

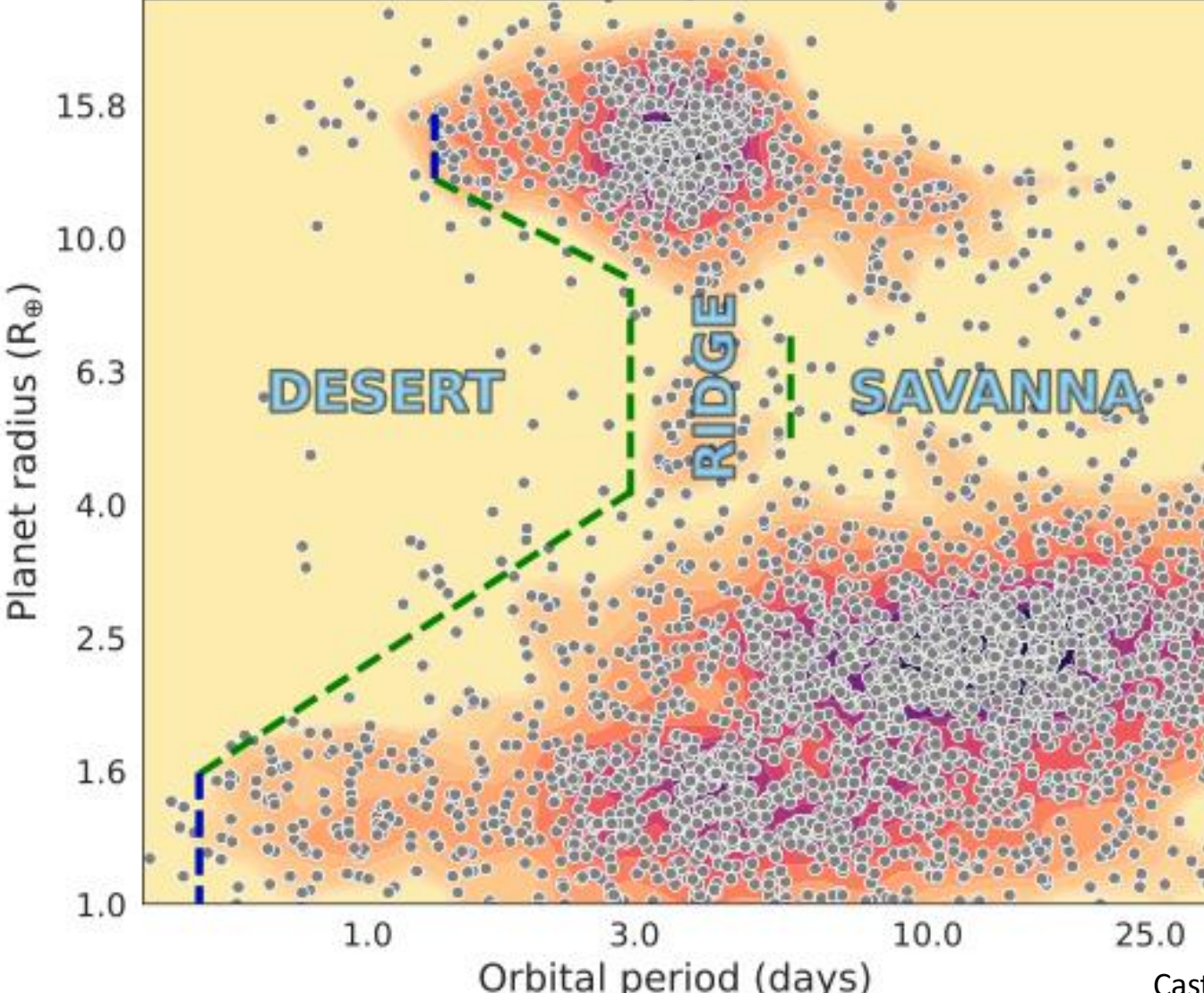
# Stellar Multiplicity in and around the Neptunian desert using Gaia DR3

