Direct Imaging and Spectroscopy with JWST

Image Credit: Olena Shmahalo, Quanta Magazine

Aarynn L. Carter

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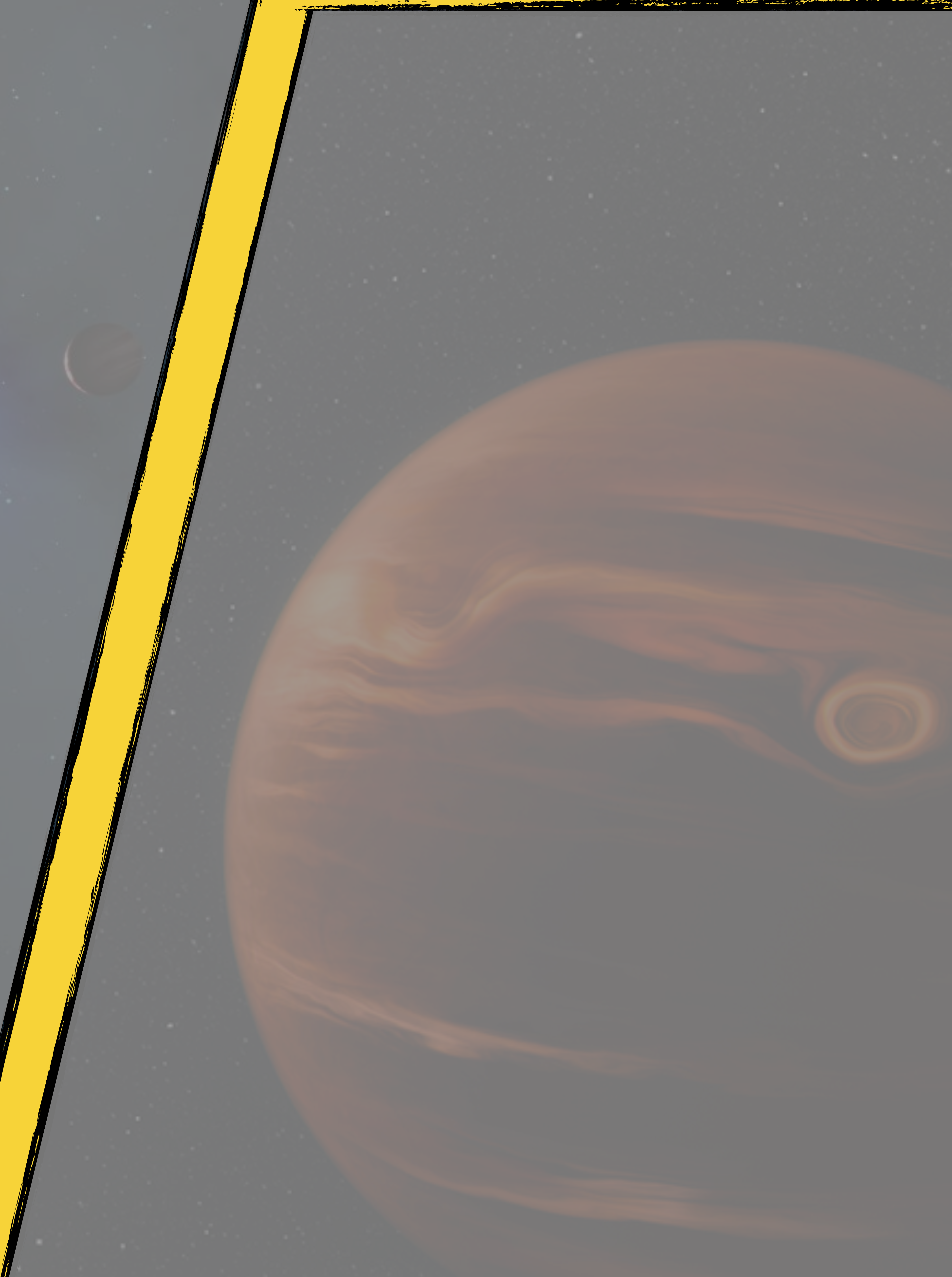
Introduction

Imaging

Spectroscopy



Direct Imaging and Spectroscopy of Exoplanets

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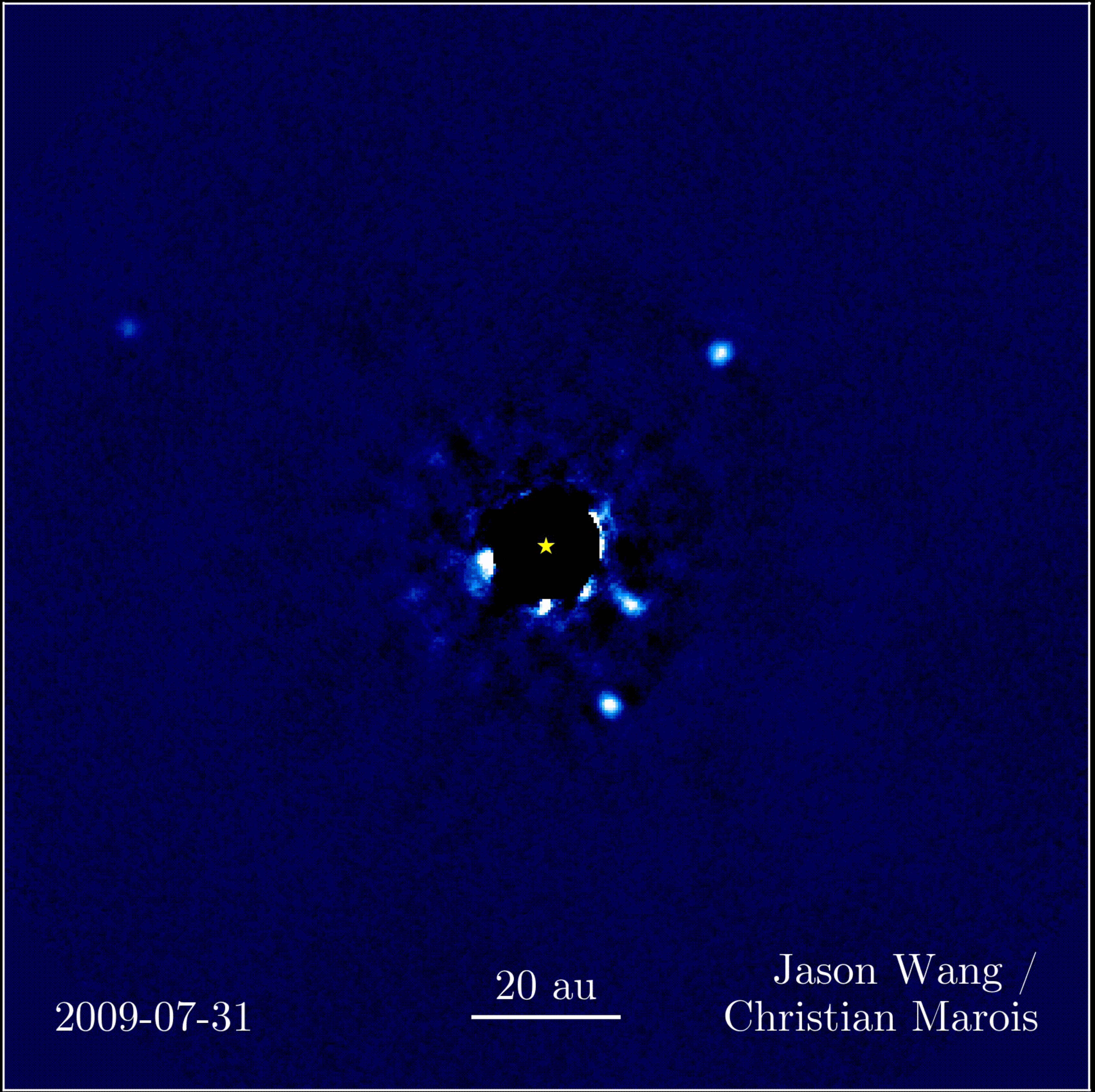

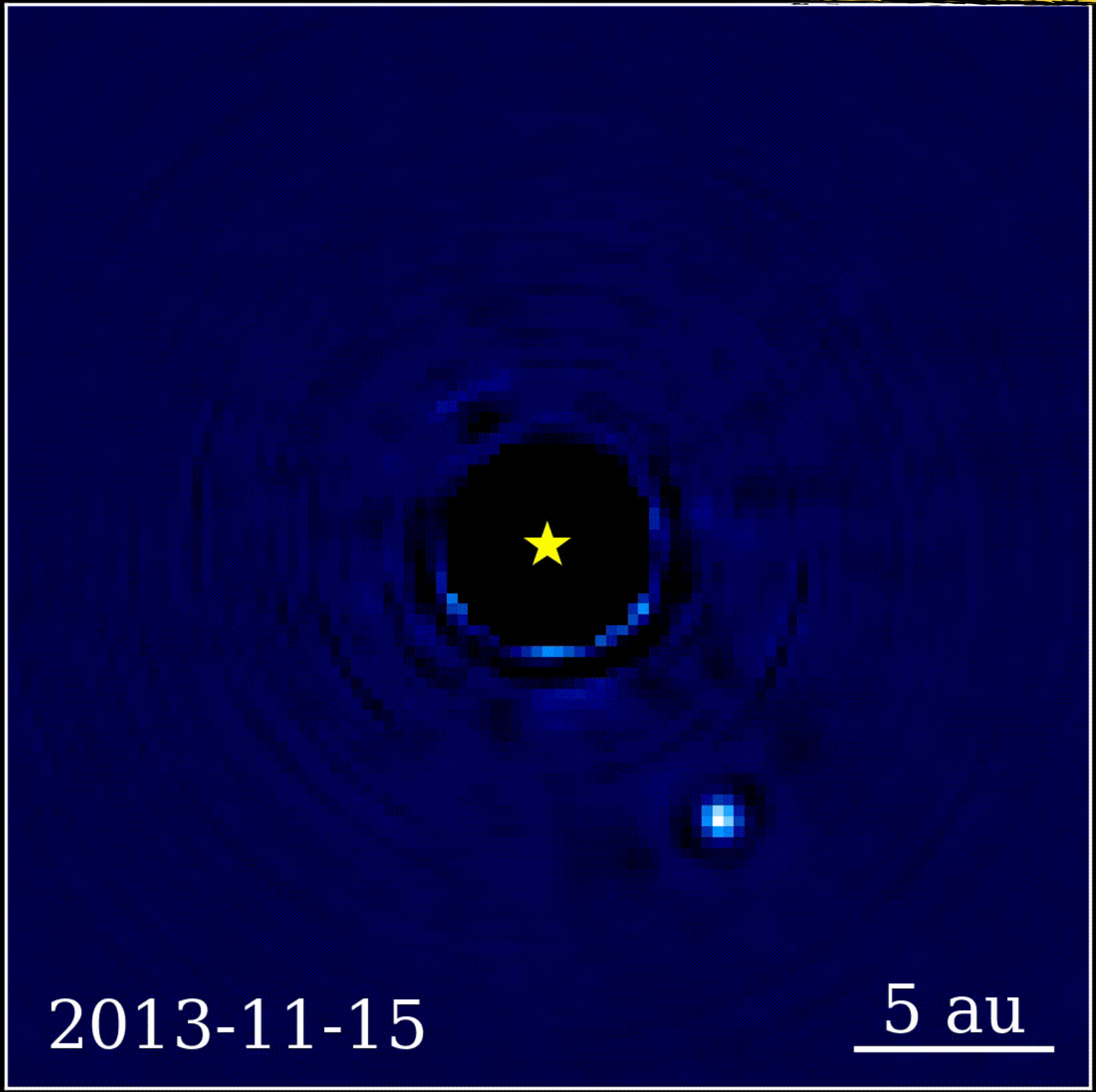

The Exoplanet Population

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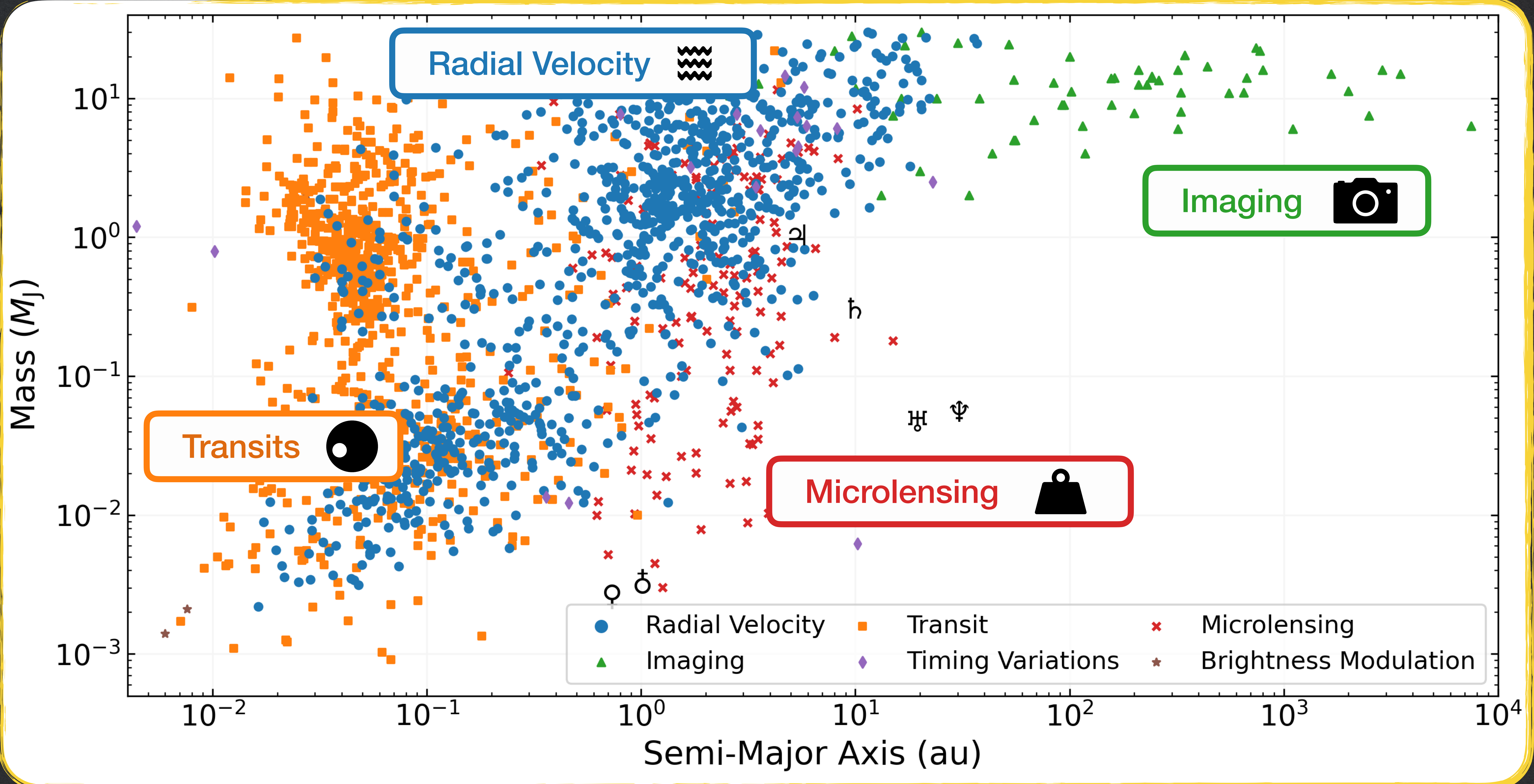

The Transit and Direct Imaging Populations

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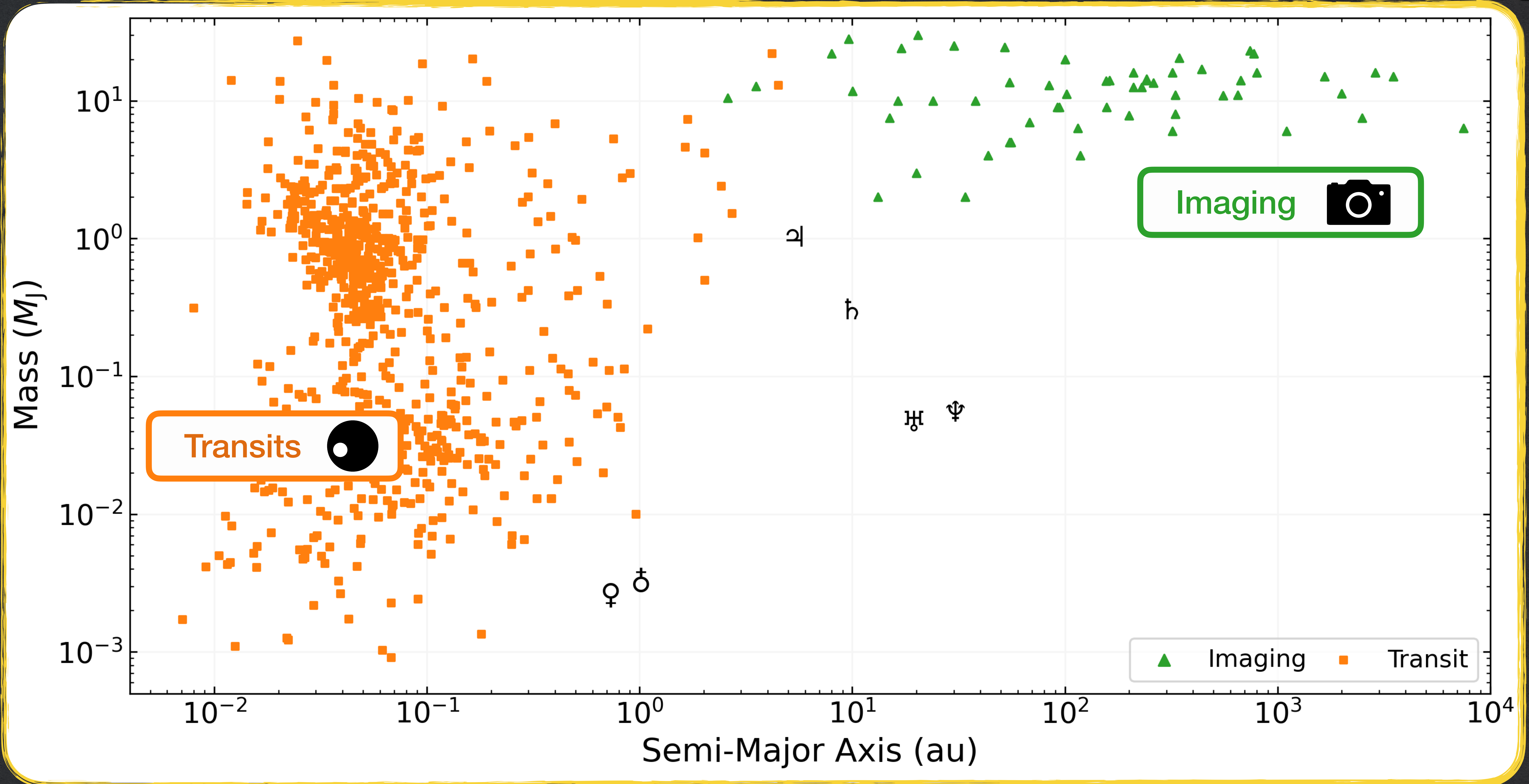

