Asteroseismology with TESS Short Cadence Data

Finding thousands of new solar-like oscillators using a probabilistic detection algorithm

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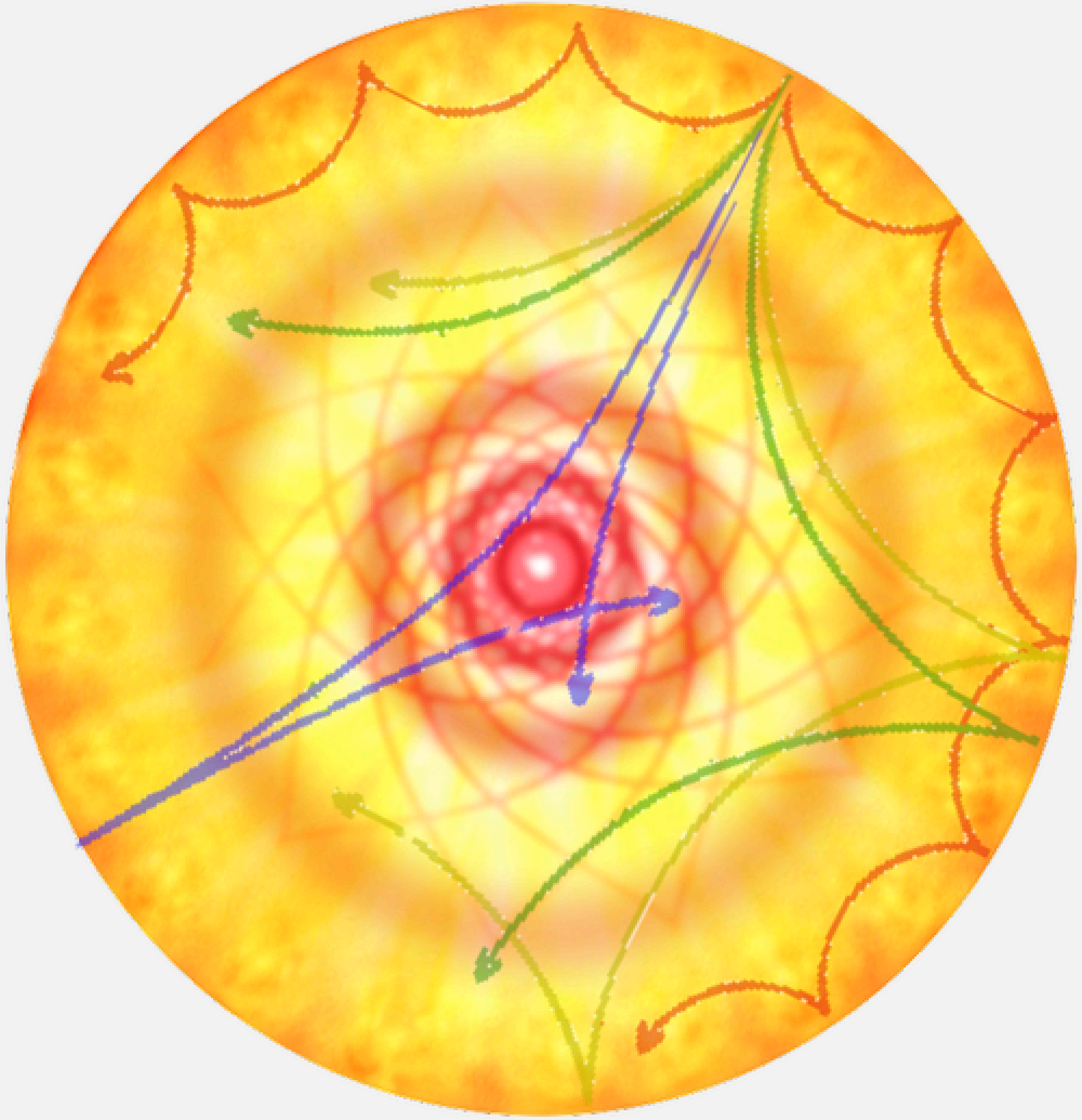
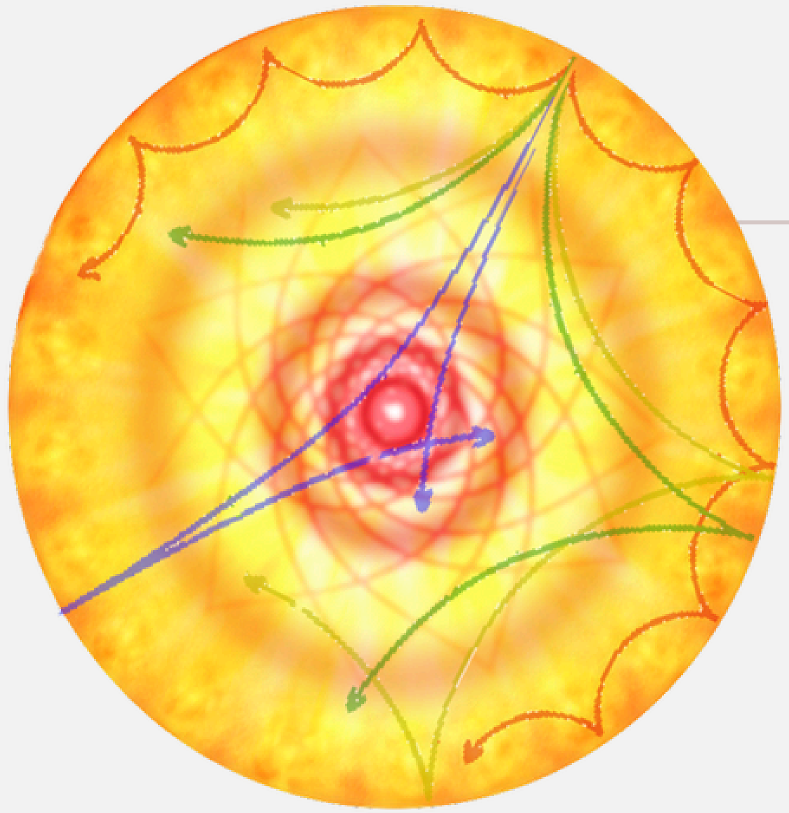
UNIVERSITY OF BIRMINGHAM

Science and Technology Facilities Council

Solar-like Oscillators





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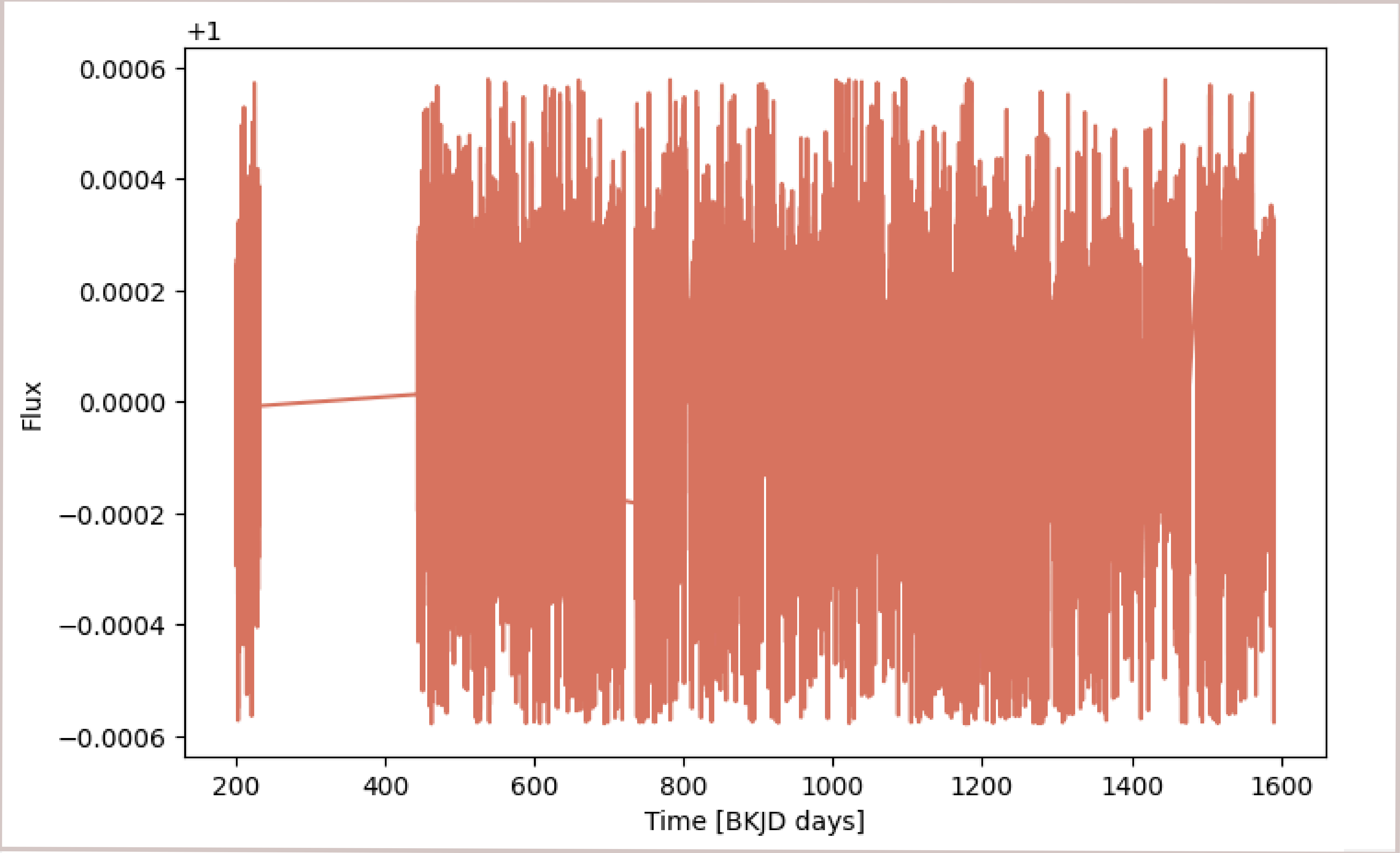

