2025 Sagan Summer Workshop

THE FUTURE OF TRANSITING EXOPLANET SEARCHES FROM SPACE IN THE NEXT DECADE

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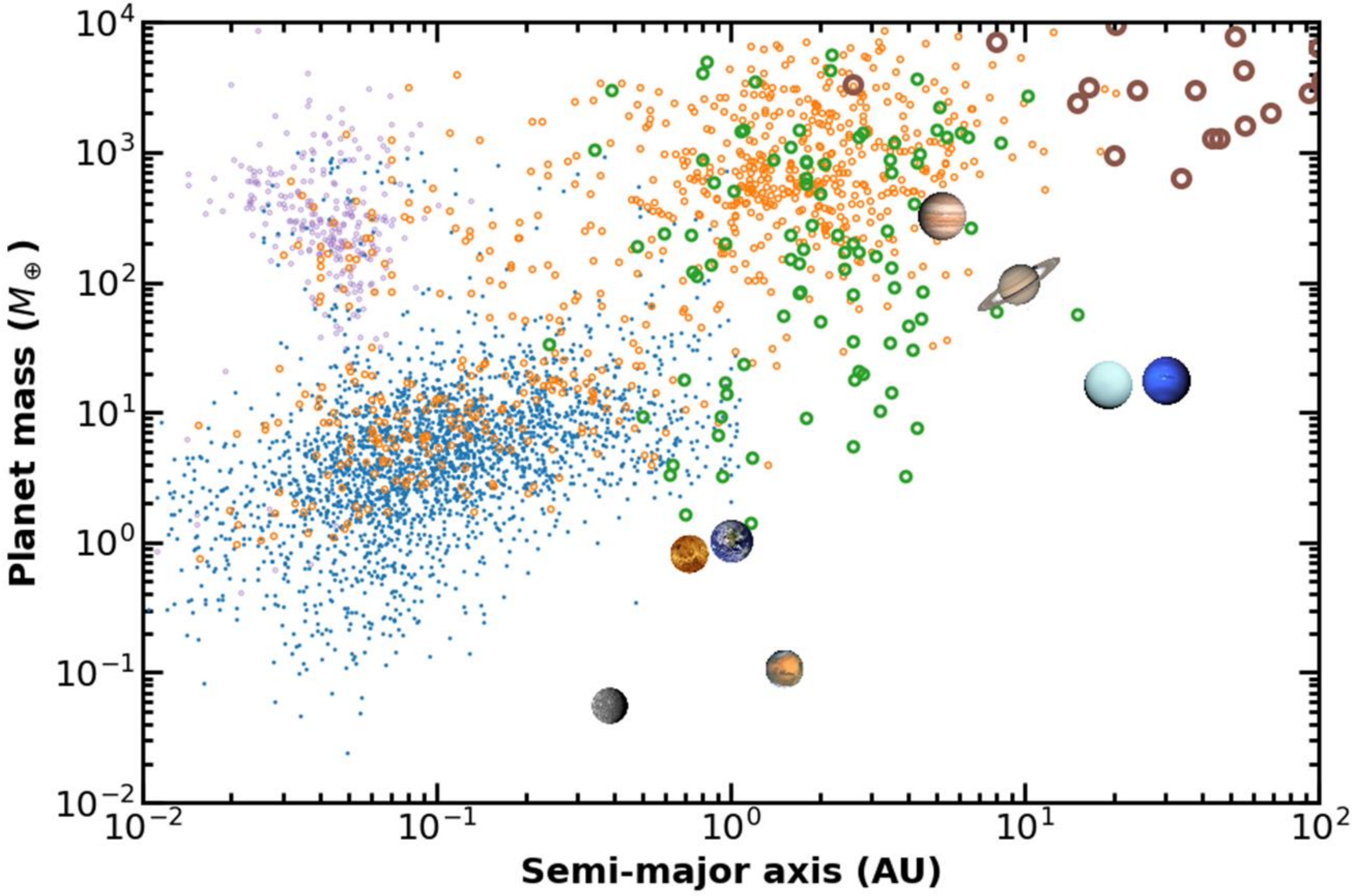
Credits: SPP 1992/Patricia Klein

What transiting planets can provide
(… depending on size, planet type, orbital distance, …)

- radii
- Planetary densities (with RV masses)
- Oblateness (gas giant shape)
- Love numbers
- Constrain planet interiors
- Phase curves
- Atmosphere spectroscopy

- Characterize individual planets
- Population studies

Exoplanet detection status today

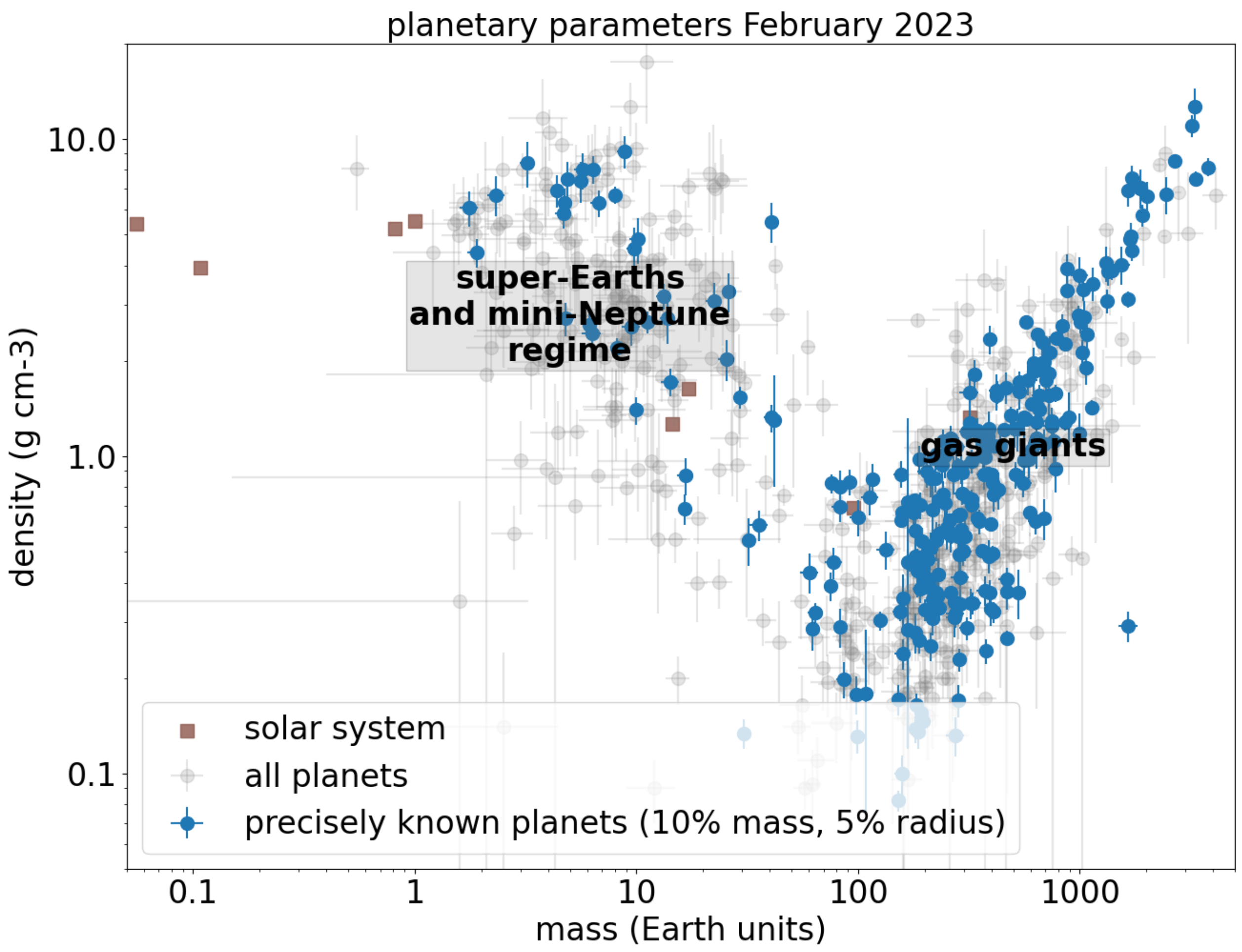


- >6000 planets in exoplanet.eu
- >1700 planets with m + r
- ~240 with m<10 M_earth and with r<2 R_earth

Many more „planet candidates".

