The PLATO Mission

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and the PLATO Team

Status

- February 2014: ESA SPC selects PLATO as the M3 mission
- October 2014: The Definition Study starts, PDR in 2018/19
- June 2017: ESA SPC adopts PLATO as the M3 mission in the Cosmic Vision Programme
- Launch planned end 2026 into halo orbit around L2

PLATO Science Goals

The overall science goals are to answer the following questions:

O1. How do planets and planetary systems form and evolve?

O2. Is our Solar System special or are there other systems like ours?

O3. Are there potentially habitable planets?

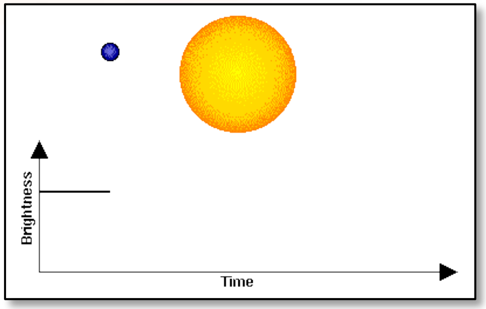
Addressing these science goals needs:

- A large number of planets of different type, well characterized for their mean density and age, around different types of stars.
- Characterized planets around solar-like stars to put our system into context.
- Characterized planets in the habitable zone.

PLATO methods

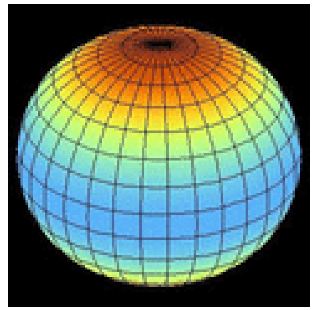
Satellite photometry

Ground-based spectroscopy



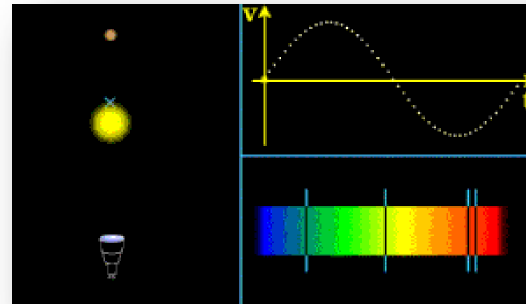
Transit detection

→ Planet/star radius ratio
→ Inclination



Asteroseismology

→ Stellar radius, mass
→ Stellar age



RV spectroscopy

→ Planet mass

→Planet radius
→Planet age

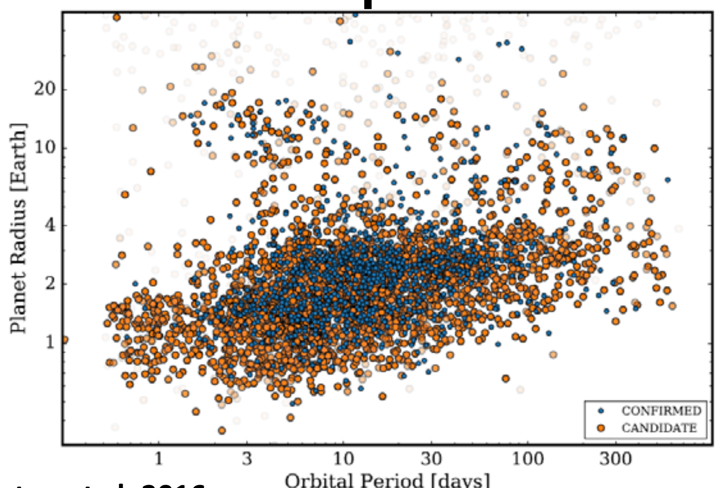
characterized

PLATO precisions: <u>The benchmark case: An Earth around a Sun at V= 10 mag:</u>

→ 3% radius; → 10% mass; → 10% age

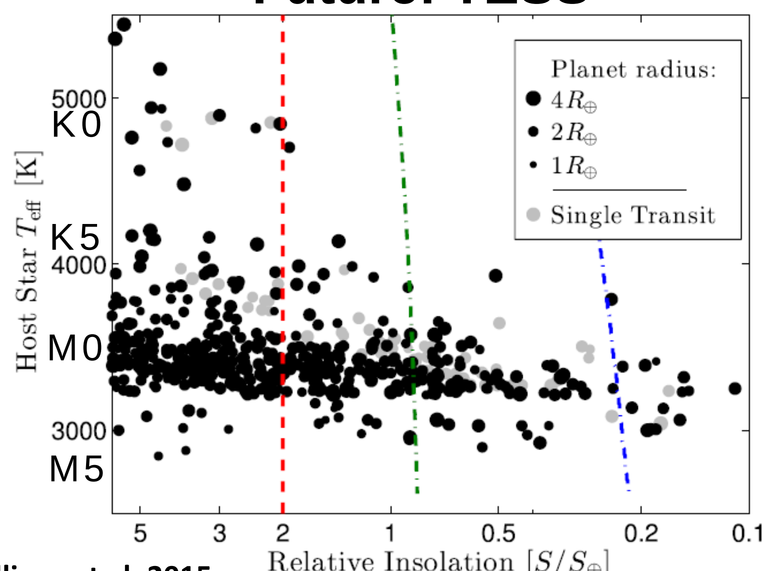
transits - detection status

Kepler



Morton et al. 2016

Future: TESS



Sullivan et al. 2015

Kepler:

- >~7000 KOIs
- ~1000 'confirmed' planets
- ~75 planets with RV measurements

K2:

- ~50 planets with RV measurements

CoRoT:

- 36 planets with RV measurements

Ground-based:

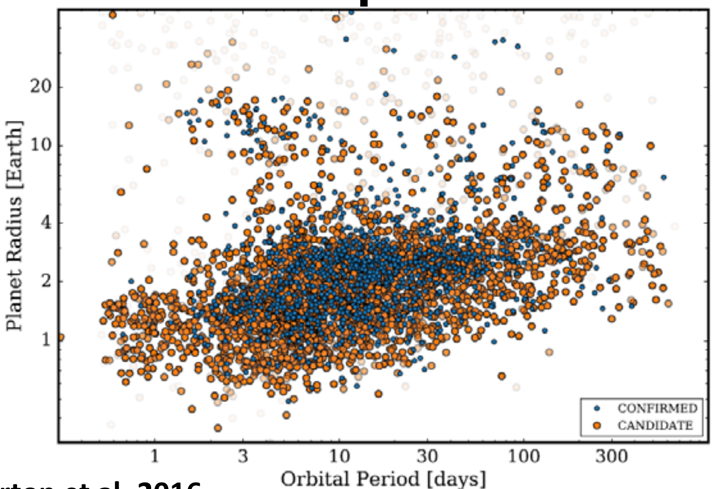
- ~300 planets with RV measurements

Total: ~450 planets with radii & masses,
- but only <20 planets with <2 Rearth
and 0% are in HZ of solar-like stars

