



*Primordial Chaos, No. 16.*  
Hilma af Klint, 1906-1907

# Atmospheric characterization of HIP 67522b with VLT/CRIRES+

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with **Florian Debras**, Baptiste Klein, **Estelle Chabrol**, **Sandrine Vinatier**, Thea Hood, Adrien Masson, **Julia Seidel**, **Claire Moutou**, Suzanne Aigrain, Annabella Meech, and Oscar Barragán

Paper: Lavail et al. (2026), arXiv:2602.03498

Slides: <https://astro.lavail.net/presentations/>

# # HIP 67522 – the host star

- Spectral type: G0V
- Association: Sco-Cen
- **Age: 17 Myr**
- Distance: ca. 128 pc (Gaia)
- $T_{\text{eff}} \sim 5700 \text{ K}$
- $\log(g) \sim 4.4$
- Magnitudes: V 9.8, J 8.3, K 8.2 (Simbad)



# # HIP 67522b – the discovery

HIP 67522 b discovered by [Rizzuto et al. \(2020\)](#) with TESS + ground-based confirmation

- Orbital period  $P_{\text{orb}} = 6.9595 \pm 0.0001$  d
- Semi-major axis  $a = 0.047$  AU ( $11.70 \pm 0.27 R_{\text{star}}$ )
- $R_p = 10.07 \pm 0.47 R_{\oplus}$  ( $\sim 0.89 R_J$ )
- Transit duration: 4.82 h
- One of the youngest transiting hot Jupiters known

HIP 67522 c confirmed by [Barber et al. \(2024\)](#),  
 $P_{\text{orb}} \sim 14$  days

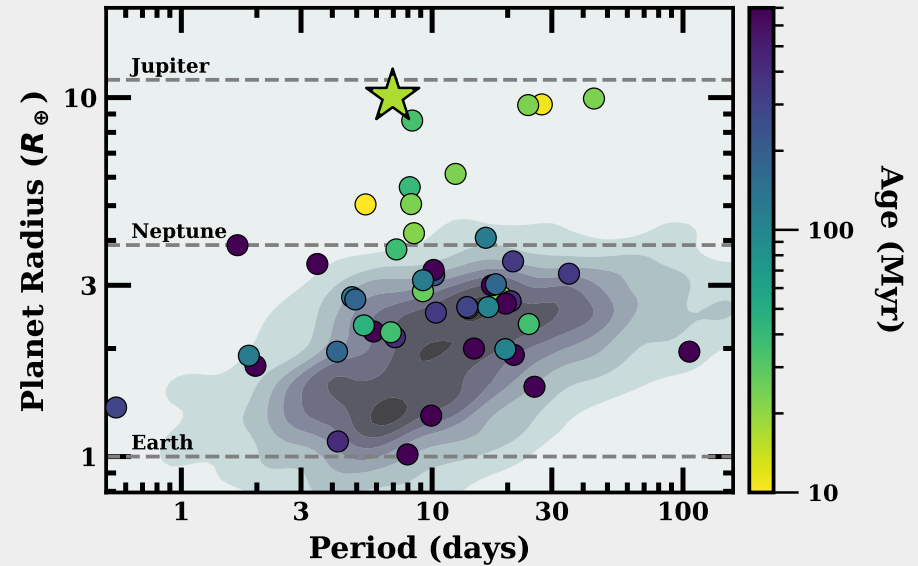


Figure 1. Observed population of all planets from Kepler as a function of the planet radius ( $R_{\oplus}$ ) and orbital period (days; A. Dattilo et al. 2023). Transiting planets with an age under 700 Myr are depicted as circles, with colors corresponding to their age derived from their host cluster or stellar association. HIP 67522 b is outlined as a star and lands well within the mature hot Jupiter part of parameter space. Planet properties from the NASA Exoplanet Science Institute (2020).

Figure from Thao et al. (2024)

# # HIP 67522b – characterization with JWST

Thao et al. (2024):

- JWST/NIRSpec G395H transmission spectroscopy (3-5  $\mu\text{m}$ )
- **Extremely puffy planet:  $\rho < 0.10 \text{ g/cm}^3$**
- **Strong molecular detections**
  - $\text{H}_2\text{O}$  ( $\geq 7\sigma$ ),  $\text{CO}_2$  ( $\geq 7\sigma$ )
  - $\text{CO}$  ( $3.5\sigma$ ),  $\text{SO}_2$  ( $\sim 2\sigma$ )
  - Metallicity  $\sim 3$  times solar, C/O solar to subsolar
- The planet is likely **experiencing substantial mass loss** ( $0.01\text{--}0.03 M_{\oplus}/\text{Myr}$ ), **sufficient for envelope destruction within a gigayear**

