Three years of atmospheric characterization with The Near Infra-Red Planet Searcher – NIRPS

Romain Allart, on behalf of the NIRPS consortium
SNSF Postdoctoral fellow
IREx, Université de Montréal

Exosystèmes V, IAP, March 31st 2026

Université de Montréal

Swiss National Science Foundation

IREX Institut Trottier de recherche sur les exoplanètes
Trottier Institute for Research on Exoplanets

Astro Québec

NIRPS: Top level requirements

- ✶ Installed on the 3.6m ESO telescope at LaSilla, Chile
- ✶ Operates simultaneously to HARPS (380-680nm)
- ✶ Connected to the solar telescope Helios

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- AO-assisted fiber-fed echelle spectrograph
- Spectral range: 0.95 - 1.8μm → Y, J, H bands
- RV precision: ~1 m/s
- High spectral stability → few systematics!
- 2 pipelines with telluric-corrected spectra
- Two instrumental modes:
  - High accuracy (HA)
    - 0.4” octagonal fiber
    - R> 80,000
  - High efficiency (HE)
    - 0.9” octagonal fiber
    - R> 70,000

The NIRPS consortium

- **Co-PIs:** R. Doyon & F. Bouchy
- **Co-Is:** F. Pepe, N. Santos, J. De Medeiros, X. Delfosse, R. Rebolo, G. Wade
- **Proj. Scientist:** E. Artigau
- **Proj. Manager:** L. Malo & F. Baron
- **System Engineer:** F. Wildi

Astro Québec · NRC-CNRC · IA instituto de astrofísica e ciências do espaço · UGA Université Grenoble Alpes · PlanetS National Centre of Competence in Research · Observatoire du Mont Mégantic · IREX Institut Trottier de recherche sur les exoplanètes / Trottier Institute for Research on Exoplanets · Université de Montréal · Université de Genève Faculté des sciences Département d'astronomie · Instituto de Astrofísica de Canarias · UFRN Universidade Federal do Rio Grande do Norte

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Operations started on April 1st 2023

725 nights of GTO over 5 years

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NIRPS consortium scientific objectives

L. Mignon

WP1 – 225 nights

- Detection of exoplanets around M dwarfs, active and young stars
- Detections of planet to be imaged with ELT

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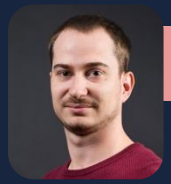

WP3 – 225 nights

- Atmospheric characterization
- Orbital architecture
- Young planets detections

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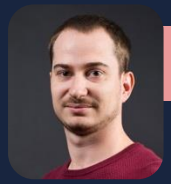

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Other sciences – 50 nights

- Stellar metallicity
- Stellar activity
- Sun monitoring
- Binaries
- Solar system objects

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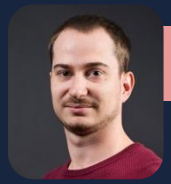

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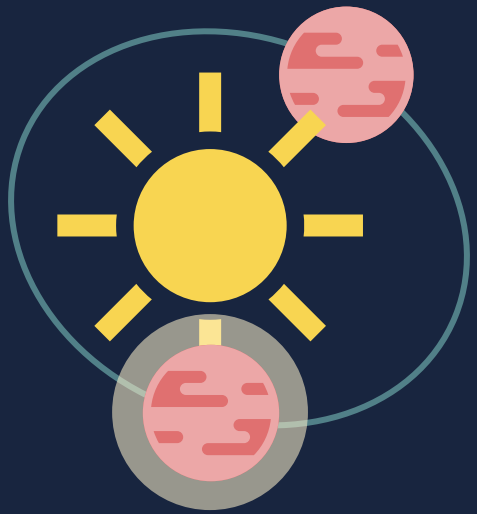
WP3 key players

WP3 scientific questions

- What are the physical and chemical properties shaping atmospheres?
- What is the occurrence of mutual misalignment in multi-planet systems?
- How can we combine atmospheric composition, escape, and orbital architecture to constrain exoplanets' evolution and formation?

WP3 scientific objectives



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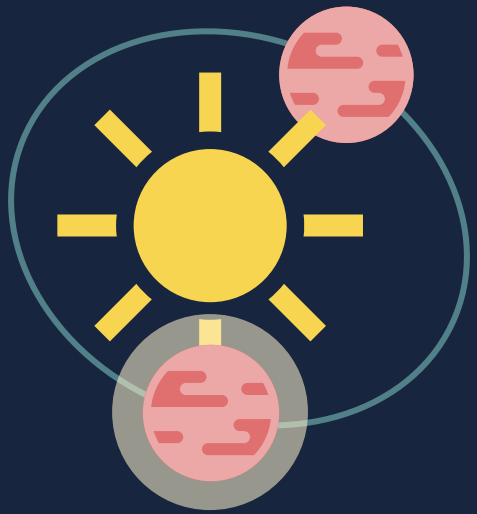

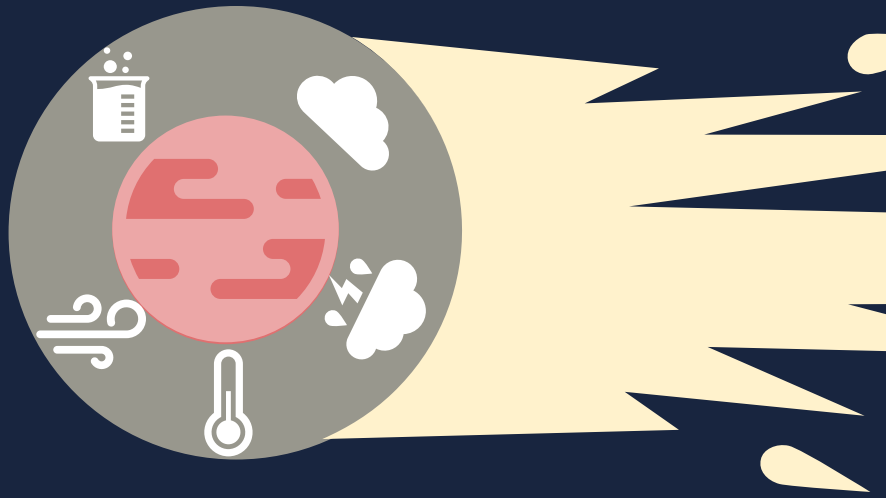

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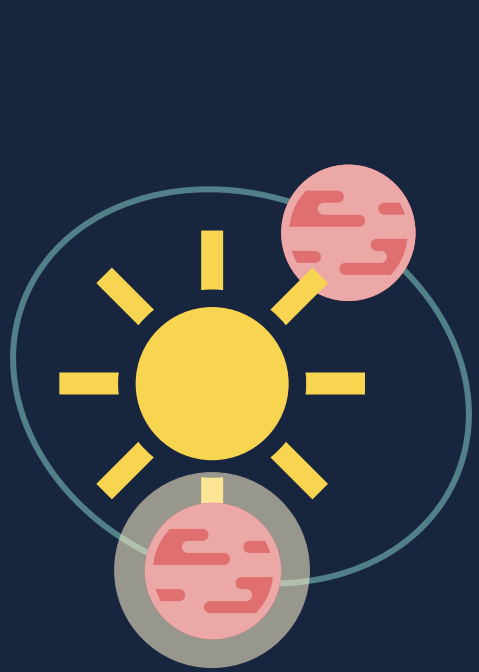

