LUVOIR
LARGE UV/OPTICAL/INFRARED SURVEYOR
&
INTERNATIONAL CONTRIBUTION

住　貴宏（阪大）

large mission Concept

Four large mission concept studies started in Jan 2016 to prepare for Astro2020 Decadal Survey

- LUVOIR
- Habitable Exoplanet Imaging Mission (HabEx)
- Origins Space Telescope (formerly Far-IR Surveyor)
- Lynx (formerly X-Ray Surveyor)

LUVOIR aperture: (on-axis)

- Plan A 15.1m is for the 8 meter SLS fairing.
- Plan B 9.2m fit to Delta IV Heavy 5m fairing

L2, Serviceable

Adapted from Testimony to Congress Given by J. Grunsfeld (May 5, 2013)

BIG BANG TO BIOSIGNATURES: THE LUVOIR MISSION CONCEPT

Jamie Doe (Acme University)

Awesome Conference
Exotic Location
Date

What is LUVOIR ?

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

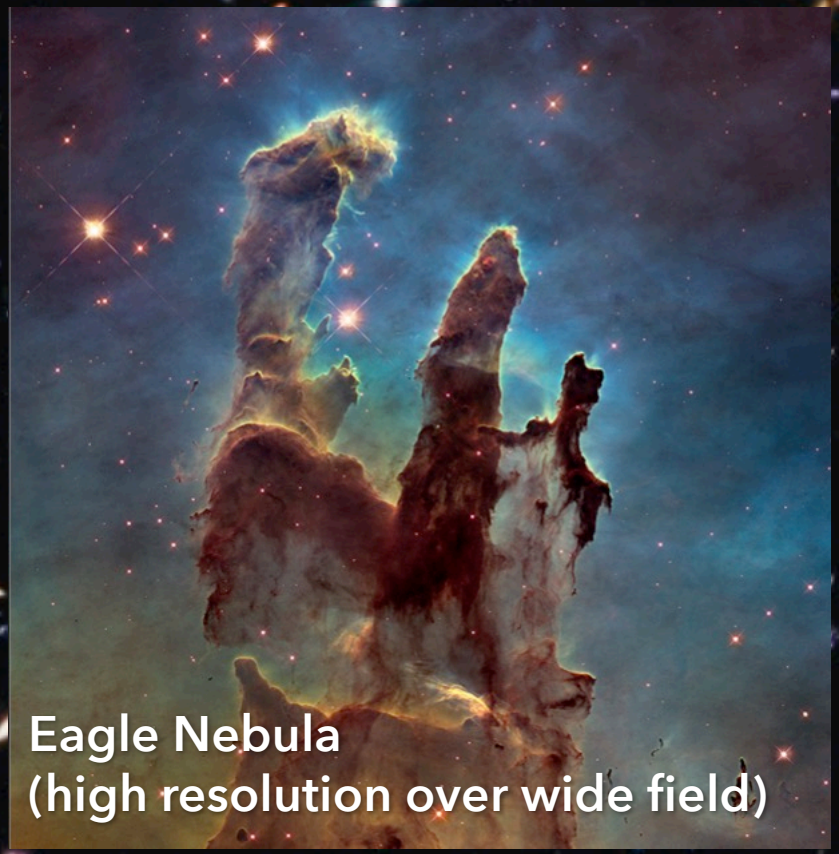
Large UV / Optical / Infrared Surveyor (LUVOIR)

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
- Hubble-like guest observer program

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

Imagine astronomy without Hubble …

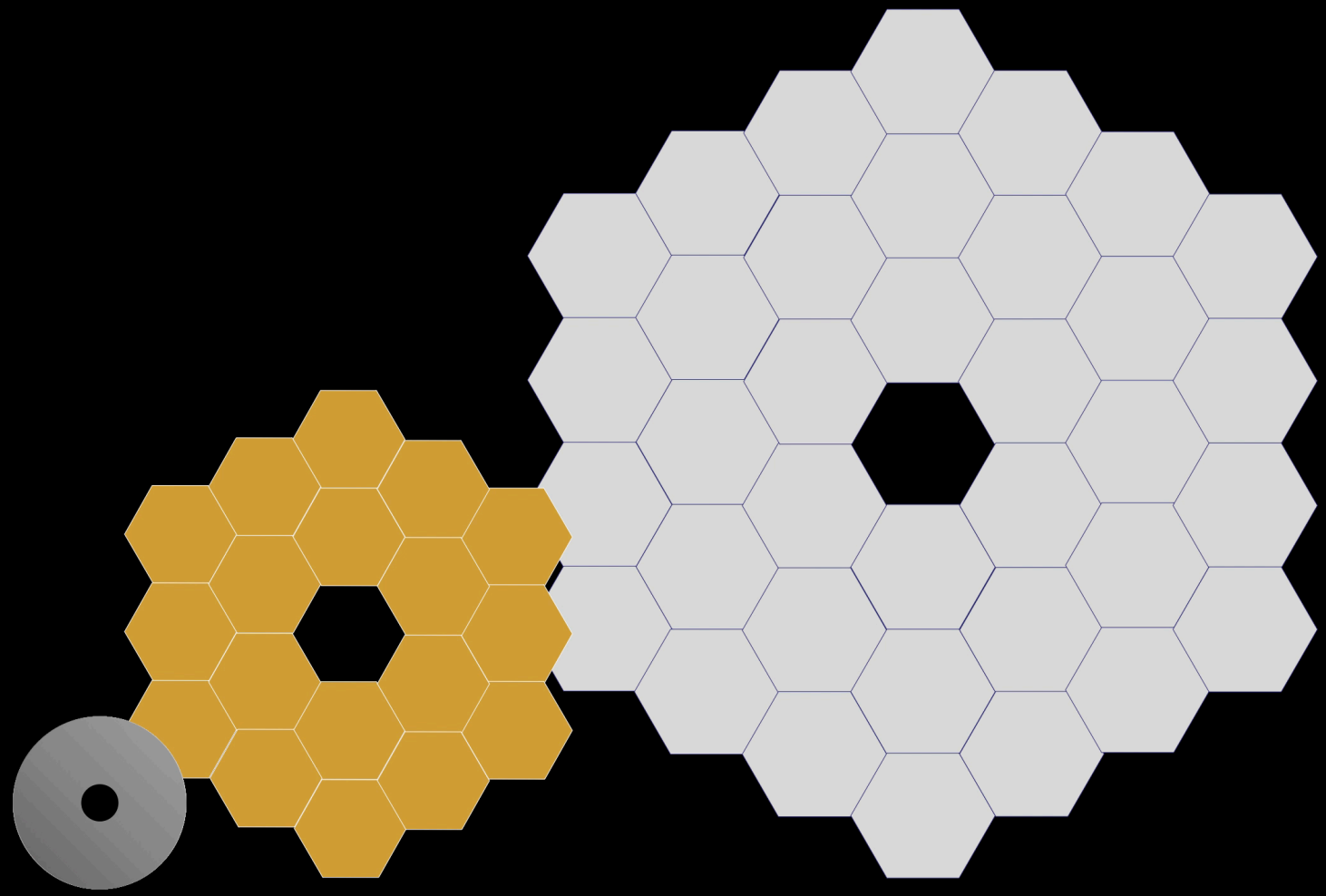


Eagle Nebula
(high resolution over wide field)

Hubble Ultra Deep Field
(ultra-deep imaging)

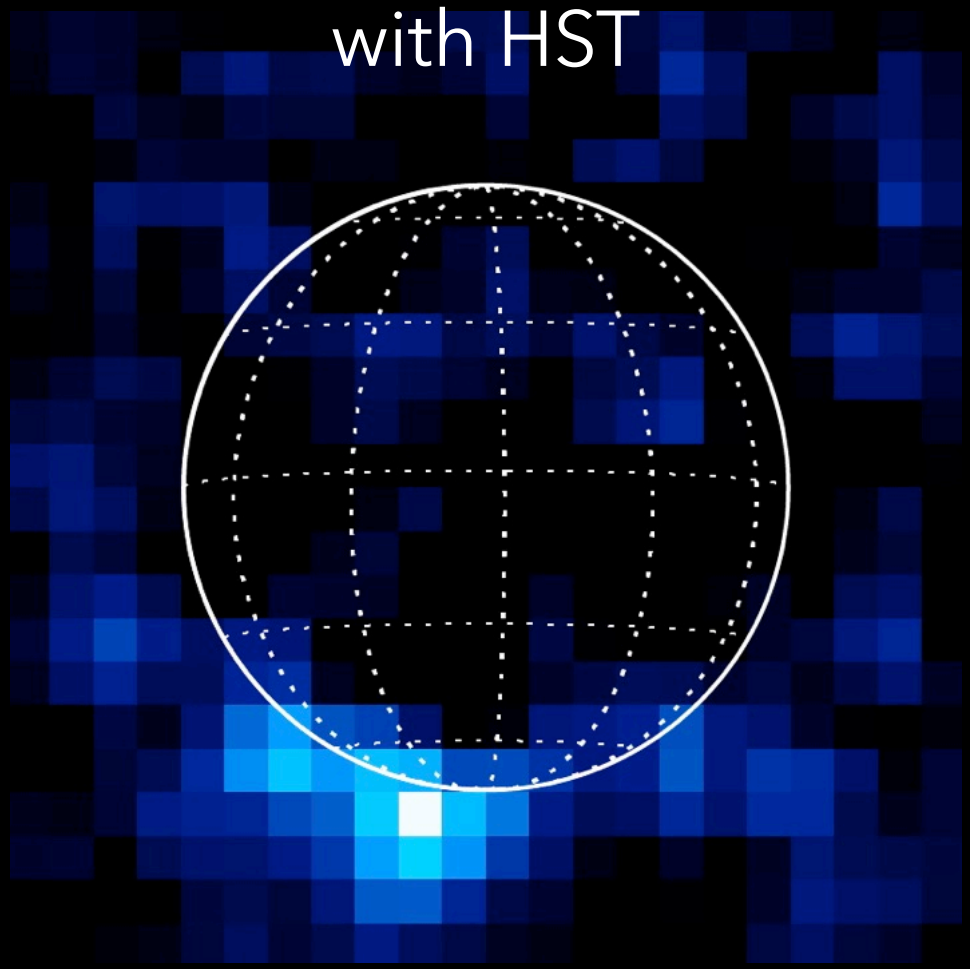
Jupiter's aurora
(UV, global monitoring)

