

Finding the connection between close-in small planets and outer giants

Judah Van Zandt
3rd year PhD student
Advisor: Erik Petigura



Website: judahvanzandt.webflow.io

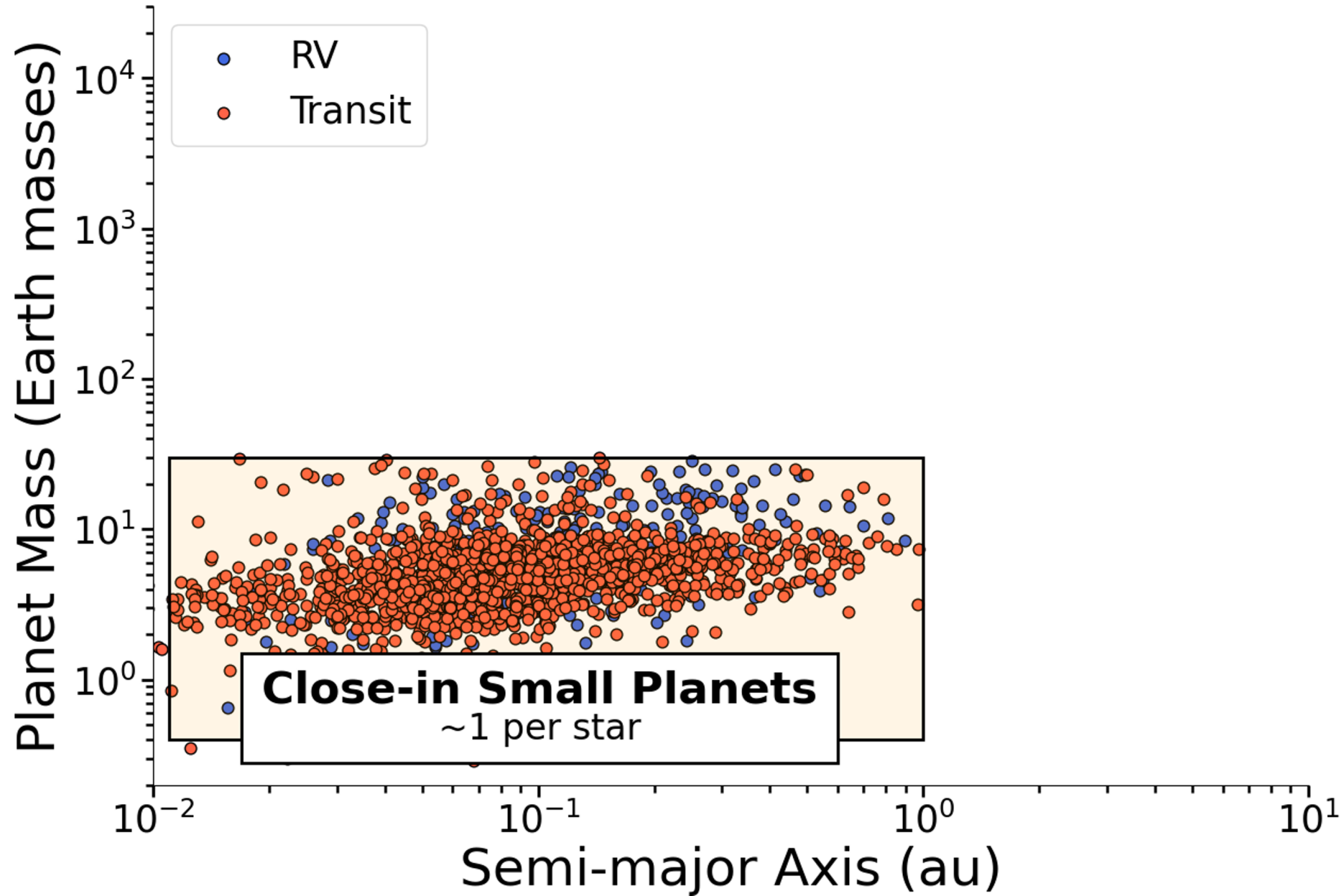
Email: judahvz@astro.ucla.edu

UCLA

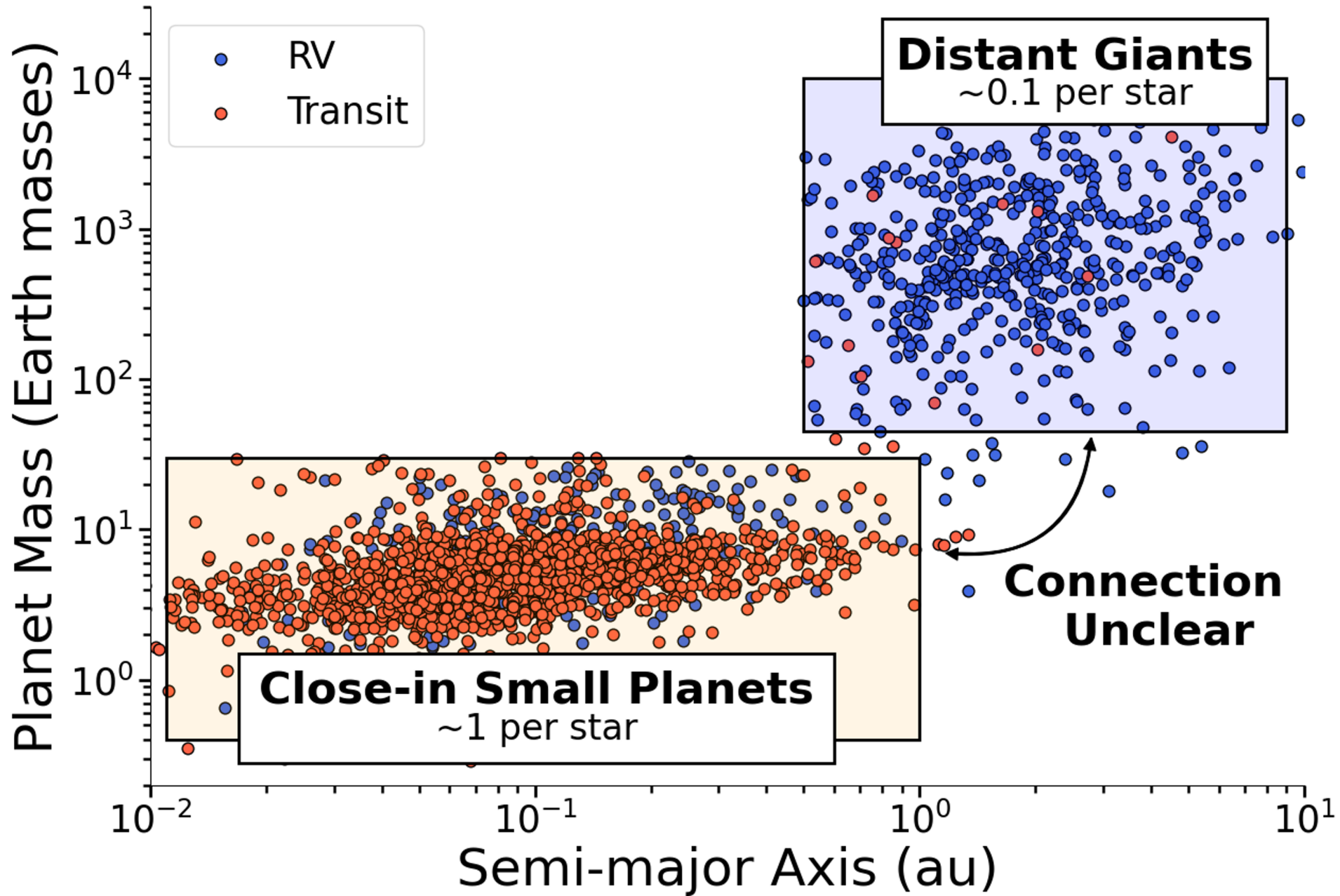