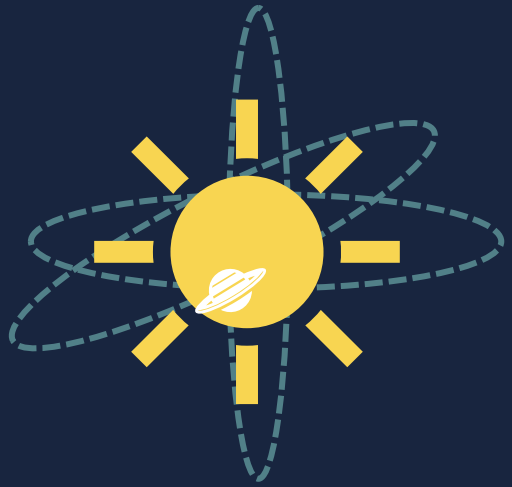

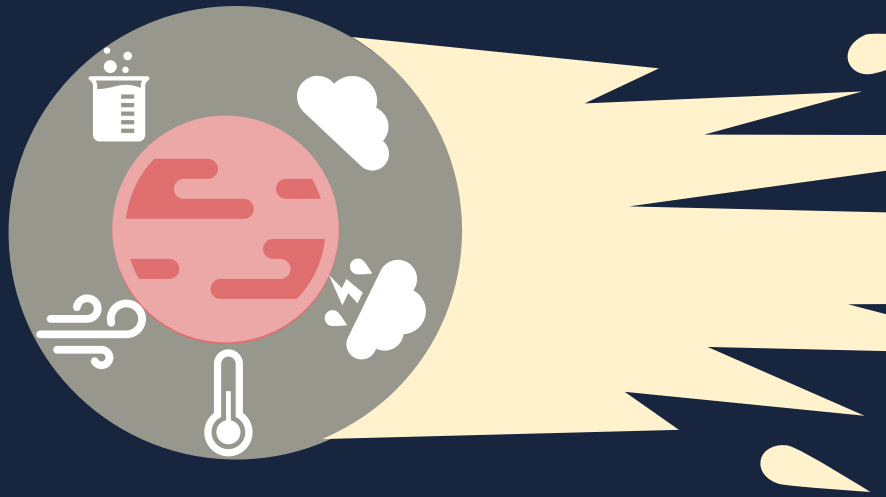

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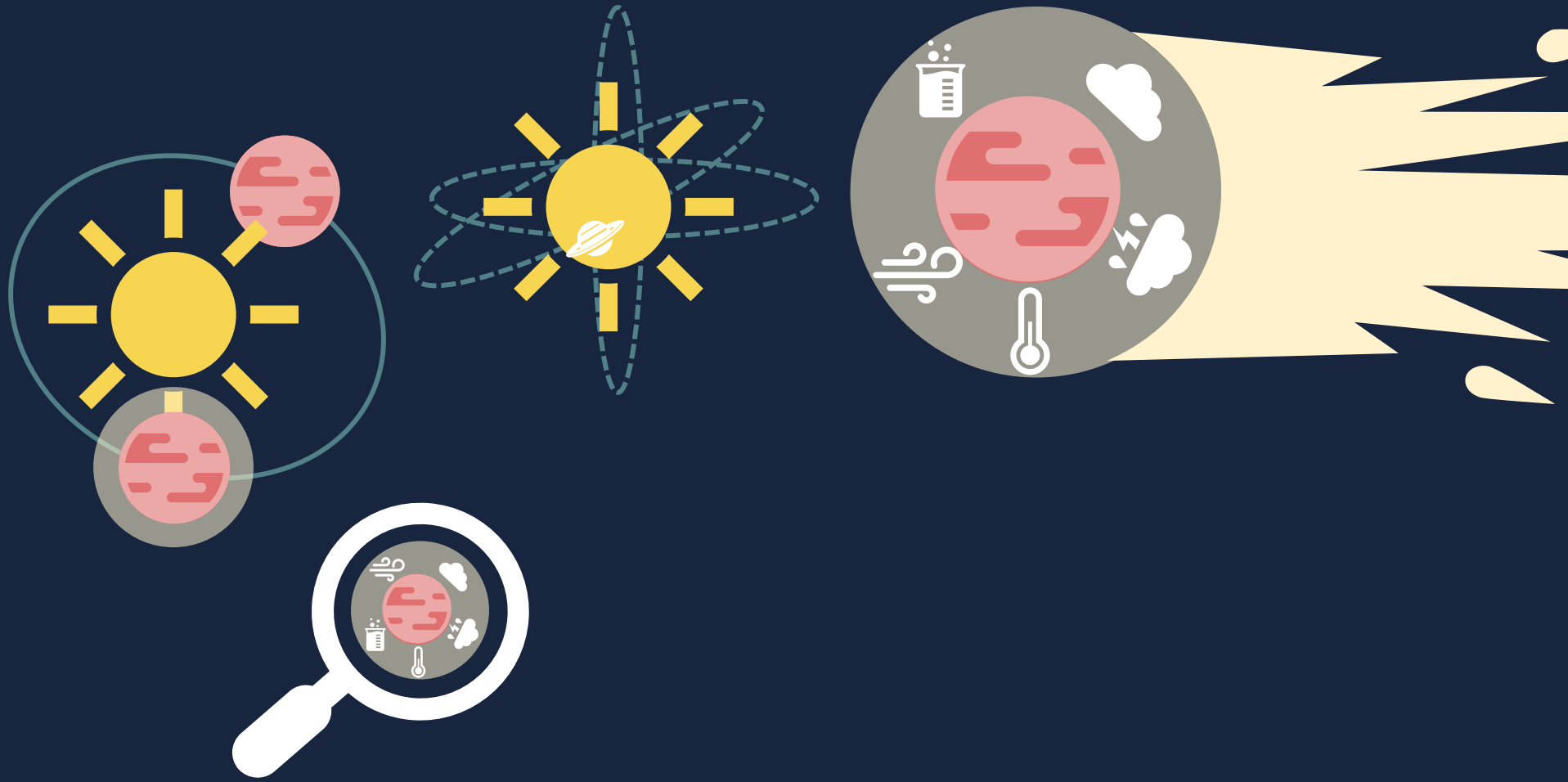

