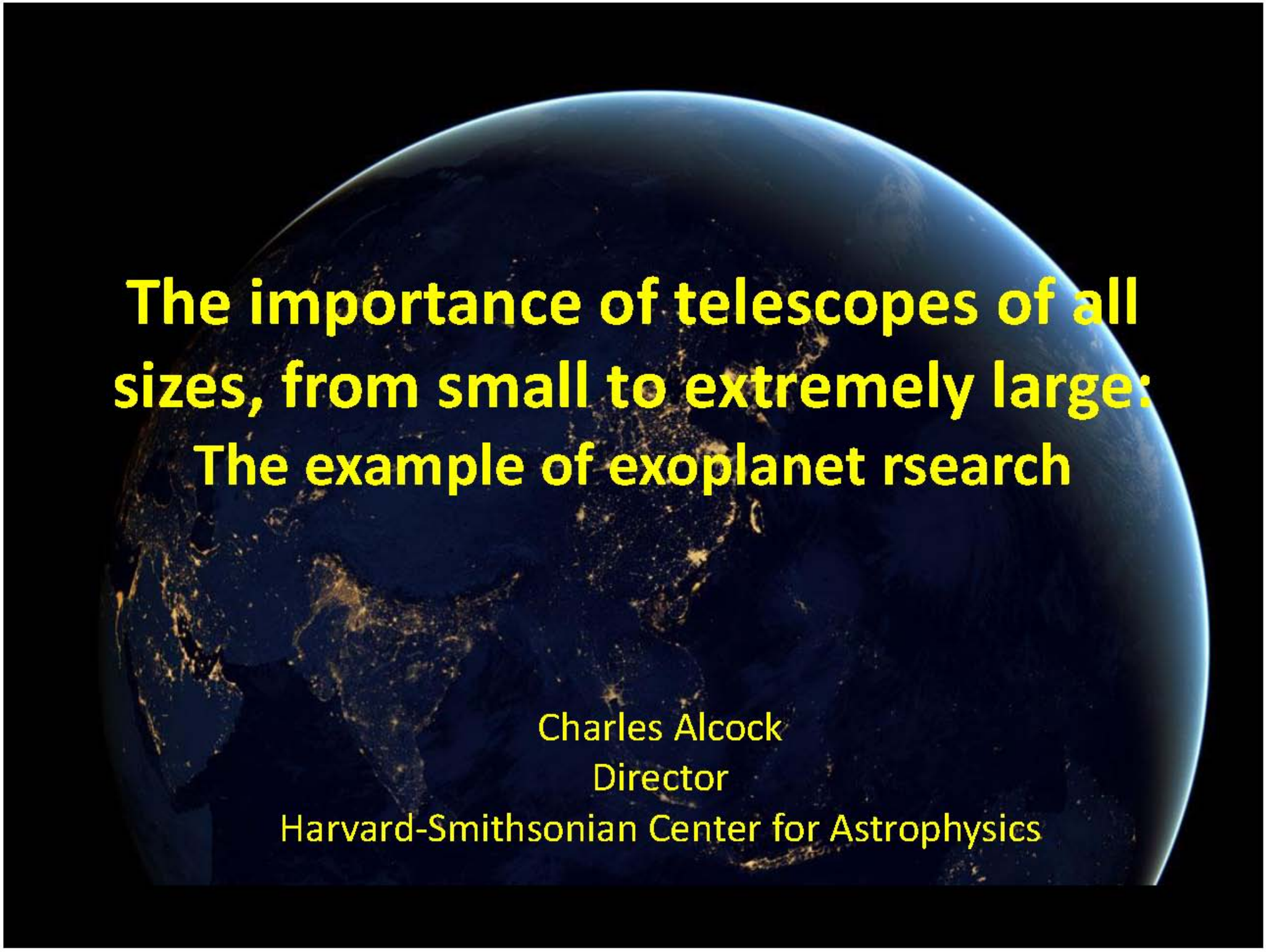
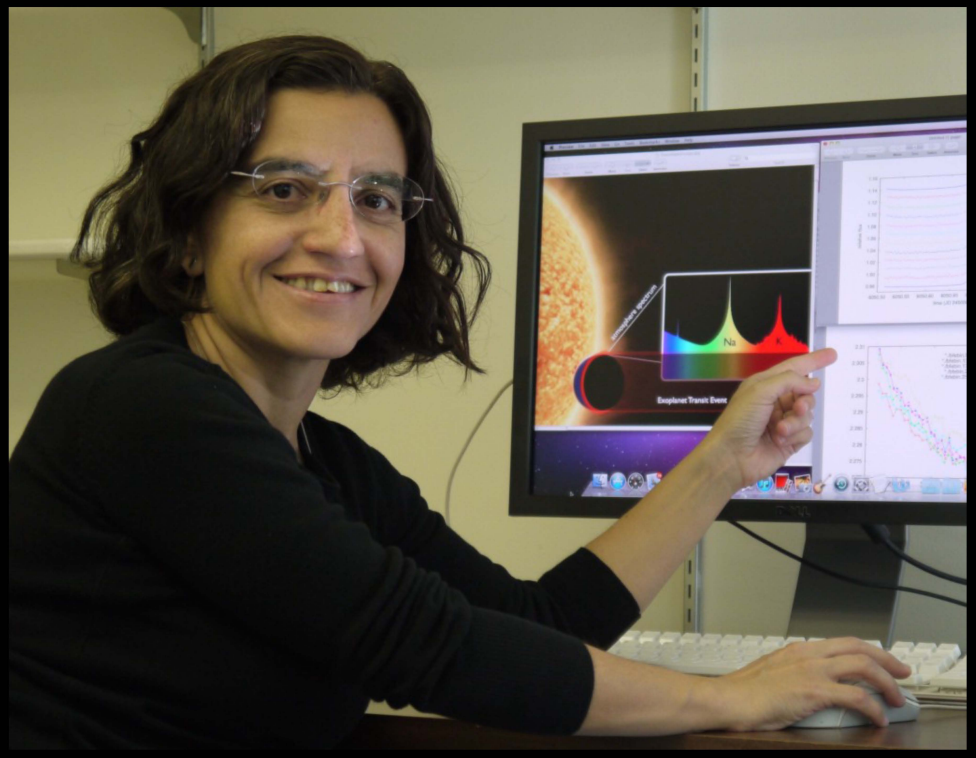


The importance of telescopes of all sizes, from small to extremely large: The example of exoplanet rsearch

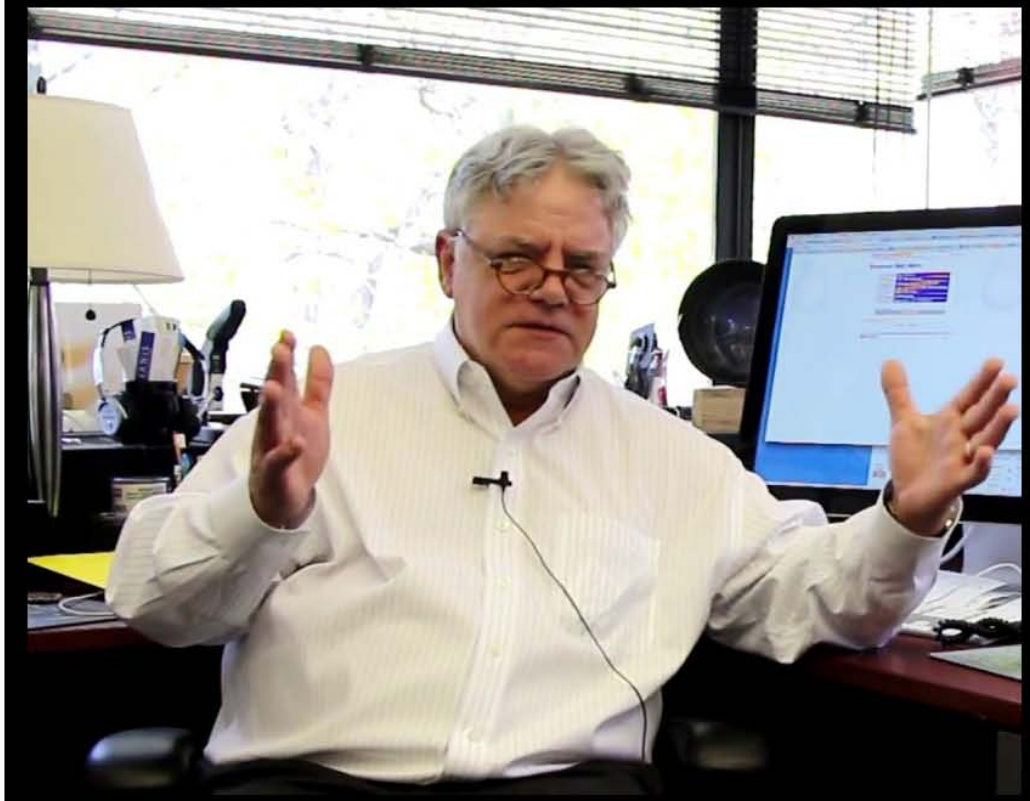
Charles Alcock
Director
Harvard-Smithsonian Center for Astrophysics

With help from:



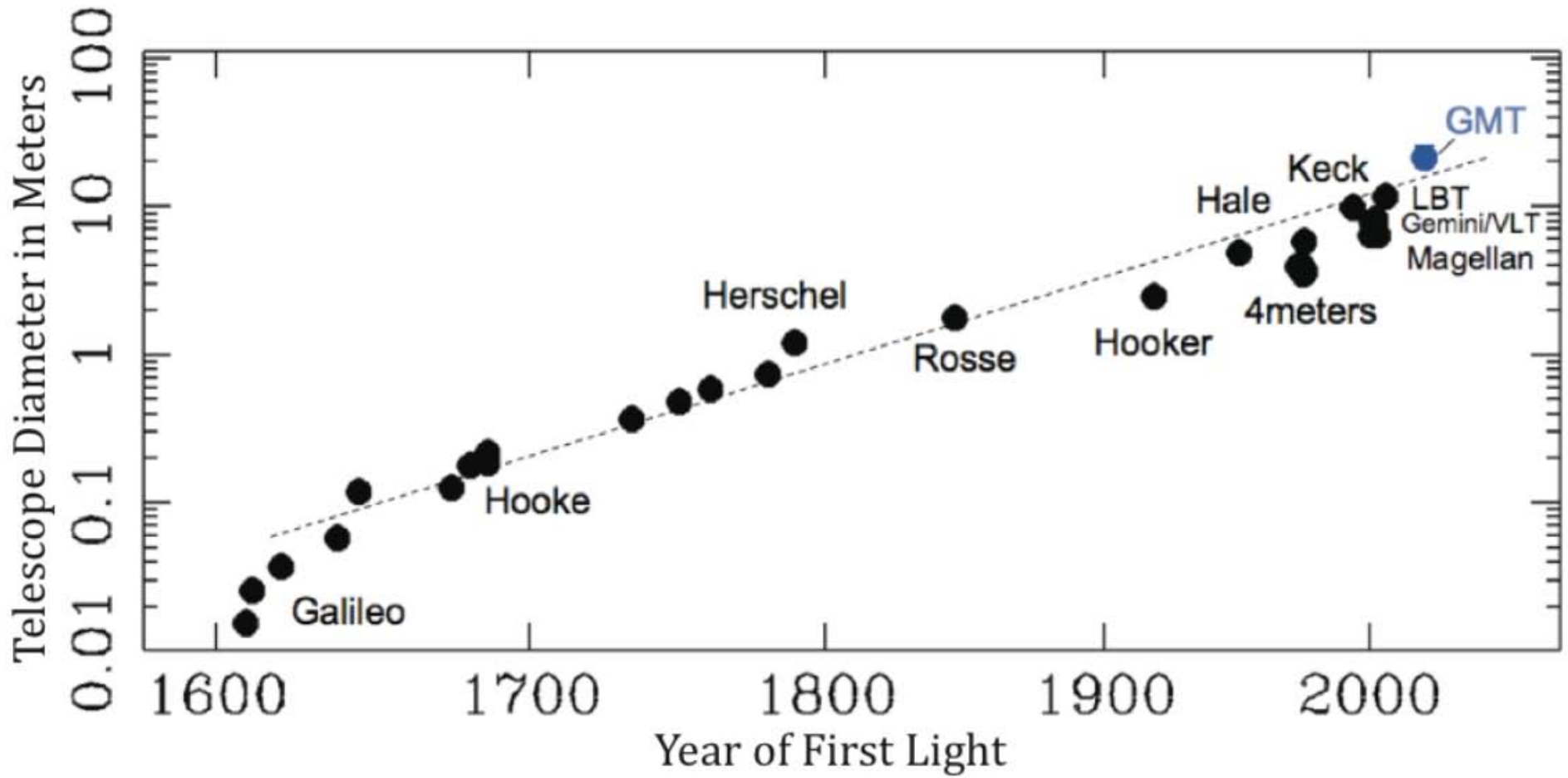
David Charbonneau and Mercedes Lopez-Morales