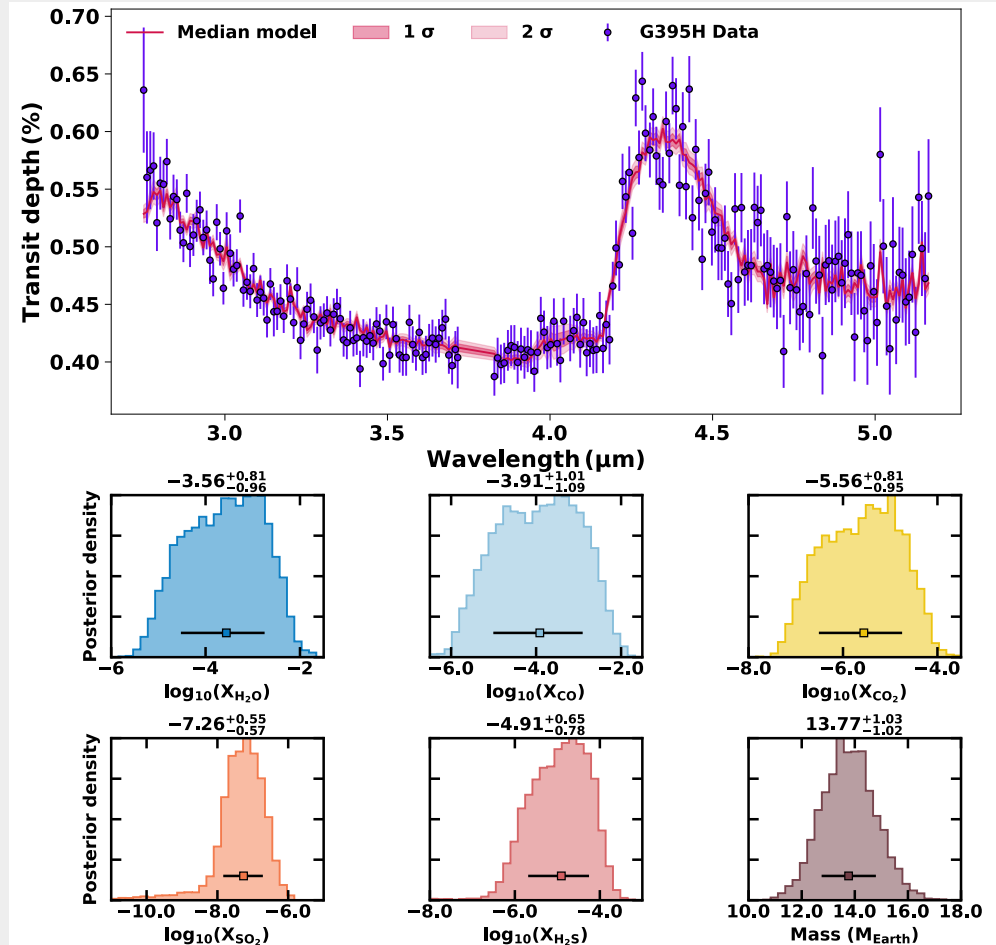


Figure from Thao et al. (2024)

# # HIP 67522b – HRS with CRIRES+

CRIRES+ at the Very Large Telescope is a

- **High-resolution ( $R \geq 10^5$ ) spectrograph / spectropolarimeter**
- operating in the near infrared in the YJHKLM bands in many wavelength settings (not full simultaneous wavelength coverage)
- Adaptive-optics fed and with a high throughput (you get photons for your money)
- The upgrade of the 1<sup>st</sup> generation CRIRES
- In science operations since 2021
- Available to everyone (ESO)
- **Very successful for exoplanet atmosphere**

Instrument paper: [Dorn et al. \(2023\)](#)



