SPIP @TBL: INTEGRATION & TESTS OF THE NIR SPECTROGRAPH AND SYNERGY WITH SPIROU @CFHT

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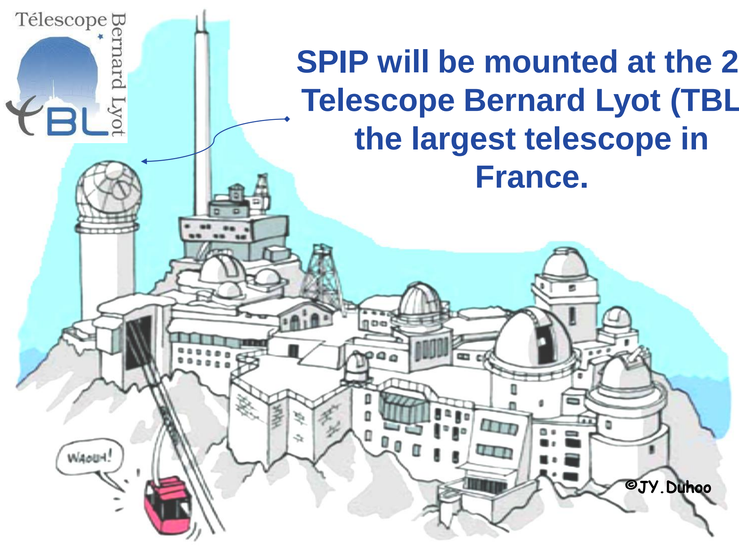
SPIP @TBL, A TWIN FOR SPIRou @CFHT

SPIP, the *SpectroPolarimètre Infra-rouge Pyrénéen* is a near-infrared echelle spectropolarimeter and a high-precision velocimeter planned to be installed atop Pic du Midi (France) by mid 2023.

This new-generation near-infrared instrument allows one to cover in a single exposure the coverage of the YJHK bands (0.95 - 2.5 µm).



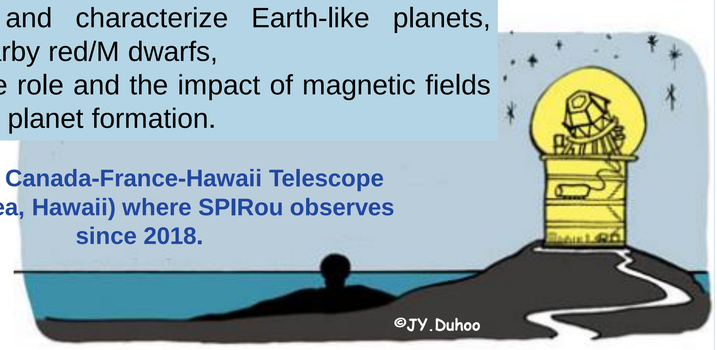
SPIP will be mounted at the 2m Telescope Bernard Lyot (TBL), the largest telescope in France.

The *Observatoire du Pic du Midi* is located in the French Pyrénées at an altitude of 2877 m.

Main science aims

SPIP & SPIRou will work together in the Near IR:

- ✧ to detect and characterize Earth-like planets, around nearby red/M dwarfs,
- ✧ to study the role and the impact of magnetic fields on star and planet formation.



The 3.6m Canada-France-Hawaii Telescope (Mauna Kea, Hawaii) where SPIRou observes since 2018.

SPIP images will resemble those collected with SPIRou, like the one shown here recorded for AU Mic in 2021 (CNRS/INSU Press Release).

Each group of three vertical stripes corresponds to one spectral order, covering a small region of the spectral domain.

The first two stripes encode the spectrum of the young active star AU Mic in the 2 orthogonal states of the selected polarization, whereas the 3rd one contains a Fabry-Perot spectrum ensuring that the radial velocity (RV) of the star can be monitored with a relative precision of 1-2 m/s.

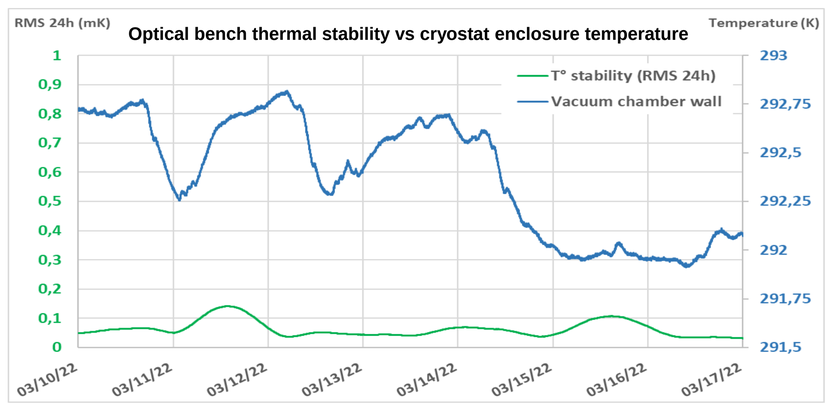
MAIN PERFORMANCES

NIR spectral range: 0.95 – 2.5 µm in a single exposure
YJHK-bands, 50 orders (#80 to #31)

