A new population of giant exoplanets with Gaia

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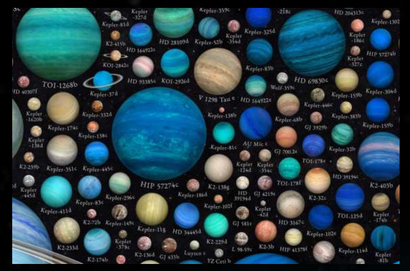
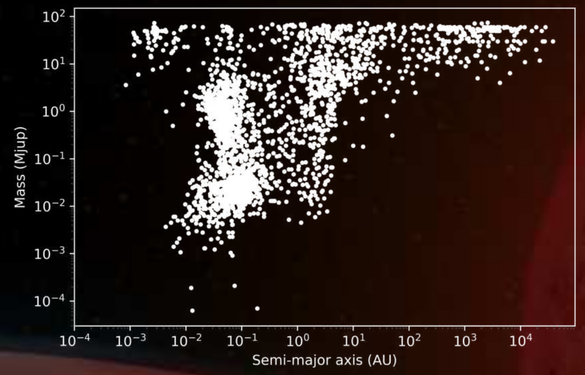
Motivations - PhD thesis



Detect giant planets (GP)



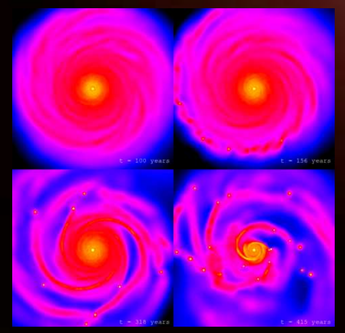
Make statistics on GP population

Understand rocky planet evolution

Short-term → Long-term

Characterize GP

Constrain models



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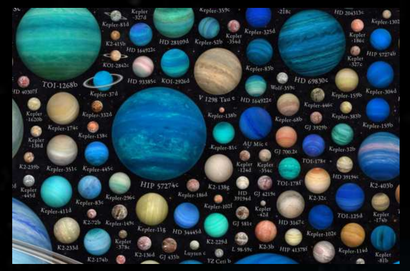

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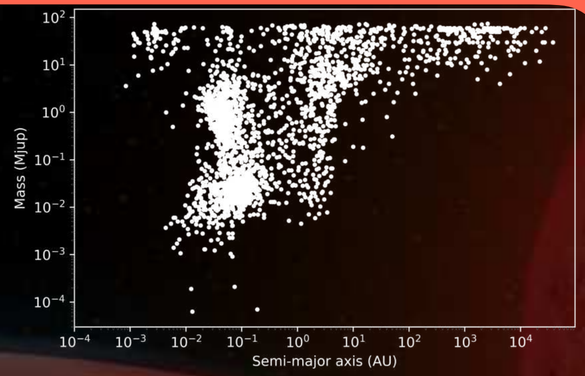

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Understand rocky planet evolution

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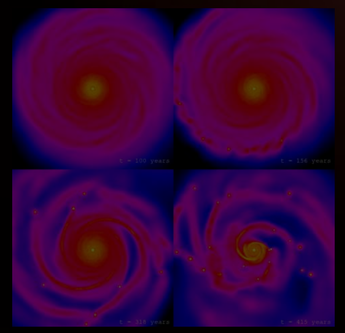
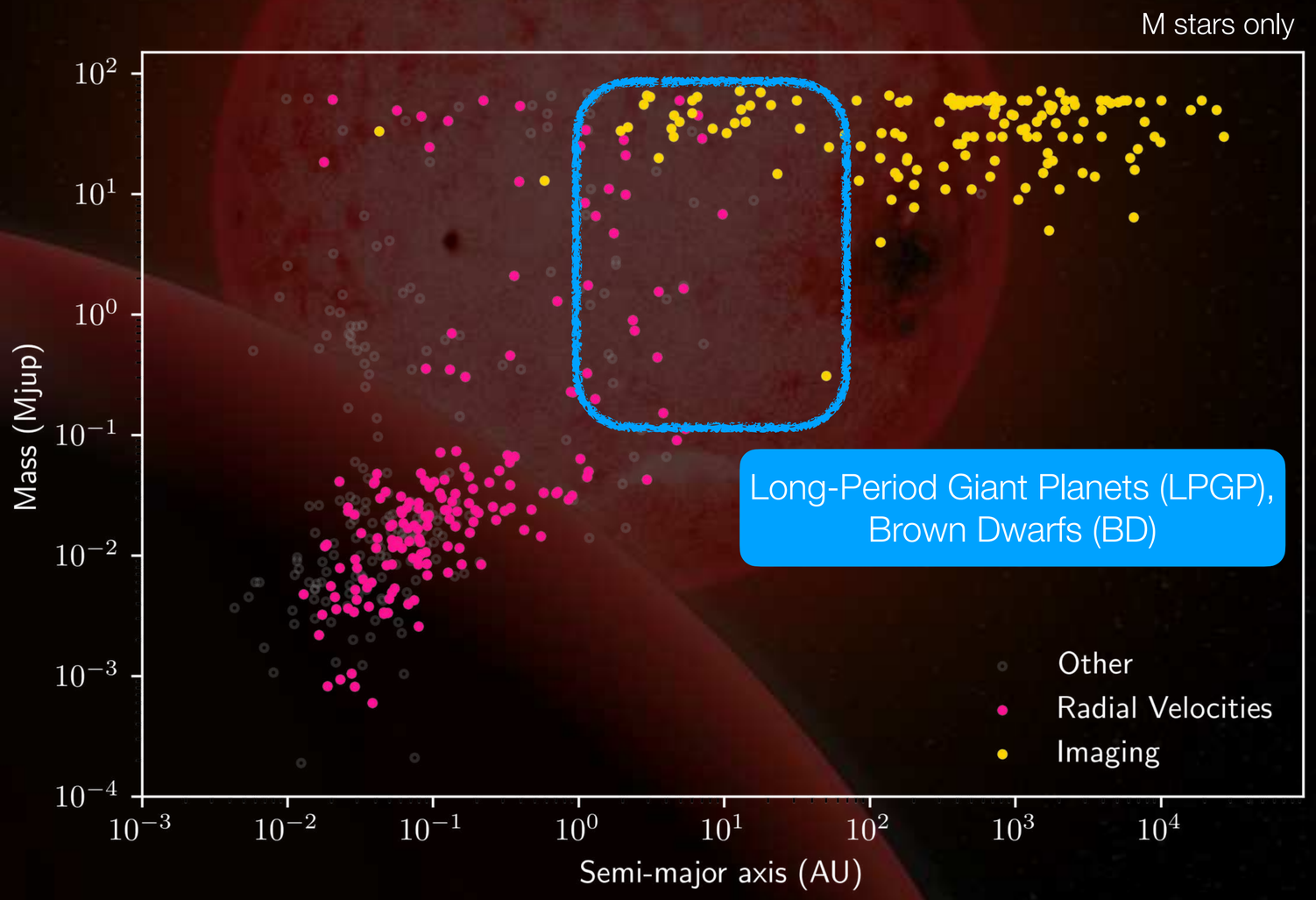


PhD thesis

Motivations - Multi-technique analysis

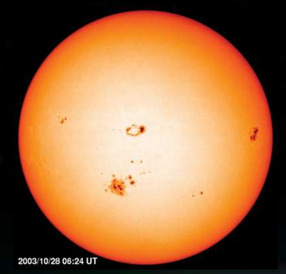
- Astrometry → Gaia DR3 (+ Hipparcos)
- Radial Velocities → Archival data
- Direct Imaging → Archival data

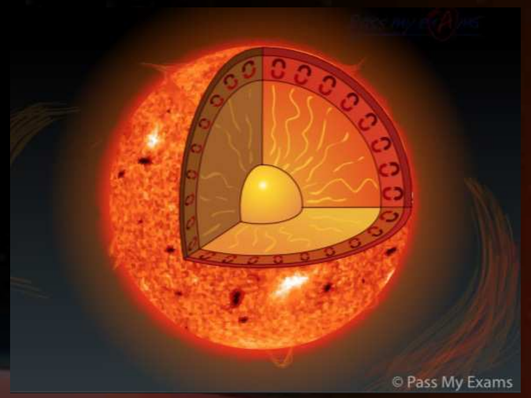
- Astrometry opens the door to the detection of new GP
- A joint analysis enables their characterization



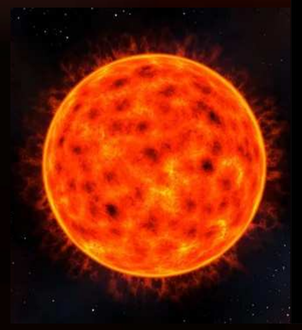
Motivations - M stars

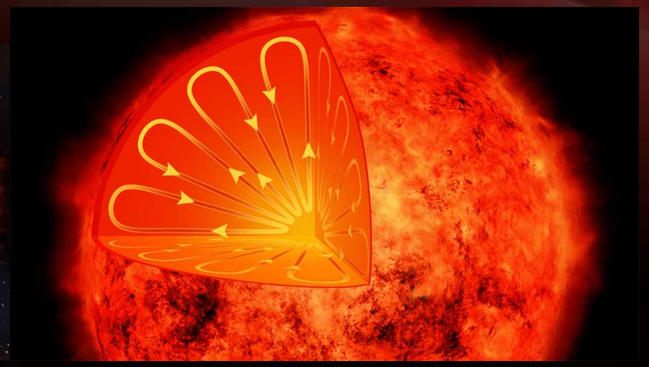
G stars





M dwarfs





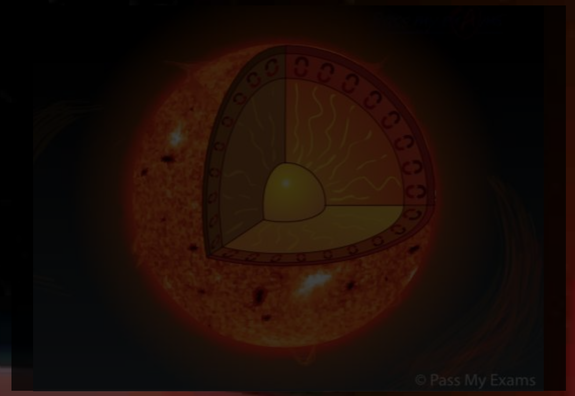
More active

Less massive, cooler

75% of stars are M dwarfs

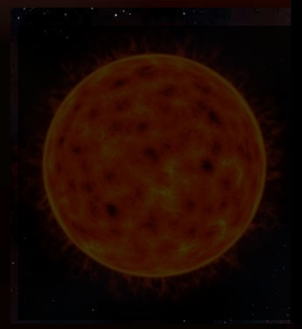
Motivations - M stars

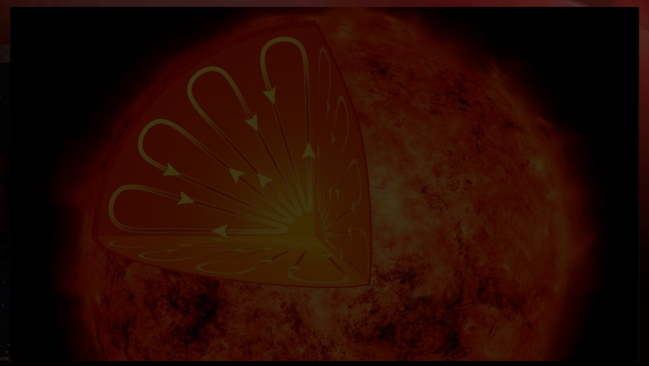
G stars



1 $M_\odot$

M dwarfs





More active

0.1-0.8 $M_\odot$

Less massive, cooler

75% of stars are M dwarfs

Searching for low-mass planets ?

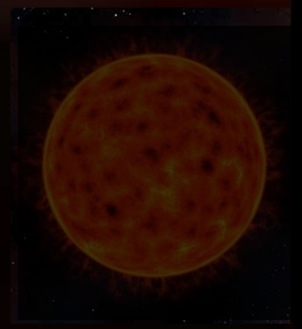
Search around M dwarfs !!

