

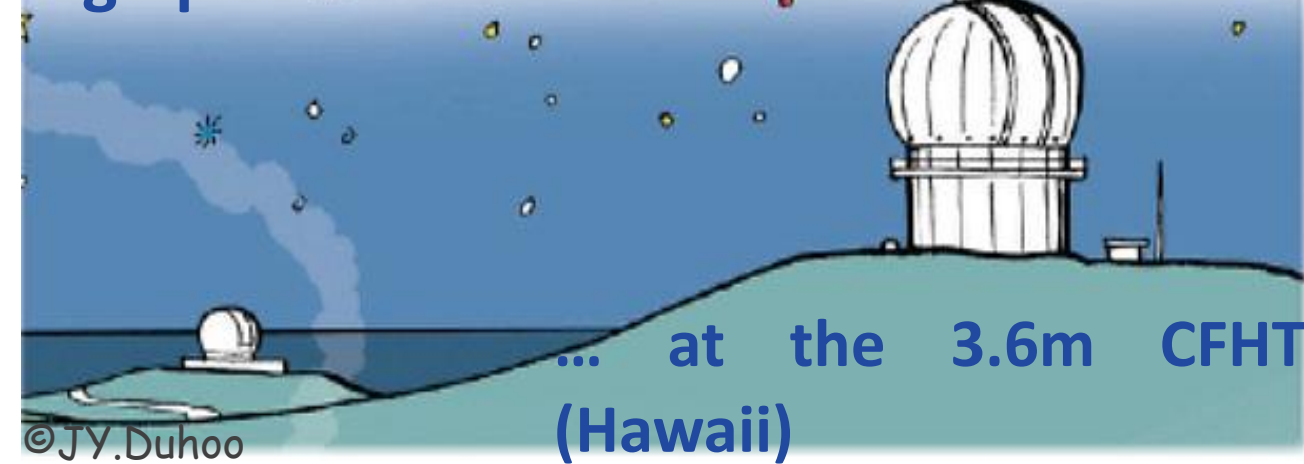
# SPIRou meets ARIEL

