

STELLAR COMPANIONS OF EXOPLANET HOST STARS IN K2

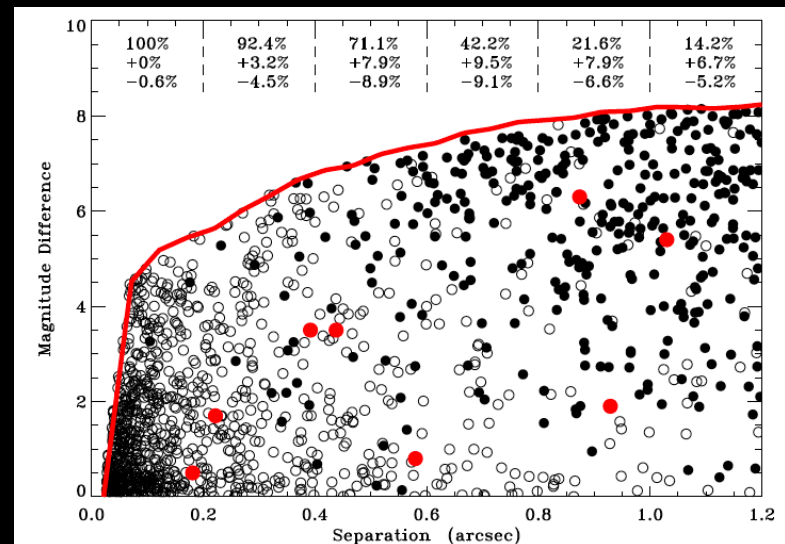
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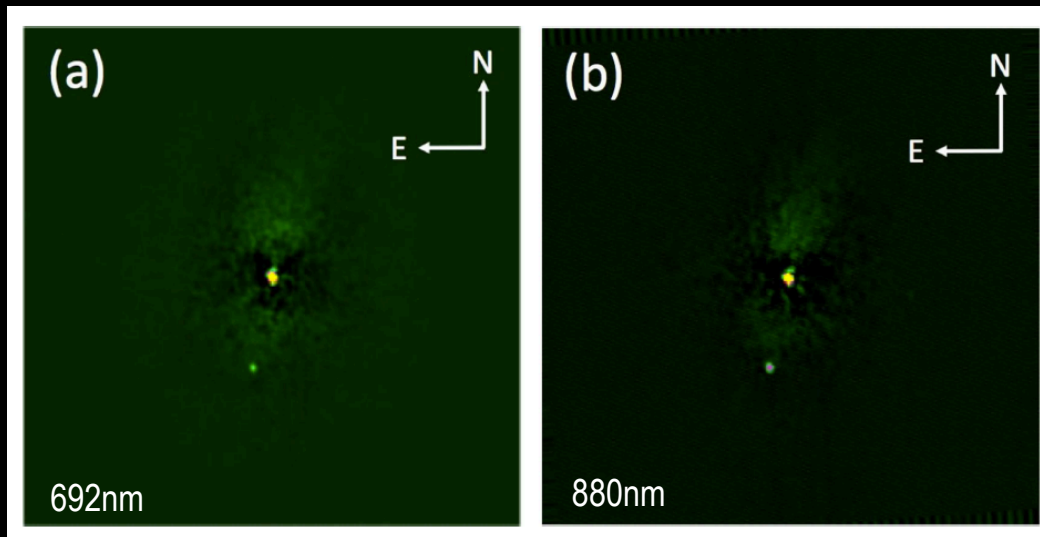
BINARY FRACTION OF PLANET HOSTS

- Raghavan et al. 2010
 - 454 FGK stars within 25pc
 - 54% single, 46% multiples
- Horch et al. 2014
 - >600 stars observed with speckle imaging
 - 40 – 50% bound companions
- Deacon et al. 2016
 - 400 Kepler wide multiples (separations > 6")
 - Pan-STARRS 1 SED fits and proper motions