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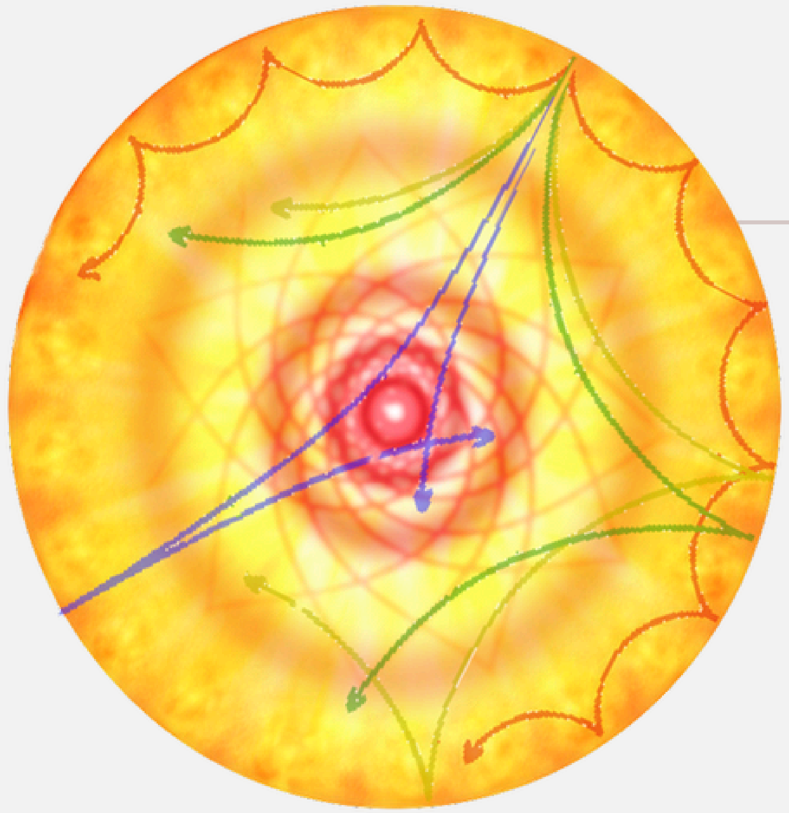
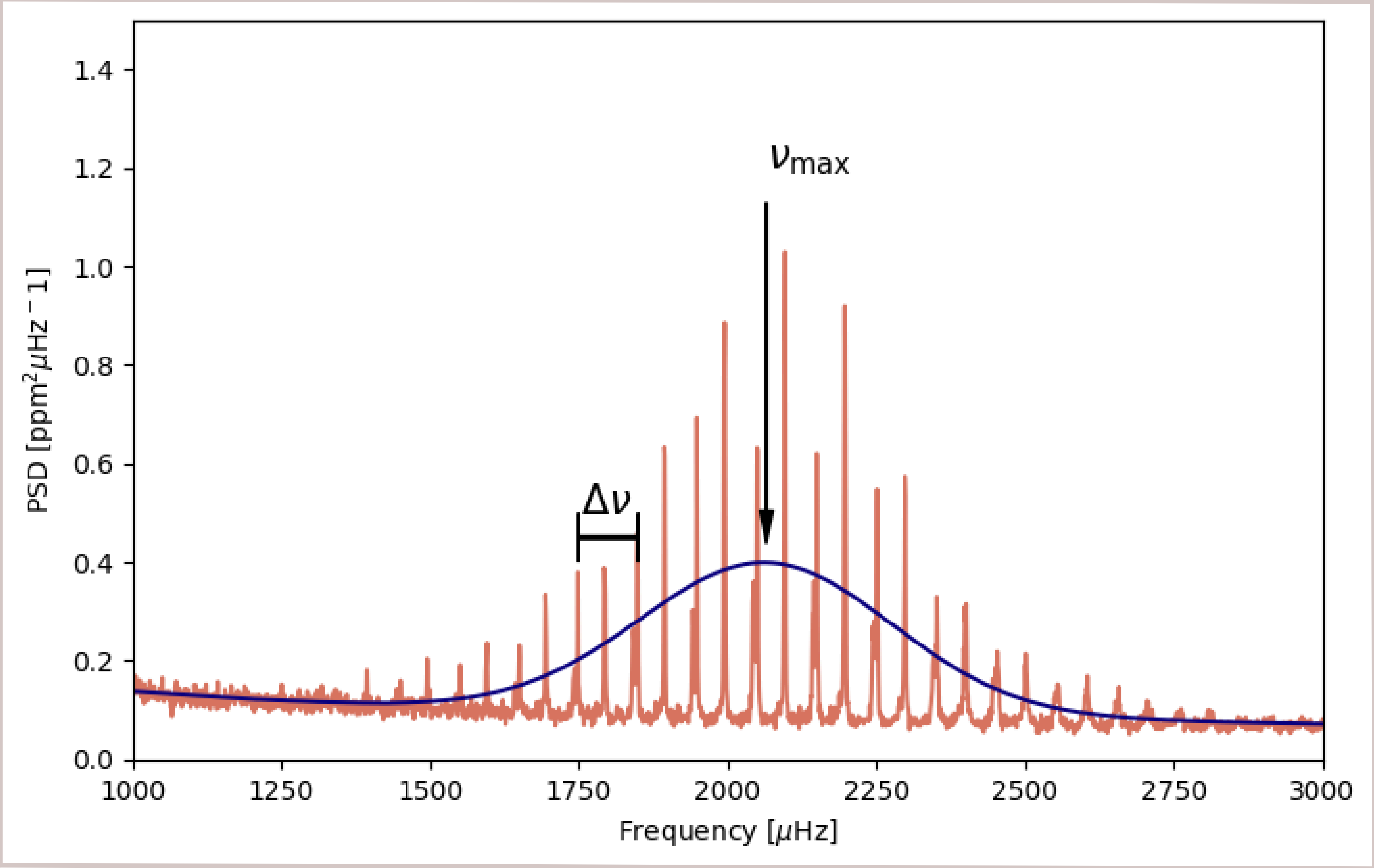
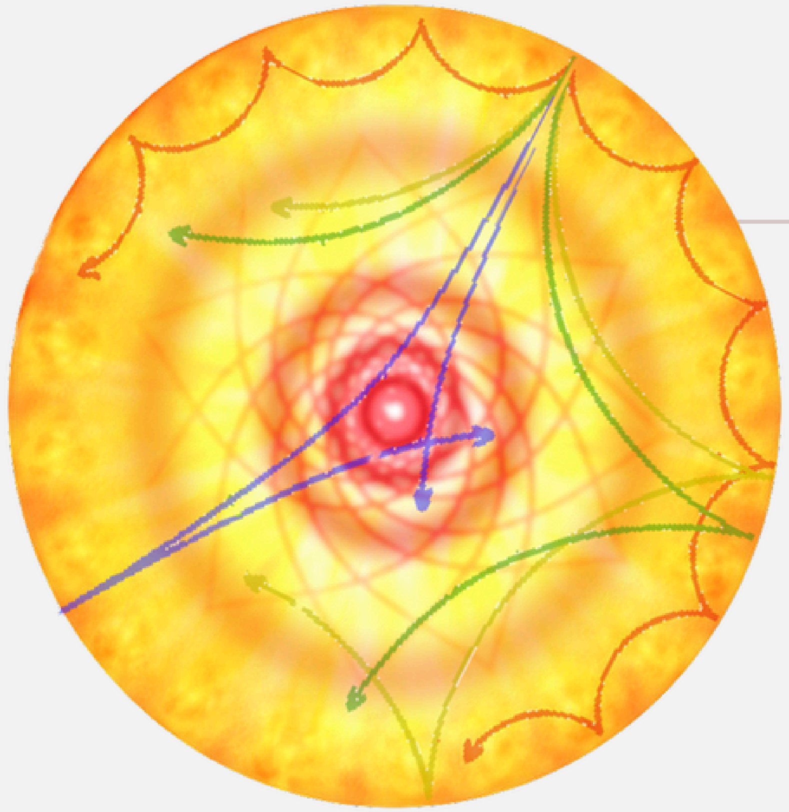


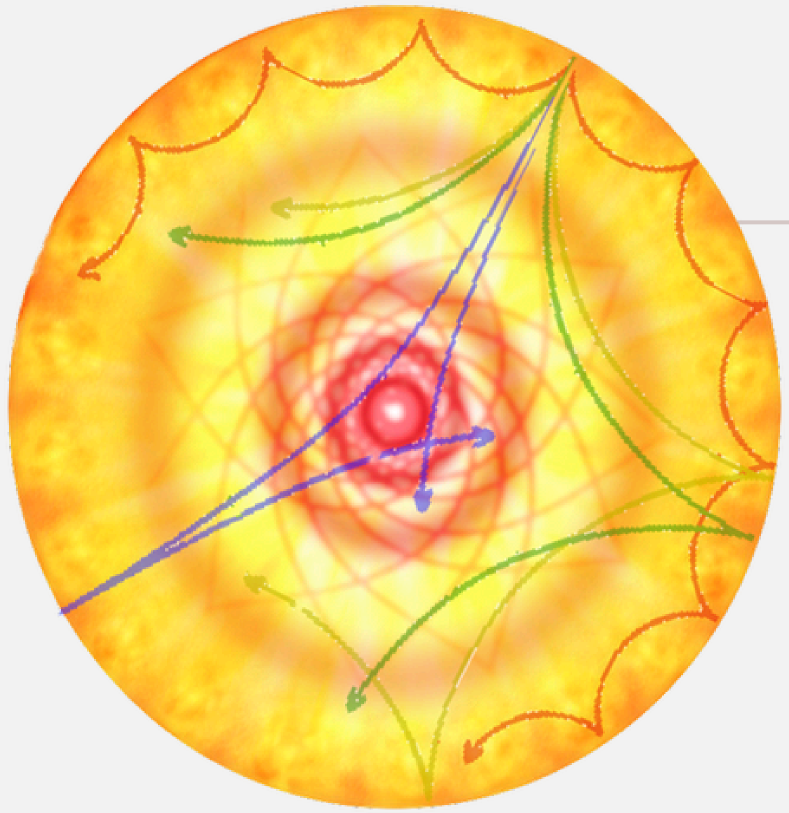




Solar-like Oscillators

Global asteroseismic parameters:

- Mass (~5%), Radius(~2%)
  - *e.g. Li et al (2022)*



Solar-like Oscillators

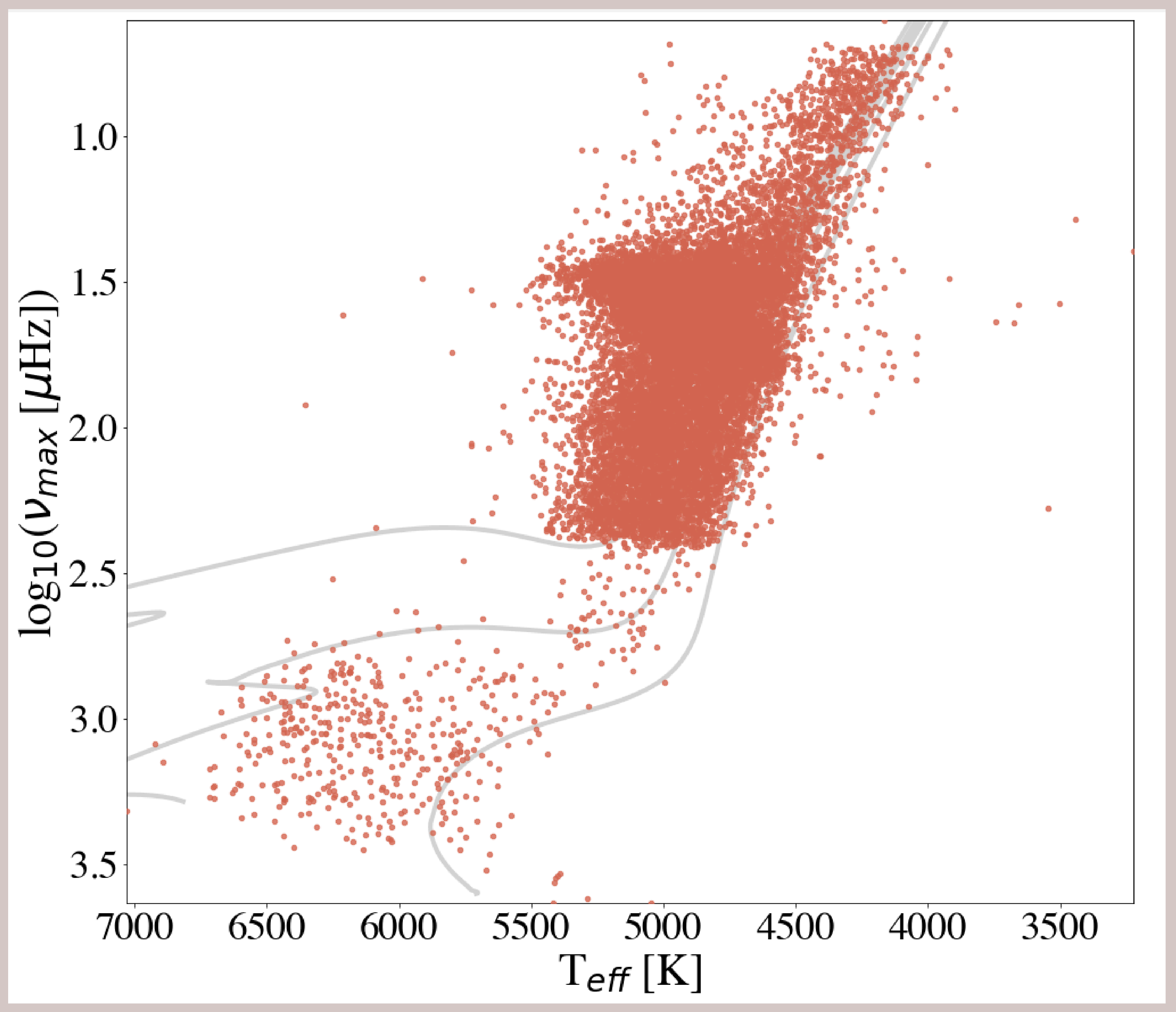
Global asteroseismic parameters:

- Mass (~5%), Radius(~2%)
    - *e.g. Li et al (2022)*

Individual mode frequencies:

- Mass (~2.5%), Radius (~1%), Age (~10%)
    - *e.g. Silva Aguirre et al. (2015)*
- Stellar structure
- Helium abundance
- Evolutionary state - clump vs RGB
- Rotational dynamics
- Stellar inclination

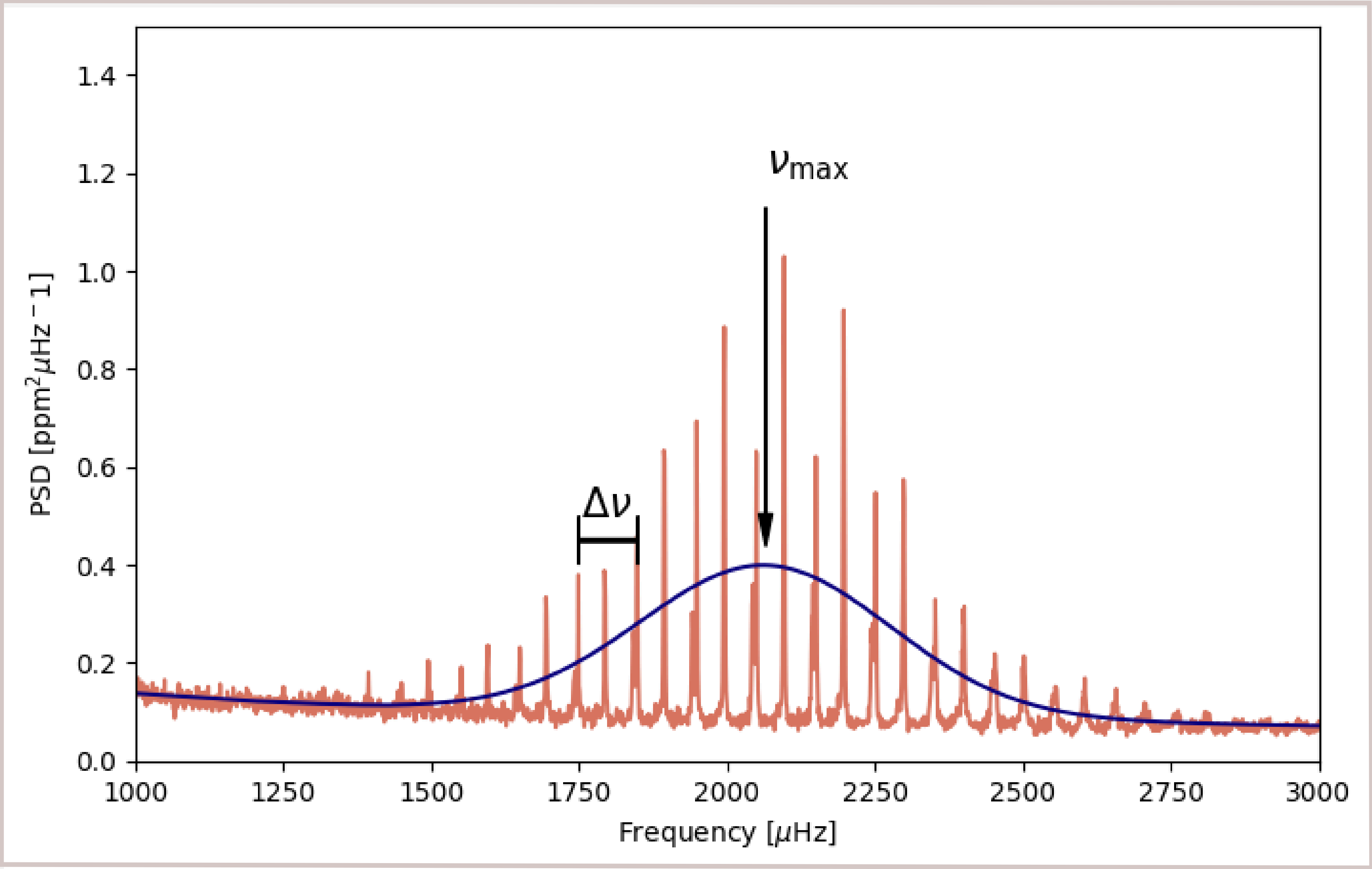
Motivation



Yu et al. 2018, Lund et al. 2016, Serenelli et al. 2017

<u>RGB (~16,000):</u>
Higher amplitude
More data

<u>MS/SG (~500):</u>
Lower amplitude
Less data

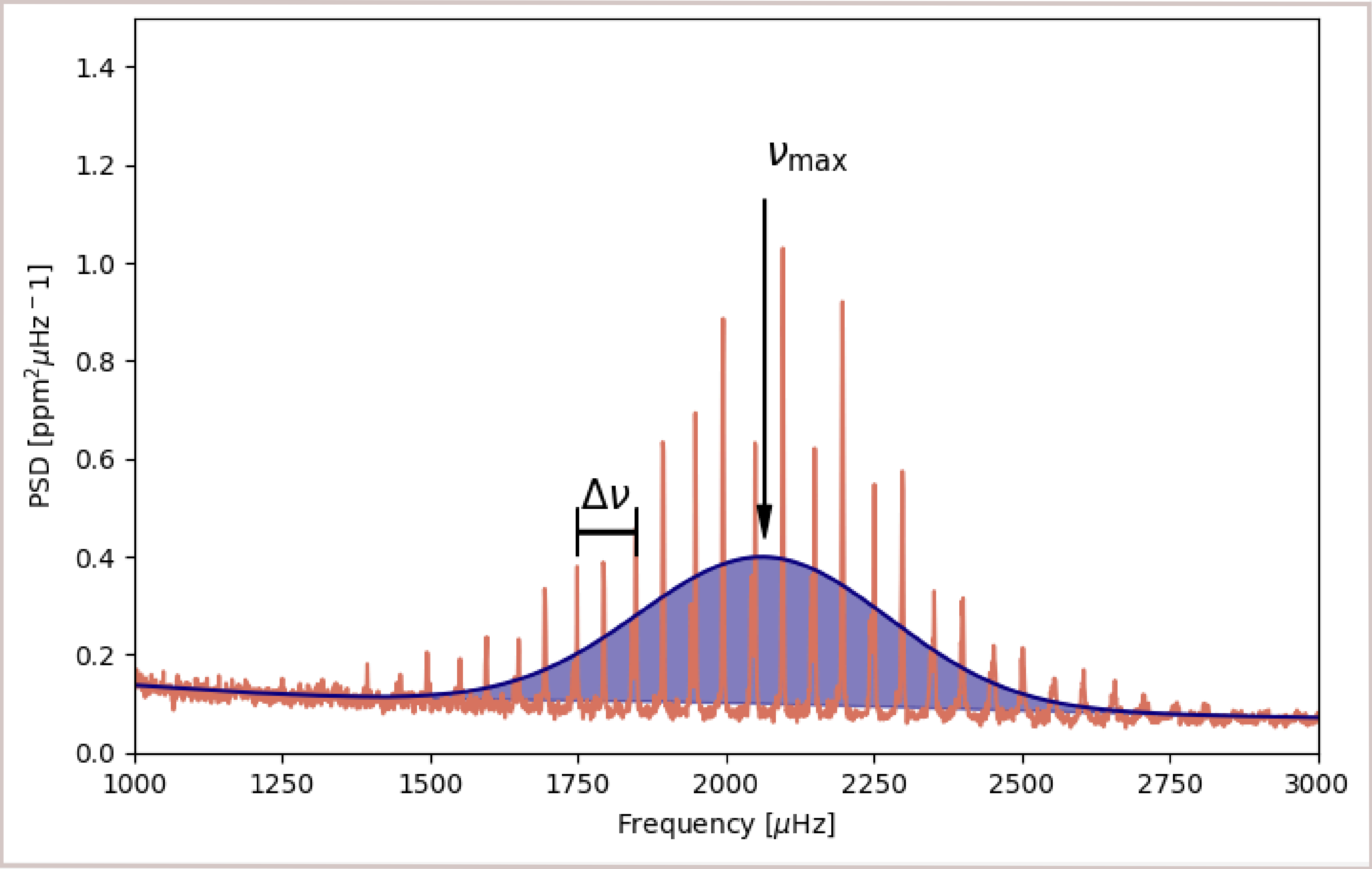


Automating Detection

With bayesian statistics

Gaussian Envelope
Power excess not consistent with the background

Repeating Pattern
Modes repeating at intervals of characteristic frequency



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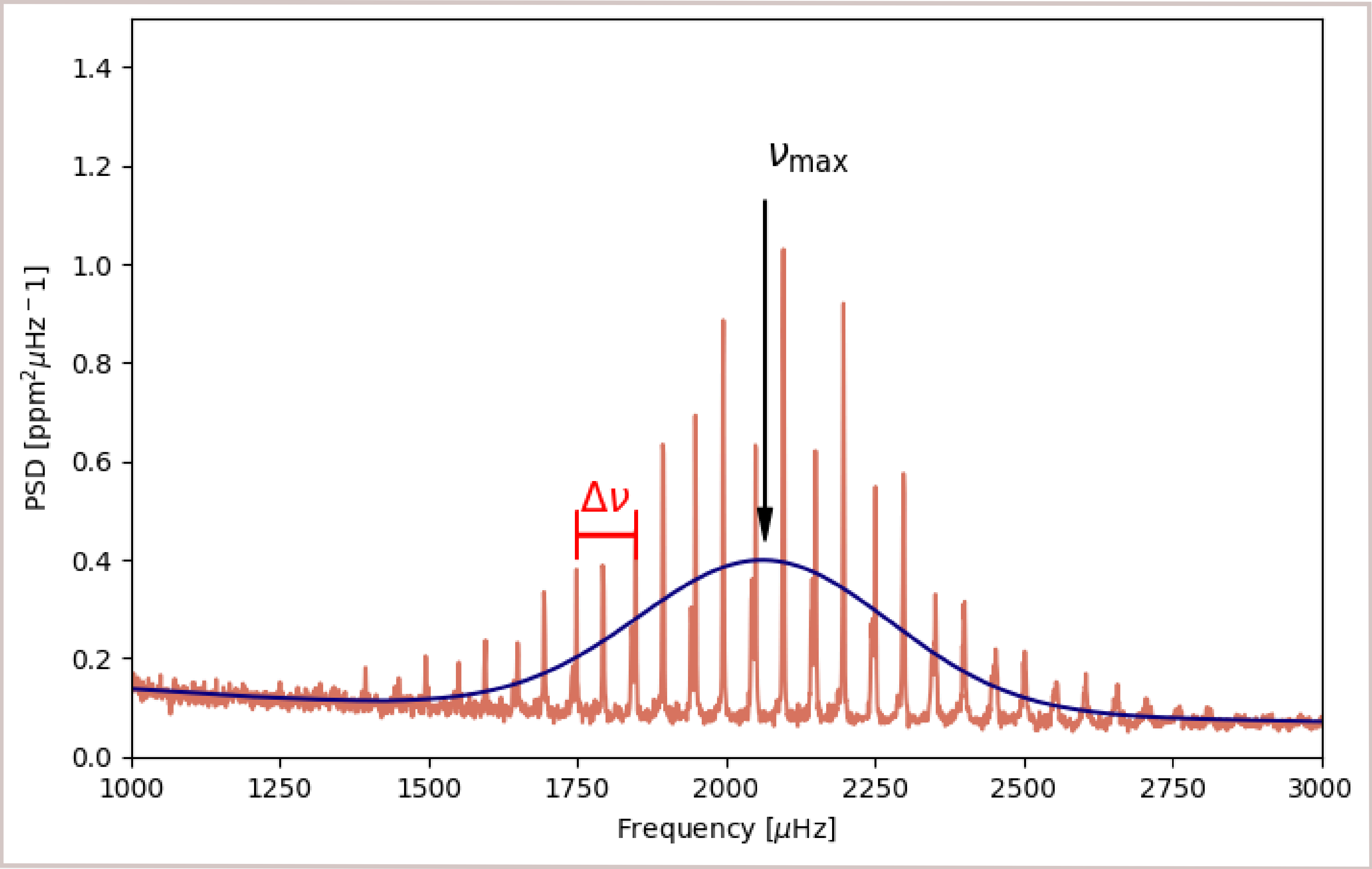

