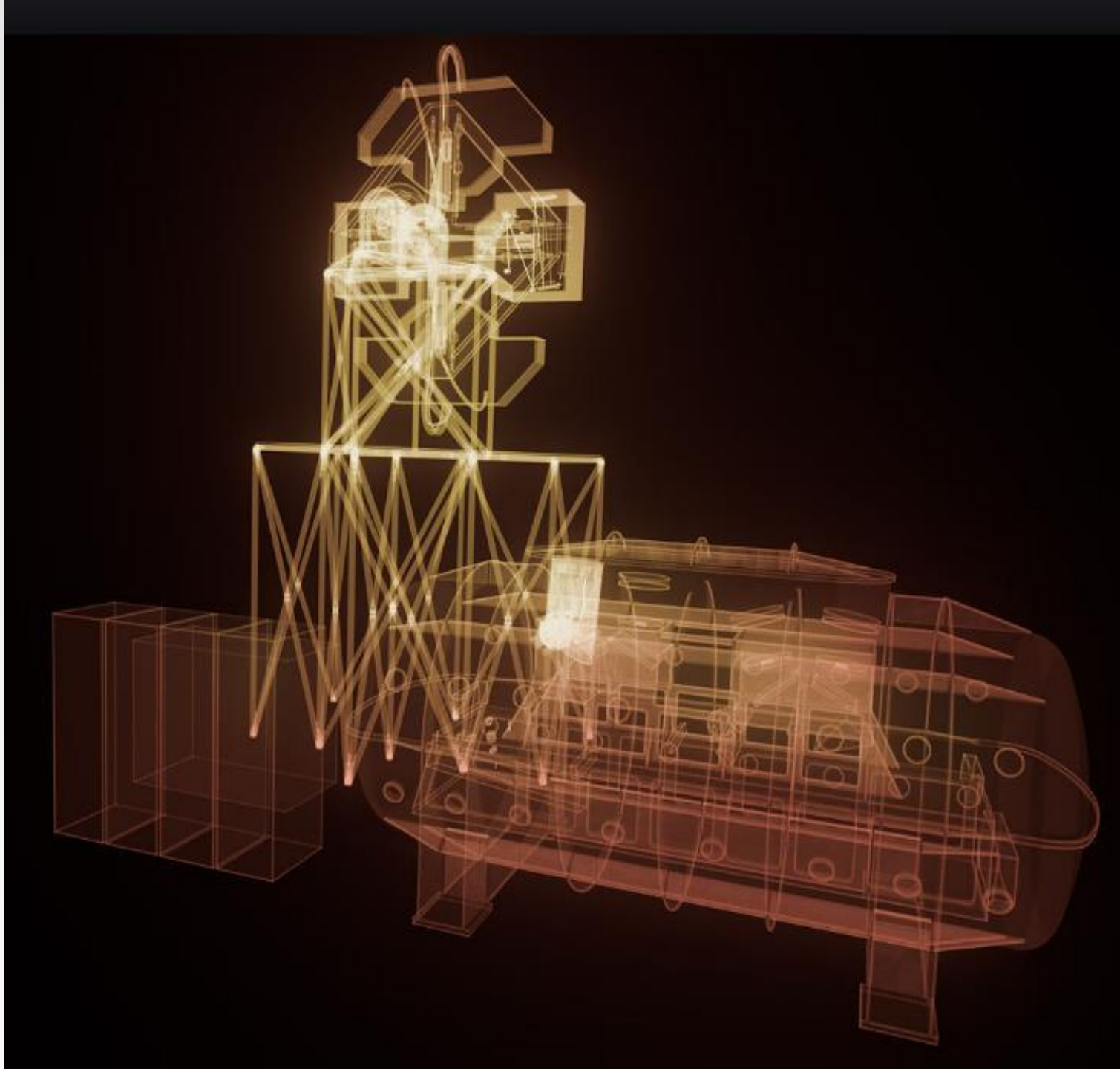
ANDES

ArmazoNes high Dispersion Echelle Spectrograph

Wolfgang Brandner & WolfganG Gaessler



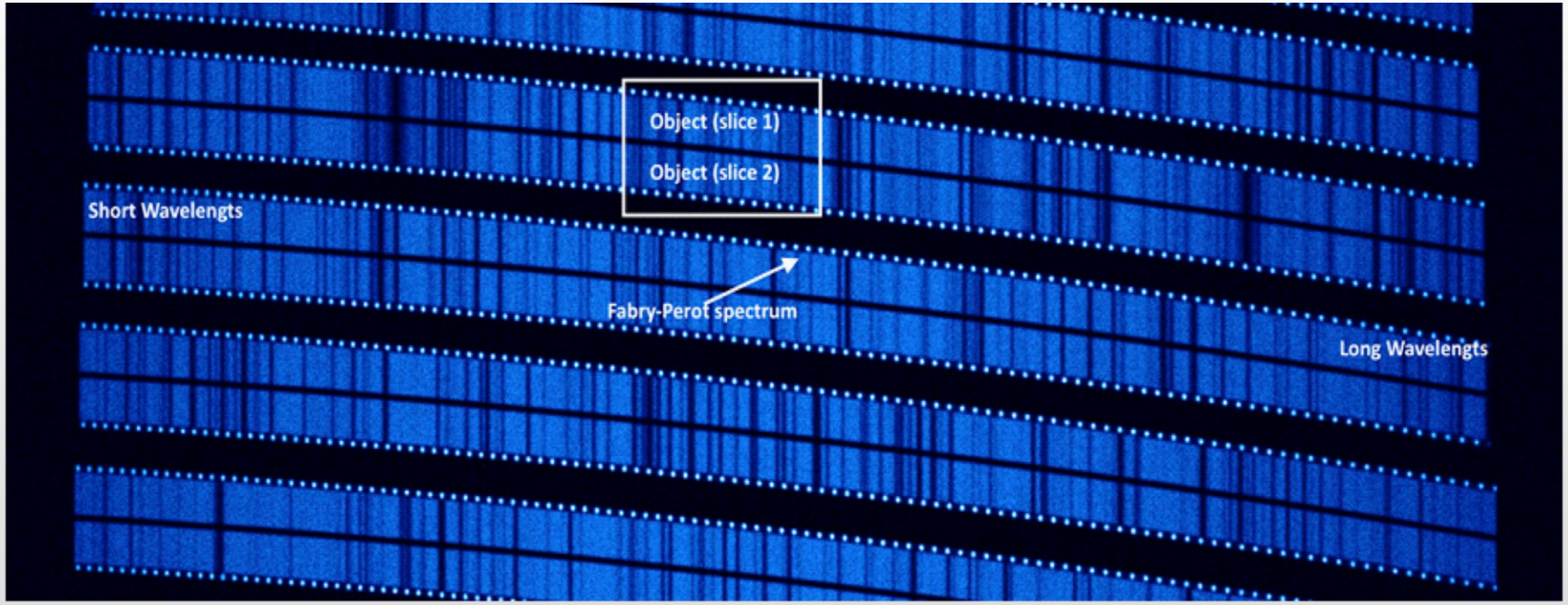
Outline

- What is ANDES ?
- What will ANDES be used for ?
- What is our interest in ANDES ?
- How will ANDES look like ?
- What is our part in ANDES ?
- Who else is involved in ANDES ?
- When will ANDES be bulit ?
- Who is in charge at MPIA ?

What is ANDES ?

High resolution spectrograph

- Spectral resolution:
  R = ƛ/Δƛ>100000
- Wavelength range:
  0. 35 – 0.4μm goal
  0.4 – 1.8μm baseline
  1.8 – 2.4μm goal
- Fiber fed, cross dispersed



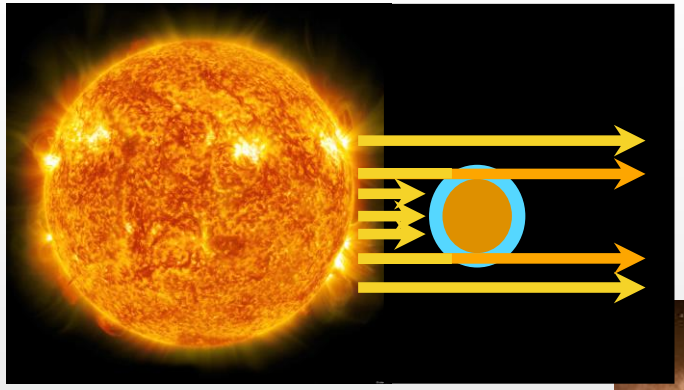
- Several interchangeable observing modes from seeing limited to diffraction limited with single fiber + integral field unit (SCAO + IFU)

Which science case will be addressed by ANDES?

