Weighing in on the masses of retired A stars with asteroseismology

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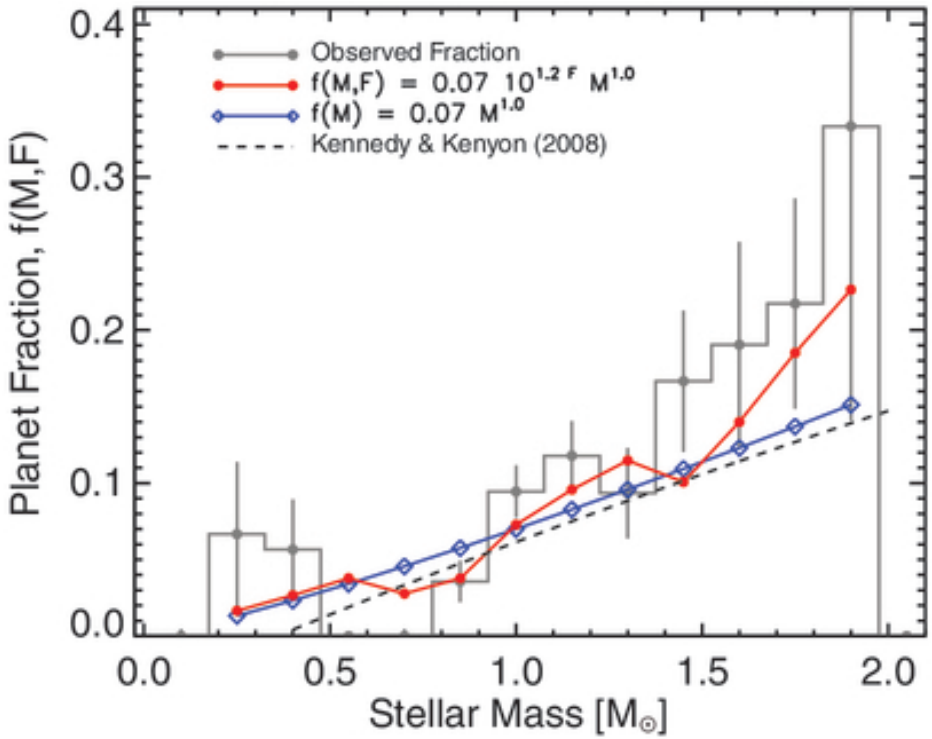
Overview

Planet occurrence as a function of stellar mass

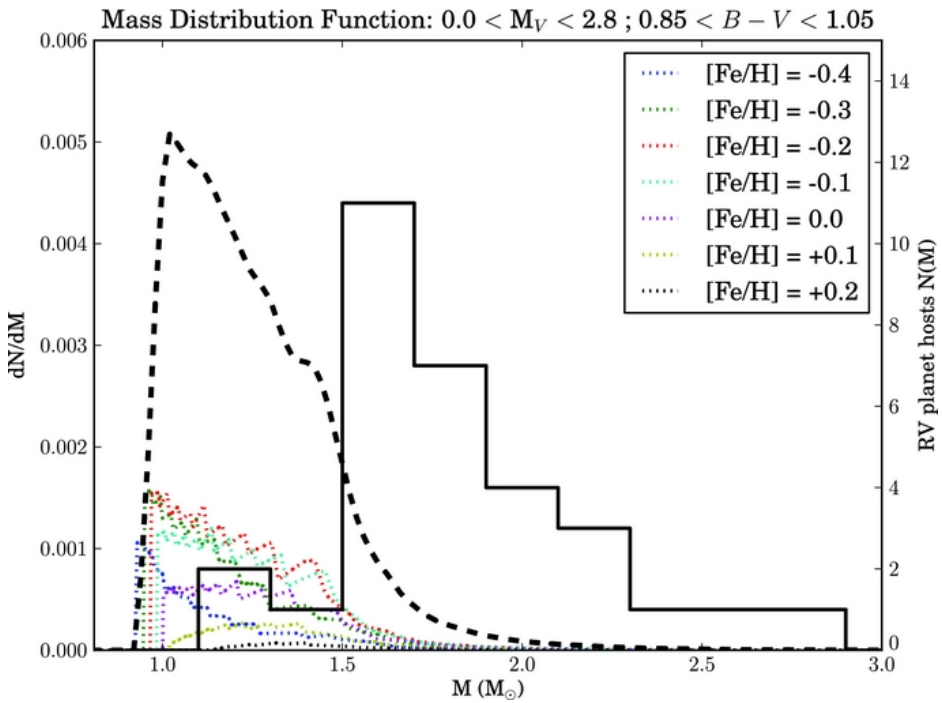
- Giant-planet occurrence increases with stellar mass
- RV searches rely on SG/RGB stars for a sample of intermediate-mass stars with $M \gtrsim 1.5\,\mathrm{M}_{\odot}$ (hence the term "retired A stars")
- Why? Their MS progenitors are hostile to precision RV



Johnson et al. (2010, PASP, 122, 905)

The "retired A star controversy"

- Masses of SG/RGB stars typically derived from combination of spectroscopy and isochrone fitting
- Mass estimates called into question by Lloyd (2011)
- Argument: selection criteria should have led to sample dominated by lower-mass stars (originating from population of late F/early G dwarfs)



