

# A JWST NIRCам Coronagraphic Imaging Survey of Nearby, Young M Dwarfs

## *Preliminary Results*

Ell Bogat

Univ. Maryland College Park / CRESST II

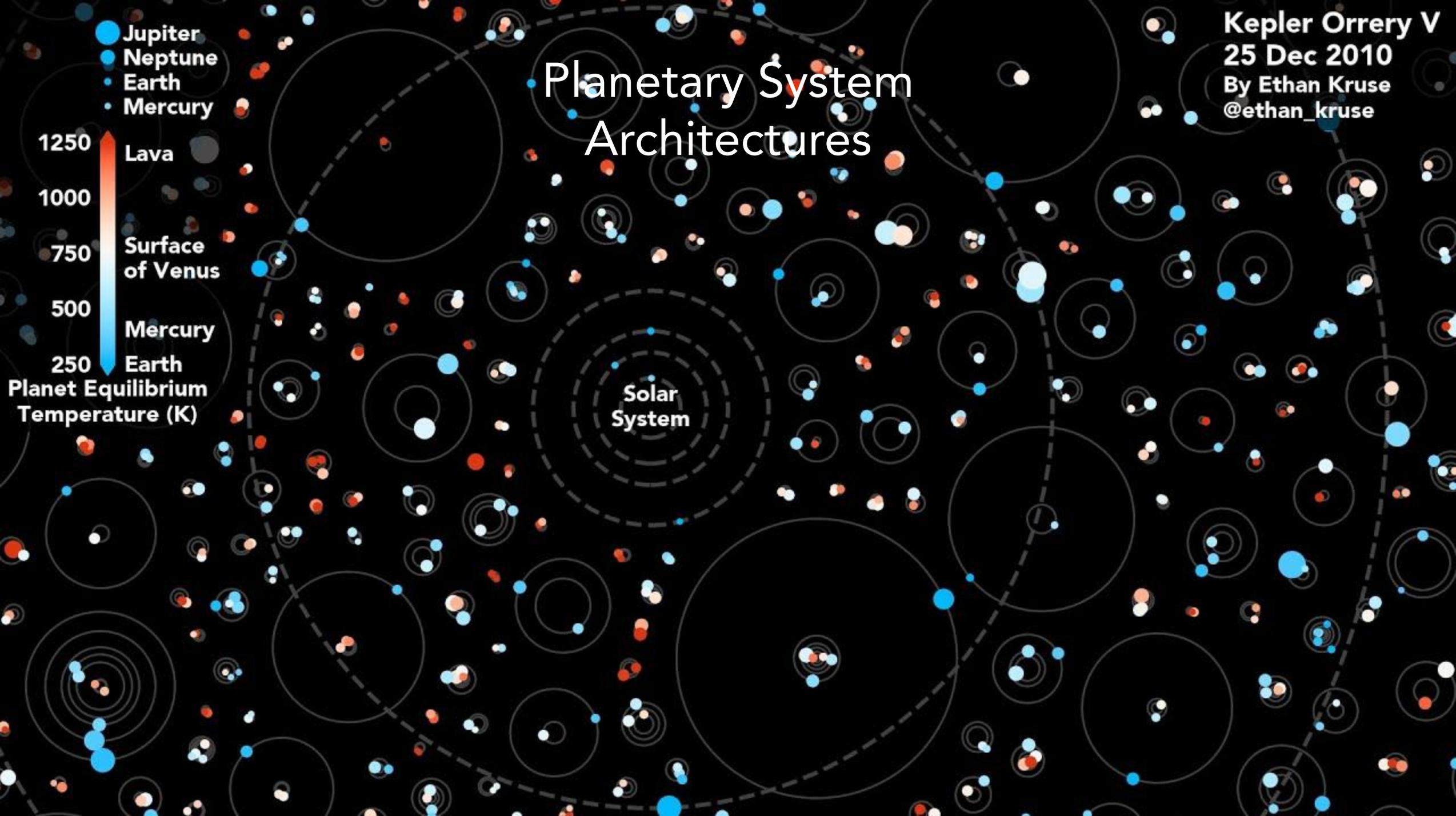
NASA Goddard Space Flight Center

ExoExplorers Seminar, January 20 2023

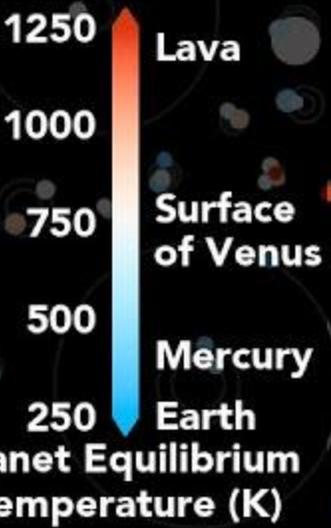
*Artist's conception of Kepler-186 f*

# Planetary System Architectures

Kepler Orrery V  
25 Dec 2010  
By Ethan Kruse  
@ethan\_kruse



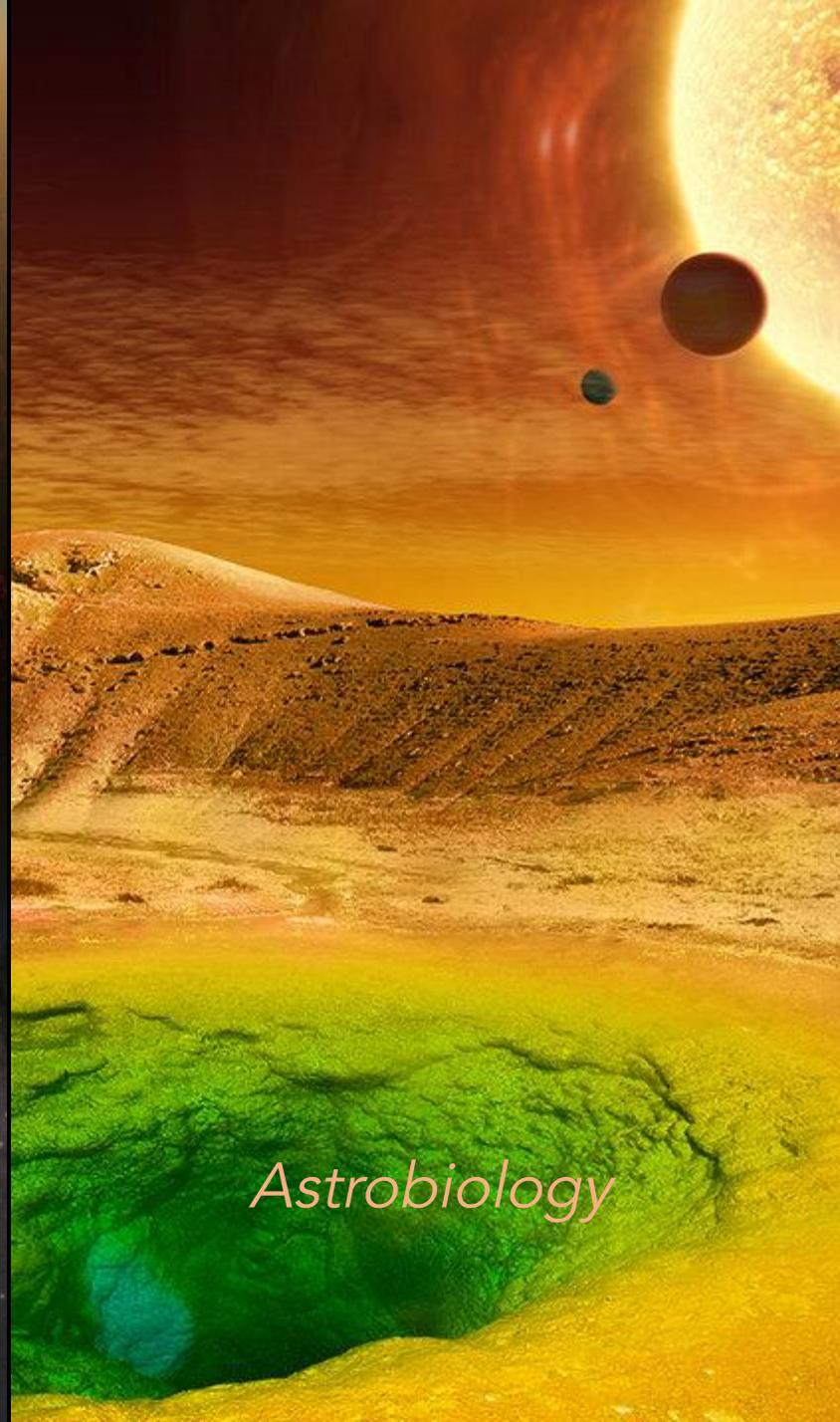
- Jupiter
- Neptune
- Earth
- Mercury



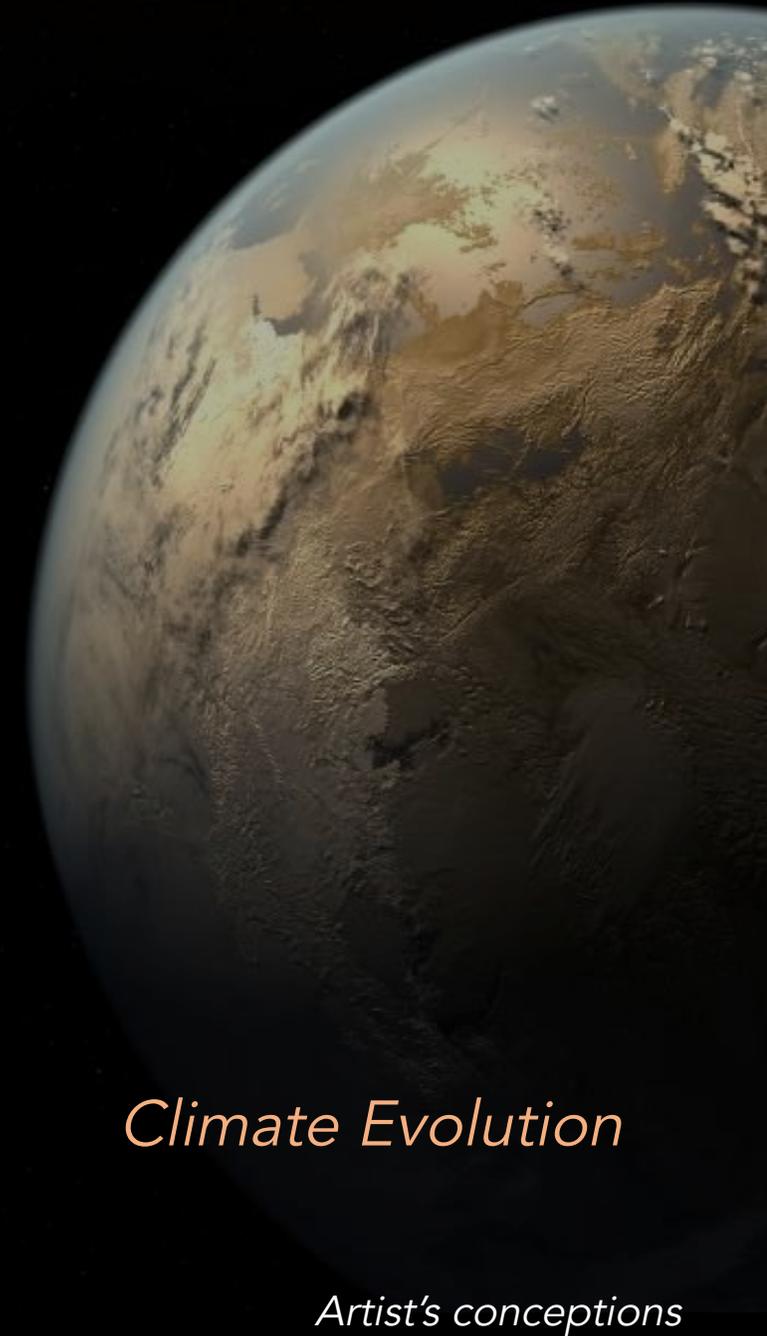
Solar System