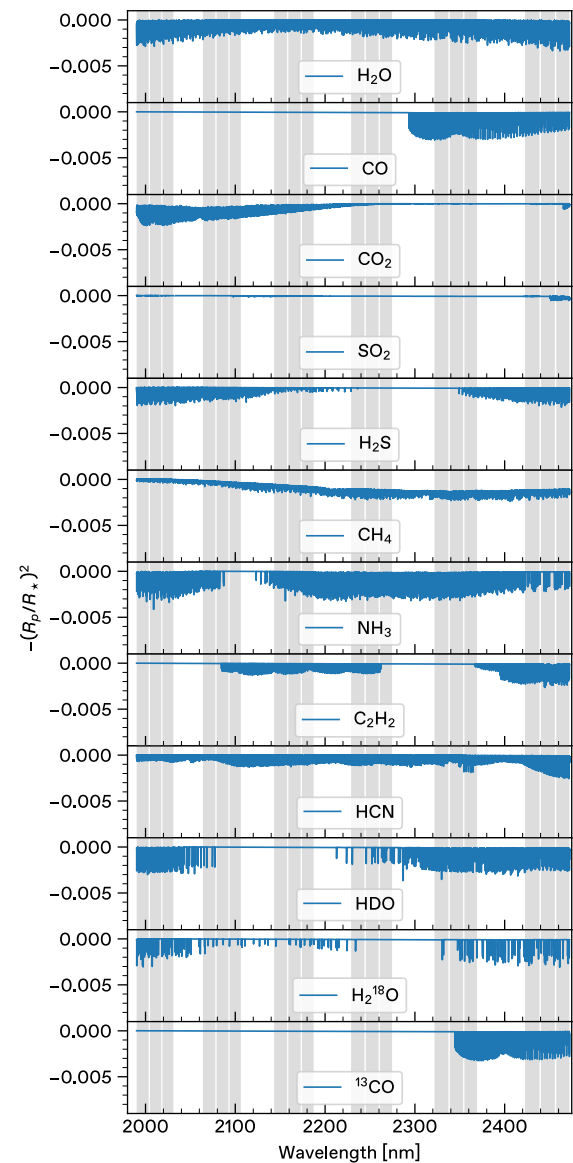
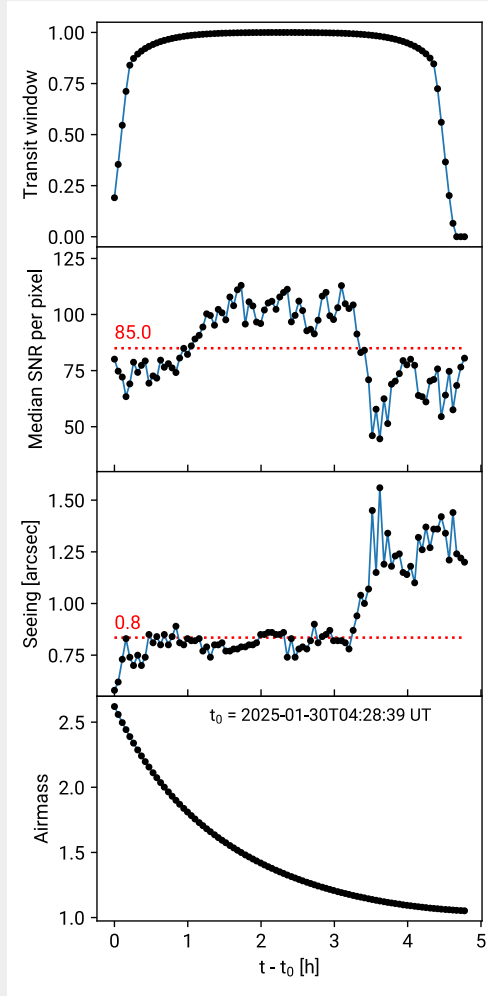
CRIRES+ at the Nasmyth focus of the VLT UT.  
Credits: ESO

# # HIP 67522b – HRS with CRIRES+

Nearly 5 hours of observations on 30 Jan 2025.

