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Including dynamical constraints in RV detection limits

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Including dynamic
RV detecti

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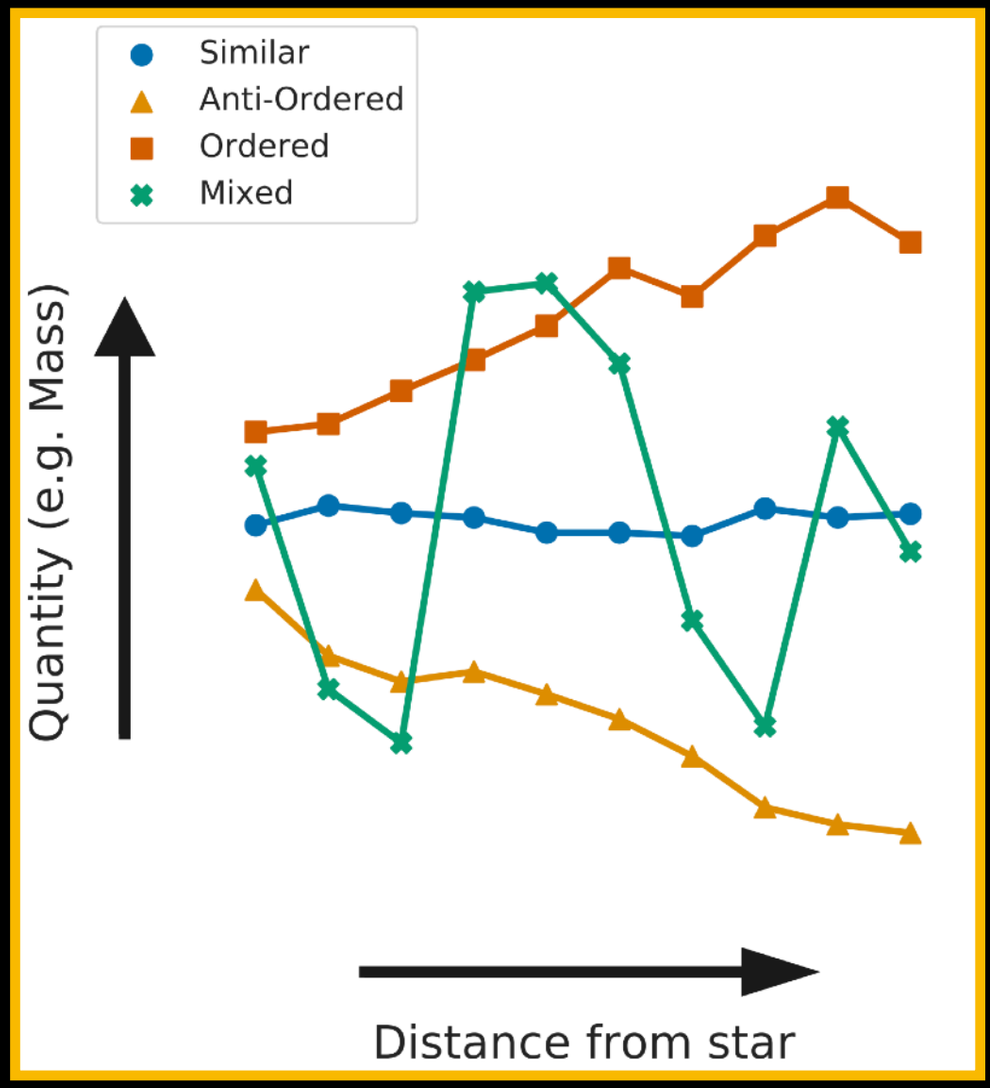
Architecture of planetary systems

