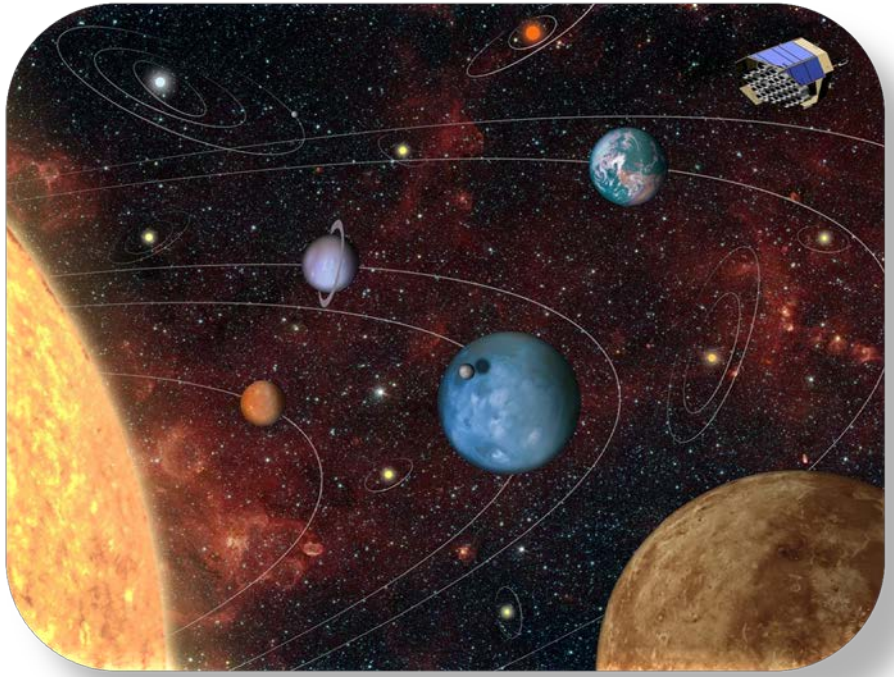
The PLATO 2.0 Mission



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and the PLATO Team

PLATO 2.0

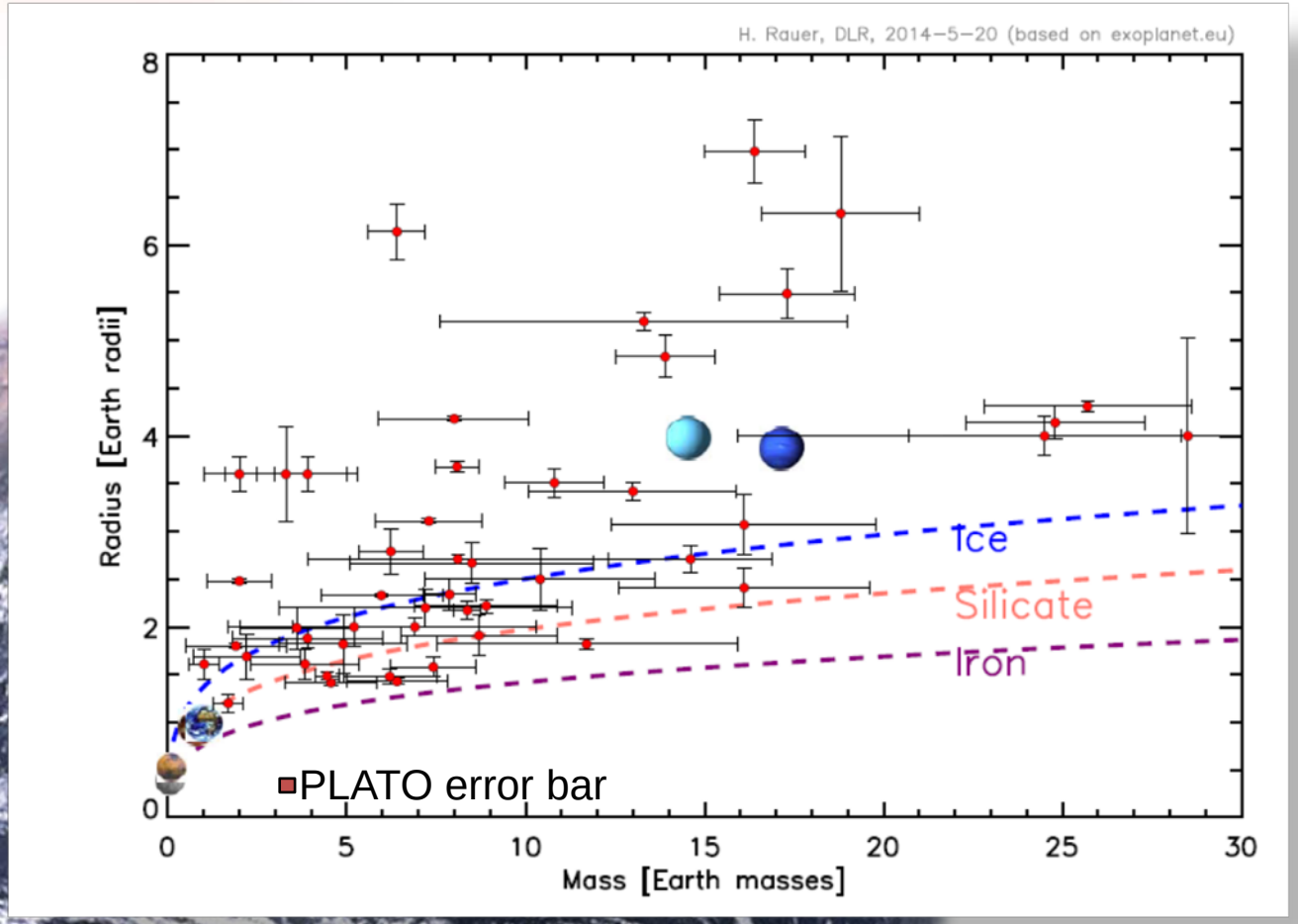
- **Selected as ESA M3 mission in February 2014**
- **Schedule:**
  - **Kick-off Phase B1 in July 2014**
  - **SRR review for mission adoption March 2016**
  - **Launch Q1 2024**

PLATO 2.0

PLATO 2.0 is a survey mission with the prime goals to:

- **detect planets down to Earth size**
- **characterize the bulk planet parameters**
  - **radius (~2%)**
  - **mass (~10%)**
  - **age (~10%)**
- **for a large sample of planets**
- **for orbital distances up to the habitable zone of solar-like stars**
- **with well-known parameters of host stars**
- **provide input for improved stellar models and to galactic science**

Diversity of „super-Earths“



Status:

- Masses vary by a factor of ~4 (with large errors)
- Radii vary by a factor of ~3

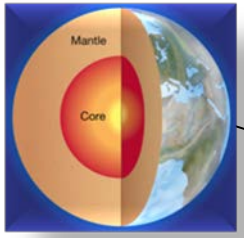
→ **PLATO goals**:

- Radius: ~2%
- Mass: ~10%

Planet diversity

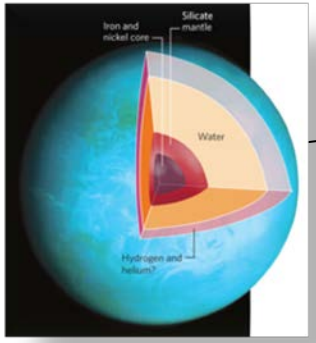
Earth

5.5 g/cm^3



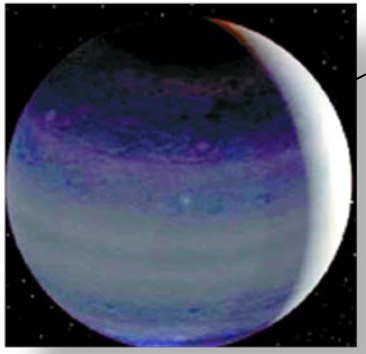
GJ1214b

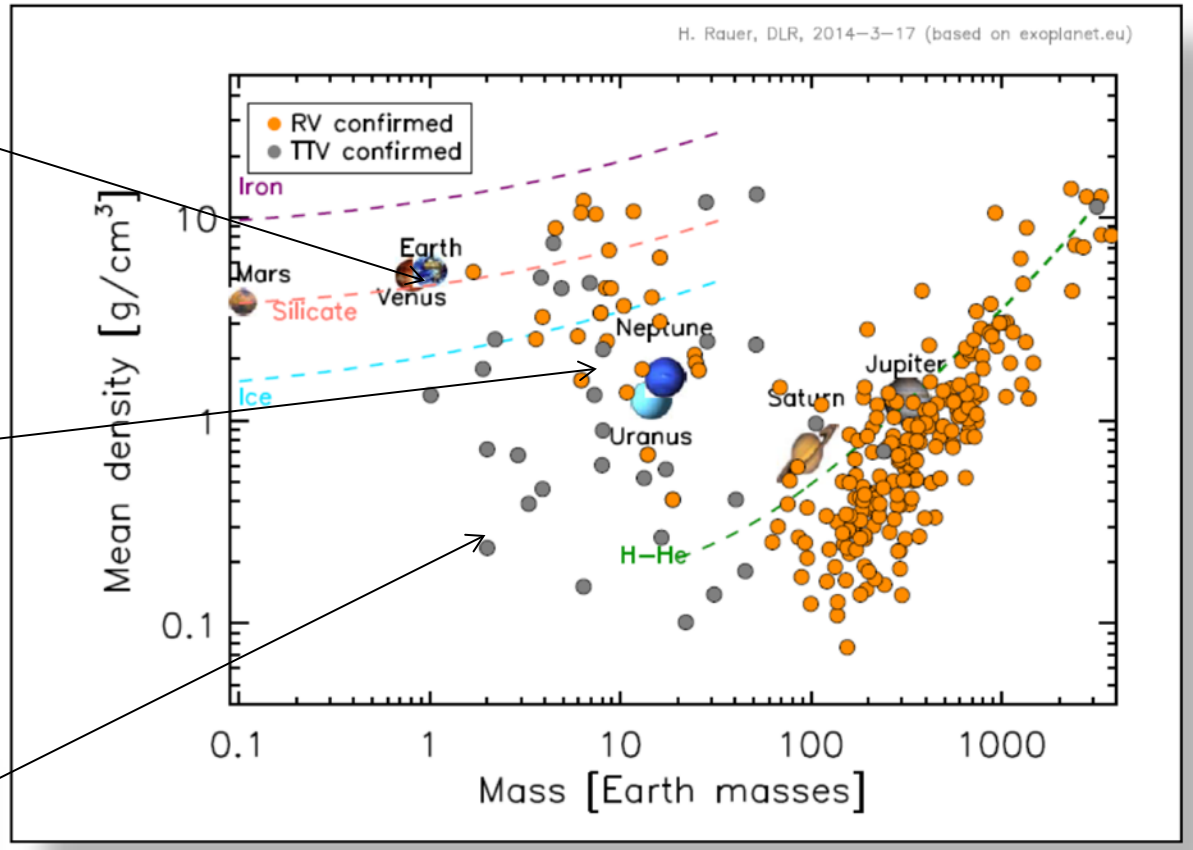
1.6 g/cm^3



Mini gas planets

<~1 g/cm^3



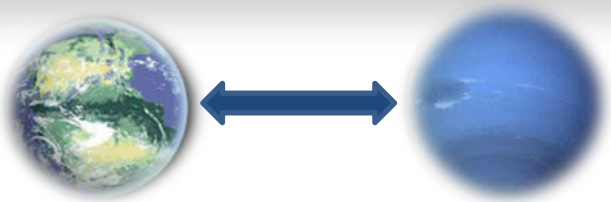


→ Need mean densities to separate terrestrial planets from mini-gas planets

„Super-Earths“: diversity and implications on habitability

Solar System planets are NOT the general rule

- Small exoplanets are very diverse:
  from Earth-like to mini-gas planets



- Mini-gas planets are likely not habitable
- Silicate-iron planets are prime targets for atmosphere spectroscopy

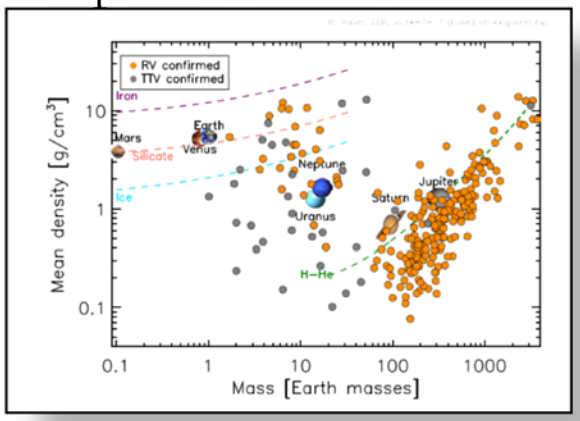
PLATO 2.0 will provide:

→ accurate mean densities to identify terrestrial planets

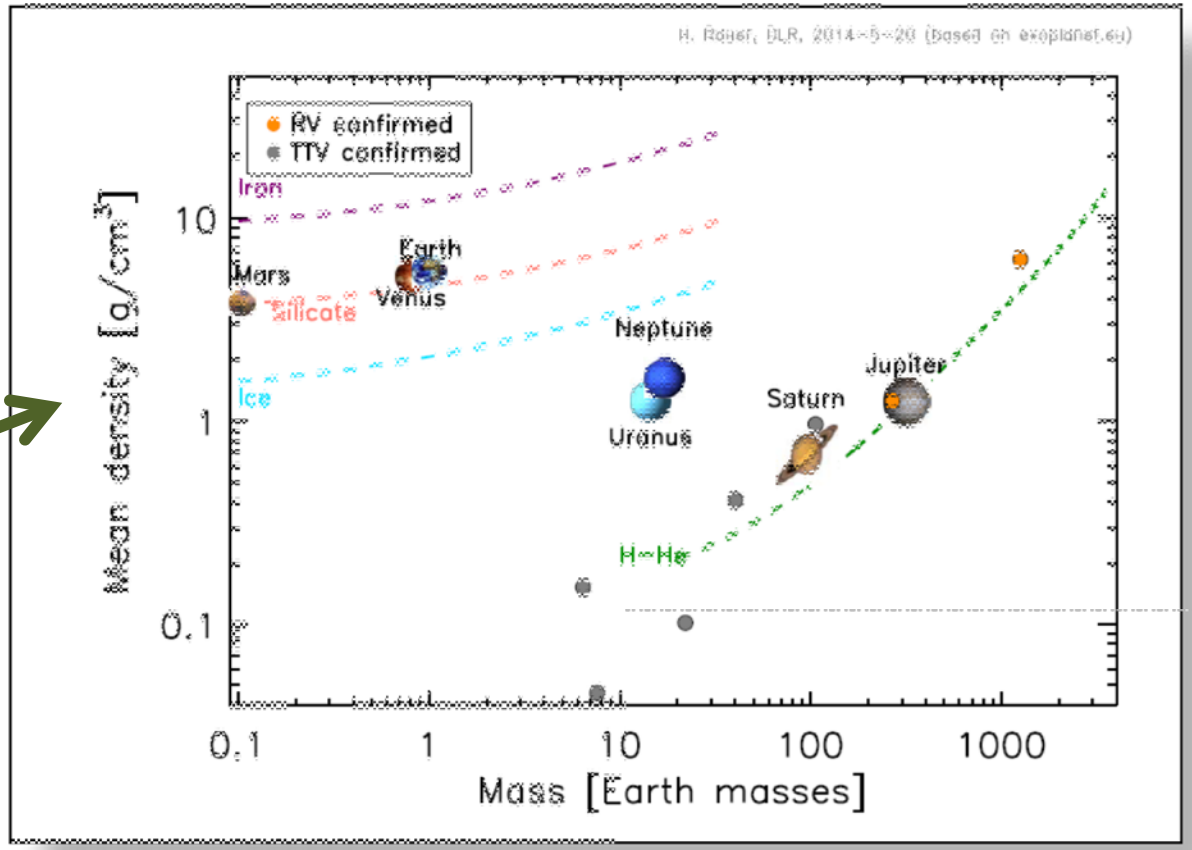
→ bulk characterize targets for atmosphere spectroscopy follow-up