and help from:

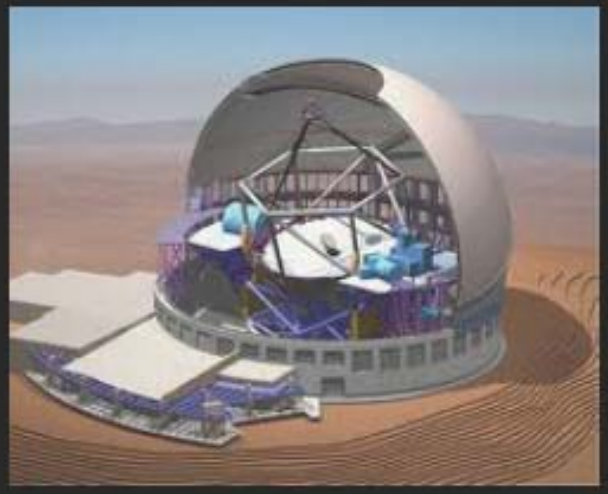


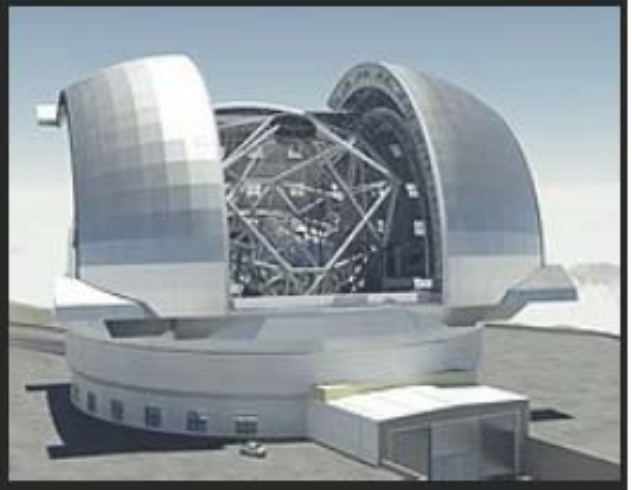
Andy Szentgyorgyi and Pat McCarthy

The size of the largest telescopes: Doubling time is ~35 years

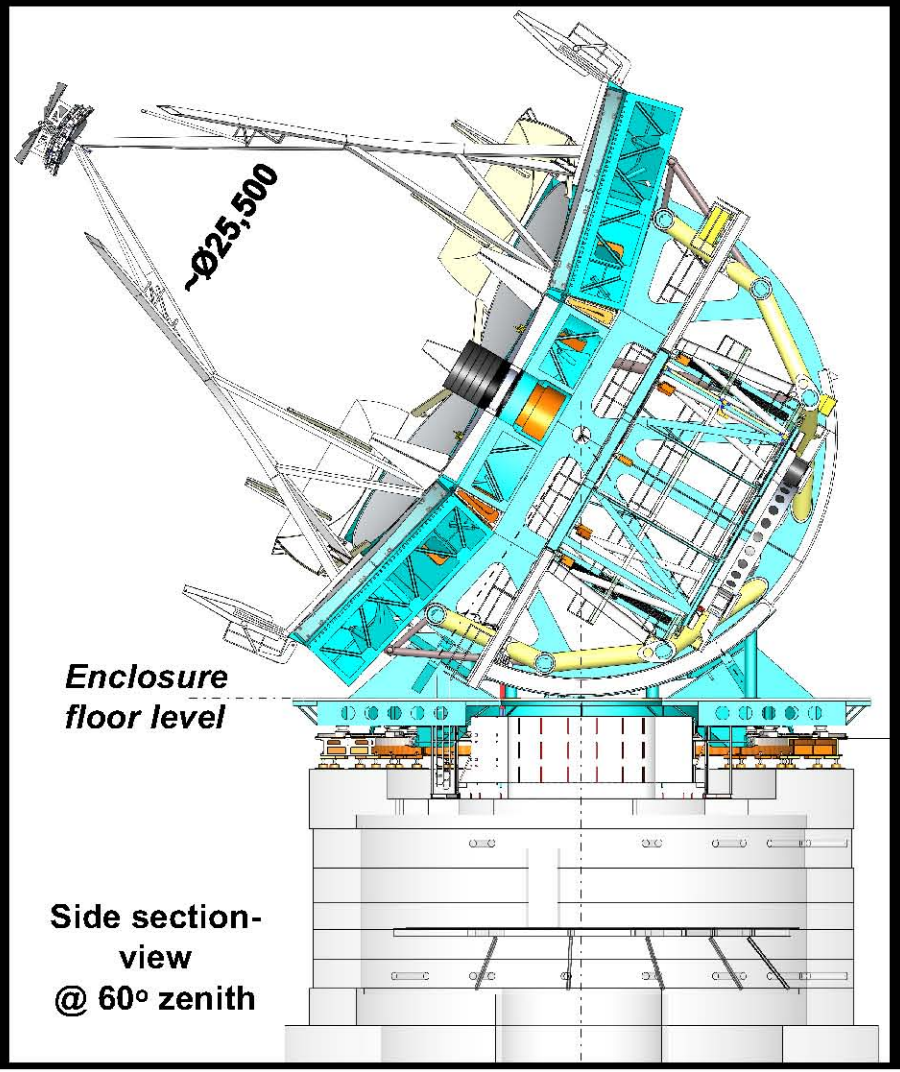


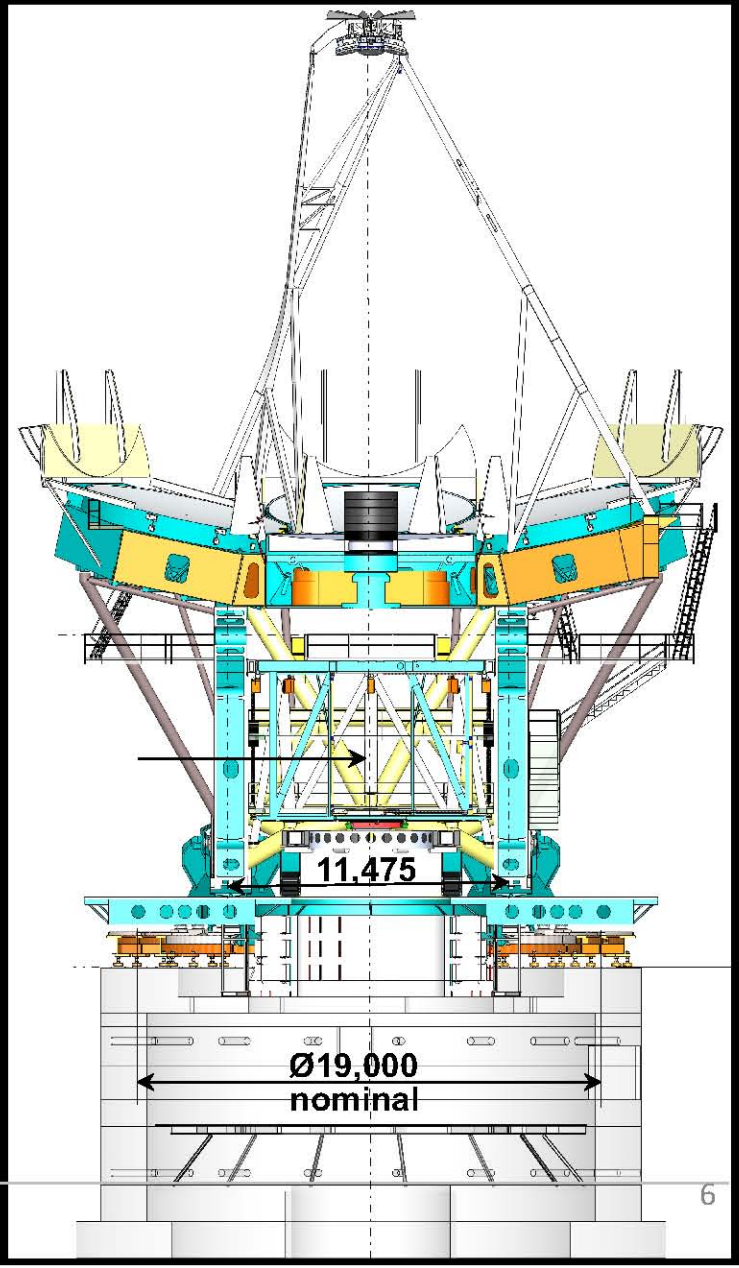
The size of the largest telescopes: Approaching 25 – 40 meters