Automating Detection

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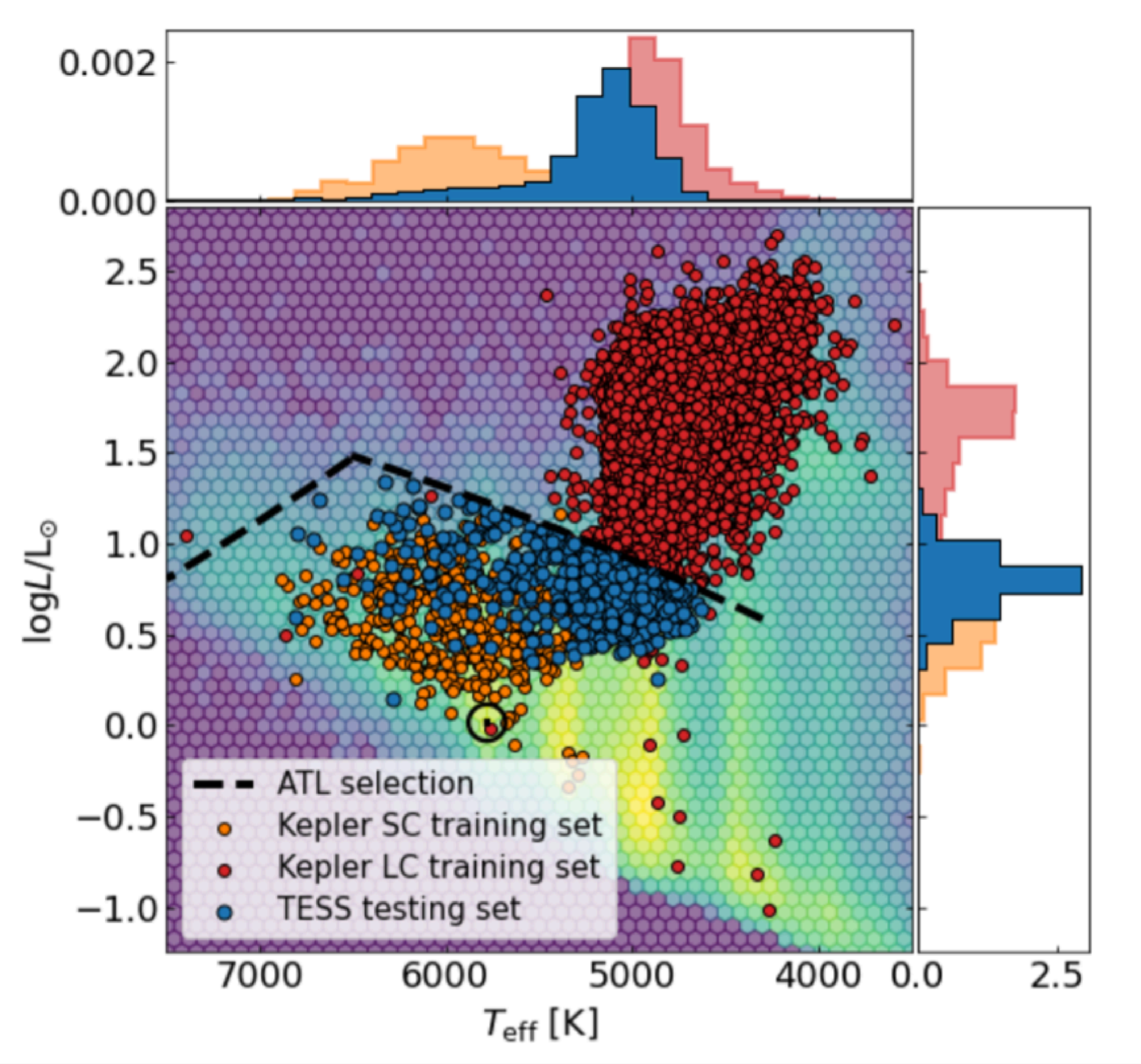
Performance

Testing Set

Asteroseismic Target List (Schofield et al. 2019):
(numax > 240 muHz, detectable)

Results

	One Module:	Two Modules:
TP Rate	94.7%	88.8%
FP Rate	8.2%	5.7%



Nielsen & Hatt et al. (2022)

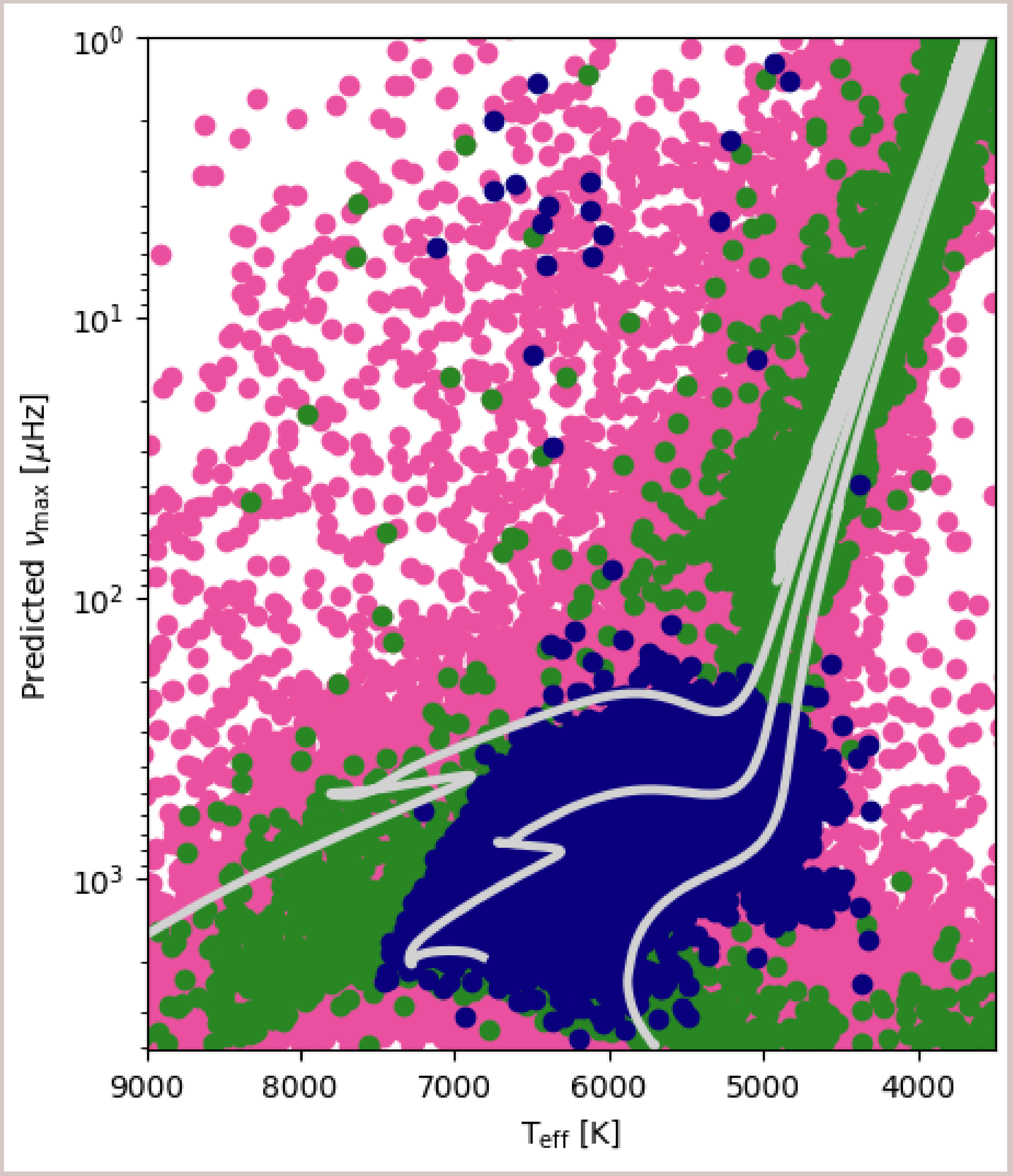
Results in TESS

Input Samples

1. Asteroseismic Target List [~ 11,000]

2. 120-sec cadence Ks < 11 [~265,000]

3. 20-sec cadence Ks < 11 [~6,000]



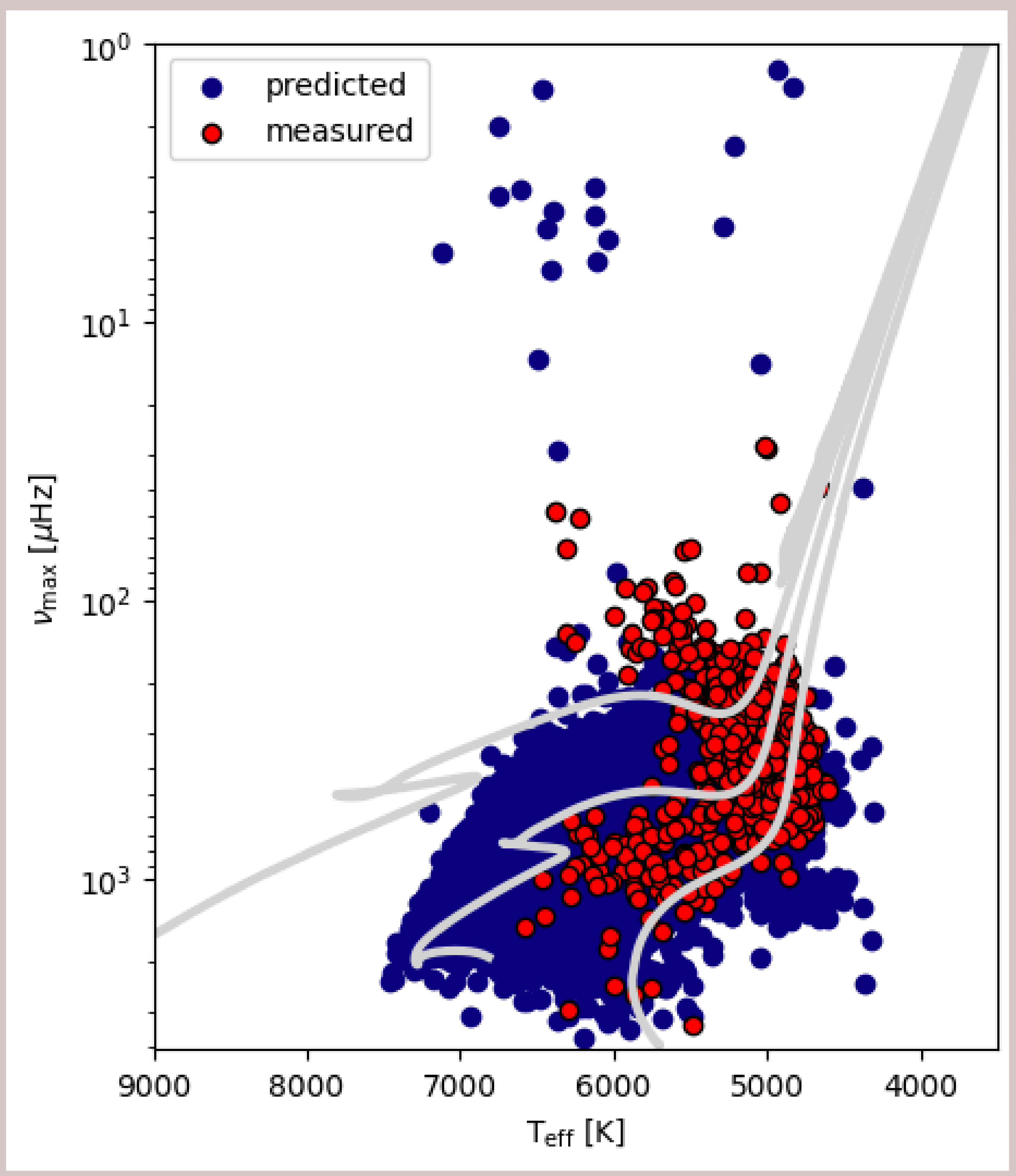
Hatt & Nielsen et al. (2022)

