

NO DEARTH OF EARTHS

Unveiling the Earth+Super-Earth Occurrence

Rate in M Dwarfs with TESS

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BACKGROUND

M Dwarfs not only make up the majority of the stellar population in the solar neighborhood but also host the majority of the terrestrial planets in our galaxy.^[1] However, there is a gap in our understanding of the variation of planet occurrence rate with stellar mass, especially for Very Low-Mass (VLM) stars with $M < 0.3M_{\odot}$ for which the statistics are not robust.^[2]

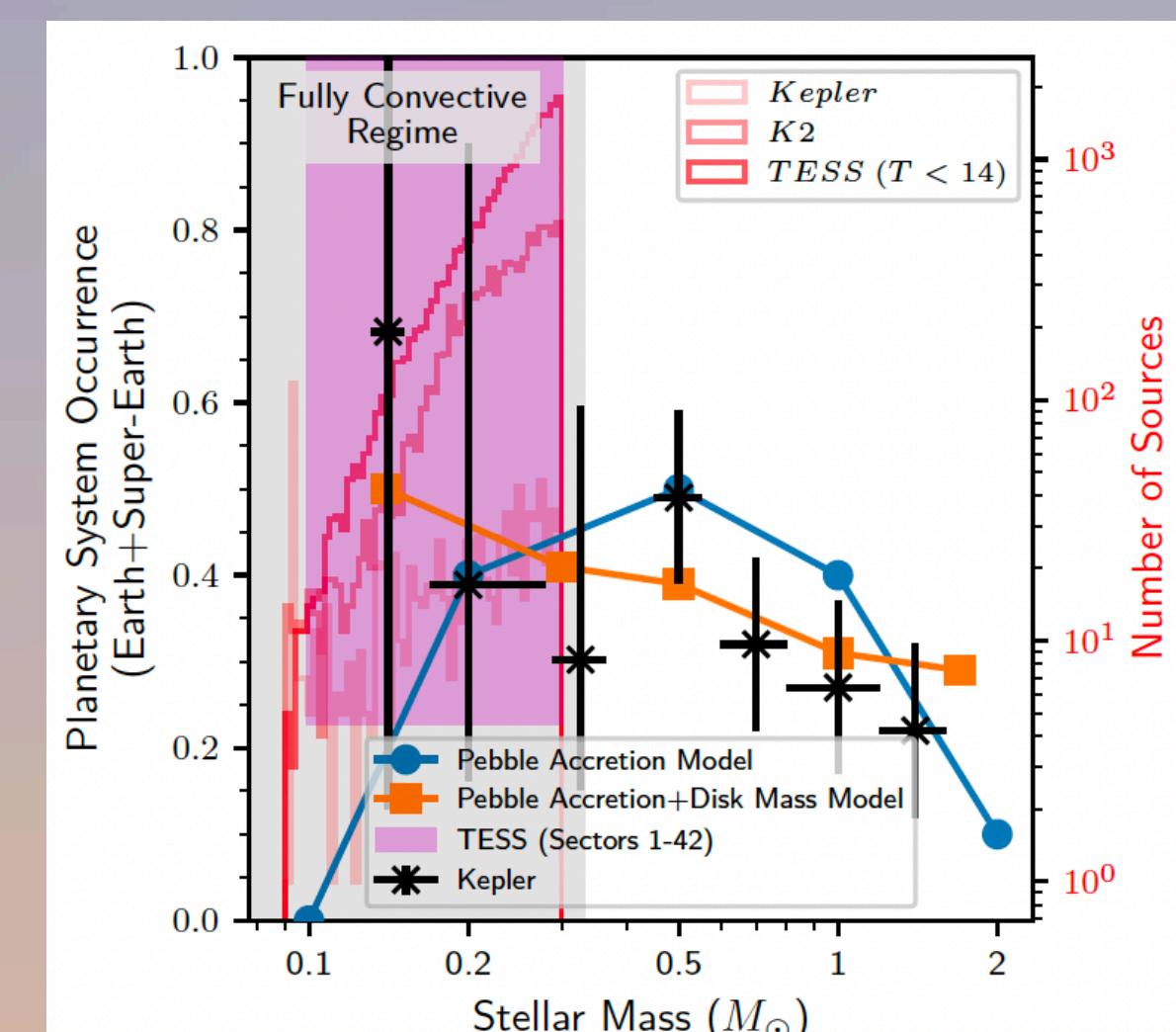


Fig 1: Comparison between pebble accretion models, Kepler, and TESS statistics. Figure adapted from TESS Cycle 5 GO Proposal 6002 (PI: Theissen)

WHAT
HAPPENS TO
PLANET
OCCURRENCE
RATES BELOW
 $0.5 M_{\odot}$?

