

Validation of TOI-7413 b: A Neptunian Planet on the Neptunian Ridge Around an M Dwarf

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Scientific Motivation

- Intermediate objects bridging sub Neptunes and gas-rich giant planets that probe the evolutionary transition between atmospheric escape and H/He envelope retention.
- Test the dependence of the Neptune Desert [1 and ref. therein] on stellar mass.
- Expand the sparse census of Neptune-sized planets around M dwarfs.

TOI-7413: A TESS Planet Candidate

Alerted as TOI on May 1, 2025 with QLP [2]

Sectors: 16, 17, 56, 57, 77, 83, 84

P_{orb}: 3.804±0.185×10⁻⁴ days, **T_{dur}:** 1.507±0.225 hours

Follow-up Observations

Photometry: MuSCAT2 (*g'*, *r'*, *i'*, *z'*), SAINT-EX (*I*+*z*, *r'*), TTT (*SDSS y*).

High-resolution Imaging: *Alopeke/Gemini*

Low-resolution Spectroscopy: *Shane/Kast* and *IRTF/Spex*

Stellar Characterization: SpT=M3.5 (*Spex*) and M4 (*Kast*), T_{eff}=3410±79 K, [Fe/H] = -0.02±0.15 dex, R_{star}=0.3209+/-0.0093 R_{sun}, inactive star