Results in TESS

Samples:

1. Asteroseismic Target List [~ 11,000]

755 solar-like oscillators



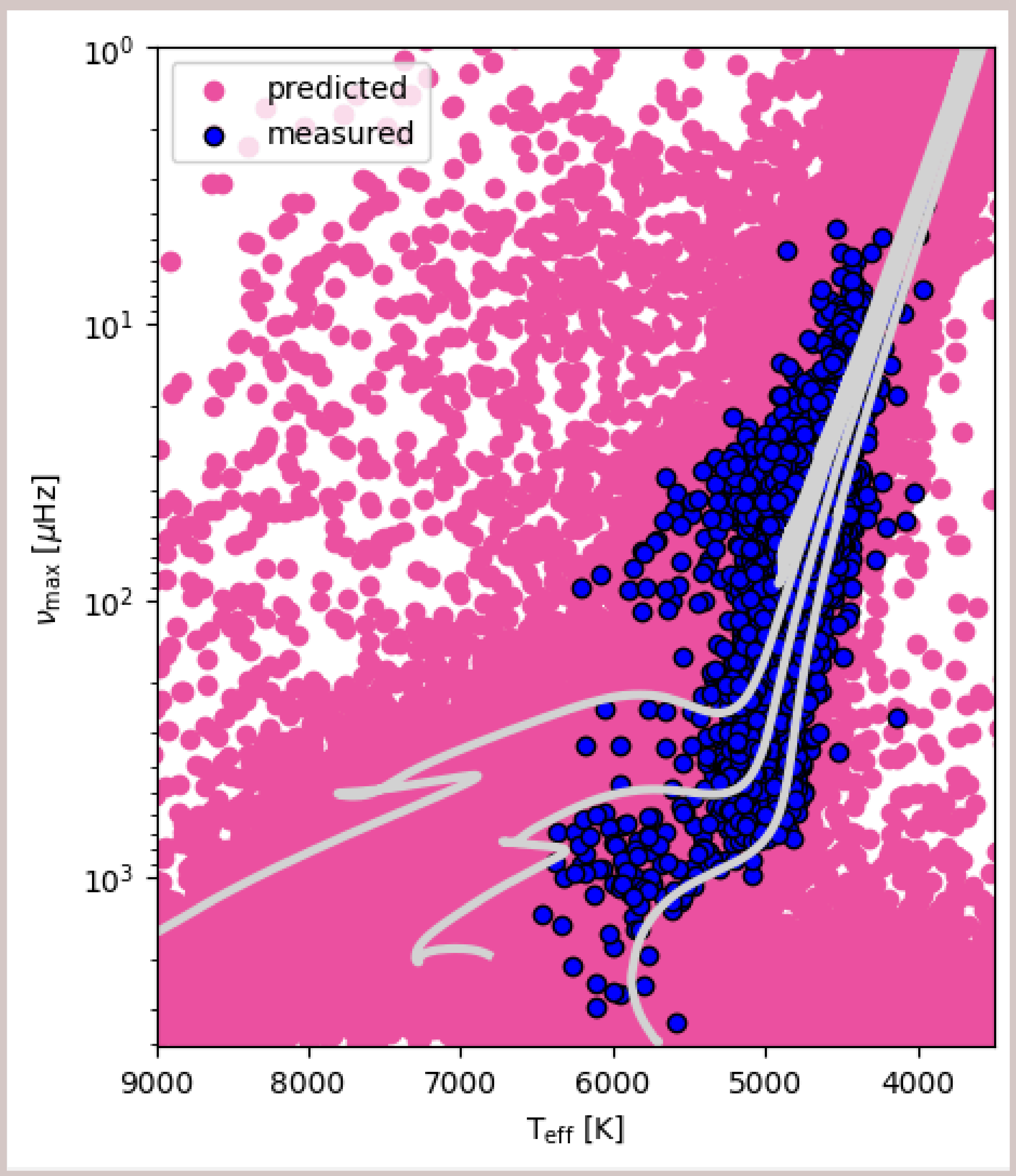
Hatt & Nielsen et al. (2022)

Results in TESS

Samples:

2. 120-sec Cadence [~ 265,000]

3,014 solar-like oscillators



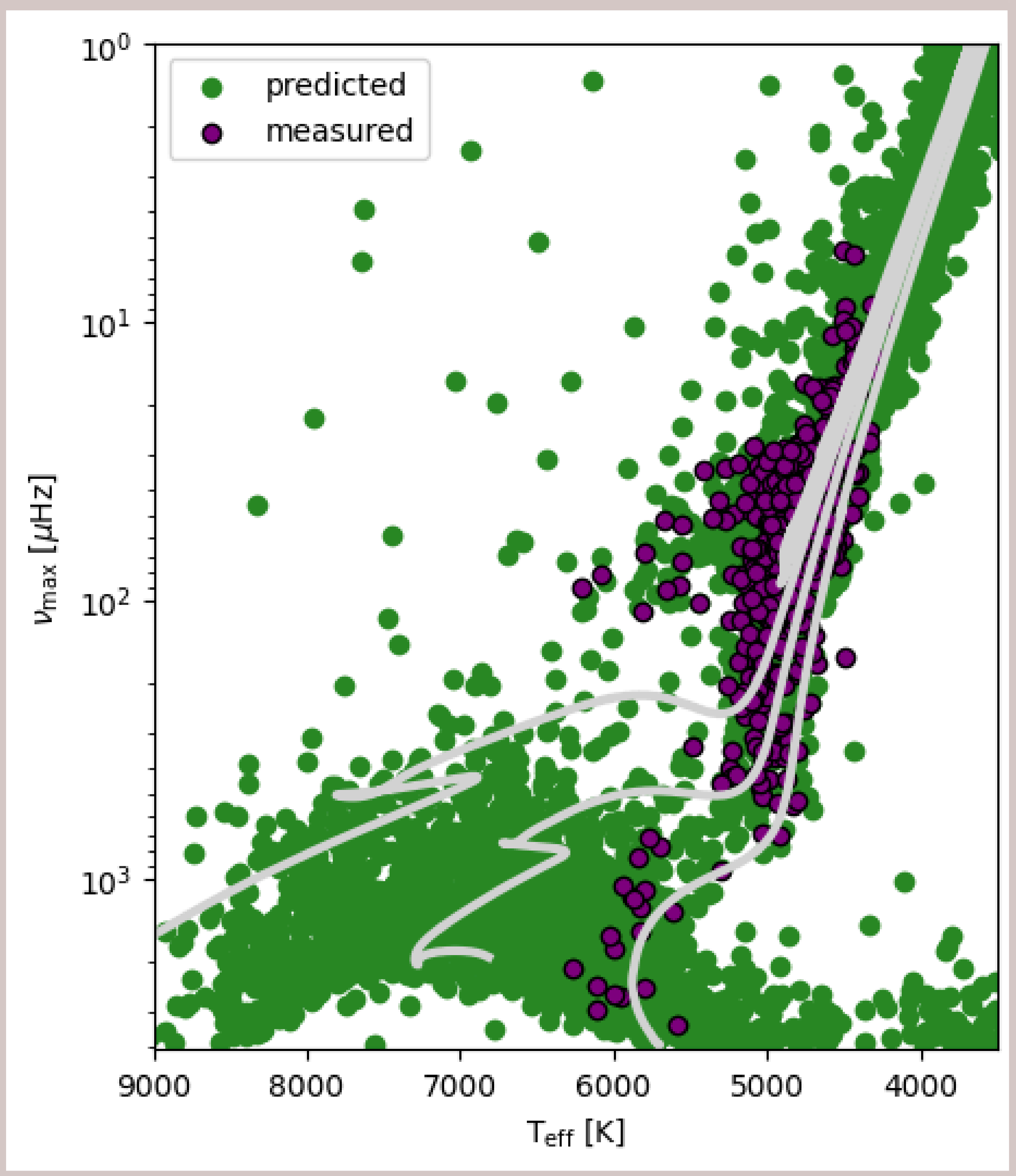
Hatt & Nielsen et al. (2022)

Results in TESS

<u>Samples:</u>

3. 20-sec Cadence [~ 6,000]

494 solar-like oscillators



Hatt & Nielsen et al. (2022)

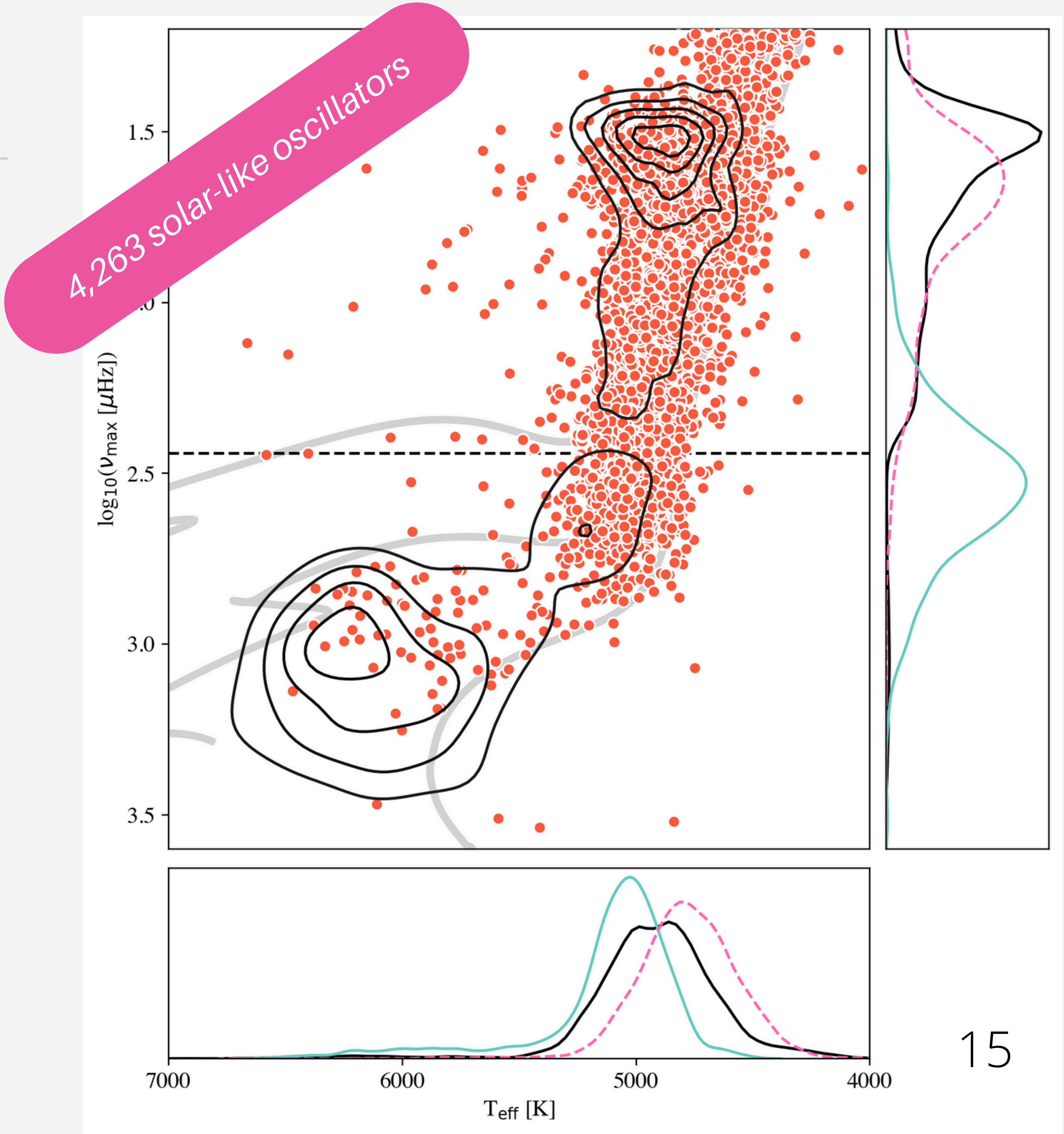
Synergies

<u>Catalogue Contents:</u>

- 27 confirmed planet hosts (Exoplanet Archive) *(Hatt & Ball (in prep))*

- 29 spectroscopic binaries (SB9)

- individual modes for ~300 targets



Hatt & Nielsen et al. (2022)

Conclusions

New pipeline including a bayesian approach incorporating lessons learned from Kepler data

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More data to come!