Architecture is a key tracer of formation and evolution

Observations reveal a wide diversity of system architectures

but could be incomplete…

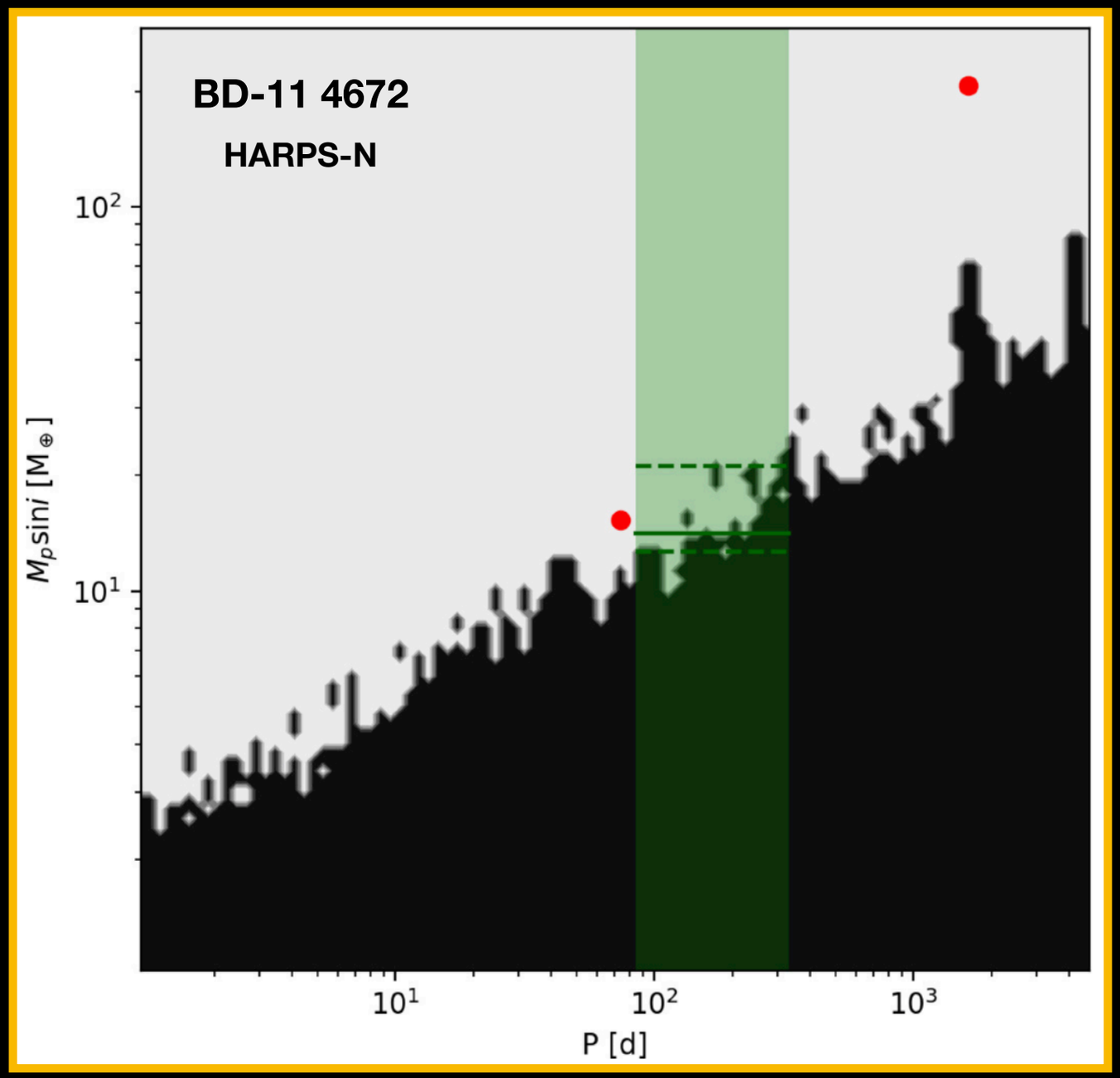
The discovery of additional planets modify our picture of planet formation and evolution



Mishra et al. 2023

Radial velocity detection limits

Barbato+2020



To quantify the level of completeness, we compute detection limits.

Injection-recovery tests

Generally, they do not account for the dynamical plausibility of injected planets.

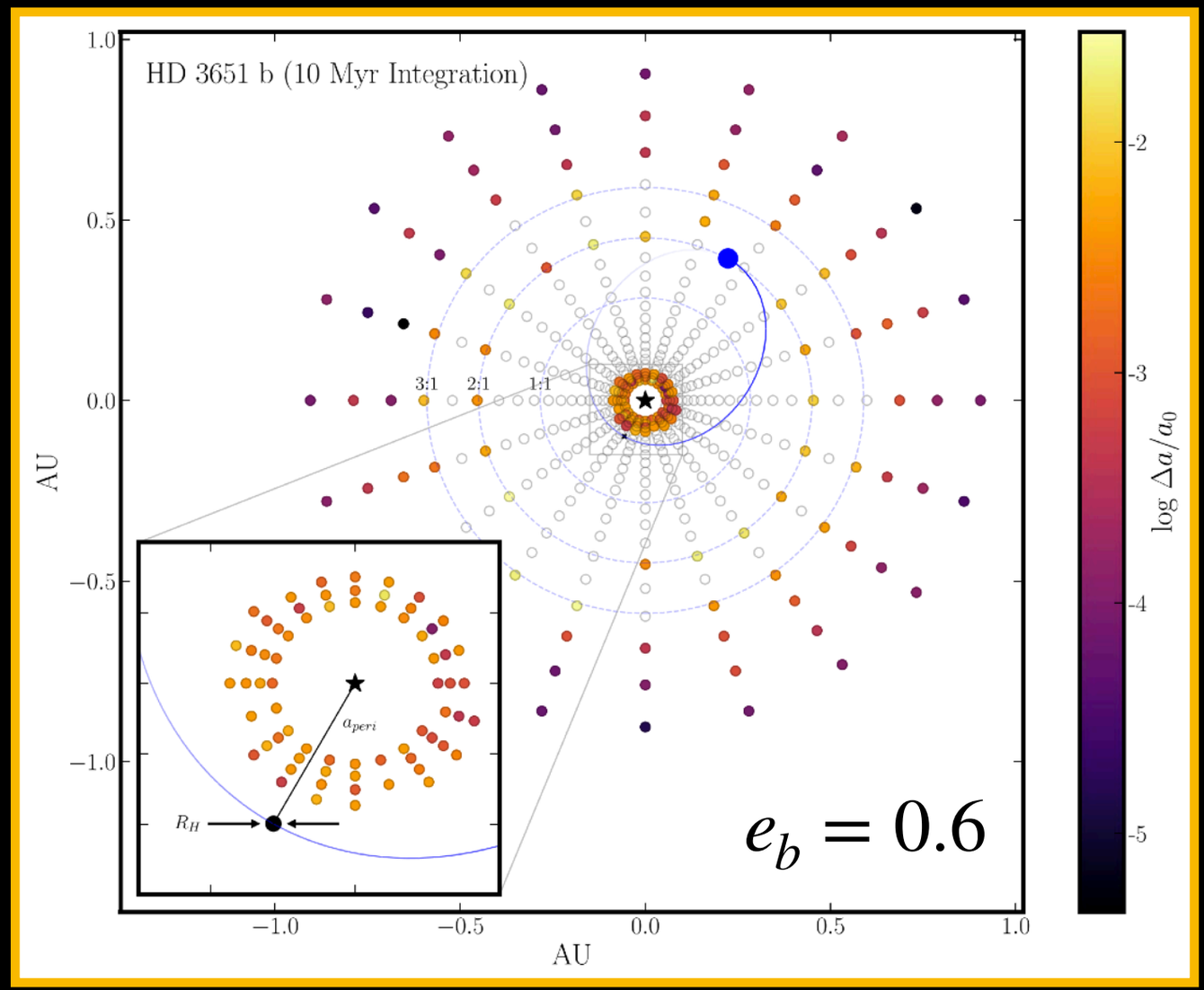
Eccentric giants

Eccentric giants clean out a whole period range.