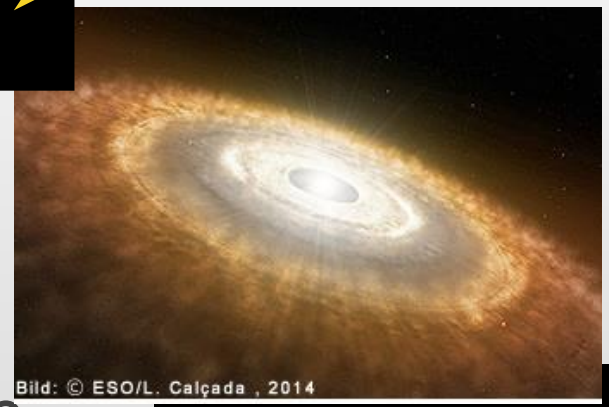
Large overlap with scientific interest at MPIA!

MPIA/APEx key science interests in ANDES

- Transmission spectroscopy of exoplanets
  - Absorption of molecules
    - Signatures of earth-like planets
    - Is there life on other planets?



  - Tracing planet formation with CO and CO isotopes in the K-band
    - Where and how do planets form?



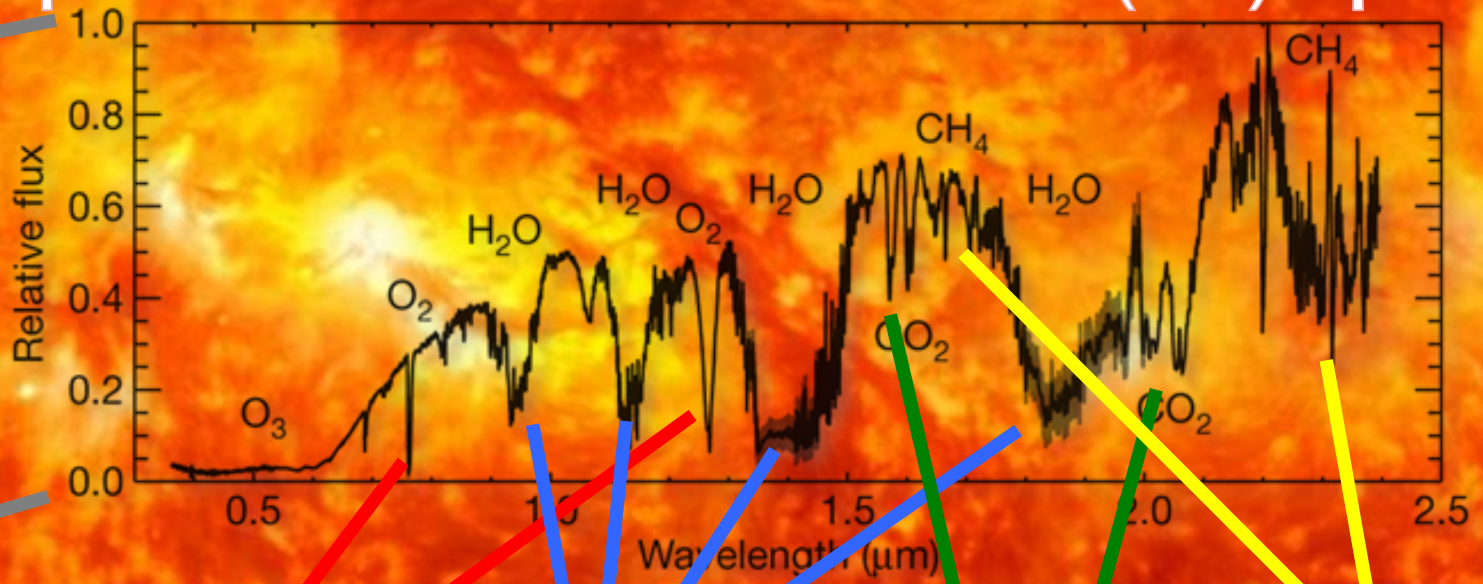
- Reflect light + self-luminous planets
  - Understand the dynamics of exoplanet atmospheres with CH_4 and CO
    - How does the planet spin, and how is the spin (mis-) aligned with the planetary orbit and the stellar spin?
    - What weather patterns are present? Are there seasonal changes?

...

