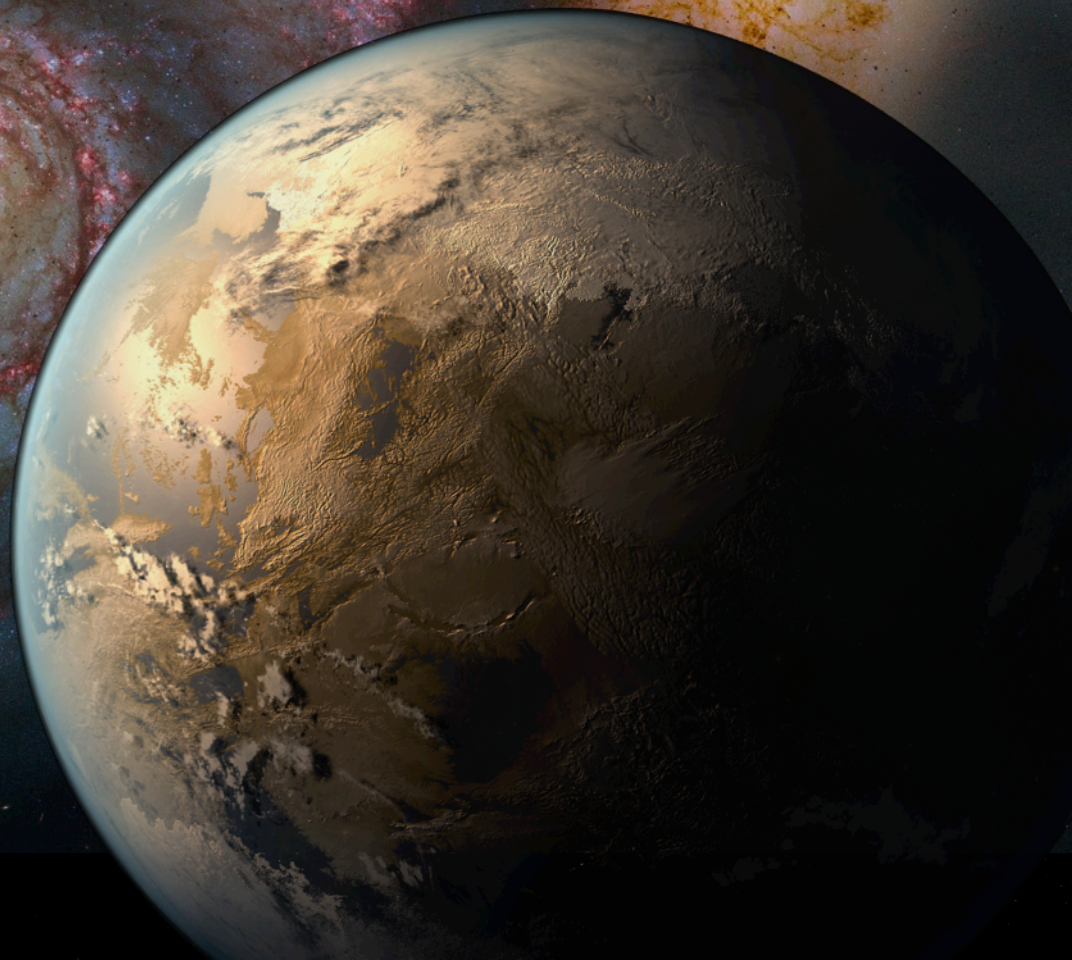
BIG BANG TO BIOSIGNATURES:
THE LUVOIR MISSION CONCEPT



STDT Nov 10, 2016

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for the STDT

Summary

LUVOIR has multiple primary science goals

① Habitable exoplanets & biosignatures

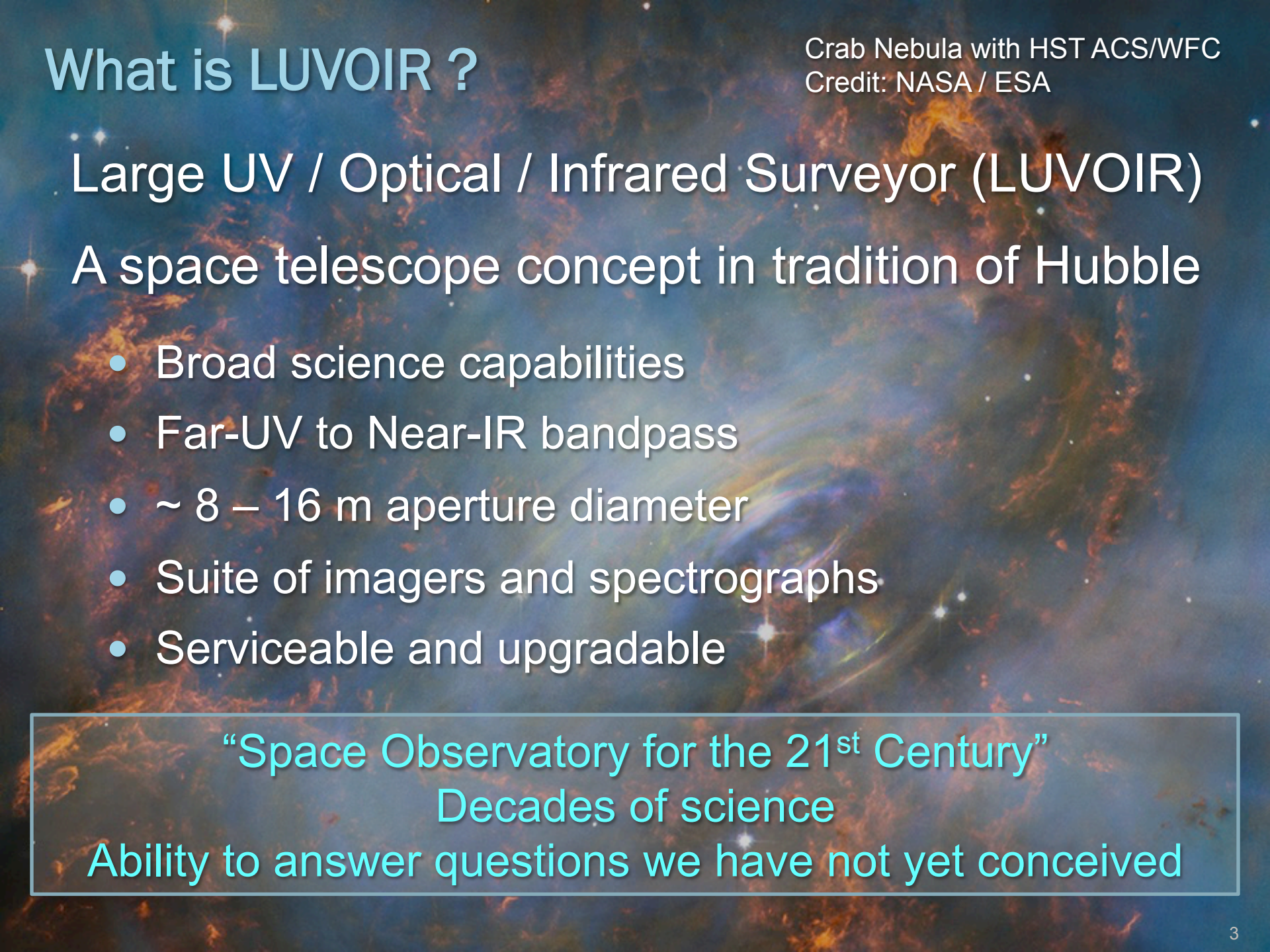
② Broad range of general astrophysics and Solar System observations

