Asteroseismology of exoplanet host stars using *Kepler* SC data

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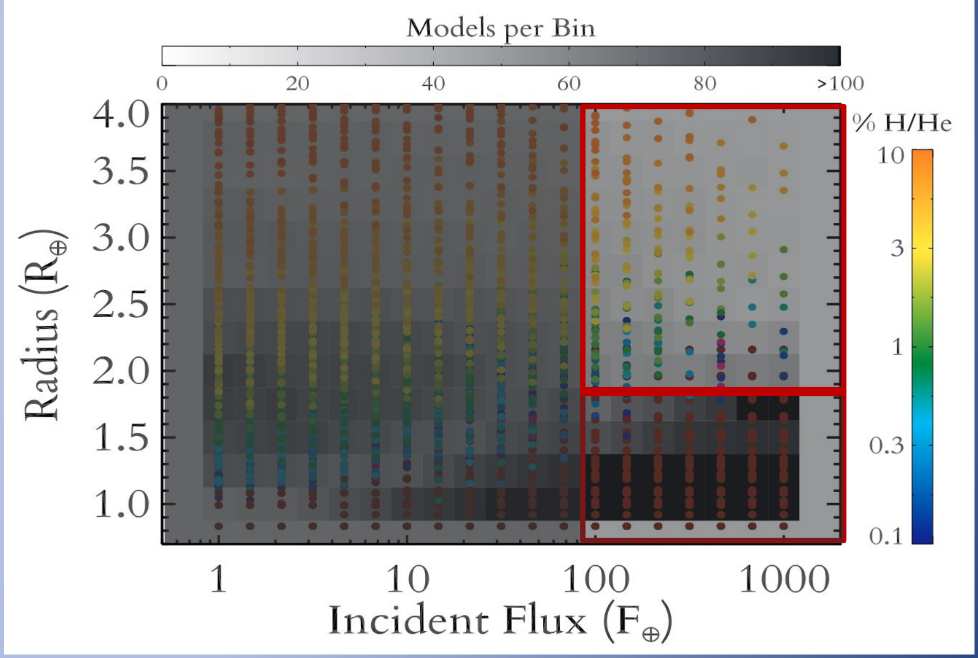
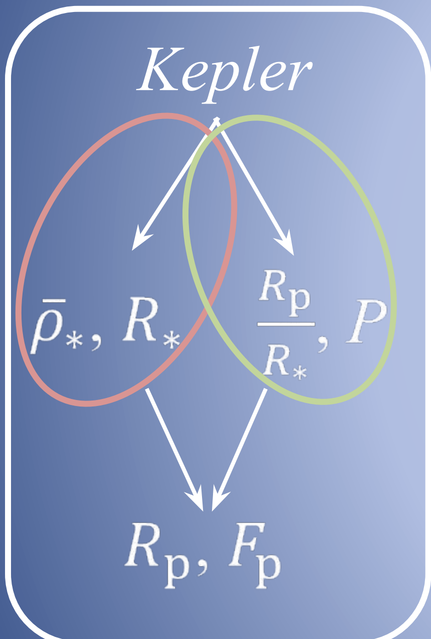
Background

