

molecular oxygen



water



carbon dioxide



methane



ANDES



NICOLAUS COPERNICUS
UNIVERSITY
IN TORUŃ

Faculty of Physics, Astronomy
and Informatics

ELT ANDES

PTA, September 11-15, 2023

Andrzej Niedzielski





Extremely Large Telescope (ELT)

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

Basic parameters:

Diameter of the main mirror - 39 m (798 segments, 4608 edge sensors)

Field of view - 10 arc min

Altitude - 3046 m (Cerro Armazones)

Multiconjugate adaptive optics

Extremely Large Telescope (ELT) - 2023



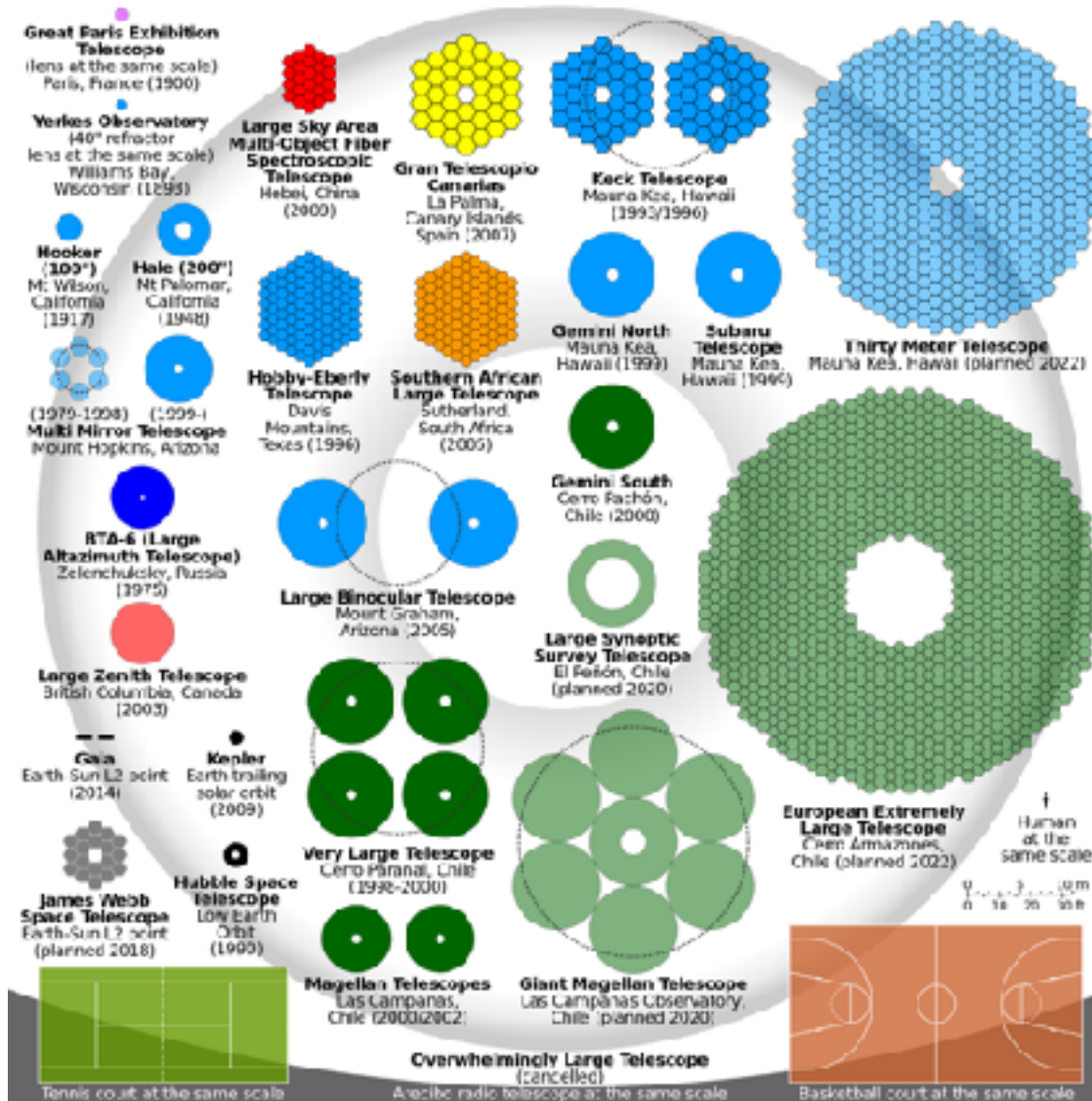


Extremely Large Telescope (ELT) - 2028 (planned)





Extremely Large Telescope (ELT) - 2028 (planned)





Extremely Large Telescope (ELT) instruments