Challenge is to blend goals into single powerful mission

LUVOIR will provide a statistical study of Goal 1, factors of ~ 100 increased science grasp over Hubble for Goal 2

Wide range of capabilities to enable decades of future investigations and unexpected discoveries

What is LUVOIR ?



Crab Nebula with HST ACS/WFC
Credit: NASA / ESA

Large UV / Optical / Infrared Surveyor (LUVOIR)

A space telescope concept in tradition of Hubble

- Broad science capabilities
- Far-UV to Near-IR bandpass
- ~ 8 – 16 m aperture diameter
- Suite of imagers and spectrographs
- Serviceable and upgradable

"Space Observatory for the 21st Century"
Decades of science
Ability to answer questions we have not yet conceived

Imagine astronomy without Hubble …

Eagle Nebula
(high resolution over wide field)

Hubble Ultra Deep Field
(ultra-deep imaging)

Jupiter's aurora
(UV, global monitoring)

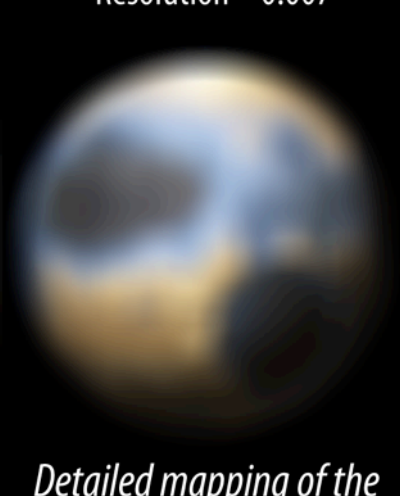
Imagine astronomy with LUVOIR …

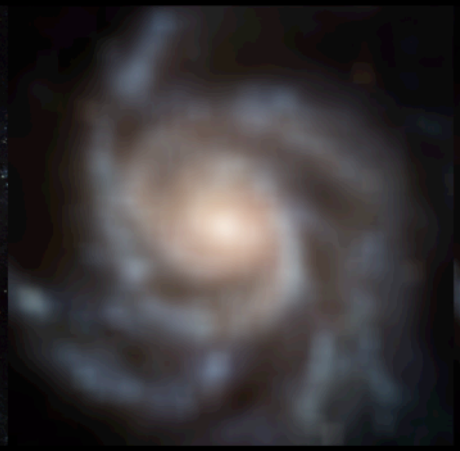
Hypothetical planet "Nine"
Located at ~1000 AU
Diameter of 40,000 km

Hubble Space Telescope (HST)
Best optical resolution (2016)
2.5m diameter (0.05")

LUVOIR
6m diameter
Resolution ~0.02"

LUVOIR
18m diameter
Resolution ~0.007"

