



# **Chasing small TESS planets with the MAROON-X spectrograph**

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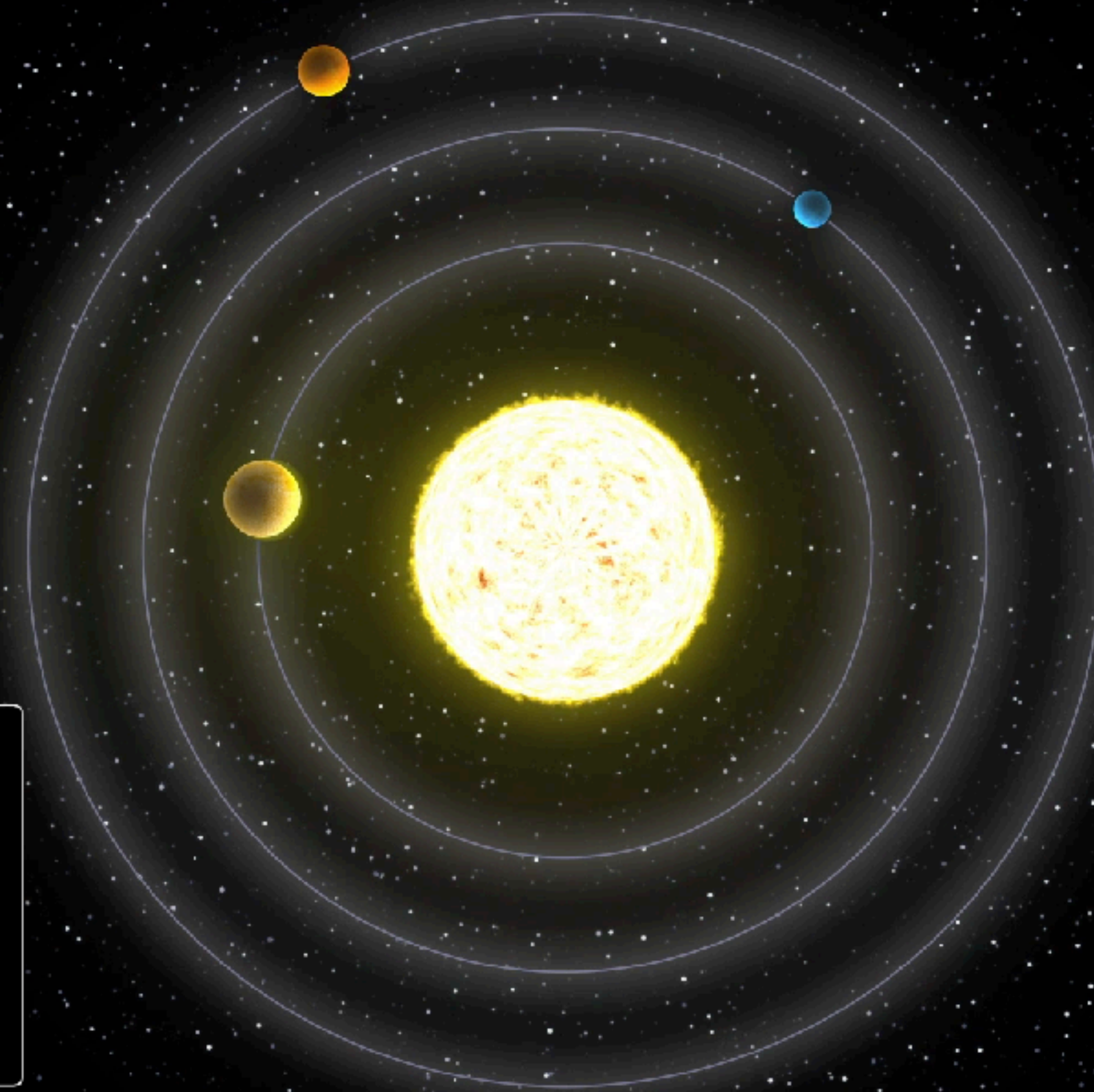
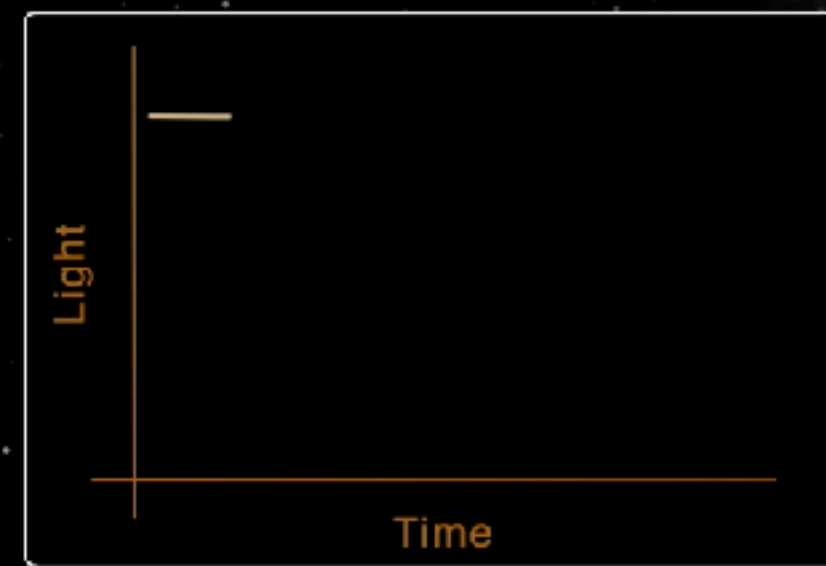
## **Jennifer Burt**

**Jet Propulsion Laboratory, California Institute of Technology**

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**GEMINI SCIENCE MEETING – JULY 26 2022**

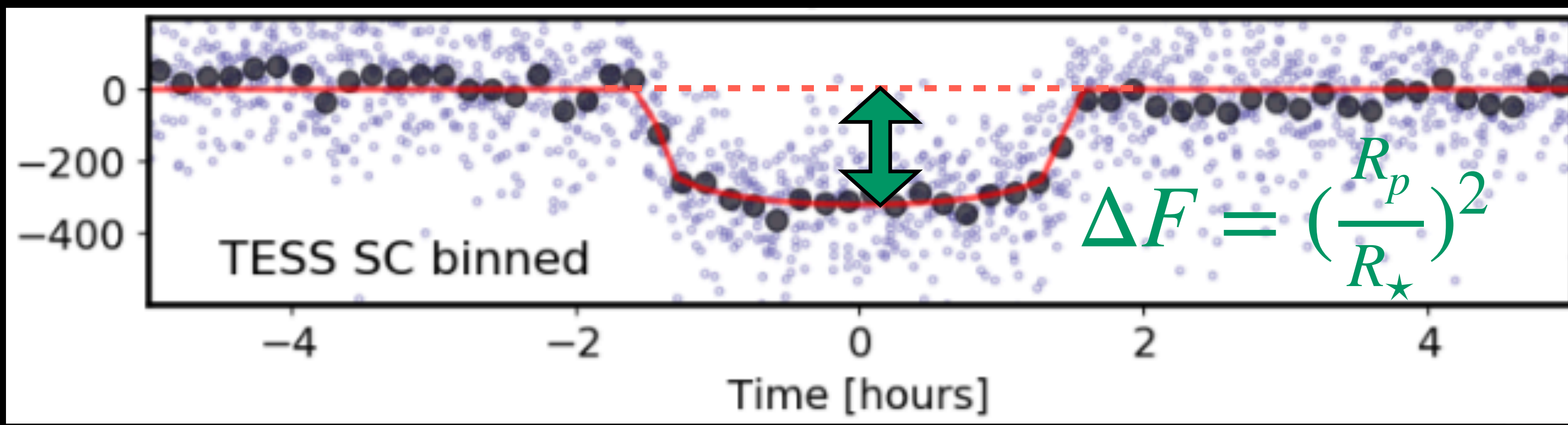
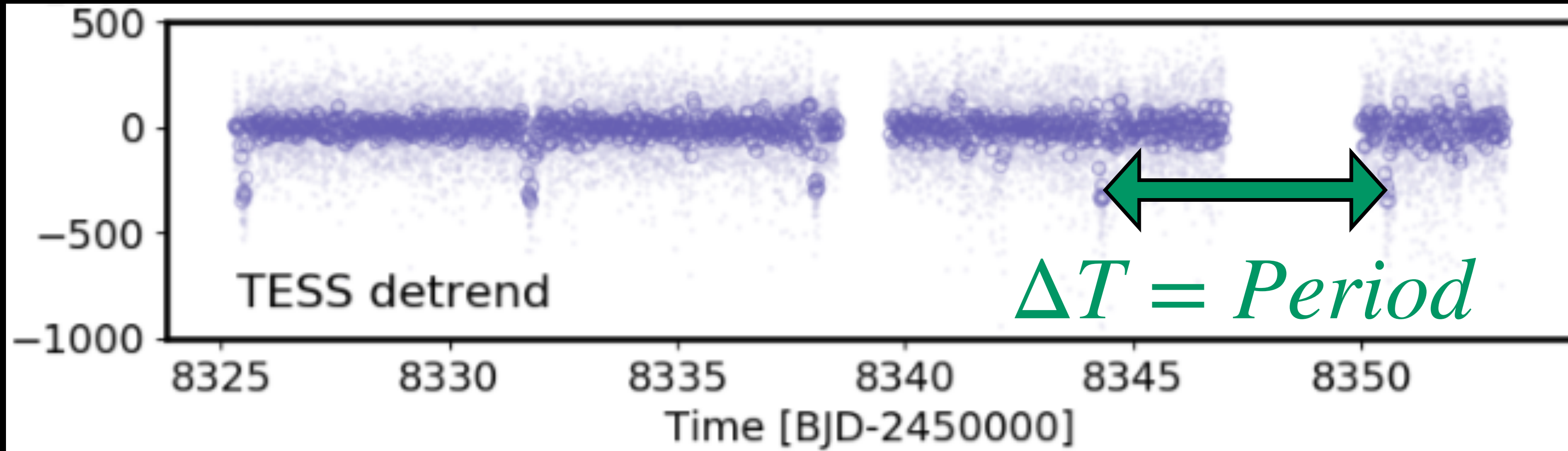
# Transiting Exoplanet Survey Satellite



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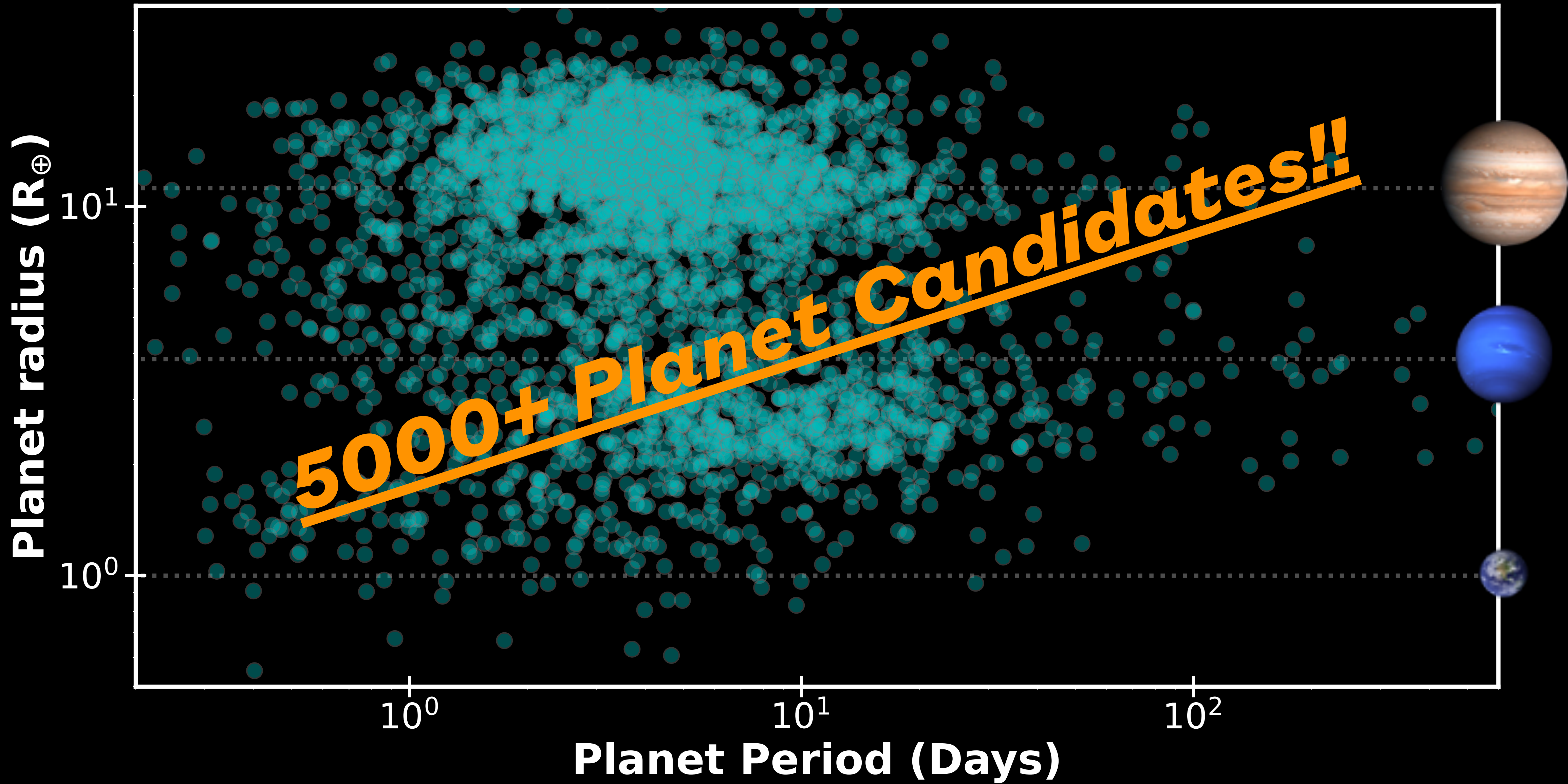




