Detecting Unresolved Binaries in Exoplanet Transit Surveys with Speckle Interferometry

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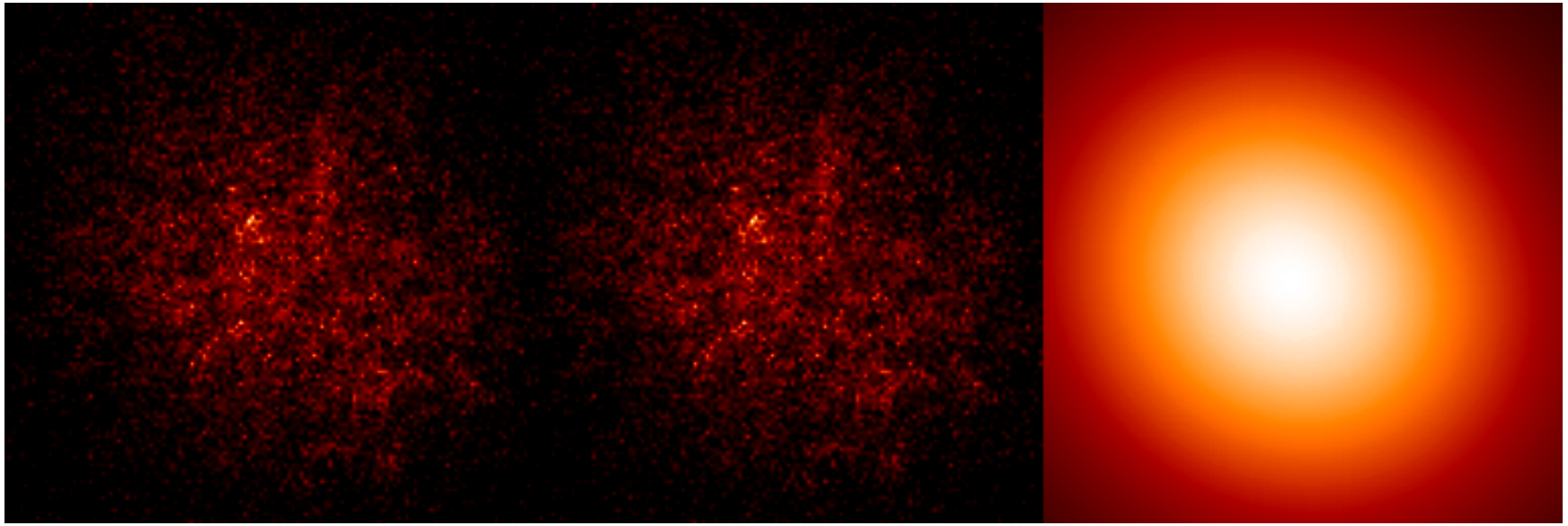
Speckle Interferometry

