



Demographics of M dwarf Binary Exoplanet Hosts Discovered by TESS

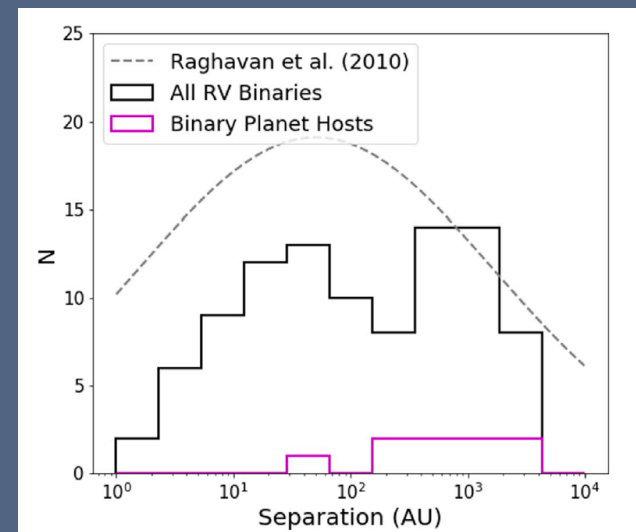
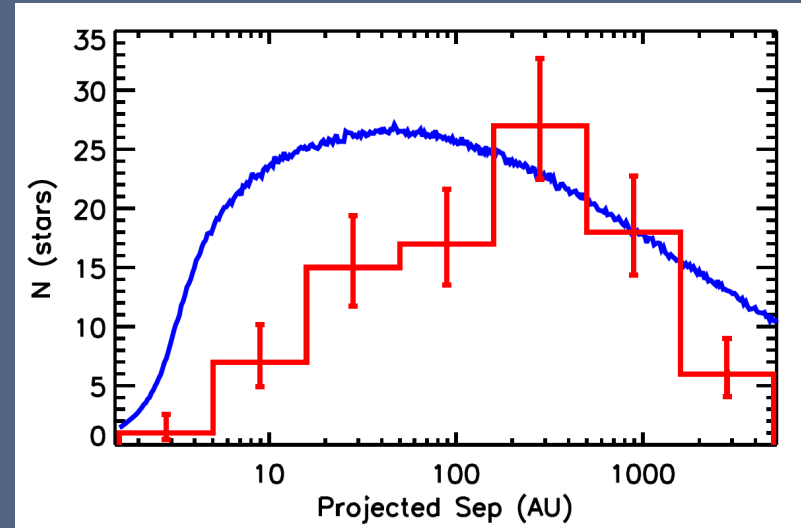
Rachel Matson (USNO)

Rebecca Gore (BAERI/SFSU), Steve Howell (NASA Ames),
David Ciardi (IPAC/Caltech), et al.

Planets in Binaries

- More than 250 planets in binary systems¹
- RV and transit surveys find fewer planets in close binaries (< 100au)
- Primarily giant planets or short period planets around solar-type stars
- M-dwarfs abundant and important for detection of Earth sized planets

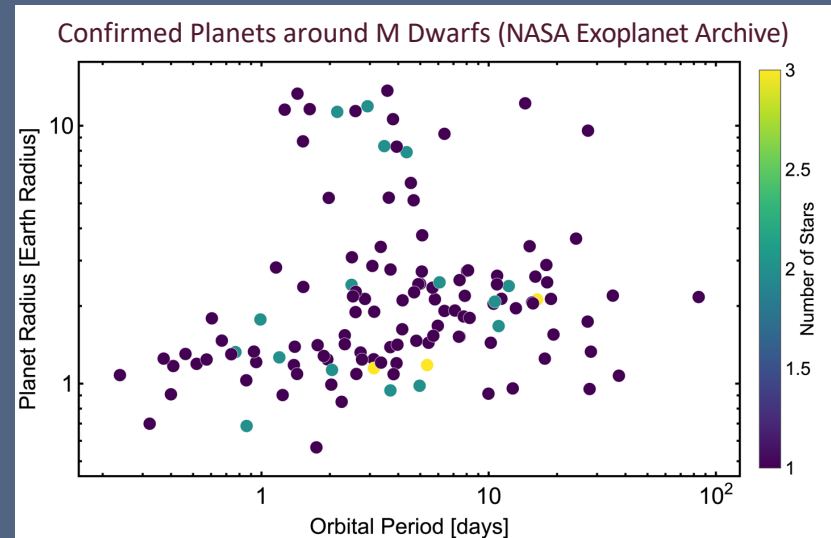
Kraus et al. 2016



Hirsch et al. 2021

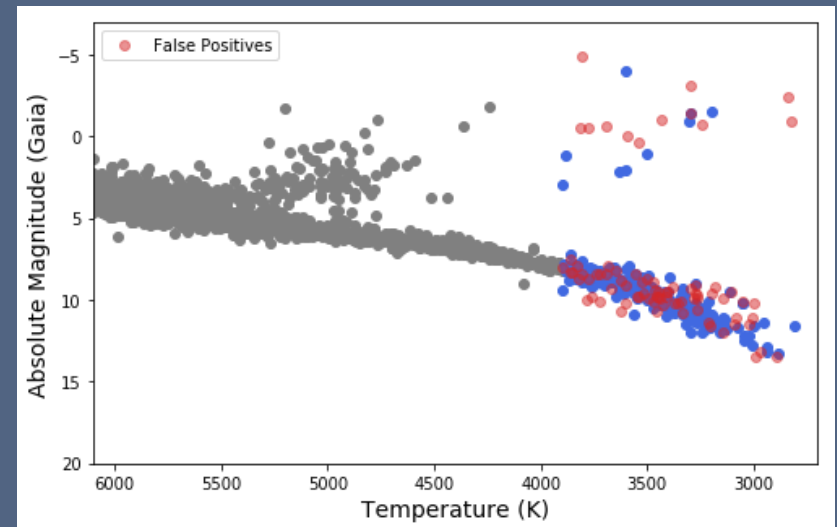
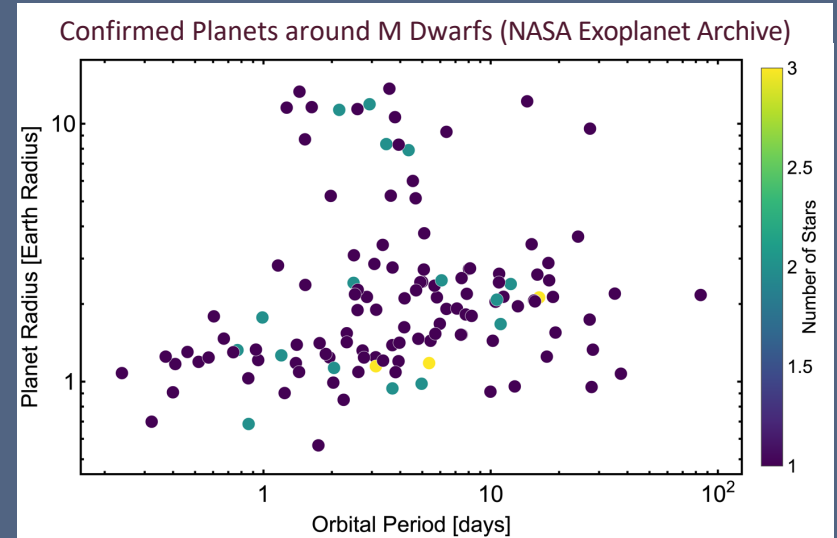
Exoplanets in M Dwarf Systems