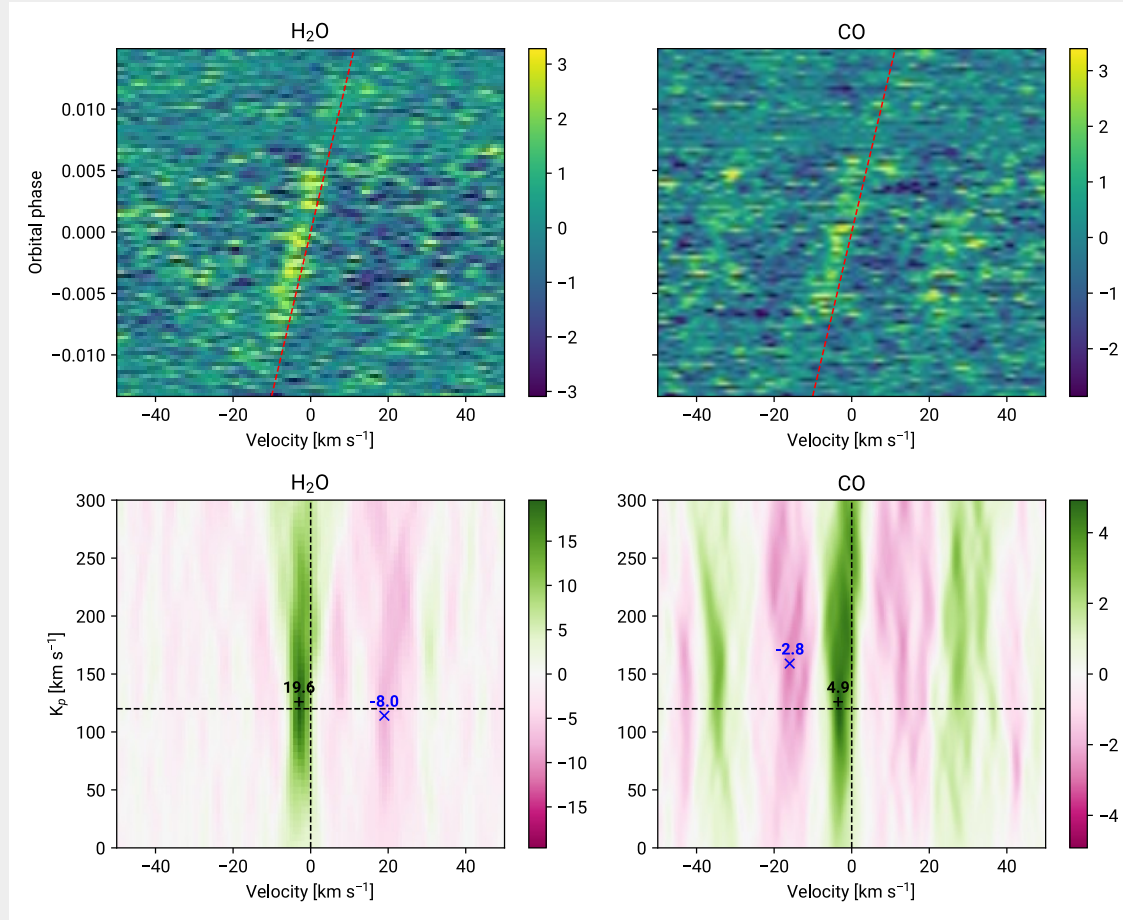
PI: **Baptiste Klein**

Observations in K band around 2000-2500 nm



# # HIP 67522b – H<sub>2</sub>O + CO detections

**Exceptionally strong H<sub>2</sub>O and CO detections.**  
This confirms the planet's extremely extended atmosphere



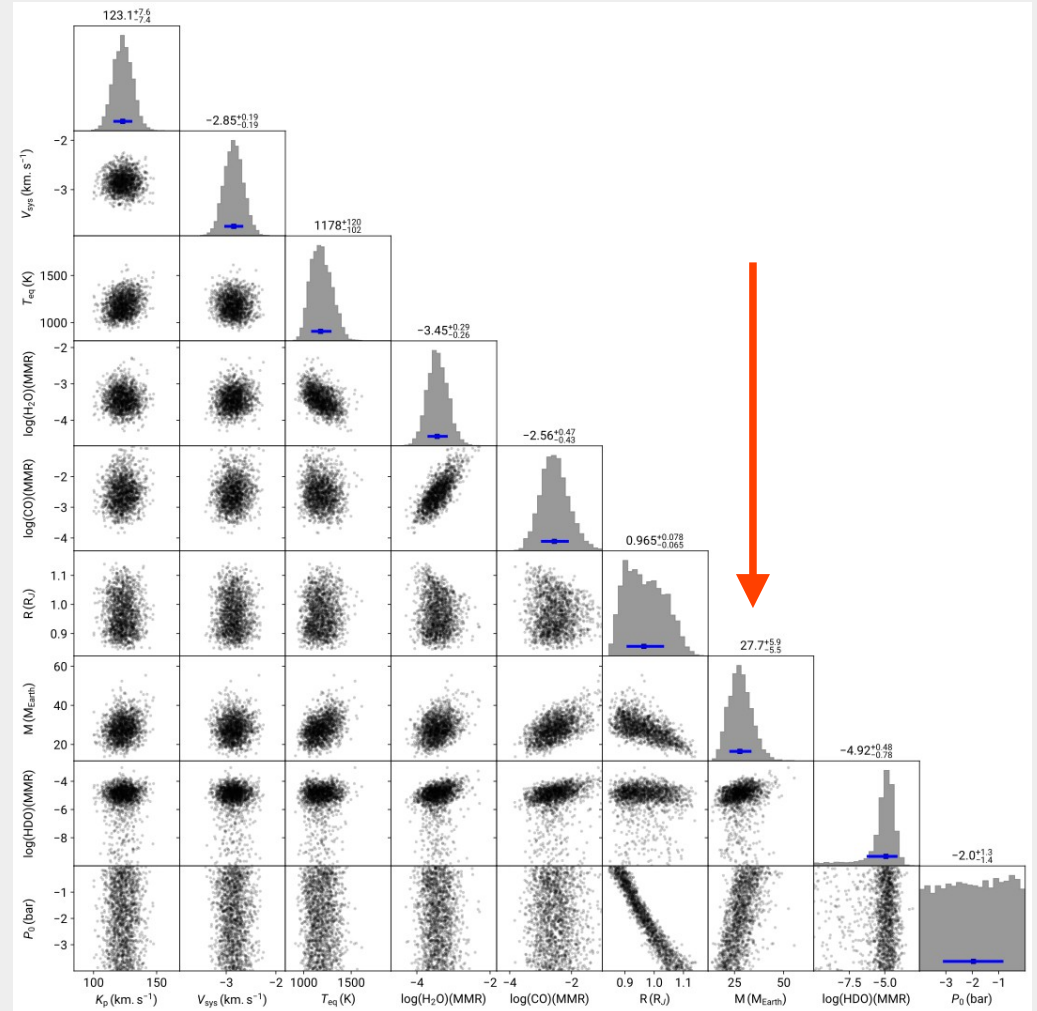
# # HIP 67522b – Heavier mass and tentative HDO