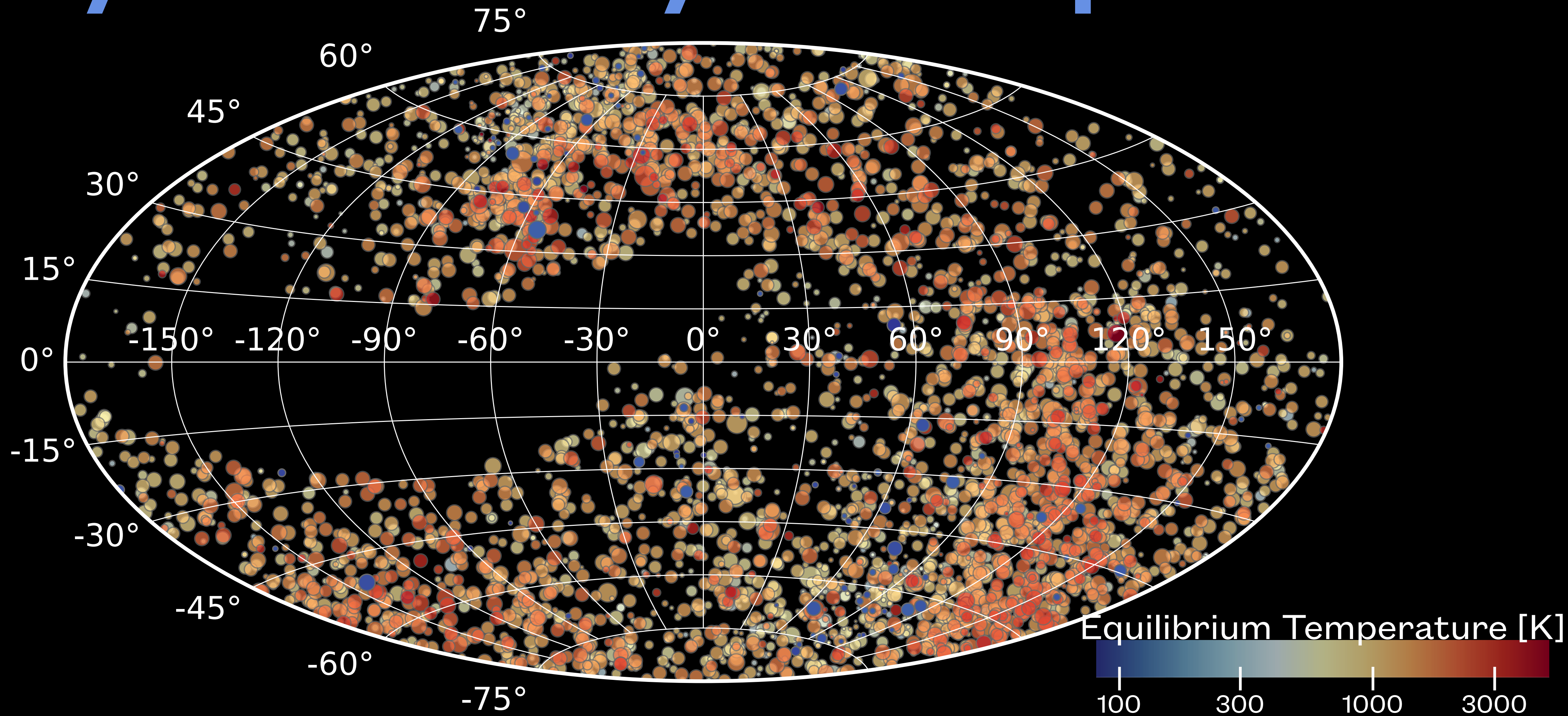
$$\text{Period} = \Delta T$$

$$R_{pl} = \sqrt{\Delta F} \cdot R_\star$$

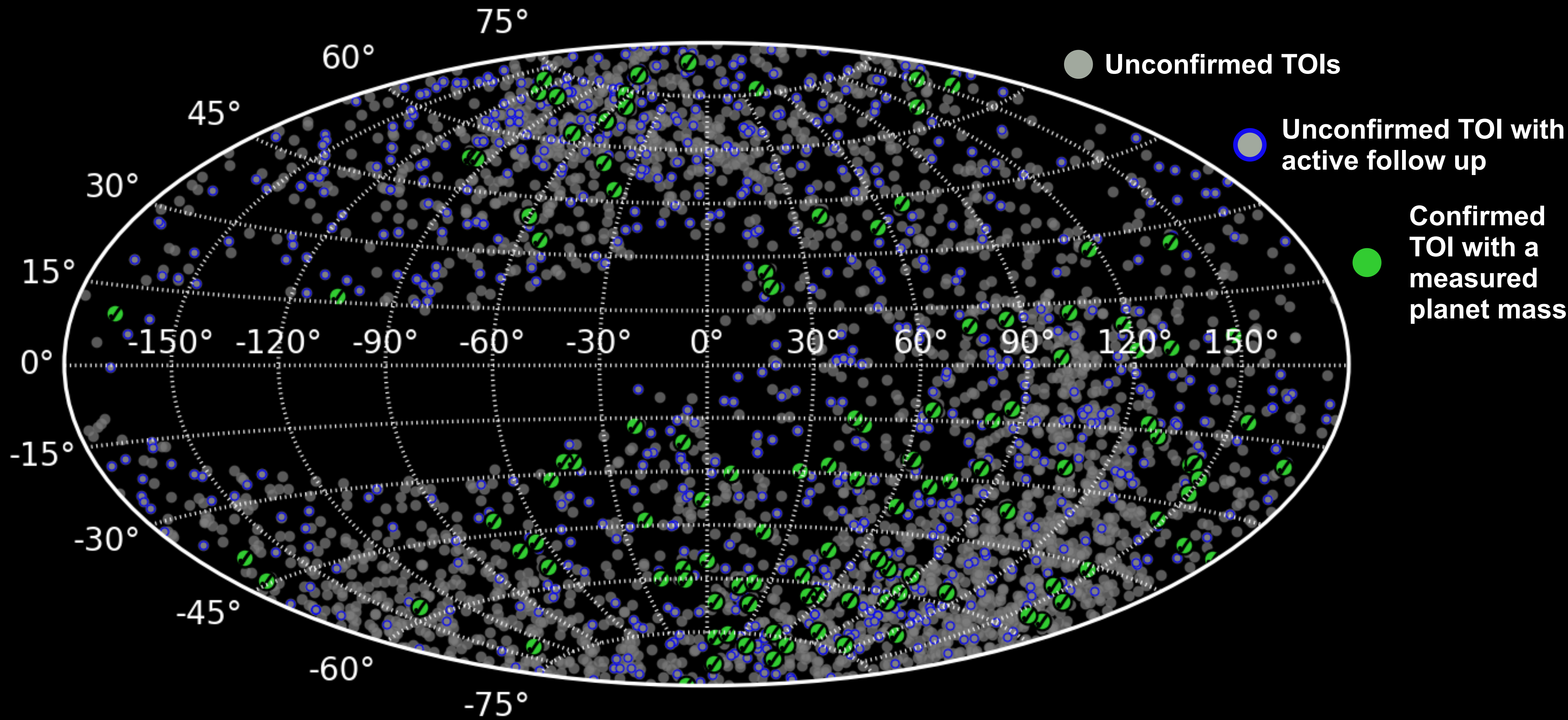




# Every bit of the sky is full of planets



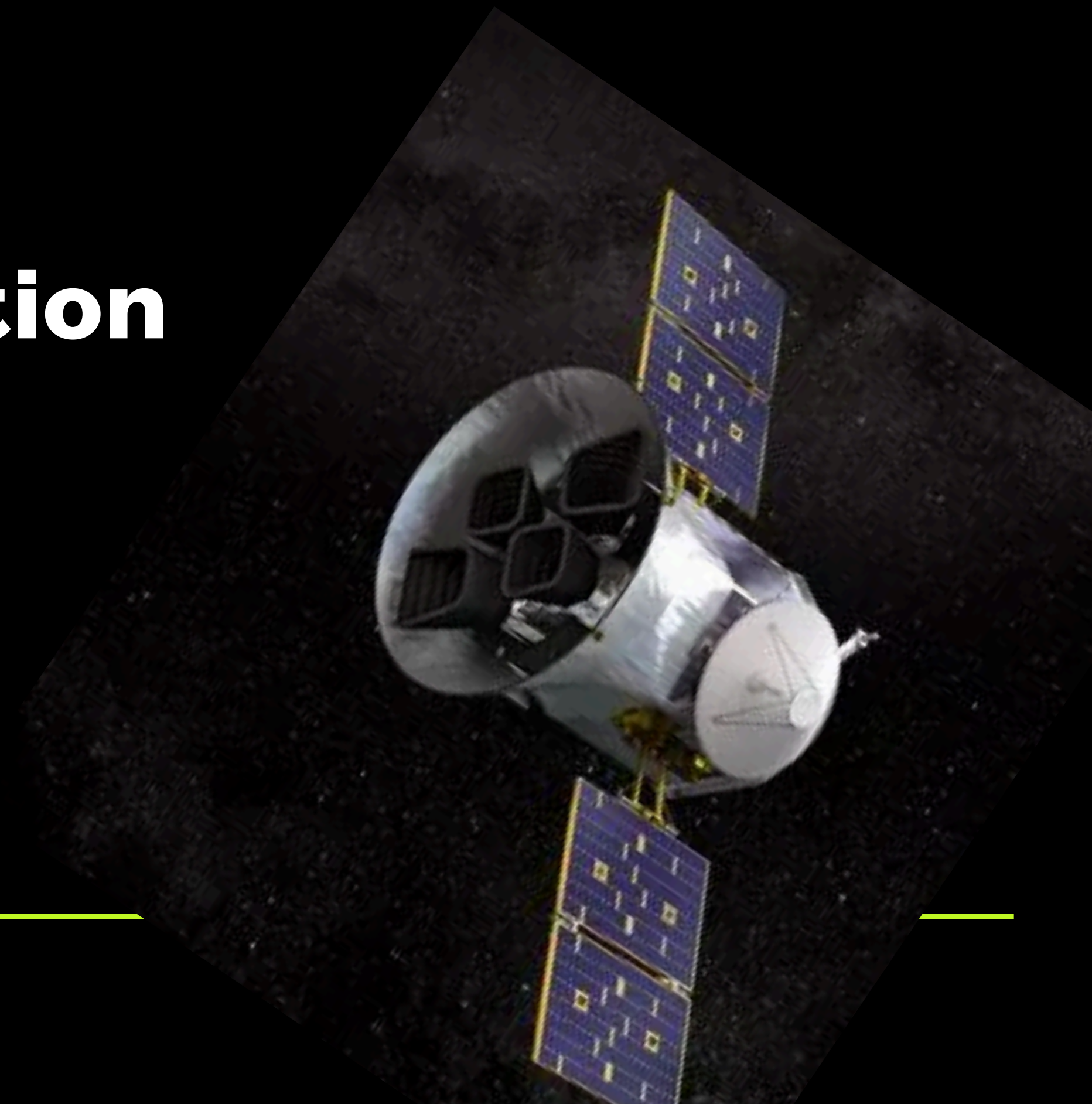
# ... but most of them lack masses



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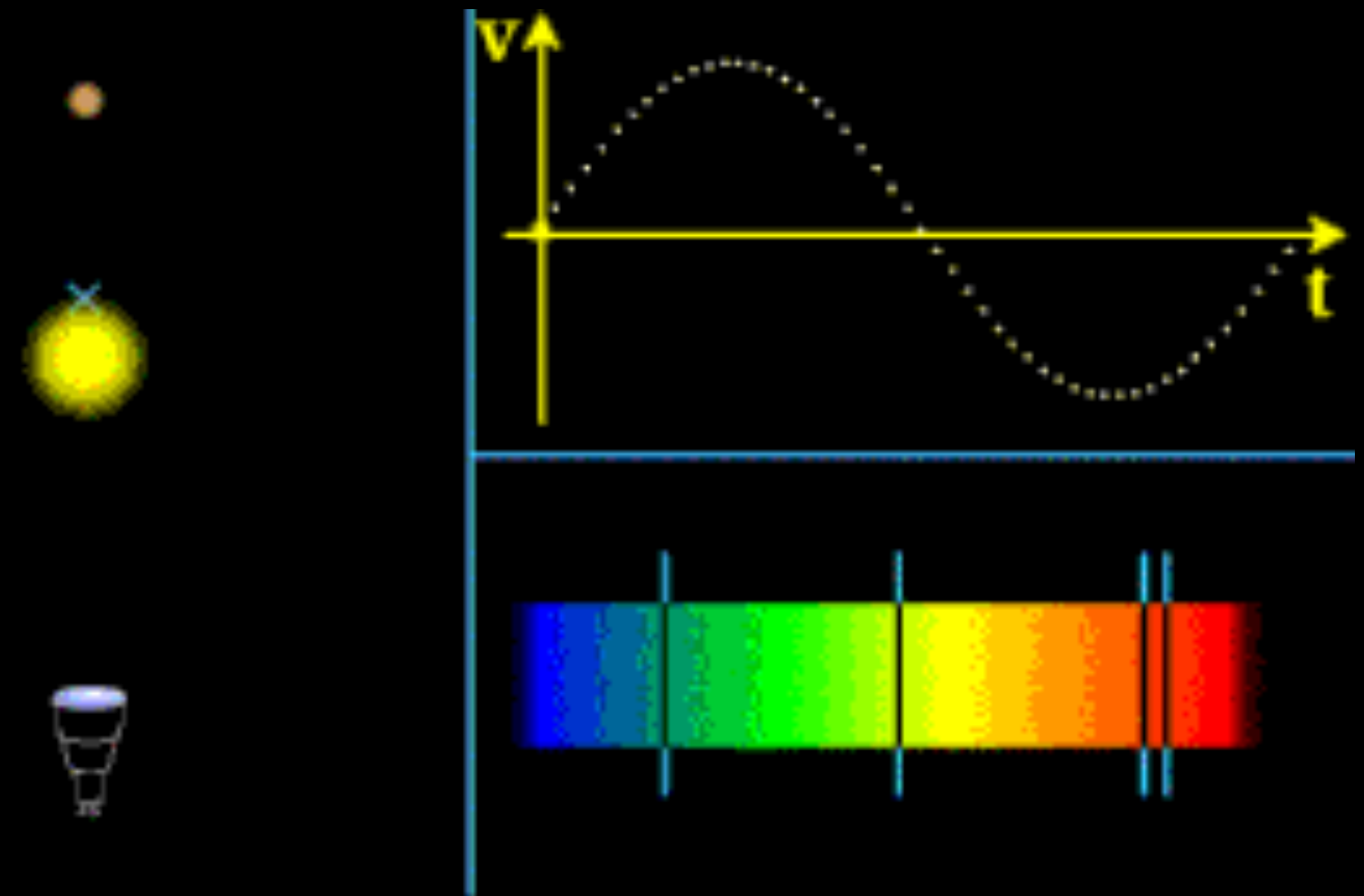
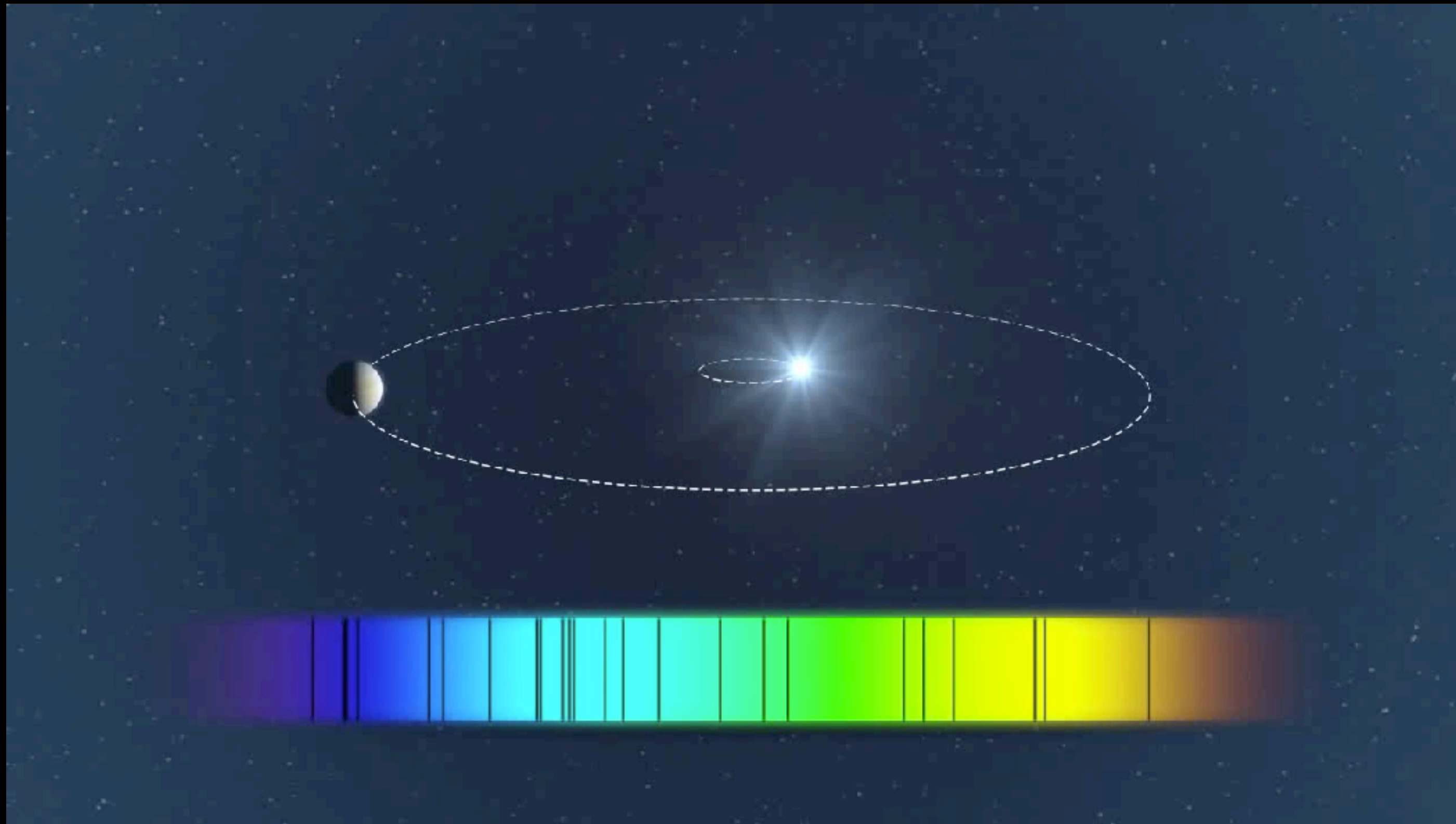
# Exoplanet masses:

- **Let us model interior compositions**
- **Are required for atmospheric characterization**
- **Inform planet formation & evolution theories**
- **Among many others...**

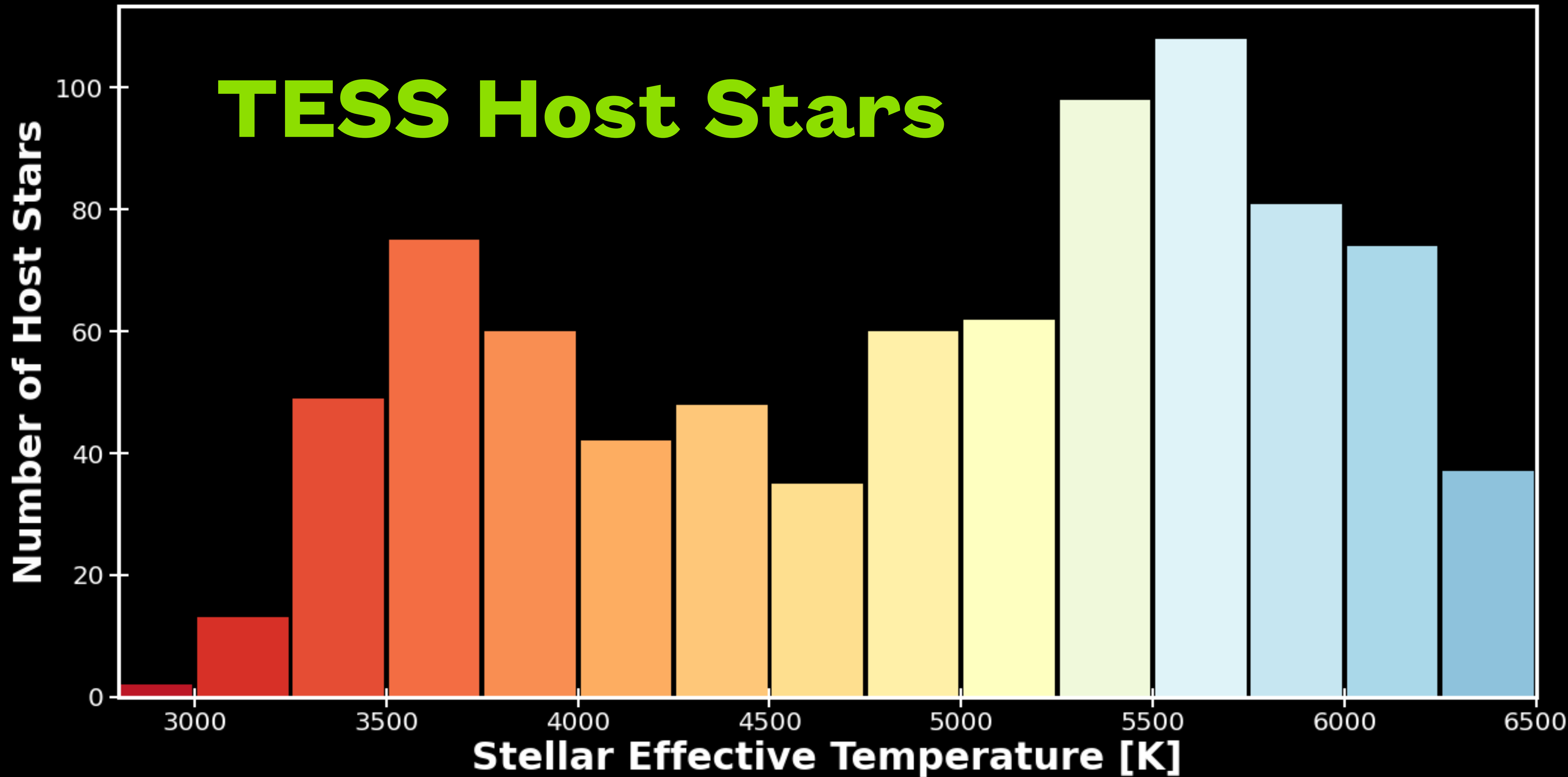




# Masses come from RV follow up

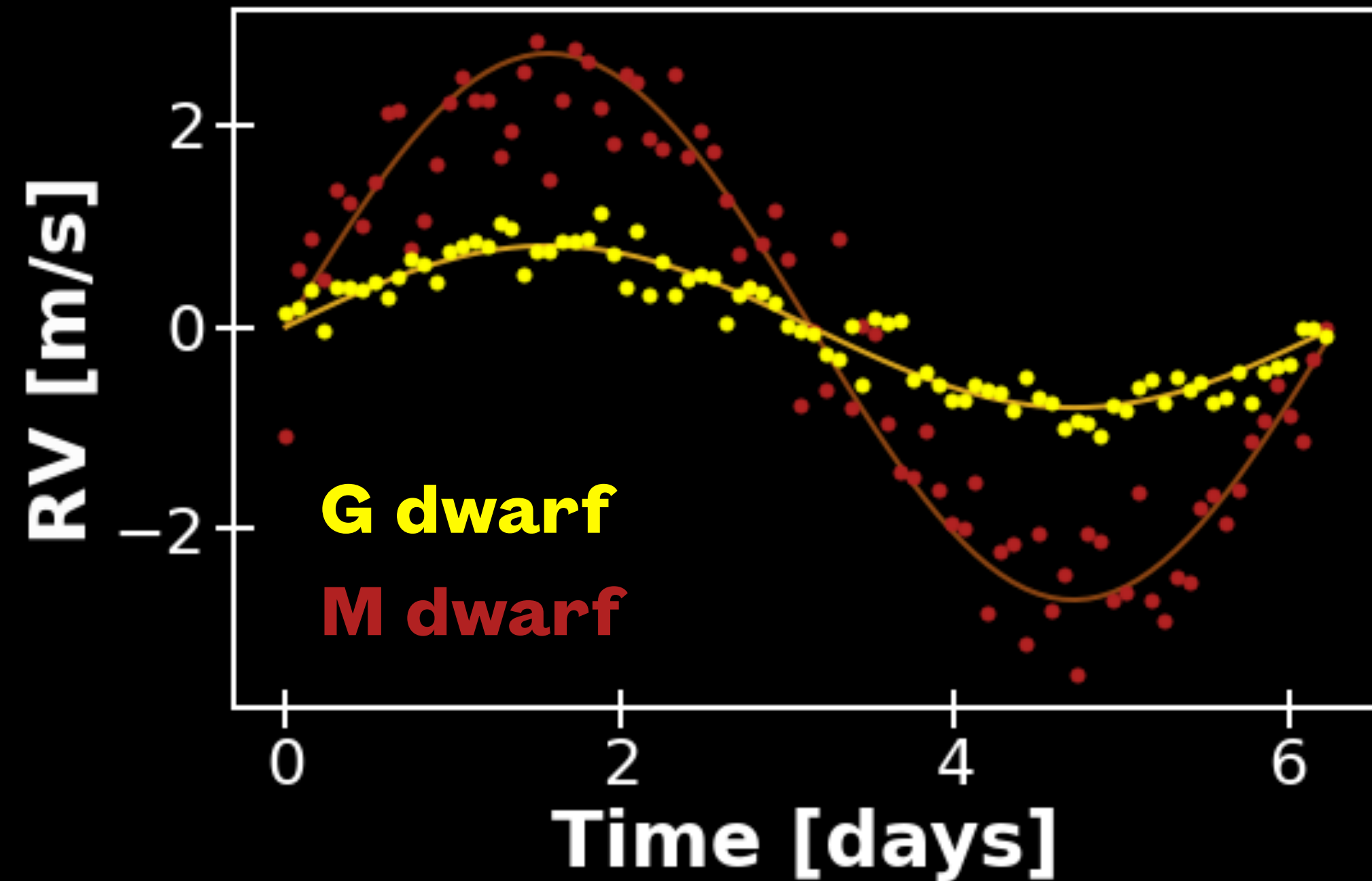
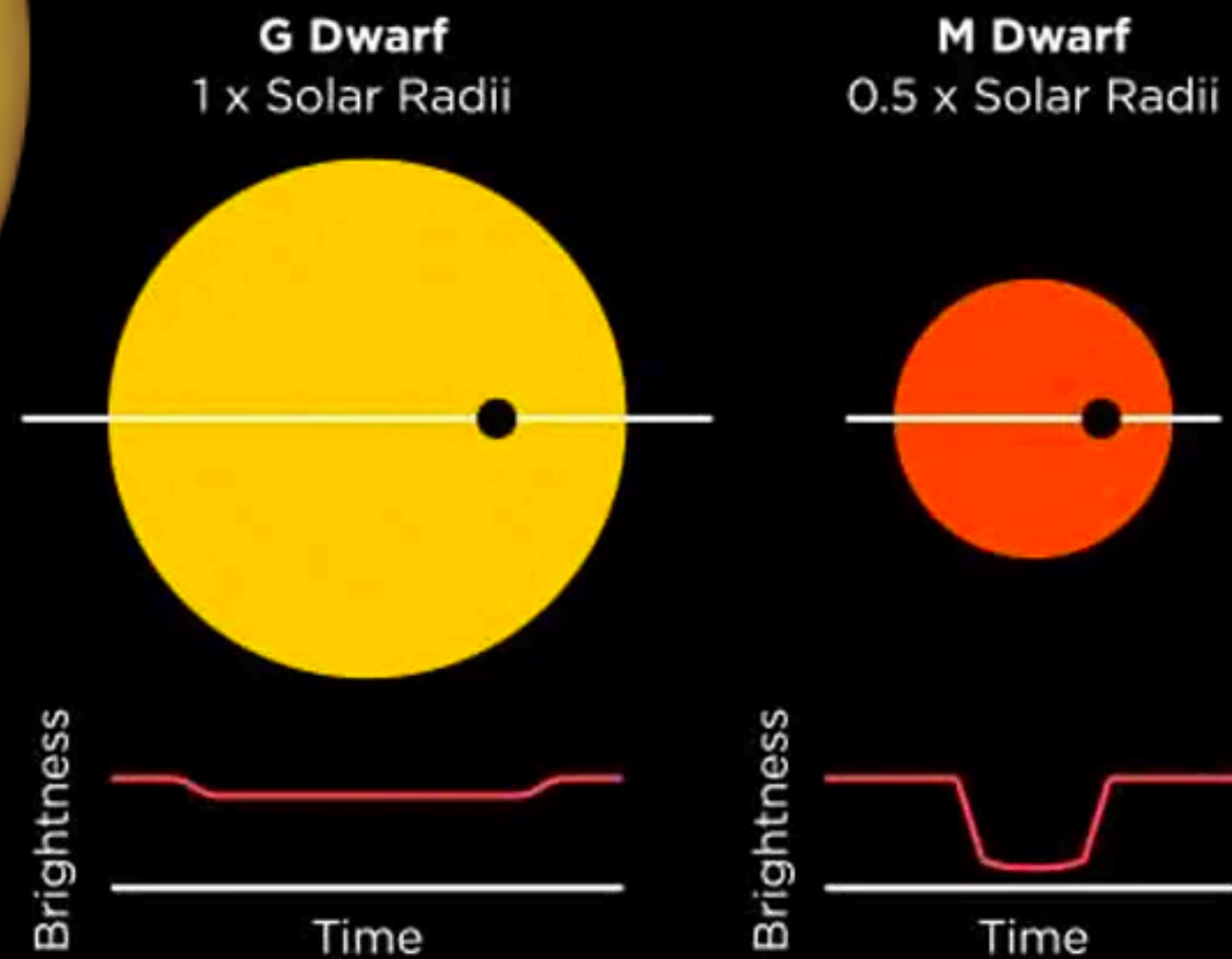
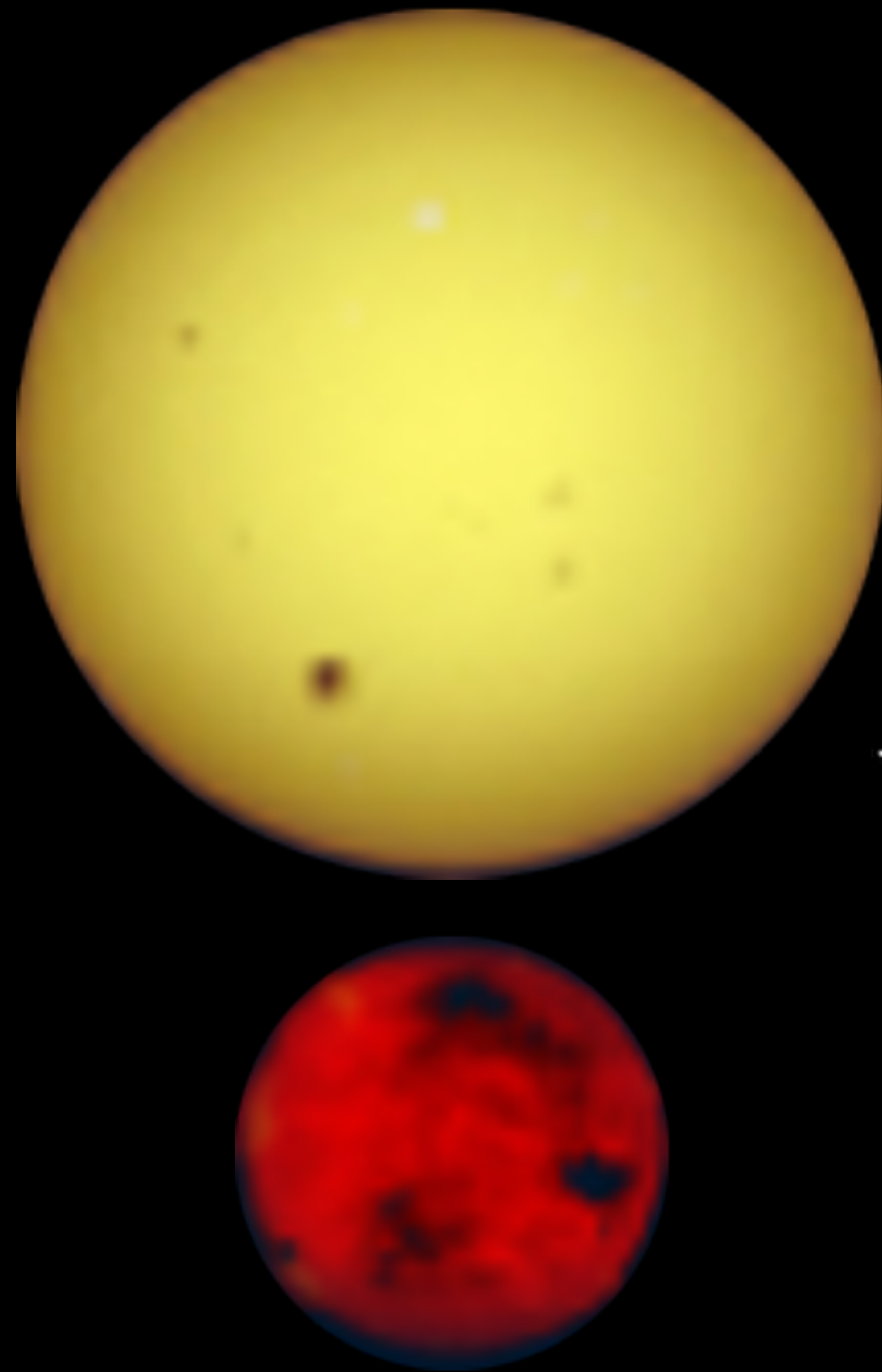


