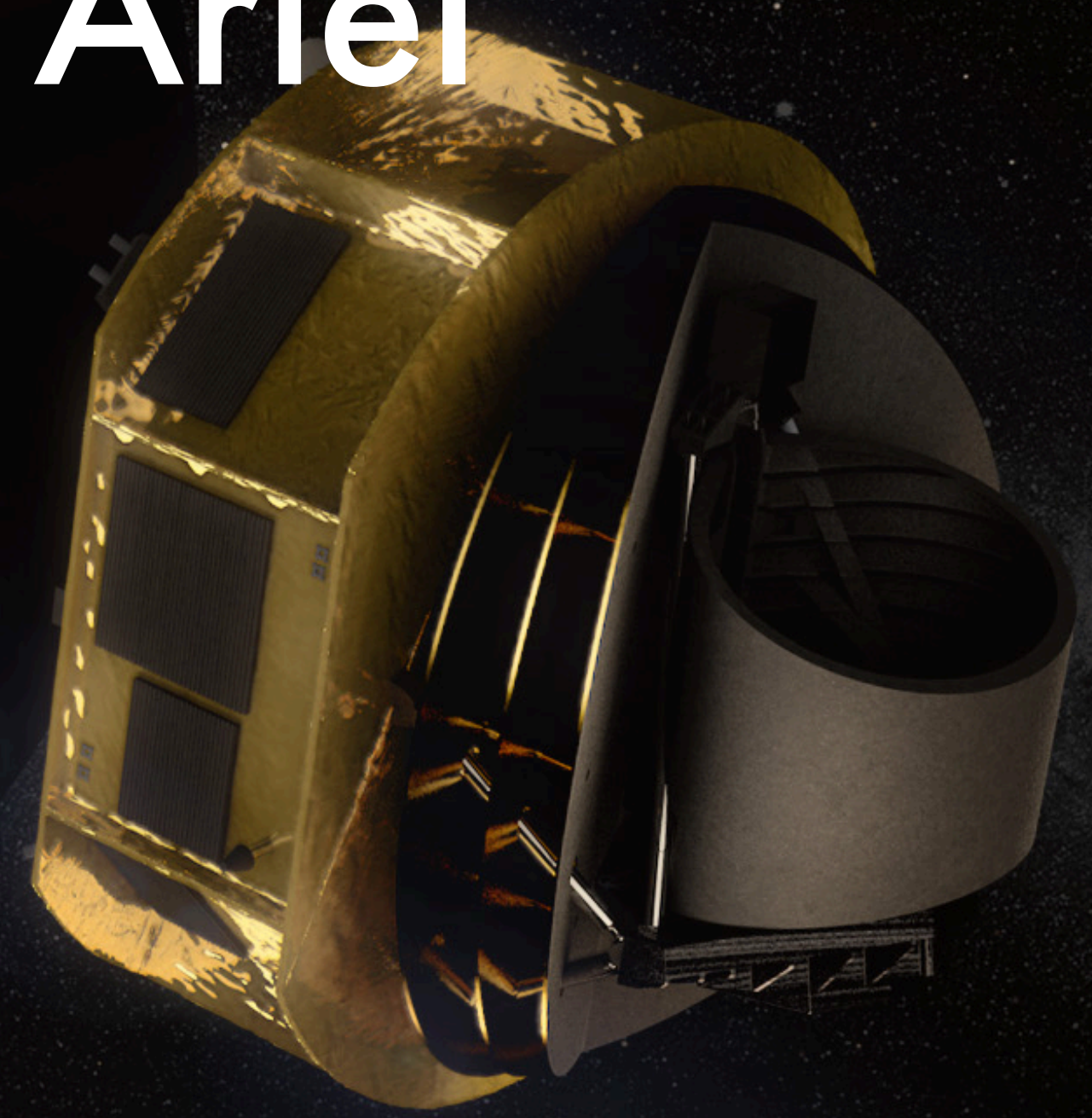
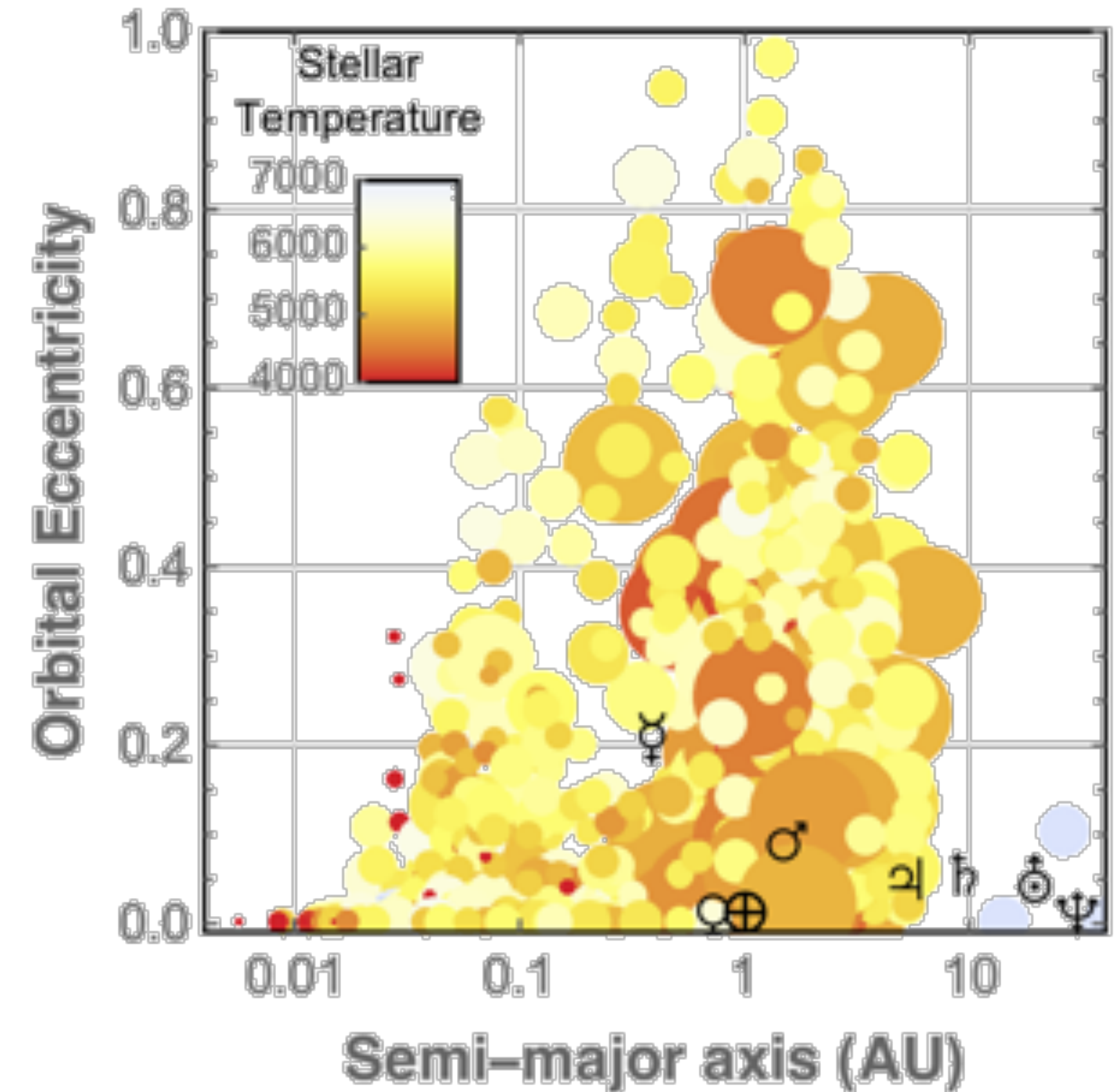
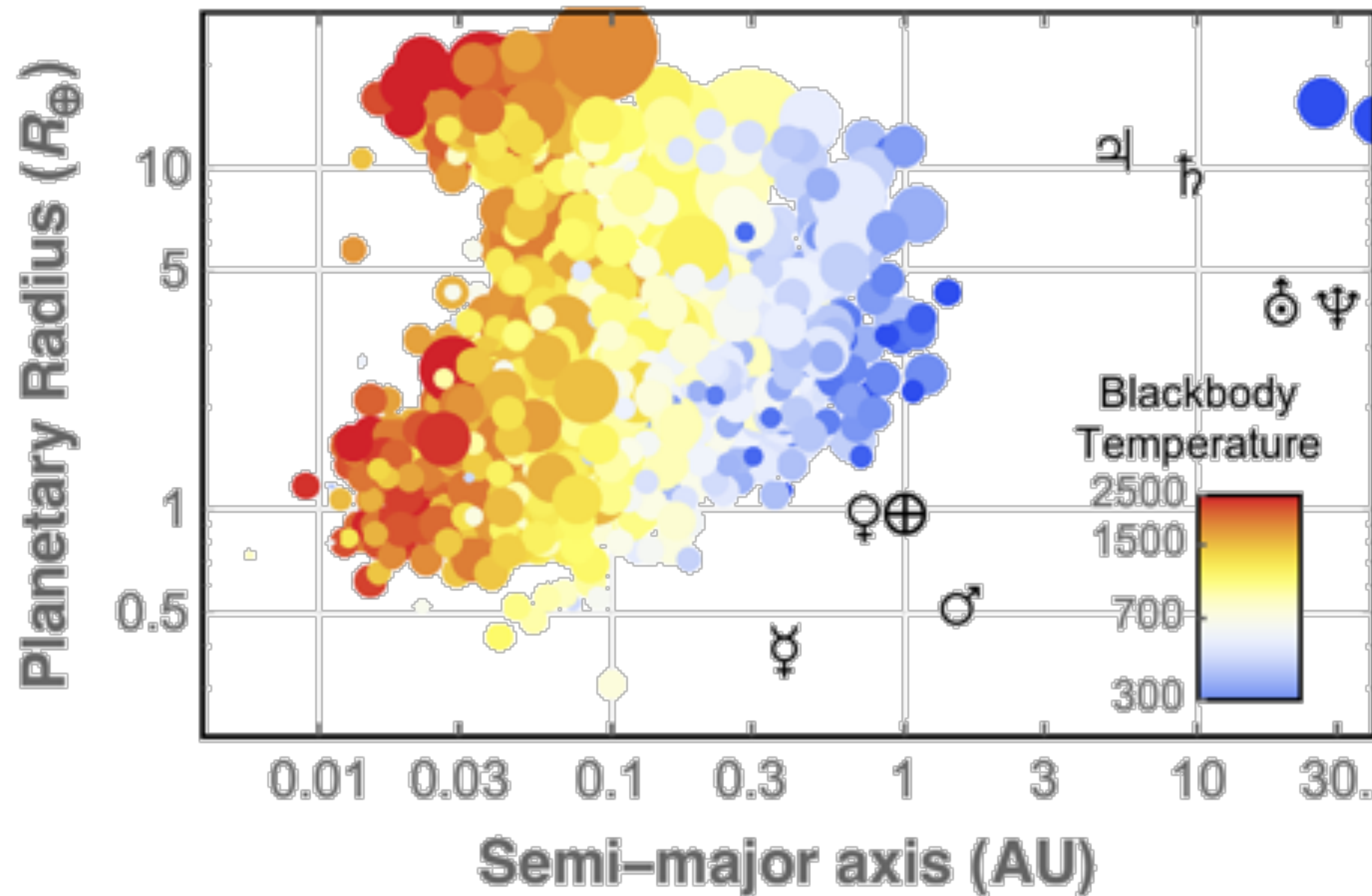


Selecting Targets For Ariel

BILLY EDWARDS



- 4000+ planets found: **Diverse population**

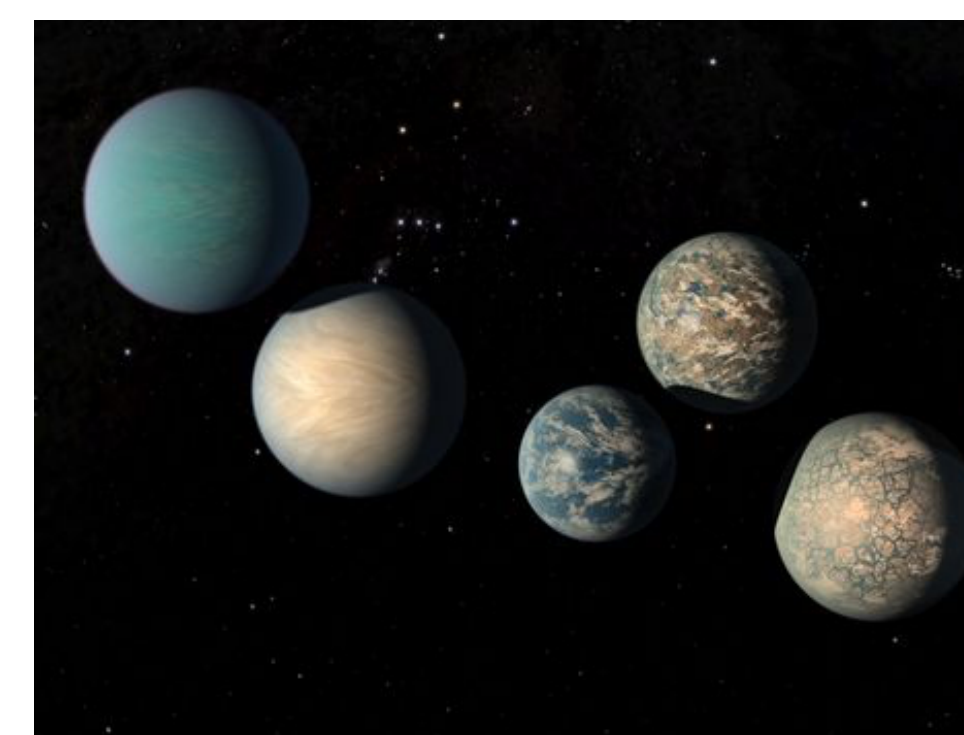
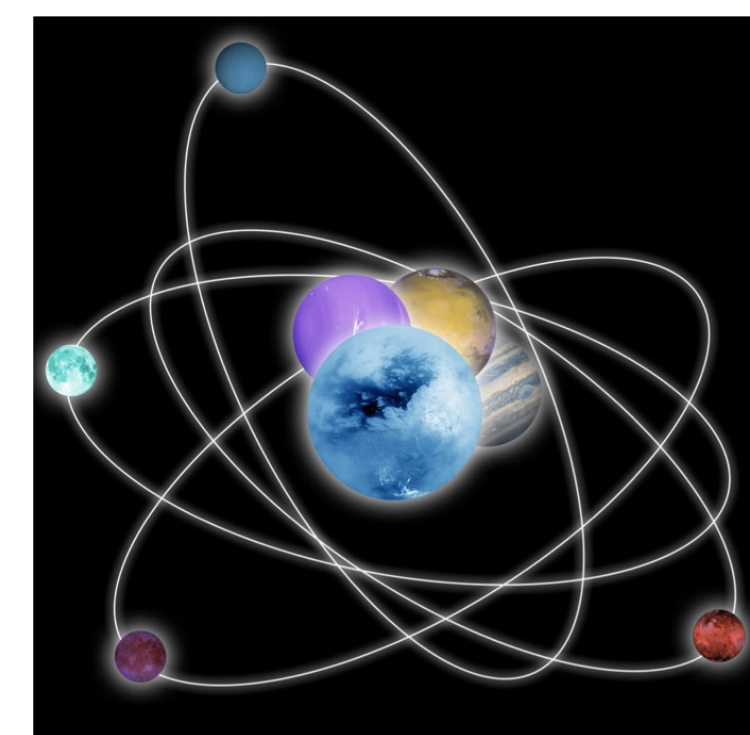
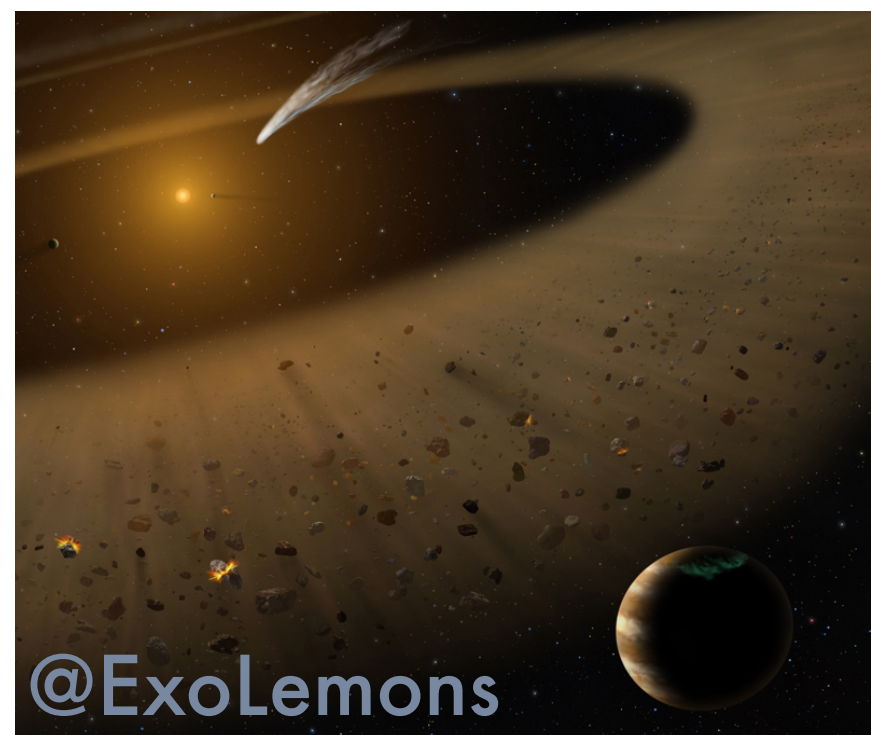




(Some) Key Exoplanet Questions



- How do planets form and evolve?
- How chemically diverse are exoplanets?
- How does chemistry correlate with other parameters?
- Have smaller planets retained H/He envelope?