Trappist system (masses with TTVs) orbits a M star

transits - detection status

Kepler



Morton et al. 2016

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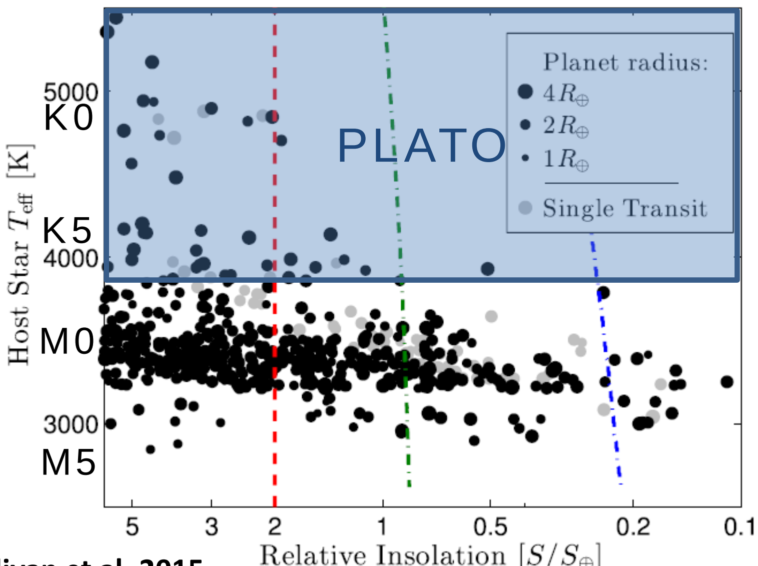

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values of eta-Earth

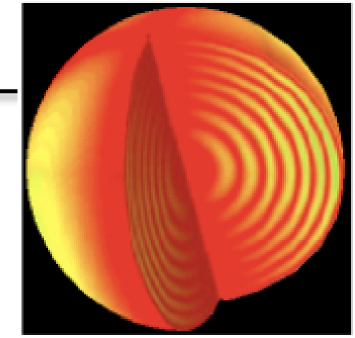
η Earth: The fraction of stars hosting Earth-like planets in their habitable zone

A non-comprehensive list from Kepler and radial velocity surveys:

reference	planet frequency	host stellar type
Catanzarite & Shao (2011) ApJ, 738, 151	1%- 3%	Sun-like stars
Traub (2012) ApJ, 745, 20	20%-58% (34%)	FGK stars
Silburt et al. (2015) ApJ, 799, 180	5.3%-9.8% (6.4%)	FGK stars
Petigura et al. (2013) PNAS, 110, 48	7%-15% (11%)	GK stars
Batalha et al. (2014) PNAS, 111, 35	11%-22%	GK stars
Foreman-Mackey et al. (2014) ApJ, 795, 64	0.8%-2.5% (1.7%)	G stars
Traub (2016), ApJ, submitted	90%-110% (100%)	G stars
Gaidos (2013) ApJ, 770, 90	31%-64% (46%)	dwarf stars
Bonfils et al. (2013) A&A, 549, A109	28%-95% (41%)	M stars
Dressing & Charbonneau (2013) ApJ, 767, 95	9%-28% (15%)	M stars
Kopparapu (2013) ApJ, 767, 8	24%-60% (48%)	M stars

→ The fraction of (super)-Earths in the habitable zone of stars is not well known.

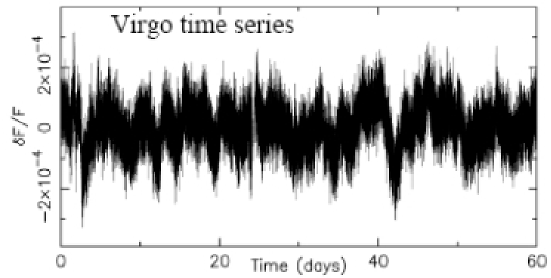
PLATO: Characterisation of host stars

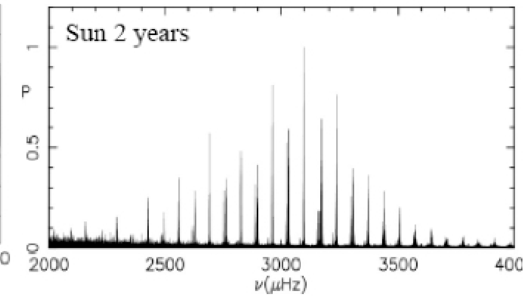


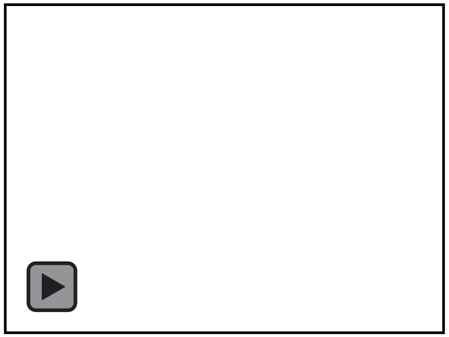
Planet parameters ← stellar parameters (asteroseismology)

Solar-like stars oscillate in many modes, excited by convection. Sound waves trapped in interior

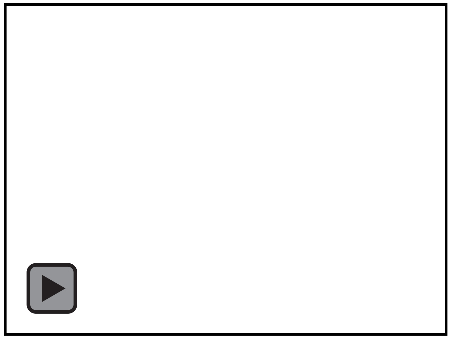
Resonant frequencies determined by structure:
→ frequencies probe structure
→ gives mass, angular momentum, age



