Benchmark eclipsing binaries in the PLATO long-stare fields

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Conclusions

- ✦ Double-lined eclipsing binaries (DEBS) are extremely valuable as benchmarks for PLATO data products.
- ✦ There will be very few suitable systems for “end-to-end” tests in the long-stare fields (“calibration targets”).
- ✦ A PLATO equivalent of the TESS “specially curated target list” is needed to ensure these high-priority DEBS (and other important targets) are observed, and are observed in the right way.

WP125500 - PLATO benchmark stars

Newly-formed WP with the aim to

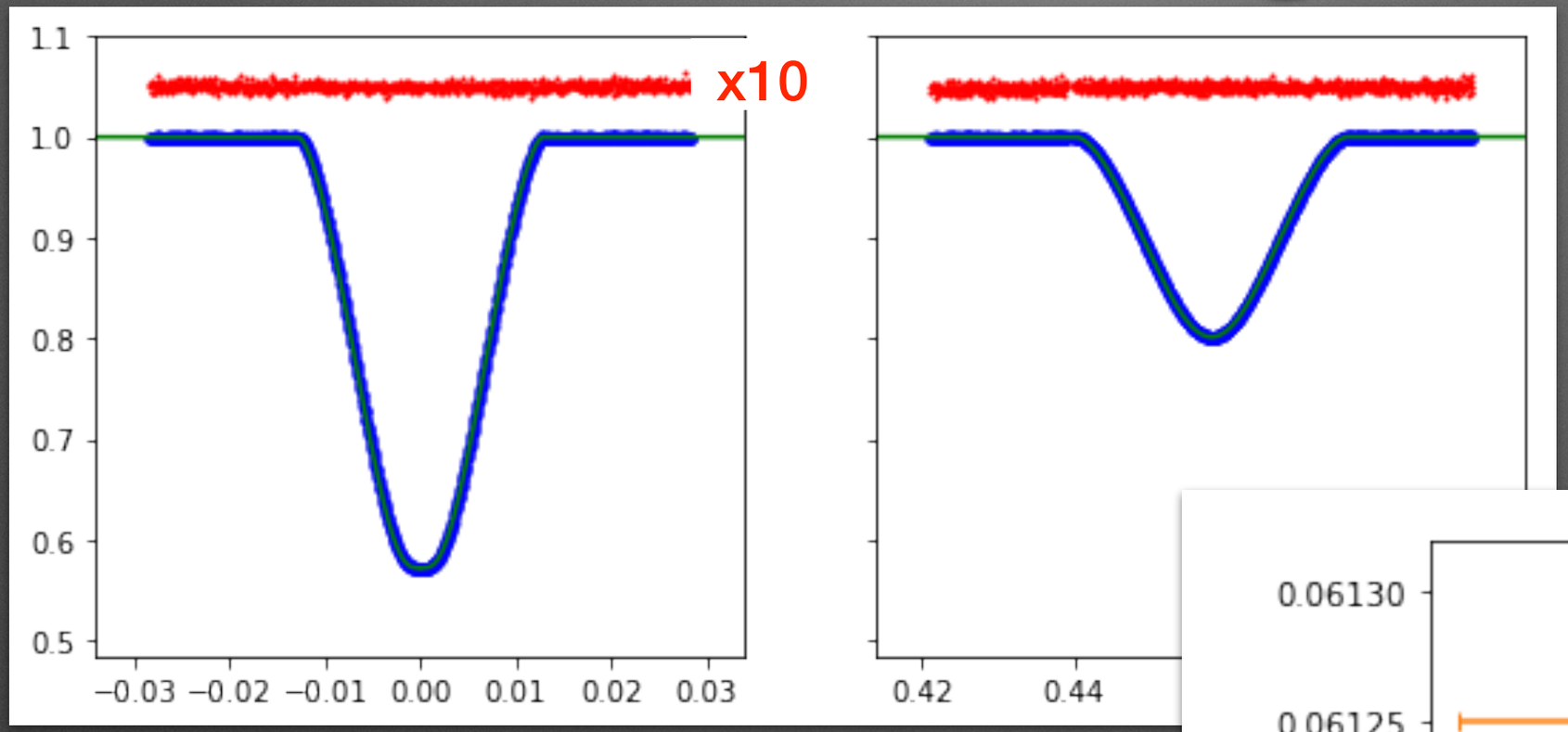
coordinate and support efforts to measure precise and accurate fundamental properties for stars that can be used to validate and improve data products from the PLATO mission.

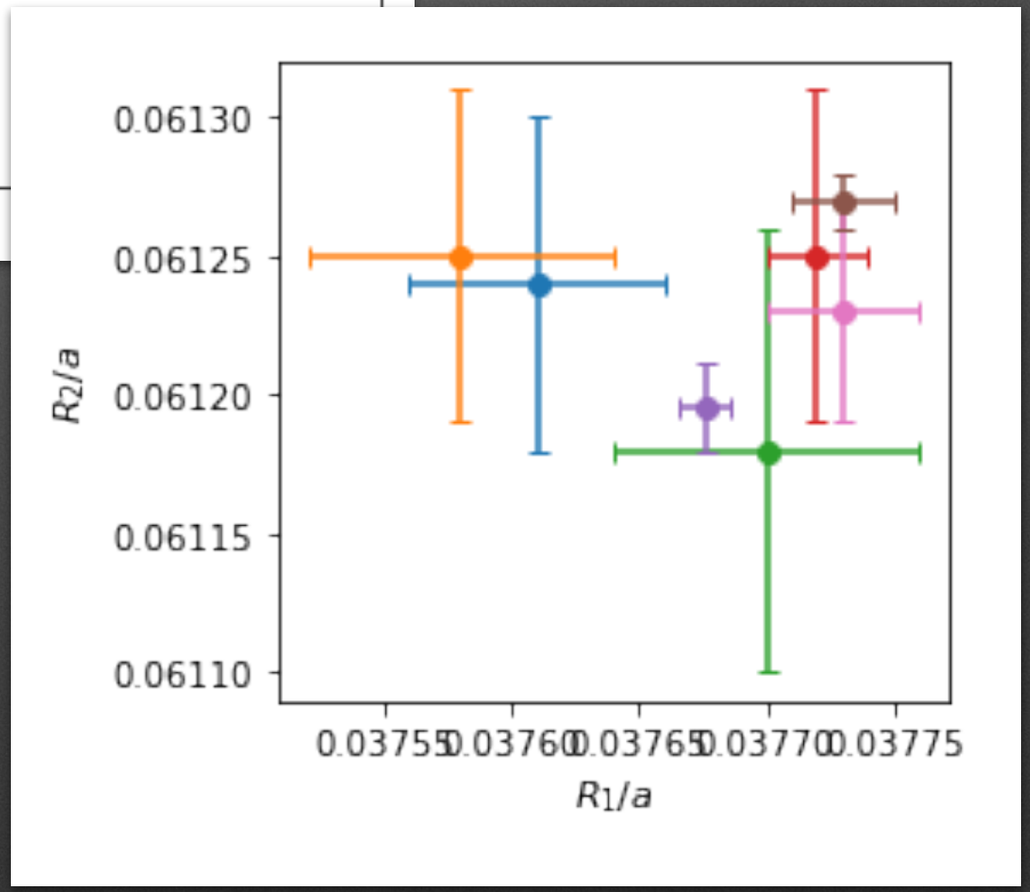
Benchmark data sets will be used to test and improve methods and models.