Exo-Earths: search for molecules present in Earth‘s atmosphere

⇔H20 as a pre-requisite of life

⇔O2/O3 and CH4 as potential biomarkers -> chemical (dis-) equilibrium



molecular oxygen

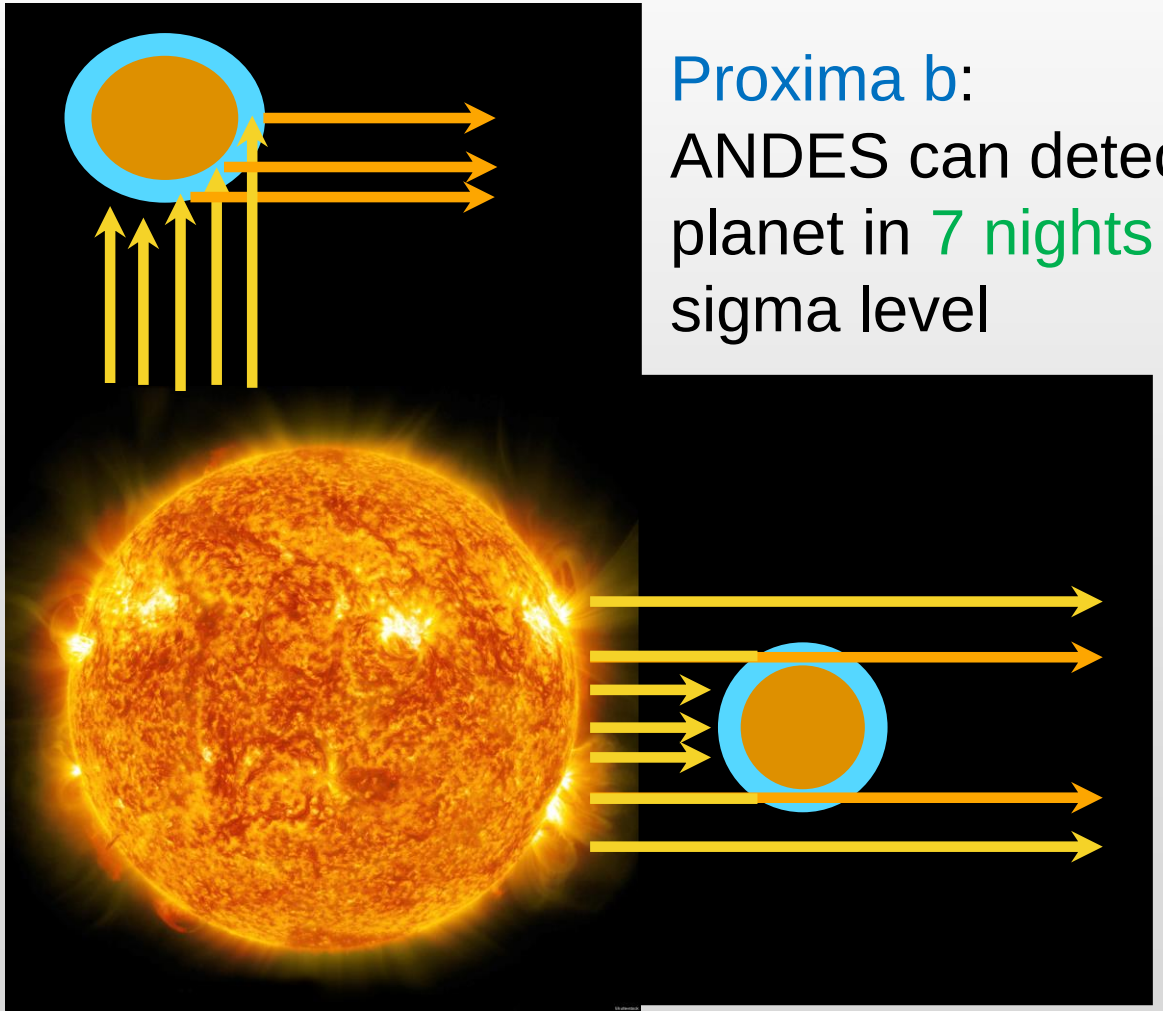
water

Carbon dioxide

methane

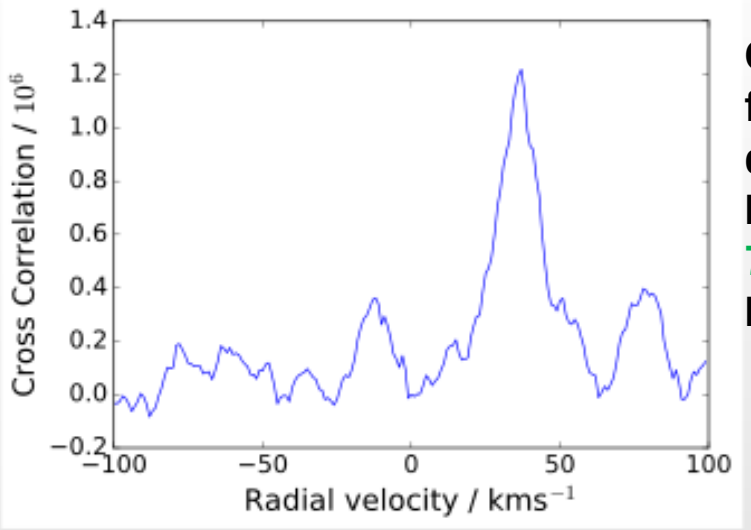
Exoplanet Atmospheres

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**

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



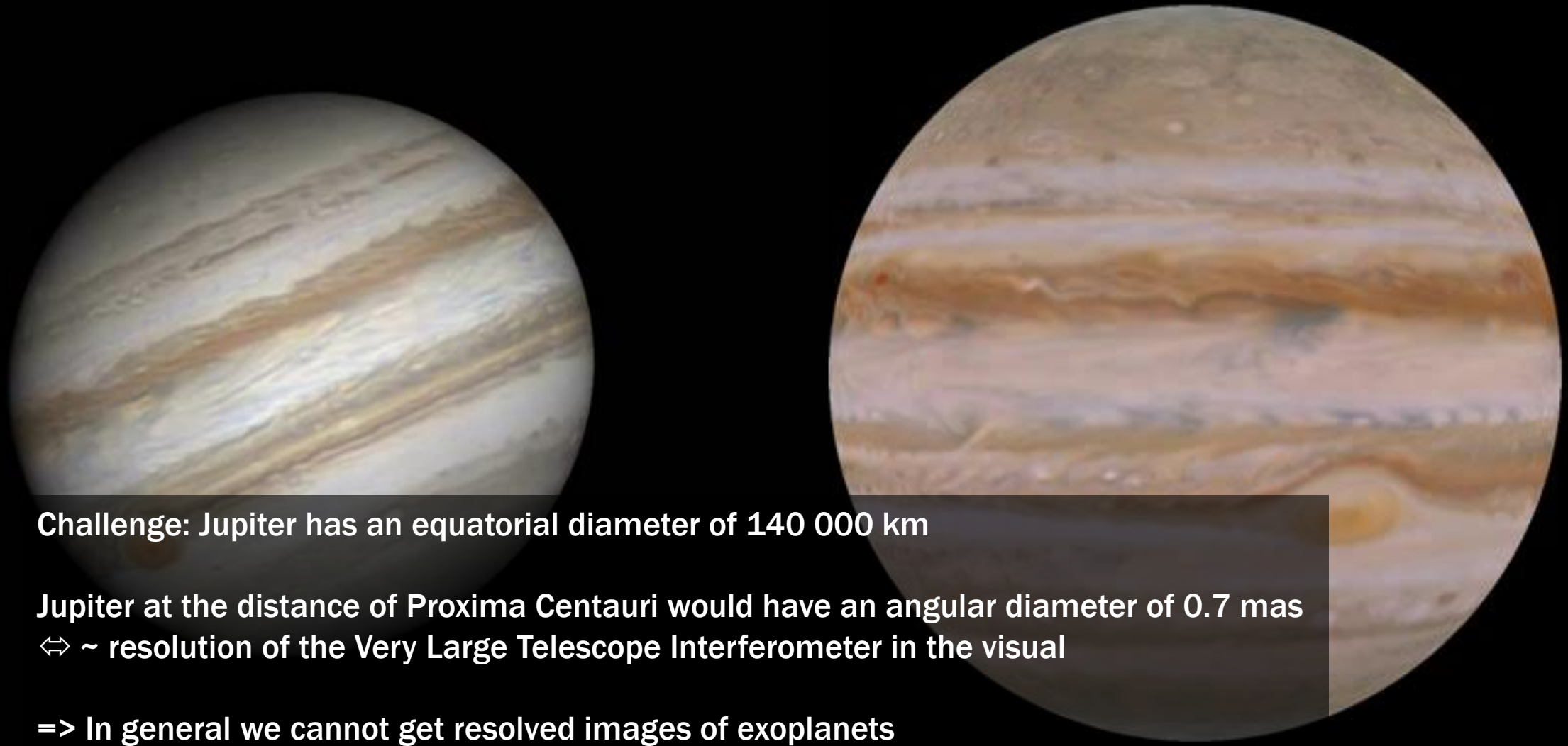
Cross-correlation function with the detection of Proxima b in O_2 in 70h (Hawker & Parry 19)

- **In transmitted light**

Trappist 1b & 1c: ANDES can detect:

- **H_20 (1.3-1.7 μm) in 2 transits**
- **H_20 (0.9-1.1 μm) in 4 transits**
- **CO_2 in 4 transits**
- **O_2 in 25 transits**

