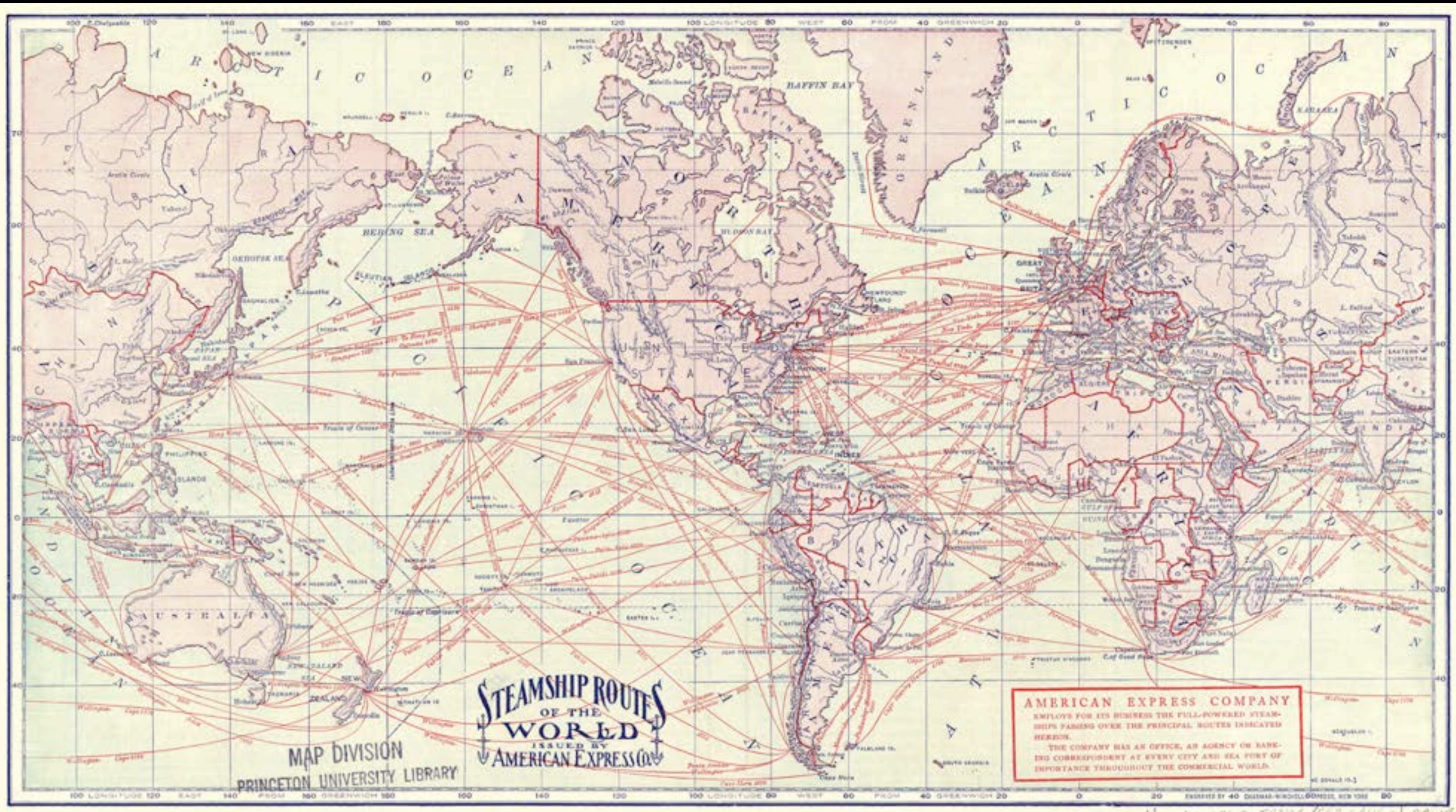
Thirty-Meter Telescope: Science, Technology and People

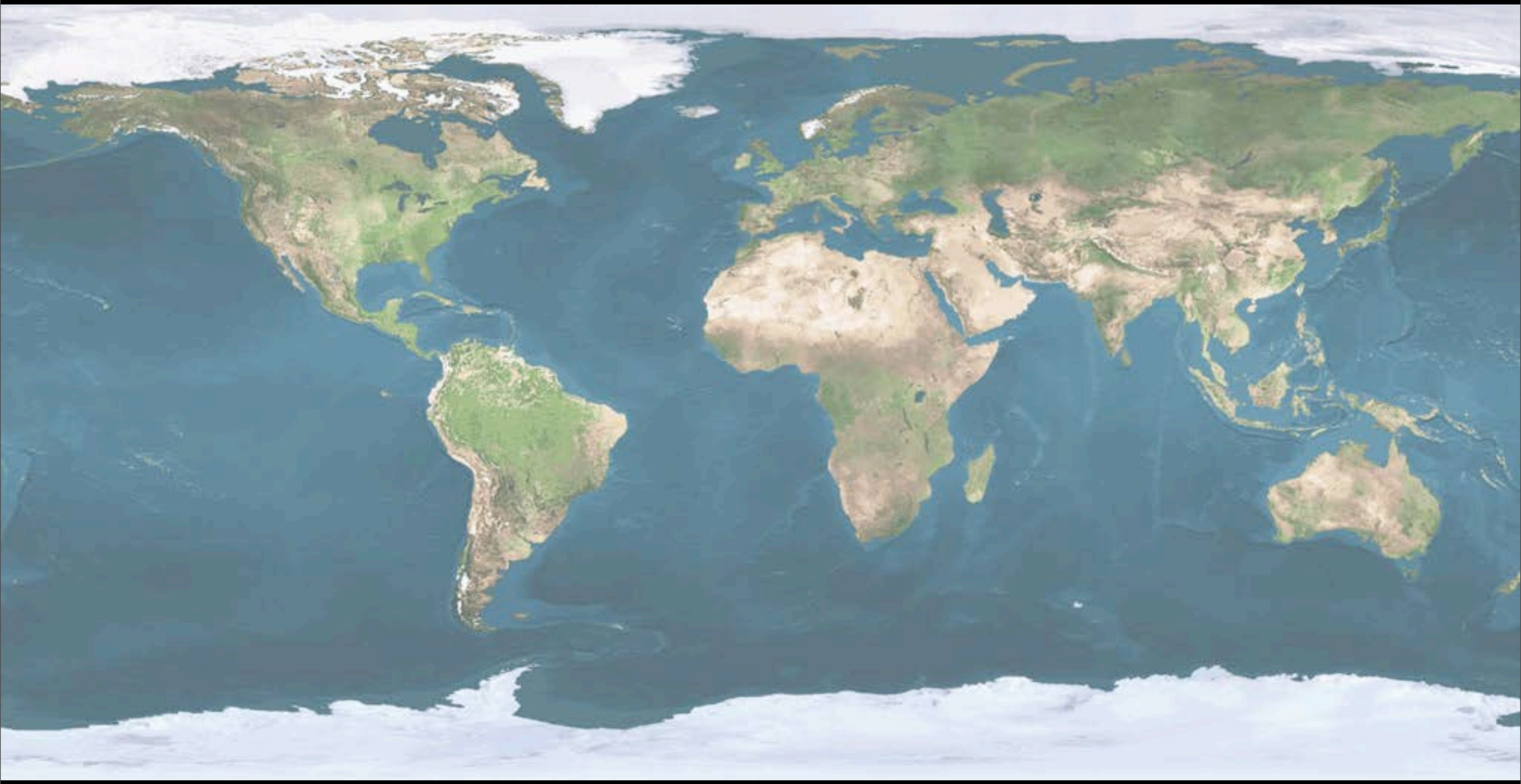
Luc Simard

National Research Council of Canada / University of Victoria

Fra Mauro World Map (1459)



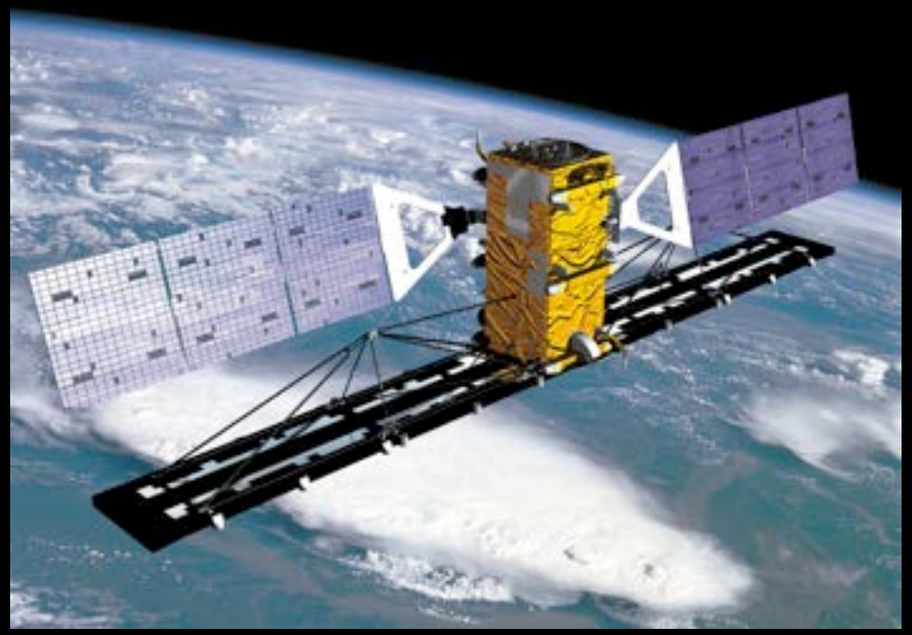
World Map
(1900)



World Map
(2012)

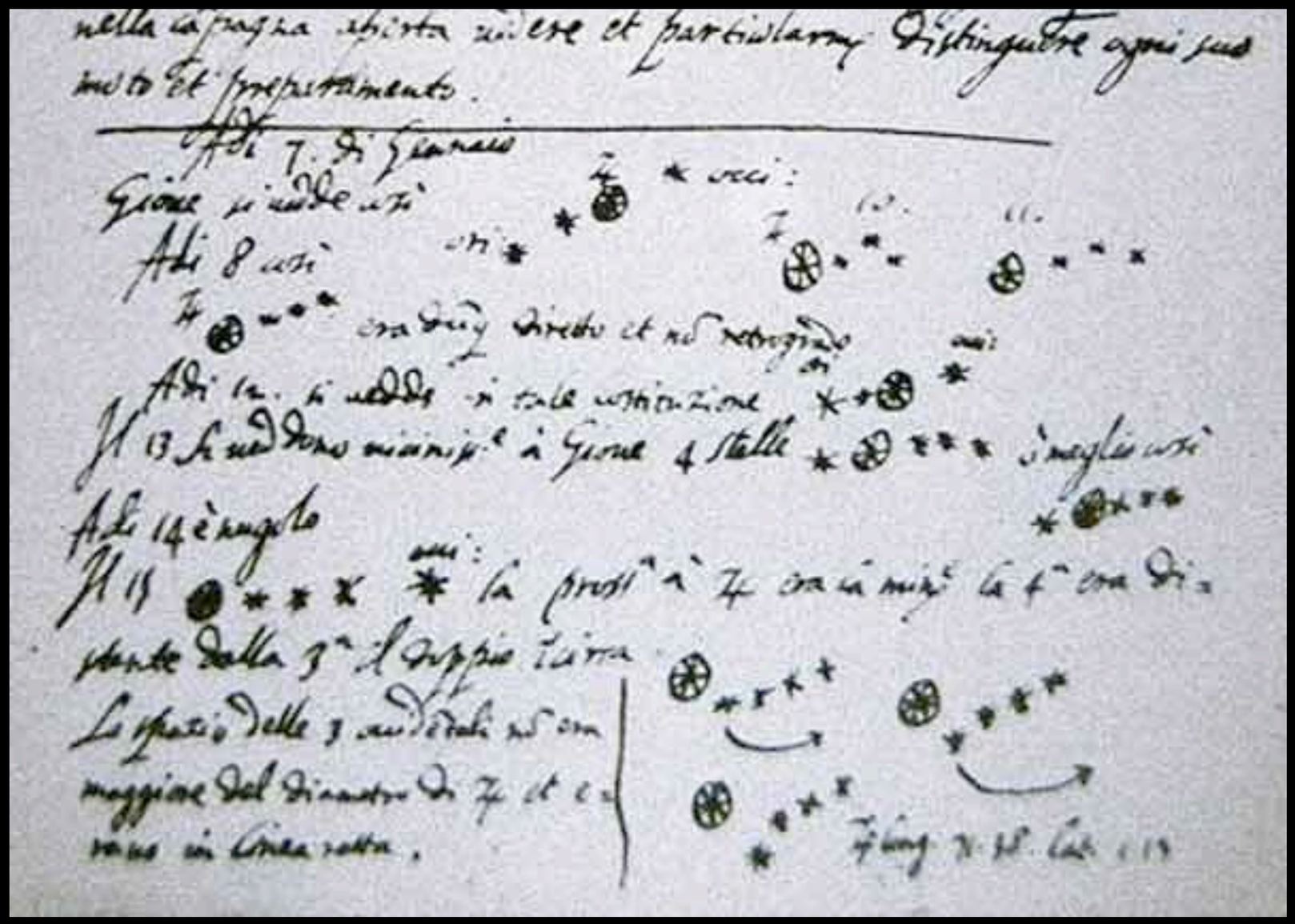
(+ continental drift ...)

?



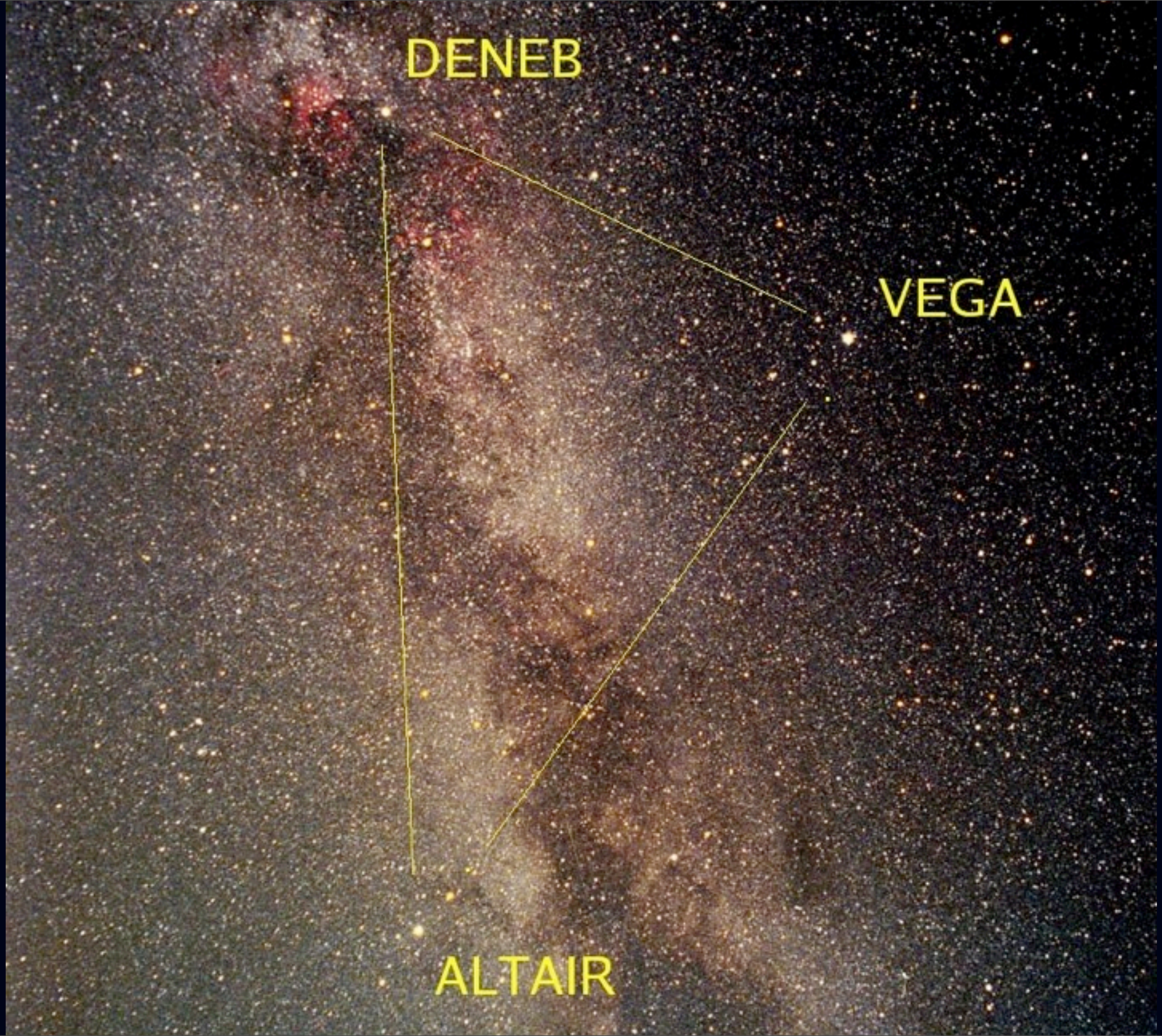
400 years ago!!