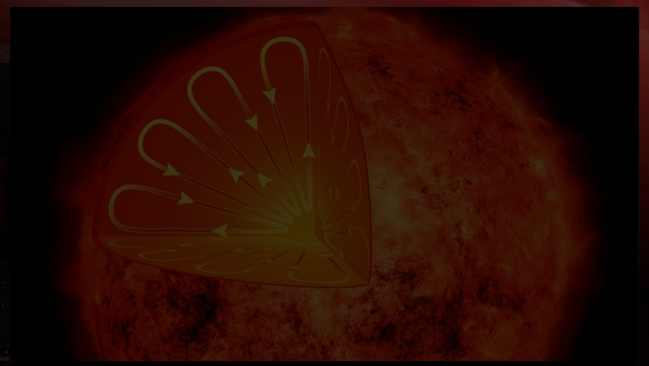
Motivations - M stars

G stars

1 $M_\odot$

M dwarfs





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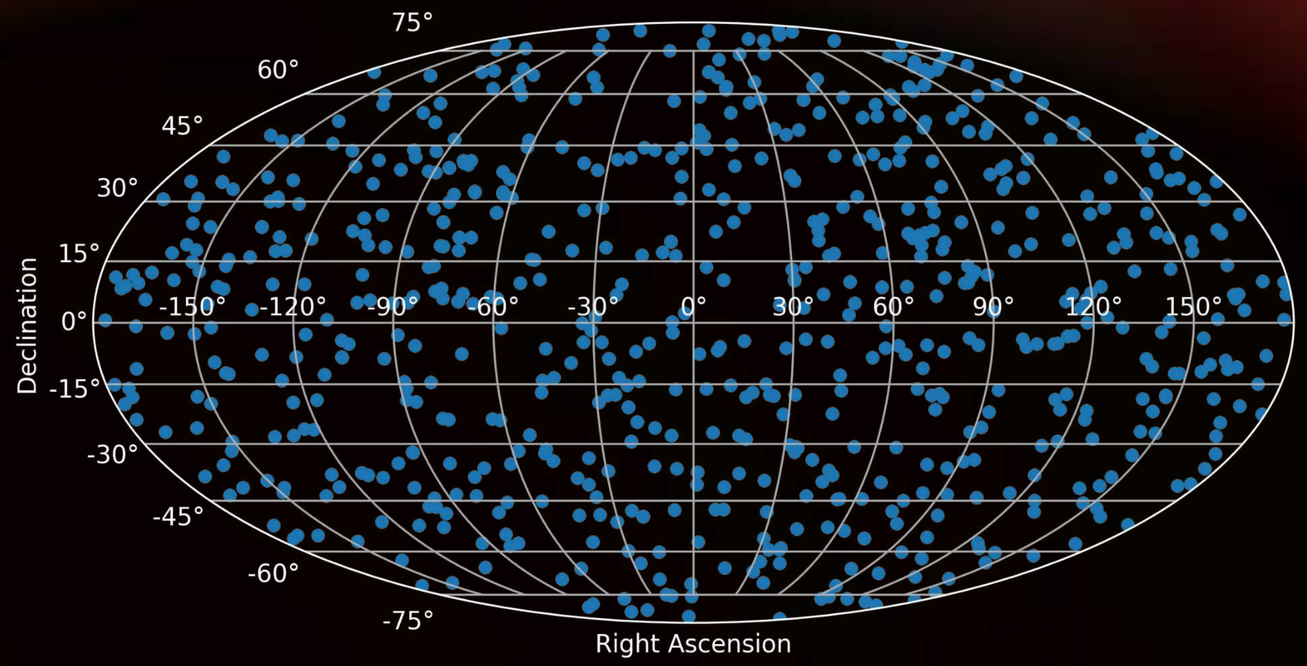
Searching for low-mass planets ?
Search around M dwarfs !!

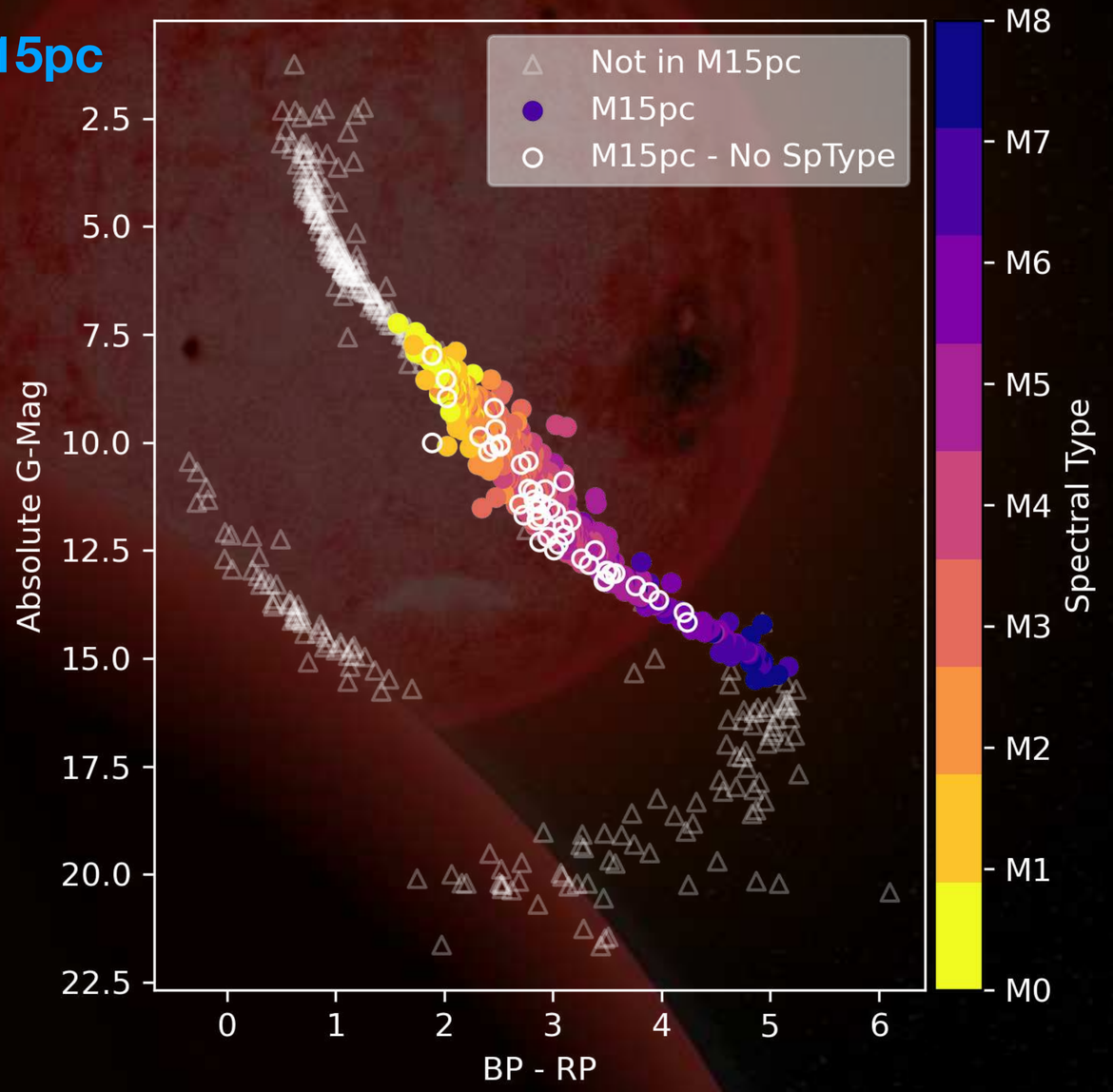
⇒ Need to understand the whole planetary system, including LPGPs or BDs

The M15pc catalog

To detect exoplanets around nearby M dwarfs : M15pc

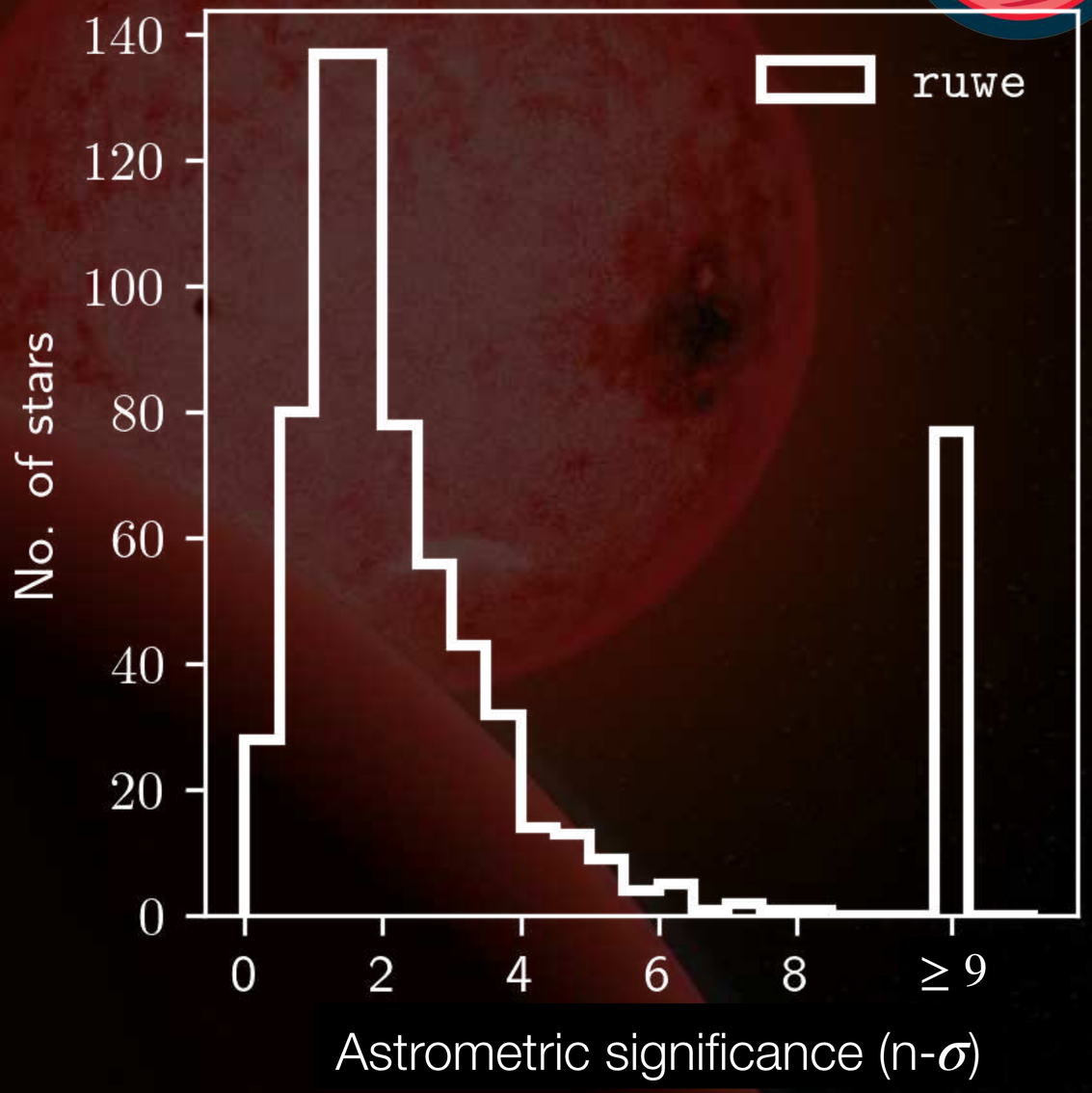
- Derived from CNS5 (Golovin et al. 2023)
- d < 15pc
- Relatively bright (Gmag < 16)
- **727 M-dwarfs**





Astrometric significance

- `GaiaPMEX` : Kiefer et al. 2024a, b
- Astrometric significance : the confidence that the object is NOT single
- Gaia DR3 (+ Hipparcos) public data