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Retrieval analysis yields a mass of  $27.7^{+5.9}_{-5.5}$  Earth masses, **~2x more massive than JWST estimate** and inconsistent at  $3\sigma$ . This is puzzling and remains unresolved without a joint JWST-CRIRES+ retrieval

This is work done by Estelle Chabrol, **check her poster** *Characterizing the atmosphere of HIP 67522 b with the combination of VLT/CRIRES+ and JWST/NIRSpec transmission spectra*



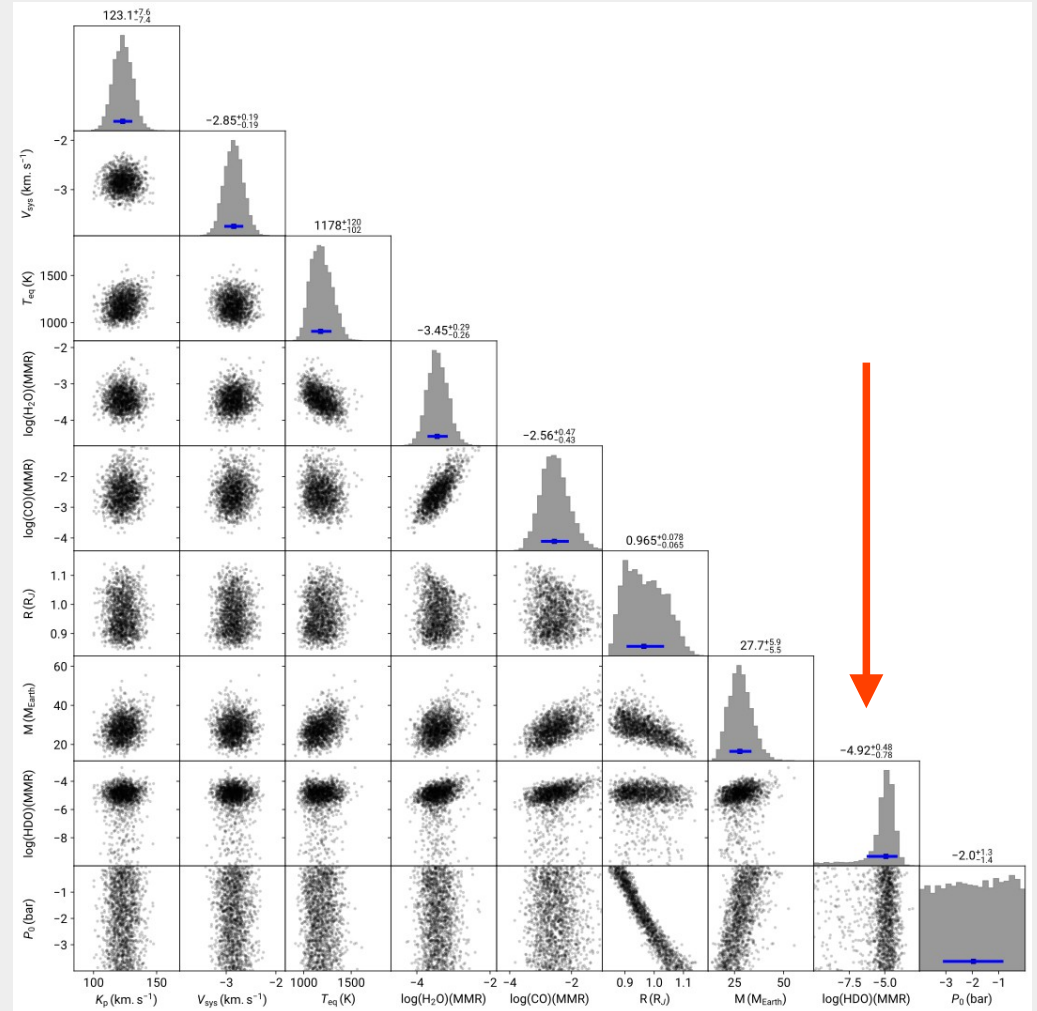
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**Tentative first detection of HDO in an exoplanet atmosphere ( $2\sigma$ )** –  $\log_{10}(\text{HDO}/\text{H}_2\text{O}) = -1.4 \pm 0.4$ , implying a **D/H enrichment factor of ~1000x relative to protosolar**. If confirmed, this would be the first detection of deuterium fractionation in an exoplanet and would require **intense atmospheric escape** to explain



# # HIP 67522b – Atmospheric escape – H $\alpha$

In October 2025, [Milburn et al. \(2025\)](#) published high-resolution spectroscopic observations with CHIRON detected a probable H $\alpha$  absorption signature during transit with an excess depth of  $3.44 \pm 0.28\%$  and a blueshift of  $21 \pm 3$  km/s. This blueshift is consistent with outflowing material pushed by the stellar wind, as expected for escaping atmospheres.

