Synergies & Opportunities for SONG in the TESS Era

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SONG Workshop, Tenerife

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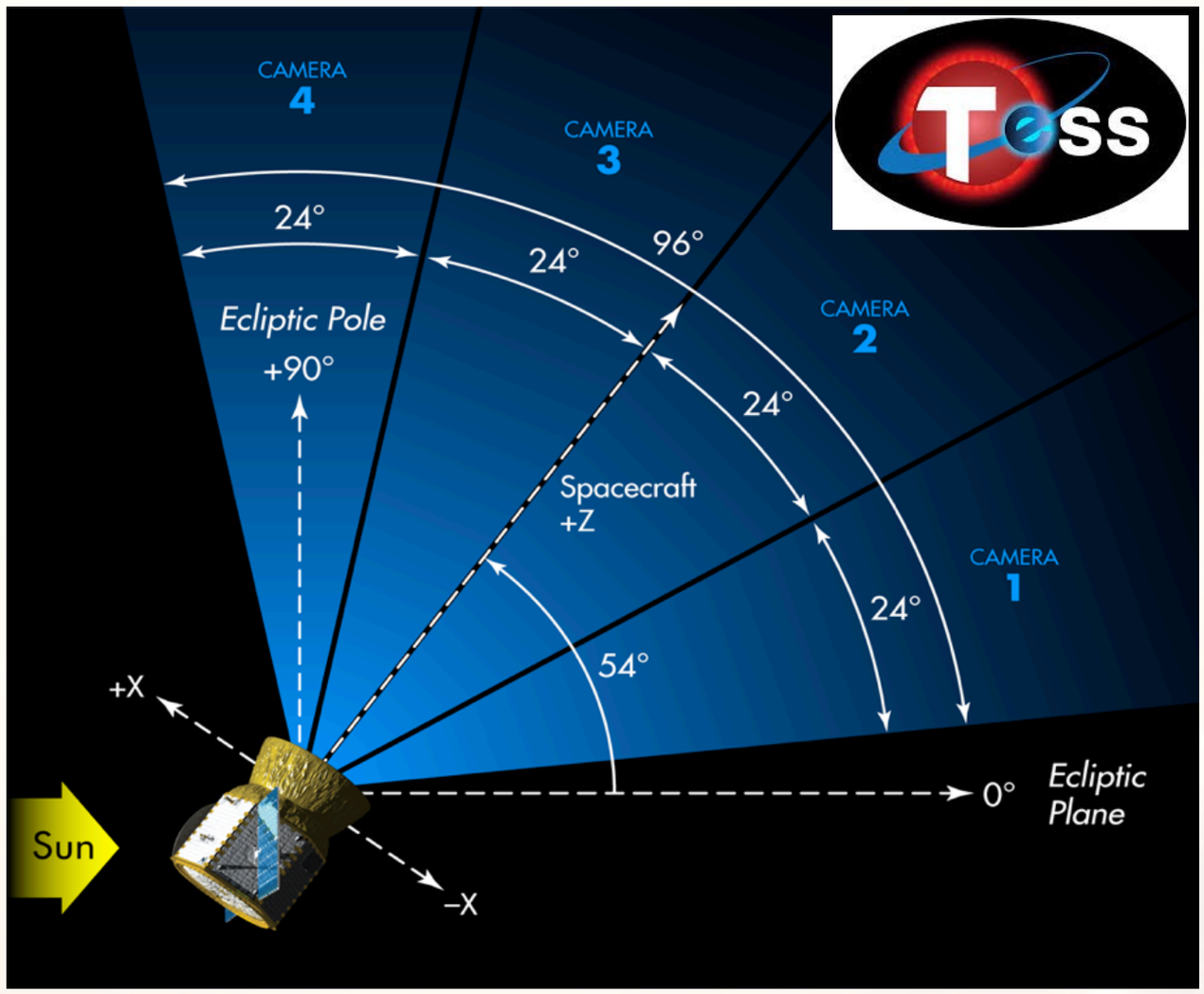
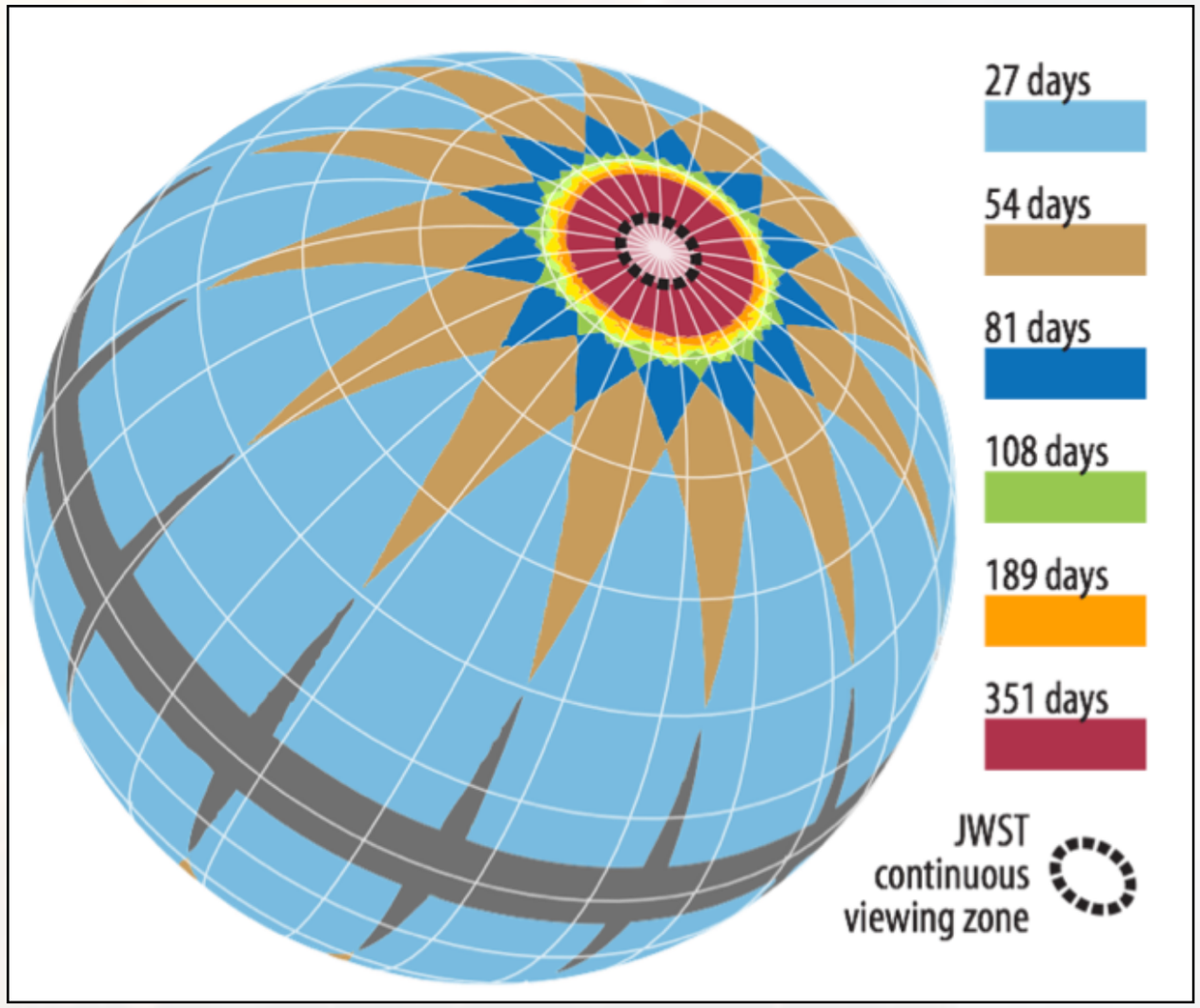
TESS Mission: Introduction & First Results

Transiting Exoplanet Survey Satellite

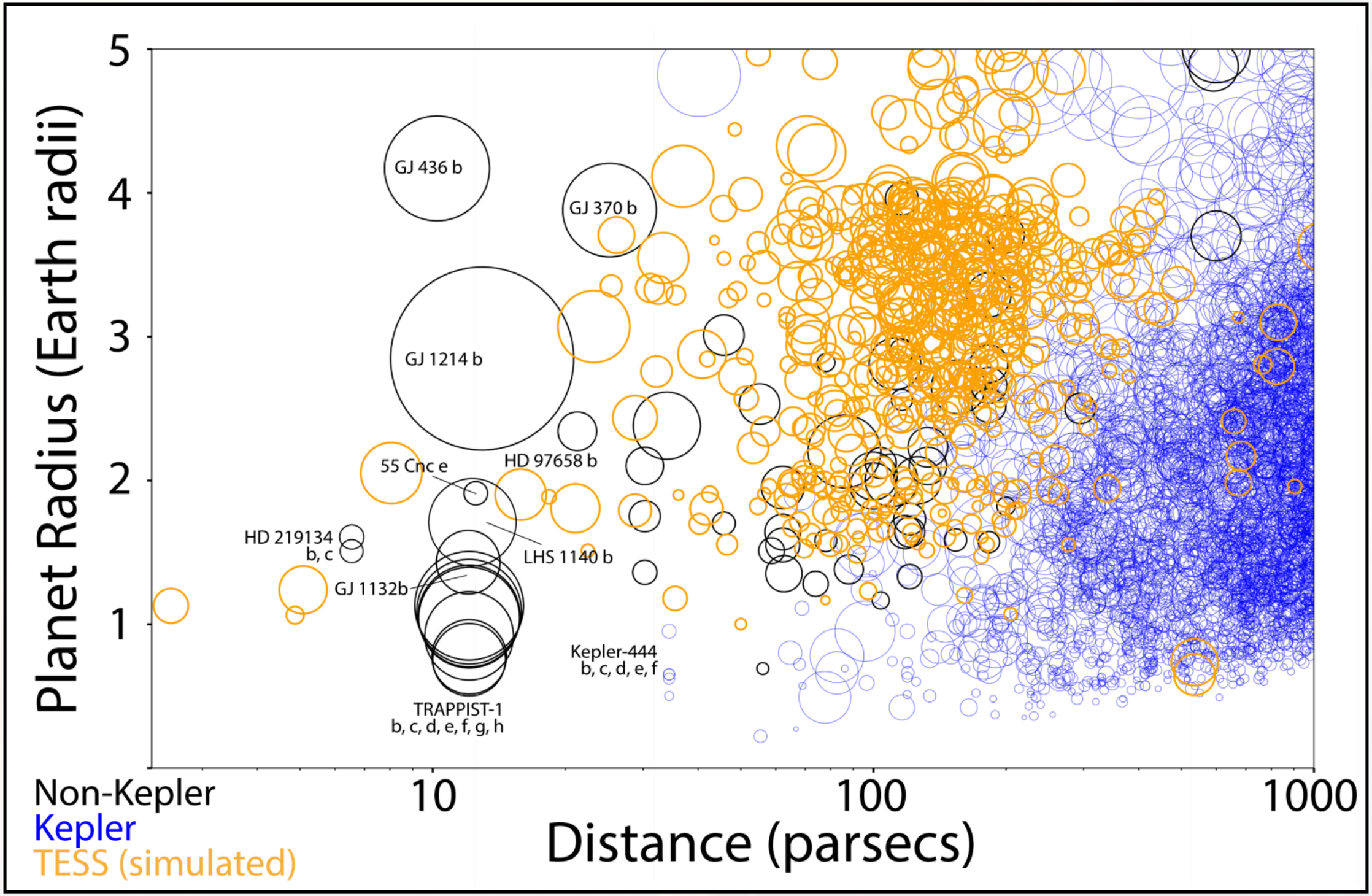




Ricker+ 2014

Level 1 requirement: discover and measure masses of 50 sub-Neptune sized planets orbiting bright stars

