# Asteroseismology of Exoplanet-Host Stars with *TESS*

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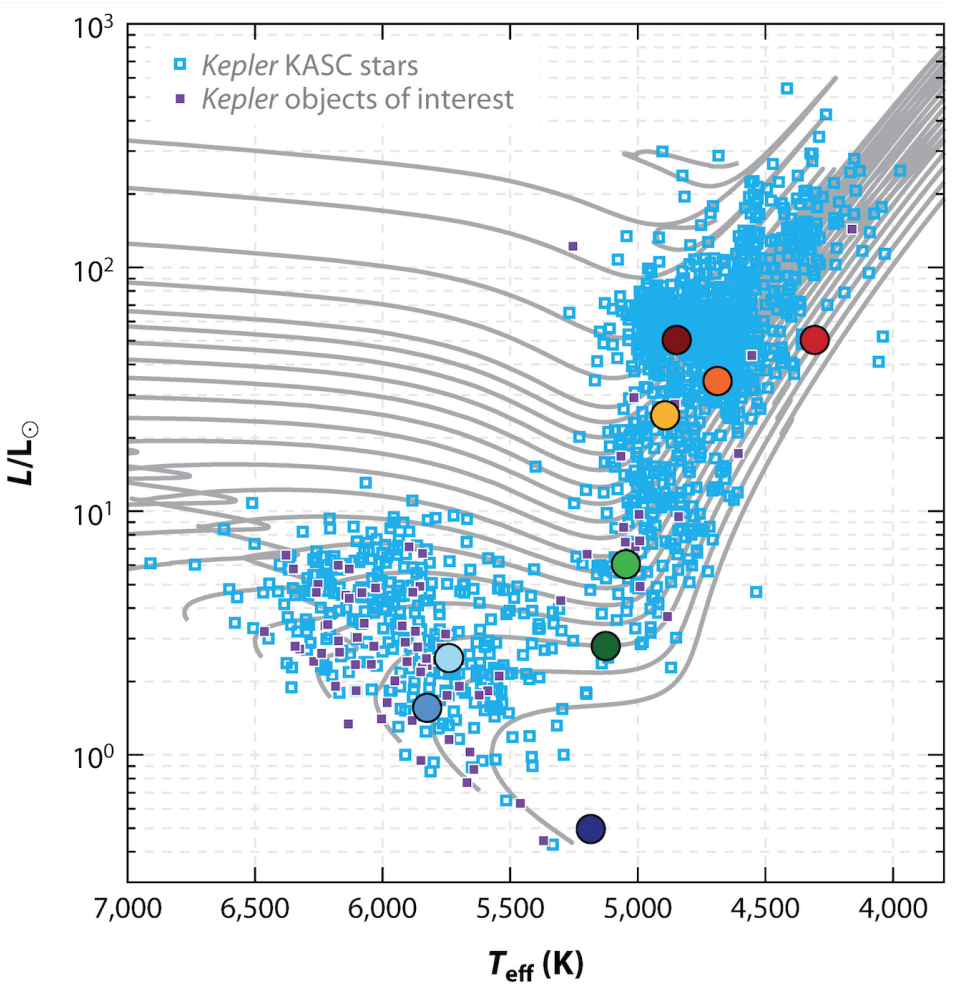
# Solar-like oscillations and the *Kepler* legacy

- Cool-star asteroseismology with *Kepler*:
  - Several hundred solar-type stars
  - Over 10,000 red giants
- $\sim$100 KOIs with detected solar-like oscillations




Chaplin & Miglio (2013)

# Synergy between asteroseismology and exoplanetology

- Precise characterisation of host stars
  - 1.2 % precision in $R$, 3.3 % in $M$ and 14 % in age for third of asteroseismic KOI sample (Silva Aguirre et al. 2015)
  - Kepler-444: oldest known system of terrestrial-size planets (Campante et al. 2015)
- Spin-orbit alignment of exoplanet systems
  - Kepler-56: first misaligned multiple-planet system (Huber et al. 2013)
  - Ensemble analysis (Campante et al. 2016)
- Orbital eccentricity determination via asterodensity profiling
  - Small planets in *Kepler* multis have low eccentricities (Van Eylen & Albrecht 2015)