Weather and dynamics in gaseous exoplanets



Challenge: Jupiter has an equatorial diameter of 140 000 km

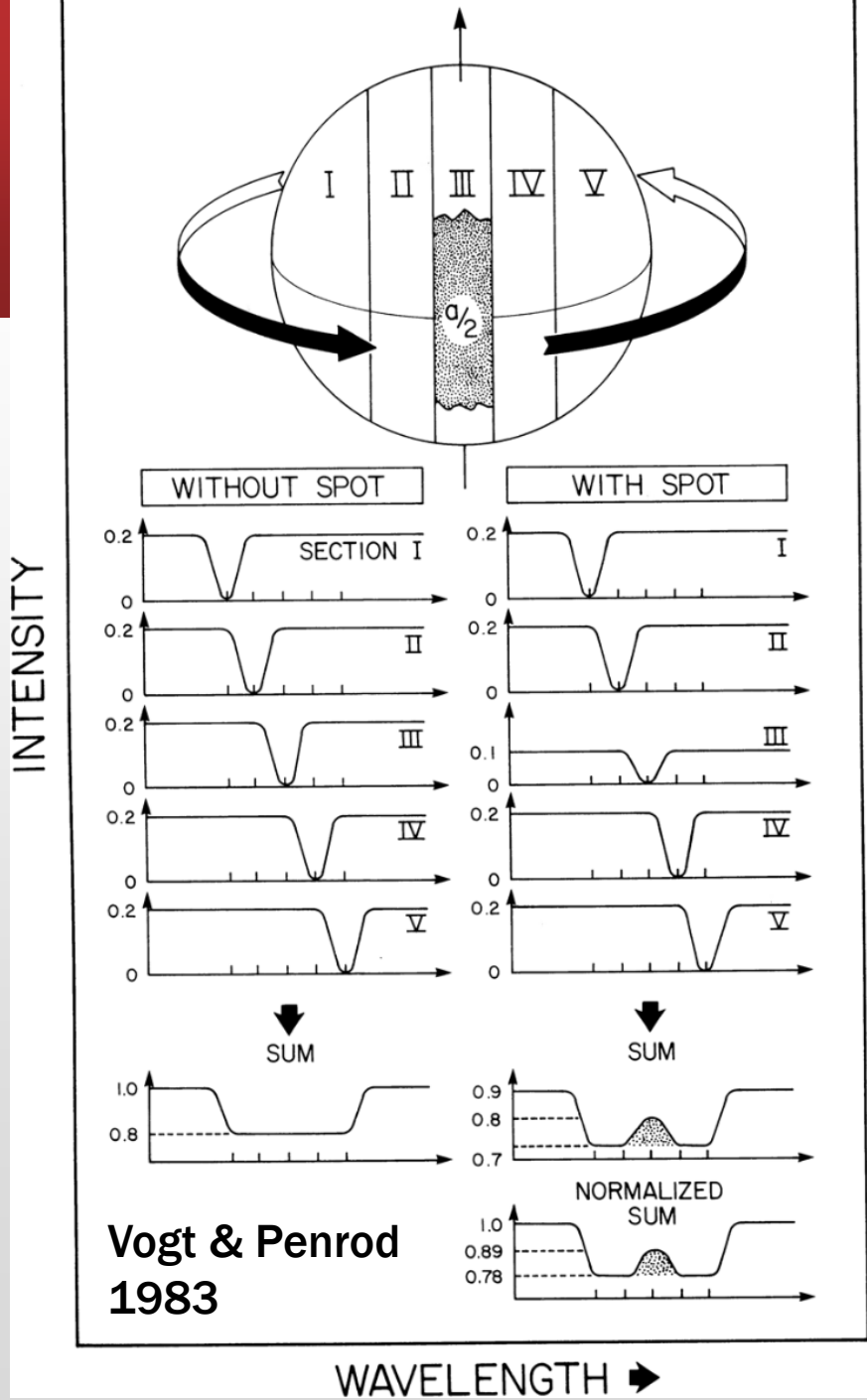
Jupiter at the distance of Proxima Centauri would have an angular diameter of 0.7 mas
⇔ ~ resolution of the Very Large Telescope Interferometer in the visual

=> In general we cannot get resolved images of exoplanets

Doppler imaging to deduce cloud maps

Crossfield et al. 2014

P = 5 hr, D=140 000 km => v_rot = 24 km/s
=> ANDES will obtain 2D cloud maps of gaseous exoplanets for comparison with 3D global circulation models



Vogt & Penrod 1983

Cosmology and fundamental constants

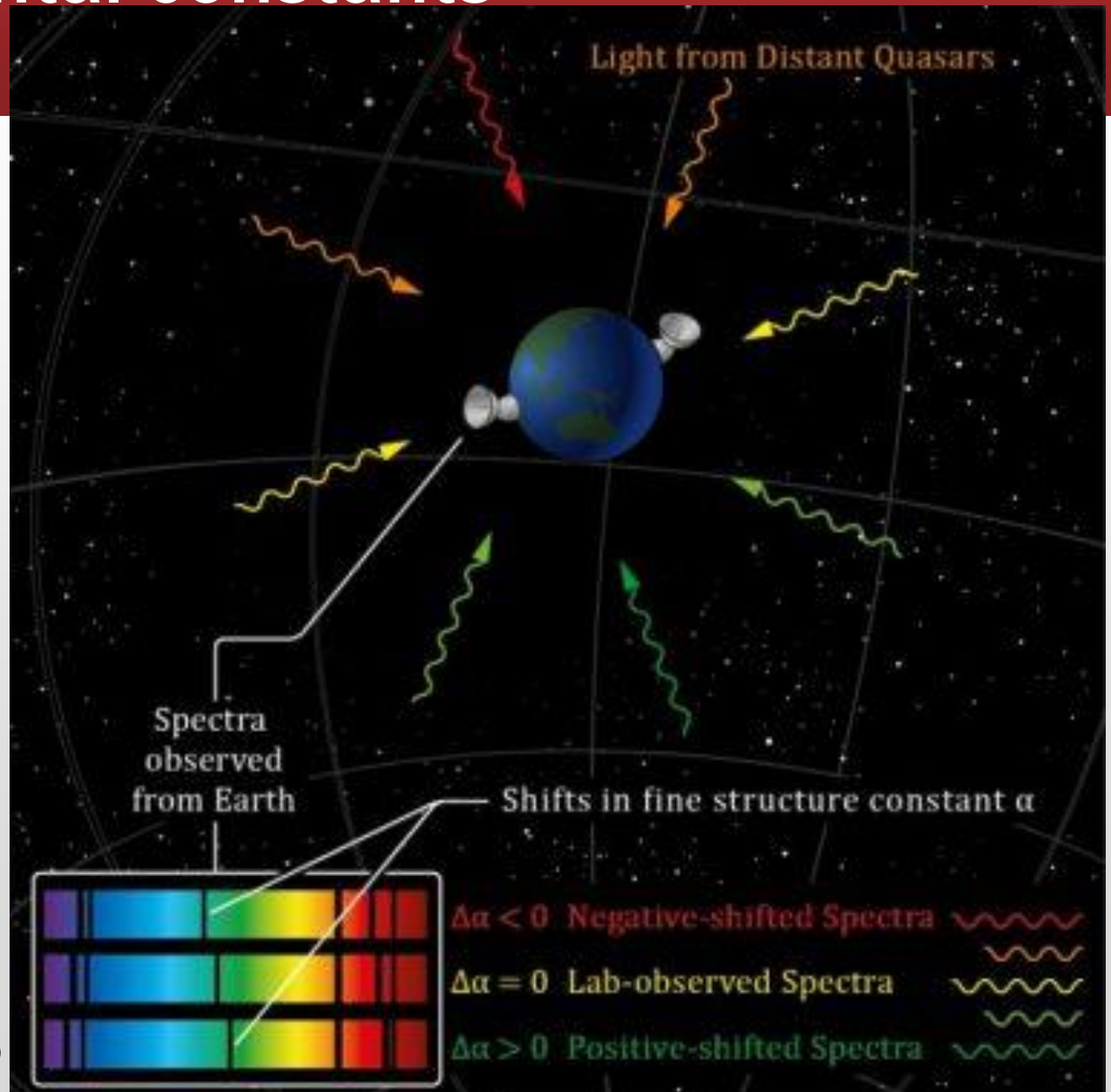
Compared to Bohr's 1913 model, atomic transitions (spectral lines) did show a shift in energy proportional to the square of the fine structure constant

Fine structure "constant" $\alpha \sim \frac{e^2}{h * c}$

(e: elementary charge, h: Planck constant, c: speed of light)