College | Physical Sciences

Physics & Astronomy

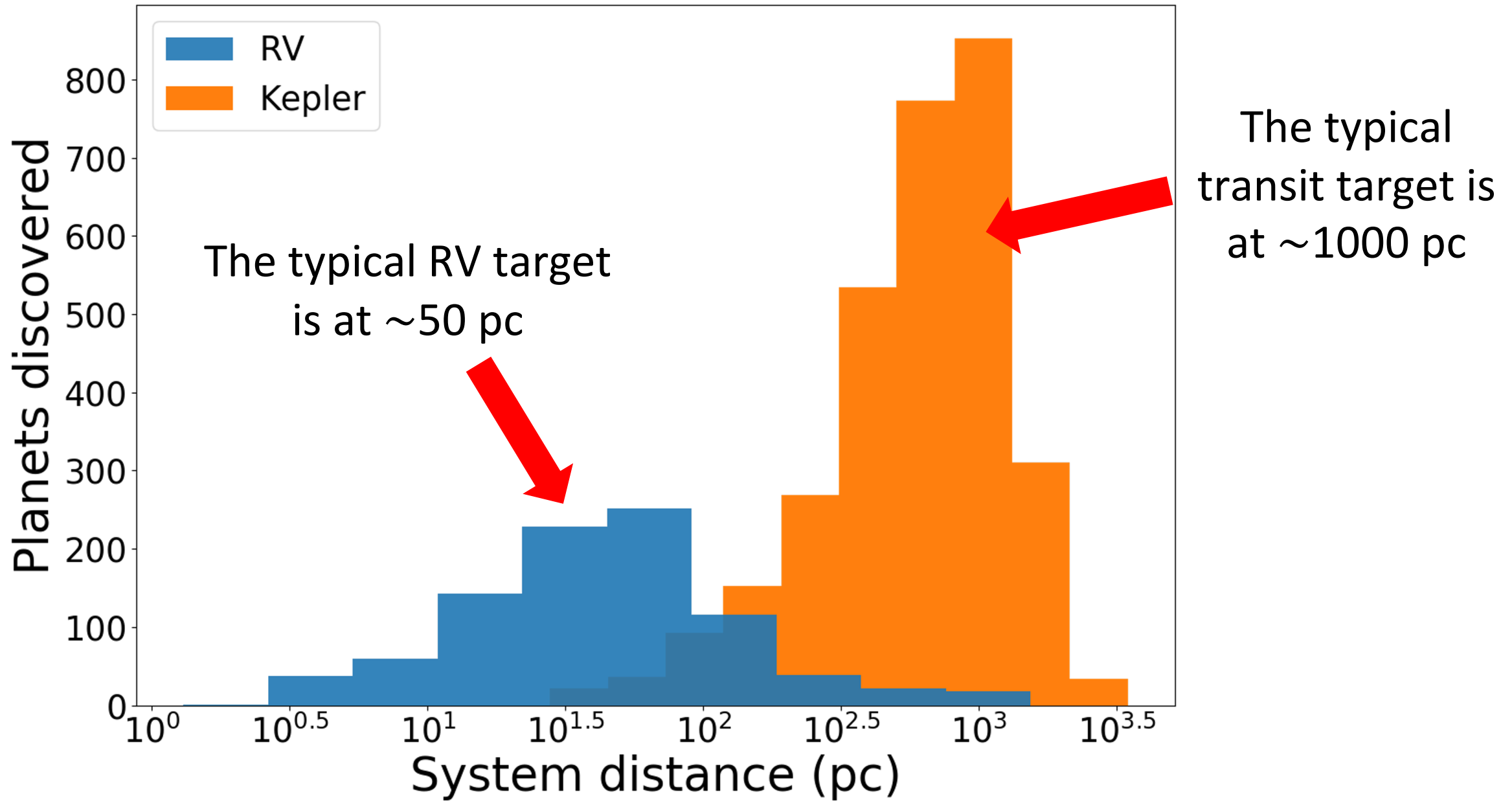
Kepler found thousands of **small, close-in** planets with transits



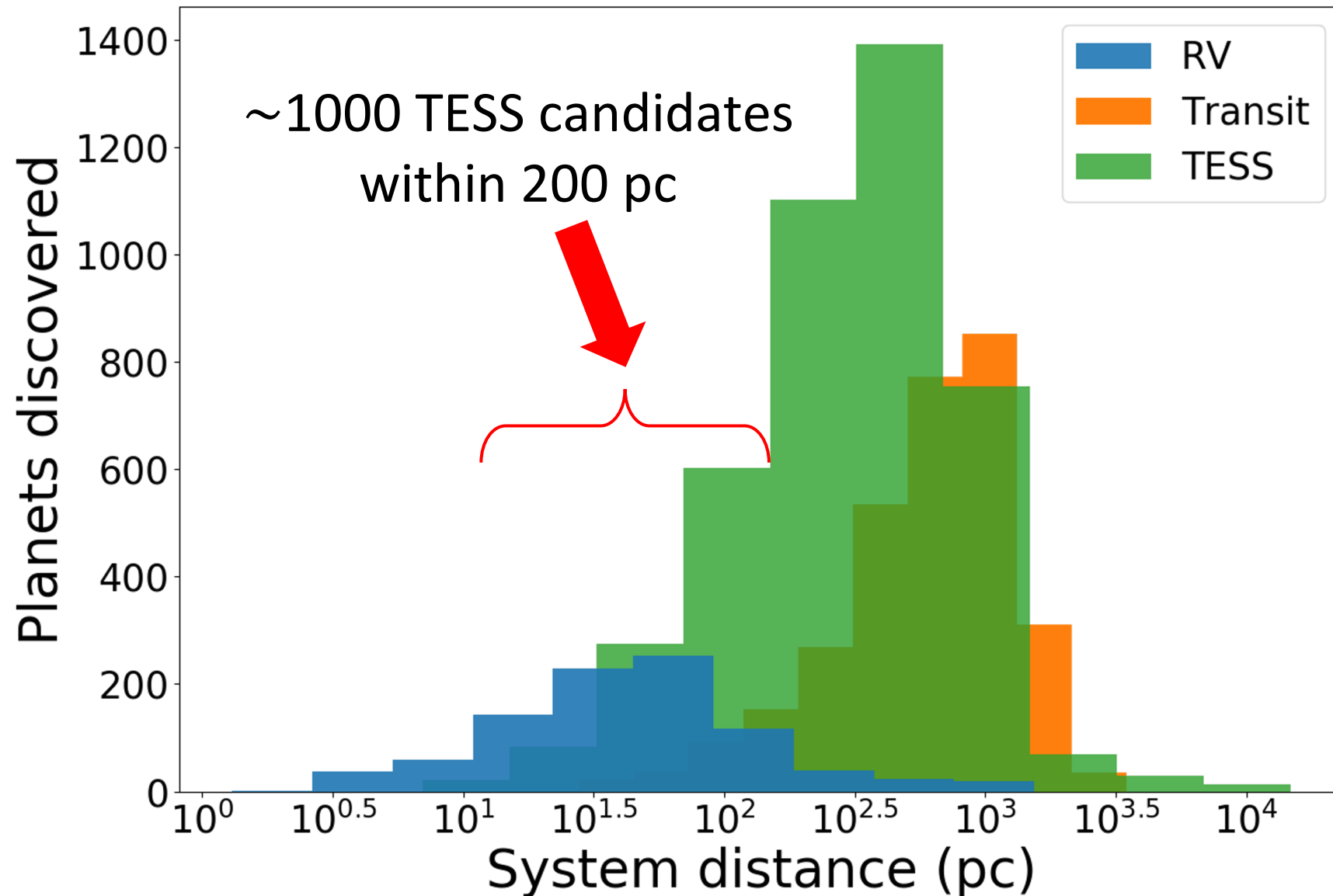
Radial velocity (RV) surveys have found hundreds of **giant outer planets**