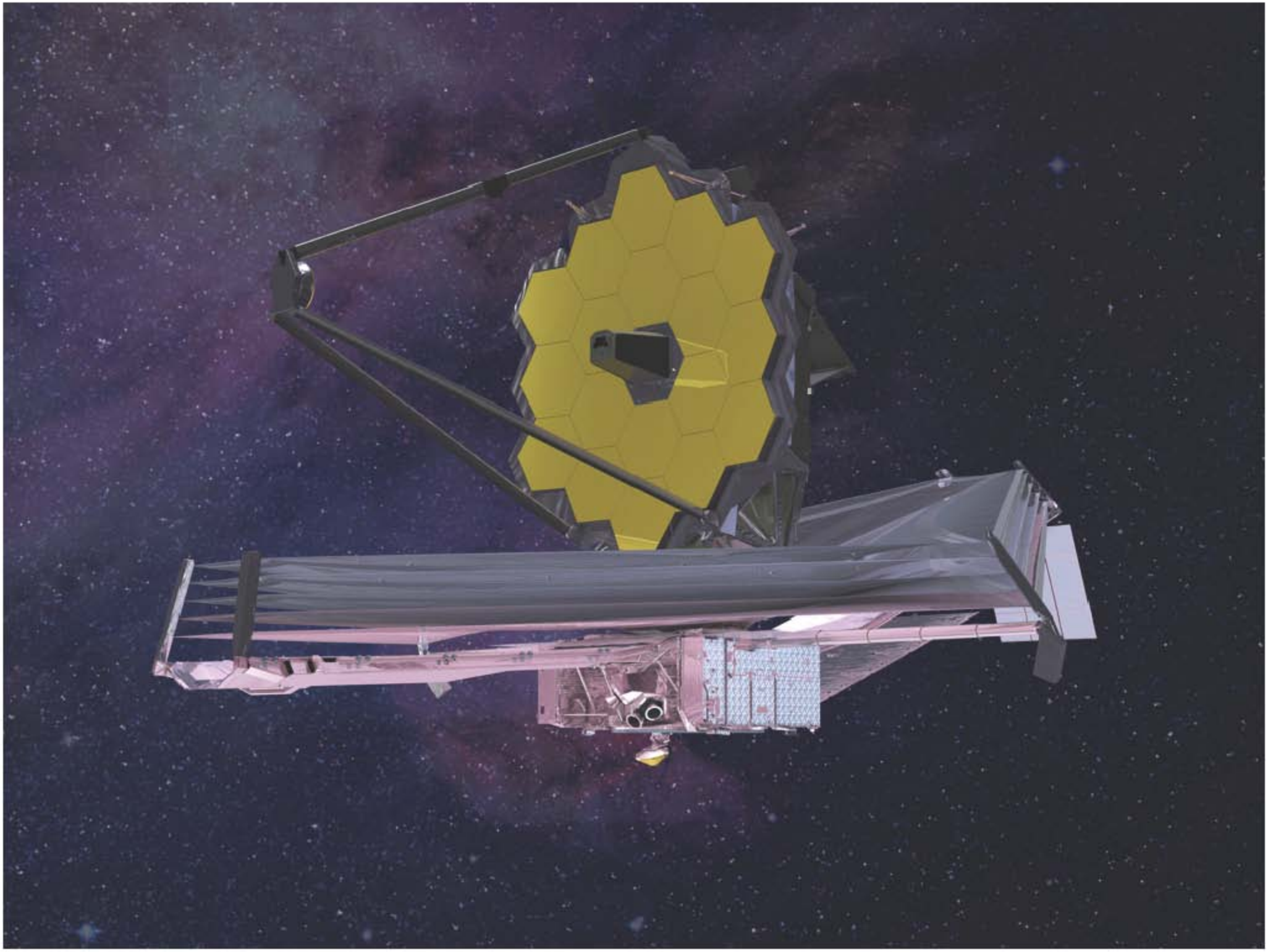




The size of the largest telescopes:





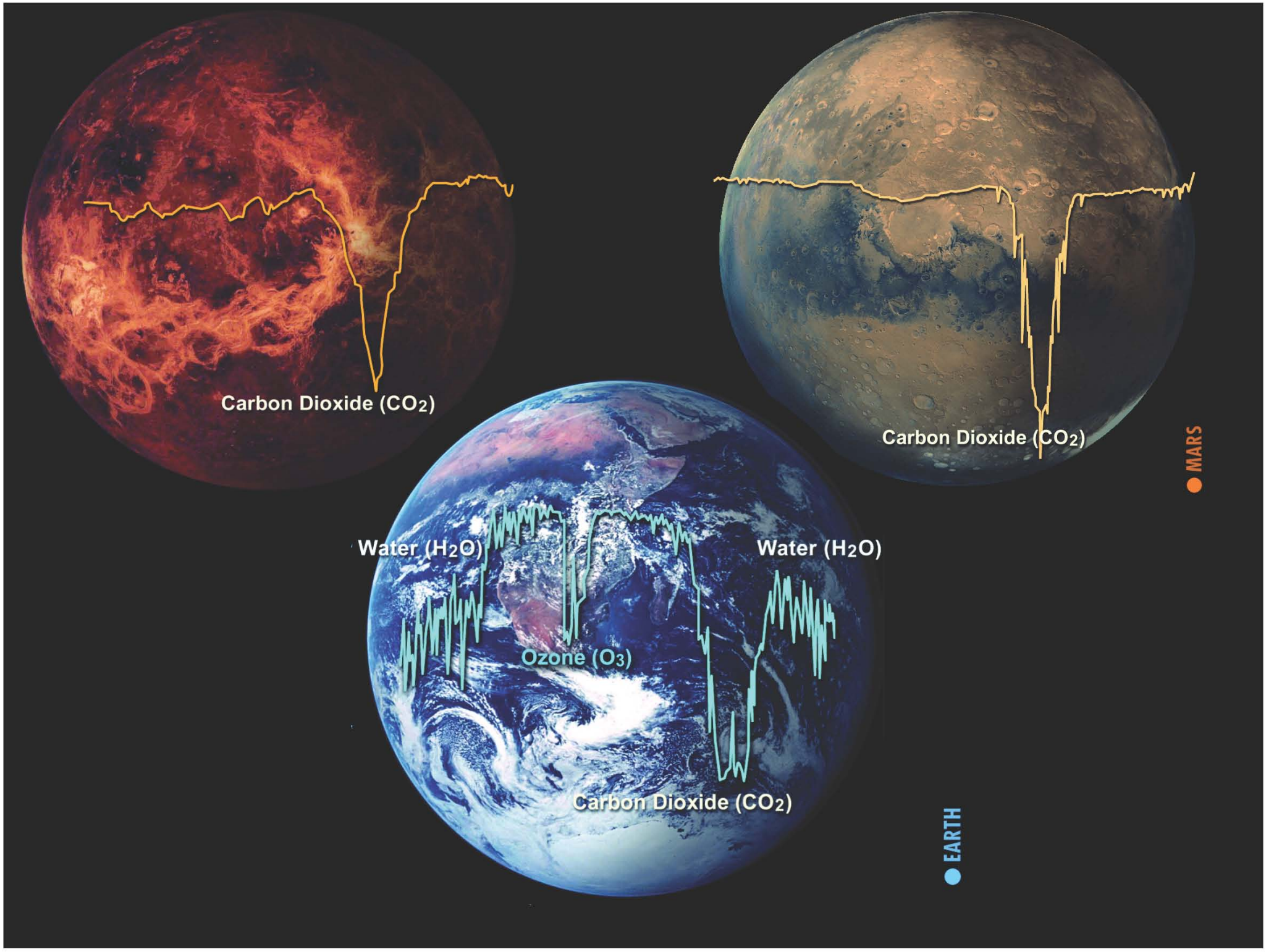


Two open questions (among many) motivate these extremely large telescopes

- Models of galaxy evolution indicate that the “first stars” in the earliest galaxies started shining when the universe was only 200-500 million years old:
  - Beyond the reach of present-day telescopes
  - How can we observe the “end of the dark ages”?
- If Earth-like planets are commonplace, is life also widespread?

Why will the GMT be so large?

- The first stars in the earliest galaxies started shining when the universe was 200-500 million years old:
  - Just beyond the reach of present-day telescopes
  - Will be accessible with the GMT
- The atmospheres of Earth-like planets will be searched for "bio-markers":
  - Oxygen (and ozone) are products of life
  - We are designing an instrument for the GMT intended to study the atmospheres of nearby exoplanets


Carbon Dioxide (CO_2)
Carbon Dioxide (CO_2)
MARS
Water (H_2O)
Ozone (O_3)
Water (H_2O)
Carbon Dioxide (CO_2)
EARTH

