

# Thirty-Meter Telescope: Science, Technology and People

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National Research Council of Canada /  
University of Victoria

# 406 years ago!!

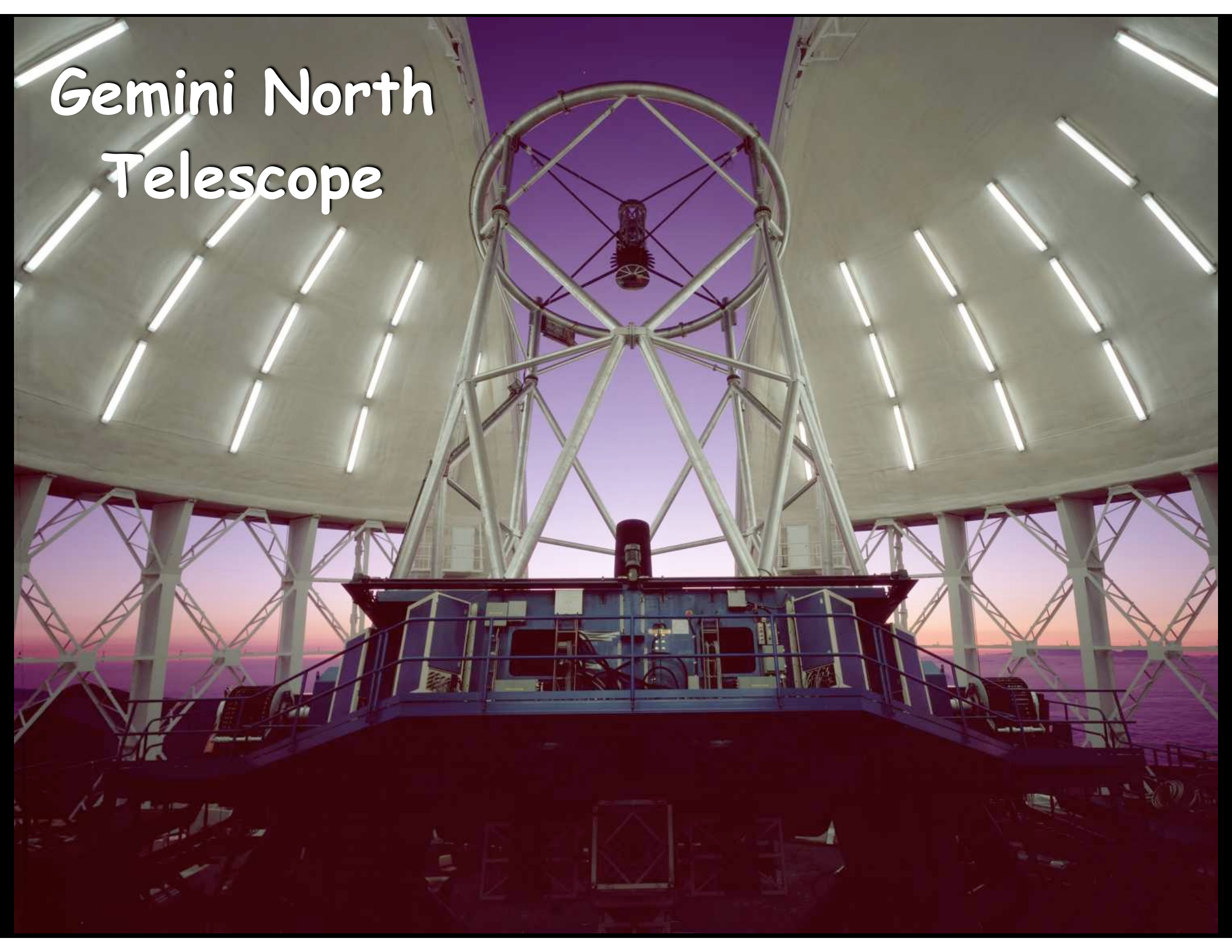


Galileo Galilei



Discovery of the Moons of Jupiter  
in Sidereus Nuncius

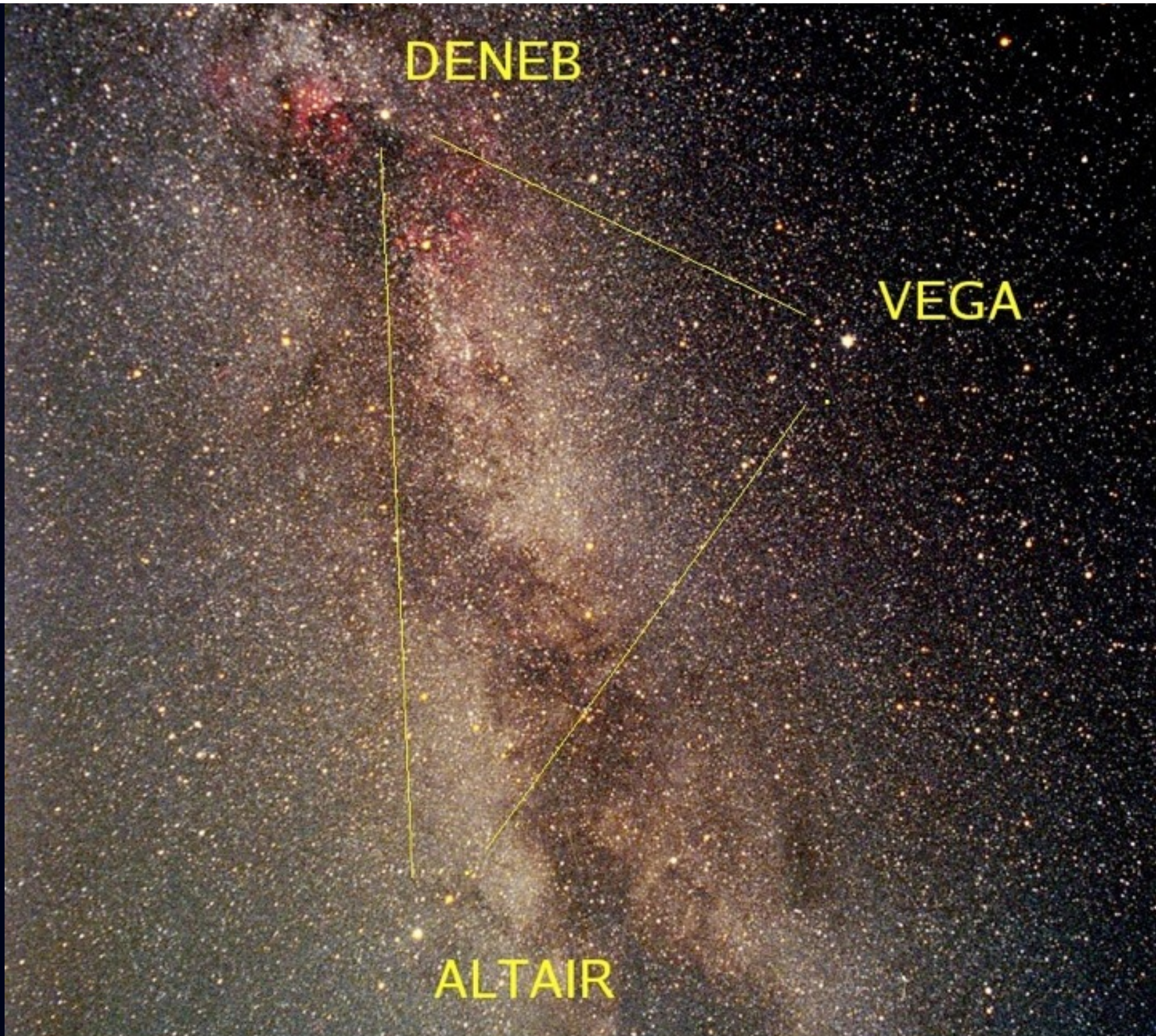
# Gemini North Telescope



DENEB

VEGA

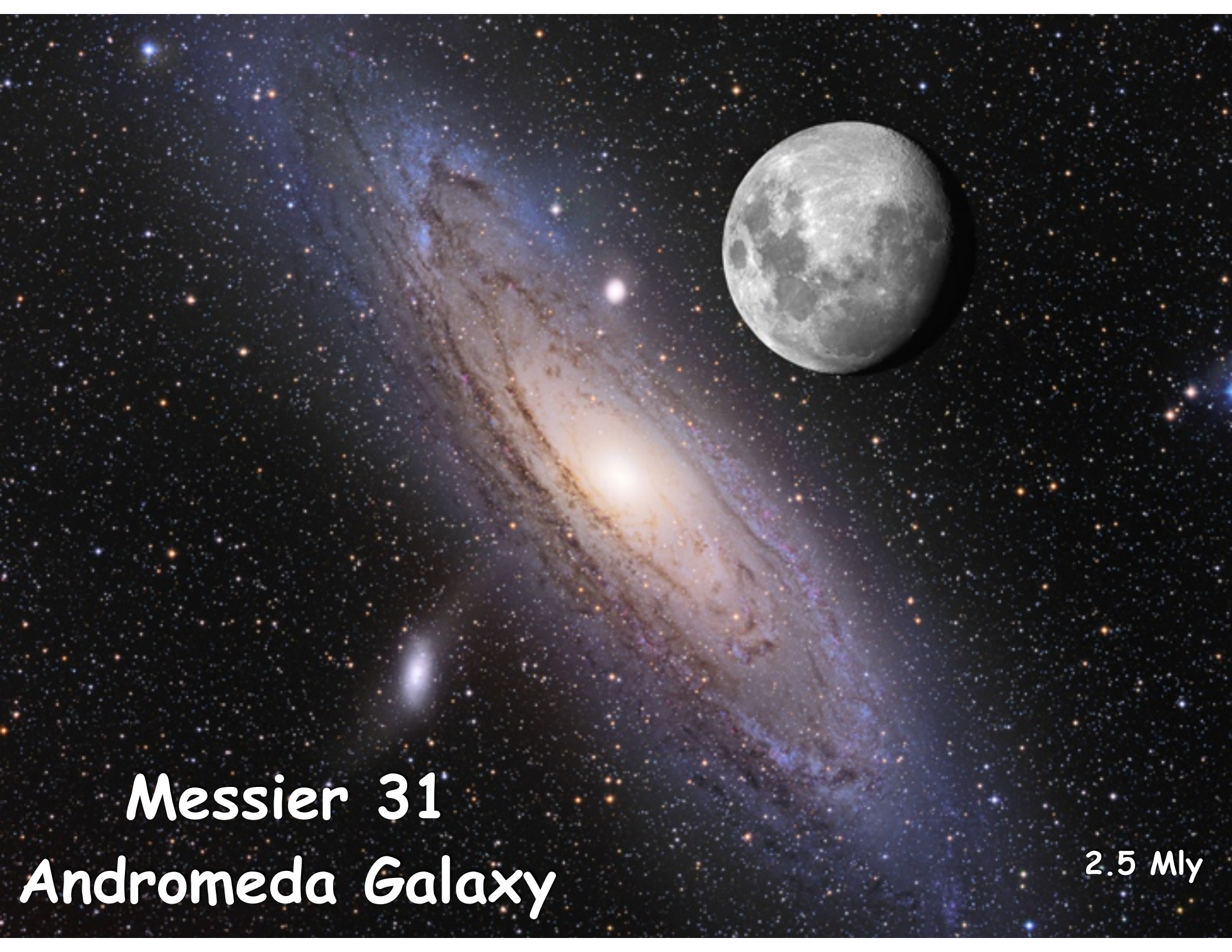
ALTAIR



# The Large and Small Magellanic Clouds

The image displays two prominent, irregularly shaped, glowing regions of interstellar dust and gas, known as the Large and Small Magellanic Clouds. The Large Magellanic Cloud is the larger, more diffuse, and irregularly shaped region on the left side of the image. The Small Magellanic Cloud is the smaller, more compact, and smoother region on the right side. Both clouds exhibit a mix of colors, including blue, green, and yellow, set against a dark background filled with numerous individual stars of varying brightness.

168,000 ly



**Messier 31**  
**Andromeda Galaxy**

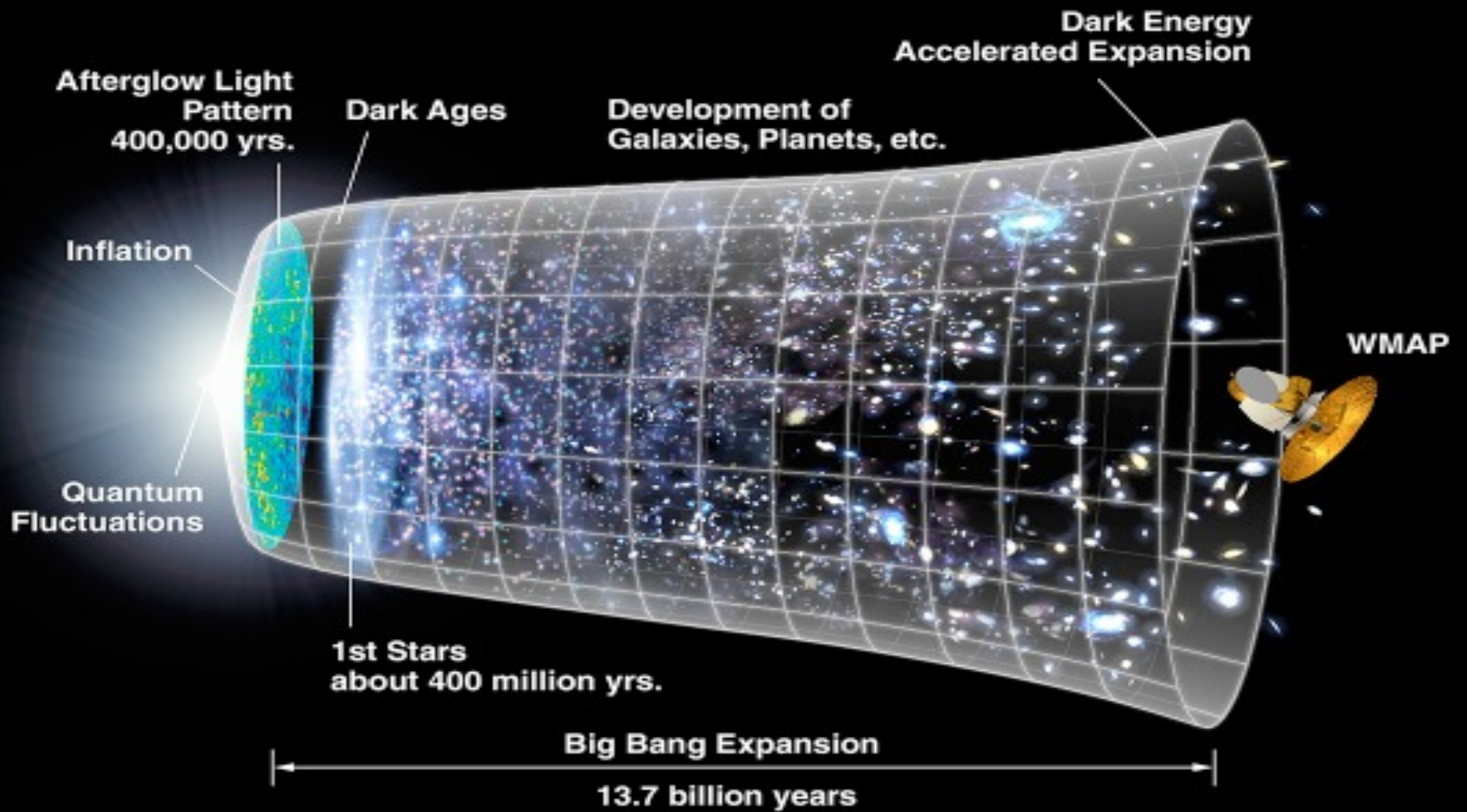
2.5 Mly

As far as telescopes can see ...