Mean density

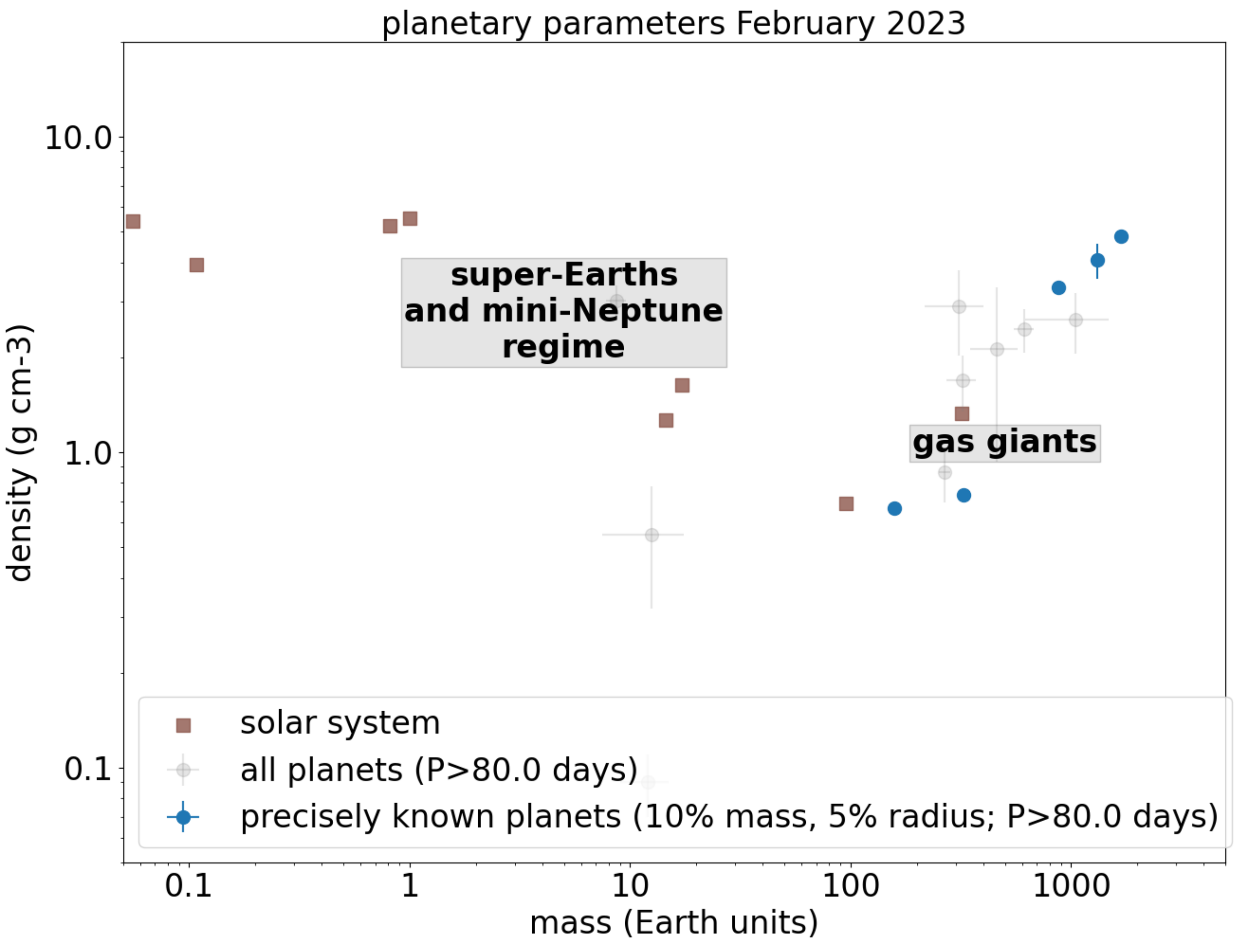
All orbital periods



Rauer et al., 2025

Mean density

Orbital Periods >80 days



Rauer et al., 2025

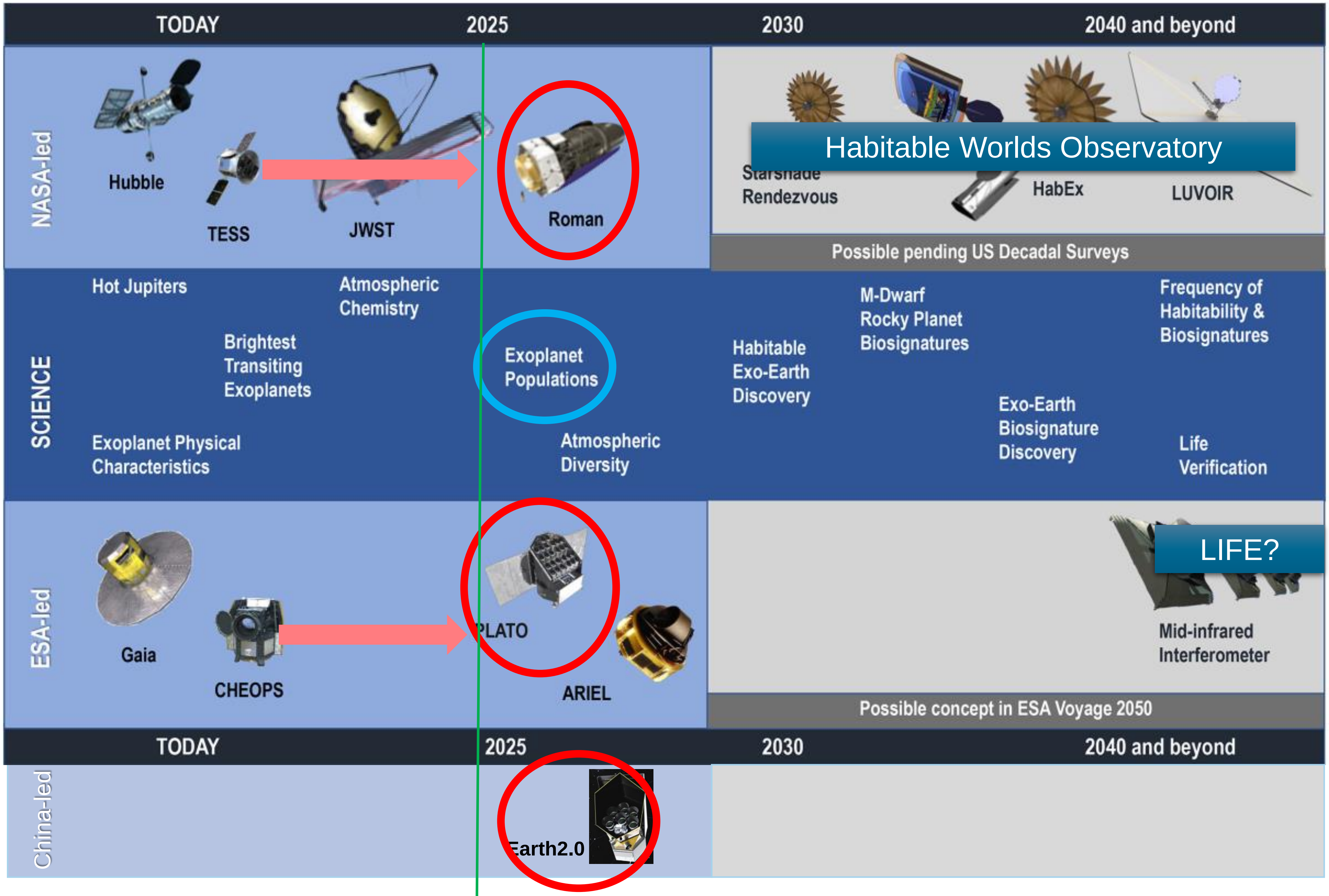
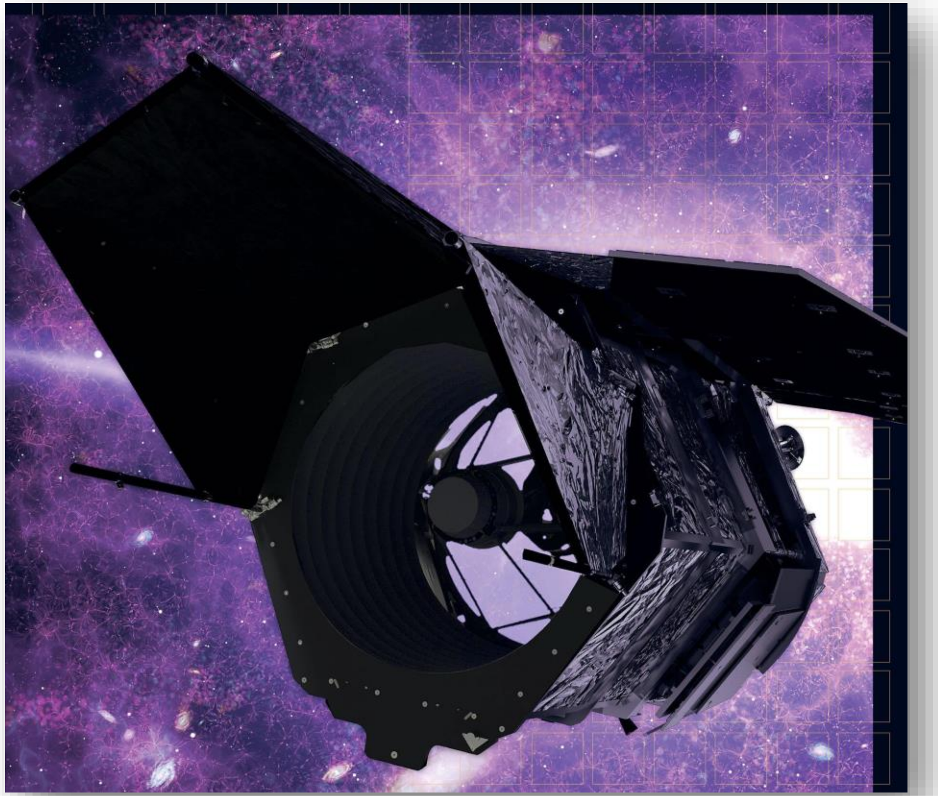