Imagine astronomy with LUVOIR …



Imagine astronomy with LUVOIR …

Europa jets observed with HST



Roth et al. (2014)

Europa jets observed with 15-m LUVOIR

Credit: G. Ballester (LPL)

UV hydrogen emission

Imagine astronomy with LUVOIR …

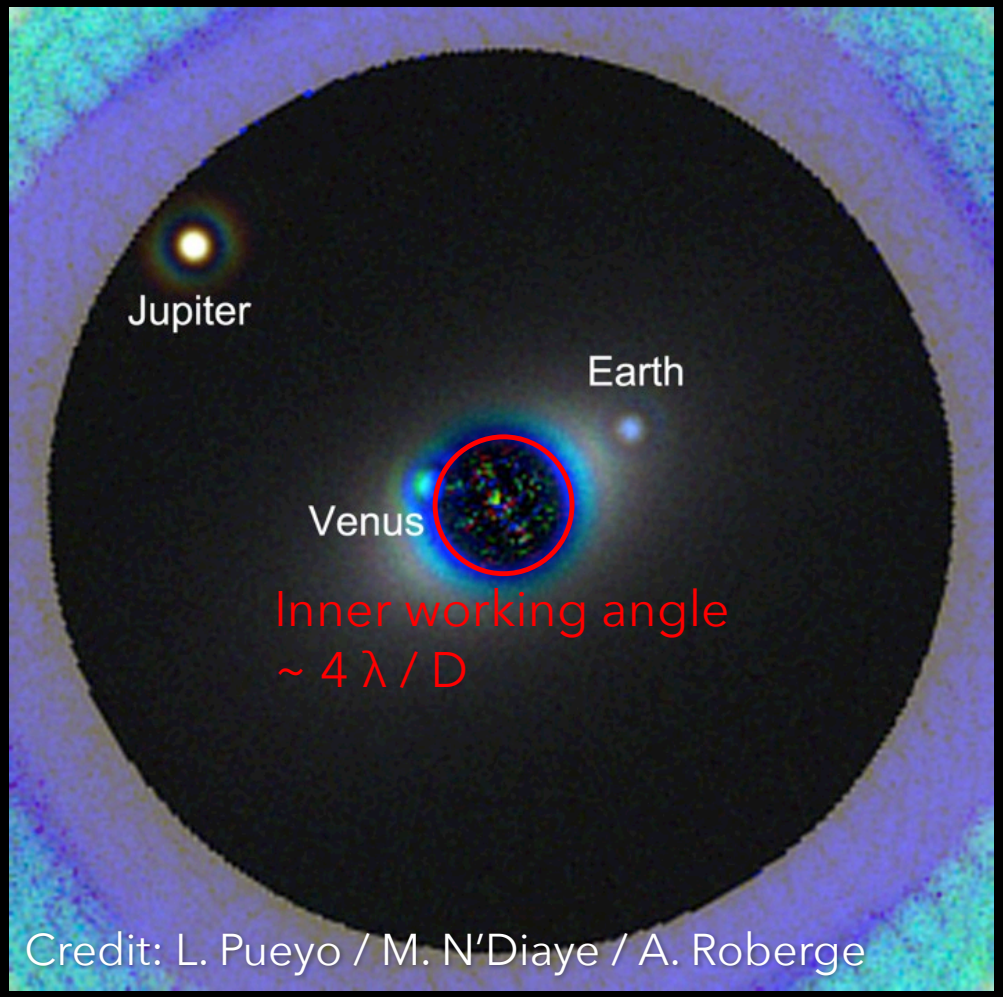
Pluto with HST

Pluto with 15-m LUVOIR

Credit: W. Harris (LPL)

Characterizing Earth 2.0 …

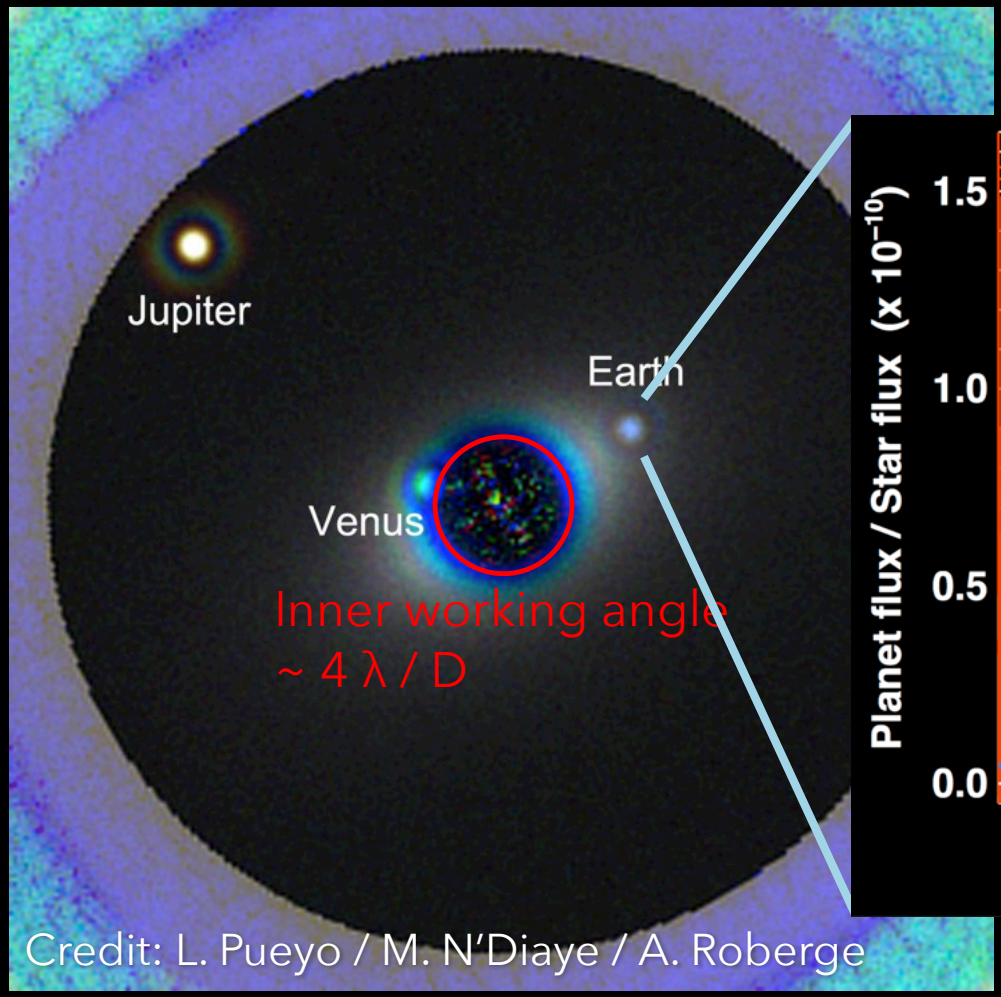
Solar System from 13 parsec
with coronagraph and 12-m telescope



