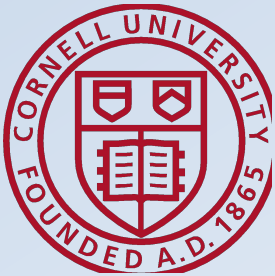


ExoGemS Survey: Exploring the Diversity of Exoplanet Atmospheres at High Spectral Resolution with Gemini GRACES

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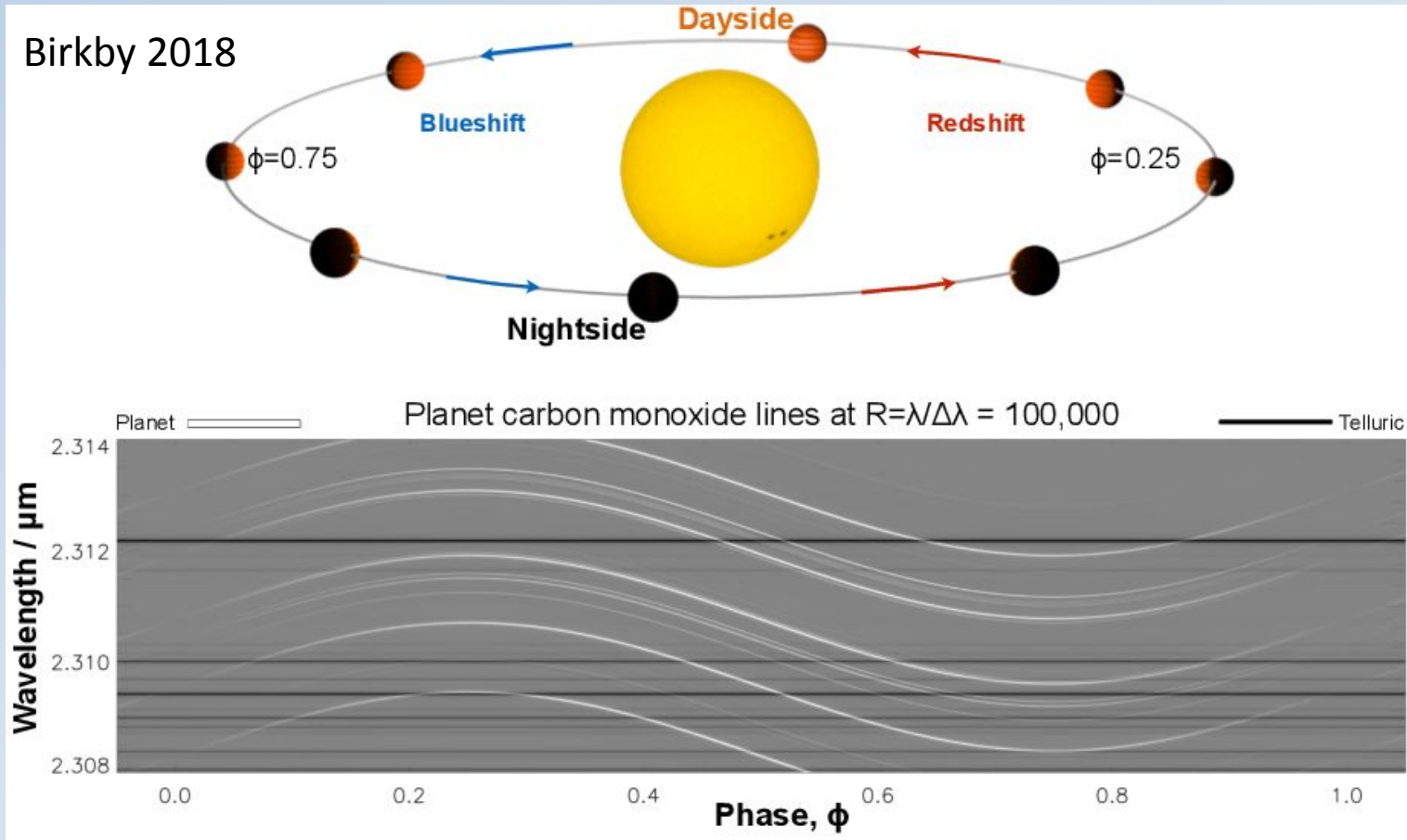
 [@Astro_journey](https://twitter.com/Astro_journey)



Gemini Science Meeting: July 27, 2022

ExoGemS Collaboration: Laura Flagg, Emily Deibert, Andrew Ridden-Harper, Ray Jayawardhana, Ernst de Mooij, Ryan MacDonald, Jonathan Fortney, Callie Hood, David Sing, Drake Deming, David Lafreniere, Matteo Brogi, & Romain Allart

High-Resolution Observations

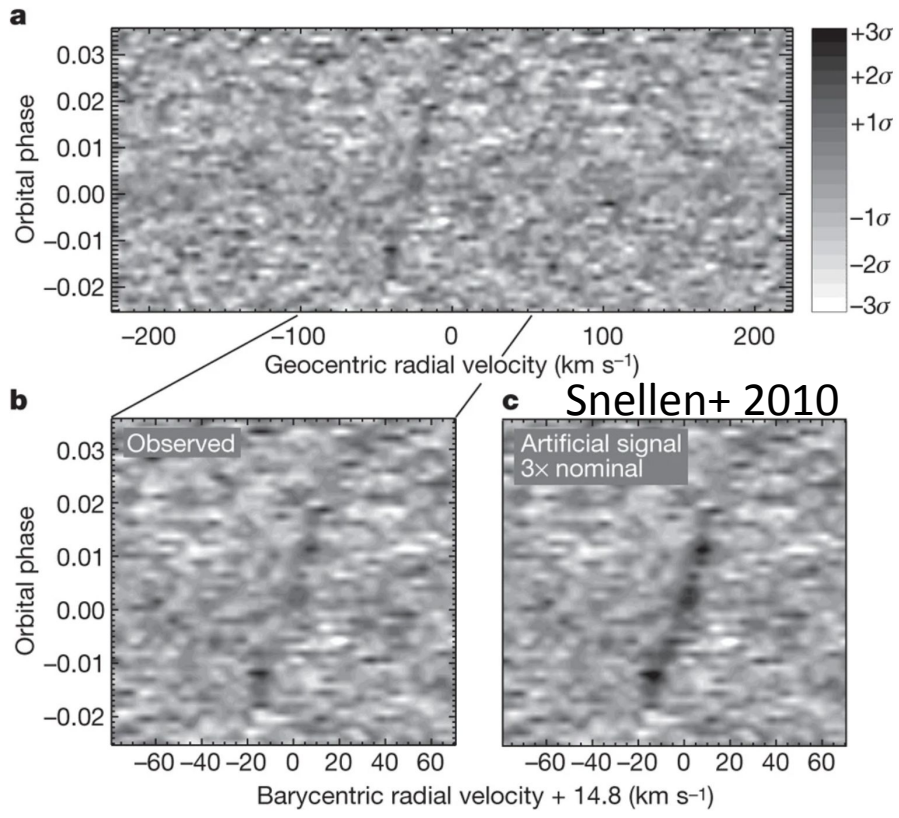


Use the large doppler-shift of the planet to disentangle its spectrum from the host star and Earth's atmosphere

Very successful technique (e.g. Snellen+ 10; Brogi+ 12, 18; Wytenbach+ 15; Ridden-Harper+ 16; Birkby+ 17; Allart+ 17; Esteves+ 17; Hoeijmakers+ 18, 19; Yan+ 18, 20; Deibert+ 19, 21; Seidel+ 19, 20; Casasayas-Barris+ 19, 21; Cauley+ 19; Herman+ 20, 21; Turner+ 20, Ehrenreich+ 20, Nugroho+20, Taberner+ 21)

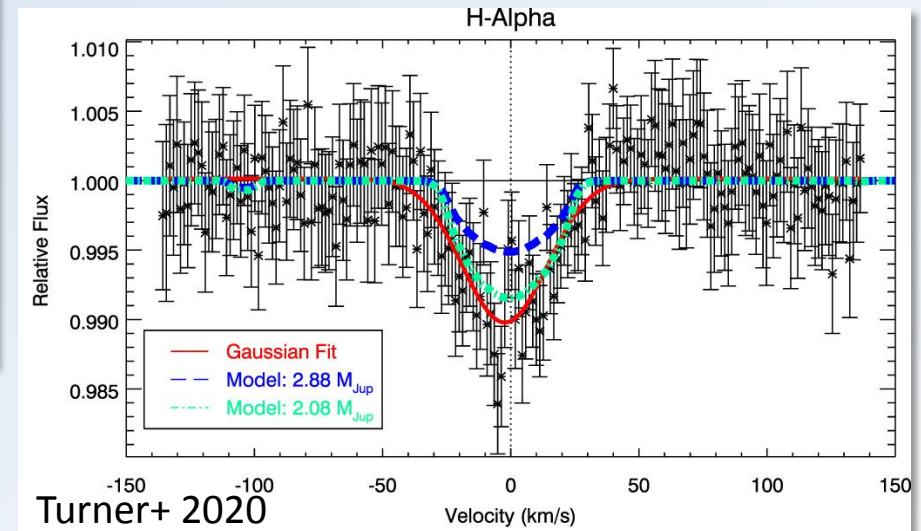
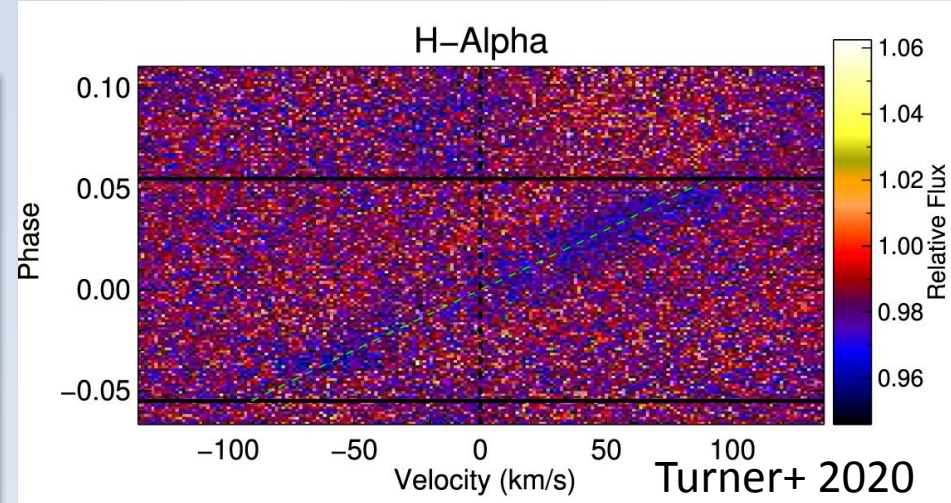
High-Resolution Observations

