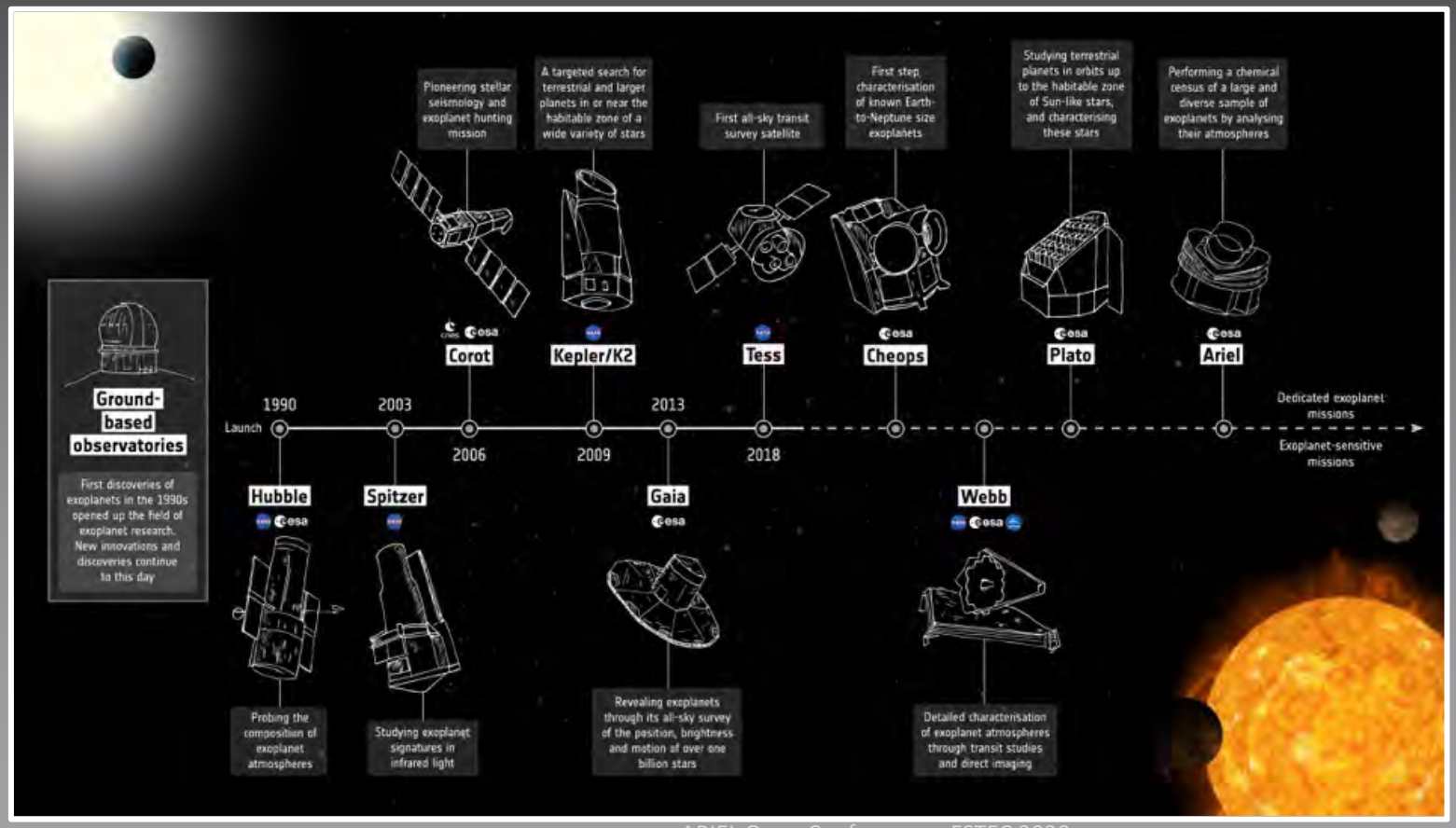
ARIEL

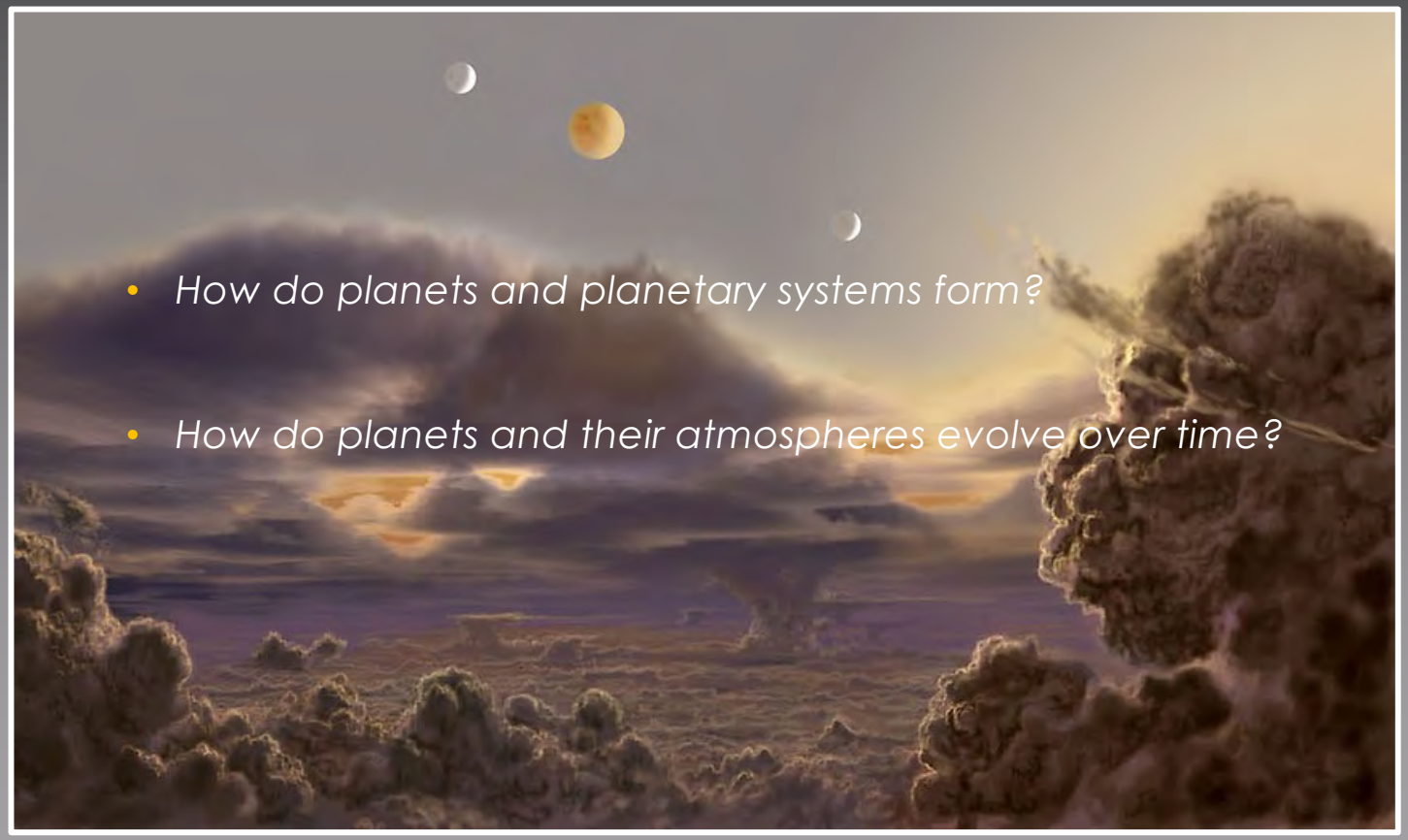
Giovanna Tinetti & ARIEL team

ARIEL Open Conference – ESTEC 2020

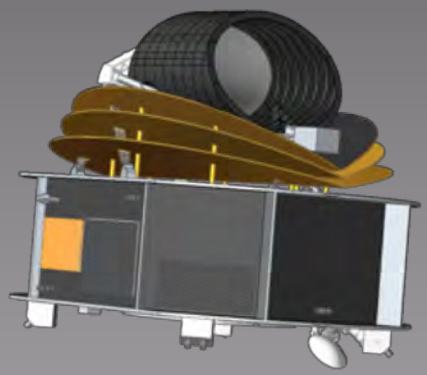
Exoplanet missions – next decade



What are exoplanet made of?

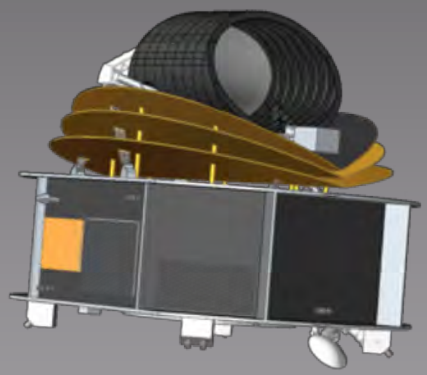


- *How do planets and planetary systems form?*
- *How do planets and their atmospheres evolve over time?*