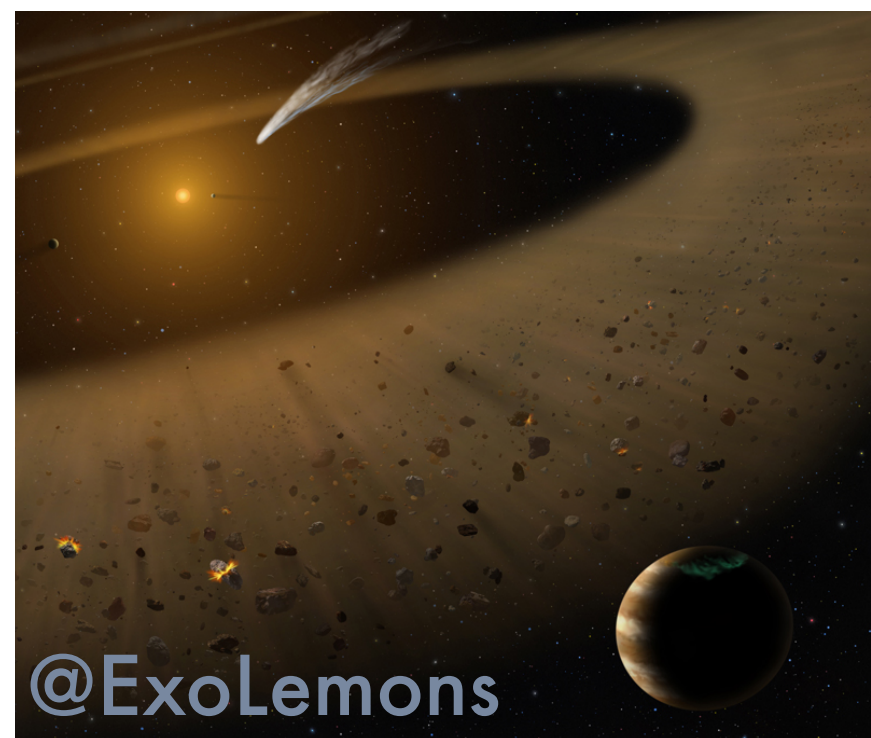




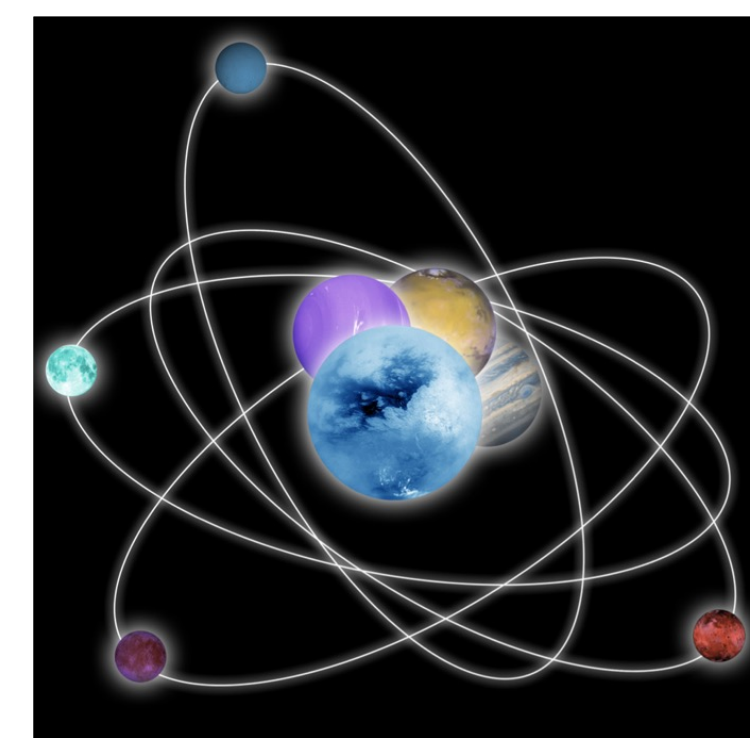
(Some) Key Exoplanet Questions



- How do planets form and evolve?
- How chemically diverse are exoplanets?
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- Have smaller planets retained H/He envelope?



Need to study the atmospheres of a large number of planets!