HD 209458b



Detection of CO

KELT-9b

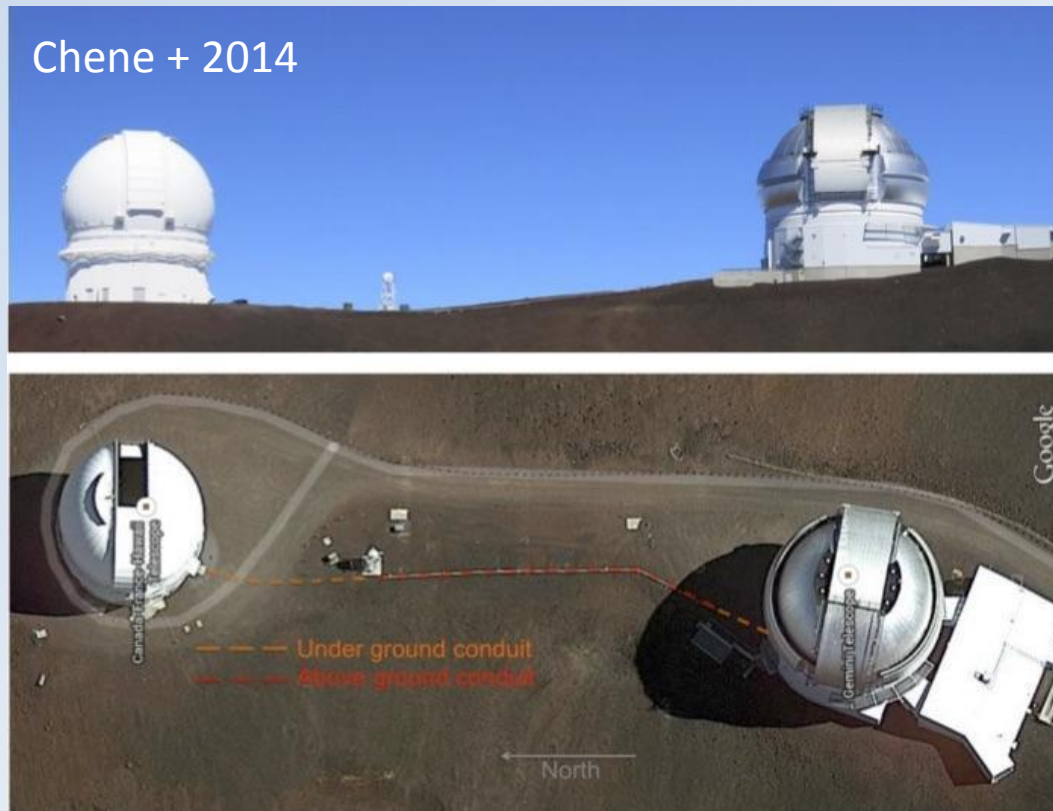


ExoGemS Survey

(Exoplanets with Gemini Spectroscopy)

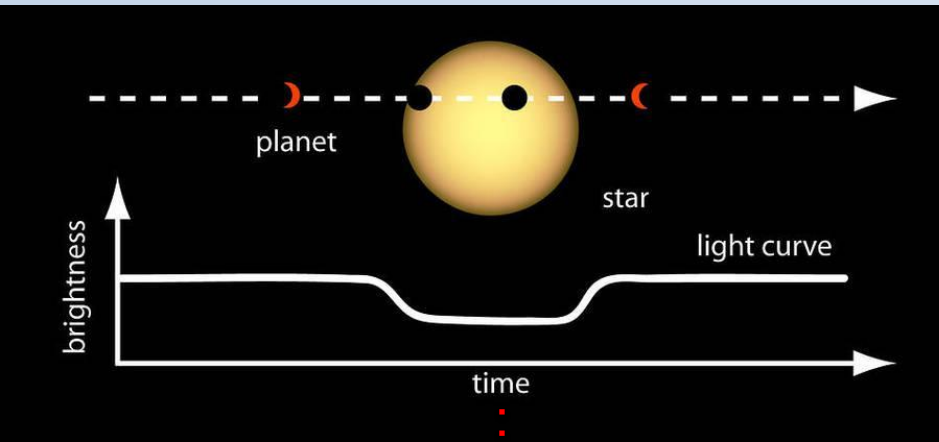
- Approved large program
- GRACES* on Gemini-N
- 400 - 1050 nm
- $R \sim 67.5 K$

*Gemini Remote Access to CFHT ESPaDOnS Spectrograph

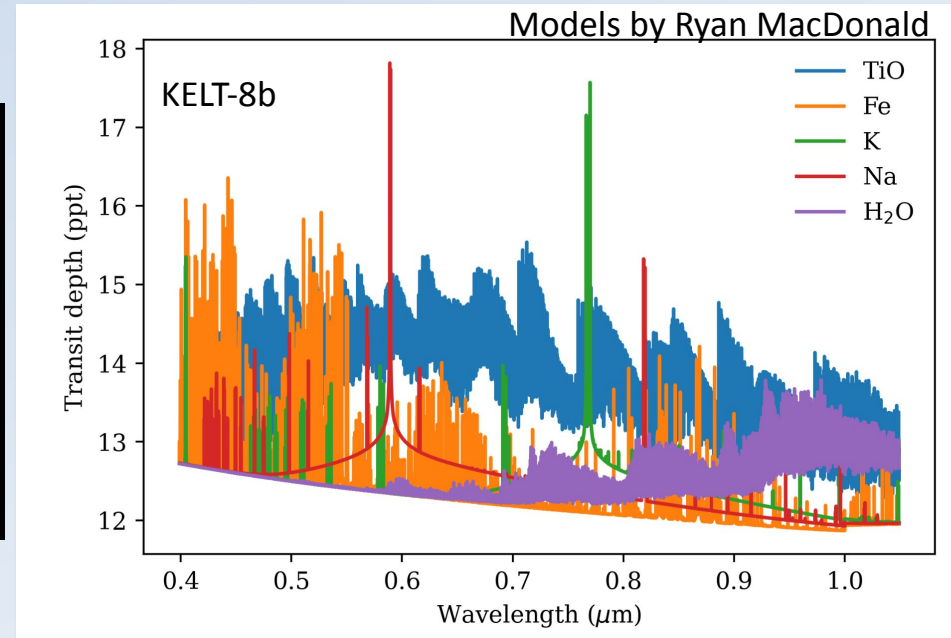


ExoGemS Survey

High-resolution transmission spectra survey



Blue-shifted : Red-shifted

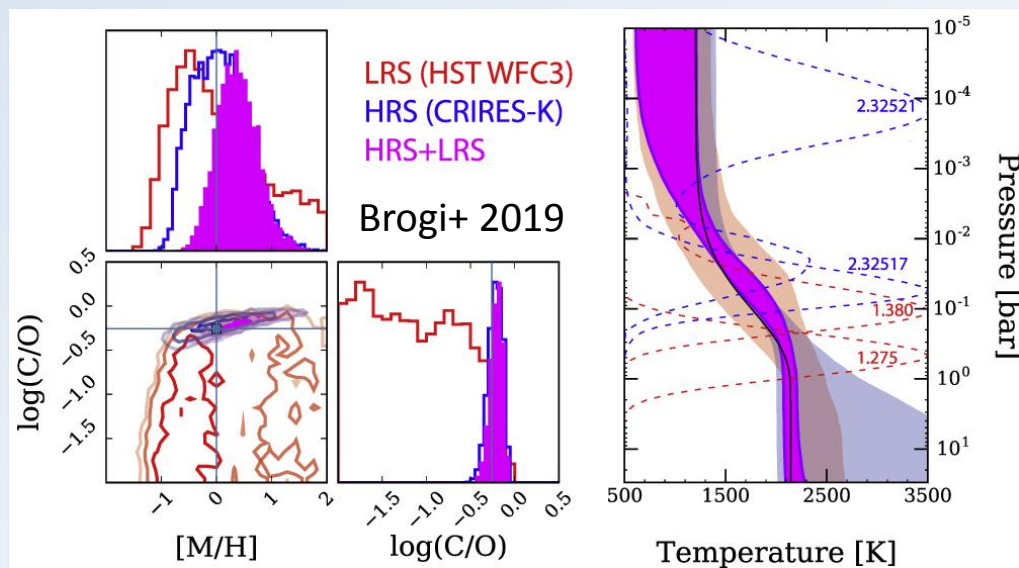
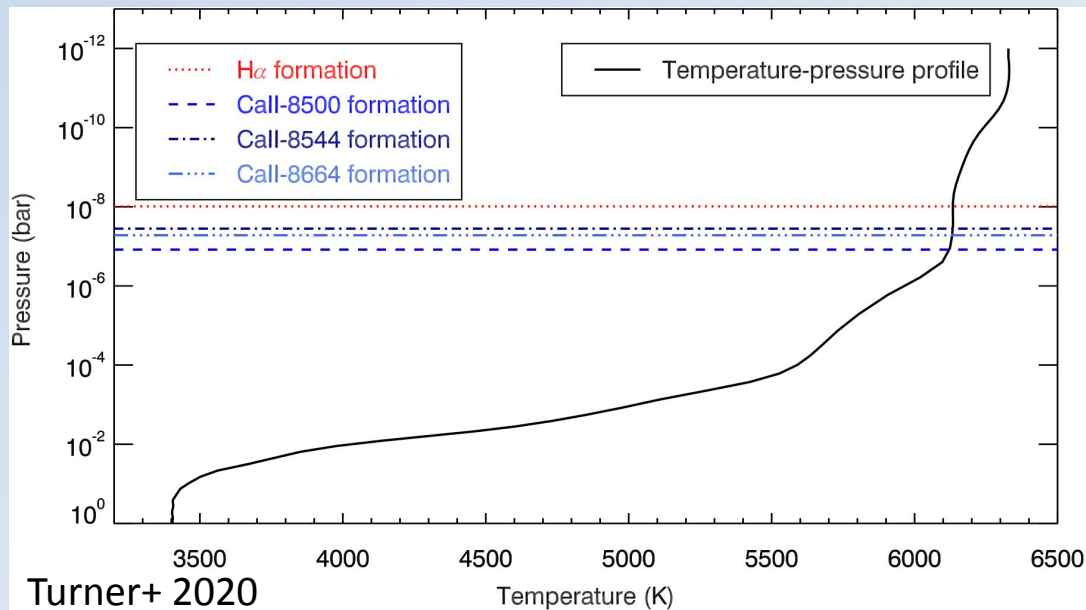


Search for species in transit (cross-correlate):