First generation instruments

HARMONI - High Angular Resolution Monolithic Optical and Near-infrared Integral field spectrograph.

MICADO - Multi-AO Imaging Camera for Deep Observations.

MORFEO - Multiconjugate adaptive Optics Relay For ELT Observations.

METIS - Mid-infrared ELT Imager and Spectrograph.



Extremely Large Telescope (ELT) instruments

Second generation instruments

ANDES

ArmazoNes high Dispersion Echelle Spectrograph.

MOSAIC

Multi-Object Spectrograph.

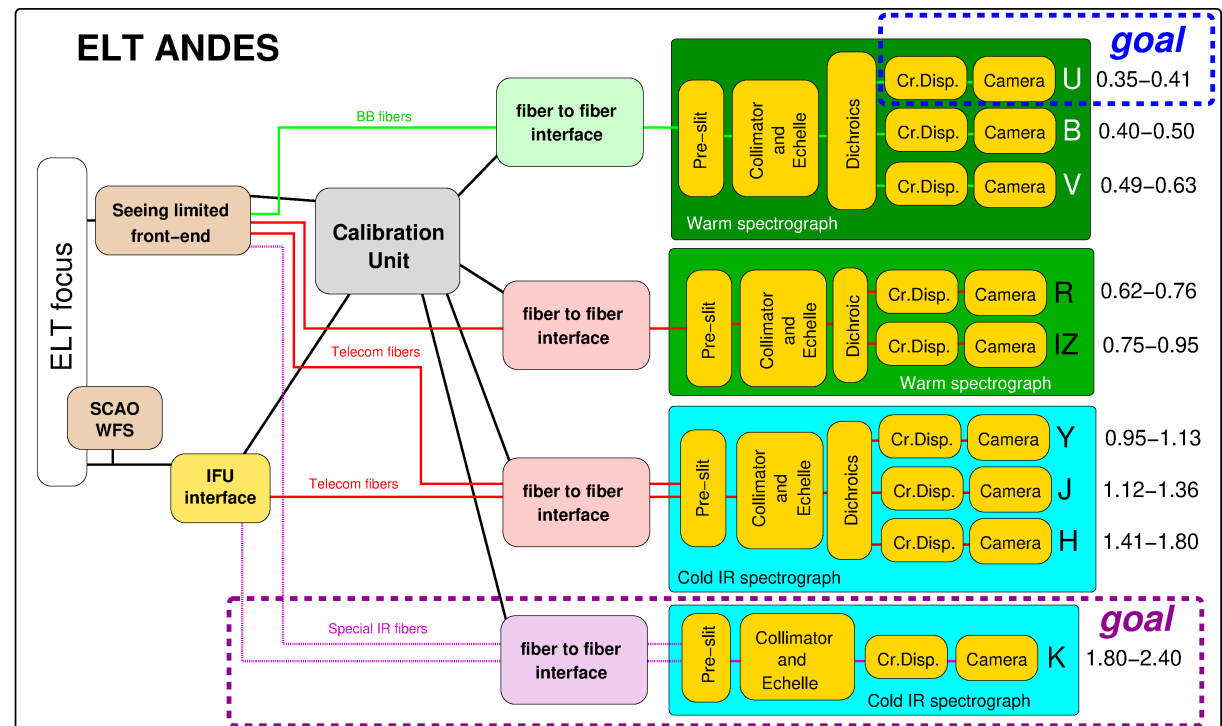


ANDES - motivation

The flagship science cases supporting the successful ELT construction proposal were the **detection of life signatures in Earth-like exoplanets** and the **direct detection of the cosmic expansion reacceleration**.