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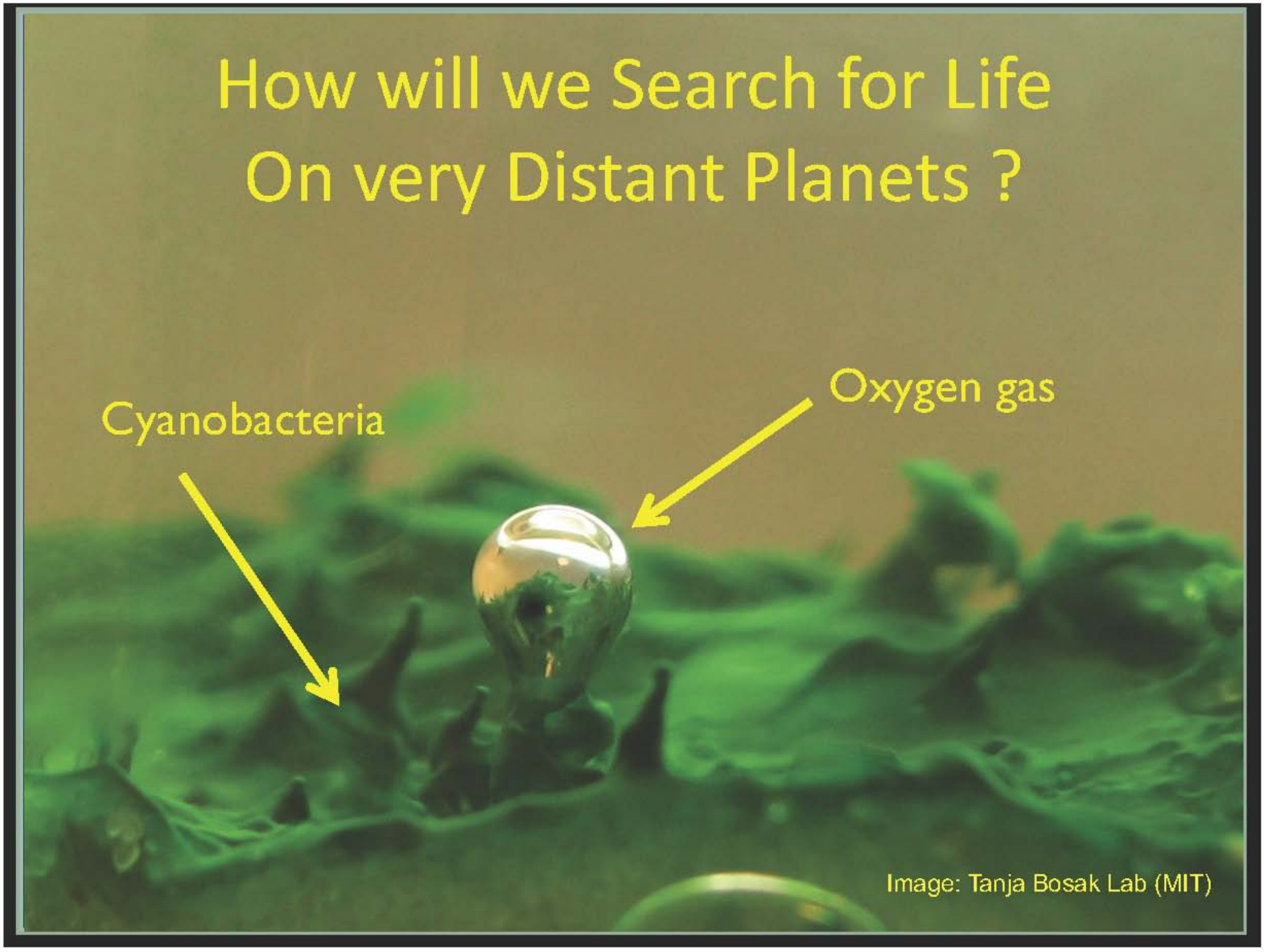
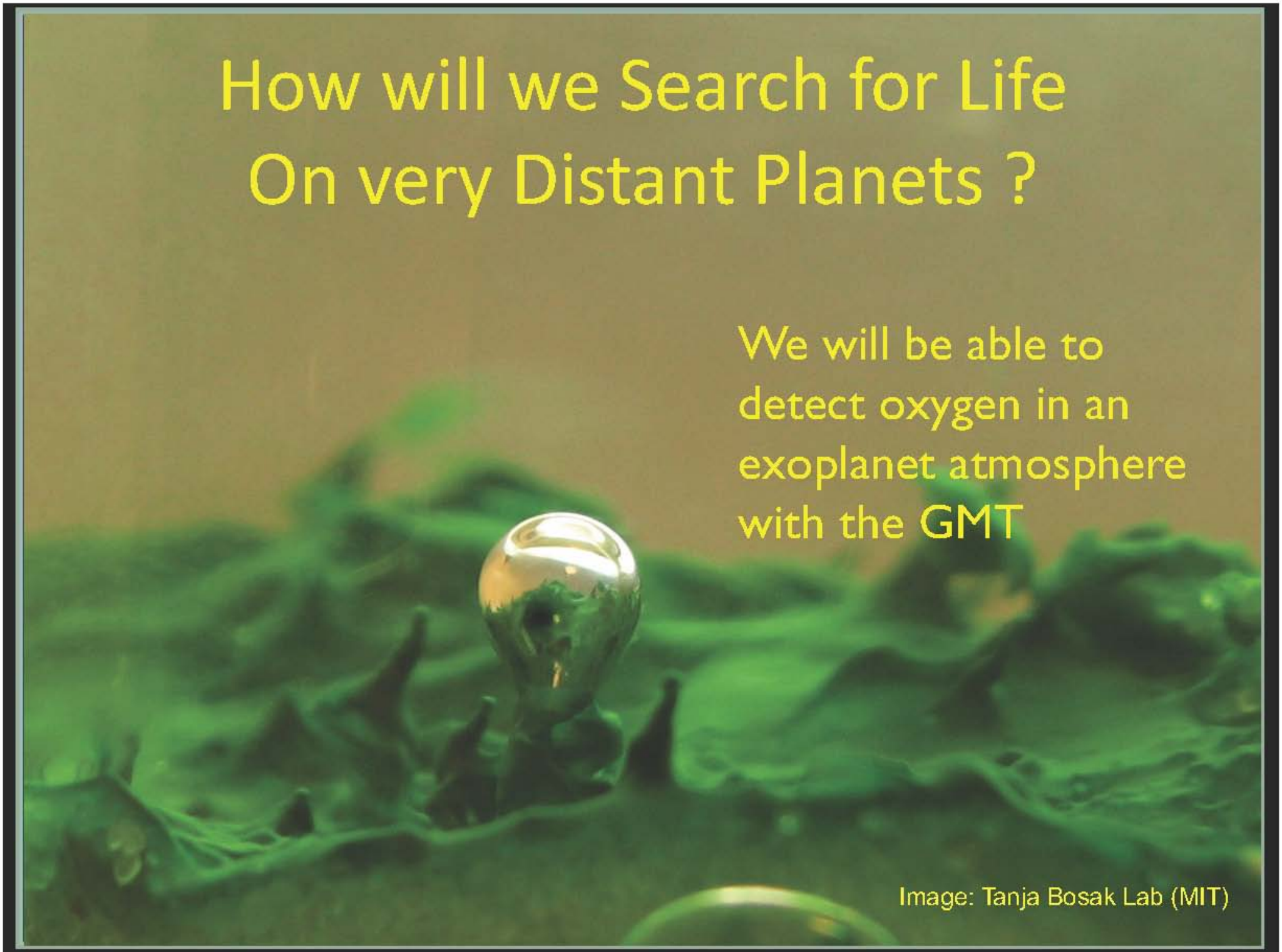

How will we Search for Life
On very Distant Planets ?
Cyanobacteria
Oxygen gas
Image: Tanja Bosak Lab (MIT)

How will we Search for Life On very Distant Planets ?

We will be able to detect oxygen in an exoplanet atmosphere with the GMT



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How will we Search for Life On very Distant Planets ?

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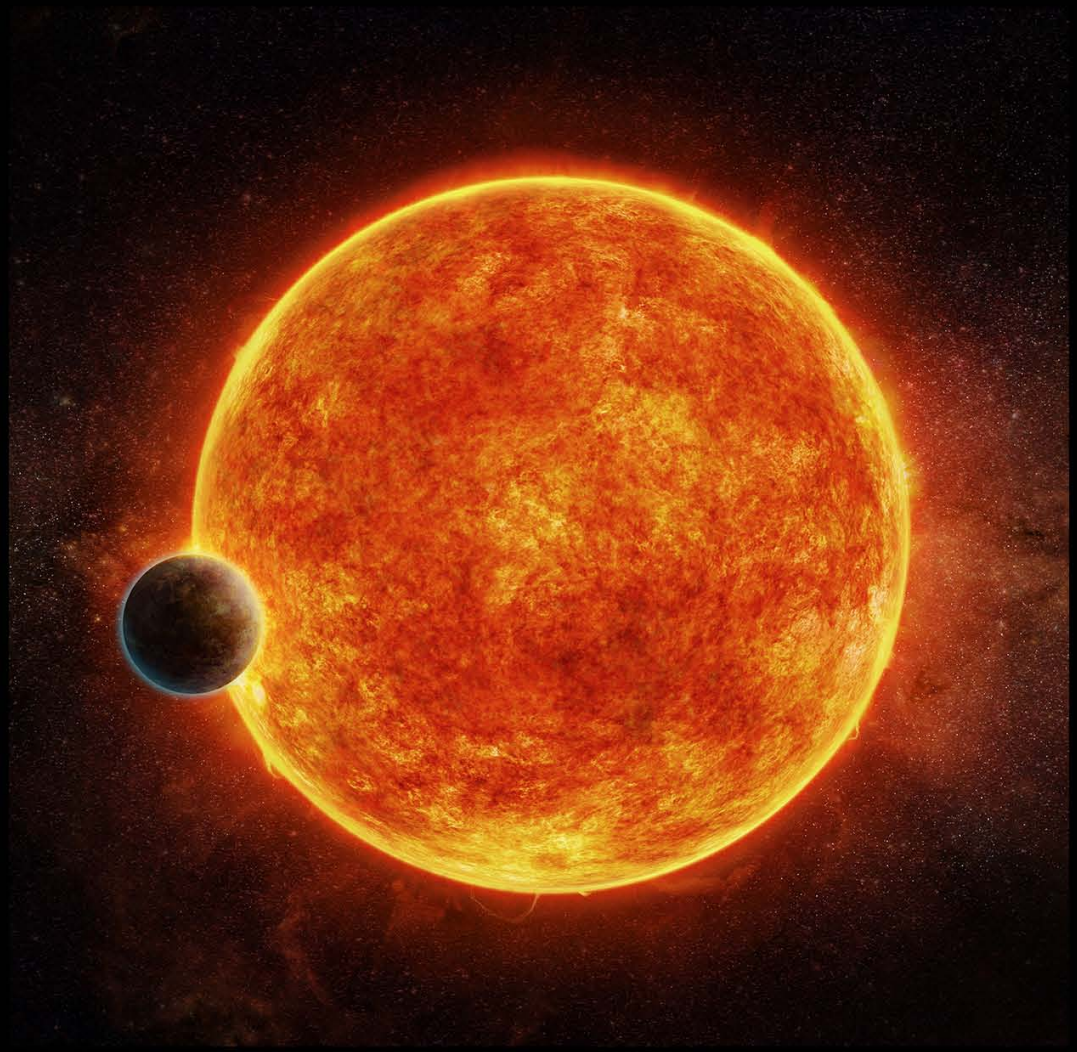

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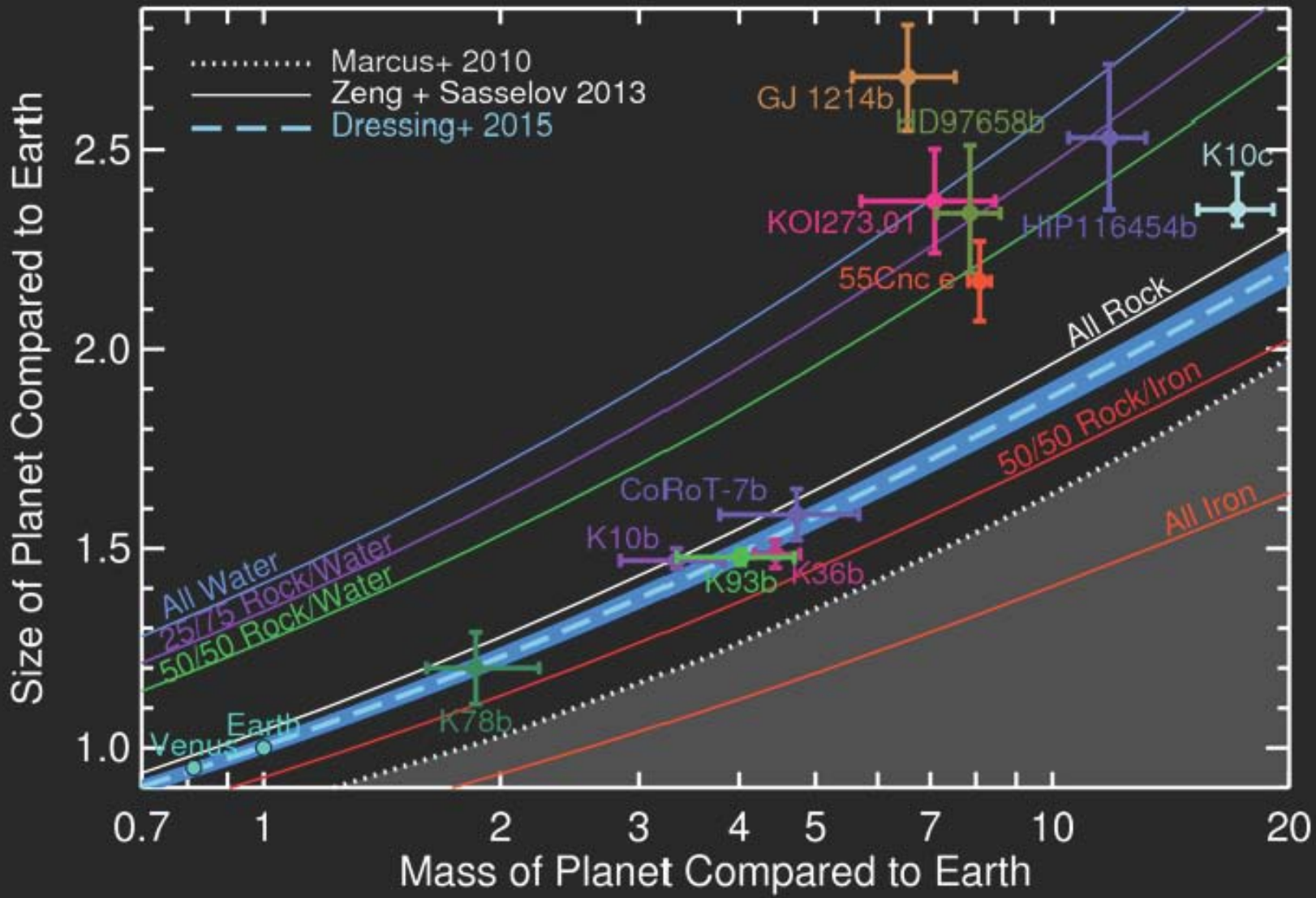