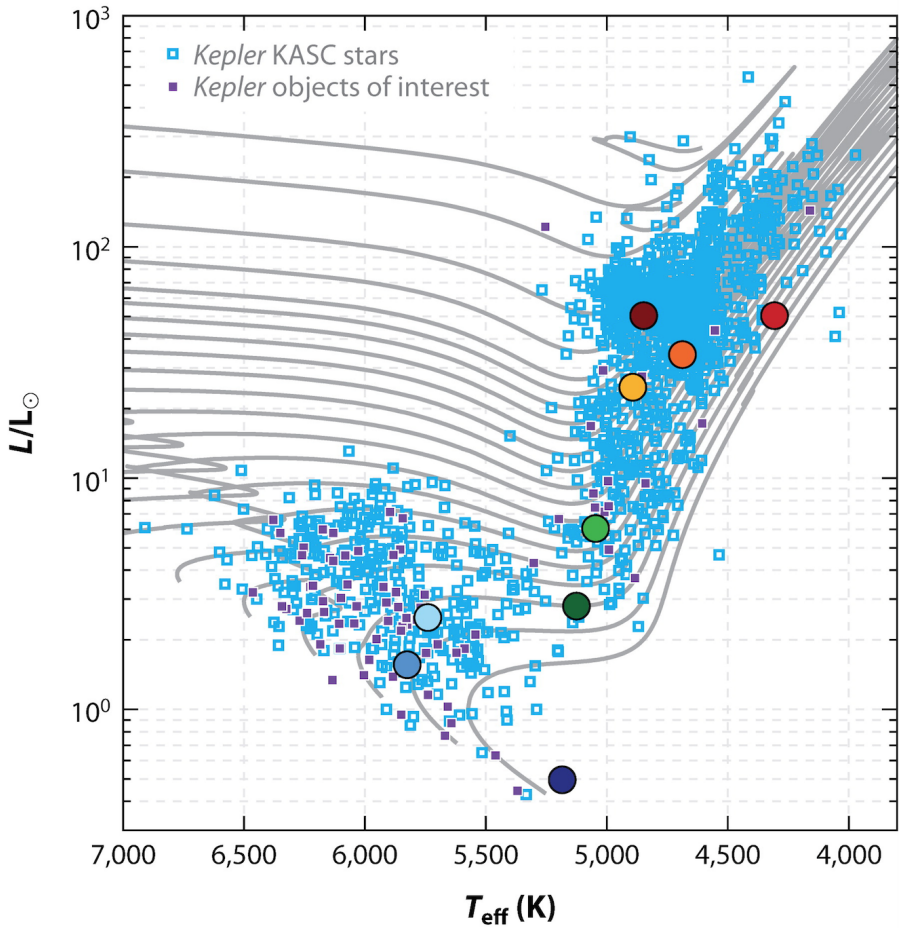
Lloyd (2011, ApJ, 739, L49)

Why this issue needs resolving?

- Important implications for way in which masses of SG/RGB stars are estimated in the absence of asteroseismology
- Direct impact on our understanding of planet occurrence as a function of stellar mass (e.g., predicting the yield of planet imaging surveys)
- **Possible way forward:** Estimate accurate and precise masses for SG/RGB host stars previously targeted by Doppler surveys using *Kepler*/K2 asteroseismology

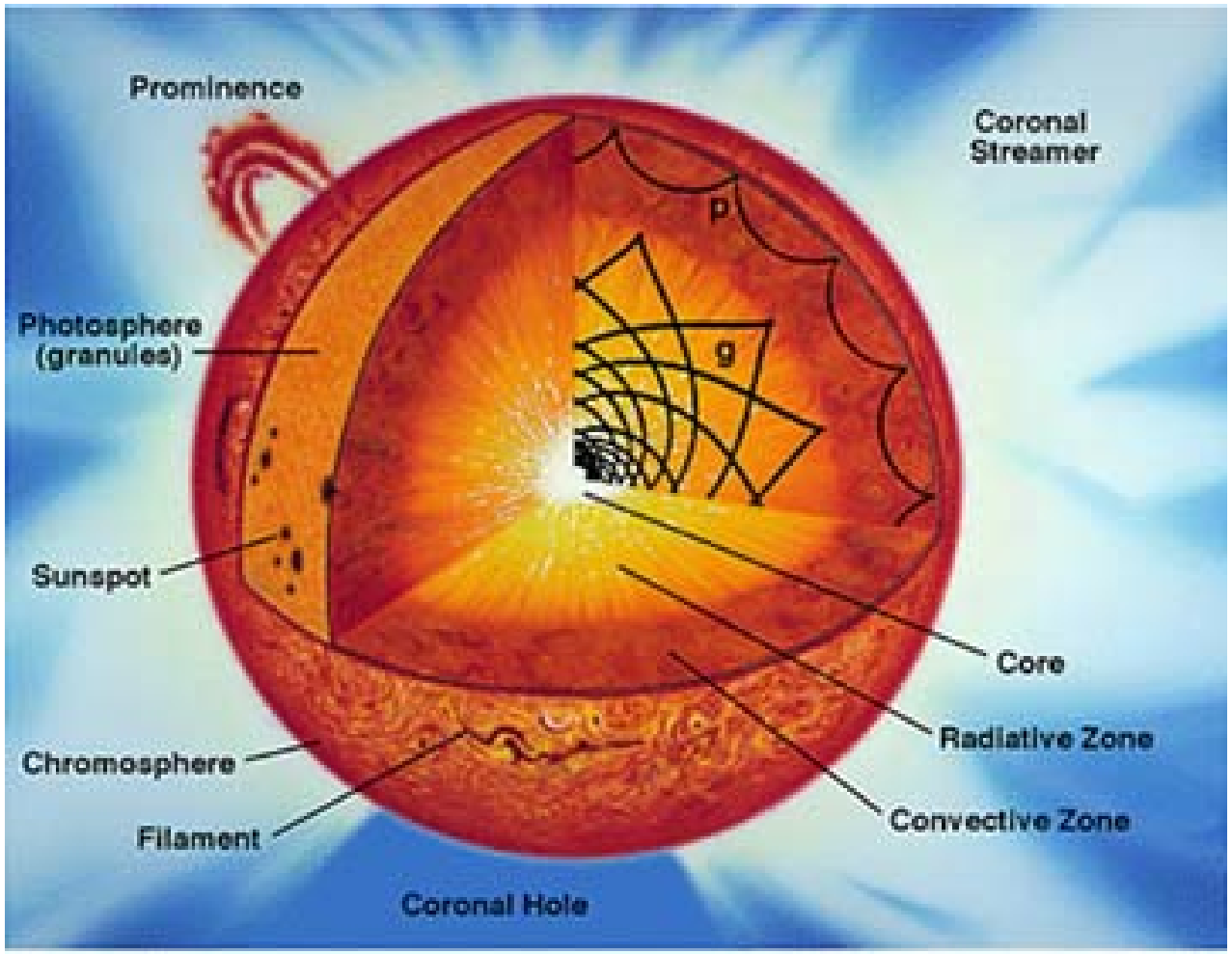
A revolution in cool-star asteroseismology

- Solar-like oscillations excited by turbulent convection
- 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, ARA&A, 51, 353)