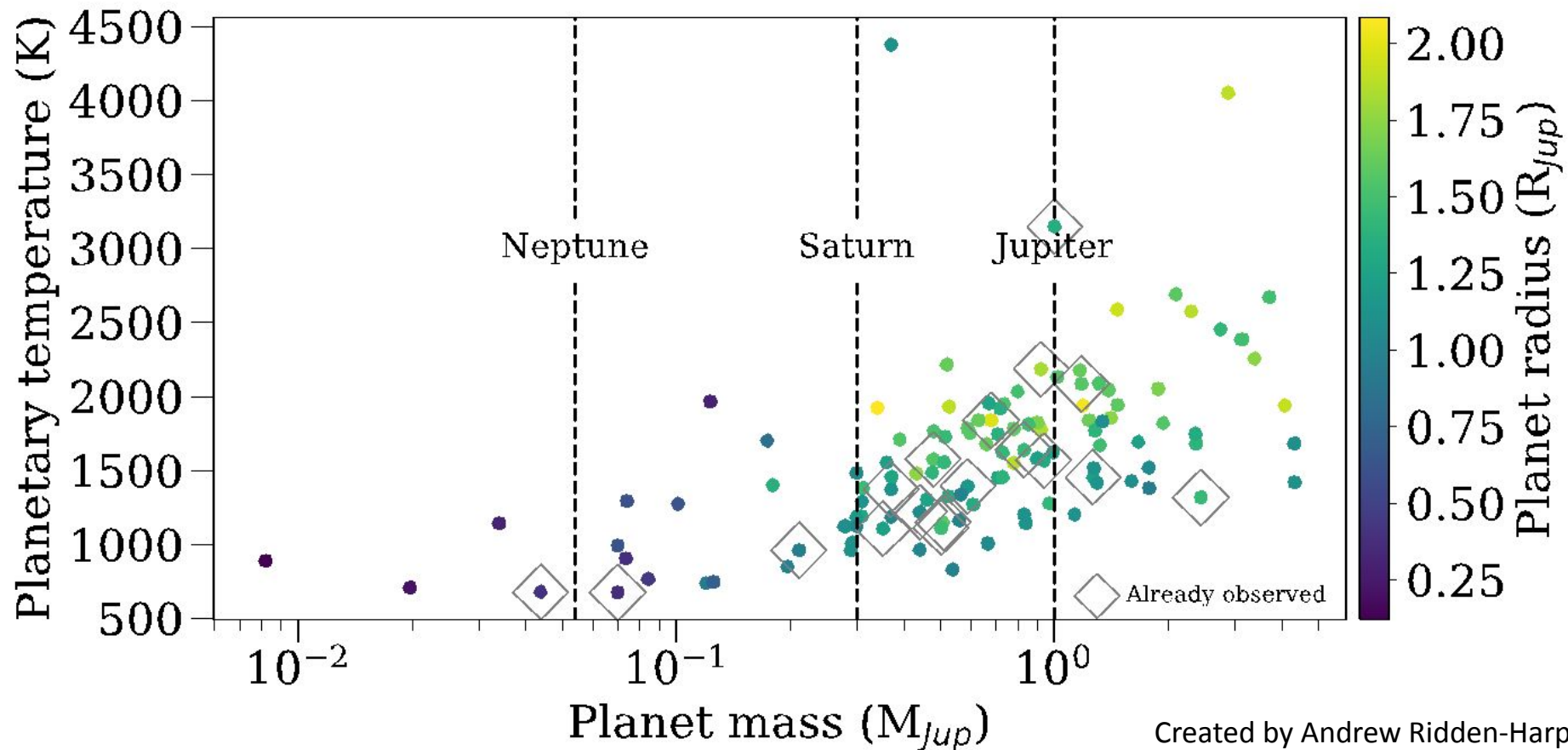
- H α , Li, K, Na, Fe, Fe II, Mg, Mn, Ca II, & many more
- TiO, VO, H₂O, FeH, CrH, and many more

ExoGemS Survey

- Find species across parameter space
- 2D/3D structure: Abundances & temperatures with altitudes and latitude
- Atmospheric winds
- Combine with low-resolution

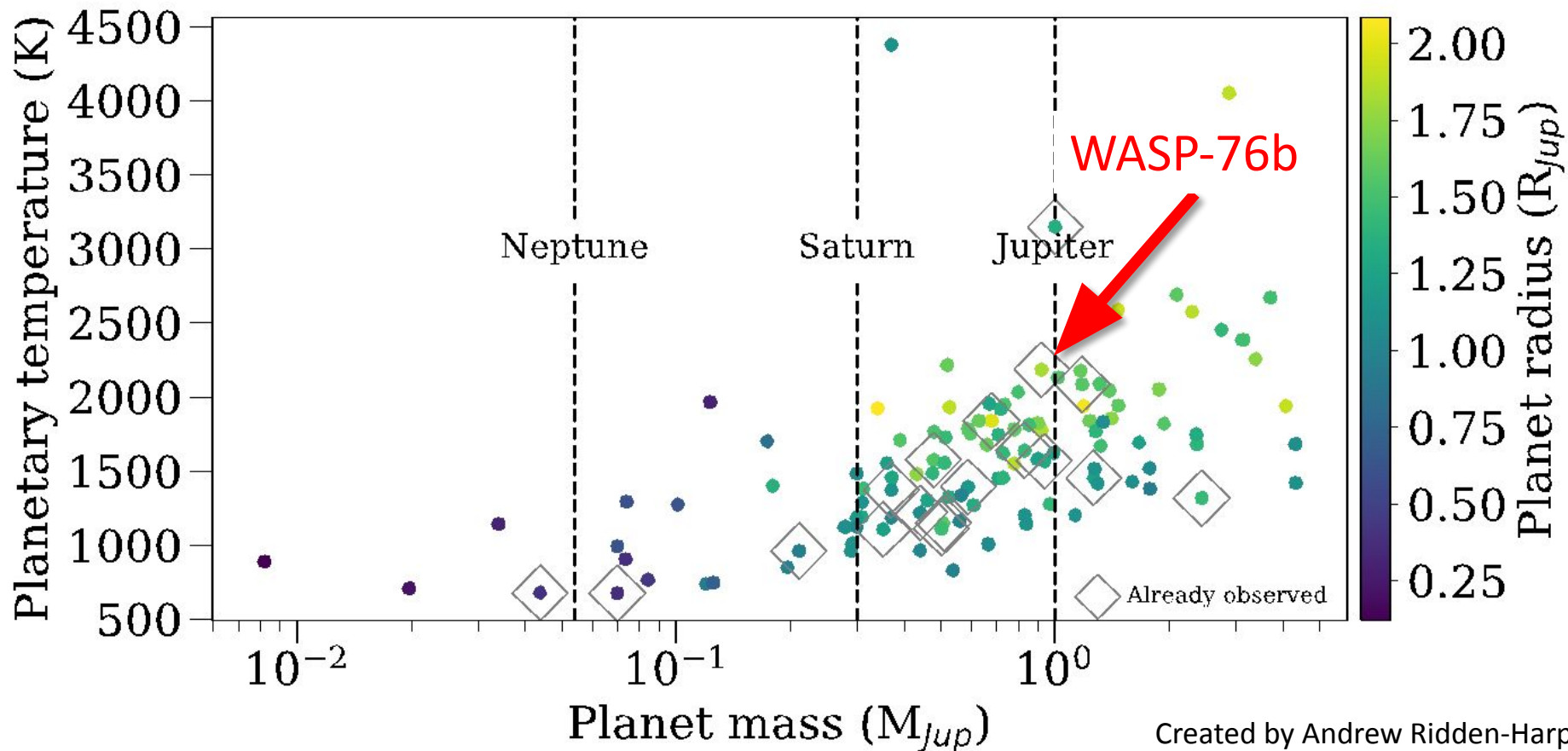


ExoGemS Observed Sample



- Planet Temperature: 670 – 3200 K
- Planet Mass: $0.7 M_{Nep}$ – $3.7 M_{Jup}$

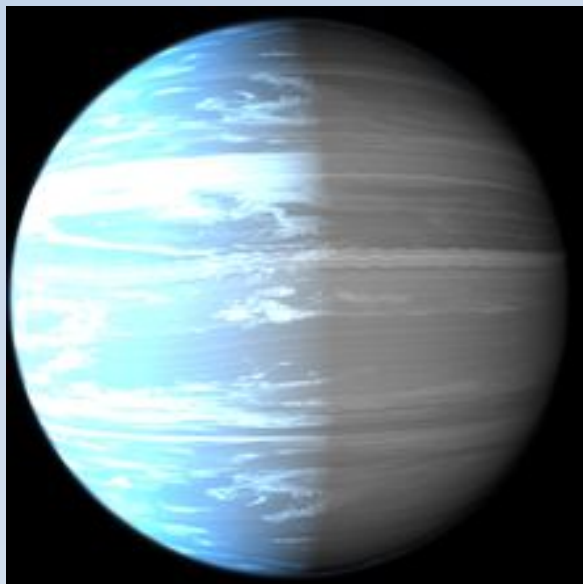
ExoGemS Observed Sample



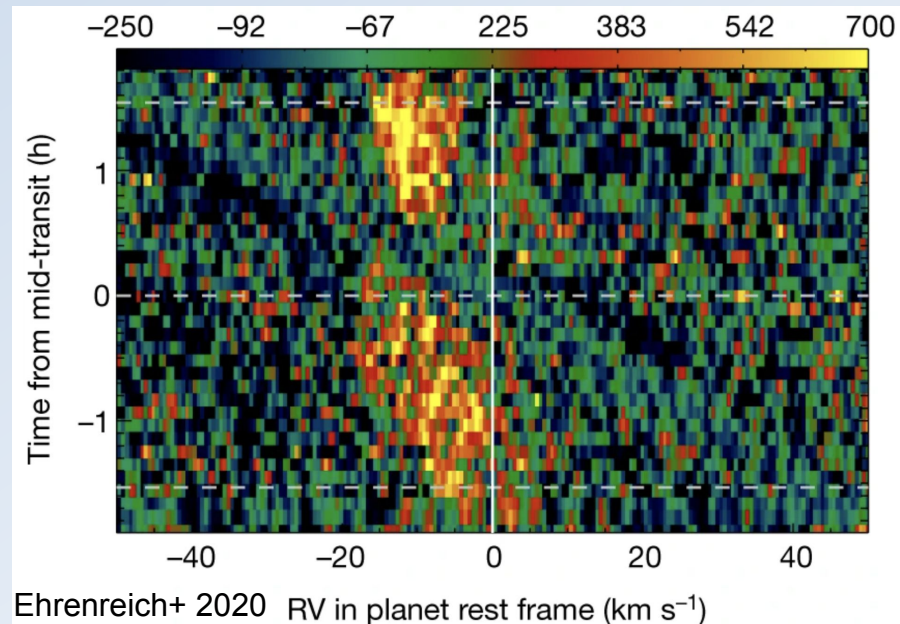
- Planet Temperature: 670 – 3200 K
- Planet Mass: $0.7 M_{Nep}$ – $3.7 M_{Jup}$