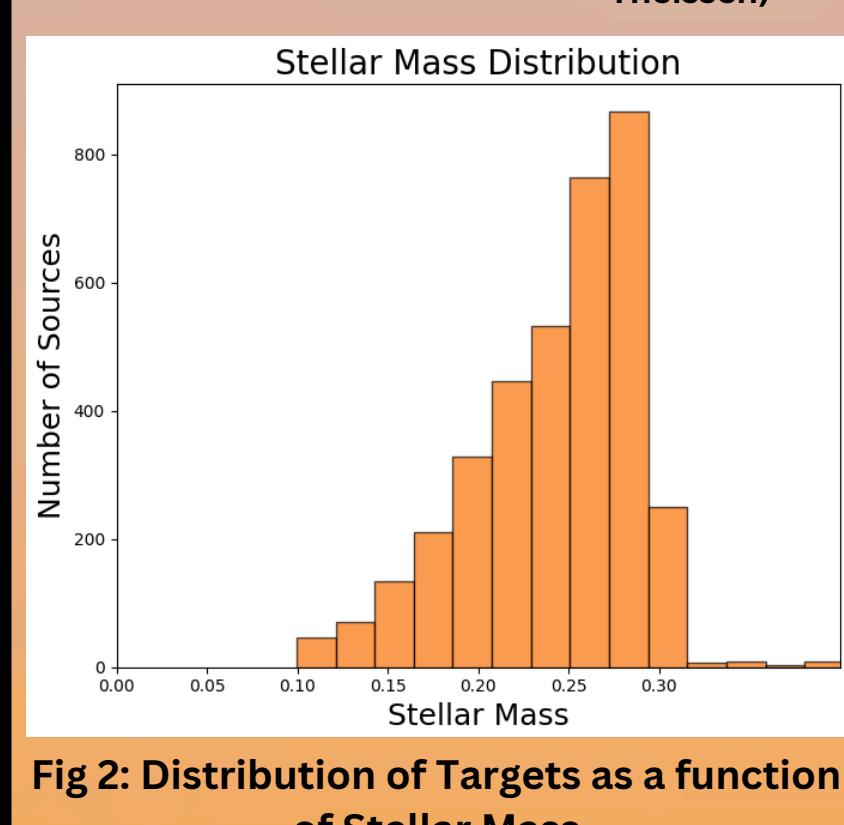


Fig 2: Distribution of Targets as a function of Stellar Mass

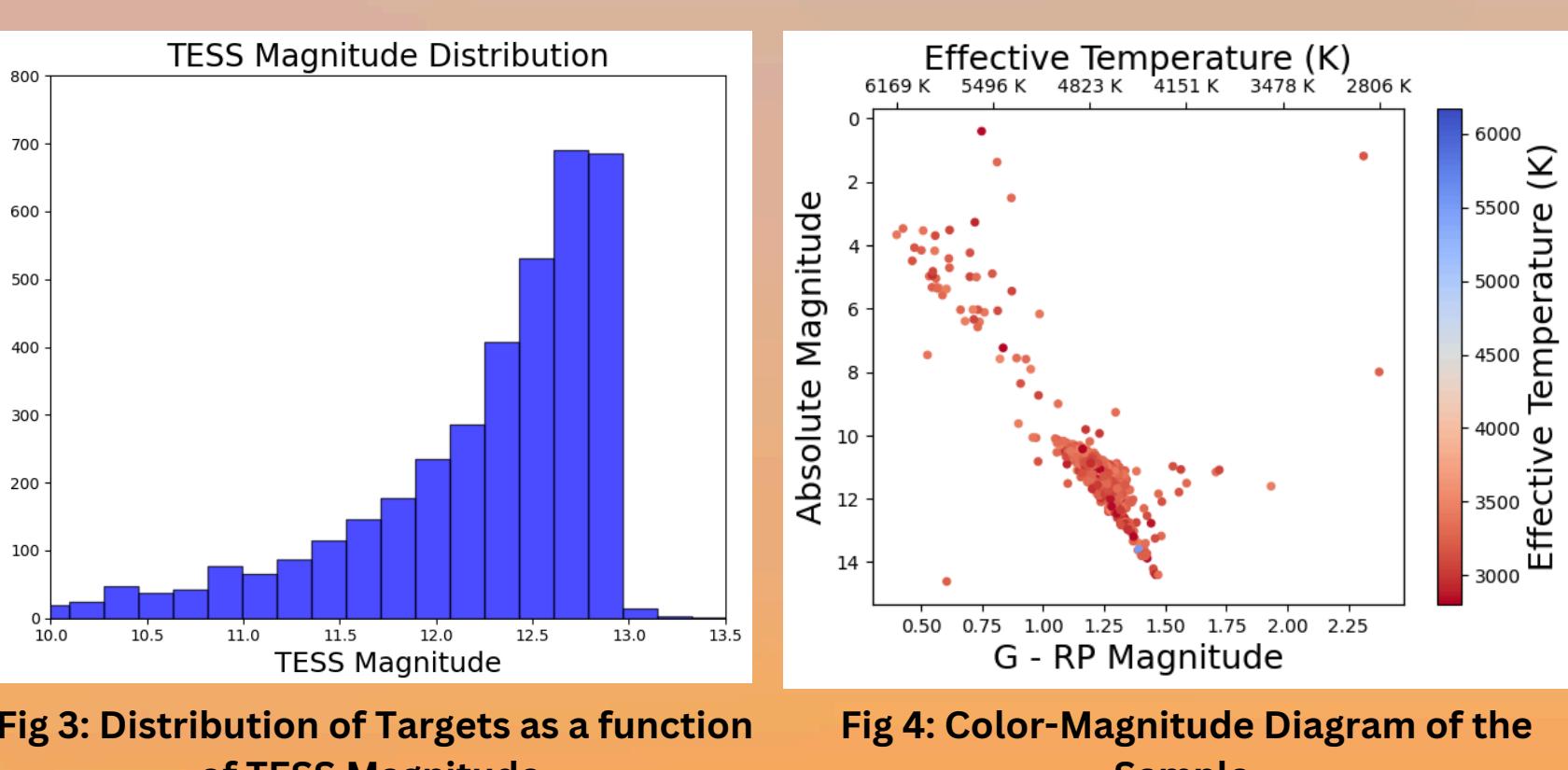


Fig 3: Distribution of Targets as a function of TESS Magnitude

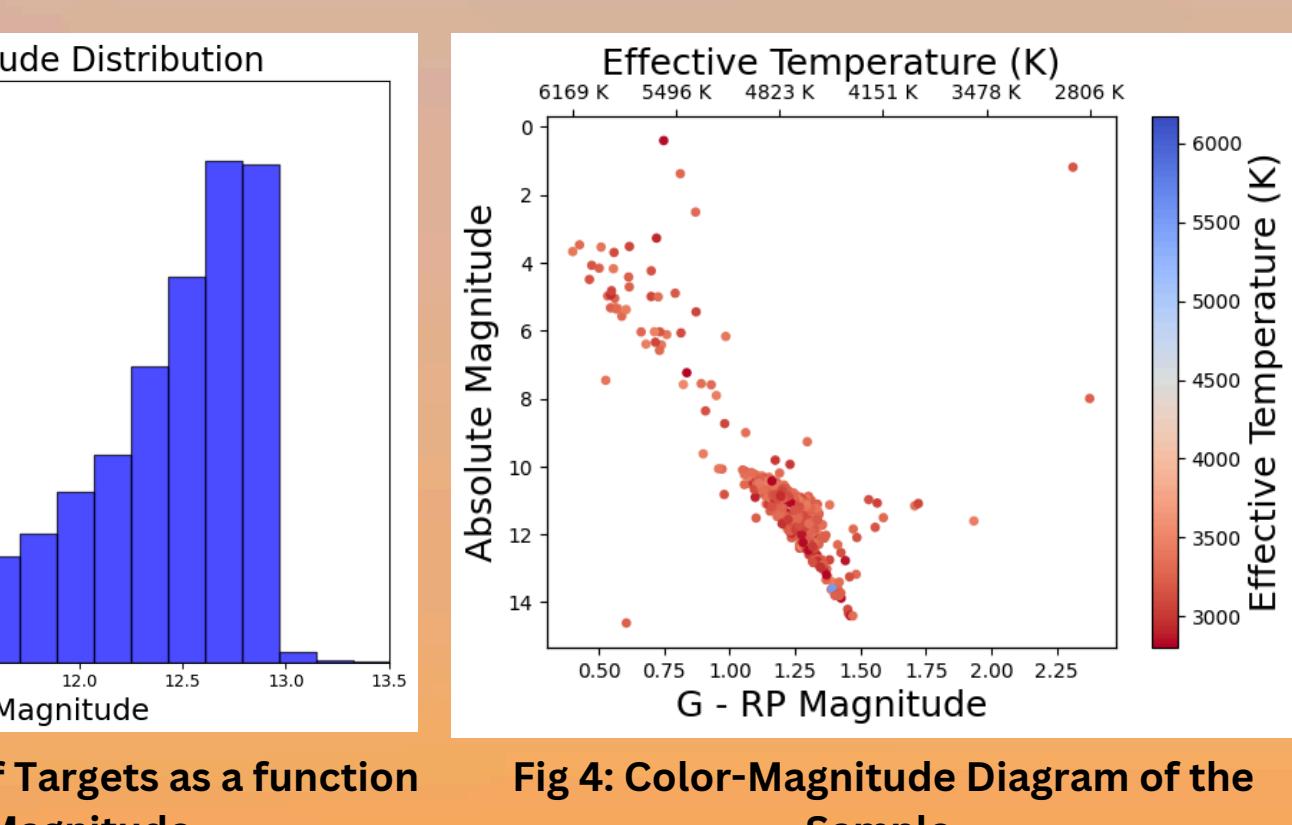


Fig 4: Color-Magnitude Diagram of the Sample

Sample Statistics

Magnitude-limited sample of 3,825 Very Low-Mass stars observed with TESS that lie within 100 pc amplifies the effective volume by ~20 times, compared to the previously targeted distance-limited sample ($d \leq 15$ PC), for these stars with $M \sim 0.1$ - $0.3M_{\odot}$. Based on our analysis and extrapolating from Kepler statistic, this sample can potentially add 7-41 NEW PLANETS around mid-/late-M dwarfs!