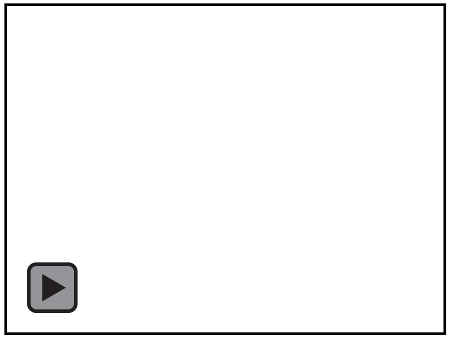




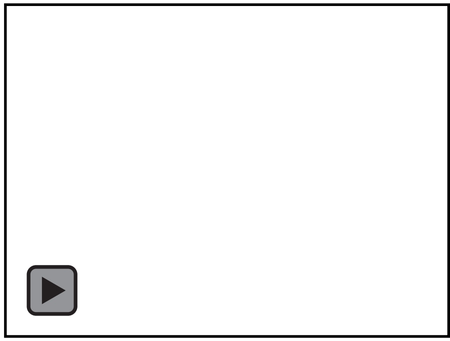
l=1, m=0



l=2, m=0



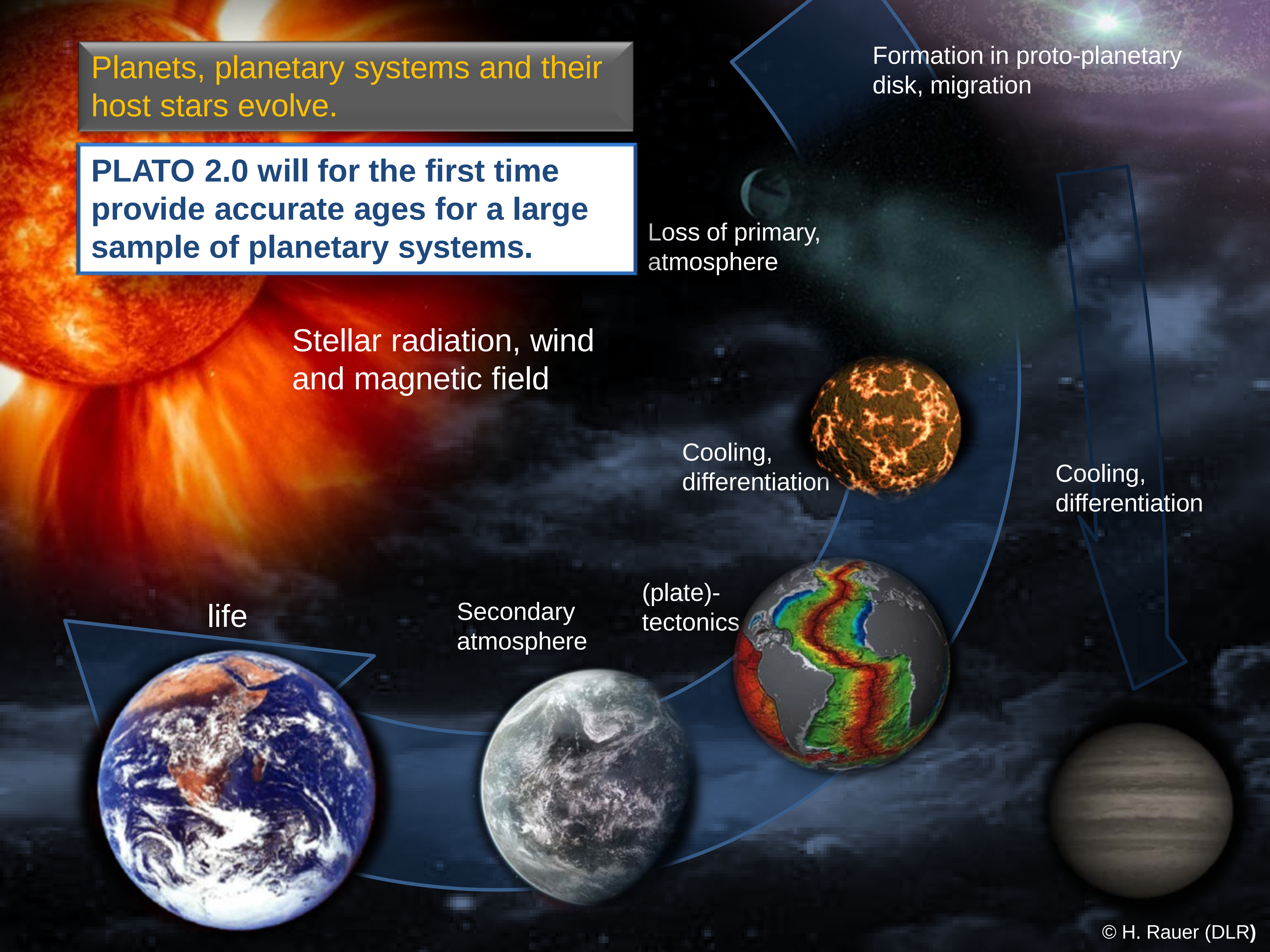
l=2, m=1



l=4, m=2

Planets, planetary systems and their host stars evolve.