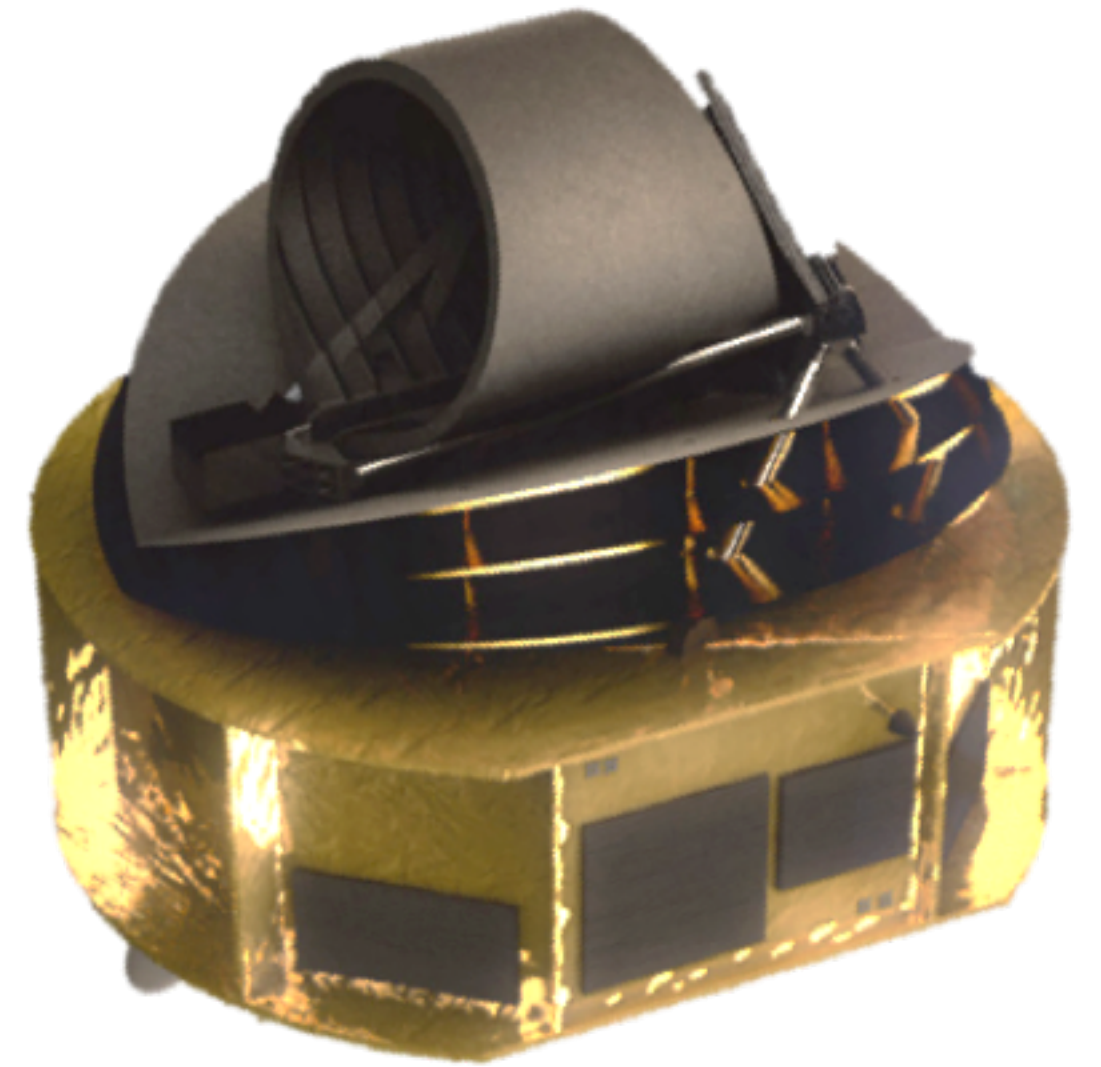


Ariel

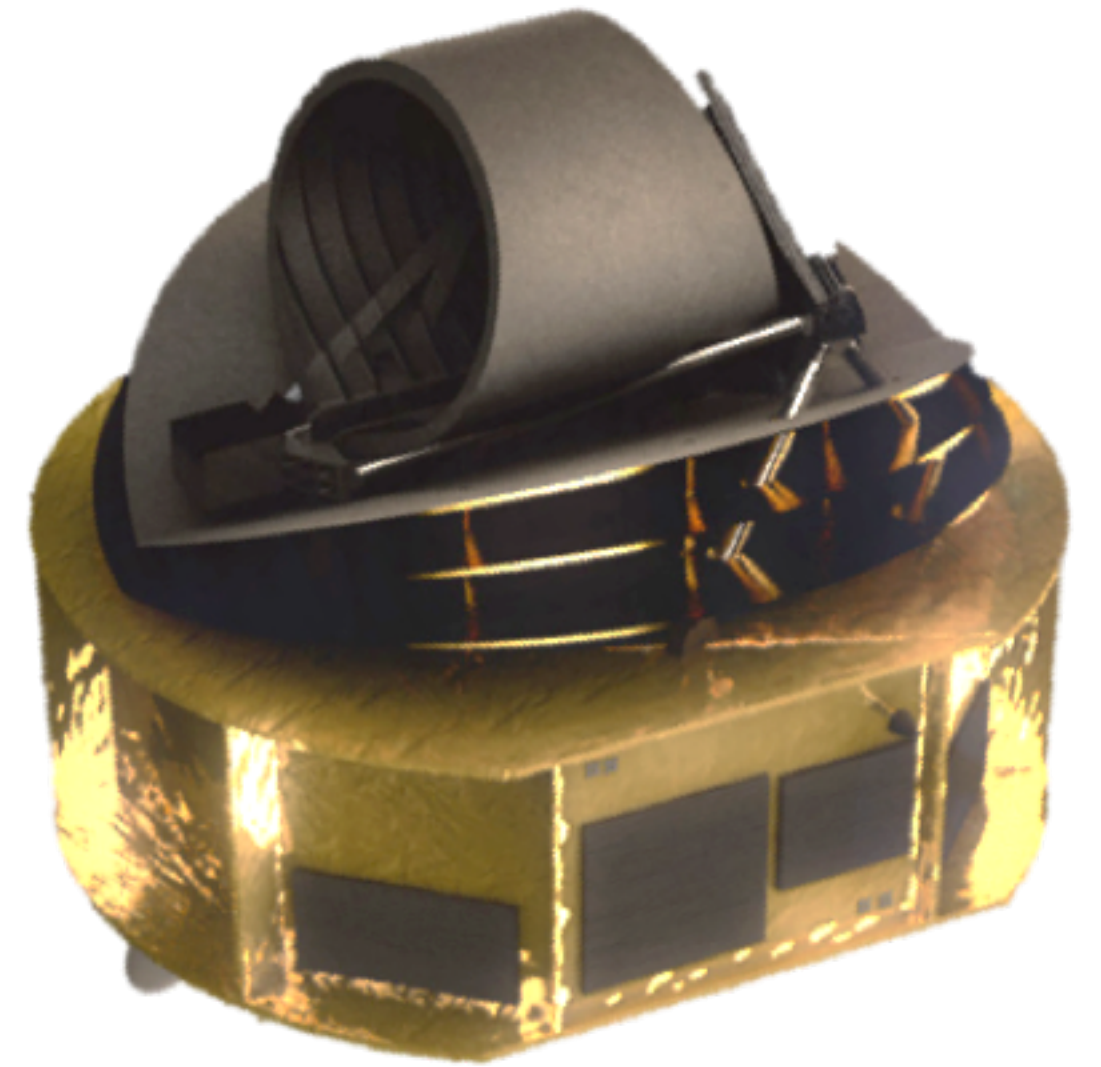




Ariel

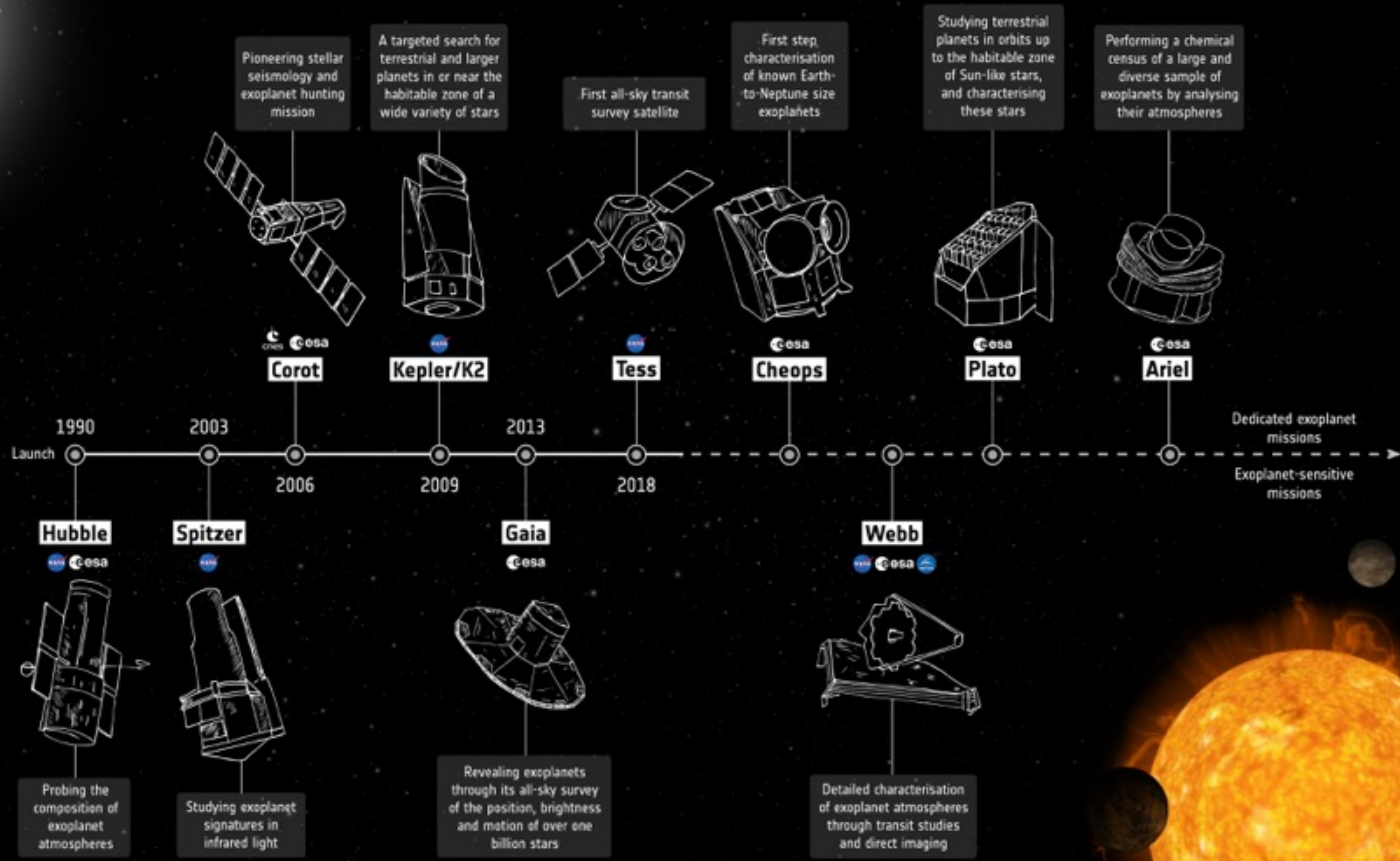


- ESA medium (M4) mission: **Launch 2028**
- Telescope aperture: **1m**
- Wavelength coverage: **0.5 - 7.8 μ m**
- Key science question:
 - **How chemically diverse are exoplanets?**
- Science goal:
 - **Observe ~1000 exoplanet atmospheres**



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



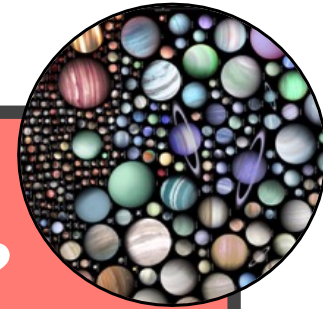


Observational Strategy

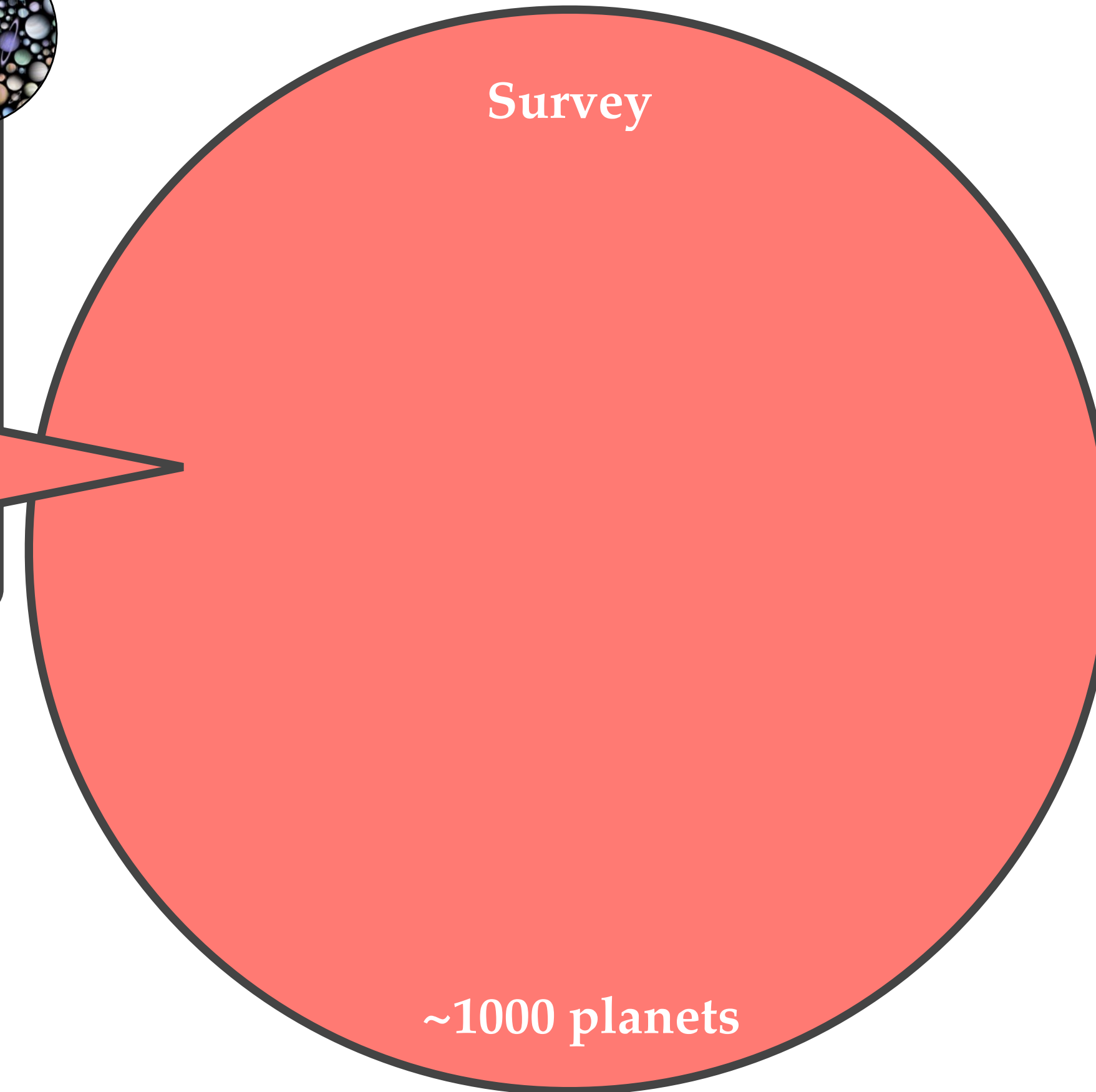


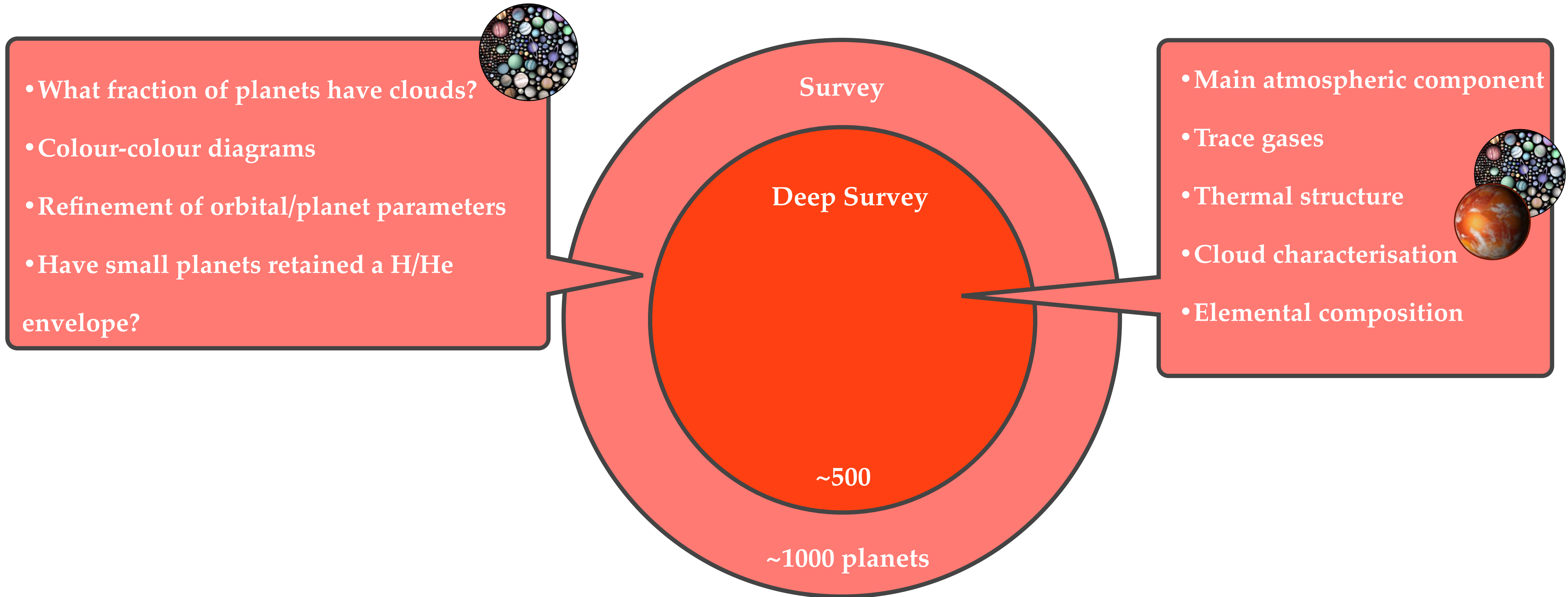


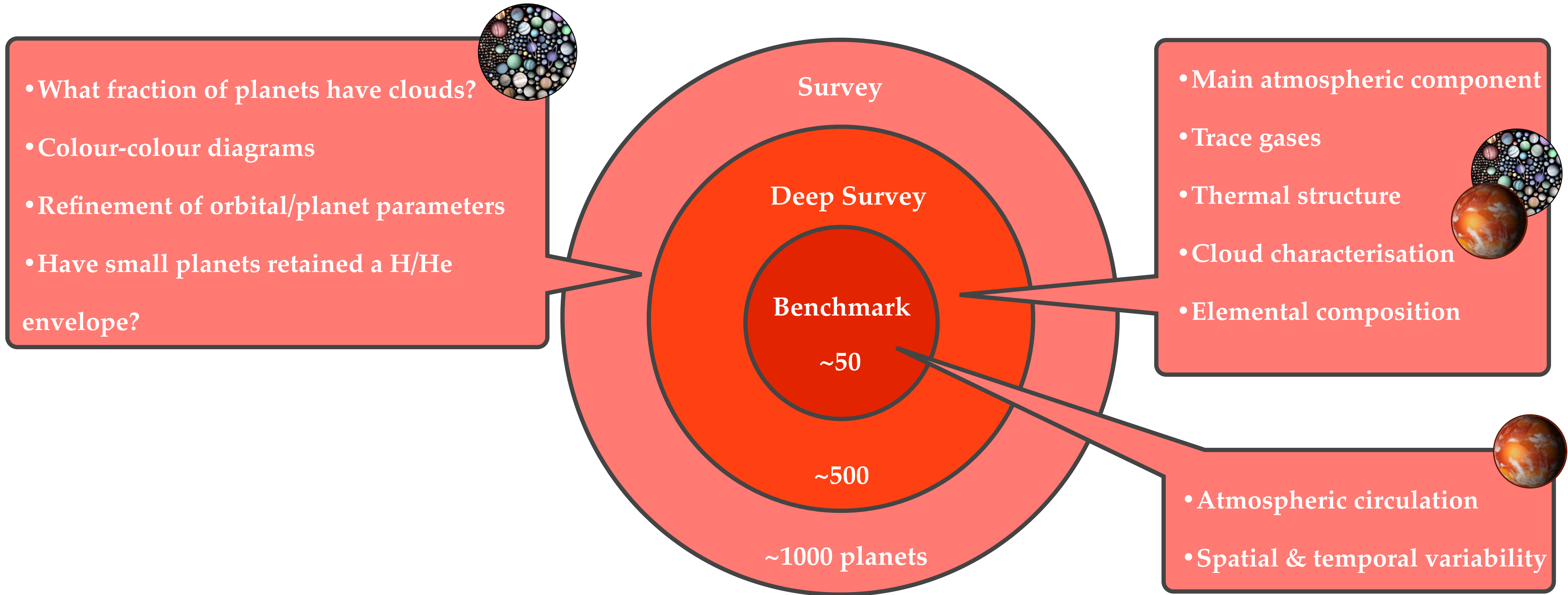
Observational Strategy

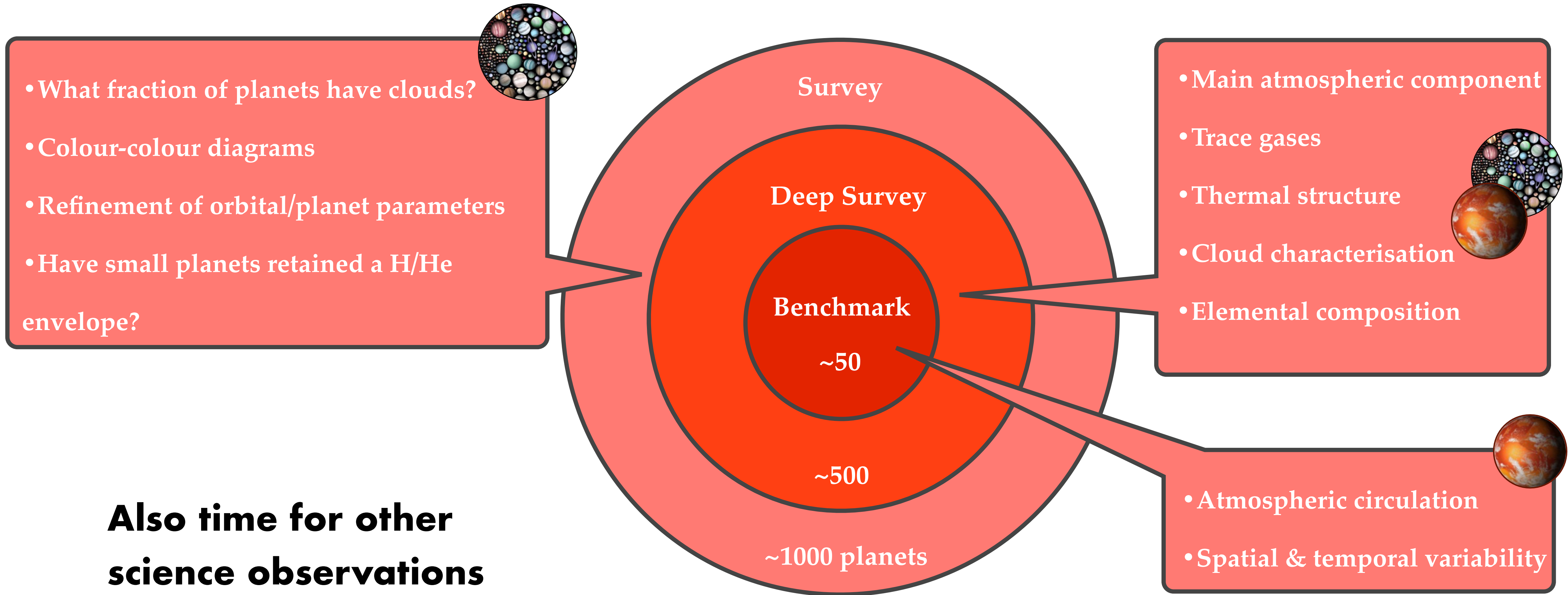


- What fraction of planets have clouds?
- Colour-colour diagrams
- Refinement of orbital/planet parameters
- Have small planets retained a H/He envelope?









