ANDES Working Group 1

Exoplanets and Protoplanetary Disks

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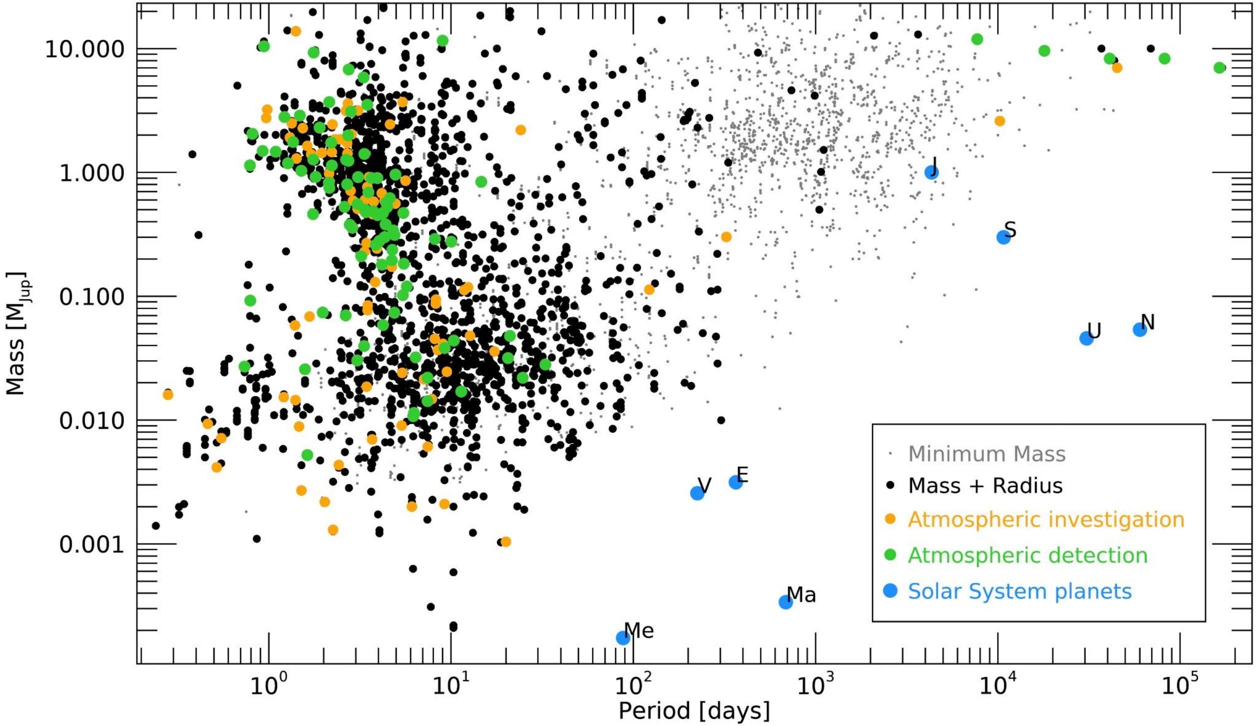
on behalf of ANDES WG1