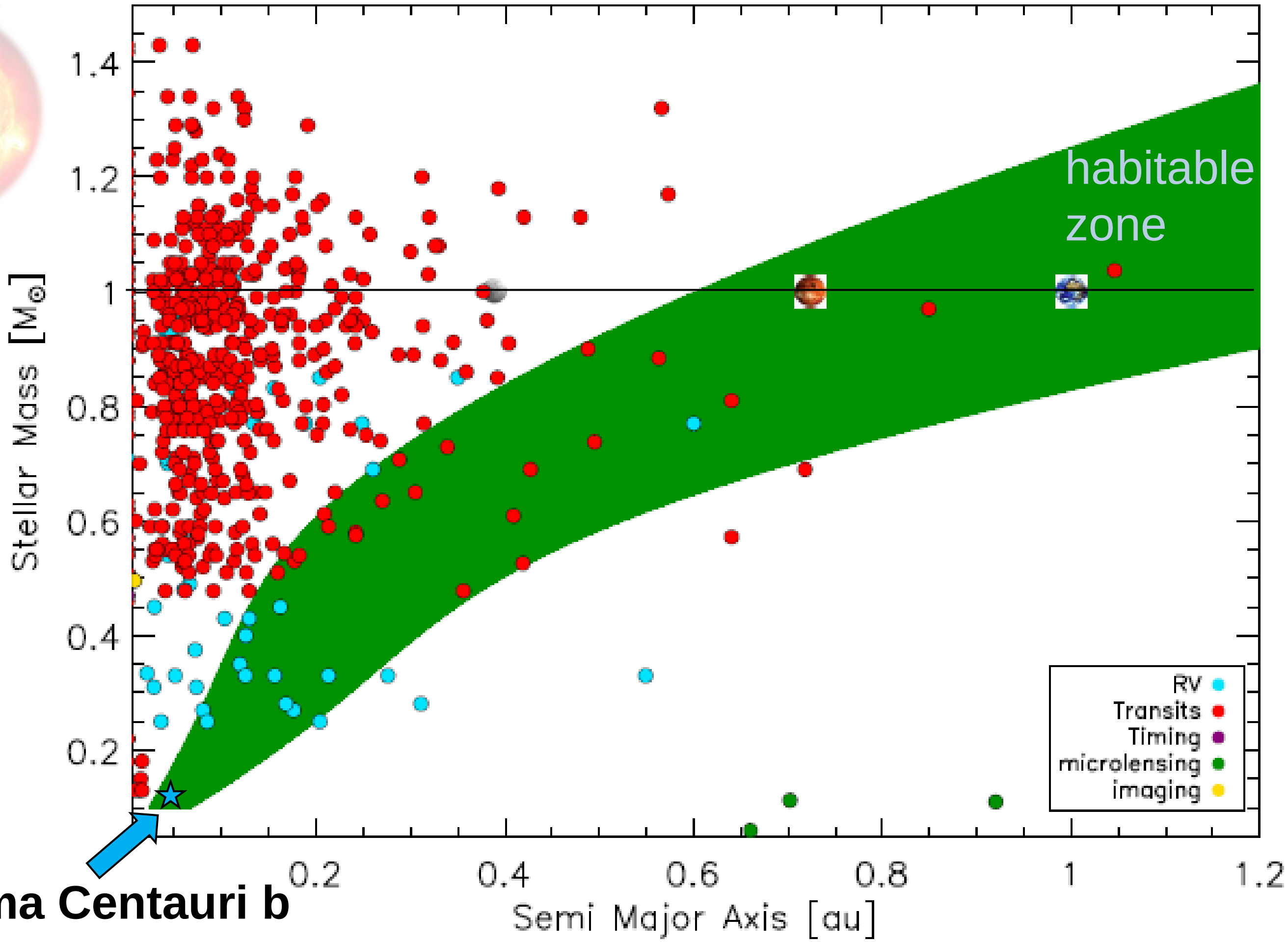
PLATO 2.0 will for the first time provide accurate ages for a large sample of planetary systems.



exoplanet hunters (+CHEOPS)

	N-cams/tel	equivalent diameter (m)	FOV (degrees^2)
	1	0.27	4 (Exo channel) [~20 pointings]
	1	0.95	105 [1 long pointing] [~18 pointings as K2]
	4	0.10	600/camera (2300/instrument) [full-sky survey]
	24	0.59	1100/camera (2124/instrument) [up to 50% of sky]
	1	0.30	0.32 [one target at a time]