Also time for other science observations e.g. phase curves



Ariel Exoplanet Catalogue



Master Catalogue

[NASA Exoplanet Catalogue](#)

Supplementary Catalogues

[Exoplanet.eu](#)

[Open Exoplanet Catalogue](#)

[TEPCat](#)



Ariel Exoplanet Catalogue



Master Catalogue

NASA Exoplanet Catalogue

Supplementary Catalogues

Exoplanet.eu

Open Exoplanet Catalogue

TEPCat

TESS Exoplanet Yield

Barclay, Pepper & Quintana, 2018

Methodology

Catalogue of target stars

Planetary occurrence statistics

Likelihood of detection with TESS



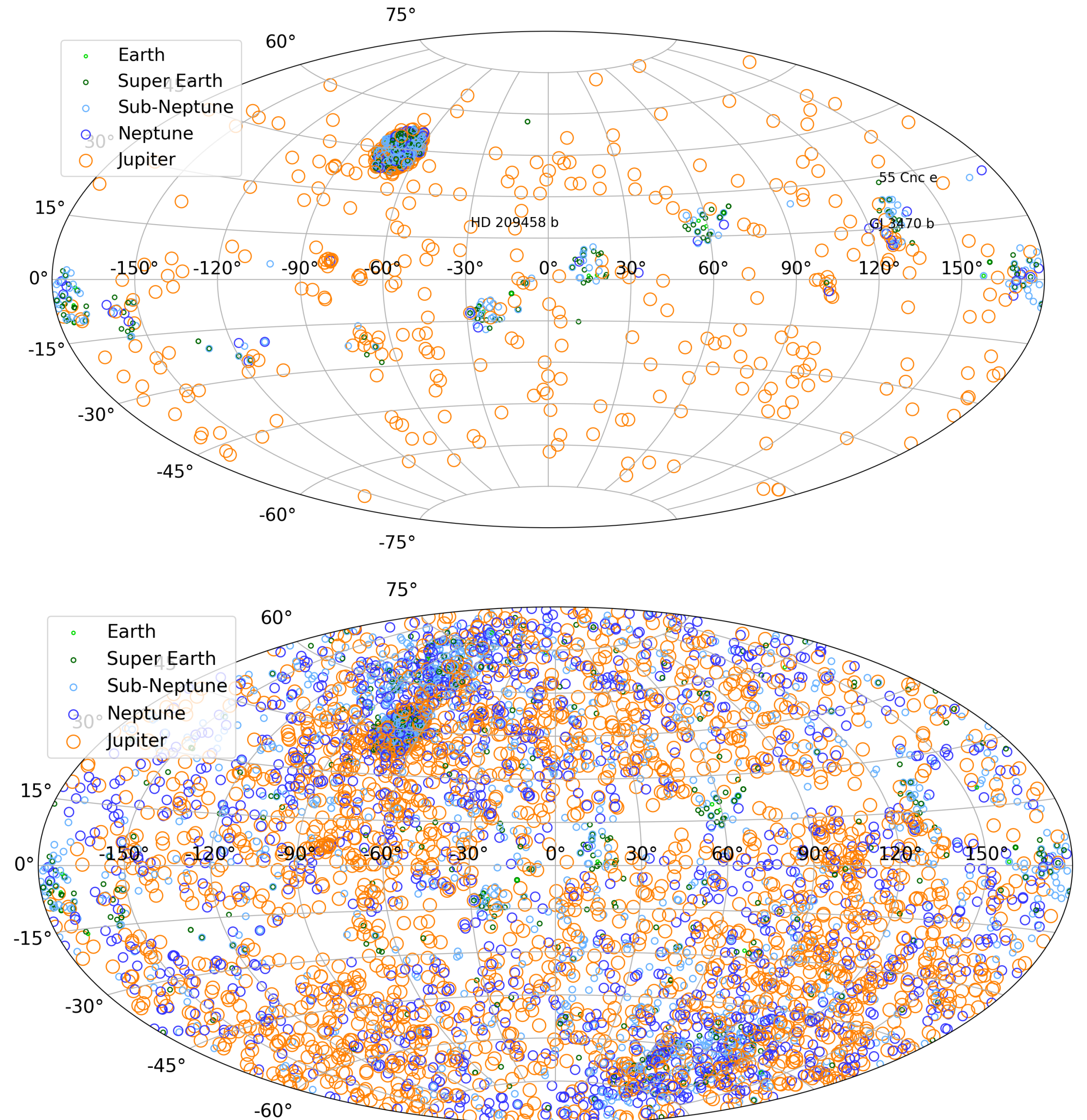
Ariel Exoplanet Catalogue



Title: A Revised Exoplanet Yield from the Transiting Exoplanet Survey Satellite (TESS)
 Authors: Barclay T., Pepper J., Quintana E. V.
 Table: Planet and host star properties for every detected planet in our simulation.

Byte-by-byte Description of file: apjsaae3e9t2_mrt.txt

Bytes	Format	Units	Label	Explanations
1- 9	I9	---	TICID	TESS Input Catalog ID number of star
11- 22	F12.8	deg	RAdeg	Right ascension, decimal degree (J2000)
24- 36	F13.9	deg	DEdeg	Declination, decimal degrees (J2000)
38- 49	F12.8	deg	ELON	Ecliptic longitude, decimal degrees
51- 60	F10.6	deg	ELAT	Ecliptic latitude, decimal degrees
62- 78	F17.15	---	Priority	CTL v6.1 priority
80- 80	I1	---	2min-target	Was this a 2-minute cadence target in our model? 1 = yes, 0 = no
82- 82	I1	---	Camera	TESS camera number, number between 1--4
84- 88	F5.1	d	Obslen	Number of days that target is observed
90- 91	I2	---	Num-sectors	Number of sectors the target is observed for
93- 98	F6.3	mag	Vmag	V-band magnitude
100-105	F6.3	mag	Kmag	2MASS Ks-band magnitude
107-112	F6.3	mag	Jmag	2MASS J-band magnitude
114-119	F6.3	mag	Tmag	TESS bandpass magnitude
121-126	F6.3	solRad	Star-radius	Stellar radius
128-132	F5.3	solMass	Star-mass	Stellar mass
134-140	F7.1	K	Star-teff	Stellar effective temperature
142-150	F9.3	pc	Distance	?=" " Distance of the star
152-152	I1	---	Subgiant	Was this star randomly selected to be a subgiant? 1 = yes, 0 = no
154-154	I1	---	Detected	Was this planet detected? 1 = yes, 0 = no
156-156	I1	---	Detected-cons	Was this planet detected using the conservative model? 1 = yes, 0 = no
158-166	F9.6	d	Planet-period	Orbital period of the planet
168-173	F6.3	Rgeo	Planet-radius	Radius of the planet
175-177	I3	---	Ntransits	Number of transits the planet has, 0 if planet does not transit
179-185	F7.3	---	Ars	Planet semimajor axis scaled by the stellar radius
187-194	F8.6	---	Ecc	Planet orbital eccentricity
196-203	F8.6	---	Rprs	Planet radius scaled by the stellar radius
205-209	F5.3	---	Impact	Planet impact parameter
211-216	F6.3	h	Duration	Planet transit duration
218-226	F9.3	10-6	Depth-obs	The observed transit depth, corrected for dilution, parts per million





Ariel Exoplanet Catalogue



- Many more surveys will provide planets for Ariel to characterise

Kepler/K2

KELT

HAT-Net

MEarth

PLATO

ESPRESSO

SPIRO

KPS

CHEOPS

WASP

NGTS

CARMENES

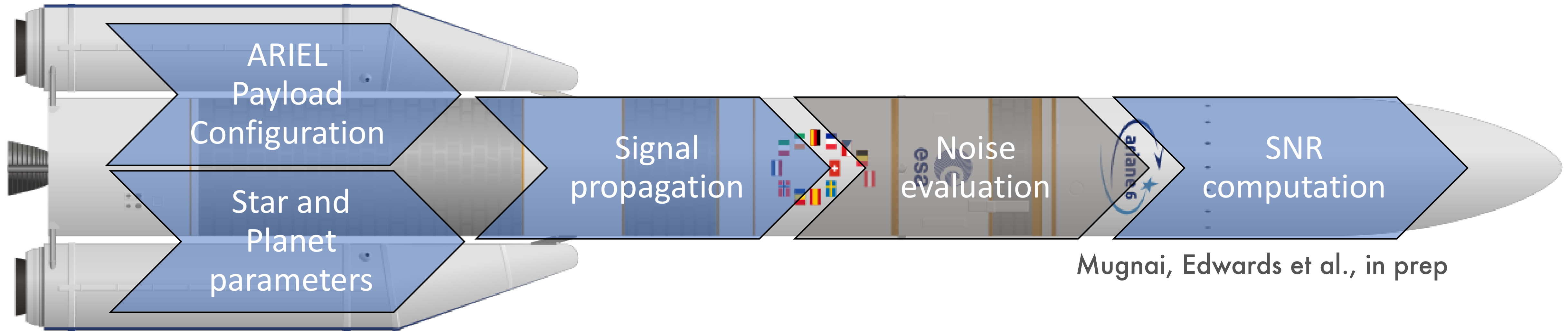
HARPS

HAT-South

SPECULOOS

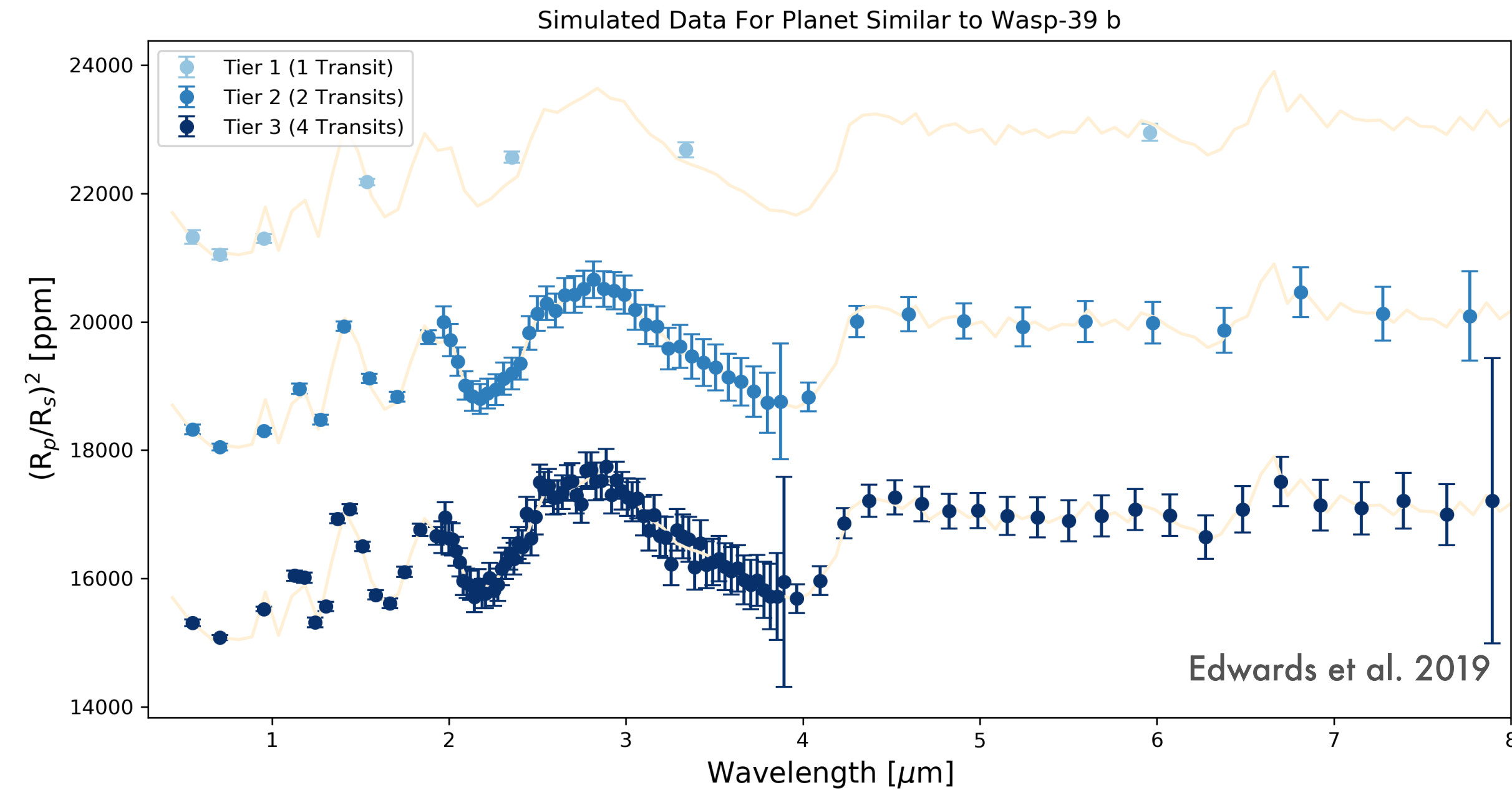
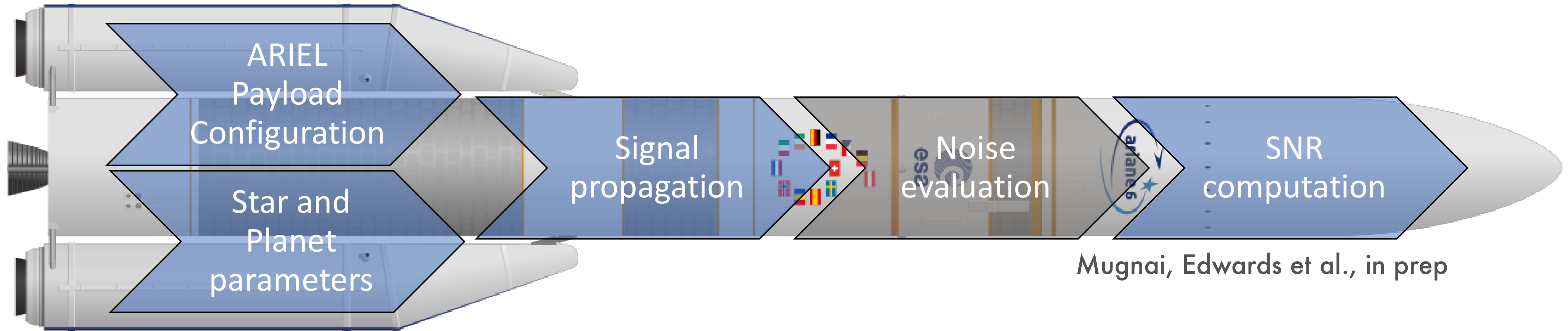