RV/transit detections come from mostly separate stellar samples



TESS provided lots of nearby transit hosts

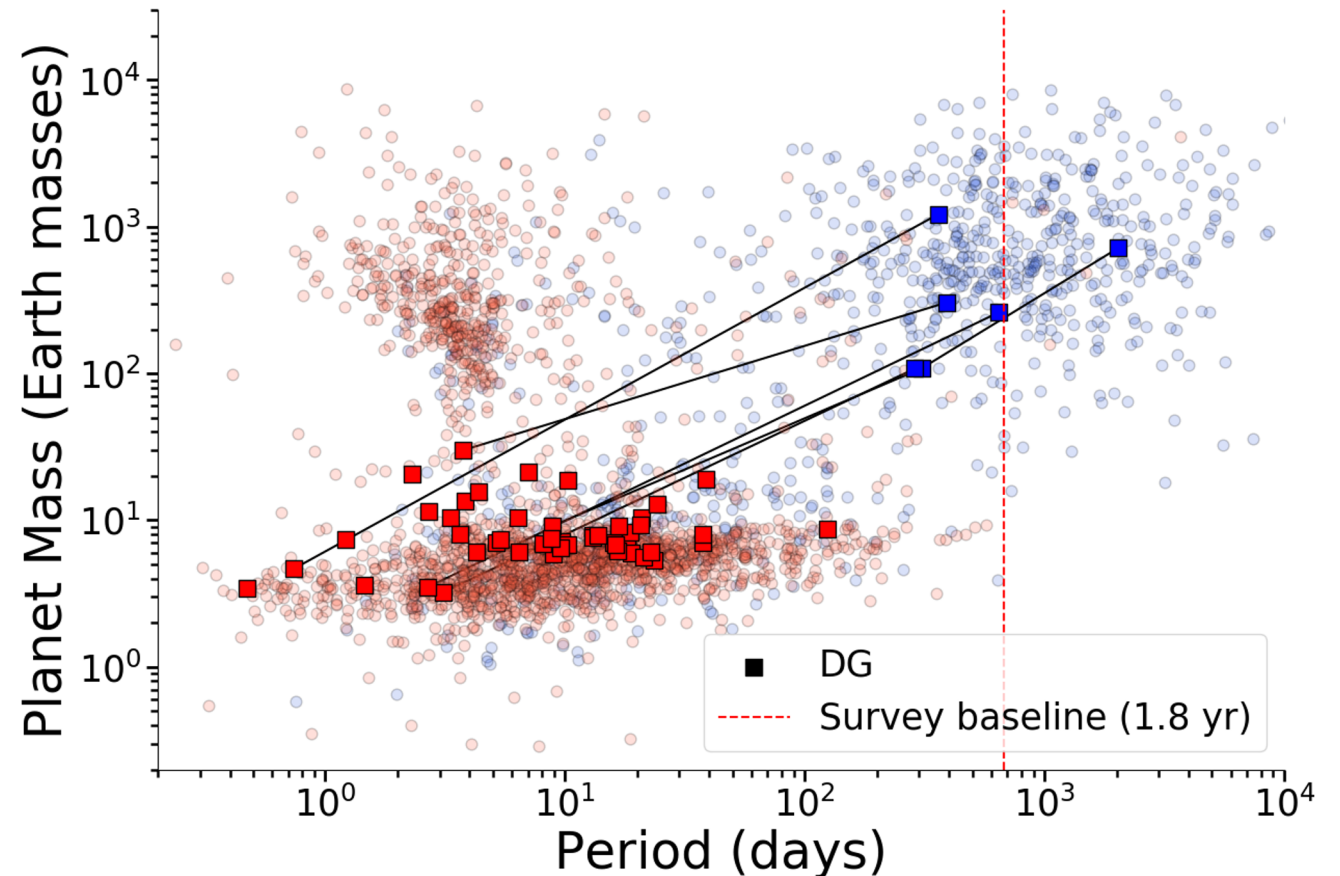


- TESS found thousands of candidate transiting systems
- These stars are close and bright, so we can observe them with RVs
- $P(\text{DG}) \sim 10\%$
 - $P(\text{DG} | \text{CS}) = ?$

The Distant Giants survey has found ~ 12 giants so far

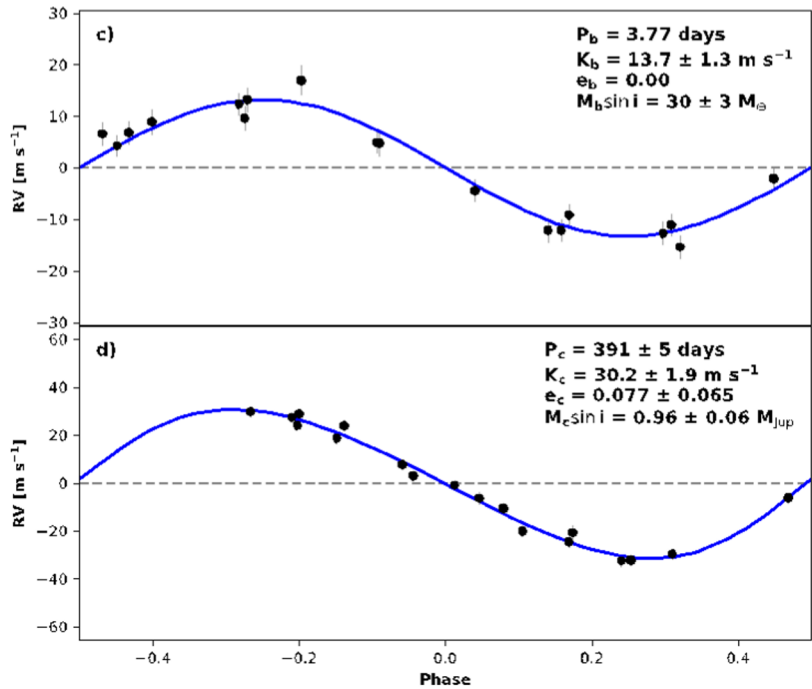
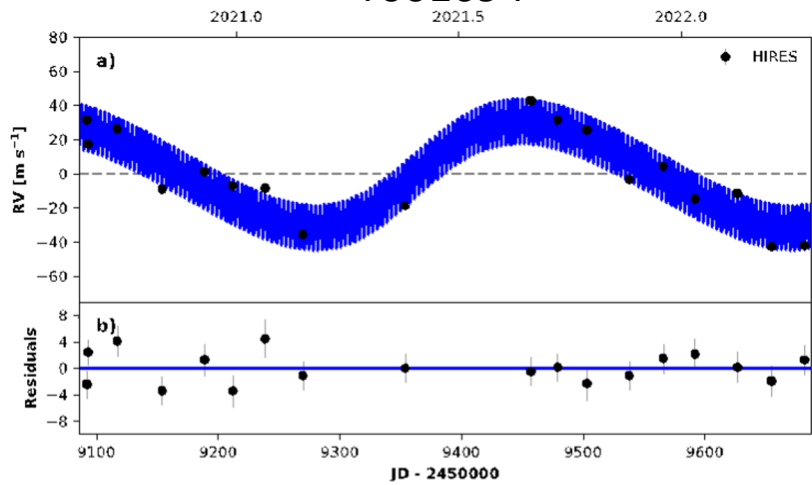
- RV survey of 47 transit hosts
- Purpose: constrain $P(\text{DG} | \text{CS})$
- 2 years complete, 1 year remaining
- Possible evidence of a correlation: $12/47 > 0.1$

M_p vs. a for transiting planets



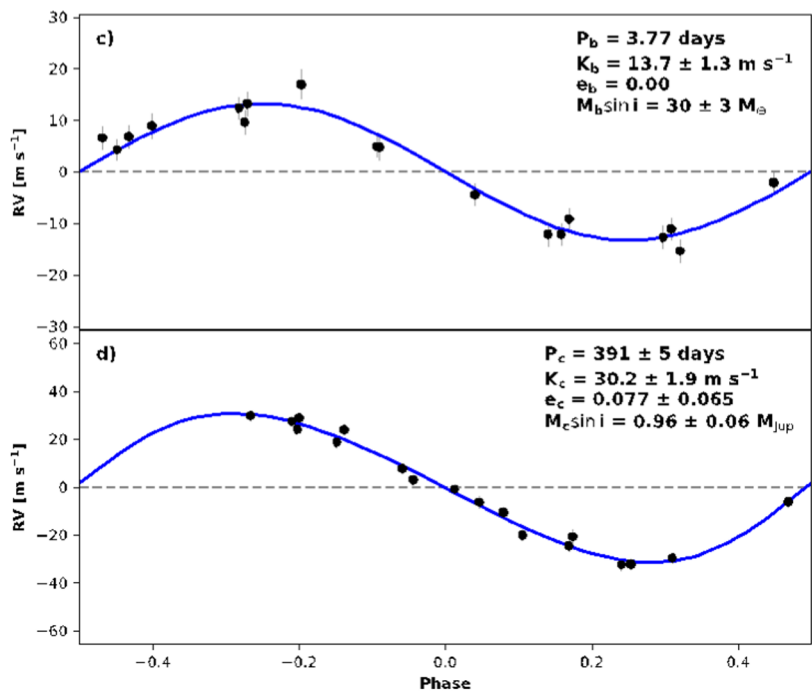
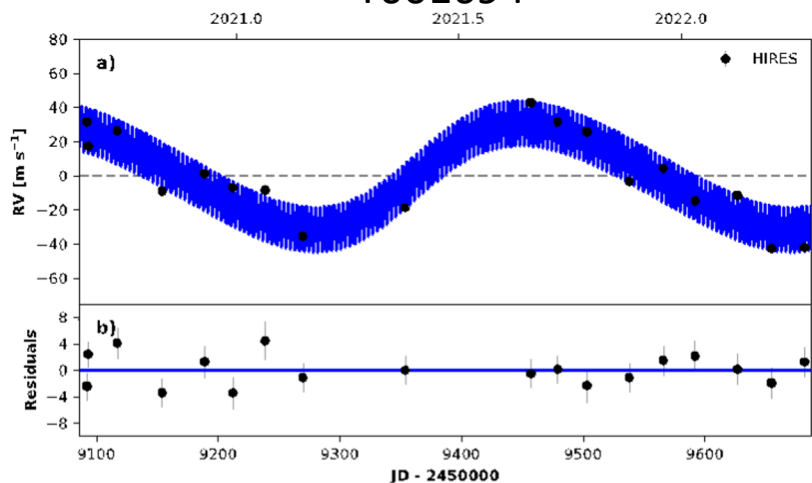
Five systems host resolved companions