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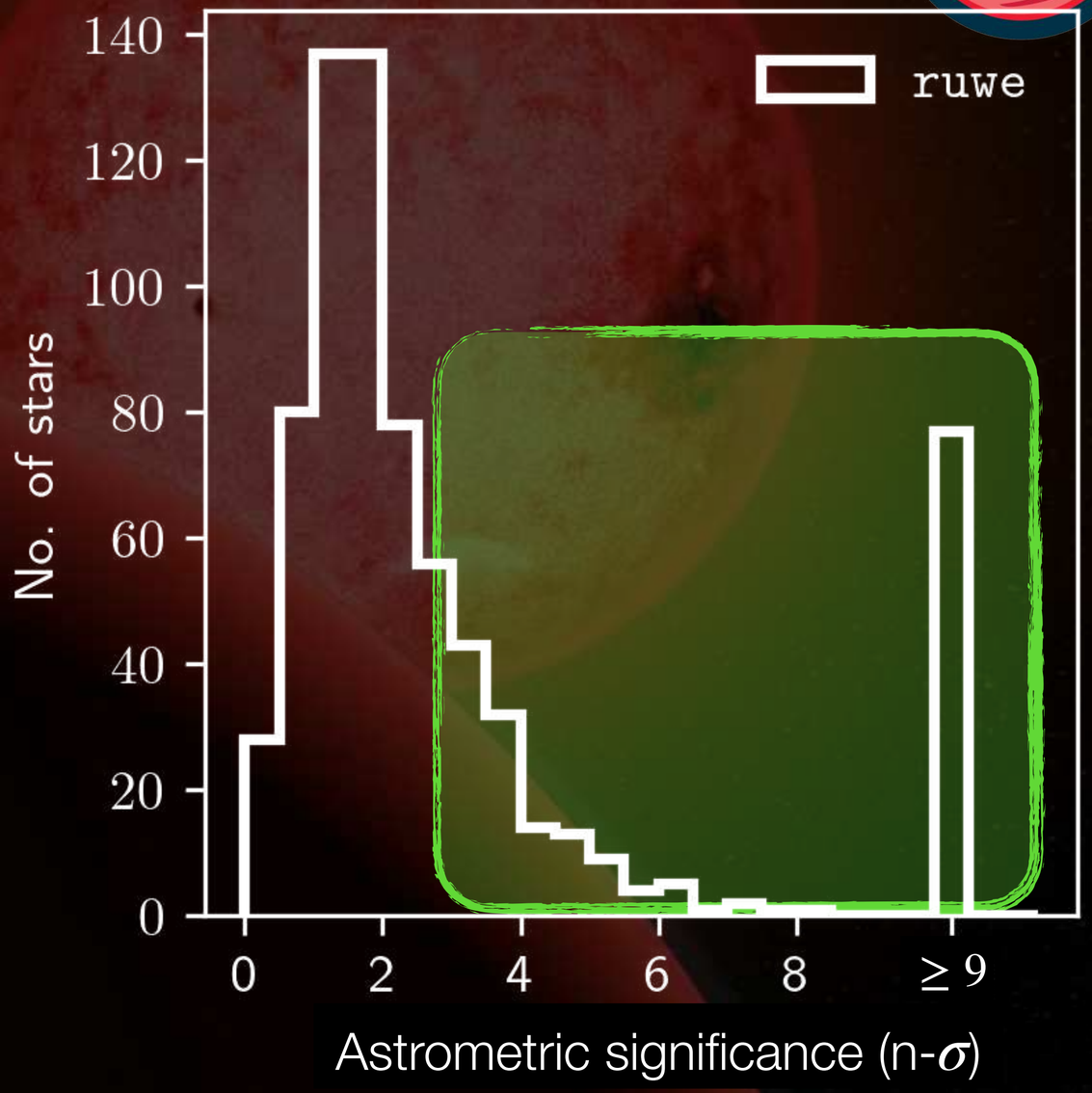
242 detections of a companion !

Multiplicity Fraction $< 33\,\%$ (In accordance with the literature, e.g. Winters et al. 2019, Offner et al. 2023)



Confidence maps

(M_p, a_p)

↓

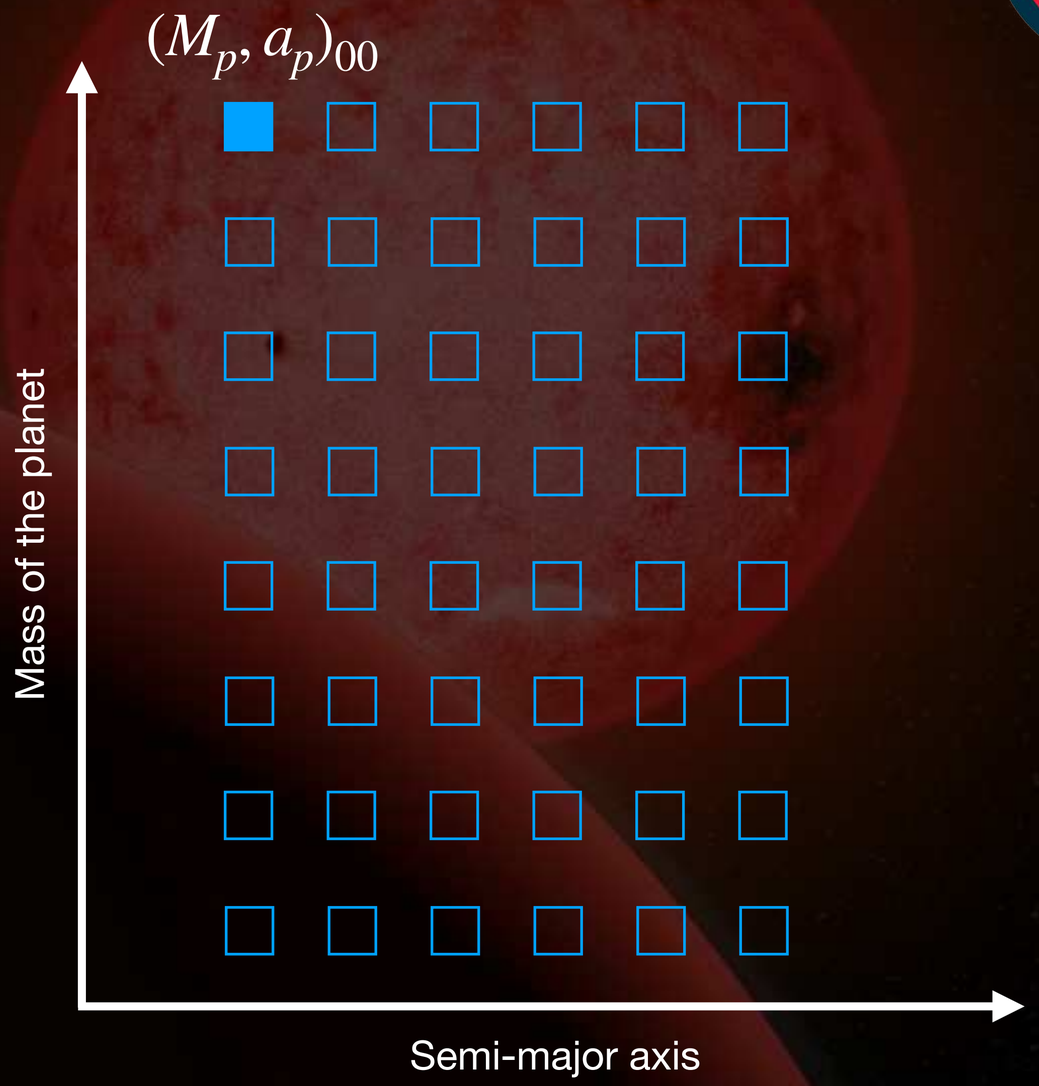
Simulate Gaia orbit

↓

Compare to DR3

↓

Assign a likelihood



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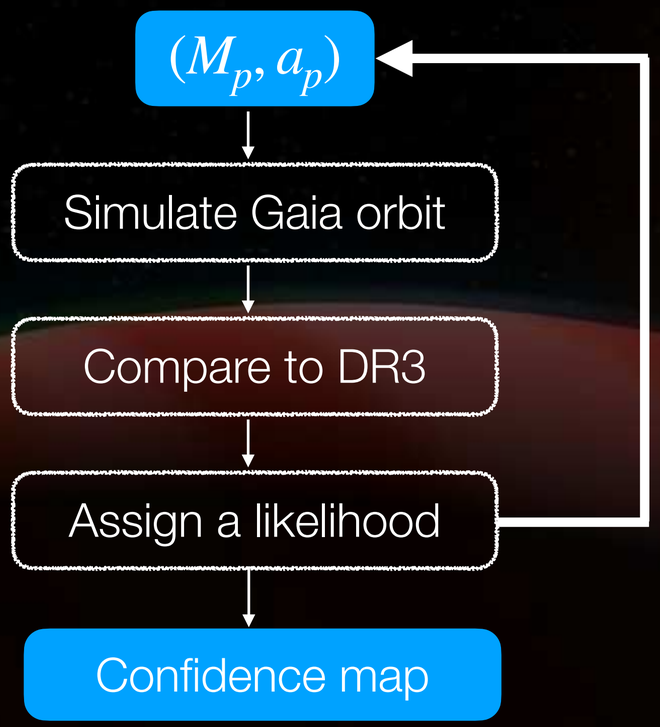

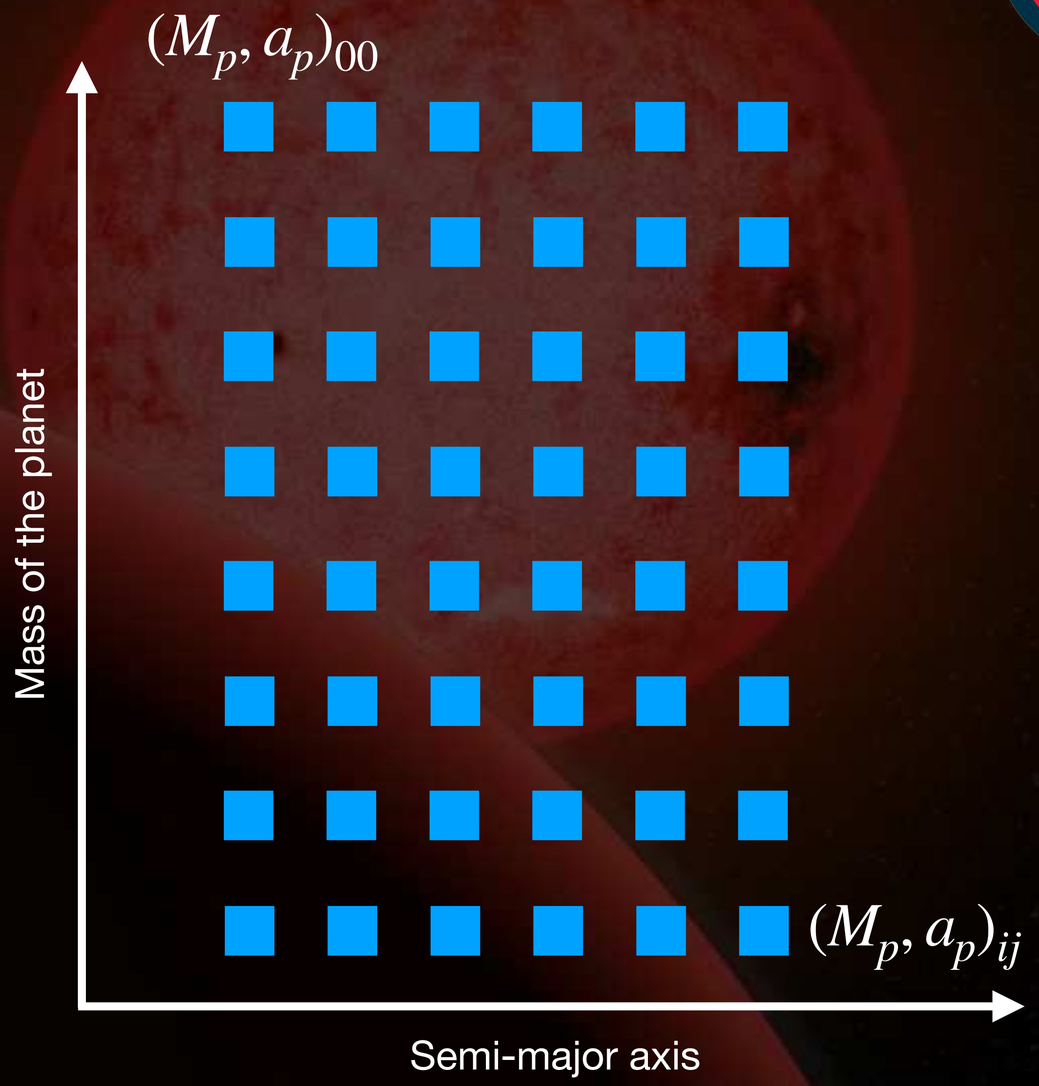

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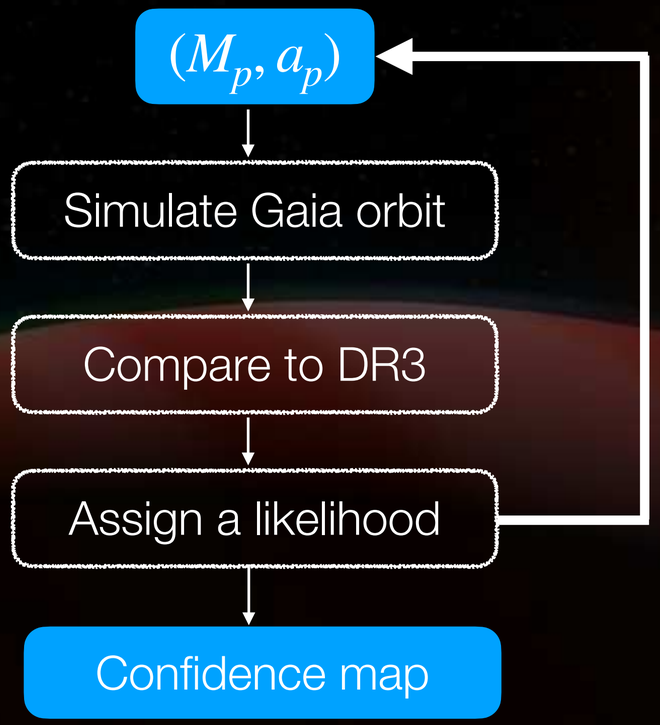

