

# A Southern Hemisphere RV Follow-up Program for TESS with PFS/Magellan



Johanna Teske  
Carnegie Observatories



Steve Sackett



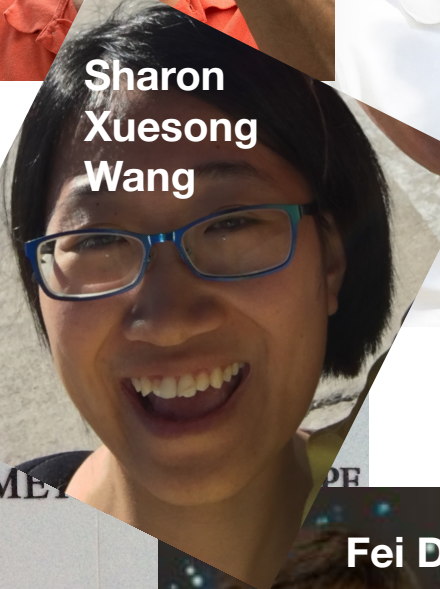
Paul Butler



Jeff Crane



Ian Thompson



Sharon Xuesong Wang



Fabo Feng



Angie Wolfgang



Nicholas Law



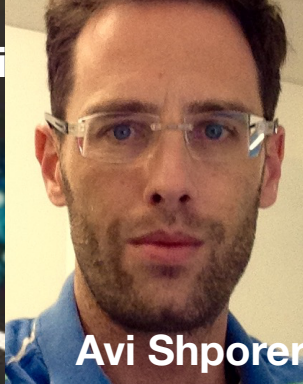
Ward Howard



Jennifer Burt



Fei Dai



Avi Shporer



Alycia Weinberger



Andrew Vanderburg



Raphaëlle Haywood

# 2018 NASA Exoplanet Research Program Grant Team

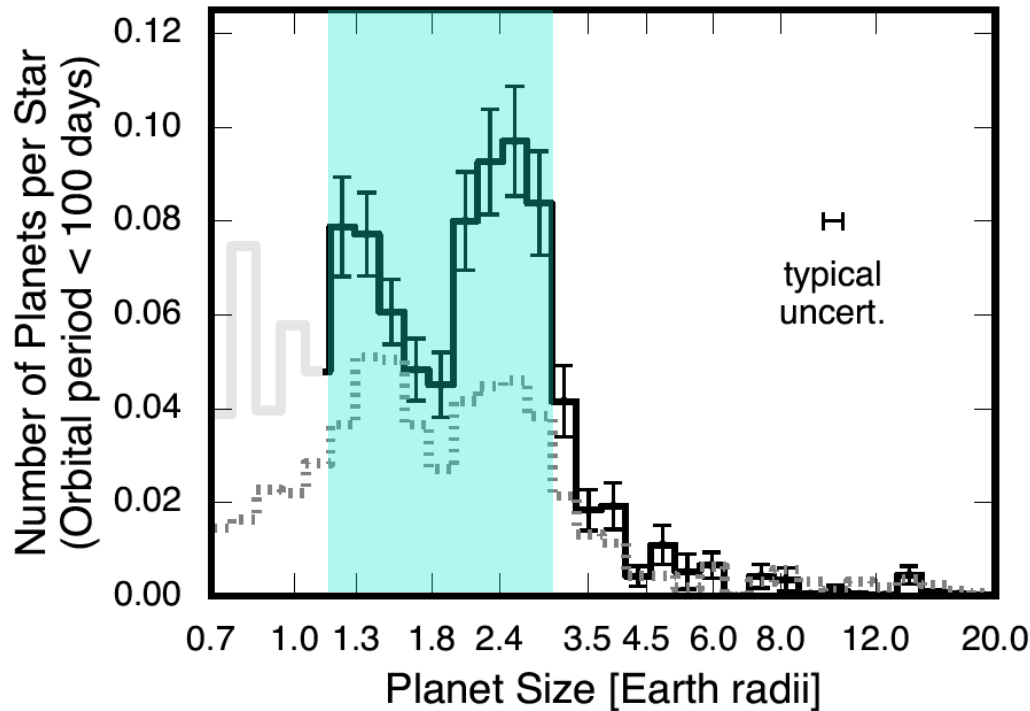
Science PI: Johanna Teske

# Do super-Earths and sub-Neptunes...

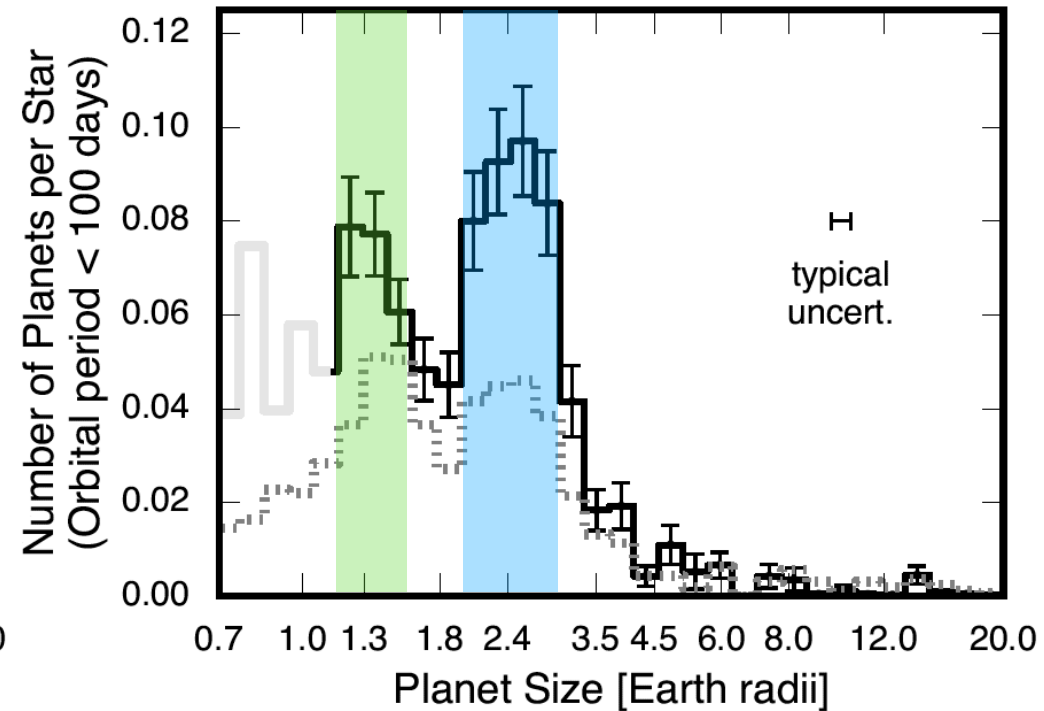
form in a similar way and get influenced by post-formation processes?

form differently from the start (and also get altered after formation)?