T001694

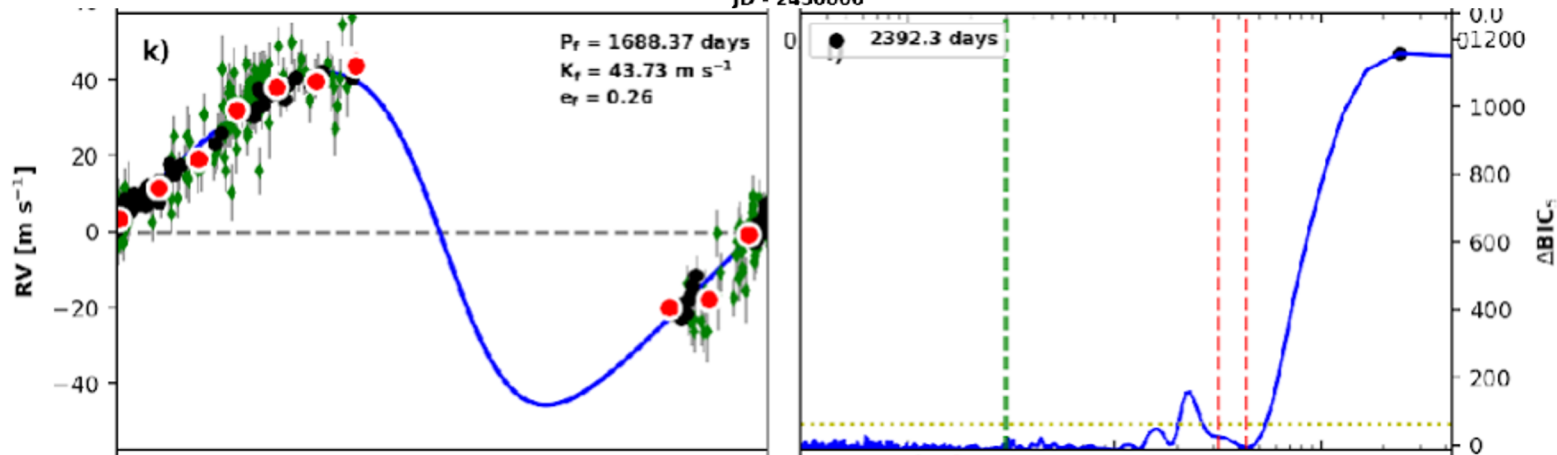
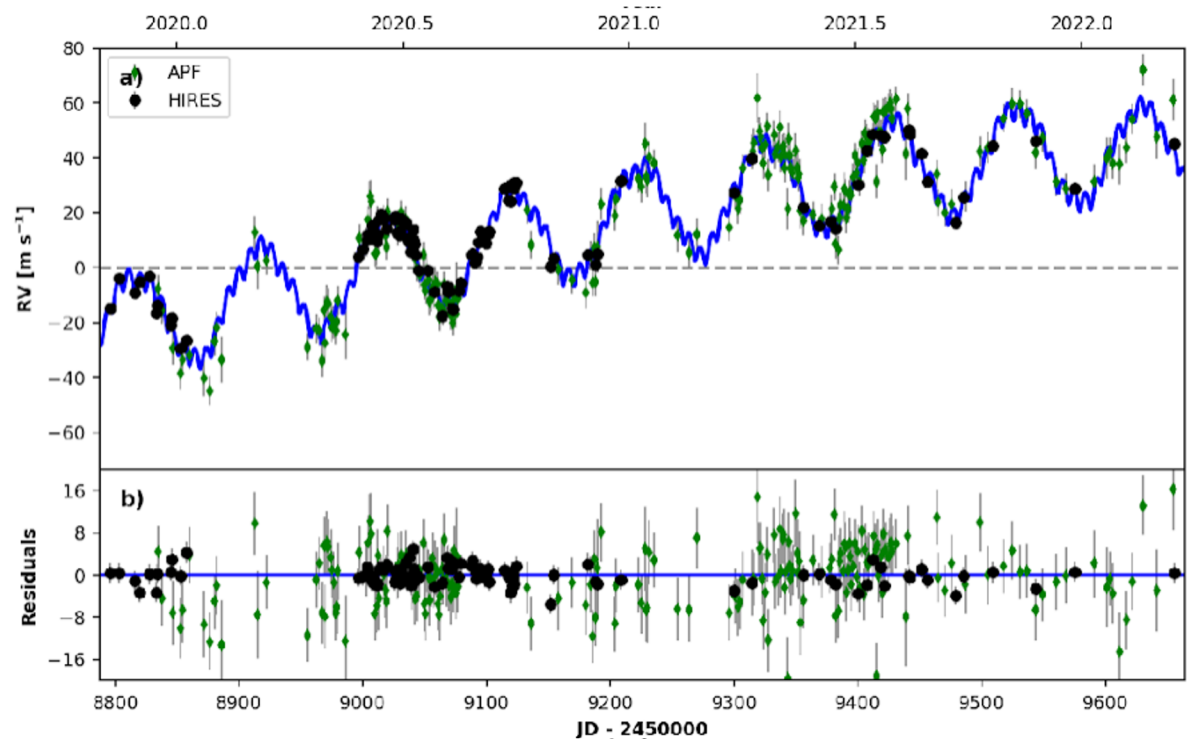


