Ariel-France Meeting 2026

Assessing Ariel's Potential for LowDensity Exoplanet Characterisation

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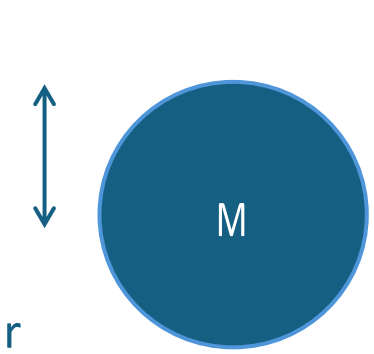
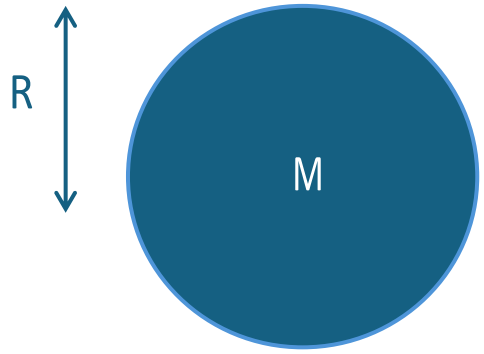
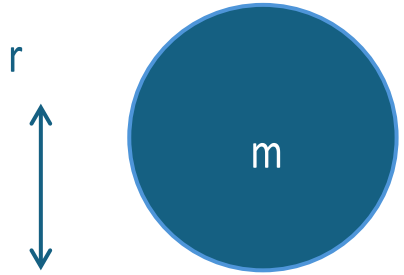
The low-density exoplanet population







Most giant planets have bulk densities between ~0.7 and ~2 g cm^3

nsity exoplanet defined by densities < ρSaturn = 0.7 g cm^3

ρSaturn	0.7 g cm^3
ρUranus	1.27 g cm^3
ρJupiter	1.33 g cm^3
ρNeptune	1.6 g cm^3

Lo
w-
de

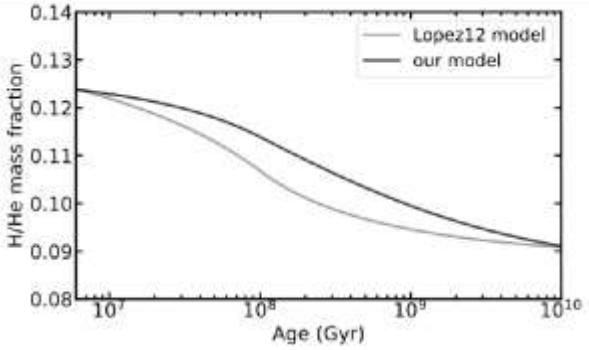
Unusually inflated

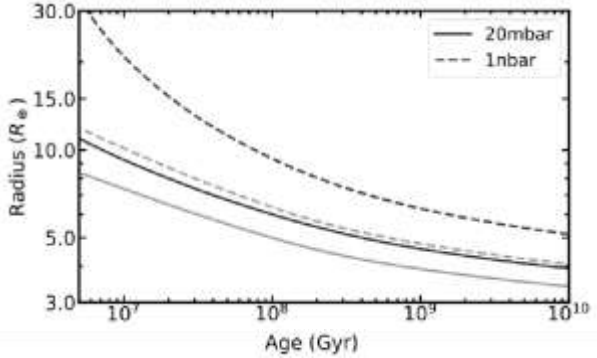
◦ Inefficient cooling process from formation? → Burrows et al. 2007,
Chabrier & Baraffe 2007, Vazan et al. 2016, Tremblin et al. 2017

◦ Additional internal or external source of energy?
→Bodenheimer et al.
2001, Leconte et al. 2010, Batygin & Stevenson 2010, Millholland 2019,
Millholland et al. 2020, Thorngren 2018