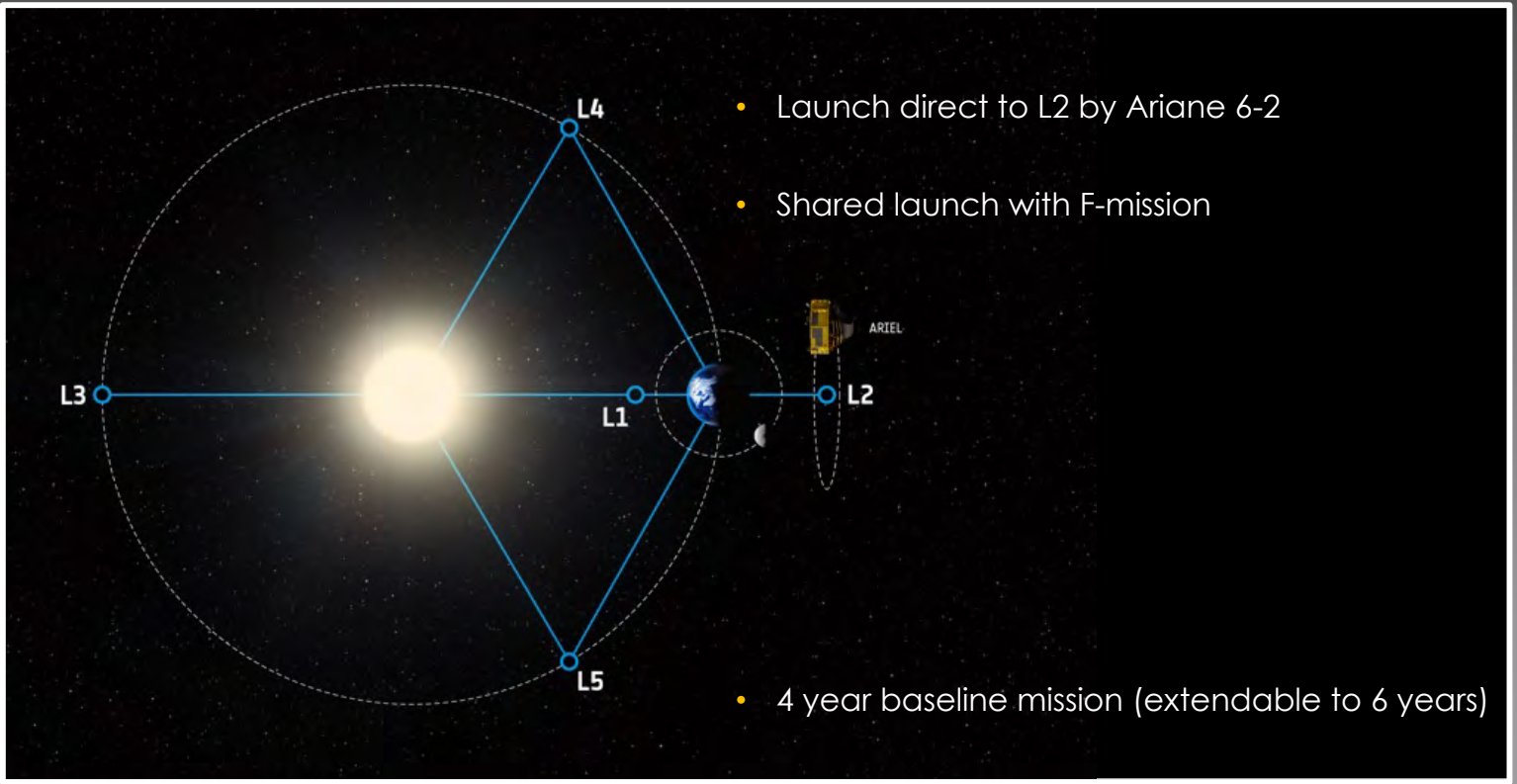


ARIEL

- Selected as ESA M4 mission in March 2018 (launch 2028)
- 1-m telescope, spectroscopy from VIS to IR
- ~1000 exoplanets observed (rocky + gaseous)
- Simultaneous coverage 0.5-7.8 micron
- Payload consortium: 17 ESA countries + US CASE & JP understudy



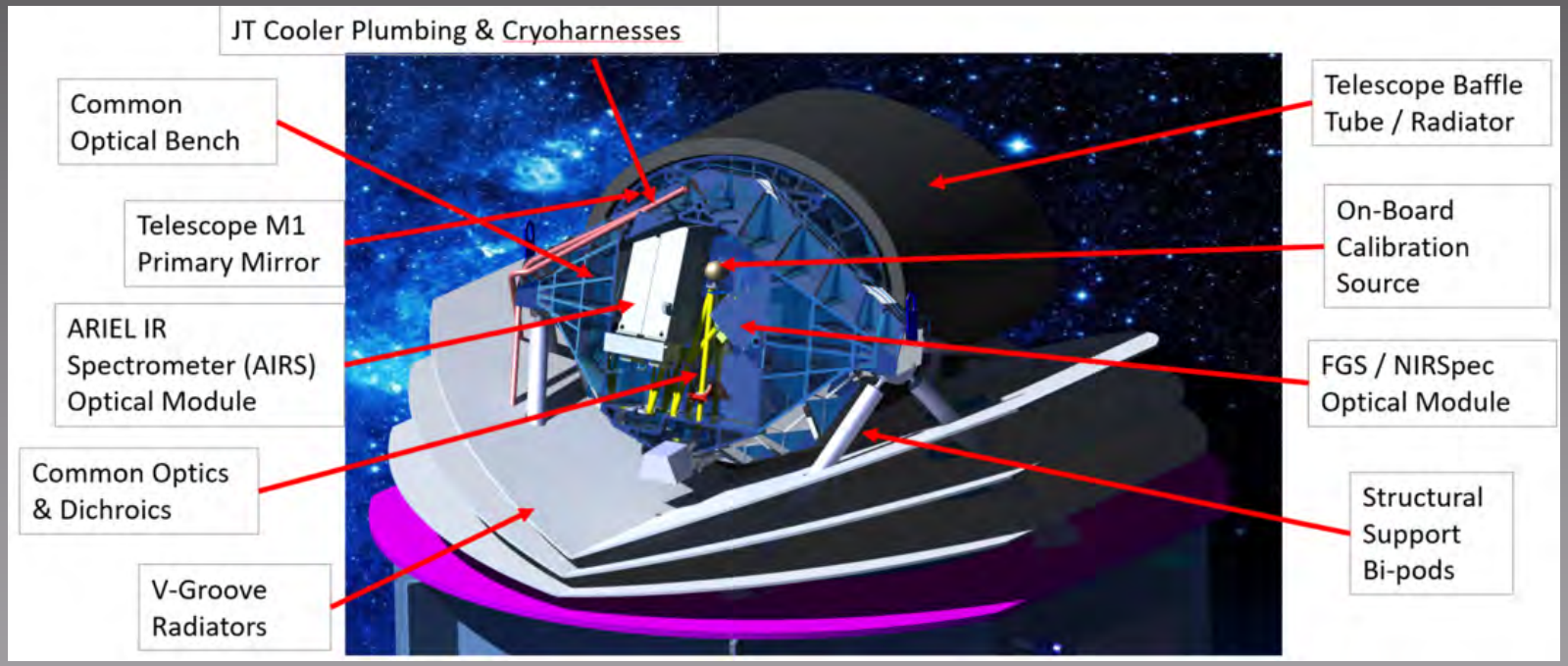
ARIEL



- Launch direct to L2 by Ariane 6-2
- Shared launch with F-mission
- 4 year baseline mission (extendable to 6 years)

ARIEL – payload design summary

PHASE B1: JUST PASSED PAYLOAD DESIGN CONSOLIDATION REVIEW

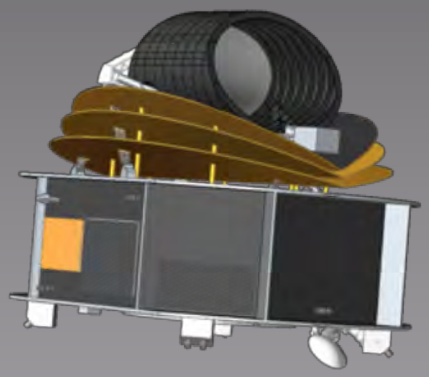


ARIEL – Spectral range/resolution

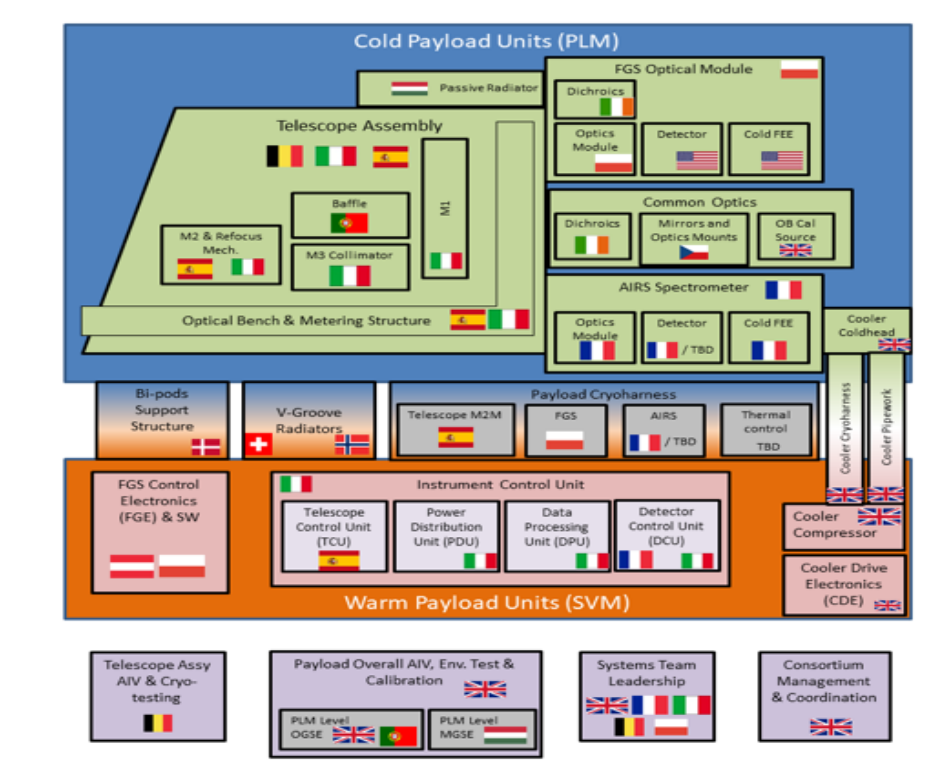
SIMULTANEOUS COVERAGE 0.5-7.8 MICRON

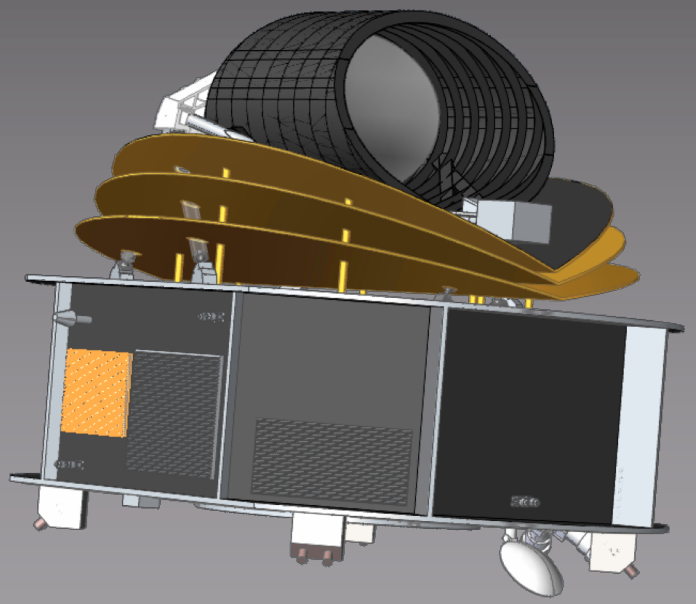
Wavelength Ranges and Spectral Resolutions of Ariel's Instrumentation

Instrument Name	Wavelength Range (μm)	Resolution
VISPhot	0.5–0.6	
FGS 1	0.6–0.81	Photometric bands
FGS 2	0.81–1.1	
NIRSpec	1.1–1.95	20
AIRS Ch0	1.95–3.9	100
AIRS Ch1	3.9–7.8	30