ExoGemS Survey

WASP-76b



Asymmetric Fe Detection

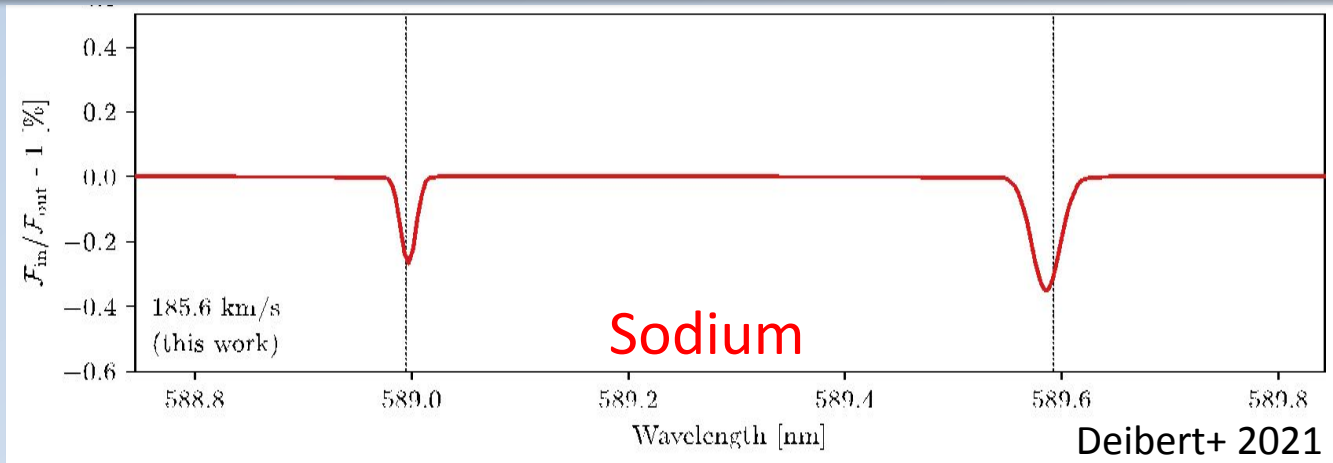


- Ultra-hot Jupiter (2200 K)
- $0.9 M_{\text{Jup}}$ & $1.8 R_{\text{jup}}$
- Many atmospheric detections (e.g. Ehrenreich+ 2020, Edwards+ 2021, Kesseli+ 2021, 2022, Langeveld+ 2022, Gandhi+ 2022)

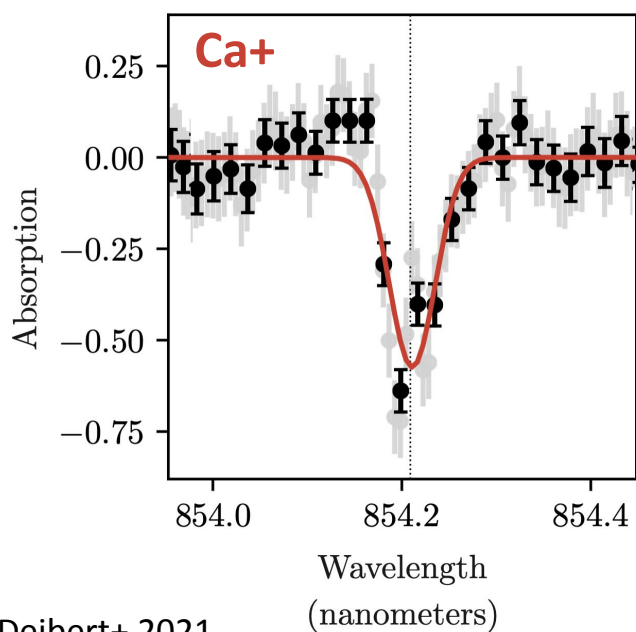
- Iron Rain, thick clouds, scale-height differences...

e.g. Ehrenreich+ 2020, Wardenier+ 2021, Saval + 2021, Sanchez-Lopez + 2022

ExoGemS Survey: WASP-76b



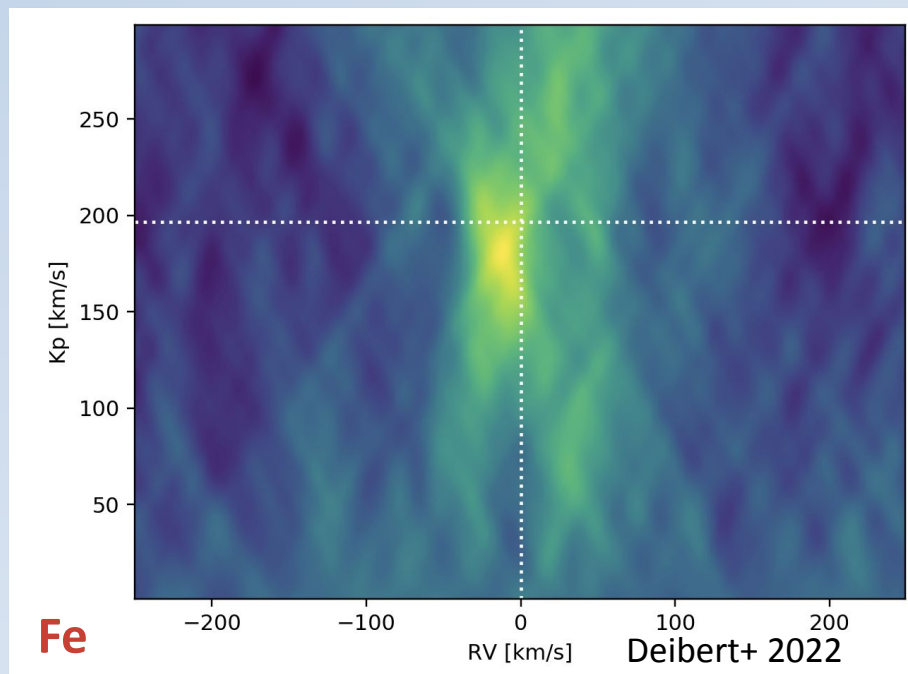
Previous Na detections: Seidel+ 19; Taberero+ 21



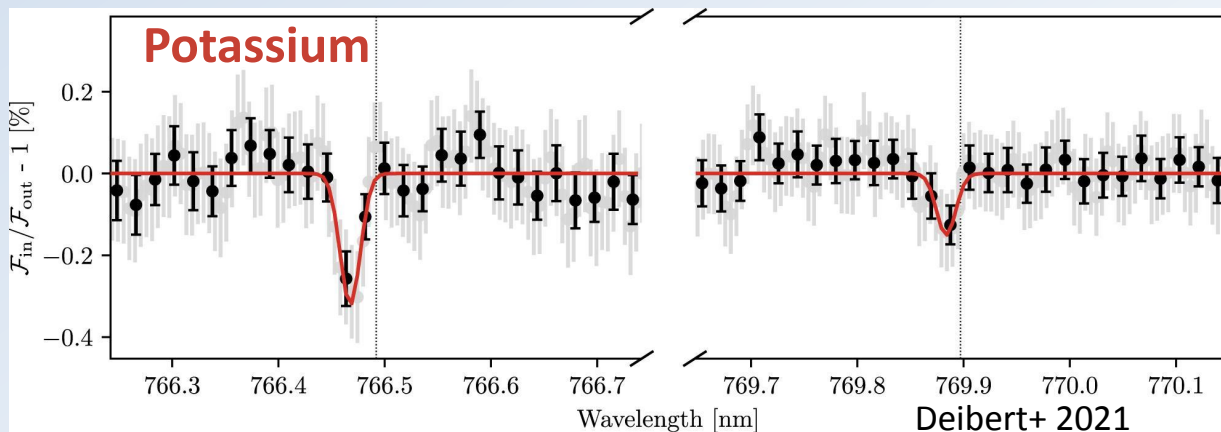
- We detected sodium and ionized calcium* (Deibert+ 2021)
- Strong calcium signal indicates that the exoplanet is hotter than expected, and/or has strong atmospheric winds