# Exoplanet Atmospheres

*Astrochemistry*



*Astrobiology*

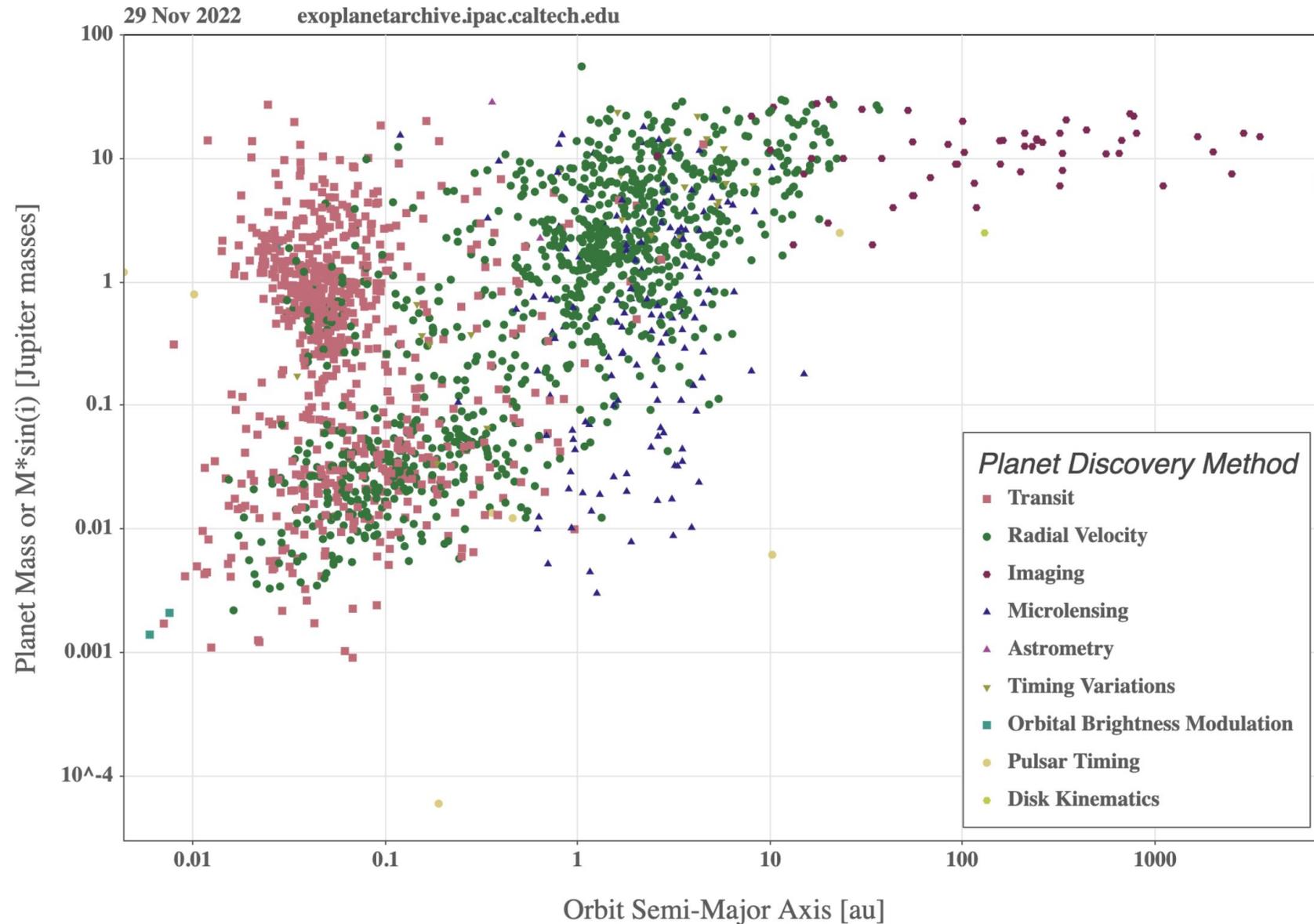


*Climate Evolution*

*Artist's conceptions*

# Studying Exoplanets with *Direct Imaging*

- *Orbital and atmospheric information*
- *Intrinsic luminosity*
- *Dynamical masses (with RV/astrometry)*



Why Is It So Hard?



Why Is It So Hard?



Why Is It So Hard?

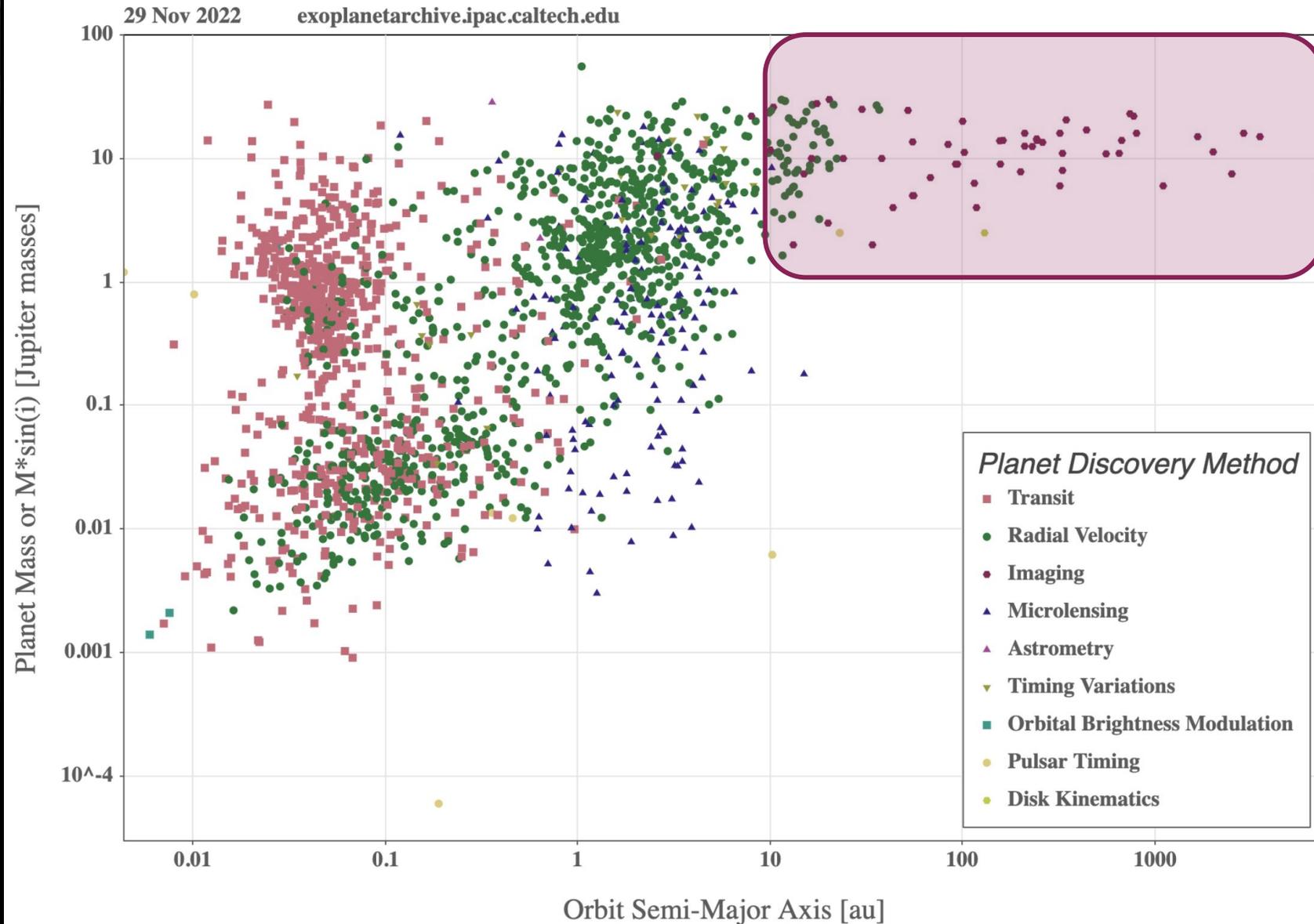


Why Is It So Hard?



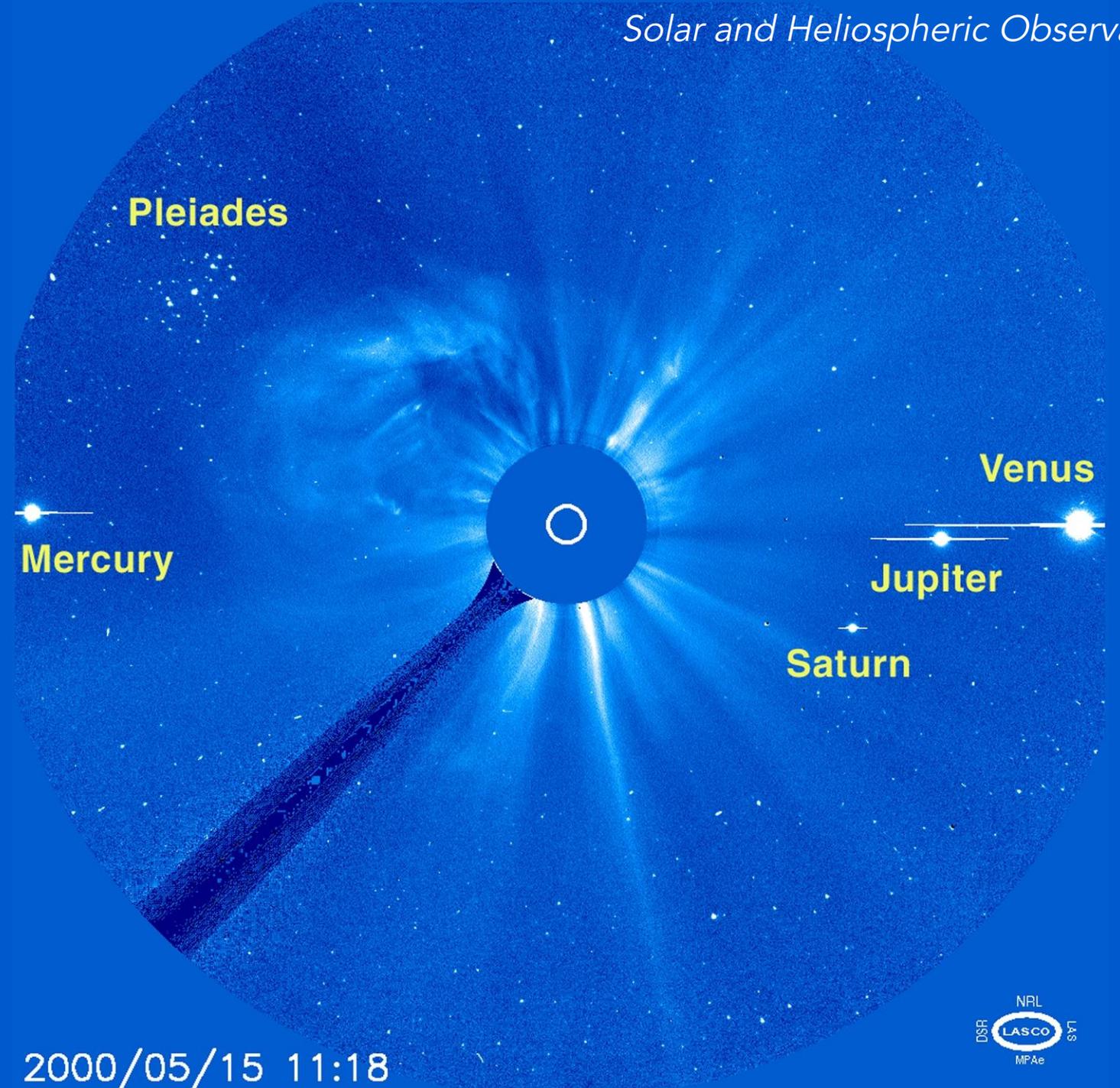
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# Studying Exoplanets with *Direct Imaging*