Meeting della strumentazione ELT a guida italiana, Napoli, 14/05/2026

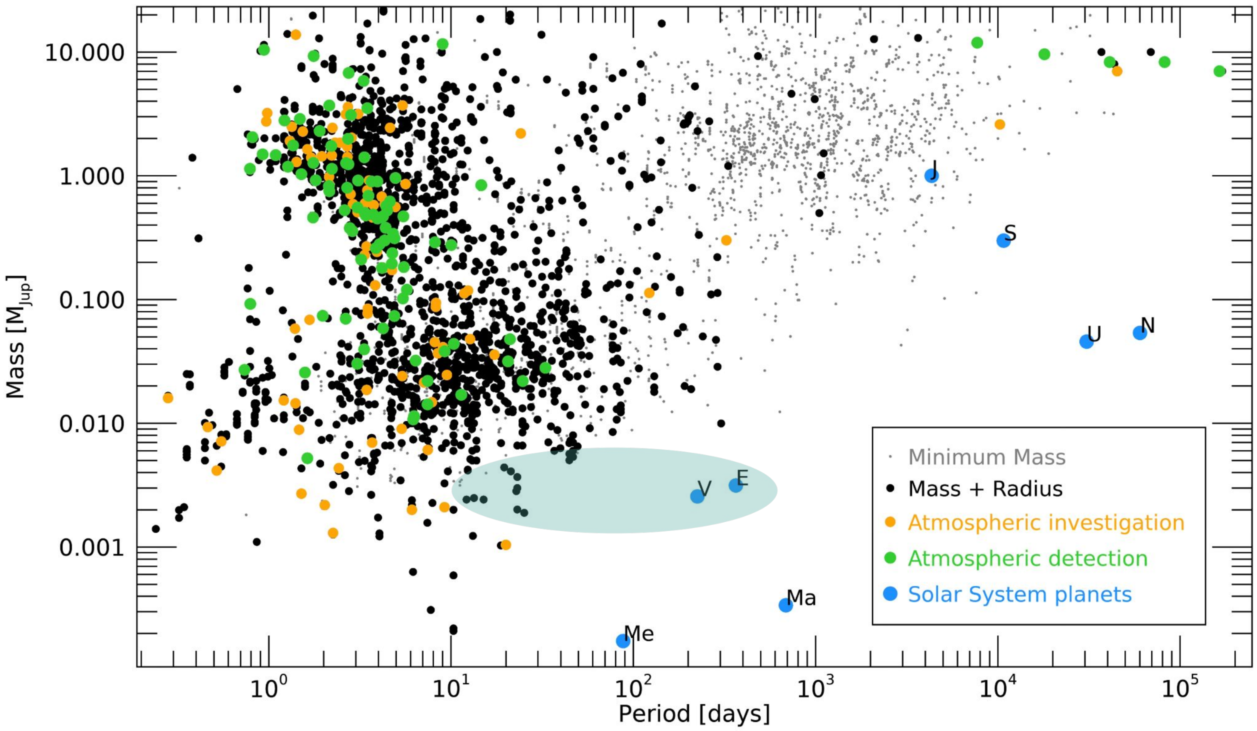
ANDES in the context

Exciting times for exoplanet science and atmospheric characterization



ANDES in the context

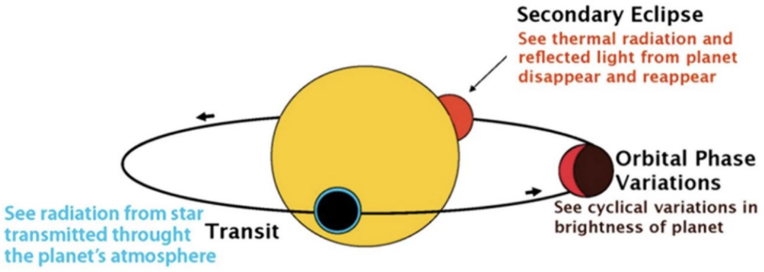
Characterization of habitable zone rocky planets is out of reach with current facilities



ANDES in the context

Characterizing the atmospheres of extrasolar planets is one of the hottest topics in exoplanetary science

Why studying exoplanetary atmospheres?

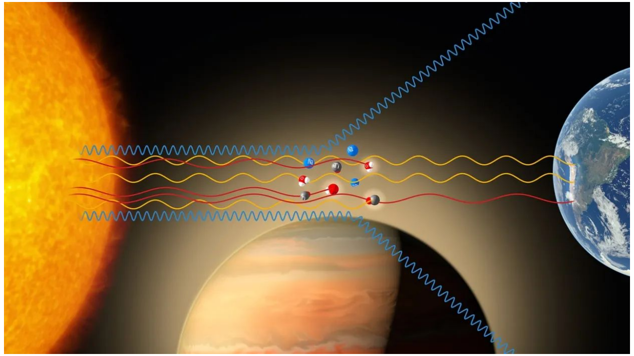


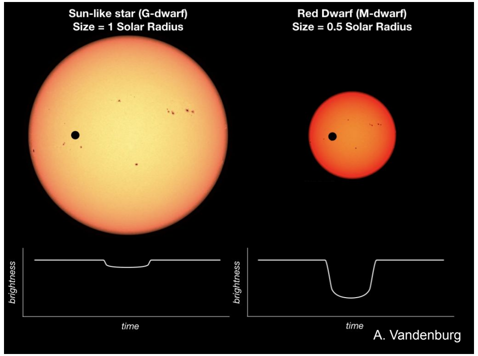
Beichman et al. 2014

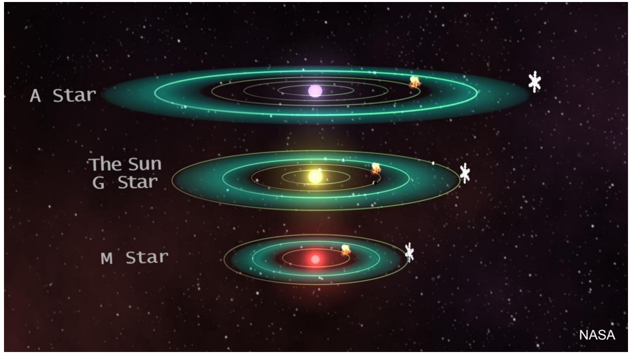
- Atmospheric composition is connected to formation and evolution of planetary systems through elemental abundances ratios
- It is associated to the interior composition of the planet
- To understand dynamics, chemistry and stellar radiation effects
- Provides the best method for detecting biomarkers on habitable planets

Transmission spectroscopy

Transmission spectroscopy relies on using ANDES as a seeing-limited spectrograph







- ANDES aims at targeting small, rocky planets in the habitable zone of M-dwarfs
- detecting biosignatures: an objective no other currently approved astronomical facility will be able to reach

