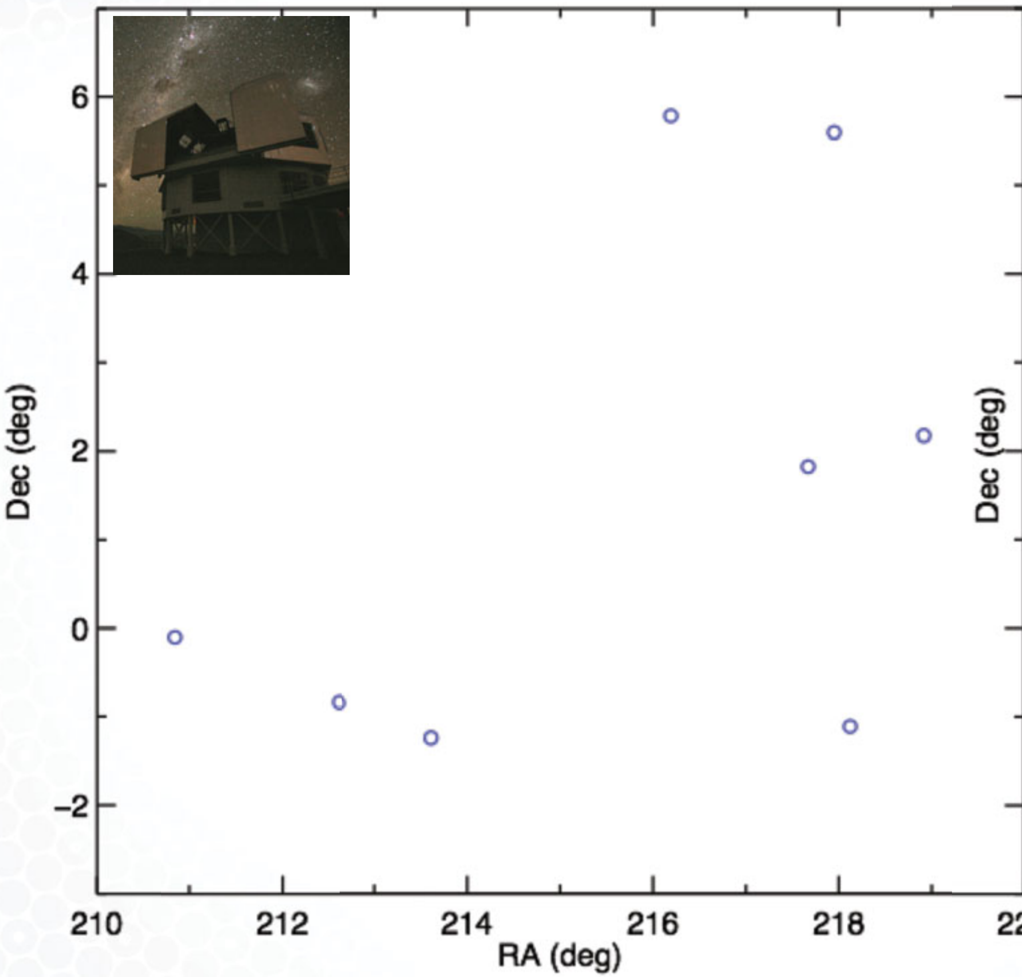