Fintan Eeles-Nolle & David Armstrong



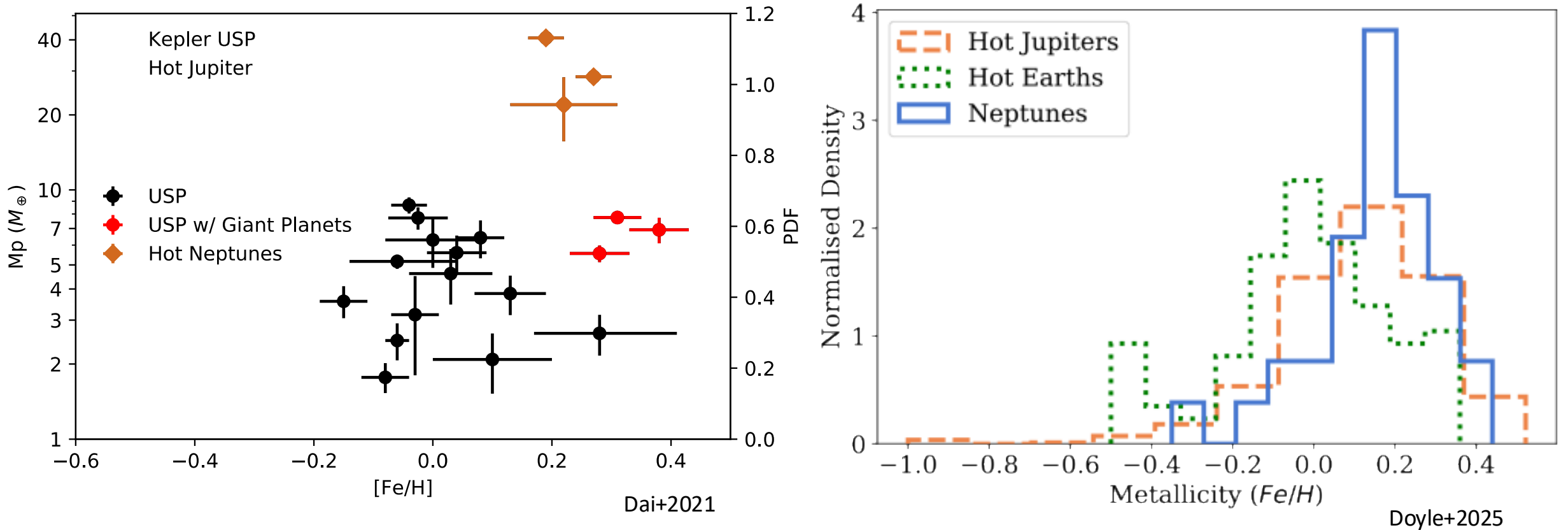
**UNIVERSITY  
OF WARWICK**

# The Hot Neptune Desert



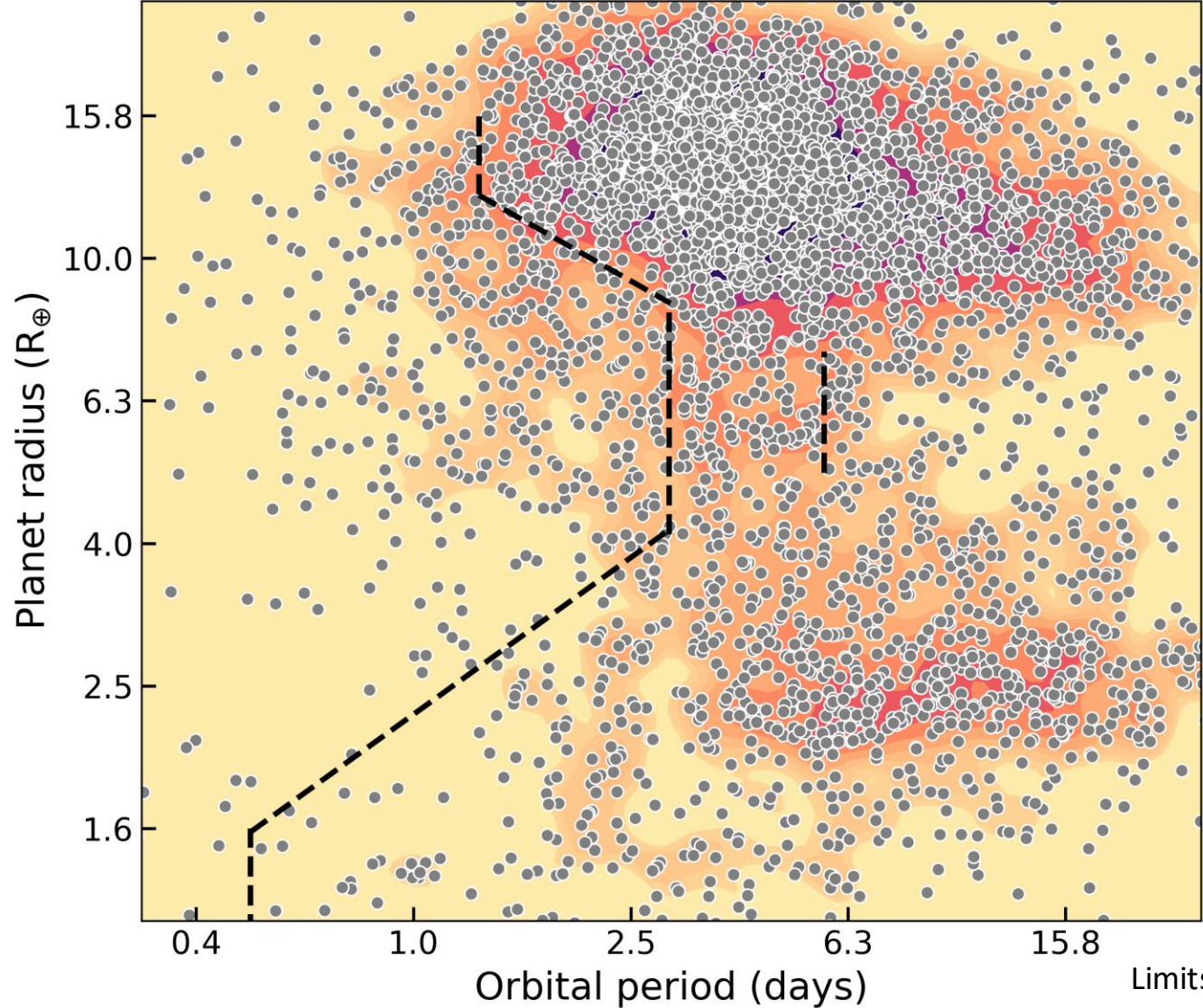
Castro-González+2024

# Hot Neptunes and Hot Jupiters - Host [Fe/H]



Both Hot Neptunes and Hot Jupiters have host stars with high [Fe/H]

