LESSONS LEARNED FROM THE HIP 41378'S SYSTEM: PREPARING FOR LONG-PERIOD PLANET CHARACTERISATION WITH PLATO

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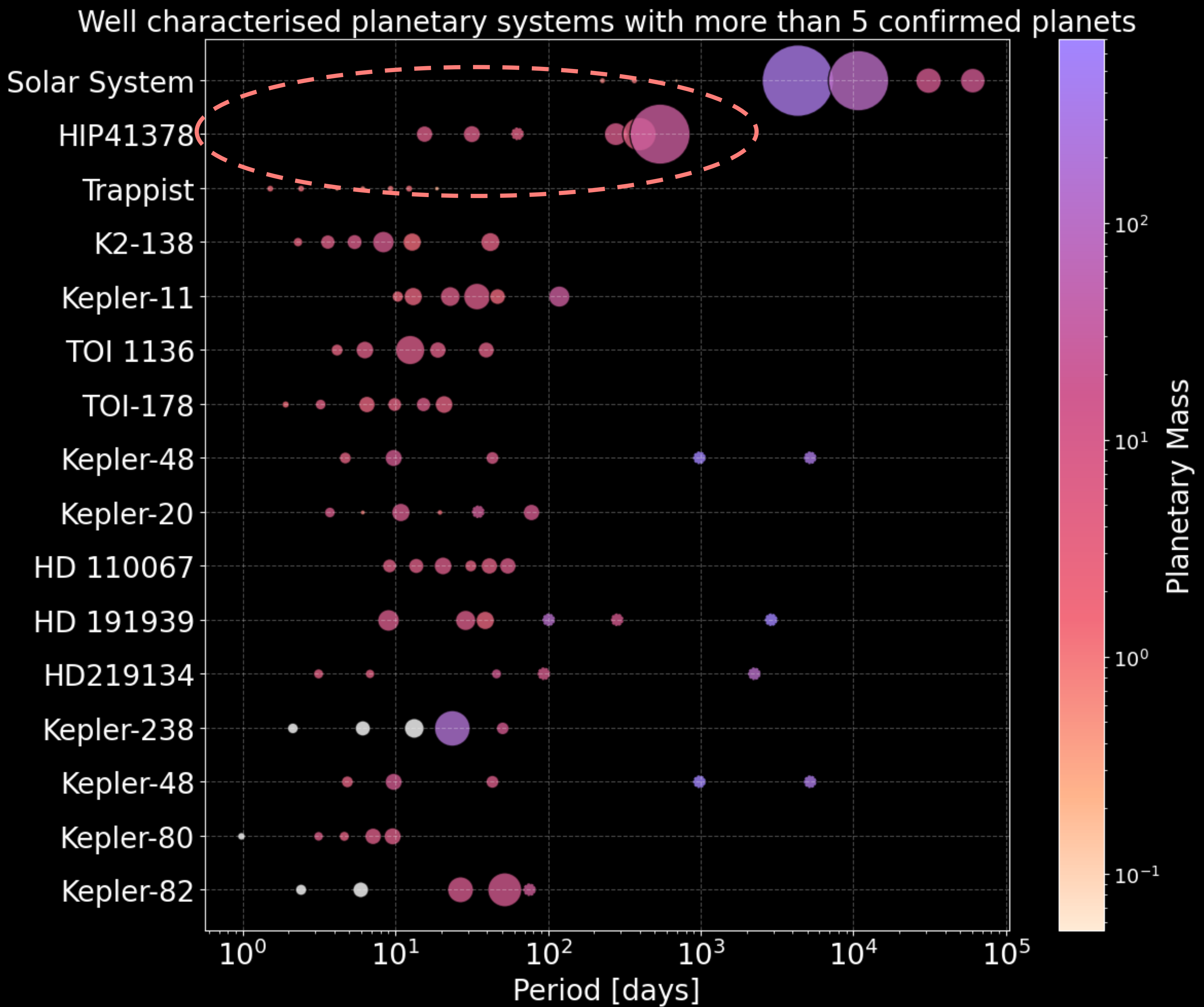
CNES Centre National d'Études Spatiales

CNRS

LAM Laboratoire d'Astrophysique de Marseille

HIP 41378 : a testbed for PLATO

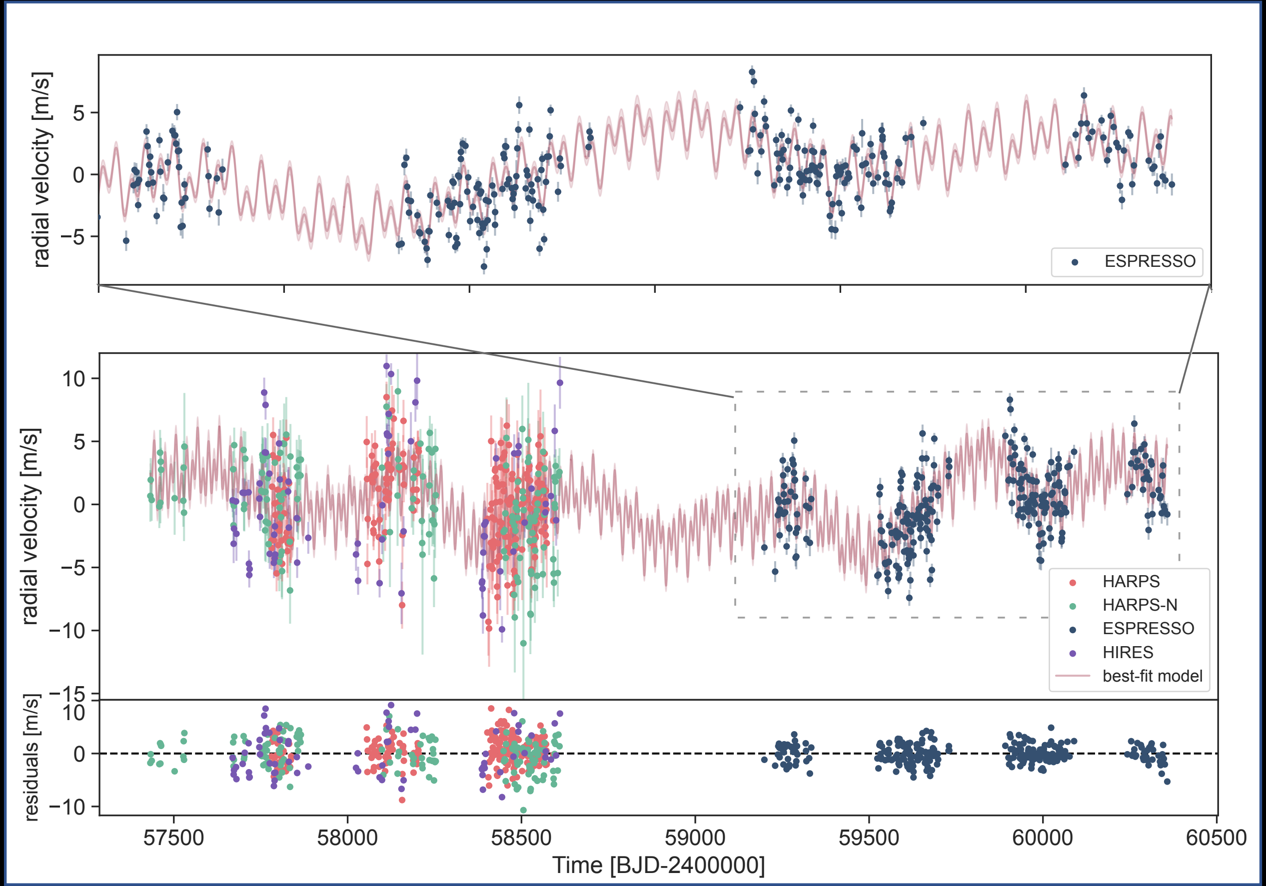


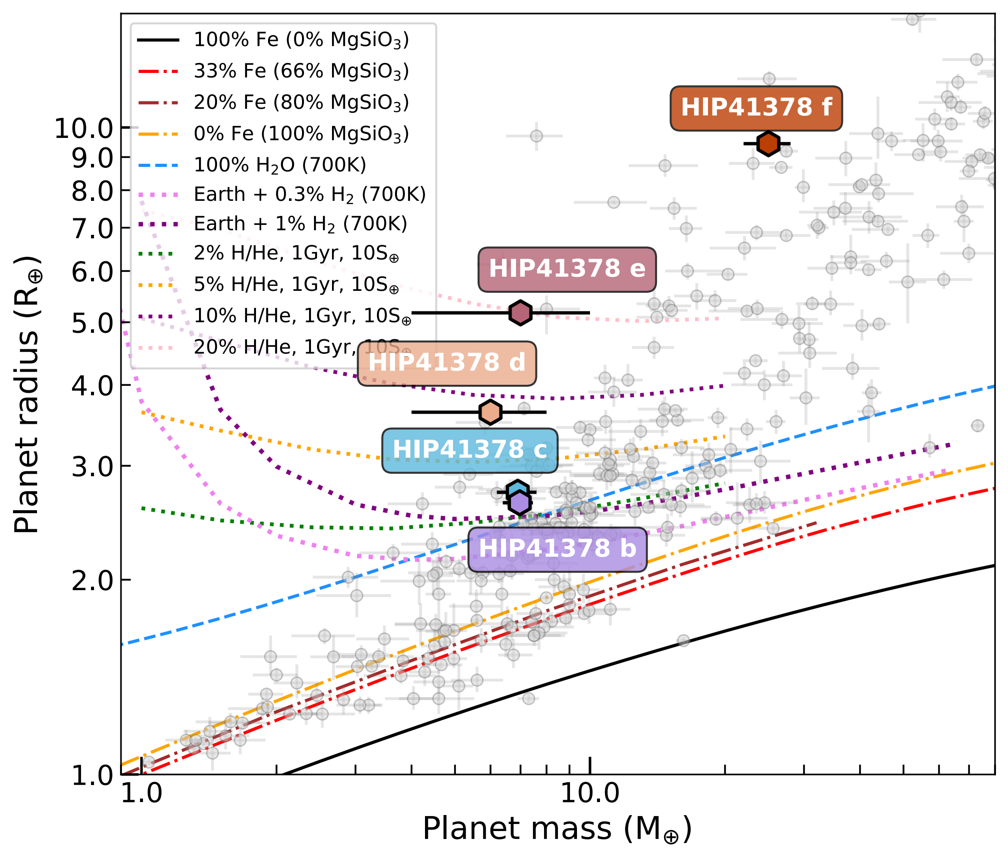
HIP 41378's planetary system

- Long-period planets
- Precise asteroseismology
- RV follow-up
- TTVs
- Star with low activity

