The Observing Accelerators with SCExAO Imaging Survey (OASIS): First Results

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El Morsy, Currie, et al. 2024, Proc. SPIE, 13097, id. 130977I; arxiv:2409.06773

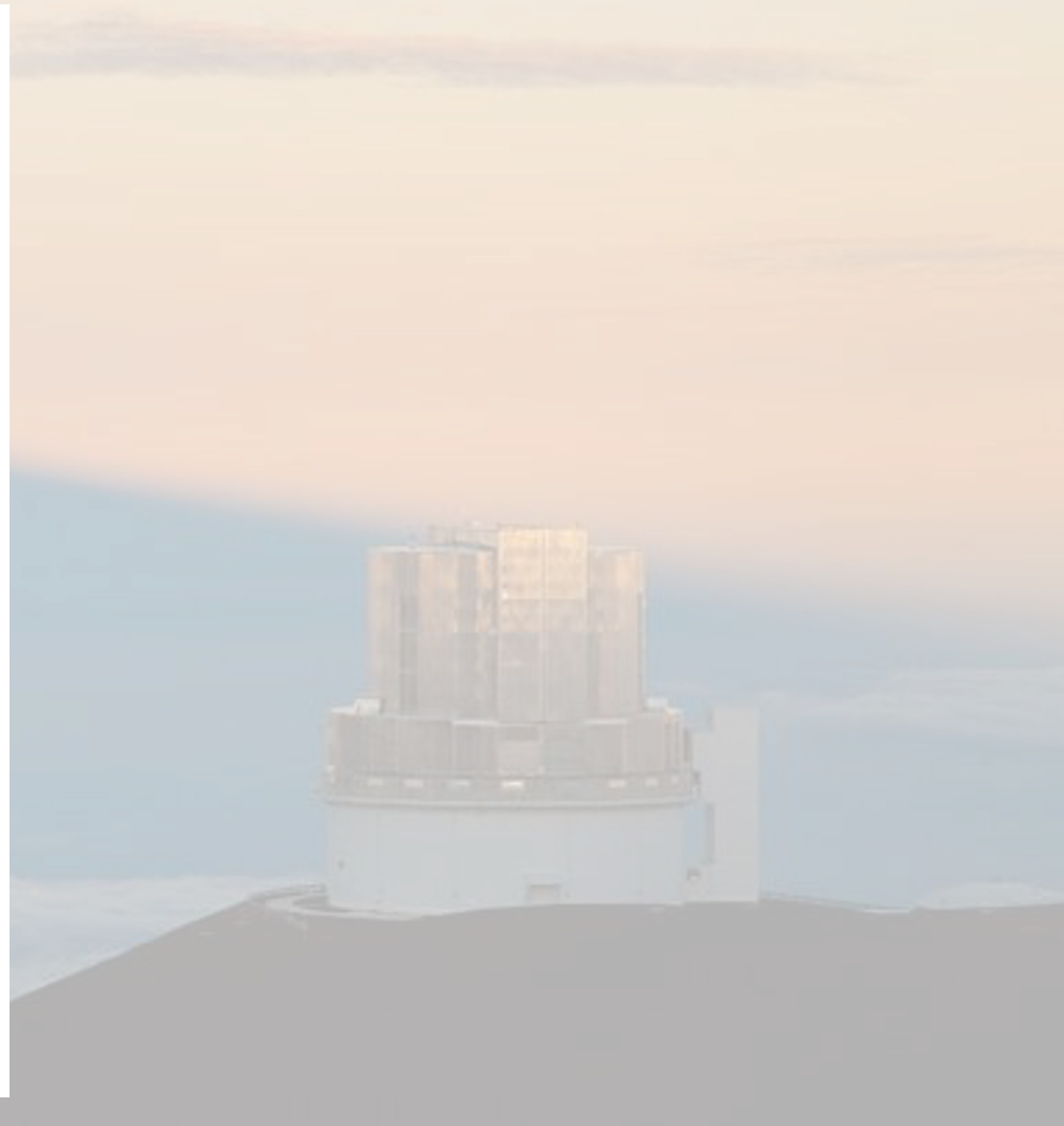
Outline

- Motivation, Basic Program Design, and Proof of Concept

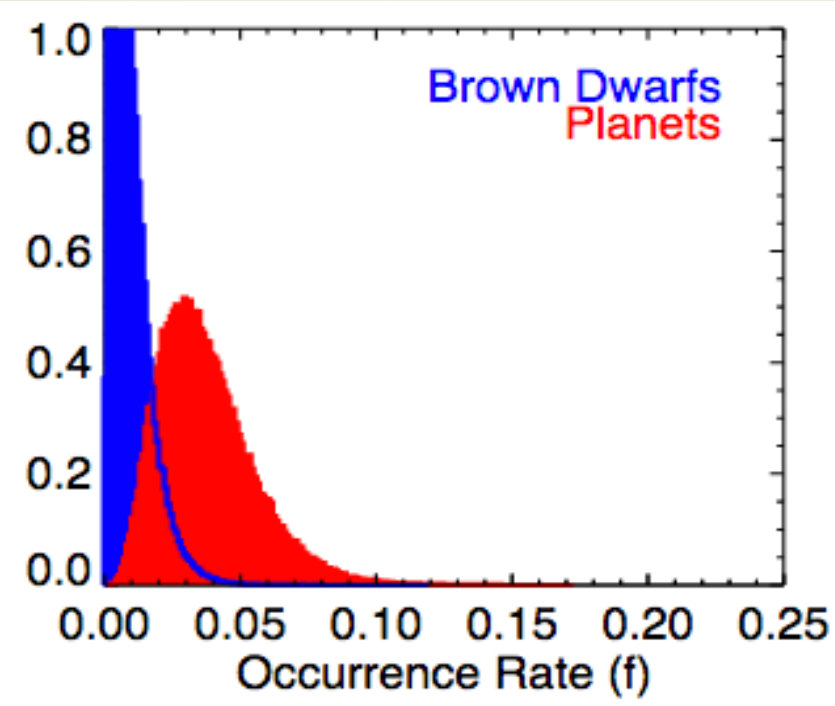
- First Results
  -a new planet!
  -a new brown dwarf/Roman CGI tech demo target

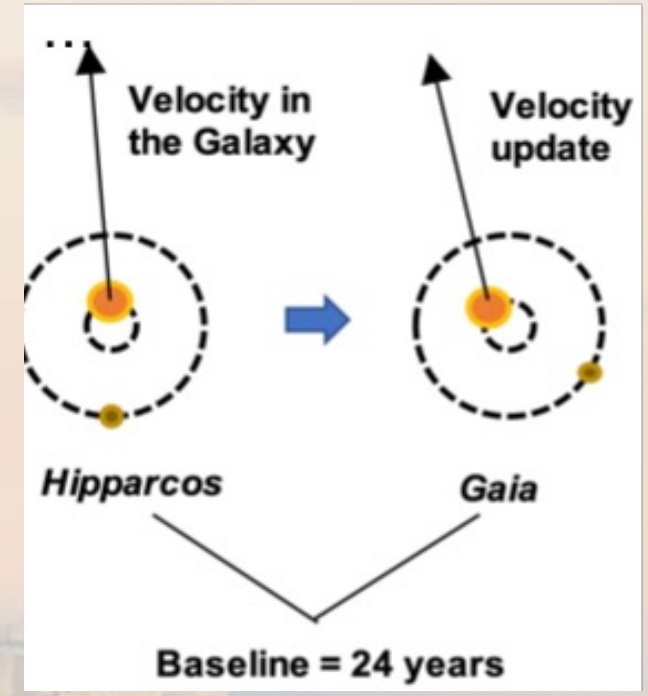
- Follow-Up Plans

- Broad Scientific Goals and Outlook



Motivation and Basic Program Design





Previous Exoplanet Imaging Searches

- Large "unbiased/blind" surveys (e.g. GPIES, SPHERE/SHINE) few discoveries
- They yield limited knowledge of planet's orbit and mass

A New Kind of Exoplanet Direct Imaging Search

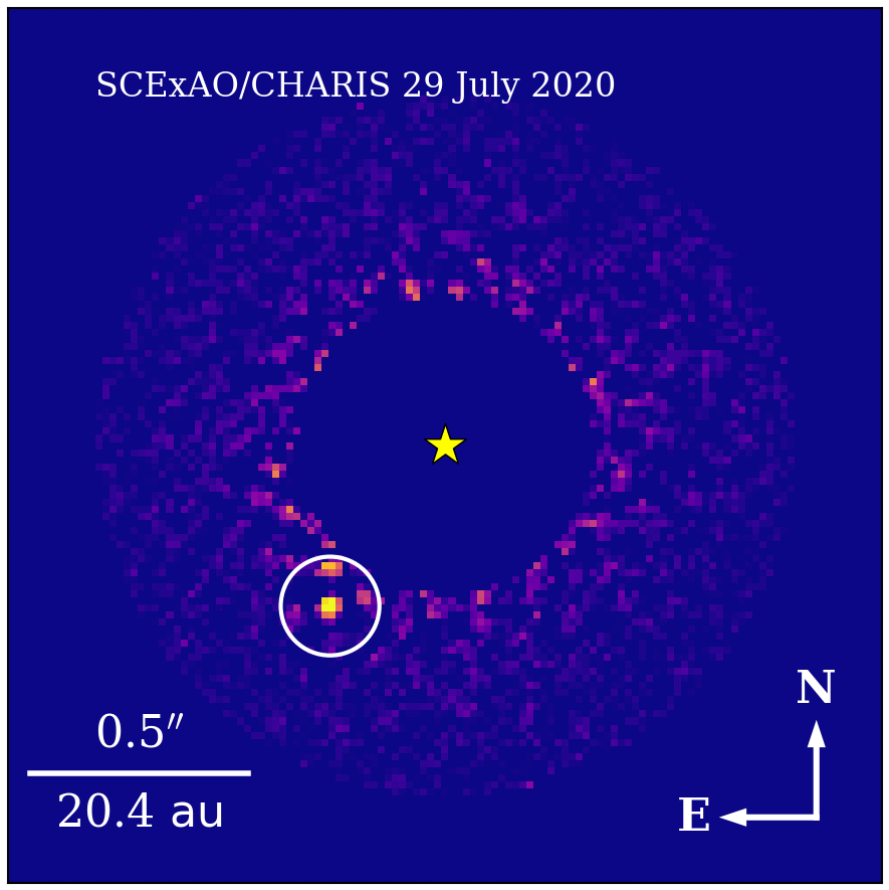
- Precision Astrometry from Gaia & Hipparcos Identifies Stars That Are Being Gravitationally Accelerated by An Unseen Companion
- Target accelerating stars that are young enough to have imageable planets