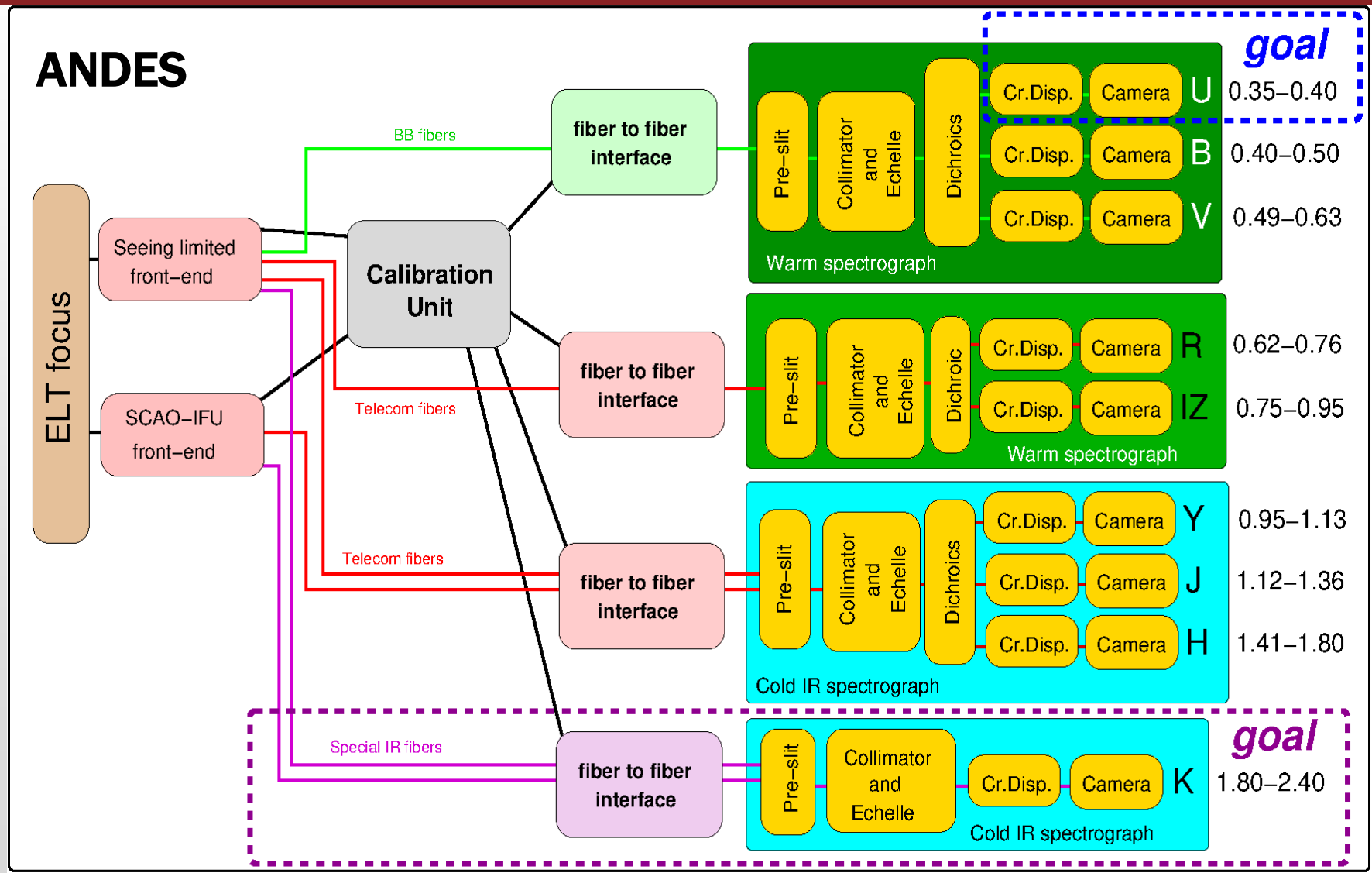
α combines electro-magnetism with quantum theory and relativity (Sommerfeld 1915) ⇔ is it constant over cosmological time?

Goal: measure $\Delta\alpha/\alpha < 10^{-6}$ (current local CODATA uncertainty is $1.5 * 10^{-10}$)



How will ANDES look like ?

- **Frontend**
  - to select different observation modes
- **Fiber Link**
  - to feed the spectrograph with light and scramble the light
- **High Resolution Spectrographs**
  - 4 times, each with other wavelength range
- **Calibration Unit**
  - with astrocomb for relative wavelength calibration, cathode lamps for wavelength referencing and halogen lamp for flat fielding



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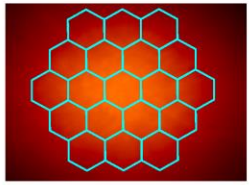
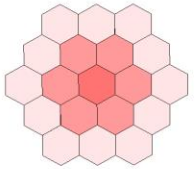
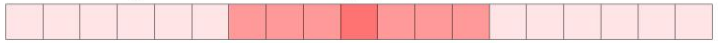
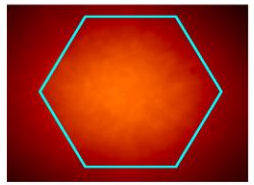
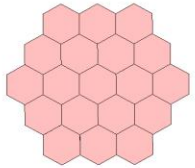
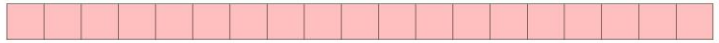
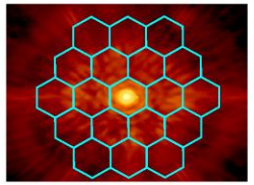
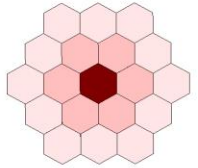
	Front–end	Fiber–to–fiber interface	Spectrometer
High throughput seeing limited observing mode	PSF on microlenses array and fibers bundle 	Light distribution on fibers bundle after fiber to fiber couplers 	Light distribution along spectrometer slit 
High accuracy seeing limited observing mode	PSF on single large fiber 	Light distribution on fibers bundle after scrambler and slicer 	Uniform light distribution along spectrometer slit 
IFU AO corrected observing mode	PSF on microlenses array and fibers bundle 	Light distribution on fibers bundle after fiber to fiber couplers 	Light distribution along spectrometer slit 

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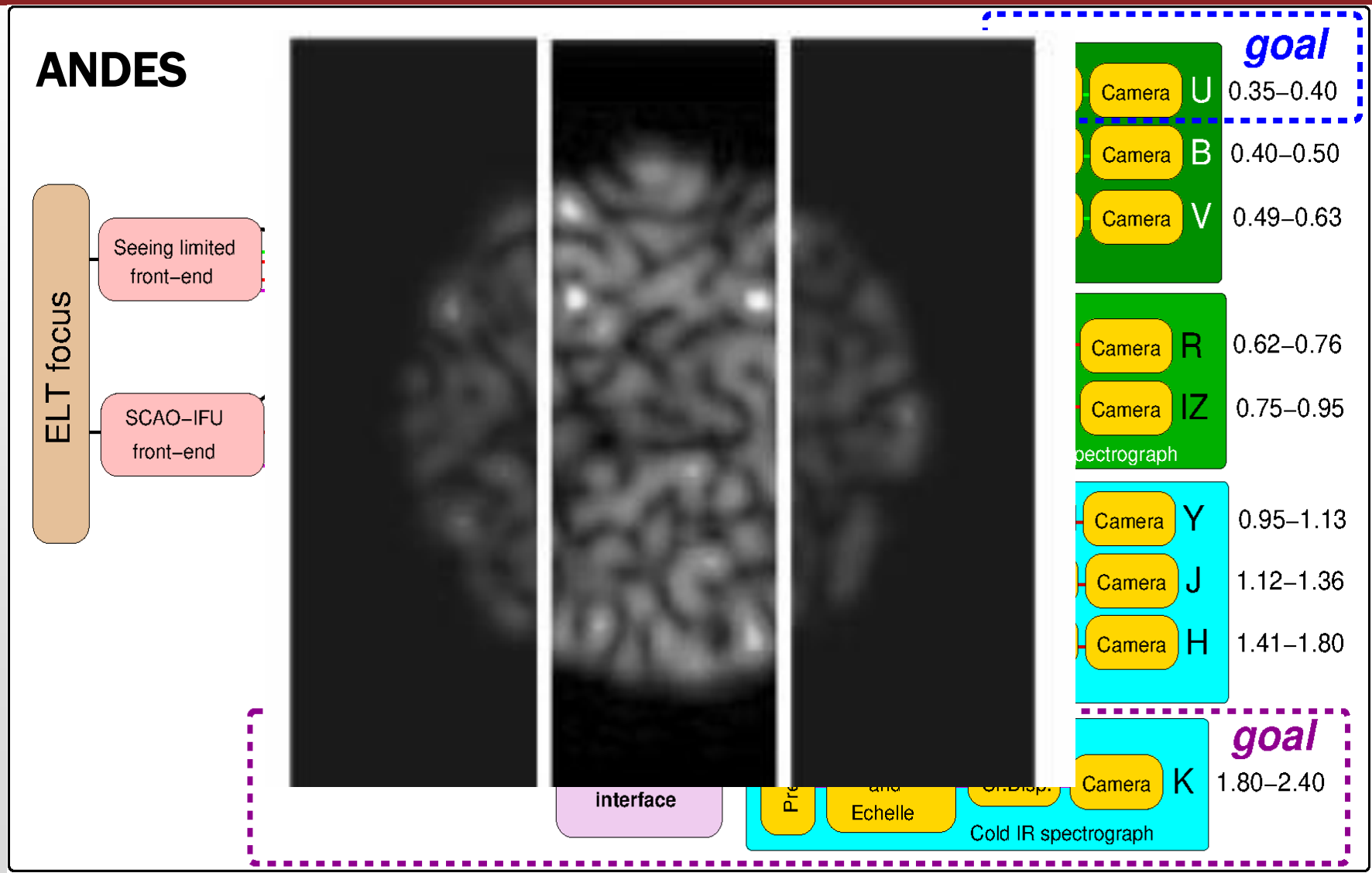