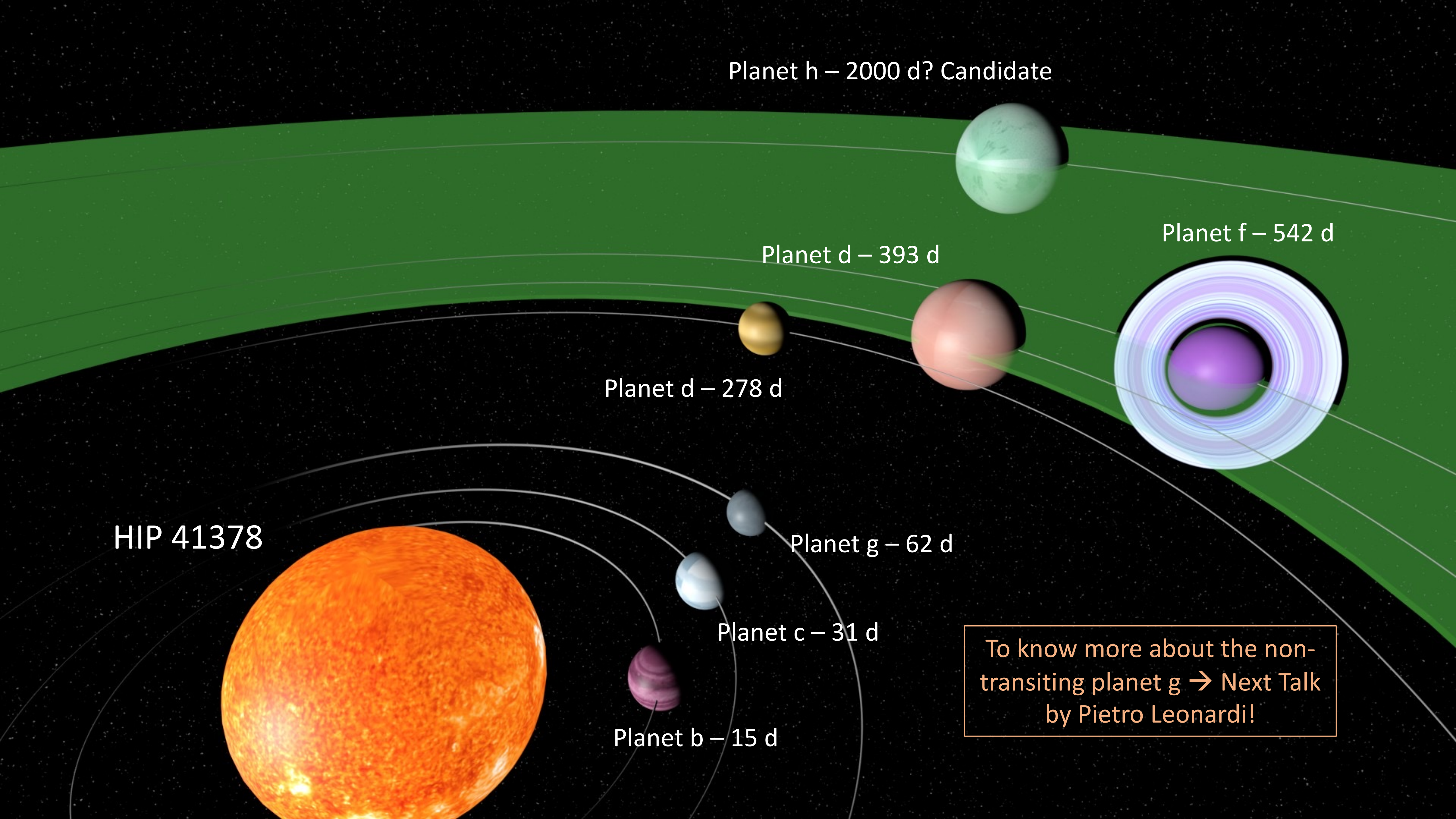
Photometry and RVs

Radius and masses of the 6 (7?) planets in the system

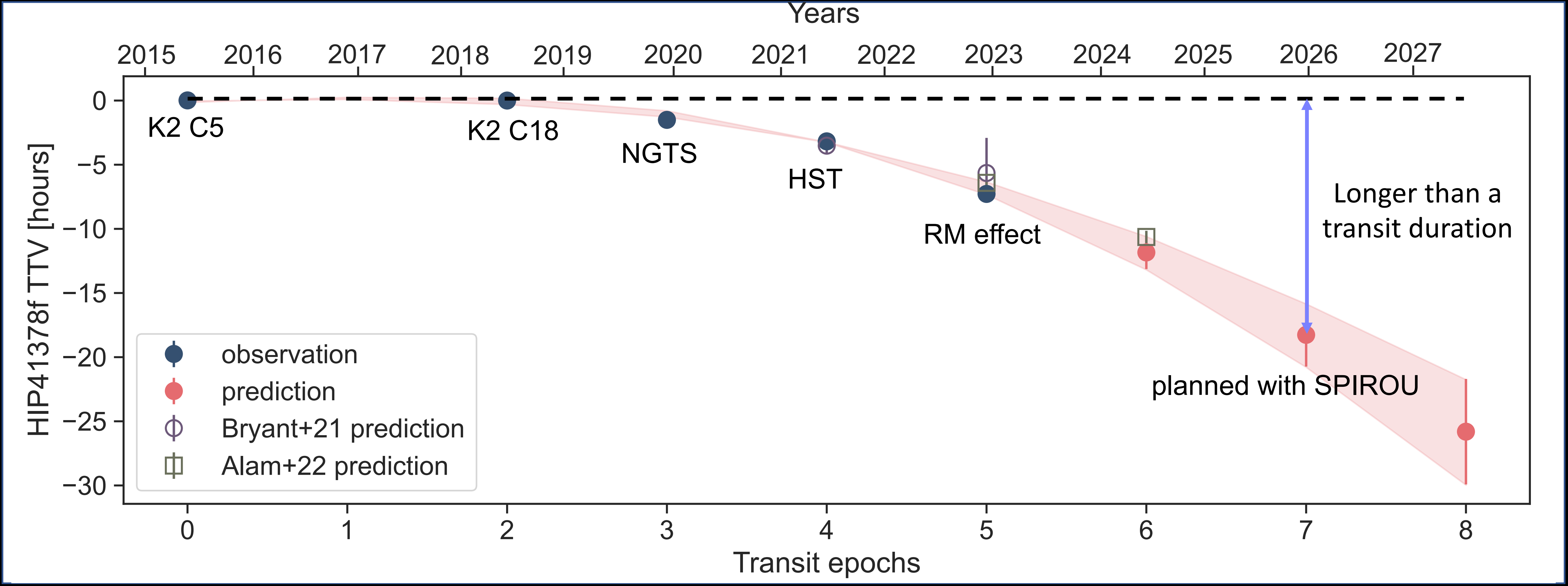




Grouffal et al. (in prep)


Planet h – 2000 d? Candidate
Planet f – 542 d
Planet d – 393 d
Planet d – 278 d
HIP 41378
Planet g – 62 d
Planet c – 31 d
Planet b – 15 d
To know more about the non-transiting planet g → Next Talk by Pietro Leonardi!

