Optimizing the selection of the future targets for **ARIEL**

Ignazio Pillitteri (INAF-OAPA)
Tiziano Zingales (INAF-OAPA)
G. Micela (INAF-OAPA)

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Sky coverage and best planets for ARIEL

ARIEL yellow book 2017

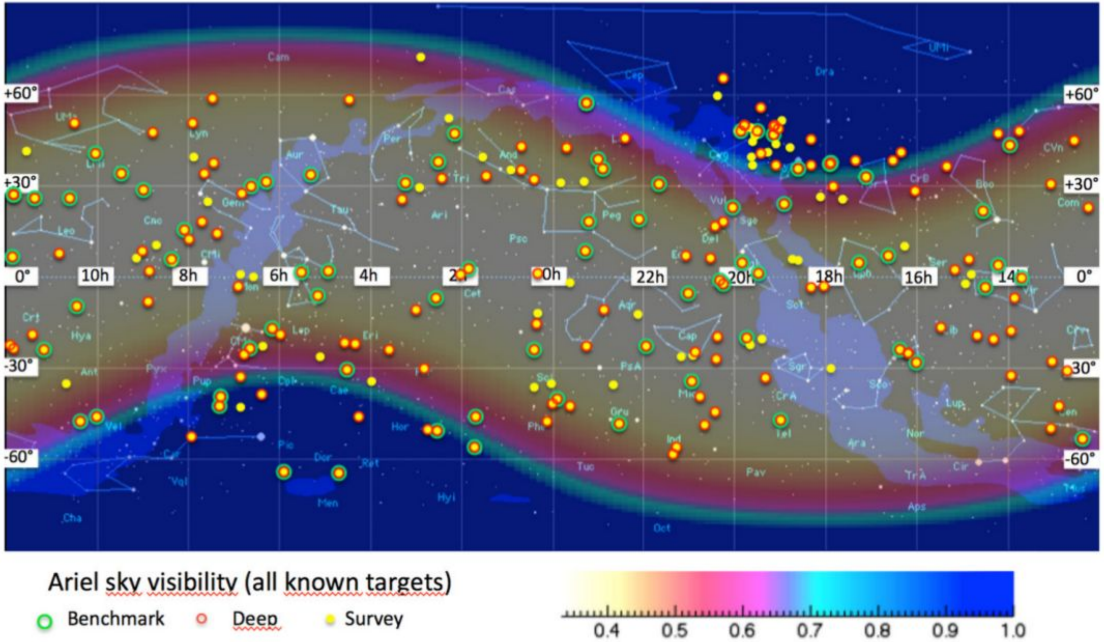


Figure 2-31: A plot illustrating the fraction of the year for which a given location in the sky (in equatorial coordinates) is visible to ARIEL, as seen from a representative operational orbit of ARIEL around L2. Orange and green targets are the currently known best targets in term of stellar brightness and planetary parameters (green are the very best, including e.g. 55 Cnc e, HD 189733b, HD 209 458 b, GJ 436 b etc.), yellow targets are currently known transiting planets observable by ARIEL.

Expected population of exoplanets at ARIEL launch

Defining a **Mission reference sample (MRS)**
~ 1000 planets available to ARIEL in 2026

Transit from ground	Survey/Facility	Jupiters	Neptunes	Super Earths
Past / Ongoing	HATNet/HATSouth (Bakos et al., 2004) WASP/SuperWASP (Pollacco et al., 2006; Maxted priv. comm.) MEarth (Nutzman et al., 2008) TRAPPIST (Gillon et al., 2016) APACHE (Sozzetti et al., 2013)	~300	~50	~30
	XO (McCullough et al. 2005) TrES (Alonso et al., 2004)			
Future	NGTS (Chazelas et al., 2012)	100	25	25
Space Transit & astrometry	**Survey/Facility**	**Jupiters**	**Neptunes**	**Super Earths**
Past / Ongoing	CoRot (Auvergne et al. 2009, Fridlund et al. 2006) Kepler (Borucki et al. 2010) K2 (Howell et al. 2014)	25 200 500	3 50 100	1 10 100
Future	GAIA (Perryman et al. 2014; Sozzetti priv. comm.) PLATO (Rauer et al., 2014; Pagano priv. comm.) CHEOPS (Fortier et al., 2014, Pagano priv. comm.) TESS (Ricker et al. 2014, Sullivan et al. 2015)	15 1000 80 1000+	0 1200 10 1800+	0 1300 5 500+
Radial velocity	**Survey/Facility**	**Jupiters**	**Neptunes**	**Super Earths**
Past / Ongoing (mainly follow-up)	HARPS/HARPS-N (Pepe et al., 2000) CORALIE (Queloz et al. 2000) CARMENES (Quirrenbach et al., 2016) AAPS (Tinney et al. 2001)	>100s	>50s	>10s
Future (mainly follow-up)	ESPRESSO (Pepe et al., 2010) GIANO (Oliva et al., 2004) SPIROU (Artigau et al. 2011)	>100s	>50s	>10s

Table 2-6: Summary of the main surveys/projects that will provide targets for ARIEL in the next ten years (Micela et al., 2015). The columns on stars and expected planets refer specifically to the observations relevant for ARIEL. J=Jupiters, N=Neptunes, SN=sub-Neptunes, SE= Super-Earths.

