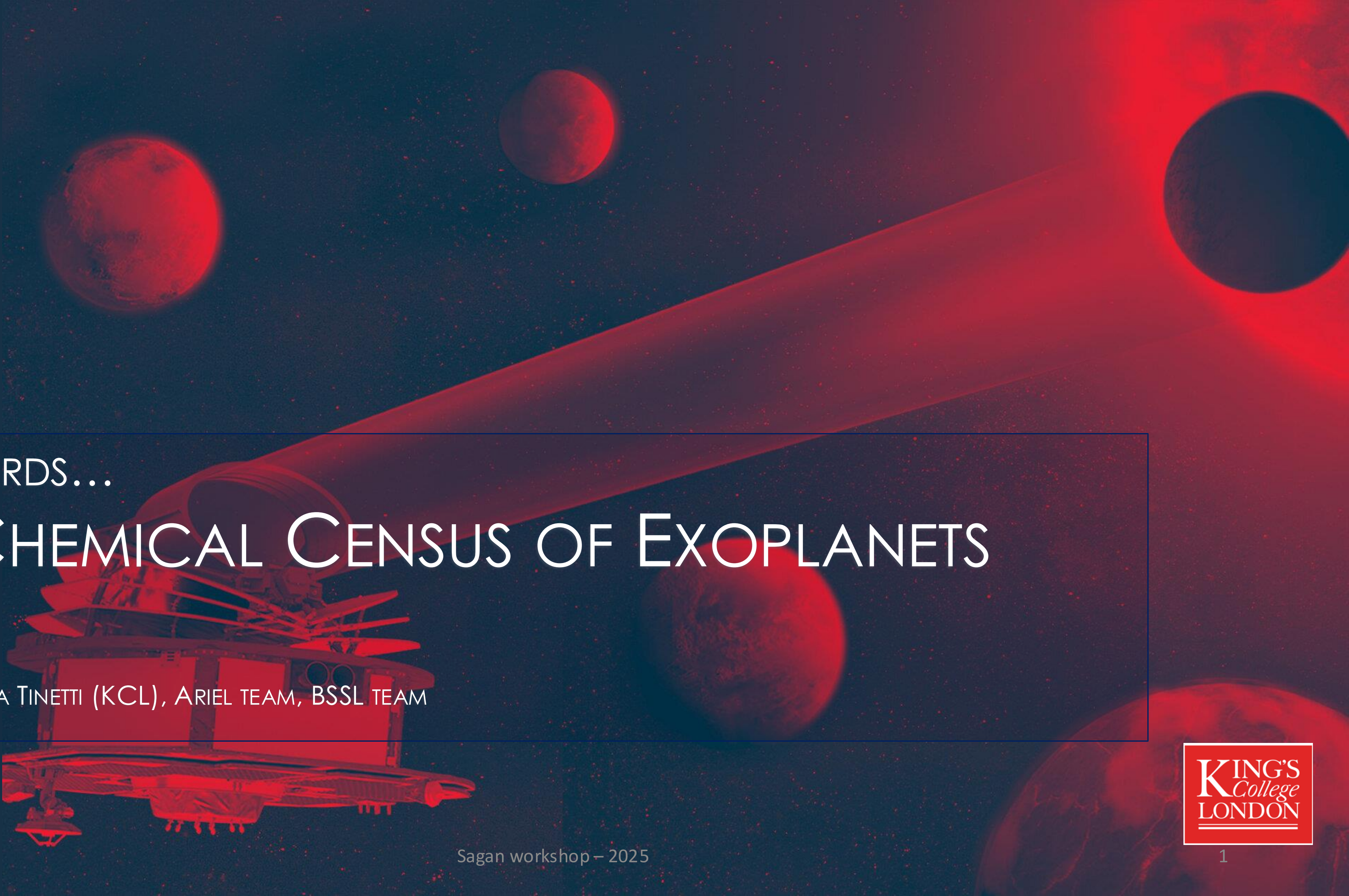


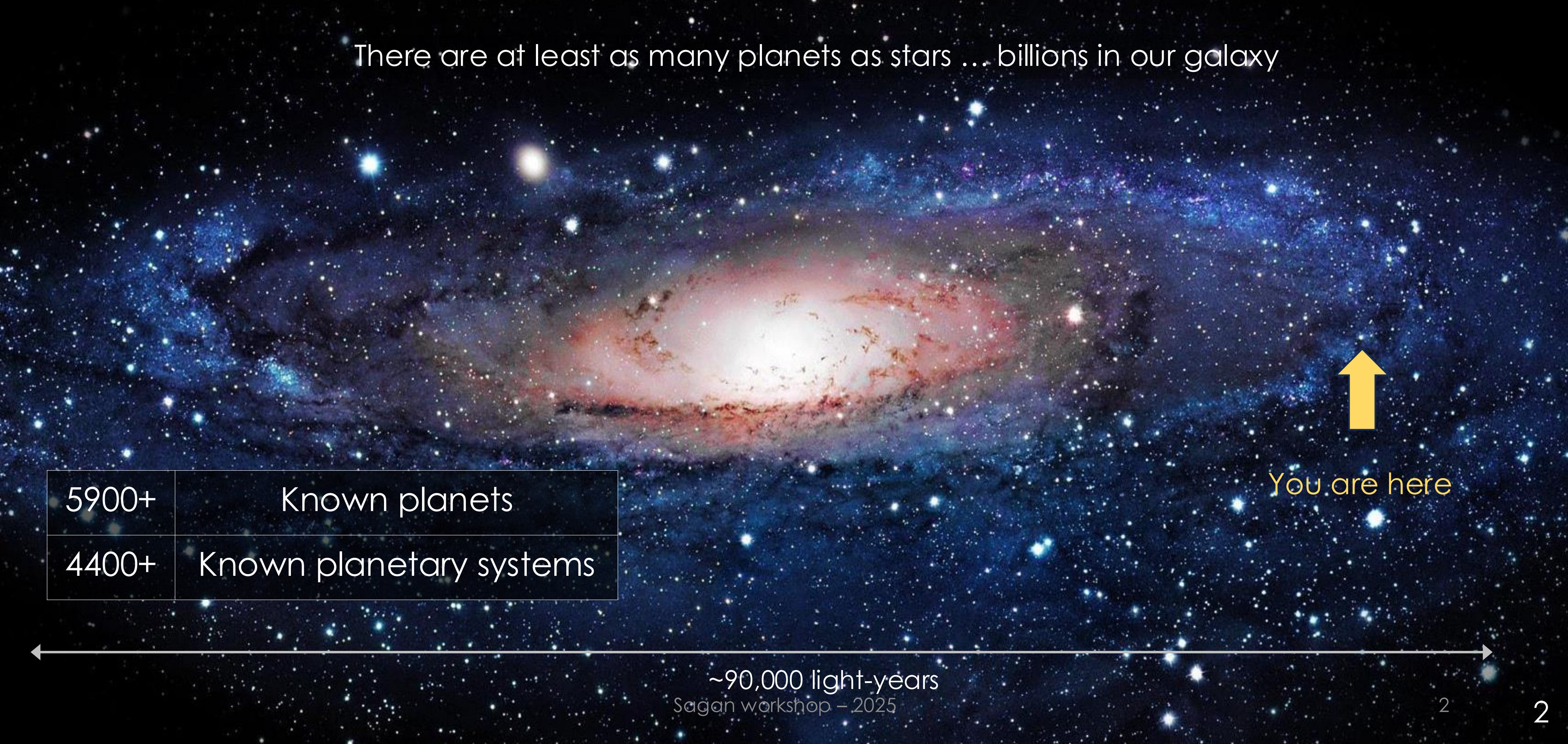
Towards…

A Chemical Census of Exoplanets

Giovanna Tinetti (KCL), Ariel team, BSSL team

Planets are around most stars

There are at least as many planets as stars … billions in our galaxy



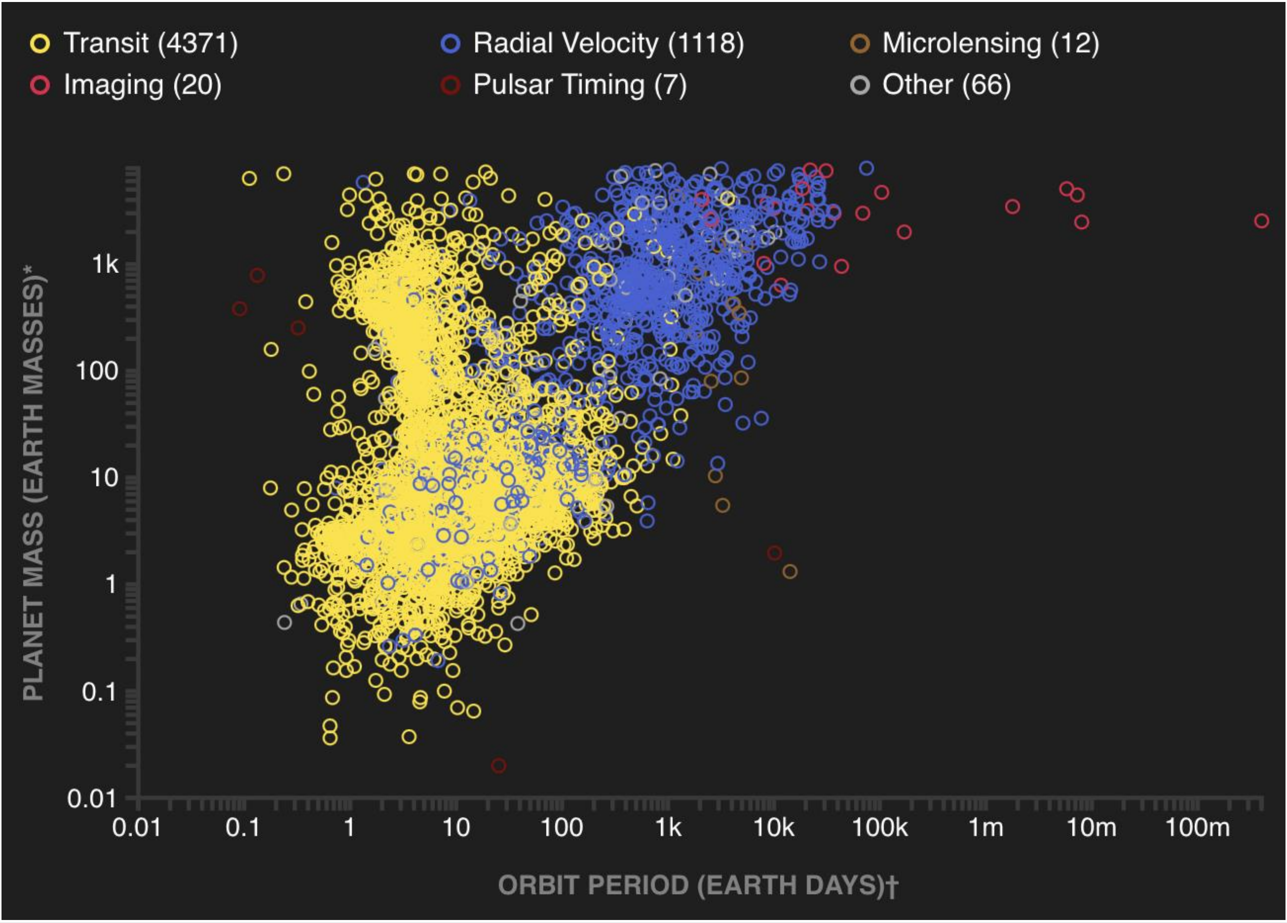
You are here

~90,000 light-years

5900+	Known planets
4400+	Known planetary systems

Planets are very diverse

Exoplanets show greater diversity than their Solar siblings, why?

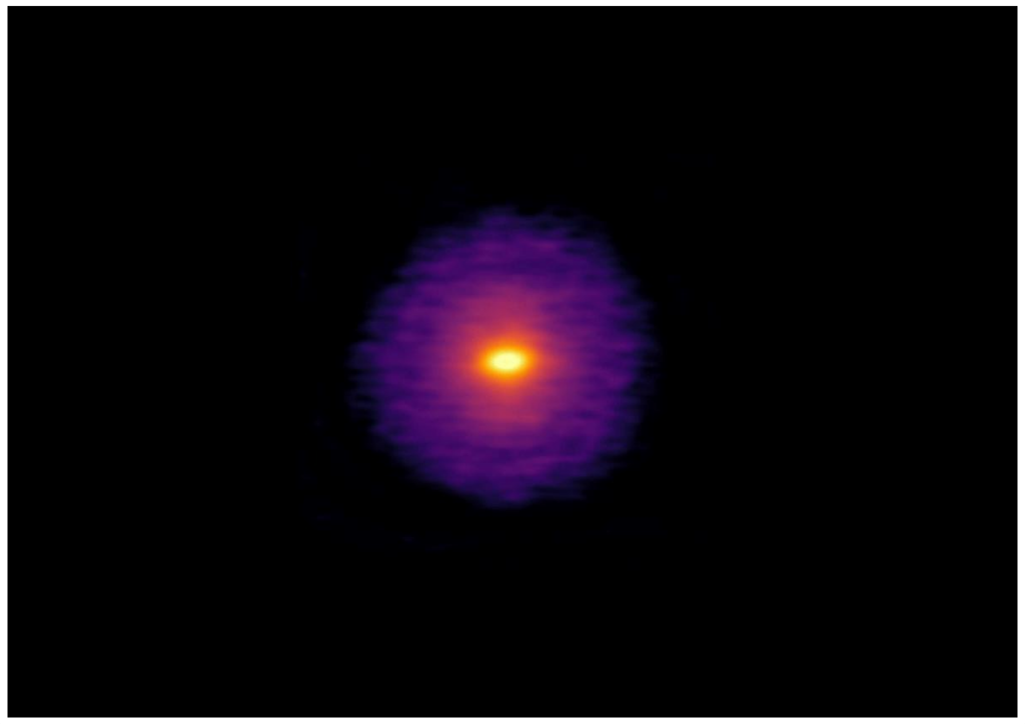


Planets are very diverse

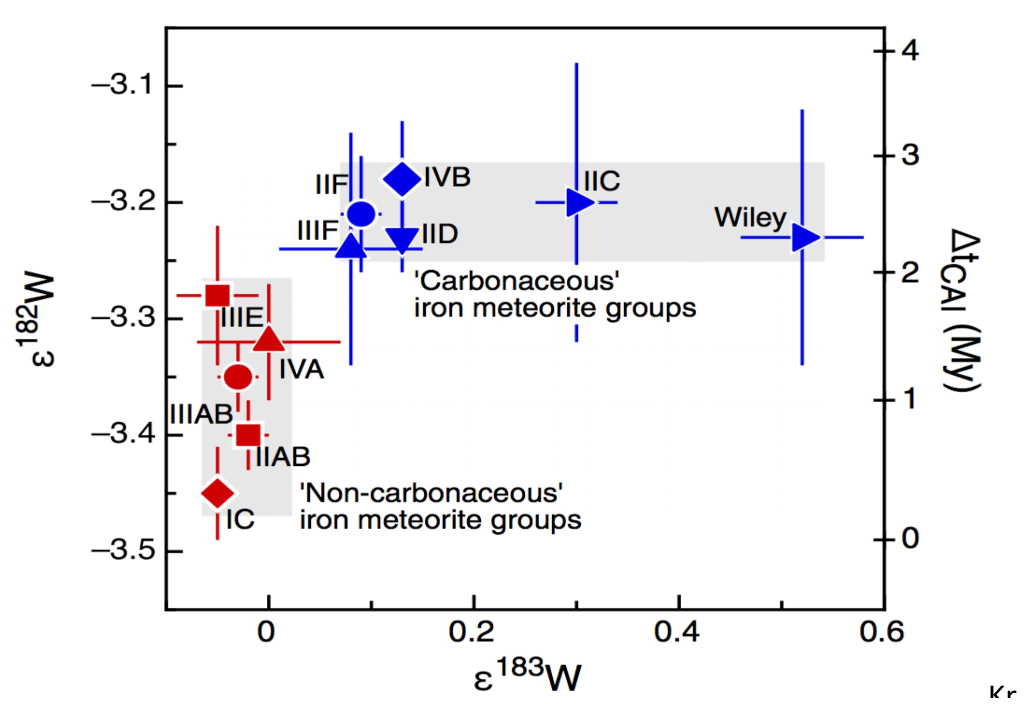
Diversity must come from formation & evolution processes

☆ Structure and chemistry of discs from ALMA + direct imaging observations in NIR, MIR

☆ Isotopic ratios from meteorites + in-situ measurements in Solar System



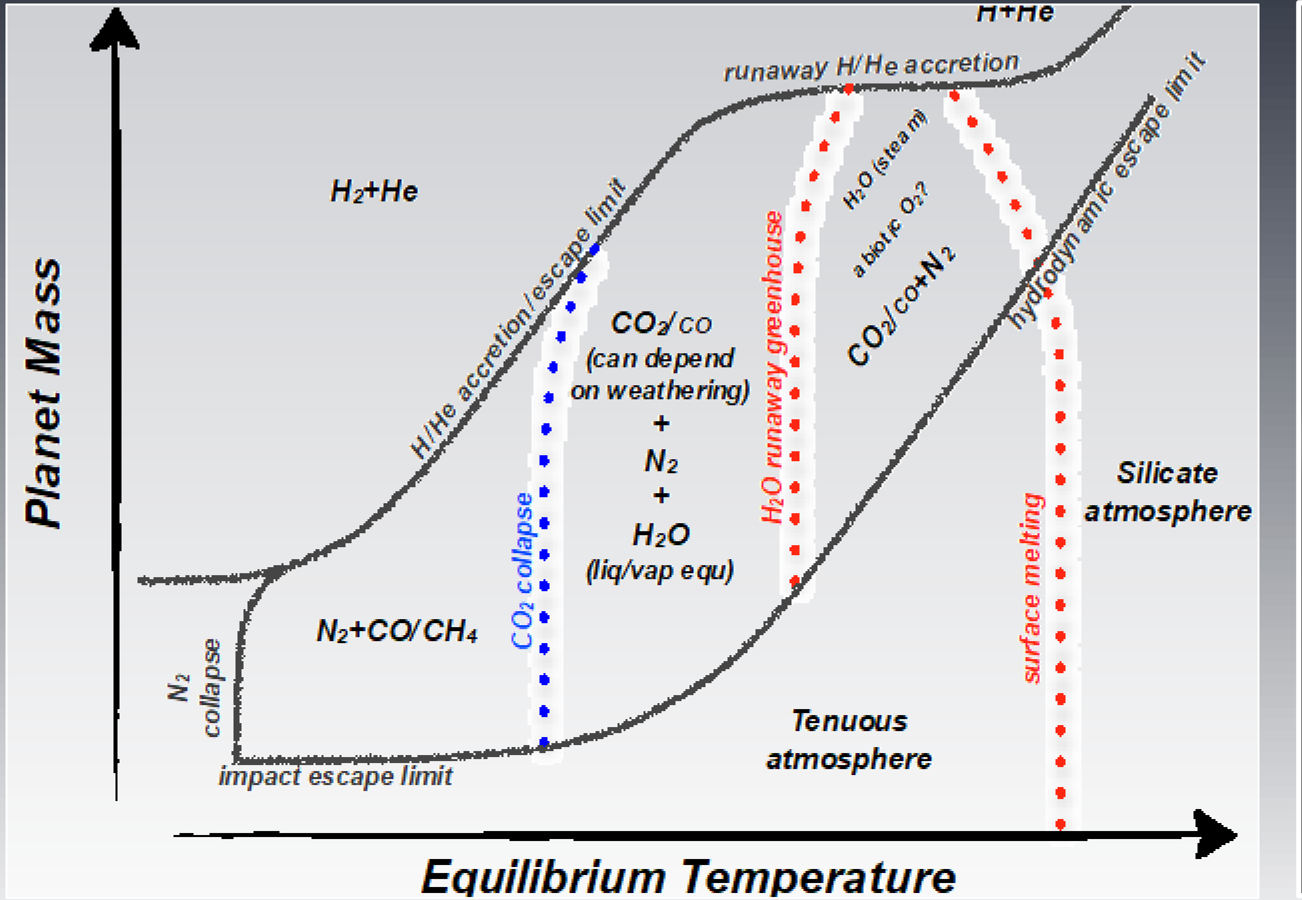
Credit ALMA

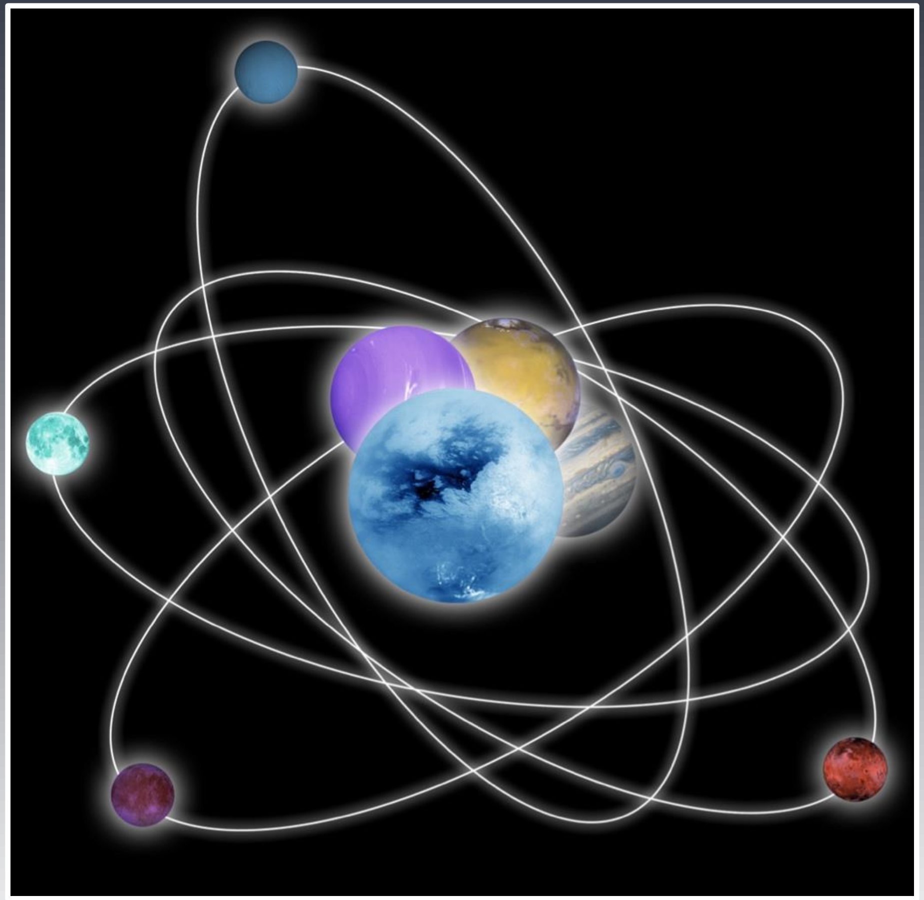


Kruijer et al. (2017); Desch et al. (2018)

Chemical diversity?

Correlation with other key parameters? Where are the transitions?