Nielsen et al. 2019 Brandt 2018, 2021

Accelerating Star Surveys: A Promising New Direction

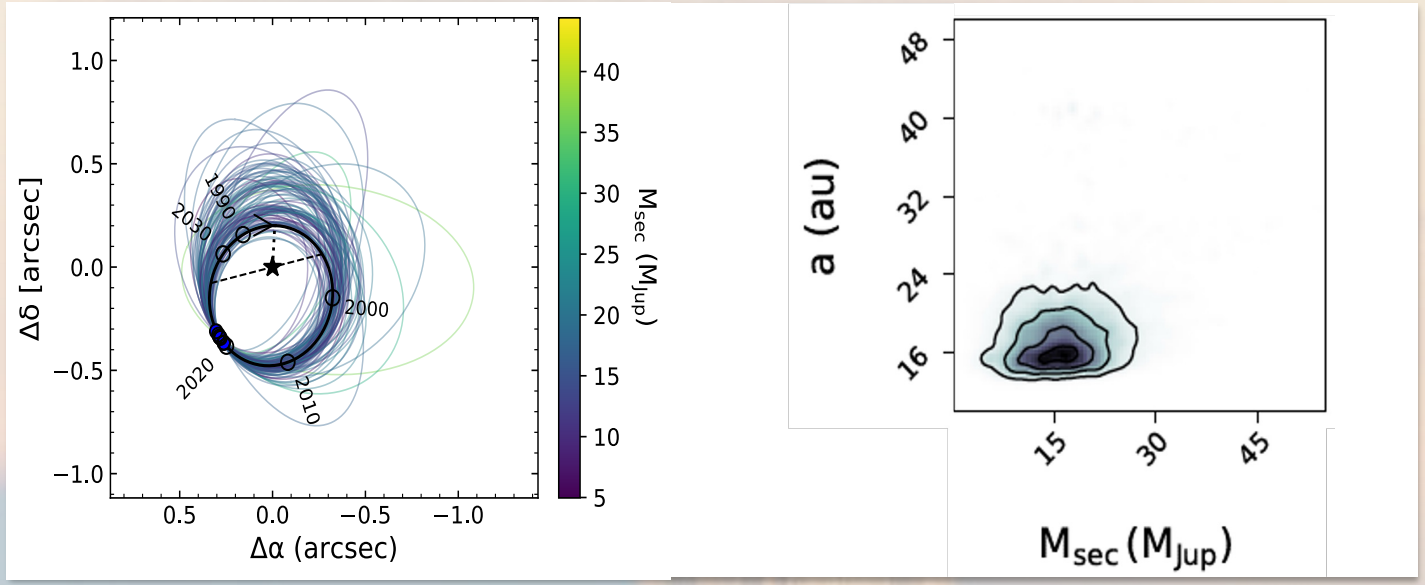
More Planet Discoveries

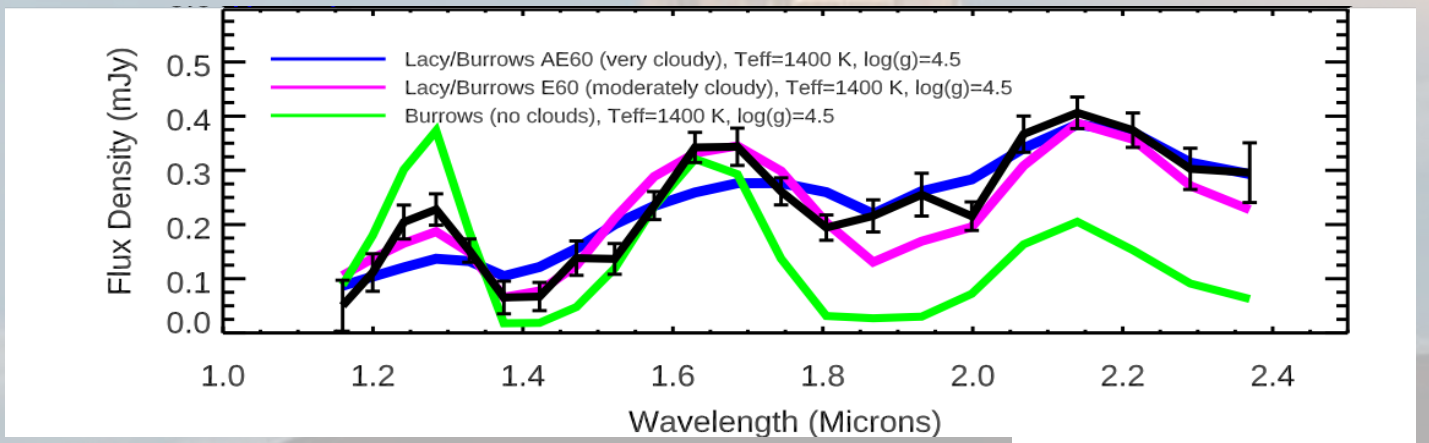
HIP 99770 b



Currie et al. 2023

Better Characterization





Currie et al. 2023

Observing Accelerators with SCExAO Imaging Survey (OASIS)

(PI. T Currie, Co-PI M. Kuzuhara)

Instruments

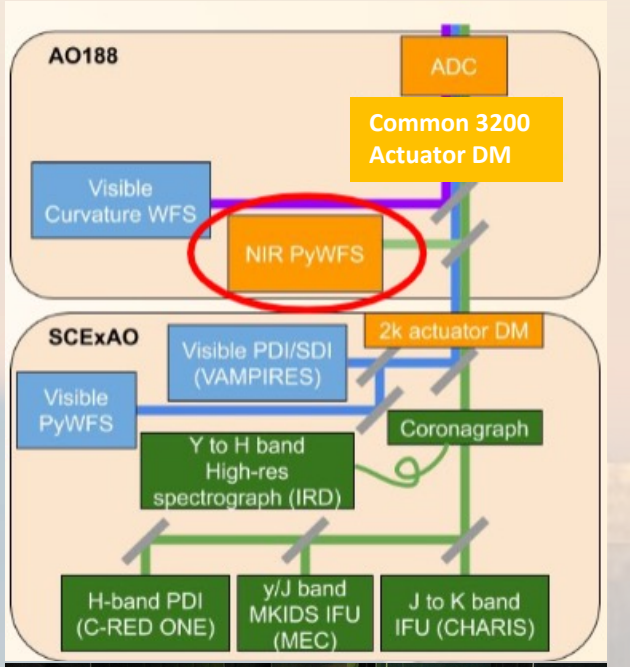
- Subaru: two-stage extreme AO system
  AO3k+SCExAO
  CHARIS IFS (1.1—2.4 microns)
  ~1e-6 contrast at 0.4”, ~1e-5 at 0.2”

- Keck/NIRC2 imaging at Lp (3.78 microns)