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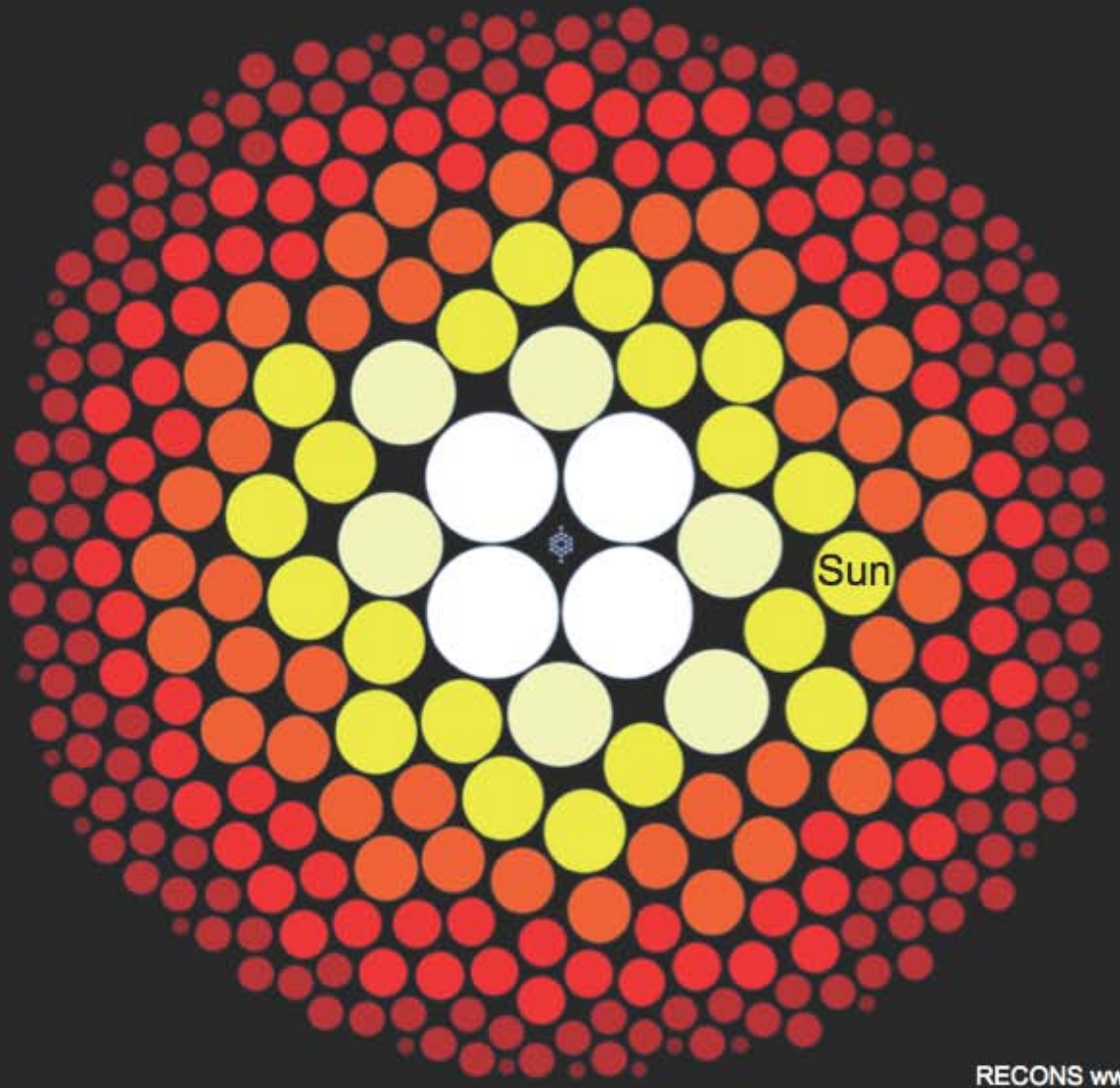
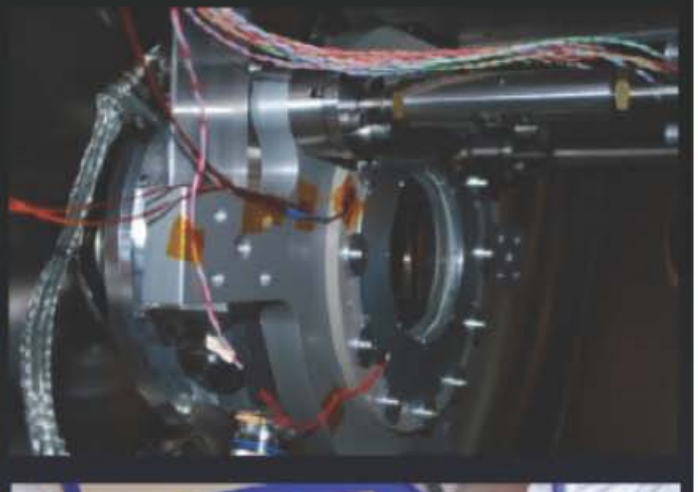


RECONS www.recons.org

How will we Search for Life On very Distant Planets ?

HARPS-N



Consortium

Geneva Observatory (Head),

CfA, Harvard University.

INAF-TNG,

University of St. Andrews,

University of Edinburgh,

Queens University Belfast

How will we Search for Life On very Distant Planets ?

- Trappist 1:
  - Seven temperate transiting planets
- Proxima Cen b
  - Non-transiting; nearest to us
- LHS 1140
  - Found by MEarth survey

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- All three orbit M dwarf stars

How will we Search for Life On very Distant Planets ?

- Trappist 1:
- Proxima Cen b
- LHS 1140
  - Good candidate for search for atmospheric O_2
- All three orbit M dwarf stars
  - Most common stars in the solar neighborhood
  - Relatively small radius favors transit spectroscopy
  - Habitable zone relatively close to the star

How will we Search for Life On very Distant Planets ?

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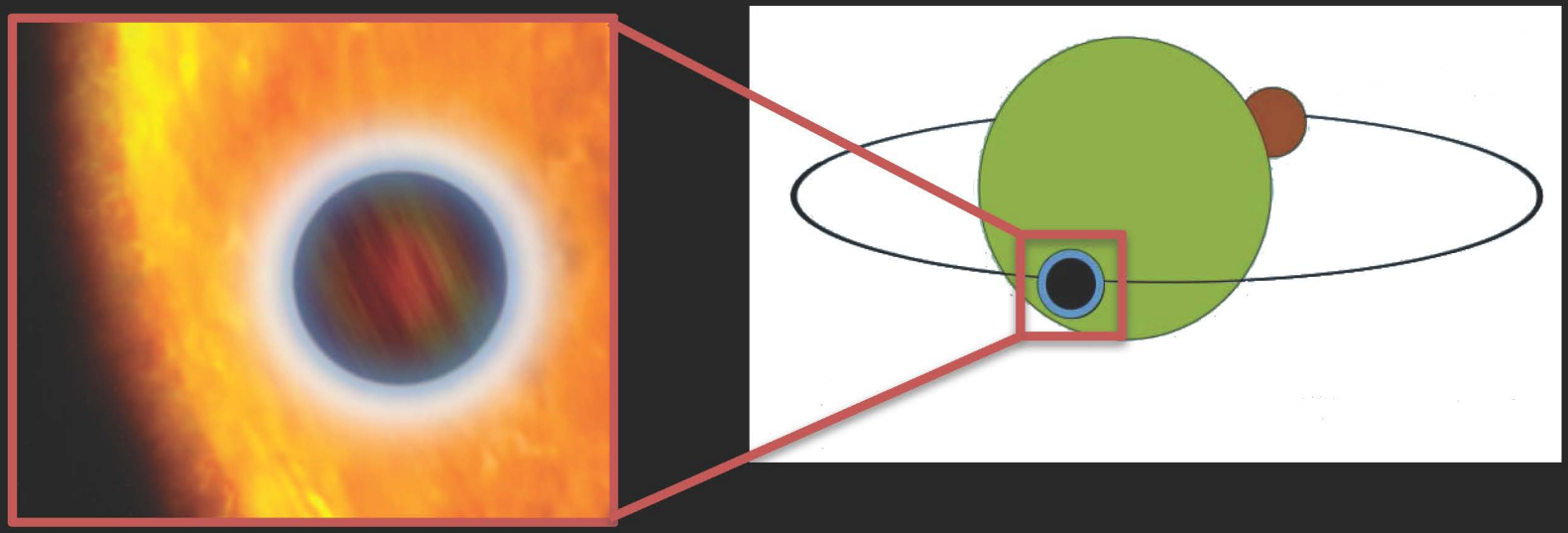

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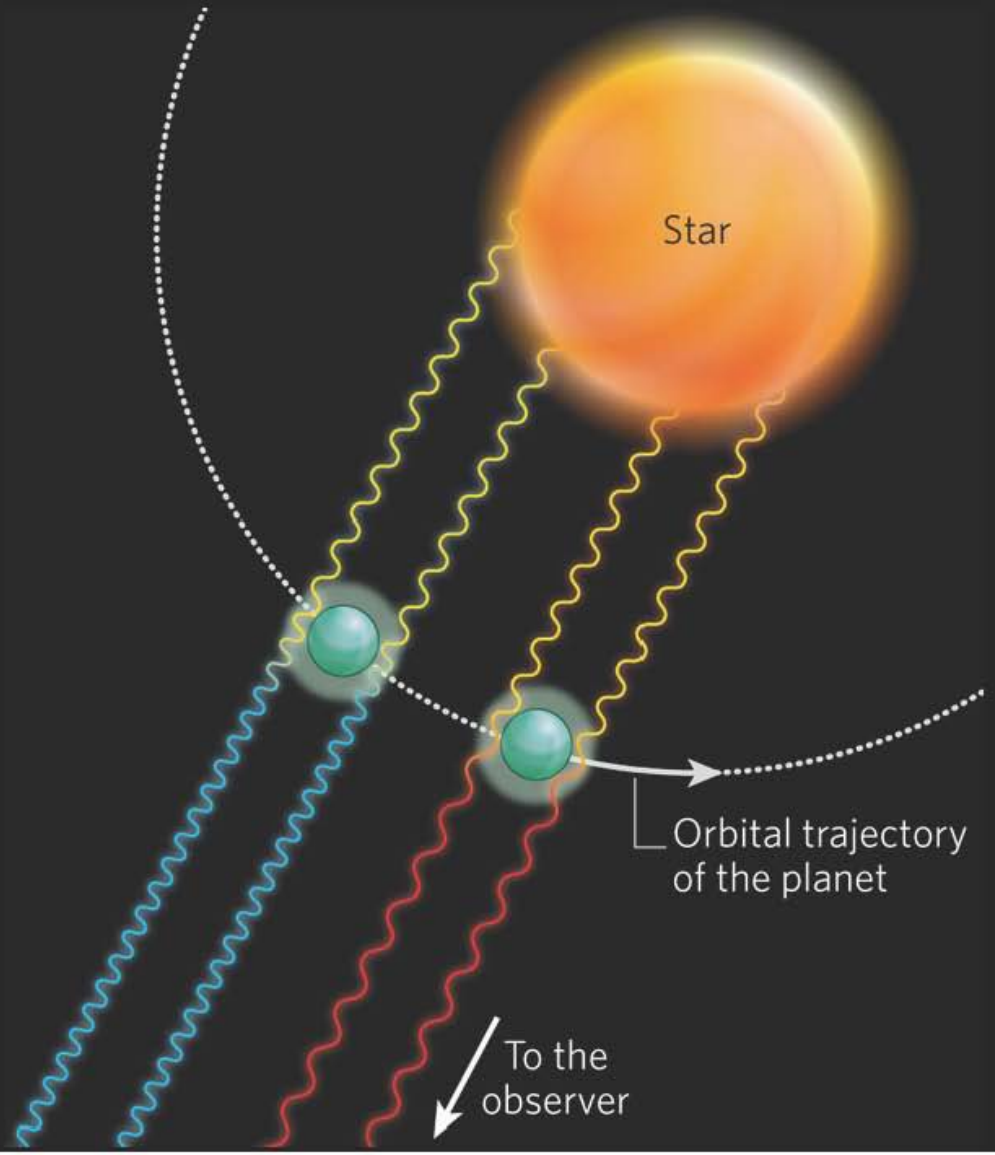