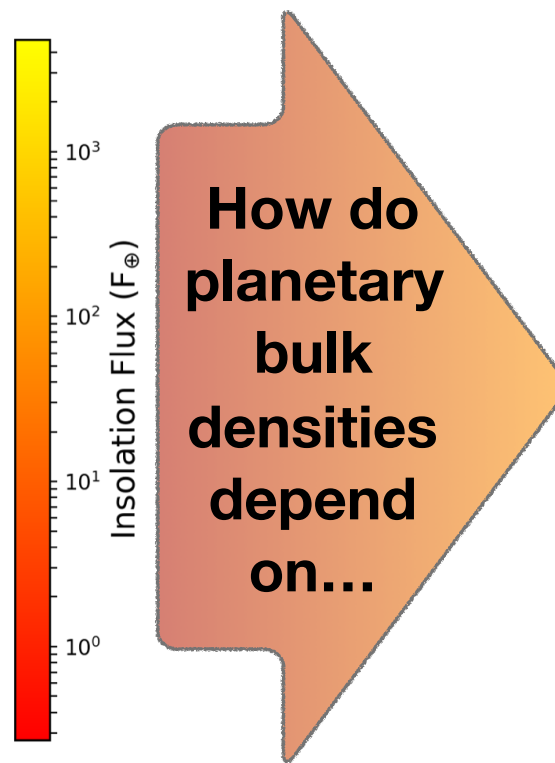
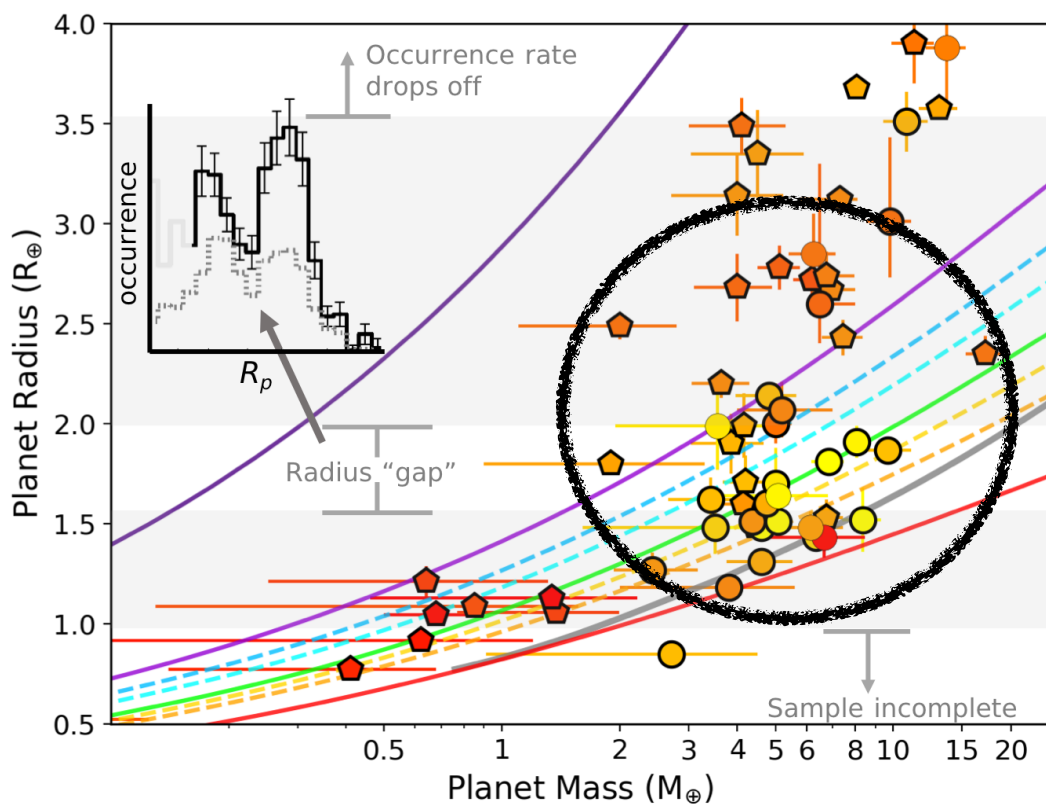
Lopez & Rice 16



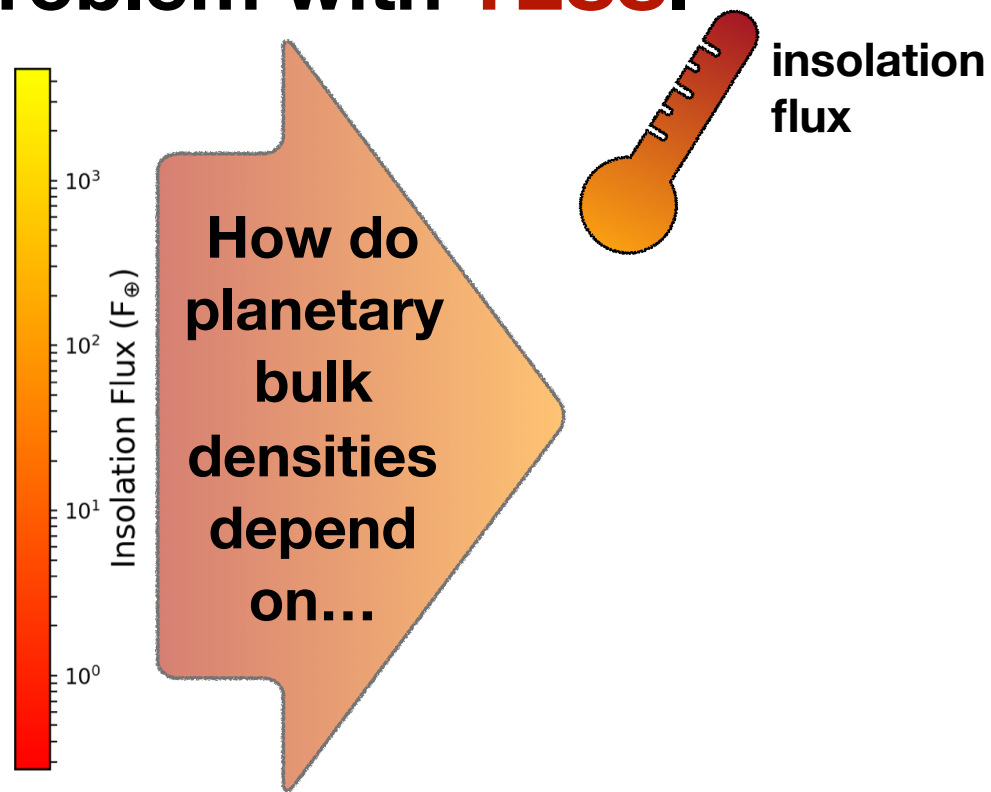
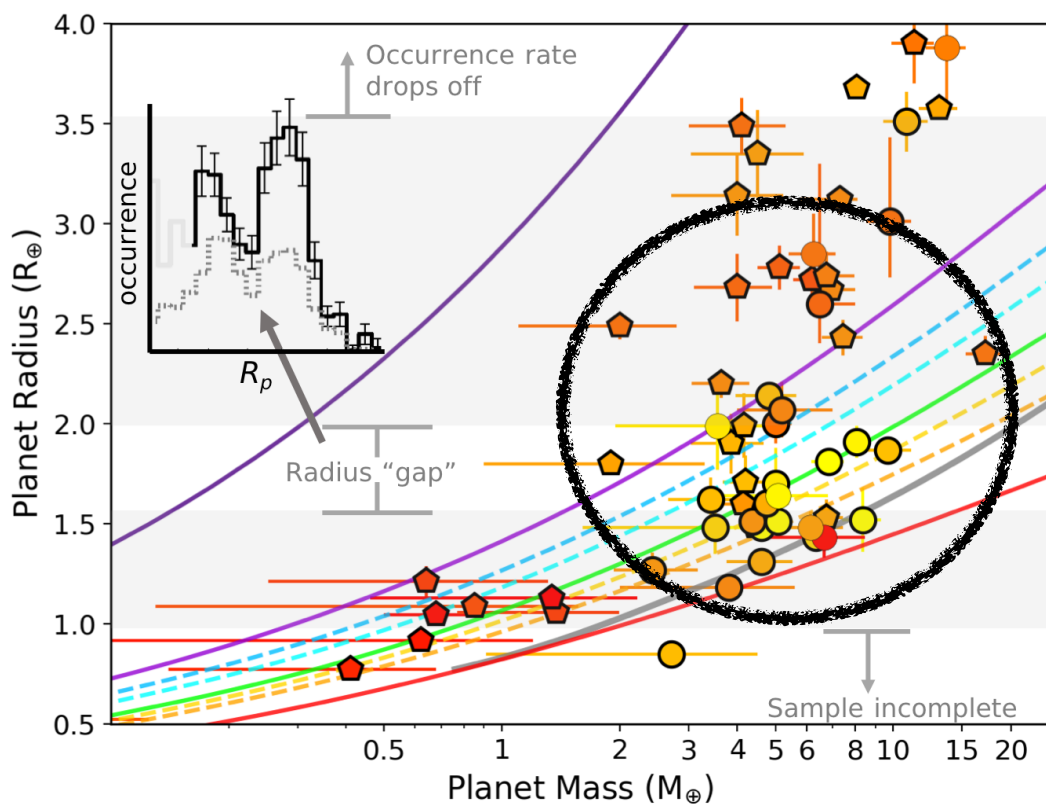
Fulton & Petigura 18



