Swiss National Science Foundation

UNIVERSITÉ DE GENÈVE

The search for exoplanets around intermediate-mass giant stars

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Stéphane Udry, Damien Ségransan, Pedro Figueira, João Faria, Jean-Baptiste Delisle
and all the CORALIE observers

3rd year PhD student
University of Geneva

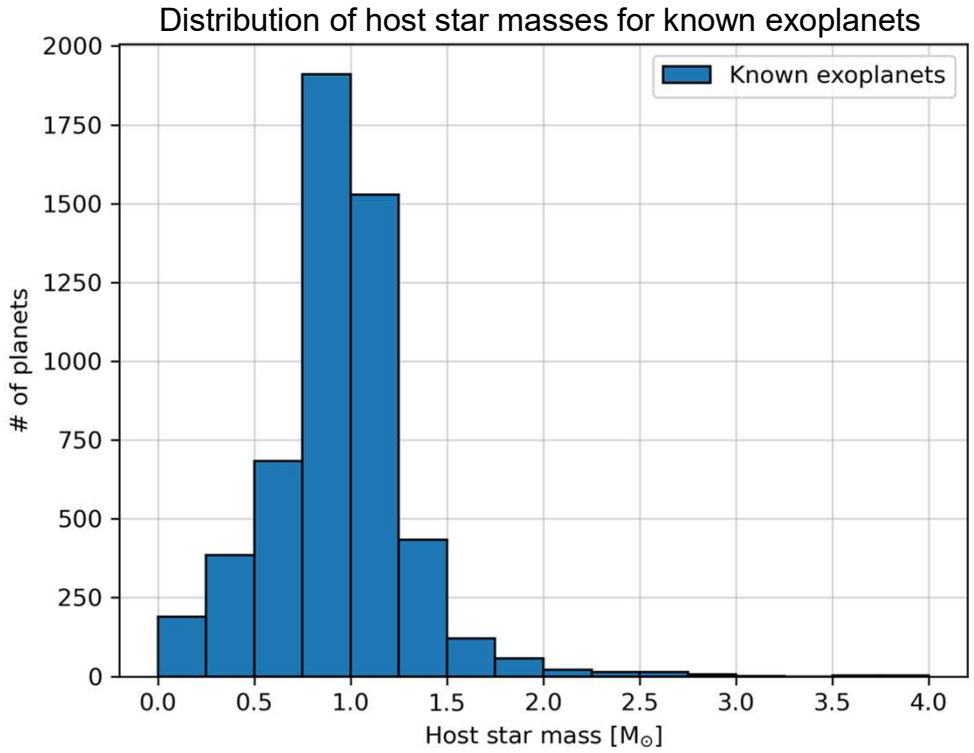
March 2026 - On the shoulders of giants - Turin

Image credit: wikimedia and freedesignfile

Why giant stars?

Increase the parameter space of host stars

- Exoplanets are mainly detected around stars with masses ≤ $1M_{\odot}$
- To understand planet formation, we need more information about planet occurrence rate vs host star mass
- Studying high mass, main sequence stars is hard
- Giant stars are bright proxies to study intermediate mass stars



NASA exoplanet archive, March 2026

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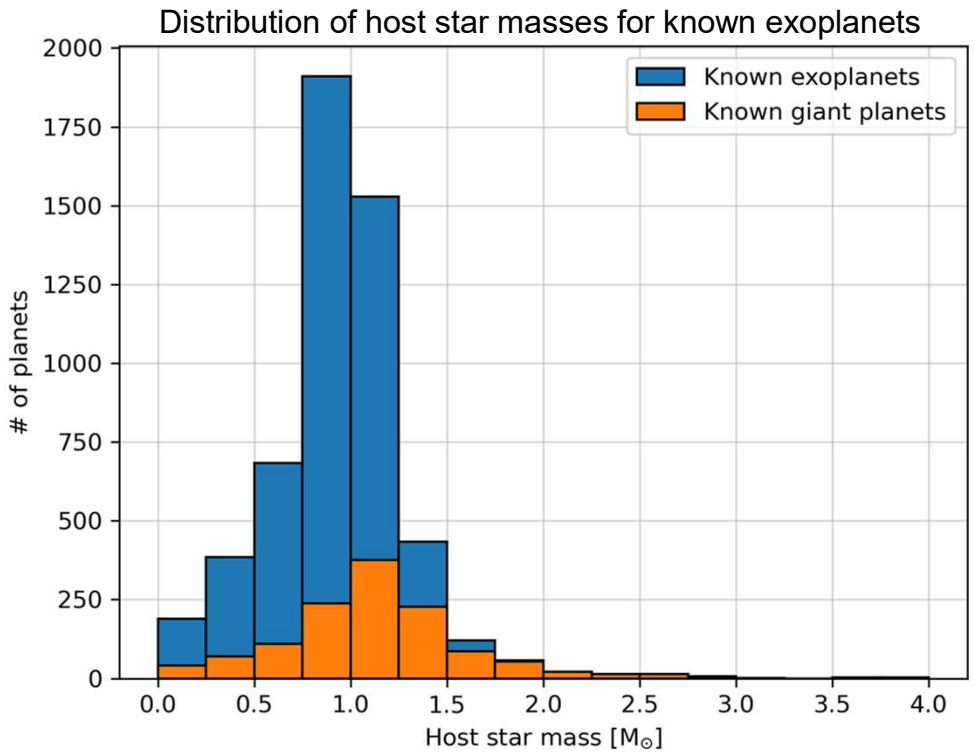

NASA exoplanet archive, March 2026

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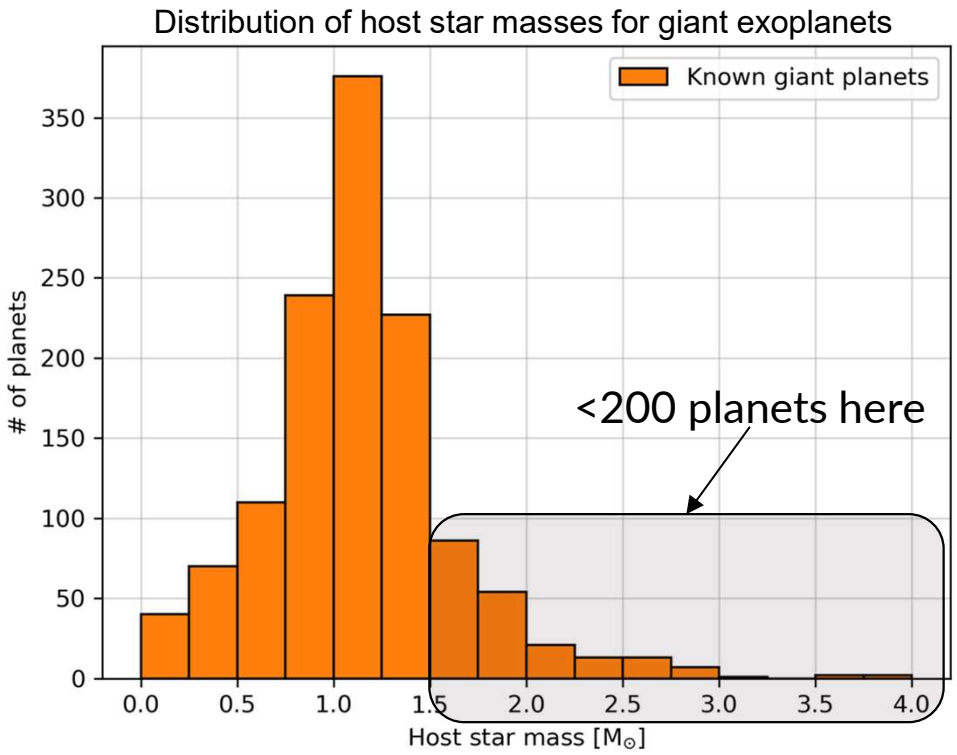
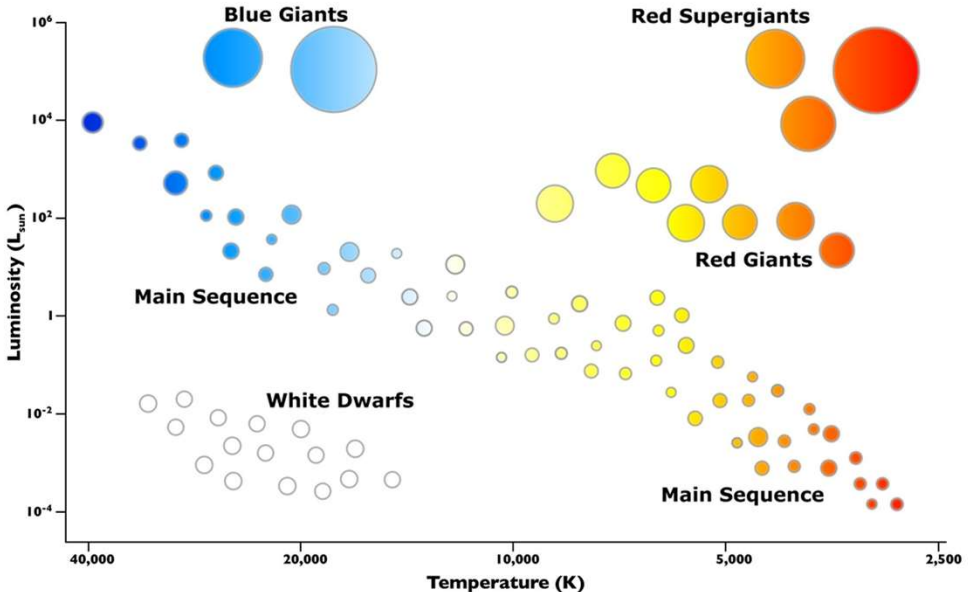


NASA exoplanet archive, March 2026

Giant stars

- After MS, massive enough stars become giant
- Radius increase
- T_{eff} drops
- Luminosity increases
- Rotation rate drops



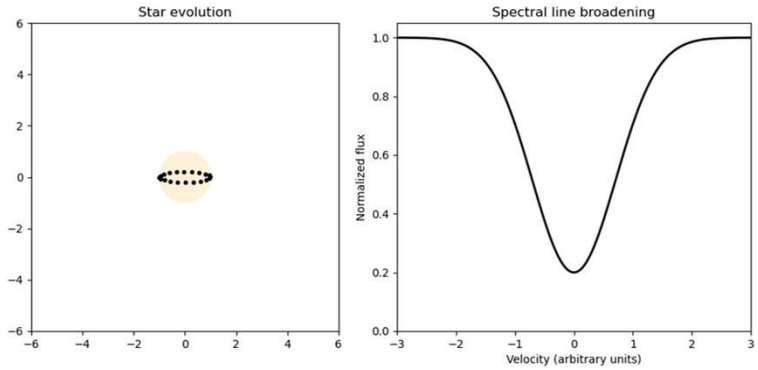
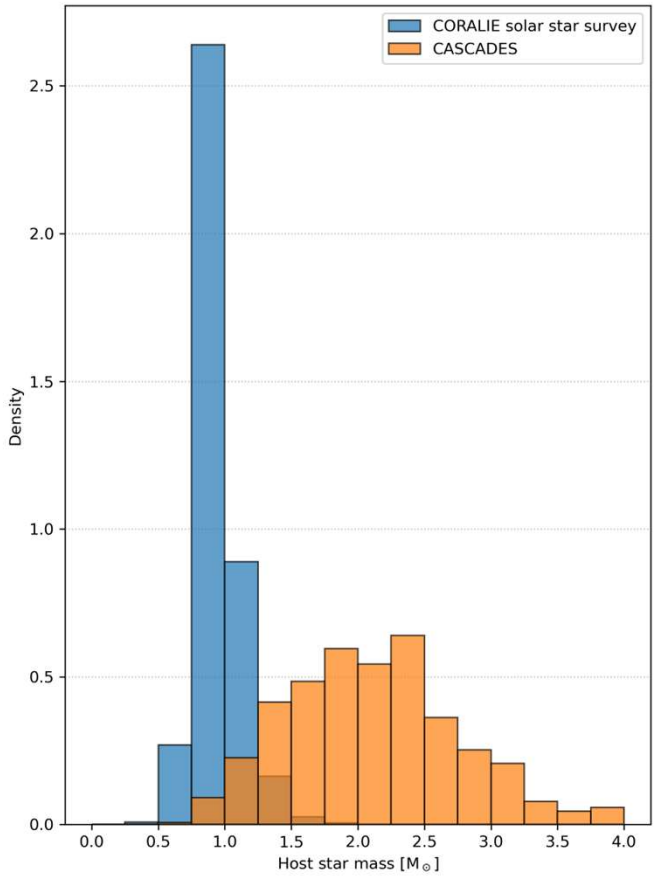


Image credit:
https://socratic.org/questions/what-is-the-hertzsprung-russell-diagram-and-why-is-it-so-important-to-astronomy-

CORALIE radial-velocity search for companions around evolved stars (CASCADES)

CASCADES

- Ongoing RV survey for 20 years
- Volume limited (d < 300pc based on HIPPARCOS)
- 641 stars of spectral type G and K
- 4 publications so far
- Many detections to be published