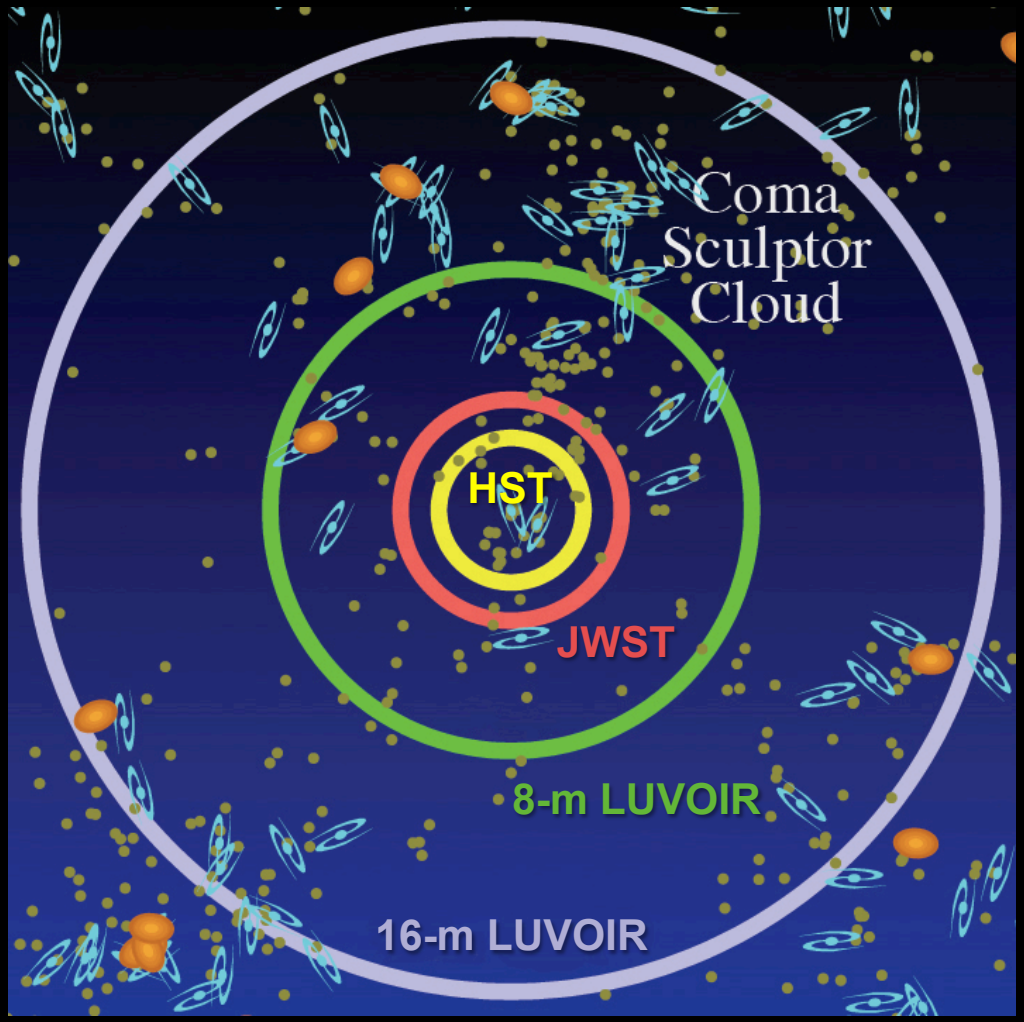




Clear Identification of local differences

Detailed mapping of the surface morphologies and composition anisotropies

How do galaxies assemble their stars?