- M dwarfs targeted by TESS for small planets
- Follow-up observations for stellar companions



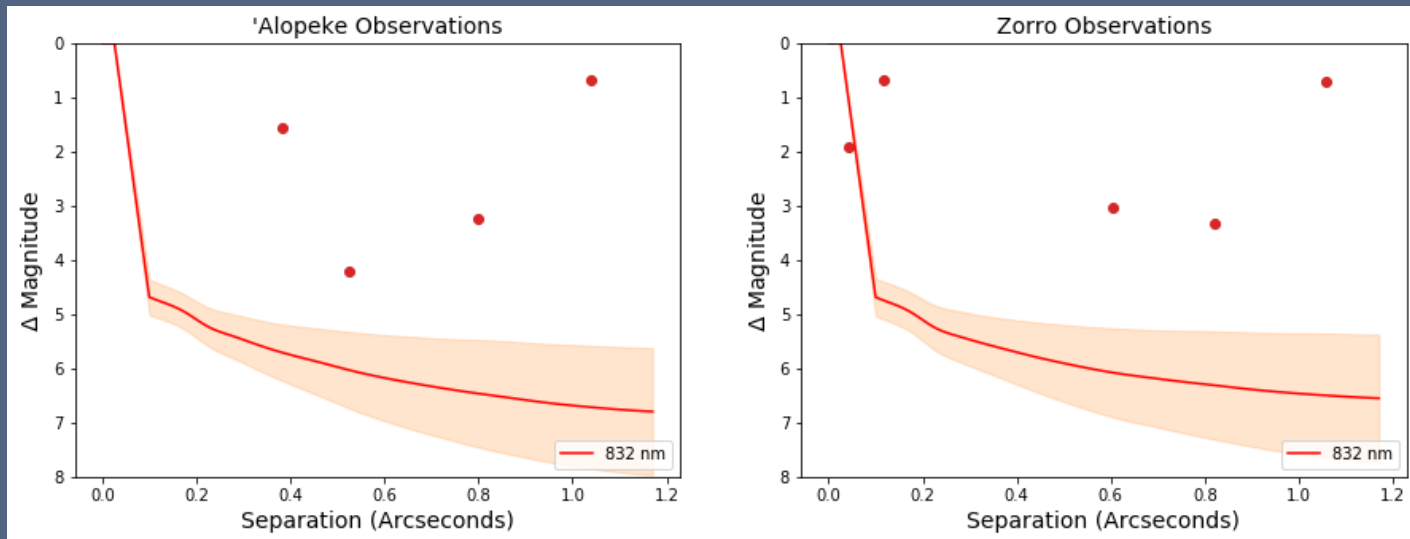
Exoplanets in M Dwarf Systems

- M dwarfs targeted by TESS for small planets
- Follow-up observations for stellar companions
- Our TOI sample:
 - 308 with $T_{\text{eff}} < 3900\text{K}$
 - Remove false positives, ambiguous candidates, likely giants
 - 221 confirmed or candidate planets



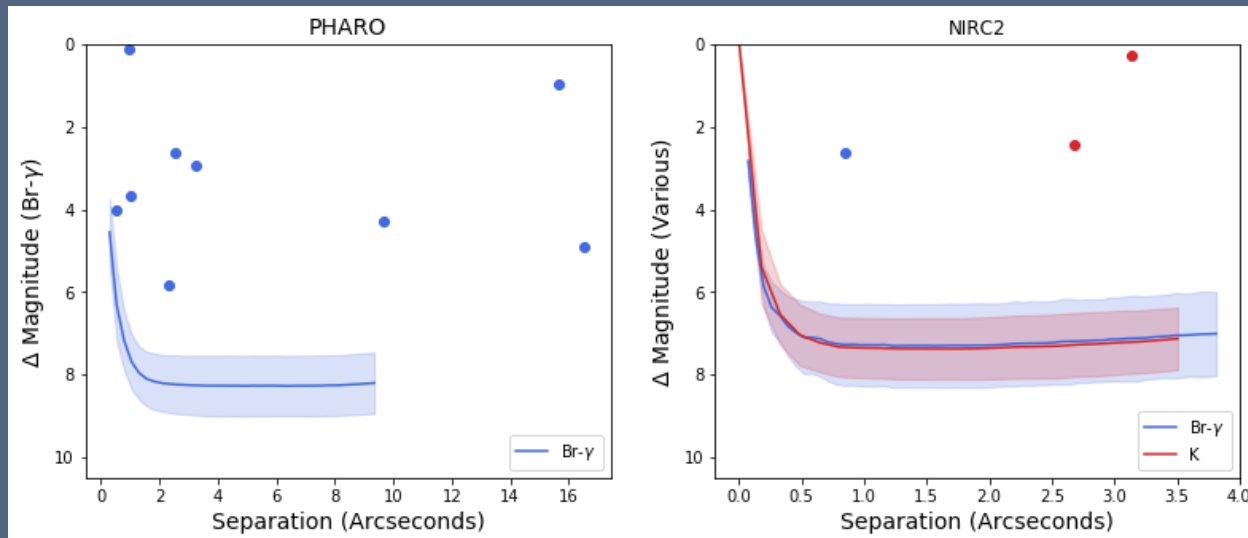
High-Resolution Observations

- Speckle interferometry:
 - 'Alopeke and Zorro – Gemini 8m (0.02")
 - NESSI – WIYN 3.5m (0.06")
 - Filters = 562, 832nm
 - 148 TOIs (67%)



High-Resolution Observations

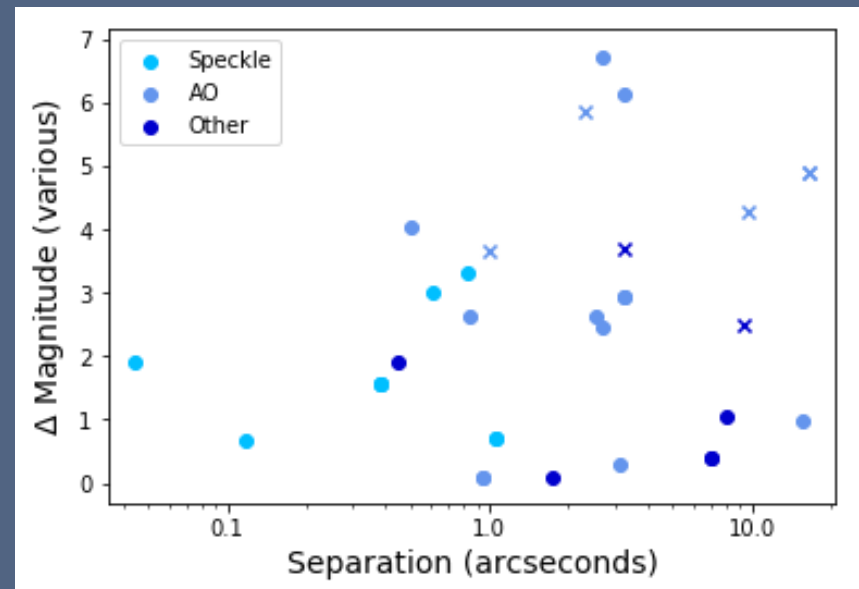
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- Adaptive Optics:
 - PHARO – Palomar 200in (0.1’')
 - NIRC2 – Keck 10m (0.05’')
 - Filters = K, Br- γ
 - 85 TOIs (38%)