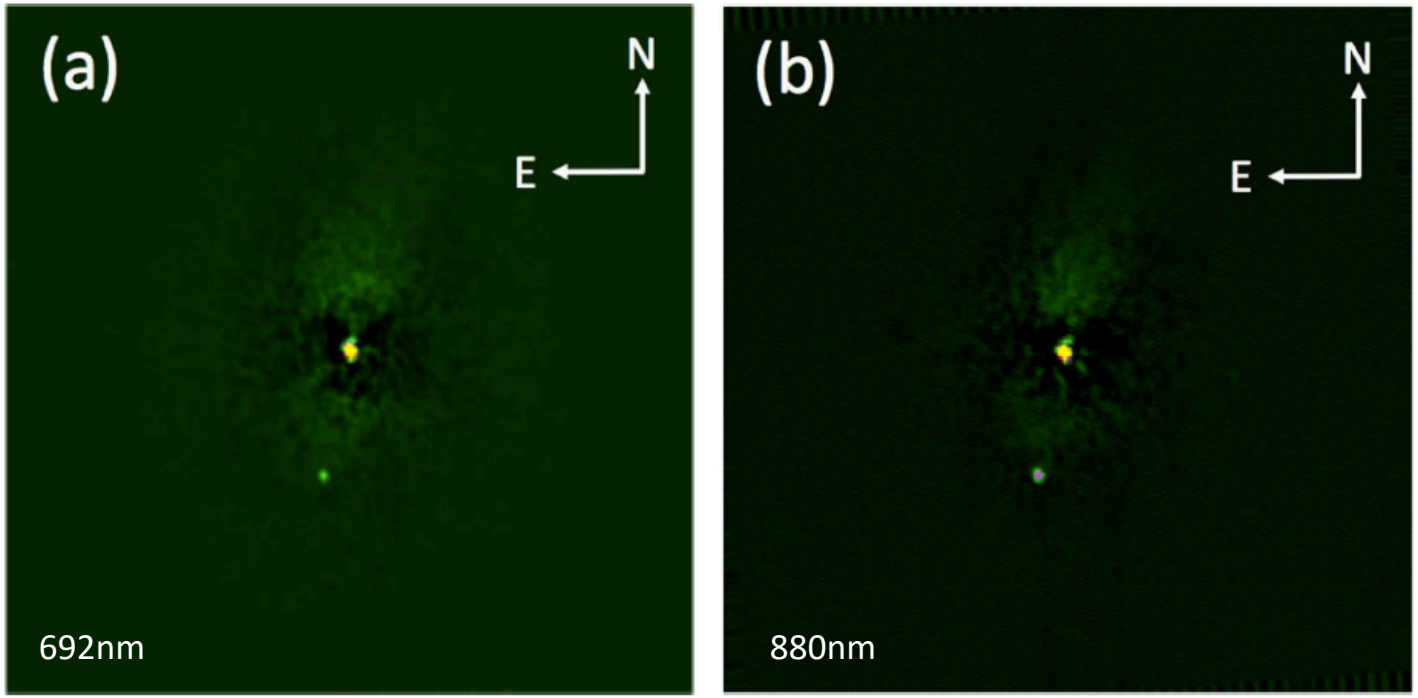


Speckles | Integrated Image | Reconstructed Image

1 arcsec

Reconstructed Images

Wittrock et al. 2016

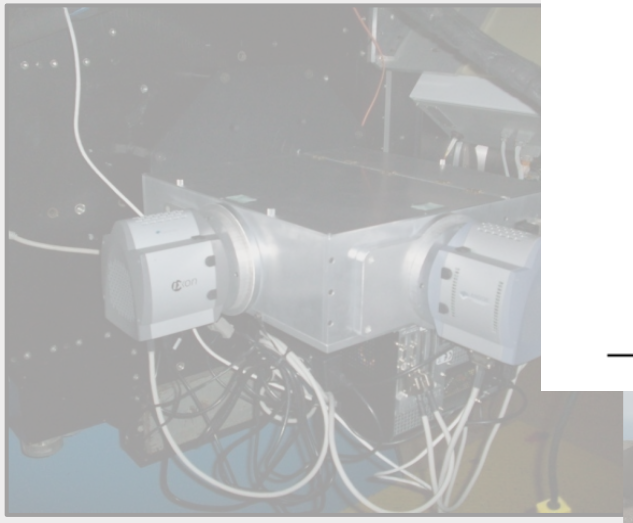


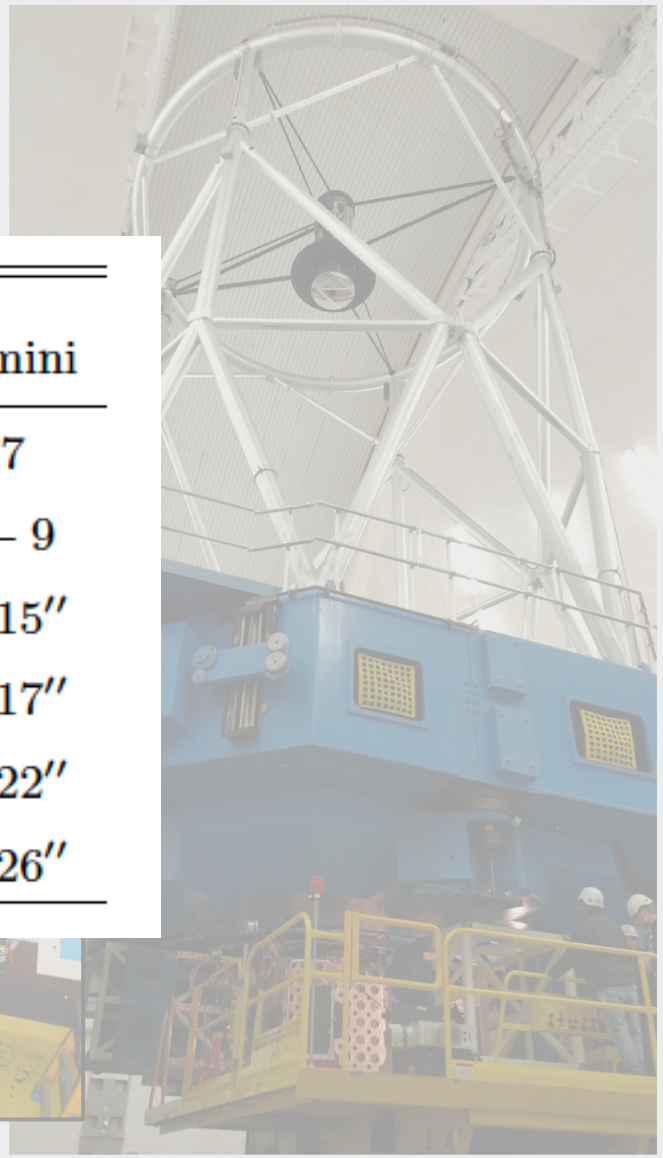
Companion to HD 2638 detected at 0.5” with
Δm = 3.8 (692nm) & 2.8 (880nm)

Exoplanet Follow-up Program

Funded by NASA Exoplanet Program to validate and characterize exop
and RV-disc
comr

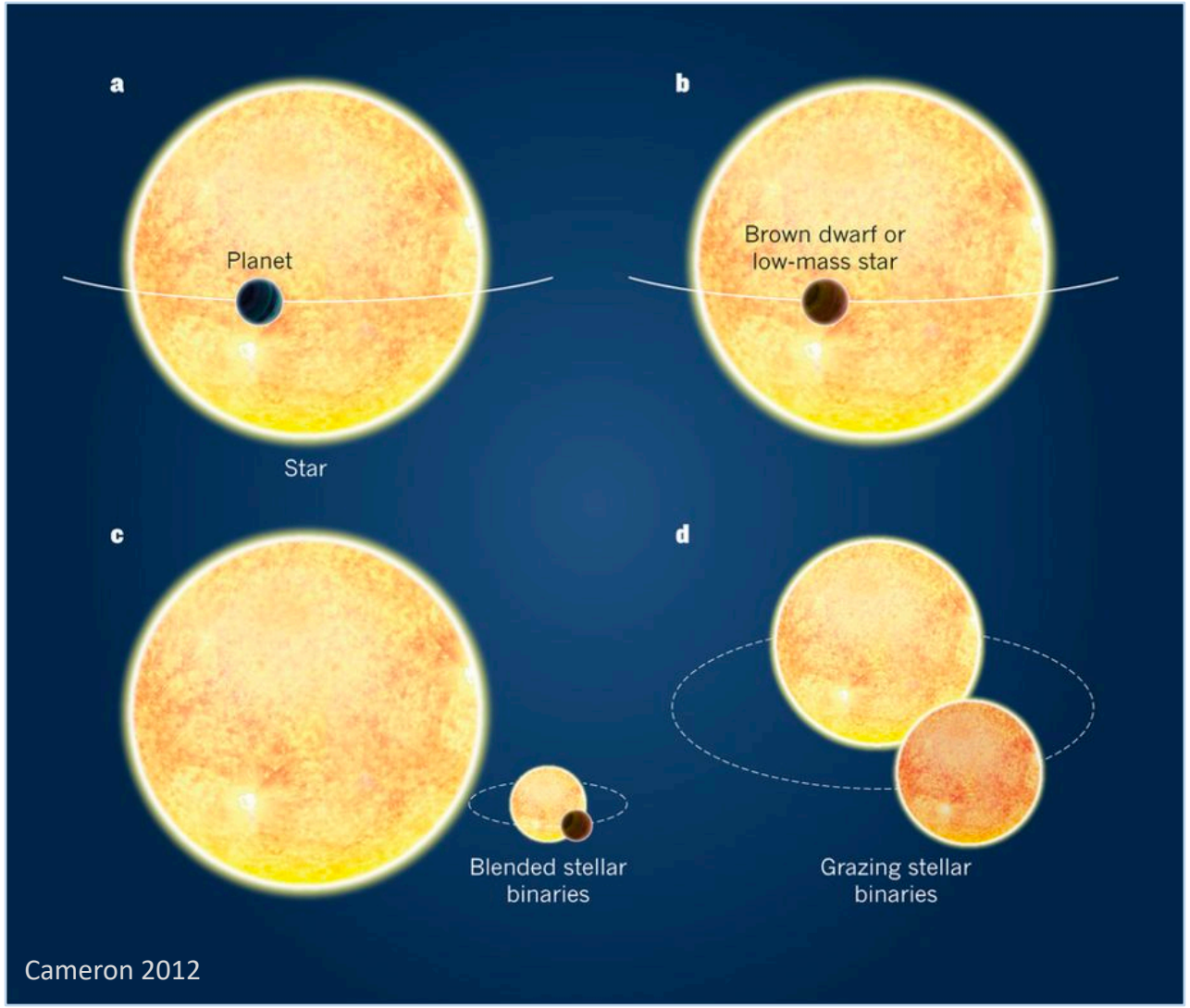
	WIYN	Gemini
Typical magnitude limit (V)	14	17
Typical contrast limit (Δm)	6.5	$7-9$
Diffraction limit at 467nm	$0.034''$	$0.015''$
Diffraction limit at 562nm	$0.040''$	$0.017''$
Diffraction limit at 716nm	$0.051''$	$0.022''$
Diffraction limit at 832nm	$0.060''$	$0.026''$