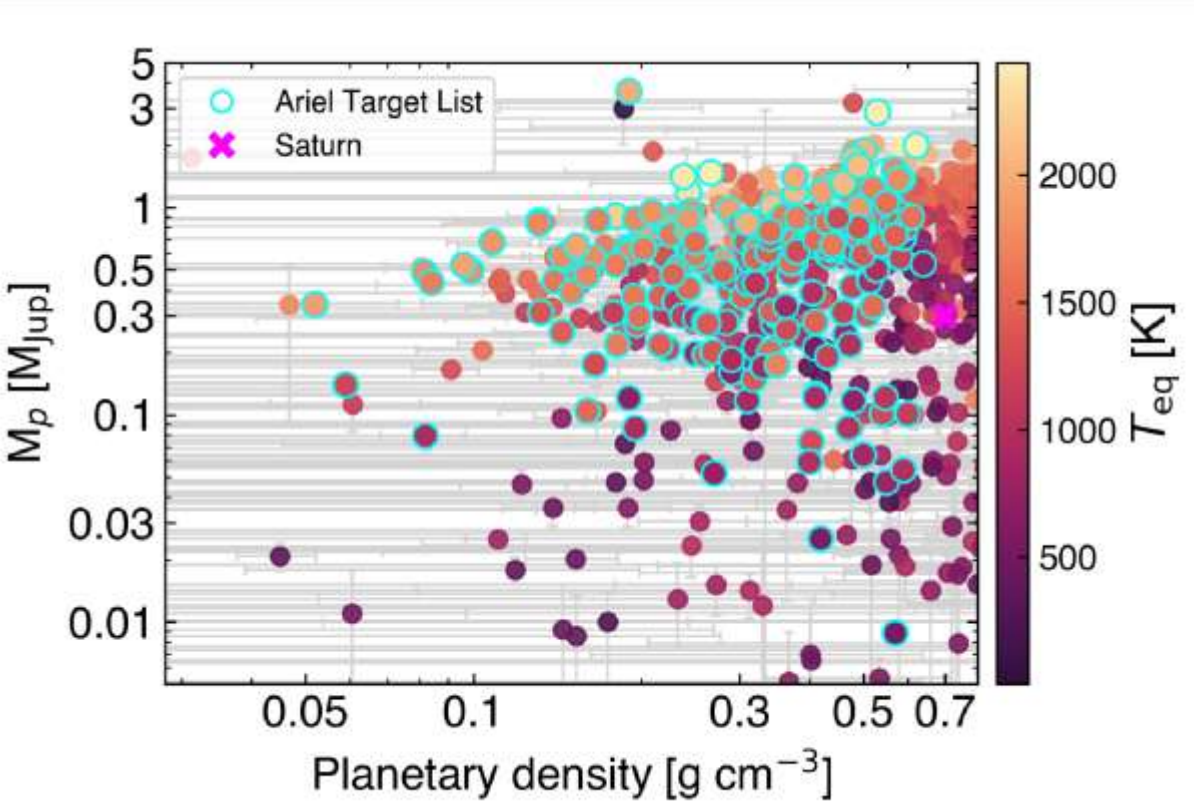
Inflated gas giants

Super-puffs



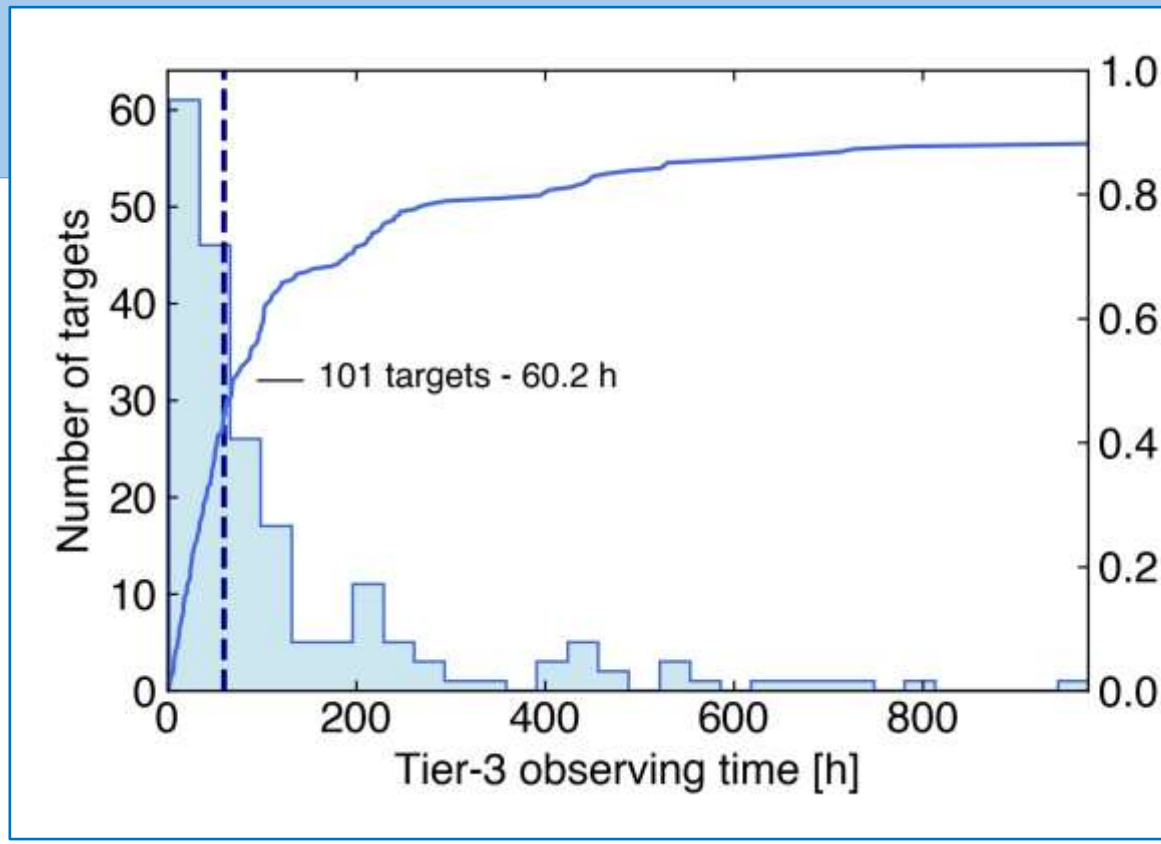


Mass-loss



The low-density exoplanet population

Target selection



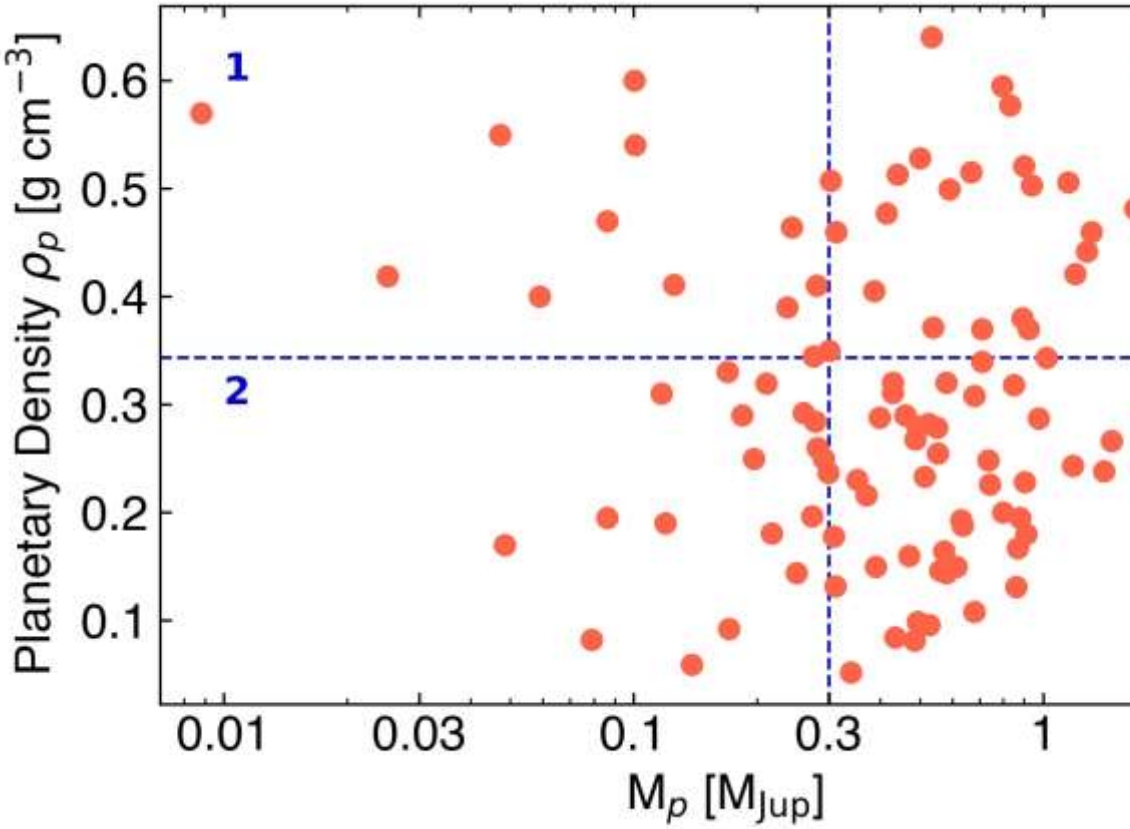
- Mission Candidate Sample (MCS)
- Tier-3 targets
- Bulk densities < $\rho_{Saturn} = 0.7$ g cm^{3}
- Selection metric ⟶ Number of Tier-3 transits x Transit duration < 50th percentile

Initial sample
Selected sample
Median observing time threshold
Total observing time
Mission fraction