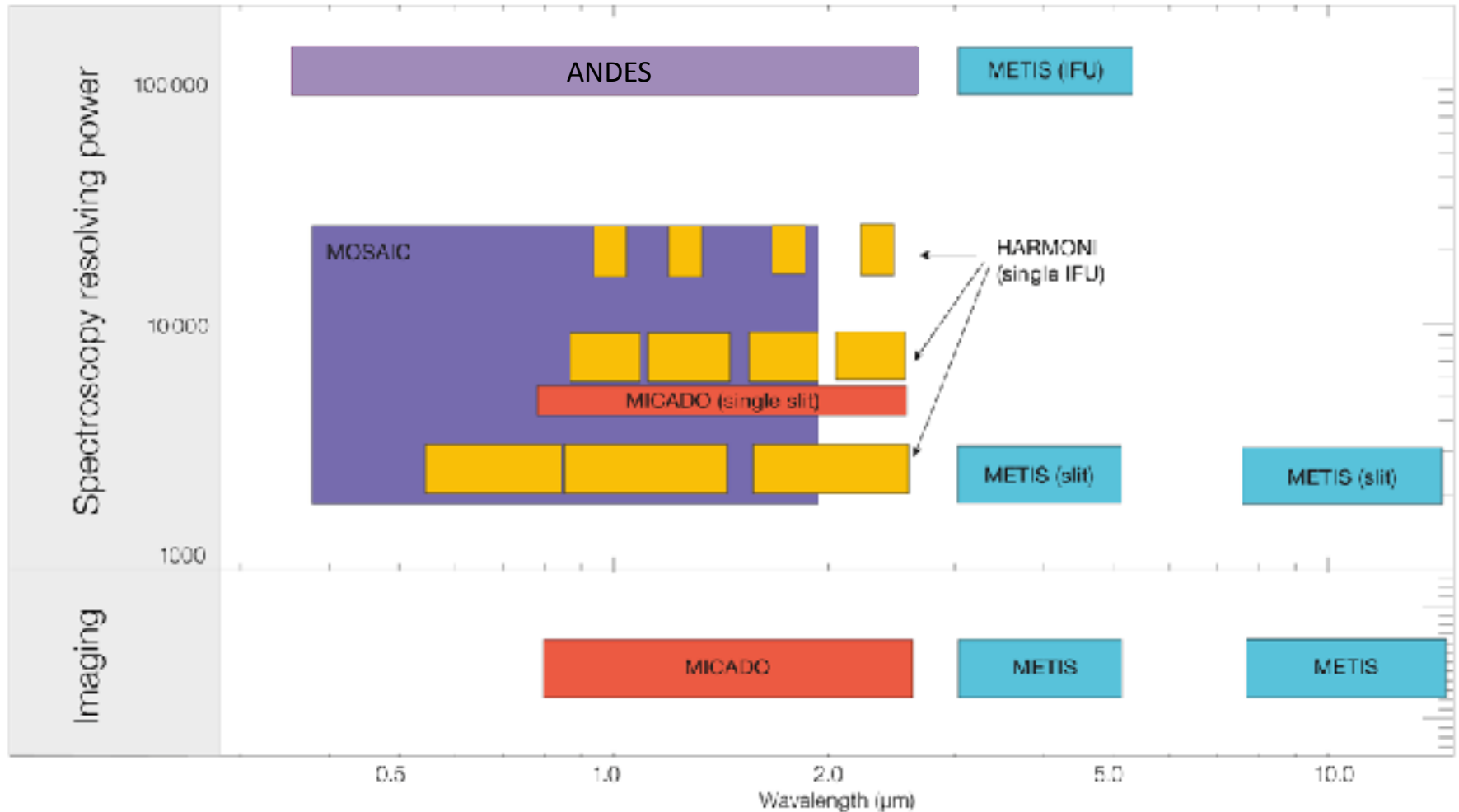
Both science cases require observations with a high-resolution spectrograph.