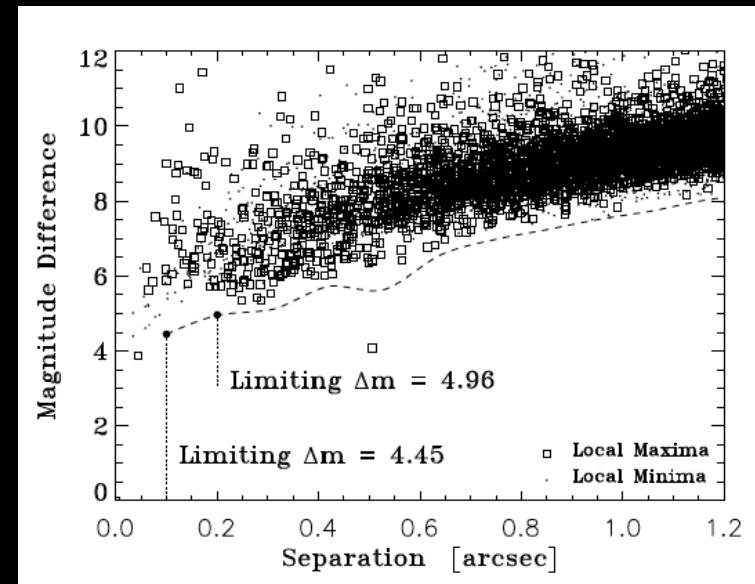


DSSI SPECKLE IMAGING

- 562, 692, 880nm (40 - 50nm wide)
- Separations of $< 0.1-1.2''$
- $\Delta \text{mag} \sim 3 - 4$ at WIYN, $\sim 5 - 6$ at Gemini (N & S)



Companion to HD 2638 detected at $0.5''$ with $\Delta m = 3.8$ (692nm) & 2.8 (880nm)



K2 EXOPLANET HOSTS

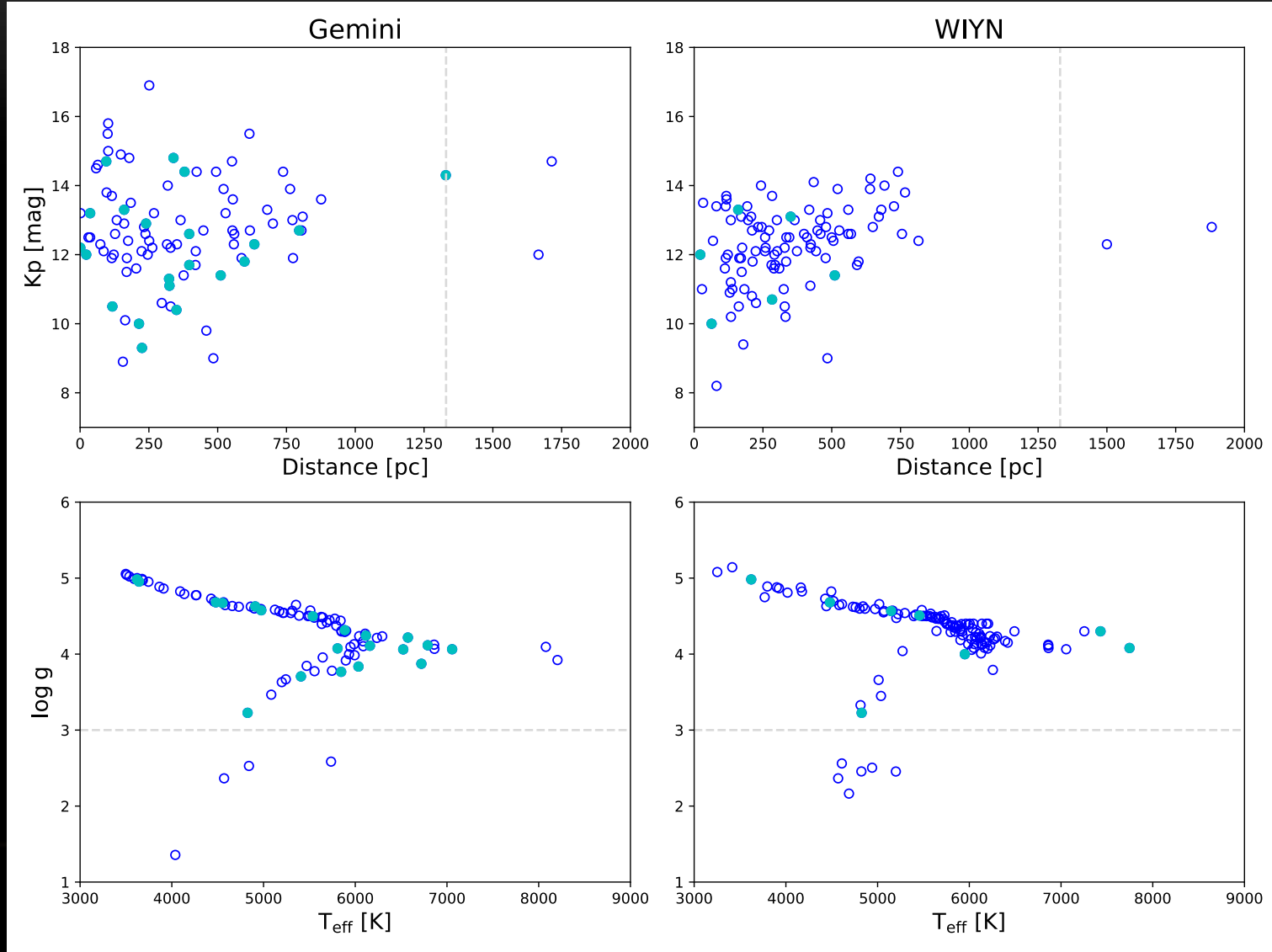
- Compare observed companions to star count simulations with known companion fraction & apply DSSI detection limits