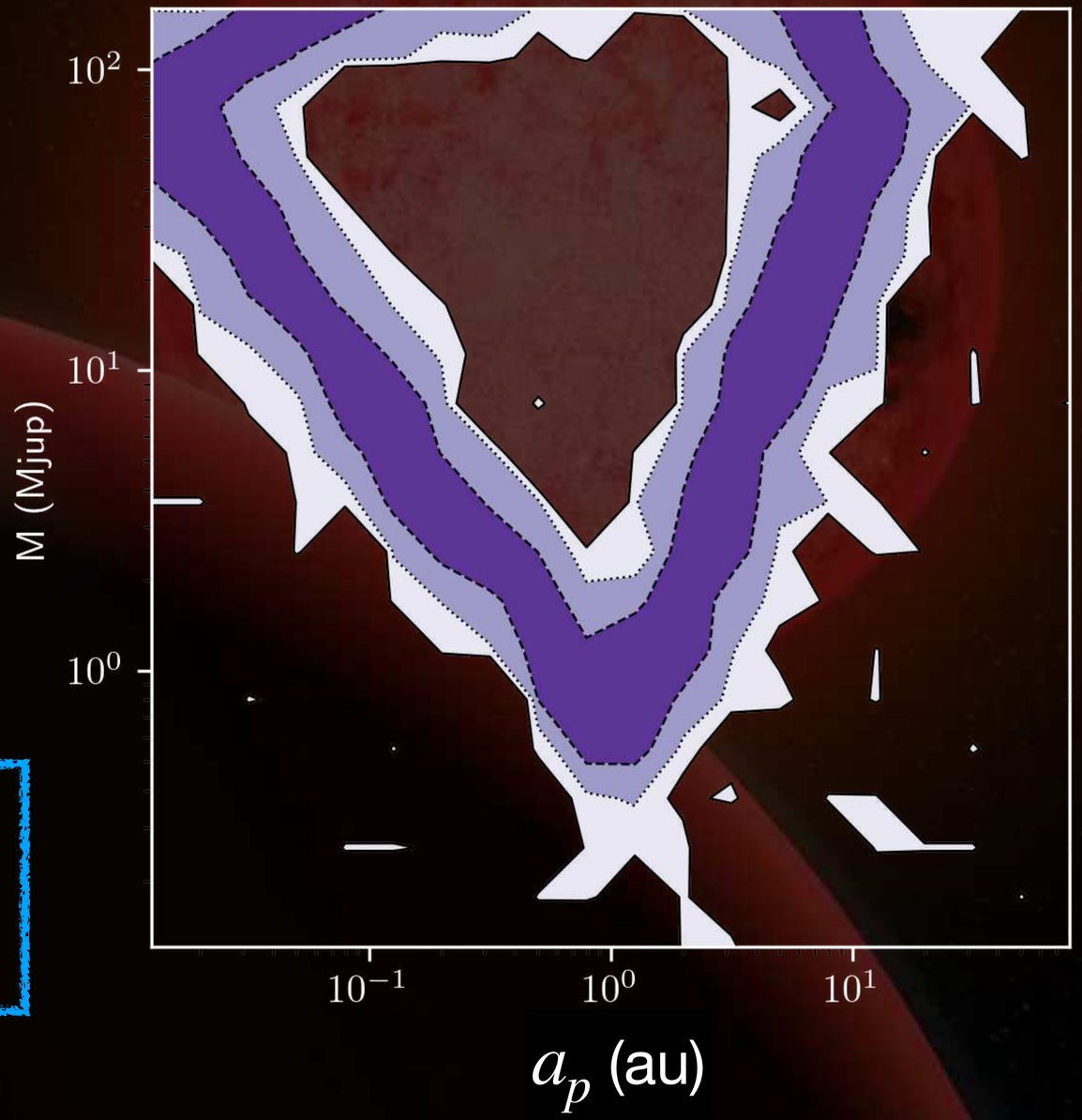

- M_p and a_p are degenerate
- 2 regimes, inflection at P=3yrs
- Astrometry reduces the parameter space

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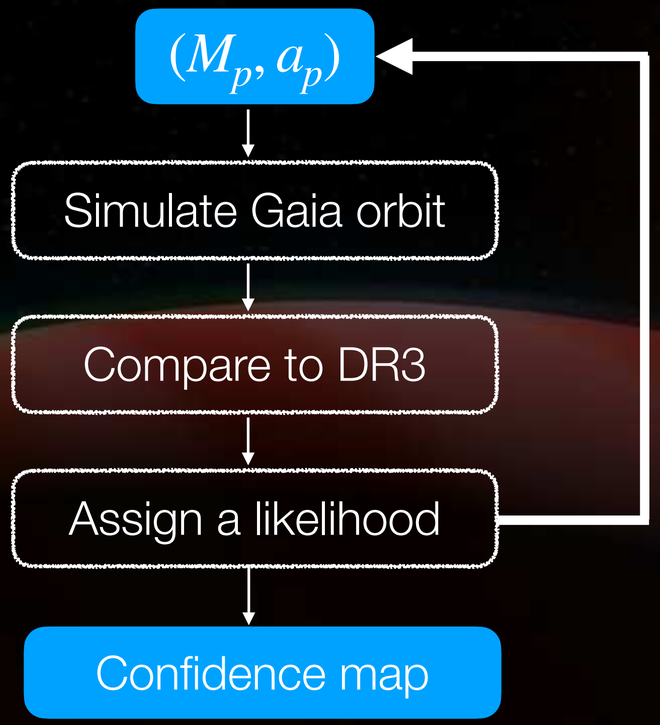