ANDES (ArmazoNes high Dispersion Echelle Spectrograph) consists of three fibre-fed spectrographs providing a spectral resolution of $\sim 100,000$ with a minimum simultaneous wavelength coverage of $0.4\text{--}1.8\ \mu\text{m}$ with the goal of extending it to $0.35\text{--}2.4\ \mu\text{m}$.





Extremely Large Telescope (ELT) instruments





ANDES - context

ESO commissioned two phase-A studies for high-resolution spectrographs, CODEX and SIMPLE, in the framework of “ESO instrumentation roadmap for ELT construction proposal” (successfully completed in 2010).

HIRES initiative: merging of CODEX and SIMPLE with a preparation of community white paper (2013).

ANDES - context

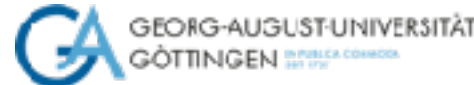
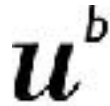
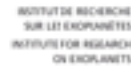
HIRES Phase A study: started 2016, successfully concluded beginning 2018.

ESO Council approves ANDES (HIRES) Construction (December 2021).

The Consortium has started phase B activities with internal Welcome (remotely on January 12-13, 2022) and Kick-off (Florence, April 27-29, 2022) Meetings and is awaiting the official kick off of Phase B with ESO.

The ANDES project is developed by an International Consortium composed by 35 Research Institutes of 14 Countries.

Brazil: Núcleo de Astronomia Observacional, Universidade Federal do Rio Grande do Norte (CI); Instituto Mauá de Tecnologia. **Canada:** Institut de Recherche sur les Exoplanètes and Observatoire du Mont-Mégantic, département de physique, Université de Montréal. **Chile:** Pontificia Universidad Católica de Chile (CI); Centre of Astro Engineering, Universidad de Chile; Department of Astronomy, Universidad de Concepcion; Center of Astronomical Instrumentation, Universidad de Antofagasta. **Denmark:** Niels Bohr Institute, University of Copenhagen (CI); Department of Physics and Astronomy, Aarhus University. **France:** Laboratoire d'Astrophysique de Marseille, CNRS, CNES, AMU (CI); Institut de Planétologie et d'Astrophysique de Grenoble, Université Grenoble Alpes; Laboratoire Lagrange, Observatoire de la Côte d'Azur; Observatoire de Haute Provence, CNRS, AMU, Institut Pythéas, Institut de Recherche en Astrophysique et Planetologie, Observatoire Midi-Pyrénées; Laboratoire Univers et Particules, Université de Montpellier. **Germany:** Leibniz-Institut für Astrophysik Potsdam (CI); Institut für Astrophysik, Universität Göttingen; Zentrum für Astronomie Heidelberg, Landessternwarte; Thüringer Landesternwarte Tautenburg; Hamburger Sternwarte, Universität Hamburg. **Italy:** INAF, Istituto Nazionale di Astrofisica (Lead Technical Institute). **Poland:** Faculty of Physics, Astronomy and Applied Informatics, Nicolaus Copernicus University in Torun. **Portugal:** Instituto de Astrofísica e Ciências do Espaço (IA) at Centro de Investigação em Astronomia/Astrofísica da Universidade do Porto (CI), Instituto de Astrofísica e Ciências do Espaço at Faculdade de Ciências da Universidade de Lisboa. **Spain:** Instituto de Astrofísica de Canarias (CI); Instituto de Astrofísica de Andalucía-CSIC; Centro de Astrobiología **Sweden:** Dept. of Physics and Astronomy, Uppsala University. **Switzerland:** Département d'Astronomie, Observatoire de Sauverny, Université de Genève (CI); Universität Bern, Physikalische Institut. **United Kingdom:** Science and Technology Facilities Council (CI); Cavendish Laboratory & Institute of Astronomy, University of Cambridge; UK Astronomy Technology Centre; Institute of Photonics and Quantum Sciences, Heriot-Watt University. **USA:** Department of Astronomy, University of Michigan.





