ON THE SYNERGY BETWEEN HWO AND GROUND-BASED HIGH-RESOLUTIONS SPECTROGRAPHS

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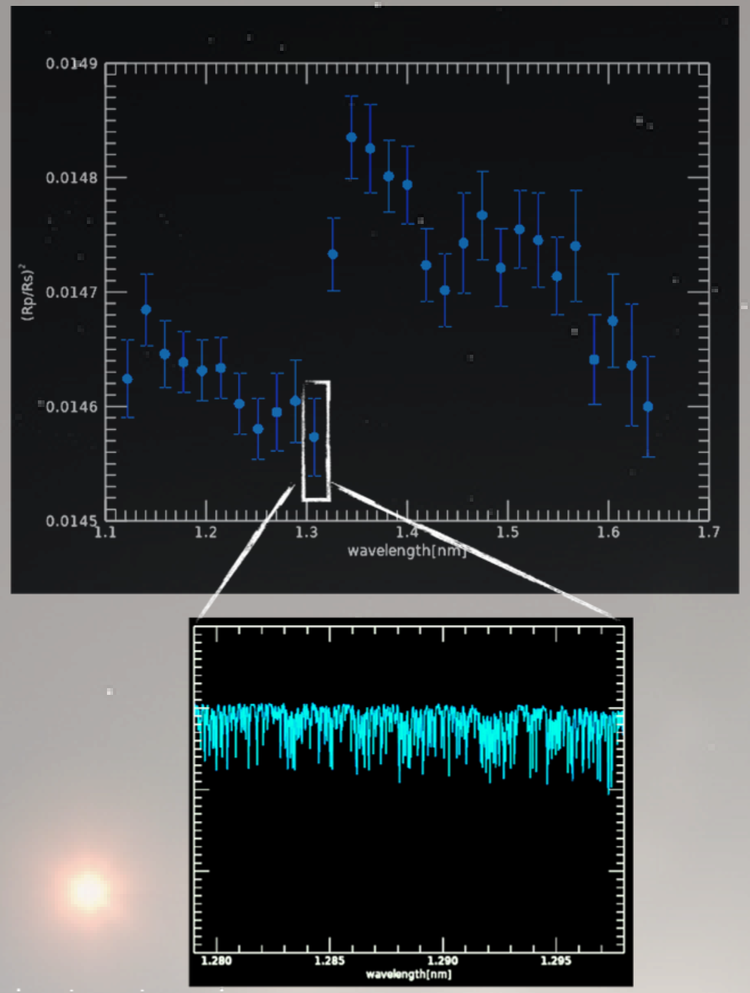
Shaping the Italian Contribution to HWO

EXOPLANETARY ATMOSPHERES: LR VS HR SPECTROSCOPY

LOW-RESOLUTION SPECTROSCOPY

- Easier to model (small number of points)
- Retains continuum information
- Degeneracies occur due to overlapping bands
- Problems with deep clouds



HIGH-RESOLUTION SPECTROSCOPY

- Computationally intensive
- Continuum information is lost with the analysis
- Avoids degeneracy between species
- Sees above the clouds

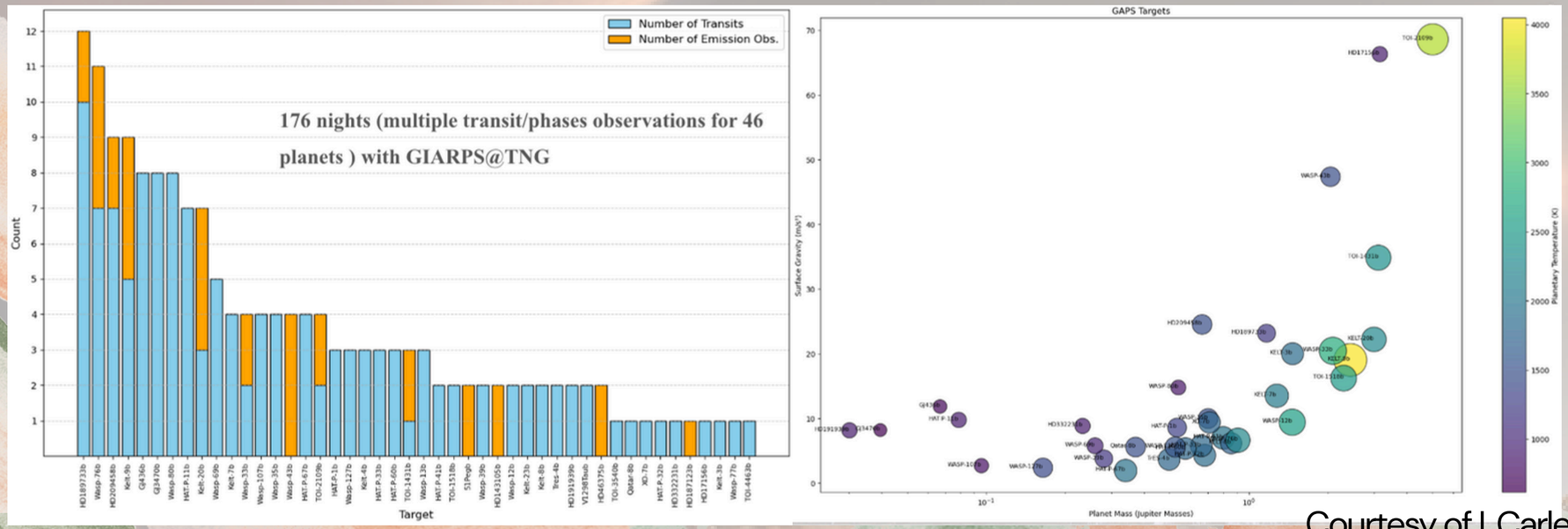
A combines analysis of HRS and LRS enables a better comprehension of exoplanetary atmospheres