High-Resolution Observations

- ExoFOP observations:
 - HRCam – SOAR 4.1m (0.05")
 - Speckle Polarimeter – SAI 2.2m (0.08")
 - 8 new companions

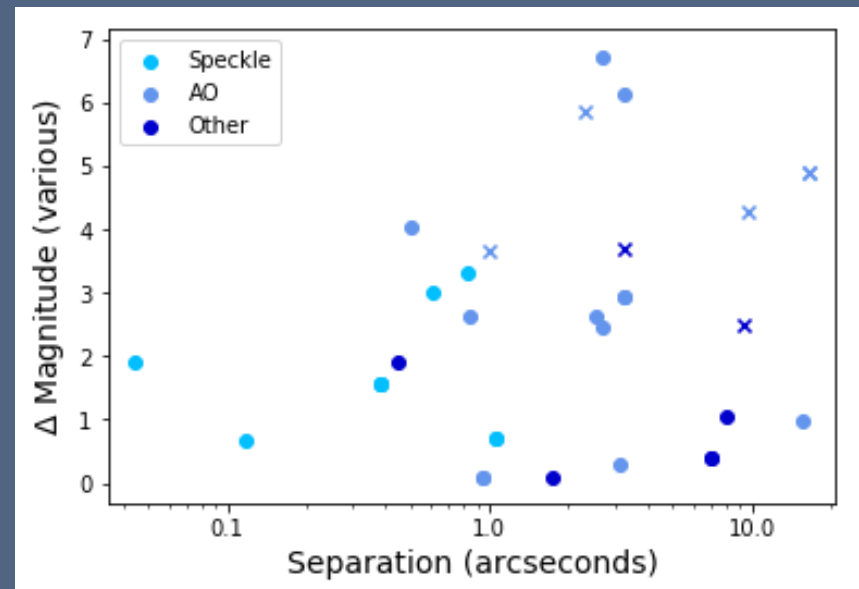
Matson et al. (in prep)



High-Resolution Observations

- ExoFOP observations:
 - HRCam – SOAR 4.1m (0.05")
 - Speckle Polarimeter – SAI 2.2m (0.08")
 - 8 new companions
- 89% of TOIs observed
- Total of 28 companions around 24 M star TOIs
- Separations 0.04 – 16"
- Verify using Gaia

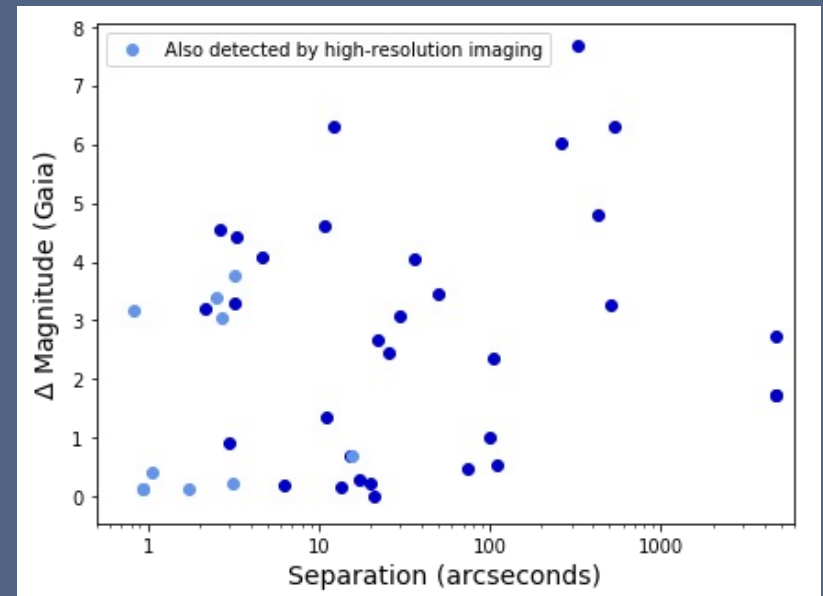
Matson et al. (in prep)



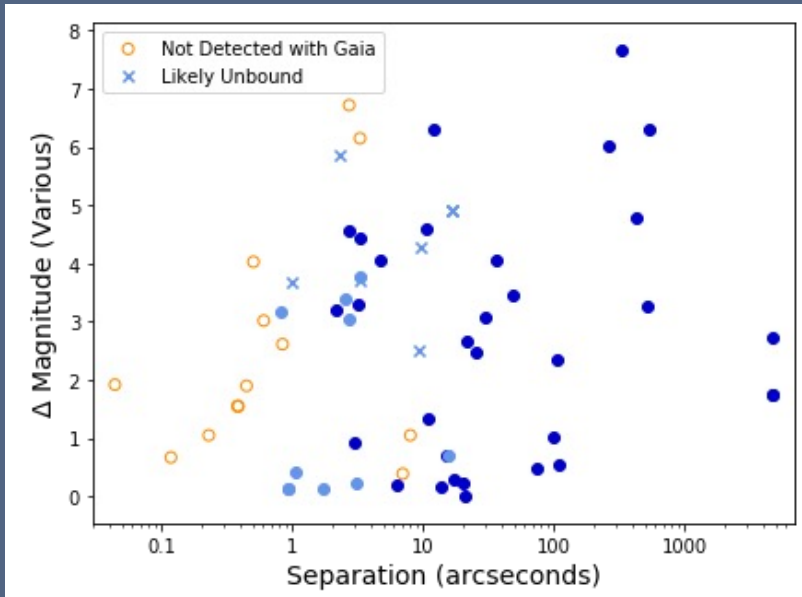
CPM Companions from Gaia

- Code adapted from El-Badry et al. 2021
- 38 companions around 35 M star TOIs
- Separations 0.8 – 540''

Matson et al. (in prep)



