The PLATO mission: **Brazil** chasing exoplanets

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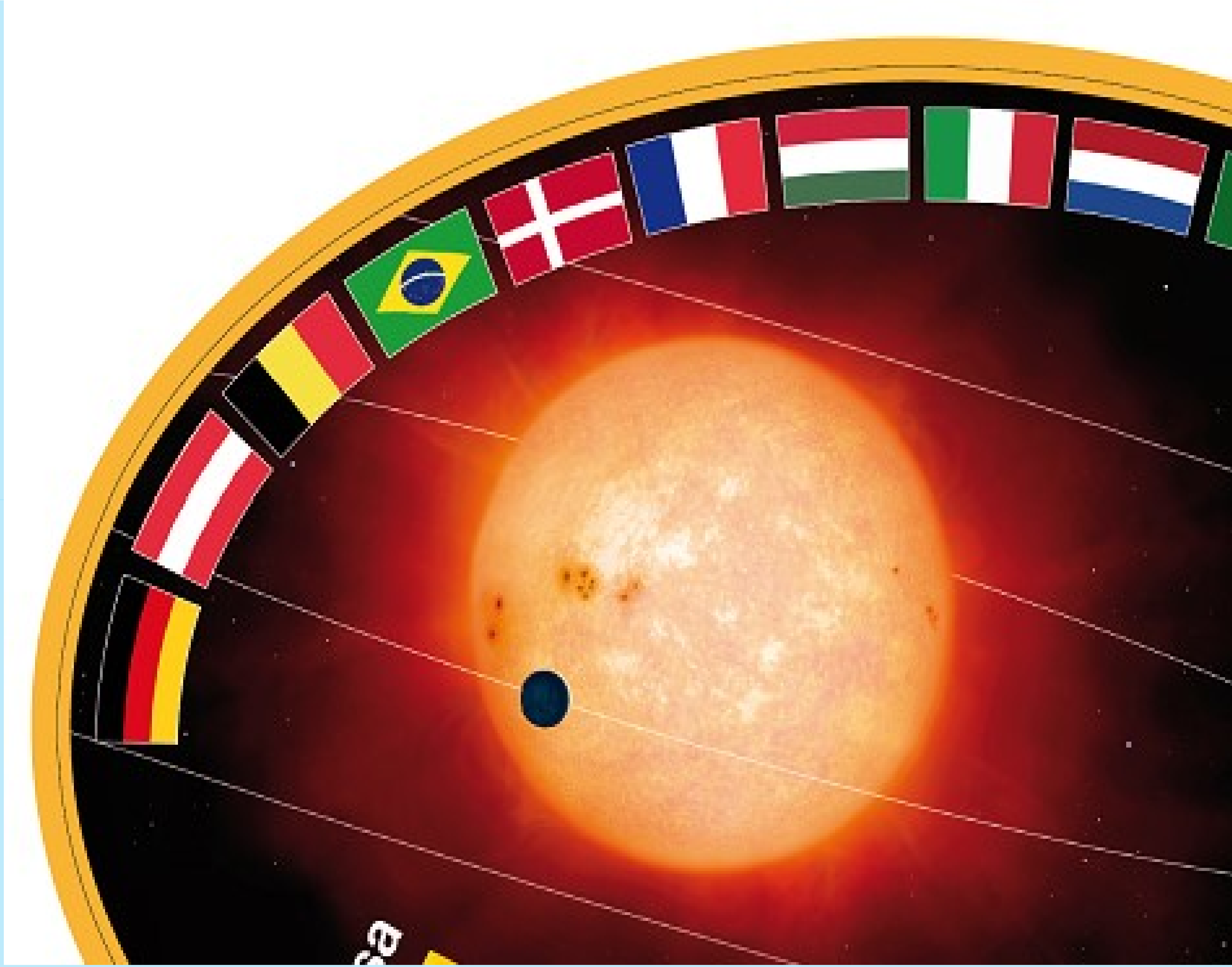


PLATO = PLanetary Transits and Oscillations of stars

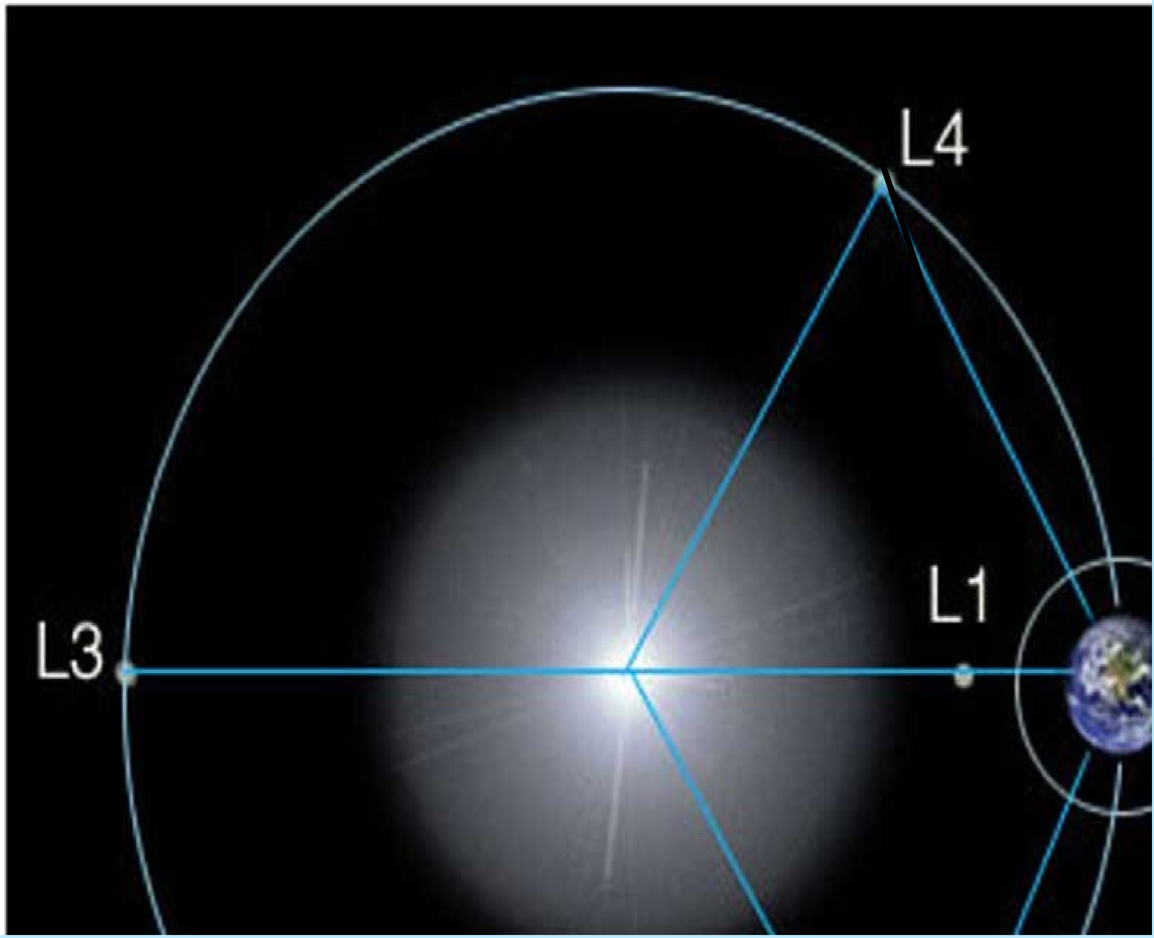
ESA's *Cosmic Vision 2015 – 2025* medium-class mission