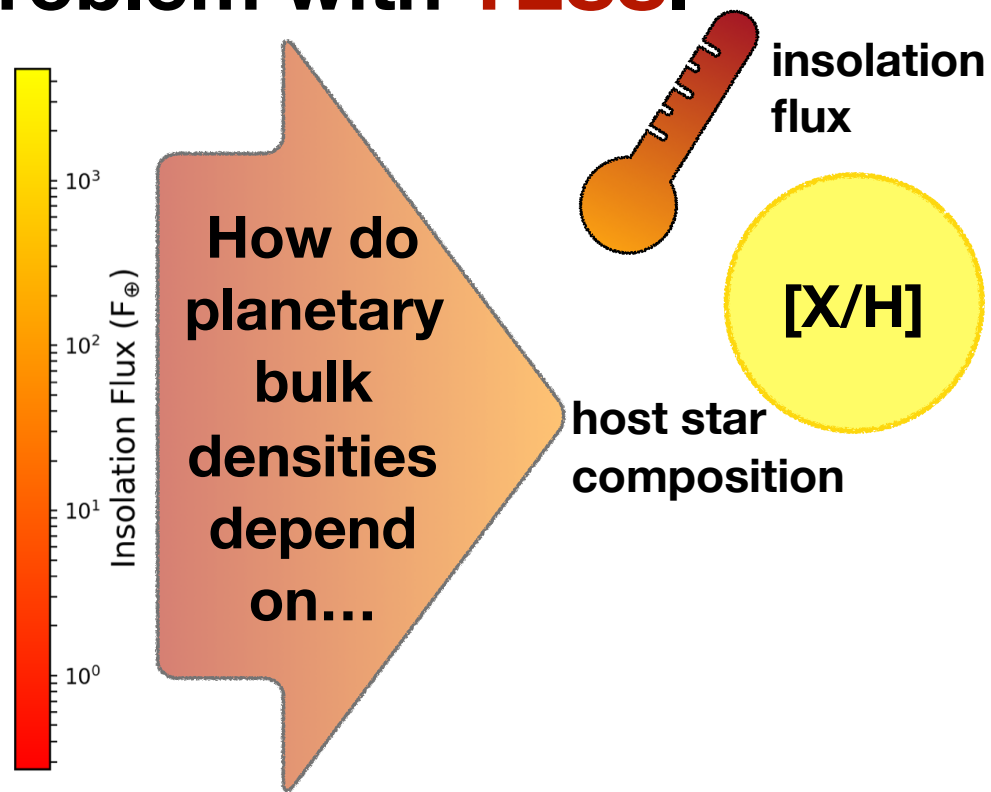
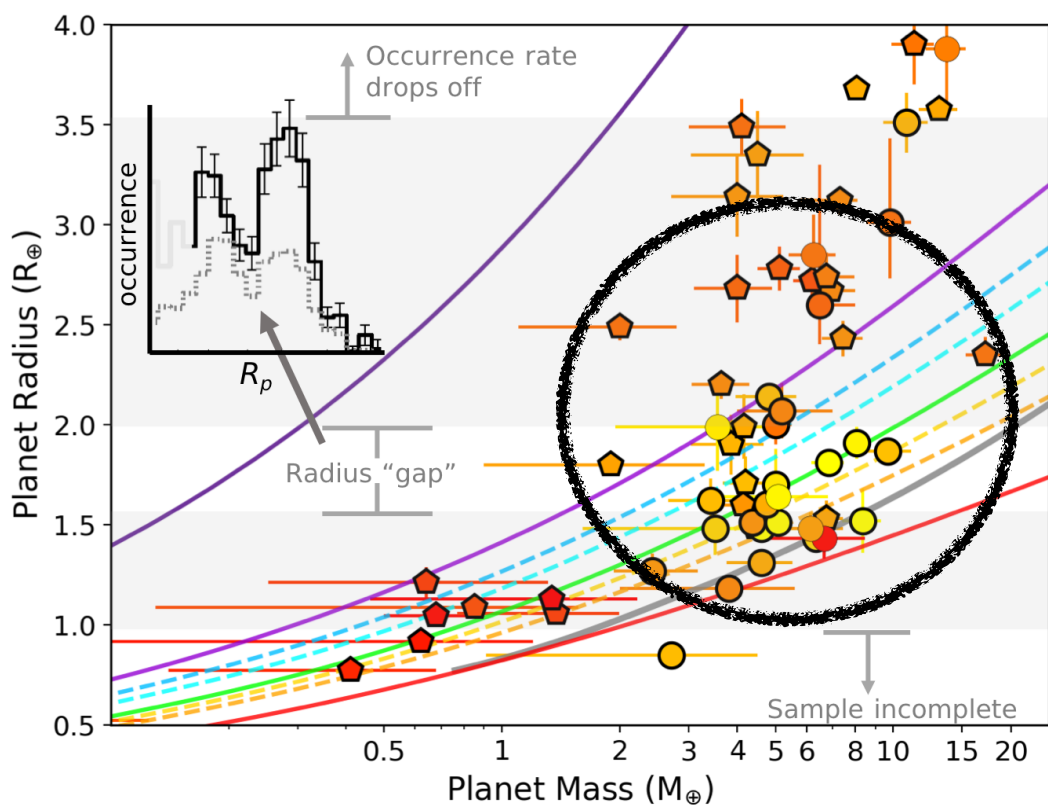
Whether super-Earths and sub-Neptunes represent **continuous** or **distinct** populations remains open. We want to further explore this problem with **TESS**.