A deep field image of the universe, showing a vast field of galaxies in various colors (white, yellow, orange, red, blue, green) and shapes (spiral, elliptical, irregular) against a black background. The galaxies are scattered across the frame, with some appearing as bright, diffuse clouds and others as smaller, more distinct points of light.

13.2 billion years

Credit:  
Gemini  
Observatory





# The TMT Partnership - A Global Family



First Light in  
Early 2024!

- 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

(Credit: TMT)



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### THIRTY METER TELESCOPE



Vancouver, British Columbia – 6 April 2015

As part of its efforts to support research excellence in areas of Canadian strength, the Government of Canada has invested in transformative infrastructure projects supporting Canada's key research strengths, such as astronomy and astrophysics, and engaged in international partnerships that foster ambitious scientific achievements in these disciplines.

To this end, on April 6, 2015, Prime Minister Stephen Harper announced the Government of Canada's intention to provide up to \$243.5 million over 10 years to support Canada's participation in the Thirty Meter Telescope (TMT), an international project that will build one of the world's largest and most advanced astronomical observatories in Hawaii. Overall projects costs are expected to total U.S. \$1.5 billion. Other partners in the project are Japan, China, India, as well as the California Institute of Technology and the University of California from the United States.

The TMT project was founded by the California Institute of Technology, the University of California, and the Association of Canadian Universities for Research in Astronomy, whose membership includes 20 universities across the country. The TMT is the result of more than a decade of scientific consultations, thorough design and planning.

### PHOTO GALLERY



PM Harper visits the Ismaili Centre in Vancouver

See all photo galleries ...

### VIDEO



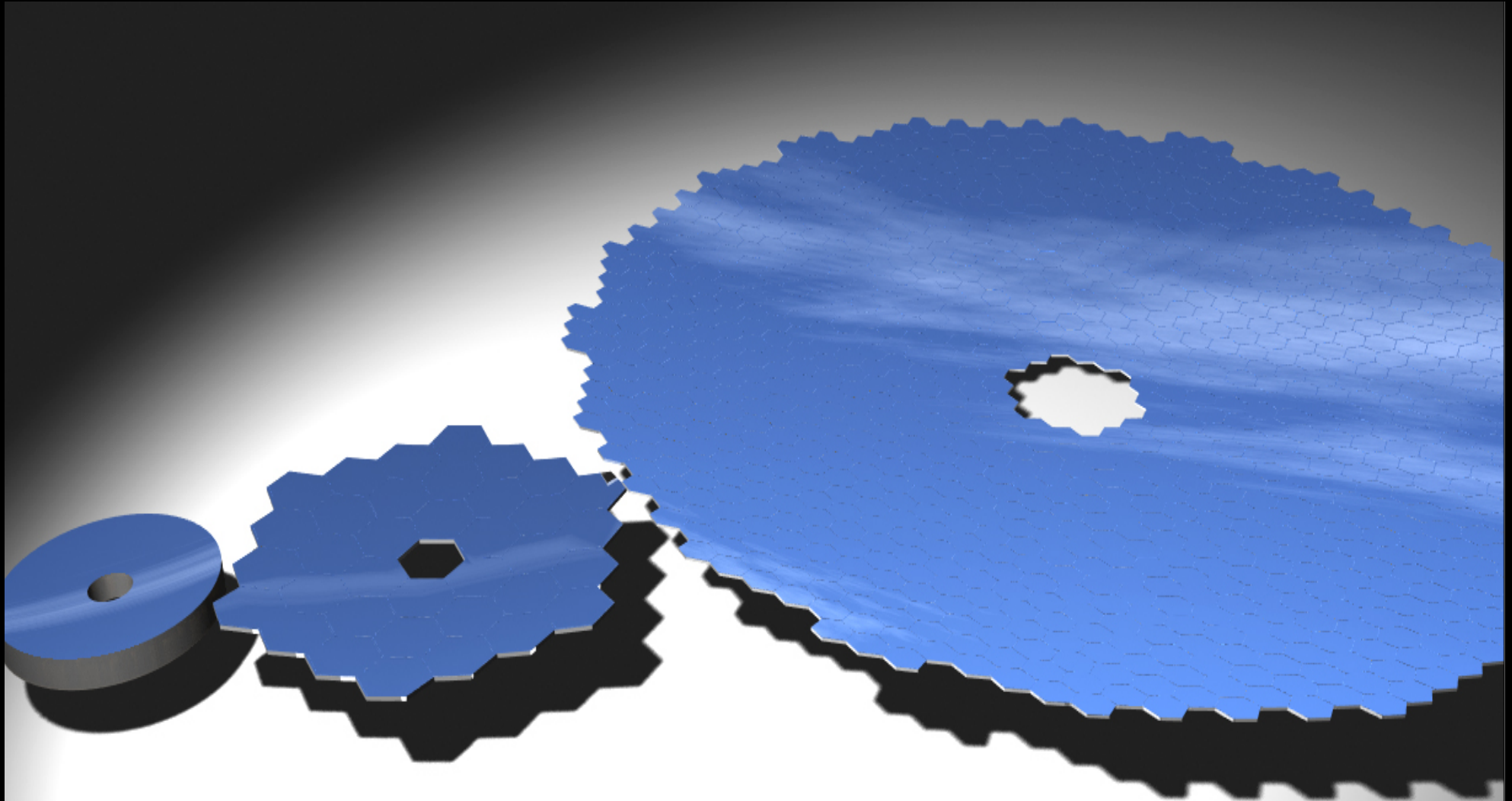
24 SEVEN – April 2nd to April 8th

See all videos ...

### RELATED ITEMS

CREATED: 6 APRIL 2015

# From Large to Extremely Large



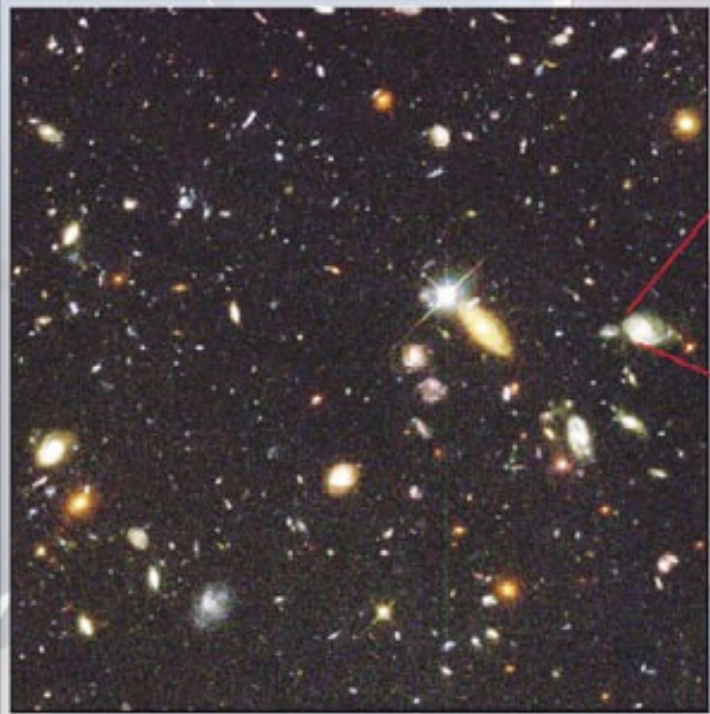
5 Meter  
Hale 200-inch  
Mirror

10 Meter  
Keck  
Mirror

30 Meter  
TMT  
Mirror

# Amazingly Sharp Images

Hubble Deep Field



HST Resolution



Currently in the design phase, the Thirty Meter Telescope (TMT) project is a collaboration between the University of California, the Associated Universities for Research in Astronomy, and the Association of Canadian Universities for Research in Astronomy and Caltech. Shown here is an example of the angular resolution that TMT will have with its adaptive optics system, comparing it to the resolution of the Hubble Space Telescope. With adaptive optics, TMT will be diffraction limited for wavelengths of  $1\mu\text{m}$  and longer. This resolution will greatly enhance the sensitivity of TMT in the infrared.

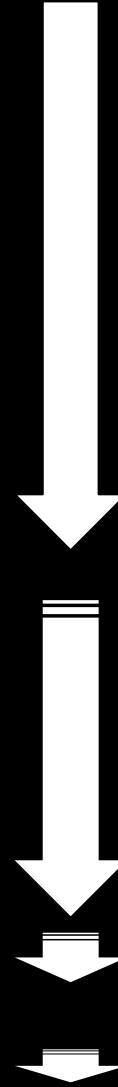


Thirty Meter Telescope (TMT) Resolution with Adaptive Optics

(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

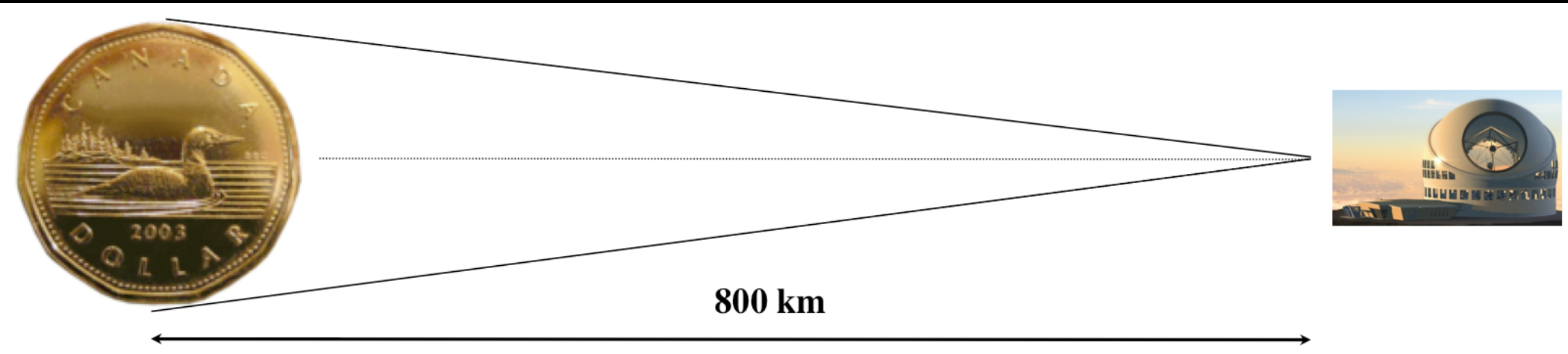
# Or a Tiny, Tiny Slice of the Moon



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

(This is 15 meters at the lunar surface!)