GAPS COLLABORATION DATA

Within the **GAPS team** , we have collected a total of **>180 nights**, Large Program GAPS2 (PI Micela)+BRIDGES (PI Borsa) with GIARPS@TNG, which combines:

-**GIANO-B** in the near-infrared: spectral coverage (0.92-2.45) μm, resolution (R~50,000)

-**HARPS-N** in the visible: spectral coverage (0.92-2.45) μm, resolution (R~50,000)



Courtesy of I. Carleo

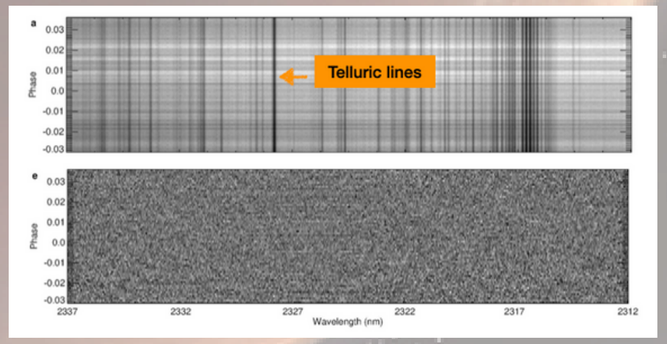
GUIBRUSH(R)

Graphical User Interface for Bayesian Retrieval at High Resolution

P. Giacobbe, F. Amadori

Raw spectrum reduction module

Data calibration



telluric removal

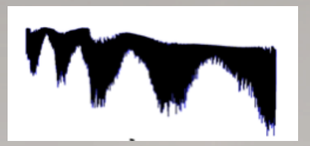
Atmospheric modeling

Molecular abundances

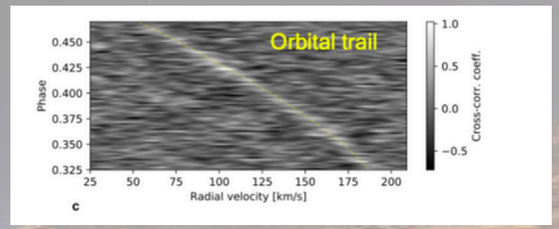
Cloud properties

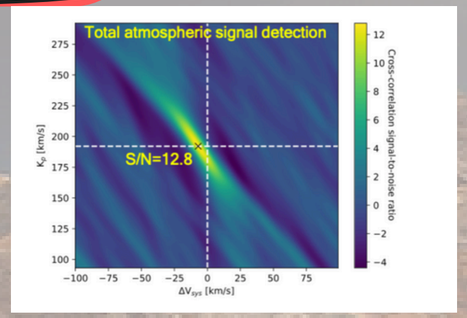
Radiative transfer (PyratBay, pRT..)