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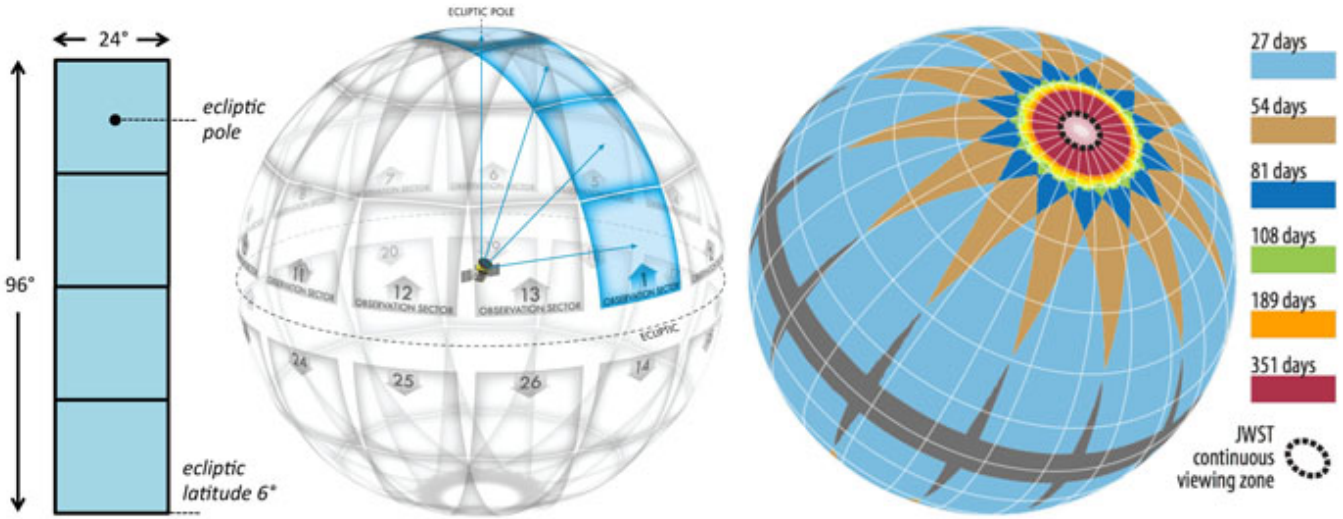
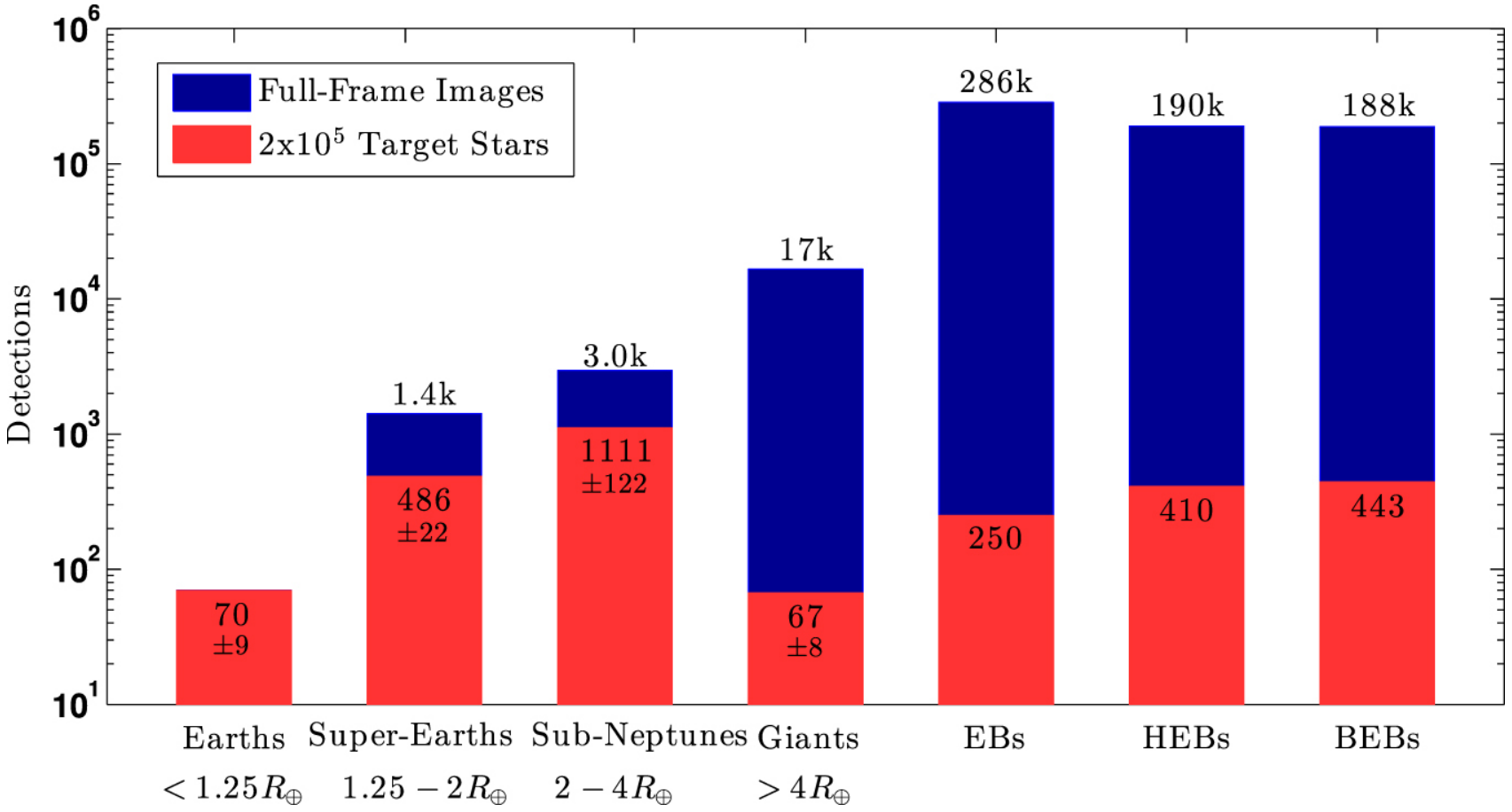
# Overview of *TESS*

- December 2017 launch
- All-sky survey (FOV shown below)
- Stars observed for at least 27 days
- 2-min cadence ($\sim 2 \times 10^5$ pre-selected FGKM dwarfs)
- 30-min cadence (full-frame images)