ARIEL 3 Tiers strategy

Mission Time Fraction

Tier name	Observational strategy	Science case
Reconnaissance survey (~30%)	Low Spectral Resolution observations of ~1000 planets in the VIS & IR, with SNR ~ 7	• *What fraction of planets are covered by clouds?* • *What fraction of small planets have still retained H/He?* • *Classification through colour-colour diagrams?* • *Constraining/removing degeneracies in the interpretation of mass-radius diagrams* • *Albedo, bulk temperature & energy balance for a subsample.*
Deep survey (~60%)	Higher Spectral Resolution observations of a sub-sample in the VIS-IR	• *Main atmospheric component for small planets* • *Chemical abundances of trace gases* • *Atmospheric thermal structure (vertical/horizontal)* • *Cloud characterization* • *Elemental composition*
Benchmark planets (~10%)	Very best planets, re-observed multiple time with all techniques	• *Very detailed knowledge of the planetary chemistry and dynamics* • *Weather, spatial & temporal variability*

Table 2-5: Summary of the survey tiers and the detailed science objectives they will address.

ESA/SCI 2017-2 (ARIEL yellow book)

Synthesis of planets population (Zingales et al. 2018)

Model of solar neighborhood stellar population

Occurrence of planets rates and masses around solar type stars (F->M)

Fluxes and magnitudes suitable for ARIEL

Distribution of metallicities

Planets occurrence and Radii vs. Masses

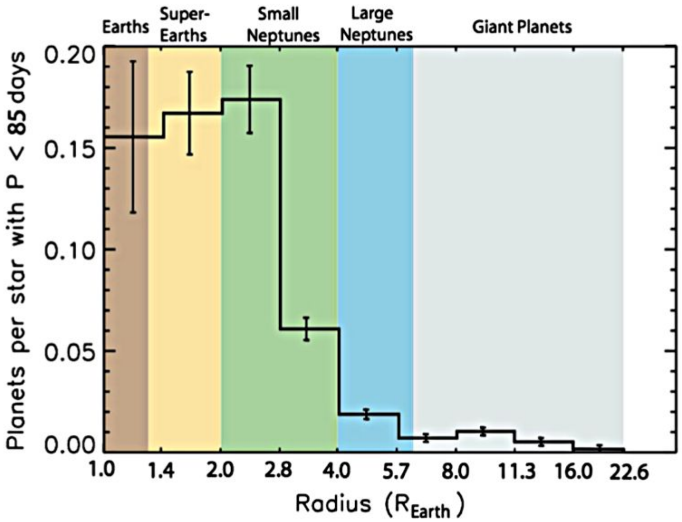


Fig. 1 Average number of planets per star and per size bin with an orbital period shorter than 85 days orbiting around F, G, K stars. The statistics was extracted from the Q1 - Q6 Kepler data [5]

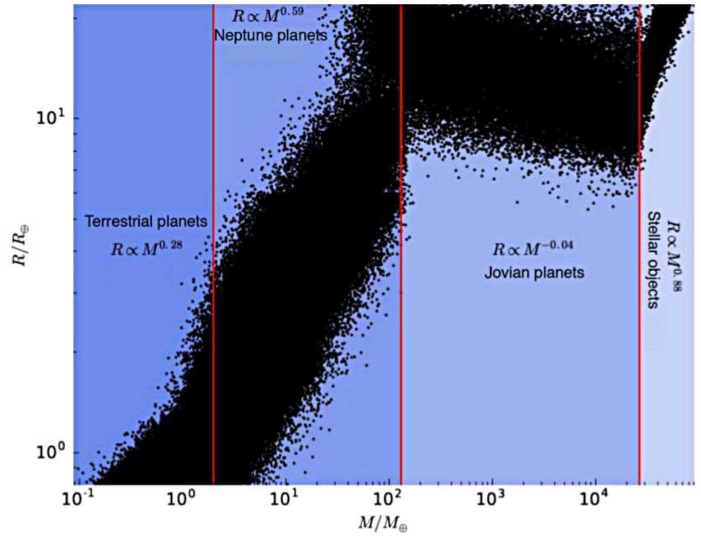


Fig. 3 Mass-Radius distribution for all the simulated planets. The mass-radius relationship has been calculated with the [3] tool

Fressin et al 2013; Chen & Kipping 2017; Zingales et al 2018

Simulation of a population of stars with planets

Zingales et al. (2017).