→ MODEL SPECTRUM

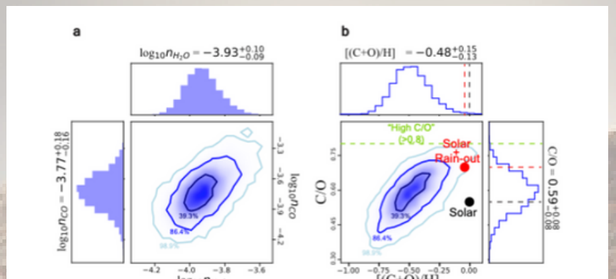


Atmospheric detection via CCF



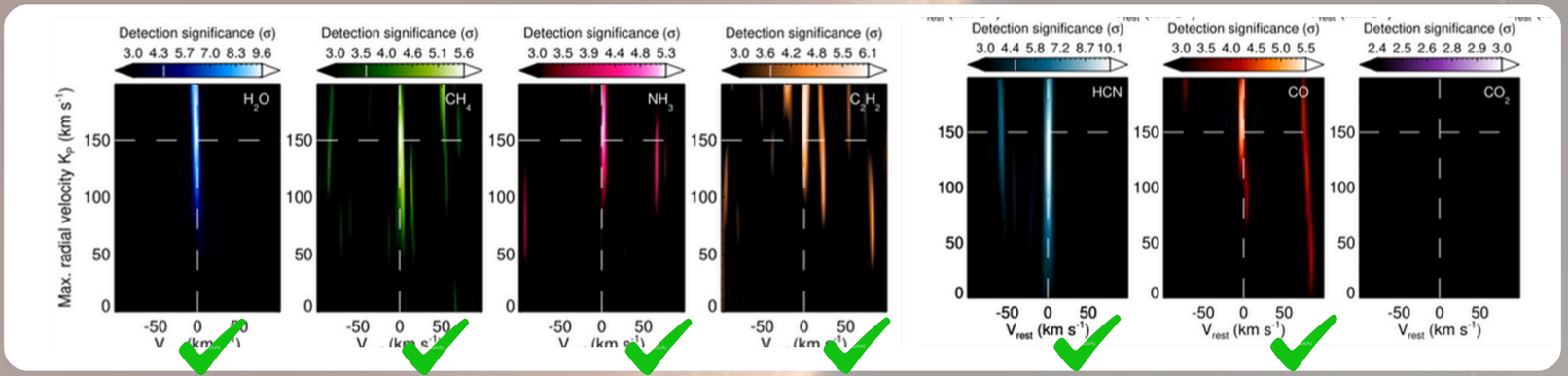


Atmospheric retrieval



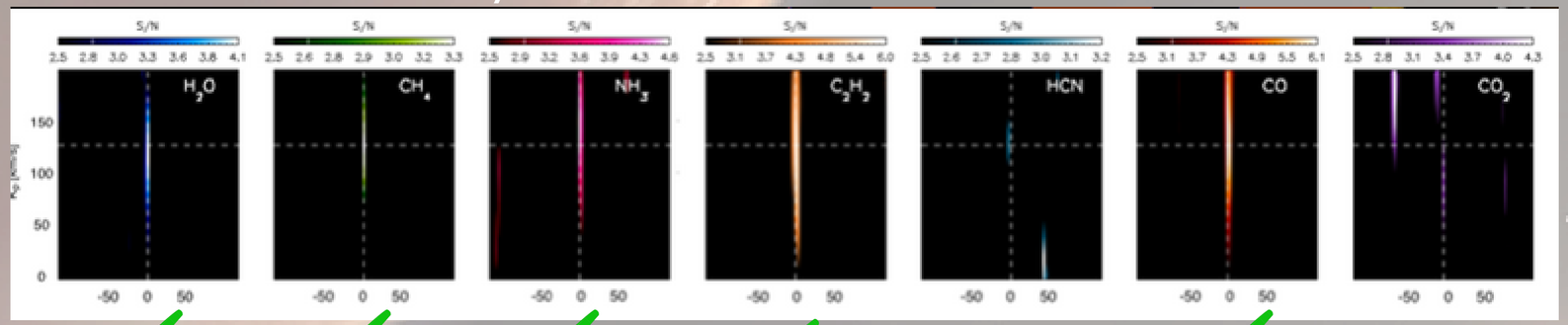
First results in cross-correlations

HD209458b , Giacobbe+2021

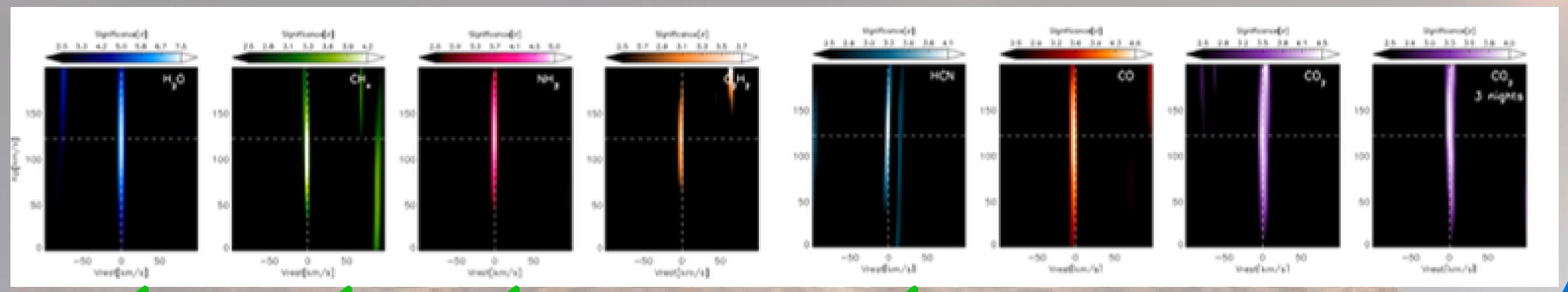


first detection of N>3 molecules in the nIR