# Seeing a Loonie from Really, Really Far Away



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

# Goodbye Twinkle, Twinkle Little Star

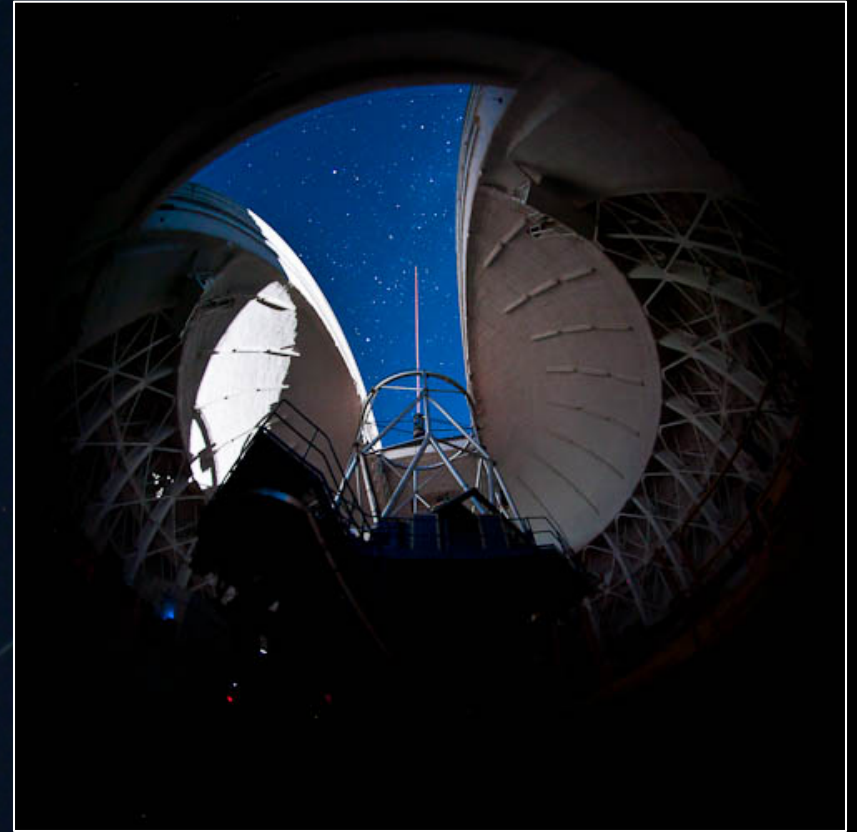
VLT ACTIVE OPTICS

IMAGE CORRECTIONS





# A New Constellation is Born!

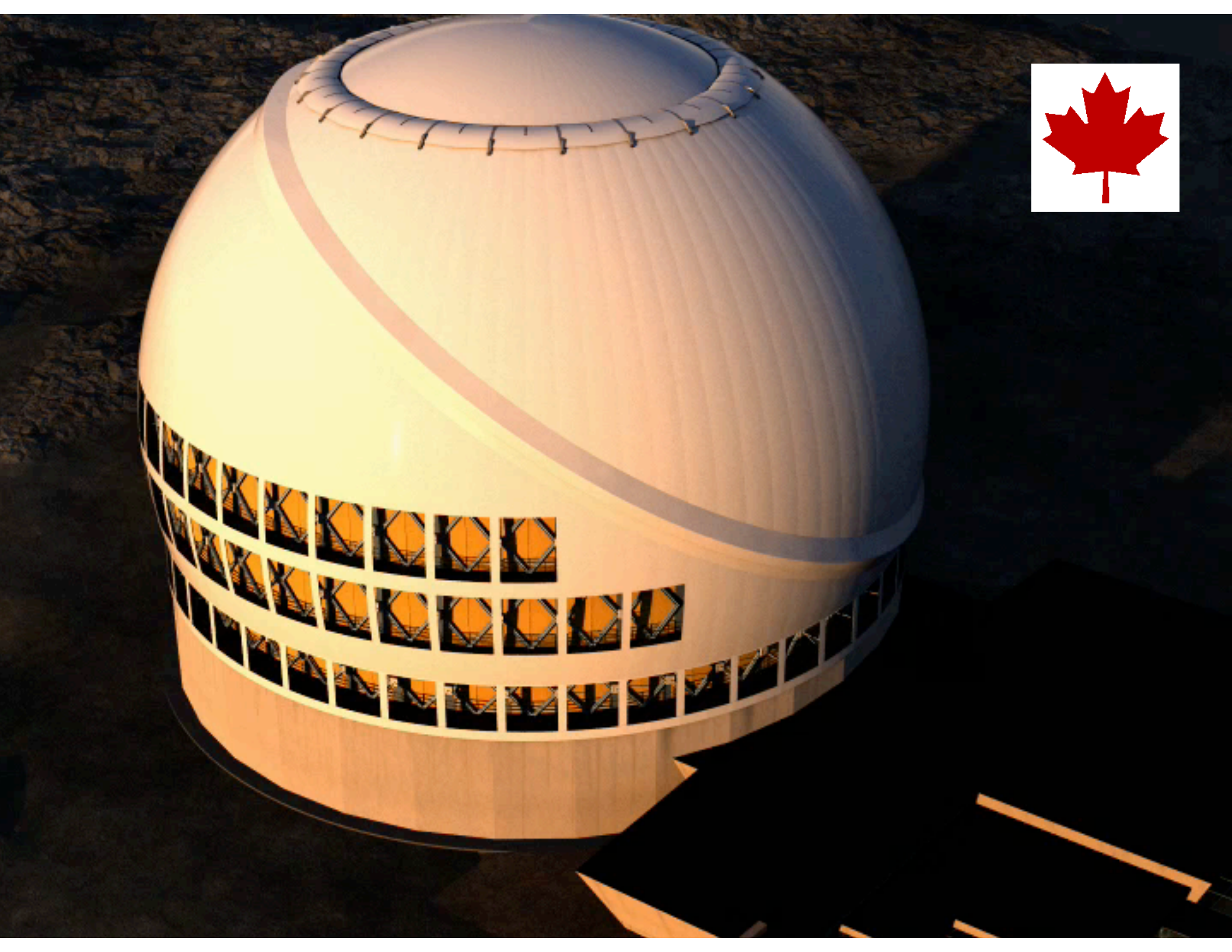


Credit:  
Gemini  
Observatory



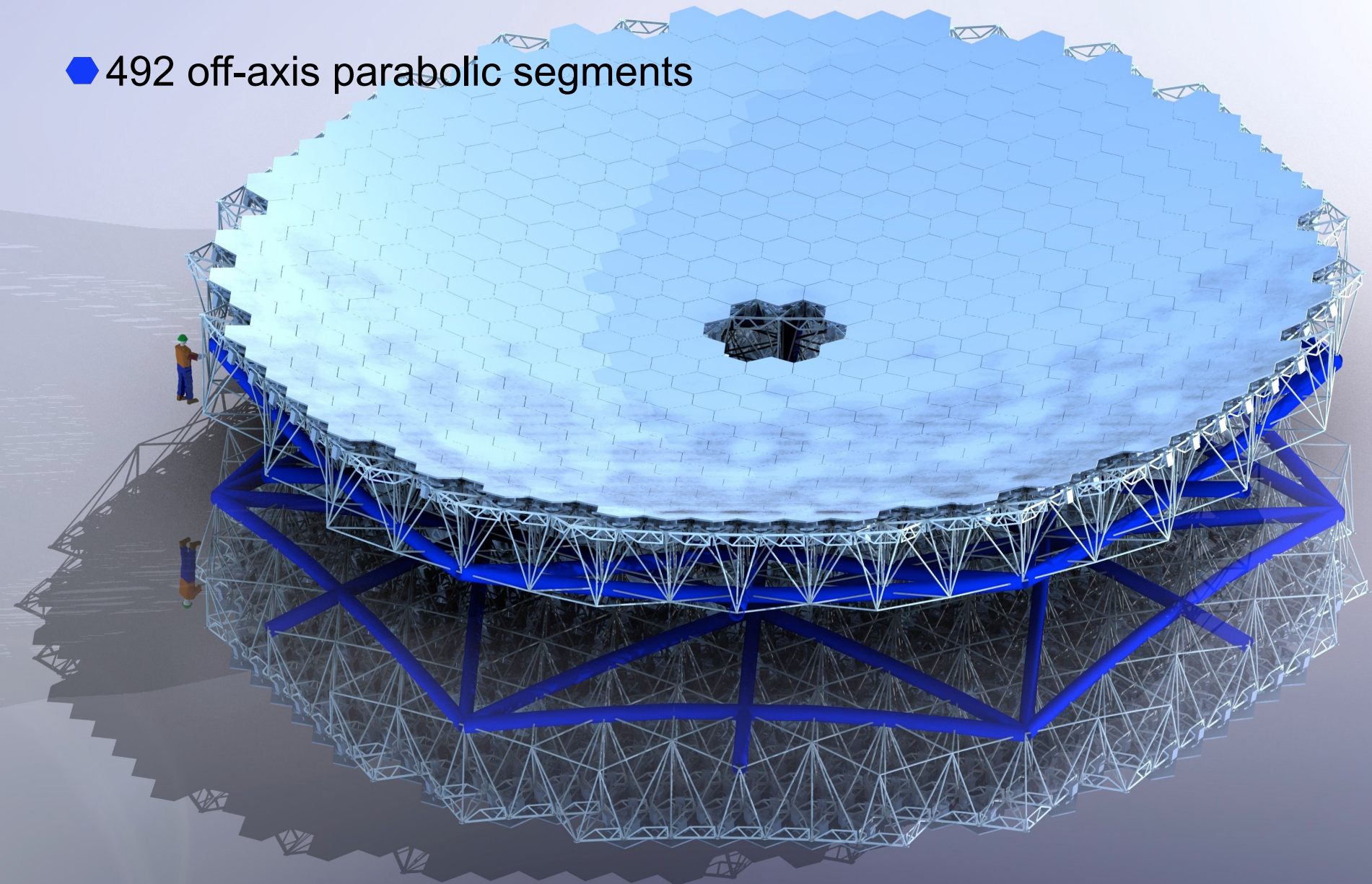
# TMT on Maunakea





# TMT primary mirror

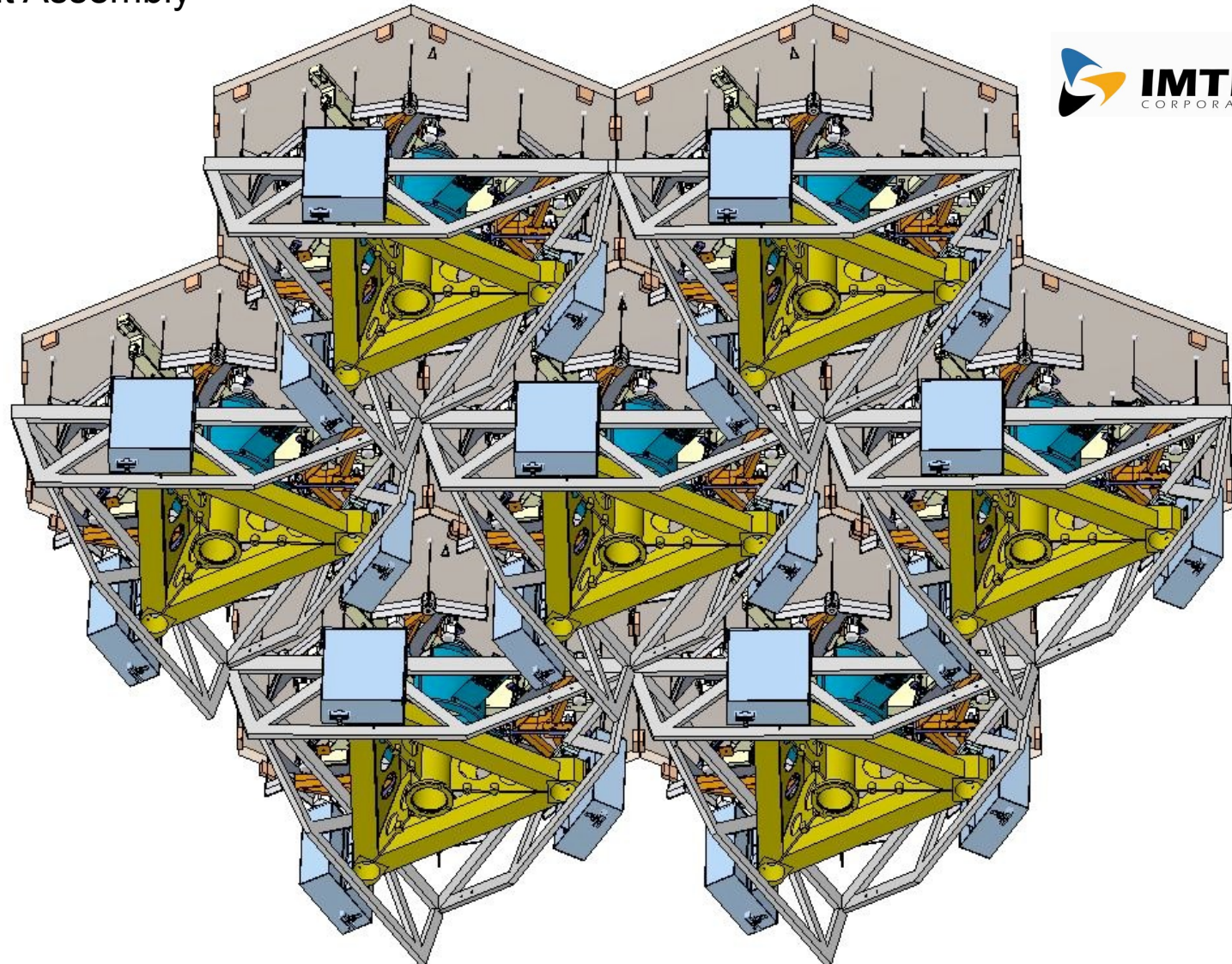
◆ 492 off-axis parabolic segments



1 TMT segment = 3 Climenhaga telescopes!

# Segment Support Assembly (SSA) Design

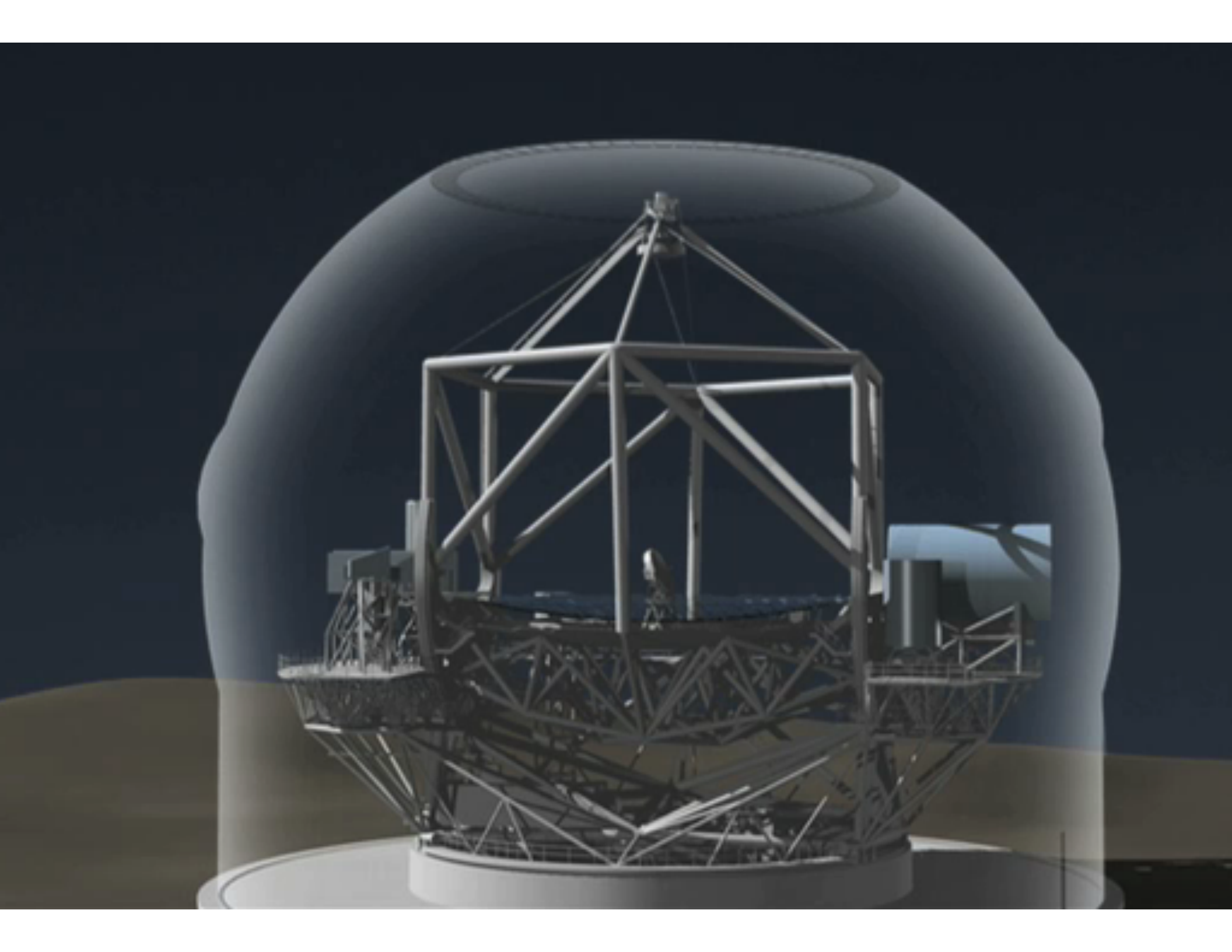
- ◆ Seven Segment Assembly  
– Bottom View