	Gemini N.	Gemini S.	WIYN	Total
562 nm Observations	0	11	0	11
692 nm Observations	34	57	127	218
880 nm Observations	34	68	127	229
Total Observations	68	136	254	458
Companions Detected (880 nm)	10	13	8	29
Unique Stars Observed	34	68	127	206
Average <i>Kepler</i> Magnitude	12.7	12.6	12.3	12.5

Right Ascension [degrees]

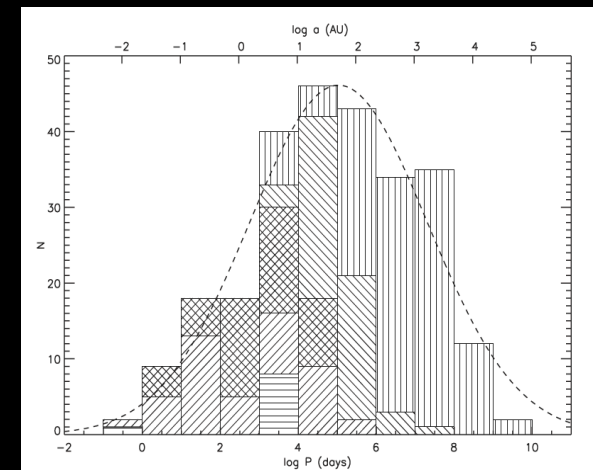
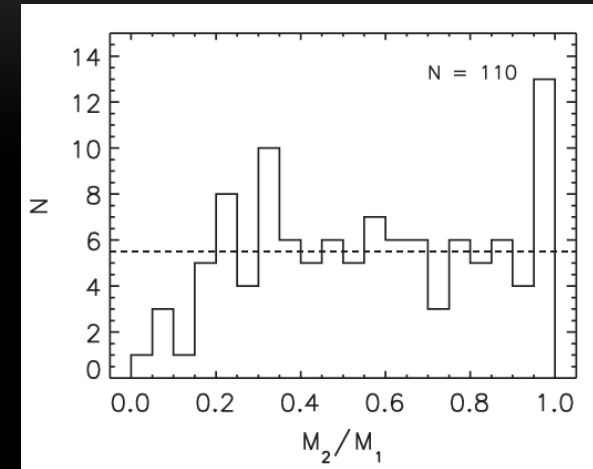
- 23/102 companions detected at Gemini = 23%
- 8/127 companions detected at WIYN = 6%