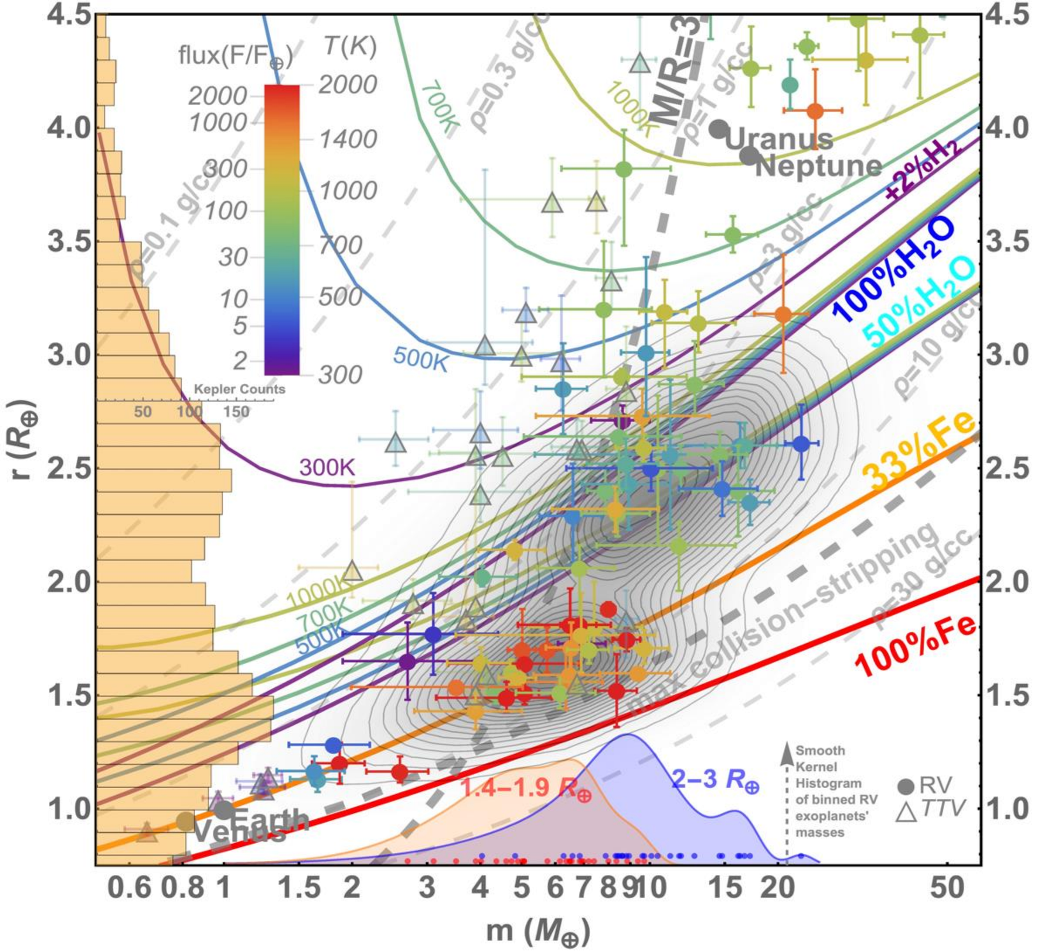




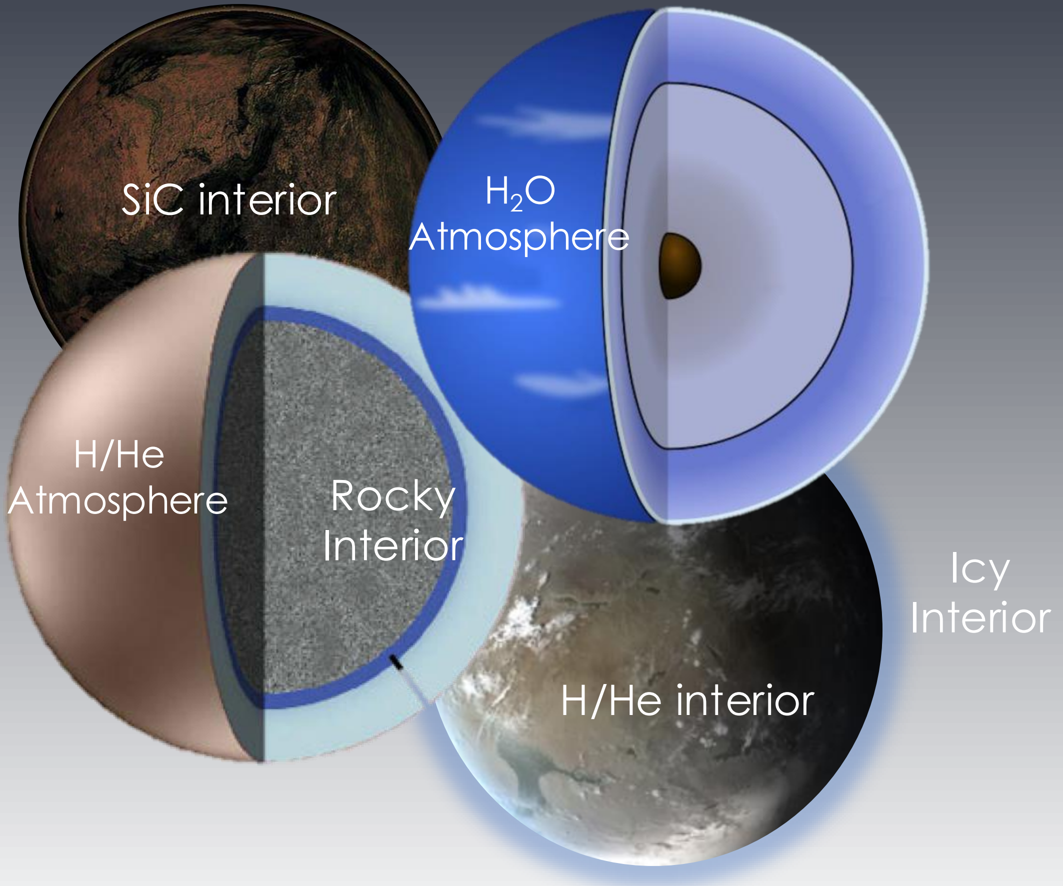
Forget and Leconte 2013

Planetary bulk composition

Many solutions compatible with the density data

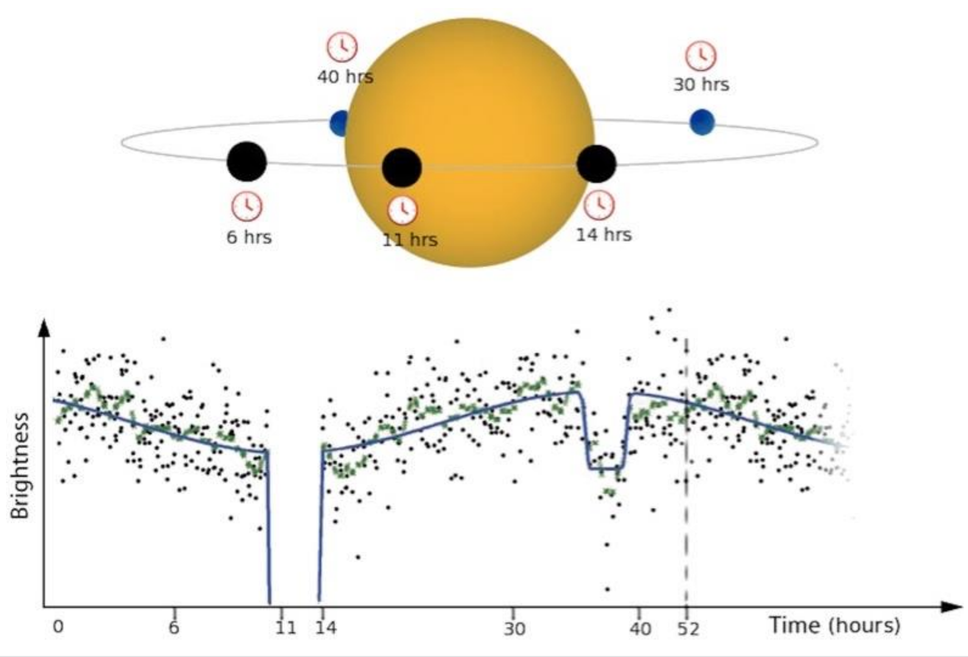


Zeng et al. 2019

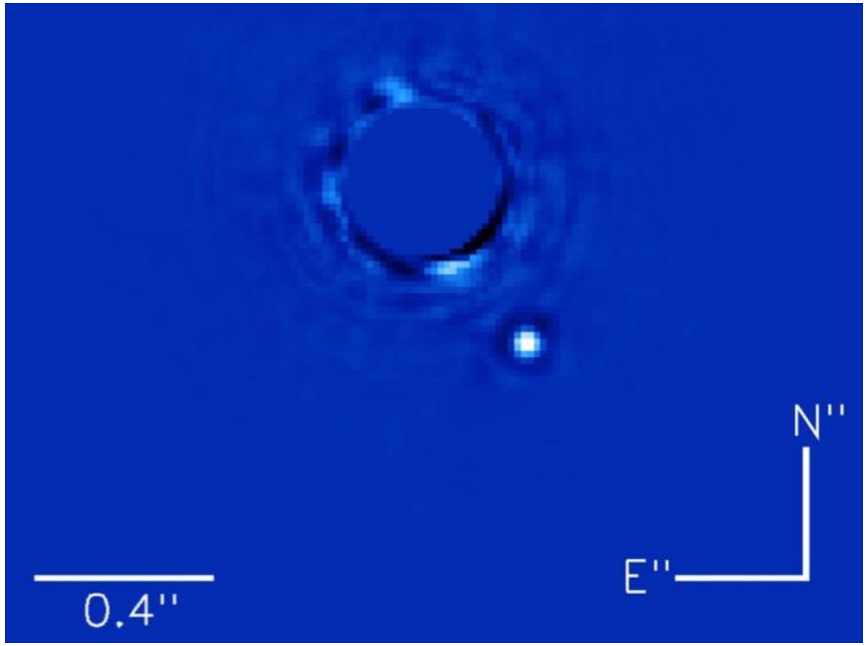


Atmospheric composition

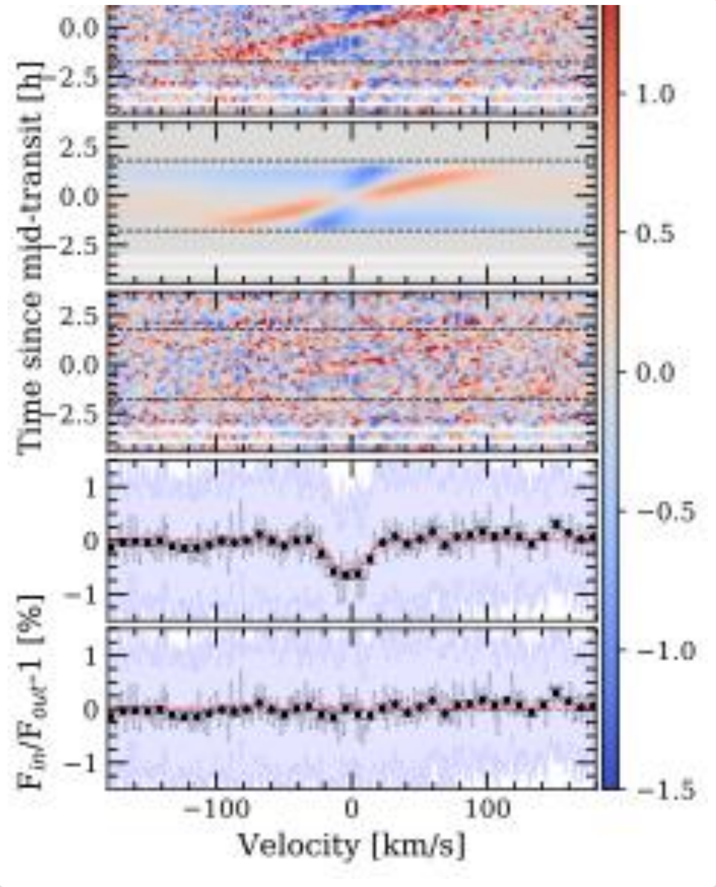
No more science fiction! Many different techniques…



Transit



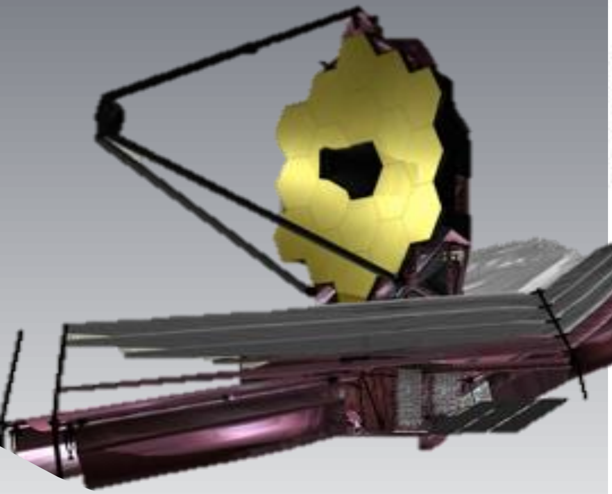
Direct imaging

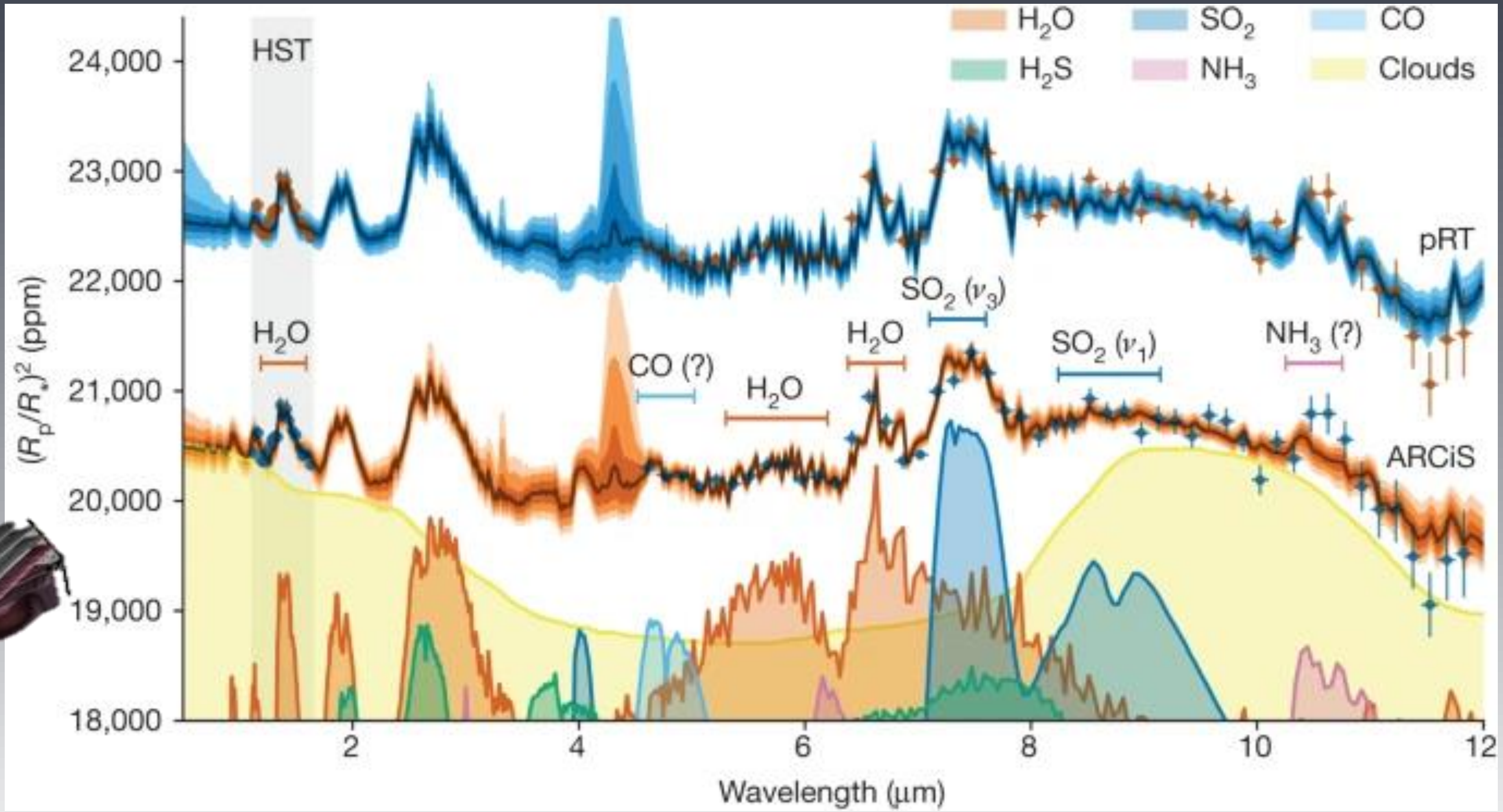


High-dispersion

Transit spectroscopy

WASP 107b



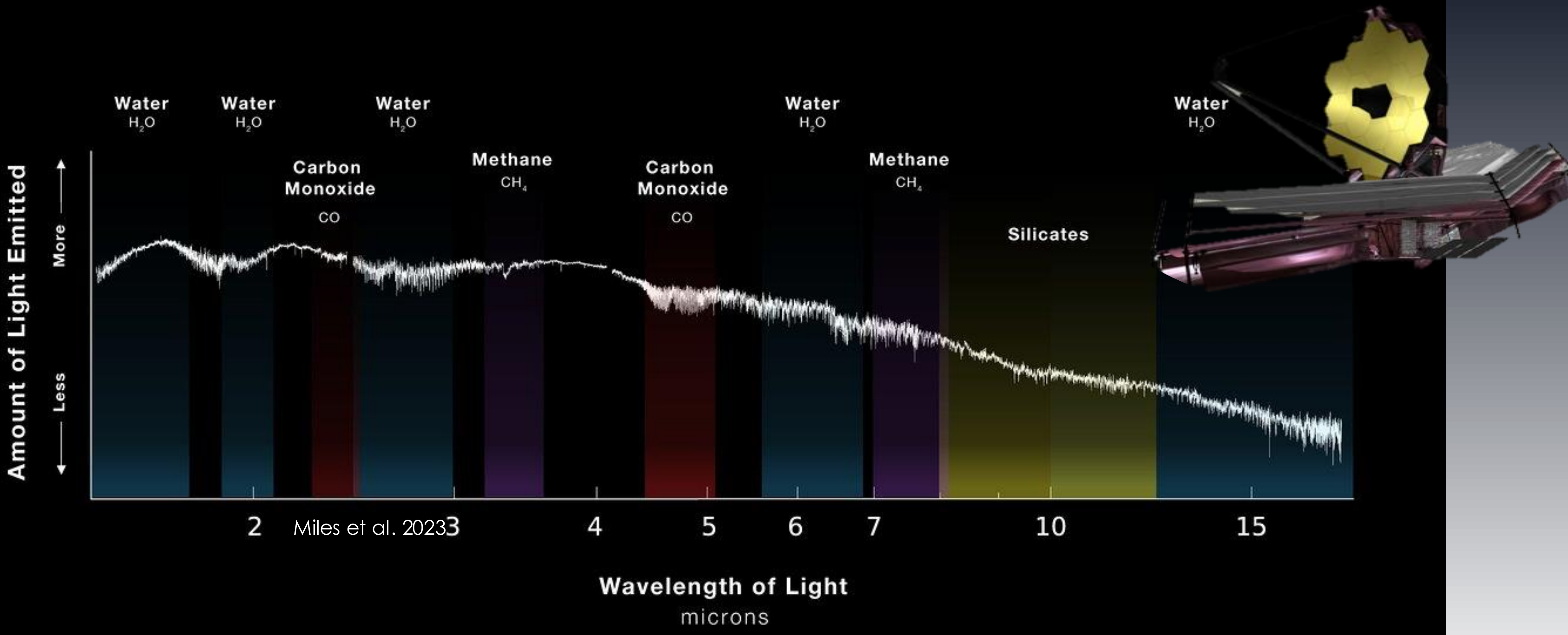


Dyrek et al. 2024

EXOPLANET VHS 1256 b

EMISSION SPECTRUM

NIRSpec and MIRI | IFU Medium-Resolution Spectroscopy



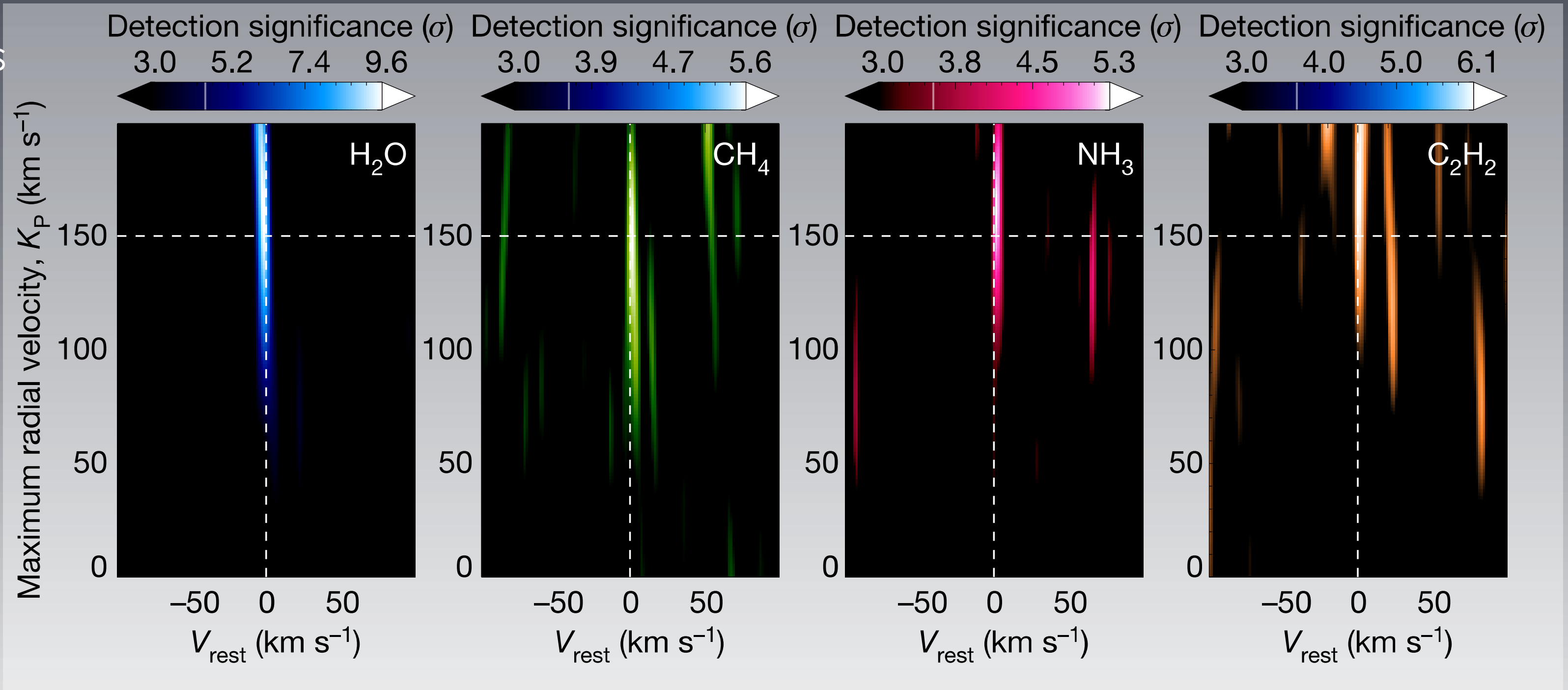
Miles et al. 2023

WEBB
SPACE TELESCOPE

Exo-atmospheres in HD

High-spectral resolution from the ground

Many atomic and ionic species
in gaseous planets' atmospheres

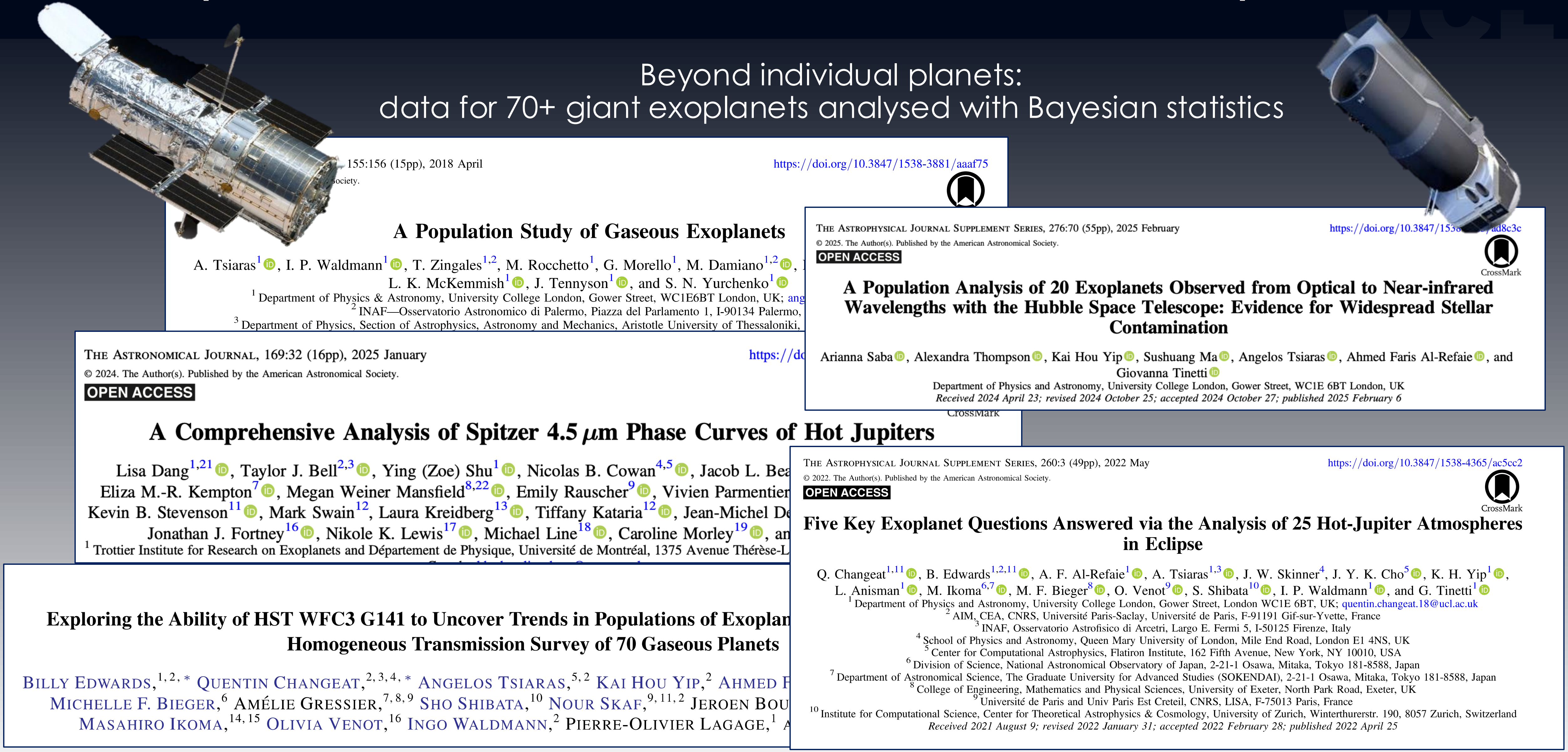


Ground based telescopes

Giacobbe et al. 2021

Population studies: H-rich atmospheres

Beyond individual planets:
data for 70+ giant exoplanets analysed with Bayesian statistics



155:156 (15pp), 2018 April https://doi.org/10.3847/1538-3881/aaaf75
ociety.

A Population Study of Gaseous Exoplanets

A. Tsiaras[1], I. P. Waldmann[1], T. Zingales[1,2], M. Rocchetto[1], G. Morello[1], M. Damiano[1,2],
L. K. McKemmish[1], J. Tennyson[1], and S. N. Yurchenko[1]
[1] Department of Physics & Astronomy, University College London, Gower Street, WC1E6BT London, UK; ang
[2] INAF—Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, I-90134 Palermo,
[3] Department of Physics, Section of Astrophysics, Astronomy and Mechanics, Aristotle University of Thessaloniki,

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The Astrophysical Journal Supplement Series, 276:70 (55pp), 2025 February https://doi.org/10.3847/153 ad8c3c
© 2025. The Author(s). Published by the American Astronomical Society.
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A Population Analysis of 20 Exoplanets Observed from Optical to Near-infrared Wavelengths with the Hubble Space Telescope: Evidence for Widespread Stellar Contamination

Arianna Saba, Alexandra Thompson, Kai Hou Yip, Sushuang Ma, Angelos Tsiaras, Ahmed Faris Al-Refaie, and
Giovanna Tinetti
Department of Physics and Astronomy, University College London, Gower Street, WC1E 6BT London, UK
Received 2024 April 23; revised 2024 October 25; accepted 2024 October 27; published 2025 February 6

The Astronomical Journal, 169:32 (16pp), 2025 January https://do
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A Comprehensive Analysis of Spitzer 4.5 μm Phase Curves of Hot Jupiters

Lisa Dang[1,21], Taylor J. Bell[2,3], Ying (Zoe) Shu[1], Nicolas B. Cowan[4,5], Jacob L. Bea
Eliza M.-R. Kempton[7], Megan Weiner Mansfield[8,22], Emily Rauscher[9], Vivien Parmentier
Kevin B. Stevenson[11], Mark Swain[12], Laura Kreidberg[13], Tiffany Kataria[12], Jean-Michel De
Jonathan J. Fortney[16], Nikole K. Lewis[17], Michael Line[18], Caroline Morley[19], an
[1] Trottier Institute for Research on Exoplanets and Département de Physique, Université de Montréal, 1375 Avenue Thérèse-L

Exploring the Ability of HST WFC3 G141 to Uncover Trends in Populations of Exoplan Homogeneous Transmission Survey of 70 Gaseous Planets

Billy Edwards,[1,2,*] Quentin Changeat,[2,3,4,*] Angelos Tsiaras,[5,2] Kai Hou Yip,[2] Ahmed F
Michelle F. Bieger,[6] Amélie Gressier,[7,8,9] Sho Shibata,[10] Nour Skaf,[9,11,2] Jeroen Bou
Masahiro Ikoma,[14,15] Olivia Venot,[16] Ingo Waldmann,[2] Pierre-Olivier Lagage,[1] A

The Astrophysical Journal Supplement Series, 260:3 (49pp), 2022 May https://doi.org/10.3847/1538-4365/ac5cc2
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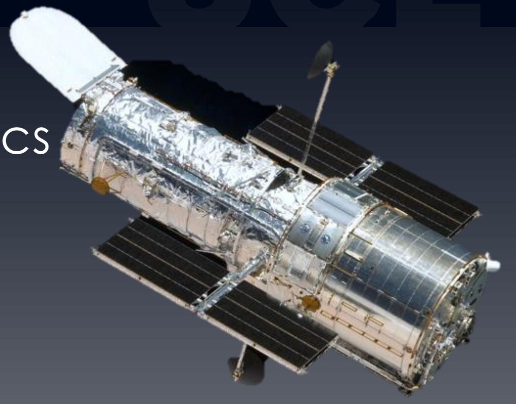
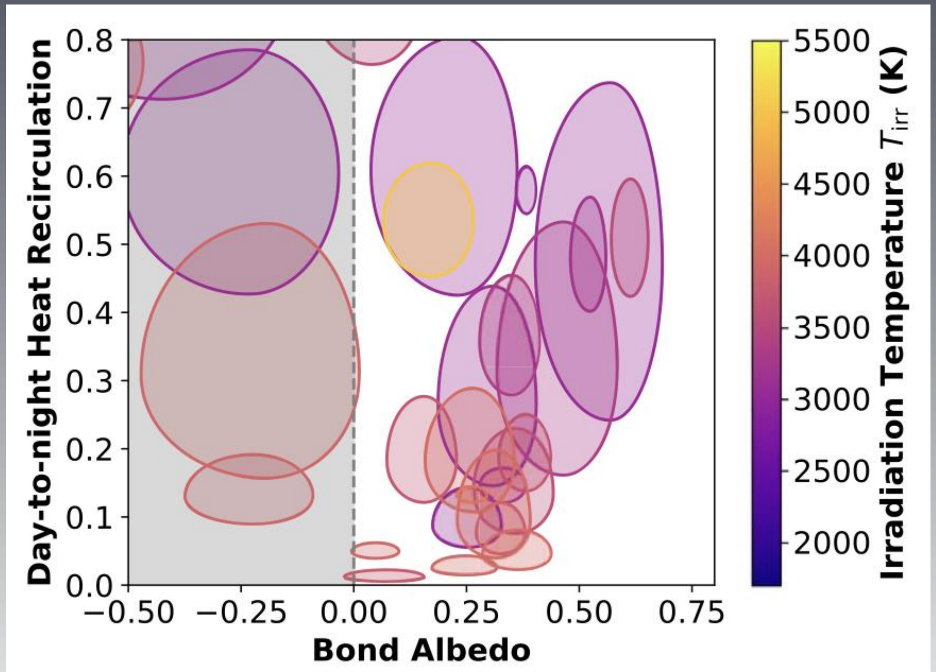
Five Key Exoplanet Questions Answered via the Analysis of 25 Hot-Jupiter Atmospheres in Eclipse