# TESS Host Stars



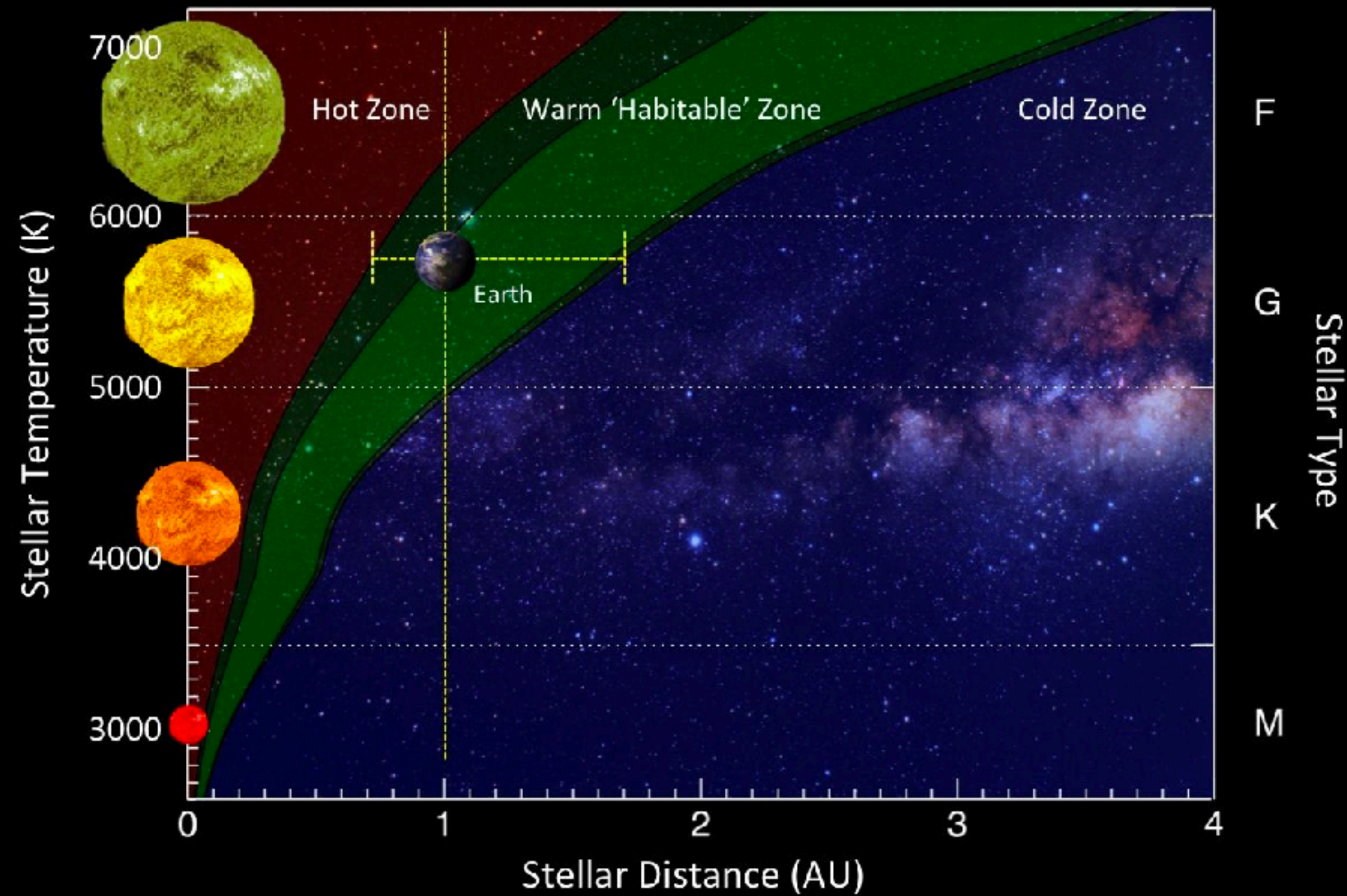
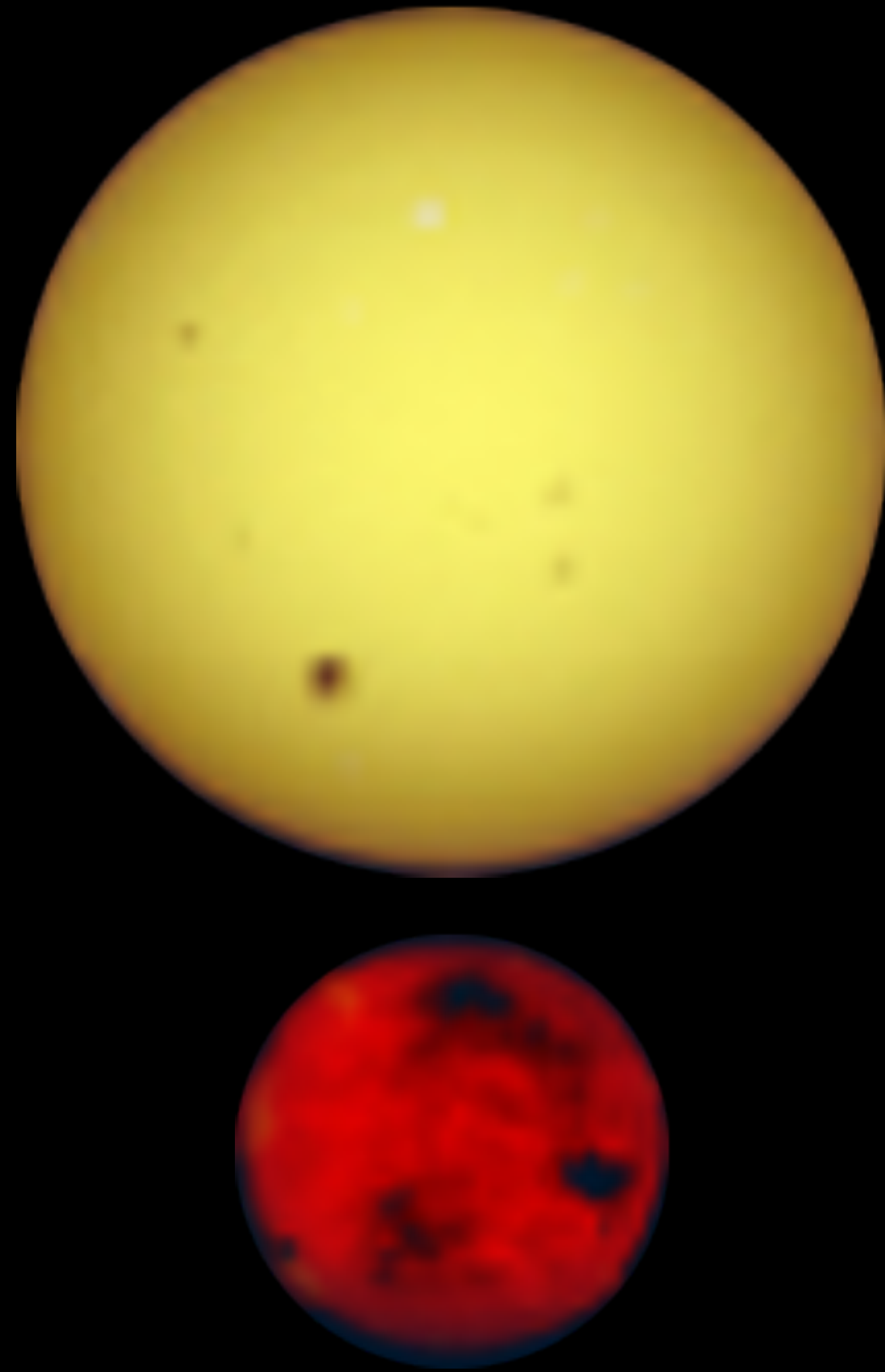
# The M dwarf advantage

## #1 - Easier to detect planets



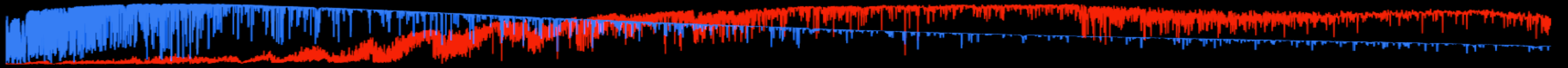
# The M dwarf advantage

## #2 - Easier to reach the HZ



5800 K

2800 K



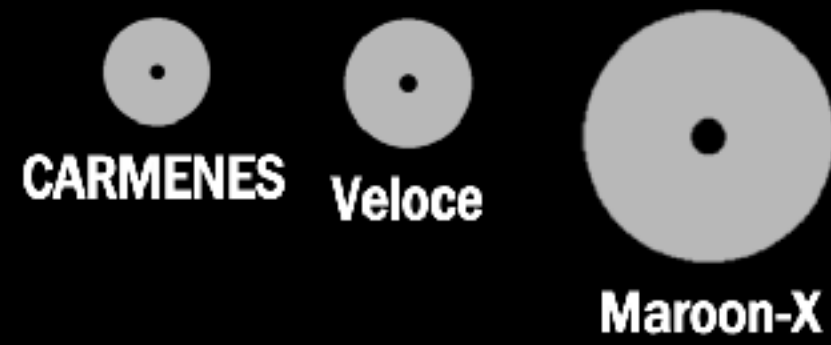
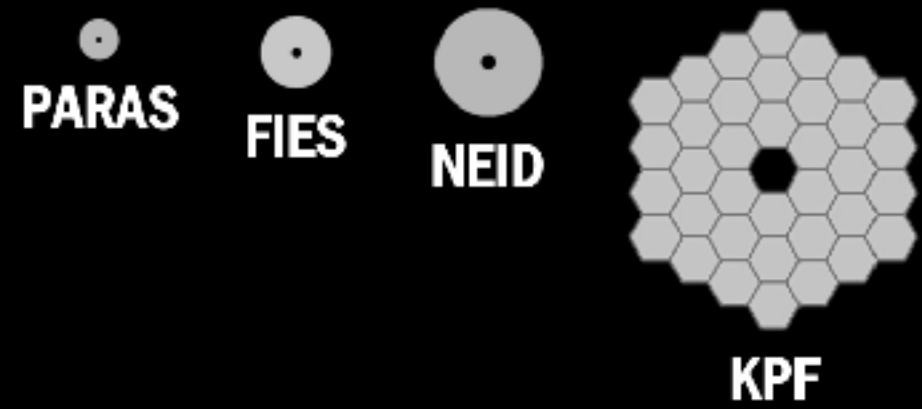
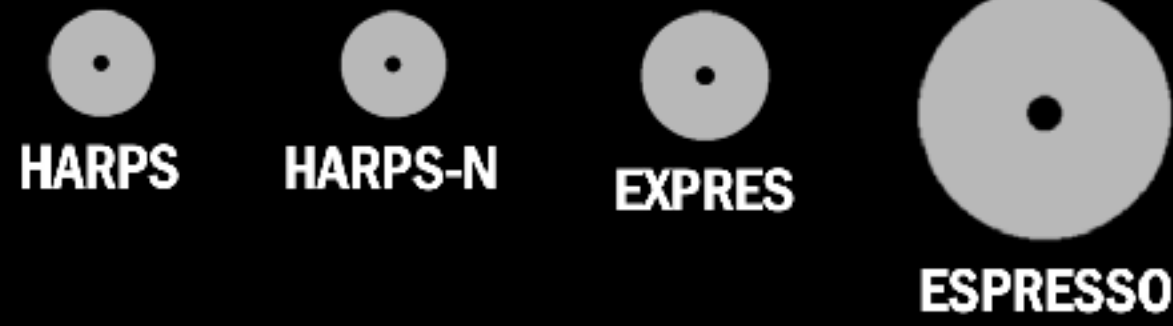
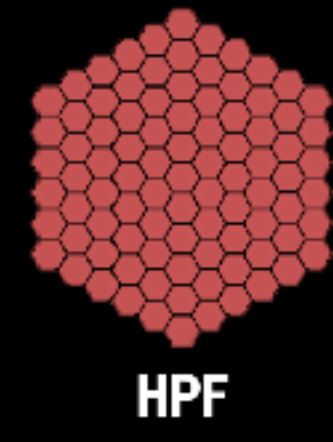
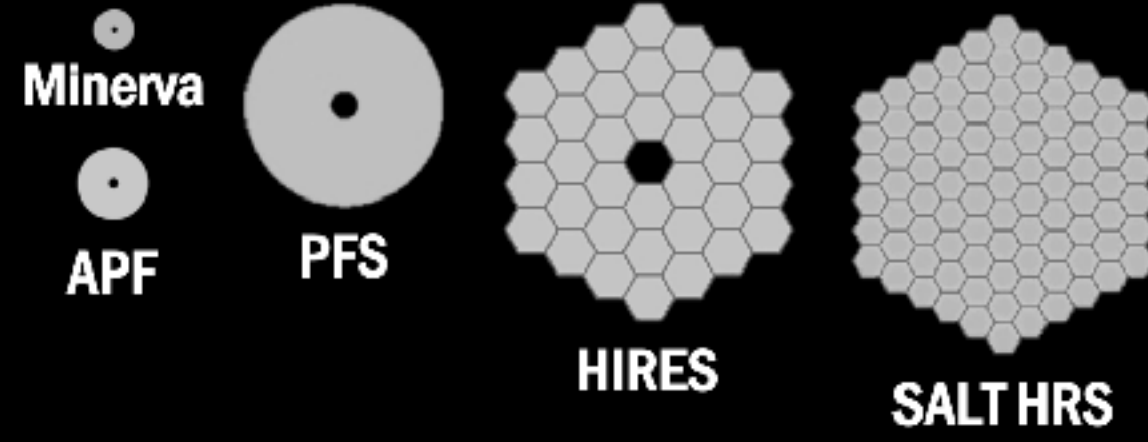
Telluric contamination