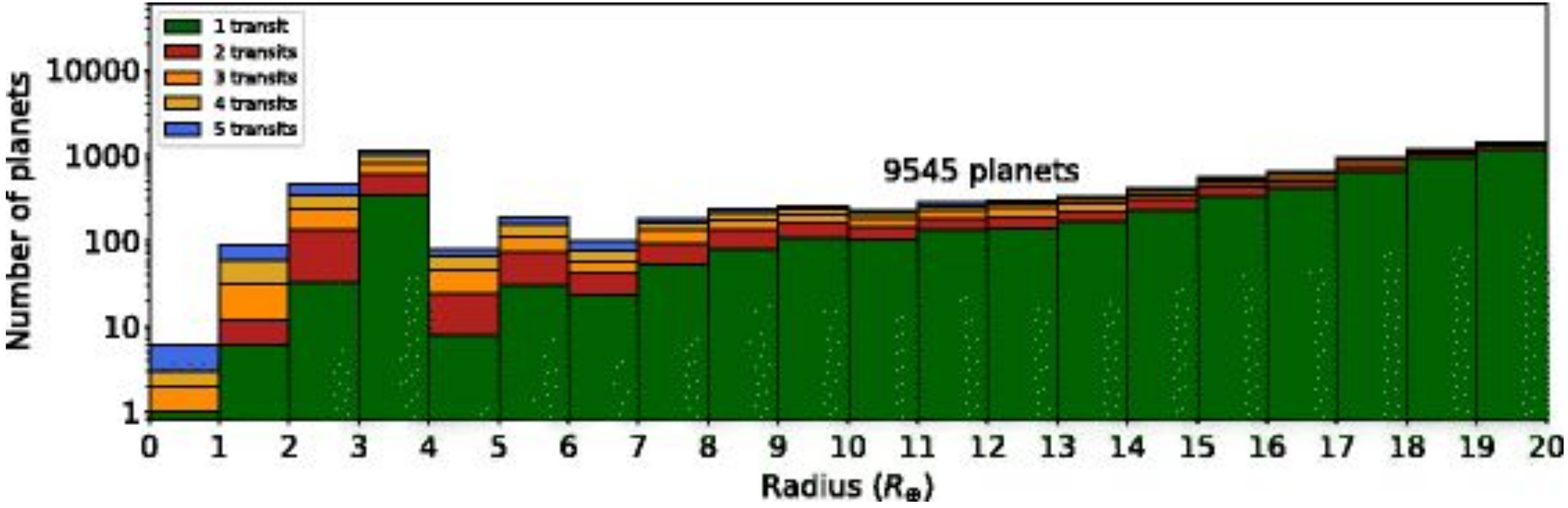
Inputs: ESA RAD model,

galactic stellar population model

planets occurrence rate (Fressin et al. 2013),

ExoSim end to end simulator for the required “visits” for each system given a SNR`

Simulation of a population of stars with planets



Zingales et al. (2018).