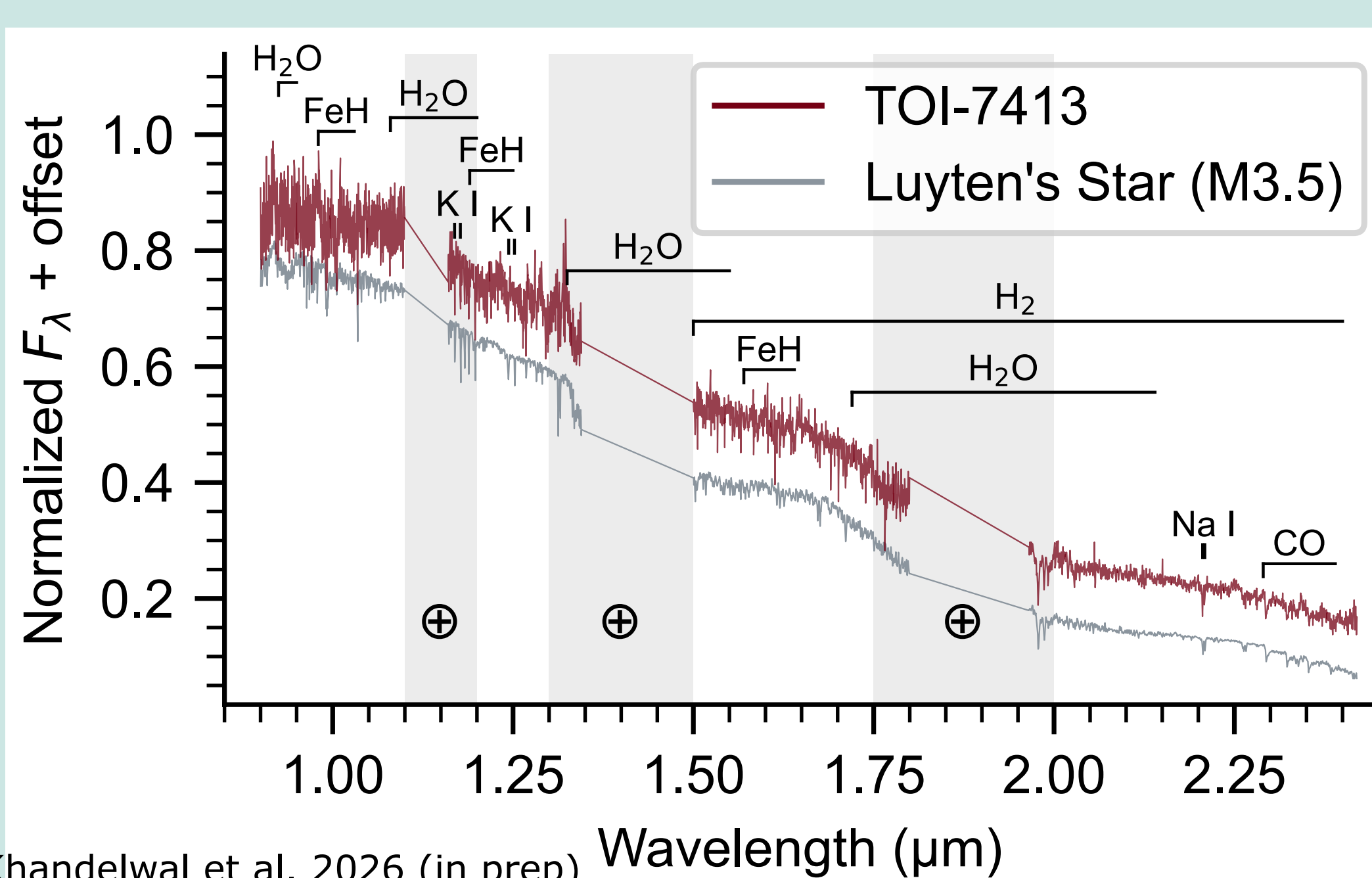
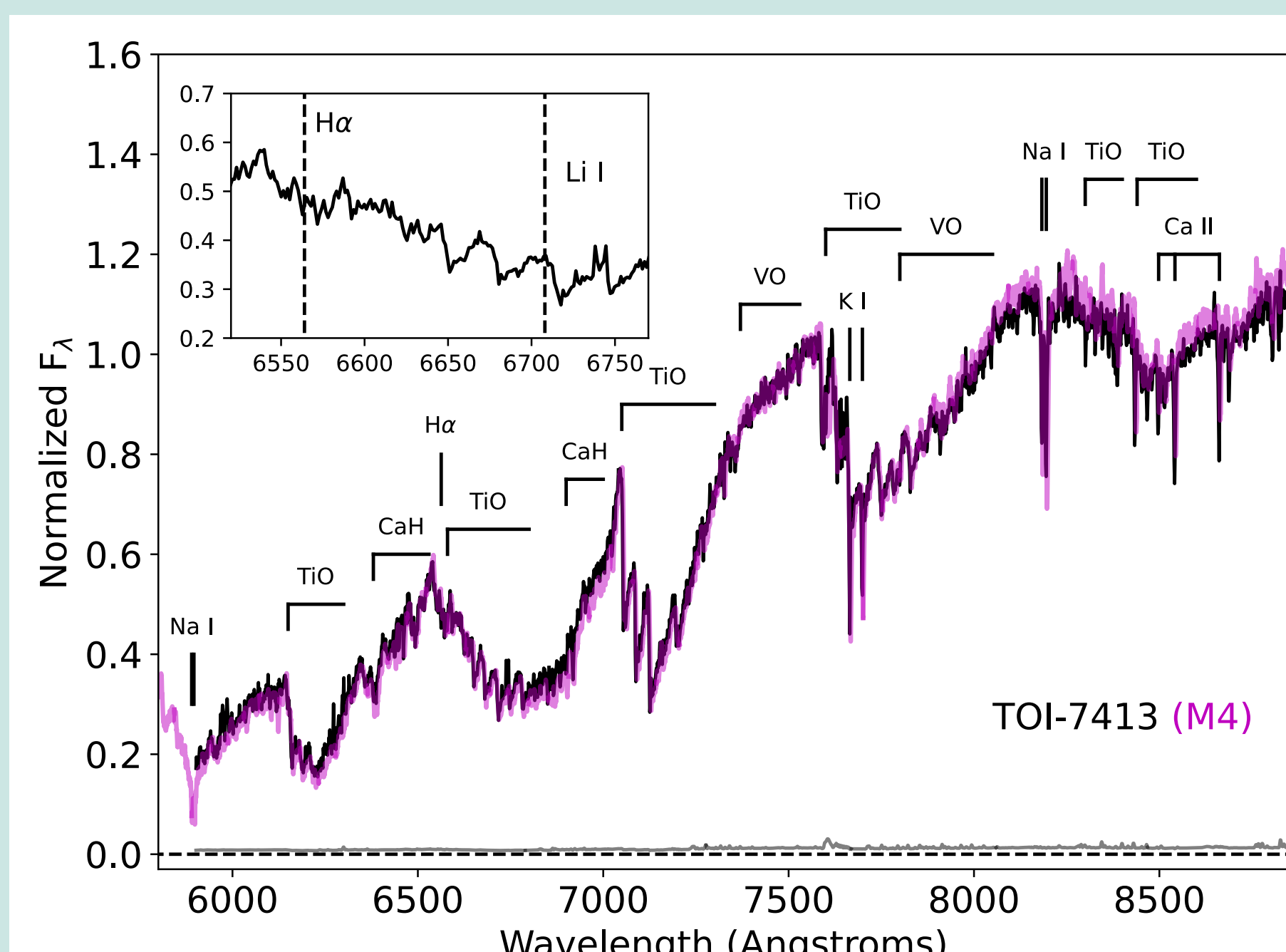


