

# New Stuff in Exoplanet Demographics

stellar companions & integrated modeling

ExoPAG 31 – Sunday, 01/12/2025

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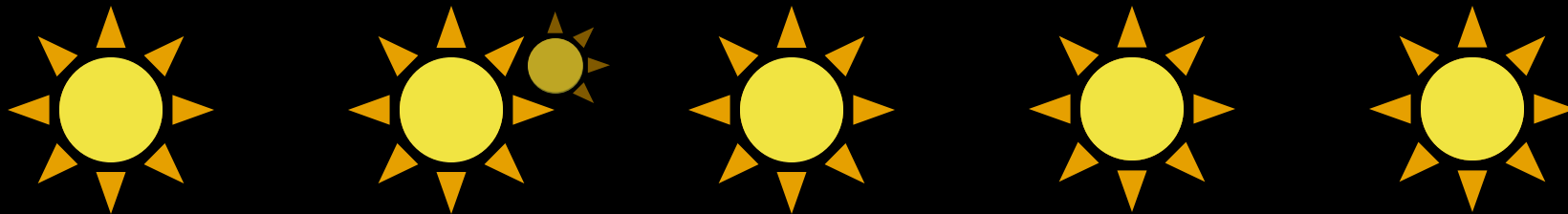
$\eta_{\oplus}$  – the frequency of Earth-like, habitable zone planets

Previously, in Bergsten et al. (2022)

$$\eta_{\oplus} \approx 10\%$$

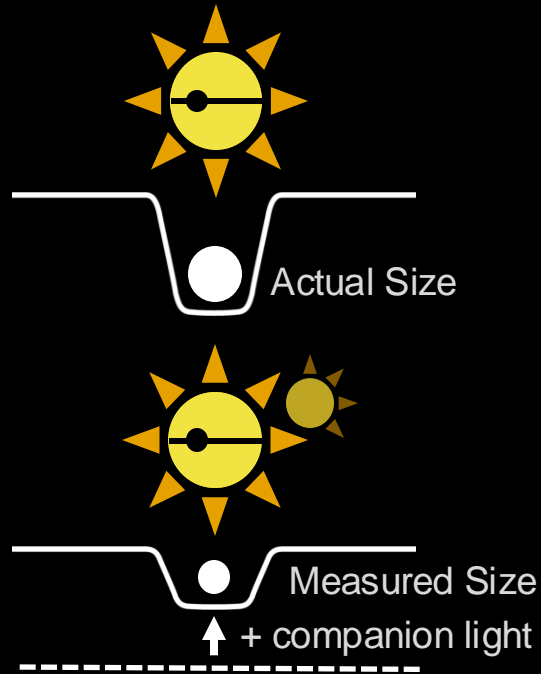
[0.7, 1.5]  $R_{\oplus}$  planets orbiting Sun-like stars

... but what about binaries?



Unresolved stellar companions mess with our measurements of:

### Planet Radii



### Detection Efficiency

10% Complete to  
1  $R_{\oplus}$  Planets

+

+50% underestimation of  
planet radii

=

10% Complete to  
1.5  $R_{\oplus}$  Planets

### Occurrence Rates

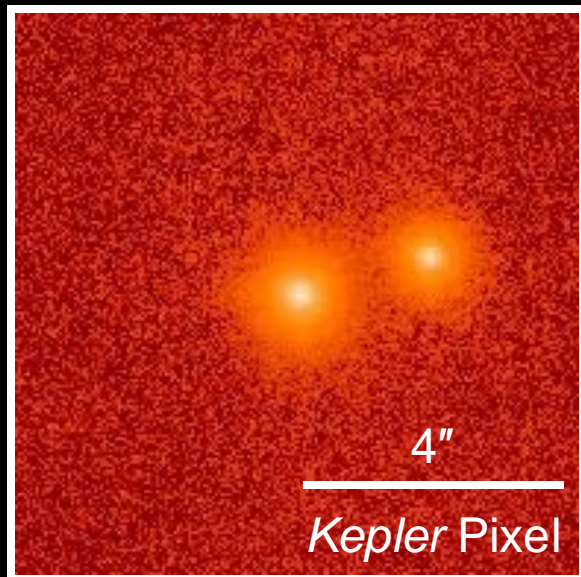
already a  
hot mess



a considerably  
hotter and  
messier mess

200 *Kepler* stars

40 systems with  
(previously) unresolved  
companions



Original Stellar Catalog

Assign Companion Systems

Draw Companion Properties

Adjust Detection Efficiency

(re)Calculate Occurrence Rates

$$\eta_{\oplus} \approx 14\%$$

Compared to  $\eta_{\oplus} \approx 10\%$  previously

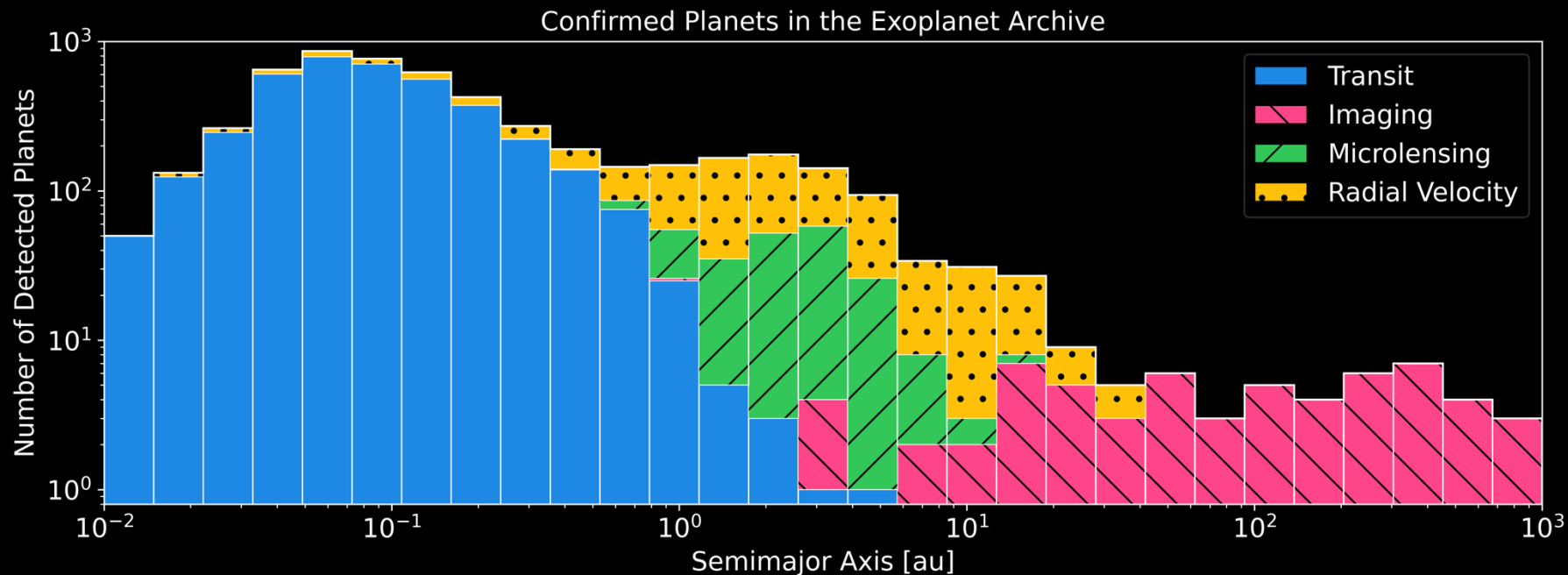
Correcting for unresolved companions  
can increase  $\eta_{\oplus}$  by 1.4x

## Integrated Demographics (*noun*):

using data from multiple surveys/methods for better occurrence rates

*Word Origin*: it sounded cool

*Clanton & Gaudi (2014, 2016); Kunimoto & Bryson (2021)*



Dissertation Talk: #315.01D  
Wednesday @ 10am  
Potomac 5-6

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Skillz:

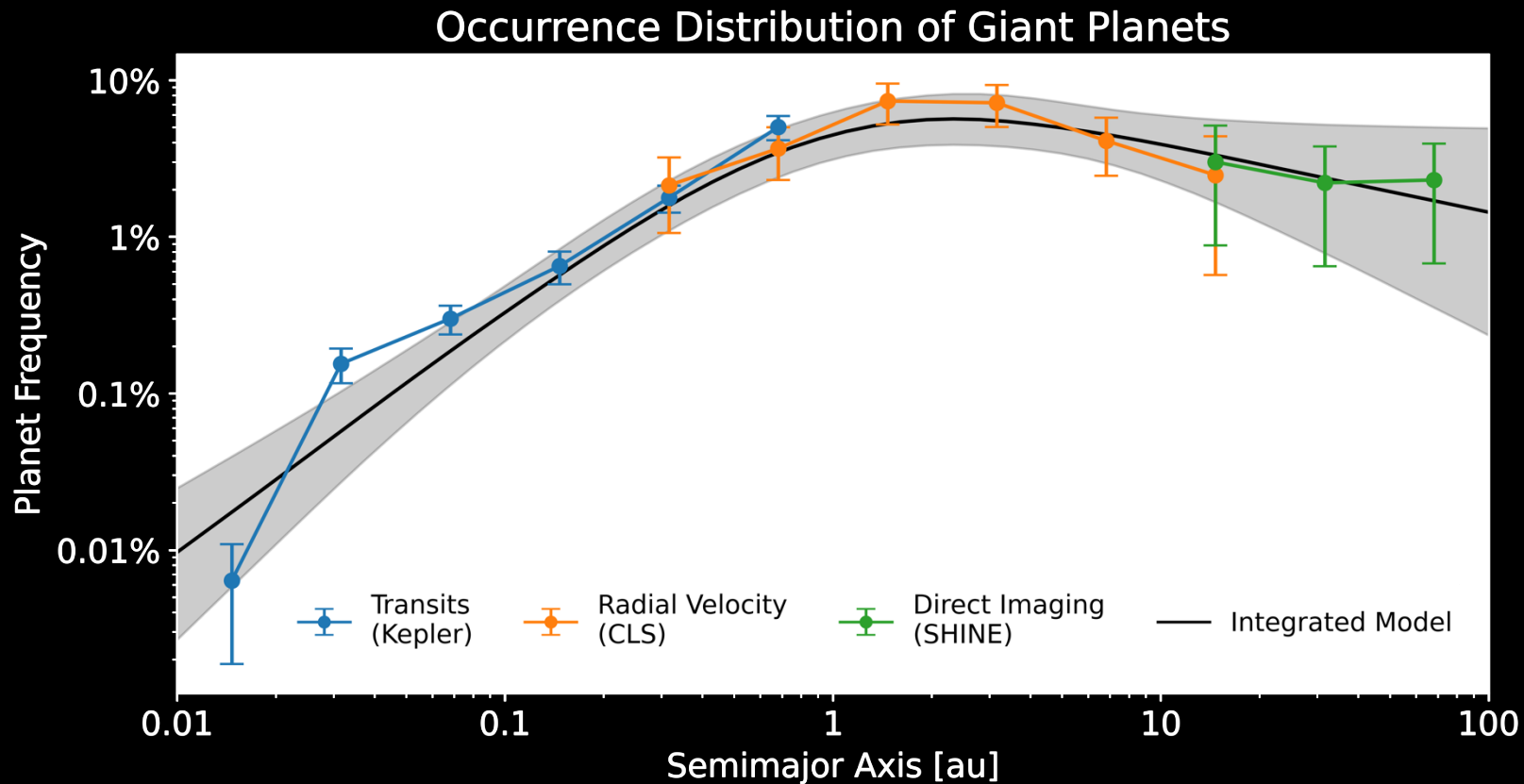
- ✓ Delusion
- ✓ Neurodivergence
- ✓ Stockholm syndrome for your career



WILL WORK FOR \$\$



PLEASE HIRE ME



see e.g., *Fernandes et al. (2019); Fulton et al. (2021)*

# Announcing a new software package for exoplanet demographics.

Every kind of exoplanet science is better  
in a population context.

More people should do demographics  
(again, Stockholm syndrome)

✧  
✧ **BARDIC** ✧  
✧

an unsubtle reference to  
Dungeons & Dragons

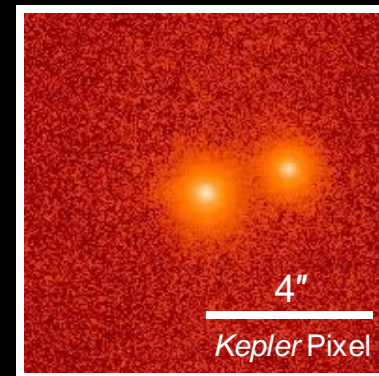
Bayesian Analysis for  
Revolutionary Demographics  
with an Integrated Census

online eventually at [github.com/gbergsten/bardic](https://github.com/gbergsten/bardic)