Benchmark stars for "end-to-end" assessment of the accuracy and precision of PLATO data products.

Double-lined eclipsing binaries fall in both categories

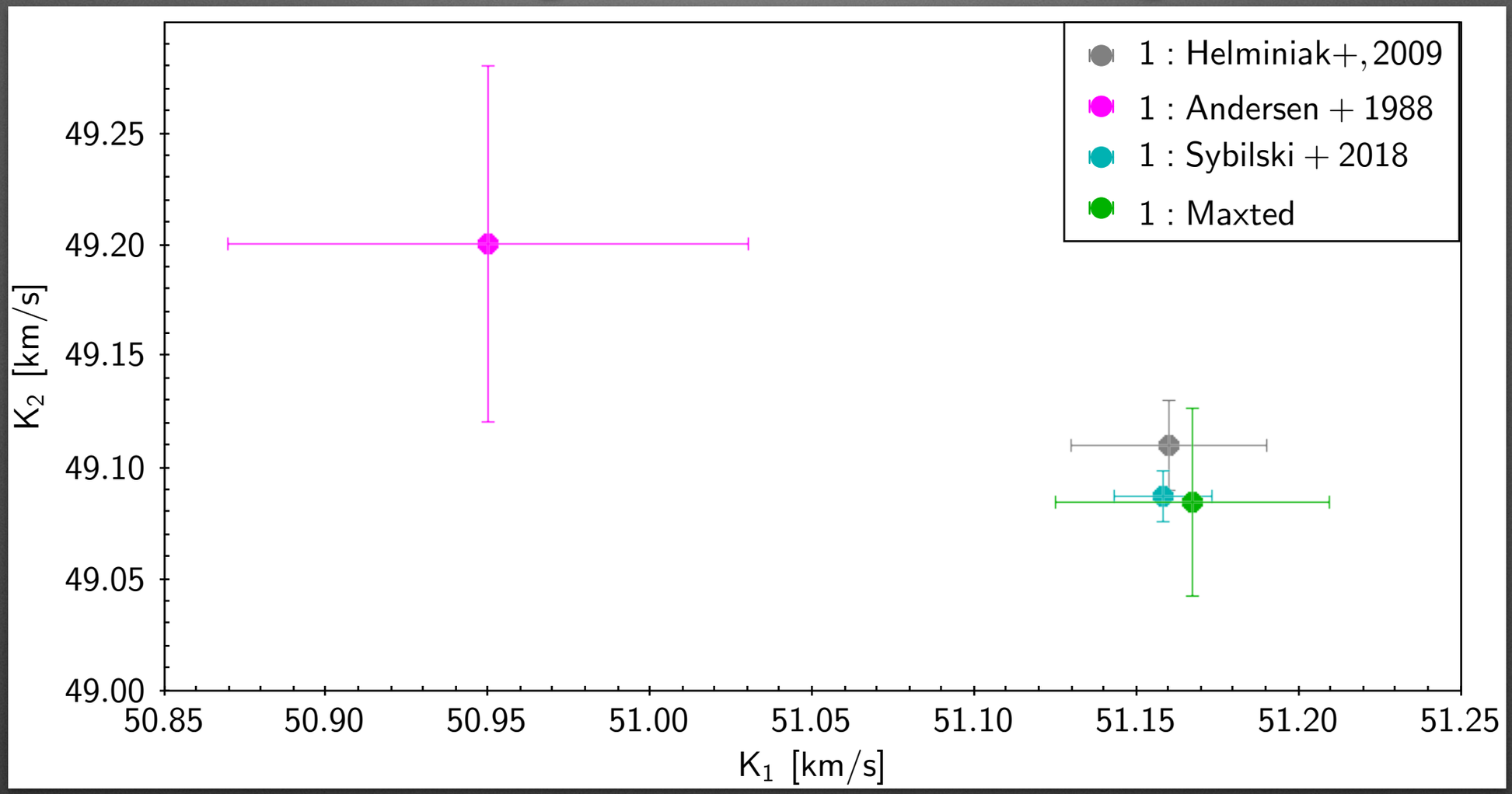
AI Phe - TESS light curves





- $R_1/a = 0.037\ldots \pm 0.00006$ (0.15%)
- $R_2/a = 0.061\ldots \pm 0.00003$ (0.05%)
- $i = 88.3??$ 0.006
- $e \cos \omega = -0.065\ldots \pm 0.00001$
- $e \sin \omega = +0.175\ldots \pm 0.00044$