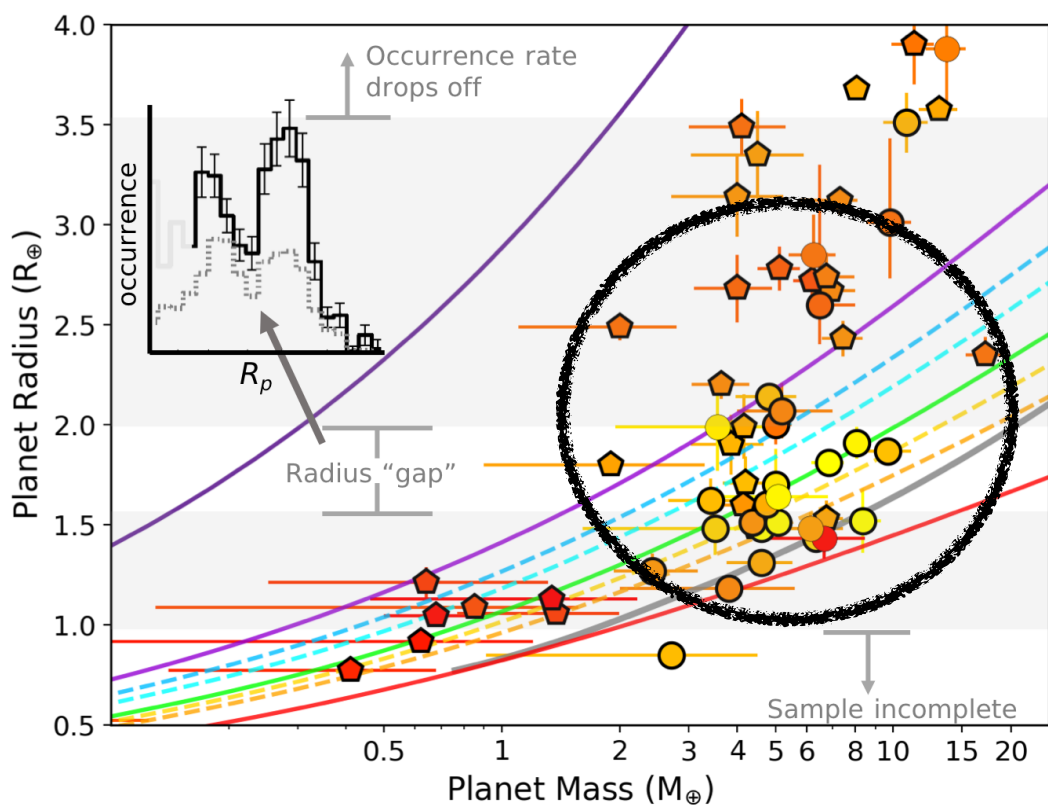
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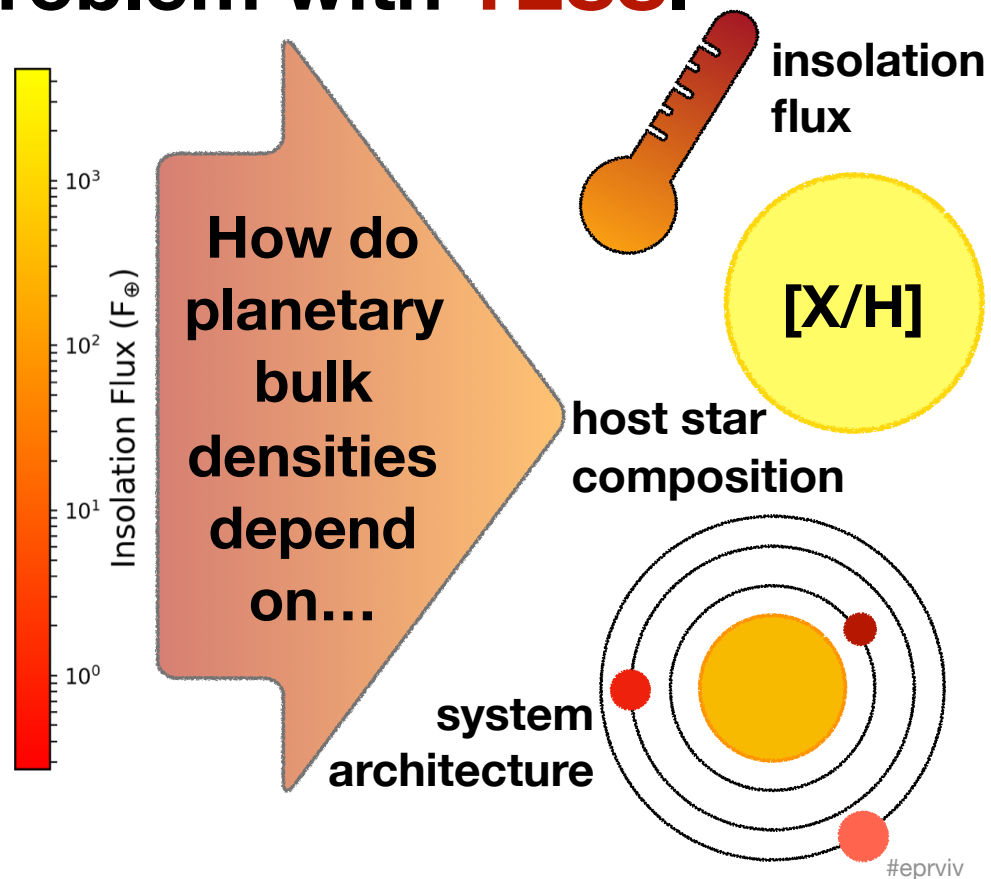
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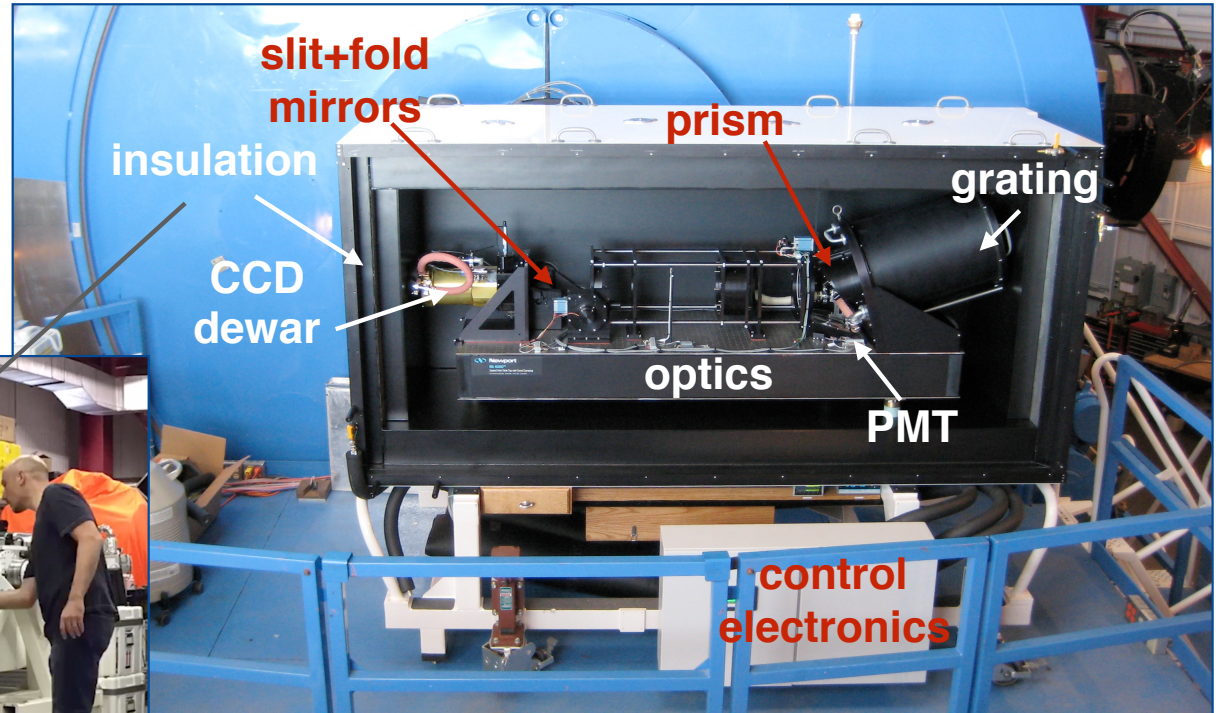
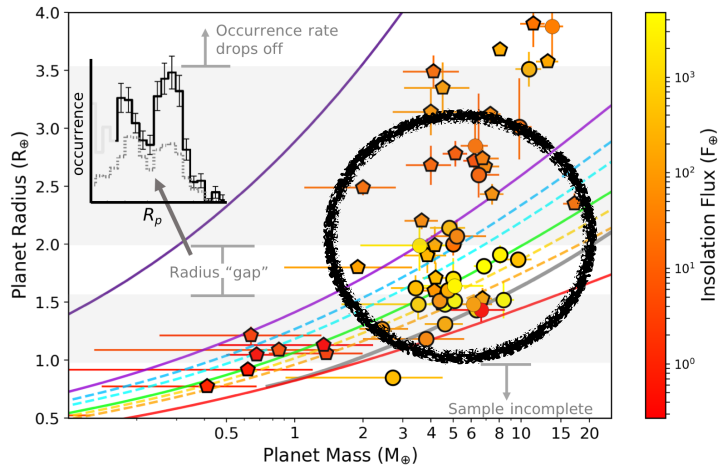
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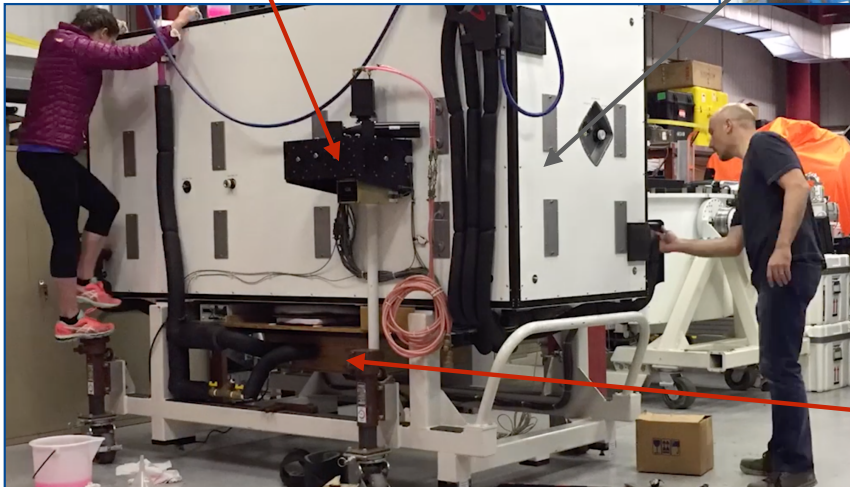
@johanneske



At the core of our survey is measuring bulk densities and thus masses of small planets, which we are doing with **Magellan II/PFS**.