K2 STELLAR PROPERTIES

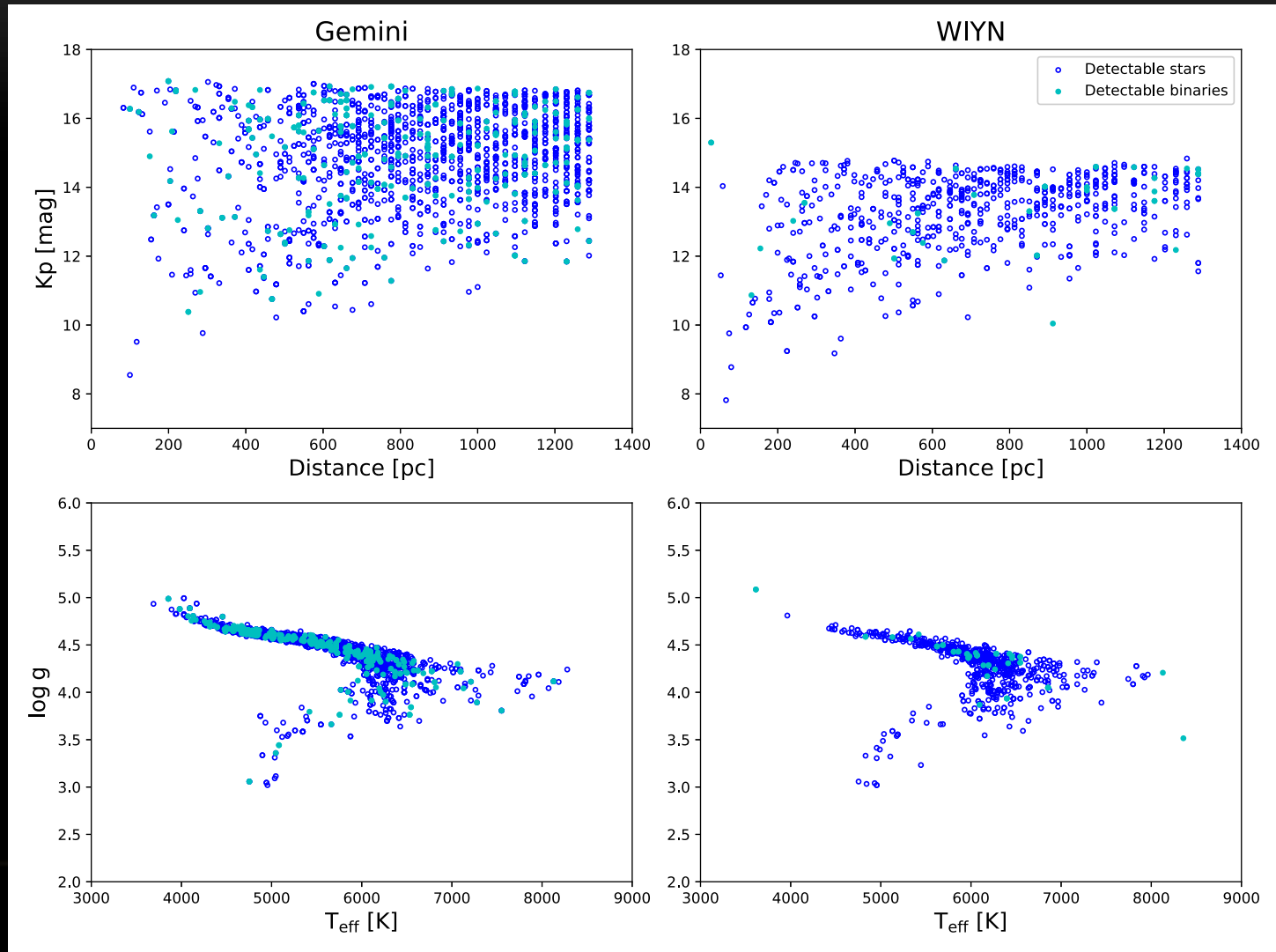


SIMULATED STARS

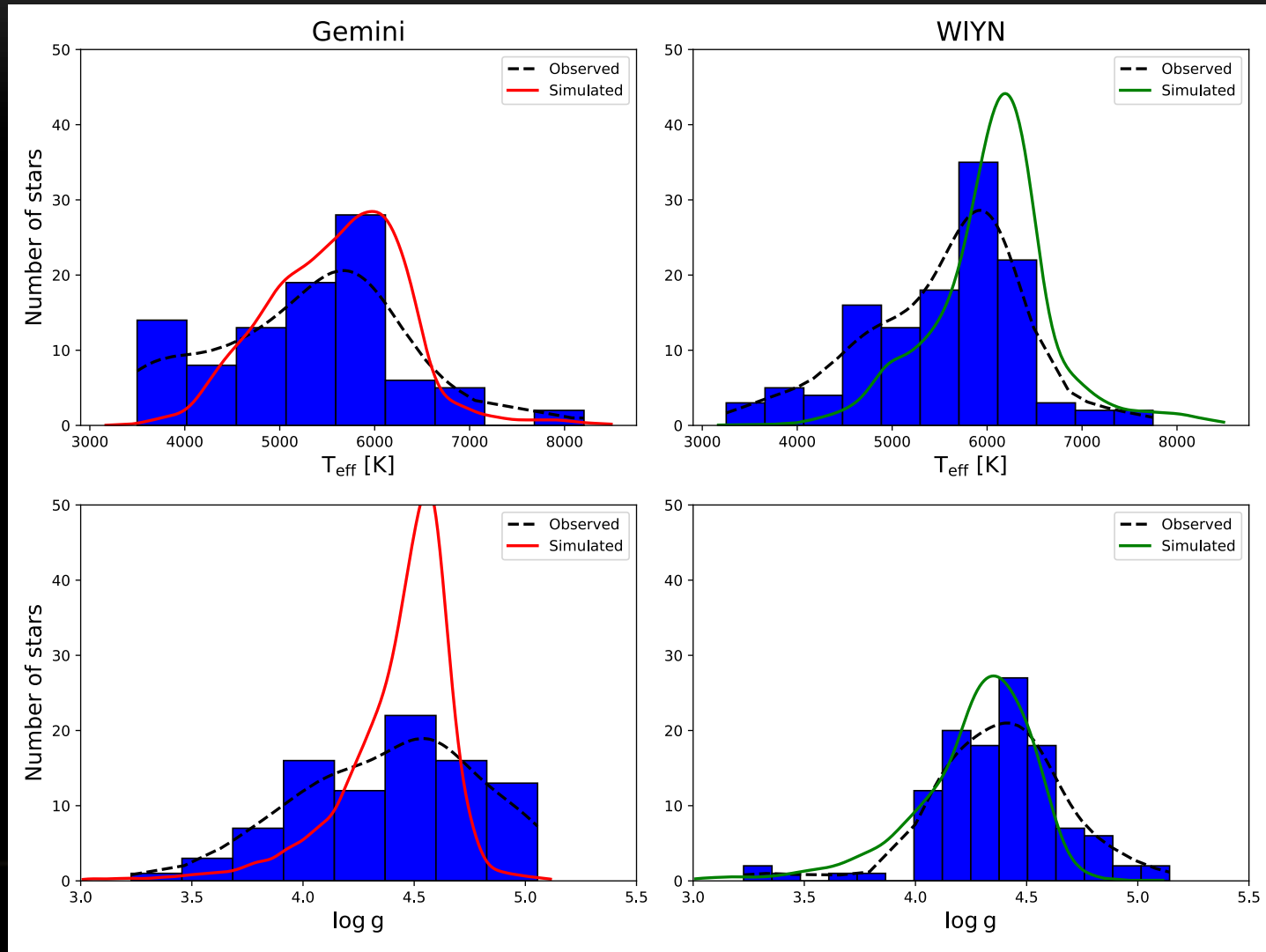
- TRILEGAL galaxy model (Girardi et al. 2005)
 - 15 pointings ($> 2 \times 10^6$ stars)
 - Cut output: $d > 1300 \text{ pc}$, $T_{\text{eff}} = 3000 - 9000 \text{ K}$, $\log g = 3 - 6$
- Add companions according to Raghavan et al. 2010 (46%)
- Determine separation and magnitude difference
- Test if detected by DSSI at Gemini or WIYN
- Add in line-of-sight binaries