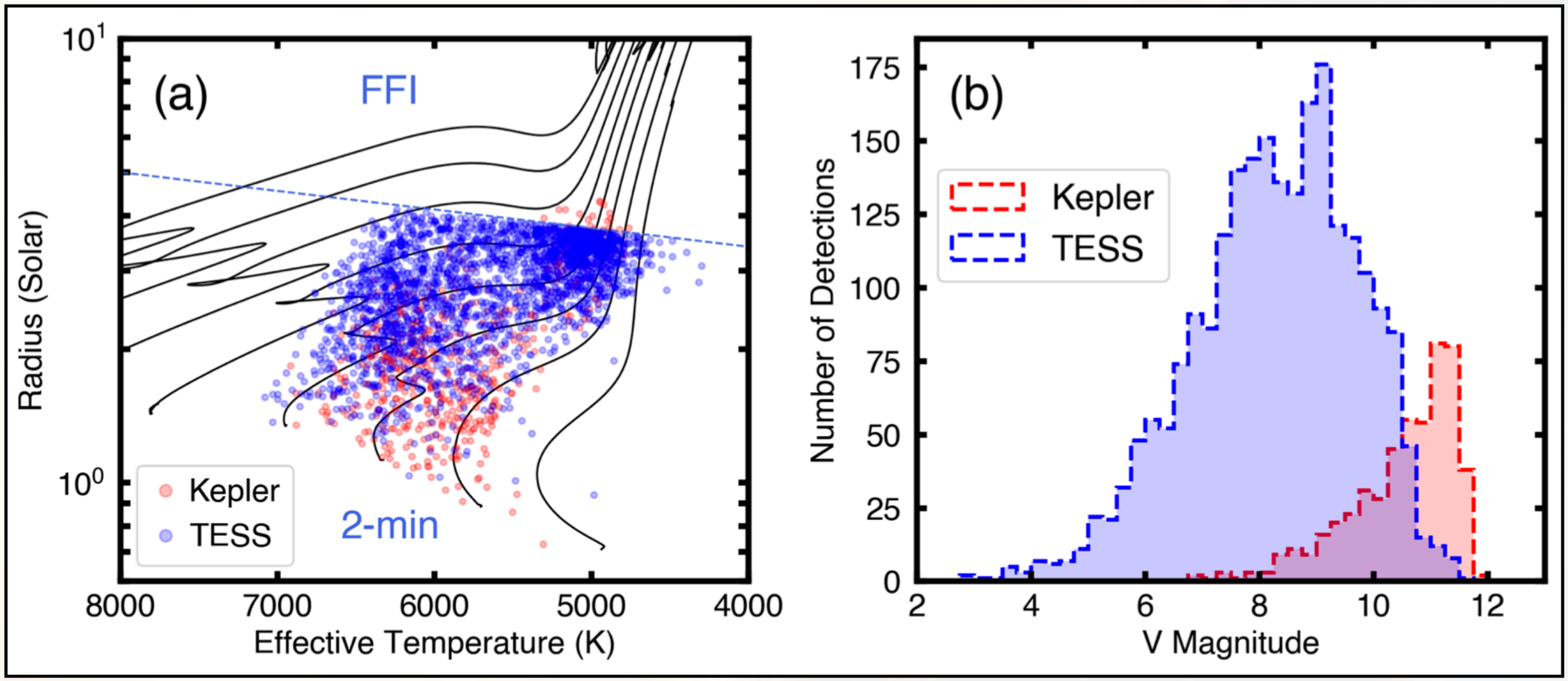
Predicted TESS Exoplanet Yields



Barclay+ 2018

Symbol size ∝ transit depth

Predicted Asteroseismic Yield



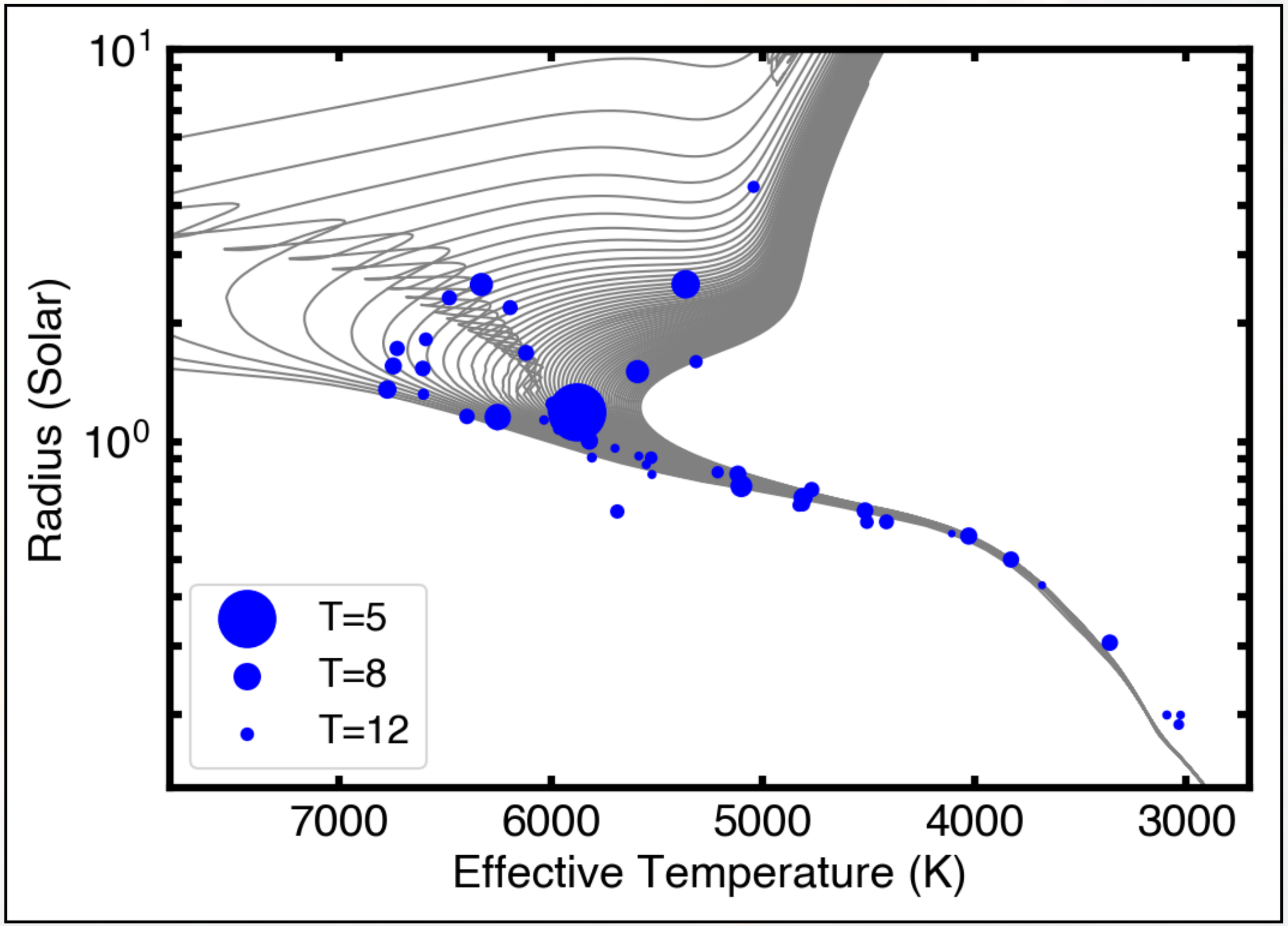
Schofield, Chaplin, Huber+ 2018, in prep

Asteroseismic Target List (ATL): 2-min cadence targets for asteroseismology of solar-like oscillators