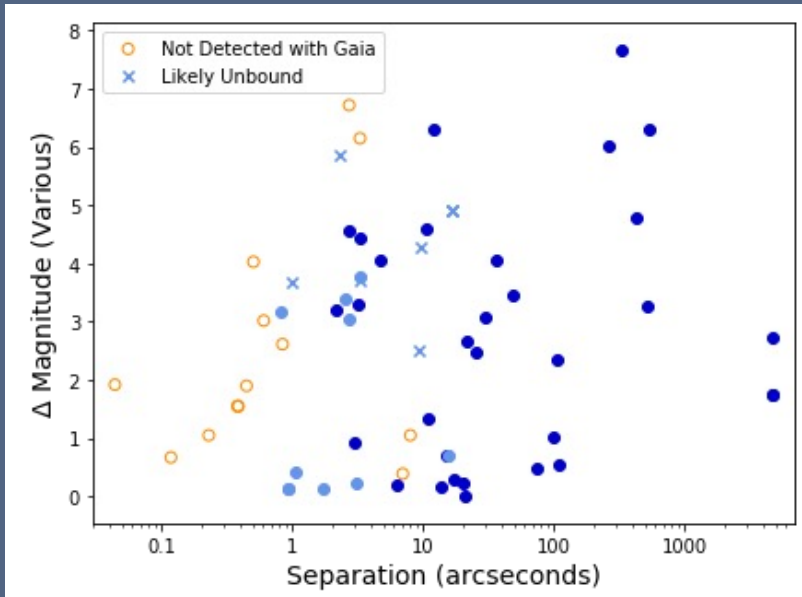
Unresolved Companions in Gaia



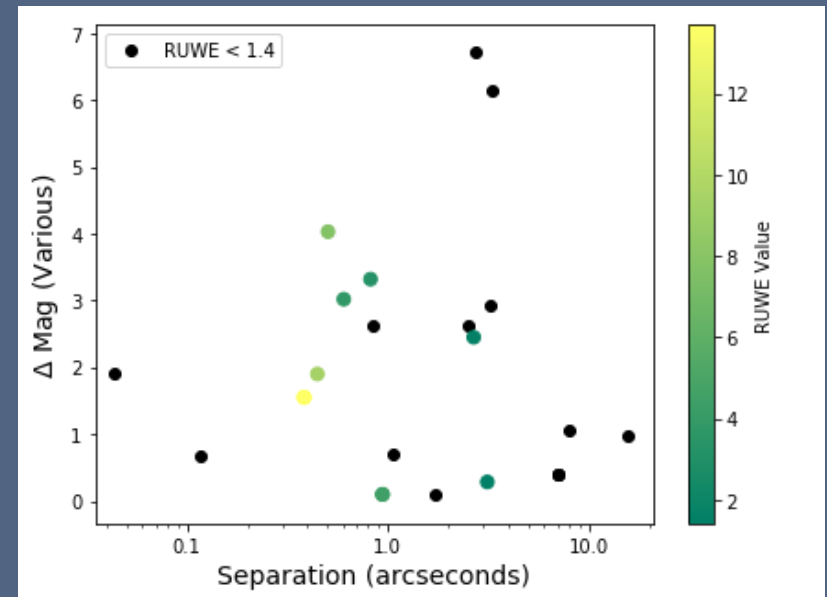
Matson et al. (in prep)

- Companions $< 0.8''$ not resolved with Gaia

Unresolved Companions in Gaia



Matson et al. (in prep)

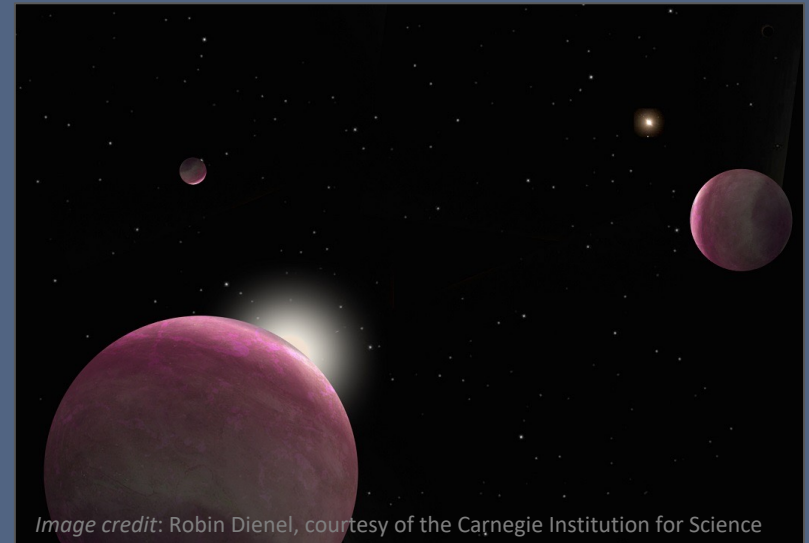


Matson et al. (in prep)

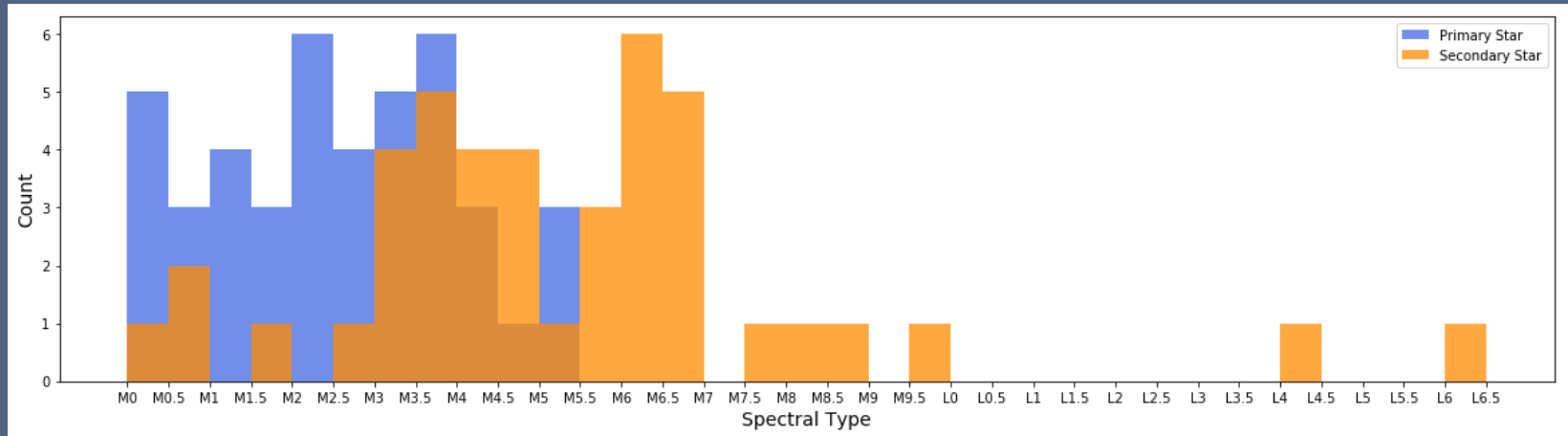
- Companions $< 0.8''$ not resolved with Gaia
- 24 have $\text{RUWE} > 1.4$ (10 with companions)
- 33% with companions have $\text{RUWE} \sim 1$