WASP-69b , Guilluy+2022



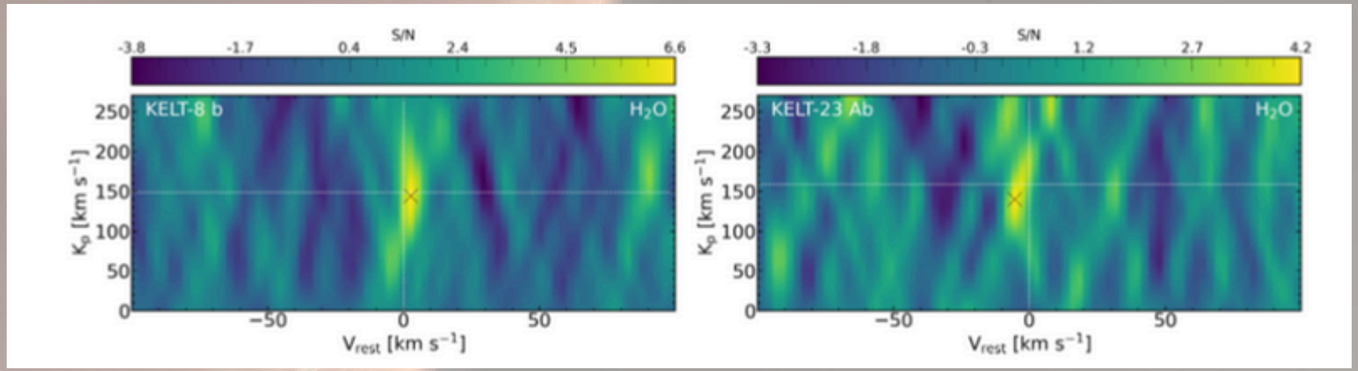
WASP-80b , Carleo+2022

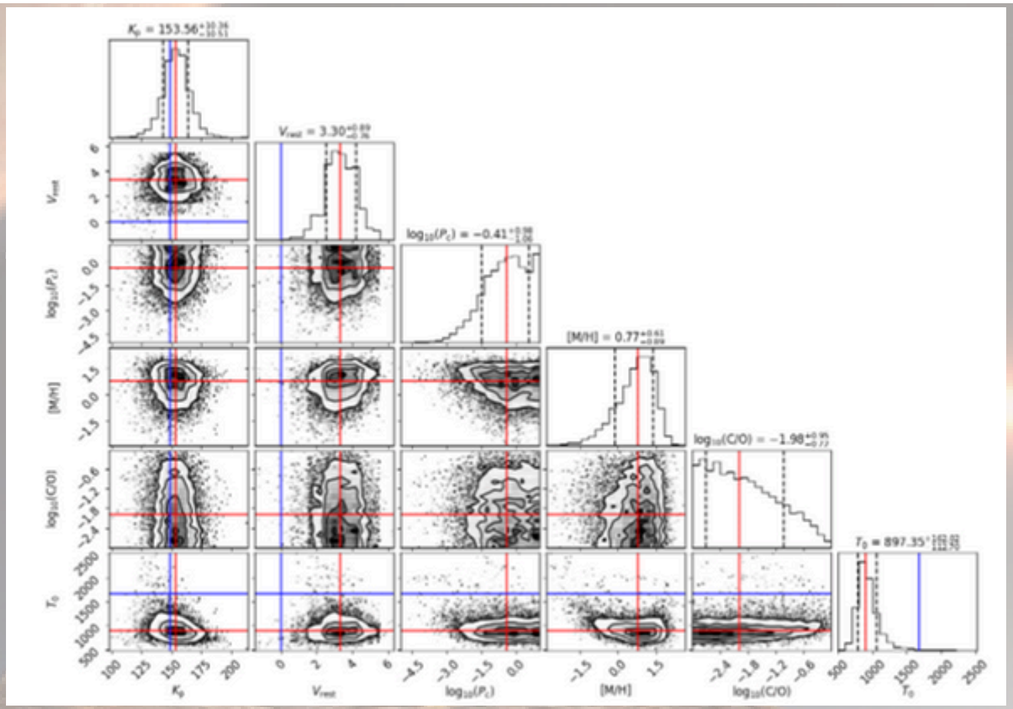


hints of disequilibrium chemistry

First retrievals

Detection of water and a preliminary characterisation of the atmospheres of the two hot Jupiters: KELT-8 b and KELT-23 Ab