ArielRad





ArielRad

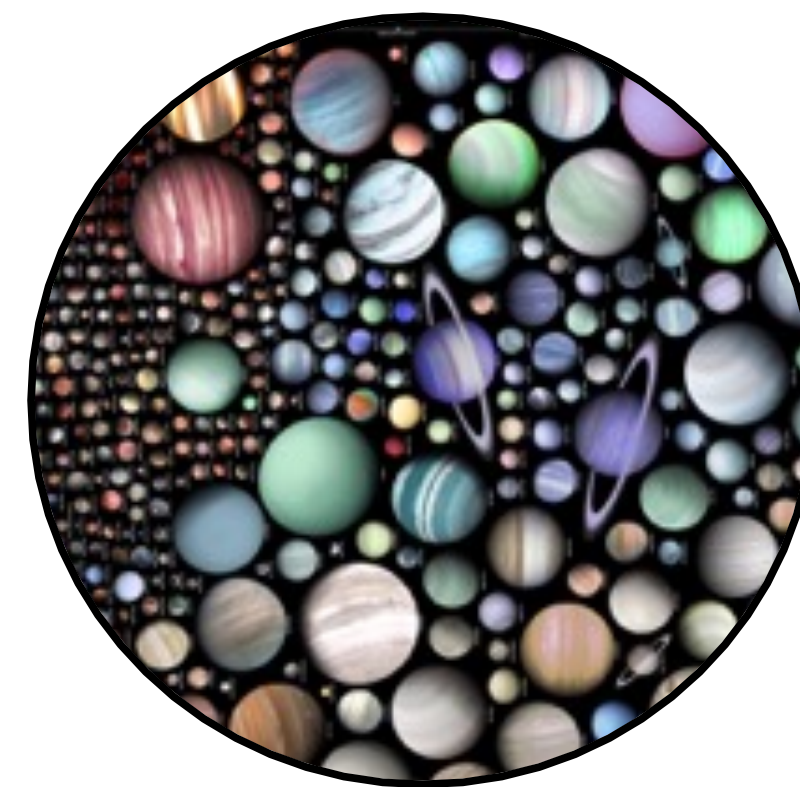
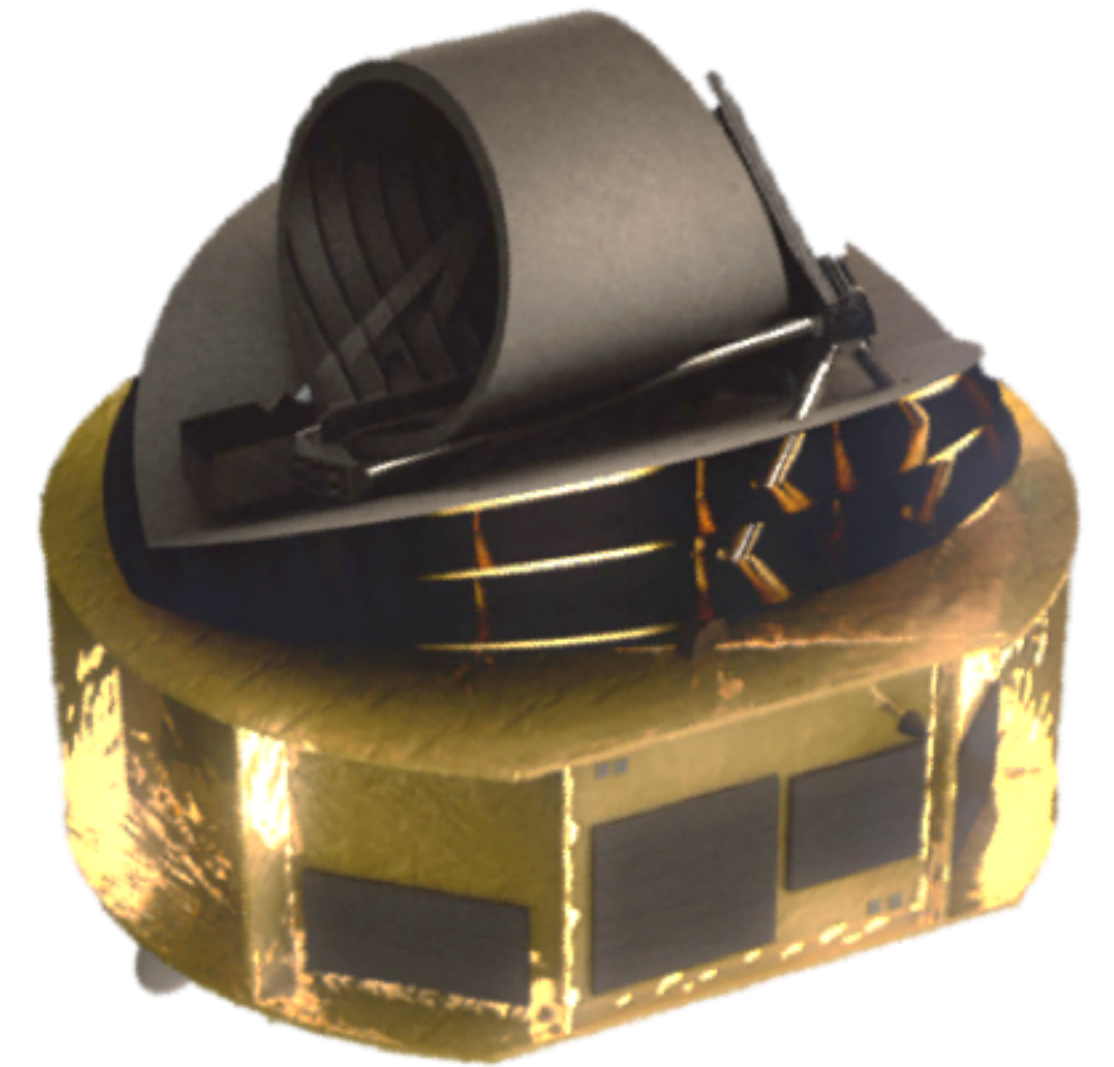




Potential Targets for Ariel

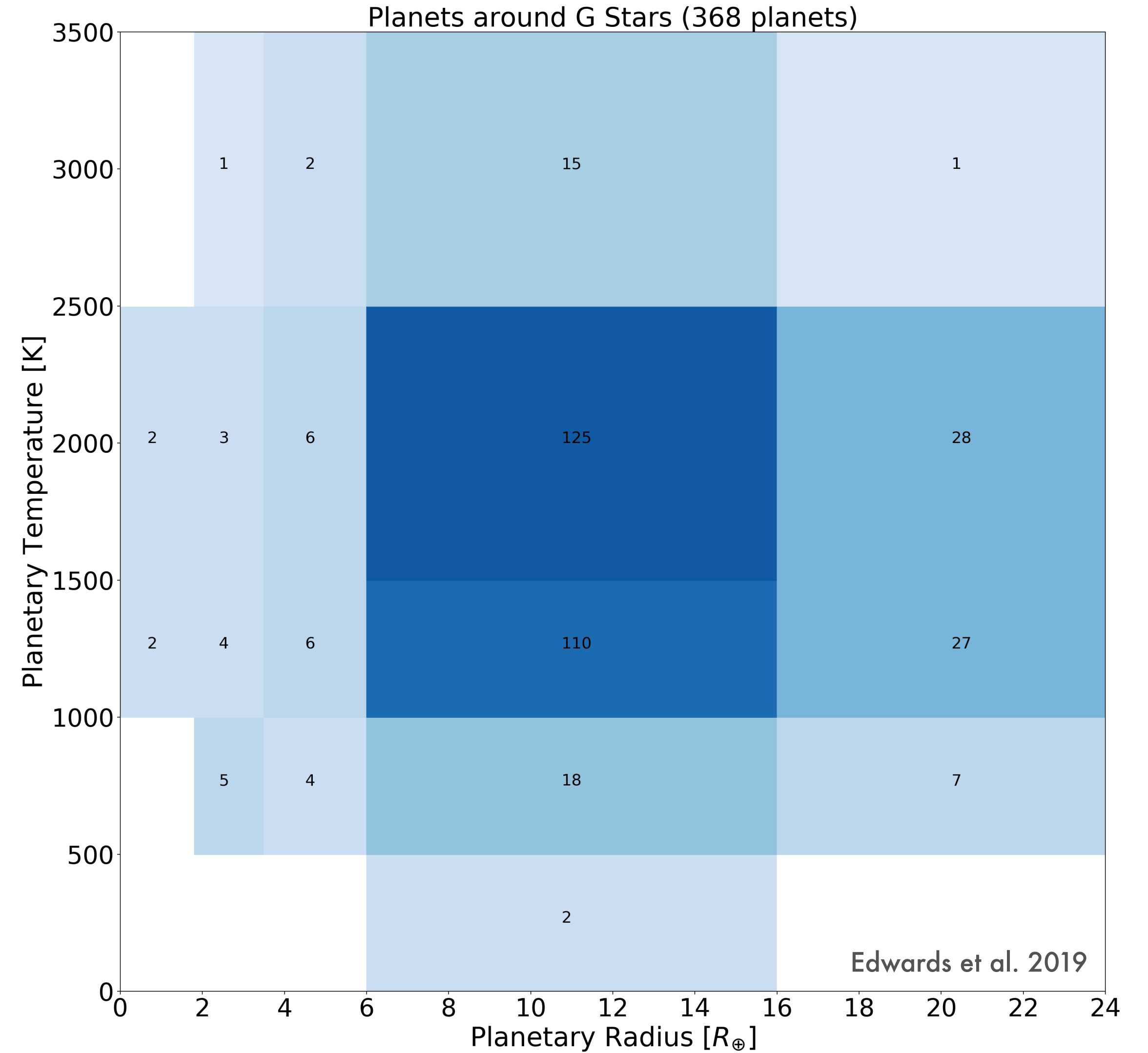
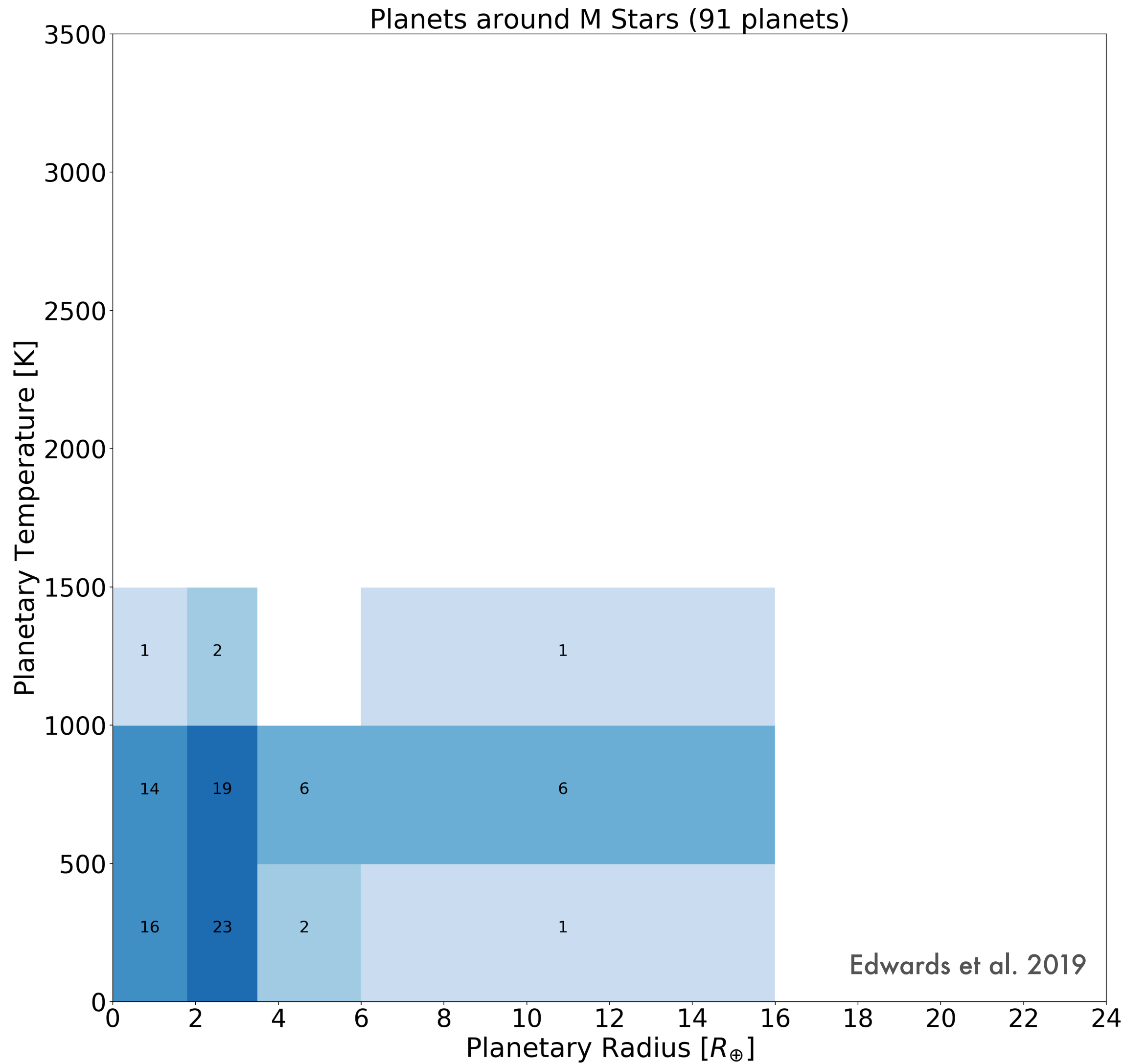


- Tier 1:
 - **~2000** planets in ≤ 5 observations
- Tier 2:
 - **~1000** planets in ≤ 20 observations
- Tier 3:
 - **~150** planets in ≤ 2 observations



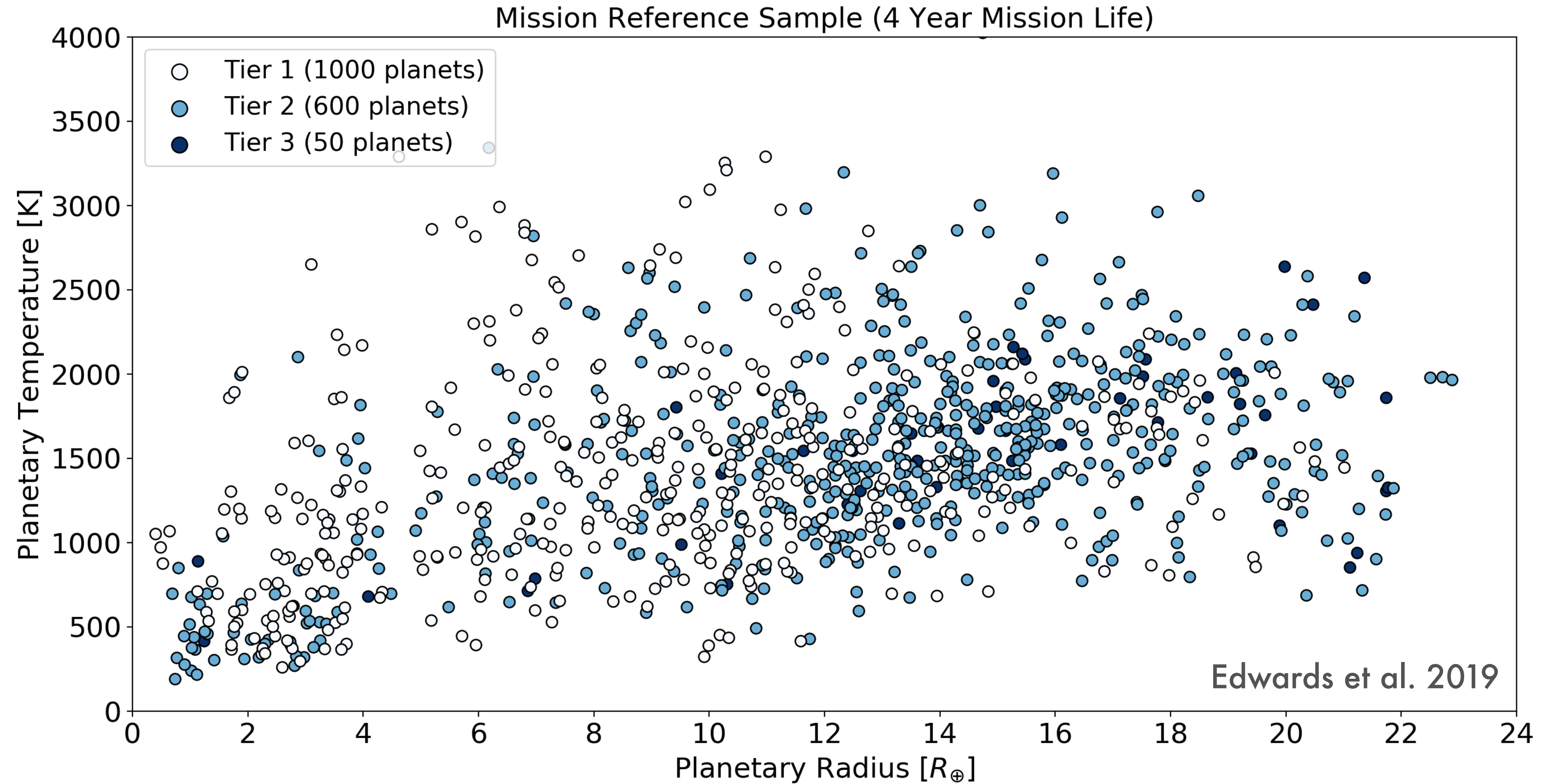


Example Mission Reference Sample





Example Mission Reference Sample



+ 10% mission time for other science (e.g. phase-curves)