Parameters' space

Star: $\mathbf{T_{eff}}$, Mass, Radius, log *g*, **metallicity [Fe/H[**

Planet: mass, $\mathbf{T_{equ}}$, radius $\mathbf{R_{pl}}$, composition

System: Period, separation, orbit inclination,

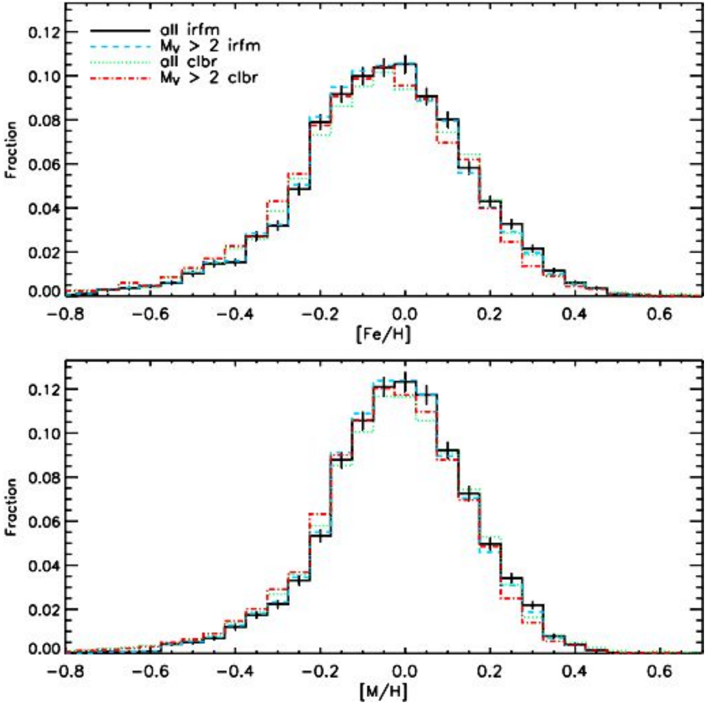
eccentricity

Reduction to a 4D space: $\mathbf{T_{eff}}$, **[Fe/H], Rpl,** $\mathbf{T_{equ}}$

Table 5 Bins of T_{eff}, [Fe/H], R_{pl}, T_{pl} defining the 4D parameter space

Stellar Temp.: T_{eff}	$3000 < T(K) < 4100$	$4100 < T(K) < 5800$	$T > 5800K$
Labels	M-Late K	Early K-G	F-G
Metallicity: [Fe/H]	[Fe/H] $<$ -0.15	$-0.15 <$[Fe/H]< 0.15	[Fe/H]> 0.15
Labels	Low [Fe/H]	Solar	High [Fe/H]
Planet Radius: R_{pl}	$R_{pl} < 3R_{\oplus}$	$3 < R_{\oplus} < 8$	$R_{pl} > 8R_{\oplus}$
Labels	Earths/ Super Earths	Neptunes	Jupiters
Planet Temp.: T_{pl}	contiguous bins: [250, 500, 800, 1200, 1600, 2600] K		