Al Phe — spectroscopic orbit

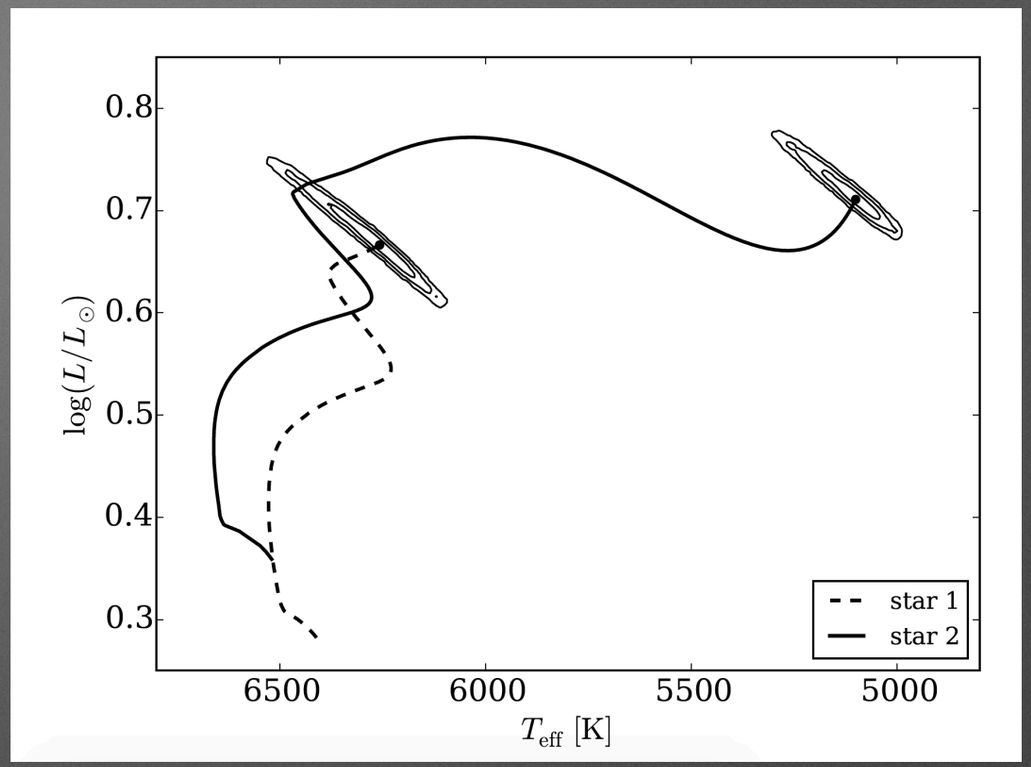


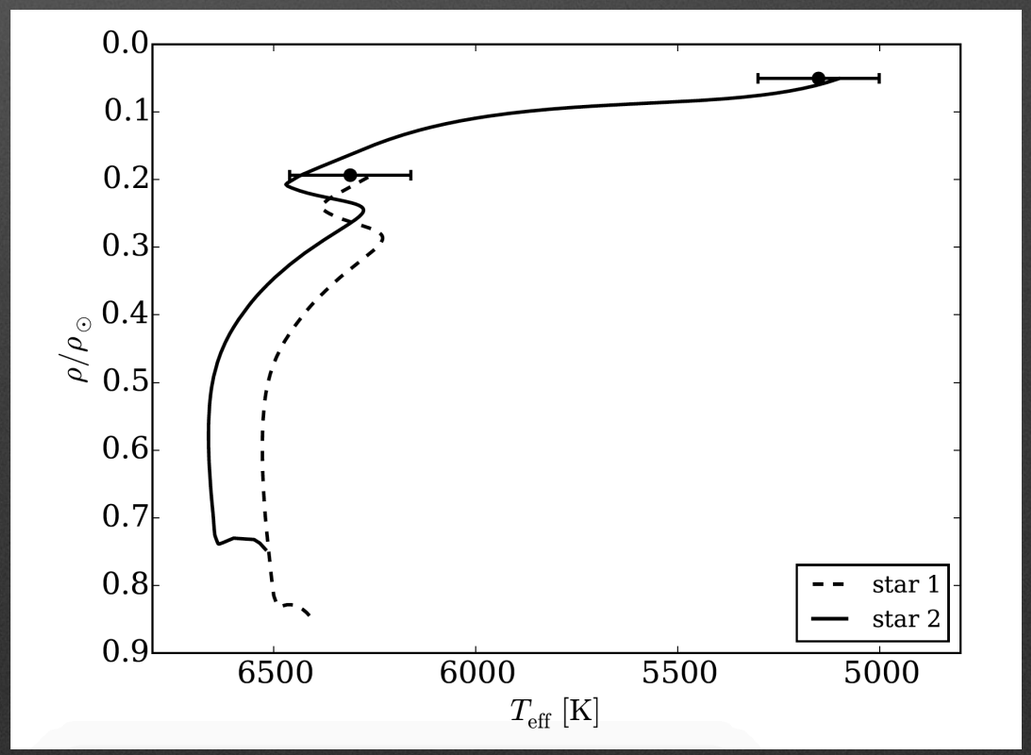
- K_1= 51.1… ± 0.013 km/s
- K_2= 49.0… ± 0.009 km/s

- M_1 = 1.1… +/- 0.0006 $M_\odot$
- M_2 = 1.2… +/- 0.0007 $M_\odot$
- a = 47.8… +/- 0.0084 $R_\odot$

Al Phe v. stellar models

- $N_{obs} = 7$
  - $M_{1,2}$, $R_{1,2}$, $T_{eff,1,2}$, [M/H]
- $N_{df} \gtrsim 6$
  - τ, M_1, M_2, Z_i, Y_i, α_{MLT}, …
- Requires high-precision data (Valle et al. 2017)
- GARSTEC model fits ⇒
  - τ = 4.4 ± 0.3 Gyr
  - Y = 0.25 — 0.28
  - Caveats
    - (τ, Y) v. α_{ov} not yet mapped
    - these values for the old mass measurements





The plan …

- Find more systems like Al Phe using TESS
  - +WASP +Gaia + 2MASS, etc.
- Measure mass and radius to high accuracy
  - spectroscopy + detailed modelling of light curves
- Estimate T_{eff} and [Fe/H]
  - currently a bottle-neck — laborious
- Calibrate stellar models
- Predict asteroseismic signal with best-fit models
- Compare predicted pulsation frequencies to PLATO

Are there any DEBS like Al Phe where asteroseismology of the main-sequence star is feasible with PLATO?

Known DEBS in/near PLATO fields

DEBCat list of 233 DEBS with accurate masses radii.

- Remove systems >5° from nominal SPF/NPF fields.
- Remove short-period systems (P<3 days)
  - i.e. non-spherical stars with forced rapid rotation
- Remove faint targets (V < 11)

Then select DEBS that have stars that are

- main-sequence stars ($R/R_\odot < 2 \times M/M_\odot$)
- likely to show solar-like oscillations
  - $M < 1.7M_\odot$
  - $T_{eff} < 7000K$
  - $L > 0.6L_\odot$