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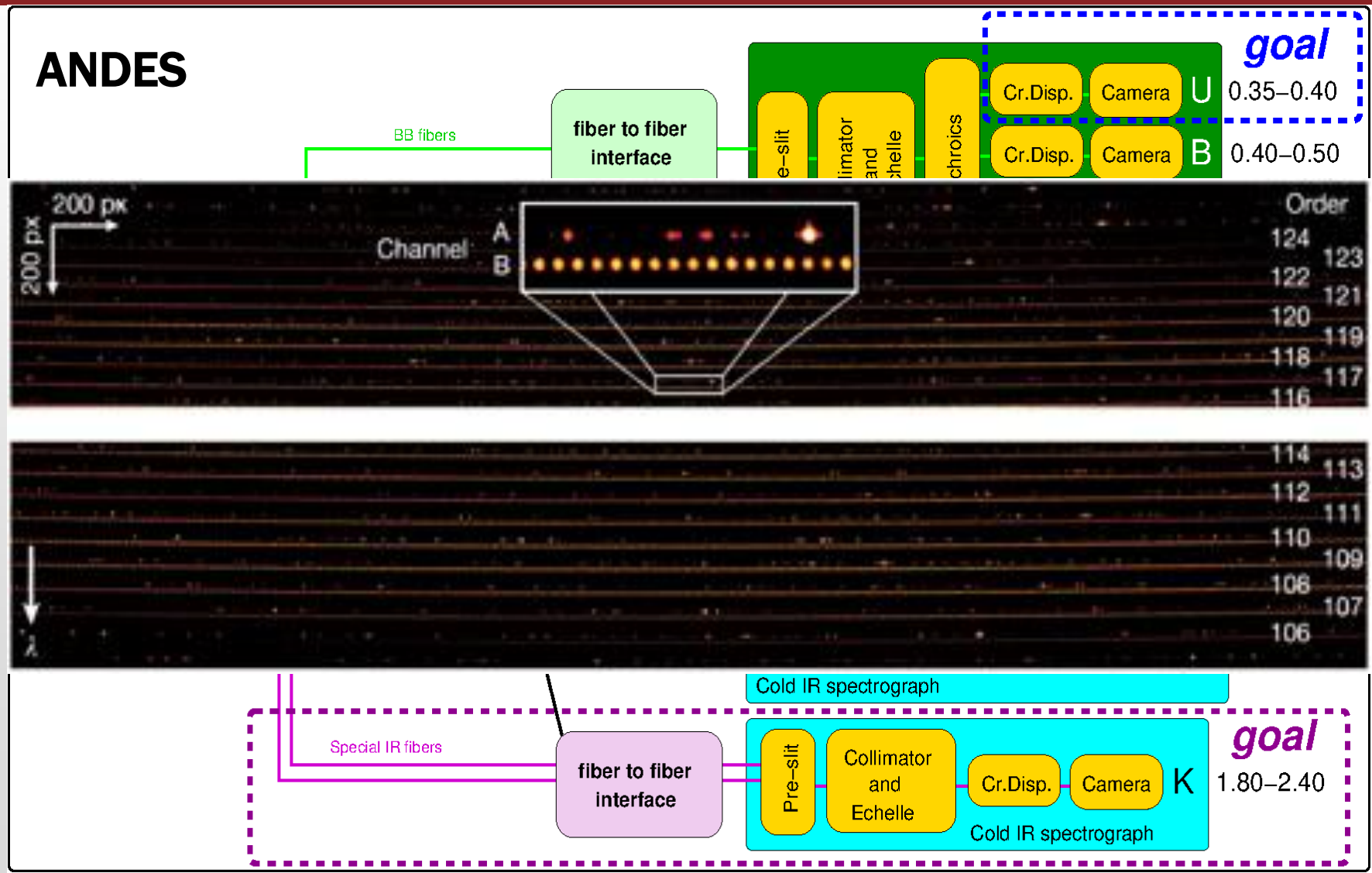
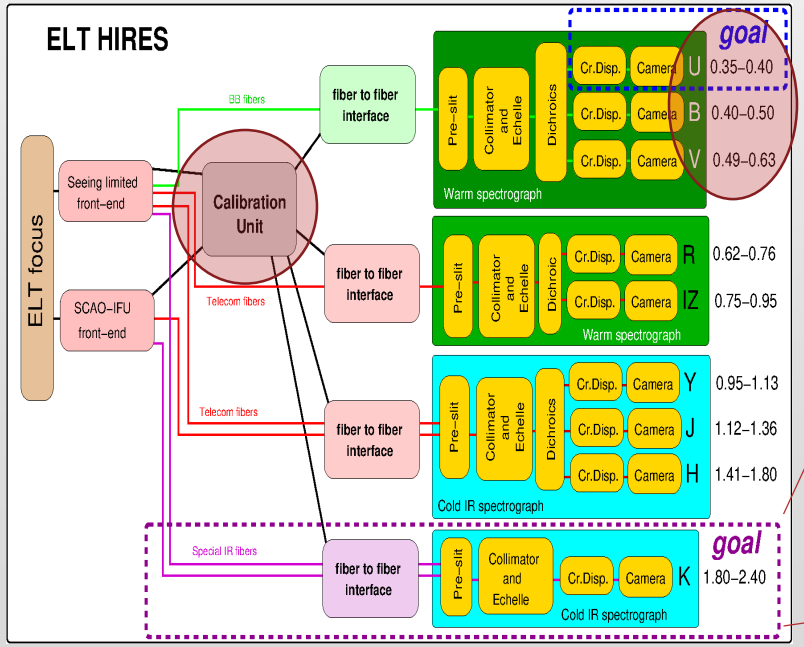
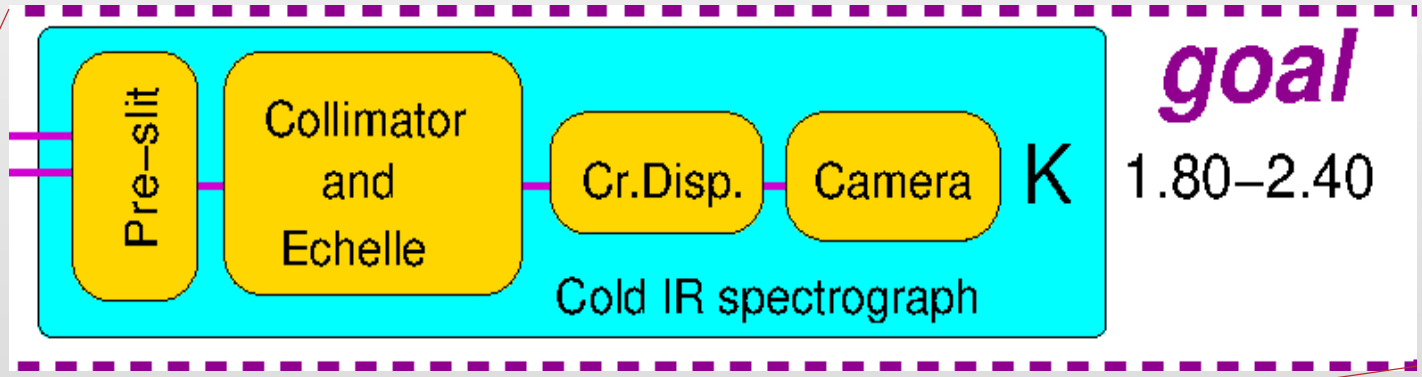


What is our part in ANDES ?