*Confirmed by Casasayas-Barris et al. 2021

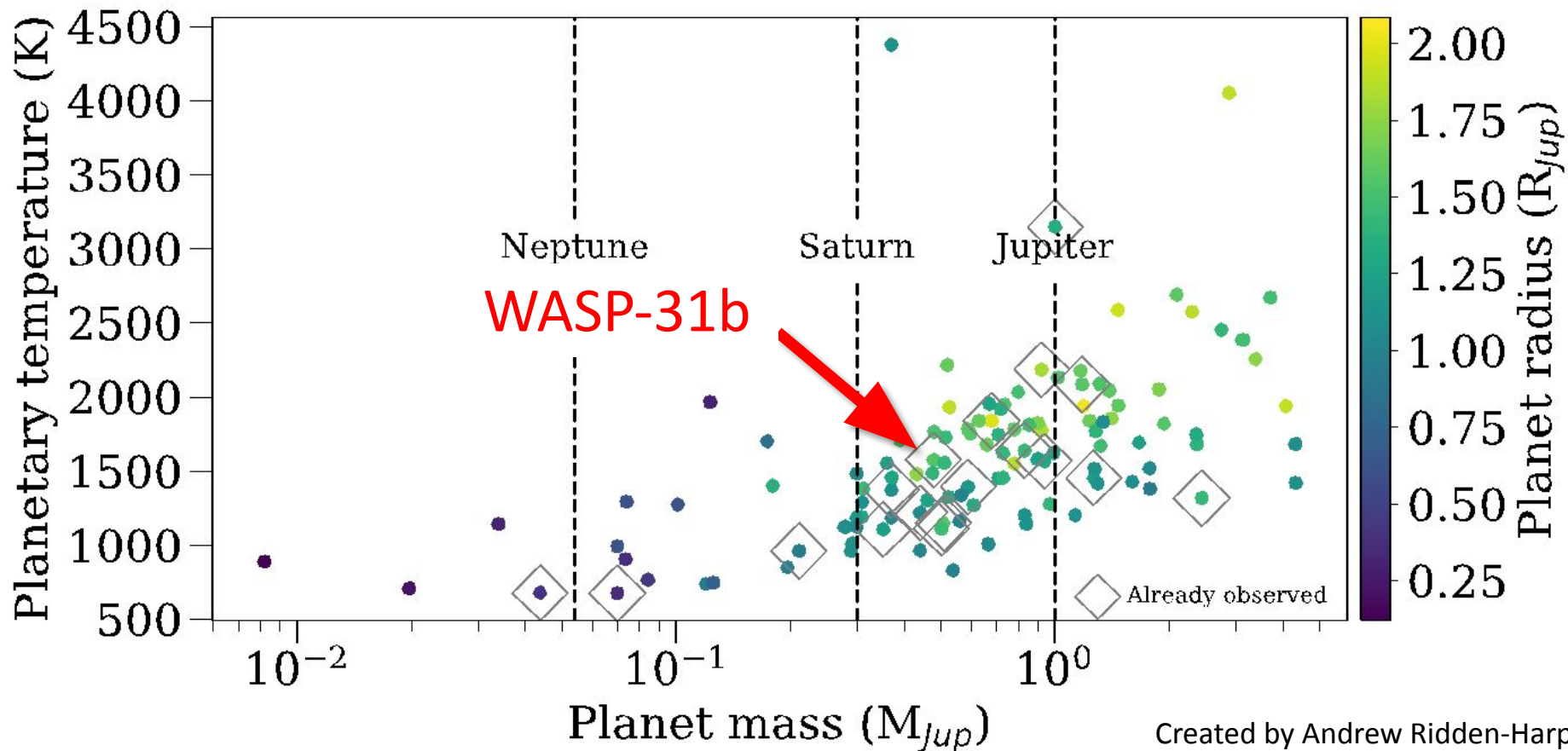
ExoGemS Survey: WASP-76b



Previous Fe detections: Ehrenreich+ 20, Kesseli+ 21



ExoGemS Observed Sample

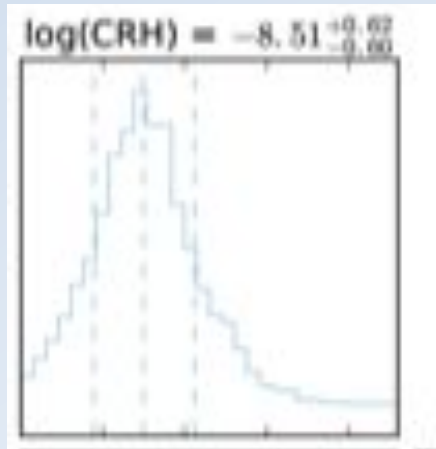


- Planet Temperature: 670 – 3200 K
- Planet Mass: $0.7 M_{Nep}$ – $3.7 M_{Jup}$

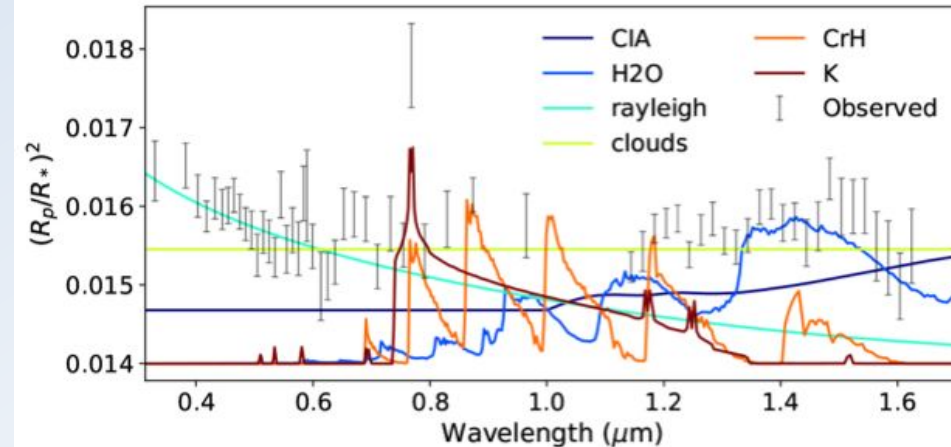
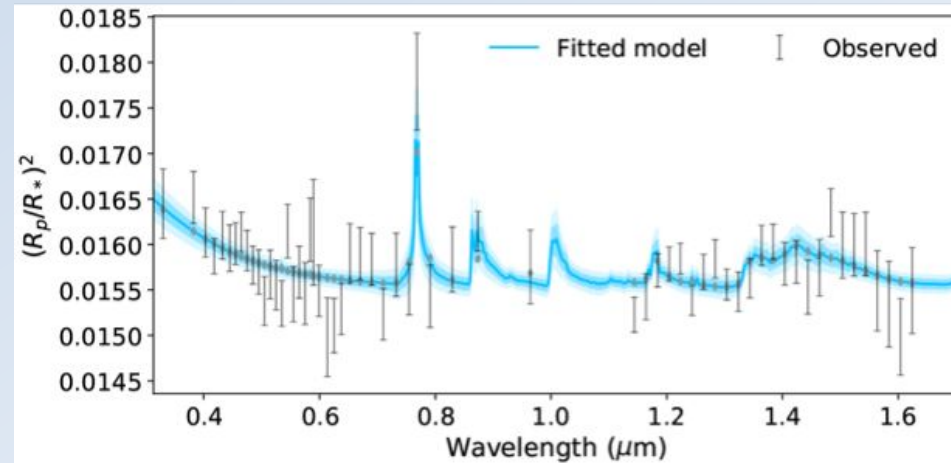
ExoGemS Survey

WASP-31b

- Puffy Hot Jupiter (1600 K)
- $0.5 M_{\text{Jup}}$ & $1.55 R_{\text{Jup}}$
- Evidence of Chromium hydride (CrH) in its atmosphere with HST

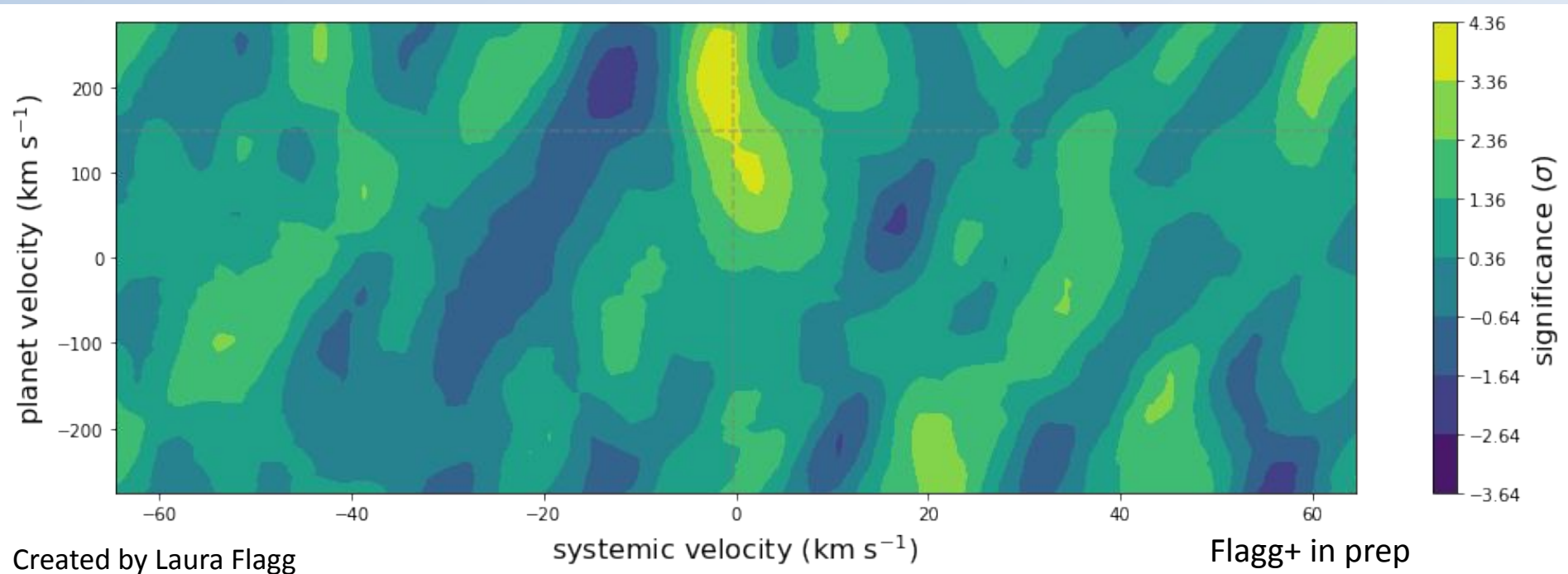


Braam+ 2020



Braam+ 2020

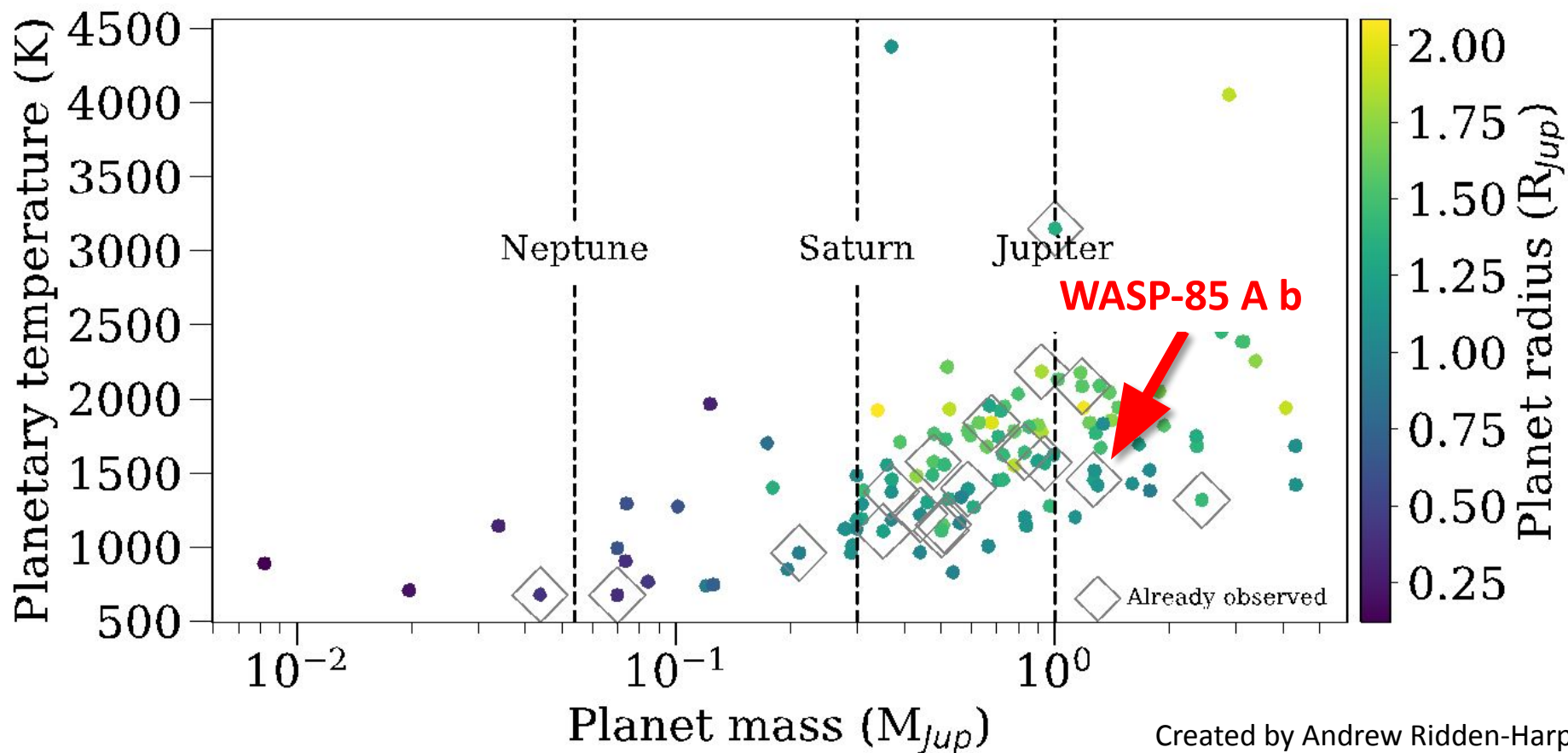
ExoGemS Survey: WASP-31b



Detection of CrH at 4σ

- Cr-bearing species --- \rightarrow formation of clouds (Braam+ 2020)
- CrH detection may be an indication of the accretion of solids during formation (Braam+ 2020)

