

# A Visible and near-infrared spectropolarimetric monitoring instrument for the VLT

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# Context

What spectropolarimetric facilities in the 2030+ era?

CFHT (3.6m): **uncertain after 2033**

ESPaDOnS: since 2004

SPIRou: since 2018

TBL (2m)

(Neo-)NARVAL: since 2006

SPIP: 2024

VISION: 2024

HARPSpol@3.6m, CRIRES+@VLT





# Outline

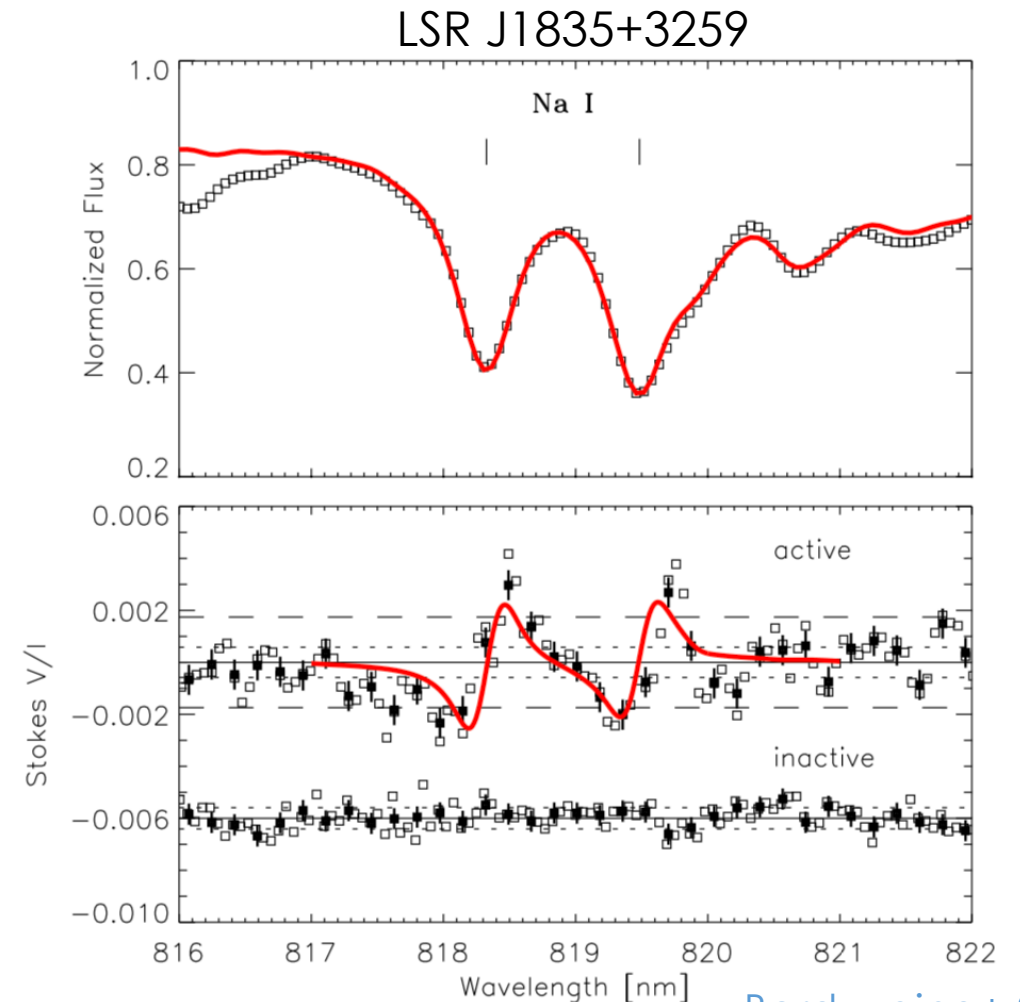
- **Stellar magnetism**, from nearby brown/cool dwarfs to massive stars in the Magellanic clouds.
  - **Formation** of stars and planets
  - **Convection** in cool supergiants
  - **Atmospheres** of exoplanets and brown dwarfs
  - Other science questions
- Proposed instrument design
- Coverage: 370-2,500 nm
  - Resolution: 70,000
  - RV stability: 1 m/s
  - Polarimetry: circ/lin
  - Available for monitoring

# 1- Magnetometry

- Magnetic fields of brown dwarfs & cool dwarfs (topologies? Variability?)
- Magnetic field of Of?p star in Magellanic clouds (magnetism & winds at low metallicity?)
- Winds of exoplanet hosting stars

Complementarity between:

- Visible range (polarimetric large-scale geometry)
- nIR range (total flux with Zeeman broadening)