Adding this dynamical information improves the system completeness.

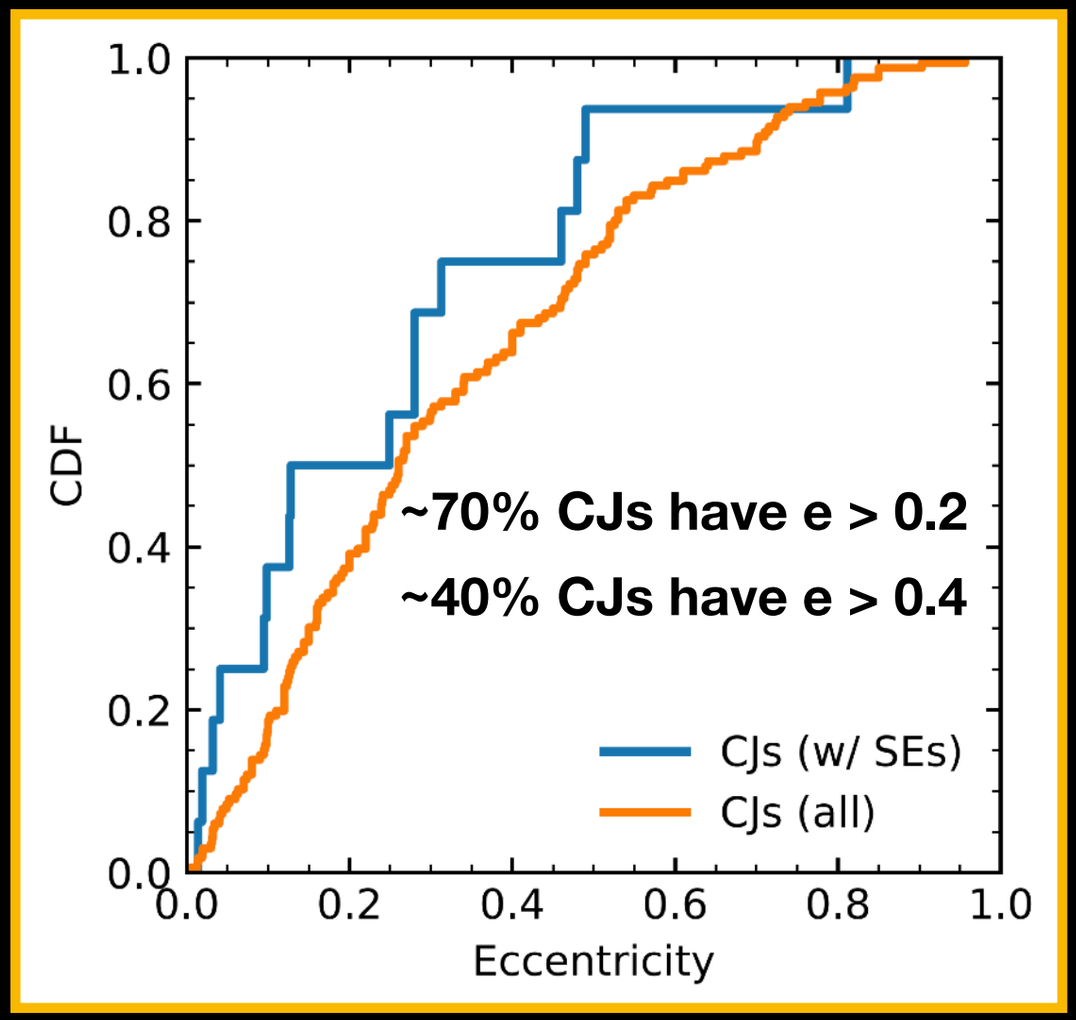
Role as standard stars.

Brewer et al. 2020

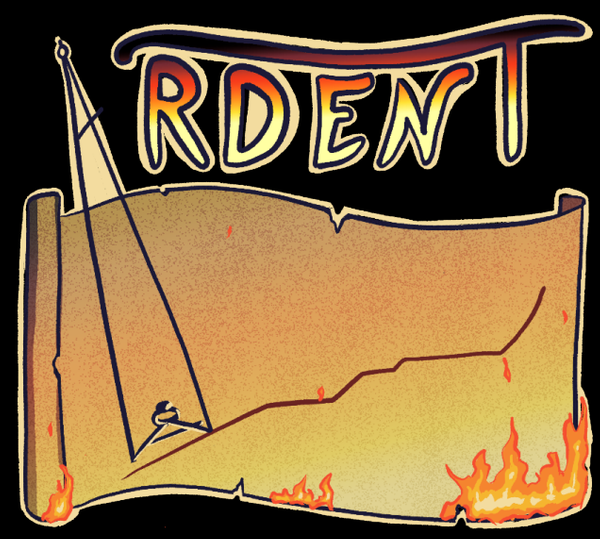


Eccentric giants

Zhu & Wu 2018



The dynamical influence of giant planets is not reflected in the detection limits.



