Correcting for Unresolved Companions in *Kepler* Occurrence Rates

KTSKTP2 – Wednesday, 2/5/2025

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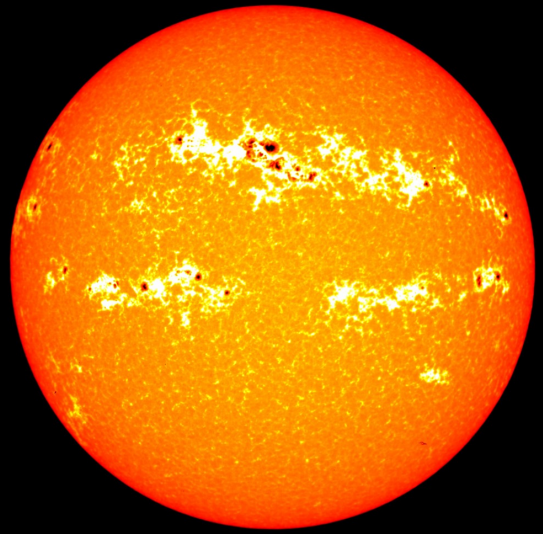
Facula



Dracula

NOT demographics in multi-star systems

see e.g., Sullivan et al. (2023); Clark et al. (2024)

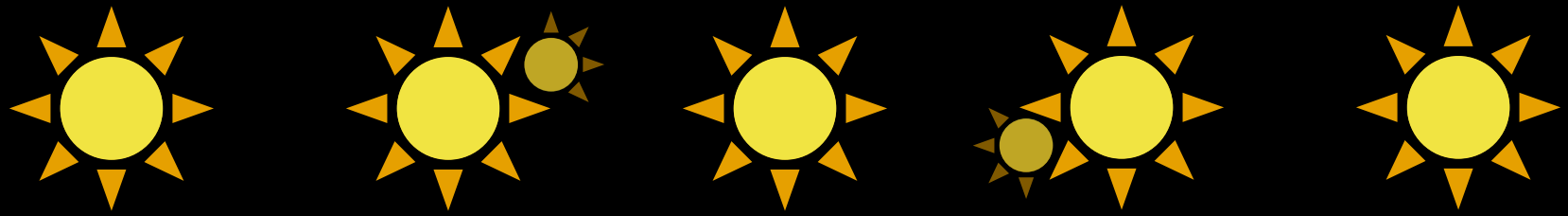
Dominic Oddo (#1.15) Catherine Clark (#1.28)

Daniel Fabrycky (#2.04) Kendall Sullivan (#4.10) Colin Littlefield (#5.07)

Instead, demographics assuming single stars...

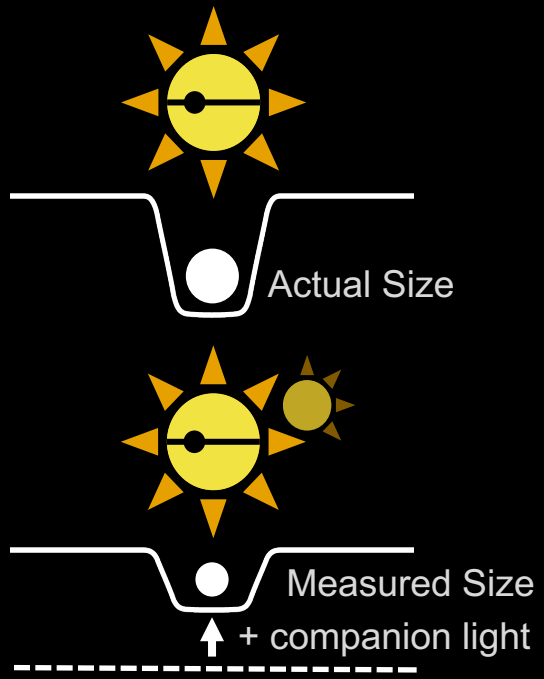
(… that aren't always singles)

see e.g., Savel et al. (2020)