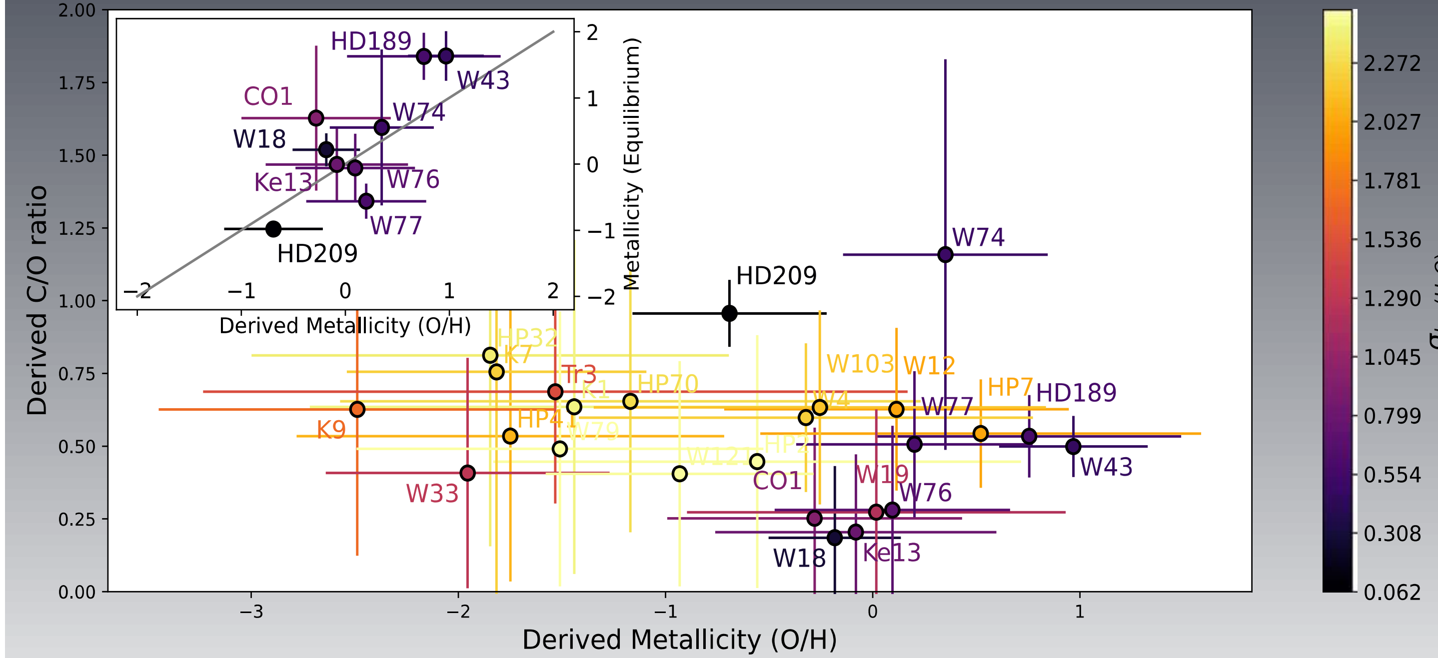
Q. Changeat[1,11], B. Edwards[1,2,11], A. F. Al-Refaie[1], A. Tsiaras[1,3], J. W. Skinner[4], J. Y. K. Cho[5], K. H. Yip[1],
L. Anisman[1], M. Ikoma[6,7], M. F. Bieger[8], O. Venot[9], S. Shibata[10], I. P. Waldmann[1], and G. Tinetti[1]
[1] Department of Physics and Astronomy, University College London, Gower Street, London WC1E 6BT, UK; quentin.changeat.18@ucl.ac.uk
[2] AIM, CEA, CNRS, Université Paris-Saclay, Université de Paris, F-91191 Gif-sur-Yvette, France
[3] INAF, Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy
[4] School of Physics and Astronomy, Queen Mary University of London, Mile End Road, London E1 4NS, UK
[5] Center for Computational Astrophysics, Flatiron Institute, 162 Fifth Avenue, New York, NY 10010, USA
[6] Division of Science, National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
[7] Department of Astronomical Science, The Graduate University for Advanced Studies (SOKENDAI), 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
[8] College of Engineering, Mathematics and Physical Sciences, University of Exeter, North Park Road, Exeter, UK
[9] Université de Paris and Univ Paris Est Creteil, CNRS, LISA, F-75013 Paris, France
[10] Institute for Computational Science, Center for Theoretical Astrophysics & Cosmology, University of Zurich, Winterthurerstr. 190, 8057 Zurich, Switzerland
Received 2021 August 9; revised 2022 January 31; accepted 2022 February 28; published 2022 April 25

Population studies: H-rich atmospheres



Beyond individual planets:
data for 70+ giant exoplanets analysed with Bayesian statistics

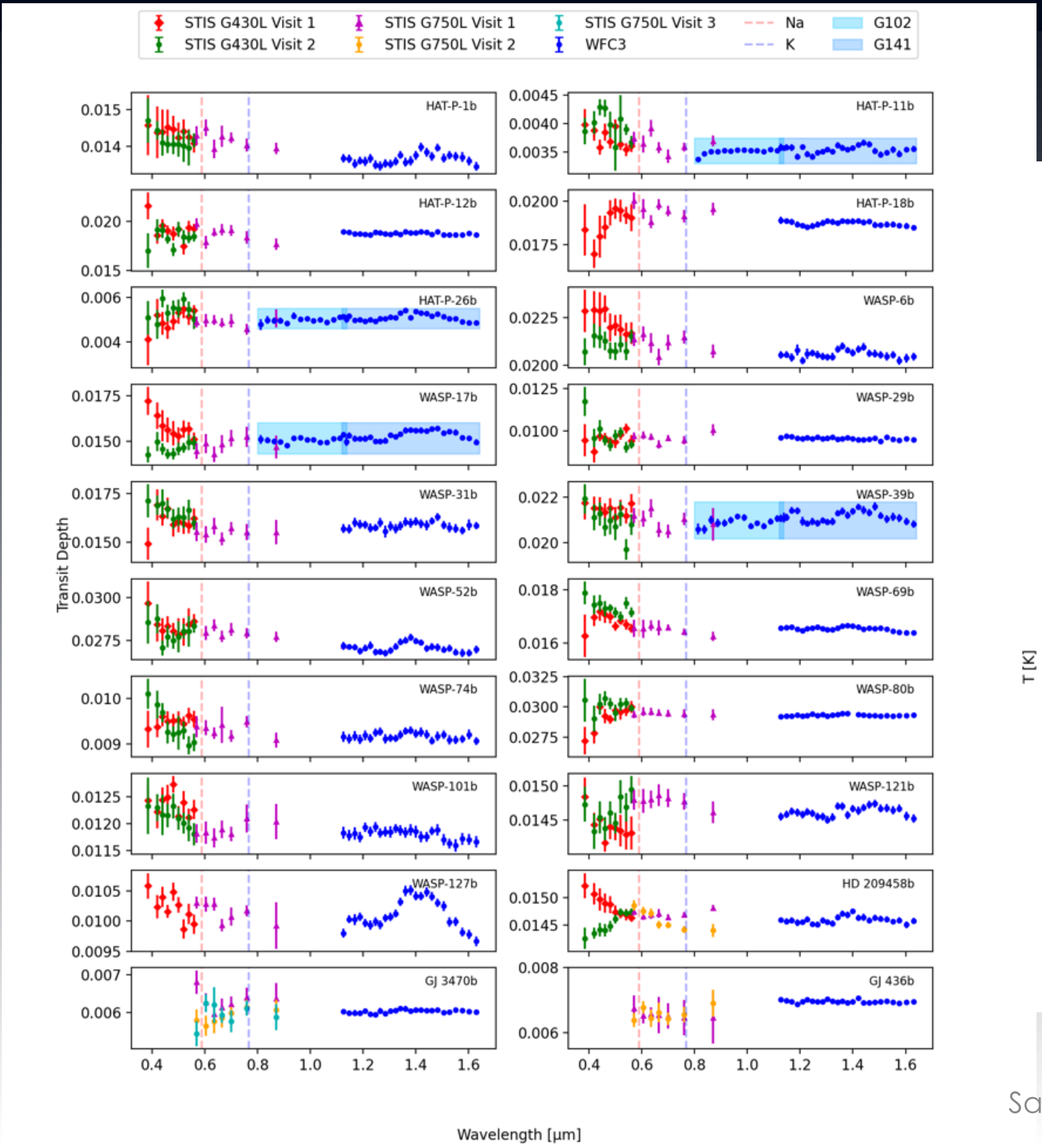


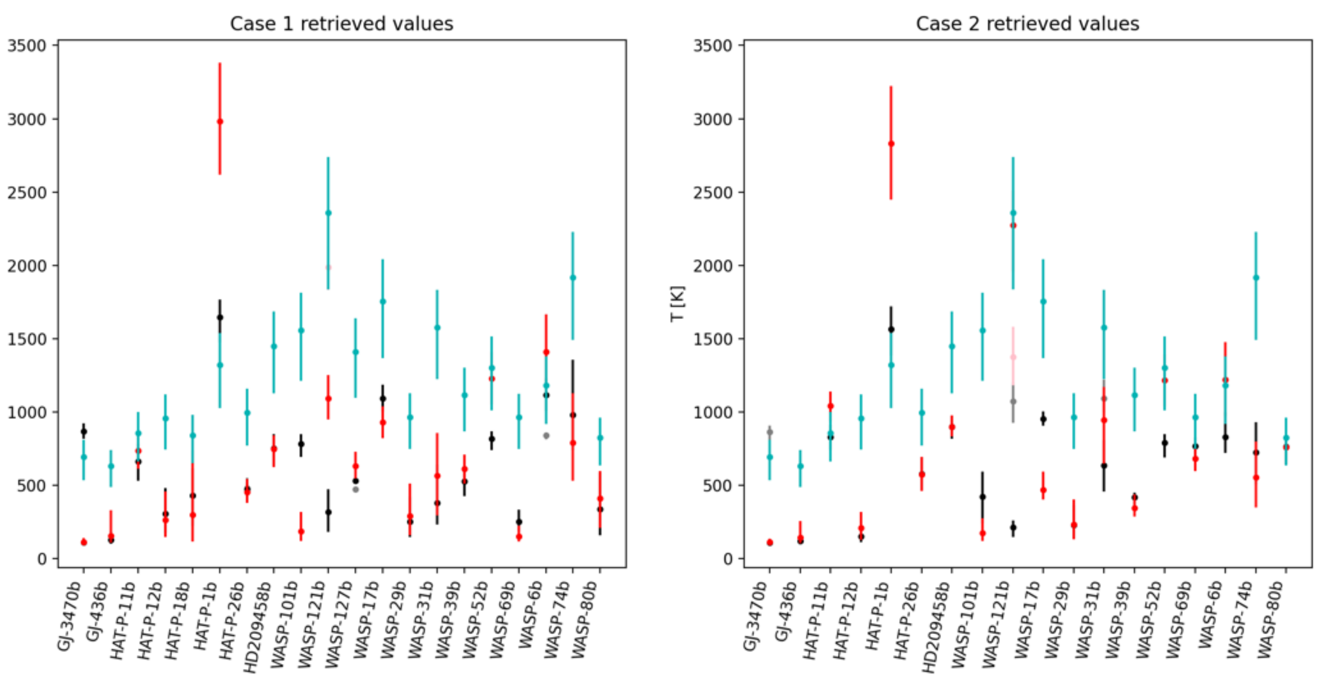


Edwards et al. 2022; Tsiaras et al. 2018; Changeat et al. 2022; Dang et al. 2024

Population studies: H-rich atmospheres

Stellar activity!!!!!!

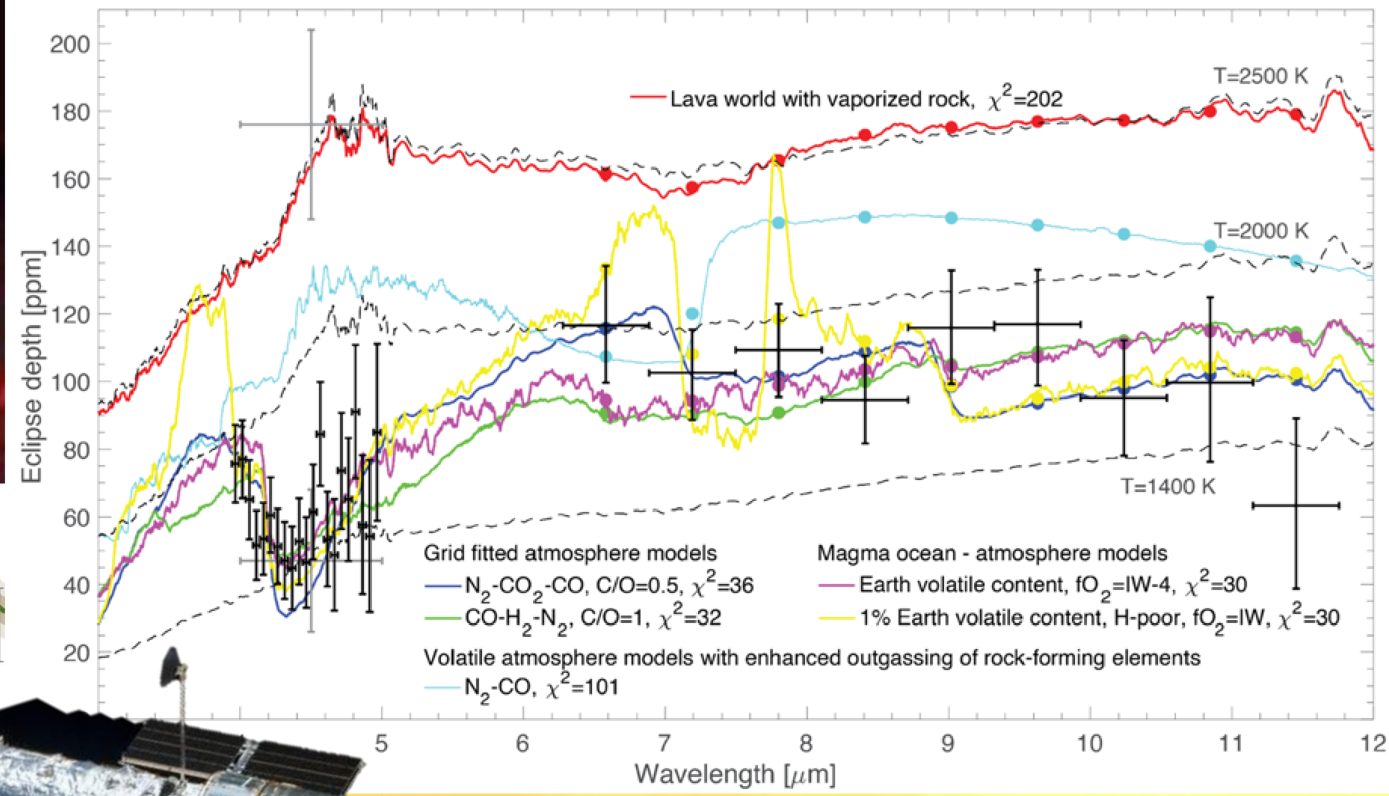




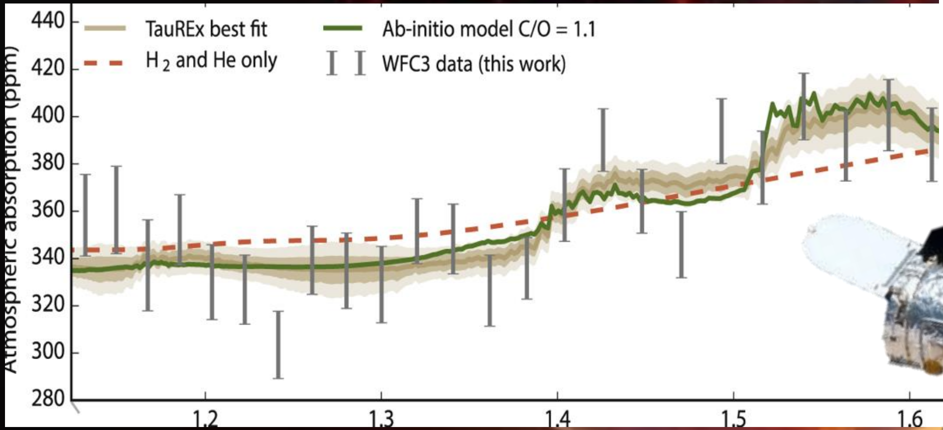
Saba et al. 2024; Thompson et al., 2023

55 Cnc e

2000 K hot! Magma ocean? There is an atmosphere…



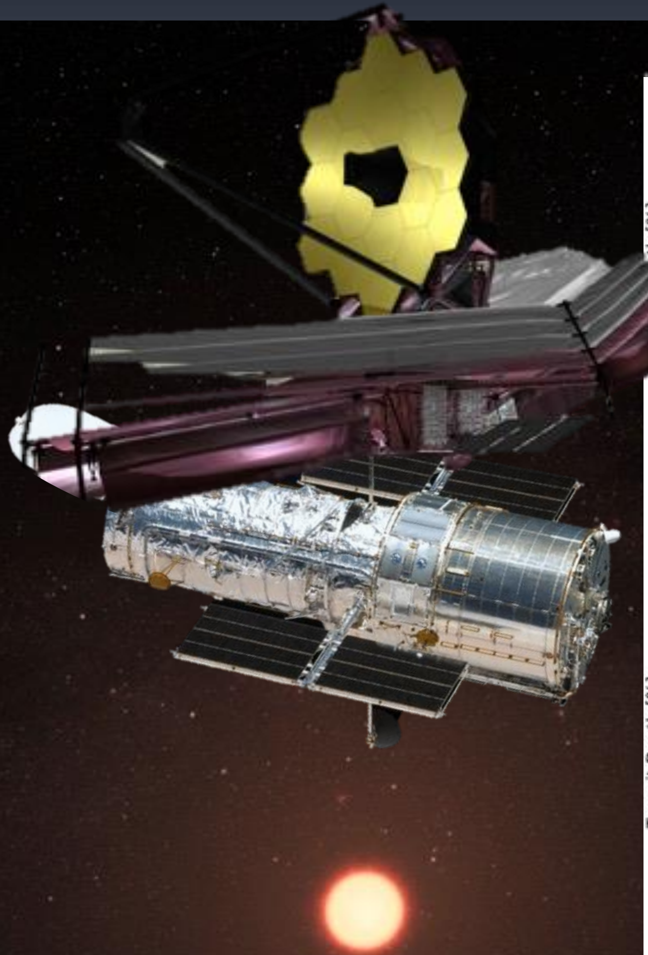
Hu et al 2024; Demory et al 2017

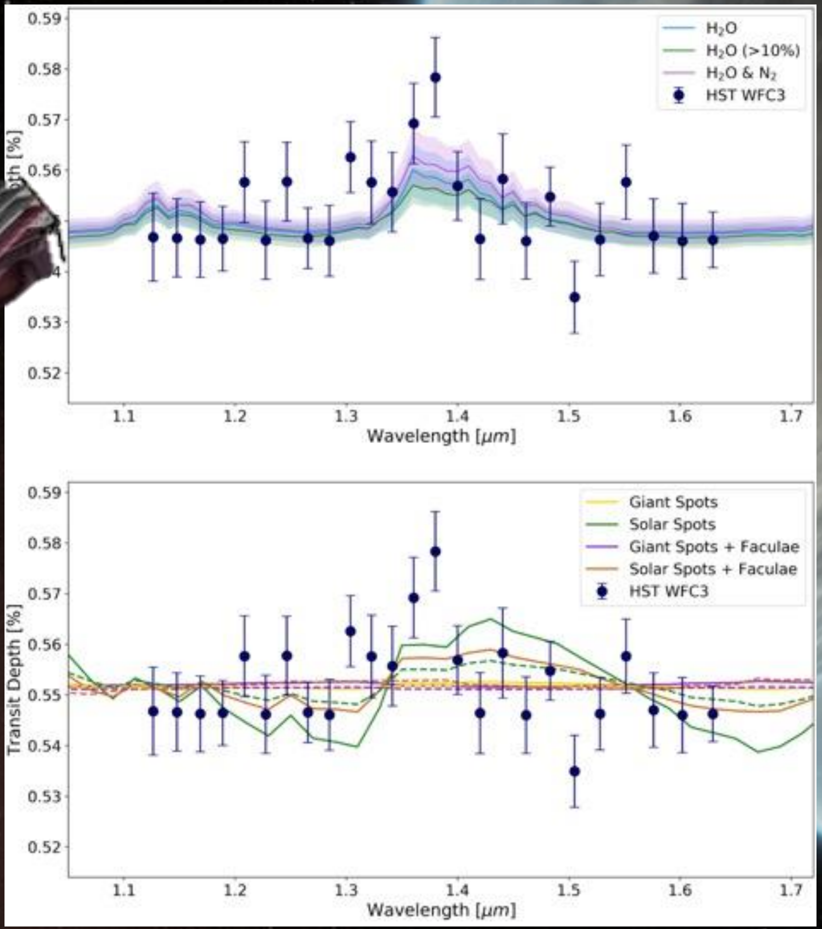


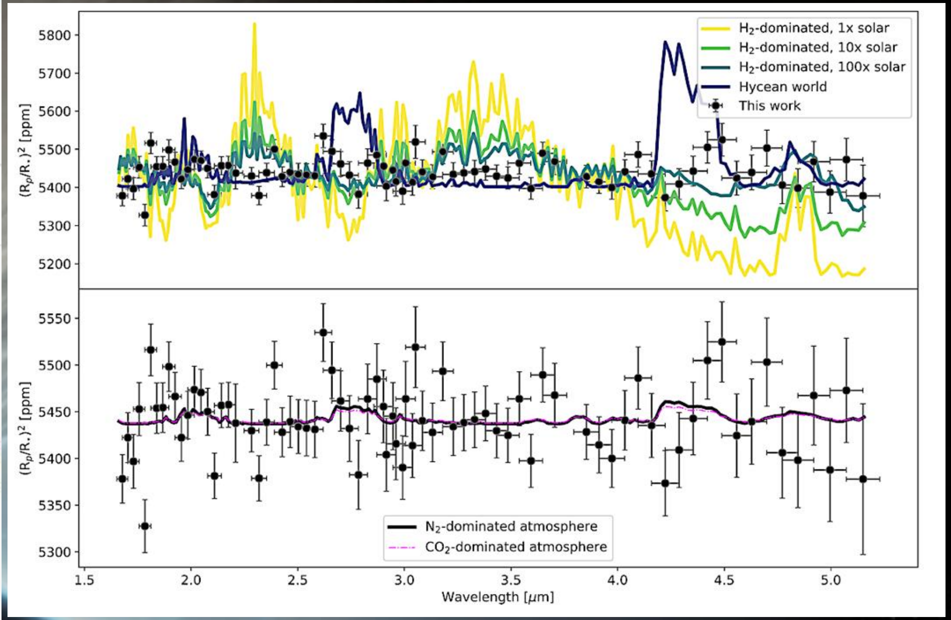
Tsiaras et al. 2018

LHS 1140b

T ~ 235 K; super-Earth (R = 1.7 $R_\oplus$) An atmosphere? Stellar activity?



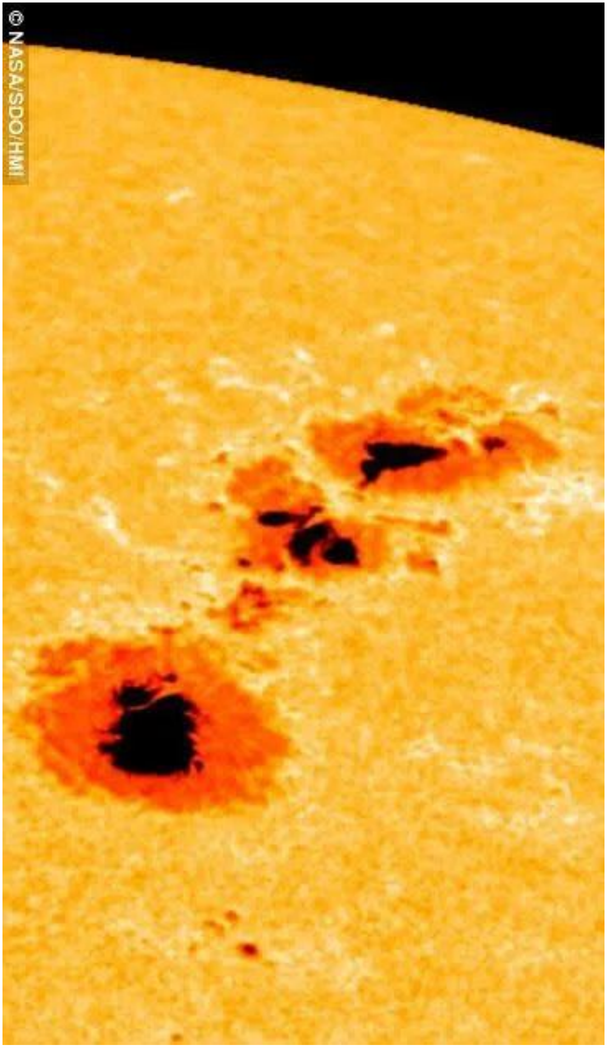




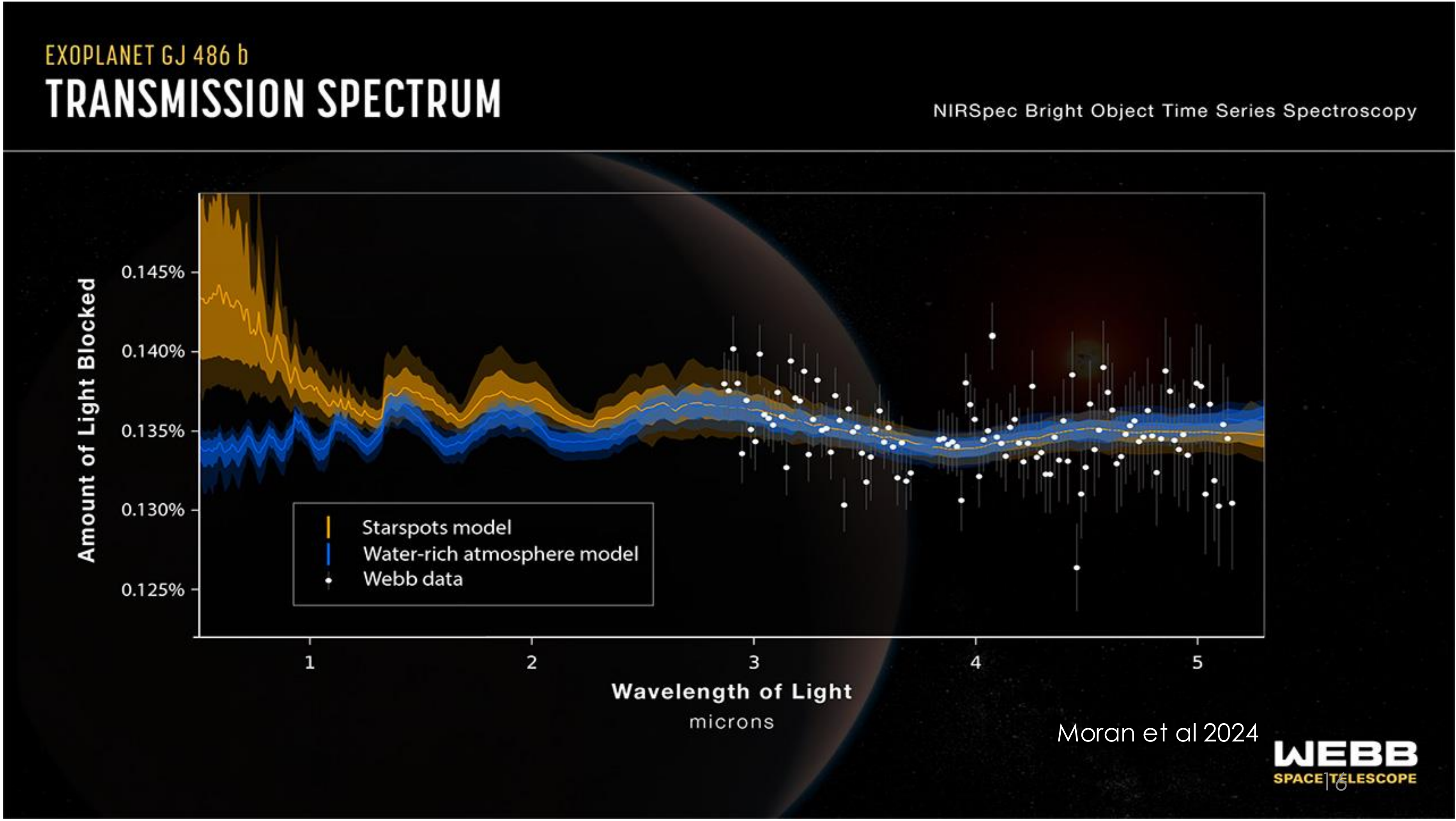
Edwards et al. 2020; Damiano et al. 2024

GJ 486b

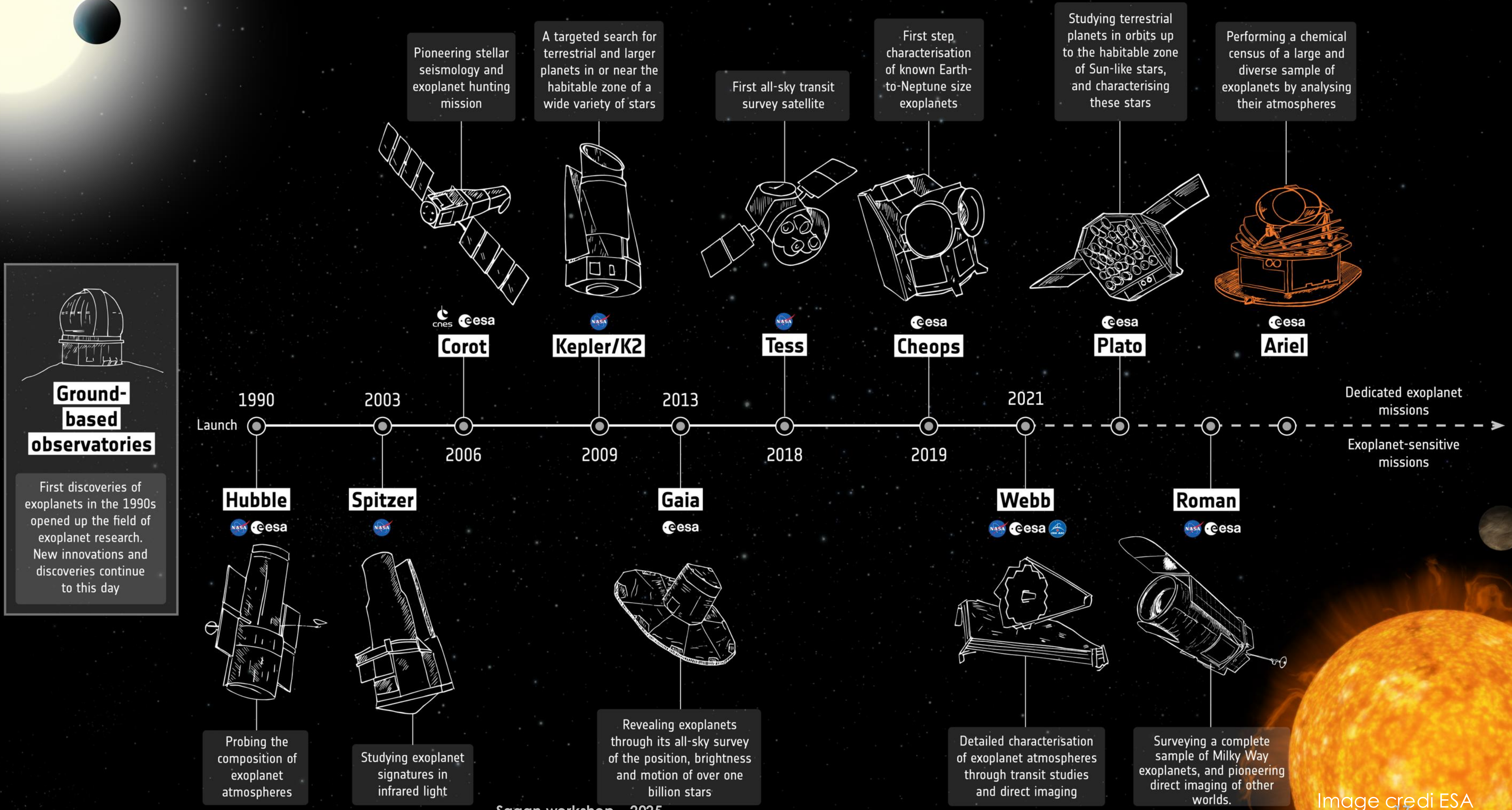
T ~ 700 K; super-Earth ($R = 1.3 R_{\oplus}$) An atmosphere? Stellar activity?