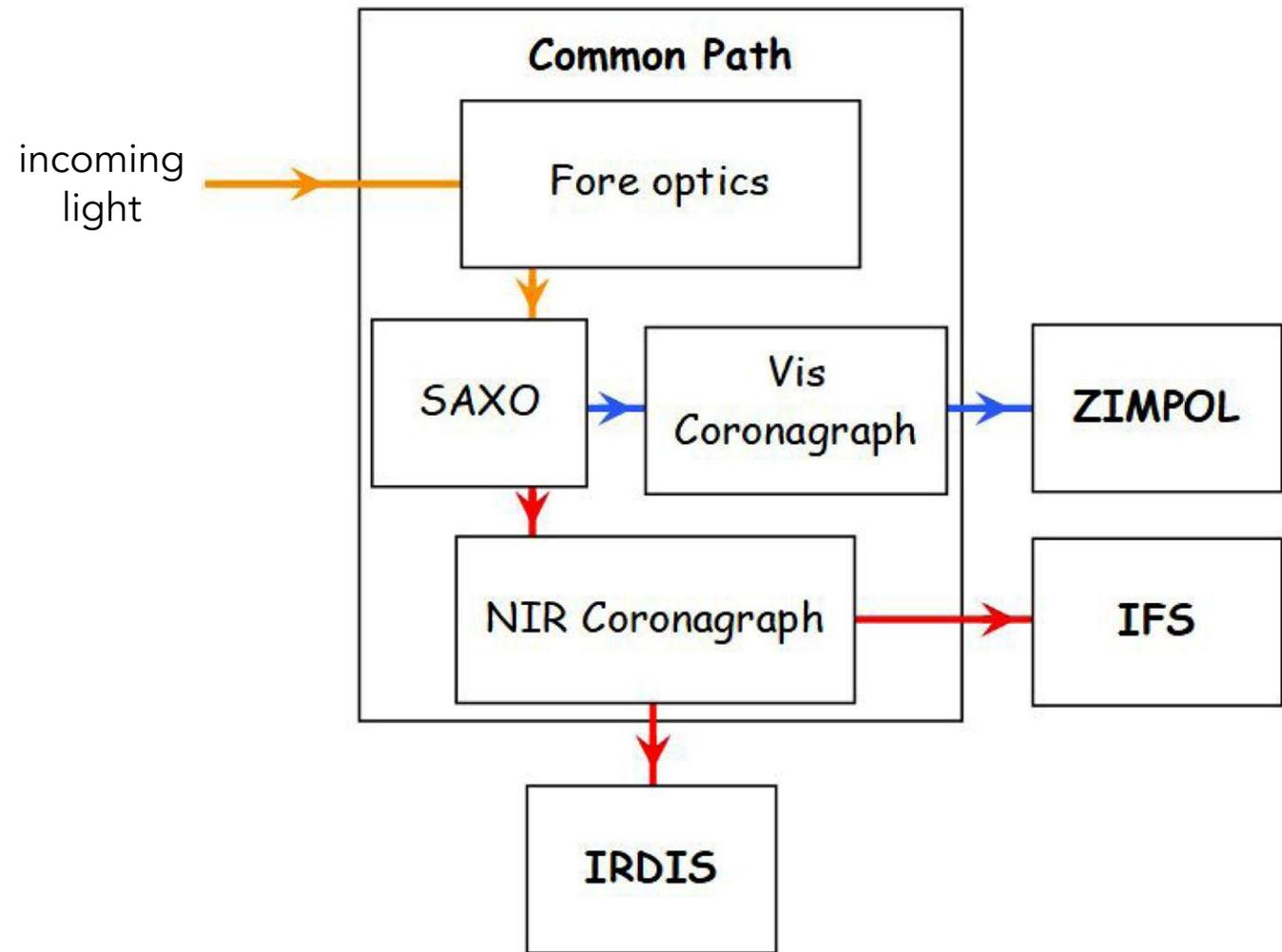
## 1. Coronagraphy





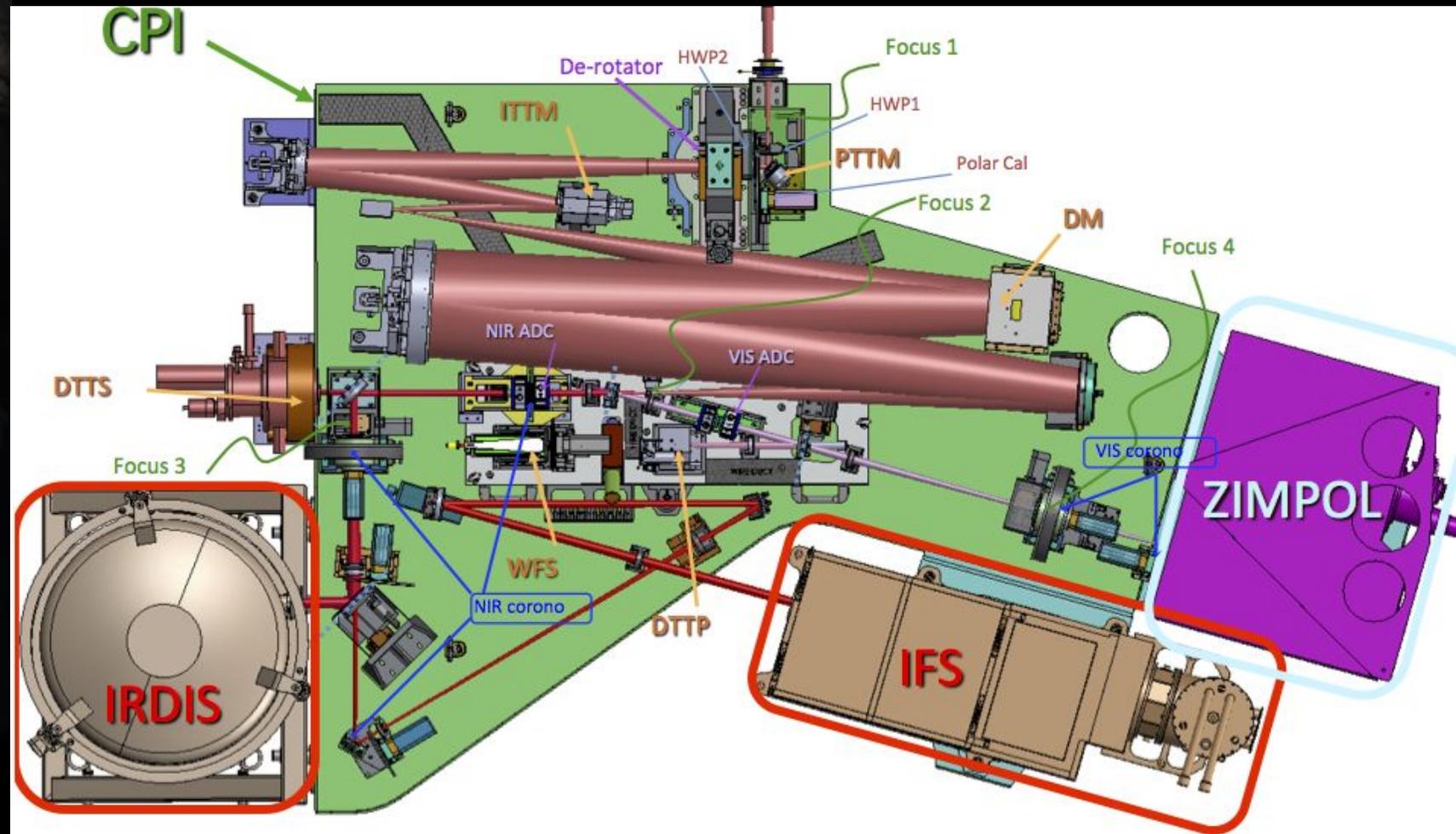
# Studying Exoplanets with *Direct Imaging*

1. Coronagraphy
2. Adaptive Optics



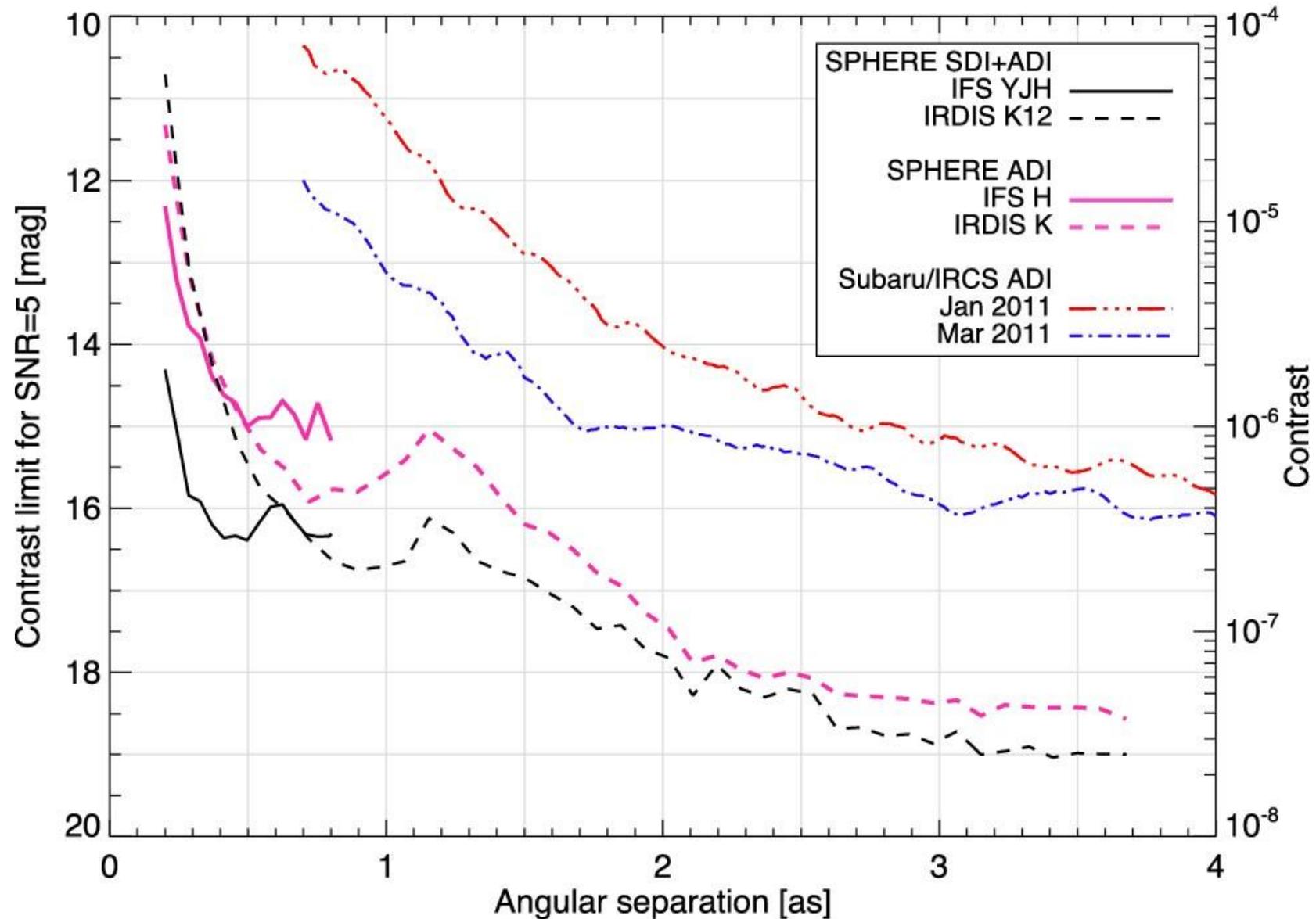
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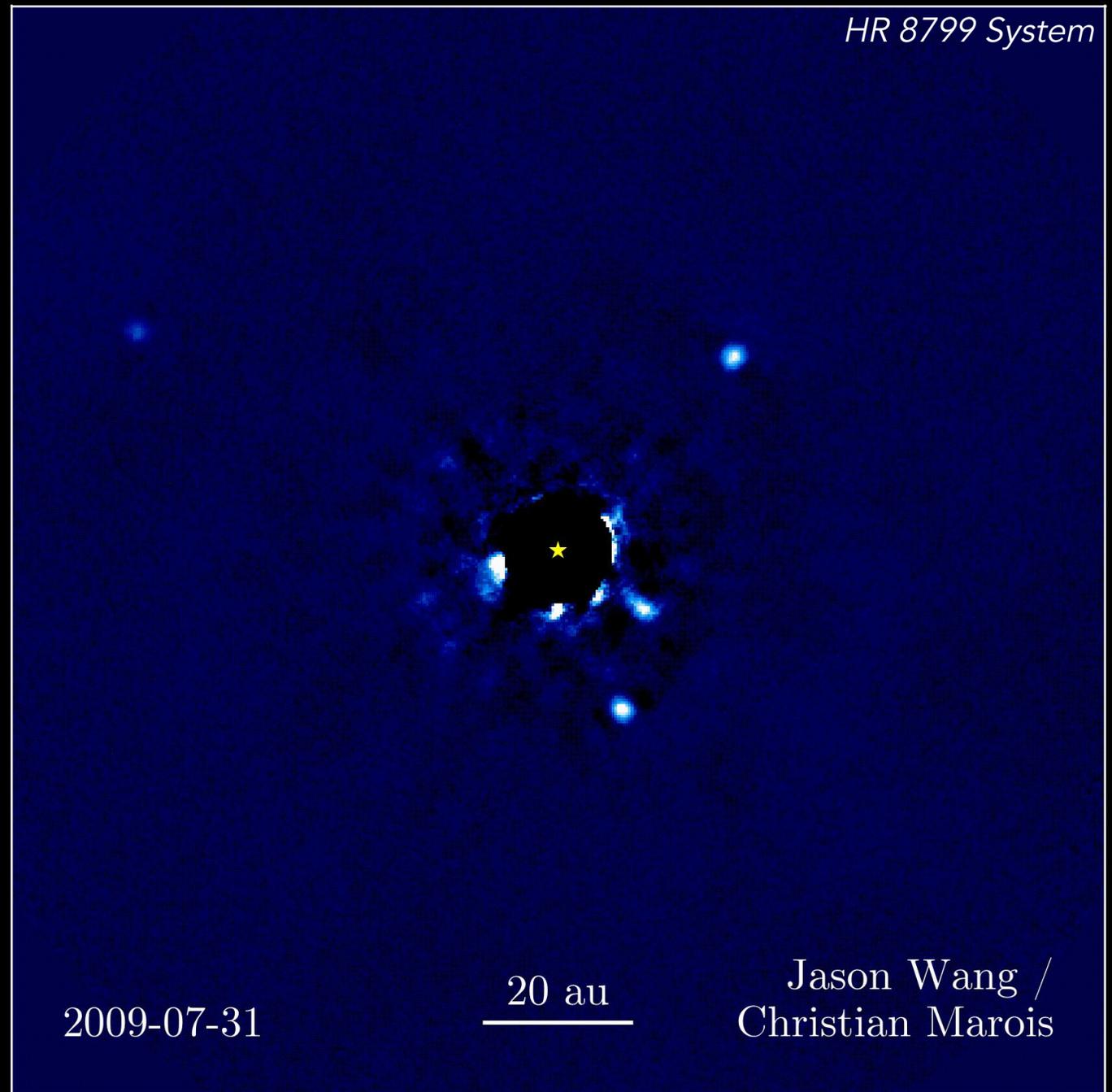
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# Studying Exoplanets with *Direct Imaging*