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

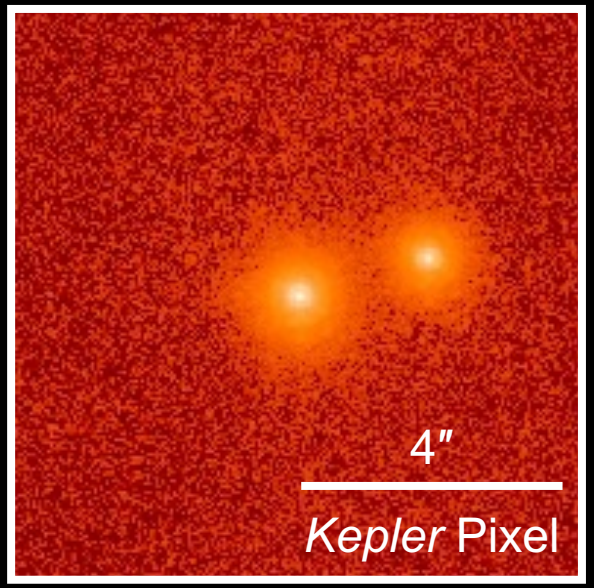
already a
hot mess

a considerably hotter and messier mess

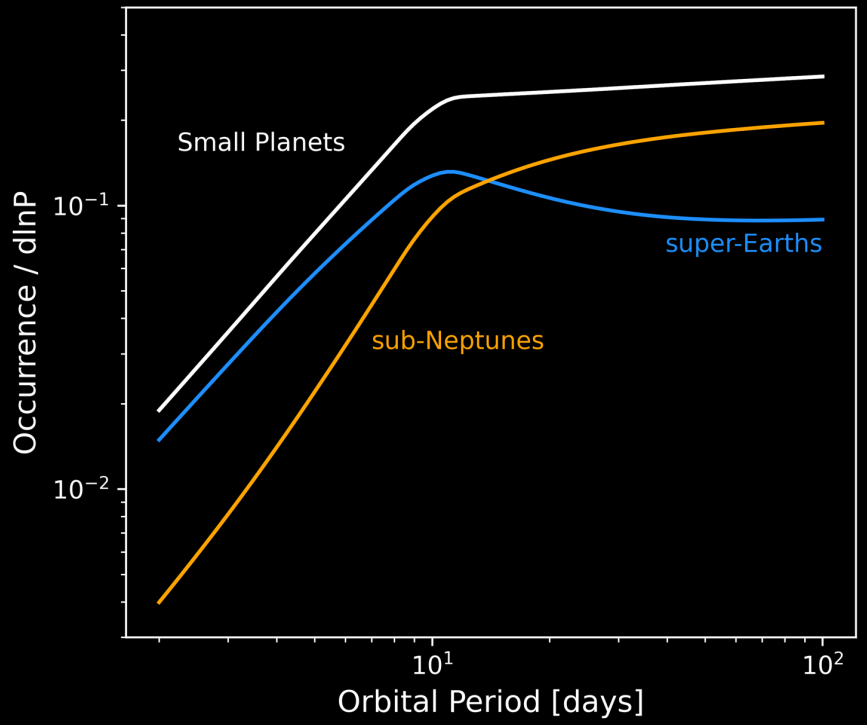
see e.g., Ciardi et al. (2015); Furlan et al. (2017)