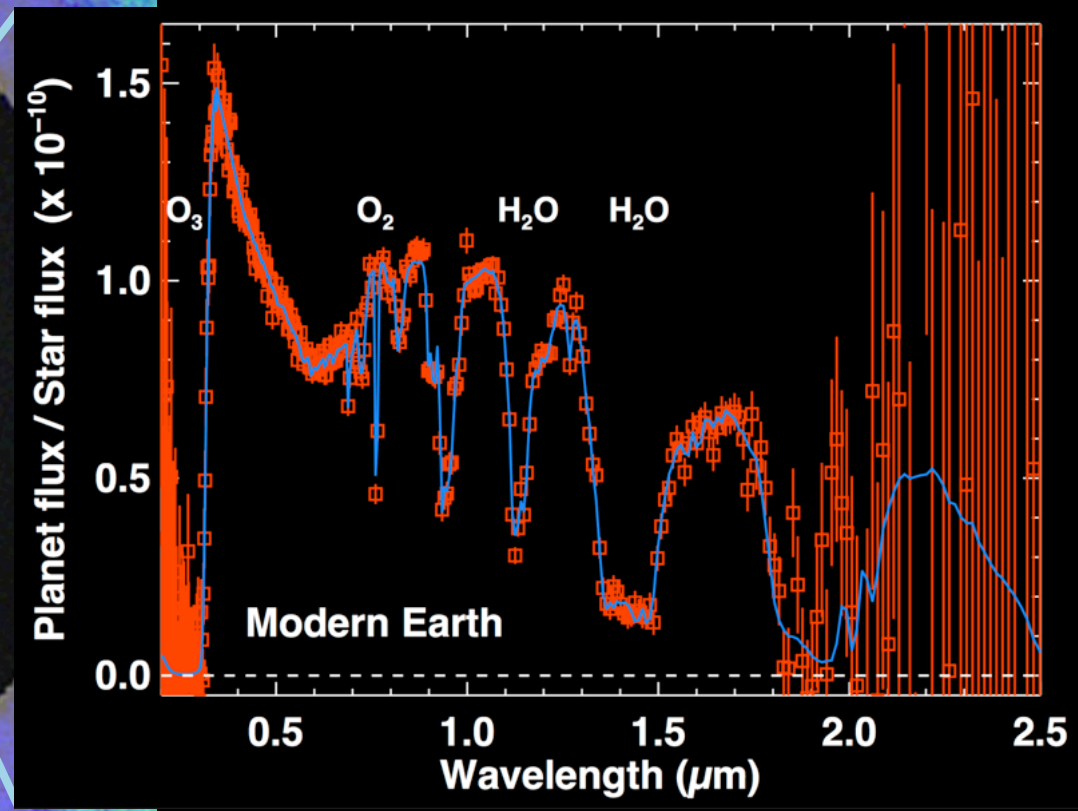
Characterizing Earth 2.0 …

Solar System from 13 parsec
with coronagraph and 12-m telescope

Distance = 10 pc
$D_{telescope}$ = 12-m
R = 150
Time = 96 hrs per band



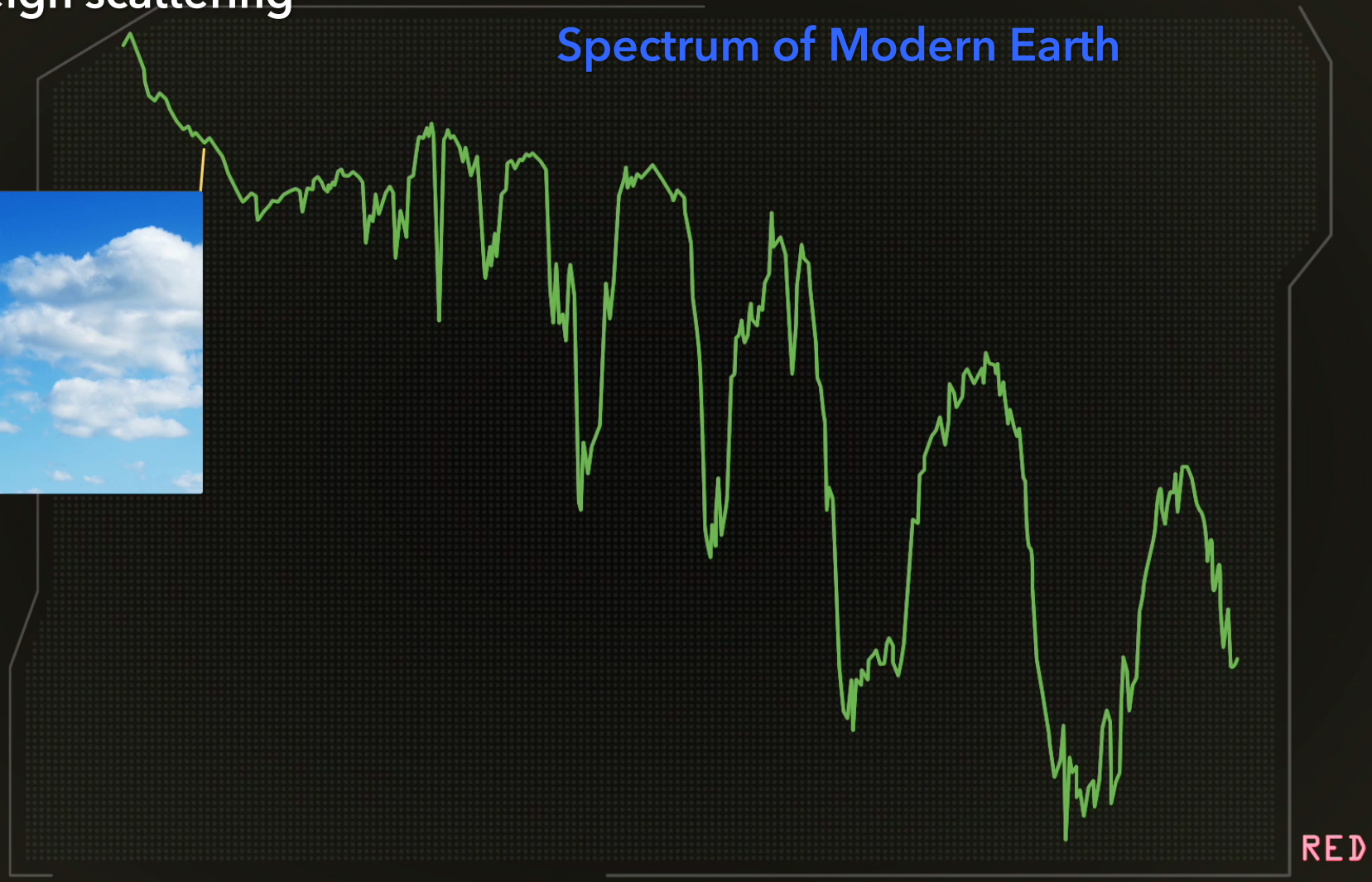
Credit: L. Pueyo / M. N'Diaye / A. Roberge