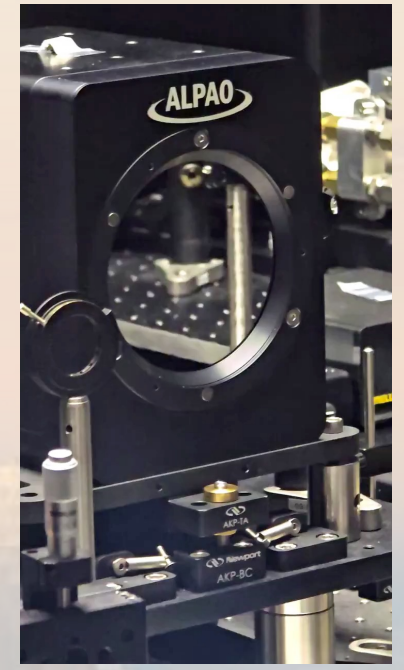
Allocation

- 42 nights (34 on Subaru, 8 on Keck) –

  this is the largest current exoplanet direct imaging search

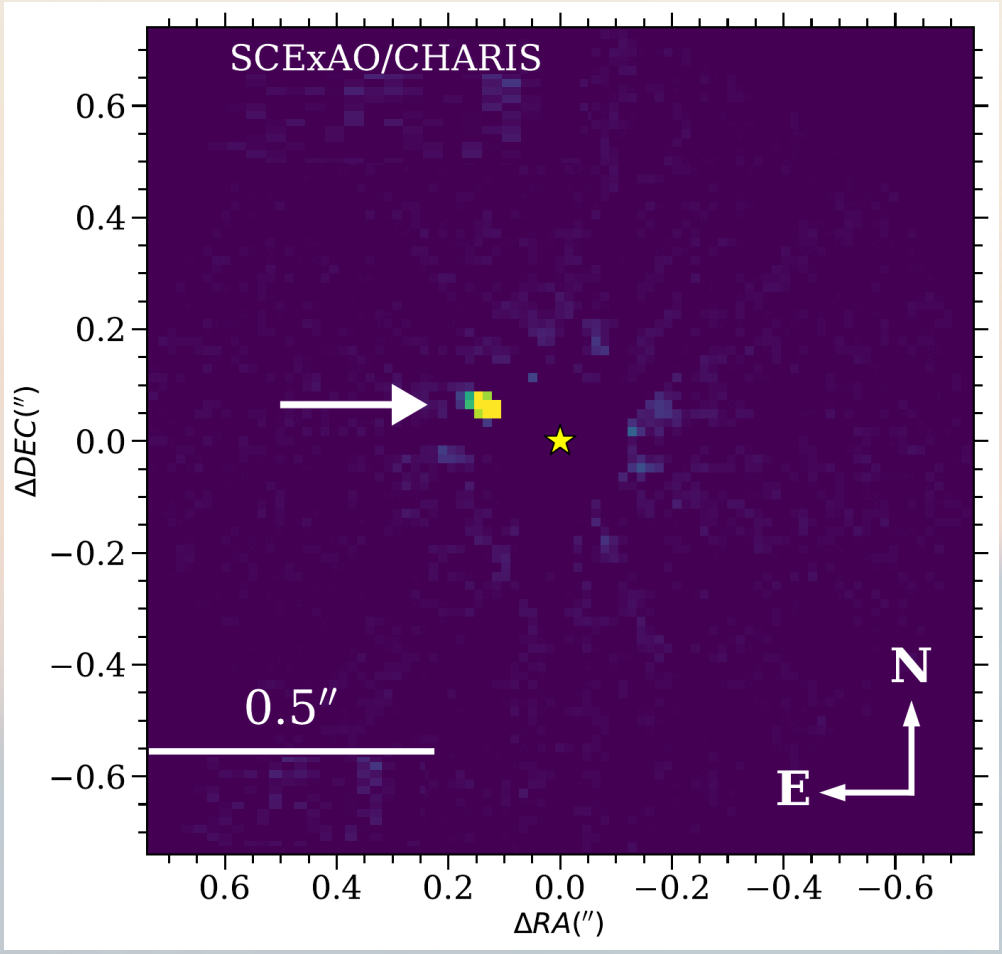


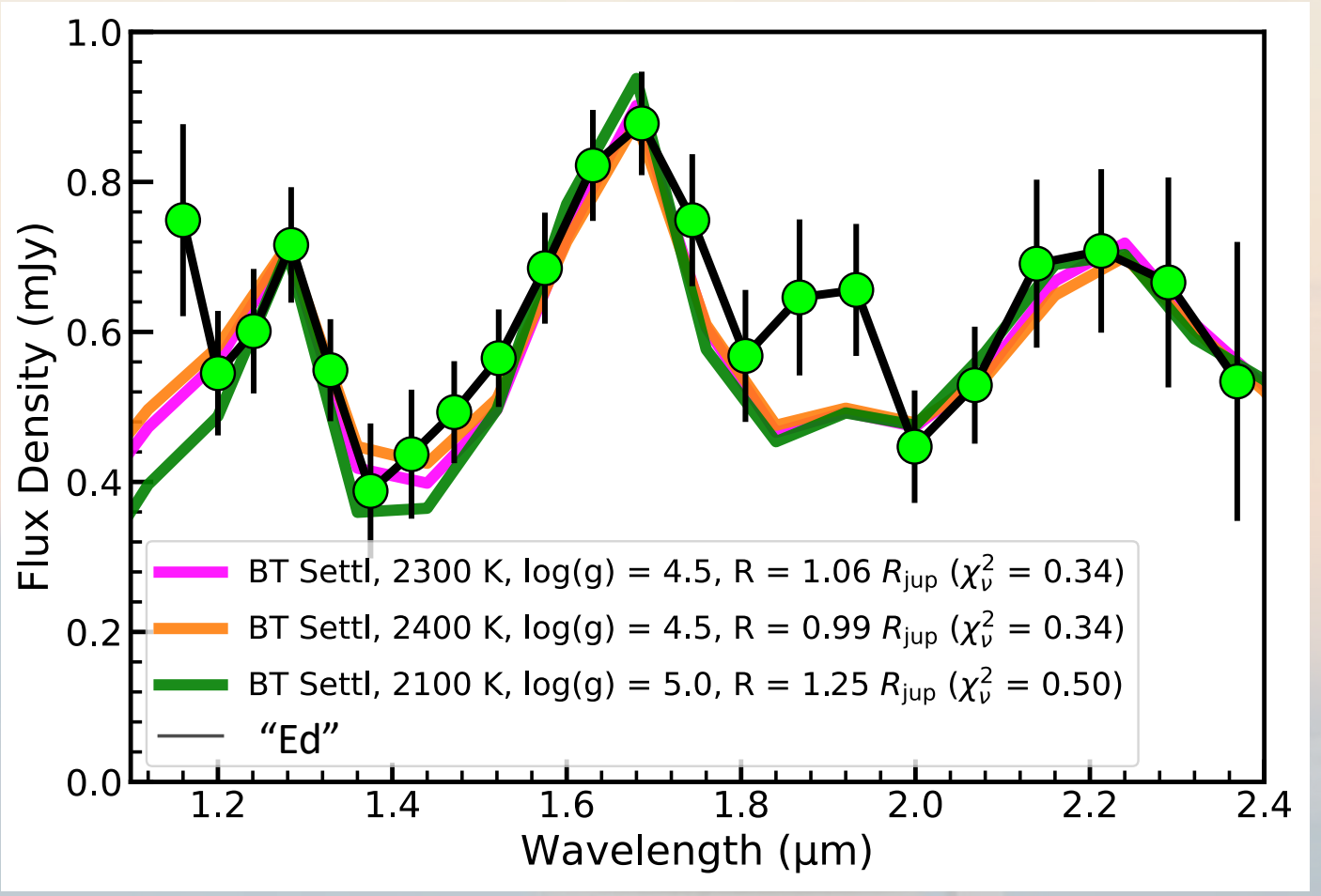
Credit: Maria Vincent (IfA)



Described in
El Morsy et al.
2024, SPIE

OASIS discovery #1 : A New Planet – HIP xxxxx b





Currie & Li et al. 2025, AJ accepted

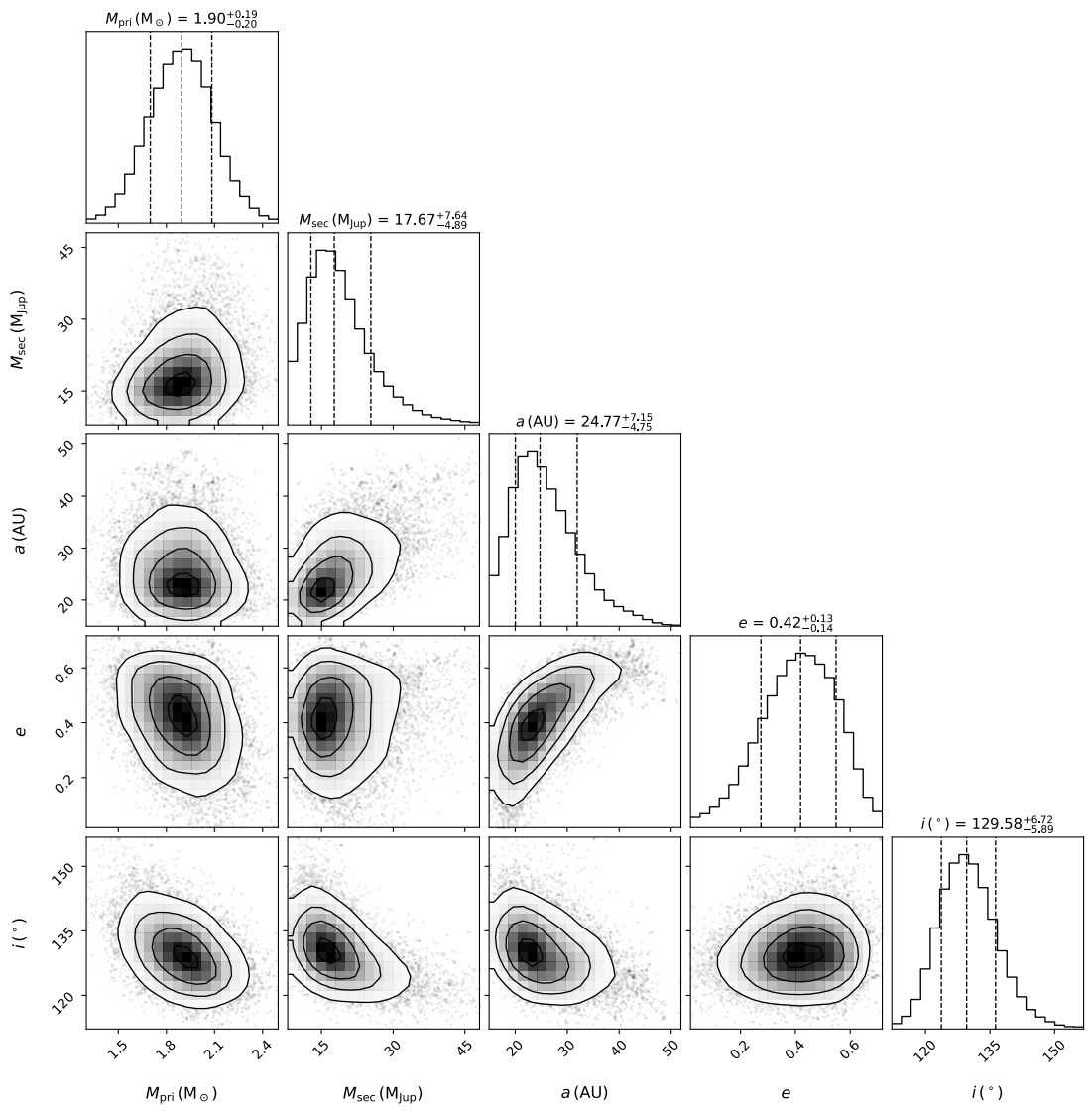
orbits a very young A star that has never been the subject of a planet search before