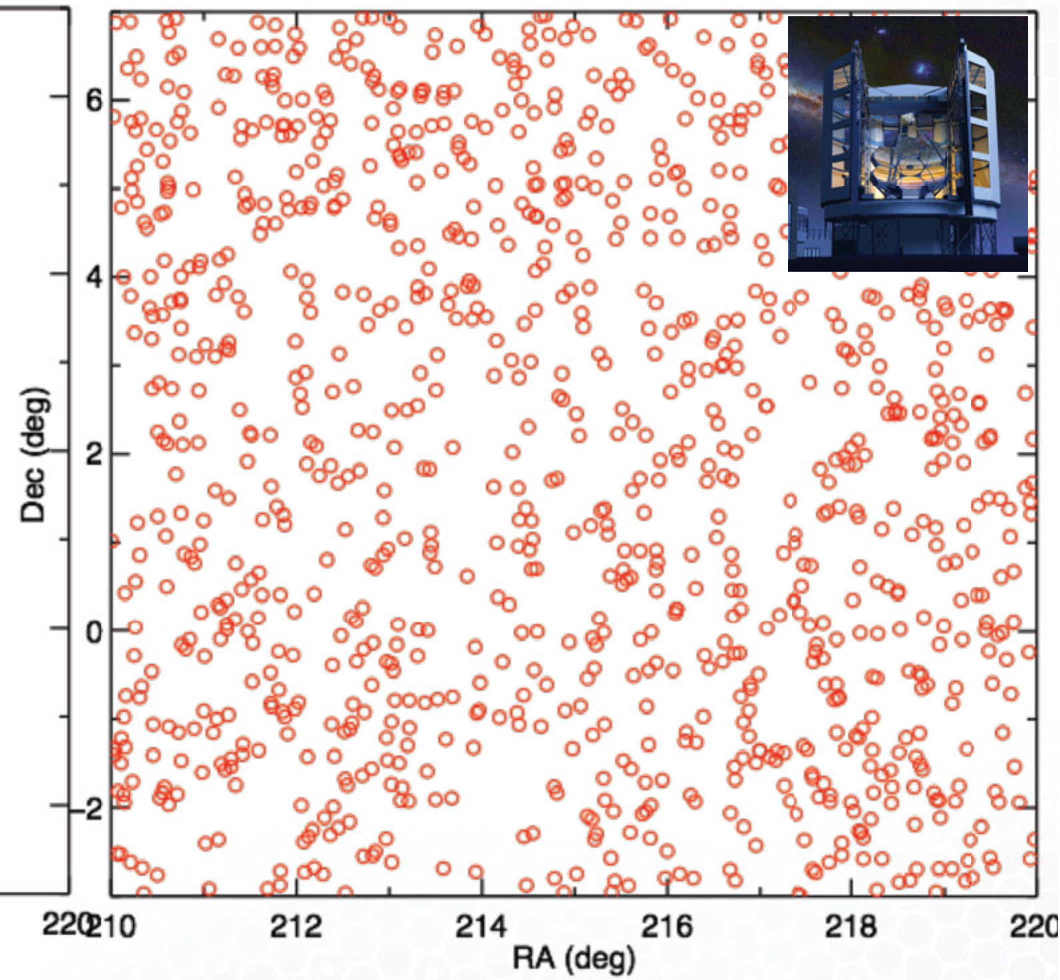