Five systems host resolved companions

T001694

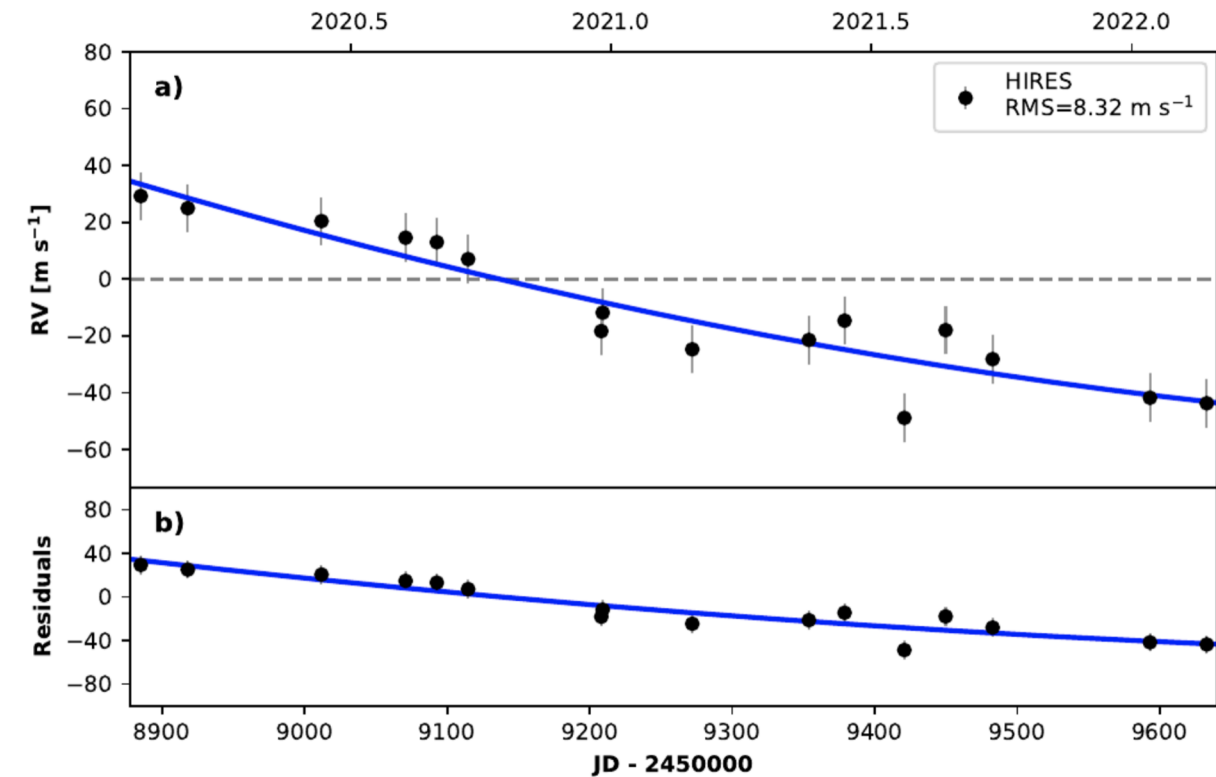


191939

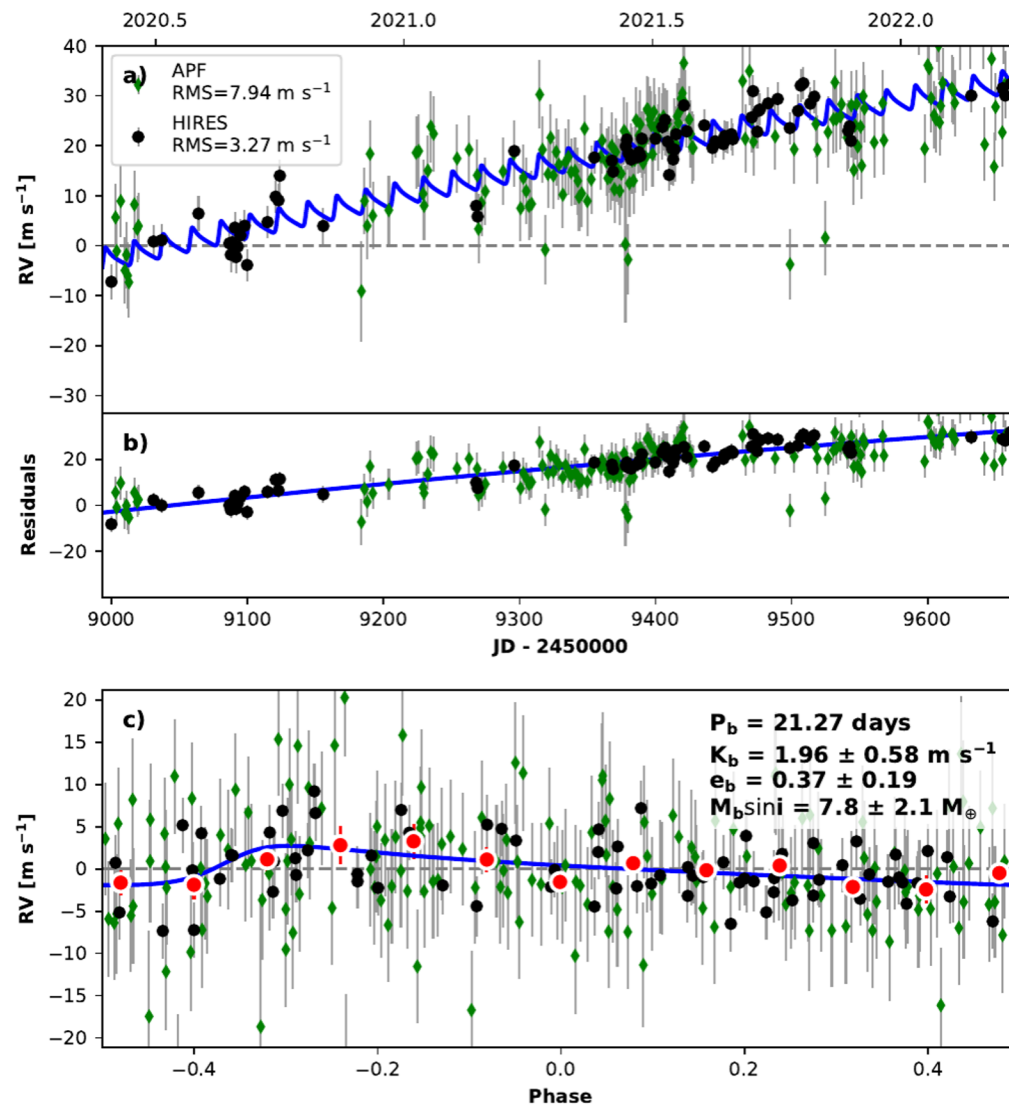


Seven systems show long-term trends

T001174



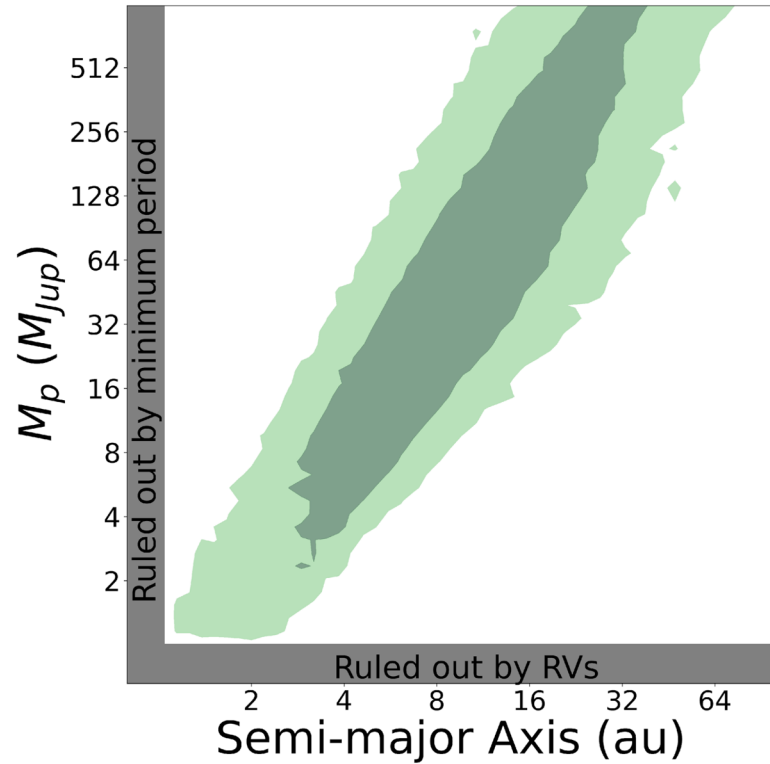
156141



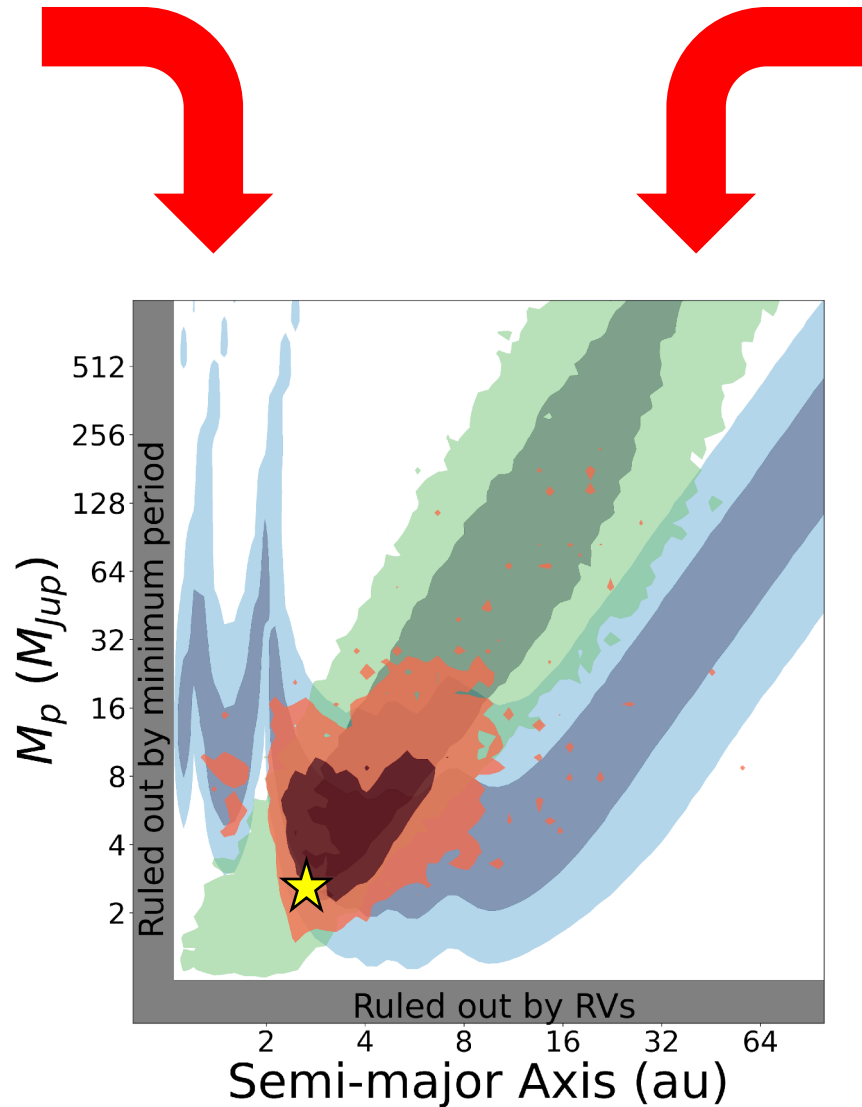
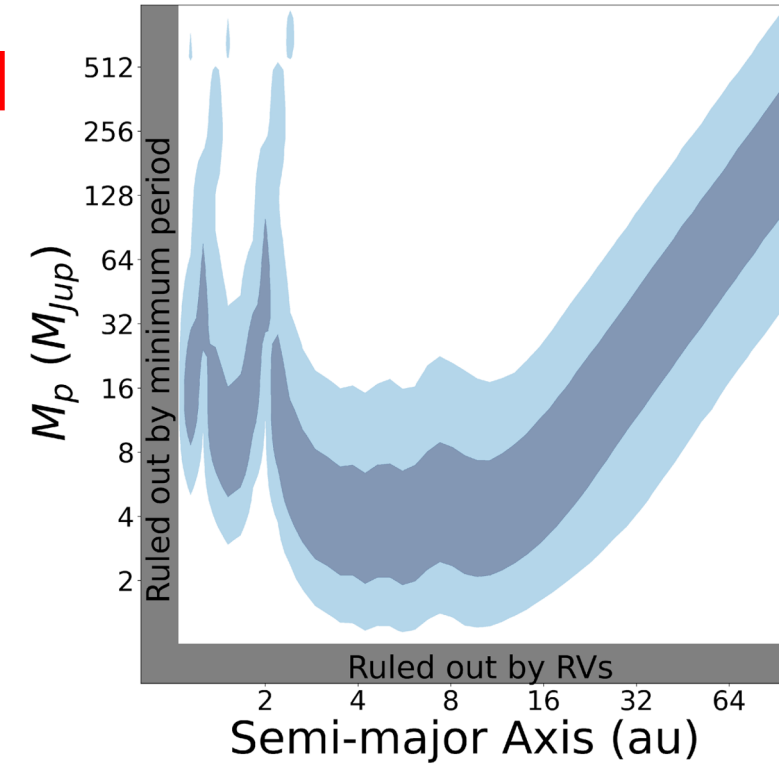
RVs and astrometry together can constrain planet properties