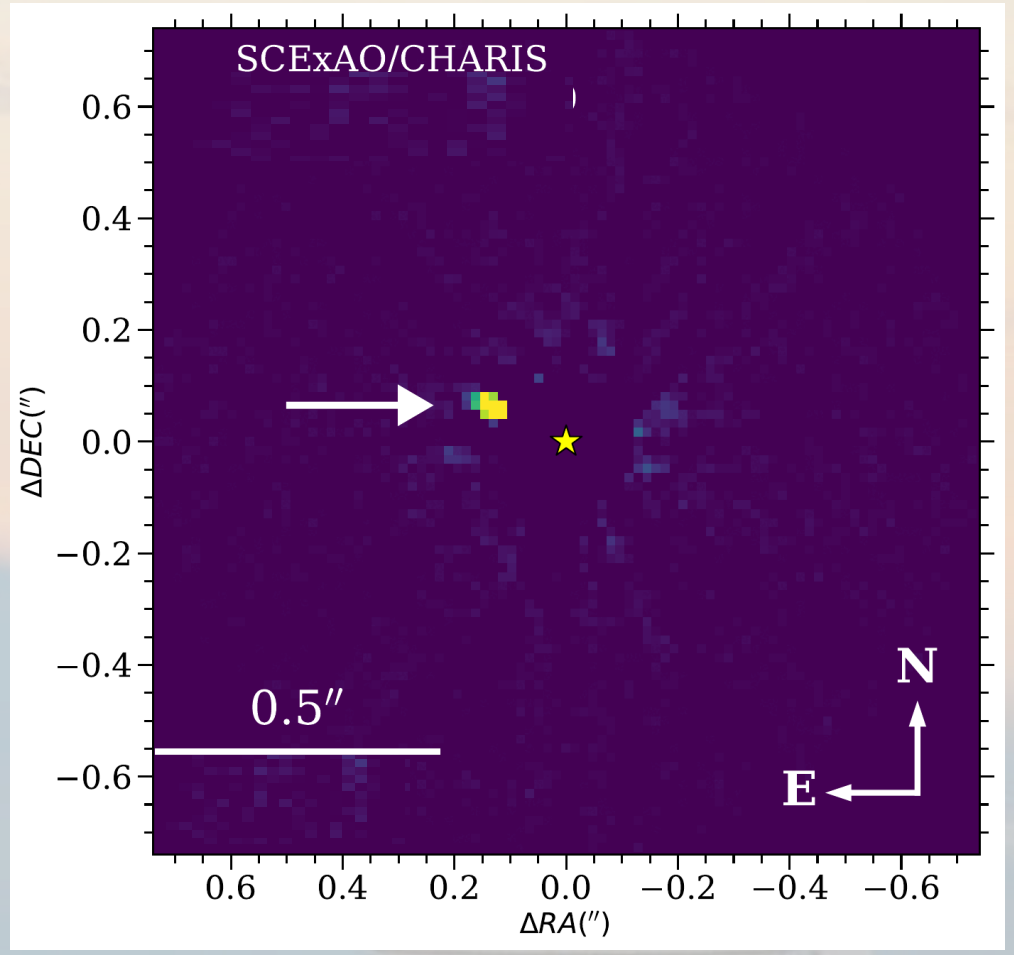
~3--4 lambda/D separation!

~2100-2400 K, M/L transition object

**TC dedicates this work to the recently departed Wallace Ishibashi Jr, former OMKS cultural monitor and friend

OASIS discovery #1 : A New Planet – HIP xxxxx b





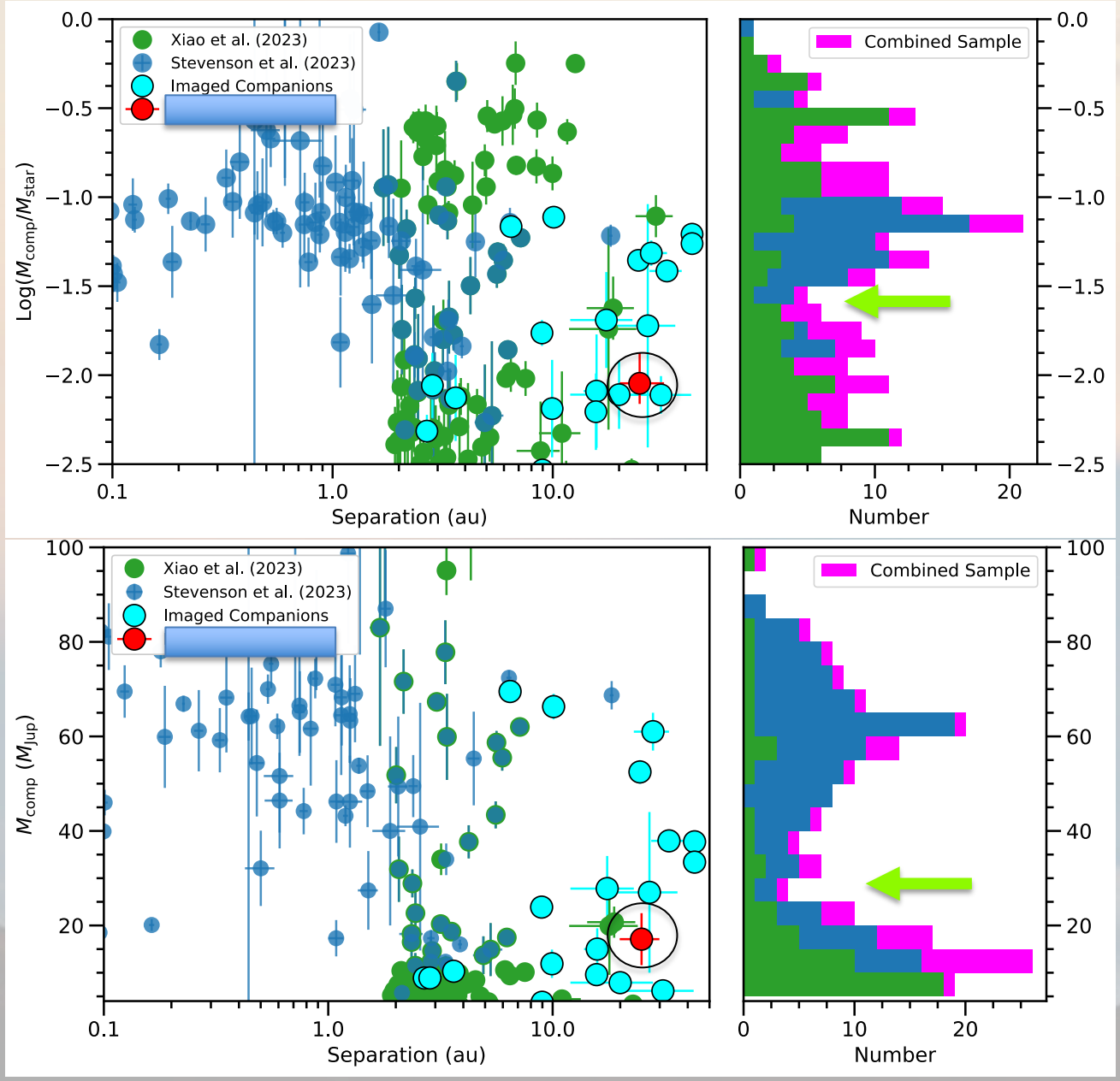
Currie & Li et al. 2025, AJ
resubmitted after minor revision

Mass: ~17.6 Mj

Mass ratio ~9e-3
(similar to HR 8799 cde, HIP 99770 b)

sma ~ 25 au, ecc ~ 0.4

HIP xxxx b: a planet, not a brown dwarf



Deuterium burning limit fails to distinguish between planets and brown dwarfs
e.g. see PPVII review
(Currie, Biller and Lagrange et al. 2023)

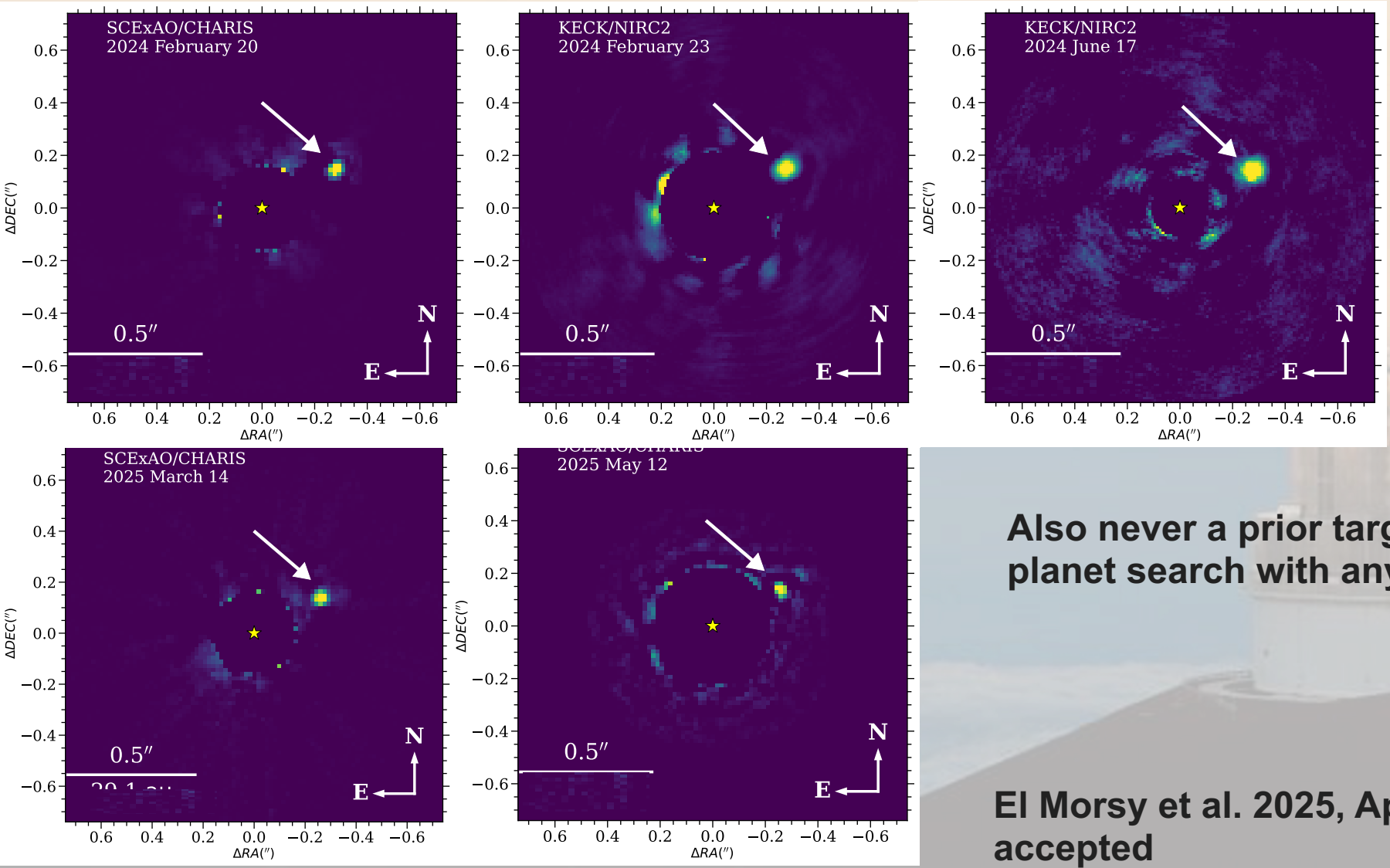
Demographics of substellar companions instead suggests a turnover in the 'planet' population at

