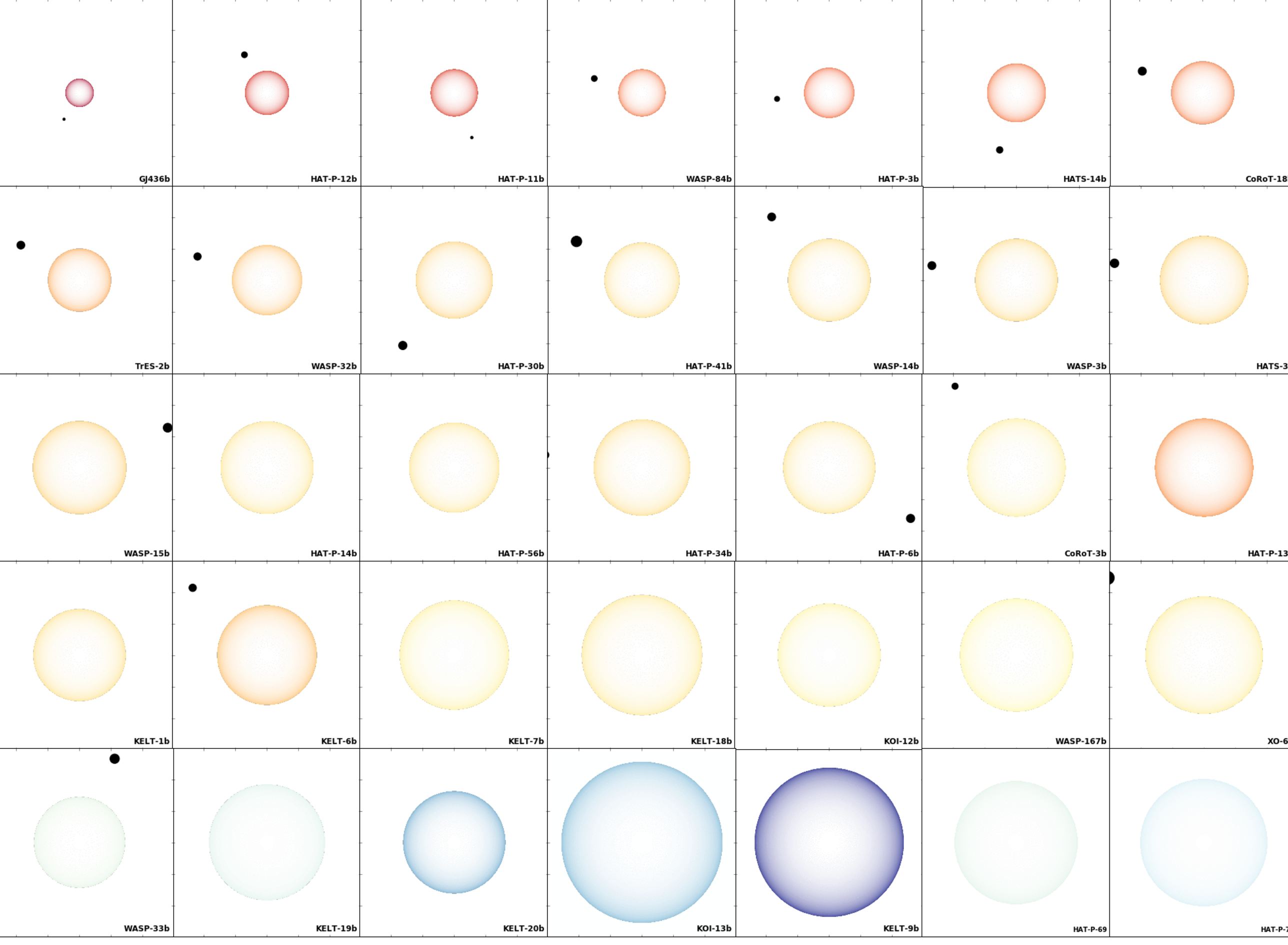
The occurrence rate of hot Jupiters from TESS

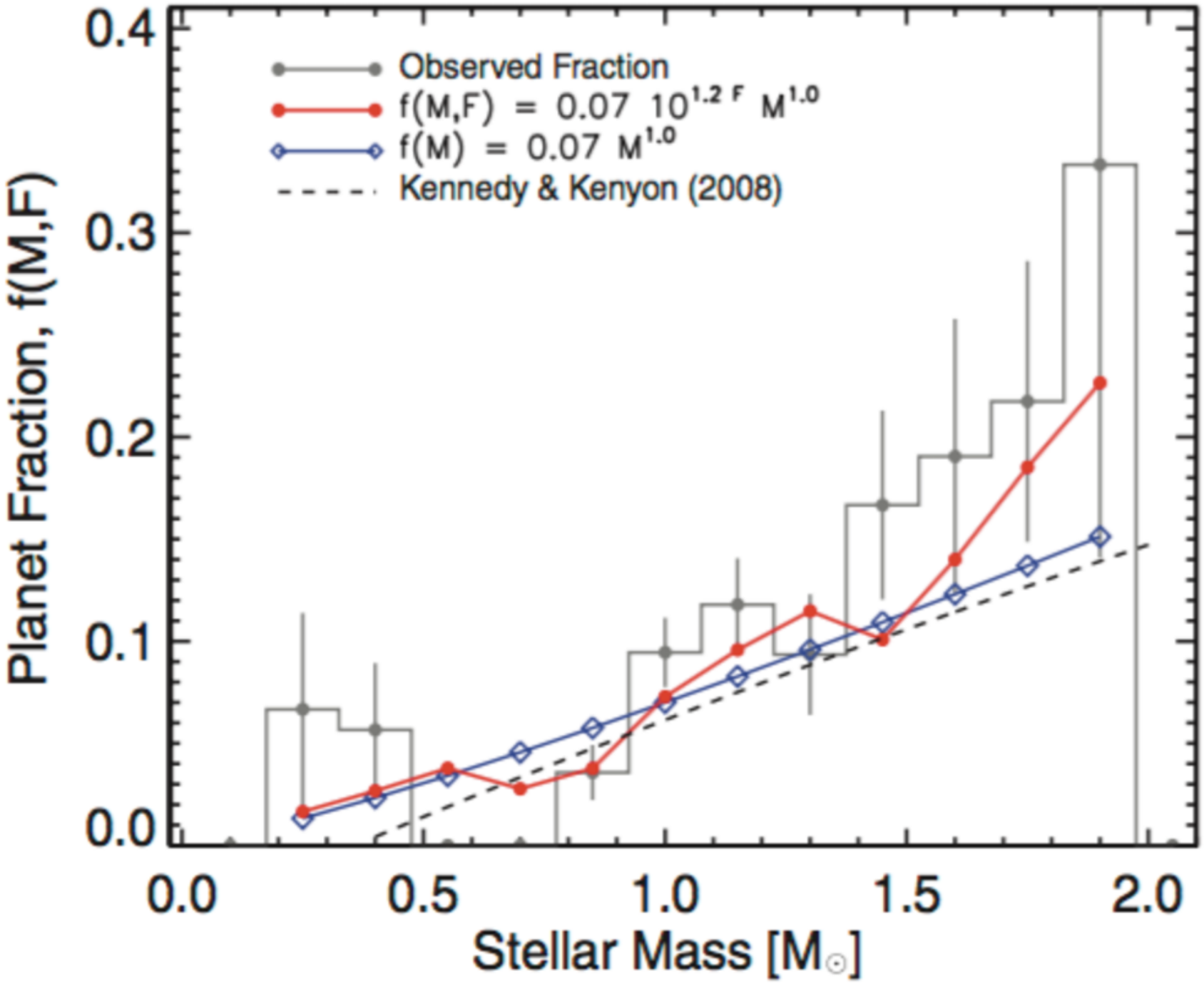
George Zhou

CENTER FOR ASTROPHYSICS
HARVARD & SMITHSONIAN

Hubble Fellow

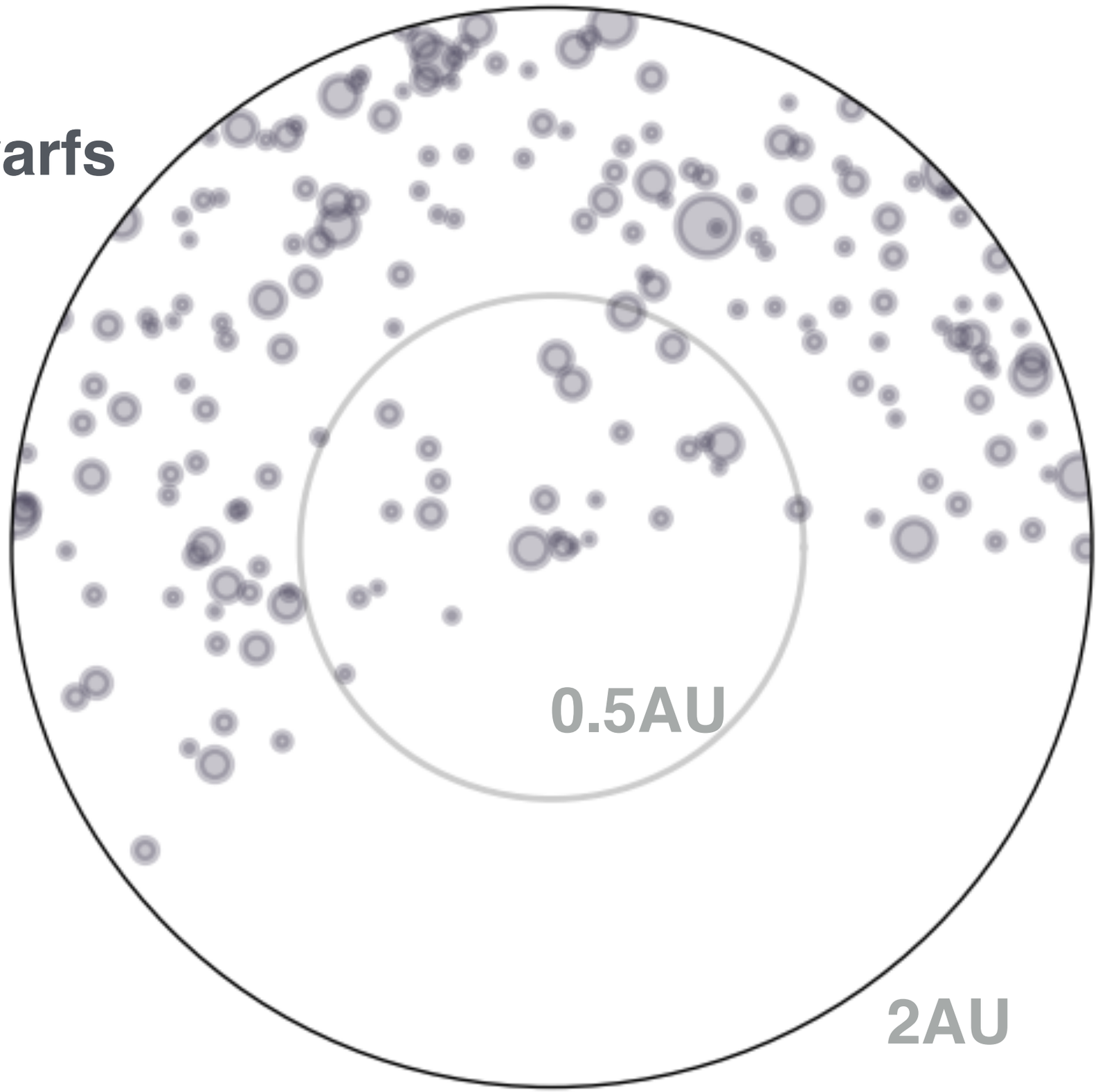

GJ436b
HAT-P-12b
HAT-P-11b
WASP-84b
HAT-P-3b
HATS-14b
CoRoT-18
TrES-2b
WASP-32b
HAT-P-30b
HAT-P-41b
WASP-14b
WASP-3b
HATS-3
WASP-15b
HAT-P-14b
HAT-P-56b
HAT-P-34b
HAT-P-6b
CoRoT-3b
HAT-P-13
KELT-1b
KELT-6b
KELT-7b
KELT-18b
KOI-12b
WASP-167b
XO-6
WASP-33b
KELT-19b
KELT-20b
KOI-13b
KELT-9b
HAT-P-69
HAT-P-7