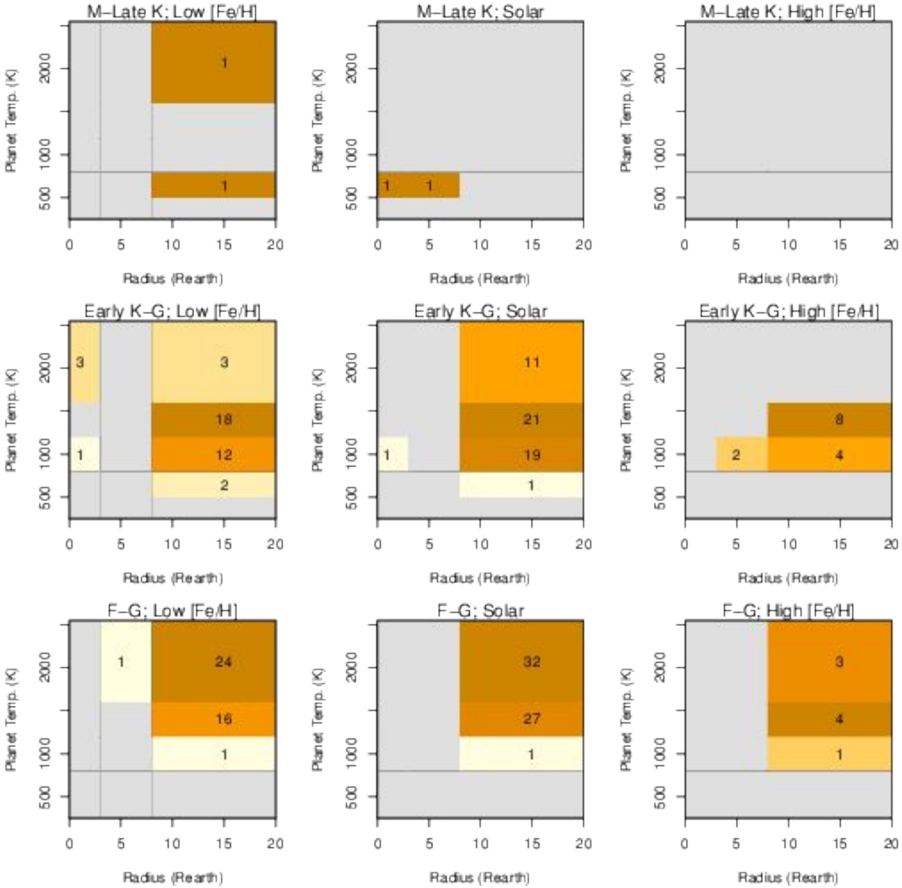
Metallicity of the parent stars



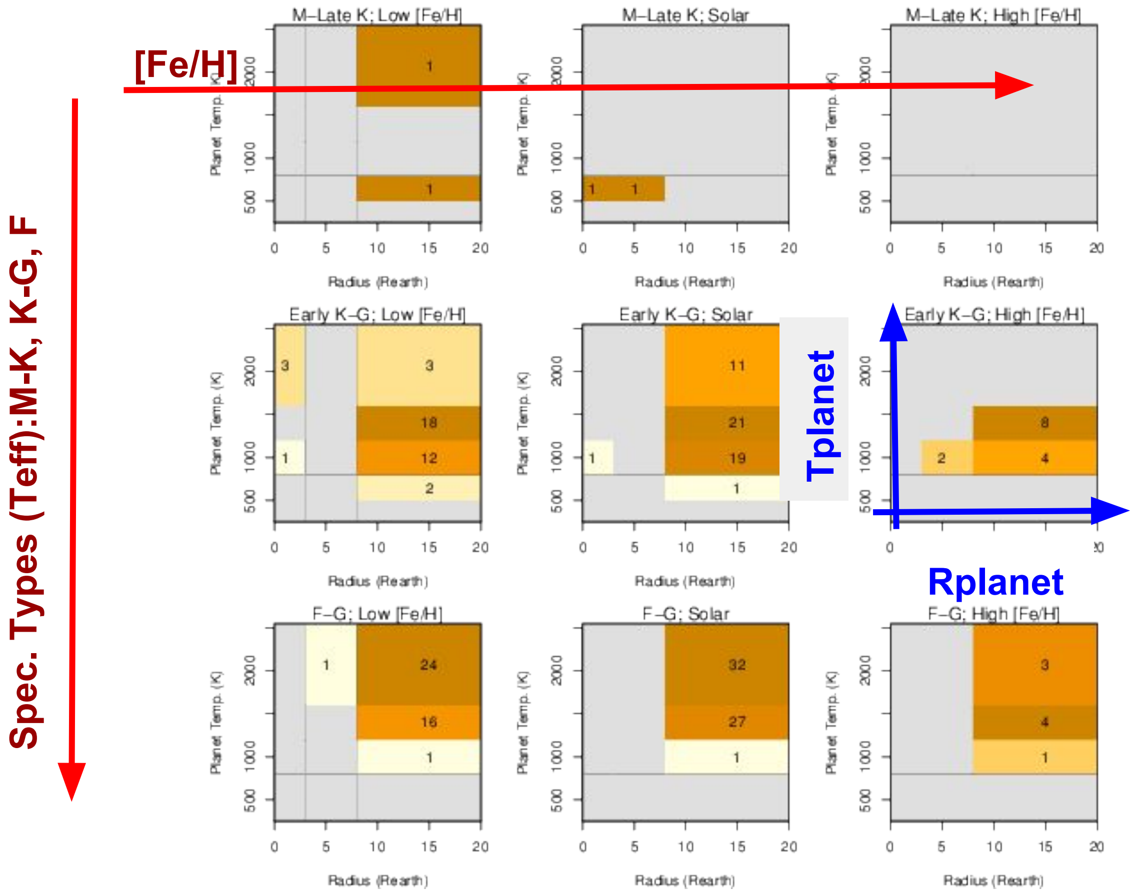
Casagrande et al. 2011

Modeled with a Gaussian of mean -0.1 and standard deviation 0.2
Generated ‘fake’ metallicities’ drawn from this model distribution function

