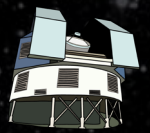


JWST Observations of Exoplanets

Dr. Joshua D. Lothringer
Assistant Astronomer, STScI



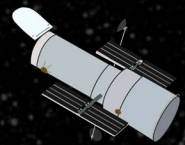
STScI | SPACE TELESCOPE
SCIENCE INSTITUTE



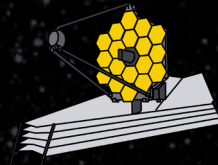
Ground

Views are my own

30m

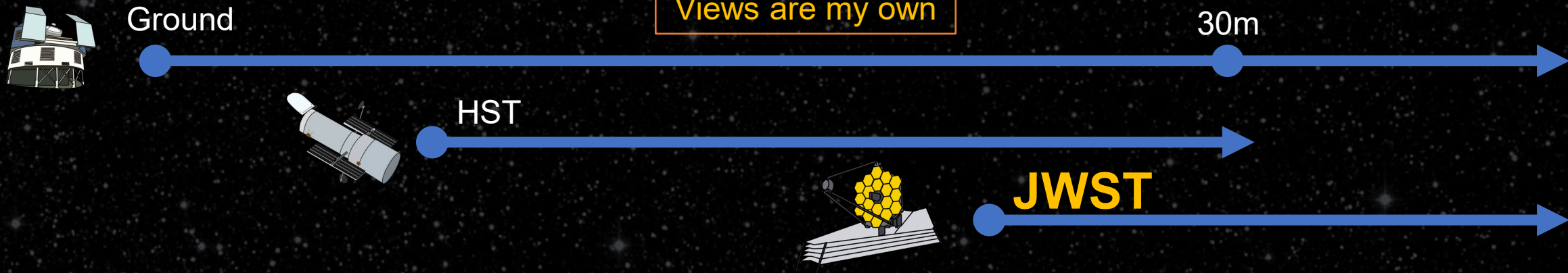


HST



JWST

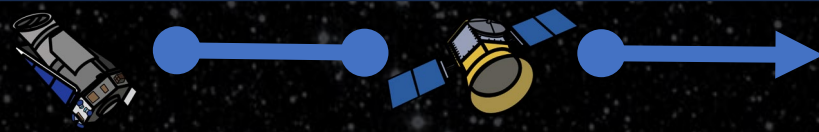


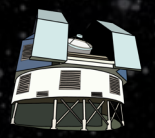


Giant Planets



Discovery Recon Characterization Utilization

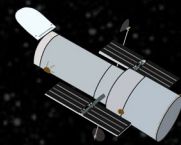




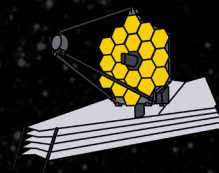
Ground

Views are my own

30m



HST



JWST



Giant Planets



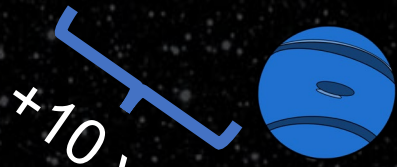
Discovery

Recon

Characterization

Utilization

(sub)-Neptunes

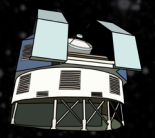


Discovery

Recon

Characterization

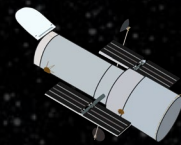
Utilization



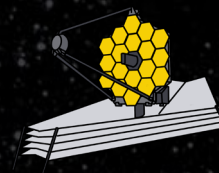
Ground

Views are my own

30m



HST



JWST



Giant Planets



Discovery

Recon

Characterization

Utilization

(sub)-Neptunes

+10 yr



Discovery

Recon

Characterization

Utilization

+10 yr



Rocky Planets

Discovery

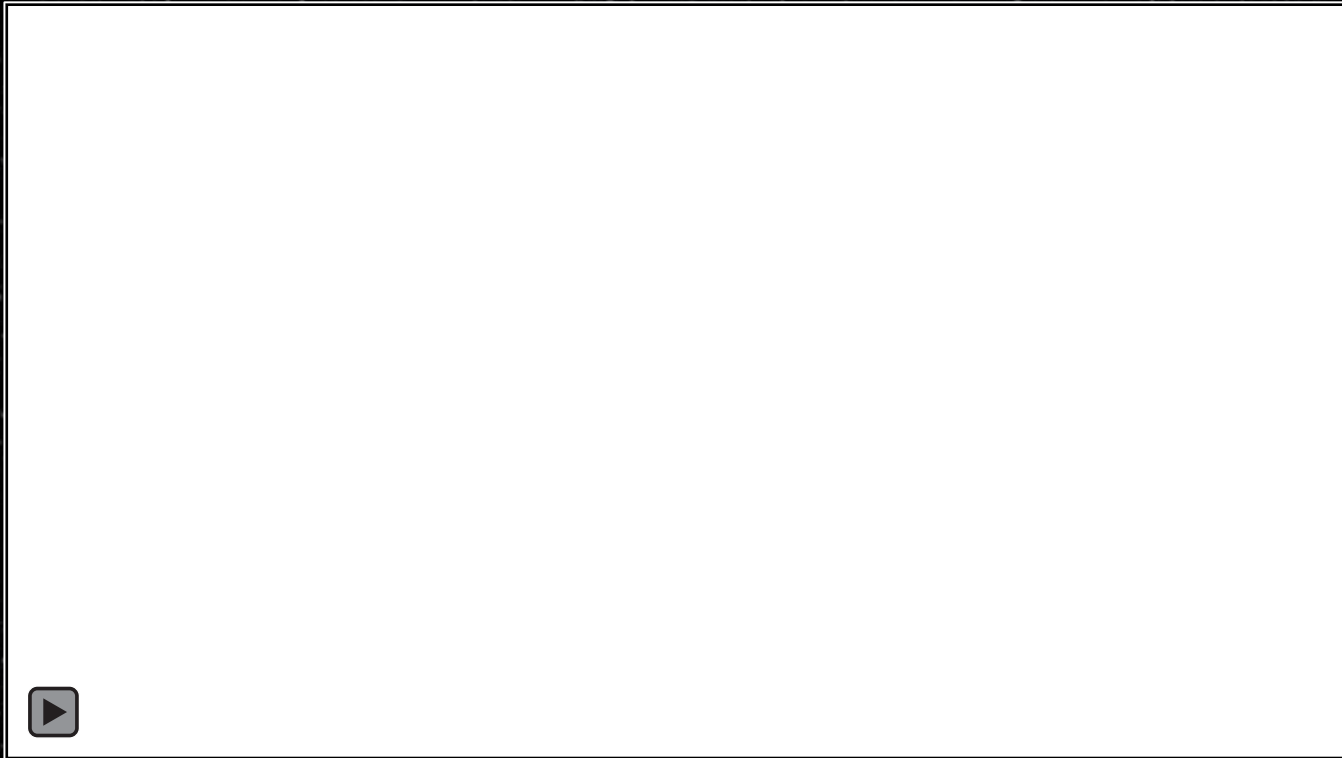
Recon

Characterization

Utilization

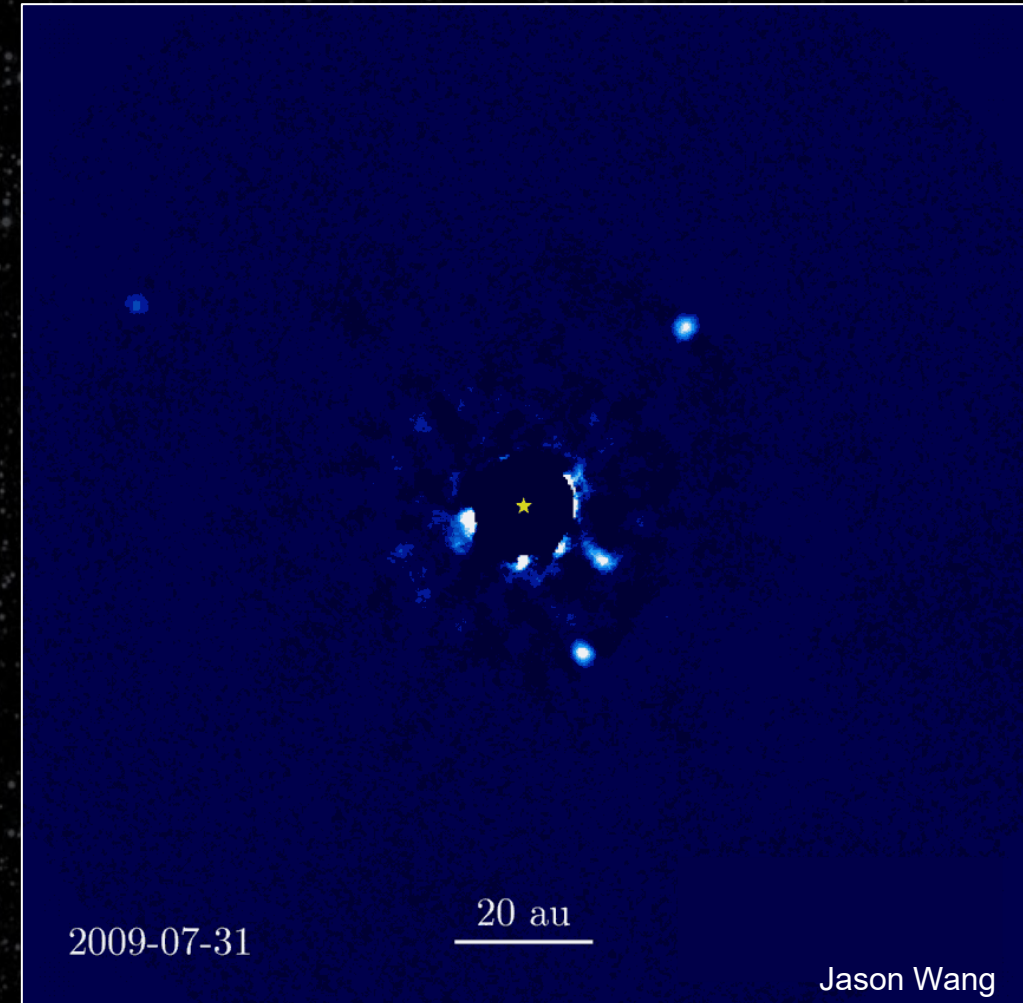
Transits, Eclipses and Phase Curves

Temporally Resolving Exoplanets



Direct Imaging

Spatially Resolving Exoplanets



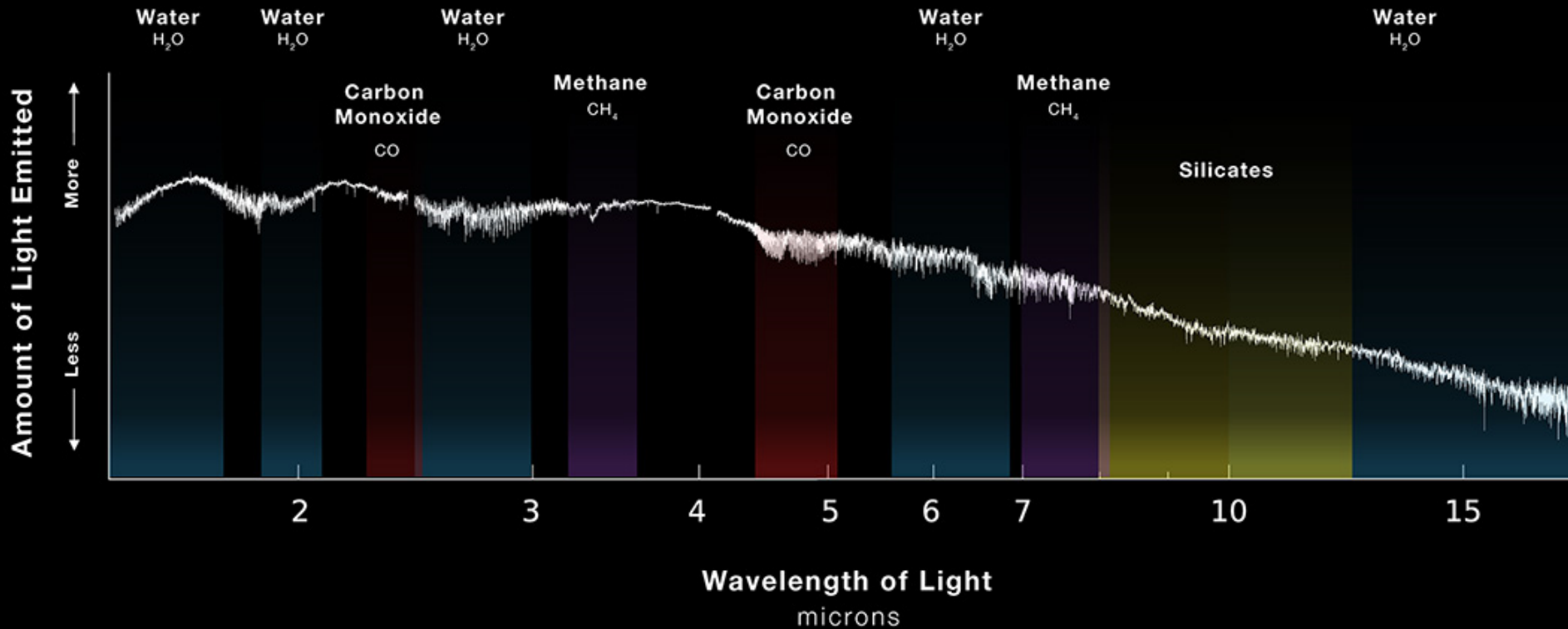
Giant Planets with JWST

Direct Imaging and Spectroscopy

EXOPLANET VHS 1256 b

EMISSION SPECTRUM

NIRSpec and MIRI | IFU Medium-Resolution Spectroscopy



WEBB
SPACE TELESCOPE

Giant Planet

VHS 1256 b



*Age of
Utilization*

**Geometry:
Direct**

Miles et al.
2023

The First Sub-Jovian Directly Imaged Exoplanet?