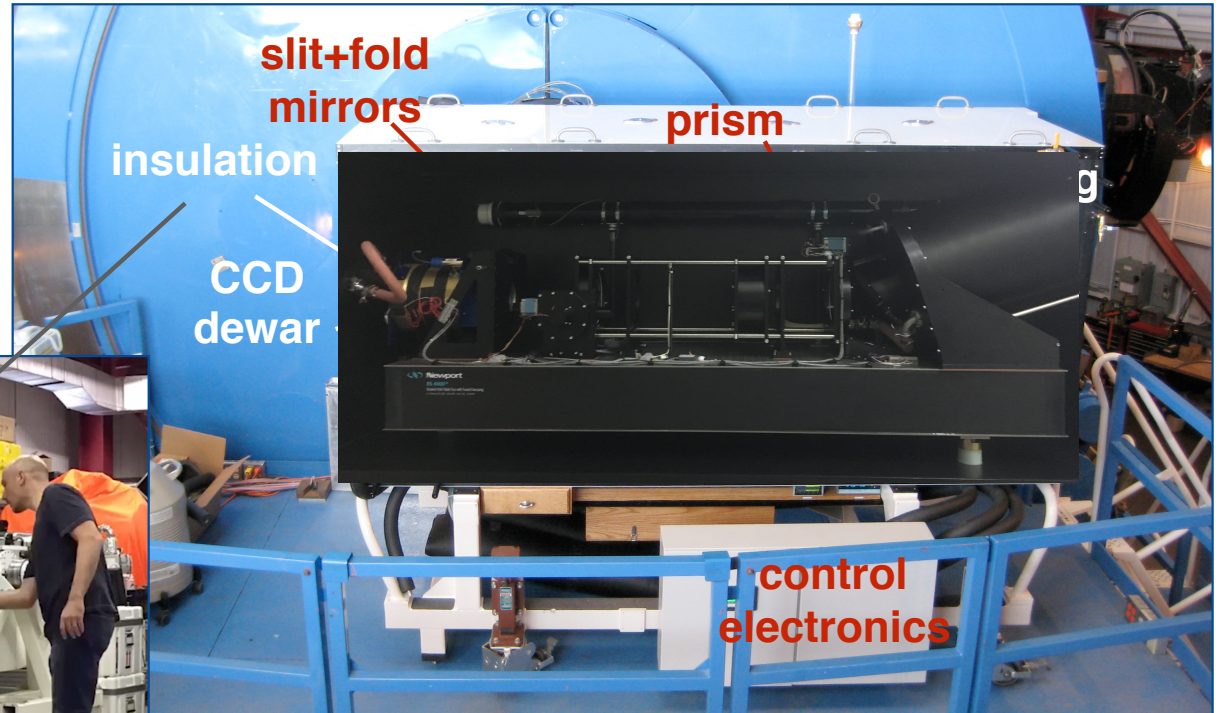
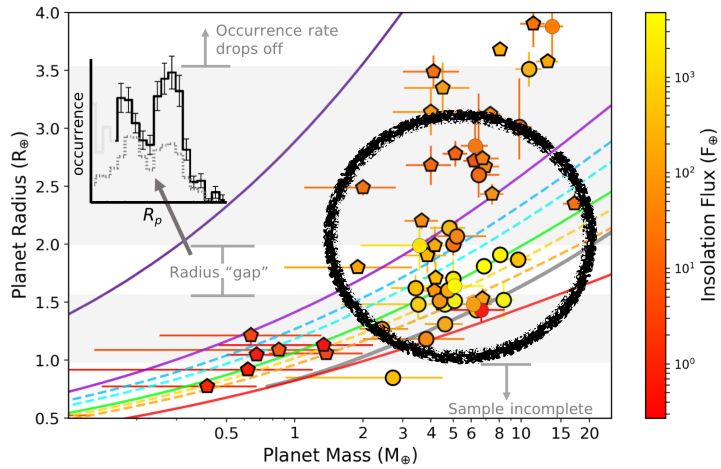
pre-slit assembly



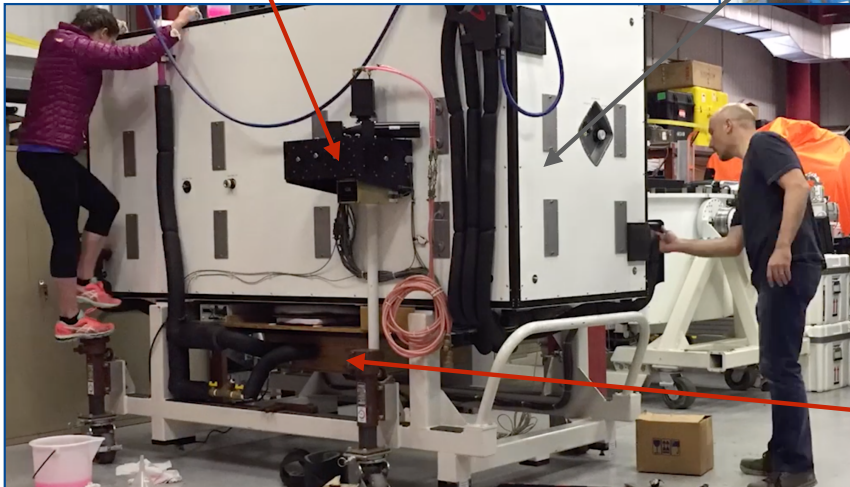
thermal control system



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pre-slit assembly



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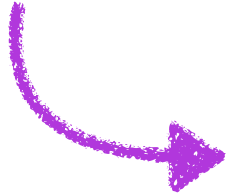
# Comprehensive Target Vetting



**Light Curves & Transit Candidates**  
**Reconnaissance Spectroscopy**  
**High-Resolution Imaging**  
**Photometric Monitoring**

# Comprehensive Target Vetting

## Robust Target Selection/Ranking

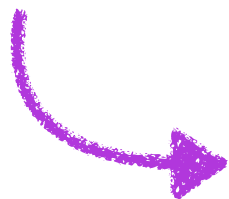


Per sector, before any new RV data are acquired

$$\text{merit} = \begin{cases} F_{\text{insol}}^{-1/3} \times T_{\text{exp}}^{-1} \times e^{-1.25(R_p - 1.8)^2} & \text{for } R_p < 3 R_{\oplus} \\ 0 & \text{otherwise} \end{cases}$$

# Comprehensive Target Vetting

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$t_{\text{exp}}$  needed to reach  $\sigma_{\text{rv}} = 2$  m/s  
(minimum  $t_{\text{exp}}$  10 min)

$K$  from Ning+18

$$\sqrt{N_{\text{obs}} \cdot K / \sigma_{\text{rv}}} \geq 6$$

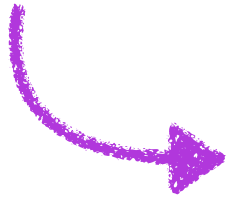
(minimum  $N_{\text{obs}} = 20$ )