- Lead of and **enhanced K-band spectrograph study** during Phase B

  + **electronics** in some work packages (still in negotiation which one)

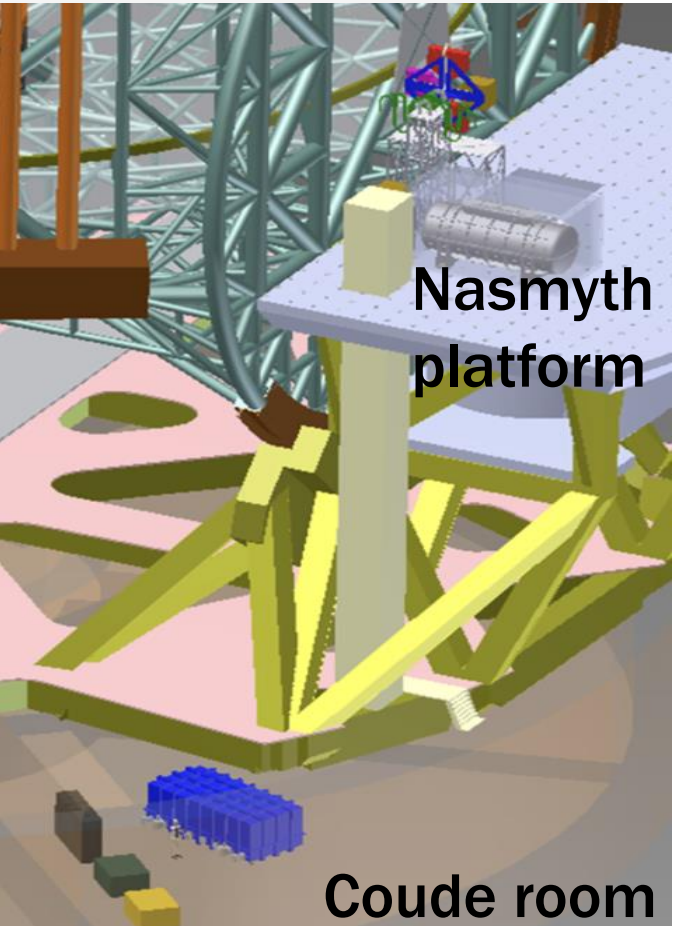


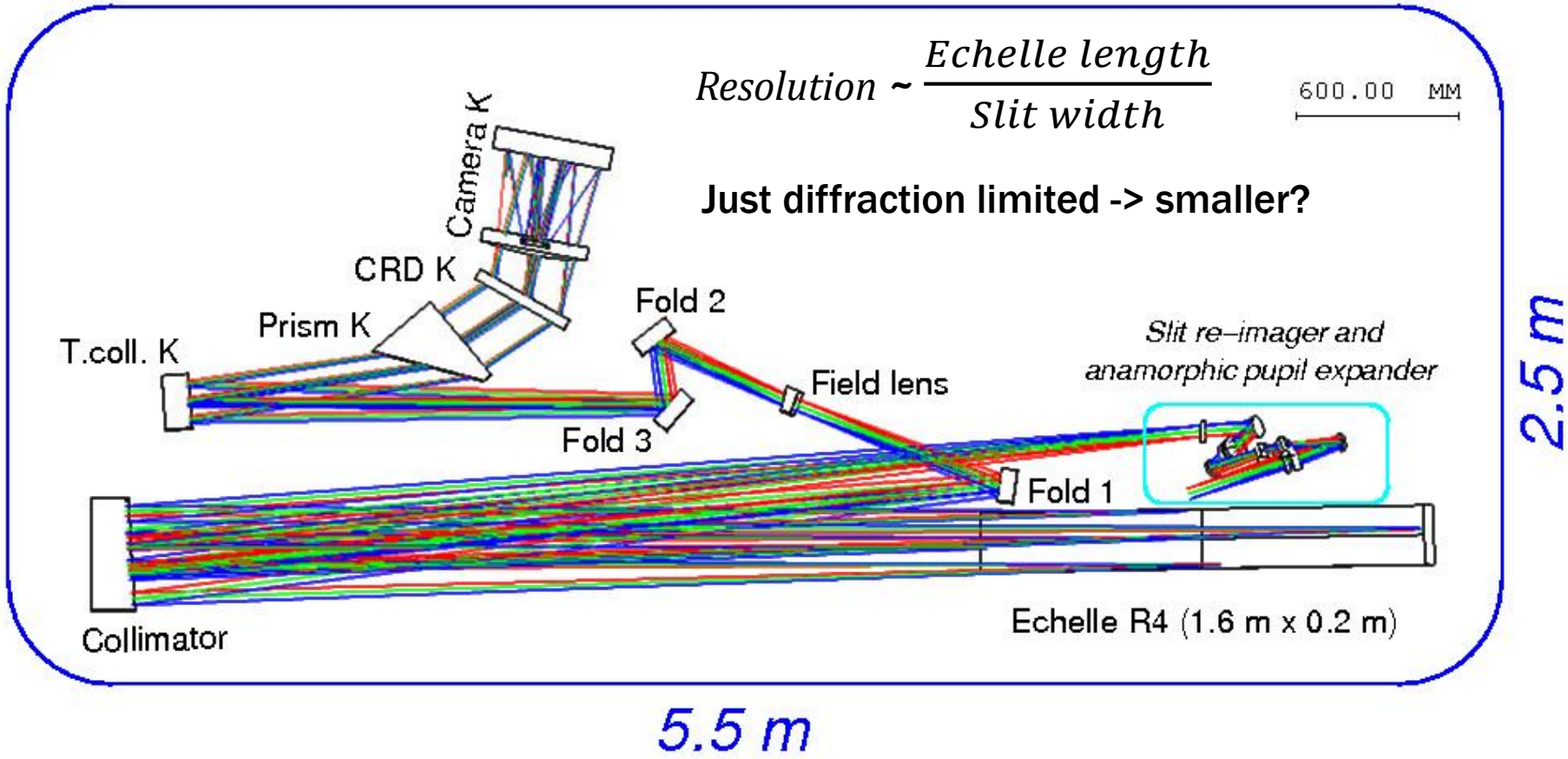


What is our part in ANDES ?

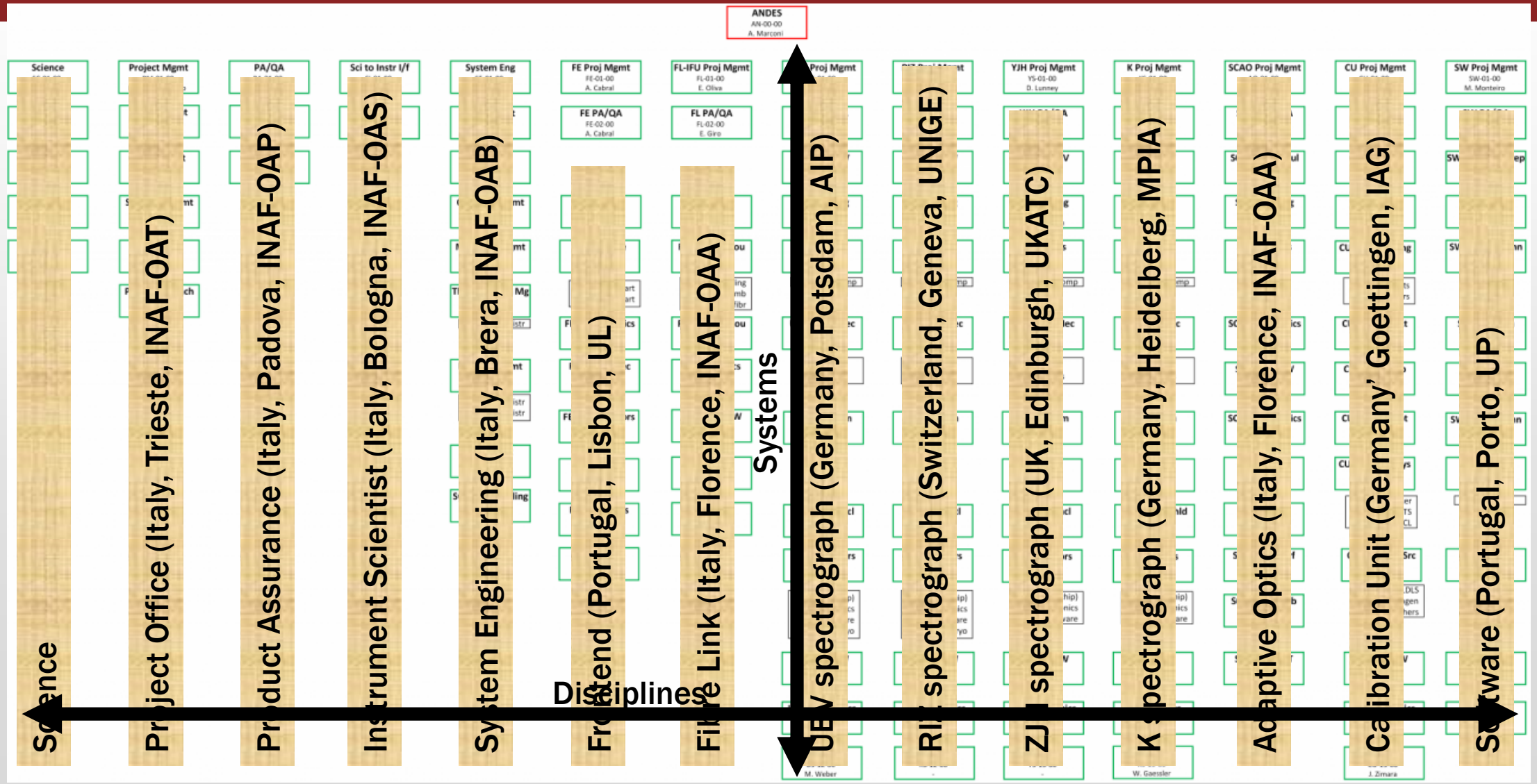
Phase A design: Same as ESPRESSO just one camera and detector instead of two.