Figure adapted from Stapelfeldt et al. 2021

Transiting planets with the Roman Galactic Bulge Time Domain Survey

Source : NASA Joins Telescope, Instruments to Roman Spacecraft

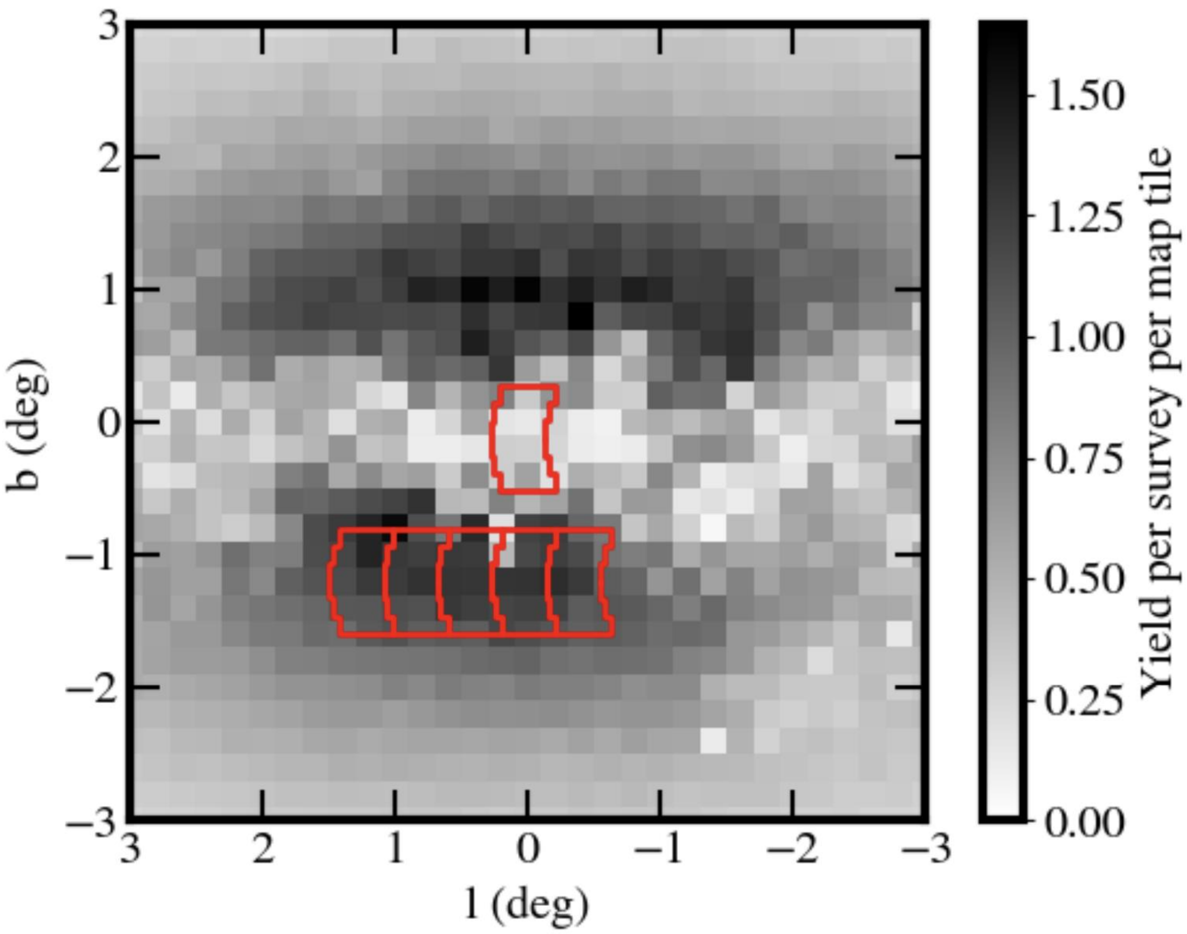


NASA

Roman Galactic Bulge Time Domain Survey

- Scheduled for launch October 2026
- Telescope size 2.4 m
- Field-of-view: 0.8 deg x 0.4 deg (0.281 deg^2)
- Designed to achieve the Roman baseline science requirements of precise planet occurrence rates, including $\eta_{\oplus}$, and enable additional astrophysics
- 5 fields + 1 Galactic center field
- 6 x 72 day observing seasons, ~12 minute cadence in broadband filter, ~67 second exposures