© NASA/SDO/HMI



Moran et al 2024



Ground-based observatories

First discoveries of exoplanets in the 1990s opened up the field of exoplanet research. New innovations and discoveries continue to this day

Launch

1990

Hubble

Probing the composition of exoplanet atmospheres

2003

Spitzer

Studying exoplanet signatures in infrared light

2006

Corot

Pioneering stellar seismology and exoplanet hunting mission

2009

Kepler/K2

A targeted search for terrestrial and larger planets in or near the habitable zone of a wide variety of stars

2013

Gaia

Revealing exoplanets through its all-sky survey of the position, brightness and motion of over one billion stars

2018

Tess

First all-sky transit survey satellite

2019

Cheops

First step characterisation of known Earth-to-Neptune size exoplanets

2021

Webb

Detailed characterisation of exoplanet atmospheres through transit studies and direct imaging

Plato

Studying terrestrial planets in orbits up to the habitable zone of Sun-like stars, and characterising these stars

Roman

Surveying a complete sample of Milky Way exoplanets, and pioneering direct imaging of other worlds.

Ariel

Performing a chemical census of a large and diverse sample of exoplanets by analysing their atmospheres

Dedicated exoplanet missions

Exoplanet-sensitive missions

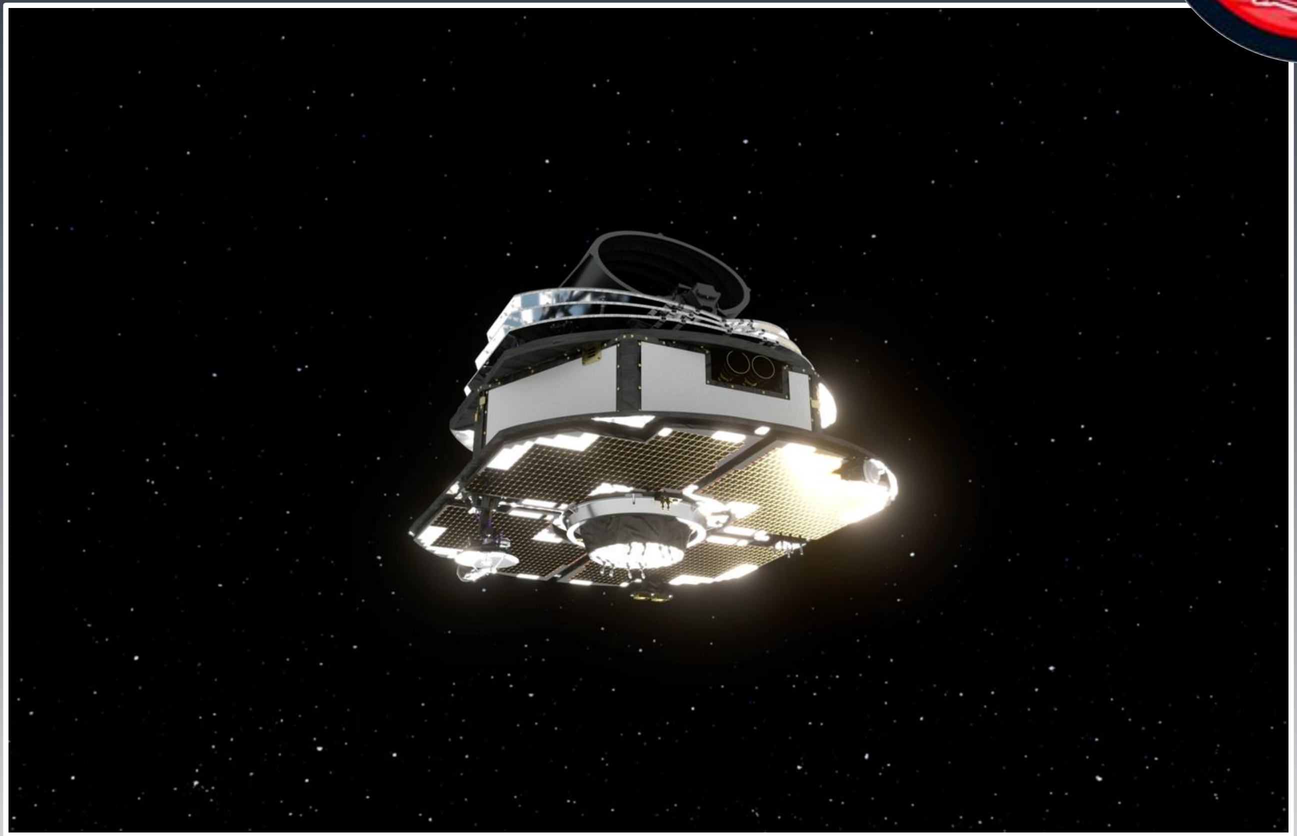
Image credi ESA

Ariel: a chemical survey

- Adopted as ESA M4 in Nov. 2020
- Launch to L2 in 2029

- 1m-class telescope
- Simultaneous coverage 0.5-7.8 μm

- ~1000 exoplanets observed
- Rocky + gaseous; 300-3000K;
- stars A-M



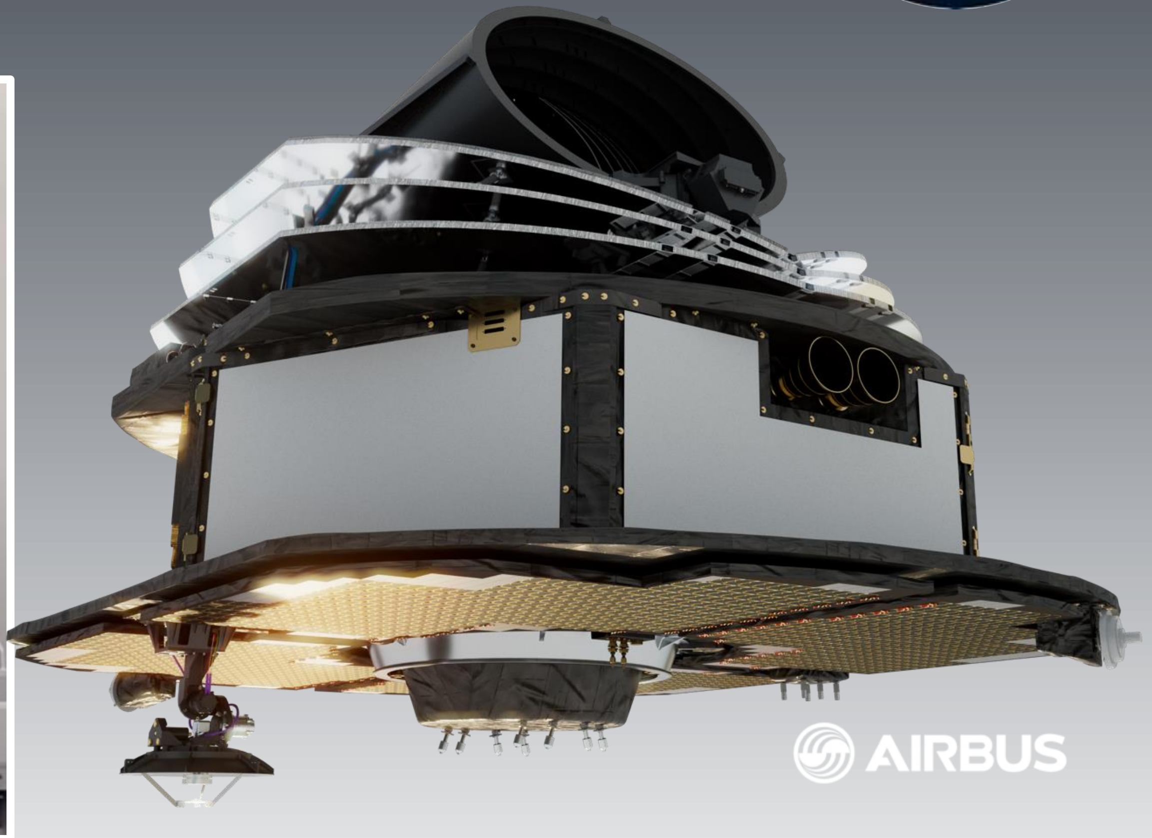
Ariel Definition Study Report – Tinetti et al. 2021, arXiv:2104.04824

Ariel spacecraft & payload

Payload delivered by a consortium of 16 ESA countries, NASA,JAXA,CSA

Ariel spacecraft & payload

Payload integrated at RAL in Didcot. Spacecraft from Airbus



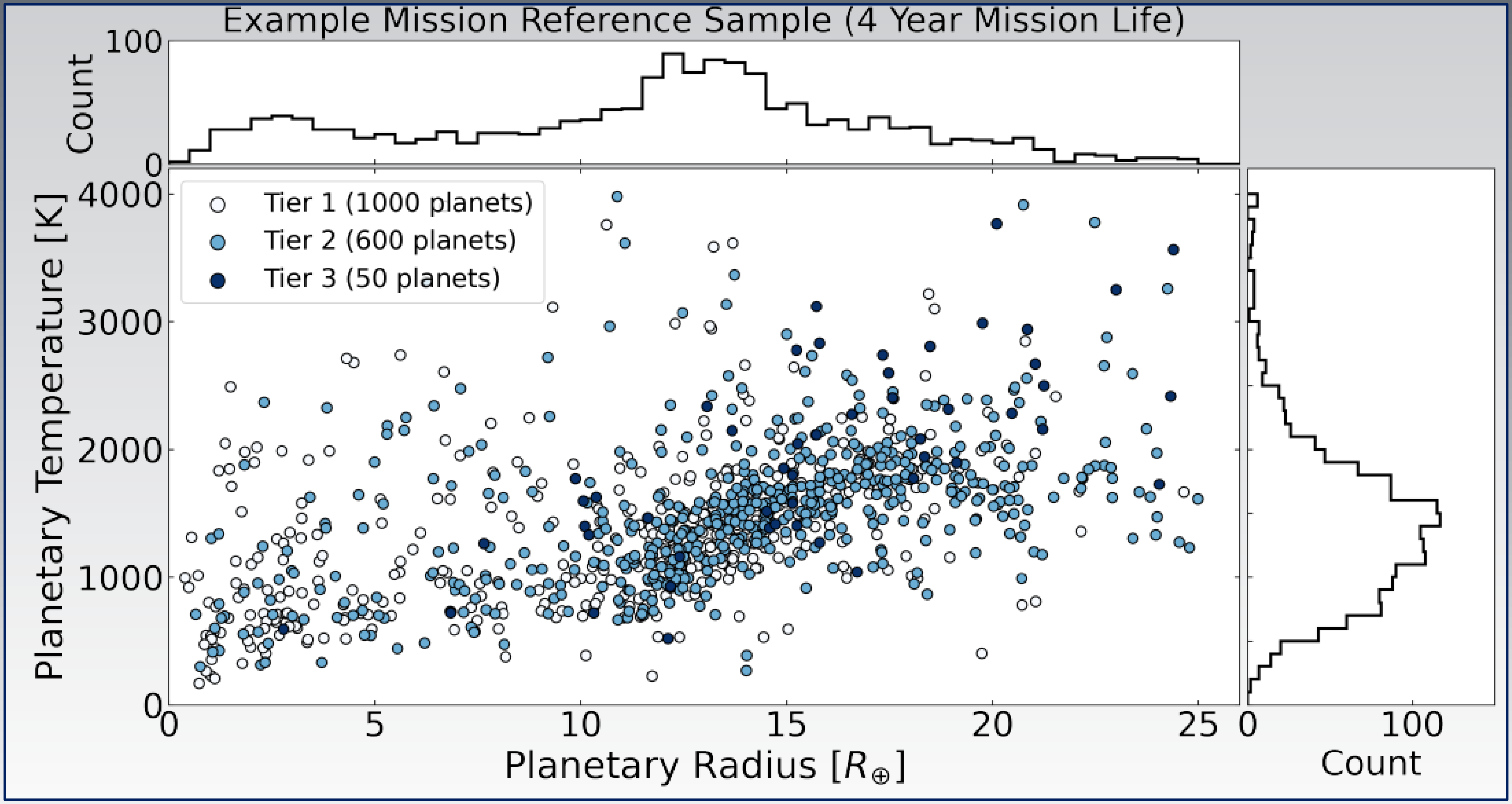
Ariel payload consortium

600+ scientists and engineers from 16 ESA countries + NASA, JAXA, and CSA

A mission is more than flying hardware…. there are people

Ariel target candidates (MCS)

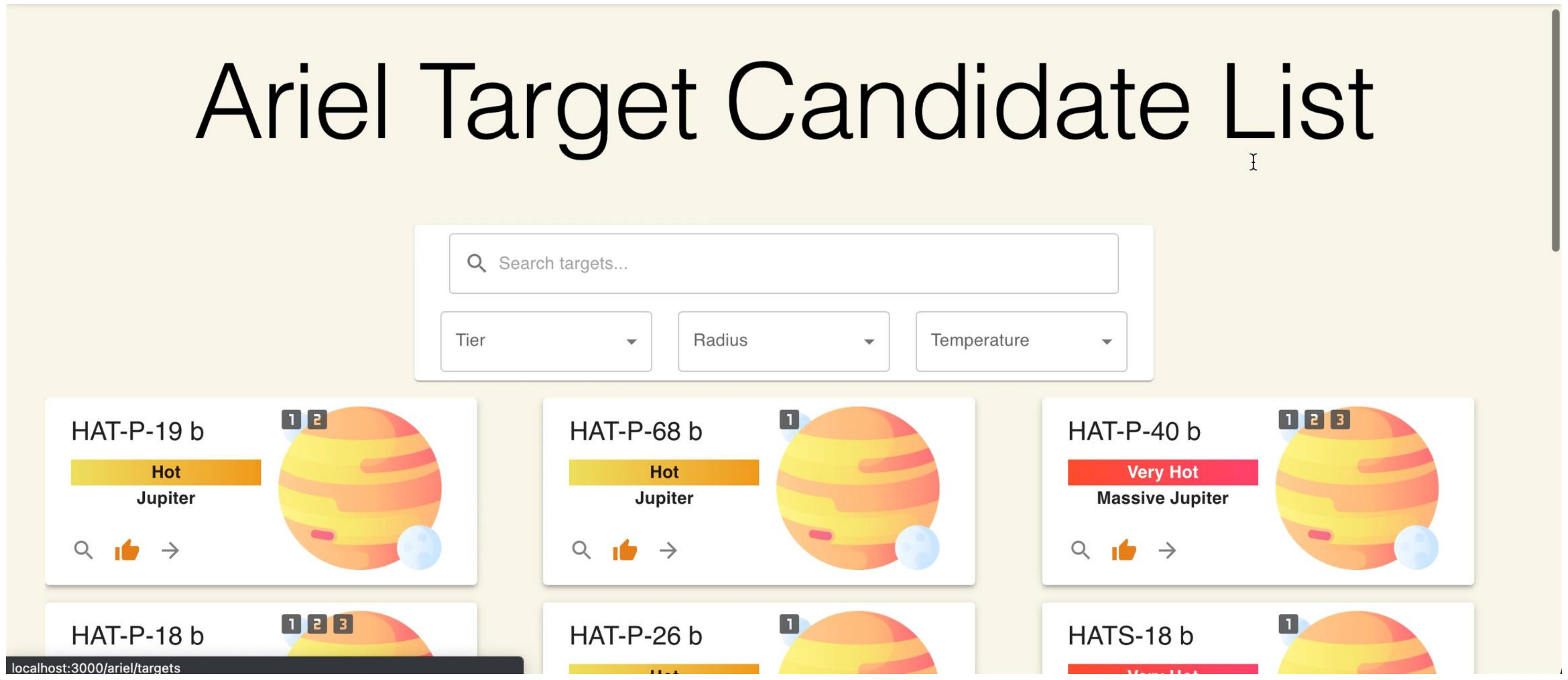
Ariel Mission Candidates Sample (MCS) available on Github



Edwards et al. 2022

Ariel target candidates

Catalogue Available soon through a new interactive, well maintained website



Ariel Target Candidate List

HAT-P-19 b
1 2
Hot
Jupiter

HAT-P-68 b
1
Hot
Jupiter

HAT-P-40 b
1 2 3
Very Hot
Massive Jupiter

HAT-P-18 b
1 2 3

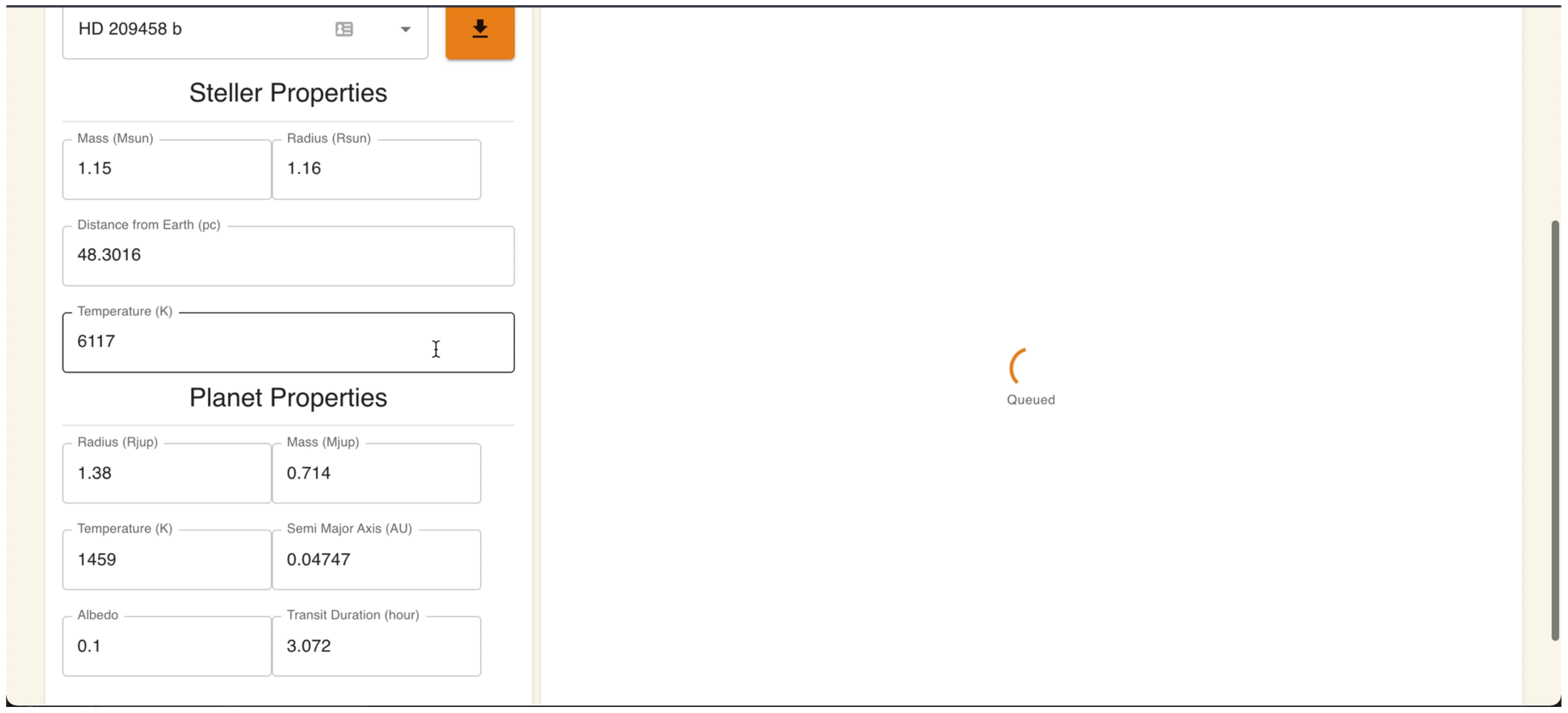
HAT-P-26 b
1

HATS-18 b
1

Credit: Al-Refaie & Nambiyath Govindan

Ariel target candidates

Catalogue Available soon through a new interactive, well maintained website



HD 209458 b

Steller Properties

Mass (Msun): 1.15

Radius (Rsun): 1.16

Distance from Earth (pc): 48.3016

Temperature (K): 6117

Planet Properties

Radius (Rjup): 1.38

Mass (Mjup): 0.714

Temperature (K): 1459

Semi Major Axis (AU): 0.04747

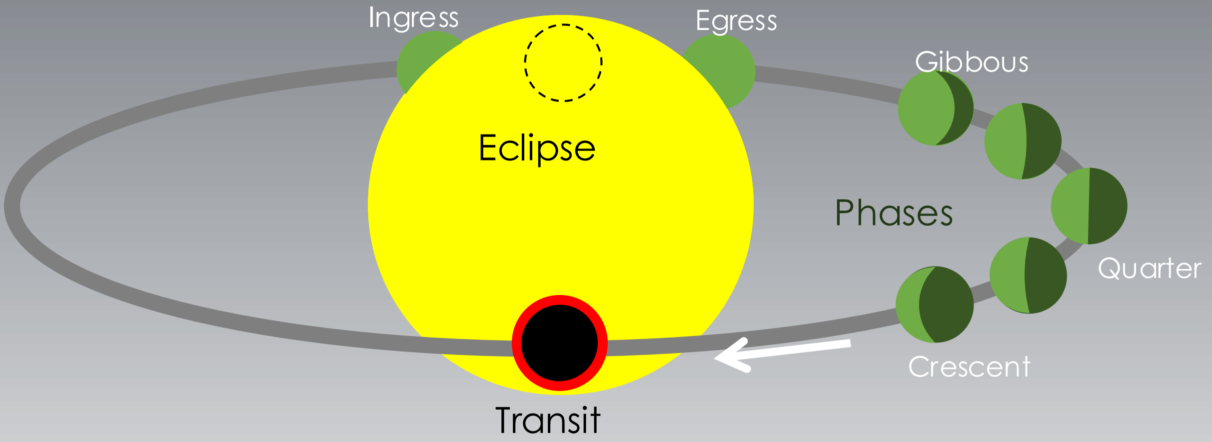
Albedo: 0.1

Transit Duration (hour): 3.072

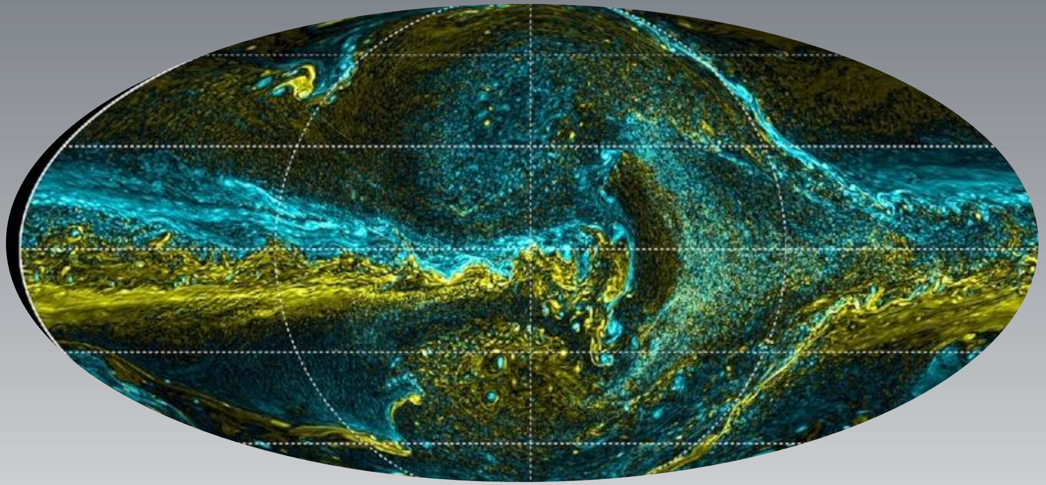
Mugnai et al, 2022

Planets are 4D complex objects

Variability in space and time: phase-curves & repeated observations



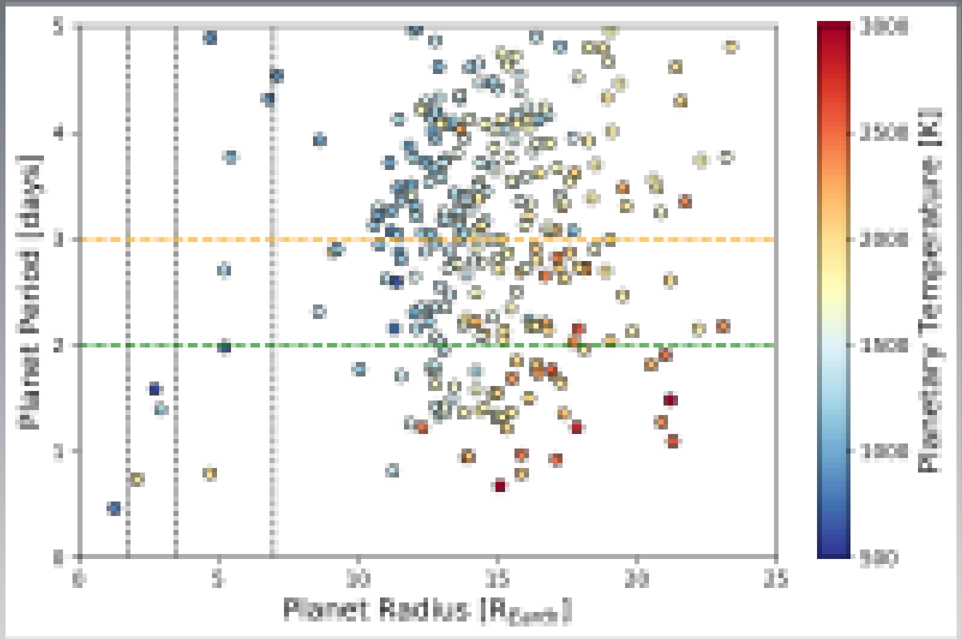
Cowan (2014)

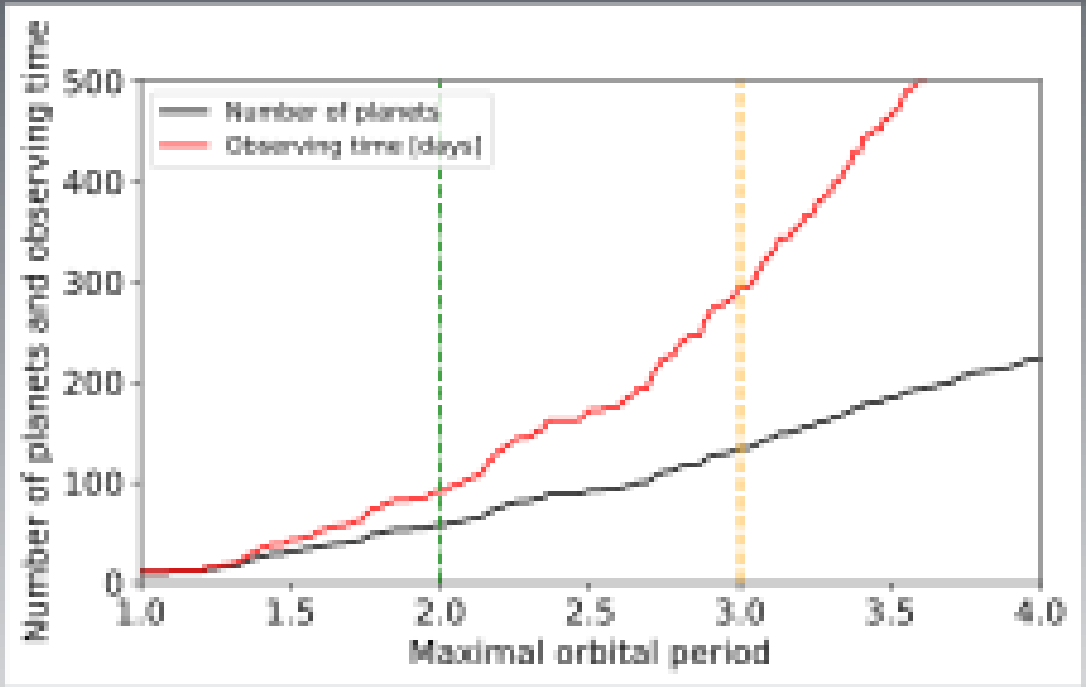


Skinner & Cho, 2022

Planets are 4D complex objects

Variability in space and time: More phase-curves….