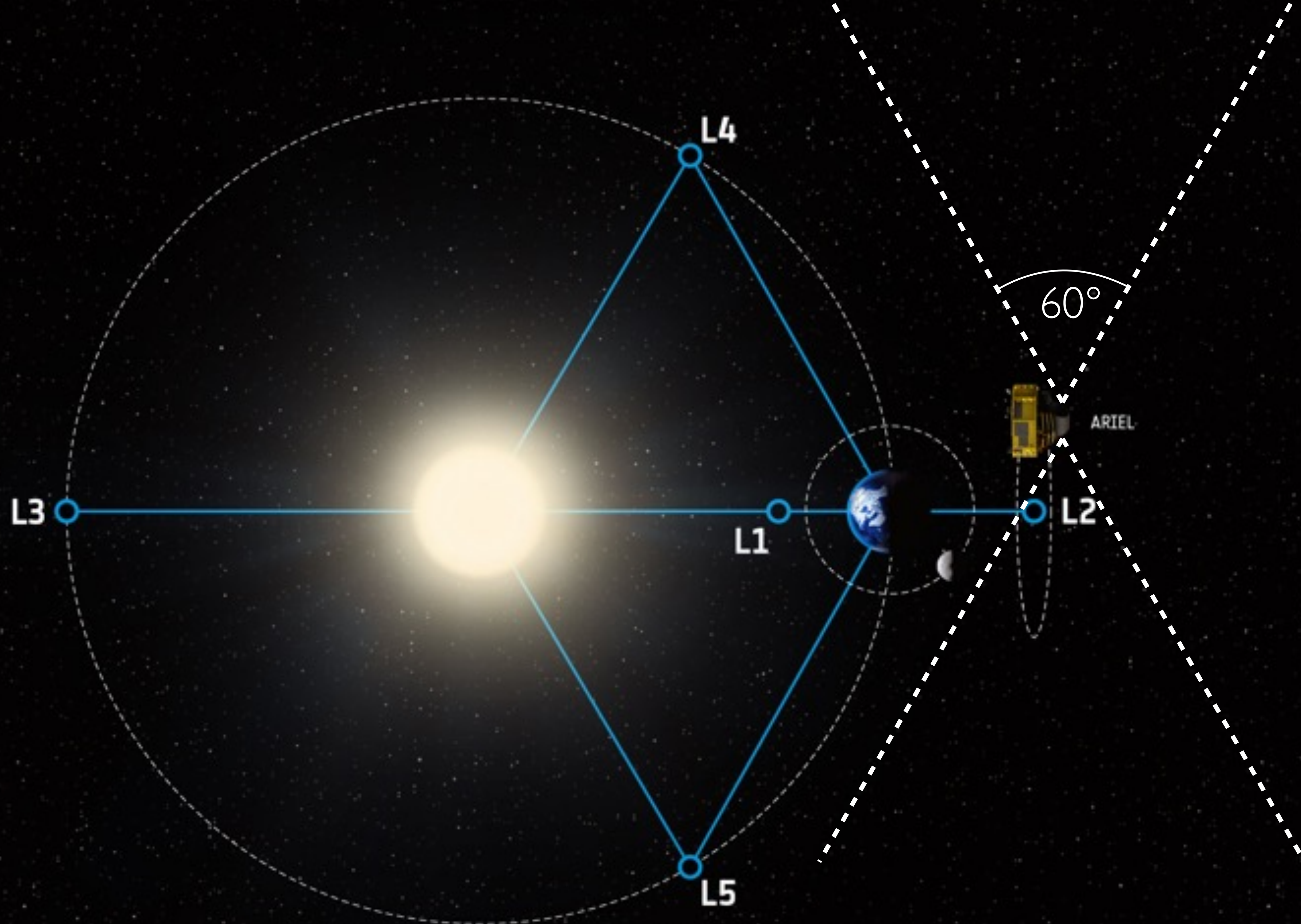


Final Selection of MRS



- **Mission Reference Sample will continue to evolve**
- **Input from the whole community**
- **Use knowledge gained from other facilities (e.g. JWST, E-ELT, Twinkle)**
- **Potential targets will be hosted on a website**
- **Ariel Public Conference: 14-16 January 2020, ESTEC, Netherlands**

PLATO + Ariel





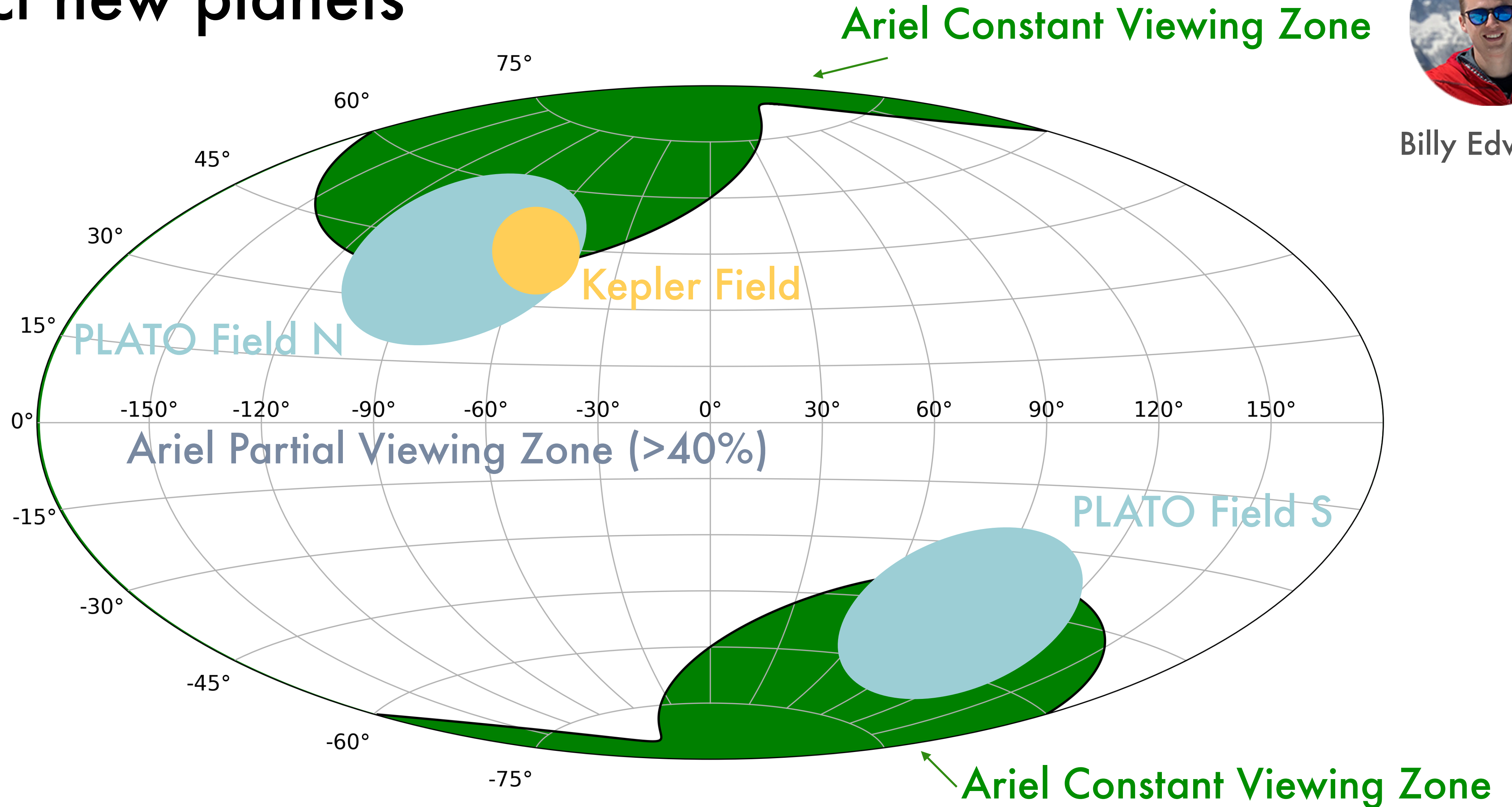
PLATO + Ariel



- Detect new planets



Billy Edwards





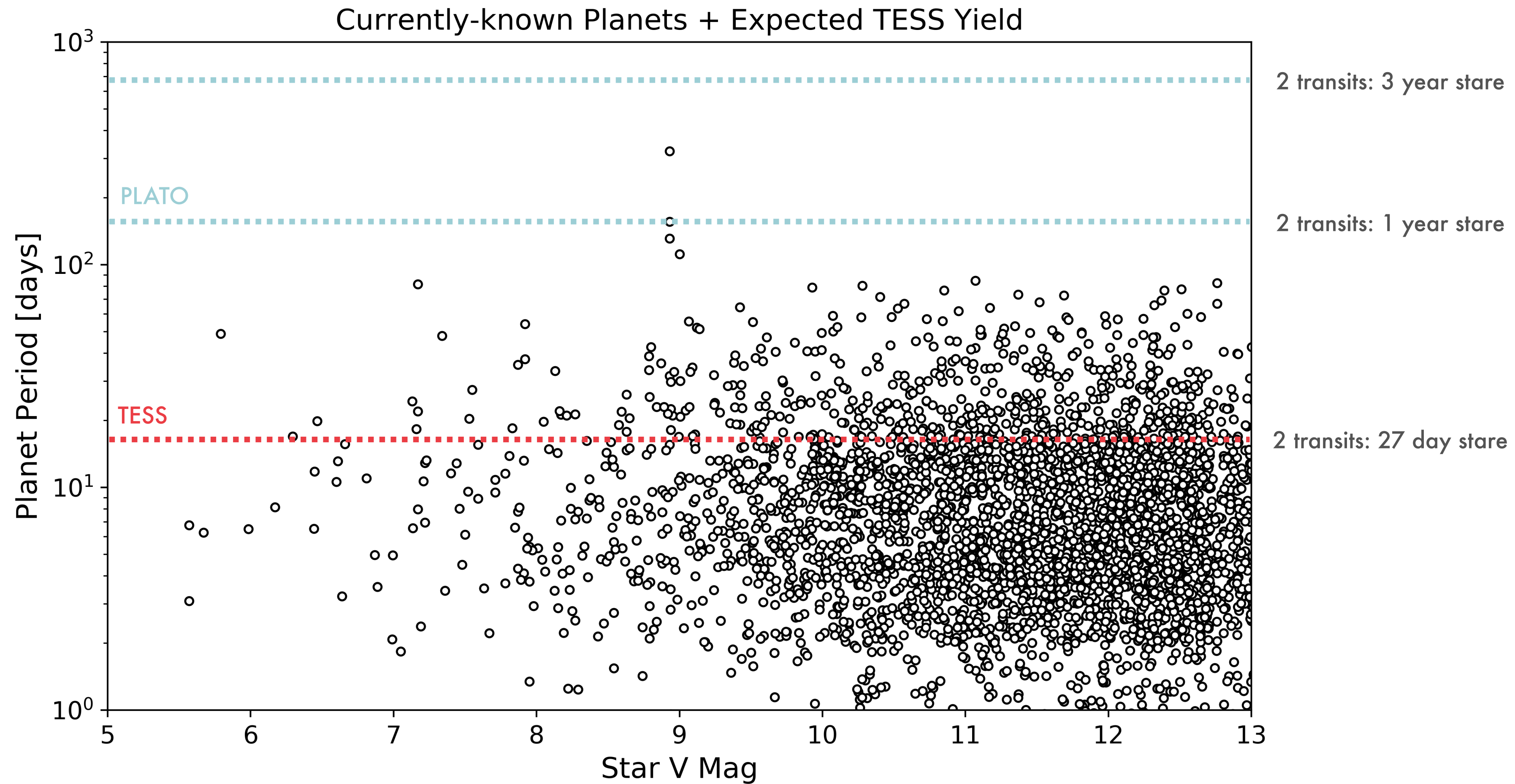
PLATO + Ariel



- Detect new planets



Billy Edwards





PLATO + Ariel



- Detect new planets



Billy Edwards

	stellar sample	24 N-cam (2+2)	24 N-cam (3+1)	24 N-cam (3+2+1)
all planets, all orbital periods, $V \leq 13$	P1+P5	~4 600	~11 000	~13 000
all planets, all orbital periods, $V \leq 11$	P1+P5 bright	~1 200	~2 700	~3 300
small planets ($R < 2 R_E$), all orbital periods, $V \leq 11$	P1+P5 bright	~770	~1 800	~2 200
small planets ($R < 2 R_E$), in HZ, $V \leq 11$	P1+P5 bright	6 - 280	3 - 140	6 - 280

Useful:
More granularity in the distribution of planets

Very Useful:
Rough distribution of planets by star type, planet size and orbital period