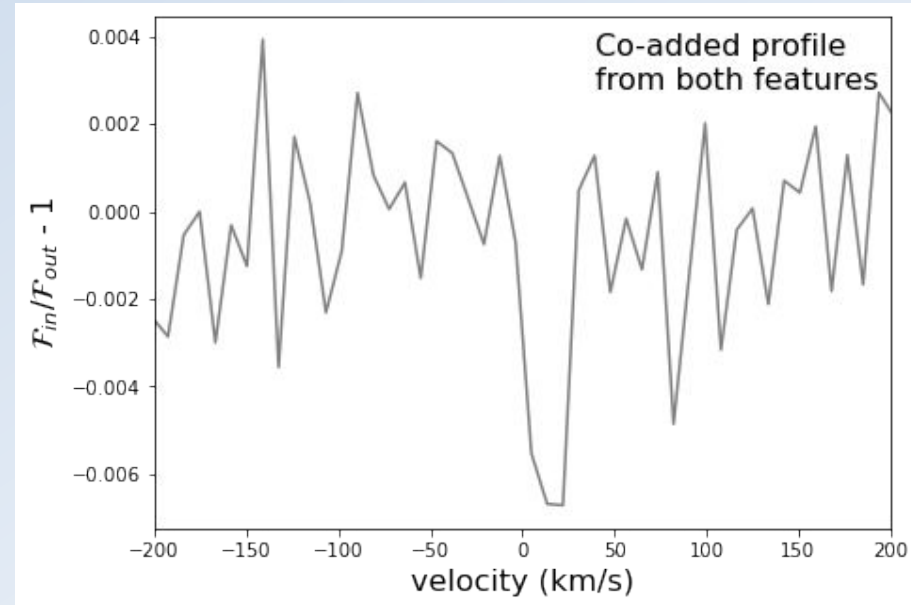
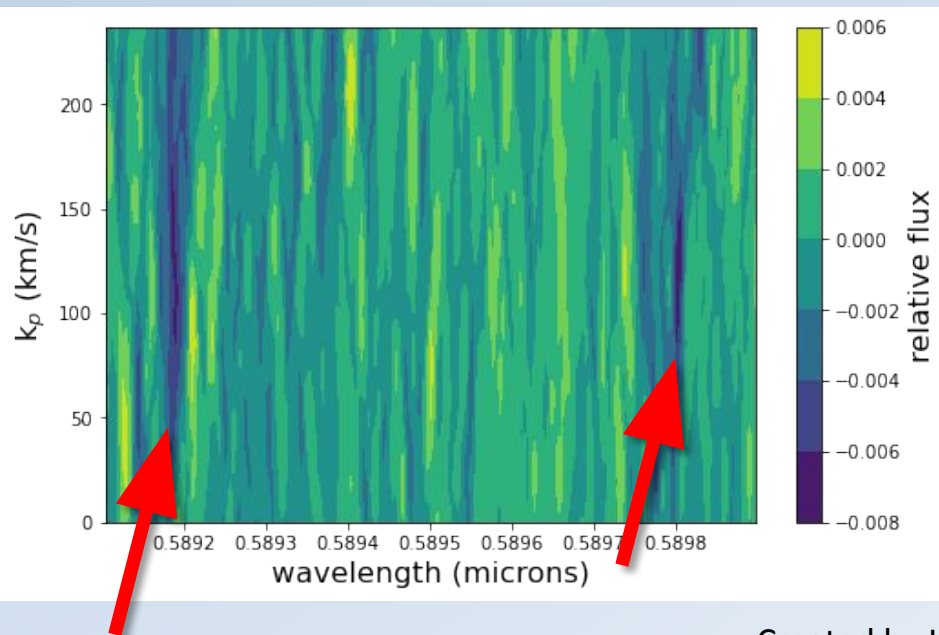
ExoGemS Observed Sample



- Planet Temperature: 670 – 3200 K
- Planet Mass: $0.7 M_{Nep}$ – $3.7 M_{Jup}$

ExoGemS Survey: WASP-85 A b

Na Detection

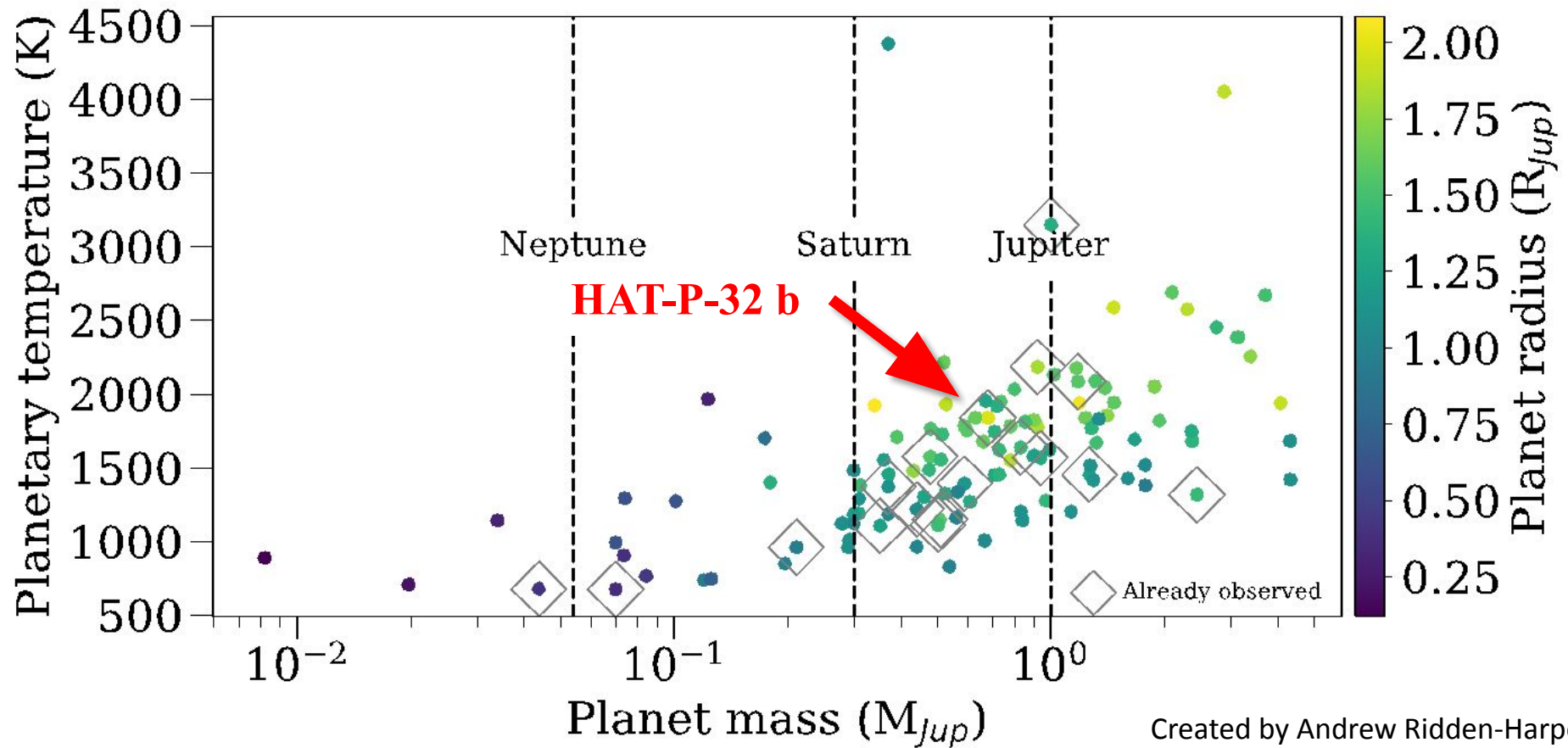


Created by Laura Flagg

Flagg+ in prep

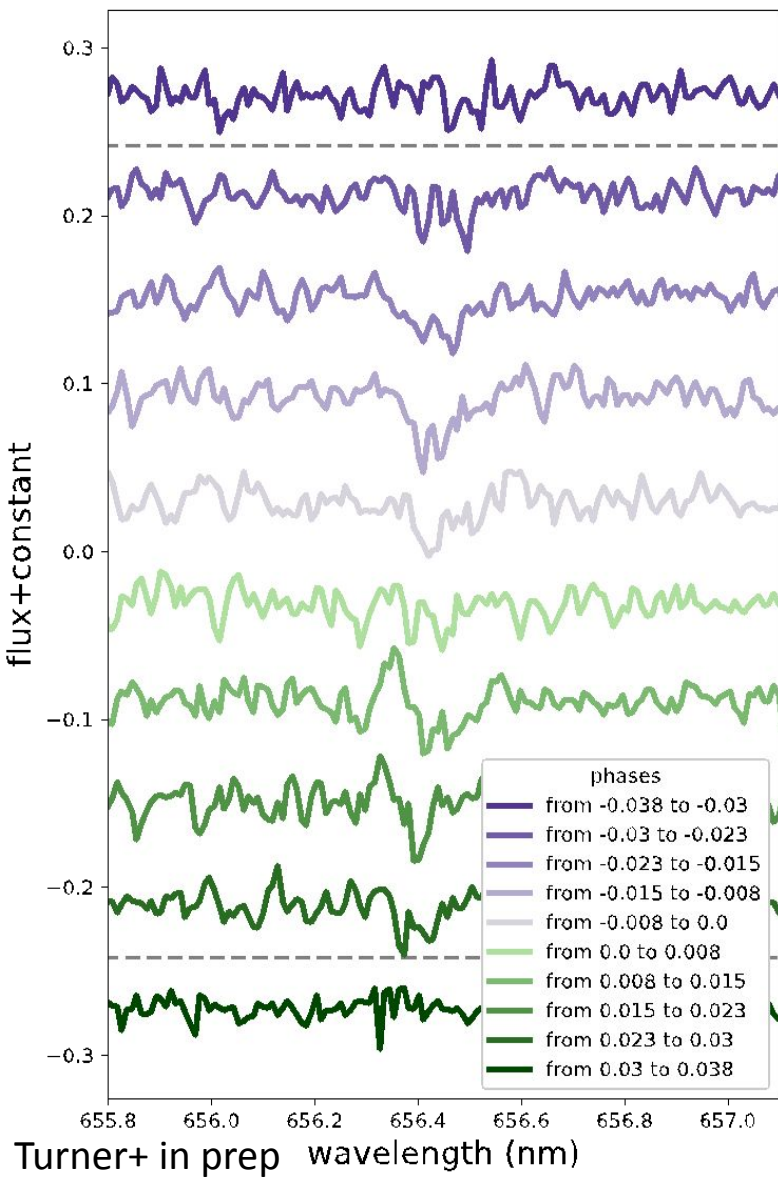
- One of a few Na detections around a very active star