http://tess.gsfc.nasa.gov/

# Expected *TESS* planet yield

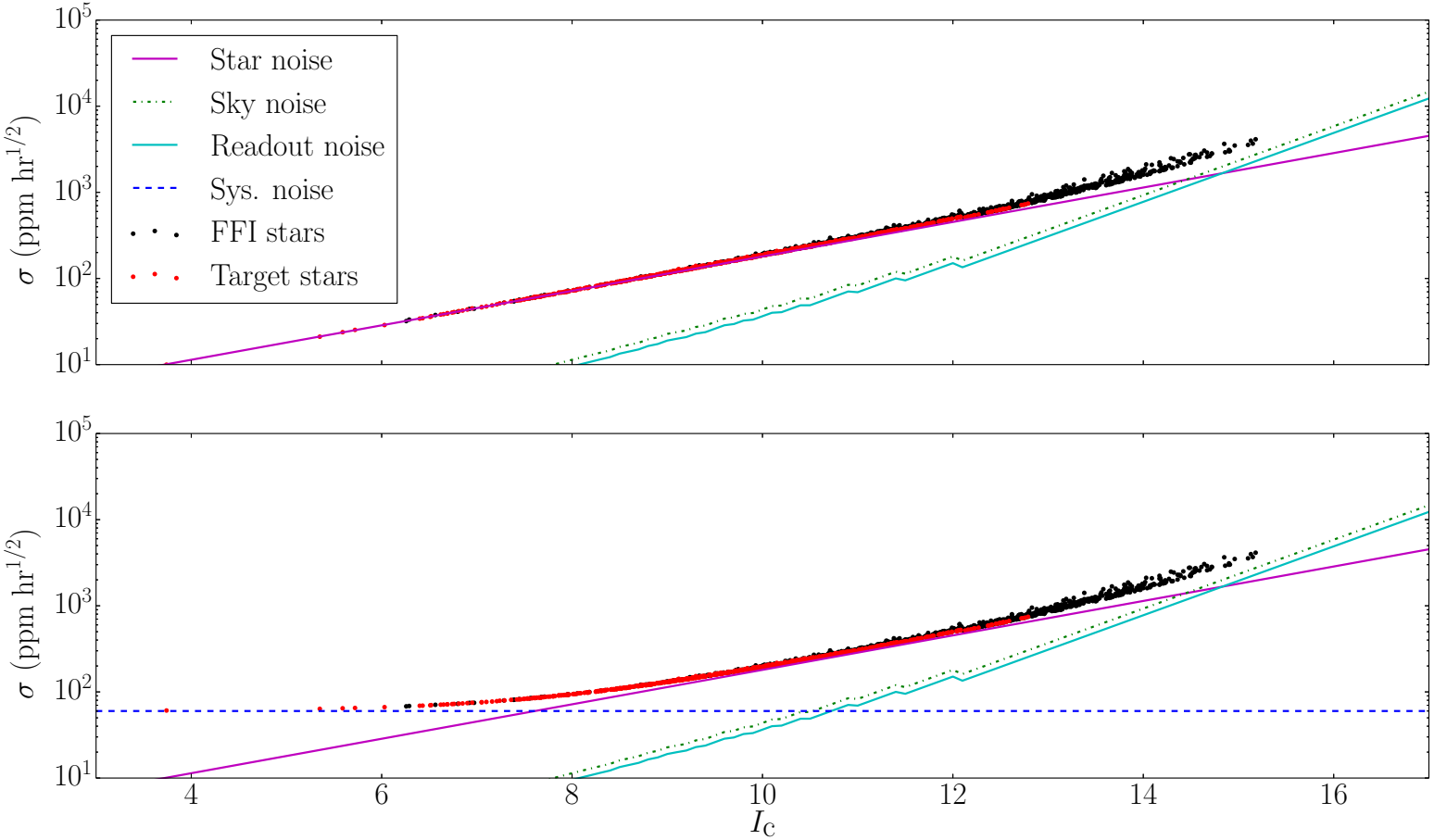



Sullivan et al. (2015)

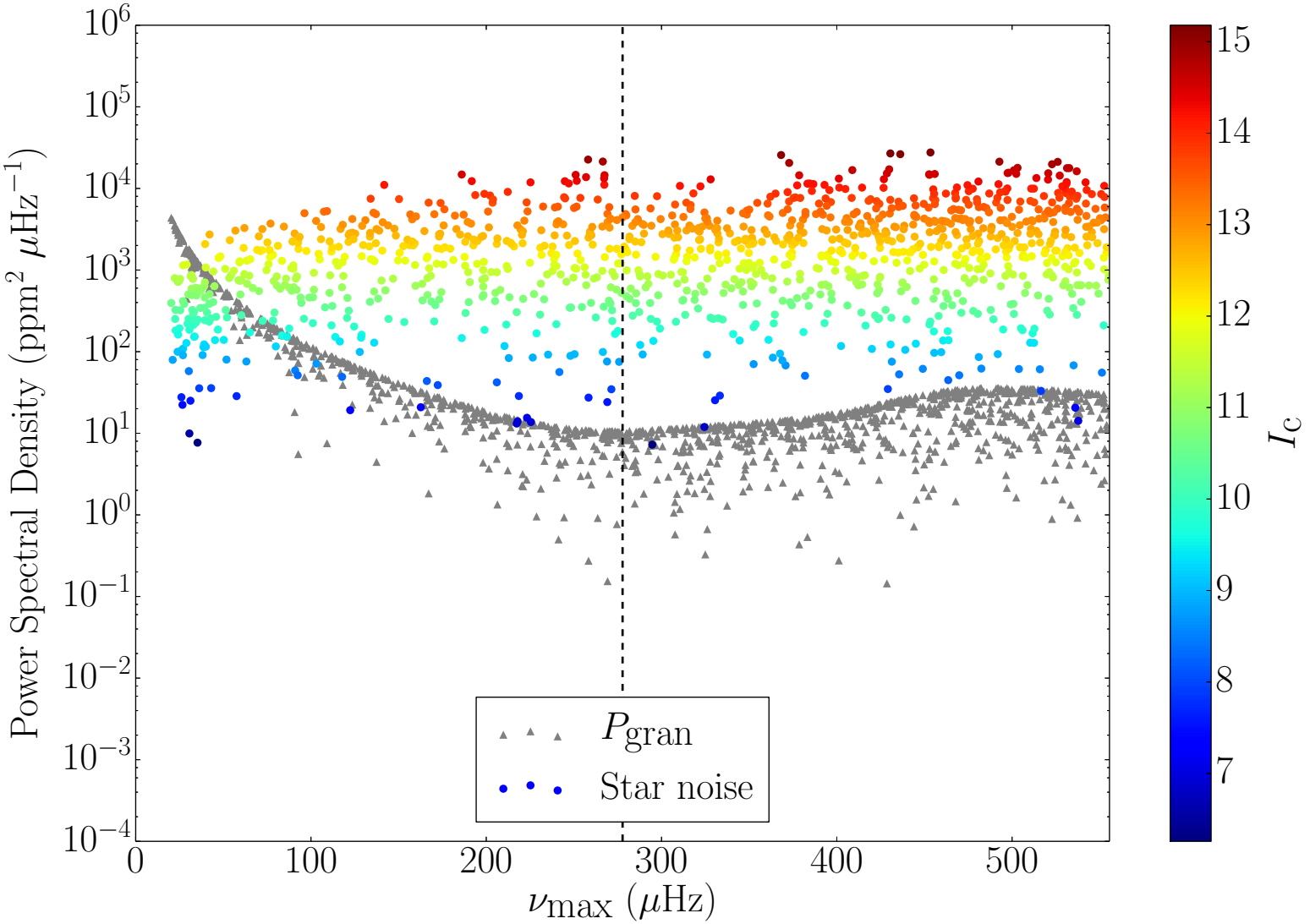
# Predicting the detectability of oscillations with *TESS*

- Excellent photometric precision will enable asteroseismology of solar-type and red-giant stars
- Detection test:
  - Sets detection threshold for excess power due to oscillations
  - Works in frequency domain
  - 5 % false alarm probability
  - Validated using *Kepler* data and adapted to *TESS* specifications