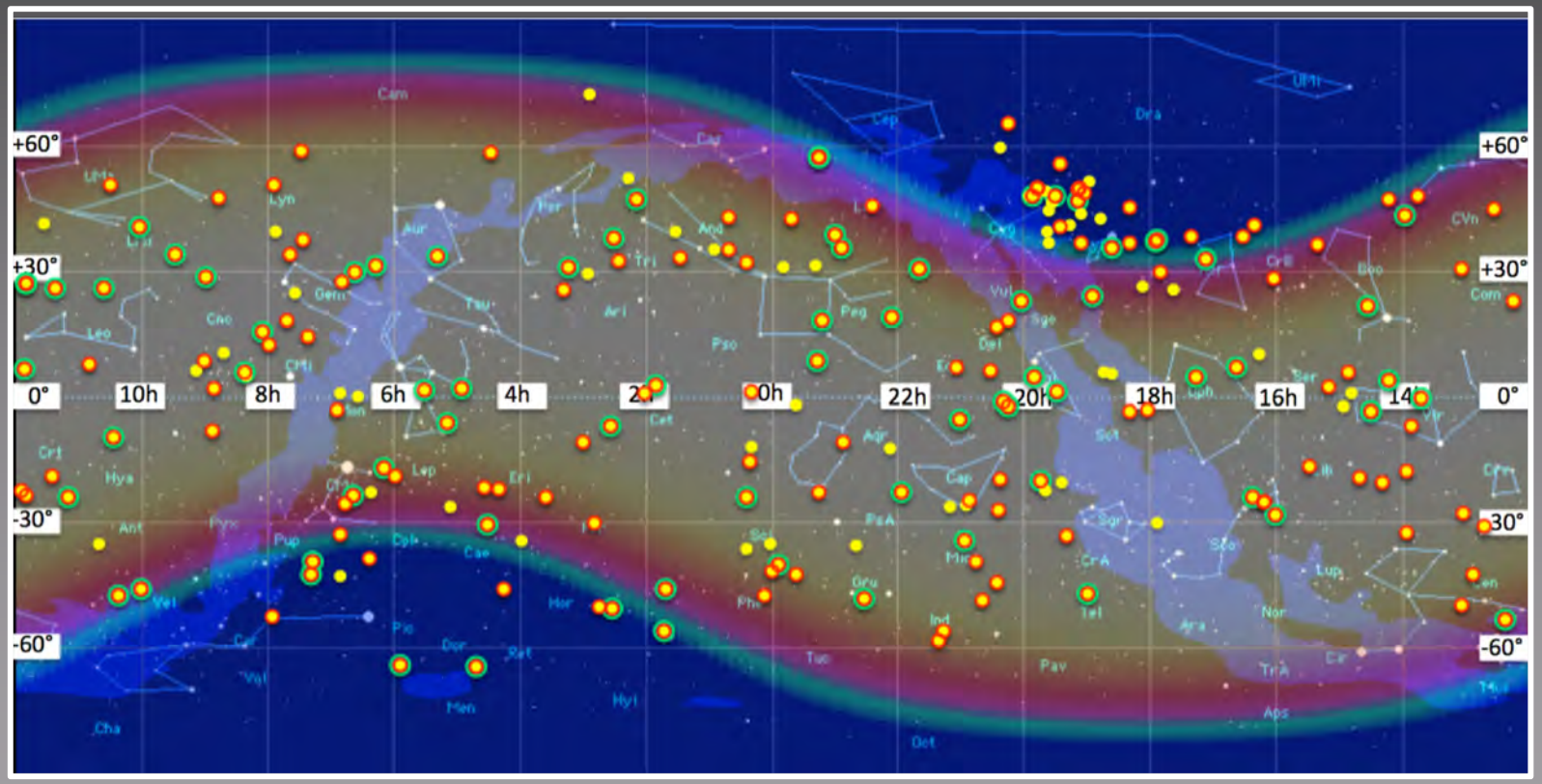


ARIEL – payload contributions





ARIEL – Sky visibility

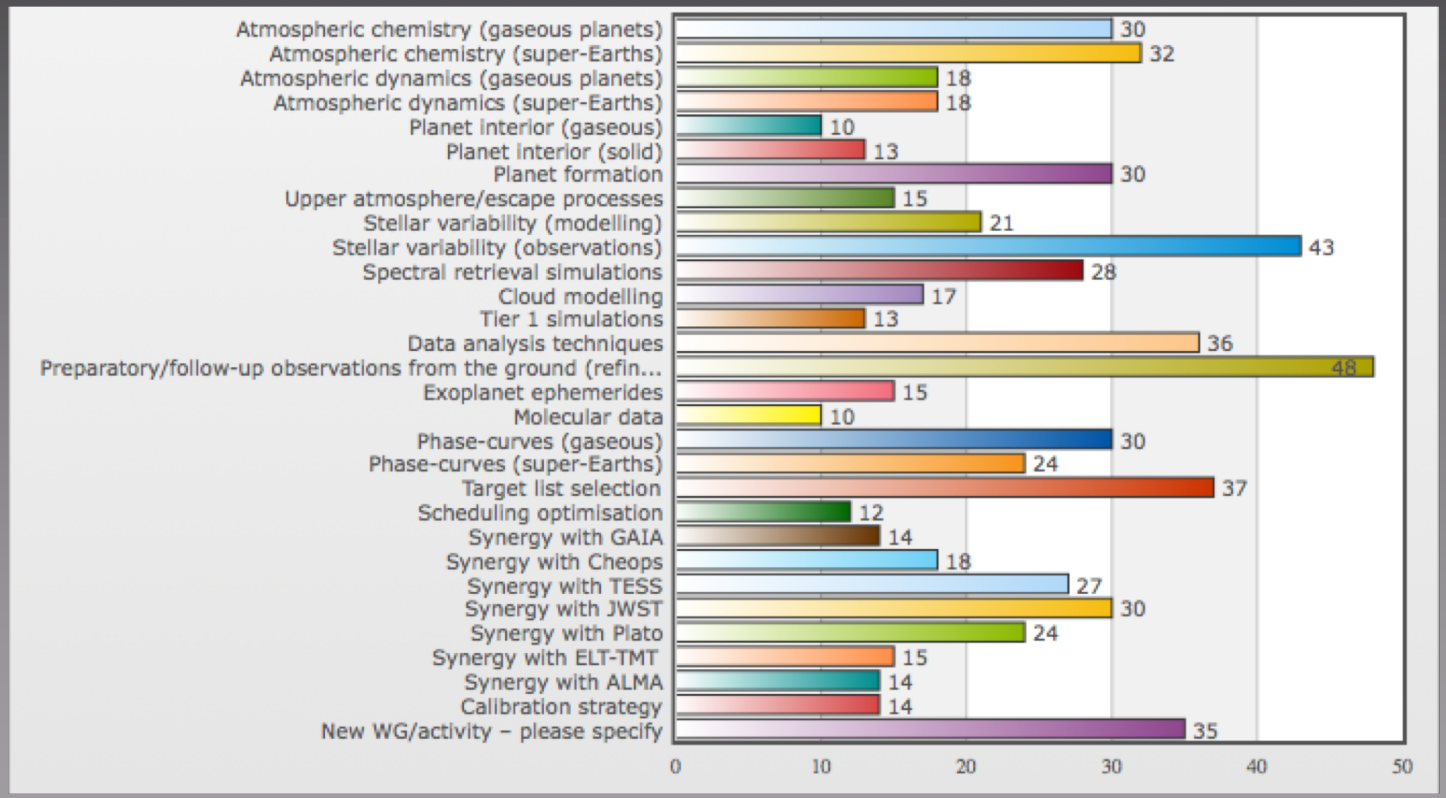


Instantaneous Sky Visibility 100% 80% 60% 40%

- Survey
- Deep
- Benchmark

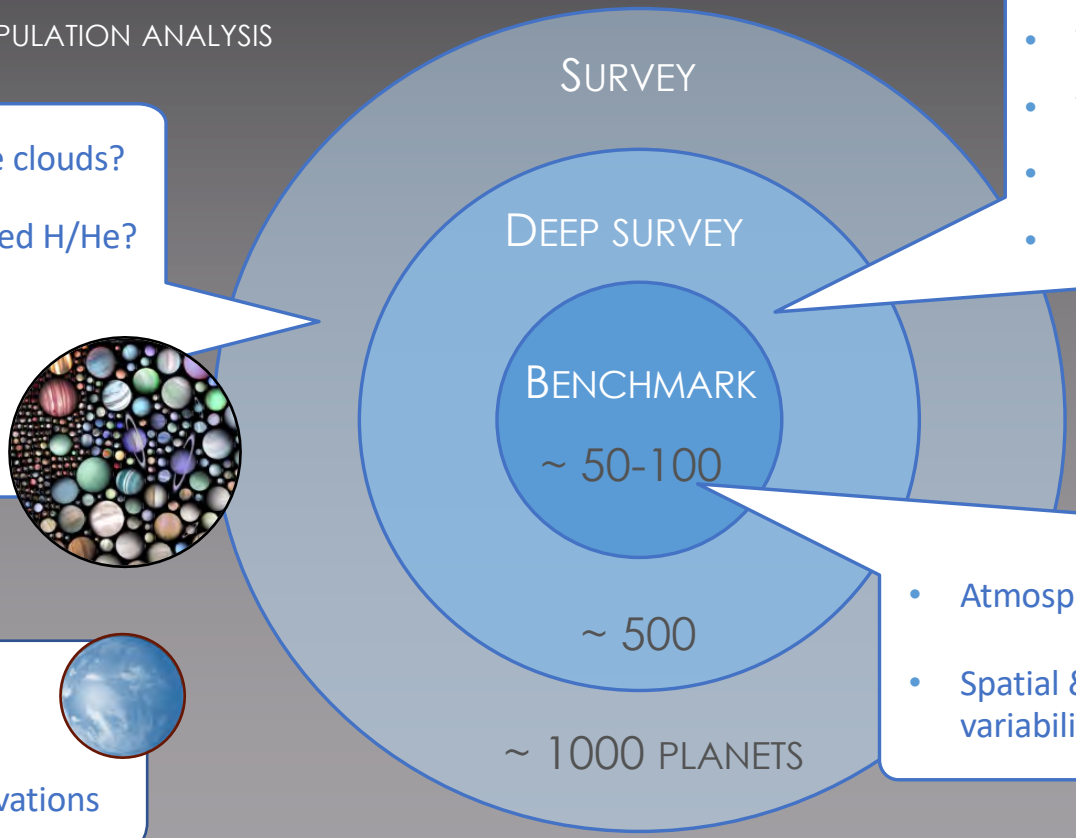
ARIEL team growing

ARIEL Science WG in Phase B



ARIEL 4-Tier approach

INDIVIDUAL PLANETS & POPULATION ANALYSIS



- What fraction of planets have clouds?
- Have small planets still retained H/He?
- Colour-colour diagrams
- Refinement of orbital/planet parameters in IR

- Main atmospheric component
- Trace gases
- Thermal structure
- Cloud characterization
- Elemental composition