Planet diversity

All planets



Planets with P>80 days

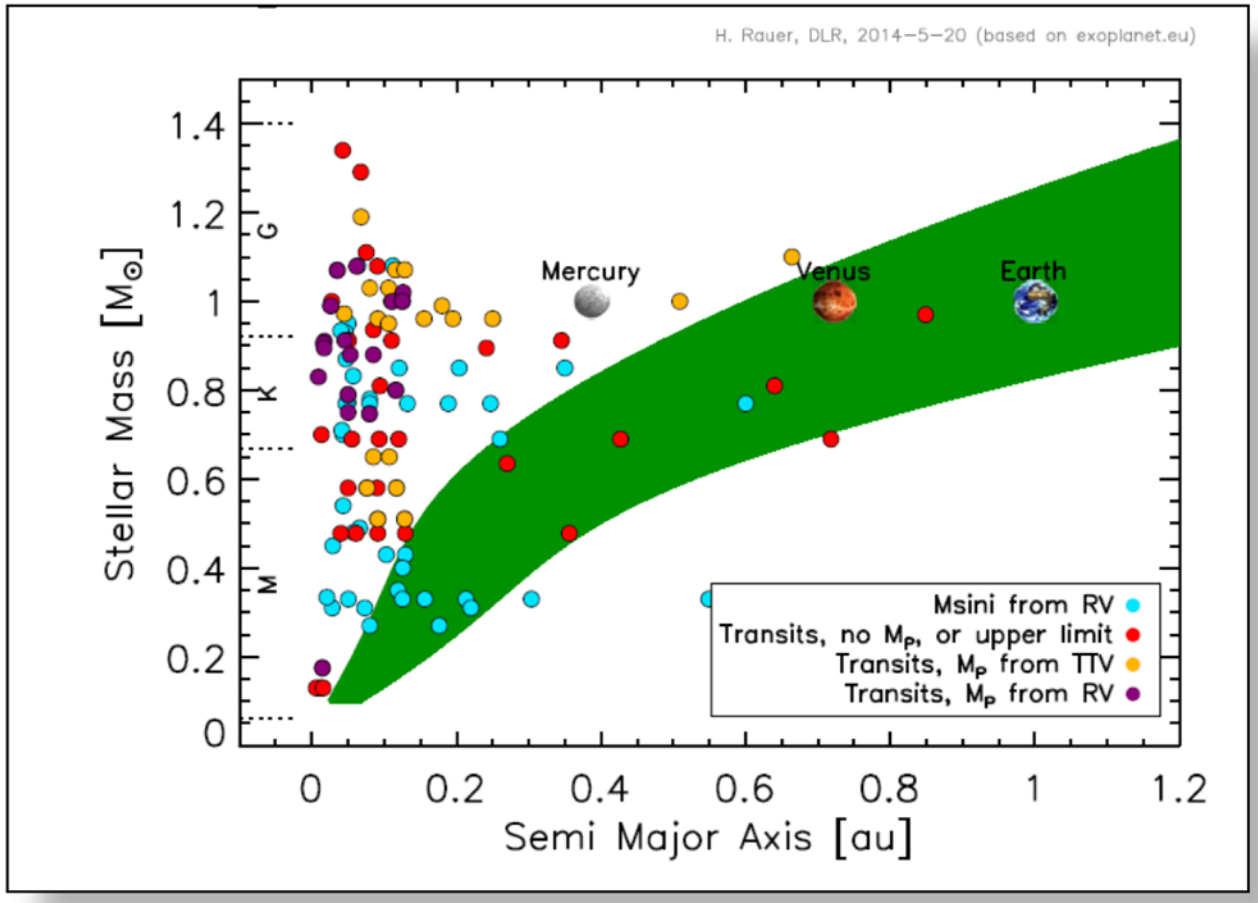


PLATO 2.0 will fill the parameter range for long orbital periods

Our knowledge on planet nature is limited to close-in planets so far.

Status: Characterized „super-Earths“ in their habitable zone

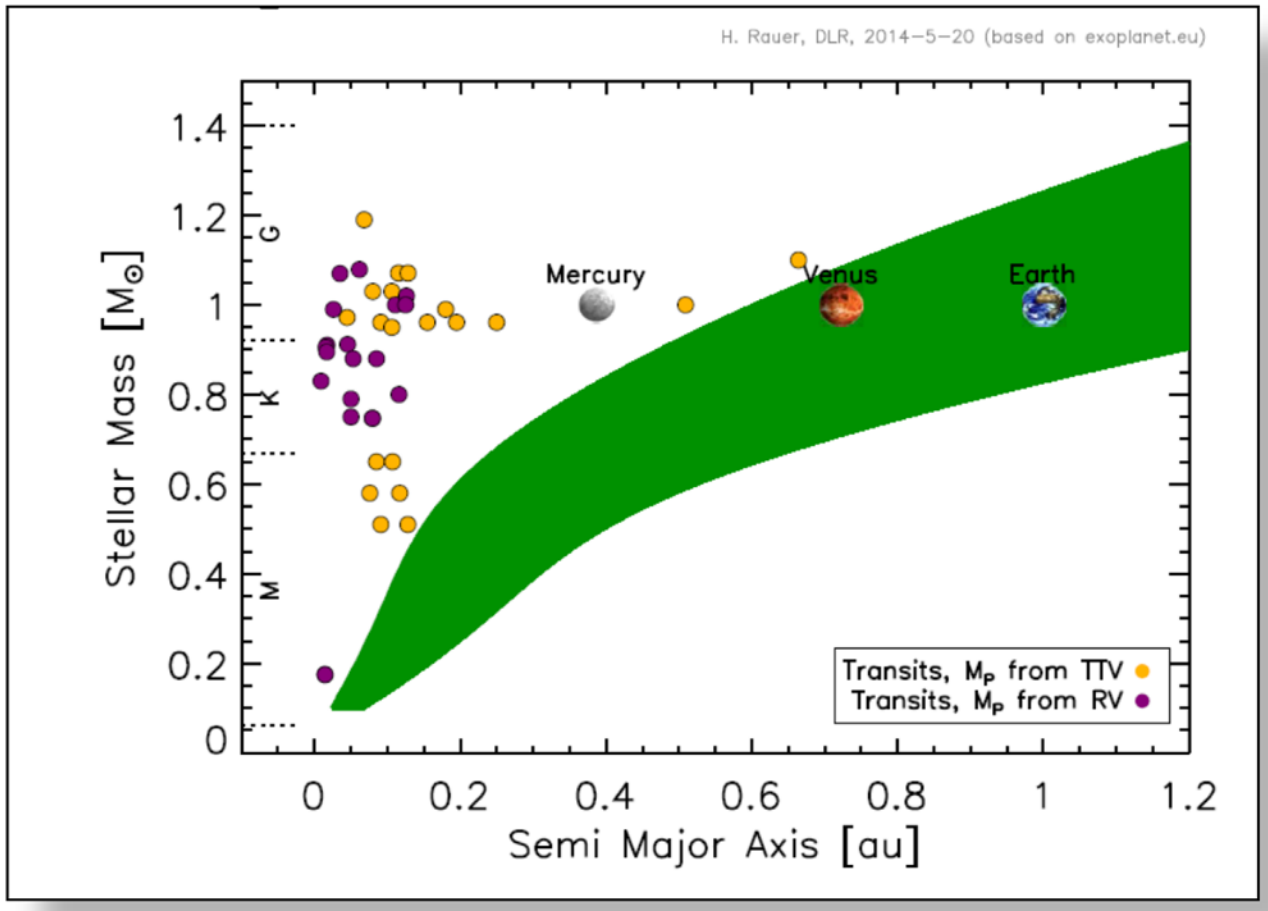
Detected super-Earths



- Goal: Detect and characterize super-Earths in habitable zones
- Status: few small/light planets in habitable zones detected

Status: Characterized „super-Earths“ in their habitable zone

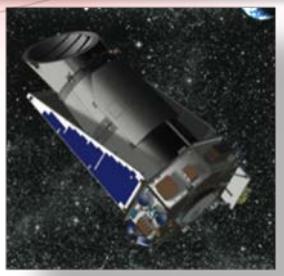
„Super-Earths“ with characterized radius and mass



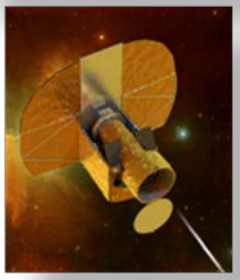
- Goal: Detect and characterize super-Earths in habitable zones
- Status: few small/light planets in habitable zones detected

→ No „super-Earths“ with known mean density in the habitable zone

Transit missions: What's next?