Transmission spectroscopy

Gas giants

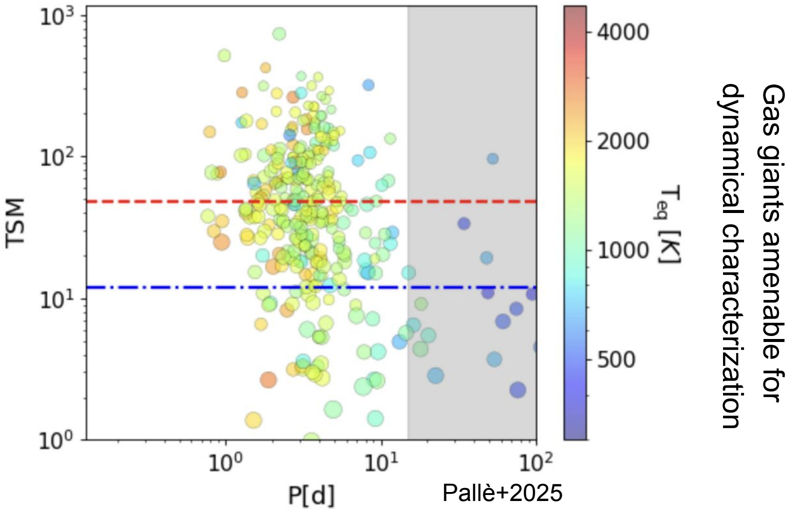
Ideal laboratory to study atmospheric dynamics in regimes not accessible in the Solar System

- chemical and isotopic compositions
- atmospheric dynamics and weather patterns
- 3D atmospheric mapping

~260 with a first characterization

~150 with a detailed characterization

ANDES: a giant leap for giant planets: from 4m to 40m telescope



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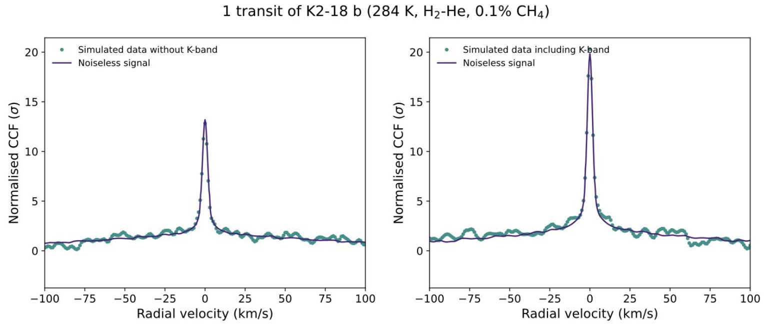
Transmission spectroscopy

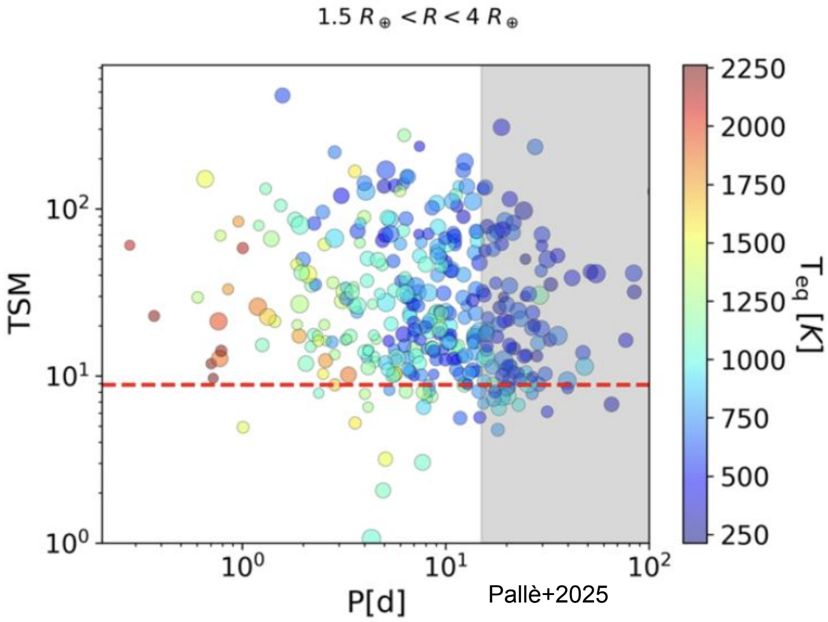
Sub-Neptunes

K2-18b



➡ Transition region between gaseous and rocky planets

Almost all known sub-Neptunes accessible with one single transit



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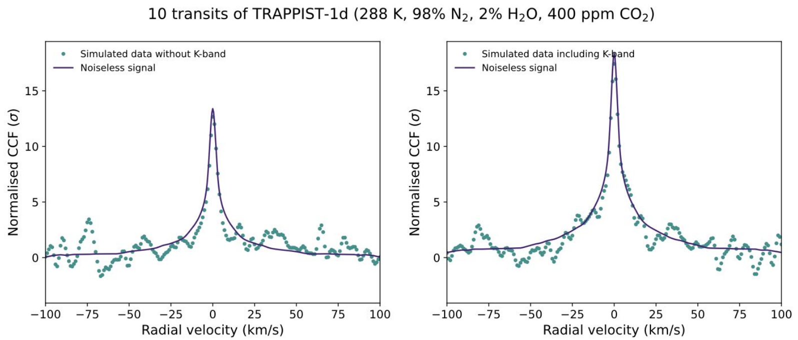
Transmission spectroscopy