Hawai‘i TESS Launch Party

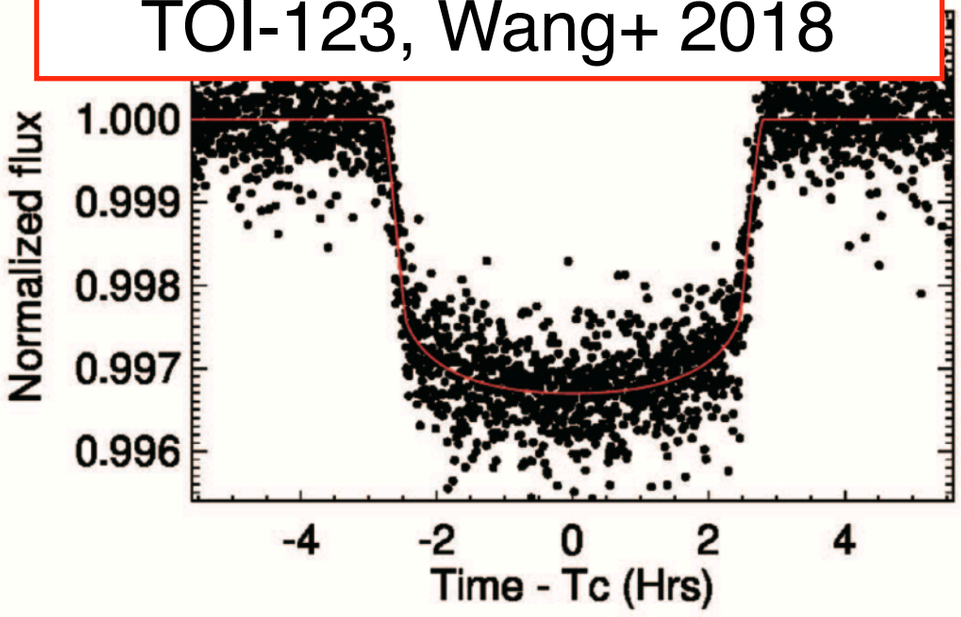
April 18 2018

First Discoveries: TESS Alerts

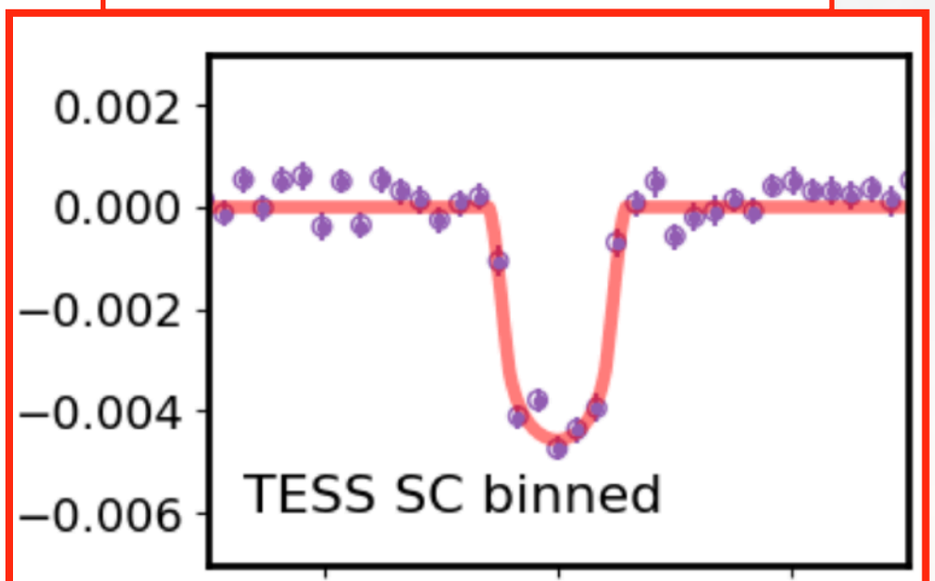


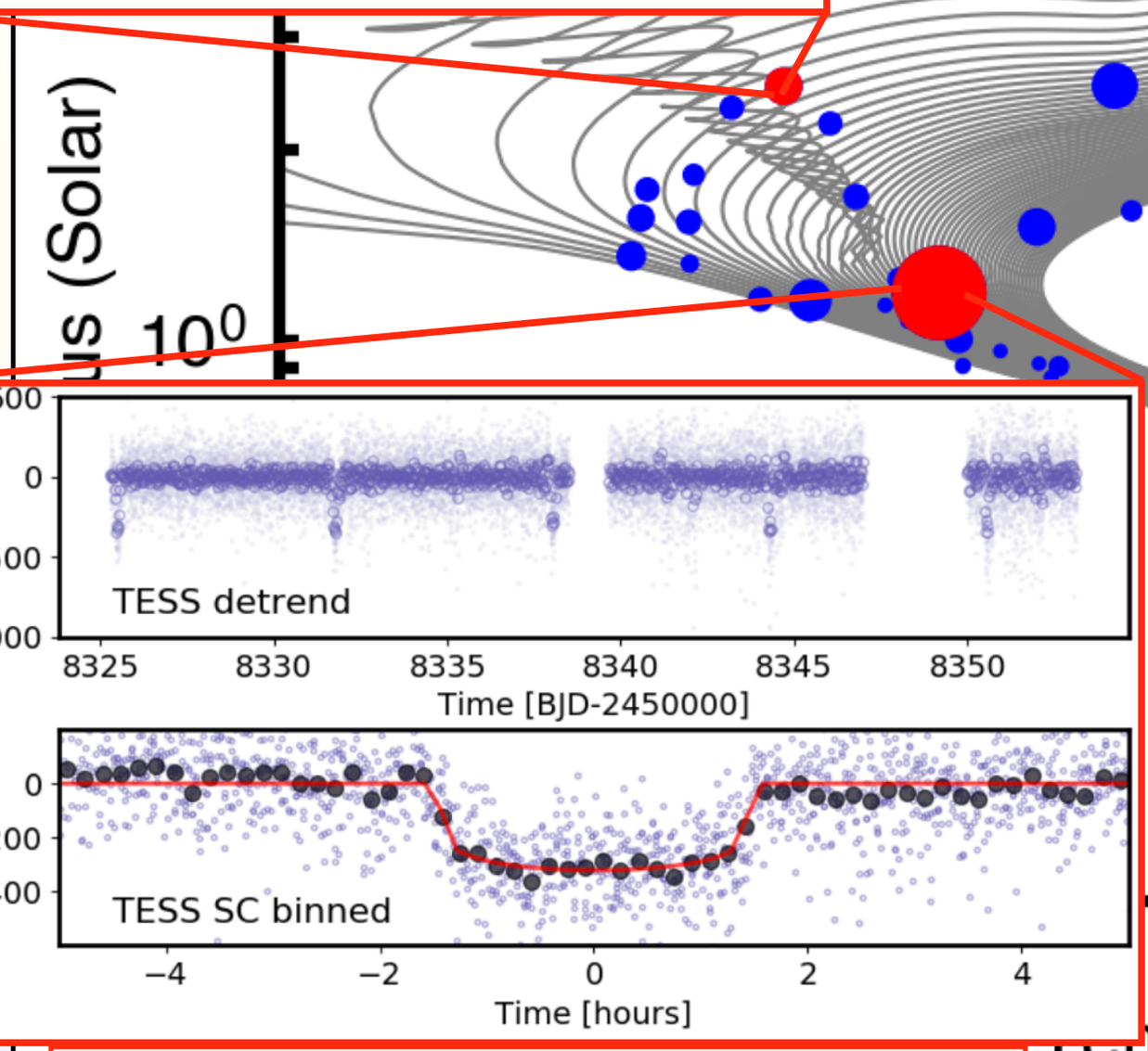
veries: TESS Alerts

TOI-123, Wang+ 2018



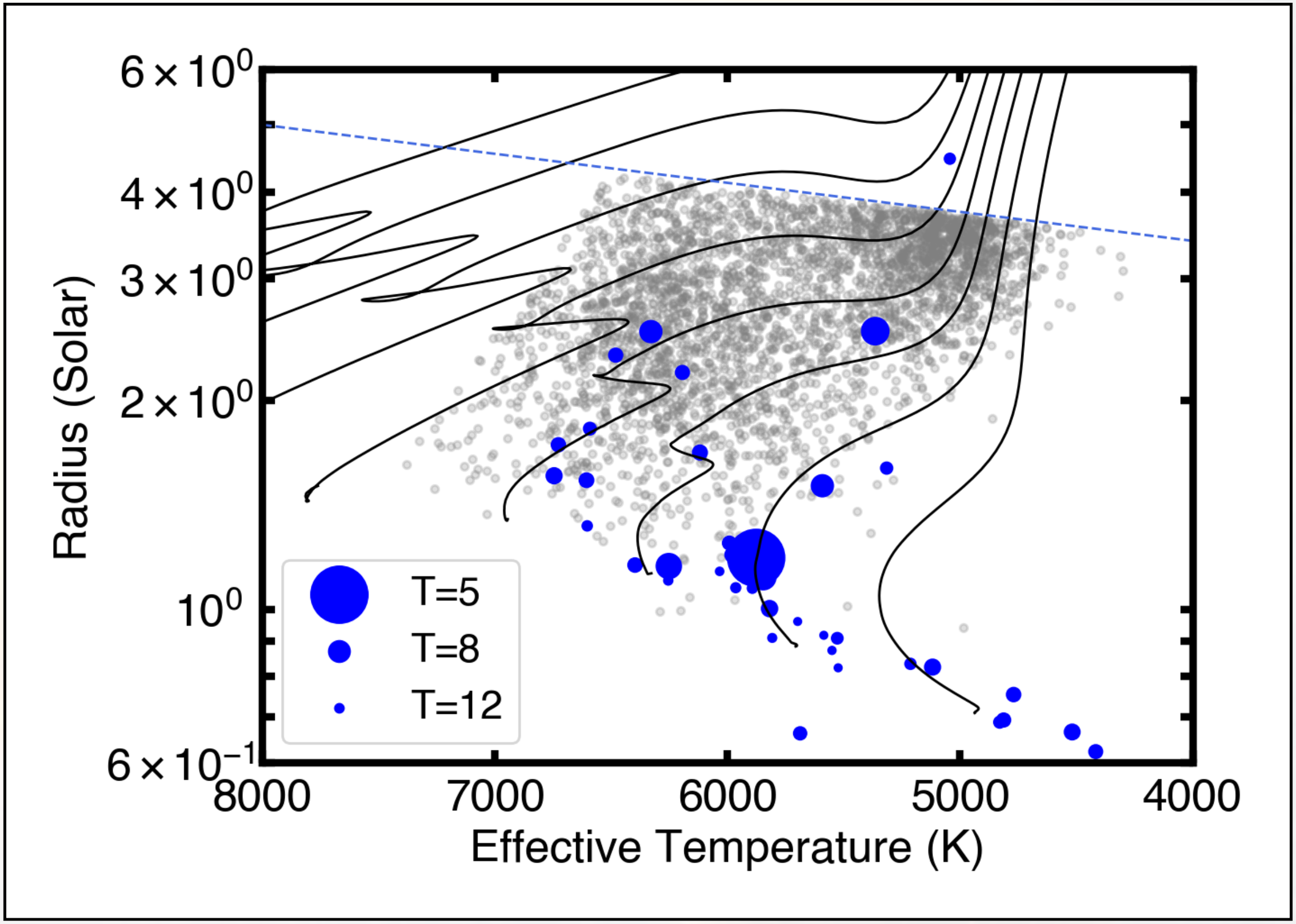
TOI-136 (LHS3844), Vanderspeck+ 2018



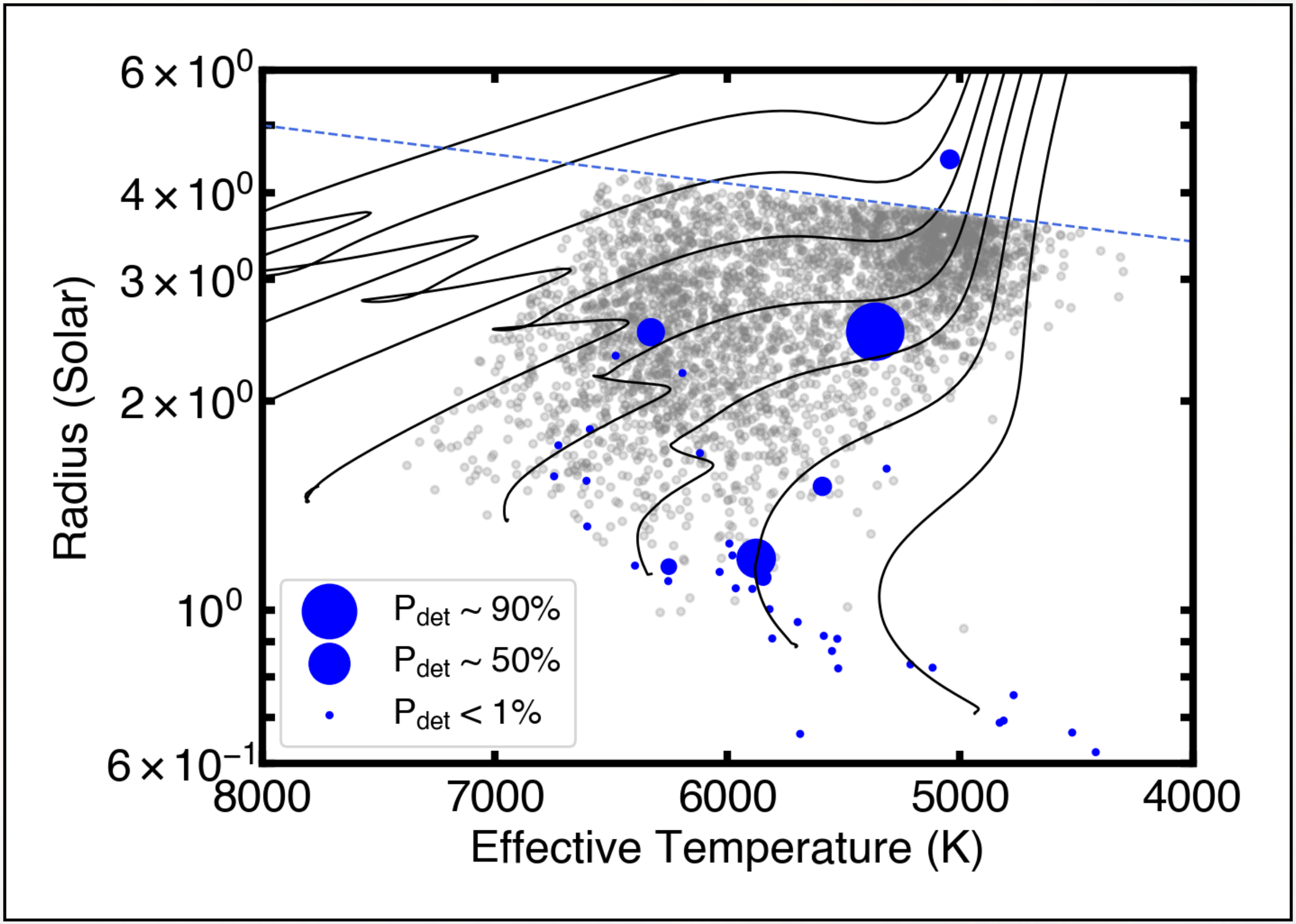


TOI-144 (π Men), Huang+ 2018

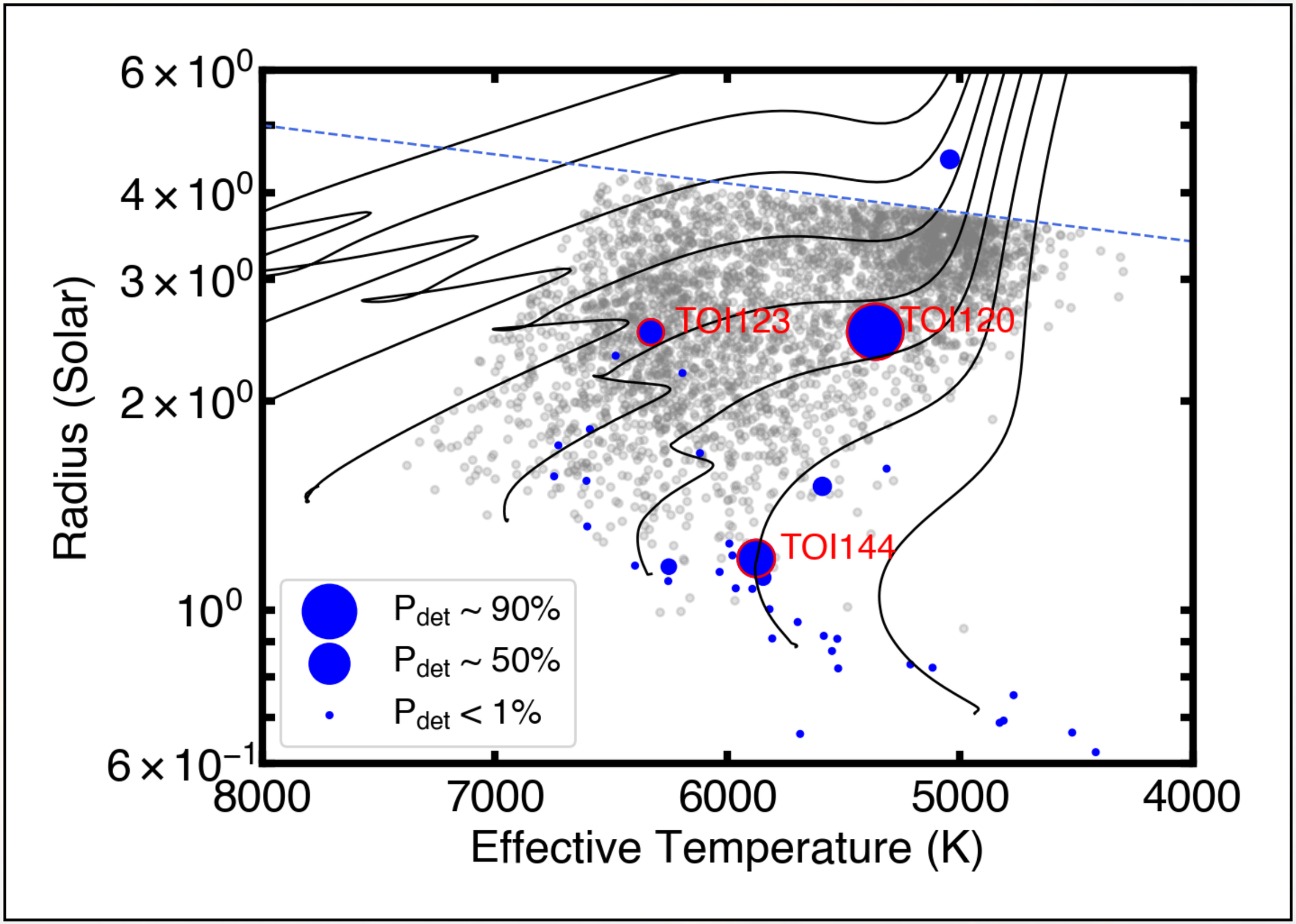
Asteroseismology of TESS Alerts



Asteroseismology of TESS Alerts

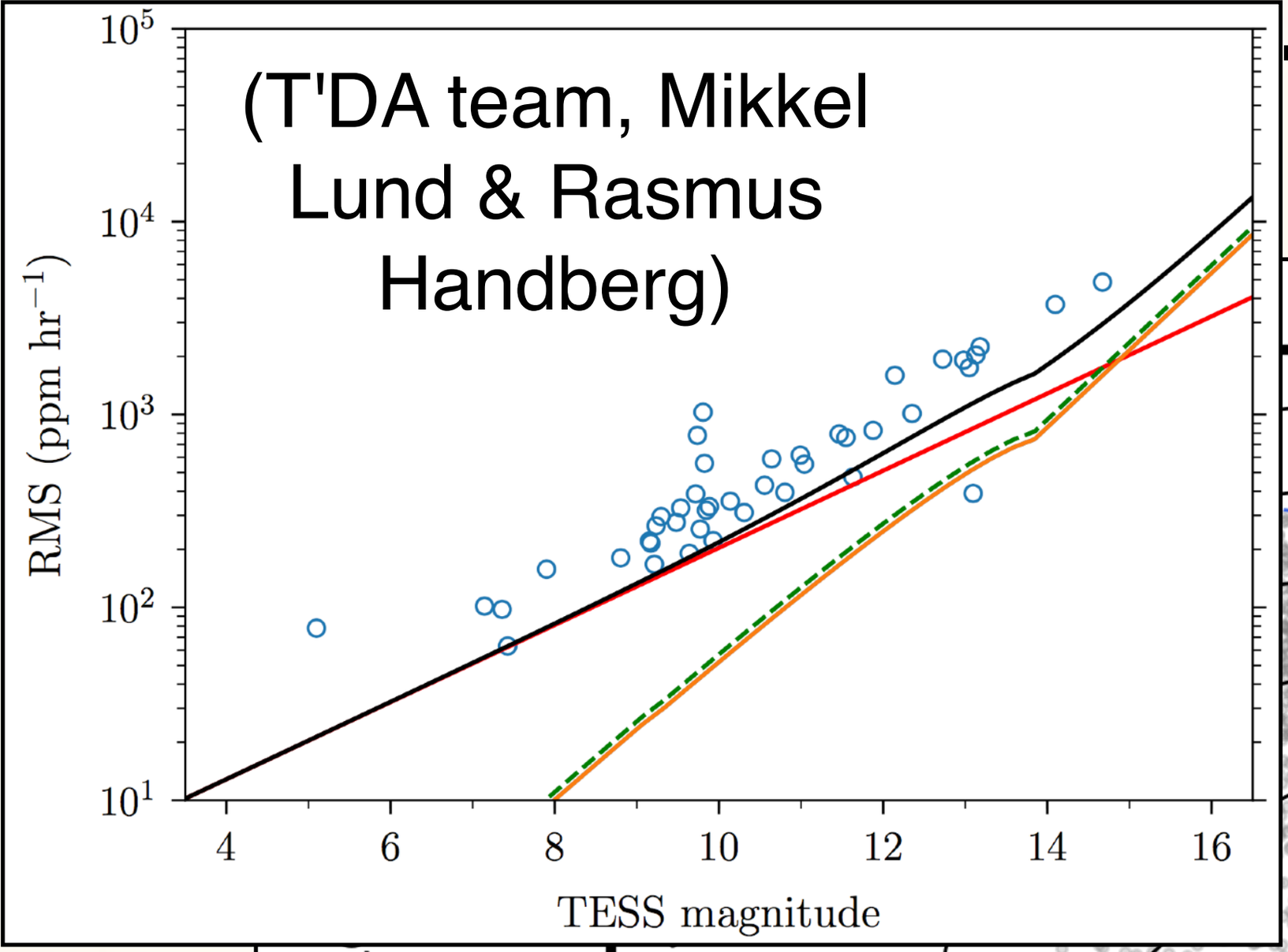


Asteroseismology of TESS Alerts

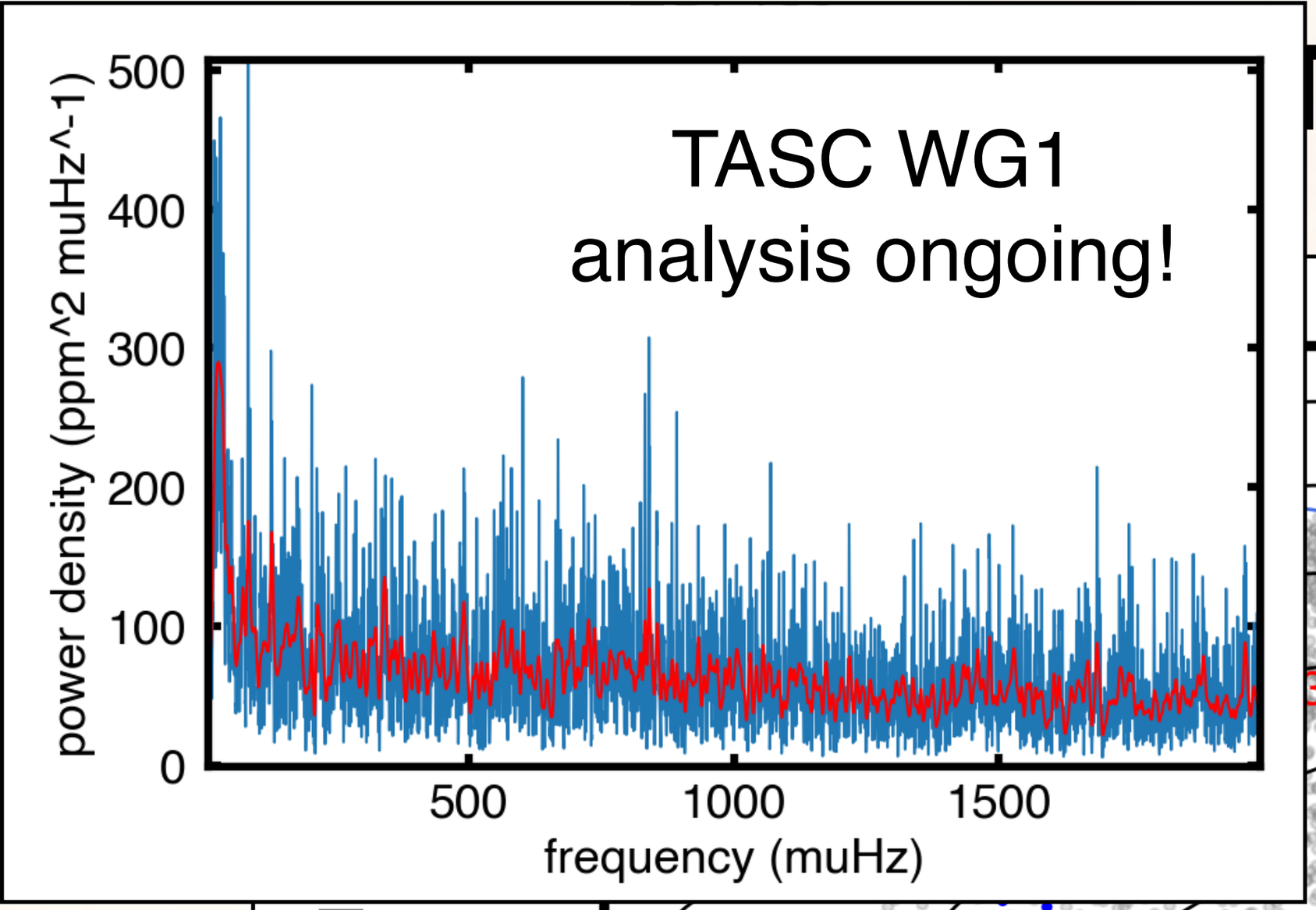


TESS Alerts

(T'DA team, Mikkel Lund & Rasmus Handberg)



TESS Alerts


TASC WG1
analysis ongoing!
power density (ppm^2 muHz^-1)
500
400
300
200
100
0
500
1000
1500
frequency (muHz)

TOI120
TOI144
P_{det} ~ 90%
P_{det} ~ 50%
P_{det} < 1%
10^0
6×10^{-1}
8000
7000
6000
5000
4000
Effective Temperature (K)

TESS & SONG Synergies I: Oscillation Amplitudes

Amplitudes of stellar oscillations: the implications for asteroseismology

H. Kjeldsen* and T.R. Bedding

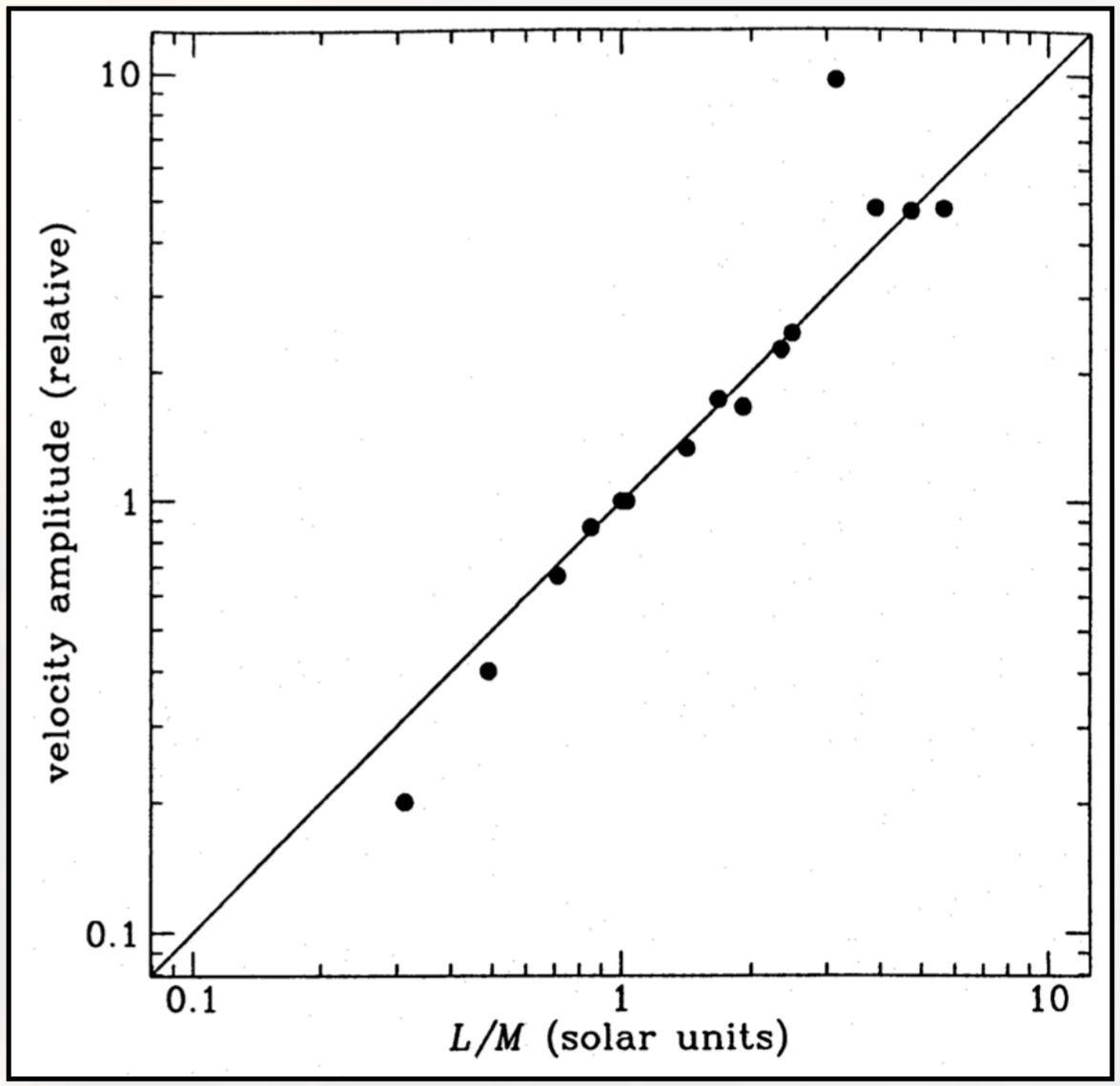
European Southern Observatory, Karl-Schwarzschild-Str. 2, D-85748 Garching bei München, Germany