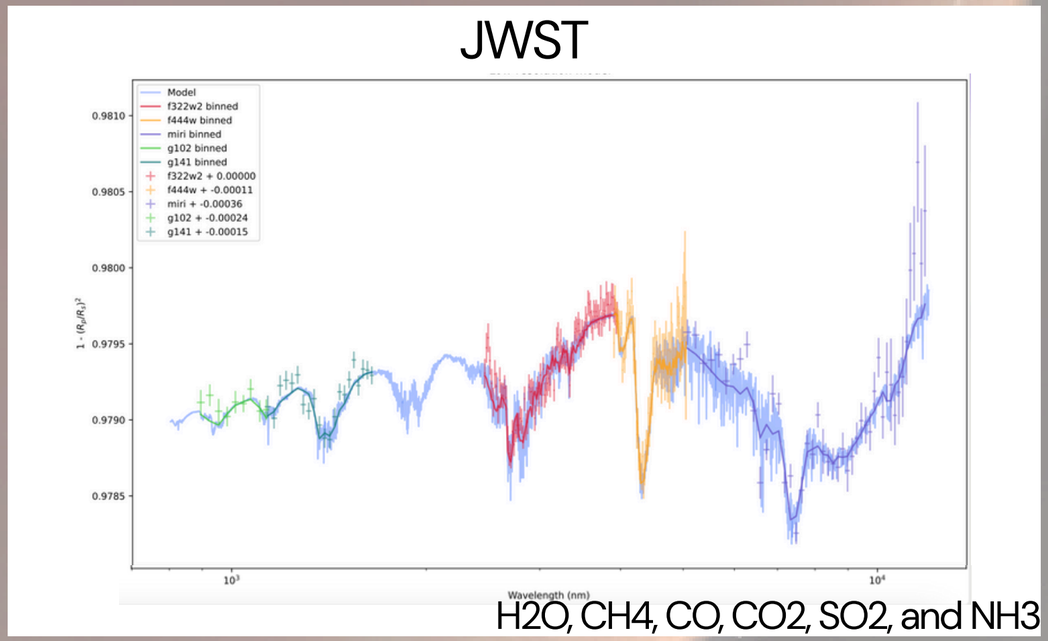


Basilicata+2025

First attemp in combining HR+LR

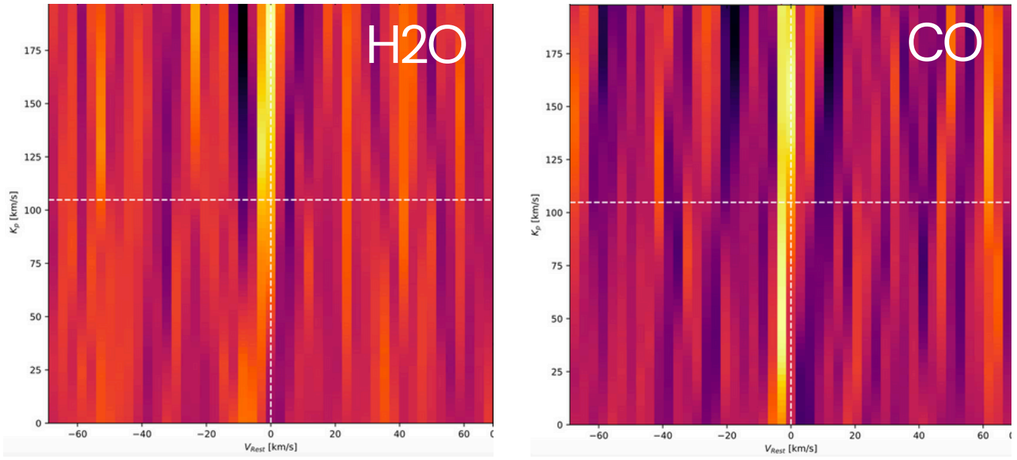
WASP-107 b

JWST

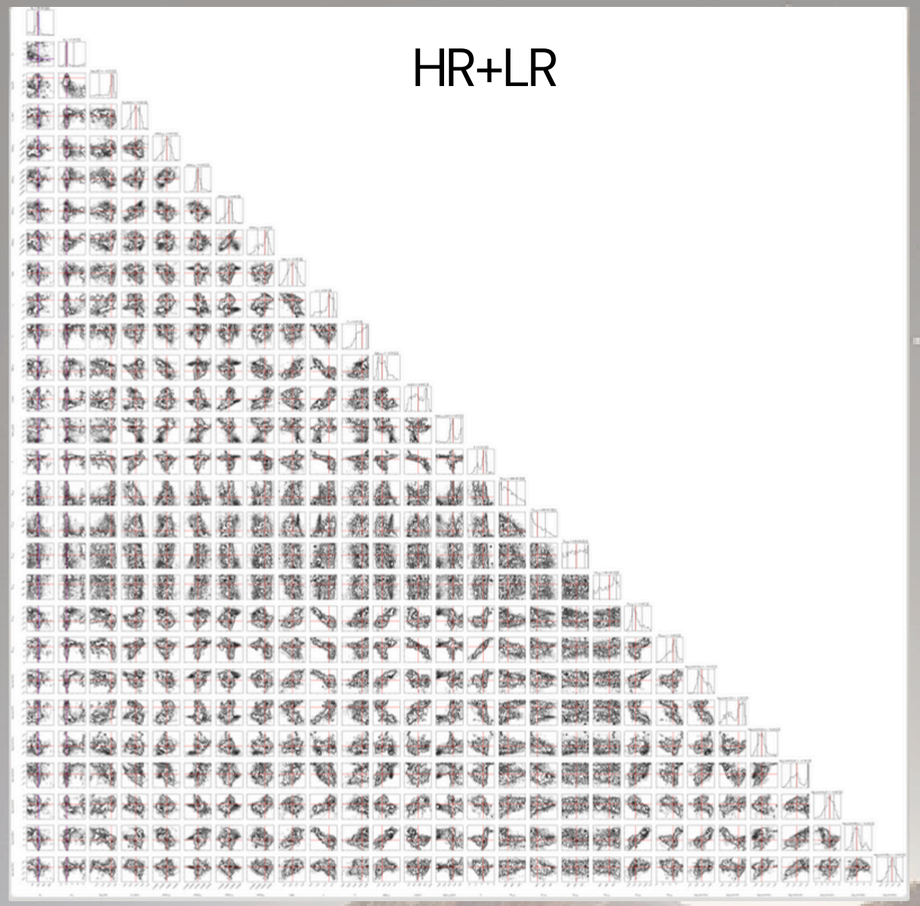


H2O, CH4, CO, CO2, SO2, and NH3

HR: GIANO-B + IGRINS



HR+LR



work in prep

Thanks to F. Amadori

First attemp in combining HR+LR

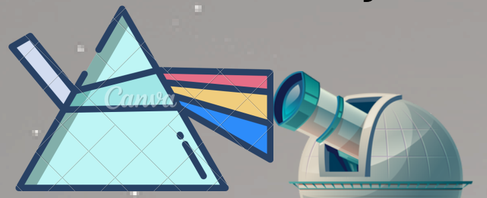
SYNTHETIC GENERATOR

Stellar Spectrum
(Phoenix)

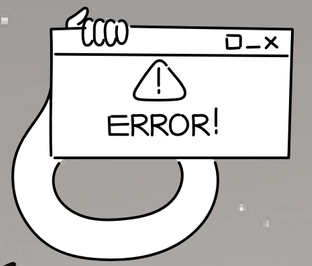
Telluric spectrum
(ESO skycalc)

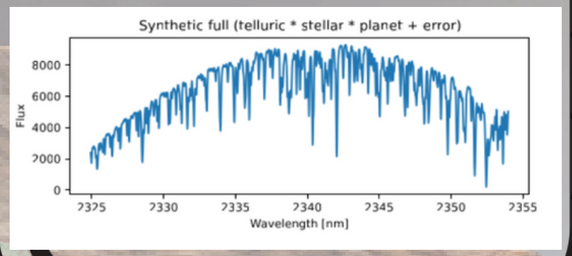
Planetary spectrum
from LR

Observed flux and SNR used as
reference for the injected signal

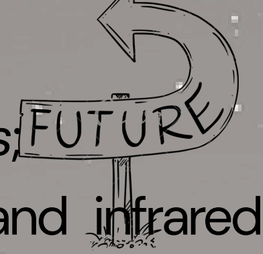


Noise
from the pipeline
reduction)





ANDES@ELT



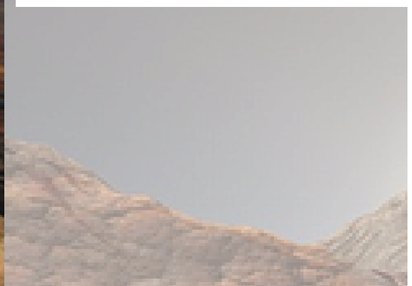
The GIARPS regime today, on Jupiter-like planets, is the same of ANDES@ELT tomorrow, on rocky planets;