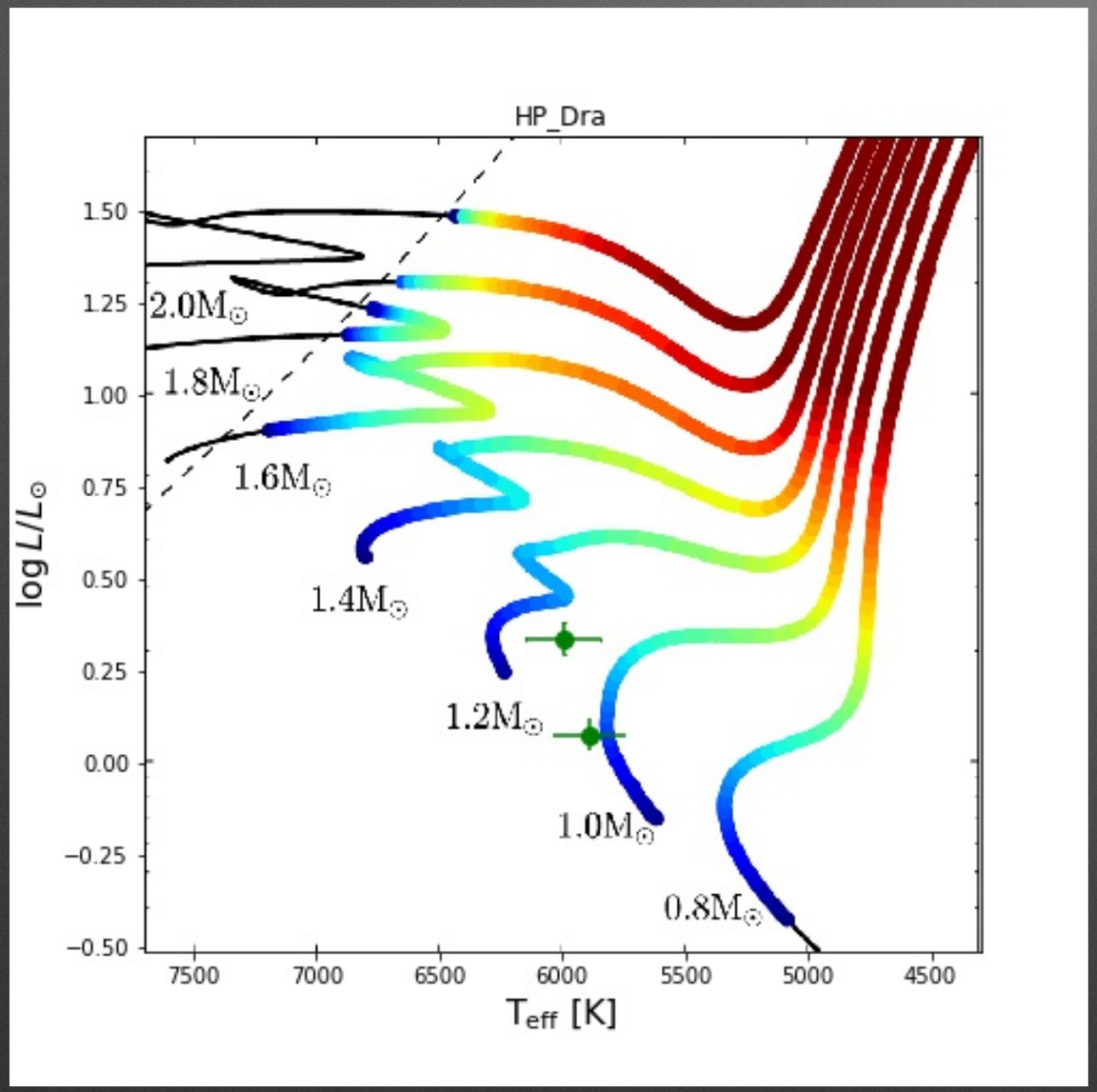
Known DEBS in/near PLATO fields

Start from DEBCat list of 233 DEBS with accurate masses radii

- Remove stars >5° from nominal SPF/NPF fields
- Remove (sub-)giants ($R/R_\odot > 2 \times M/M_\odot$)
- Remove massive/hot stars ($T_{eff} > 7000K$, $M > 1.7M_\odot$)
- Remove K-/M-dwarfs ($L < 0.6L_\odot$)
- Remove faint stars ($V < 11$)
- Remove short-period systems ($P<3$ days)
  - non-spherical stars with forced rapid rotation