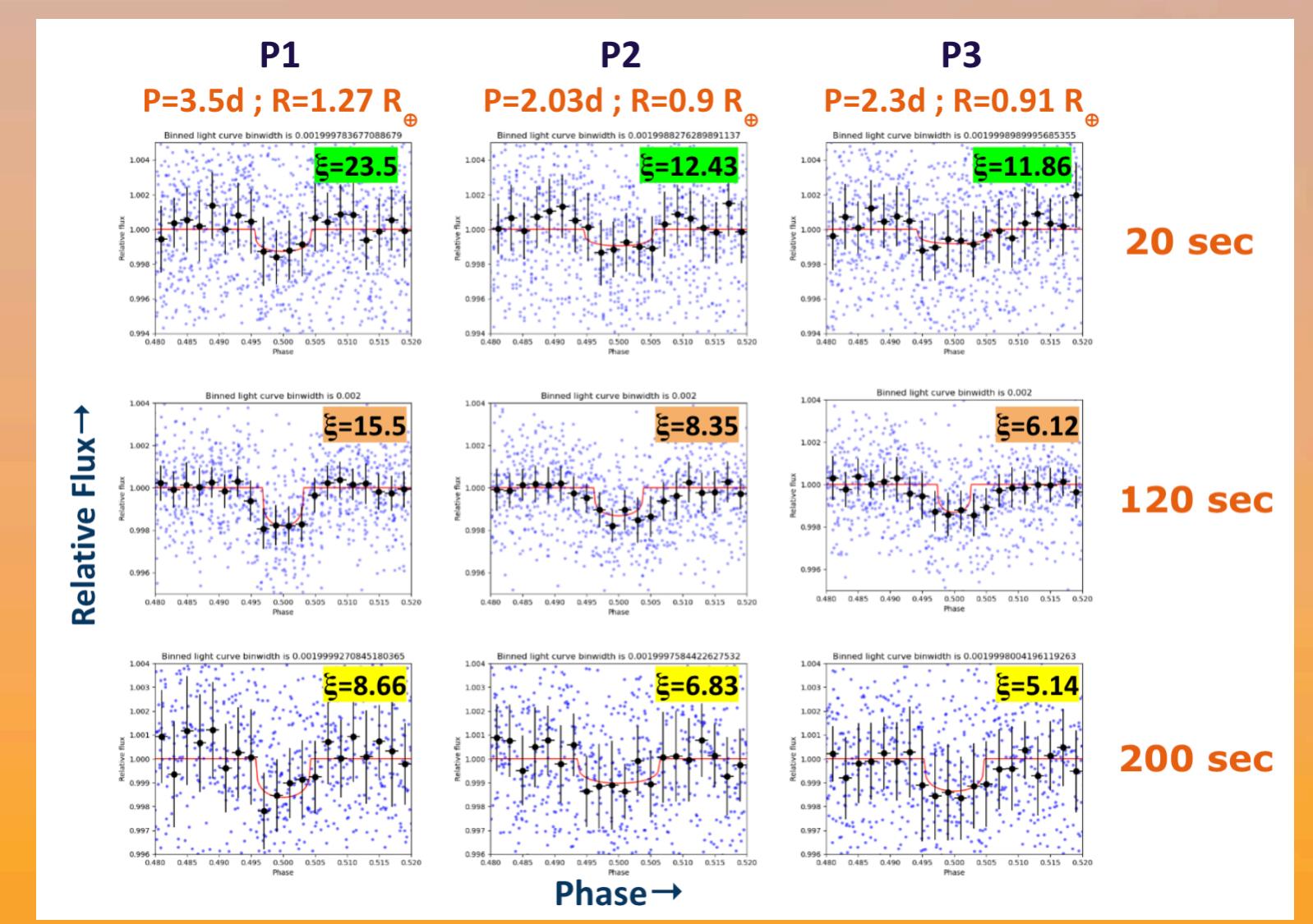
EXOPLANET SURVEY AND CHARACTERIZATION PROGRAM FOR EARTH-LIKE ROCKY PLANETS



EXOSCAPER is a survey program for the detection and characterization of terrestrial planets around faint stars. Utilizing a custom pipeline, EXOSCAPER has identified candidates that TESS pipelines have previously missed and has validated known candidates with increased sensitivity.

EXOSCAPER achieves an efficiency of ~85% and is designed to detect multi-planetary systems, perform integrated statistical vetting using community-sourced tools, as well as measure stellar rotation periods and flares.

TOI 2267 - TIC 459837008



MULTI-PLANET SYSTEM OF THREE EARTH-SIZED PLANETS AROUND A M5V AND M6V BINARY ALSO RECOVERED BY EXOSCAPER!

EXOSCAPER DETECTED 1 OF 3 PLANETS IN THE TOI-2267 SYSTEM, TOI-2267.02, BEFORE THE FIRST TESS PIPELINE ALERT!

OCCURRENCE RATE

ABSOLUTE BAYESIAN COMPUTATION

POPULATION MONTE CARLO (ABC PMC)^[4]