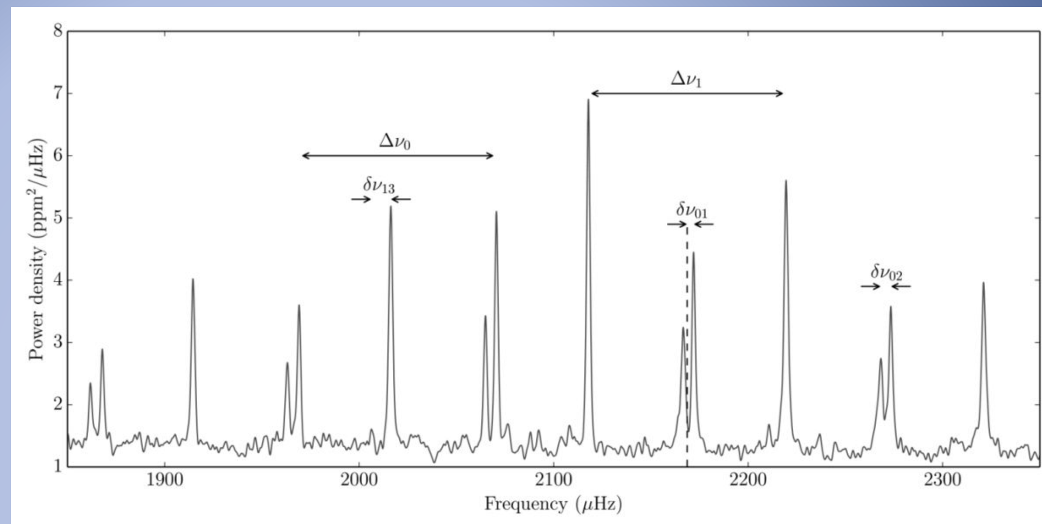
- Models predict stripping of envelope by photo-evaporation.
- $F > 100\ F_\oplus$ and $1.8 < R/R_\oplus < 4.0$: missing.
- $F > 100\ F_\oplus$ and $1.8\ R_\oplus$: over-abundant.
- Asteroseismology is essential.



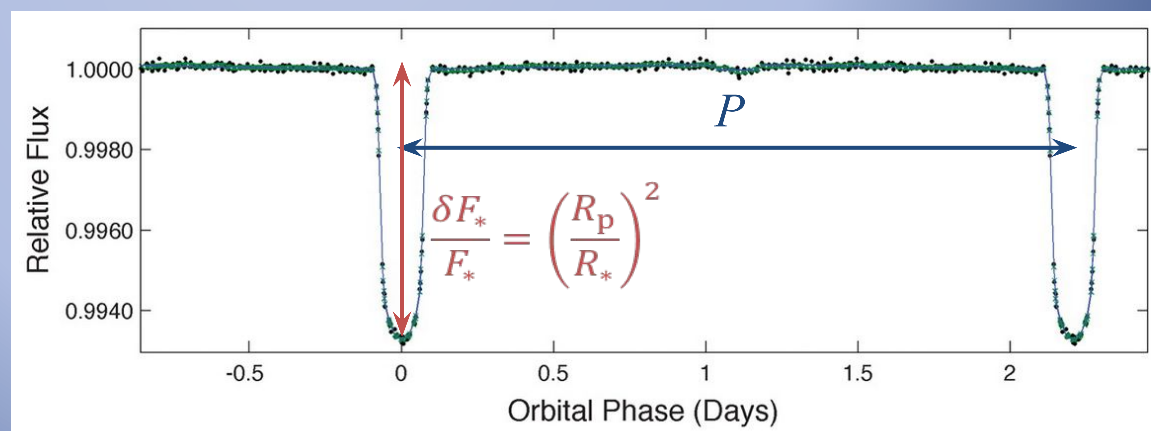
Lopez and Fortney, 2013 (ApJ, 776, 2)

Planetary radius and incident flux



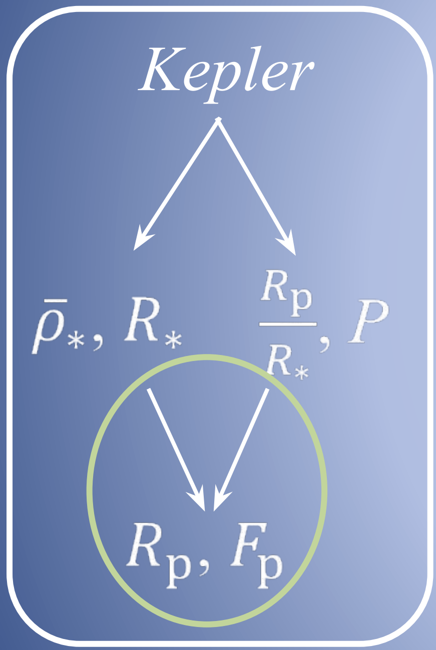


KIC 1129542616 as observed by *Kepler*



HAT-P-7, Borucki et al. (2009), Science 325, 709

Planetary radius and incident flux



- Radius:

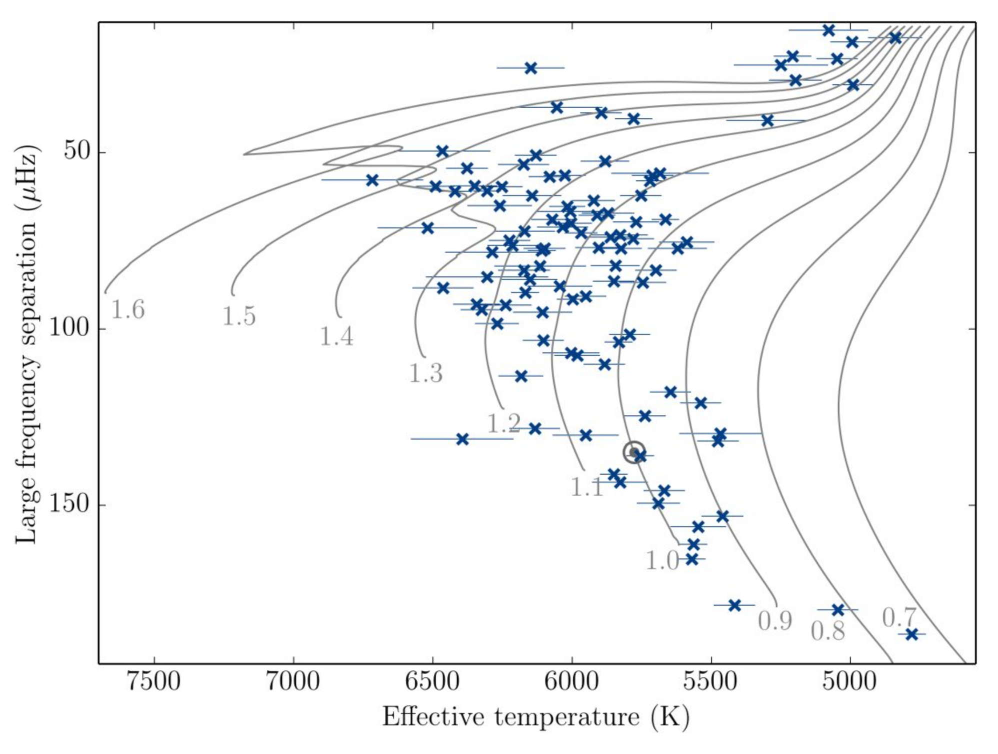
$$R_p = \left(\frac{R_p}{R_*}\right) R_* \,.$$

- Incident flux:

$$\frac{F_p}{F_\oplus} = \left(\frac{\bar{\rho}_*}{\bar{\rho}_\odot}\right)^{-\frac{2}{3}} \left(\frac{P}{1\ \mathrm{yr}}\right)^{-\frac{4}{3}} \left(\frac{T_{\mathrm{eff},*}}{T_{\mathrm{eff},\odot}}\right)^{4} .$$