Received 7 December 1993 / Accepted 4 March 1994

$$(\delta L/L)_{\rm bol} \propto \frac{v_{\rm osc}}{\sqrt{T_{\rm eff}}}.$$

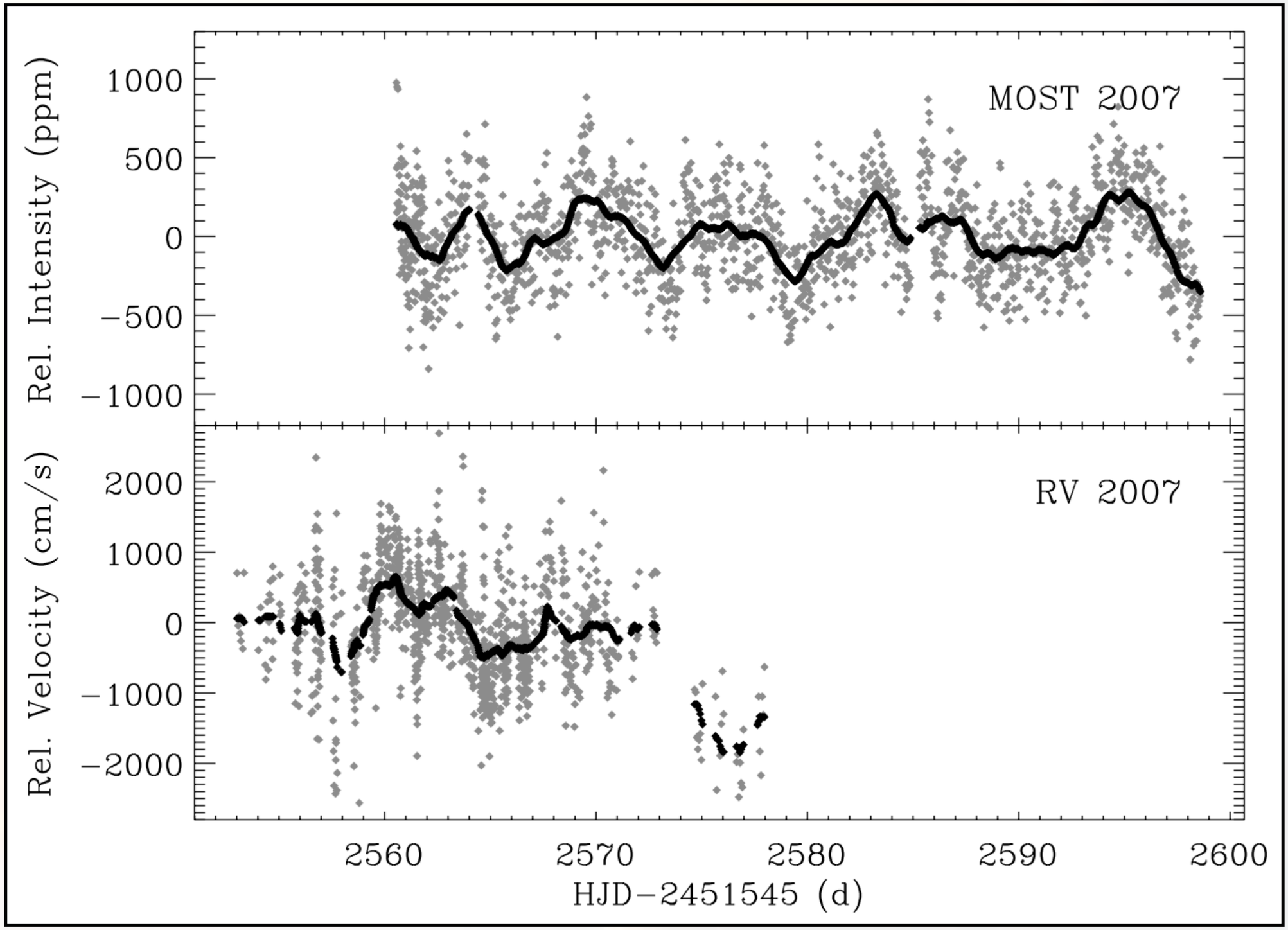
Measuring amplitudes in velocity and intensity are critical to understand driving and damping of modes!

➔ *see talk by Günther Houdek*



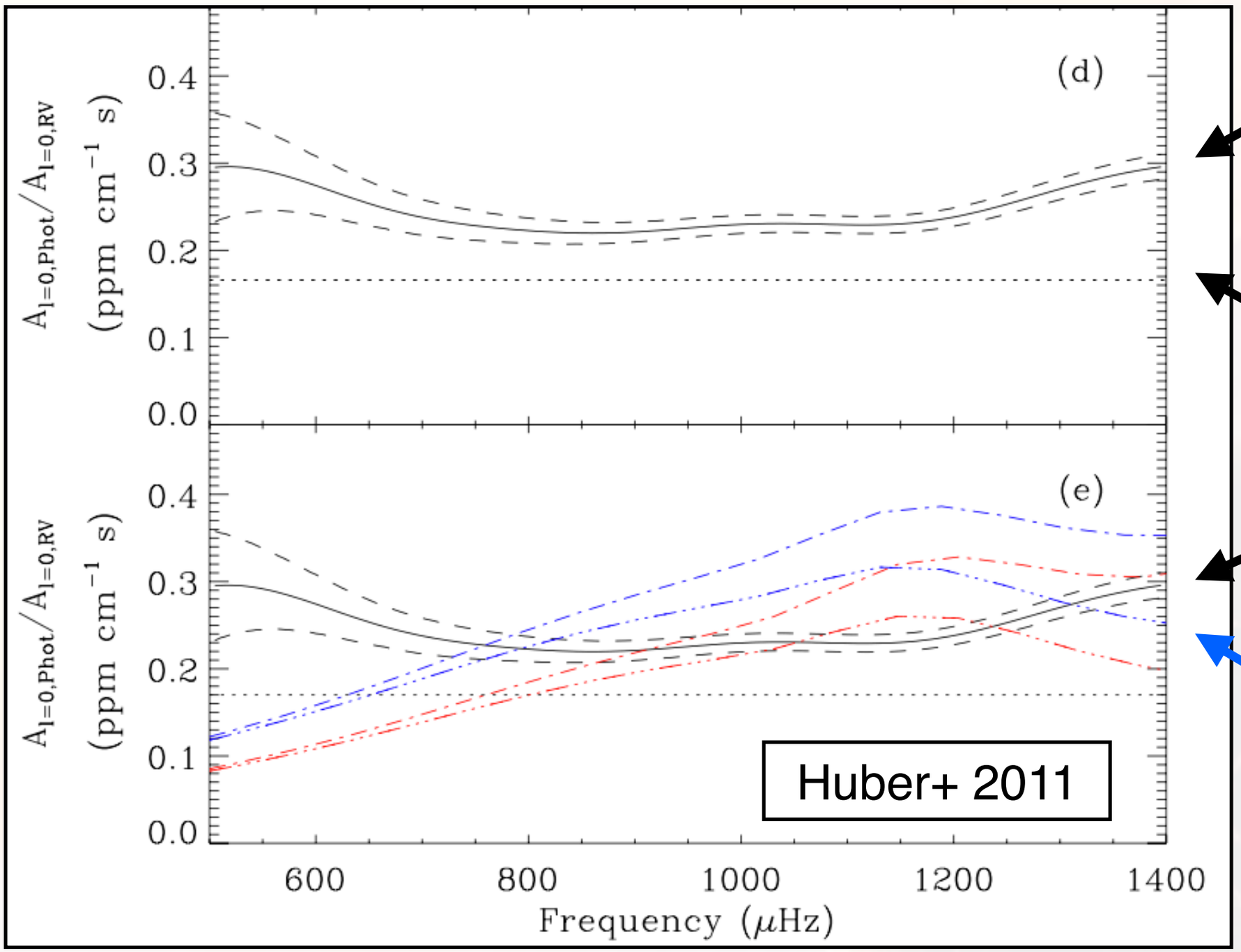
Models by JCD & Frandsen (1983)

All-time Favorite: Procyon



Arentoft+ 2008, Bedding+ 2010, Huber+ 2011

All-time Favorite: Procyon



Observations

KB95 Scaling Relation

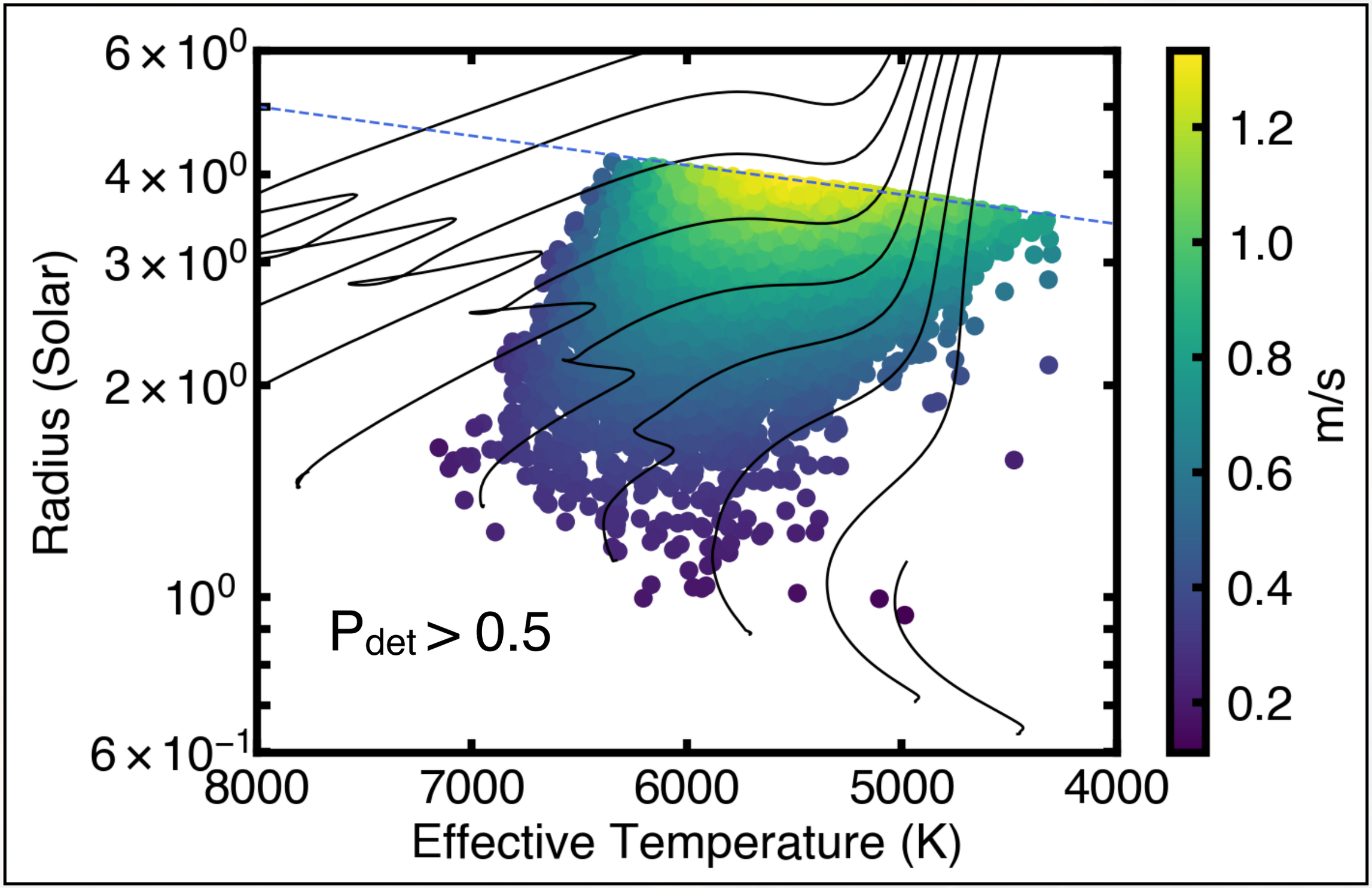
Observations

Houdek 2010 models

Observed amplitude ratio ~40% higher than expected!