The New Opportunity of JWST

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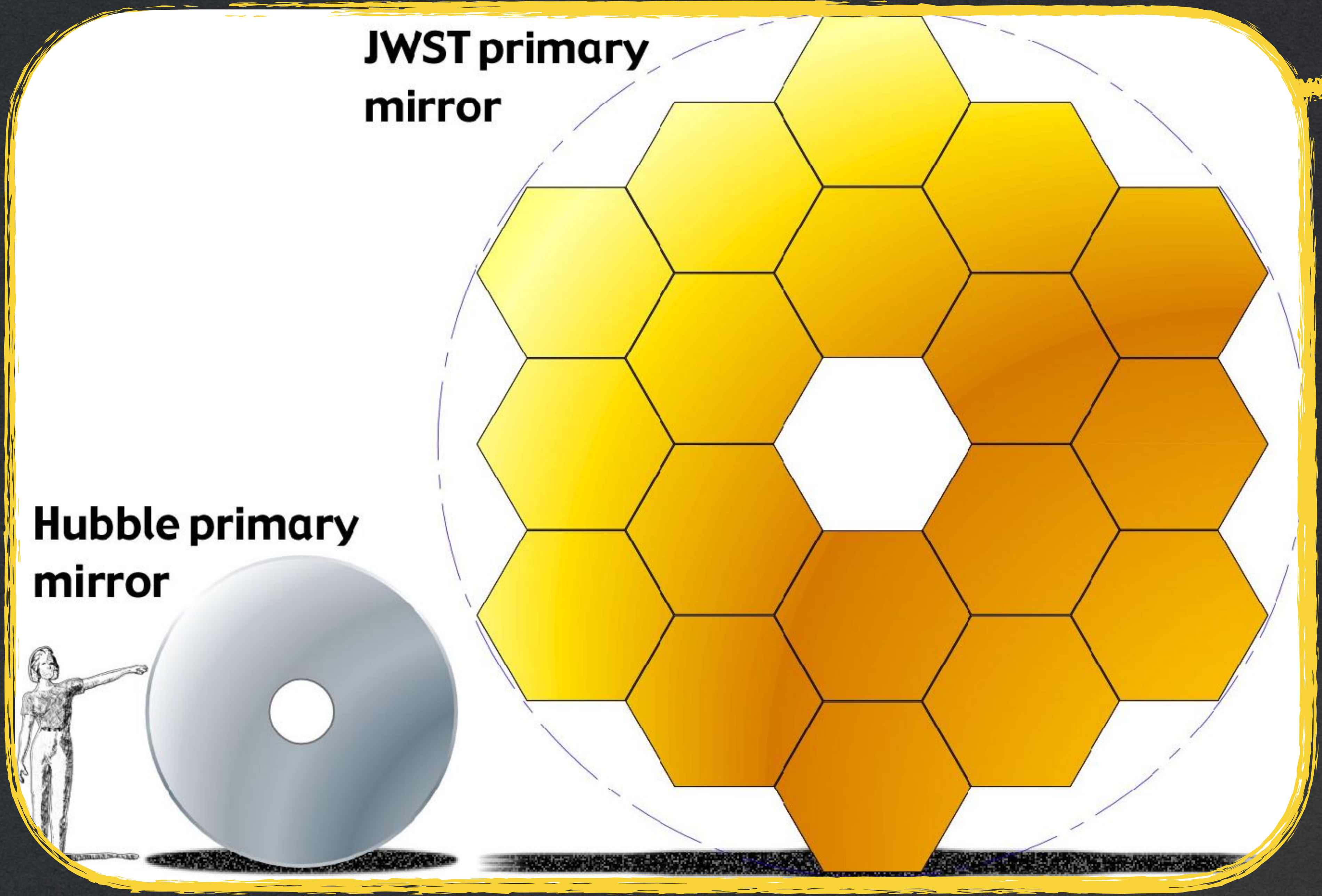

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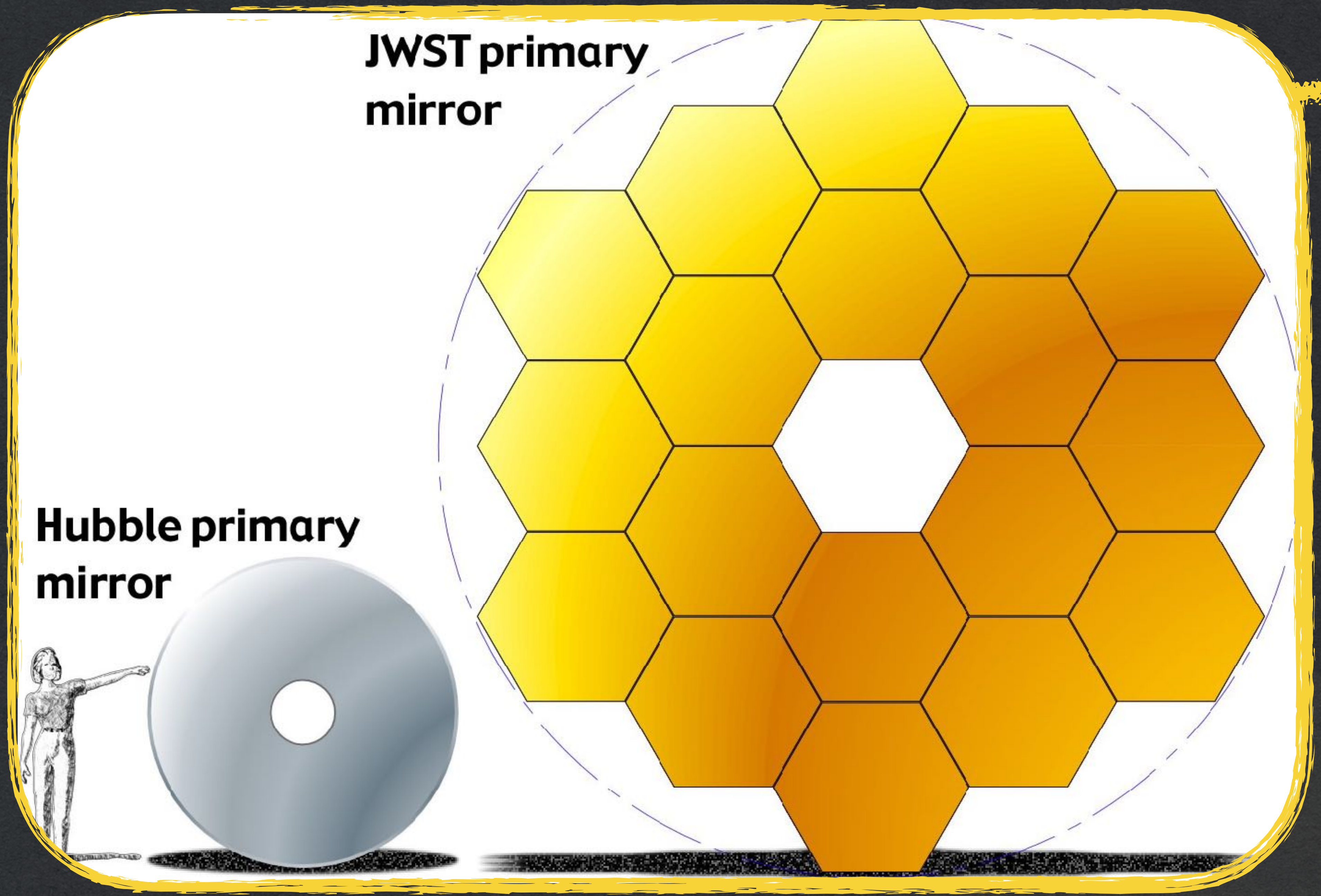

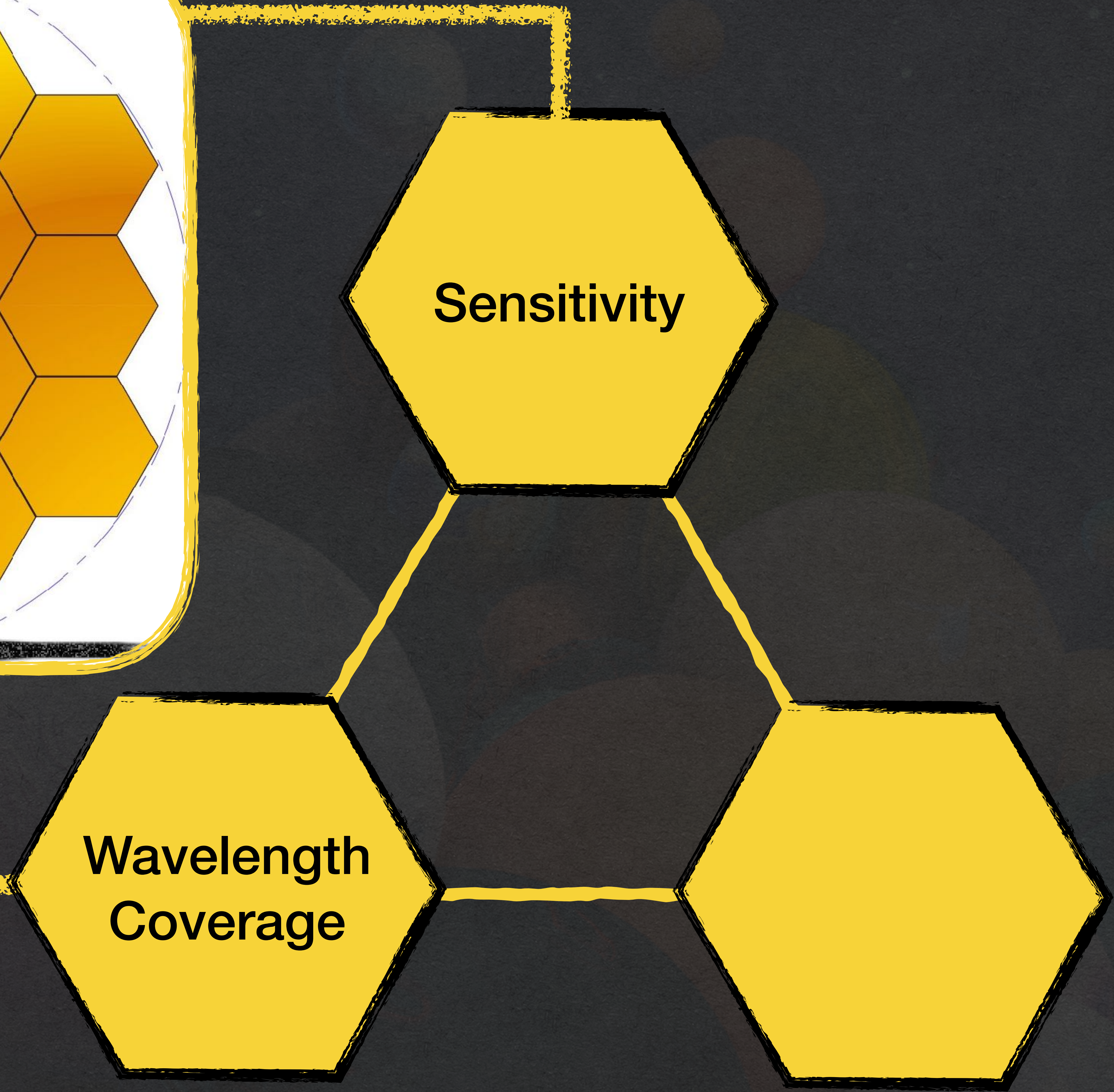

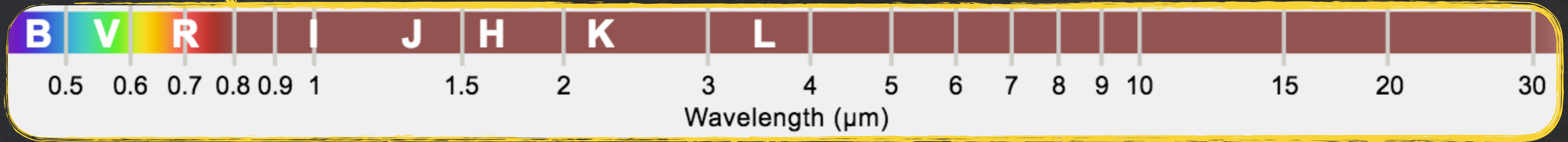

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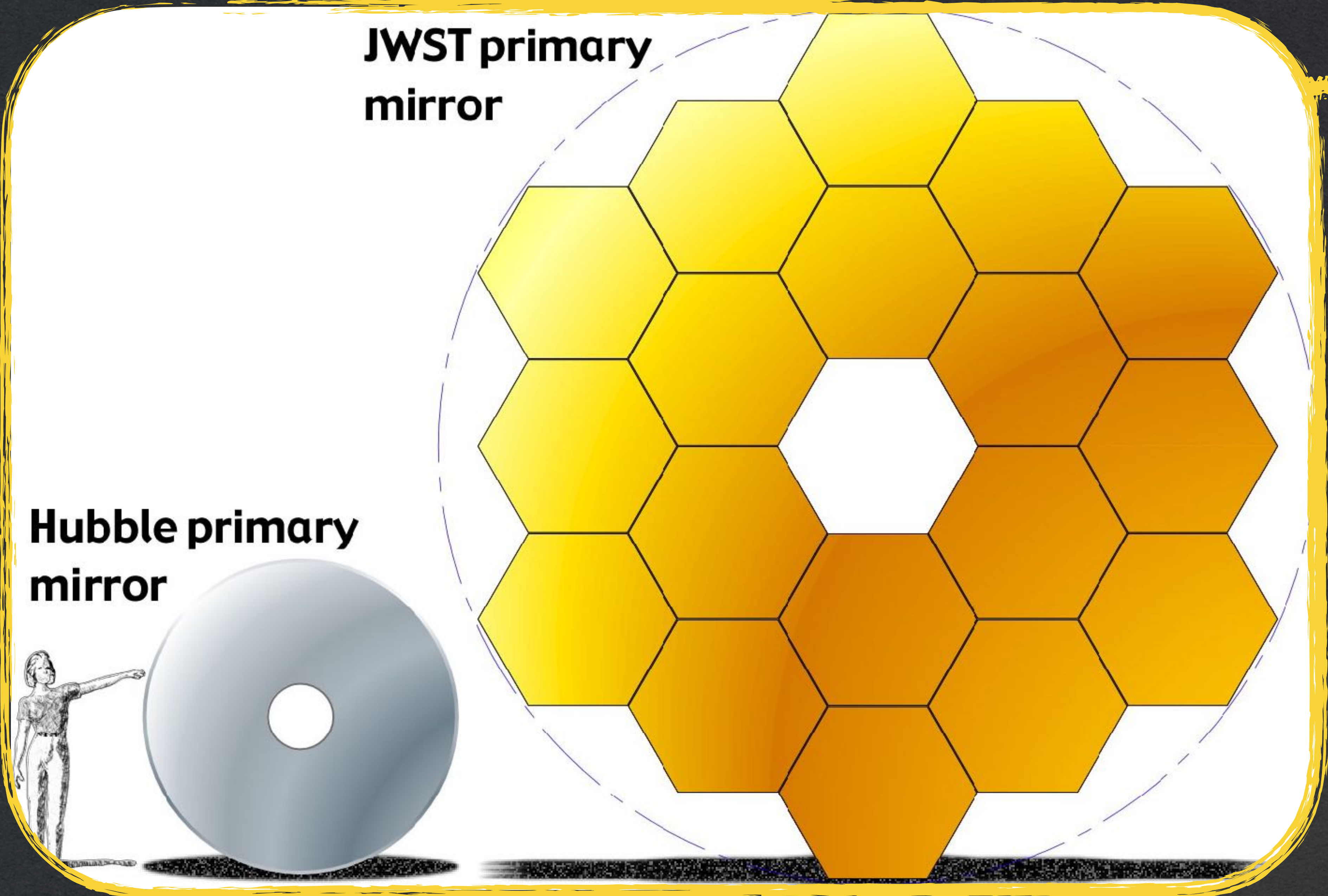
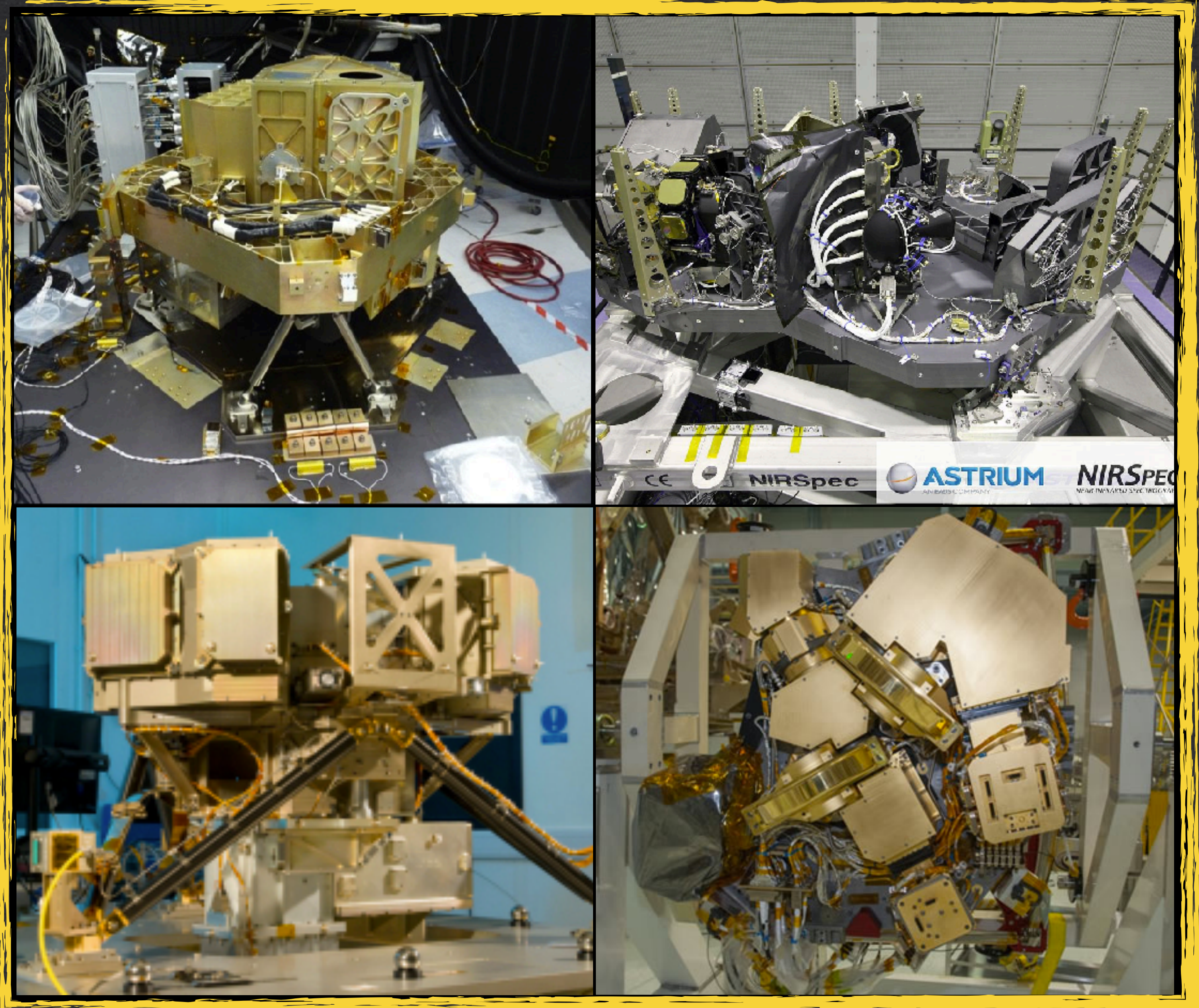
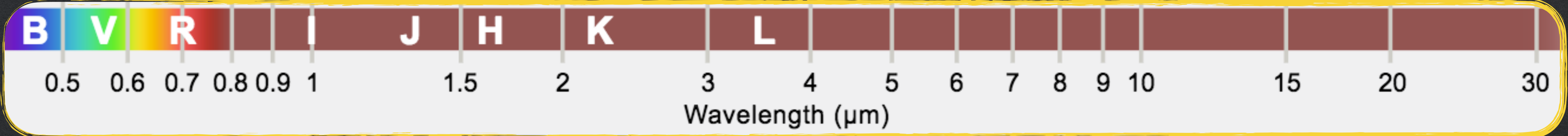