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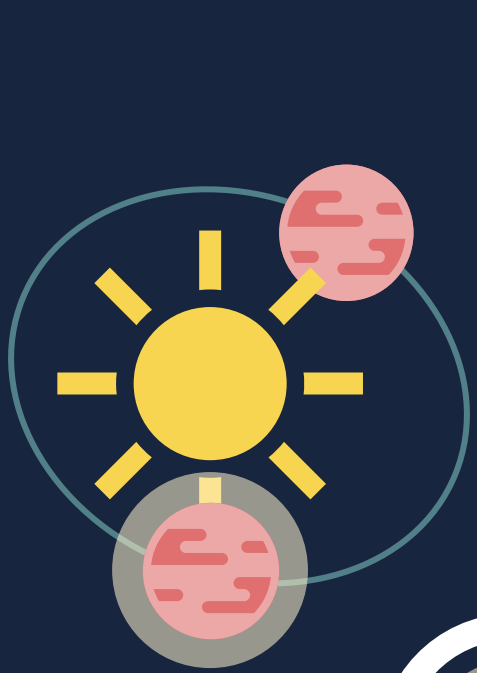
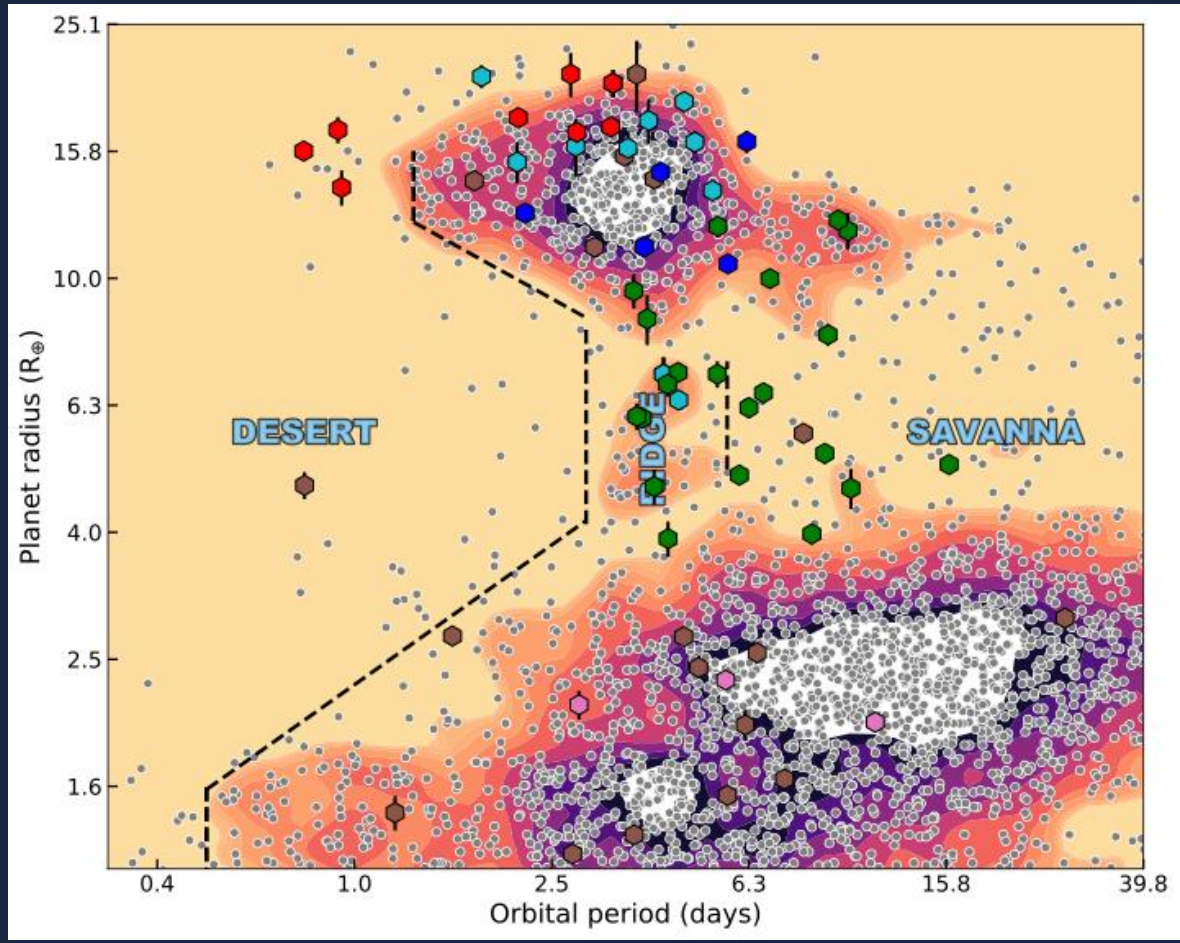


NIRPS WP3 sample

Emission survey ~26%
In-depth characterization ~27%
Transit survey ~17%
Helium survey ~22%
Temperate sub-Neptunes ~8%
Targets stopped/completed