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-END-

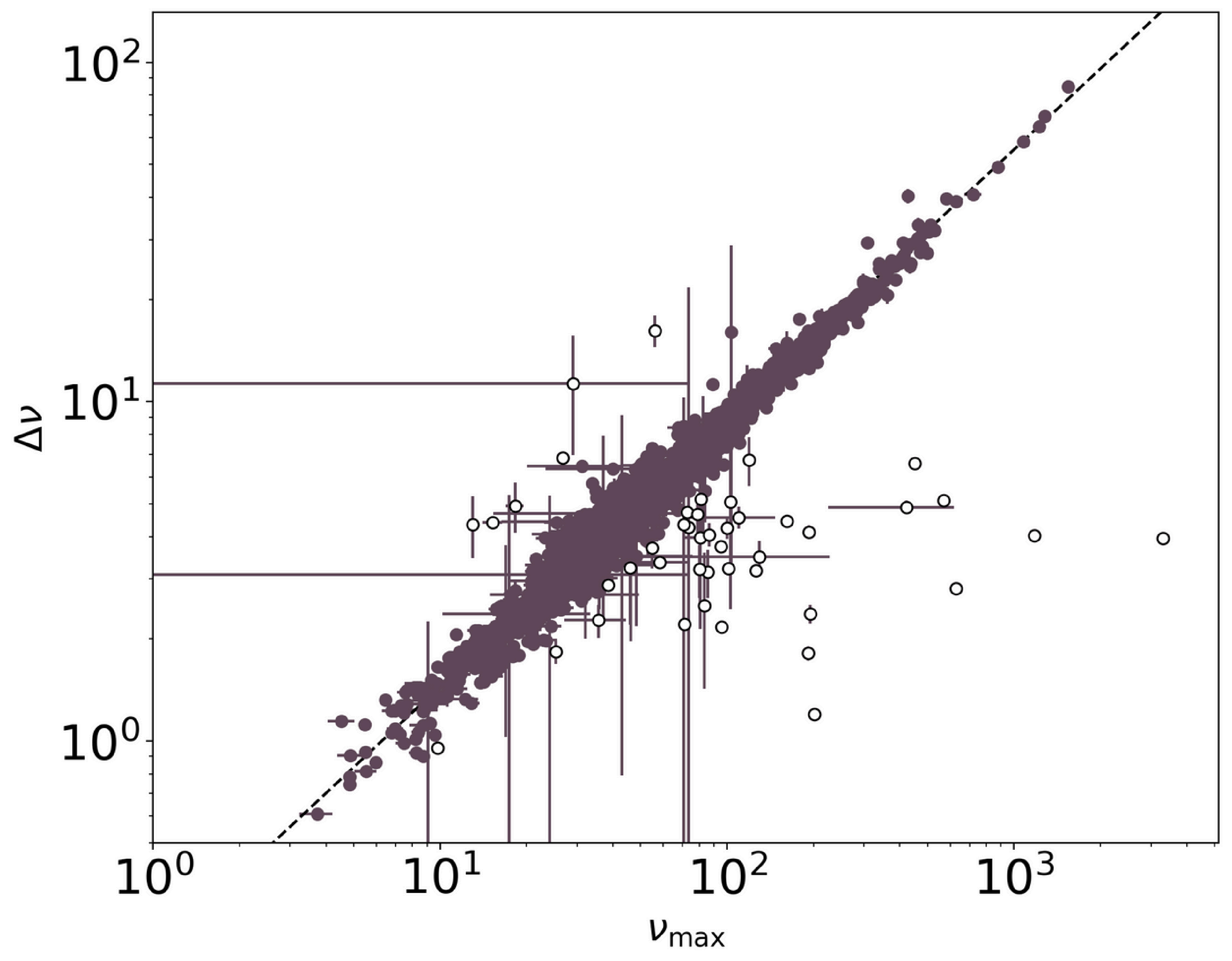
Results in TESS

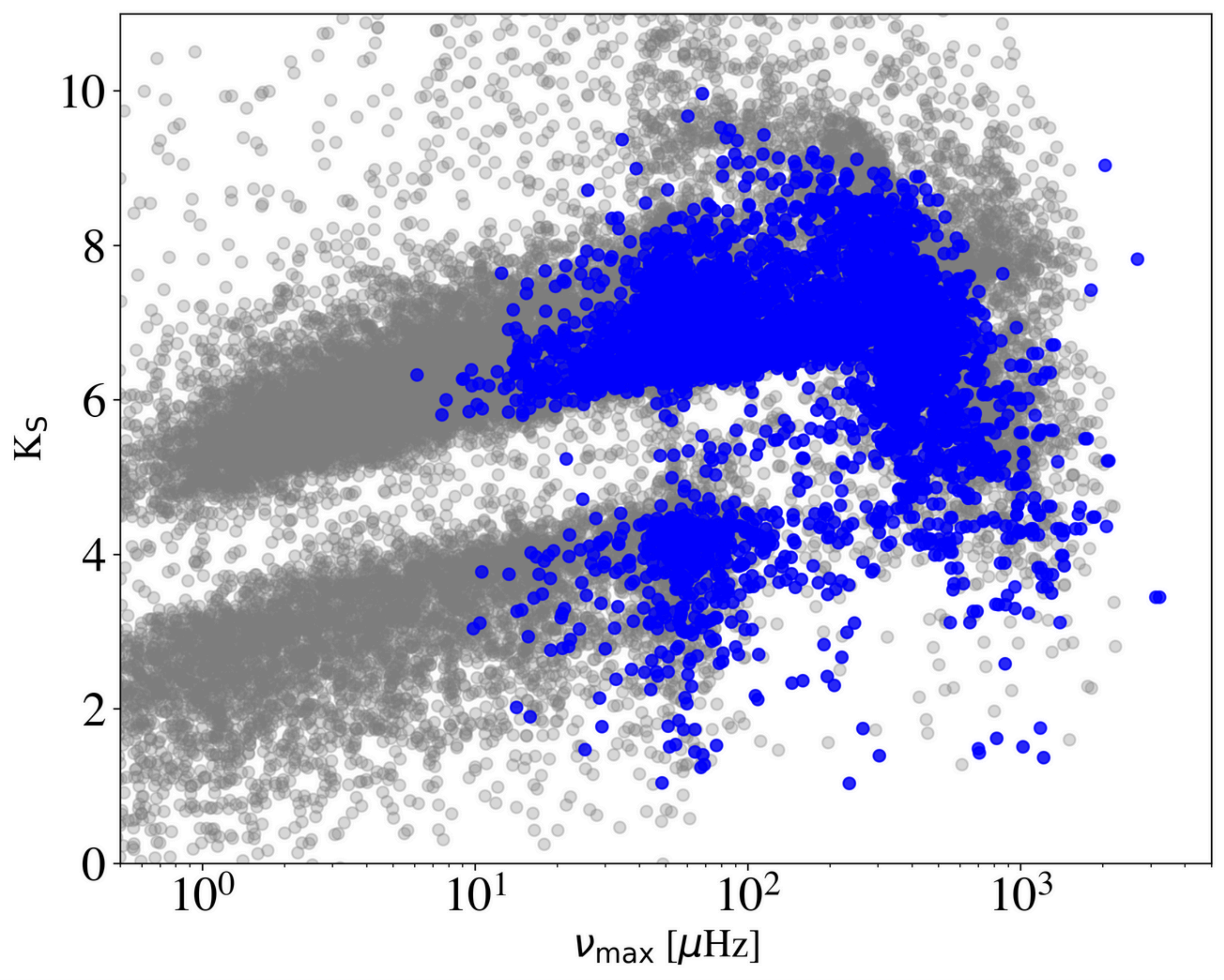
Causes of Discrepancy

- Error in stellar parameters (Temp, mass, parallax etc)
- Underestimated noise levels
- Sub-optimal aperture masks
- Contamination from periodic variables
- Not including the effect of activity
- Physics?

Hatt & Nielsen et al. (in prep)