Credit: T. Robinson / G. Arney

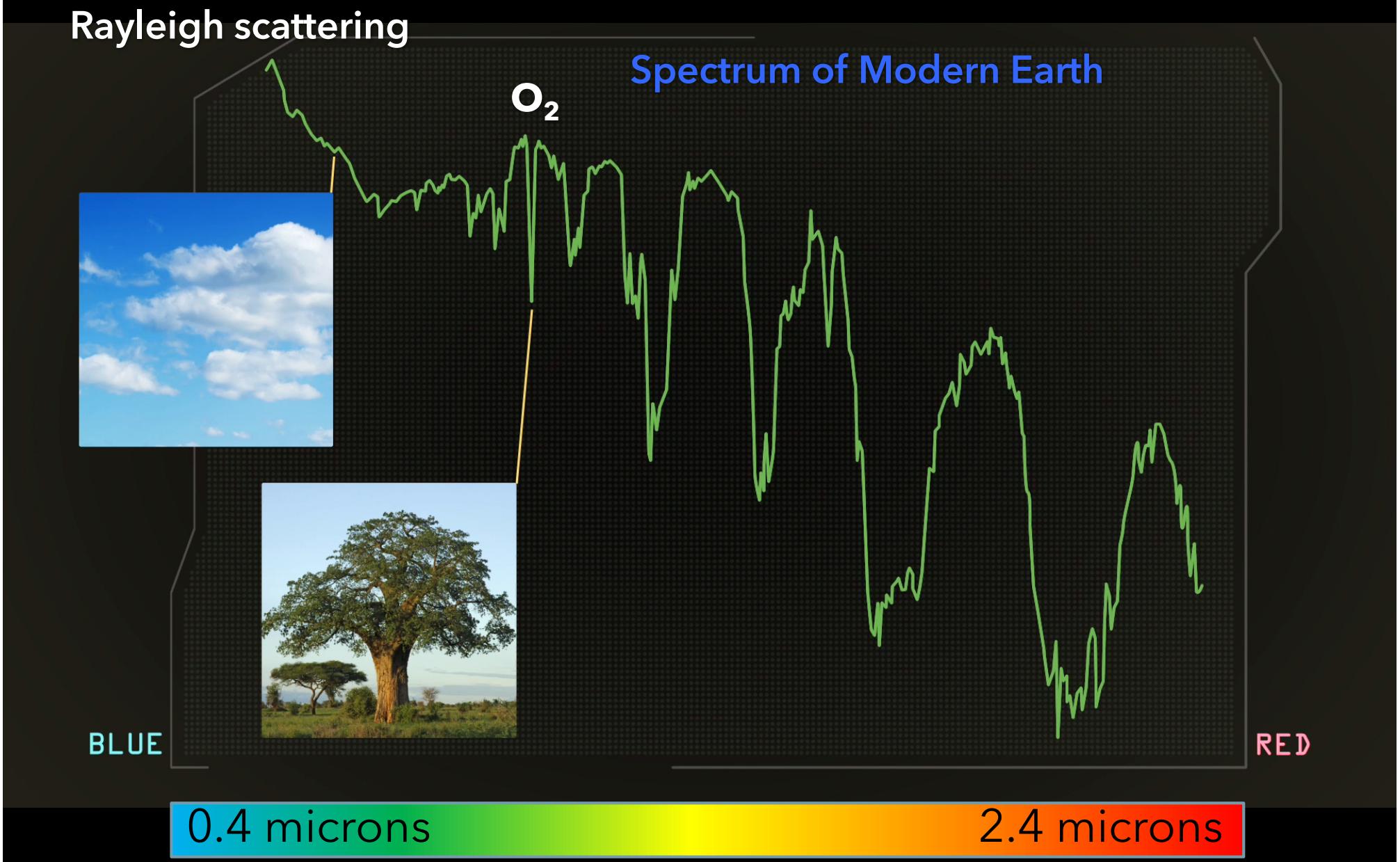
The search for life – biosignatures

Rayleigh scattering

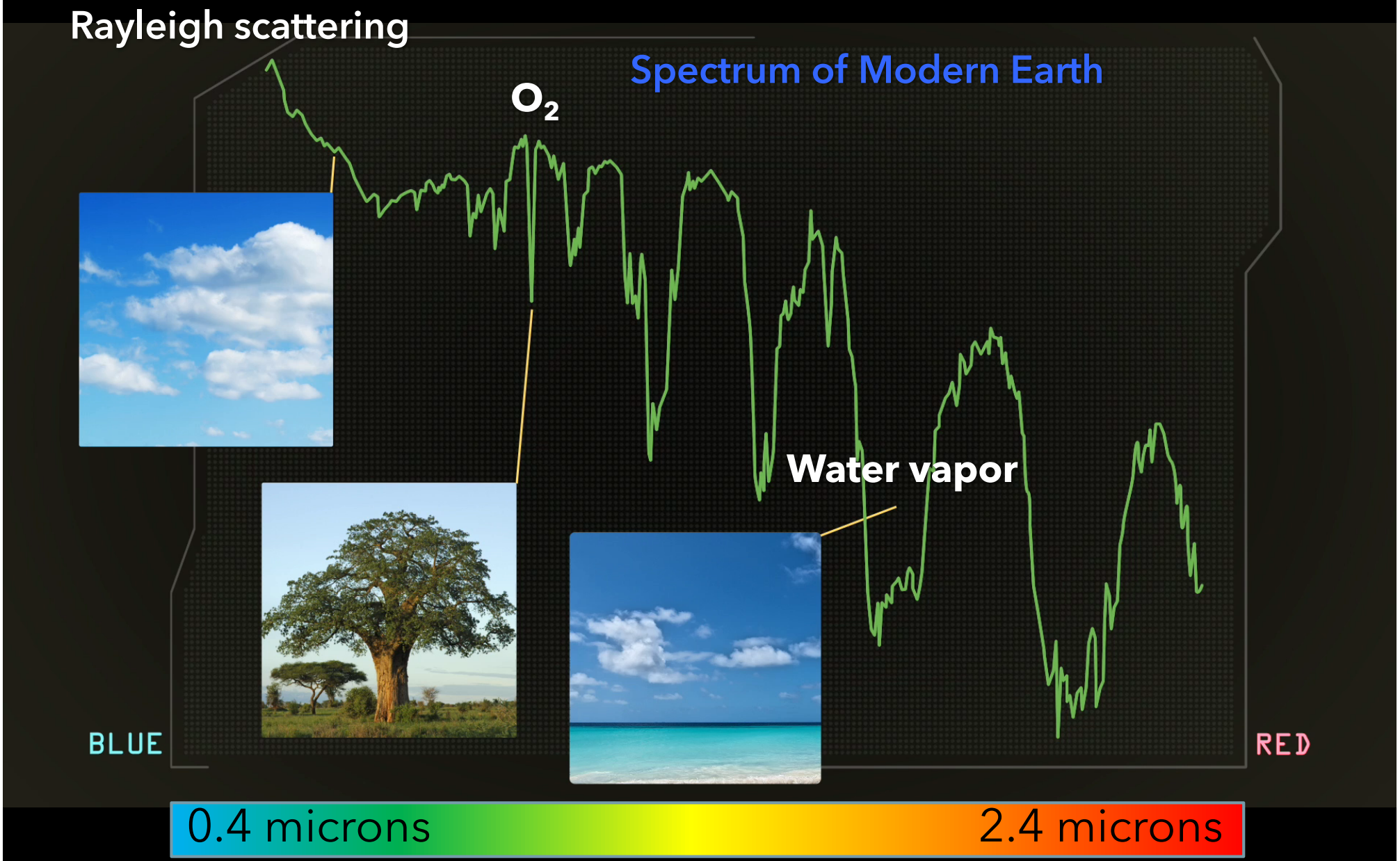


0.4 microns — 2.4 microns

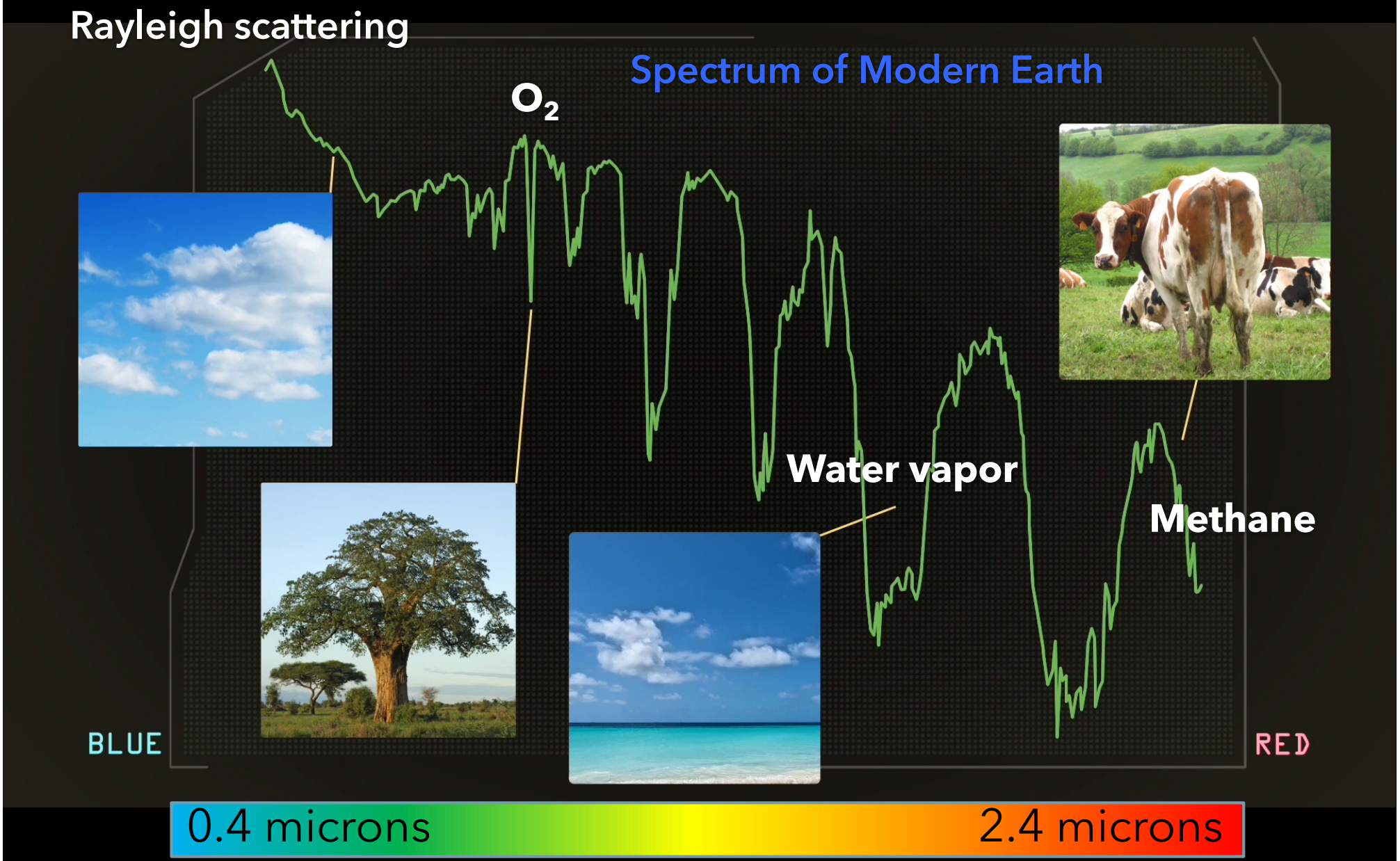
The search for life – biosignatures



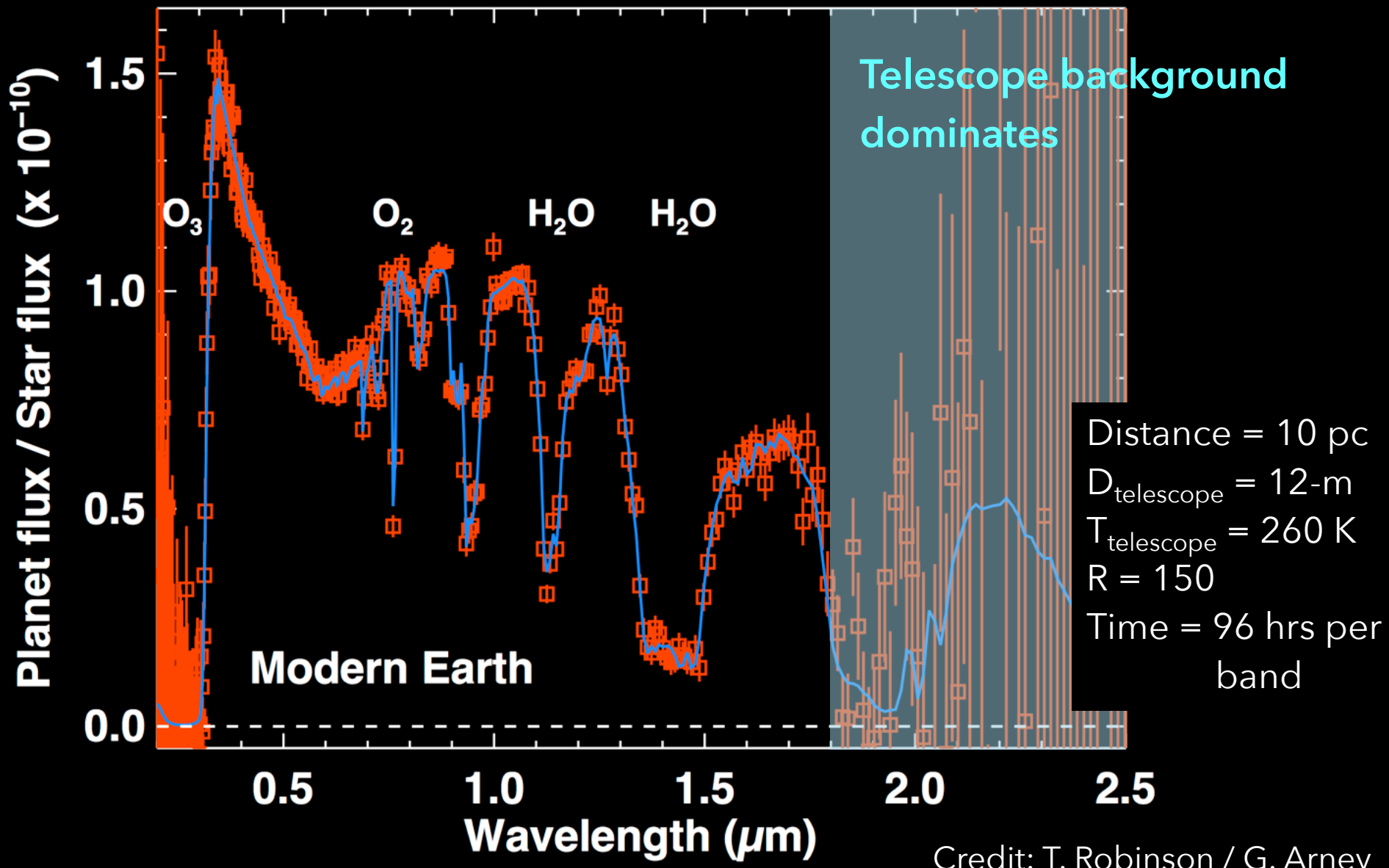
The search for life – biosignatures



The search for life – biosignatures



Reality check …



Distance = 10 pc