~25 Mj; M/Mstar ~ 0.025 (PPVII review, Kiefer et al. 2019, Currie et al. 2023; Feng et al. 2023)

HIP xxxx b lies well below the mass and mass ratio turnover from planets to brown dwarfs
(see plots on left)

Currie & Li 2025

OASIS discovery #2 – HIP xxxxx B
A brown dwarf companion suitable for
Roman Coronagraph Technology Demonstration

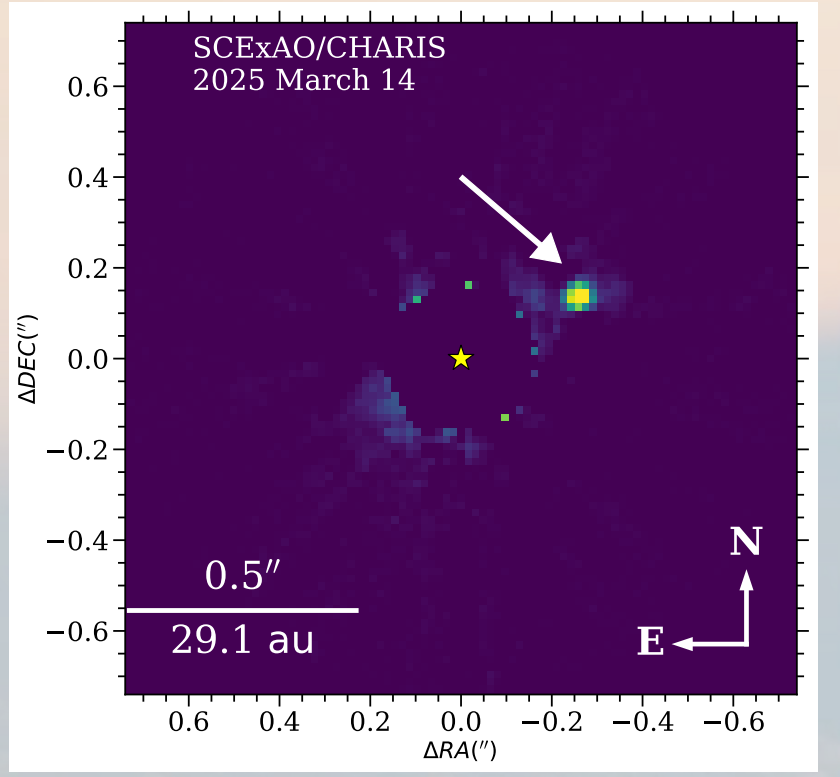


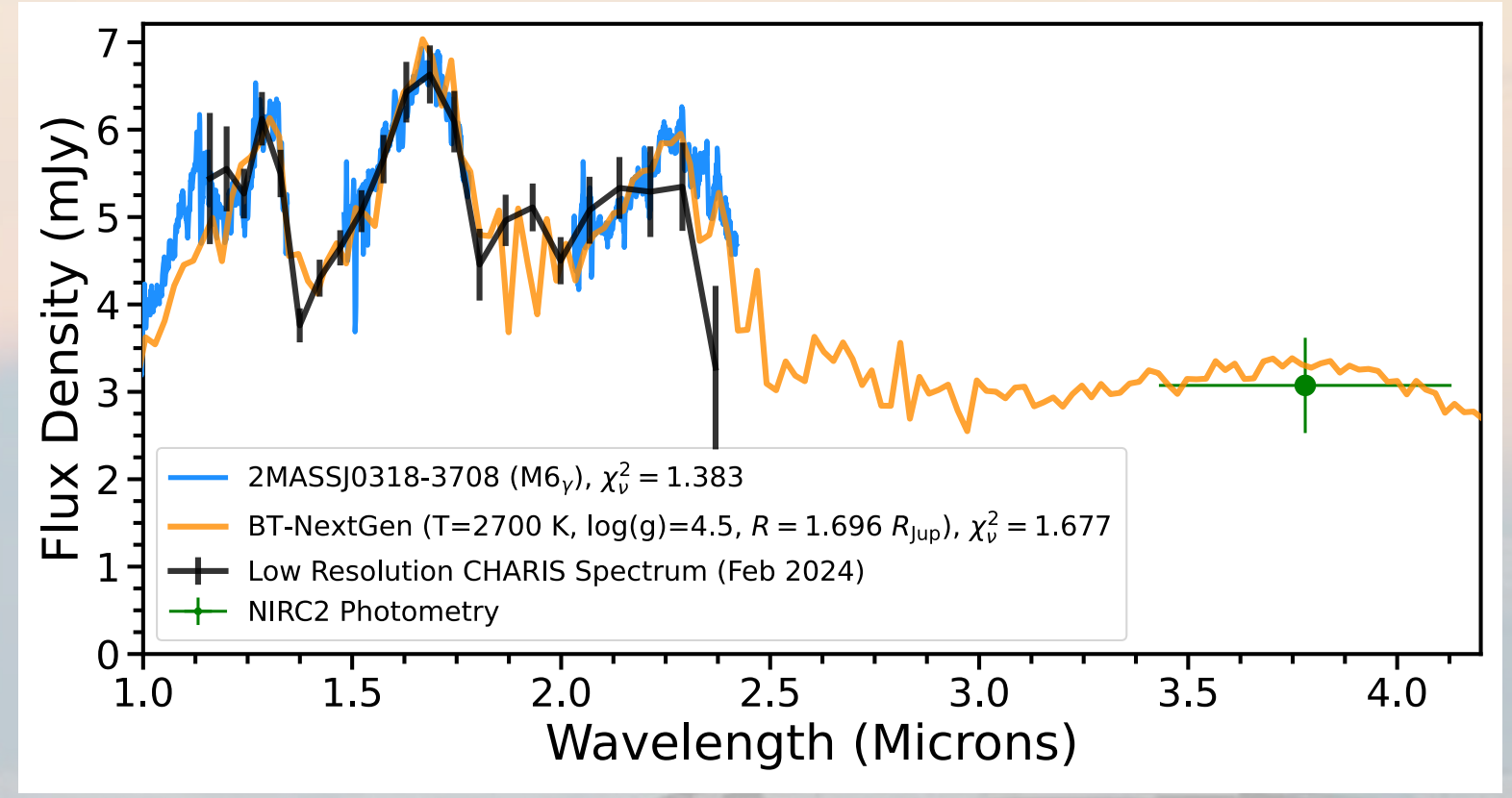
Also never a prior target for a deep planet search with any technique

El Morsy et al. 2025, ApJ Letters, accepted

OASIS discovery #2 – “ELLA”:
A brown dwarf companion suitable for
Roman Coronagraph Technology Demonstration