## Stellar Companions

- Observed 200 stars with AO & found 40 w/ unresolved companions
- Implemented corrections for unresolved companions in pop.sim.
- Doing so can increase  $\eta_{\oplus}$  by 1.4x (from 10  $\rightarrow$  14%)



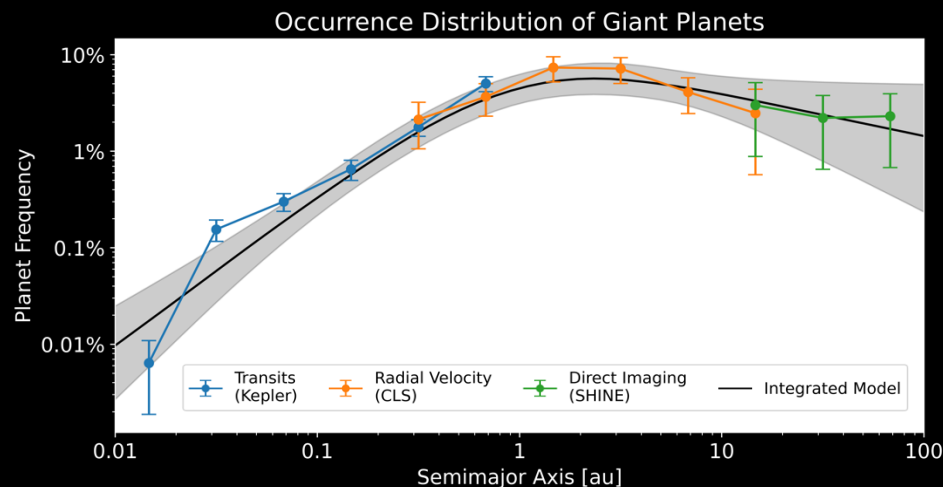
## Integrated Demographics

- New technique for demographics w/ multiple surveys/methods
- Starting w/ giant planet occurrence rates
- Software package coming soon!

Dissertation Talk: #315.01D  
**Wednesday @ 10am in Potomac 5-6**

AWESOM SAG Splinter Session  
**Monday @ 9am in Annapolis 1-2**

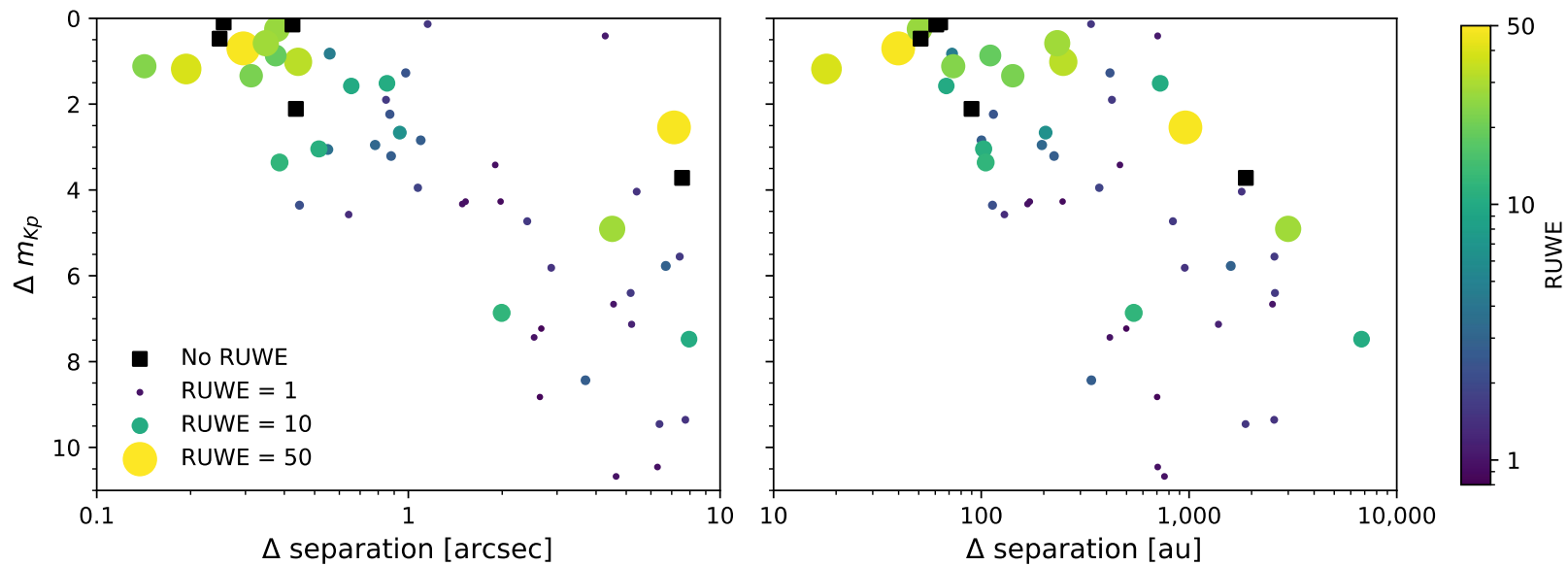
DEIA Policy: #340.01  
**Wednesday @ 2pm in NH 4**