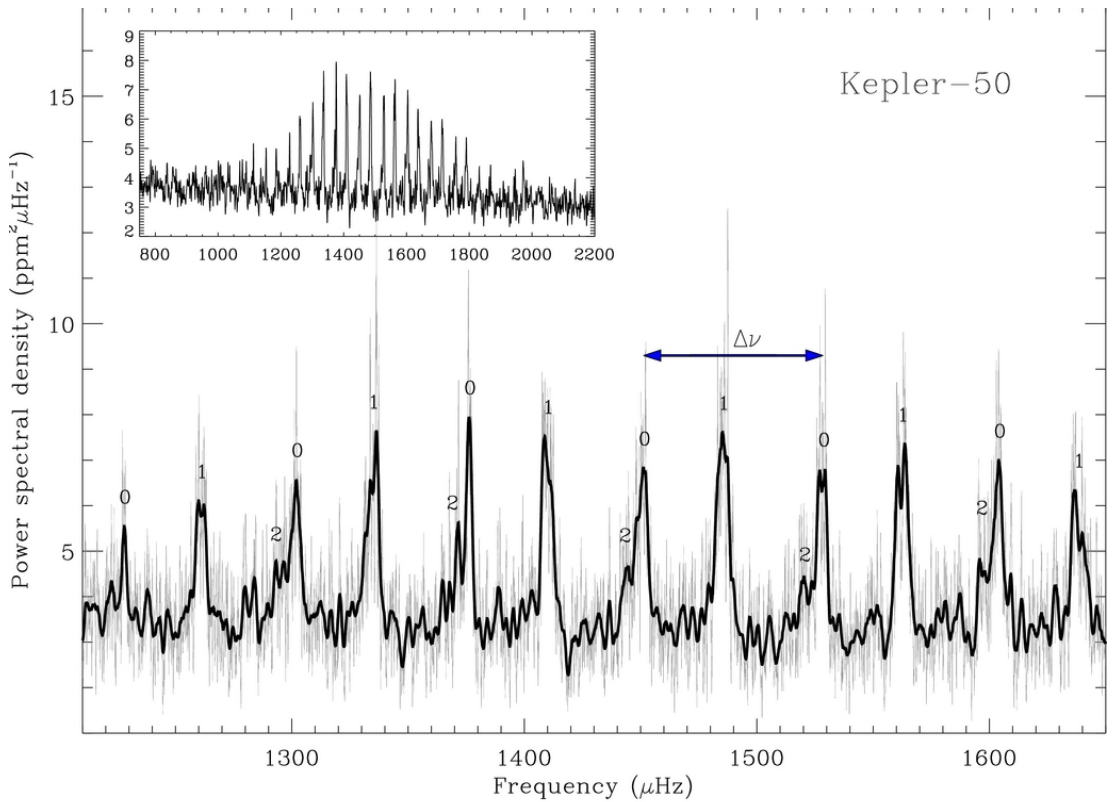
Physical nature of the oscillations



Power spectrum of solar-like oscillations

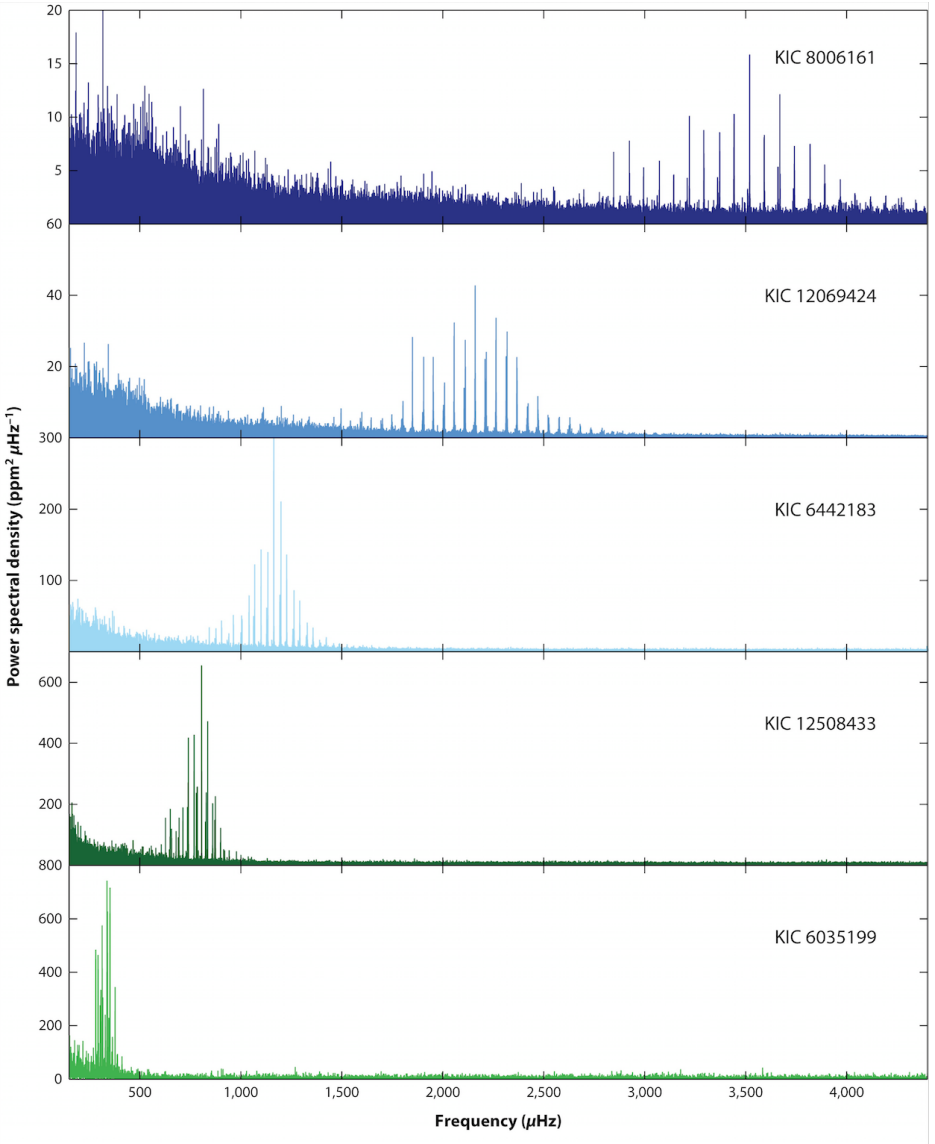
Global asteroseismic parameters

- $\Delta\nu \propto \langle\rho\rangle^{1/2}$
- $\nu_{\rm max} \propto g T_{\rm eff}^{-1/2}$



Chaplin et al. (2013, ApJ, 766, 101)