Z

Y

J

H



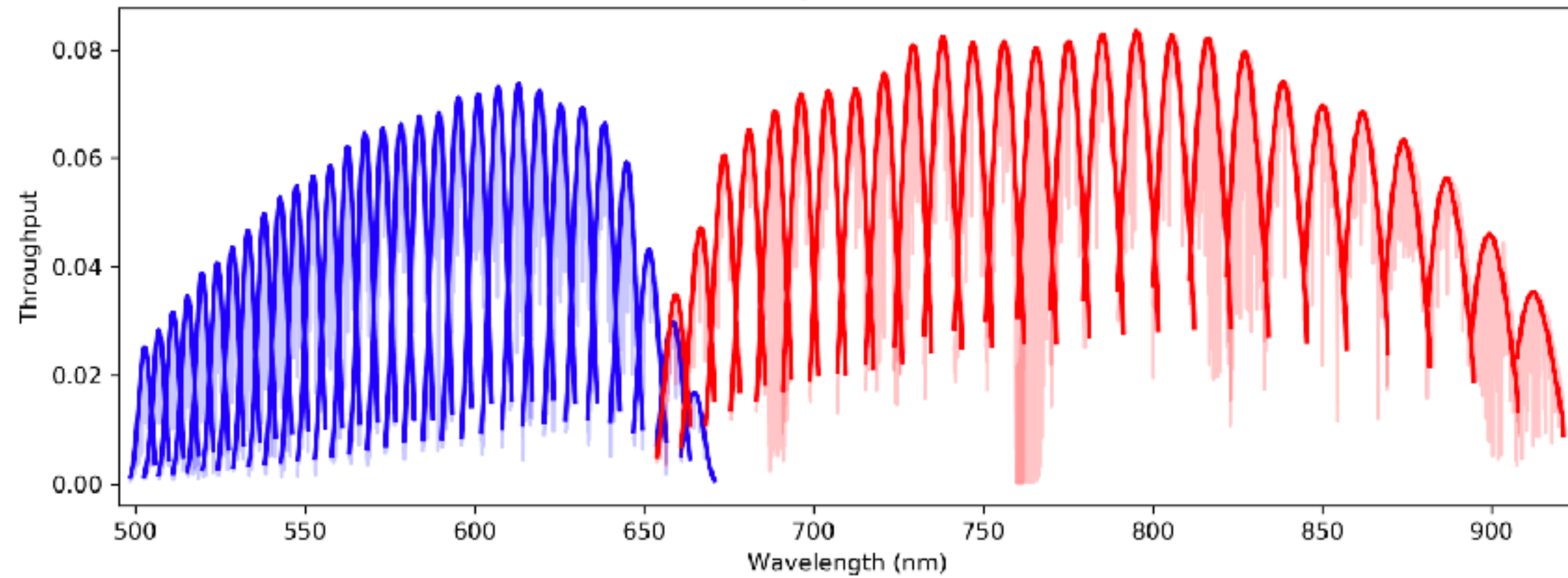
Sam Halverson

*Spectral coverage and relative aperture are approximate*

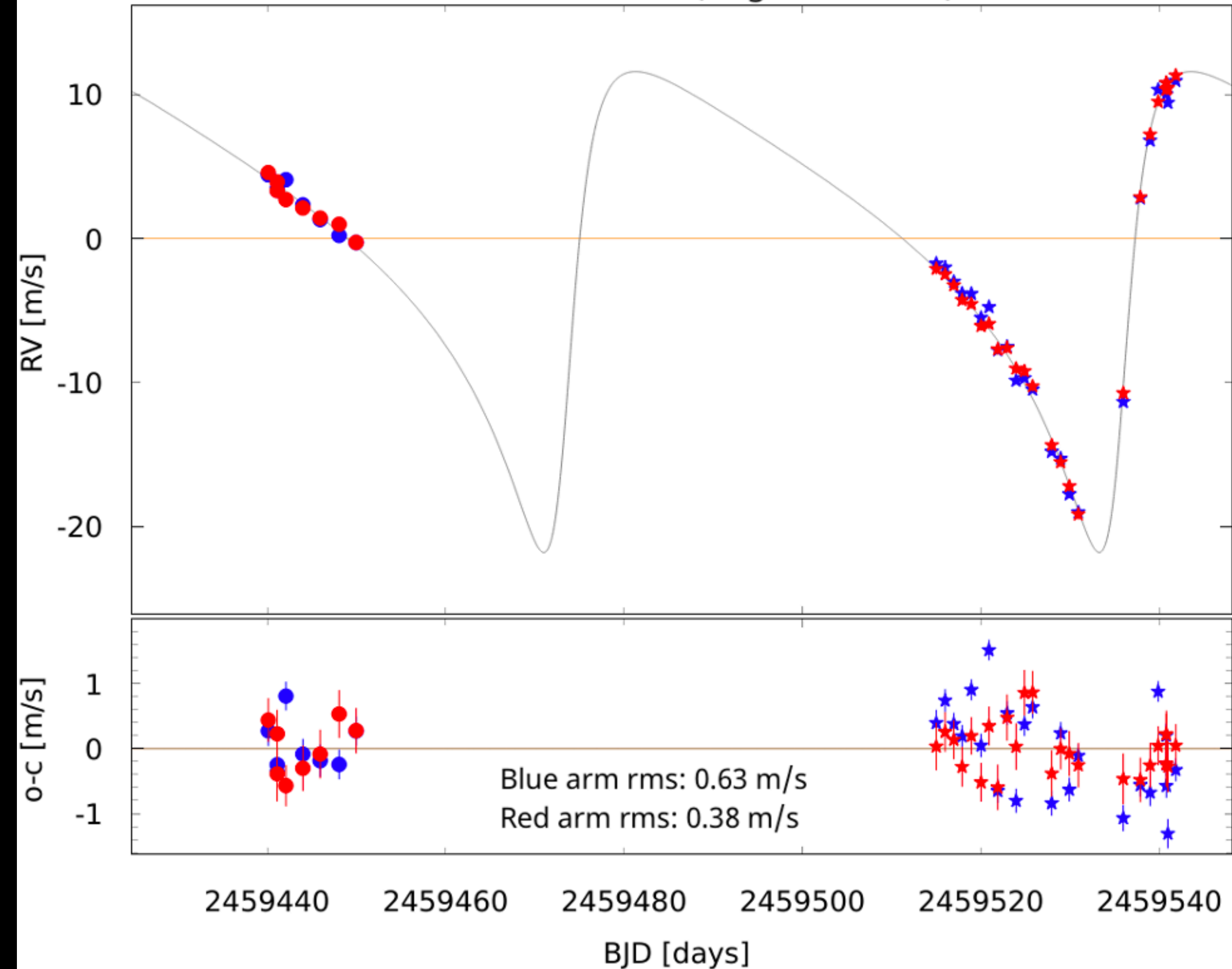
# MAROON-X

**R~85,000**  
**500 - 920nm**  
**fiber-fed echelle spectrograph**

MAROON-X Efficiency (at 2019-12-12 05:26:37)

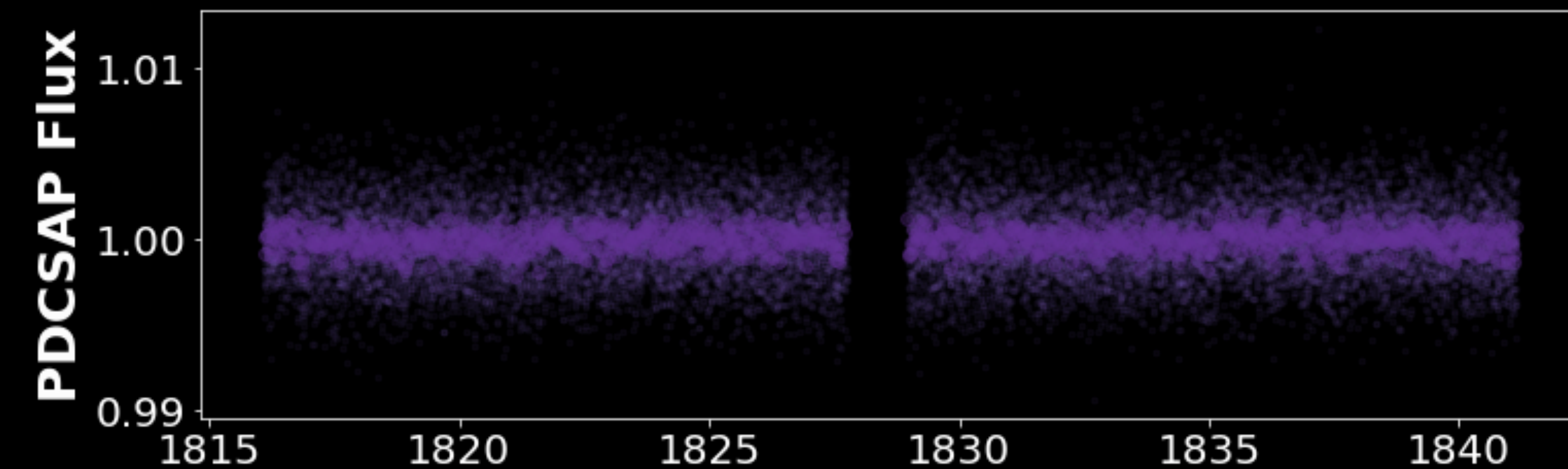
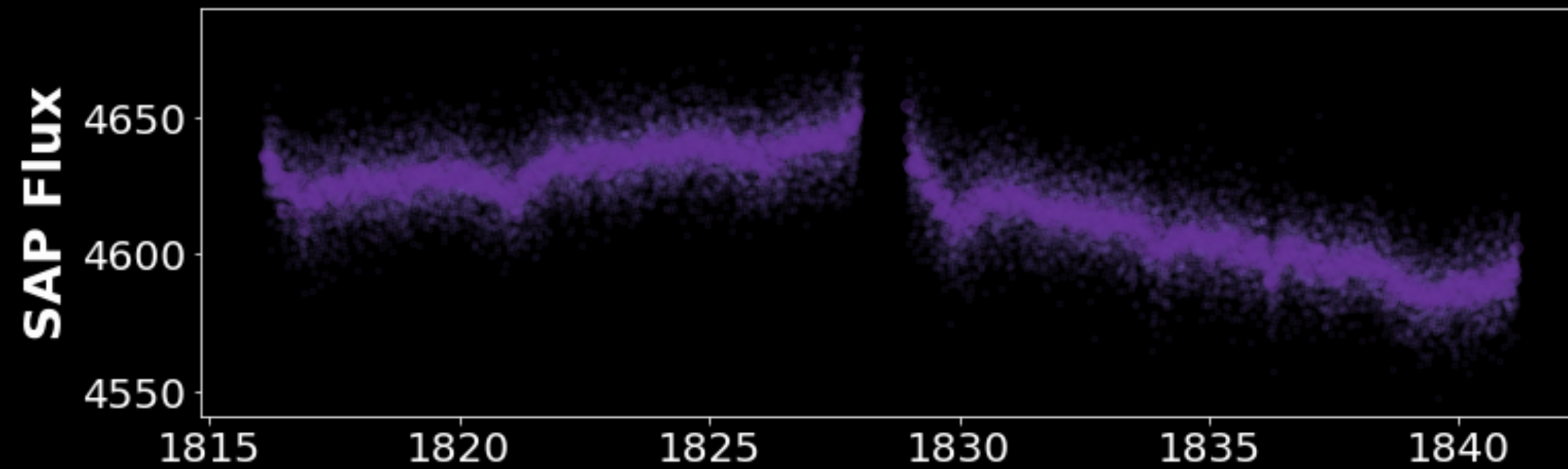


MAROON-X HD3651 RVs (Aug + Nov 2021)

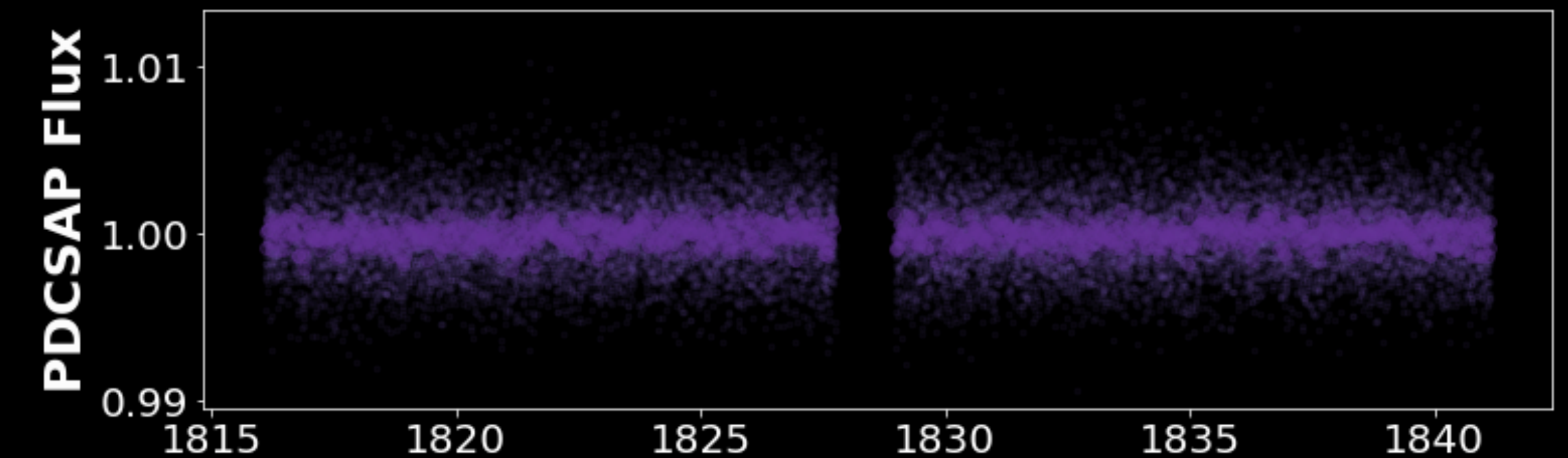
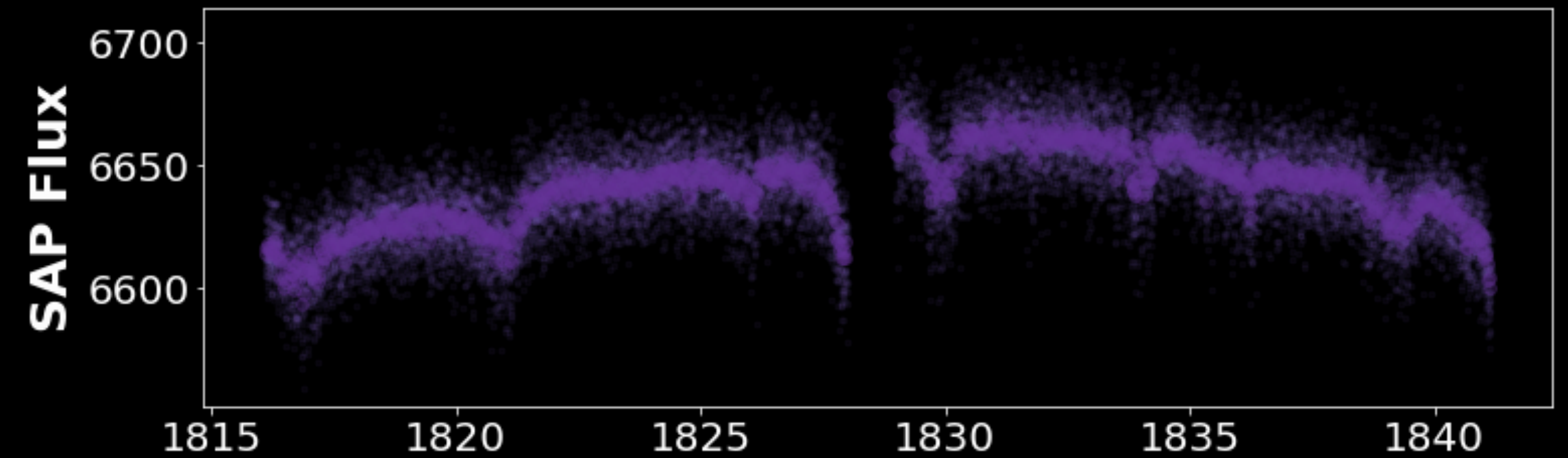