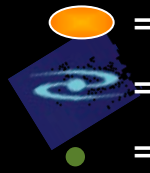


Map of Galaxies within 12 Mpc of Our Galaxy

Circles show distance out to which individual solar-type stars can be detected

Provides ages and star formation histories

Need LUVOIR to reach the nearest giant elliptical galaxies



= Large Elliptical Galaxy

= Large Spiral Galaxy

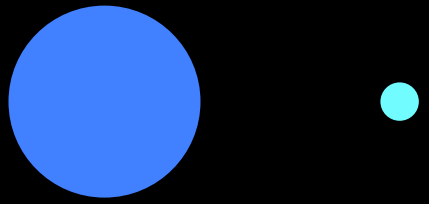
= Dwarf Galaxy

Monitoring Solar System ocean moons

UV oxygen emission from Europa water vapor jets observed with HST

Credit: NASA/ESA/L. Roth/SWRI/University of Cologne

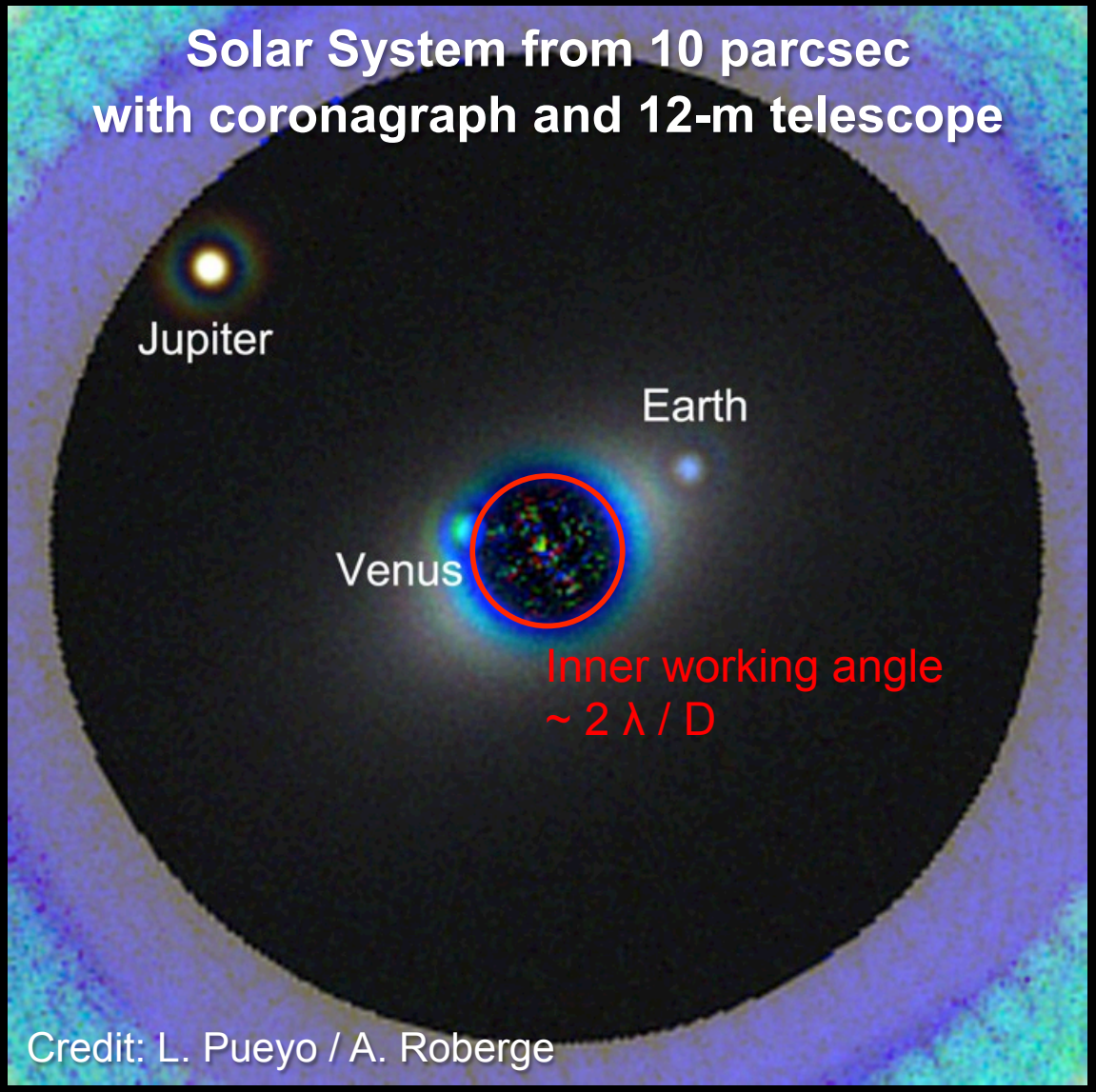
For illustration …



HST resolution (2.4-m)

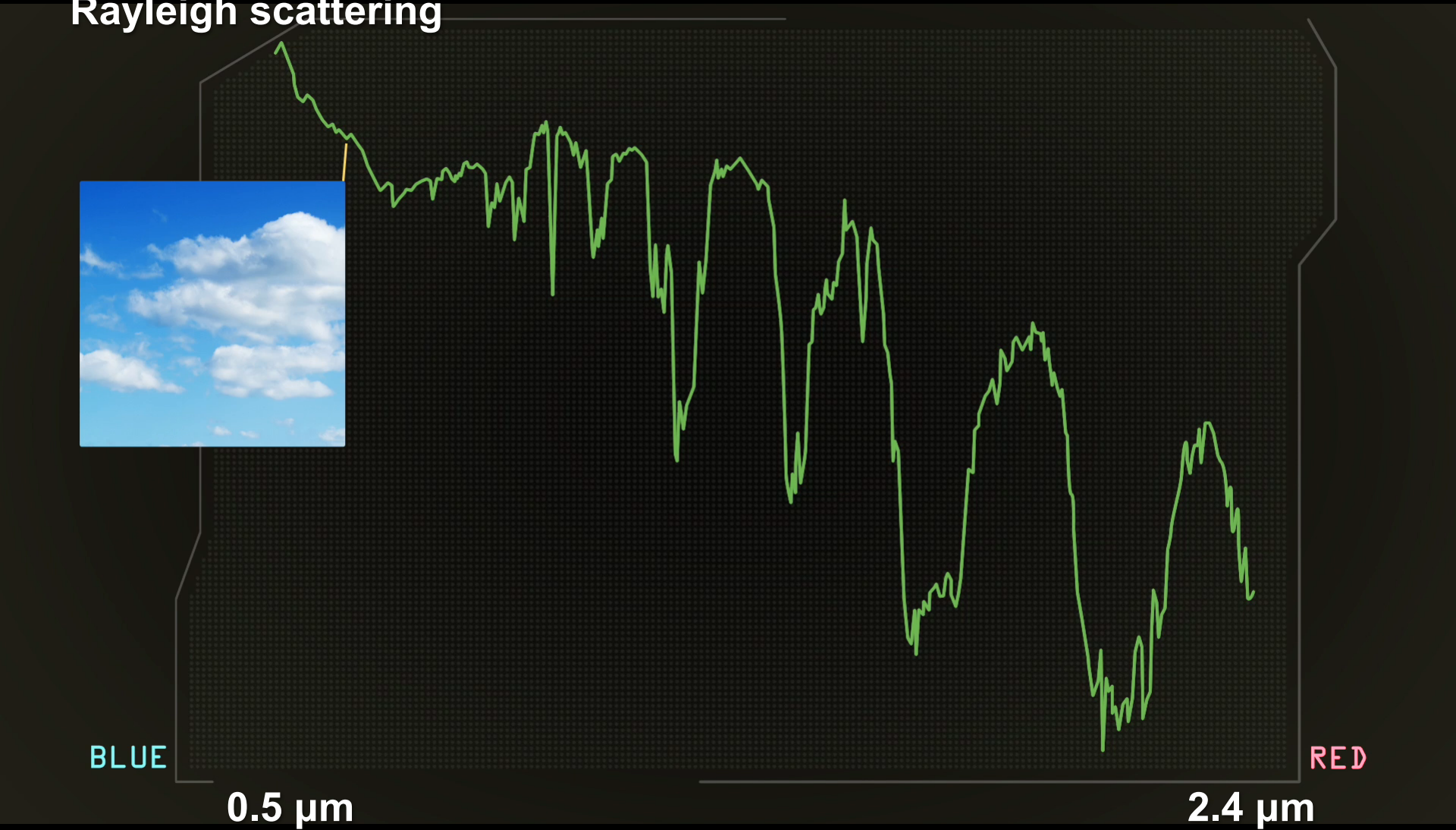
LUVOIR resolution (12-m)