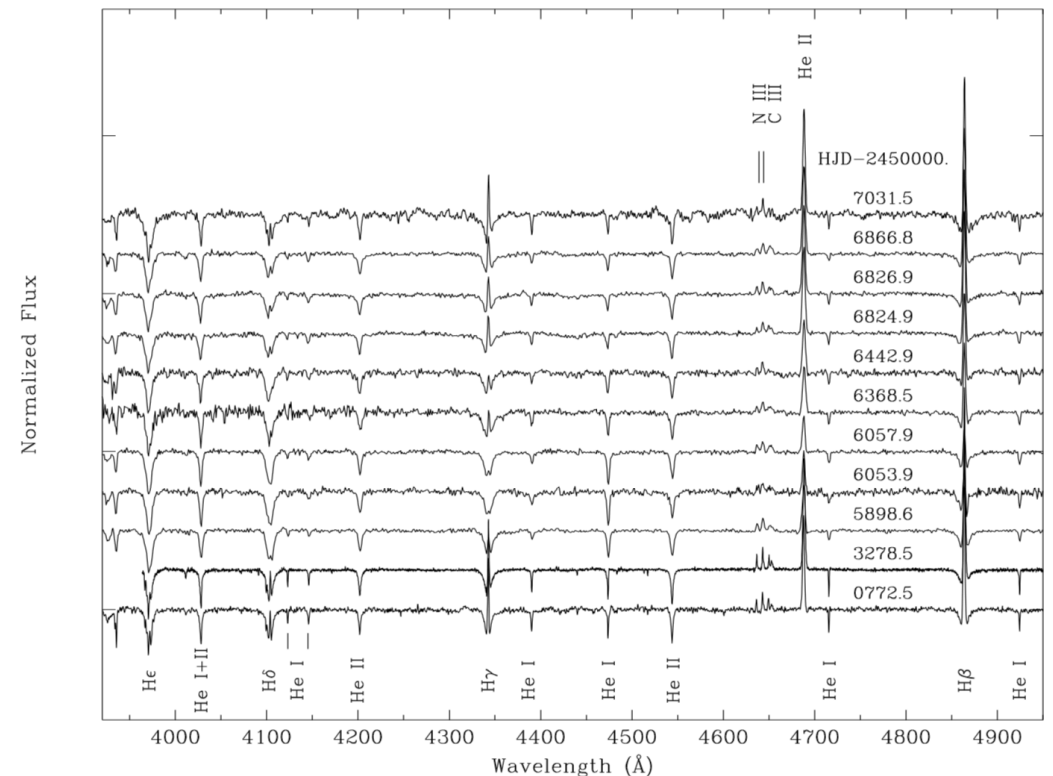
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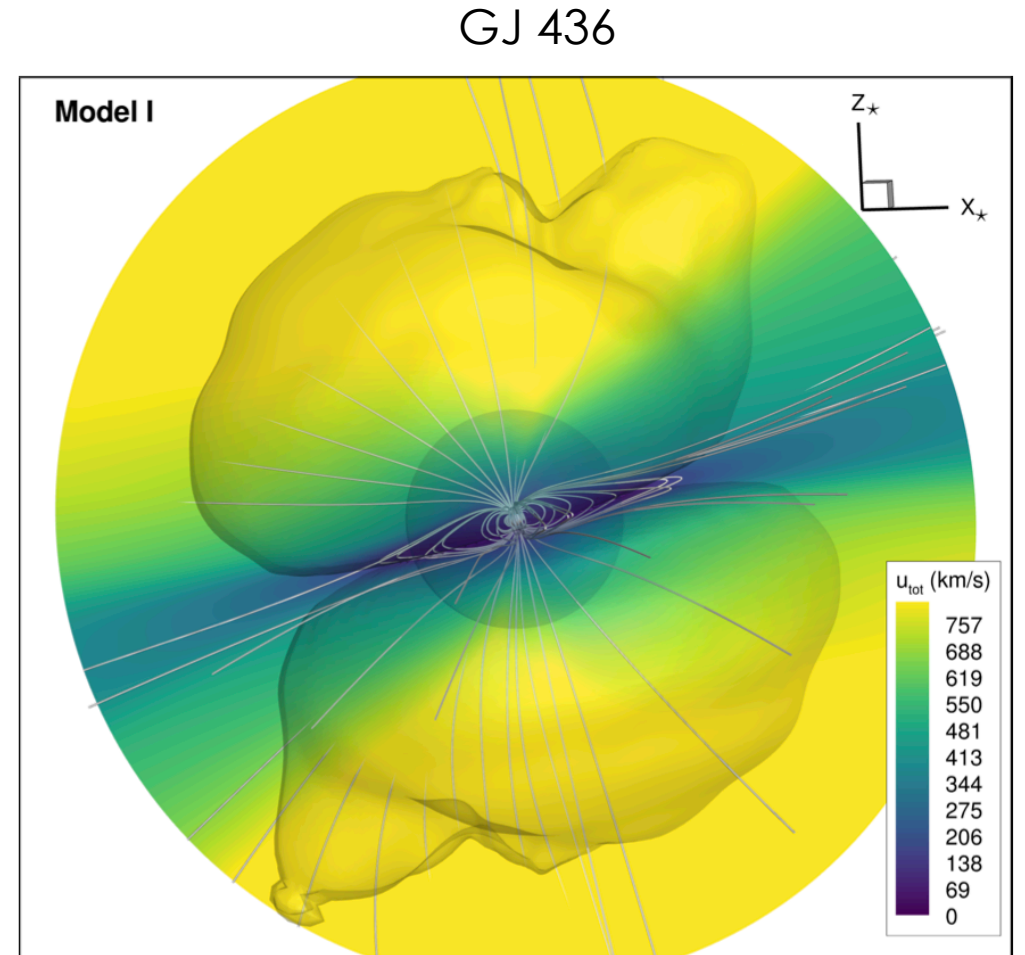


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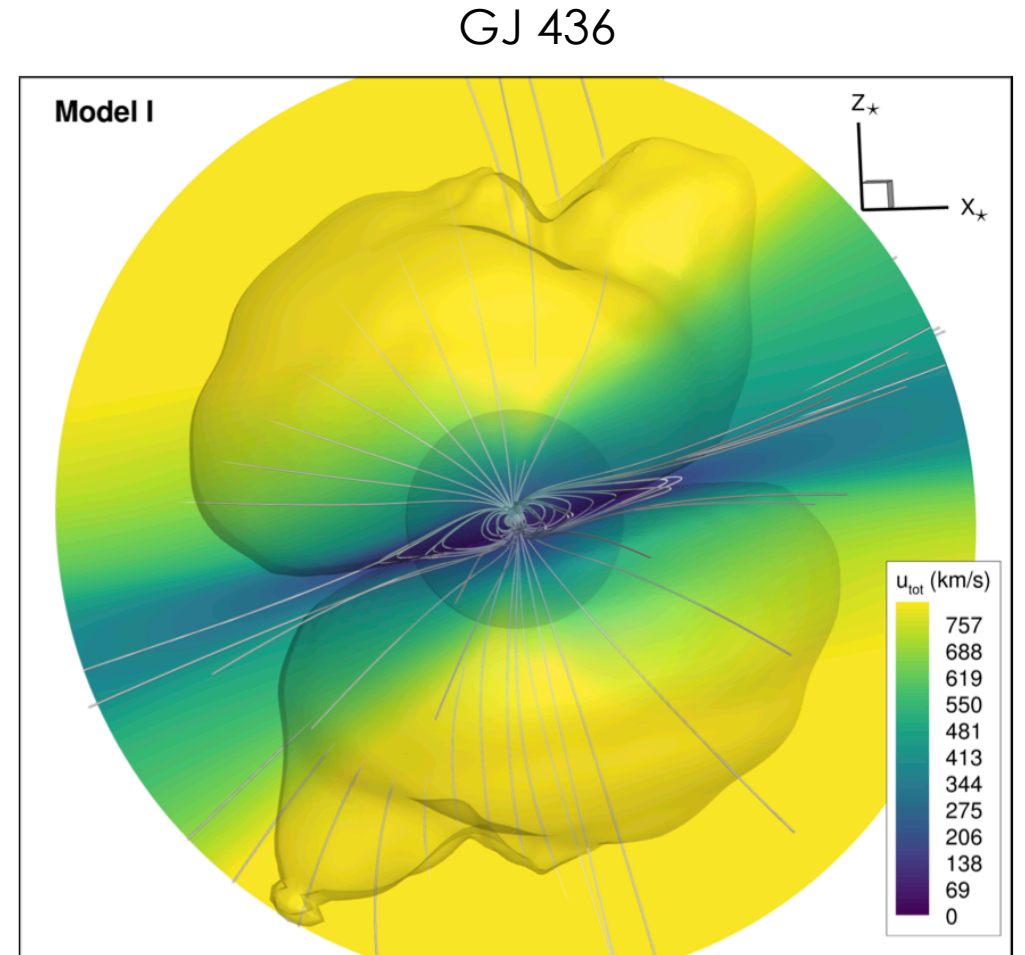