The asteroseismic host star sample

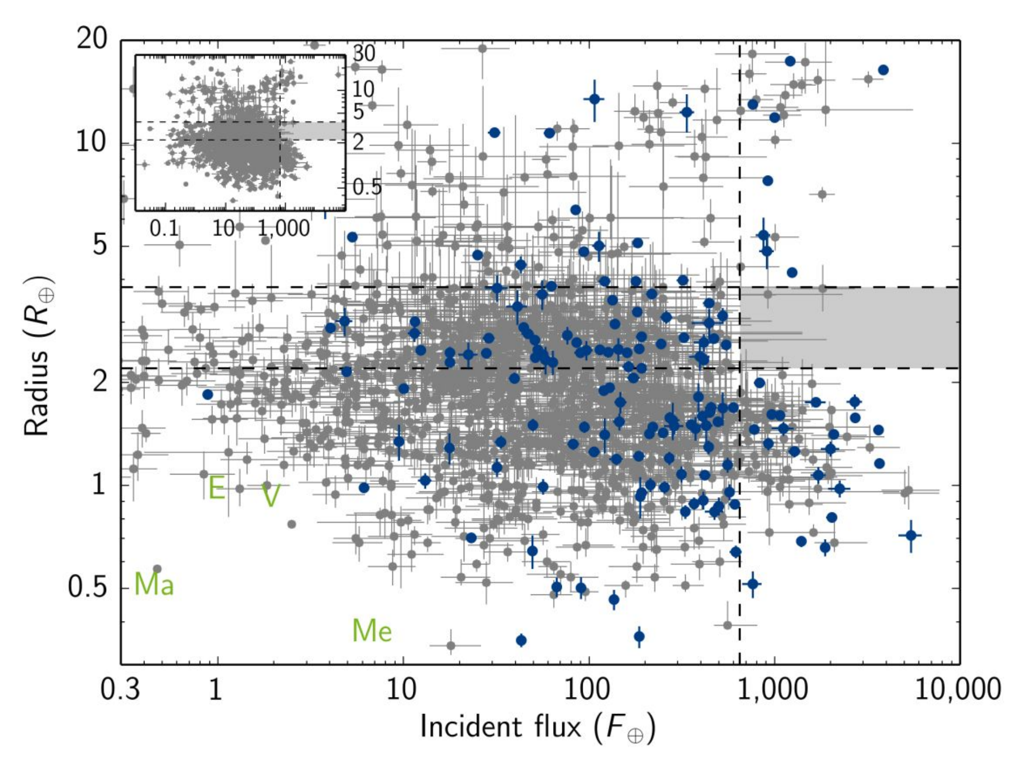
- 102 confirmed and candidate exoplanet host stars brighter than 13.5 mag with SC data.



The radius-flux diagram

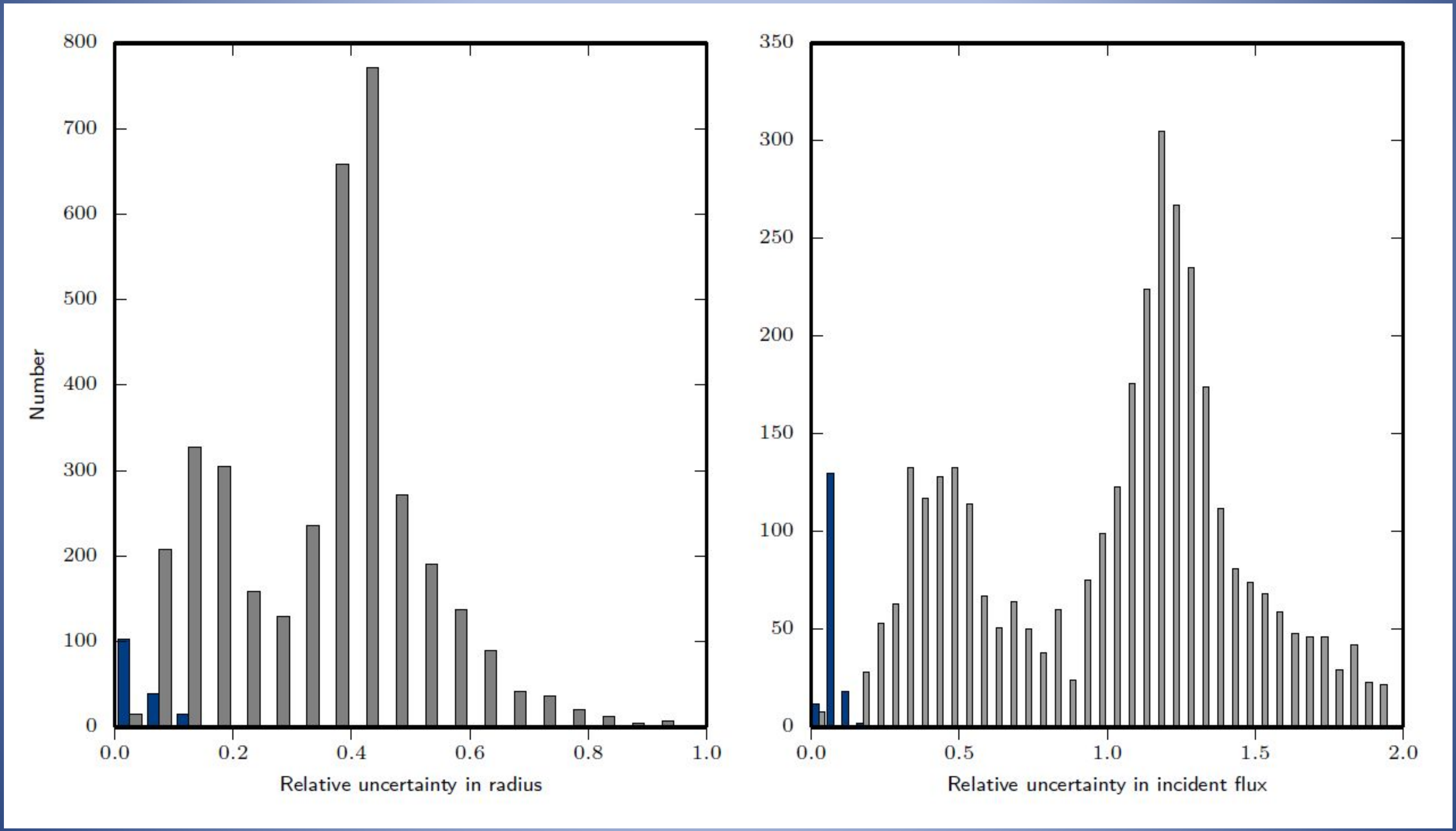
- Empty region: $F > 650\ F_{\oplus}$ and $2.2 < R/R_{\oplus} < 3.8$.