A Python package for the computation of dynamical detection limits

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RV data + dynamical viability

$$\mathcal{P}_{miss} = (1 - \mathcal{P}_d) \times \mathcal{P}_s$$

data *stability*

Data-driven detection limits

Mass

$\mathcal{P}_d \sim 1$

$\mathcal{P}_d < 1$

Period

$$\mathcal{P}_{miss} = (1 - \mathcal{P}_d) \times \mathcal{P}_s$$

data *stability*

Data-driven detection limits

Dynamical detection limits

$\mathcal{P}_d < 1 \quad \mathcal{P}_s > 0$

$\mathcal{P}_s = 0$

Orbital stability estimation

Analytic: orbit crossing, AMD-stability

Numeric: Short-term integrations and chaos estimation

REBOUND **Drift in** a

Application to TOI-1732

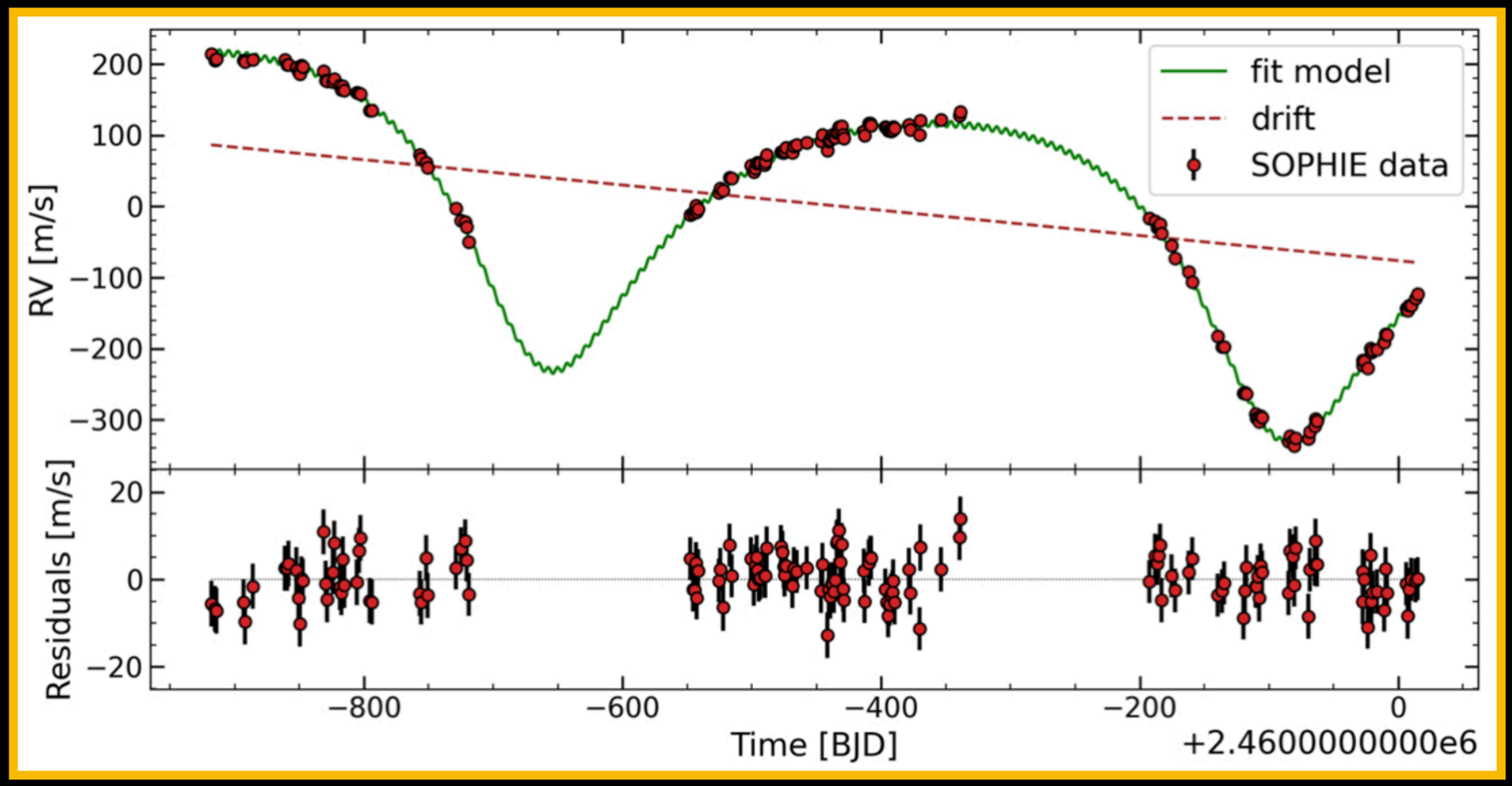
Inner sub-Neptune (P=7d) $e_b \sim 0$

Outer cold Jupiter (P=570d) $e_c = 0.362 \pm 0.003$

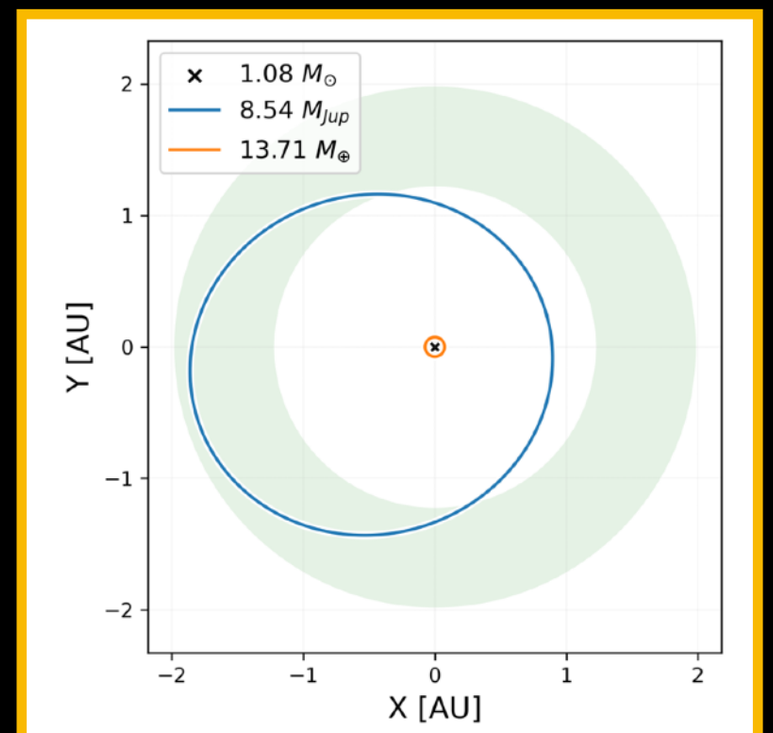
} **152 SOPHIE RVs**

Orbiting a solar analog.

Martioli+2023



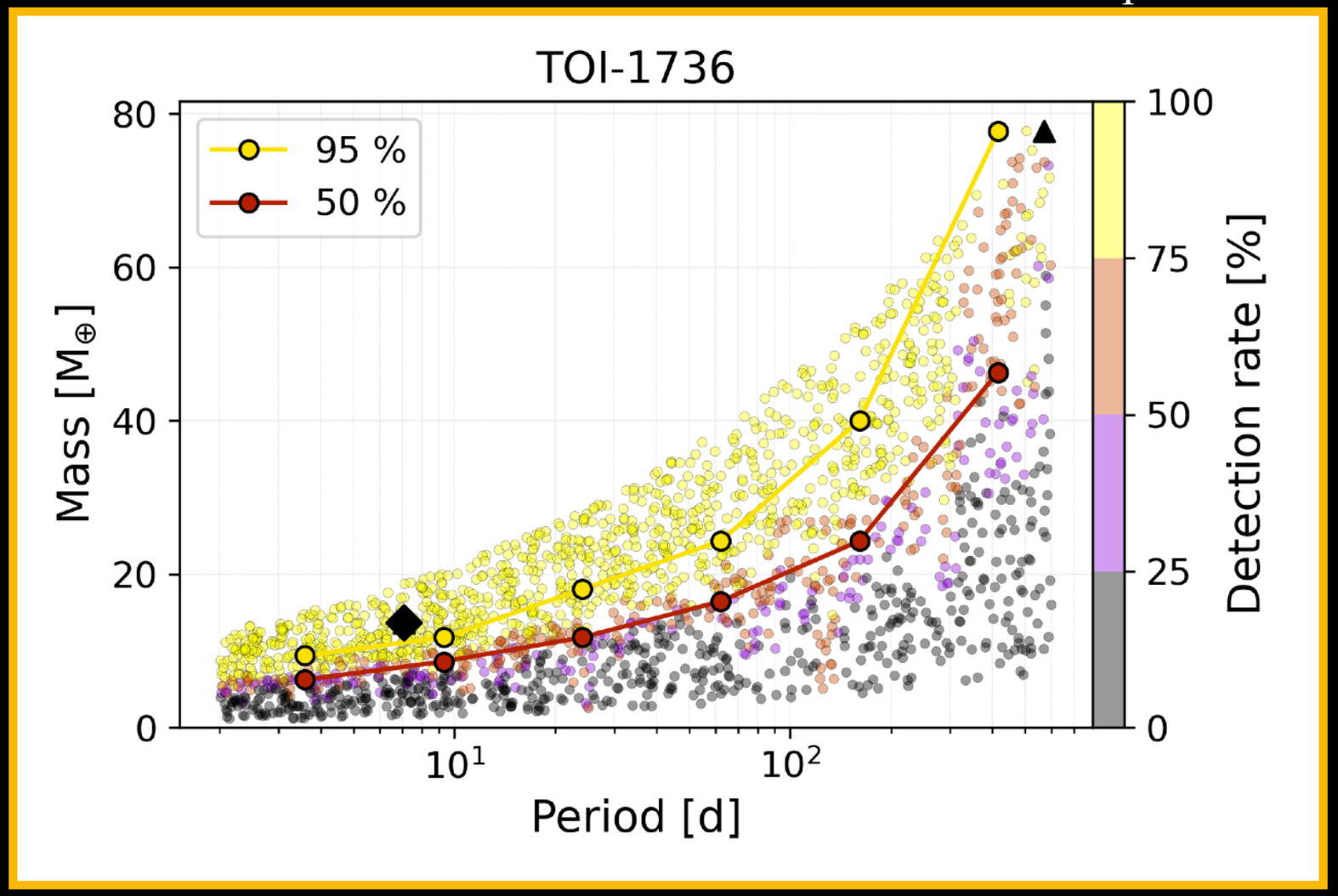
(ARDENT output)