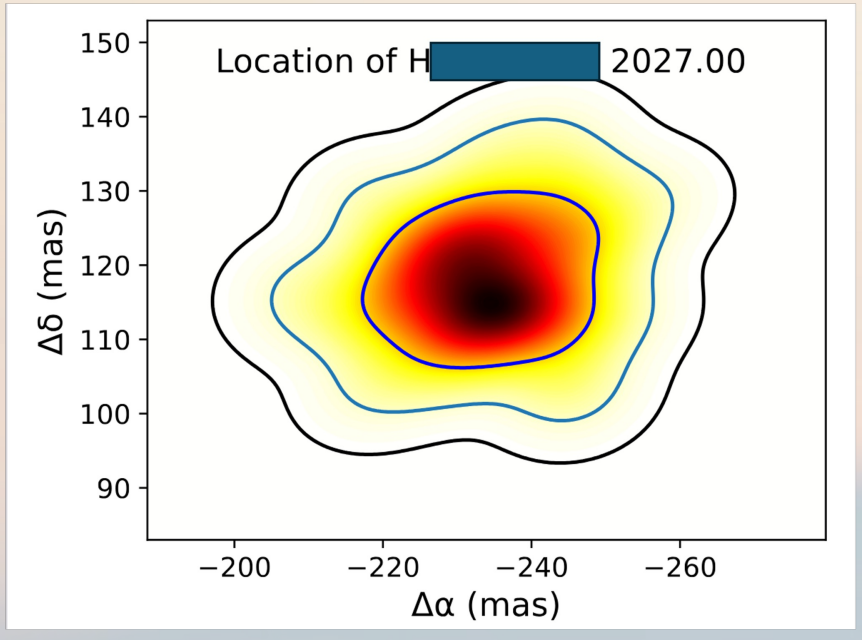
60 Mj brown dwarf at ~11 au





El Morsy et al. 2025

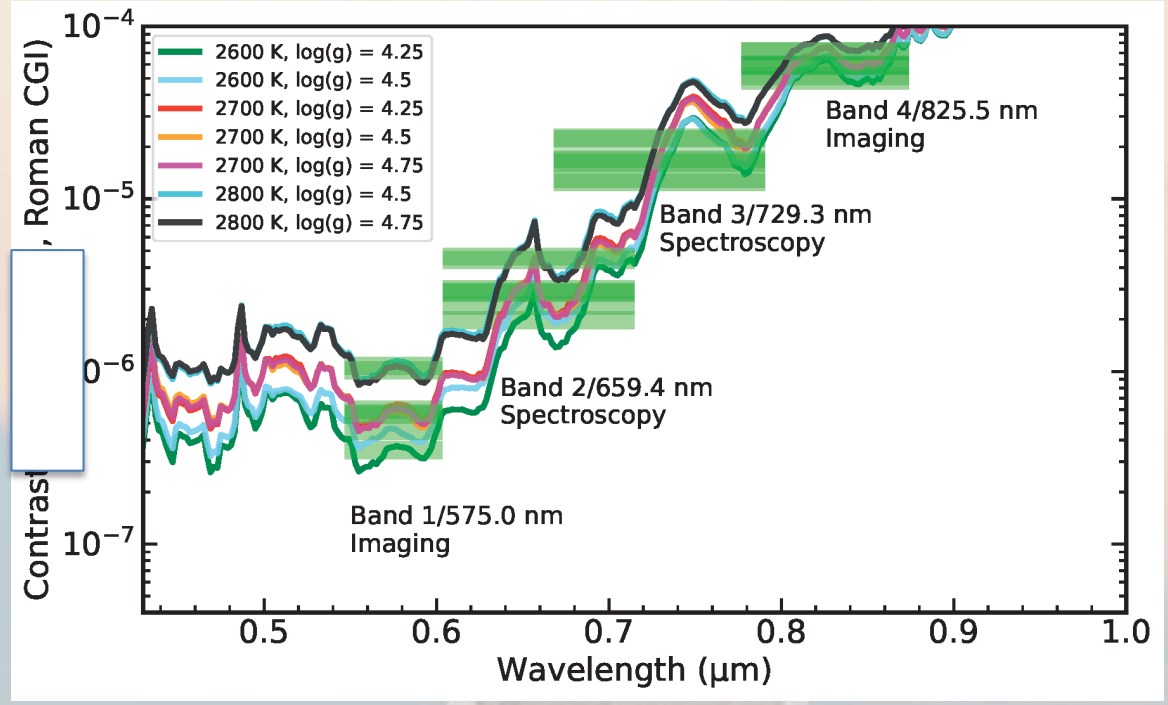
OASIS discovery #2 –:
Suitable for Roman CGI Tech Demo



Predicted location in January 2027

- Should lie ρ ~ 0.″26
- Well within the 0.″15–0.″45 dark hole region where Roman CGI should get

contrast of ≈ 2×10^{-8} or lower

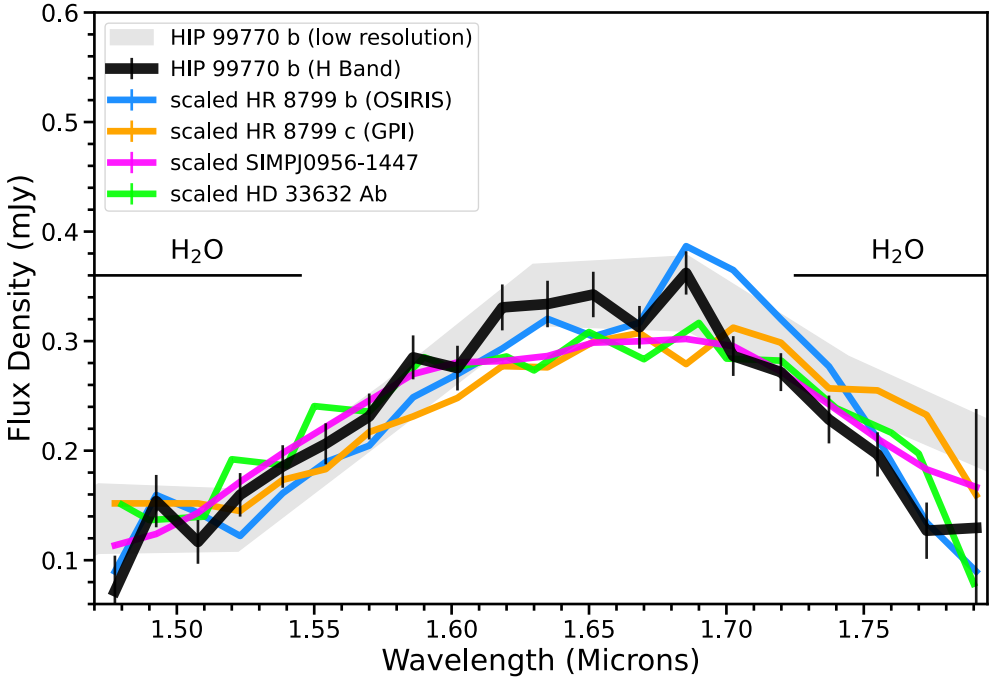


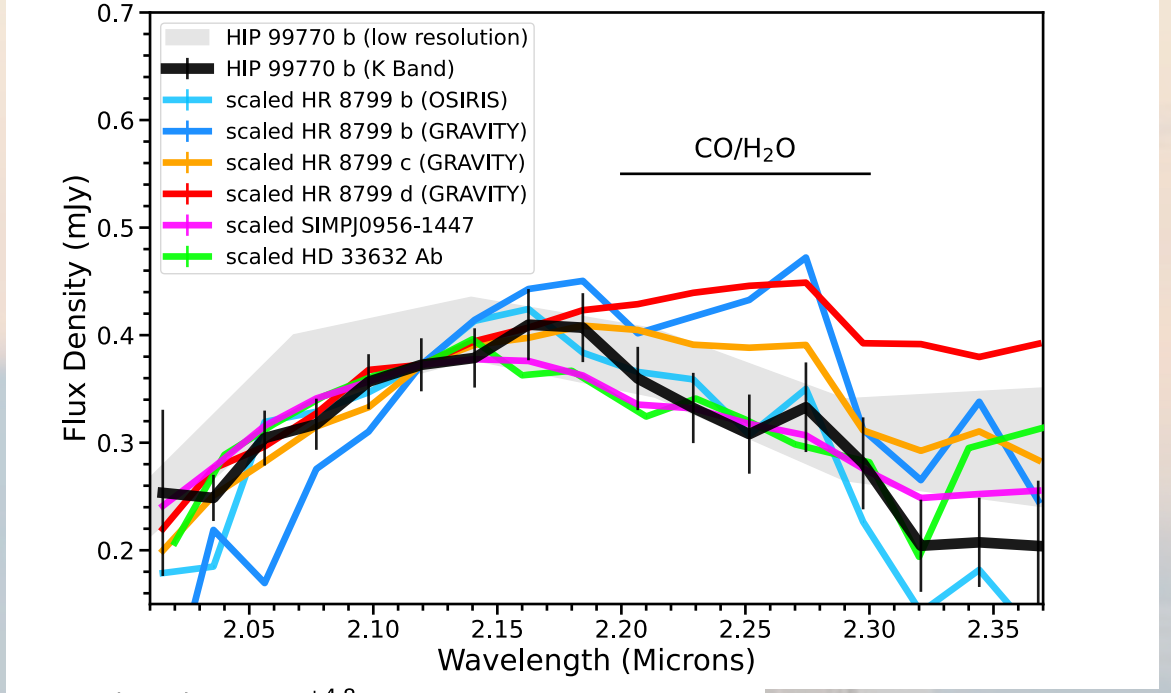
Predicted contrast in the coronagraph's passbands for different atmosphere models

- Predicted 575 nm contrast of a few x 10^{-7}
- **<u>A high SNR detection will fulfill TTR5</u>**

- **highly suitable target for demonstrating Threshold Technical Requirement (TTR5) due to its predicted contrast, location and primary star brightness**
  (and proximity to the Roman Continuous Viewing Zone and vetted PSF reference stars)

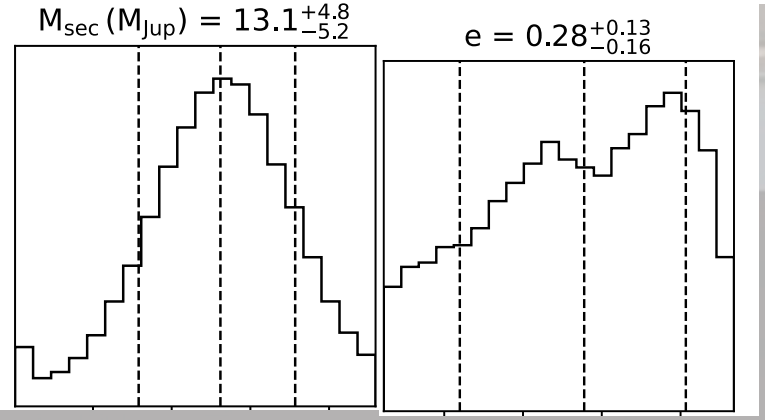
Follow-Up Plans
(e.g. HIP 99770 b)





H and K band spectroscopy
- Probes surface gravity, carbon chemistry

Dynamical Modeling with longer time baseline
- Improves constraints on orbits and masses