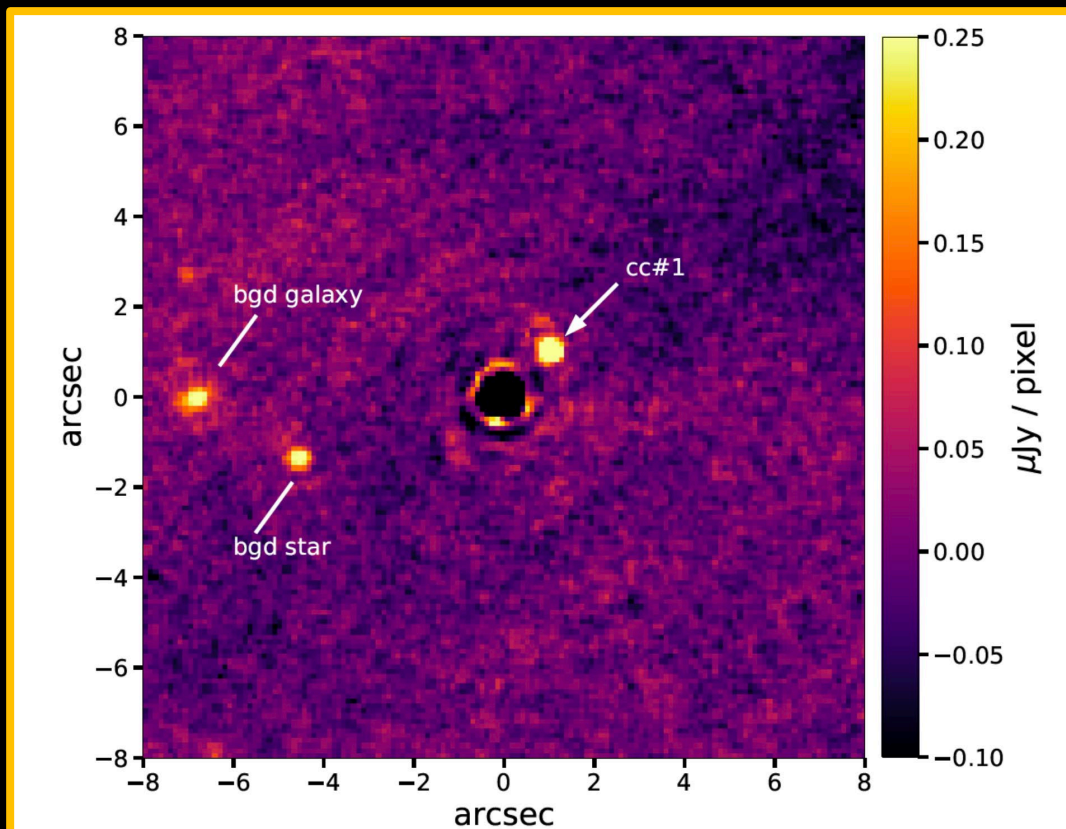


Fig. 1: JWST/MIRI image in the F1140C filter of TWA 7. North is up, and East is left. The status of three identified sources are indicated. Note that the faint signal north of the background galaxy is an artefact.

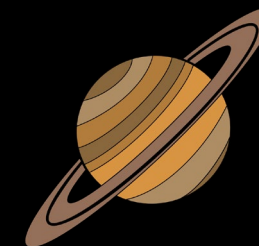
TWA-7b

- <6.4 Myr
- $0.3 M_{\text{Jup}}$
- Pending co-motion

JWST has sensitivity to
 $\sim 0.1 M_{\text{Jup}}$ and $\sim 250 \text{ K}$
(PIDs 4050 & 5835)

Giant Planet

TWA-7b



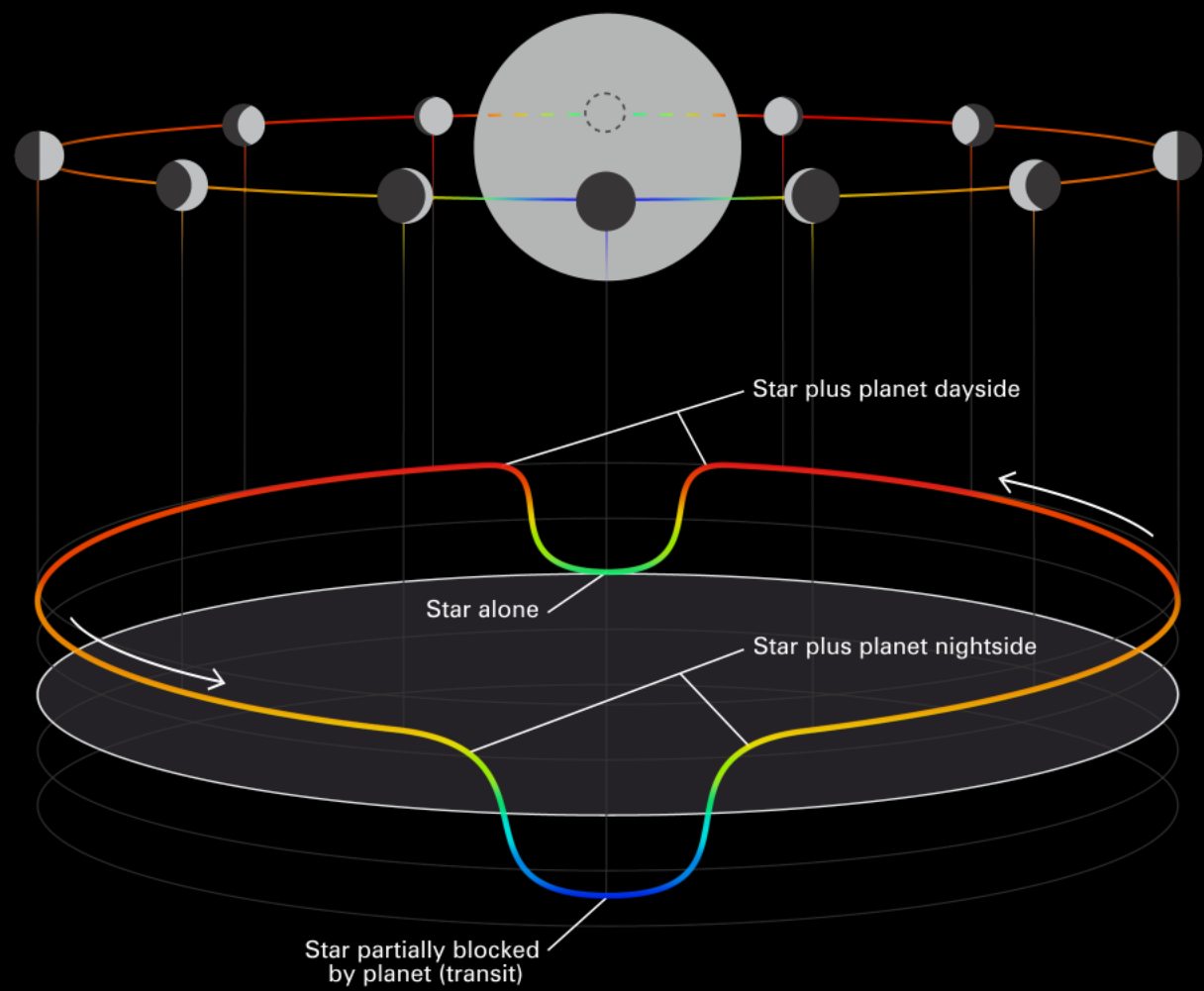
Age of Utilization

Geometry: Direct

Lagrange et al.
2025 submitted

Giant Planets with JWST

Transit, Eclipses, and Phase Curves



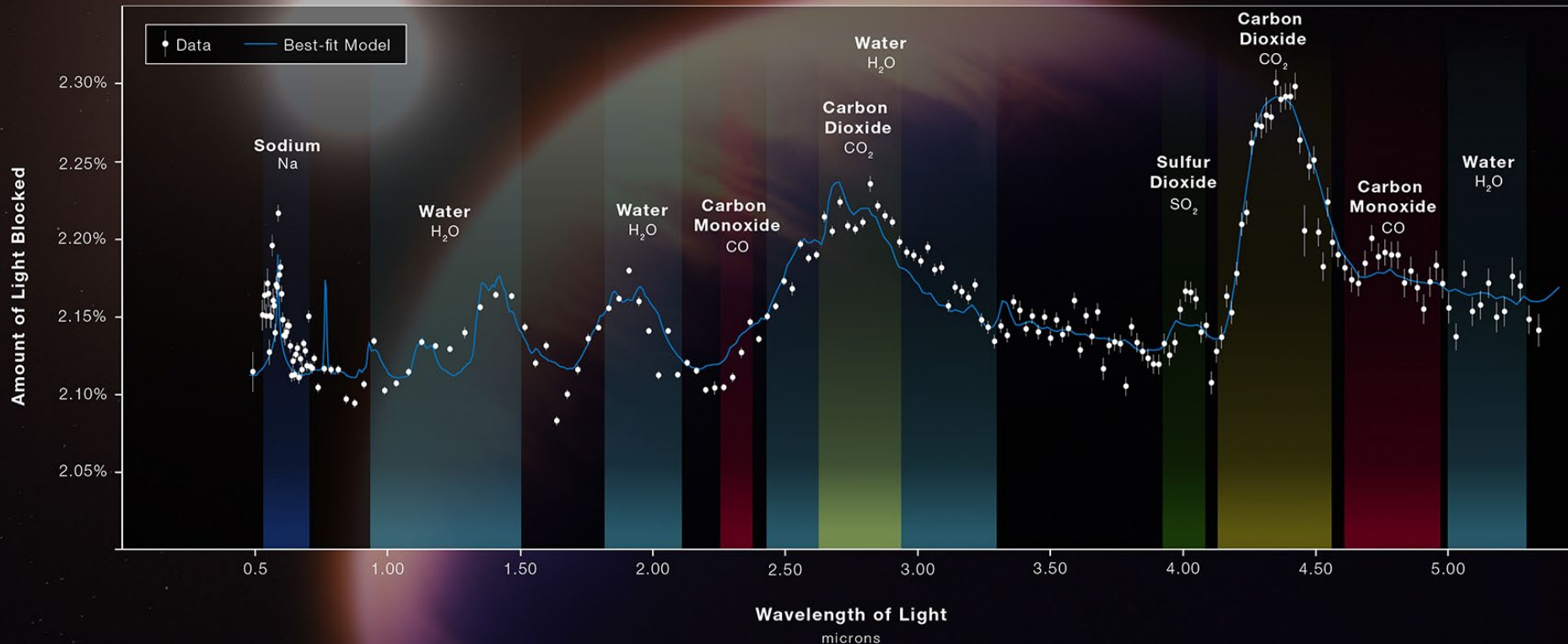
Amount of Infrared Light from the star-planet system



HOT GAS GIANT EXOPLANET WASP-39 b ATMOSPHERE COMPOSITION

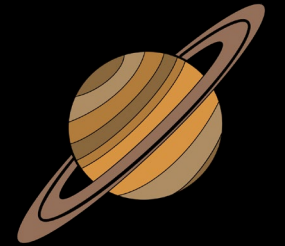
1. Carbon Species
2. Photochemistry
3. Limb-Limb Asymmetries

NIRSpec PRISM



Giant Planet

WASP-39b



*Age of
Utilization*

*Geometry:
Transit*

Rustamkulov et al.

Ahrer et al.

Alderson et al.

Feinstein et al.

2023

WEBB
SPACE TELESCOPE

The international journal of science / 23 February 2023

nature



BRAVE NEW WORLDS

JWST offers unprecedented insights into exoplanets

Fighting back
Ukraine's scientists defy the odds to keep doing research

Smart decision
Why the world must ban autonomous lethal weapons

Climate crisis
Tree rings suggest drought helped end the Hittite empire

Vol. 611, No. 7420
nature.com

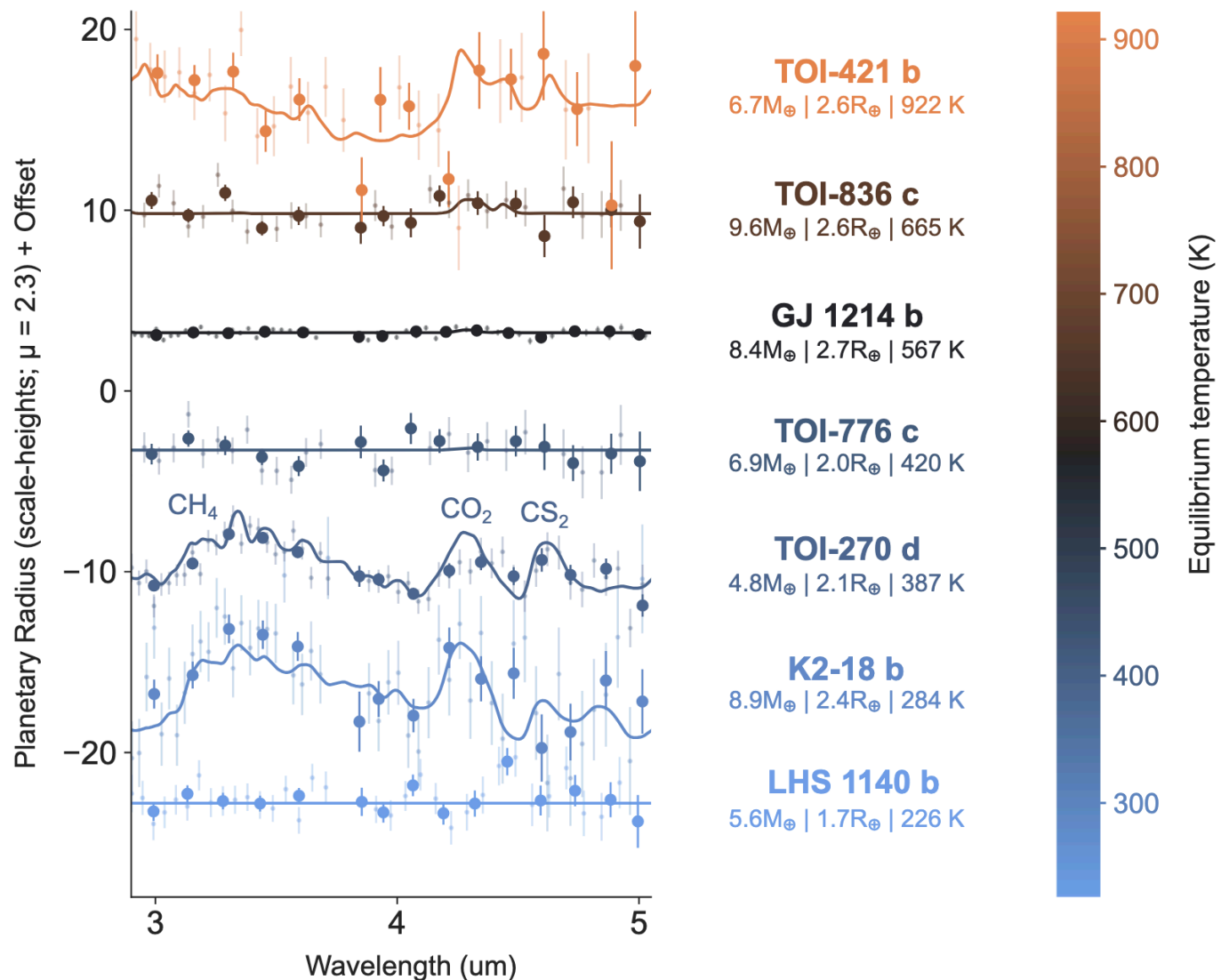
11 Articles in *Nature* special collection from the **JWST Transiting Exoplanet Community Early Release Science Program** (ERS 1366; PIs: Batalha, Bean, Stevenson)