Known Small Exoplanets

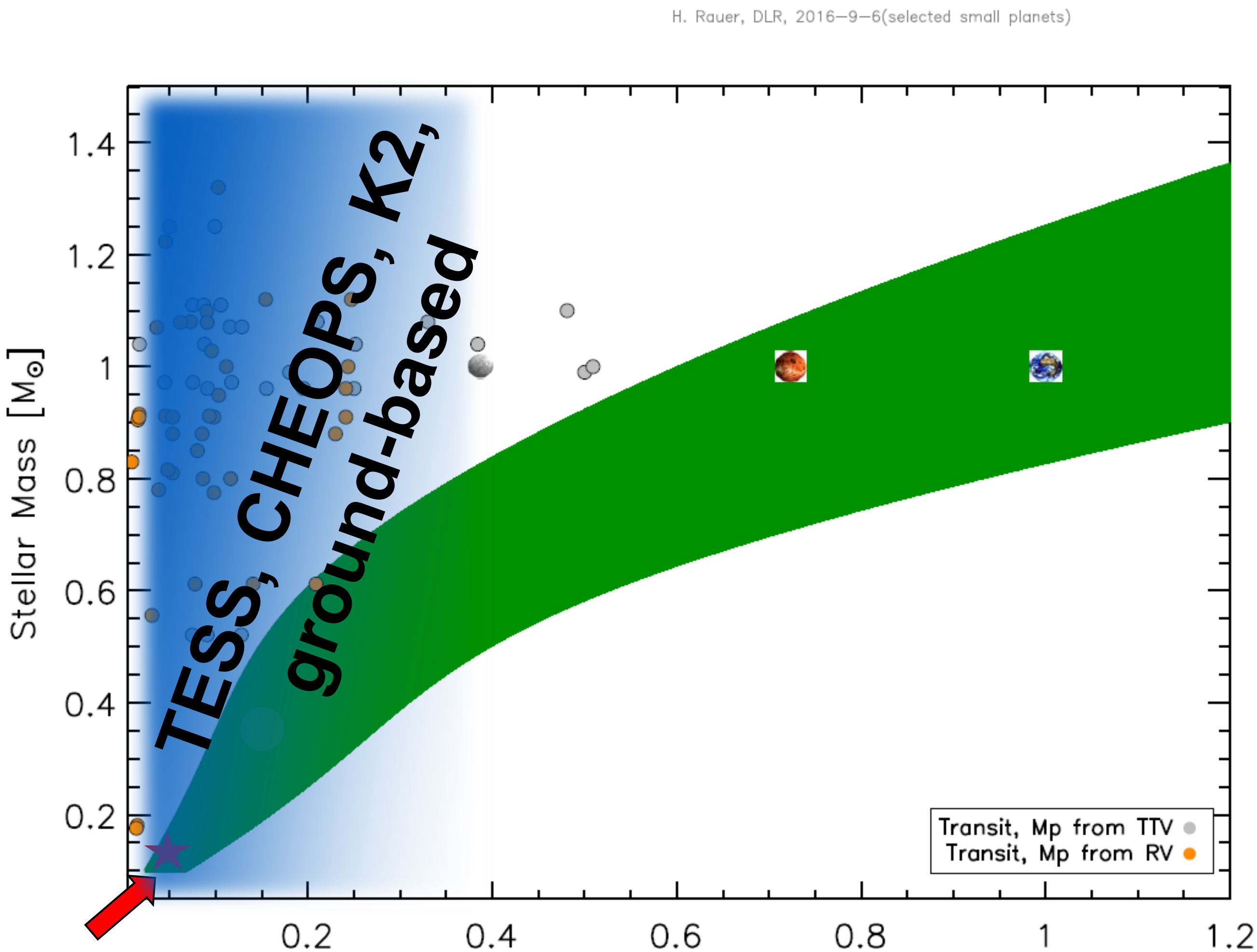


Proxima Centauri b

$M_p$sin$i$: 1.27 $M_\oplus$

Anglada-Escudé et al 2016

Bulk characterized super-Earths



LHS 1140b: RV mass
TRAPPIST: TTV masses

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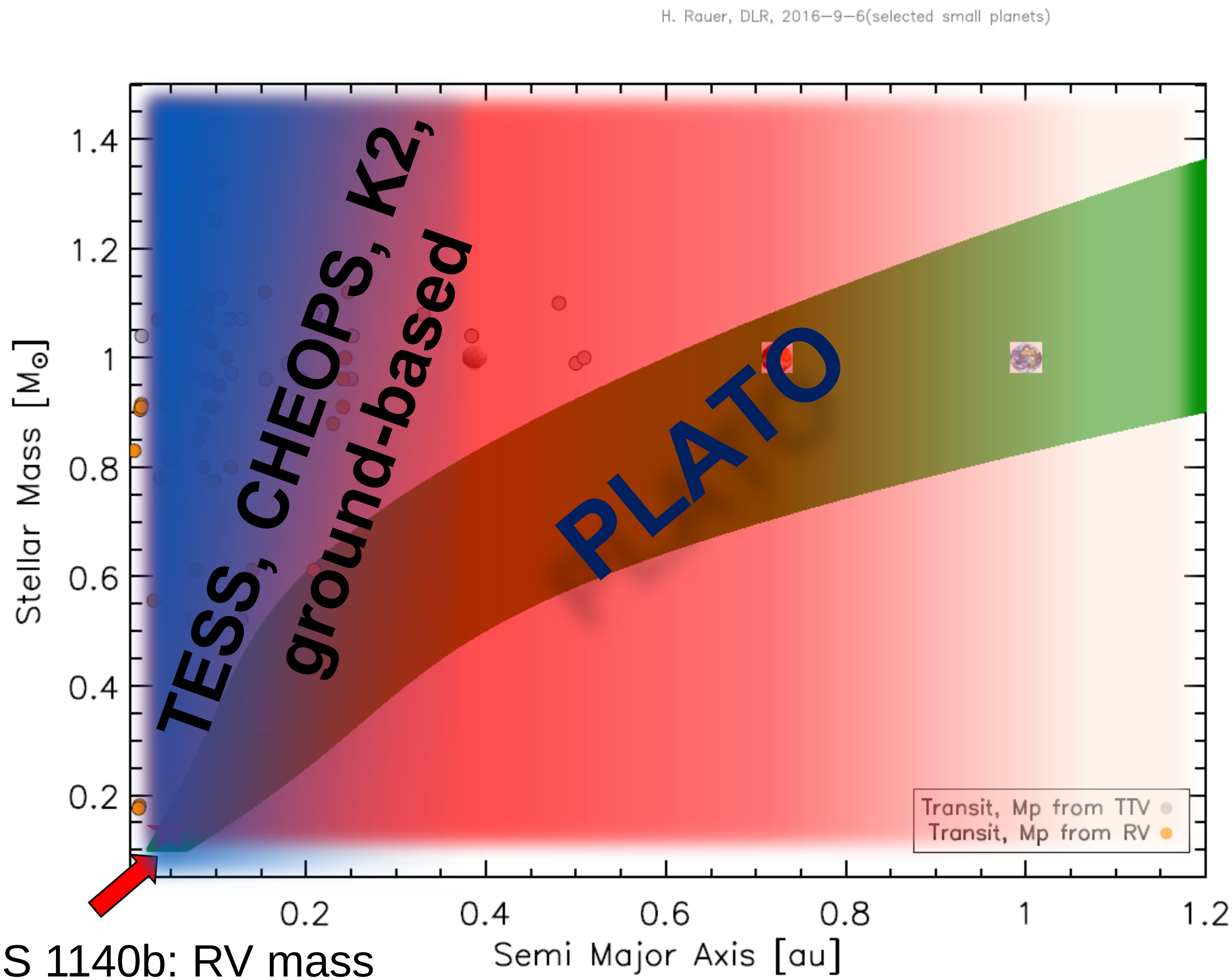


LHS 1140b: RV mass
TRAPPIST: TTV masses

The PLATO Instrument

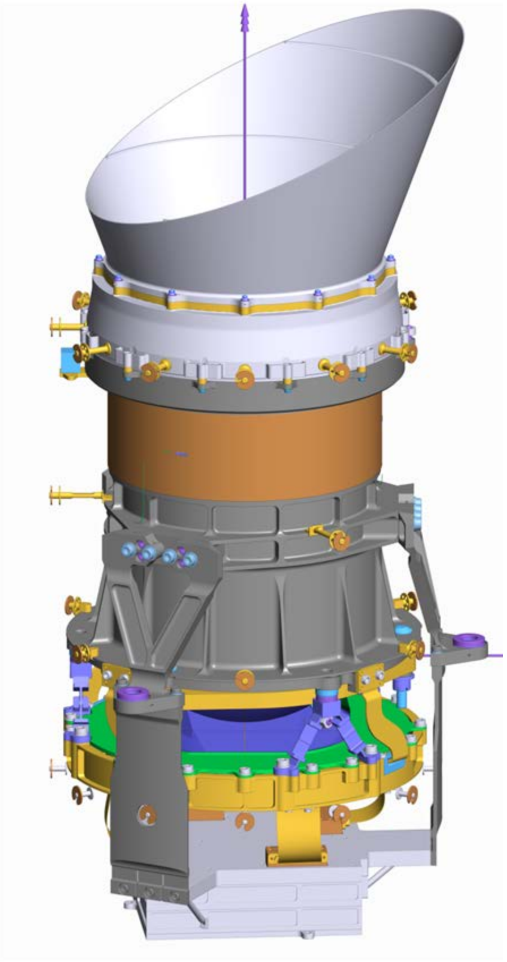
24 Normal cameras:

- 12cm effective aperture telescopes
- range: ~8 (4) ≤ m_V ≤ 11 (13)
- FOV payload ~49°x 49°
- Each camera has 4 x CCD, each 4510×4510px,

  (2 Gpixels, 0.74 m^2 silicon)
- Pixels size: 18 μm square
- read-out cadence: 25 sec
- operate in "white light" (500 – 1050 nm)

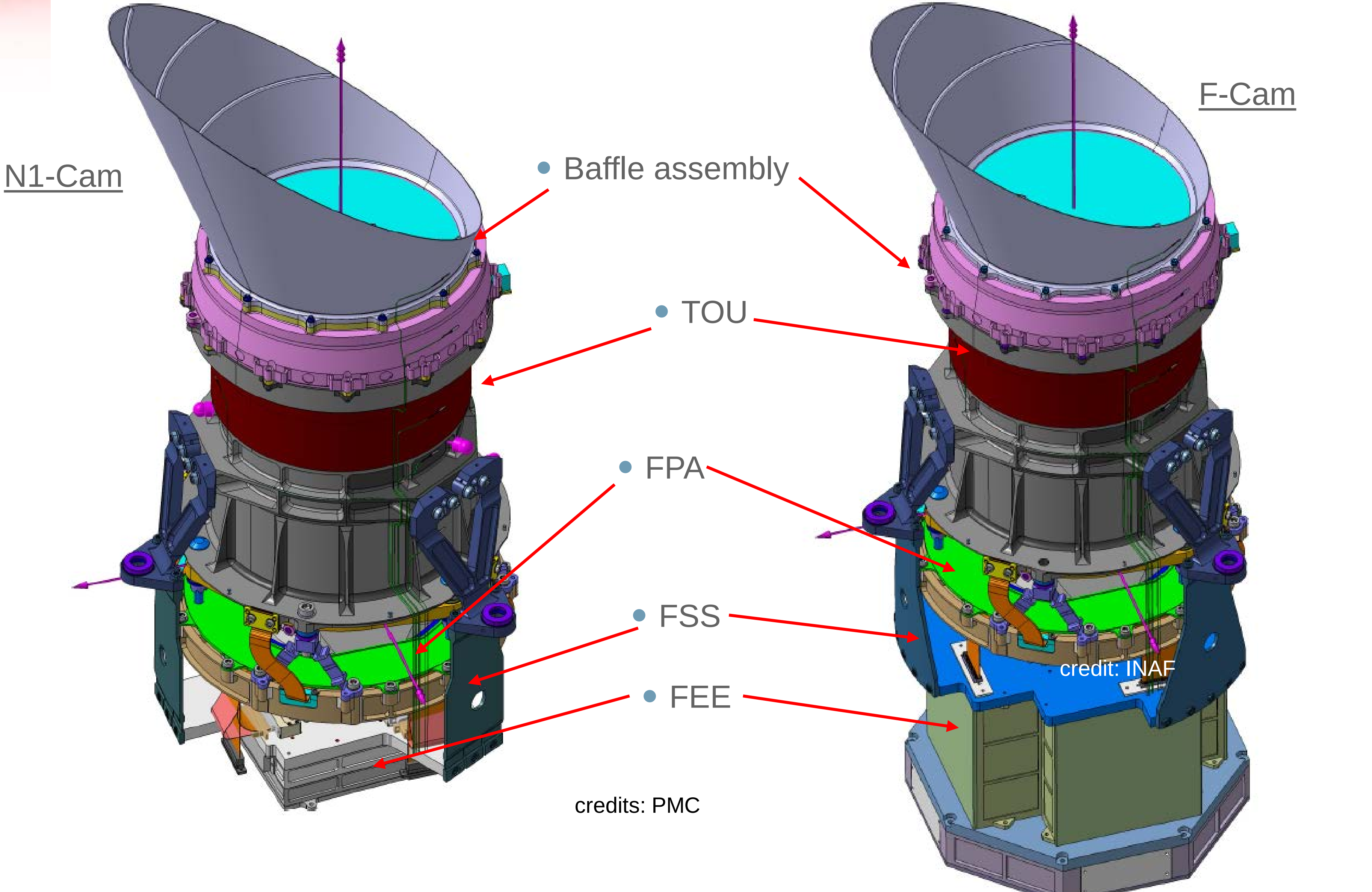
2 Fast cameras:

- read-out cadence: 2.5 sec
- one „red" and one „blue" camera
- frame-transfer mode (half FOV as N-CAM)



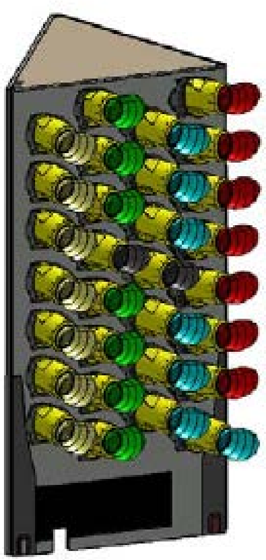
PLATO N-camera

Instrument Overview

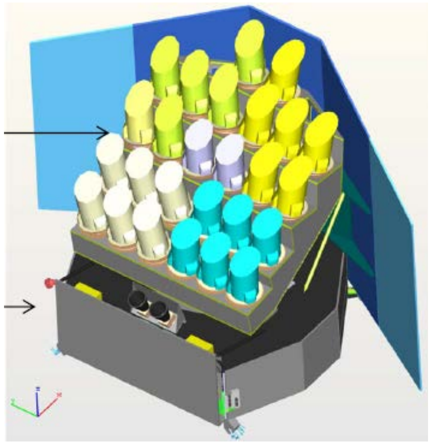


PLATO Instrument

Cameras mounted on an optical bench,
final selection of design in 2018:

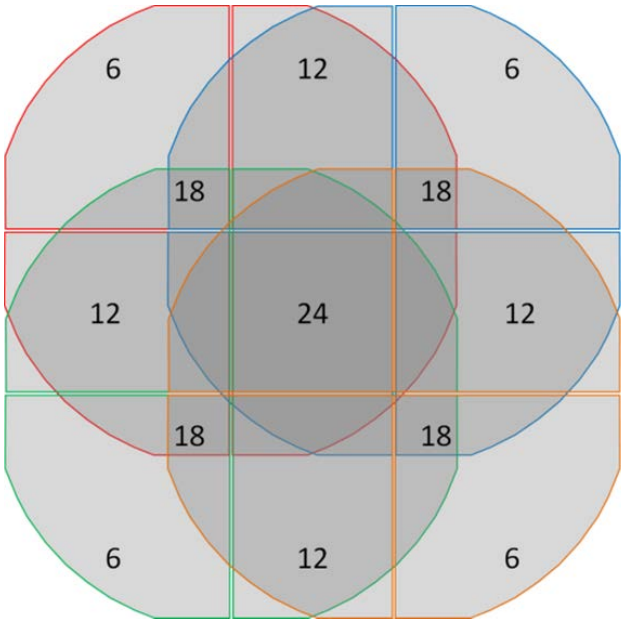


Astrium



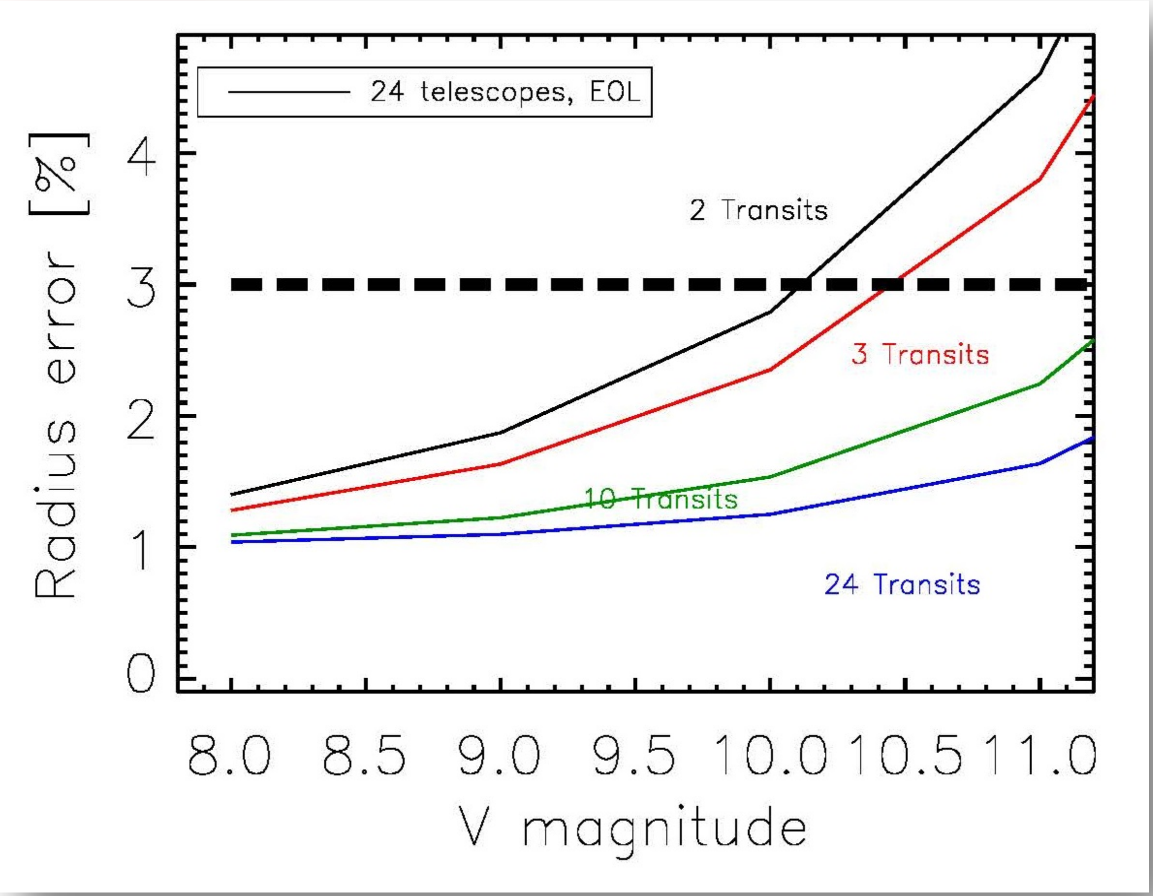
OHB

Field-of-view:



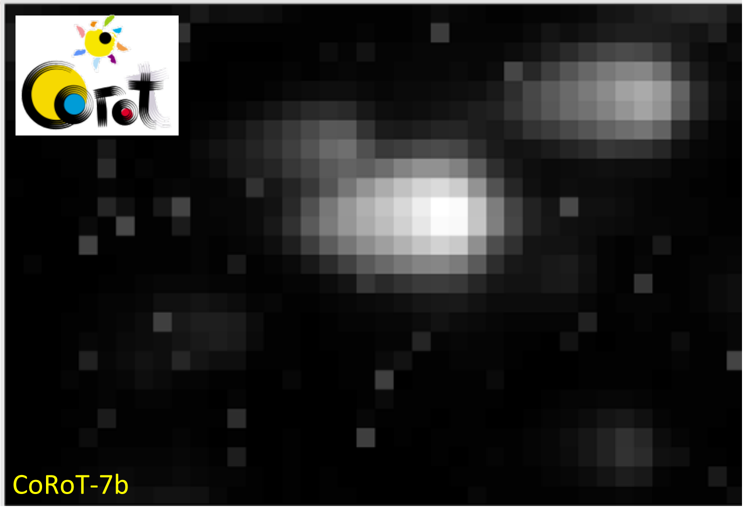
- Total FoV: 1037 deg^2 per camera (instant FoV 2124 deg^2)
- **24 „normal" cameras -** arranged in 4 groups of 6 cameras each
- **2 „fast" cameras** used for pointing