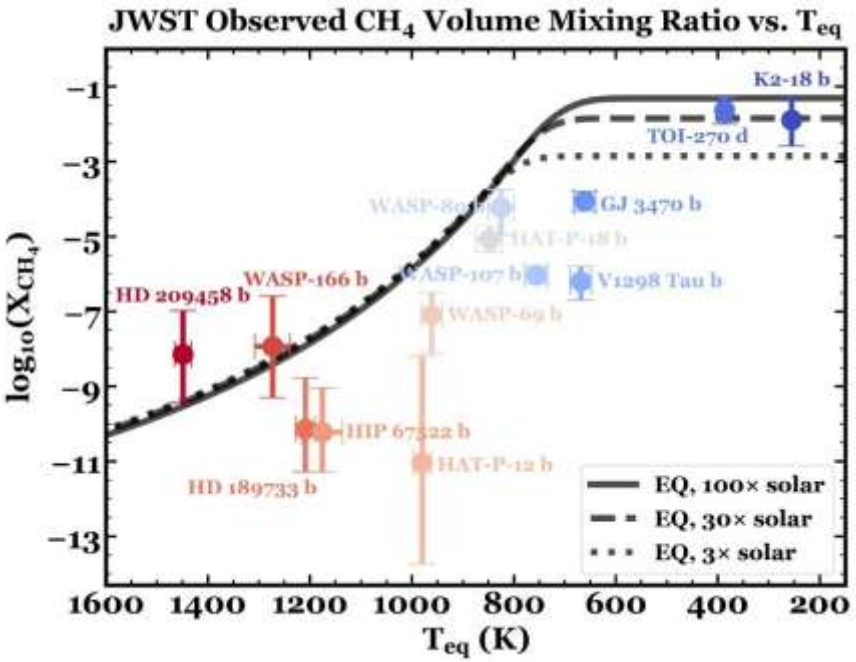
Four science cases

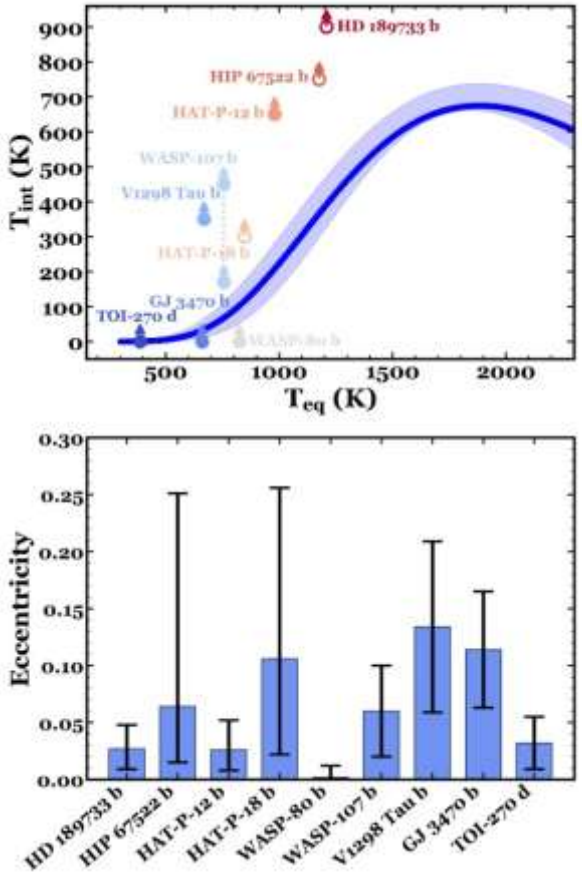
ρSaturn / 2 = 0.35 g cm^3
MSaturn = 0.3 MJup

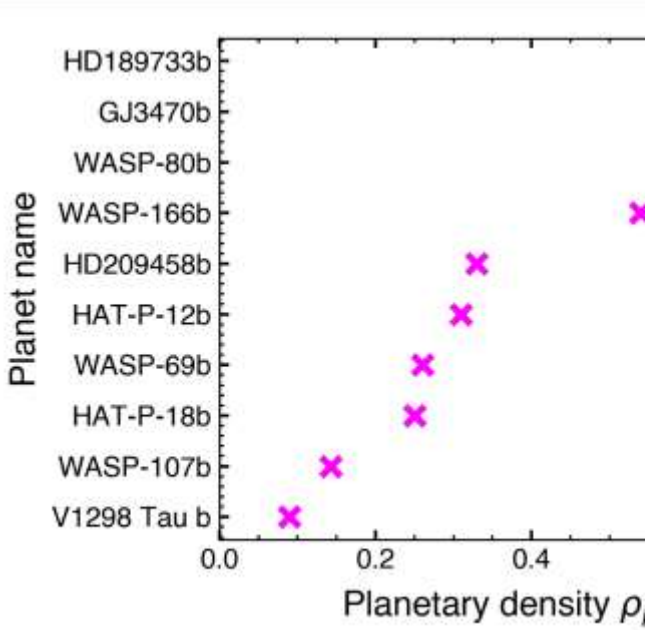
Density Population	Extreme	Low-density
Inflation Population	45	25
Saturn/Jupiter		
Sub-Saturn	19	12



For H/He-dominated atmospheres with T < 1000 K, methane is expected as the dominant carbon-bearing species (Moses et al., 2013)