$D_{telescope}$ = 12-m
$T_{telescope}$ = 260 K
R = 150
Time = 96 hrs per band

Credit: T. Robinson / G. Arney

Confirming biosignatures

Access to many molecules is essential for understanding state of atmosphere

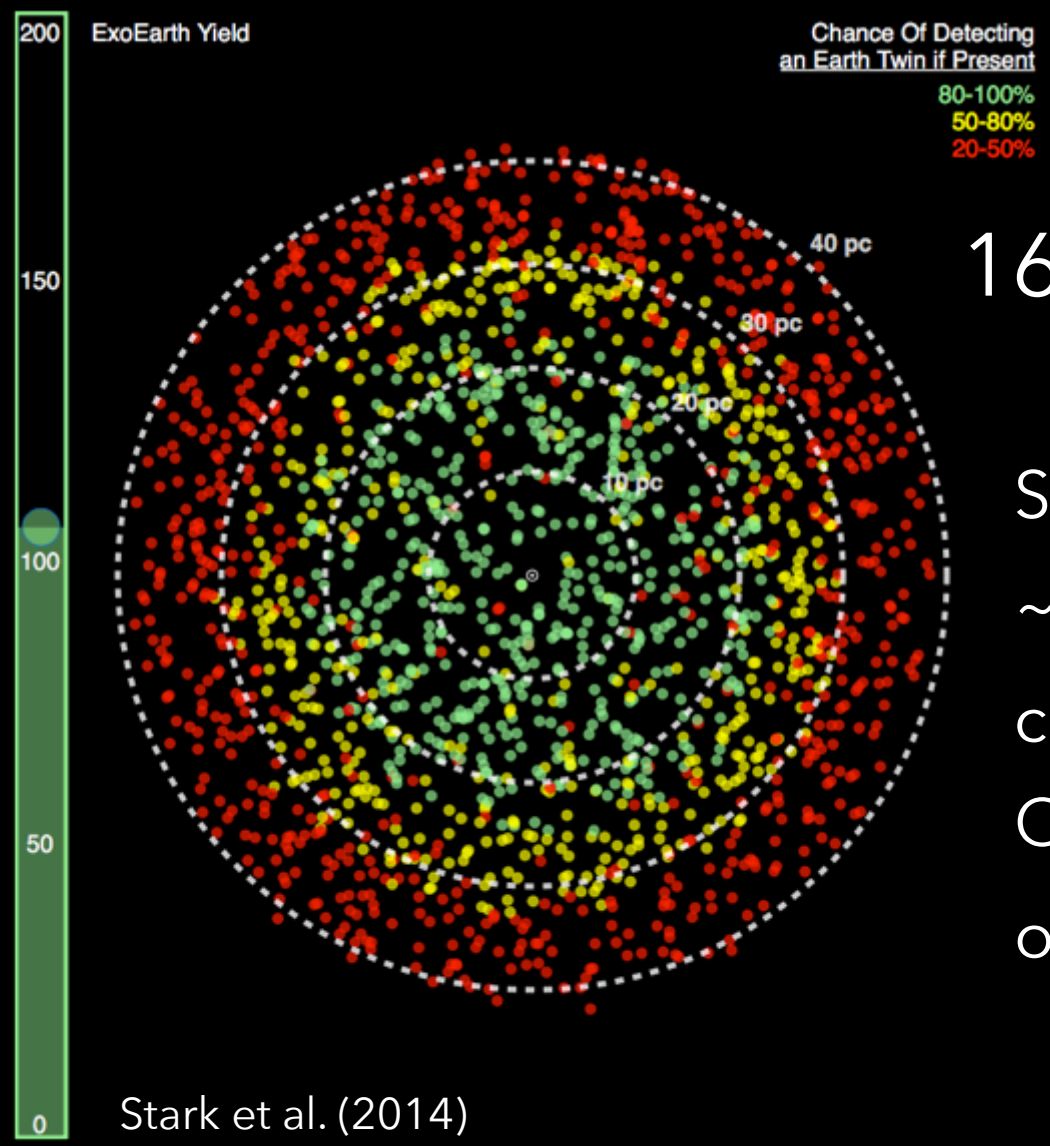
- 0.2 – 2.5 μm contains absorption bands of O_2, O_3, O_4, H_2O, CO, CO_2, CH_4

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 candidate survey yield



Stark et al. (2014)