Fig. Left: SpeX spectrum of TOI-7413 with M3.5V standard Luyten's Star. Right: KAST spectrum of TOI-7413



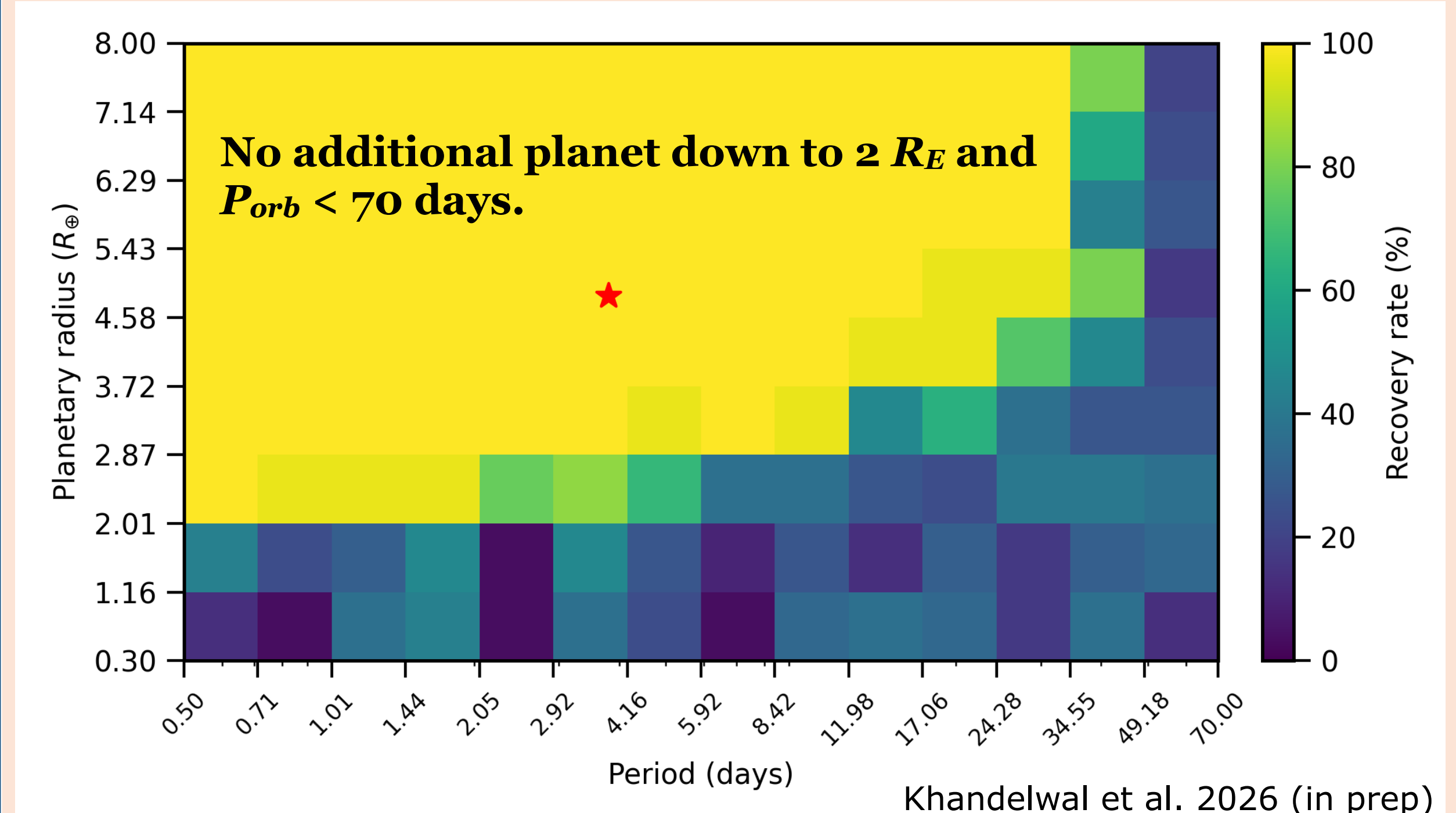
Validation of the planet

Used **TRICERATOPS** [4] for validation