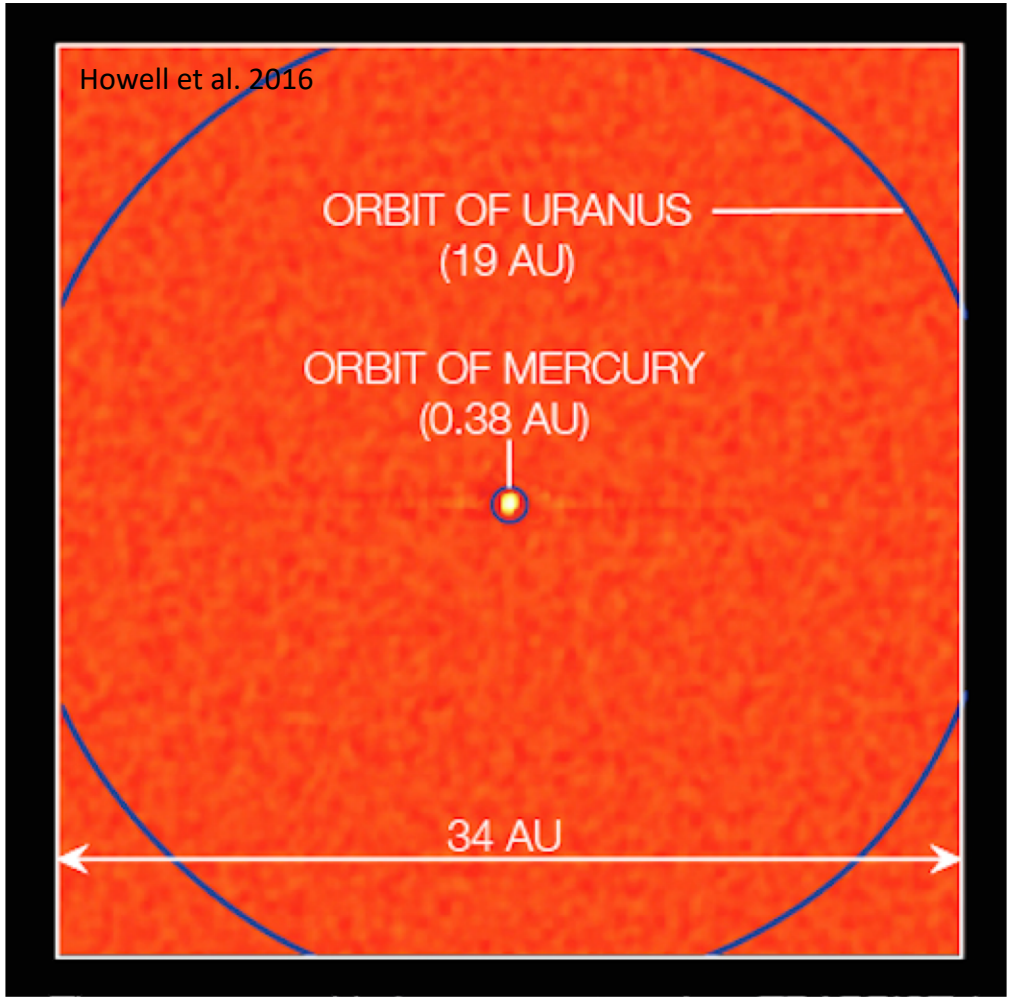


Exoplanet Validation

- Photometric contamination from nearby sources
- High-resolution imaging to detect nearby stars
- Constrain probabilistic validation
- Accurate planetary radii