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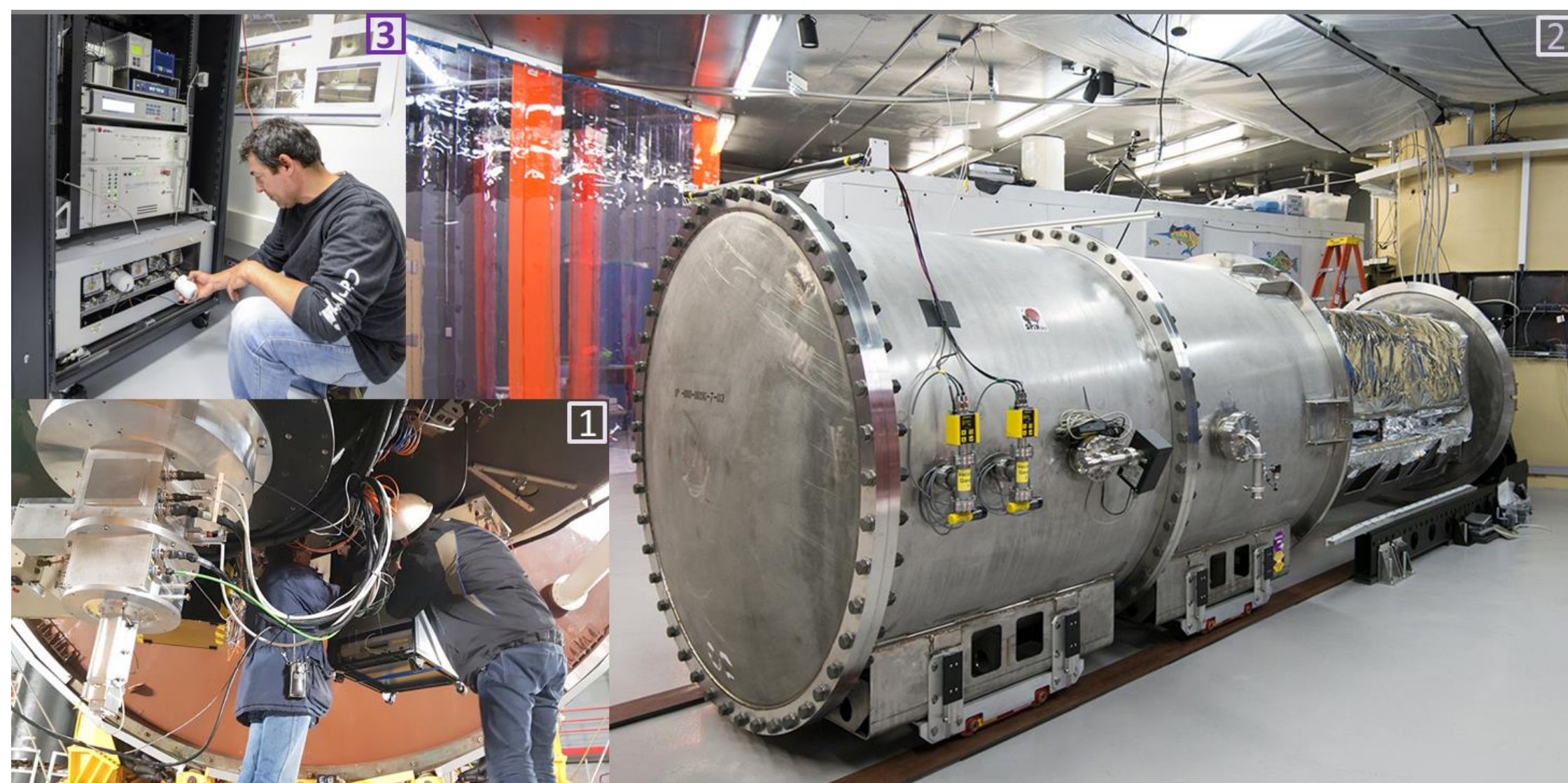
## SPIRou OVERVIEW