~1000 Quasars (m_r < 21)

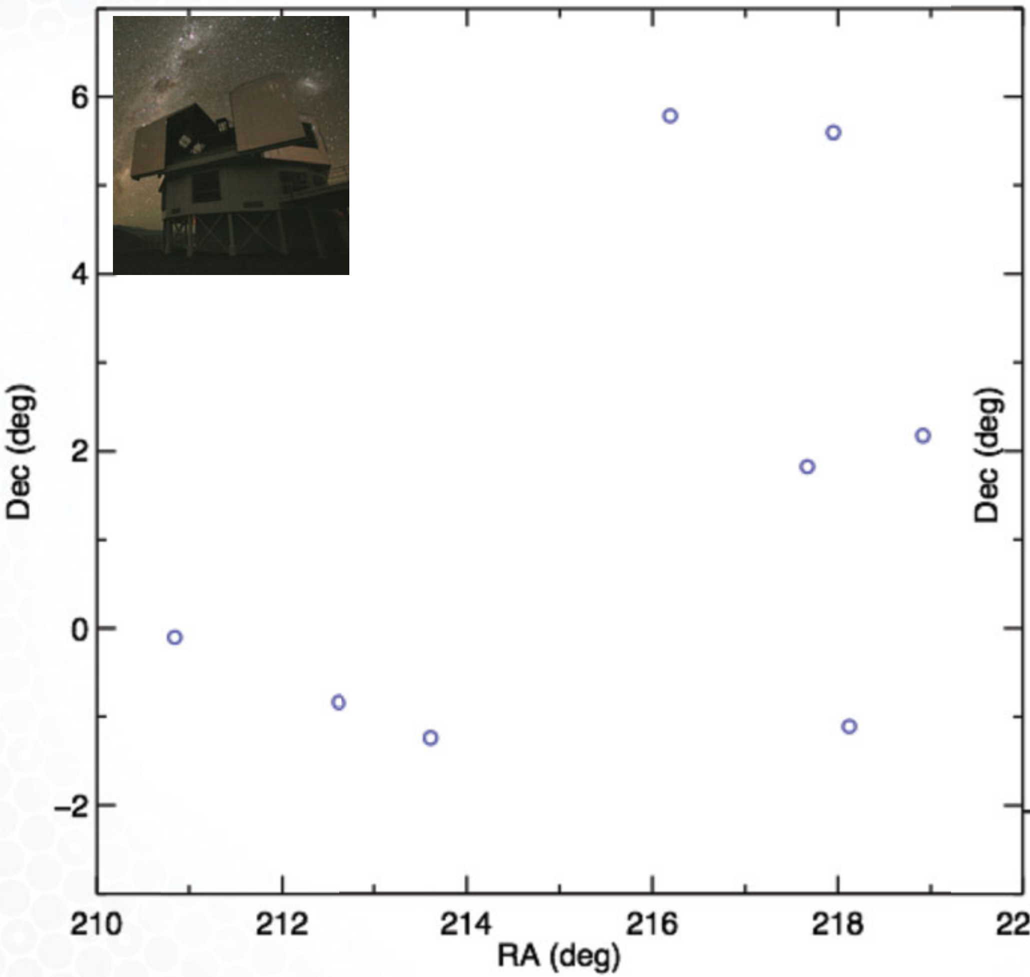


Credit: G. D. Becker, Ryan Cooke

Quasars w/in reach at z=2:

Single exposure, multi-object spectroscopy

8 QSOs ($m_r < 18$)



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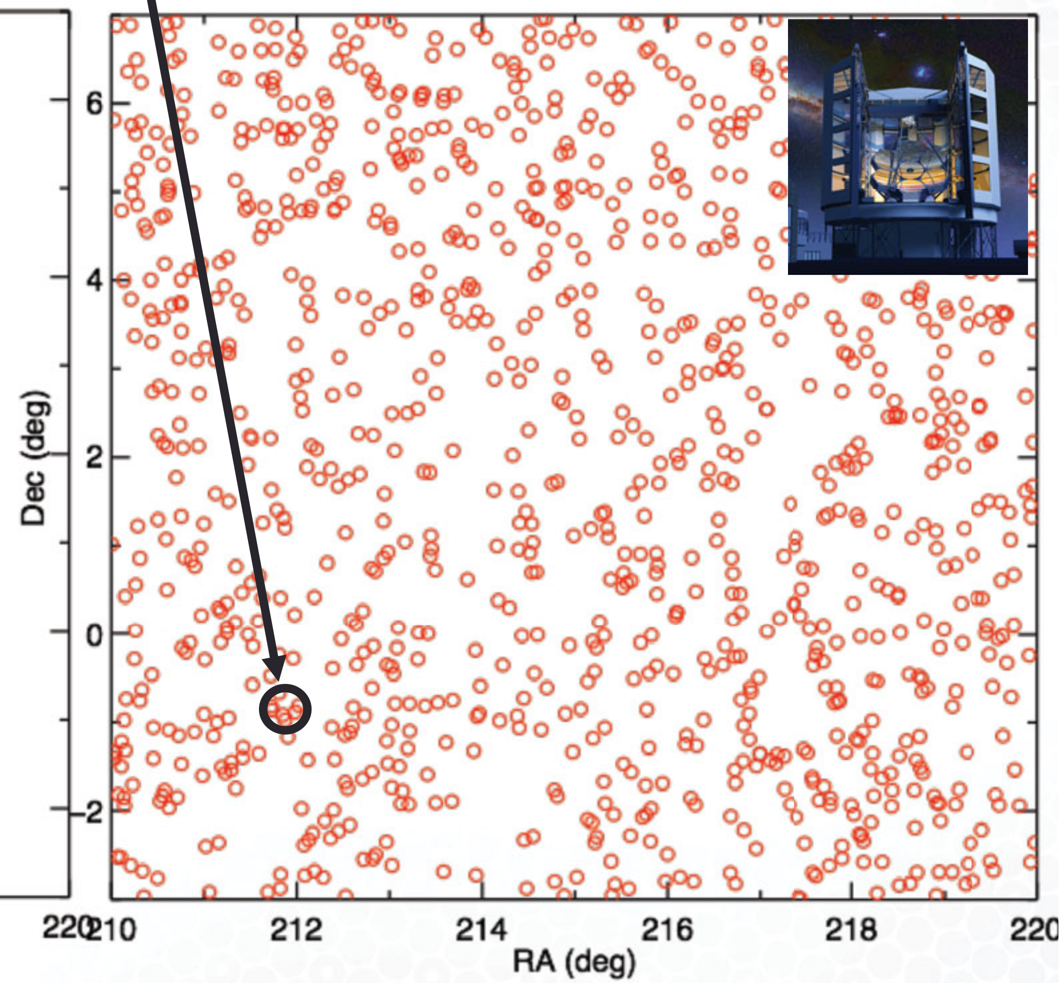