# *TESS* photometric noise model

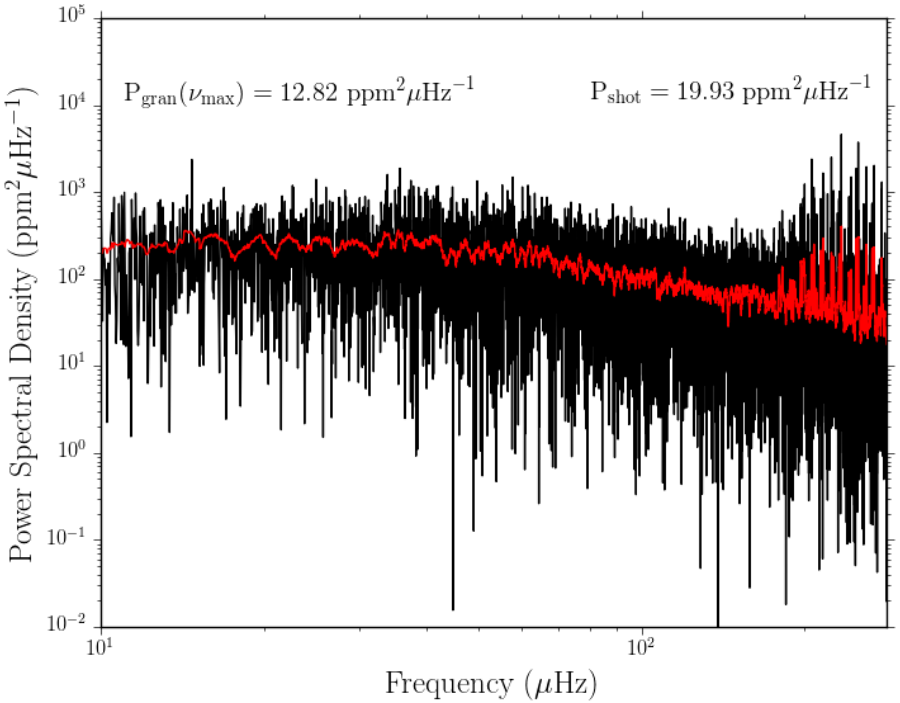


# Background power spectral density

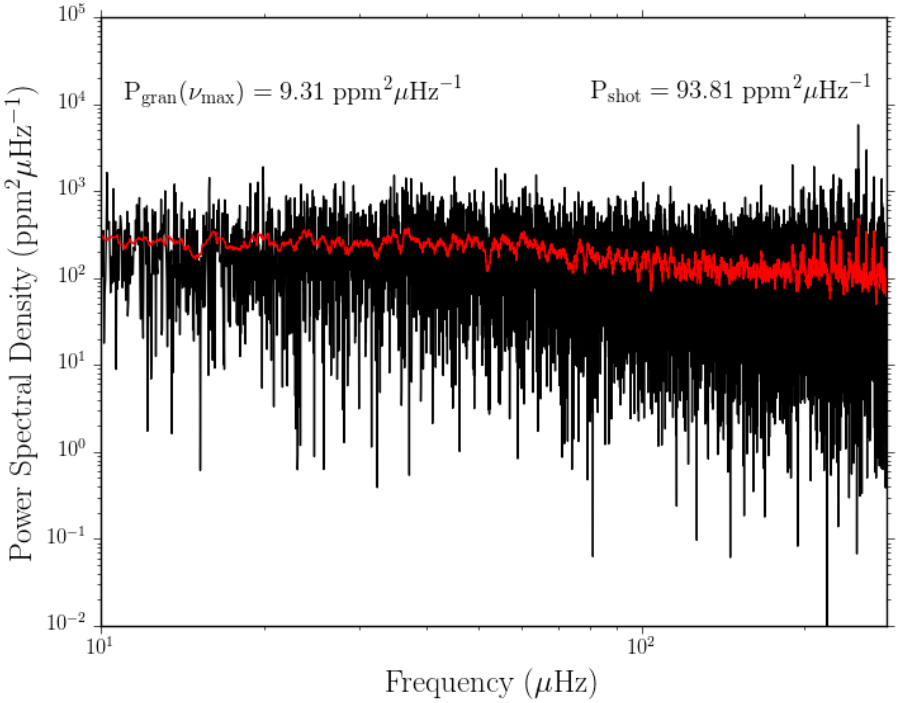


# Kepler-56 as seen by *Kepler* and *TESS*

*Kepler*



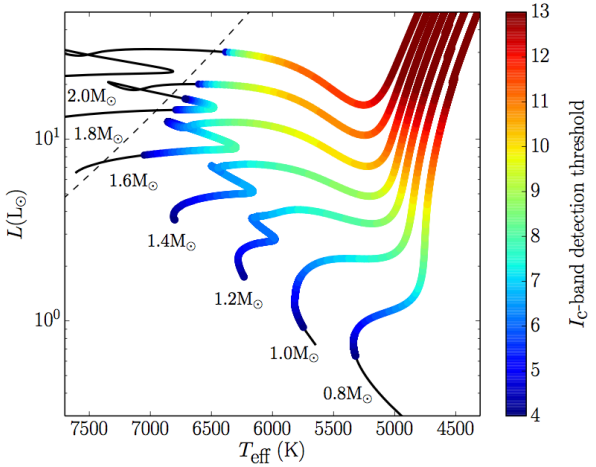

*TESS*



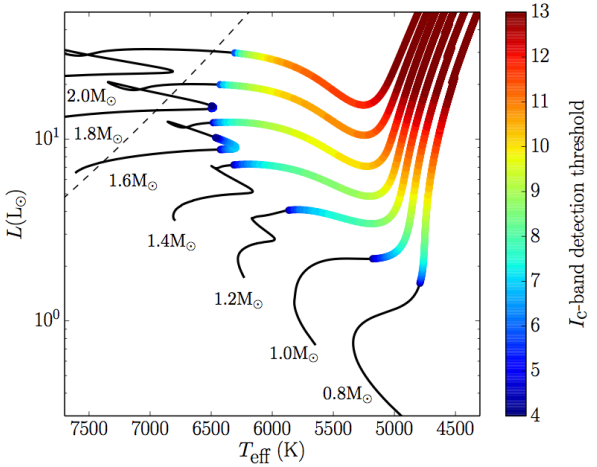

Figures courtesy of James Kuszlewicz

# Detectability of oscillations across the HR diagram

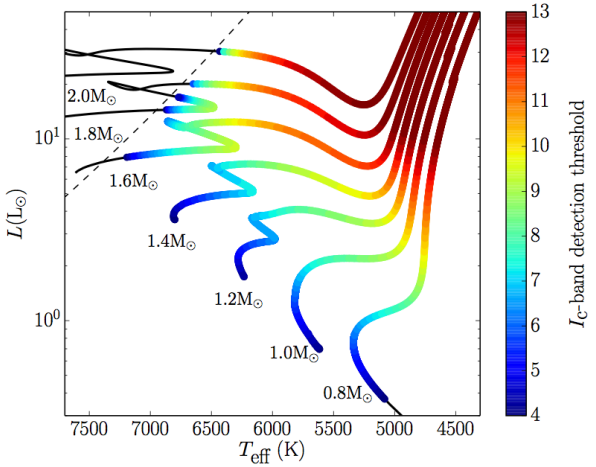
## *TESS* 2-min cadence (target stars)



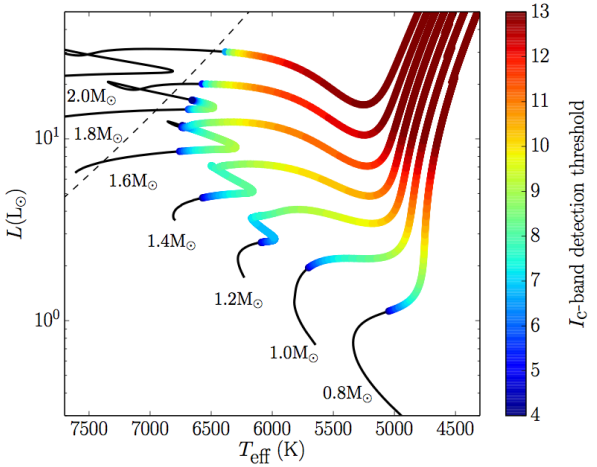