Seifahrt et al. 2020

# TOI-1685 & TOI-1693

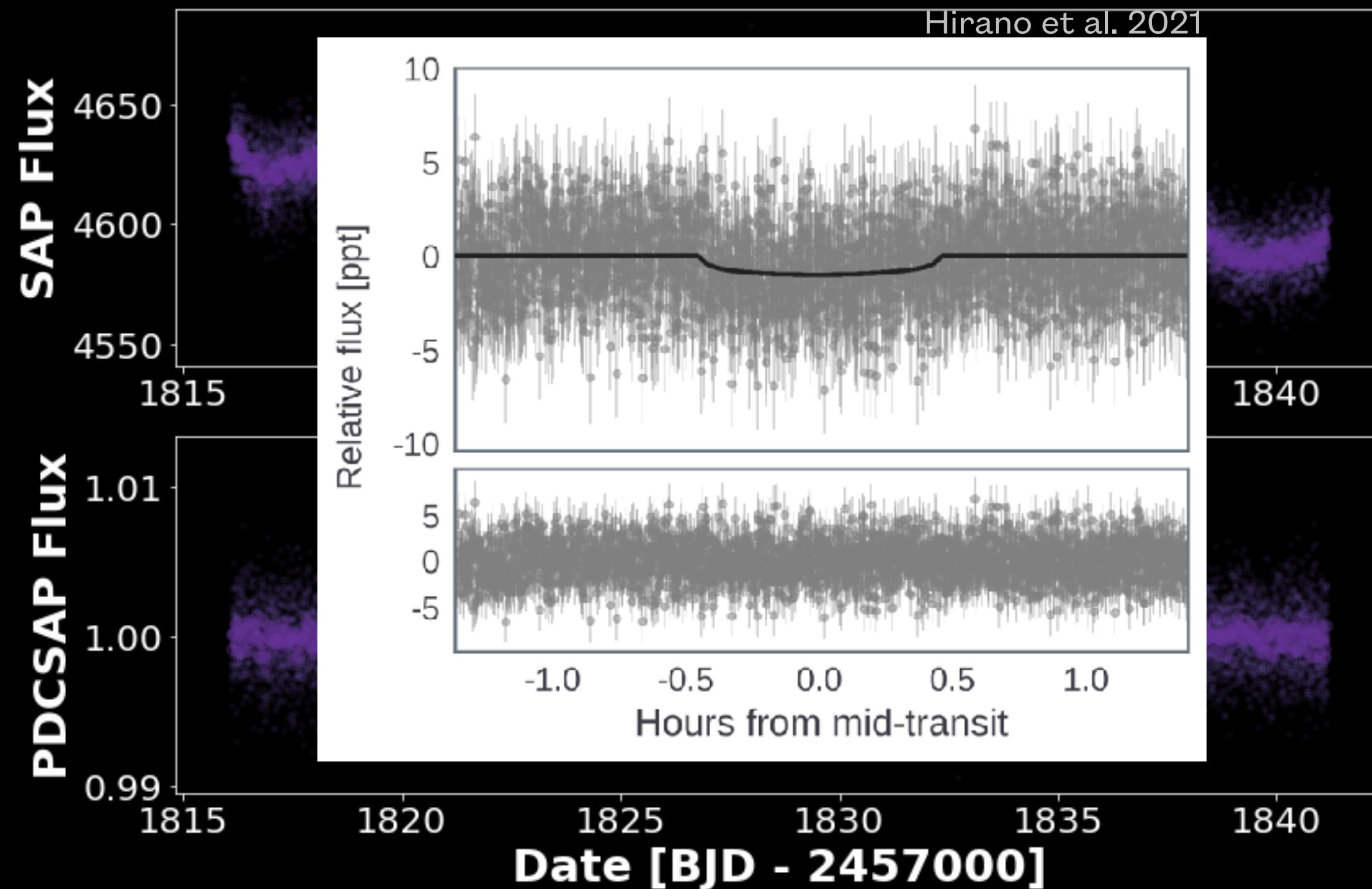


**TOI-1685**  
**M3V star 3460 K**  
**0.46 R<sub>⊙</sub> 0.46 M<sub>⊙</sub>**

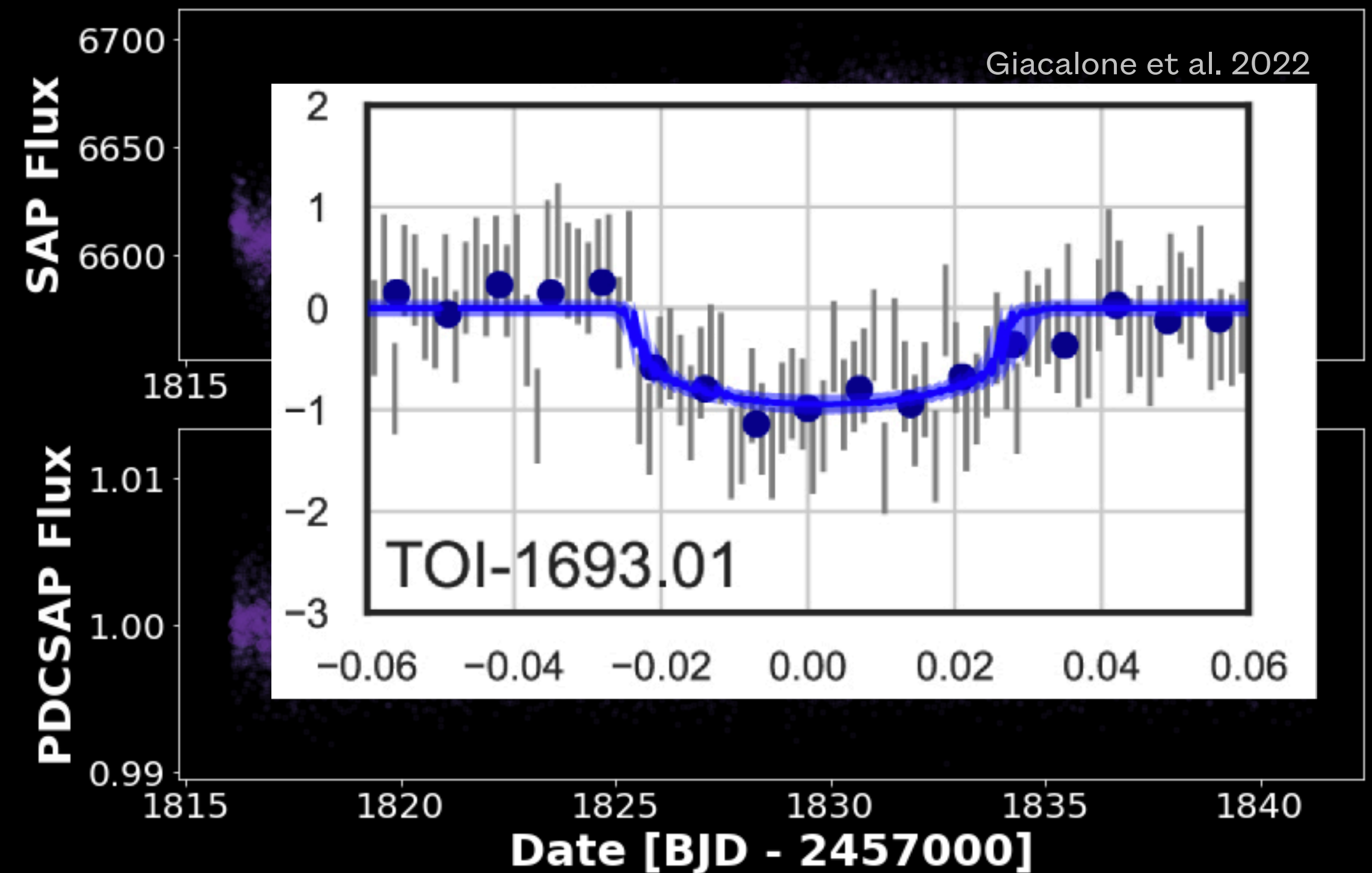


**TOI-1693**  
**M3V star 3470 K**  
**0.46 R<sub>⊙</sub> 0.46 M<sub>⊙</sub>**

# TOI-1685 & TOI-1693



**TOI-1685**  
**M3V star 3460 K**  
**0.46 R<sub>⊙</sub> 0.46 M<sub>⊙</sub>**  
**V=13.4**



**TOI-1693**  
**M3V star 3470 K**  
**0.46 R<sub>⊙</sub> 0.46 M<sub>⊙</sub>**  
**V=13**



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**Warning, these  
are preliminary  
results**

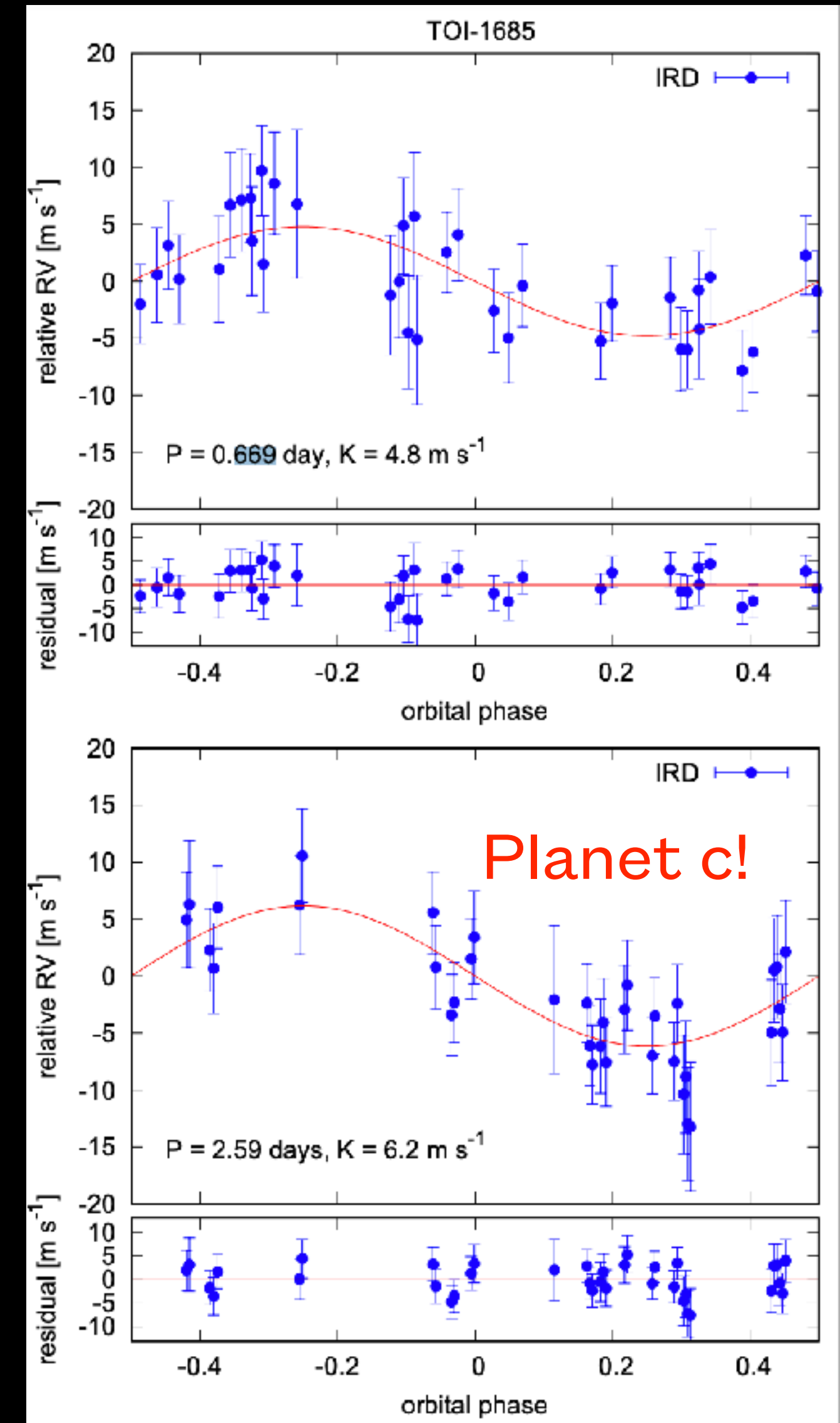
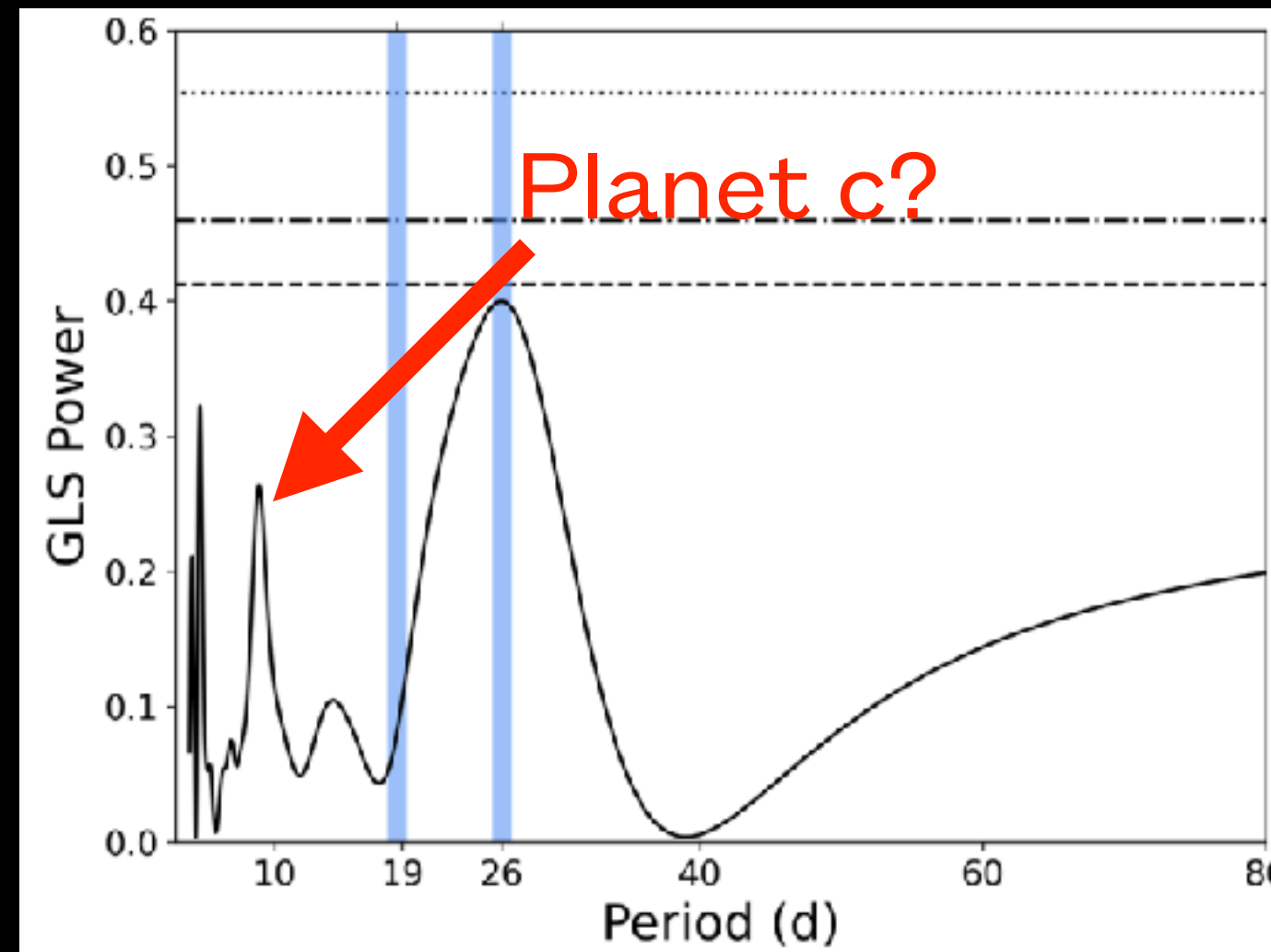
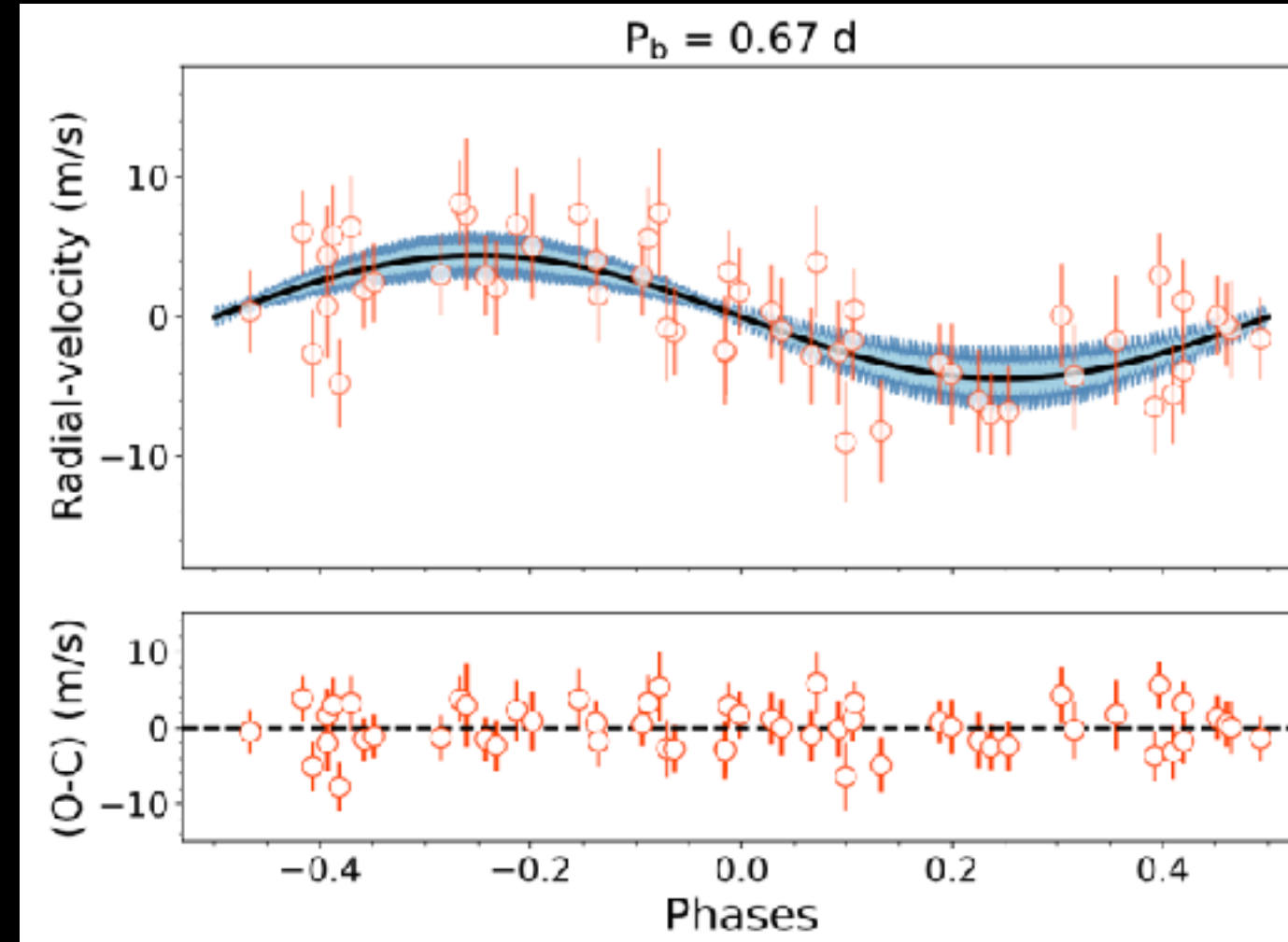
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# TOI-1685