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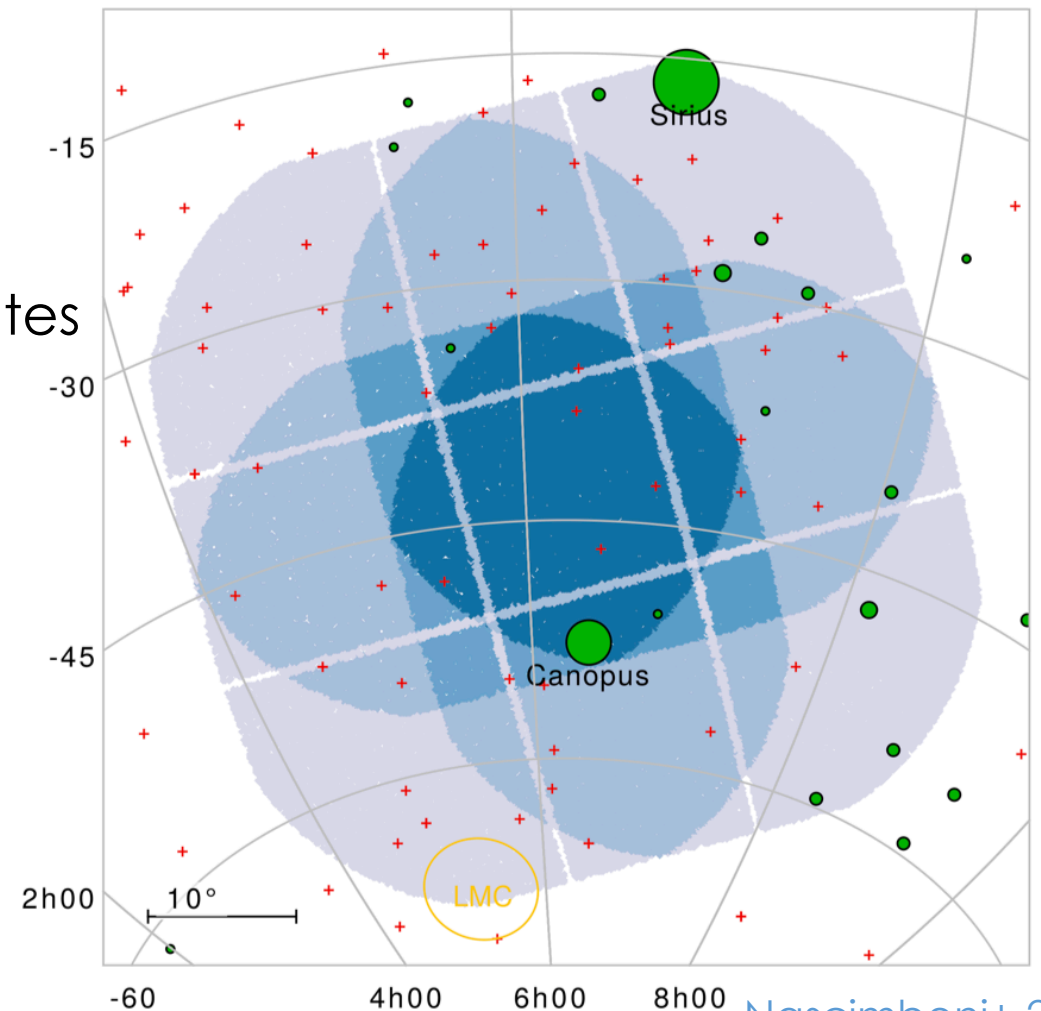
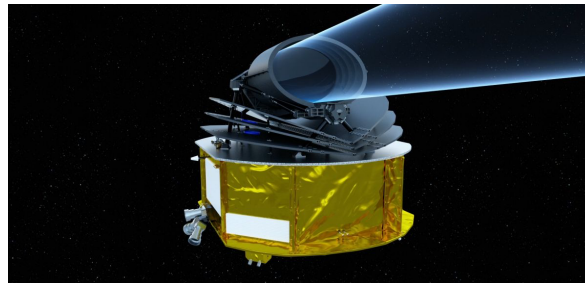
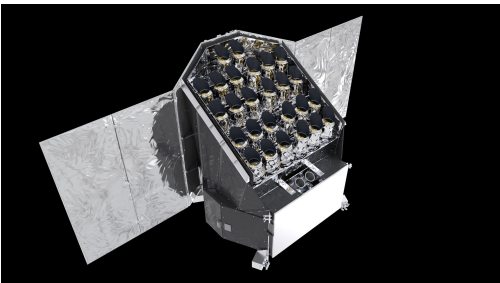
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# 1- Magnetometry

- Follow up of PLATO targets (southern field)
  - synergy with seismology (cf. J. Ballot)
  - jitter filtering (cf. J.-F. Donati)
  - space weather around planetary candidates (cf. J. Morin)
- Activity modeling during ARIEL transits