launch in 2026, SOYUZ (Kourou)

> 2.000 kg, 1.2 billion Euros

Orbit: Sun-Earth L2 → 4.5 years

PLATO's orbit

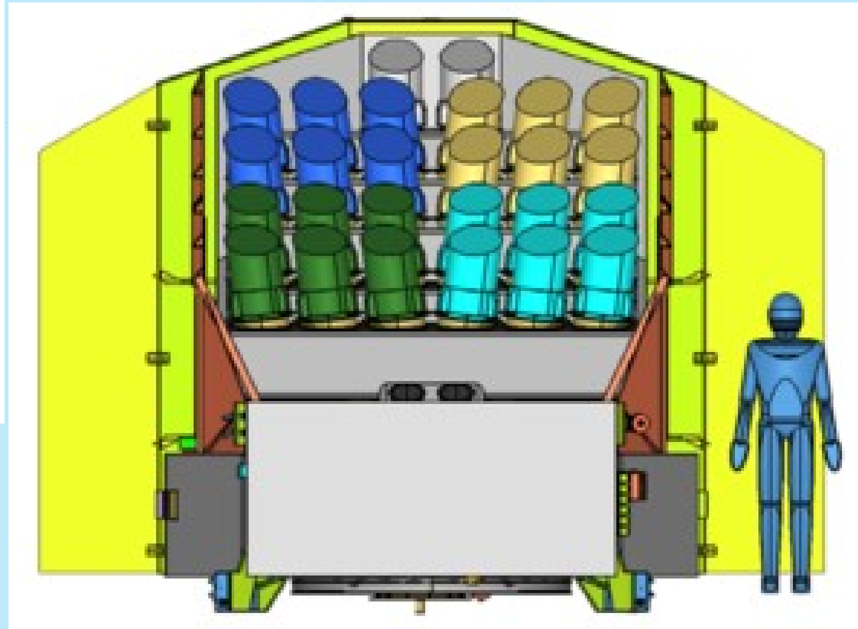


... In *Lagrange's Sun-Earth* L2 point

Why is that? Because it is a most stable spot in the *Solar System*

PLATO'S mounting scheme

26 ~ 30 cm telescopes
≈ 3 m equivalent diameter
⌧⌧ detection and characterization of **Earths** around stars up to V = 11



Equivalent diameter of a ≈ 3 m dish

KEPLER: 105 sq degrees
PLATO: 2232 sq degrees

1,000,000 stars will be observed

NASA's *KEPLER* satellite: ⌦ ⌦

There are in the Milky-Way
about

6 BILLION EARTH-LIKE PLANETS

Orbiting Solar-type stars

(Kunimoto & Mathews 2020)

⌦ ⌦ **ASTROBIOLOGIA**

What will do PLATO?

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⌦ search mainly for Earth-like exoplanets orbiting nearby stars

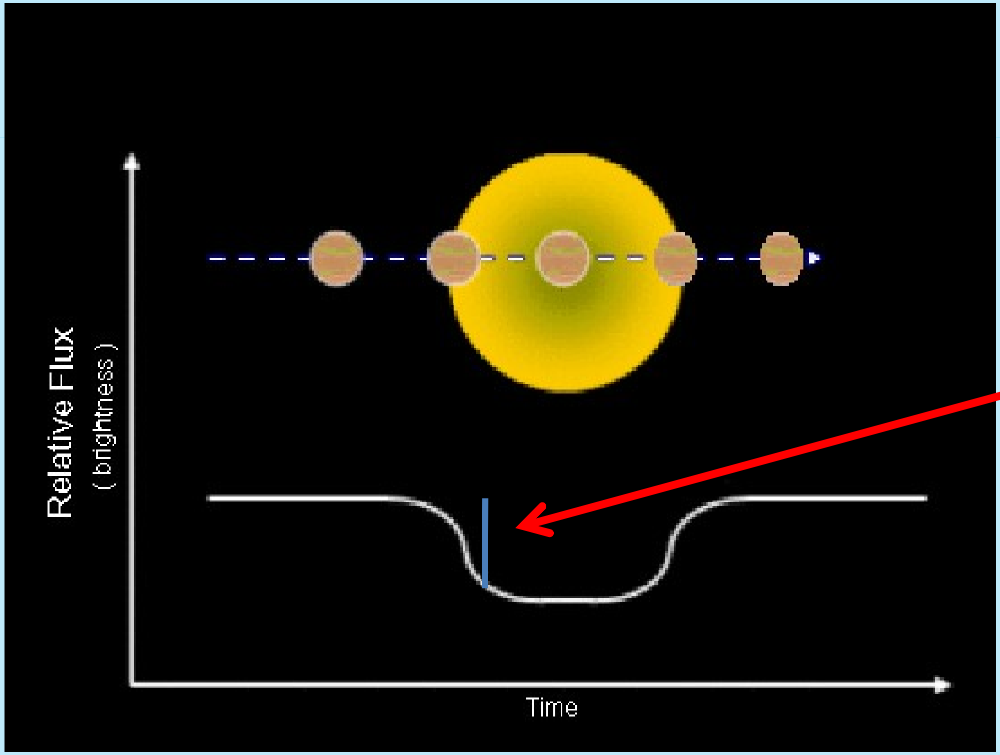
⌦ Determine **accurate** physical properties of the host stars through seismology

⌦⌦ planetary parameters will be known with unprecendeted precision:

2% in R, 4-10% in M and 10% in age

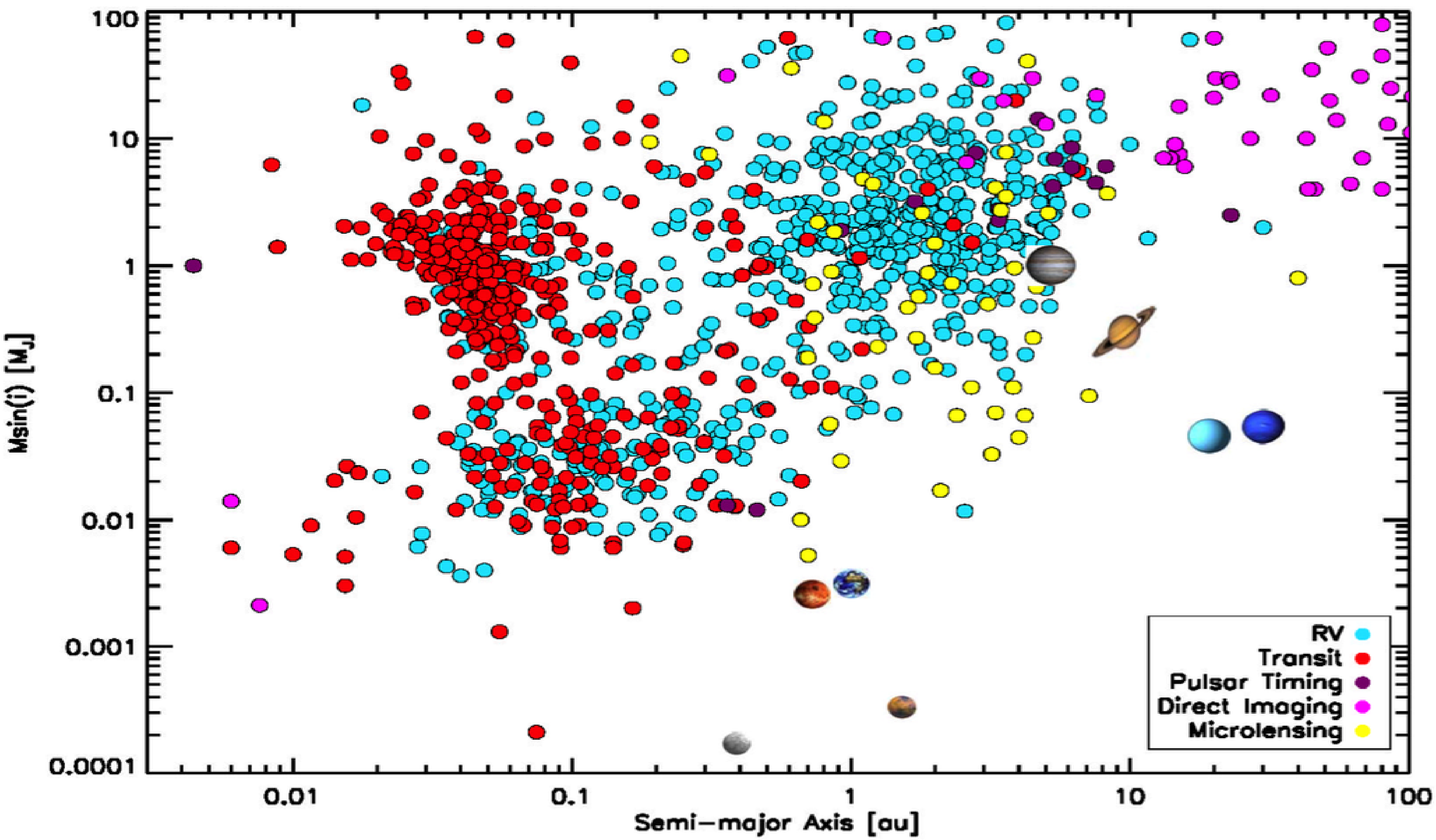
And how will *PLATO* detect exoplanets?

⌧ ⌧ by the "transit method" :



When *transiting* in front of a star, the planet makes a small eclipse

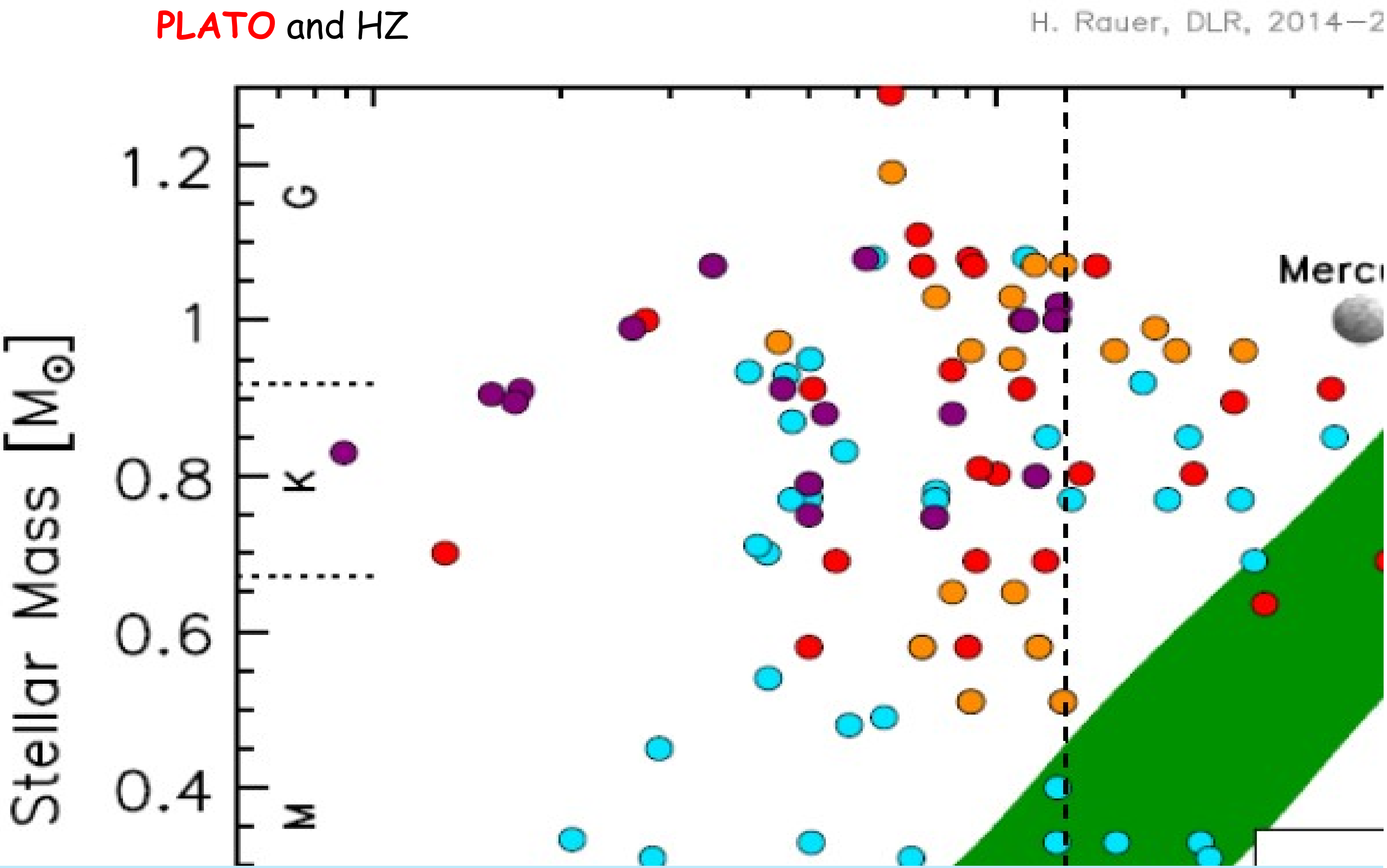
The eclipse's depth is proportional to the planet/star surface ratio