Leaves only 5 systems where one or both stars are ok

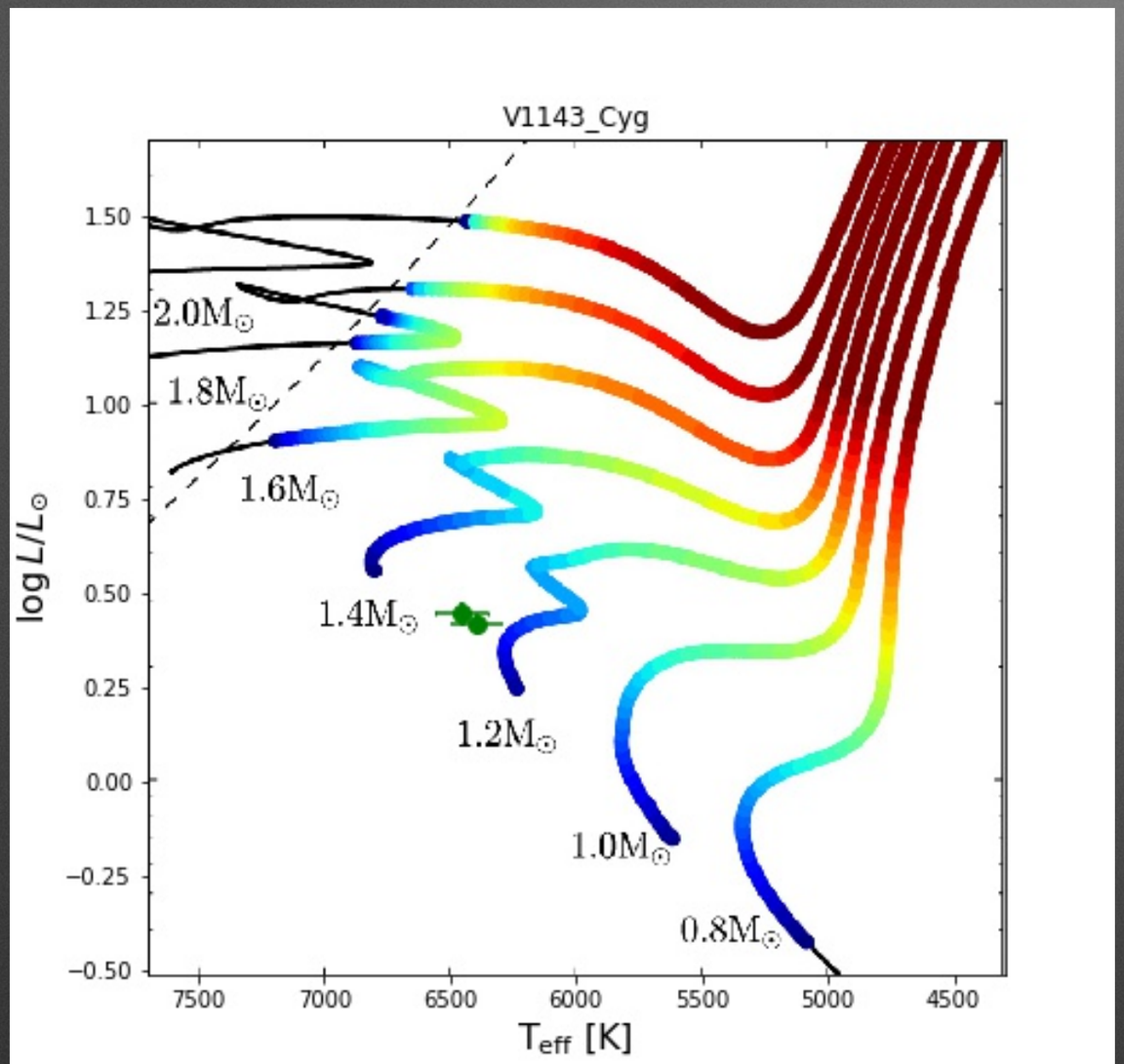
HP Dra



- P = 10.76 days
- V = 7.94
- M_1 =1.13 $M_\odot$
- R_1 = 1.37 $R_\odot$
- M_2 = 1.09 $M_\odot$
- R_2 = 1.05 $R_\odot$
- [Fe/H] = ?

Ideal benchmark (?). Do asteroseismic signals overlap?
Needs [Fe/H] measurement.

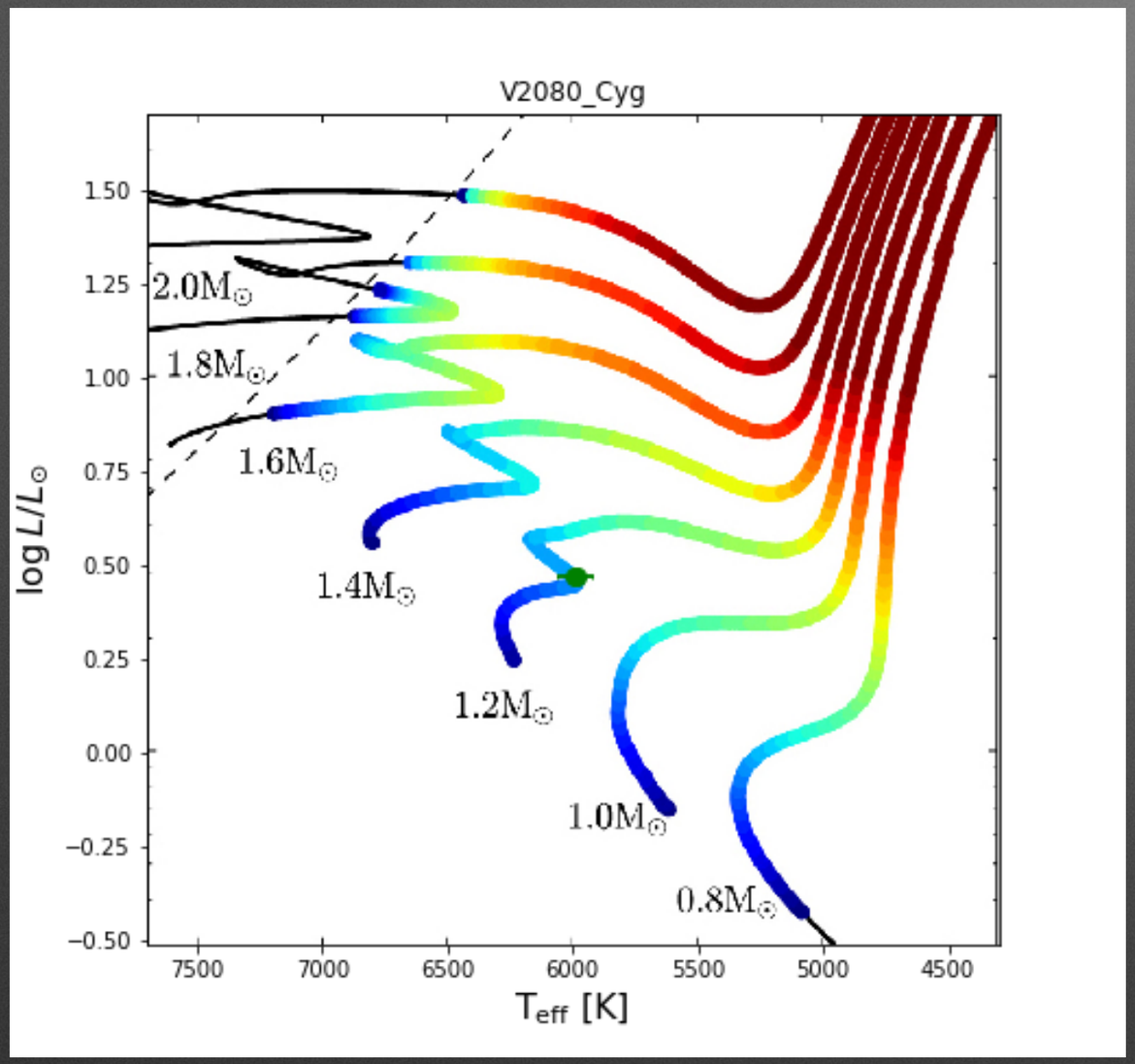
V1143 Cyg



- P = 7.64 days
- V = 5.86
- M_1 =1.35 $M_\odot$
- R_1 = 1.35 $R_\odot$
- M_2 = 1.33 $M_\odot$
- R_2 = 1.32 $R_\odot$
- [Fe/H] = ?

Overlap between asteroseismic signals and too bright?
Needs [Fe/H] measurement.