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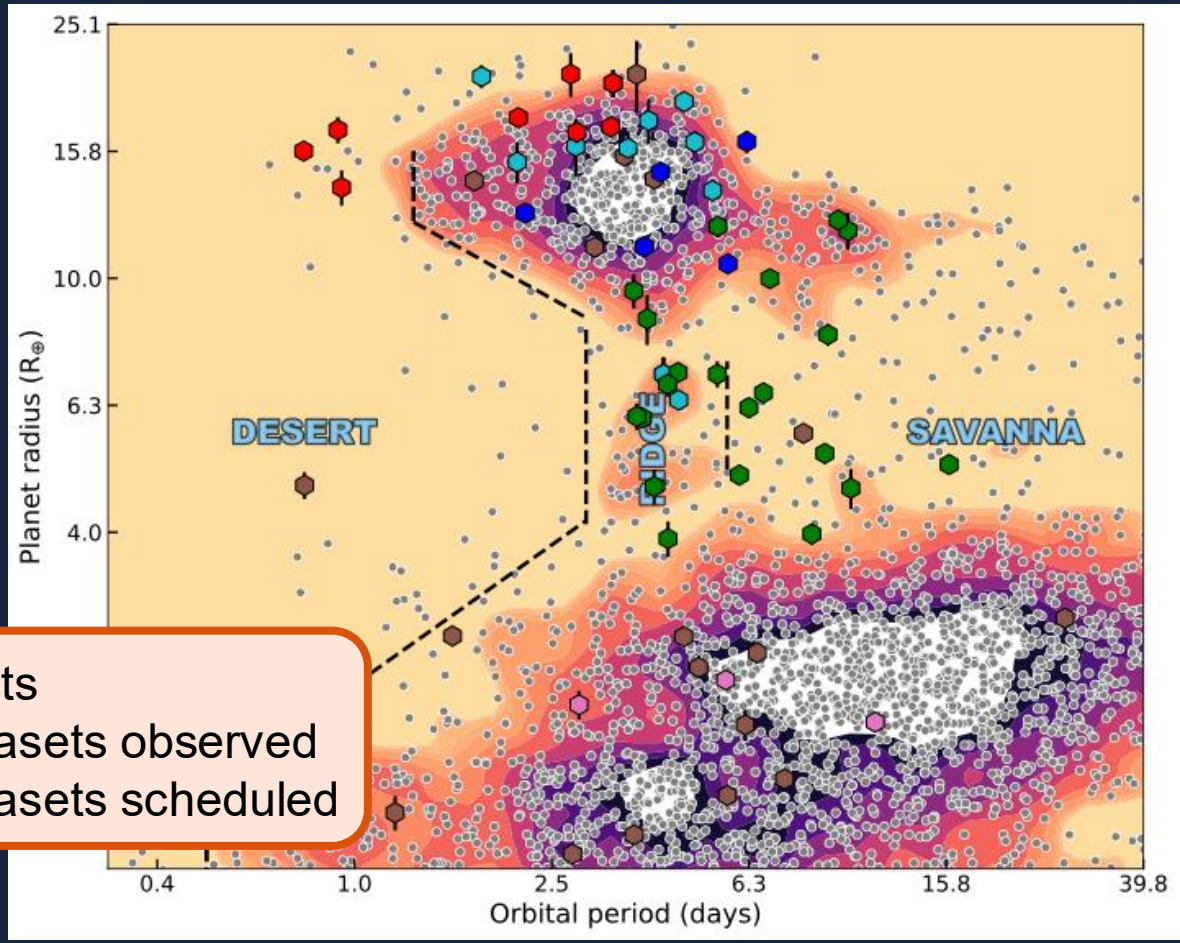
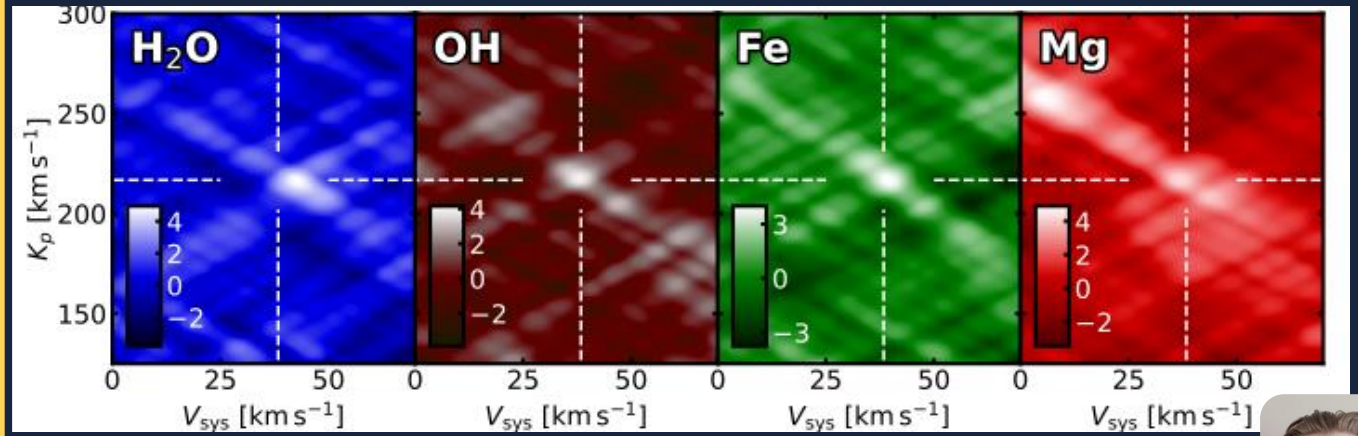
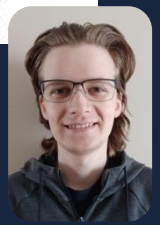


- **~90** most promising exoplanets
- **147** transit & **45** emission datasets observed
- **123** transit & **77** emission datasets scheduled

Detection of volatile and refractory elements in the ultra-hot Jupiter WASP-121b

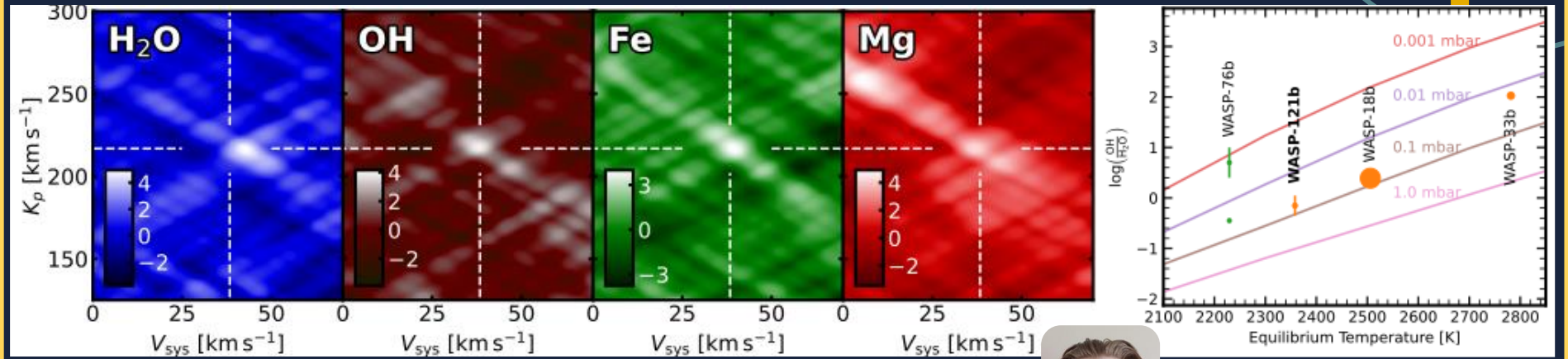


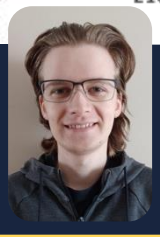


Bazinet et al. 2025

Detection of volatile and refractory elements in the ultra-hot Jupiter WASP-121b

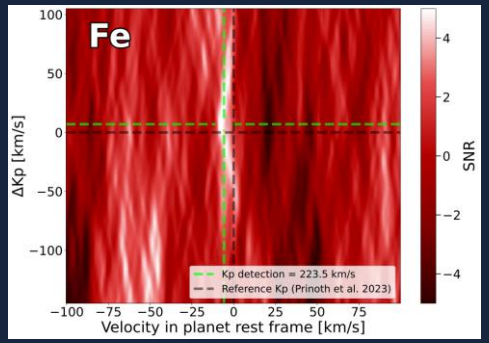
Abundances constraints inform planet formation scenario



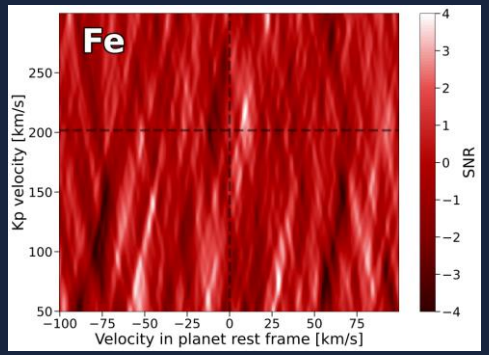


Bazinet et al. 2025

H^- hides metal signatures in the transmission spectrum of ultra-hot Jupiters



HARPS



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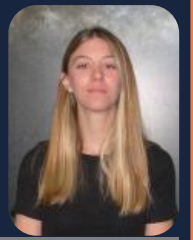