SIMULATED STELLAR PROPERTIES

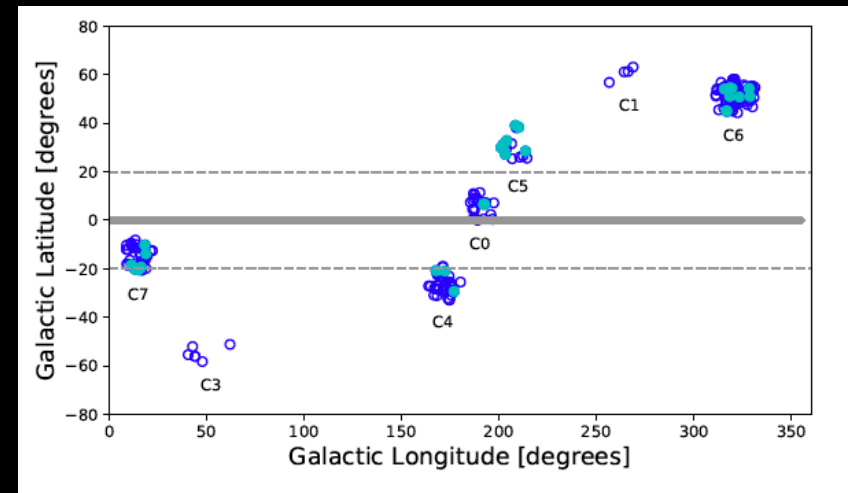


STELLAR DISTRIBUTIONS

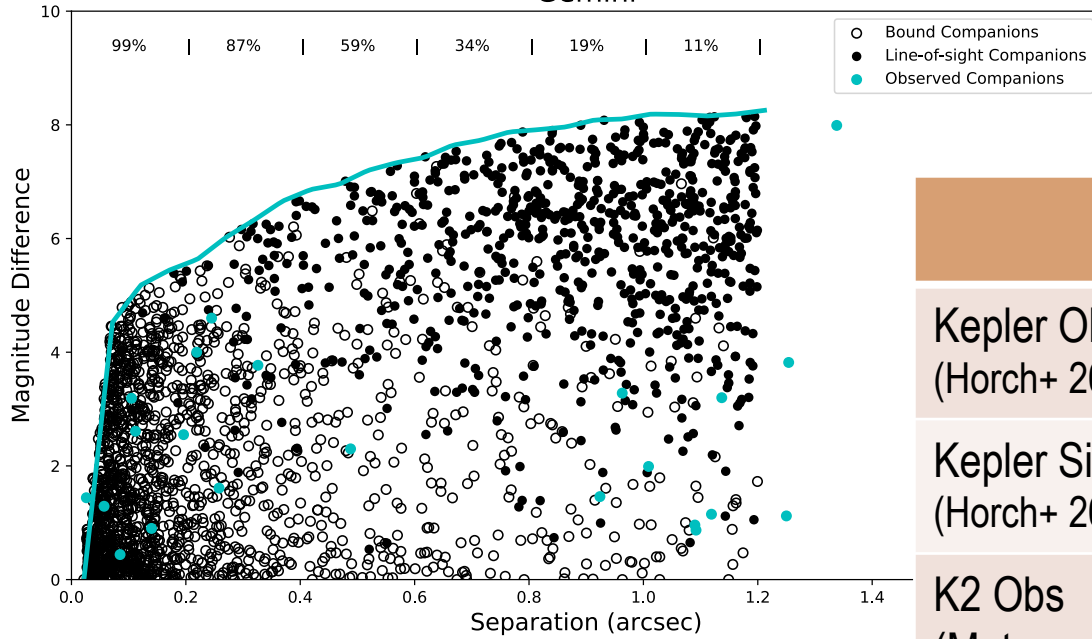


COMPANION FRACTIONS BY CAMPAIGN

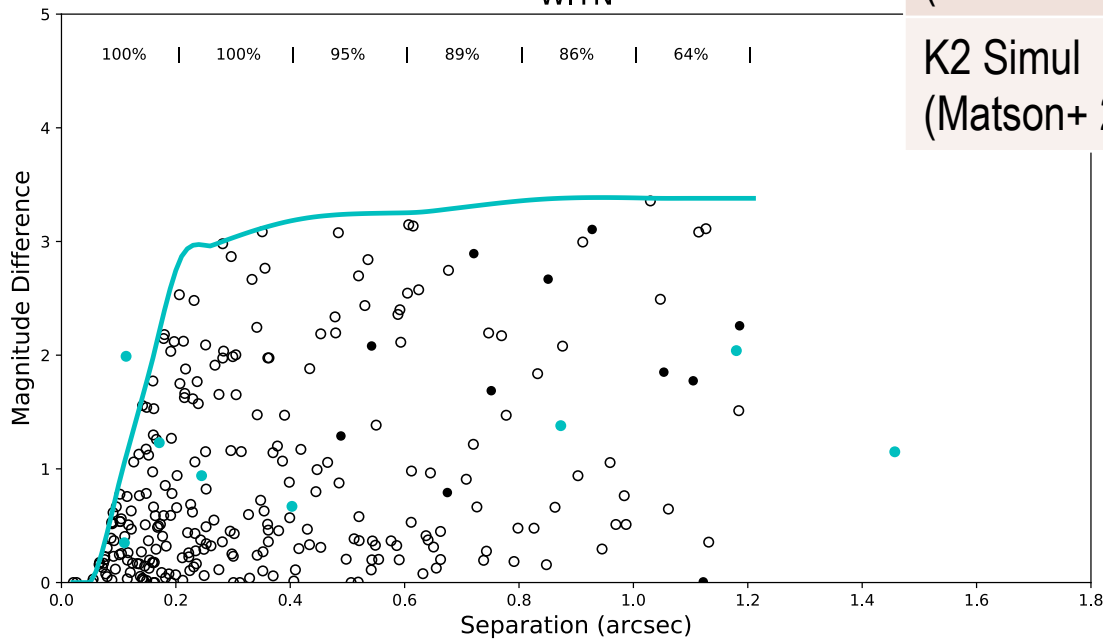
Location	Gemini		WIYN	
	Bound	Line-of-sight	Bound	Line-of-sight
C0 - top	$17 \pm 1\%$	$4.2 \pm 0.6\%$	$8 \pm 2\%$	$0.2 \pm 0.2\%$
C0 - middle	$19 \pm 2\%$	$3.9 \pm 0.6\%$	$5 \pm 1\%$	$0.2 \pm 0.2\%$
C0 - bottom	$18 \pm 1\%$	$8.8 \pm 0.9\%$	$10 \pm 2\%$	$0.4 \pm 0.3\%$
C4 - top	$20 \pm 2\%$	$1.2 \pm 0.4\%$	$7 \pm 2\%$	$0 \pm 0\%$
C4 - middle	$23 \pm 2\%$	$0.7 \pm 0.4\%$	$5 \pm 2\%$	$0 \pm 0\%$
C4 - bottom	$21 \pm 2\%$	$0.2 \pm 0.2\%$	$10 \pm 3\%$	$0.5 \pm 0.5\%$