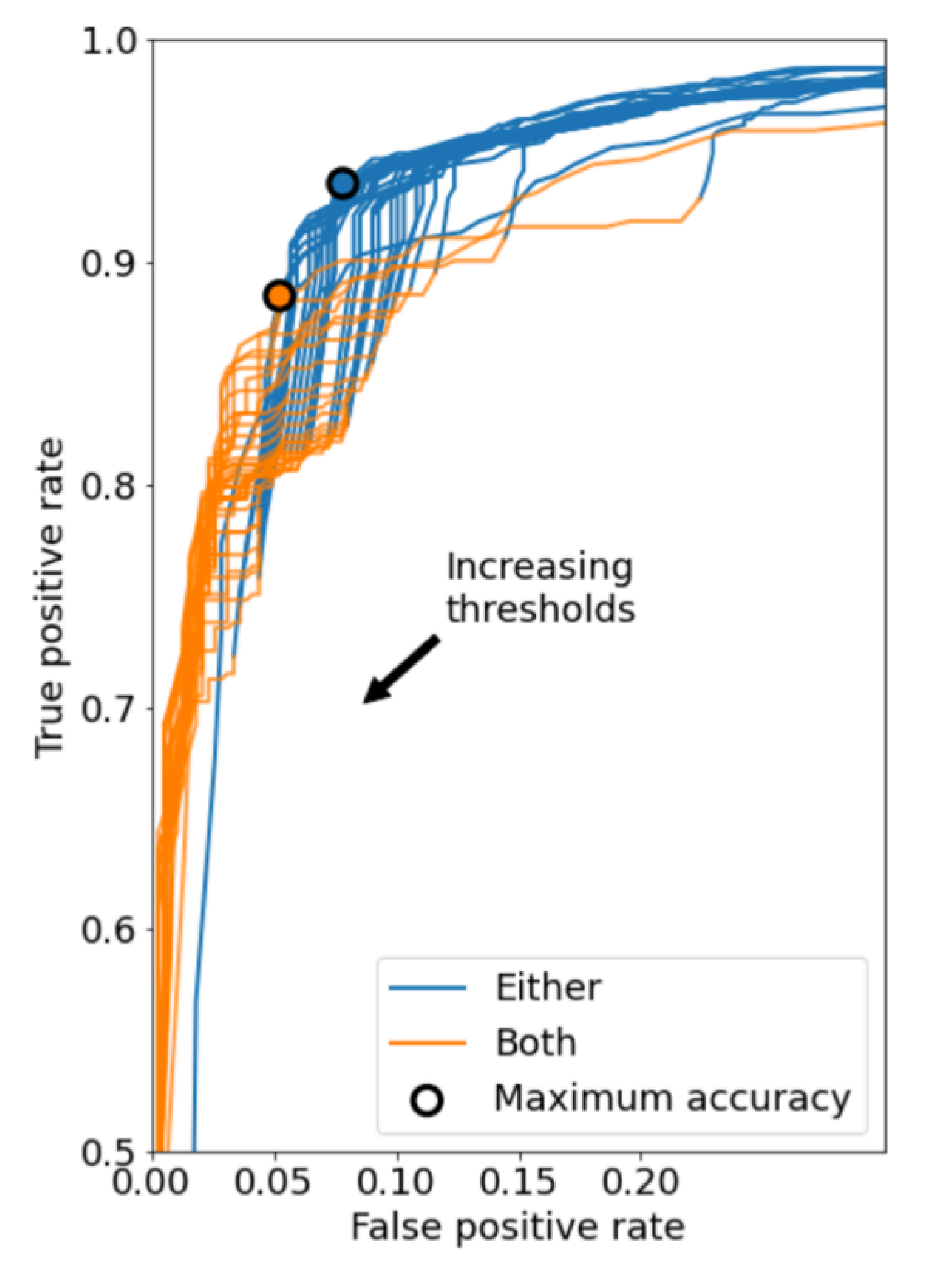
120-second Targets

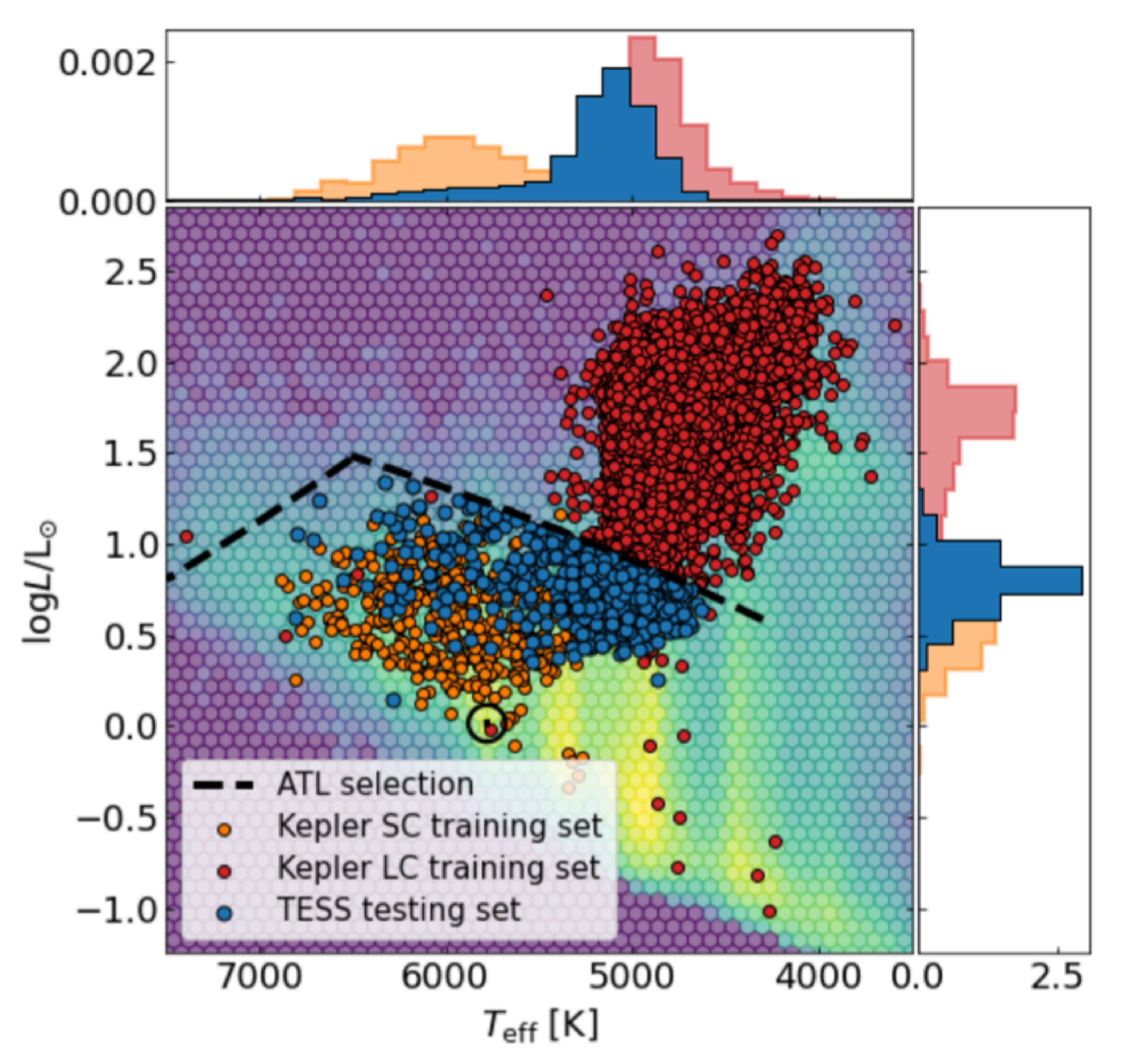


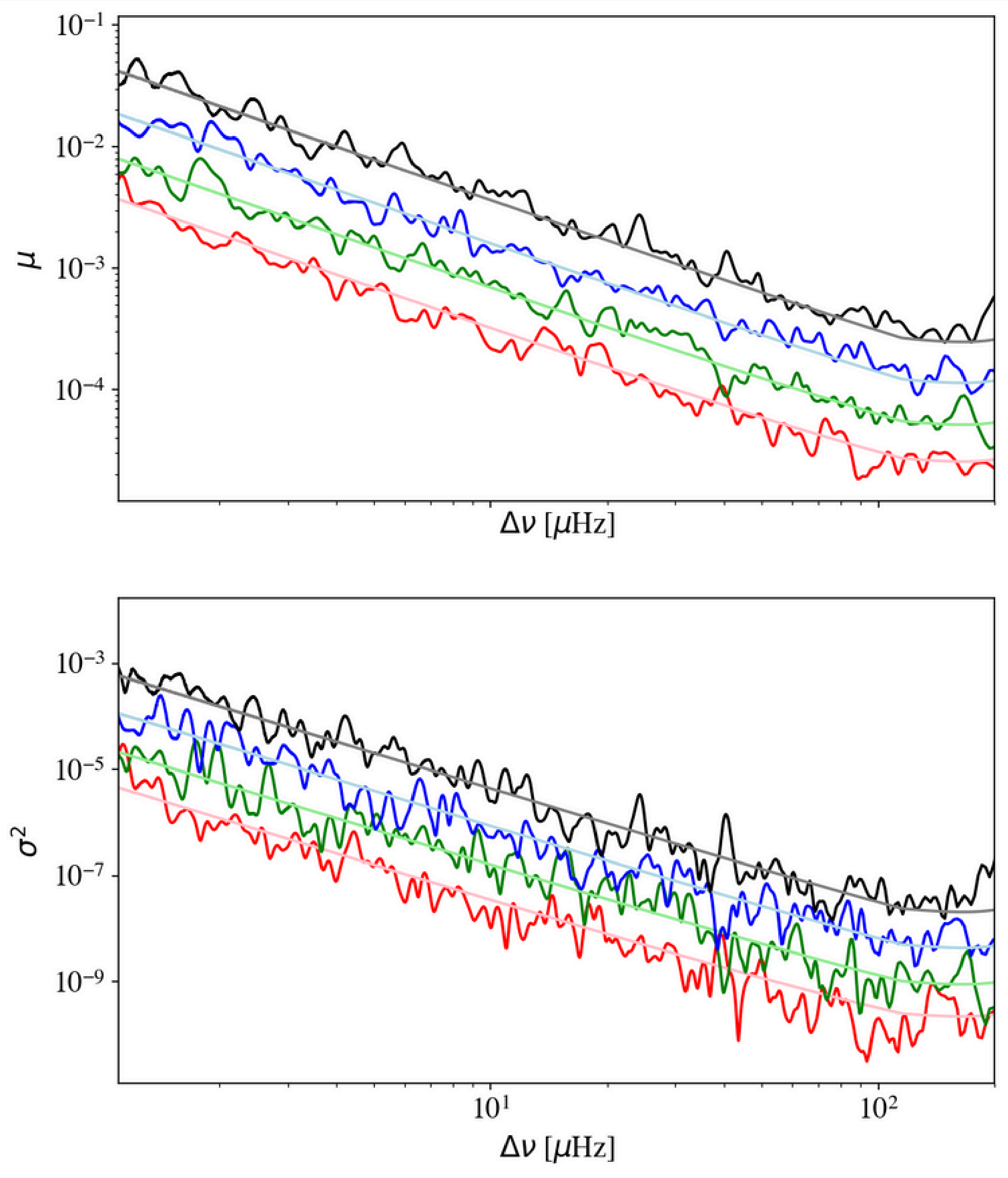


Hatt & Nielsen et al. (in prep)

Performance

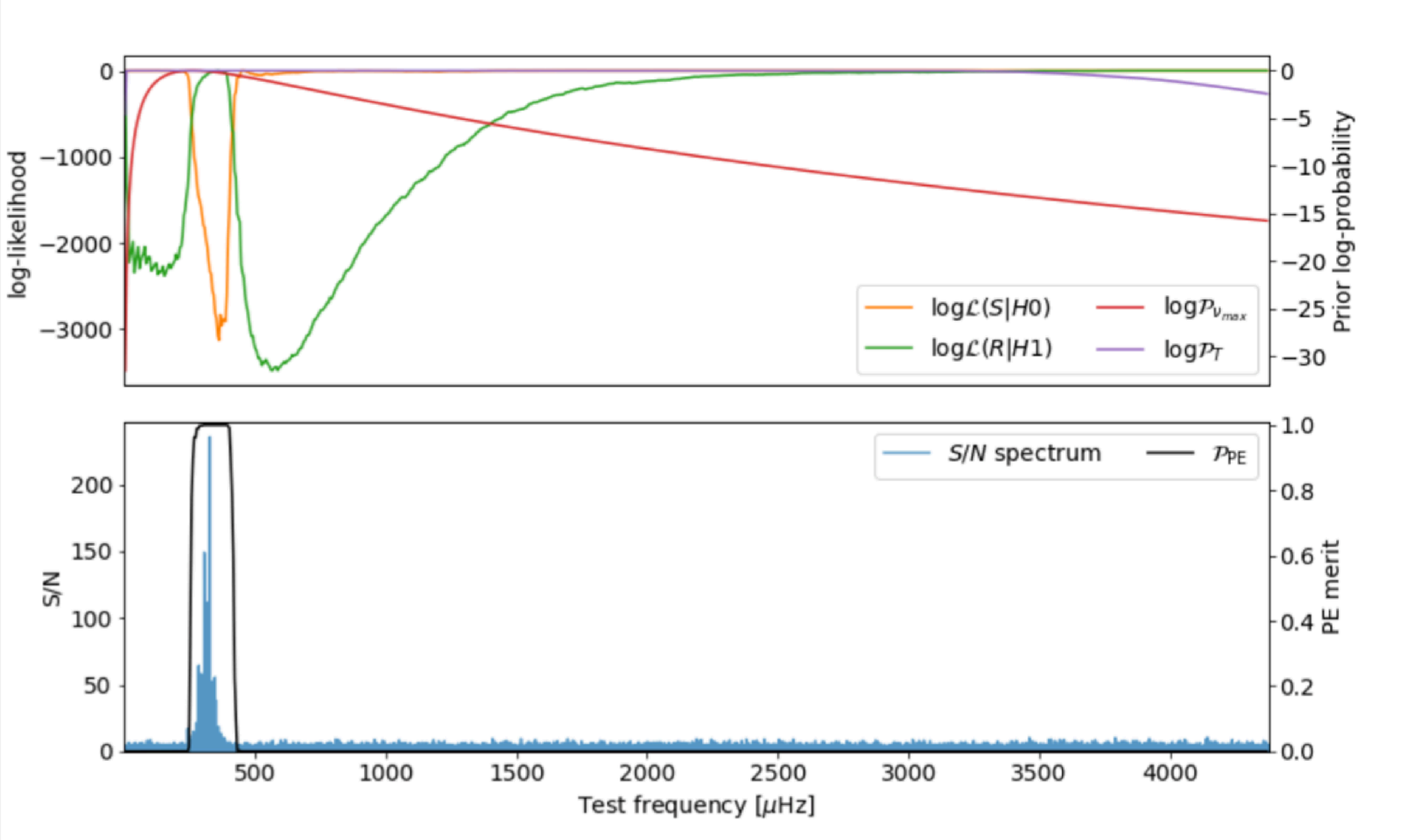






Nielsen & Hatt et al. (2022)