Galileo Galilei



Discovery of the Moons of Jupiter in Sidereus Nuncius

Gemini North Telescope


DENEB
VEGA
ALTAIR

The Large and Small Magellanic Clouds

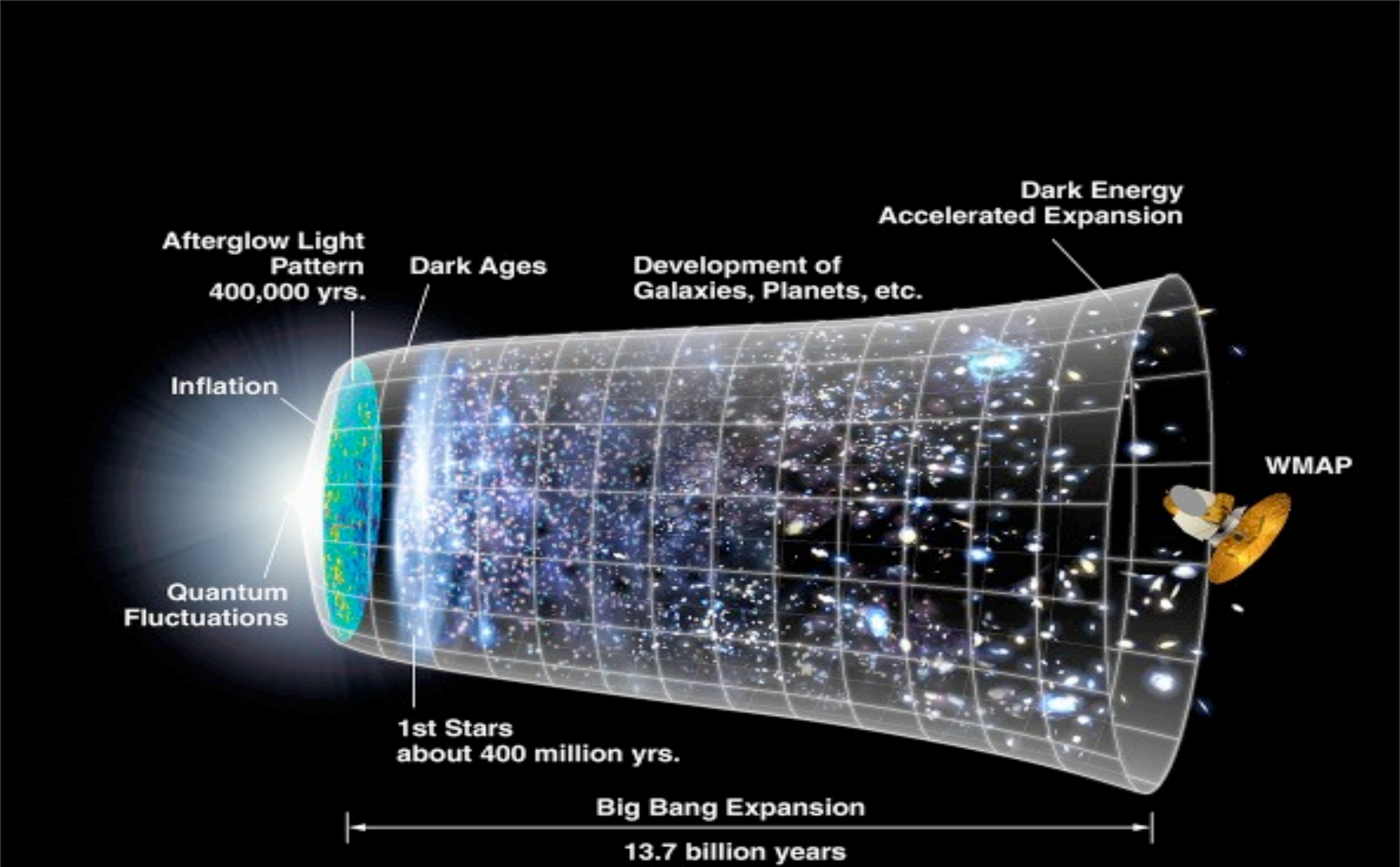
168,000 ly

Messier 31
Andromeda Galaxy
2.5 Mly

As far as telescopes can see ...

13.2 billion ly

Credit:
Gemini
Observatory

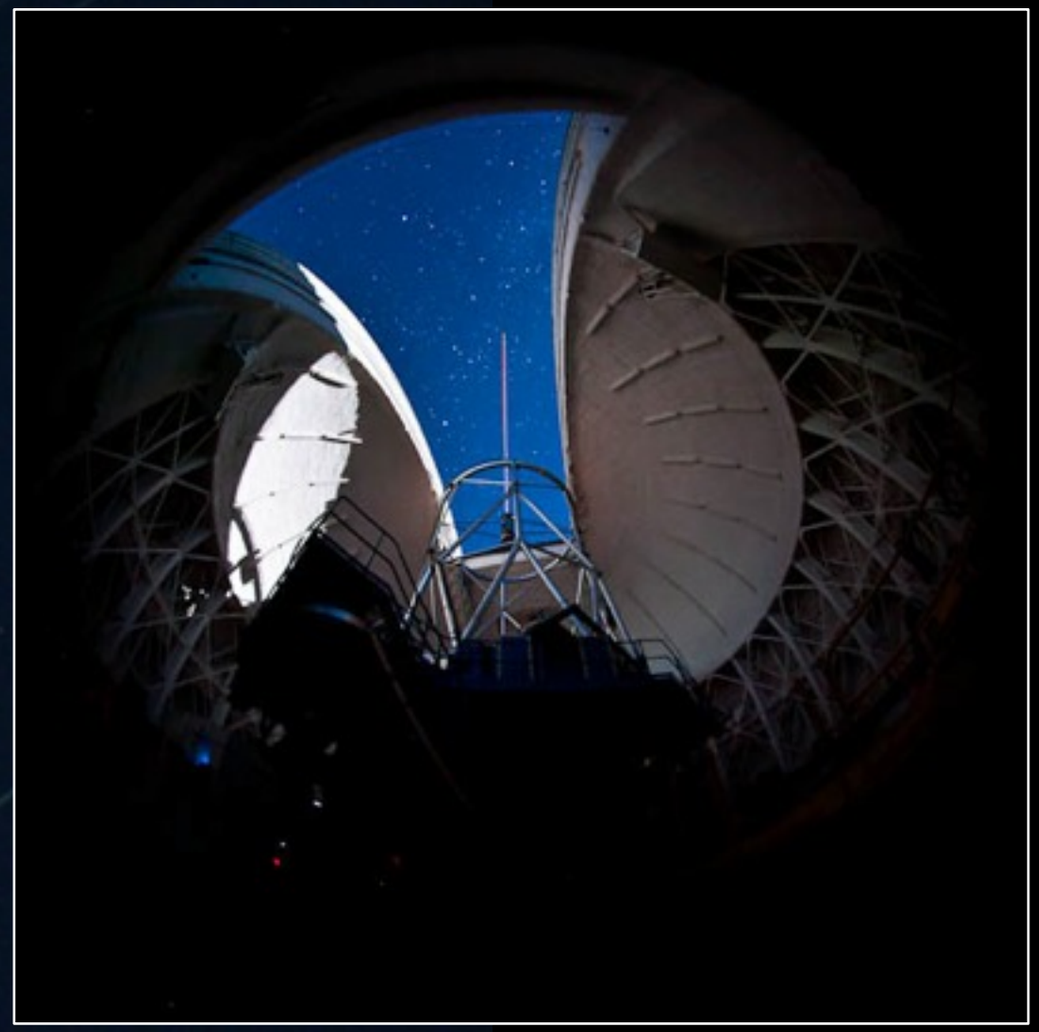

Dark Energy
Accelerated Expansion
Afterglow Light
Pattern
400,000 yrs.
Dark Ages
Development of
Galaxies, Planets, etc.
Inflation
WMAP
Quantum
Fluctuations
1st Stars
about 400 million yrs.
Big Bang Expansion
13.7 billion years

Goodbye Twinkle, Twinkle Little Star

VLT ACTIVE OPTICS

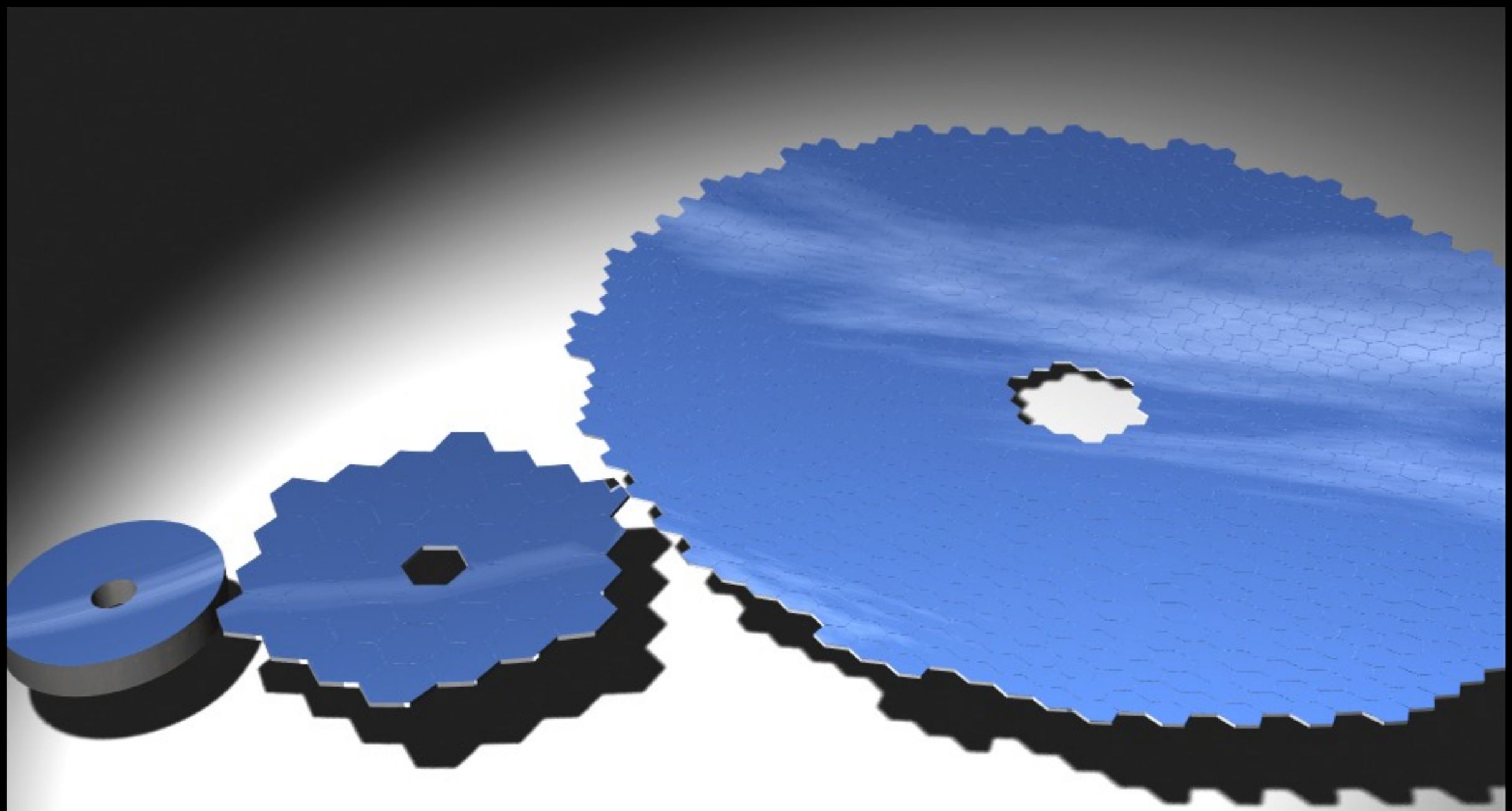
IMAGE CORRECTIONS

A New Constellation is Born!