C5 - top	$17 \pm 3\%$	$0 \pm 0\%$	$7 \pm 3\%$	$0 \pm 0\%$
C5 - middle	$21 \pm 3\%$	$0.3 \pm 0.3\%$	$11 \pm 3\%$	$0 \pm 0\%$
C5 - bottom	$23 \pm 3\%$	$0.5 \pm 0.3\%$	$7 \pm 2\%$	$0 \pm 0\%$
C6 - top	$17 \pm 3\%$	$0 \pm 0\%$	$4 \pm 3\%$	$0 \pm 0\%$
C6 - middle	$21 \pm 4\%$	$0.4 \pm 0.4\%$	$7 \pm 3\%$	$0 \pm 0\%$
C6 - bottom	$20 \pm 3\%$	$0.3 \pm 0.3\%$	$7 \pm 3\%$	$0.8 \pm 0.8\%$
C7 - top	$18 \pm 1\%$	$19 \pm 1\%$	$7 \pm 1\%$	$0.2 \pm 0.2\%$
C7 - middle	$19 \pm 1\%$	$13 \pm 1\%$	$7 \pm 1\%$	$0 \pm 0\%$
C7 - bottom	$19 \pm 2\%$	$11 \pm 1\%$	$9 \pm 2\%$	$0.9 \pm 0.4\%$
Total \pm stdev	$19 \pm 2\%$	$7 \pm 6\%$	$8 \pm 2\%$	$0.3 \pm 0.3\%$