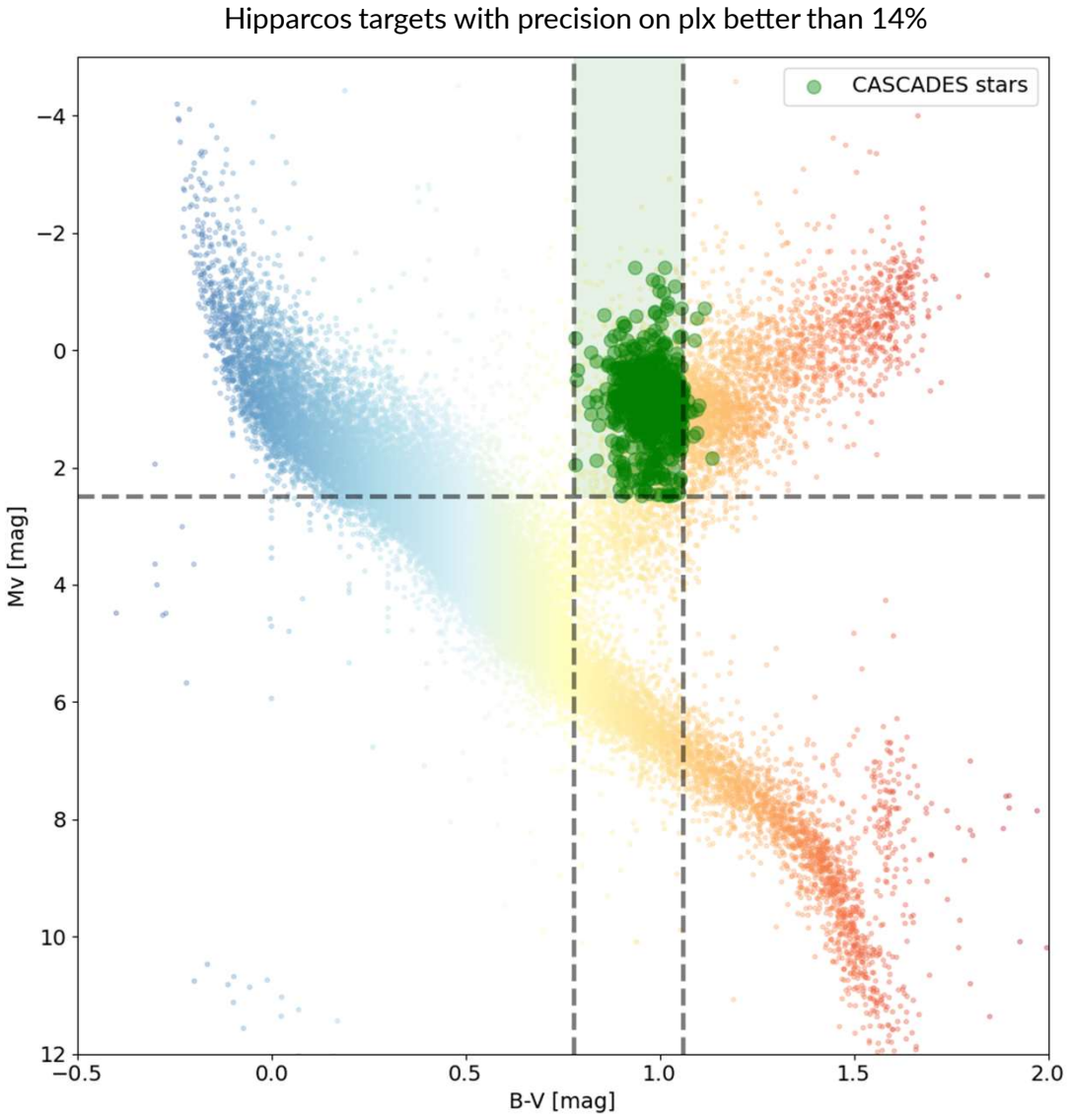
⚠️ Precise mass estimates for giant stars are hard to obtain

Slide 8

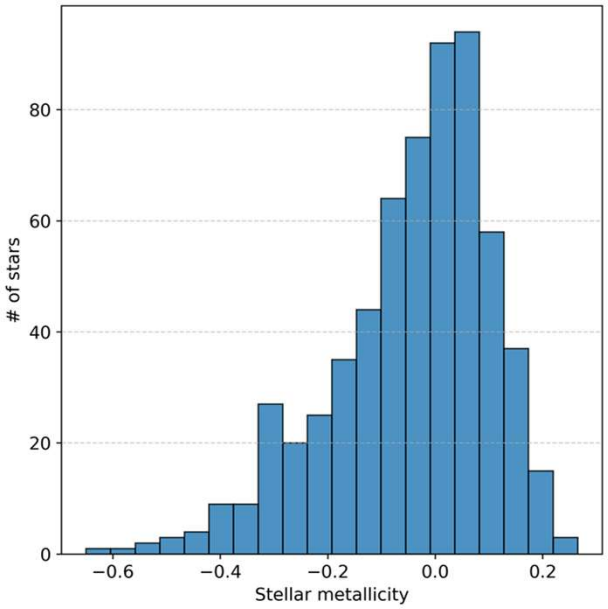
1 May want to show the stellar params of 703 instead of distribution of host star mass of all exoplanets
Emile Fontanet; 17/03/2026

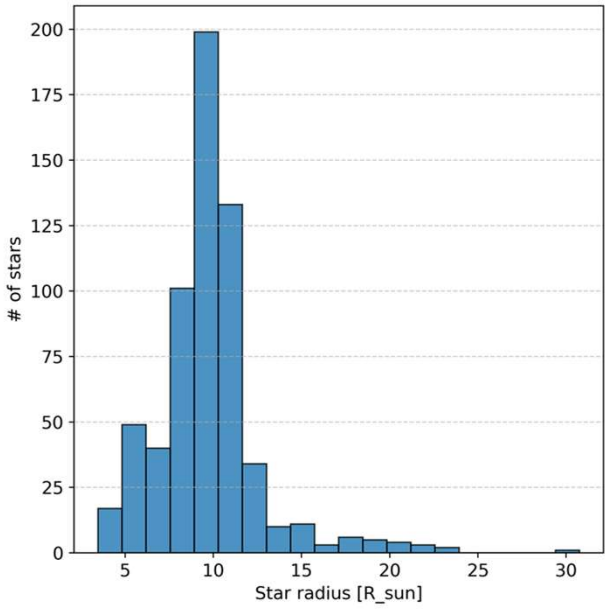
The CASCADES sample

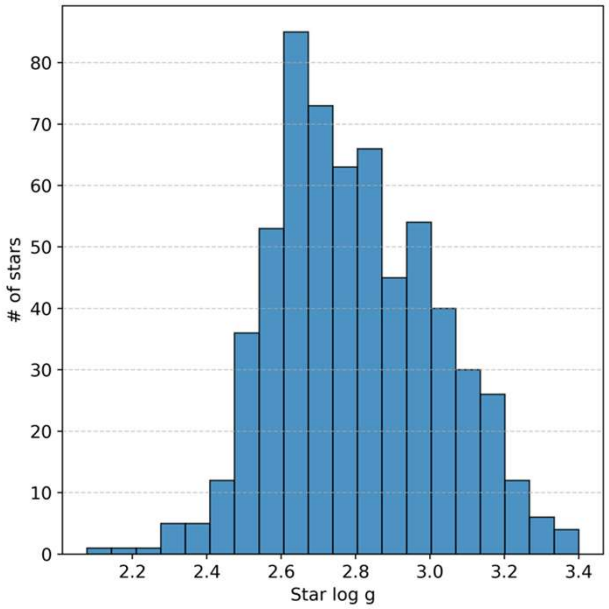
- Stars with precision on parallax better than 14%
- M_V < 2.5 and B-V > 0.78 to avoid MS stars
- B-V < 1.06 to avoid later type stars



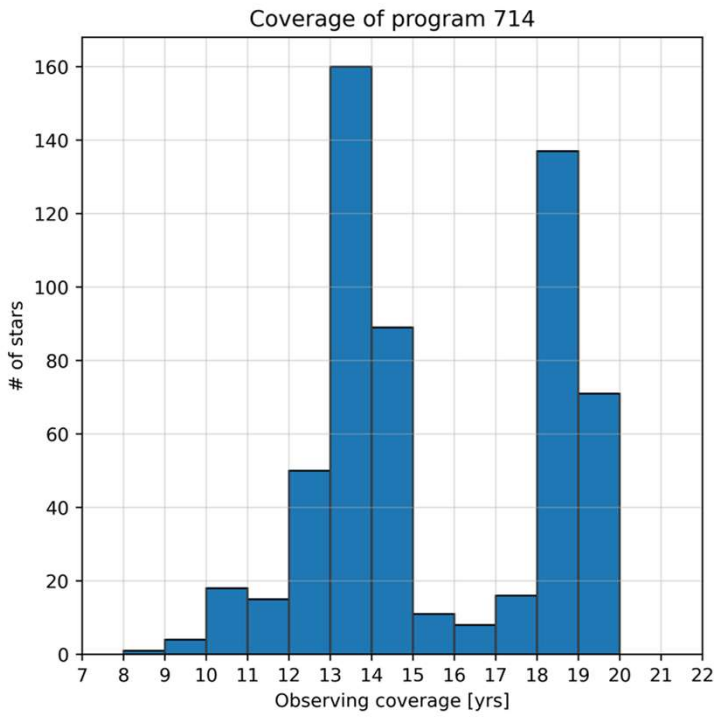
Stellar parameters



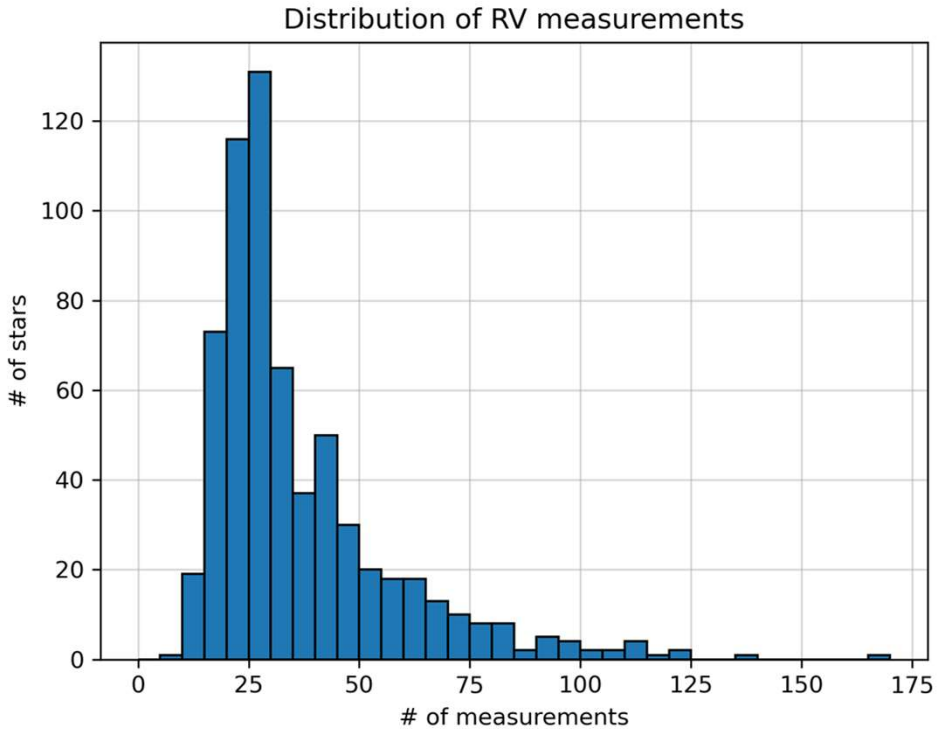




Observing status



> 85% of the stars of the survey have been followed for more than 13 years



90% of the stars have at least 18 individual measurements

Many other giant-star exoplanet-search programs exist!

Survey	References
The Lick G- and K-giant survey	Frink et al. (2001); Hekker et al. (2006b)
The ESO planet search program	Setiawan et al. (2003)
The Okayama Planet Search Program	Sato et al. (2005)
with the collaborative survey "EAPS-Net"	Izumiura (2005)
The Tautenburg observatory Planet Search	Hatzes et al. (2005); Döllinger et al. (2007)
Retired A-stars and their companions	Johnson et al. (2006)
The CORALIE & HARPS search in open clusters	Lovis & Mayor (2007)
with the follow-up program	Delgado Mena et al. (2018)
The Penn States Torún Planet Search	Niedzielski et al. (2007)
with the follow-up program Tracking Advanced Planetary Systems	Niedzielski et al. (2015)
The BOAO K-giant survey	Han et al. (2010)
The Pan-Pacific Planet Search	Wittenmyer et al. (2011)
The Exoplanet aRound Evolved StarS project	Jones et al. (2011)
The Boyunsen Planet Search	Lee et al. (2011)

Credit: Gaël Ottoni's thesis

Our analysis of the full sample

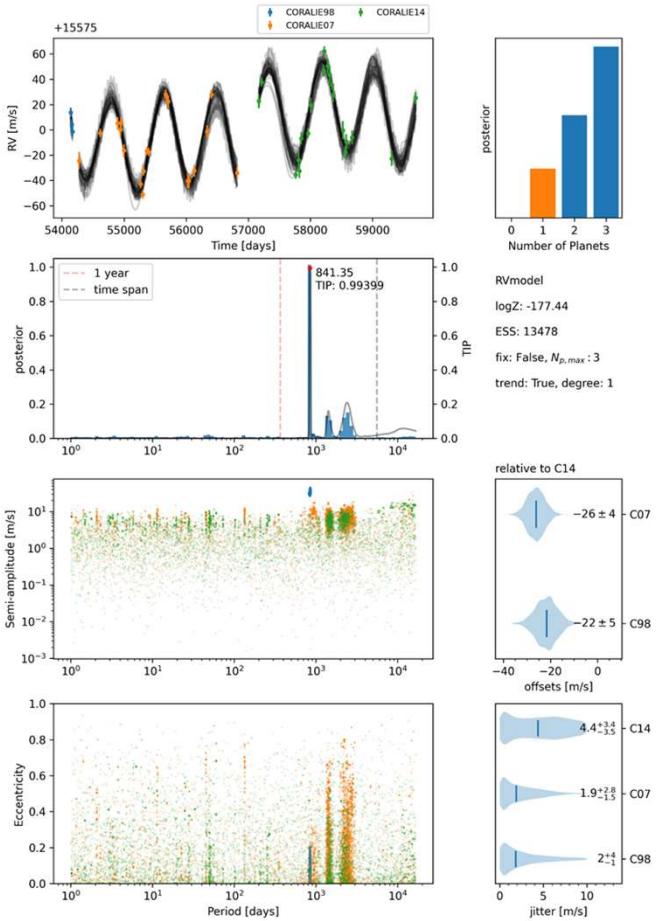
Global analysis

We use kima (Faria 2018) for the analysis of every star in the sample

Priors used for the analysis:

- P ~ log_uniform(1, 3 * Tspan)
- K ~ modified_log_uniform(1, RV_span)
- E ~ Kumaraswamy(0.8, 3)
- W, phi ~ Uniform(0,2*pi)
- Ins stability ~ Uniform(0,20)

Result example



https://ui.adsabs.harvard.edu/abs/2018JOSS....3..487F/abstract

CASCADES candidates

A few examples

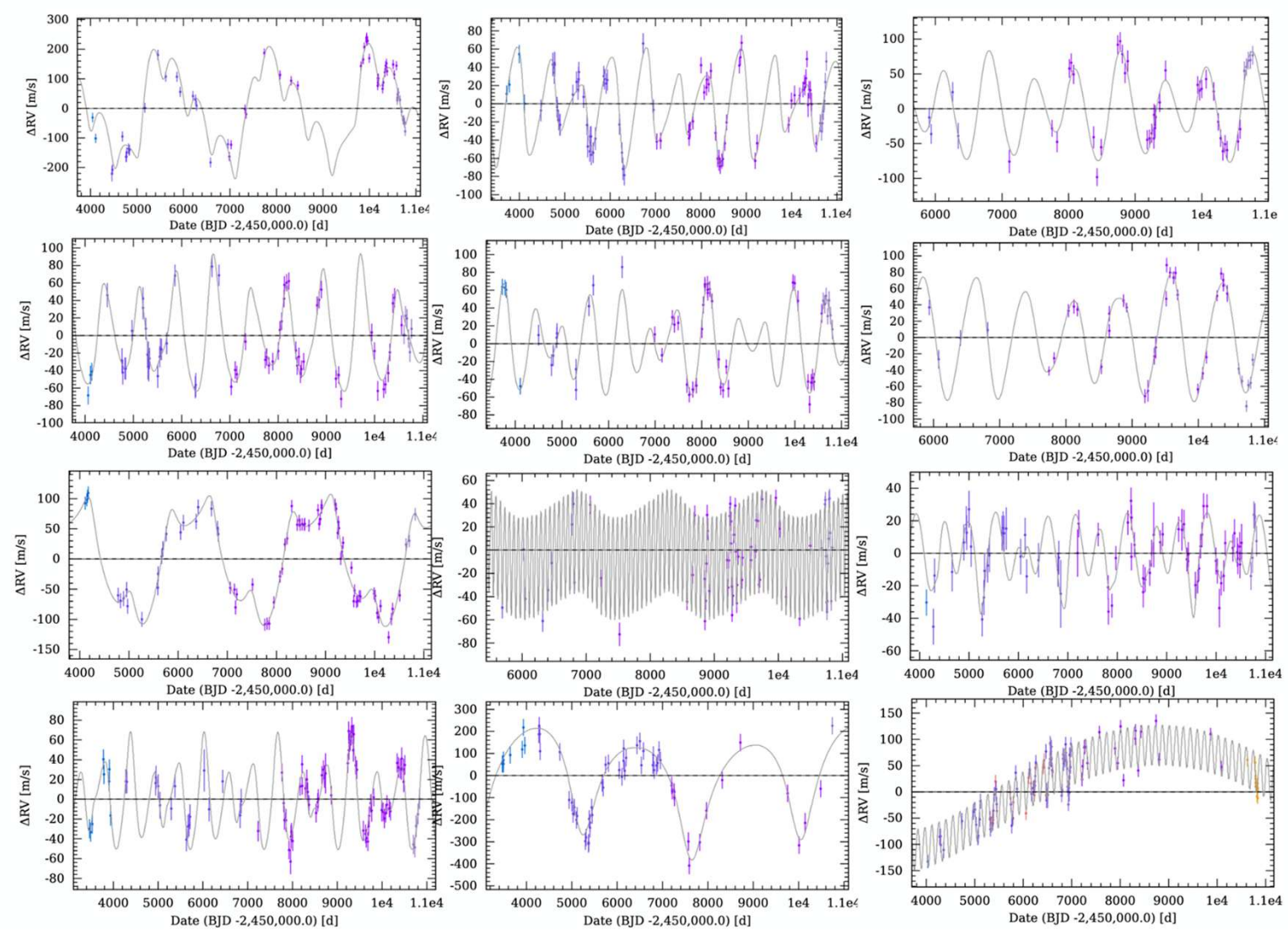
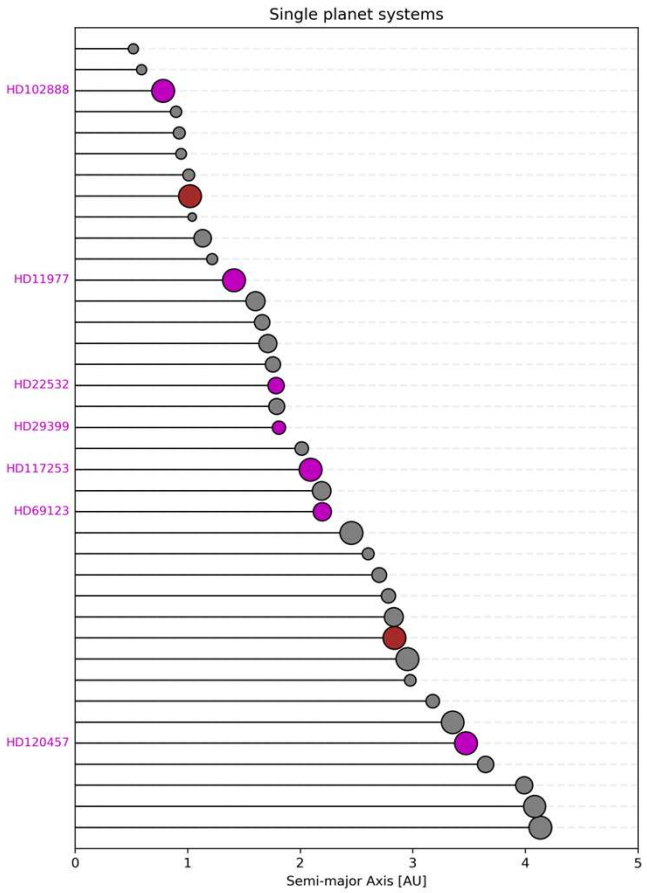


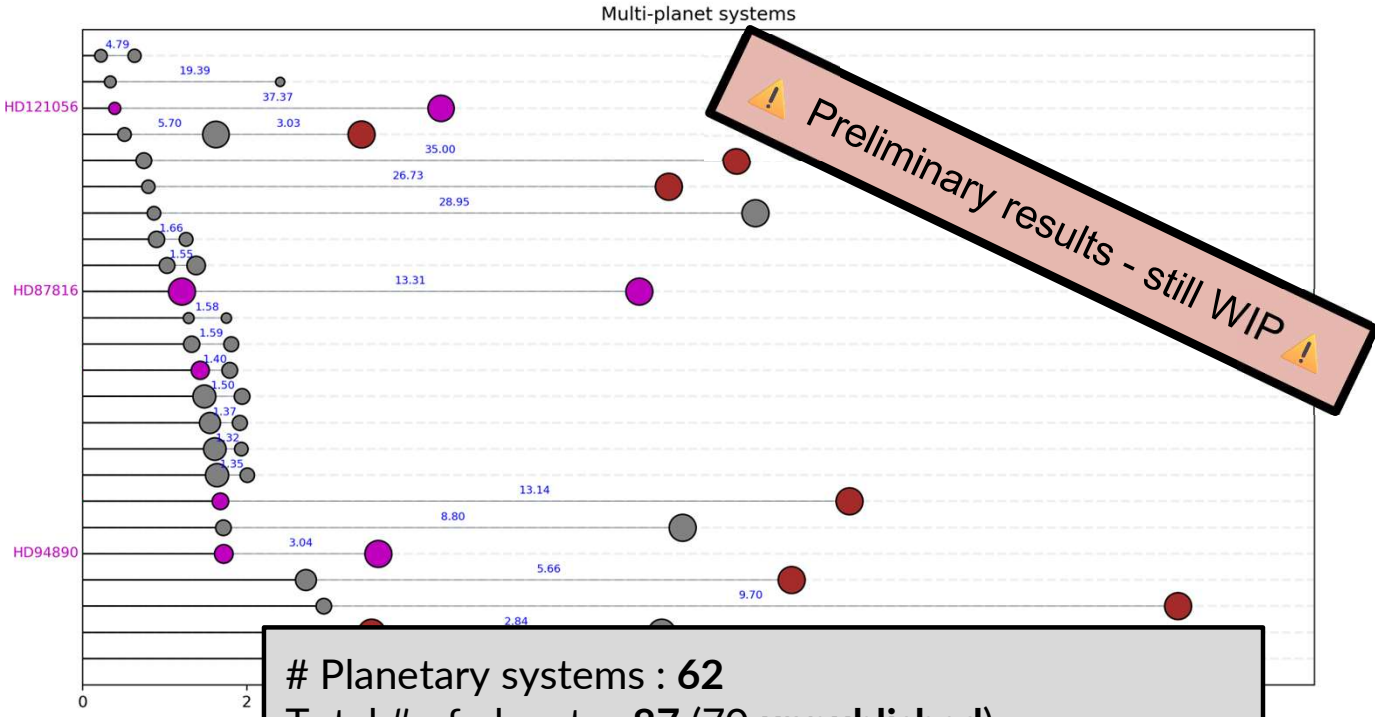
Figure: S. Udry talk at Coimbra, July 2025

CASCADES planets

- Unpublished “planet”
- Published planet
- 13 M_jup < Msin(i) < 30 M_jup

Systems with at least one planet with
- 25d < P < 3600d
- 0.8_Mjup < Msin(i) < 30M_jup



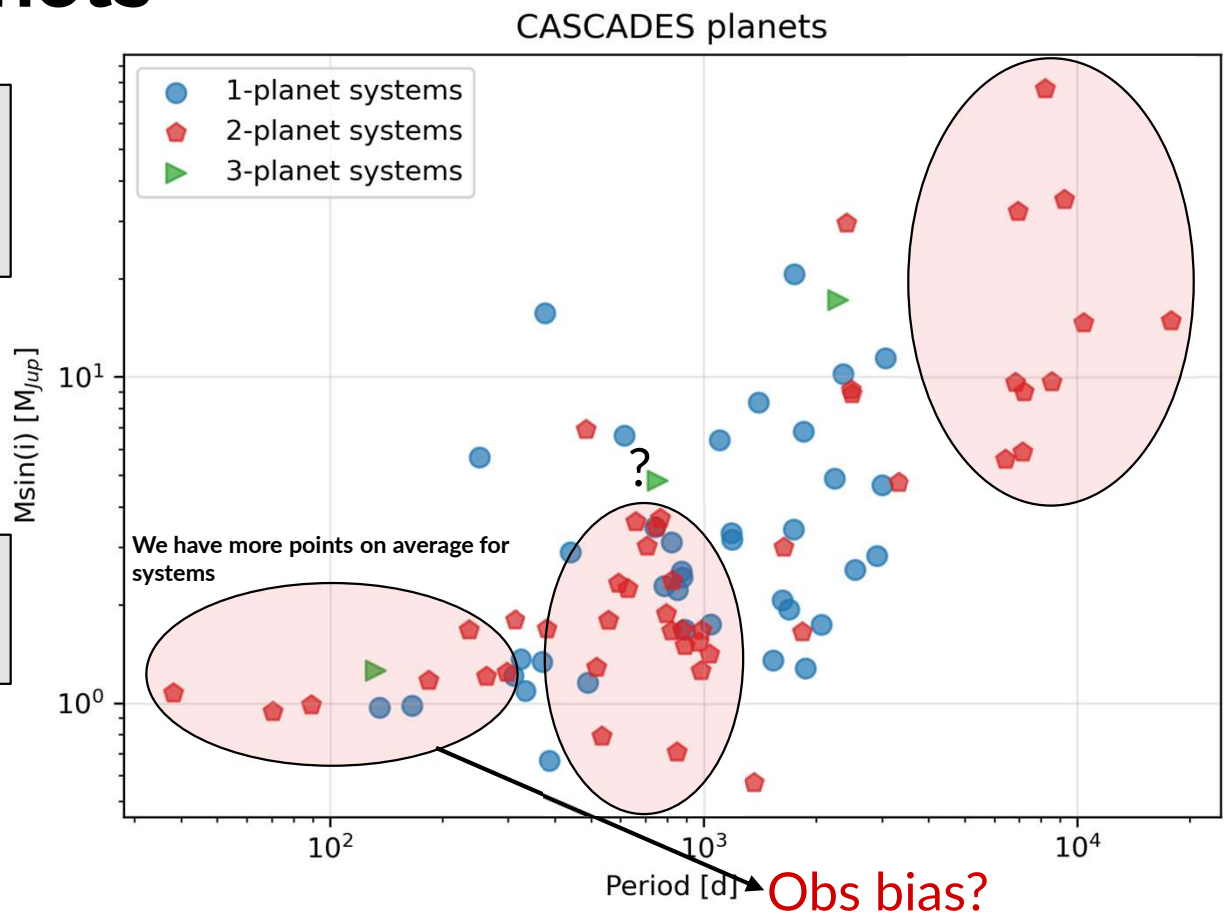


Planetary systems : **62**
Total # of planets : **87** (70 **unpublished**)
Single-planet systems: **38** (61%)
Multiple giant-planet systems: **24** (39%)
- Two-planet systems: **23**
- Three-planet systems: **1**