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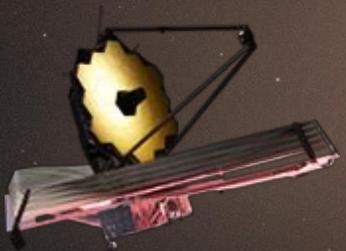
1. Coronagraphy
2. Adaptive Optics
3. Operation in Space

blocked starlight



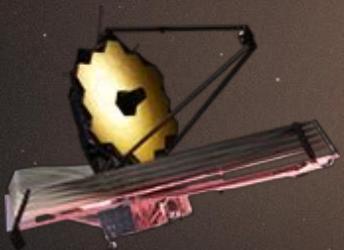
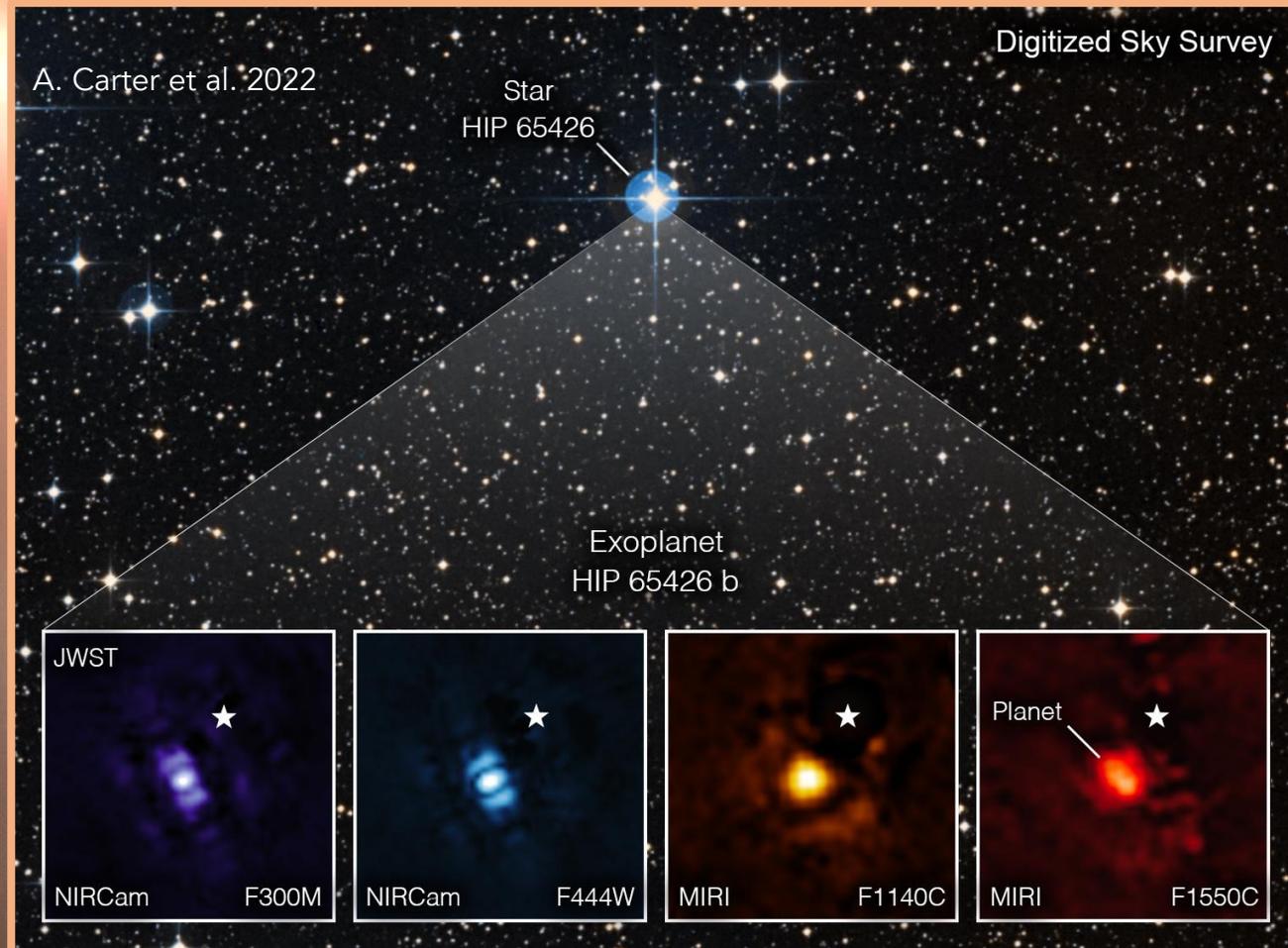
PDS 70b

JWST:  
Access to Young Giant Planets



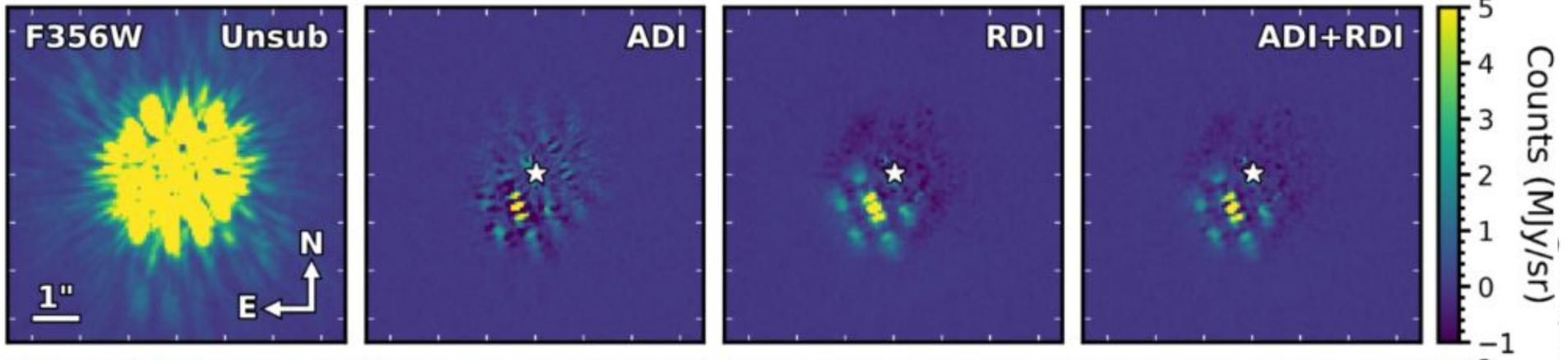
*Artist's conception*

# JWST: Access to Young Giant Planets



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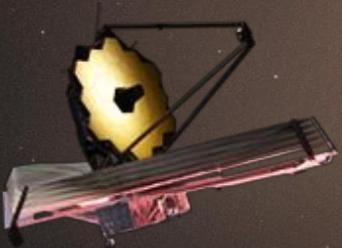
A. Carter et al. 2022



Angular  
Differential  
Imaging

Reference  
Differential  
Imaging

Both!



# JWST: Guaranteed Time Observation Program 1184



## The Team

Charles Beichman (Co-I)

Jarron Leisenring (Co-I)

Michael Meyer (Co-I)

Marie Ygouf (Co-I)

Tom Barclay

Ell Bogat\*

Geoff Bryden

Per Calissendorff

Mattew De Furio

Tyler Groff

Kellen Lawson\*  
*\*Early career folks leading data analysis*

Michael McElwain

# JWST: Guaranteed Time Observation Program 1184



A JWST NIRC  
Cam  
Coronagraphic  
Imaging Survey of  
Nearby, Young M Dwarfs

RED GIANTS

# The Sun's cool neighbors

A HERTZSPRUNG-RUSSELL (H-R) diagram of our stellar neighborhood skews heavily to the cool, red M stars. More than two-thirds of our Sun's neighbors fall into this category. At the other end of the spectrum, we have no hot O and B stars in the neighborhood, and only one A star. *Astronomy: Roen Kelly*

Bright stars  
↑  
Luminosity  
↓  
Dim stars

Sirius A

Procyon A

Alpha Centauri A

Sun

Tau Ceti

Alpha Centauri B

Epsilon Eridani

Epsilon Indi A

61 Cygni A

61 Cygni B

AX Microscopium

Lacaille 9352

GX Andromedae

Kapteyn's Star

Lalande 21185

Gliese 725 A

Kruger 60 A

Wolf 1061

Gliese 1

Gliese 687

Gliese 674

Ross 154

Gliese 725 B

Luyten's Star

GQ Andromedae

Ross 780

Barnard's Star

Ross 128

Kruger 60 B

YZ Ceti

Ross 614 A

TZ Arietis

EZ Aquarii A

UV Ceti

Proxima Centauri

Ross 248

Gliese 1061

Gliese 1245 A

Wolf 424 A

Gliese 1002

BL Ceti

Wolf 359

Gliese 1245 B

DX Cancri

LHS 292

SO 0253-1652

SCR 1845-6357

DEN 1048-3956

Epsilon Indi B

Epsilon Indi C

WHITE DWARFS

Sirius B

Van Maanen's Star

Procyon B

WD 1142-645

Surface temperature (kelvins)

30,000

20,000

10,000

5,000

2,500

1,000

O5

B0

B5

A0

A5

F0

F5

G0

G5

K0

K5

M0

M5

L0

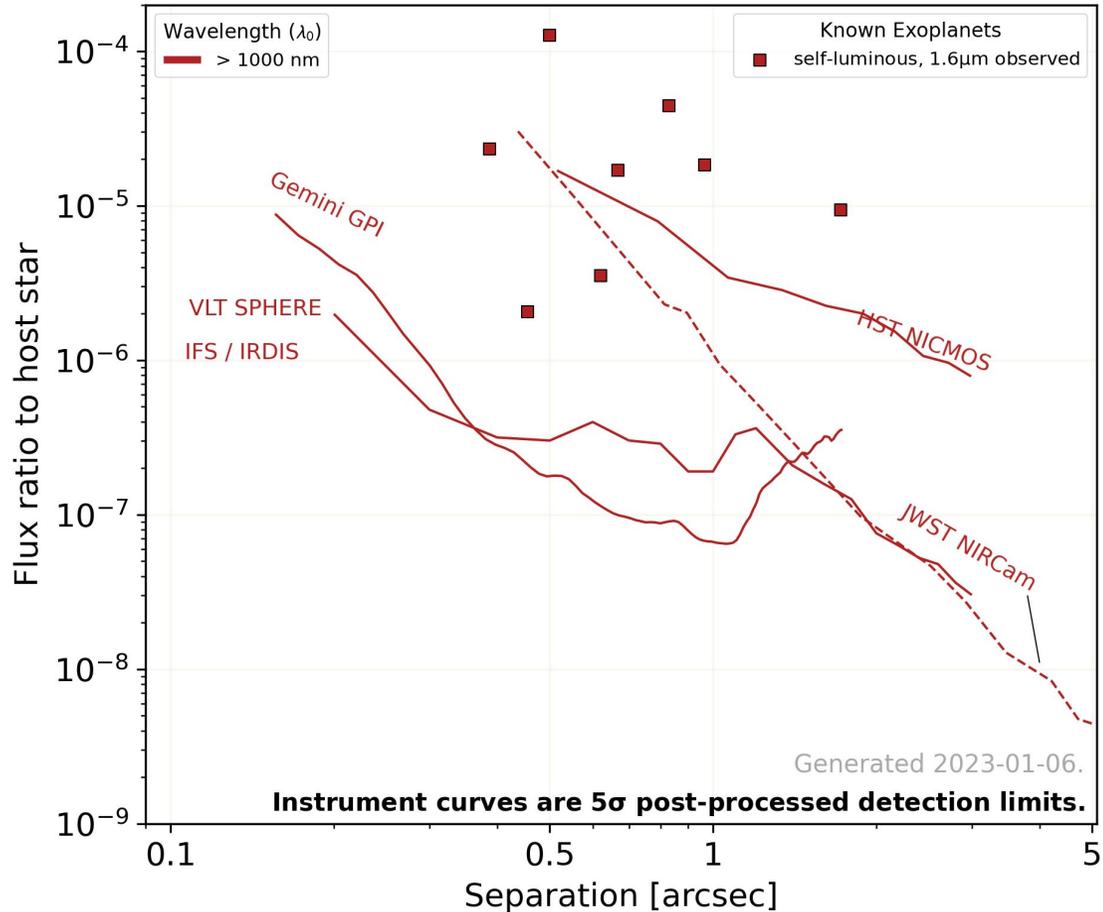
L5

T0

T5

# JWST: Guaranteed Time Observation Program 1184

Direct-imaging Instrument Contrast Curves (assuming infinite integration time)