# The Hot Neptune Desert - TOI PCs



Limits from Castro-González+2024

# Gaia DR3 Astrometry

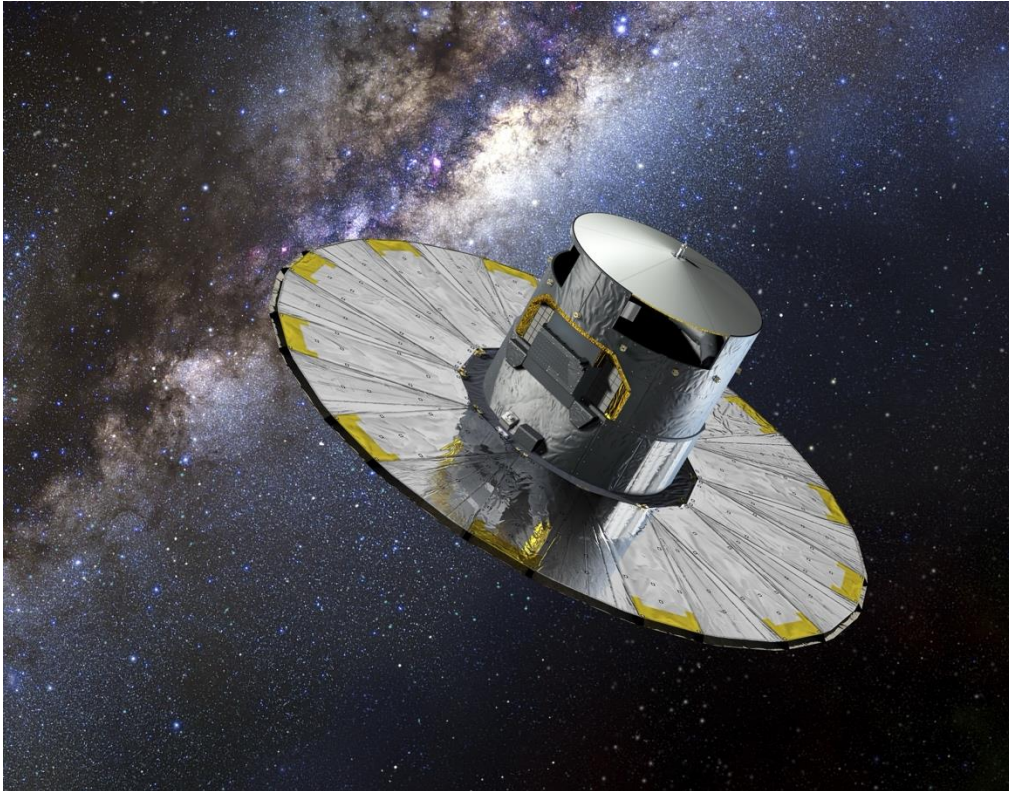


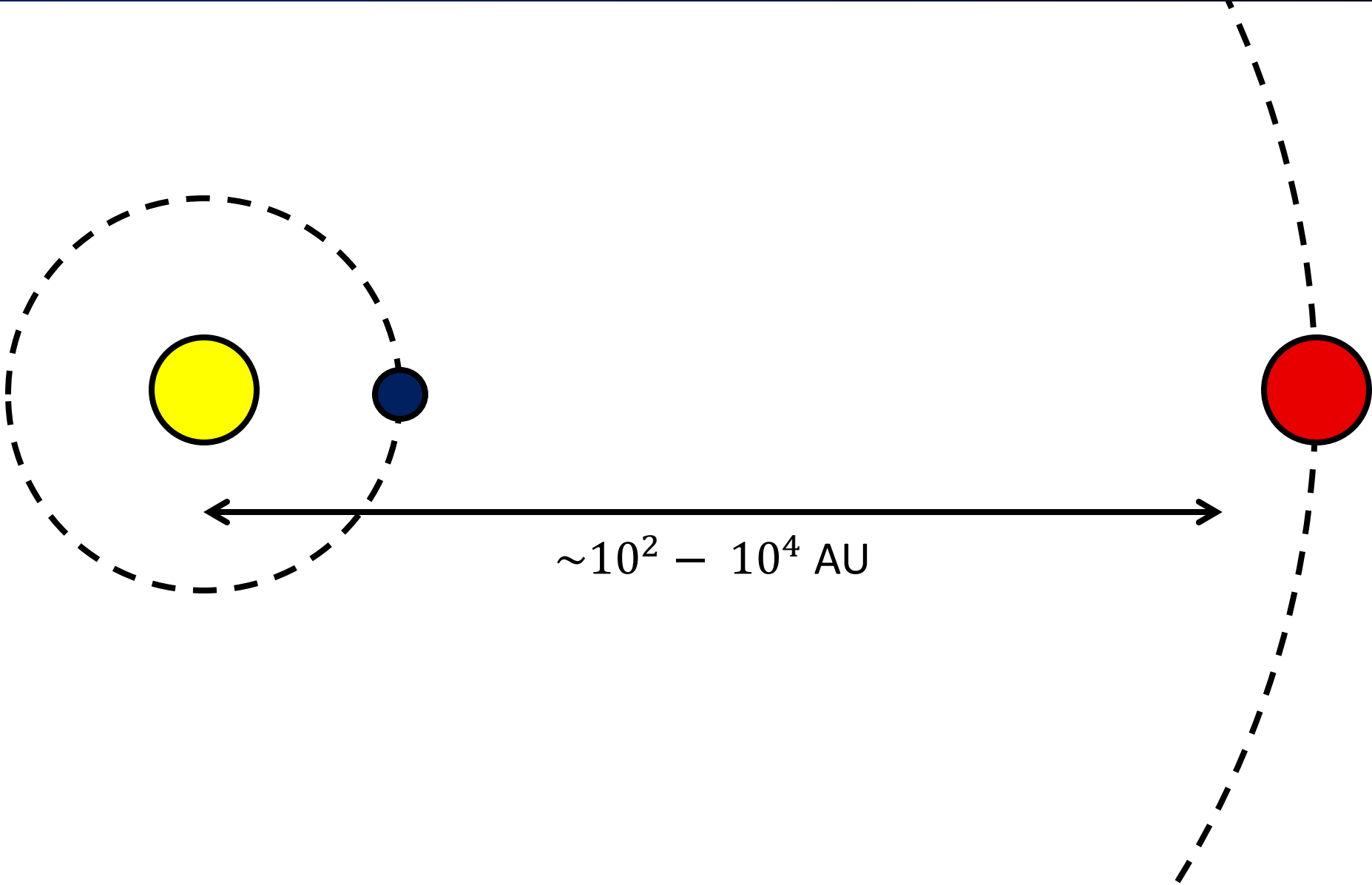
Image credit: ESA

## Why Gaia?

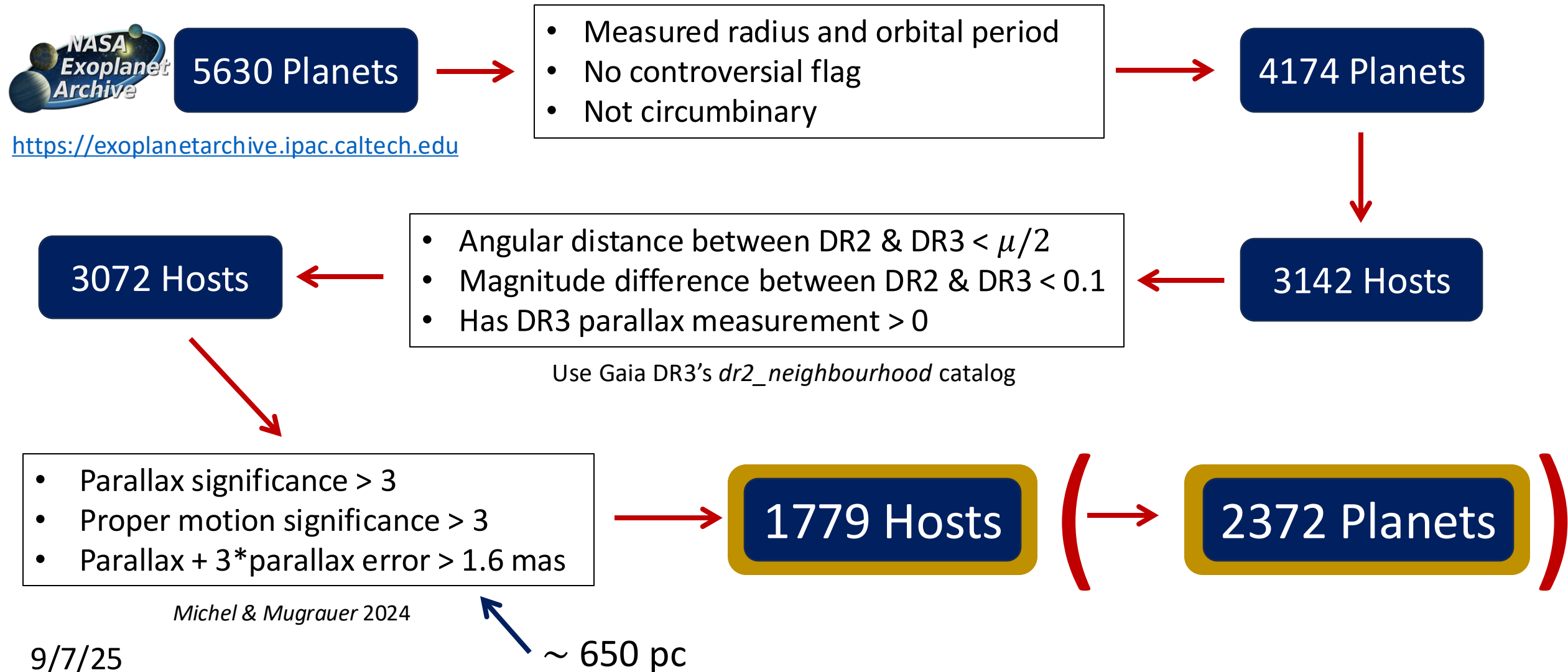
DR3 (Gaia Collaboration+2023) contains:

- ~1.8 billion objects with a G magnitude
- ~1.5 billion objects with 5/6 parameter astrometric solutions
- For  $G \approx 20$  objects:
  - Median  $\sigma_p = 0.5$  mas
  - Median  $\sigma_\mu = 0.5$  mas/yr
- For  $G < 15$  objects:
  - Median  $\sigma_p = 0.02$  mas
  - Median  $\sigma_\mu = 0.02$  mas/yr
- 470 million objects with derived astrophysical parameters ( $T_{eff}$ ,  $logg$ , [M/H], ...)