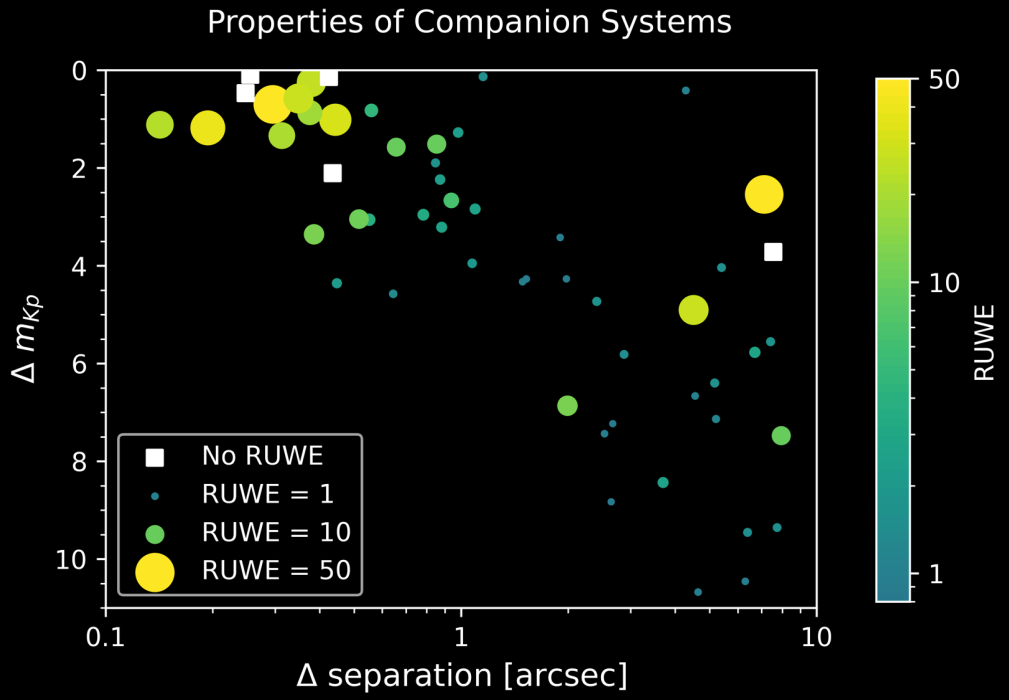
200 *Kepler* stars

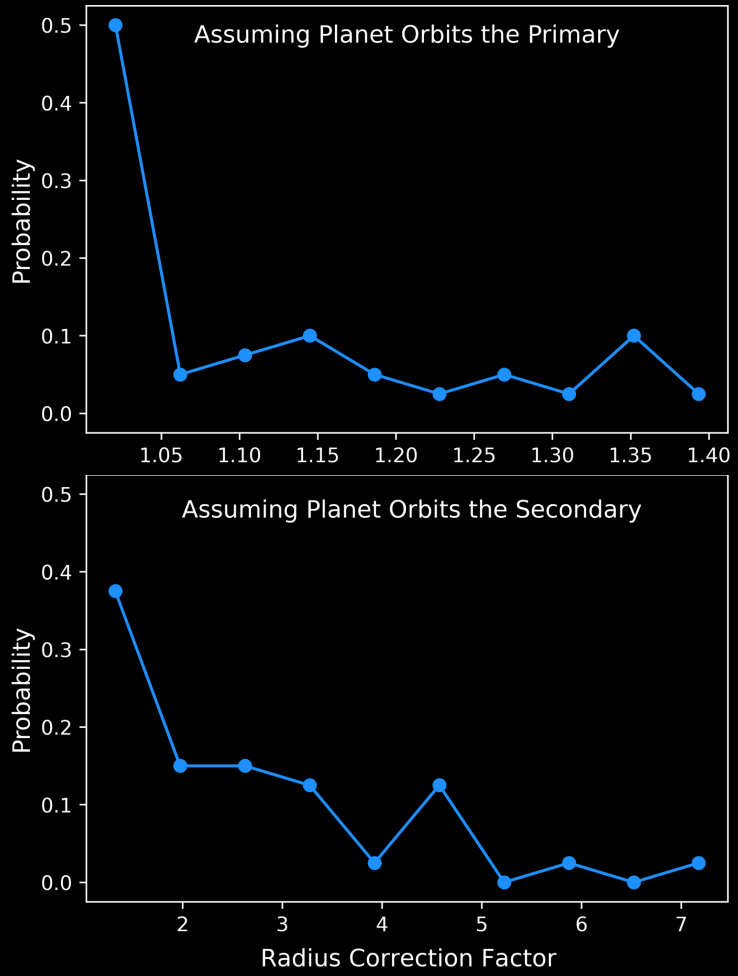
40 systems with (previously) unresolved companions

