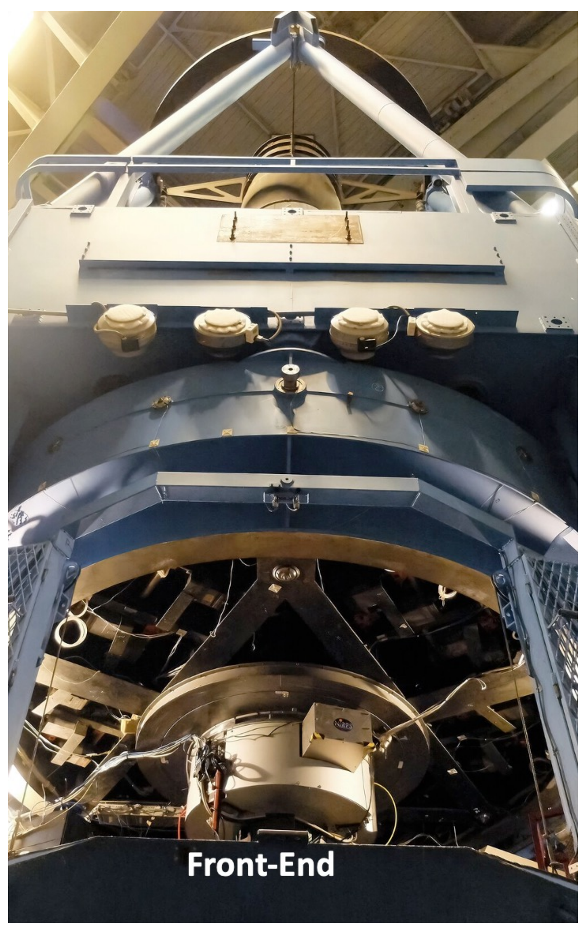
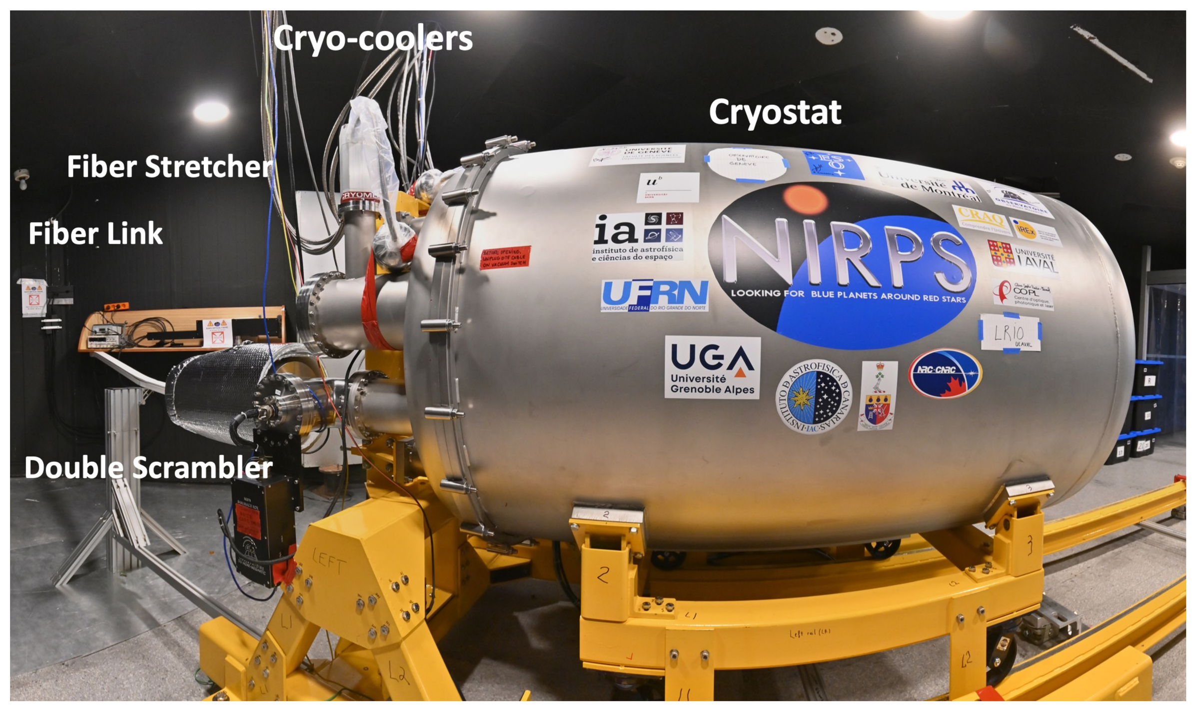
On-Sky performances and science objectives of the new nIR spectrograph NIRPS