Retired A-stars have more giant planets

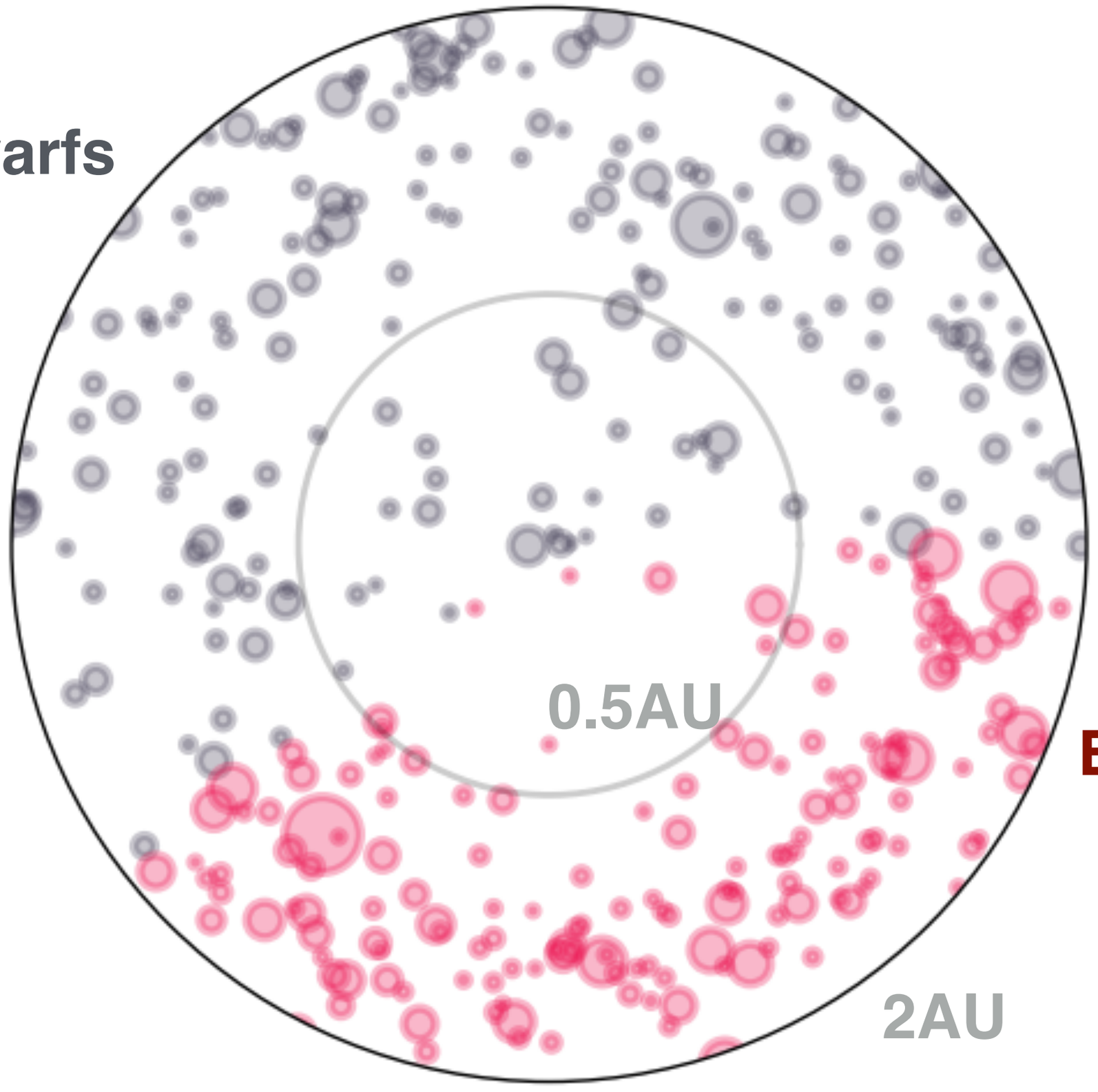


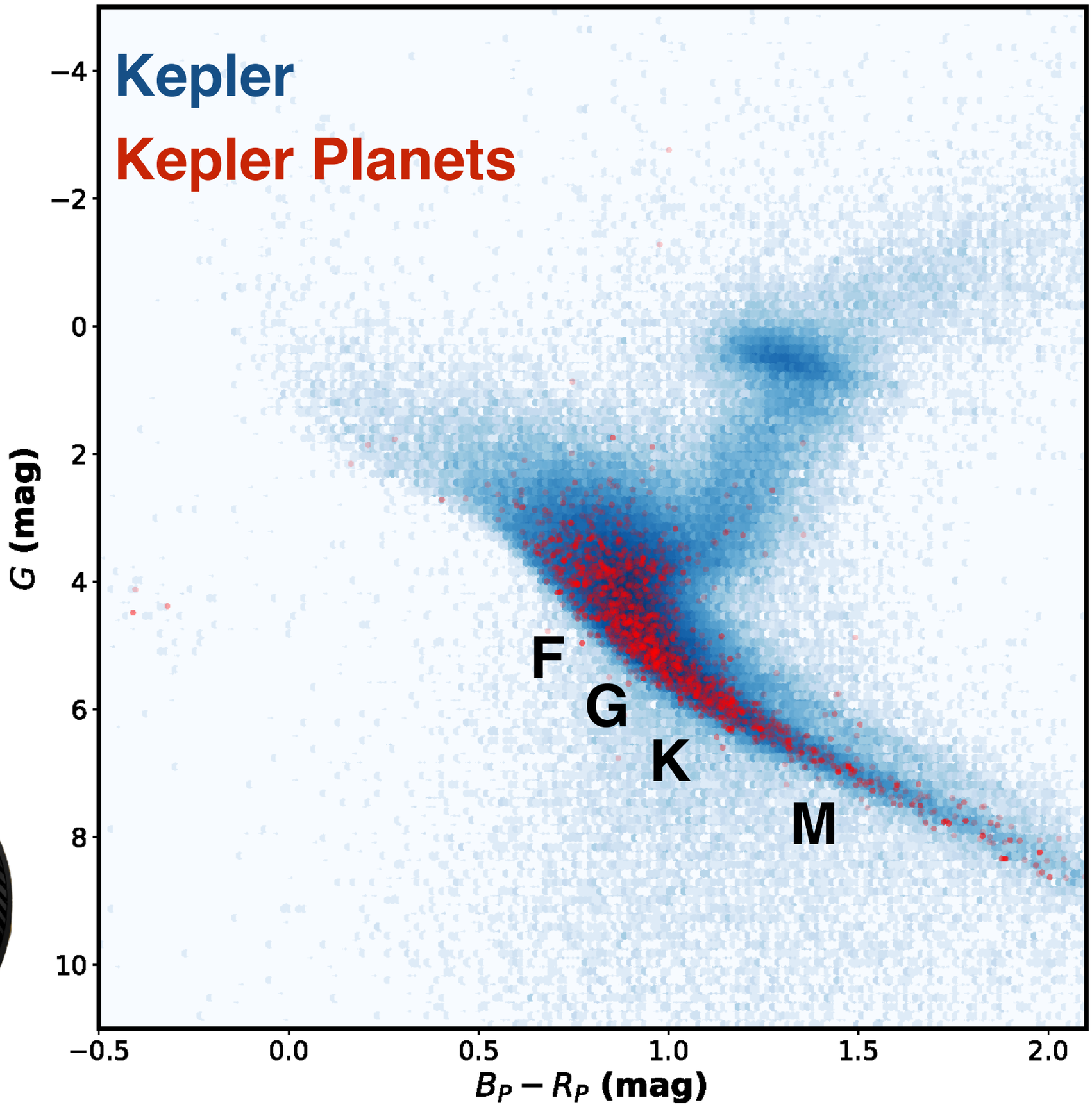
Johnson+ 2010, also see Jones+ 2014

Giant planets from RV

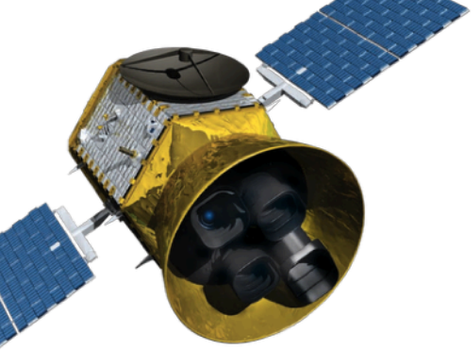


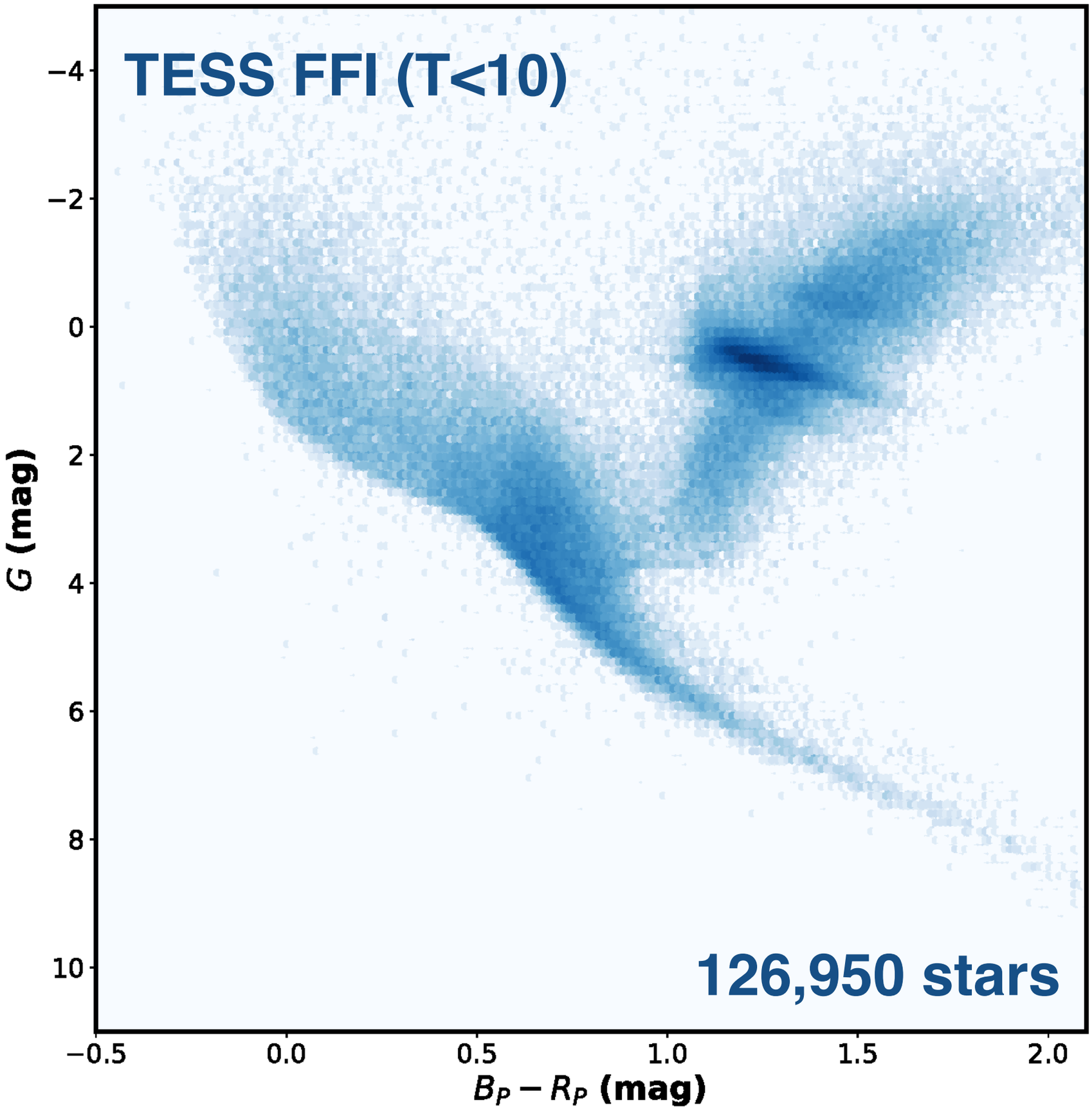
Giant planets from RV

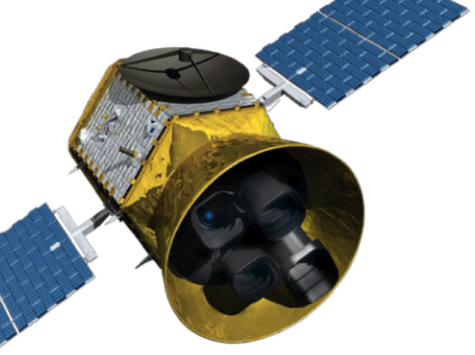


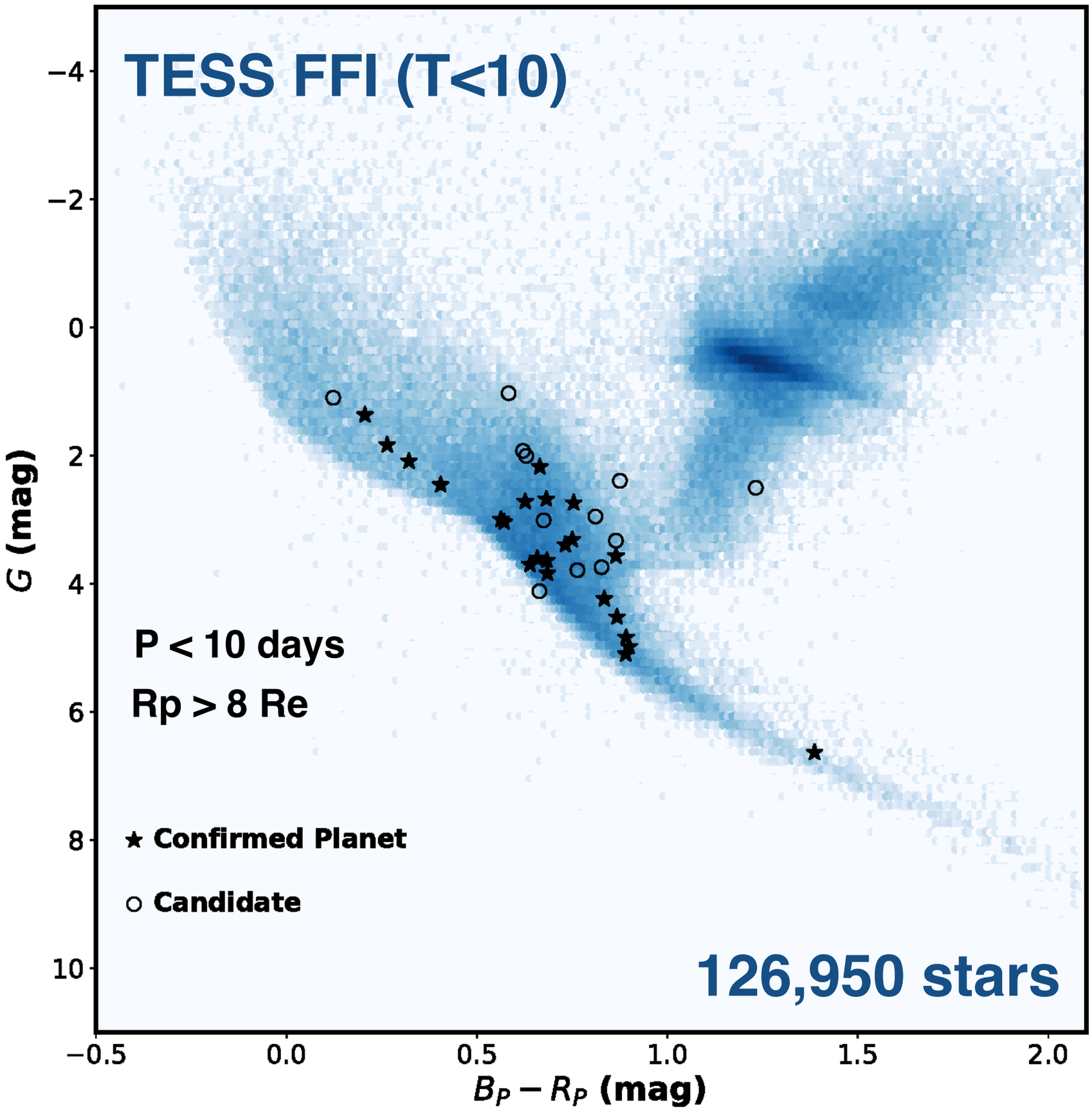

Kepler
Kepler Planets
F
G
K
M
−4
−2
0
2
4
6
8
10
G (mag)
−0.5
0.0
0.5
1.0
1.5
2.0
$B_P - R_P$ (mag)

kepler.fun




TESS FFI (T<10)
126,950 stars
−4
−2
0
2
4
6
8
10
G (mag)
−0.5
0.0
0.5
1.0
1.5
2.0
$B_P - R_P$ (mag)