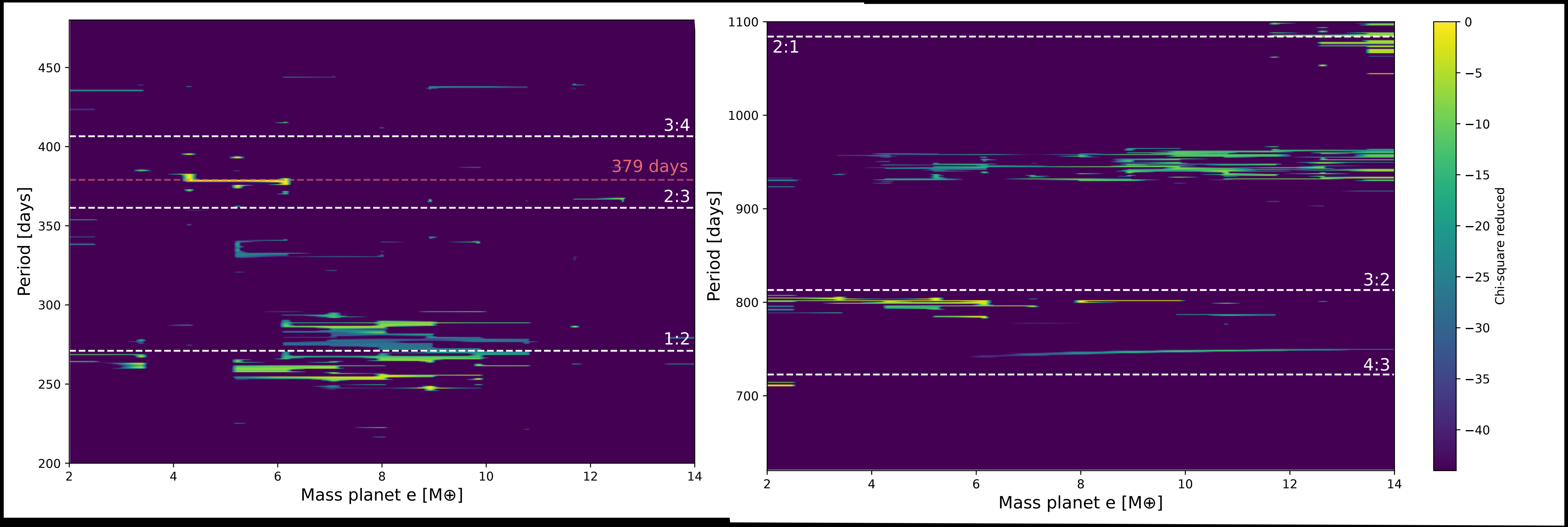
TTVs for the external system of HIP 41378



Grouffal (PhD, 2025, submitted)

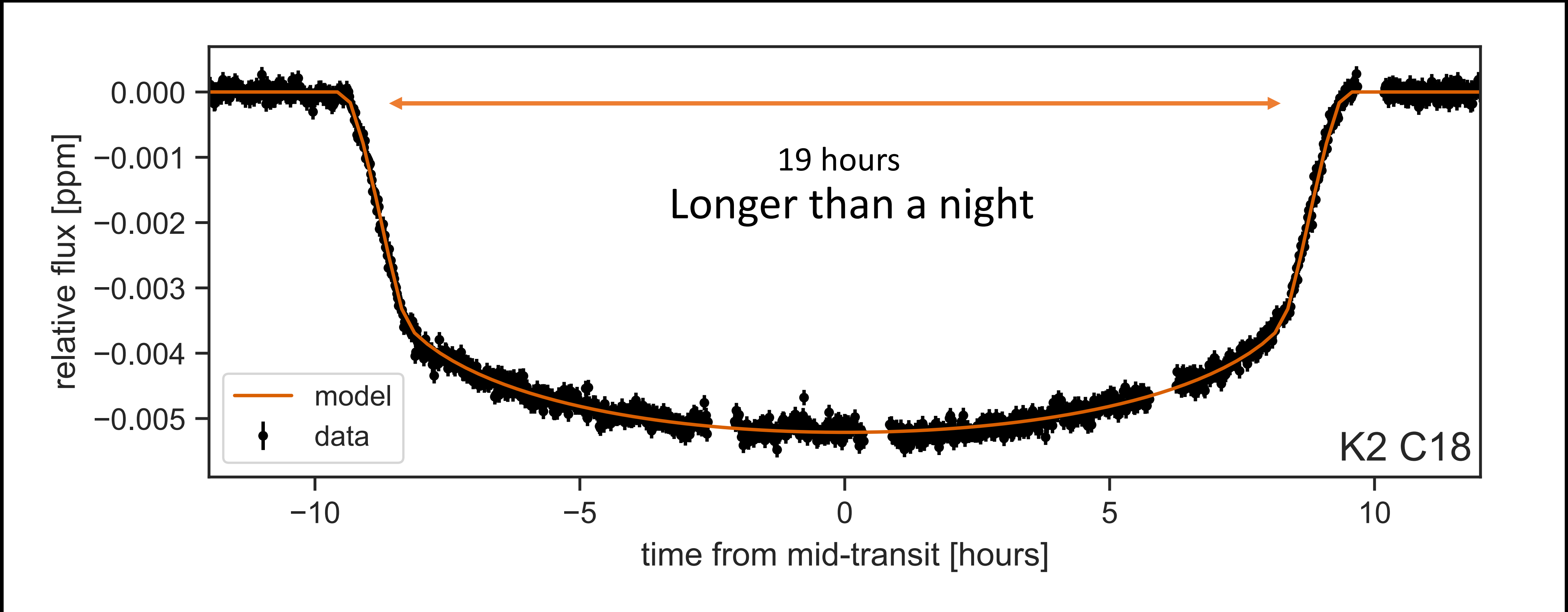
TTVs for the external system of HIP41378

Is it possible to put constraints on the other planets of the system with only 5 transits?