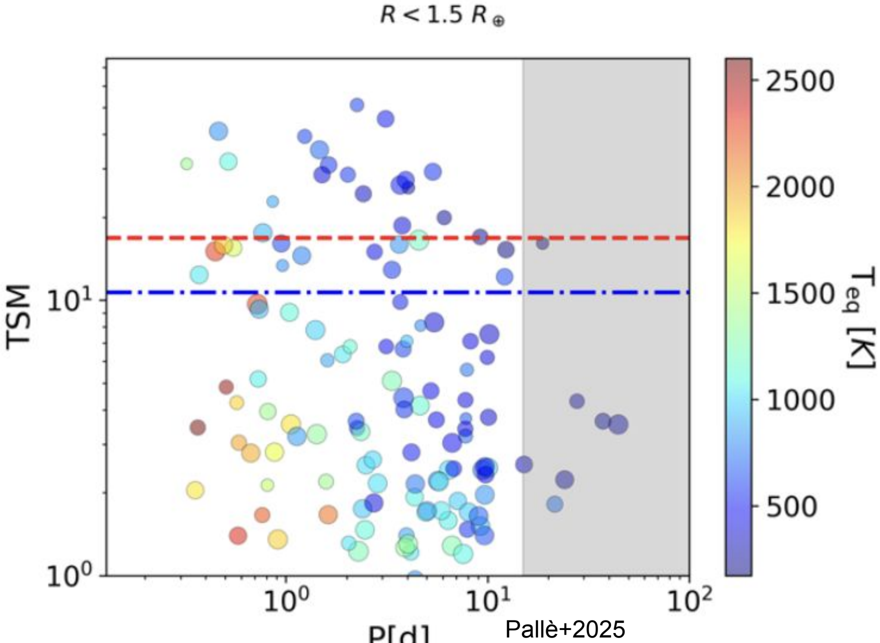
Rocky planets

Trappist-1d



Earths only accessible with multiple transits

Detectability thresholds for ANDES will be extremely target-dependent



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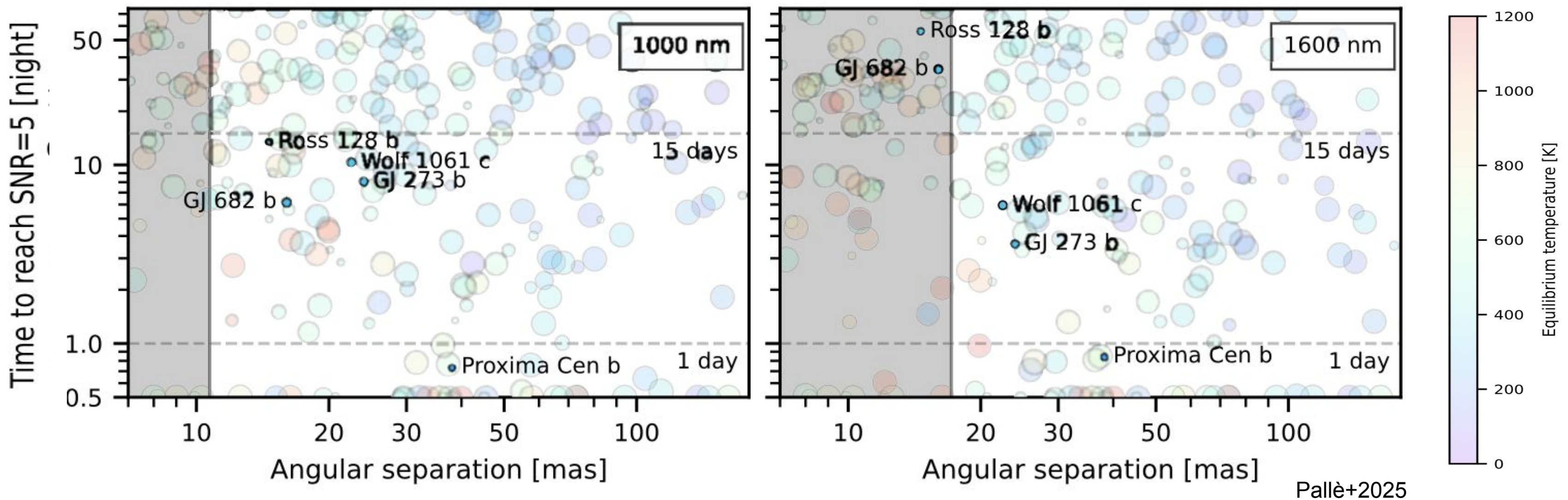
with 5 transits

Reflection spectroscopy

- the reflected light science case relies on adaptive optics systems coupled with smaller spaxel-size IFUs: **coupling high-resolution spectroscopy with high-contrast imaging**
- possibility to target non-transiting, and thus more nearby, rocky planets (HZ!)
- surface features can, in principle, be probed in the reflected-light geometry
- could be used to detect the major molecular constituents of their atmosphere (e.g., H_2O, CO_2, CH_4, NH_3, O_2) and constrain the presence of clouds, ice caps, and liquid water on their surface

Reflection spectroscopy



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The “golden sample”: 5 rocky planets in the habitable zone which are the most favorable currently known in terms of SNR