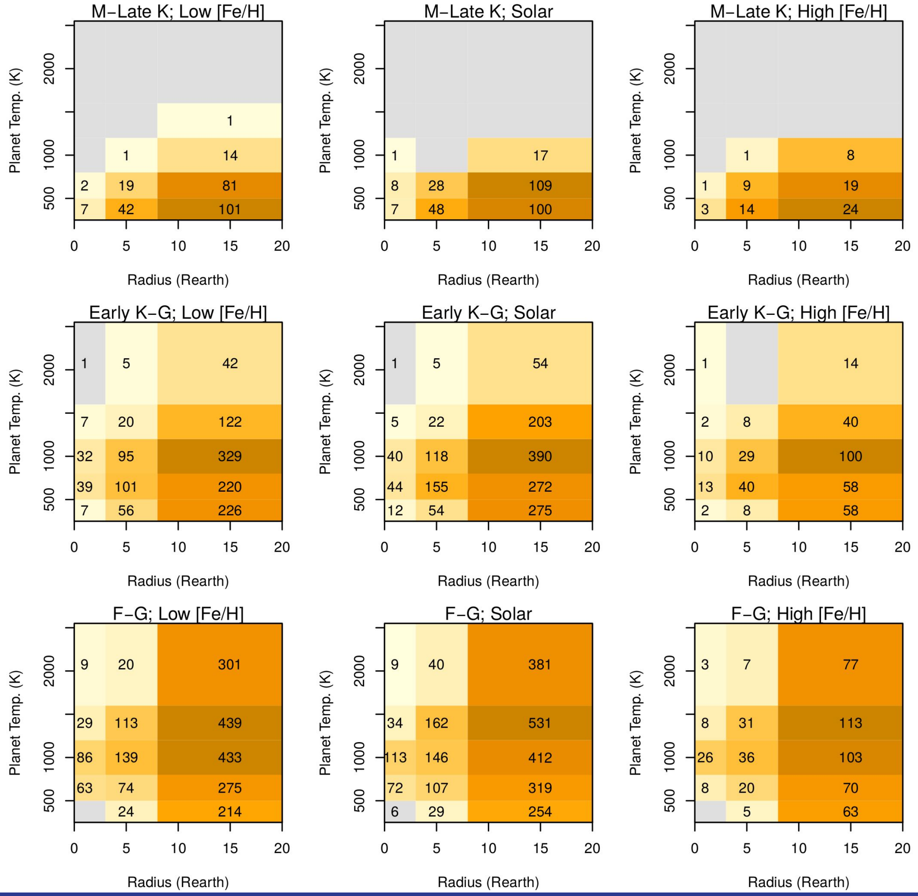
Distribution of the known systems

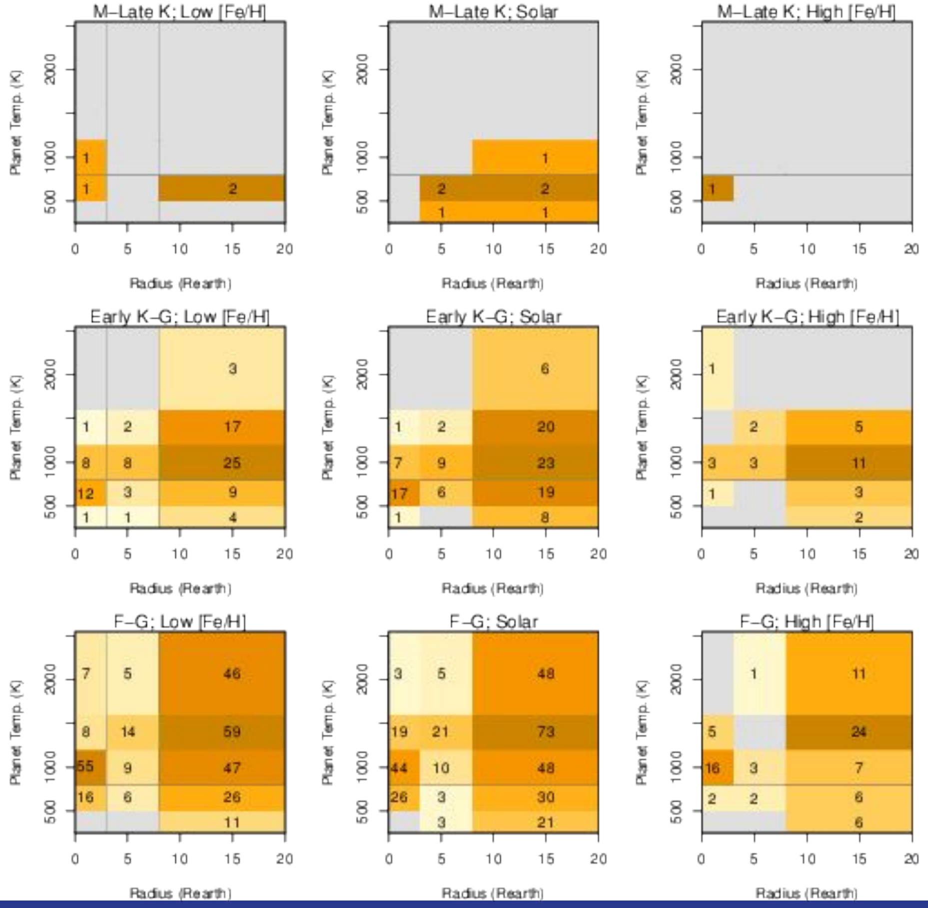


Distribution of the known systems



Distribution of the parent distribution (~9545 systems)