➔ *see Torben Arentoft & Paul Beck talks*

The SONG-TESS Sample



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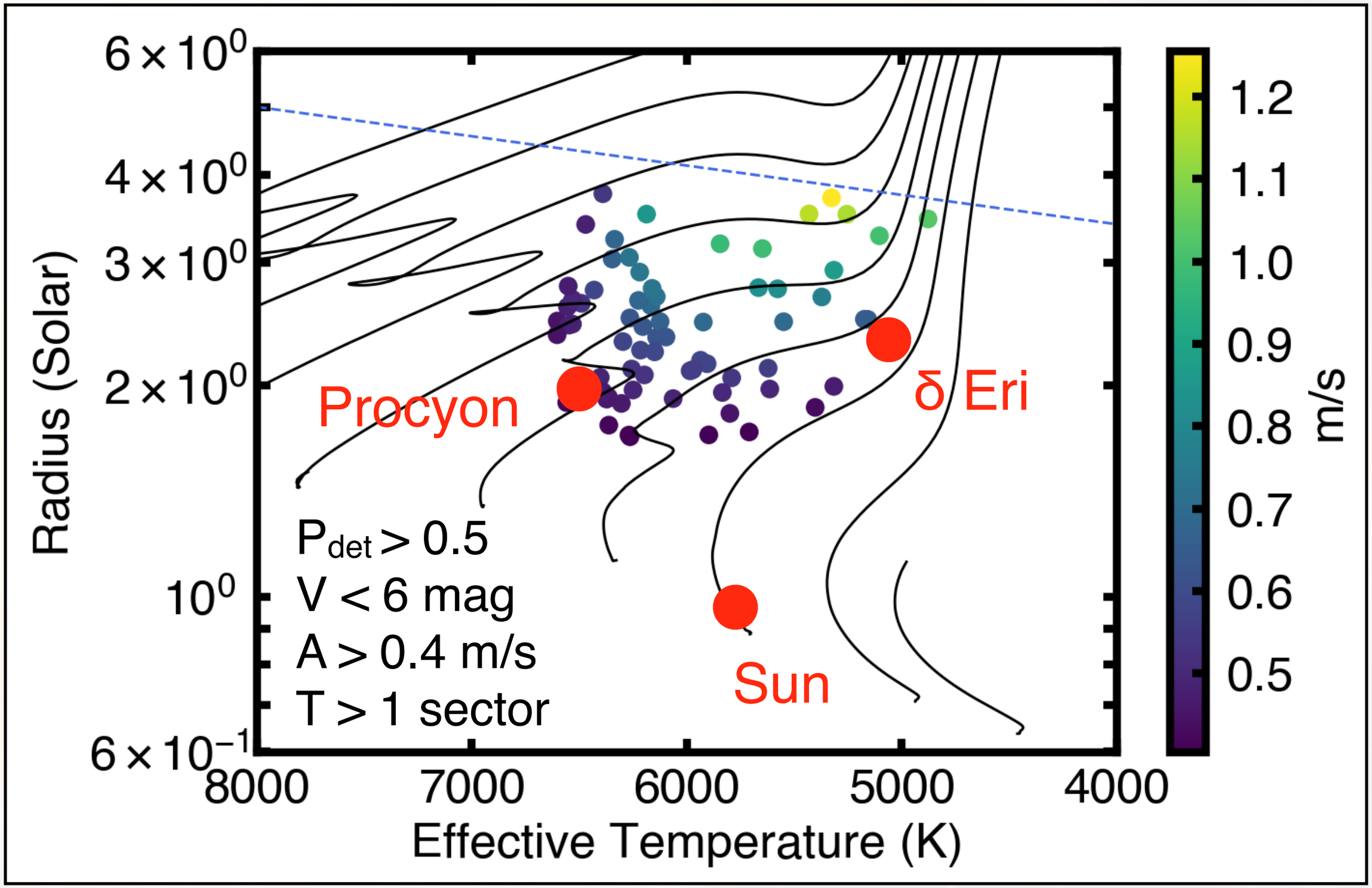
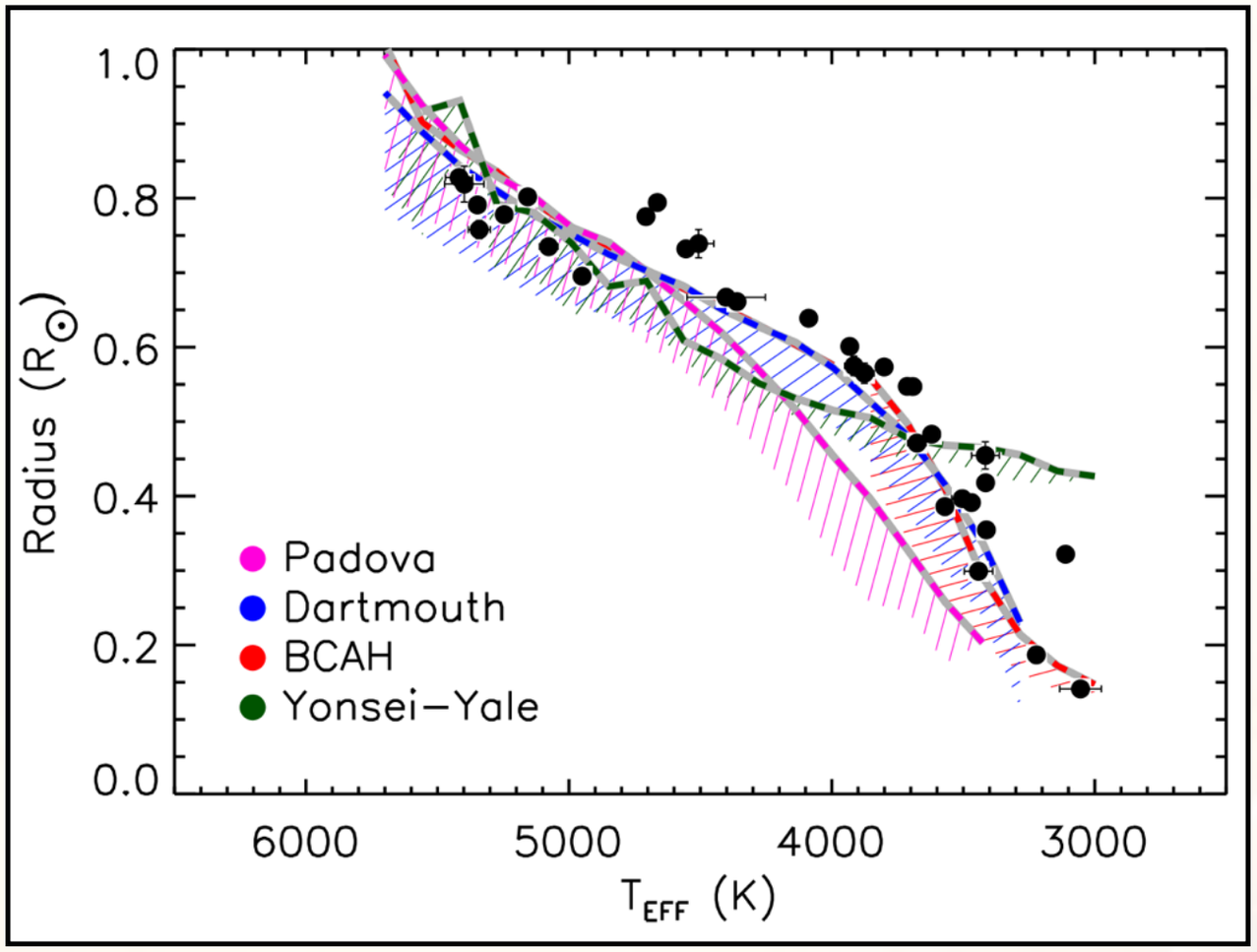
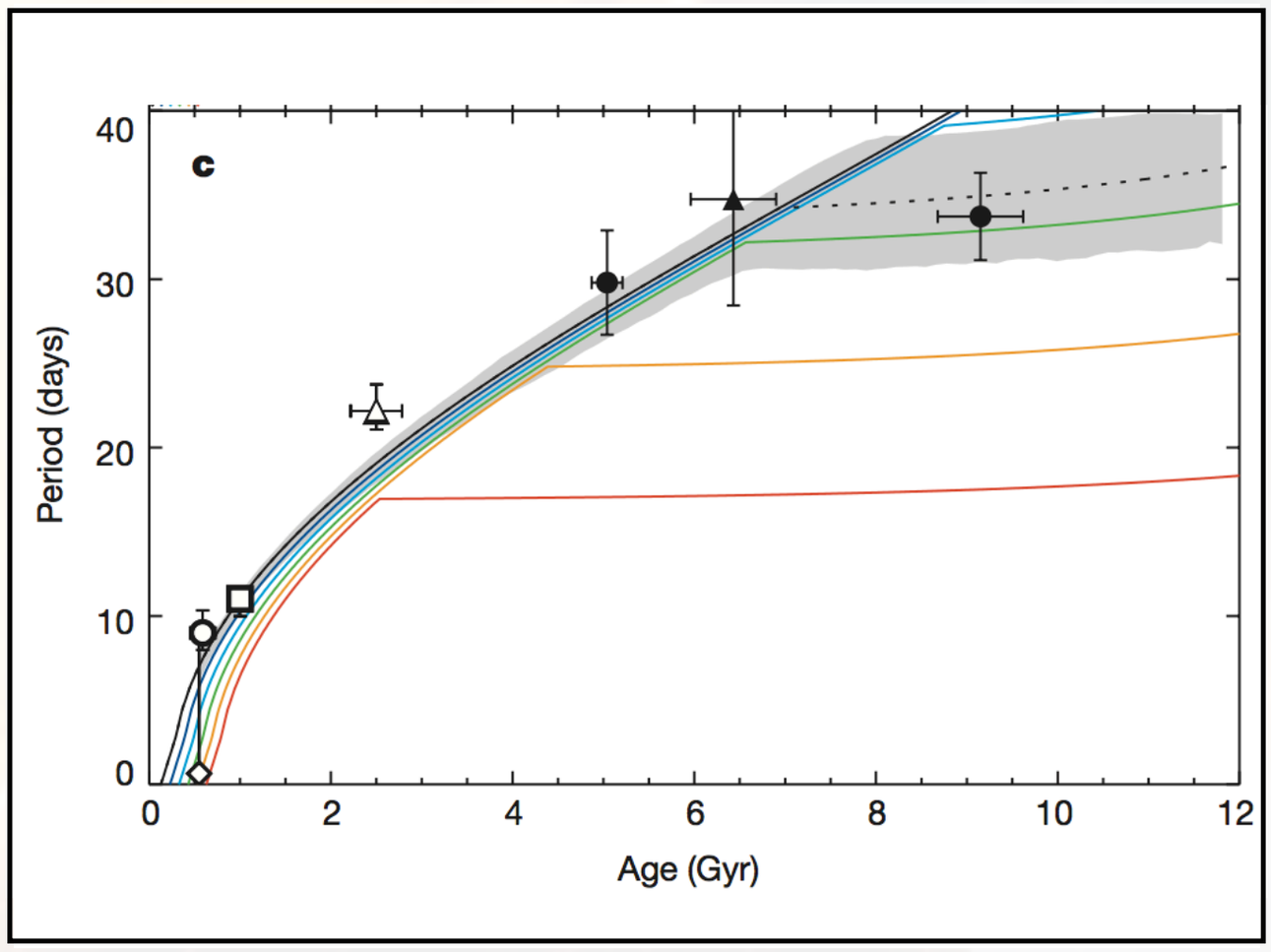


TESS & SONG Synergies II: Asteroseismology of Cool Dwarfs

G/K Dwarfs: Why bother?





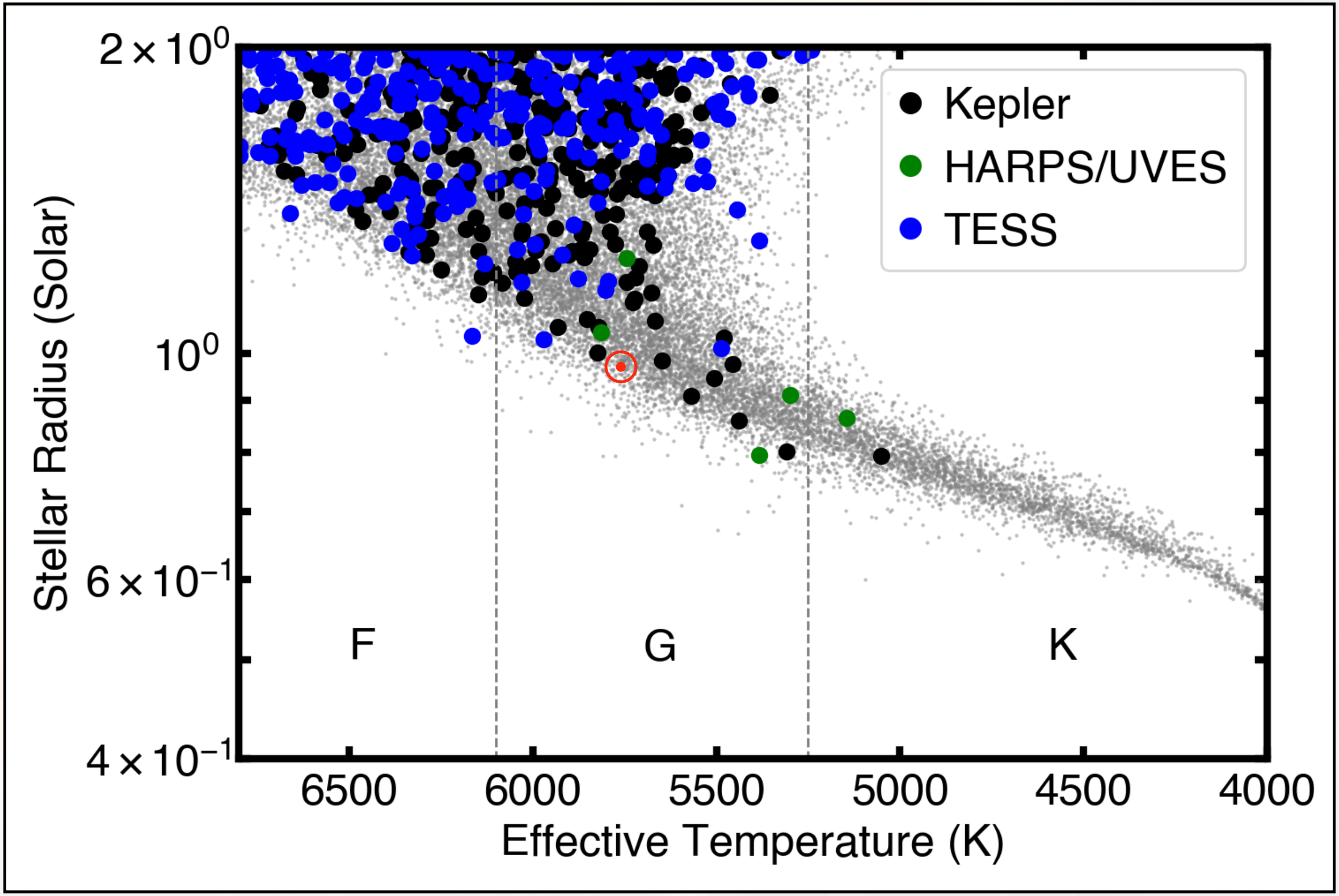
Cool dwarf radii at fixed T_{eff} underestimated by ~5-20%

Boyajian+ 2012

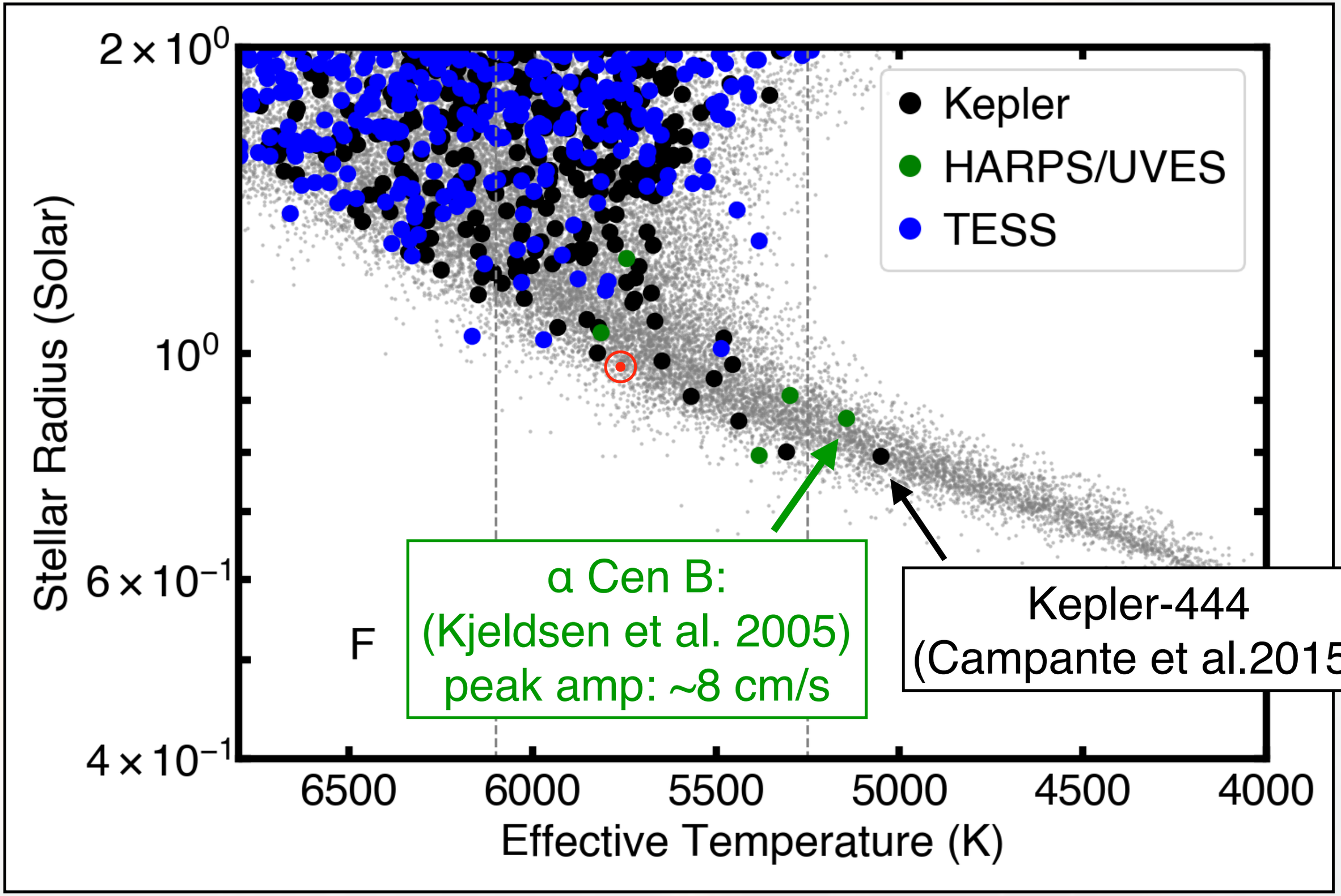
Gyrochronology needs cool dwarf calibrators!