Sensitivity

Wavelength Coverage

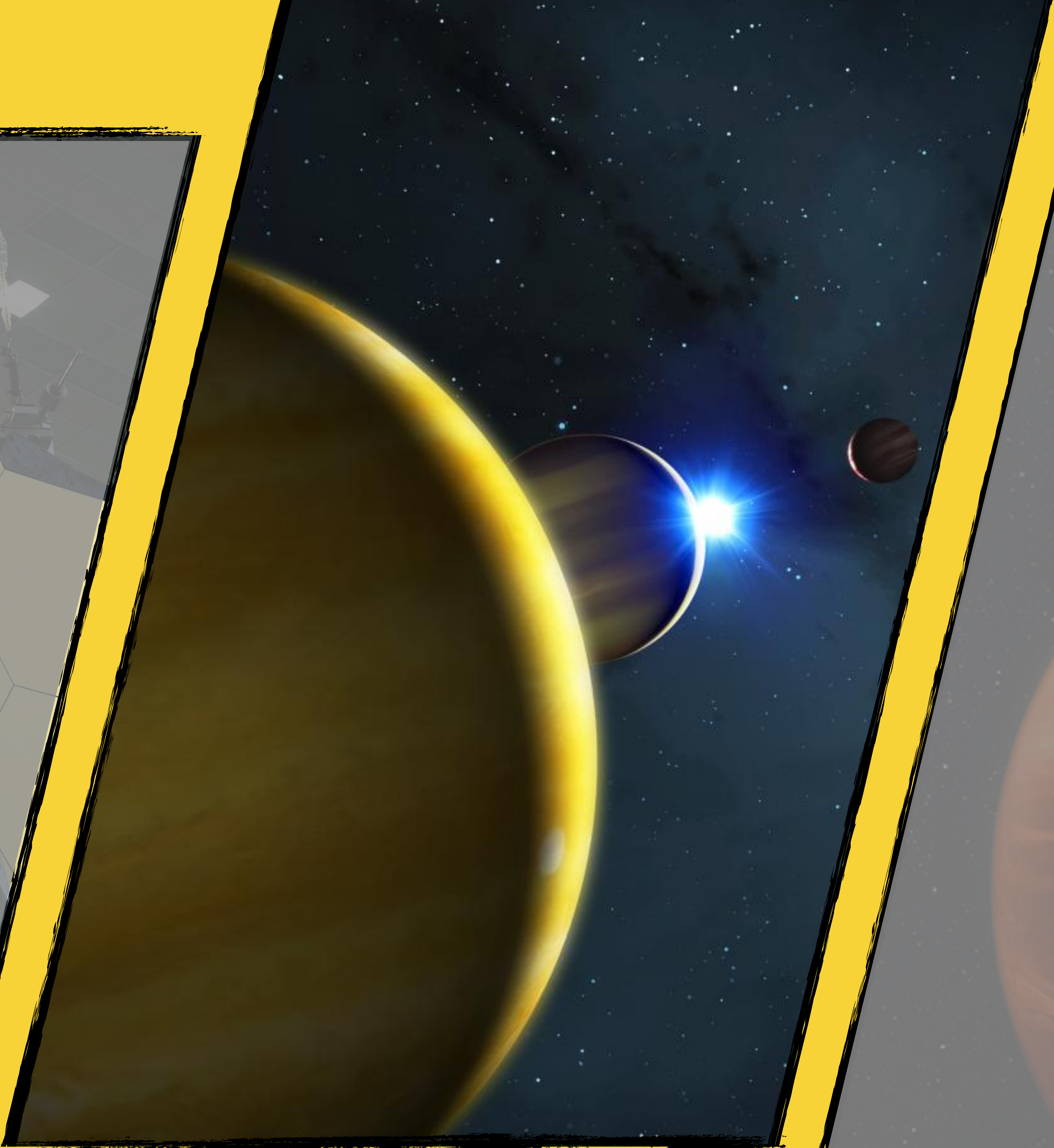
Versatility





Introduction

Imaging



Spectroscopy

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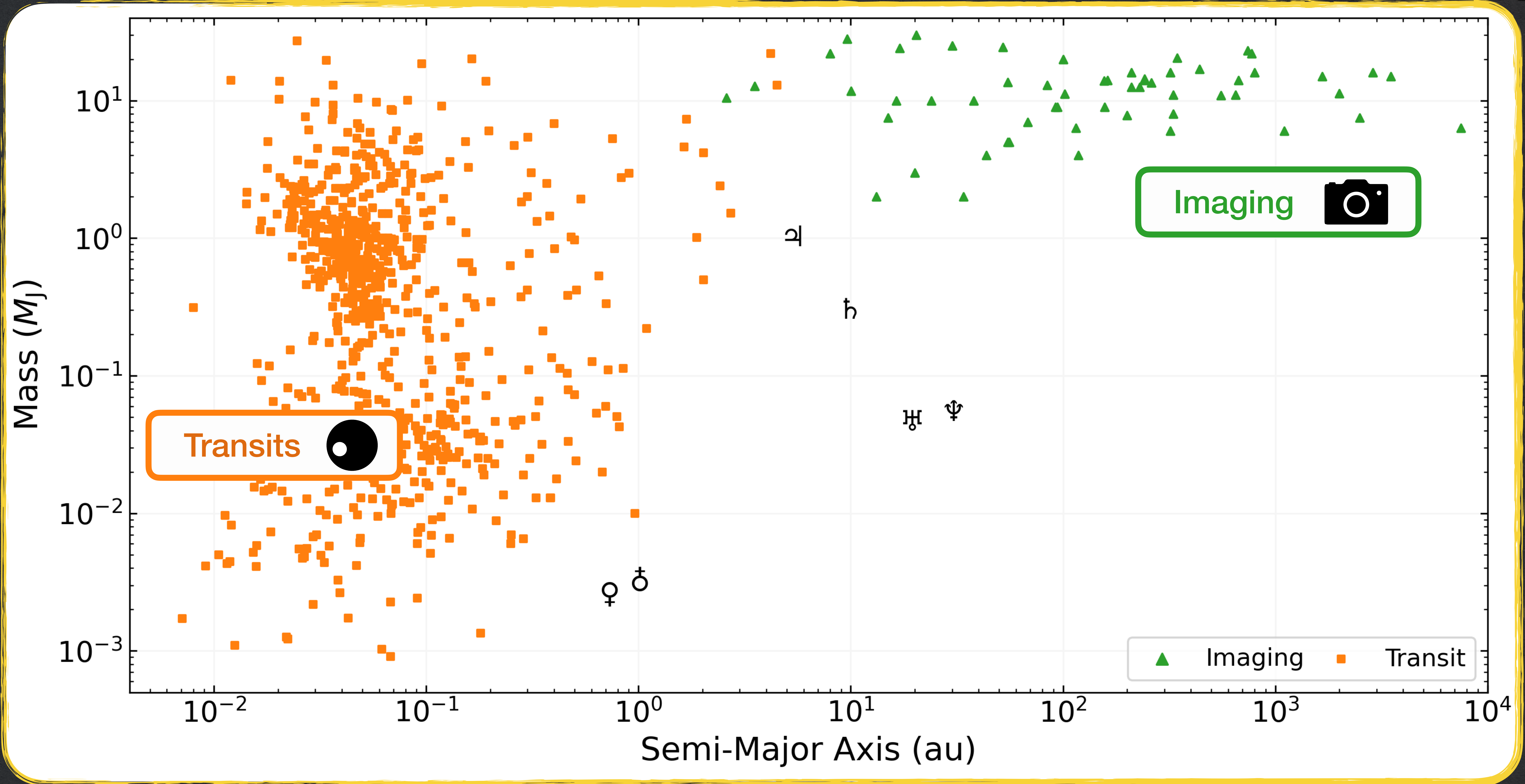

Imaging Exoplanets with Early Release Science

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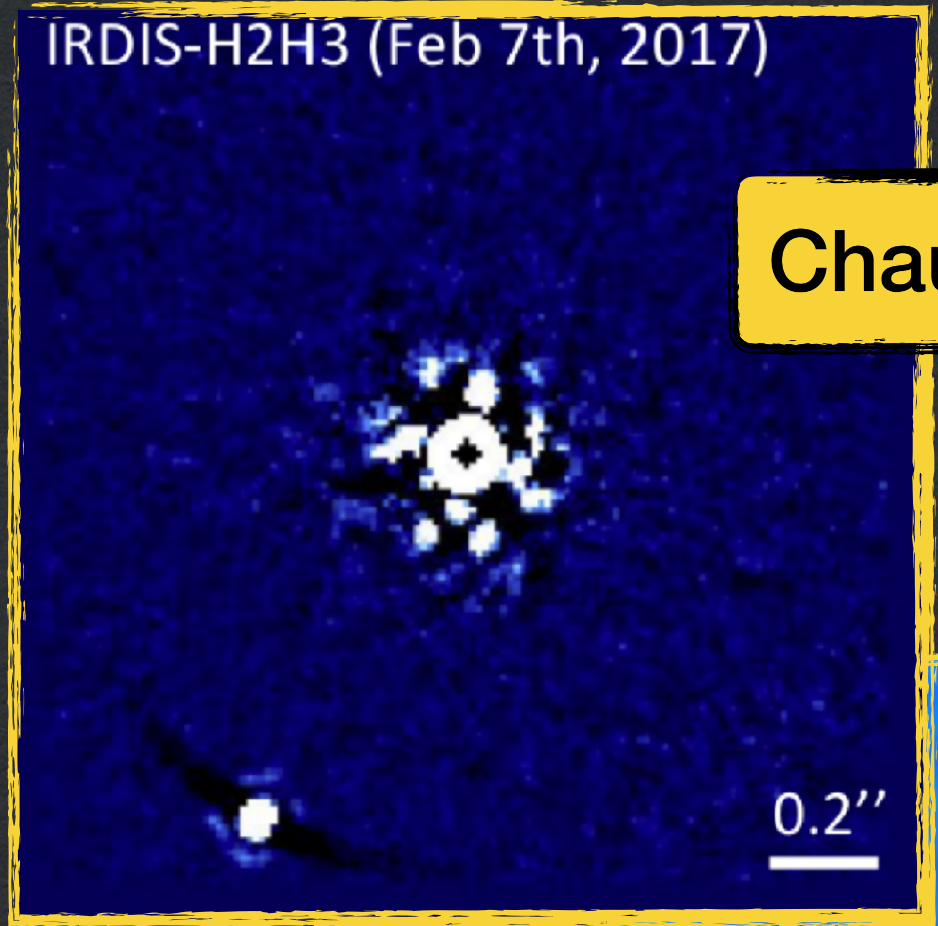
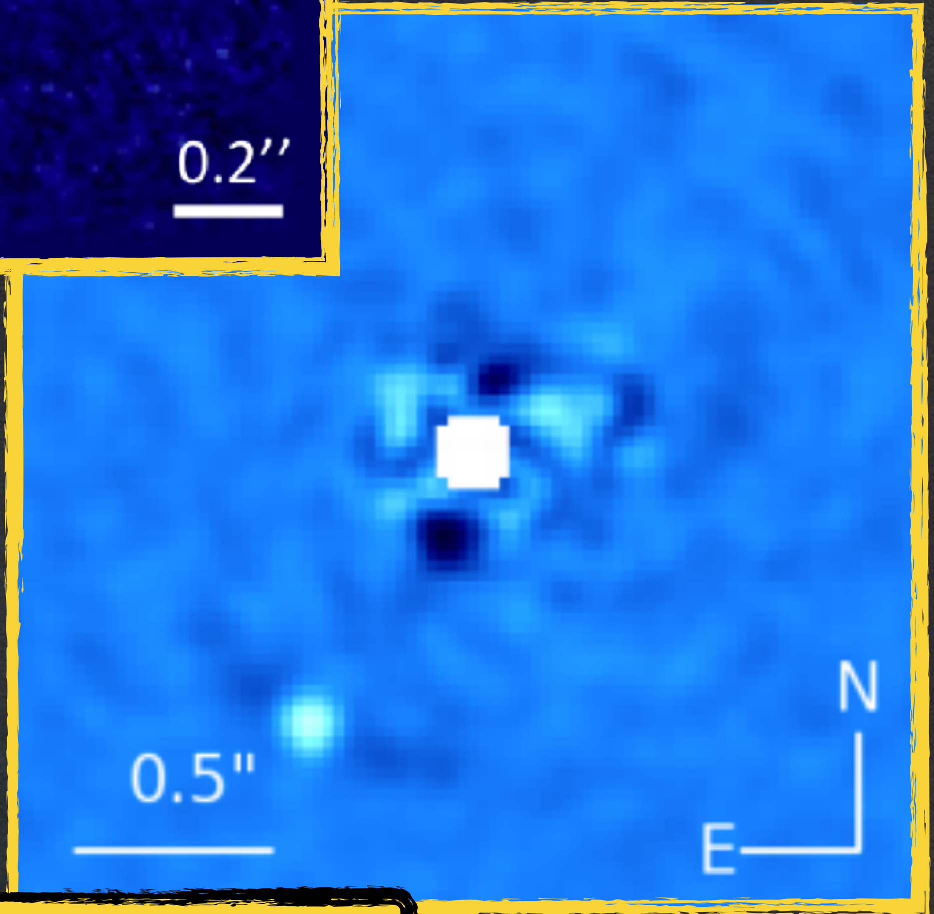
HIP 65426 b