Vaulato et al. 2025a, b

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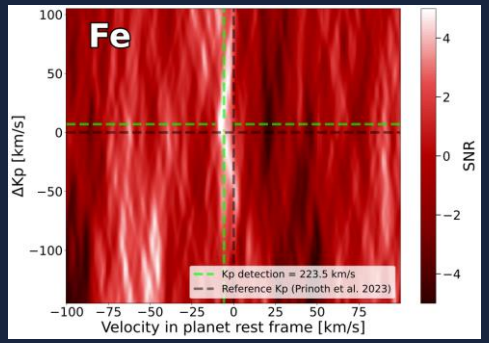
Broad wavelength range unlock continuum opacities constraints



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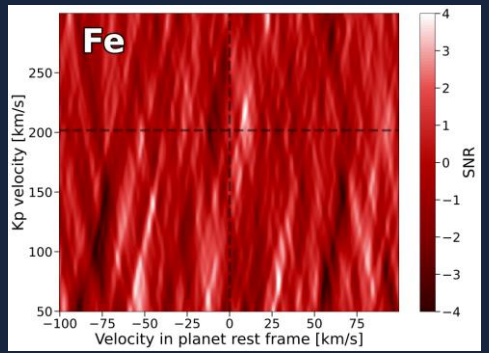

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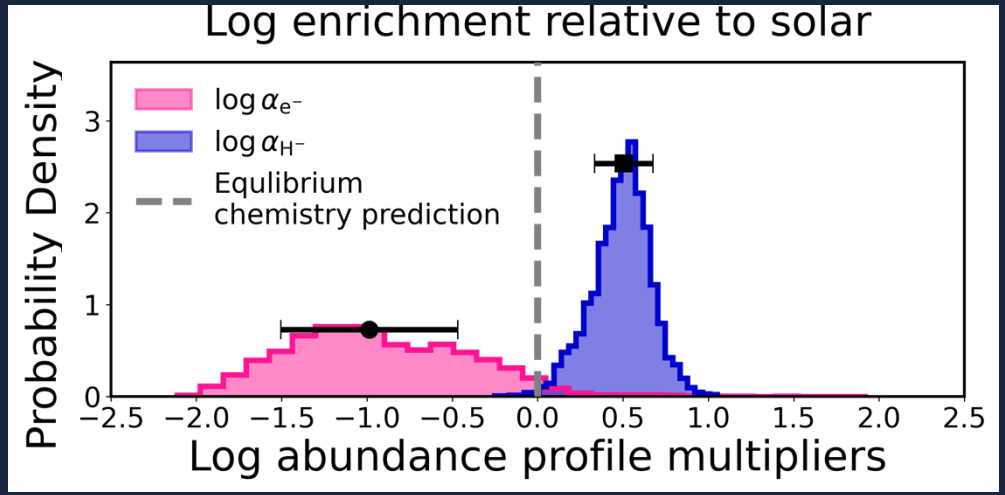
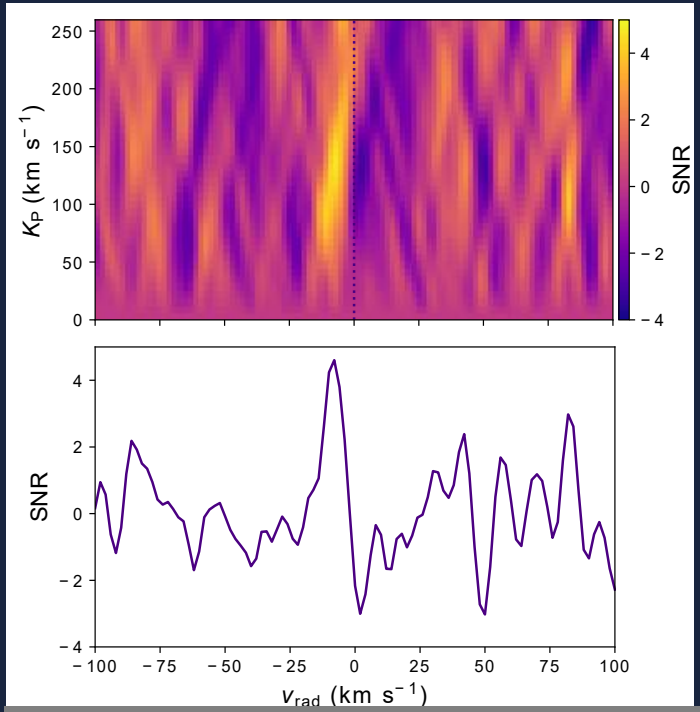
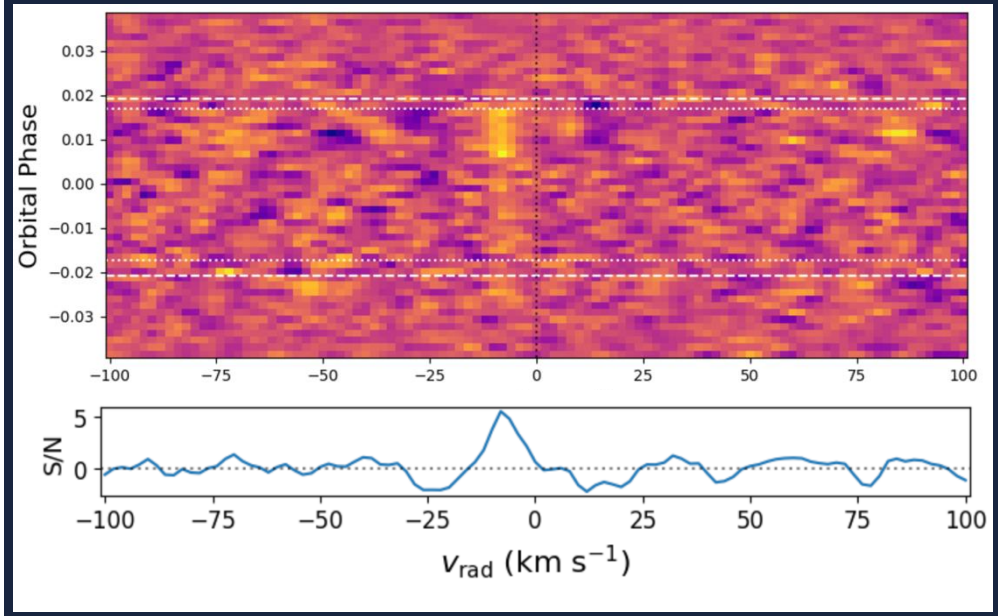


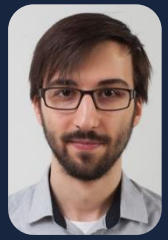
Vaulato et al. 2025a, b

Detection of water in the puffy hot Saturn WASP-127b

Single transit commissioning observation confirms HR papers (Boucher+2023, Nortmann+2024)