CASCADES planets

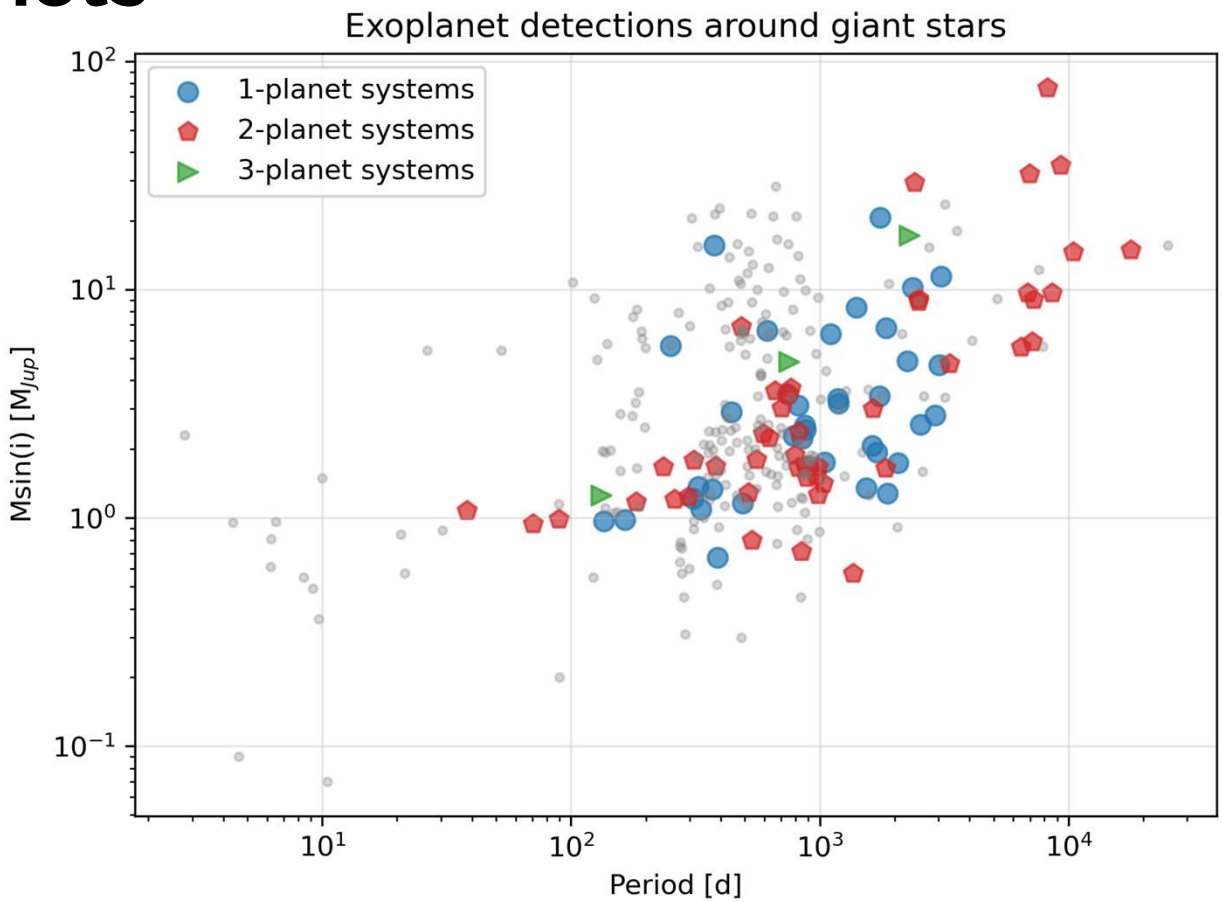
We find planets at low (<300 d) periods mainly in multiple systems. This could be explained by an observing bias.

We also observe an excess of systems for planets at periods between 600 and 1000 days



Companions of P<3600 planets

CASCADES planets

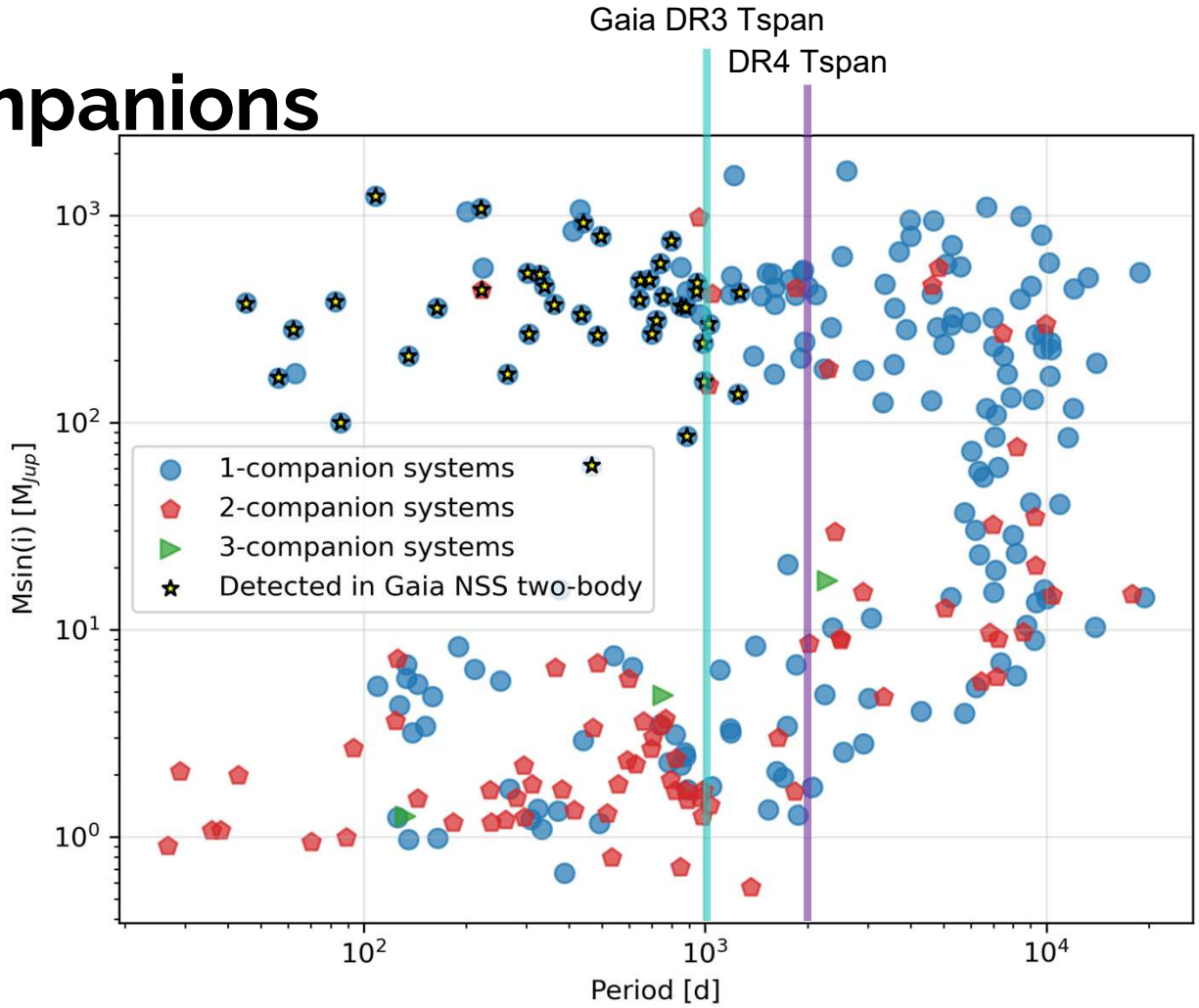


Other planets from the NASA archive

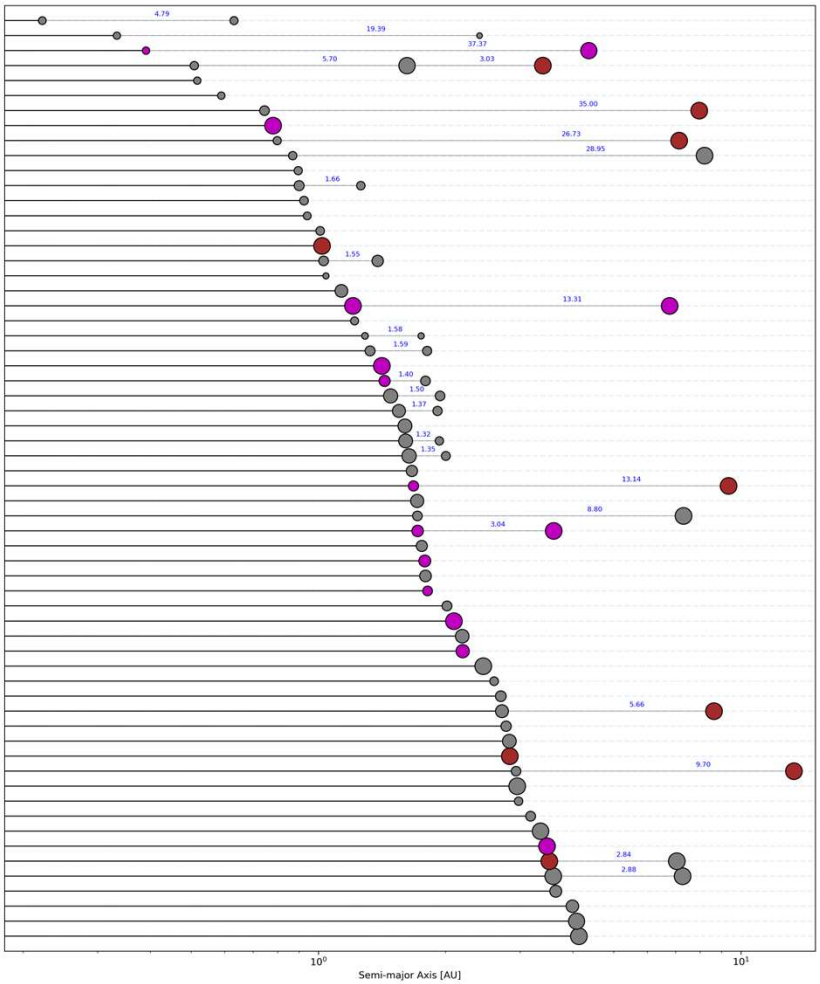
CASCADES companions

Our survey also finds > 100 binaries

Most of them are detected by Gaia at P < 1000 days



Occurrence rate comparison



# of systems with at least one giant planet

Johnson et al. (2007): 8.9% ±2.9%
(101 stars, ΔT ~10 yrs)

Wittenmyer et al. (2020): 7.8% +9.1% −3.3%
(129 stars, ΔT ~ 5 yrs)

Wolthoff et al. (2022): 10.7%+2.2% −1.6%
(482 stars, no homogeneous coverage, ΔT <13 yrs

⚠ No completeness correction

CASCADES: 62/641 ~9.7 +-1.2%
(641 stars, ΔT ~ 20 yrs)

Our sample is **large**, and covers a **long baseline** compared to previous studies

⚠ All these occurrences might be "polluted" by fake planets. Great care is required before publishing anything ⚠

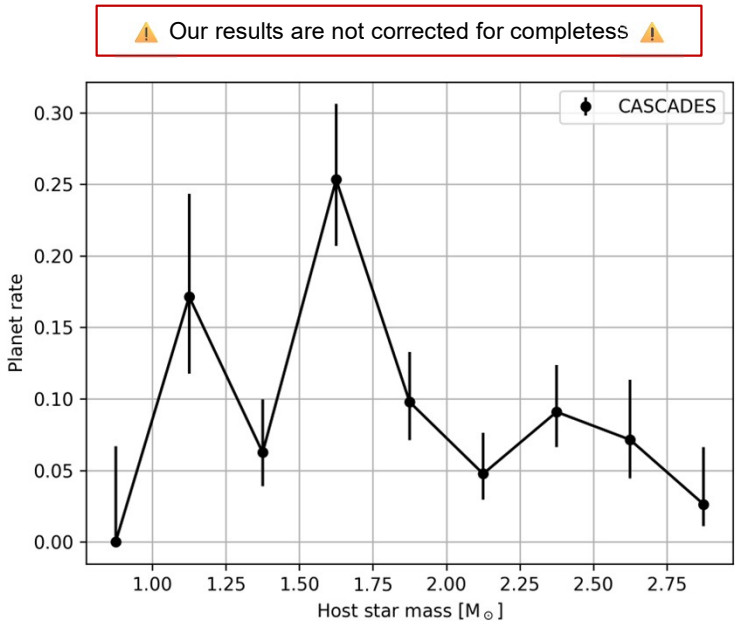
Dependence on host star mass

This only considers planets with:

- 89d < P < 3600d
- 0.8Mjup < Mp < 30Mjup

To compare with the results of Wolthoff et al 2022

We observe a peak of occurrence between ~1.5 and 2 solar masses.



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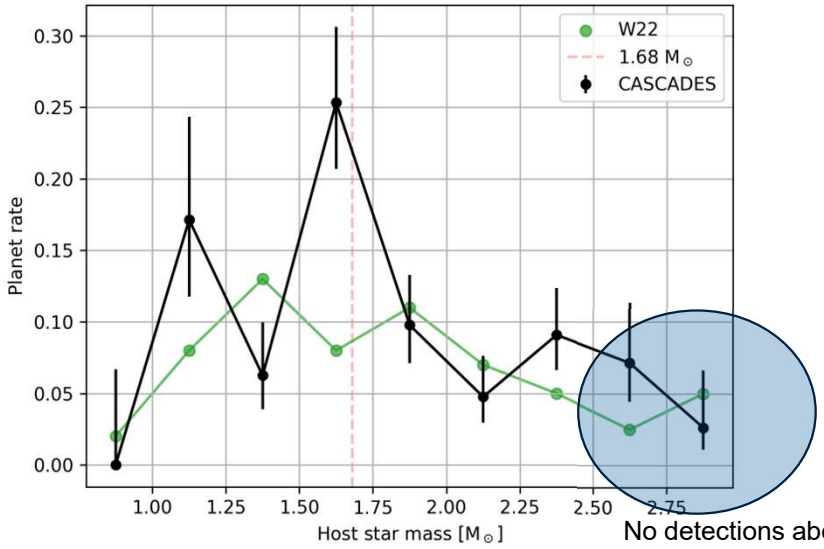
Wolthoff et al (2022) observe a peak at 1.68 Msun

No planet detected around stars more massive than 3 solar masses

The results are still preliminary, and we only count here the planets we are «sure» of

⚠ Our results are not corrected for completess ⚠

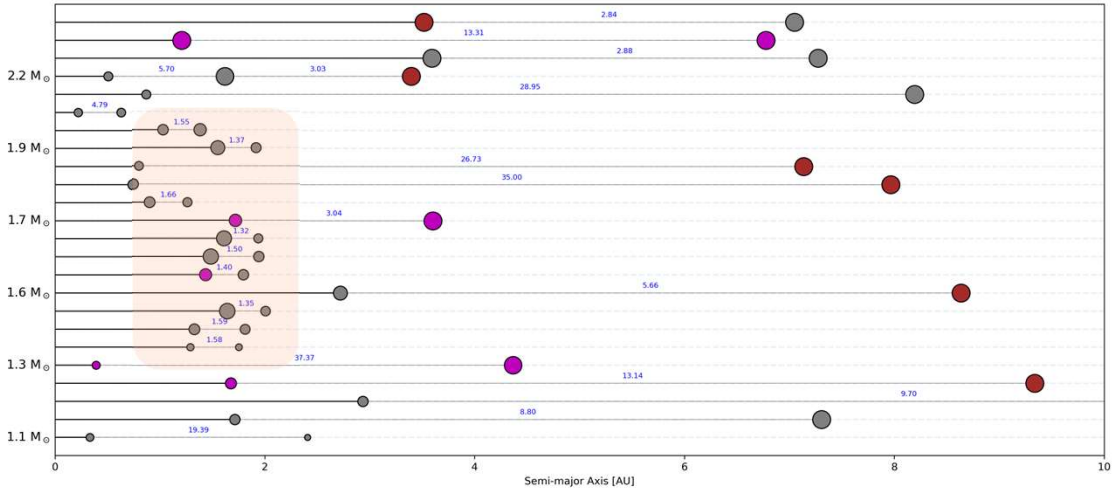


No detections above 3 Msun

Wolthoff et al 2022. https://ui.adsabs.harvard.edu/abs/2022A&A...661A..63W

Are we really looking at planets?