# TOI-1685 b

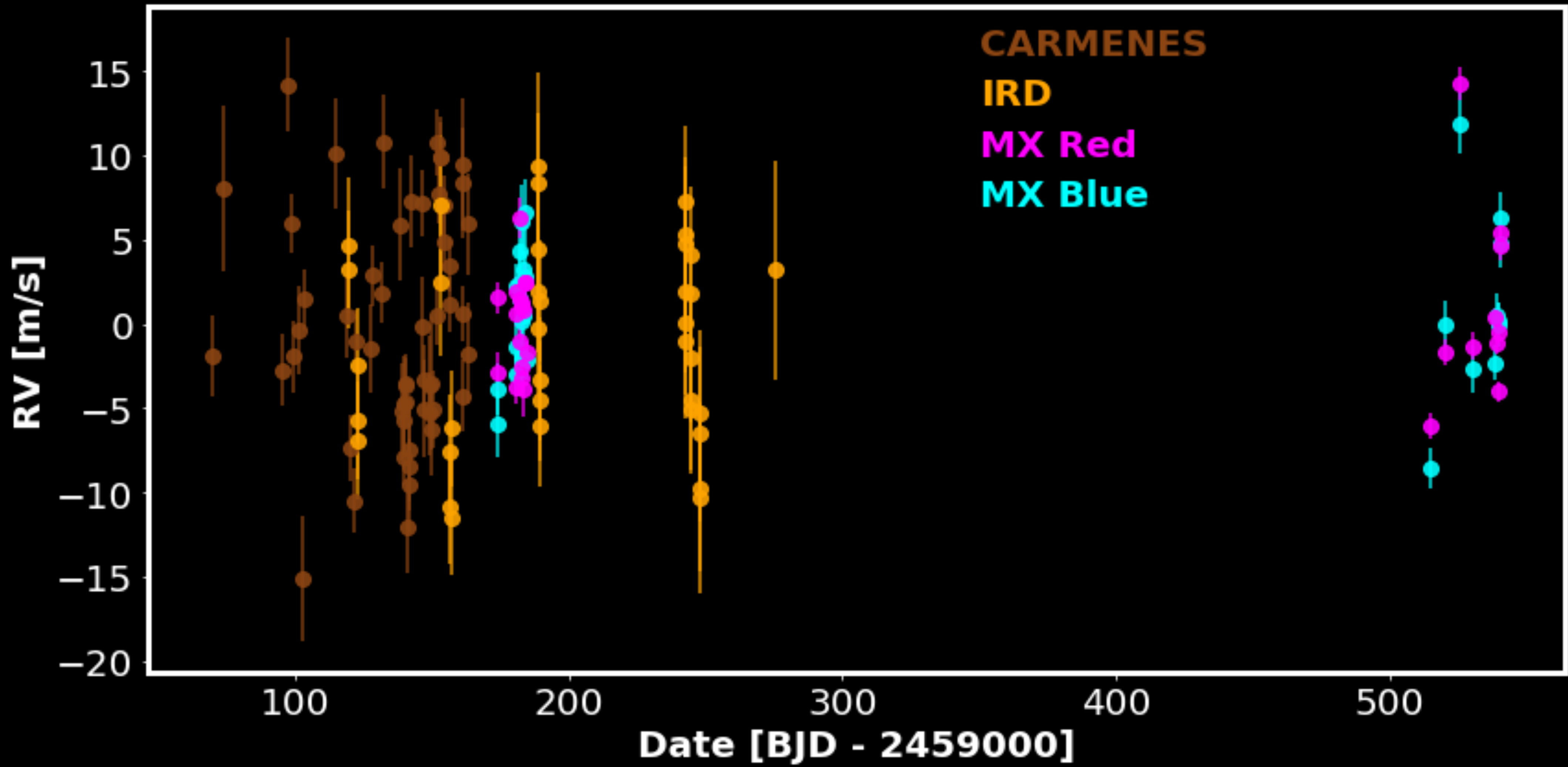
Planet b	Bluhm '21	Hirano '21
<b>Semi-amp</b>	$4.41 \pm 0.73$	$4.9 \pm 1.4$
<b>Mass</b>	$3.78 \pm 0.63$	$3.43 \pm 0.93$
<b>Radius</b>	$1.70 \pm 0.07$	$1.459 \pm 0.065$
<b>Density</b>	$4.21^{+0.95}_{-0.82}$	$6.1^{+0.95}_{-0.82}$

Bluhm et al. 2021

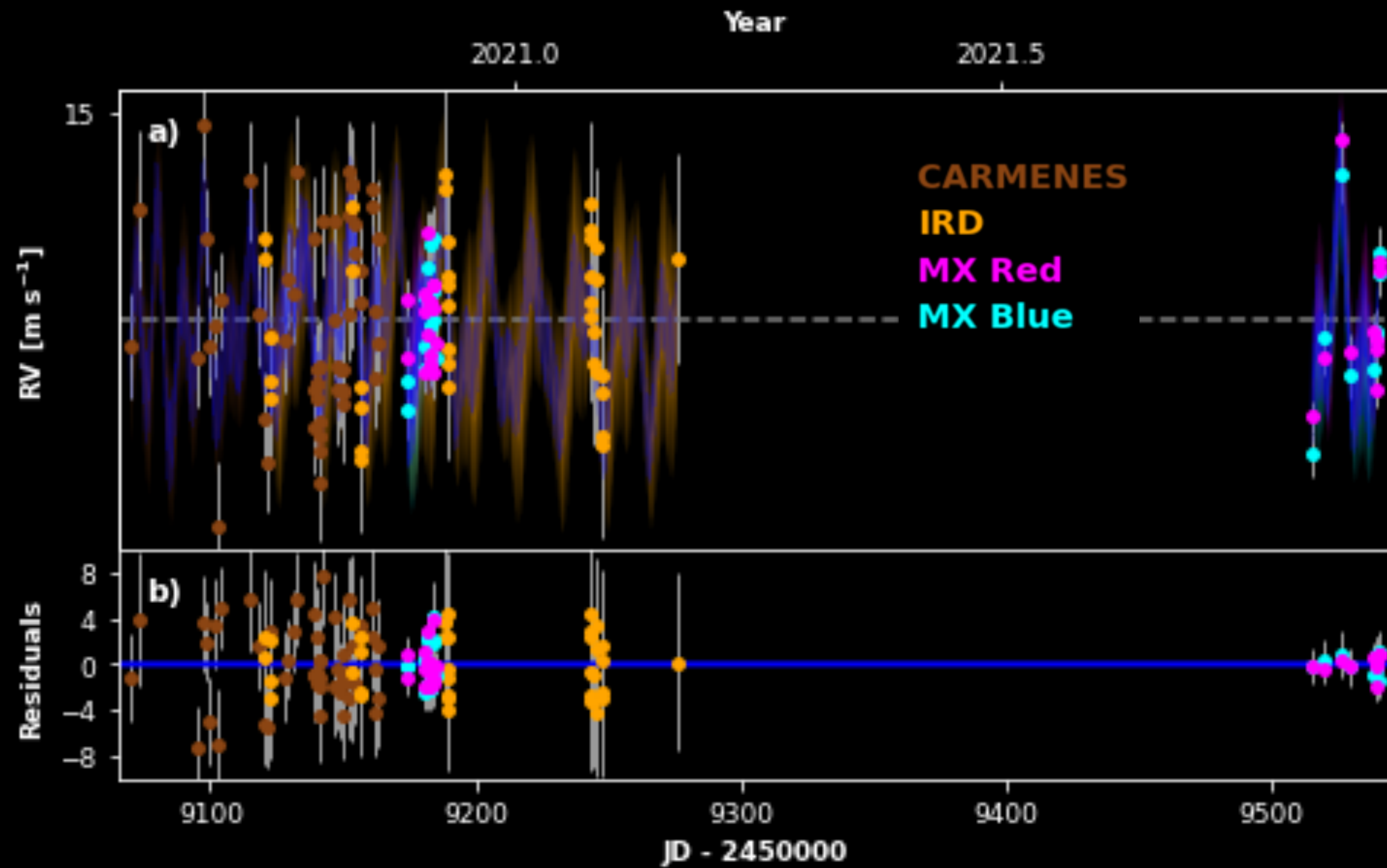


Hirano et al. 2021

# TOI-1685 combined RV data

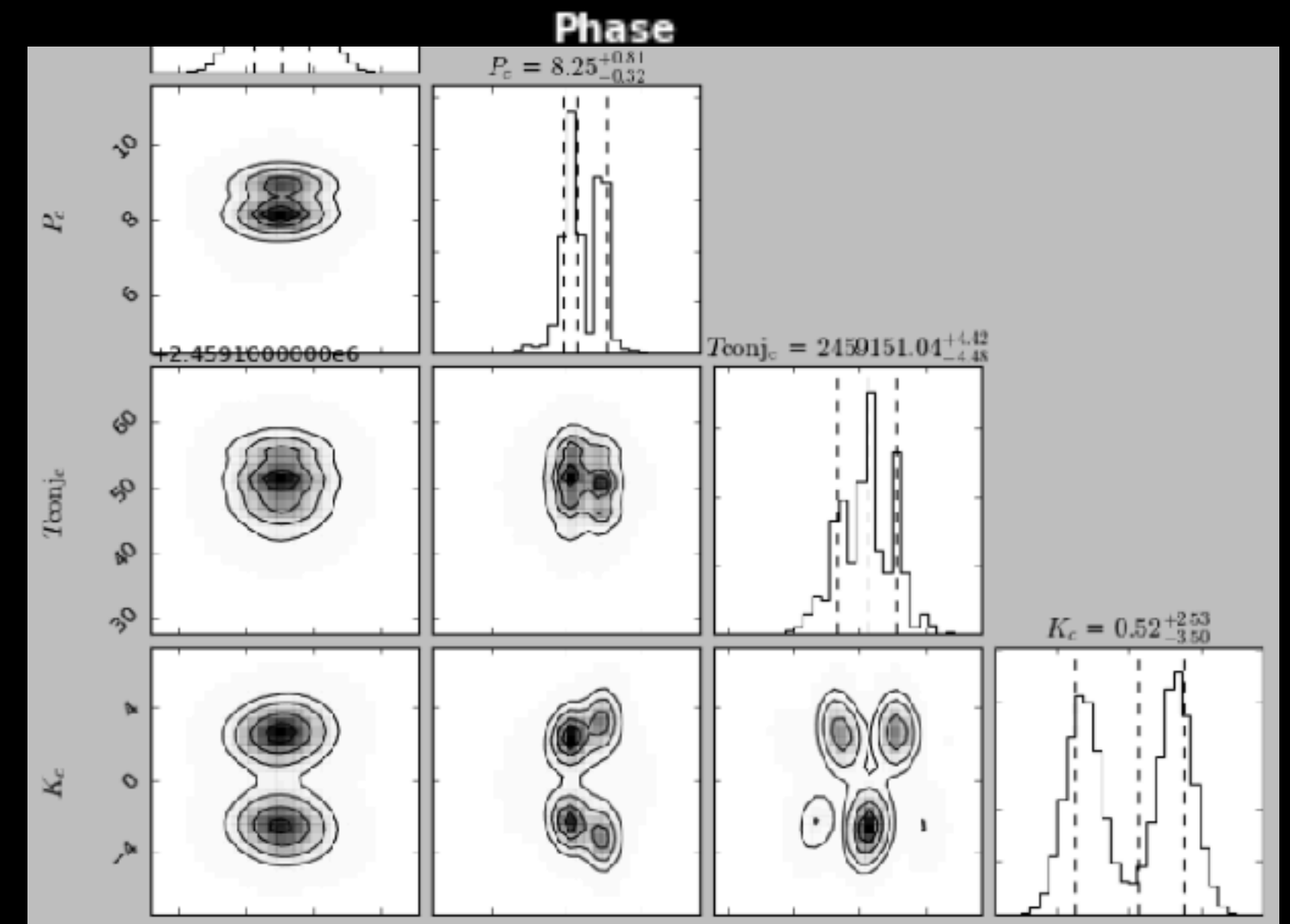
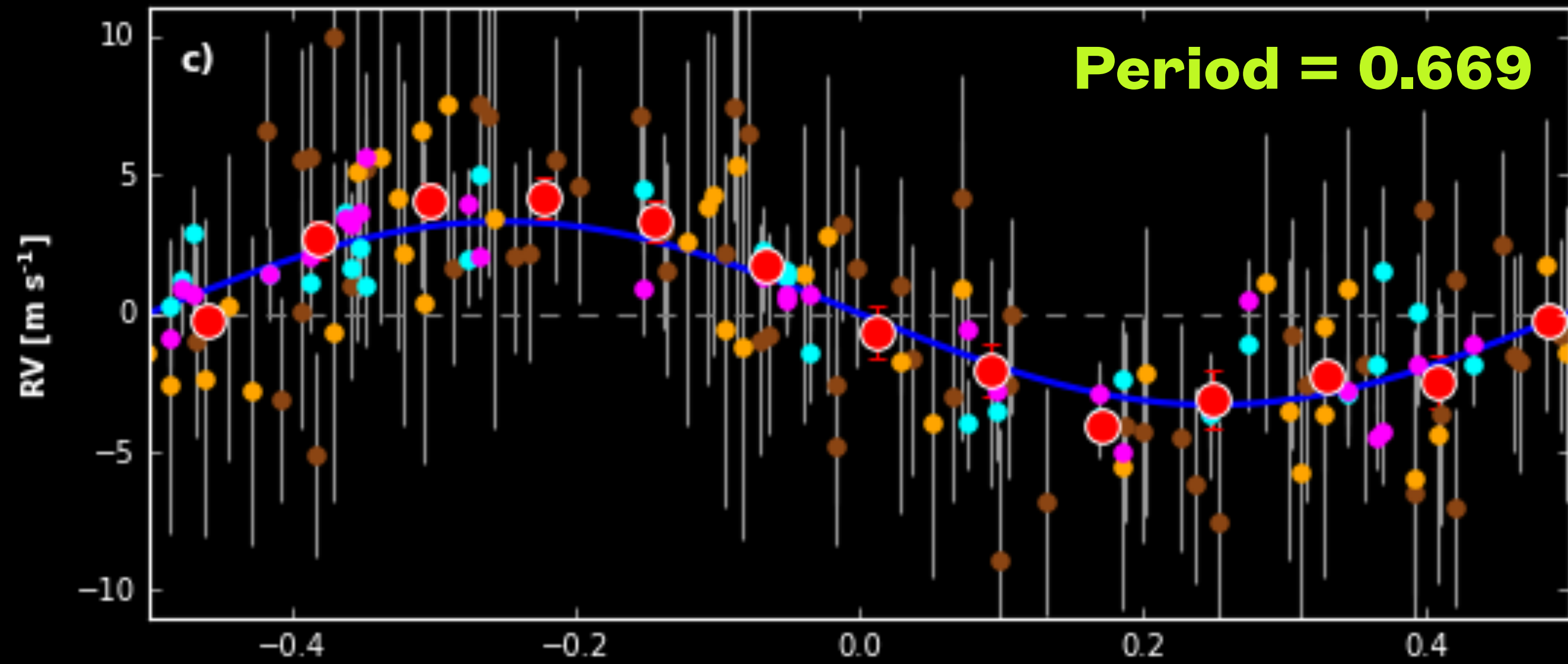