F. Bouchy[1], R. Doyon[2], F. Pepe[1], N. Santos[3], R. Rebolo[4], X. Delfosse[5], J.R. De Medeiros[6], G. Wade[7], E. Artigau[2], L. Malo[2], F. Baron[2], F. Wildi[1], C. Lovis[1], B. Canto Martins[6], J. Gonzales Hernandez[4], S. Barros[3], L. Mignon[5], R. Allart[2], and the NIRPS team

(1) Observatoire de Genève, Université de Genève, Switzerland; (2) Observatoire du Mont-Mégantic, Université de Montréal, Canada; (3) Instituto de Astrofisica e Ciencias do Espaço, Universidade do Porto, Portugal; (4) Instituto de Astrofisica de Canarias, Tenerife, Spain; (5) Institut de Planétologie et d'Astrophysique de Grenoble, Universié Grenoble Alpes, France; (6) Universidade Federal do Rio Grande do Norte, Natal, Brazil; (7) Royal Military College, Kingston, Canada

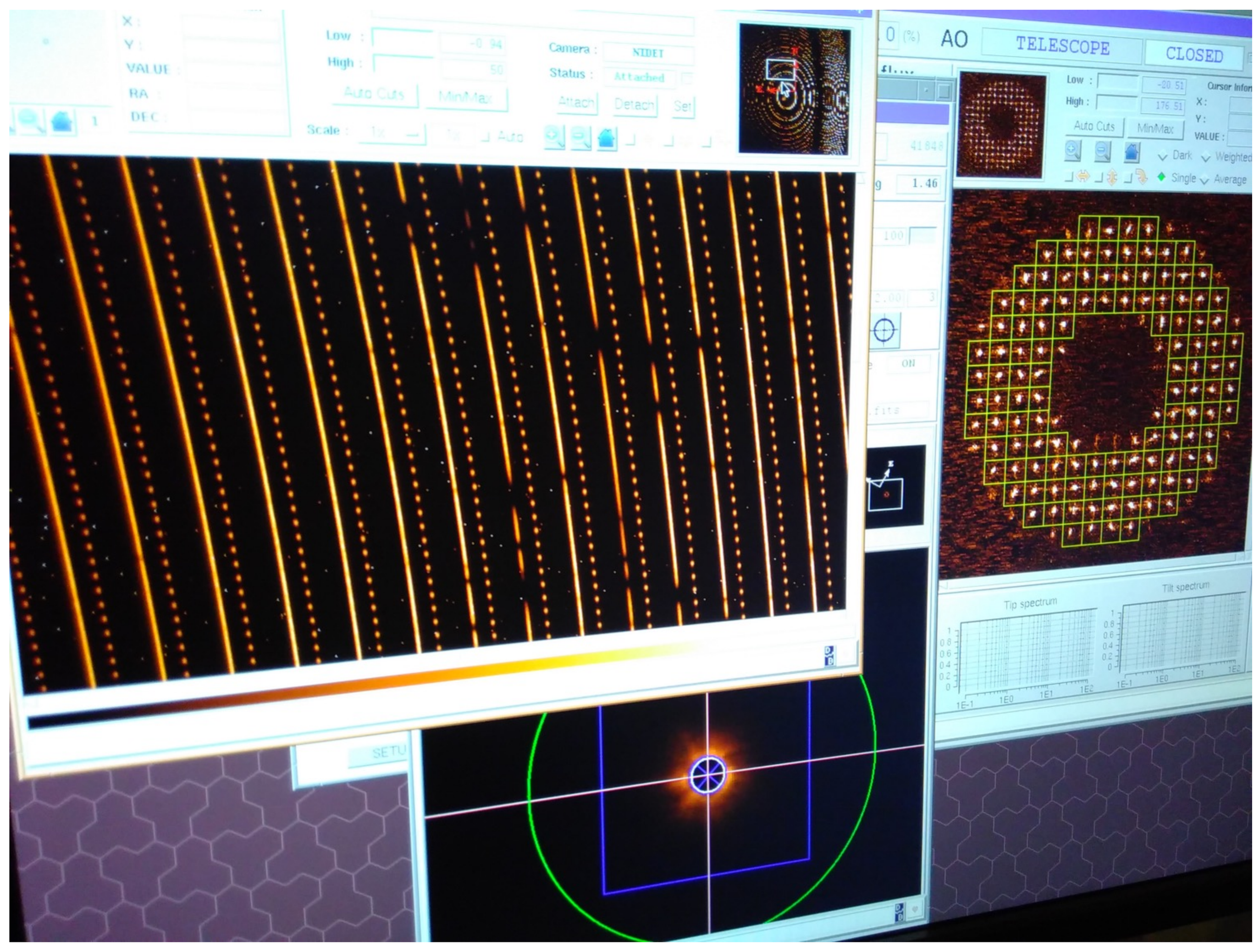