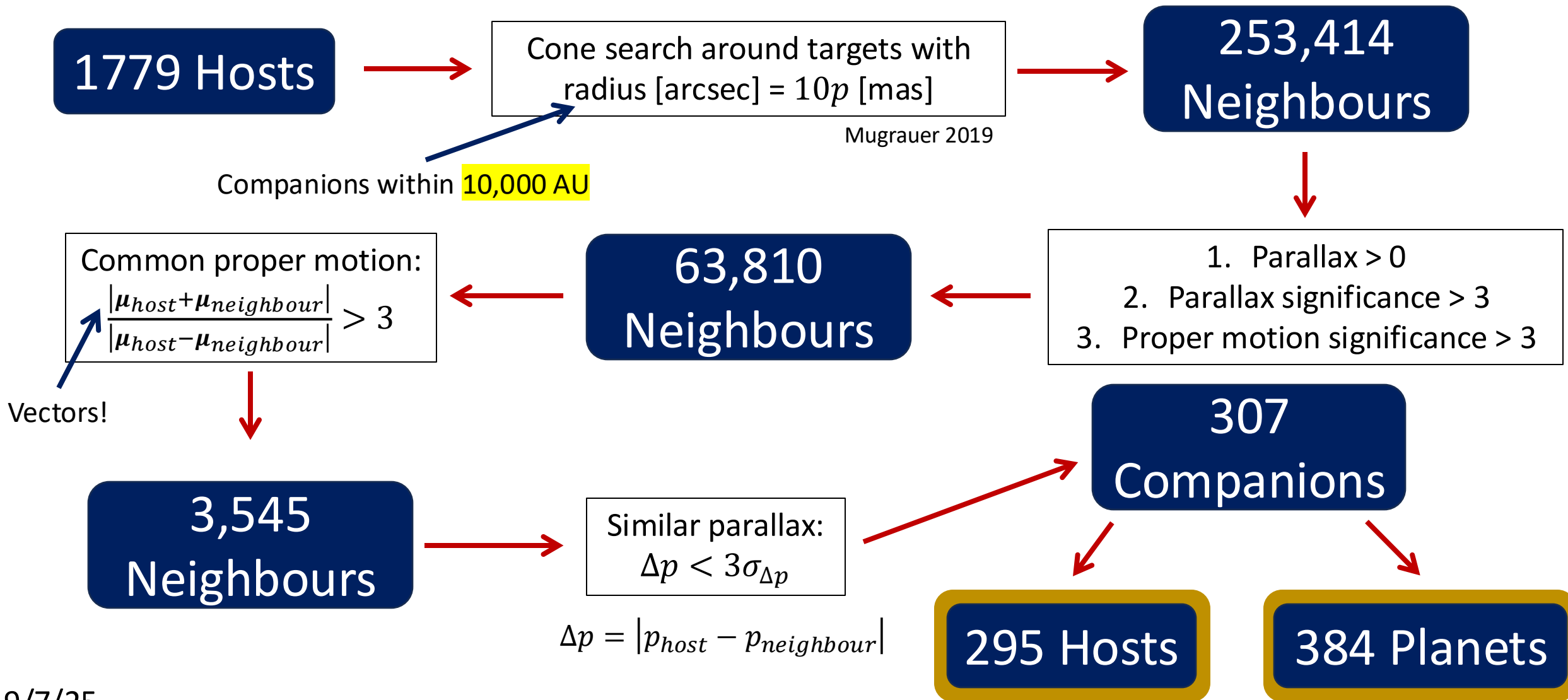
# Wide Stellar Companions



# Selecting Exoplanet Hosts



# Search for Common Proper Motion Companions



# TOI Companion Search

TFOPWG Disposition = PC



7203 TOI



2927 Hosts



3075 TOI



<https://exofop.ipac.caltech.edu/tess/>

CPM Companion Search



608  
Companions



557 Hosts

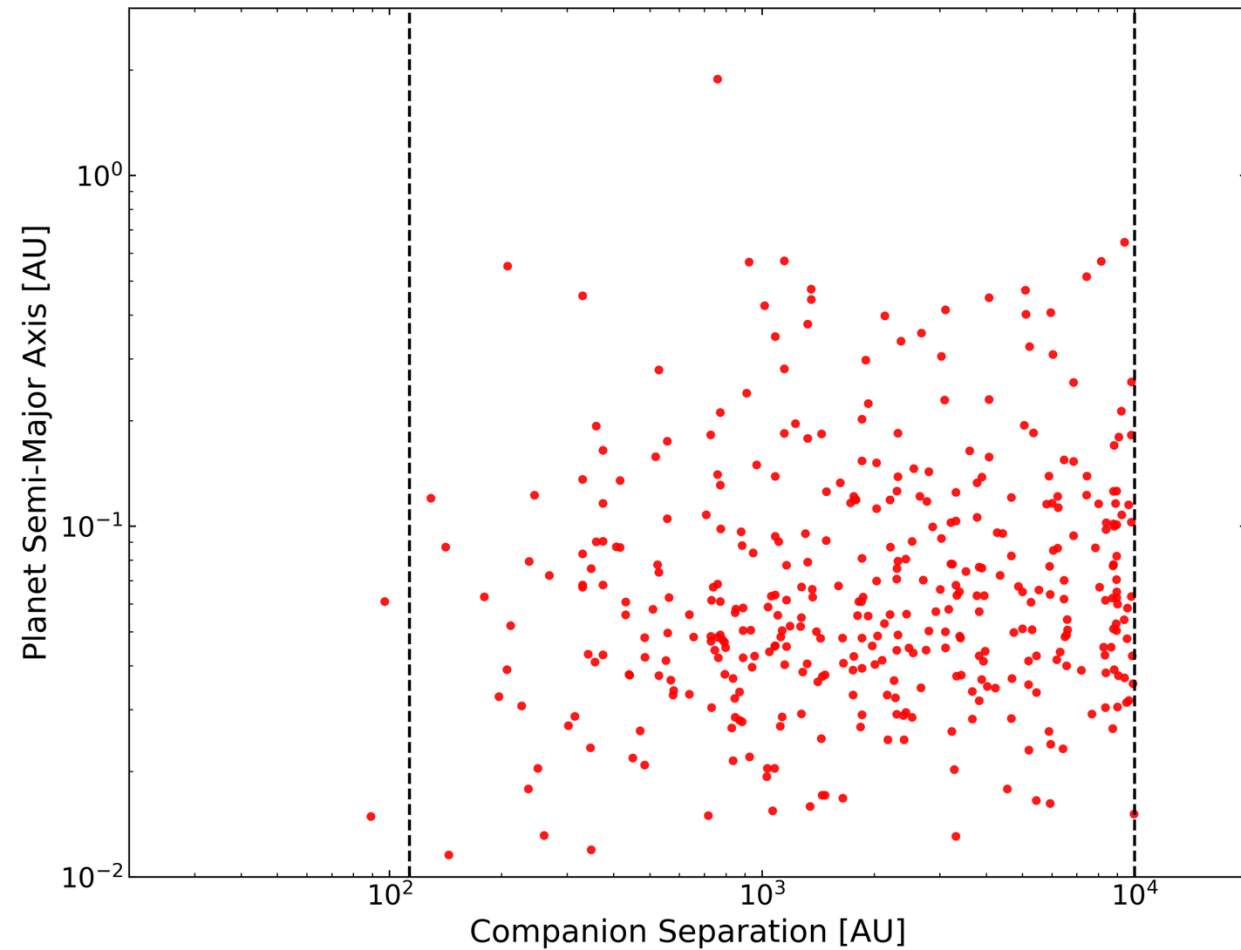


578 TOI

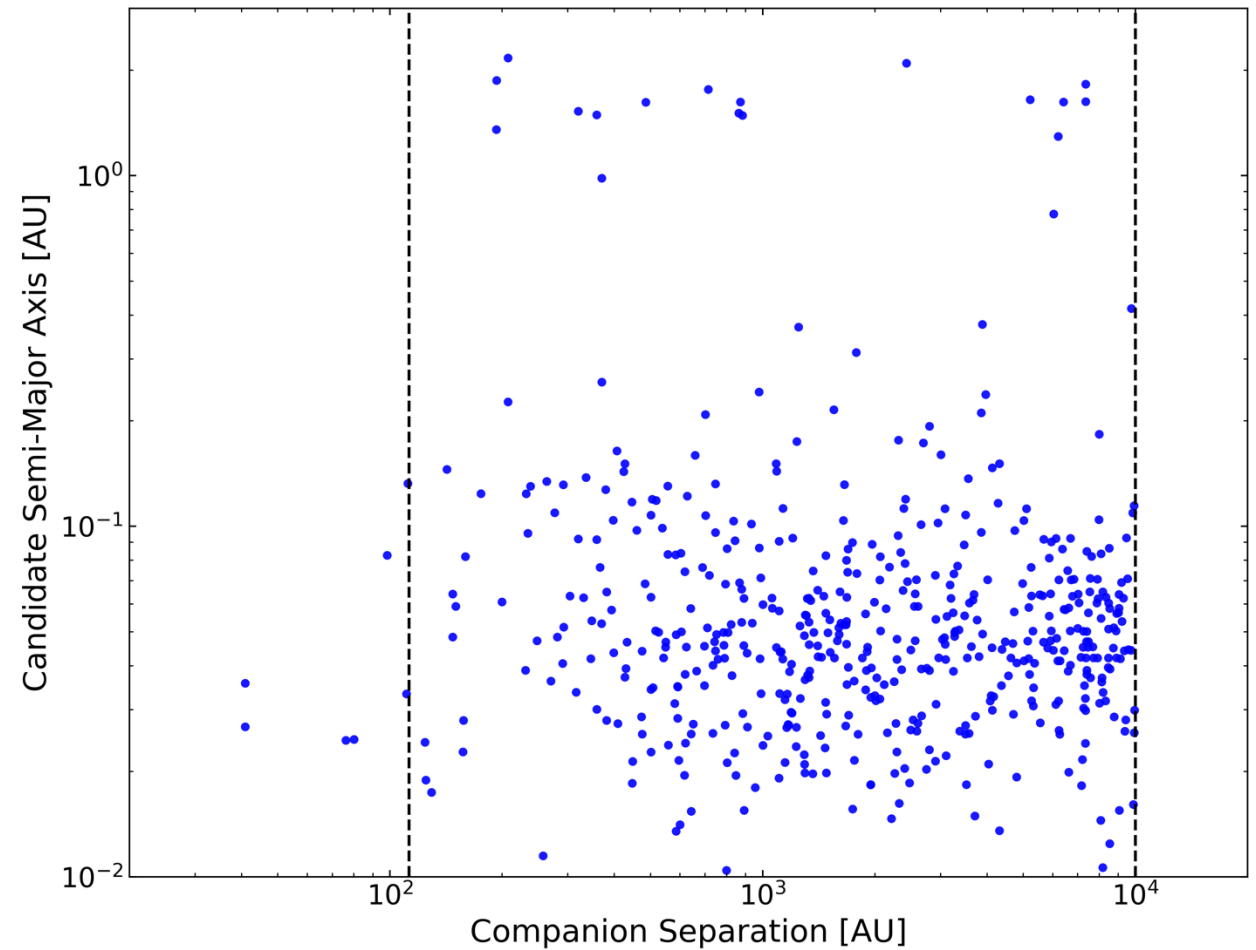