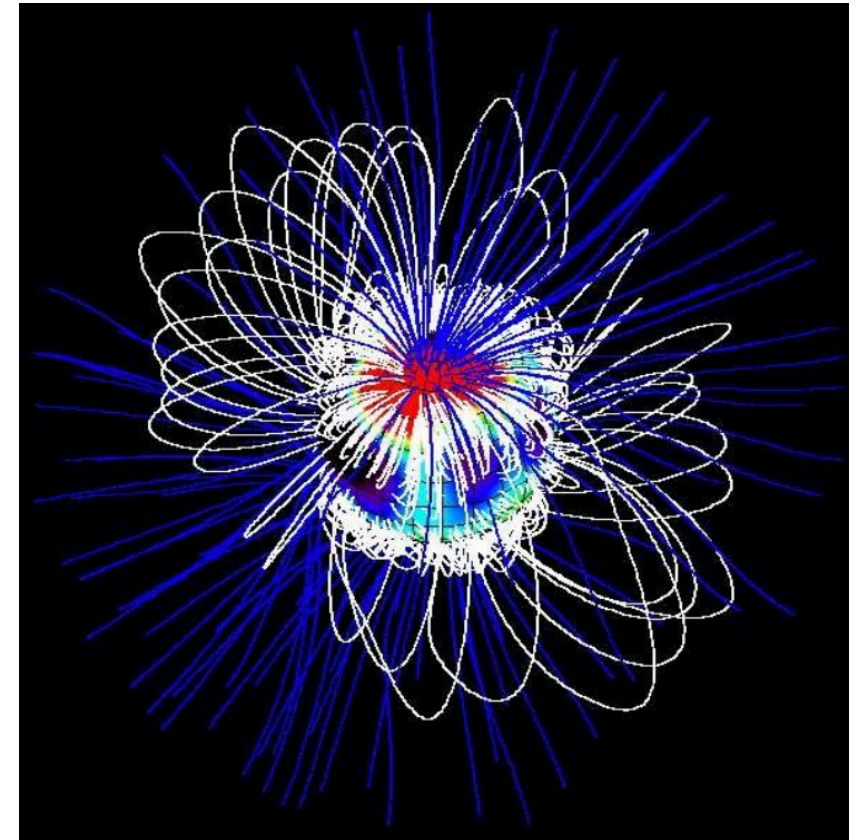




## 2- Formation of stars & planets

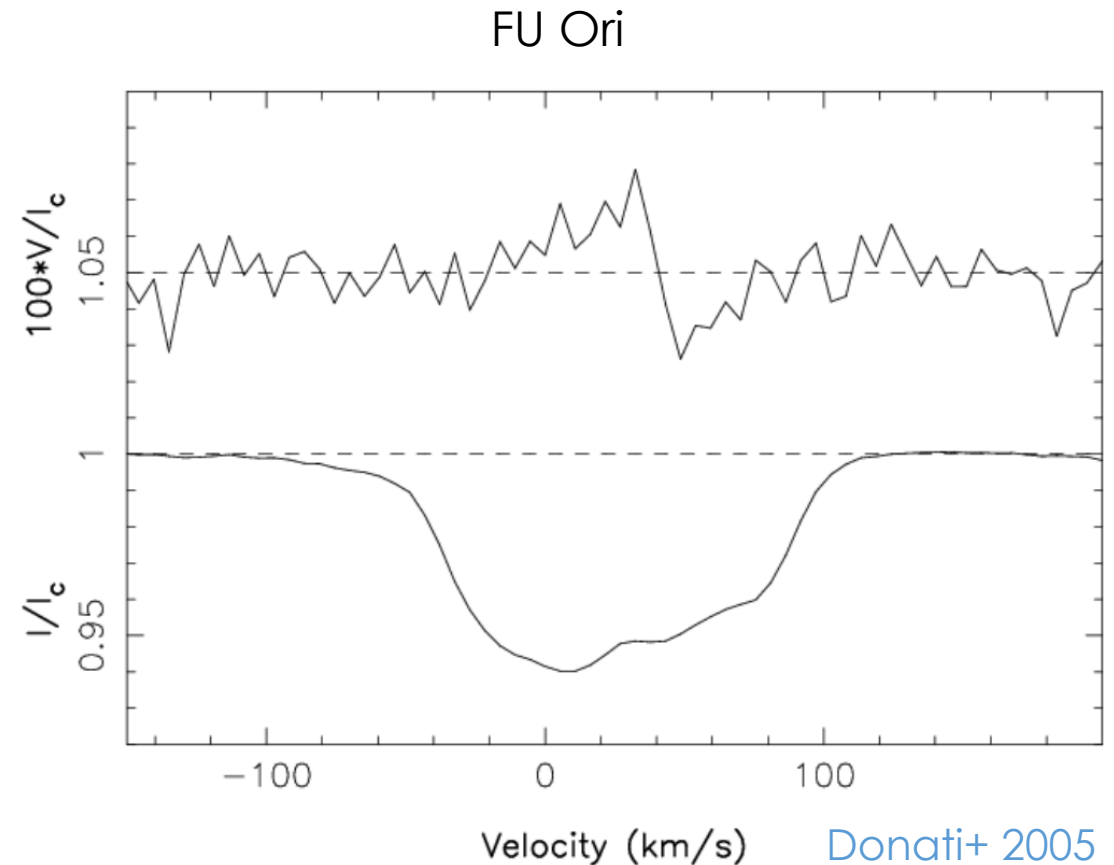
- Magnetospheric accretion  
From Class I (nIR) to ZAMS (Vis)  
in southern star forming regions
- Magnetic fields in inner gaseous discs  
(topology? Variability?)
- Early migration of Hot Jupiters