The “easy” sample

giving priority to systems requiring 1-2 visits

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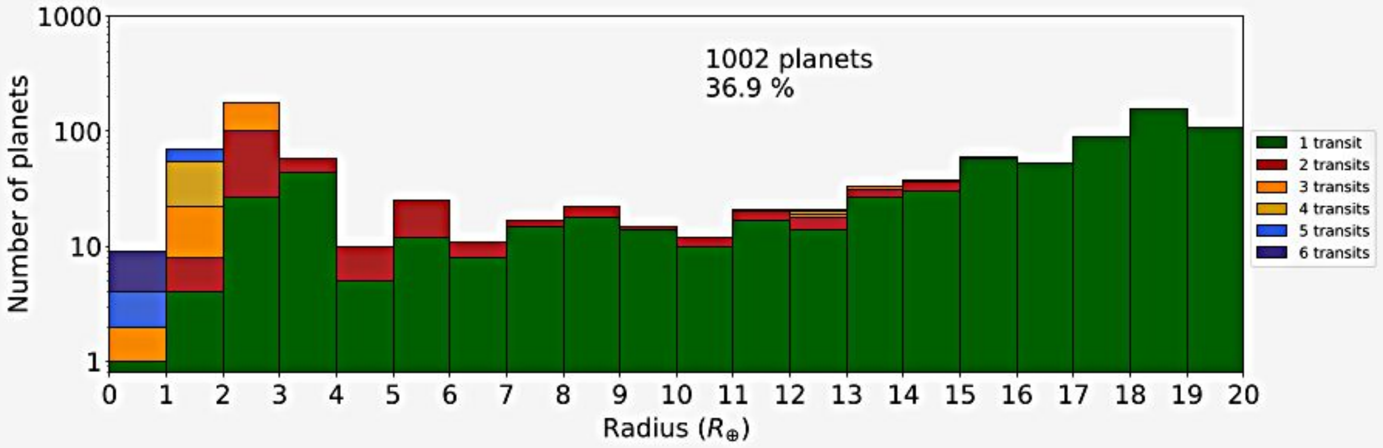
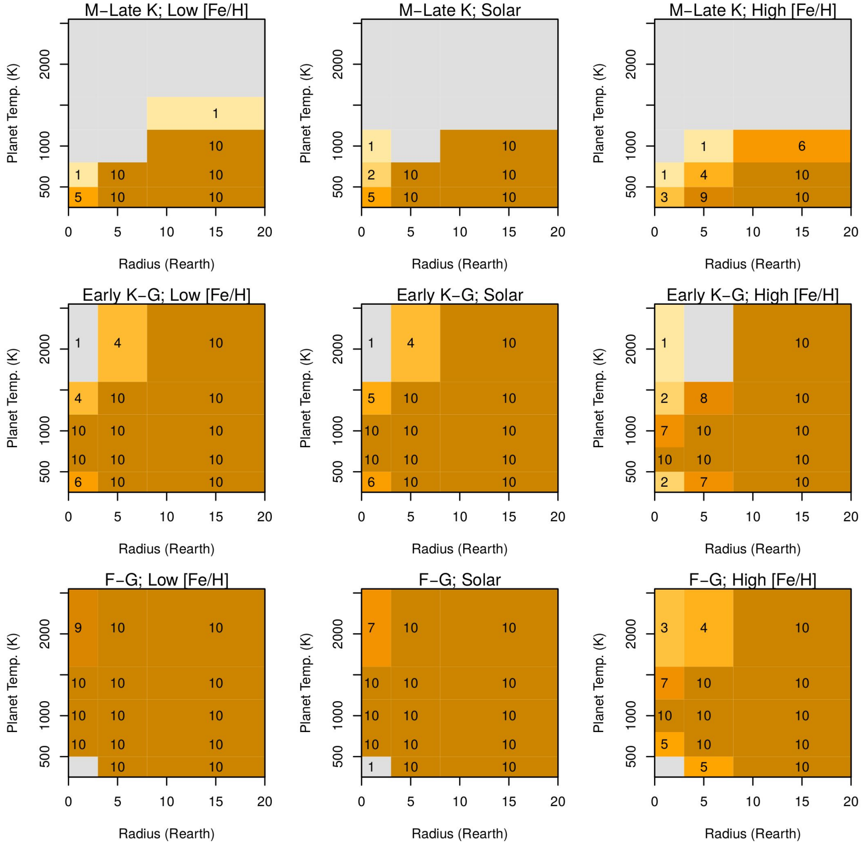