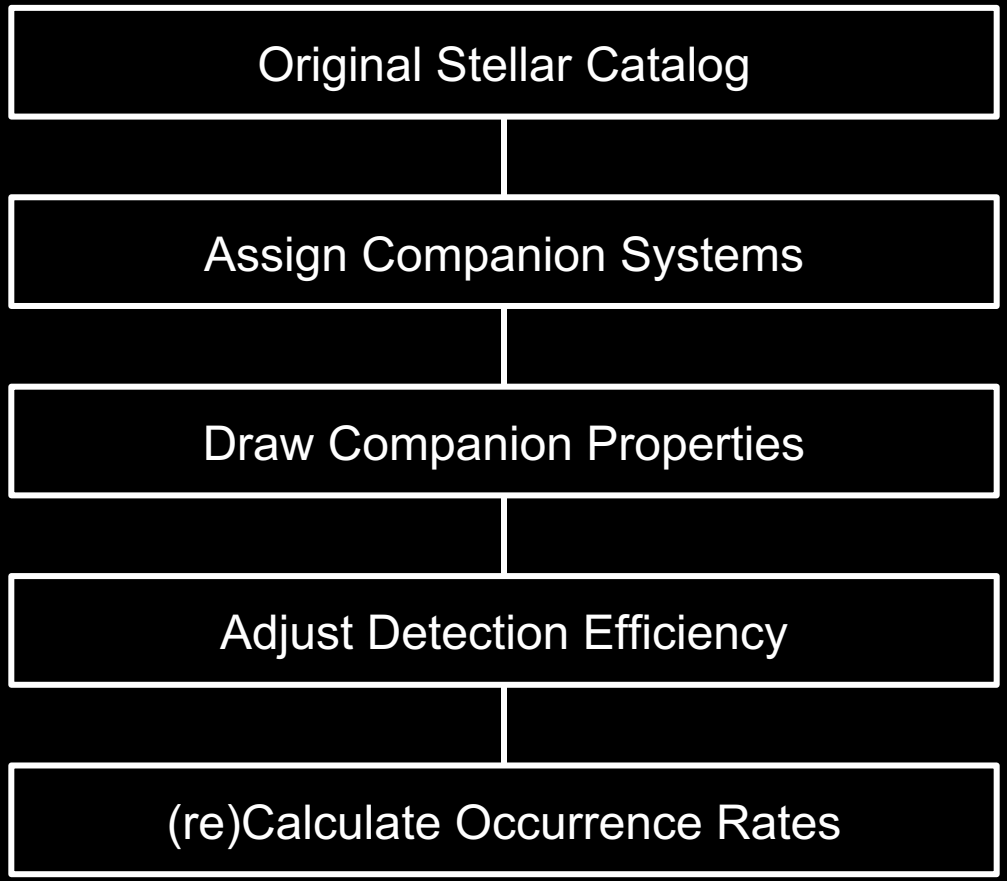


Occurrence Rates from Bergsten et al. (2022)

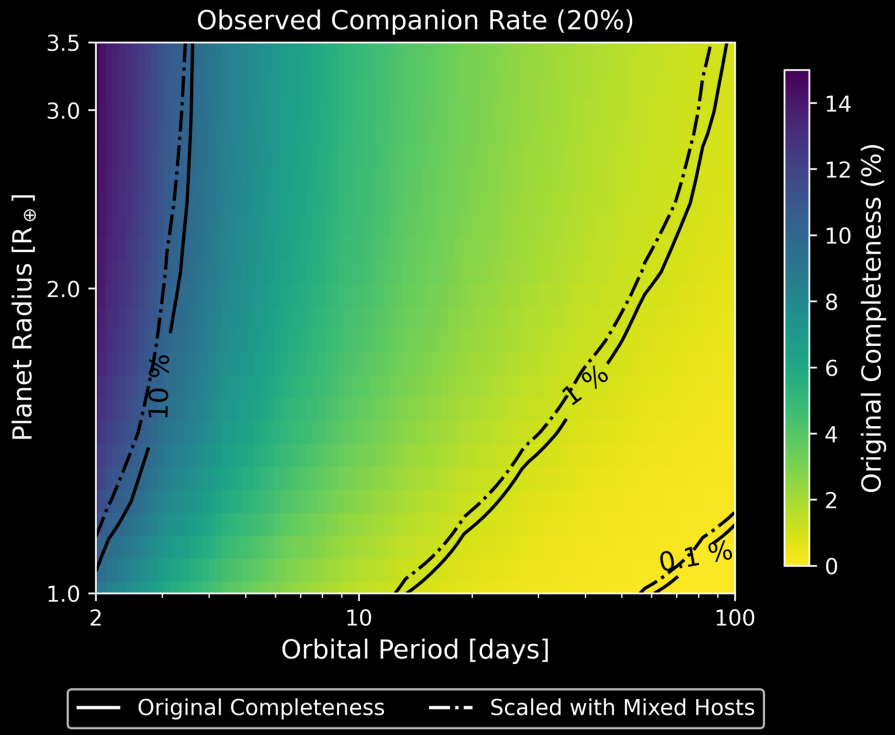



Properties of Companion Systems
Δ m_{Kp}
Δ separation [arcsec]
No RUWE
RUWE = 1
RUWE = 10
RUWE = 50
RUWE