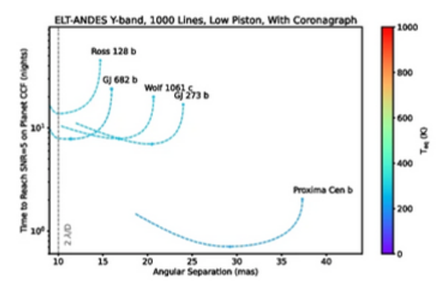
European Extremely Large Telescope (ELT) will be the largest ground-based telescope at visible and infrared wavelengths

ANDES@ELT: is the high-resolution (R=100 000), optical-infrared spectrograph, two observational techniques

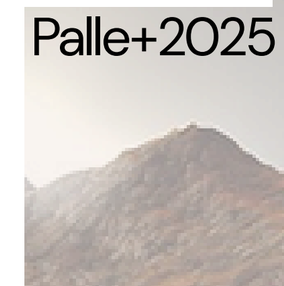
- high-dispersion for transmission-emission spectroscopy (0.5–1.8 μm interval (with the goal to extend the coverage to the blue and to the K band)
- high spatial contrast for reflected light (extreme Adaptive Optics (AO) and/or coronagraphic system) Y, J, and H bands→ Characterization of exoplanets atmospheric composition and the exploration of habitable zone planets: reflected light atmospheric signal of a **golden sample of 5 nearby non-transiting habitable zone earth-sized planets within a few tenths of nights**