SPIRou (SpectroPolarimètre Infra-Rouge) is an innovative and challenging near IR high-resolution spectropolarimeter, and high precision velocimeter ...



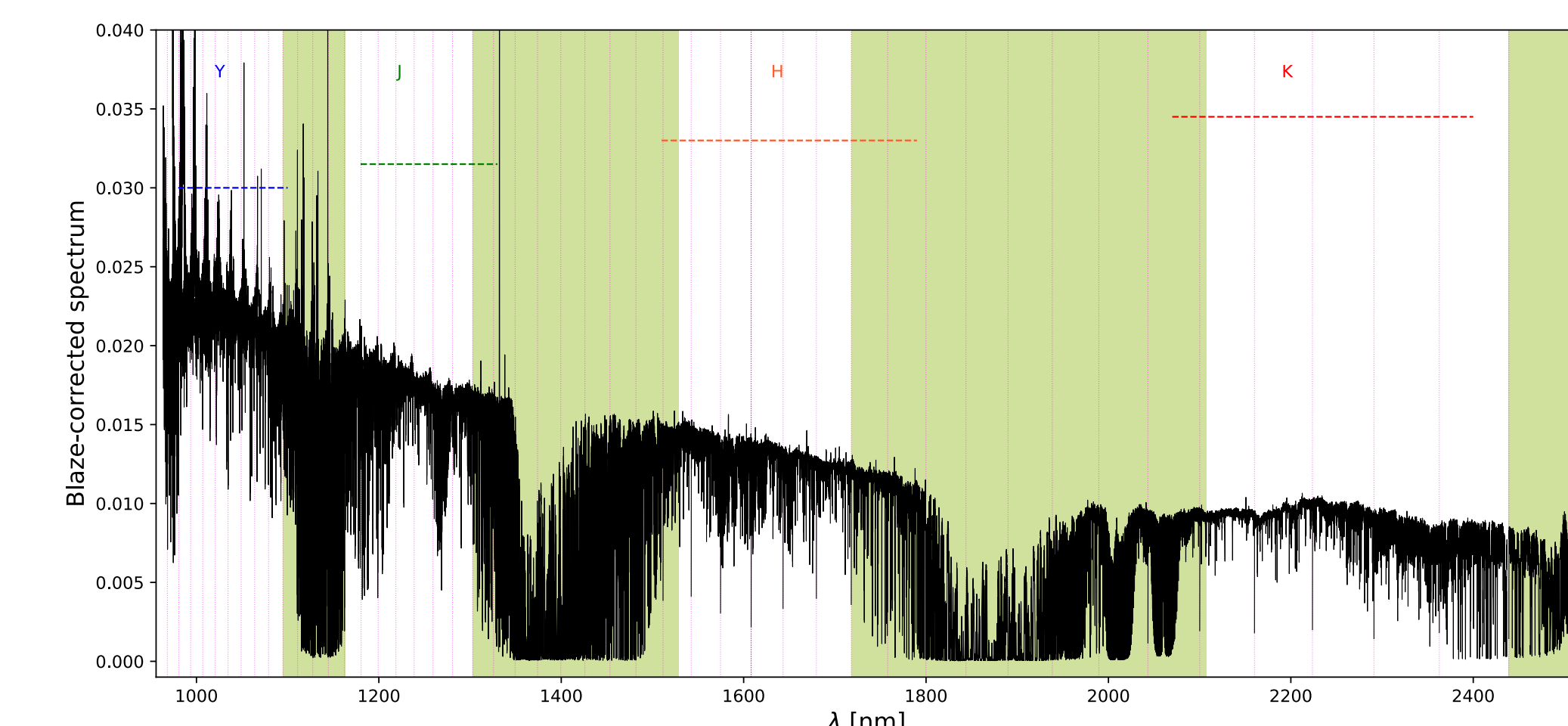
### Main science aims

- ✧ The search of Earth-like planets around M-dwarfs;