# Companion Separations

Confirmed Exoplanet Sample

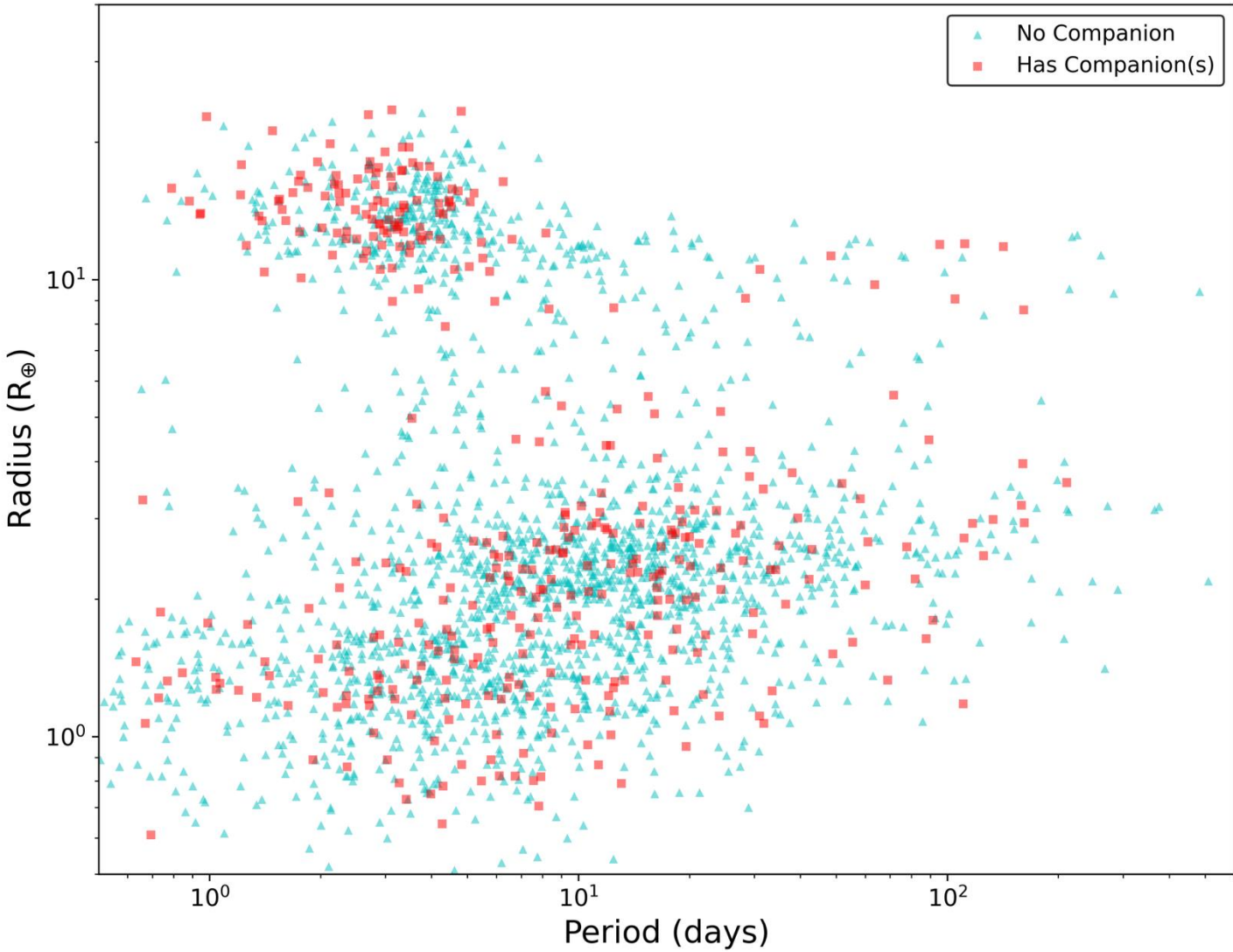


Planet Candidate Sample



Eeles-Nolle+(2025)

# Stellar Multiplicity Rate – Confirmed Exoplanets

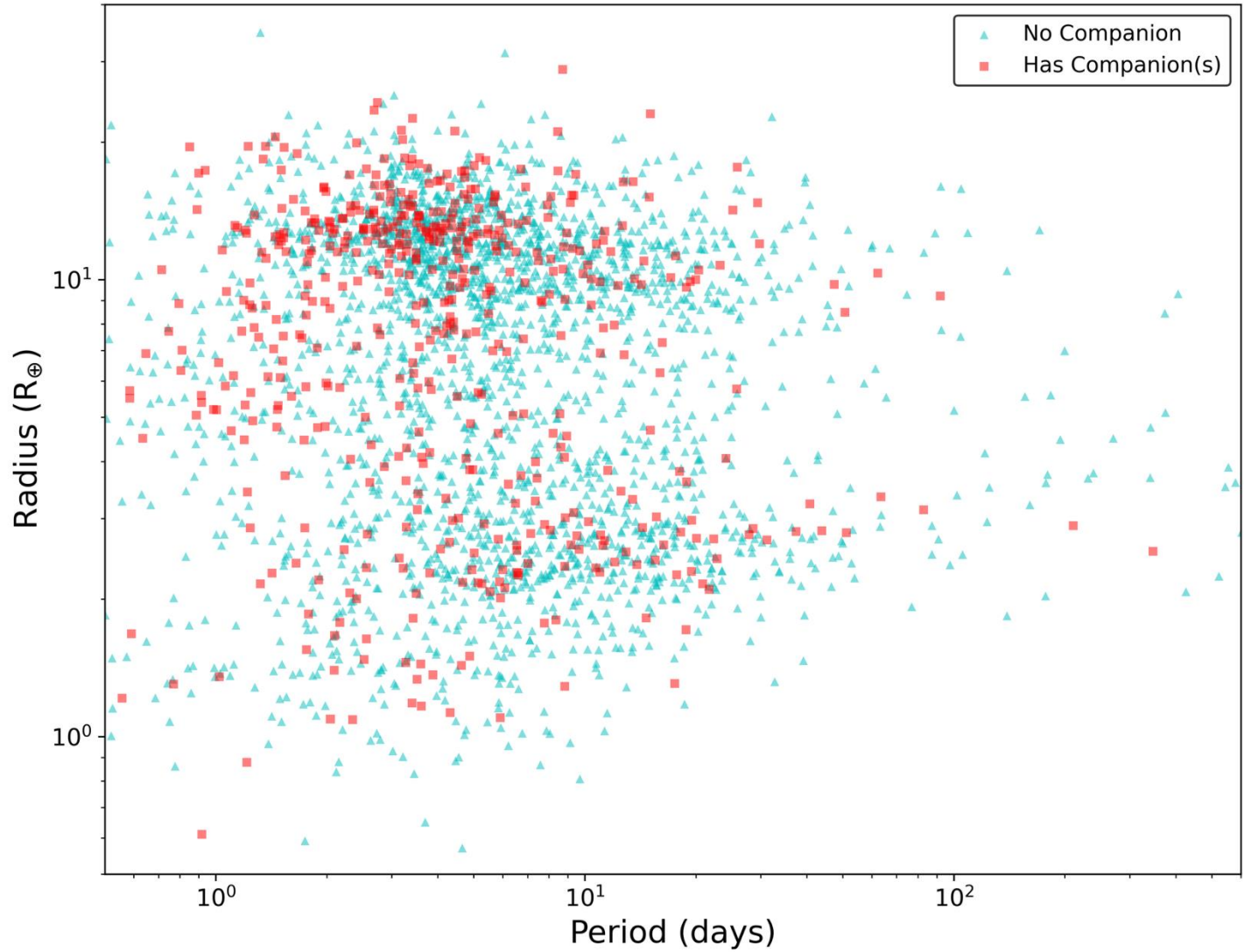


$16.6 \pm 0.9\%$

- $21.6 \pm 2.9\%$  (González-Payo+2024)
- $16.0 \pm 0.8\%$  (Michel & Mugrauer+2024)
- $23.2 \pm 1.6\%$  (Fontanive & Bardalez Gagliuffi+2021)
- $15 \pm 1\%$  (Mugrauer+2019)

Eeles-Nolle+(2025)