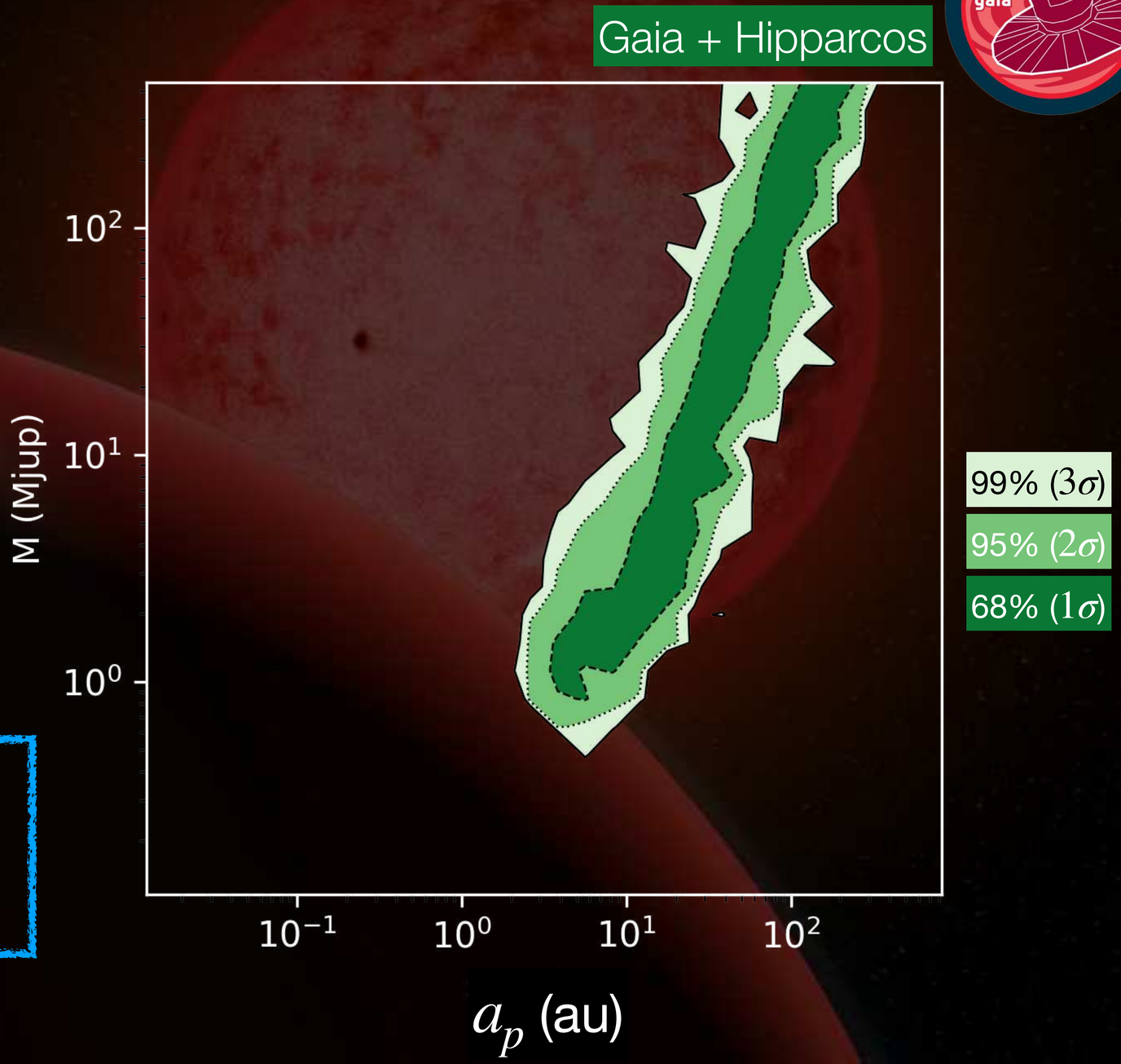

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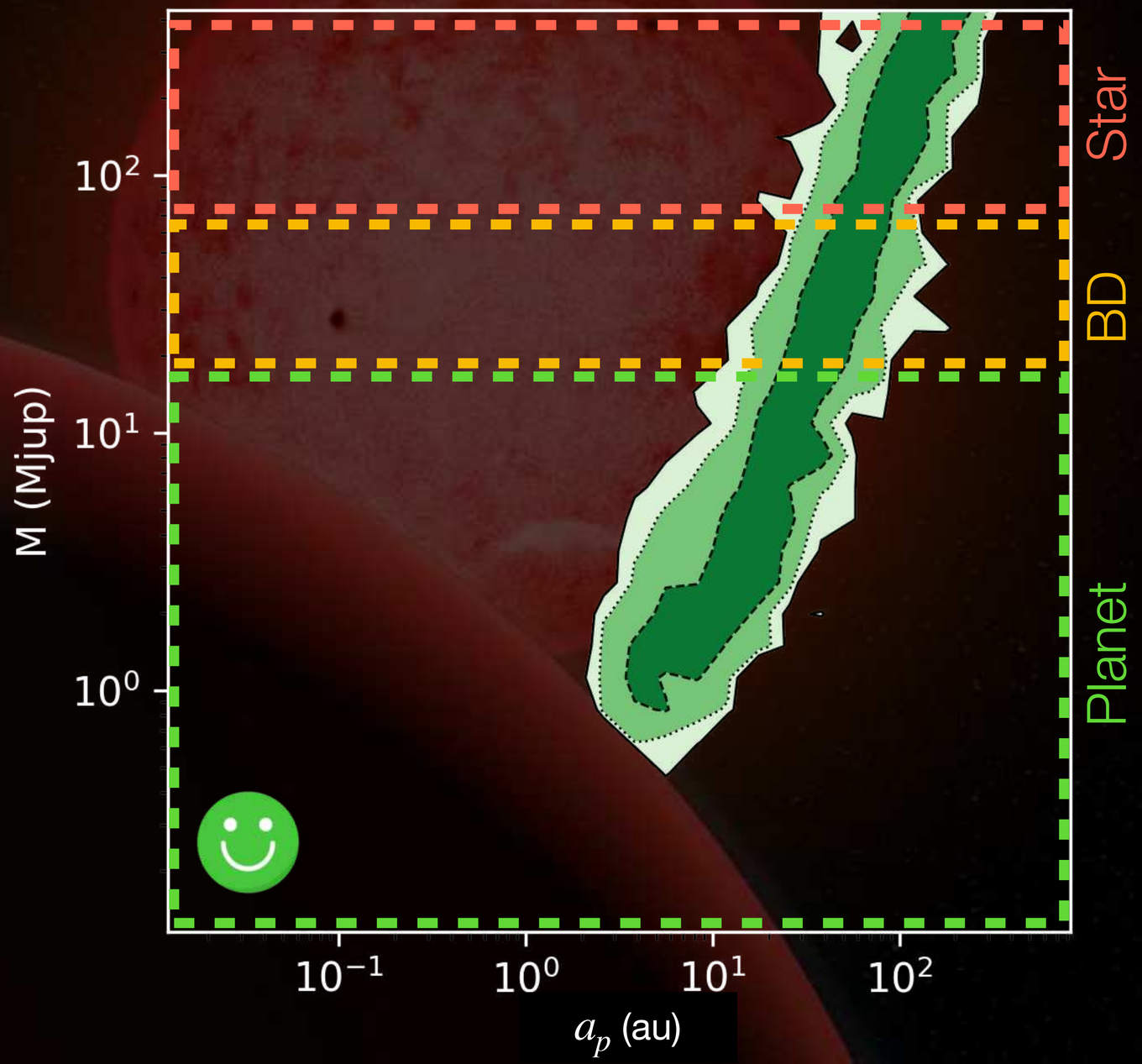
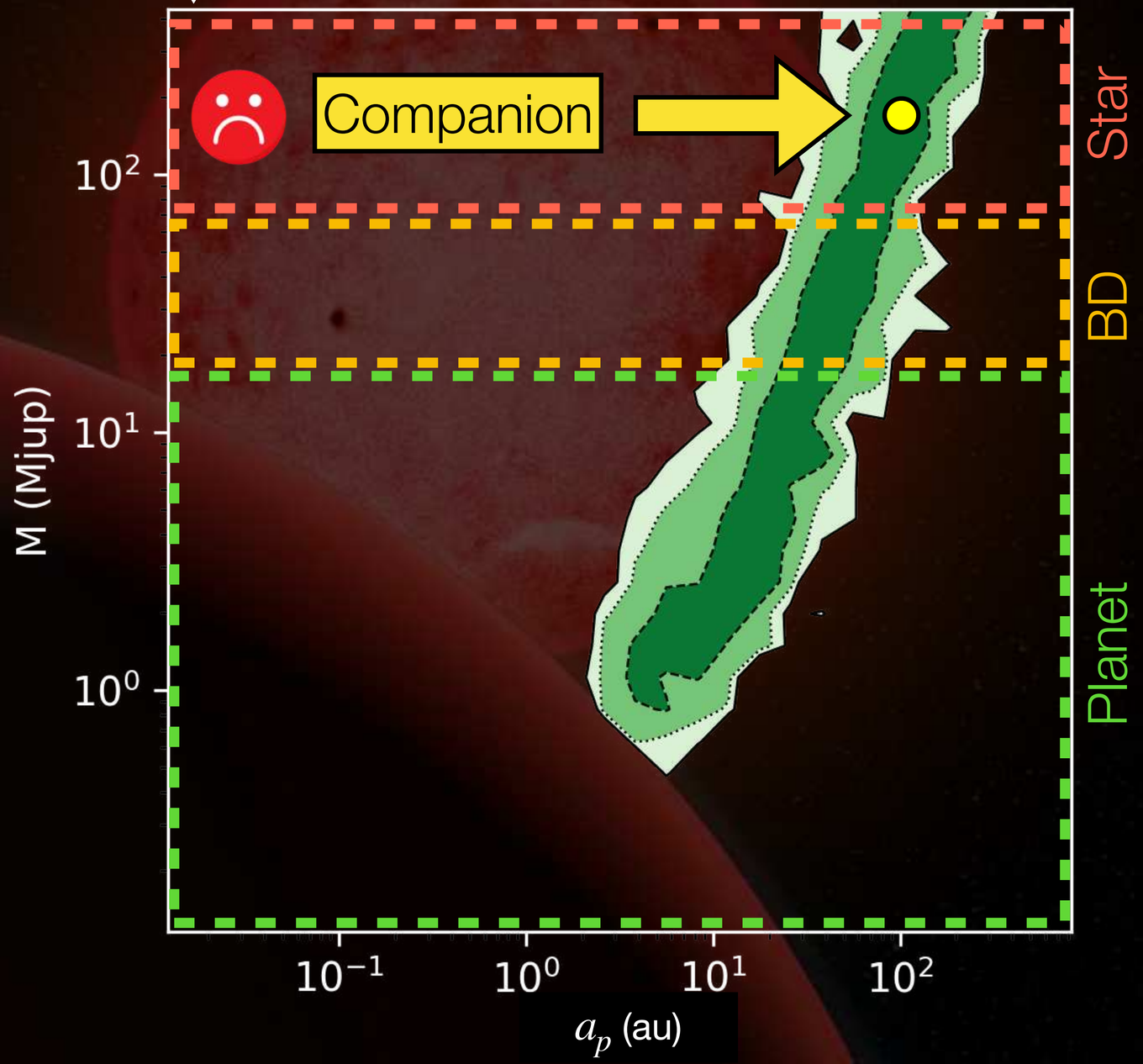
The exoplanet iceberg



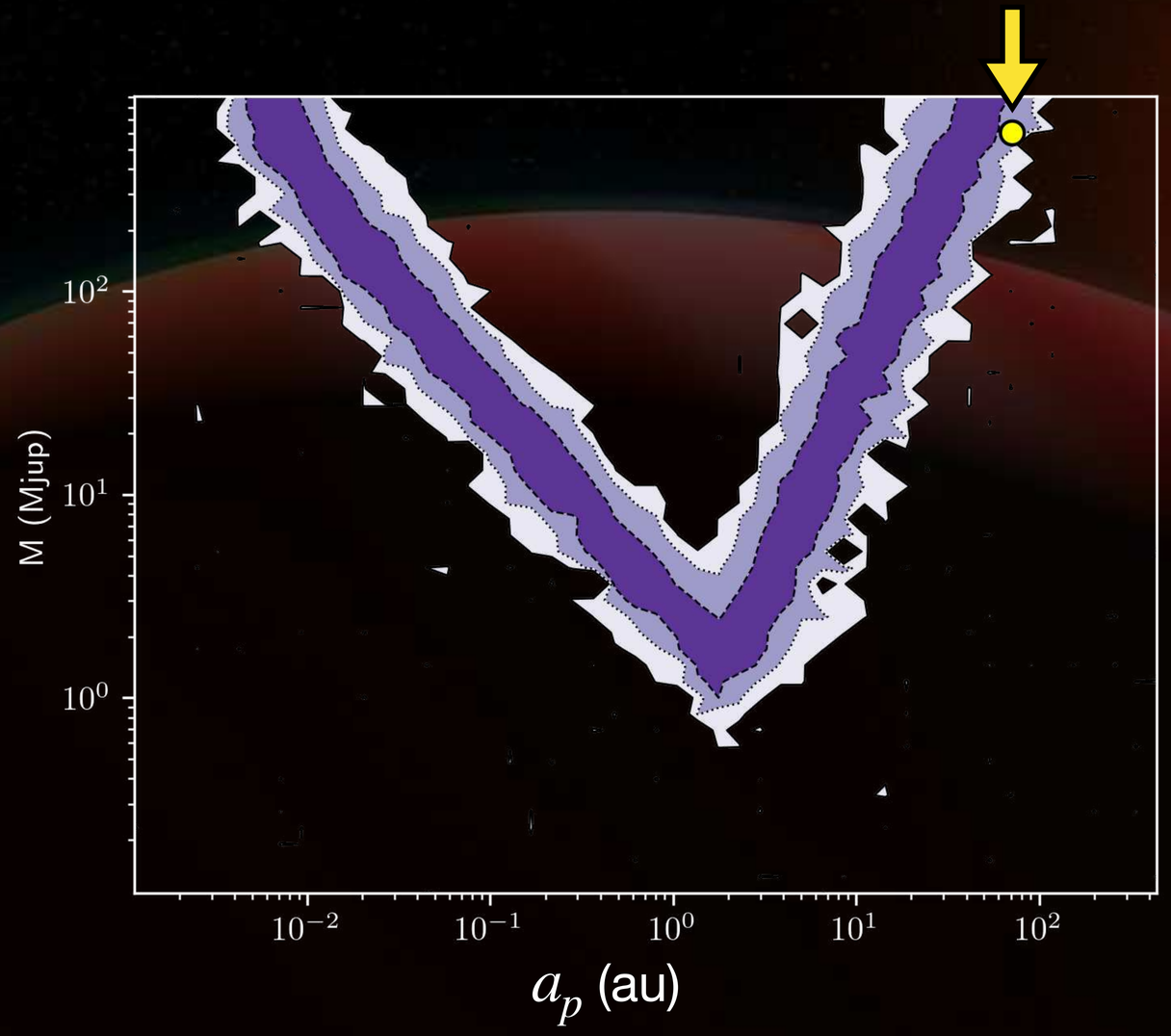
The exoplanet iceberg

Host star : GJ 15 A
Known companion : GJ 15 B ($0.16 M_\odot$, 135au)



Exclude binary stars

Known companion in WDS



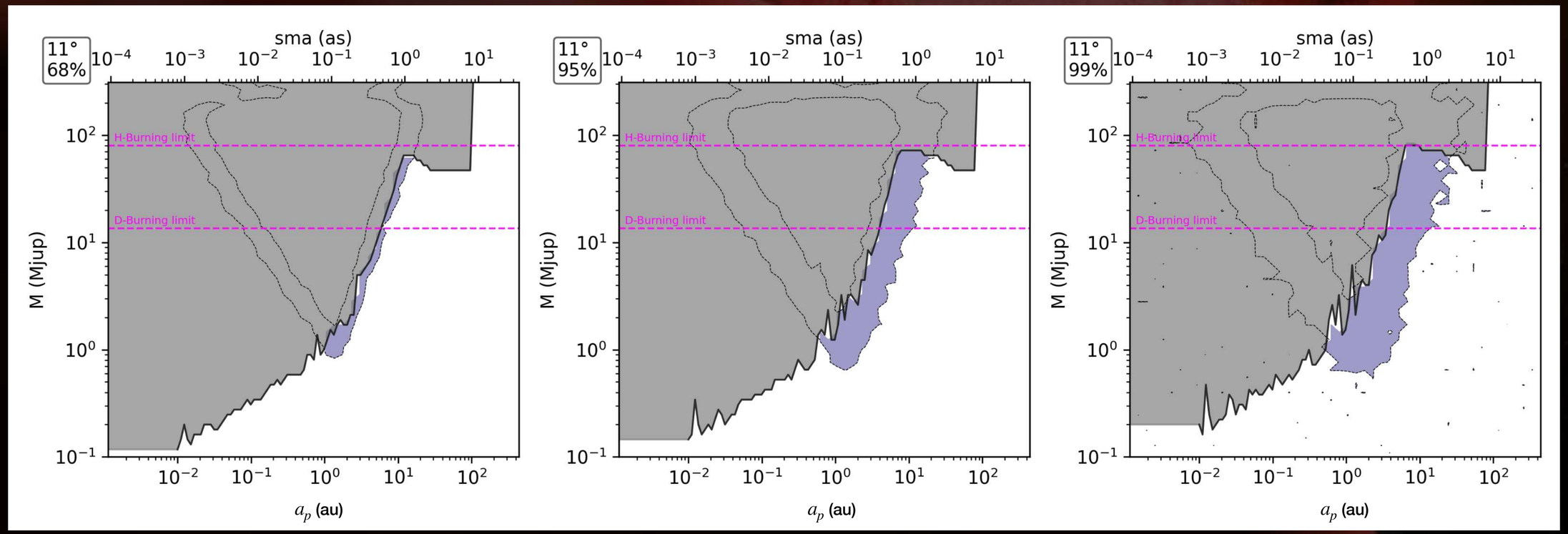
- Systematic vetting using the WDS catalog (Mason et al. 2001)
- Physical associations
- Compare with GaiaPMEX detection maps

26 close binaries excluded from the candidates substellar companions

Host star : HD38B (WDSJ00057+4549B)
Known companion : HD38A ($0.6 M_\odot$, 70au)

Joint analysis - Identifying substellar companions

- Astrometry → Gaia, Hipparcos
- Radial Velocities → SOPHIE, HARPS, HIRES etc.
- Direct Imaging → HST, Robo-AO, POKEMON etc.