V2129 Oph



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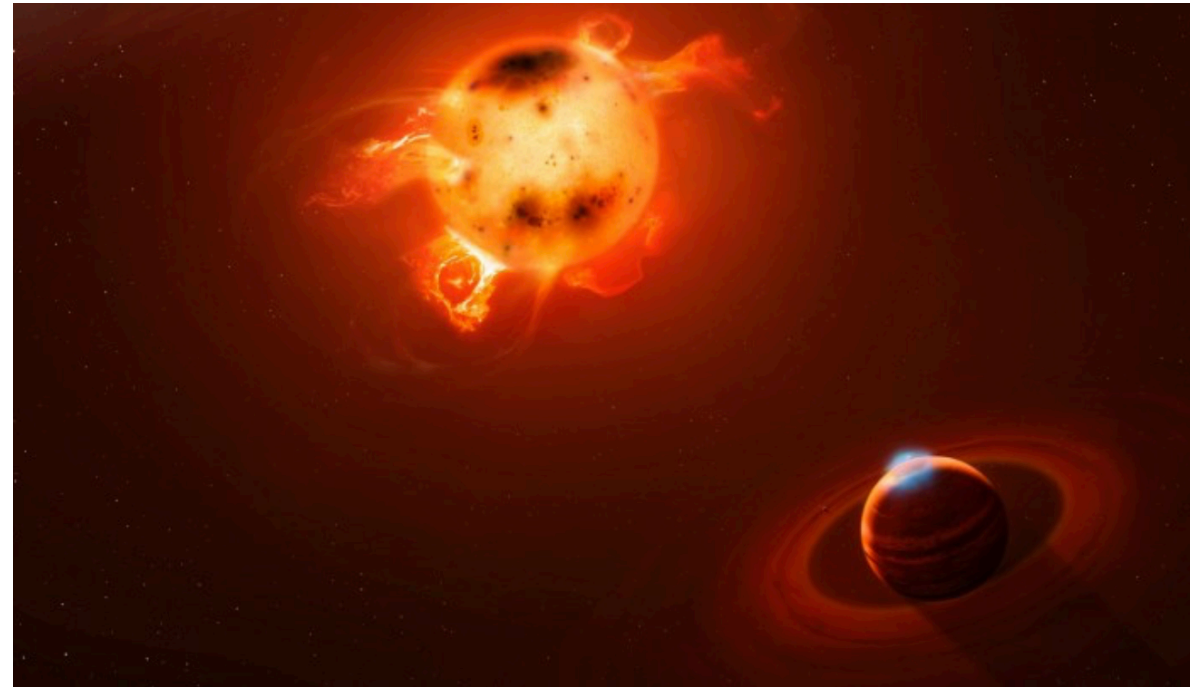
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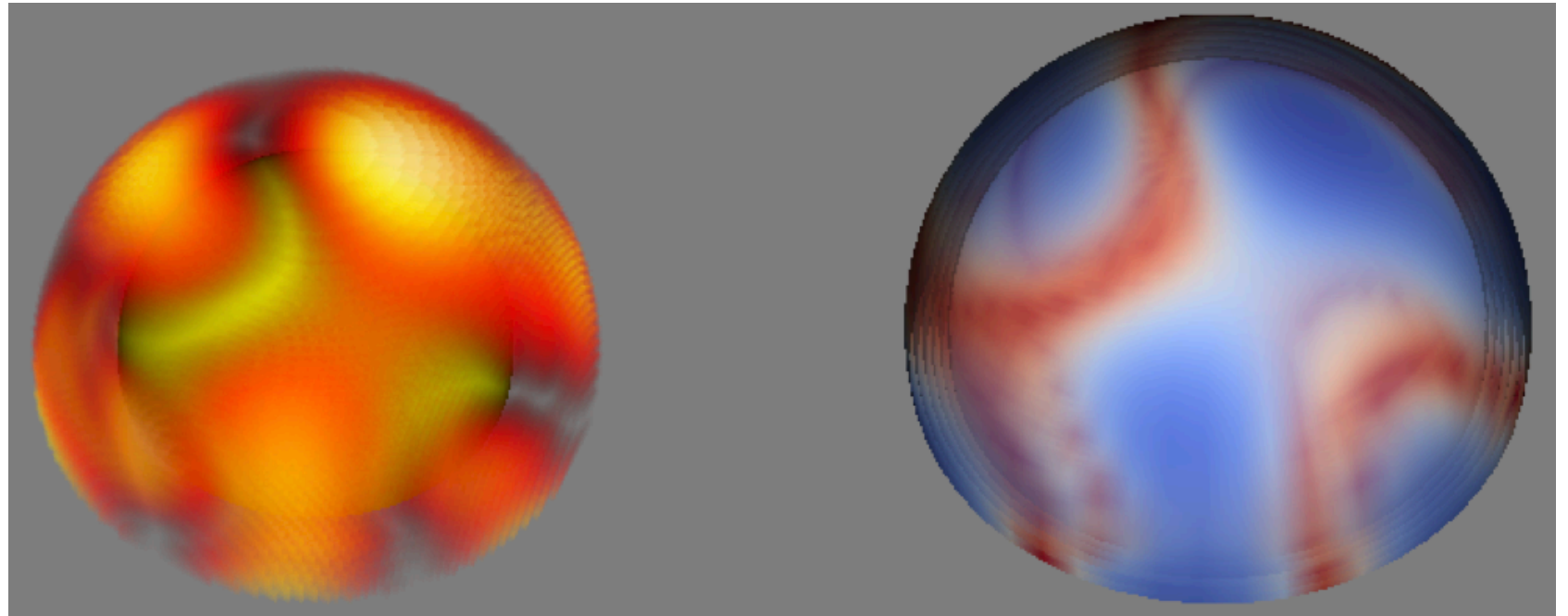
V830 Tau