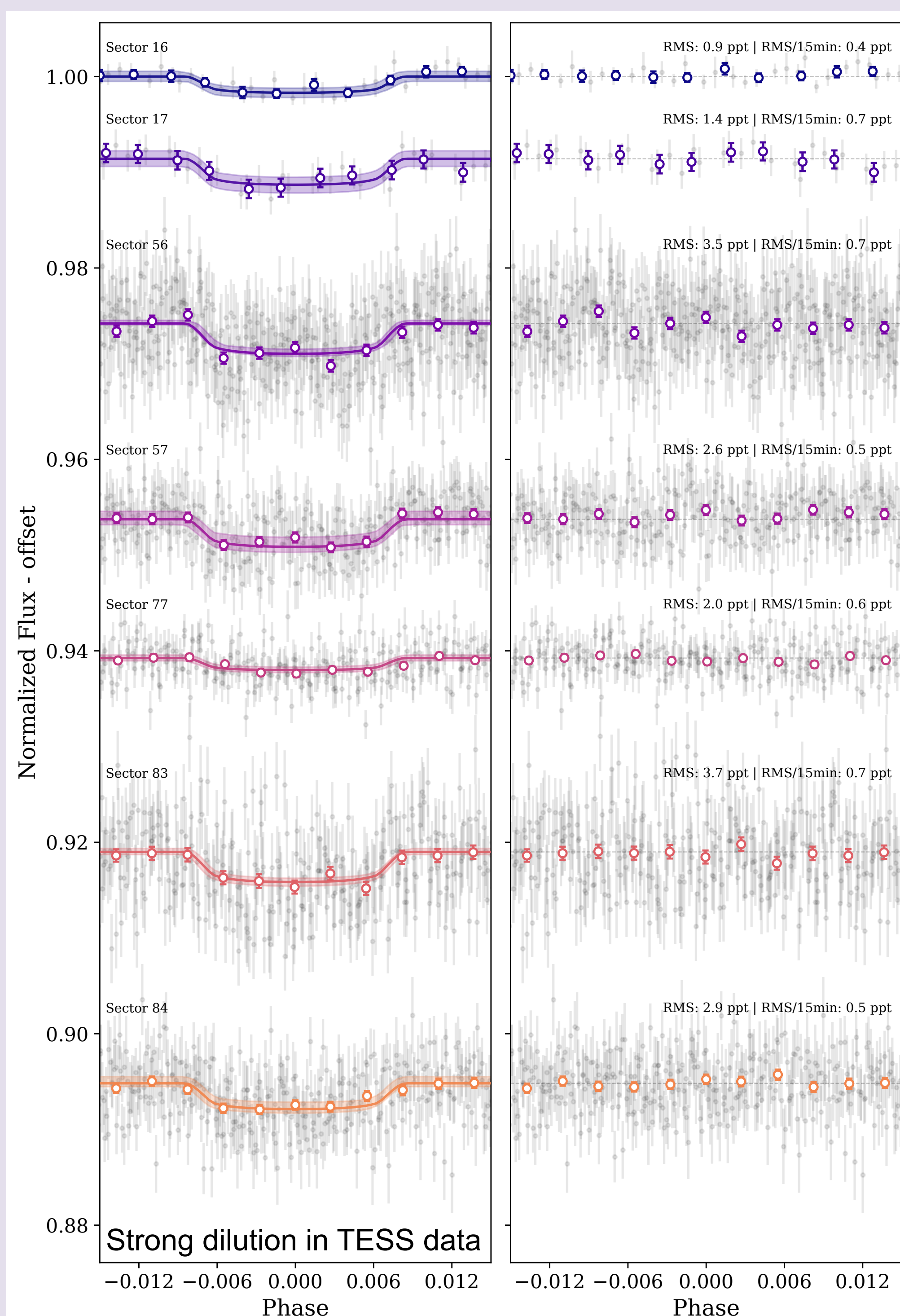
False positive probability (**FPP**) < 0.015

Nearby False positive probability (**NFPP**) = 0

Injection-Recovery Tests



Global Transit Fit with GPs



Fitting results:

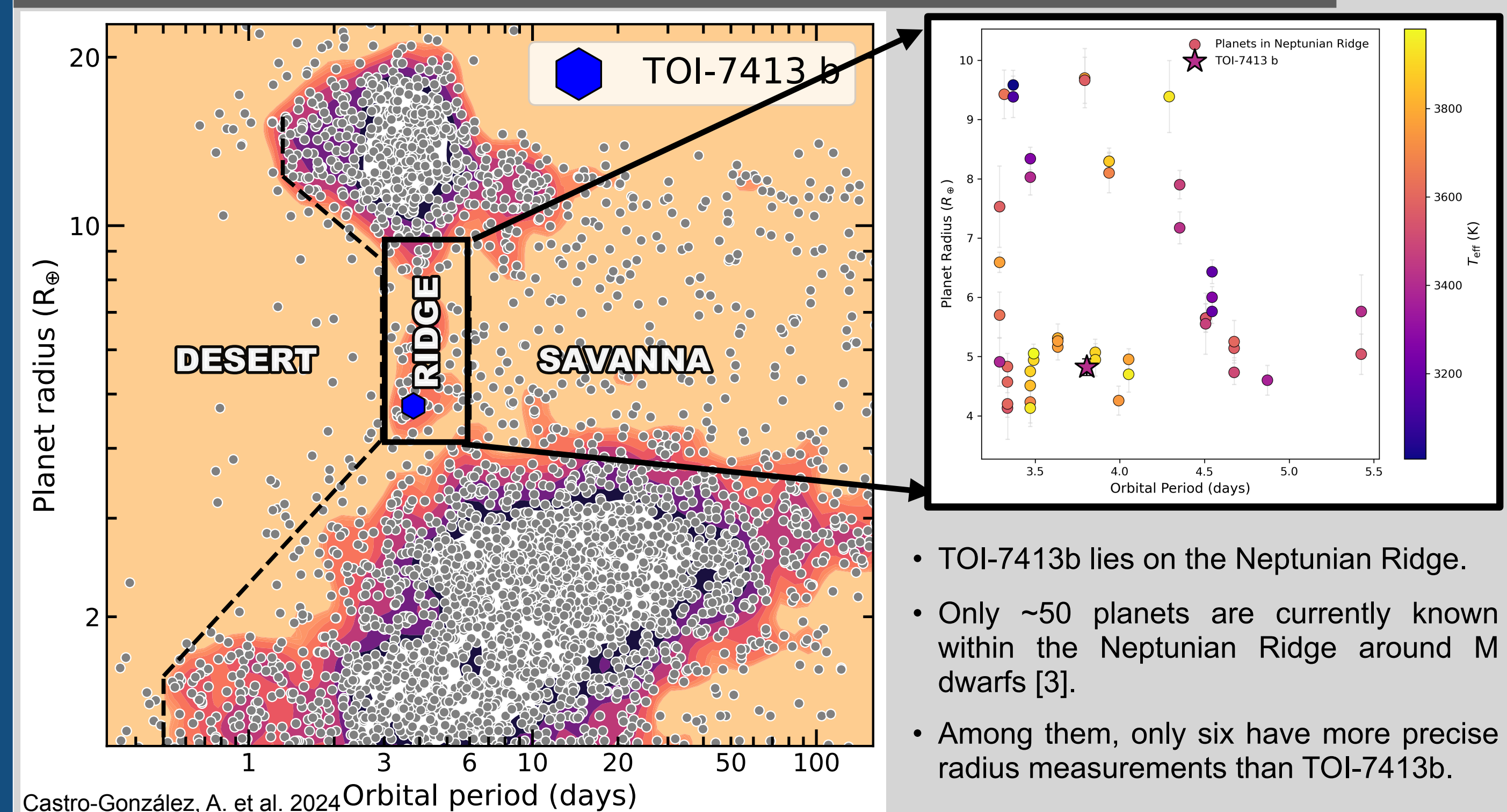
Transit Depth: 19.0±0.2 ppt. **Inclination (i):** 89.31±0.21 deg, **a/R_{star}:** 21.03±0.33

R_p/R_{star}: 0.1379±0.0009 hence, **Planetary Radius (R_p):** 4.82±0.14 R_⊕, **b:** 0.25±0.07

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TOI-7413 b in the Neptunian Ridge



Summary and Conclusions

- We validate TOI-7413b using multi-band photometry, spectroscopy, high-resolution imaging and statistical validation.
- TOI-7413b is a 4.82±0.14 R_⊕ planet orbiting an inactive M3.5 dwarf with an orbital period of 3.804 days.
- Its location on the Neptunian Ridge makes it an important addition to the still limited sample of similar planets around M dwarfs.
- TOI-7413b provides a valuable data point for future studies of the Neptunian Ridge and the dependence of planetary evolution on stellar mass.

References

- [1] Castro-González, A. et al. 2024, A&A, 689, A250
- [2] Huang, Chelsea X. et al. 2020, RNAAS, 4, 206
- [3] NASA Exoplanet Archive
- [4] Gomez Barrientos, J. et al 2025, AJ, 170, 148
- [5] Espinoza, N. et al. 2022, MNRAS, 490, stz2688
- [6] Khandelwal et al. 2026 (in prep.)