However, **the detection requires confirmation** due to possible **stellar H $\alpha$  variability** comparable to the transit signal amplitude.

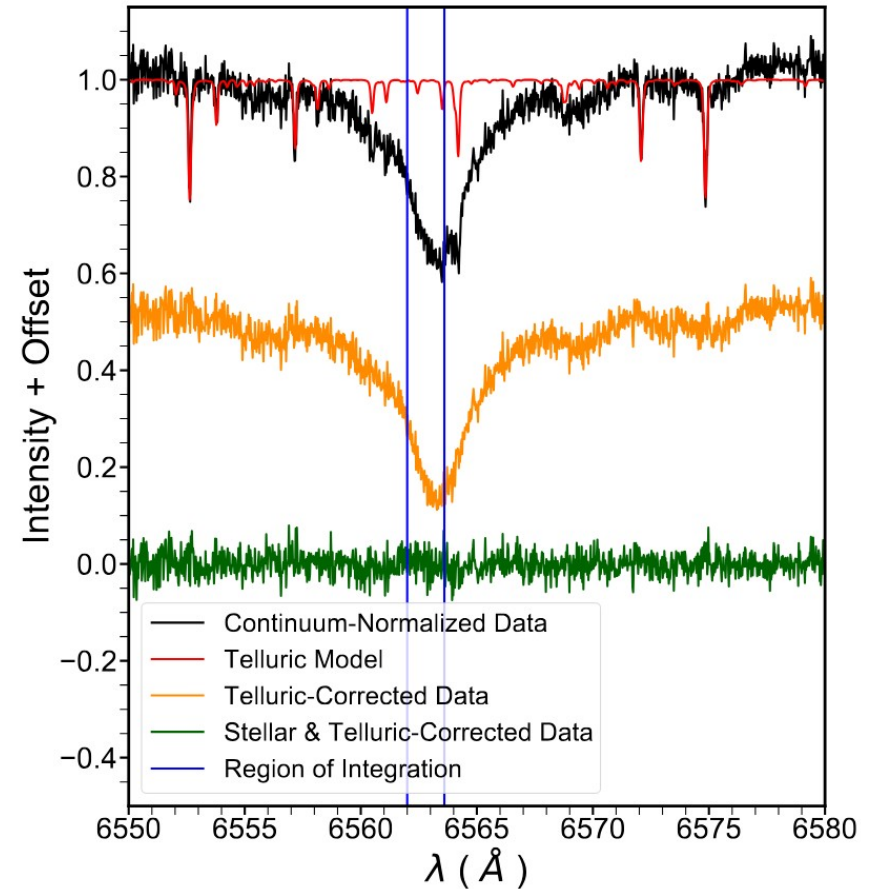


Figure 9 from Milburn et al. (2025)

# # HIP 67522b – Atmospheric escape – flares

In July 2025, [Ilin et al. \(2025\)](#) reported a bombshell:

**“flares in HIP 67522 cluster near the innermost planet’s transit phase. Indicating persistent magnetic star-planet interaction in the system. The stability of interaction implies that the innermost planet is continuously self-inflicting a six time higher flare rate than it would experience without interaction.”**

(emphasis my own)