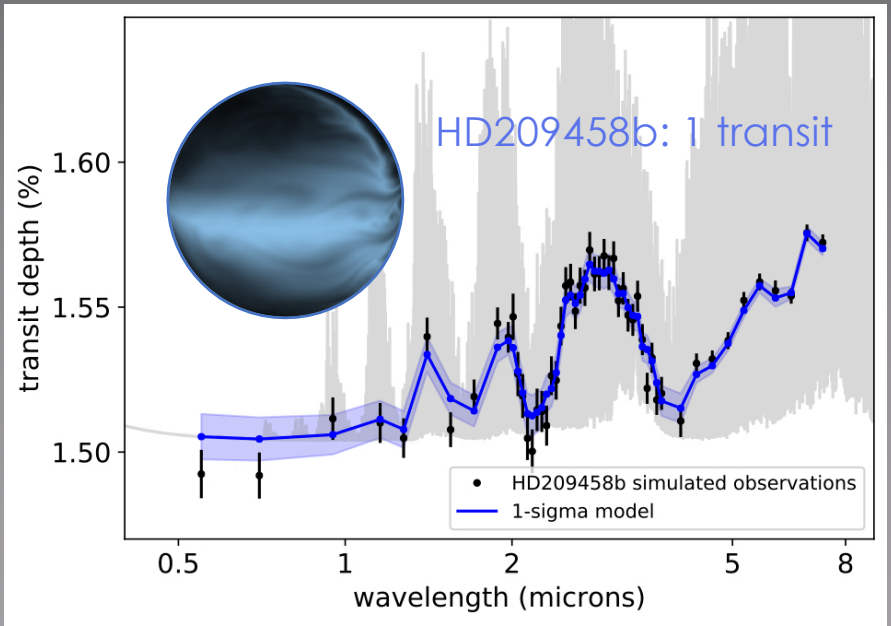
- Phase-curves
- Tailored observations

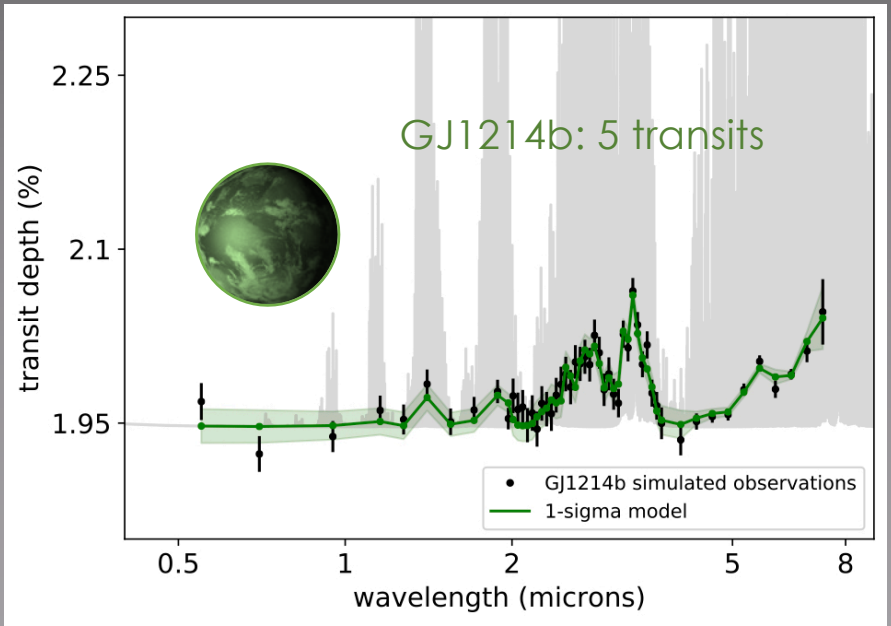
- Atmospheric circulation
- Spatial & temporal variability

ARIEL Data: Tier 2 spectra

Optimal SNR/R to retrieve:

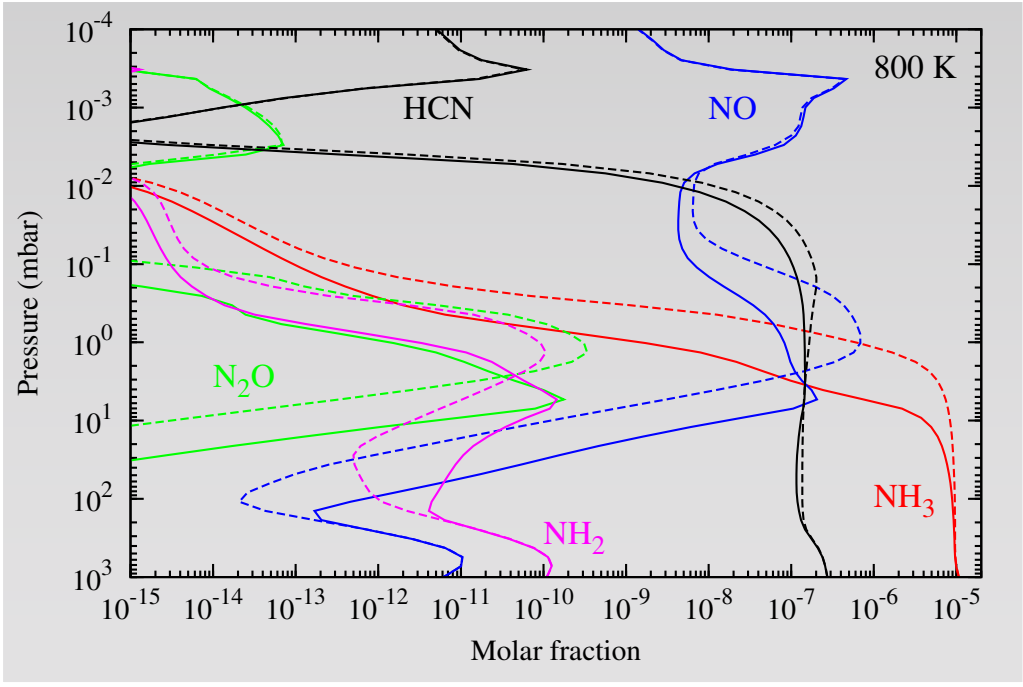
- Main/trace gases abundances
- Thermal & chemical profiles
- Cloud characterisation



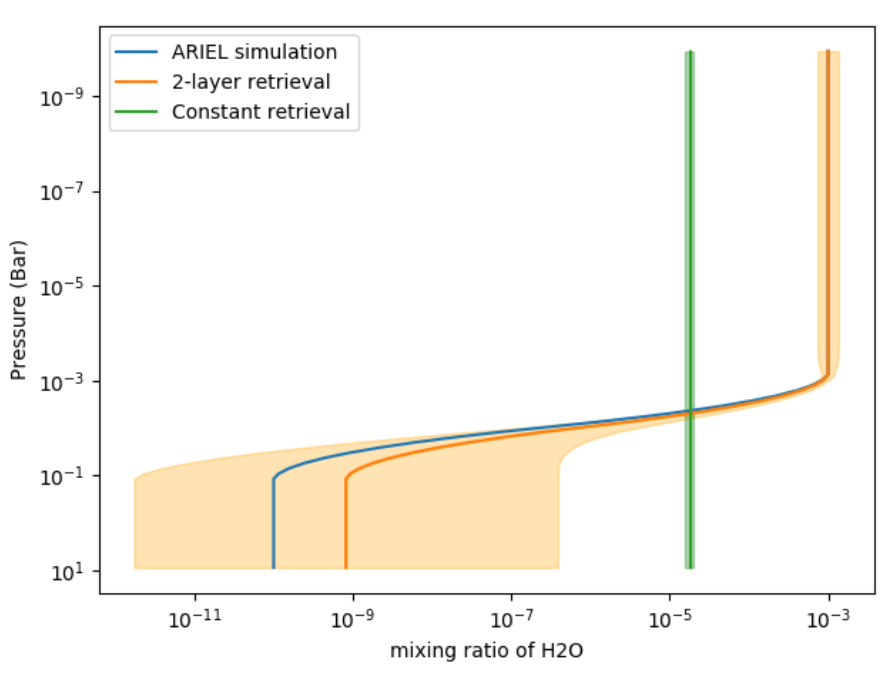


Atmospheric chemistry

SIMULATIONS & RETRIEVAL OF CHEMICAL PROFILES FROM ARIEL TIER-2 SPECTRA



Venot et al., 2018



Changeat et al, 2019

Link with planet formation

KEY MOLECULAR SPECIES/ELEMENTAL RATIOS CONNECTING ATMOSPHERES AND FORMATION

Lithogenous & Refractory Elements:

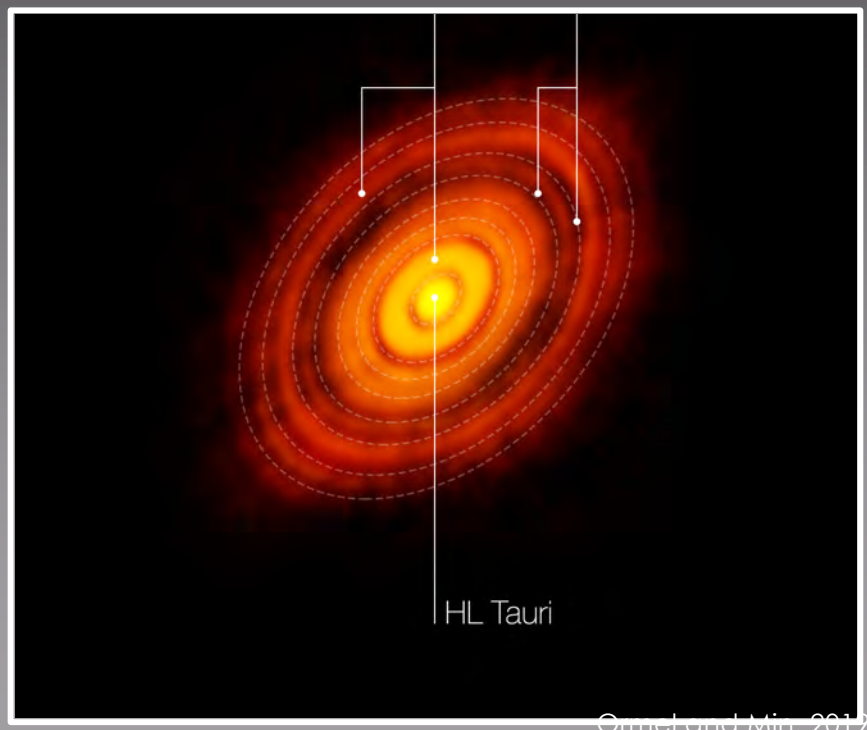
SiO (*)
AlO
CaO
TiO (*)
VO (*)
MgH
TiH

Atmophile elements:

H2O (*)
CO (*)
CO2 (*)
CH4 (*)
NH3 (*)
HCN (*)
C2H2 (*)
C2H4 (*)
C2H6 (*)

Moderately & Highly Volatile elements:

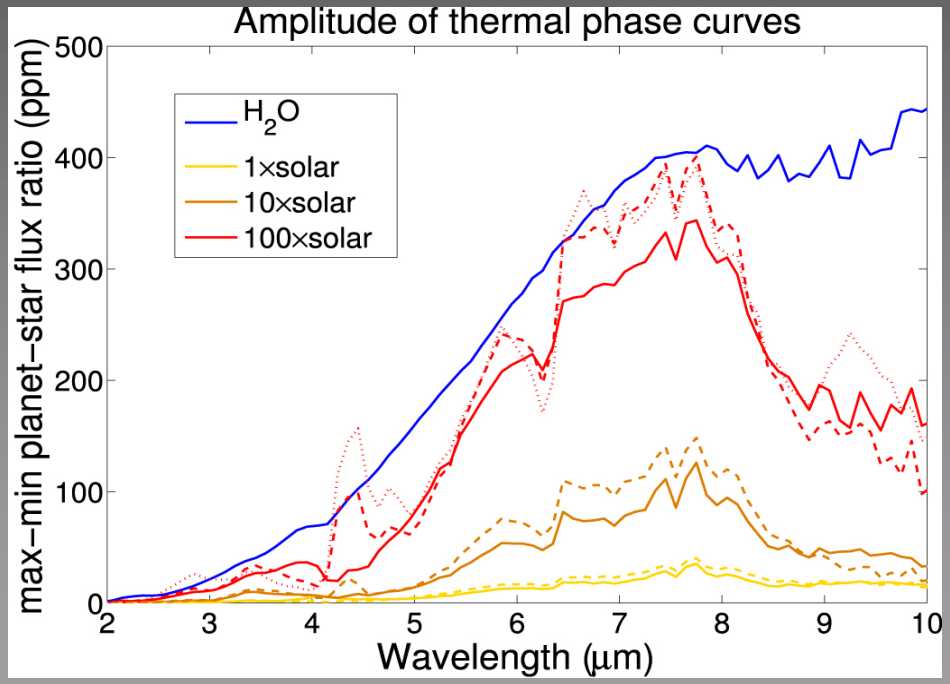
HF
H2S
SO
SO2 (*)
NaH
HCl
HBr
KCl
PH3 (*)