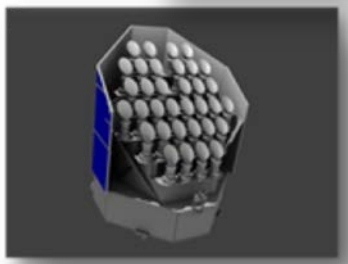


- **K-2 (Kepler 2) (NASA)** observe fields in the ecliptic plane for ~80 days/field



- **CHEOPS (ESA, launch 2017):** follow-up, radii of detected (RV)planets,

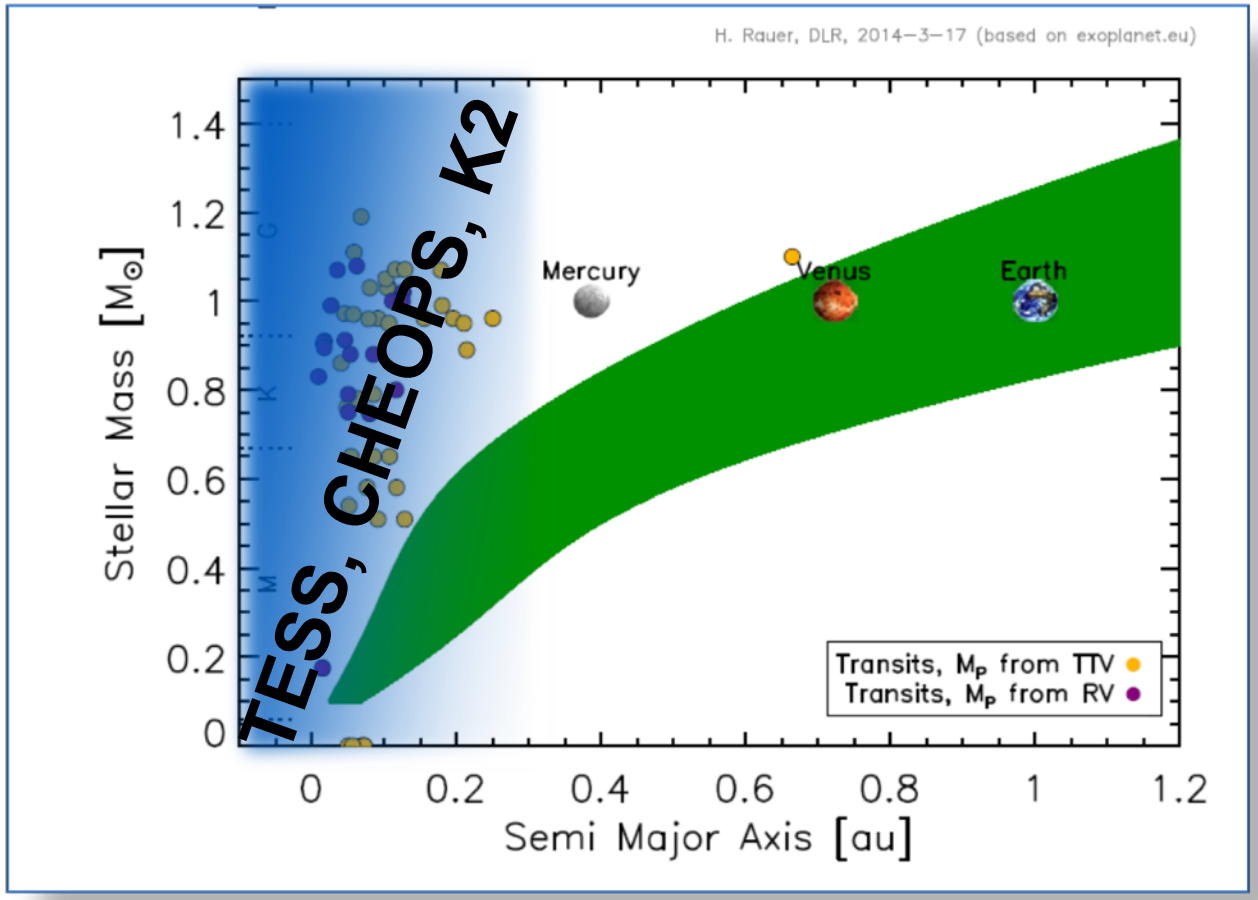
- **TESS (NASA, launch 2017):** scan the whole sky, ~1 month/field, ~2% of sky at poles for 1 year



- **PLATO 2.0 (ESA, launch 2024)** detect and characterize (density, age) terrestrial planets around solar-like stars up to the habitable zone