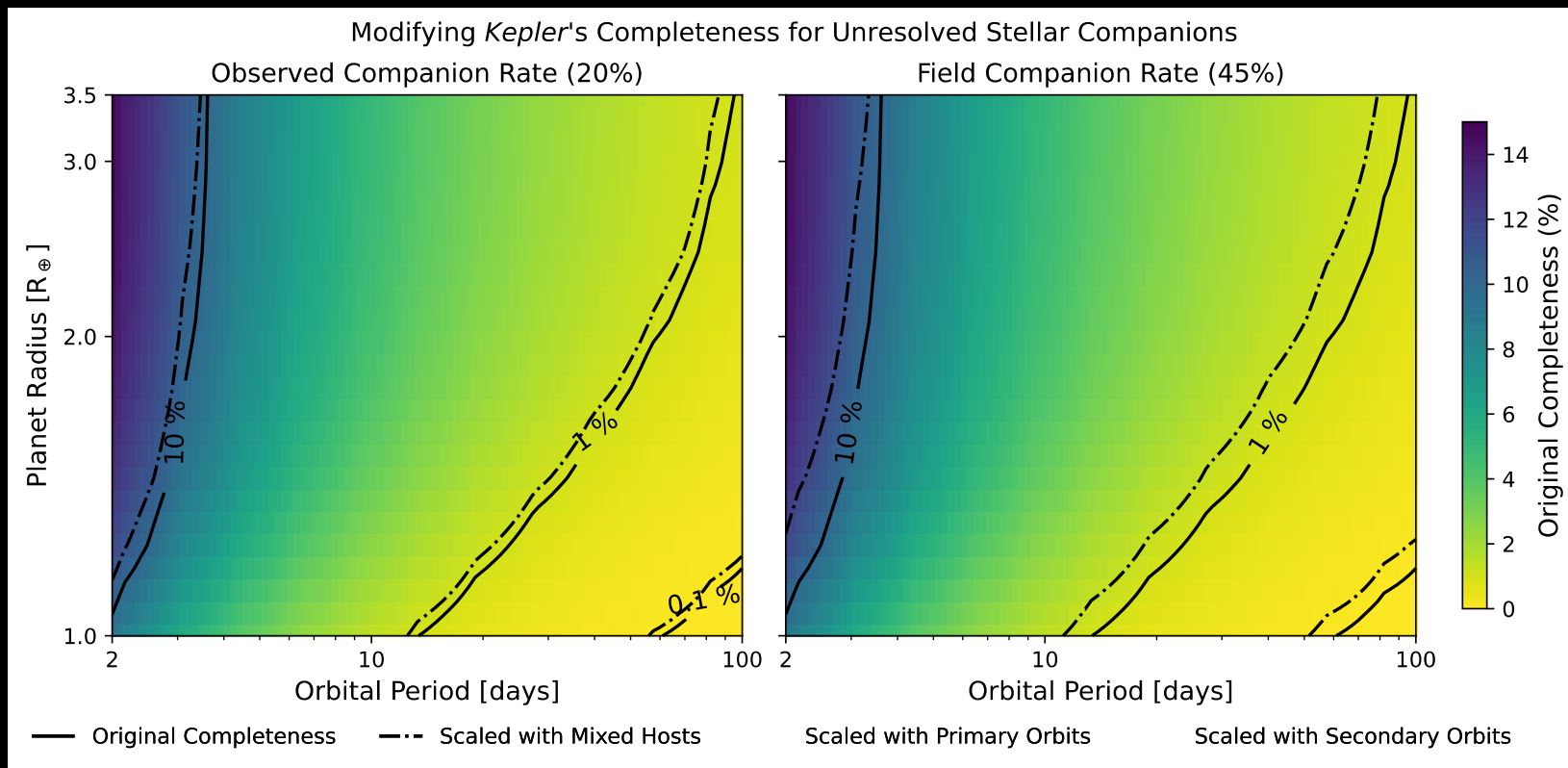


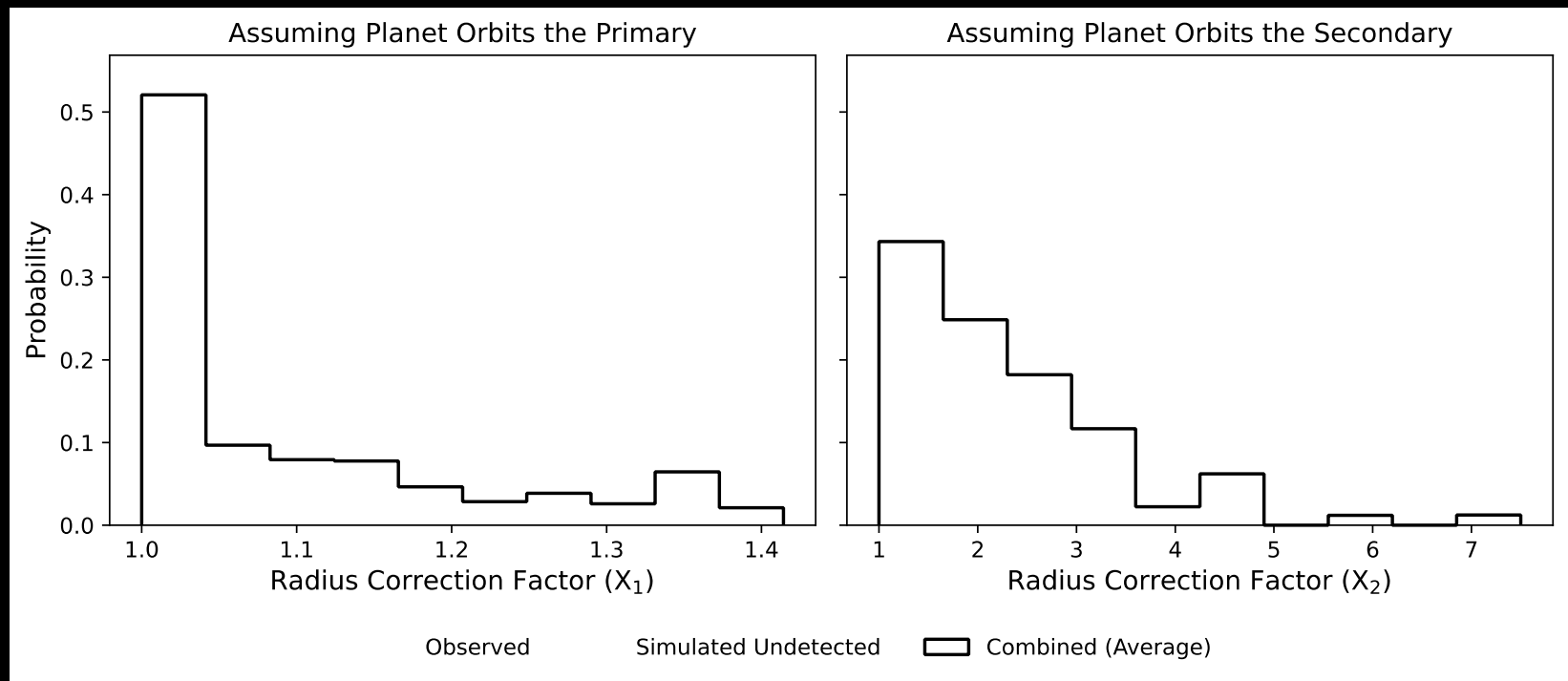
# BACKUP SLIDES

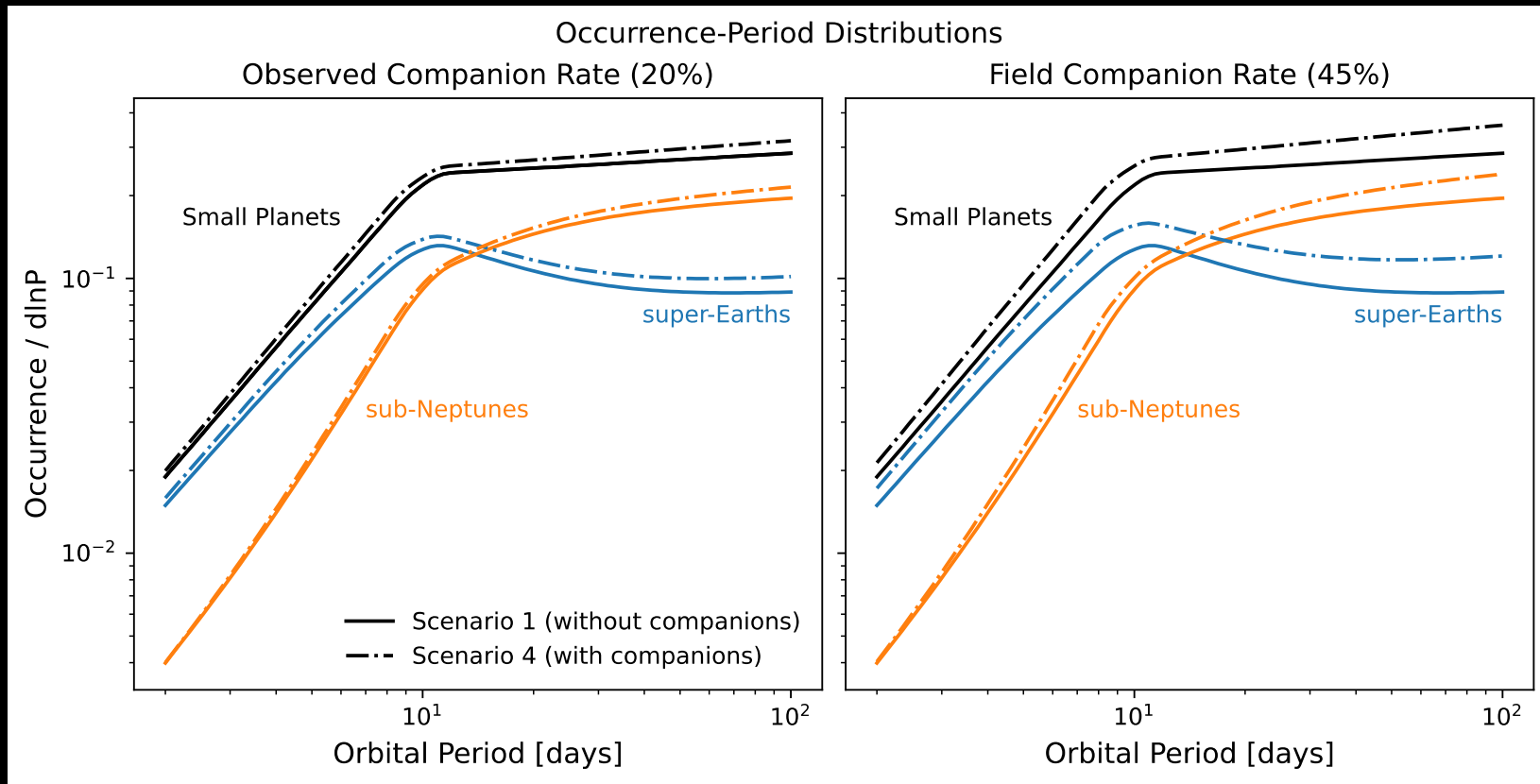
for the inquisitive audience

## Properties of Companion Systems

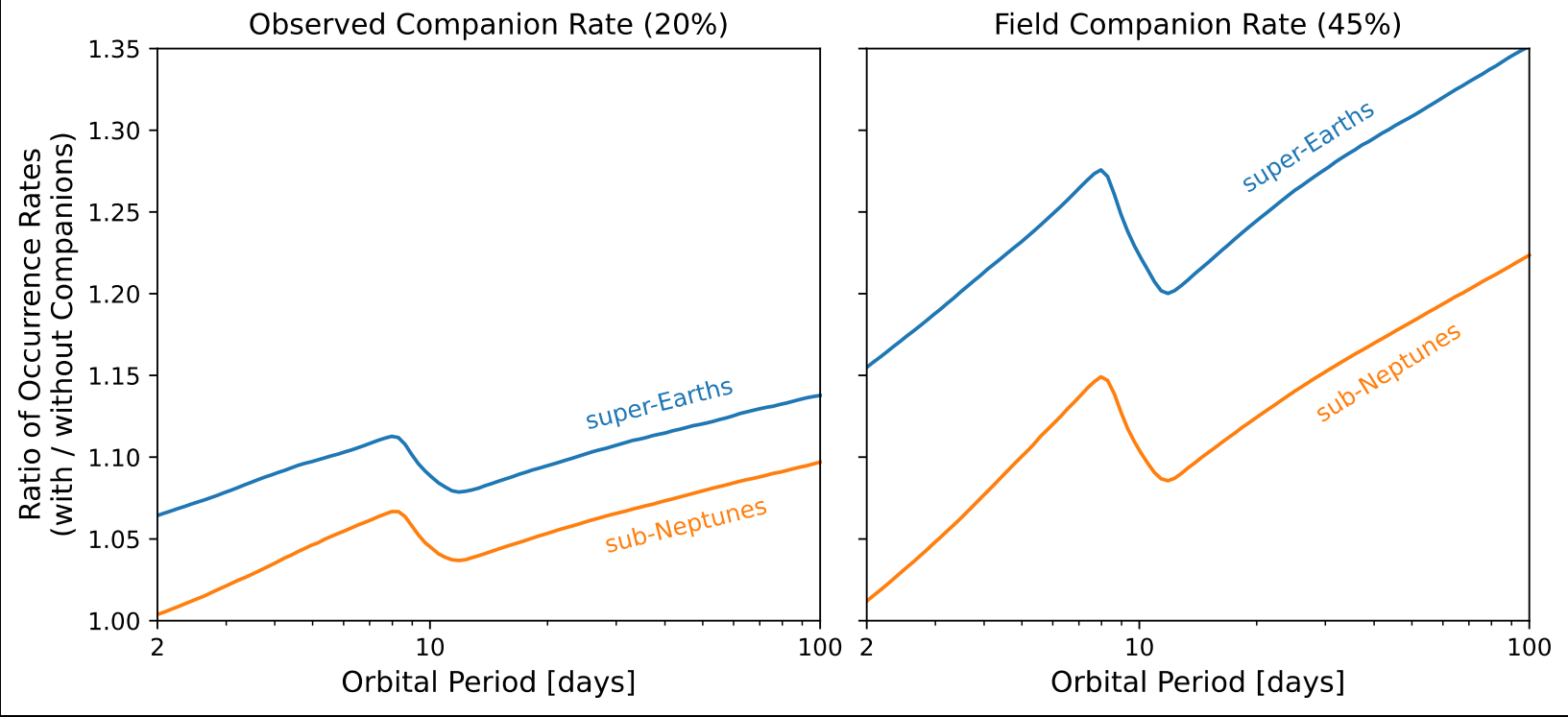