16-m telescope

Spectra of

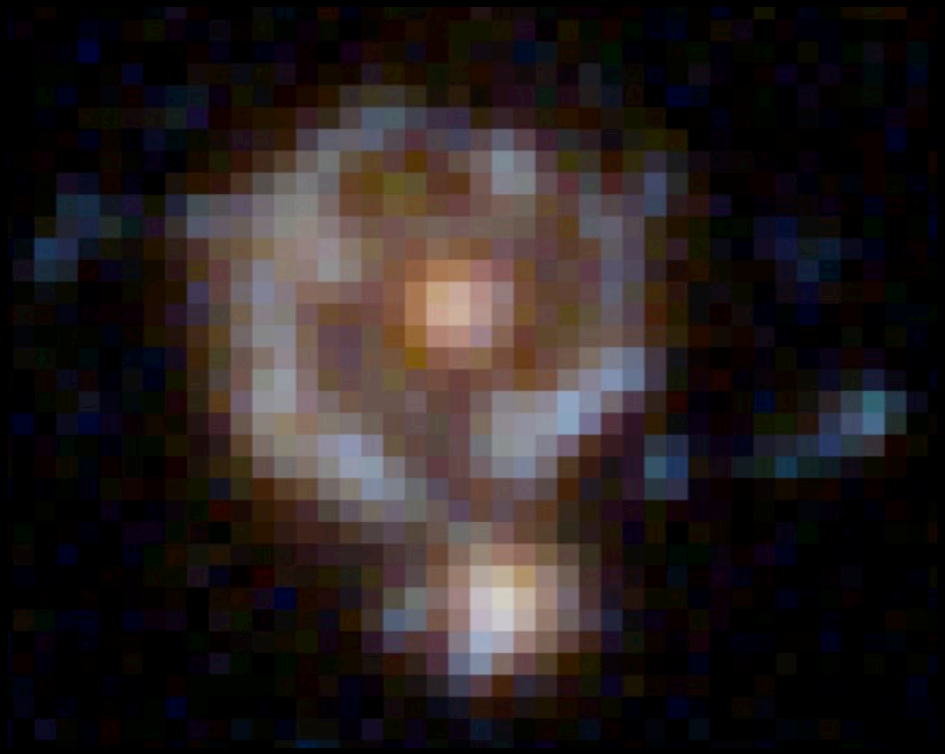
~ 100 exoEarth

candidates

Over 500 total exoplanets

observed

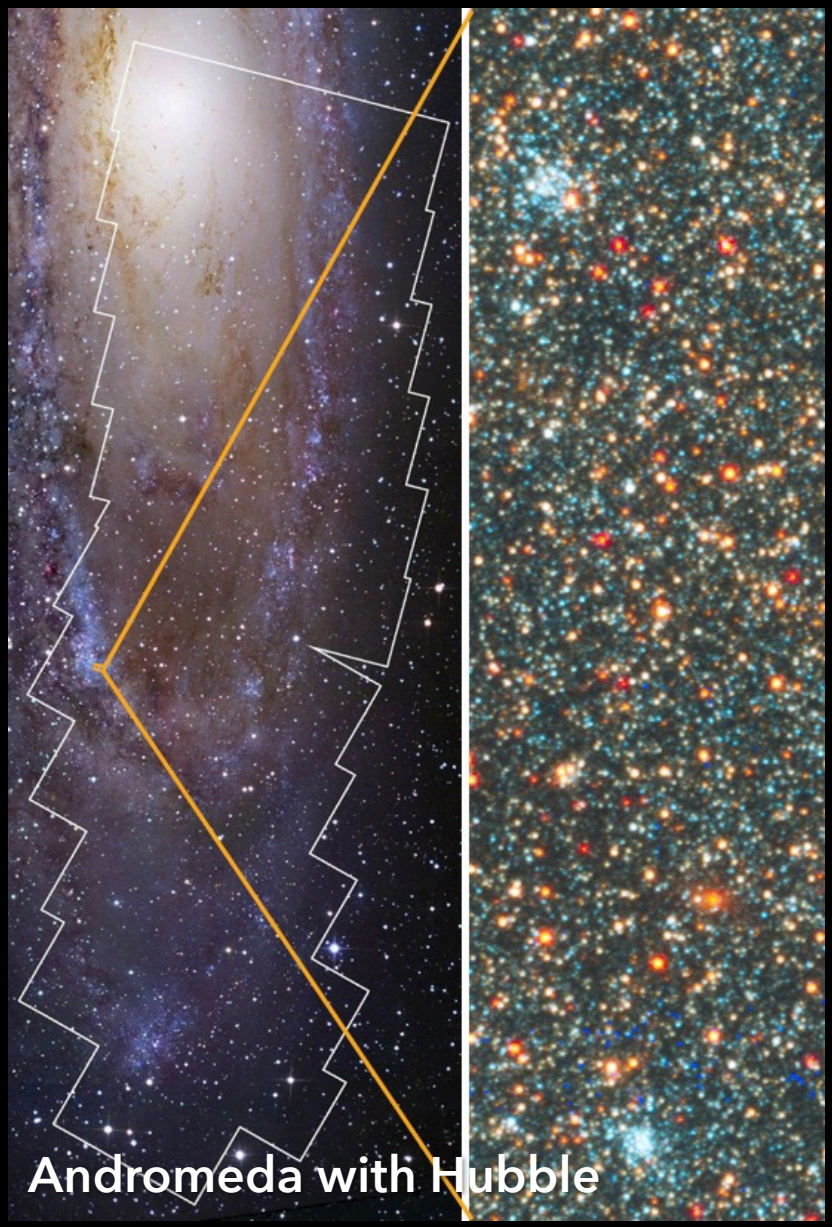
Imagine astronomy with LUVOIR …



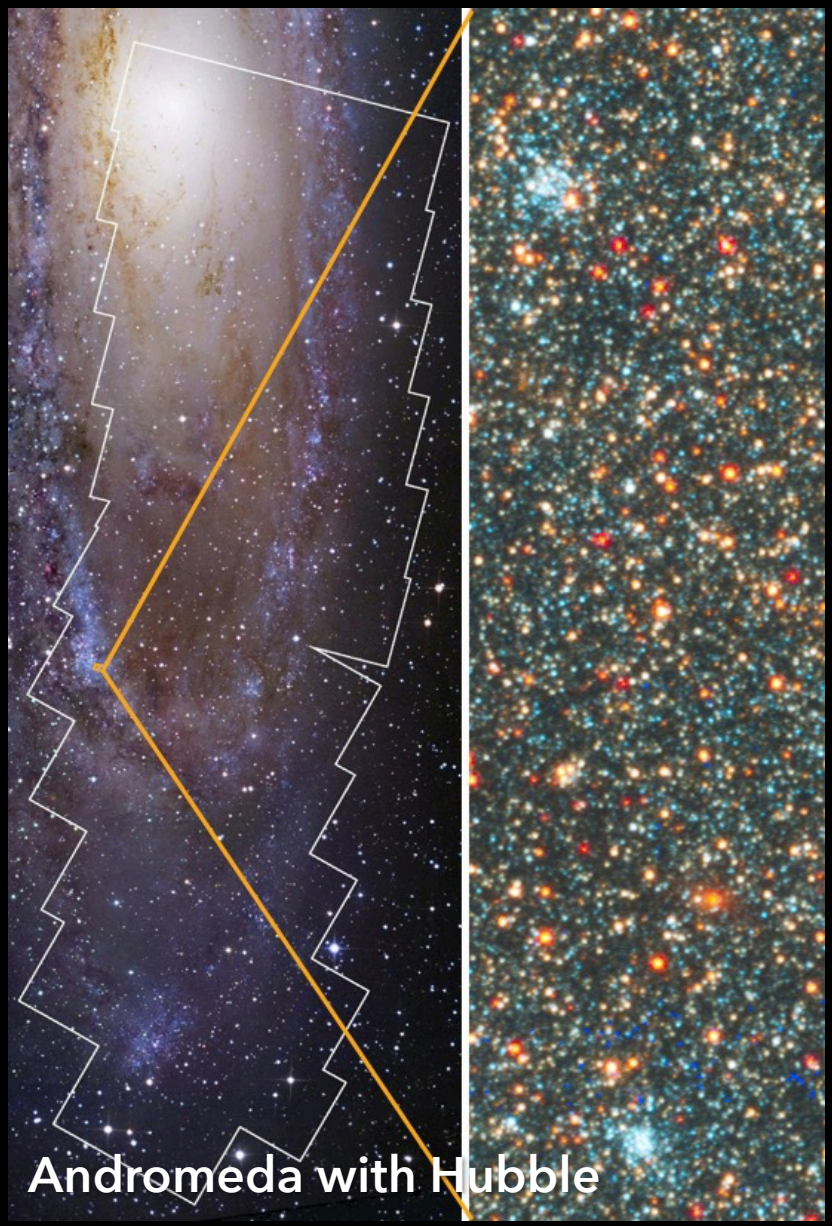
Galaxy at z = 2
with HST

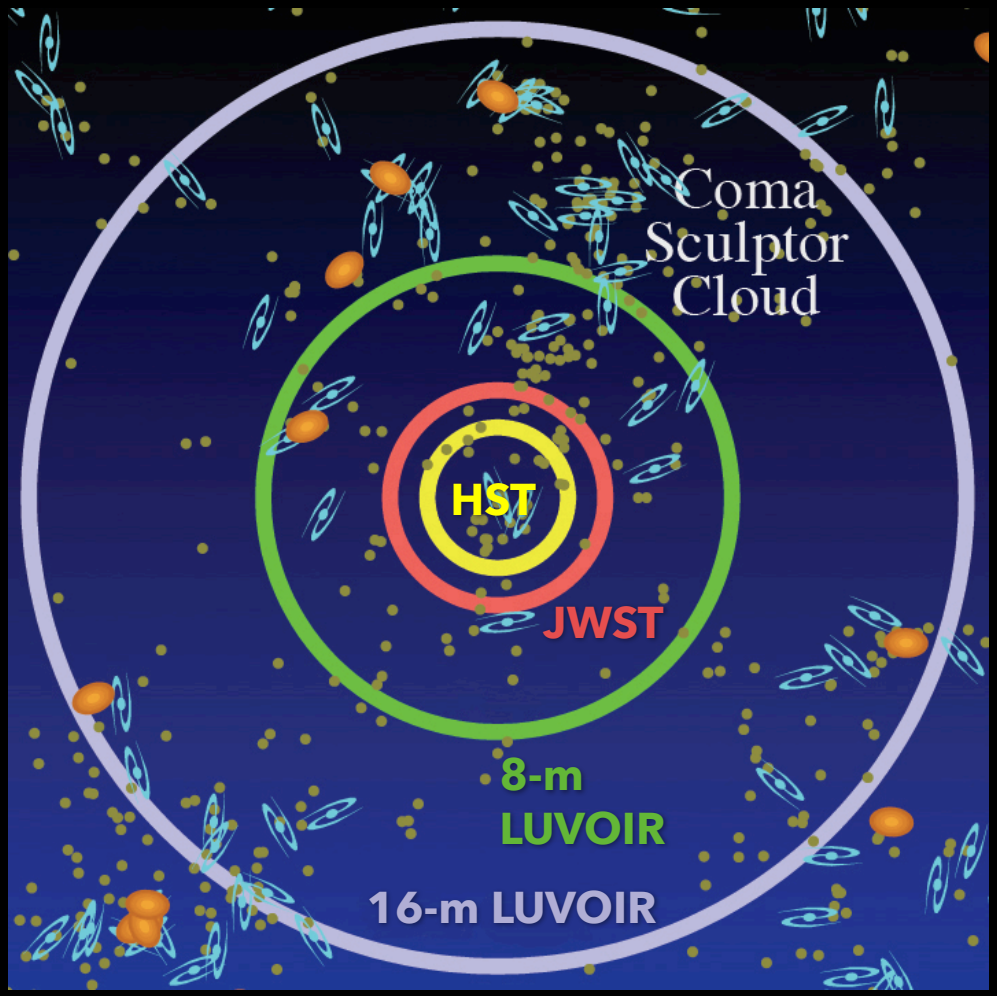
Galaxy at z = 2
with 12-m LUVOIR

How do galaxies assemble their stars?