Prospects: Characterized „super-Earths“ in their habitable zone

„Super-Earths“ with characterized radius and mass

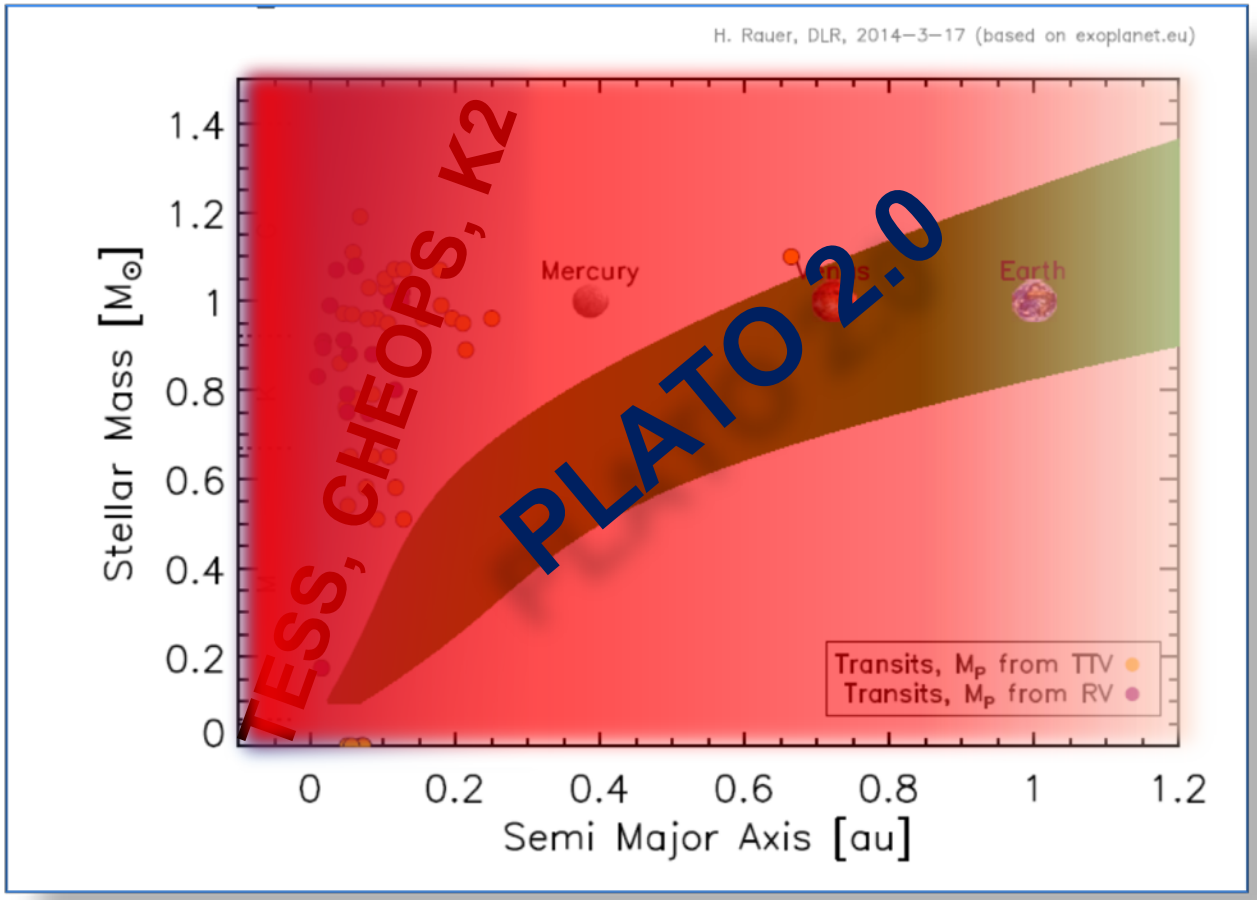


- TESS, CHEOPS, K2 will mainly cover orbital periods up to ~80 days

TESS ecliptic poles

Prospects: Characterized „super-Earths“ in their habitable zone

„Super-Earths“ with characterized radius and mass

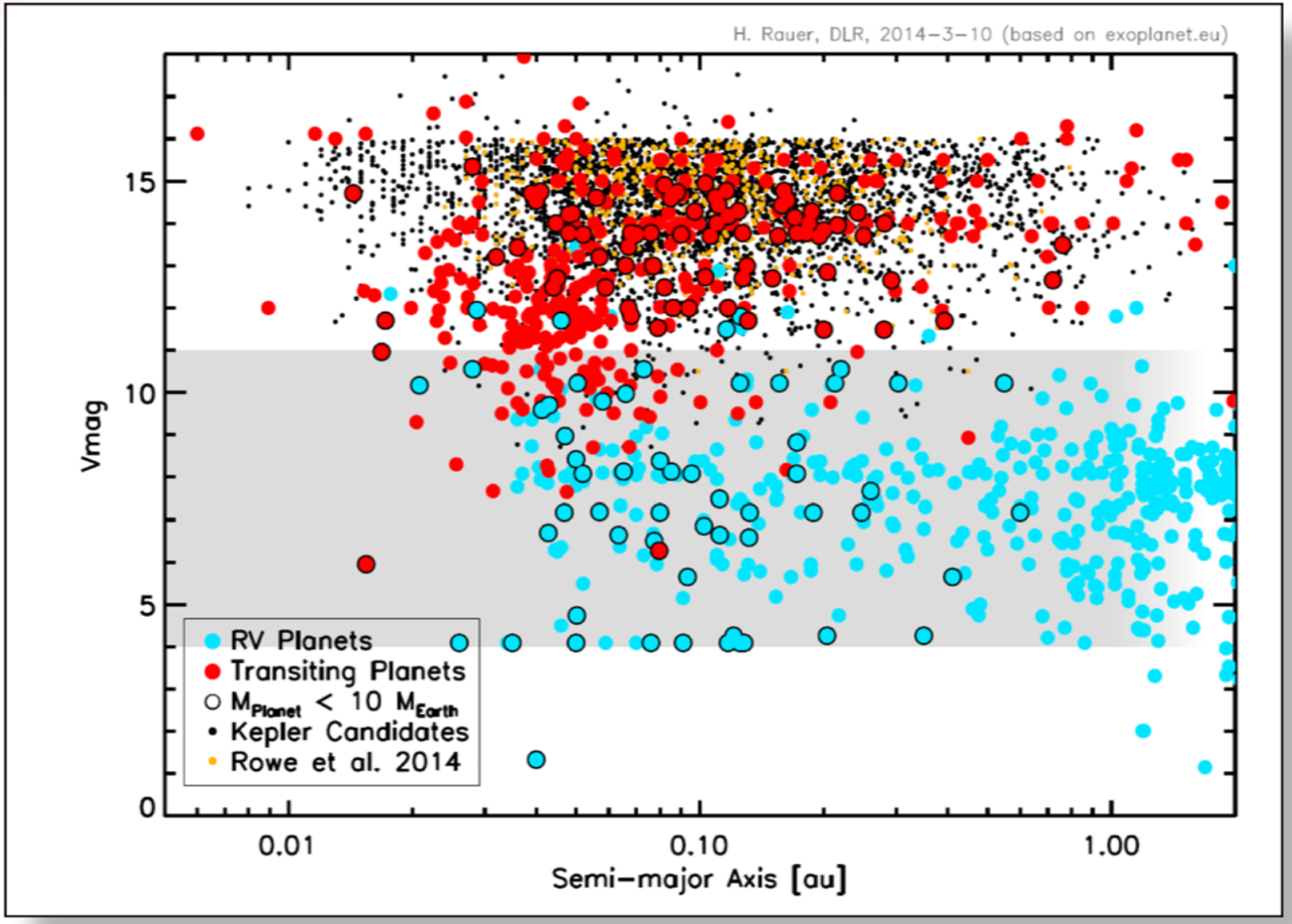


- TESS, CHEOPS, K2 will mainly cover orbital periods up to ~80 days
- PLATO 2.0: Detect and characterize planets up to the habitable zone of solar-like stars.

TESS ecliptic poles

PLATO 2.0 magnitude range

Magnitude range for density characterization and age



The Method

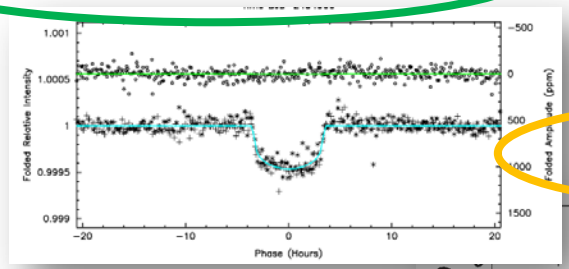
PLATO 2.0 will focus on bright stars:

- 4 – 11 mag for full characterization
- to 13 mag for Earth-sized planet detection
- to 16 mag for larger planet detection
- **Accuracy around solar-like stars for PLATO 2.0:**
  - **radius ~2%**
  - **mass ~10%**
  - **age known to ~10%**

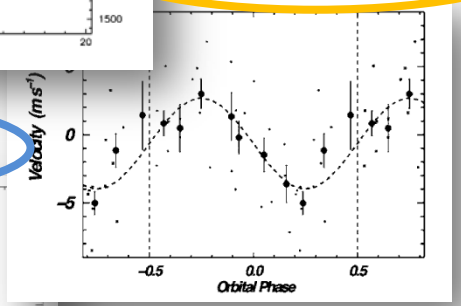
Techniques

Example: Kepler-10 b (V=11.5 mag)

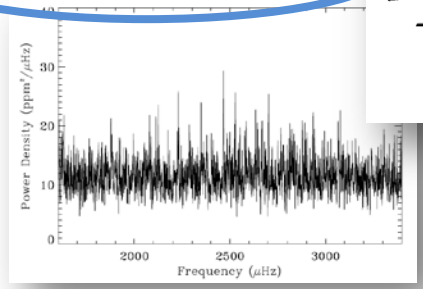
Photometric transit



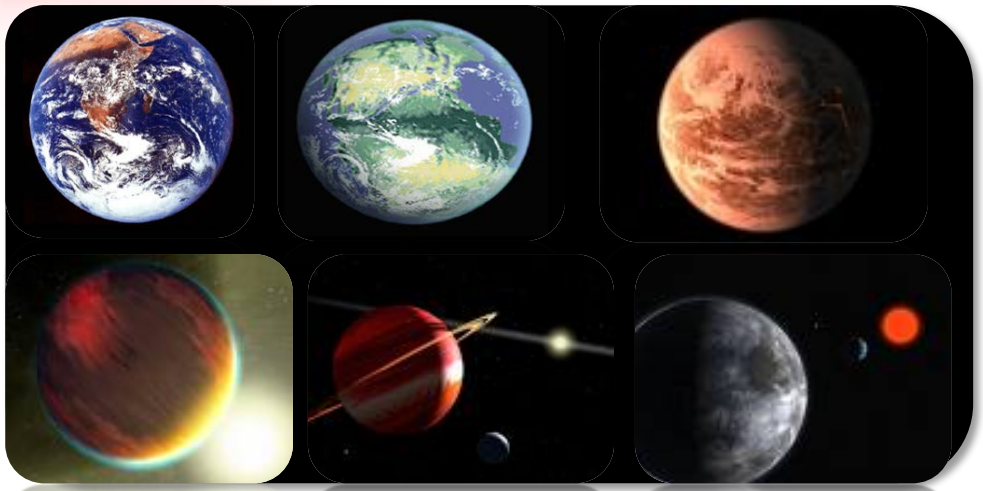
RV – follow-up



Asteroseismology



PLATO 2.0: Exoplanets and Stars



Characterization of exoplanets …

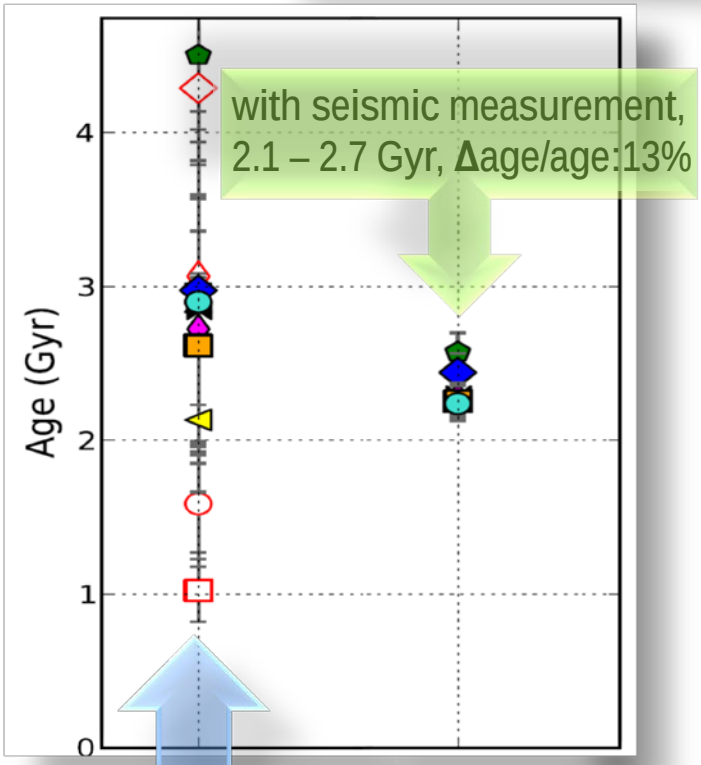
- **Mass + radius → mean density**
  (gaseous vs. rocky, composition, structure)
- **Orbital distance, atmosphere**
  (habitability)
- **Age**
  (planet and planetary system evolution)