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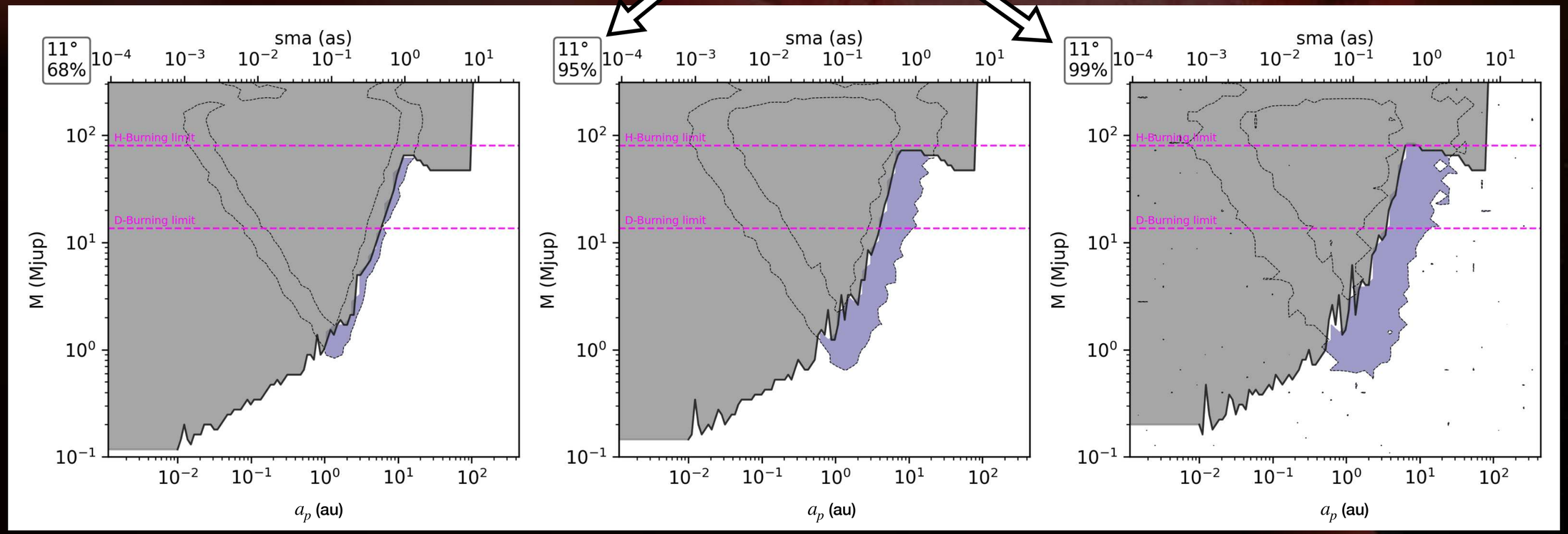
Inclination Confidence



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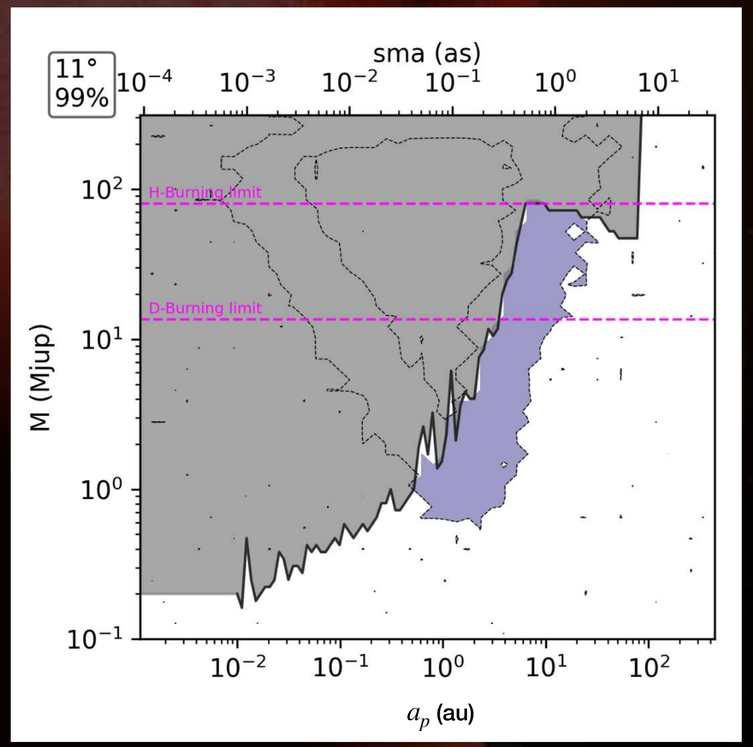

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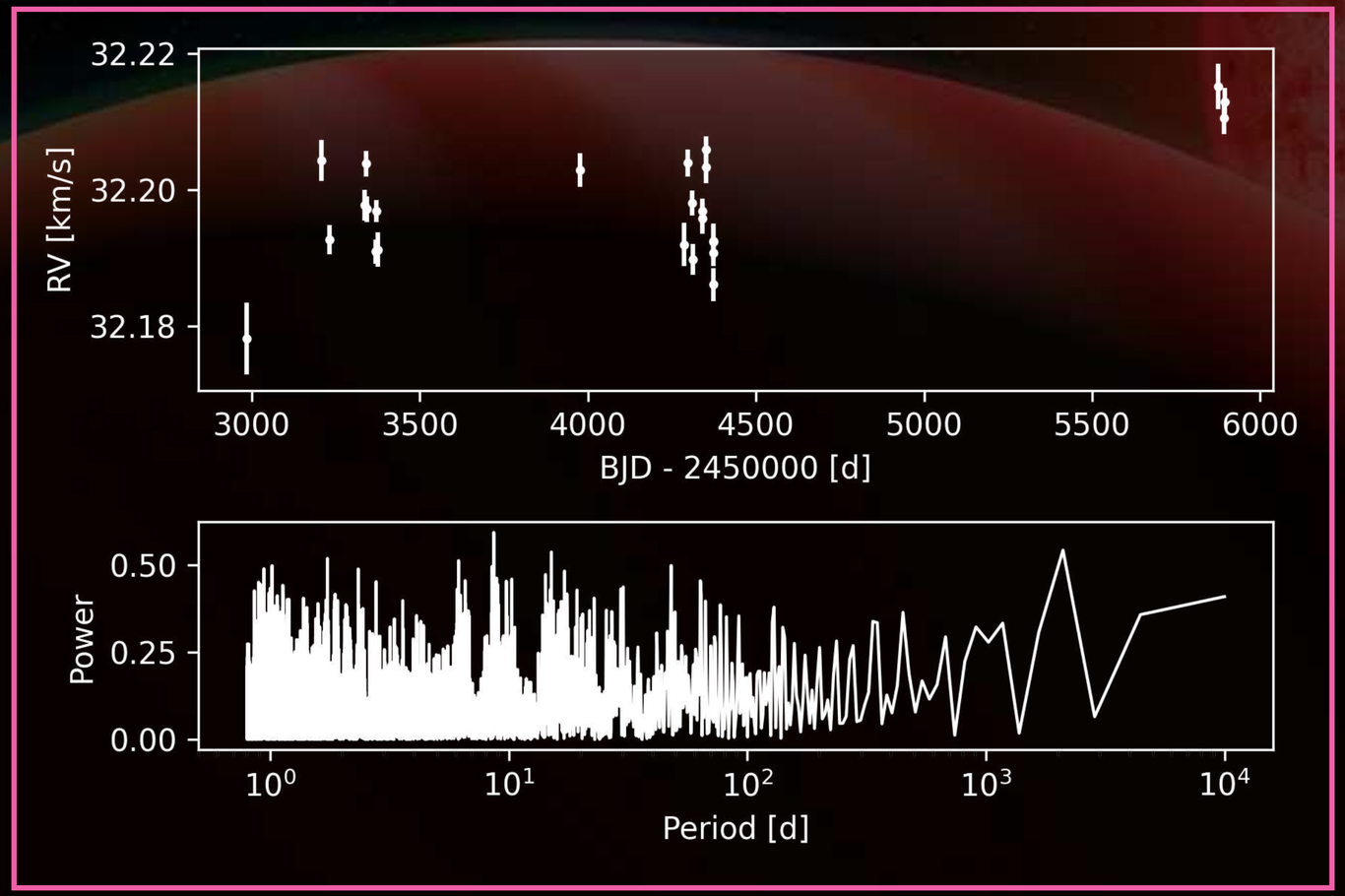
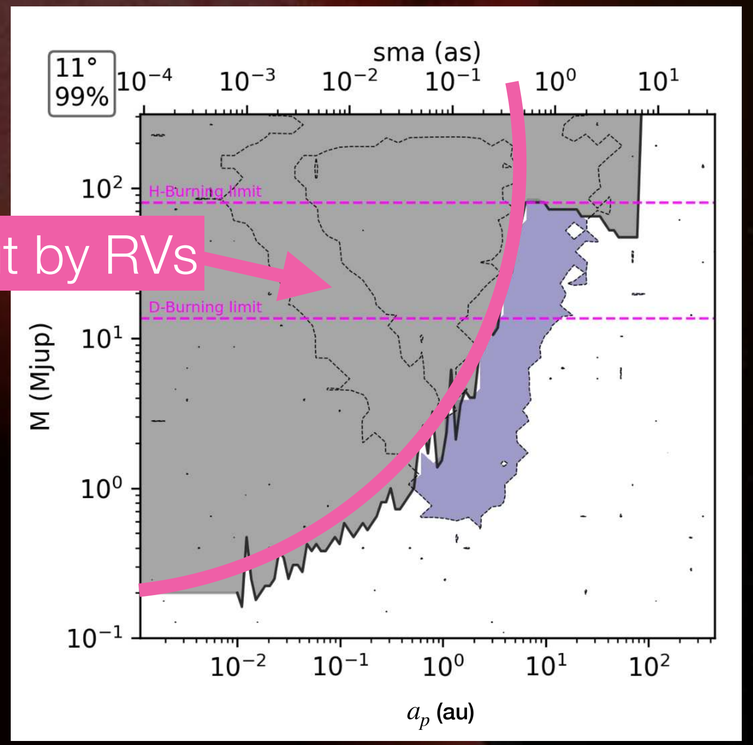


Ruled out by RVs



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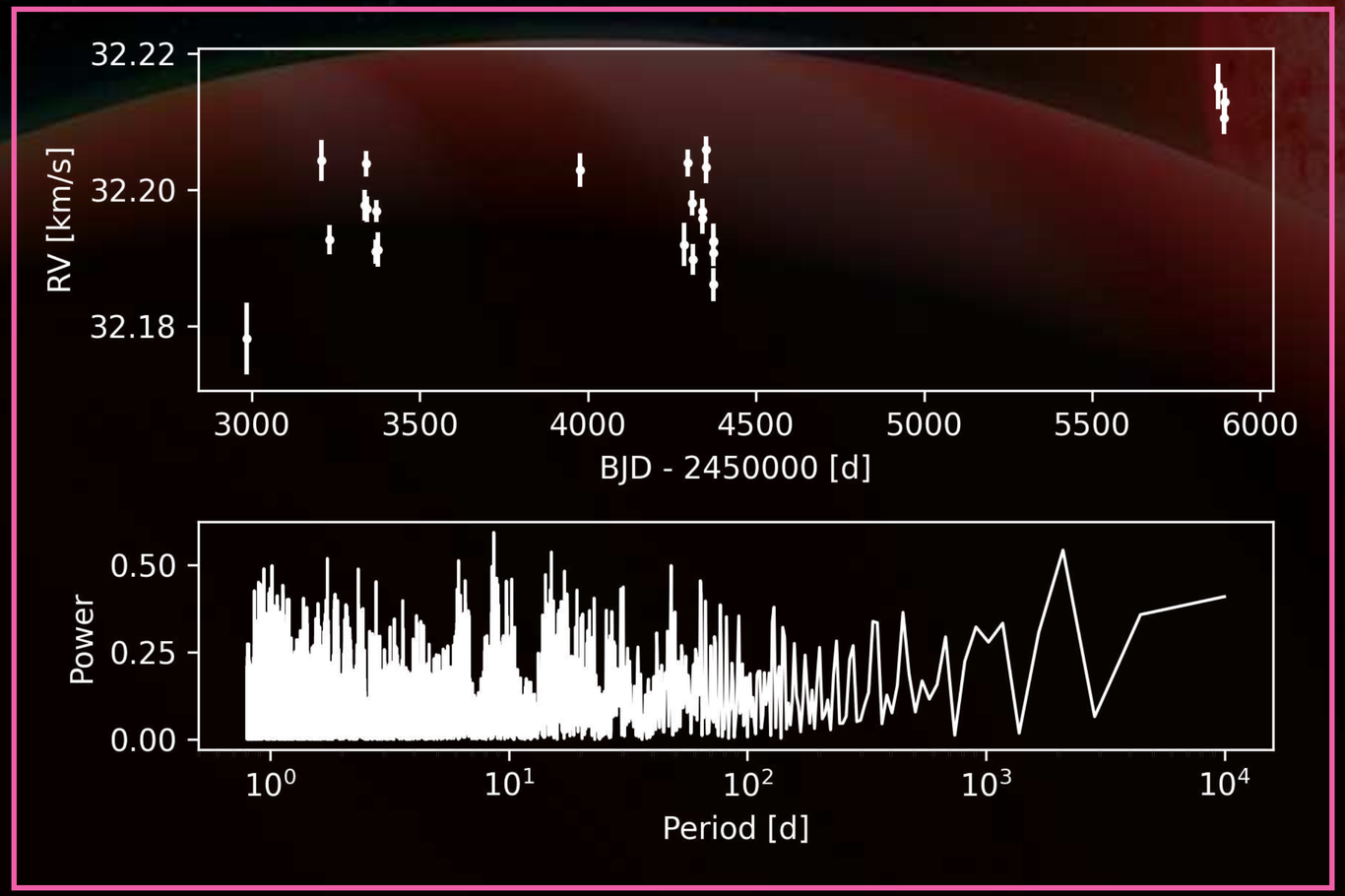