Imaging Earth 2.0



The search for life : biosignatures

Spectrum of Modern Earth



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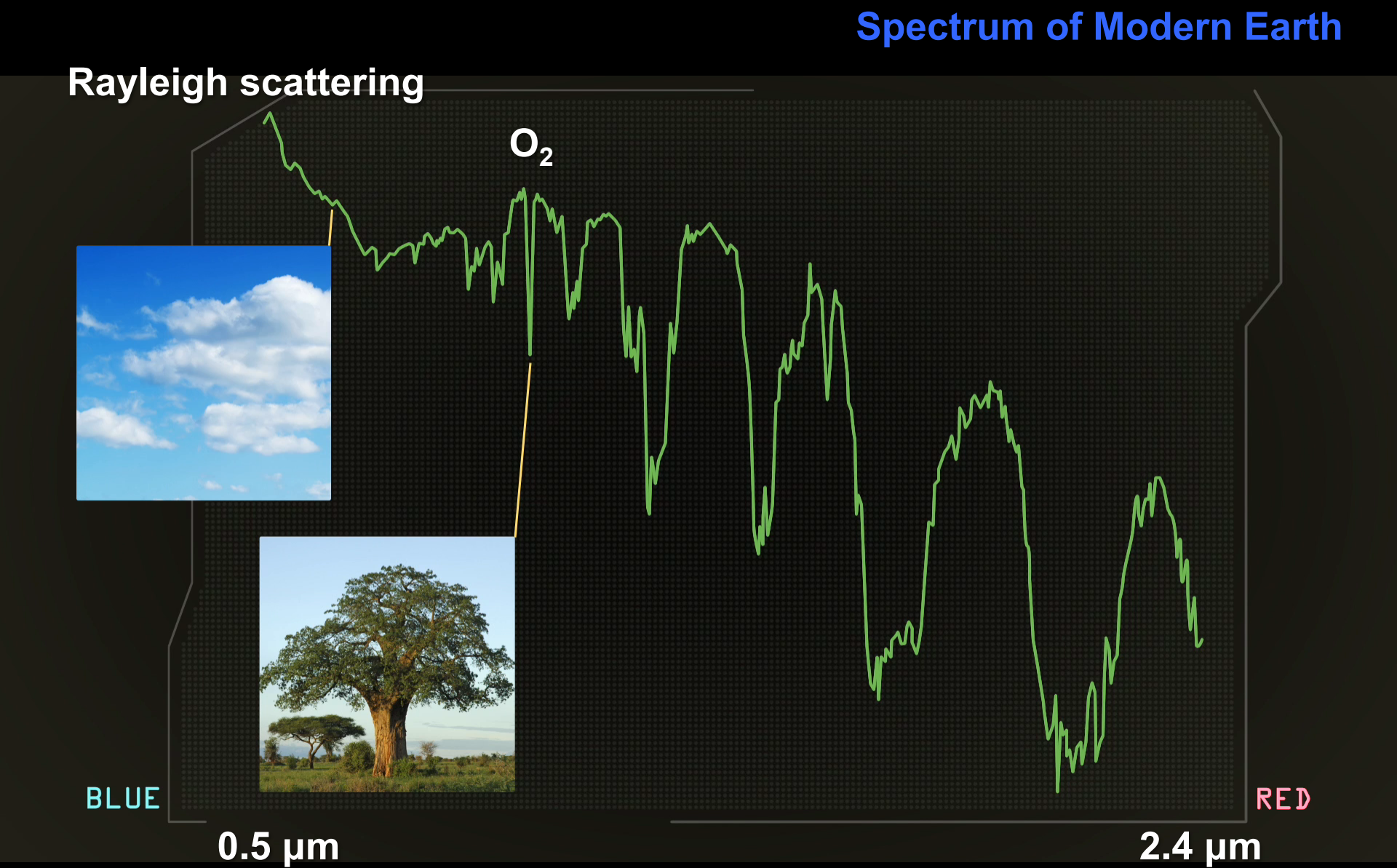