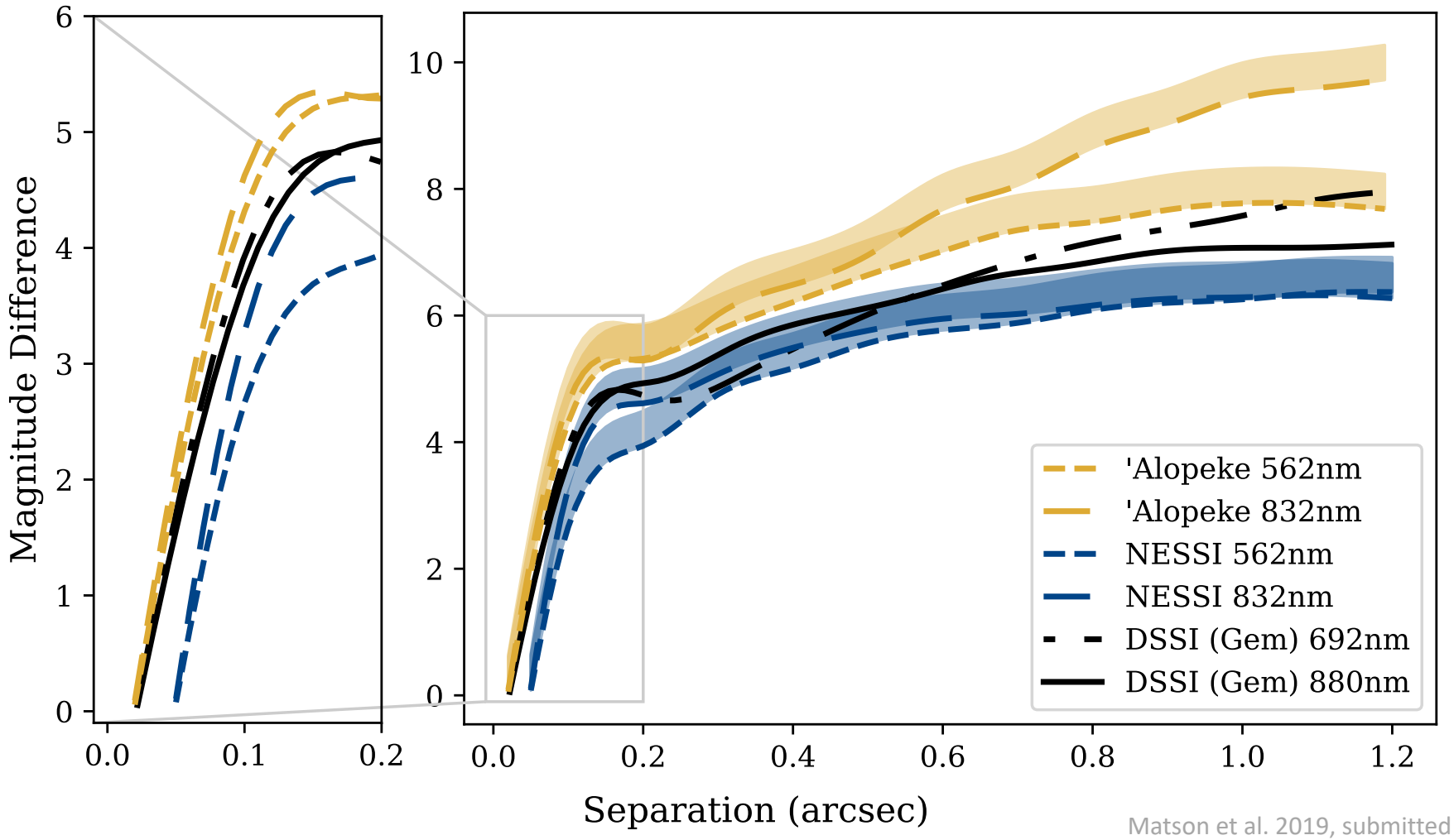


Exoplanet Validation



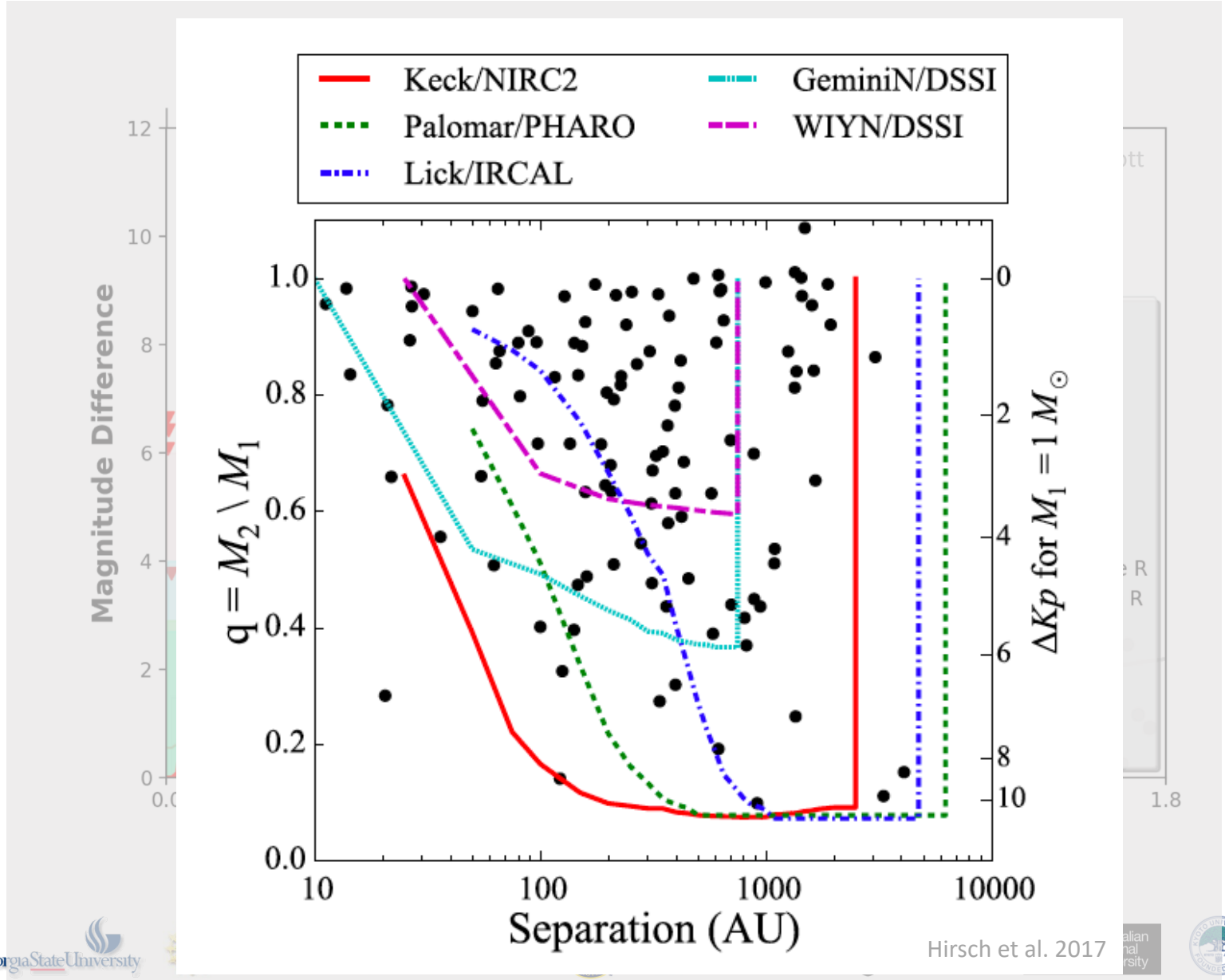
Speckle imaging resolved from 0.3 -17 AU around TRAPPIST-1, detecting no companions from slightly inside the orbit of Mercury out to roughly the orbit of Uranus.