⇨ The hot-super-Earth desert.



Hot exoplanets with $R < 2.2\ R_{\oplus}$ are likely rocky.

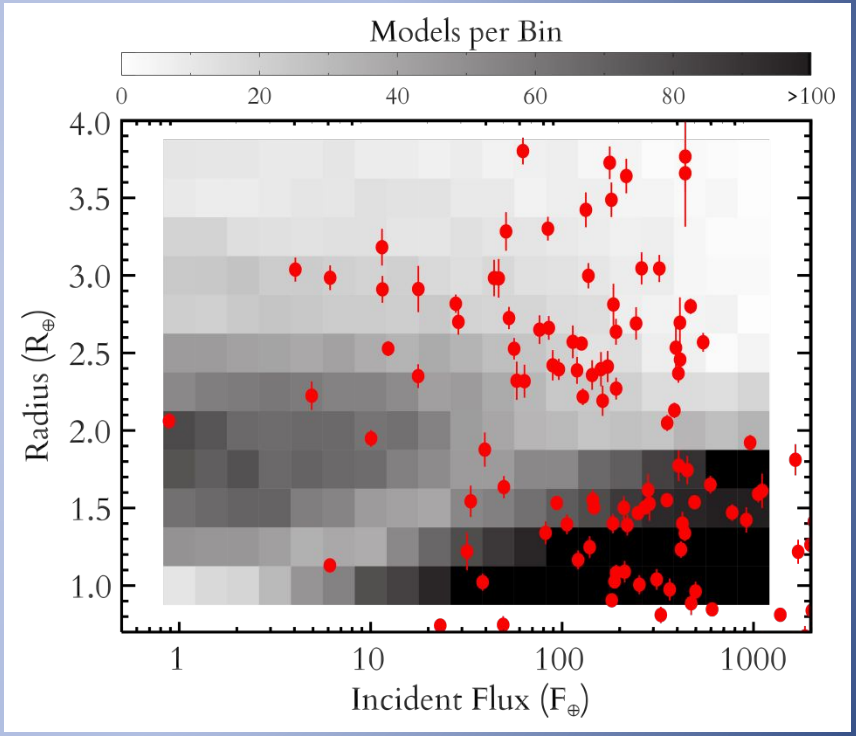
Uncertainties



Improved transit properties

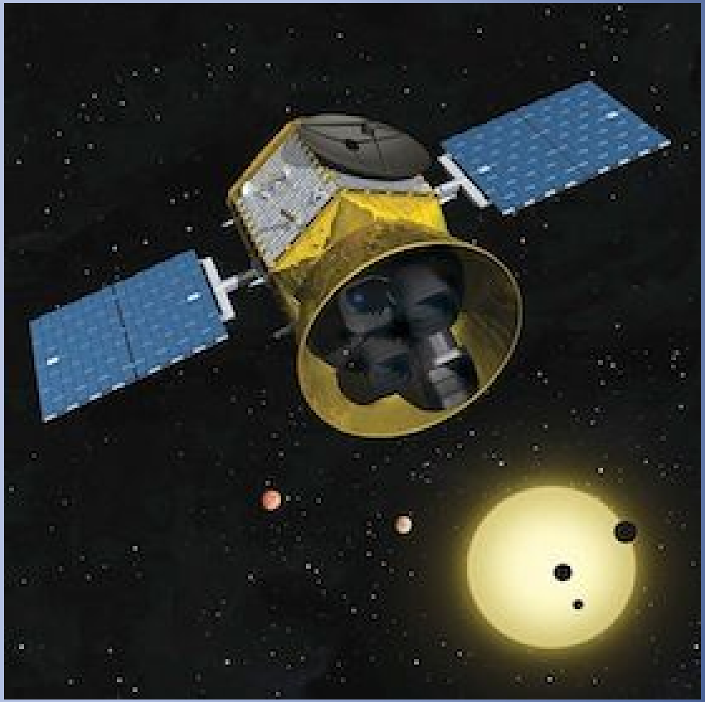
13.82

- Re-analysis of 139 planets mostly from the seismic sample.
- Bimodal distribution in radius with a minimum at $R_p \sim 2R_\oplus$.
- Caused by a transition in composition?



Importance of TESS

- TESS will observe most of the bright FGK dwarfs at a short cadence.
- Essentially no selection bias for the solar-like MS, unlike *Kepler*.
- Should be able to estimate the large separation for a large portion of these stars.