Donati+ 2016, Yu+ 2017

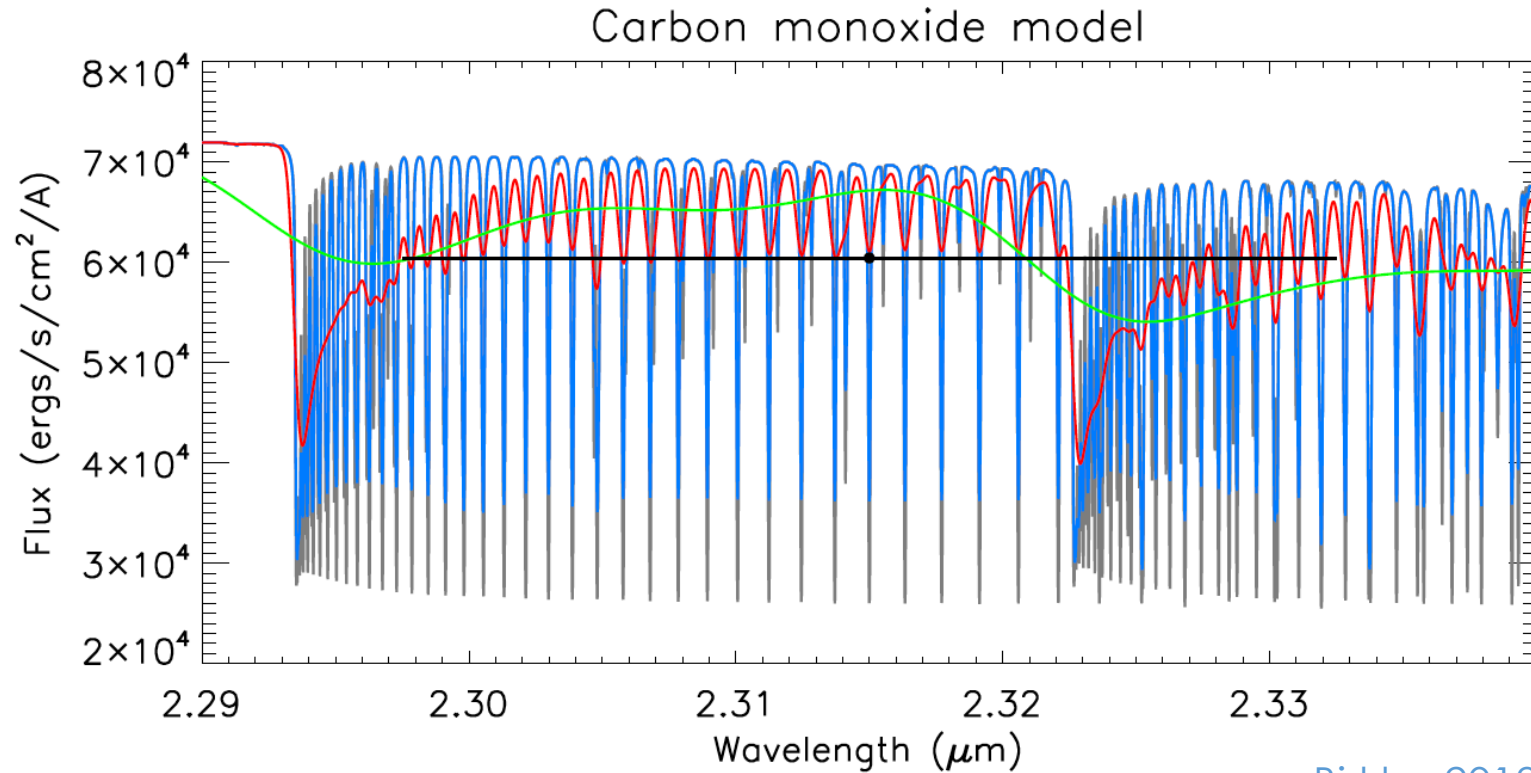
# 3- Surface convection

- Spectropolarimetric imaging of giant convective cells on red supergiants  
(cf. A. Chiavassa)



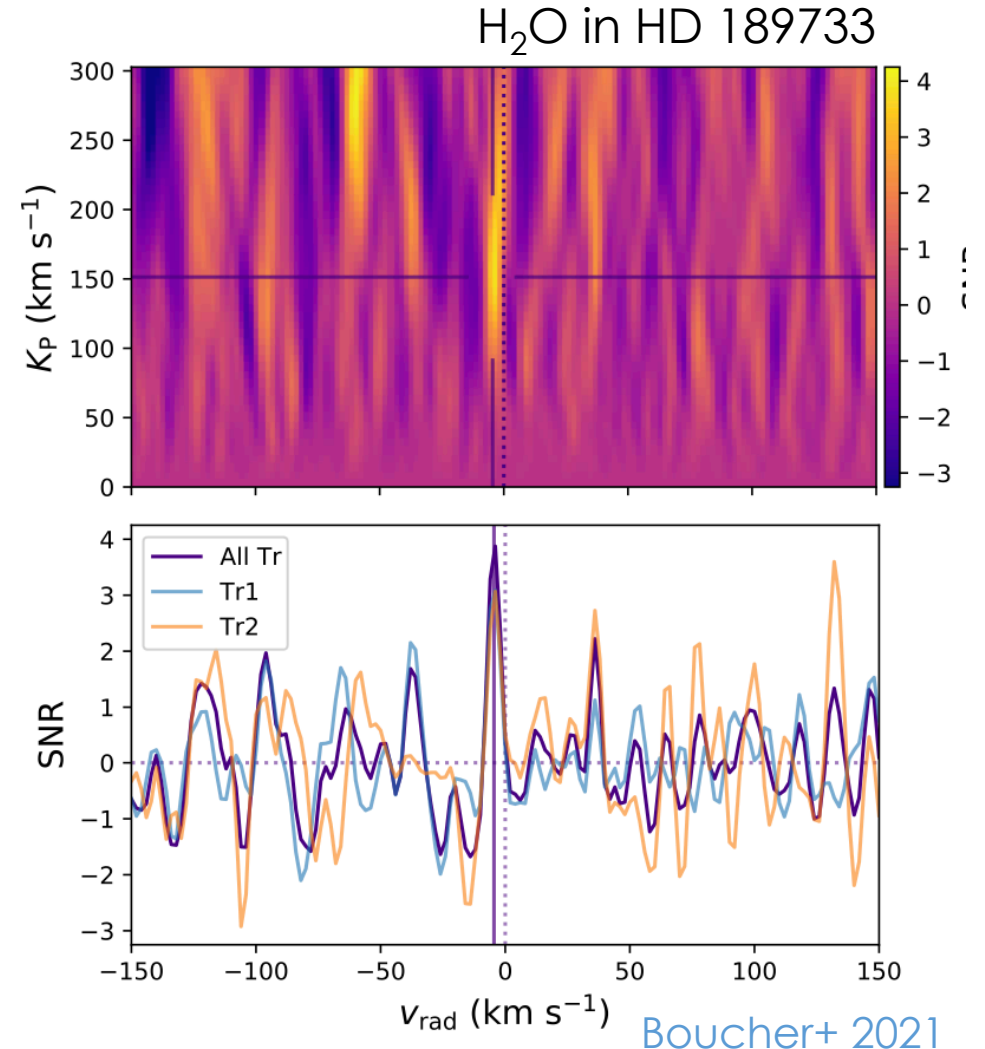
# 4- Atmospheres of planets & BDs

- Planetary lines shifted by 10s – 100s km/s
- HR required to detect lines
- Many lines: boost S/N via CCF  
(  $S/N \propto \sqrt{N_{\text{lines}}}$  )