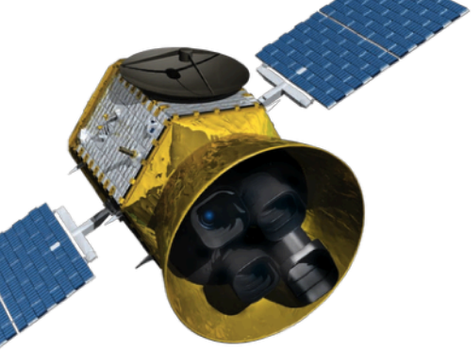


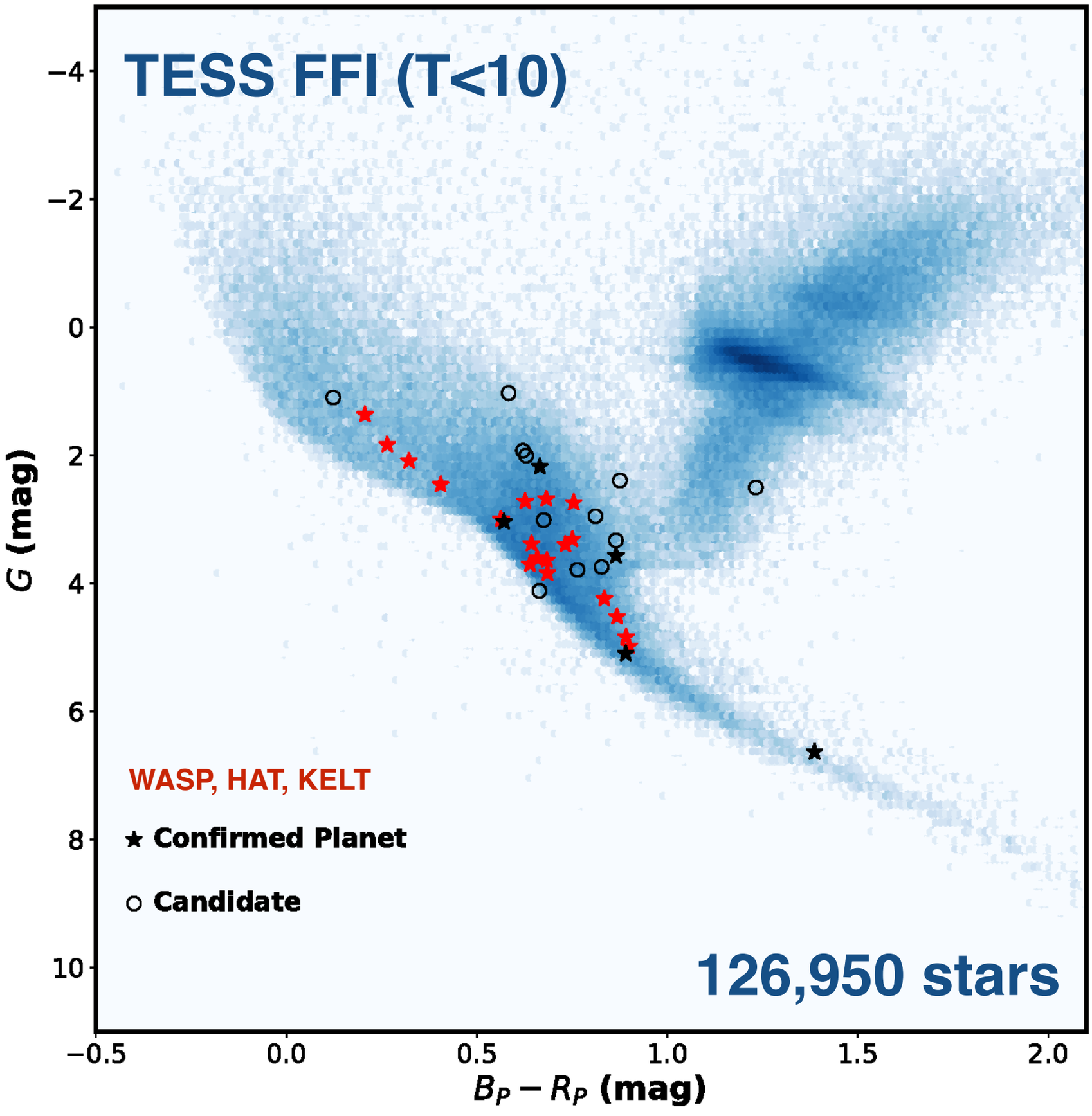
31 candidates

18 confirmed

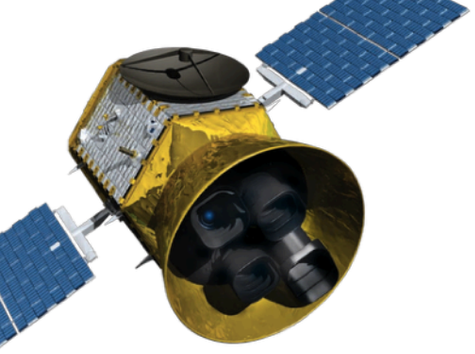
3 active

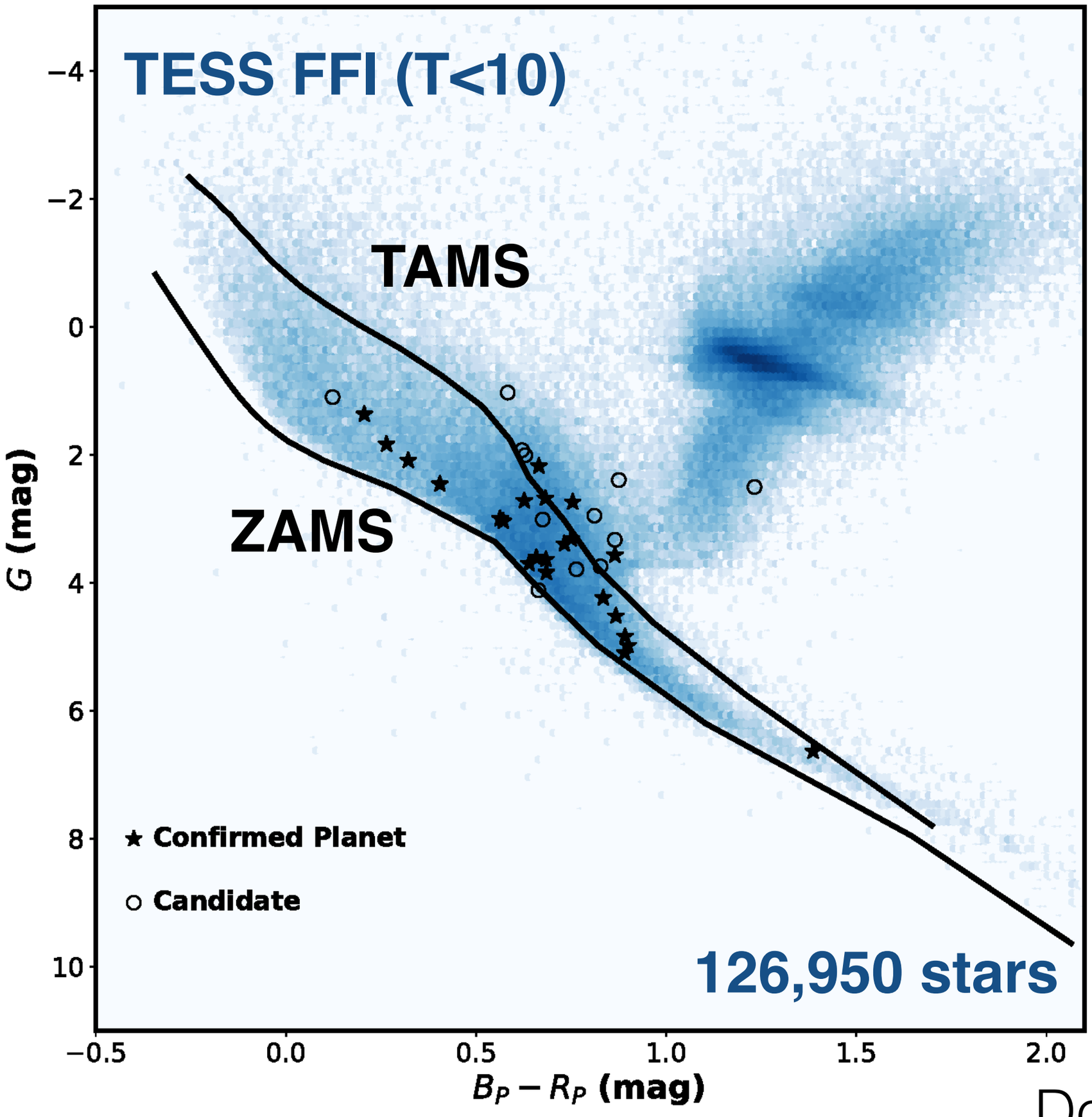
10 False Positives





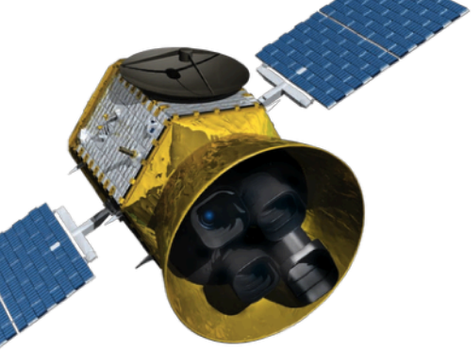
18 confirmed

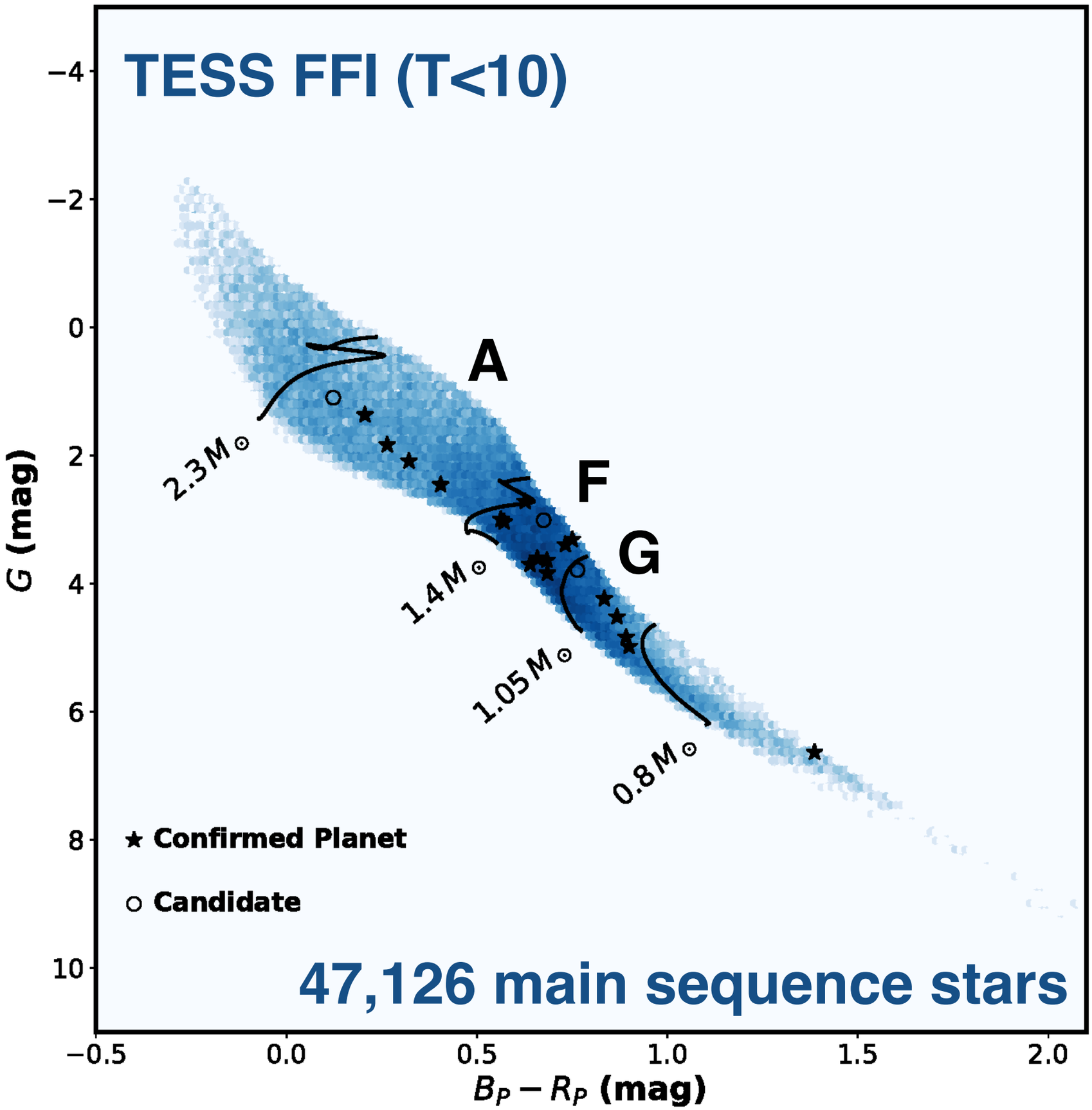


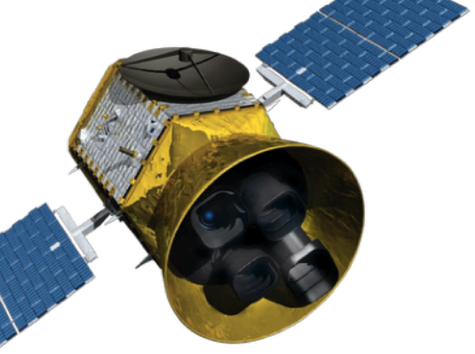


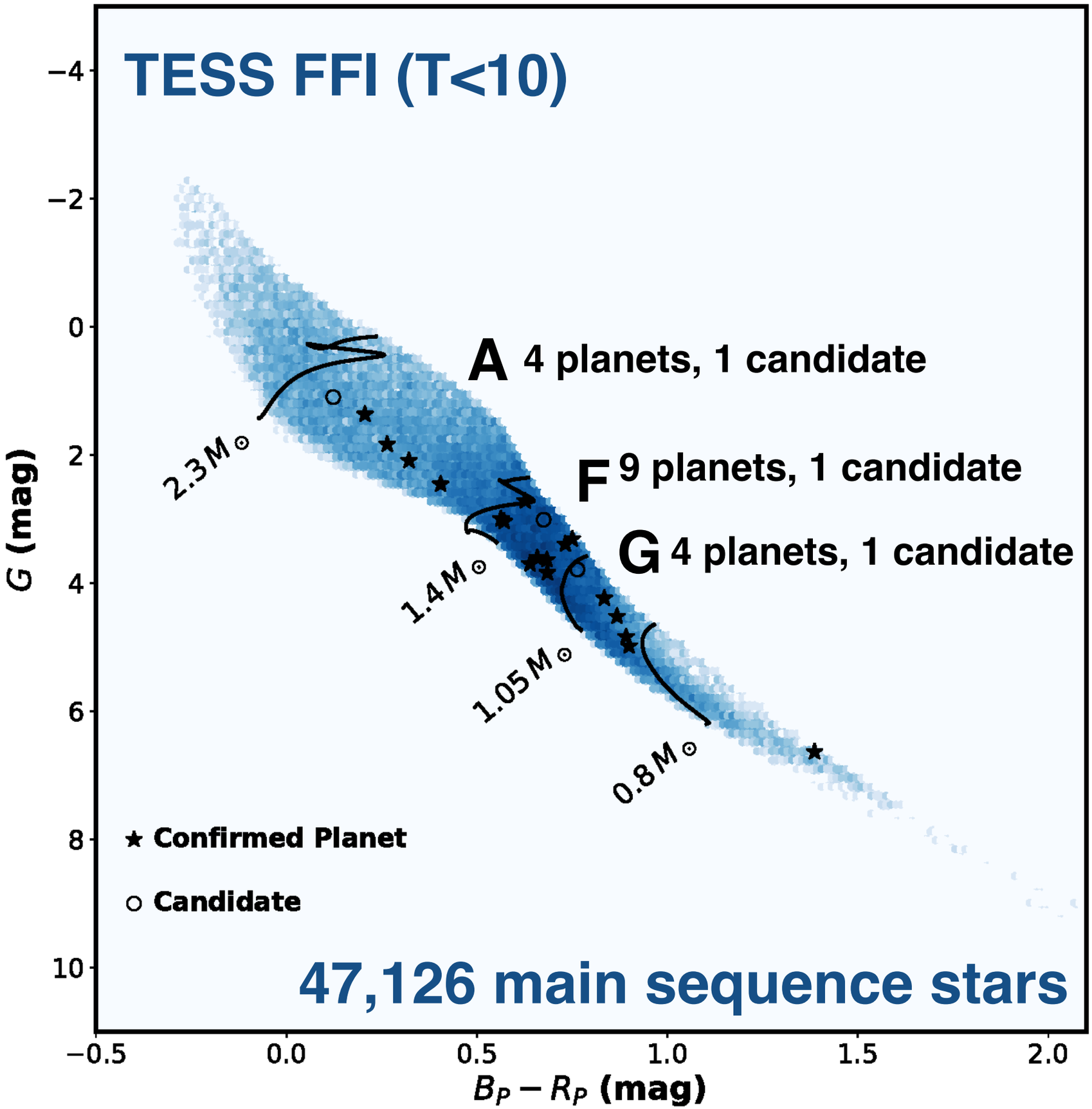
MIST isochrones
(M/H=0)

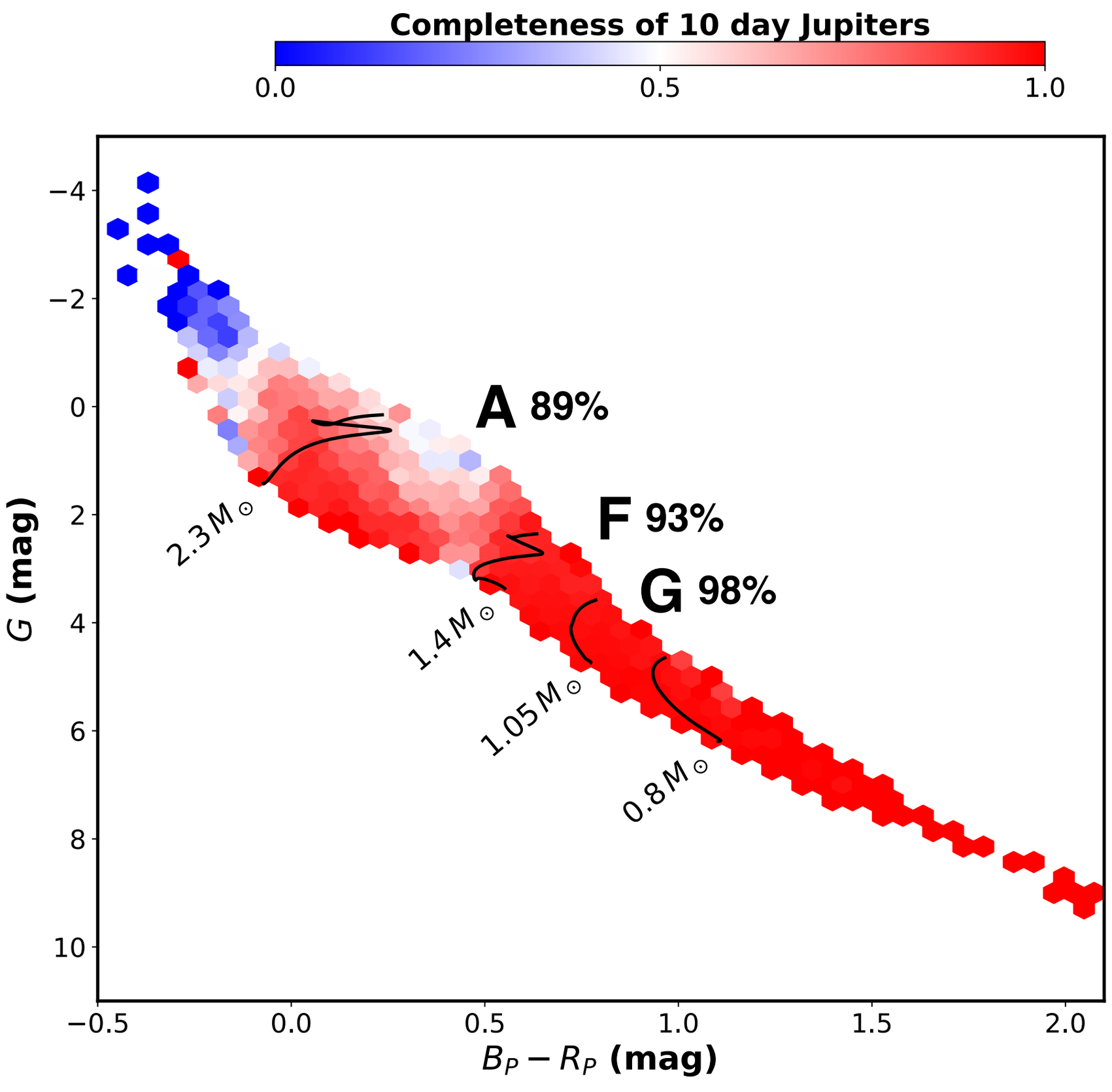
Dotter+ 2016



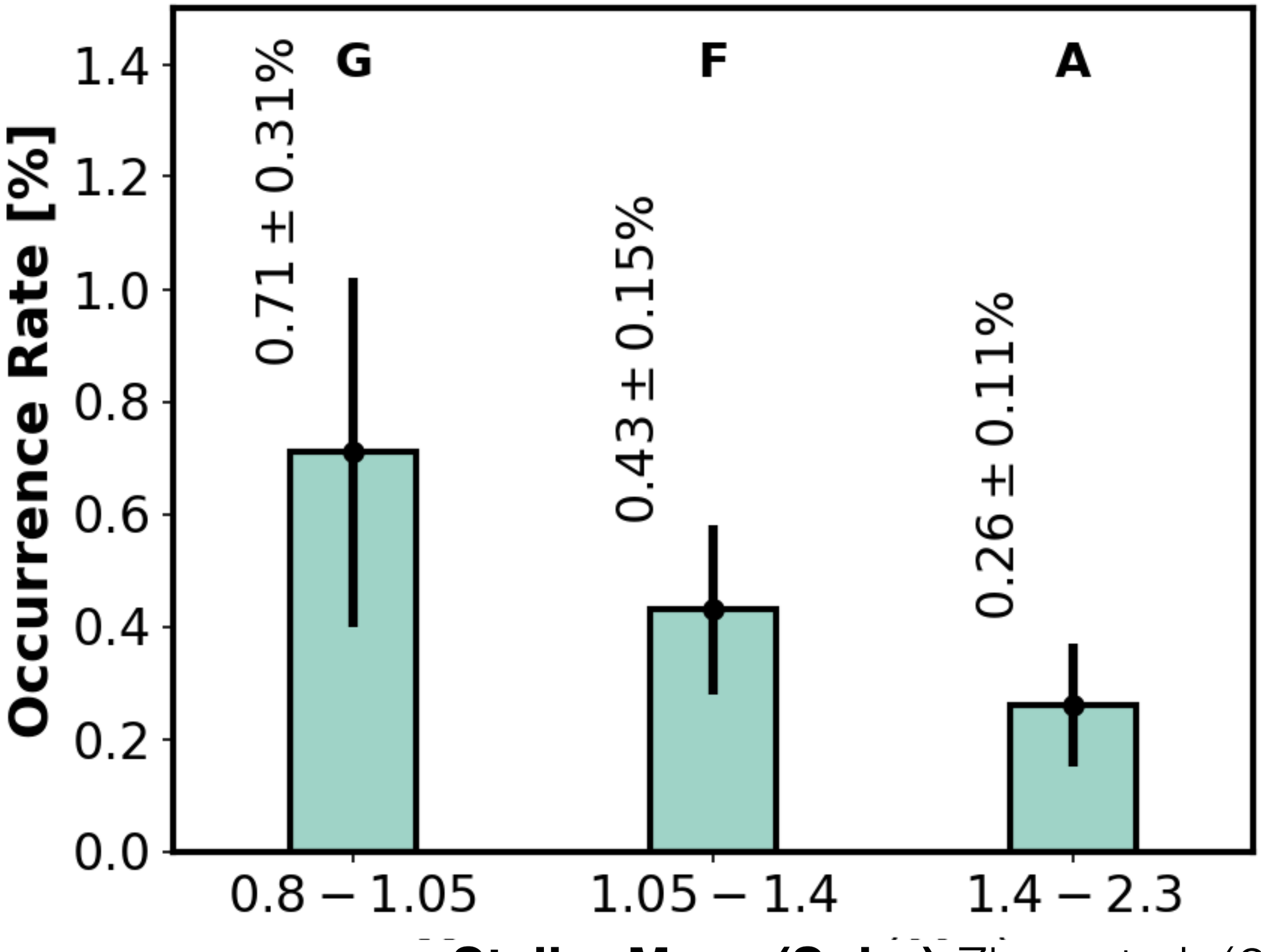

TESS FFI (T<10)
A
F
G
2.3M⊙
1.4M⊙
1.05M⊙
0.8M⊙
★ Confirmed Planet
○ Candidate
47,126 main sequence stars
−4
−2
0
2
4
6
8
10
G (mag)
−0.5
0.0
0.5
1.0
1.5
2.0
$B_P - R_P$ (mag)