Peak throughput: 10-15 %
Spectral resolving power: 70 ± 5k
Thermal noise at 2.35 µm: < flux from a H~9 mid-M dwarf

Optimal focus: < 5 µm
Image quality: diffraction limited (< 1 px)

Thermal stability challenge: < 1 mK RMS over 24h
Radial velocity precision: ~ 1 m.s^{-1} RMS

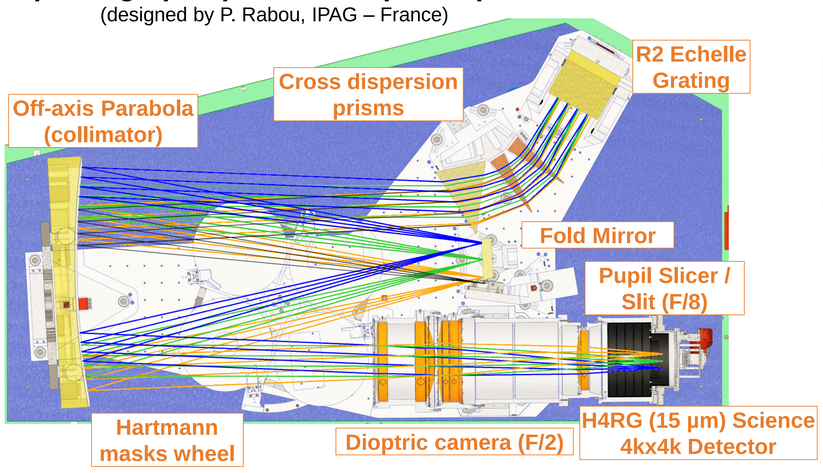


Thermal stability of the spectrograph unit recorded at the middle of the bench during in-lab tests, showing an RMS value < 0.2 mK and unaffected by the temperature variations of the cryostat external enclosure.

THE SPECTROGRAPH UNIT / IN-LAB INTEGRATION AND TESTS

Spectrograph optical concept and path

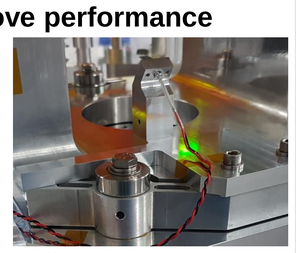
(designed by P. Rabou, IPAG – France)



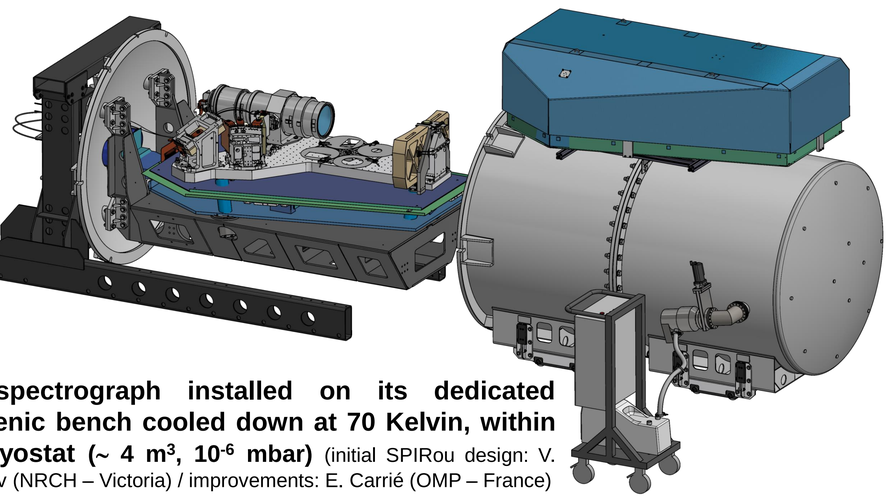
Using SPIP and SPIRou to further improve performance

New hermetic feedthroughs (2 science + 1 reference fibers) cooled down to 2°C for thermal noise reduction

Quantifying the scrambling performance of the SPIRou and SPIP pupil slicers with a dedicated bench