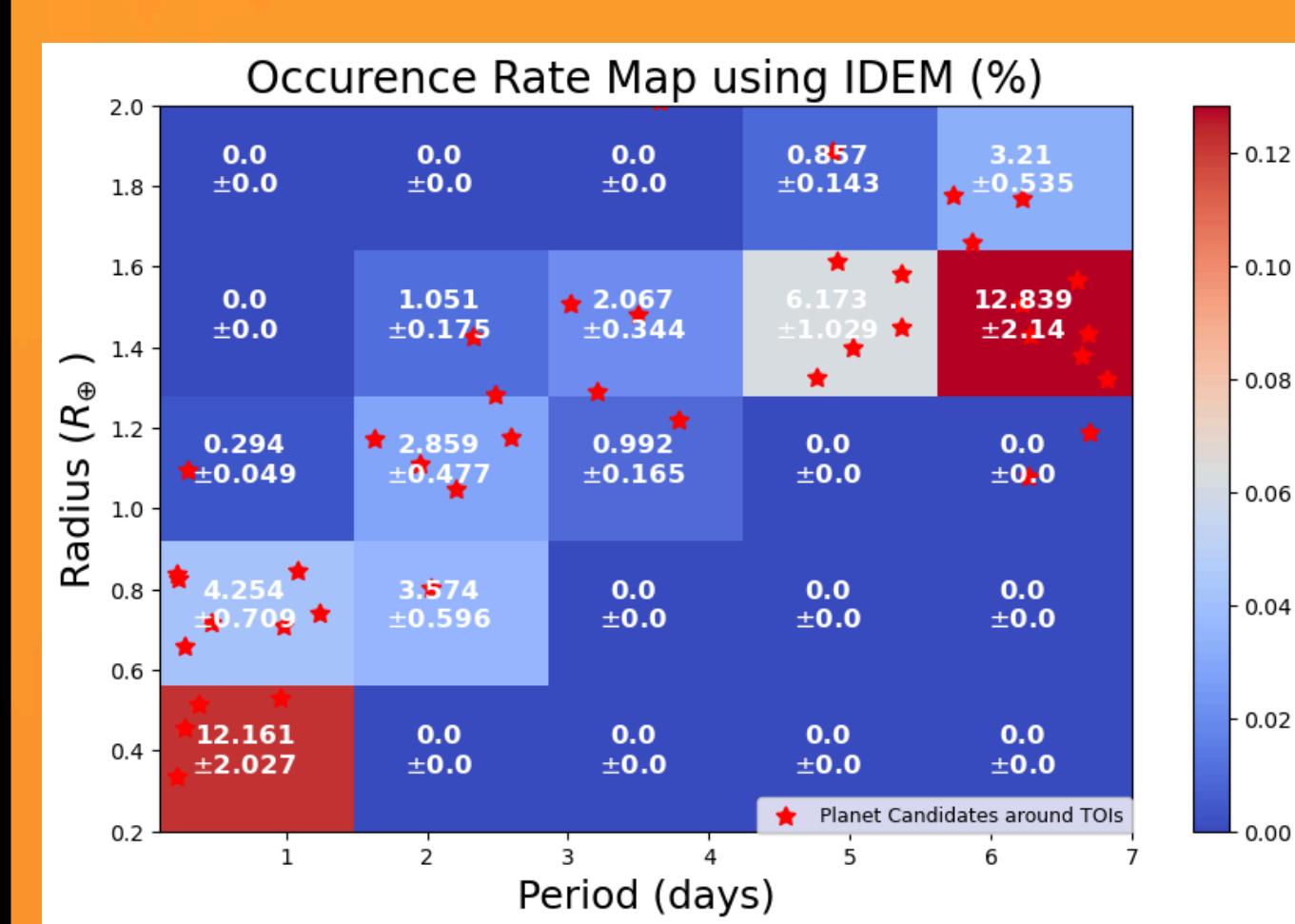


Fig 6: Occurrence Rate Estimates computed using IDEM

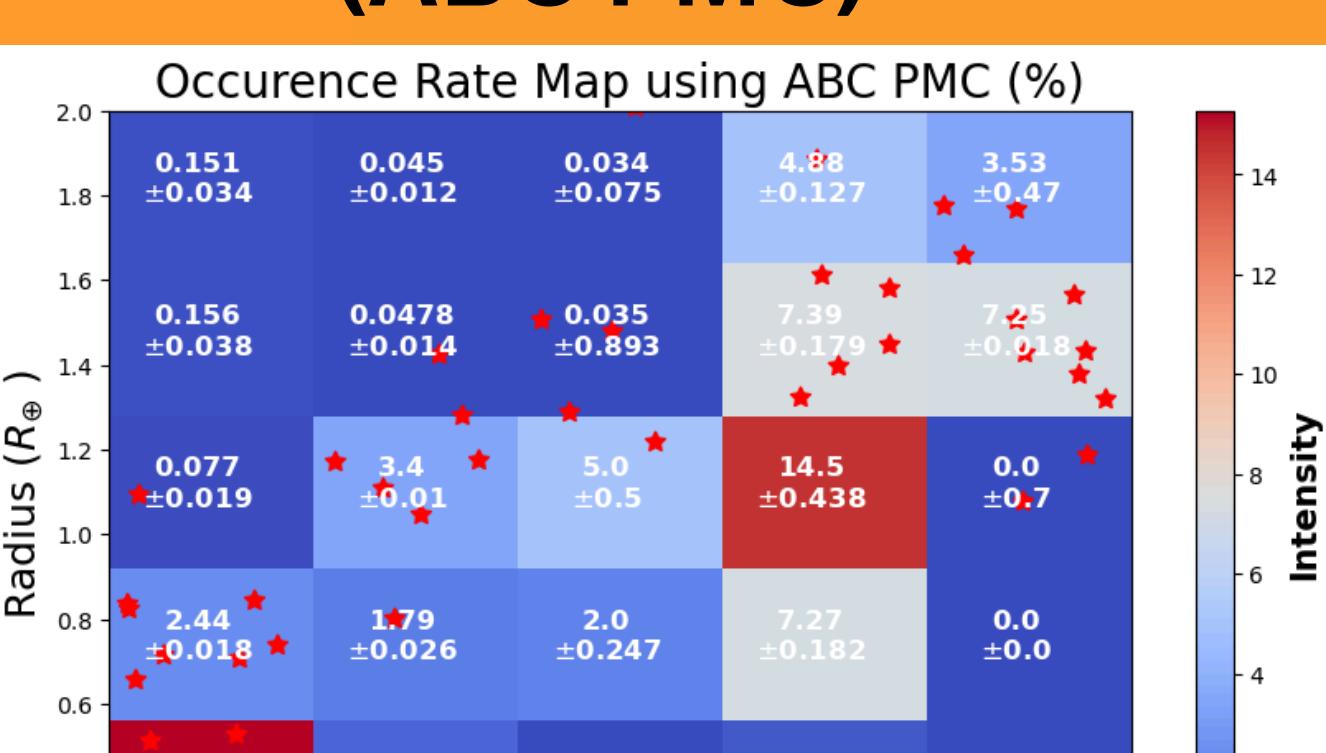


Fig 7: Occurrence Rate Estimates computed using ABC PMC

$\eta = 0.61 \pm 0.34$ PLANETS PER STAR

$\eta = 0.76 \pm 0.77$ PLANETS PER STAR

CURRENT FINDINGS

PLANET CANDIDATE STATISTICS

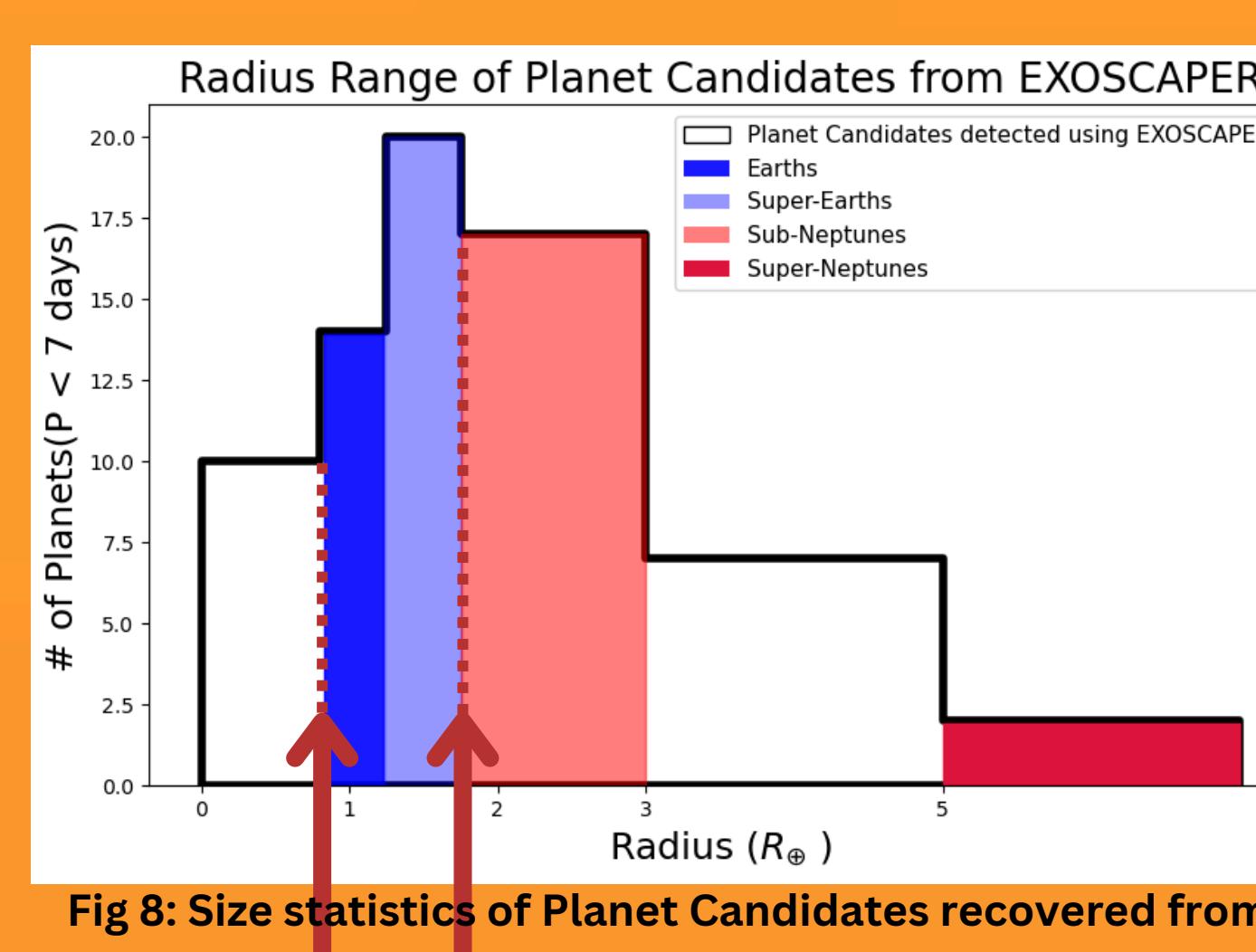