Multiple systems - ordered by star mass

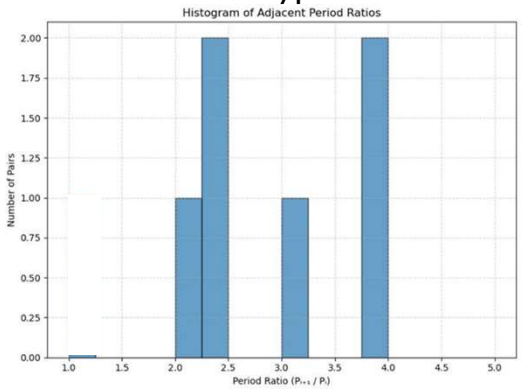


Planetary systems : **62**
Total # of planets : **87**
Single-planet systems: **38** (~60%)
Multiple giant-planet systems: **24** (~40%)
- Close to “resonance”: 12 (~50%)

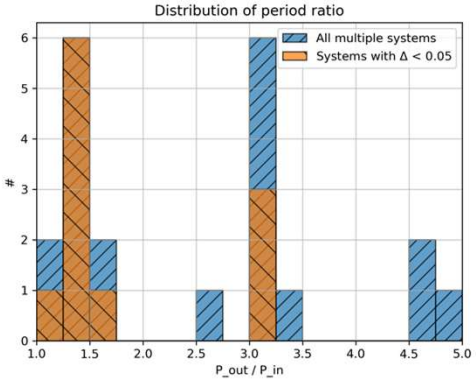
⚠️ Is this a physical phenomenon due to the larger mass of the primary star, or is it something else? ⚠️

Almost none of these systems have clear periodicities in line-profile indicators (FWHM, BIS)

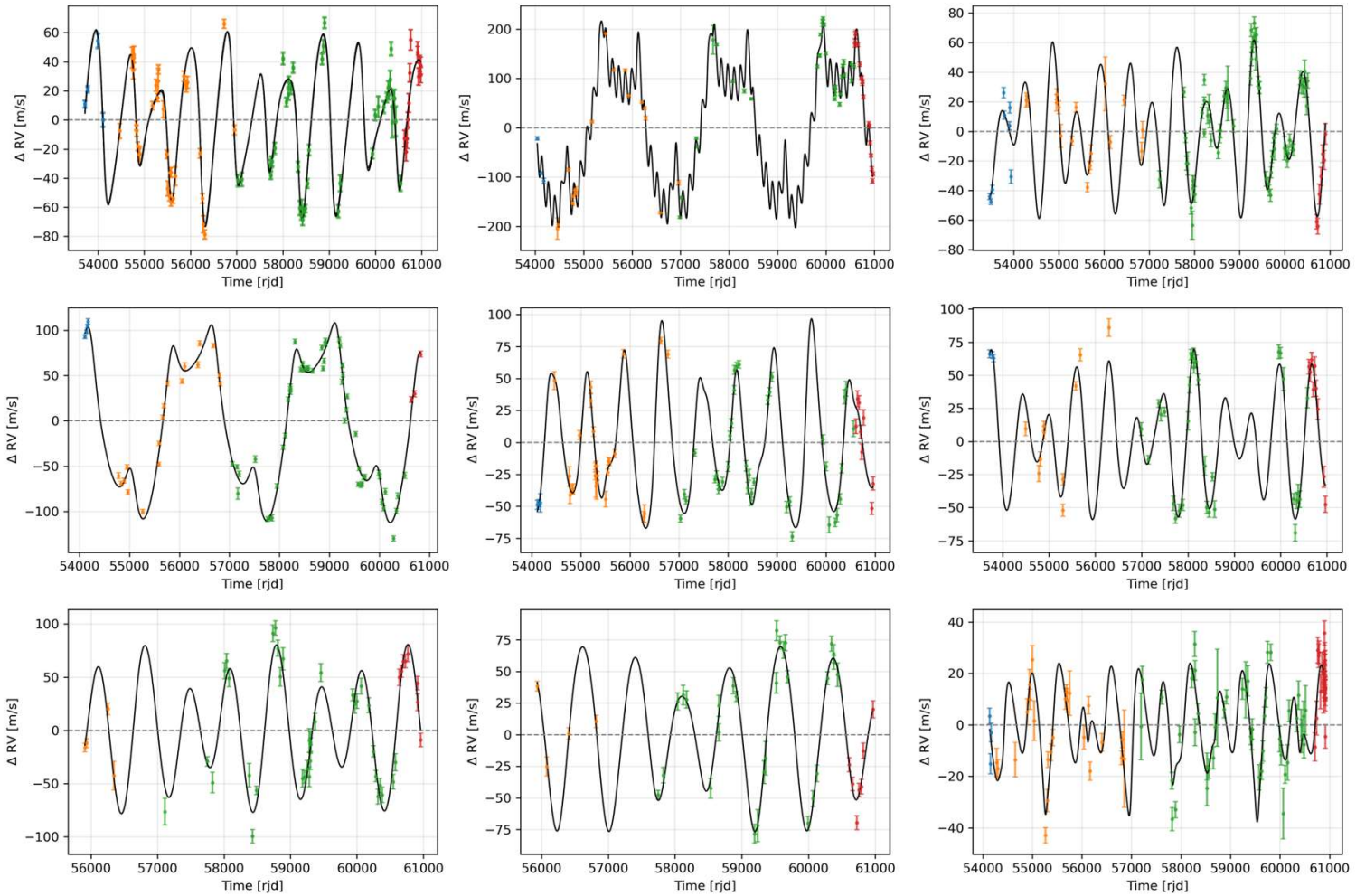
For solar-type stars



For giant stars

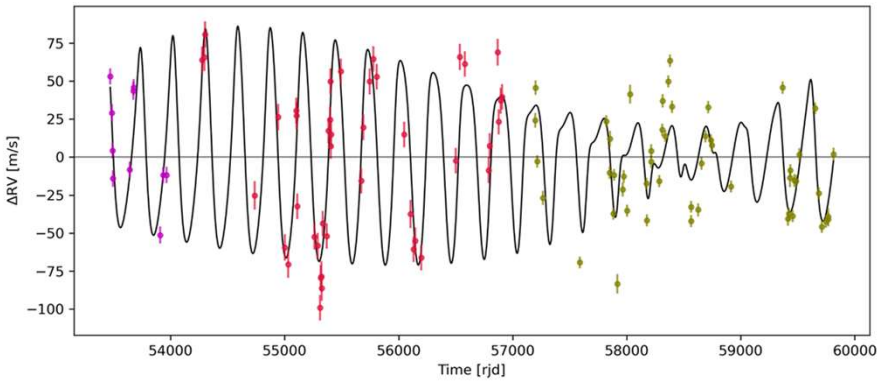


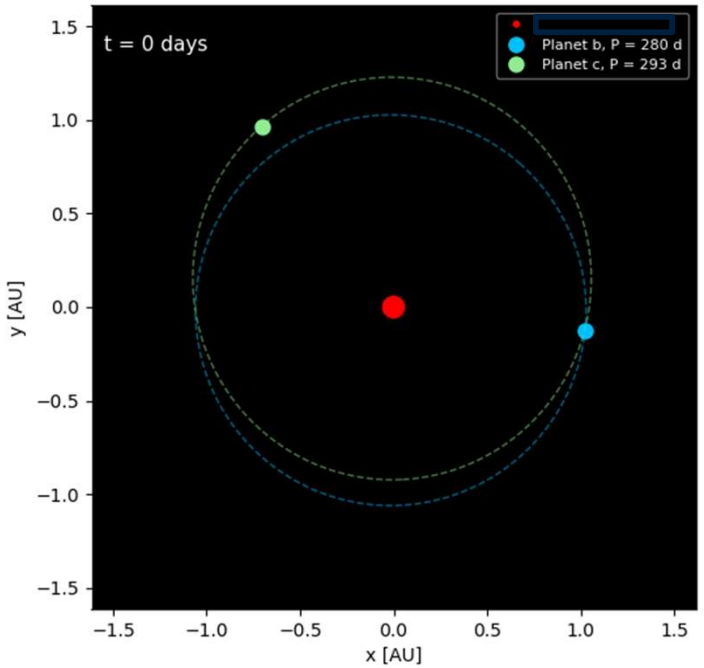
Systems with period ratio close to “resonance” – Examples



Co-orbital system? Or pulsations?

- We even find a system close to 1:1
- Should not be modeled by the sum of two Keplerians
- The two periods (280 d & 293 d) are likely due to stellar activity
- Nothing in FWHM, H-alpha, but a similar signal in the BIS





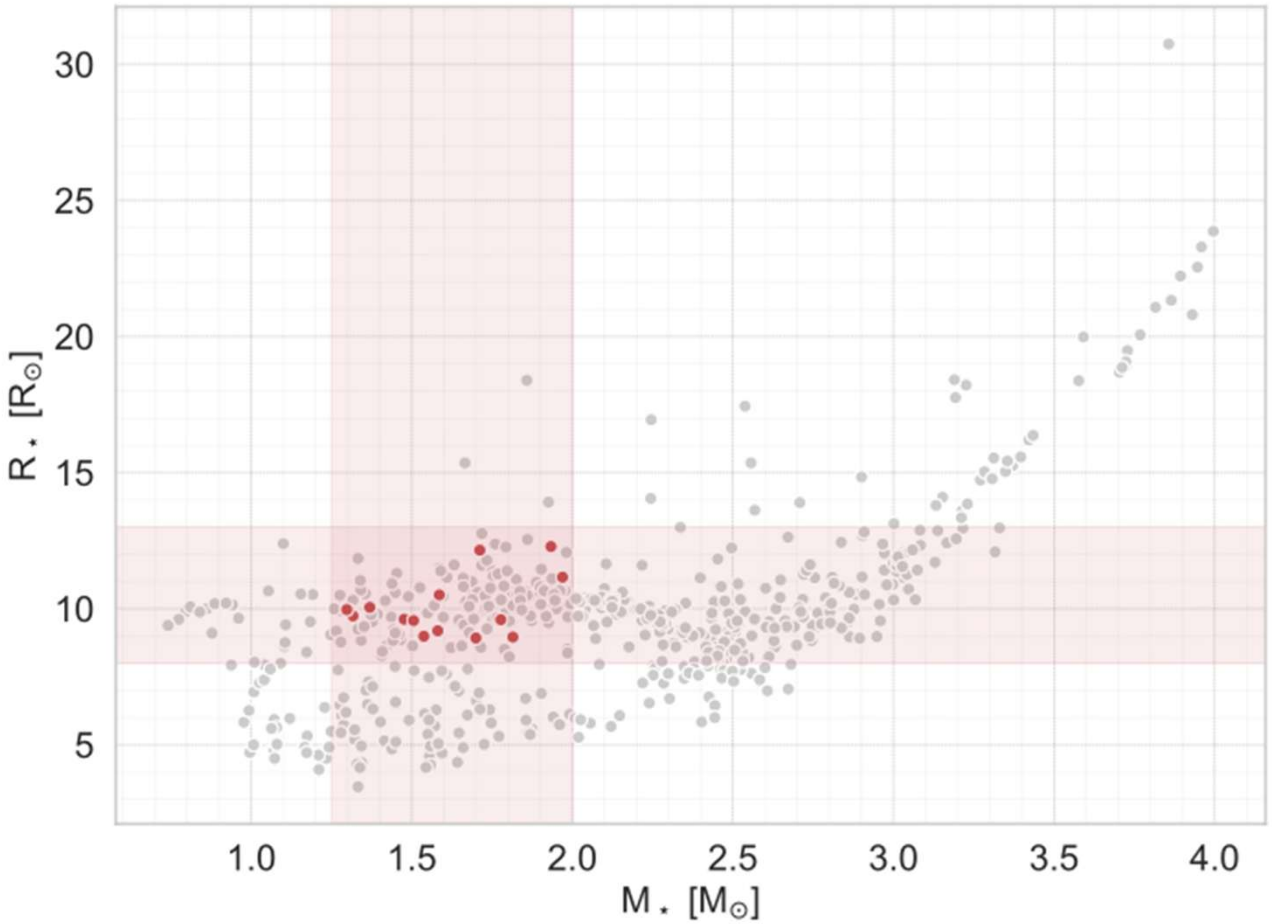
Another subset of enigmatic cases

A dozen stars showing strong signals in RV as well as in one activity indicator (FWHM and/or BIS)