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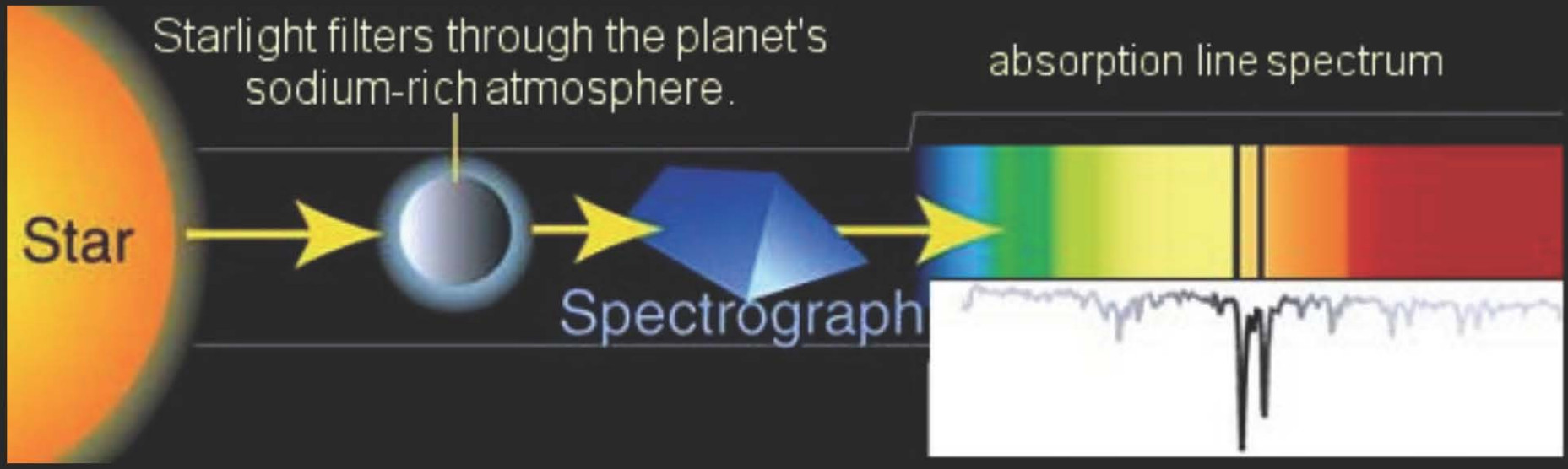

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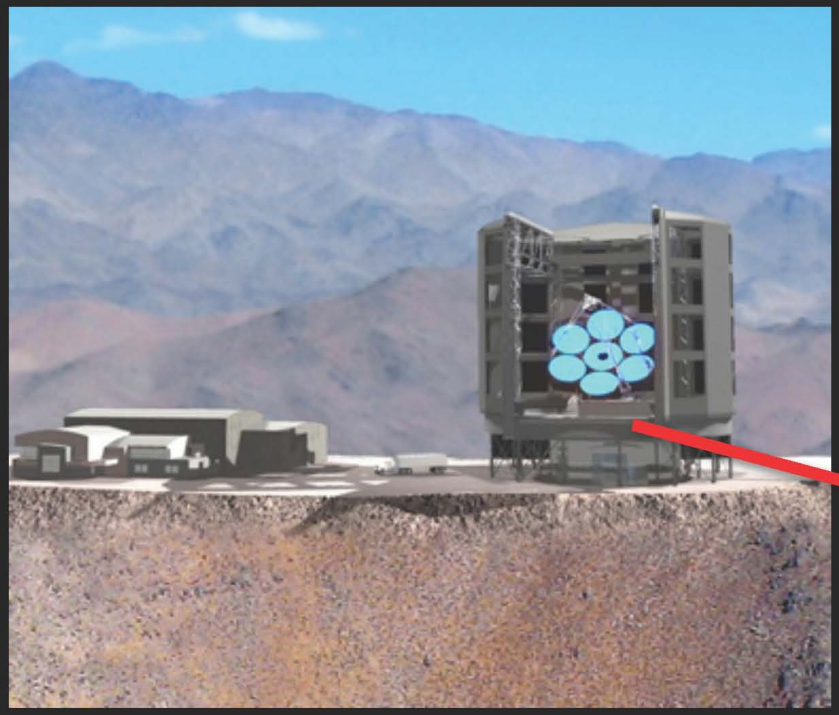
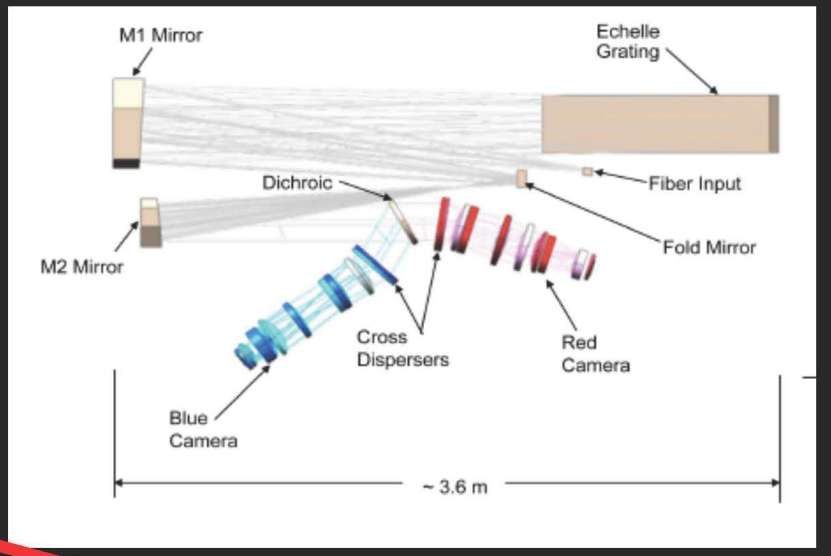
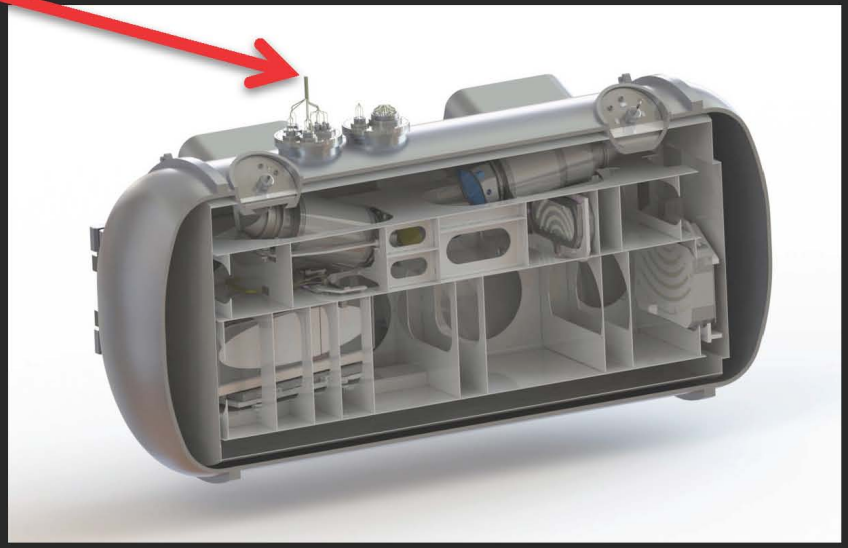
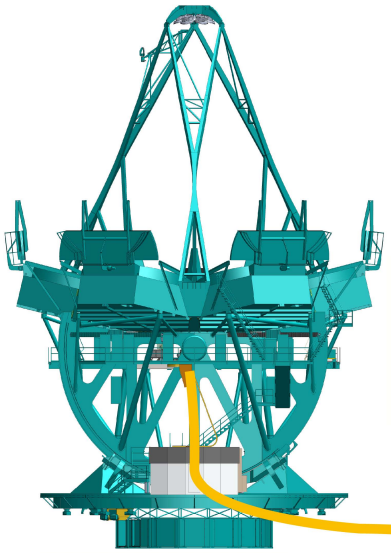








GMT (Not to scale)