~7-9 M_{Jup}, 1300-1600 K



Chauvin et al. 2017



Cheetham et al. 2019

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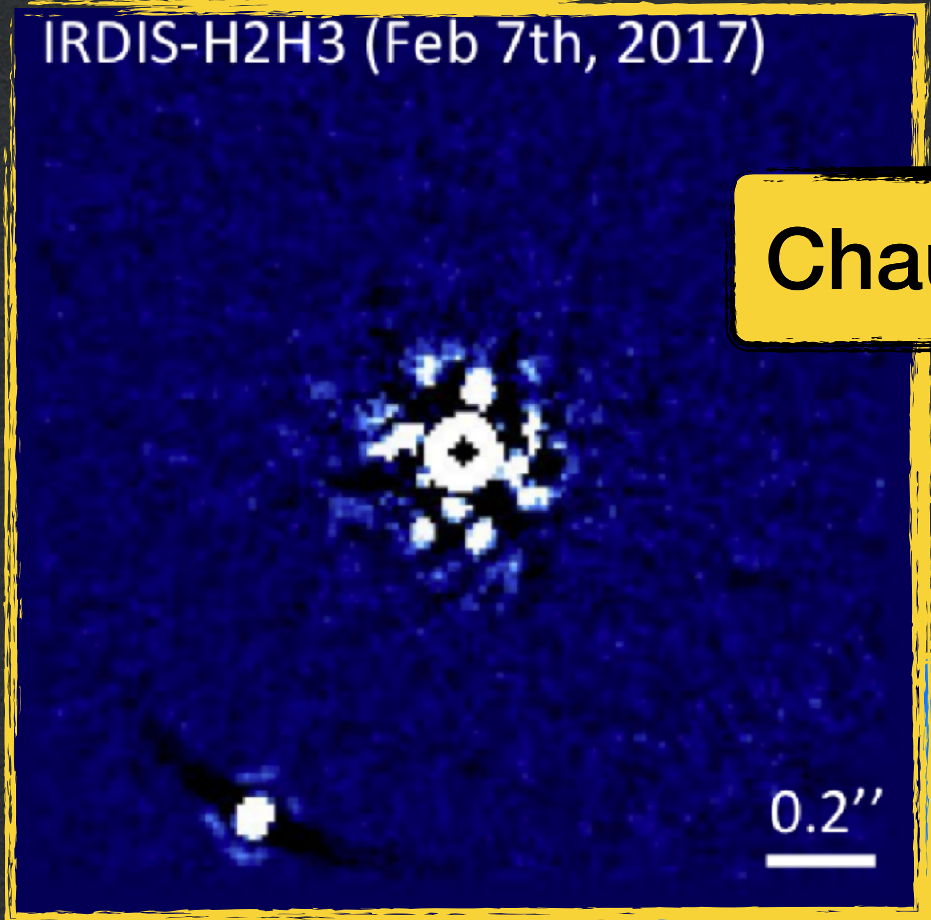
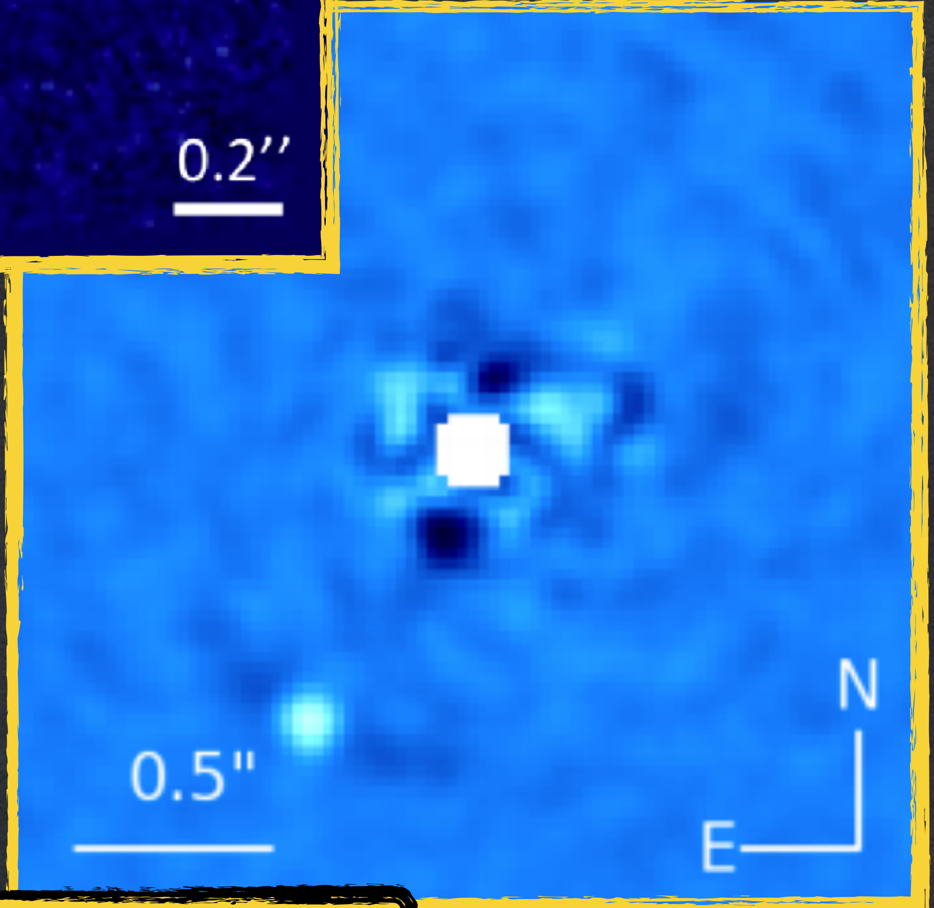
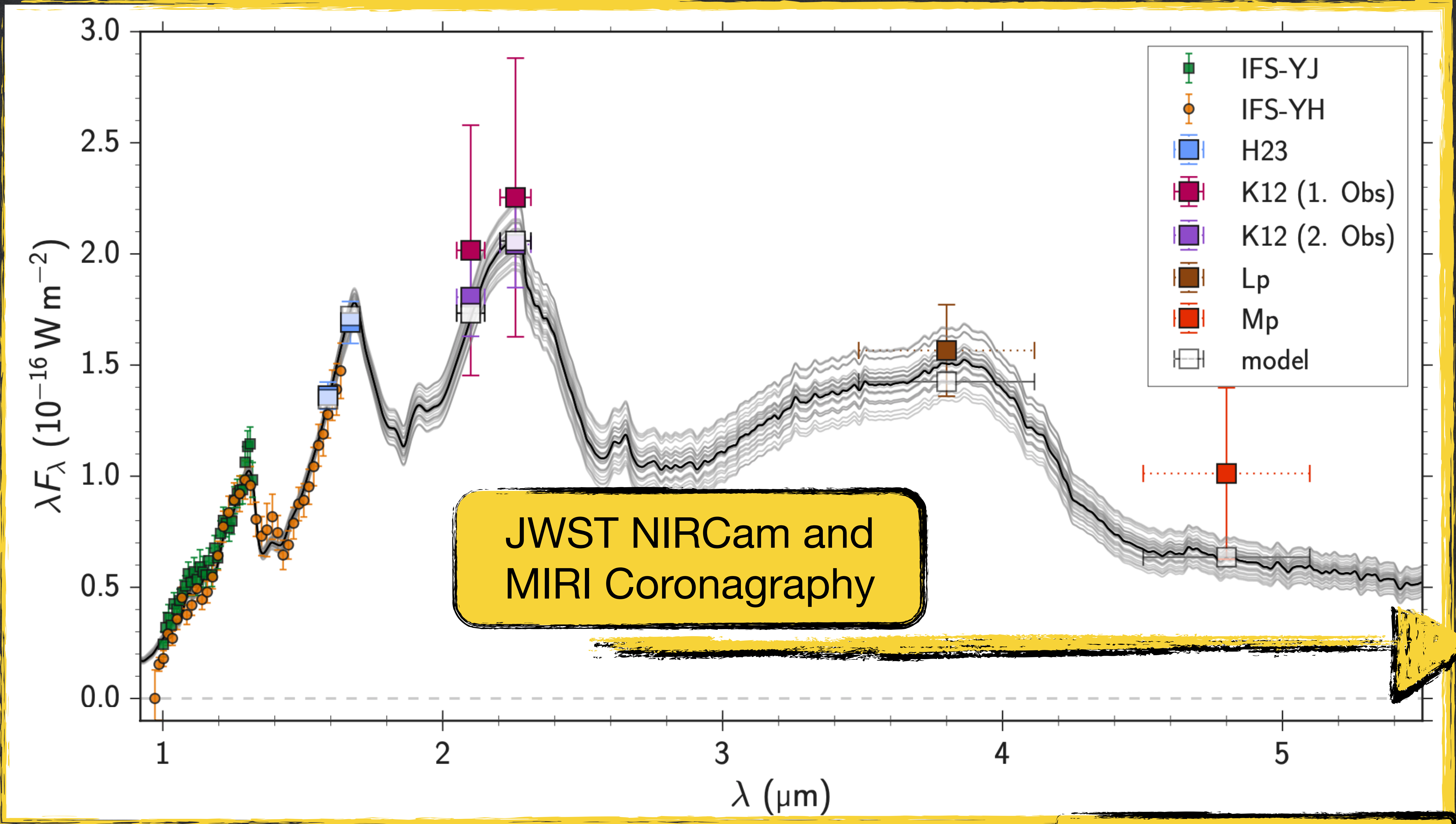


Chauvin et al. 2017



Cheetham et al. 2019



JWST NIRCam and MIRI Coronagraphy

Cheetham et al. 2019

Residual Stellar Light Contaminates Images

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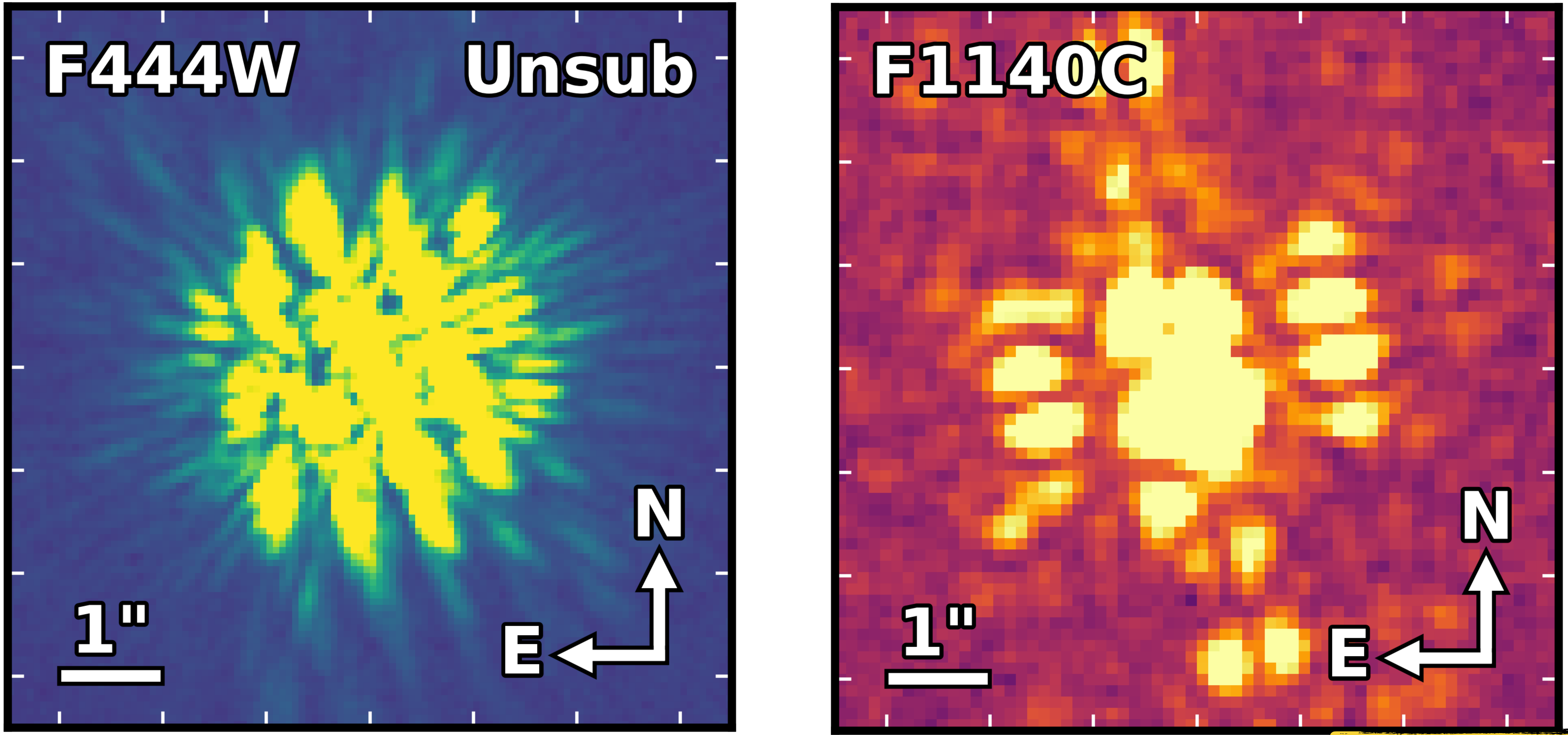

Carter et al. 2023

The First Images of an Exoplanet with JWST

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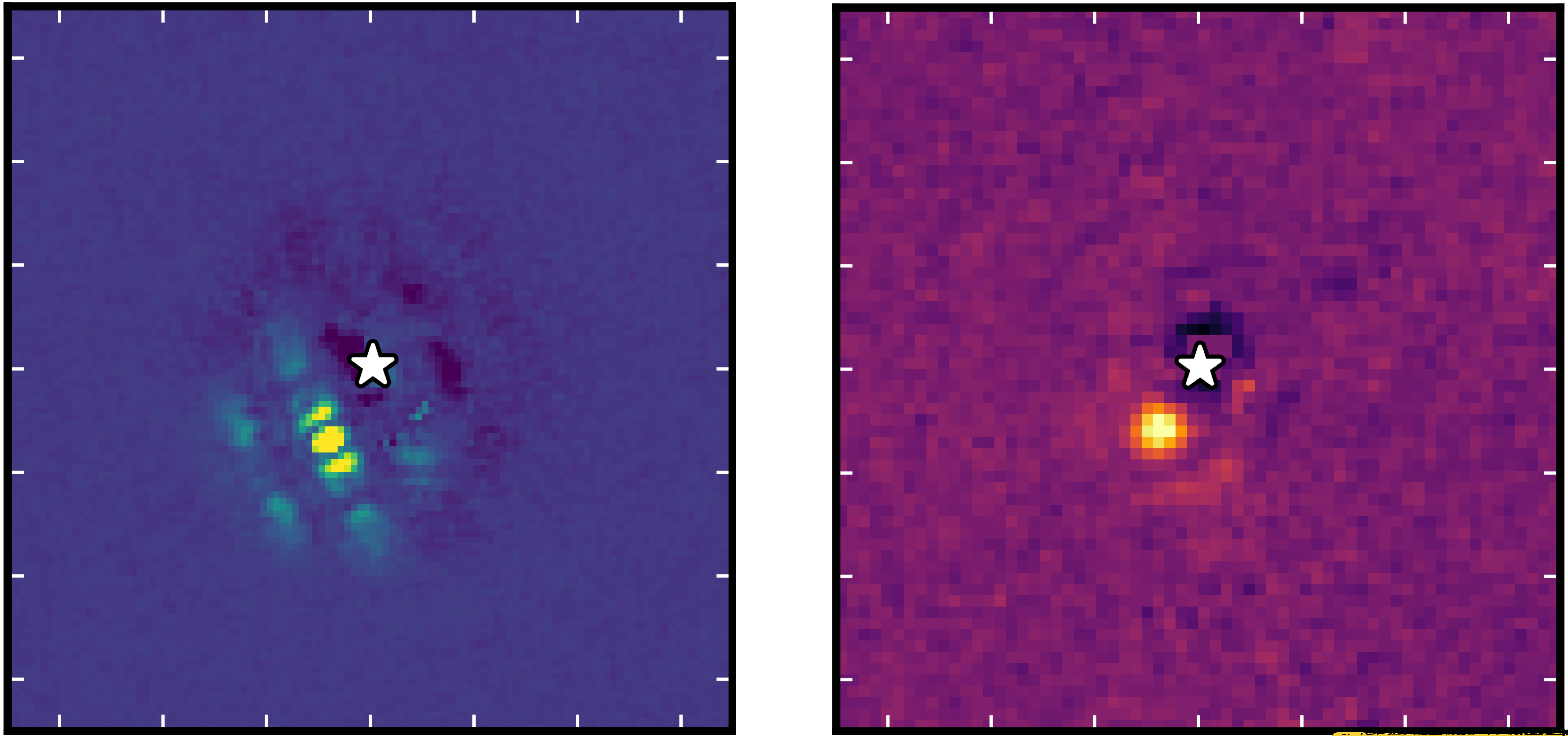

Carter et al. 2023

HIP 65426b Detected from 2-16 µm

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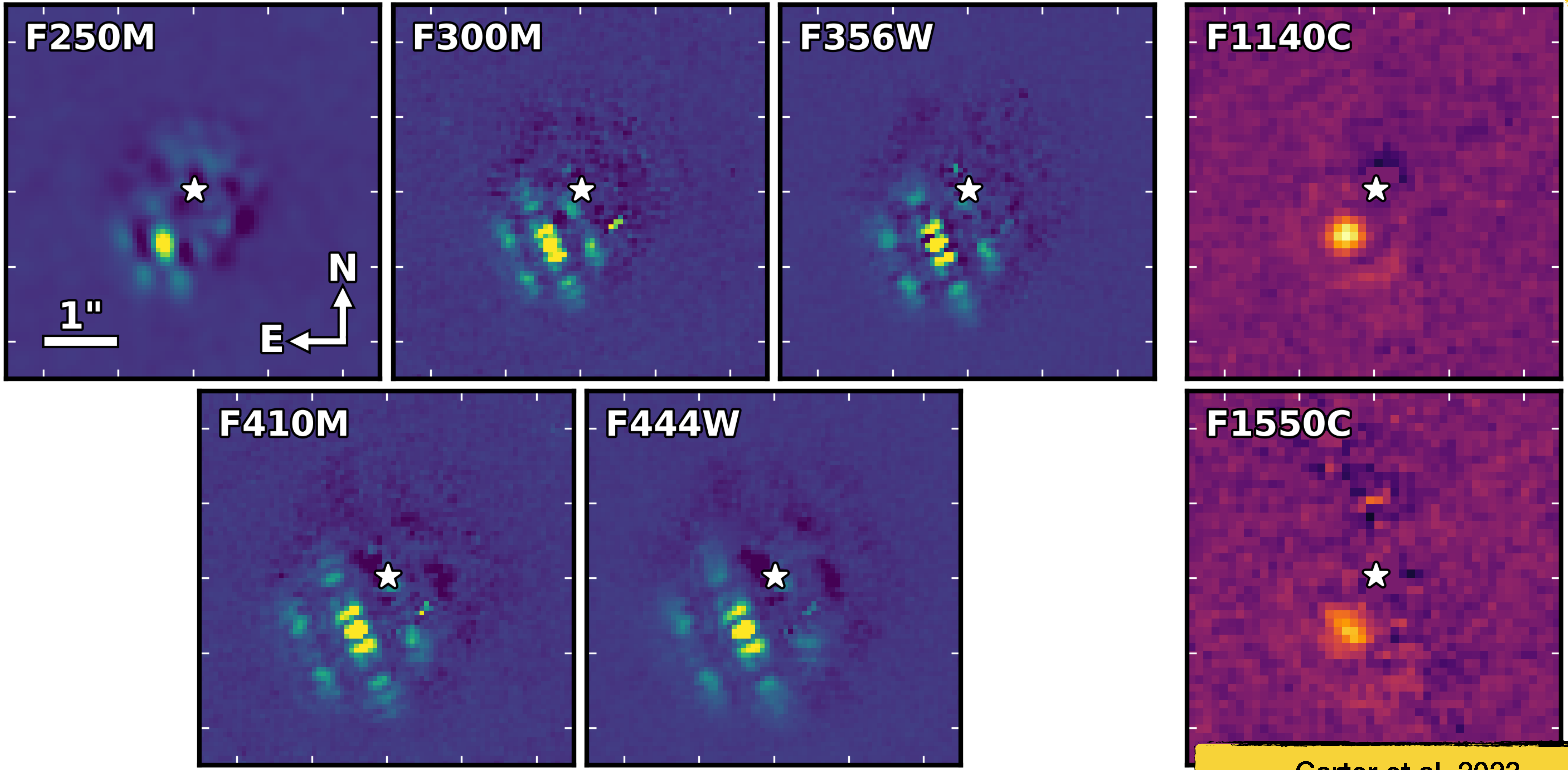

Carter et al. 2023

Precise Measurements Across the Full Spectrum

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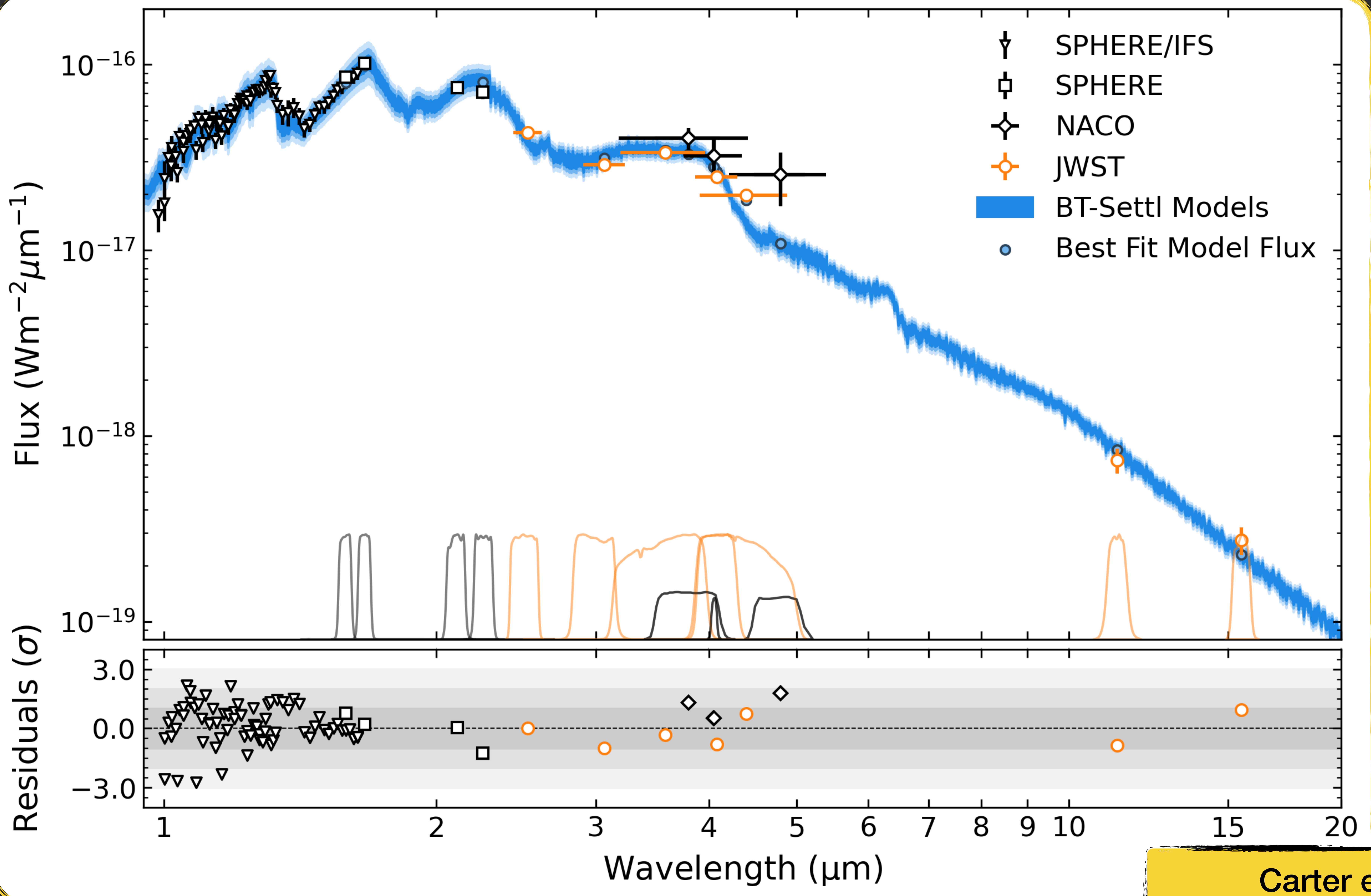

Carter et al. 2023

What Advantages will JWST Provide?