- ✧ The study of the magnetic field role on stars / planets formation



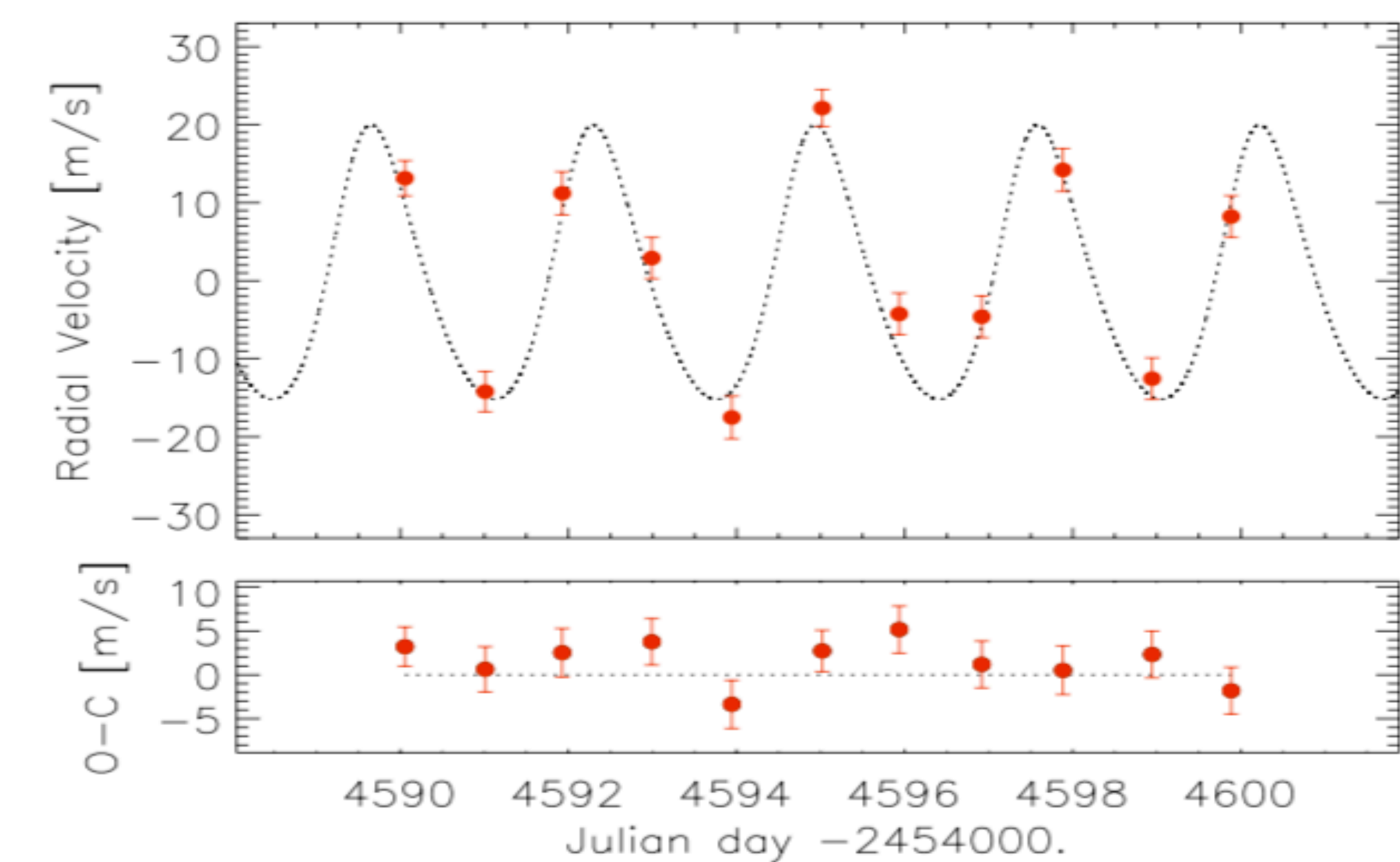
Overview of the main SPIRou sub-systems: (1) the Cassegrain unit (2) the spectrograph enclosed in its cryostat; (3) the Calibration module.