Credit:
Gemini
Observatory

From Large to Extremely Large

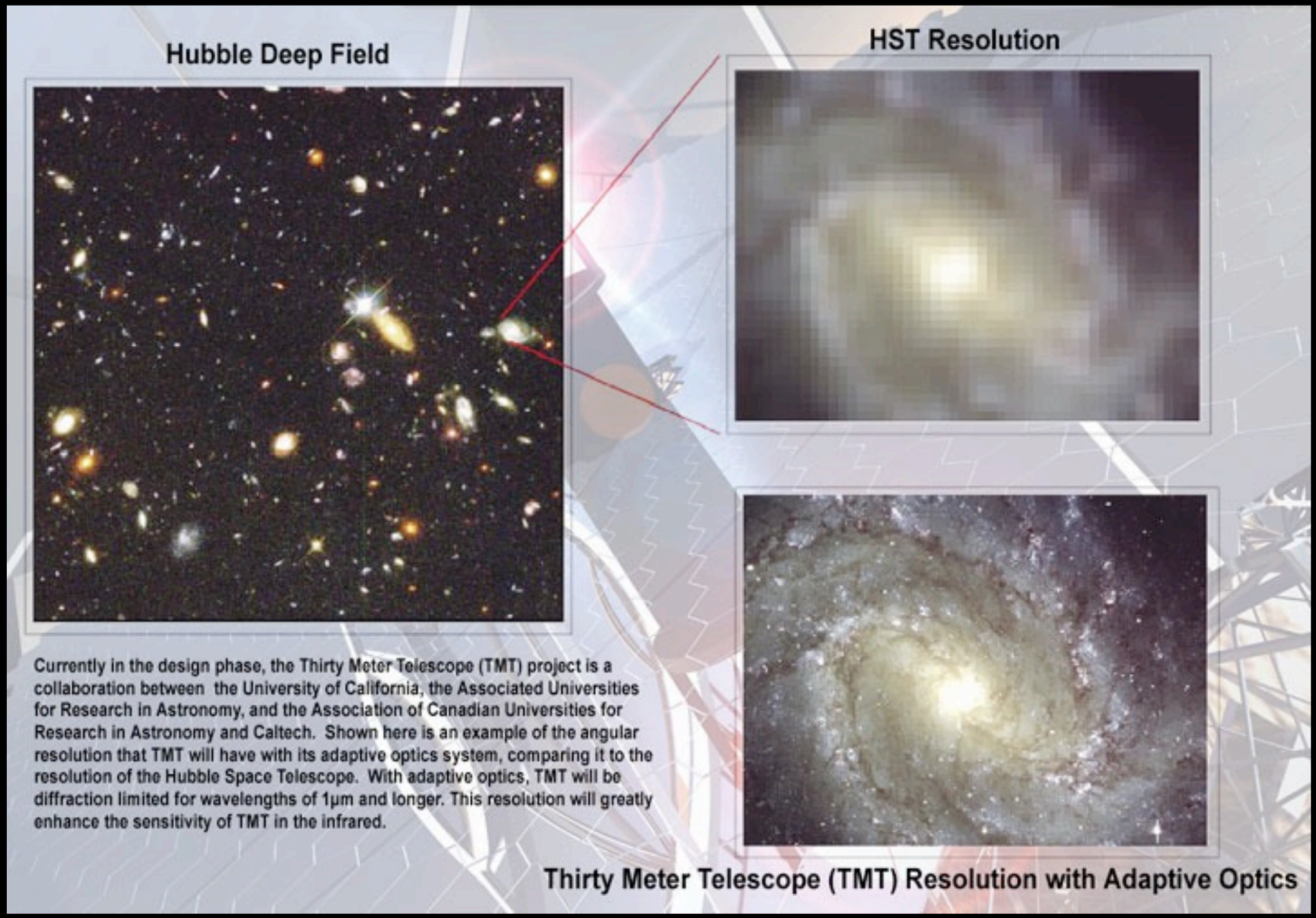


5 Meter
Hale 200-inch
Mirror

10 Meter
Keck
Mirror

30 Meter
TMT
Mirror

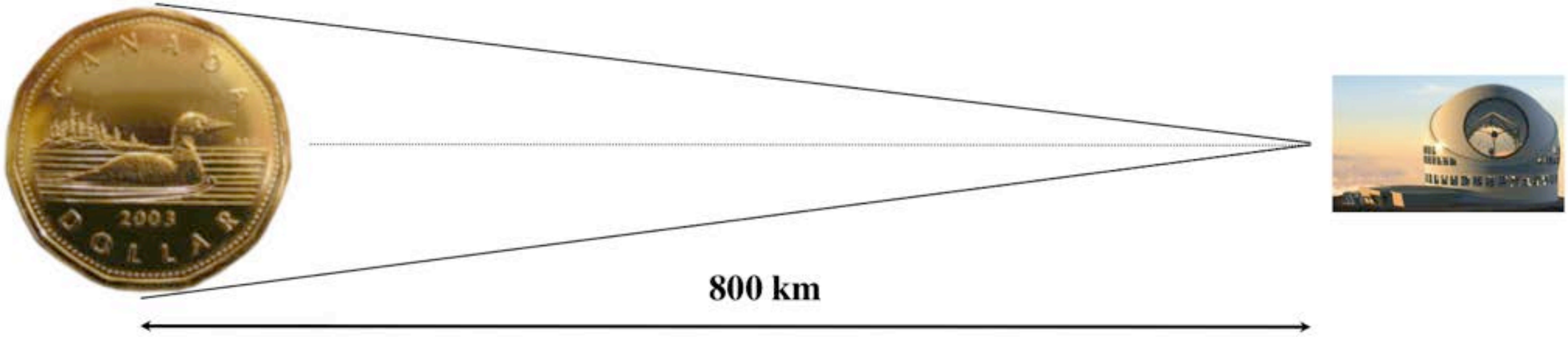
Amazingly Sharp Images



(Credit: Mike Bolte, UCO/Lick)

The Hubble Space Telescope is only 2.4 meters in diameter after all - TMT will have 10x its angular resolution

Seeing a Loonie from Really, Really Far Away



The distance between Victoria and Calgary is 730 km ...

Or a Tiny, Tiny Slice of the Moon

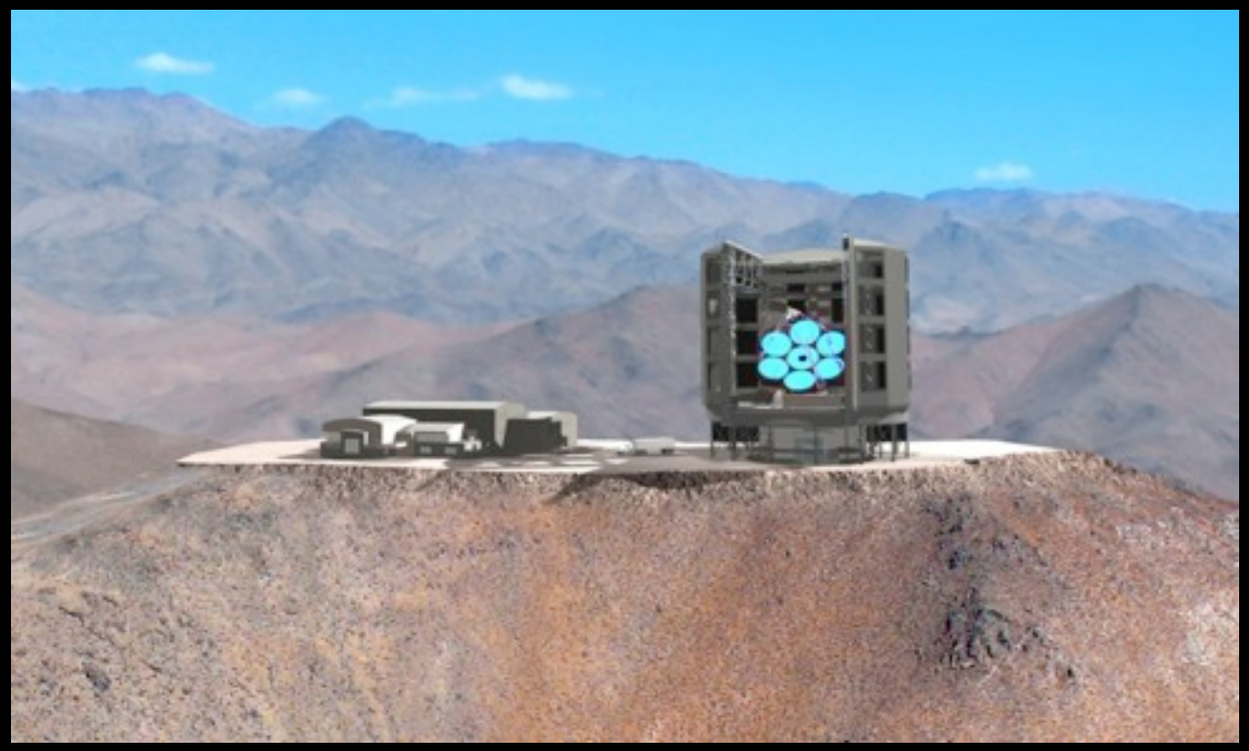
Divide the diameter of the Moon into two million parts ... TMT could see seven parts

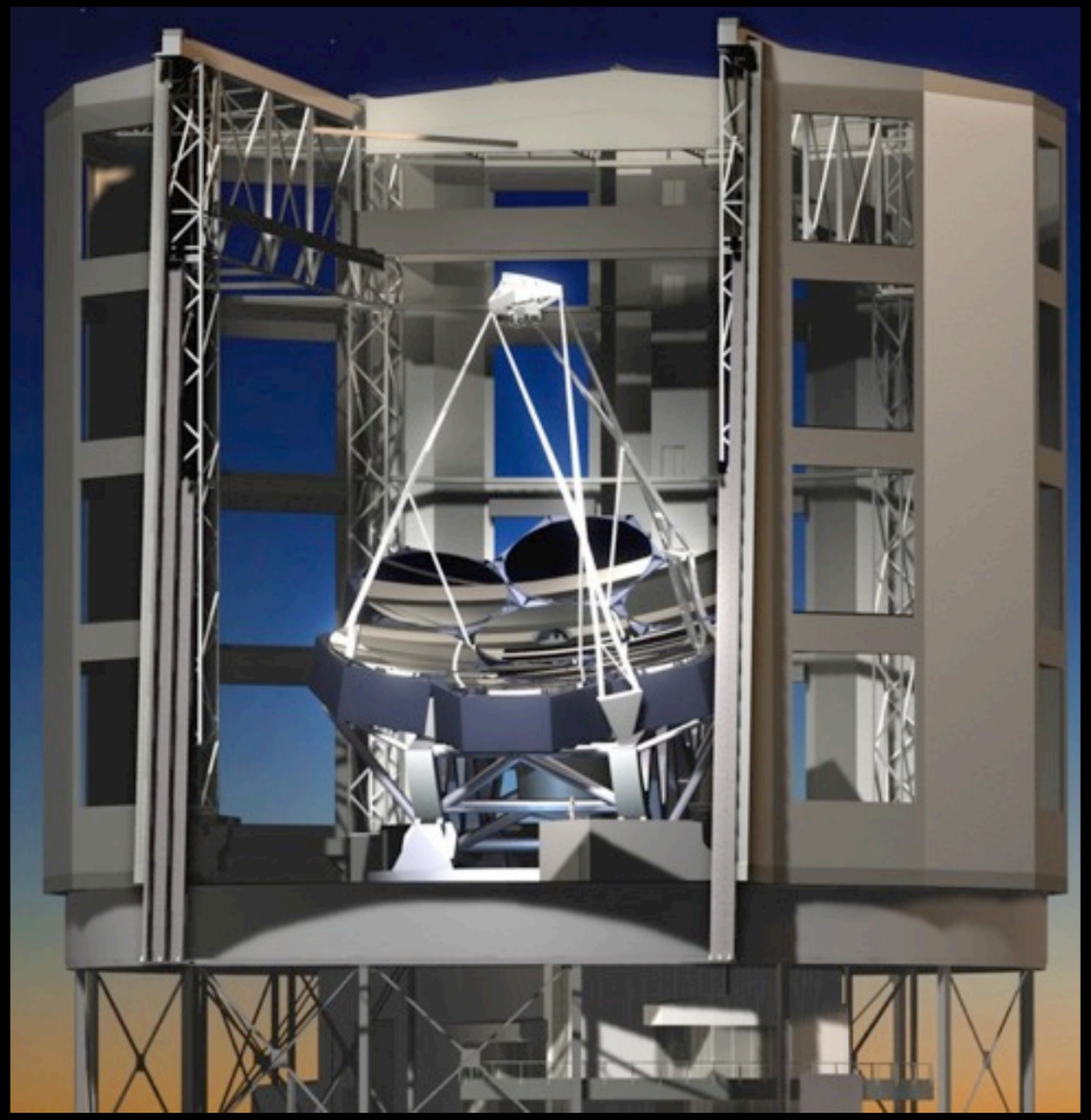
A Useful Measurement Unit for ELTs … The Boeing 747-8I

Wingspan of 68.5m

Empty operating weight of 215 tons

Giant Magellan Telescope (GMT)



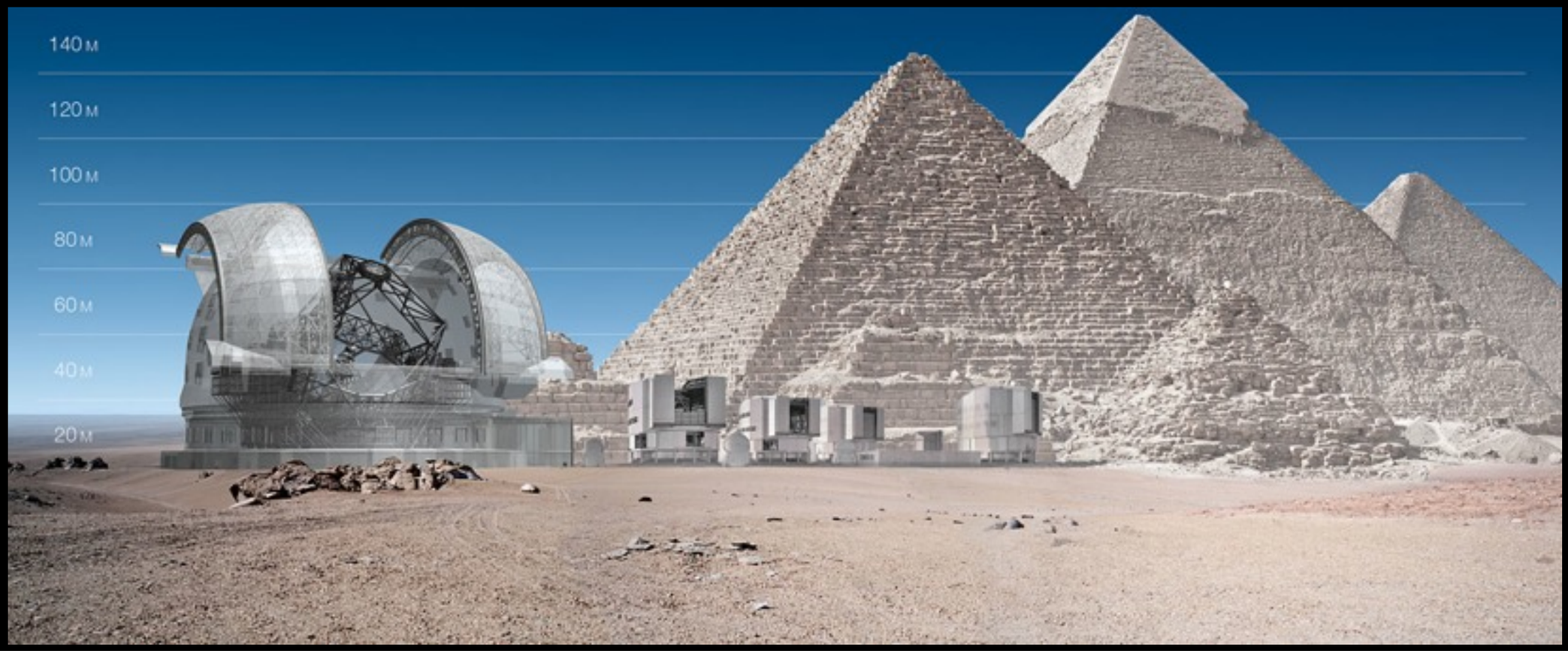


- Astronomy Australia Ltd
- Australian National University
- Carnegie Institution for Science
- Harvard University
- Korea Astronomy &Space Science Institute
- Smithsonian Institution
- University of Texas at Austin
- Texas A&M University
- University of Arizona
- University of Chicago

European Extremely Large Telescope

Located on Cerro Armazones, Chile - 20 km from the VLT at Cerro Paranal

(Credit: ESO)