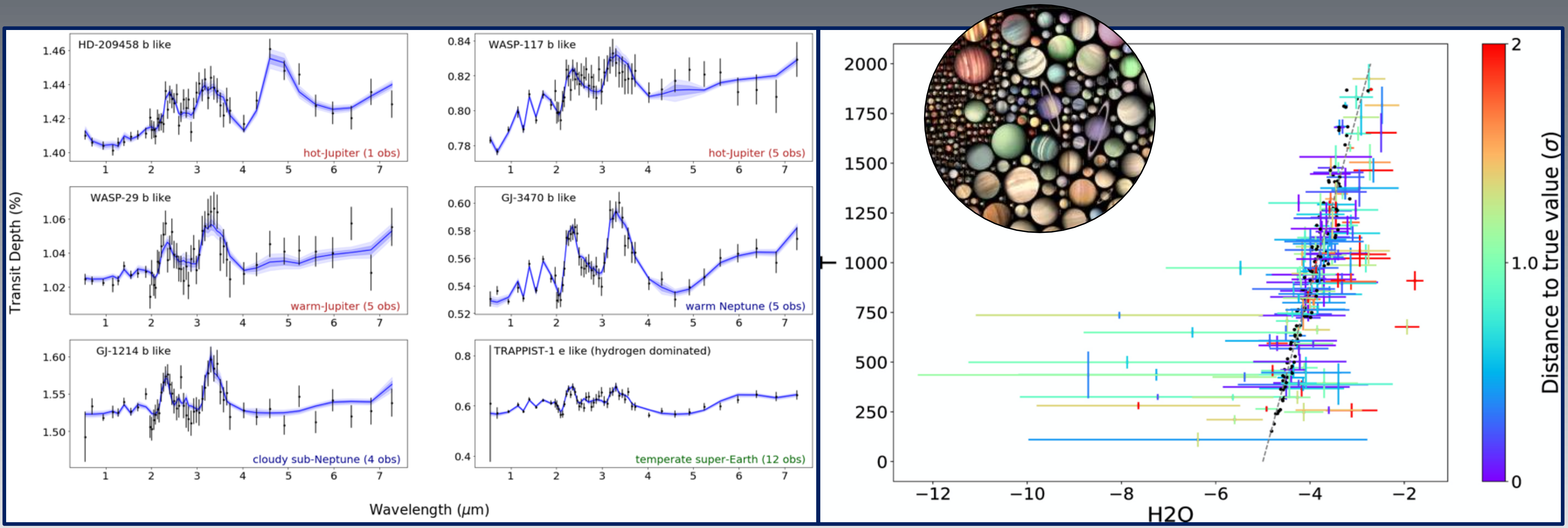
Charnay, Dang, Cowan et al 2025

Conclusion

All three of our analyses lead to similar conclusions. By dedicating $\sim 20 - 25\%$ of the lifetime of the Ariel mission, we could observe $\sim 100 - 150$ exoplanets if imposing constraints on phase curve

Chemical survey

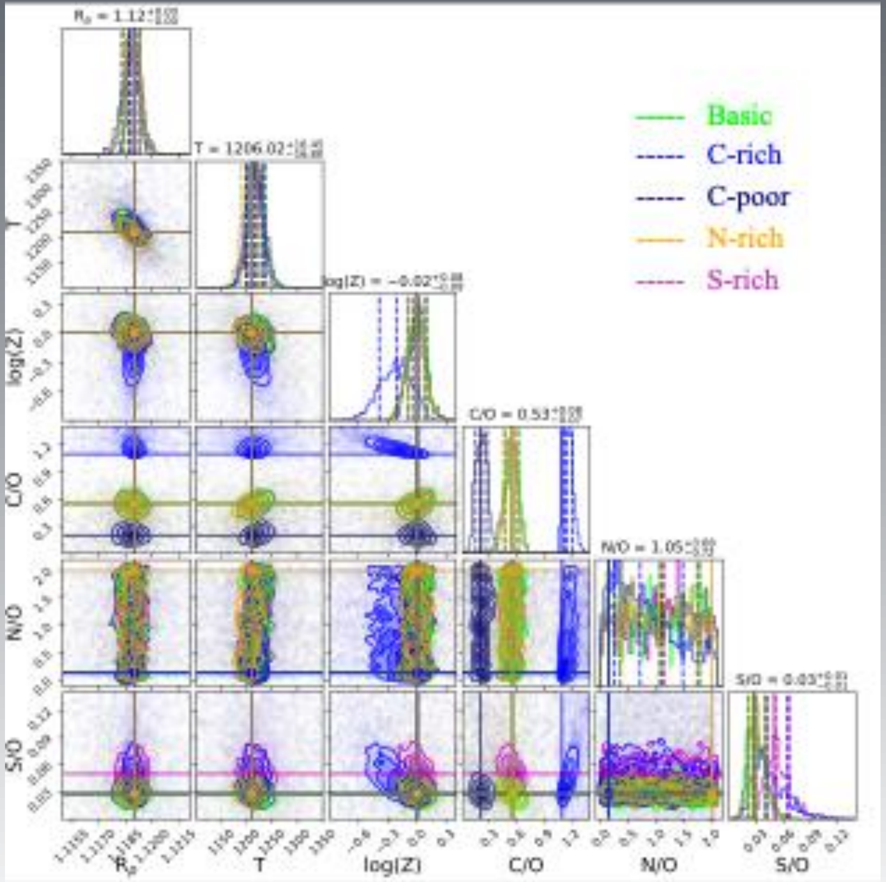
Searching for chemical and cloud transitions

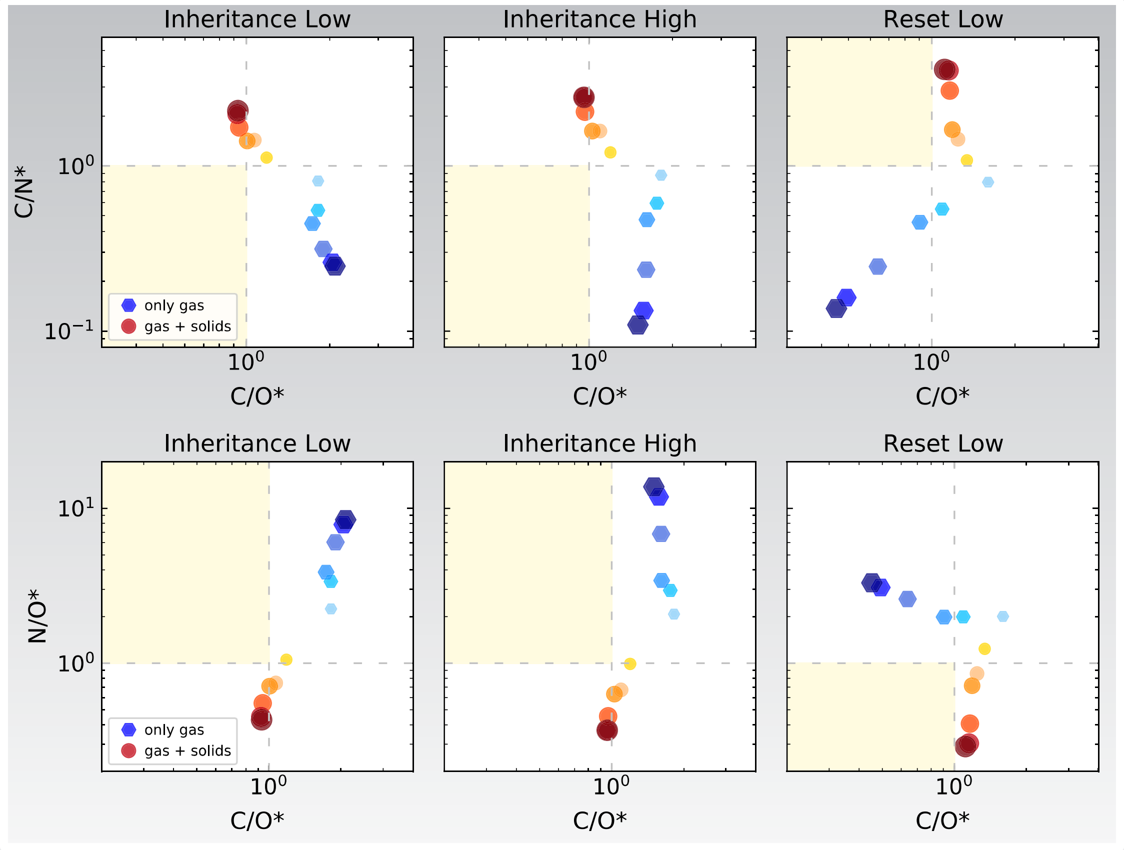


Changeat et al. 2020; see also Mugnai et al 2022, Bocchieri et al., 2024; Ma et al. in prep.

Link to planet formation

Ariel ability to detect elemental ratios in giant planets' atmospheres: beyond C/O

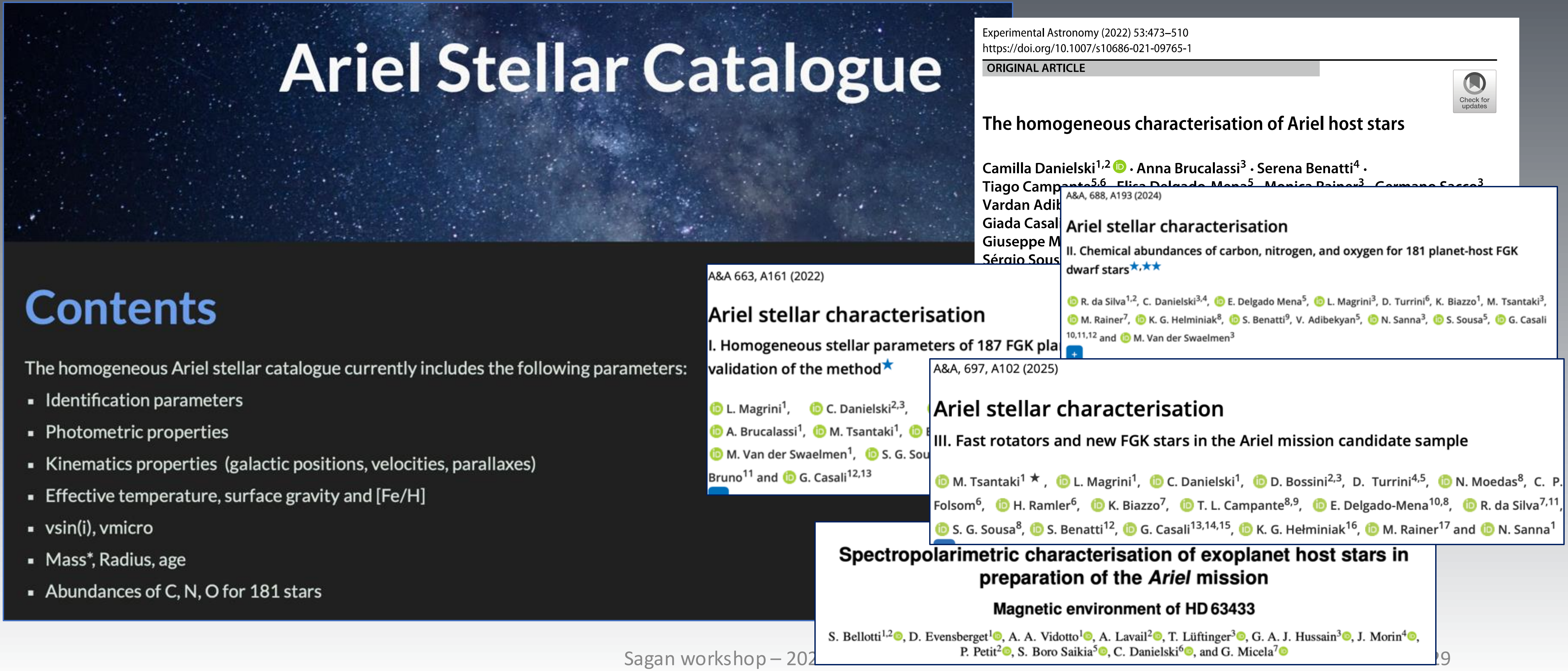




Fang et al. 2023

Pacetti et al 2022; Turrini et al. 2021

Focus on Ariel targets: stars



Ariel Stellar Catalogue

Contents

The homogeneous Ariel stellar catalogue currently includes the following parameters:

- Identification parameters
- Photometric properties
- Kinematics properties (galactic positions, velocities, parallaxes)
- Effective temperature, surface gravity and [Fe/H]
- vsin(i), vmicro
- Mass*, Radius, age
- Abundances of C, N, O for 181 stars

Experimental Astronomy (2022) 53:473–510
https://doi.org/10.1007/s10686-021-09765-1

ORIGINAL ARTICLE

Check for updates

The homogeneous characterisation of Ariel host stars

Camilla Danielski[1,2] · Anna Brucalassi[3] · Serena Benatti[4] ·
Tiago Campante[5,6] · Elisa Delgado Mena[5] · Monica Rainer[3] · Germano Sacco[3]
Vardan Adib
Giada Casal
Giuseppe M
Sérgio Sous

A&A 663, A161 (2022)

Ariel stellar characterisation

I. Homogeneous stellar parameters of 187 FGK pla
validation of the method★

L. Magrini[1], C. Danielski[2,3],
A. Brucalassi[1], M. Tsantaki[1],
M. Van der Swaelmen[1], S. G. Sou
Bruno[11] and G. Casali[12,13]

A&A, 688, A193 (2024)

Ariel stellar characterisation

II. Chemical abundances of carbon, nitrogen, and oxygen for 181 planet-host FGK dwarf stars★,★★

R. da Silva[1,2], C. Danielski[3,4], E. Delgado Mena[5], L. Magrini[3], D. Turrini[6], K. Biazzo[1], M. Tsantaki[3], M. Rainer[7], K. G. Helminiak[8], S. Benatti[9], V. Adibekyan[5], N. Sanna[3], S. Sousa[5], G. Casali[10,11,12] and M. Van der Swaelmen[3]

A&A, 697, A102 (2025)

Ariel stellar characterisation

III. Fast rotators and new FGK stars in the Ariel mission candidate sample

M. Tsantaki[1] ★ , L. Magrini[1], C. Danielski[1], D. Bossini[2,3], D. Turrini[4,5], N. Moedas[8], C. P. Folsom[6], H. Ramler[6], K. Biazzo[7], T. L. Campante[8,9], E. Delgado-Mena[10,8], R. da Silva[7,11], S. G. Sousa[8], S. Benatti[12], G. Casali[13,14,15], K. G. Hełminiak[16], M. Rainer[17] and N. Sanna[1]

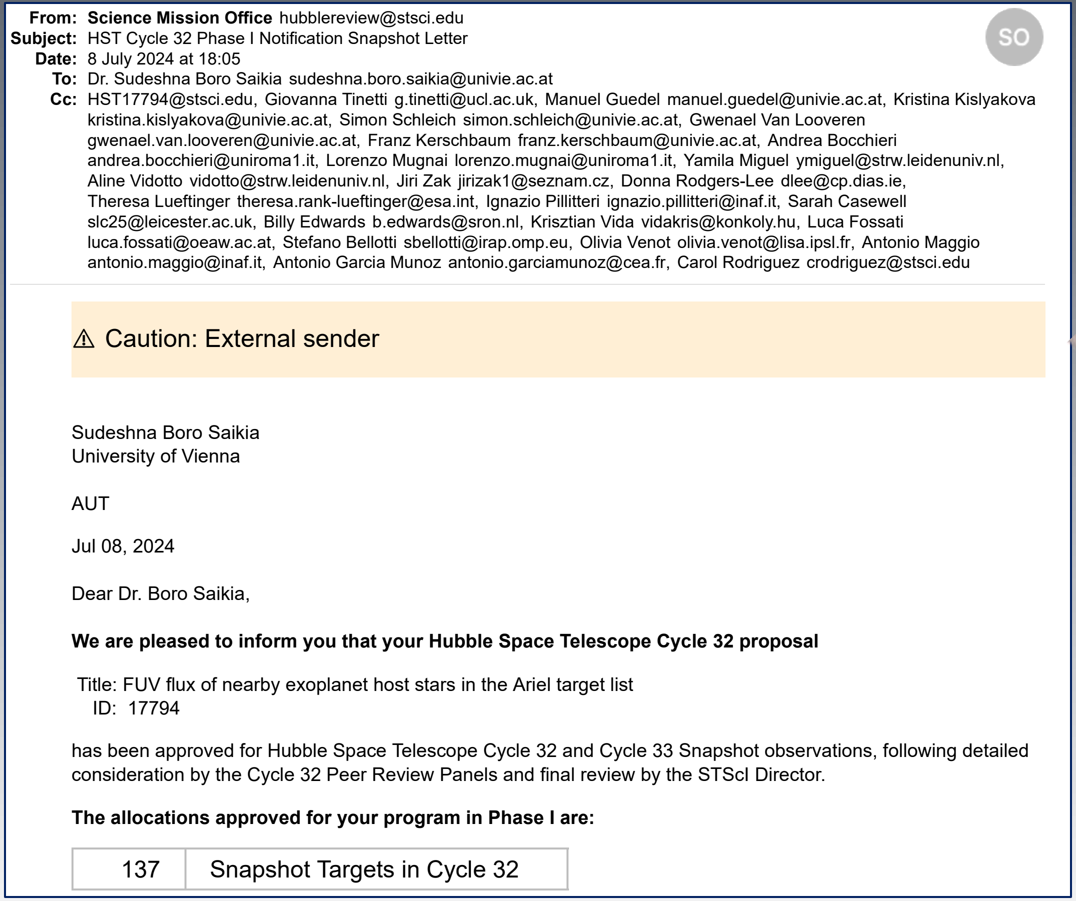
Spectropolarimetric characterisation of exoplanet host stars in preparation of the *Ariel* mission

Magnetic environment of HD 63433

S. Bellotti[1,2], D. Evensberget[1], A. A. Vidotto[1], A. Lavail[2], T. Lüftinger[3], G. A. J. Hussain[3], J. Morin[4],
P. Petit[2], S. Boro Saikia[5], C. Danielski[6], and G. Micela[7]

Focus on Ariel targets: stars

Targets monitoring is being prioritised to maximise the science return of Ariel



From: **Science Mission Office** hubblereview@stsci.edu
Subject: HST Cycle 32 Phase I Notification Snapshot Letter
Date: 8 July 2024 at 18:05
To: Dr. Sudeshna Boro Saikia sudeshna.boro.saikia@univie.ac.at
Cc: HST17794@stsci.edu, Giovanna Tinetti g.tinetti@ucl.ac.uk, Manuel Guedel manuel.guedel@univie.ac.at, Kristina Kislyakova kristina.kislyakova@univie.ac.at, Simon Schleich simon.schleich@univie.ac.at, Gwenael Van Looveren gwenael.van.looveren@univie.ac.at, Franz Kerschbaum franz.kerschbaum@univie.ac.at, Andrea Bocchieri andrea.bocchieri@uniroma1.it, Lorenzo Mugnai lorenzo.mugnai@uniroma1.it, Yamila Miguel ymiguel@strw.leidenuniv.nl, Aline Vidotto vidotto@strw.leidenuniv.nl, Jiri Zak jirizak1@seznam.cz, Donna Rodgers-Lee dlee@cp.dias.ie, Theresa Lueftinger theresa.rank-lueftinger@esa.int, Ignazio Pillitteri ignazio.pillitteri@inaf.it, Sarah Casewell slc25@leicester.ac.uk, Billy Edwards b.edwards@sron.nl, Krisztian Vida vidakris@konkoly.hu, Luca Fossati luca.fossati@oeaw.ac.at, Stefano Bellotti sbellotti@irap.omp.eu, Olivia Venot olivia.venot@lisa.ipsl.fr, Antonio Maggio antonio.maggio@inaf.it, Antonio Garcia Munoz antonio.garciamunoz@cea.fr, Carol Rodriguez crodriguez@stsci.edu

⚠ Caution: External sender

Sudeshna Boro Saikia
University of Vienna

AUT

Jul 08, 2024

Dear Dr. Boro Saikia,

We are pleased to inform you that your Hubble Space Telescope Cycle 32 proposal

Title: FUV flux of nearby exoplanet host stars in the Ariel target list
ID: 17794

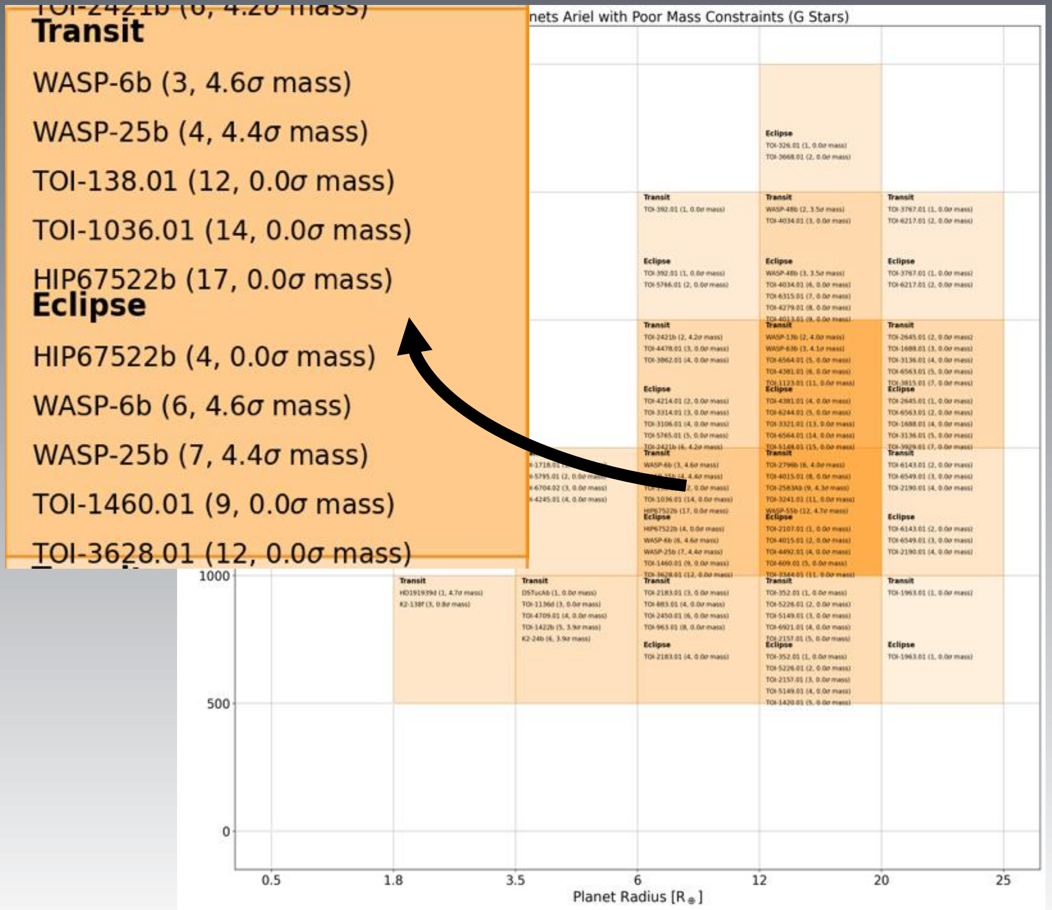
has been approved for Hubble Space Telescope Cycle 32 and Cycle 33 Snapshot observations, following detailed consideration by the Cycle 32 Peer Review Panels and final review by the STScI Director.