Fiber loss 11% Nasmyth vs 79% Coude





Who else in involved in ANDES ?



Who else is involved in ANDES ?

Principal Investigator (PI): A. Marconi

Executive Board & Institutes

- **Brazil: J. Renan de Medeiros**
  Federal Univ. of Rio Grande do Norte
- **Canada: R. Doyon (new partner for Phase B)**
  Univ. De Montreal, Herzberg Astrophysics Victoria
- **Denmark: J. Fynbo**
  Univ. of Copenhagen, Univ. Aarhus, Danish Tech. Univ.
- **France: I. Boisse**
  LAM Marseille, LAGRANGE Nice, IPAG Grenoble, IRAP/OMP Toulouse, LUPM Montpellier
- **Germany: K. Strassmeier**
  AIP Potsdam, Univ. Göttingen, Landessternwarte Heidelberg, MPIA Heidelberg, Thüringer Landesternwarte Tautenburg, Univ. Hamburg
- **Italy: A. Marconi**
  INAF Istituto Nazionale di AstroFisica (Lead)
- **Poland: A. Niedzielski**
  Nicolaus Copernicus Univ. in Toruń
- **Portugal: N. Santos**
  Inst. Astrofísica e Ciências do Espaço, CAUP Porto, Lisbon
- **Spain: R. Rebolo**
  Inst. Astrofísica de Canarias (IAC), Inst. Astrofísica de Andalucía (IAA - CSIC), Centro de Astrobiología (CSIC-INTA) Madrid
- **Sweden: N. Piskunov**
  Uppsala Univ., Lunds Univ., Stockholm Univ.
- **Switzerland: C. Lovis**
  Univ. de Genève, Univ. Bern
- **United Kingdom: M. Haehnelt**
  Univ. of Cambridge, UK Astronomy Technology Centre, Heriot-Watt Univ.
- **USA: T. Bergin (new partner for Phase B)**
  Univ. of Michigan

When will ANDES be built ?

- Total estimated cost of baseline design is ~35 MEUR, + 550 FTEs
- ~125 GTO nights which will be used for Consortium science programs

- Schedule
- Phase A: 2016-2018 Completed!
- Phase B (PDR): 2022-2023
- Phase C (FDR): 2024-2025
- Integration (PAE): 2026-2029
- Commissioning & PAC: 2029/2030

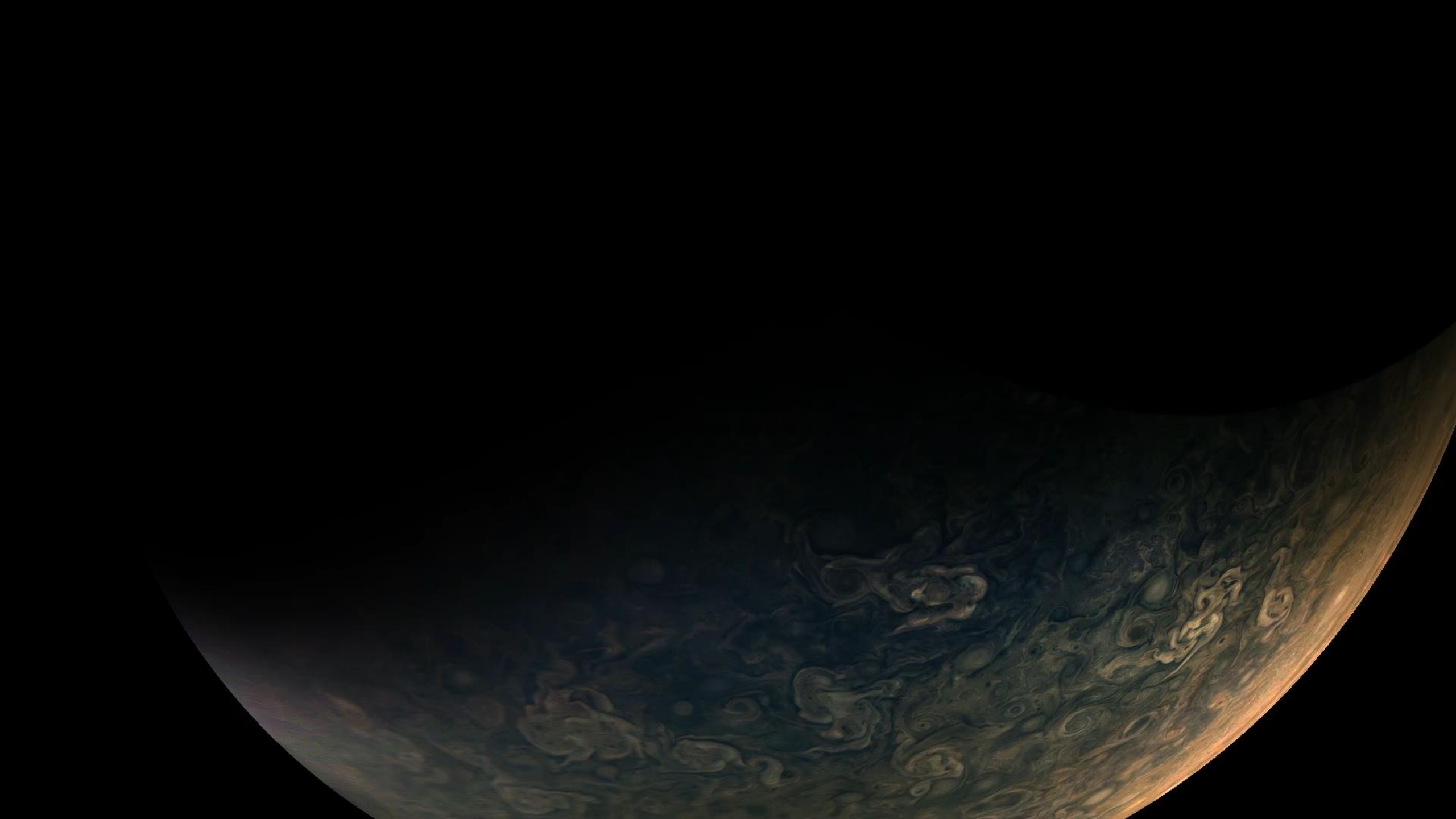
Who is in charge at MPIA ?

- Local Project PI
  - Laura Kreidberg

- Local Project Lead
  - Wolfgang Brandner

- Local Project Scientist
  - Paul Mollier

- Local Project Manager
  - Wolfgang Gaessler



Fundamental Physics: variation of the fundamental constants