Application to TOI-1732

Data-driven detection limits

Stalport+2025

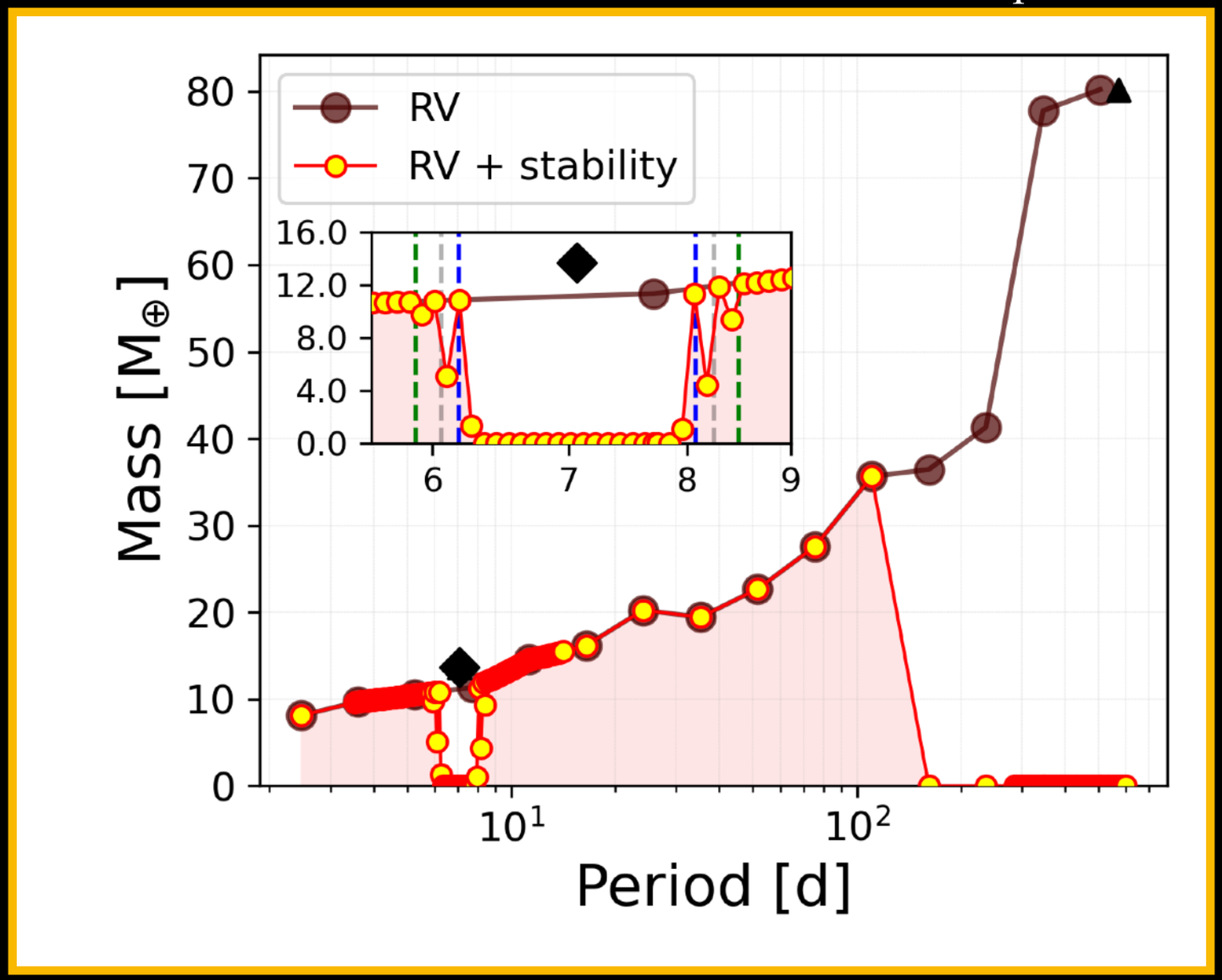


`ARDENT_DetectionLimitRV(rangeP=[2., 600.])`

Application to TOI-1732

Dynamical detection limits

Stalport+2025

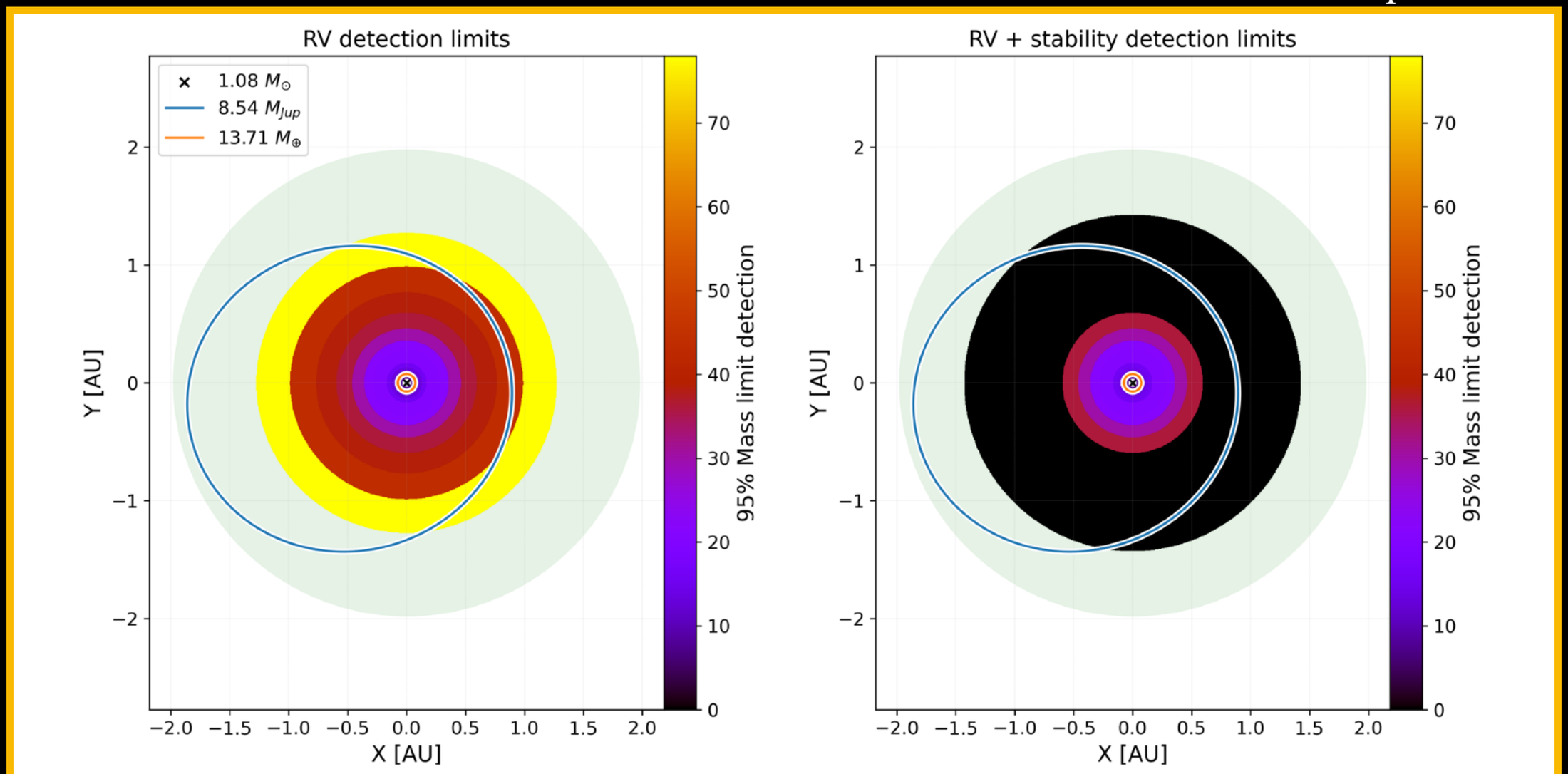


`ARDENT_DetectionLimitStab(NlocalCPU=4)`

Application to TOI-1732

Dynamical detection limits

Stalport+2025



`ARDENT_FinalPlot()`

ARDENT

An open-source Python package for the computation of dynamical detection limits