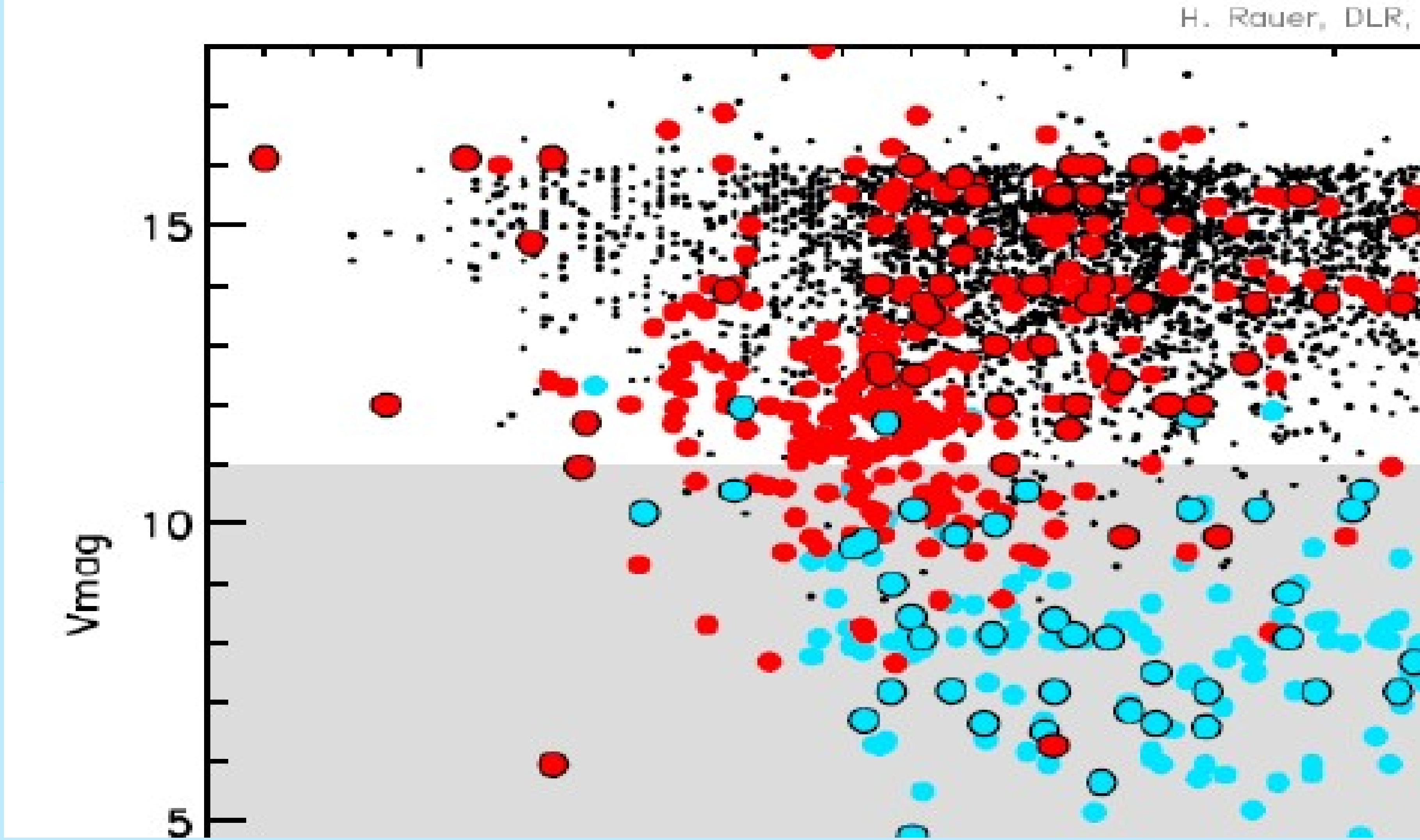
Current status of planet detection

Red dots = planets with M and R determined. Blue dots = RV detections with Msini limits. (PLATO mission.com)

PLATO and HZ



Super Earth exoplanets (1< Mplanet ≤ **10** MEarth or Rplanet ≤ 3 Rearth) for different host star masses with respect to the position of the Habitable Zone (in green). Black dashed line: current max distance of super Earths with RV and transit measurements. Thin line: most distant planet with transits and TTV. Orange dashed line: distant goal of PLATO for fully characterized (transit + RV) super Earths.



Detectable exoplanets as a function of V mag of host stars

Gray shaded band = prime detection range of PLATO 2.0 (4<V<11) for Earth-like planets.