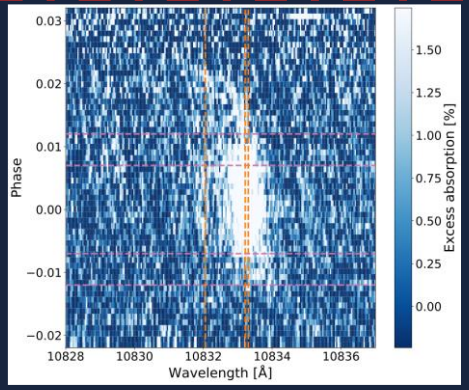


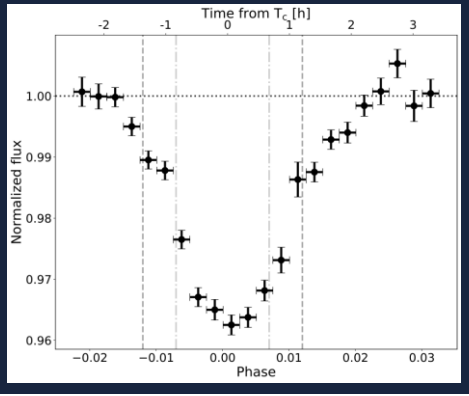
Bouchy et al. 2025; First light of NIRPS

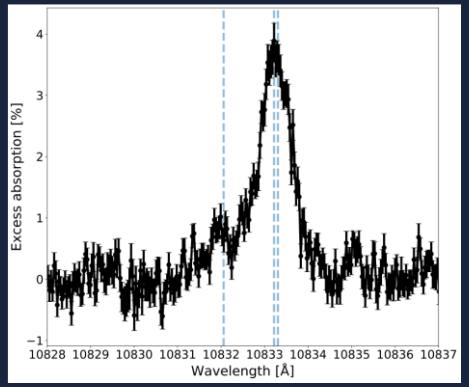
Frédéric Genest

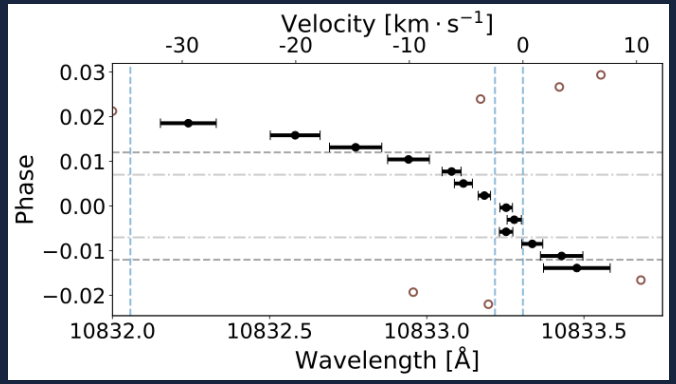
Revisiting the history of WASP-69b

Atmospheric escape and orbital architecture are key to constrain exoplanets' evolution









See Nortmann+2018

Allart et al. 2025

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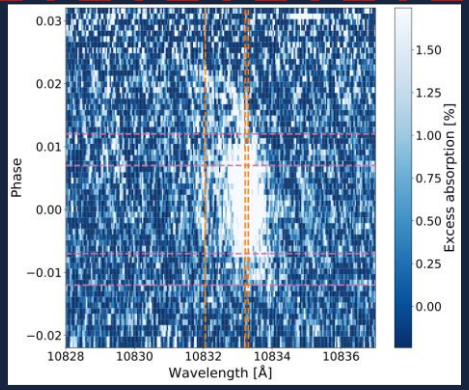