van Saders+ 2016, Metcalfe & van Saders 2018

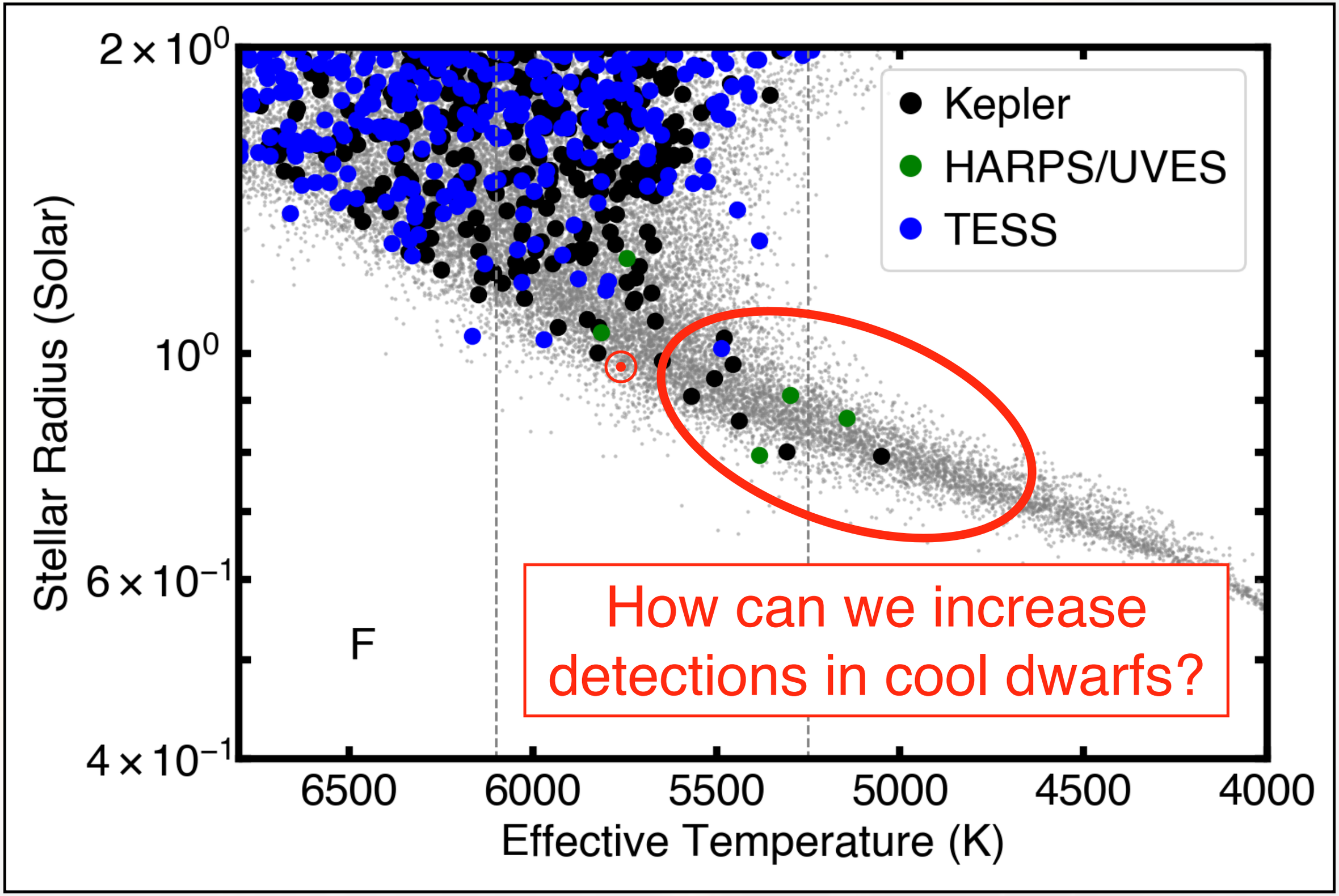
Seismic Detections for Cool Dwarfs



Seismic Detections for Cool Dwarfs



Seismic Detections for Cool Dwarfs



Option 1:

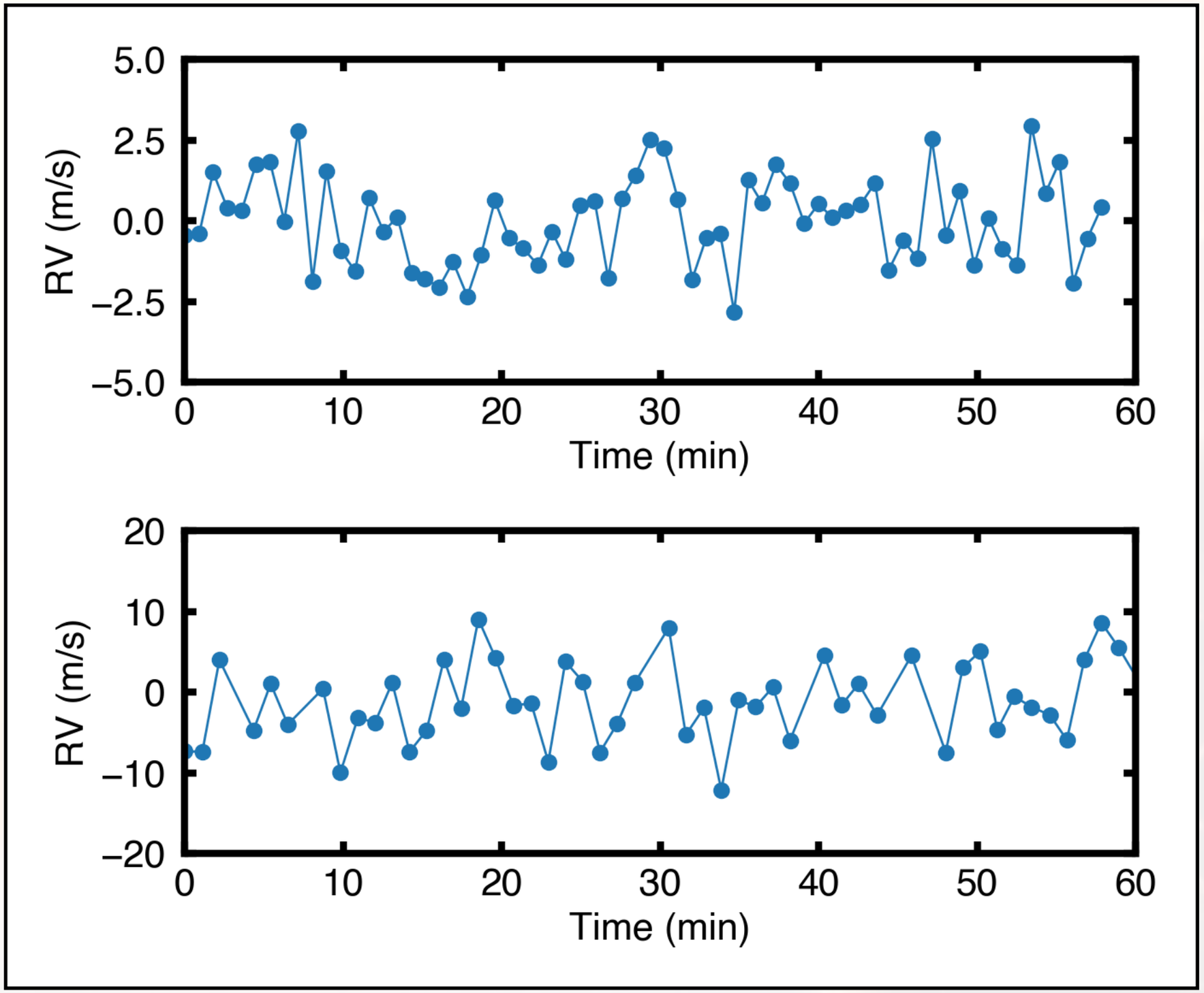
Very high-cadence RVs with 8+m class telescopes

Option 2:

Very long observing campaigns with network of smaller telescopes

Assumption: short-term instrumental noise floor is smaller than signal (i.e. we can beat down by √N)

Cool Dwarfs: Pilot Observations



HD219134

K3V, V=5.5

Keck/HIRES

σ ~ 1.3 m/s

σ Dra

K0V, V=4.7

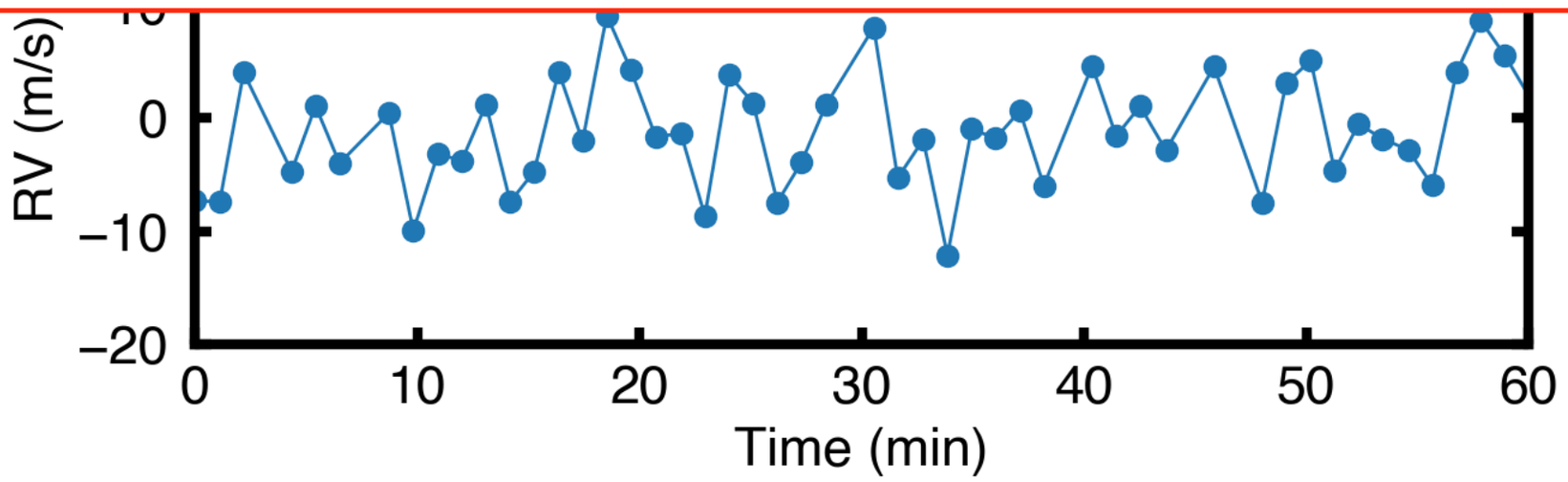
SONG

σ ~ 4 m/s

Cool Dwarfs: Pilot Observations

Problem: Typical early K dwarf amplitude (~7 cm/s) requires ~25 nights on Keck or ~300+ single-site nights on SONG.

Need to increase N!



HD219134

K3V, V=5.5

Keck/HIRES

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K0V, V=4.7

SONG

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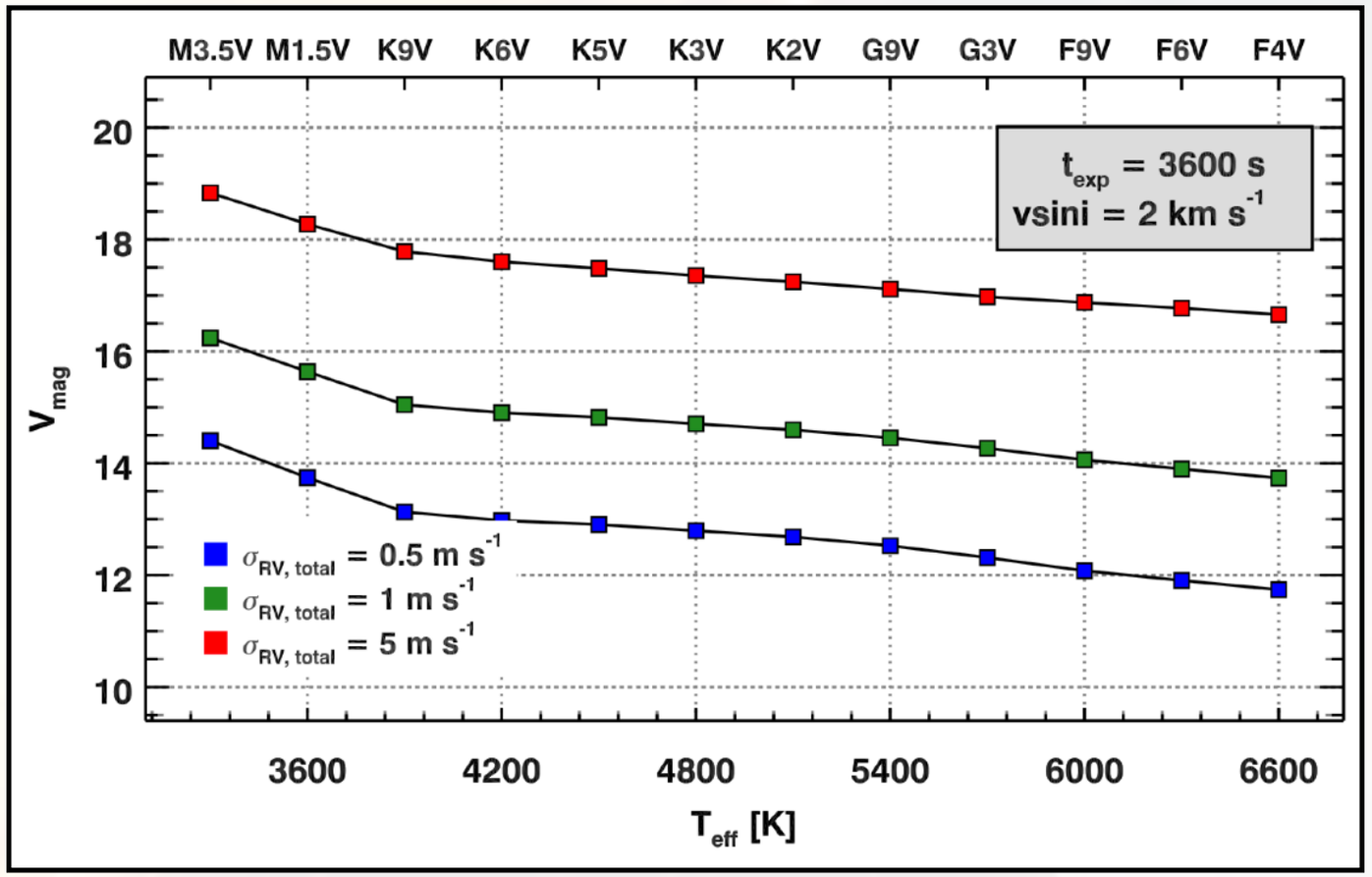
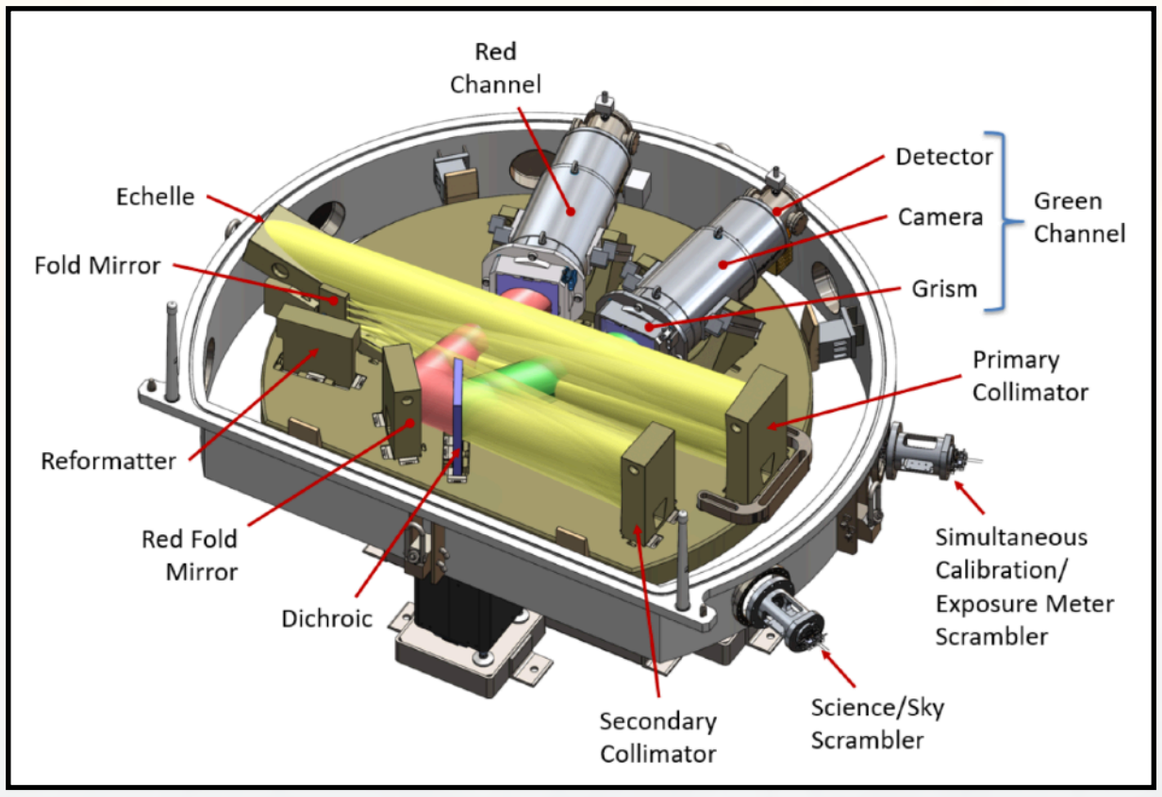
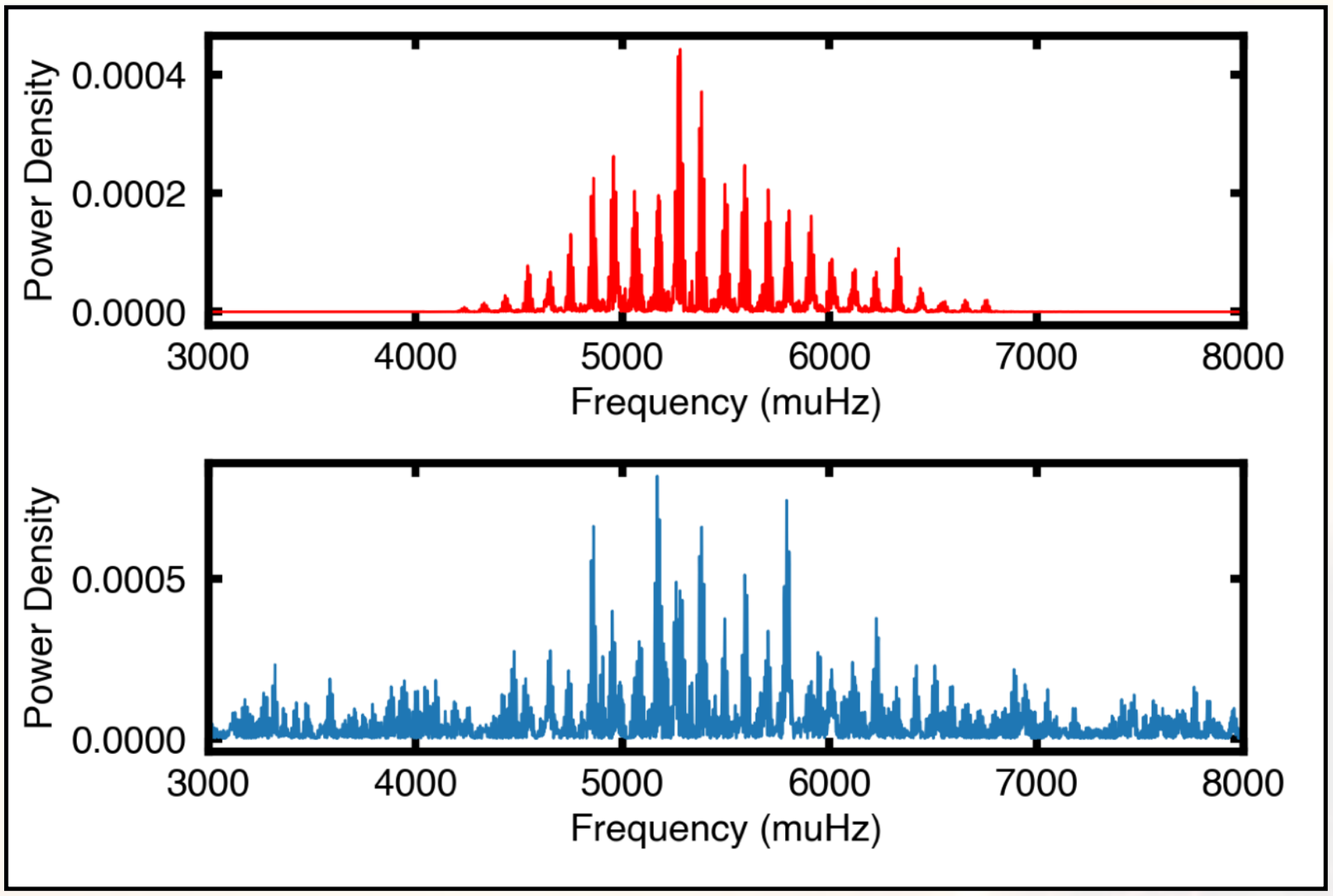
Keck Planet Finder (KPF)