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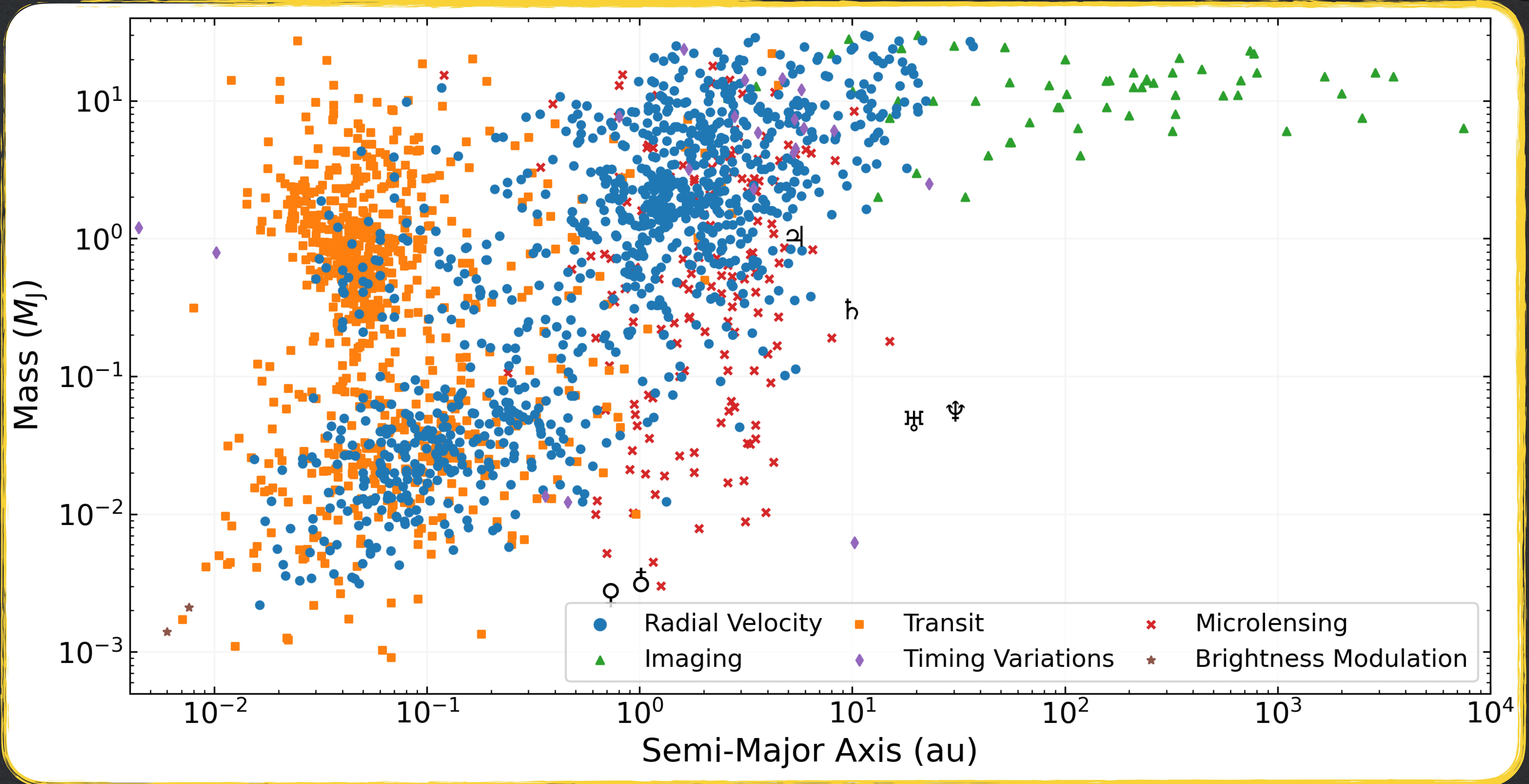

Imaging Giant Exoplanets With Independent Mass Constraints

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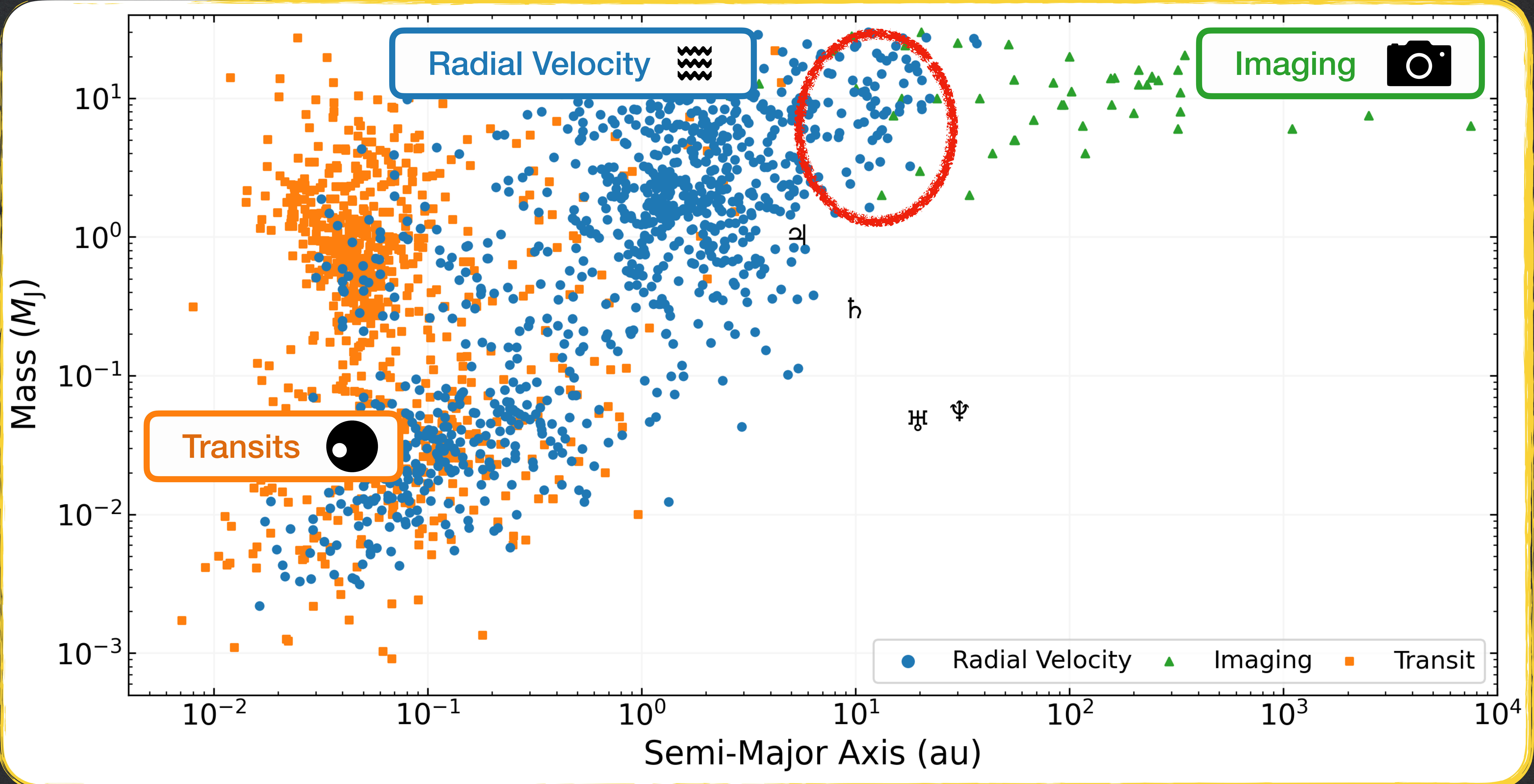

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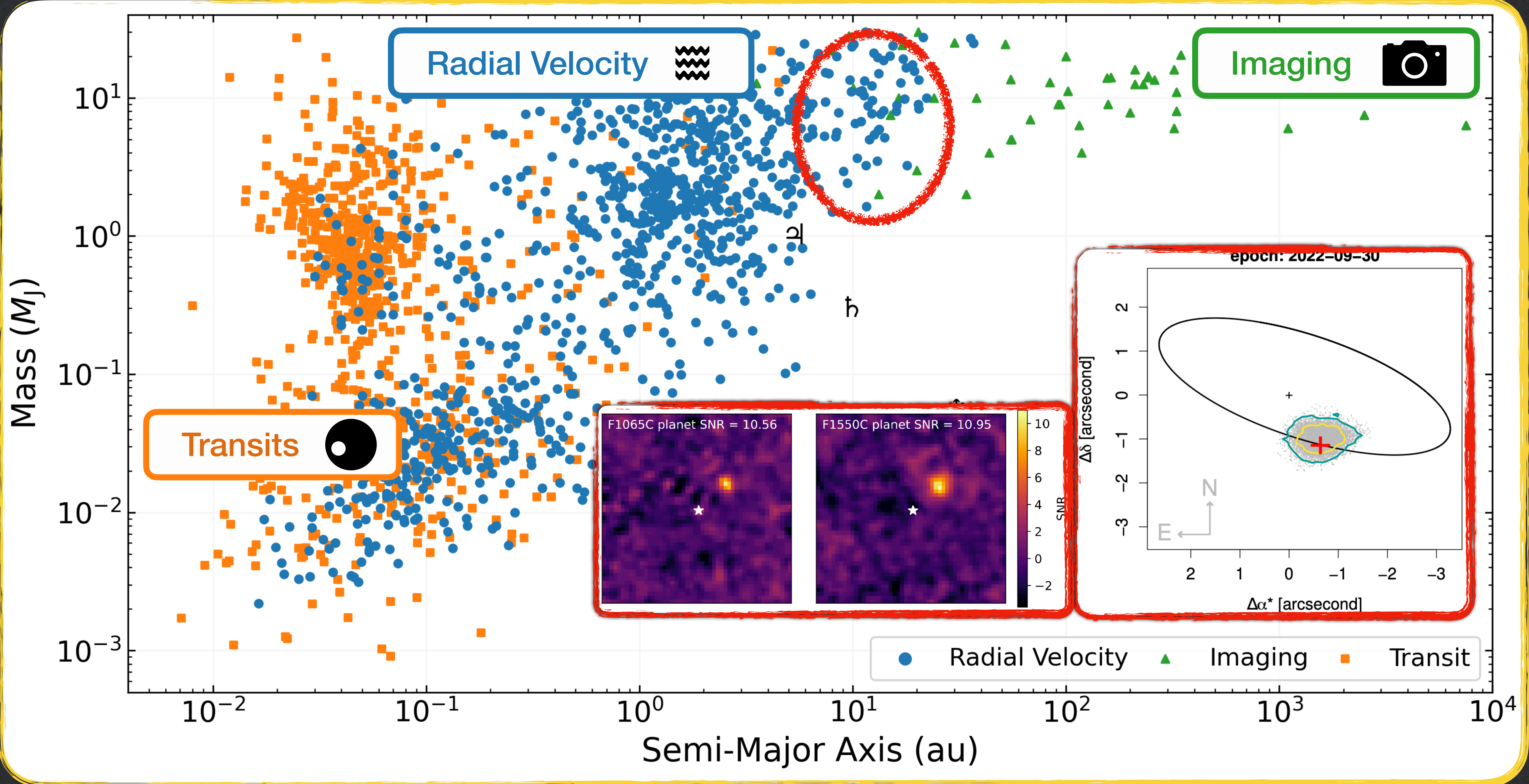

Imaging Sub-Jupiter Mass Exoplanets

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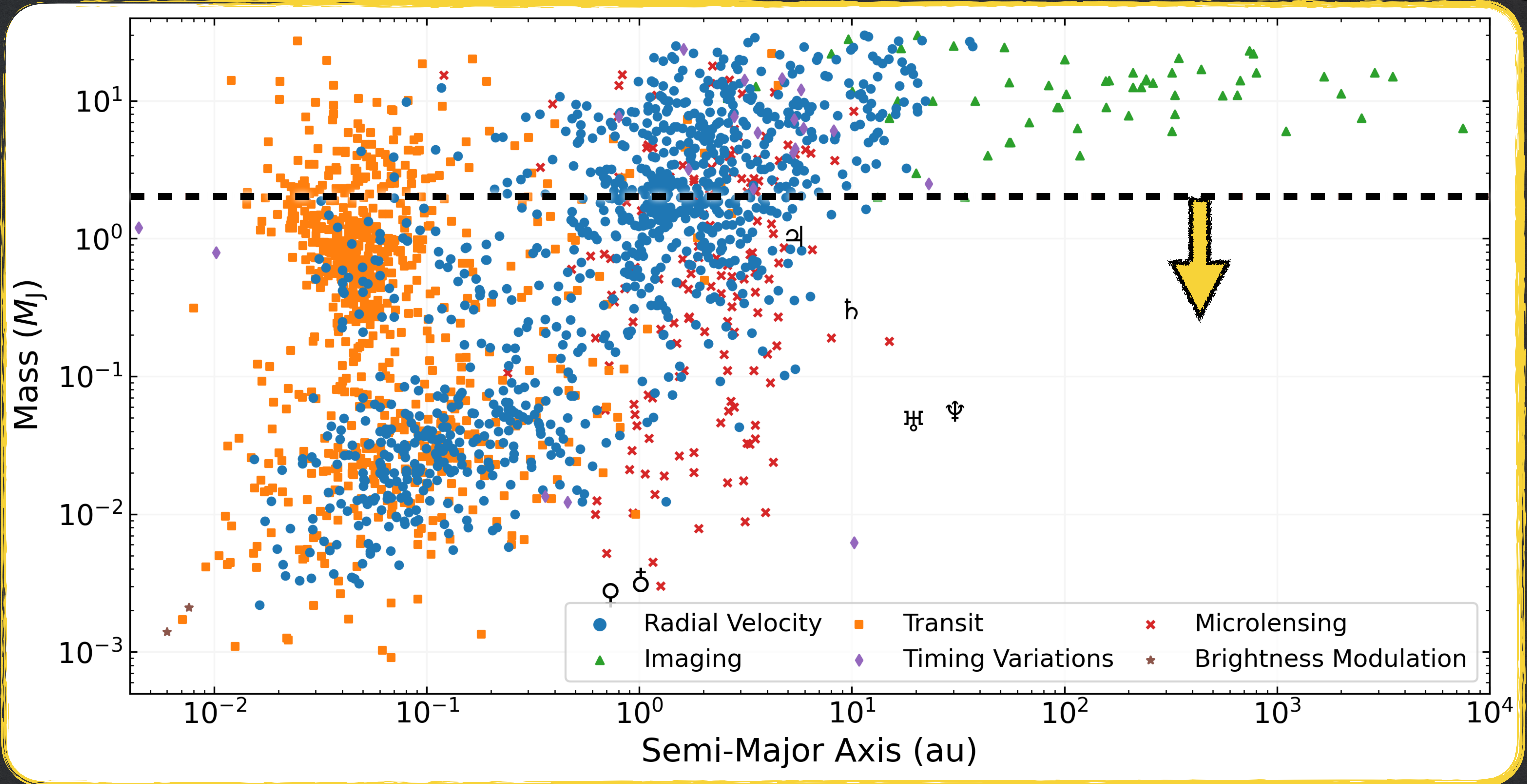

Sub-Jupiter Mass Sensitivity with JWST

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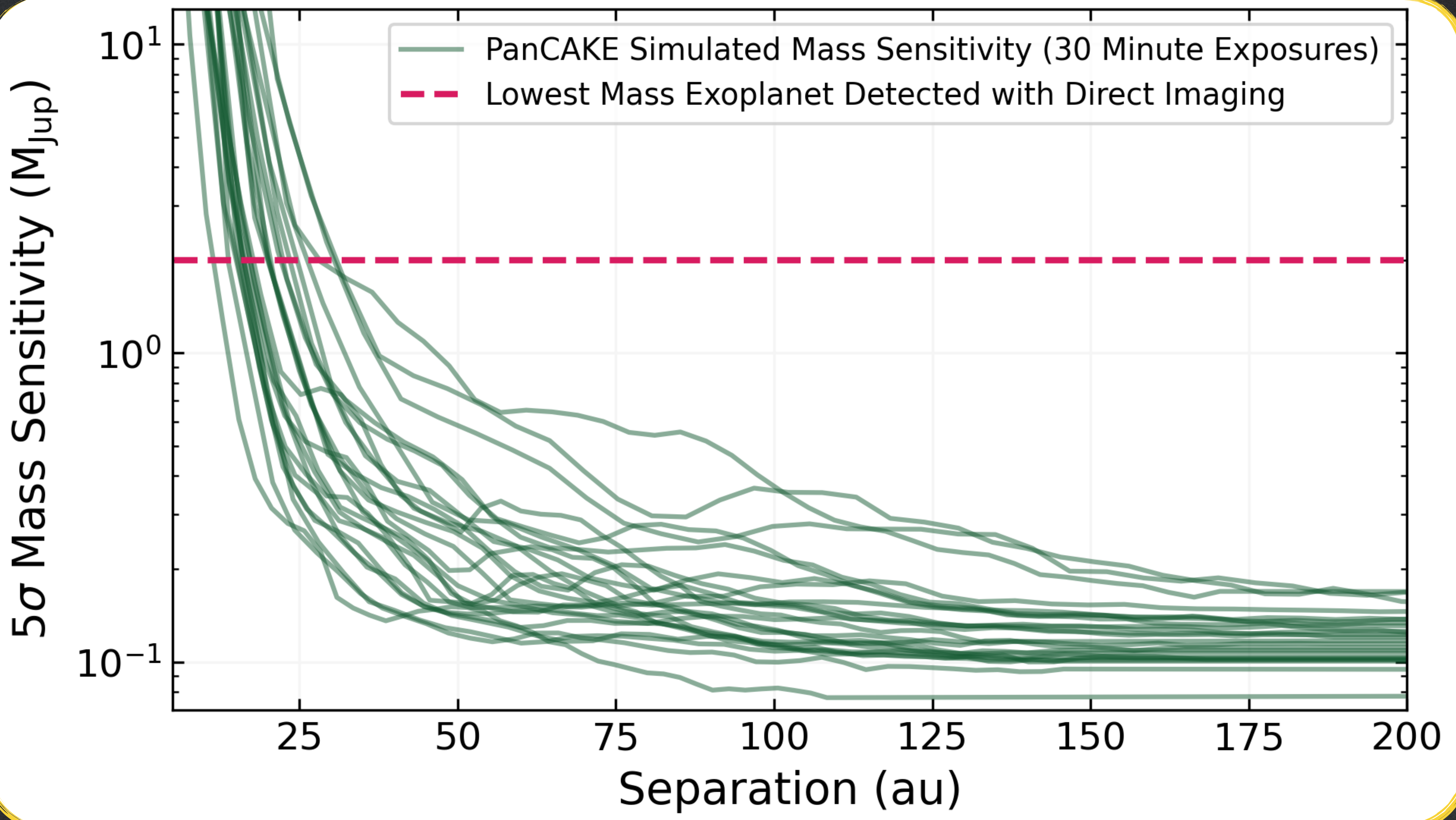