**Spectral range: 0.96 – 2.48  $\mu\text{m}$**   
in a single exposure, no gaps, YJH and K bands  
49 orders



Example of a reduced blaze-corrected Stokes I spectrum obtained for HD189733 in September 2018. The beginning of each diffraction order is indicated through a magenta vertical dotted line and the Y, J, H and K bands are shown as the horizontal dashed lines on the top. The green vertical bands indicate the spectral ranges dominated by tellurics

**Spectral resolution:  $70 \pm 5\text{K}$**   
**Radial velocity precision:  $2 \text{ m.s}^{-1}$**



Radial velocity curve of GJ436 obtained with SPIRou, confirming the presence of the planet GJ436b. Residuals of 2.5 m/s

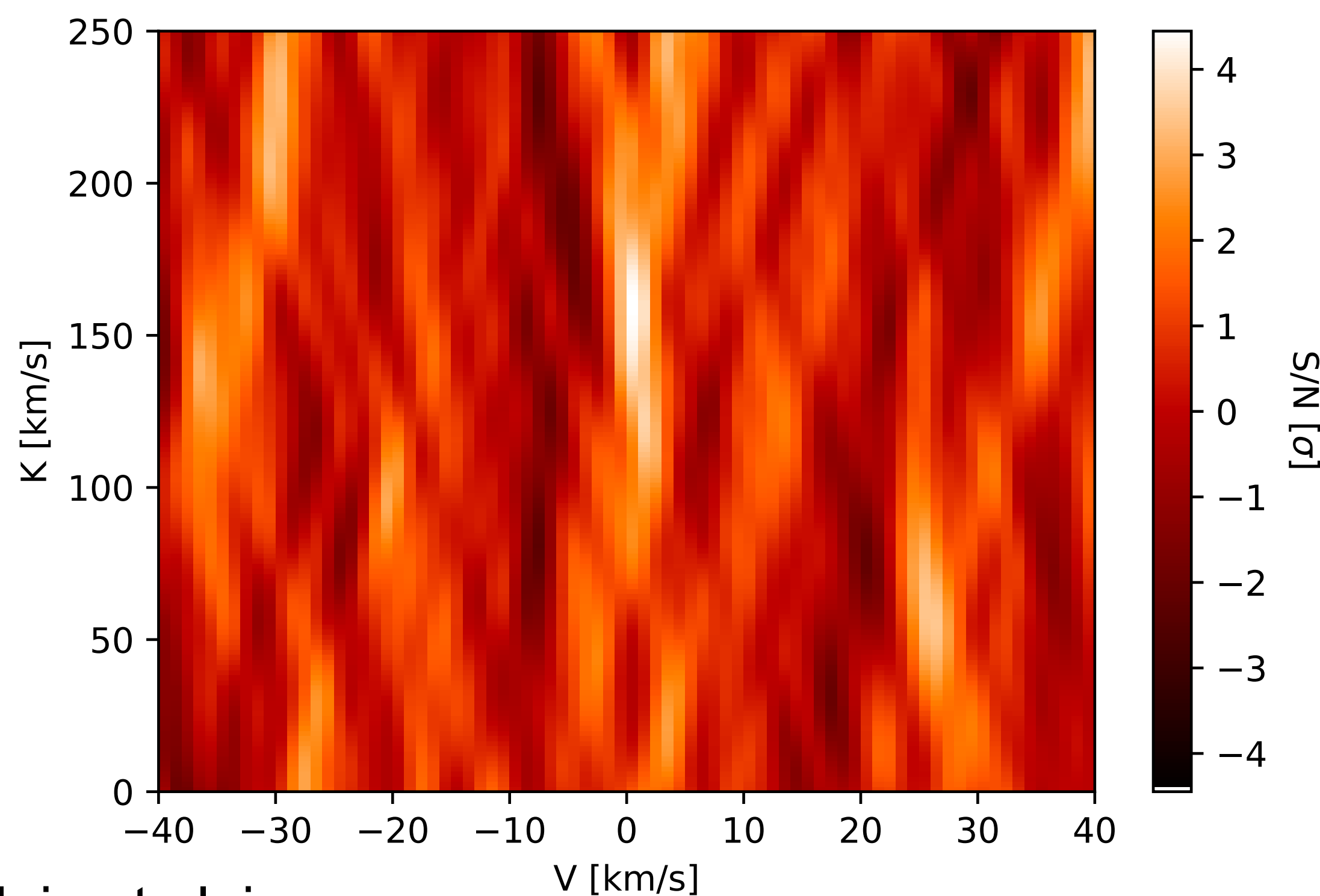
## HOW TO COMBINE SPIRou & ARIEL ?

### 1. HIGH RESOLUTION ATMOSPHERIC CHARACTERIZATION

- ✧ SPIRou is optimal for **transmission spectroscopy**: large nIR domain, high spectral resolution, dry Earth atmosphere, service observing
- ✧ **Atmosphere composition and winds**: the combination of SPIRou and ARIEL would resolve model degeneracies (Brogi & Line 2019)
- ✧ Simultaneous **Rossiter-McLaughlin** anomaly can be measured to get planet obliquities
- ✧ Planet's rotation period can be derived (Snellen et al 2014)
- ✧ Phase curves and eclipse observations: temperature, albedo, atmospheric circulation

### IN PREPARATION AND IN COMPLEMENT TO ARIEL, SPIROU IS ABLE TO ENLARGE SIGNIFICANTLY OUR KNOWLEDGE OF PLANETARY ATMOSPHERES

**Example: cross correlation of high resolution simulated spectrum of HD 189733b with water lines**  
Expected 4 sigma detection of water