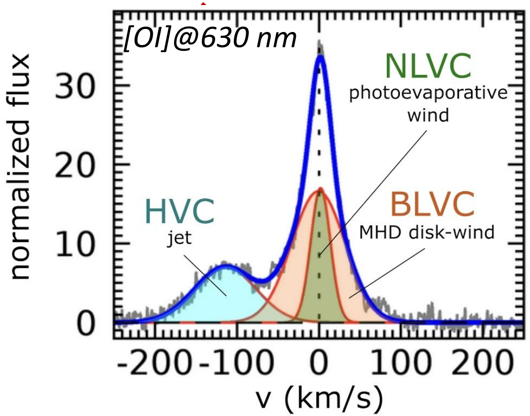
Proxima Cen b is the best habitable-zone rocky planet target

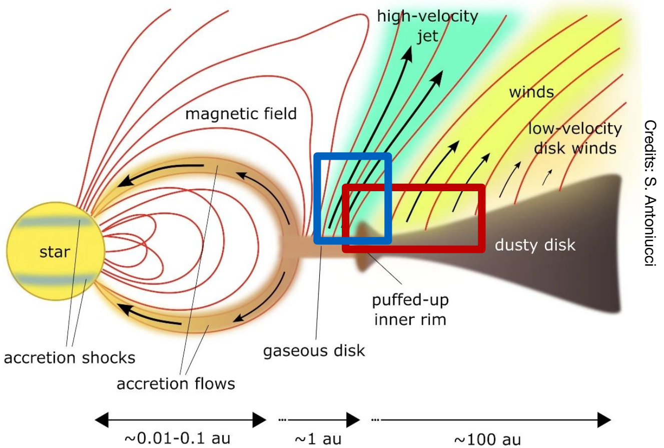
Young gas giants

The main gain of ANDES is in angular resolution

- direct detection and characterization down to the snow line (potential hints from Gaia or RVs)
- mass-luminosity relation in relation with formation & evolution processes
- chemical composition, clouds, 3D atmospheric circulation
- physics of accretion for young protoplanets in connection with their circumplanetary disks
- 3D orbital and dynamical characterization including the measurement of obliquities
- potential first discoveries of young exomoons

Protoplanetary disks

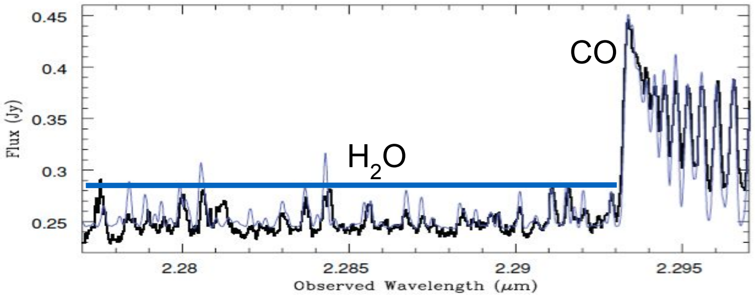




ANDES: high sensitivity & high resolution in the optical range

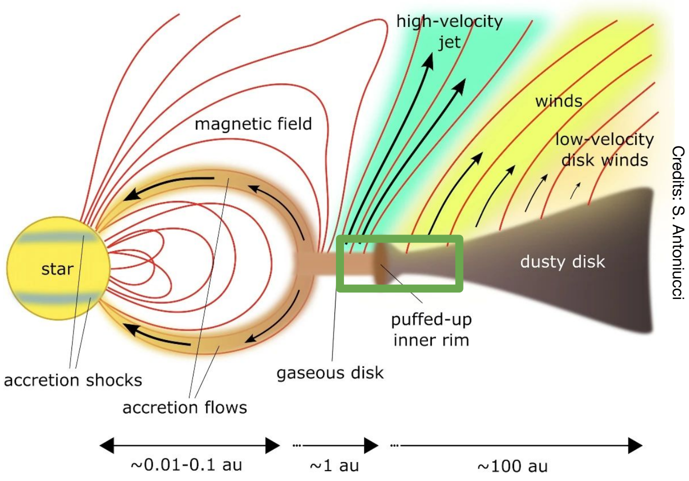
- probe the kinematics and **gas content of the inner region of the disk**: allow the separation of the kinematic components at low velocity (NLVC, BLVC) to distinguish emission from a photoevaporative wind from that of the gas bound in the disk (Pallé+2025)
- test different **jet launching** models from the observation of the high-velocity kinematic component (Giannini+2019)
- Hα emission of accreting forming planets

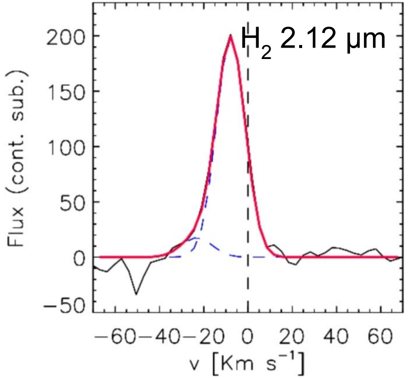
Protoplanetary disks

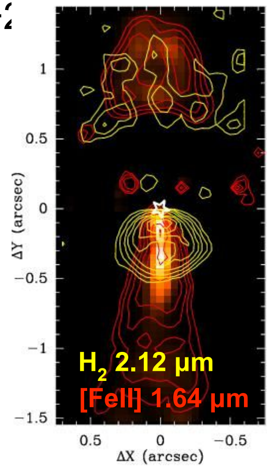


ANDES: high sensitivity & high resolution in K band

- molecular lines (CO, H_2O, OH) trace the inner hot regions and are observed in emission in strong accretors, giving important clues for planet-forming regions (Najita+2009, Doppmann+2011)
- high-resolution spectral imaging of molecular component (H_2) provides information on the role of molecular winds in the PPD evolution (Agra-Amboage+2014; Gangi+2020)
- accretion properties of embedded sources (Nisini+2005, Alcalá+2014, Antoniucci+2014, Manara+2 Biazzo+2025)