The search for life : biosignatures

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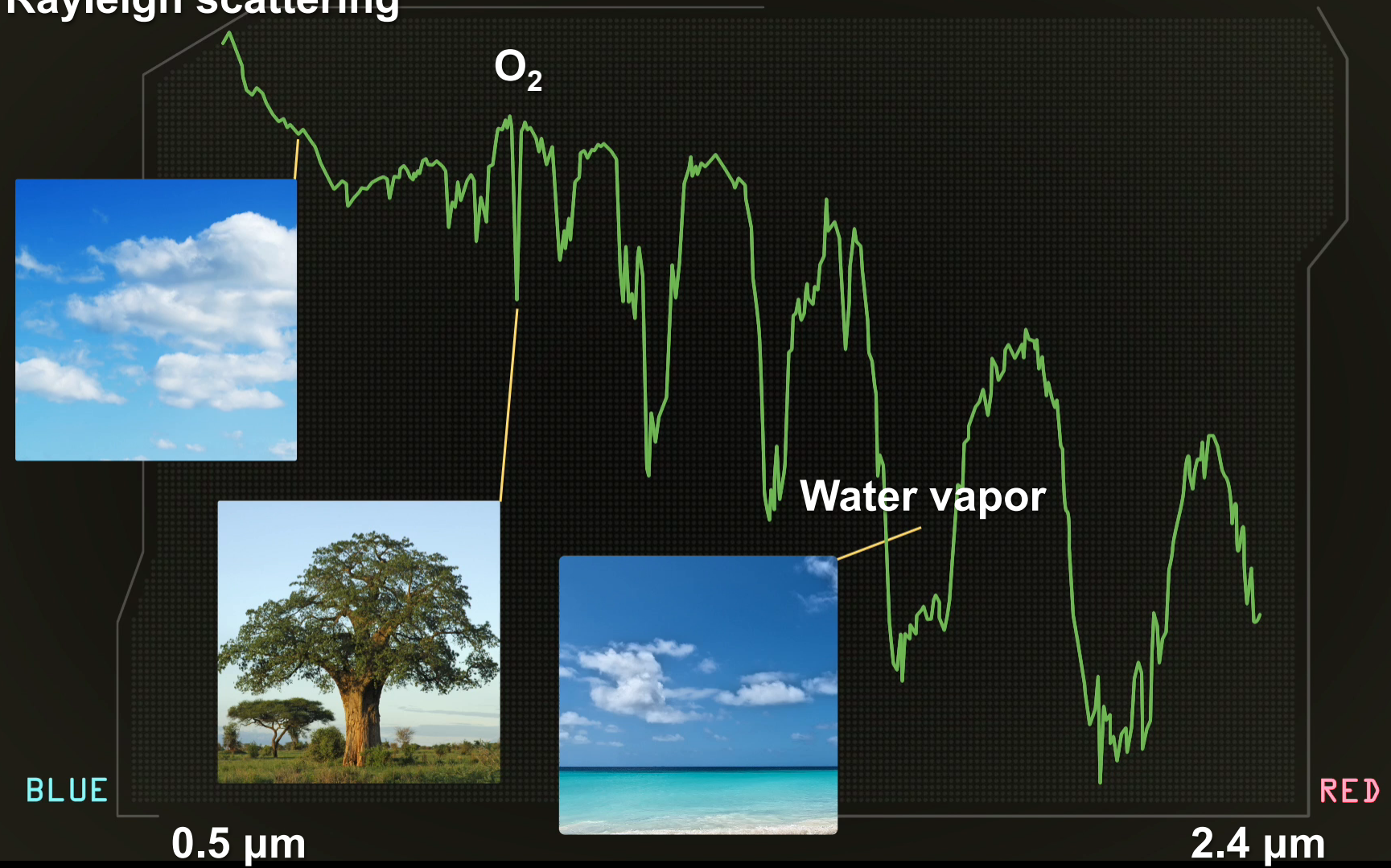
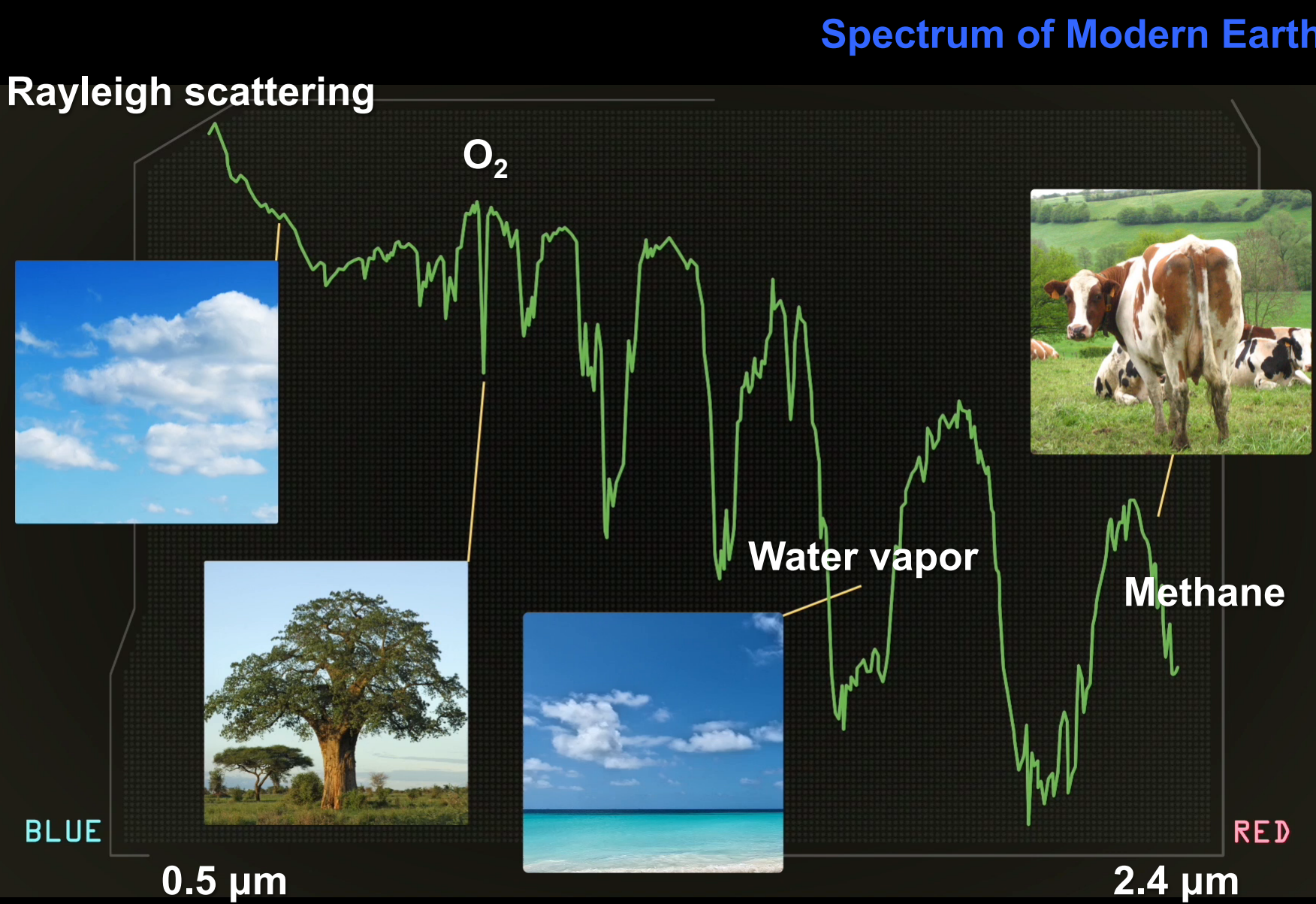
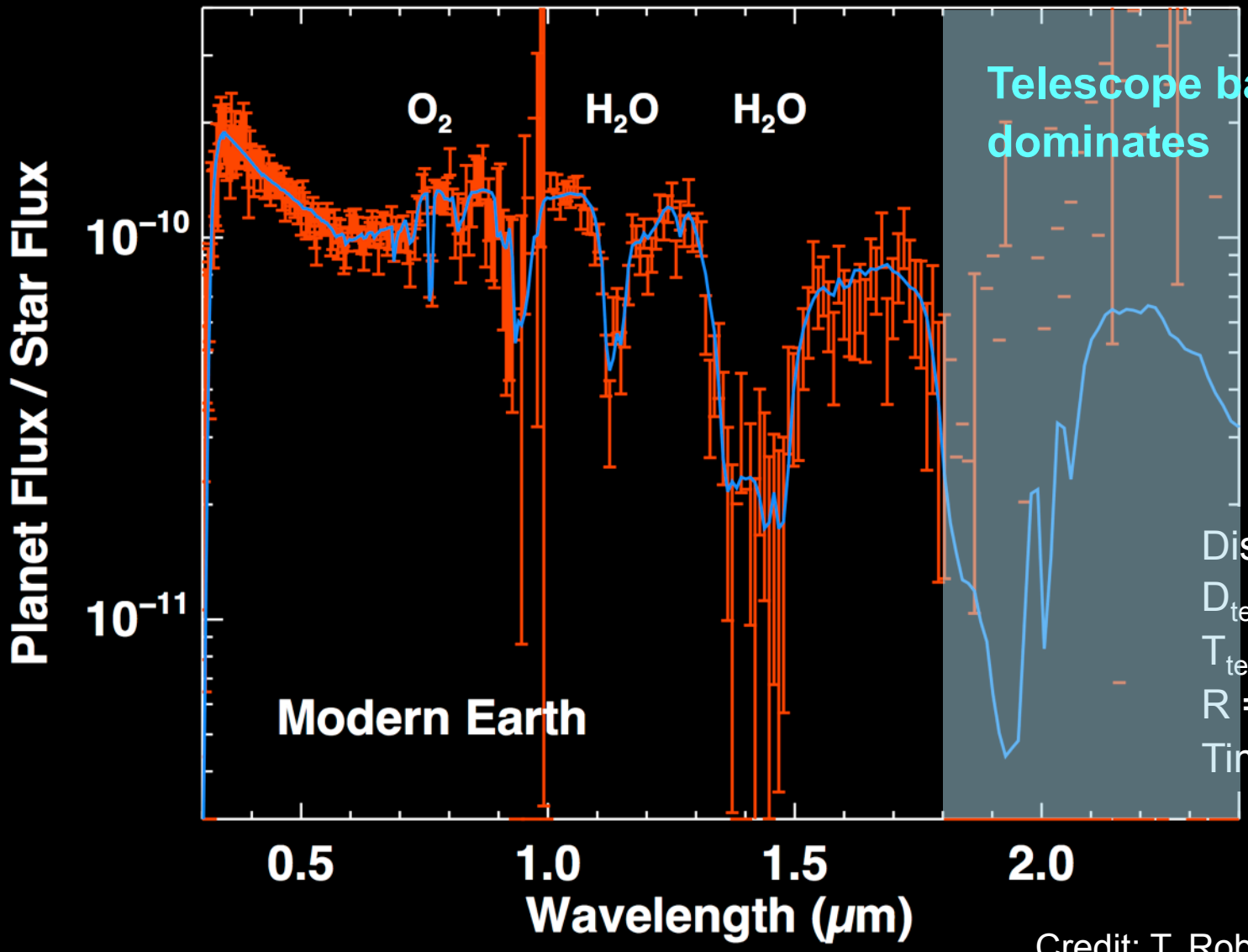