HD 191939

RVs



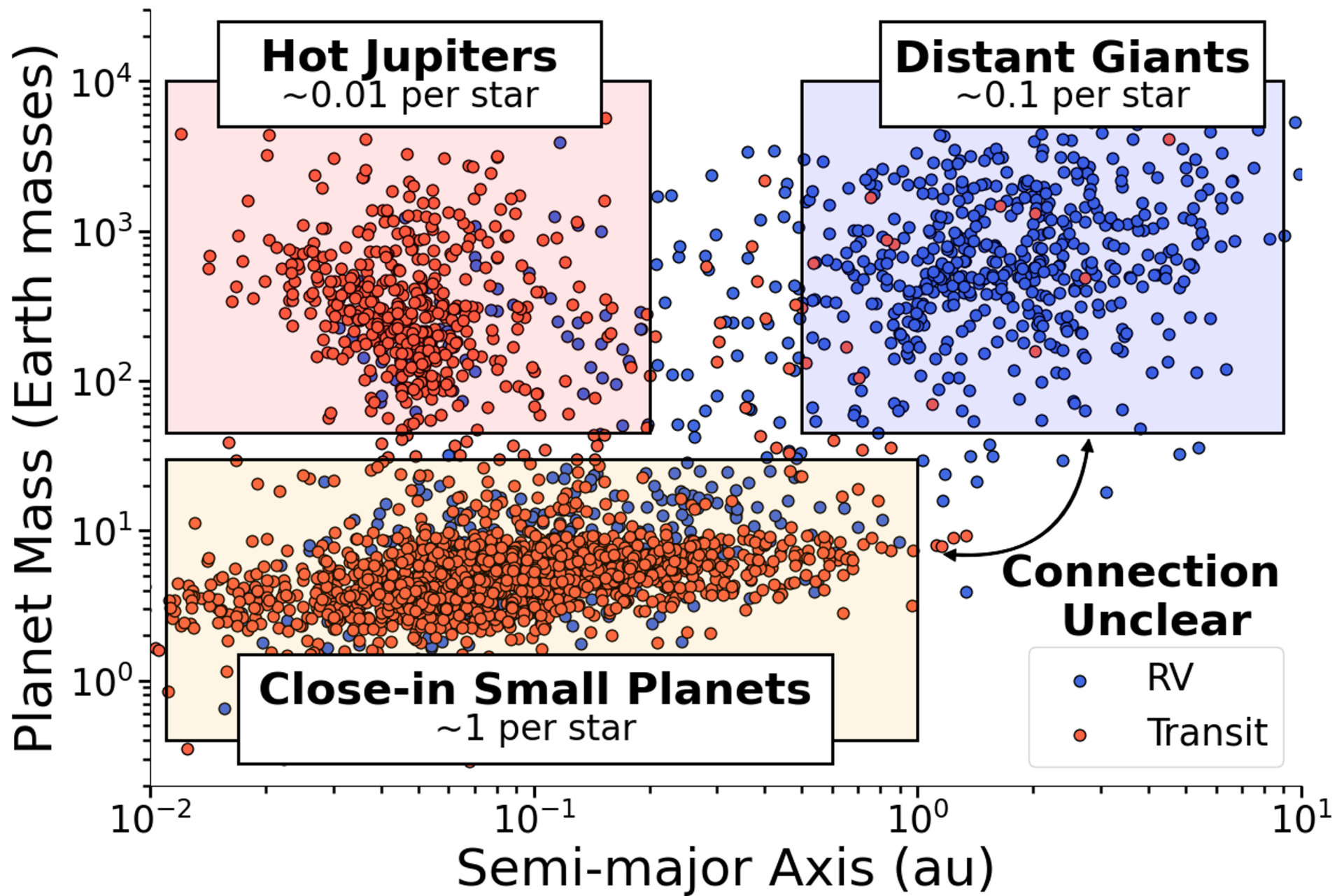
Astrometry

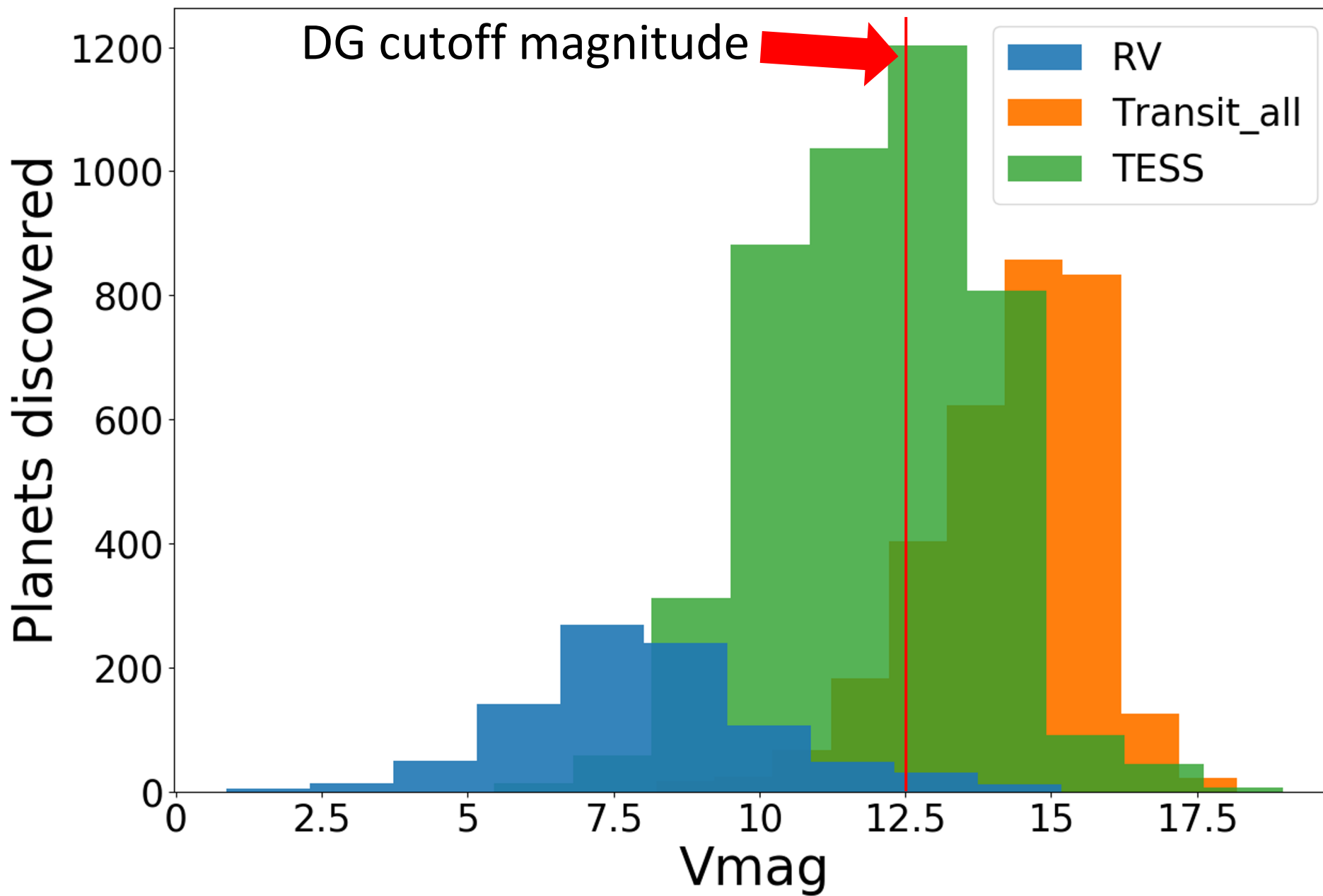


Lubin, Van Zandt, et al. 2021

Key takeaways

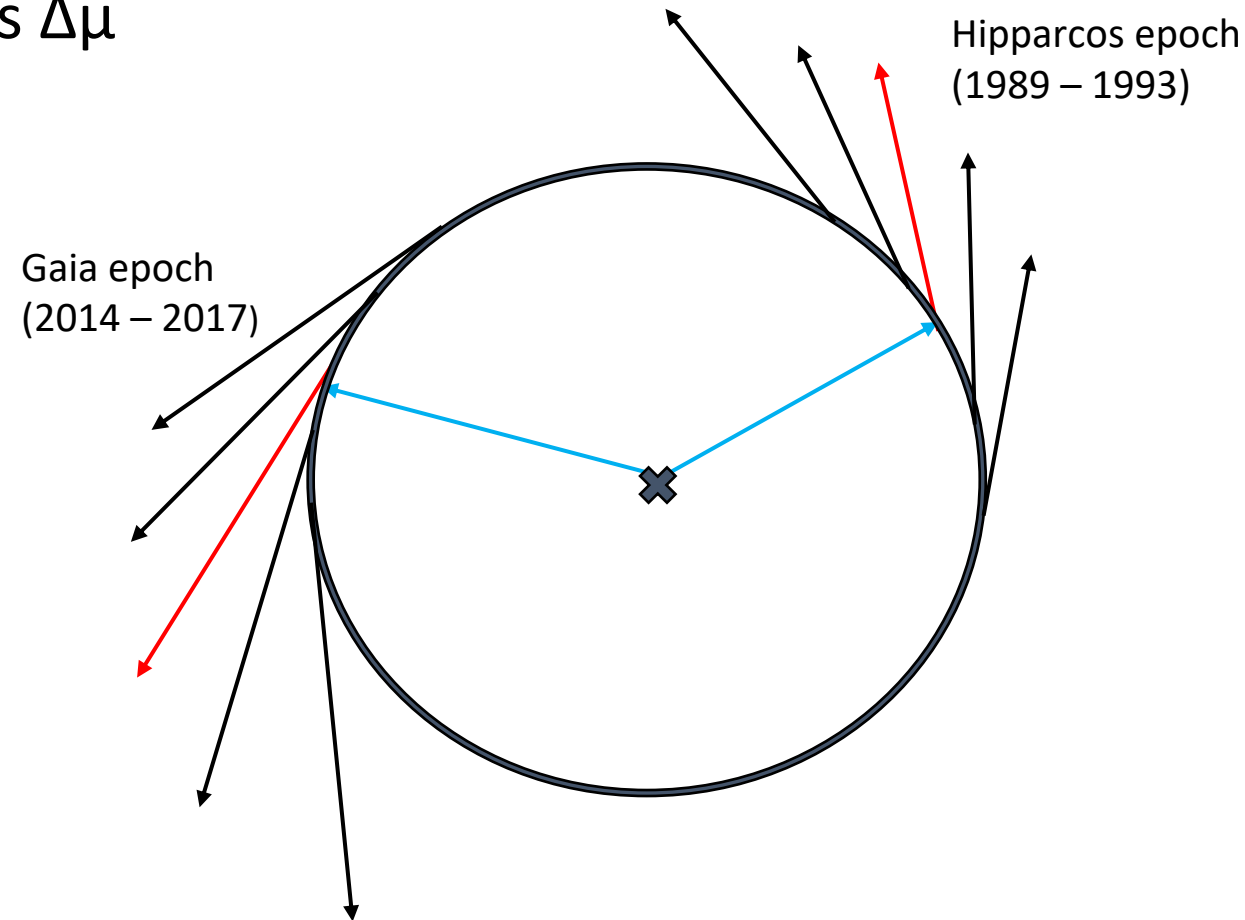
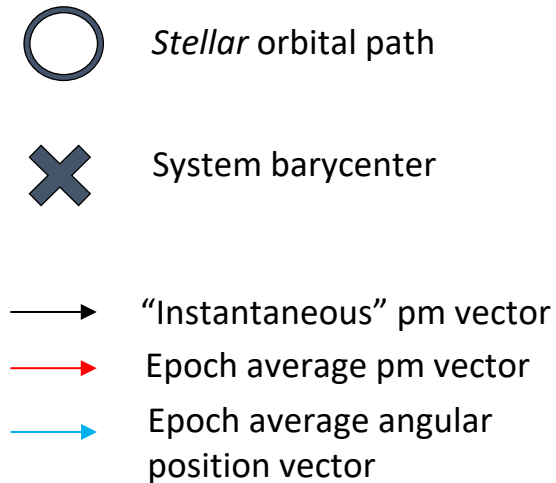
- It's not clear how big outer planets and small inner ones affect each other
- My survey is searching for distant giants in transiting systems
- We've found giants in 5 systems and evidence in 7 more
