PLATO

PLAnetary Transits and Oscillations of Stars

→ revealing the interior of planets and stars

→ completing the age of planet discovery for Earth-sized planets

→ constraining planet formation

Heike Rauer and the PLATO team

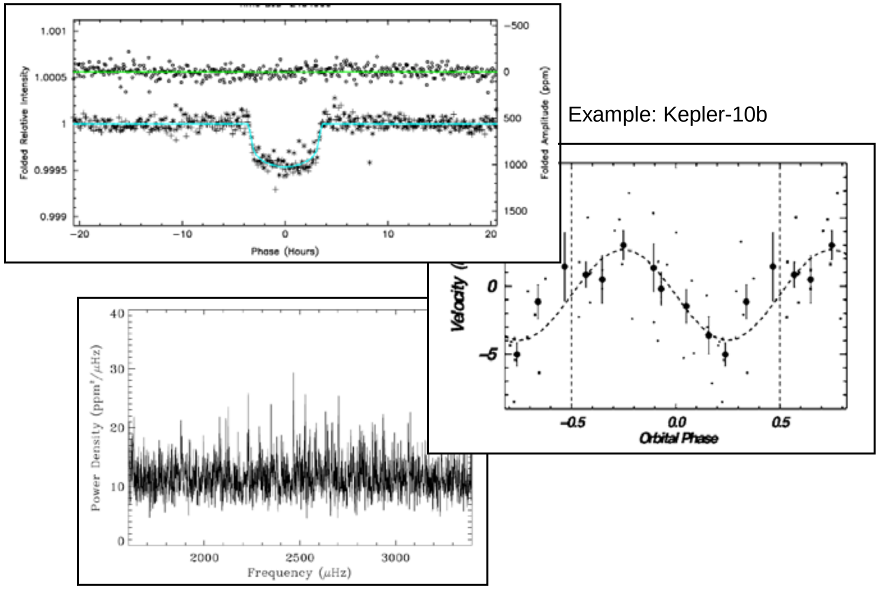
The PLATO Consortium: 501 members from 23 countries
(European, Brazil, US, Chile, Canada, Australia)

The PLATO mission

Techniques:

- photometric transits
- asteroseismology
- ground based spectroscopy for radial velocity

Example: Kepler-10b



PLATO :

- **very large samples of bright stars**
- **continuous photometric monitoring from space, in the visible**
- **ultra-high precision**
- **very wide field**

Accuracy for an Earth around a solar-like star:

*** planet radius up to 2%**

*** planet mass up to 10%**

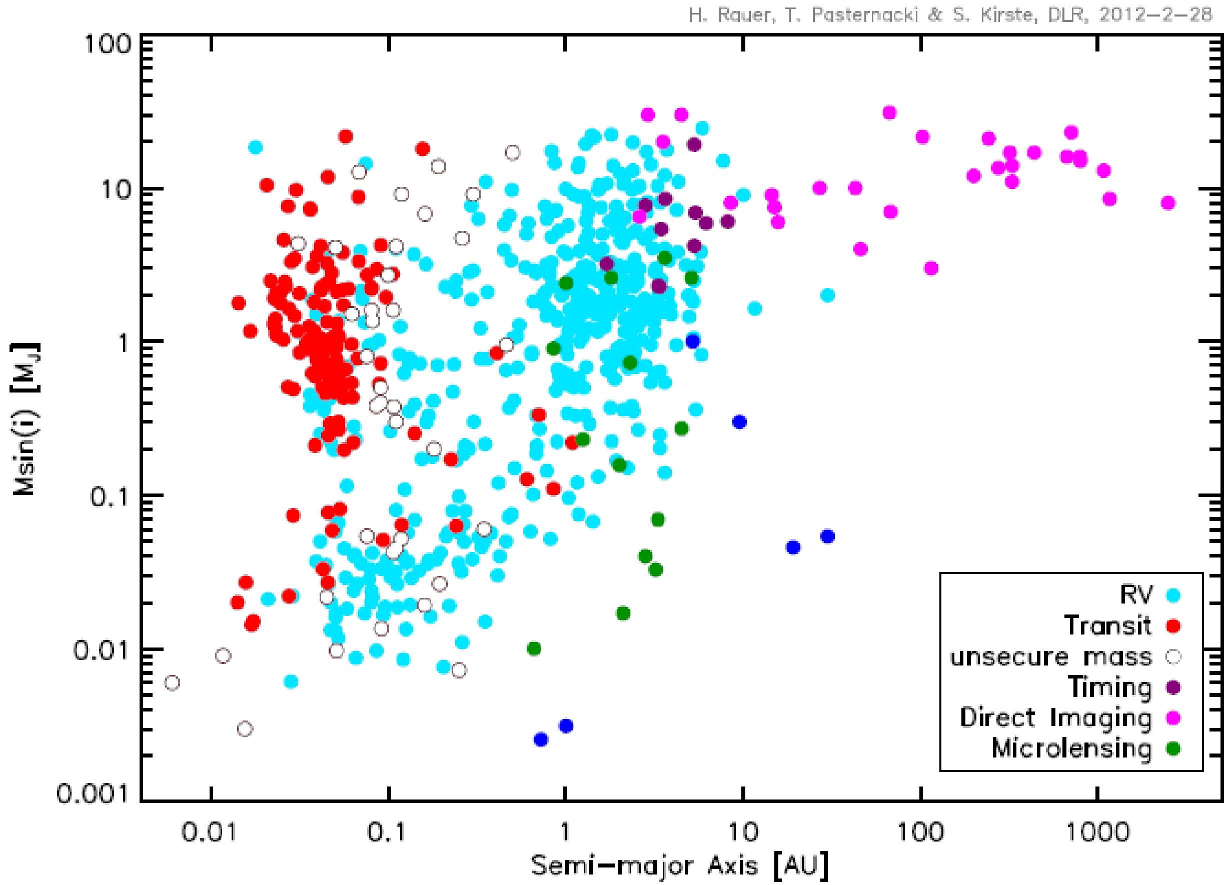
*** age known to 10%**

And much better for larger planets!