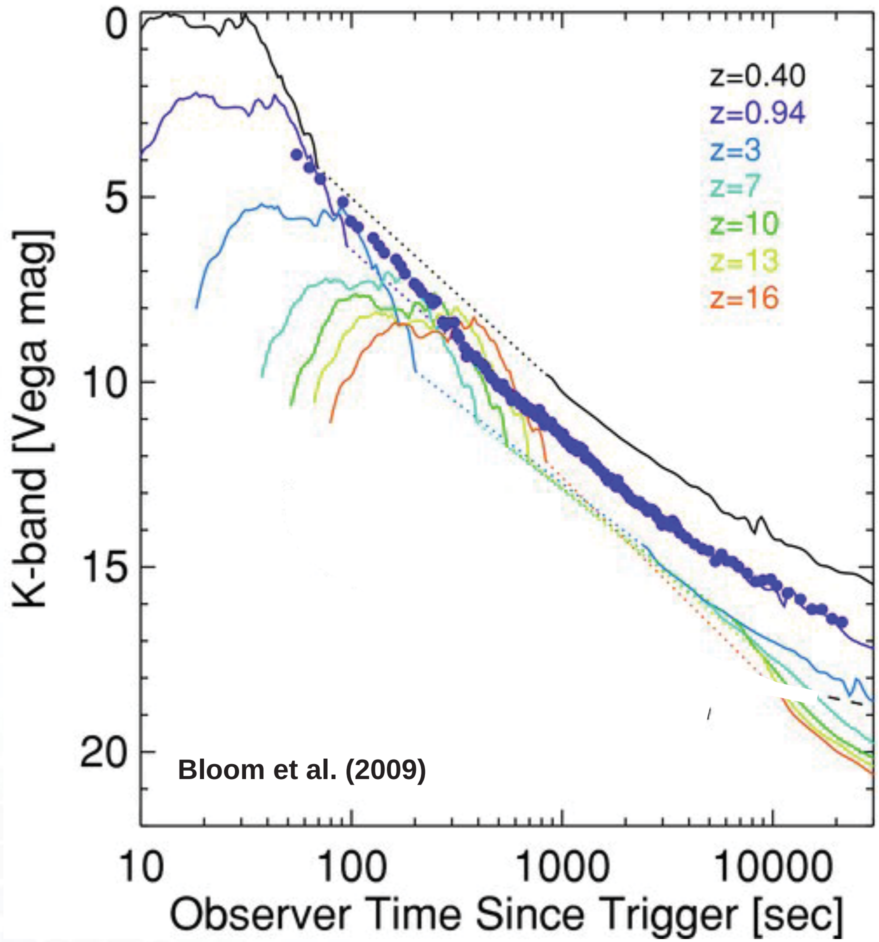
Credit: G. D. Becker, Ryan Cooke

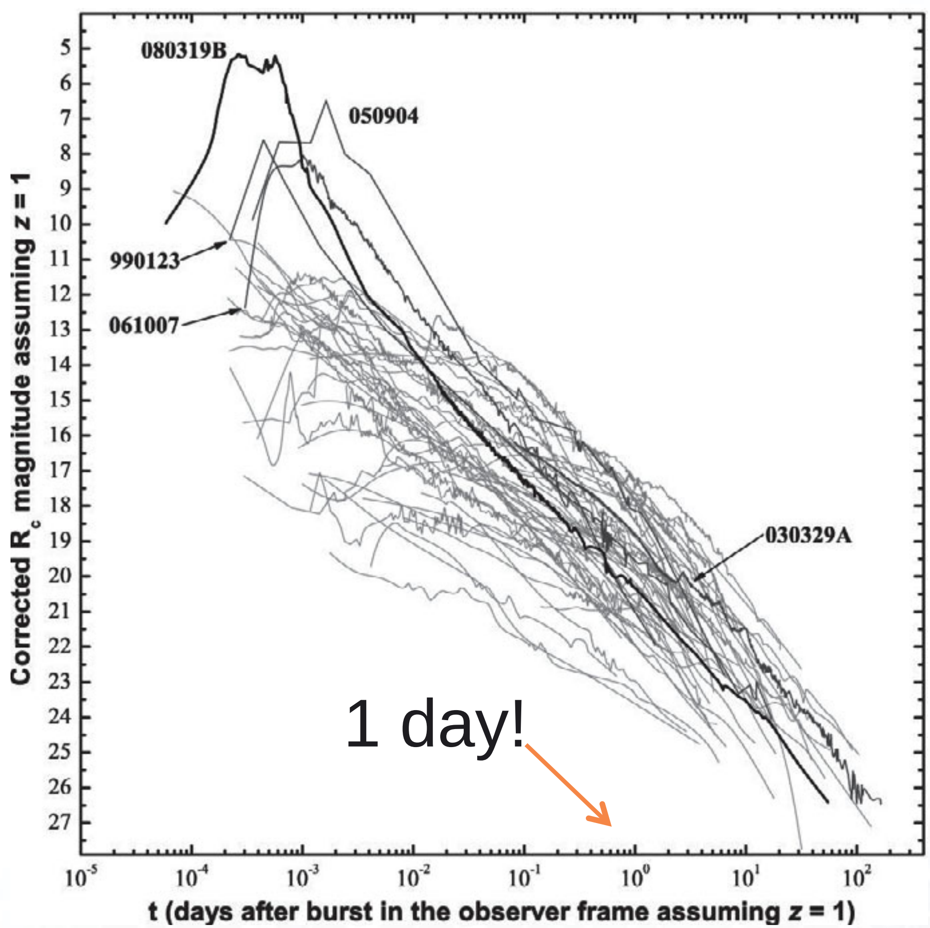
Galaxy formation and the IGM:

GMT

GRB's as cosmic probes:

GRBs are easily detected at their peak … but fade *very* rapidly.