needs characterization of stars

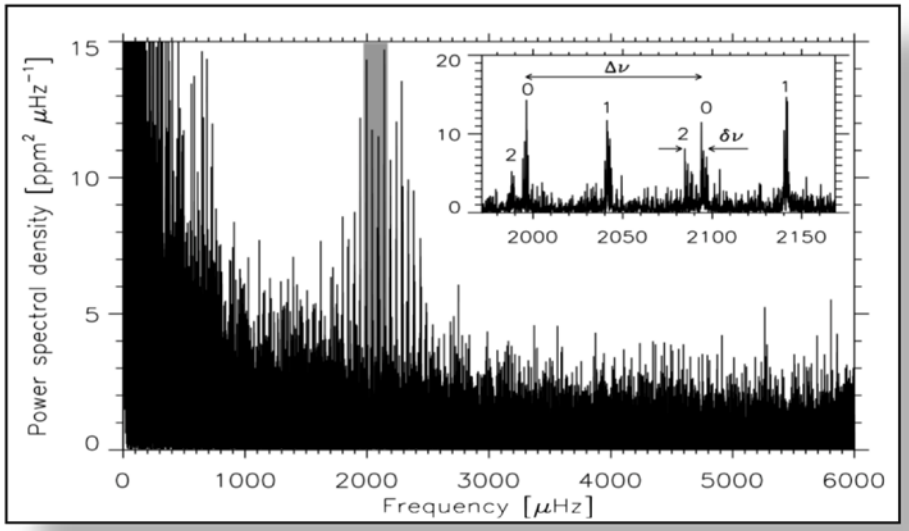
- **Stellar mass, radius**
  (derive planet mass, radius)
- **Stellar type, luminosity, activity**
  (planet insolation)
- **Stellar age**
  (defines planet age)

Asteroseismology

CoRoT and Kepler have demonstrated that the required accuracies can be met



Example: HD 52265 (CoRoT), a G0V type, planet-hosting star, 4 months data

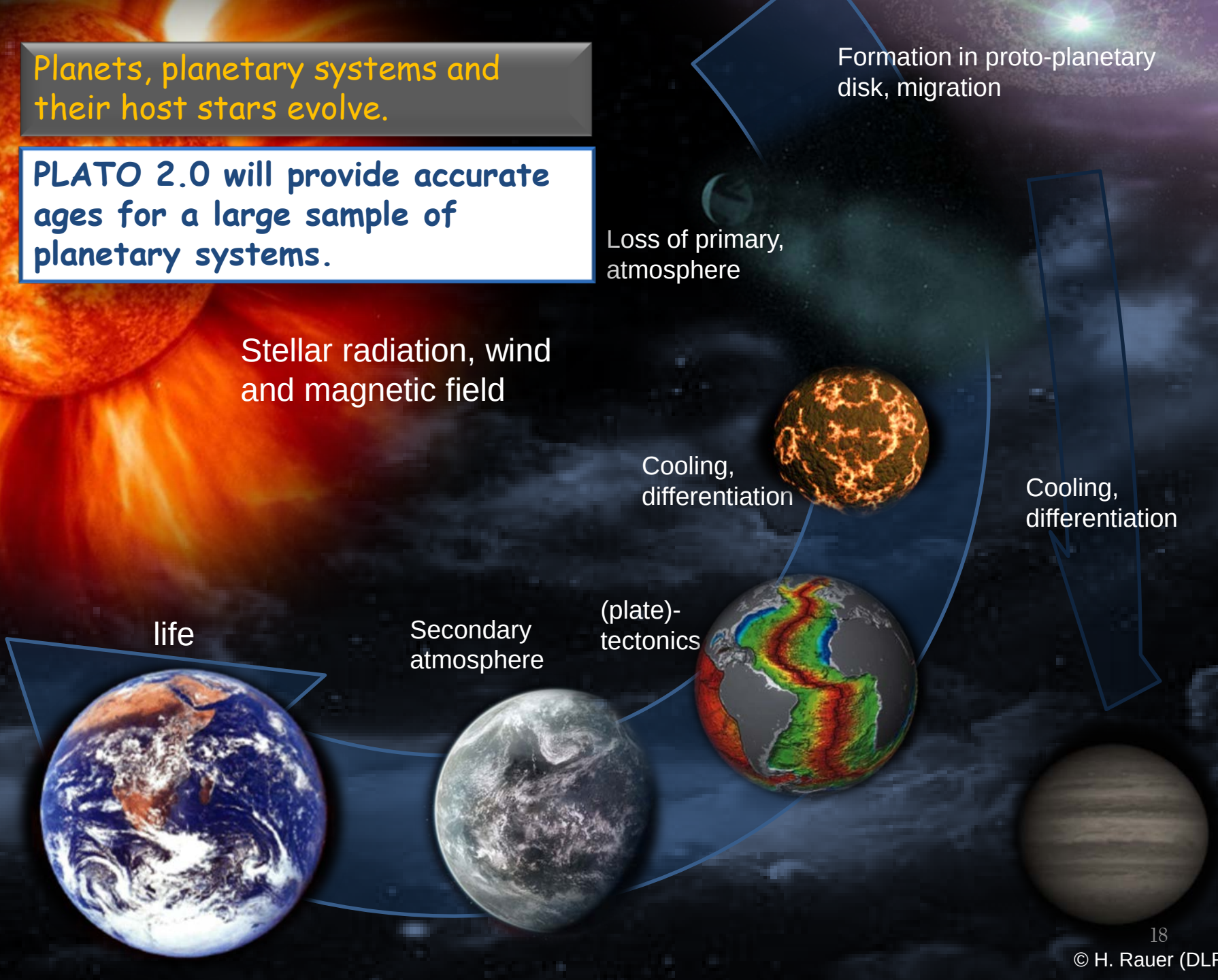


(Gizon et al. 2013)

Seismic parameters: Radius: 1.34 ± 0.02 R_{sun},
Mass: 1.27 ± 0.03 M_{sun},
Age: 2.37 ± 0.29 Gyr

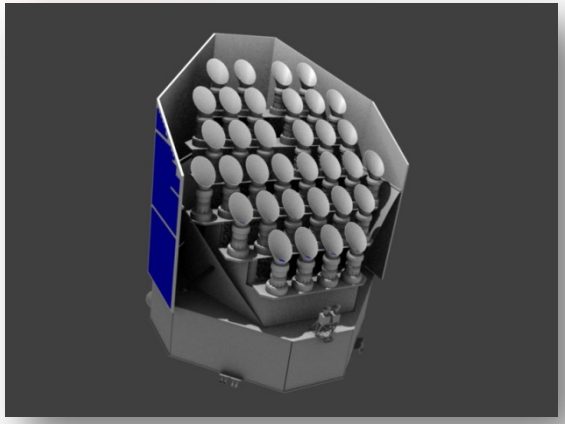
Planets, planetary systems and their host stars evolve.

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



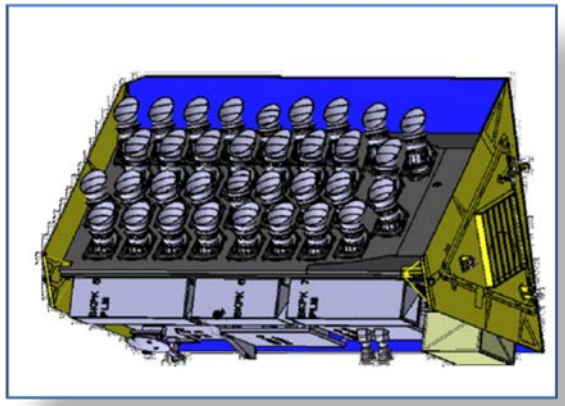
PLATO 2.0 instrument

Two designs studied:



Multi-telescope approach:

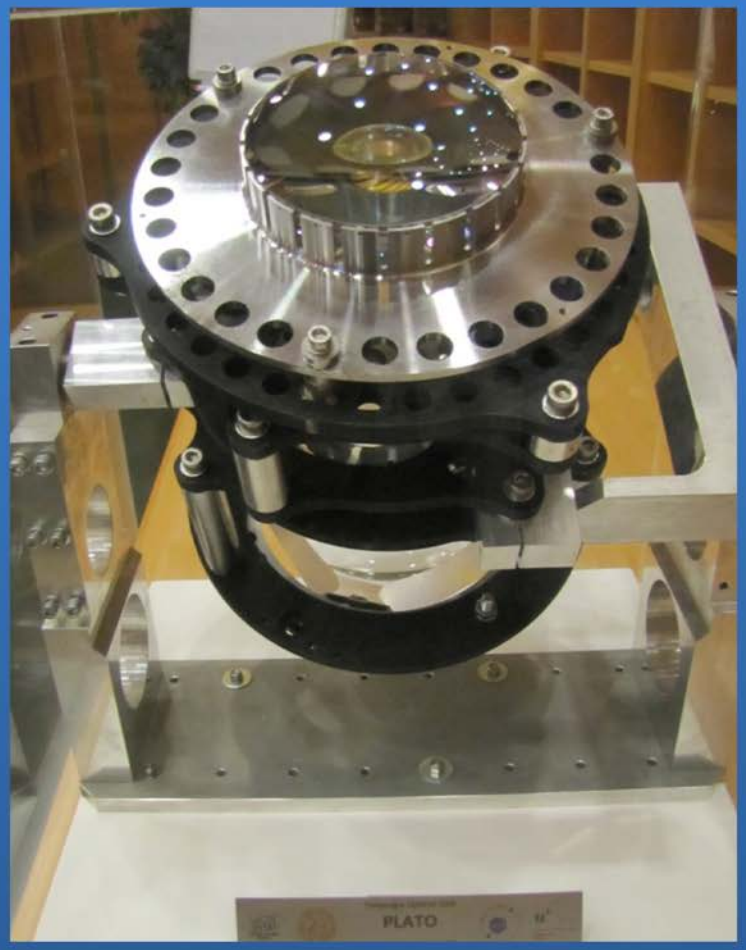
- *Large FOV (Large number of bright stars)*
- Large total collecting area *(provides high sensitivity allowing asteroseismology)*
- Redundancy



- 32 «normal» 12cm cameras, cadence 25 s, white light
- 2 «fast» 12cm cameras, cadence 2.5 s, 2 colours
- dynamical range: $4 \leq m_V \leq 16$

- L2 orbit
- Nominal mission duration: 6 years

PLATO 2.0 instrument



BreadBoard of one PLATO 2.0 Telescope

- Aspheric feasibility demonstrated
- CaF lenses demonstrated
- Alignment in warm demonstrated

Field of View

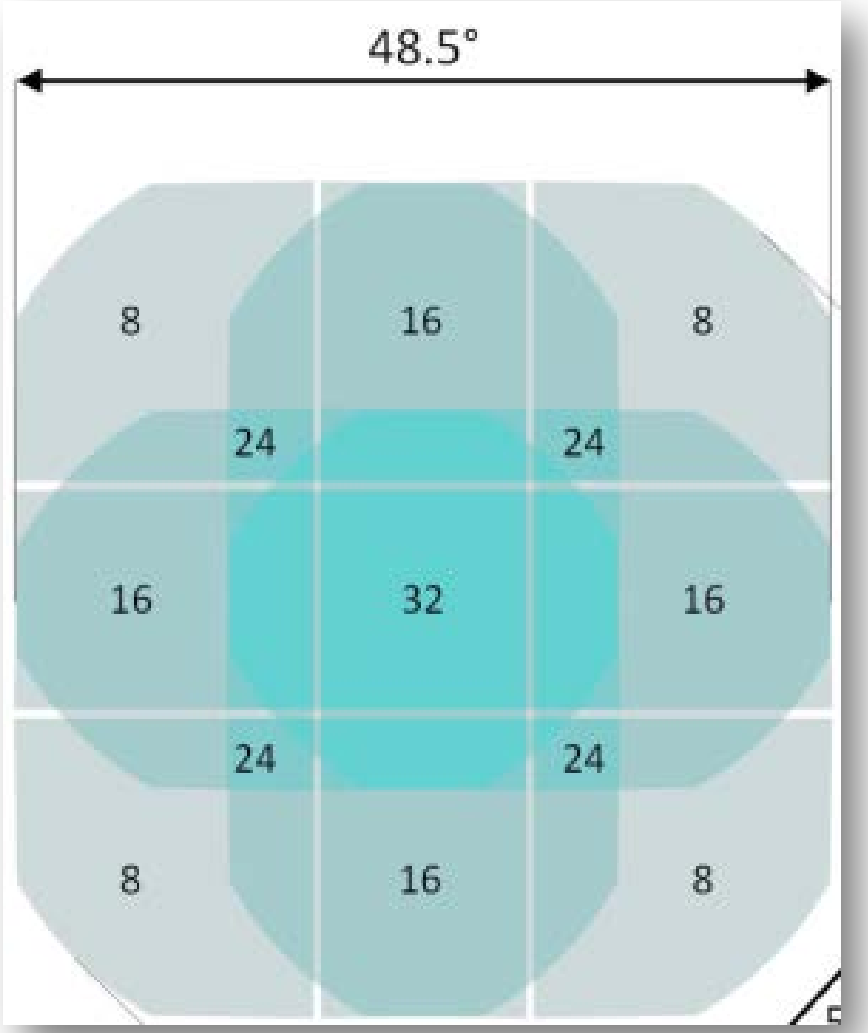
Overlapping line of sight for

4 groups of 8 cameras

To increase the FoV

Optimizing:

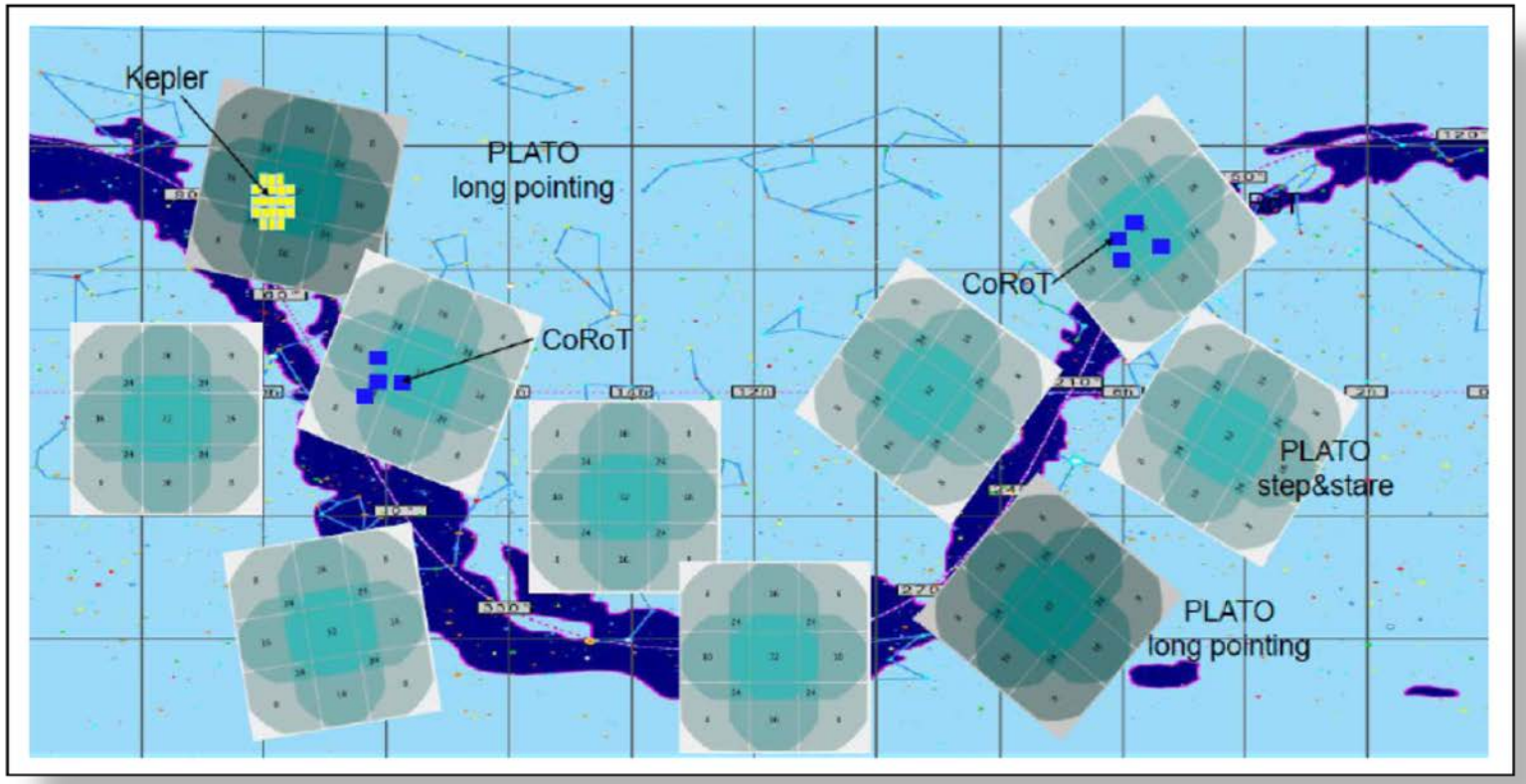
- No. of stars at given noise level
- No. of stars at given magnitude



Baseline observing strategy

6 years nominal science operation:

- **2 long pointings of 2-3 years**
- **step-and-stare phase (2-5 months per pointing)**



→ covers ~50% of the sky

PLATO 2.0: Number of Light Curves

For the baseline observing strategy:

Noise level	Magnitude limit	4300 deg^2 (long stare fields)	20,000 deg^2 (plus step and stare fields)
(ppm/√hr)	m_V	Number of cool stars	Number of cool stars
34	11	**22,000**	**85,000**
80	13	**267,000**	**1,000,000**

Detection of Earth-sized planets
+ asteroseismology
+ radial velocity

+ Detection of Earth-sized planets
+ ...