- $P(\text{DG} | \text{CS})$ is an important statistic for improving planet formation models and uniting two prominent planet classes





RVs and astrometry place complementary constraints on companion properties

- RVs provide $\{\dot{\gamma}, \ddot{\gamma}\}$
- Hipparcos-Gaia Catalog of Accelerations* provides $\Delta\mu$



*Brandt 2021

Supplemental – RV slope

The green region tracks constant $\{\dot{\gamma}, \ddot{\gamma}\}$

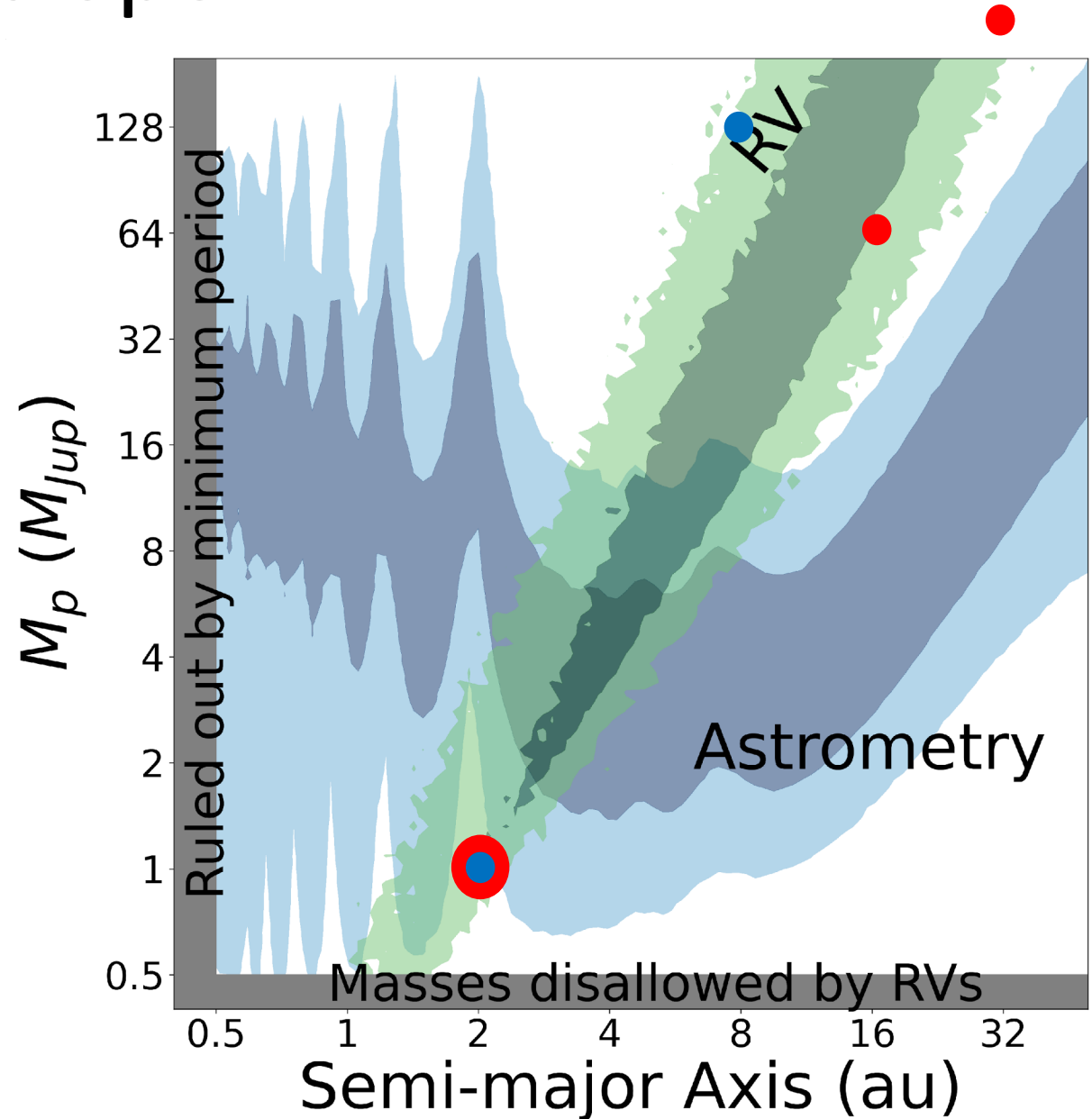
$$\dot{\gamma} = -K\dot{\nu} \sin(\nu + \omega) \propto \frac{K}{P} \propto \frac{m_p}{a^2}$$