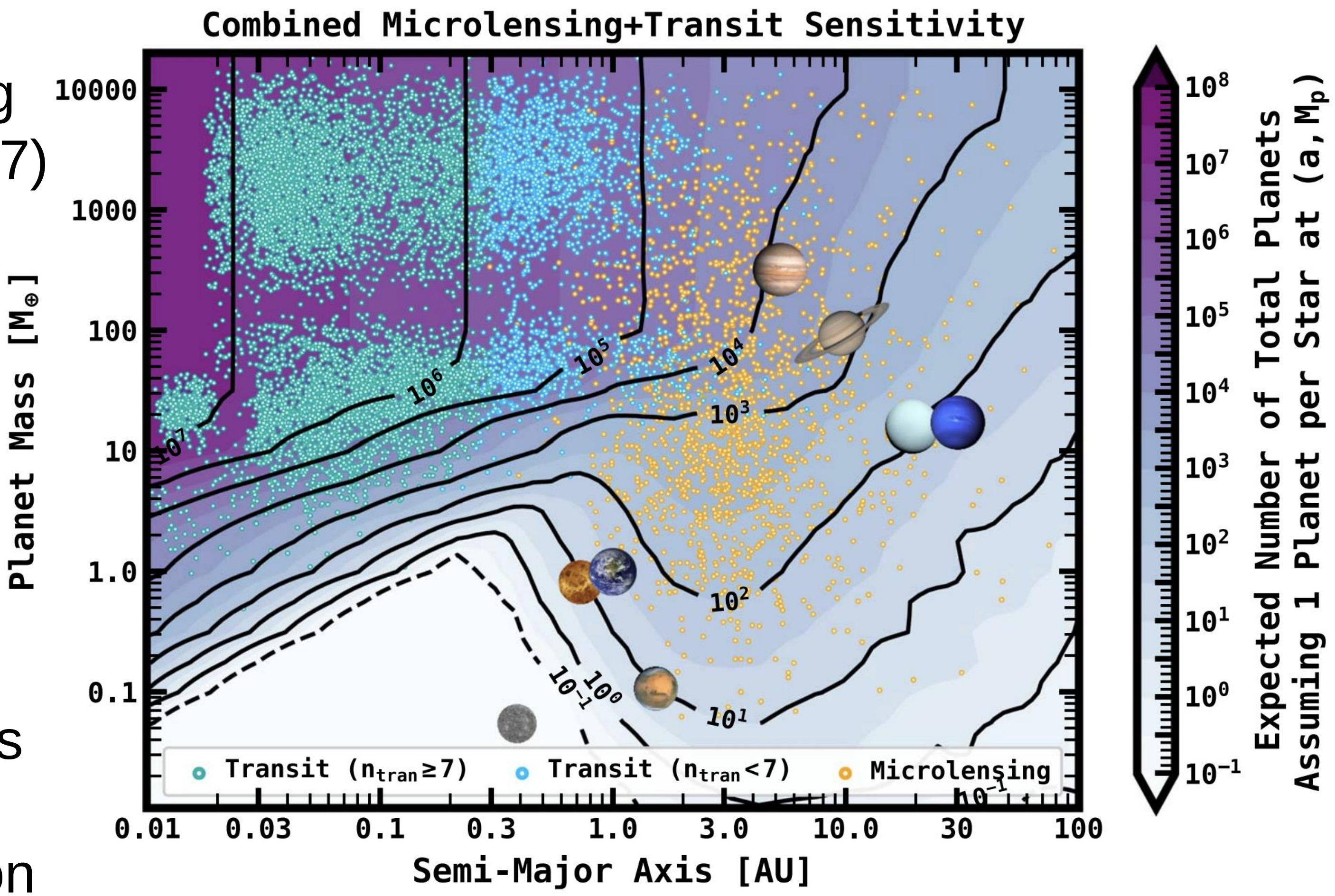
GBTDS Definition Committee Report (2024)



credit Caltech/IPAC-NExScI

Transiting planet yields

- Survey simulations down to 21st mag (Wilson et al. 2023, Montet et al. 2017) predict 60,000-200,000 transiting planets
- 90-95% will be giant planets
- Limited ability to follow-up/confirm individual planet candidates, but ensemble will be useful for statistics
- Overlap between the expected transiting and microlensing detections between 0.3-3 au will also enable significant improvements in population studies



Wilson+2023

credit Caltech/IPAC-NExScI

Transiting planets with the PLATO mission

ESA – M. Pédoussaut

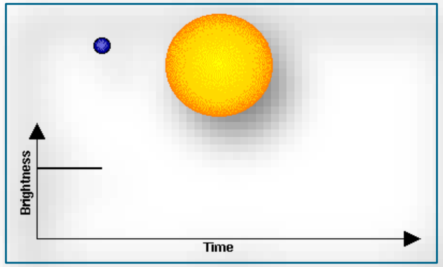
PLATO Mission (ESA)
(PLAnetary Transits and Oscillations of stars)

ESA/ATG medialab

- ESA M3 mission
- Launch December 2026
- 26 telescopes with 12cm aperture each
- First 10 flight model cameras completed
- ~49°x 49° field-of-view
- High precision photometry : $4 \leq m_V \leq 11$ (13)
- 4 years mission operations (8.5 yrs consumables)
- Goal: Detect and characterize (radius, mass, age) exoplanets, including small planets in the habitable zone of solar-like stars.

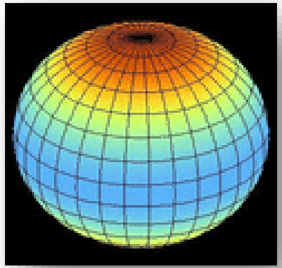
The PLATO Mission

Methods:



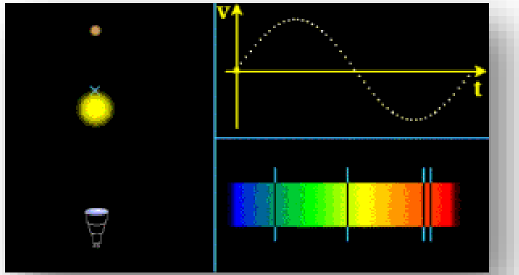
Transit detection

→ Planet/star radius ratio
→ Inclination



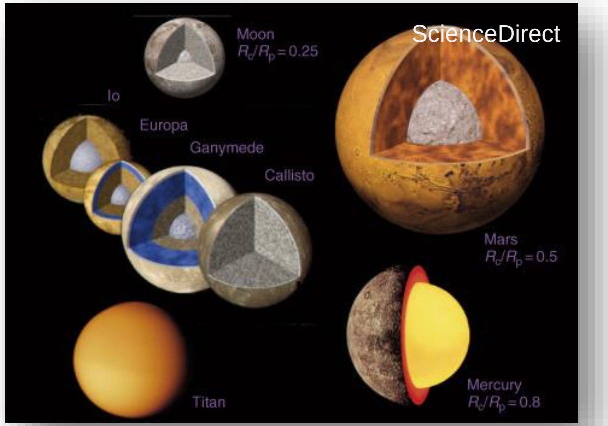
Asteroseismology

→ Stellar radius, mass
→ Stellar age

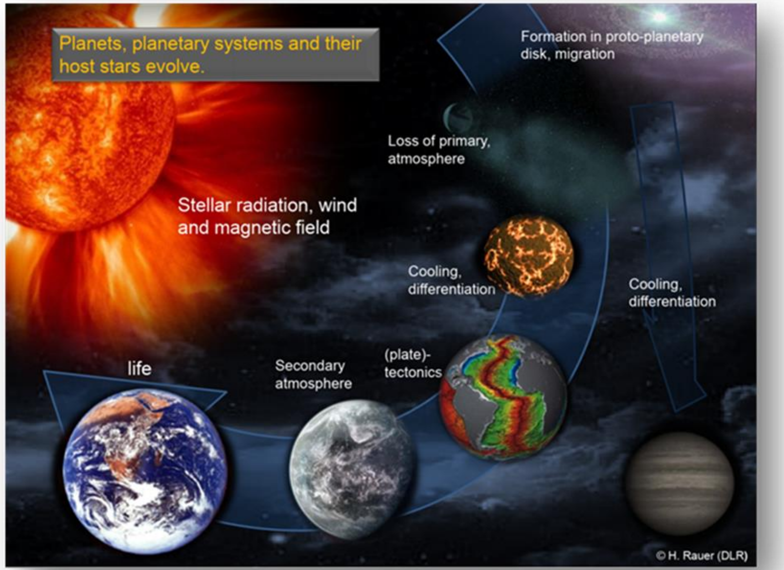


Ground-based observations

→ Planet mass



- **Mean density**
- **Age**



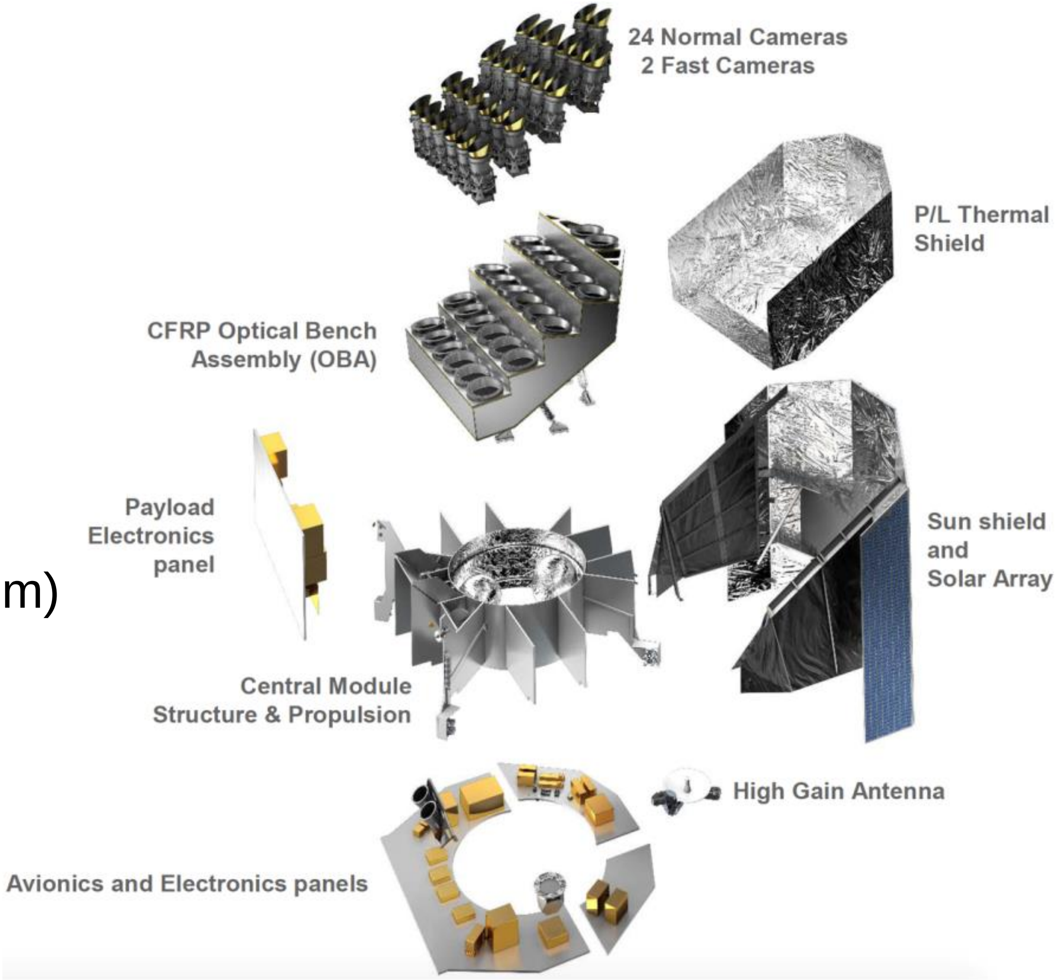
The PLATO Instrument

24 Normal cameras:

- 12cm aperture telescopes
- range: ~4 ≤ m_V ≤ 13
- FOV payload ~49°x 49° (2132 deg^2)
- Each camera has 4 x CCD, each 4510×4510px
- Pixel scale 15 arsec/pixel
- read-out cadence: 25 sec
- operate in “white light” (500 – 1000 nm)

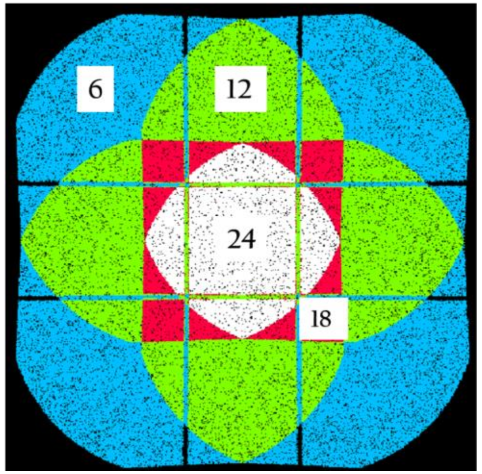
2 Fast cameras:

- range: ~4 ≤ m_V ≤ 8.2
- read-out cadence: 2.5 sec
- one “red“ & one “blue“ camera



ESA/OHB

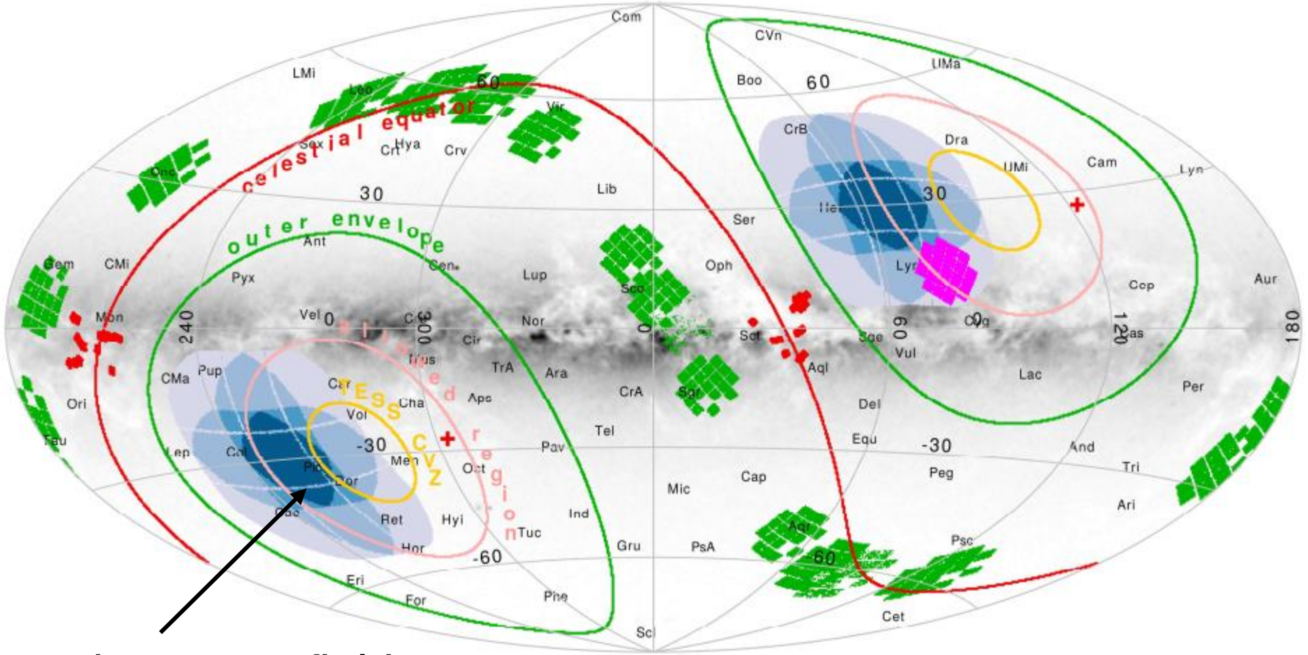
A camera during testing



Total FOV ~2132 deg^2

(vs 105 deg^2 Kepler)

PLATO fields



First target field

PLATO will observe
(assuming 2 target fields observed 2 years each):

- ~15 000 dwarf and subgiant stars (F5 to K7) with V < 11 mag
- > 245 000 dwarf and subgiant stars
- V < 13 mag
- V < 16 mag for M stars

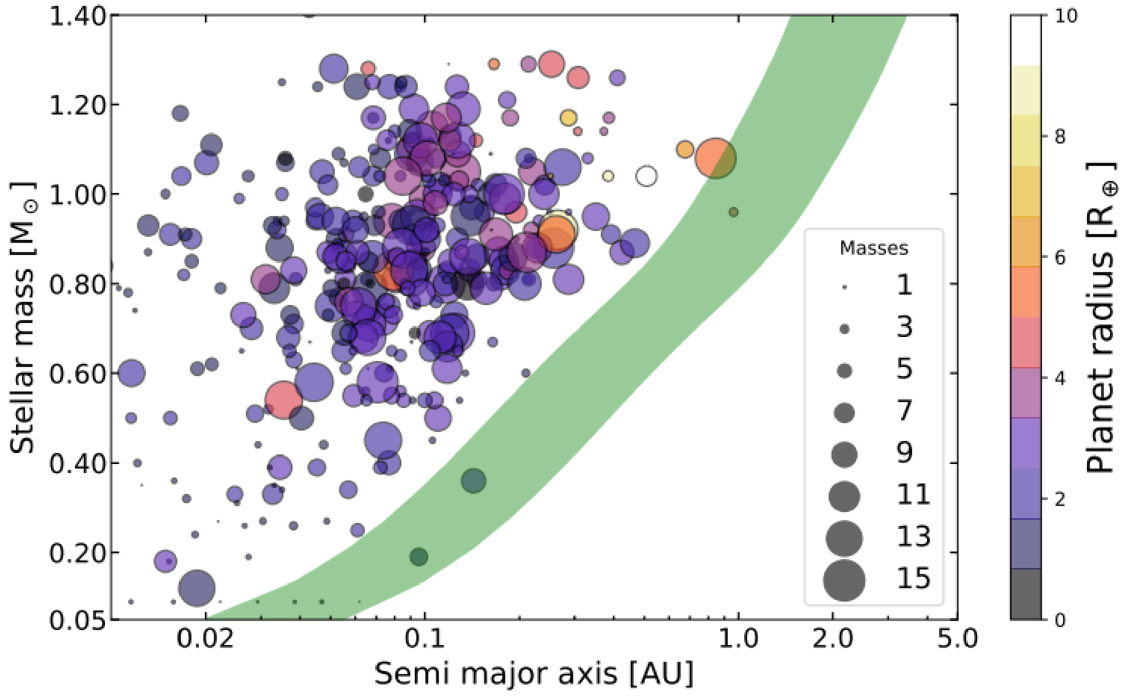
A word on data analysis:

- Planets and stars will be analyzed by the PLATO pipelines
- Organize RV for mass determination (for Prime Sample)

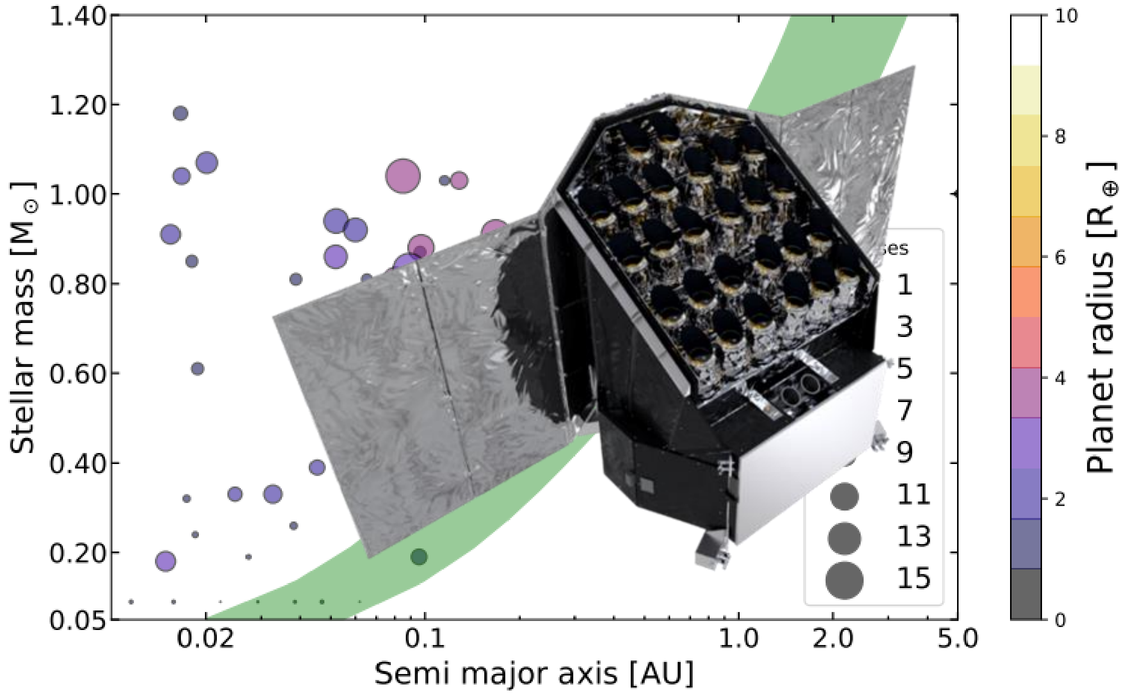
→ **Deliver a catalogue of planet parameters based on same pipeline**

Small planets in the habitable zone

Mass <15 M_earth, radius <10R_earth



With <10% mass and <5% radius precisions



Rauer et al., 2025

PLATO yield of transiting planets

Expected transit yields with 4 years mission scenarios:

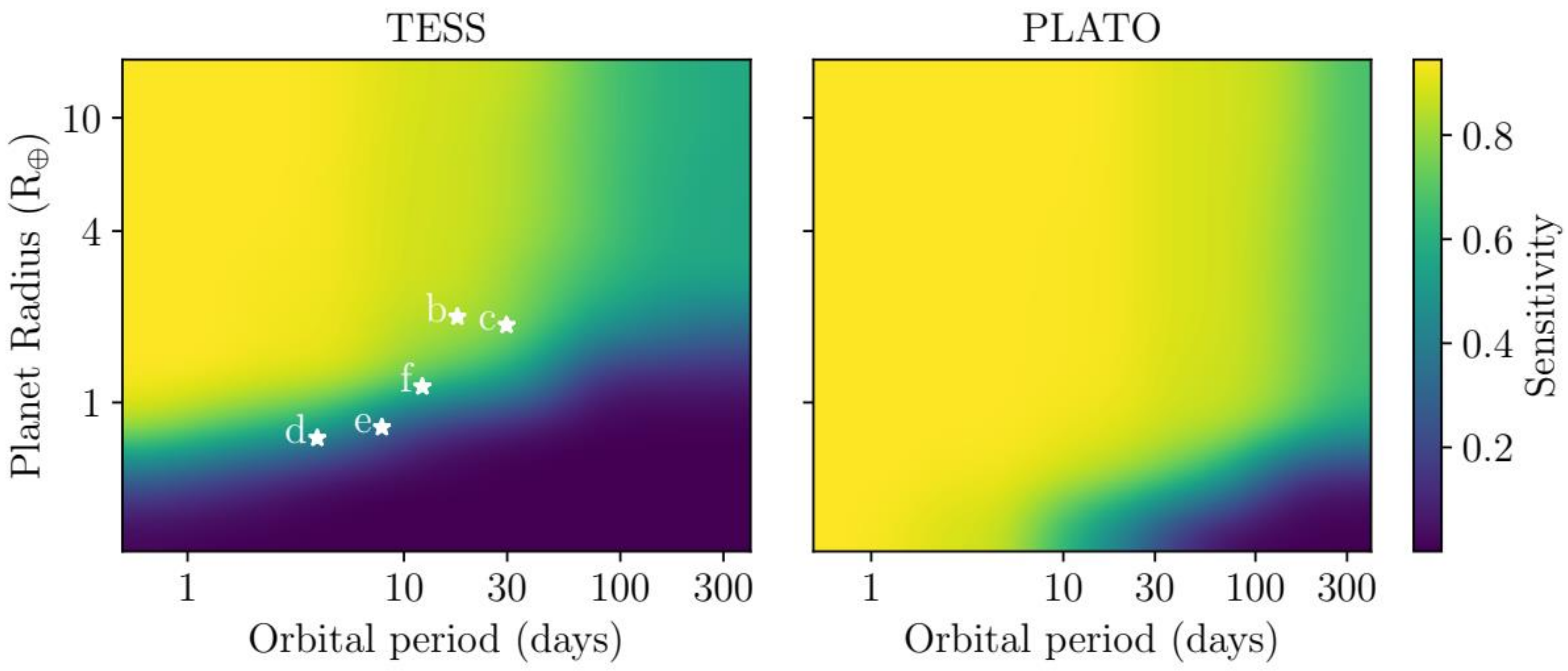
Targets	Observing Strategy	
	2+2 years	3+1 years (step+stare)
V<11 mag, all planet types	1200 - 1350	2300 - 2700
V<13 mag, all planet types	4600 - 7150	10300 - 10800
V<11 mag, planets <2 r_earth, G0V host star	0 - 120	0 - 140

← Large uncertainty due to unknown eta-Earth!