Ormel and Min, 2019

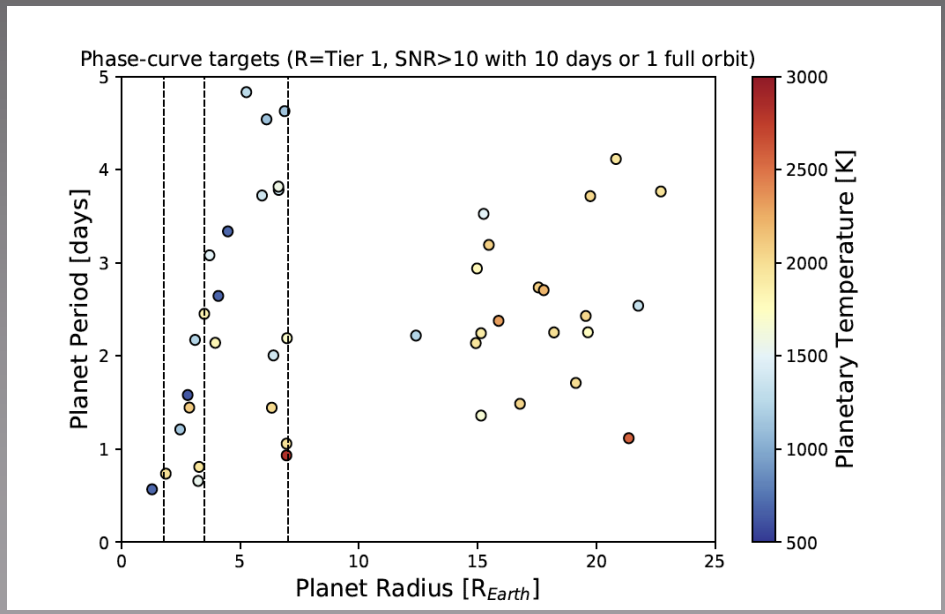
Phase-curves

SPECTROSCOPY & MULTI-BAND PHOTOMETRY



Charnay et al., 2015

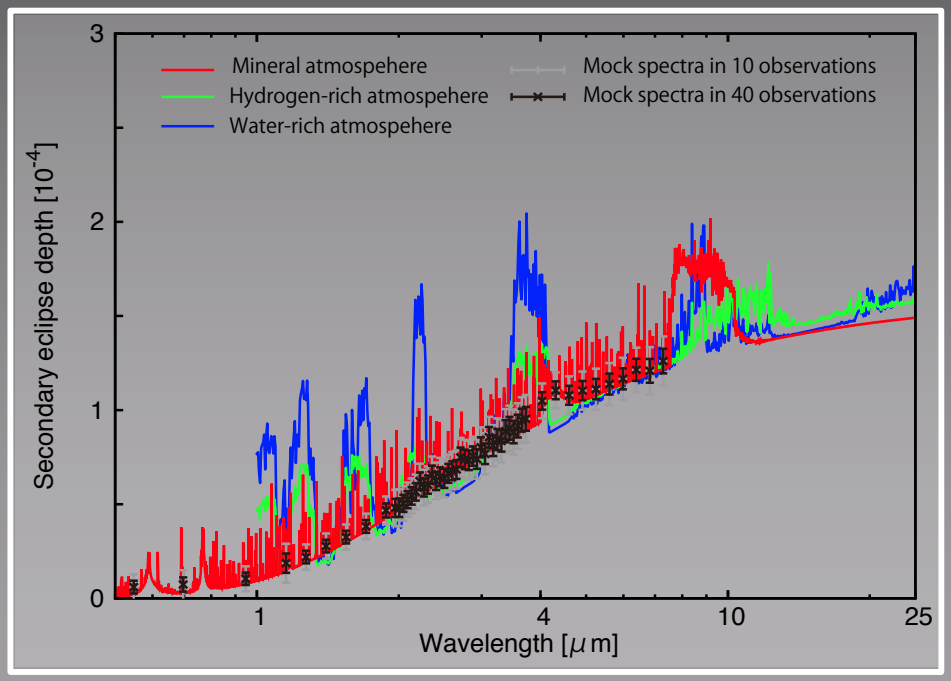
5% - 13% ARIEL time could be dedicated to Phase-curves



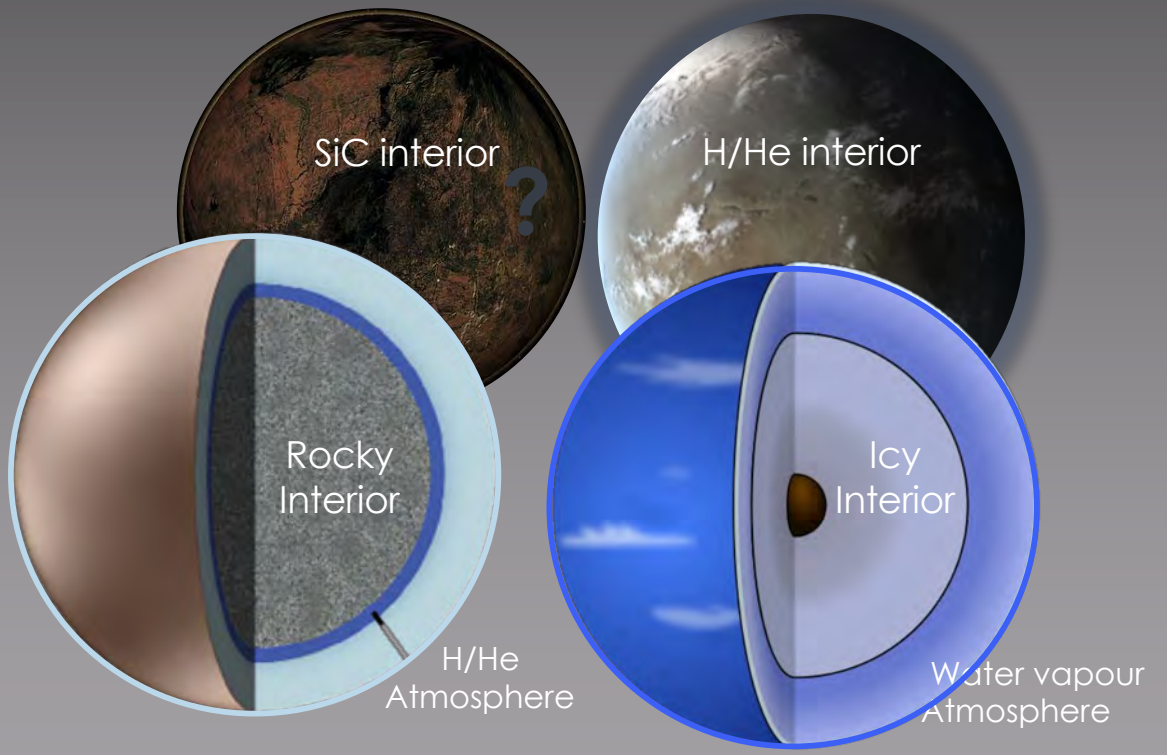
Phase-curve WG

Low gravity planets

Is H2 still there? Is there a secondary atmosphere? How thick is the atmosphere? What are the trace gases?

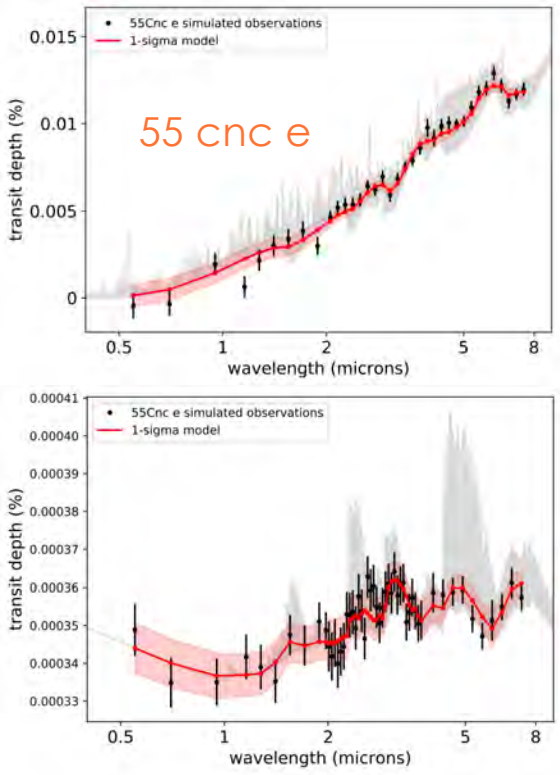


Ito et al.