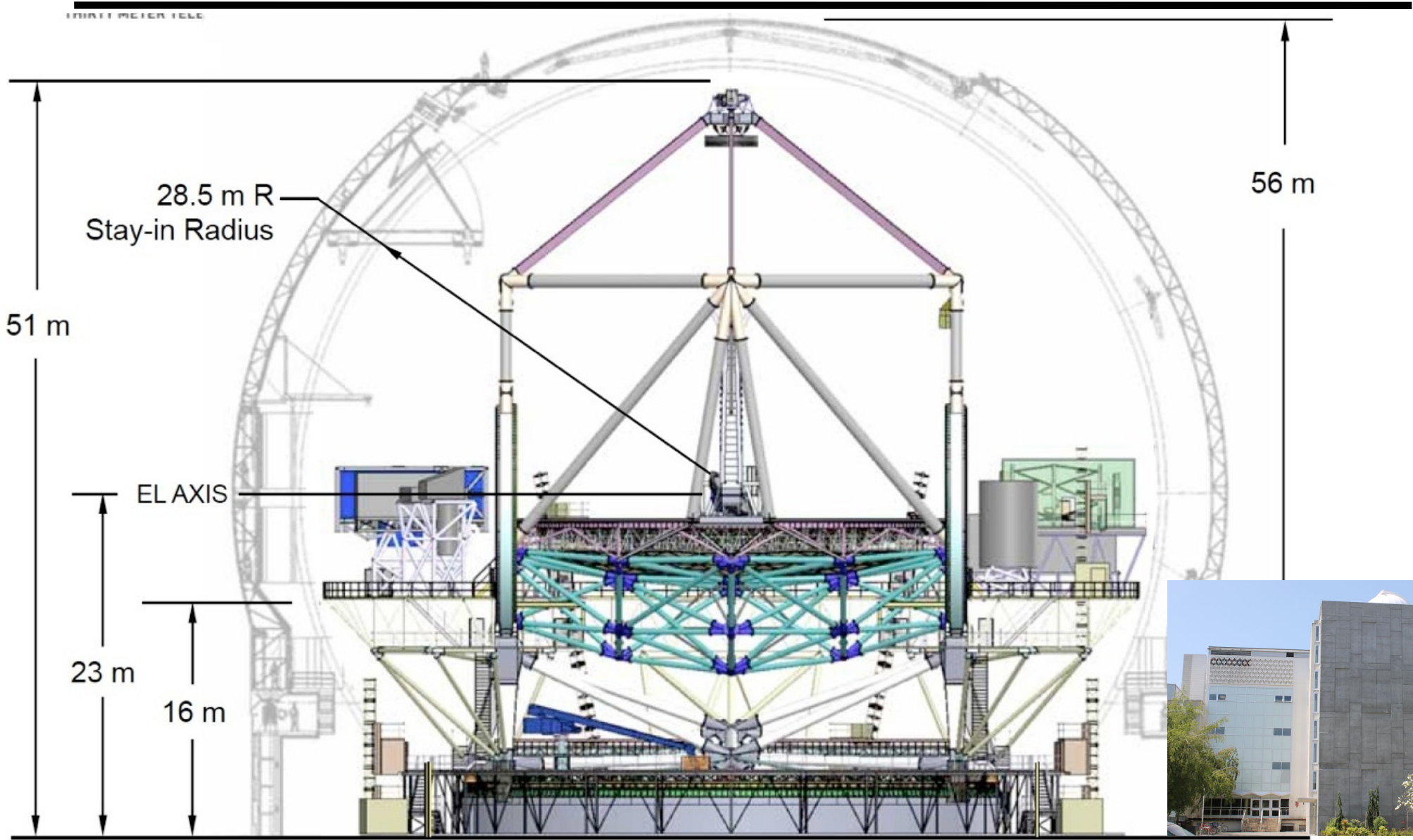
# Full Scale Segment on Segment Support Assembly

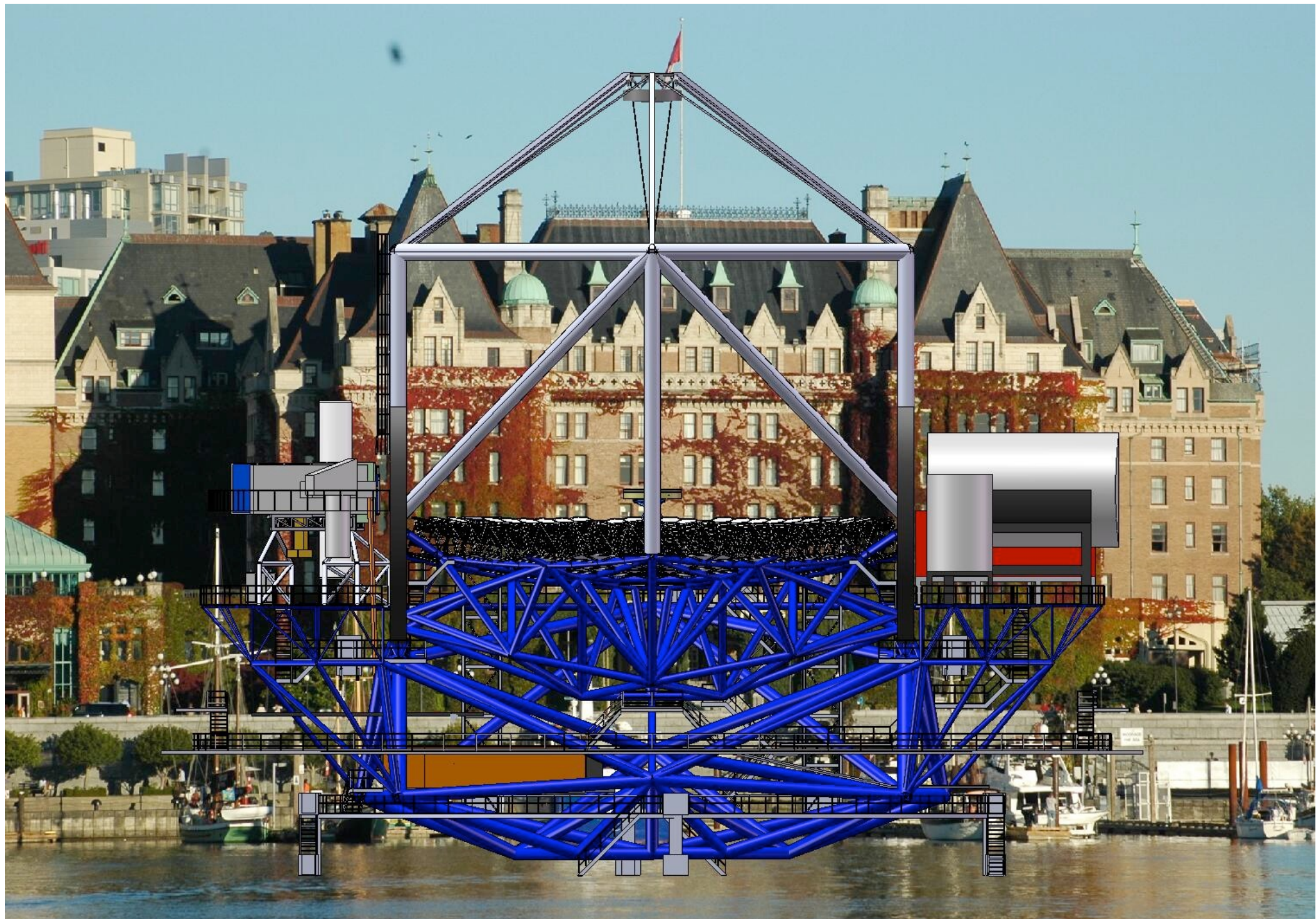
Unveiled at 2014 CASCA Meeting in Québec City!