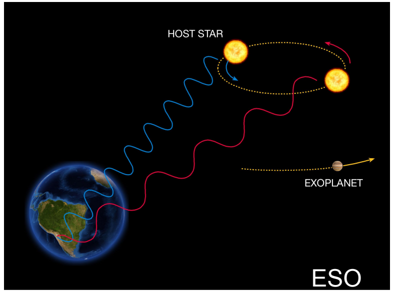




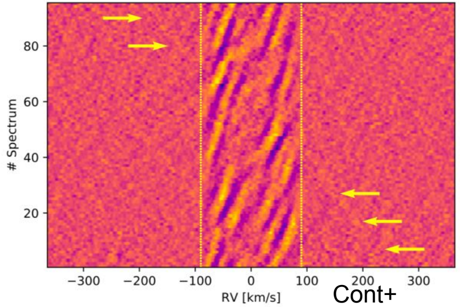
Synergy with METIS

Additional science cases

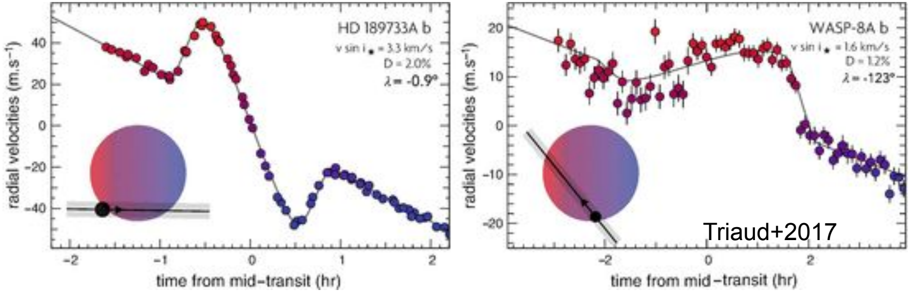
Radial velocity mass measurements



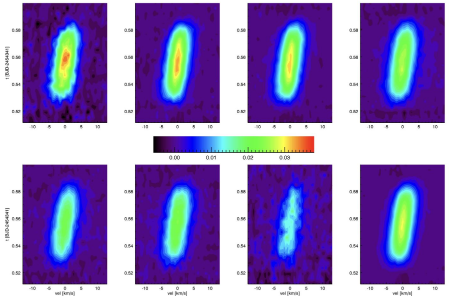
Stellar pulsations & Stellar science cases



Rossiter-McLaughlin effect and obliquity measurements



Chromatic Rossiter-McLaughlin effect

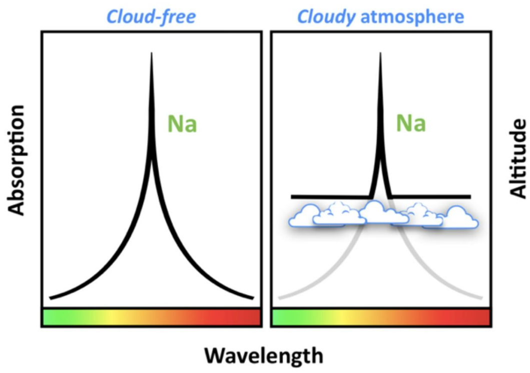


Synergies

PLATO will have found new interesting candidates for atmospheric characterization, possibly with their albedo information

Necessity for an in depth characterization of the most interesting star-planet systems: X, EUV, NUV, mass, radius… All available facilities will be important for this

Ariel (and JWST) will allow for (quasi) simultaneous HR+LR retrievals



The Italian WG1 community

- 7 members of the International ANDES Science Team WG1:

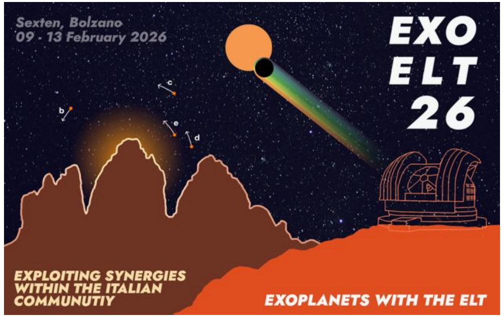
  K. Biazzo, A. Bonomo, F. Borsa, M. Brogi, P. Giacobbe, J. Maldonado, L. Pino