TESS FFI (T<10)
A 4 planets, 1 candidate
F 9 planets, 1 candidate
G 4 planets, 1 candidate
2.3M⊙
1.4M⊙
1.05M⊙
0.8M⊙
★ Confirmed Planet
○ Candidate
47,126 main sequence stars
G (mag)
$B_P - R_P$ (mag)
−4
−2
0
2
4
6
8
10
−0.5
0.0
0.5
1.0
1.5
2.0

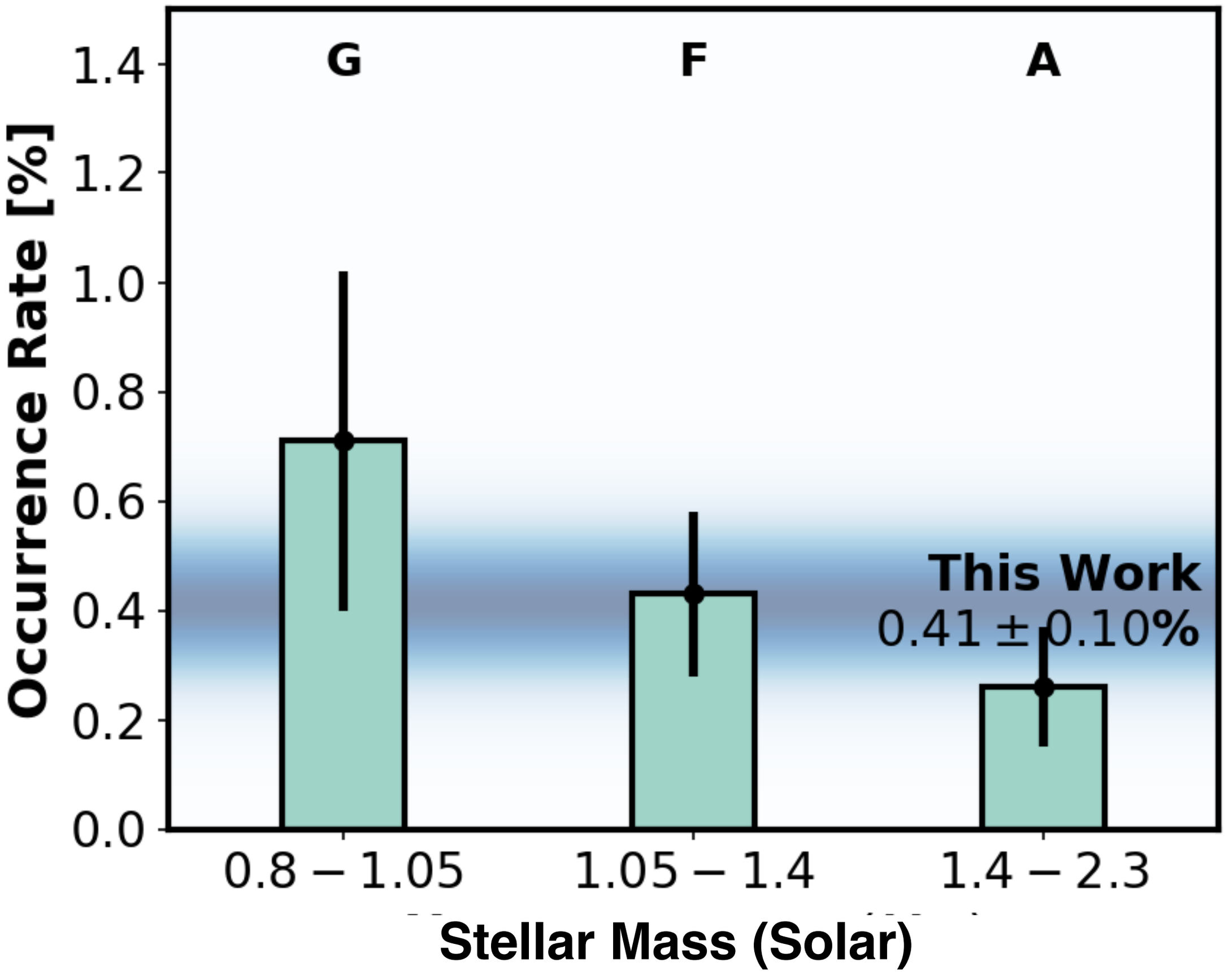

Completeness of 10 day Jupiters
0.0
0.5
1.0
A 89%
F 93%
G 98%
2.3M⊙
1.4M⊙
1.05M⊙
0.8M⊙
G (mag)
$B_P - R_P$ (mag)
−4
−2
0
2
4
6
8
10
−0.5
0.0
0.5
1.0
1.5
2.0

TESS HJ Occurrence Rate

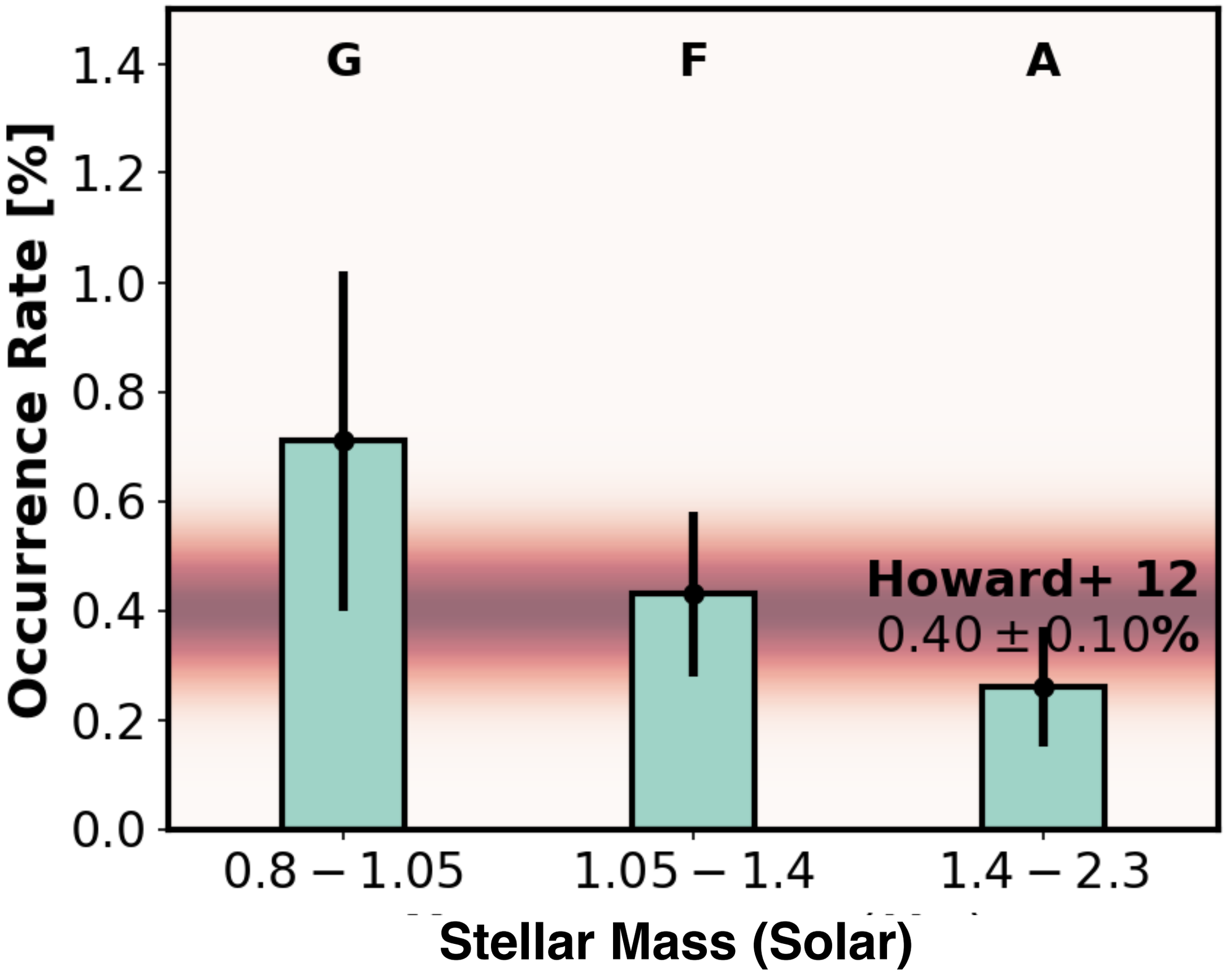


Zhou et al. (2019)