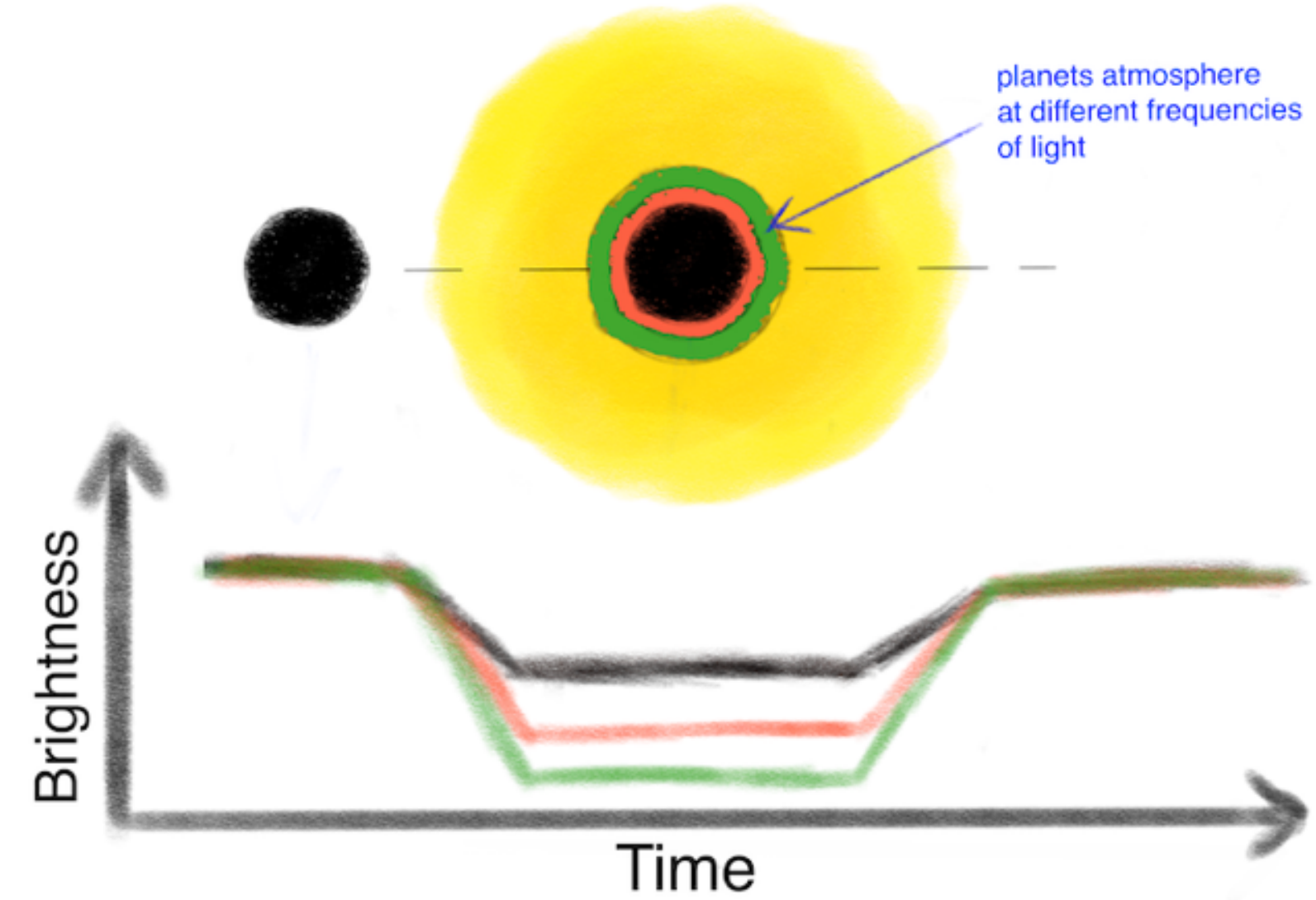
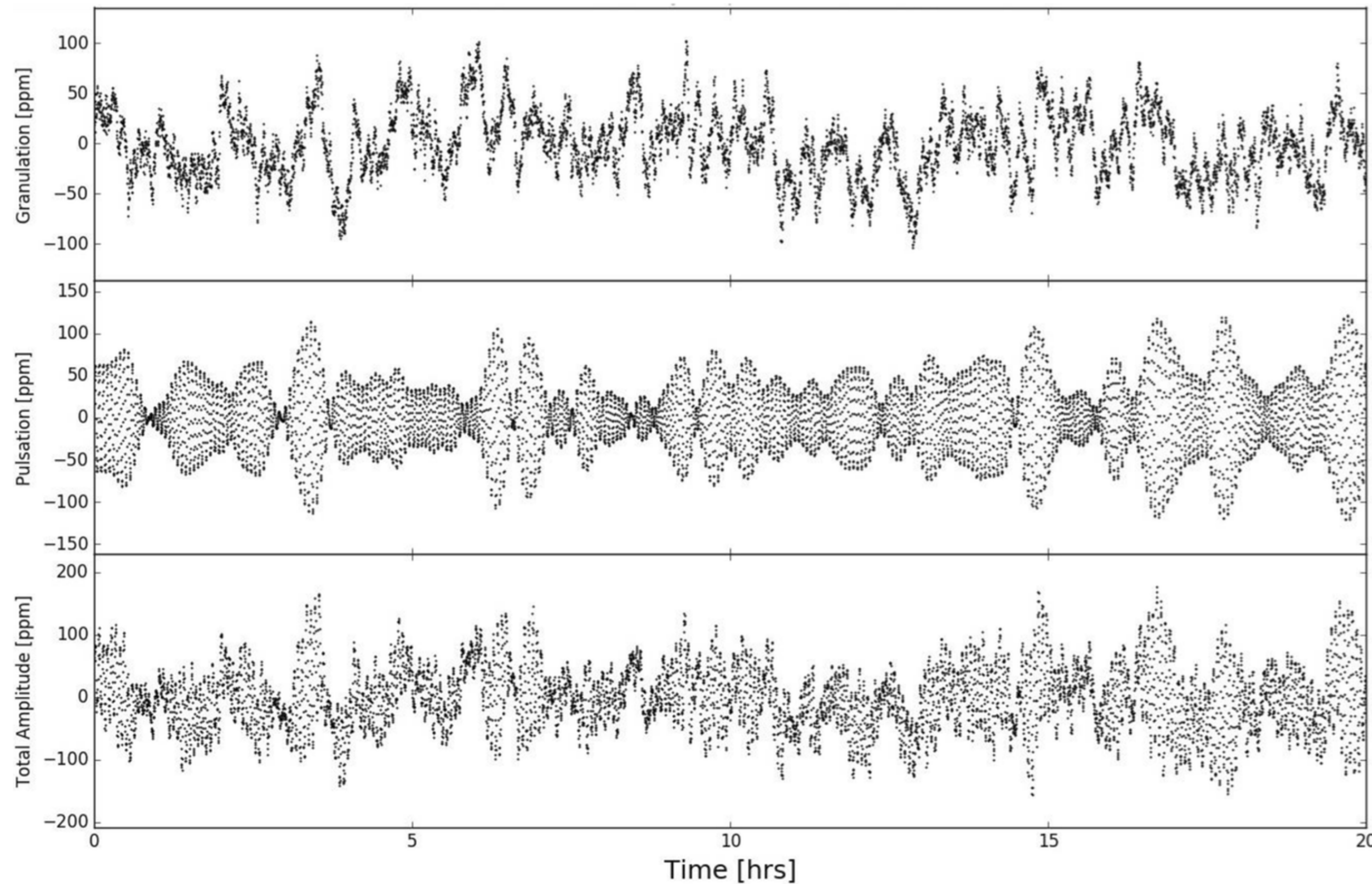
Gold Standard:
Study similar to Barclay et al. 2018



PLATO + Ariel



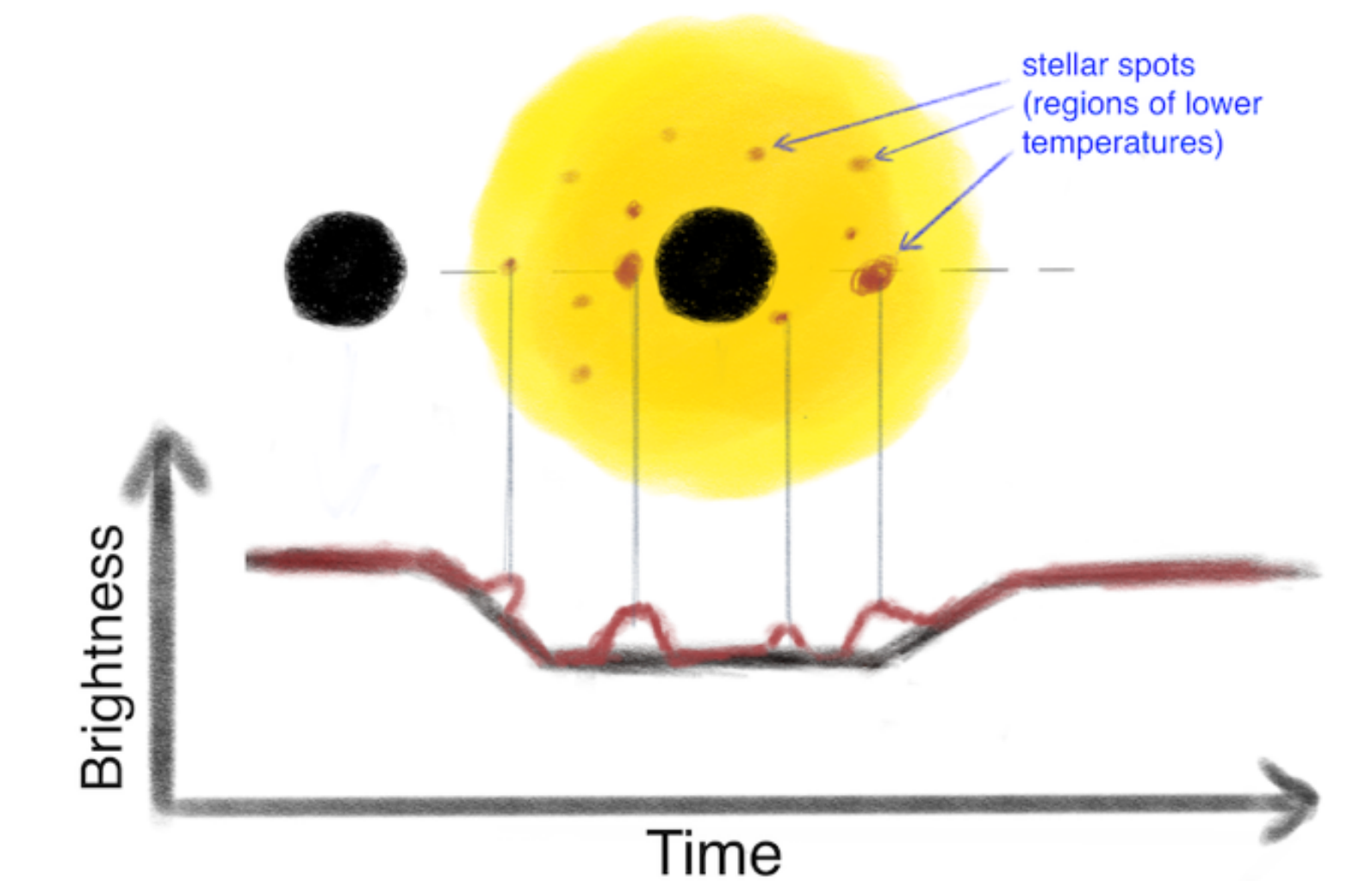
- Characterising host star



Ingo Waldmann



Nikos Nikolaus

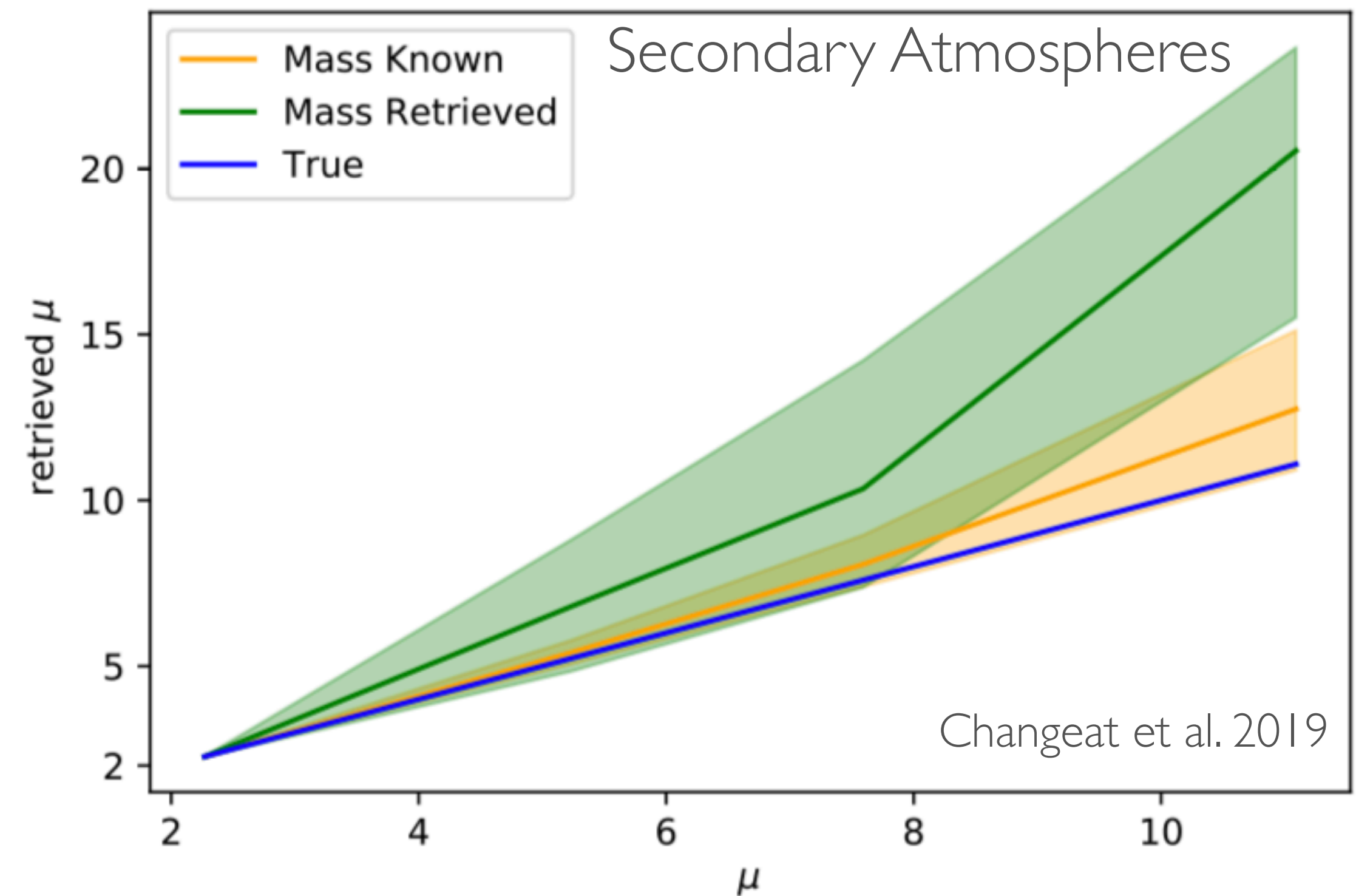
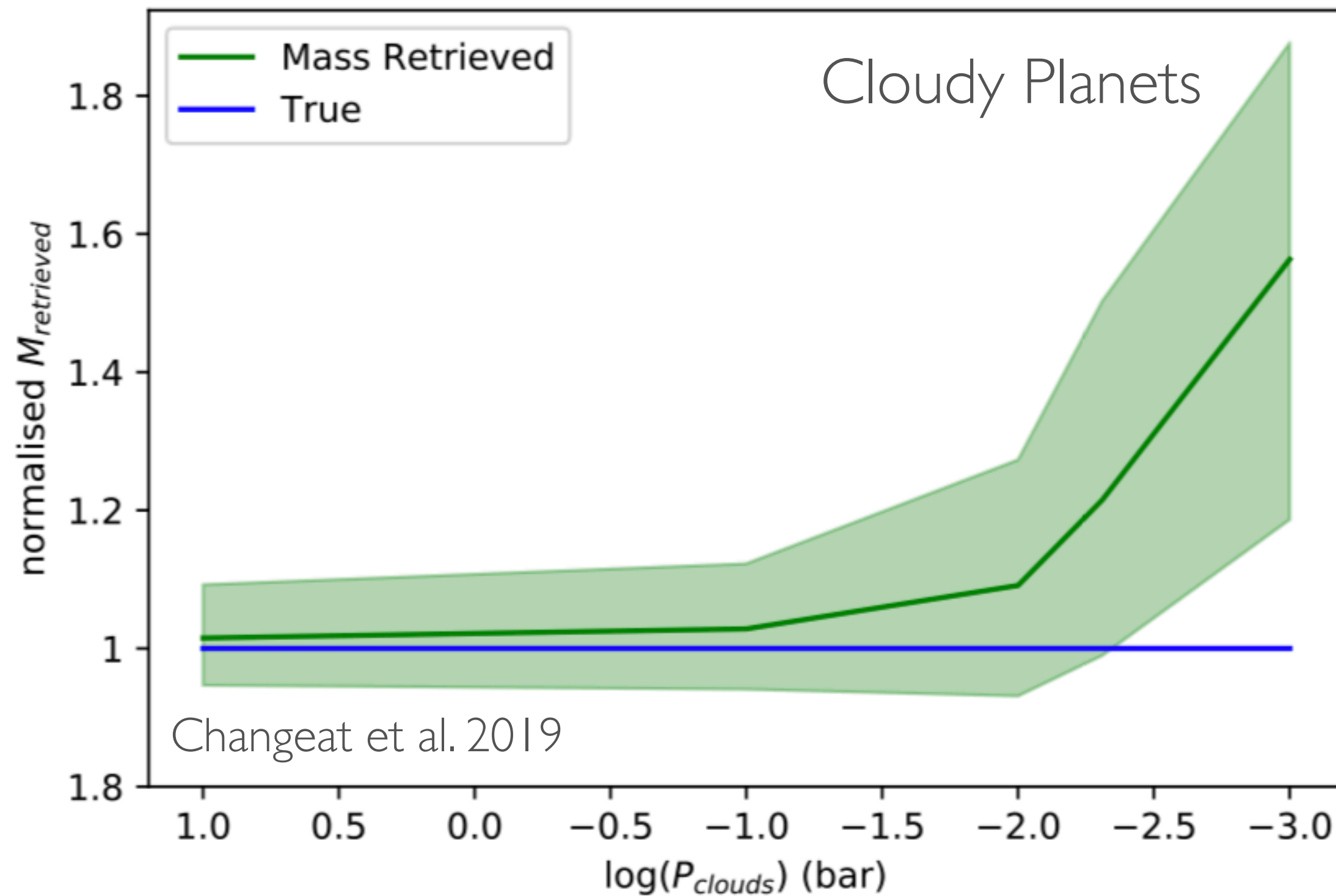


Subhajit Sarkar

- Planet Masses: Very useful for...