How do galaxies assemble their stars?





Map of Galaxies within 12 Mpc of Our Galaxy

= Large Elliptical Galaxy

= Dwarf Galaxy

= Large Spiral Galaxy

The LUVOIR architectures

Architecture A

- 15-m diameter telescope
- Four instruments

Instruments
Coronagraph A
LUMOS A
High-Definition Imager
POLLUX

Architecture B

- ~ 9-m diameter telescope
- Three instruments

Instruments
Coronagraph B
LUMOS B
ONIRS

The LUVOIR instruments

Observational challenge

Faint planets next to bright stars

Solution

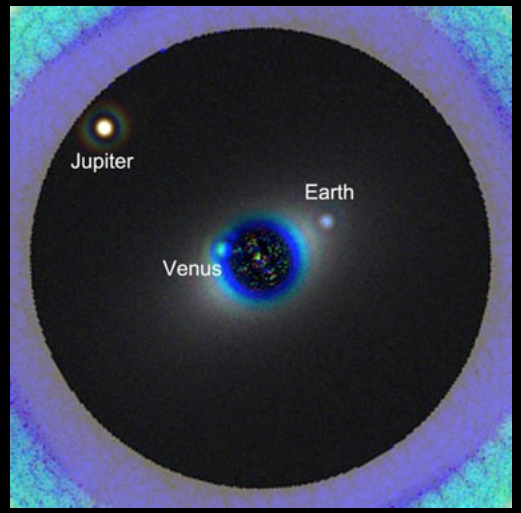
Optical / Near-IR Coronagraph

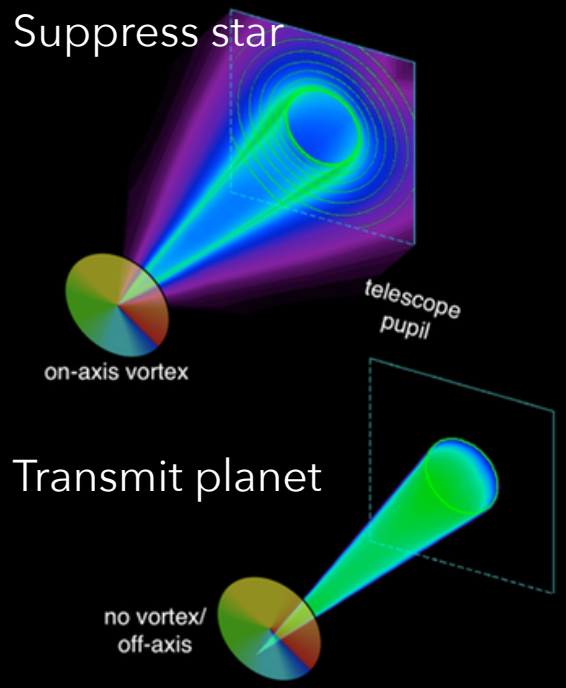
Contrast < 10^{-10} to observe exoEarths

Multi-resolution spectroscopy

Bandpass: 0.2 μm to 2.5 μm

Tech development via WFIRST coronagraph





Vector vortex coronagraph
Credit: D. Mawet (Caltech)

The LUVOIR instruments

Observational challenge

No UV through Earth's atmosphere

Solution

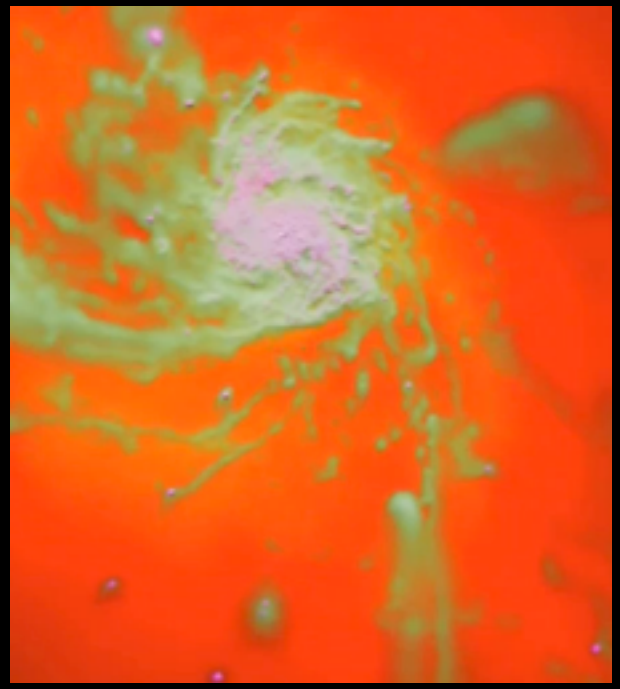
LUMOS

Multi-object spectroscopy (R = 500 – 45,000)

Bandpass: 100 nm to 400 nm

UV imaging

Major upgrade of HST STIS



HST STIS UV instrument

The LUVOIR instruments

Observational challenge

Imaging wide fields at high resolution

Solution

High-Definition Imager

2 x 3 arcmin field-of-view

Bandpass: 0.2 μm to 2.5 μm

High precision astrometry capability (measure planet masses, etc.)

Major upgrade of HST WFC3

HST Wide Field Camera 3

The LUVOIR instruments

Observational challenge

Measuring warm molecules present in Earth's atmosphere

Solution

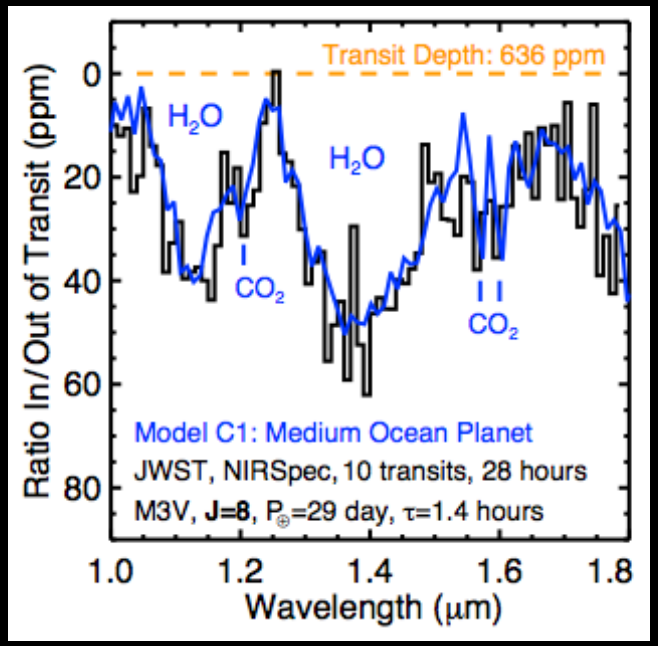
Optical / Near-IR Spectrograph

Multiple resolutions up to R ~ 10^5

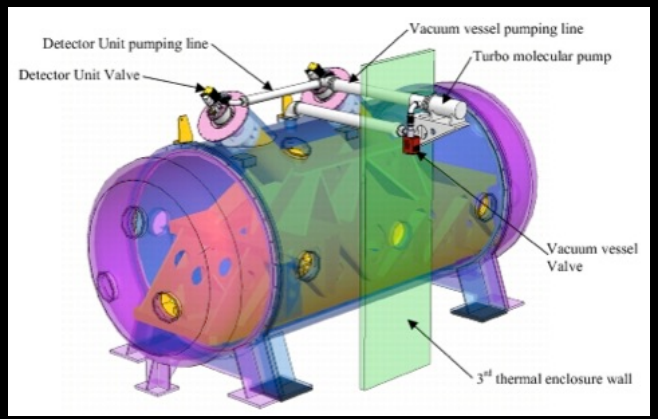
High photometric precision (transits)

Possibly high precision RV capability

Ground-based analogs in development



Credit: Natasha Batalha



ESPRESSO spectrograph for VLT (Credit: ESO)

POLLUX: a European contribution to the LUVOIR mission study

Based on ARAGO(M5)

- POLLUX is a concept for a UV spectro-polarimeter with high resolution point-source capability (R ~ 10^5)
- Complementary to the LUMOS instrument
- To be defined & designed by a consortium of 10 European institutions, with leadership/support from CNES
- The conceptual study conducted by CNES could serve as a support for a future ESA contribution

Technological challenges

Need heavy lift launch vehicle with large fairing

Suitable vehicles (SLS and commercial) in development

Compatibility of UV and coronagraphy

New lab work shows UV reflective mirrors are just fine for coronagraphy

Ultra-high contrast observations with a segmented telescope

Coronagraphs can be designed for segmented telescopes. Working hard to demonstrate needed system stability