Bovie et al. 2025

Broader Scientific Impact

- Anchoring Luminosity Evolution Models

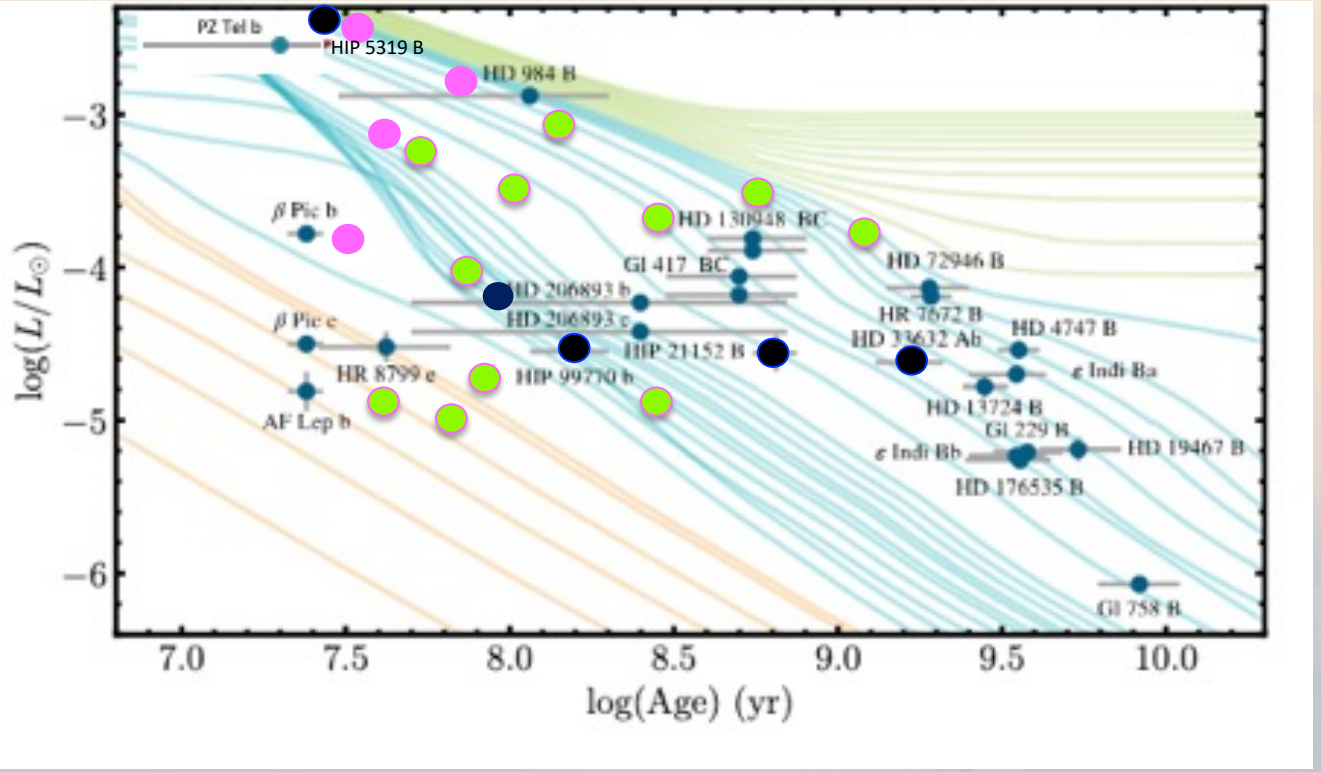
  Measuring dynamical masses for many planets and low-mass brown dwarfs with different ages

→ empirically constrain gas giant luminosity evolution vs mass

- Evolution of Atmospheric Properties Vs. Mass

  dynamical masses + atmospheres

→ how the atmospheres jovian exoplanets and low-mass brown dwarfs of different masses evolve with time



- Dark blue – published discoveries
- Magenta – unpublished discoveries
- Green – hypothetical results from survey

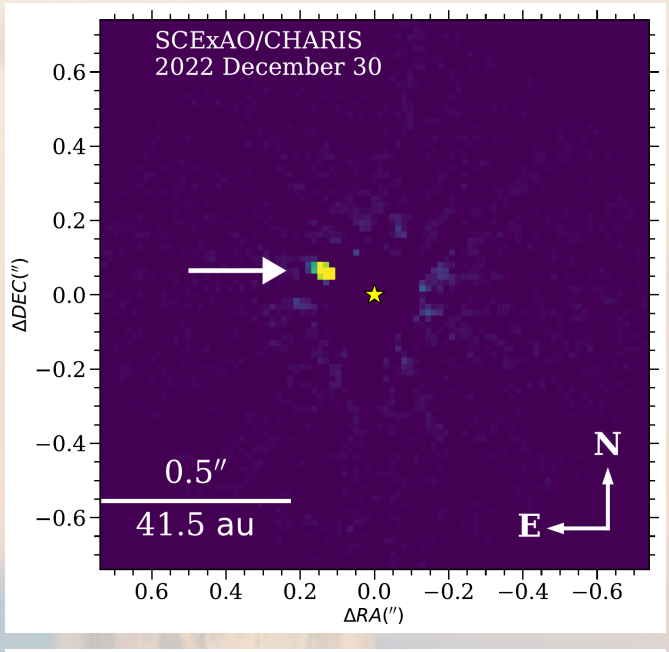
Summary

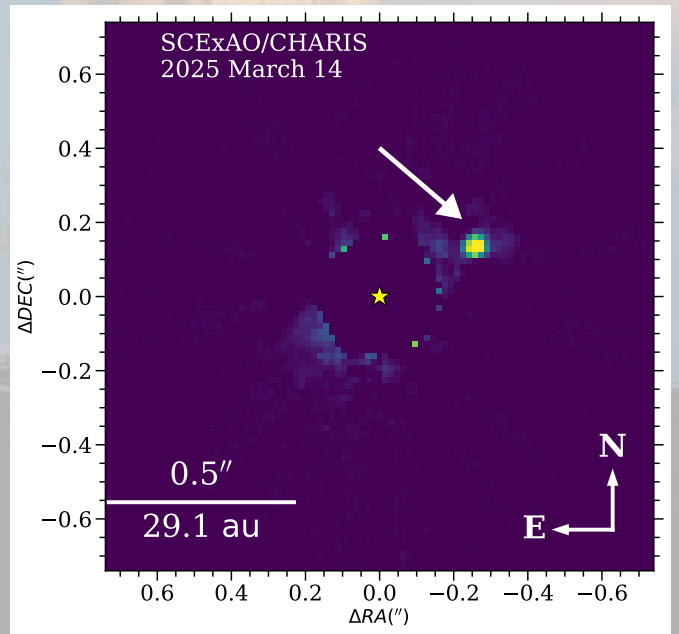
- OASIS: A Subaru Intensive Survey combining Direct Imaging and Astrometry

- First Results (soon to be accepted)
  -a new planet!
  -a new brown dwarf/Roman CGI tech demo target