Low gravity planets

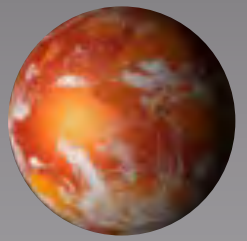
ARIEL TIER1, TIER 2 & PHASE-CURVES WILL PROVIDE INFORMATION ABOUT THE ATMOSPHERIC COMPOSITION & THICKNESS



Mission Time Required to Achieve Tier 1 Resolutions (at S/N > 7) for the 113 Small Planets in the Example MRS Assuming Different Mean Molecular Weights

Atmospheric Mean Molecular Weight	Number of Planets	Required Science Time (hr)
2.3	All	~1000 (t_0)
5	50	t_0 + ~360
	All	t_0 + ~3000
8	50	t_0 + ~1100
	All	t_0 + ~9200
10	50	t_0 + ~1900
15	50	t_0 + ~4400
18	25	t_0 + ~1700
	50	t_0 + ~6400
28	25	t_0 + ~4300
	50	t_0 + ~15,600

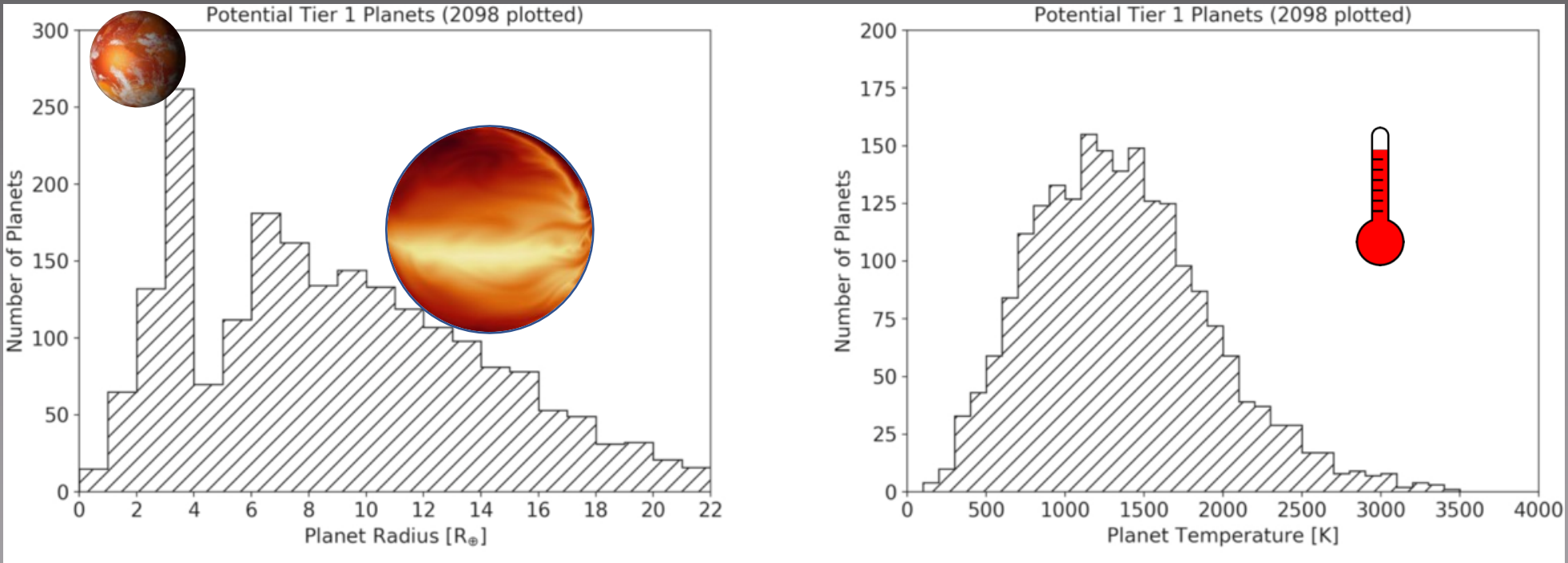
Note. The total science time over the 4 yr primary life is ~24,800 hr. t_0 is the time spent observing small planets in Tier 1 of the standard MRS.



Edwards et al. 2019

ARIEL targets – planets

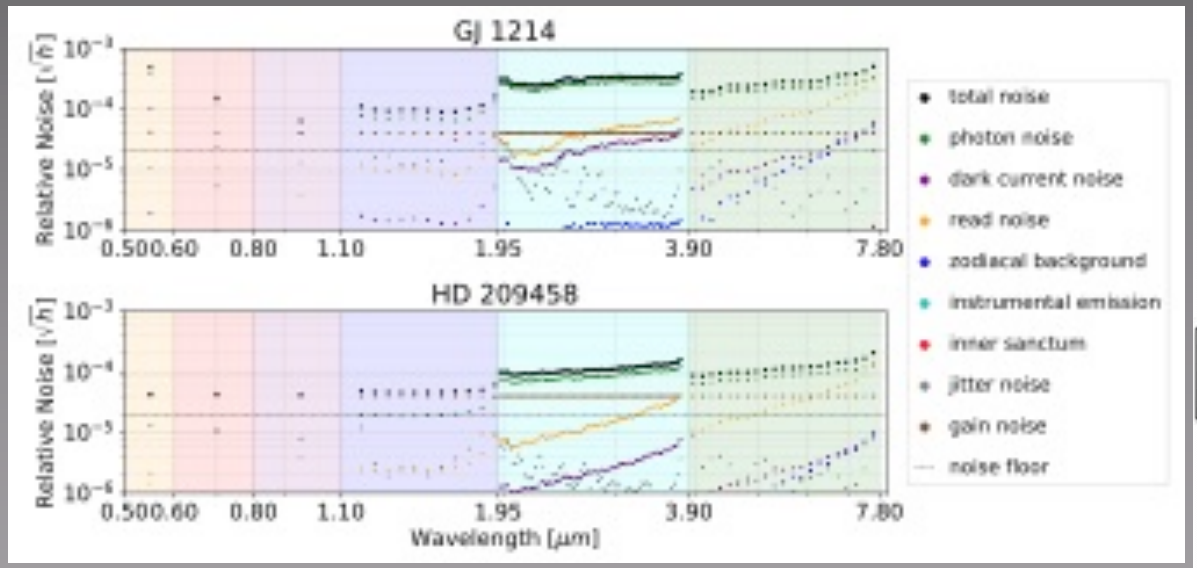
https://arielmission.space/target-list/

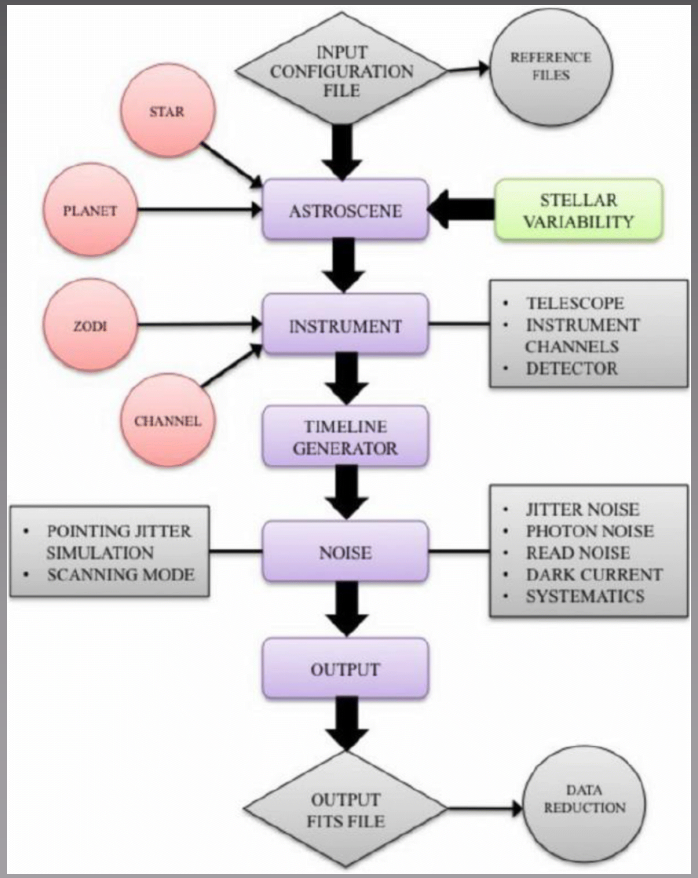


Edwards et al. 2019

ARIEL – Simulators

EXO-SIM, ARIEL-RAD



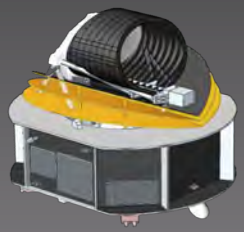


Pascale et al., 2015: Sarkar et al 2018; Mugnai et al., 2020

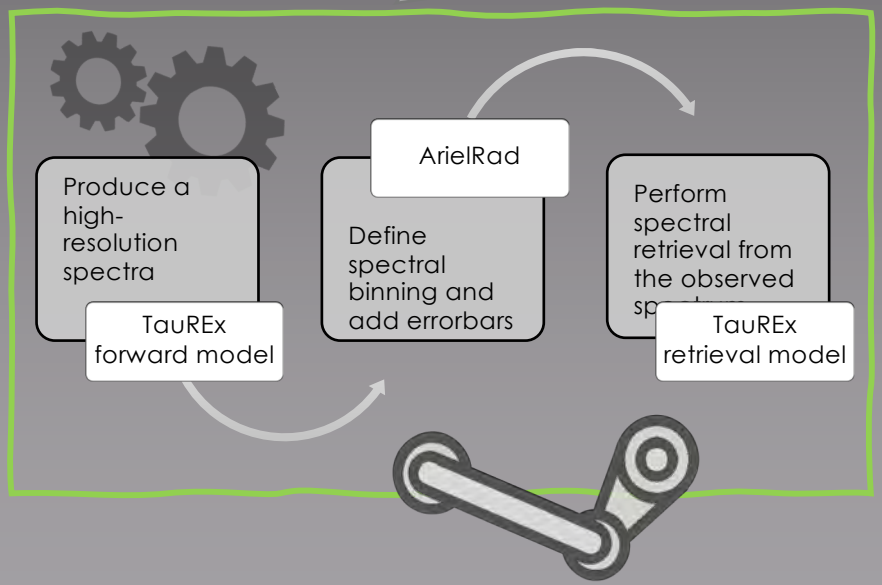
ARIEL – Simulators

ALFNOOR: 1000 LIGHTS

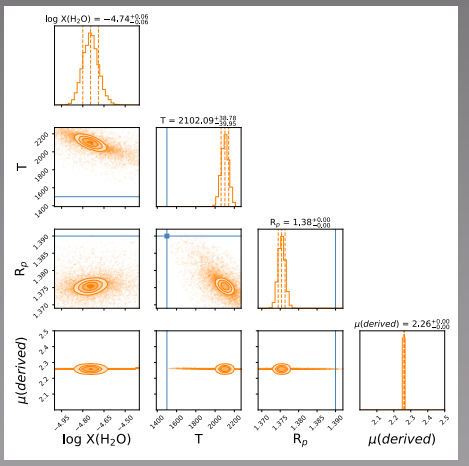
ARIEL target list containing information about star, planet, chemistry and observation strategy