Series of short, readable "LUVOIR Tech Notes" available at
http://asd.gsfc.nasa.gov/luvoir/tech/

STDT voting members

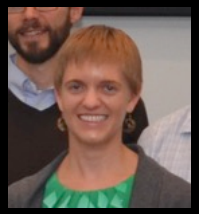
Debra Fischer
(Yale)

Brad Peterson
(Ohio State / STScI)

Jacob Bean
(Chicago)

Daniela Calzetti
(U Mass)

Rebekah Dawson
(Penn State)


Courtney Dressing
(Caltech)

Lee Feinberg
(NASA GSFC)

Kevin France
(Colorado)

Olivier Guyon
(Arizona)

Walter Harris
(Arizona / LPL)

Mark Marley
(NASA Ames)

Leonidas Moustakas
(JPL)

John O'Meara
(St. Michael's)

Vikki Meadows
(Washington)

Ilaria Pascucci
(Arizona)

Marc Postman
(STScI)

Laurent Pueyo
(STScI)

David Redding
(JPL)

Jane Rigby
(NASA GSFC)

Aki Roberge
(NASA GSFC)

David Schiminovich
(Columbia)

Britney Schmidt
(Georgia Tech)

Karl Stapelfeldt
(JPL)

Jason Tumlinson
(STScI)

International Ex-Officio Non-Voting Members

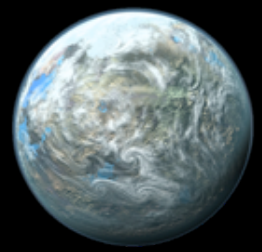
International Ex-Officio Non-Voting Members

Name	Institution	Role
Martin Barstow	Leicester	UK Space Agency representative
Lars Buchhave	Copenhagen	DASTI representative
Nicholas Cowan	McGill	CSA representative
Marc Ferrari	LAM	CNES representative
Ana Gomez de Castro	Madrid	SNPRDI representative
Thomas Henning	Max Planck	DLR representative
Antonella Nota	ESA	ESA representative
Takahiro Sumi	Osaka	JAXA representative

How we're doing the study

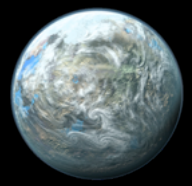
Six Community Working Groups

- Exoplanets
- Cosmic Origins
- Solar System
- Simulations
- Communications
- Technology



Five Instrument Teams

Difference between LUVOIR and HabEx ?



Both LUVOIR and HabEx have two primary science goals

- Habitable exoplanets & biosignatures
- Broad range of general astrophysics

The two architectures will be driven by difference in focus

- For LUVOIR, both goals are on equal footing. LUVOIR will be a general purpose "great observatory", a successor to HST and JWST in the ~ 8 – 16 m class
- HabEx will be optimized for exoplanet imaging, but also enable a range of general astrophysics. It is a more focused mission in the ~ 4 – 8 m class

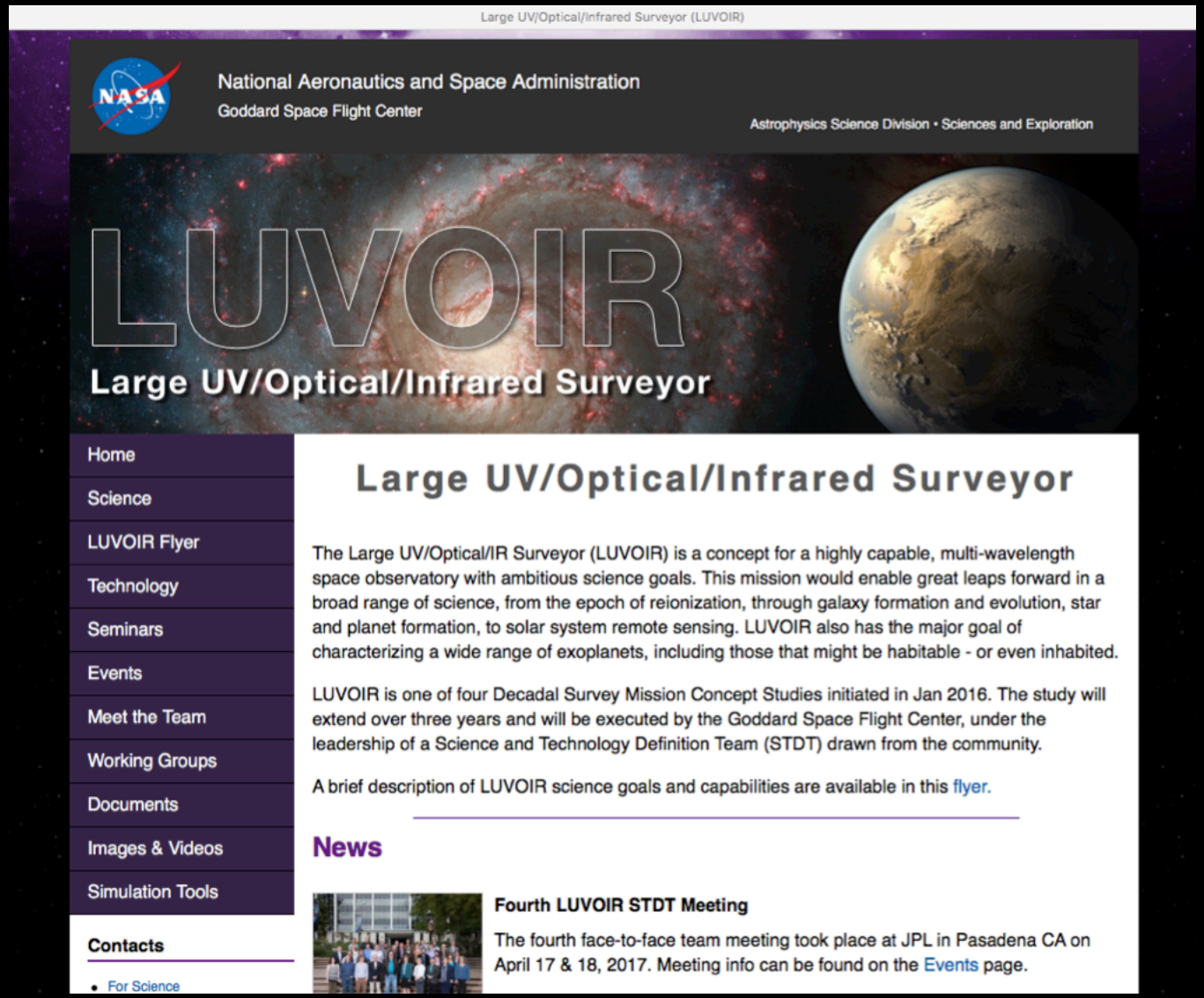
Similar exoplanet goals, differing in quantitative levels of ambition

- HabEx will *explore* the nearest stars to "search for" signs of habitability & biosignatures via direct detection of reflected light
- LUVOIR will *survey* more stars to "constrain the frequency" of habitability & biosignatures and produce a statistically meaningful sample of exoEarths

The two studies will provide a continuum of options for a range of futures

Get involved with LUVOIR

http://asd.gsfc.nasa.gov/luvoir/



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

宇宙科学の今後20年の構想を検討する委員会（通称：20年委員会）

2014年末にISASから宇宙科学コミュニティにRFI（研究領域の目標・戦略・工程表提供のお願い）を送出し、集まった回答をISASがとりまとめています。一方で、宇宙科学の将来計画を継続して改善していくために、今後20年ほどの長期ロードマップを理工学のコミュニティが主体となり提言する必要性が強く認識され、本委員会を設置し、検討を開始することになりました。

日本の宇宙理学/工学における現状の開発能力とこれまでに考えられている計画をISASが整理した「宇宙科学の実行戦略」文書を参考にして把握したうえで、候補となっているミッション構想の科学的価値や実現可能性を総合的に検討する。

- 可能であればミッション構想に優先順位をつけ、理学と工学の競争的かつ協調的な発展による今後20年のロードマップを策定する。2030年代を見越した長期的な方向性を明確にしたうえで、2020年代になすべきこと、手に入れるべきキー技術を抽出する。シナリオは複数有って良い。
- RFI回答に示された各コミュニティの意見を反映しつつも、できるだけ自由な発想で構想を練っていただく。工学委員会では工学の視点からのミッション提案の方向性と技術開発戦略の構築を別途進めており、これと適宜やりとりしながら検討を進める。
- 20年委員会は今後20年の構想に関する素案を作るとともに、理工学委員会と宇宙研との議論を経て、最終的な提言をまとめる。その際、理工学委員会が各コミュニティとの仲介の役割を担う。
- 来年6月ごろまでに素案をまとめることを目指して作業を行なう。
- なお、20年委員会の委員各位には大変な作業をお願いすることになるが、日本の宇宙科学の突破口となる案を作っていただくよう上記の内容について依頼し、理工学委員会幹事団がそれをサポートする。

光近赤外天文学の将来20年の展望

- 2025年~WFIRSTへの参加

- 2030年後半～ （SPICA以後）

海外大型計画への参加

- LUVOIR Space Telescope（超大型汎用）
- HabEx Space Telescope（生命探査専用）

国内戦略的中型

- WISH？以外はないのが実情ー＞課題

LUVOIR Architecture A (15-m)

Credit: A. Jones (GSFC)