Howard & Fulton 2016  
Dumusque+17

$$N_{\text{obs}} \times t_{\text{exp}} \times 3$$

# Comprehensive Target Vetting

## Robust Target Selection/Ranking



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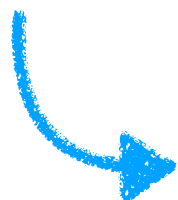
+ if stellar  $P_{\text{rot}}$  is < 15 days,  
do not observe

Howard & Fulton 2016  
Dumusque+17

# Comprehensive Target Vetting

## Robust Target Selection/Ranking

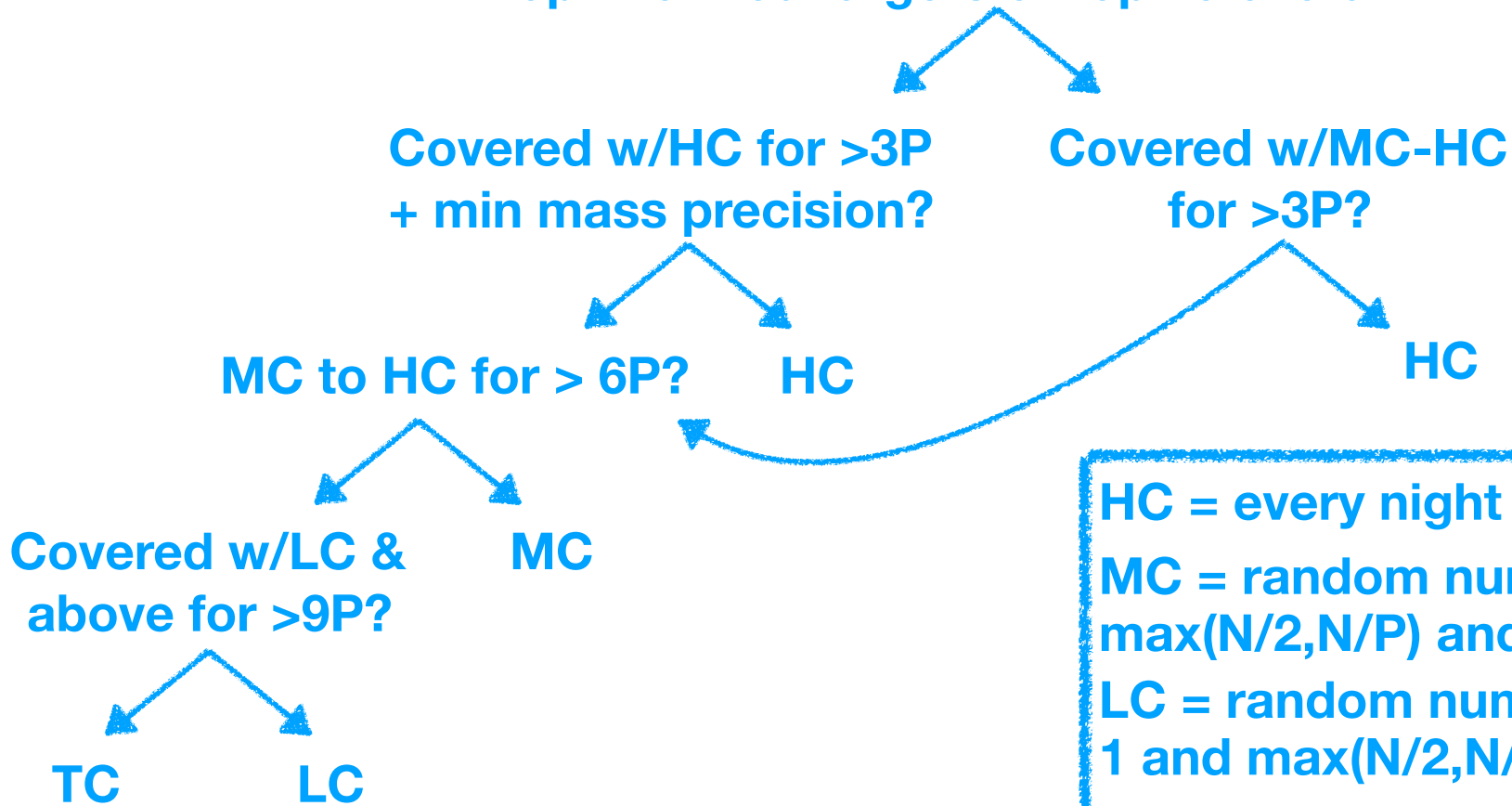
### RV Strategy Randomly Assigned to Each Target



Consider metric ranking,  
planet orbital period(s),  
number of nights in observing run  
minimum absolute  $M_p$  precision

# RV Strategy Randomly Assigned to Each Target

Top 2 ranked targets or top 25 overall?



HC = every night (N)  
MC = random number between  $\max(N/2, N/P)$  and N  
LC = random number between 1 and  $\max(N/2, N/P)$   
TC = 1

**Comprehensive Target Vetting**

**Robust Target Selection/Ranking**

**RV Strategy Randomly Assigned to Each Target**

**Publish Mass Constraints at end of Survey**



**Regardless of statistical significance**  
**Avoid bias in mass-radius relation**  
**Share plans in TFOP/ExoFOP-TESS**

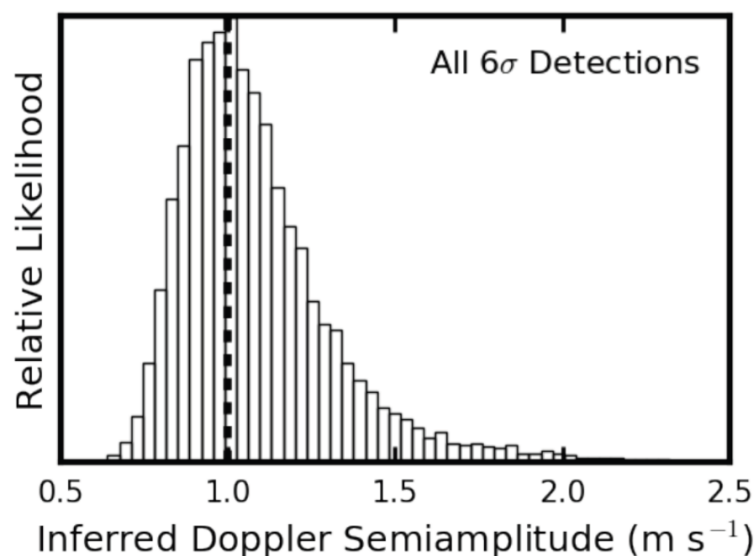
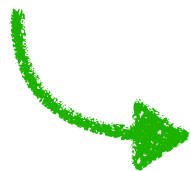