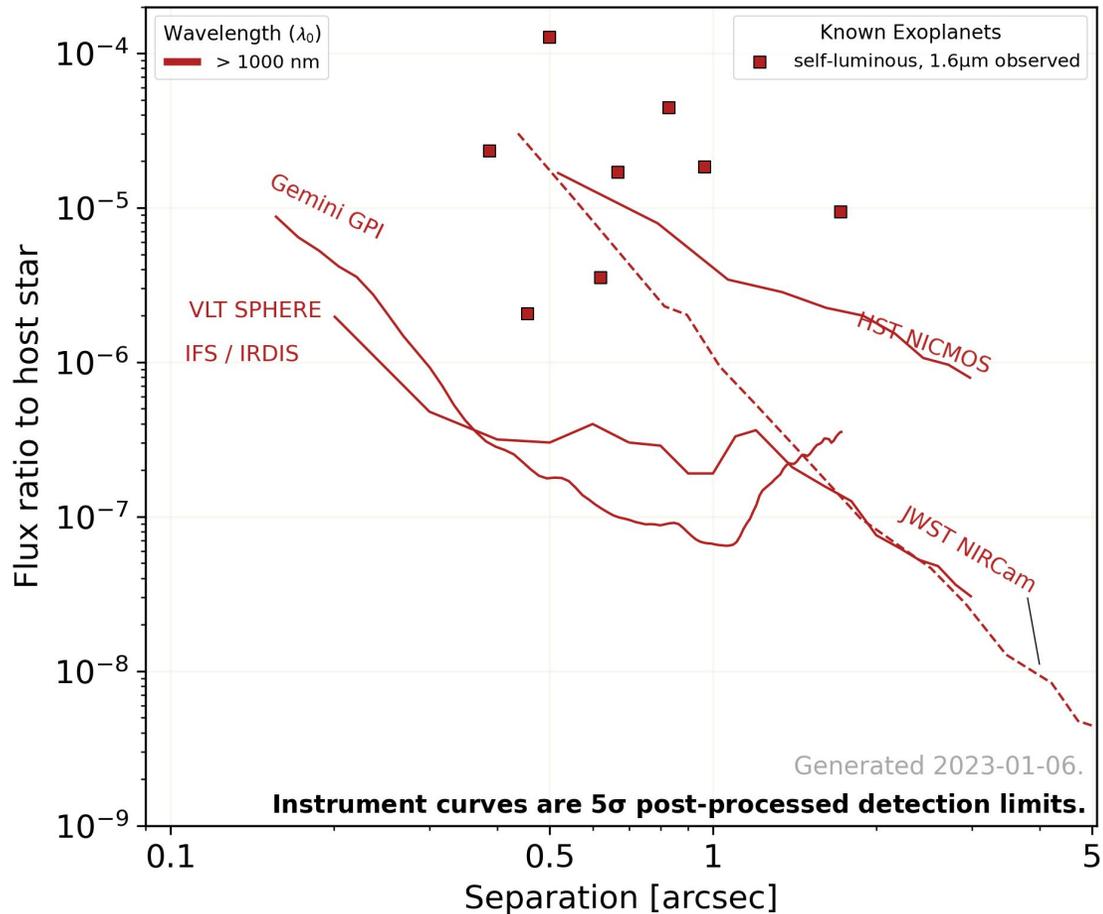


<https://github.com/nasavbailey/DI-flux-ratio-plot>



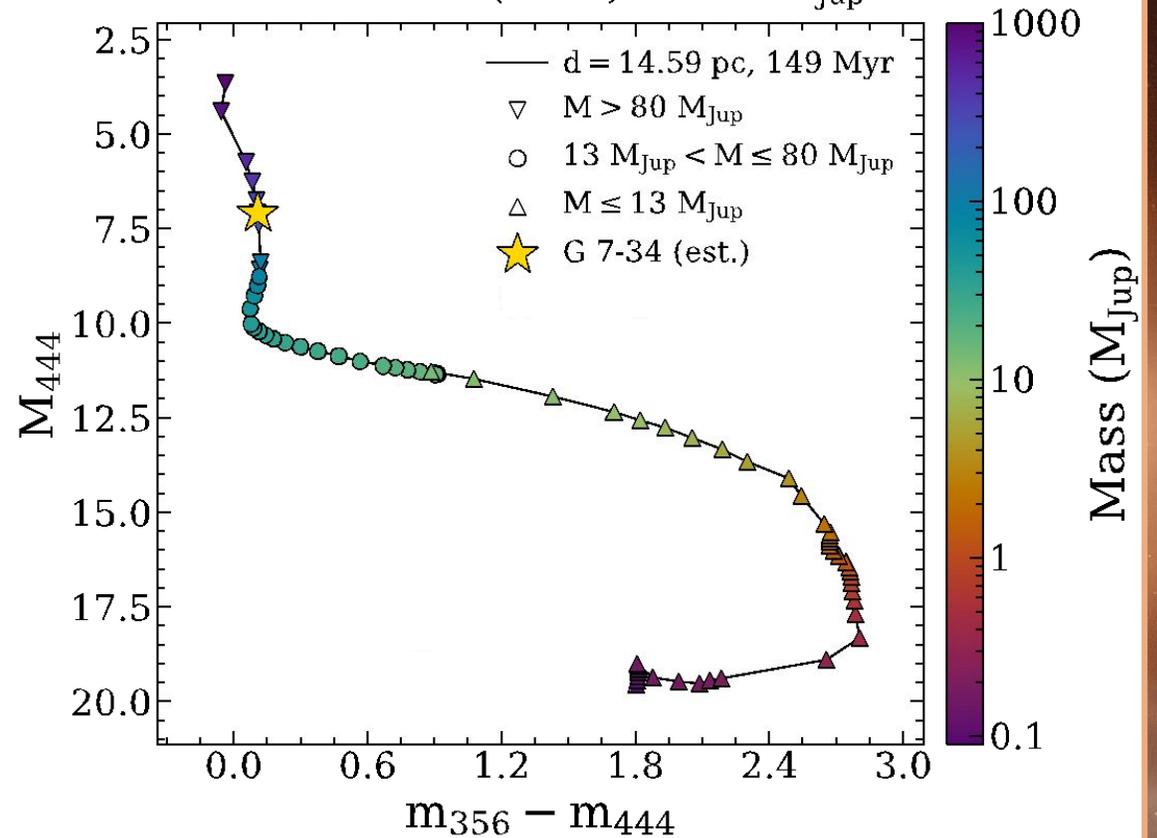
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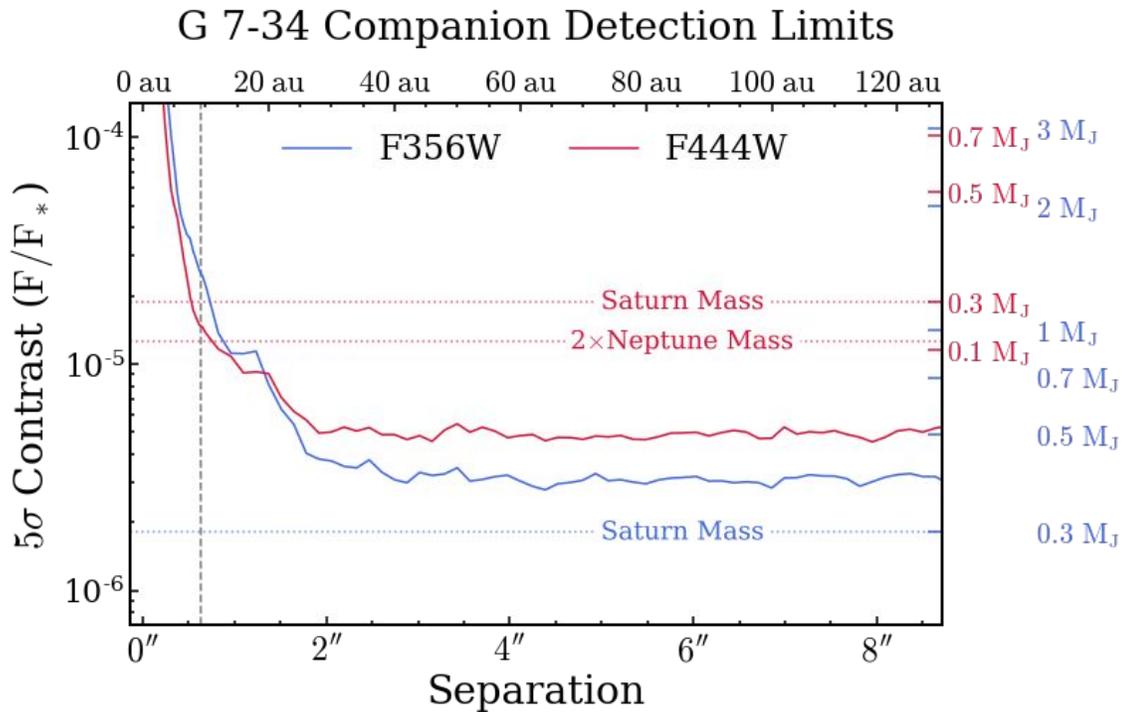
<https://github.com/nasavbailey/DI-flux-ratio-plot>

AMES-Cond:  $M \geq 2 M_{\text{Jup}}$   
 Linder et al. (2019):  $M < 2 M_{\text{Jup}}$