(sub-)Neptunes with JWST

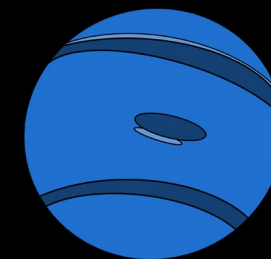
Transits, Eclipses, and Phase Curves

JWST's Exploration of sub-Neptune Exoplanet Atmospheres

Highlights as of March 2025



(sub)-
Neptunes

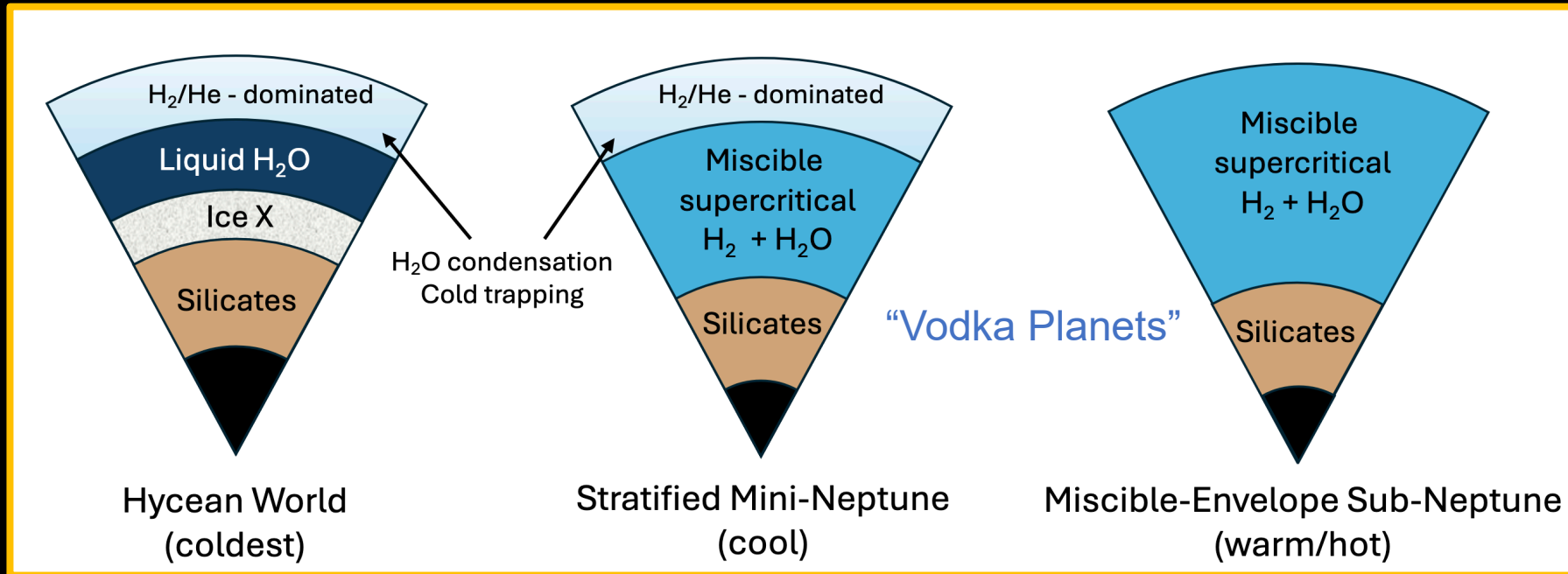


*Age of
Characterization*

**Geometry:
Transiting**

Espinoza & Perrin
2025

Sub-Neptune and super-Earth exoplanets may be very unlike anything in our Solar System



(sub)-
Neptunes



*Age of
Characterization*

**Geometry:
Transiting**

Benneke et al.
2023

Rocky Exoplanets with JWST

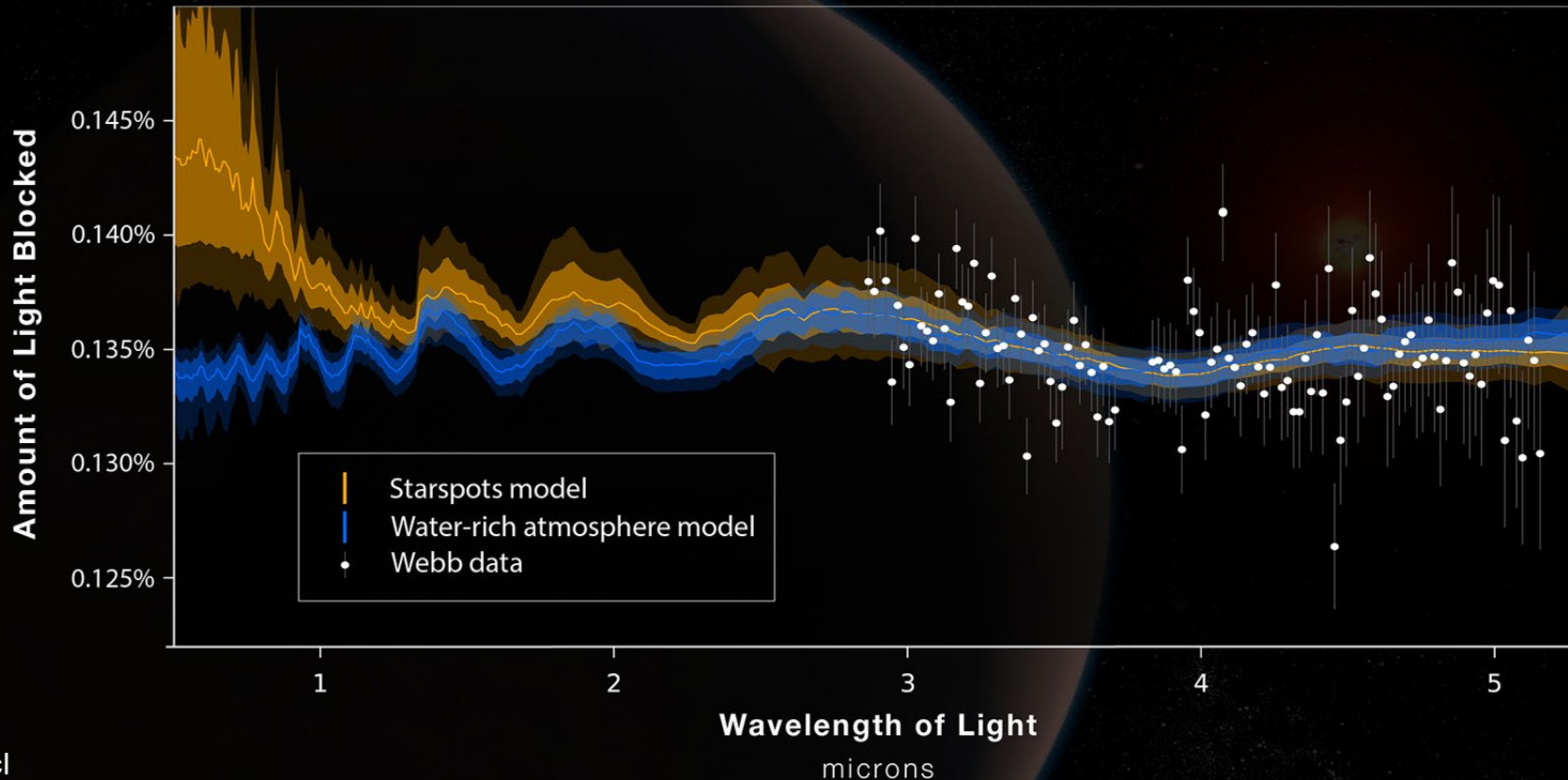
Transits, Eclipses, and Phase Curves

Terrestrial Worlds are the new frontier

EXOPLANET GJ 486 b

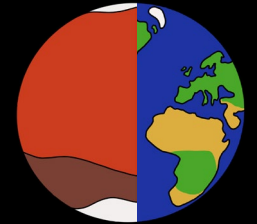
TRANSMISSION SPECTRUM

NIRSpec Bright Object Time Series Spectroscopy



Rocky
Planets

GJ 486 b



Age of
Reconnaissance

Geometry:
Transiting

Moran &
Stevenson
et al. 2023

The Rocky Worlds DDT Program

A direct recommendation from the...

Report of the Working Group on Strategic Exoplanet Initiatives with HST and JWST

Seth Redfield, Wesleyan University (Chair)

Natasha Batalha, NASA Ames

Björn Benneke, University of Montréal

Beth Biller, University of Edinburgh (STUC Chair)

Nestor Espinoza, Space Telescope Science Institute

Kevin France, University of Colorado

Quinn Konopacky, University of California, San Diego

Laura Kreidberg, Max Planck Institute for Astronomy

Emily Rauscher, University of Michigan

David Sing, Johns Hopkins University

Neill Reid, Space Telescope Science Institute (ex officio)

Elena Sabbi, Space Telescope Science Institute (ex officio)

x3 Town Halls

x42 White Papers

x75 Survey Responses

Redfield+2024

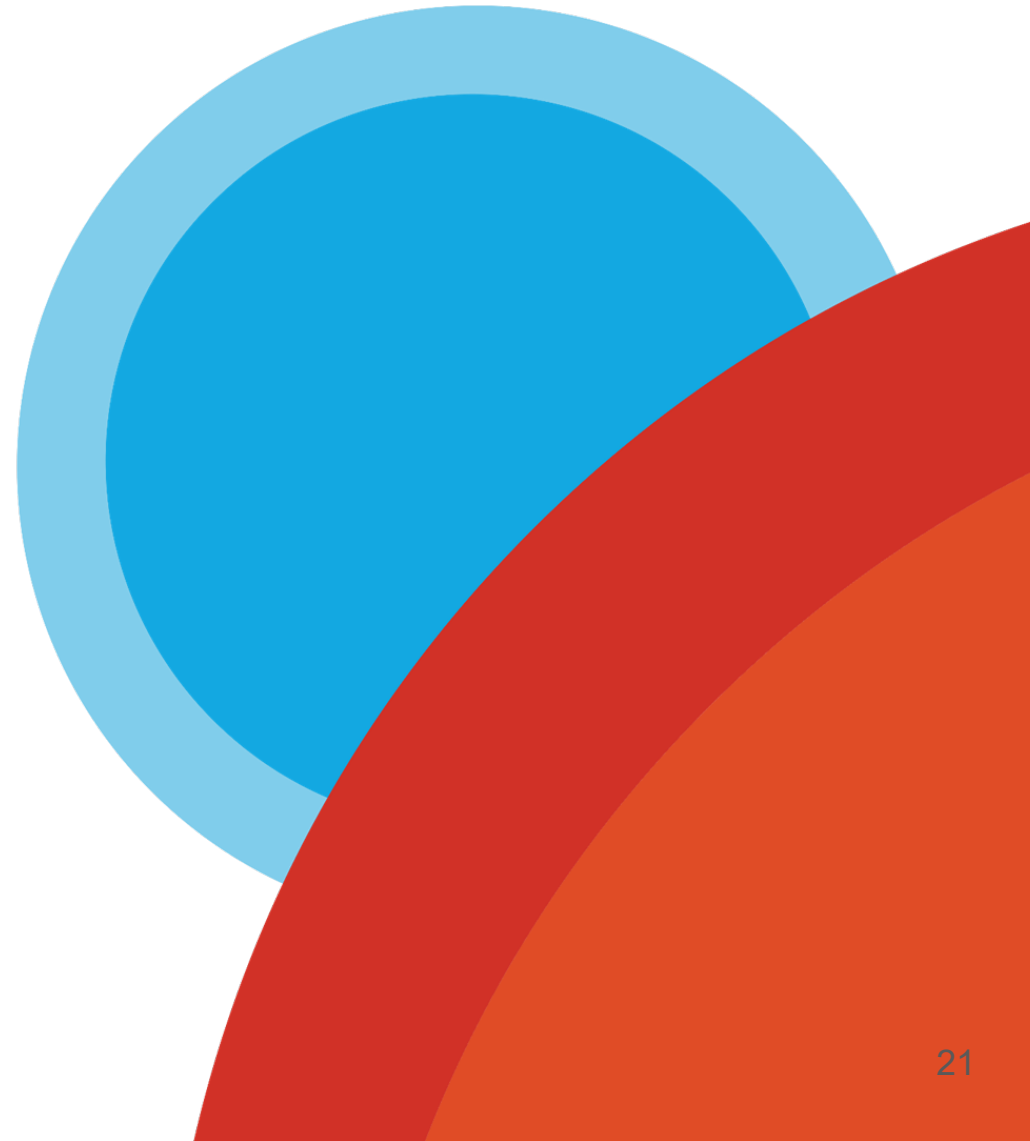
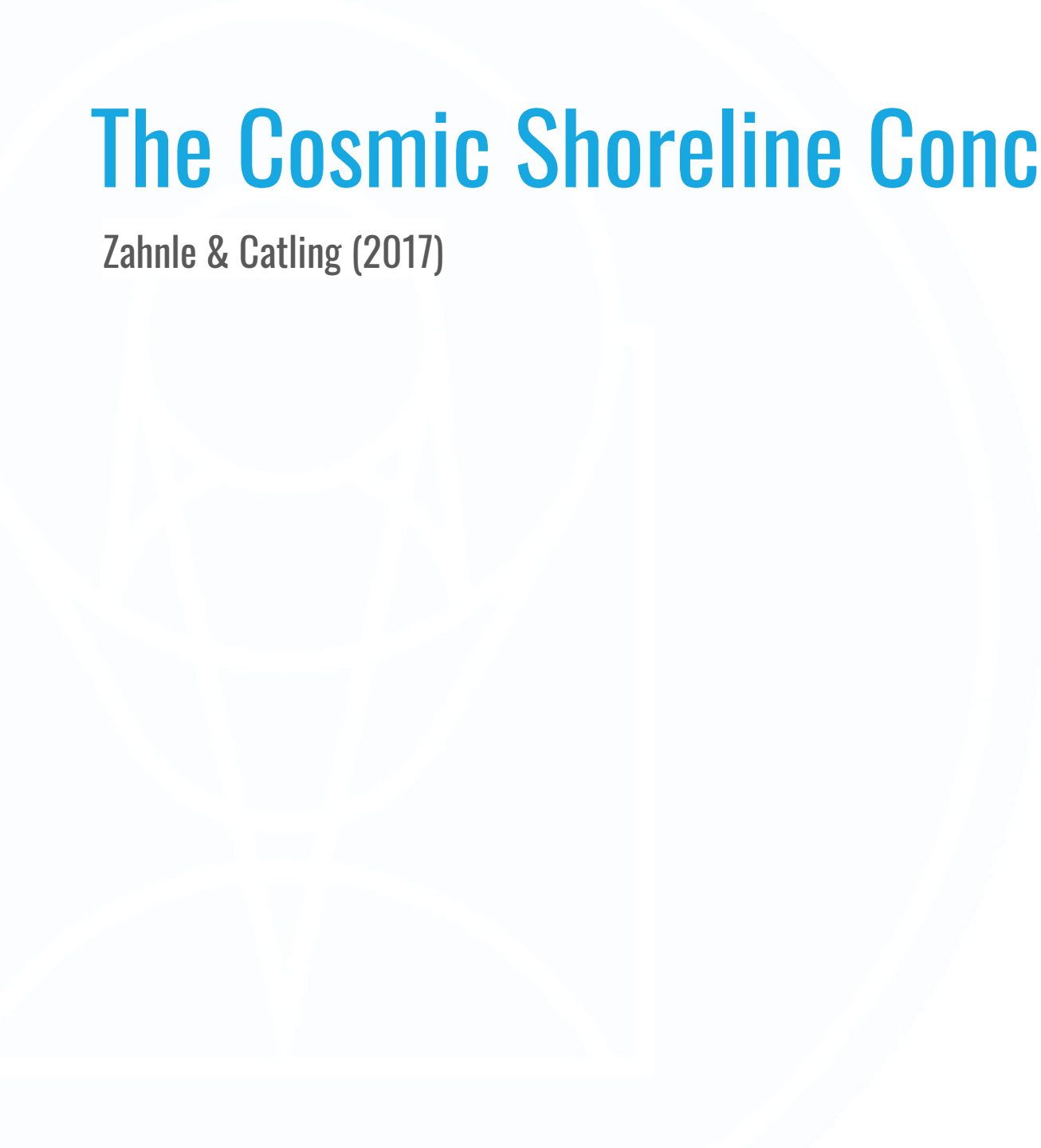
Led by Néstor Espinoza and
Hannah Diamond-Lowe

The Rocky Worlds DDT Program

- **Main aim:** look for **evidence of atmospheres** in rocky exoplanets orbiting **M-dwarf stars**.
- **With what?** **500 hours** of JWST for planet/atmospheric characterization + **250 HST/UV** orbits for stellar characterization.
- **How? Core Implementation Team (CIT)** deals with data + community (at STSCI); **Science Advisory Council (SAC)** advises the CIT.