- Follow-Up Plans

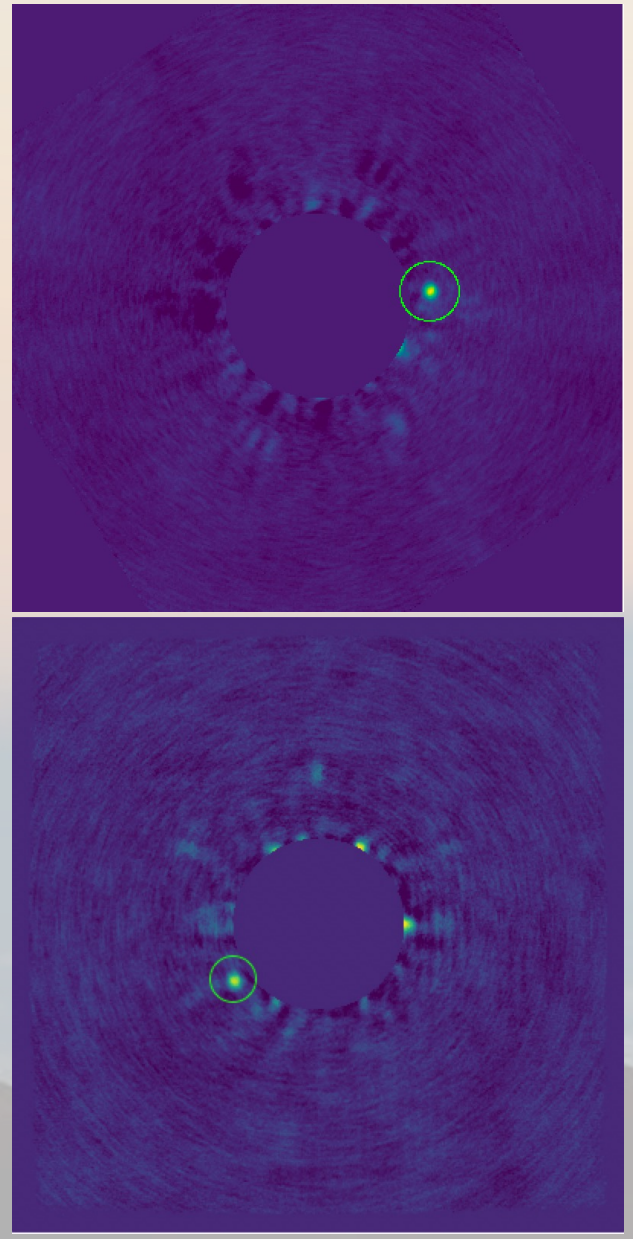
- Broad Scientific Goals and Outlook

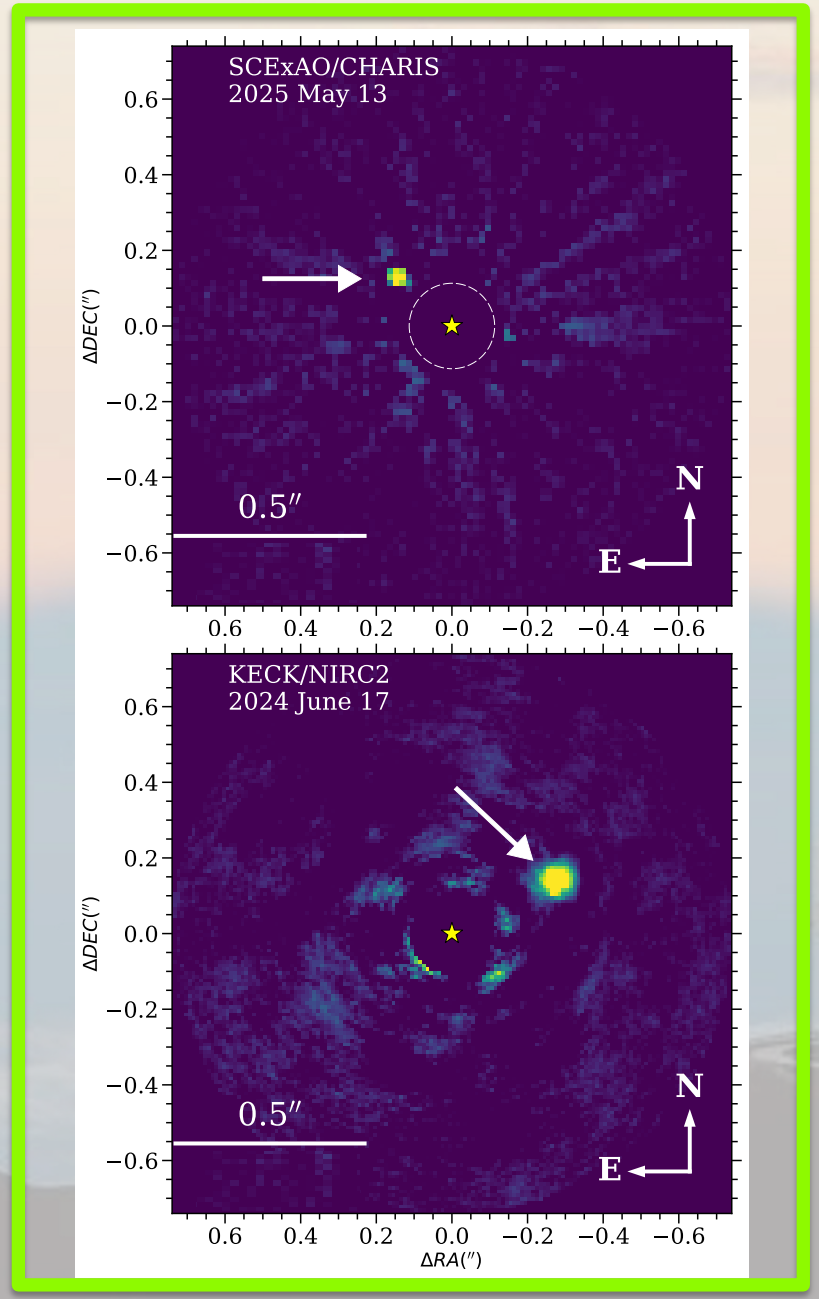


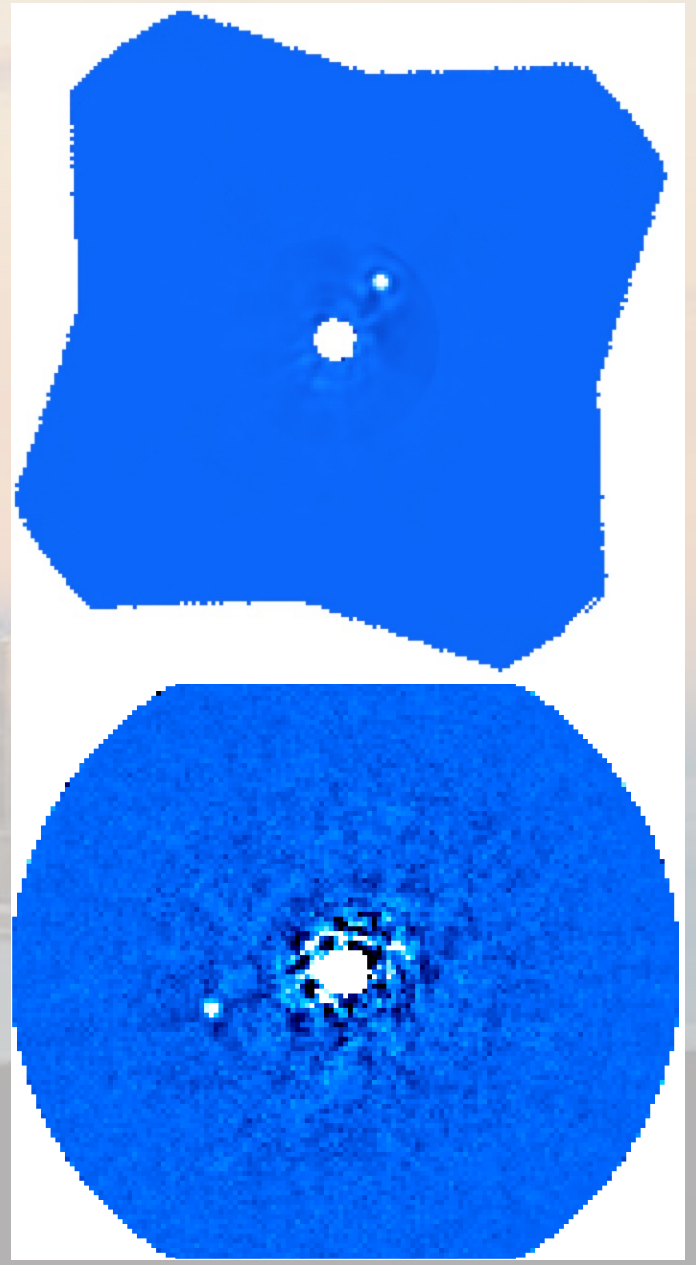


Backup Slides

Selected New Discoveries (incomplete list)



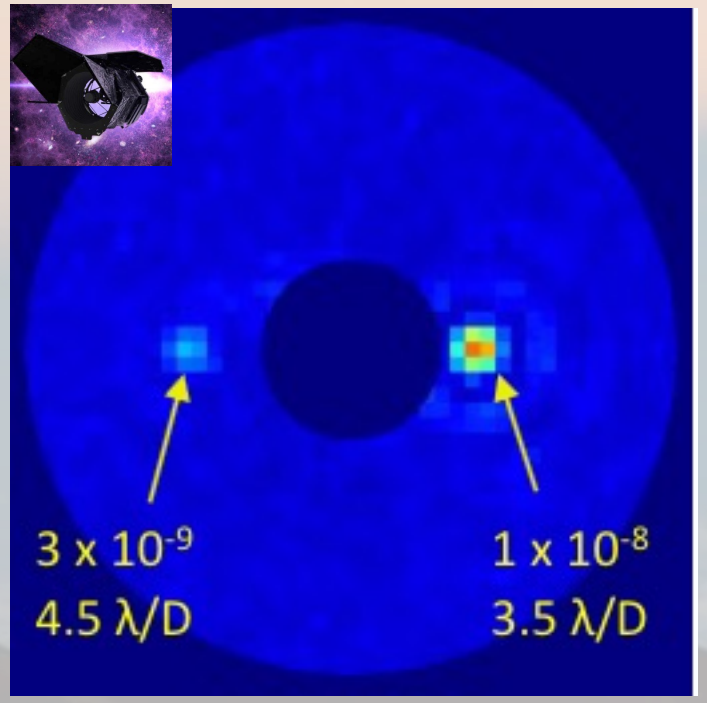




Program Impact for NASA:
Improving the Prospects for a Successful CGI Tech Demo

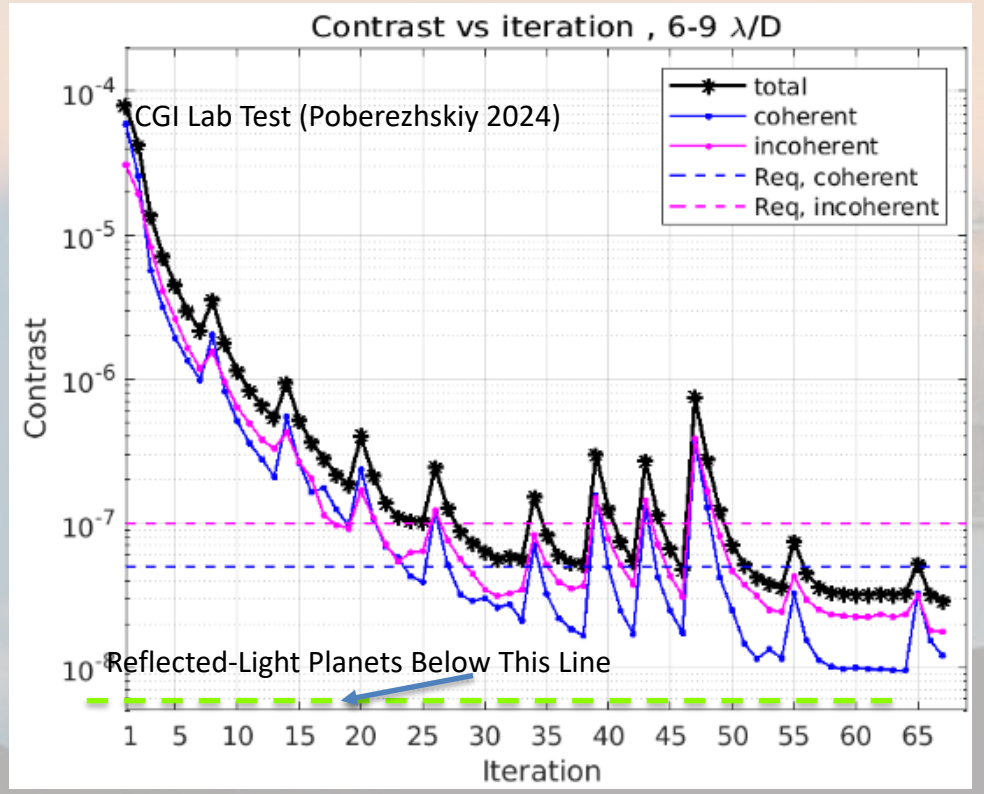
Roman CGI ”tech demo”: wavefront control in space

… if successful, possible follow-on science program



Significant concerns

- Very few if ANY known suitable companions satisfying CGI TTR5 + Obj 2.2.1-2.2.5
- Even fewer near a bright PSF ref star



- Even in principle, reflected-light planet detection very challenging

Unless CGI is provided a flexible list of tech demo-suitable targets before flight, it risks not meeting its goals