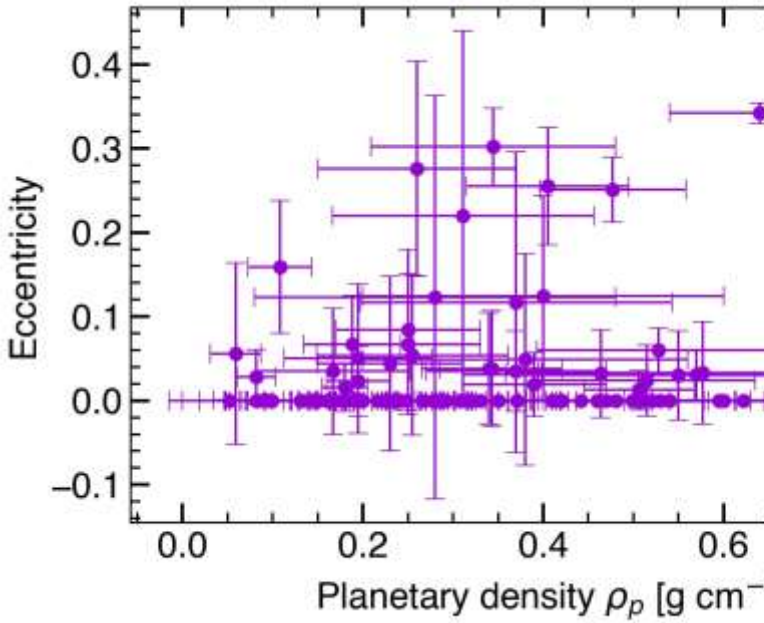


The missing methane problem

A dedicated sample and the need to refine orbital parameters

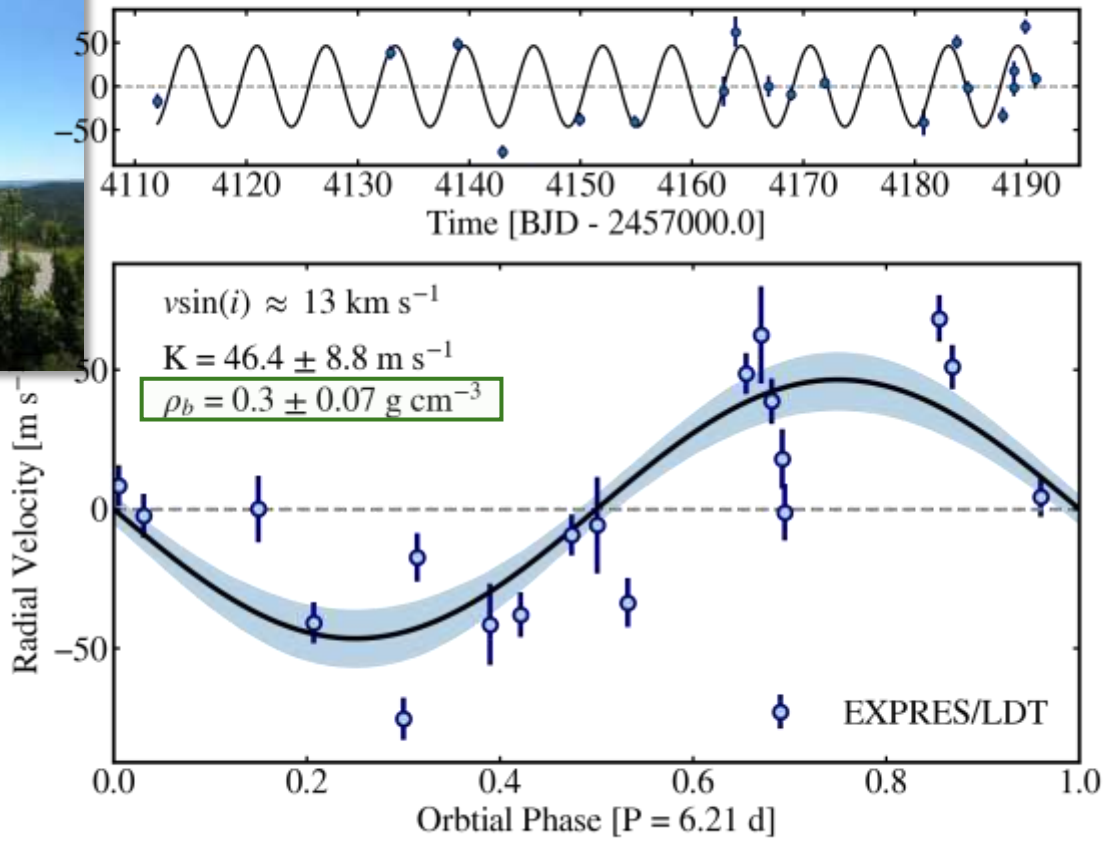
13 targets among our final selection with Teq < 1000 K

Planet name	ρ_p [g cm^{-3}]	σ_ρ [g cm^{-3}]	N_{T3}	R_p [R_{Jup}]	e	σ_e
TOI-1420b	0.08	0.03	1.00	1.06	0.00	
K2-24c	0.17	0.15	3.00	0.72	0.00	·
WASP-107b	0.19	0.06	1.00	0.94	0.00	· · ·
TOI-1173b	0.20	0.04	2.00	0.82	0.02	0.04
HAT-P-18b	0.25	0.08	4.00	0.99	0.08	0.10
TOI-5398b	0.29	0.10	3.00	0.92	0.00	· · ·
WASP-69b	0.29	0.07	1.00	1.06	0.00	· · ·
WASP-139b	0.31	0.10	8.00	0.80	0.00	· · ·
HAT-P-12b	0.32	0.03	4.00	0.96	0.00	· · ·
TOI-2876b	0.33	0.21	17.00	0.86	0.00	· · ·
HAT-P-26b	0.40	0.20	7.00	0.56	0.12	0.12
HATS-72b	0.41	0.03	8.00	0.72	0.00	· · ·
TOI-1803c	0.42	0.42	21.00	0.38	0.00	· · ·



RV follow-up observations

Confirmation of TOI-2114b from the TESS Planet Candidates (TPC) sample



Dr. Alex Polanski
Percival Lowell Postdoctoral Fellow

- Ariel-EXPRES program
- EXPRES spectrograph, Lowell Discovery Telescope (4.3 m, ~ 30 cm/s)
- Refine the orbital parameters of confirmed planets

prep

- Confirm new Targets of Interest (TOIs)
- Measure stellar obliquities for Tier-3 targets