Giant Planet Hunting in the Gaps of ALMA Disks

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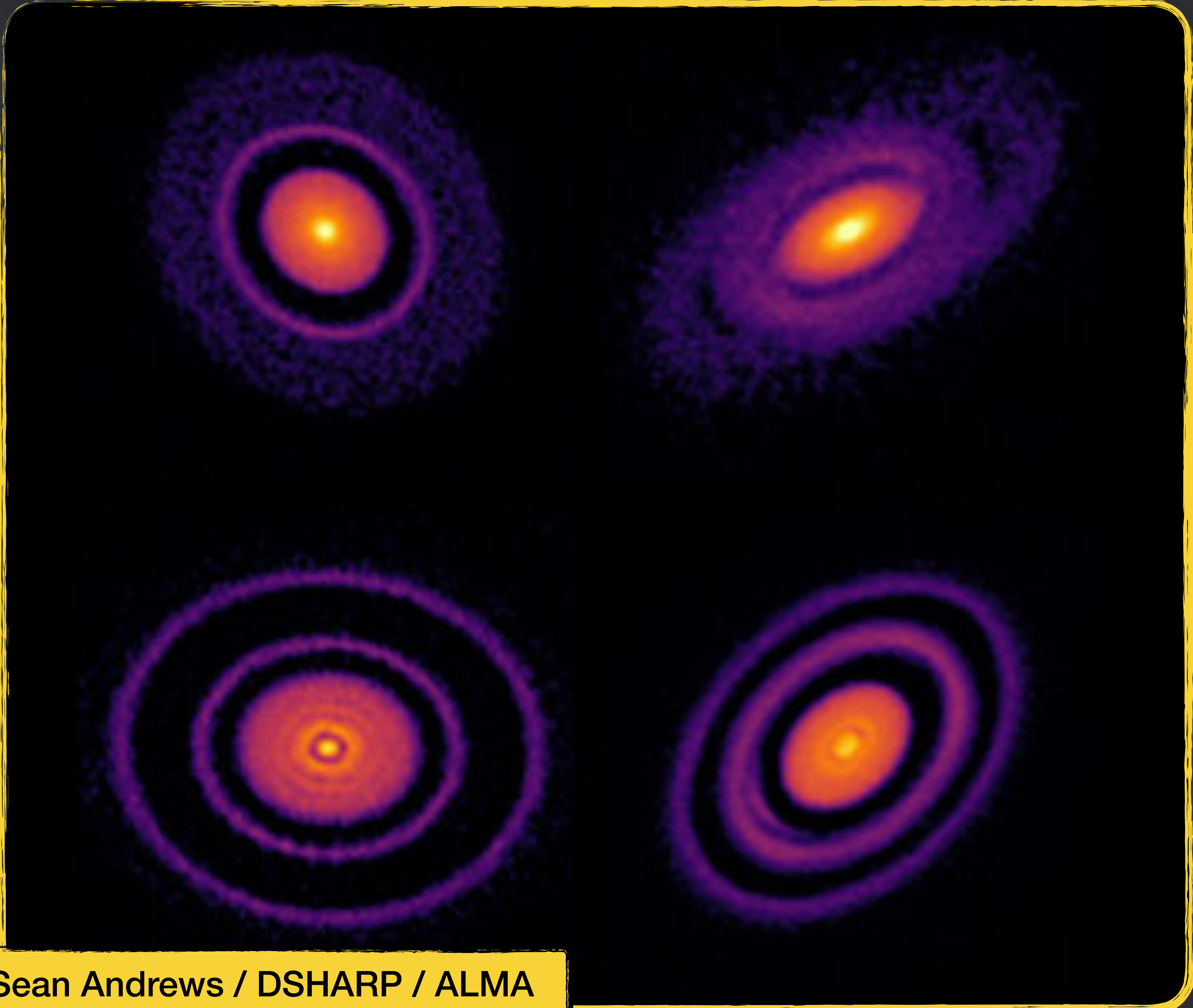
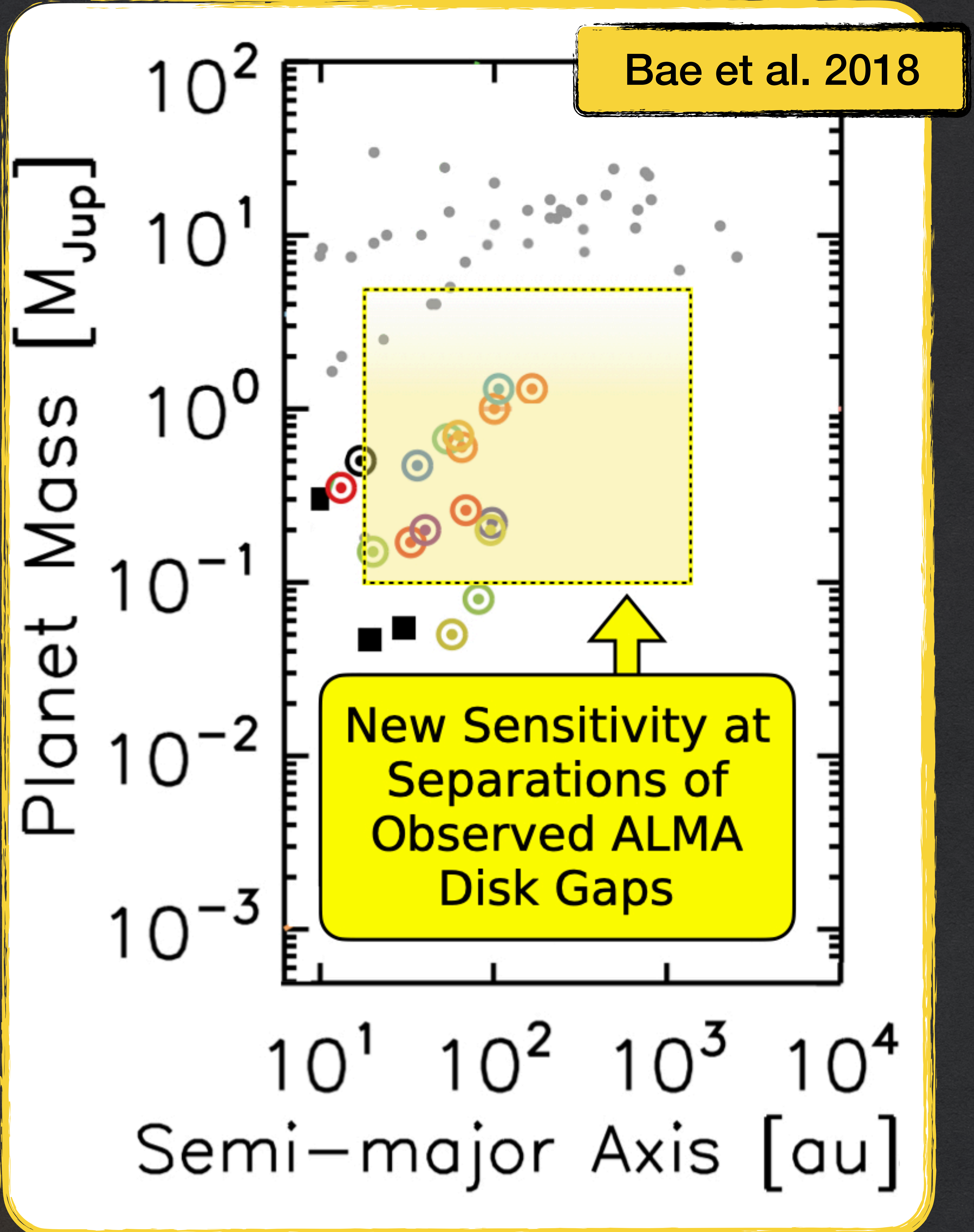


Sean Andrews / DSHARP / ALMA



Long Term Characterisation of New Exoplanet Benchmarks

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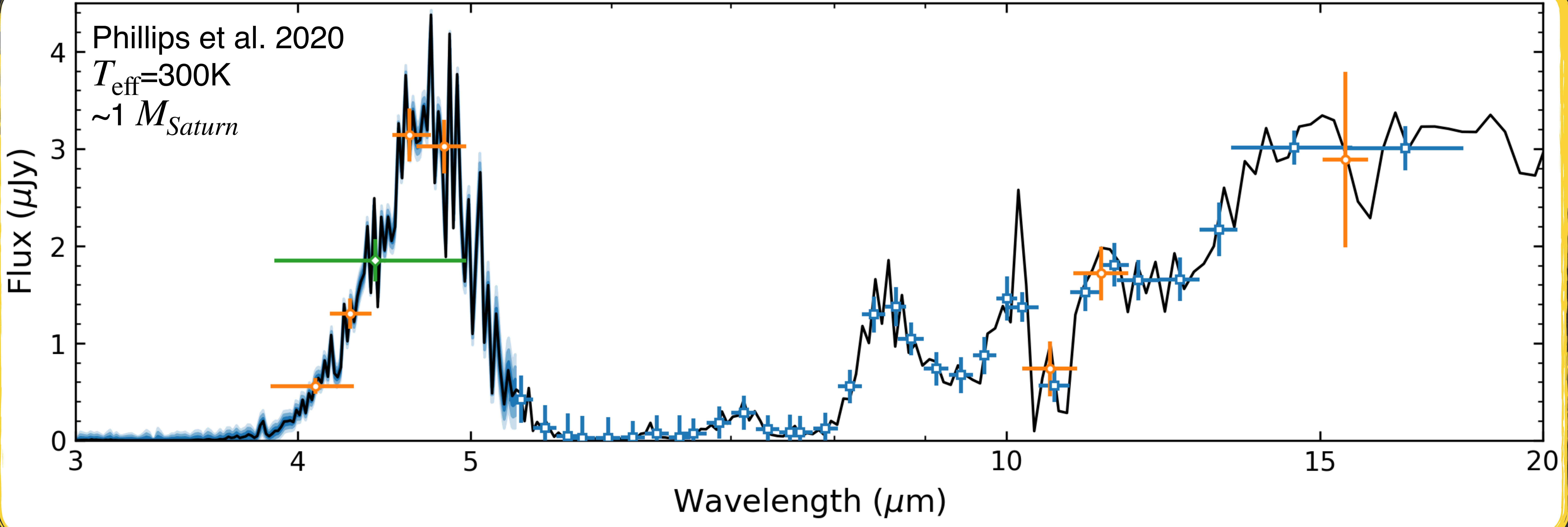
Pathfinder Survey Observation

Coronagraphic Follow Up

Spectroscopic Follow Up



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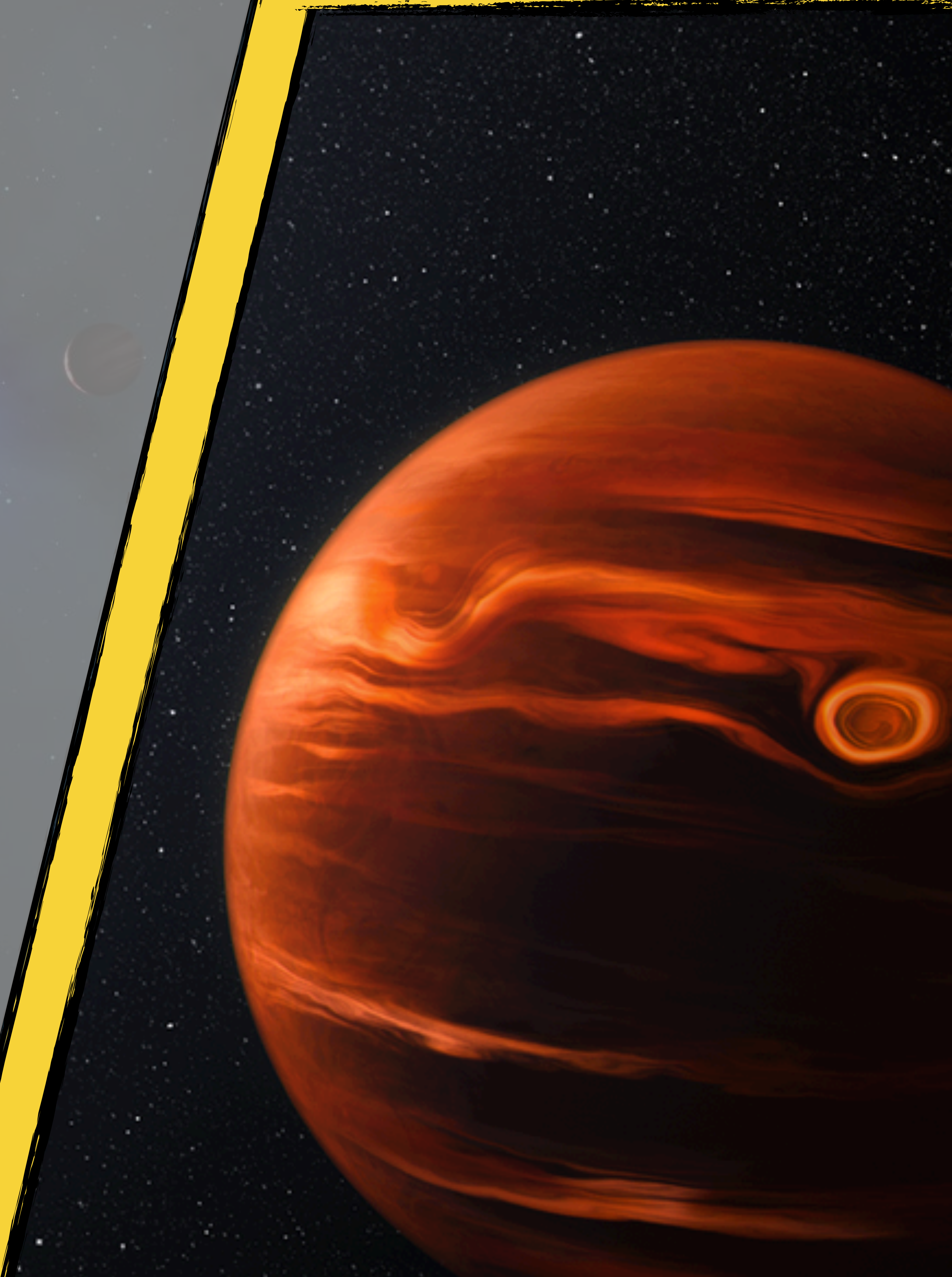

Spectroscopy Provides Incredible Atmospheric Detail

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Spectroscopy with Early Release Science

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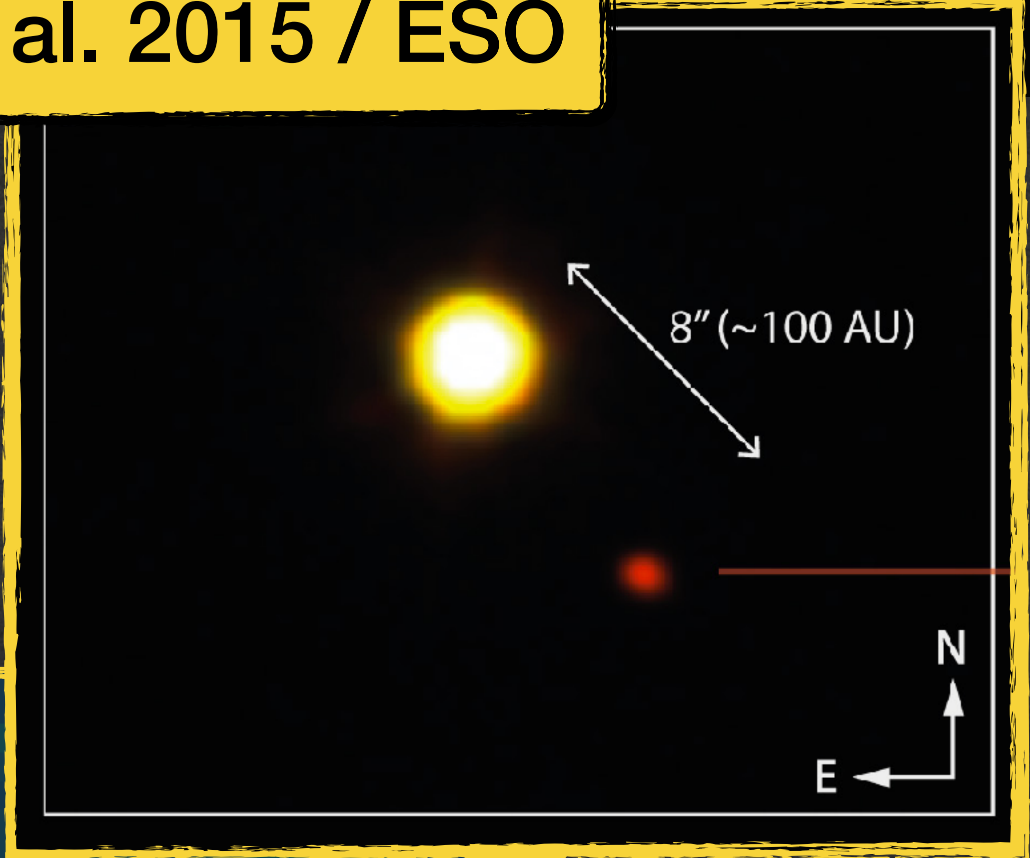
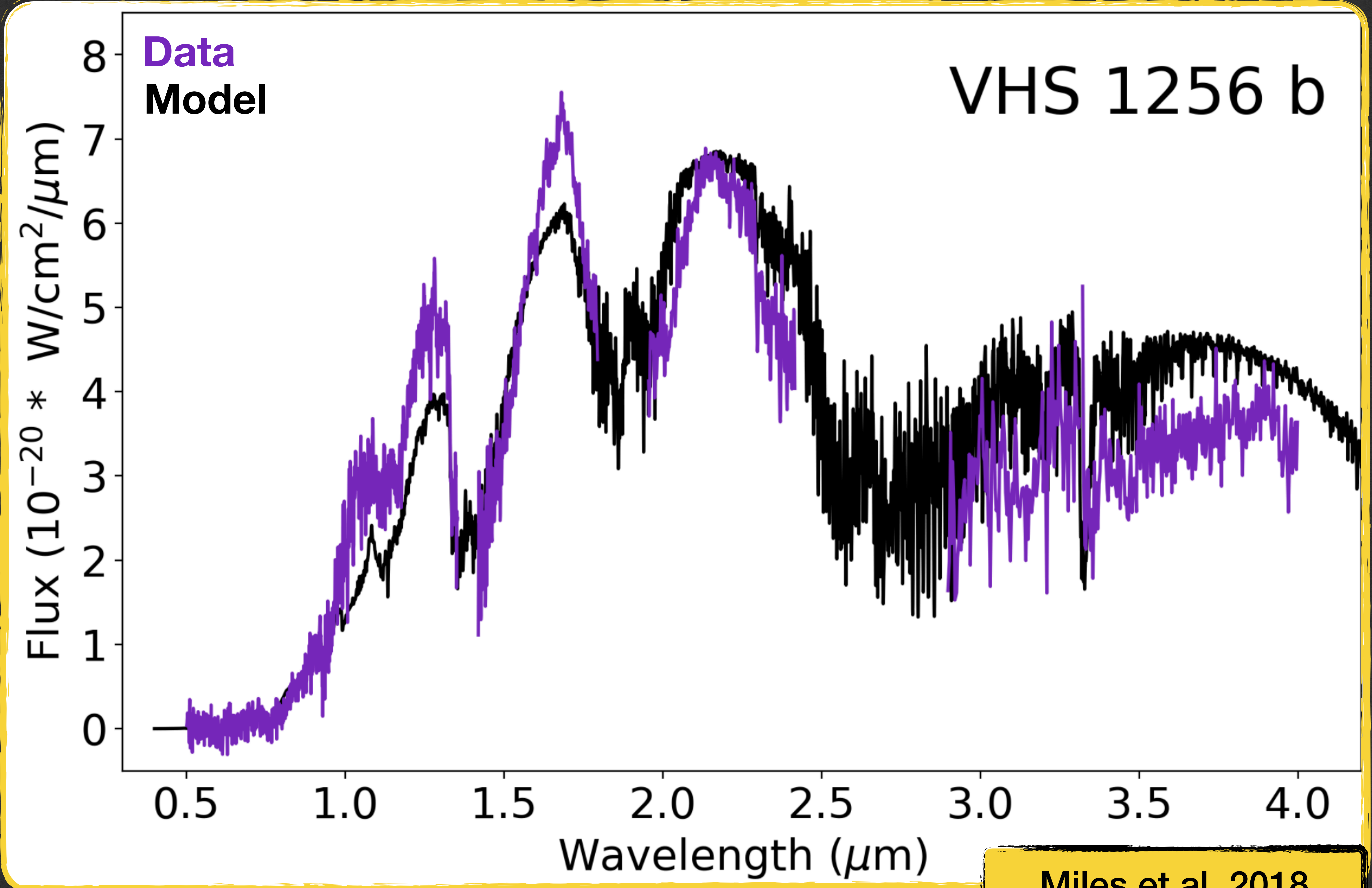
VHS 1256b