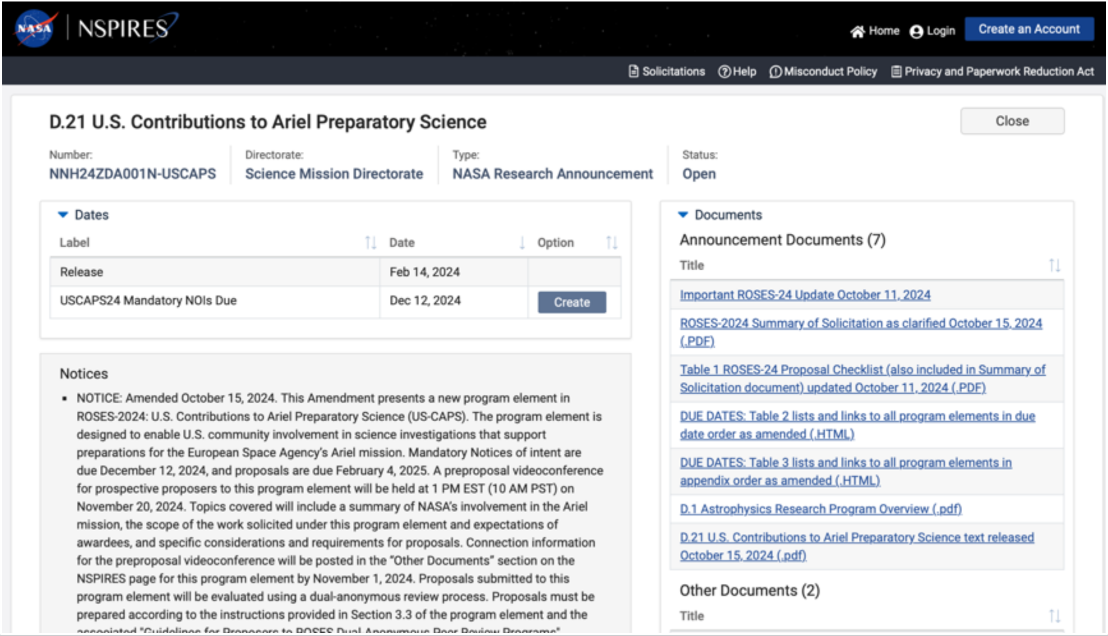
The allocations approved for your program in Phase I are:

137	Snapshot Targets in Cycle 32

Focus on Ariel targets: masses

Targets monitoring is being prioritised to maximise the science return of Ariel





D.21 U.S. Contributions to Ariel Preparatory Science

Number: NNH24ZDA001N-USCAPS

Directorate: Science Mission Directorate

Type: NASA Research Announcement

Status: Open

Dates

Label	Date	Option
Release	Feb 14, 2024	
USCAPS24 Mandatory NOIs Due	Dec 12, 2024	Create

Notices

- NOTICE: Amended October 15, 2024. This Amendment presents a new program element in ROSES-2024: U.S. Contributions to Ariel Preparatory Science (US-CAPS). The program element is designed to enable U.S. community involvement in science investigations that support preparations for the European Space Agency's Ariel mission. Mandatory Notices of intent are due December 12, 2024, and proposals are due February 4, 2025. A preproposal videoconference for prospective proposers to this program element will be held at 1 PM EST (10 AM PST) on November 20, 2024. Topics covered will include a summary of NASA's involvement in the Ariel mission, the scope of the work solicited under this program element and expectations of awardees, and specific considerations and requirements for proposals. Connection information for the preproposal videoconference will be posted in the "Other Documents" section on the NSPIRES page for this program element by November 1, 2024. Proposals submitted to this program element will be evaluated using a dual-anonymous review process. Proposals must be prepared according to the instructions provided in Section 3.3 of the program element and the

Documents

Announcement Documents (7)

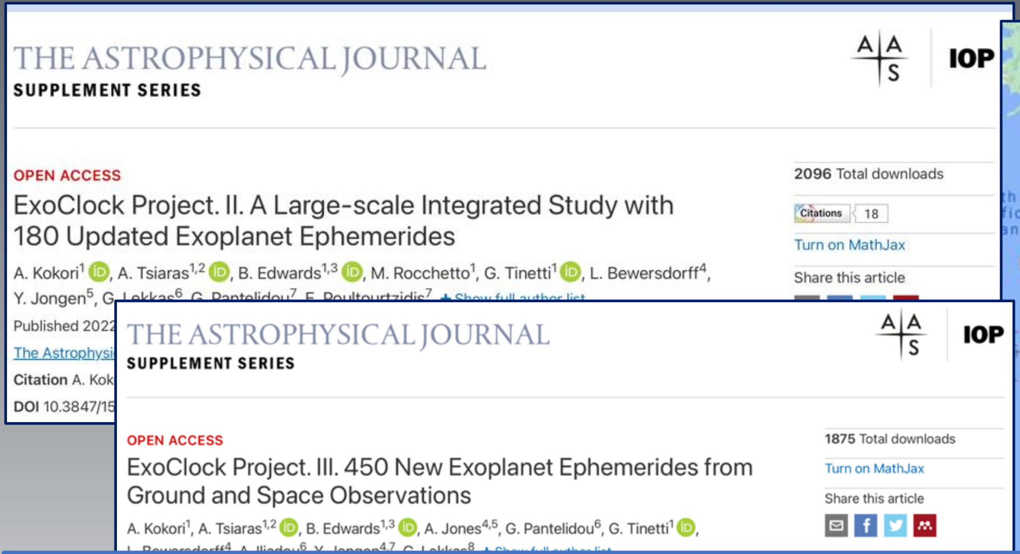
Title
Important ROSES-24 Update October 11, 2024
ROSES-2024 Summary of Solicitation as clarified October 15, 2024 (.PDF)
Table 1 ROSES-24 Proposal Checklist (also included in Summary of Solicitation document) updated October 11, 2024 (.PDF)
DUE DATES: Table 2 lists and links to all program elements in due date order as amended (.HTML)
DUE DATES: Table 3 lists and links to all program elements in appendix order as amended (.HTML)
D.1 Astrophysics Research Program Overview (.pdf)
D.21 U.S. Contributions to Ariel Preparatory Science text released October 15, 2024 (.pdf)

Other Documents (2)

Title

ExoClock: target ephemerides+

2000+ participants from 70+ countries (77% amateurs). New paper submitted ☺



THE ASTROPHYSICAL JOURNAL
SUPPLEMENT SERIES

OPEN ACCESS

ExoClock Project. II. A Large-scale Integrated Study with 180 Updated Exoplanet Ephemerides

A. Kokori[1], A. Tsiaras[1,2], B. Edwards[1,3], M. Rocchetto[1], G. Tinetti[1], L. Bewersdorff[4], Y. Jongen[5], G. Lekkas[6] G. Pantelidou[7] E. Poultourtzidis[7] + Show full author list

Published 2022

The Astrophysi

Citation A. Kok

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ExoClock Project. III. 450 New Exoplanet Ephemerides from Ground and Space Observations

A. Kokori[1], A. Tsiaras[1,2], B. Edwards[1,3], A. Jones[4,5], G. Pantelidou[6], G. Tinetti[1], L. Bewersdorff[4], A. Iliadou[6], Y. Jongen[4,7], G. Lekkas[8], + Show full author list

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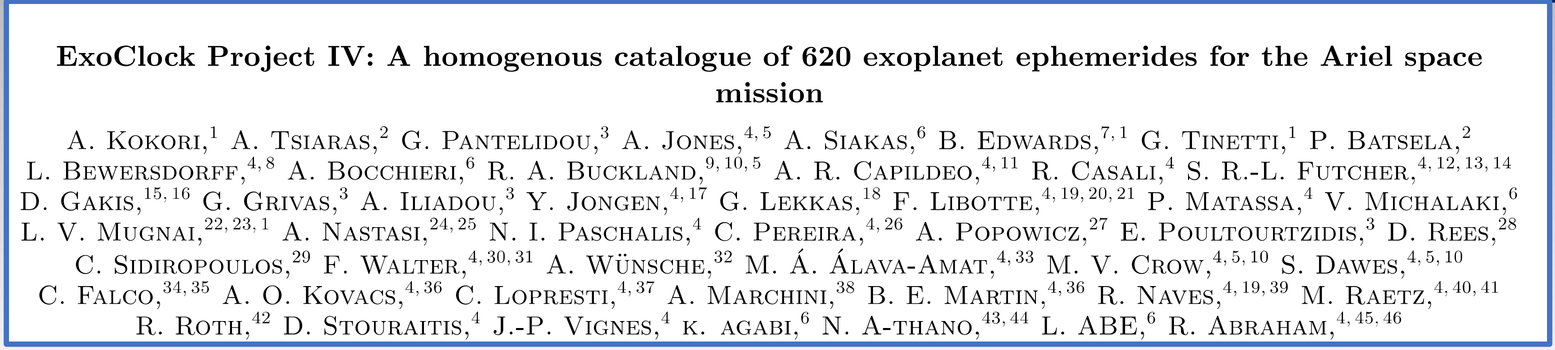
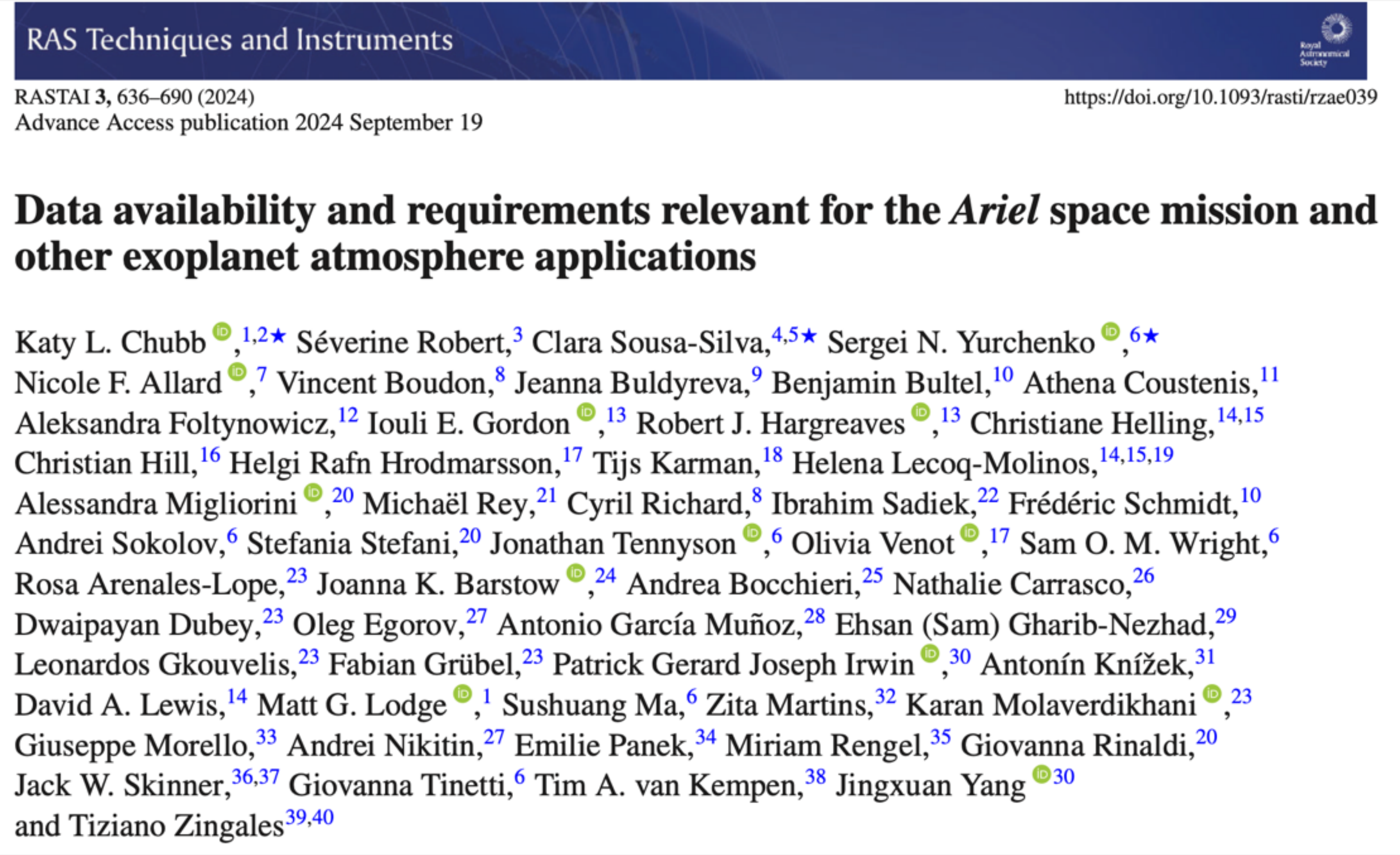


ExoClock Project IV: A homogenous catalogue of 620 exoplanet ephemerides for the Ariel space mission

A. Kokori,[1] A. Tsiaras,[2] G. Pantelidou,[3] A. Jones,[4,5] A. Siakas,[6] B. Edwards,[7,1] G. Tinetti,[1] P. Batsela,[2] L. Bewersdorff,[4,8] A. Bocchieri,[6] R. A. Buckland,[9,10,5] A. R. Capildeo,[4,11] R. Casali,[4] S. R.-L. Futcher,[4,12,13,14] D. Gakis,[15,16] G. Grivas,[3] A. Iliadou,[3] Y. Jongen,[4,17] G. Lekkas,[18] F. Libotte,[4,19,20,21] P. Matassa,[4] V. Michalaki,[6] L. V. Mugnai,[22,23,1] A. Nastasi,[24,25] N. I. Paschalis,[4] C. Pereira,[4,26] A. Popowicz,[27] E. Poultourtzidis,[3] D. Rees,[28] C. Sidiropoulos,[29] F. Walter,[4,30,31] A. Wünsche,[32] M. Á. Álava-Amat,[4,33] M. V. Crow,[4,5,10] S. Dawes,[4,5,10] C. Falco,[34,35] A. O. Kovacs,[4,36] C. Lopresti,[4,37] A. Marchini,[38] B. E. Martin,[4,36] R. Naves,[4,19,39] M. Raetz,[4,40,41] R. Roth,[42] D. Stouraitis,[4] J.-P. Vignes,[4] k. agabi,[6] N. A-thano,[43,44] L. ABE,[6] R. Abraham,[4,45,46]

Ariel Databases

A new paper and Database about spectroscopic, chemical and cloud data for Ariel

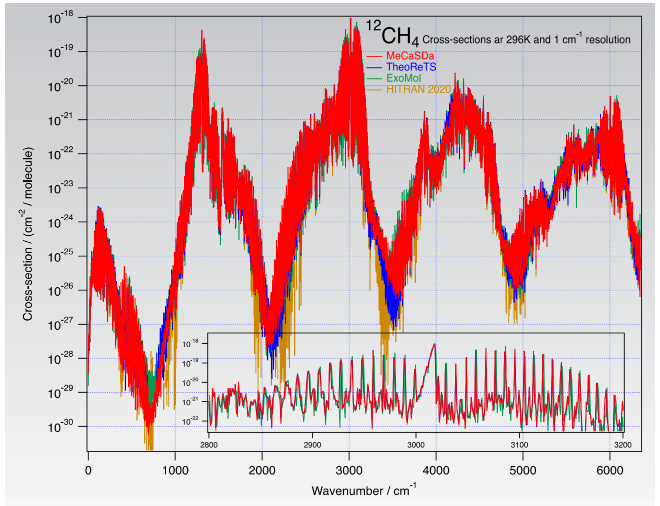


RAS Techniques and Instruments

RASTAI **3,** 636–690 (2024)
Advance Access publication 2024 September 19
https://doi.org/10.1093/rasti/rzae039

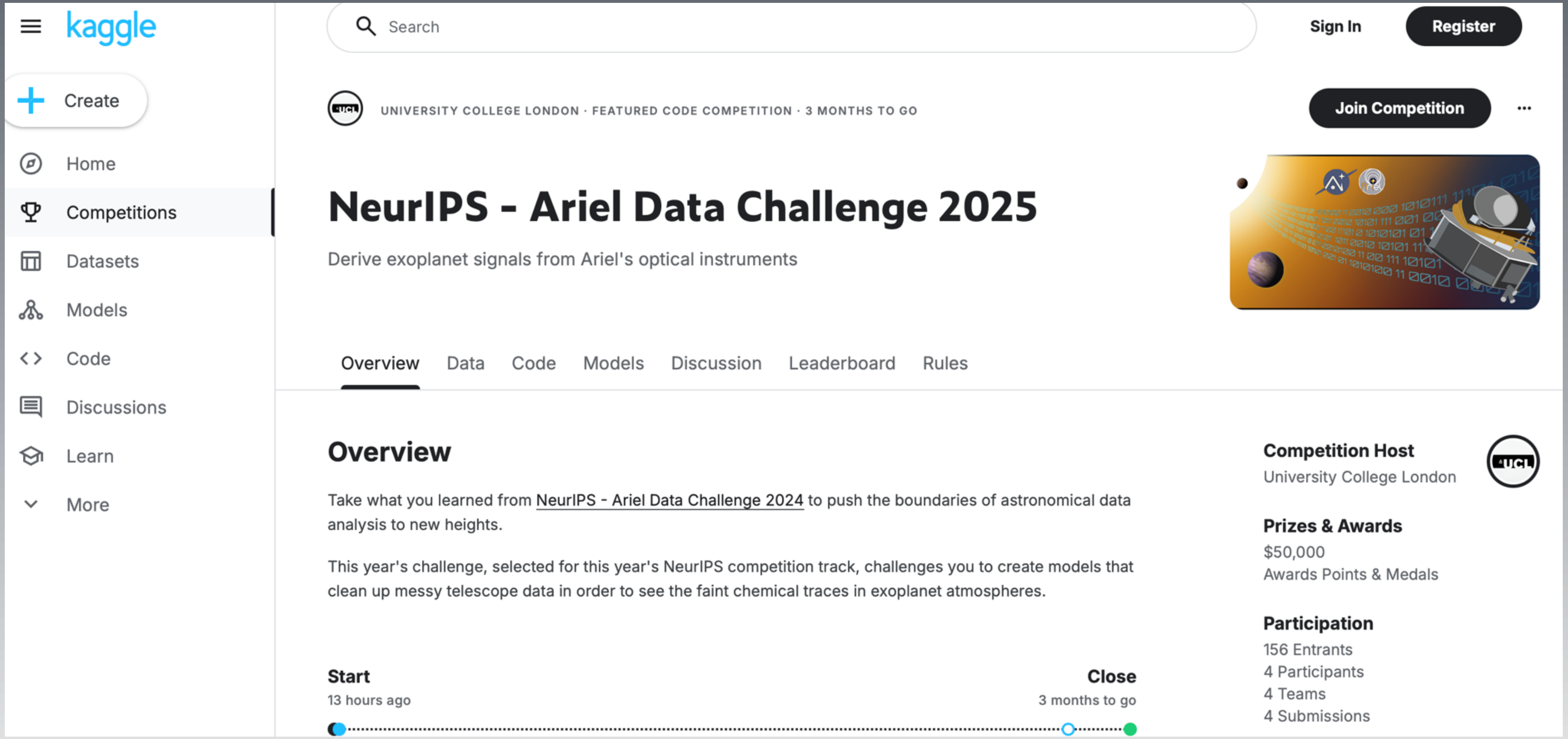
Data availability and requirements relevant for the *Ariel* space mission and other exoplanet atmosphere applications

Katy L. Chubb,[1,2]★ Séverine Robert,[3] Clara Sousa-Silva,[4,5]★ Sergei N. Yurchenko,[6]★ Nicole F. Allard,[7] Vincent Boudon,[8] Jeanna Buldyreva,[9] Benjamin Bultel,[10] Athena Coustenis,[11] Aleksandra Foltynowicz,[12] Iouli E. Gordon,[13] Robert J. Hargreaves,[13] Christiane Helling,[14,15] Christian Hill,[16] Helgi Rafn Hrodmarsson,[17] Tijs Karman,[18] Helena Lecoq-Molinos,[14,15,19] Alessandra Migliorini,[20] Michaël Rey,[21] Cyril Richard,[8] Ibrahim Sadiek,[22] Frédéric Schmidt,[10] Andrei Sokolov,[6] Stefania Stefani,[20] Jonathan Tennyson,[6] Olivia Venot,[17] Sam O. M. Wright,[6] Rosa Arenales-Lope,[23] Joanna K. Barstow,[24] Andrea Bocchieri,[25] Nathalie Carrasco,[26] Dwaipayan Dubey,[23] Oleg Egorov,[27] Antonio García Muñoz,[28] Ehsan (Sam) Gharib-Nezhad,[29] Leonardos Gkouvelis,[23] Fabian Grübel,[23] Patrick Gerard Joseph Irwin,[30] Antonín Knížek,[31] David A. Lewis,[14] Matt G. Lodge,[1] Sushuang Ma,[6] Zita Martins,[32] Karan Molaverdikhani,[23] Giuseppe Morello,[33] Andrei Nikitin,[27] Emilie Panek,[34] Miriam Rengel,[35] Giovanna Rinaldi,[20] Jack W. Skinner,[36,37] Giovanna Tinetti,[6] Tim A. van Kempen,[38] Jingxuan Yang[30] and Tiziano Zingales[39,40]



Ariel Data Challenges 2025

ADC 2025: just started!!!!!!



UNIVERSITY COLLEGE LONDON · FEATURED CODE COMPETITION · 3 MONTHS TO GO

NeurIPS - Ariel Data Challenge 2025

Derive exoplanet signals from Ariel's optical instruments

Overview

Take what you learned from NeurIPS - Ariel Data Challenge 2024 to push the boundaries of astronomical data analysis to new heights.

This year's challenge, selected for this year's NeurIPS competition track, challenges you to create models that clean up messy telescope data in order to see the faint chemical traces in exoplanet atmospheres.

Start
13 hours ago

Close
3 months to go

Competition Host
University College London

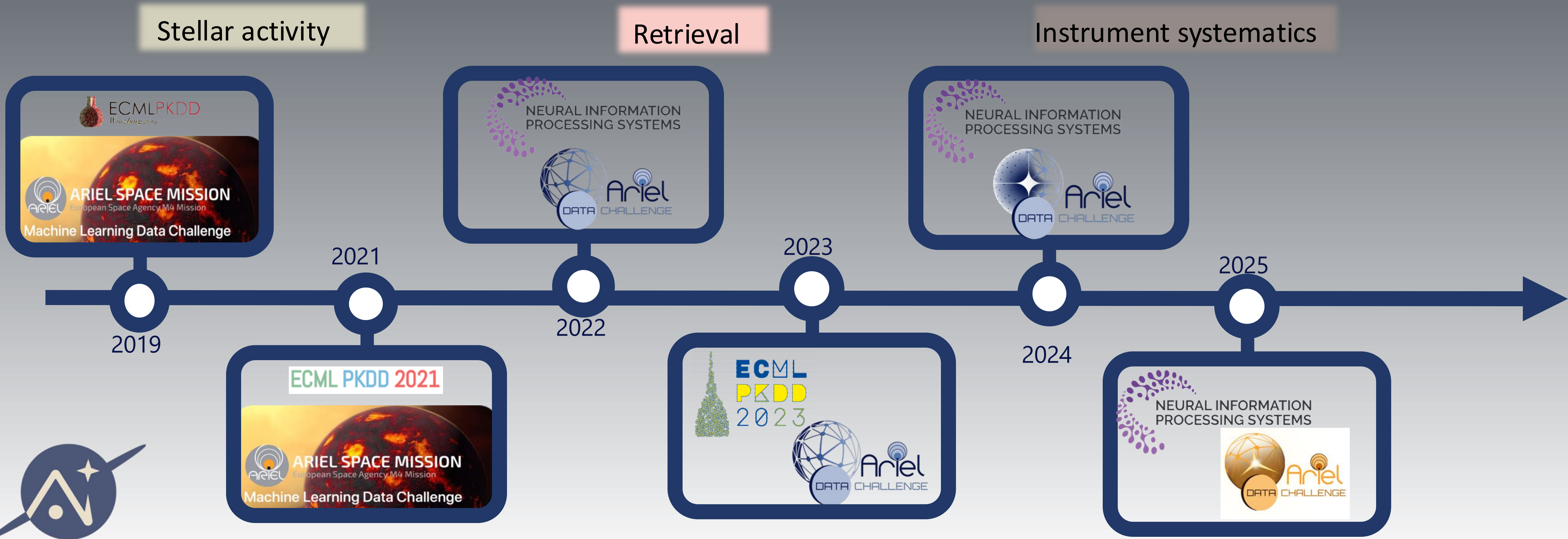
Prizes & Awards
$50,000
Awards Points & Medals

Participation
156 Entrants
4 Participants
4 Teams
4 Submissions

A mission is more than flying hardware…. There is XAI ☺

6 years of Ariel Data Challenges

A huge global success. ADCs yearly planned to support ground segment activities



Stellar activity

Retrieval

Instrument systematics

2019

2021

2022

2023

2024

2025

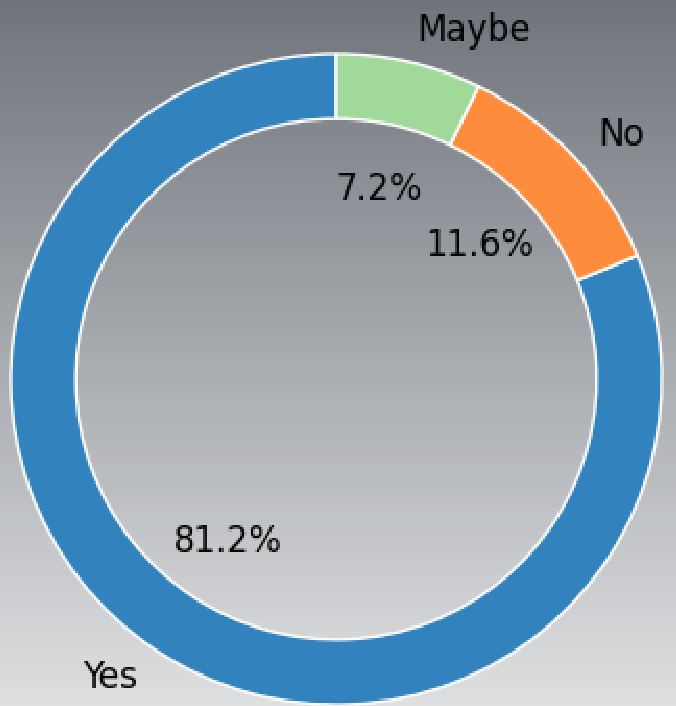
Ariel Data Challenge 2024

77 Countries

6000+ Entrants

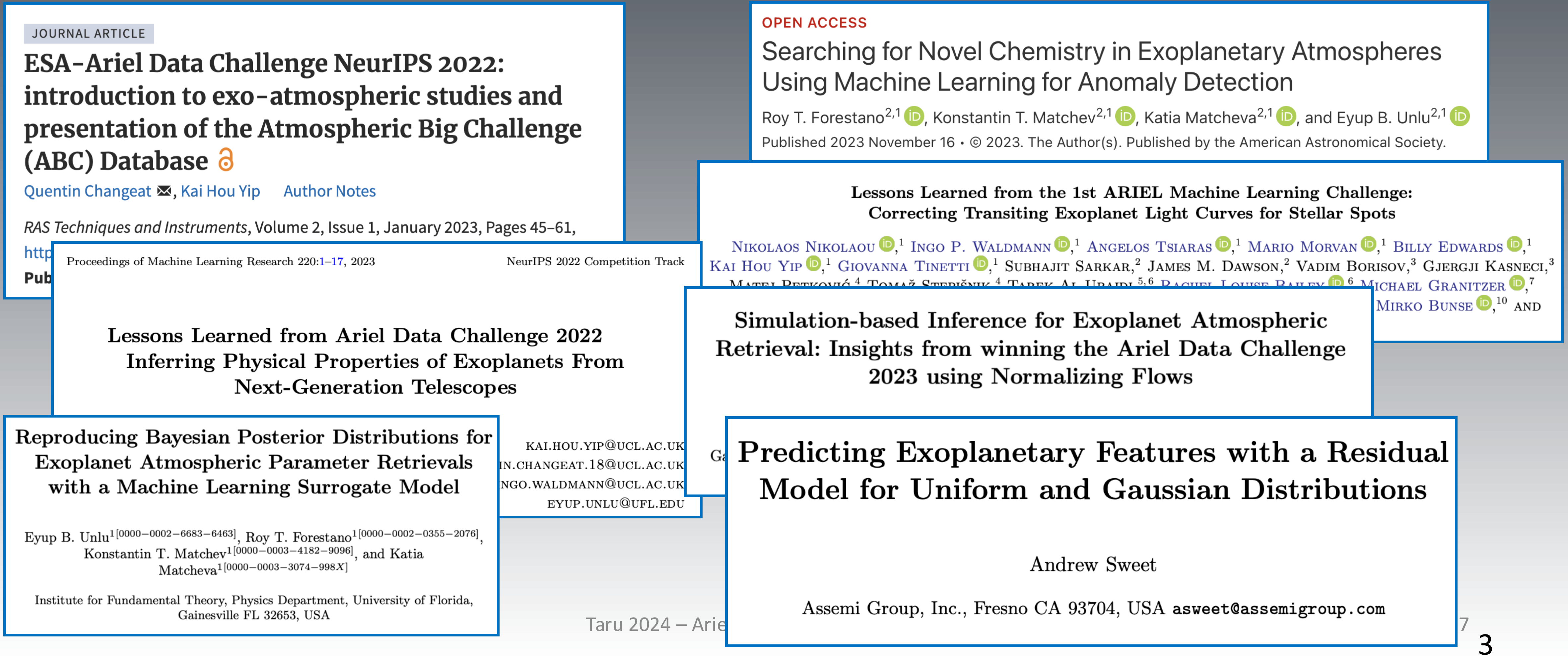
23,000+ Submissions

Is your work/study related to ML/AI?



Ariel Data Challenges

All the data and codes are open sourced to drive progress



JOURNAL ARTICLE

ESA-Ariel Data Challenge NeurIPS 2022: introduction to exo-atmospheric studies and presentation of the Atmospheric Big Challenge (ABC) Database

Quentin Changeat ✉, Kai Hou Yip   Author Notes

RAS Techniques and Instruments, Volume 2, Issue 1, January 2023, Pages 45–61,

http

Pub

OPEN ACCESS

Searching for Novel Chemistry in Exoplanetary Atmospheres Using Machine Learning for Anomaly Detection

Roy T. Forestano[2,1], Konstantin T. Matchev[2,1], Katia Matcheva[2,1], and Eyup B. Unlu[2,1]

Published 2023 November 16 • © 2023. The Author(s). Published by the American Astronomical Society.