ARIEL payload configuration



Posteriors x 1000 planets

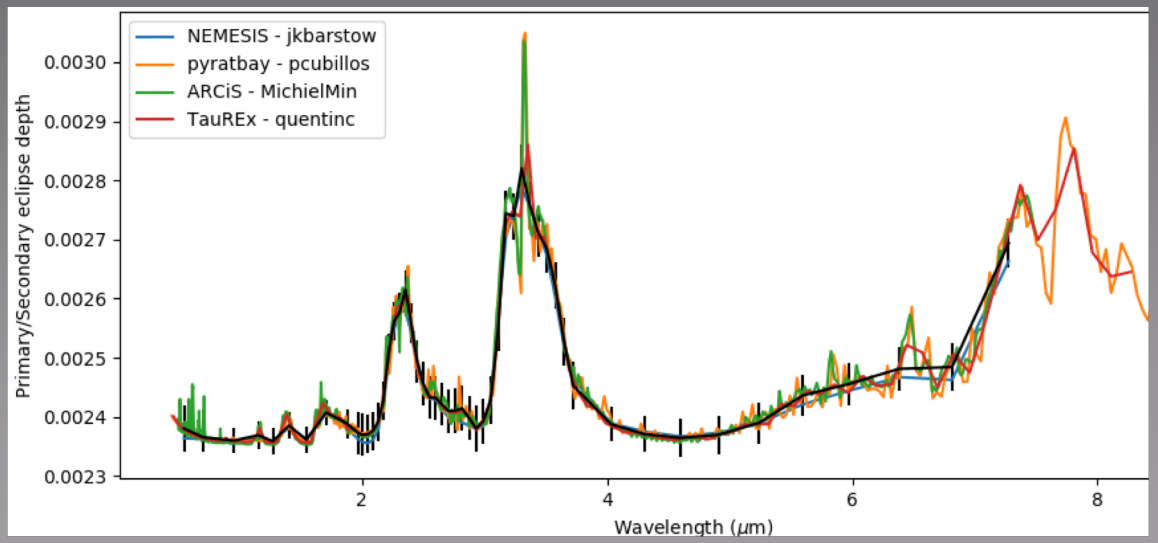


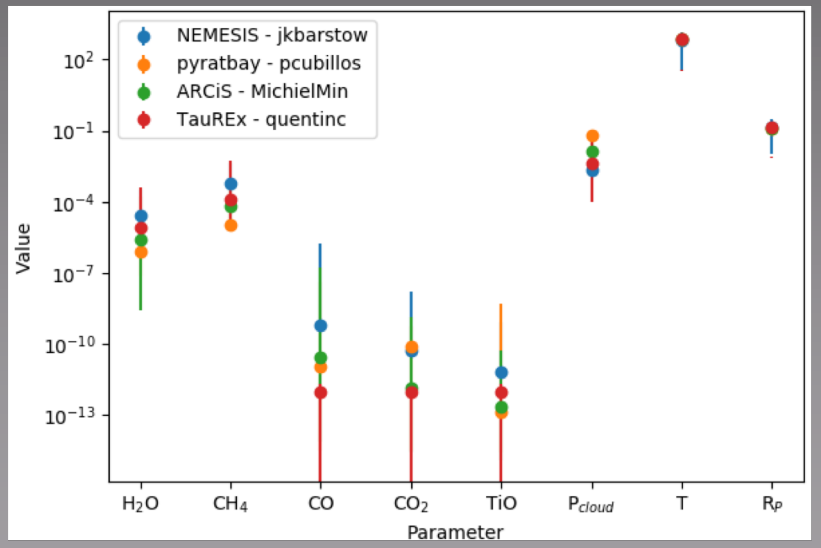
Mugnai & Al-Refaie, 2020

ARIEL – Spectral retrievals

MANY SPECTRAL RETRIEVAL MODELS AVAILABLE TO THE CONSORTIUM

ARIEL Data Challenge 2019 – Blind challenge mini Neptune

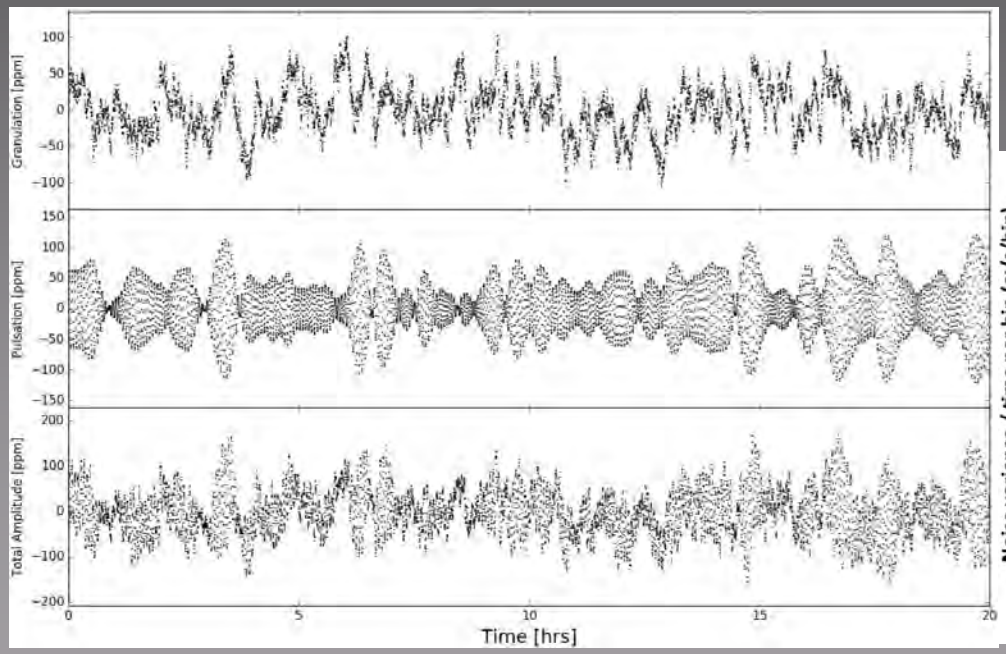




ARIEL Data Challenge 2019; Spectral retrieval WG

Stellar activity: pulsation/granulation

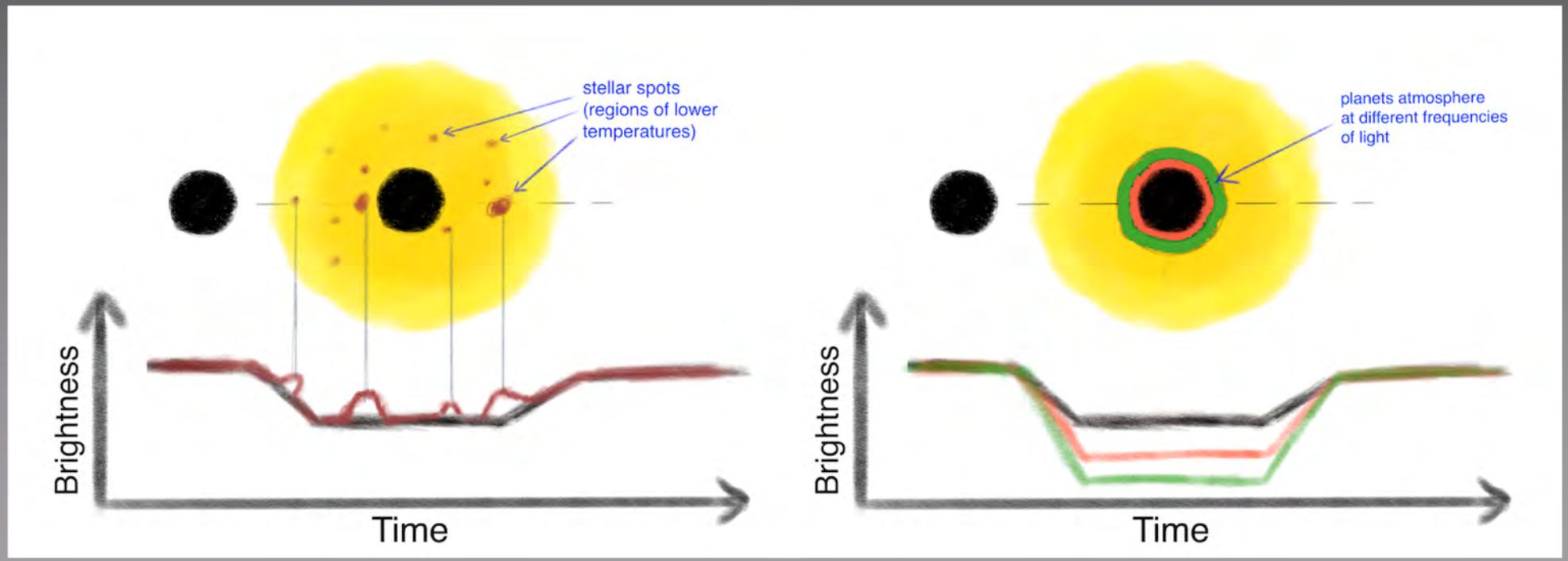
CONVECTION-DRIVEN VARIABILITY ARISING FROM PULSATIONS & GRANULATIONS IS NOT AN ISSUE FOR ARIEL DATA



Sarkar et al. 2018

Stellar activity: spots & faculae

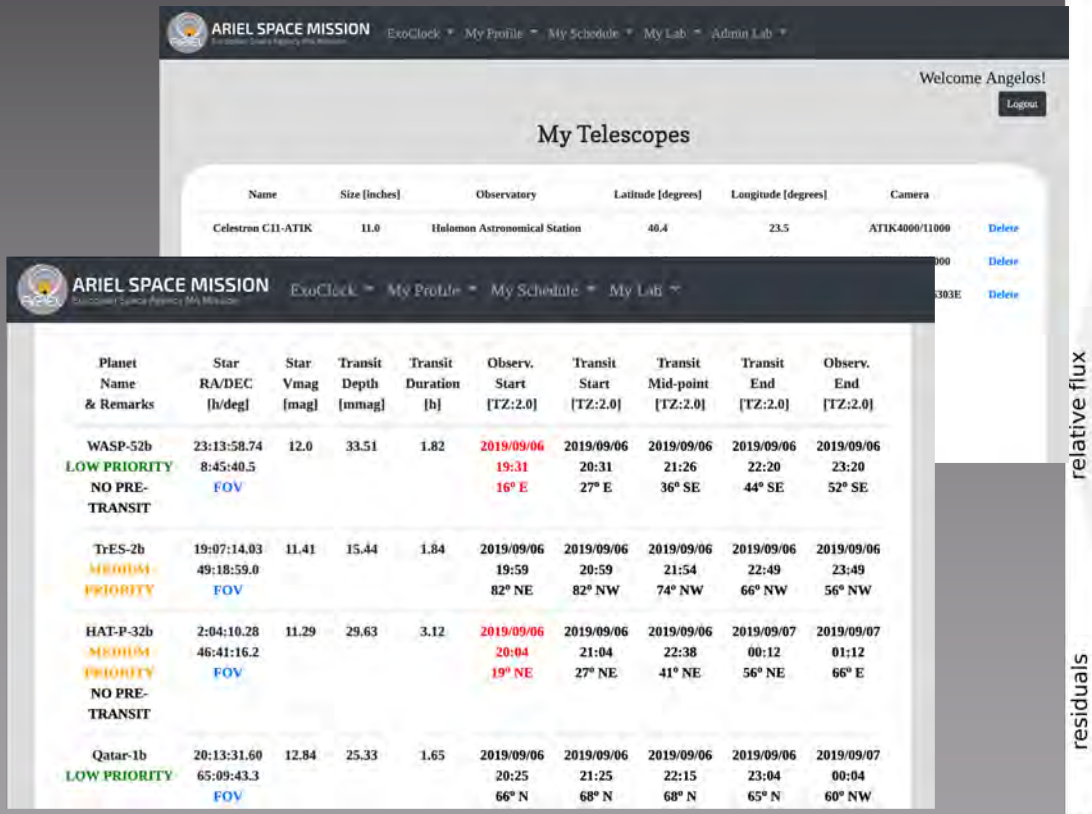
PLANET DOES CROSS SPOTS & FACULAE: MORE VICIOUS PROBLEM…AI SOLVABLE?