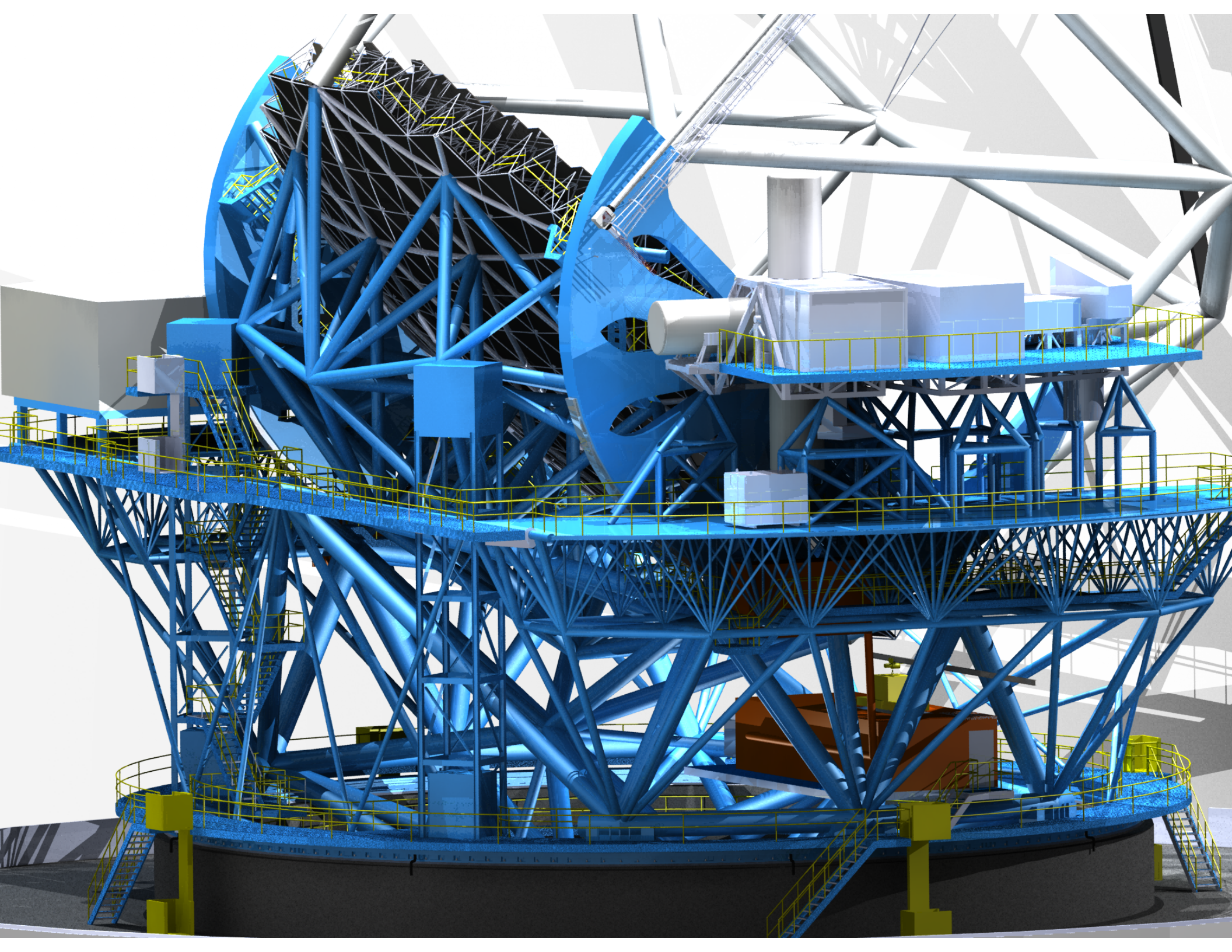




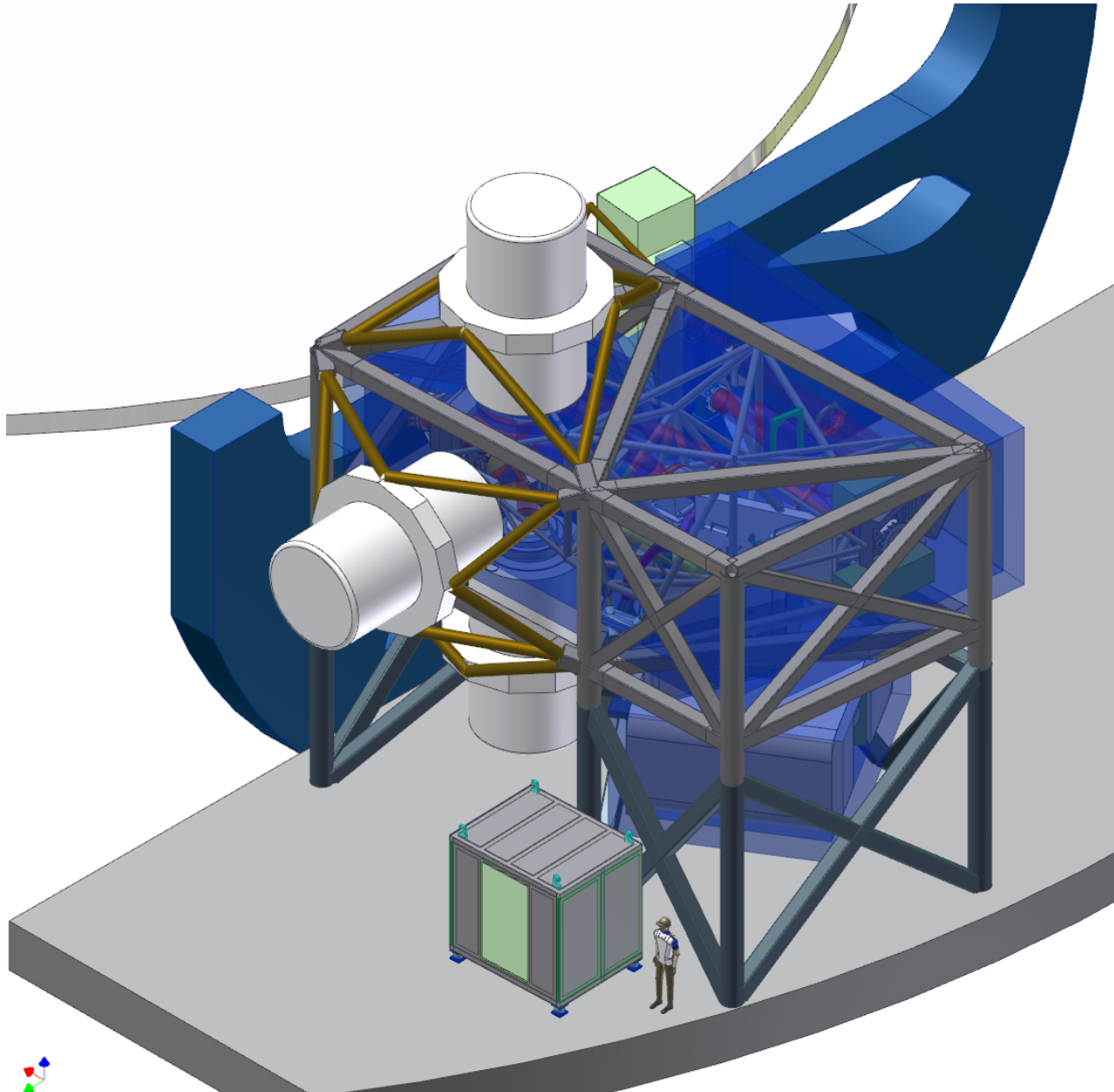
# Key Dimensions



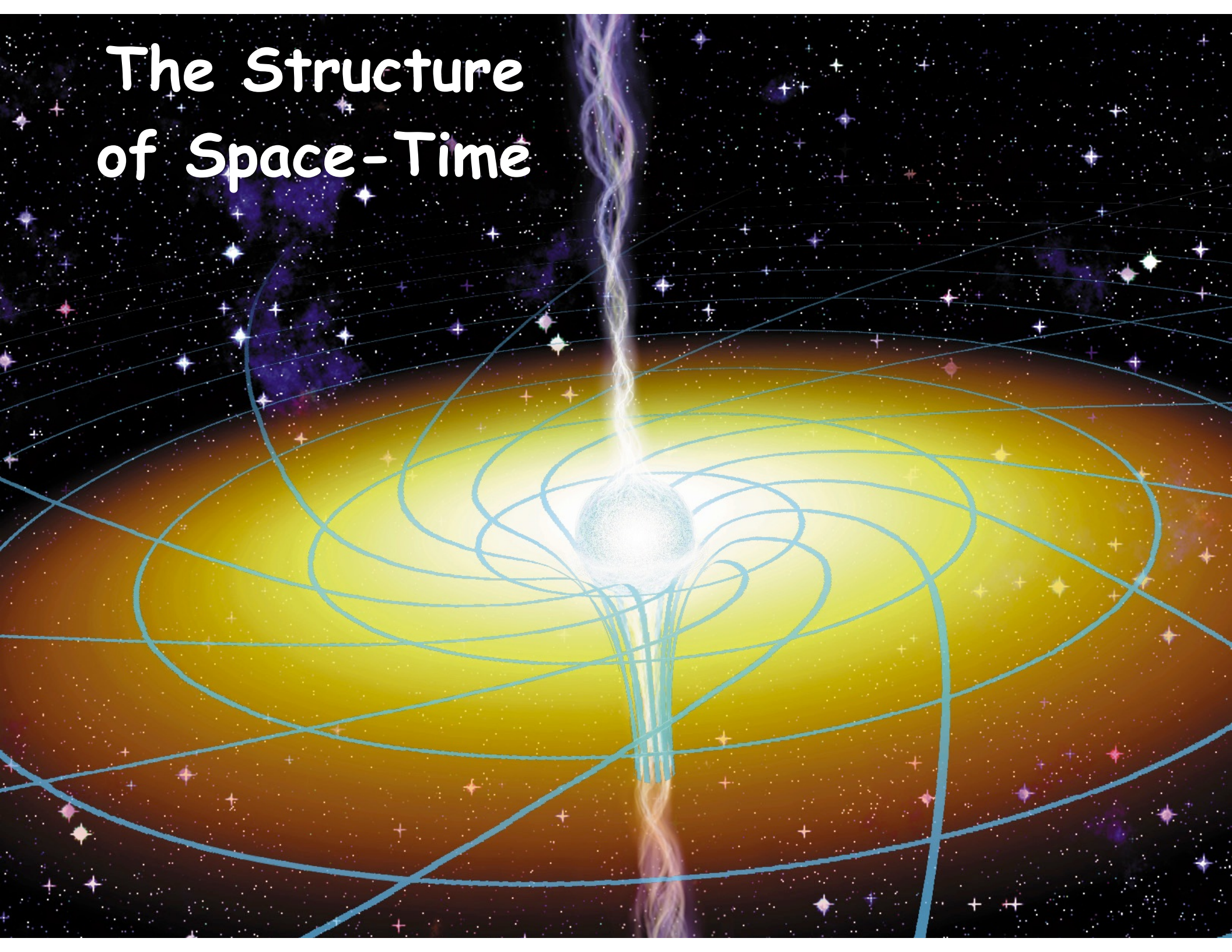




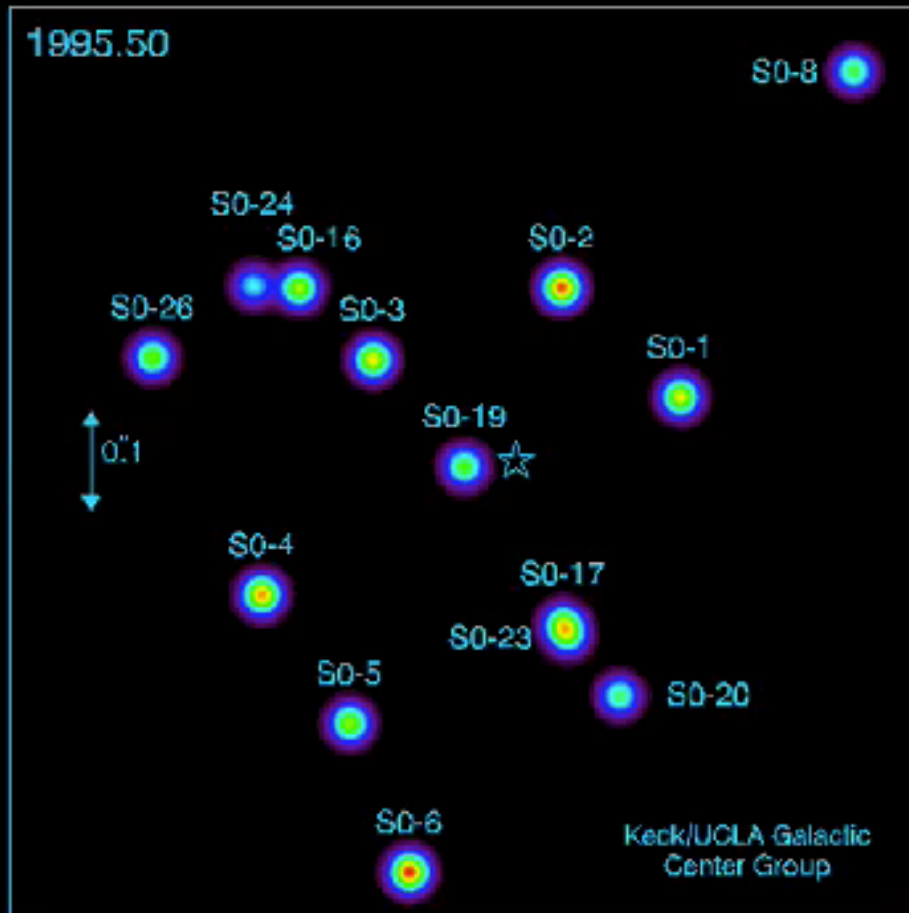
# Narrow-Field IR AO System (NFIRAOS): TMT's First-Light Facility AO system



# The Structure of Space-Time



# Einstein and the Galactic Center

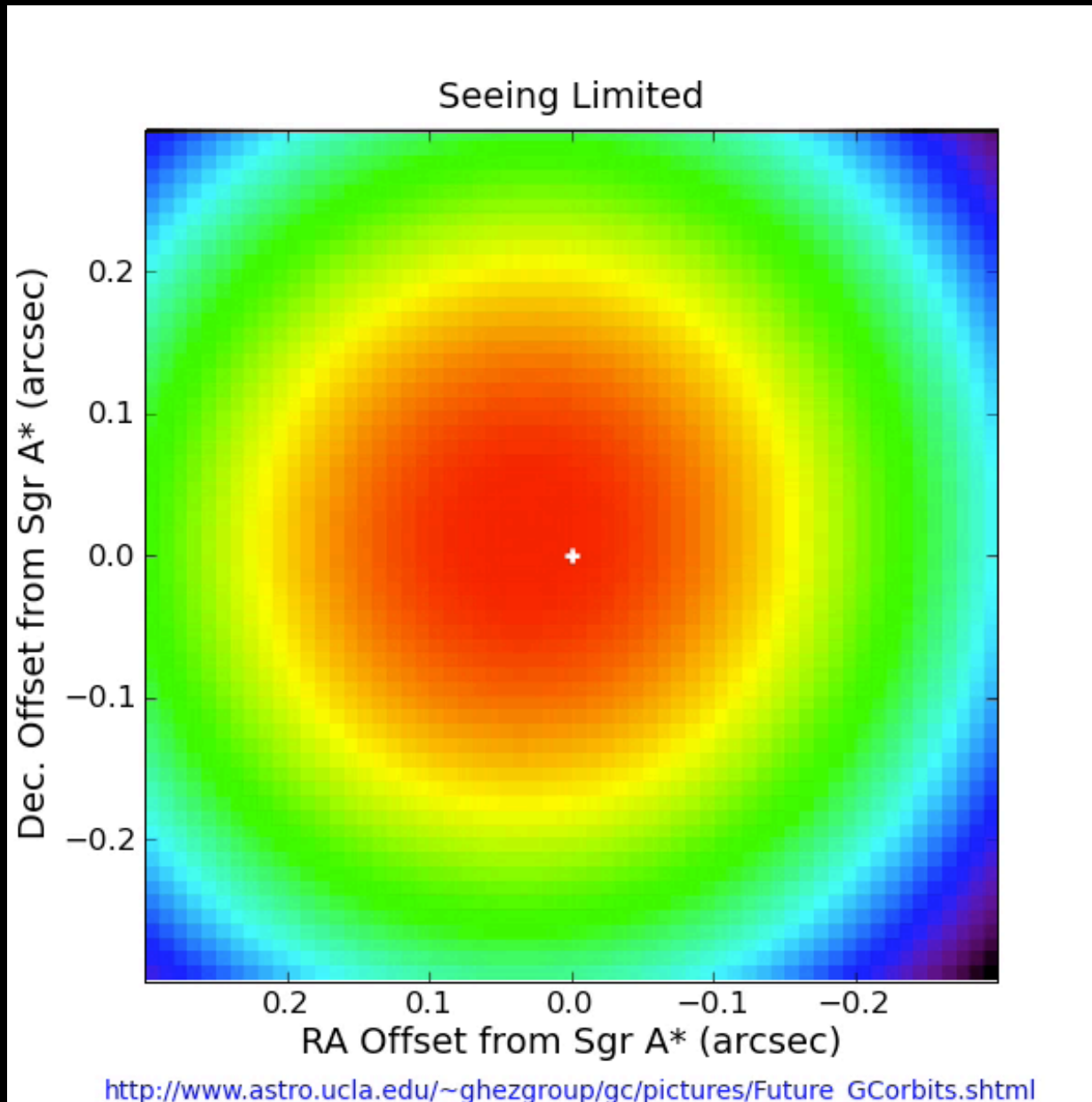


The center of our Milky Way harbors a supermassive black hole with a mass of four million times the Sun!

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



# The Universe in Motion

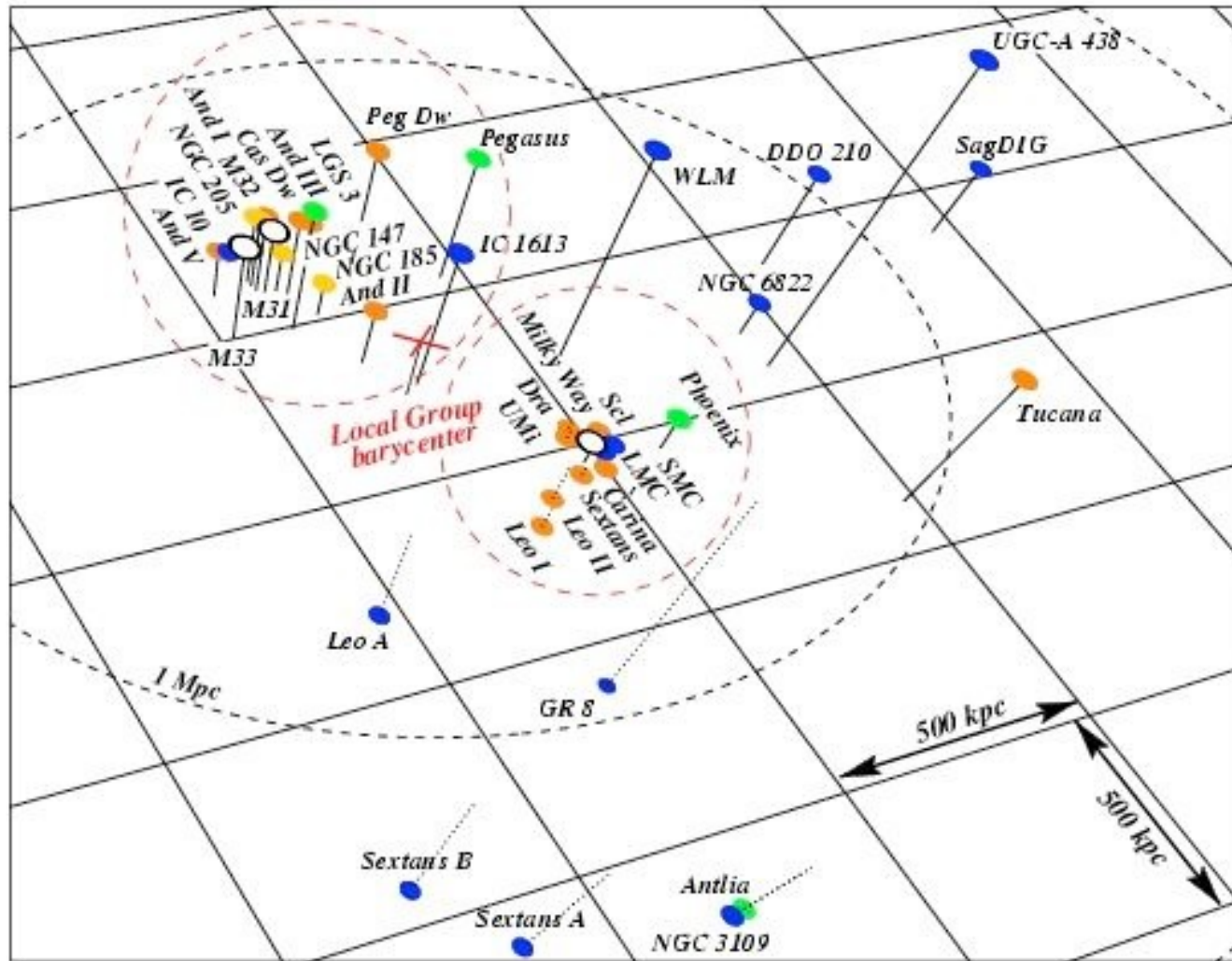


[www.twig-world.com](http://www.twig-world.com)