Detection Limits



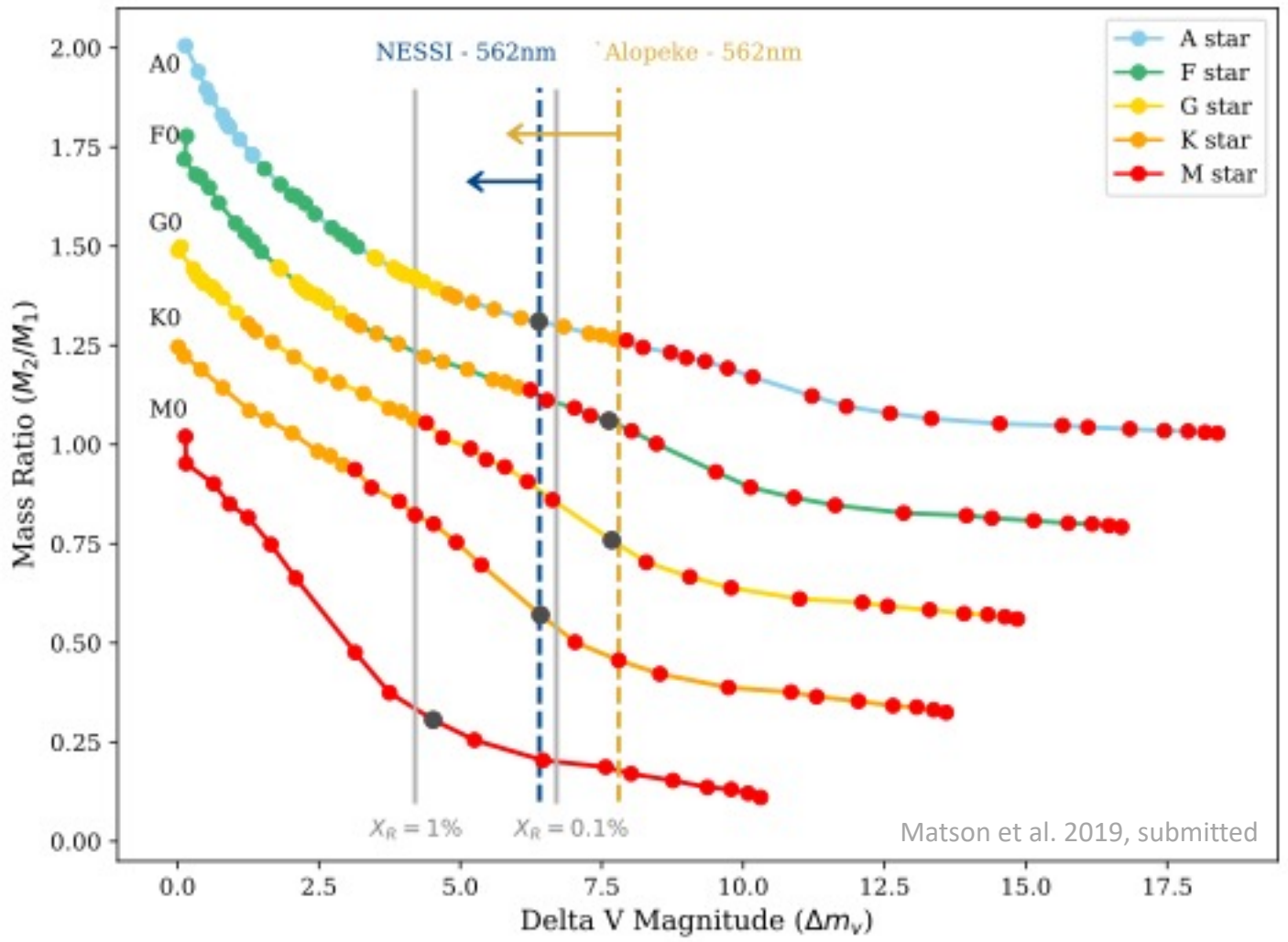
Matson et al. 2019, submitted

Detection Limits



Hirsch et al. 2017

Companion Magnitude Difference



Matson et al. 2019, submitted

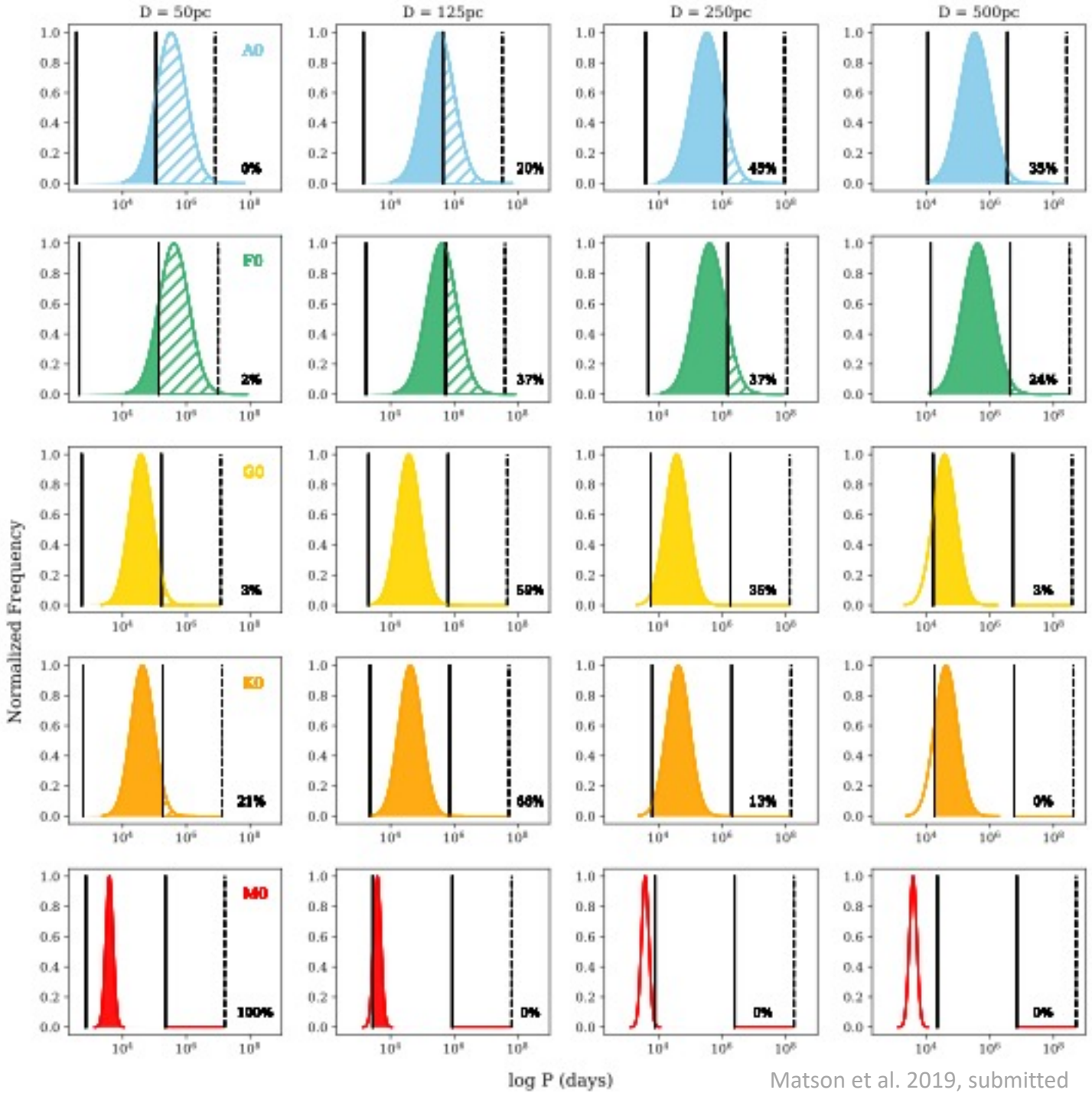
- Fractional transit depth (Morton & Johnson 2011):
  - 0.01 ~ $\Delta m = 5$
  - 10^{-4} ~ $\Delta m = 10$
- Planet radii correction factor (Ciardi et al. 2015):

$$X_R = r_P \text{ (true)} / r_P \text{ (obs)}$$

Companion Separation

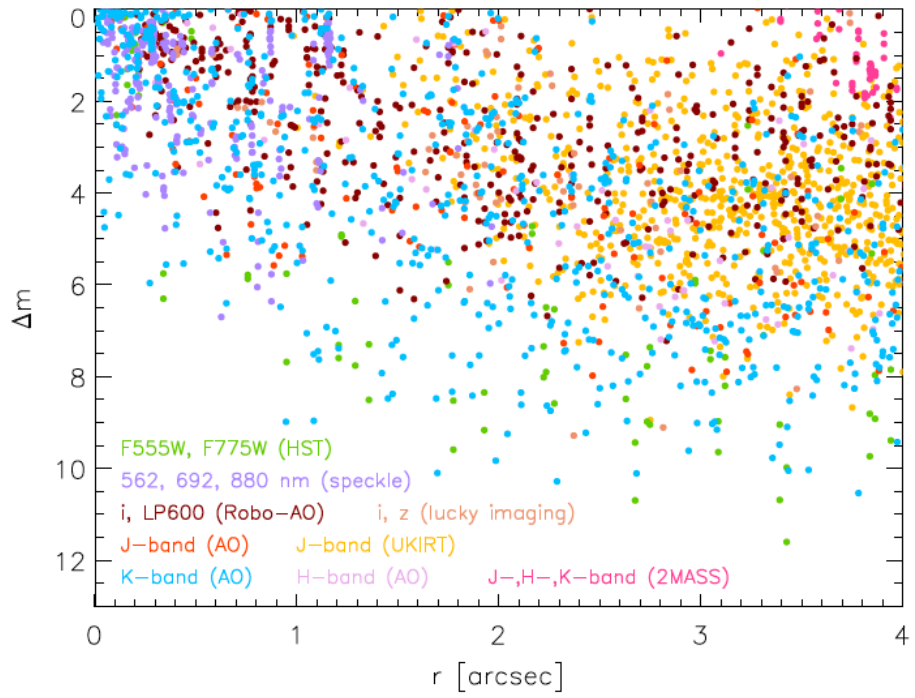
- Kepler planets ~150 - 1000pc
- Tess planets < 500pc