- 62 members of the Italian ANDES Science Team WG1

  Coordinators: K. Biazzo, M. Brogi, L. Pino

- ExoELT Italy 2026 conference

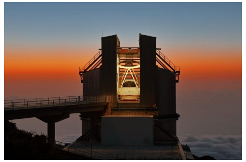
  ANDES as the favourite ELT instrument for the exoplanet community



- Preparing for ANDES with different Italian-led surveys

BRIDGES

BRIDGES: Building a Road to the In-Depth investiGation of Exoplanetary atmosphereS

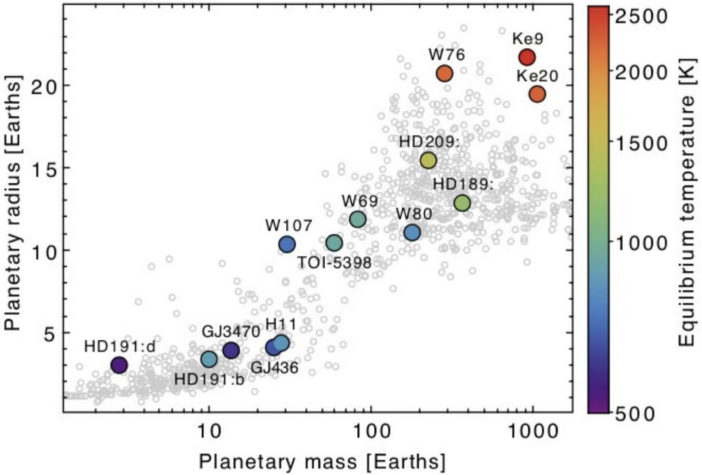


Conducting the deepest high-resolution, simultaneous VIS and nIR atmospheric characterization of a carefully selected sample of exoplanets

- Chemical and physical characterization
- Constrain the formation and migration paths
- Explore atmospheric variability
- Test and develop models

GIARPS@TNG has the perfect and unique match of HR and large wavelength coverage needed

Sample chosen to cover a large portion of the Radius-Mass-Teq diagram



BRIDGES

Conceived also for the need of being ready for ANDES@ELT

the detection of a biomarker in a planetary atmosphere will be reached by combination of tens of transits

From U to K band

GIARPS covers a similar wavelength range!

With such a number of transits, we could be not dominated by photon noise (limited by stellar activity? systematics?)

A Large Program like BRIDGES is exploring for the first time this regime

The Italian WG1 community

A possible re-prioritization of science cases will be discussed within International WG1 ST

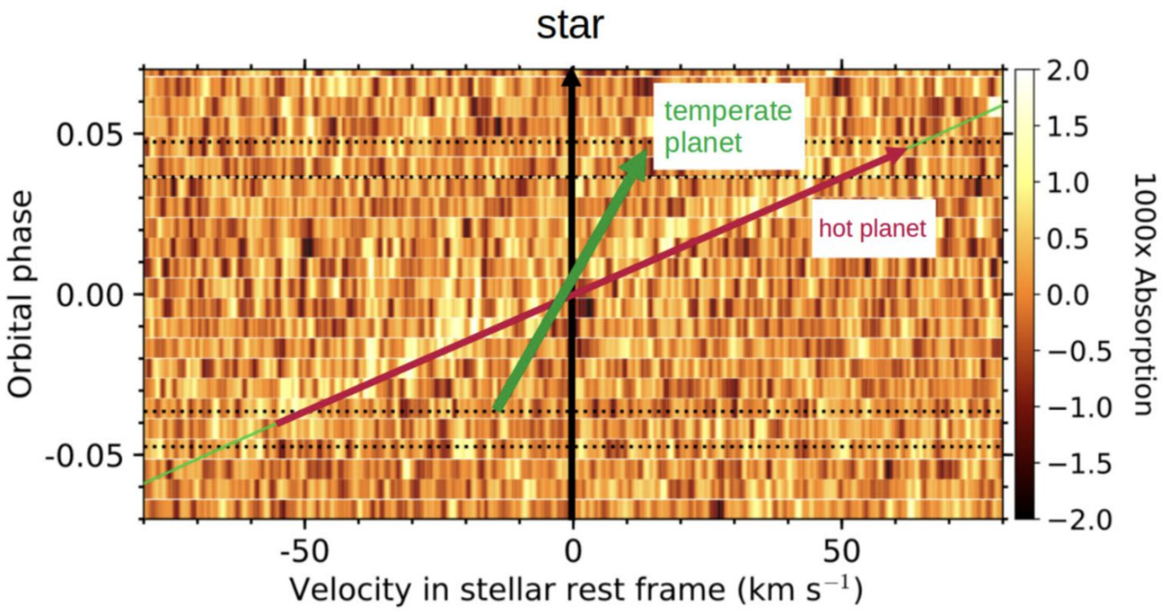
As italian component, we stress:

- Importance of R=100k (both for atmospheric detection and dynamics)
- Time prioritization for YJH IFU
- Time prioritization for K wrt U band (molecules)

We invite the Italian exoplanet community for any suggestion


ELT
H2O FOUND!
CH4 DETECTED!
CO2 ANALYZED!
LIFE? (CO2) - YES!
ATMOSPHERIC COMPOSITION OF EXOPLANET HD 189733b
ESOPLANET CHARACTERIZATION VIA ANDES SPECTROSCOPY
"THAT'S ALL, FOLKS!"
ELT & ANDES:
the age of rocky exoplanets characterization
ANDES