Name	SpecTyp ($T_{\rm eff}$) [K]	d [pc]	V [mag]	P [d]	$m \sin i$ [$m_\oplus$]	$R_{\rm p}$ [$R_\oplus$]	$T_{\rm eq}$ [K]	sep [mas]	contrast [10^{-8}]	nights
Proxima Cen b	M (2900 K)	1.30	11.01	11.19	1.1	1.07	217	37.3	11.2	0.67
Ross 128 b	M (3163 K)	3.37	11.12	9.87	1.4	1.15	283	14.7	12.5	13
GJ 273 b	M (3382 K)	3.80	9.84	18.65	2.9	1.64	266	24.0	7.52	6.5
Wolf 1061 c	M (3309 K)	4.31	10.10	17.87	3.4	1.81	275	20.7	9.57	5.8
GJ 682 b	M (3237 K)	5.01	10.94	17.48	4.4	2.11	259	16.0	16.0	7.2



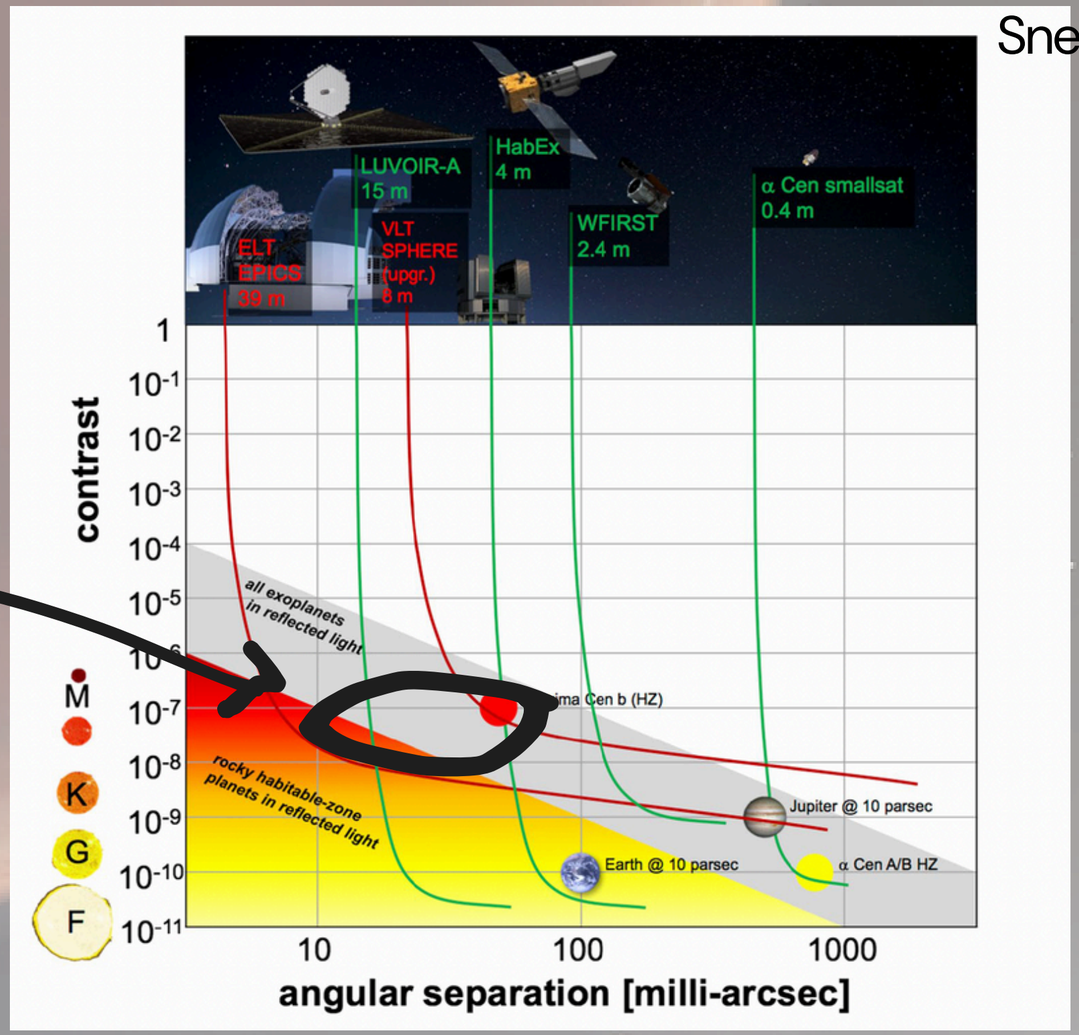


Palle+2025



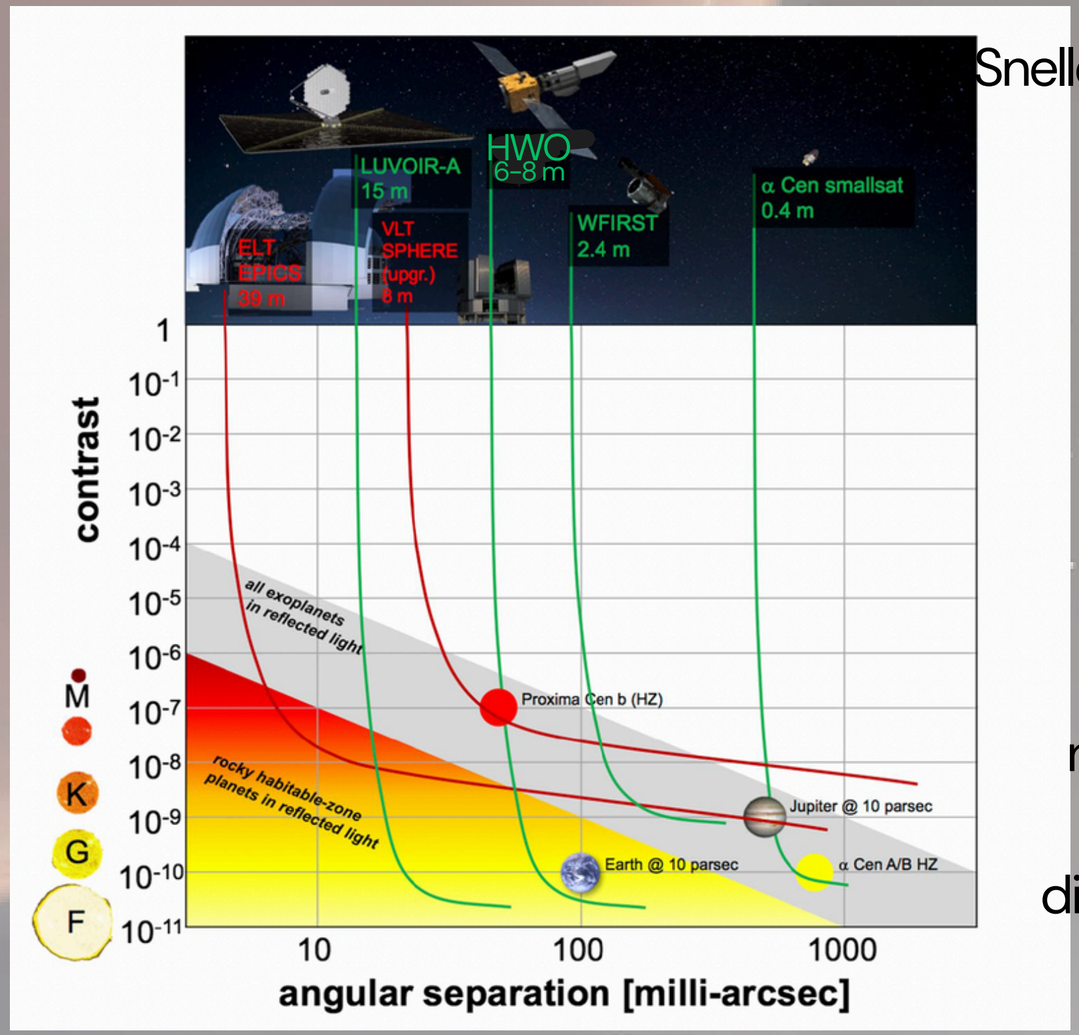
ANDES@ELT

Snellen+2022



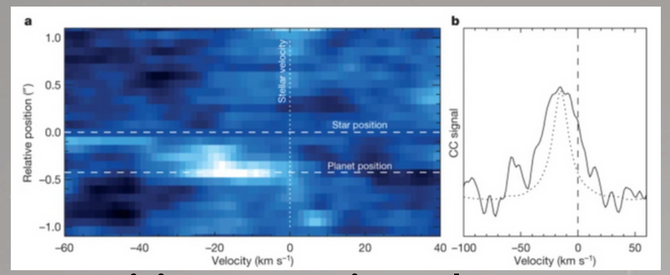
ANDES

ANDES@ELT + HWO



Snellen+2022

e.g., Snellen+2015 CRIRES /VLT + AO for β Pictoris b



non-transiting massive planets

ANDES+ PCS for HDS+HCI

direct imaging+ cross-correlation

Complementary: atmospheric characterisation of multiplanetary systems around Sun-like stars, with the final aim of exploring their formation conditions.

HWO

Earth-like planets around solar-type stars

IGRINS, GIANO-B, CRIRES+ESPRESSO + HST and JWST

ANDES@ELT + HWO

Thanks for the attention