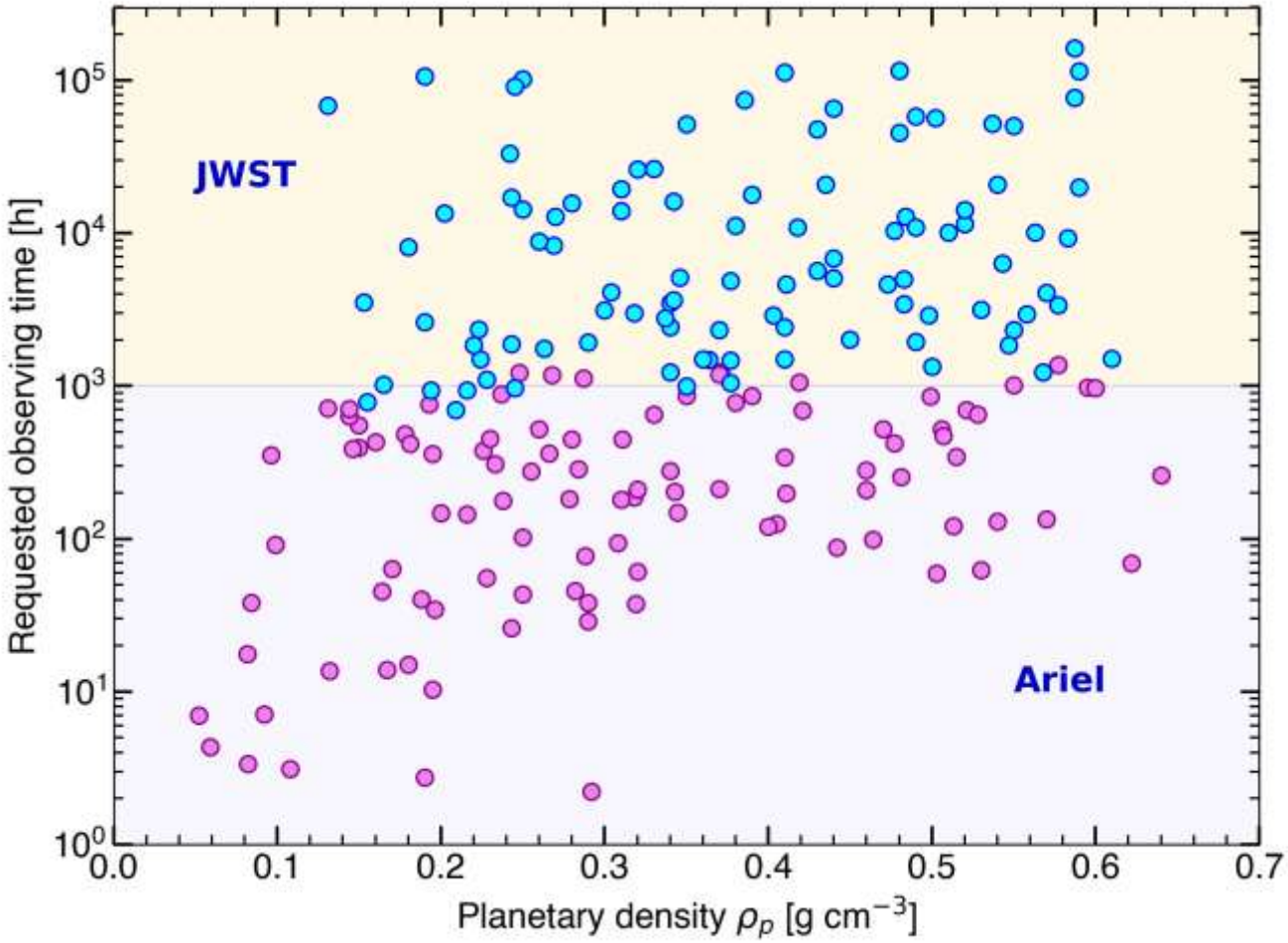
Feasibility for RV follow-up observations

Planet name	ρ_p [g cm^{-3}]	σ_ρ [g cm^{-3}]	N_{T3}	R_p [R_{Jup}]	e	σ_e	T_{eq} [K]	V-mag	K [m s^{-1}]	$v \sin i$ [km s^{-1}]
TOI-1420b	0.08	0.03	1.00	1.06	0.00		958.30	11.65	8.50	2.00
K2-24c	0.17	0.15	3.00	0.72	0.00	·	608.07	11.28	2.62	2.00
WASP-107b	0.19	0.06	1.00	0.94	0.00	· · ·	734.27	11.59	17.00	2.50
TOI-1173b	0.20	0.04	2.00	0.82	0.02	0.04	945.16	11.04	9.67	2.00
HAT-P-18b	0.25	0.08	4.00	0.99	0.08	0.10	848.00	12.60	27.10	0.50
TOI-5398b	0.29	0.10	3.00	0.92	0.00	· · ·	948.68	10.06	15.70	7.50
WASP-69b	0.29	0.07	1.00	1.06	0.00	· · ·	959.38	9.87	38.10	2.20
WASP-139b	0.31	0.10	8.00	0.80	0.00	· · ·	919.77	12.46	14.00	4.20
HAT-P-12b	0.32	0.03	4.00	0.96	0.00	· · ·	958.41	12.66	35.80	0.50
TOI-2876b	0.33	0.21	17.00	0.86	0.00	· · ·	928.89	12.40	19.50	· · ·
HAT-P-26b	0.40	0.20	7.00	0.56	0.12	0.12	993.78	11.76	8.50	1.80
HATS-72b	0.41	0.03	8.00	0.72	0.00	· · ·	739.51	12.32	16.15	0.80
TOI-1803c	0.42	0.42	21.00	0.38	0.00	· · ·	612.27	11.87	2.10	1.00