The search for life : biosignatures



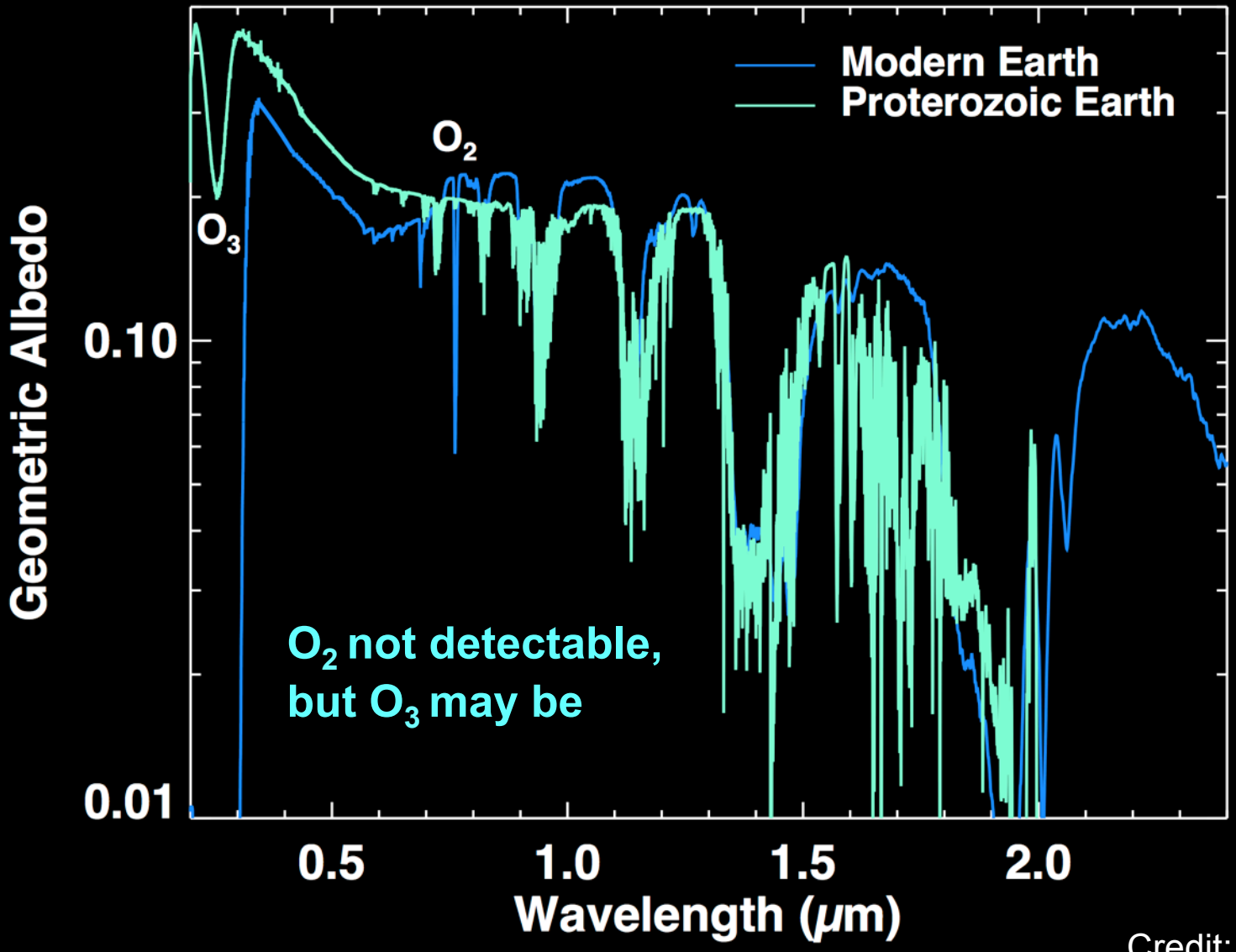
Reality check ...