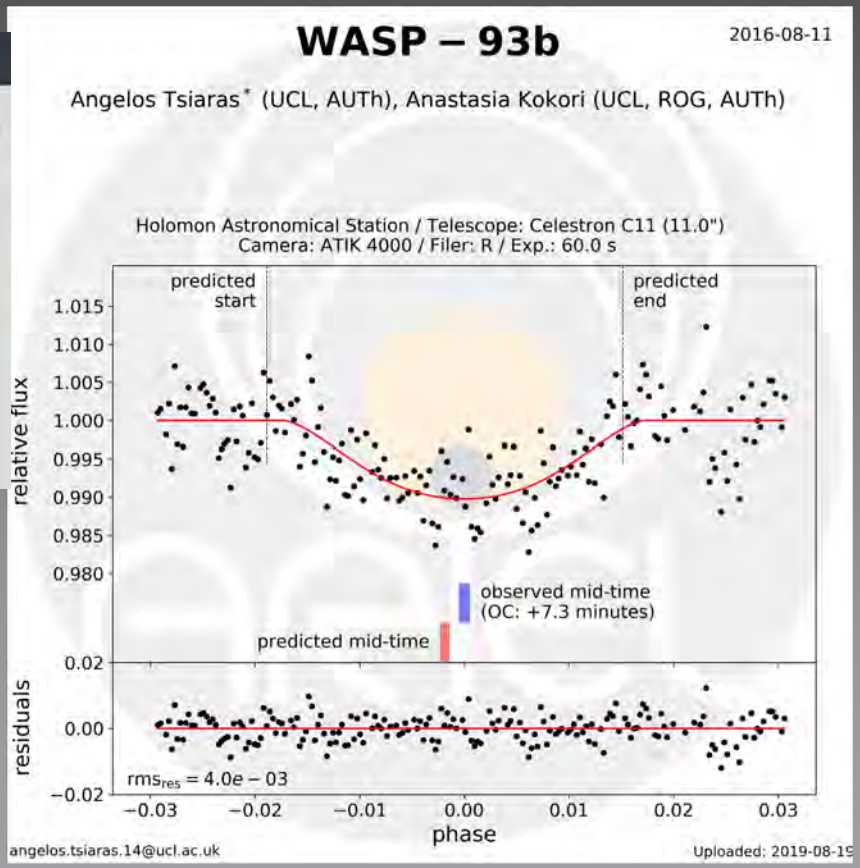



ARIEL Data Challenges
2019
UCL
CENTRE FOR SPACE
EXOCHEMISTRY DATA
europlanet
ARIEL Open Conference – ESTEC 2020
ARIEL
UK SPACE AGENCY
ECMLPKDD
Würzburg 16.–20.09.2019

ExoClocks

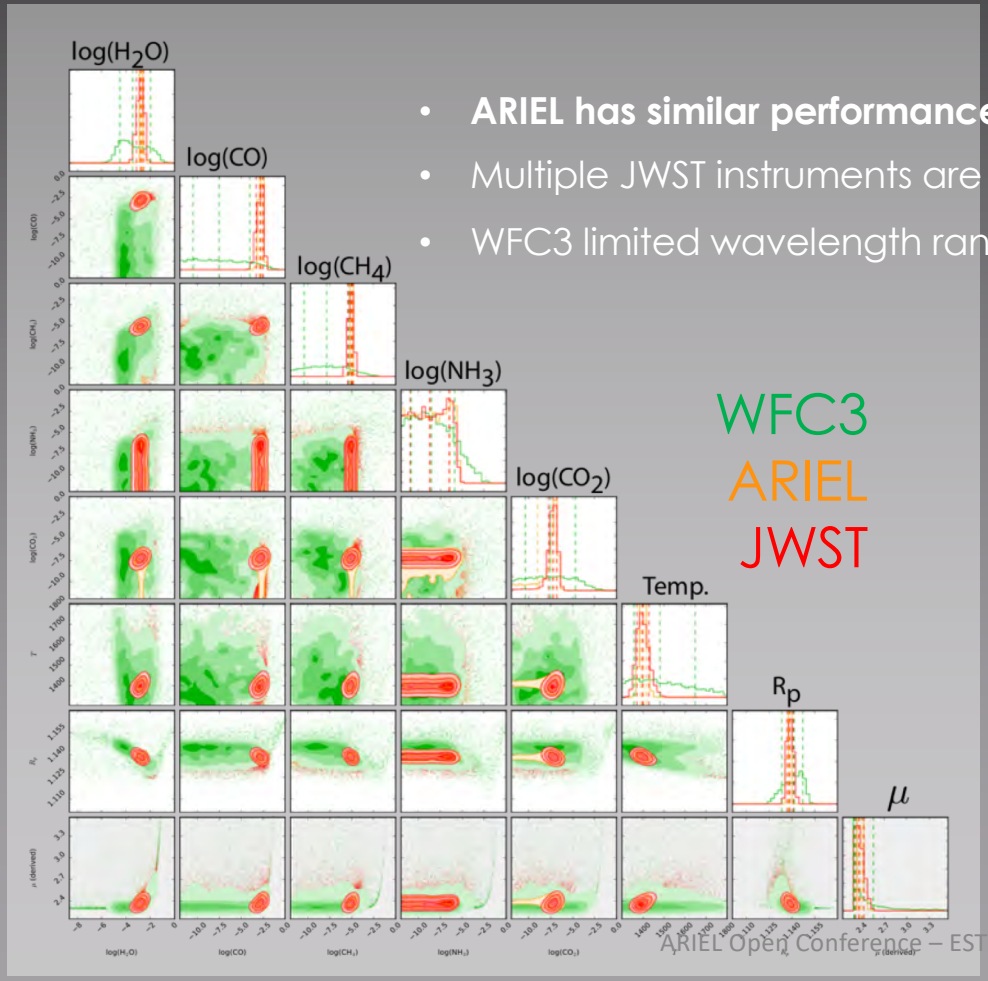
exoclock.space





Kokori & Tsiaras, 2019

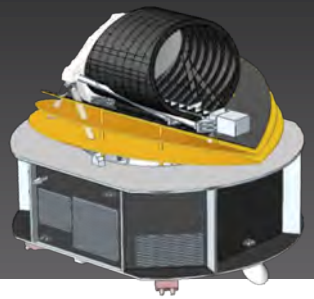
Synergies JWST/HST

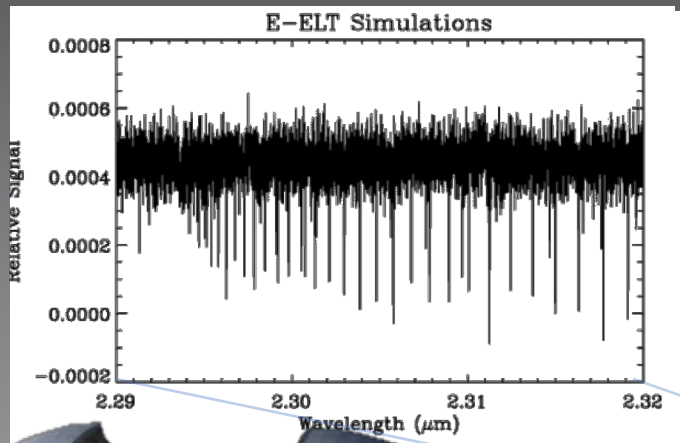


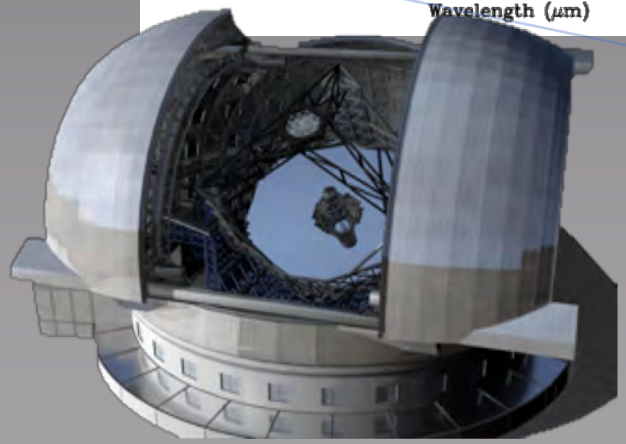
- **ARIEL has similar performances to JWST for warm/hot planets around bright stars**
- Multiple JWST instruments are combined here
- WFC3 limited wavelength range gives highly degenerate solutions

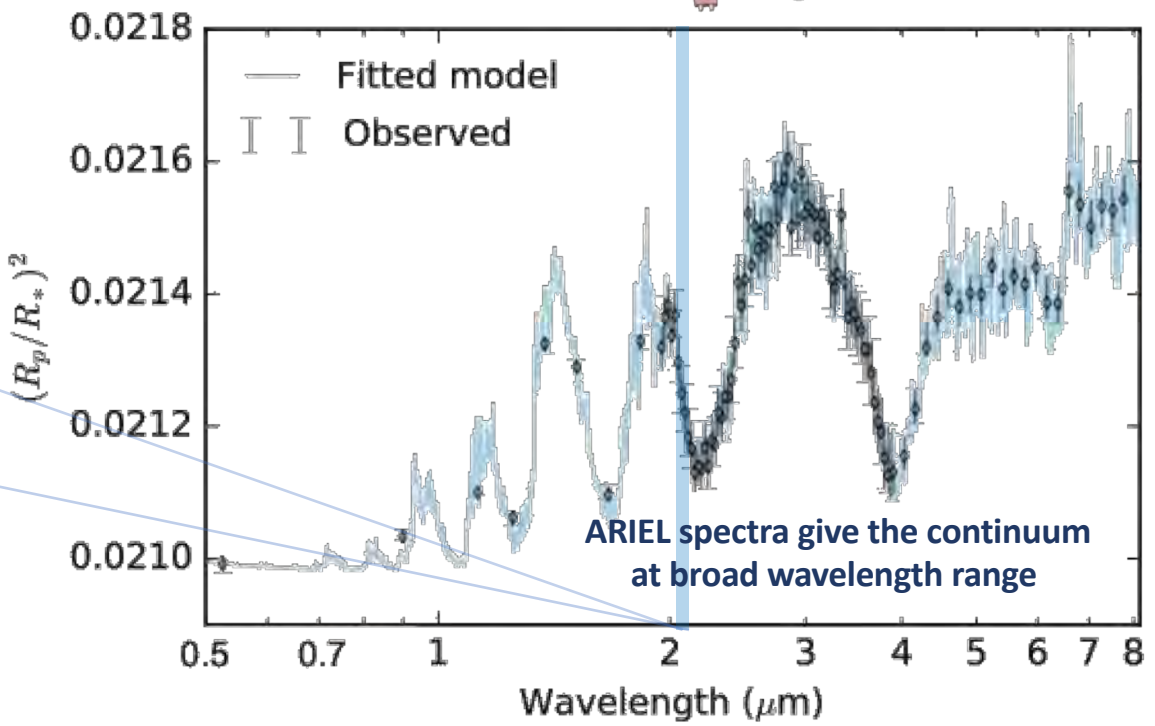
Synergies ground

HIGHLY COMPLEMENTARY TO LARGE, GROUND-BASED FACILITIES









Conclusions

- Exoplanets appear to be ubiquitous in our Galaxy
- The number of discovered exoplanets is increasing exponentially, but we still know very little about them
- ARIEL has been conceived to deliver the first chemical survey of ~ 1000 exoplanets, probing uniformly the gamut of planet and stellar parameters
- Results obtained in Phase B have shown that ARIEL instrument will enable even more compelling science that what we presented in Phase A.
- Interested in helping? You are welcome to join! ☺