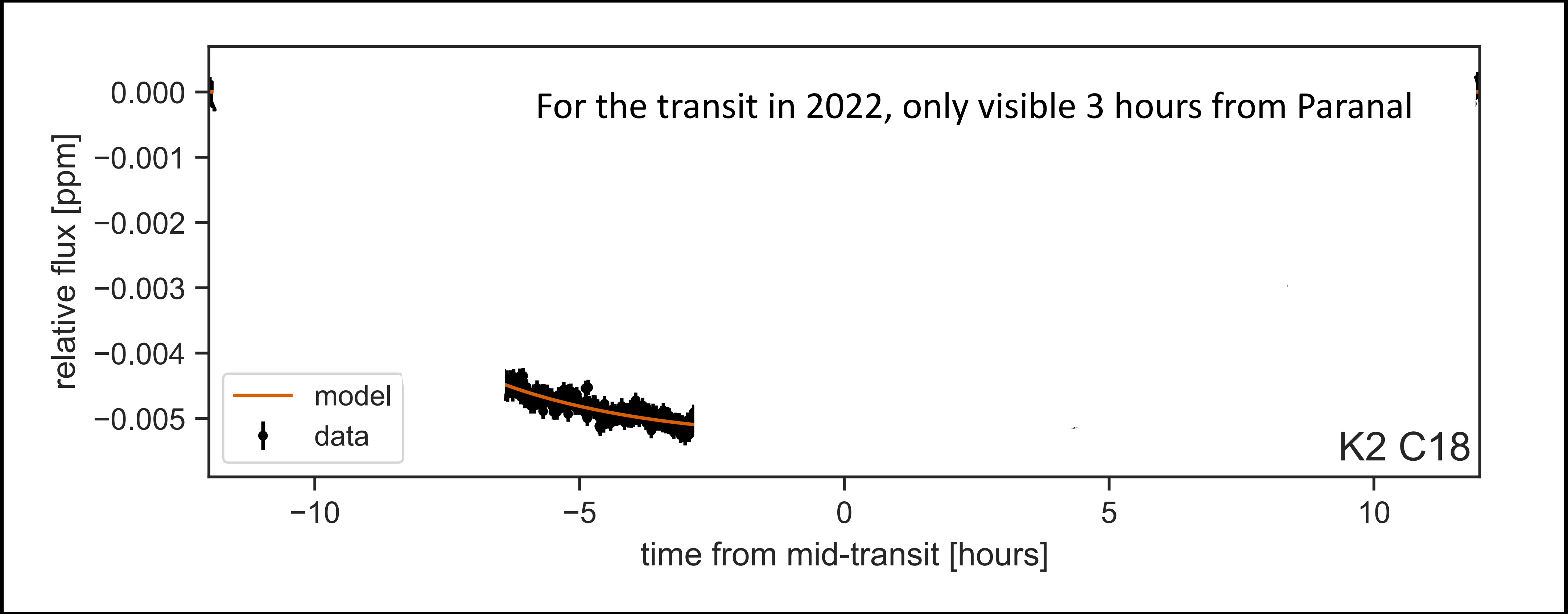


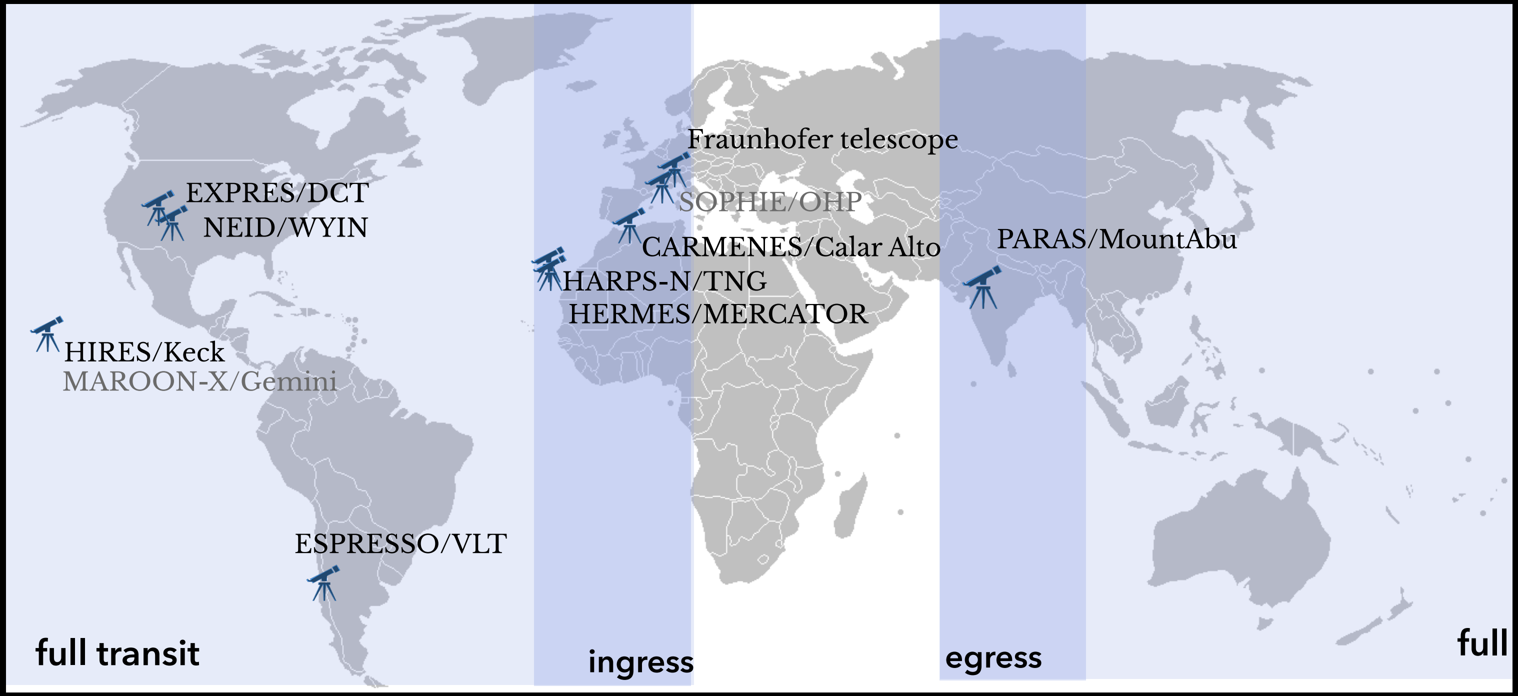
Grouffal (PhD, 2025, submitted)

Transit of HIP41378 f from the ground

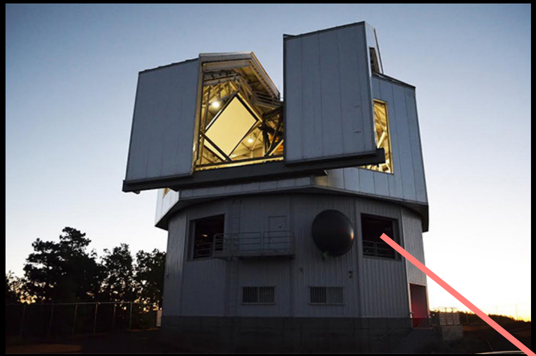


Transit of HIP41378 f from the ground




Fraunhofer telescope
EXPRES/DCT
NEID/WYIN
SOPHIE/OHP
CARMENES/Calar Alto
PARAS/MountAbu
HARPS-N/TNG
HERMES/MERCATOR
HIRES/Keck
MAROON-X/Gemini
ESPRESSO/VLT
full transit
ingress
egress
full

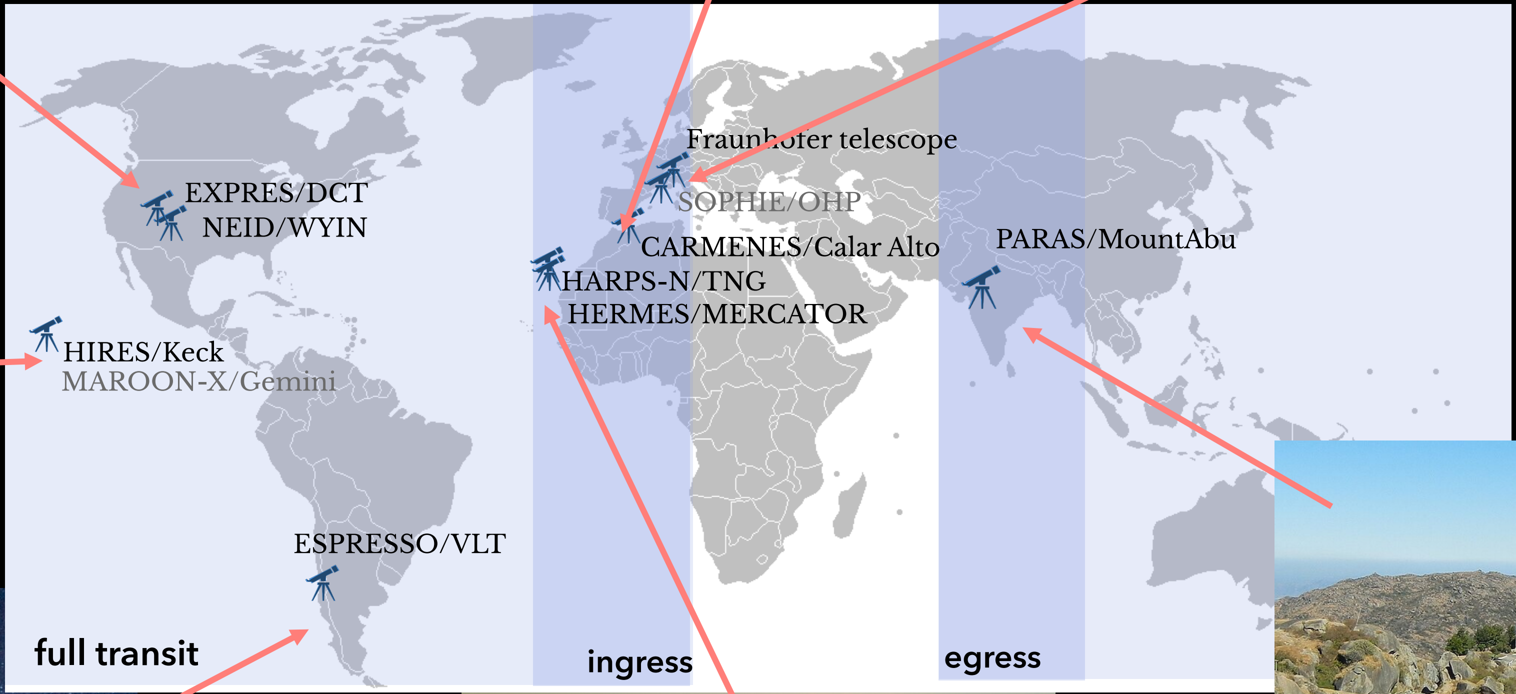
credit: Lowell Observatory/DCT



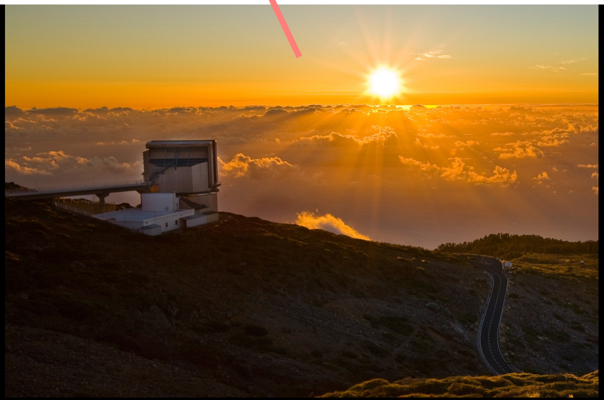
Credit: NOAO/AURA/NSF

Credist: Sven Kohle and Till Credner

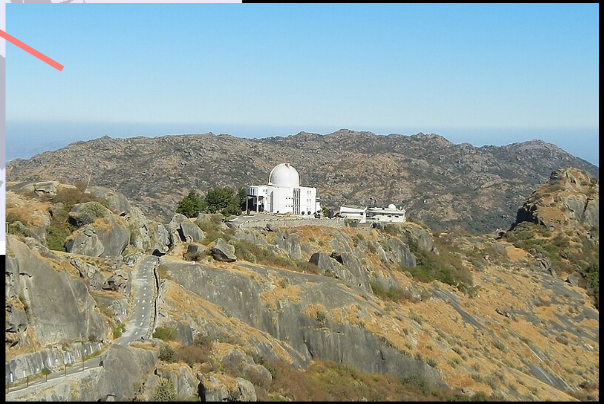
Credits: NASA



Credits: ESO/B. Tafreshi (twanight.org)