Lessons Learned from the 1st ARIEL Machine Learning Challenge: Correcting Transiting Exoplanet Light Curves for Stellar Spots

Nikolaos Nikolaou,[1] Ingo P. Waldmann,[1] Angelos Tsiaras,[1] Mario Morvan,[1] Billy Edwards,[1] Kai Hou Yip,[1] Giovanna Tinetti,[1] Subhajit Sarkar,[2] James M. Dawson,[2] Vadim Borisov,[3] Gjergji Kasneci,[3] Matej Petković,[4] Tomaž Stepišnik,[4] Tarek Al Uraidi,[5,6] Rachel Louise Bailey,[6] Michael Granitzer,[7]

Mirko Bunse,[10] and

Proceedings of Machine Learning Research 220:1–17, 2023   NeurIPS 2022 Competition Track

Lessons Learned from Ariel Data Challenge 2022 Inferring Physical Properties of Exoplanets From Next-Generation Telescopes

KAI.HOU.YIP@UCL.AC.UK
IN.CHANGEAT.18@UCL.AC.UK
NGO.WALDMANN@UCL.AC.UK
EYUP.UNLU@UFL.EDU

Simulation-based Inference for Exoplanet Atmospheric Retrieval: Insights from winning the Ariel Data Challenge 2023 using Normalizing Flows

Ga

Reproducing Bayesian Posterior Distributions for Exoplanet Atmospheric Parameter Retrievals with a Machine Learning Surrogate Model

Eyup B. Unlu[1] [0000−0002−6683−6463], Roy T. Forestano[1] [0000−0002−0355−2076], Konstantin T. Matchev[1] [0000−0003−4182−9096], and Katia Matcheva[1] [0000−0003−3074−998X]

Institute for Fundamental Theory, Physics Department, University of Florida, Gainesville FL 32653, USA

Predicting Exoplanetary Features with a Residual Model for Uniform and Gaussian Distributions

Andrew Sweet

Assemi Group, Inc., Fresno CA 93704, USA asweet@assemigroup.com

Ariel Data Policy

A very open approach: foundation of good rigorous science and reproducibility

Science Demonstration Phase

Data will be released immediately after processing and quality control

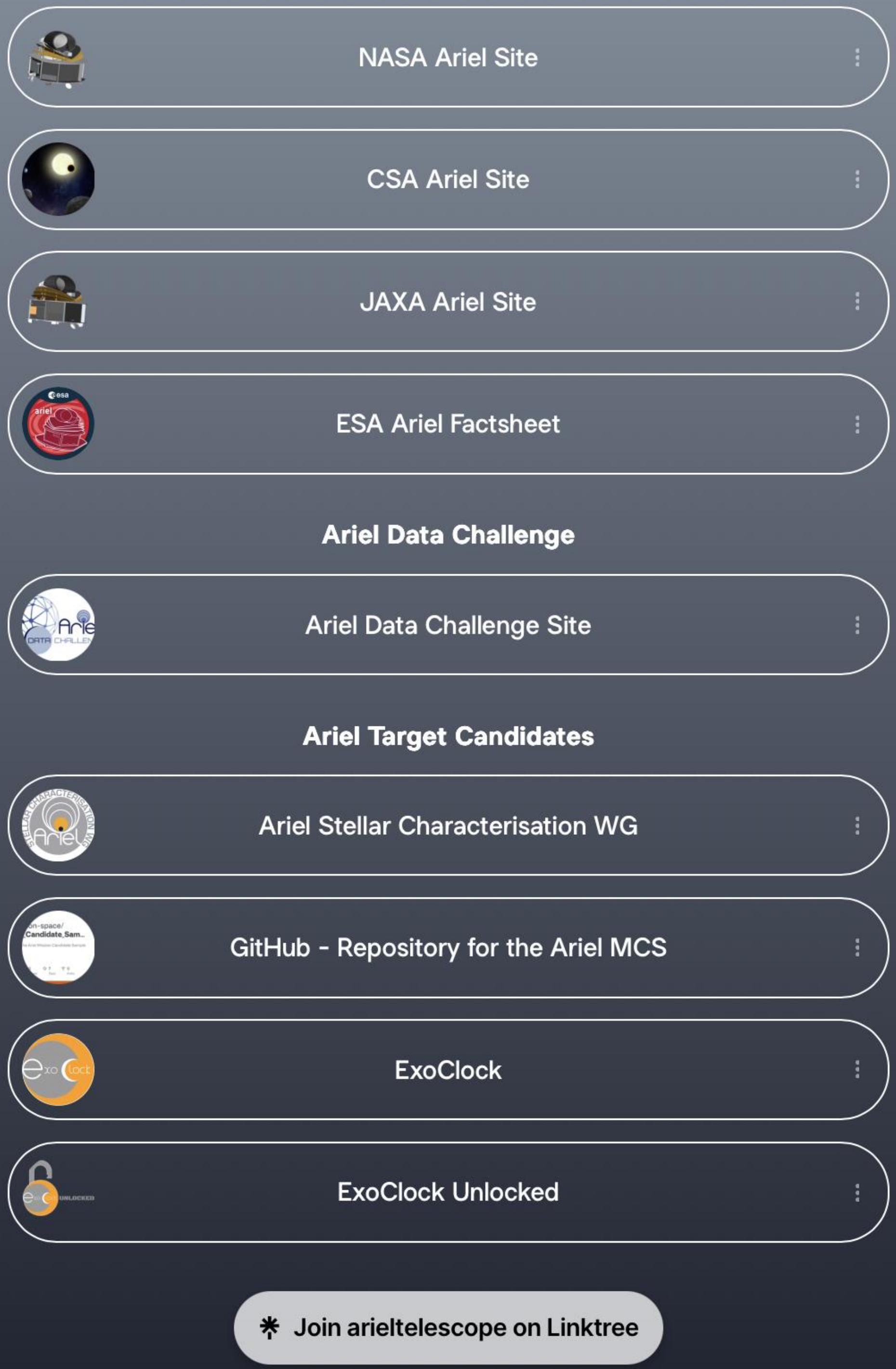
Nominal Science Operations Phase

- Tier 1 data public immediately after quality control is completed;
- Tier 2, 3 data public 6 months after quality control is completed;
- Tier 4 data public 1 year after quality control is completed.

Complementary Science data

- 5%-10% time available for other science, allocated through ESA calls
- Proprietary to the proposers for 6 months

Strong commitment to open-source software, Explainable AI solutions



NASA Ariel Site

CSA Ariel Site

JAXA Ariel Site

ESA Ariel Factsheet

Ariel Data Challenge

Ariel Data Challenge Site

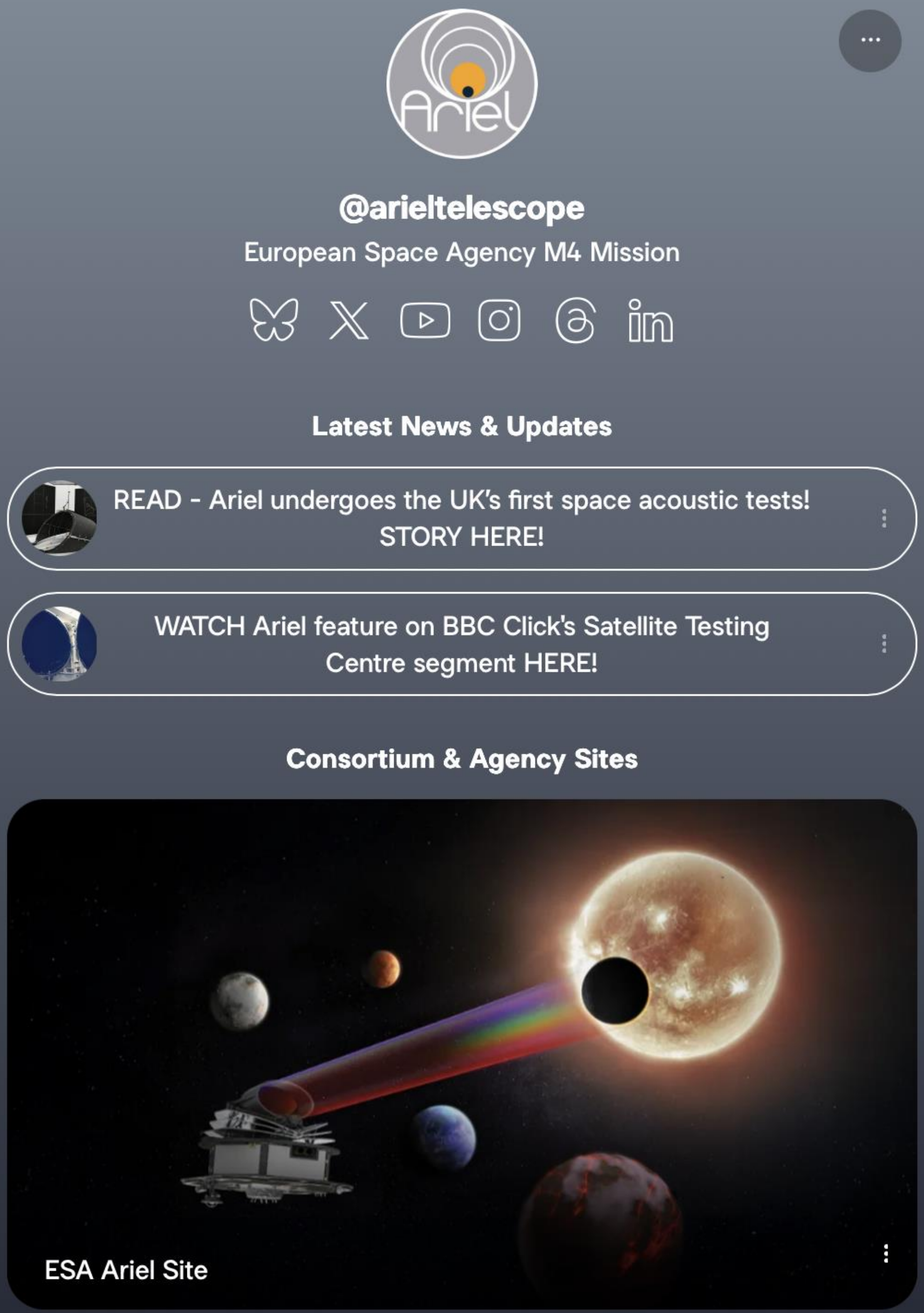
Ariel Target Candidates

Ariel Stellar Characterisation WG

GitHub - Repository for the Ariel MCS

ExoClock

ExoClock Unlocked



@arieltelescope

European Space Agency M4 Mission

Latest News & Updates

READ - Ariel undergoes the UK's first space acoustic tests! STORY HERE!

WATCH Ariel feature on BBC Click's Satellite Testing Centre segment HERE!

Consortium & Agency Sites

ESA Ariel Site

Ariel Open Conference 2026

@ ESA ECSAT, 17-19 March 2026.   Ariel special issue to be published by RASTI

RAS Techniques and Instruments

academic.oup.com/rasti

OXFORD

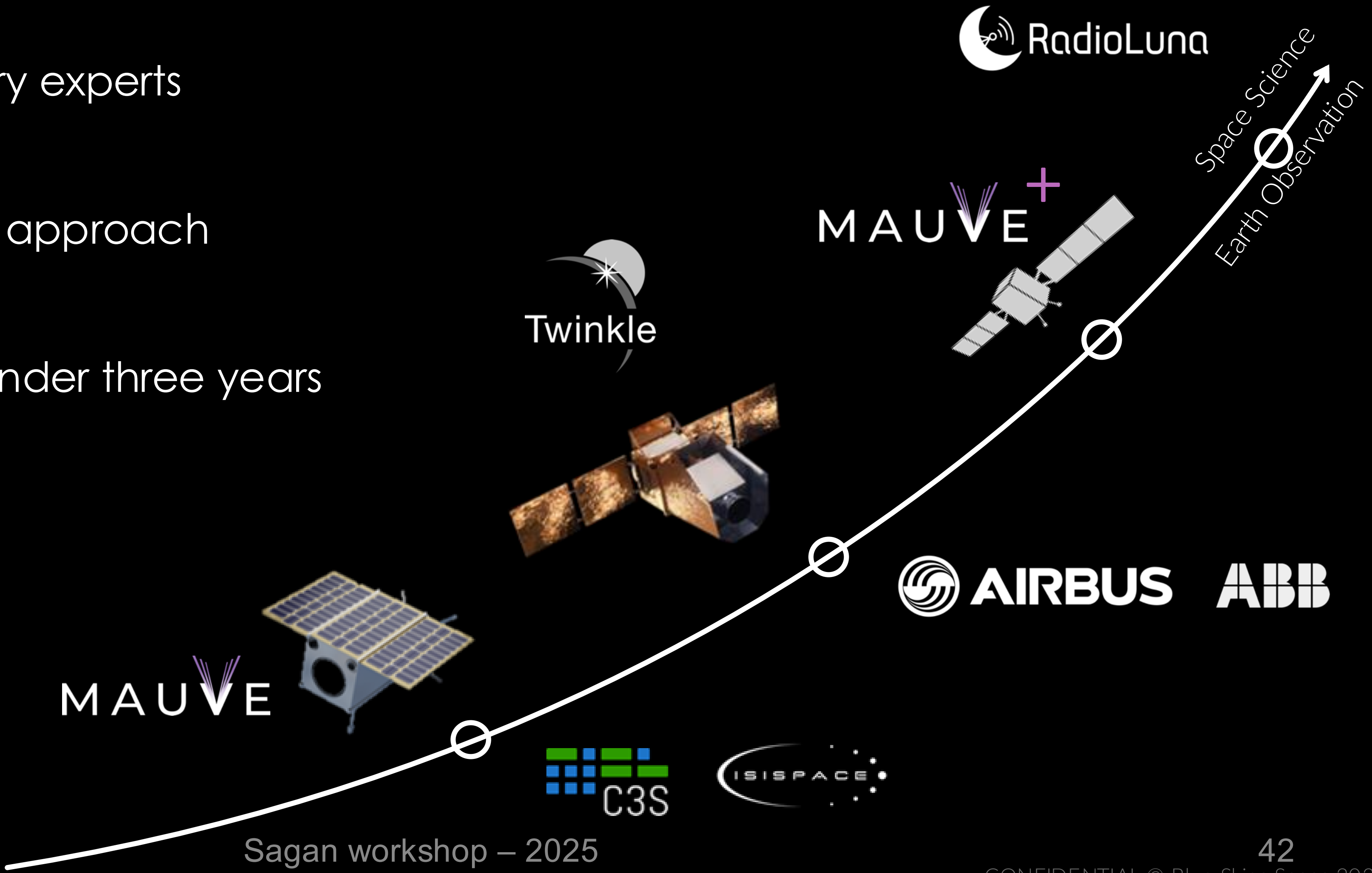
Mauve ready for launch

Blue Skies Space announces Mauve launch scheduled for October 2025

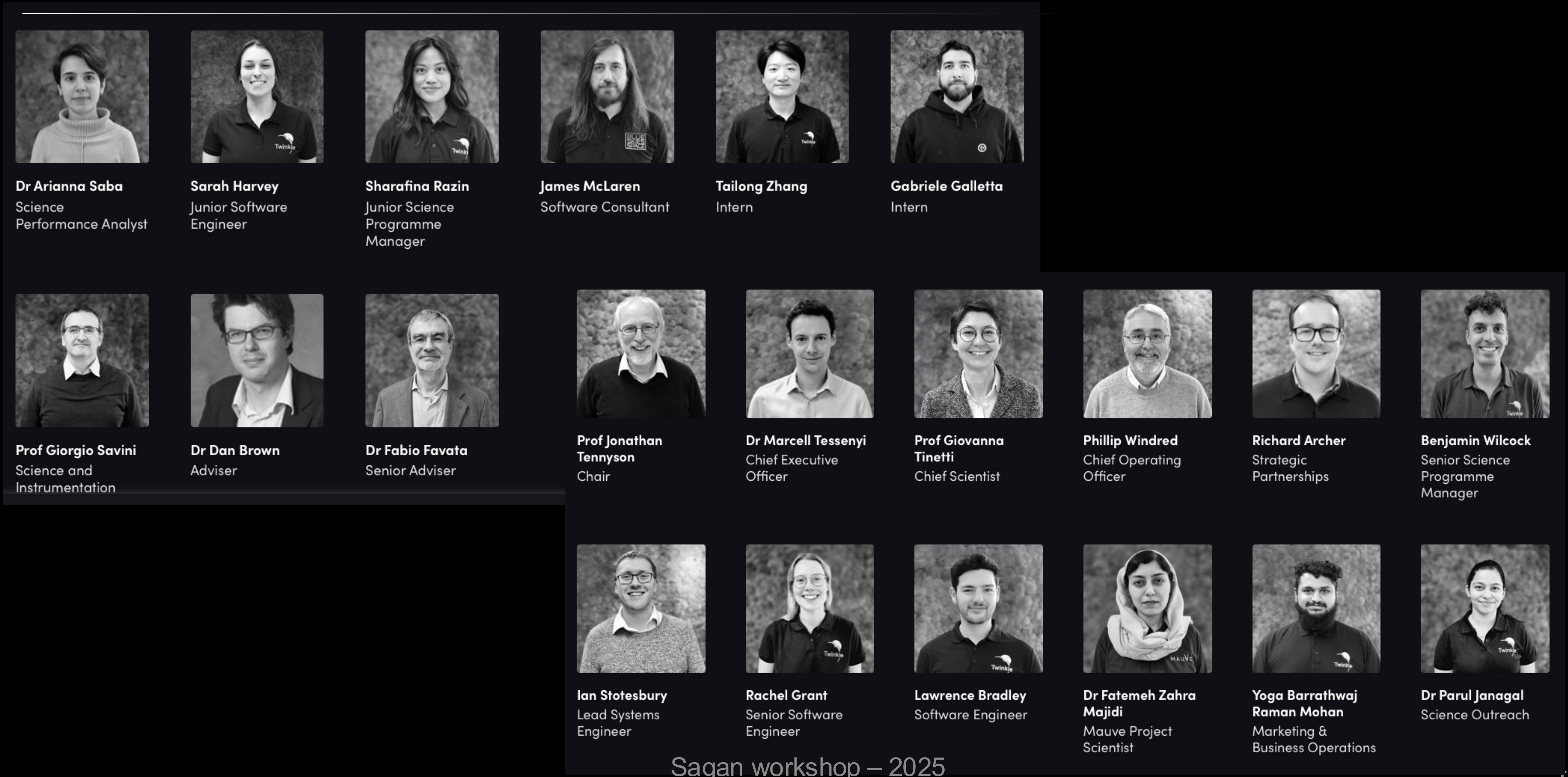
Mauve prepares for launch after successful integration and test campaigns

Blue Skies Space Roadmap

- Built by industry experts
- High heritage approach
- Delivered in under three years



Meet the Team



Dr Arianna Saba
Science Performance Analyst

Sarah Harvey
Junior Software Engineer

Sharafina Razin
Junior Science Programme Manager

James McLaren
Software Consultant

Tailong Zhang
Intern

Gabriele Galletta
Intern

Prof Giorgio Savini
Science and Instrumentation

Dr Dan Brown
Adviser

Dr Fabio Favata
Senior Adviser

Prof Jonathan Tennyson
Chair

Dr Marcell Tessenyi
Chief Executive Officer

Prof Giovanna Tinetti
Chief Scientist

Phillip Windred
Chief Operating Officer

Richard Archer
Strategic Partnerships

Benjamin Wilcock
Senior Science Programme Manager

Ian Stotesbury
Lead Systems Engineer

Rachel Grant
Senior Software Engineer

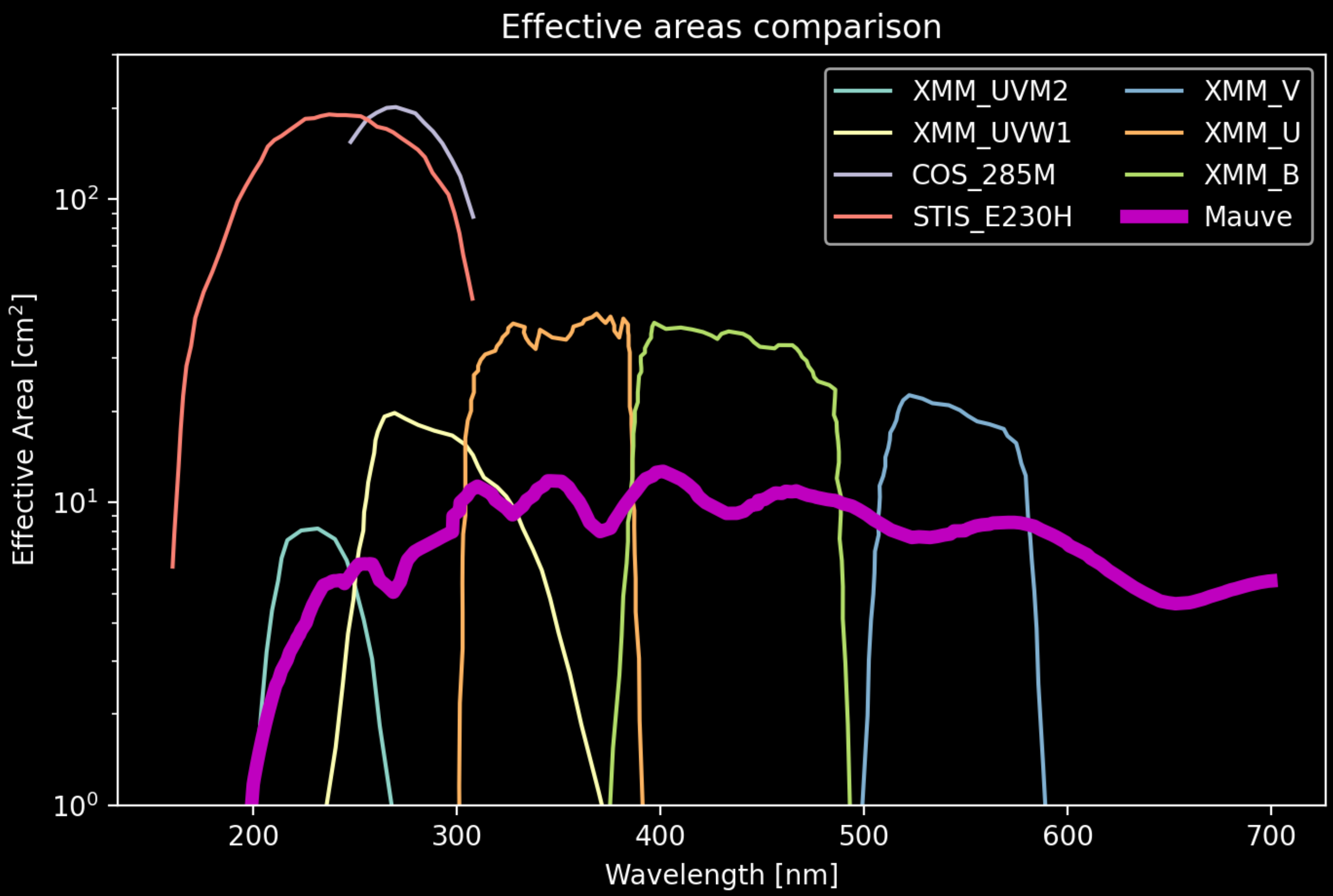
Lawrence Bradley
Software Engineer

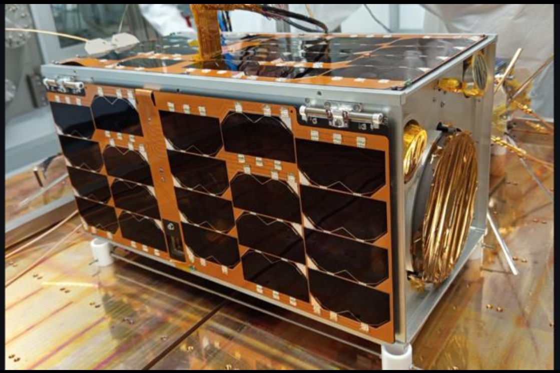
Dr Fatemeh Zahra Majidi
Mauve Project Scientist

Yoga Barrathwaj Raman Mohan
Marketing & Business Operations

Dr Parul Janagal
Science Outreach

Comparison of MAUVE with known facilities





Wavelength range	200 - 700 nm (NUV + Visible)
Resolution	R = 20 - 65
Telescope	13 cm Cassegrain
Spectrometer	2-mirror grating spectrograph with CMOS linear array detector
Launch	October this year
Orbit	LEO polar – 500 km
Field of View	~105'' full cone

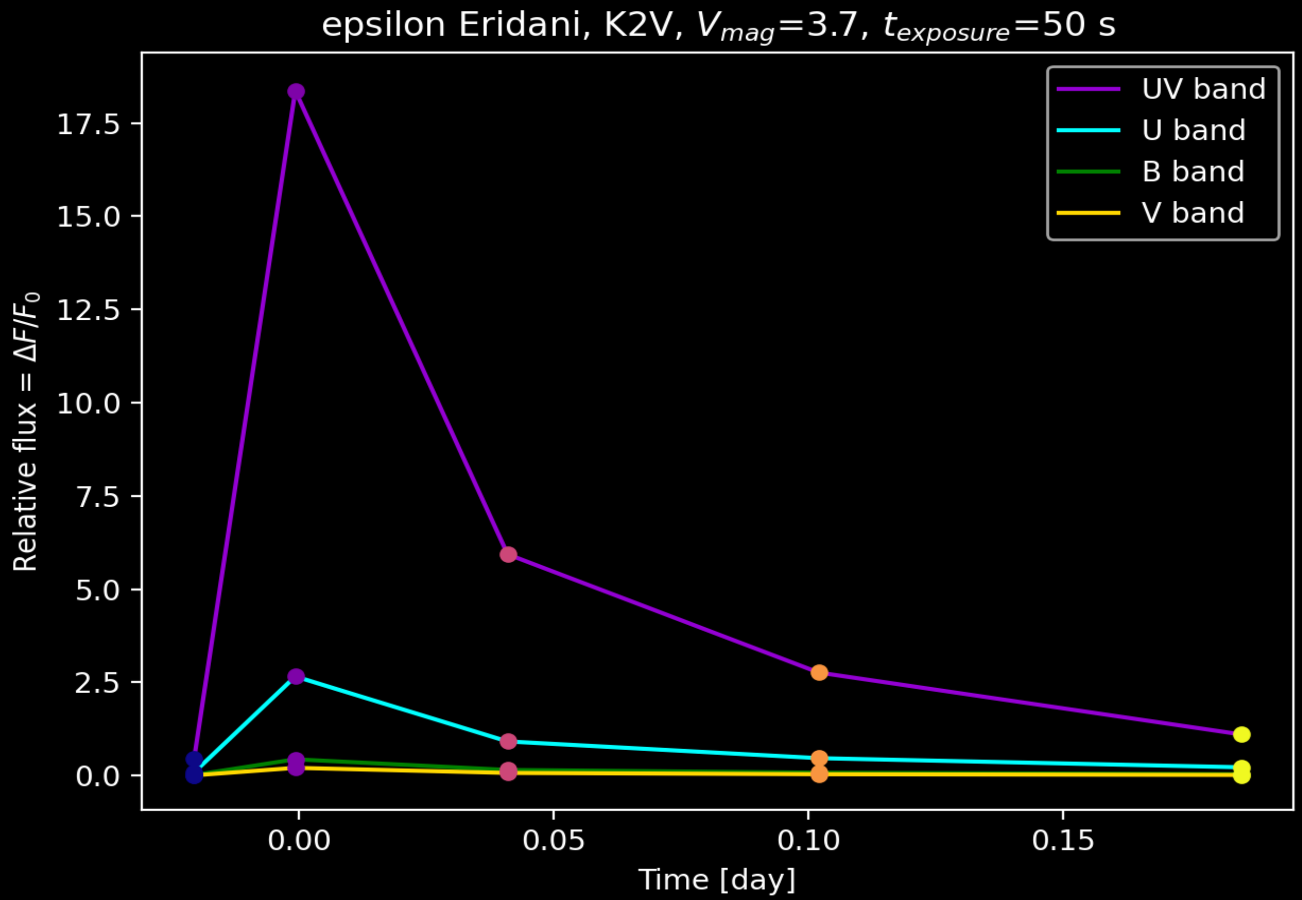
Funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101082738.

Epsilon Eridani, K2V, V=3.7

Light curves showing the relative flux increase over the course of th flare event.

Different wavelength bands selected, highest contrast in the UV.