Periods mostly in the 100-200d range

Signals are out of phase by ~90°

Some of them have been published as “detections”



Credit: Gaël Ottoni’s PhD thesis

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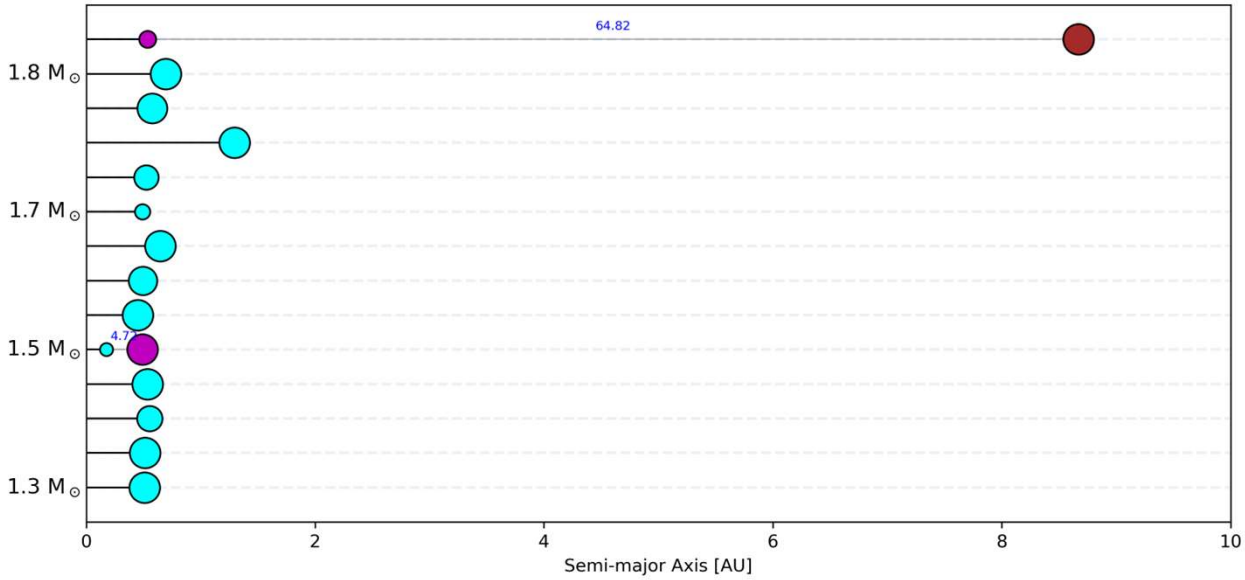


One example

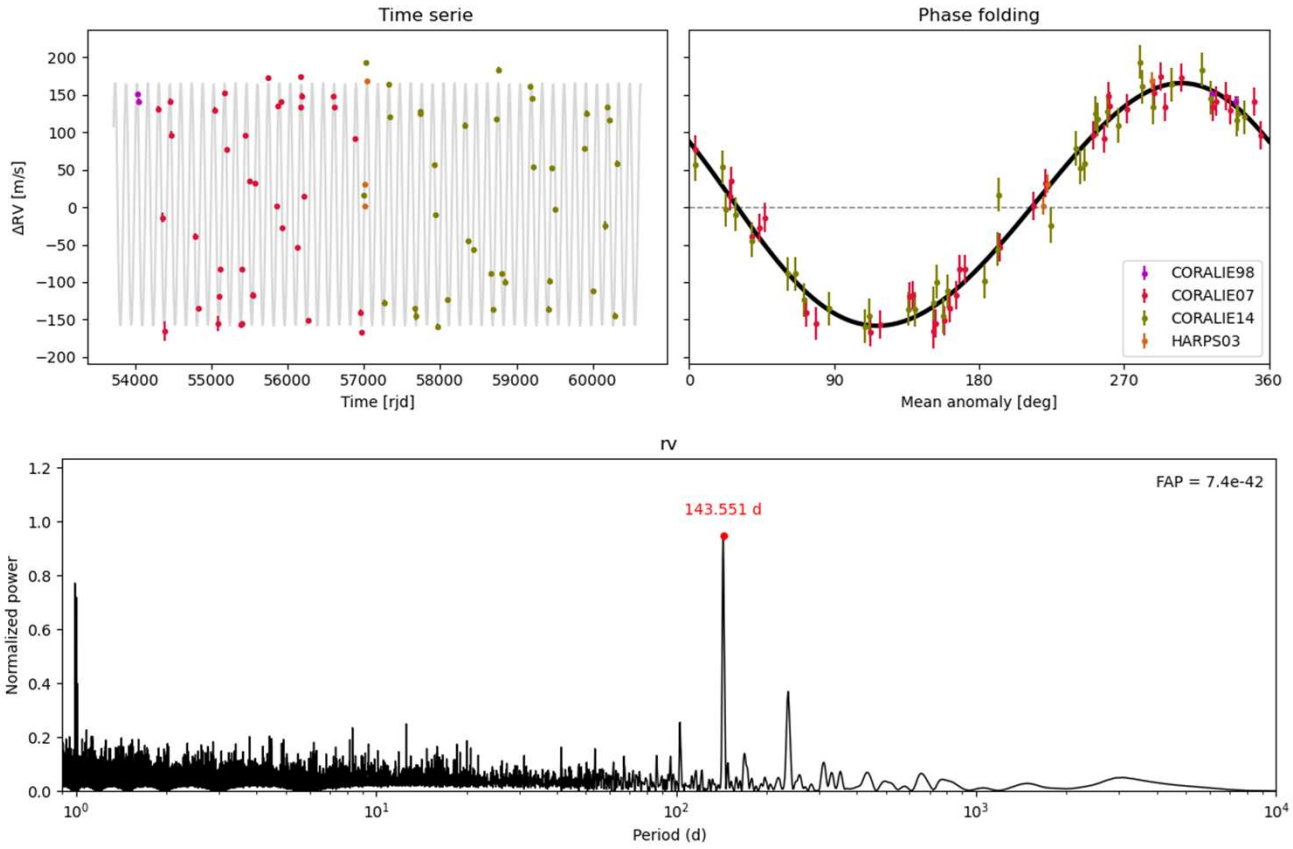
K giant

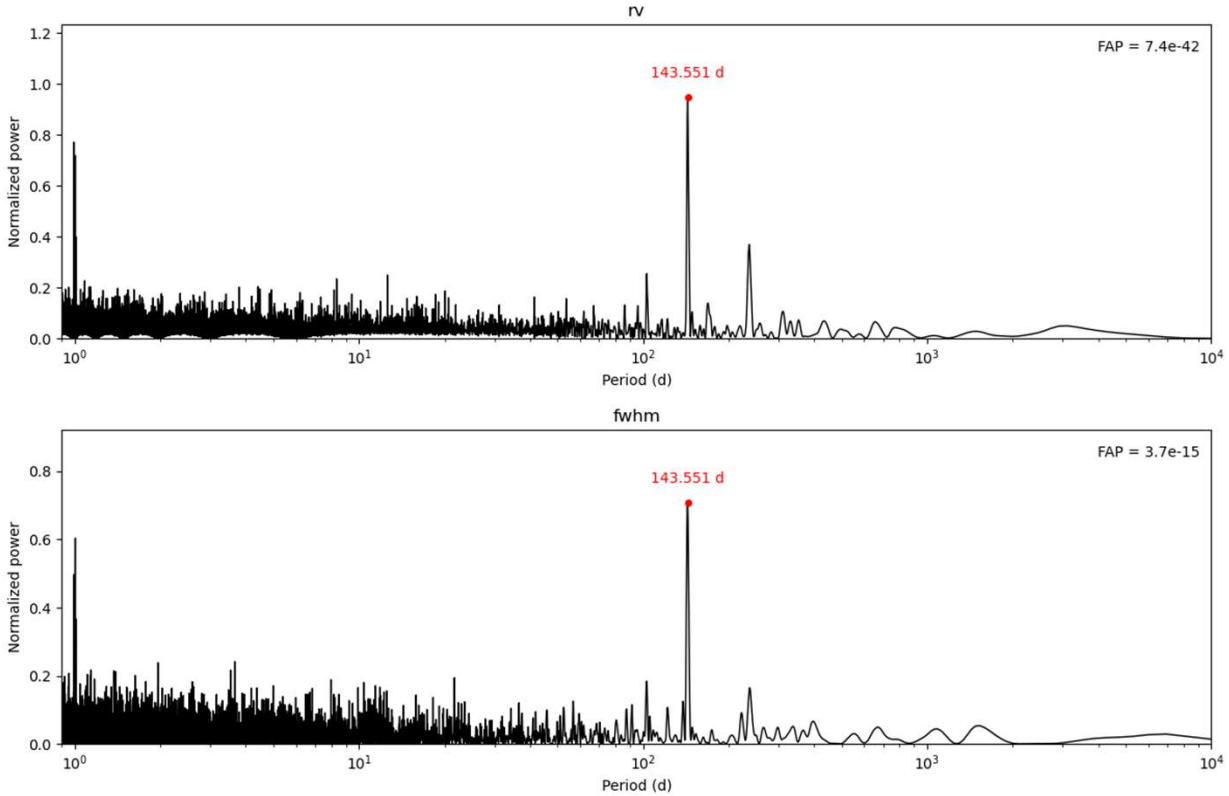
Period in the RVs of 143 days

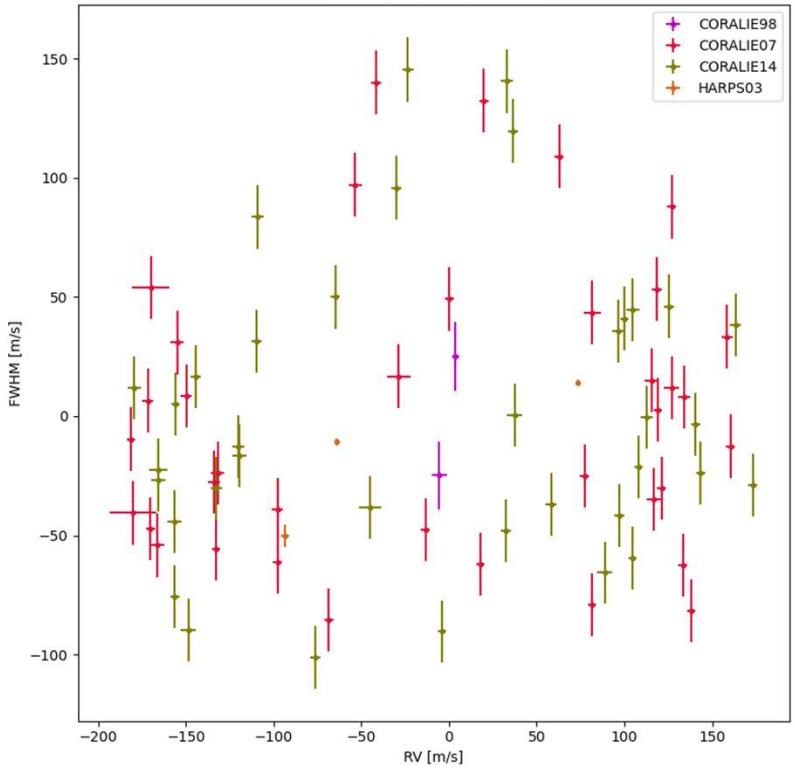
Amplitude of ~160 m/s

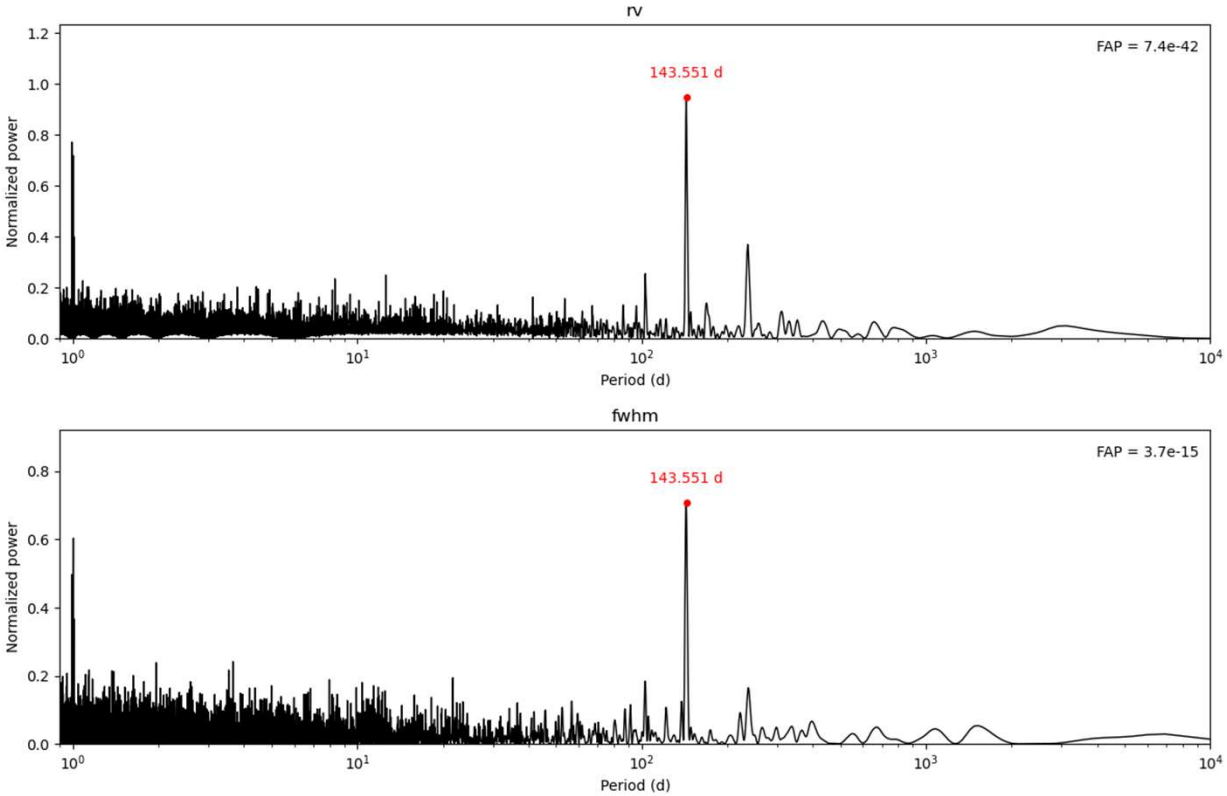
Signal at the same period in FWHM

The two signals are not in phase, shift of 90°




rv
FAP = 7.4e-42
143.551 d
Normalized power
Period (d)
fwhm
FAP = 3.7e-15
143.551 d
Normalized power
Period (d)