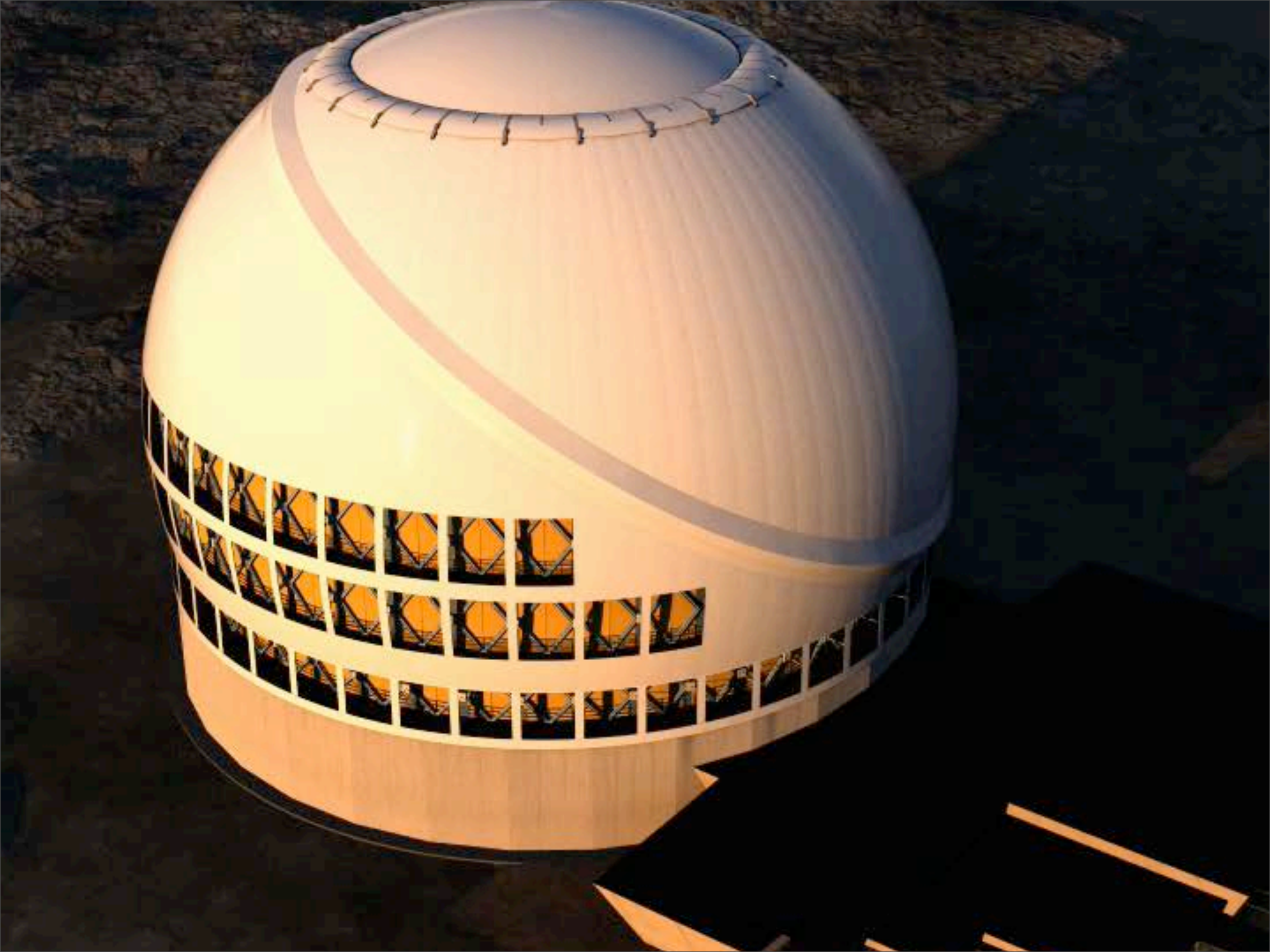


The Thirty Meter Telescope (TMT)

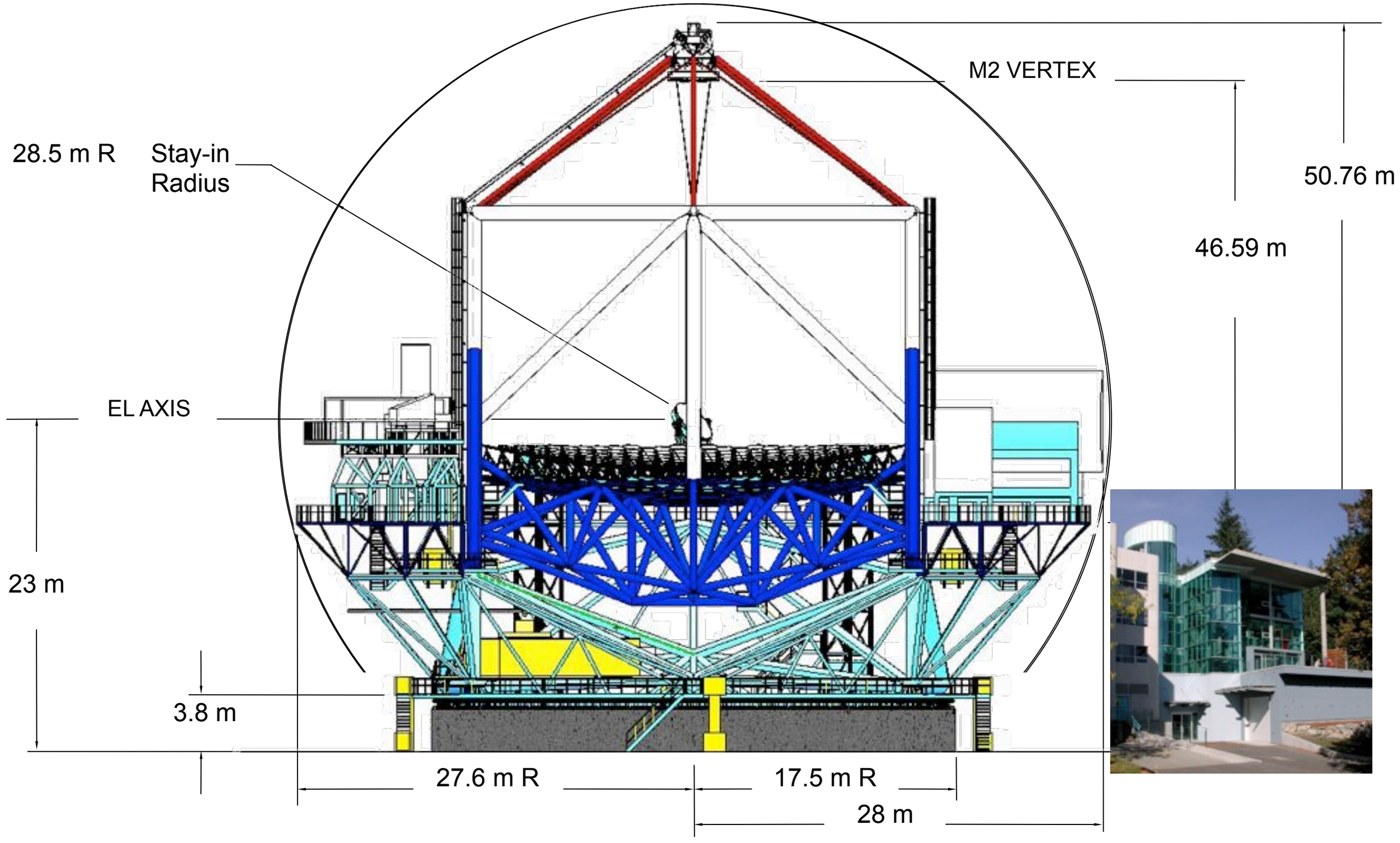
(Credit: TMT)

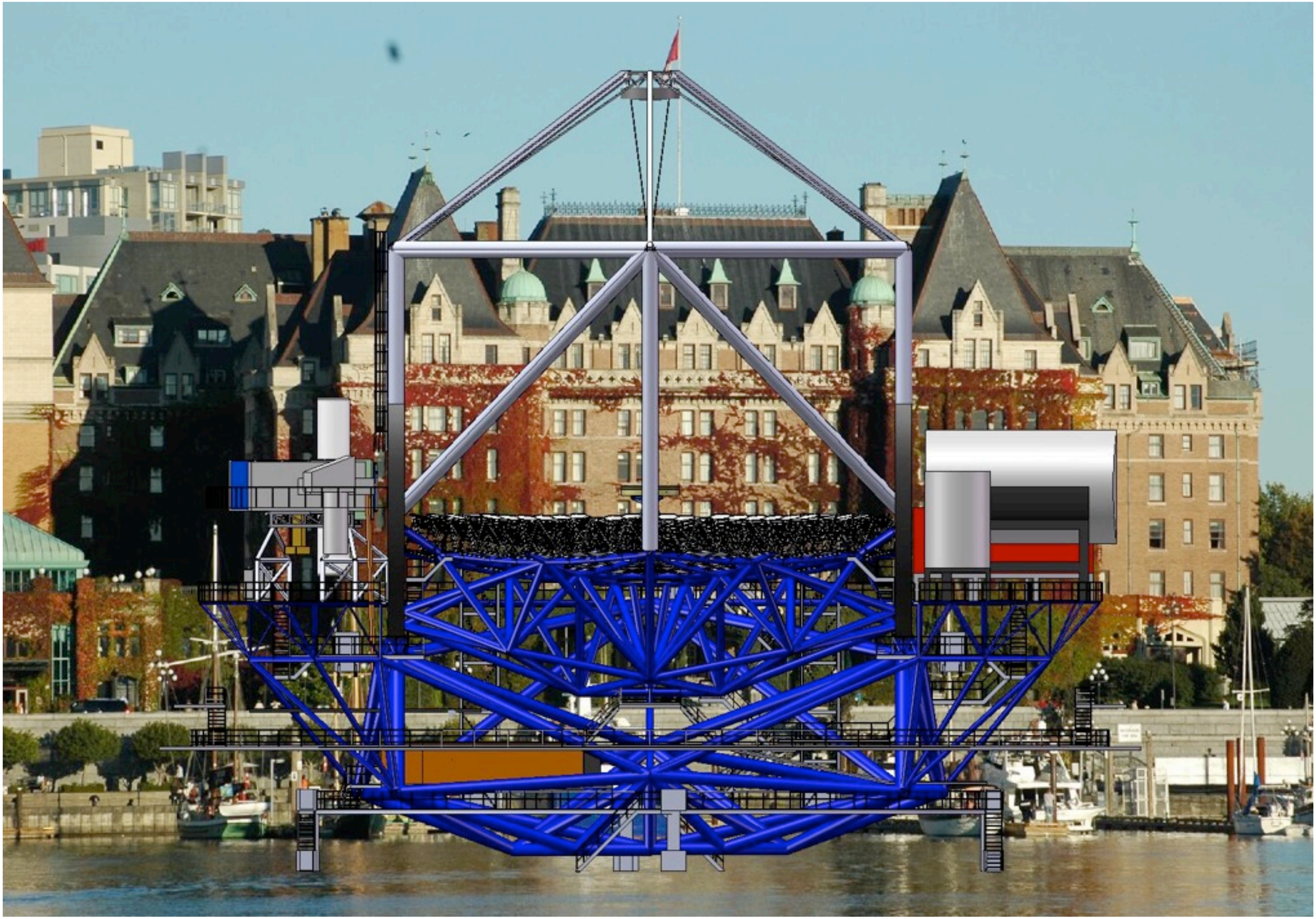
- University of California
- California Institute of Technology
- Association of Canadian Universities for Research in Astronomy
- National Astronomical Observatory of Japan
- Chinese Academy of Sciences
- Department of Science and Technology of India