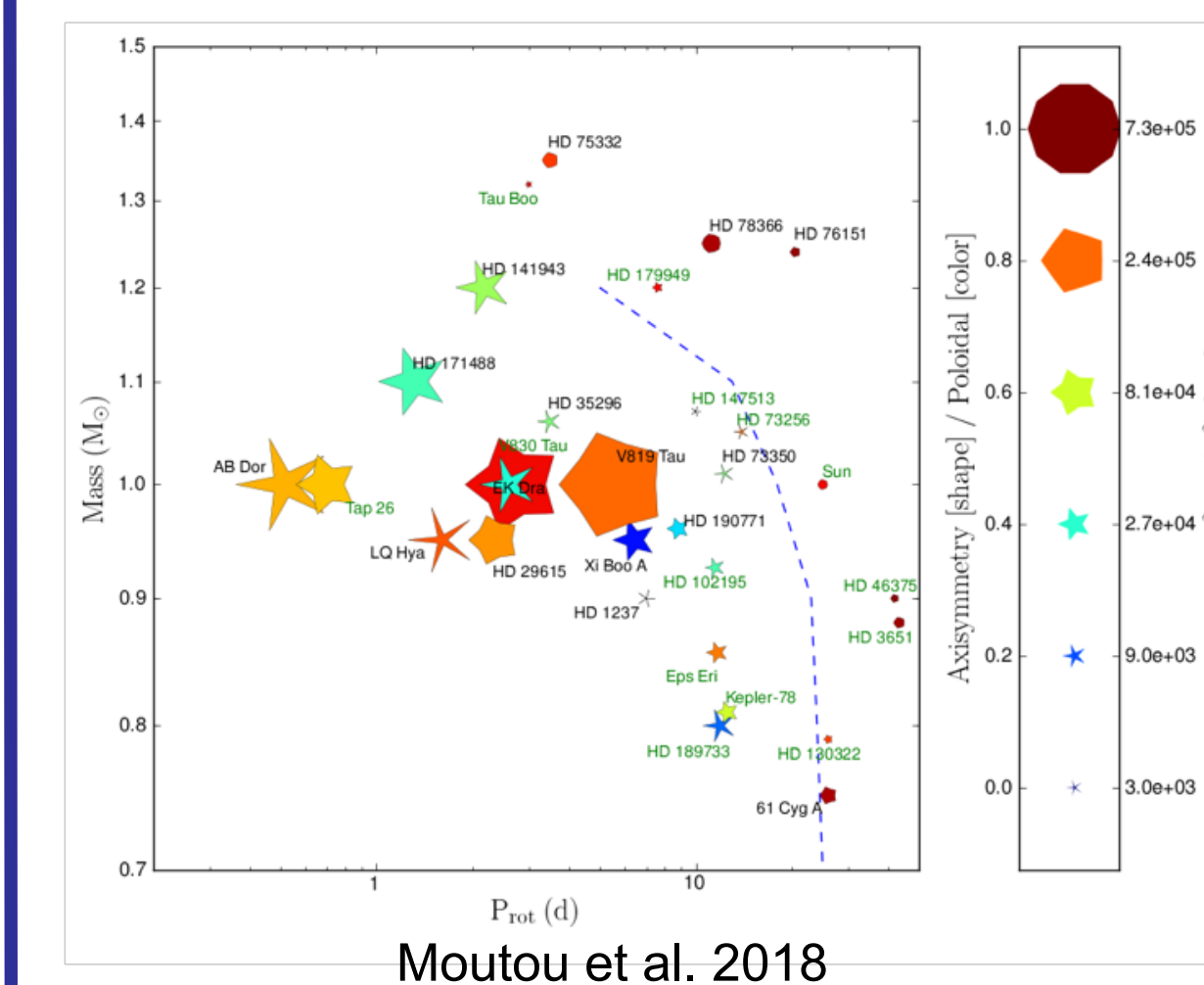
Klein et al. in prep

### 2. STELLAR ACTIVITY FILTERING

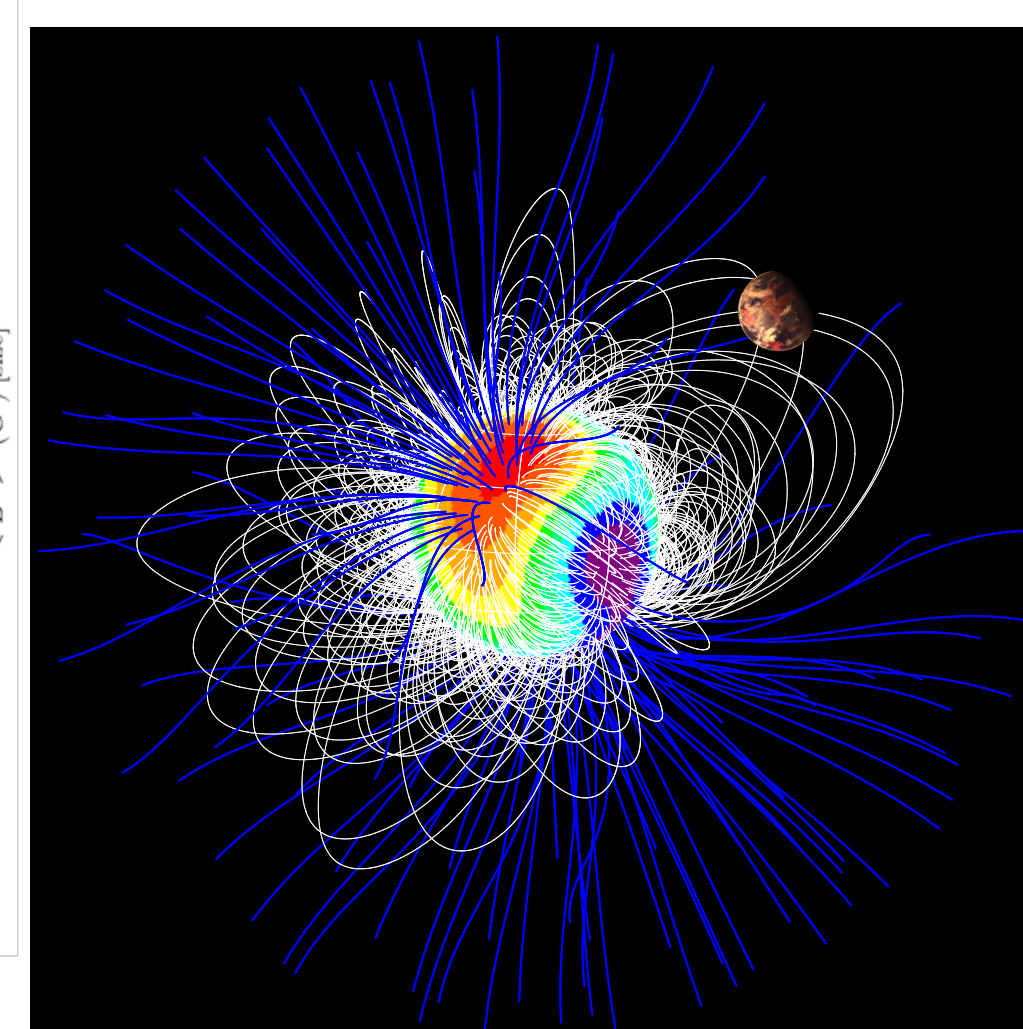
- ✧ SPIRou measures the circular polarization in stellar lines, producing series of Stokes V profiles (Donati et al. 97) => reconstruction of the **magnetic large-scale topology** of the stellar surface and **distribution of brightness features**
- ✧ Observing in the nIR domain offers the possibility to estimate the **small-scale magnetic field** concentrated in spots as well
- ✧ Magnetic field characterization is critical to evaluate stellar « noise »: **select best targets for ARIEL**, observe simultaneously to **correct for stellar variability** (Zhang et al 2018)
- ✧ Observations in spectropolarimetry should be simultaneous to planetary characterization measurement for a proper modelling (Fares et al. 2018)
- ✧ Star-planet interactions can be estimated, and planetary magnetic field (Cauley et al. 2019) - which can be critical for habitability (Vidotto et al. 2013)

### POLARIMETRIC OBSERVATIONS WOULD GREATLY IMPROVE THE ATMOSPHERIC CHARACTERIZATION FROM ARIEL AND HELP SELECT BEST TARGETS