# 4- Atmospheres of planets & BDs

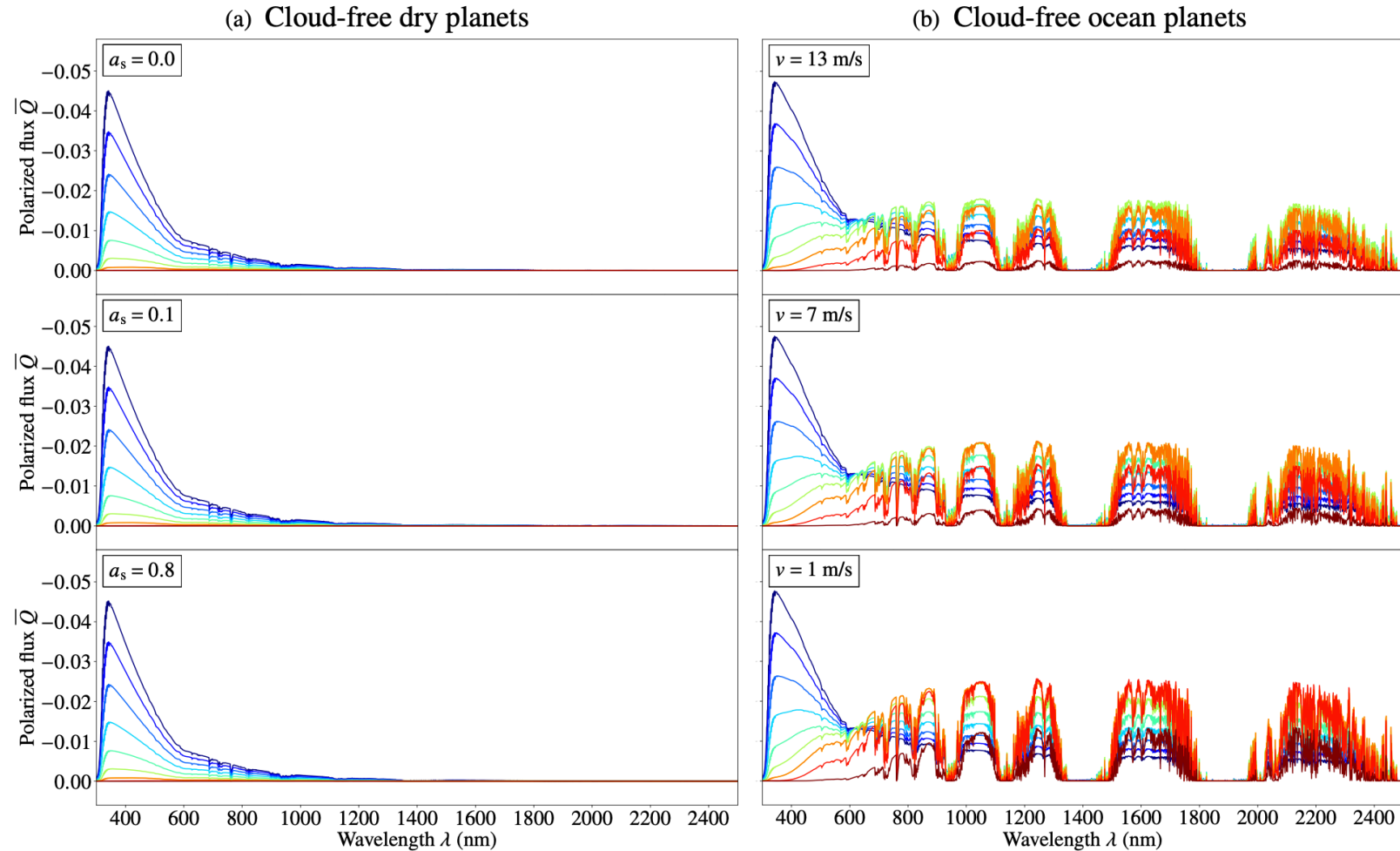
- Chemical composition
- Temperature
- Winds, rotation
- Ocean glint





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- Chemical composition
- Temperature
- Winds, rotation
- Ocean glint



## 5- Additional science

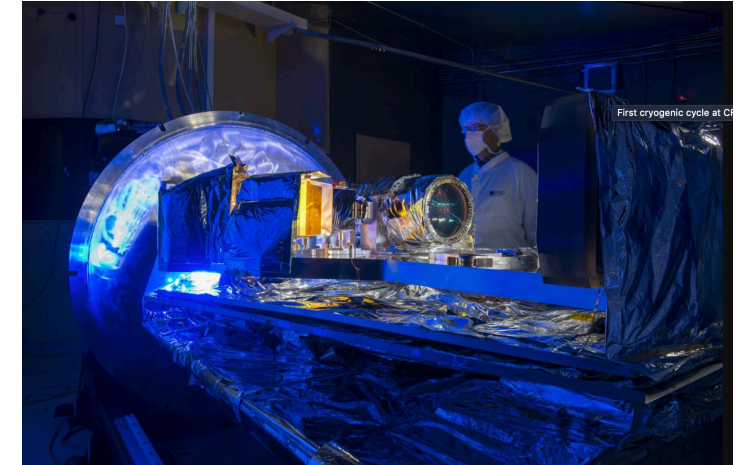
- Chemical evolution & kinematics of Milky Way
- Search for HZ exo-earth around cool dwarfs
- Brightness mapping (DI) of BDs
- Seismology of stars in the halo
- (...)