Predictions



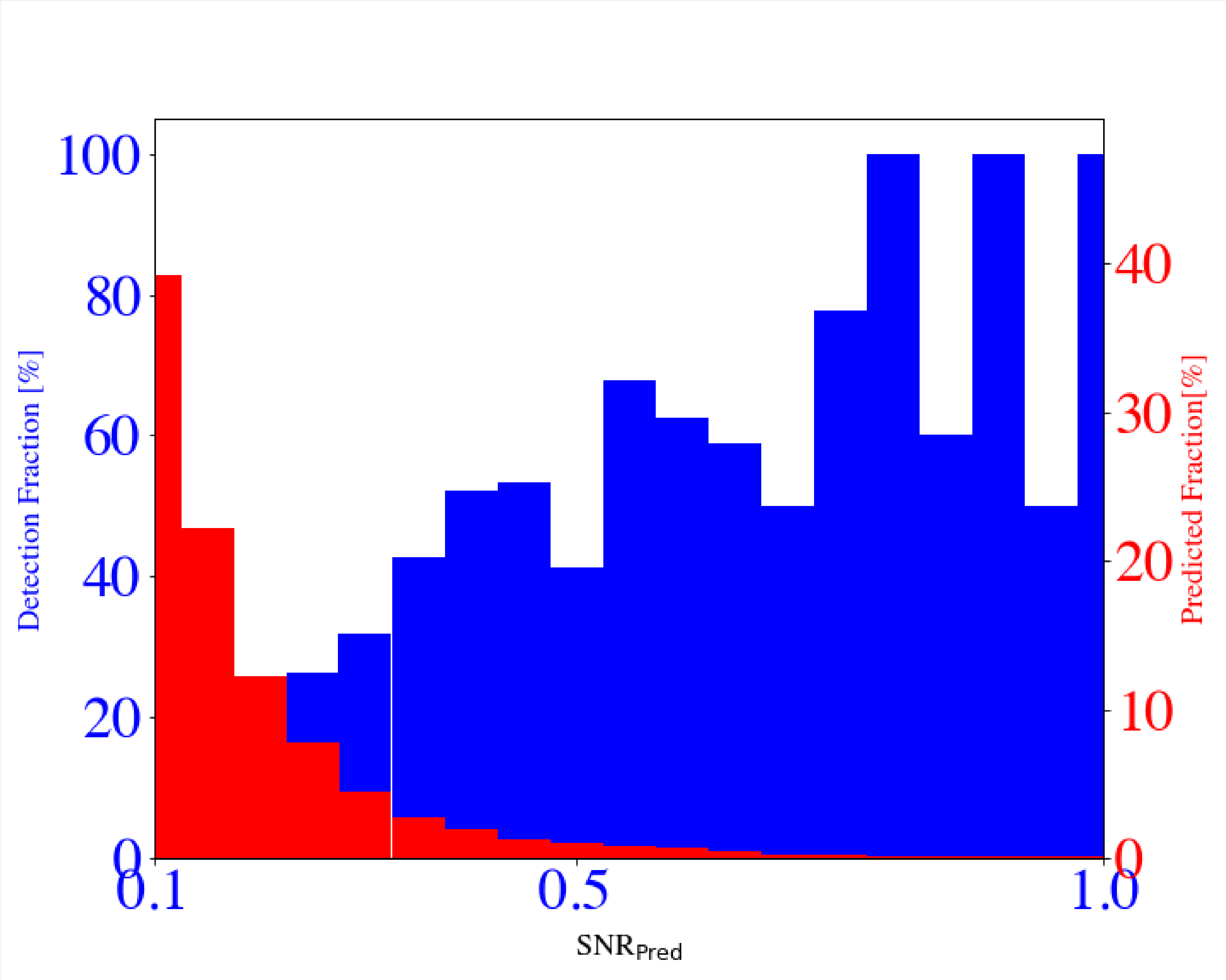
$$A_{\max} = A_{\max,\odot}\beta\, V \left(\frac{\nu_{\max}}{\nu_{\max,\odot}}\right)^{-1}\left(\frac{T_{\rm eff}}{\mathrm{T}_{\rm eff,\odot}}\right)^{1.5}.$$

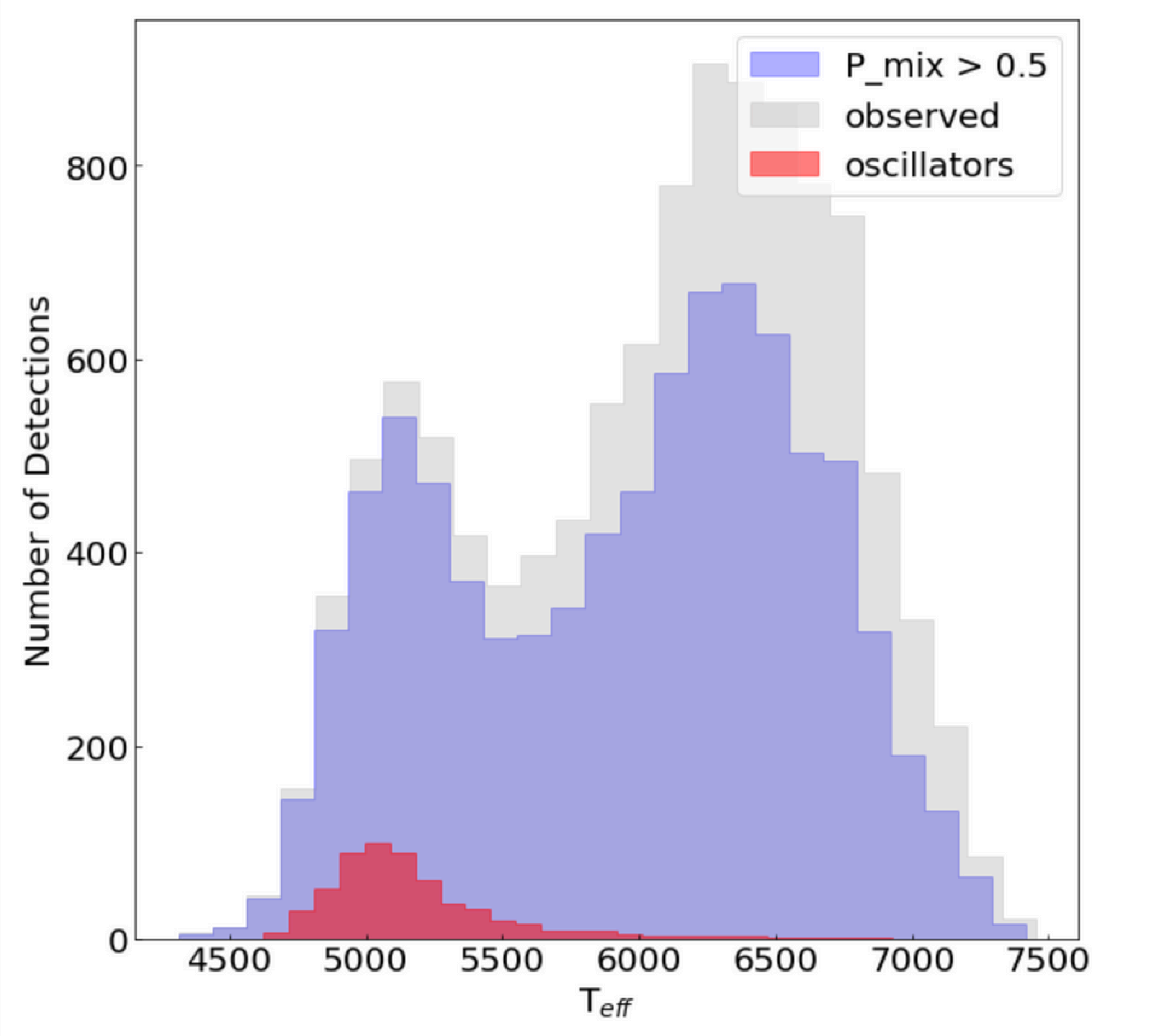
$$H_{\rm env} = \eta^2 D^2 H_{\rm env,\odot}\left(\frac{\nu_{\max}}{\nu_{\max,\odot}}\right)^{-\alpha}\tilde{A}^2_{max},$$

$$\beta = 1 - \exp\left(-\frac{T_{\rm red} - T_{\rm eff}}{\Delta T}\right),$$

Nielsen & Hatt et al. (2022)

ATL compare





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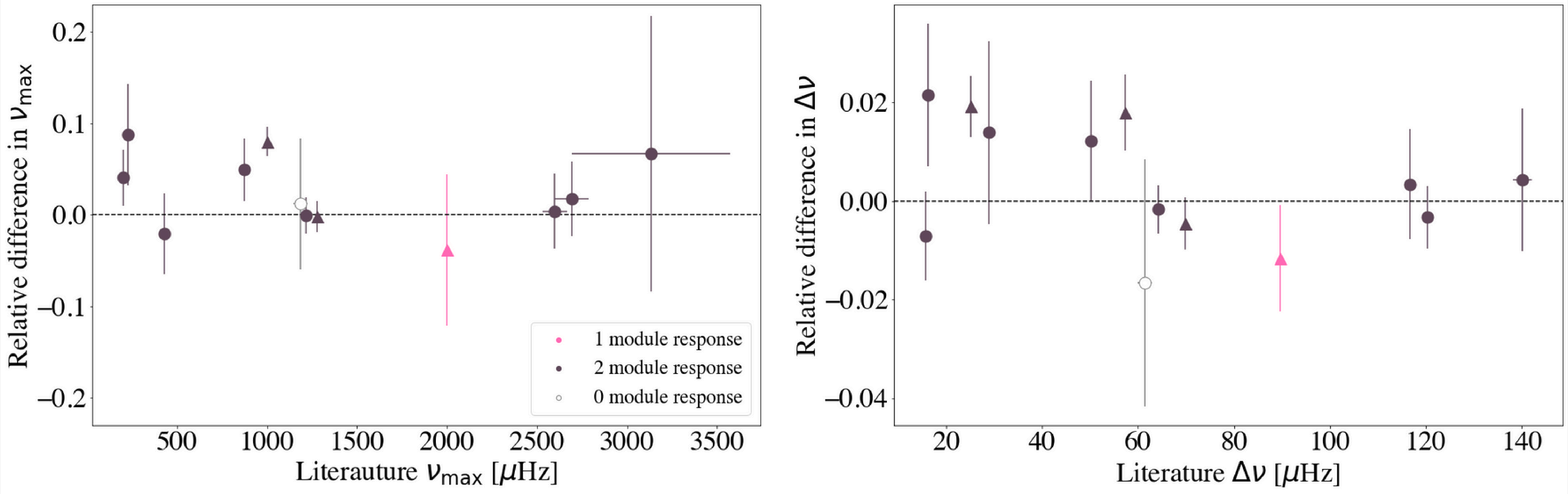
Literature sample



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