# Comprehensive Target Vetting

## Robust Target Selection/Ranking

RV Strategy Randomly Assigned to Each Target

Publish Mass Constraints at end of Survey

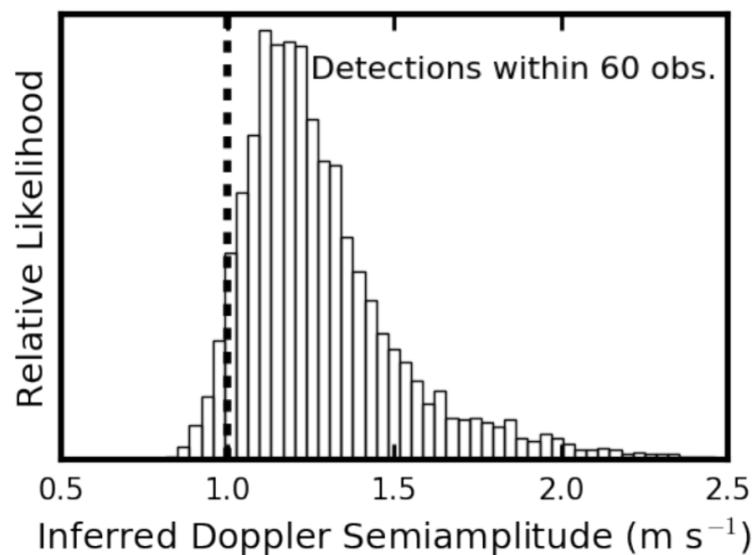
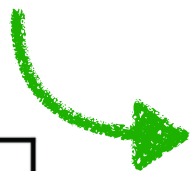
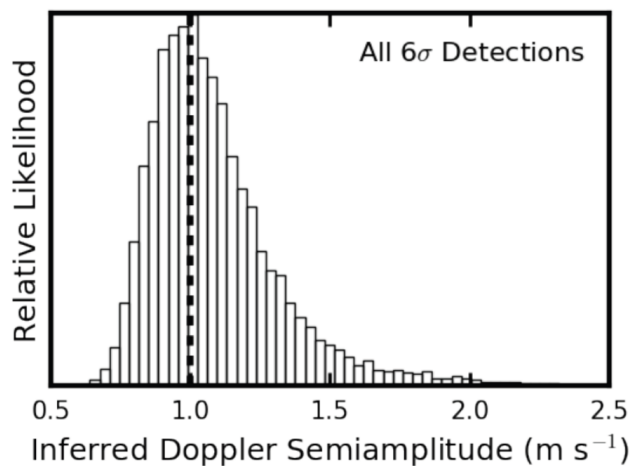


# Comprehensive Target Vetting

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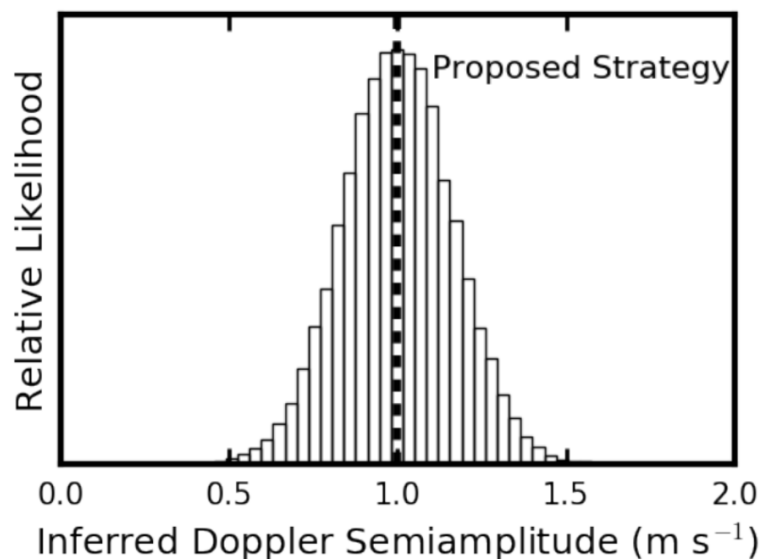
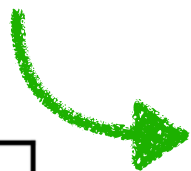
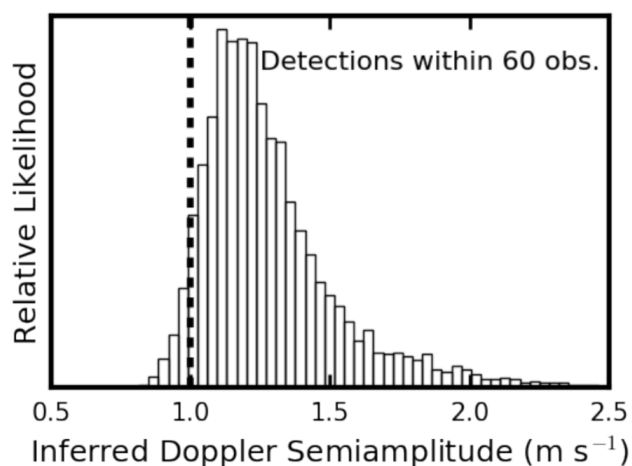


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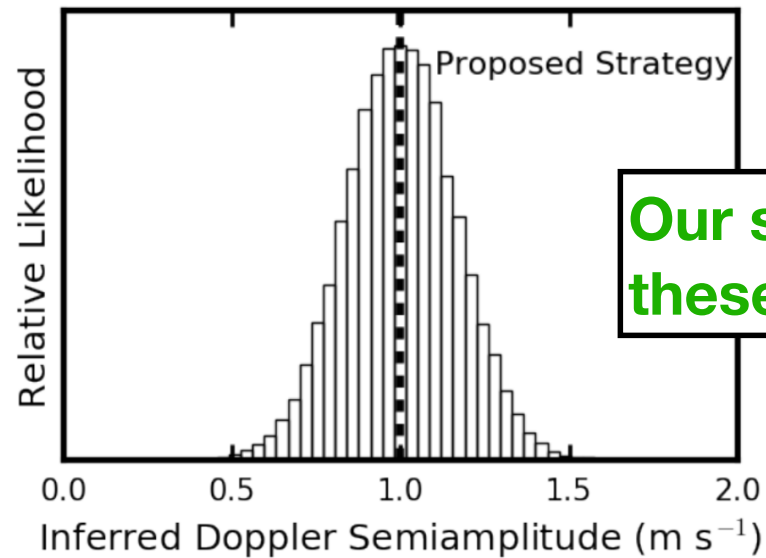
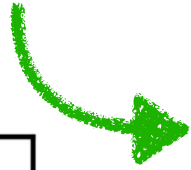
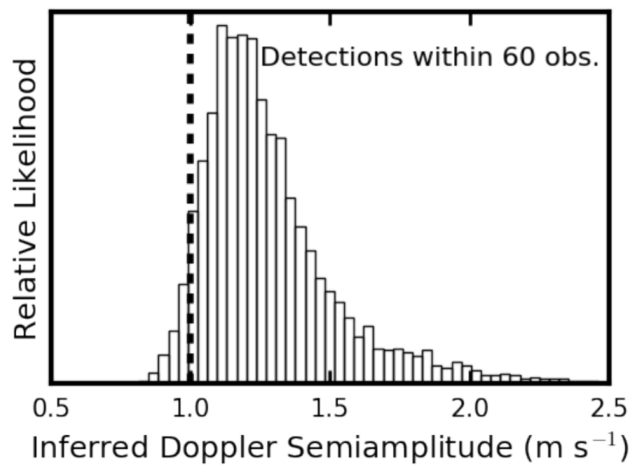


# Comprehensive Target Vetting

## Robust Target Selection/Ranking

### RV Strategy Randomly Assigned to Each Target

### Publish Mass Constraints at end of Survey



**Our survey follows these principles.**

# Comprehensive Target Vetting

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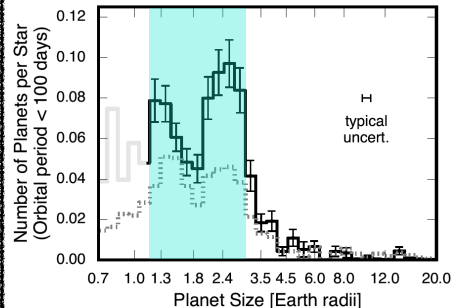
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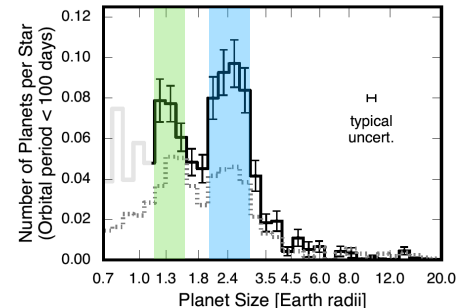


#### Do super-Earths and sub-Neptunes...

form in a similar way  
and get influenced by  
post-formation  
processes?



form differently from  
the start (and also  
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# Comprehensive Target Vetting