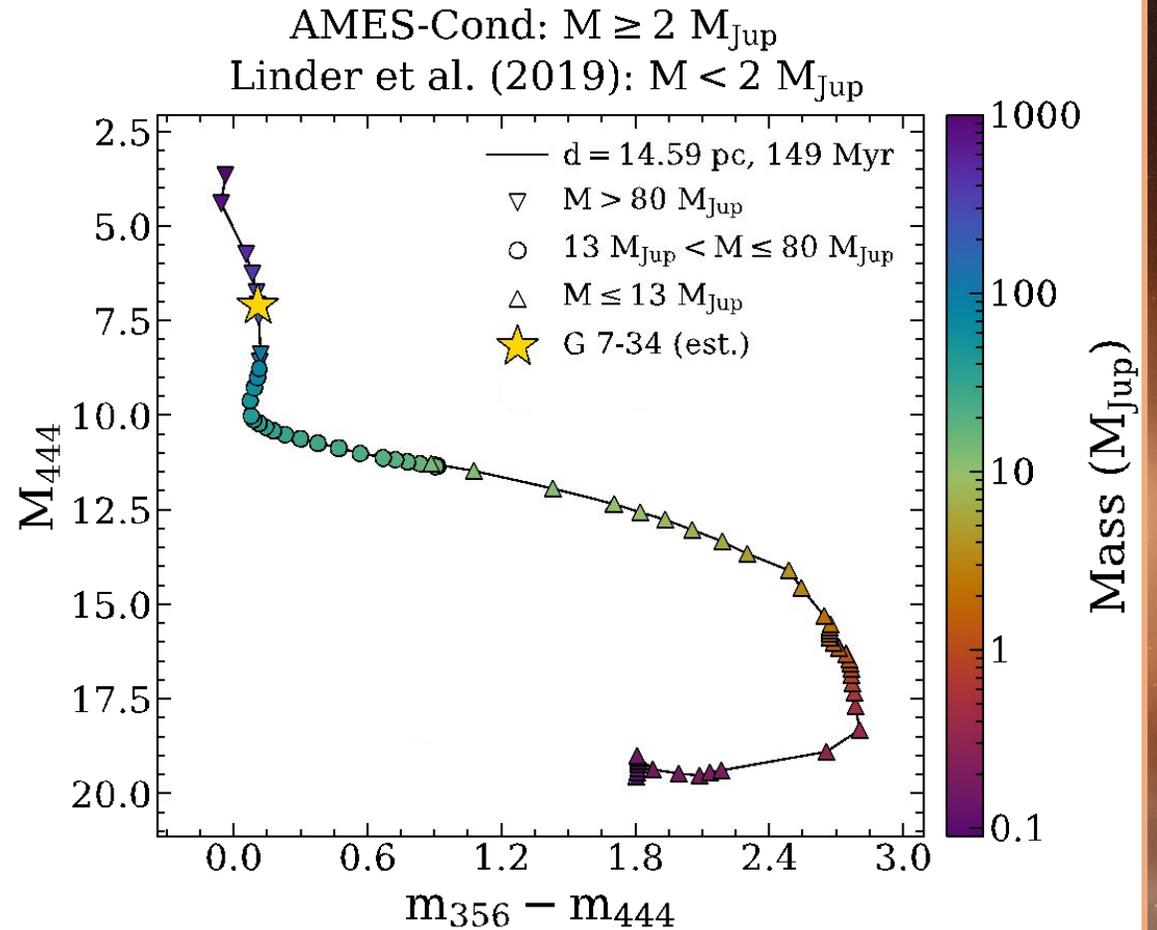


K. Lawson

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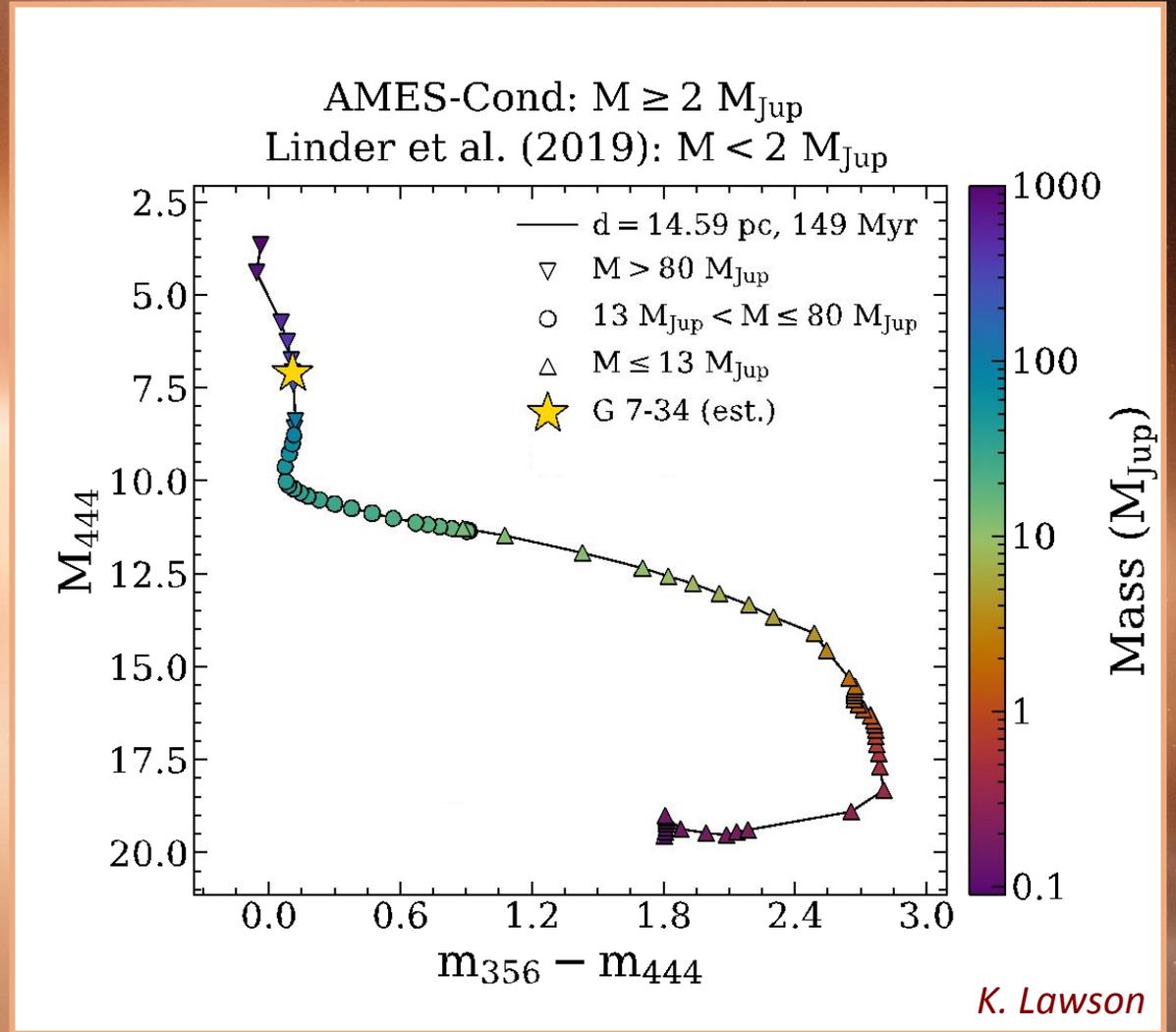
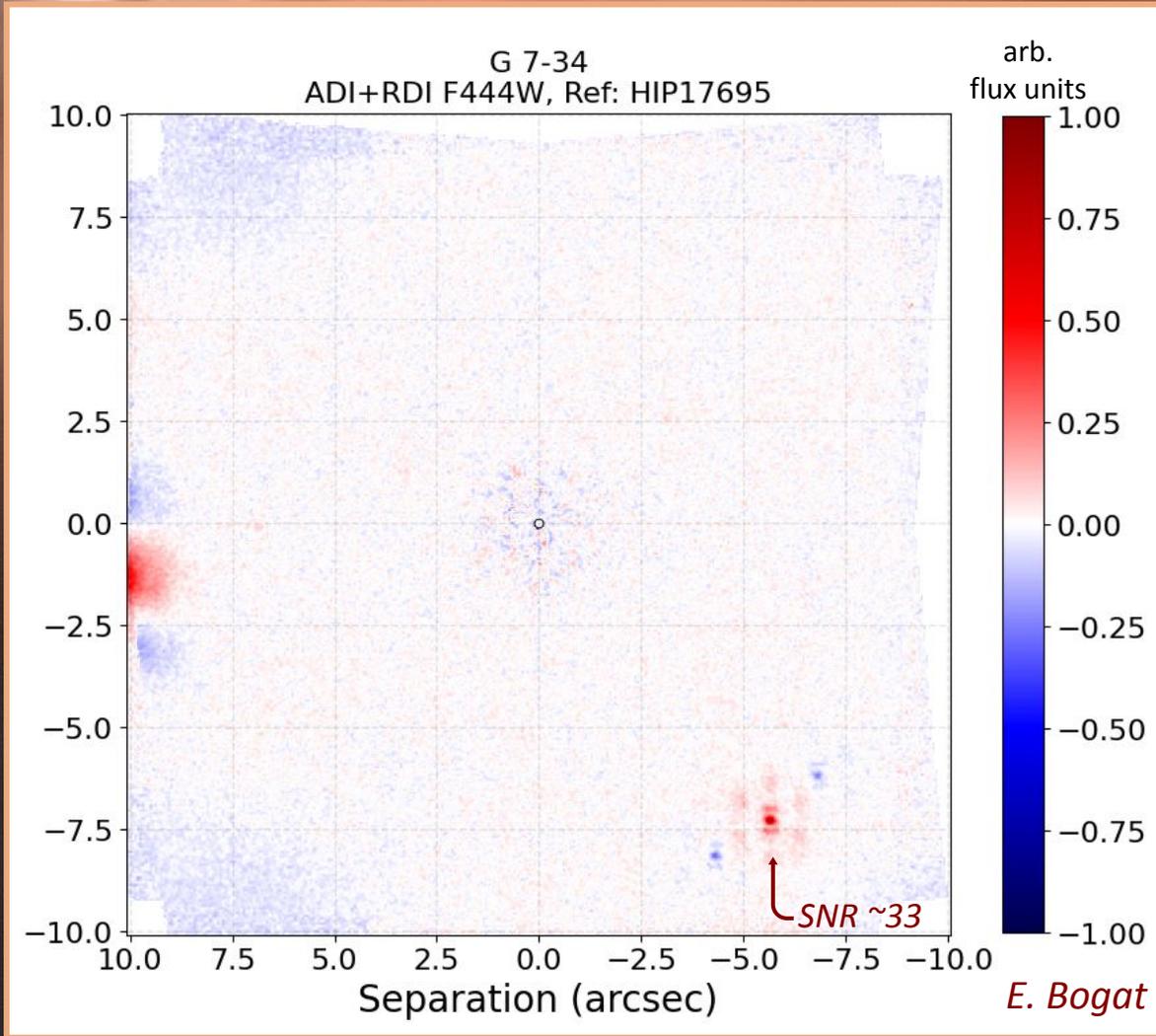


K. Lawson

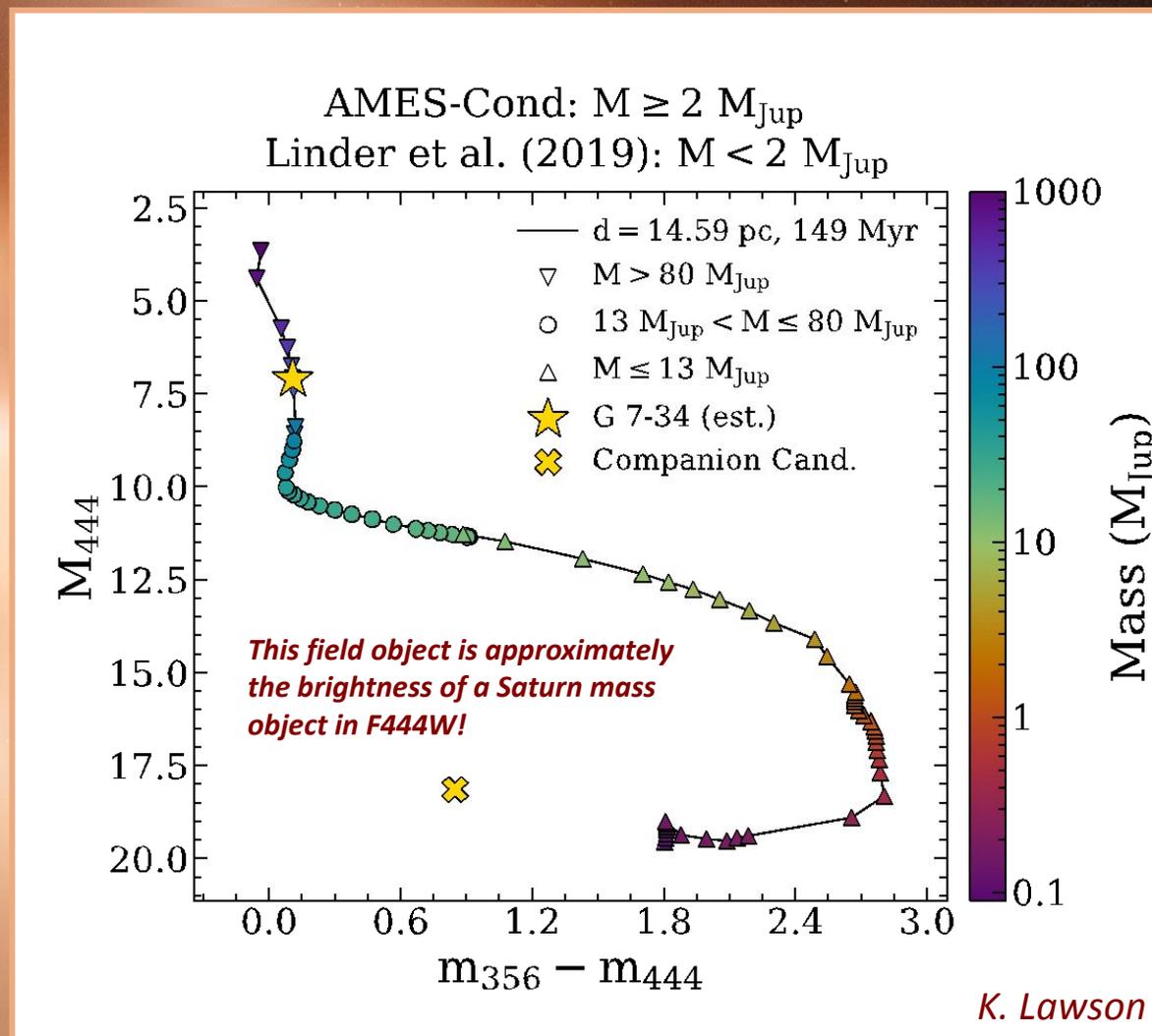
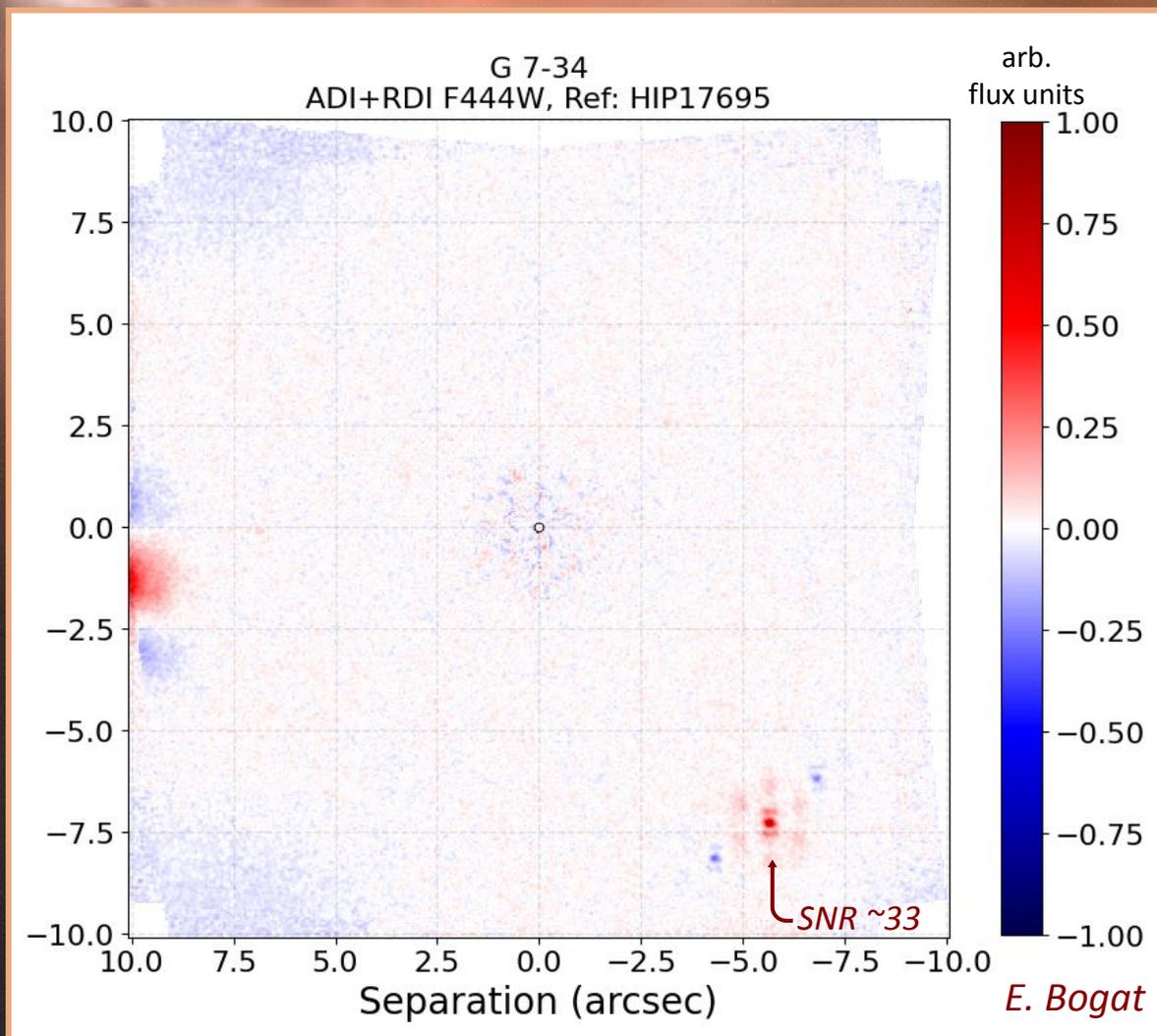