~14-24 M_{Jup}, 1000-1200 K

Gauza et al. 2015 / ESO



Zhou et al. 2020



Miles et al. 2018

An "Exoplanet" Atmosphere In Unprecedented Detail

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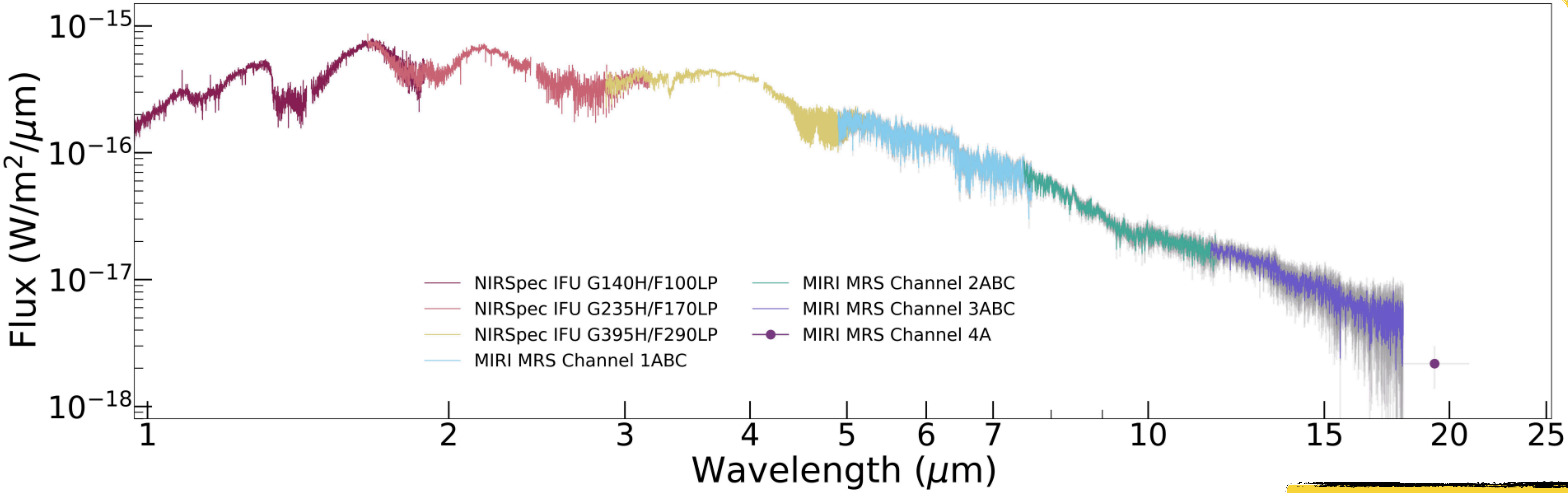

Miles et al. 2023

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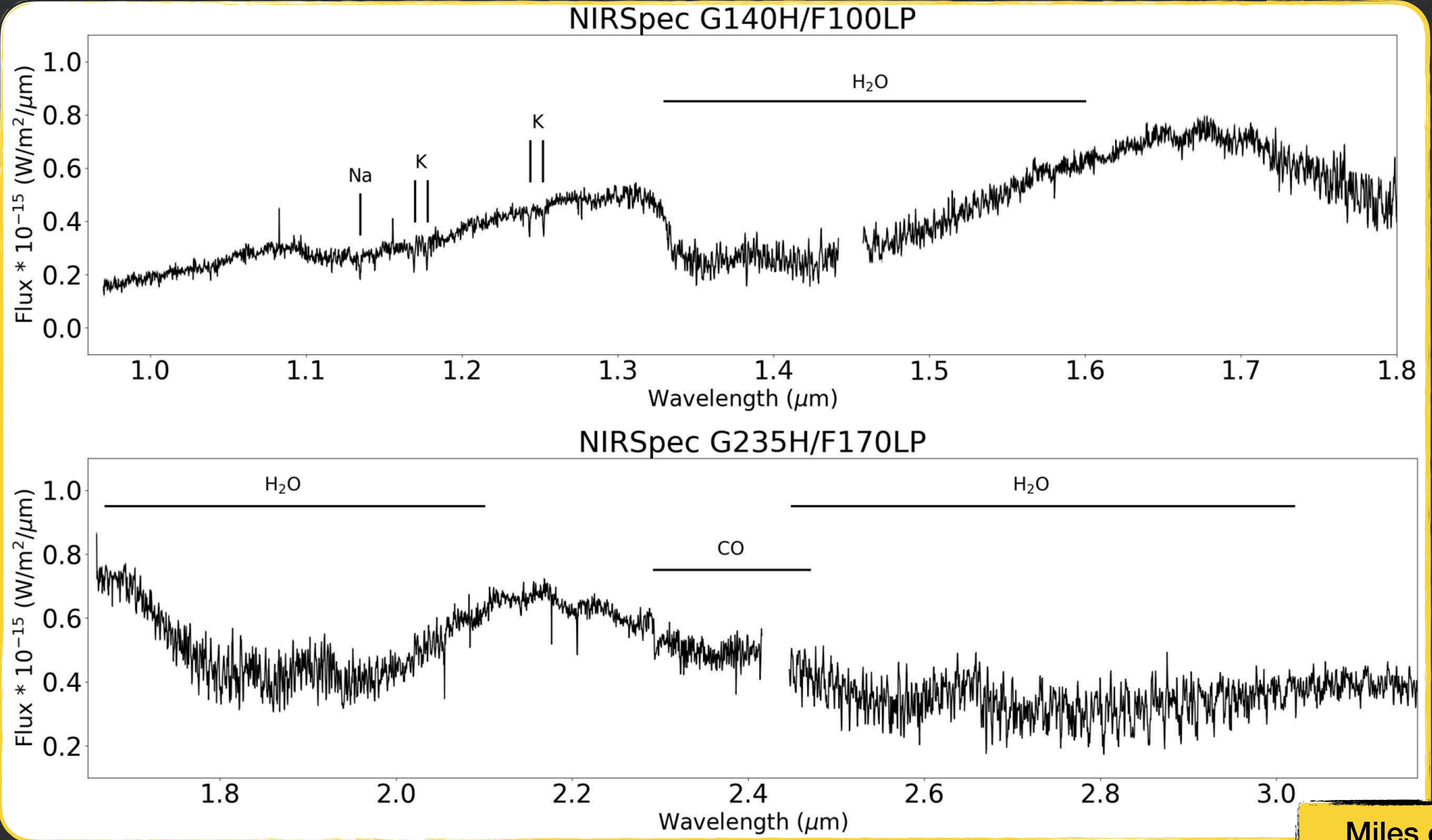

Miles et al. 2023

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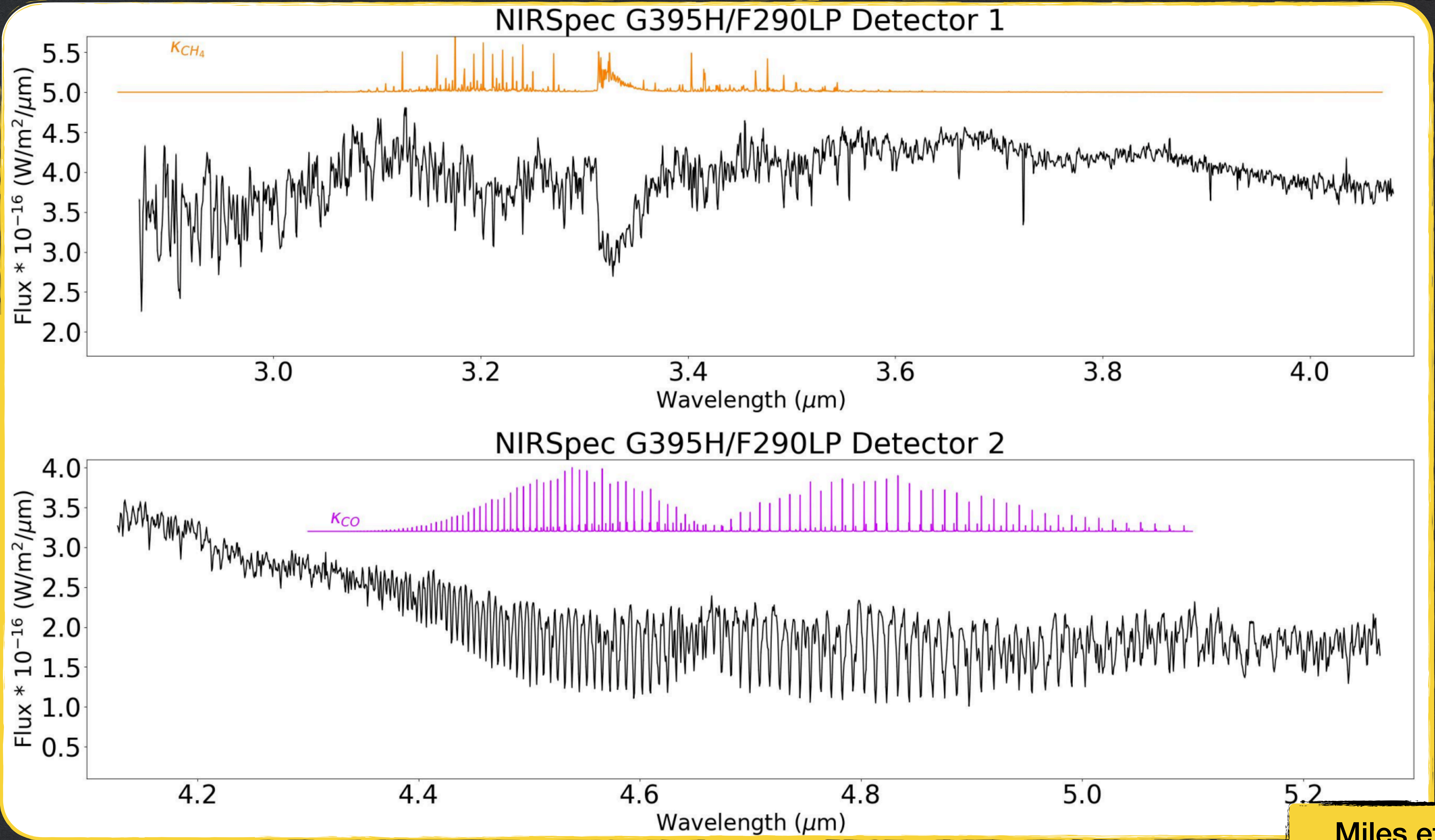

Miles et al. 2023

Evidence for Absorption From Silicate Clouds

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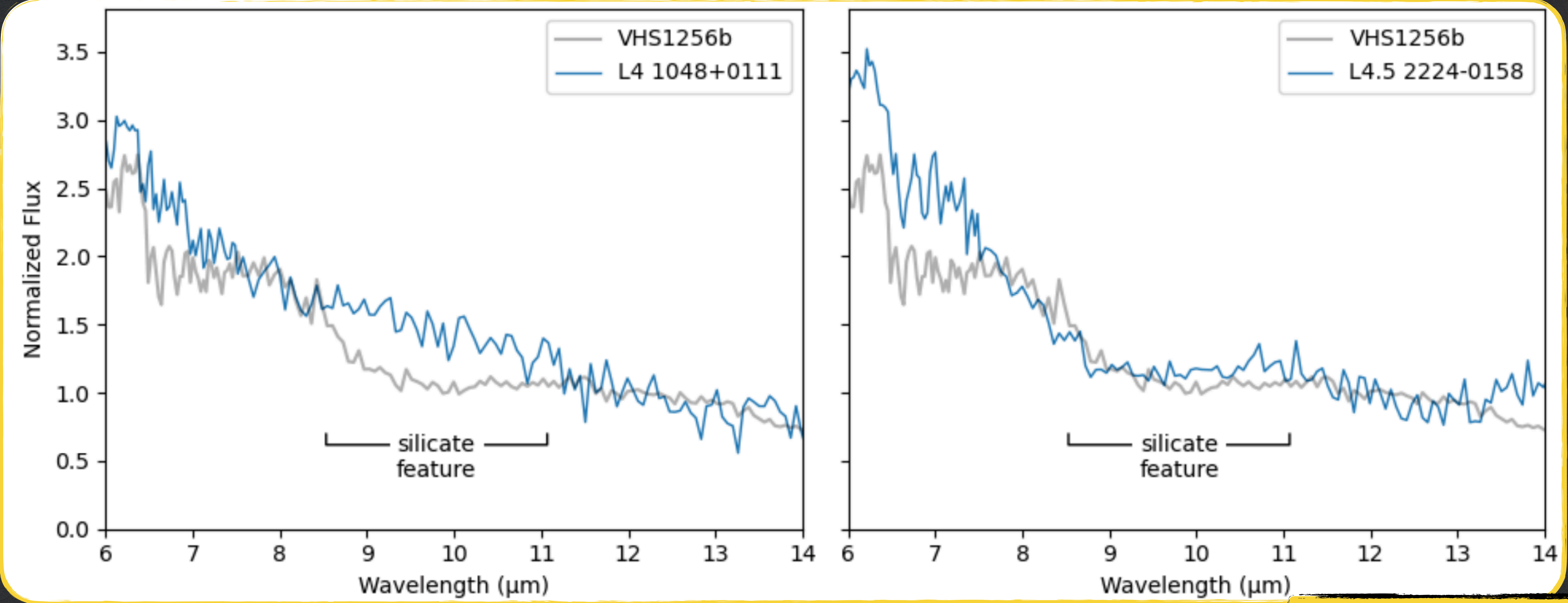

Miles et al. 2023

Atmospheric Model Fitting Is Very Challenging!