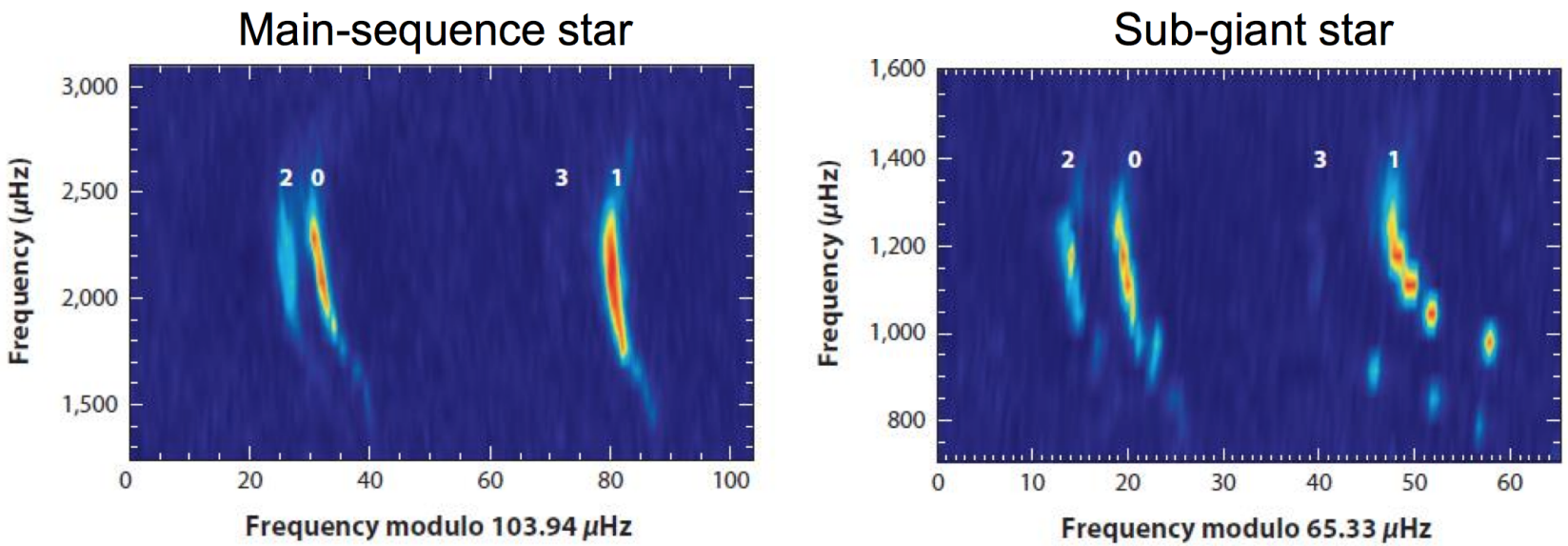
"Sun in time"



Increasing size and age

Chaplin & Miglio (2013, ARA&A, 51, 353)

Mixed modes in evolved stars



Chaplin & Miglio (2013, ARA&A, 51, 353)

- Precise characterisation of host stars
  - 1.2 % precision in R, 3.3 % in M and 14 % in age for a third of asteroseismic KOIs (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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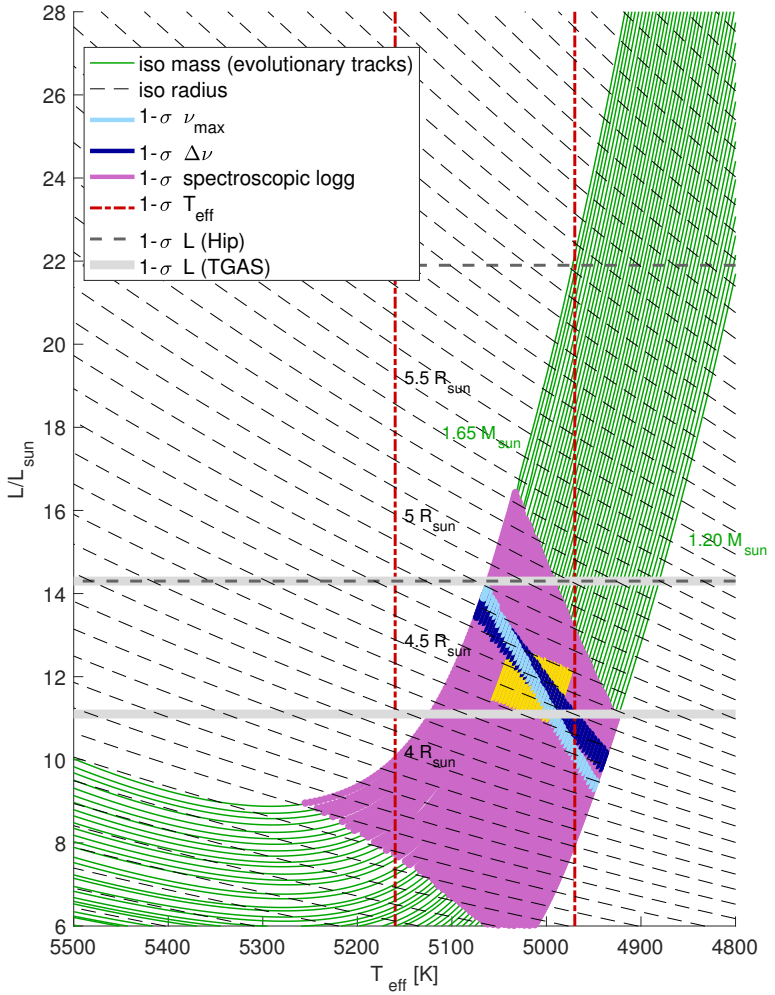
Accurate stellar masses from asteroseismology

- Tests of the accuracy of asteroseismic masses limited to stars in binary systems and in clusters
- Recent studies of red-giant members of open clusters show no evidence of systematic offsets (see, e.g., Miglio et al. 2016, and references therein)