https://github.com/manustalport/ardent

- Tighten the detection limits
- Inform RV follow-ups
- Test the dynamical viability of planet candidates

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RDENT

Supplementary material

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Dynamical detection limits iteration

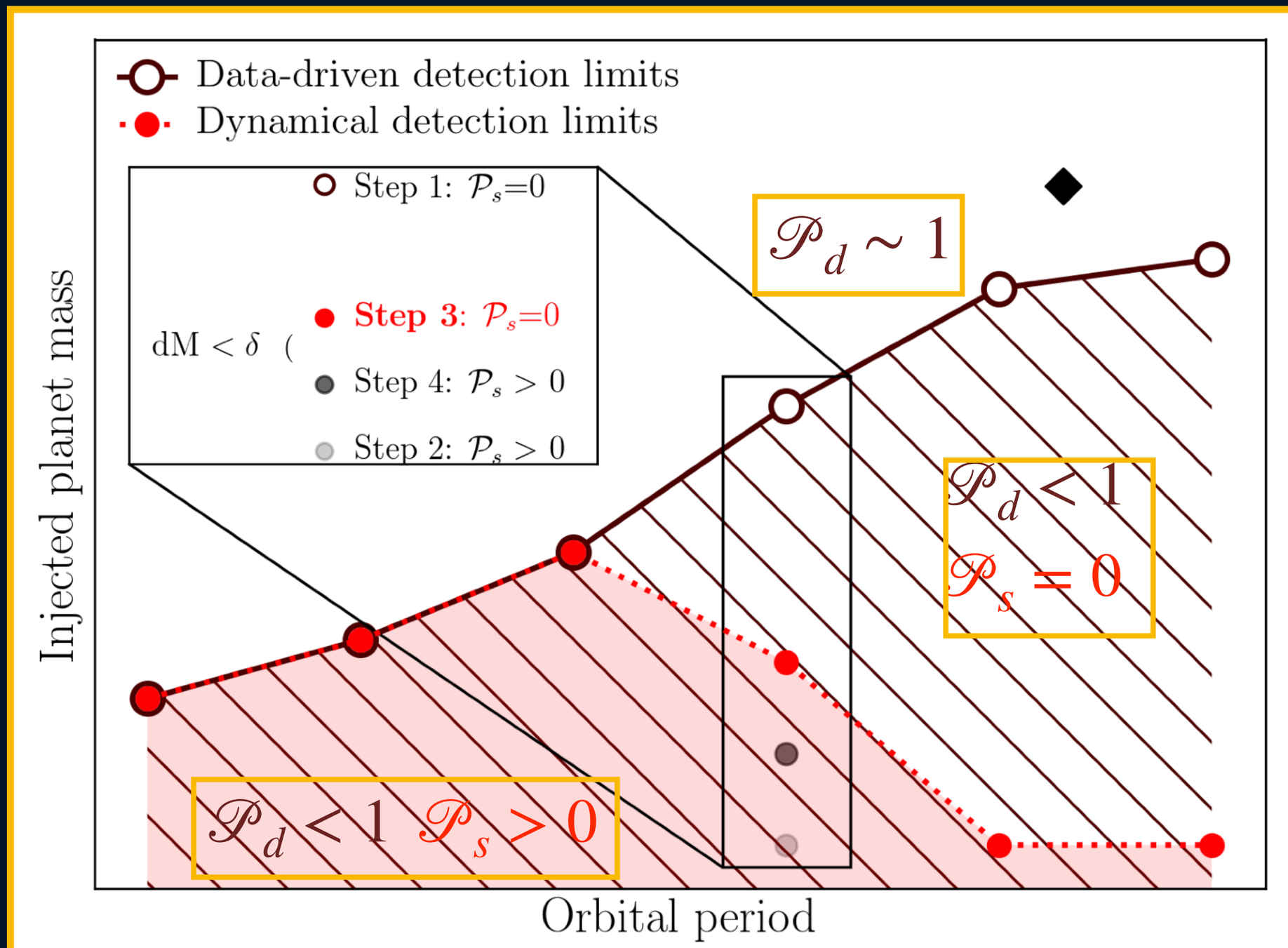
$$\mathscr{P}_{miss} = (1 - \mathscr{P}_d) \times \mathscr{P}_s$$