- Next-generation RV spectrograph for Keck 1
- σ~0.3 m/s in 10 sec for V=6; fast readout (maybe)
- PI Andrew Howard (Caltech)

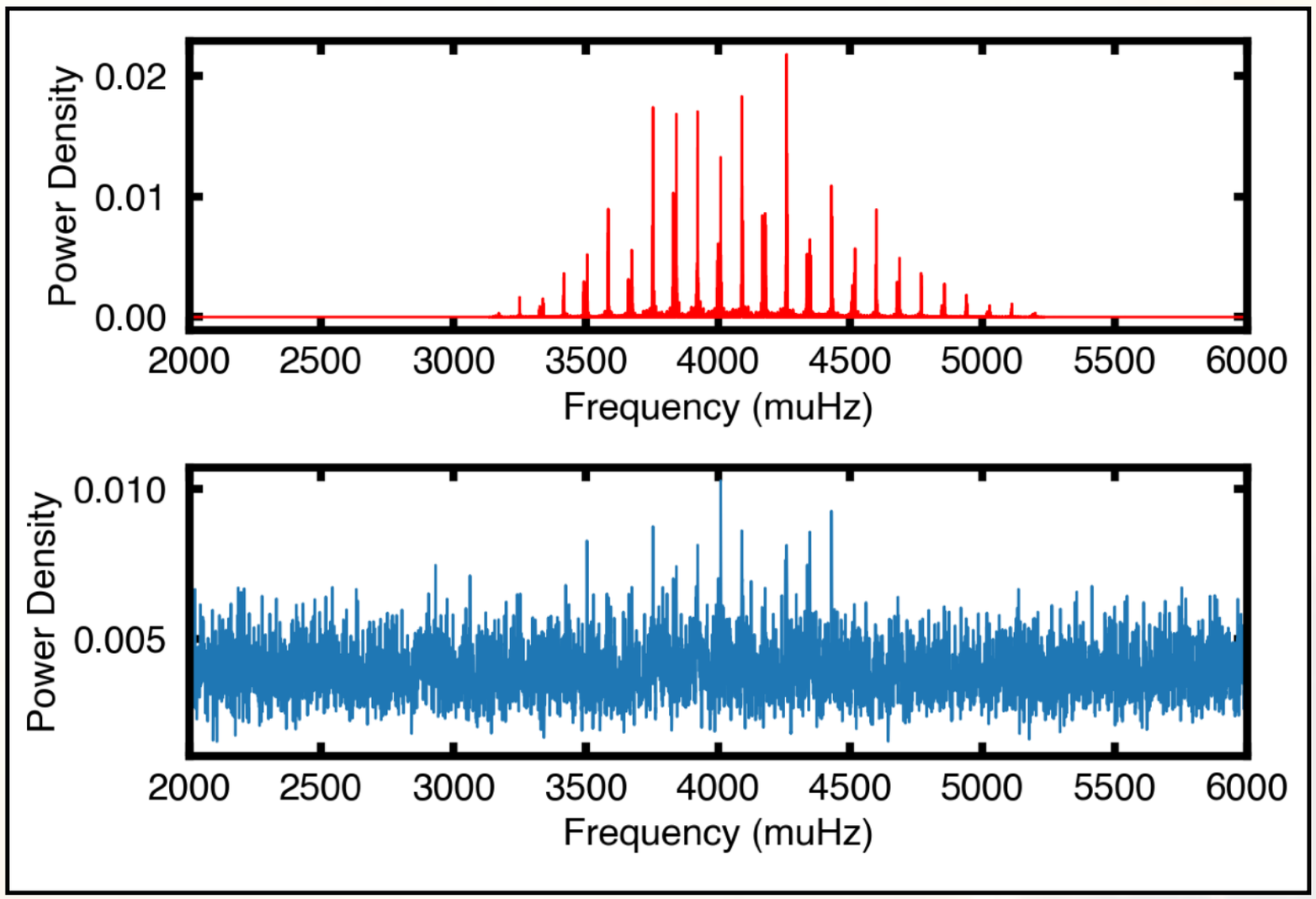
HD219134 with KPF



- ~3 nights with 30 second cadence & σ=0.4 m/s (photon noise, KPF simulator)
- ~4.5 cm/s amplitude (L/M scaling)

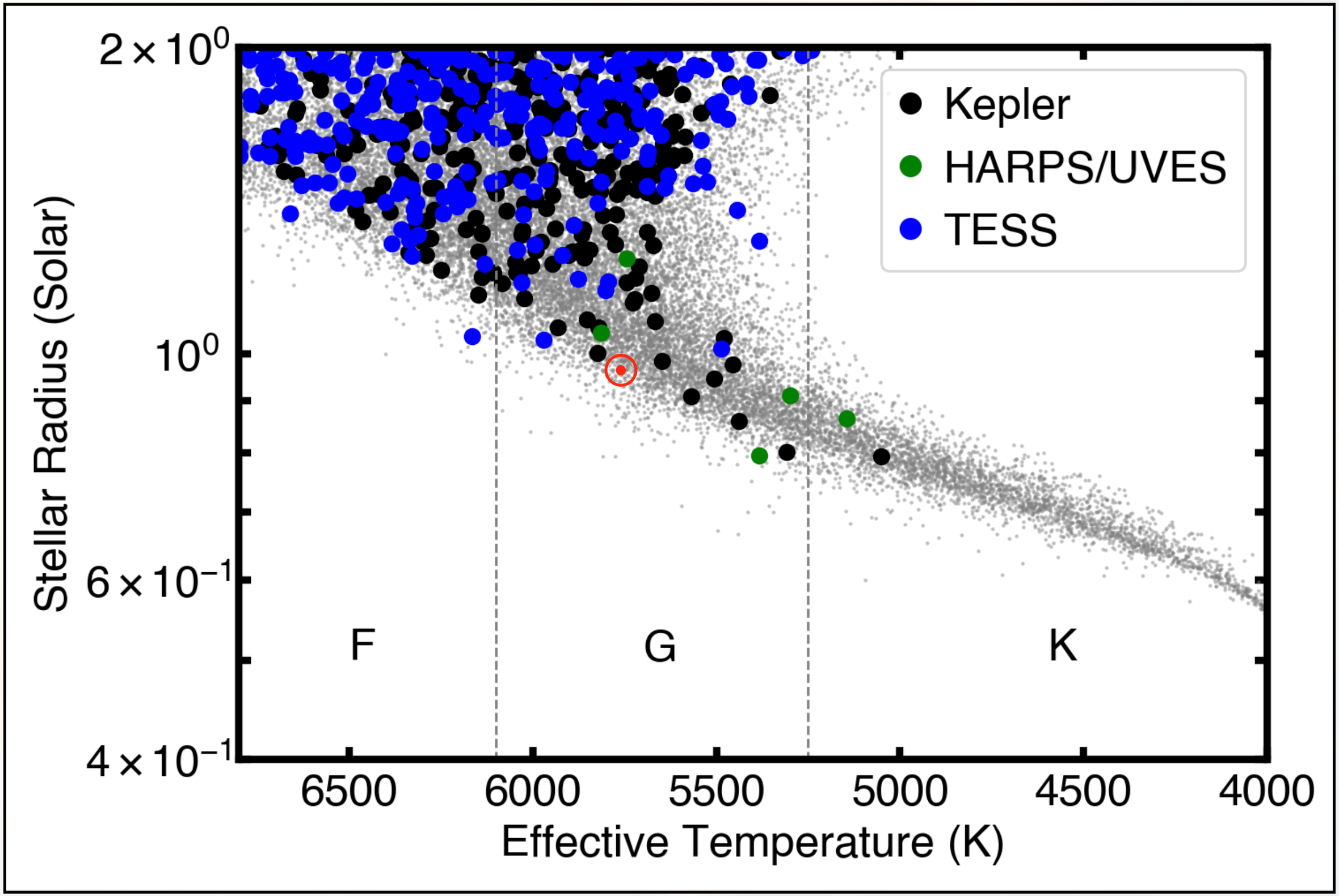

SONG
?
STELLAR OBSERVATIONS NETWORK GROUP

Late G / early K with SONG Network

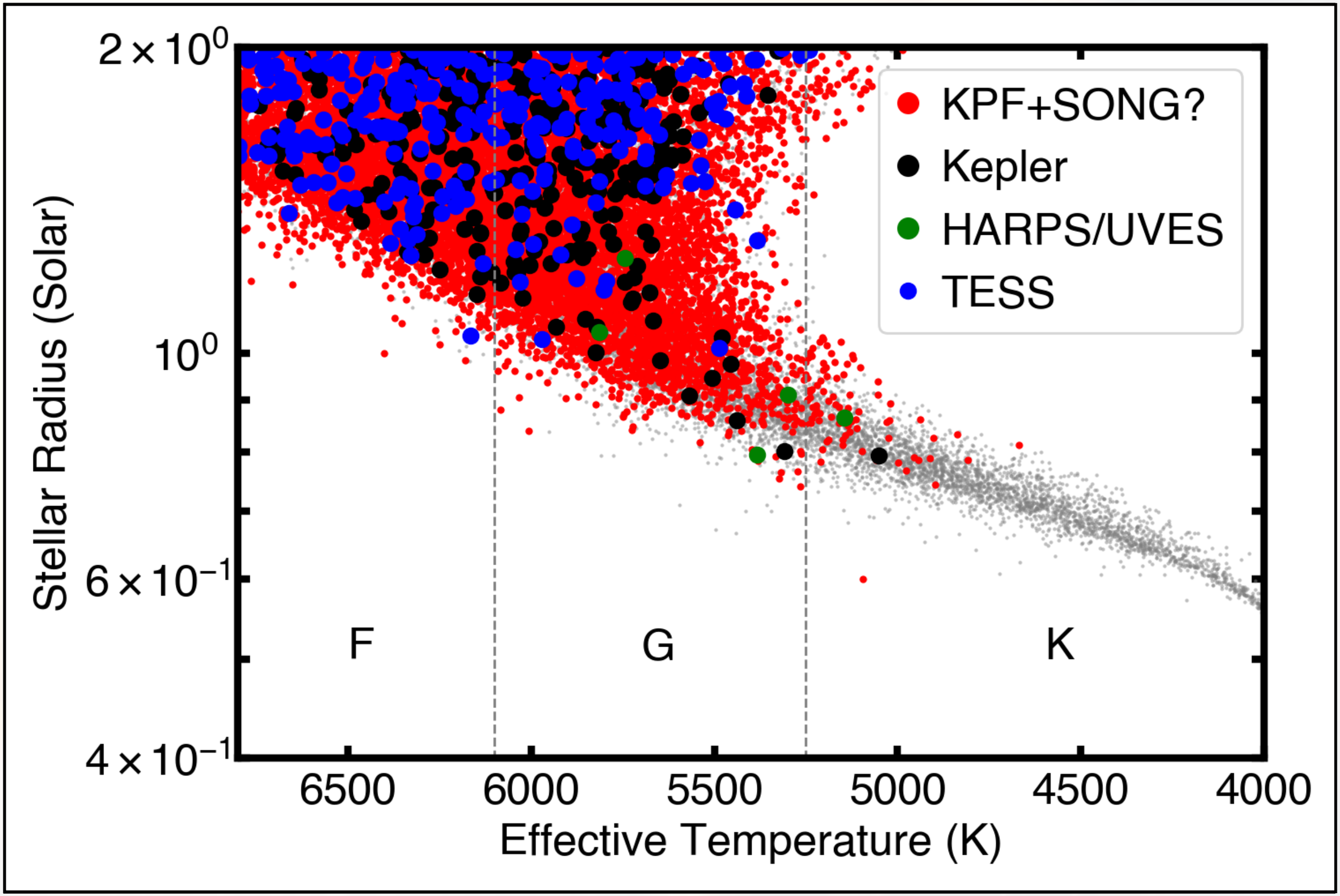


- ~6 month observations with ~80% duty cycle, 1 minute cadence with 4 m/s RV precision (cf σ Dra)
- ~8 cm/s amplitude (similar to α Cen b)