Gemini



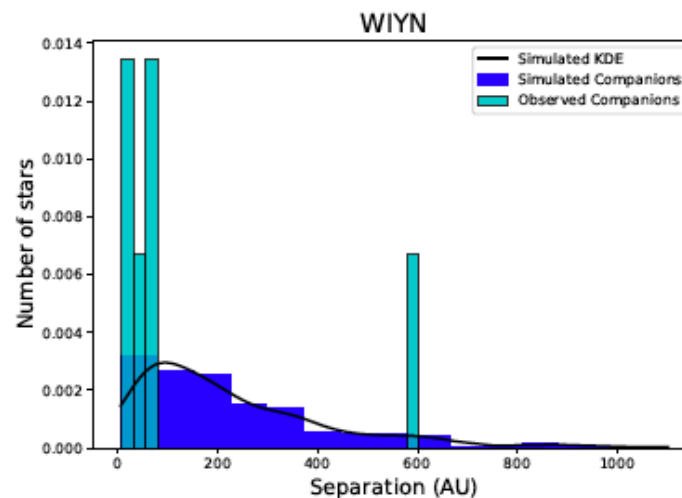
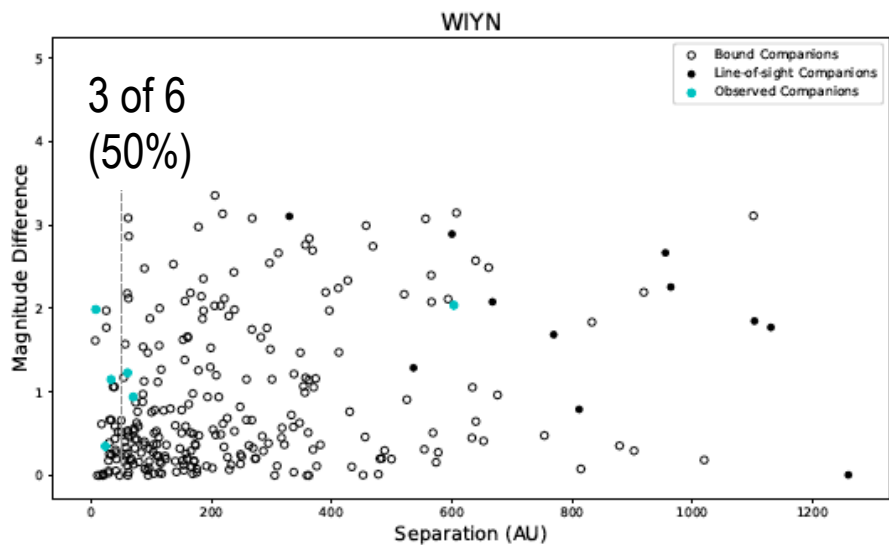
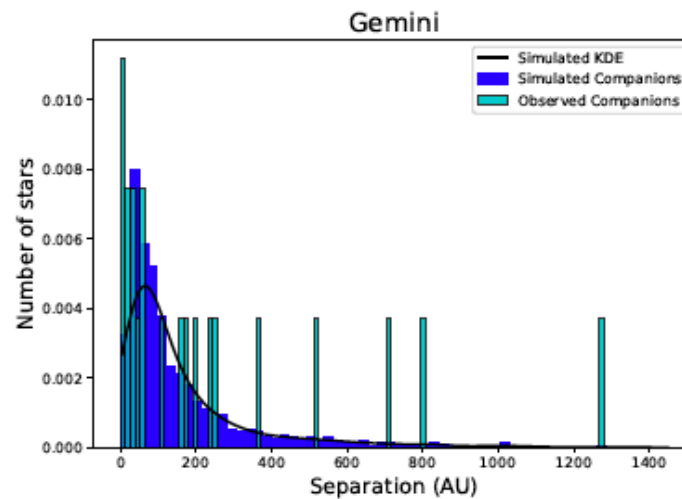
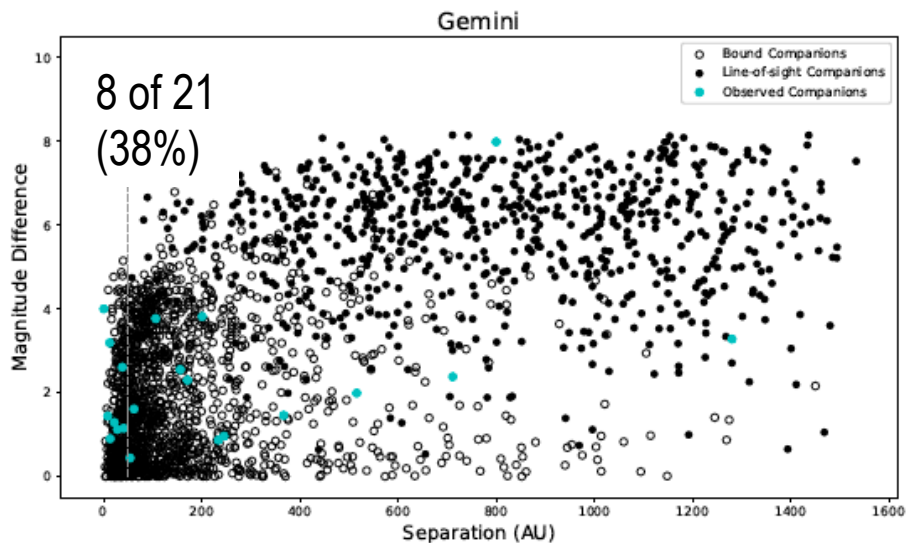
WIYN



	Gemini	WIYN
Kepler Obs (Horch+ 2014)	$22.8 \pm 8.1\%$	$7.1 \pm 1.1\%$
Kepler Simul (Horch+ 2014)	$19.7 \pm 0.4\%$	$7.8 \pm 0.4\%$
K2 Obs (Matson+ 2017)	$20 \pm 5\%$	$5 \pm 2\%$
K2 Simul (Matson+ 2017)	$26 \pm 6\%$	$8 \pm 2\%$

- “Average” detection limits
- Low mass stars
- Suppression??

CLOSE STELLAR COMPANIONS



SUMMARY

- Speckle imaging detects stellar companions at diffraction limit of telescope ($\sim 0.027 - 0.05''$)
- Used to validated exoplanets and study multi-star systems with planets
- Kepler and K2 host stars are $\sim 40 - 50\%$ binaries
- No evidence of suppressed stellar companions
- Extend to more K2 and TESS planet hosts using new speckle instruments at WIYN & Gemini