K2 observations of the exoplanet-host star HD 212771

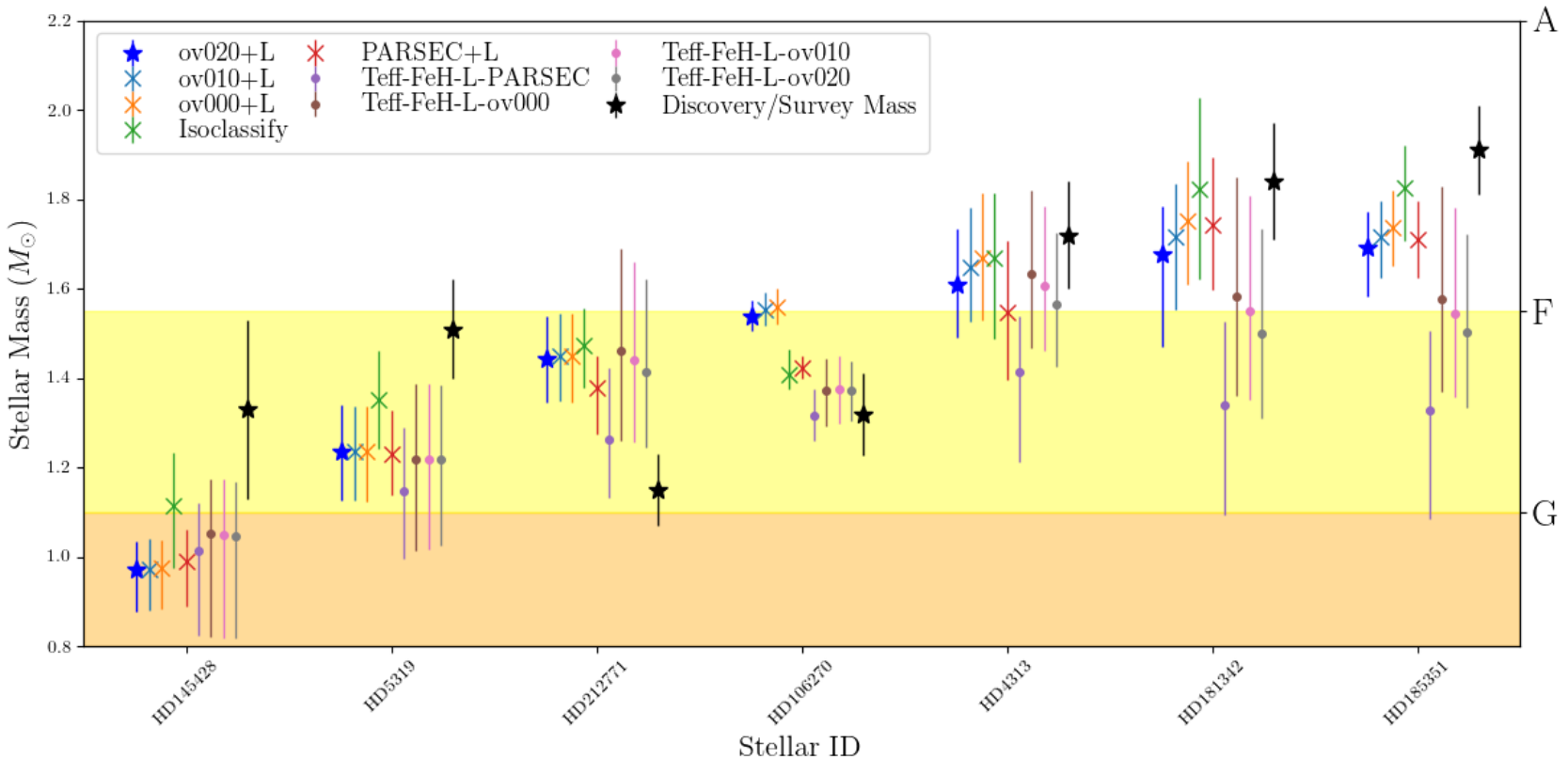
- First asteroseismic characterisation of known host with K2
- Subgiant host, being amongst Doppler targets of Johnson et al. (2007)
- Hosts Jovian planet in long-period orbit
- Mass from Bayesian grid-based modelling using asteroseismic, spectroscopic and astrometric constraints



Campante, Veras et al. (2017, submitted)

Ensemble results I

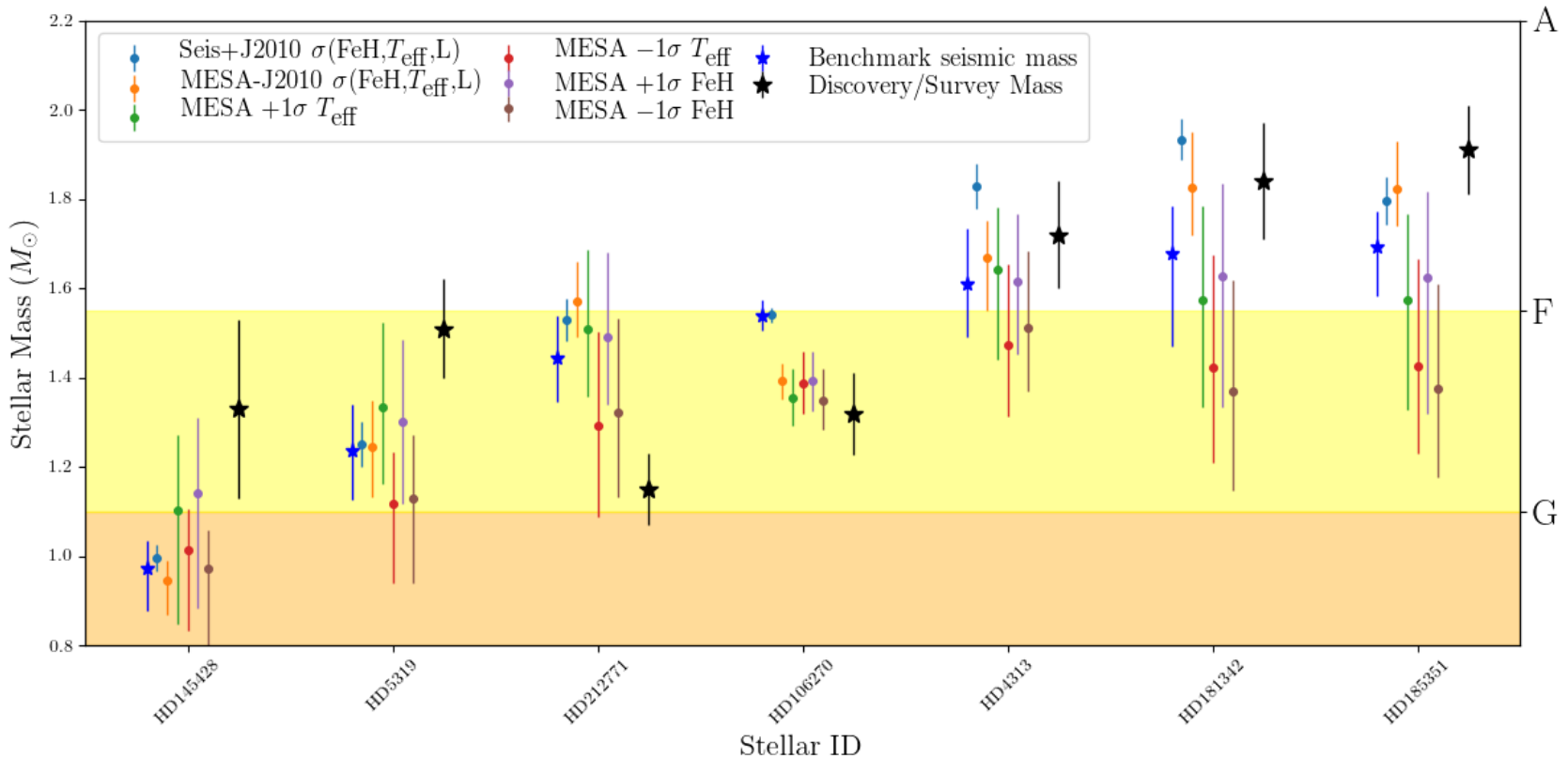
Varying the input physics in the models



North et al. (2017, in prep.)