- Constrain the absence – or presence – of hot super-Earths even further.



http://space.mit.edu/TESS/TESS/TESS_Overview.html

Conclusion

- We have detected a hot-super-Earth desert, which is consistent with expectations of photo-evaporation from theory.
- This will be an added constraint for models of the evolution of planetary systems.
- TESS will allow further tests.
- Planets with R < 2.2 $R_{\oplus}$ are probably rocky (since they do not appear to evaporate).

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ARTICLE

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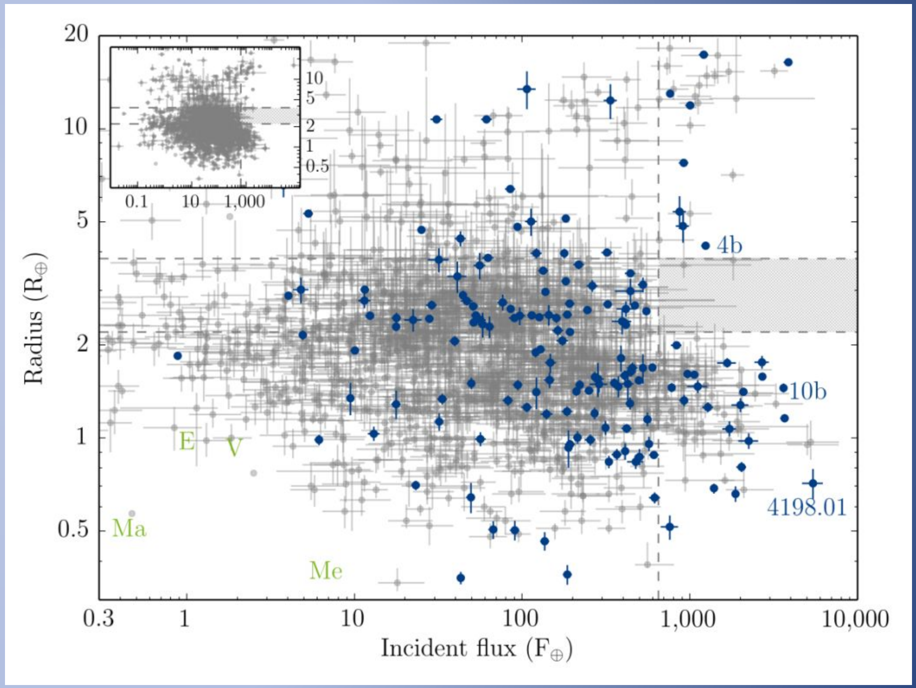
Hot super-Earths stripped by their host stars