arXiv: 1811.0218

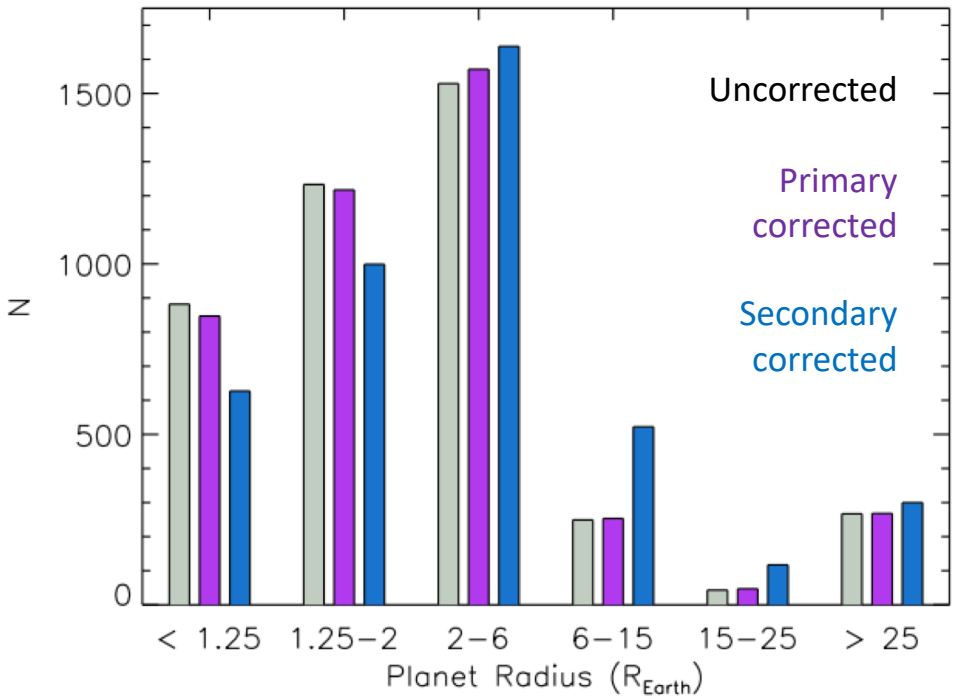


Matson et al. 2019, submitted

Binaries & Exoplanets



Furlan et al. 2017

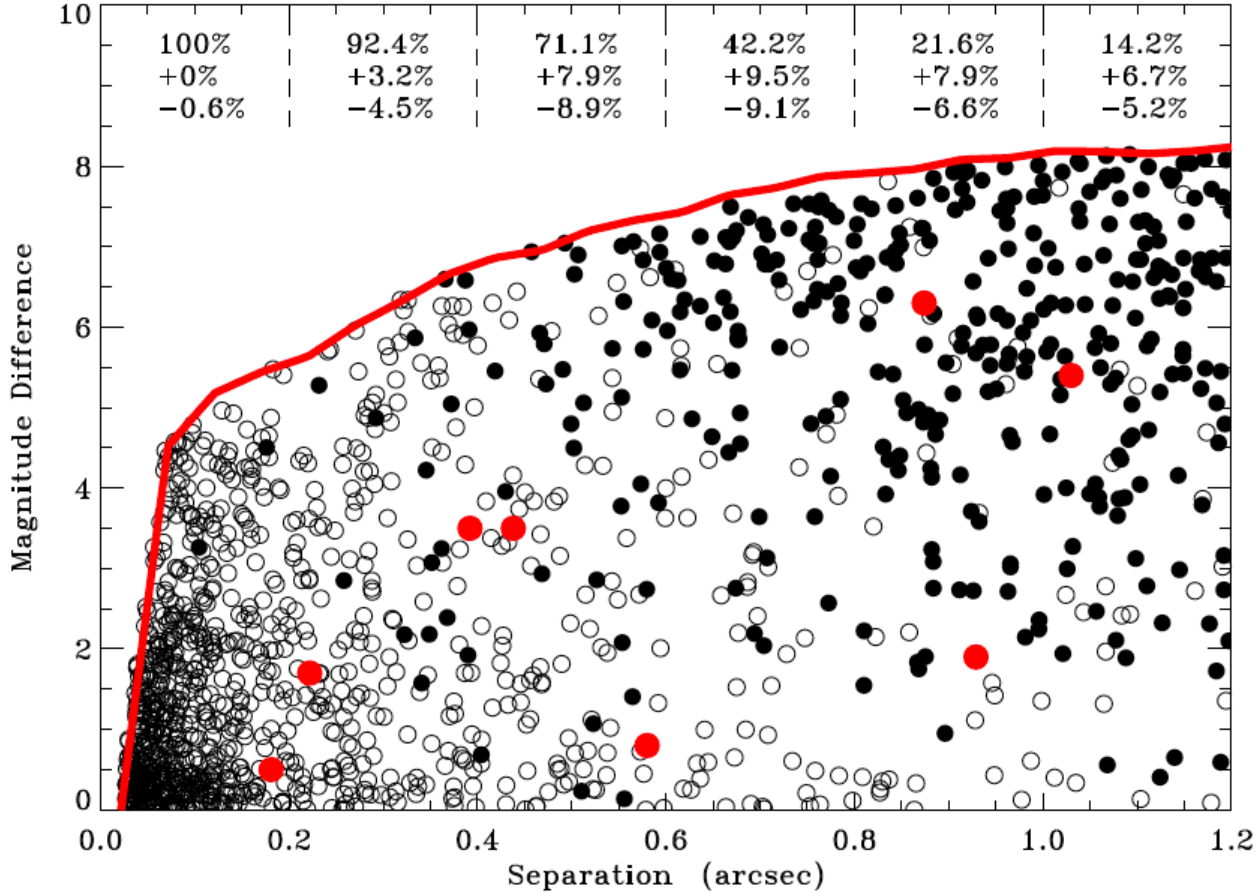


- Furlan et al. 2017: 2297 companions around 1907 stars = ~30% within 4”
- Hirsch et al. 2017: planet radii underestimated by 1.17 (1.65)
- Bouma et al. 2018: occurrence rates of planets < $2R_E$ overestimated by up to 50%.