Ensemble results II

Introducing small biases in the spectroscopy



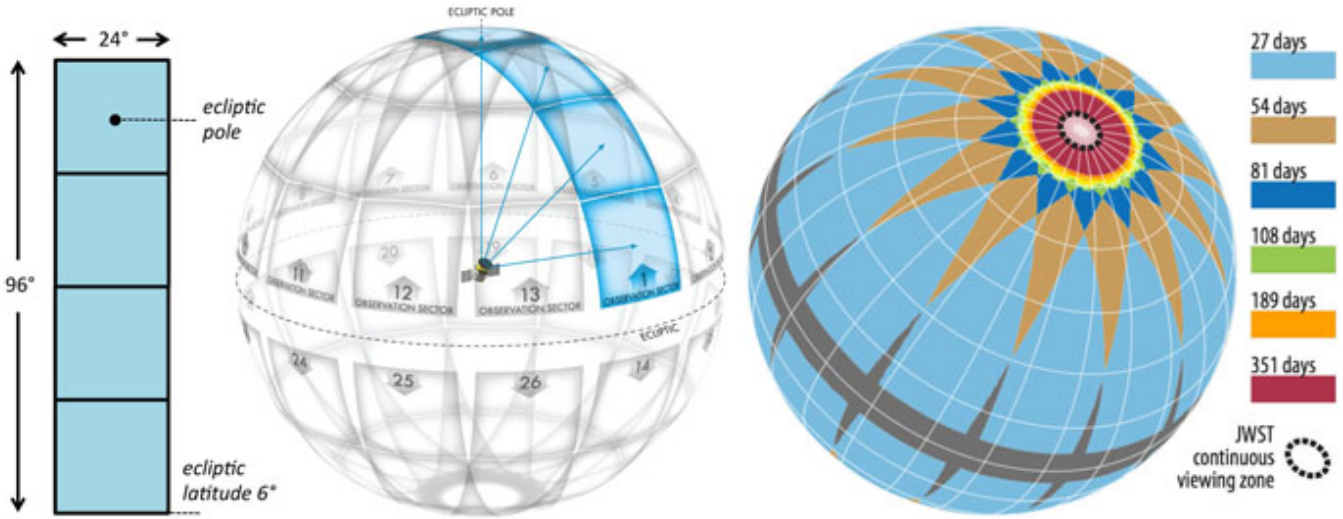
North et al. (2017, in prep.)

Take-home message

- In the absence of asteroseismology, mass estimates of retired A stars are highly susceptible to:
  - Different input physics in the models
  - Potential biases in the spectroscopy (and underestimated uncertainties)
- Need for a larger sample of benchmark asteroseismic masses (see potential of *TESS* next)

An all-sky survey for transiting planets

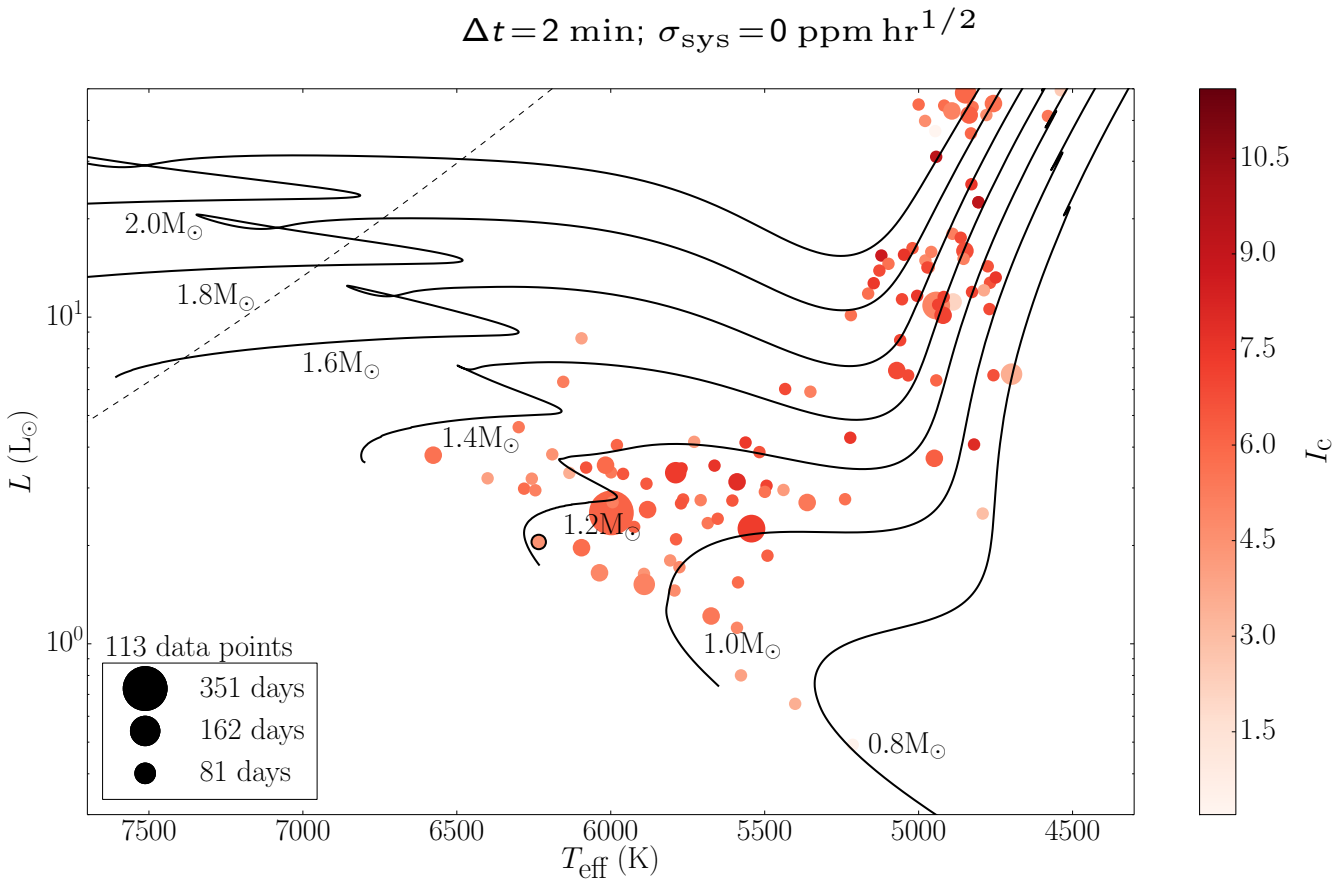
- March 2018 launch
- All-sky survey
- Stars observed for at least 27 days
- 2-min cadence ($\sim 2 \times 10^5$ pre-selected FGKM dwarfs)
- 30-min cadence (full-frame images or FFIs)