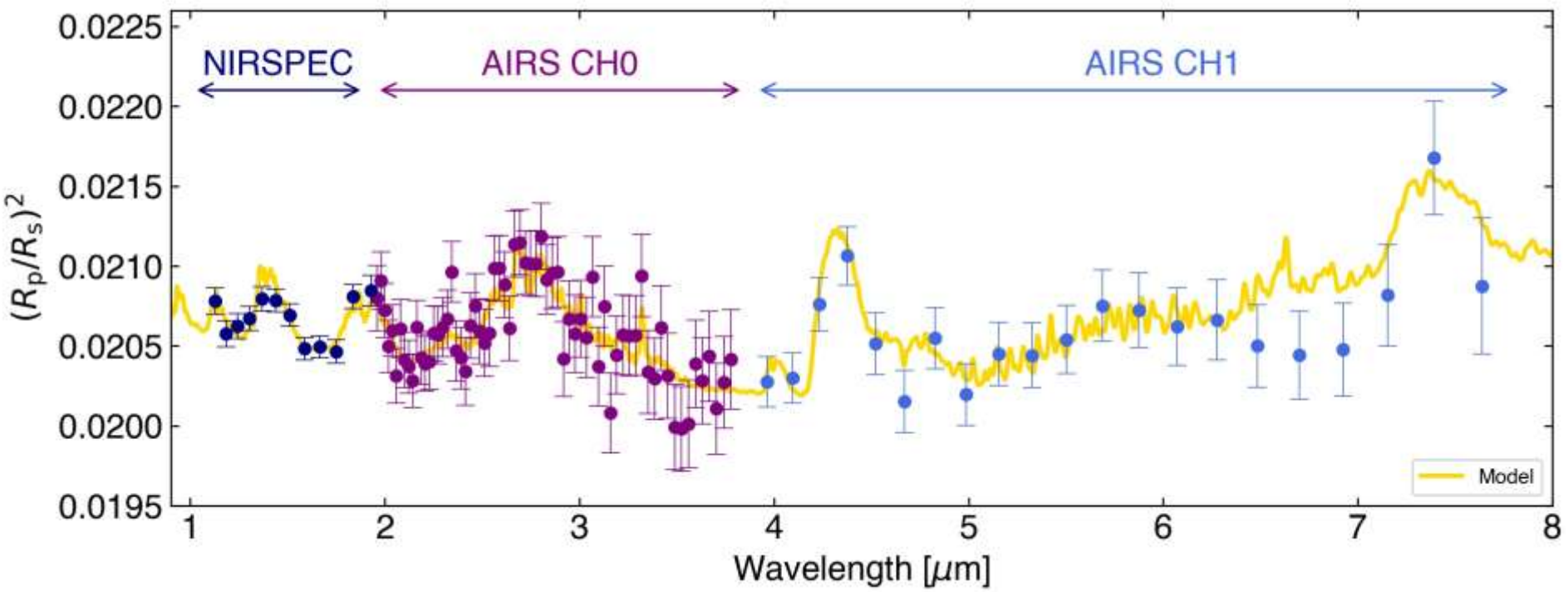
Southern hemisphere → ESO VLT/ESPRESSO or HARPS at La Silla