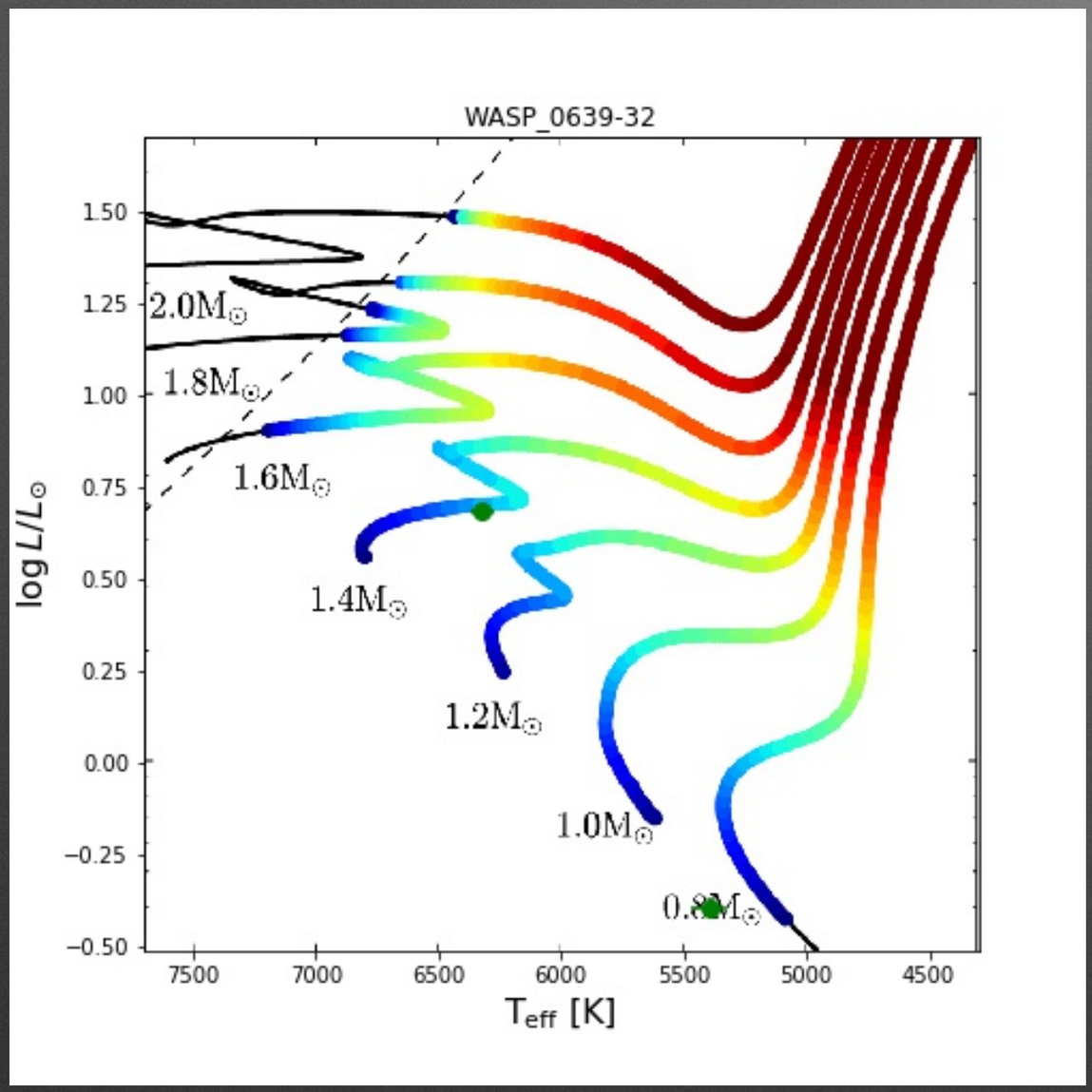
V2080 Cyg

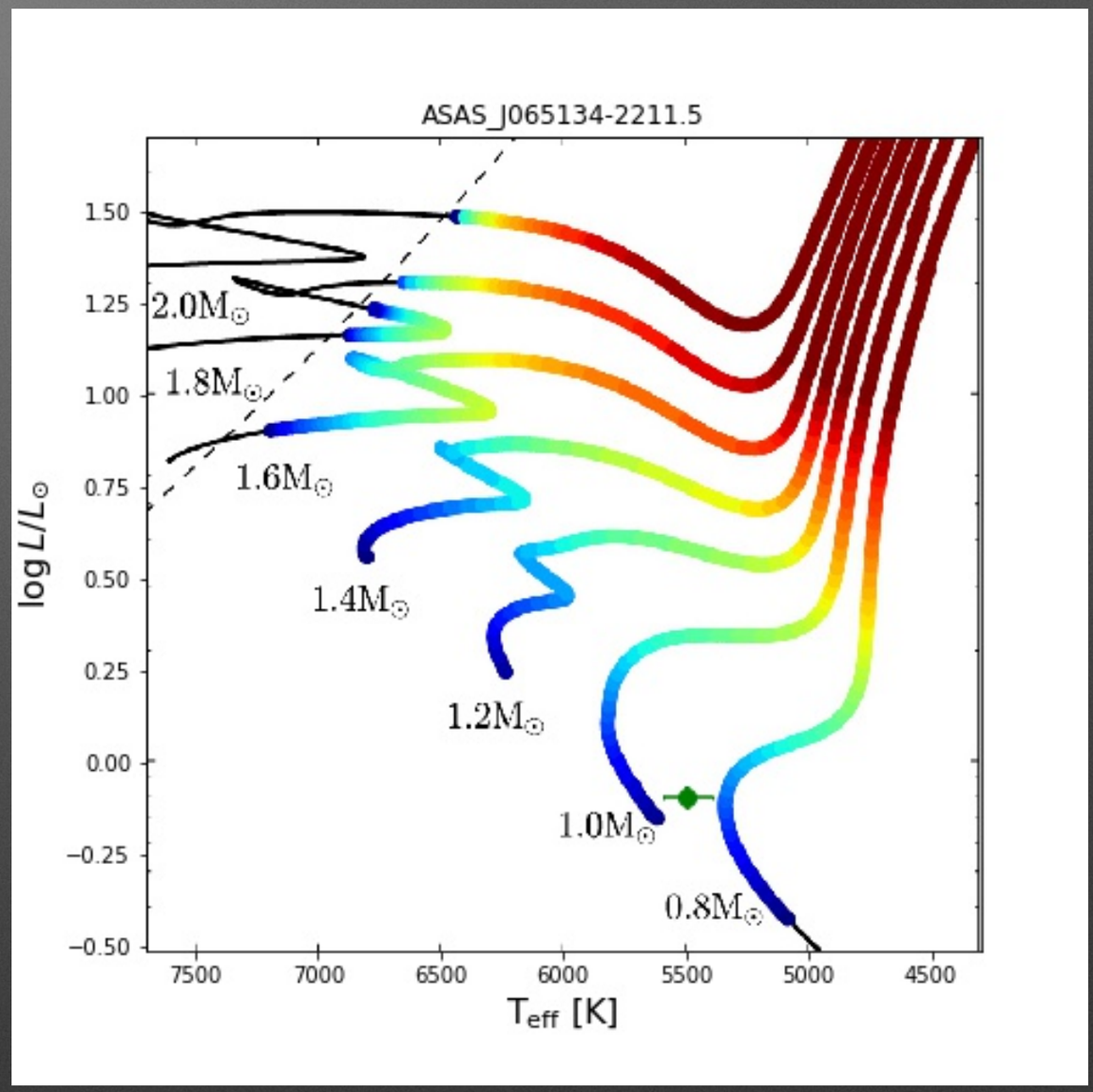


- P = 4.934 days
- V = 7.40
- M_1 =1.19 $M_\odot$
- R_1 = 1.60 $R_\odot$
- M_2 = 1.16 $M_\odot$
- R_2 = 1.60 $R_\odot$
- [Fe/H] = ?