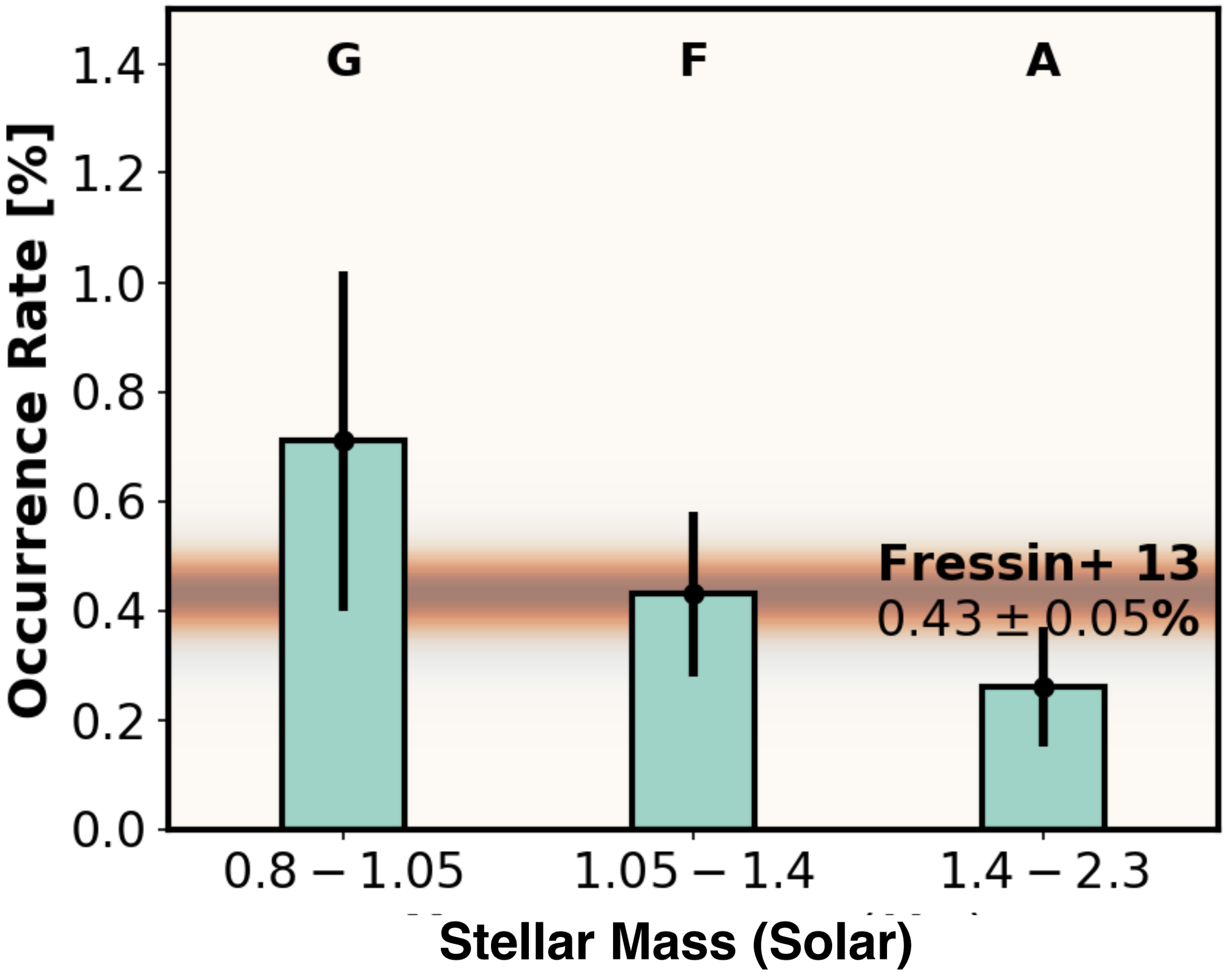
TESS HJ Occurrence Rate



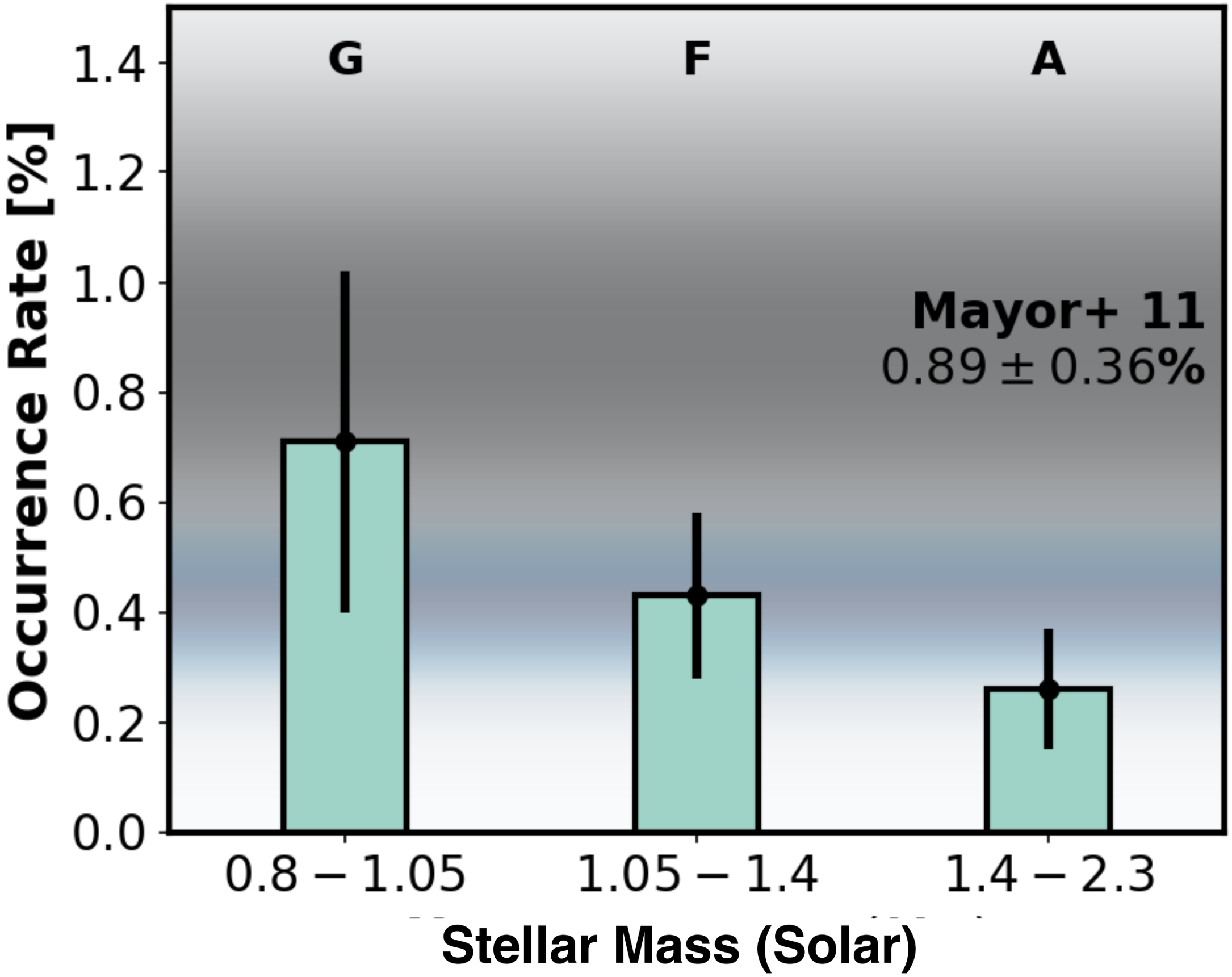
TESS vs Kepler HJ Occurrence Rate



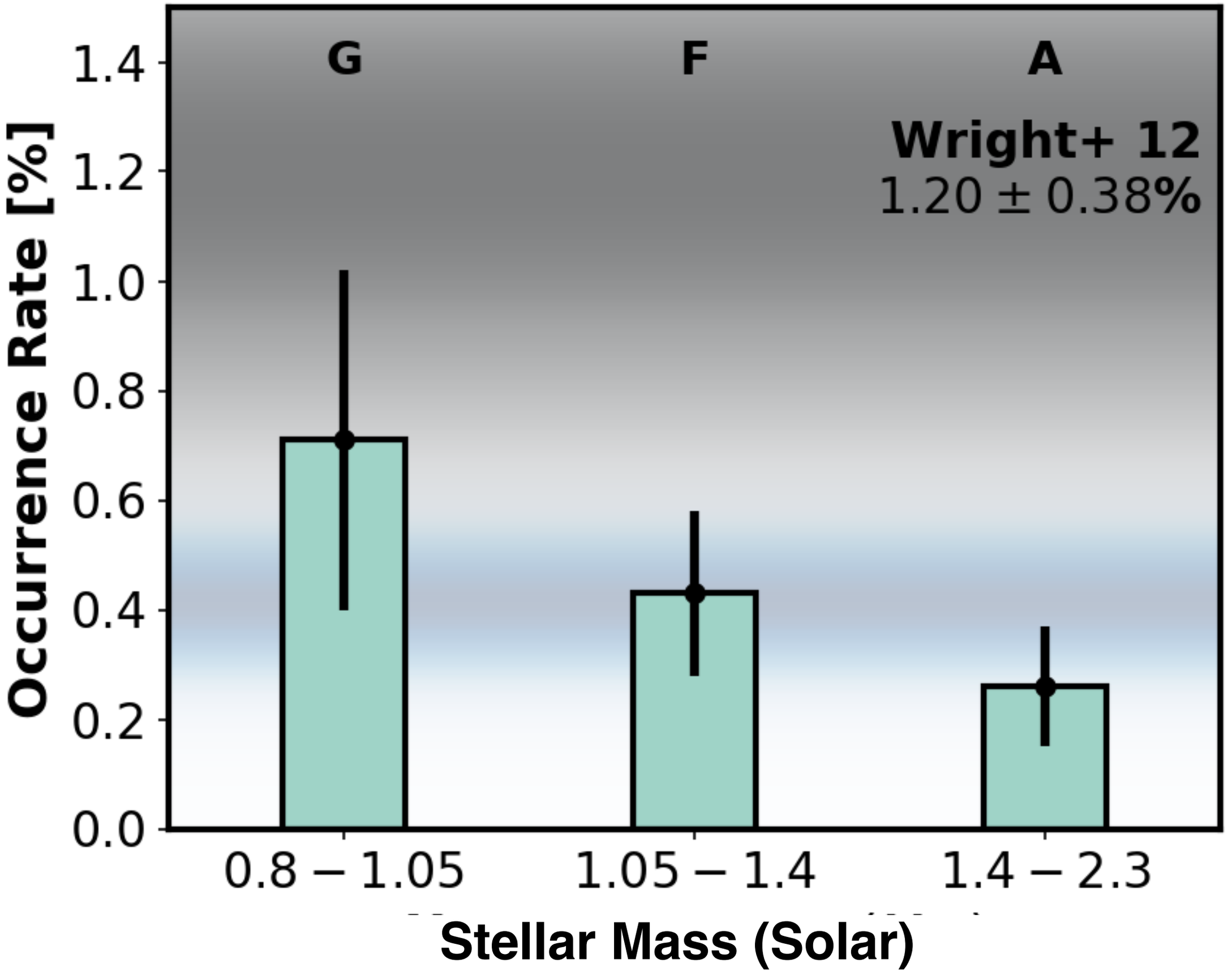
TESS vs Kepler HJ Occurrence Rate

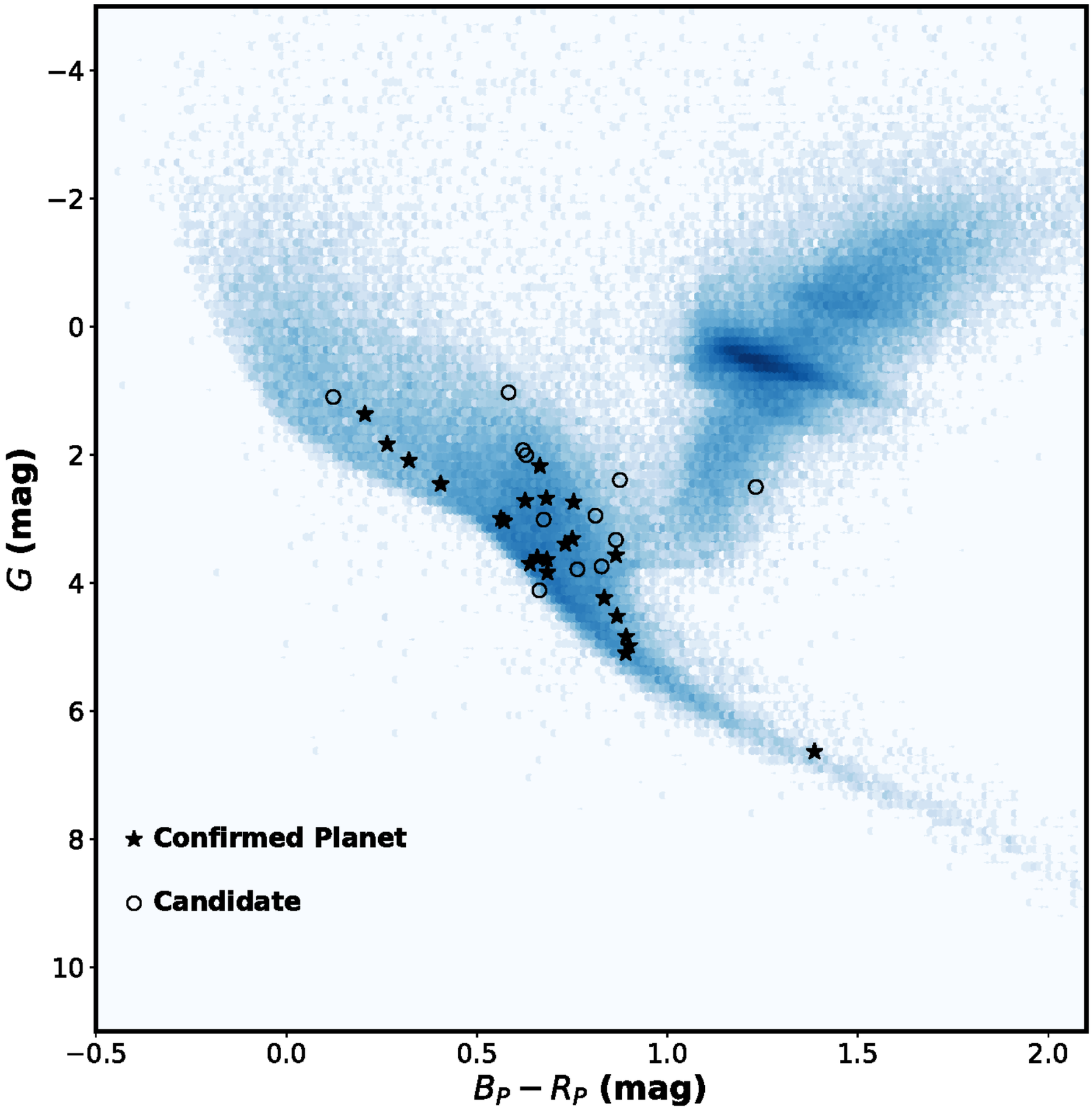


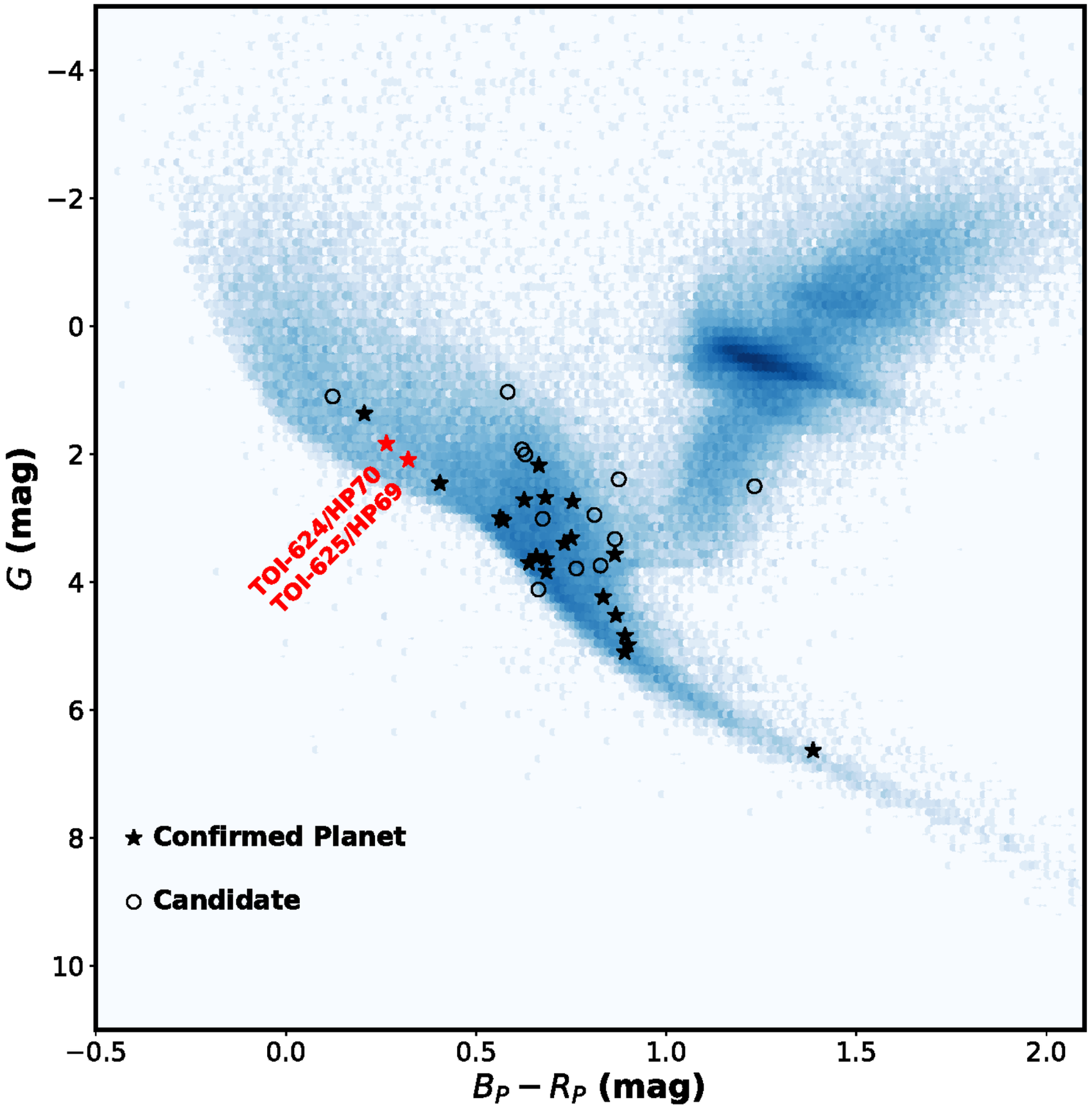
TESS vs RV HJ Occurrence Rate

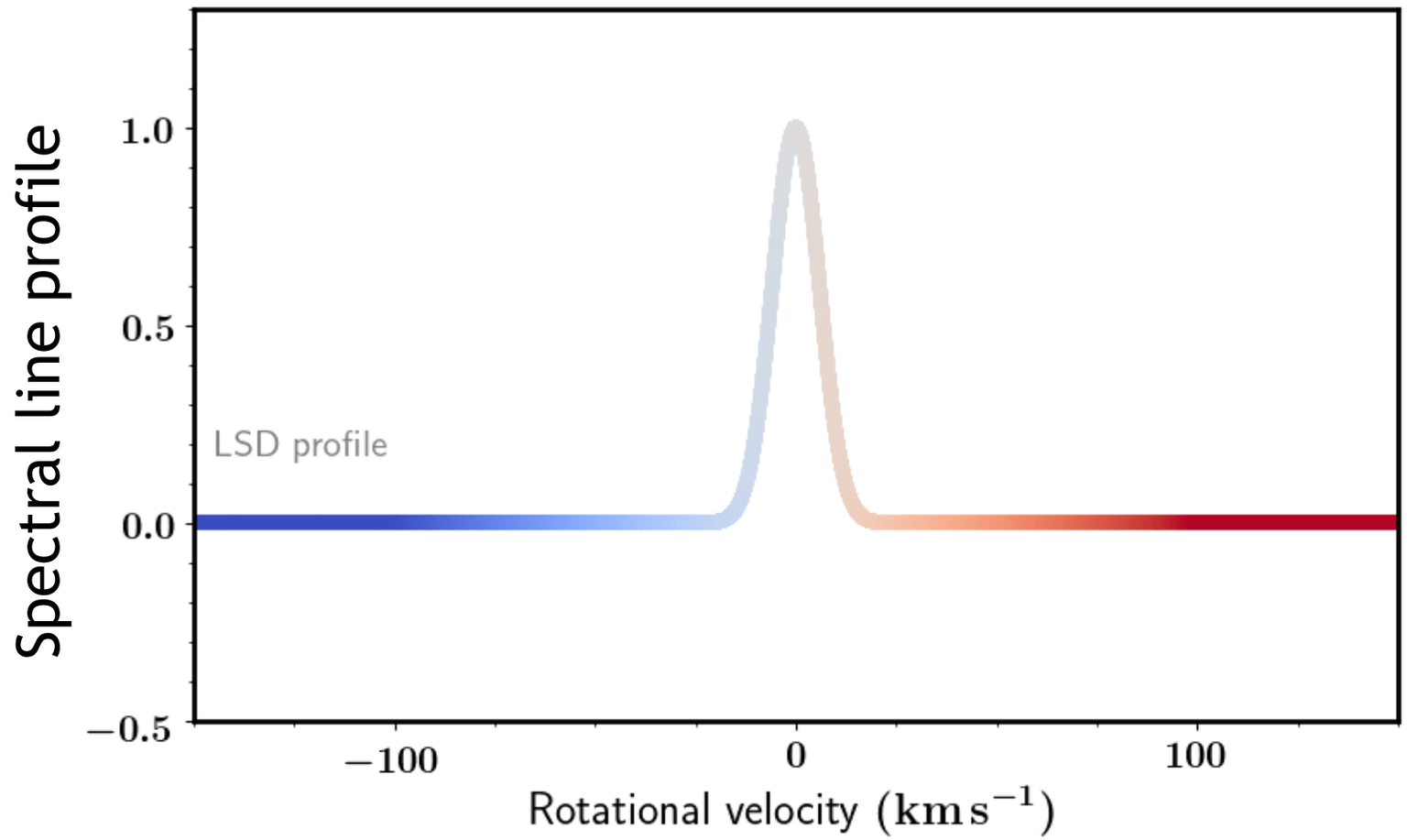


TESS vs RV HJ Occurrence Rate

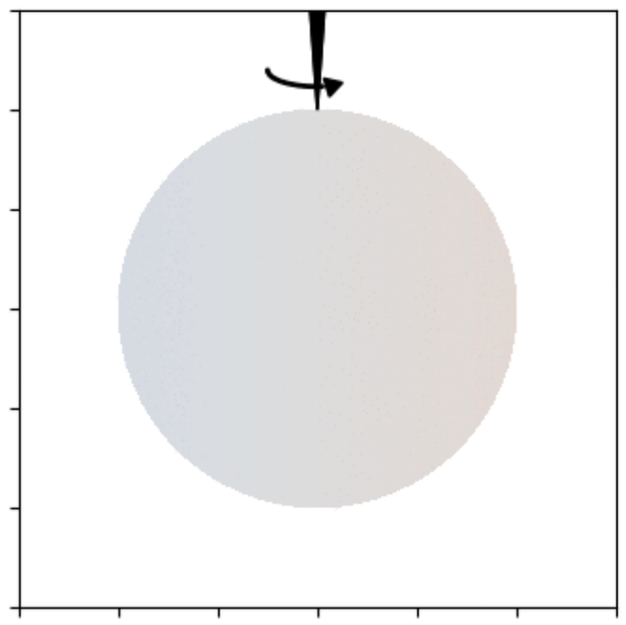



−4
−2
0
2
4
6
8
10
G (mag)
−0.5
0.0
0.5
1.0
1.5
2.0
$B_P - R_P$ (mag)
★ Confirmed Planet
○ Candidate