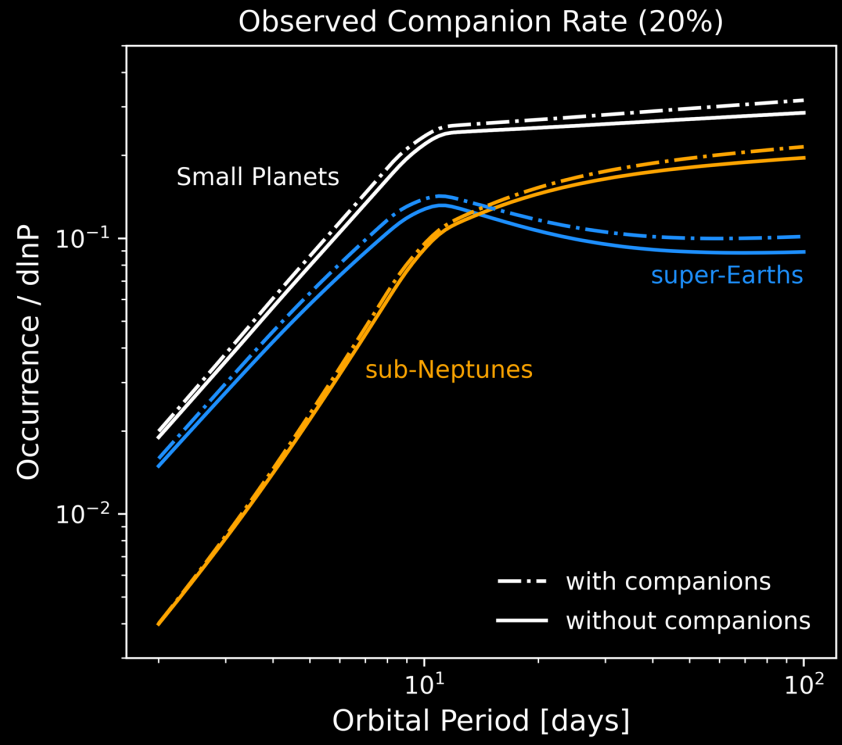

Assuming Planet Orbits the Primary
Assuming Planet Orbits the Secondary
Probability
Radius Correction Factor

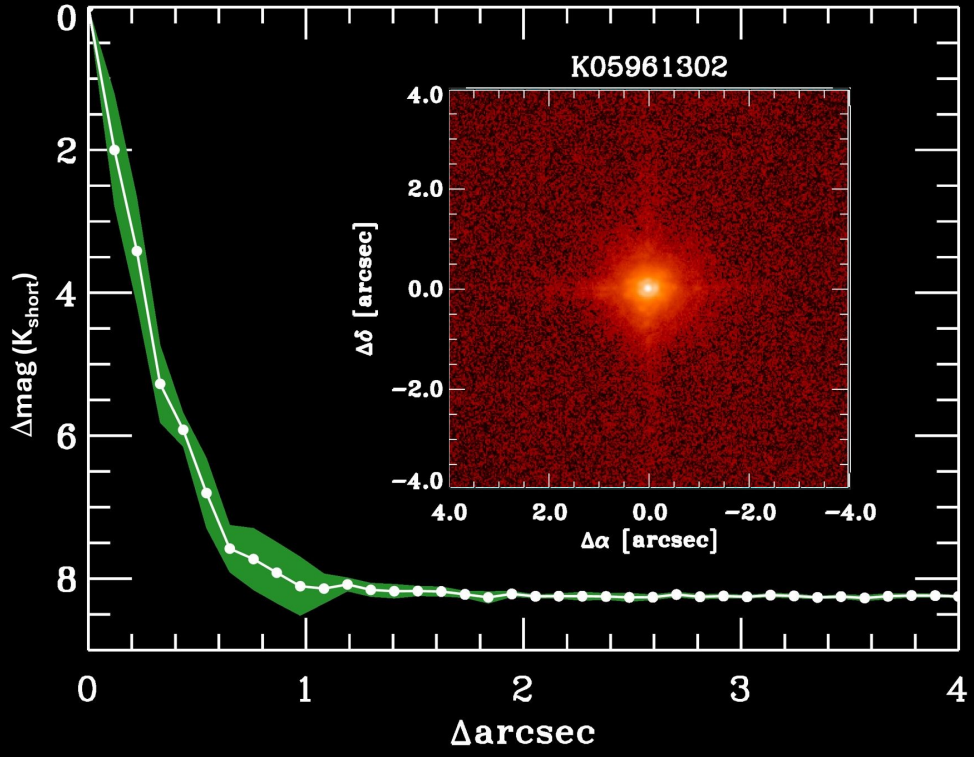

Original Stellar Catalog
Assign Companion Systems
Draw Companion Properties
Adjust Detection Efficiency
(re)Calculate Occurrence Rates