# Stellar Multiplicity Rate – Exoplanet Candidates

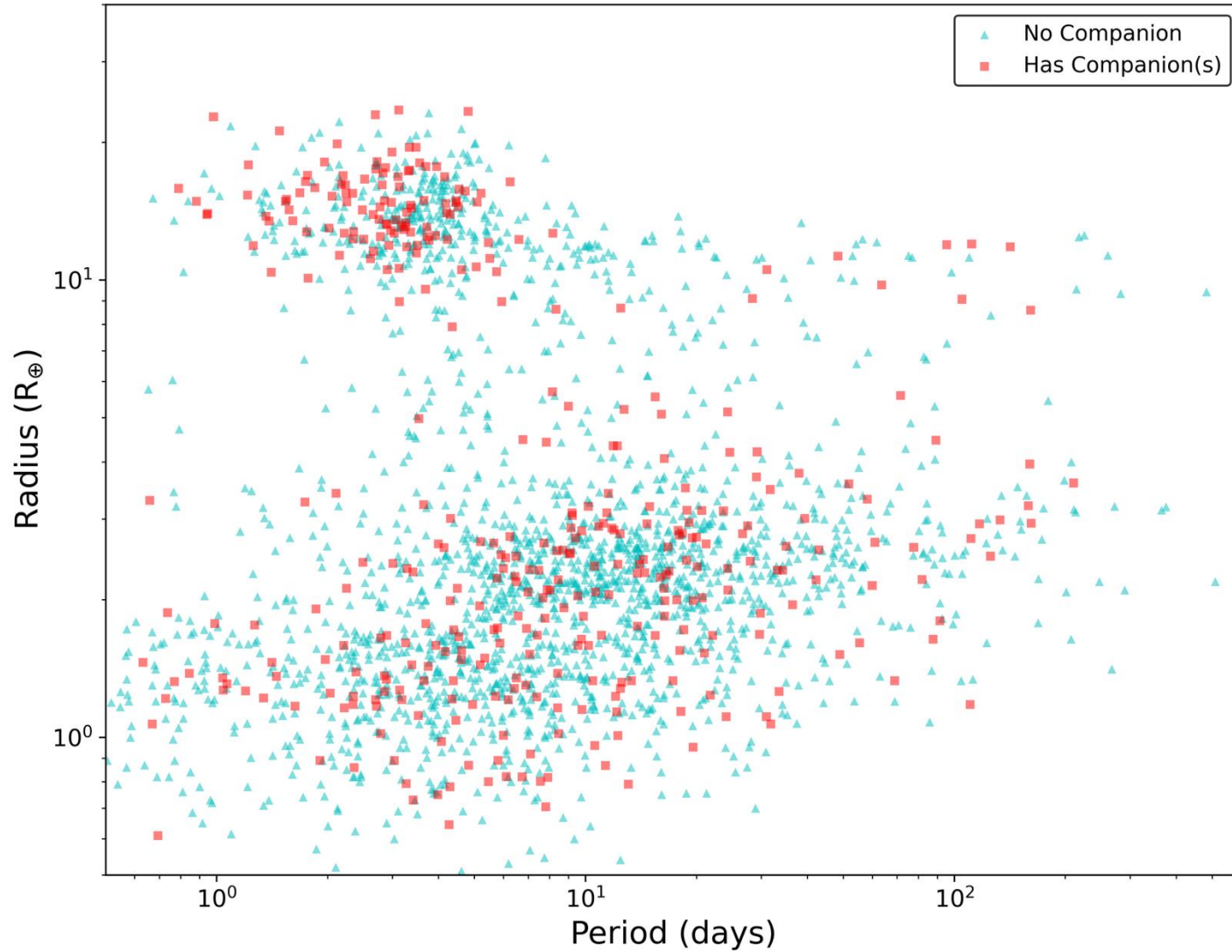


$19.8 \pm 0.7\%$

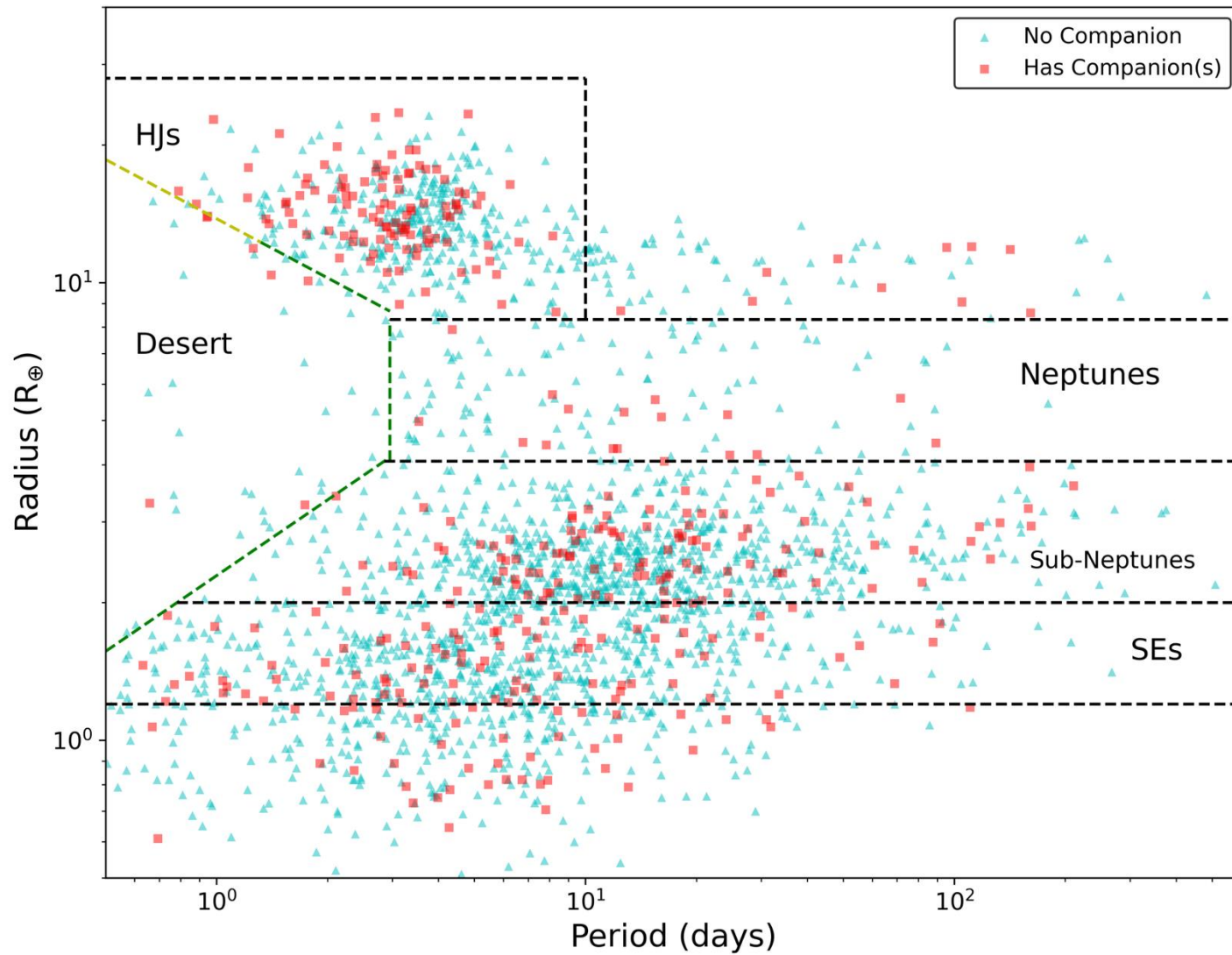
$19.9 \pm 1.5\%$  (Mugrauer+2023)

Eeles-Nolle+(2025)