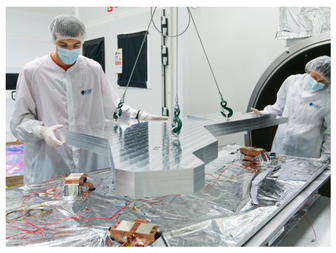
Implementing a LED to mitigate the effect of detector persistence on the spectra of faint stars



The spectrograph installed on its dedicated cryogenic bench cooled down at 70 Kelvin, within the cryostat (~ 4 m^3, 10^{-6} mbar) (initial SPIRou design: V. Reshetov (NRCH – Victoria) / improvements: E. Carrié (OMP – France)

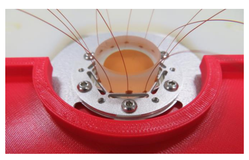
Assembly and Integration of the cryogenic spectrograph

External frame and cold bus: the cold bus is linked to 2 cryocoolers.

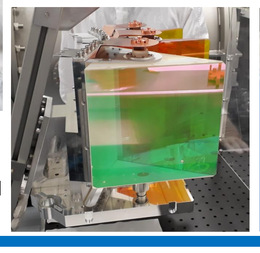


Positioning of the cryogenic bench in Aluminum on its 3 bipods

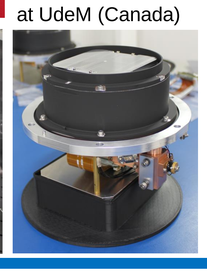
Integrating the off-axis Parabola inside its dedicated mount



Bonding of pucks on the optical components, ensuring a stress-free positioning

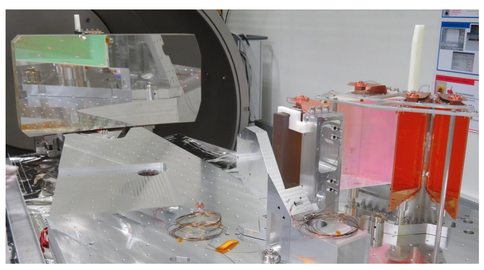


The 2 ZnSe prisms and the Infrasil prism on their dedicated mount



Test of the detector at UdeM (Canada)

Alignment in progress at IRAP (Toulouse, France)



Before cooling down, the collimator is moved to its nominal position to account for the thermal shrinkage of the bench.

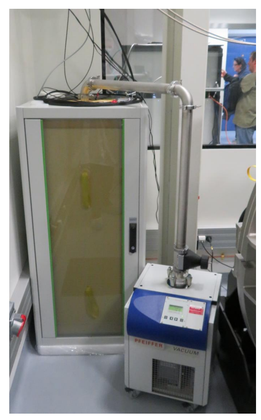
Pupil Slicer verification and optical alignment with the parabolic collimator focal distance

OTHER SPIP SUB-SYSTEMS

Optimized Fluoride fibers, with a 90 µm of core diameter and a length of up to 45 m, link the cryogenic spectrograph to its sub-systems, in particular:

The Cassegrain unit at TBL focal plane, including an achromatic polarimeter, an image stabilizing unit (ISU) and an atmospheric dispersion correction (ADC)

The Calibration unit delivered by Observatoire de Haute-Provence (OHP - France)



The Fabry-Perot Radial Velocity unit delivered by Geneva Observatory in Switzerland

CONCLUSION & PERSPECTIVES

AITV perspectives:

- ✧ **Spectrograph AIT at OMP: 2021 – 2022**
- ✧ **Overall instrument, acceptance tests: 2022B and 2023A**
- ✧ **Instrument re-integration on-site at TBL: Summer 2023**
- ✧ **First-light: 2023B**

SPIP will share the TBL with Neo-Narval (working at optical wavelengths) and will observe in coordination with SPIRou and ESPaDOnS at CFHT.

More details on the SPIP instrument in Baratchart et al. (SPIE 12184-178, 2022) and on the SPIRou instrument in Donati et al. (2020)

In memory of our SPIP and SPIRou colleagues who left us too early since 2017, Les Saddlemyer (local PM of the SPIRou cryostat, NRC-H), Pierre Soler (OMP Director), Laurent Parès (SPIRou&SPIP Cassegrain Unit optical architect, OMP/IRAP) and Jeff Botte (Head of logistics dept., OMP/IRAP and UAR831).

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★SPIP is an international collaboration led by OMP / IRAP (France) and involving OHP / LAM, Canada, Switzerland and several industries, in addition to OMP / IRAP, for the technical components. The SPIP science team largely overlaps with that of SPIRou, in particular regarding the French and Canadian communities.

SPIE. Paper number: 12184-173 (Challita et al. 2022)

The adventures of SPIRou & SPIP:

spirou.omp.eu & spip.omp.eu

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