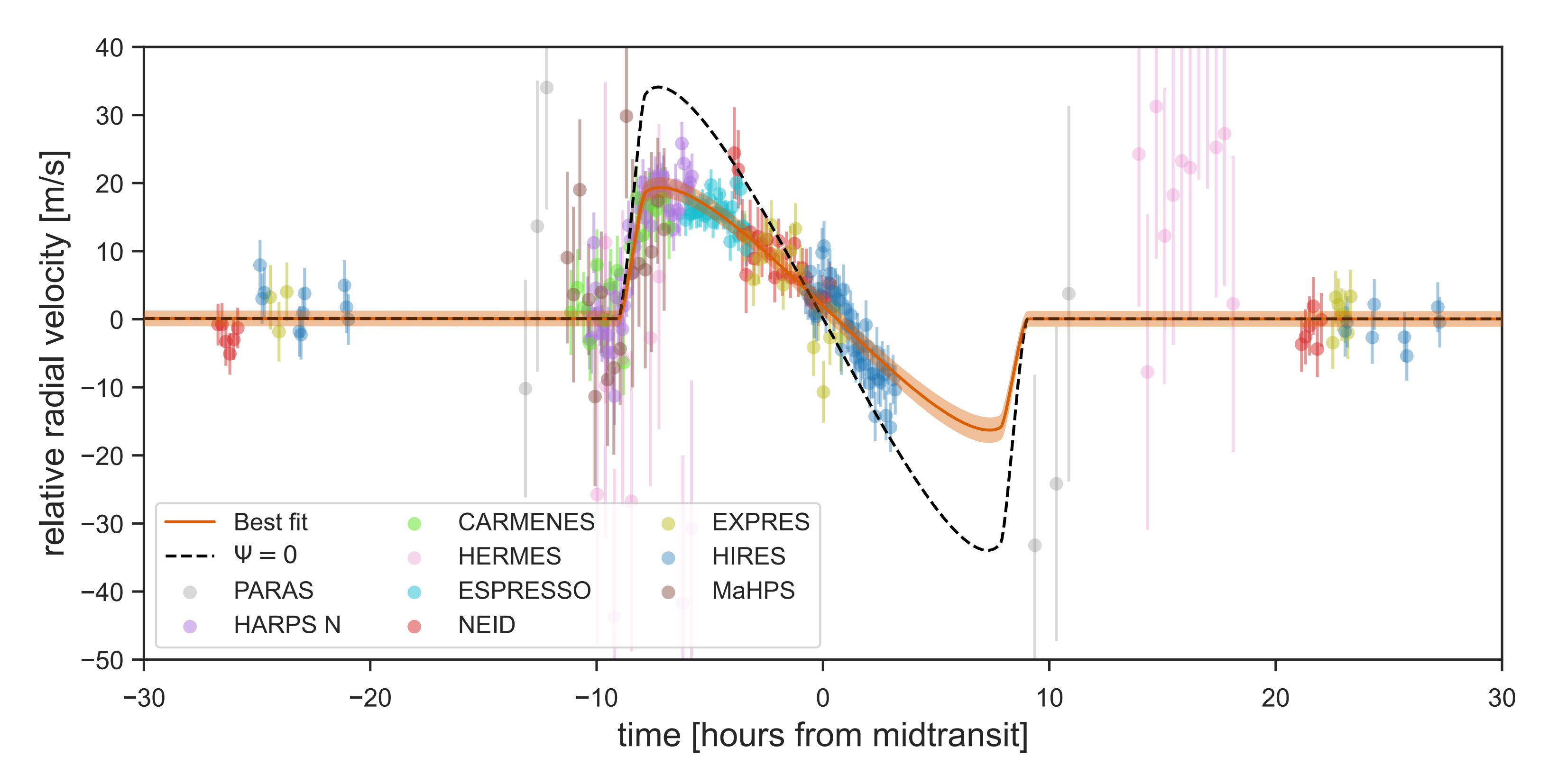


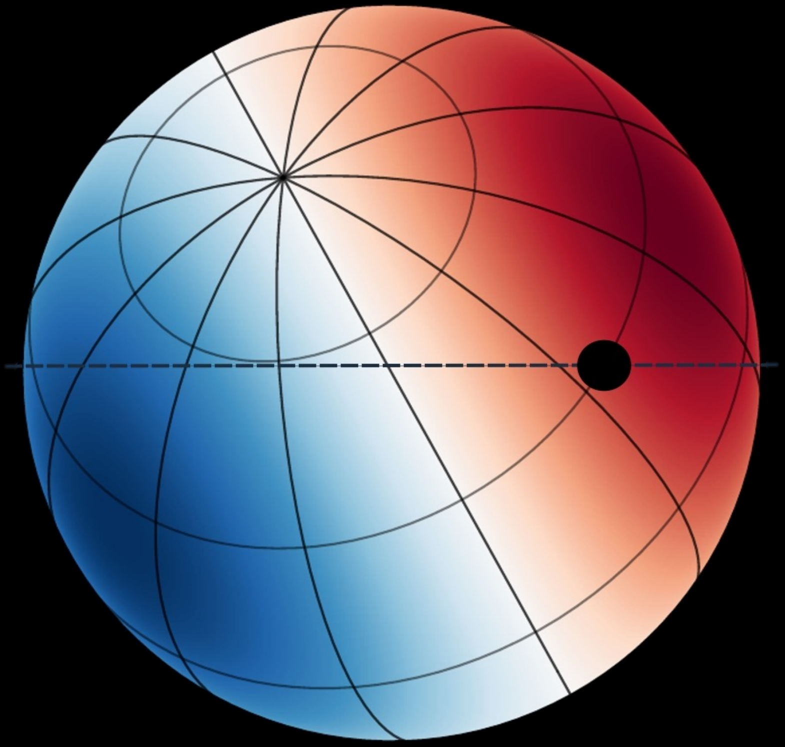
Credit: INAF-TNG



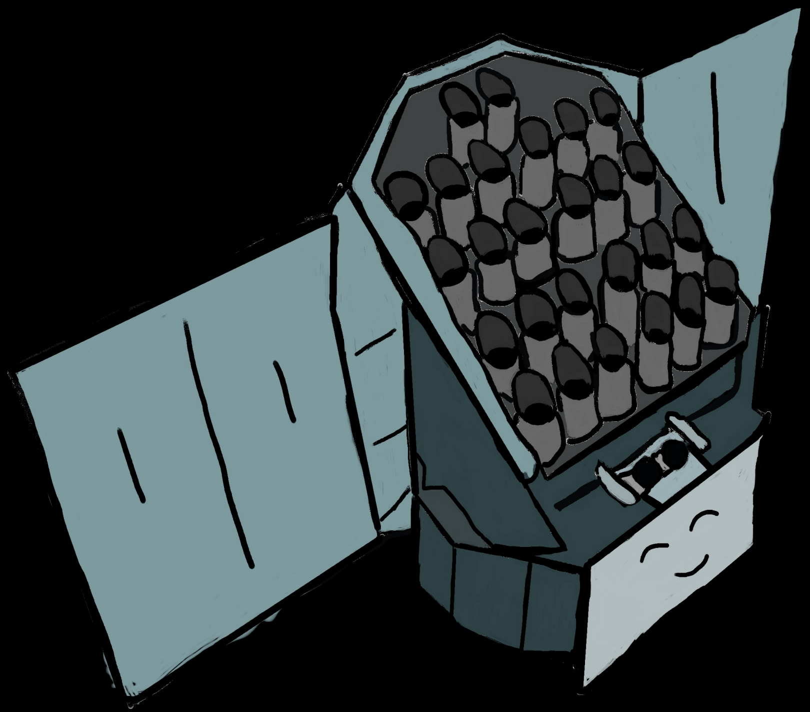
Credit: Wikipedia

RM effect HIP41378 f





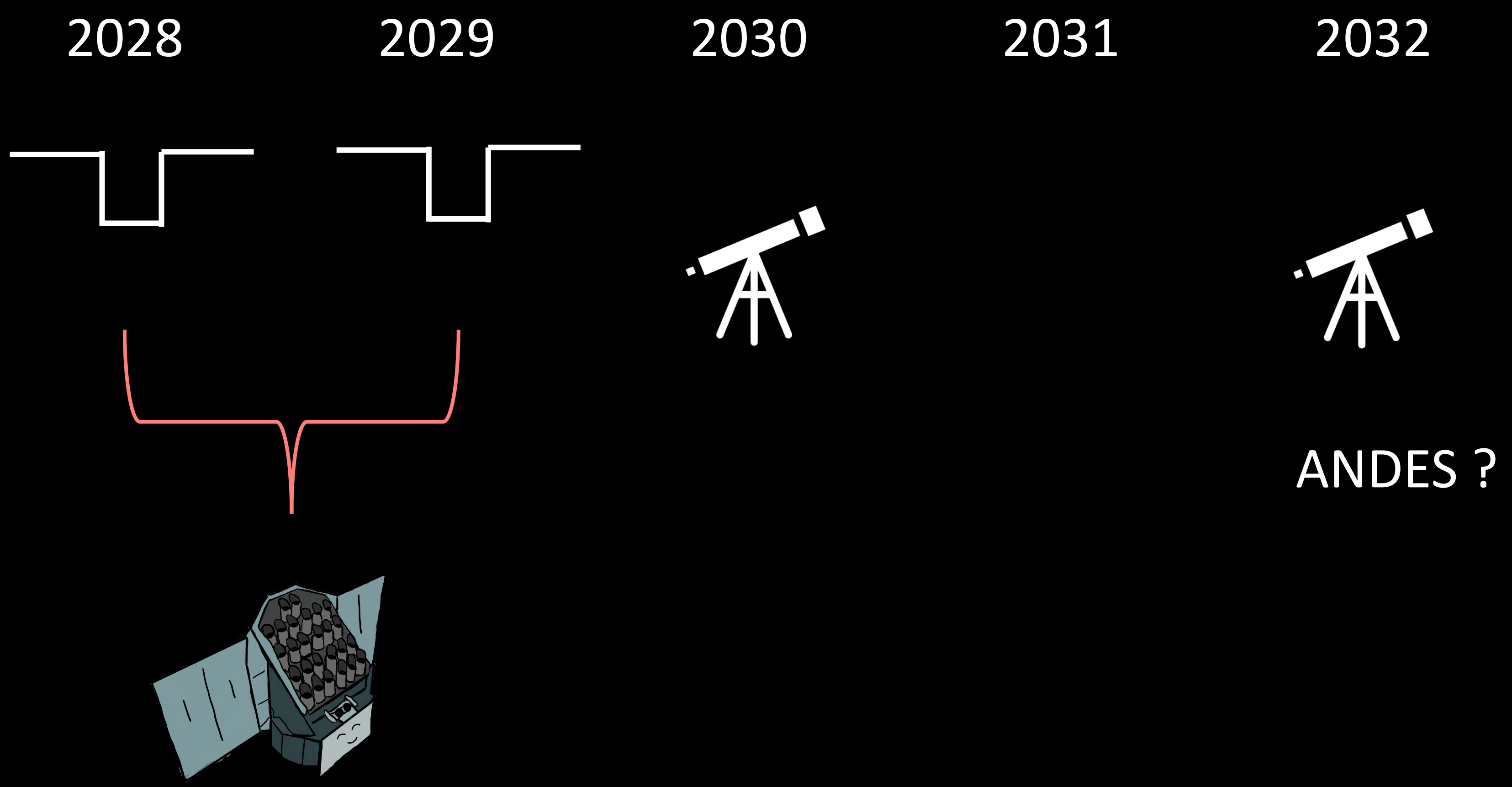
Grouffal et al. (submitted)