CORALIE98
CORALIE07
CORALIE14
HARPS03
FWHM [m/s]
RV [m/s]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Normalized power
Period (d)
fwhm
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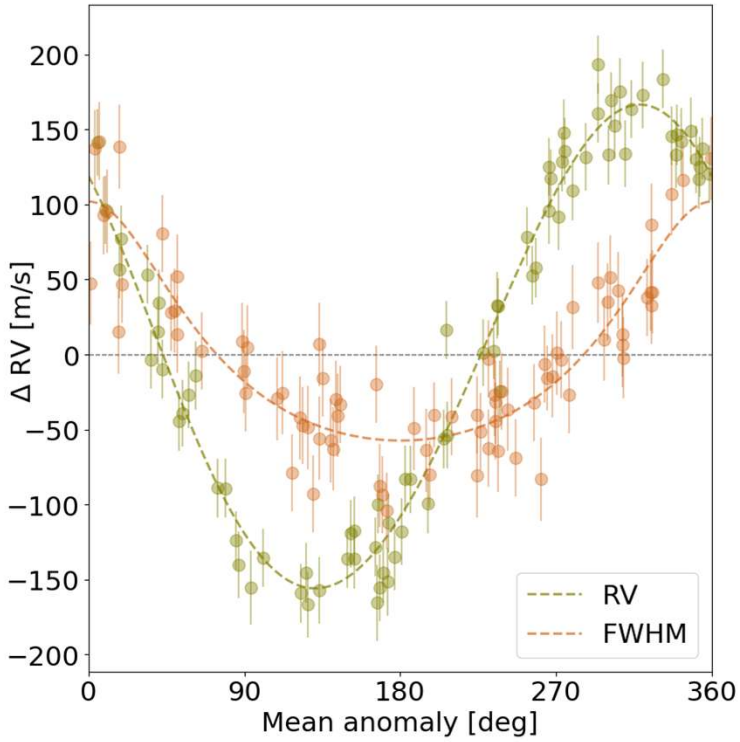
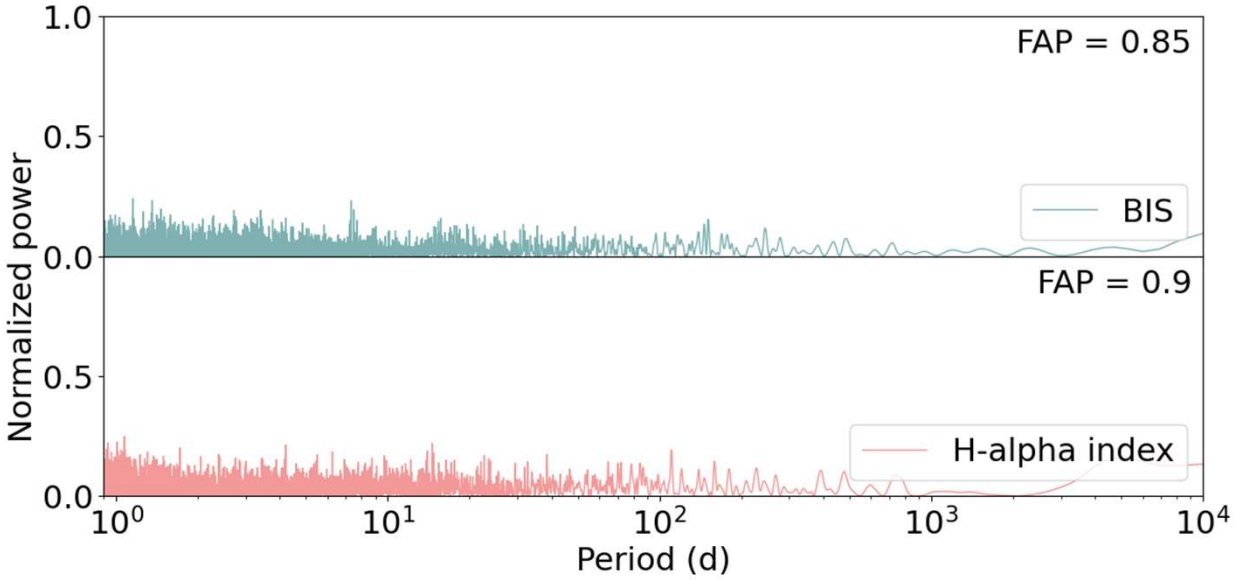
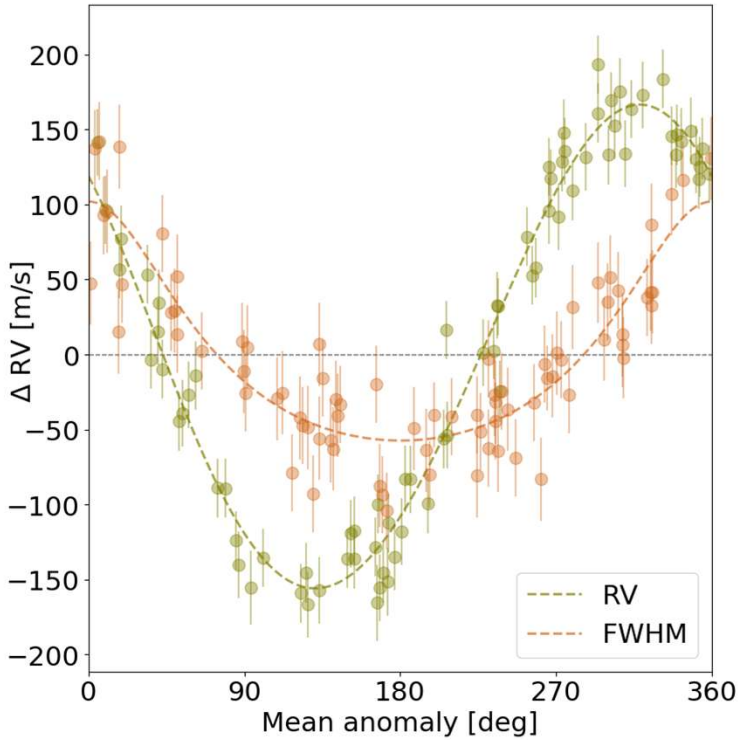
Normalized power
Period (d)


Δ RV [m/s]
Mean anomaly [deg]
RV
FWHM


FAP = 0.85
BIS
FAP = 0.9
H-alpha index
Normalized power
Period (d)

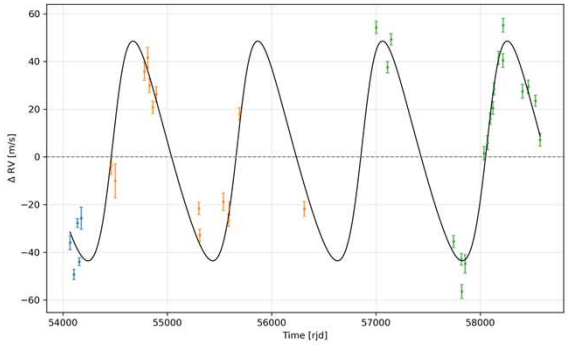

RV
FWHM
Δ RV [m/s]
Mean anomaly [deg]

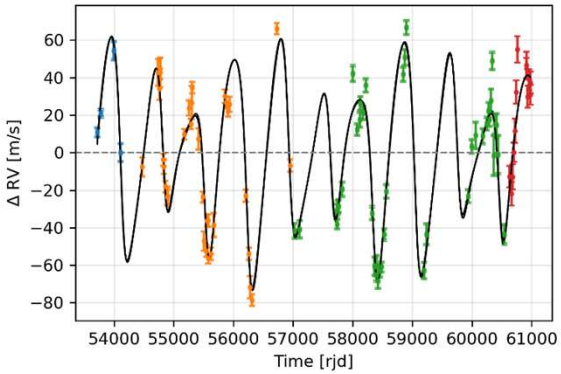
– To recap, out of 640 stars:

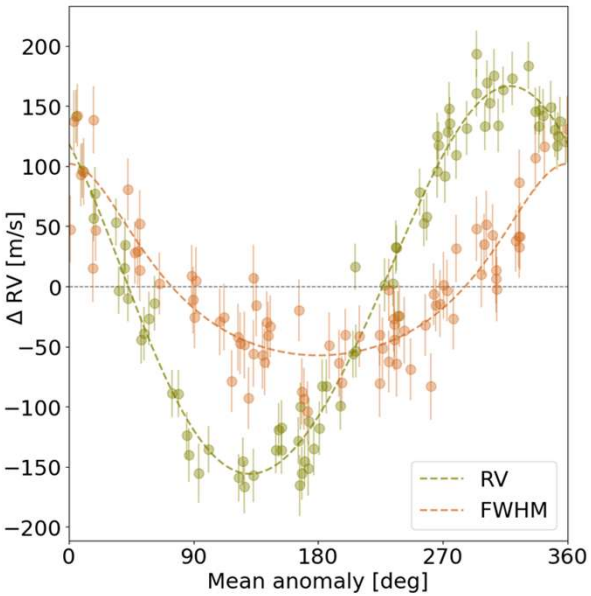
62 planetary systems → **10** systems close to "resonance"

+

13 signals with phase-lag in FWHM/BIS







Remaining ideas

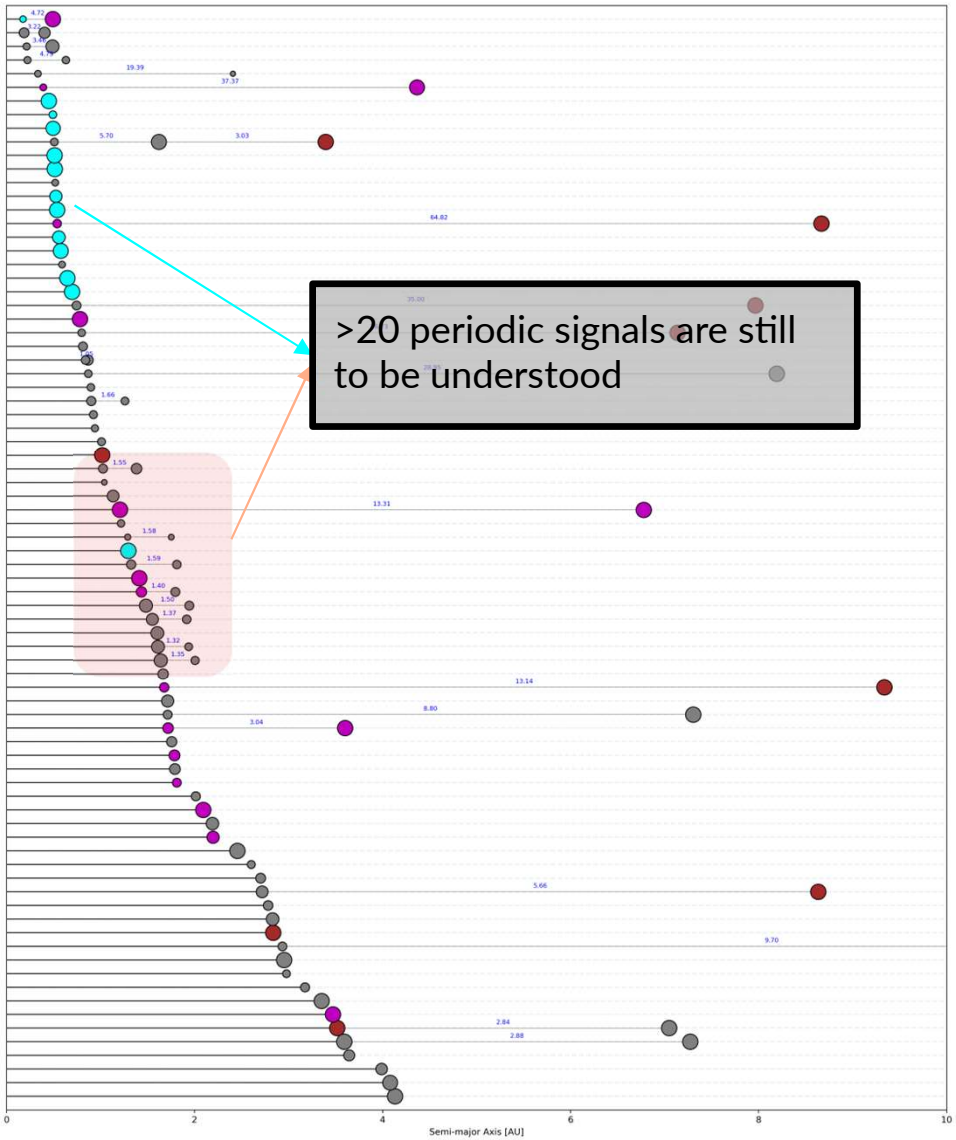
NIRPS dTemp (Artigau et al 2024) / LBL RVs

Non-radial pulsation model (Spaeth et al 2024)

Dynamical analysis (for “resonant” systems, co-orbital)

Kima analysis with GP using FWHM+BIS

Gaia DR4?