Asteroseismic signals will overlap.

WASP 0639-32 and ASAS J065134-2211.5

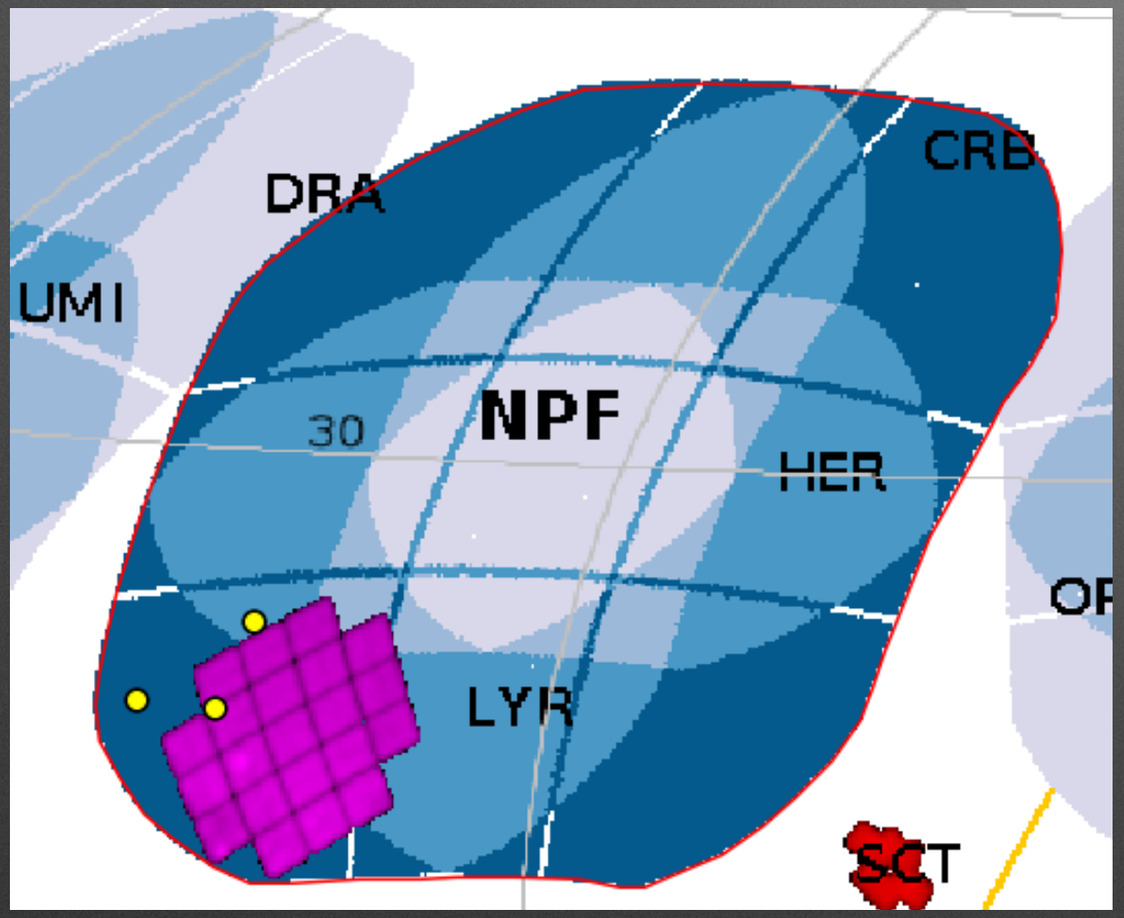


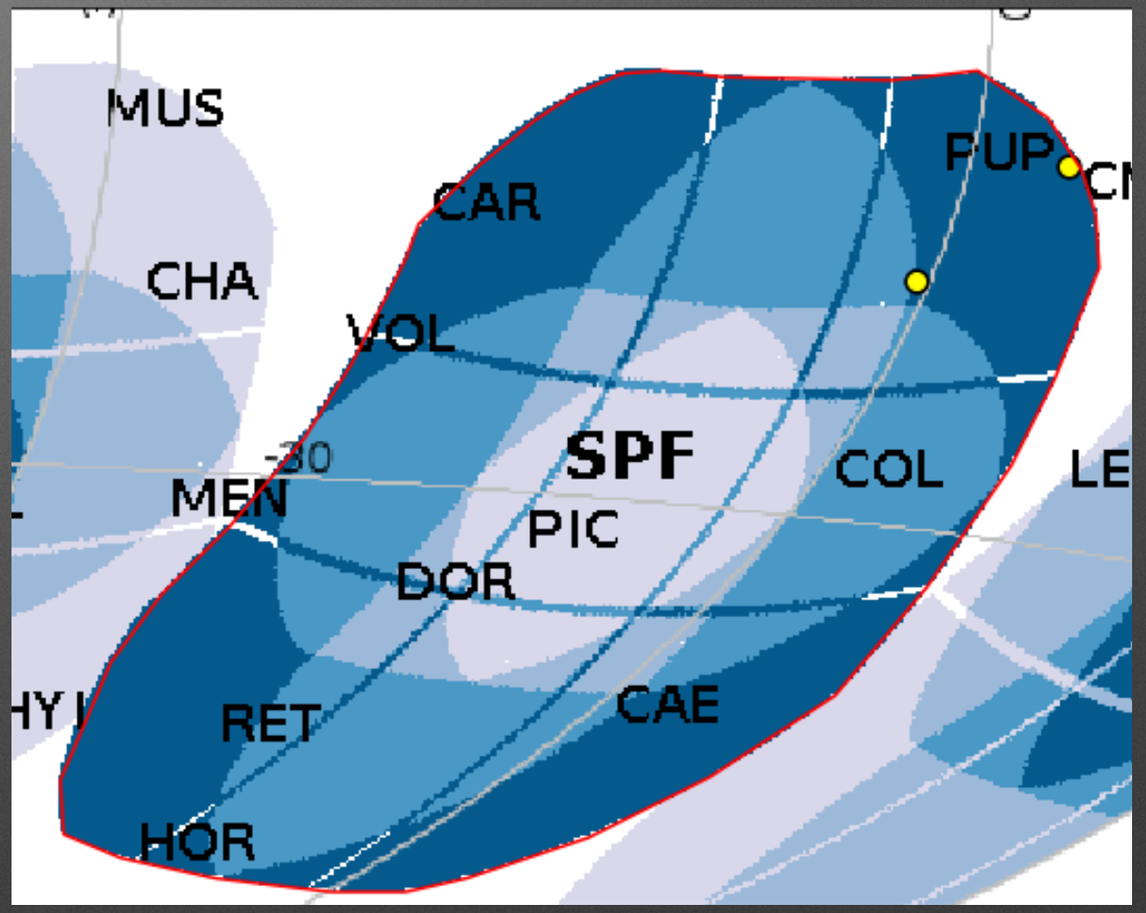


Brighter star by itself may be useful benchmark

Sky position of DEBCat sample

Galactic coordinates

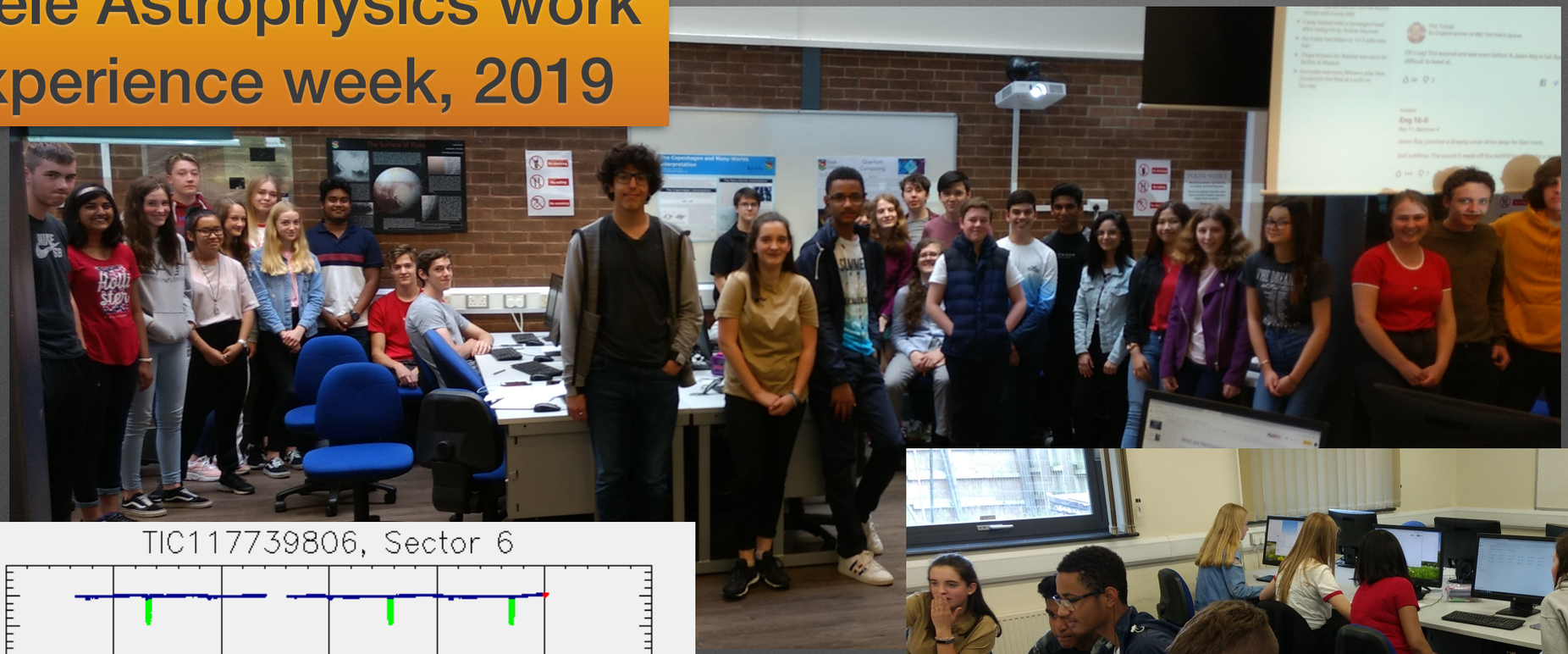


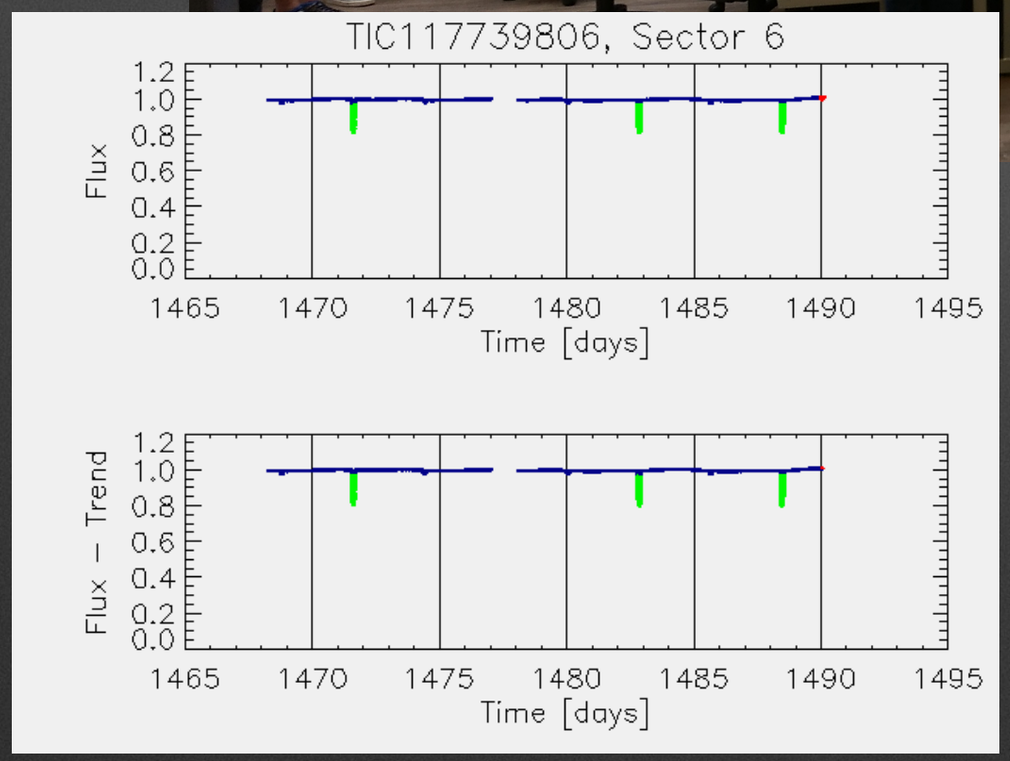


None of these stars have Kepler light curves

New targets from WASP and TESS

Keele Astrophysics work experience week, 2019





About 10 candidates for benchmark system in/near SPF

Follow-up of new targets

- New Xamidimura telescopes will be used to get multi-band photometry.
- All targets need spectroscopy.
- Spectral analysis for T_{eff} and [Fe/H] is a bottleneck.
- Further progress dependent on future funding.