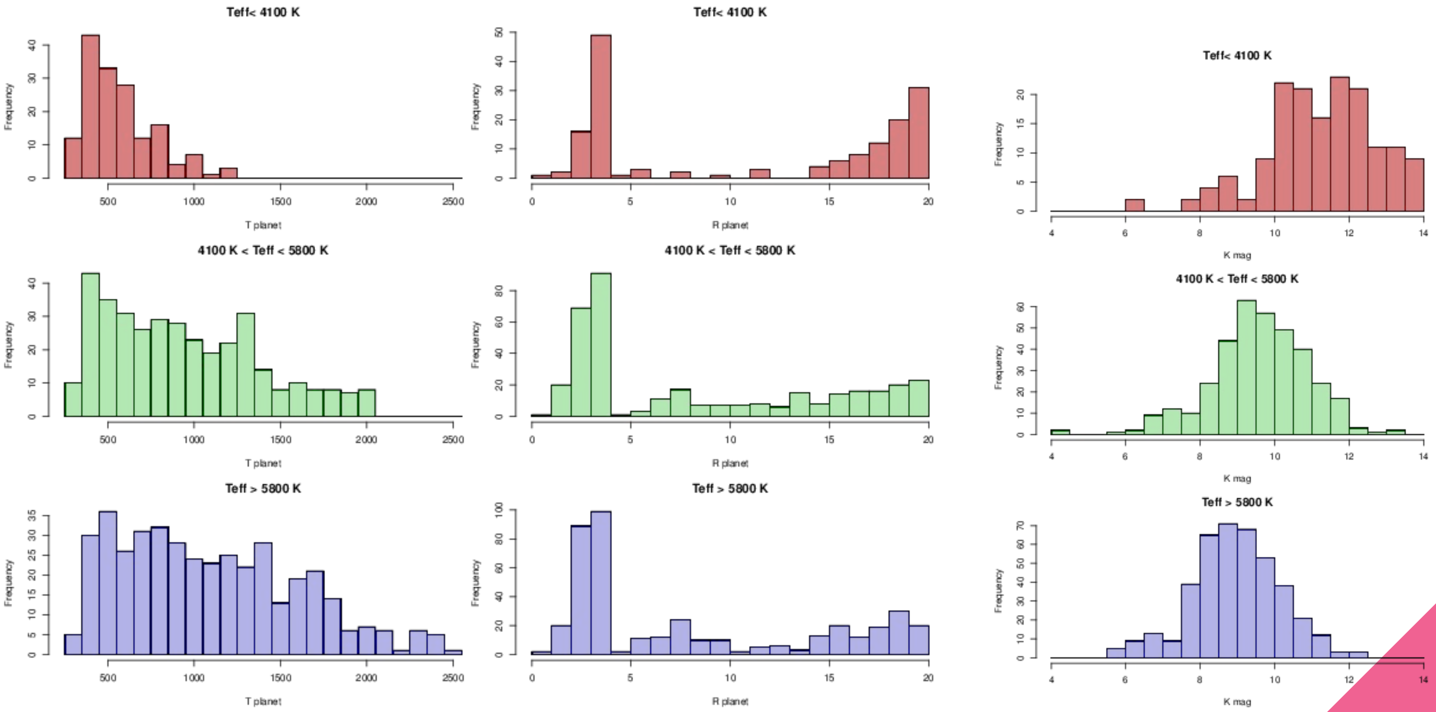
Fig. 11 ARIEL MRS Tier 1 planets organised in size-bins. Different colours indicate the number of transits/eclipses needed to reach Tier 1 performances

A different strategy for the Tier 1 sample



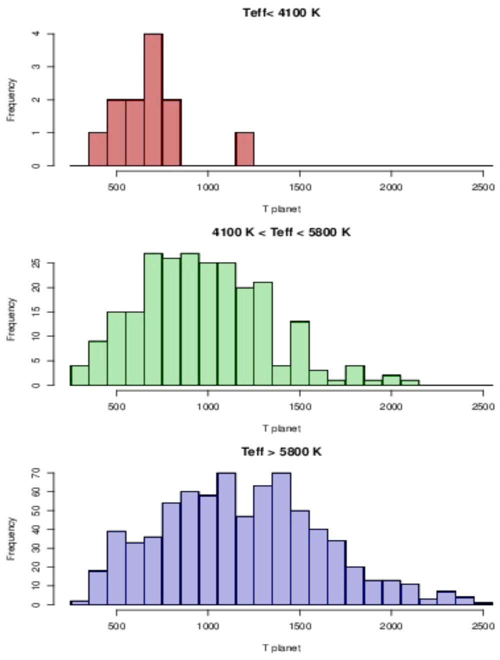
coverage of the 4D space parameters, keep at most ~10 objects per cell

Properties of the selected systems

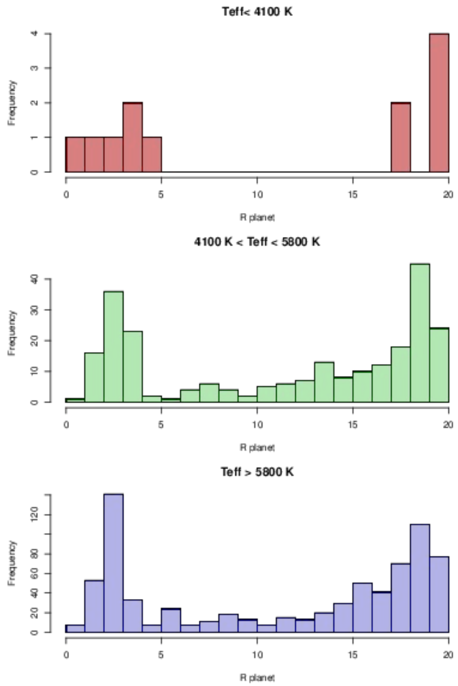


Tplanet Rplanet K mag

Properties of the easy systems



T planet



R planet

Conclusions

ARIEL will be able to observe at least 1000 planets divided in 3 Tiers of objects with different SNR and scientific aims

Synthesis of the sample for Tier 1 ~ 1000 systems to be observed in 4 yrs with at most 5 visits

Different strategies can be devised to optimize the outcome of the observing time

A scheme of priority can equally distribute the observations over the parameters' space that covers from M to F hosts and from Earths to (hot) Jupiters masses