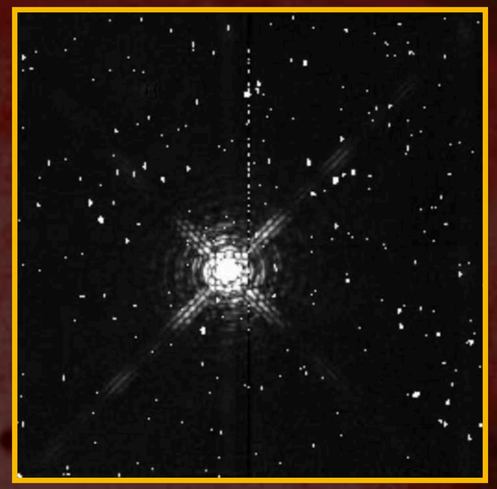

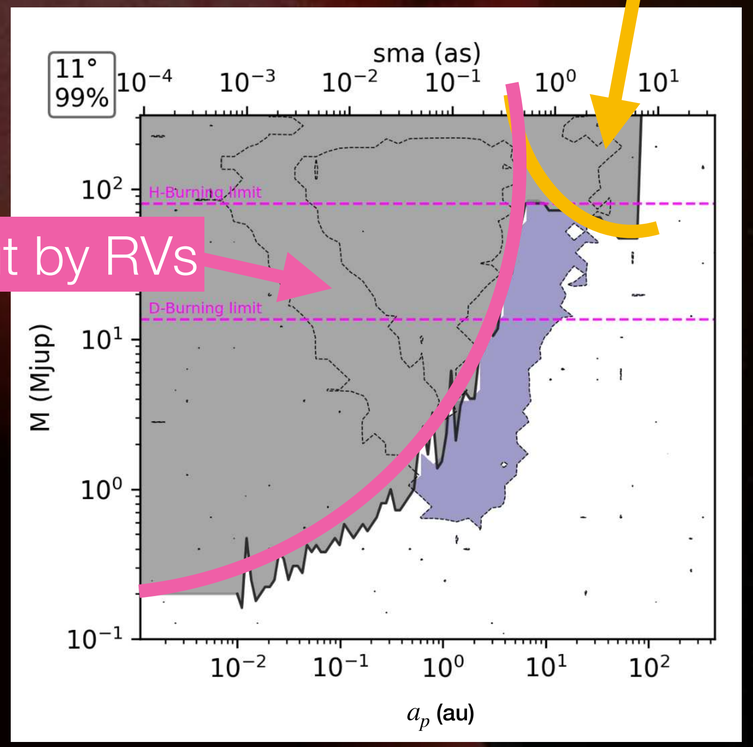

Ruled out by DI

Ruled out by RVs

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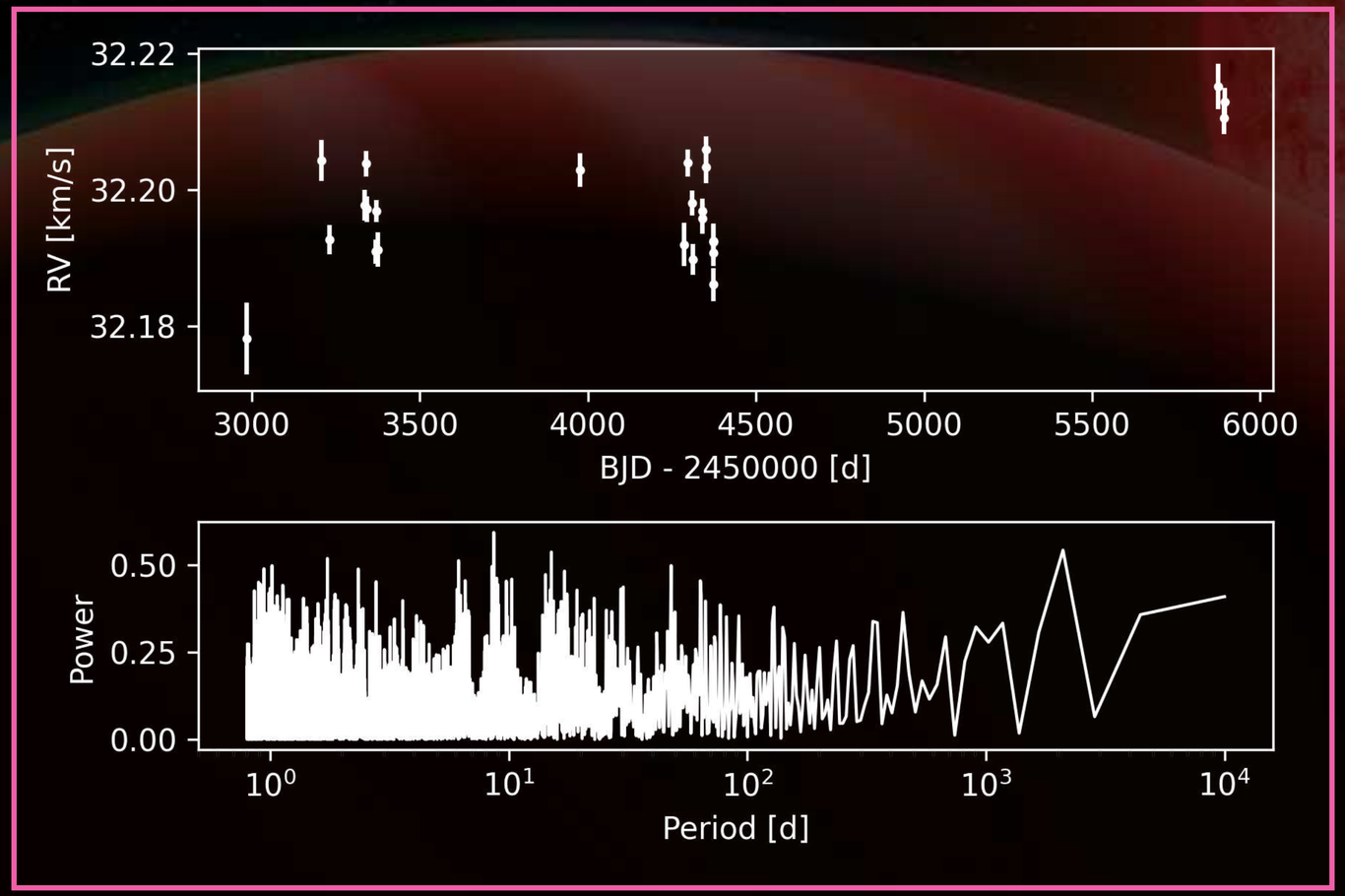