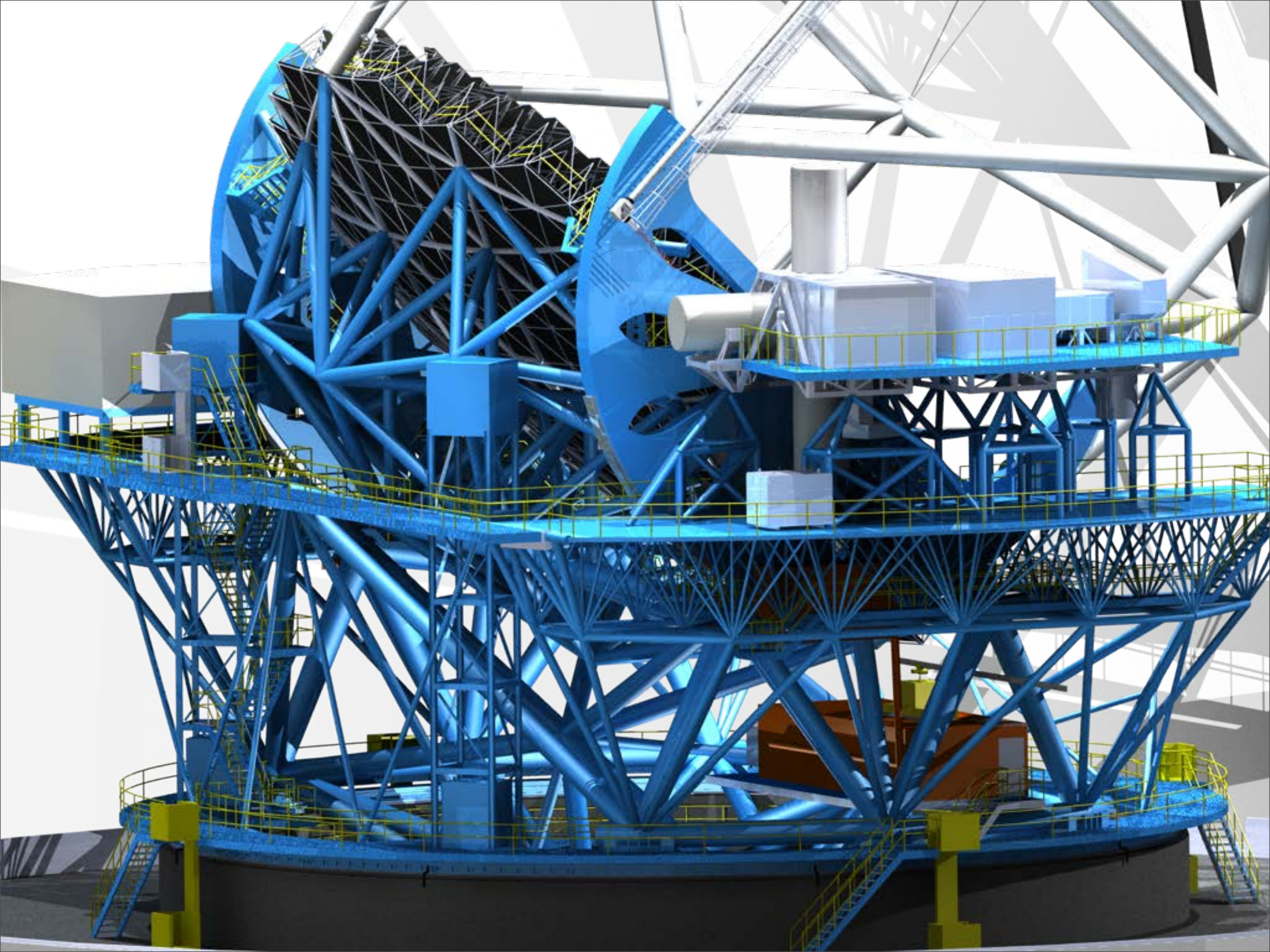
TMT on the Summit of Mauna Kea



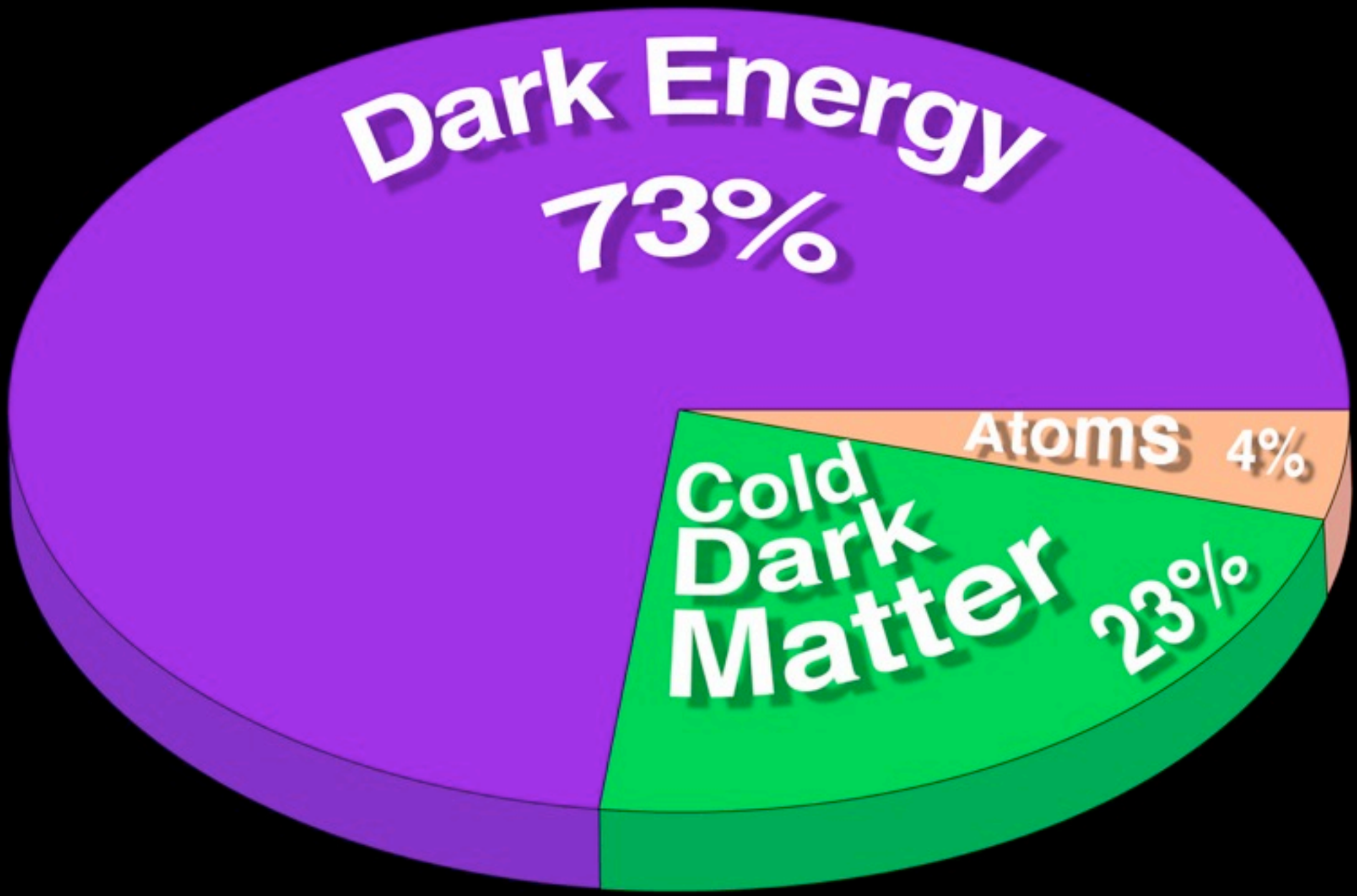
Key Dimensions







The "Dark" Universe



The Cosmic Web

Quasi-Stellar Objects

Us

The Cosmic Web with ELTs

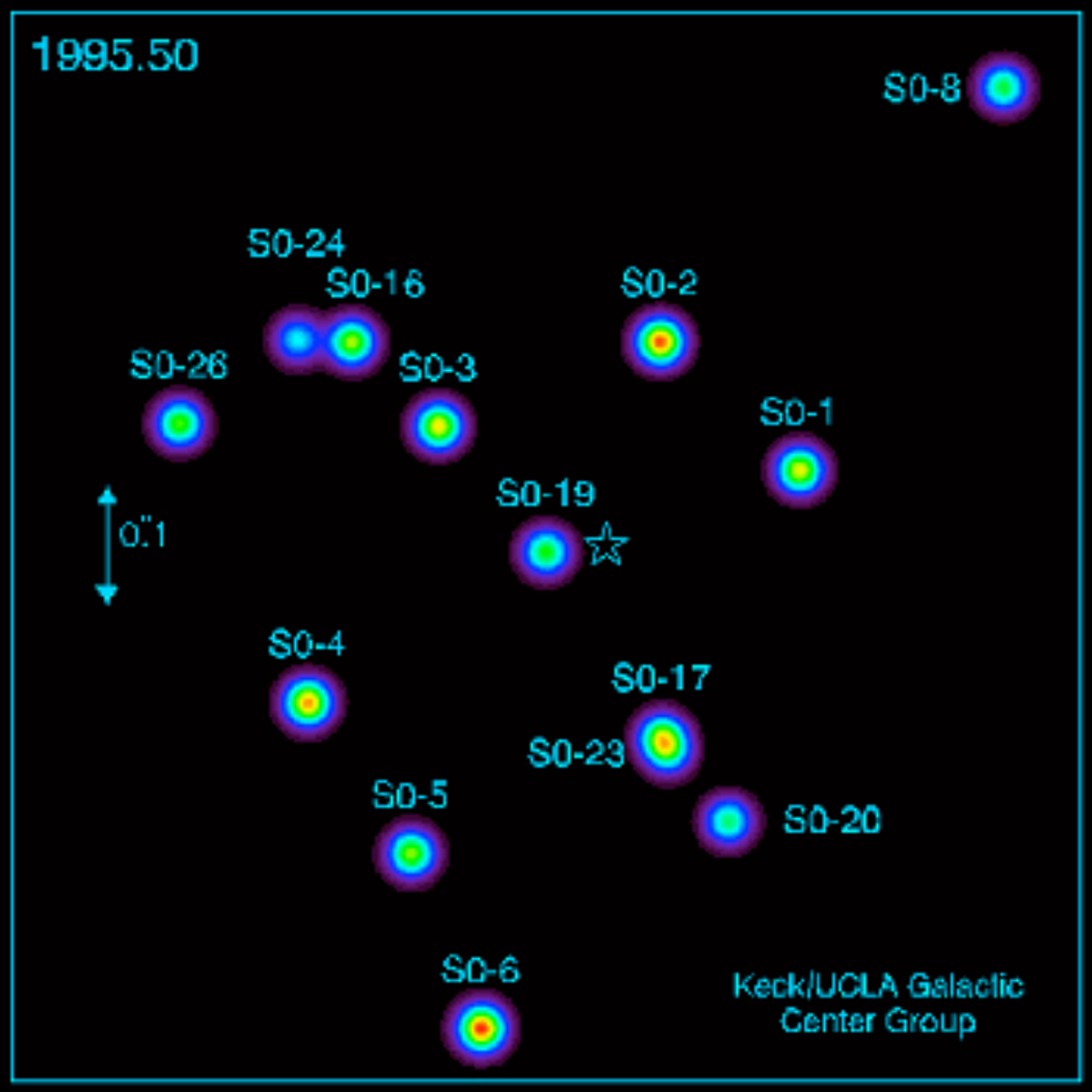
Background Galaxies

200x more sightlines!

Us

The Structure of Space-Time

Einstein and the Galactic Center

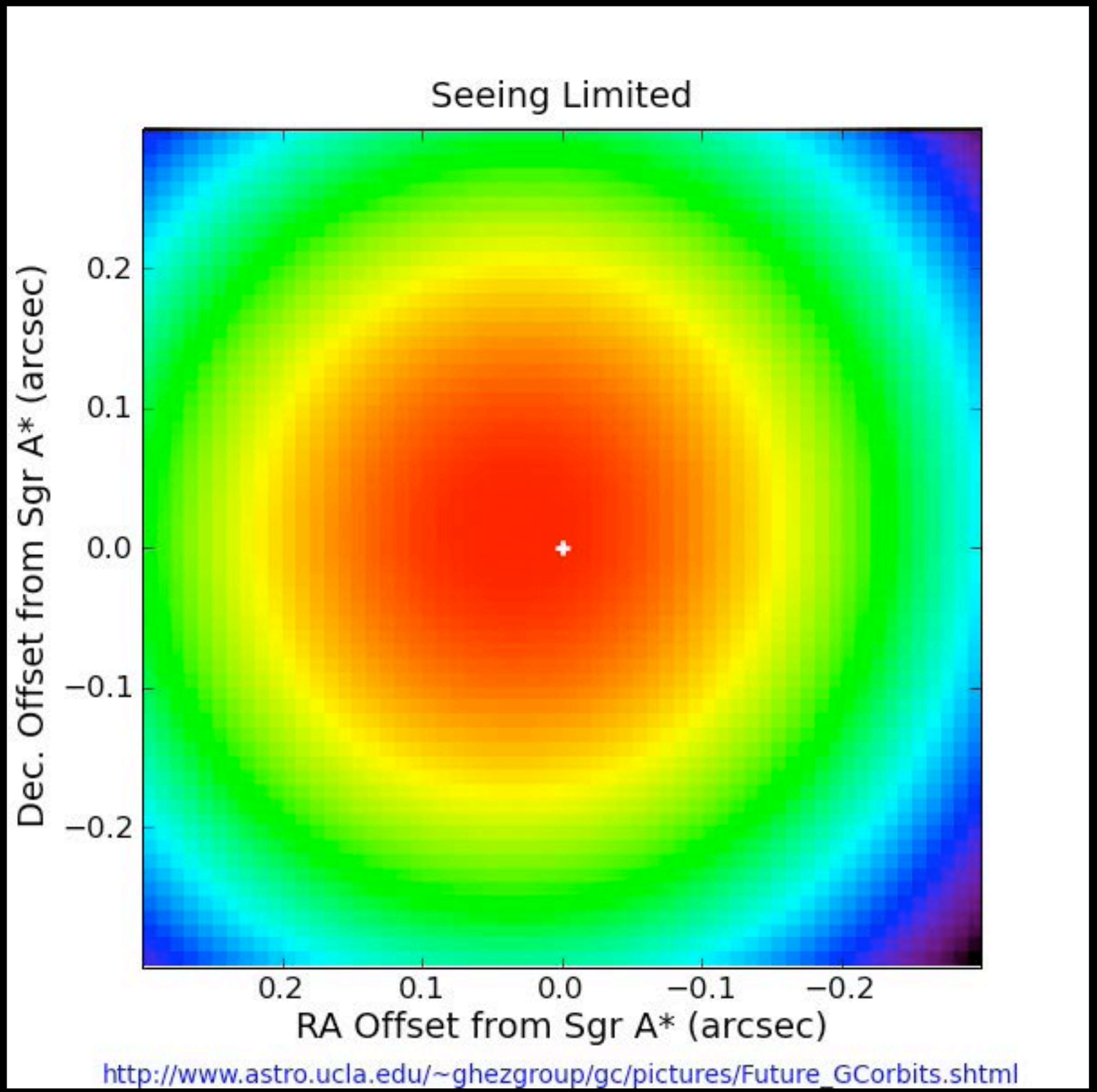


The center of our Milky Way harbors a supermassive black hole with a mass of four million times the Sun!

Time to put Einstein through a new test ...

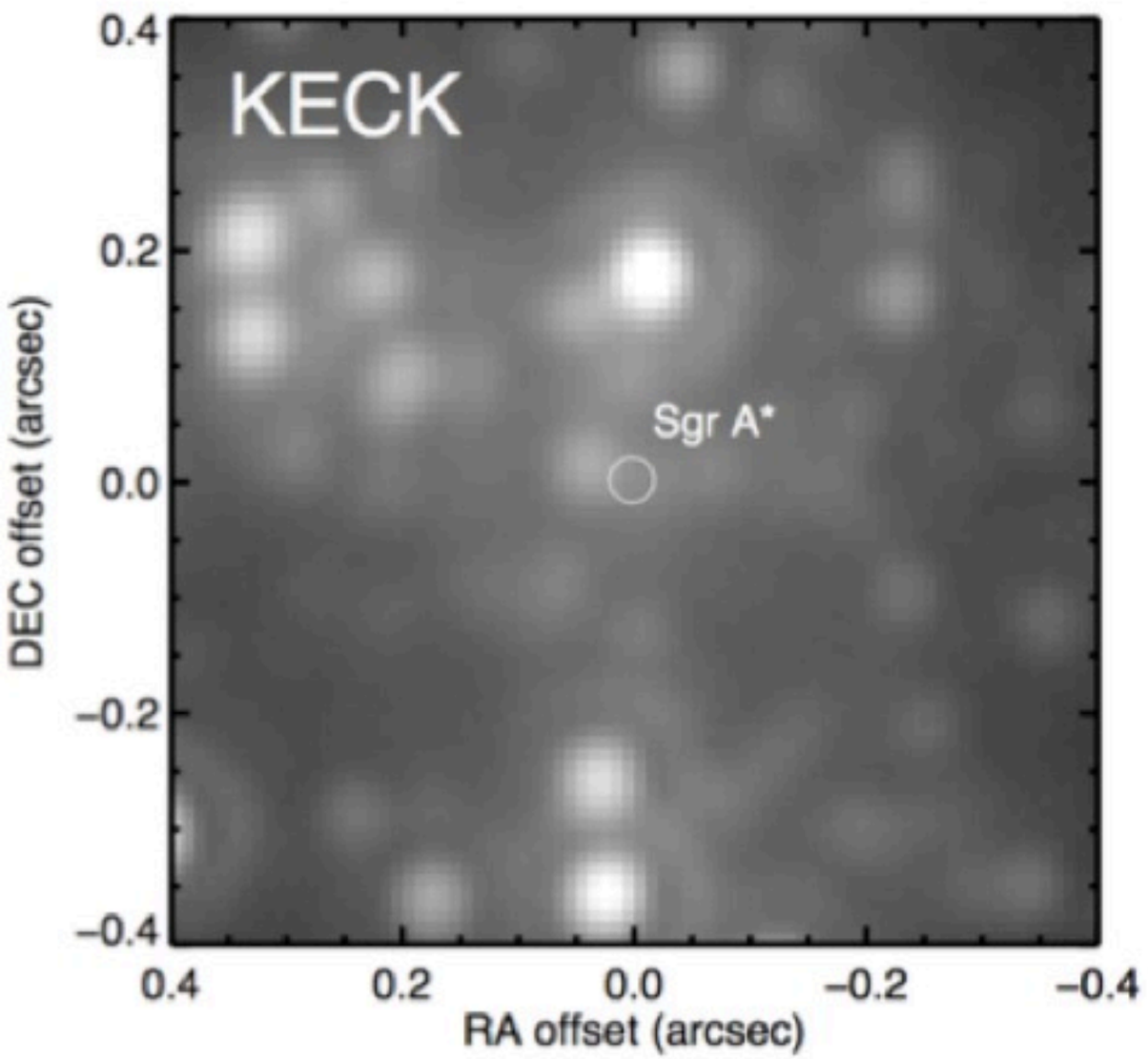
(Our GPS would not work without General Relativity)