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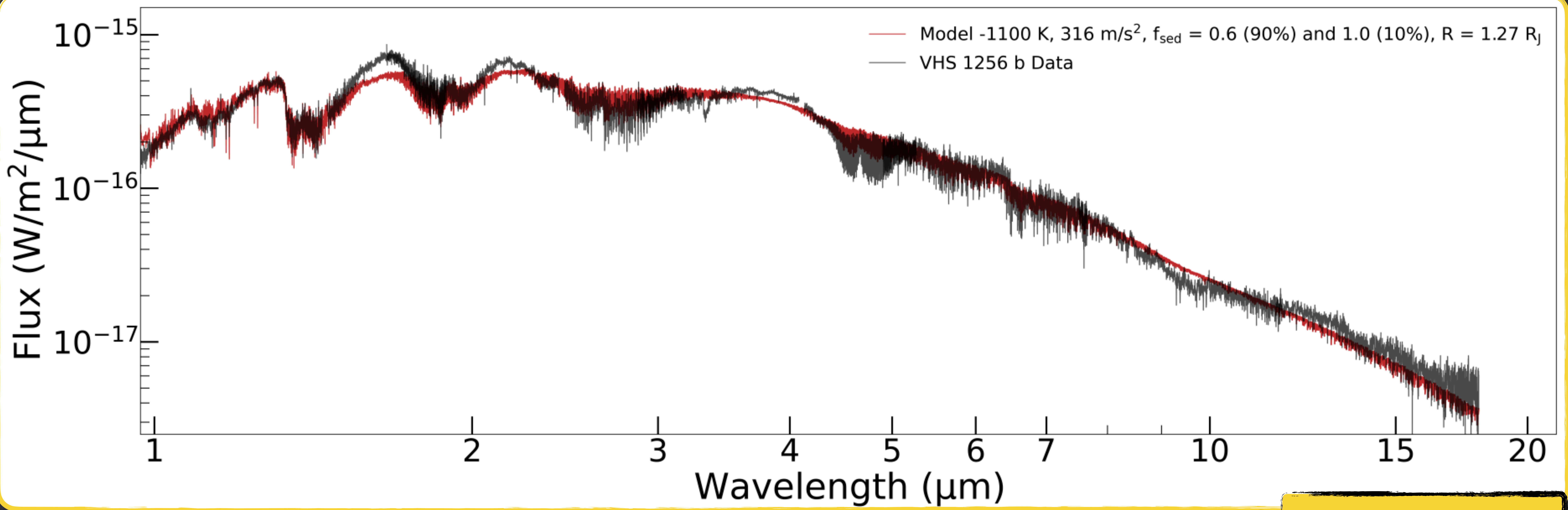

Miles et al. 2023

Much More to Explore Beyond VHS 1256 b

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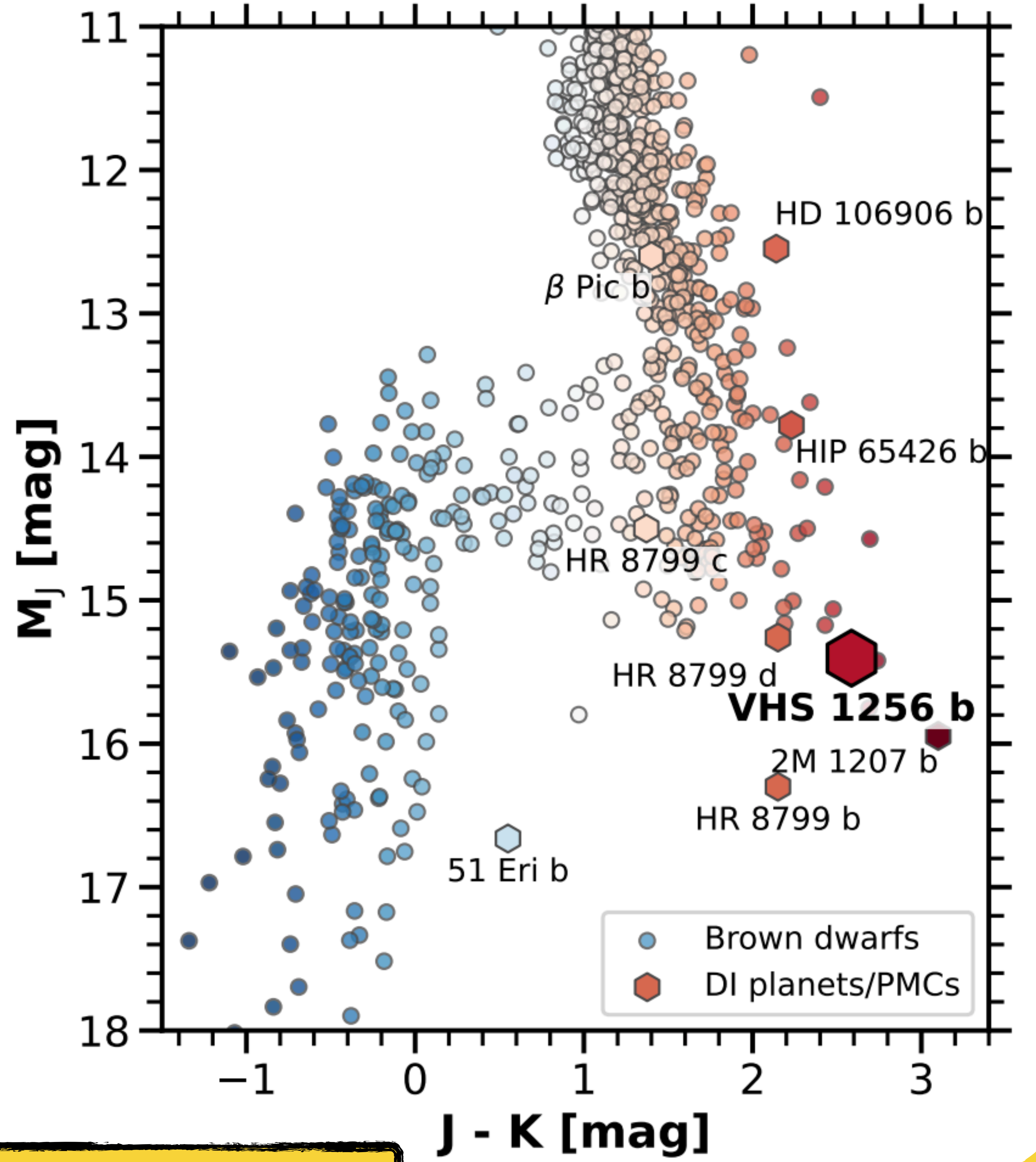

Miles et al. 2023

How do atmospheres evolve across different temperature regimes?

What is the extent and prevalence of disequilibrium chemistry and clouds?

How does atmospheric variability change across the population?

How far can we push JWST's spectroscopic modes?

JWST Spectroscopy of a ~450 K Brown Dwarf

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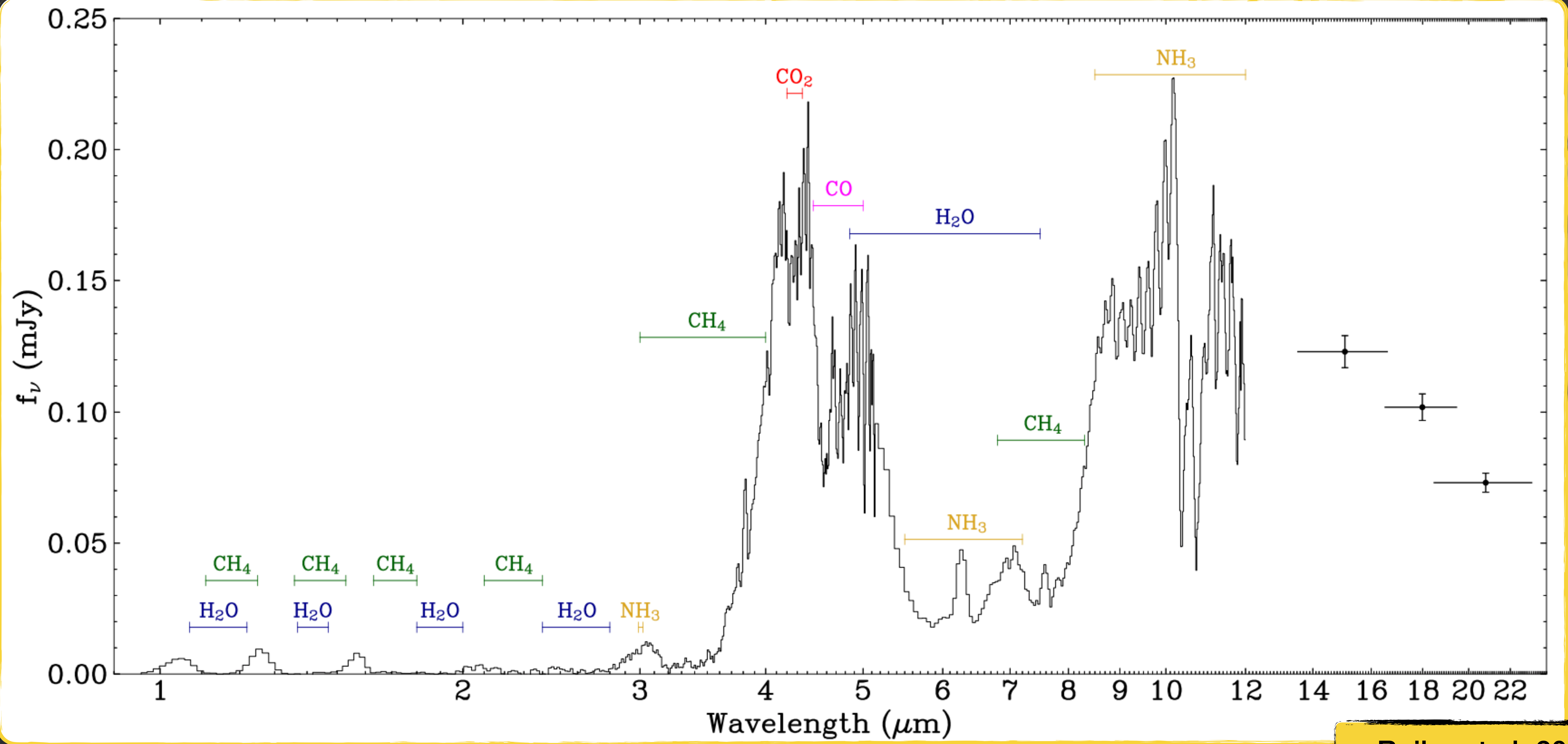

Beiler et al. 2023

Spectroscopy at Short Angular Separations

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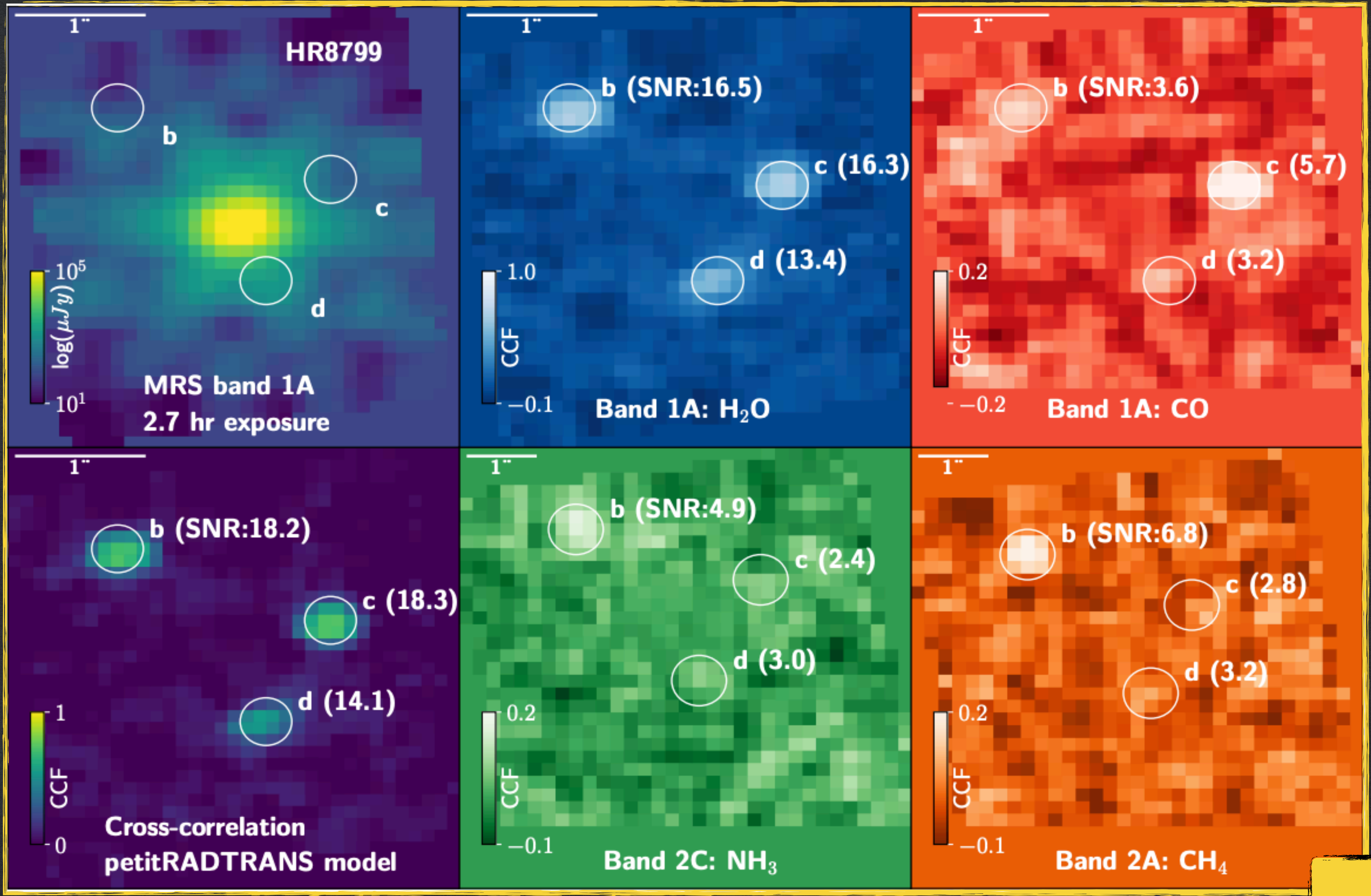

Patapis et al. 2022

Direct Spectroscopy Observations of Exoplanets are Possible with JWST

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Pathfinder Survey Observation

Coronagraphic Follow Up

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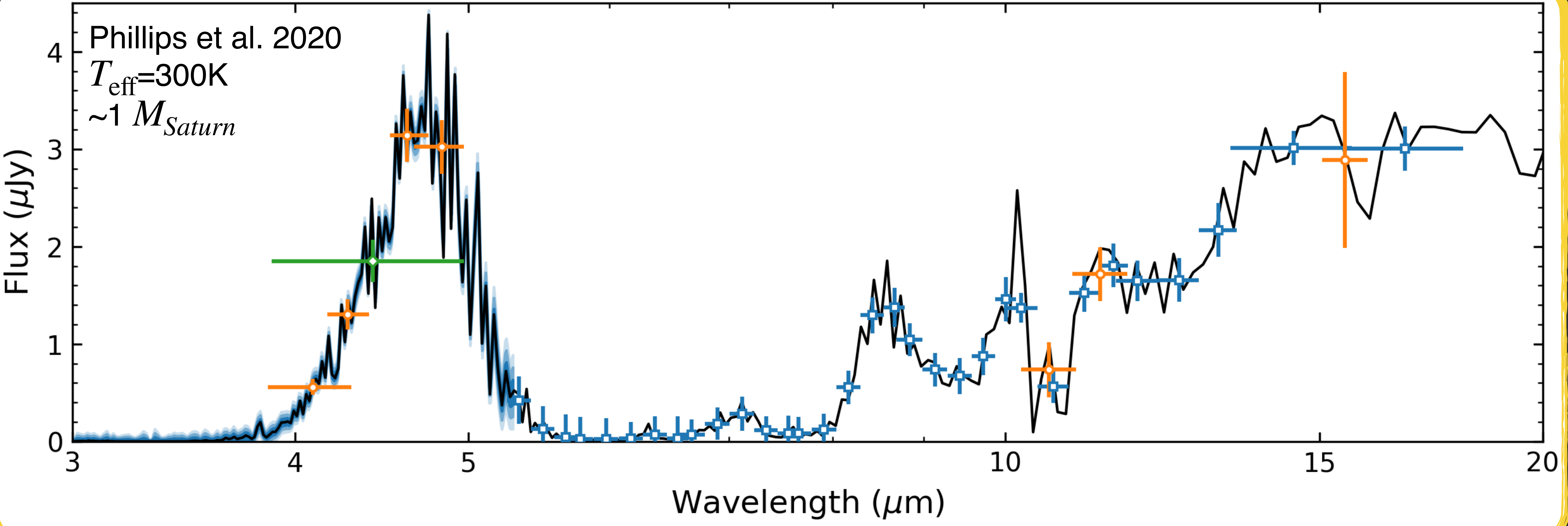

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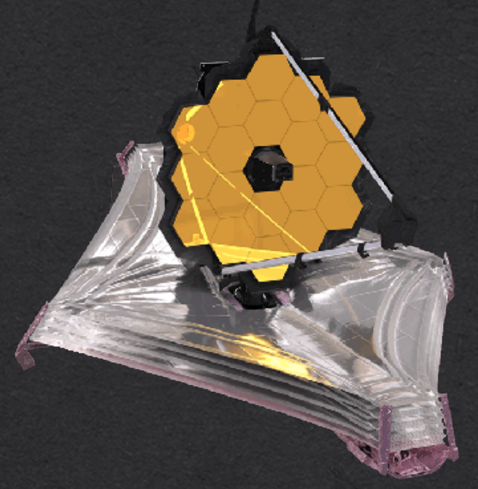
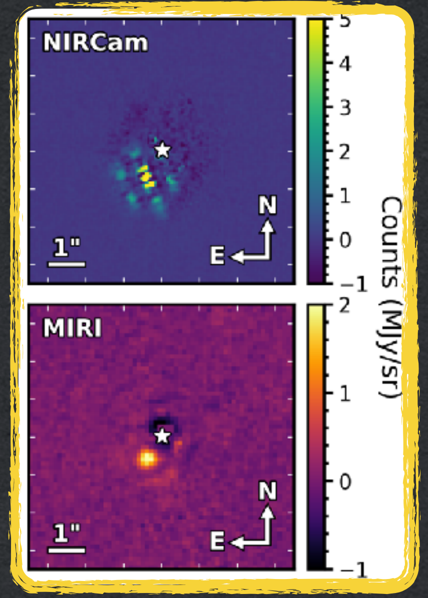
Conclusions

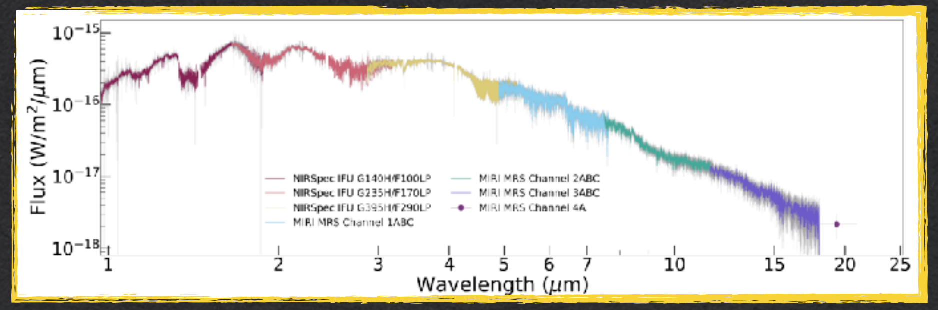
JWST presents an unprecedented opportunity to characterise a diverse range of exoplanets with high sensitivity and broad wavelength coverage for both direct imaging and spectroscopy observations.

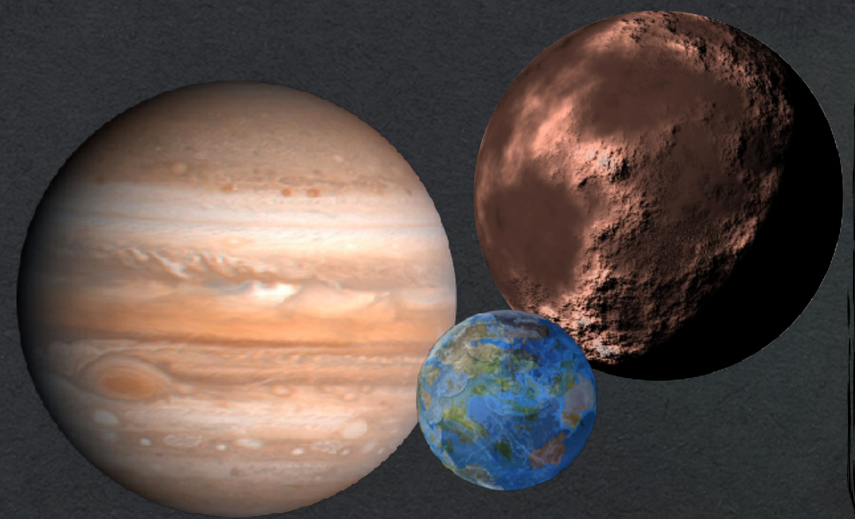




JWST coronagraphic imaging is exceeding its nominal predicted performance, and opens the door to observations beyond 5 micron, and imaging observations of sub-Jupiter mass objects for the first time.

Spectroscopic observations with JWST provide an unrivaled amount of information and will greatly advance our understanding of exoplanet / brown dwarf atmospheric physics and chemistry.





These observations are only the beginning, and represent a small fraction of the exoplanet imaging science that will be performed throughout the entire lifetime of JWST. There is a wealth of discovery to look forward too!


Questions
NASA