Multiplicity of M dwarf TOIs

- Detect 47 companions to 42 TOIs ($19.4 \pm 2.7\%$)
- M dwarfs:
 - Winters et al. 2019 ($23.7 \pm 1.3\%$)
 - Clark et al. 2024 ($23.5 \pm 2.0\%$)
- Planet hosts:
 - Fontanive et al. 2022 ($23.2 \pm 1.6\%$)
 - Mugrauer et al. 2023 ($19.5 \pm 1.5\%$)
 - Michel & Mugrauer 2024 ($19.2 \pm 0.9\%$)



Estimated Stellar Parameters

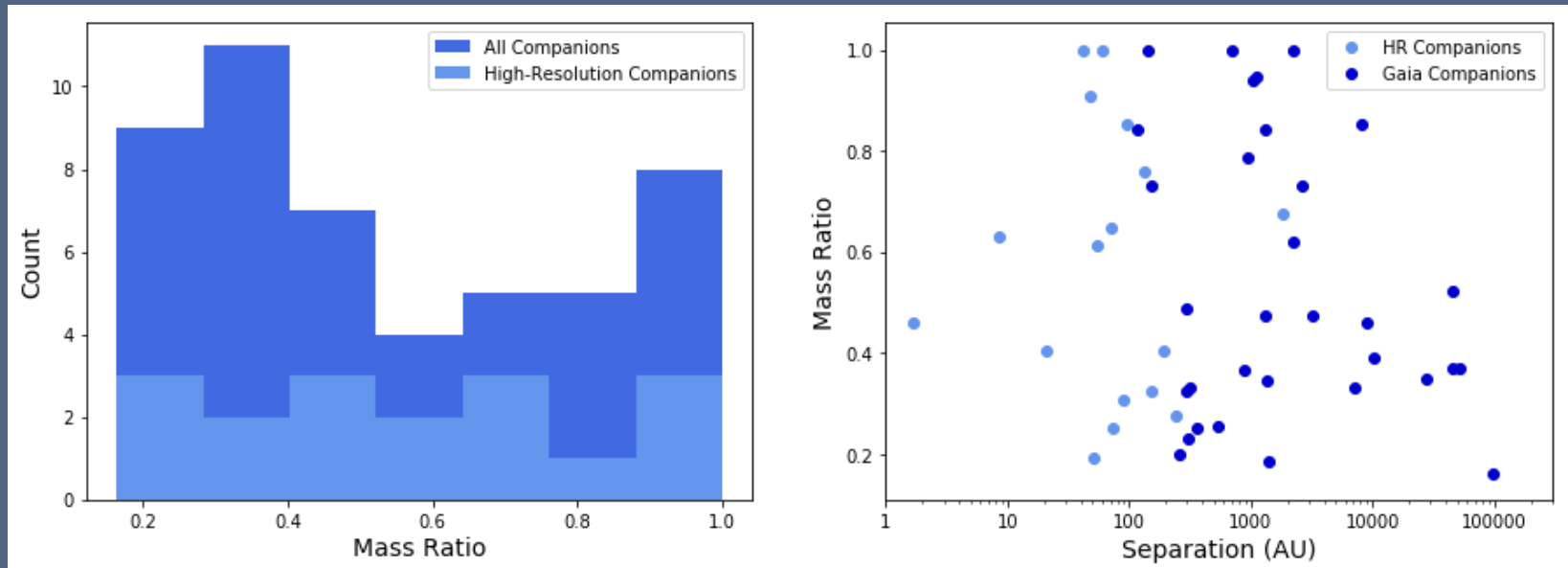


Matson et al. (in prep)

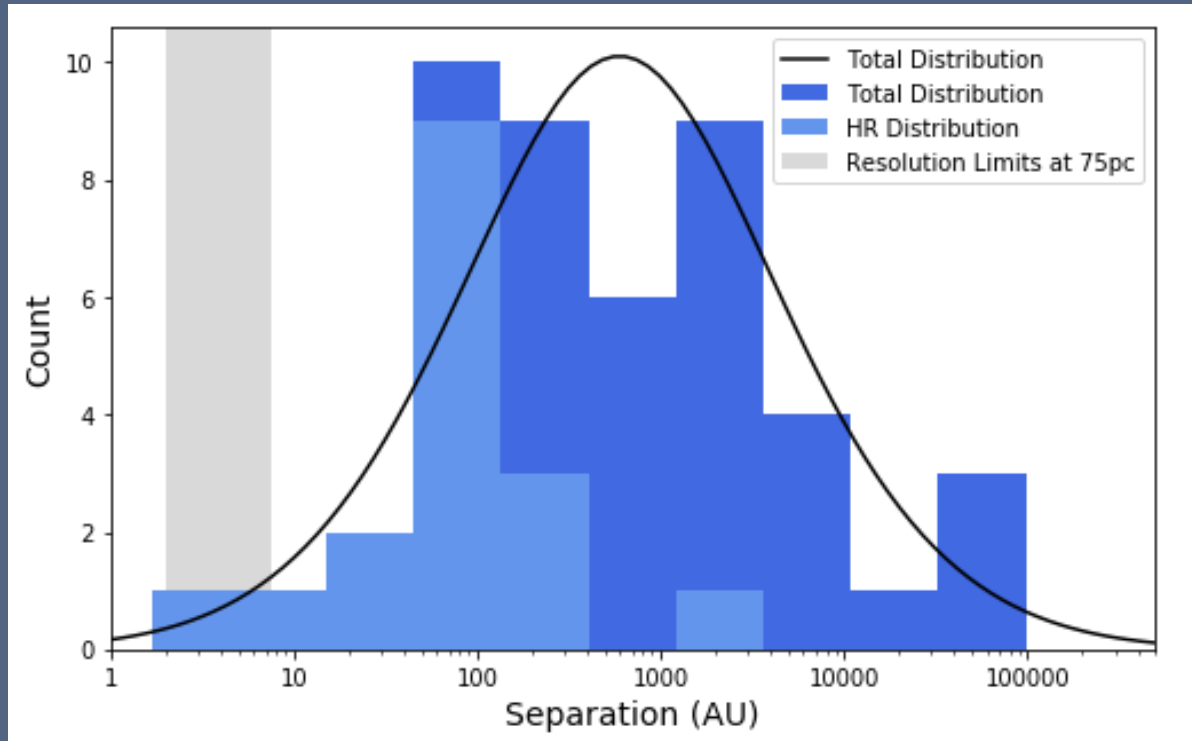
- TIC temperature and observed delta magnitudes to estimate masses using Pecaut & Mamajek (2013)
- Early M dwarfs due to TESS observational limits

Binary Mass Ratio

Matson et al. (in prep)