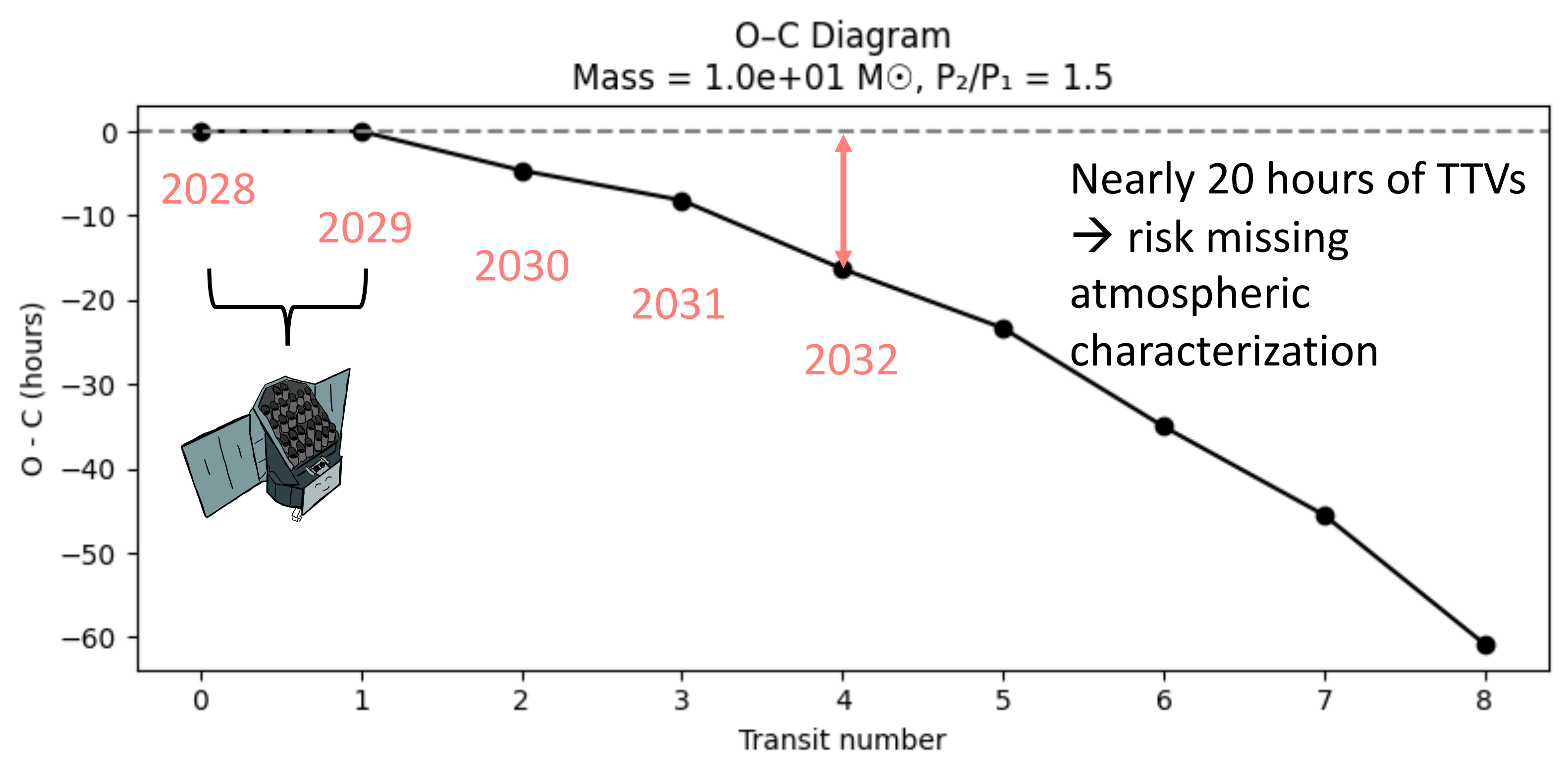
Let’s jump to 2028–2029!

The first PLATO results are in, and long-period exoplanets have been detected!

TTVs for long-period planets



TTVs for long-period planets



Very simple example with an Earth-like planet (365 days, 1 $M_\oplus$, ecc=0.06)

Companion planet:

P = 547.5 days

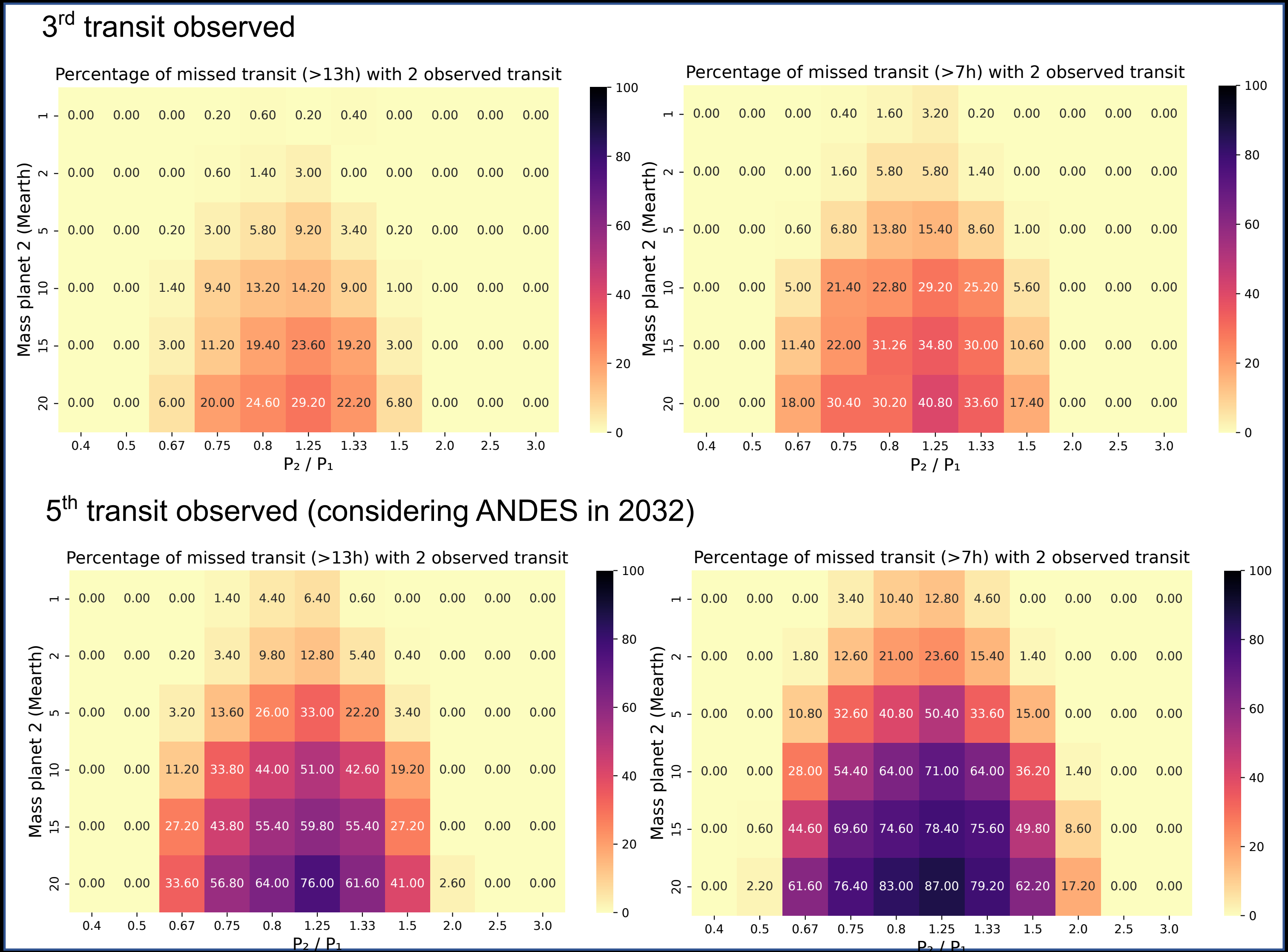
M = 9 $M_\oplus$

ecc = 0.08

Omega = 50 deg

Grouffal (PhD, 2025, submitted)