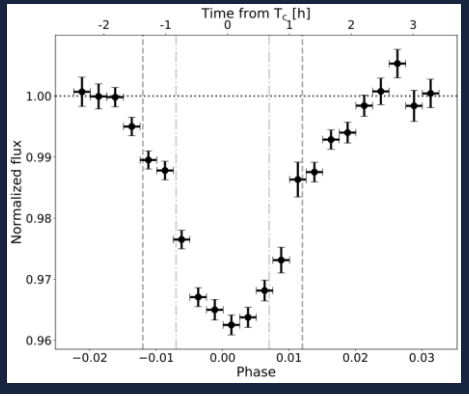

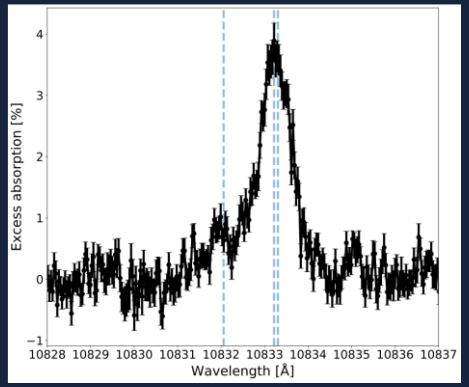

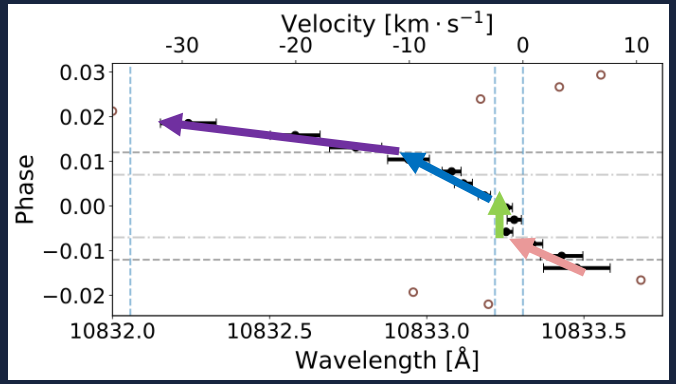

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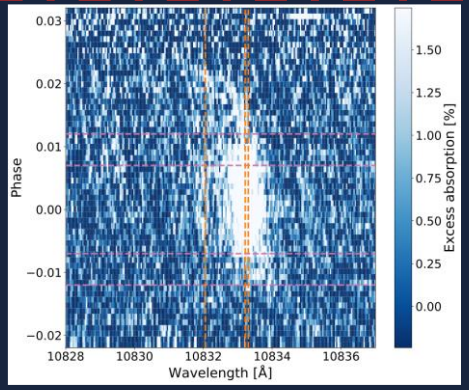
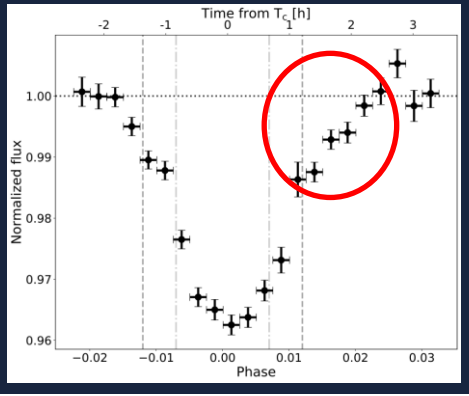
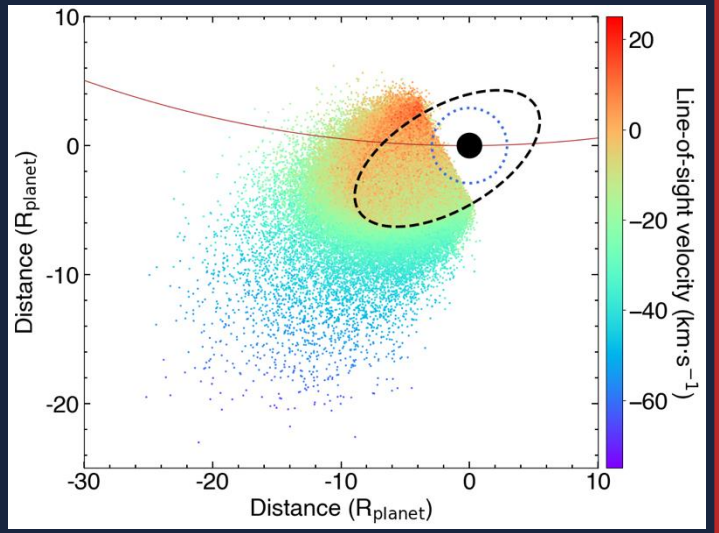
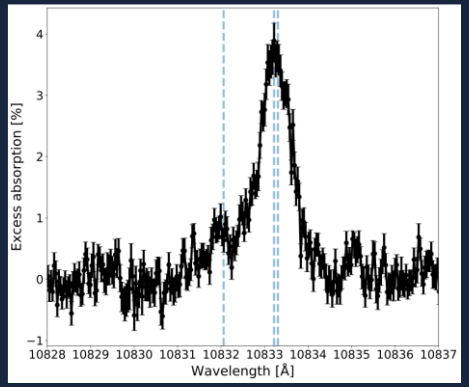
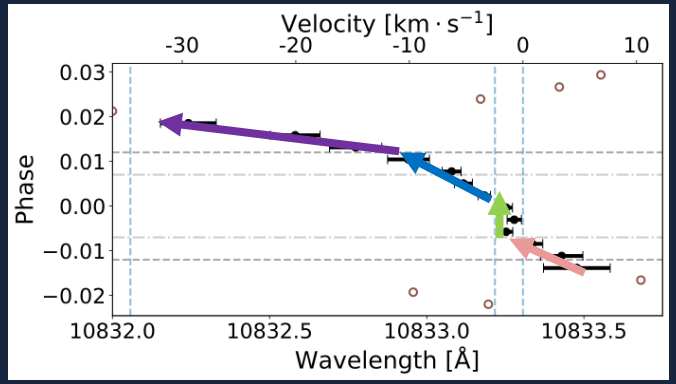








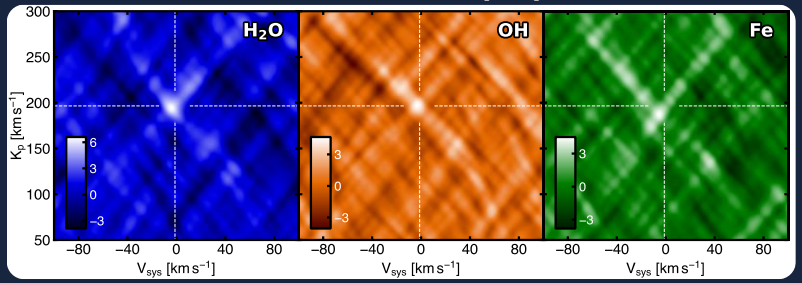


See Nortmann+2018

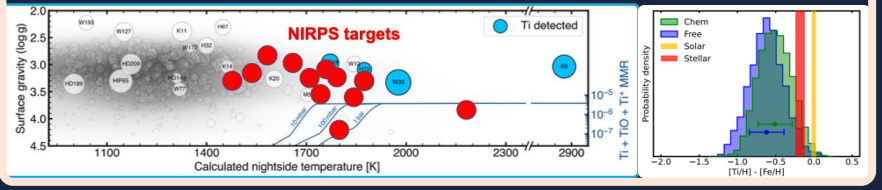
Allart et al. 2025

Many more results are coming!

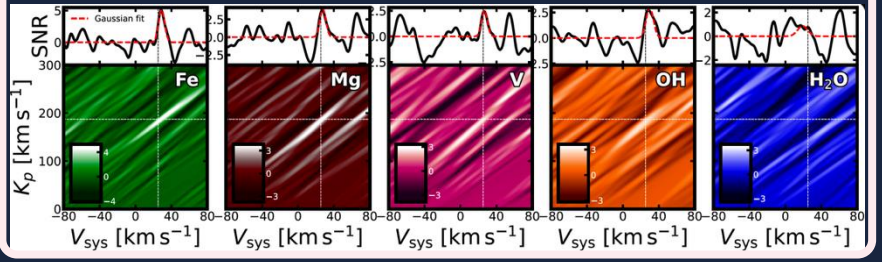
Vaulato et al. in prep.



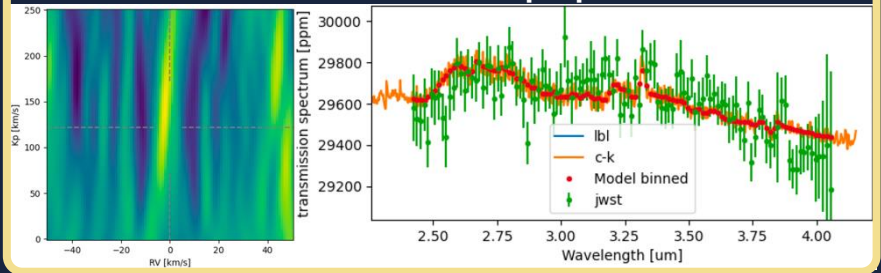
Pelletier et al. submitted



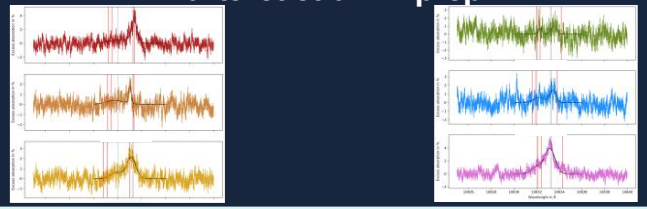
Costa Silva et al. in prep.



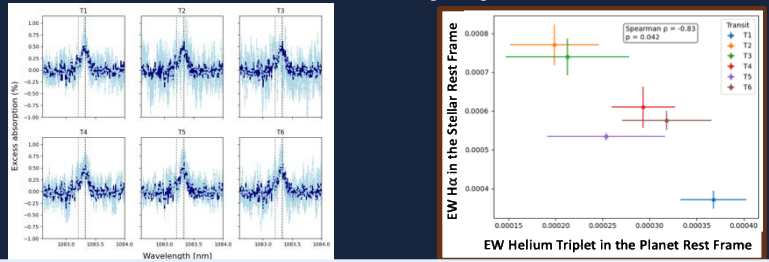
Genest et al. in prep.



Carteret et al. in prep.