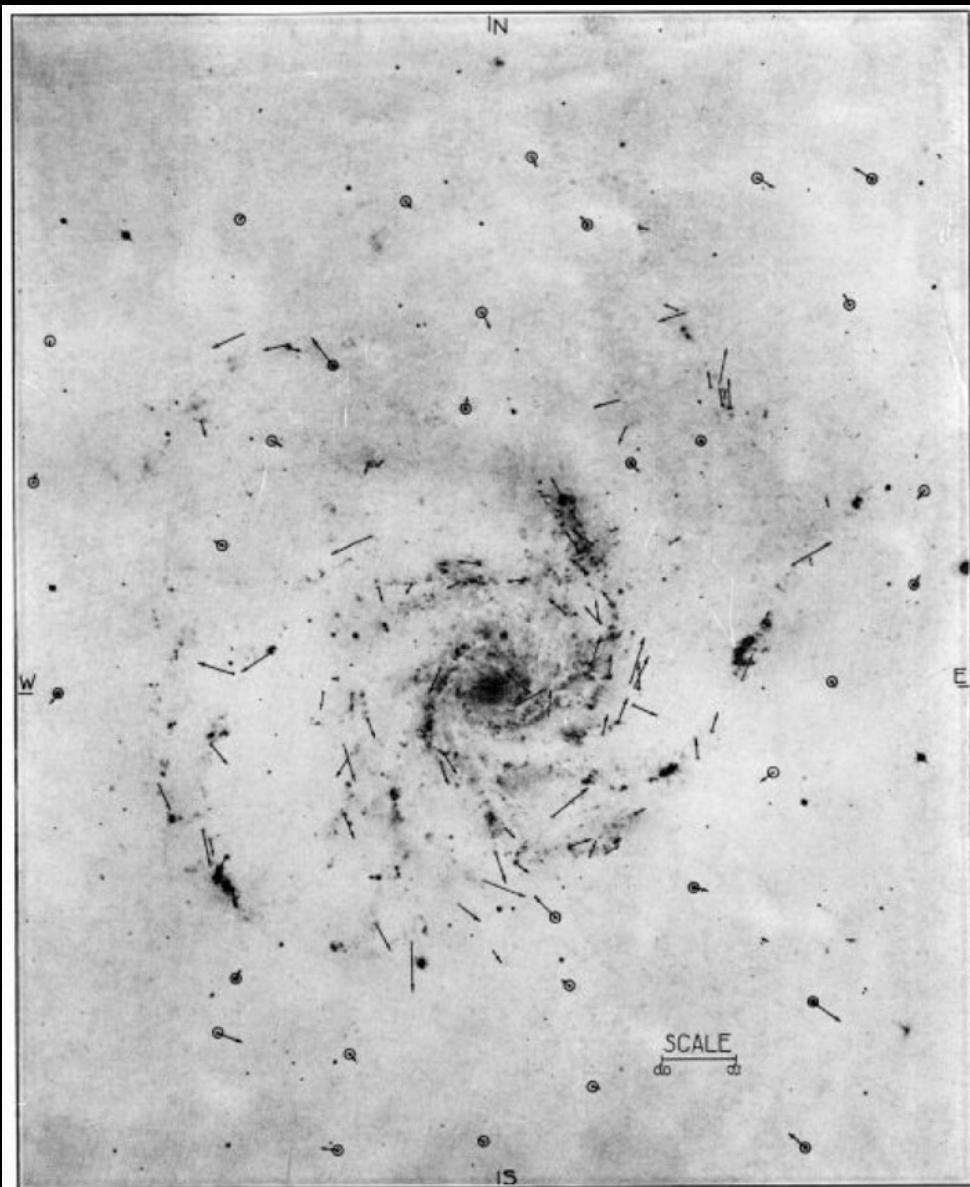
TMT will reveal the immovable sky as a dizzying cosmic ballet ...



# Dancing with Galaxies: The Local Group



# van Maanen's Dream



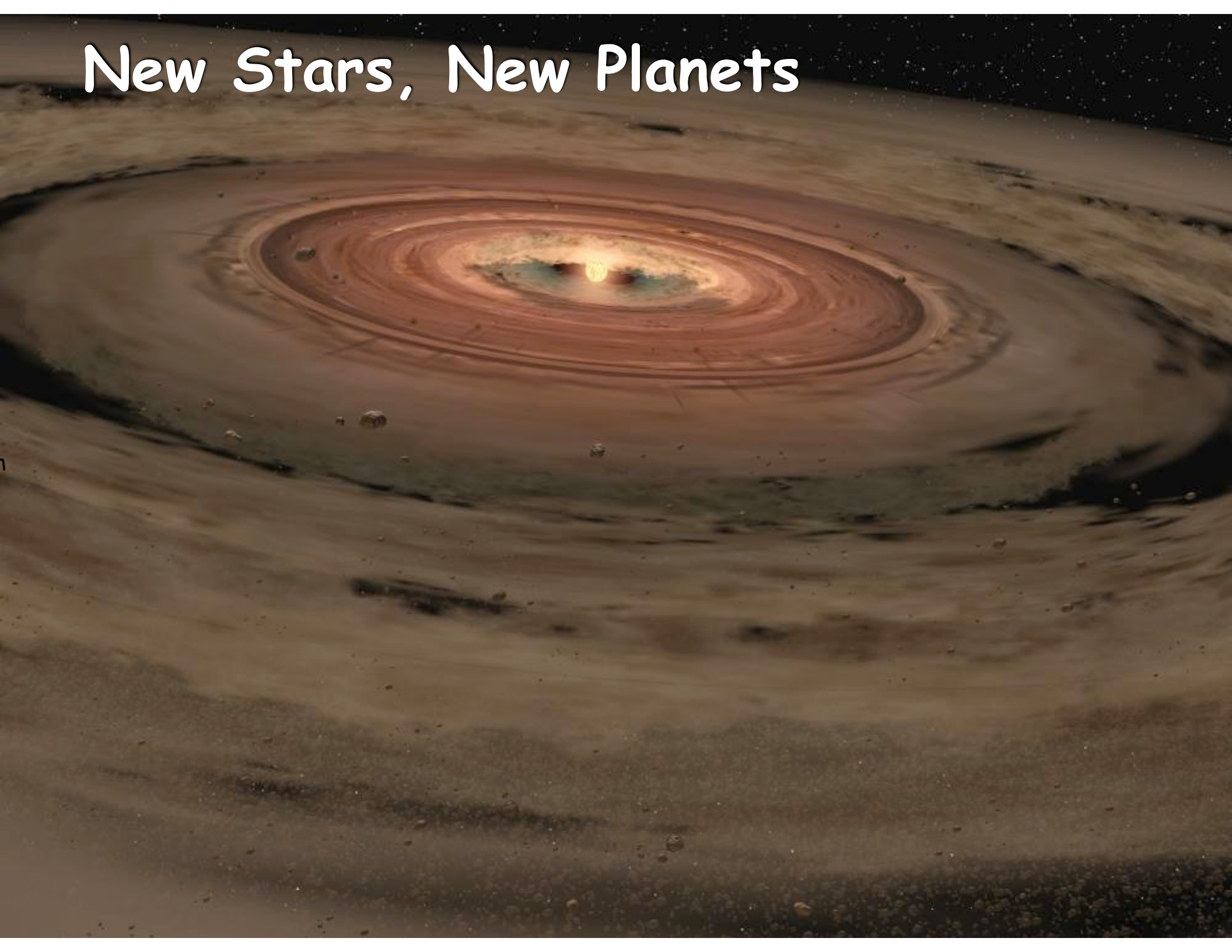
INTERNAL MOTIONS IN MESSIER 101

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  $1 \text{ mm} = 10^5$ . 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

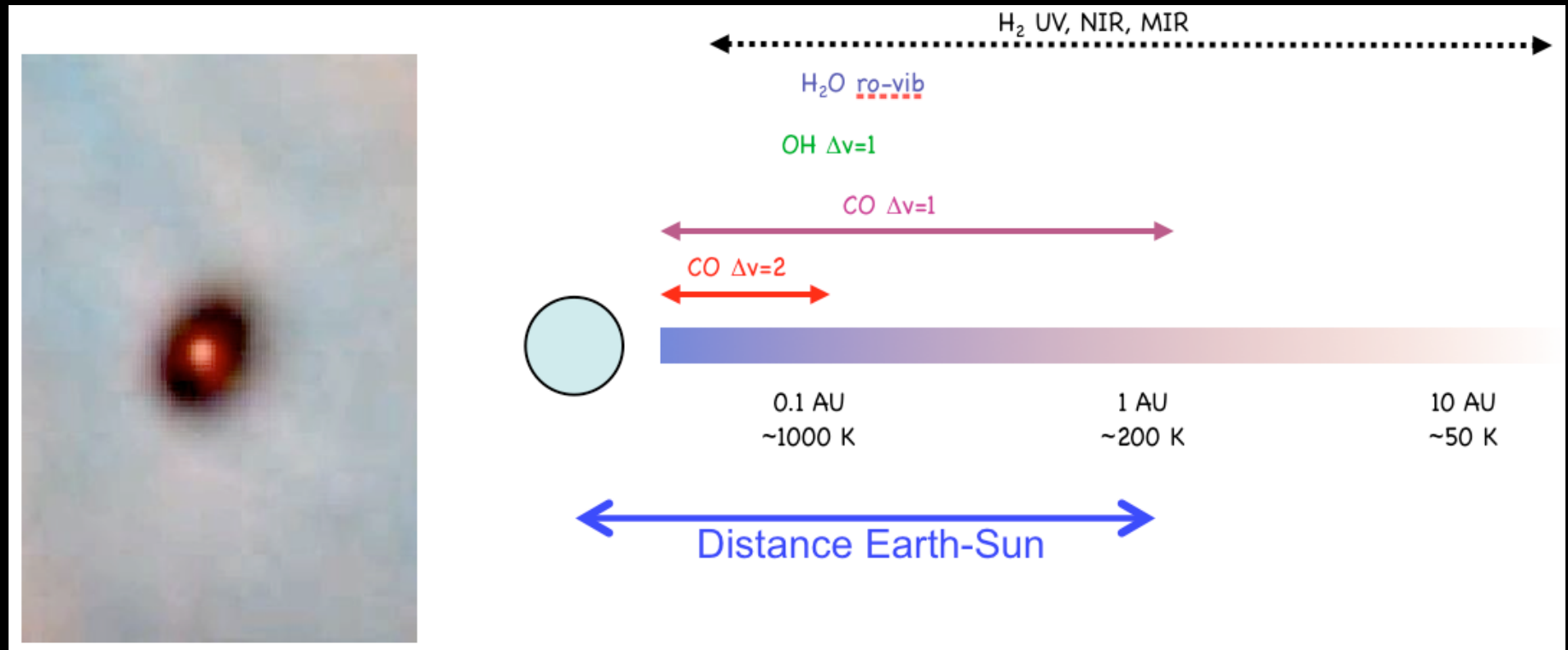


# A Planet Forming Disk



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

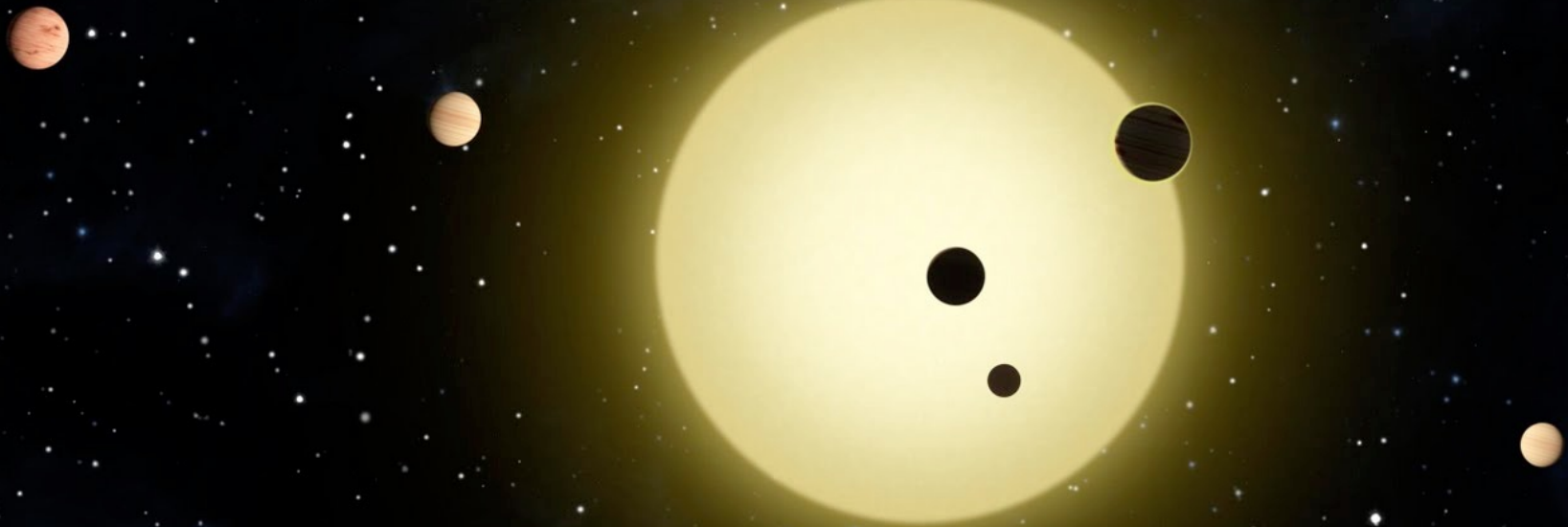
# The Building Blocks of Life



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

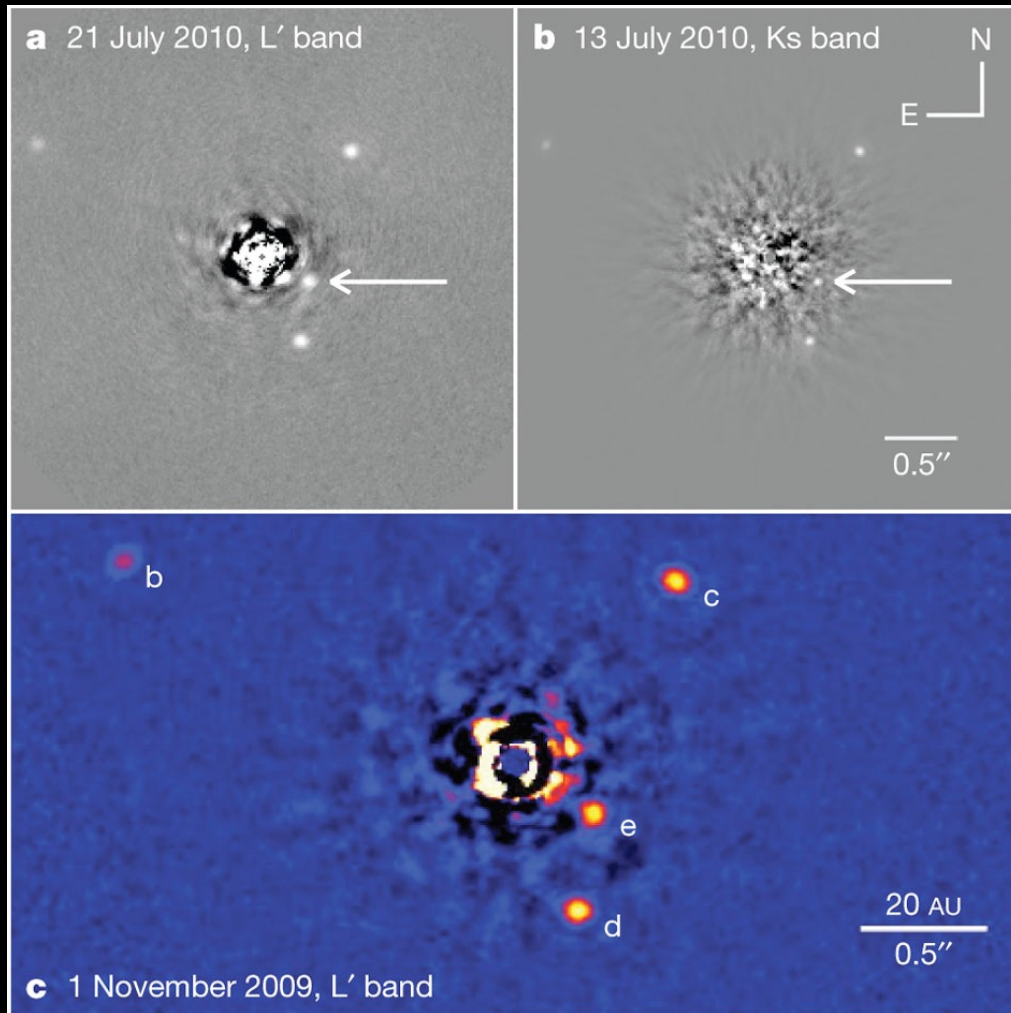
Powerful spectrographs will help us identify complex molecules and show us how they are deposited onto the surface of newly formed planets.