Predicting transits in the presence of TTVs

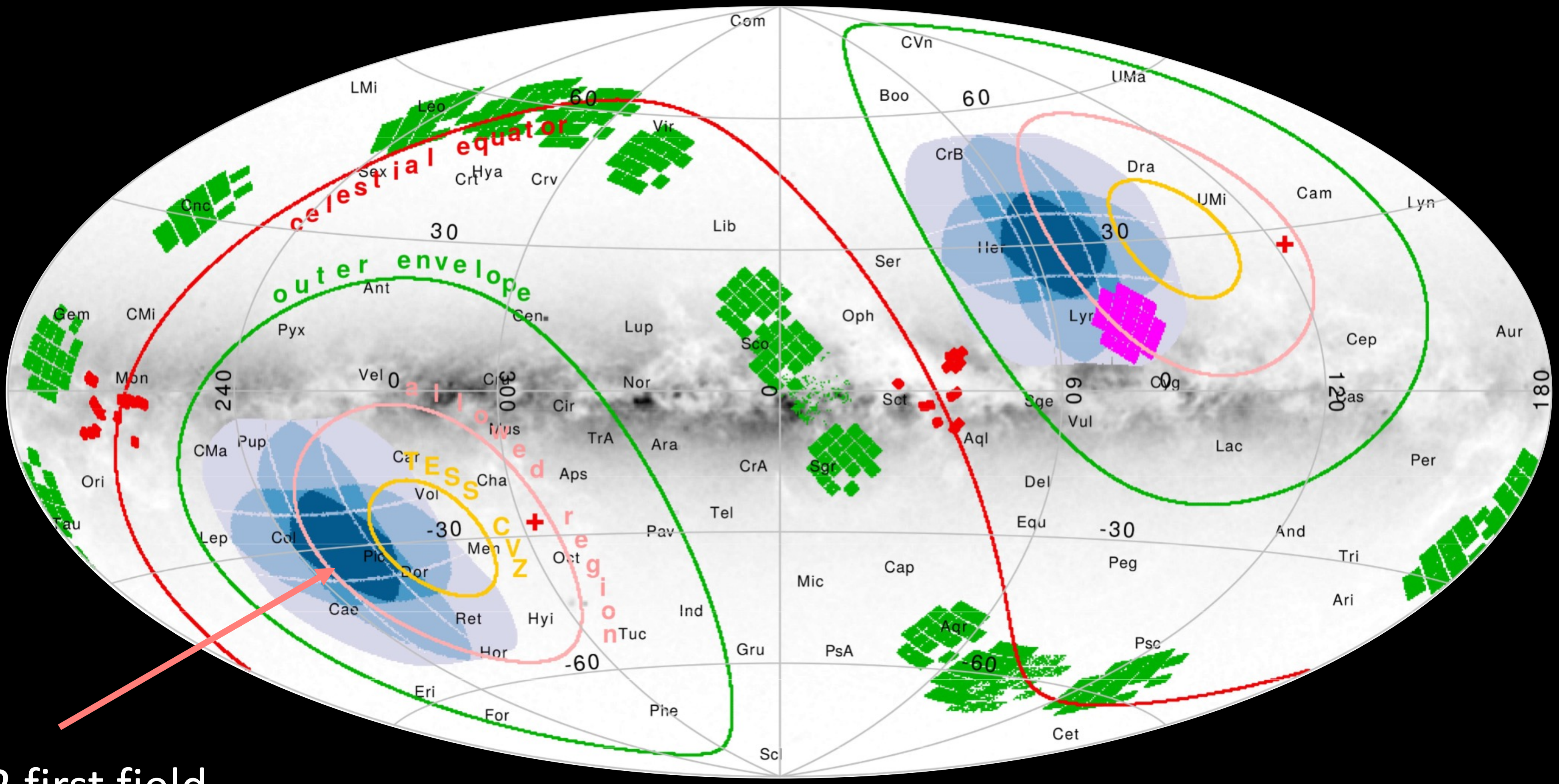


Two scenarios:

- Two consecutive transits have been observed, and we attempt to observe the third.

- Two consecutive transits have been observed with PLATO in 2028 and 2029, the fifth transit is planned with in 2032.

Follow-up of transiting long-period planets



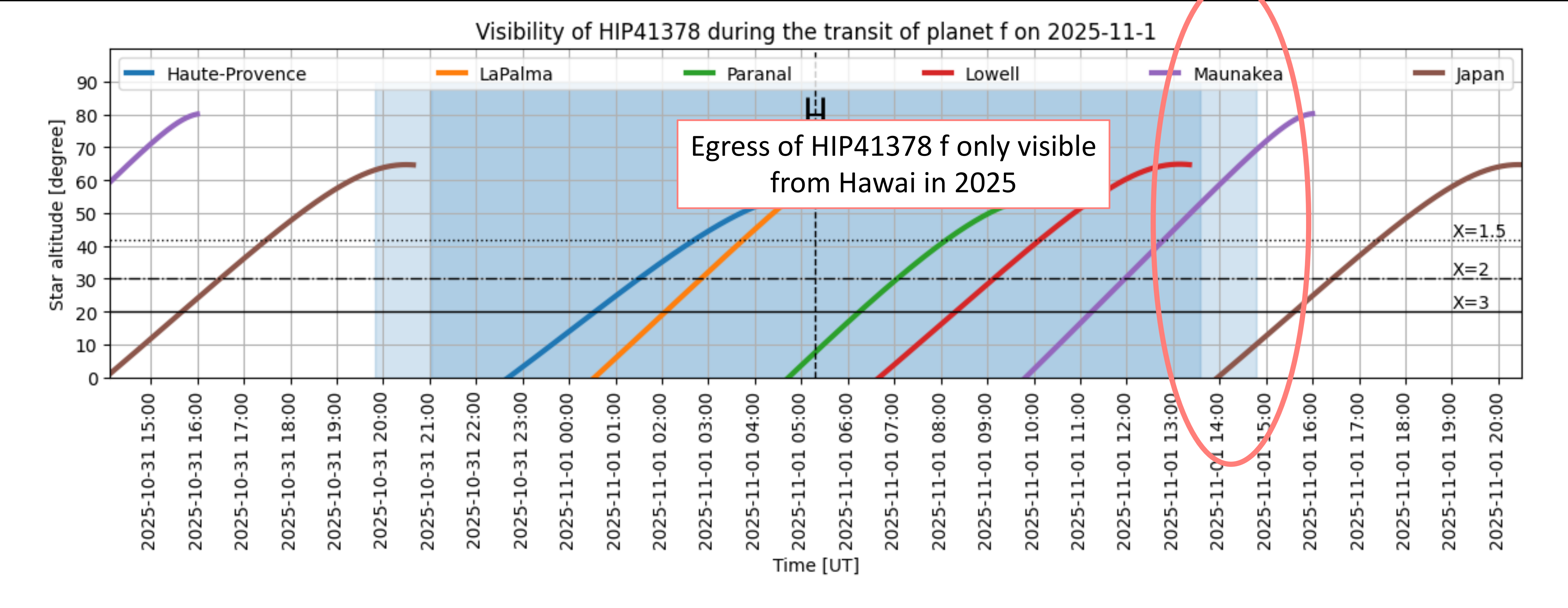
LOPS2 first field

Follow-up of transiting long-period planets

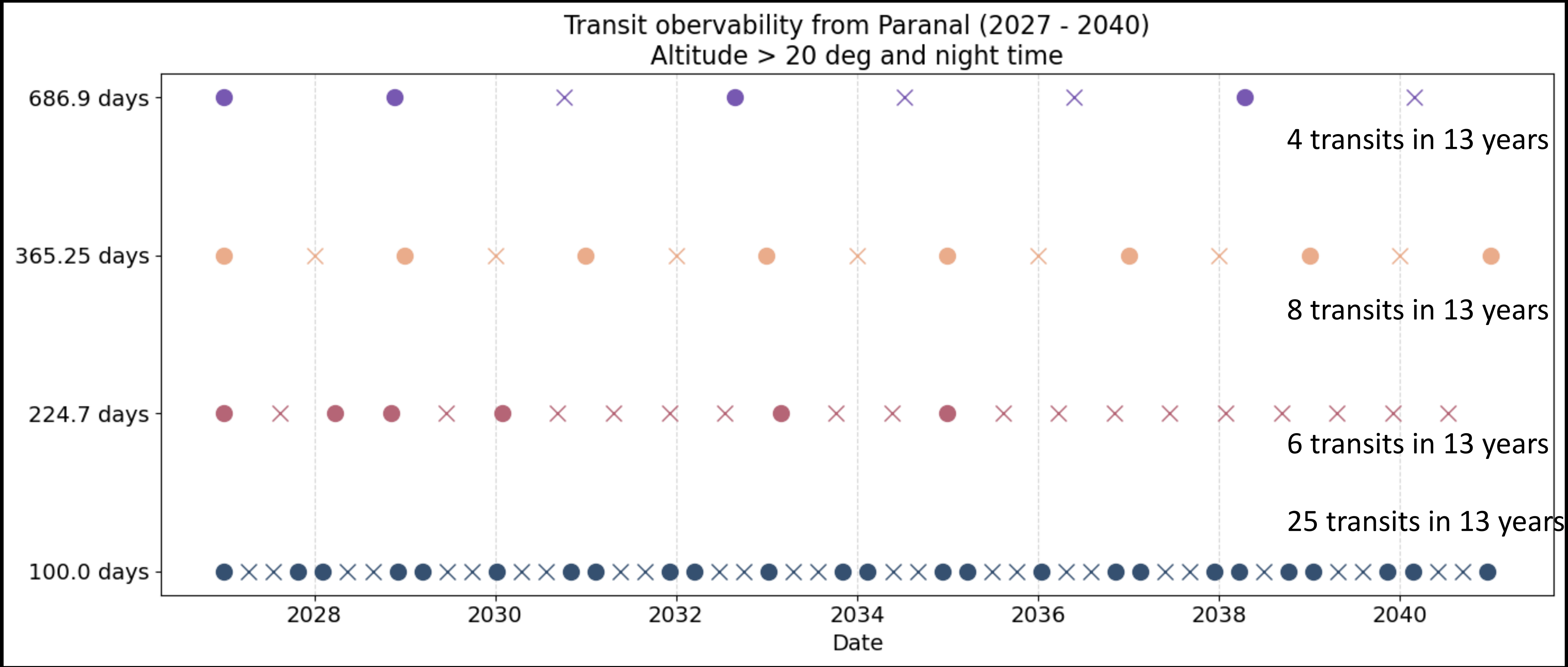
Follow-up of transiting long-period planets