### Relative Increase in Occurrence Rates when Correcting for Unresolved Companions



	Description	$\eta_{\oplus}$ [%]		Increase Relative to No Companions
		Conservative	Optimistic	
	<b>No treatment of stellar companions</b>	$8.4^{+2.2}_{-3.2}$	$13.3^{+3.4}_{-4.8}$	–
Observed Rate (20%)	Planets orbit primary	$9.2^{+2.5}_{-3.6}$	$14.6^{+3.9}_{-5.5}$	$1.10^{+0.40}_{-0.62}$
	Planets orbit secondary	$10.8^{+3.0}_{-4.3}$	$17.1^{+4.6}_{-6.4}$	$1.29^{+0.47}_{-0.72}$
	<b>Mix of primary/secondary orbits</b>	$9.9^{+2.8}_{-3.9}$	$15.7^{+4.2}_{-5.9}$	$1.18^{+0.43}_{-0.66}$
Field Rate (45%)	Planets orbit primary	$9.9^{+2.8}_{-3.9}$	$15.7^{+4.2}_{-5.9}$	$1.18^{+0.43}_{-0.66}$
	Planets orbit secondary	$16.0^{+4.6}_{-6.1}$	$25.1^{+7.0}_{-9.1}$	$1.89^{+0.69}_{-1.05}$
	<b>Mix of primary/secondary orbits</b>	$12.3^{+3.5}_{-4.8}$	$19.4^{+5.3}_{-7.2}$	$1.46^{+0.53}_{-0.83}$