$\mathscr{P}_{miss} = 0$ **if**

$\mathscr{P}_d = 1$

or

$\mathscr{P}_s = 0$



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Chaos calibration

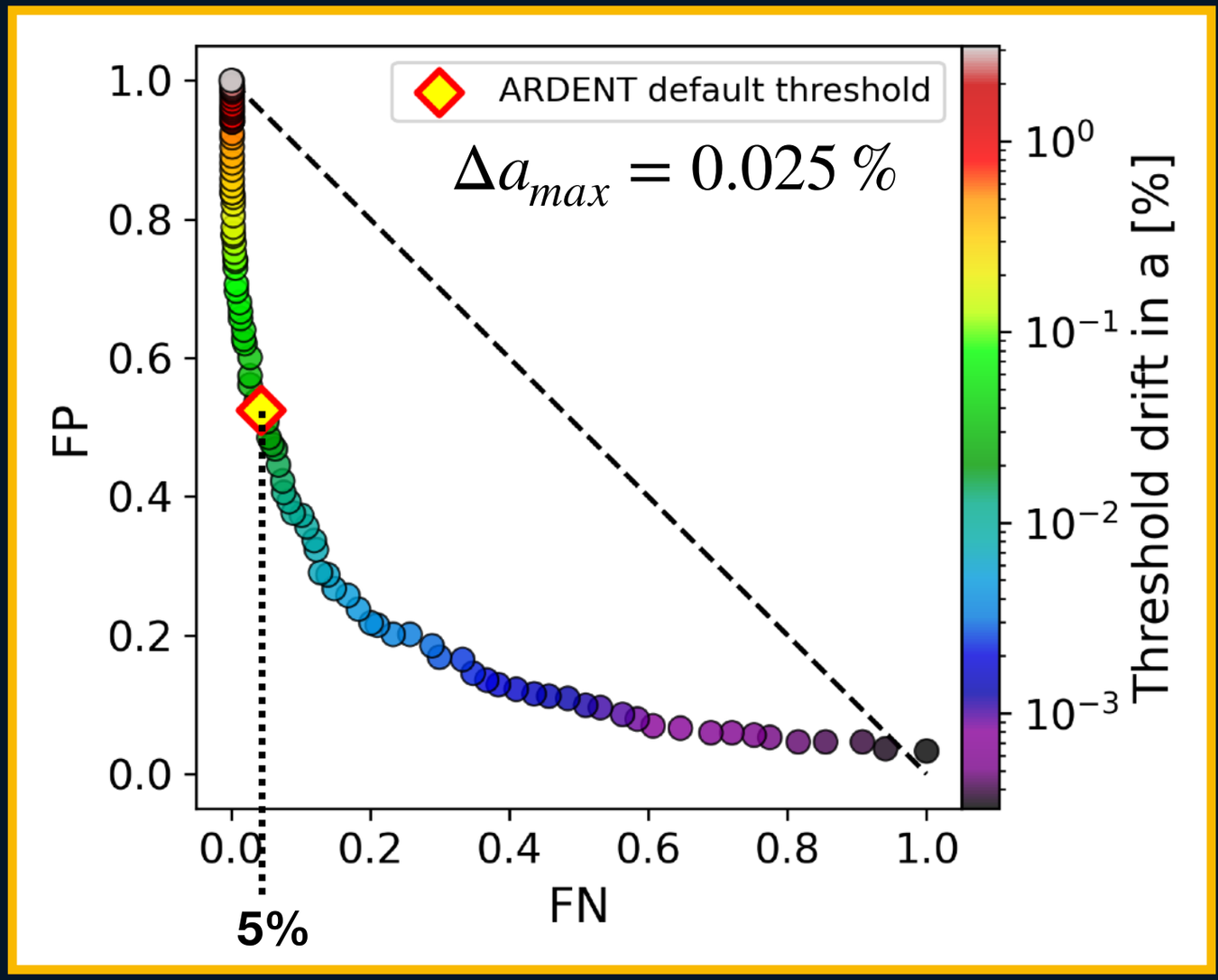
Drift in semi-major axes a

A conceptually simple chaos indicator

Threshold drift calibrated from SP-CJ simulated systems.

FP: fake stable

FN: fake unstable



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