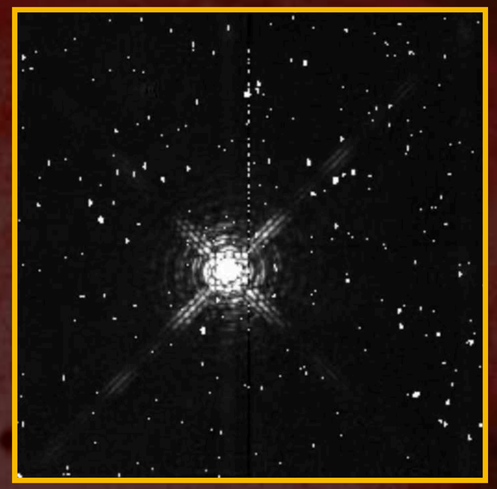

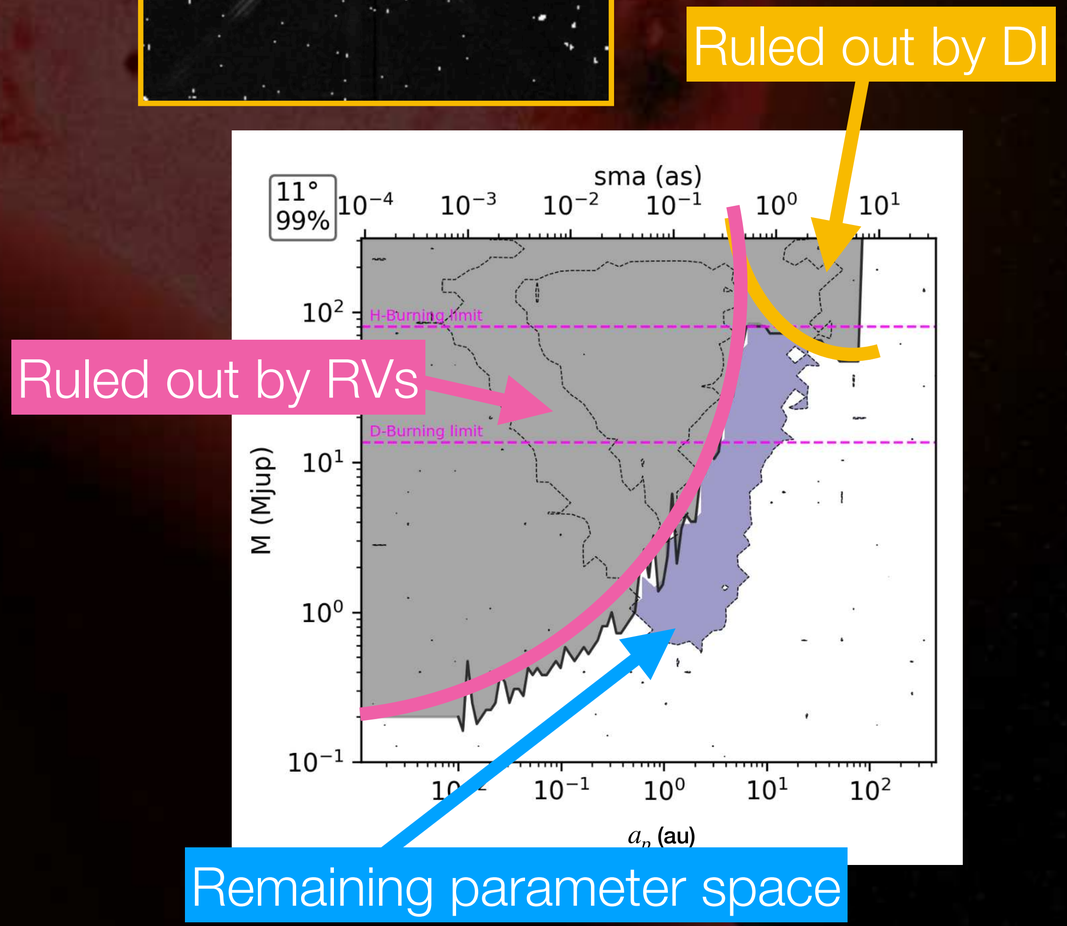

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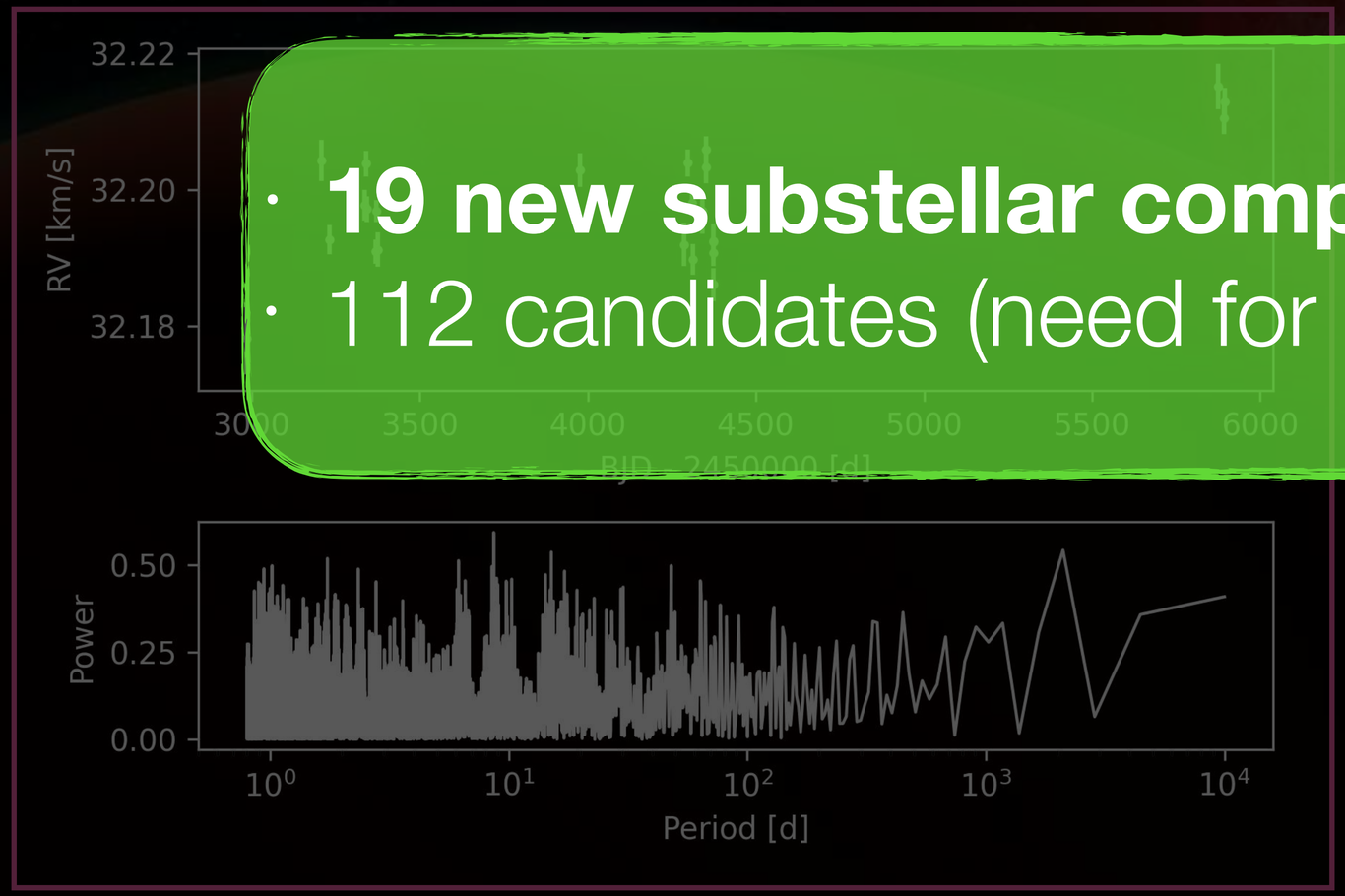
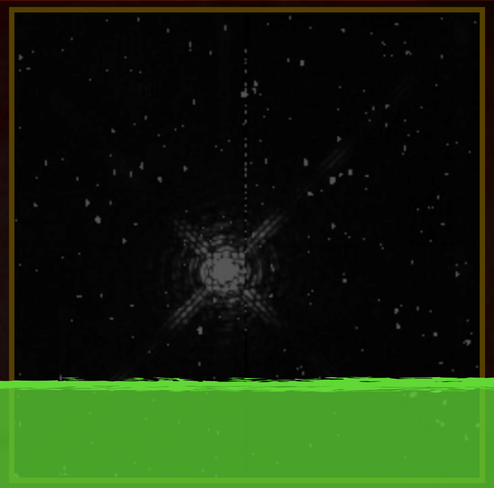
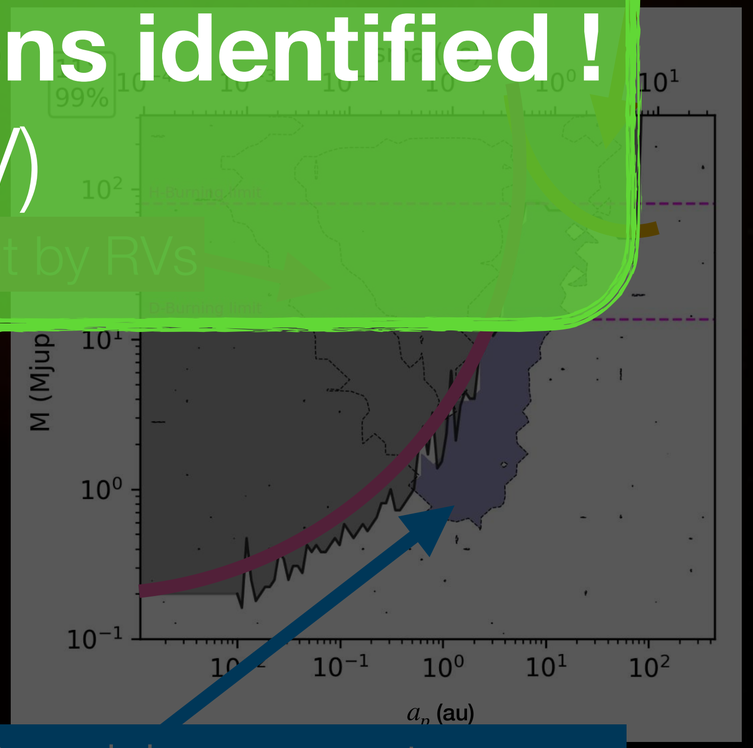
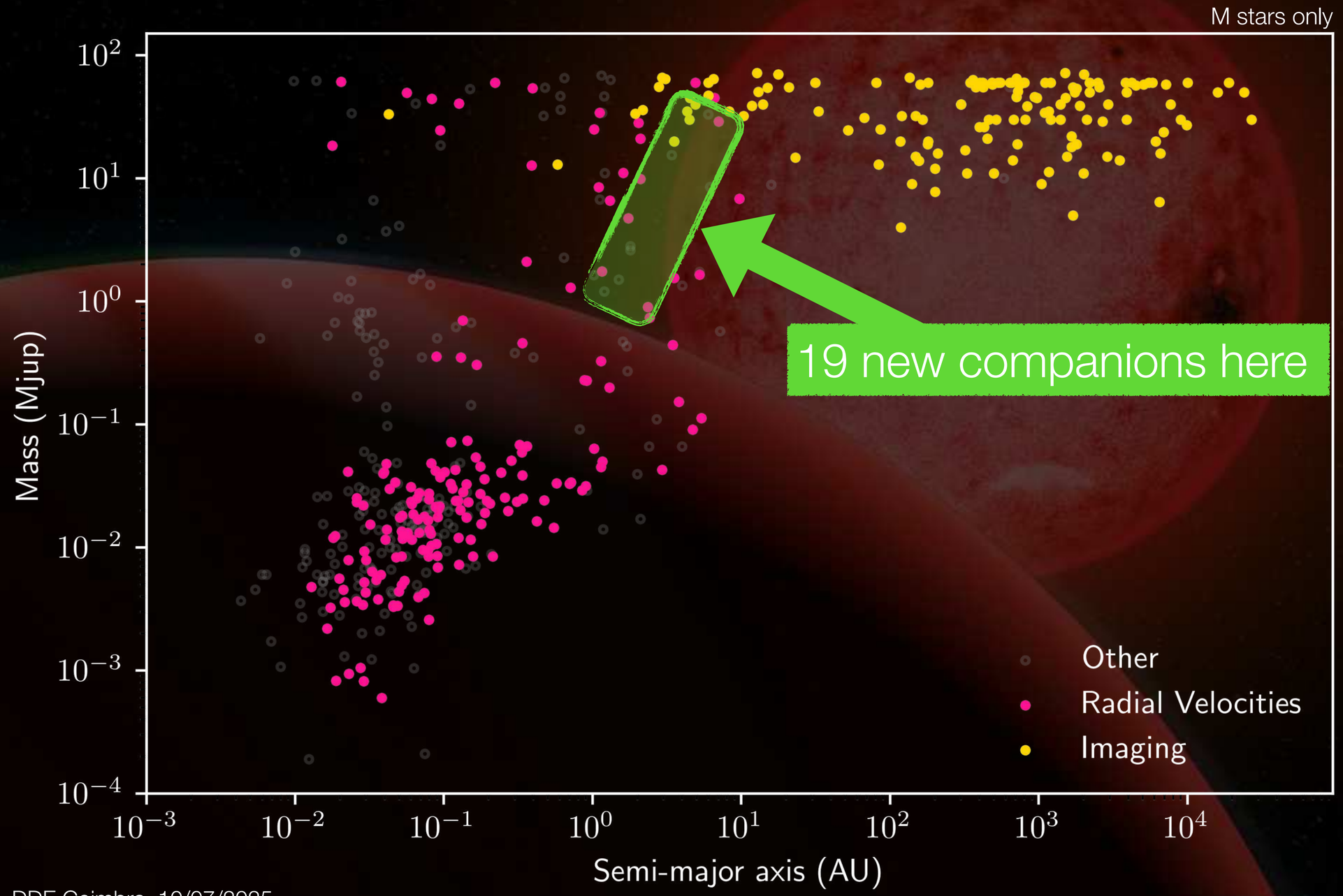


- **19 new substellar companions identified !**
- 112 candidates (need for DI/RV)

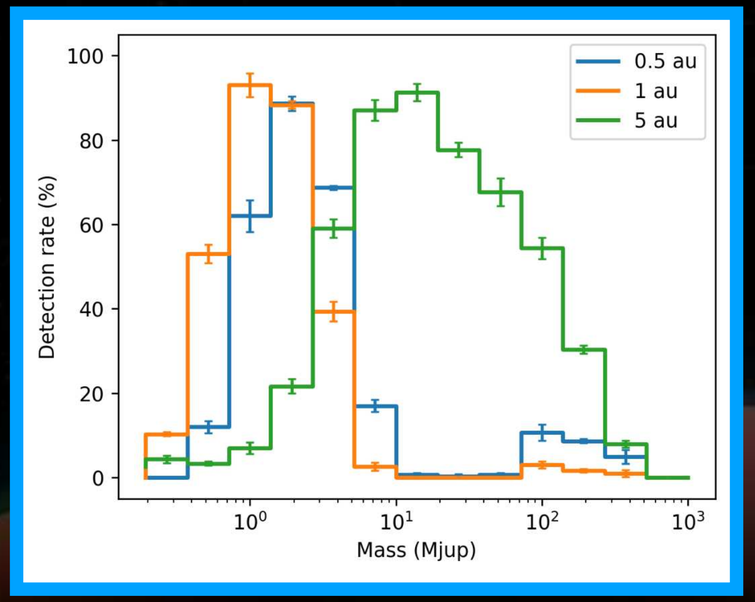




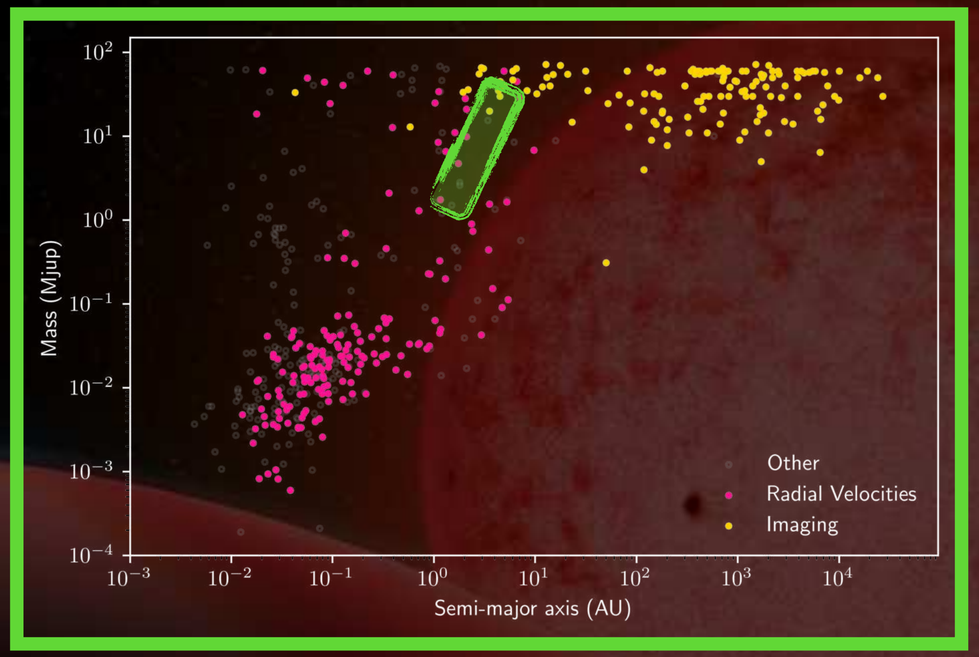
Filling the void



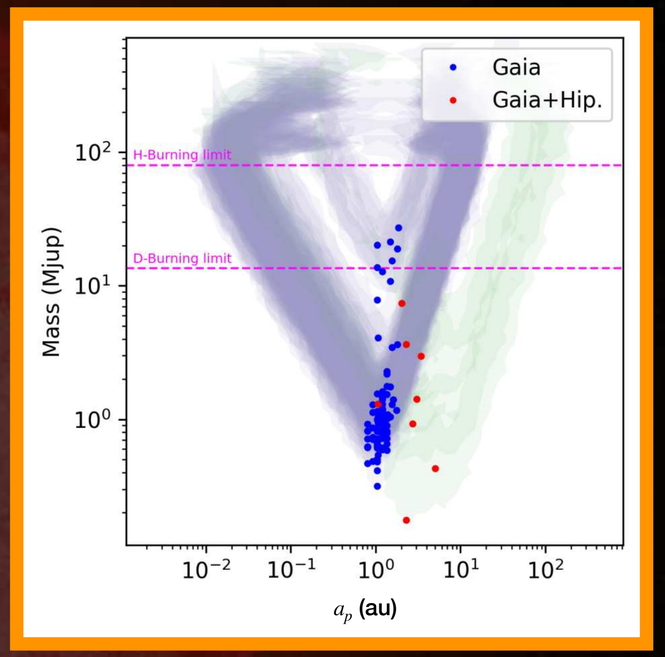
Results



242 companions detected



19 substellar comp. identified



112 candidates substellar comp.

Perspectives

M15pc

- Characterizing the companions with MCMC
- Destriez et al. in prep.

Observations

- RVs at OHP : 4.5 nights in 2025
- DI at Keck (dome shutter currently kaput)
- DI at VLT ?

Future work

- Analyze RV data from SOPHIE
- Transit photometry in joint analysis
- Prepare for Gaia DR4

Thank you !
Any questions

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