ESA-SCI(2017)1; Heller et al. 2021, Matuszewski et al. (2024), Cabrera et al. (in prep.)

see also Rauer et al. 2025

- Comparison of PLATO sensitivity to TESS

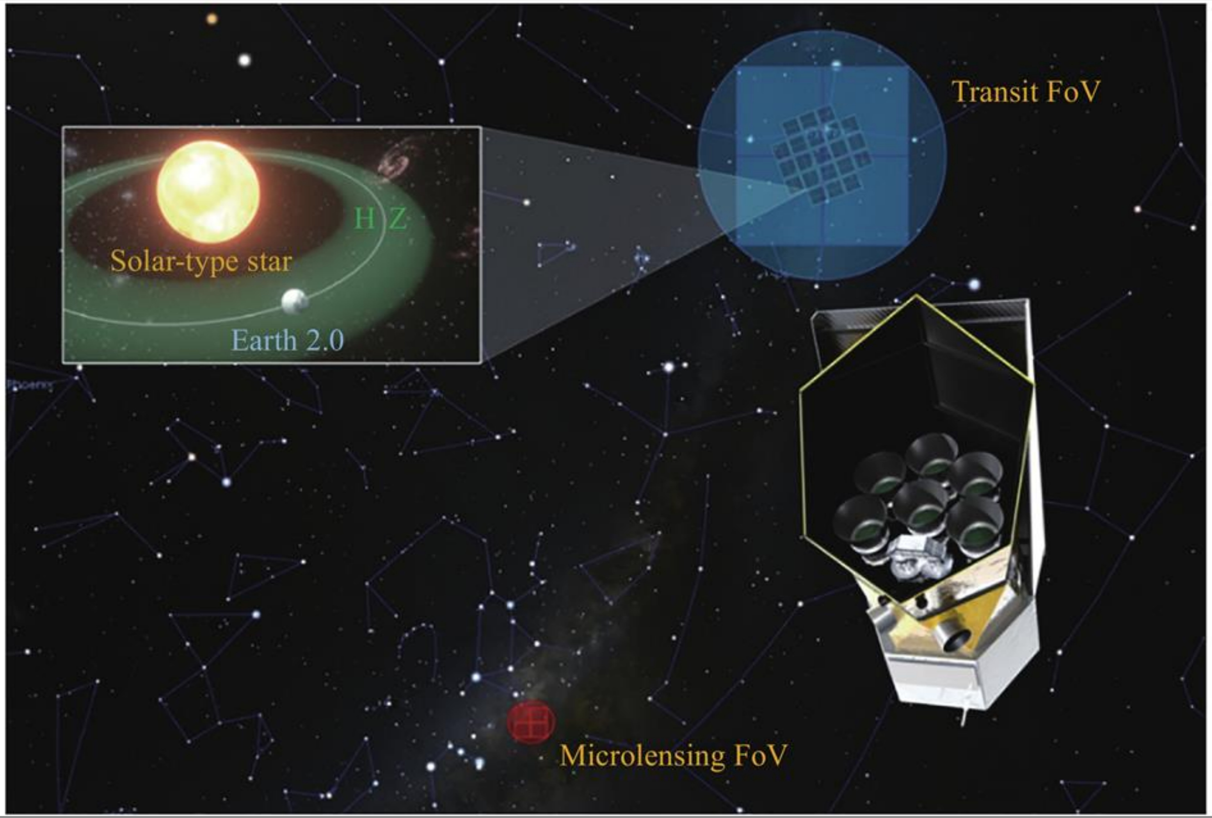


for 12 TESS sectors

for 2 years on a PLATO field

Eschen et al. 2025

Transiting planets with the Chinese Earth 2.0 mission

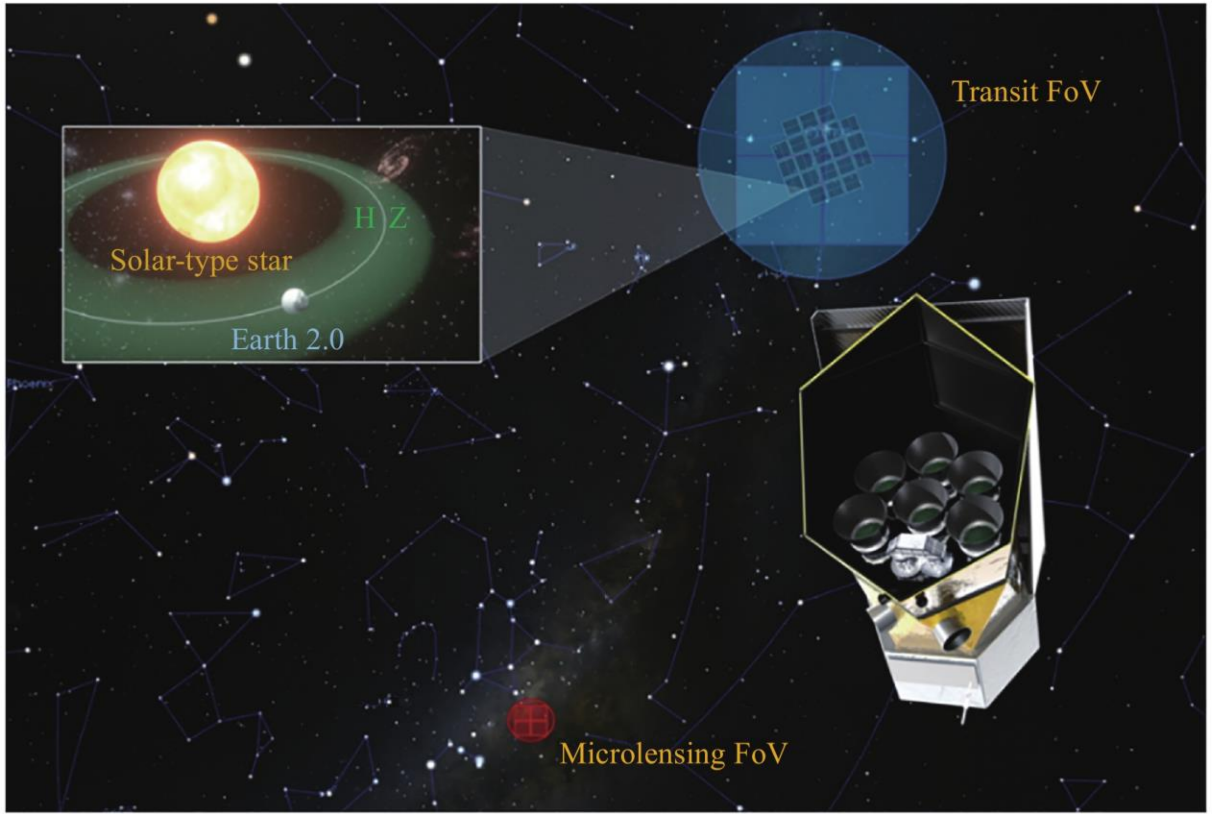


Ge et al. 2024

Chinese Earth 2.0 mission

- Scheduled to launch 2028
- 6 x 28cm telescopes, 550 square degree field of view, returning to the Kepler field
- Expected to reach 28ppm/6.5hr
- Yield of ~40,000 transiting planets

  (Ge et al. 2024)



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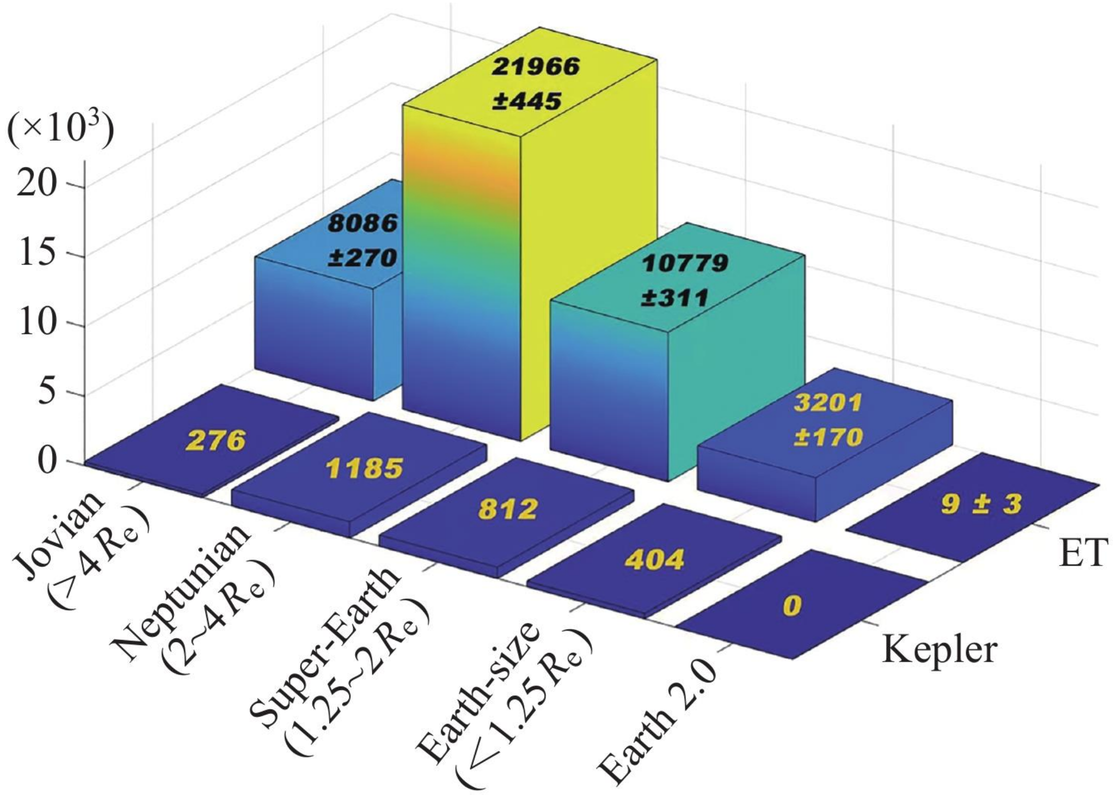