- Hans Kjeldsen, Simon Albrecht, Guy R. Davies,
- Sarbani Basu, Daniel Huber, Anders B. Justesen, Christoffer Karoff, Victor Silva Aguirre, Vincent Van Eylen, Christina Vang,
- Torben Arentoft, Thomas Barclay, Tim R. Bedding, Tiago L. Campante, William J. Chaplin, Jørgen Christensen-Dalsgaard, Yvonne P. Elsworth, Ronald L. Gilliland, Rasmus Handberg, Saskia Hekker, Steve D. Kawaler, Mikkel N. Lund, Travis S. Metcalfe, Andrea Miglio, Jason F. Rowe, Dennis Stello, Brandon Tingley and Tim R. White.

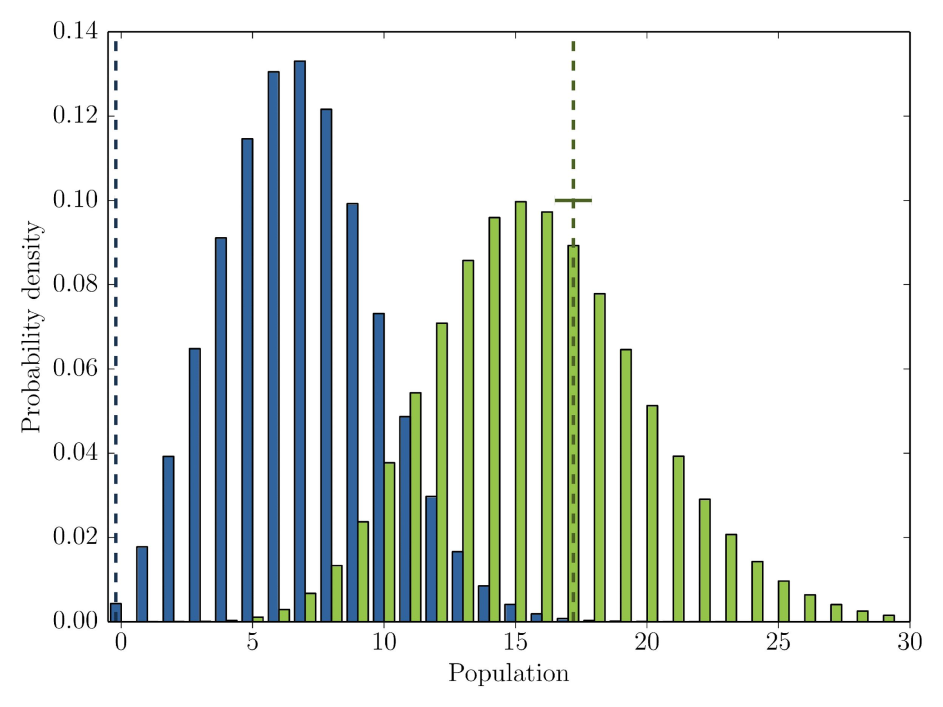
Selection effects and false positives

- Selection effects:
  - Detection sensitivity (miss: low R, low F planets).
  - Short-cadence data (miss: high R, low F planets).
- False positives:
  - Removed %'s according to Fressin et al (2013).

⇨ Neither affect the desert.



Significance



- Observed number in the desert: 0 ± 0.04 .

$\Rightarrow$ Less than 0.4% of the simulations return 0 planets in the desert.

- Observed number below the desert: 17 ± 0.7 .

$\Rightarrow$ Not statistically significant (note selection effects).