(a) $T = 27$ d, $\sigma_{\rm sys} = 0$ ppm hr$^{1/2}$.




(b) $T = 27$ d, $\sigma_{\rm sys} = 60$ ppm hr$^{1/2}$.



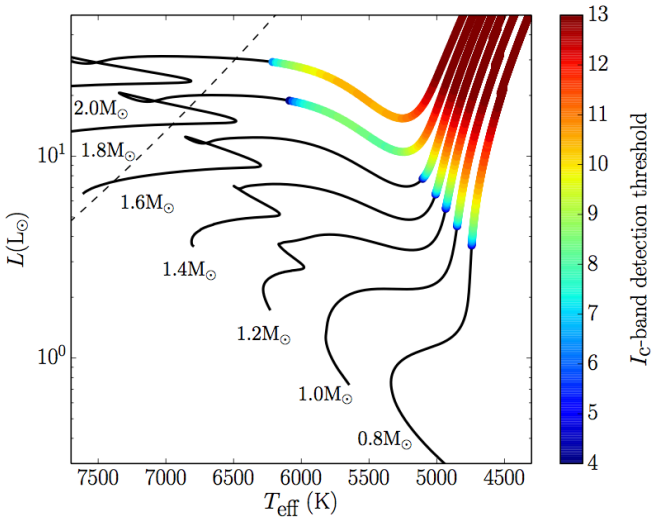

(c) $T = 351$ d, $\sigma_{\rm sys} = 0$ ppm hr$^{1/2}$.




(d) $T = 351$ d, $\sigma_{\rm sys} = 60$ ppm hr$^{1/2}$.

# Detectability of oscillations across the HR diagram

*TESS* 30-min cadence ('full-frame image' or FFI stars)

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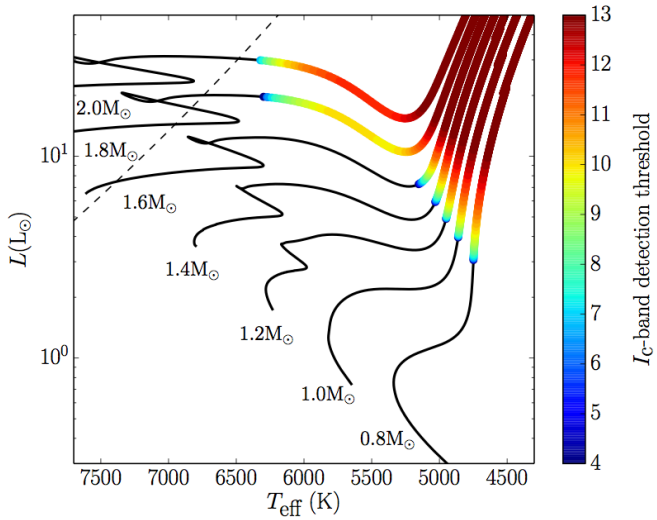



(b) $T = 351$ d, $\sigma_{\rm sys} = 60$ ppm hr$^{1/2}$.