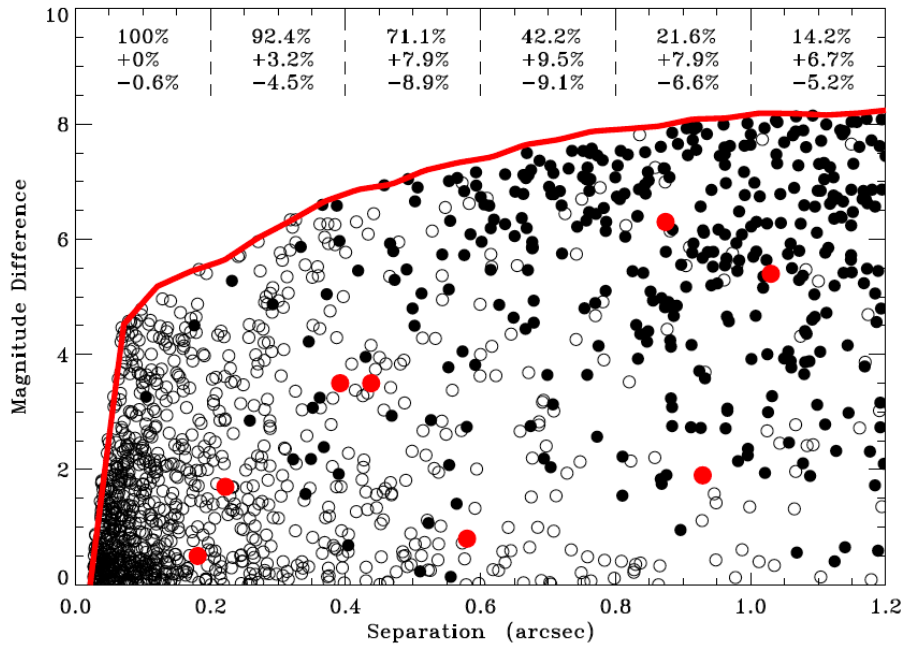
Detected Companions

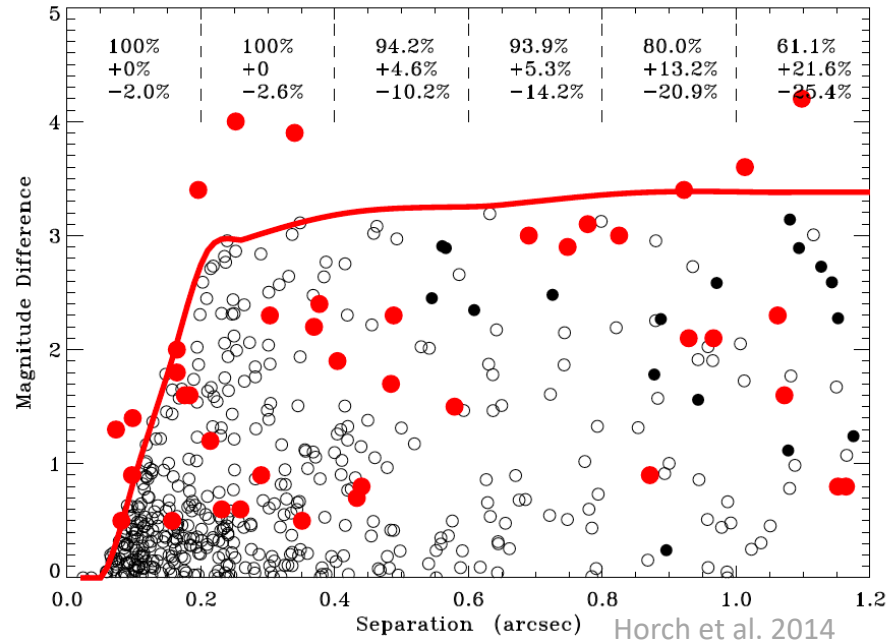
- Show 40 – 50% of Kepler host stars have companions
- Most companions within 1” are bound