Seismic Detections for Cool Dwarfs



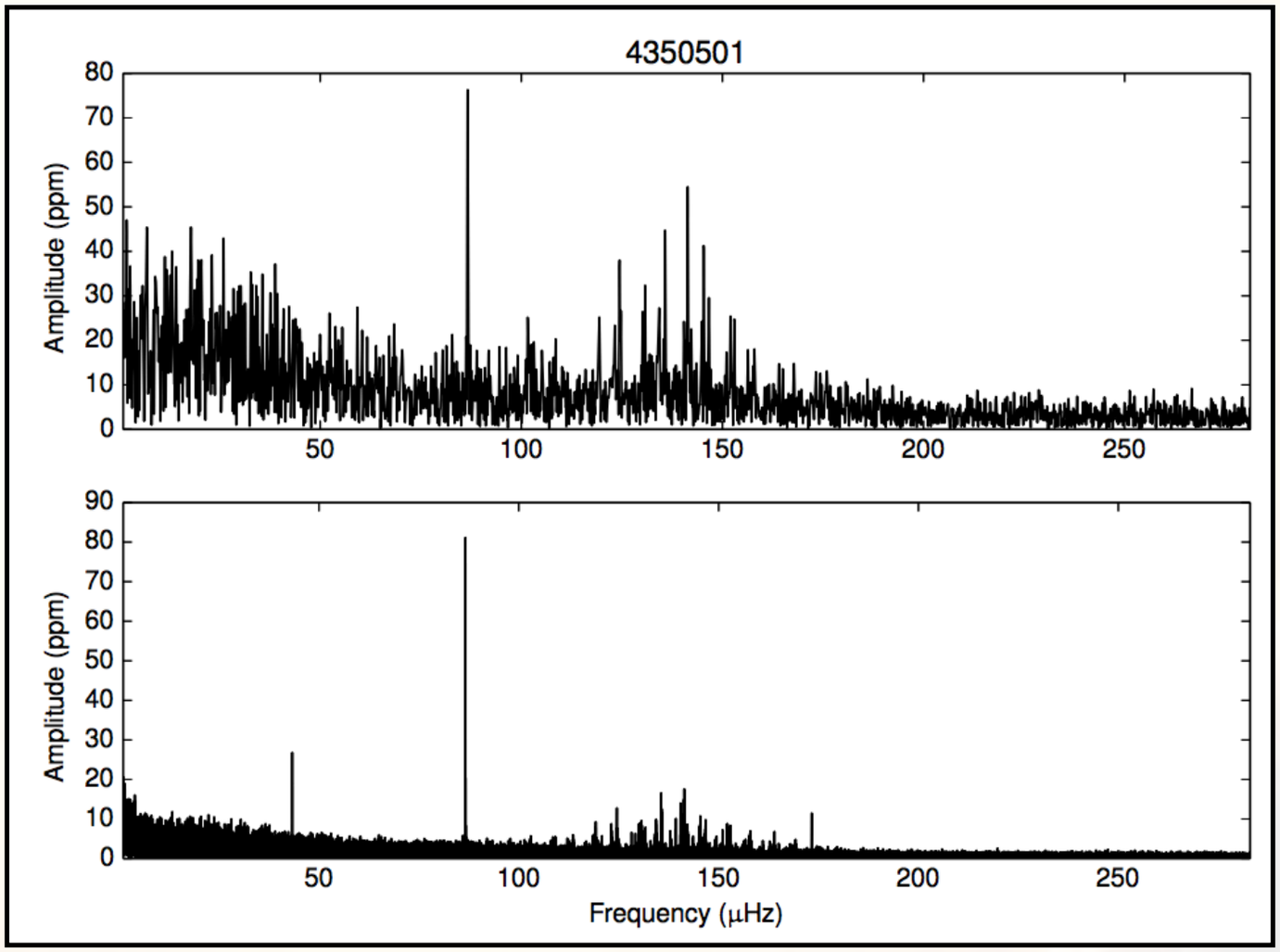
Seismic Detections for Cool Dwarfs



TESS & SONG Synergies III:

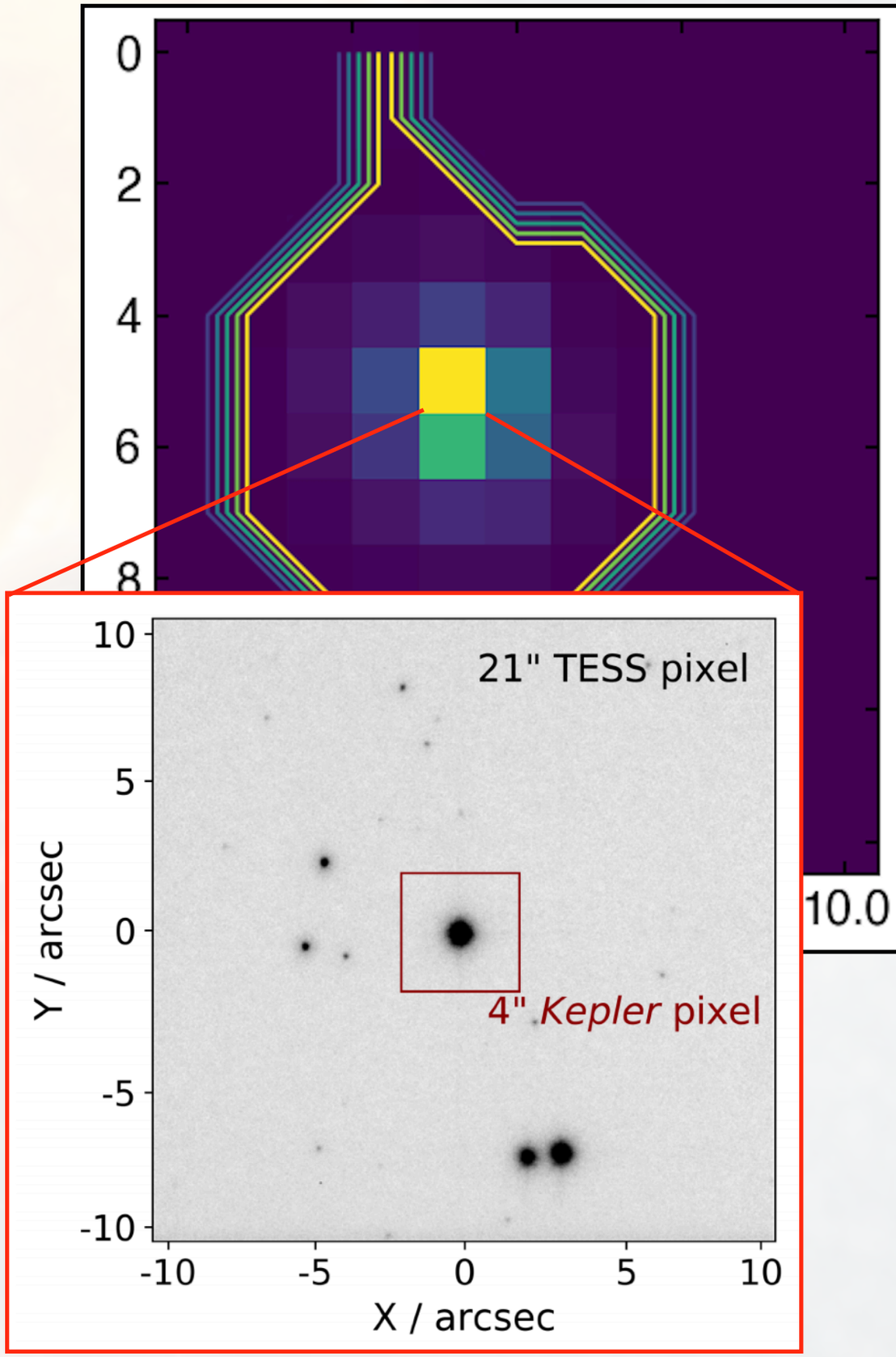
Additional Thoughts ...

Follow-up of blended stars

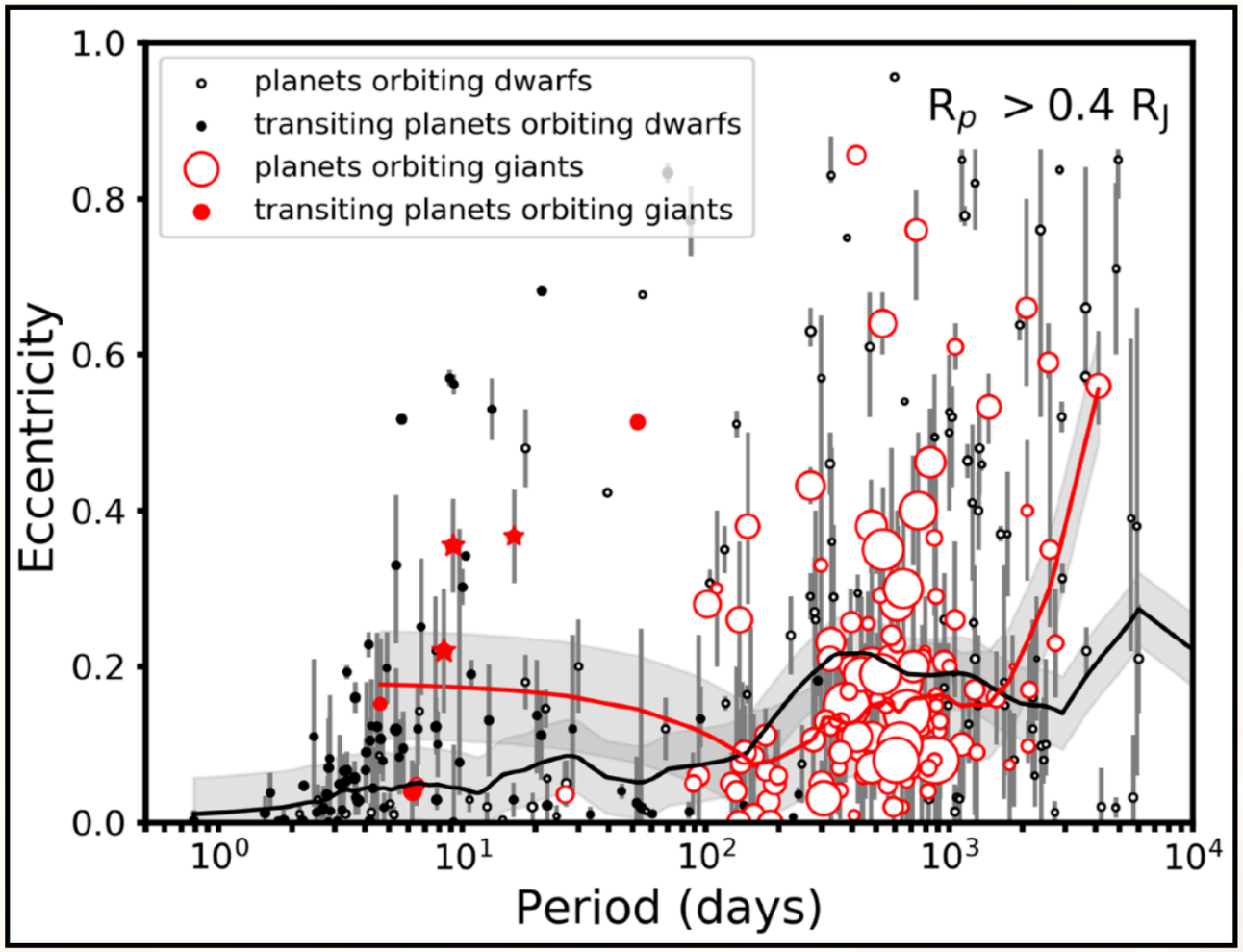


Bedding+ 2010, Colman+ 2017

hybrid pulsators, eclipsing binaries, triple systems ...

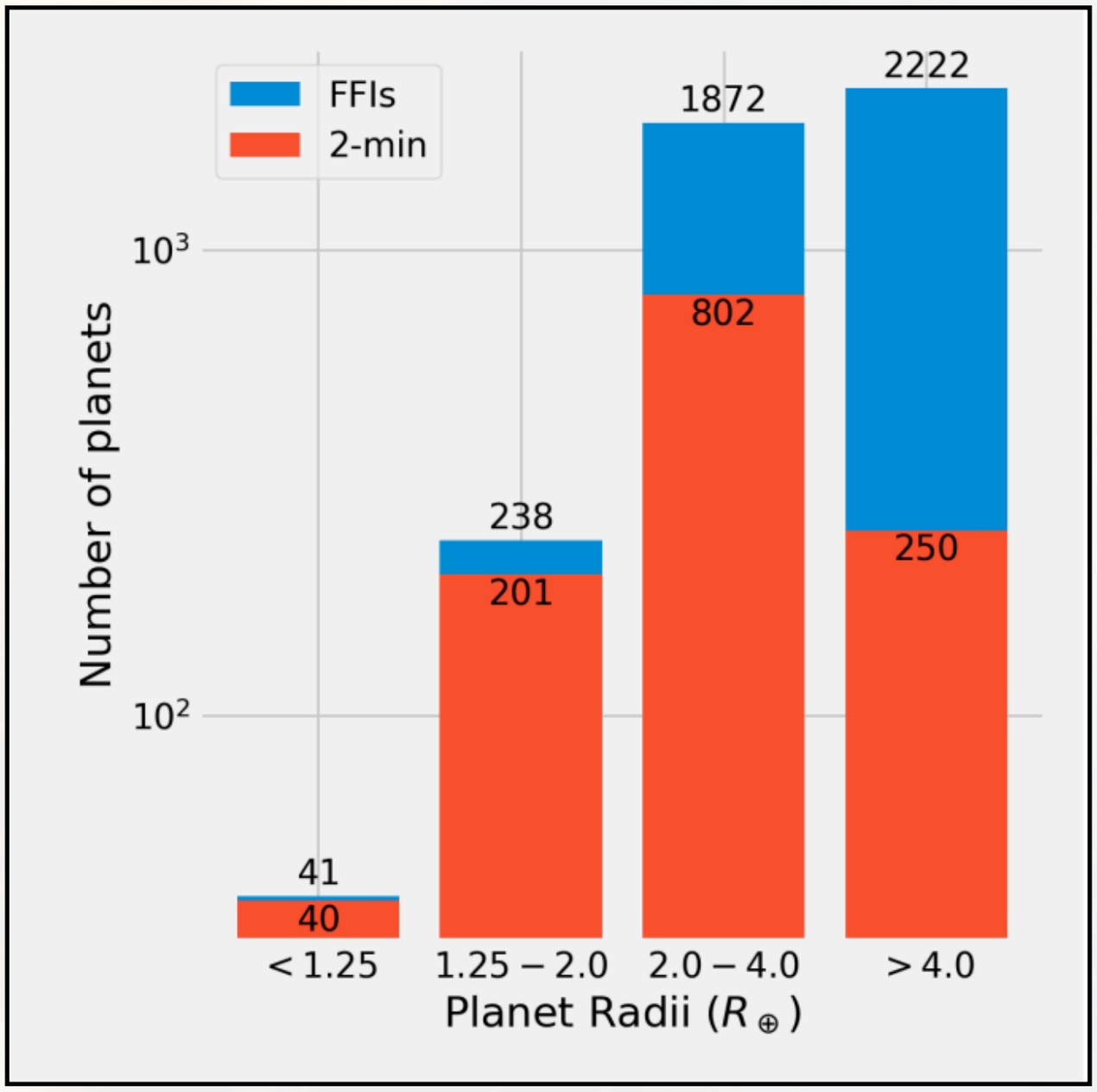


Masses of TESS Gas Giant Planets



Grunblatt+ 2018

TESS Level 1 Requirement ?



Barclay+ 2018

how do gas giant architectures change across the H-R diagram?

Conclusions

- **First TESS results:** precision as expected, tentative seismic detections & more sectors are on the way

- **TESS - SONG Synergy I:** *simultaneous* amplitudes in velocity and intensity. Large sample available with TESS!

- **TESS - SONG "Synergy" II:** asteroseismology of cool dwarfs that can't be done with TESS. Important to calibrate models (radius inflation) & gyrochronology. SONG *network* required to make this science case happen

- **TESS - SONG Synergy III:** follow-up of blended TESS stars, masses of gas-giant planets