# Planet Types

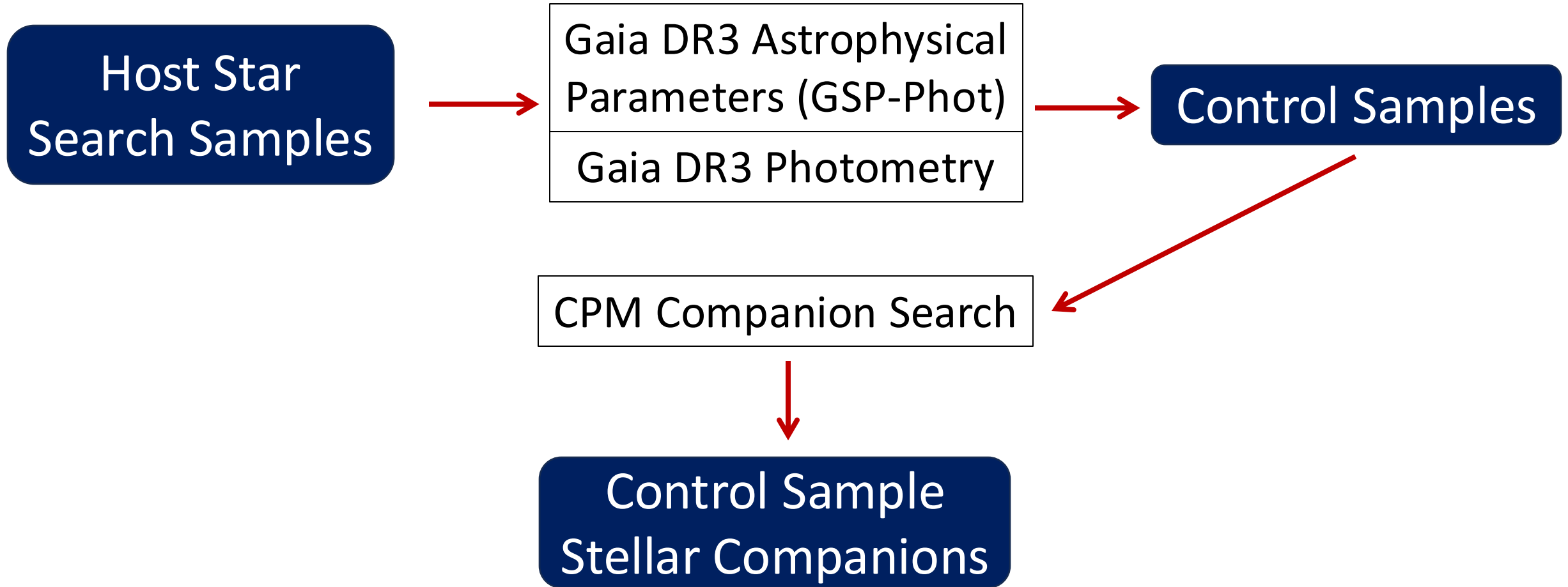


# Planet Types

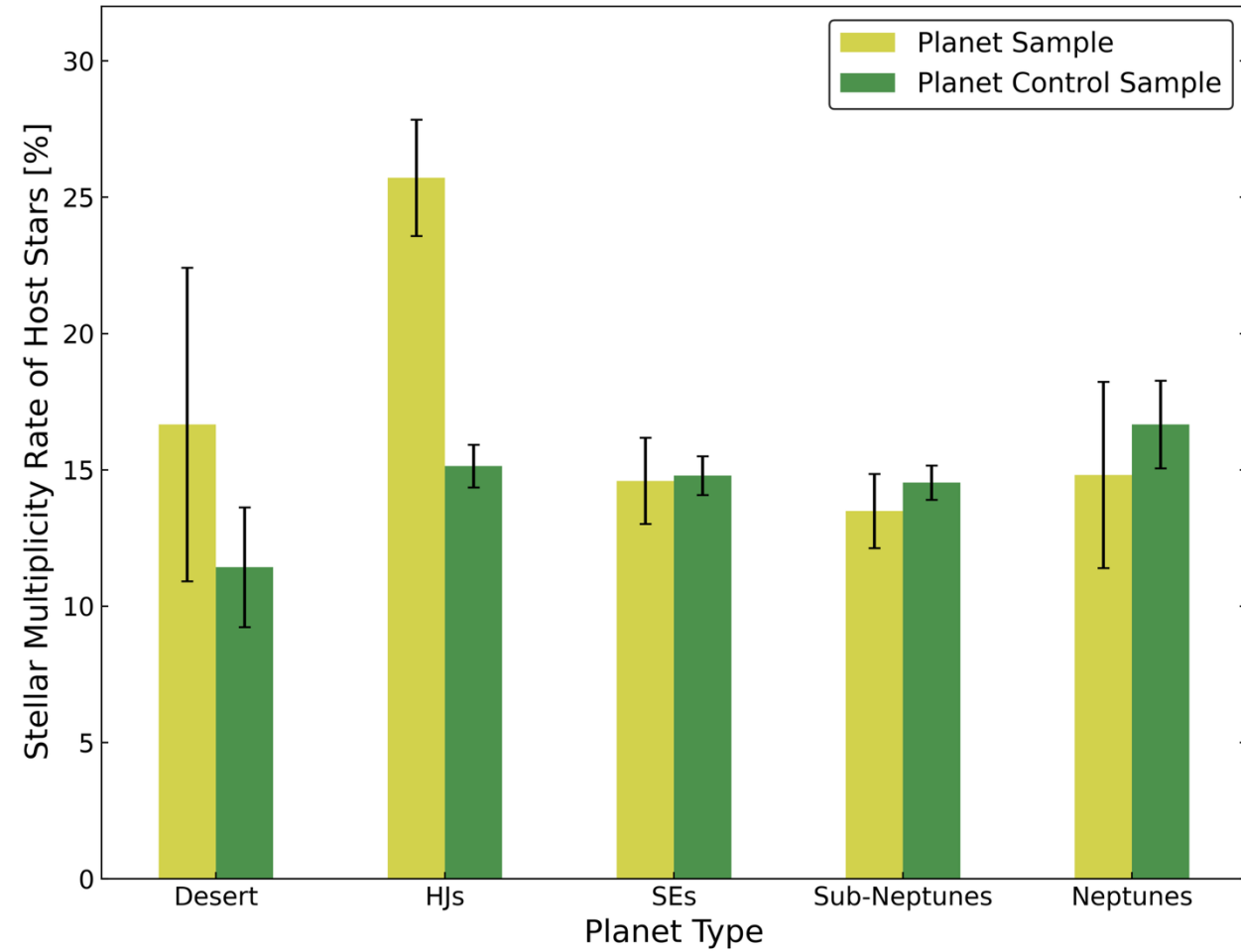
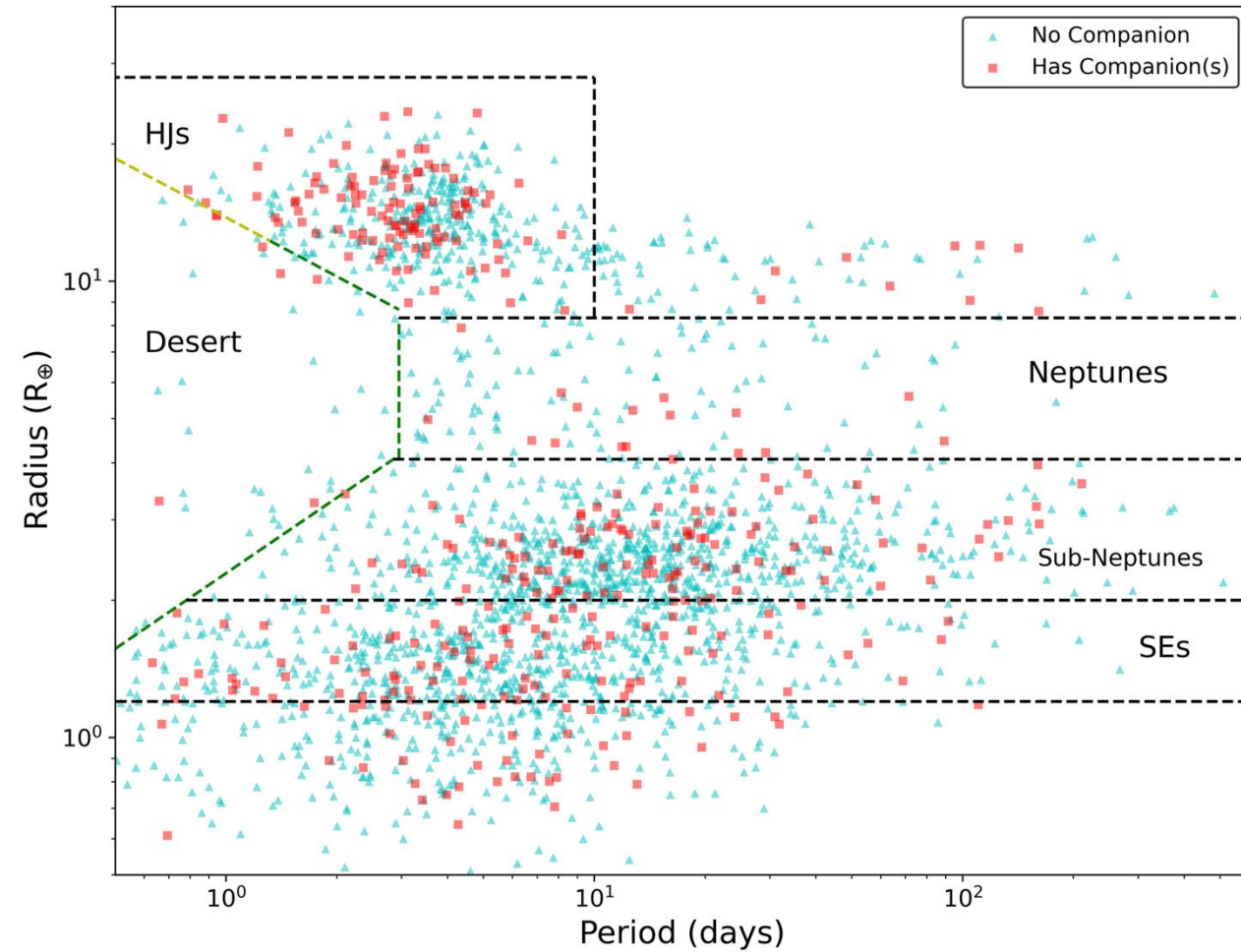