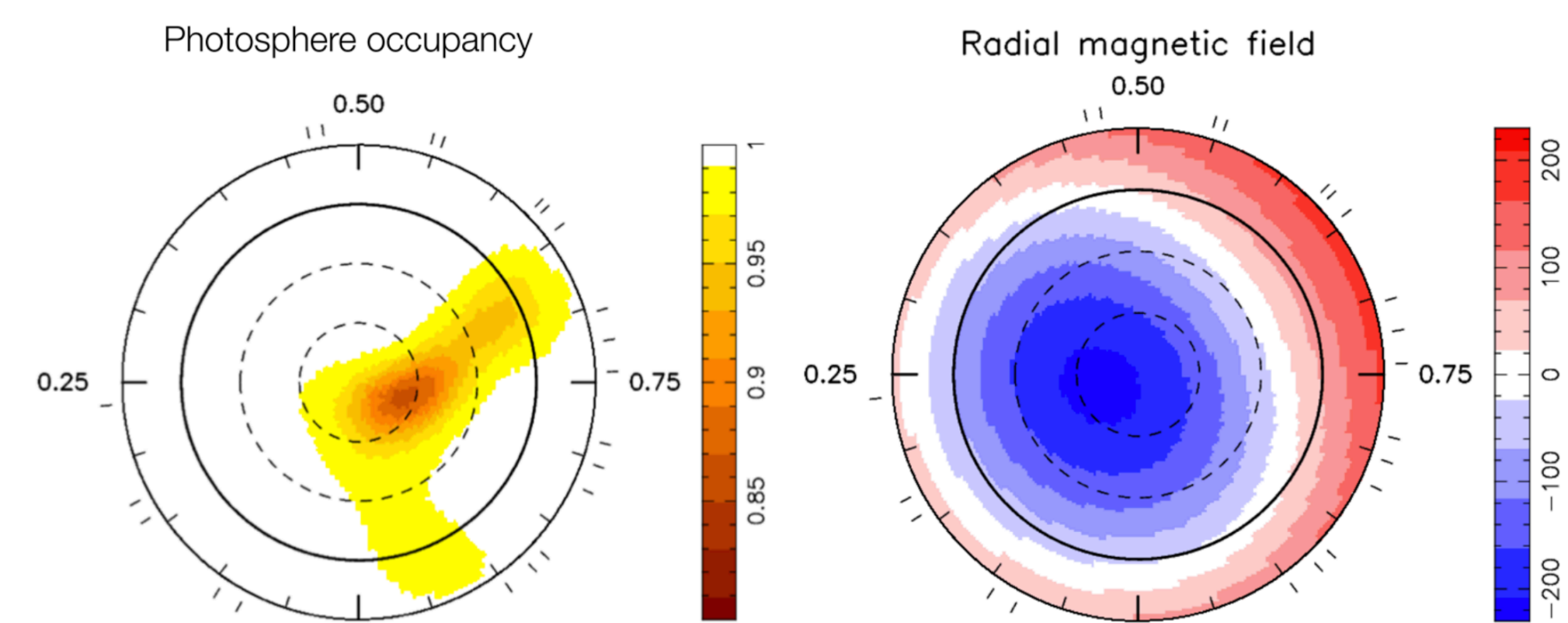
**Example: magnetic topologies of planet hosting stars**



Moutou et al. 2018



Moutou et al. 2016  
Magnetic topology of Kepler 78



Surface brightness and radial magnetic field of GJ 358  
Hebrard et al. 2016

## CONCLUSIONS

- ✧ High resolution spectropolarimeter installed at CFHT
- ✧ Current radial velocity precision : 2m/s

### Combination with ARIEL :

- ✧ Higher resolution spectrum in the near infrared
- ✧ Possibility to filter out stellar activity

### Complement :

- ✧ 2021: SPIP – SpectroPolarimetre Infrarouge Pic du midi, France

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<sup>†</sup>SPIRou is an international project led by France (IRAP/OMP) and involving the CFHT, Canada, Switzerland, Brazil, Taiwan and Portugal. The SPIRou science consortium gathers over 100 scientists from more than 30 research institutes in 11 different countries.

**SPiE** Paper number: 10702-221 (Challita et al. 2018)

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The adventures of SPIRou on the dedicated website:  
<http://spirou.irap.omp.eu>



### ACKNOWLEDGEMENTS

The SPIRou team thanks all funding agencies in France (the IDEX initiatives in Toulouse and Marseille, DIM-ACAV in Paris, Labex OSUG@2020 in Grenoble, CNRS / INSU, Université de Toulouse Paul Sabatier and Université Grenoble-Alpes, Région Occitanie / Pyrénées-Méditerranée in Toulouse), Canada (CFI, NRC), Brazil (LNA), Switzerland (Geneva Observatory), Portugal (FCT), Taiwan (ASIAA) for their financial and / or manpower contribution. SPIRou also thanks the Board of CFHT for covering a significant fraction of SPIRou's construction costs and allocating human resources to the project. This project received funding from the European Research Council (ERC) under the H2020 research & innovation programme (grant agreements #740651 NewWorlds).