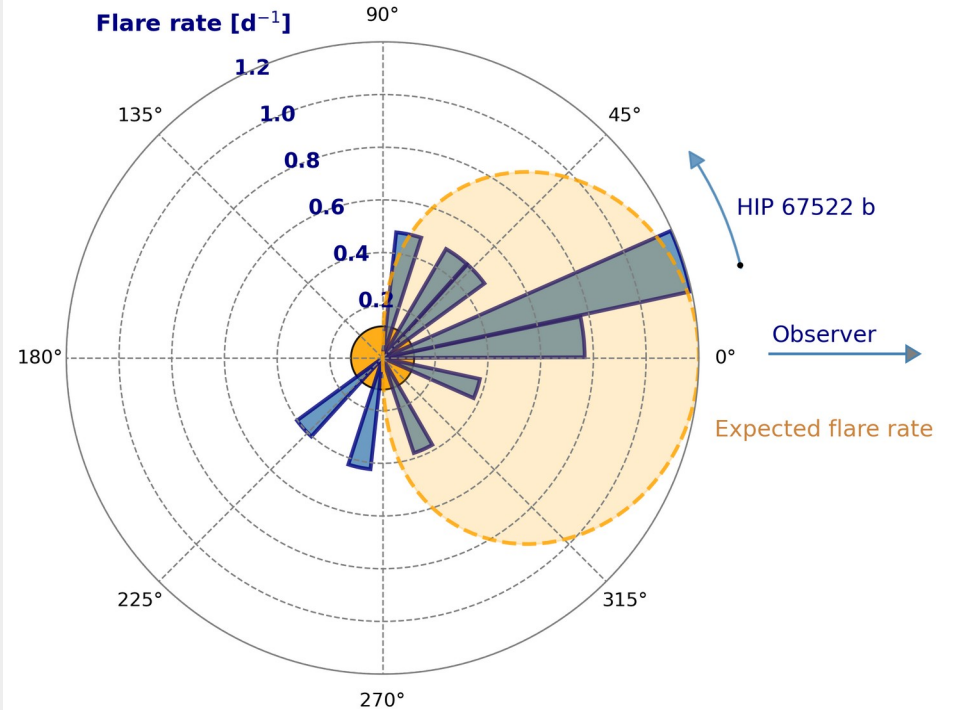


Figure from Ilin et al. (2025)

# # HIP 67522b – Atmospheric escape – flares

*Fig. 1: Planet-induced flaring in the HIP 67522 system. HIP 67522 b is shown as it perturbs the star's inclined magnetic field. The perturbation travels along the magnetic field line highlighted in white, toward the stellar surface, where it triggers flares at the footpoint, which is periodically visible to the observer.*

Ilin et al. (2025)

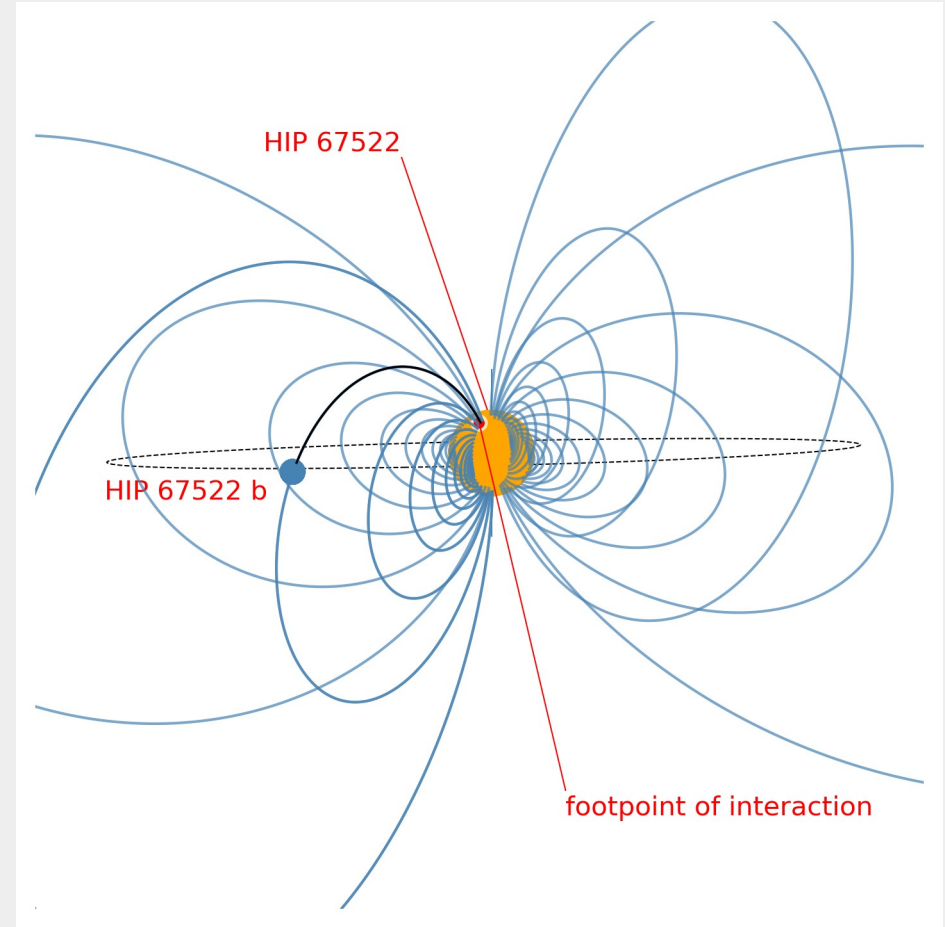
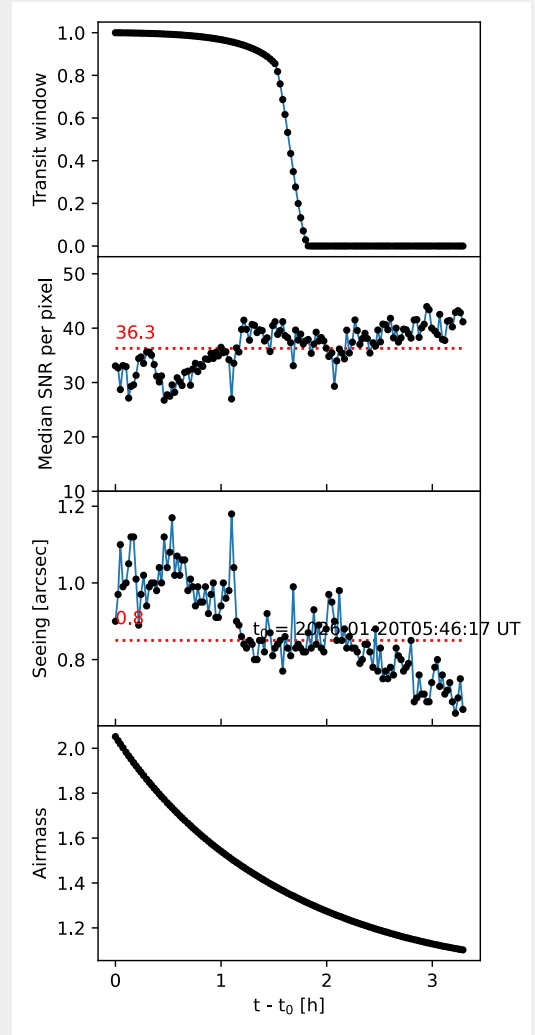