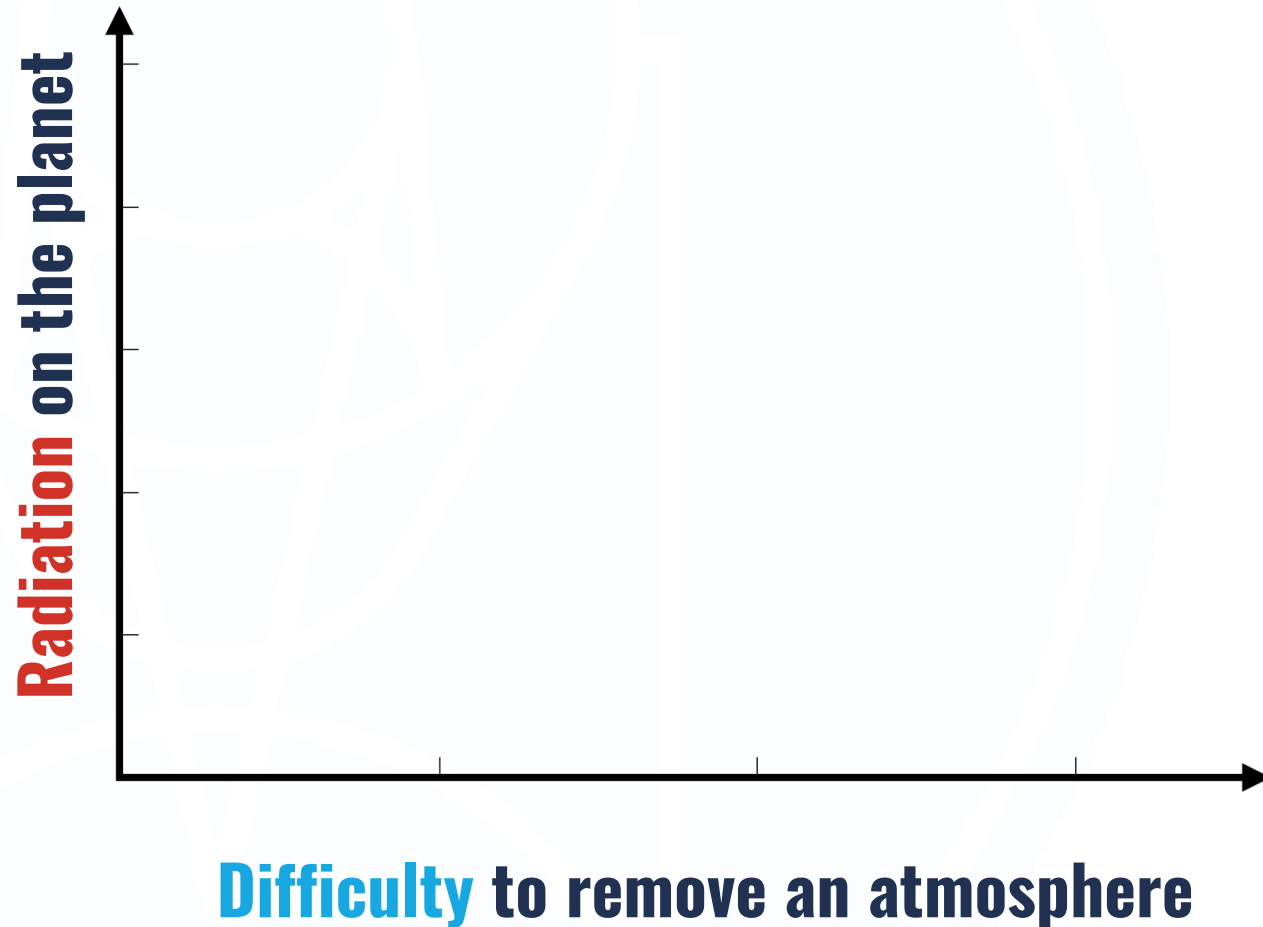
The Cosmic Shoreline Concept

Zahnle & Catling (2017)



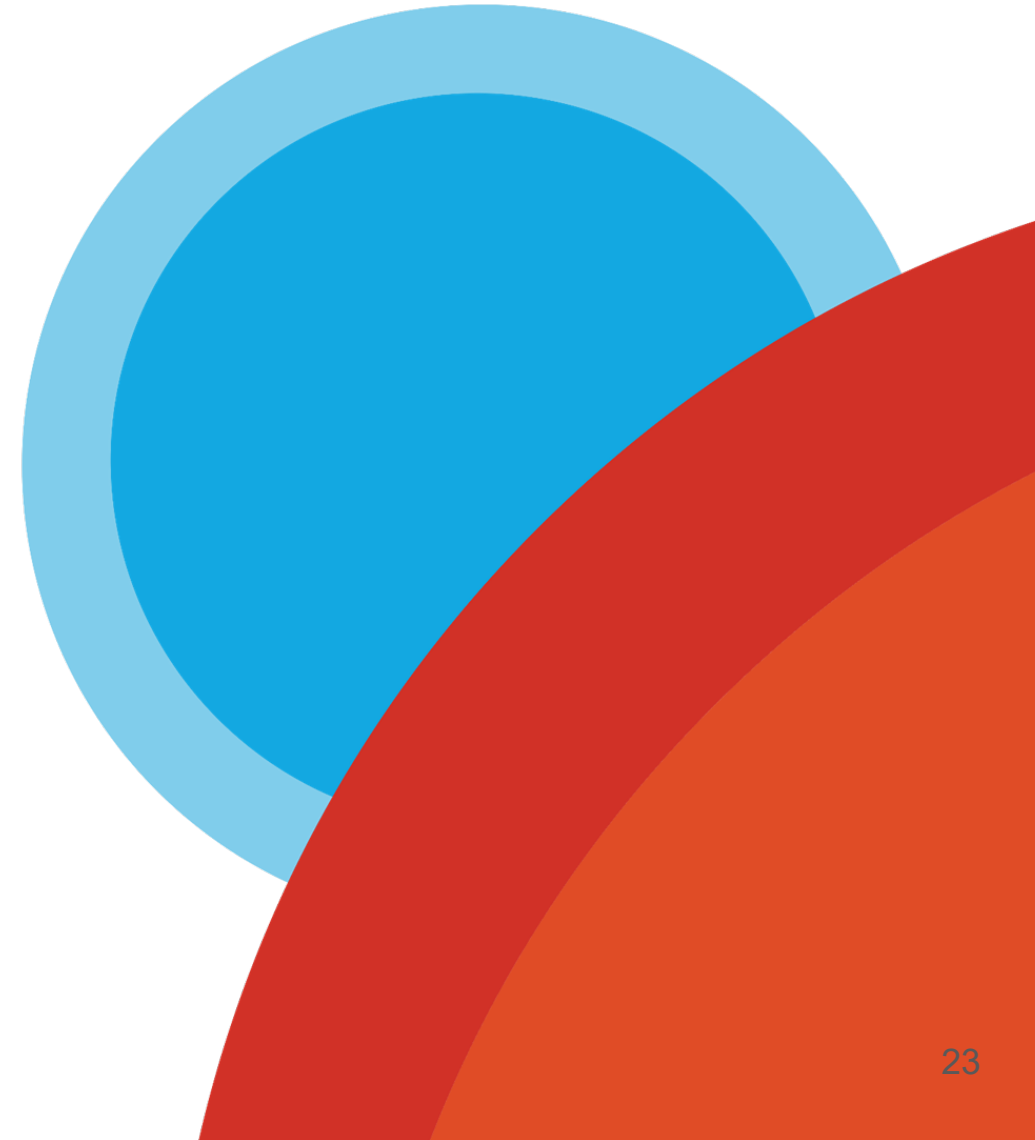
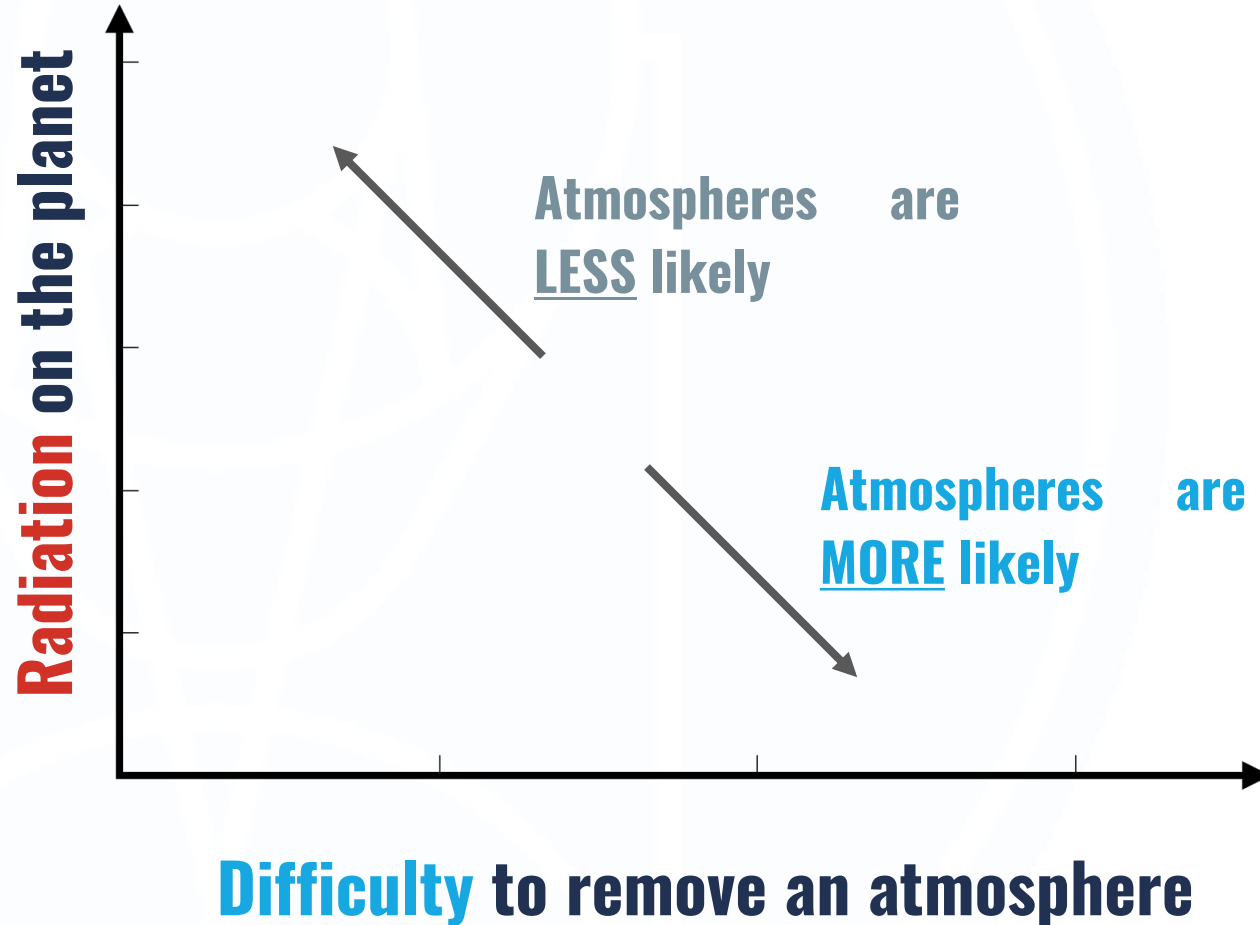
The Cosmic Shoreline Concept

Zahnle & Catling (2017)



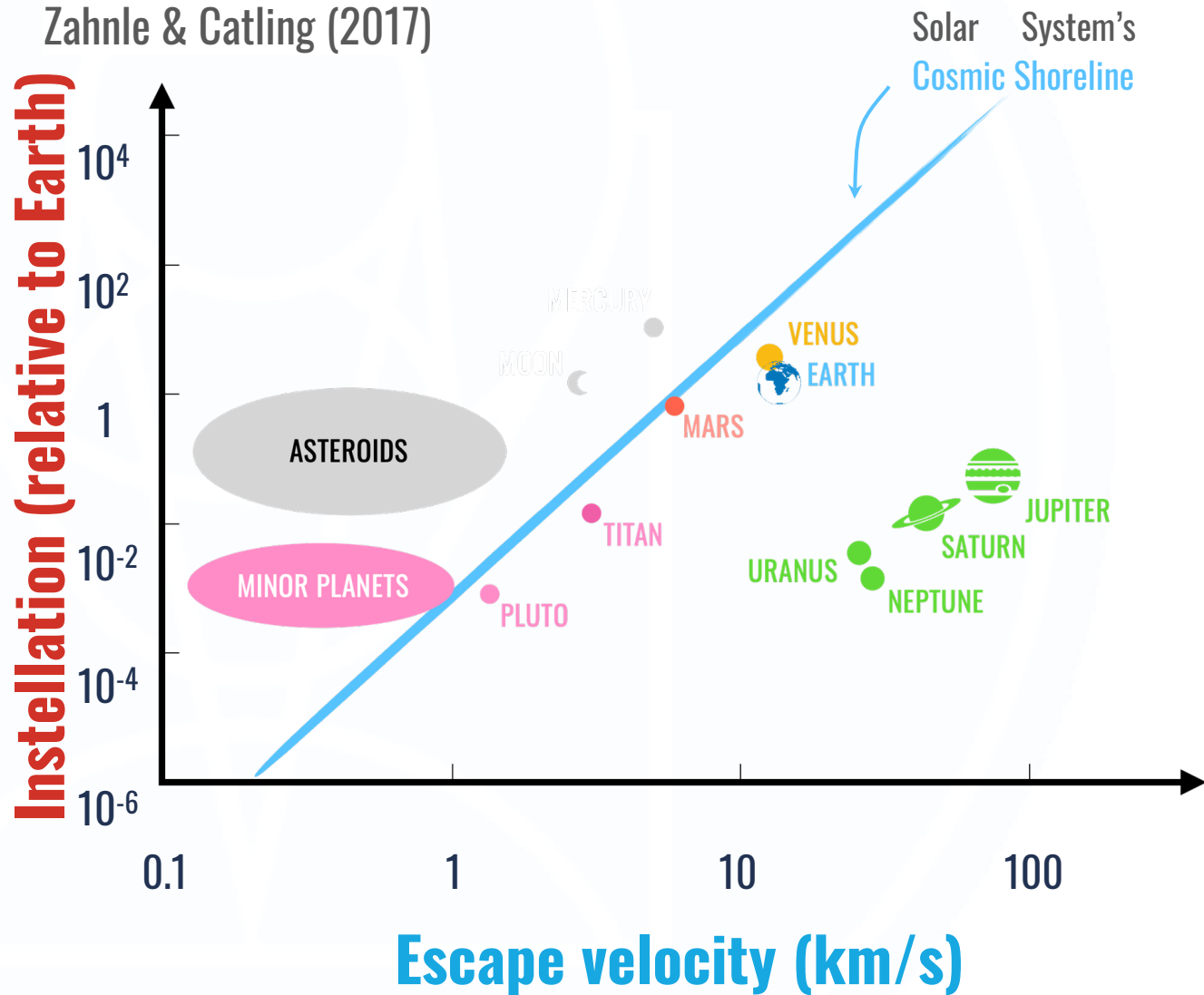
The Cosmic Shoreline Concept

Zahnle & Catling (2017)