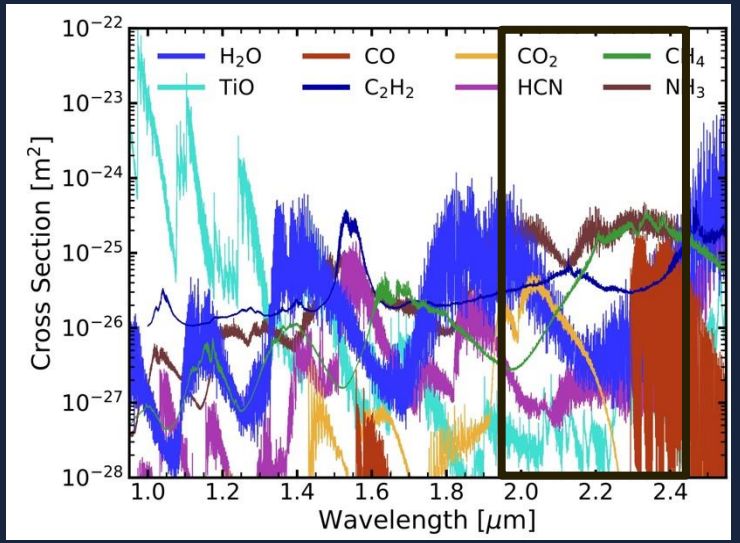


Mraz et al. in prep.



Extension of NIRPS toward the K-band

- Access to CO + CH_4, CO_2, NH_3 and H_2O molecular bands



Extension of NIRPS toward the K-band

- Access to CO + CH_4, CO_2, NH_3 and H_2O molecular bands

- Access to emission specta of lower T_{eq} giant planets
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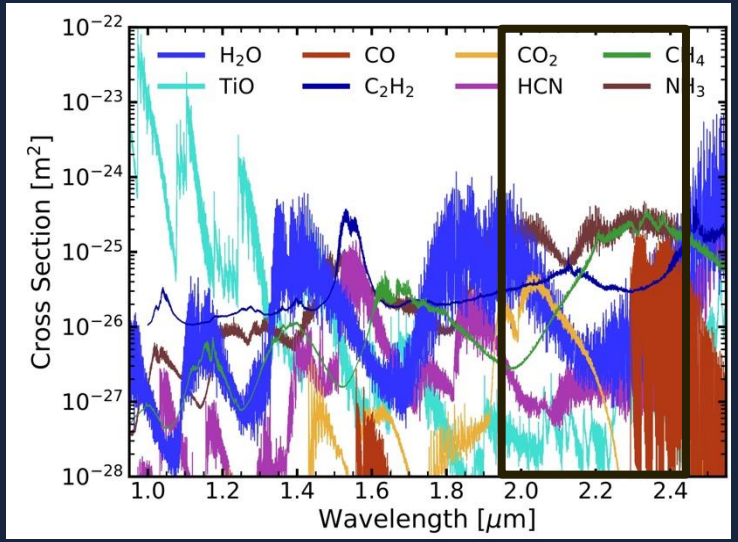
- CO + H_2O + OH +CH_4 ⟹ C/O ratio
- C/O ratio + refractory + He + RM

  ⟹ Overview of processes shaping formation and evolution



Extension of NIRPS toward the K-band

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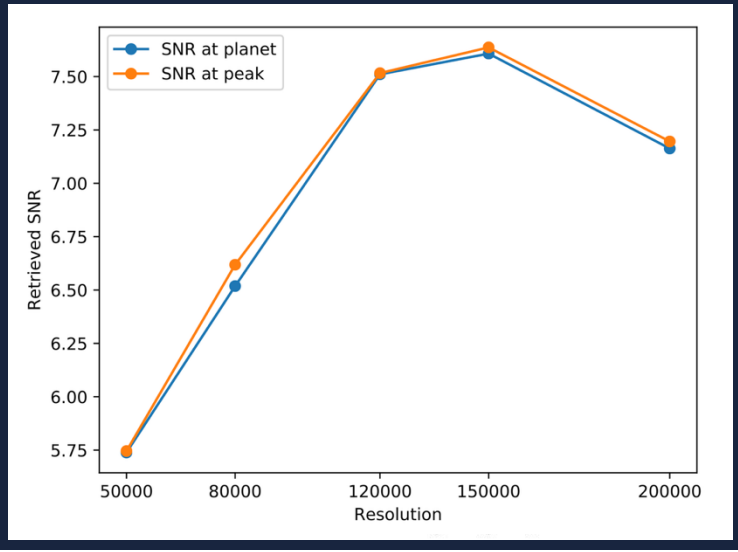
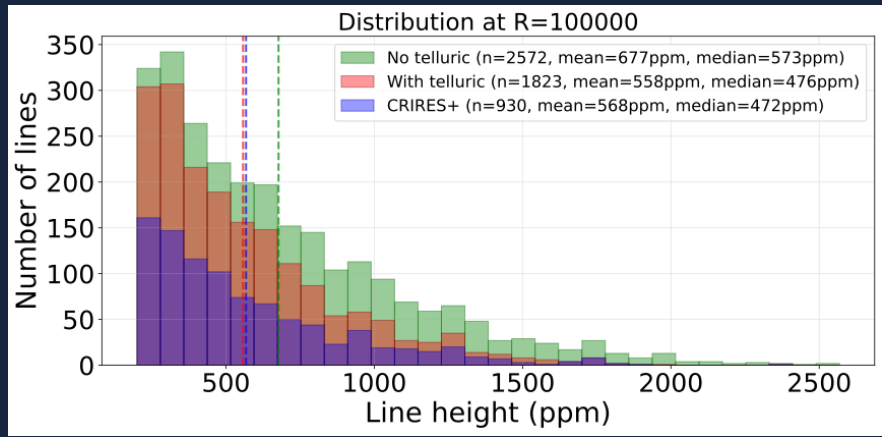
- C/O ratio + refractory + He + RM

  $\Longrightarrow$ Overview of processes shaping formation and evolution

- Top-level requirements:
  - Spectral Resolution : ~150'000
  - Spectral domain : 1.95-2.45 microns
  - Coupled to mono-mode fiber
  - Total efficiency > 10%; ideally 15%
  - Ultra-stable instrument / high fidelity
  - Simultaneous to HARPS and NIRPS
  - **New partners welcome!**

For CO: 2 KIRS events ≥ 1 CIRES+ event





How do 4m telescopes fit in the ELT era?

- NIRPS time allocation and long-duration program ⟹ **Atmospheric surveys**
  - Identify the best close-in planets for ELT
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    1) Keystone close-in planets
    2) Extend toward larger populations studies (Neptunes, sub-Neptunes)

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- NIRPS is the pathfinder to ELT/ANDES:
  - Fiber-fed AO-assisted spectrograph ⟹ mitigation of persistence, modal noise
  - With HARPS, similar wavelength coverage: UBVR and YJH

    ⟹ Missing K band? Ongoing discussion to add it!

4-m class telescopes are complementary to the ELT

Summary

- NIRPS dedicates 225 nights to exoplanets' atmospheres and orbital architectures
- Population surveys of composition, dynamics, escape, and orbital architecture
  - Statistical constraints on the evolution and formation of exoplanets
- High-fidelity and high S/N spectra
  - Detailed insights into physical and chemical processes
  - Atmospheric variability

NIRPS is the main ESO HR instrument for atmospheric characterization in P117!

⟹ **Preparation for ELT instruments: ANDES, PCS**

- Proximity to the instrumental teams is crucial for obtaining the best science.

Stay tuned for more exciting NIRPS results in the coming months!!!