Quentin Changeat





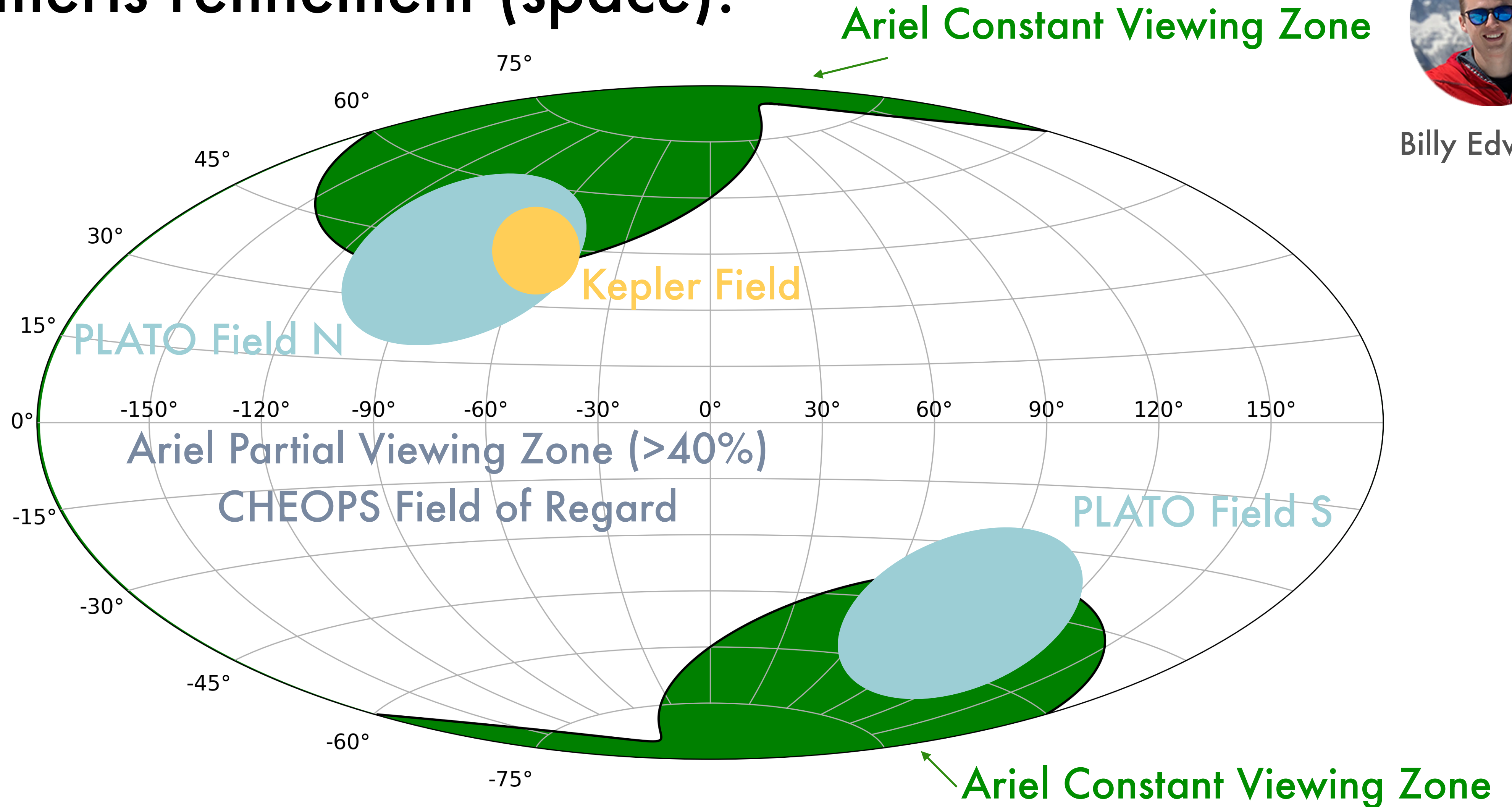
PLATO + Ariel



- Ephemeris refinement (space):



Billy Edwards





PLATO + Ariel



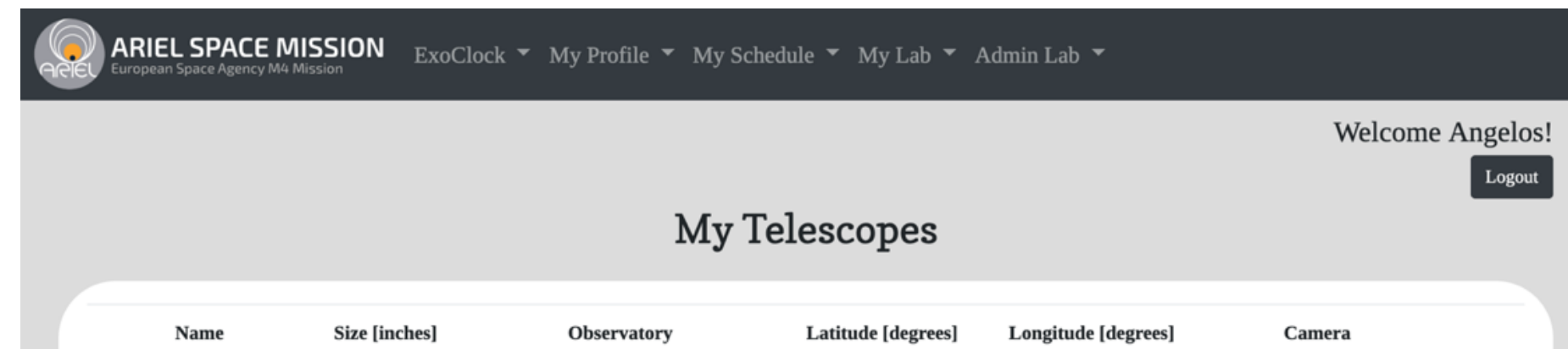
• Ephemeris refinement (ground):

Original Research By Young Twinkle Students (ORBYTS):
Ephemeris Refinement of Transiting Exoplanets

Billy Edwards^{1*}, Quentin Changeat¹, Kai Hou Yip¹, Angelos Tsiaras¹, Jake Taylor², Bilal Akhtar³, Josef AlDaghir³, Pranup Bhattarai³, Tushar Bhudia⁴, Aashish Chapagai³, Michael Huang³, Danyaal Kabir⁴, Vieran Khag⁴, Summyyah Khaliq⁴, Kush Khatri³, Jaidev Kneth⁴, Manisha Kothari⁴, Ibrahim Najmudin³, Lobanaa Panchalingam⁴, Manthan Patel³, Luxshan Premachandran⁴, Adam Qayyum⁴, Prasen Rana³, Zain Shaikh³, Sheryar Syed⁴, Harnam Theti⁴, Mahmoud Zaidani³, Manasvee Saraf¹, Damien de Mijolla¹, Hamish Caines¹, Anatasia Kokori^{5,6}, Marco Rocchetto^{7,1}, Matthias Mallonn⁸, Matthieu Bachschmidt⁹, Josep M. Bosch¹⁰, Marc Bretton¹¹, Philippe Chatelain¹², Marc Deldem¹³, Romina Di Sisto^{14,15}, Phil Evans¹⁶, Eduardo Fernández-Lajús^{14,15}, Pere Guerra¹⁷, Ferran Grau Horta¹⁸, Wonseok Kang¹⁹, Taewoo Kim¹⁹, Arnaud Leroy²⁰, František Lomoz²¹, Juan Lozano de Haro²², Veli-Pekka Hentunen²³, Yves Jongen²⁴, David Molina²⁵, Romain Montaignut²⁰, Ramon Naves²⁶, Manfred Raetz²⁷, Thomas Sauer²⁸, Americo Watkins²⁹, Anaël Wünsche¹¹, Martin Zibar³⁰, Marcell Tessenyi^{31,1}, Giorgio Savini^{1,32,31} & Giovanna Tinetti^{1,31}



Angelos Tsiaras



Planet Name & Remarks	Star RA/DEC [h/deg]	Star Vmag [mag]	Transit Depth [mmag]	Transit Duration [h]	Observ. Start [TZ:2.0]	Transit Start [TZ:2.0]	Transit Mid-point [TZ:2.0]	Transit End [TZ:2.0]	Observ. End [TZ:2.0]
WASP-52b LOW PRIORITY NO PRE-TRANSIT	23:13:58.74 8:45:40.5 FOV	12.0	33.51	1.82	2019/09/06 19:31 16° E	2019/09/06 20:31 27° E	2019/09/06 21:26 36° SE	2019/09/06 22:20 44° SE	2019/09/06 23:20 52° SE
TrES-2b MEDIUM PRIORITY	19:07:14.03 49:18:59.0 FOV	11.41	15.44	1.84	2019/09/06 19:59 82° NE	2019/09/06 20:59 82° NW	2019/09/06 21:54 74° NW	2019/09/06 22:49 66° NW	2019/09/06 23:49 56° NW
HAT-P-32b MEDIUM PRIORITY NO PRE-TRANSIT	2:04:10.28 46:41:16.2 FOV	11.29	29.63	3.12	2019/09/06 20:04 19° NE	2019/09/06 21:04 27° NE	2019/09/06 22:38 41° NE	2019/09/07 00:12 56° NE	2019/09/07 01:12 66° E
Qatar-1b LOW PRIORITY	20:13:31.60 65:09:43.3 FOV	12.84	25.33	1.65	2019/09/06 20:25 66° N	2019/09/06 21:25 68° N	2019/09/06 22:15 68° N	2019/09/06 23:04 65° N	2019/09/07 00:04 60° NW



Anastasia Kokori



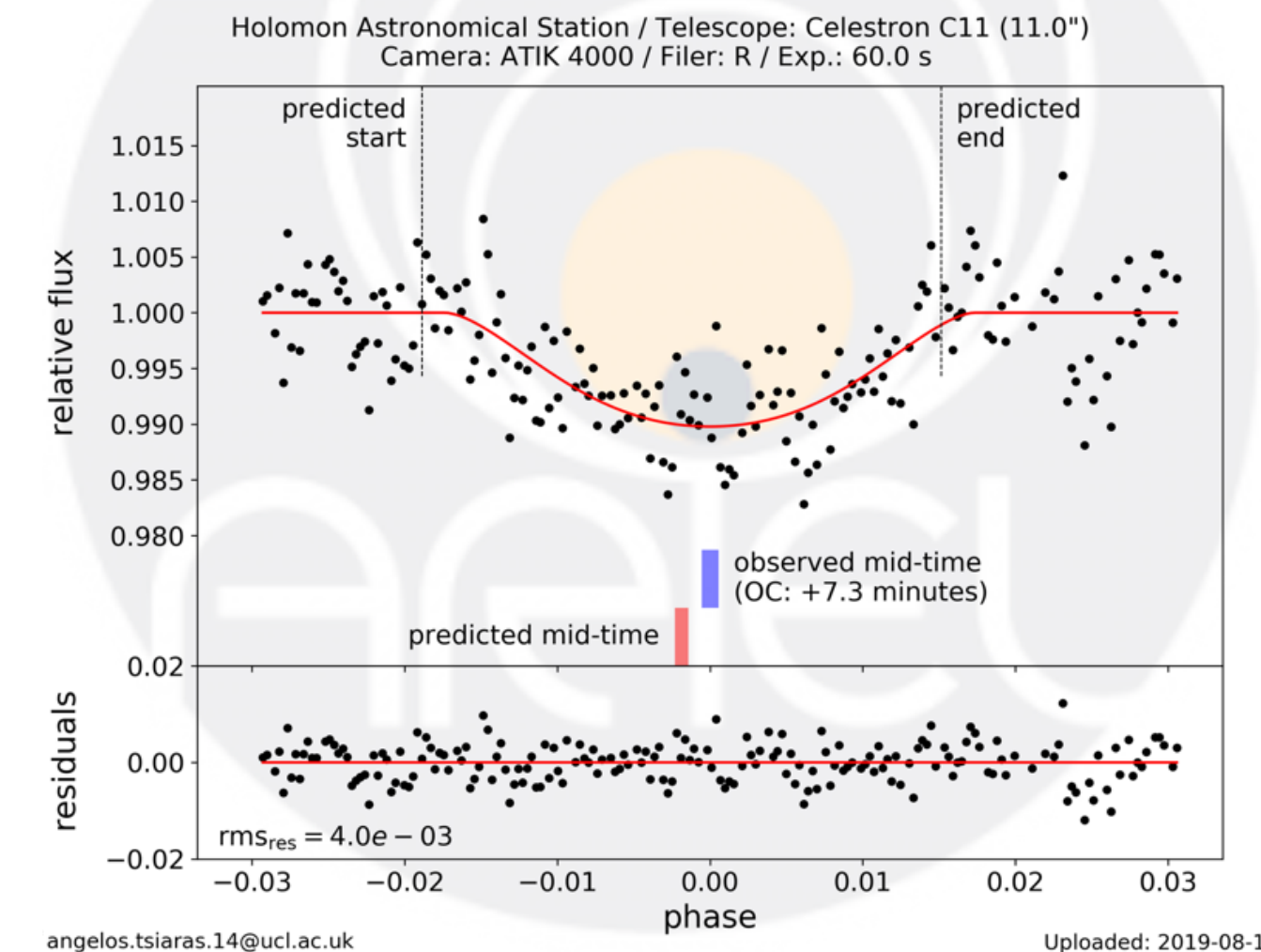
Billy Edwards

ExoClock (www.exoclock.space)

WASP – 93b

2016-08-11

Angelos Tsiaras* (UCL, AUTH), Anastasia Kokori (UCL, ROG, AUTH)



- **Ariel will spectroscopically characterise a population of exoplanets**
- **Ariel MRS will be selected from a diverse list of potential targets**
- **PLATO will be key in adding to that list and characterising other systems**

THE ASTRONOMICAL JOURNAL

OPEN ACCESS

An Updated Study of Potential Targets for Ariel

Billy Edwards¹ , Lorenzo Mugnai² , Giovanna Tinetti¹ , Enzo Pascale^{2,3} , and Subhajit Sarkar³

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[The Astronomical Journal, Volume 157, Number 6](#)

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ARIEL's next Science, Mission & Community 2020 conference will be held on 14 – 16 January 2020 at ESTEC in the NL.

[Registration is now open!](#)



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