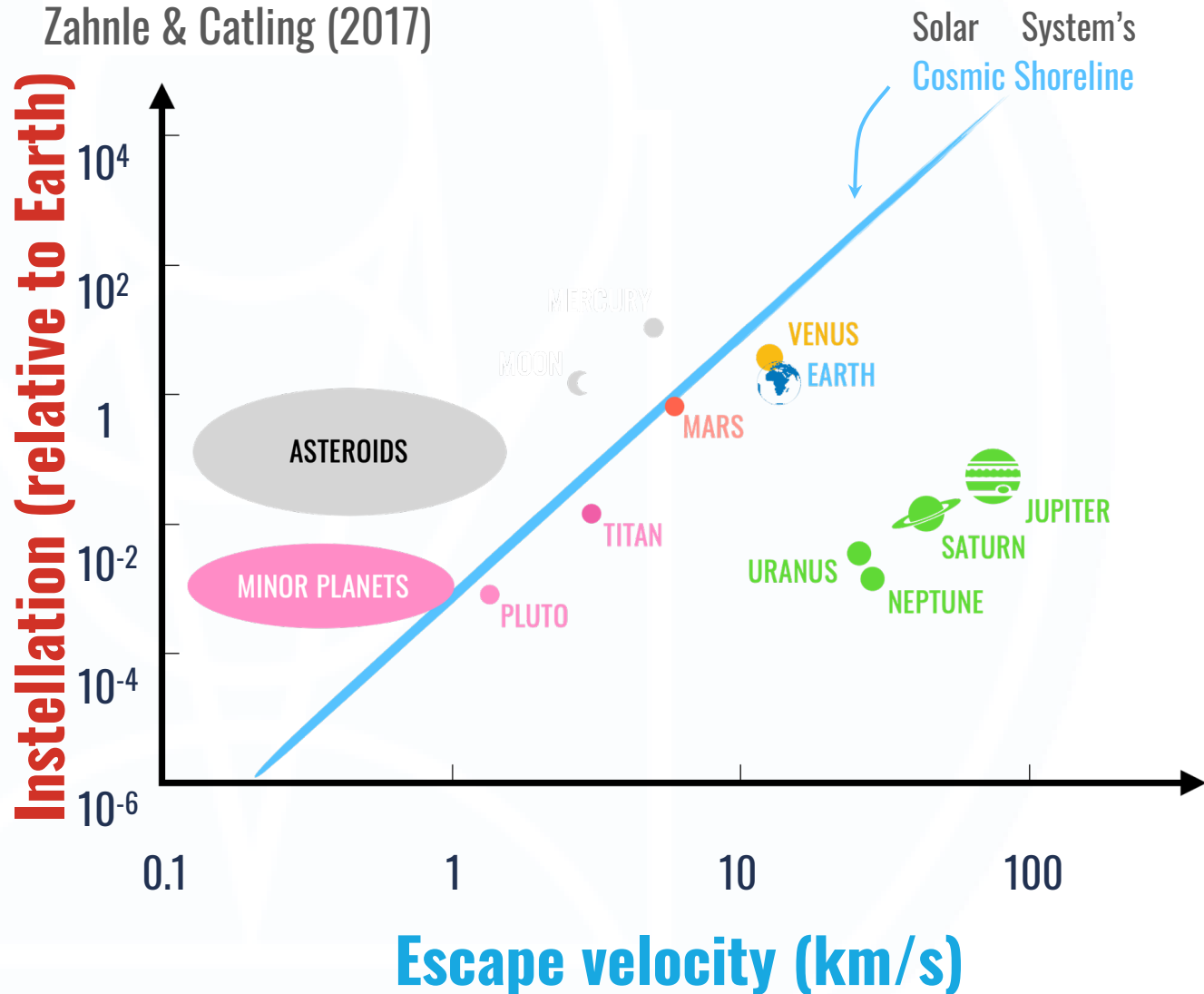
The Cosmic Shoreline Concept

Zahnle & Catling (2017)



The Cosmic Shoreline Concept

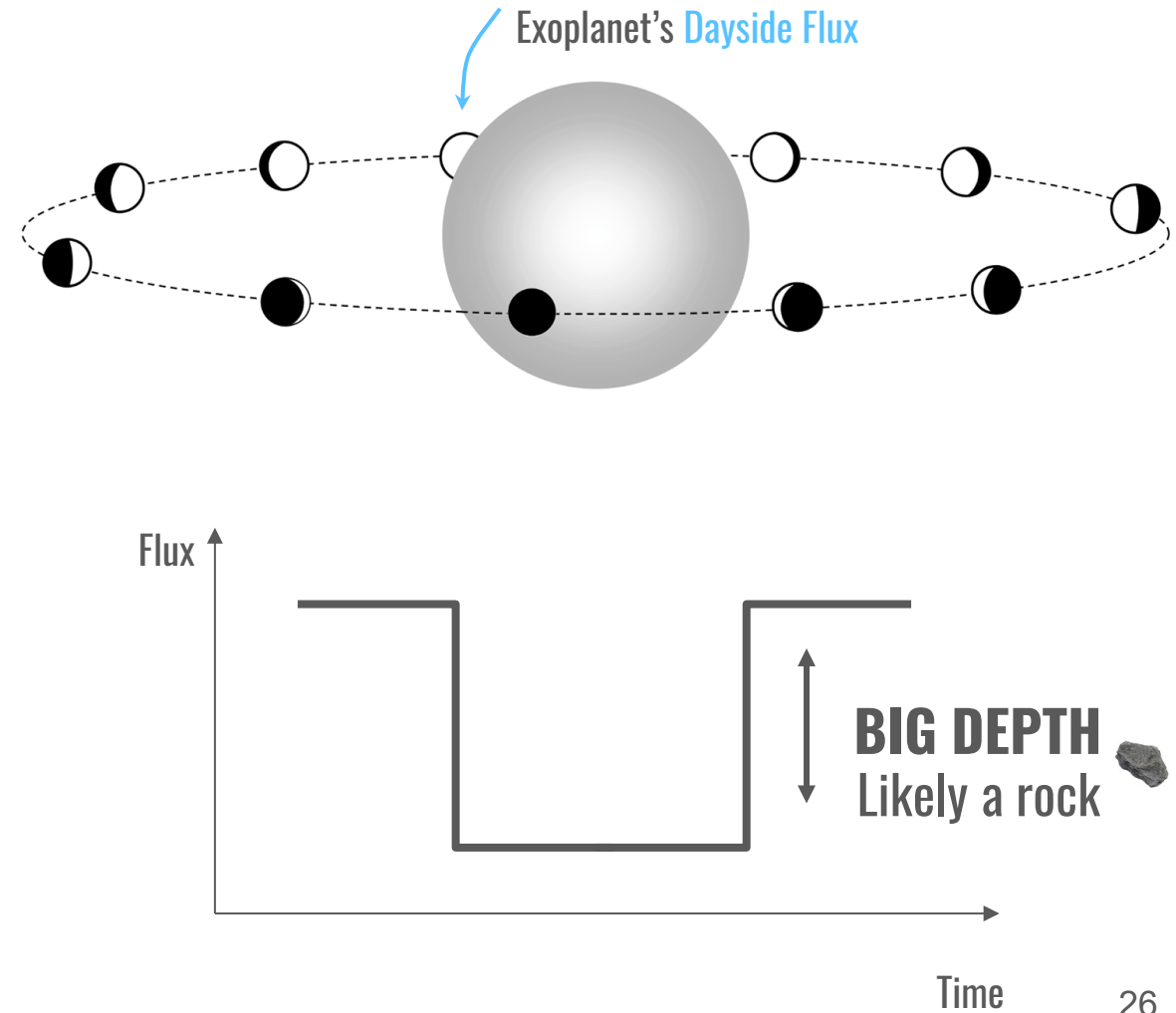
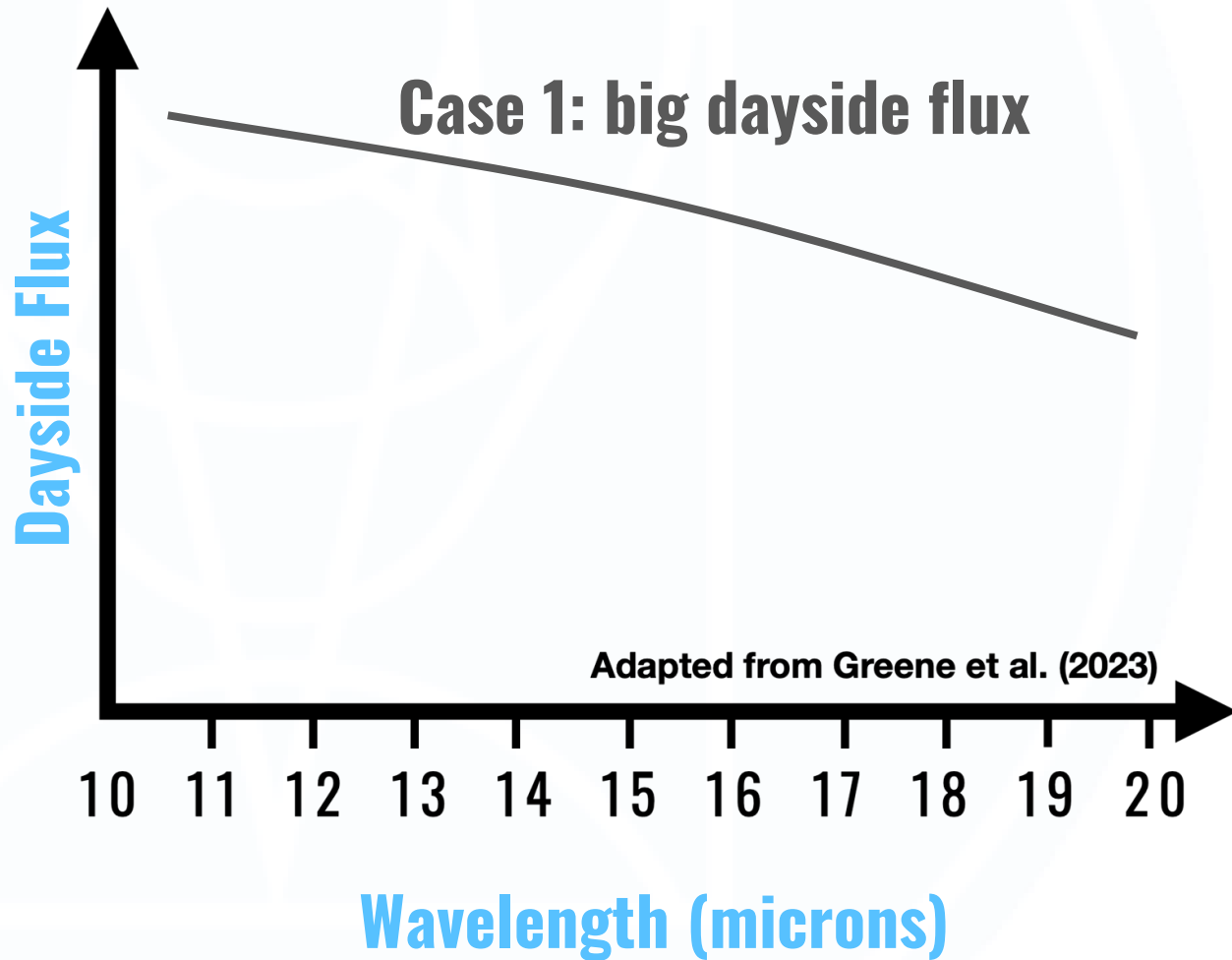
Zahnle & Catling (2017)