# Overall *TESS* asteroseismic yield

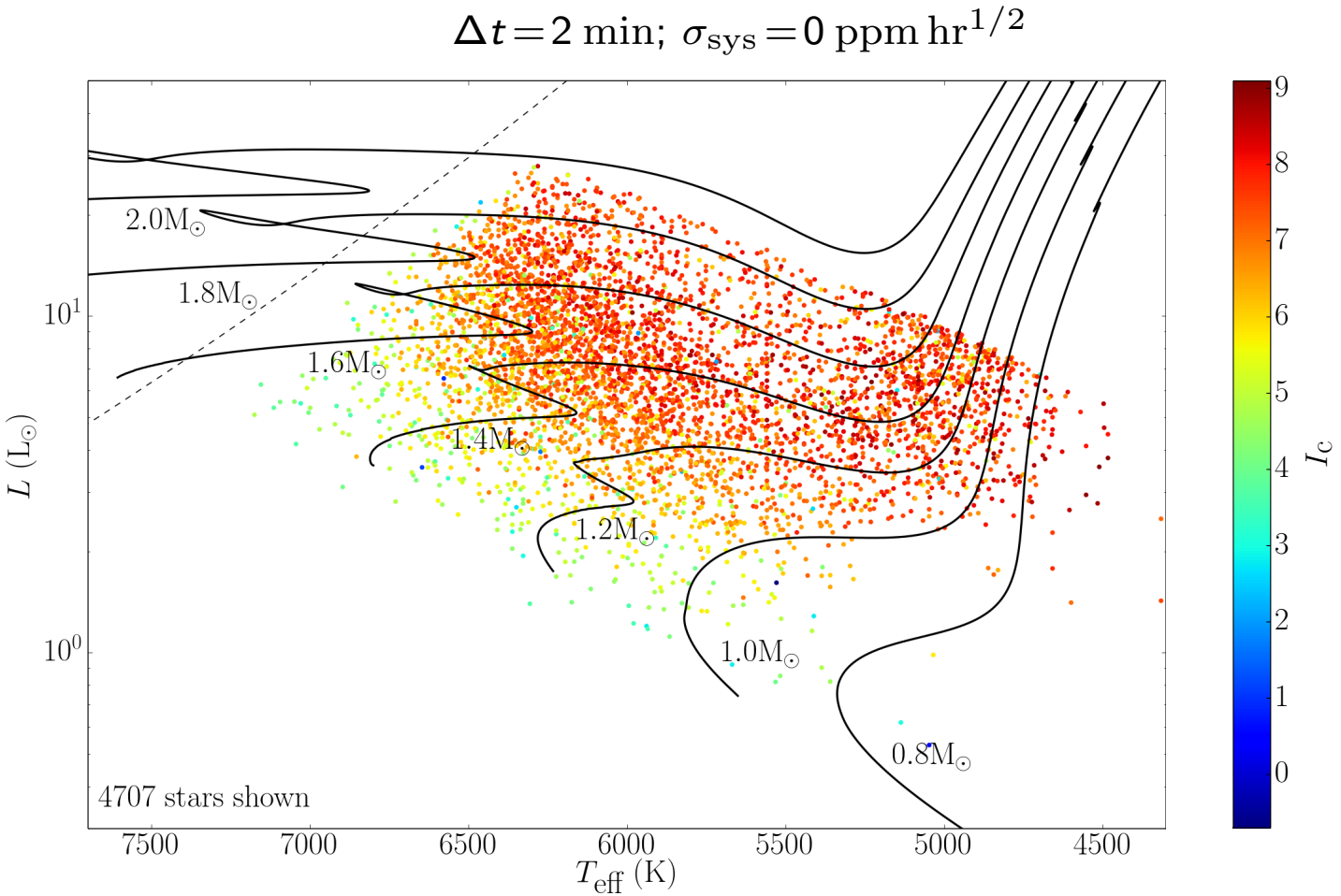
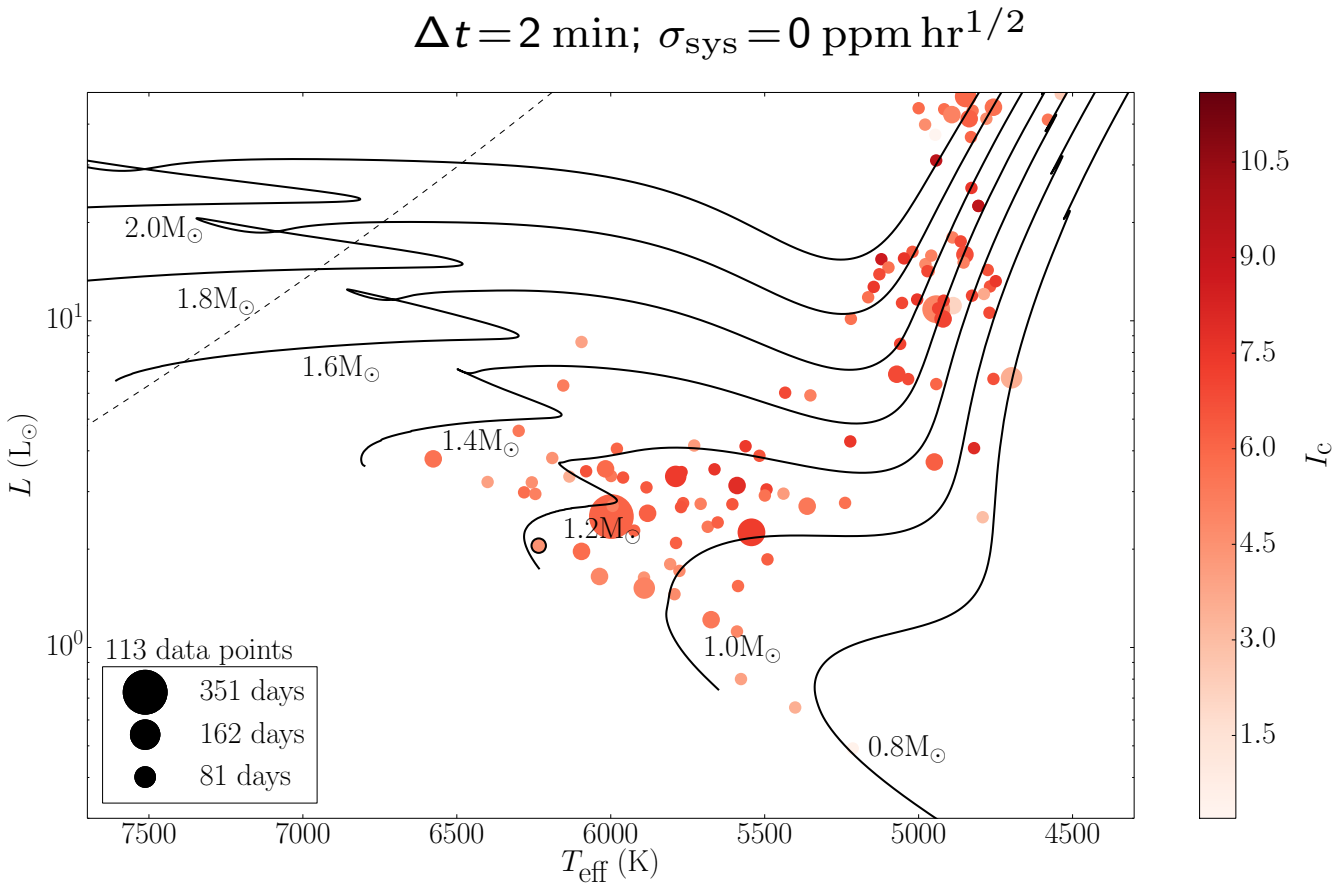



Figure courtesy of Mat Schofield (go and see his poster!)