ExoGemS Observed Sample

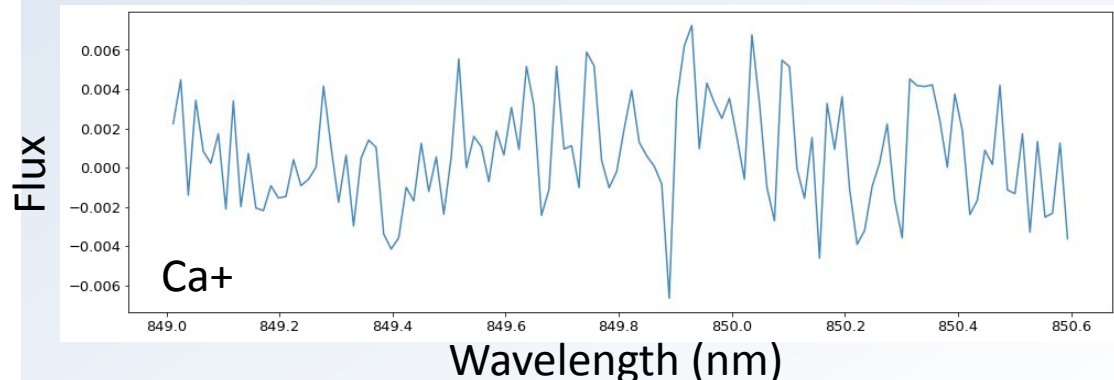
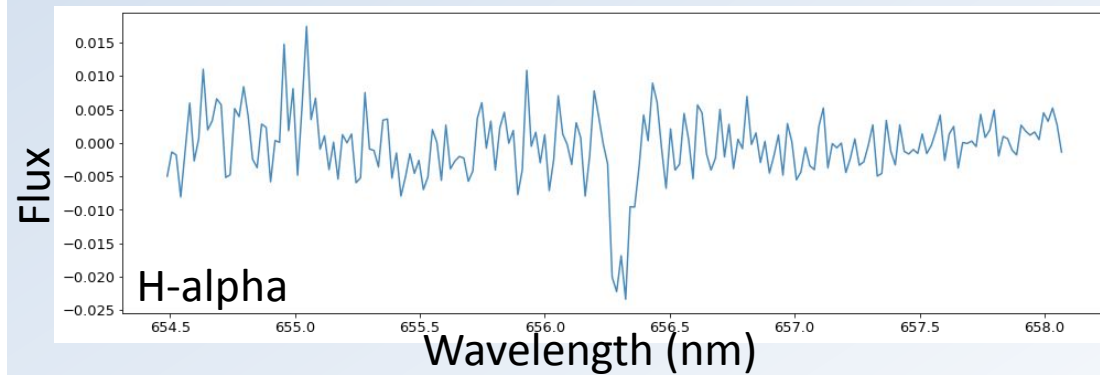


- Planet Temperature: 670 – 3200 K
- Planet Mass: $0.7 M_{Nep}$ – $3.7 M_{Jup}$

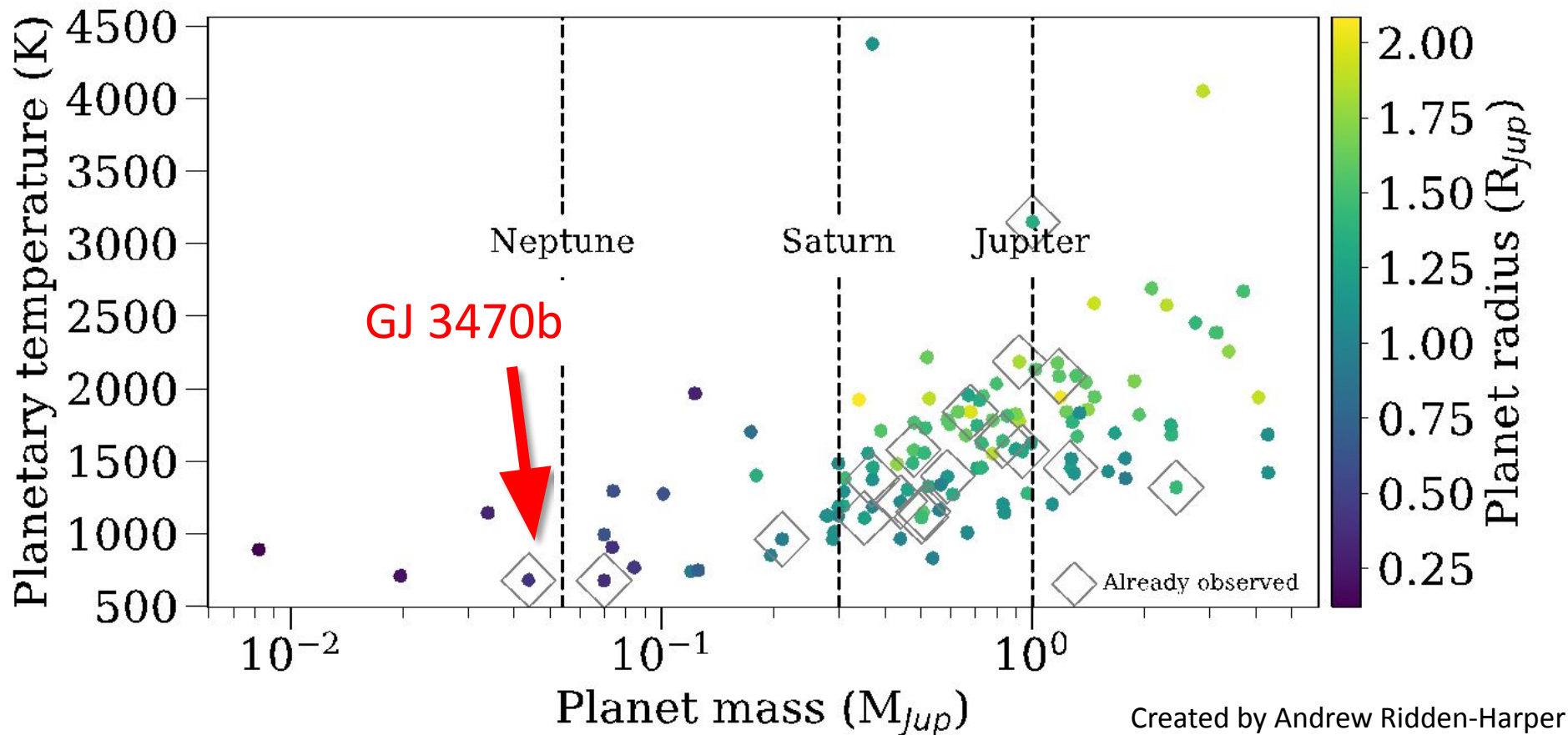
ExoGemS Survey: HAT-P-32 b



- Hints of an early ingress in H-alpha
 - Consistent with Czesla+2022
- $R(\text{H-alpha}) > \text{Roche Lobe}$