The Near-InfraRed Planet Searcher (NIRPS) is a new ultra-stable near-infrared (YJH) spectrograph equipped with an AO system, installed on ESO 3.6-m Telescope in La Silla, Chile and operated together with the exoplanet hunter HARPS. Achieving a radial velocity precision close to 1 m/s, NIRPS is designed to explore the exciting prospects offered by the M dwarfs, focusing on three main science cases: 1) High-precision RV survey of M dwarf aiming at detecting Earth-like planets in the habitable zone; 2) Mass (and density) measurements of planetary candidates orbiting M dwarfs from transit surveys, and 3) Atmospheric characterization of exoplanets via transmission spectroscopy. NIRPS consortium started in April 2023 a comprehensive program totalizing 725 nights over 5 years.



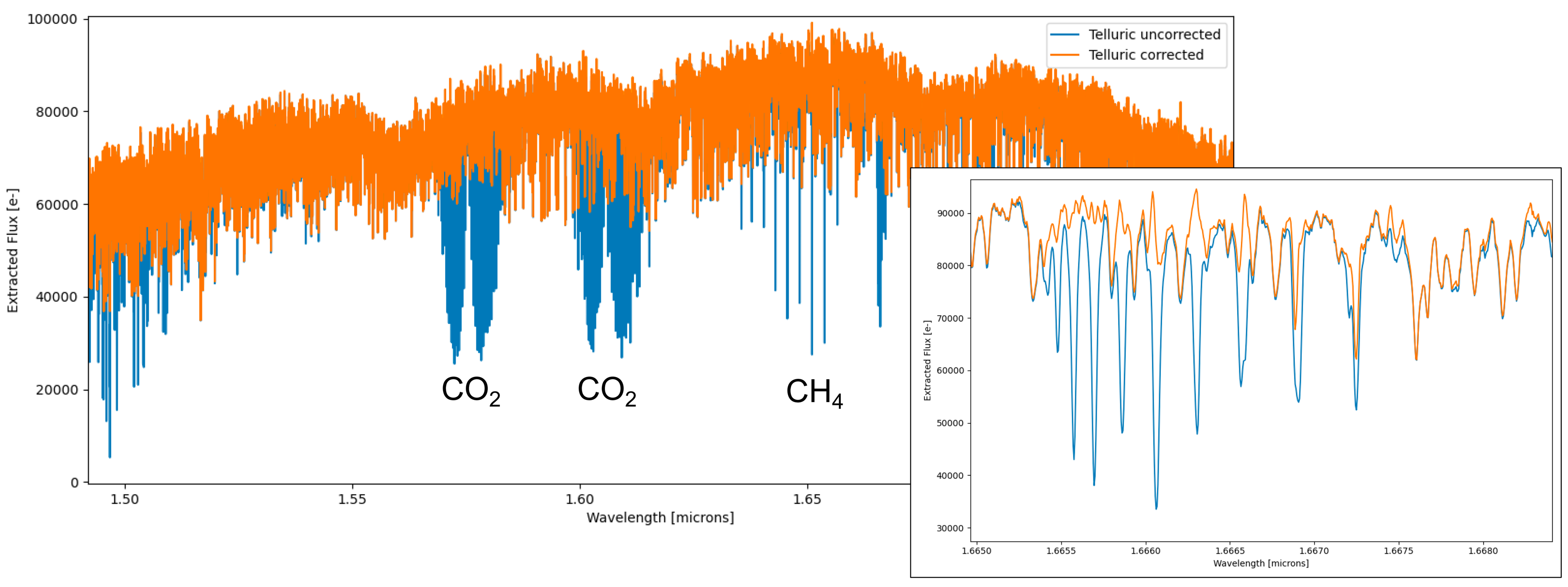
First RV spectrograph equipped with an AO system