# *TESS* asteroseismic yield of exoplanet-host stars

- There are three separate contributions to this yield:
  - Previously known hosts (transiting or not)
  - *TESS* target hosts (2-min cadence)
  - *TESS* FFI hosts (30-min cadence)

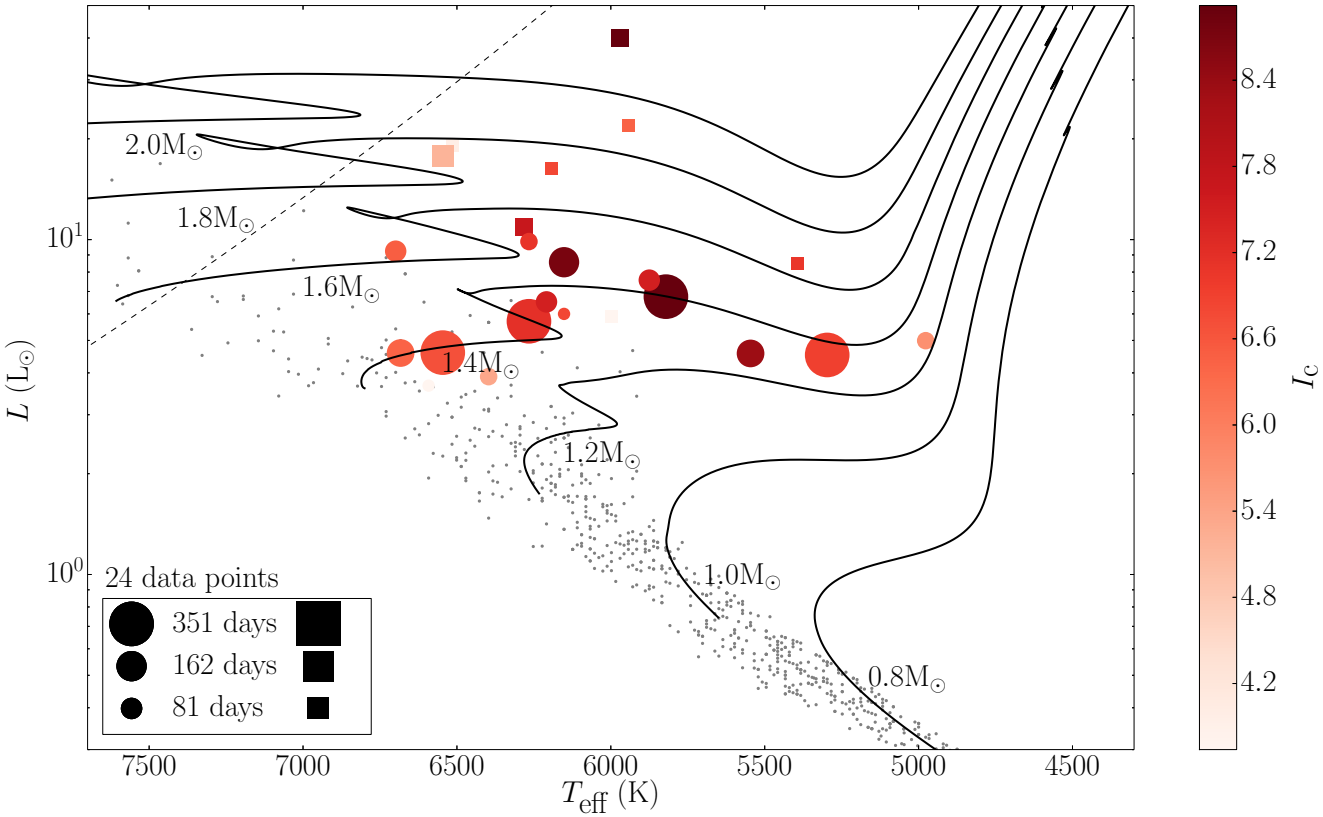
# Asteroseismic yield of known exoplanet-host stars



# Asteroseismic yield of *TESS* target hosts

Based on synthetic target-host population of Sullivan et al. (2015)

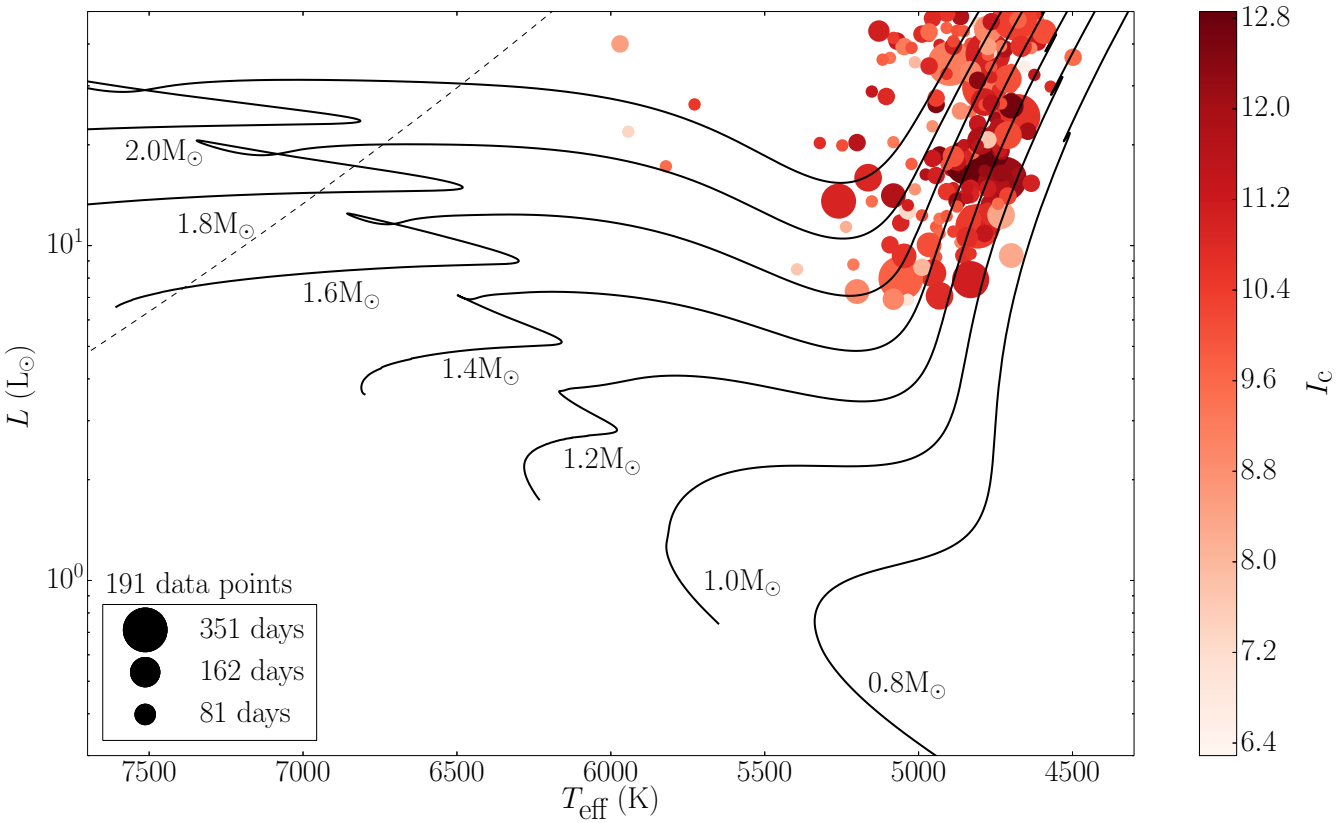
$(\Delta t = 2\ \mathrm{min};\ \sigma_{\mathrm{sys}} = 0\ \mathrm{ppm\,hr}^{1/2})$