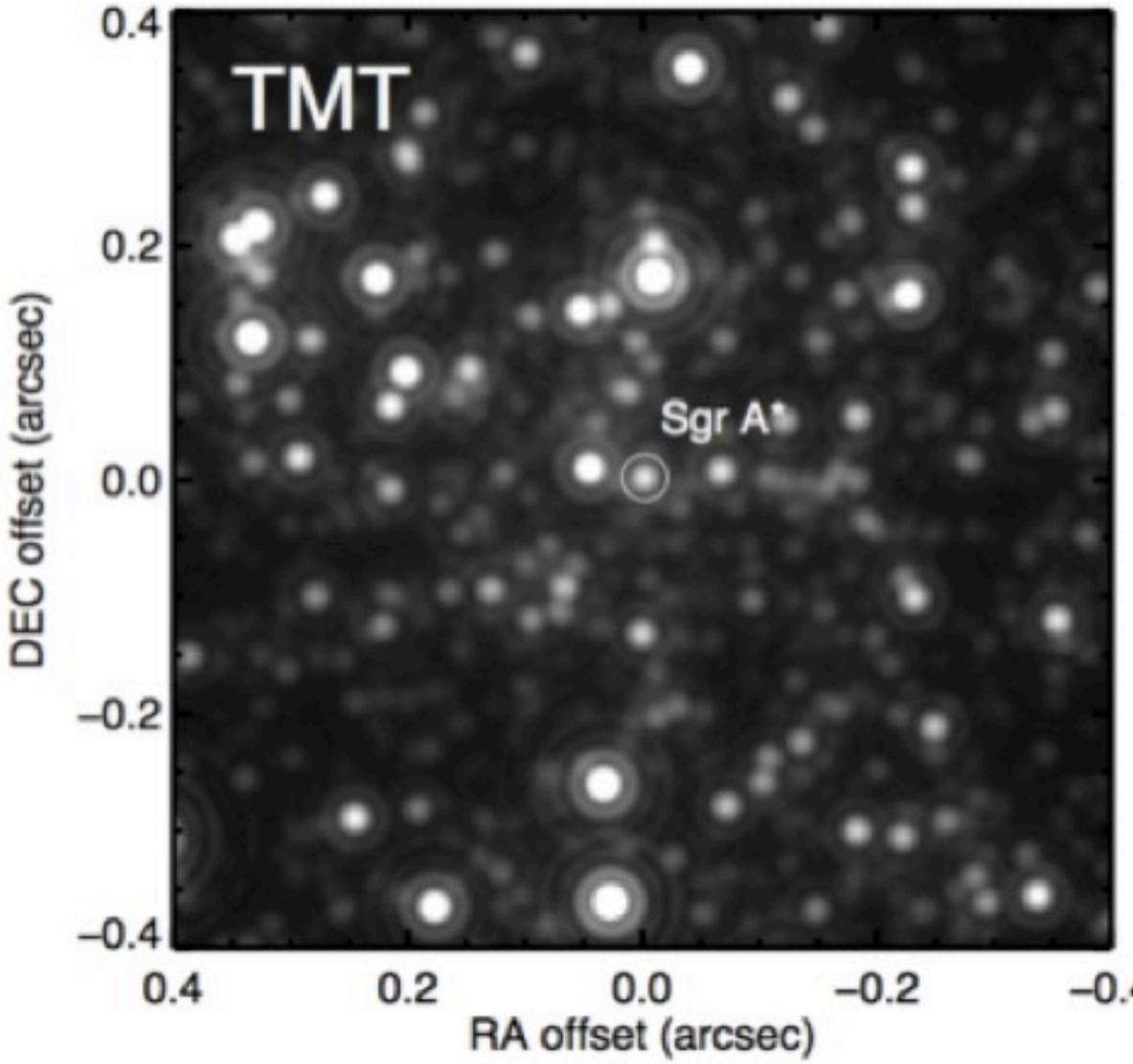
A Much Sharper View of the Galactic Center: The Movie



http://www.astro.ucla.edu/~ghezgroup/gc/pictures/Future_GCorbits.shtml

A Much Sharper View of the Galactic Center





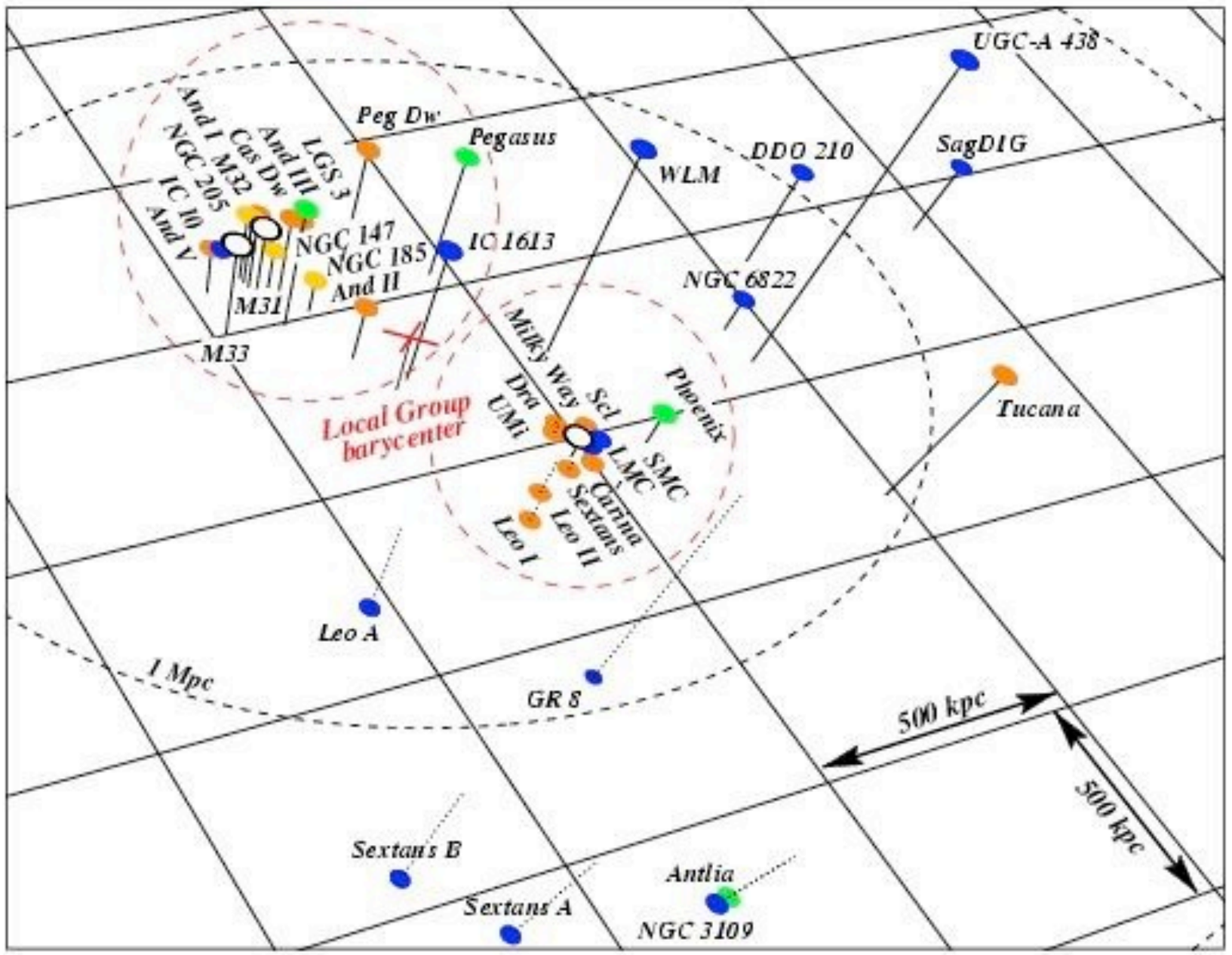
(Credit: Leo Meyer / Andrea Ghez, UCLA)

The Universe in Motion

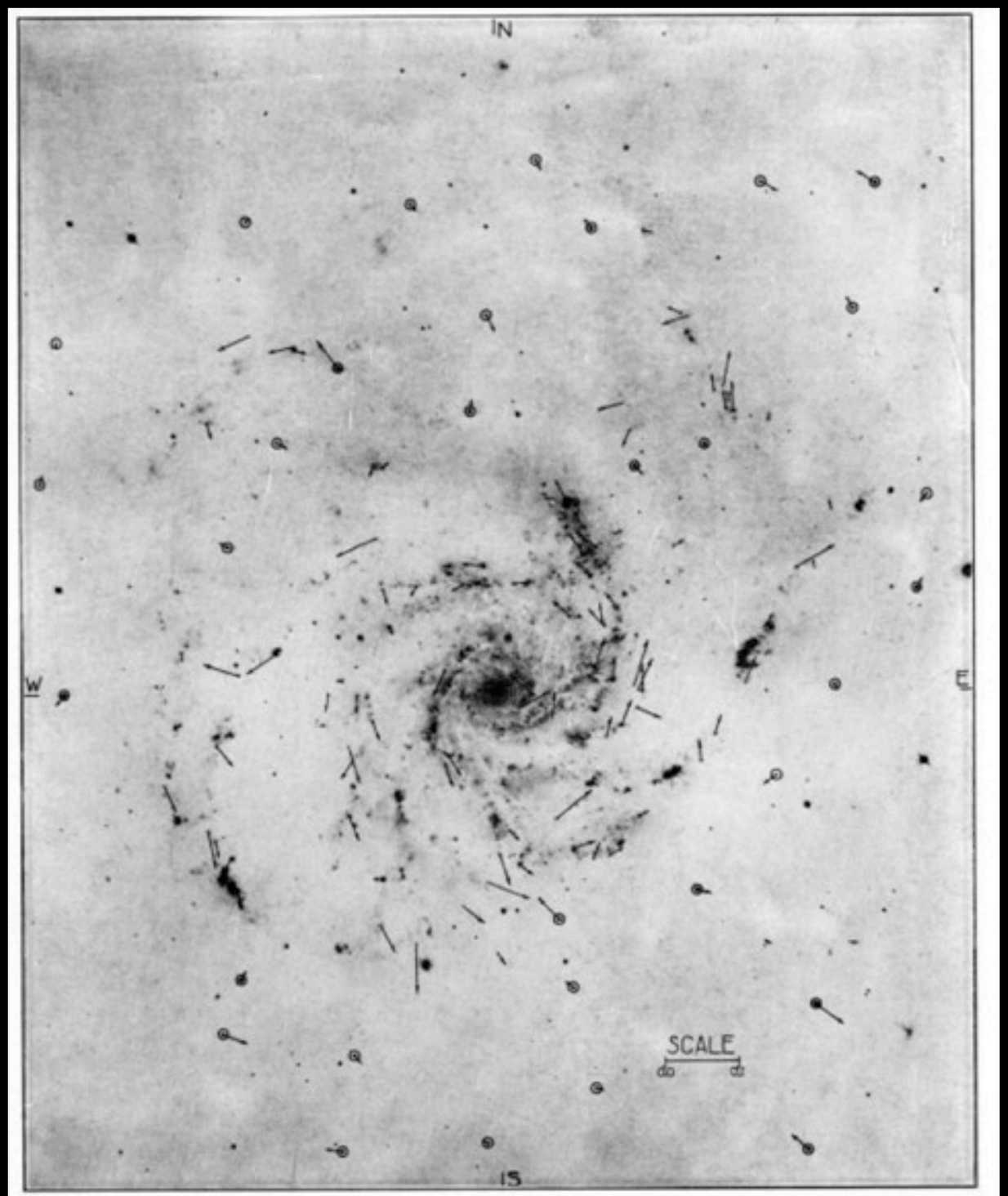
www.twig-world.com

In the same way that measurements of continental drift transformed our idea of an immovable planet, TMT will reveal the immovable sky as a dizzying cosmic ballet ...

Dancing with Galaxies:
The Local Group



van Maanen's Dream



INTERNAL MOTIONS IN MESSIER 101

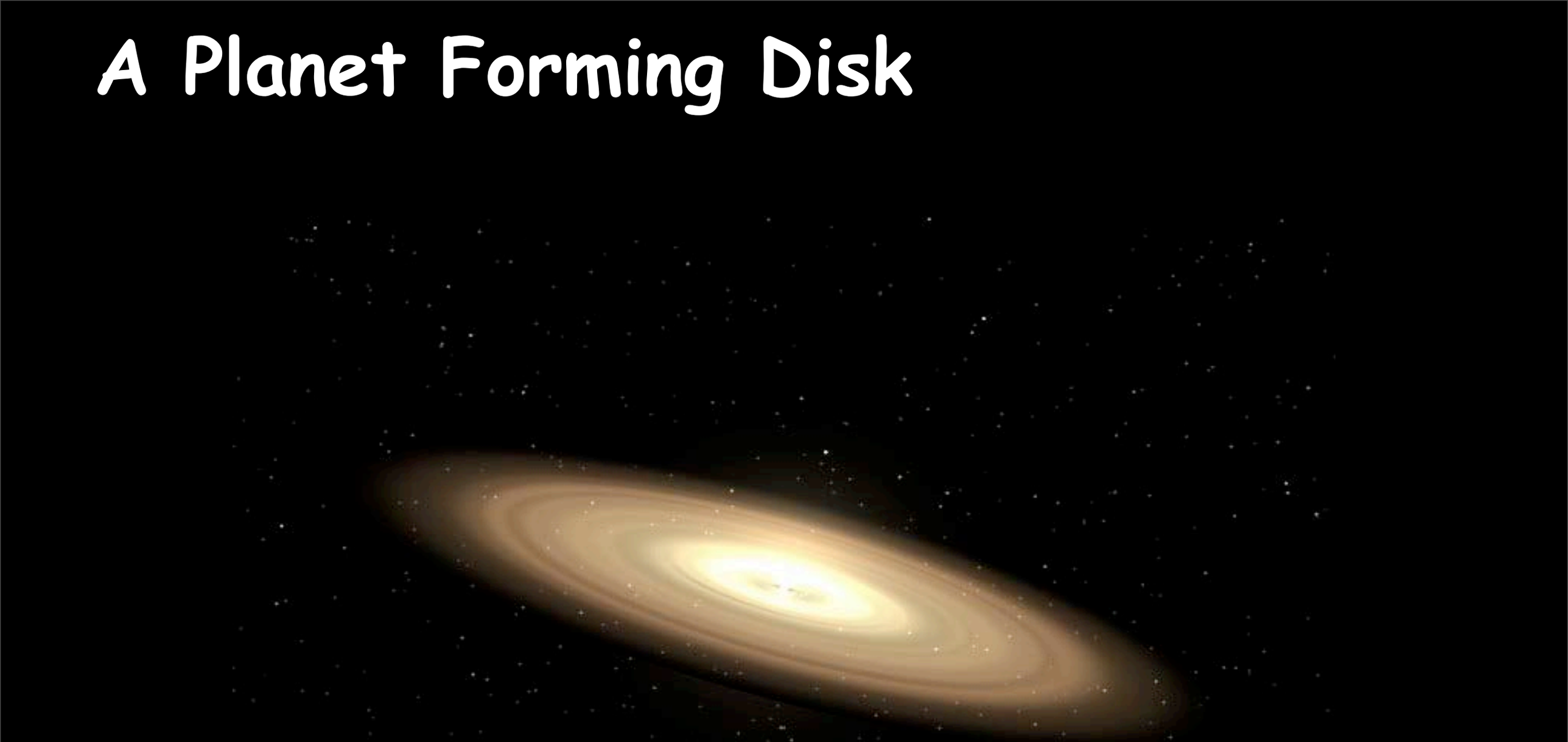
The arrows indicate the direction and magnitude of the mean annual motions. Their scale (0″.1) is indicated on the illustration. The scale of the nebula is 1 mm = 10″.5. The comparison stars are inclosed in circles.