HJ radius limits from Yee+2021

# Control Samples



# Confirmed Exoplanet Results

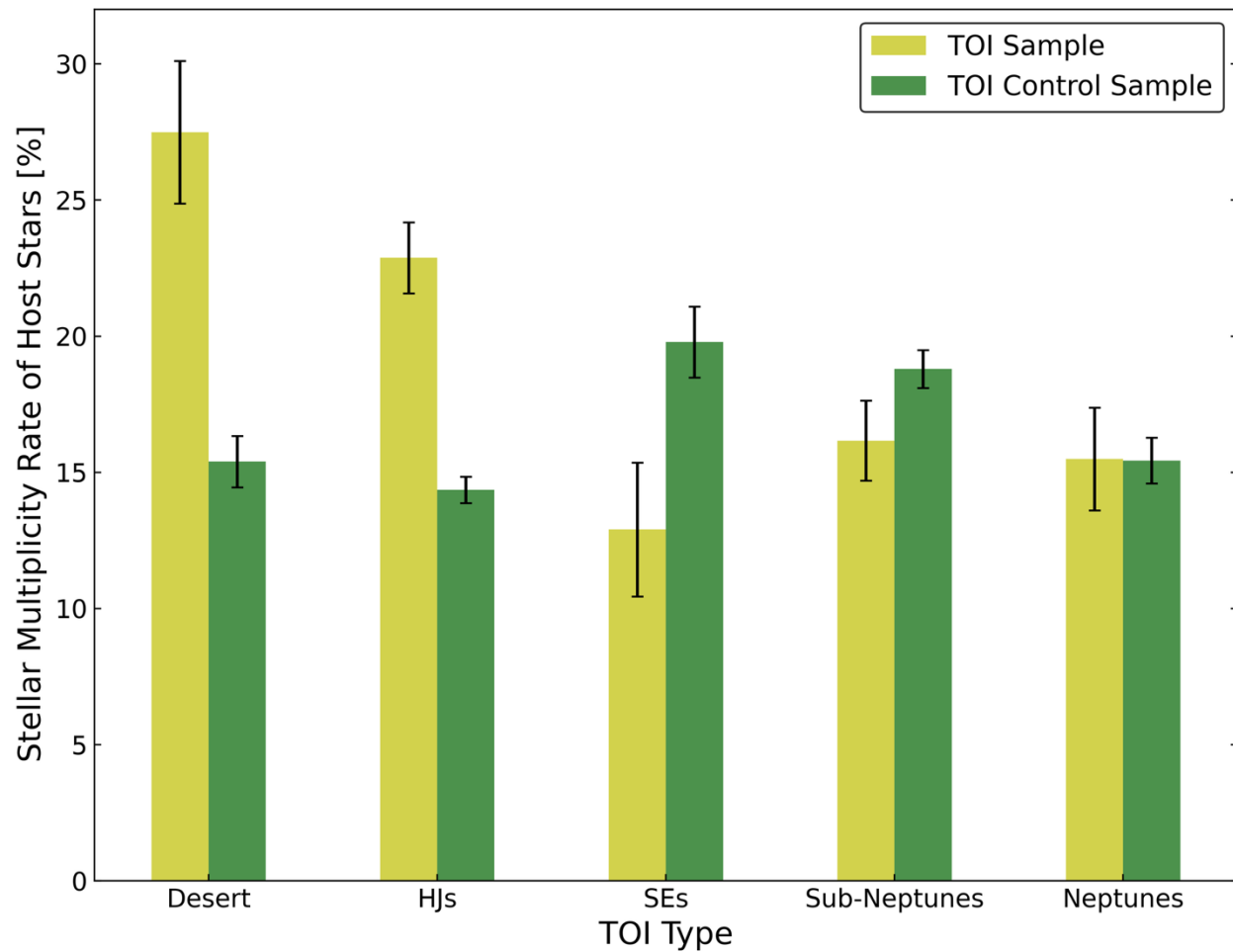
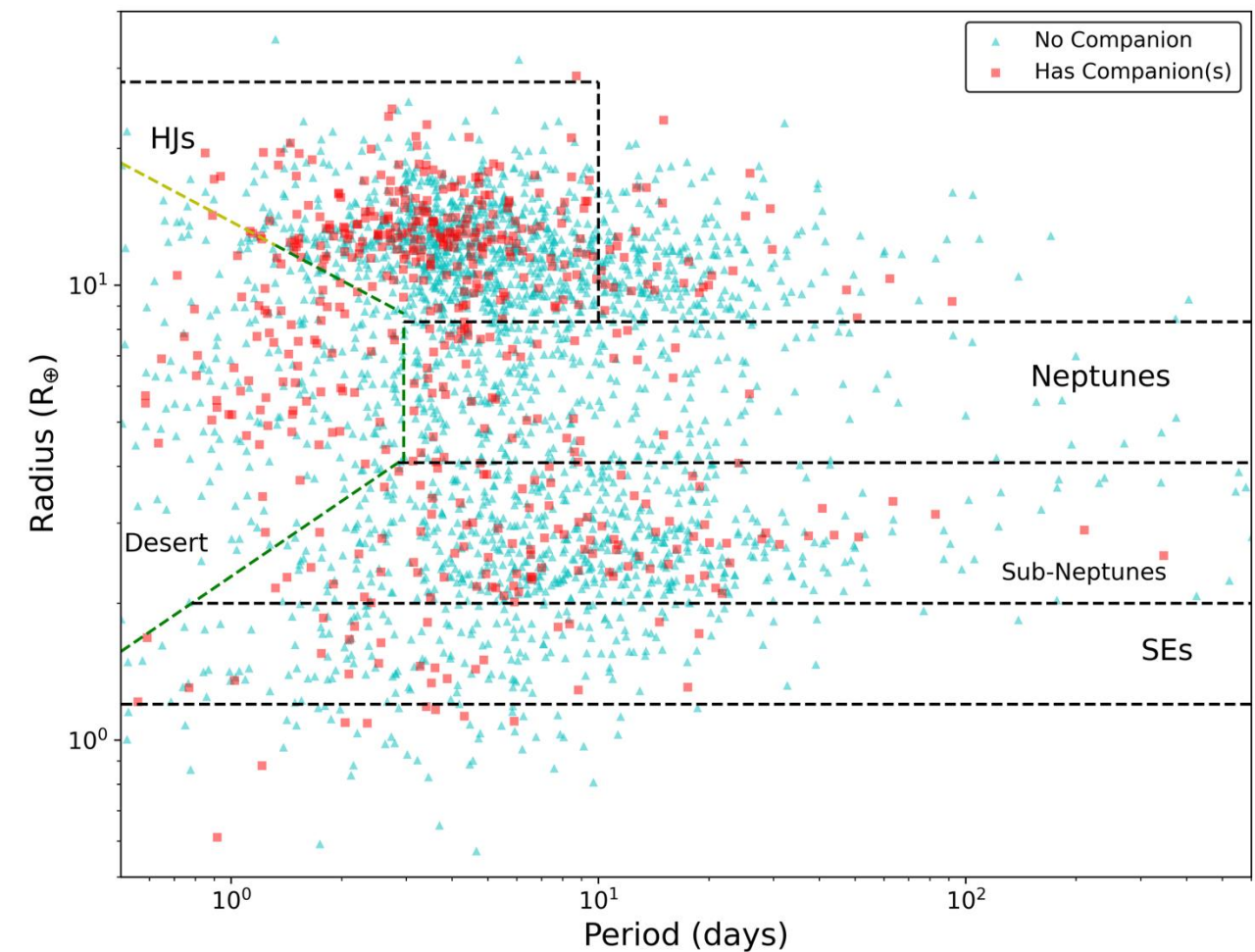


Desert:  $0.85\sigma$

HJs:  $4.76\sigma$

Eeles-Nolle+(2025)

# TOI Planet Candidate Results



Desert:  $4.40\sigma$

HJs:  $6.10\sigma$

Eeles-Nolle+(2025)



- Use Gaia DR3 astrometry to determine the possible companionship of neighbouring stars using proper motion and parallax
- Reproduce the known higher than field stellar multiplicity rate for Hot Jupiter hosts for both *confirmed exoplanets* and *TESS planet candidates*
- Hot Neptune Desert hosts are more difficult:
  - 1) *Confirmed planets* may follow the HJ high stellar multiplicity trend (cannot confirm due to low sample sizes)
  - 2) *TESS PCs* follow the HJ high stellar multiplicity rate trend