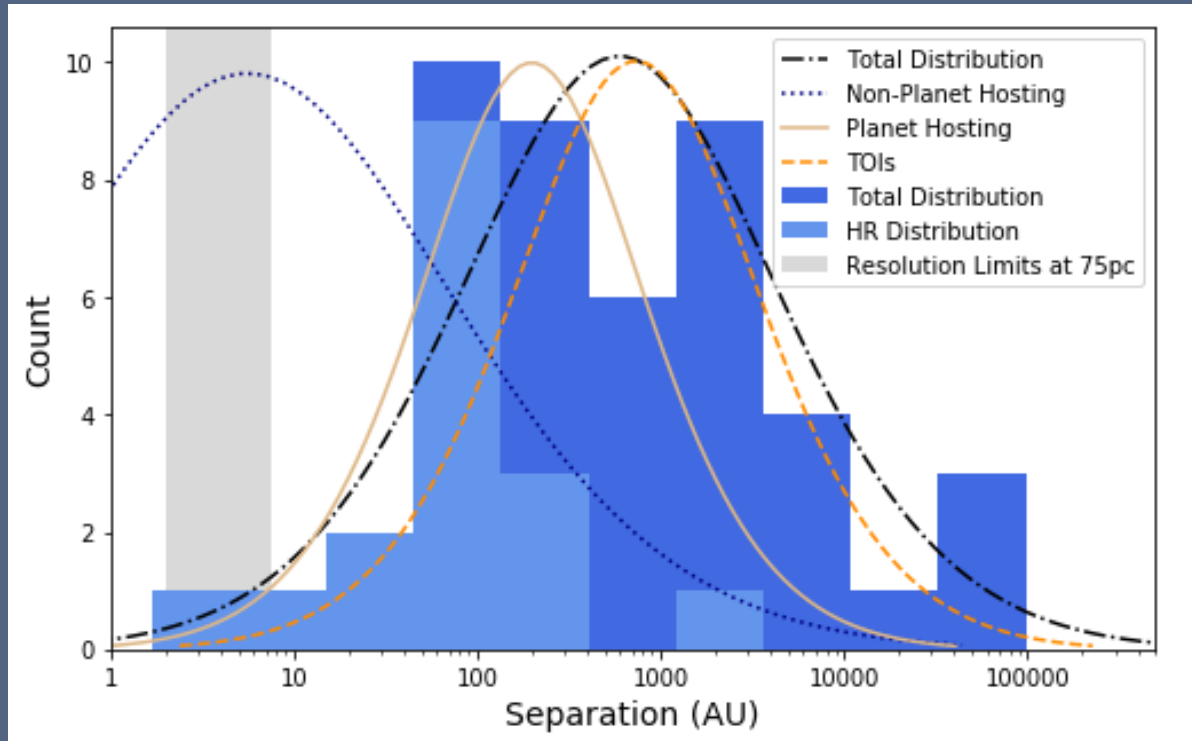


Binary Projected Separation



Matson et al. (in prep)

Binary Projected Separation

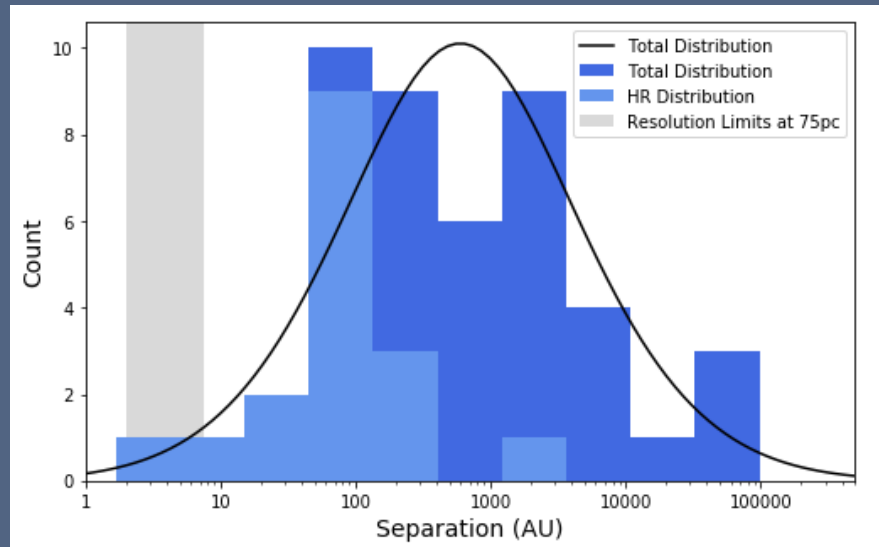
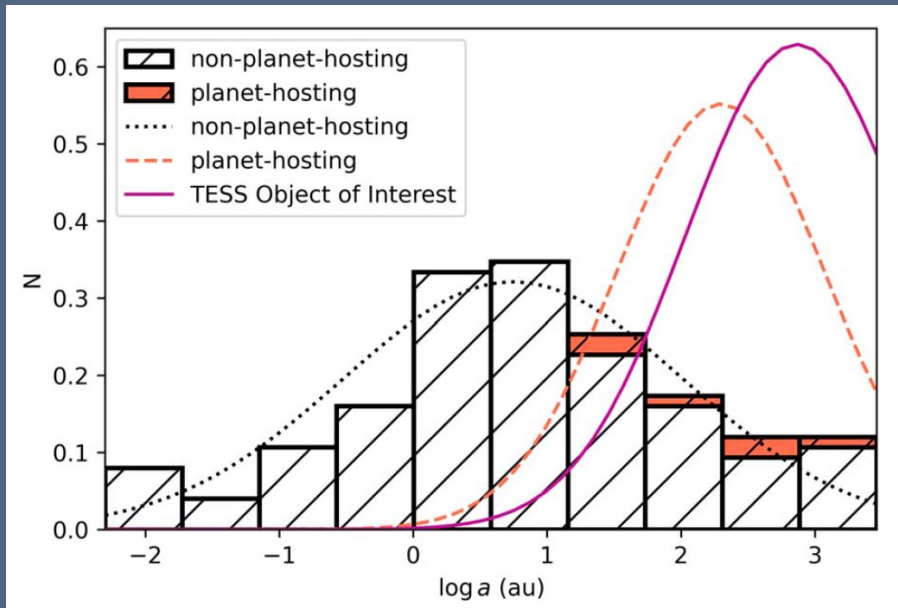