ANDES - management

Principal Investigator

[Alessandro Marconi](#) (University of Florence, Italy)

Project Scientist

[Roberto Maiolino](#) (University of Cambridge, UK)

Project Manager

[Paolo Di Marcantonio](#) (INAF Trieste, Italy)

ESO Project Engineer

[Oliver Pfuhl](#)

ESO Project Scientist

[Celine Peroux](#)

ESO Project Manager

[Frédéric Derie](#)



ANDES - science goals

Exoplanets and protoplanetary disks

The study of exoplanet atmospheres for a wide range of planetary objects, from gas giants to rocky planets, and from hot to temperate planets.

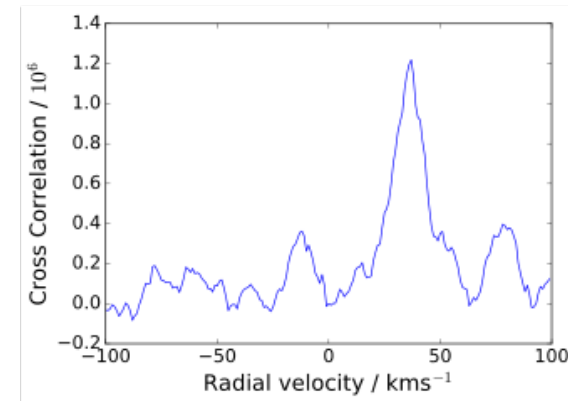
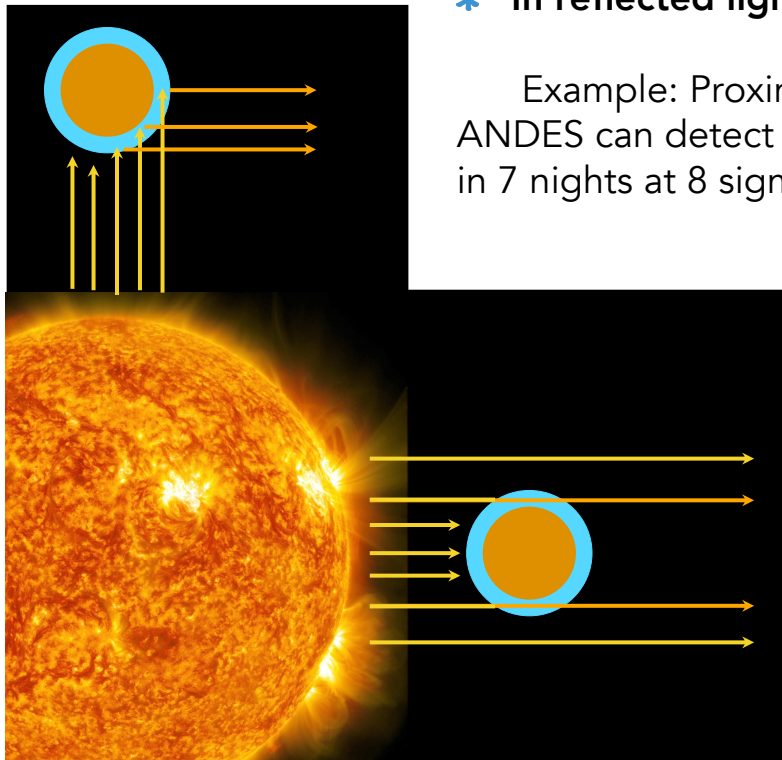
PL: A. Niedzielski (UMK, EB, SC)

EXOPLANET ATMOSPHERES

Use high-resolution spectroscopy to disentangle the planetary and stellar spectra by comparing the combined spectrum to a star-only reference spectrum aided by the radial velocity offset (e.g. Snellen+15)