# Available facilities

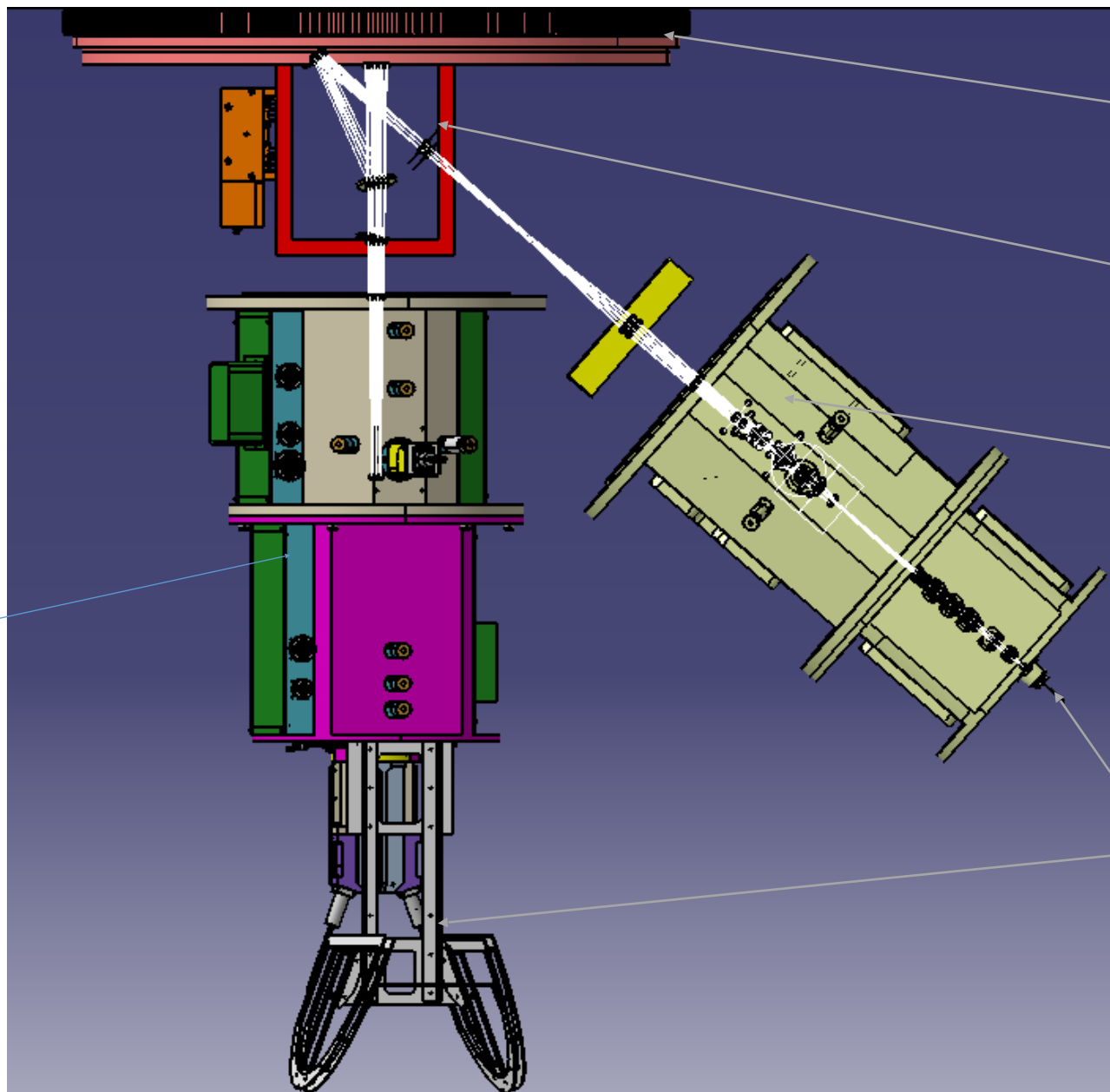
|                     | UVES | FORS | ESPRESSO | HARPS | GIARPS            | NIRPS | ESPaDOnS | X-Shooter | CARMENES          | SPIRou | CRIRES+                 |
|---------------------|------|------|----------|-------|-------------------|-------|----------|-----------|-------------------|--------|-------------------------|
| Vis coverage        | ✓    | ✓    | ✓        | ✓     | ✓                 | ✗     | ✓        | ✓         | ✓                 | ✗      | ✗                       |
| nIR coverage...     | ✗    | ✗    | ✗        | ✗     | ✓                 | ✓     | ✗        | ✓         | ✓                 | ✓      | ✓ ⚠<br>(several frames) |
| ... incl. K band    | ✗    | ✗    | ✗        | ✗     | ✓                 | ✗     | ✗        | ✓         | ✗                 | ✓      | ✓                       |
| R > 60,000          | ✓    | ✗    | ✓        | ✓     | ✓ ⚠<br>(vis only) | ✓     | ✓        | ✗         | ✓                 | ✓      | ✓                       |
| < 2 m/s velocimetry | ✗    | ✗    | ✓        | ✓     | ✓ ⚠<br>(vis only) | ✓     | ✗        | ✗         | ✓ ⚠<br>(vis only) | ✓      | ✗                       |
| Polarimetry         | ✗    | ✓    | ✗        | ✓     | ✗                 | ✗     | ✓        | ✗         | ✗                 | ✓      | ✓                       |
| 8m reflector        | ✓    | ✓    | ✓        | ✗     | ✗                 | ✗     | ✗        | ✓         | ✗                 | ✗      | ✓                       |

# Preliminary instrument design

- nIR arm inspired from SPIRou@CFHT/SPIP@TBL
- Vis arm inspired from ESpaDOnS@CFHT/Neo-NARVAL@TBL,



IR polarimeter



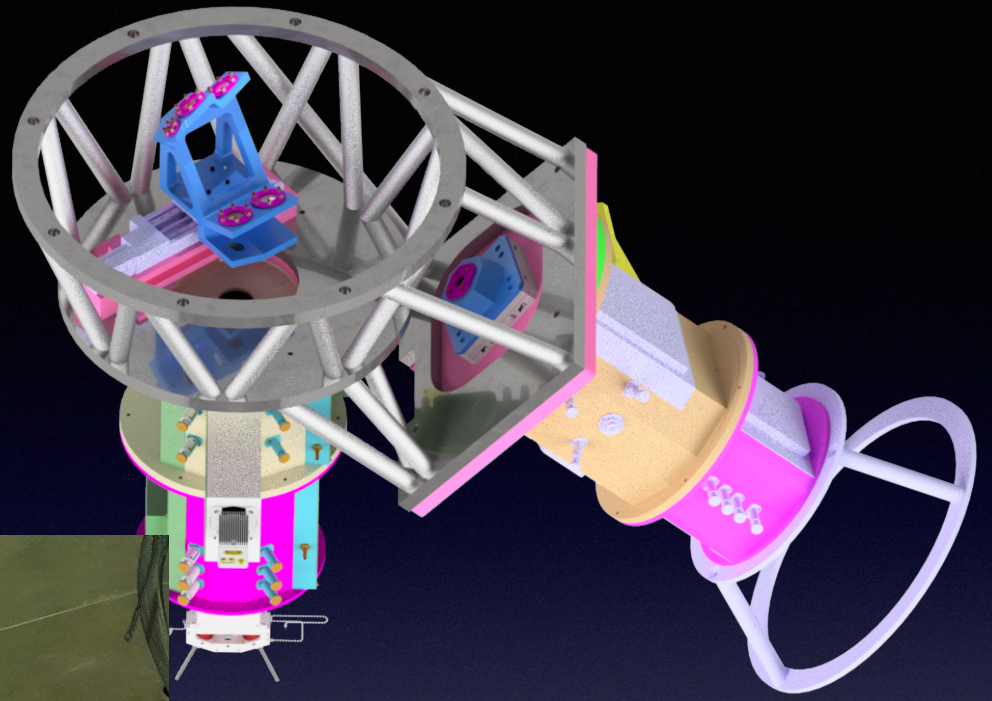
Field derotator

VIS/IR separation with  
polarization compensation

VIS polarimeter

Fiber link







# Conclusions

- Large spectral domain for optimized S/N through X-correlation (atmospheres, magnetometry, velocimetry)
- Polarimetry required for magnetometry, activity jitter filtering, new diagnoses on exoplanet atmospheres
- Availability must allow for monitoring programs
- Complementarity with ANDES@ELT
- Heritage from VISION @ Pic du Midi (2m) & CFHT (4m)