NIRPS is equipped with an Adaptive Optics (AO) system using a 14x14 Shack-Hartmann wavefront sensor in I-band (700-980 nm) coupled to a 15x15 deformable mirror allowing to feed the 0.4" fiber of the High Accuracy (HA) mode (R~88'000) or the 0.9" fiber of the High Efficiency (HE) mode (R~75'200). The AO system guarantees very good coupling: the total efficiency at blaze angle is 4.0-8.0% in HA and 5.0-9.5% in HE. The AO is also used to perform high-angular resolution snapshot on the guiding camera to identity blended and/or diluted stellar systems.



Simultaneous operation with the state-of-the-art HARPS spectrograph

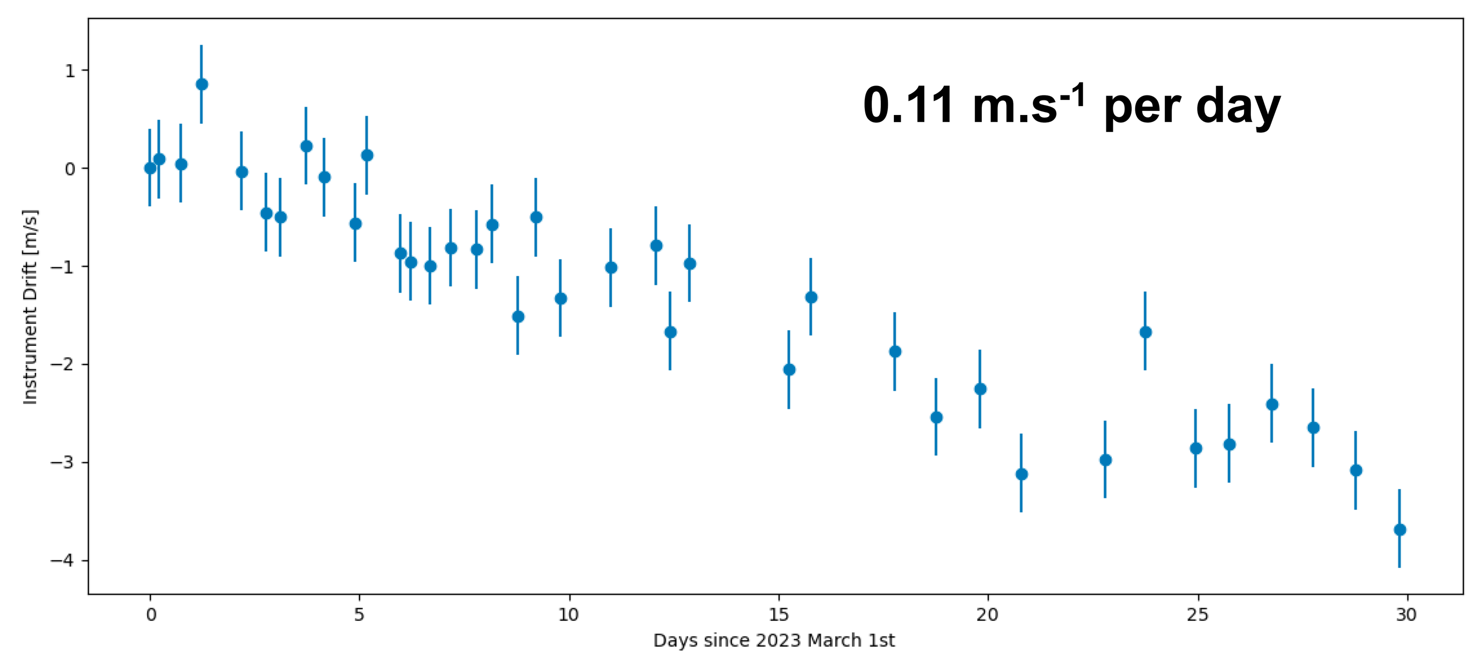
The NIRPS Front-End located above the HARPS one includes a VIS/NIR dichroic beam splitter. The AO system is mounted on a tip-tilt plate to compensate for misalignment with HARPS fiber entrance. This allows HARPS and NIRPS to operate simultaneously without any additional overhead and to cover 378-691 nm and 972-1919 nm in one shot.