Distance = 10 pc
$D_{telescope}$ = 12-m
$T_{telescope}$ = 270 K
R = 150
Time = 50 hrs

Credit: T. Robinson / G. Arney

Detecting biosignatures on other Earths



Credit: G. Arney

Confirming biosignatures

Access to many molecules is essential for understanding state of atmosphere

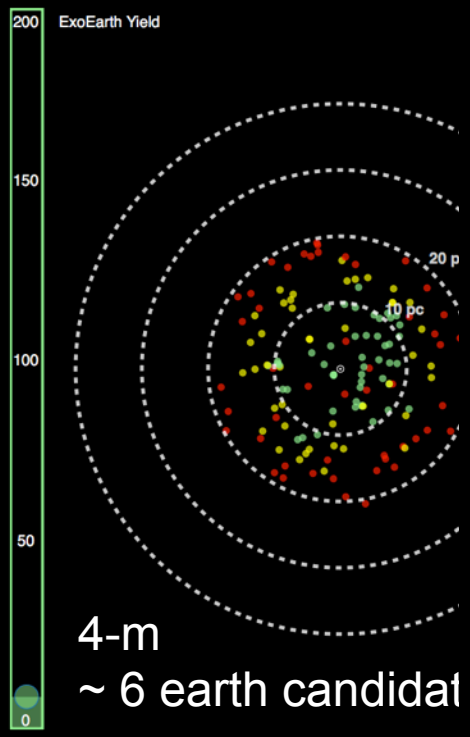
- 0.2 – 2.4 μm contains absorption bands of O_2, O_3, O_4, H_2O, CO, CO_2, CH_4

Access to multiple bands of same molecule aids abundance measurement

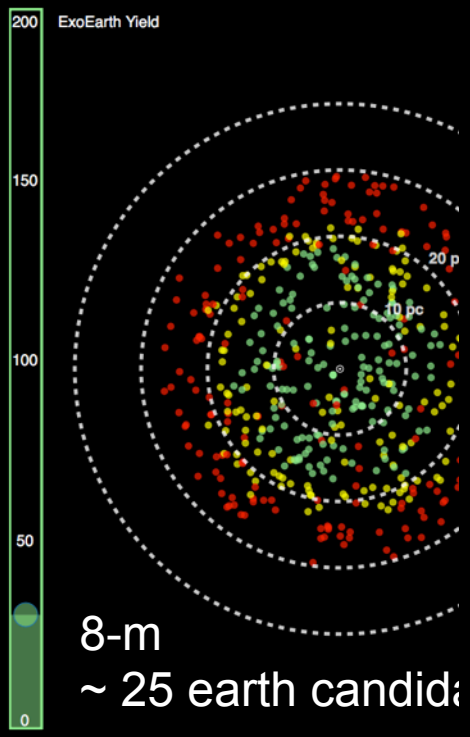
Broad spectral bandpass and UV spectrum of star can likely rule out false positive oxygen biosignatures

Since IWA ~ λ / D, observing hab. zone planets at longer wavelengths demands larger telescope aperture

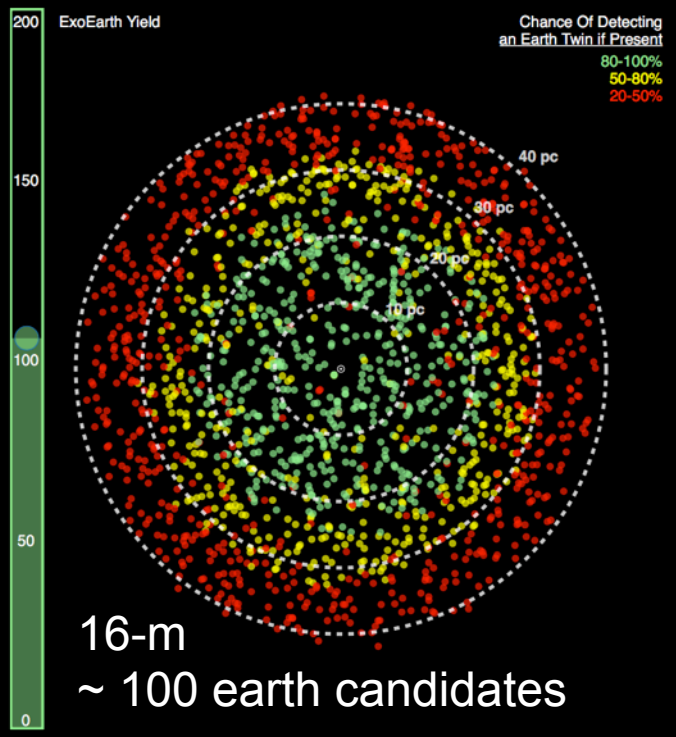
ExoEarth candidates as function of aperture



4-m
~ 6 earth candidat



8-m
~ 25 earth candid



16-m
~ 100 earth candidates

Stark et al. (2014)

If frequency of habitable conditions is 10%,
need 30 candidates to guarantee seeing one true exoEarth
(at 95% confidence)

The exoplanet zoo