Ge et al. 2024

credit Caltech/IPAC-NExScI

Mission Comparison

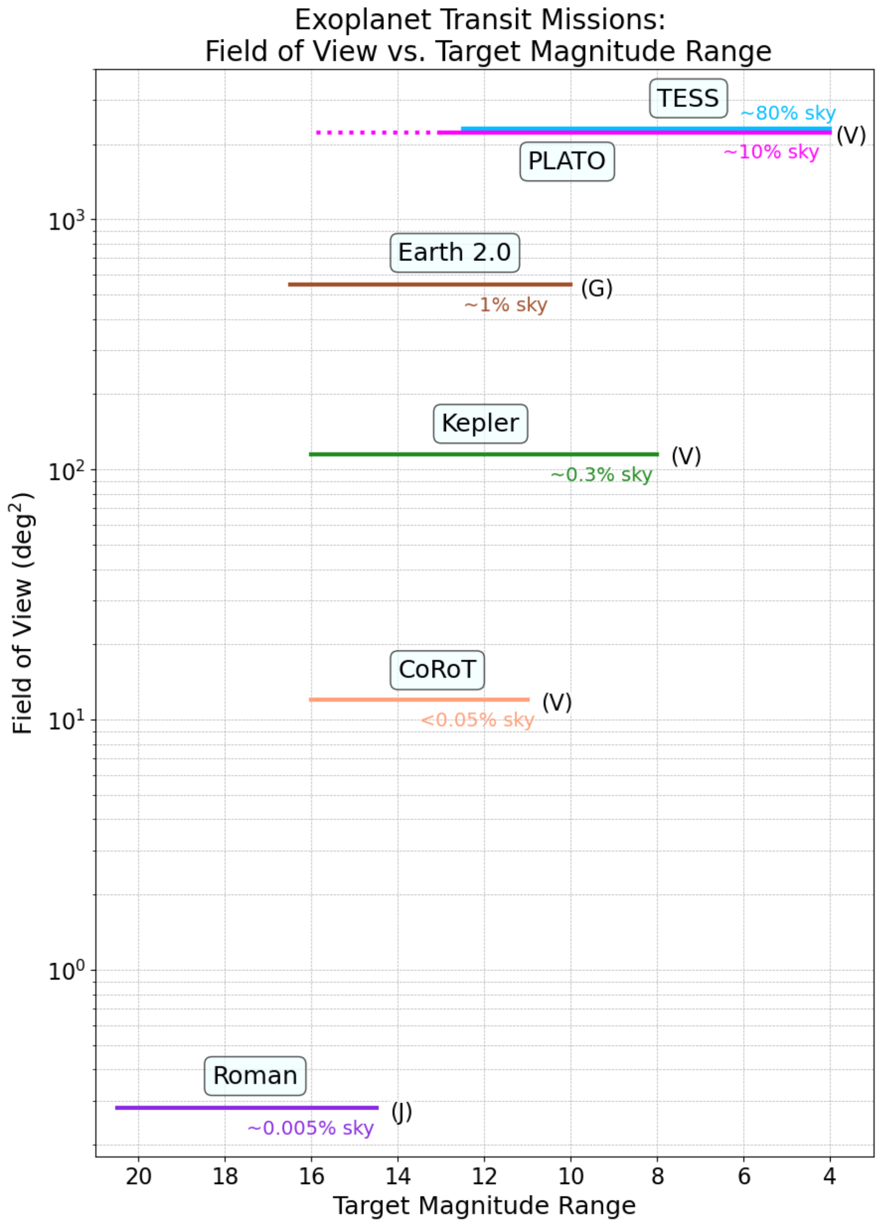
The detection range of transit missions is determined by telescope aperture size and field-of-view:

- Small telescope size → bright target stars (CoRoT, TESS, CHEOPS, PLATO):
  - ground-based radial velocity follow-up to determine planetary masses.
  - asteroseismology on host stars for ages

- Large telescope size → more (fainter) targets (Kepler, Roman, Earth 2.0):
  - high number of detected planets
  - planet population studies

- Large field-of-views provide more targets (TESS, PLATO, Earth 2.0):
  - several small telescopes
  - Stepping/scanning several target fields

- The combination of bright target stars with large fields results in high number of detected and characterized planets.



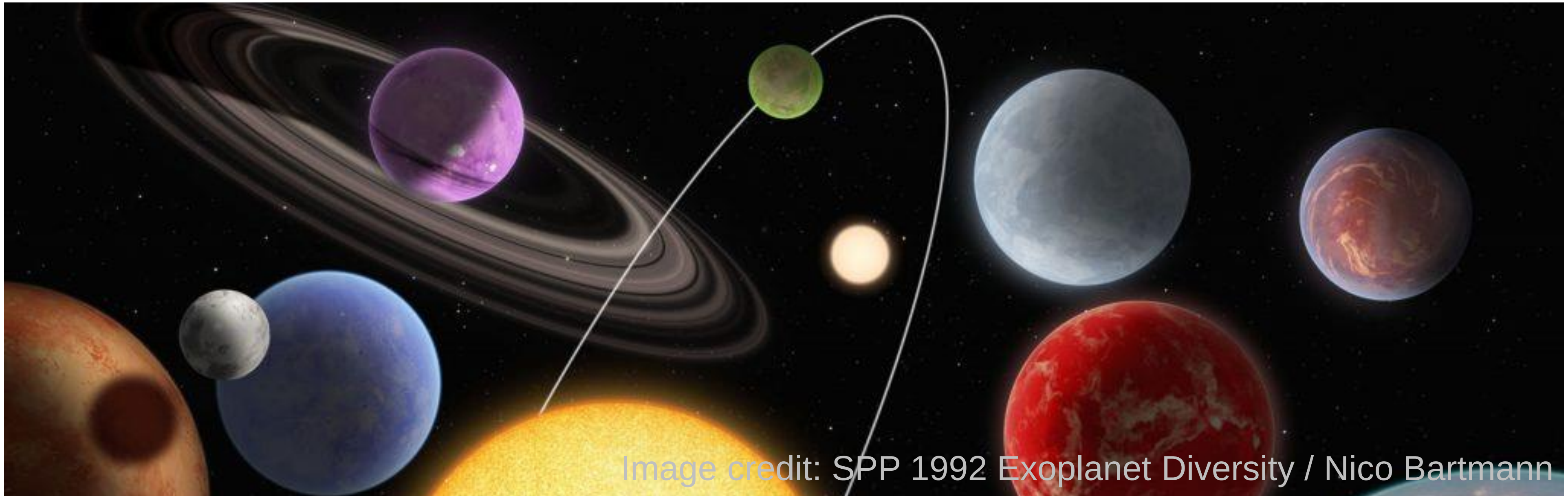
credit Caltech/IPAC-NExScI

Summary

Exoplanet research in the next decade:

- large population studies for understanding planet occurances and planet formation theories (Roman, Earth 2.0)
- populations of characterized planets: different types, ages, interiors, .., understanding planet evolution (PLATO)

→ to be combined with atmosphere characterization from JWST, ARIEL and … HWO, LIFE.



Thanks to

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