Optical Fiber

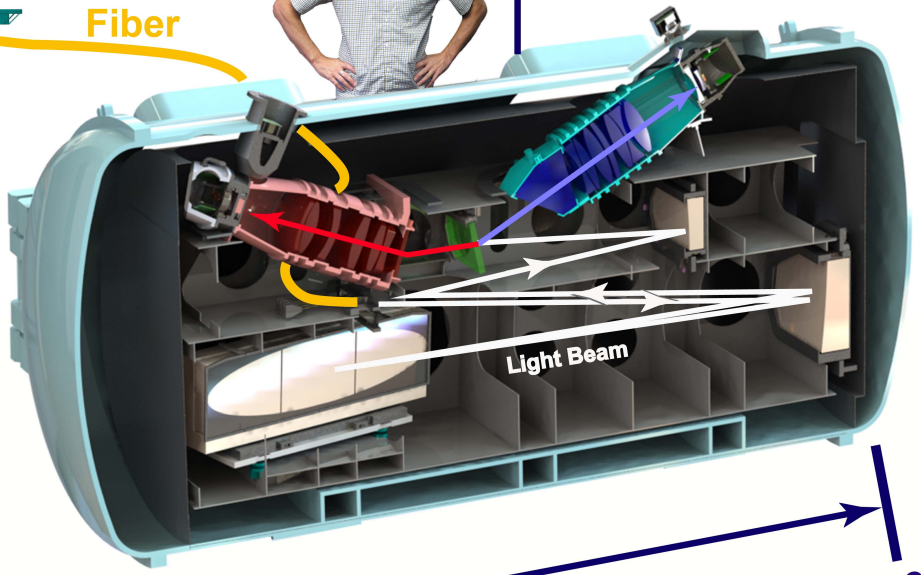
Dave Charbonneau

1.9 meters

1.7 meters

1.5 meters

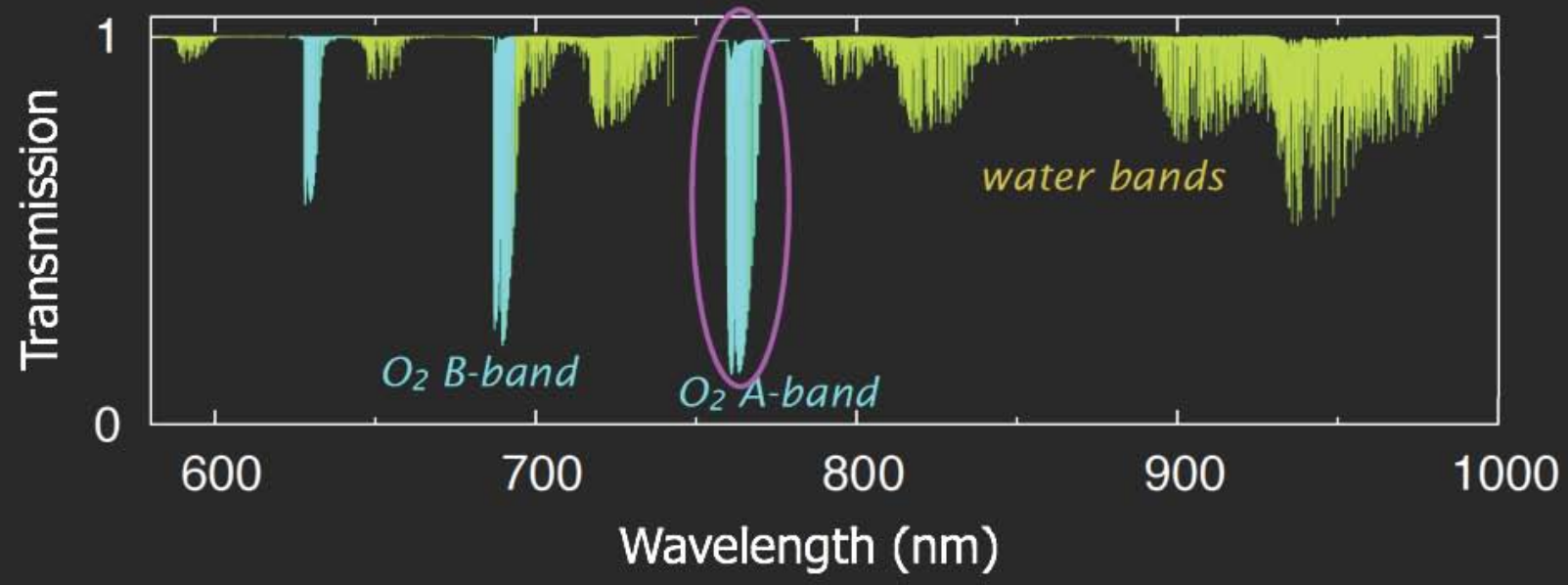
Mercedes Lopez-Morales



Elisabeth Newton

4.3 meters

How will we Search for Life On very Distant Planets ?



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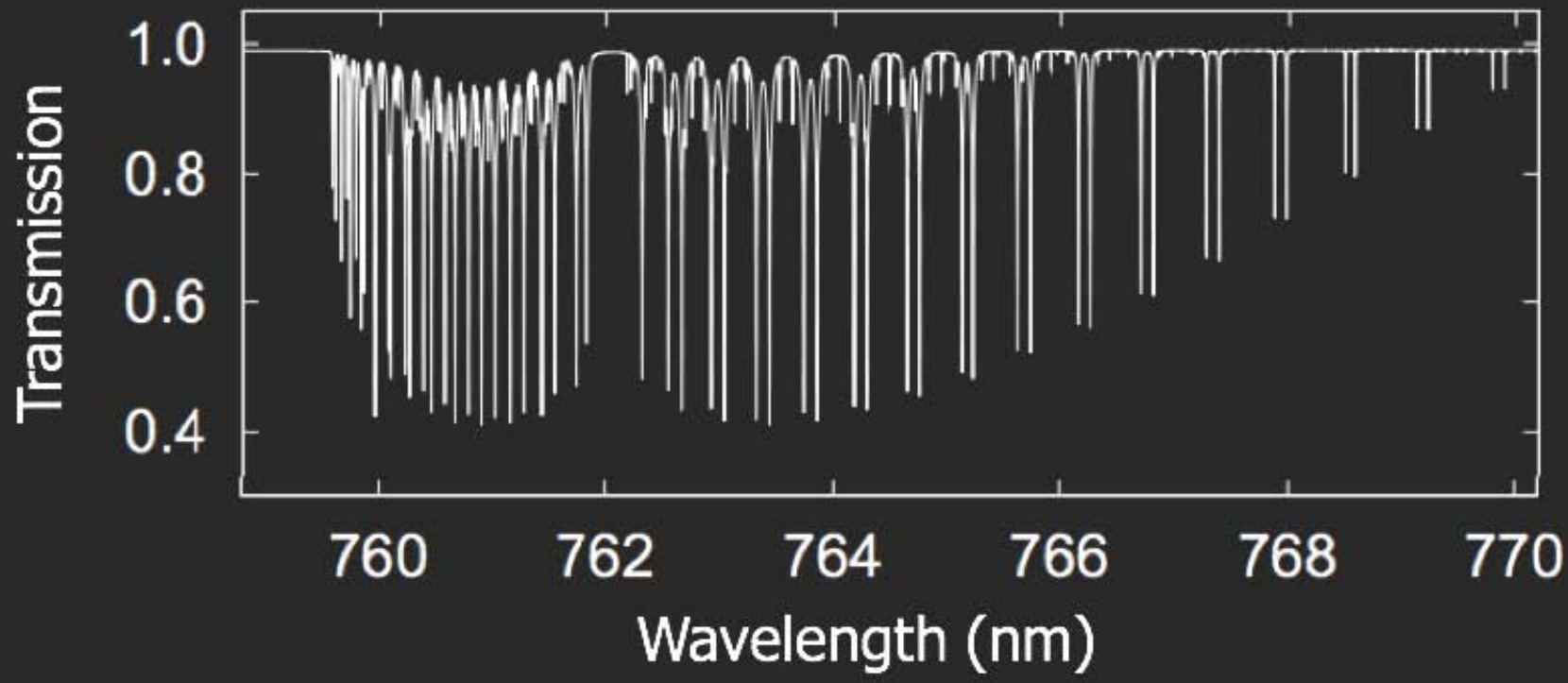

Why will the GMT be located in Chile?

- Excellent atmospheric conditions: dry, laminar
- Very dark skies, far from cities and towns
- Well-educated local population from which to recruit technical staff
- Very good legal and political environment for astronomical telescopes
- Great synergy with other international observatories

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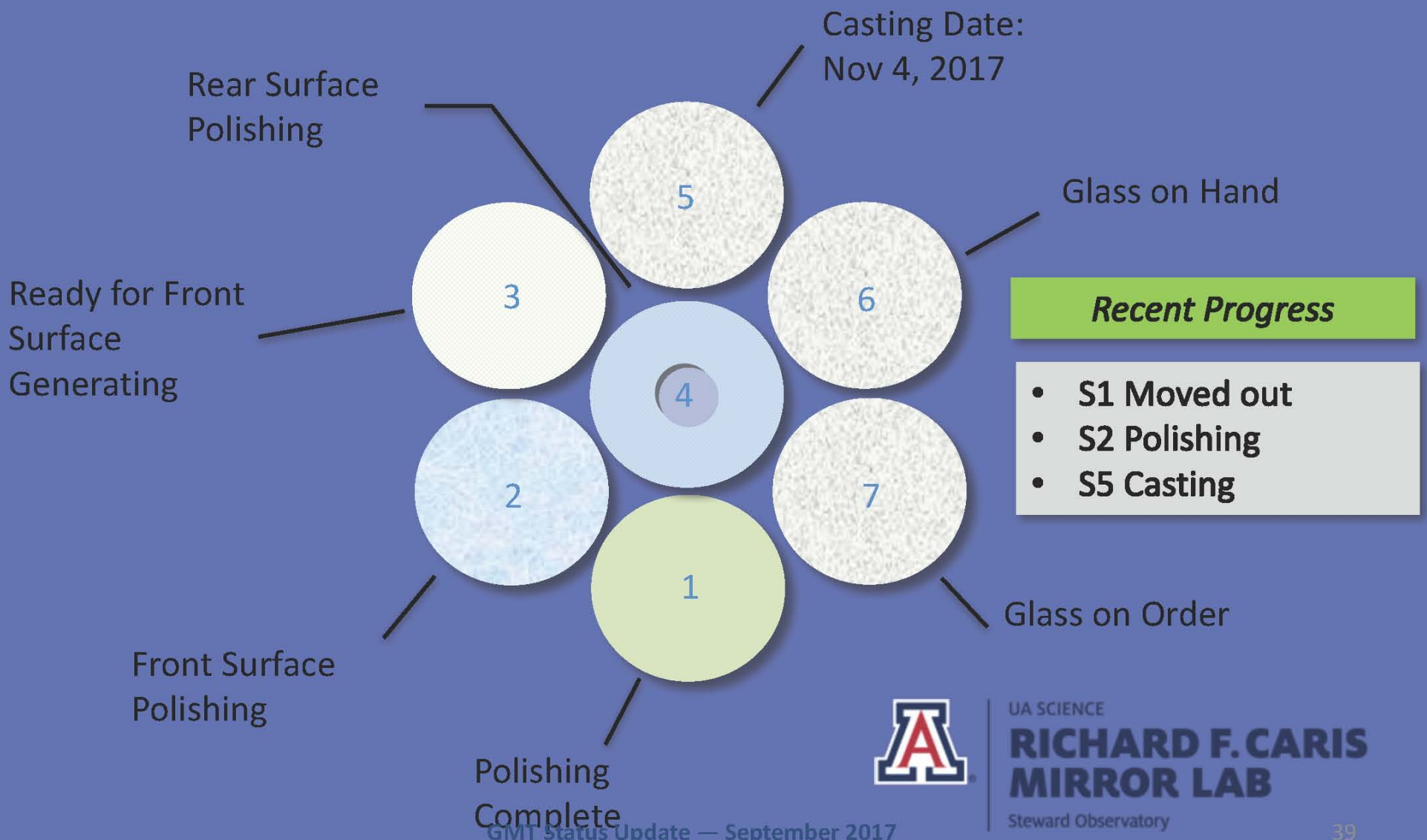
Bajo
Huasco
Vallenar
Sarco
▲19,127 ft.
Cerro del Potro
El Tránsito
Domeyko
GMT
El Tofo
La Serena
Coquimbo
Guanta
Cerro de las Tórtolas
▲20,735 ft.
Vicuña
Punta Lenga de Vaca
Pichasca
Ovalle
Samo Alto
IV
Punitaqui
Caleta Teniente
Canela Alta
Combarbalá
Mincha
Illapel