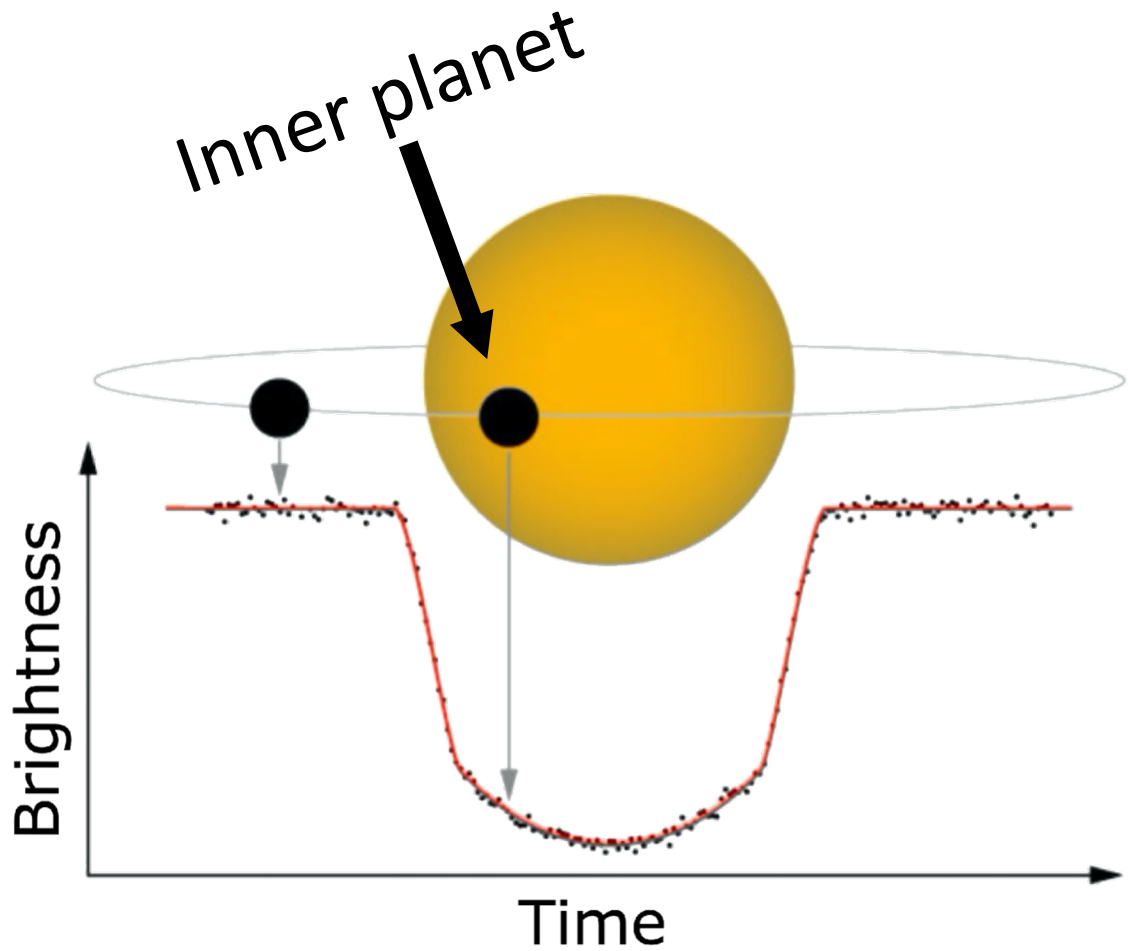
$$\ddot{\gamma} \propto \frac{K}{P^2} \propto \frac{m_p}{a^{7/2}}$$

$$K = \sqrt{\frac{G}{1-e^2}} \frac{m_p \sin(i)}{\sqrt{a(m_p + m_\star)}} \propto \frac{m_p}{\sqrt{a}}$$

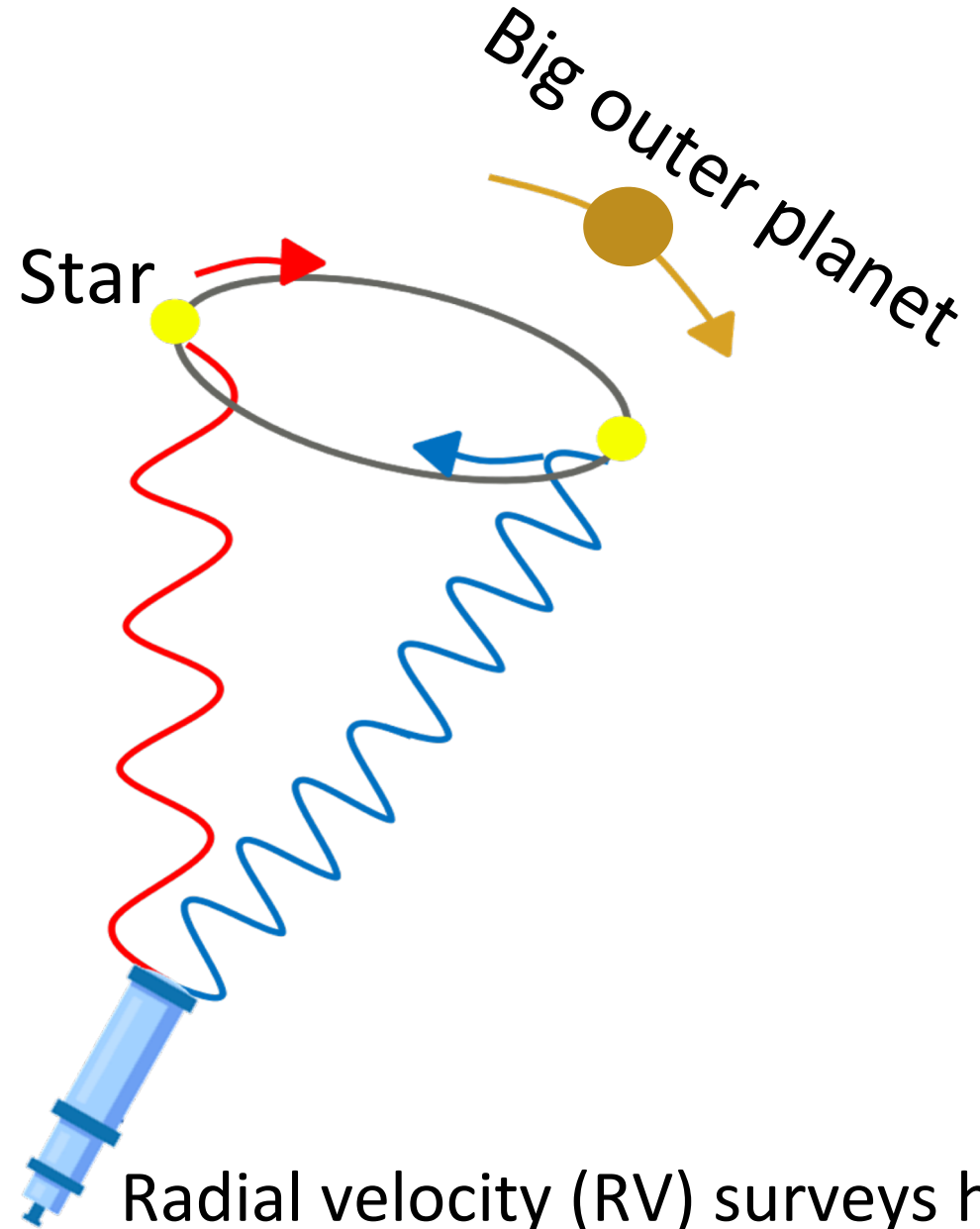
$$P = \frac{2\pi a^{3/2}}{\sqrt{G(m_p + m_\star)}} \propto a^{3/2}$$

$$\dot{\nu} = \frac{2\pi\sqrt{1-e^2}}{(1-e\cos(E))^2 P} \propto \frac{1}{P}$$





Kepler found thousands of **small, close-in** planets with transits



Radial velocity (RV) surveys have found hundreds of **giant outer** planets