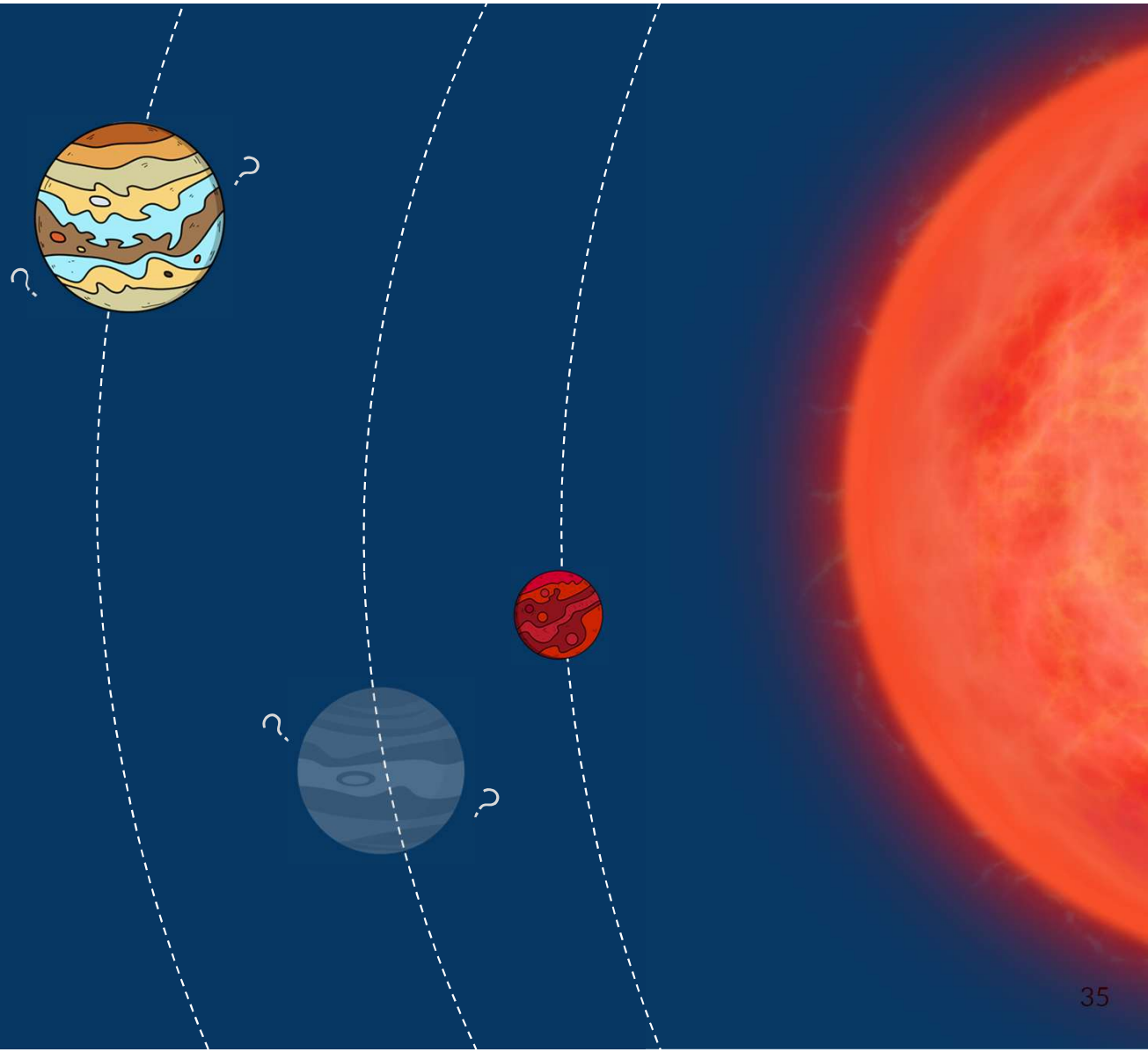


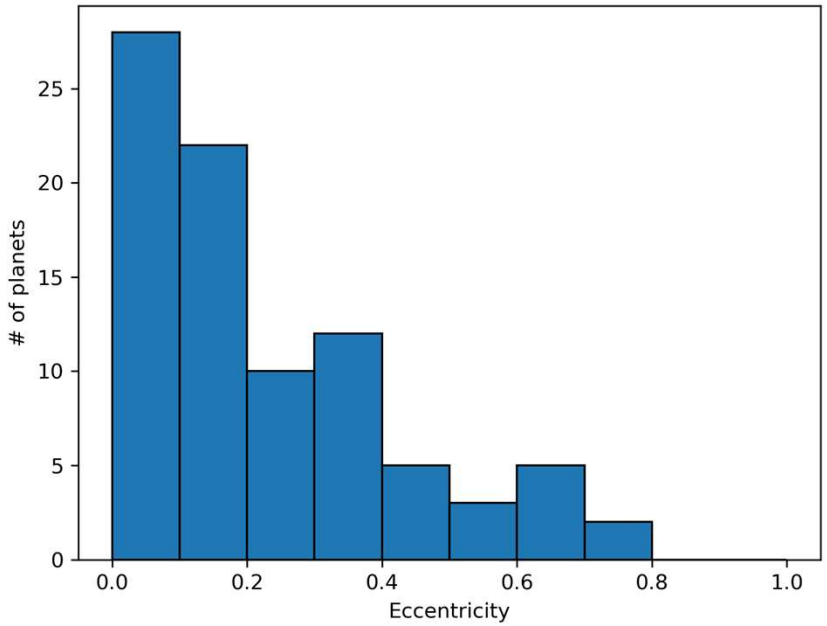
In summary

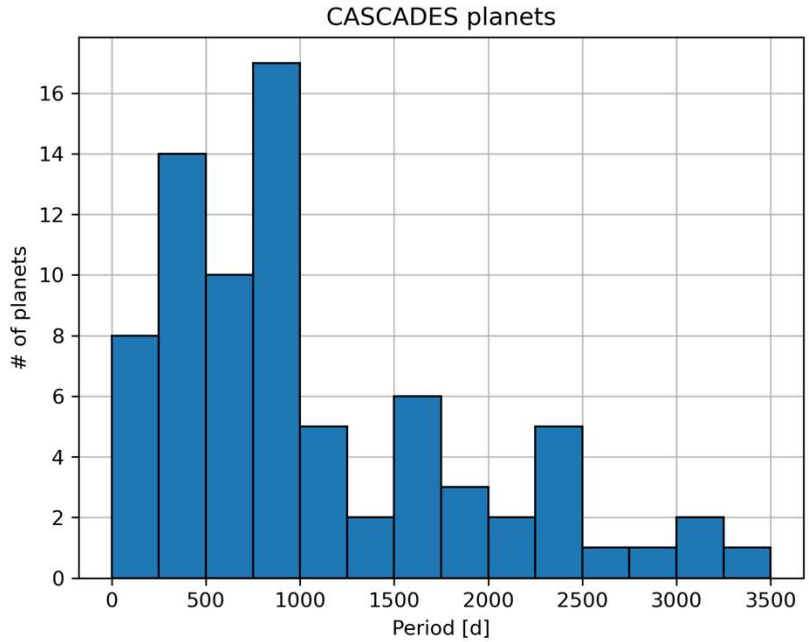
We have a 20-year-long RV survey of intermediate-mass giant stars

We expect to publish the occurrence rates of our sample in the coming year

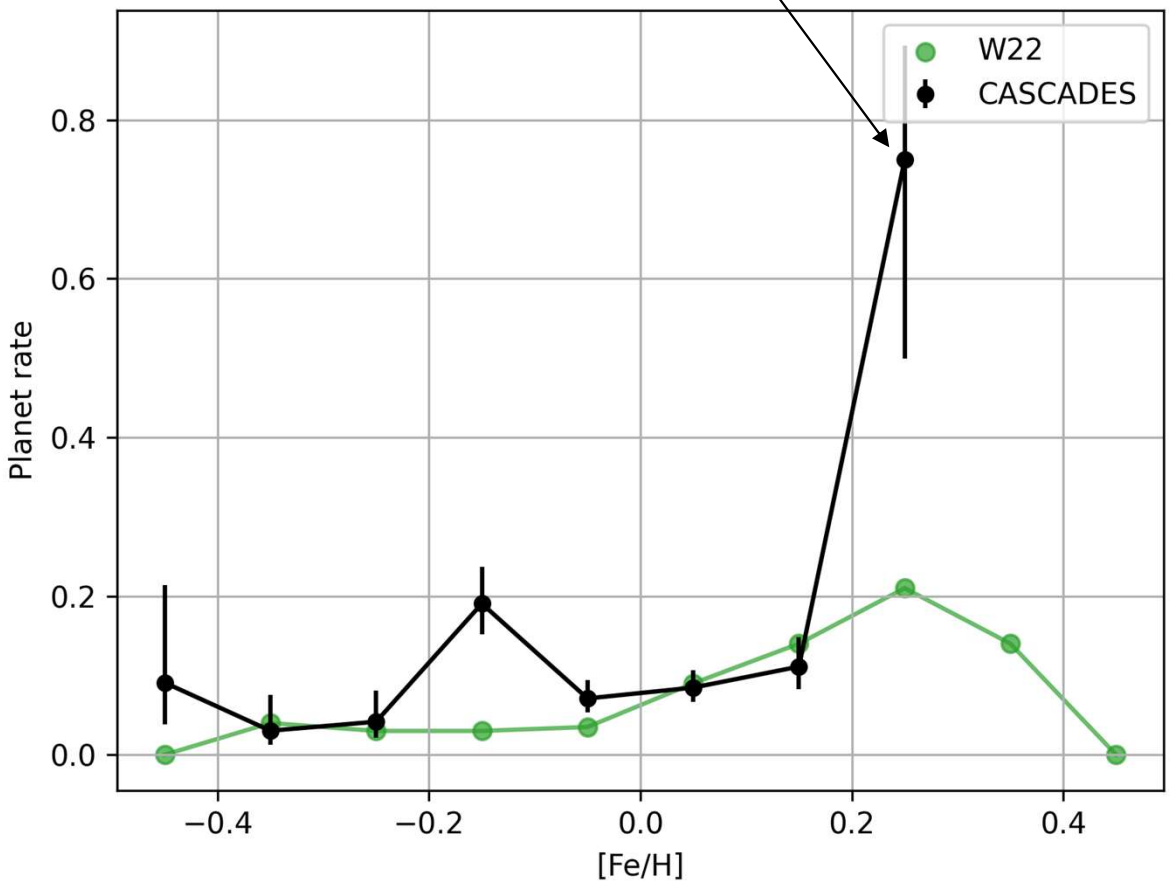
As we observe many spurious RV signals, we need to be very careful before publishing anything




25
20
15
10
5
0
# of planets
0.0
0.2
0.4
0.6
0.8
1.0
Eccentricity


CASCADES planets
16
14
12
10
8
6
4
2
0
# of planets
0
500
1000
1500
2000
2500
3000
3500
Period [d]

We only have 4 stars at a metallicity larger than 0.2, among which 3 host a planet



Possible answer

Surface feature?

✅ Periods correspond ~ rotation

❌ signals of this amplitude should produce a photometric signal

Radial pulsation?

✅ Could explain the pi/2 phase-shift

❌ Periods are expected to be (much) shorter

Non-radial pulsation?

🤔 Could be the explanation, proposed by Spaeth et al. (2024), but some points still need to be addressed (wavelength dependence, periods, BIS,?)

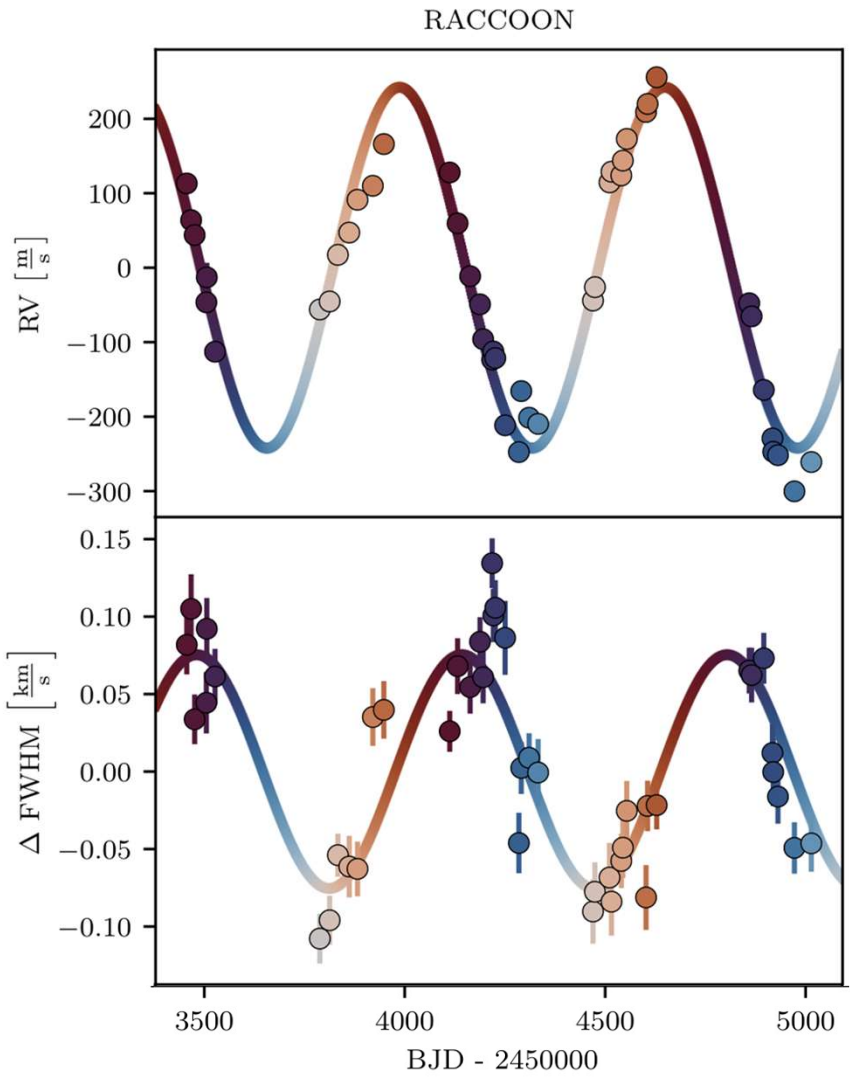


Fig 4 from Spaeth, D., et al.: A&A, 689, A91 (2024)

NIR (preliminary) results

- The same effect is recovered by both HARPS and NIRPS
- The amplitude is the same with both instruments
- Phase-lag also seen in the NIR
- Several “detected planets” might be the result of this type of effect