Limit for giant planets V=16 (https://sci.esa.int/web/plato)

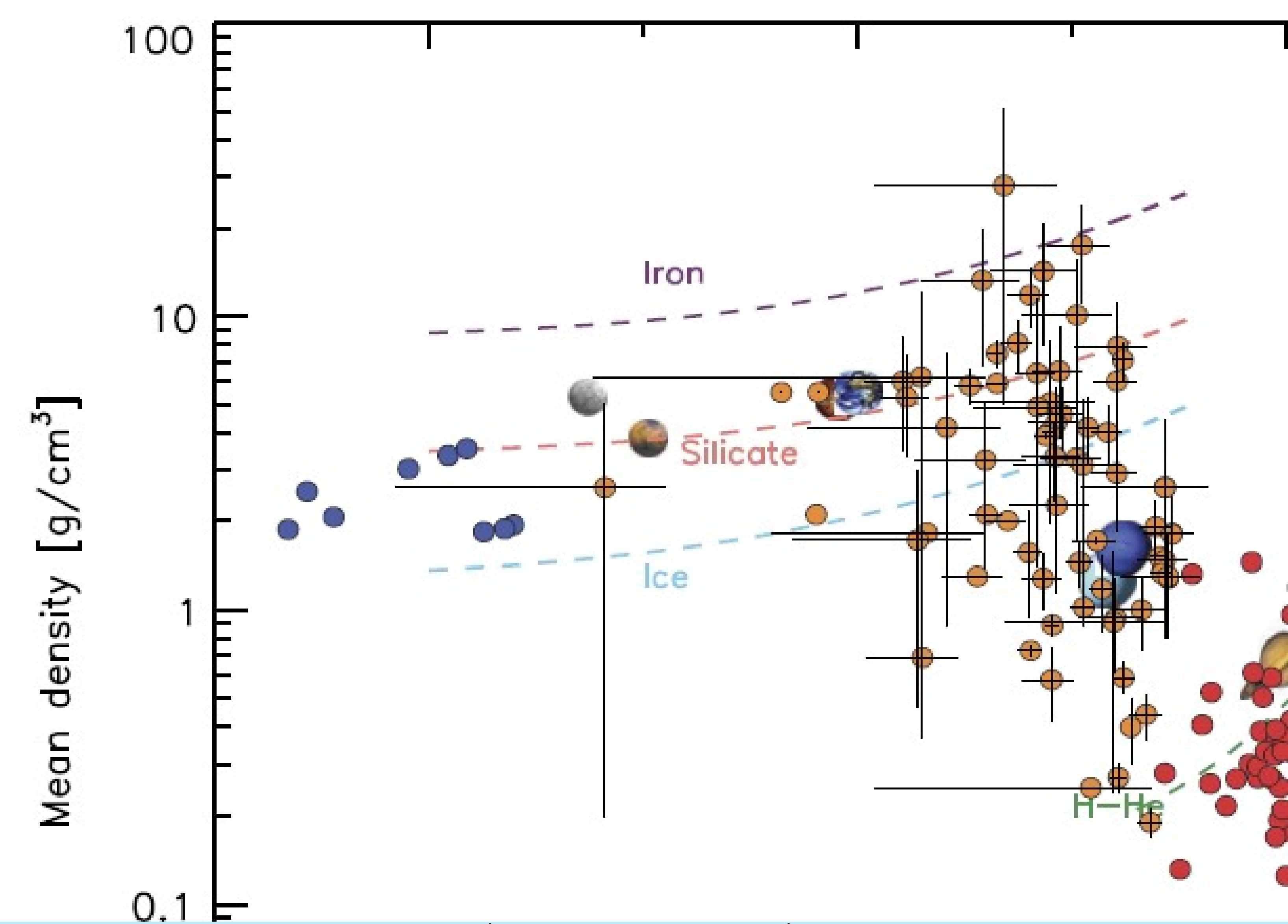
PLATO & planetary science:

◆ Planets around solar-type stars + intermediate mass stars, subgiant, giants and post-RGB stars ⌦ ⌦ ⌦ ⌦ unprecedently good statistics for formation and evolution of planetary systems

◆ Planet atmospheres: albedos, metallicity, molecular composition, clouds ⌦ ⌦ ⌦ ⌦ identification of best targets for deep spectroscopy

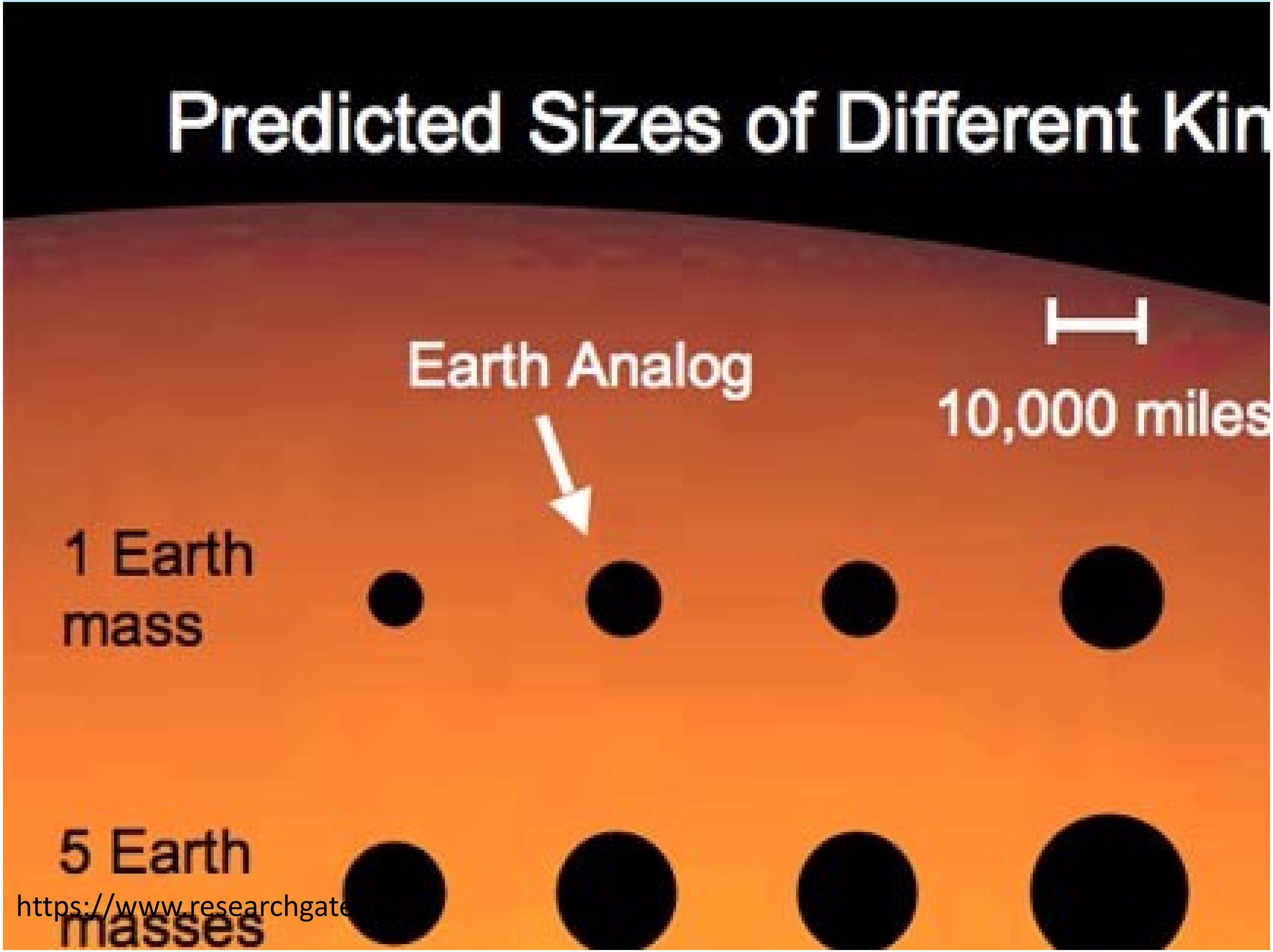
◆ Detection of rings, moons, Trojan, exocomets