An overview

- 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

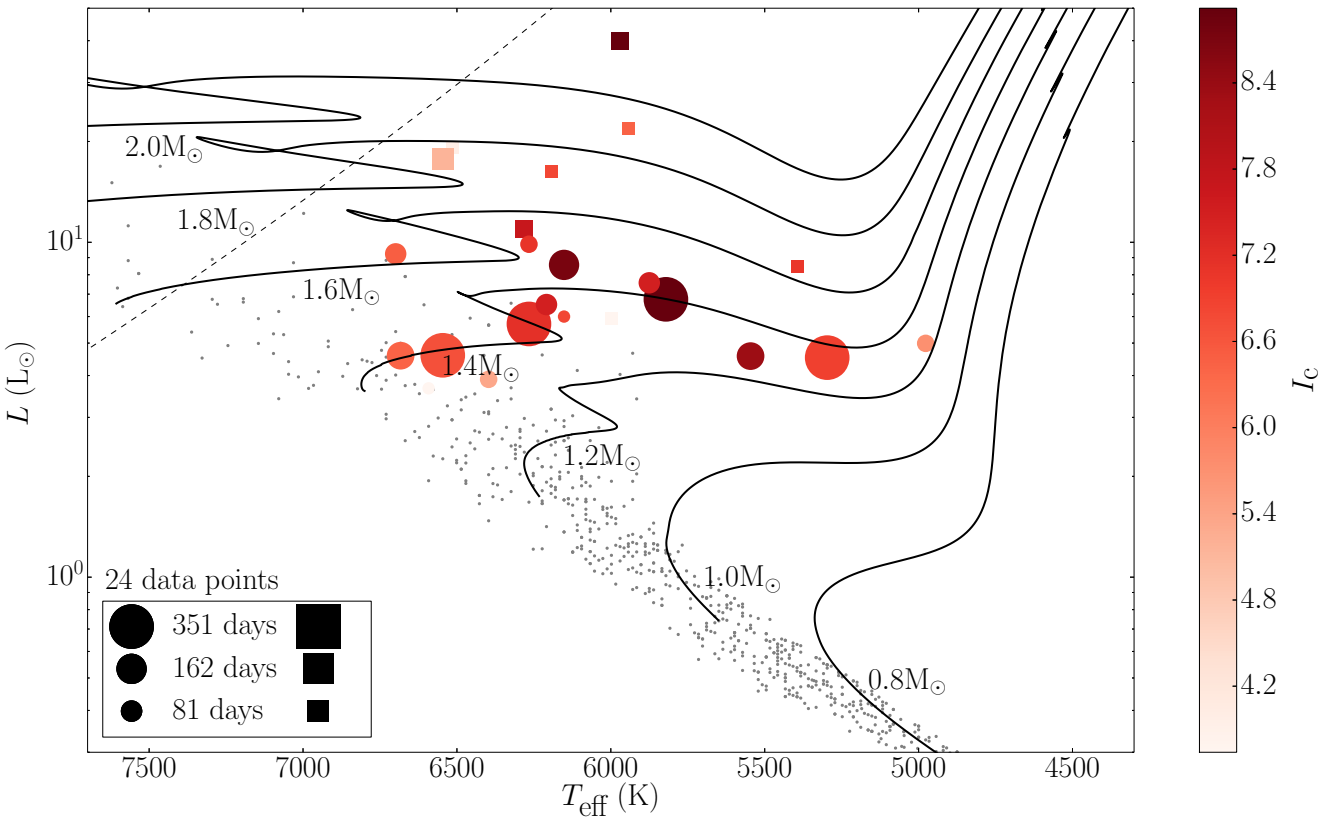


Campante et al. (2016, ApJ, 830, 138)

Asteroseismic yield of *TESS* target hosts

Based on synthetic target-host population of Sullivan et al. (2015, ApJ, 809, 77)