* In reflected light

Example: Proxima b
ANDES can detect planet
in 7 nights at 8 sigma level



CCF with the
detection of
Proxima b in O₂
in 70h (Hawker &
Parry 19)

* In transmitted light

Example: Trappist 1 & 2 ANDES can detect:

- H₂O (1.3-1.7 μm) in 2 transits
- H₂O (0.9-1.1 μm) in 4 transits
- CO₂ in 4 transits
- O₂ in 25 transits



ANDES - science goals

Stars and Stellar Populations

The vast light-collecting power of the ELT will enable detailed high-resolution spectroscopy of individual stars, and in particular very faint red dwarfs and distant red giants in nearby galaxies

PL. E. Niemczura (UWr)



ANDES - science goals

Galaxy Formation and evolution and the intergalactic medium

The detection of the first generation of stars and the observational characterisation of their properties is one of the main objectives of extragalactic astrophysics.

PL: A. Pollo (UJ, NCBJ)



ANDES - science goals

Cosmology and Fundamental Physics

ANDES will allow to search for, identify and ultimately characterise any new physics through several different but fundamentally interrelated observations which will enable a unique set of tests of the current cosmological paradigm.

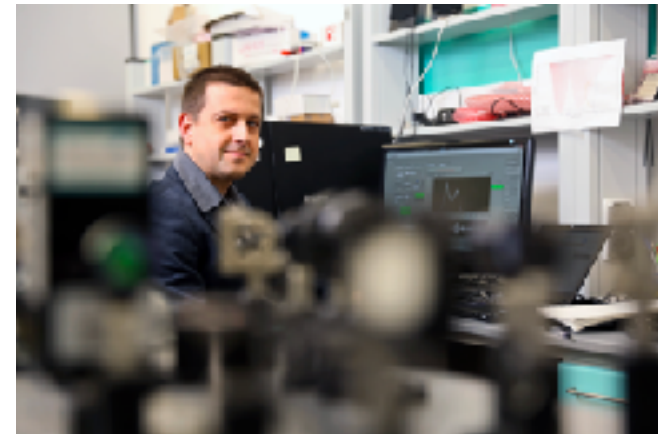
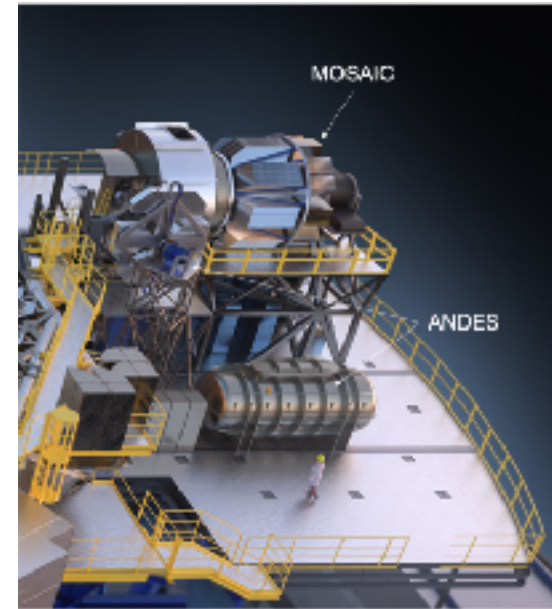


ANDES - Polish contribution

Calibration Unit

The purpose of the CU is to provide light for calibration of ANDES.

PL: P. Maślowski (UMK, PM) - internal reference system.