Figure from Ilin et al. (2025)

# # HIP 67522b – HRS with CRIRES – round 2 w/ ESPRESSO

We decided to investigate the atmospheric escape and got DDT observations in Jan. 2026 with CRIRES+ and ESPRESSO simultaneously

- 3.5 hours covering ½ transit and post-transit trail
- PI: Alexis Lavail + Julia Seidel
- CRIRES+ in the Y band to target He 1083 nm
- ESPRESSO for notably H $\alpha$ , also atomic species
- CRIRES+ data taken in **spectropolarimetry** → we can get a snapshot detection of the stellar magnetic field

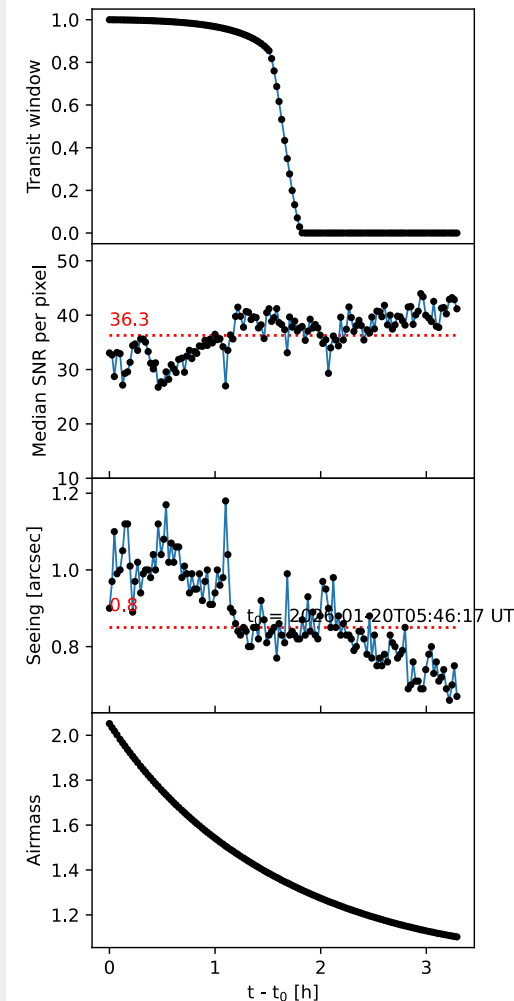


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There is also an accepted and ongoing HARPSpol programme (PI Ilin) to detect and map the stellar magnetic field with Zeeman Doppler Imaging



# # HIP 67522b – takeaway messages

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## **HIP 67522 b is a unique laboratory.**

- CRIRES+ in K-band: exceptionally strong H<sub>2</sub>O and CO detections, confirming the puffy atmosphere
- Retrieval mass (around 28 M<sub>Earth</sub>) ~ 2 times higher than JWST estimate – tension unresolved, joint retrieval needed (Chabrol et al. in prep.)
- Tentative first HDO detection in an exoplanet (2 sigma): D/H enrichment ~1000 times protosolar, but similar to Venus, pointing to intense atmospheric escape
- Evidence for magnetic star-planet interaction (Ilin et al. 2025): planet-induced flares
- Next steps:
  - Investigate atmospheric escape with He 1083 nm line and H $\alpha$  (CRIRES+ ESPRESSO),
  - Characterize and map the stellar magnetic field (HARPSpol)
  - Confirm the HDO detection – promising window at 3.5  $\mu$ m (CRIRES+ round 3?)