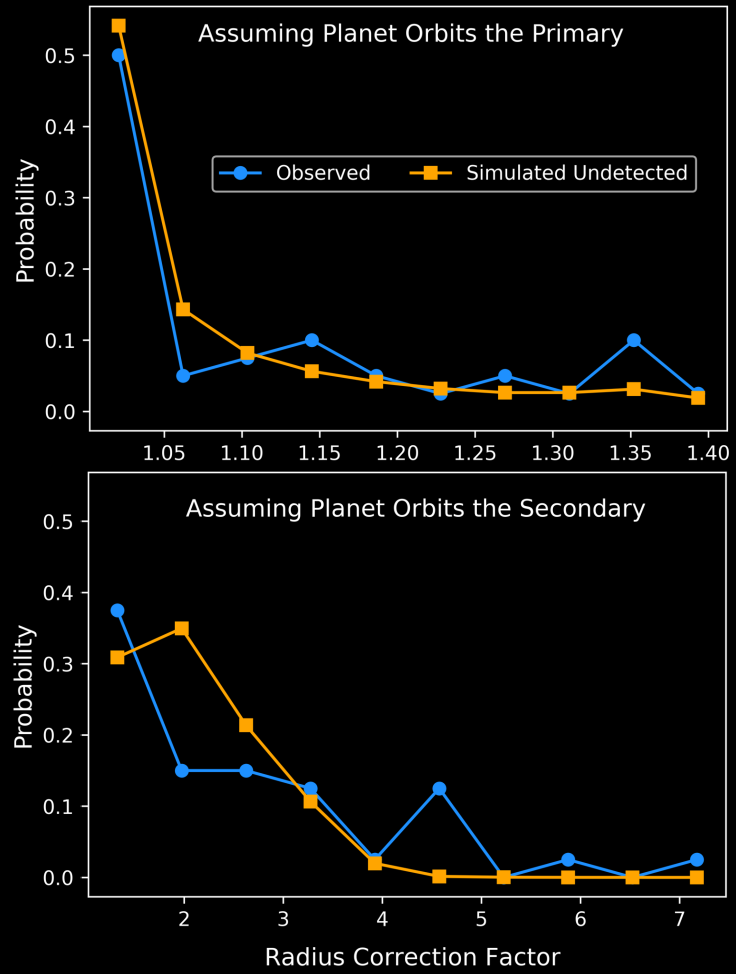
Adjusted Detection Efficiency



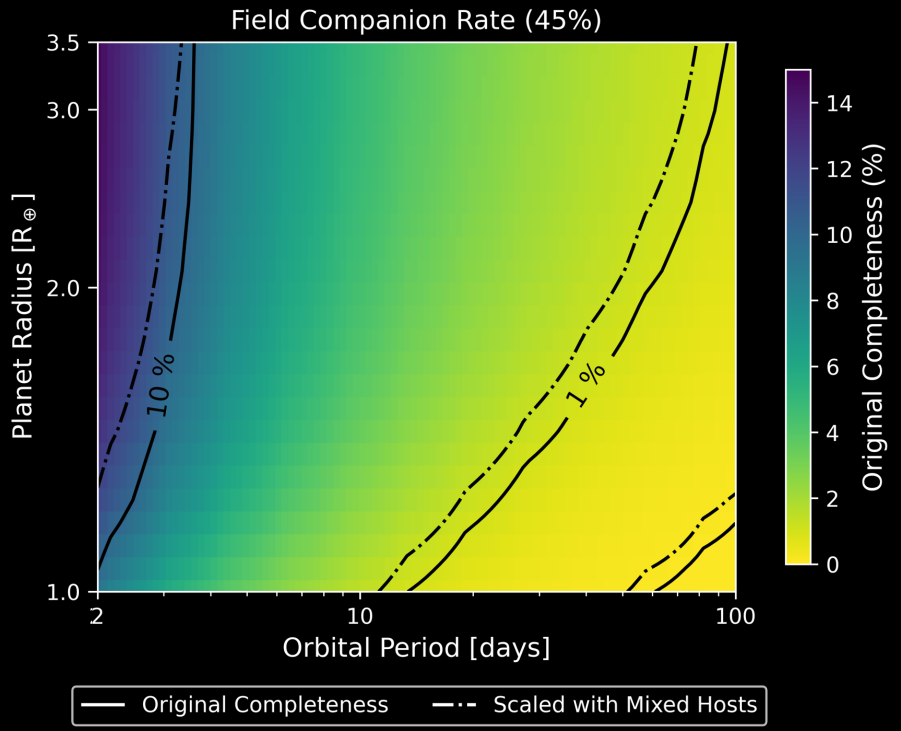
Recalculated Occurrence Rates



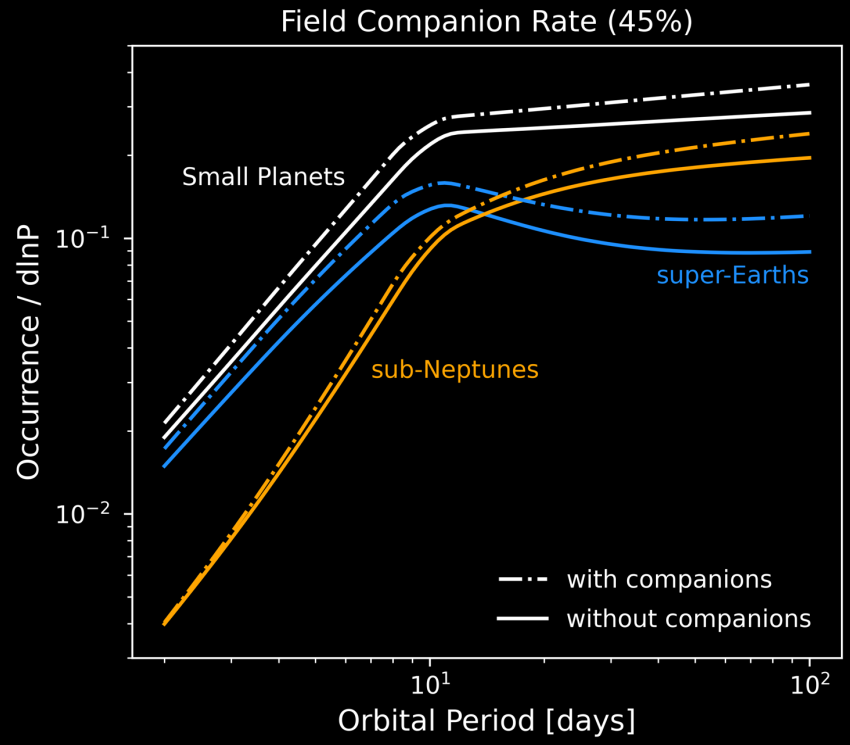

K05961302
Δmag (K_short)
Δarcsec