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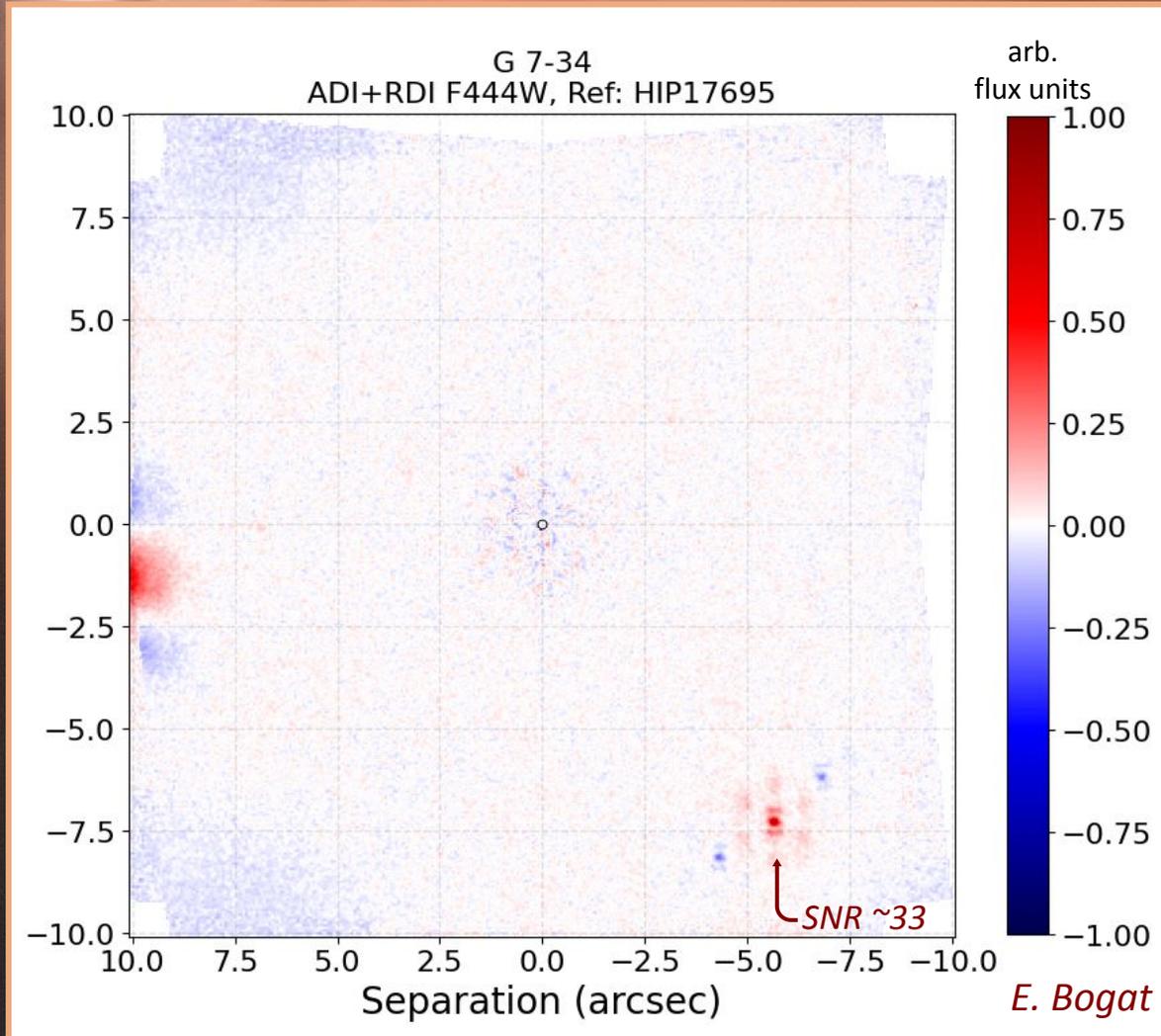
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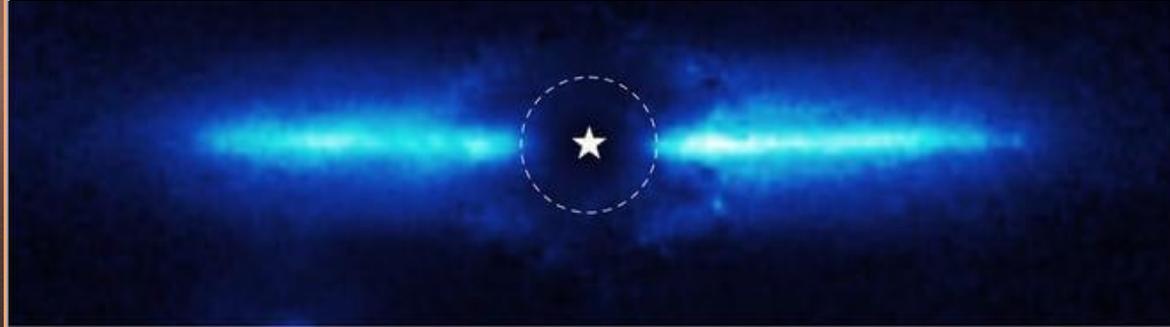
## Summary

- Sensitivity to **sub-Saturn mass planets** on wide orbits around nearby, young M dwarfs
- **No obvious companions** (Jupiter+ mass or brown dwarfs) detected
- Continuing analysis of dimmest sources and possible **demographics limits**
- **AU Mic disk detected** in 3-5 microns for the first time!
  - Look out for Lawson et al. 2023

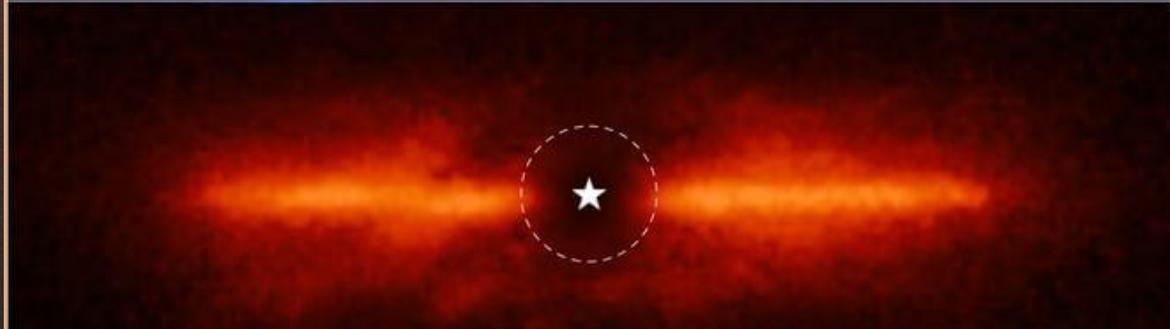
# JWST: Guaranteed Time Observation Program 1184

AU Microscopii

F356W



F444W

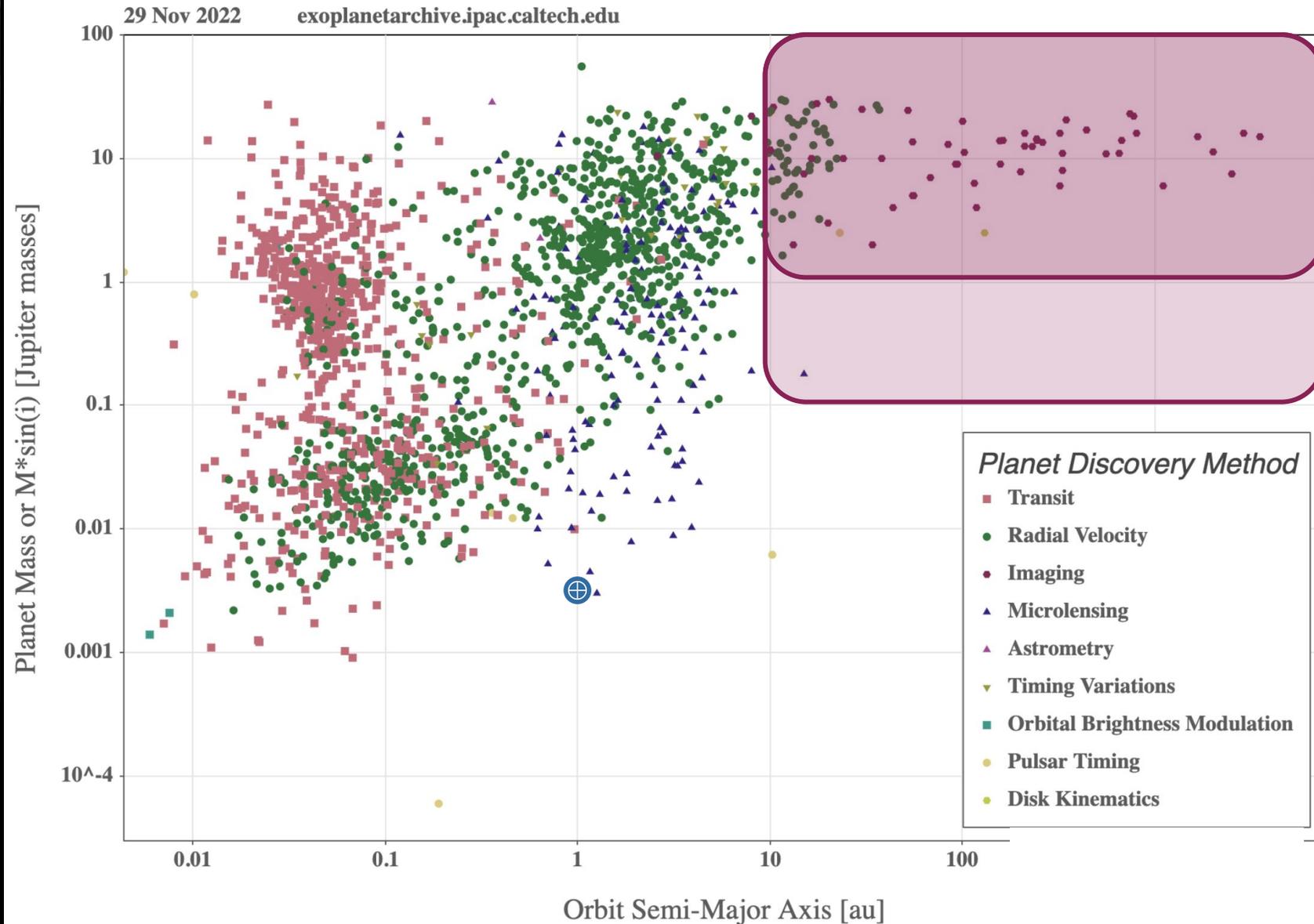


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ROMAN:  
Access to Mature Exo-Jupiters