Backup slides

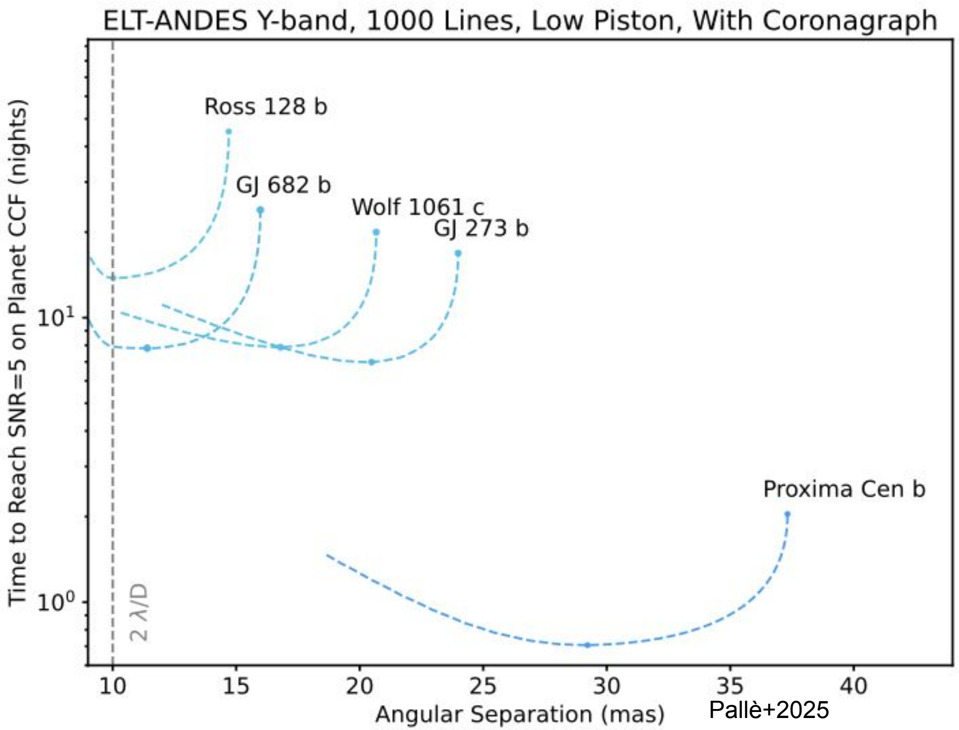


Backup slides

The "Golden sample"

Name	SpecTyp (T_{eff}) [K]	d [pc]	V [mag]	P [d]	$m \sin i$ [$m_\oplus$]	R_p [$R_\oplus$]	T_{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

Backup slides



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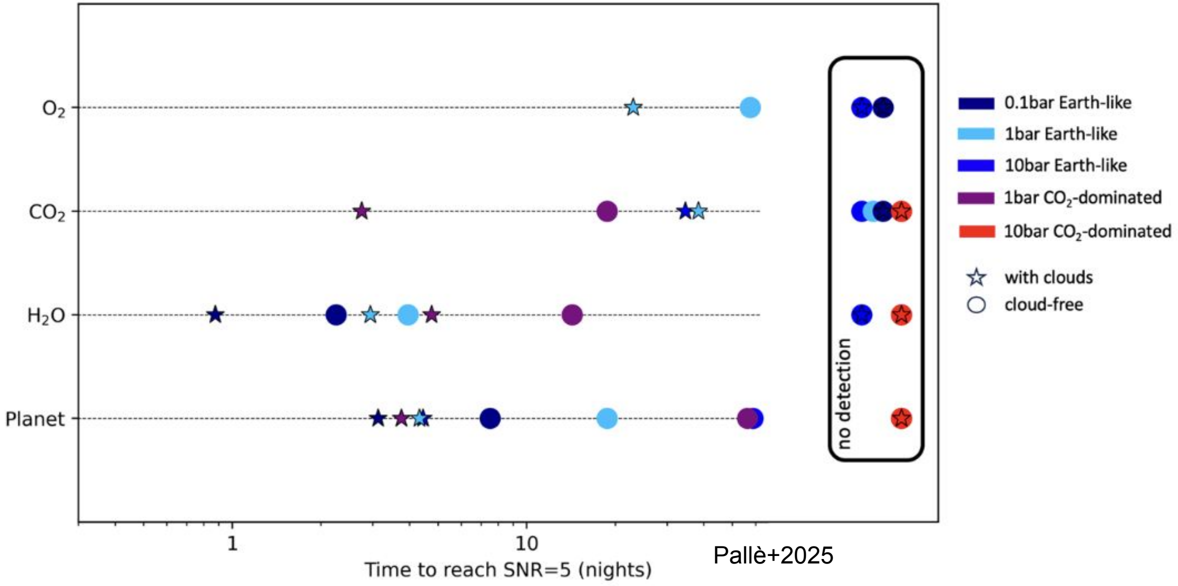
Backup slides

Even in a worst-case expected scenario, Proxima Cen b would be detected within 7 nights of observing time



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