## Robust Target Selection/Ranking

RV Strategy Randomly Assigned to Each Target

Publish Mass Constraints at end of Survey

~30 new small, well-characterized planets

Updated M-R relation

Longer period planet constraints

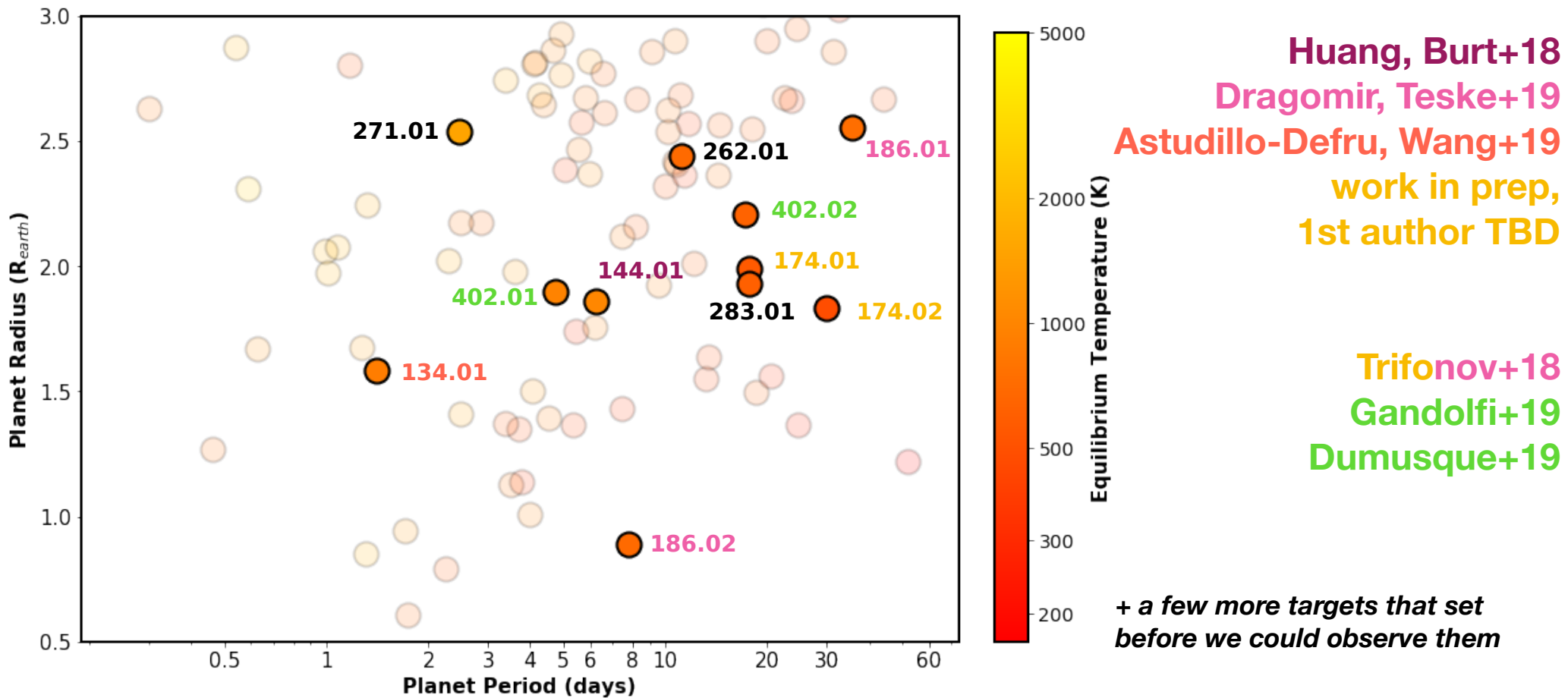
RV observations for other groups to  
combine with additional data

Host star compositions

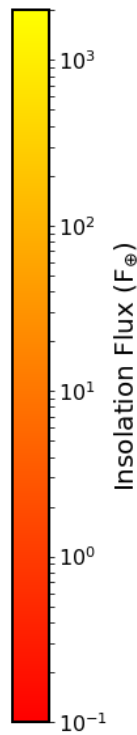
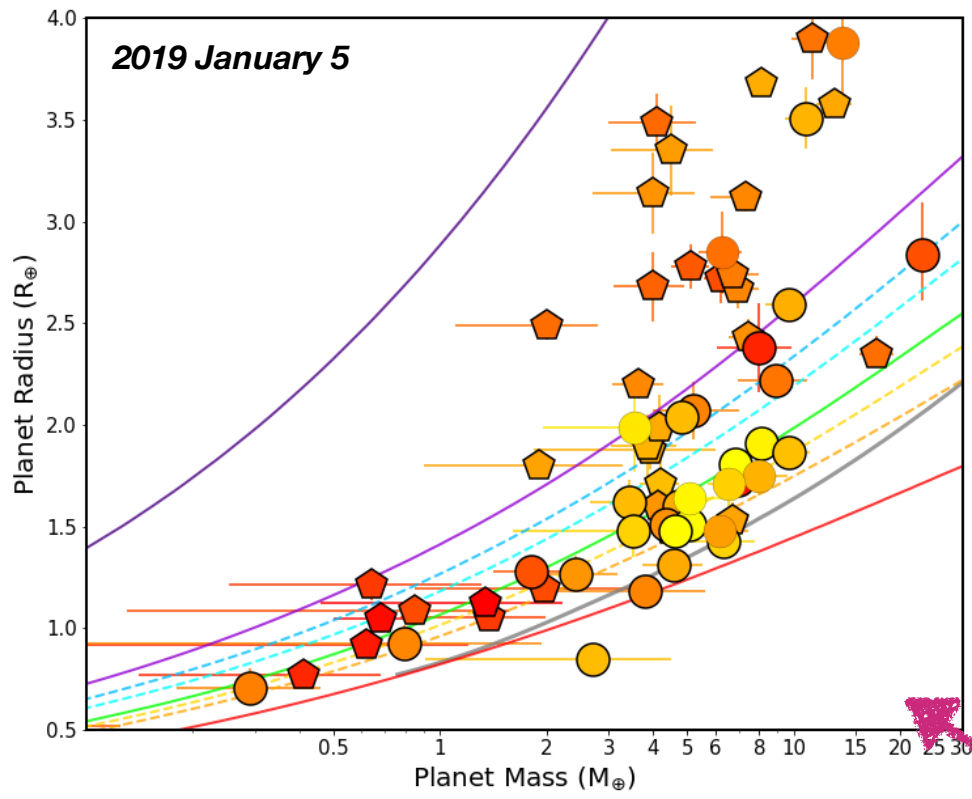
Stellar rotation periods

High-resolution images

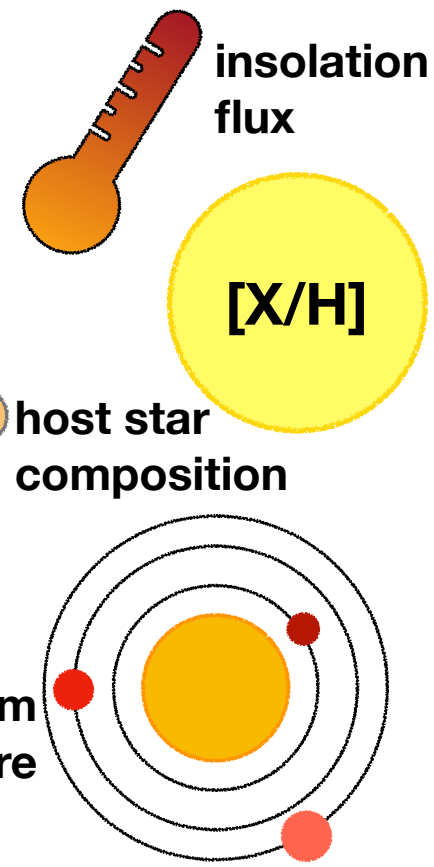
# Targets in Magellan-TESS Survey Thus Far



# A Southern Hemisphere RV Follow-up Program for TESS with PFS/Magellan



How do planetary bulk densities depend on...



Over the next few years, we will fill in this diagram!