◆ First large-scale catalogue of bulk characterized planets with accurate parameters



Mean density vs. Mass diagram

Dashed lines indicate density-mass relationships: green = Jupiter-like; violet = iron; pink = silicate; light blue = water ice. Solar system planets are shown and blue dots are their large moons. Red dots = exoplanet gas giants; orange dots = low-mass exoplanets (Noack et al. 2017)



https://www.researchgate

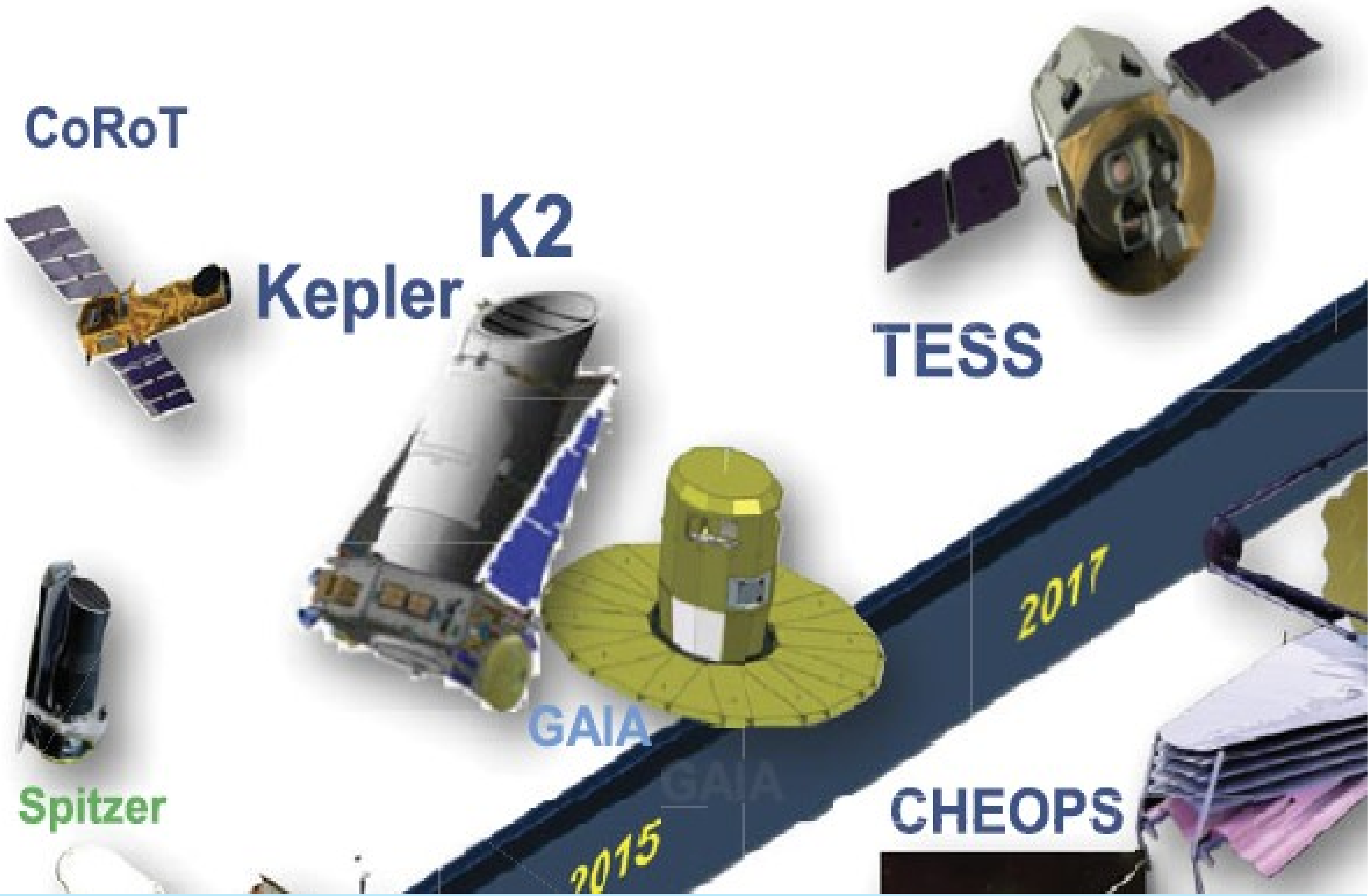
PLATO can give answers to other questions:

- What is the frequency & distribution of rocky planets ?

- What is the mass limit of gaseous giant cores?

- At what distance from the star and when the gas accretion stops?

- How the properties of planetary systems depend on the stellar spectrum, its metallicity, chemical composition and age?