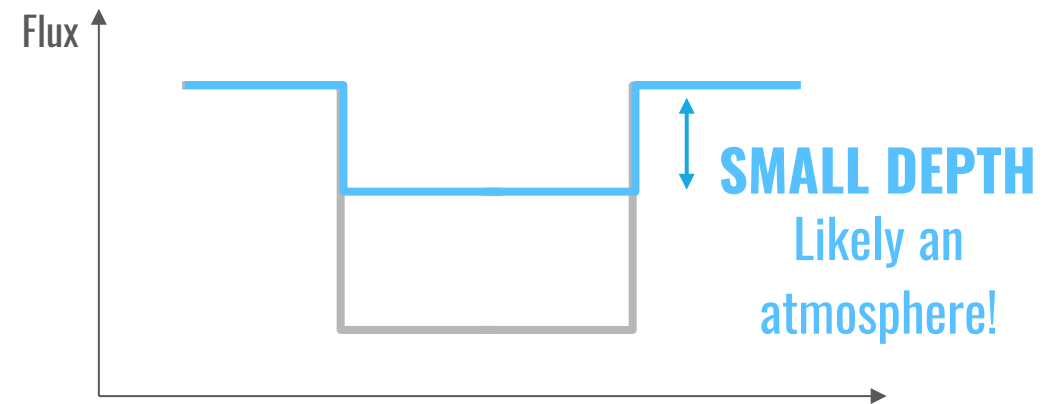
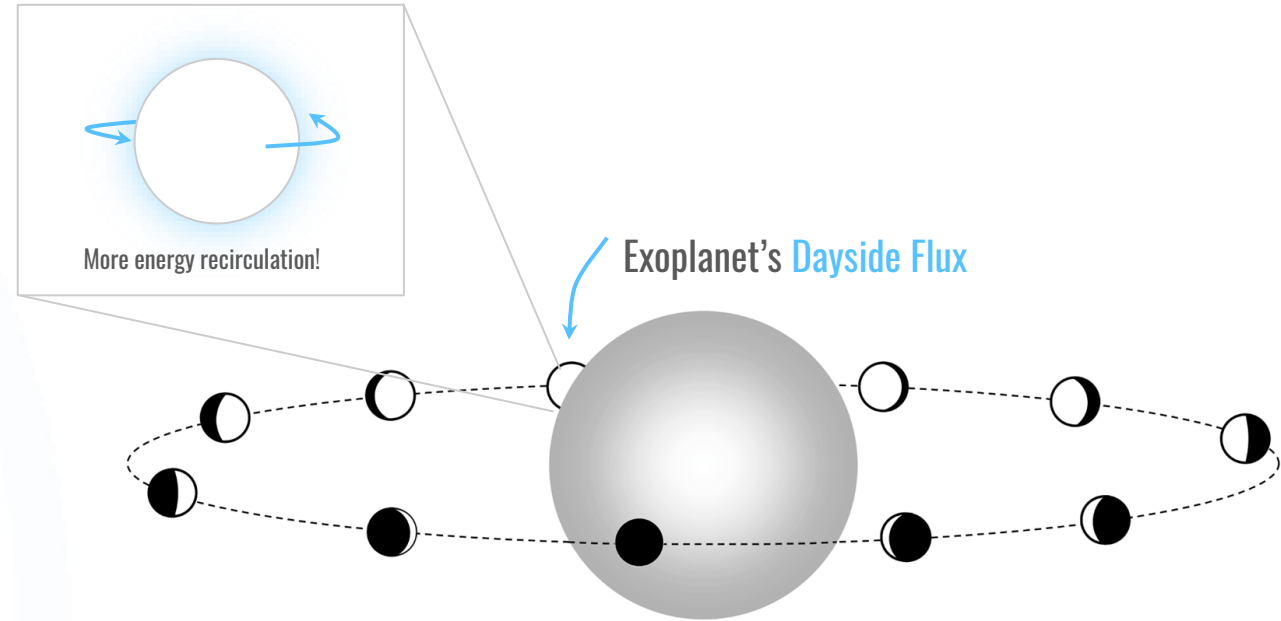
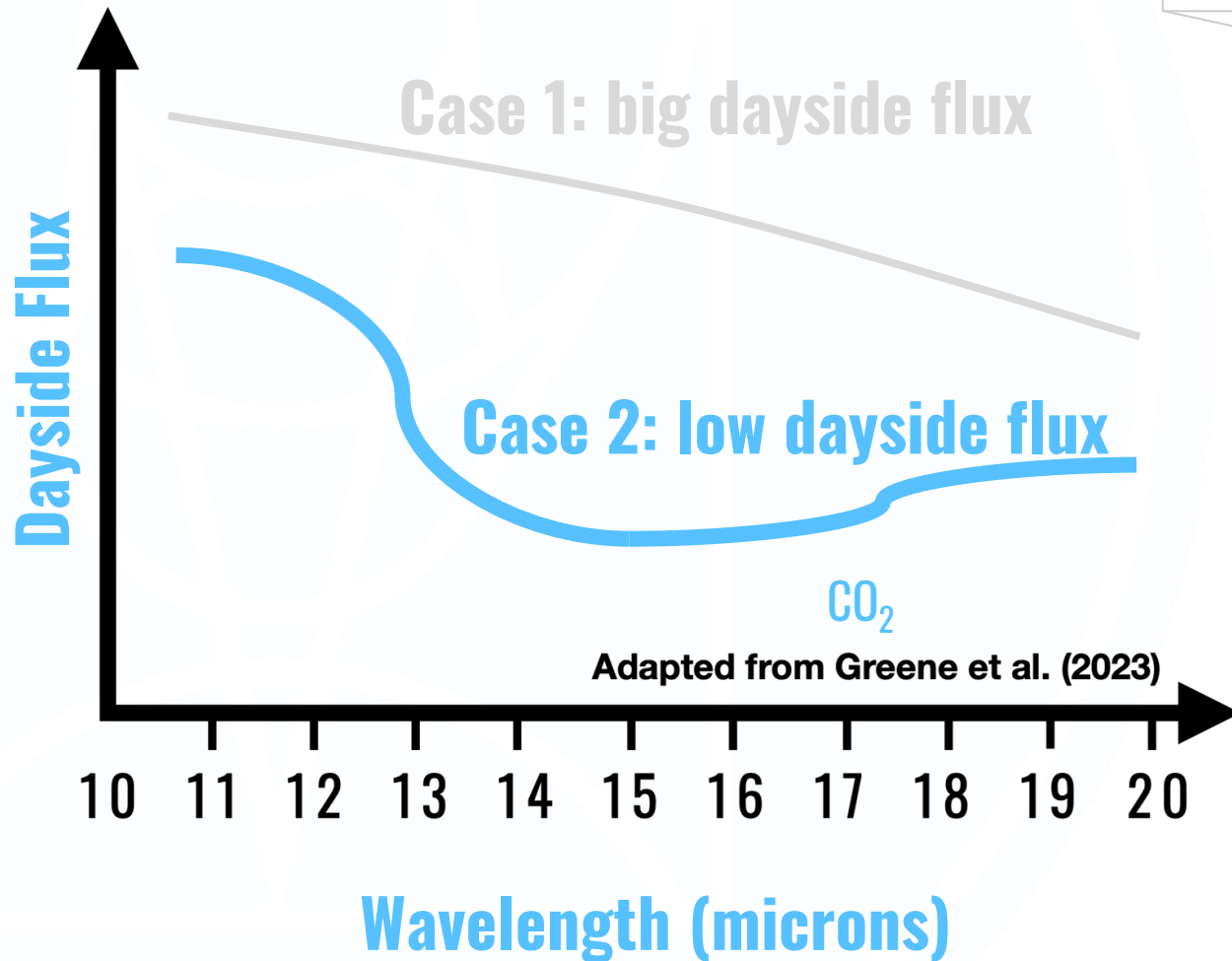
Does the Cosmic Shoreline apply for
EXOPLANETS?

Would the Cosmic Shoreline change for
OTHER STARS?

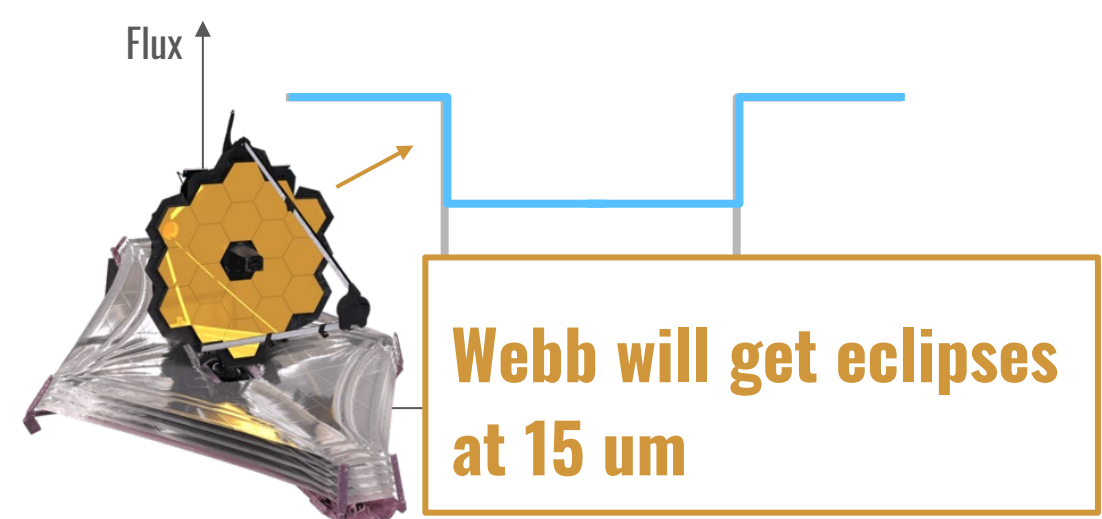
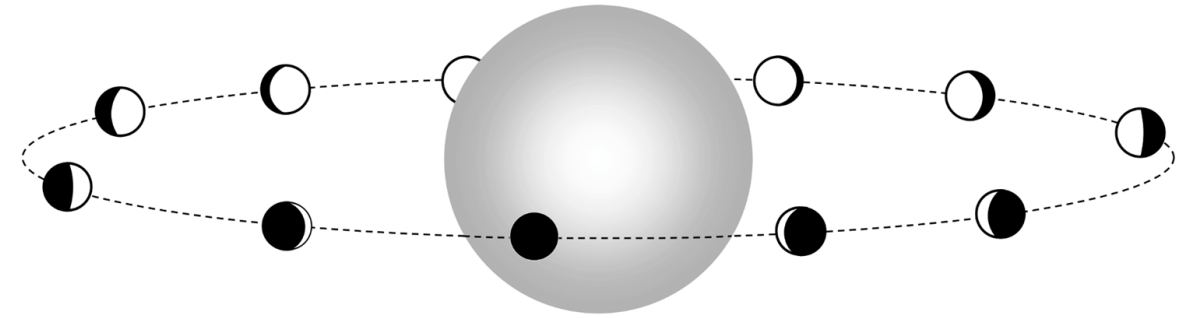
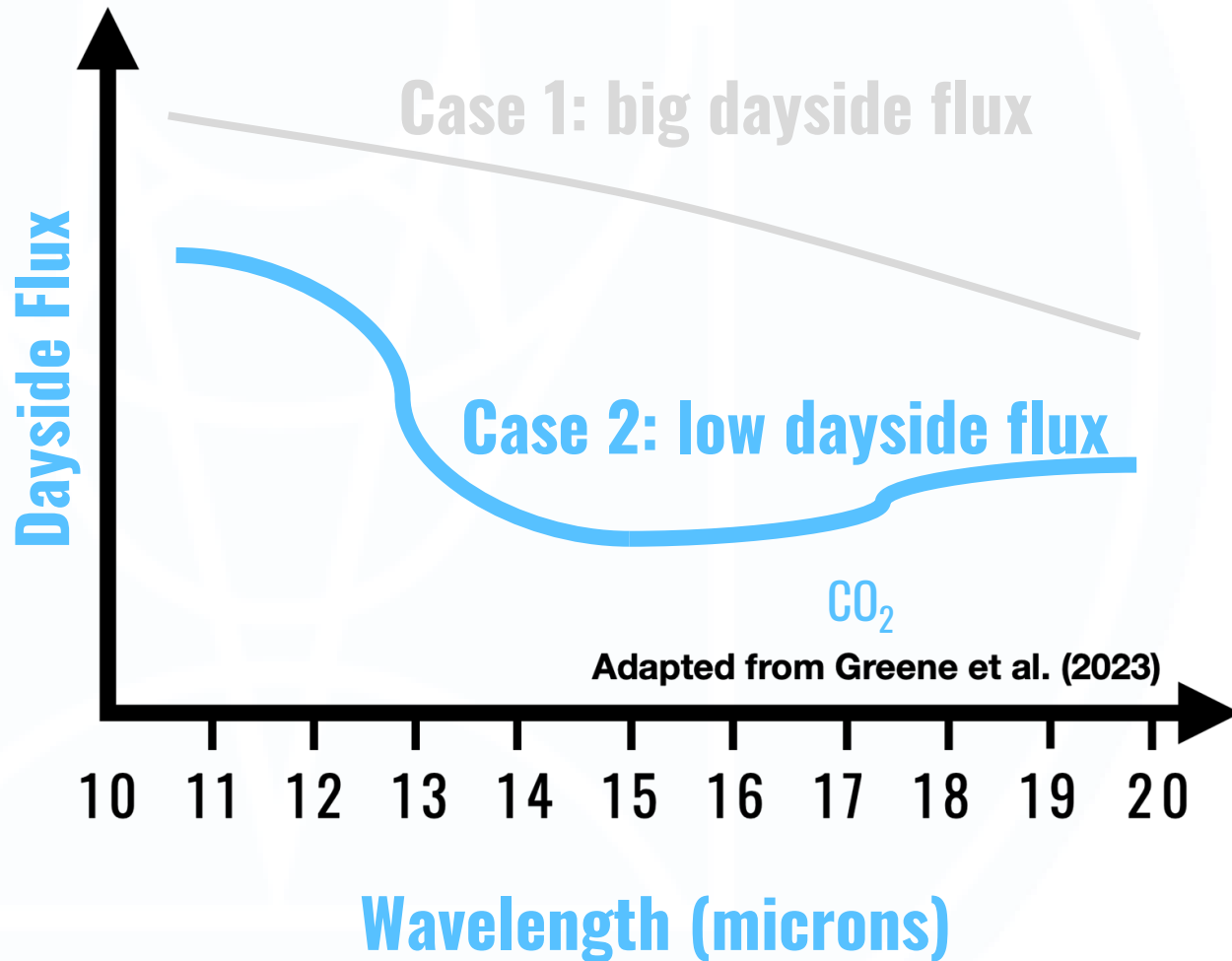
Secondary eclipses