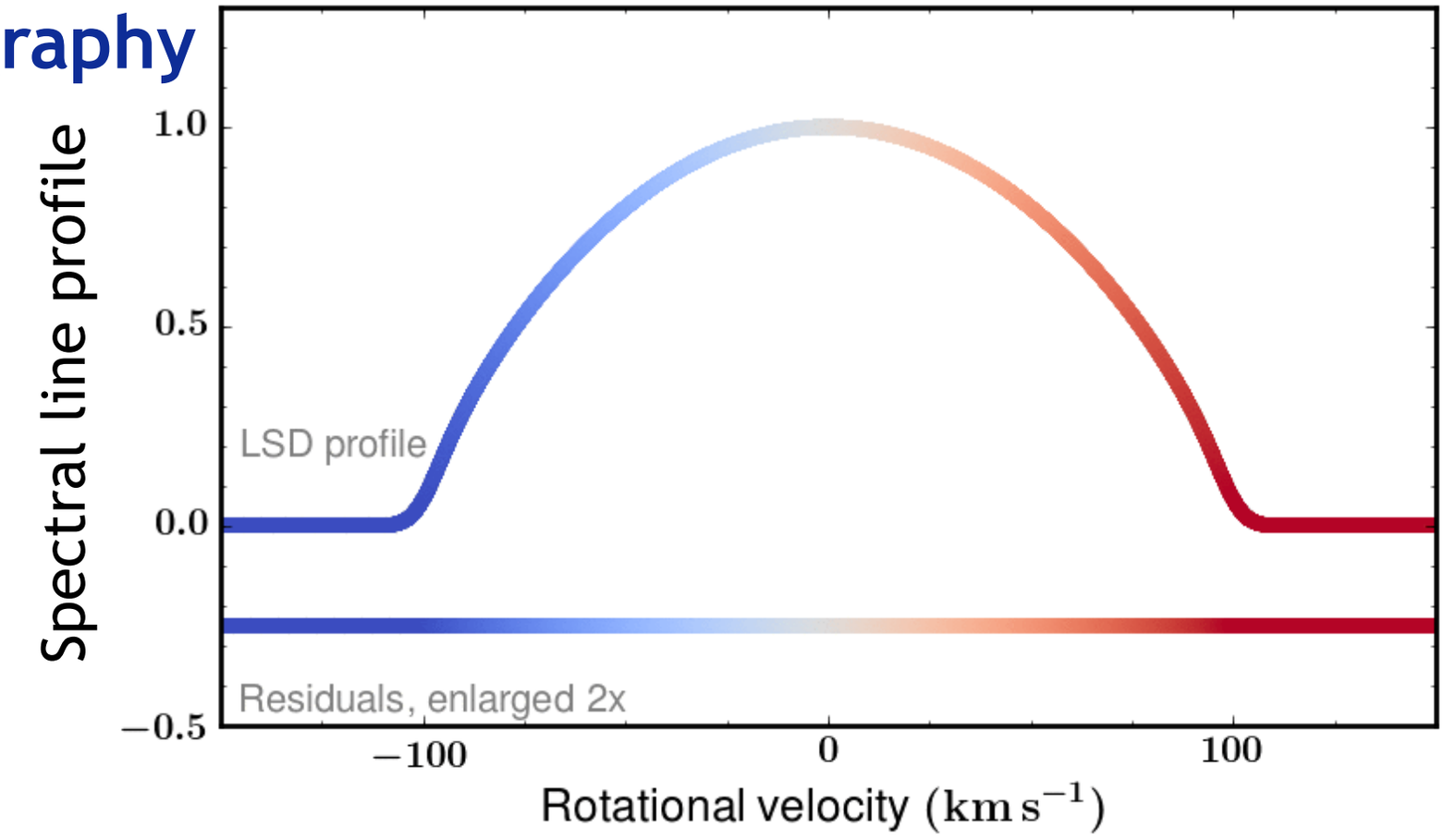

TOI-624/HP70
TOI-625/HP69
★ Confirmed Planet
○ Candidate
G (mag)
$B_P - R_P$ (mag)
−4
−2
0
2
4
6
8
10
−0.5
0.0
0.5
1.0
1.5
2.0