"Preliminary Evidence of Internal Motion in the Spiral Nebula Messier 101" - van Maanen et al. 1916

TMT will allow us to measure the rotation of the Andromeda galaxy (1/30,000,000 Full Moon Diameter / year) over a few years

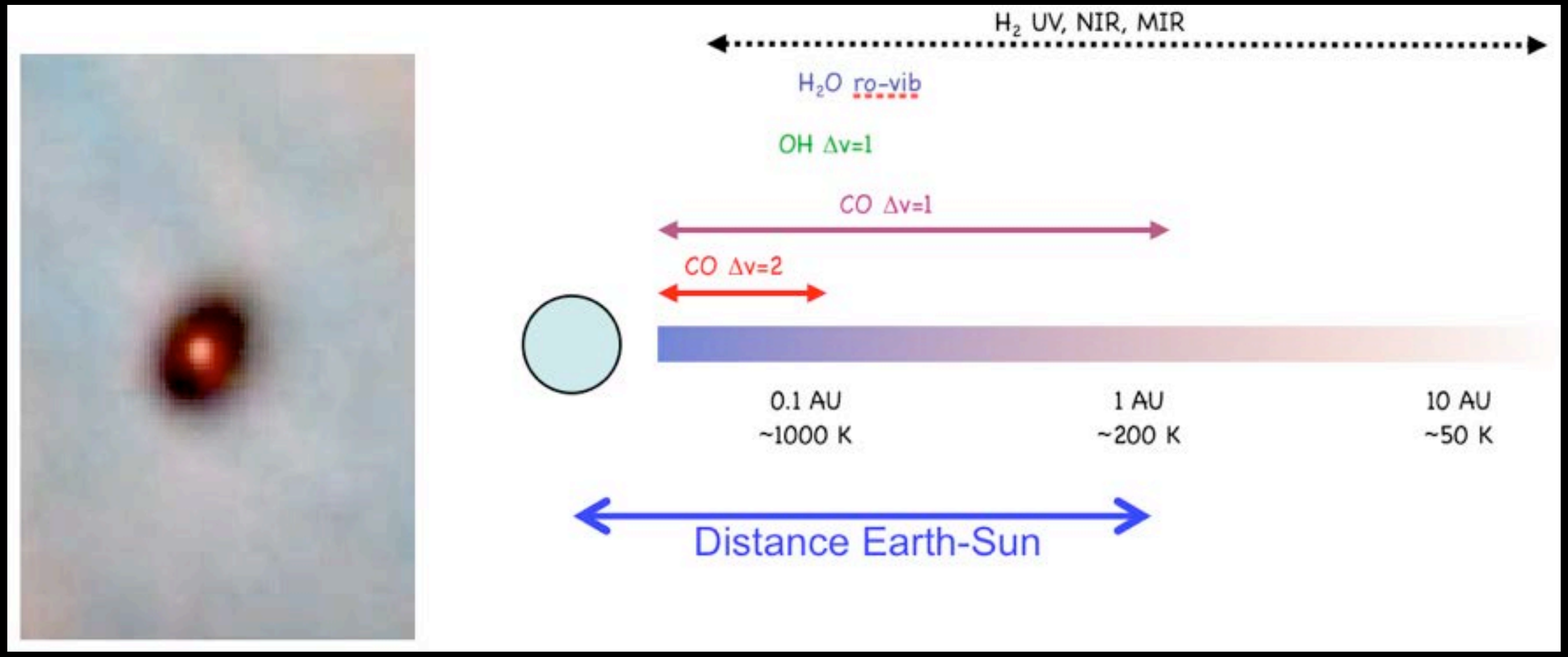
New Stars, New Planets

A Planet Forming Disk



This “nebular hypothesis” was first proposed by Emanuel Swedenbord (1734), Immanuel Kant (1755) and Pierre-Simon Laplace (1796) !

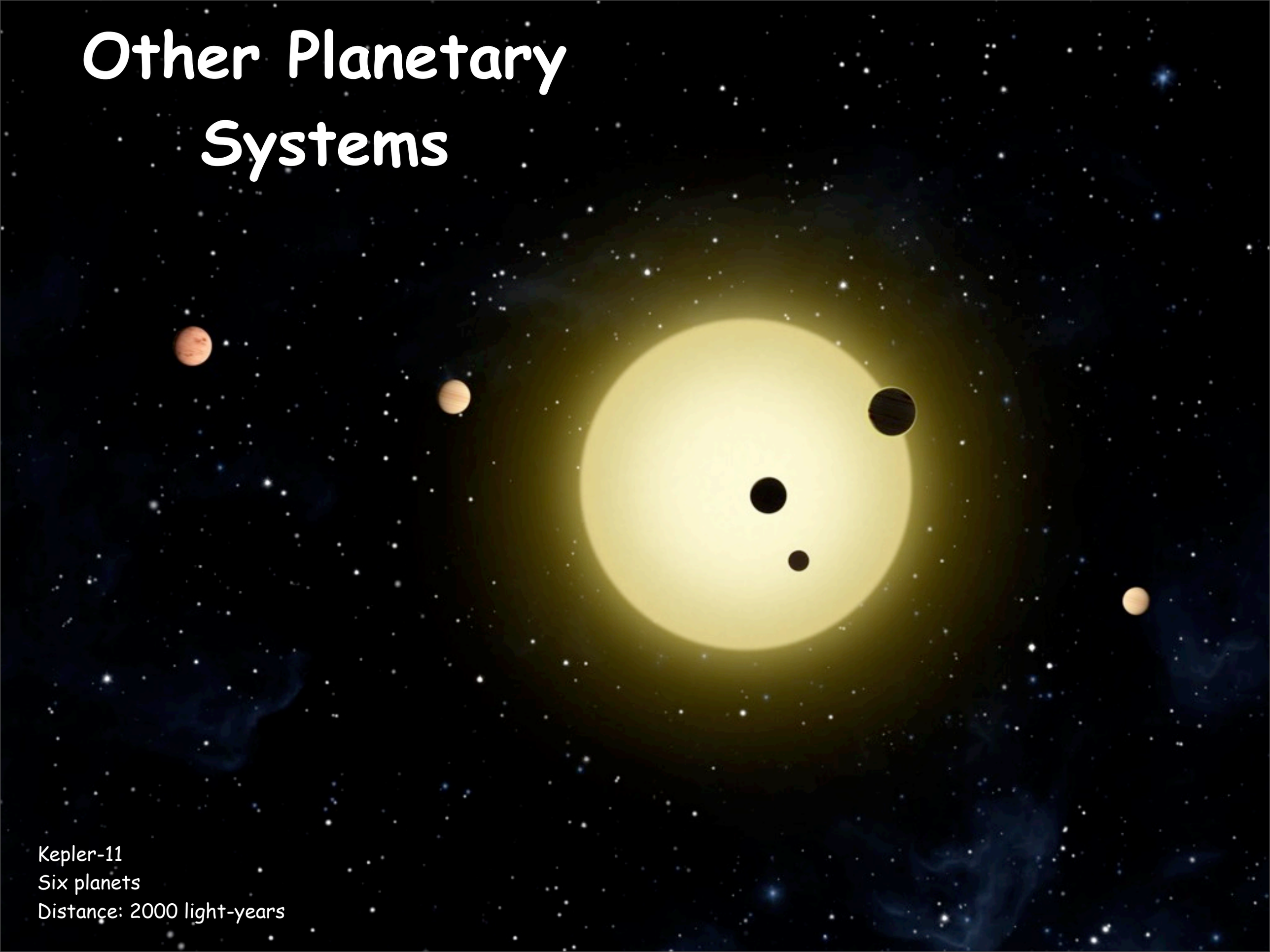
The Building Blocks of Life



Our sharper eyes will be able to probe the space around other stars on scales comparable to the Sun-Earth distance.

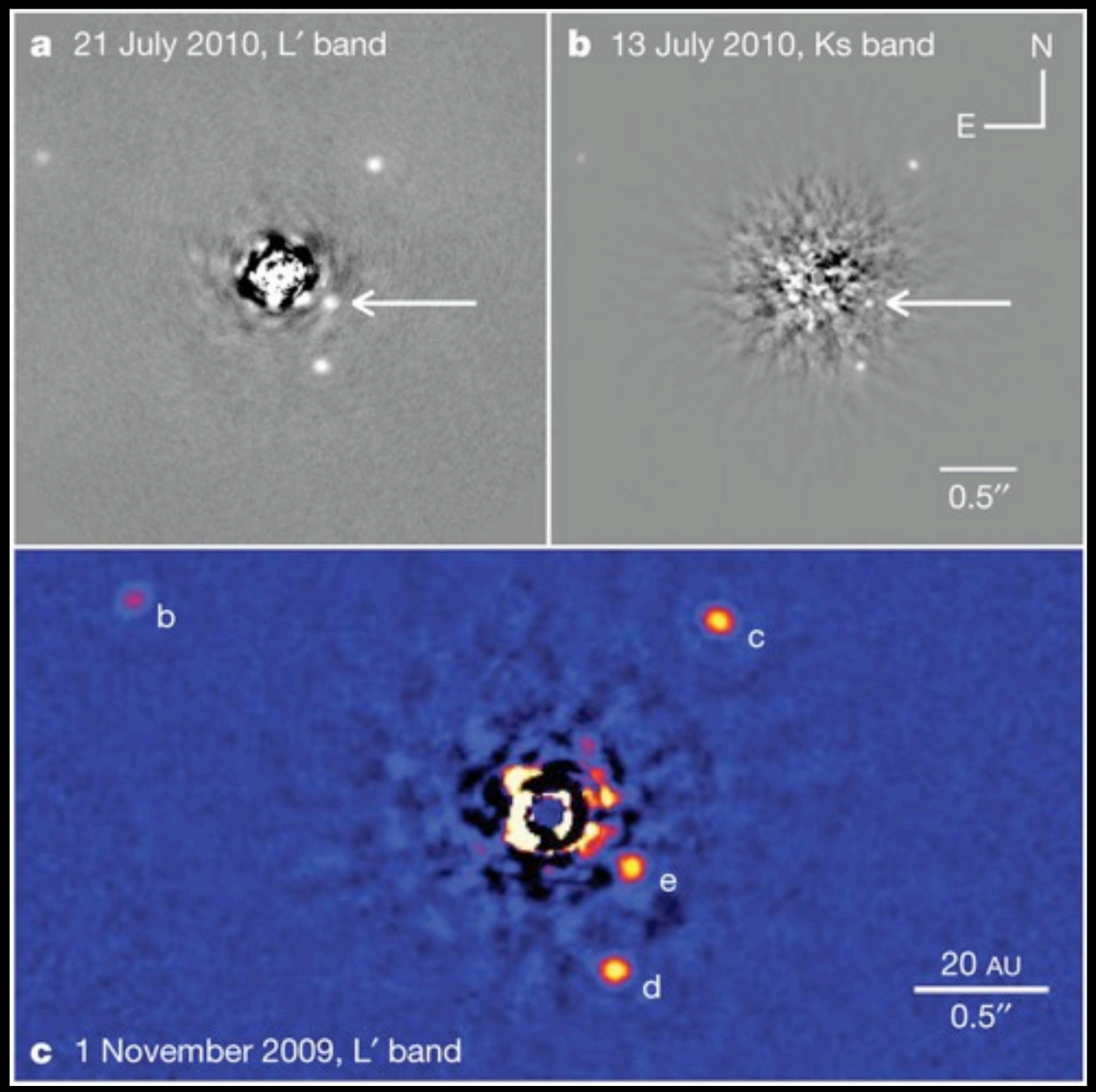
Powerful spectrographs will help us identify complex molecules and show us how they are deposited onto the surface of newly formed planets.

Other Planetary Systems



Kepler-11
Six planets
Distance: 2000 light-years

Direct Imaging of Planetary Systems



(Credit: Marois et al. 2008,2010)

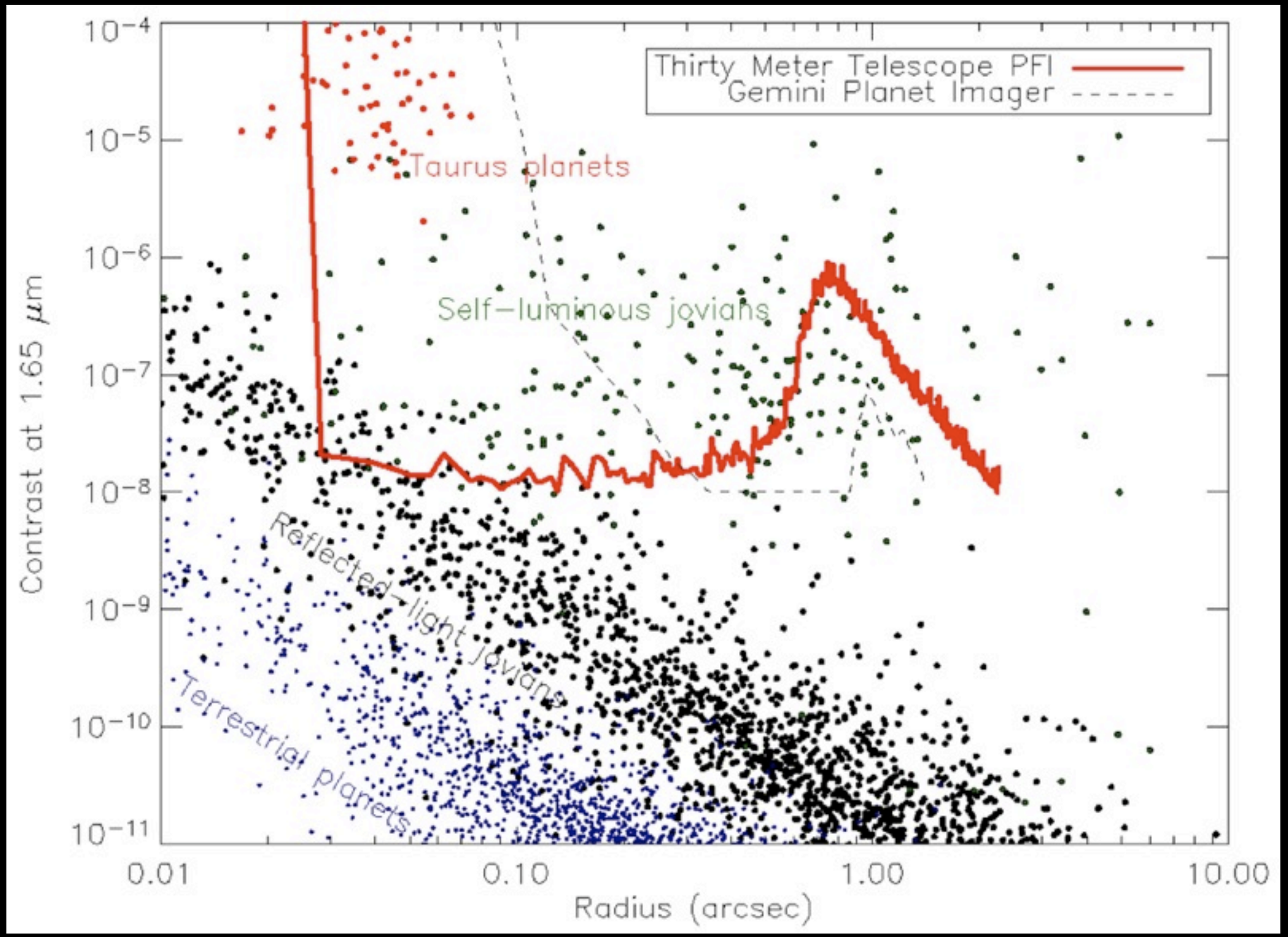
First system imaged in 2008 by a Canadian team!

The HR 8799 system is at a distance of 130 light-years from Earth

The contrast ratio between their host star and the exoplanets is ~ 50,000

Direct Imaging of Planetary Systems with TMT

Contrast ratio of → 100 million!



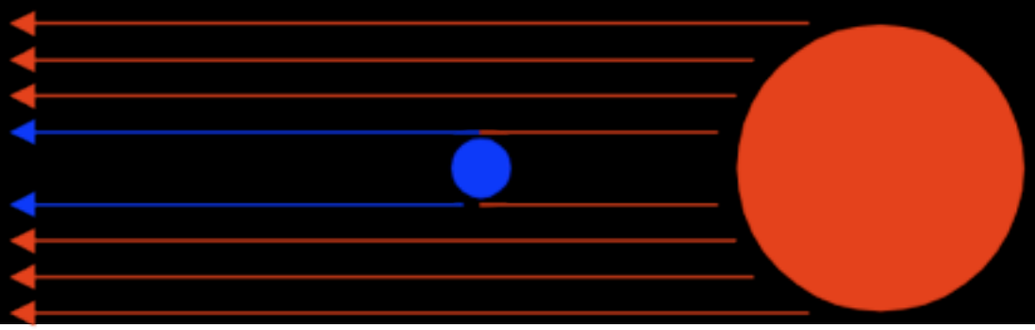
Another Earth?