# Other Planetary Systems



Kepler-11  
Six planets  
Distance: 2000 light-years

# Direct Imaging of Planetary Systems



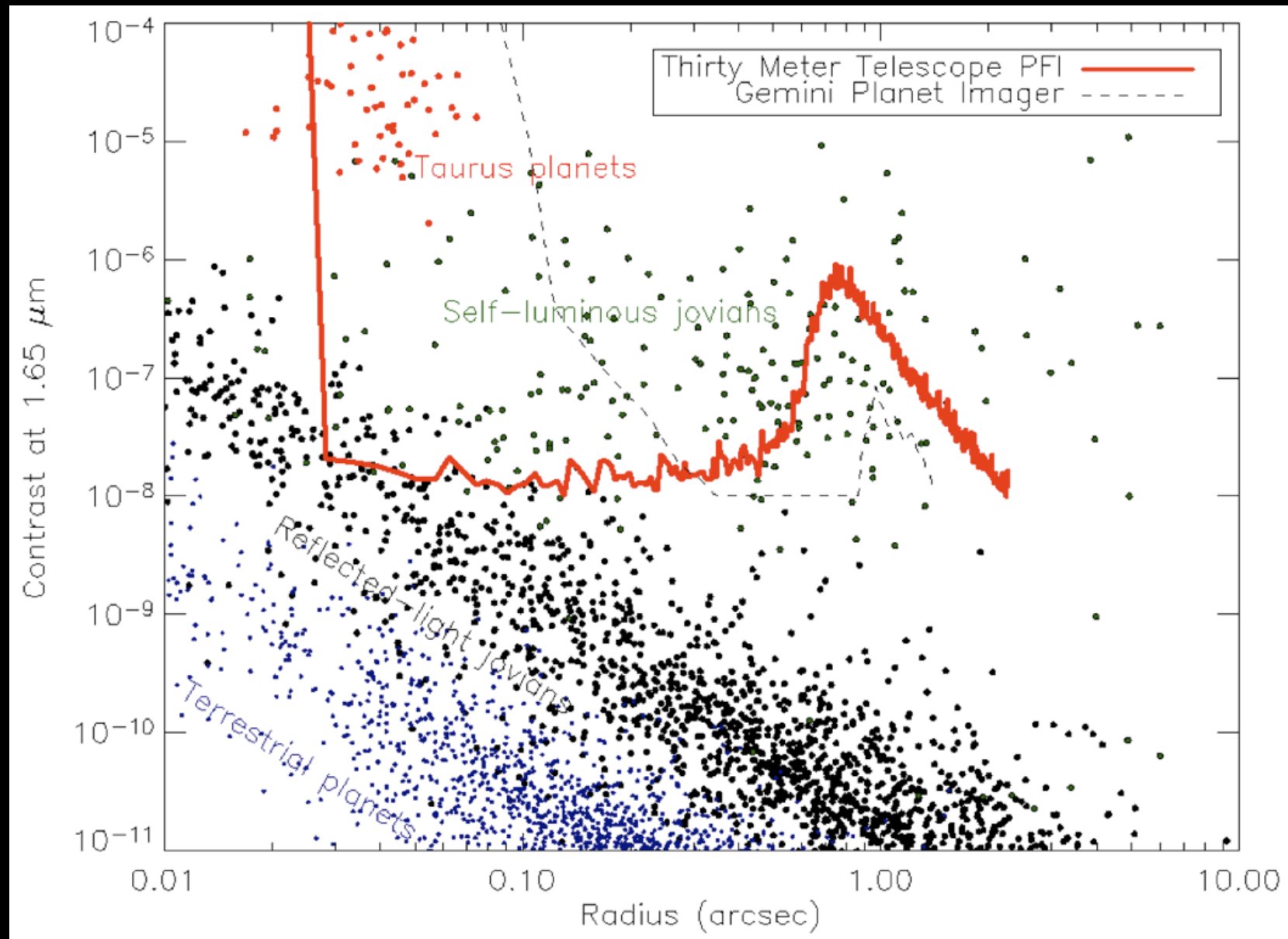
First system imaged in 2008 by a Canadian team!

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  $\sim 50,000$

(Credit: Marois et al. 2008,2010)

# Direct Imaging of Planetary Systems with TMT



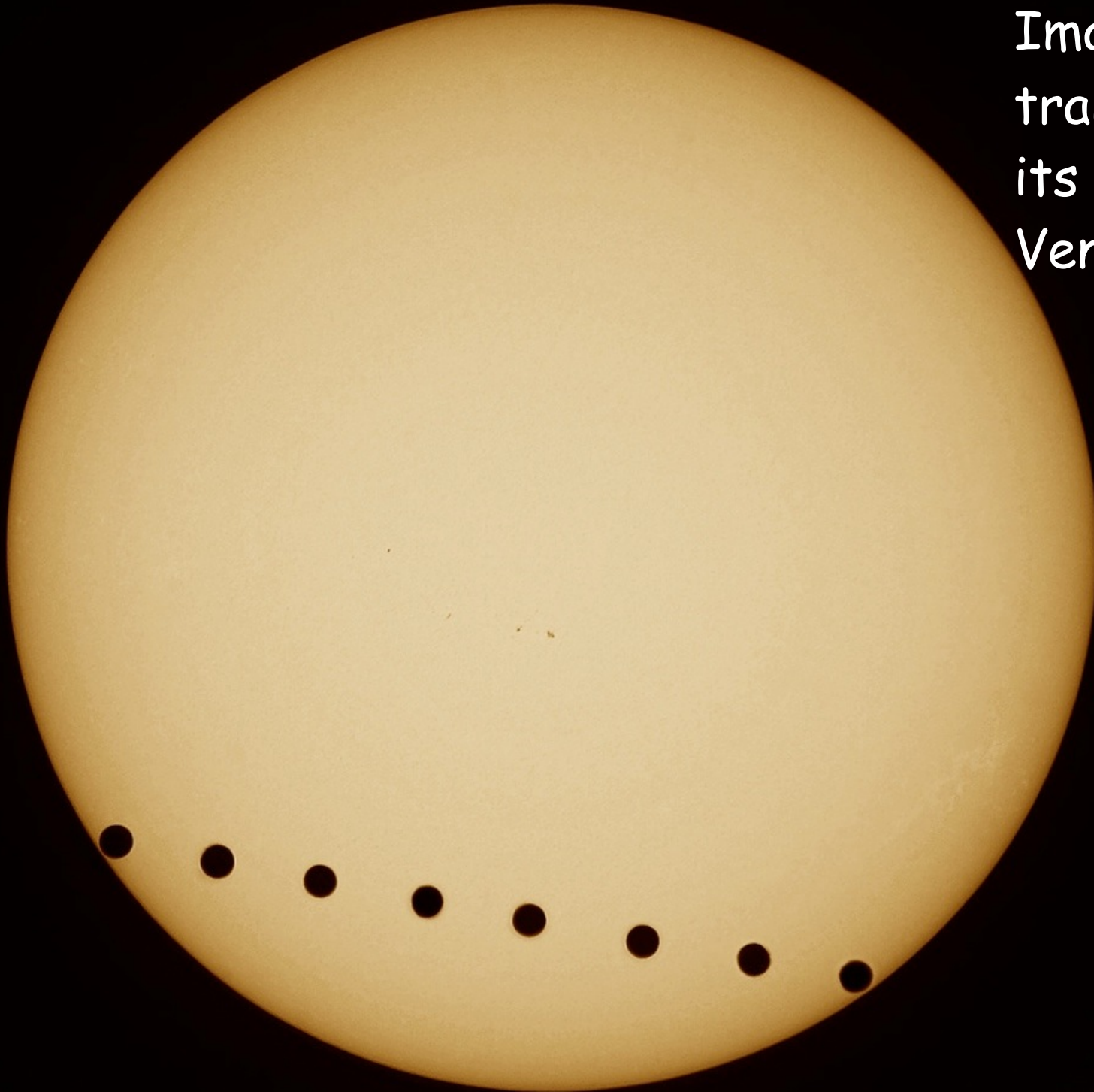
Contrast  
ratio of  $\rightarrow$   
100 million!



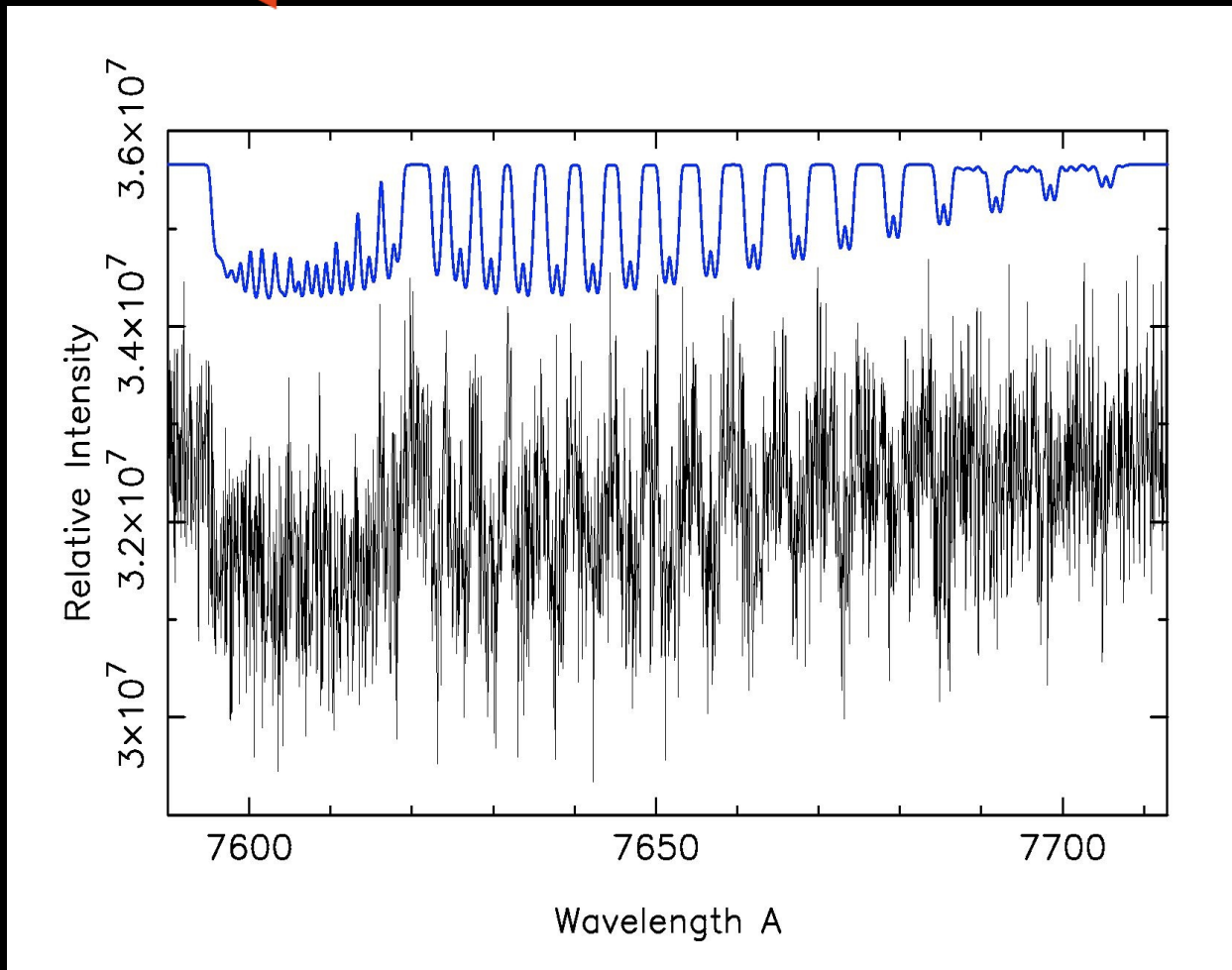
# Another Earth? Life?