Secondary eclipses

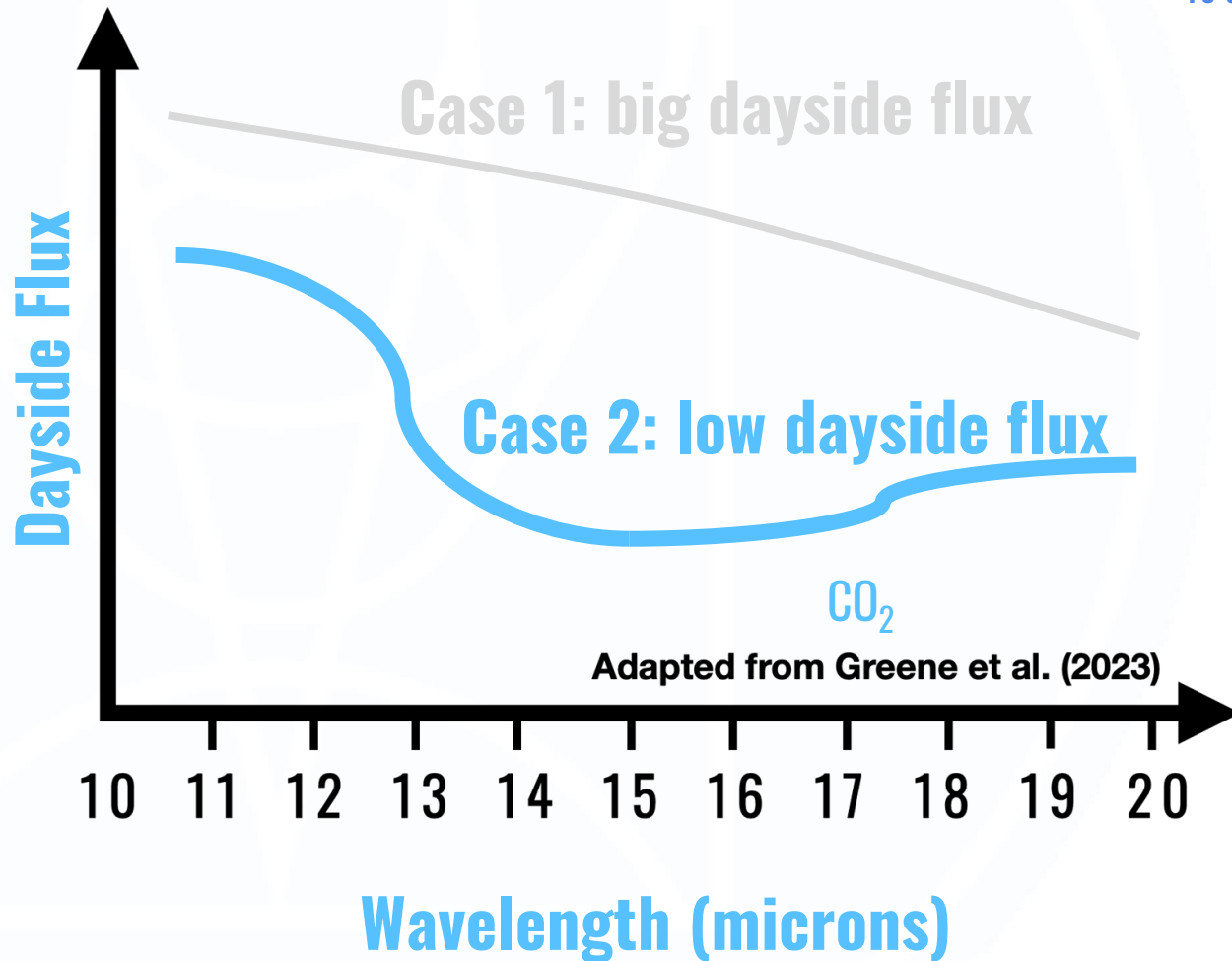


Secondary eclipses



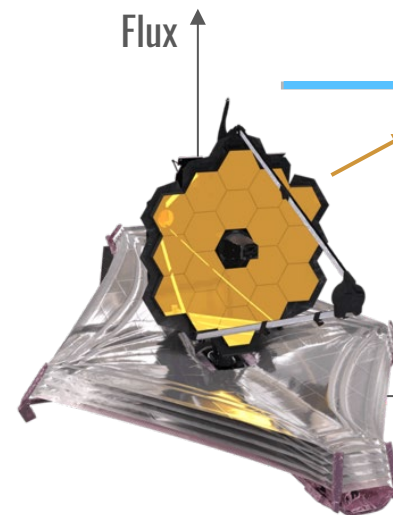
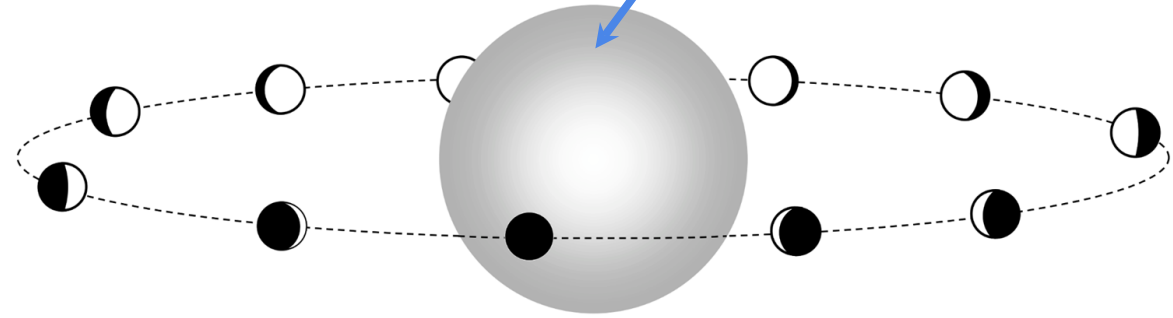
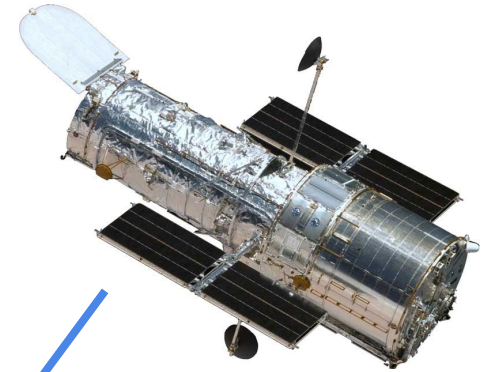
To answer: is it an atmosphere/rock?

Secondary eclipses



Hubble will get stellar UV irradiation

To answer: *why* is it an atmosphere/rock?



Webb will get eclipses at 15 um

To answer: is it an atmosphere/rock?

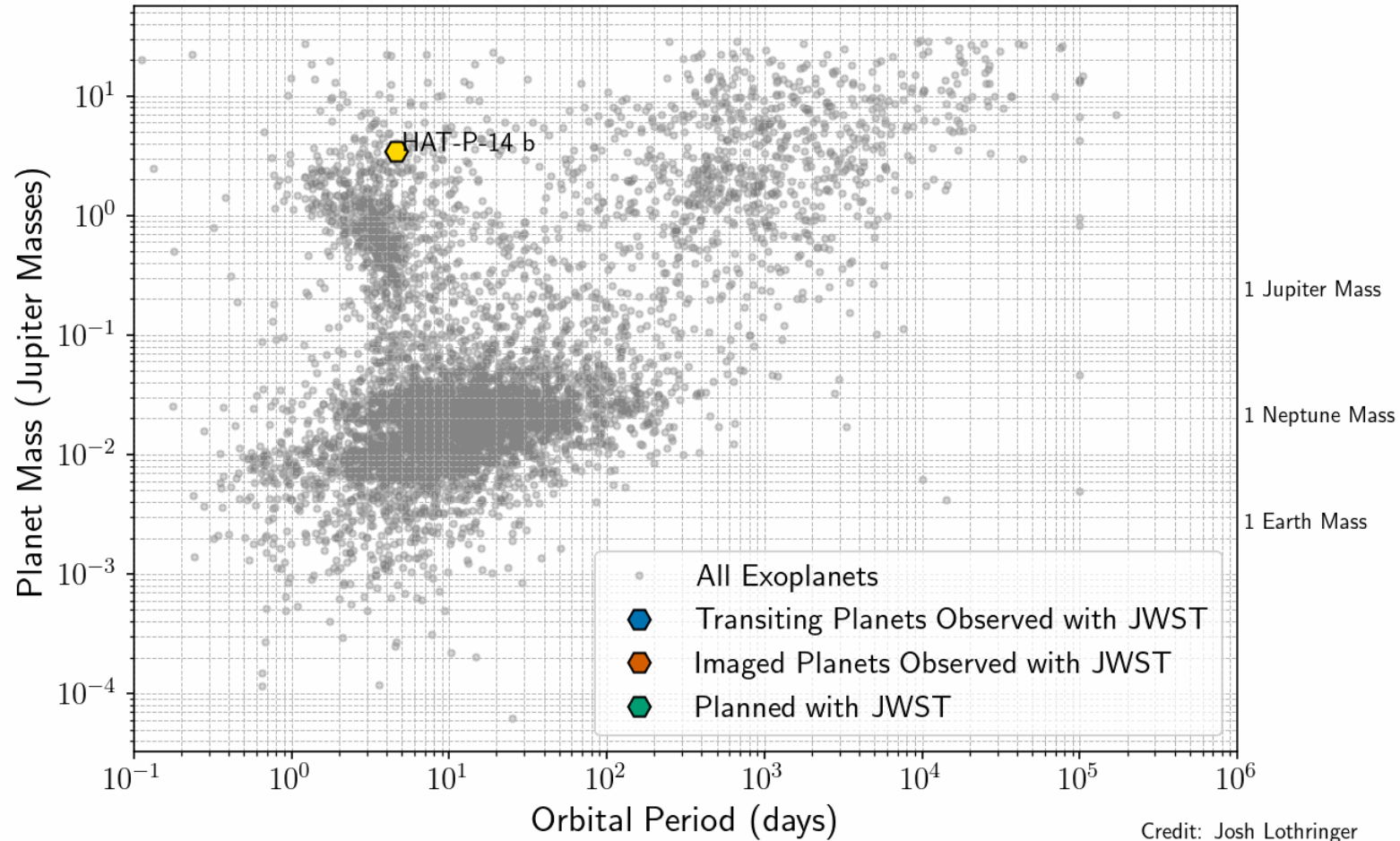
NASA's newest flagship has kicked-off a **Golden Age** for exoplanet science

- JWST's exoplanet program is broad and bustling.
 - Over 4,000 hours of observations of 148+ different planets
- We are placing the Solar System in its cosmic context, while revealing the diversity of worlds that defy comparison to our own.

Dr. Joshua D. Lothringer
Jlothringer@stsci.edu
Jlothringer.github.io

JWST Exoplanet Observations

2022-05-02 05:46:15



Extra

Statistics

Total hours observed

4282.0

Planets observed

148

Additional planets planned

28

Hours on transiting exoplanets

3599

Hours on directly imaged exoplanets

683

Hours on the TRAPPIST-1 system

376

Rocky planets observed (incl. planned)

44

999.2 hours of observation

Neptune-like planets observed (incl. planned)

44

865.7 hours of observation

Gas giant planets observed (incl. planned)

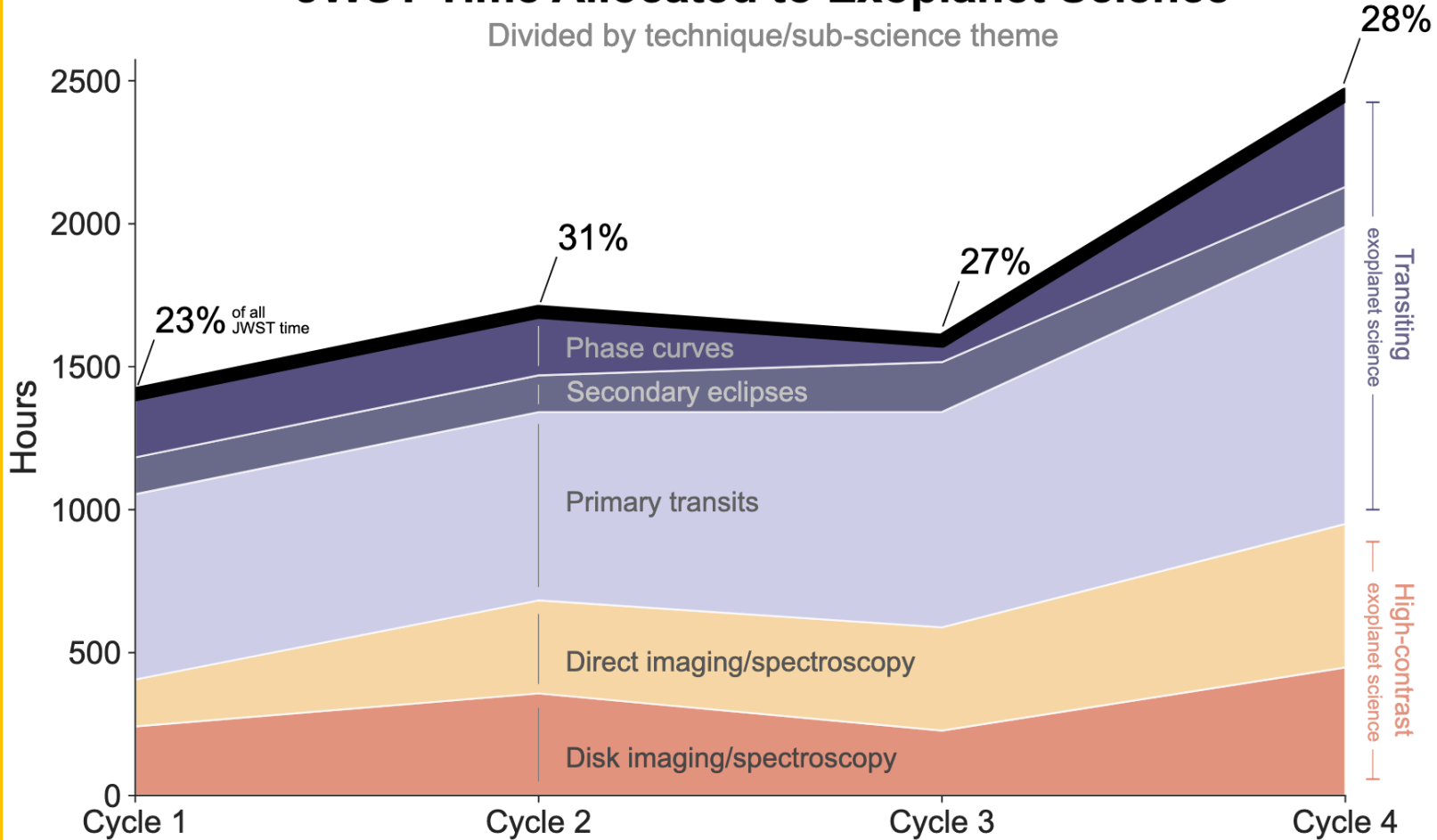
81

1663.2 hours of observation

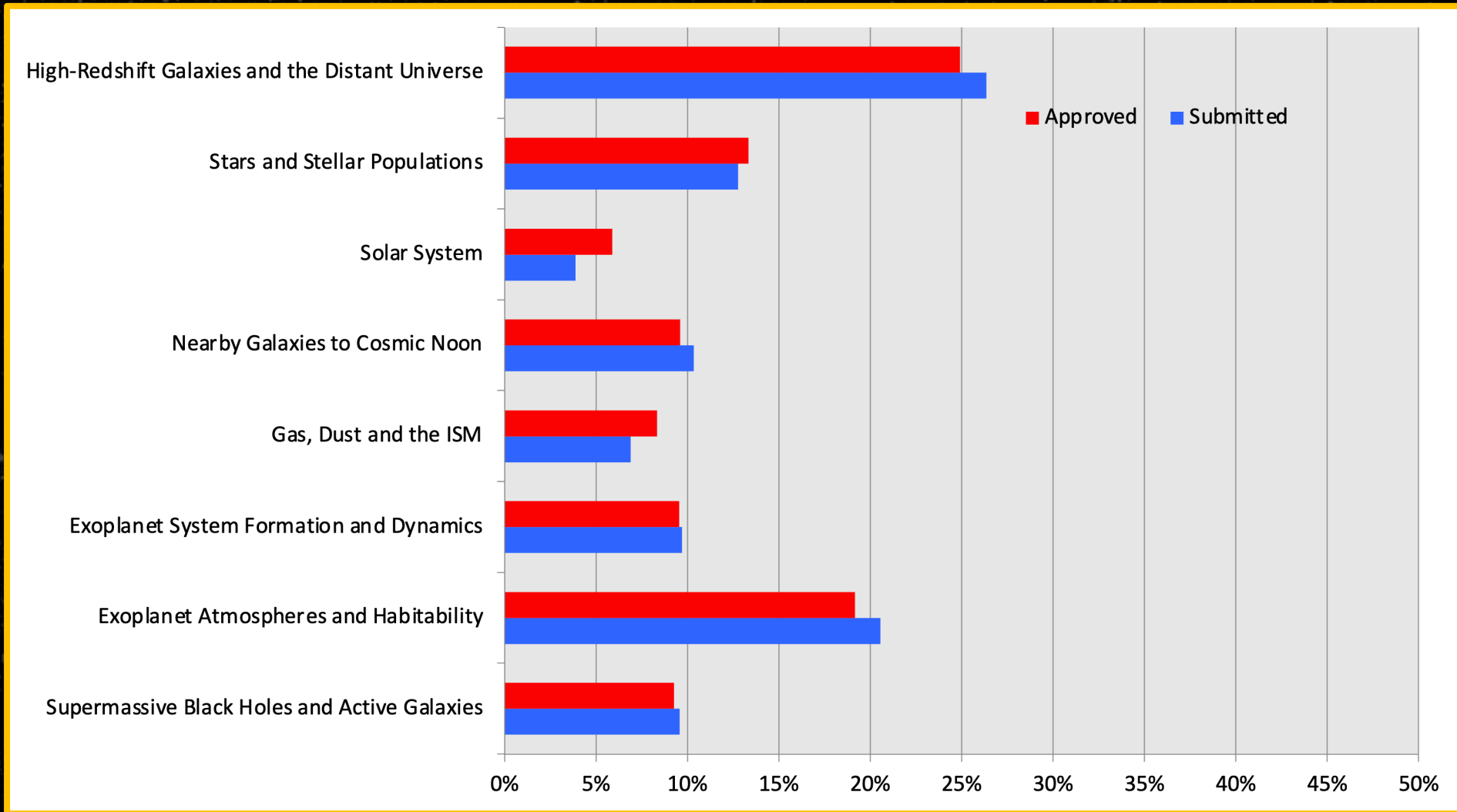
<https://jlothringer.github.io/Dashboard.html>