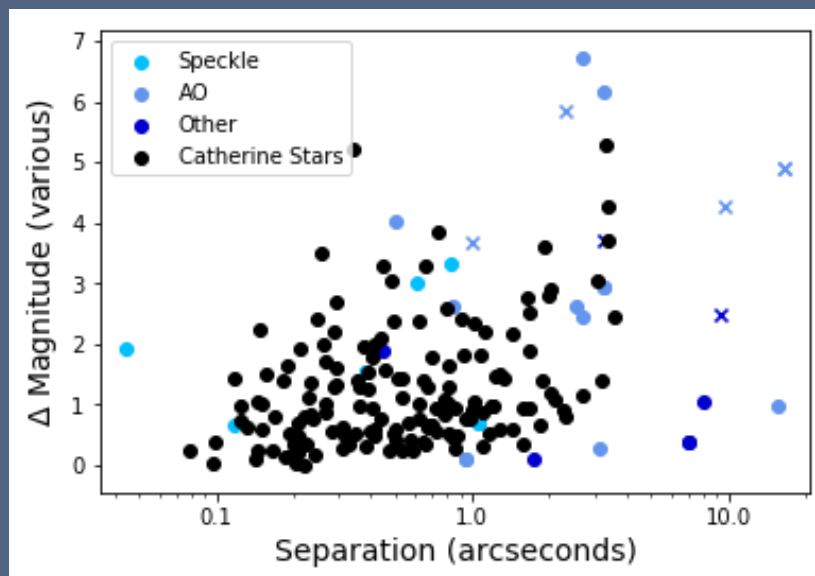
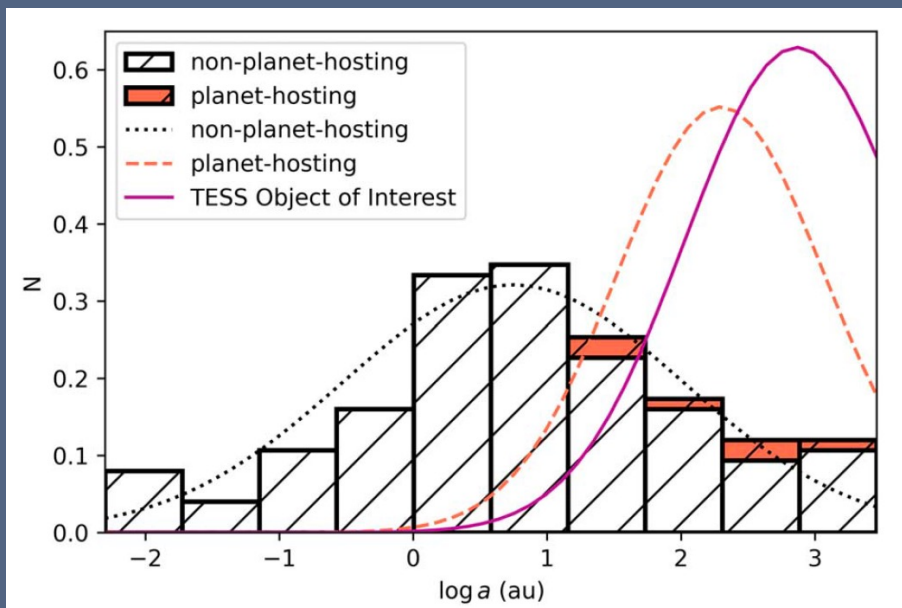
Matson et al. (in prep)

Clark et al. 2024 - Non-planet hosting M stars peak = 5.6au

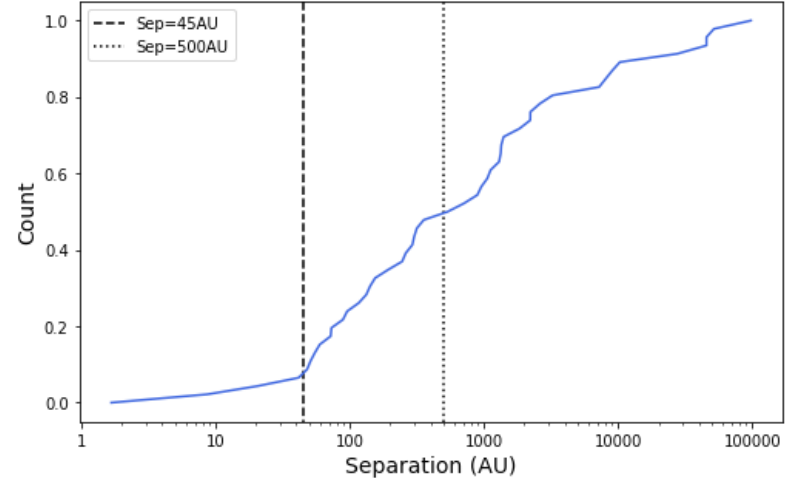
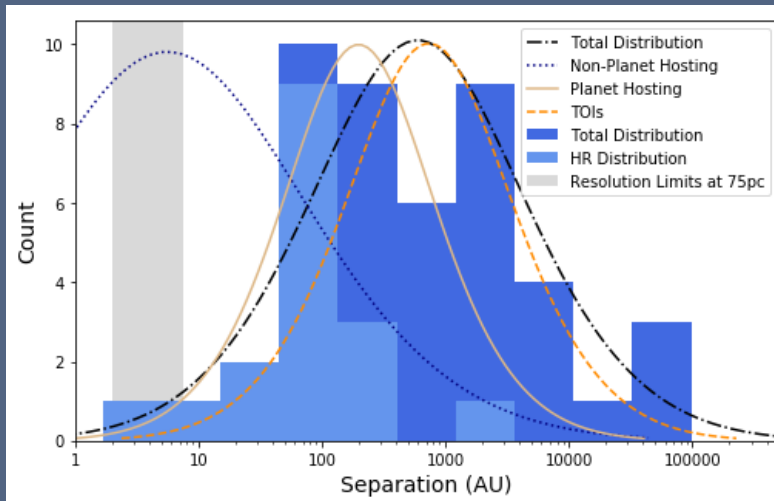
Clark et al. 2024 - Planet hosting M stars peak = 198au