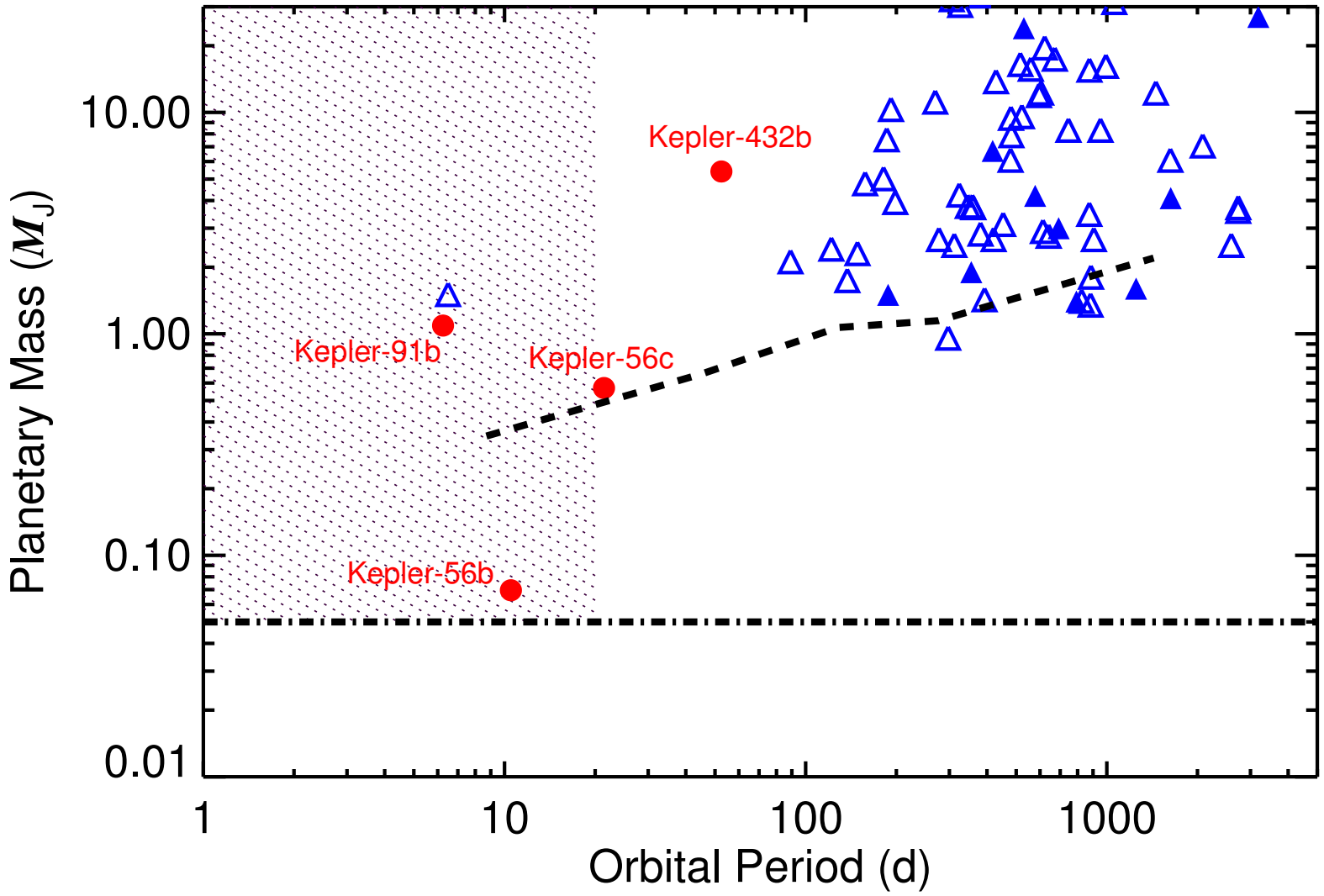
# Asteroseismic yield of *TESS* FFI hosts

Based on synthetic FFI-host population of Sullivan et al. (2015)

($\Delta t = 30$ min; $\sigma_{\rm sys} = 0$ ppm hr$^{1/2}$)



# Asteroseismology of red-giant hosts with *TESS*



# Summary

- Asteroseismic yield of known exoplanet-host stars
  - Over 100 known hosts with detections
  - Link to ESA's *CHEOPS*
- Asteroseismic yield of *TESS* target hosts
  - Few dozen *TESS* target hosts (mainly F dwarfs and subgiants)
- Asteroseismic yield of *TESS* FFI hosts
  - Up to 200 red-giant hosts spanning a range of masses
- Results to be presented in Campante et al. (submitted to ApJ)

$\Longrightarrow$ Threefold improvement relative to *Kepler*!