Primary Mirror Production



Recent Progress

- **S1 Moved out**
- **S2 Polishing**
- **S5 Casting**

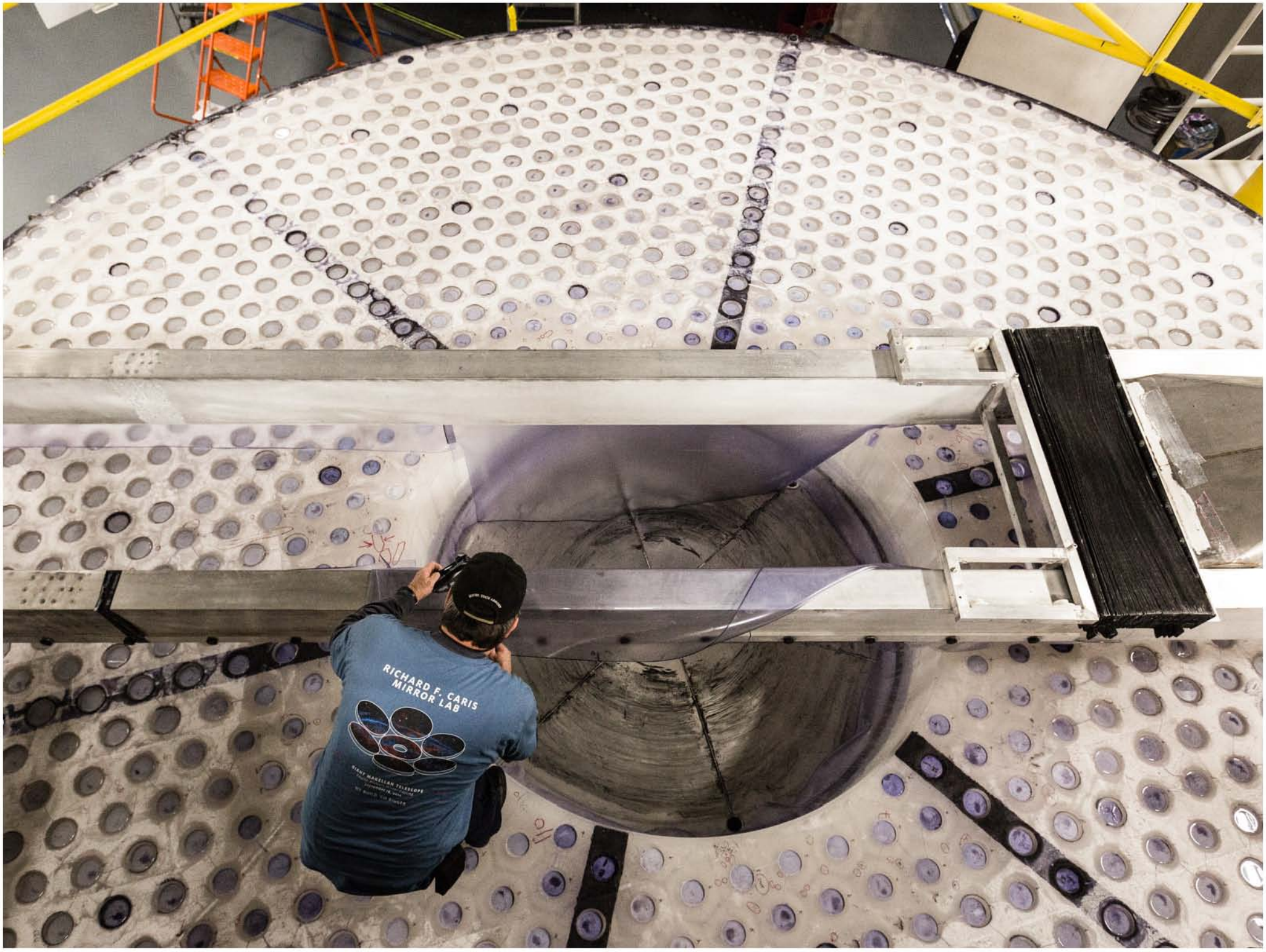
UA SCIENCE
RICHARD F. CARIS
MIRROR LAB
Steward Observatory


Mirror #1
Mirror #2


OVERSIZE LOAD
GIANT MAGELLAN TELESCOPE

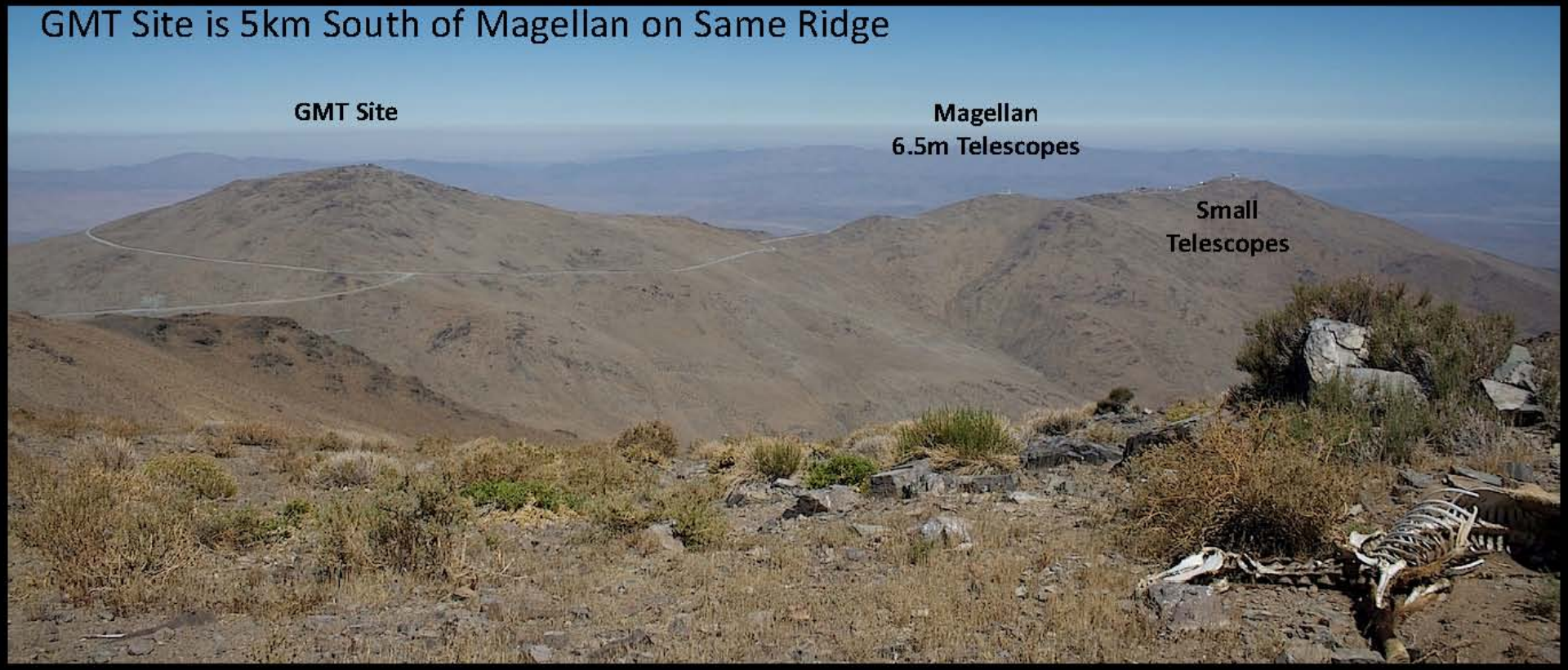
Photo: Ray Bertram


RICHARD F. CARIS
MIRROR LAB
LPM
GMT

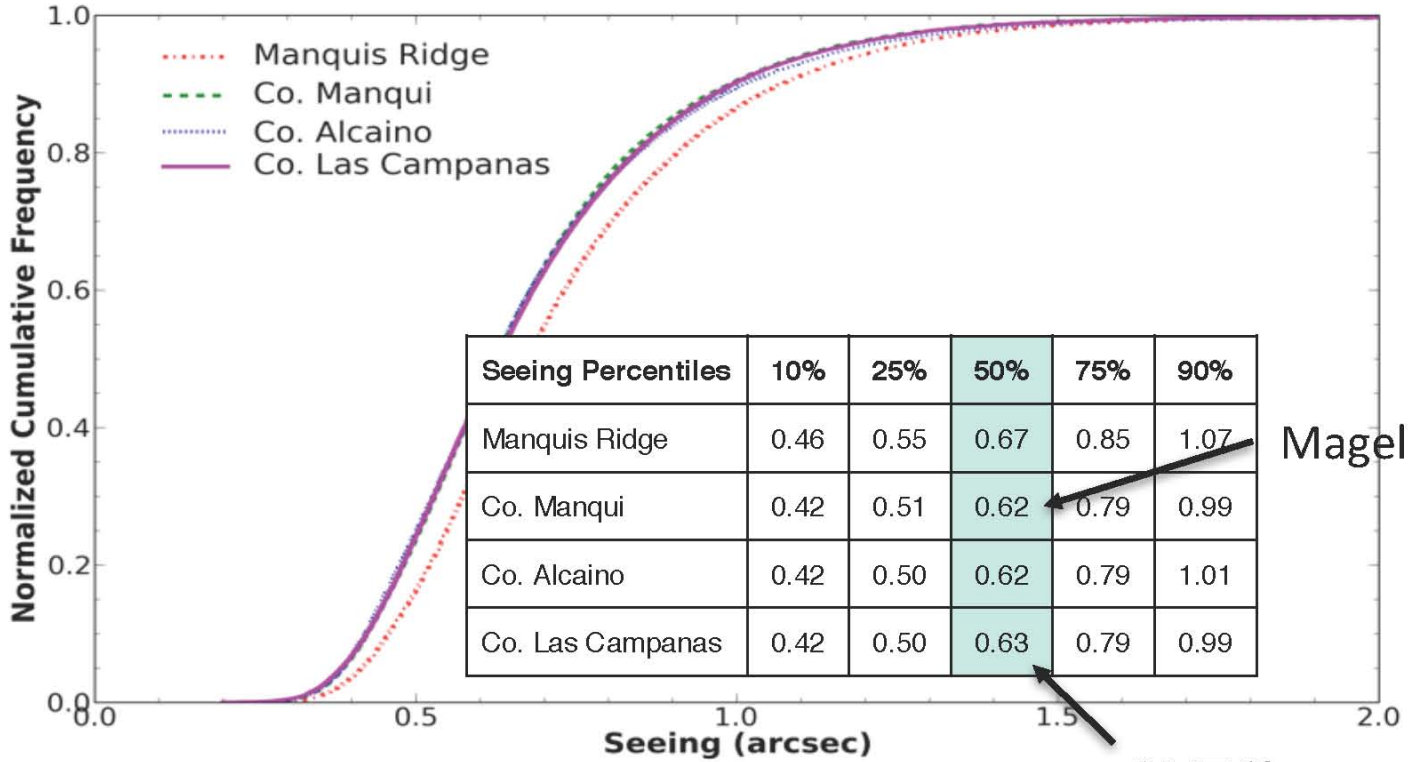

RICHARD F. CARIS
MIRROR LAB


45T
KONECRANES
GMT
OHARA
RICHARD F. CARIS
MIRROR LAB
ARIZONA

Las Campanas Observatory



- MASS/DIMM site testing from 1990-95 and 2005-2010
- *No evidence that seeing has evolved over 20+ years*
- ***Median seeing at GMT site is 0.63 arcseconds in the 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

Magellan Site

GMT Site


Warehouse / M1 Factory /
M2 Metrology
Summit Support
Building
Summit Utility Building
Enclosure


Summit
Warehouse / M1 Factory /
M2 Metrology
Main Access Road
Support Site Loop Road
Residence

Thank you!
And Good Luck!