Horch et al. 2014



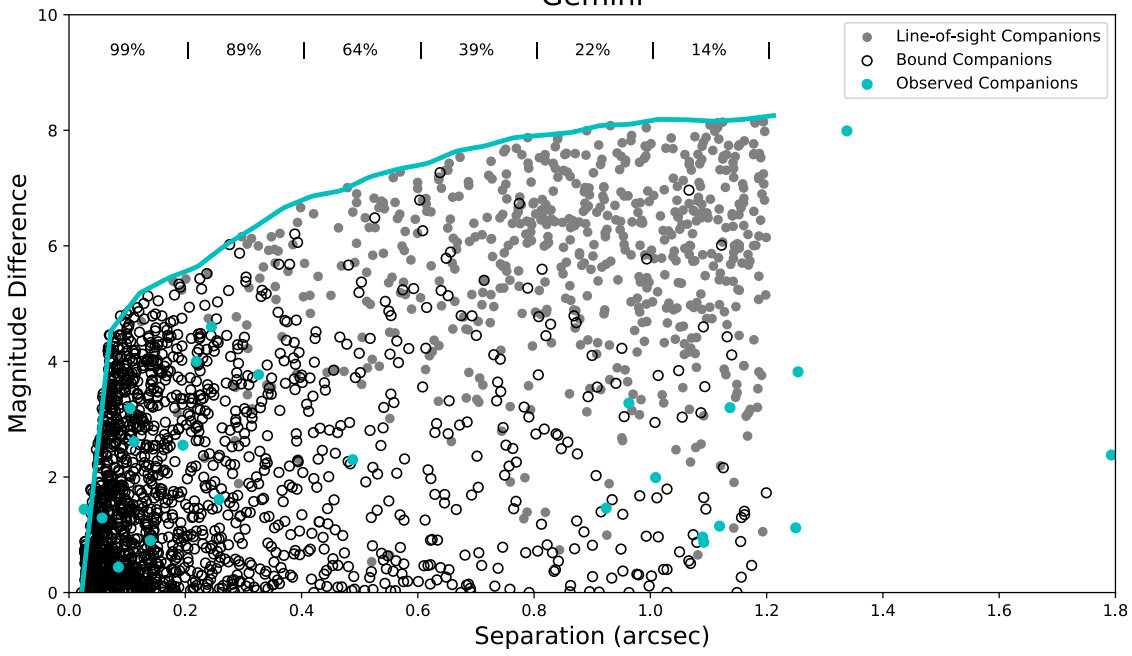
Kepler

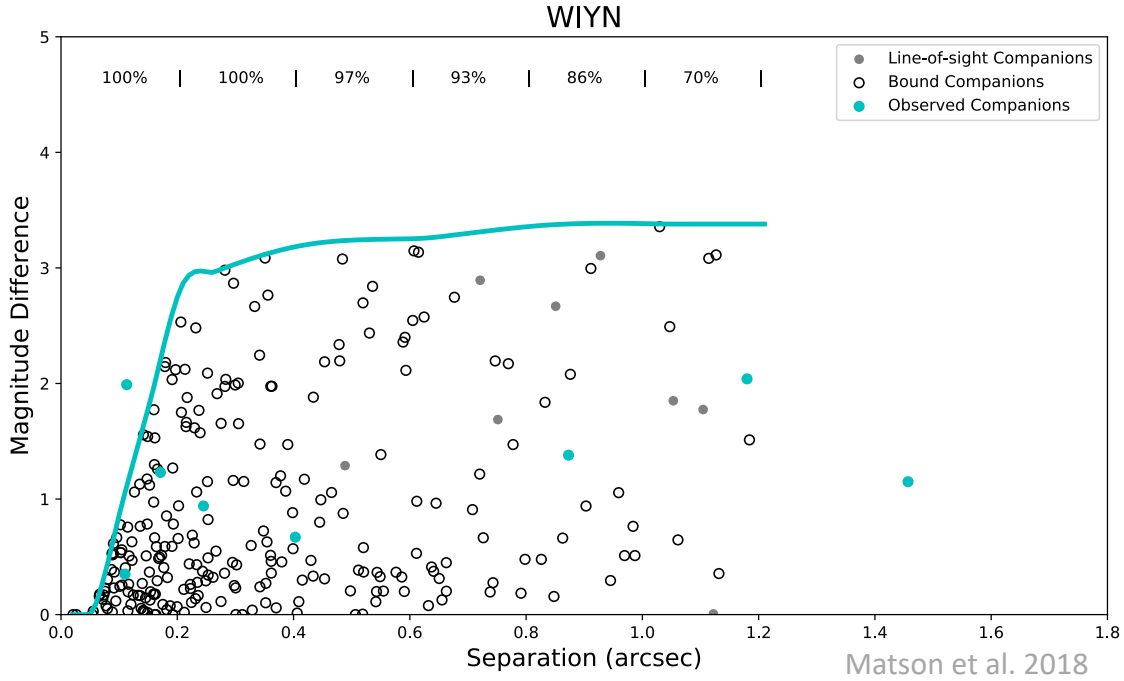




Horch et al. 2014

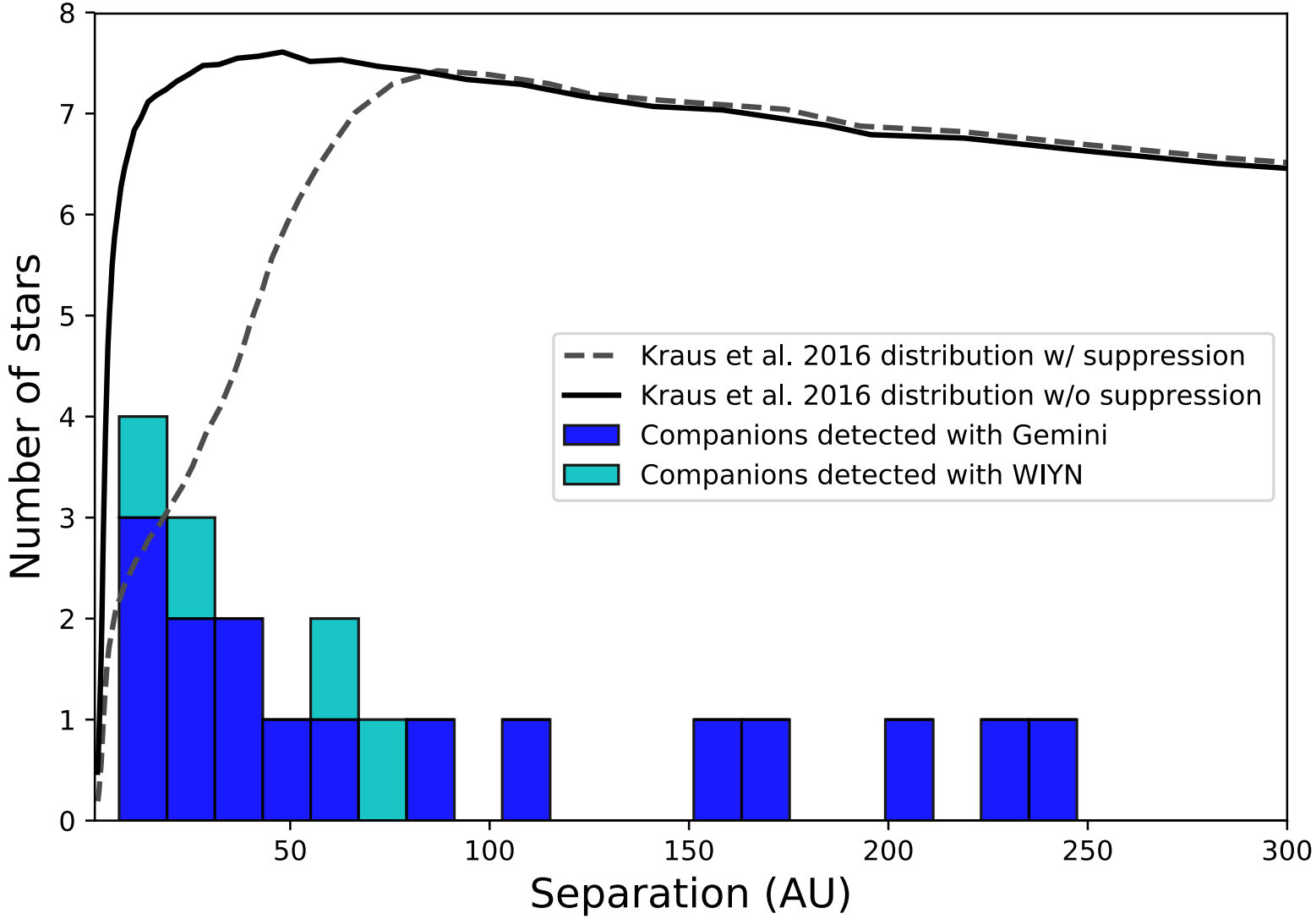
K2





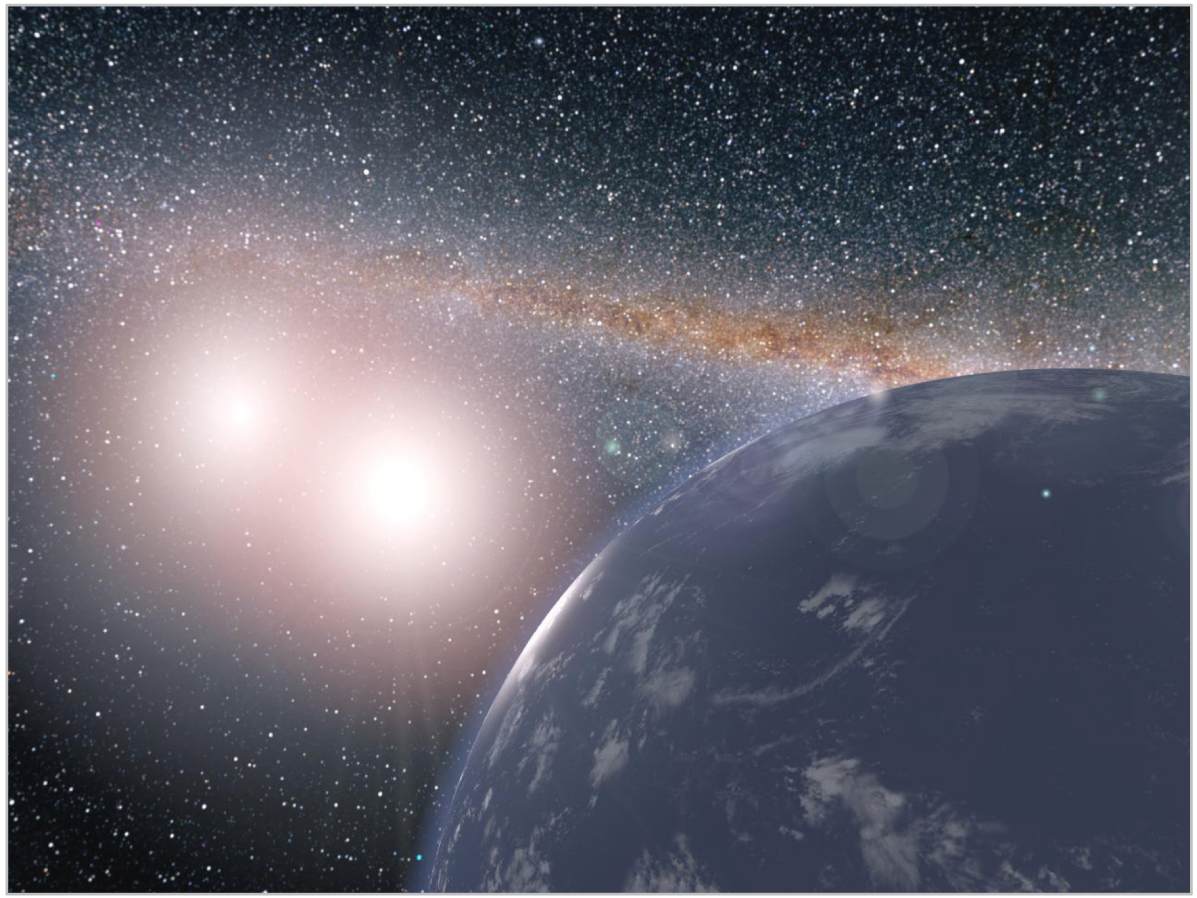
Matson et al. 2018

Matson et al. 2018



Summary

- Speckle interferometry detects companions within 0.02 – 1.0” and $\Delta m < 10$
- Validate planets, derive accurate planet parameters & occurrence rates
- Show that, in general, planet hosts are equally likely to be binary as field stars



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