JWST Time Allocated to Exoplanet Science

Divided by technique/sub-science theme



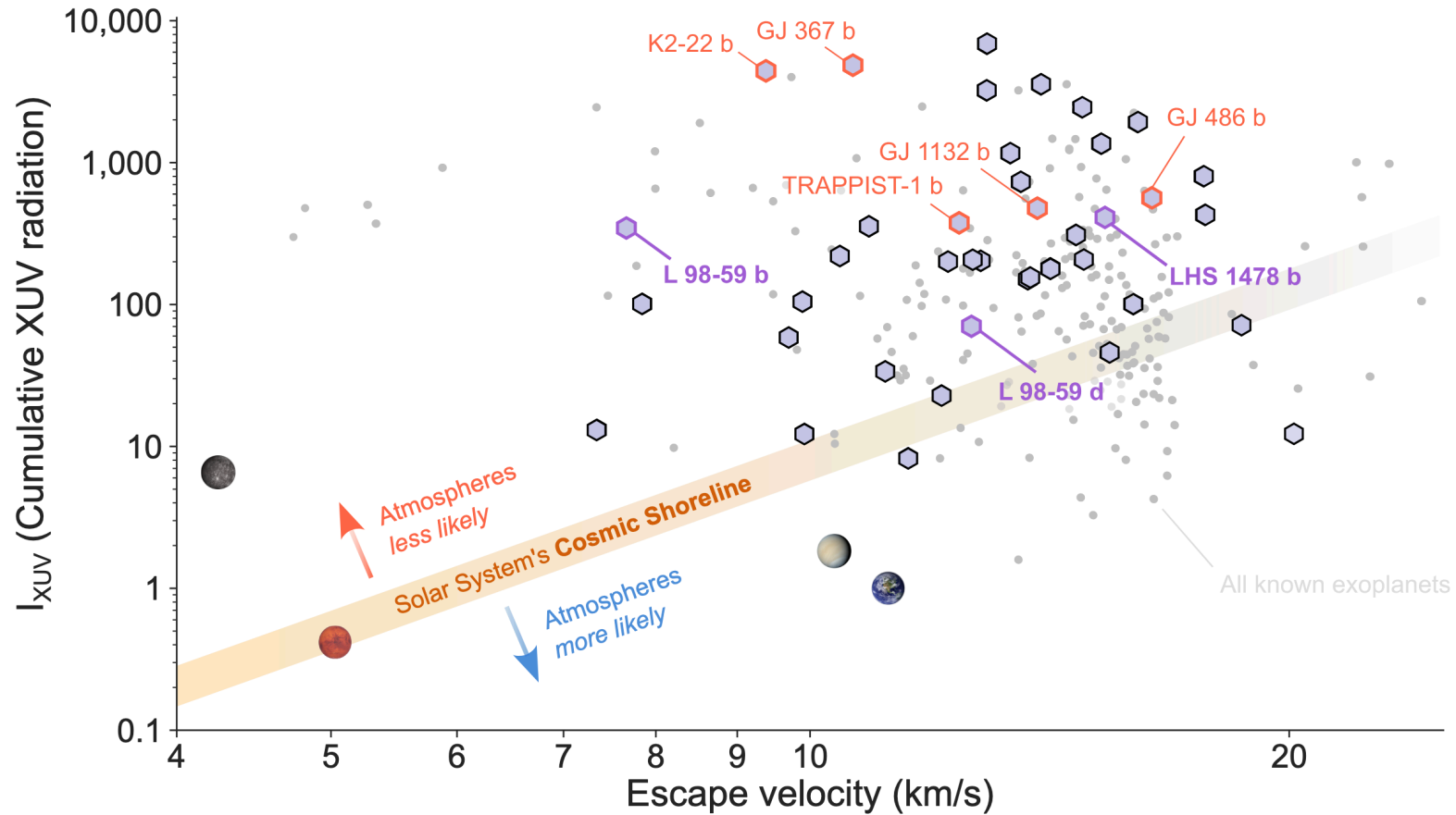
JWST Cycle 4 TAC Results



Hours per science category

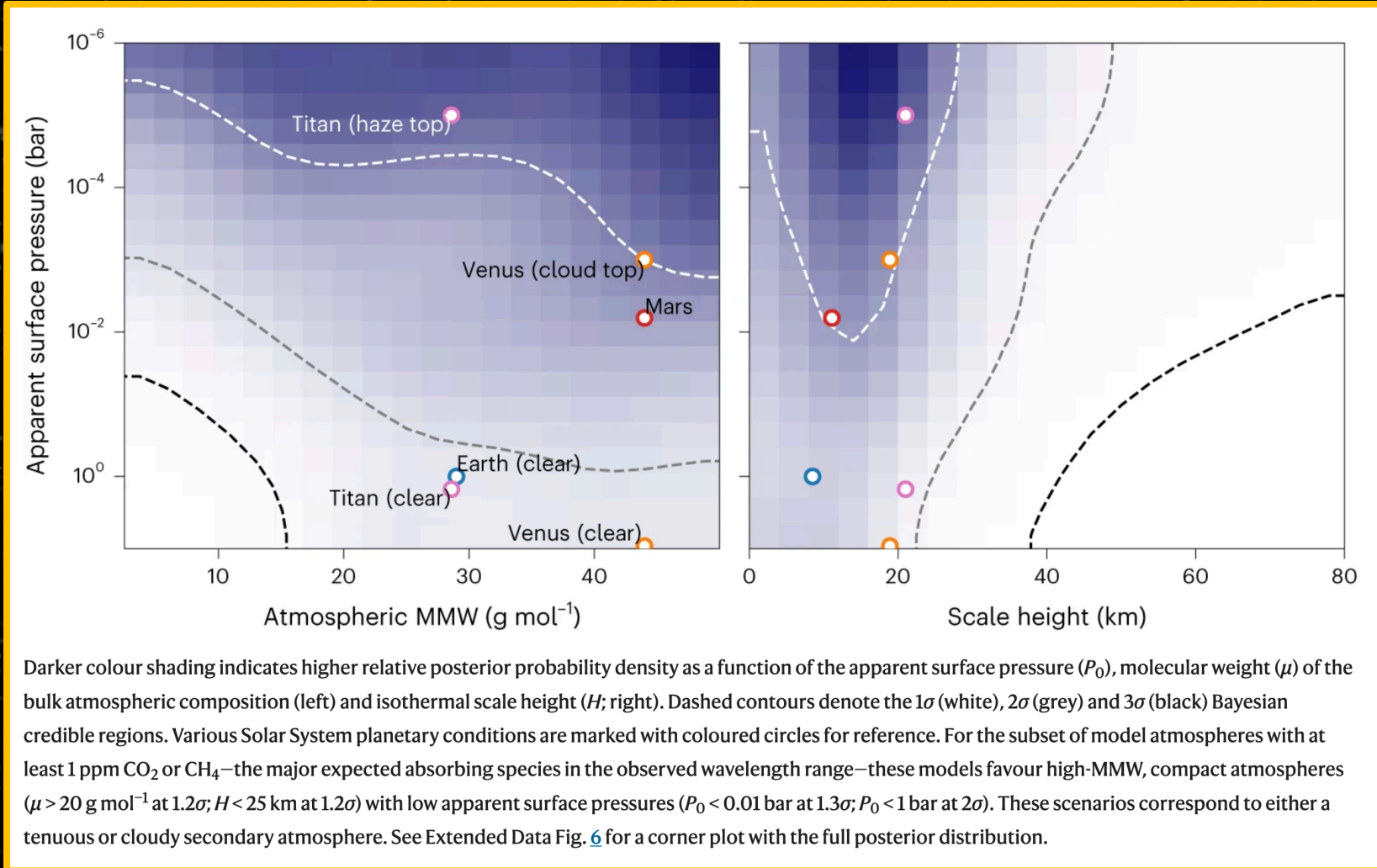
JWST Exploration of Rocky exoplanets orbiting M-dwarfs

As of March, 2025



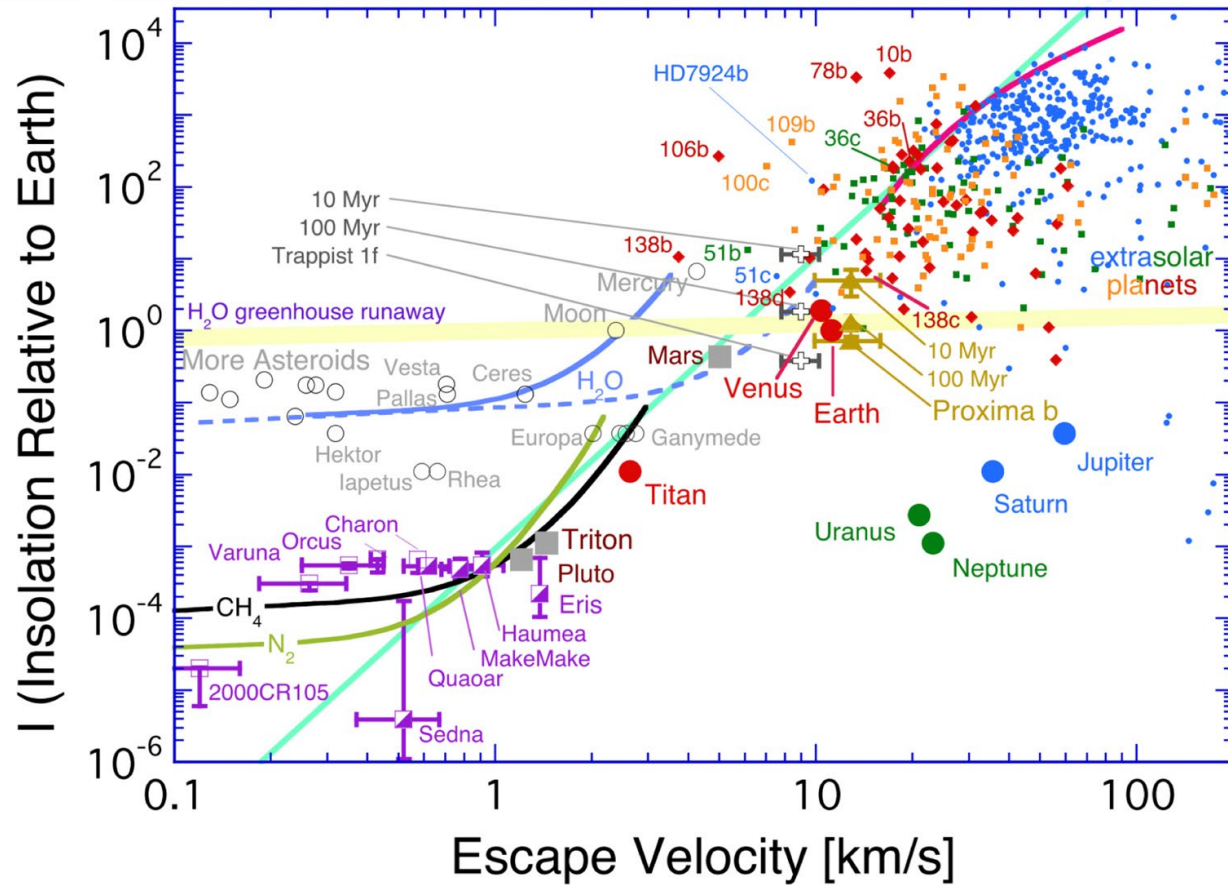
Espinoza & Perrin
2025

LHS 475 b, a warm (586 K), 0.99 Earth-radius exoplanet



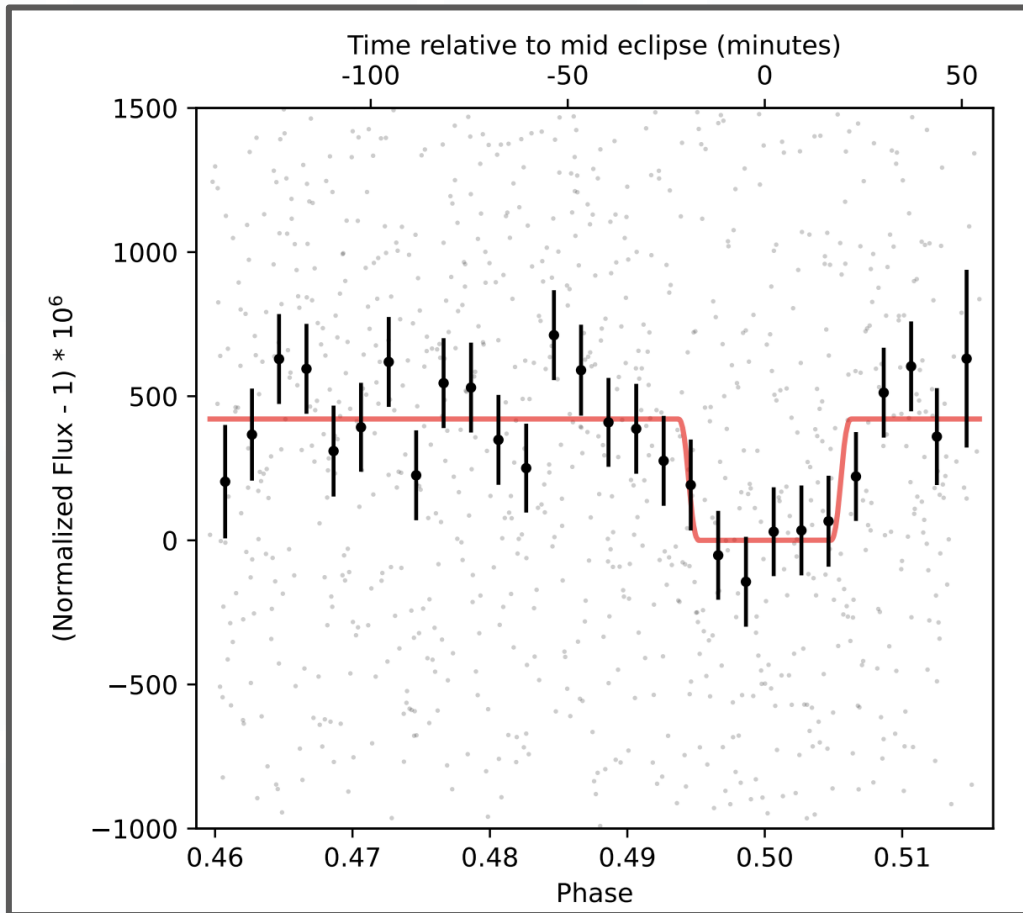
The Cosmic Shoreline Concept

Zahnle & Catling (2017)



Expected data products

Examples of expected data products for JWST



- **We expect to release lightcurves from each 15-um observation.** This will include time-series photometry, models and a small report.
- **We also expect to report eclipse depths and absolute fluxes from the star.** Those will be released per observation as well.