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

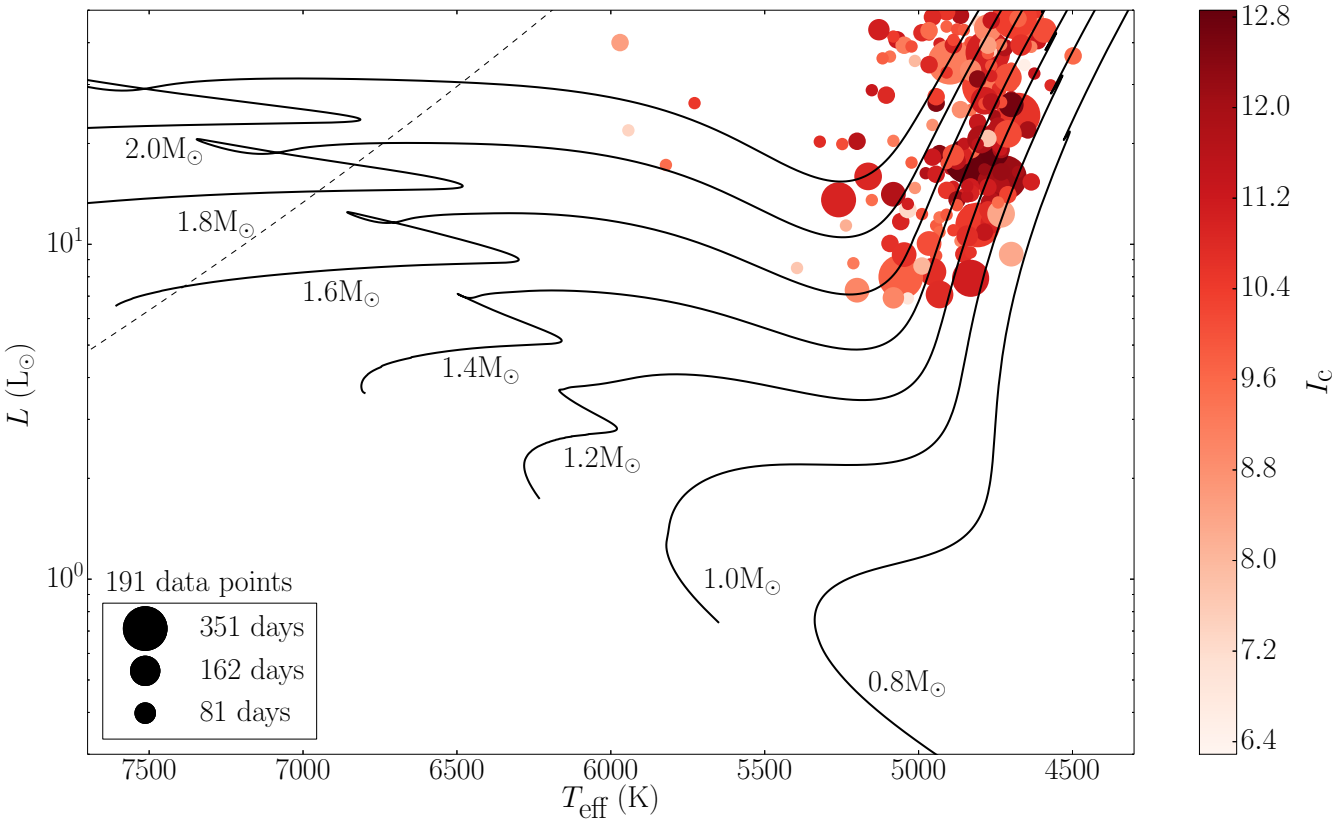


Campante et al. (2016, ApJ, 830, 138)

Asteroseismic yield of *TESS* FFI hosts

Based on synthetic FFI-host population of Sullivan et al. (2015, ApJ, 809, 77)

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



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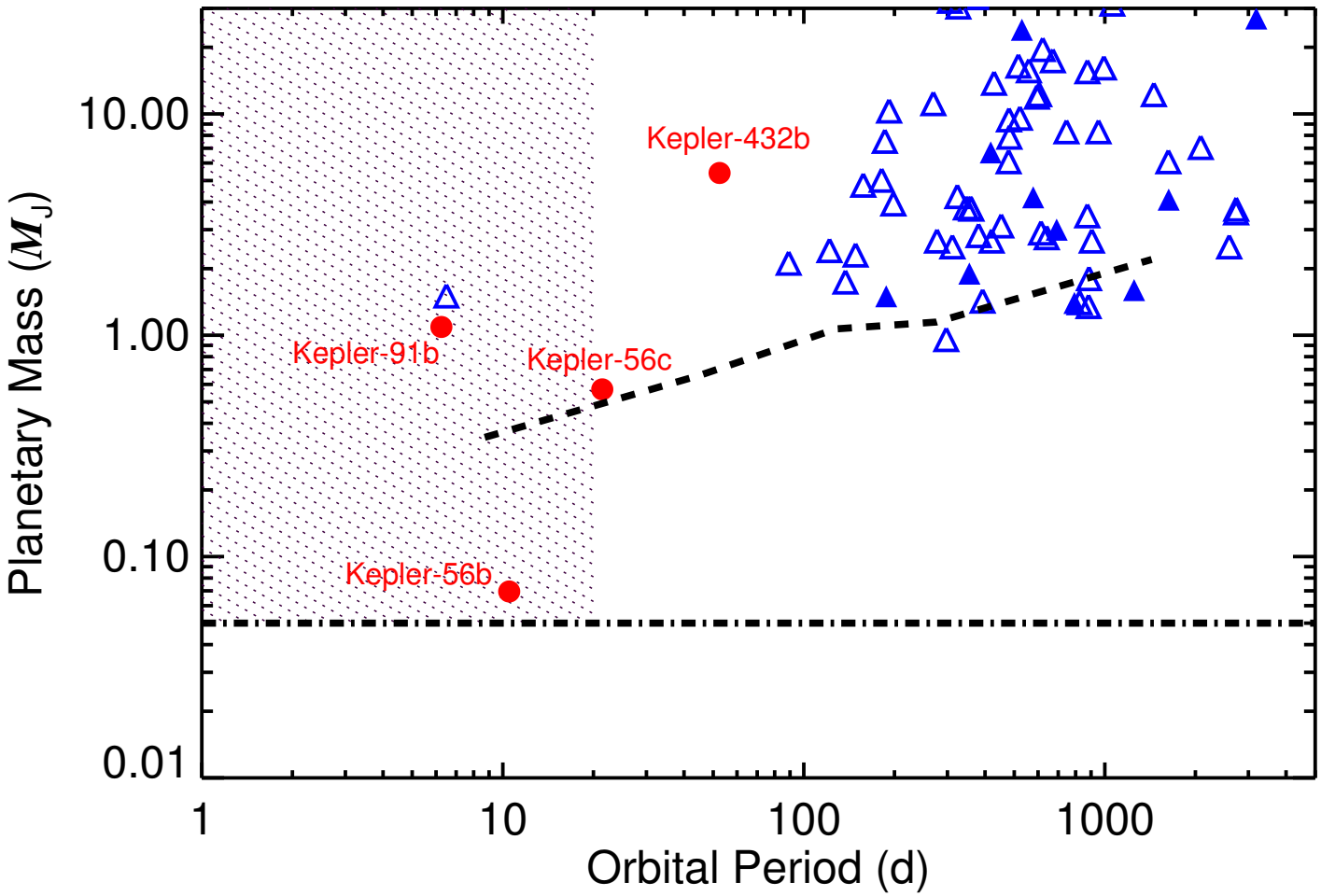
Asteroseismology of red-giant hosts with *TESS*



Campante et al. (2016, ApJ, 830, 138)

Thank you!

I'm the lead of *PLATO* WP128220 "Solar-like stars with planets". Interested in collaborating? Drop me an email.

I'm also currently looking for a PhD student to work on Asteroseismology&Exoplanets with *TESS* (deadline: March 31).

Email: *campante@bison.ph.bham.ac.uk*