Overview of past and future missions relevant for exoplanet characterization (Noack et al. 2017)

The quest for exoplanet masses ("follow-up")

⌘ needed to define the kind of exoplanet we are dealing with: the rocky ones are the more interesting for **ASTROBIOLOGY**

⌘ very high resolution spectrograph needed

Telescopes to which Brazil has access:

ESO's 3.6 m La Silla telescope: NIRPS spectrograph

Hawaii-Japan-Brazil PLANETS 1.85 m high-tech Haleakala telescope: Echelle spectrograph

Complementary science (1 million stars)

- Binaries: characterization & discovery of low mass companions
- Massive stars, low & intermediate red giants: internal structure and evolution
- Structure & origin of SdB stars
- WDs: seismology in the space era
- Angular moment studies through gravity modes, important for a lot of stellar phenomena: gyrochronology, magnetic activity cycles, stellar dynamos, surface activity, rotation…

Brazilian science with PLATO's data:

⌘ Stellar rotation & stellar spots

⌘ Stellar seismology of pulsating stars

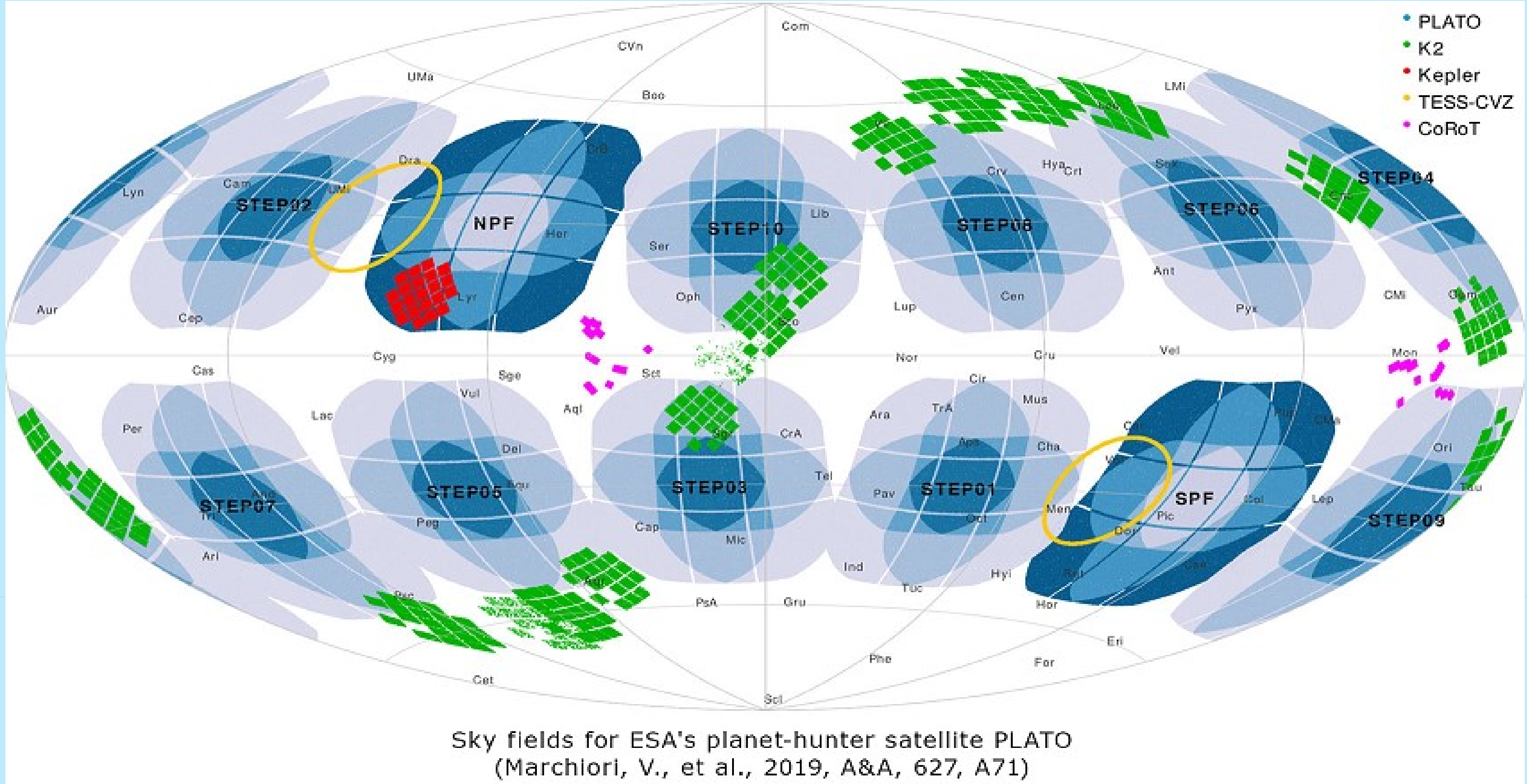
⌘ T Tauri stars

⌘ Exoplanets: detection, characterization, follow up...

And what **Brazilian engineering** will do for *PLATO* ? (*CoRoT's heritage*)