# TOI-1685 b (& c?)



**GP Period: 18.25 +/- 0.52**

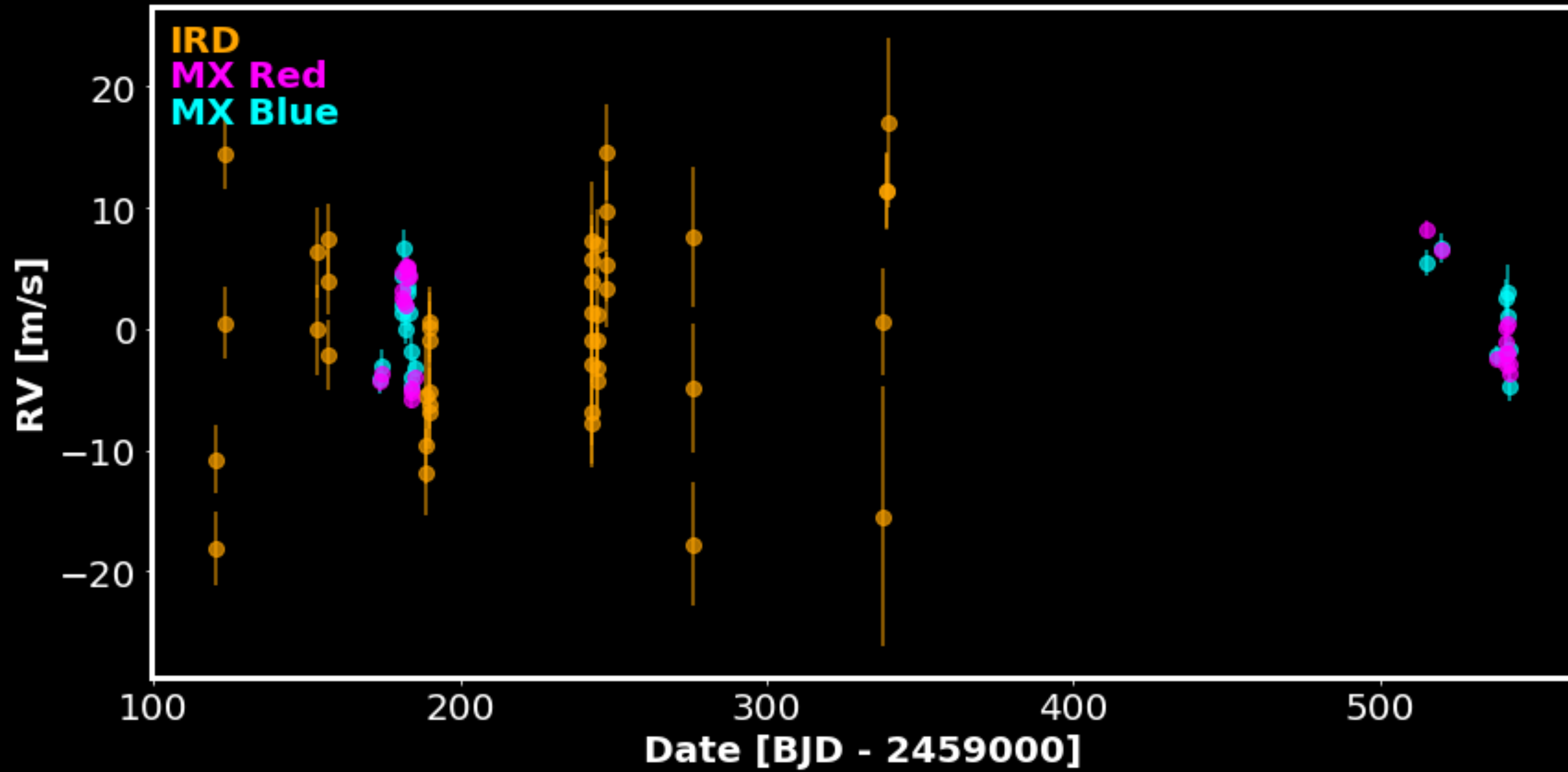
**GP Lifetime: 125 +/- 48**



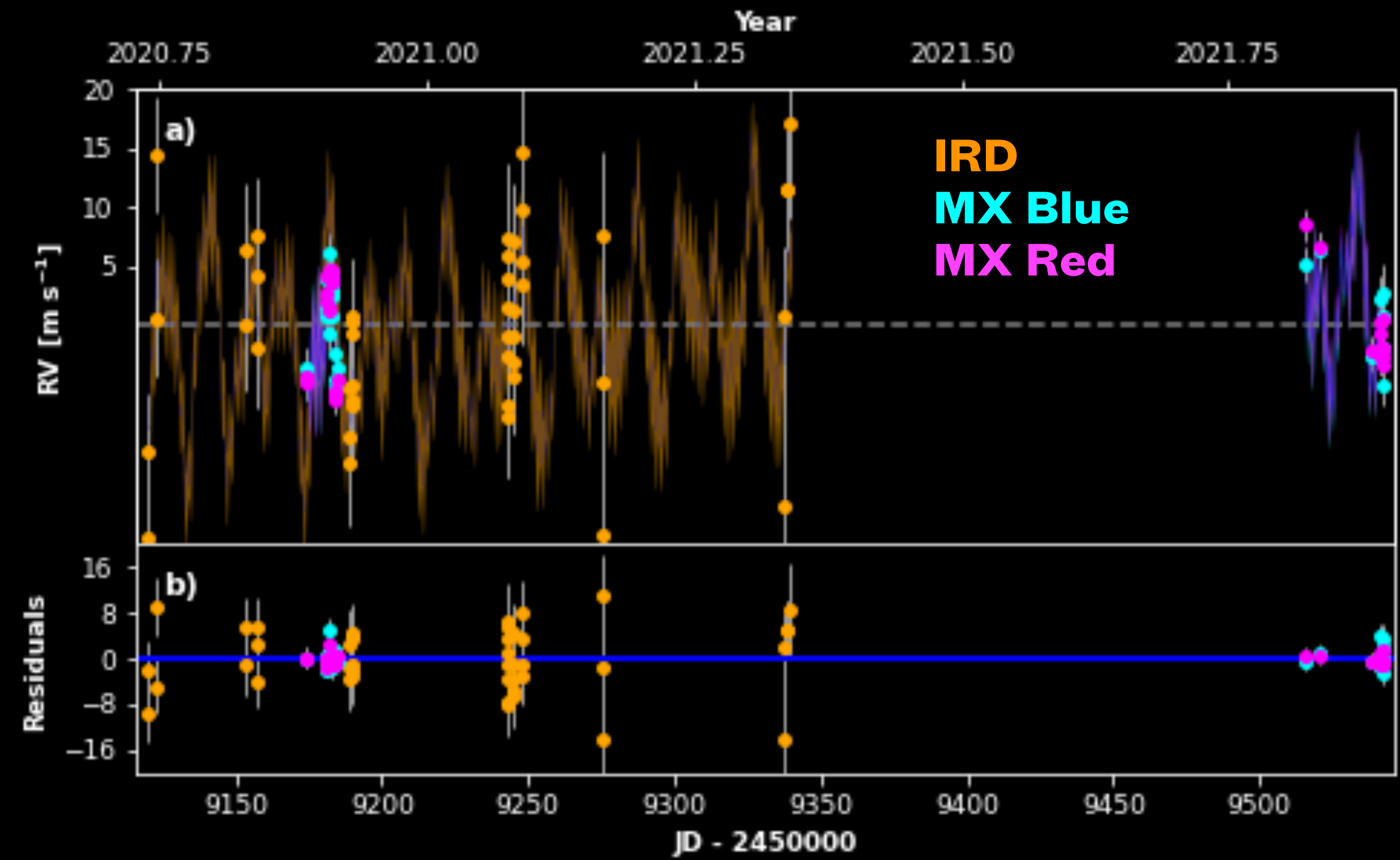
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# TOI-1693

# TOI-1693 combined RV data

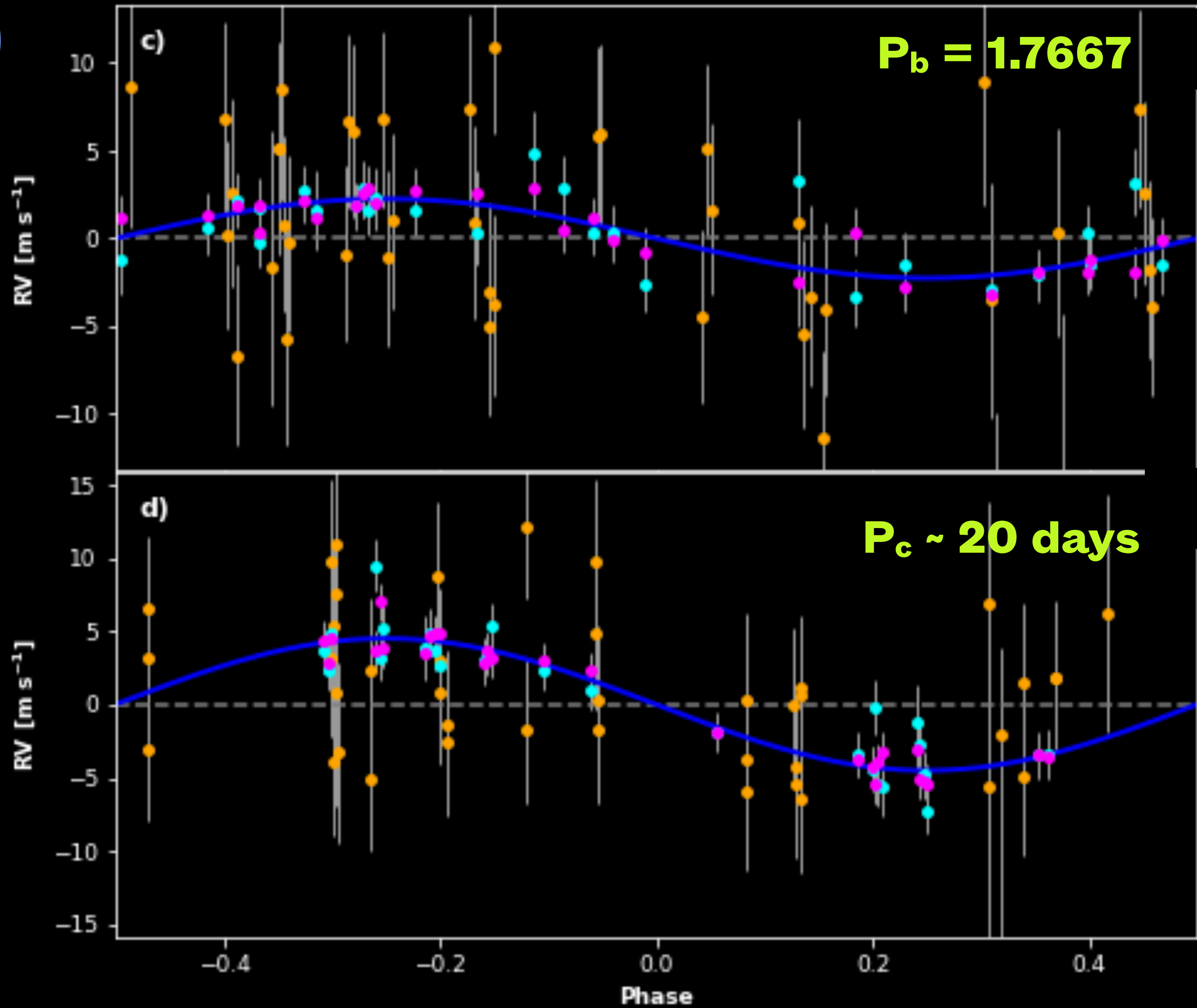


# TOI-1693 b (& c?)

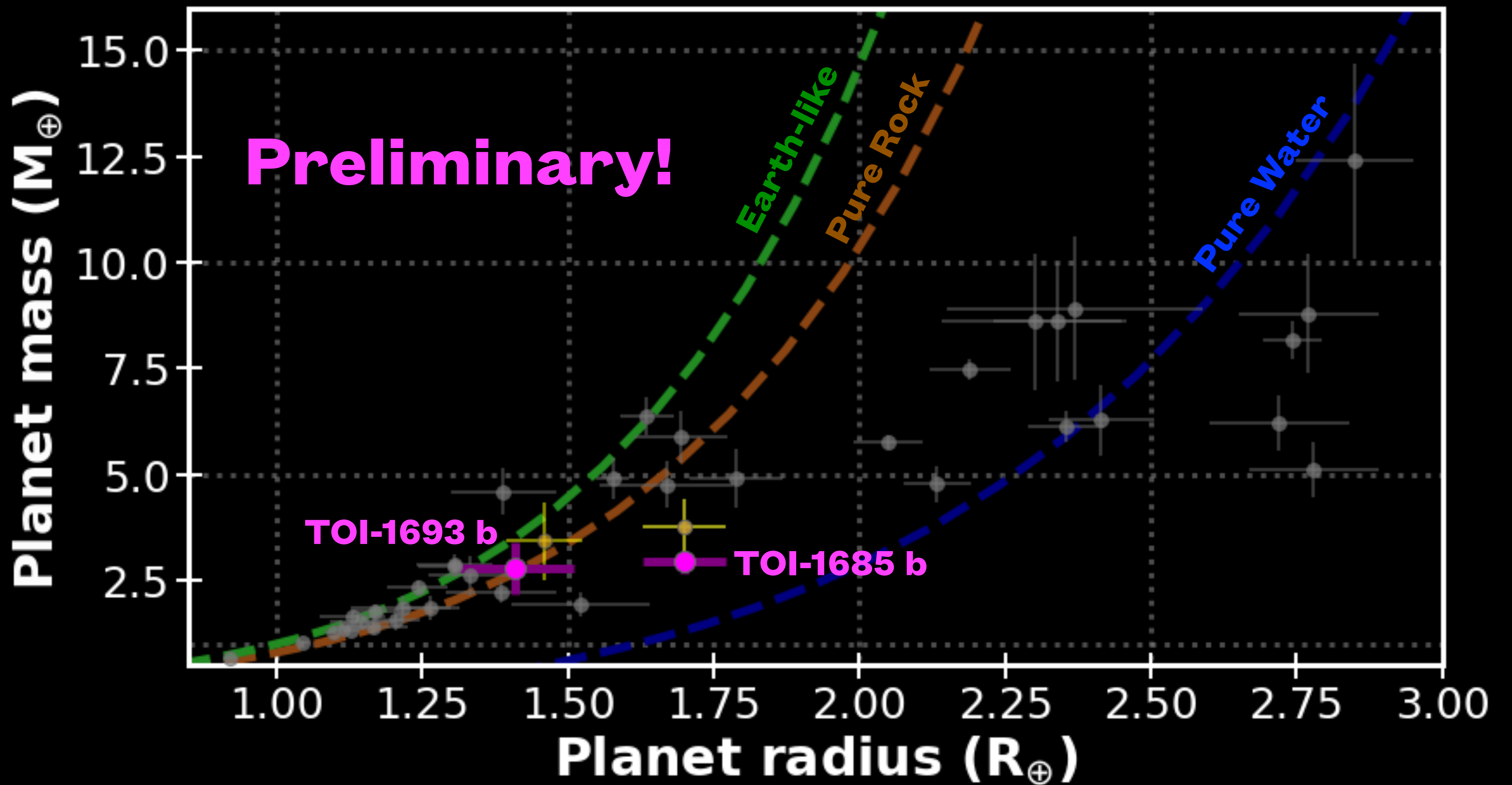


**GP Period: 10.2 +/- 3.1**

**GP Lifetime: 48 +/- 66**







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# Conclusions

- **TESS is producing a plethora of small planet candidates around nearby M dwarf stars**
- **Many exhibit signatures of additional, non-transiting companions at longer periods**
- **Confirming these planets requires high precision, red-sensitive, RV spectrographs & large apertures**
- **TOI-1685 b & TOI-1693 b are exciting candidates for super Earth atmospheric characterization**



# **Chasing small TESS planets with the MAROON-X spectrograph**

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## **Jennifer Burt**

**Jet Propulsion Laboratory, California Institute of Technology**

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**GEMINI SCIENCE MEETING – JULY 26 2022**