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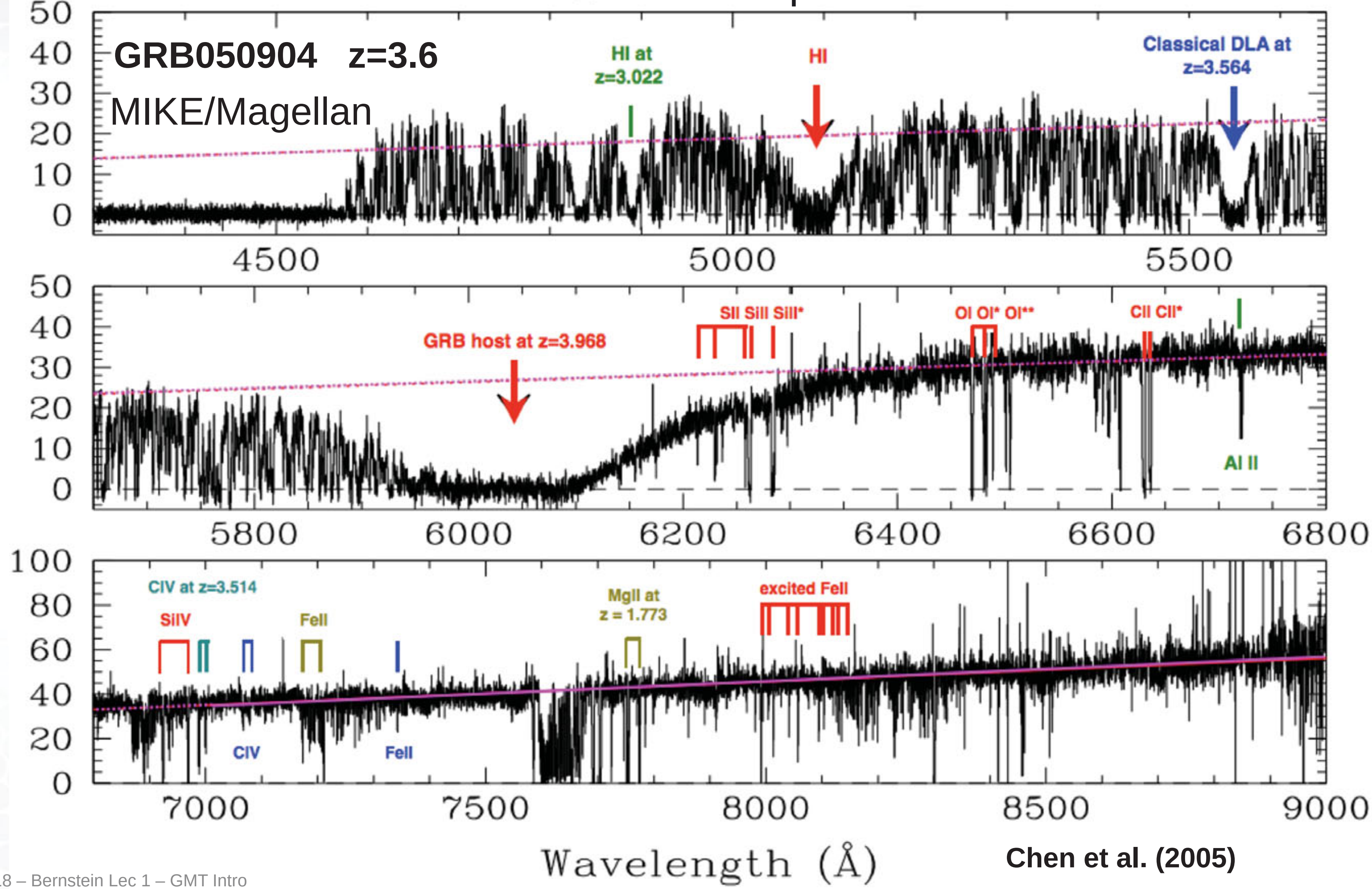

Chen et al. (2005)

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