ANDES - Polish contribution

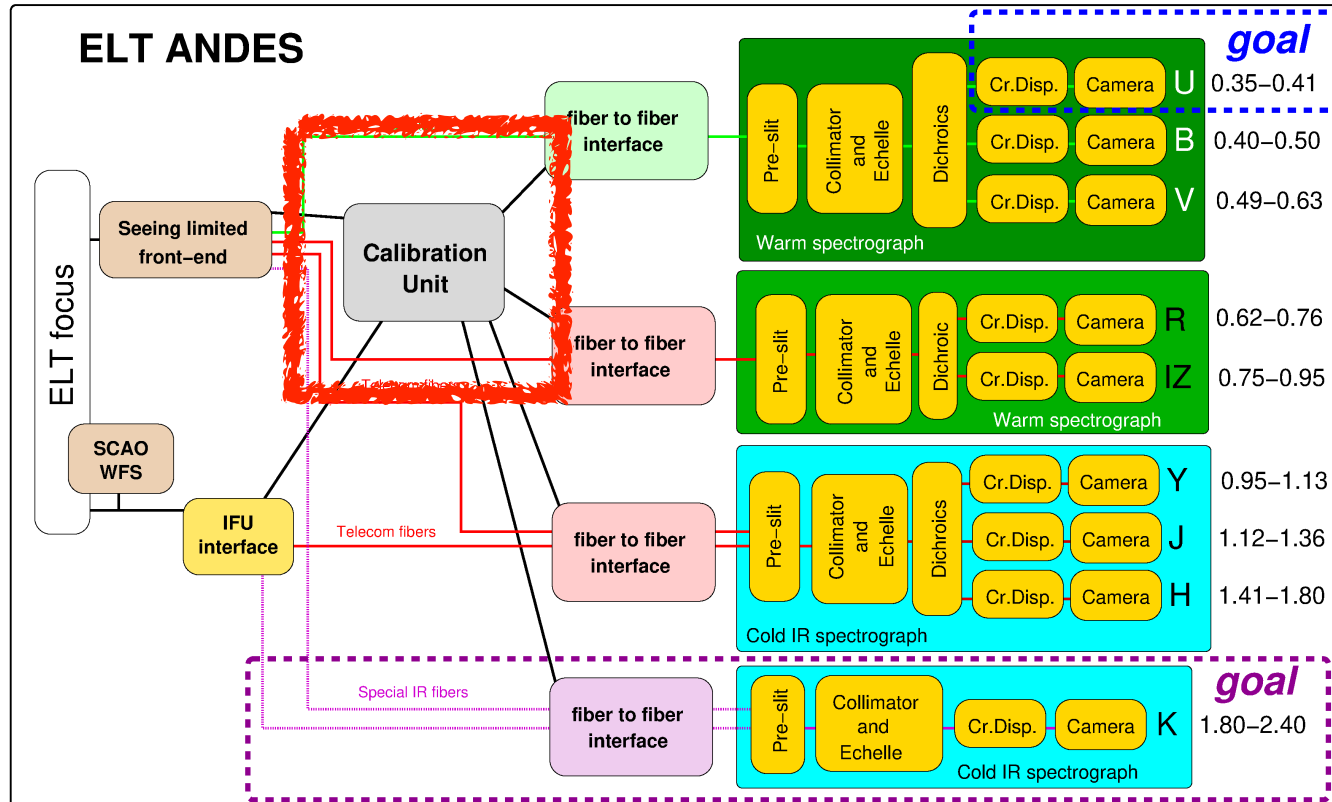


Figure 2. ANDES architectural design, outlining the instrument subsystems: Front End (seeing-limited and AO assisted with SCAO unit), Fibre Link, Calibration Unit, VIS-Blue, VIS-Red, NIR and NIR-Red (cold spectrographs).

ANDES - estimated cost and commissioning

The total cost of the instrument has been estimated to be around 35 millions of Euros (45 including NIR-RED), with over 650 FTEs required for the duration of the project.

Considering a completion of Phase B in 2024, the instrument should start commissioning at the telescope in 2030/2031.

References:

Marconi, A. et al. 2022, *ANDES, the high resolution spectrograph for the ELT: science case, baseline design and path to construction*, Proceedings of the SPIE, Volume 12184, id. 1218424 16 pp.

Marconi A. et al. 2020, *HIRES, the High-resolution Spectrograph for the ELT*, The Messenger, vol. 182, p. 27-32

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