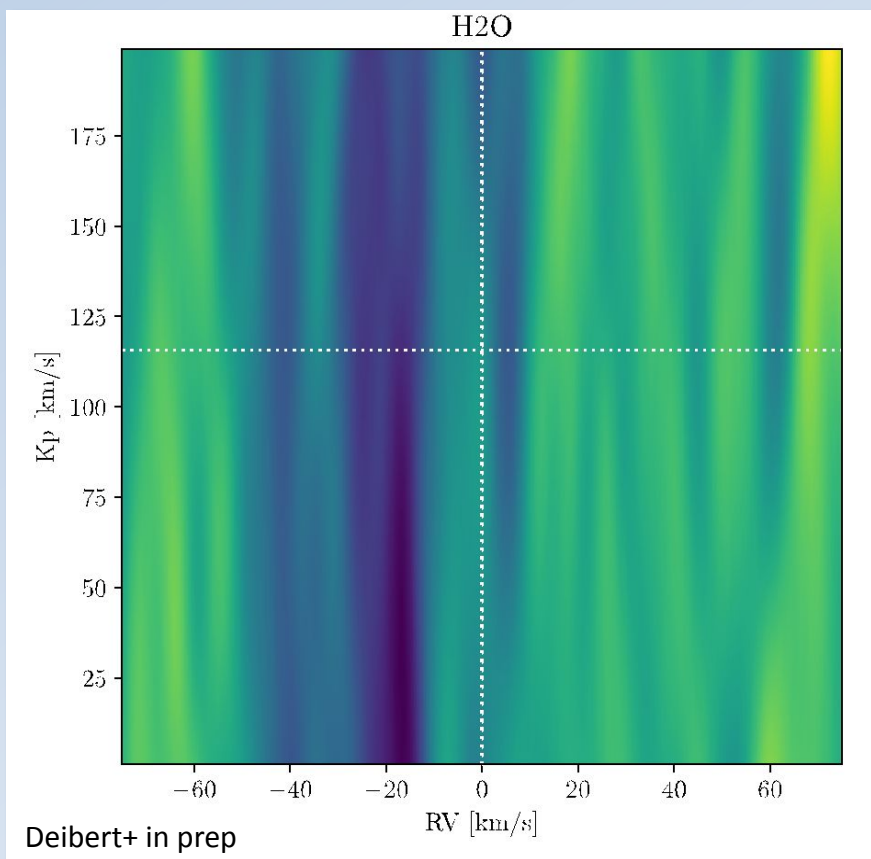
ExoGemS Observed Sample



- Planet Temperature: 670 – 3200 K
- Planet Mass: $0.7 M_{Nep}$ – $3.7 M_{Jup}$

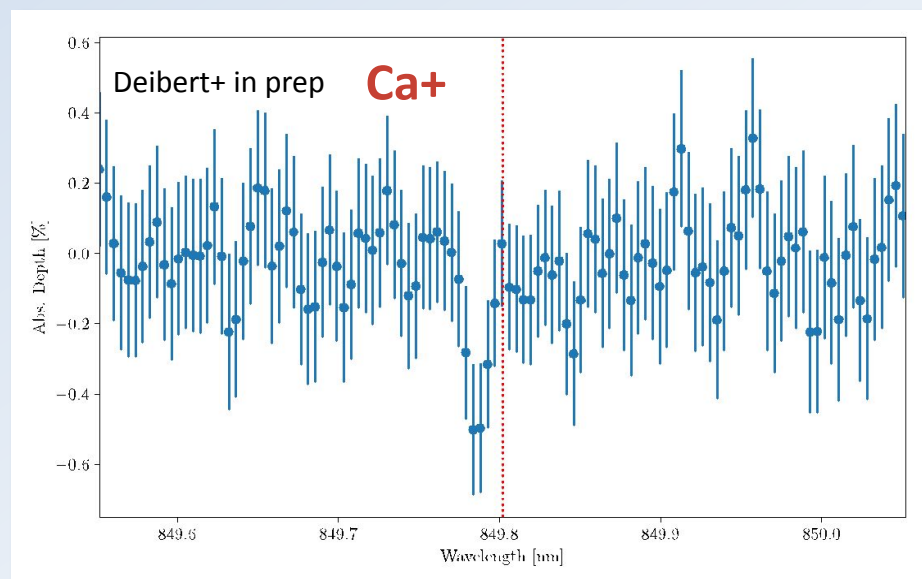
ExoGemS Survey: GJ 3470b

Non-detection of water



Previous H₂O detection with HST: Benneke+ 2019

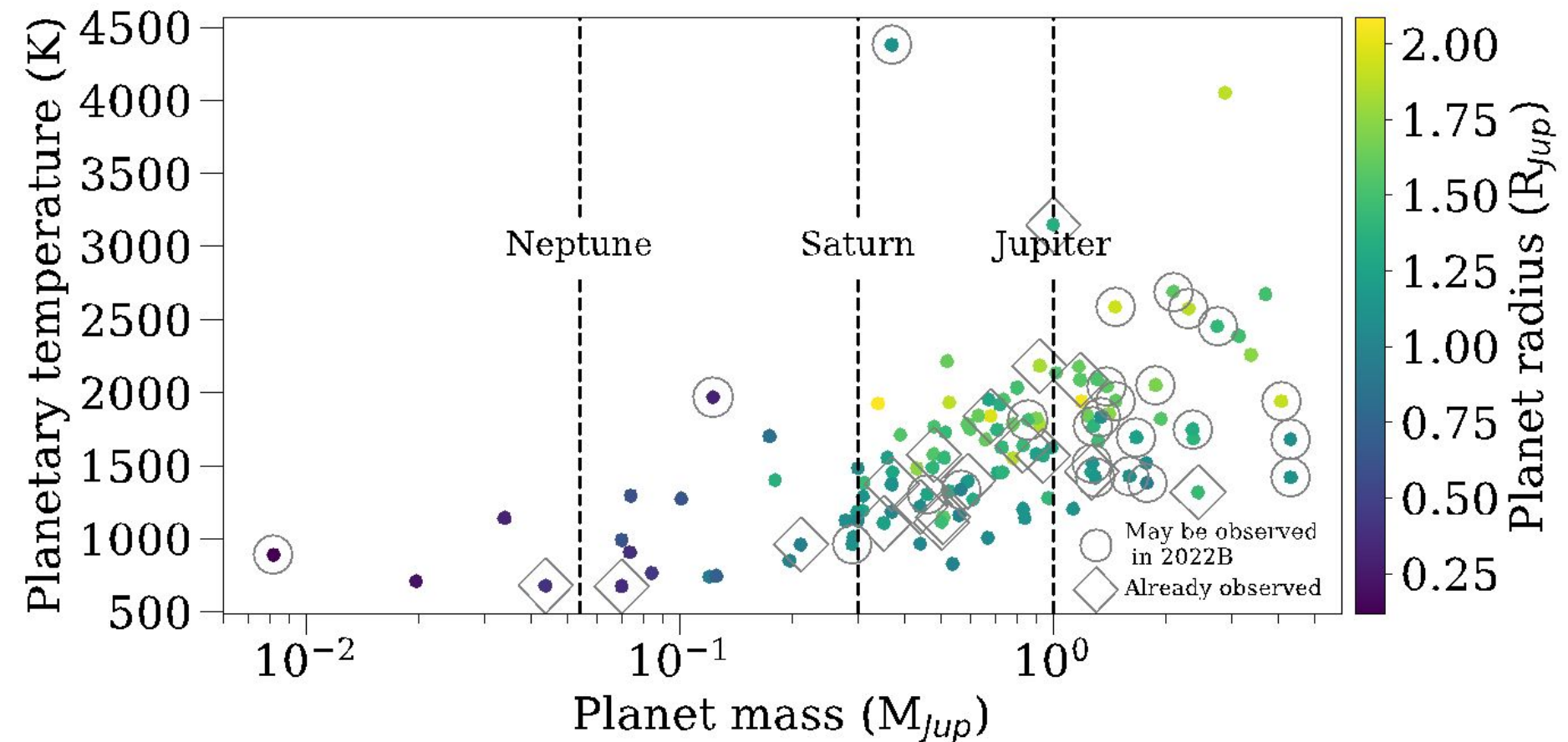
- Super-Puff
- 670 K
- $4.19 R_{\text{Earth}}$ & $0.7 M_{\text{Nep}}$



Likely caused by stellar activity

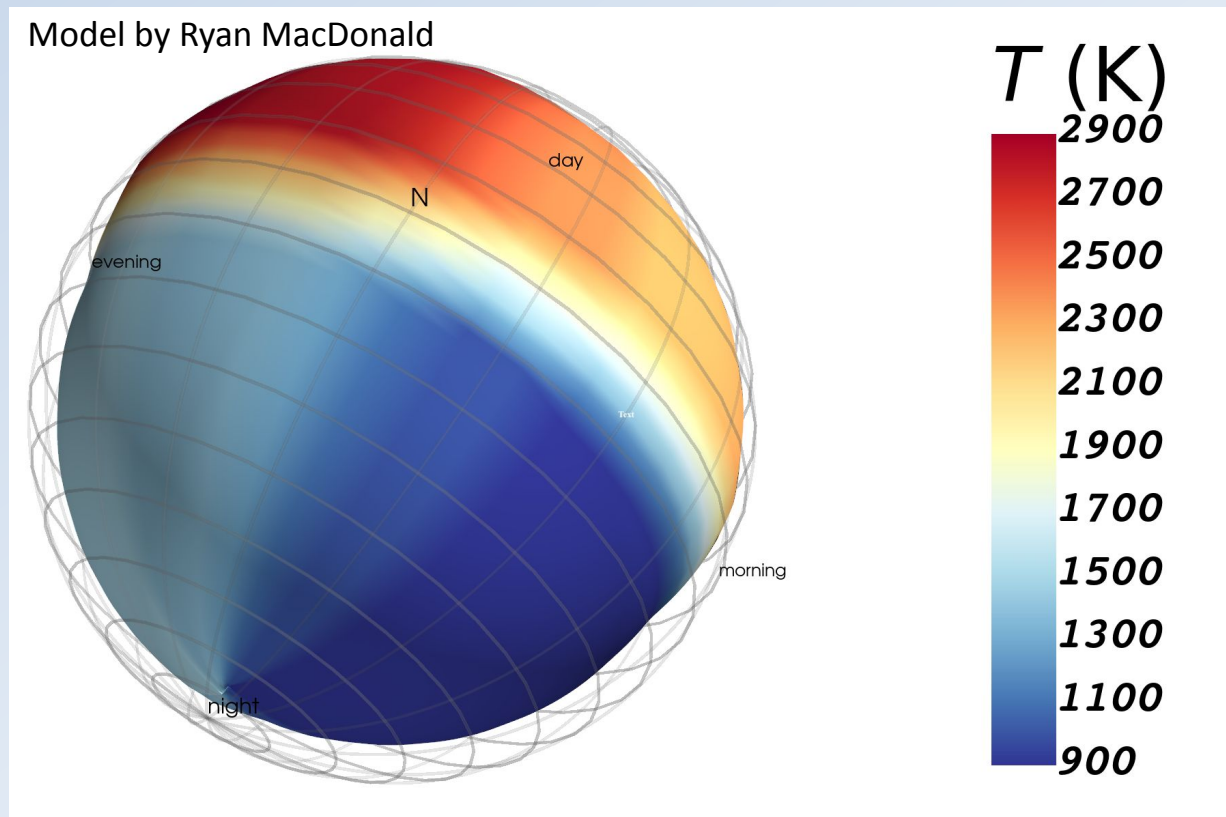
ExoGemS Survey: Next Steps

- 1 more year of observations
 - Concentrate on JWST targets and low-res detections



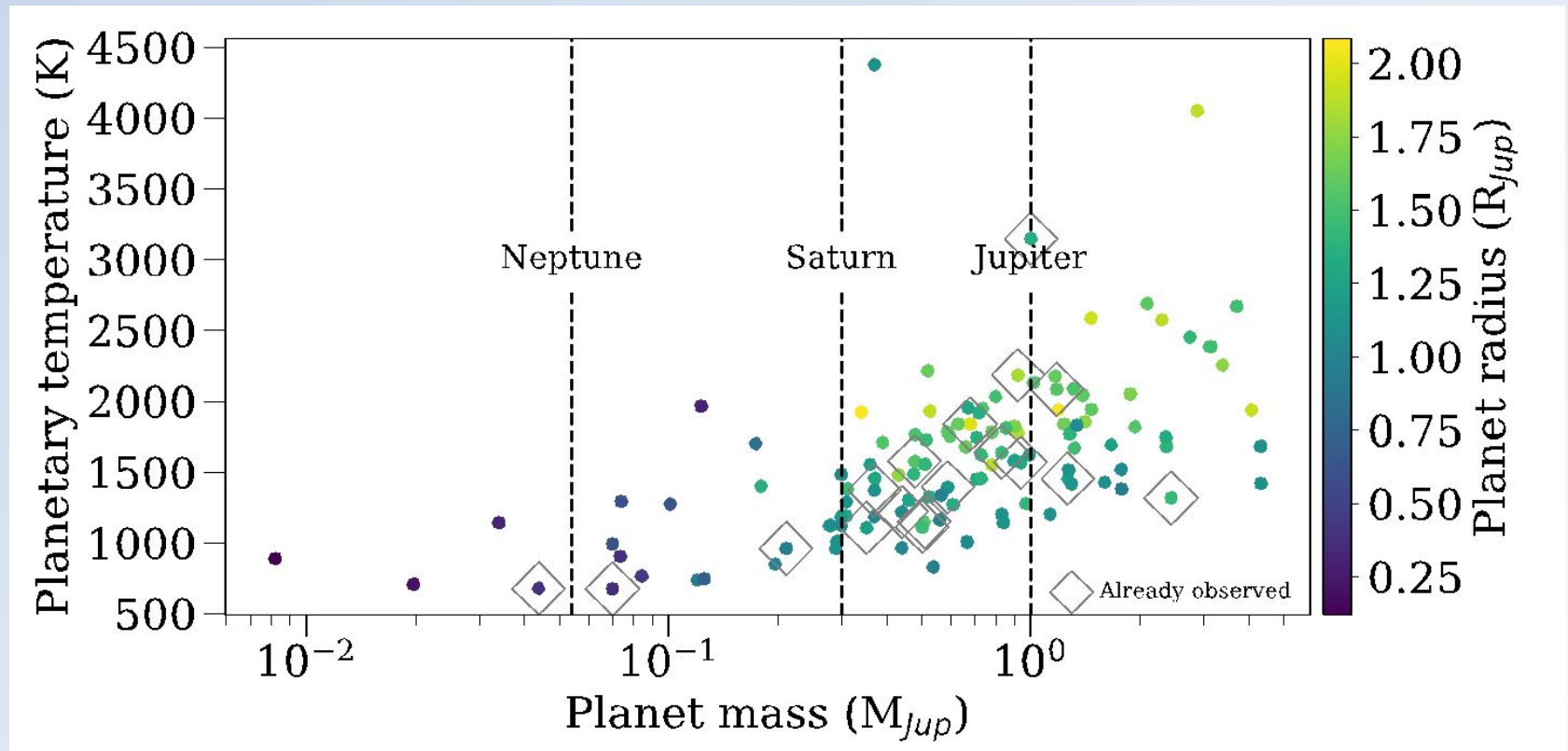
ExoGemS Survey: Next Steps

- 3D Models
- Understand stellar activity
- Put non-detections in context



ExoGemS Survey: Summary

- ExoGemS Survey aims to explore the diversity of exoplanet atmospheres
- Preliminary results show promise of ExoGemS



ExoGemS Survey: Summary

- ExoGemS Survey aims to explore the diversity of exoplanet atmospheres
- Preliminary results show great promise