Multi-instrument follow-up like for HIP41378 f,
difficult from the South

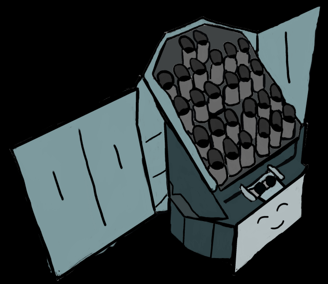
Follow-up of transiting long-period planets



Follow-up of transiting long-period planets



Lessons learned for the PLATO mission



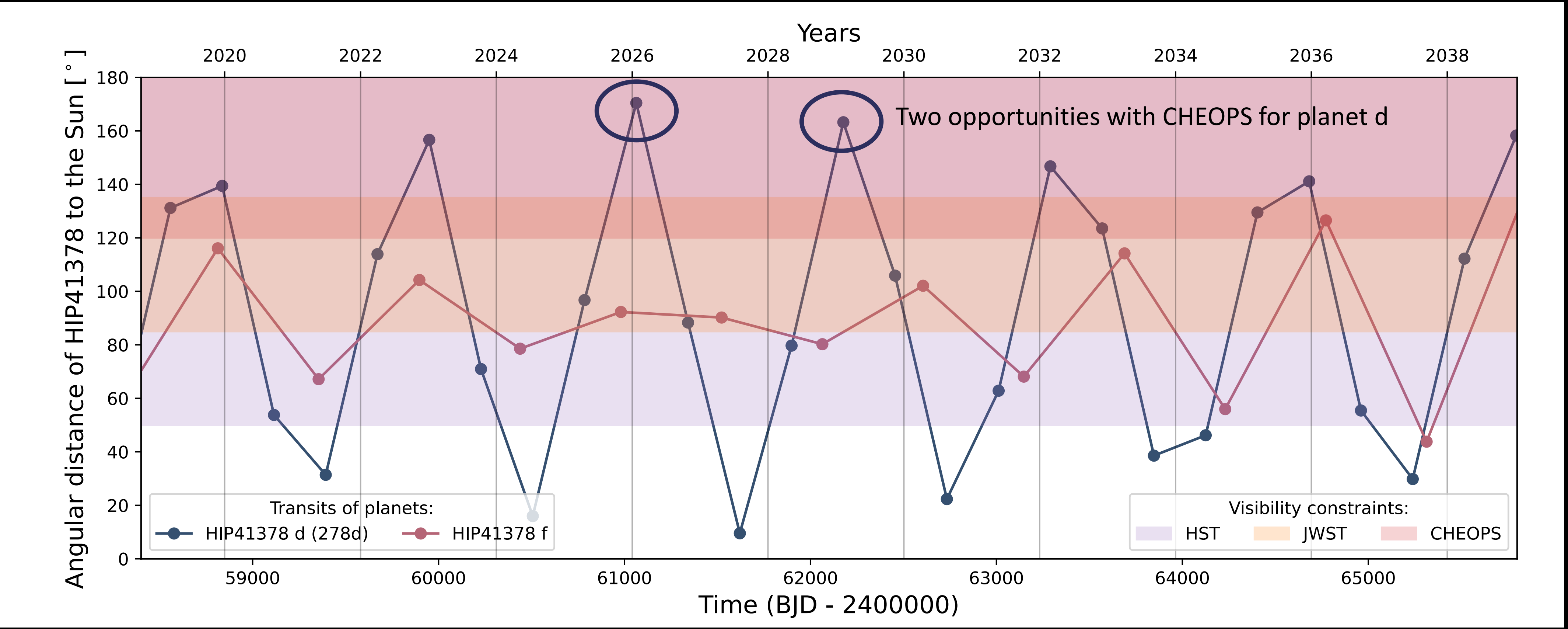
- **TTVs in long-period planets** can be significant. To enable future atmospheric characterization, we must follow up as many transits as possible and observe for durations longer than the transit itself.

- 2 transits are not enough to detect TTVs, at least 3 years on the same targets are needed for Earth-like planets with TTVs.

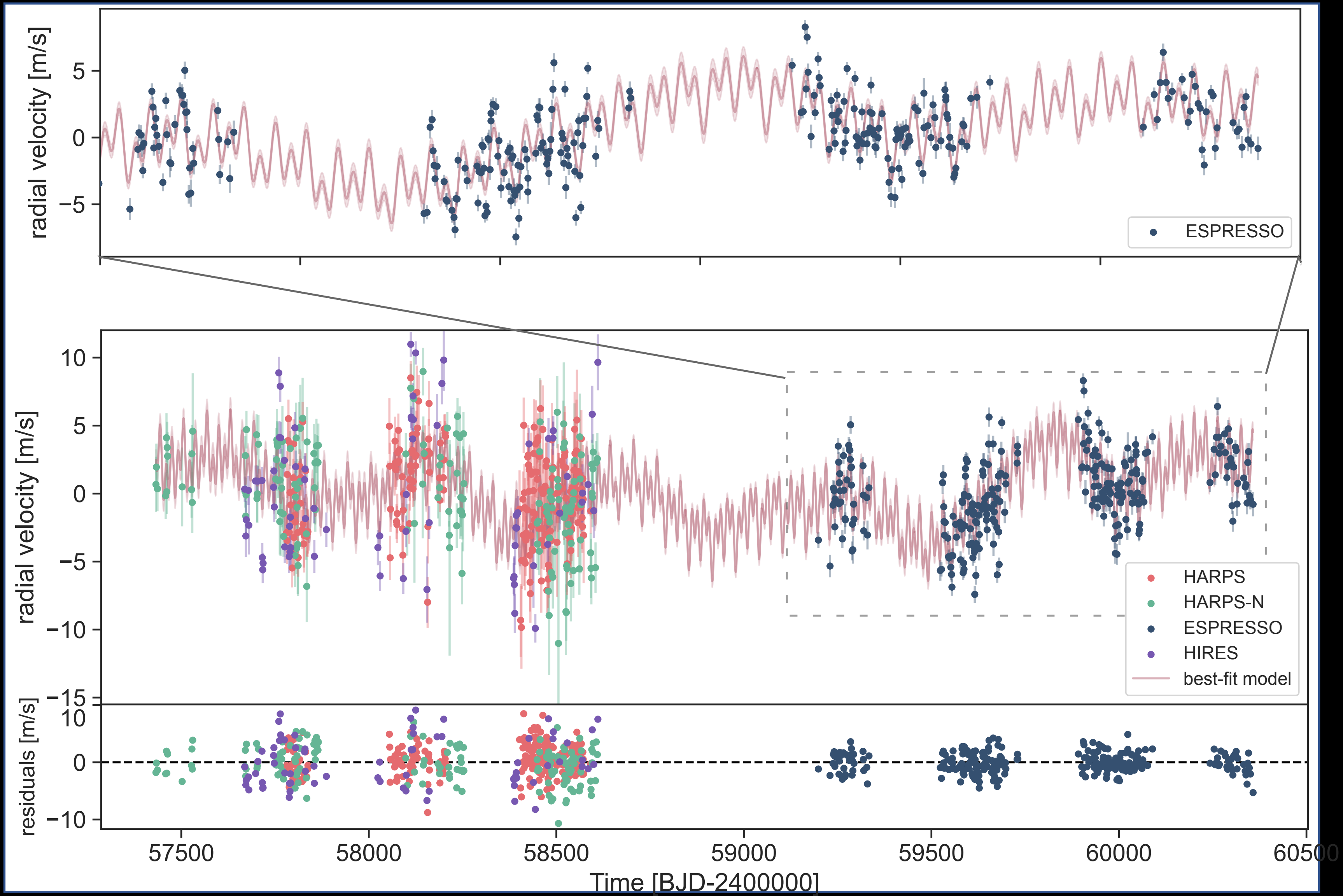
- **From the ground**, only a few transits will be observable. Careful planning and coordination across multiple instruments will be essential to ensure successful observations.

Follow-up of transiting long-period planets

Future observations of HIP 41378 from space



Radial velocities



Planet b (15 days)
$m_b = 6.97^{0.49}_{0.58}\, M_\oplus$

Planet c (31 days)
$m_c = 6.9 \pm 0.7\, M_\oplus$

Planet d (278 days)
$m_d = 6 \pm 2\, M_\oplus$

Planet e (393 days)
$m_e = 7 \pm 3\, M_\oplus$

Planet f (542 days)
$m_f = 25 \pm 3\, M_\oplus$

Planet g (62 days)
$m_g = 5.3 \pm 0.9\, M_\oplus$

Planet h (2000 days ?)
$m_g = 58 \pm 4\, M_\oplus$

Grouffal et al. (in prep)

RV follow-up of long-period planets