Fig 8: Size statistics of Planet Candidates recovered from EXOSCAPER

COMPARISON

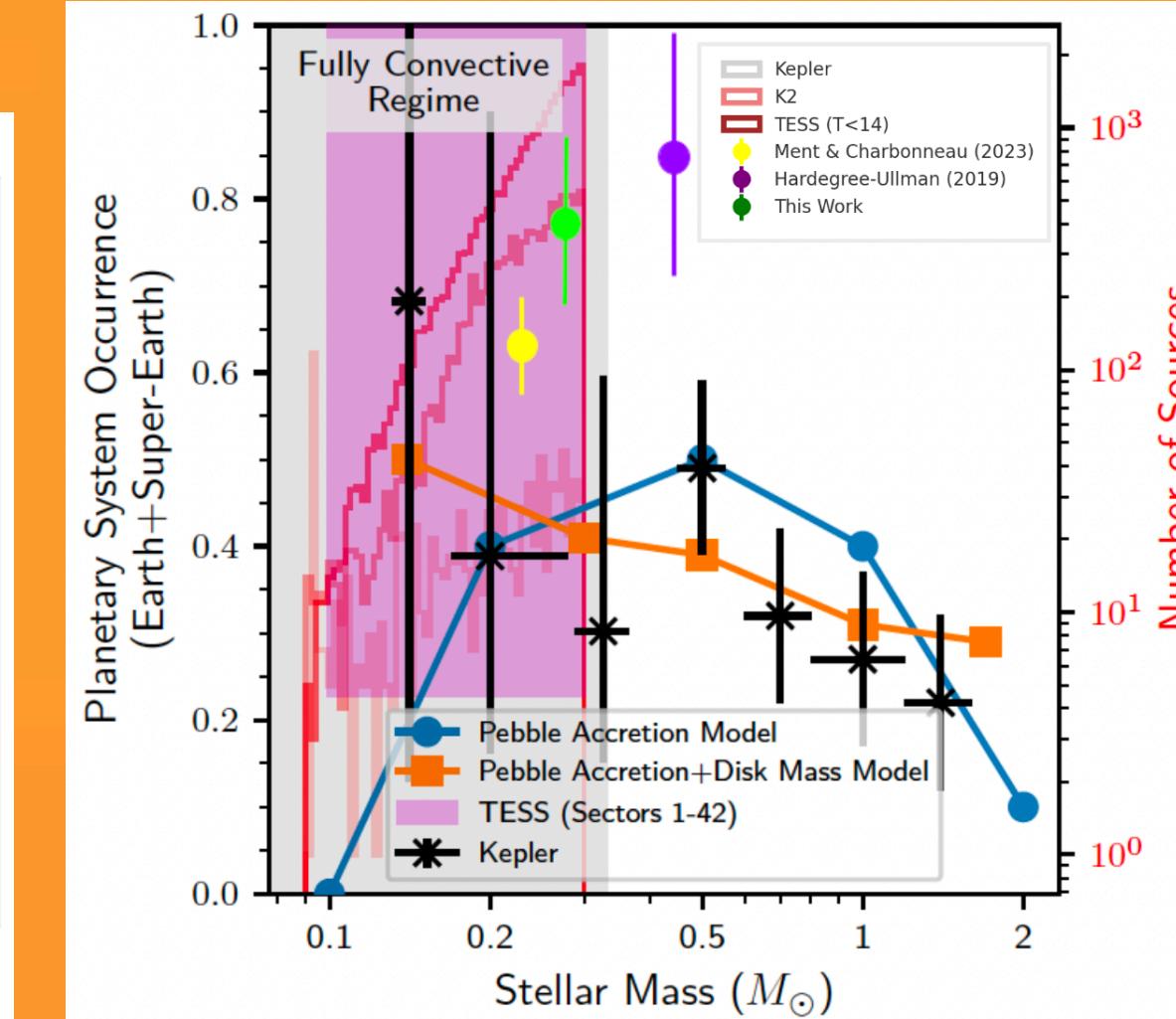


Fig 9: Updated Comparison of Planet Occurrence Rate Variation with Stellar Mass

NO DEARTH OF EARTHS AFTER ALL!

CONSISTENT WITH PEBBLE ACCRETION

3,825 Very Low Mass Stellar Sample $T=8$ to 13 TESS Mag ; $M = 0.1$ - $0.3 M_{\odot}$

Planet Detection using EXOSCAPER (TLS Search; SDE ≥ 10)

98 Planet Candidates detected

35 Confirmed Planet Candidates (around TOIs)

63 Planet Candidates in Follow-Up

MORE RESULTS COMING SOON IN KARPOOR ET AL (IN PREP)!!

ACKNOWLEDGEMENT

We gratefully acknowledge the support of NASA's SMD and the TESS team through the TESS Cycle 5 GO proposal 6002. This research utilizes publicly available data from MAST and ESA's Gaia Mission. We also recognize and acknowledge that this work was conducted on the unceded territory of the Kumeyaay Nation, whose people continue to uphold their political sovereignty and cultural traditions within the San Diego community.

SELECT REFERENCES

- [1] Hardegree-Ullman et al., 2019, AJ, 158, 75
- [2] Mulders et al., 2015, ApJ, 798, 112
- [3] Dressing and Charbonneau, 2013, AJ, 767, 195
- [4] Kunimoto and Matthews, 2020, AJ, 159, 248