Follow-up time needed

Full follow-up of the expected planet yield from core sample

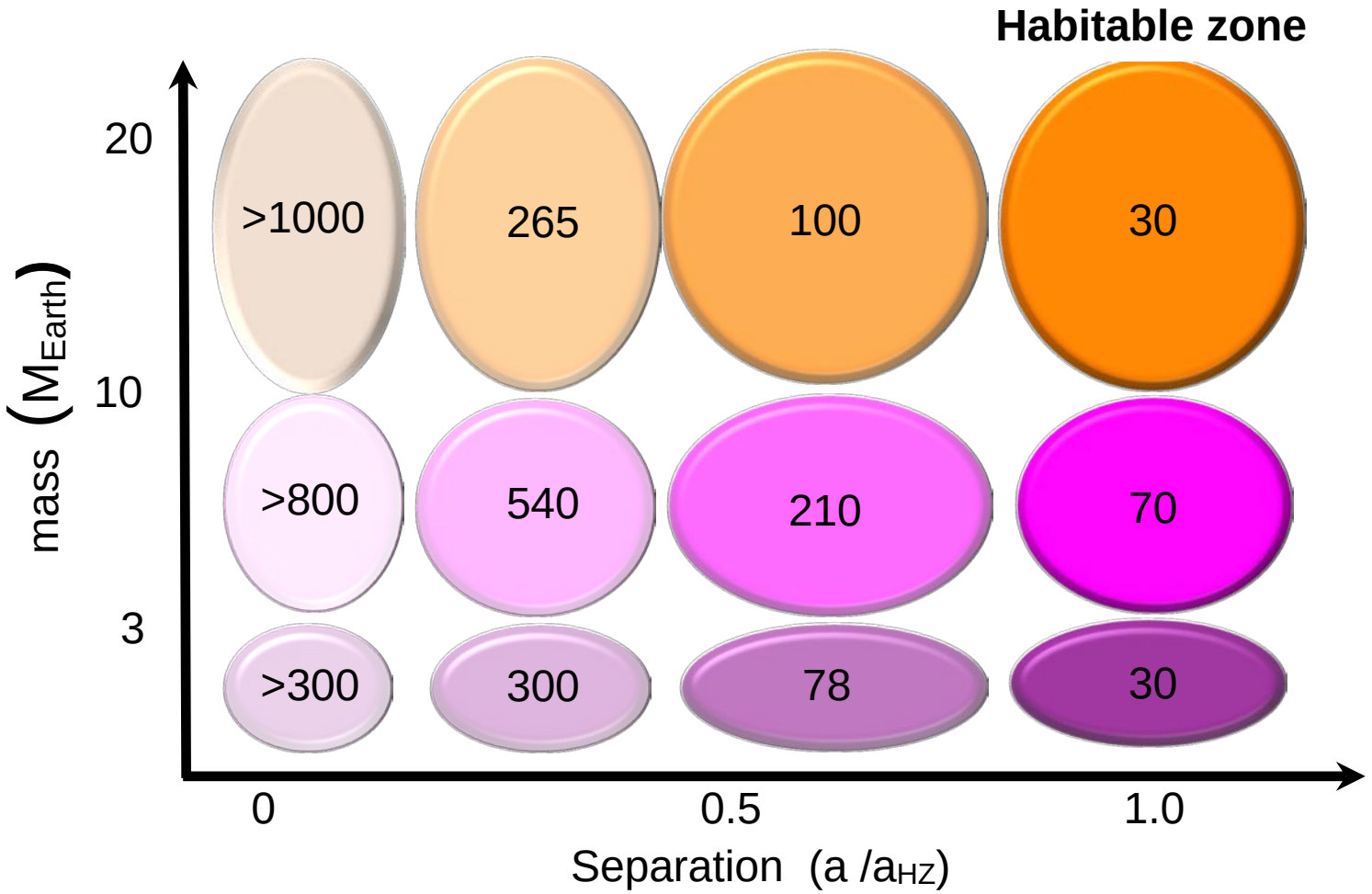
Radial velocity precision	Telescope	Type of objects	Example time distribution
10m/s	1-2m	Giant planets on short/medium orbits	50 nights/yr for 6 yrs on 3 tel.
		medium orbits	
<20cm/s	8m	Earths/Super-Earths on long orbits	40 nights/yr for 6 yrs on 1 tel.

Follow-up needs world-wide support.

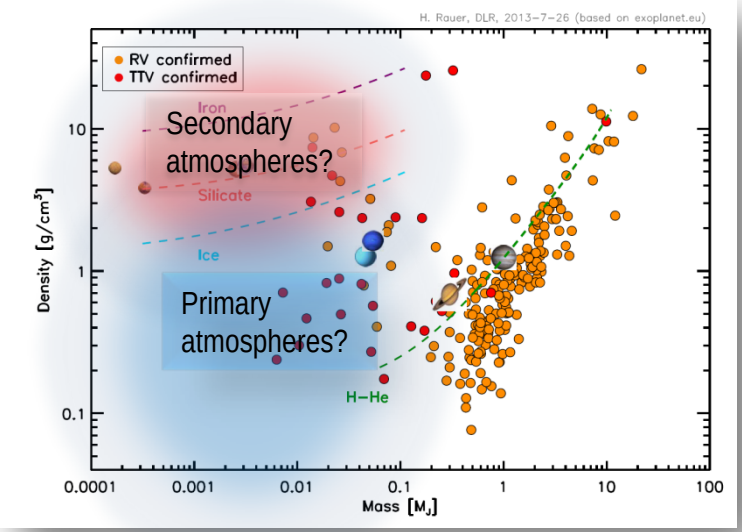
Few hardest cases (eg faintest hosts with Earths in the habitable zone) will need E-ELT

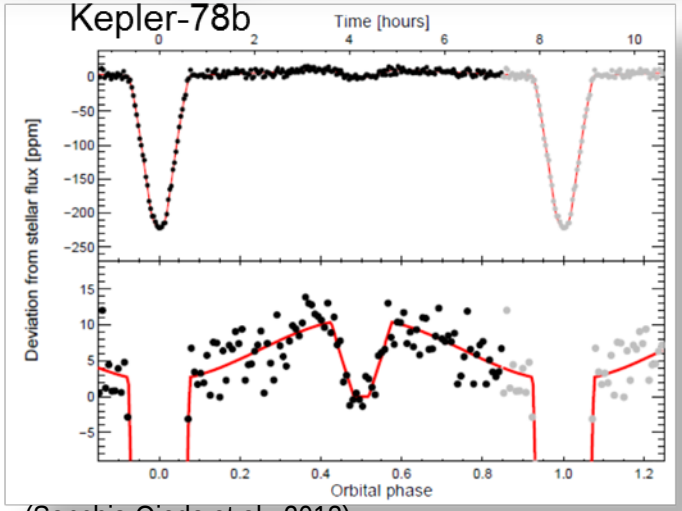
Total numbers of characterized planets in core sample

Number of characterized planets (**Earth to Neptune mass**) after detailed model of radial velocity efforts and the impact of stellar activity:



Planet diversity & comparative planetology





(Sanchis-Ojeda et al., 2013)

PLATO 2.0 will provide planets with:

- mean density
  → composition and structure (rocky, mini-gas)
  → constrain atmosphere scale heights
- albedo and its diversity
  → indicative for clouds, hazes
- accurate ages
  → evolutionary pathways
- characterized host stars
  → incident flux, stellar activity

→ 1 000 000 high quality light curves of stars
→ PLATO 2.0 data are open access to the community

Upcoming meetings

You are welcome to attend the

PLATO 2.0 Science Conference

December 3-5, 2014

Catania, Italy