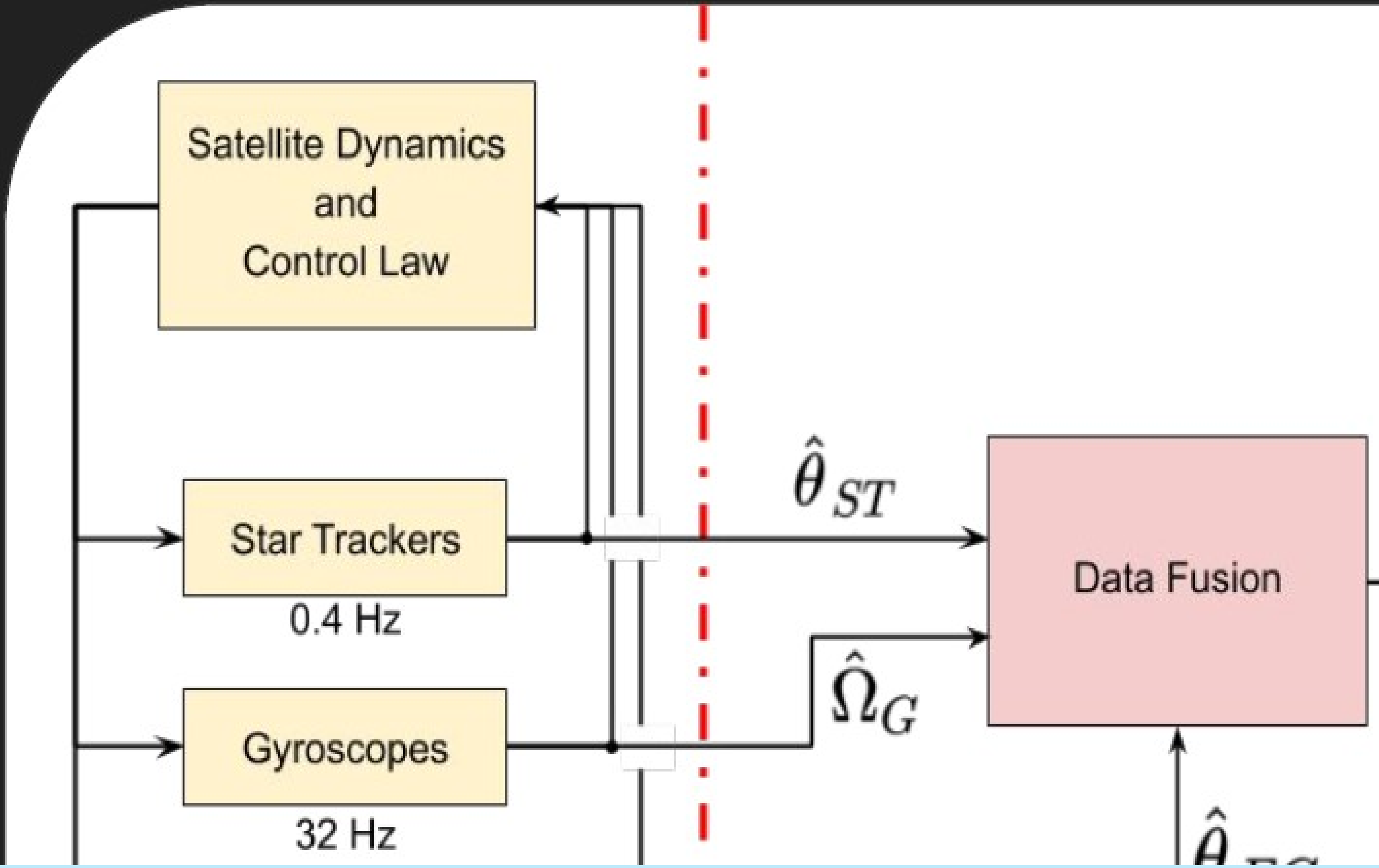
- Atitude control system + jitter correction + photometric masks (software)
  (Polythecnic School, São Paulo University)

- Electronic simulator of the satellite's imaging system + instrument control unit + hardware data compression (hardware + software)
  (Mauá Institute of Technology) .



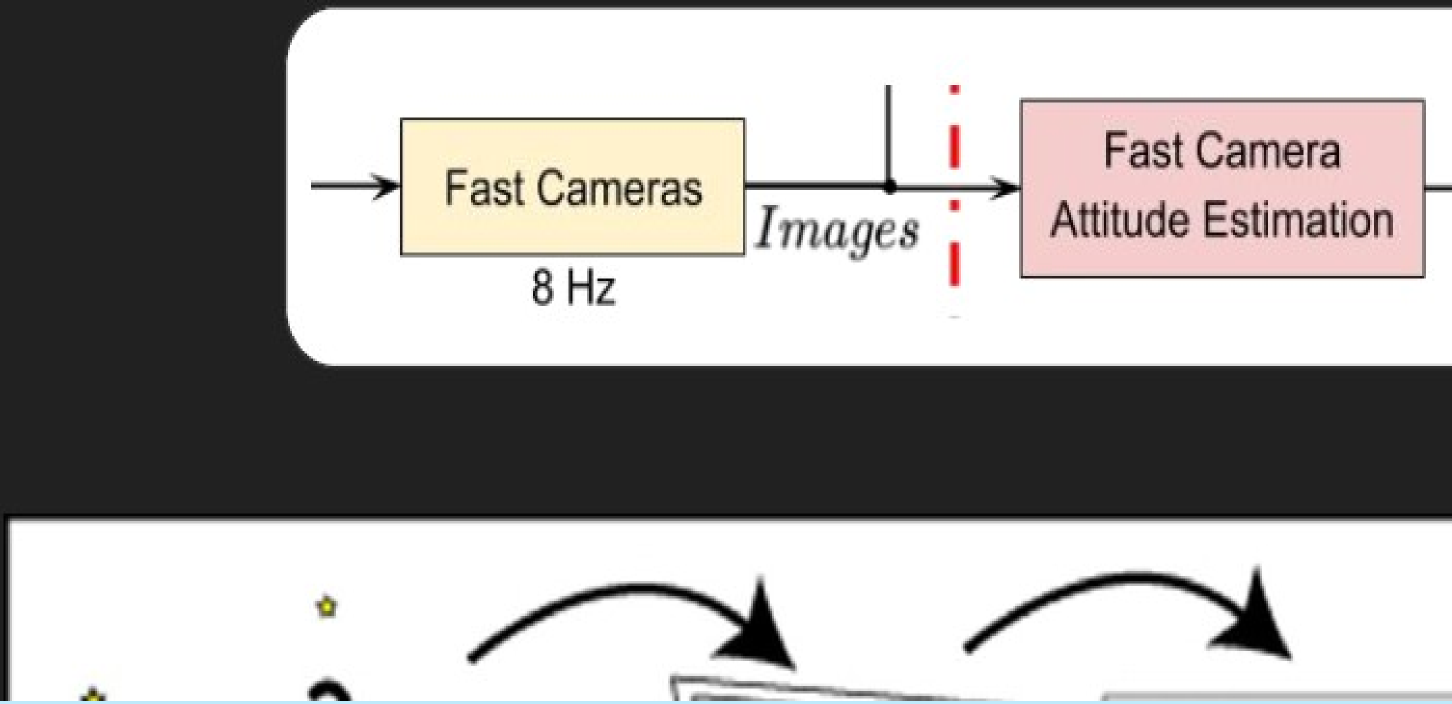
Front cover of *Astronomy&Astrophysics* (july 2019), showing a figure of the paper by Brazilian engineers about the work done with imagery of the PLATO satellite (Marchiori et al. 2019). The entire sky can be seen in galactic coordinates and the observation fields of PLATO (blue), KEPLER (red and green) , TESS (yellow ellipses) and CoRoT (pink) are shown for comparison. PLATO observations will cover almost 50% of the sky.

Line-of-sight estimation and control



Aykroyd, Duleba & Fialho, 2020

Stellar sensors using satellite's fast cameras



These are quite complex software engineering operations. The solutions were accomplished by Brazilian engineers

Financing the Brazilian participation in ***PLATO***:

FAPESP's Thematic project,

⌧ ⌧ About R$ 7 milhões (~ US$ 1.4 Mi) in 4 years.
(equipment, scholarships, travel expenses...)

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Thank you