Clark et al. 2022 - M star TOIs peak = 735au





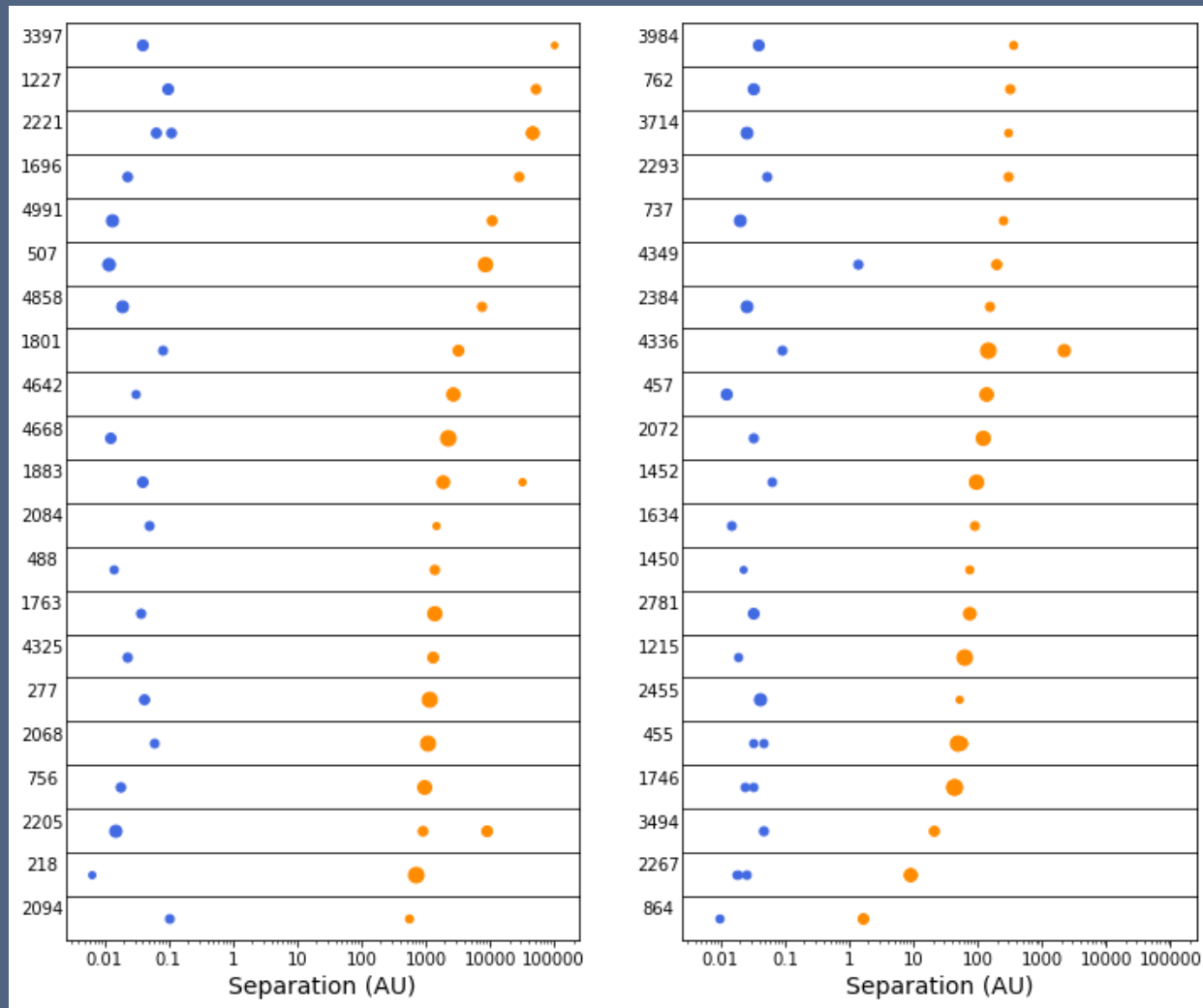
Binary Projected Separation



Matson et al. (in prep)

Detect 16 stellar companions within 200au (38%), only 5 within 50au

Binary and Planet Separations

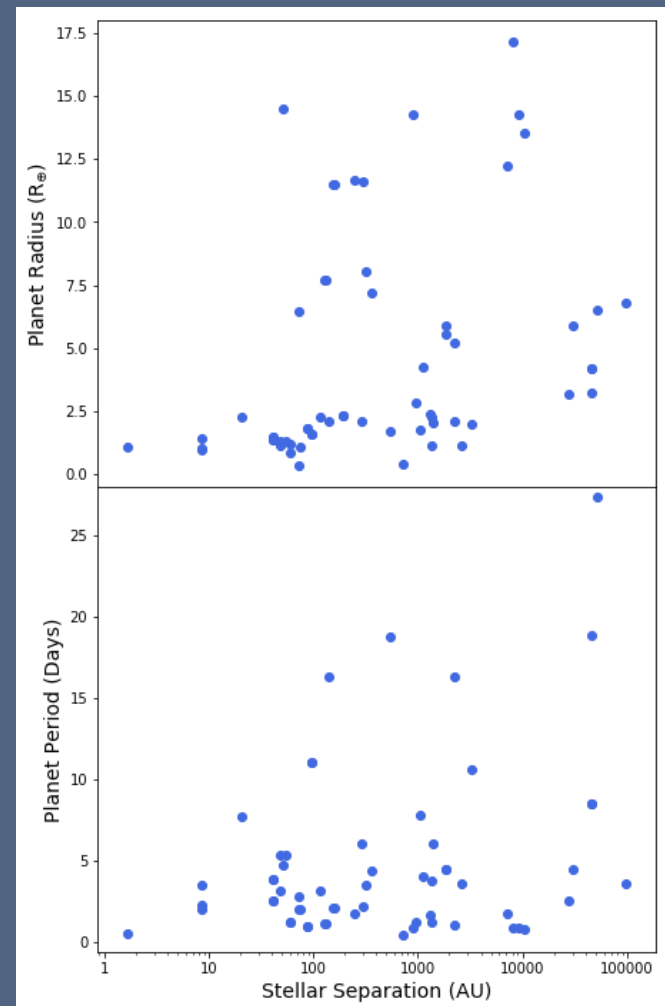
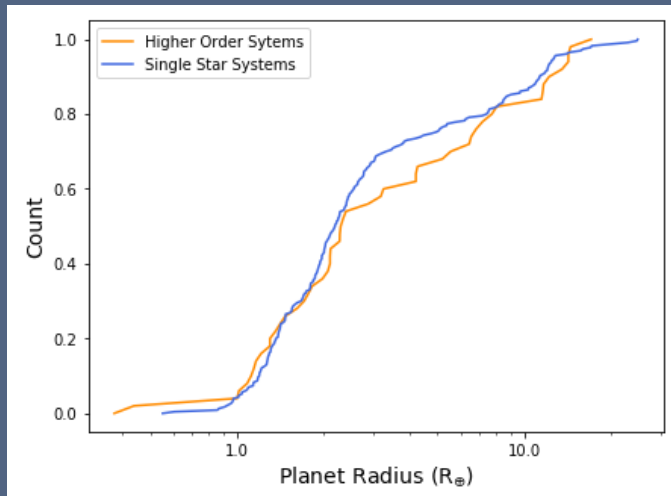
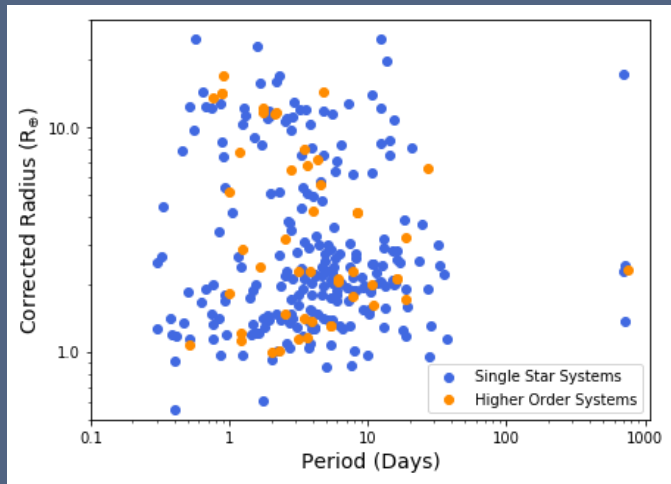


Multiplicity of M dwarf Planet Hosts

- $19.4 \pm 2.7\%$ of M dwarfs with transiting planet candidates have stellar companions
- Multiplicity consistent with field M dwarfs and general exoplanet host star population
- Detect fewer close binaries ($<50\text{au}$) than for M dwarfs without known planets
- 3 of 5 systems with close companion ($<50\text{au}$) are multi-planet systems in close binaries

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Transiting Planet Properties



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