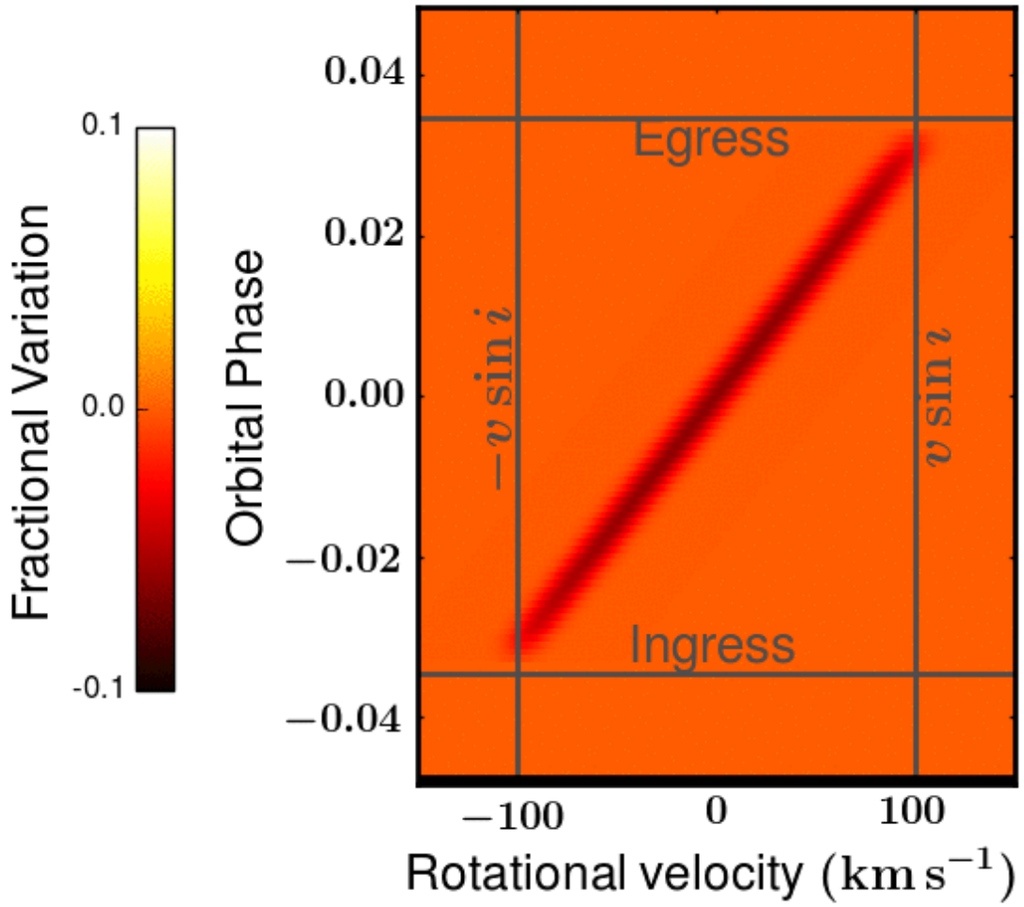


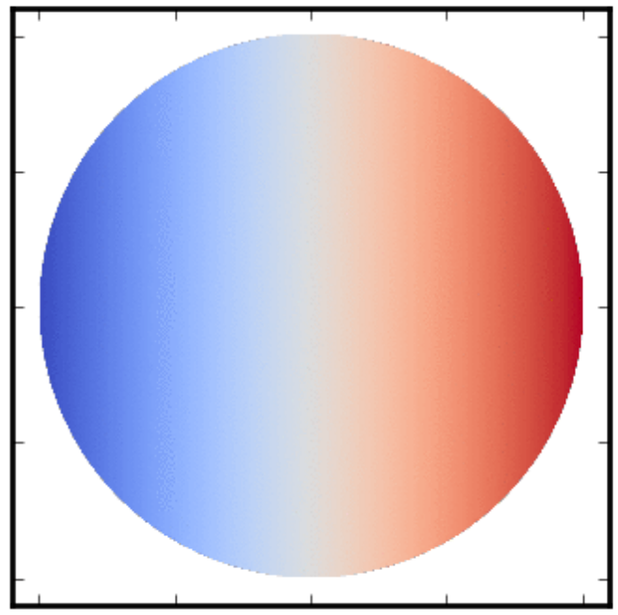
Early type stars are rapidly rotating



Doppler tomography

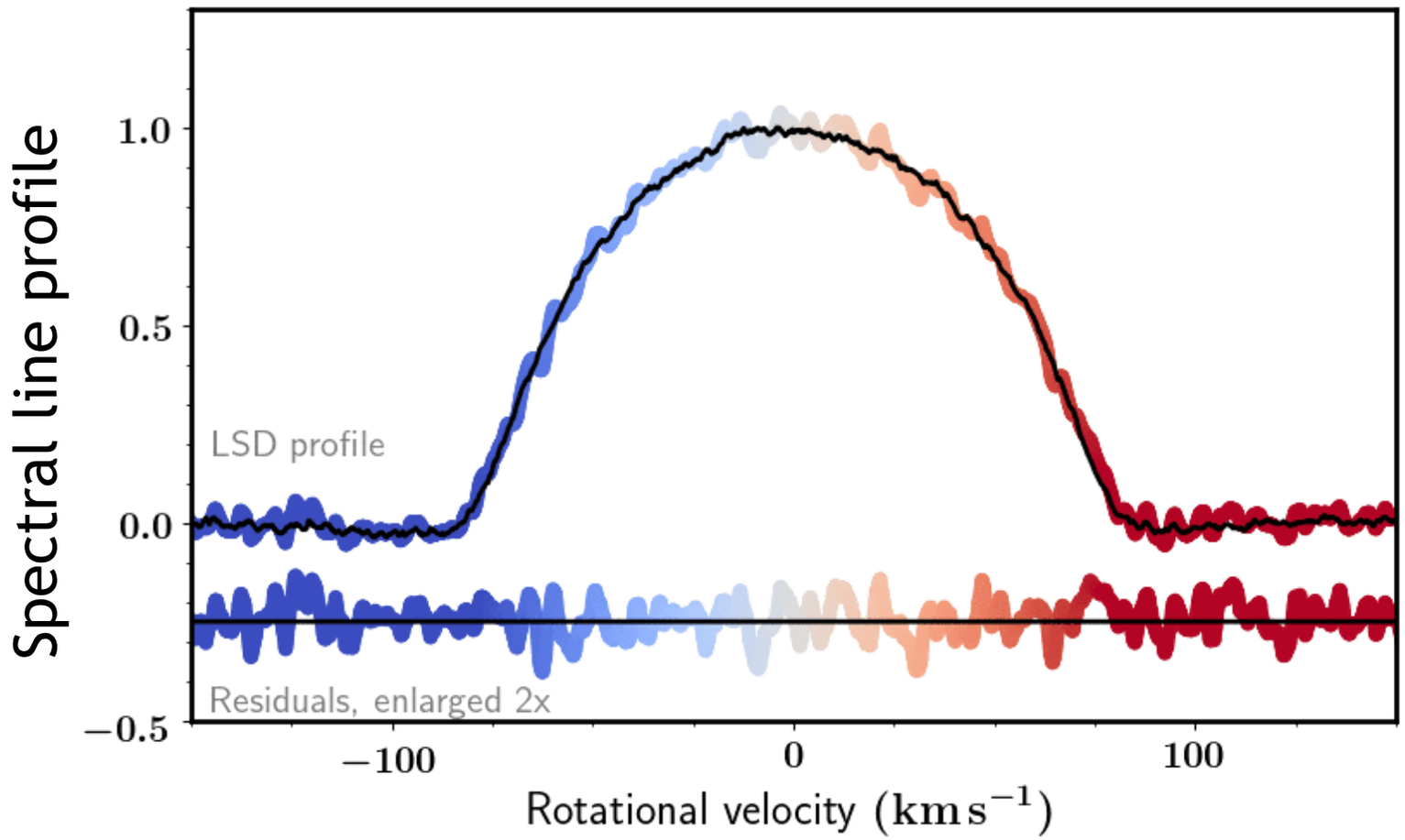


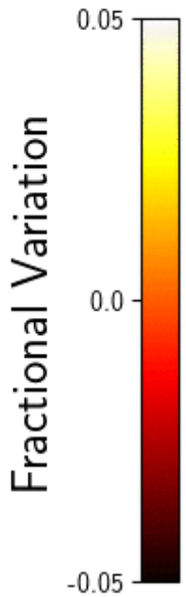


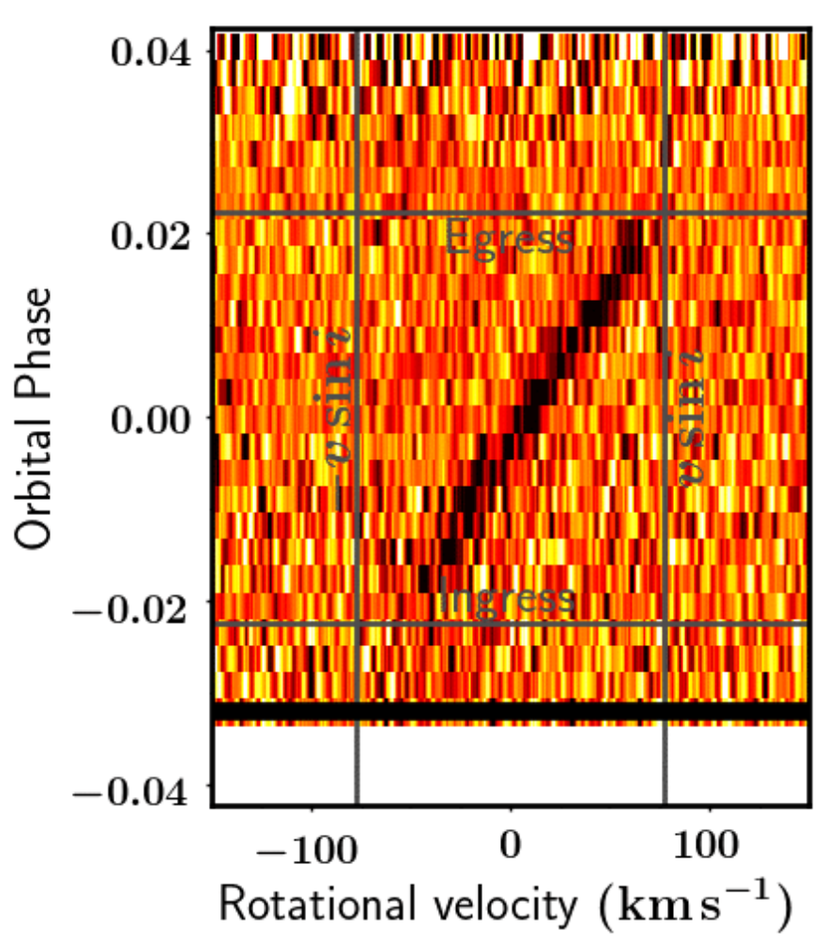


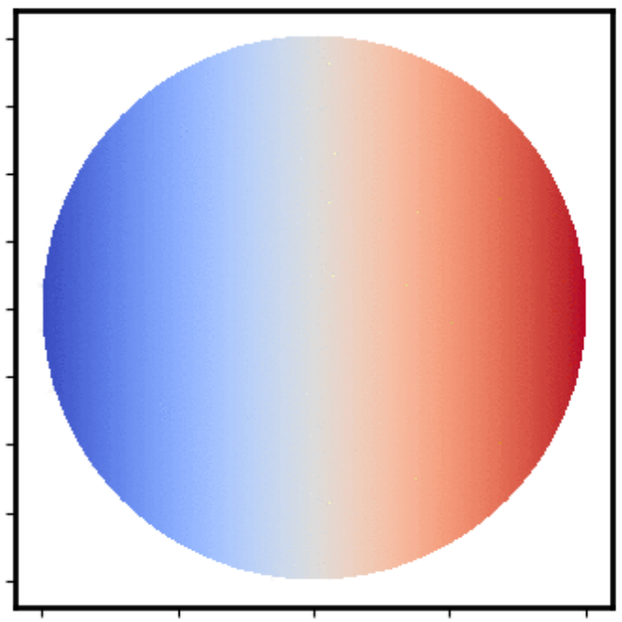
See Donati+ 1997
Collier Cameron+ 2010

TOI-625
HAT-P-69b



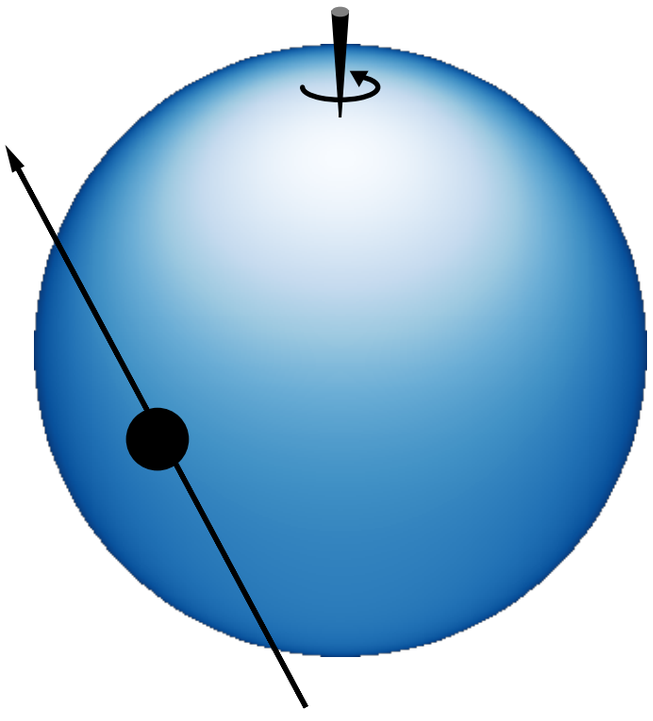


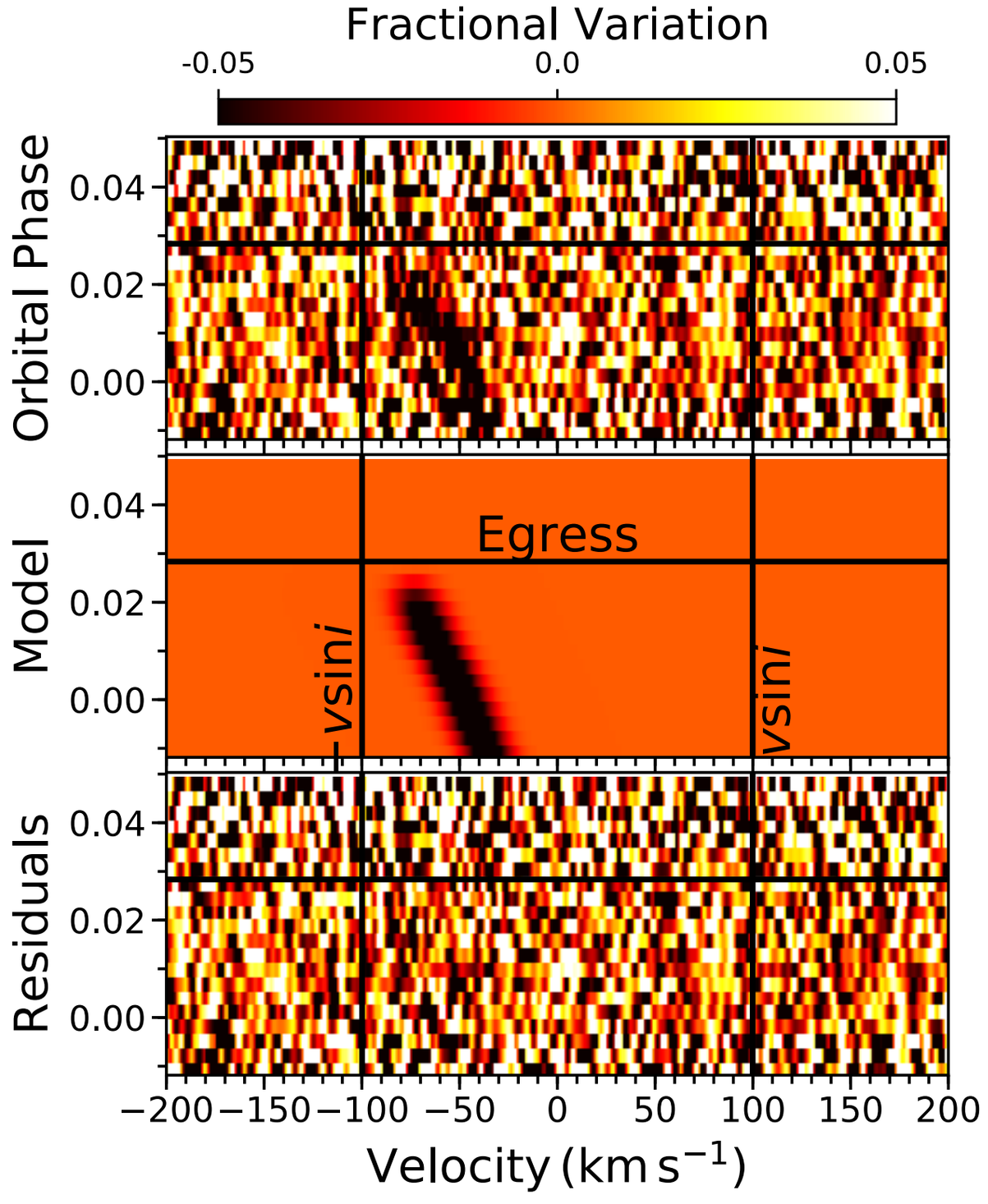




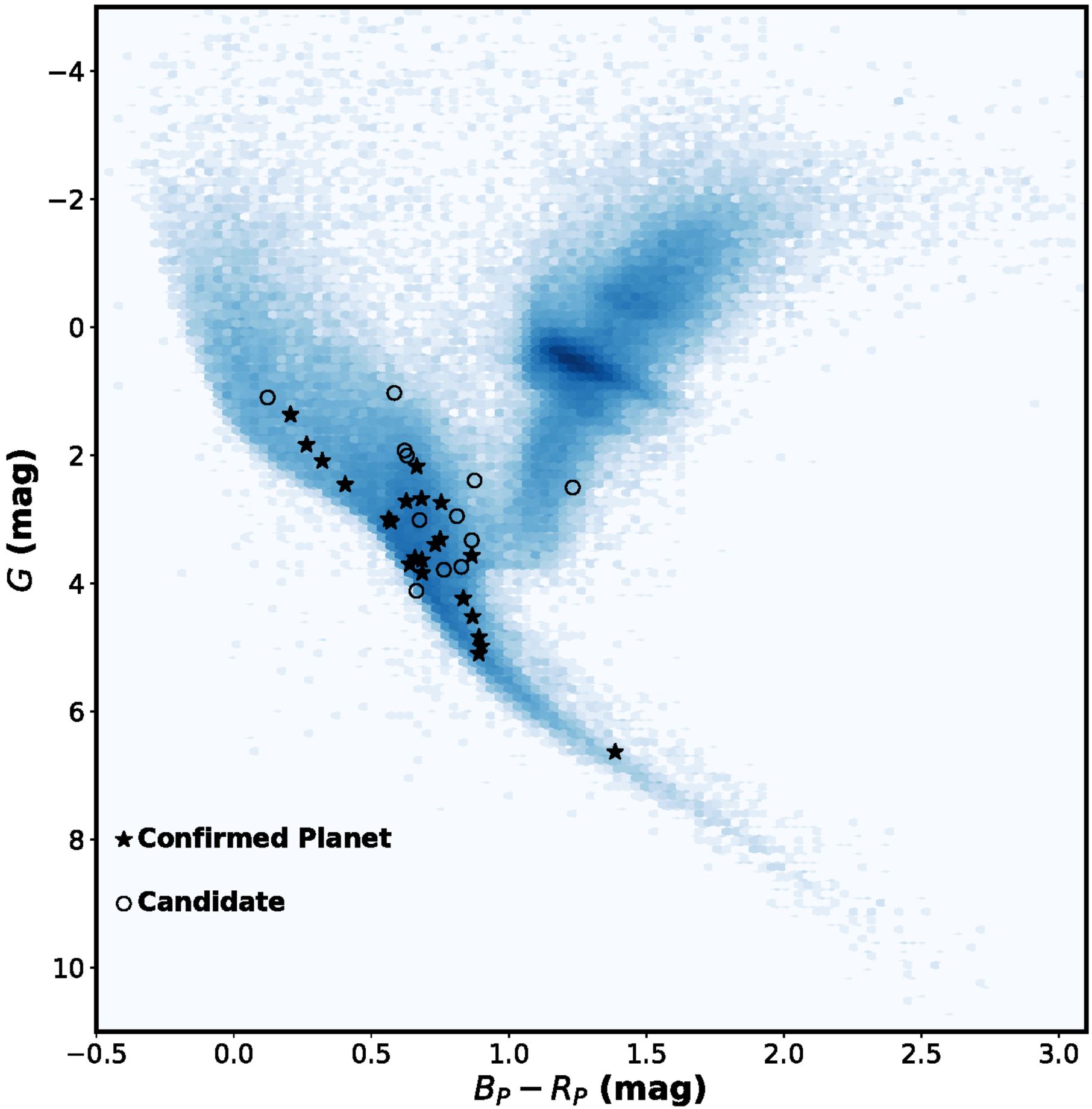
1.5m FLWO / TRES

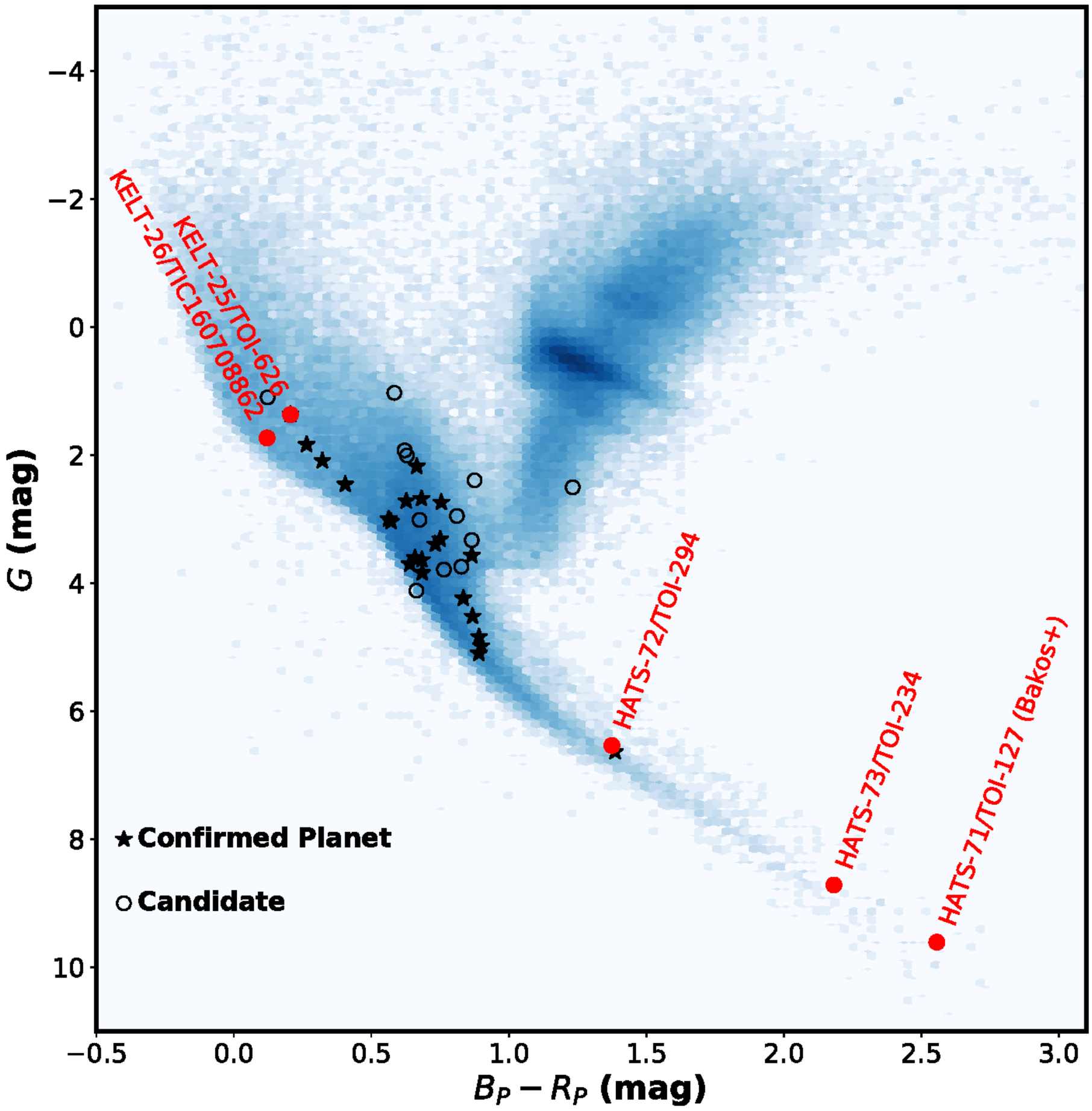
TOI-624
HAT-P-70b



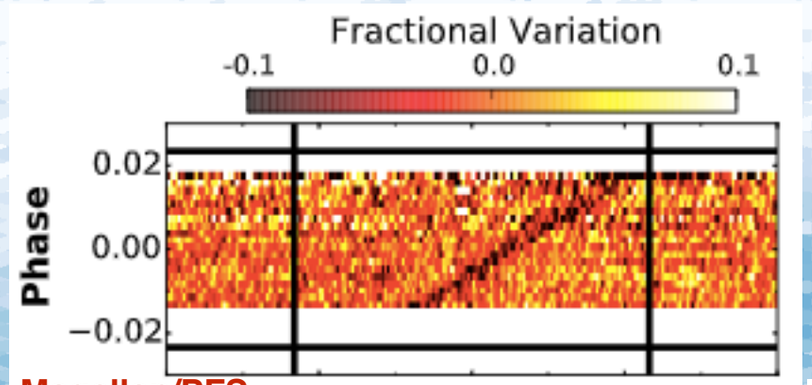


1.5m FLWO / TRES

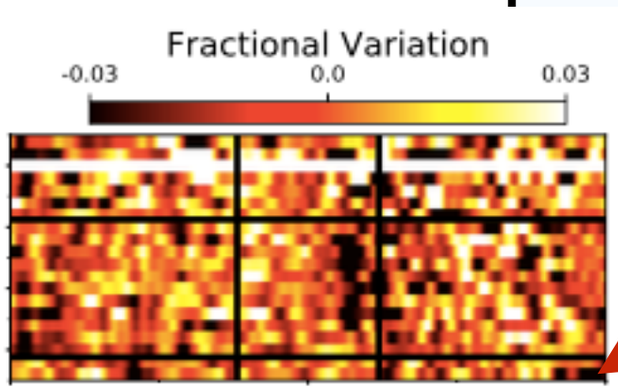

−4
−2
0
2
4
6
8
10
G (mag)
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
$B_P - R_P$ (mag)
Confirmed Planet
Candidate


KELT-26/TIC160708862
KELT-25/TOI-626
HATS-72/TOI-294
HATS-73/TOI-234
HATS-71/TOI-127 (Bakos+)
Confirmed Planet
Candidate
G (mag)
$B_P - R_P$ (mag)
−4
−2
0
2
4
6
8
10
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0

Romy Rodriguez+



Magellan/PFS



Minerva-Australis

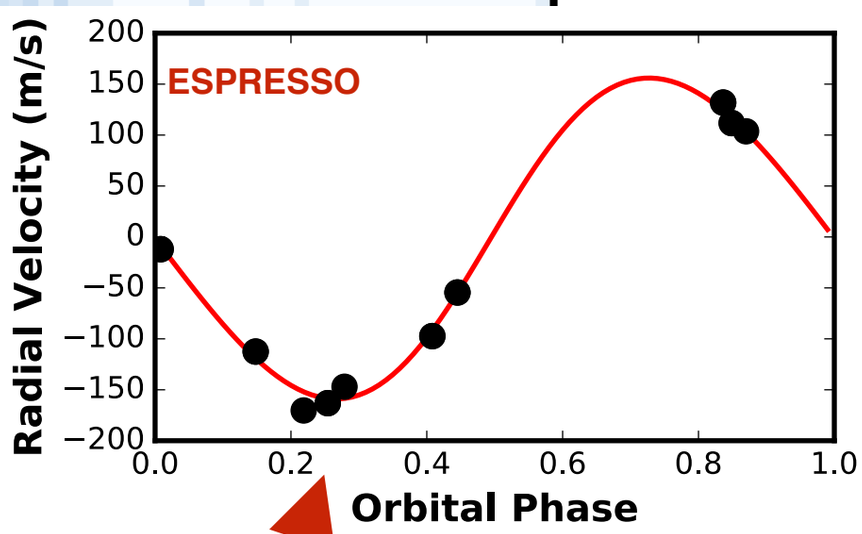
KELT-26/TIC160708862

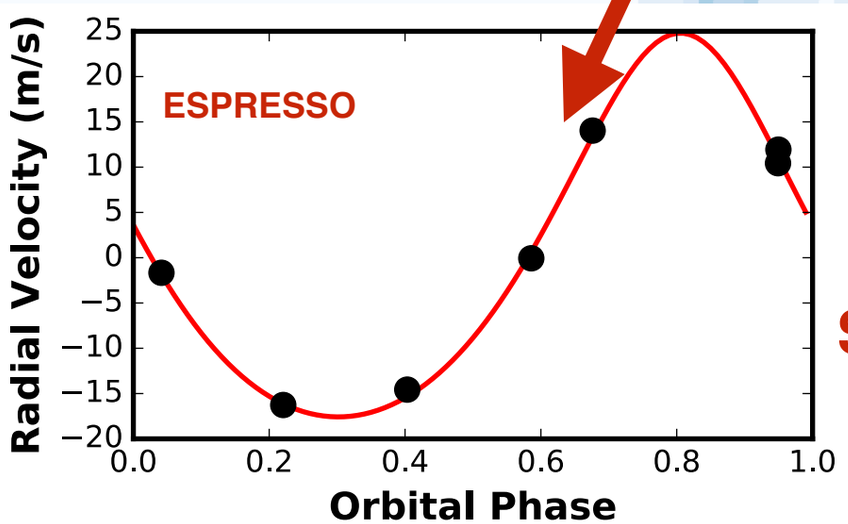
KELT-25/TOI-626

HATS-72/TOI-294

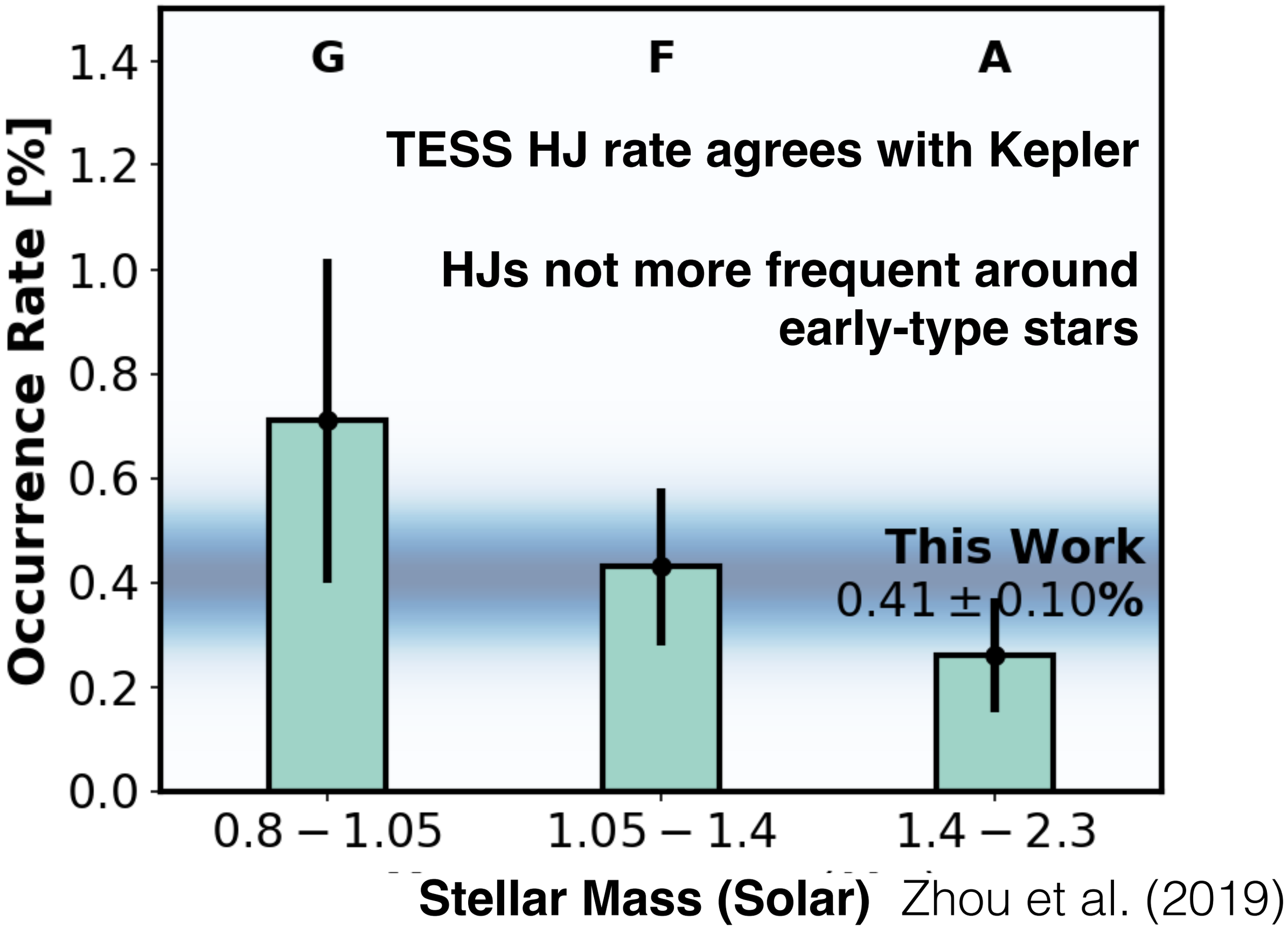
HATS-73/TOI-234

HATS-71/TOI-127 (Bakos+)