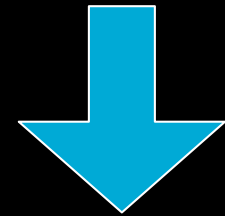
Imagine an exoplanet  
transiting in front of  
its host star ... like  
Venus in June 2012



# The Hunt for Bio-Markers

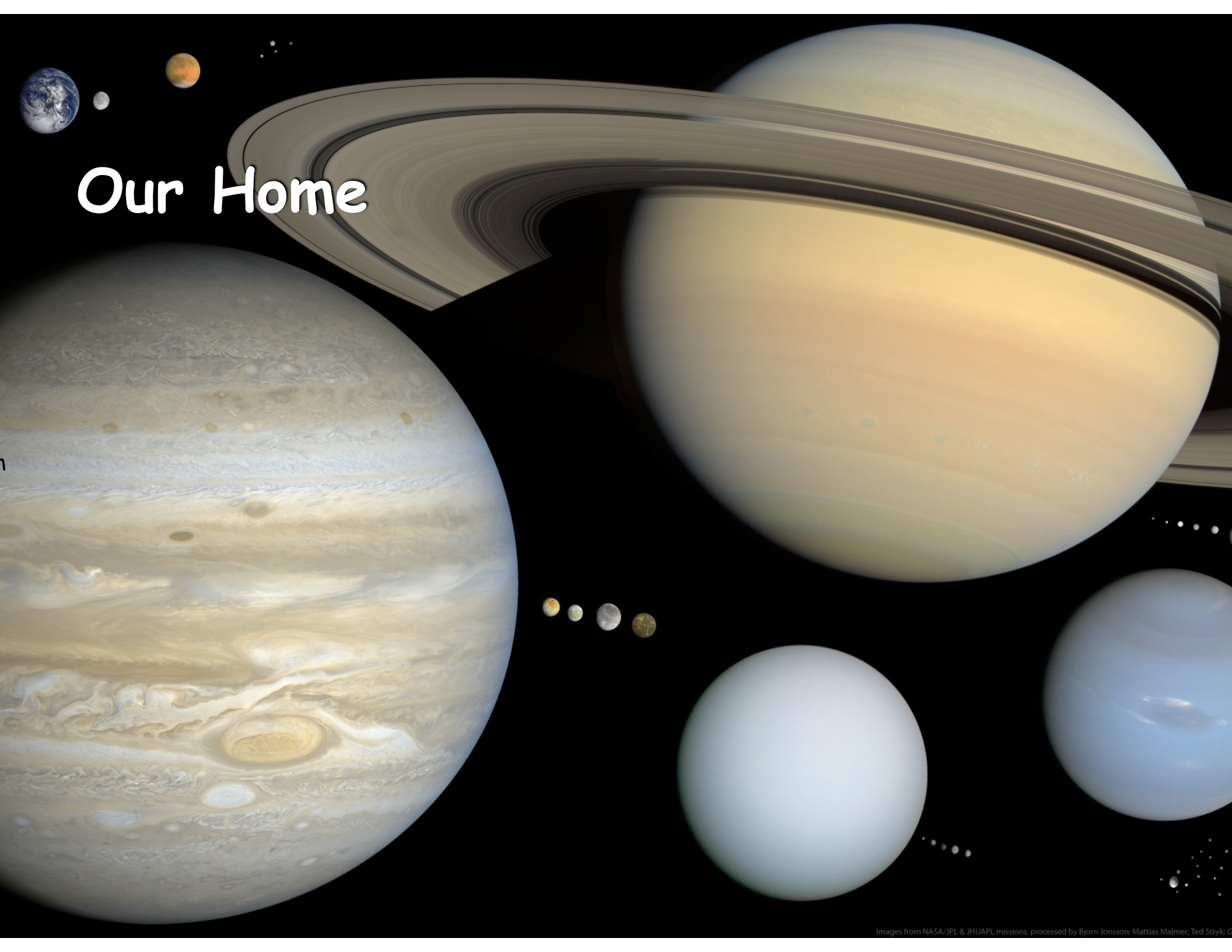


Oxygen  
(+ industrial  
pollution ...?)

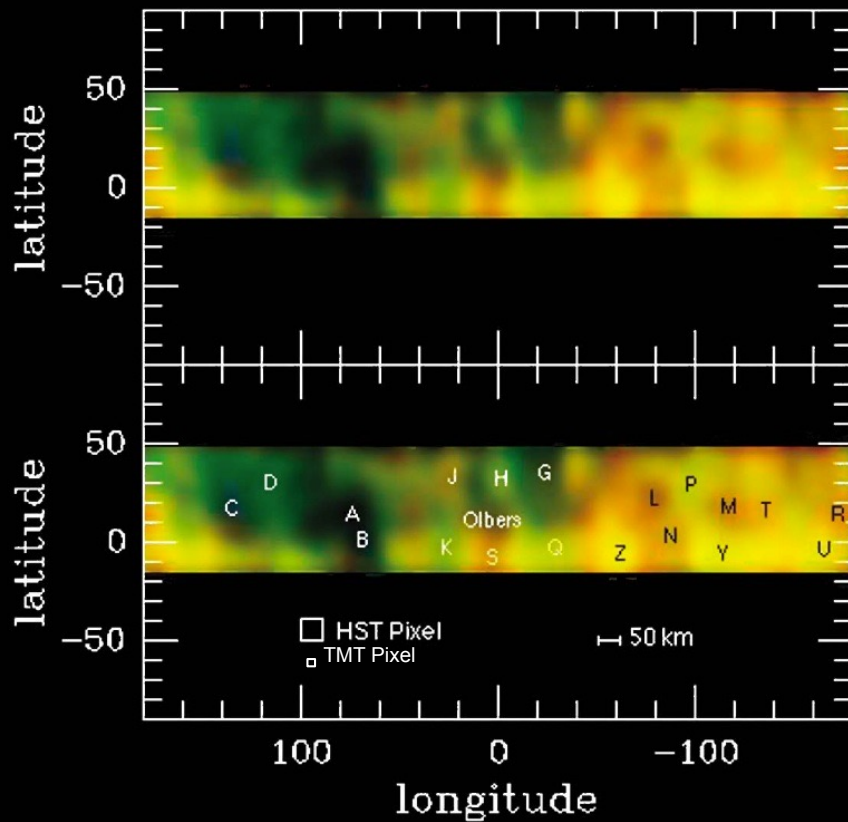


Life!

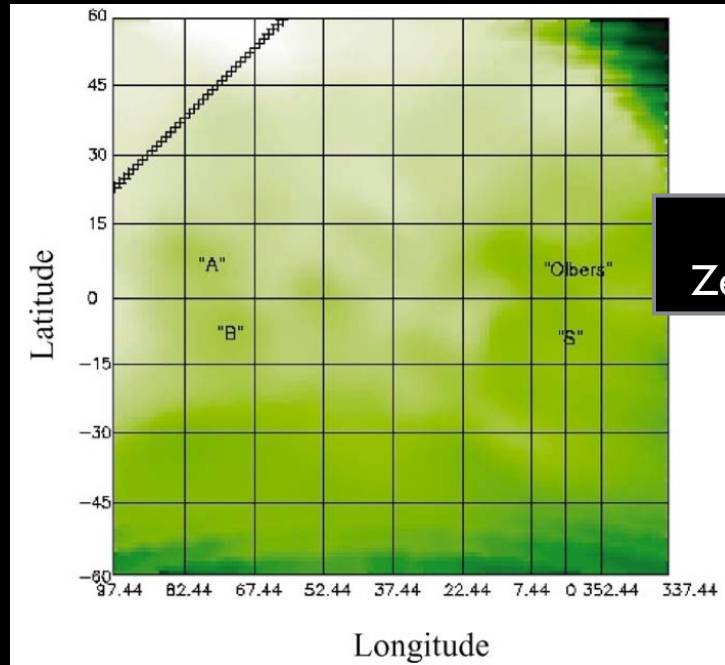
# Our Home



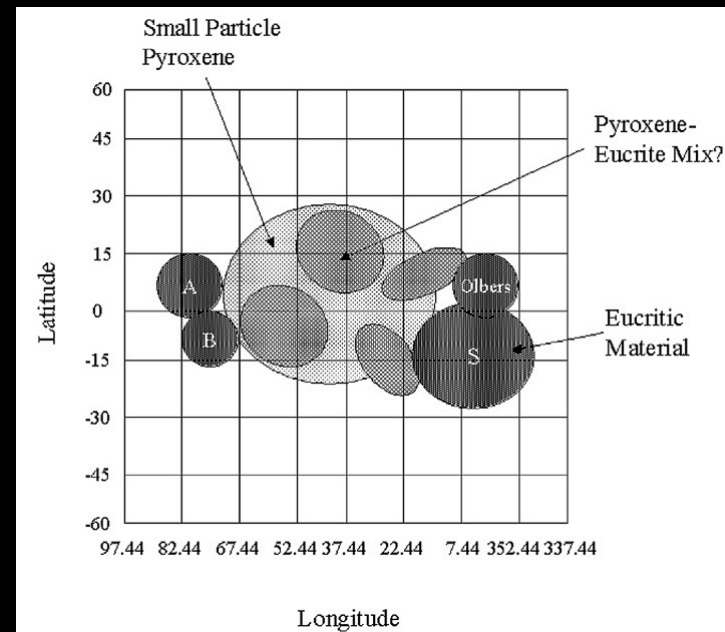
# Geological Mapping of Asteroids



Vesta  
(Binzel et al. 1997)



Keck AO  
Zellner et al. 2005



# 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

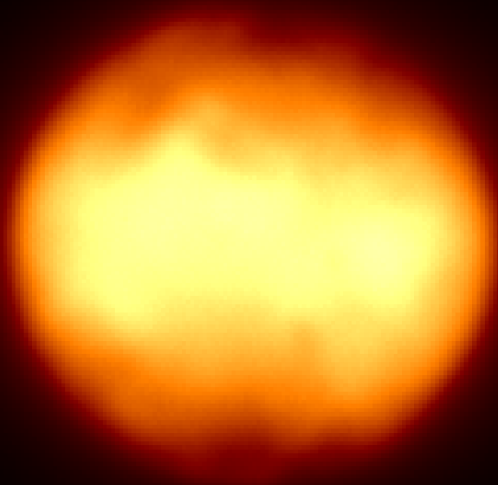
Cracks are seen in this ice - it looks like a liquid broke through and froze again

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

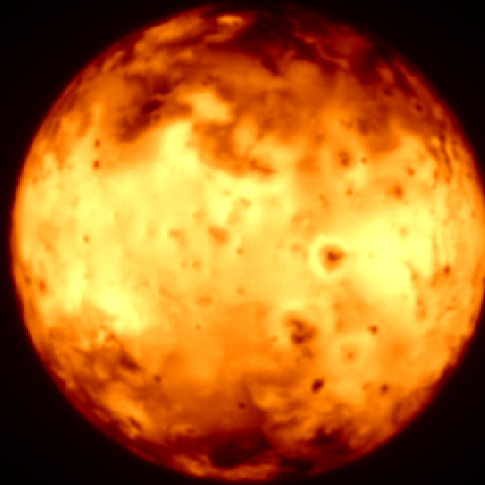
Galileo would be proud!

# The Volcanoes of Io

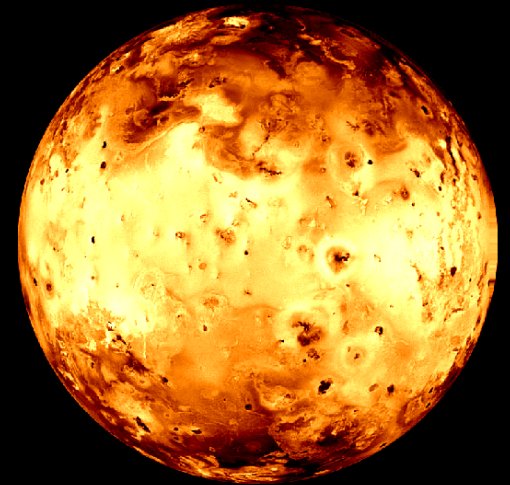
Keck AO H-band



TMT IRIS H-band



Galileo



Io Simulation

Io Simulation

T. Do/UCLA/IRIS/TMT

Also playing:

Giant storms on Jupiter

Methane rain fall on Titan

Water geysers of Enceladus

Nitrogen geysers blowing in the wind on Triton

And ... ?

# Pluto and Charon

Charon



0.05"

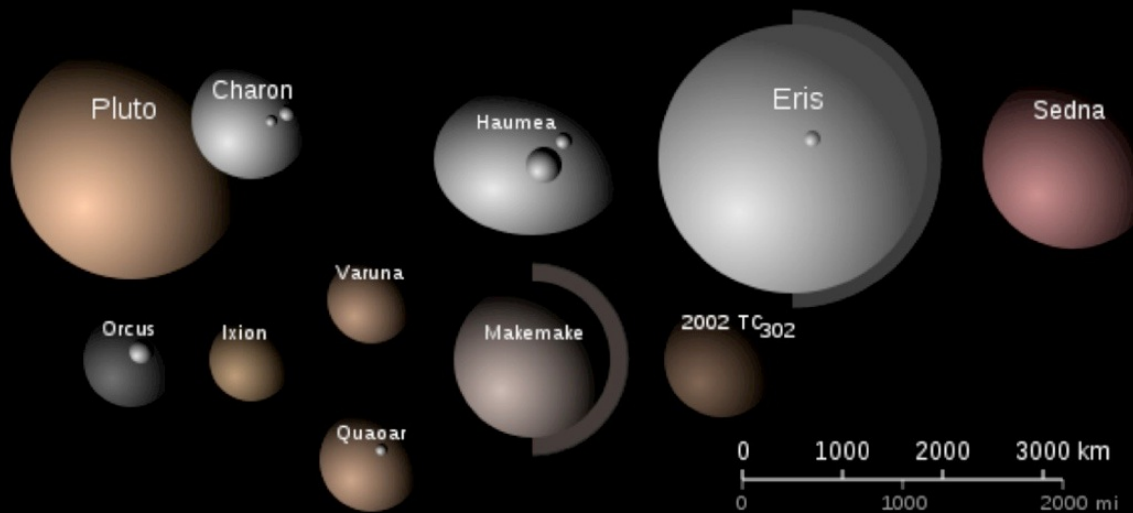
Pluto



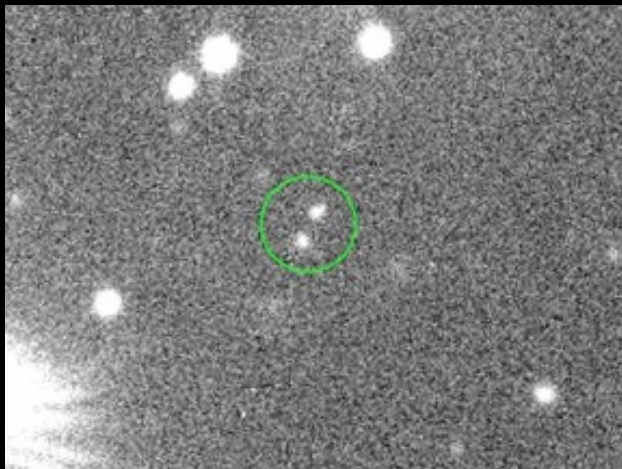
IRIS / TMT / G. Walth



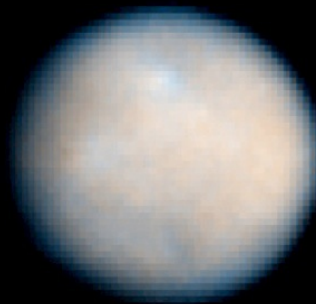
# The Kuiper Belt



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



1 Ceres by HST



13 elements (~Pluto)

Keck Observations of (9) Metis



3 elements (~Haumea)