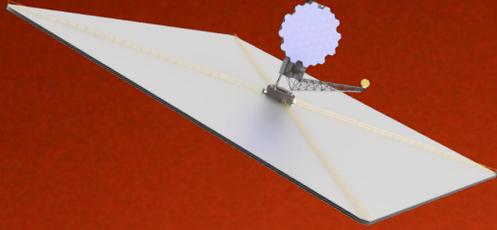
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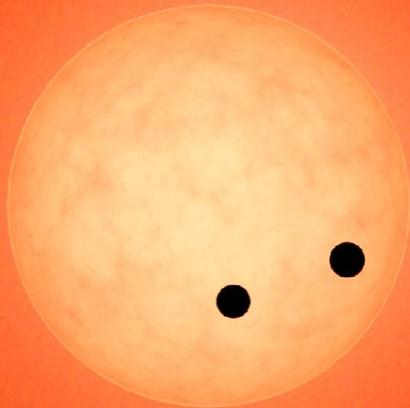


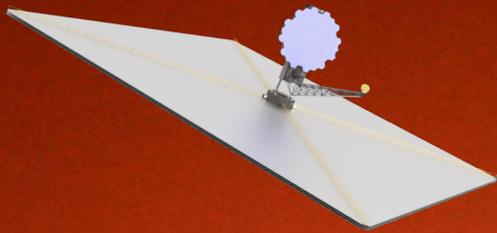
Preliminary imaging simulation  
Sun-like star at 3 parsecs  
Warm Jupiter at 2 AU

M. Rizzo / N. Zimmerman (NASA GSFC)

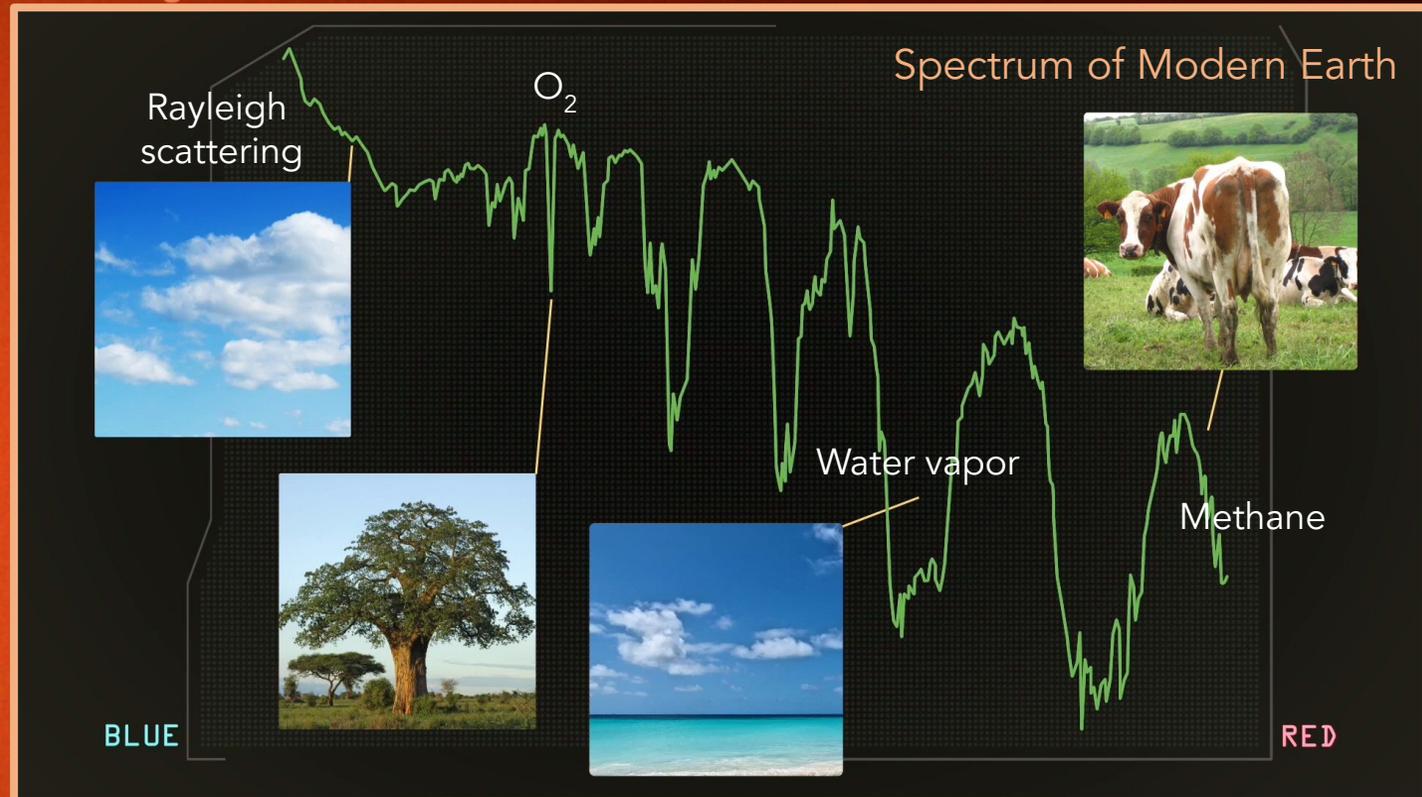
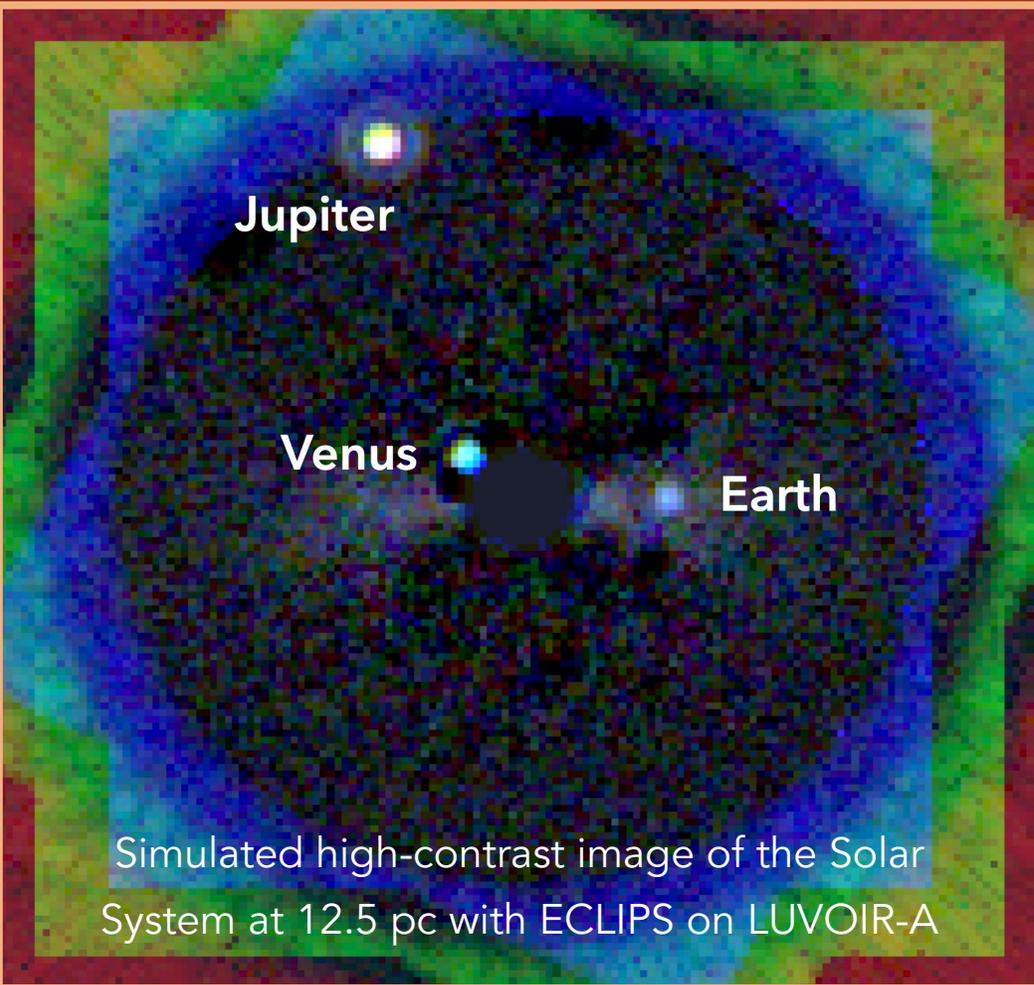


# Habitable Worlds Observatory: Access to Exo-Earths

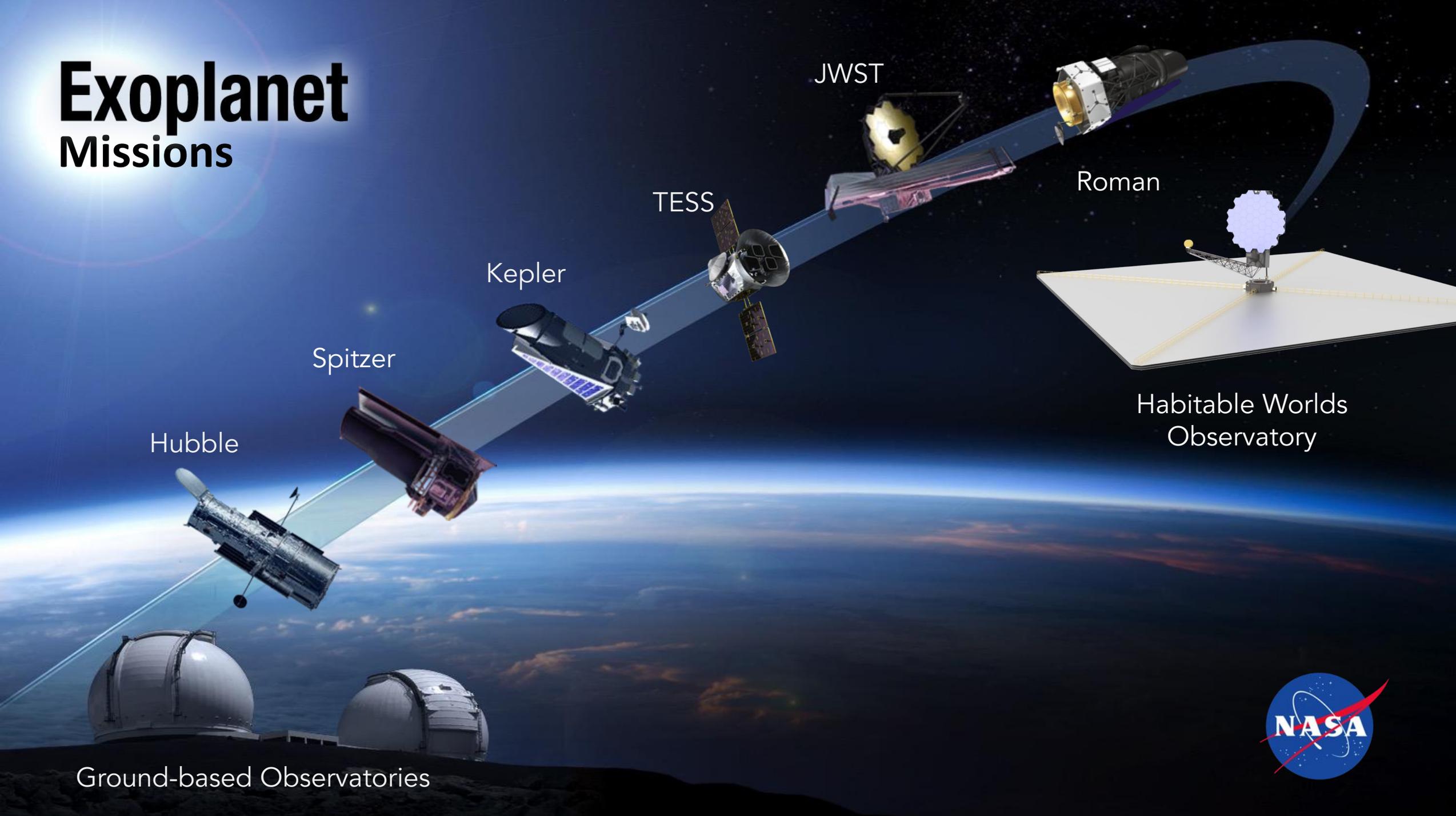




# Habitable Worlds Observatory: Access to Exo-Earths



# Exoplanet Missions



JWST

TESS

Kepler

Spitzer

Hubble

Roman

Habitable Worlds  
Observatory

Ground-based Observatories