H-band portion of the S1D spectrum of Proxima Centauri (M5.5V) observed with NIRPS in HA mode with 200s exposure time with and without telluric correction.

Incredible intrinsic stability and RV precision

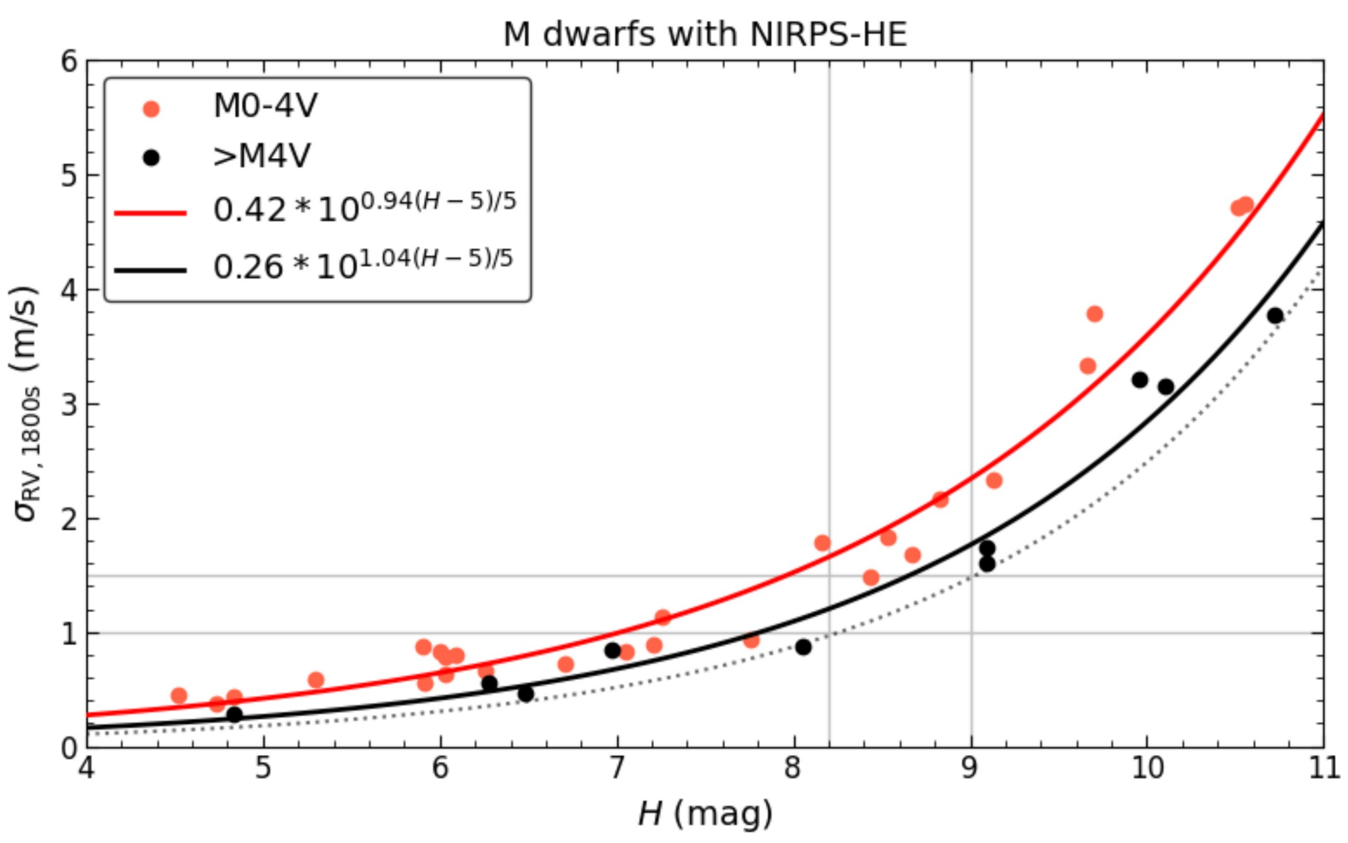
The spectrograph is installed inside a cylindrical vacuum cryostat maintained at 75 K with a stability better than 0.1 mK over 1 day. The instrumental drift is of the order of 3 m/s in 1 month. The simultaneous FP reference is then no longer required and the default observing mode is simultaneous Sky for OH emission lines correction.