Synergies with JWST

- Complementary samples
- Close watch to JWST atmospheric updates



Simulations to demonstrate feasibility with Ariel



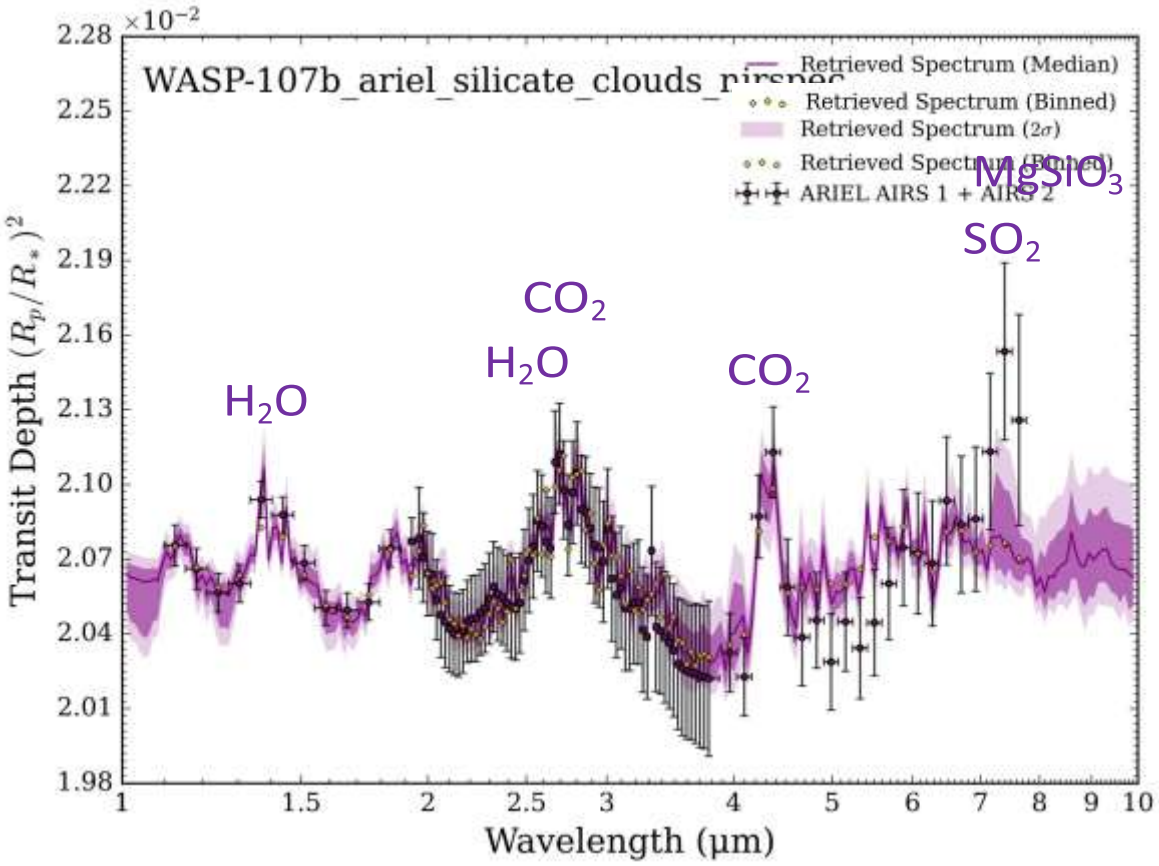
The benchmark target WASP-107b

Reduced χ^{l}= 0.59

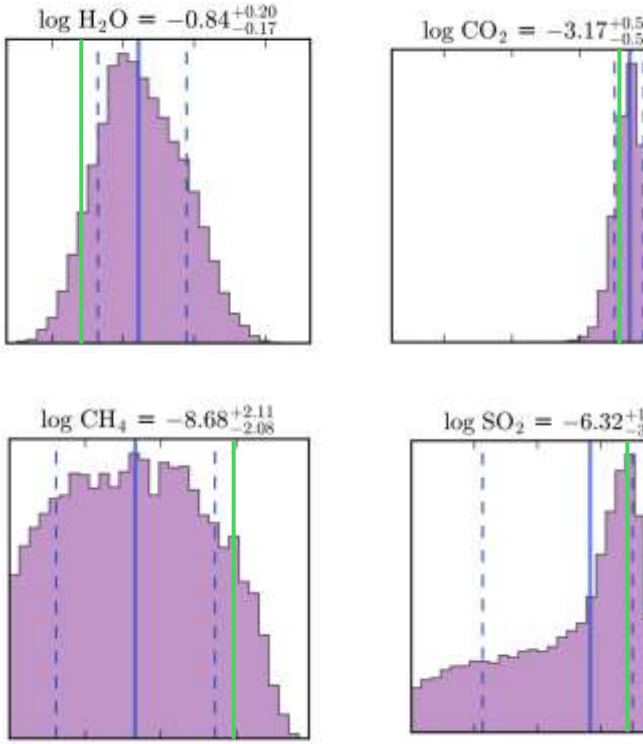
Model from Welbanks et al. 2024

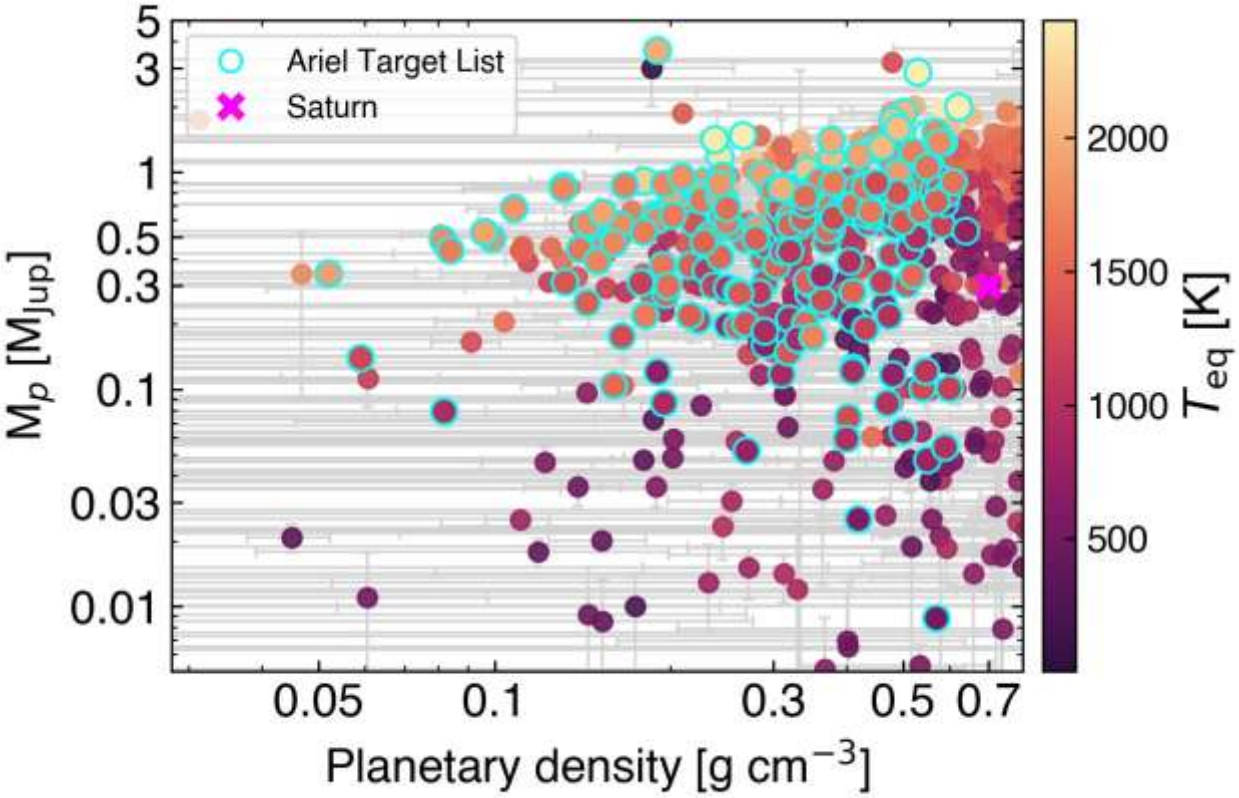
Noise on the transit floor ArielRad, Mugnai et al., 2020 and 2025

Retrieval results



True values





Retrievals POSEIDON, MacDonald & Madhusudhan 2017, MacDonald 2023 True values from Welbanks et al., 2024

Conclusions

- 228 targets with densities < 0.7 g cm^3
- Spanning a full range of masses and radii to test different inflation mechanisms
- A focus on the “missing-methane problem”

- Orbital parameters being refined through the Ariel-EXPRES RV survey and complementary ground-based proposals
  - Synergies with JWST
    - Dyrek & Lagage et al., RASTI, in prep.
    - adyrek@stsc