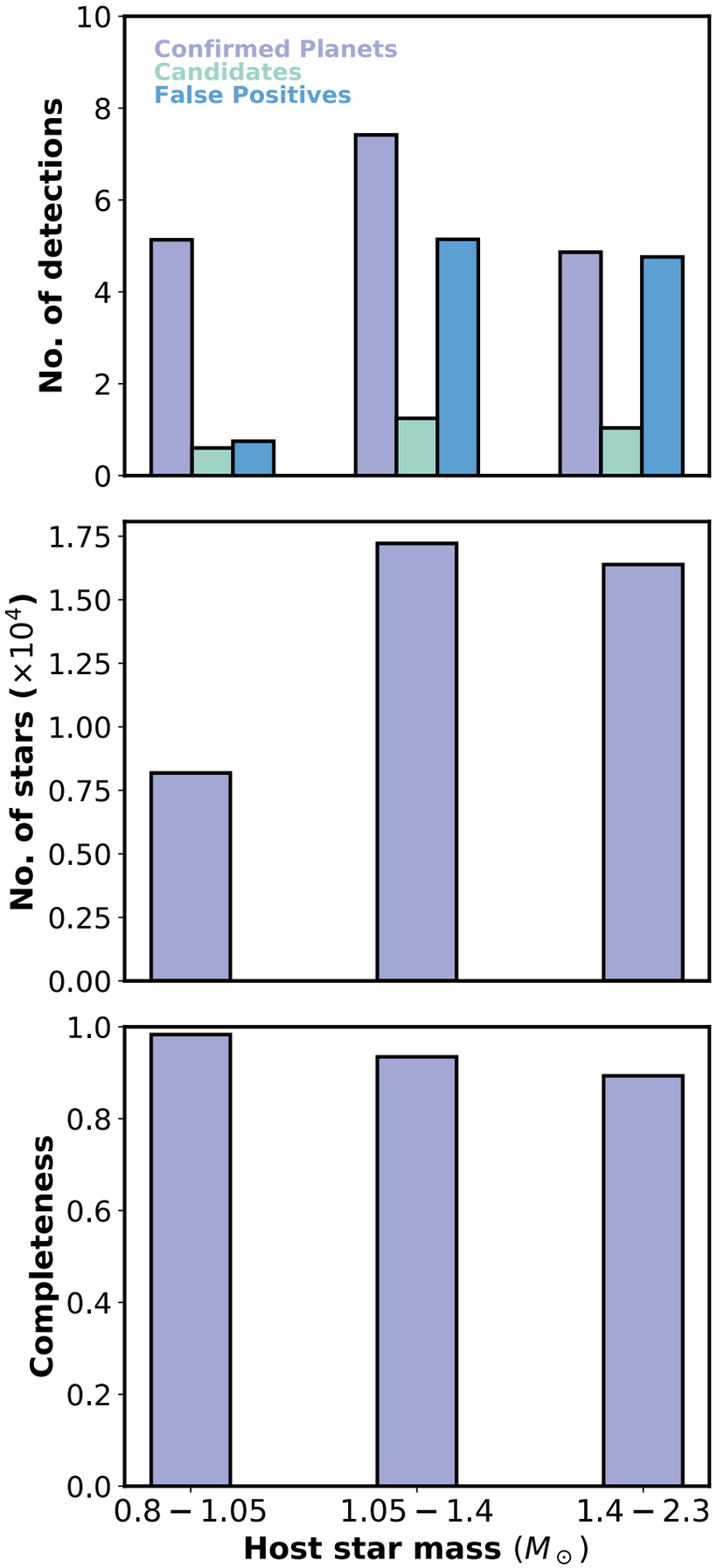




See Daniel Bayliss



Zhou et al. (2019)


Confirmed Planets
Candidates
False Positives
No. of detections
No. of stars ($\times 10^4$)
Completeness
0.8 − 1.05
1.05 − 1.4
1.4 − 2.3
Host star mass ($M_\odot$)

N

$M_\star\ (M_\odot)$

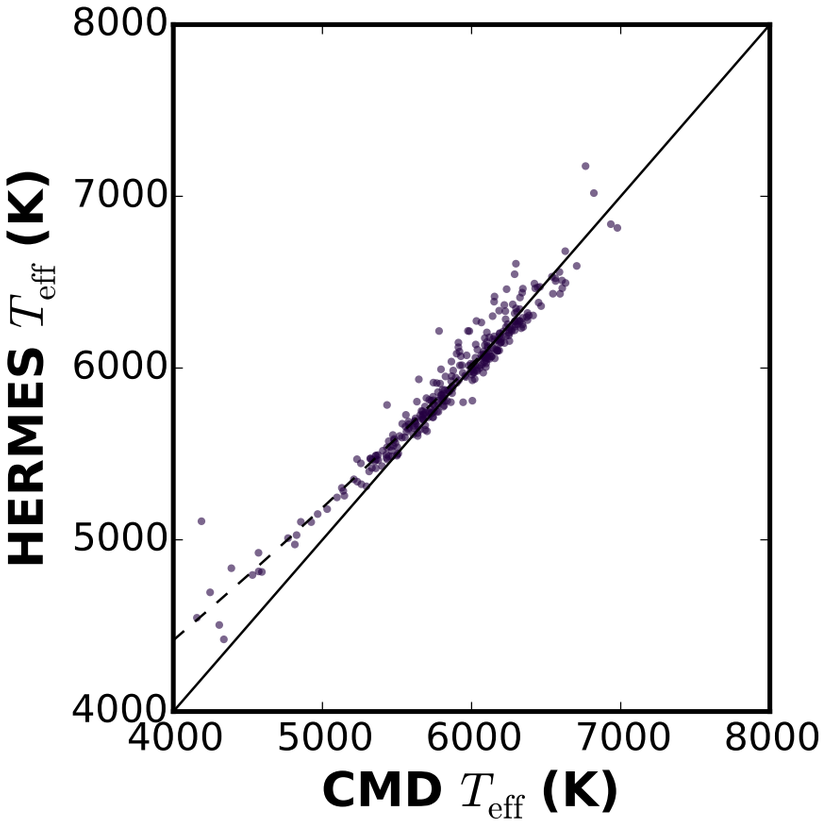
$T_{\rm mag}$

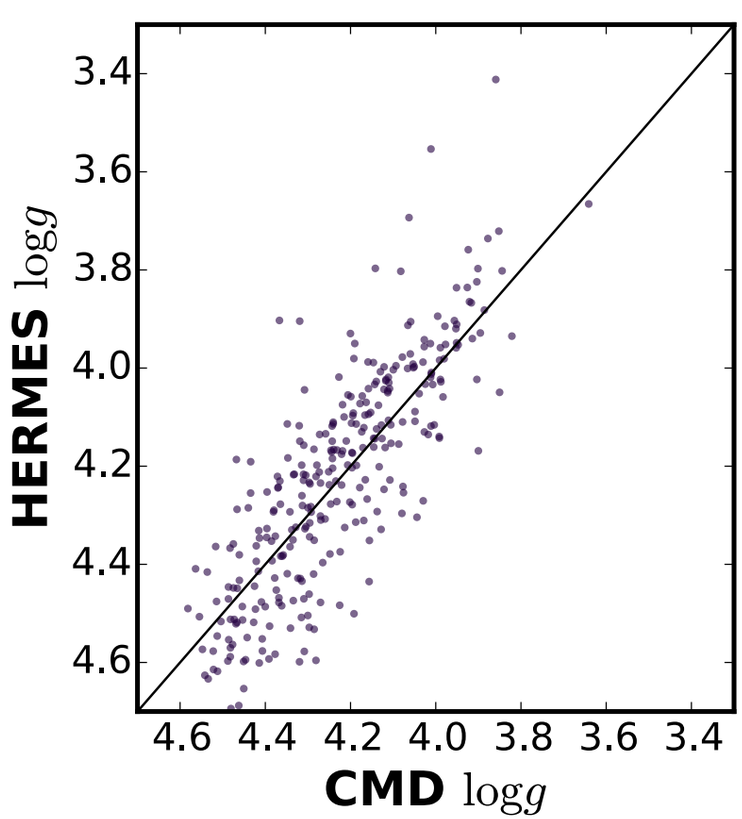
Distance (pc)

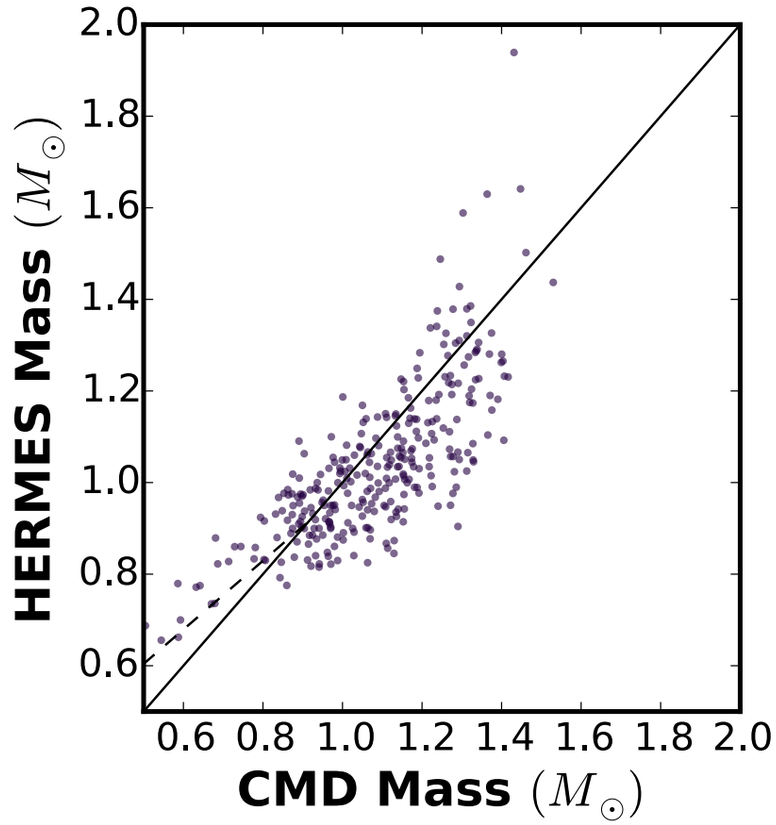
$T_{\rm eff}$ (K)

$\log\ g$

TESS-HERMES $[M/H]$


8000
7000
6000
5000
4000
4000
5000
6000
7000
8000
HERMES $T_{\rm eff}$ (K)
CMD $T_{\rm eff}$ (K)


3.4
3.6
3.8
4.0
4.2
4.4
4.6
4.6 4.4 4.2 4.0 3.8 3.6 3.4
HERMES $\log g$
CMD $\log g$


2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0
HERMES Mass $(M_\odot)$
CMD Mass $(M_\odot)$

TOI-624
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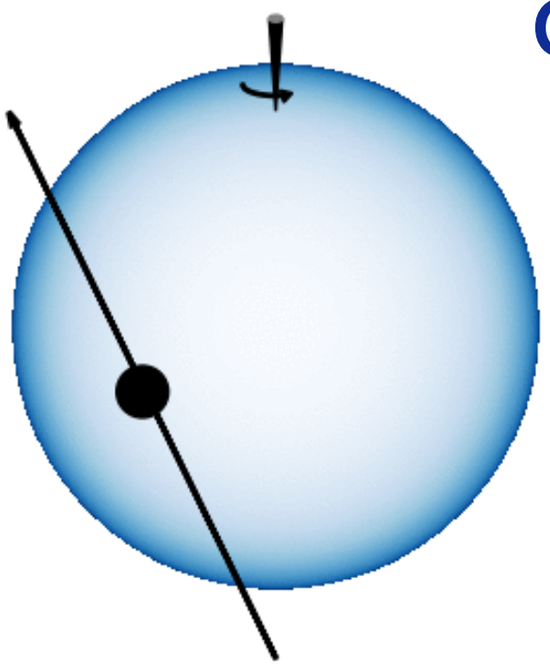
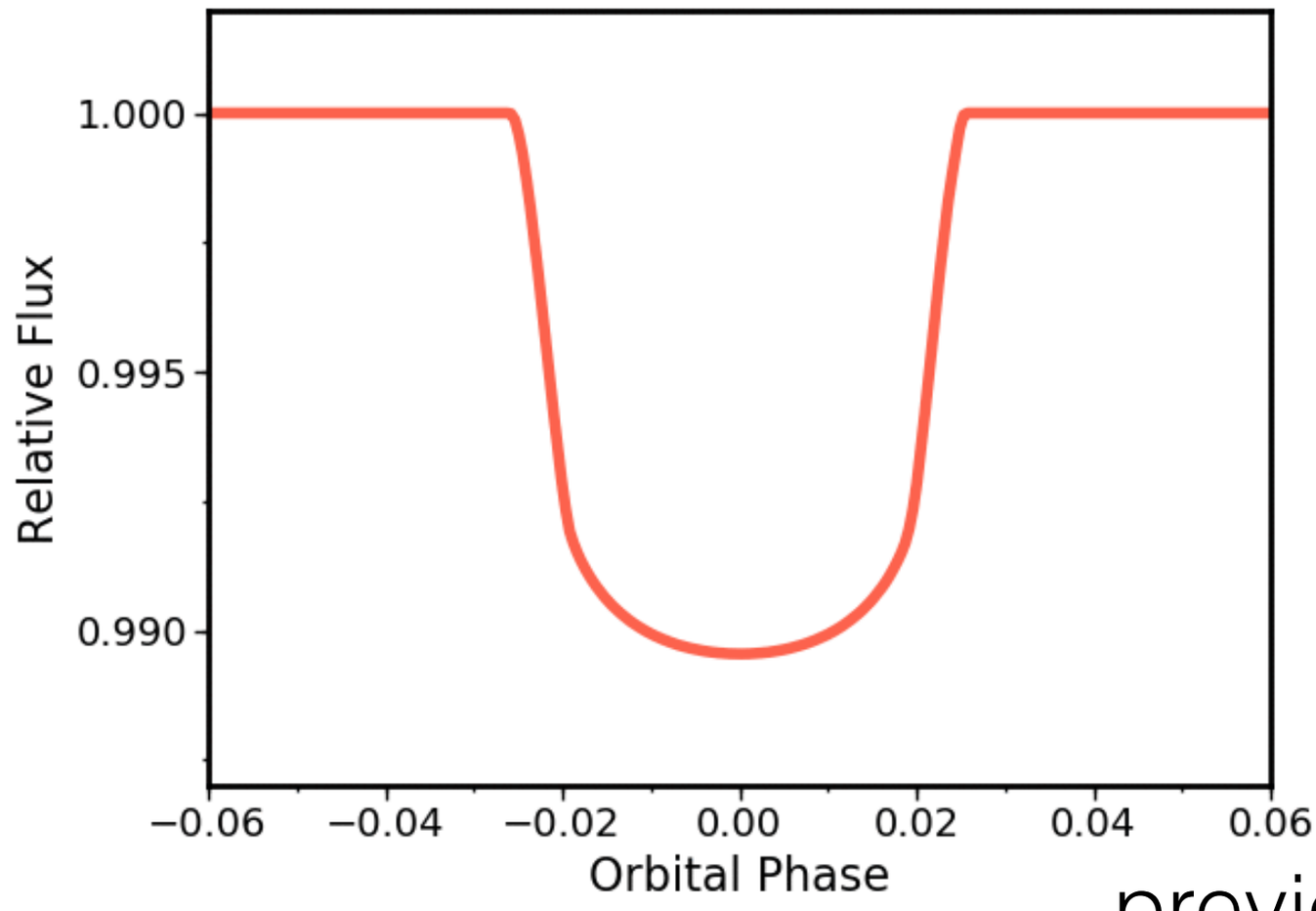
Gravity darkening effect





See Barnes+ 2009

previously detected
for Kepler-13

TOI-624
HAT-P-70b