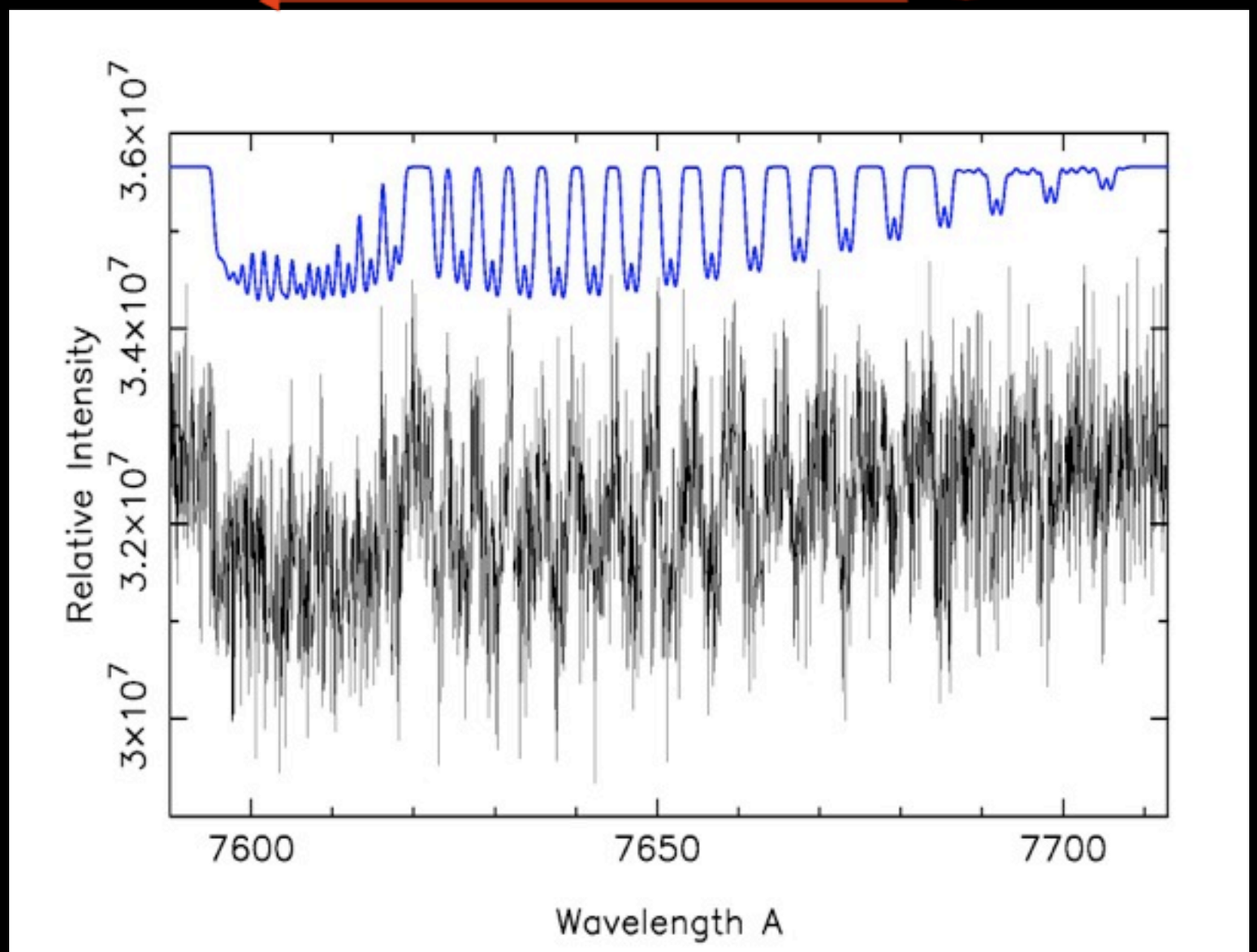
Life?

Imagine an exoplanet transiting in front of its host star ... like Venus last June

The Hunt for Bio-Markers

To Earth

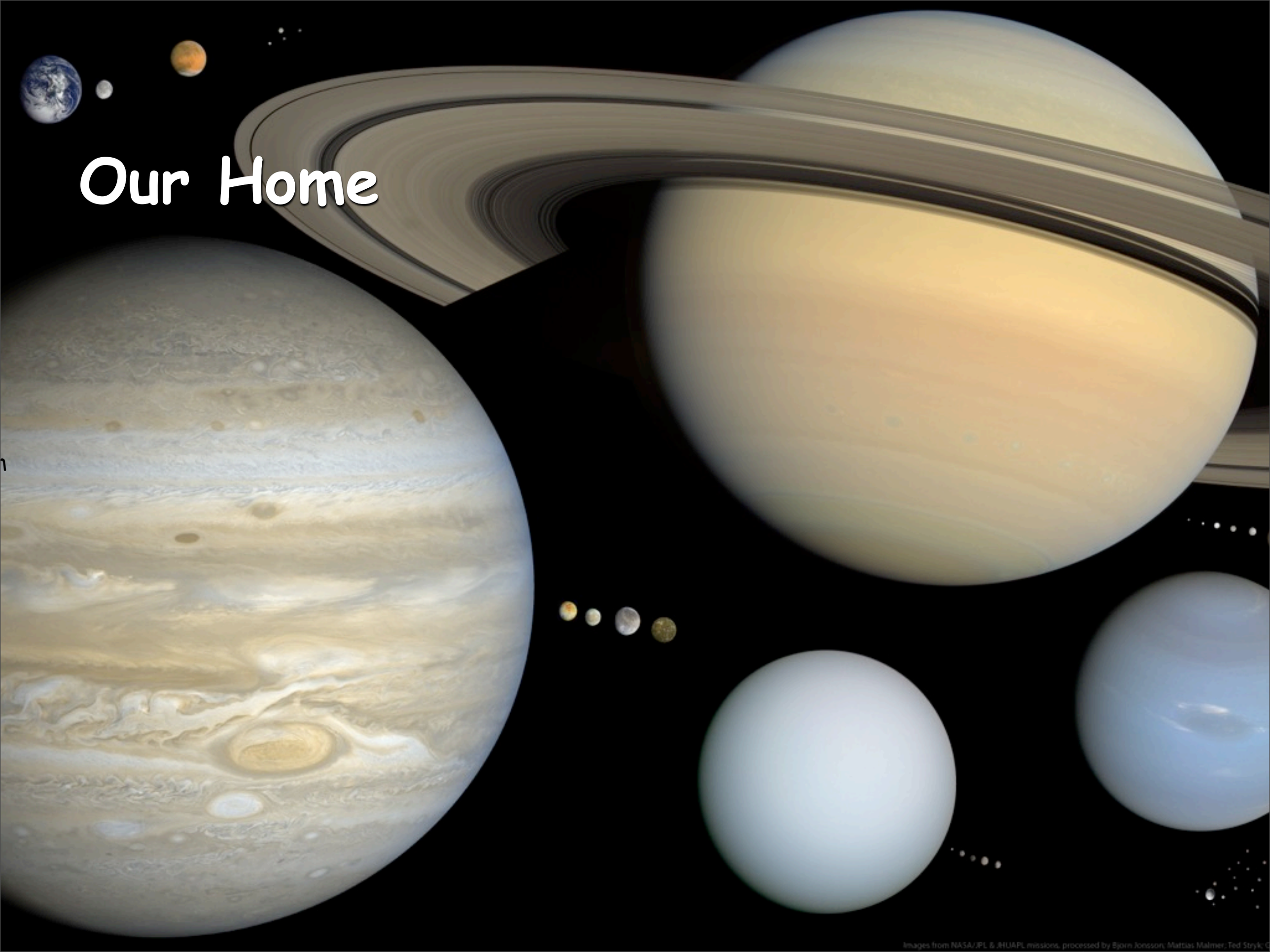




Oxygen

Life!

Our Home


Images from NASA/JPL & JHUAPL missions, processed by Bjorn Jonsson, Mattias Malmer, Ted Stryk

The Ocean of Europa

Europa at the resolution of TMT adaptive optics (Mike Brown, Caltech)

This Galilean satellite of Jupiter is entirely covered by a thick sheet of ice over a (liquid?) ocean

Cracks are seen in this ice - it looks like a liquid broke through and froze again

Measuring the chemical composition of material near these cracks could tell us something about the underlying ocean

Galileo would be proud!

The Volcanoes of Io

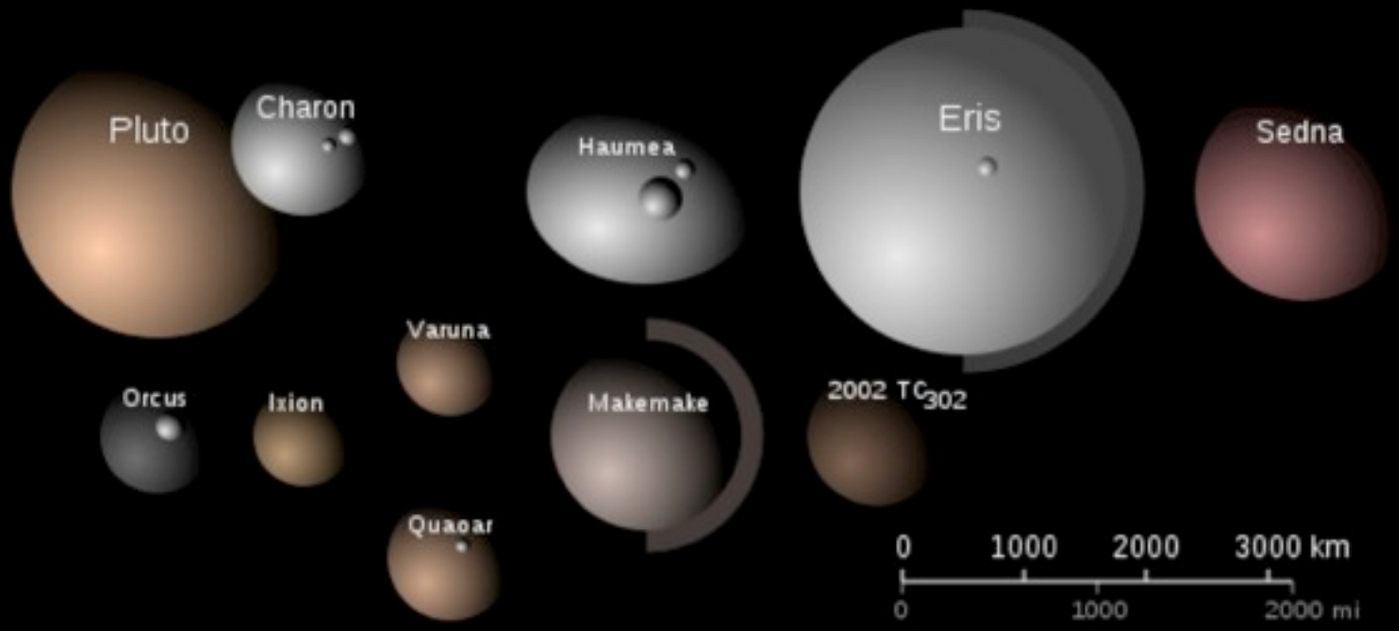
Keck/AO+NIRC2 Keck/NGAO TMT/AO+IRIS

(Credit: Franck Marchis, UC Berkeley/SETI)

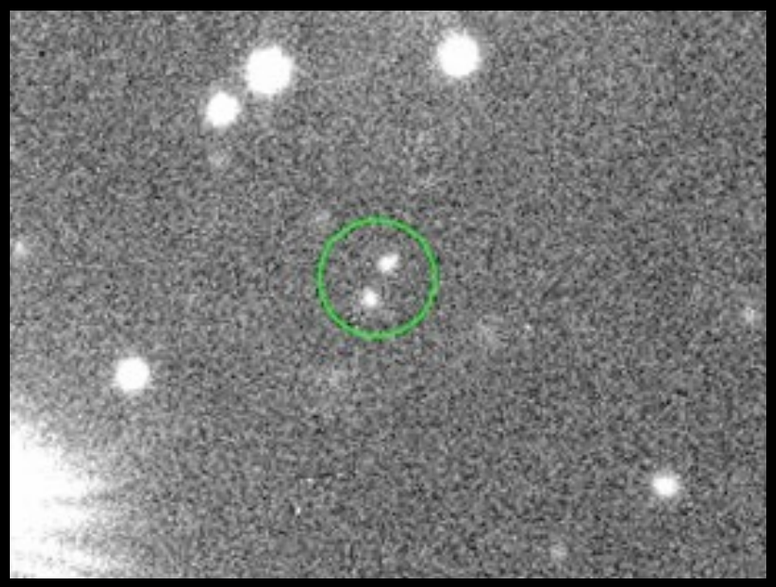
Also playing:

- Giant storms on Jupiter
- Methane rain fall on Titan
- Nitrogen geysers blowing in the wind on Triton
- ...

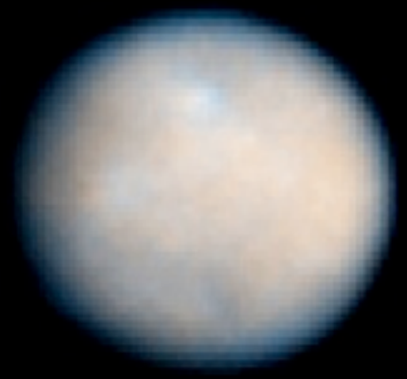
The Kuiper Belt



Sorry Pluto,
but you are
not a planet ...

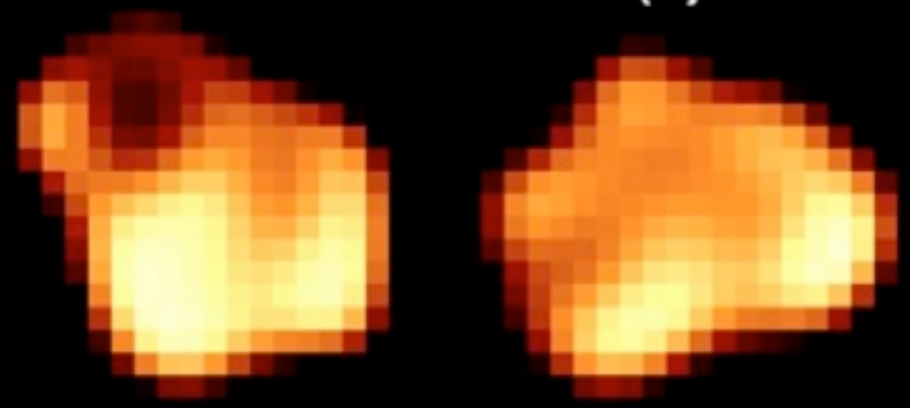


1 Ceres by HST



13 elements (~Pluto)

Keck Observations of (9) Metis



3 elements (~Haumea)

(Credit: Franck Marchis, UC Berkeley/SETI)

Why TMT?

- To transform our understanding of the Universe

- To contribute to our "Knowledge-based Society":
  - ➡ "Brain gain"
  - ➡ Opening new opportunities for our kids

- To bring real economic benefits:
  - ➡ Development of unique expertise within industry (e. g., medical science, cryogenic cooling, large structures)
  - ➡ Linking companies with new partners

- To promote peace and understanding among nations

KING MARK
HIGH QUALITY
姚記
扑克
庆贺
姚记扑克A股上市
股票代码:002605
上海姚记扑克股份有限公司

Distant shores are
waiting for us!

Image Credit: Mila Zinkova via Wikipedia