Monitoring of the NIRPS intrinsic drift over 30 days measured with the Uranium-Neon Hollow-Cathode lamp. The typical drift of 0.1 m/s per day illustrates the unprecedented stability of NIRPS.

First spectrograph equipped with a fiber stretcher to attenuate modal noise

The use of small multimode fibers in the nIR introduces modal noise. A dedicated fiber stretcher was developed and implemented on the two pairs of NIRPS fibers allowing a significant reduction in modal noise. The AO is also used to scan the fiber input to homogeneously fill in fiber propagation modes. The relative stability and reproducibility of the spectral flat-field are measured at the level of 0.2-0.3% in HE.



Estimated RV photon-noise rescaled to a 30mn exposure for M dwarfs observed with NIRPS as a function of H magnitude. Black and red lines correspond to empirical relationships for late (>M4) and early dwarfs (M0-M4), respectively. The dotted line showcases the lower envelope of the RV photon noise for non-rotating late M dwarfs under good observing conditions.

Unprecedent online & real-time Data Reduction Software

Spectra and RVs are extracted in real time at the telescope using an adapted version of the state-of-the art ESPRESSO pipeline which includes optimal extraction, wavelength calibration, flat-field correction, telluric correction, sky emission correction, flux calibration, cross-correlation function. Additional post-processing steps like the Line-By-Line method for RV computation is done using the APERO pipeline adapted from SPIROU.

First exciting scientific results of NIRPS consortium presented at Exo-5

Parallel Talk 986 – R. Allart - *First light and results for atmospheric characterization with NIRPS*
Parallel Talk 1234 – K. Al Moulla - *Characterizing Solar-Type Activity with HELIOS*
Poster 435 – A. Suarez - *NIRPS takes a look at Proxima*
Poster 601 – Y. Frensch - *Transiting giant planets around low-mass stars*
Poster 616 – L. Parc - *TOI-756c, an eccentric warm giant companion to the TESS Sub-Neptune.*
Poster 661 – Y. Carteret - *WASP-69b: global modelling of helium escape as seen with NIRPS*
Poster 967 – D. Mounzer - *High-resolution exploration of sub-Neptunes' atmospheres with NIRPS*
Poster 1275 – L. Mignon - *The NIRPS blind search of exoplanets around M dwarfs*