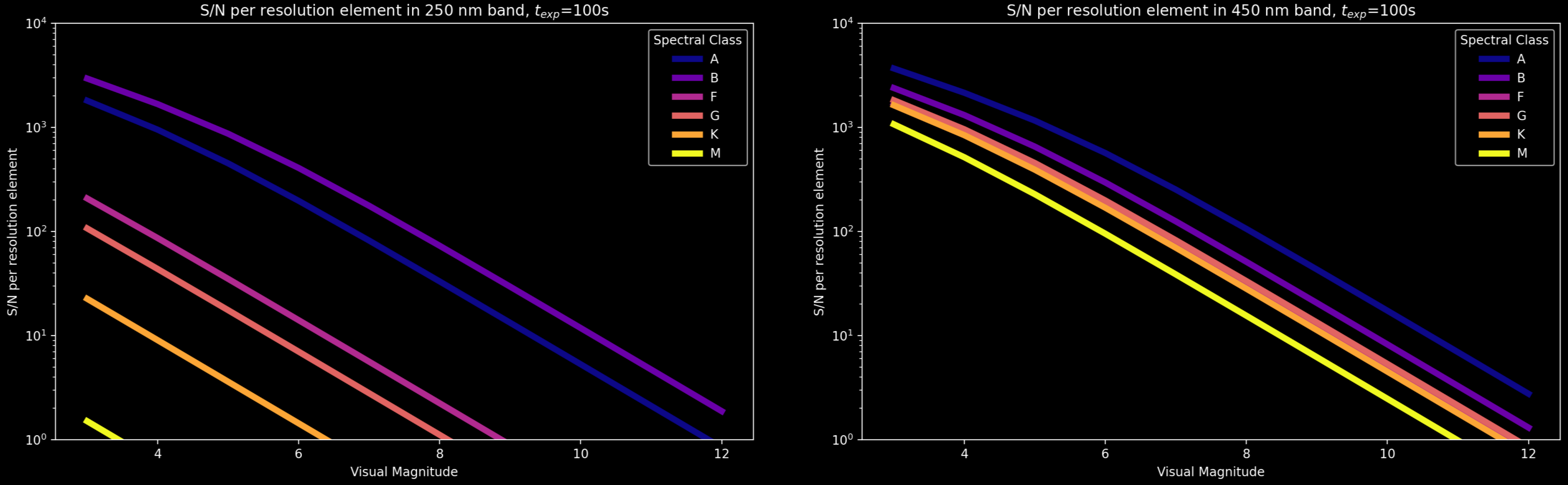


Saba et al. (2025)

Mauve sensitivity

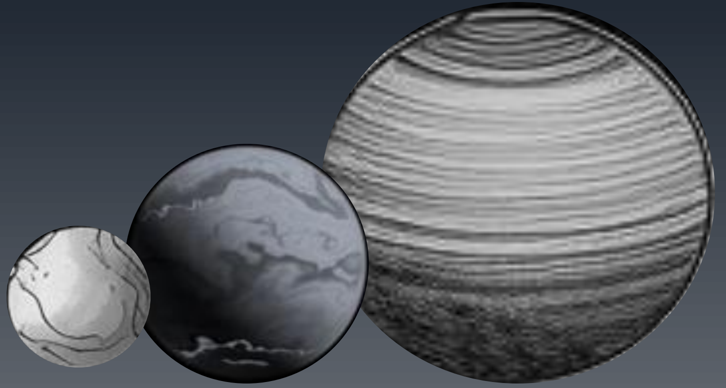
MAUVE

General performance capabilities of the observatory



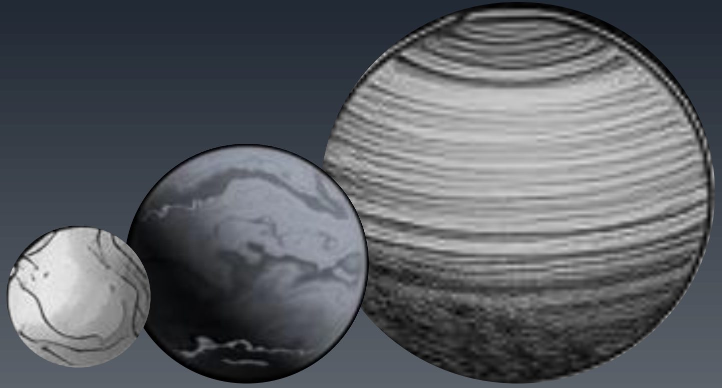
Saba et al. (2025)

Conclusions



- Planets are ubiquitous in our galaxy, they are very diverse
- We have a host of questions to answer in the next decade:
  - ? How do planets form? How do planets evolve?
  - ? How diverse are exoplanets chemically?
  - ? Does chemical diversity correlate with other parameters?
- Population studies of exoplanets are key to unlocking their statistical properties.

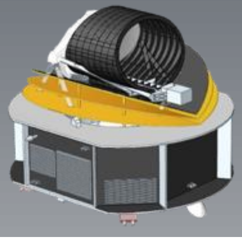
Conclusions

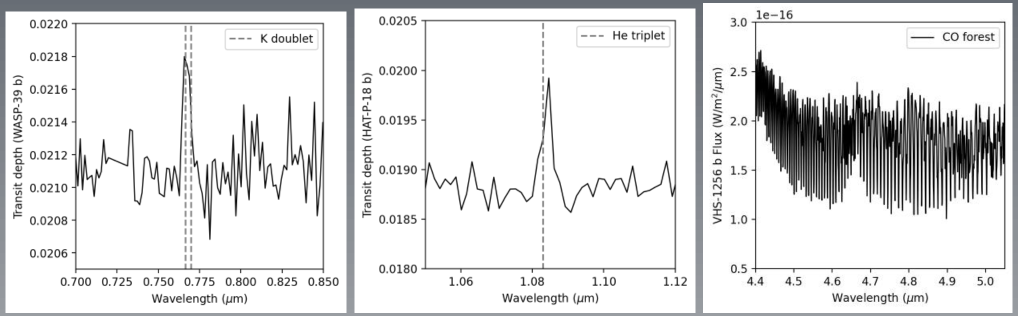


- An increasing number of exoplanet atmospheres are/have been observed from space and the ground.
- With Webb, Roman and Ariel, population-based studies of exoplanet atmospheres and their stellar hosts, offer an unparalleled opportunity to uncover chemical trends and how they correlate with stellar/planetary/orbital parameters.
- We advocate an ecosystem of small and moderate size facilities from space and the ground to complement largest facilities
- This information is key to guide our understanding of formation and evolution mechanisms of the planets in our galaxy.

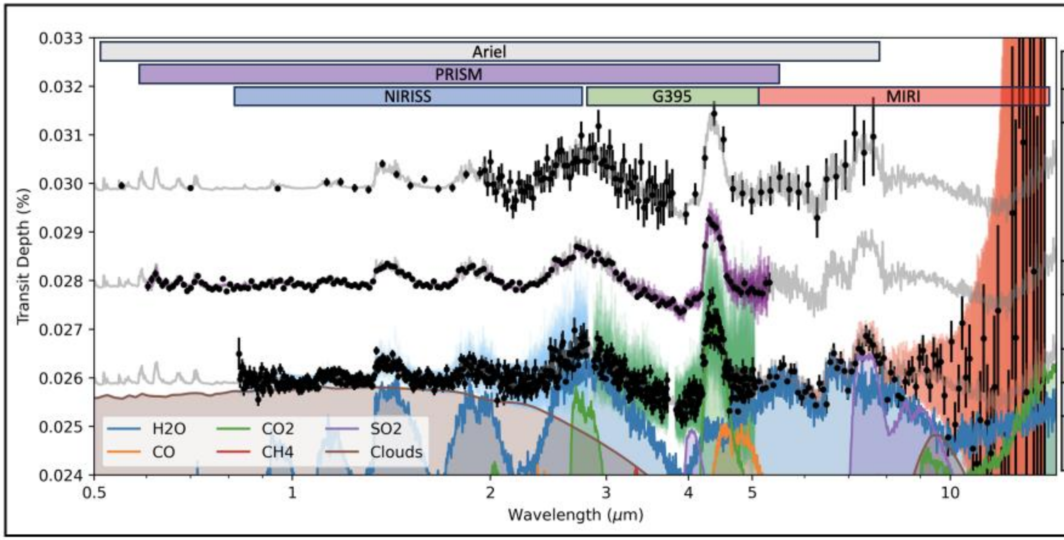
Synergy Ariel-Webb

COMPLEMENTARITY AND SYNERGY BETWEEN ARIEL AND WEBB WILL BE TRANSFORMATIONAL



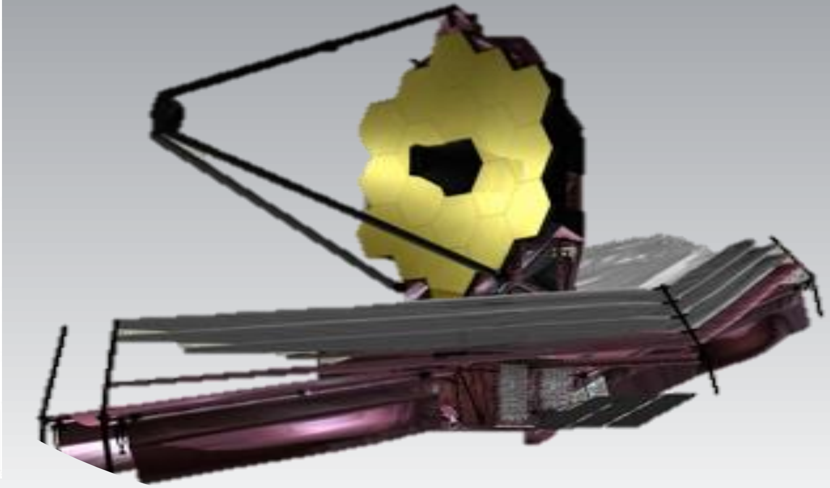


Changeat, Lagage et al. in prep



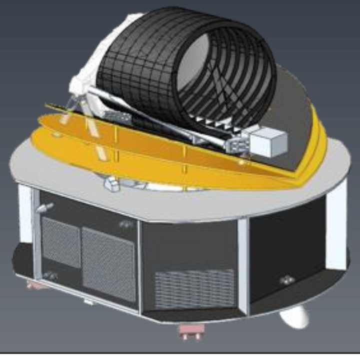
	Ariel	JWST
Diameter	0.9 m	6.5 m
Wave	0.5 – 7.8 simultaneous	NIRISS: 0.8 – 2.9 PRISM: 0.6 – 5.3 Grisms: 1 – 5.2 NIRCam: 2.5 – 5 MIRI-LRS: 5 – 12 MIRI-MRS: 5 - 28
Res	15 to 100	Up to 3000
Type	Survey	General observatory
Nplanets	~1000	100+ (primary)
Launch	2029	2021
Duration	4 years (primary)	5 years Fuel for 20

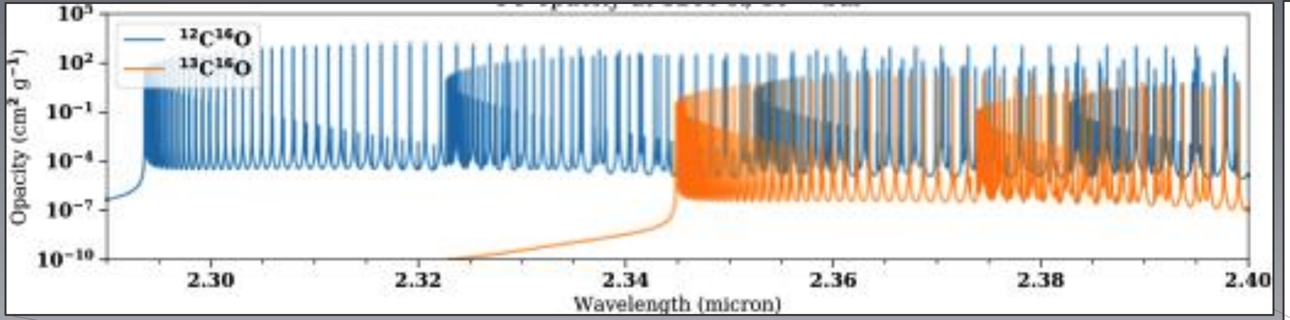
Changeat, Lagage et al. in prep

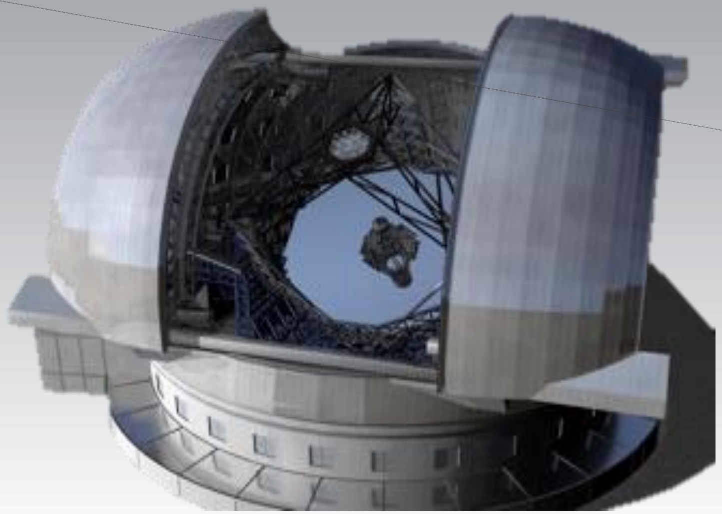


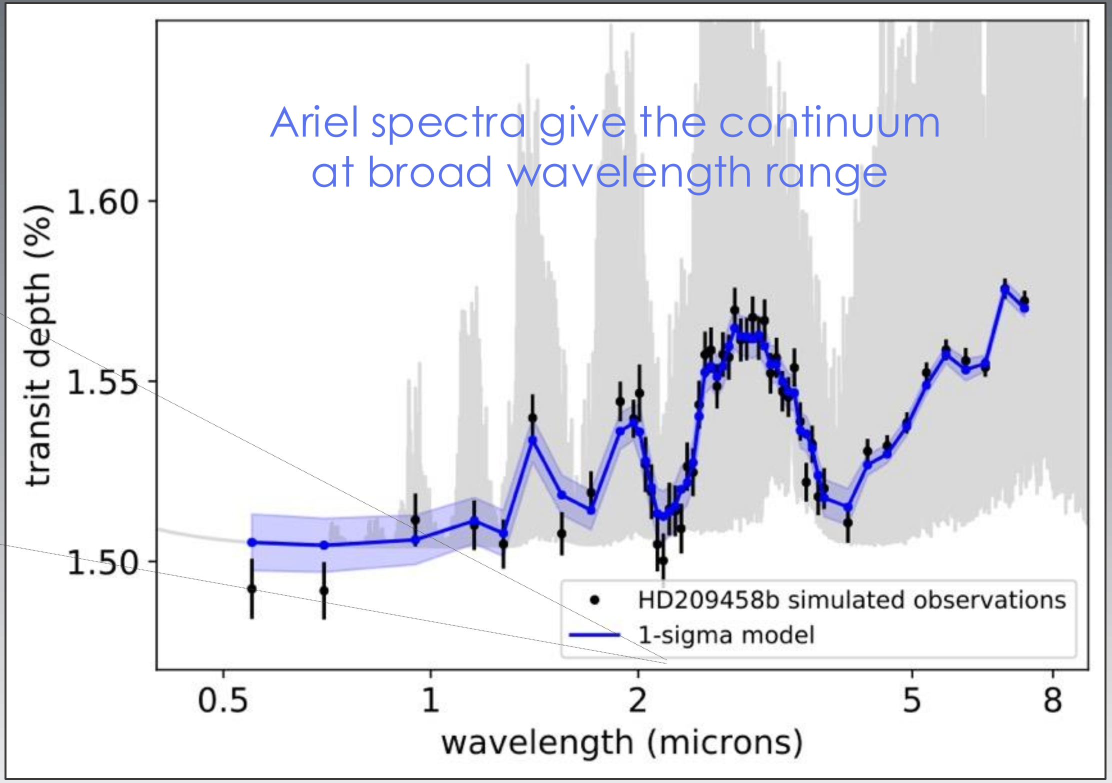
Synergies ground

HIGHLY COMPLEMENTARY TO LARGE, GROUND-BASED FACILITIES







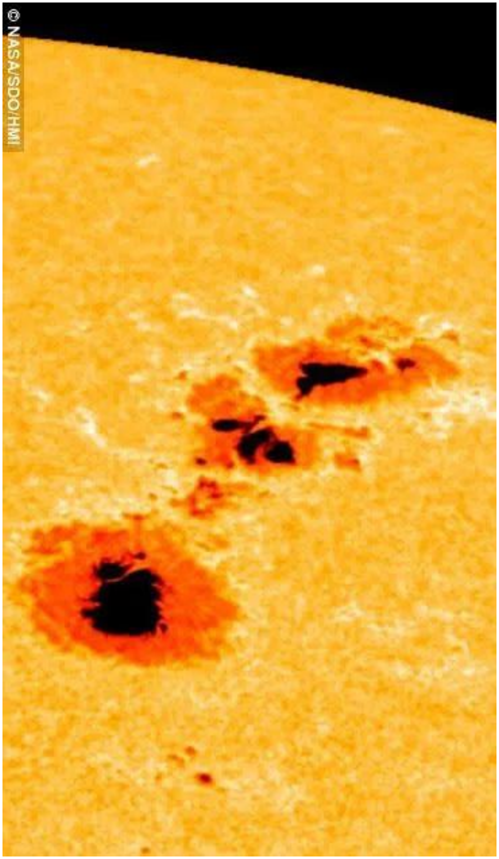


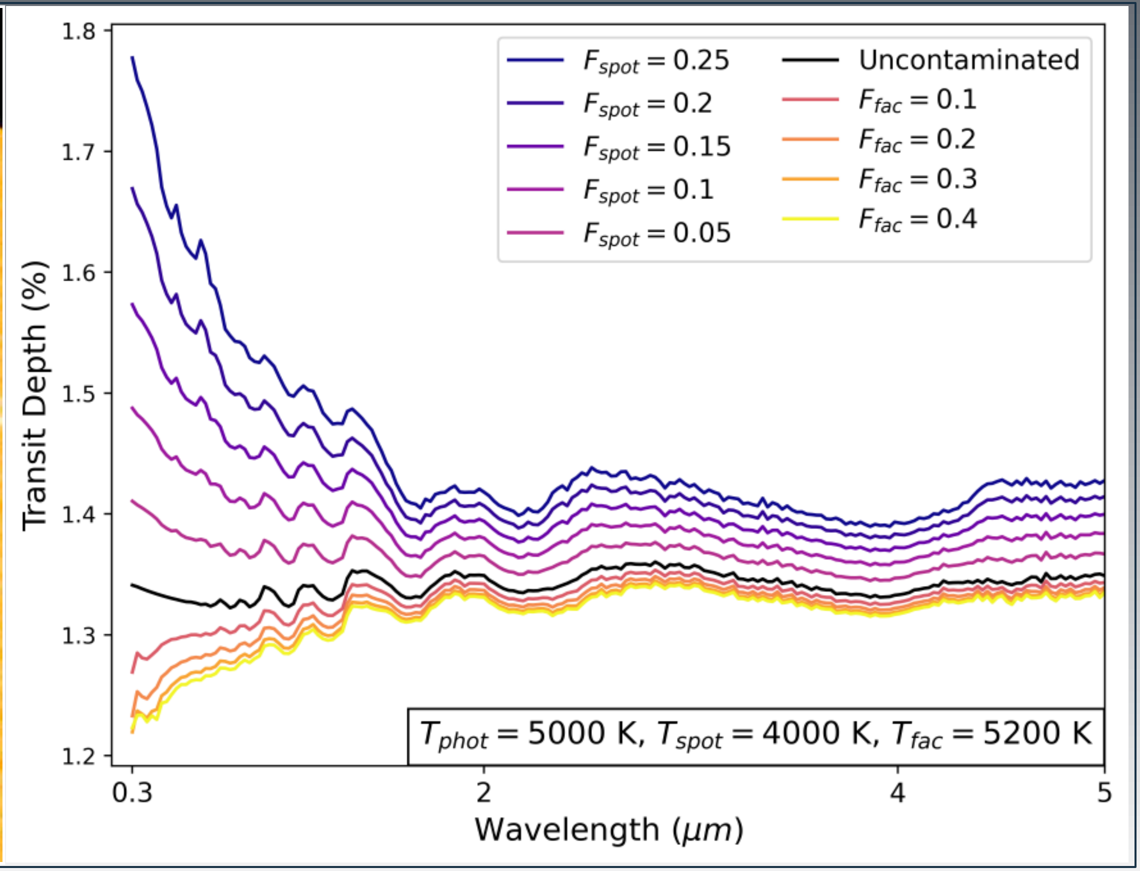
Ariel spectra give the continuum at broad wavelength range

Ariel ELT synergy WG

Stellar contamination

ARIEL TIER 3 OBSERVATIONS WILL HELP UNDERSTANDING IMPACT OF CONTAMINATION THROUGH TIME

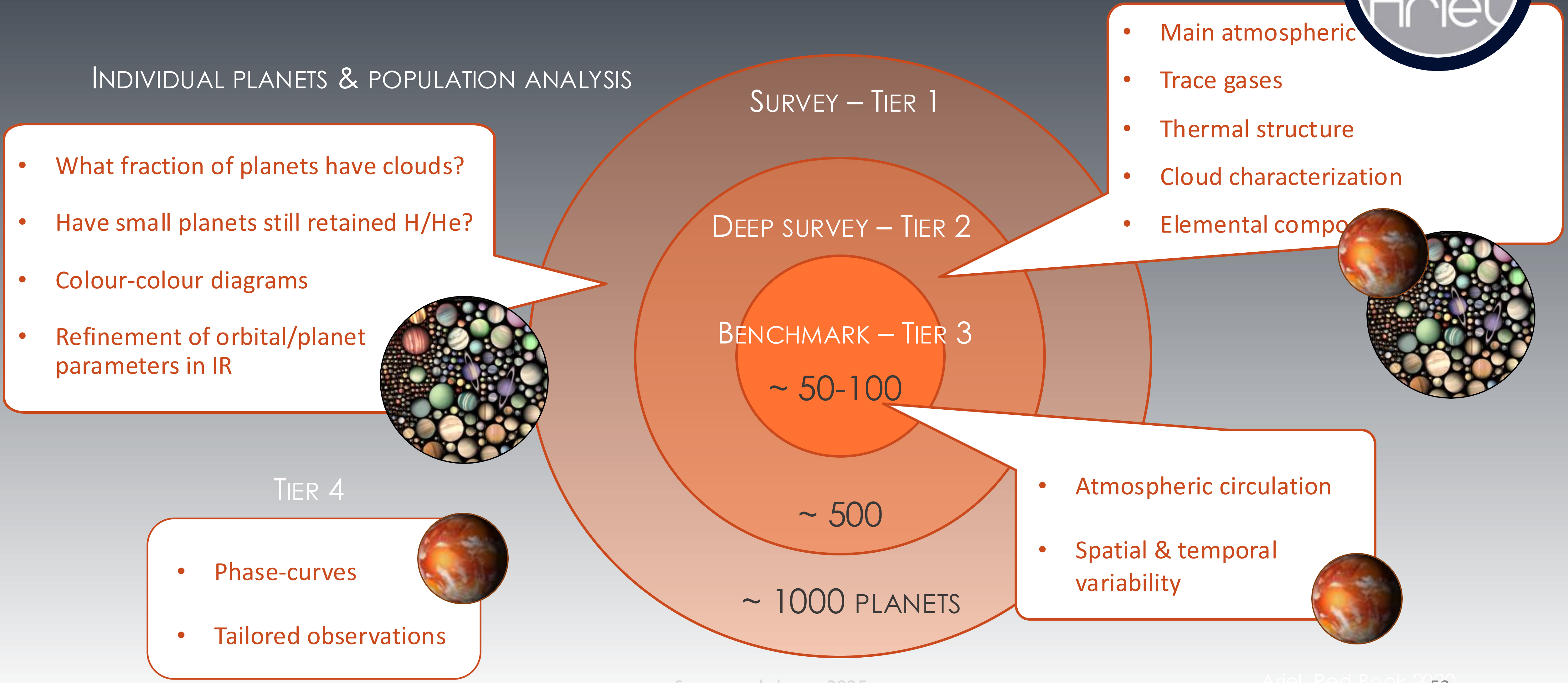




Thompson et al. 2025

Ariel 4-Tier approach

INDIVIDUAL PLANETS & POPULATION ANALYSIS



SURVEY – TIER 1

DEEP SURVEY – TIER 2

BENCHMARK – TIER 3

~ 50-100

~ 500

~ 1000 PLANETS

- 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
- Trace gases
- Thermal structure
- Cloud characterization
- Elemental compo

- Atmospheric circulation
- Spatial & temporal variability

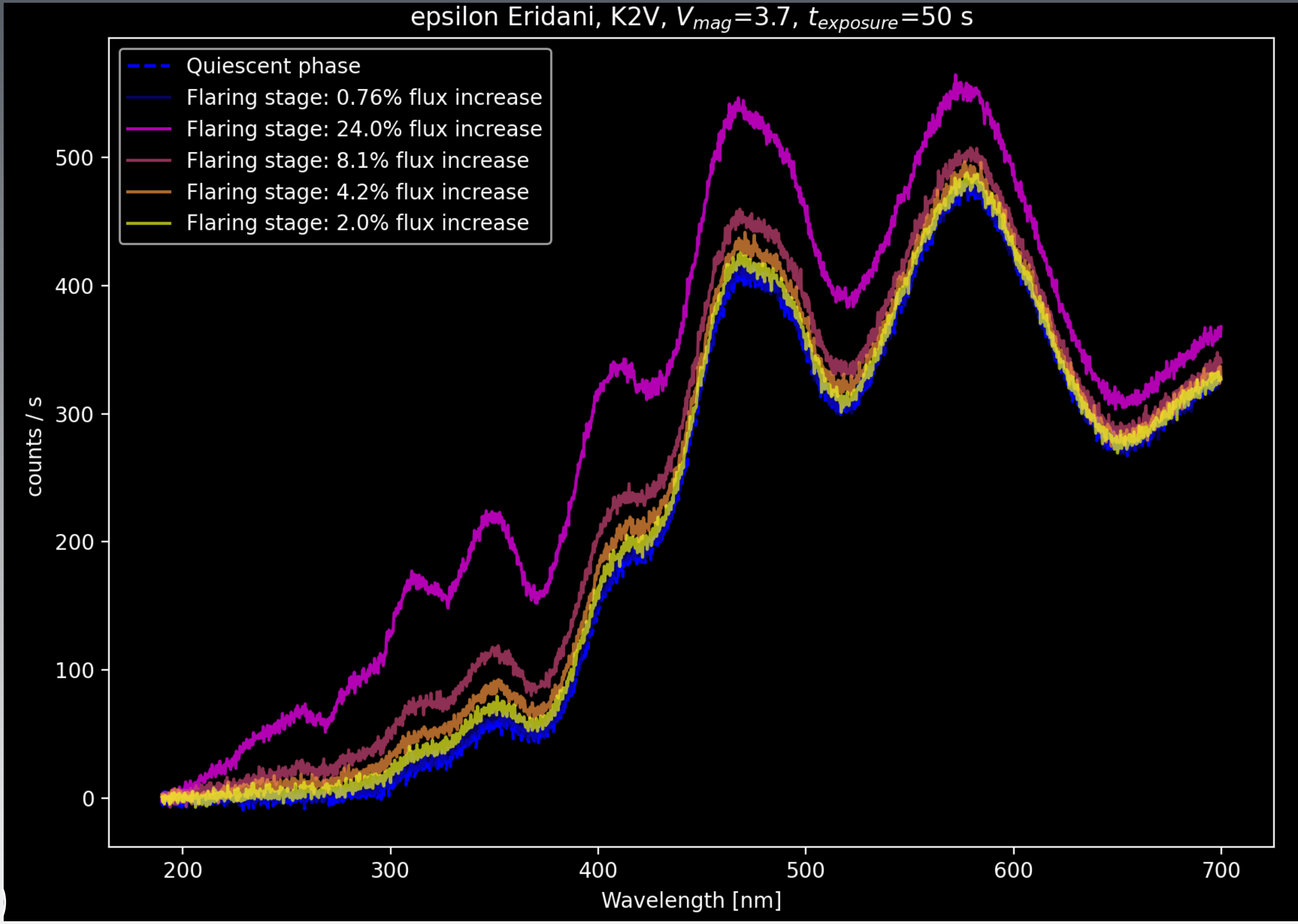
TIER 4

- Phase-curves
- Tailored observations

Ariel Red Book 2020

Epsilon Eridani, K2V, V=3.7

- Simulated Mauve spectra at different stages of the flare event.
- Quiescence, flare peak and decay stages are clearly distinguishable from one another.
- High contrast across the wavelength range accessible to Mauve, and specifically in the UV.



Saba et al. (2025)