Δδ [arcsec]
Δα [arcsec]

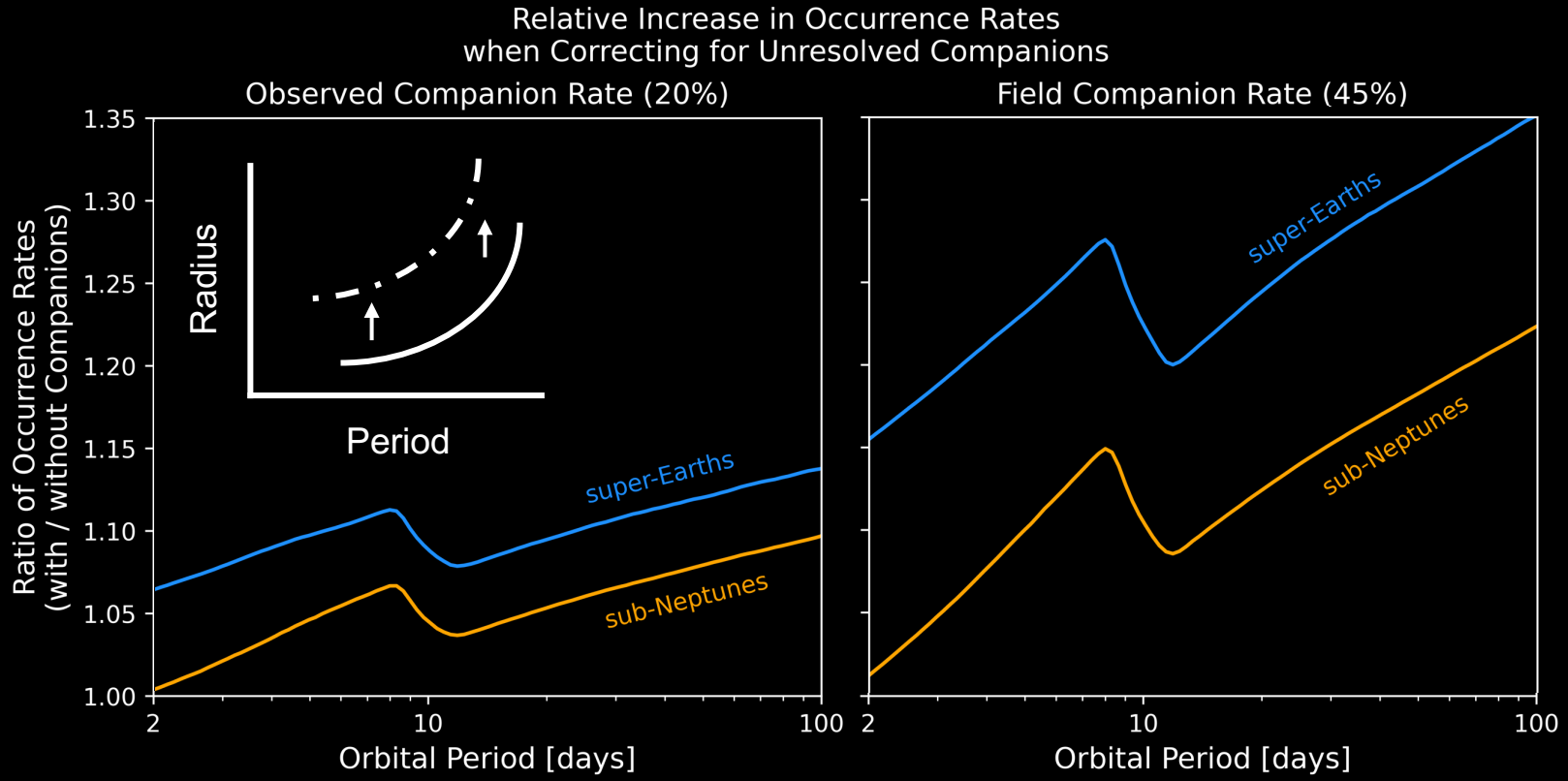

Assuming Planet Orbits the Primary
Observed
Simulated Undetected
Probability
Assuming Planet Orbits the Secondary
Probability
Radius Correction Factor