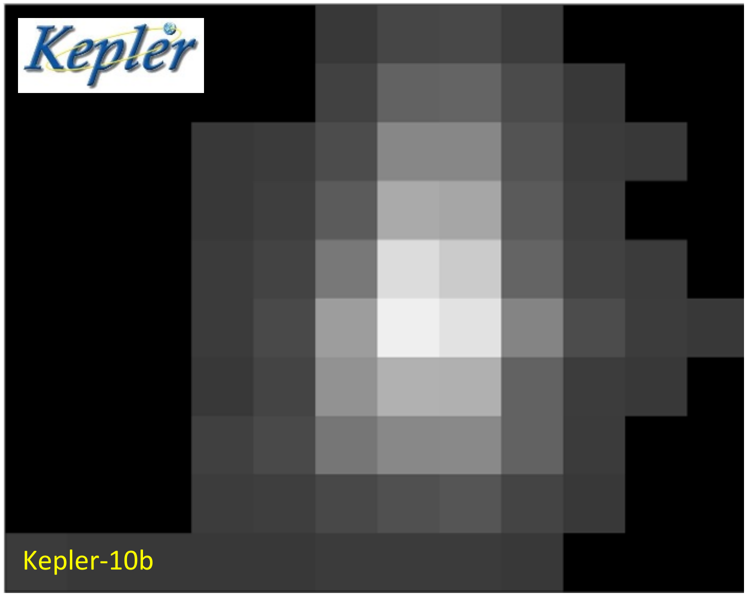
Planet radius



- Accuracy for PLATO radii for 24 N-cameras
- **Earth-sized planet orbiting a G0V star**
- Stellar radius known from asteroseismology
- No stellar activity considered

Imagette approach





- Reading full images of all cameras: ~**195 Tbit/day**.
- Telemetry available using K band: **435 Gbit/day**.
- A high **reduction factor** is reached by reading „imagettes" and by onboard computing.

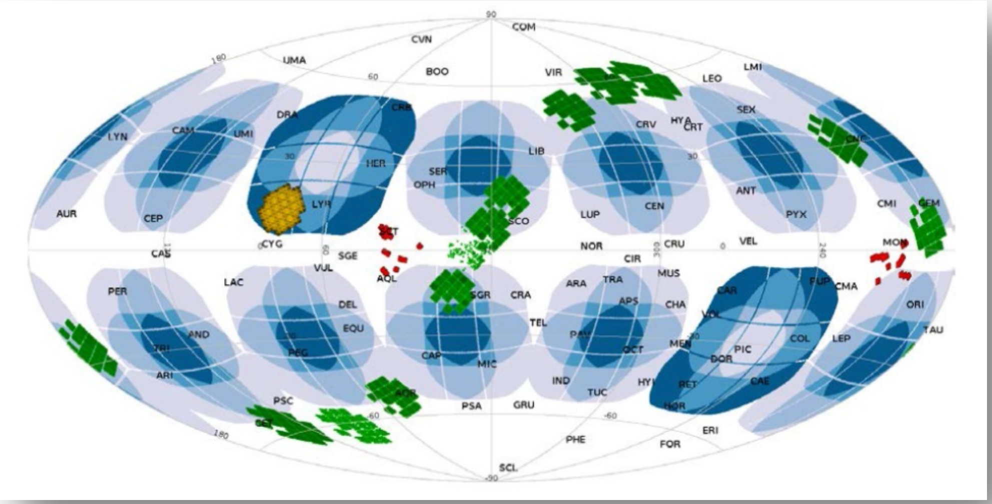
→ Imagettes of „bright stars" (core sample) processed on ground

→ Imagettes of „fainter stars (statistical sample) are mainly processed onboard

PLATO Baseline Observing Scenario

- Launch in 2026 into orbit around L2 Earth-Sun Lagrangian point.
- Mission science operations: 4 years duration.
- Satellite/instrument designed to last with full performance for 6.5 years.
- Consumables will last 8 years.

- Observing strategy:
  - Baseline:
    2 long pointings of 2 years
  - Alternative:
    3 years + 1 year step-and-stare phase



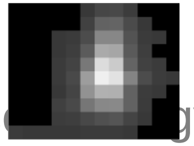
- The final observing strategy will be fixed ~2 yrs before launch and can be adapted during the mission.

data products: lightcurves

- PLATO has a set of lightcurve samples defined with different precision.
- The main samples are:

  - **core sample:** ~15 000 dwarf and sub-giant stars with <11 mag
    - Lightcurve sampling: 25 s
    - Imagettes transmitted for analysis on ground

    → high precision planet and stellar parameters (radii, asteroseismology)



  - **„statistical“ sample**: >245 000 dwarf and sub-giant stars with <13 mag
    - Lightcurve sampling: 600 s, computed on board

    → statistics, good planet radii precision; but no asteroseismology, no RV

    → TTV analysis

    - For the brightest stars in the sample (<11 mag): Imagettes can be transmitted to ground with 25 s sampling

    → RV possible for planet mass determination

see PLATO Science Management Plan, 11.10.2017

PLATO follow-up

There are two kinds of follow-up observations:

1) Observations designed to detect false positives (filtering observations).

2) Observations needed to characterise the planetary mass (radial velocity observations).

- The team performing these observations (GOP Team) will be selected through an open call by ESA.
- The issue of the AO is planned for 3 years (TBC) before the PLATO launch.
- The GOP Team will organise their respective telescope resources and execute the observations. Data will be made available to PMC and ESA for L3-level data production.
- ESA will take the lead in establishing agreements and managing relations with main ground-based facilities.
- The PMC will be responsible to generate requirements for the execution of the ground-based observations program.

Guest Observer programme

- ESA will issue calls for proposals for complementary science programs
- The targets must be within the PLATO sky fields defined by the SWT
- The duration of the proposed observations cannot exceed the observation durations of the corresponding sky fields.
- The first call will be issued nine months before launch
- More open calls will be issued during the mission (once per year, TBC)
- At any given time, 8% of the science data rate (excluding calibration data) will be allocated to the guest observers.
- Proposals on targets of opportunity possible, but they will be executed on a best effort basis

PLATO contribution to planetary sciences

PLATO will detect transit signals of thousands of planets which are bright enough for radial velocity spectroscopy to determine their masses.

PLATO will provide:

- **A sample of well characterized Earth-Sun analogues**
  → unique to PLATO
- Characterized terrestrial planets in the HZ – high accuracy in radii, ages.
- Small-planet diversity – how unique is Earth?
- Planets at all ages, understand planet evolution.
- Finding out if there is a „multidimensional H-R-diagram for planets“ – a classification scheme for planets.
- Provide a target list for atmosphere spectroscopy.

PLATO Community

Thank you!