Adjusted Detection Efficiency



Recalculated Occurrence Rates





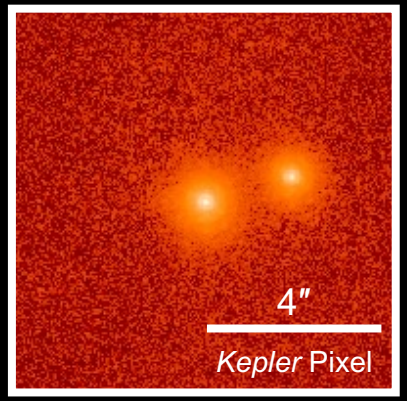
bump @ 10 days due to (insignificant) difference in free parameters

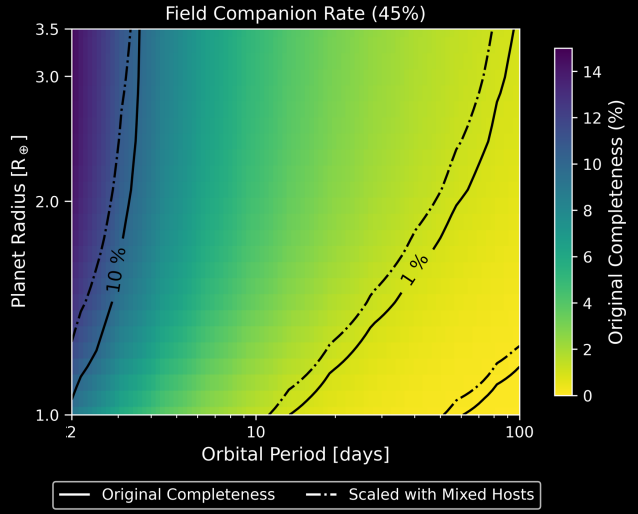
$\eta_\oplus$ – the frequency of Earth-sized, Habitable Zone planets

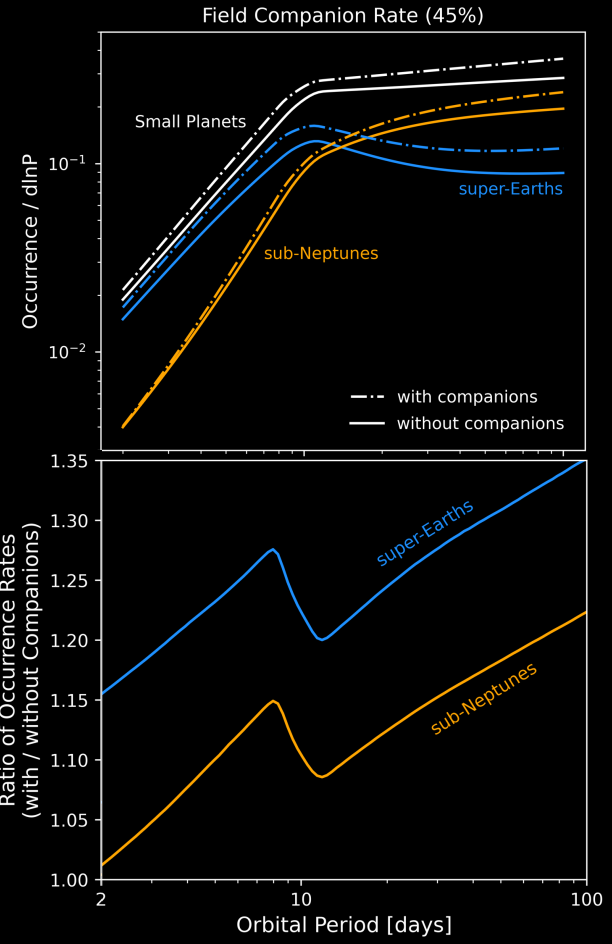
	$\eta_\oplus$ [%]	Relative Increase
Assuming Singles	$8.4^{+2.2}_{-3.2}$	--
Observed Rate (20%)	$9.9^{+2.8}_{-3.9}$	1.18
Field Rate (45%)	$12.3^{+3.5}_{-4.8}$	1.46

Doesn't matter which models you use!

Correcting for unresolved companions can lead to an average 1.2-1.4x *relative increase* in $\eta_\oplus$







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