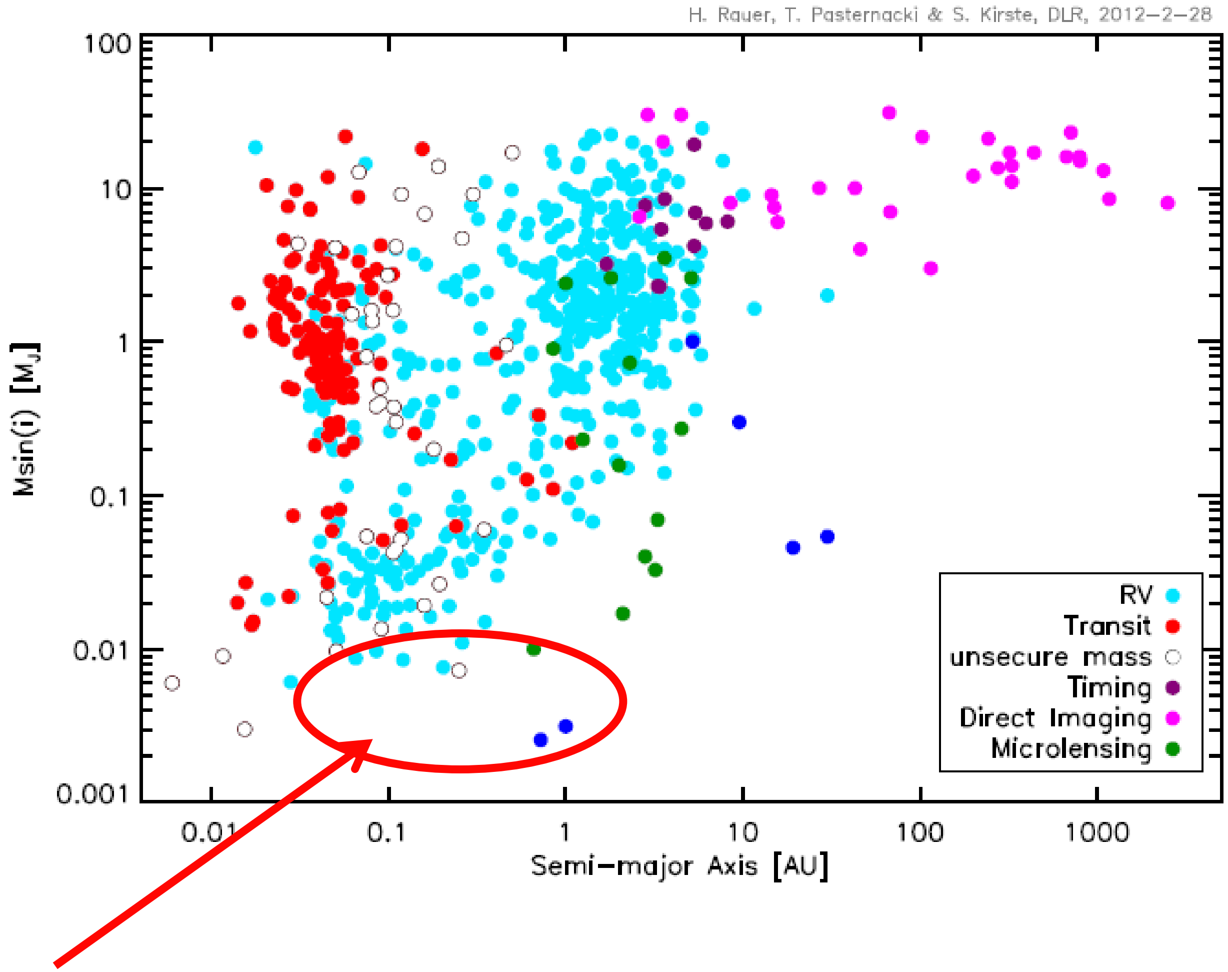
PLATO current status

- PLATO consortium applied to ESA to enter the M3 competition.
- PLATO already finished mission studies during M2 competition.
- The PLATO consortium will be re-adjusted to fit the M3 timeline (launch 2022/24)
- The science case is refined in the context of the 2022/24 launch perspective, taking into account recent Kepler and rv-survey results

Planet Detections

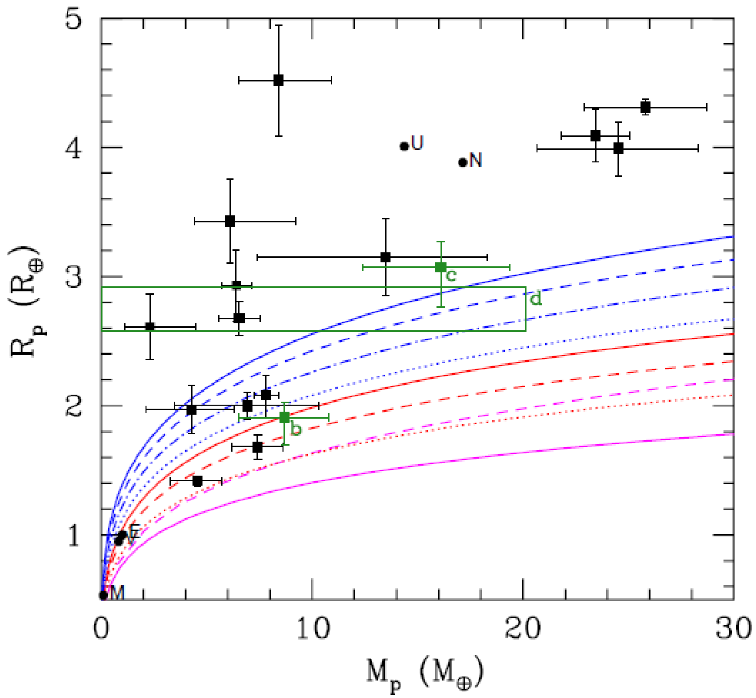


Planet Detections

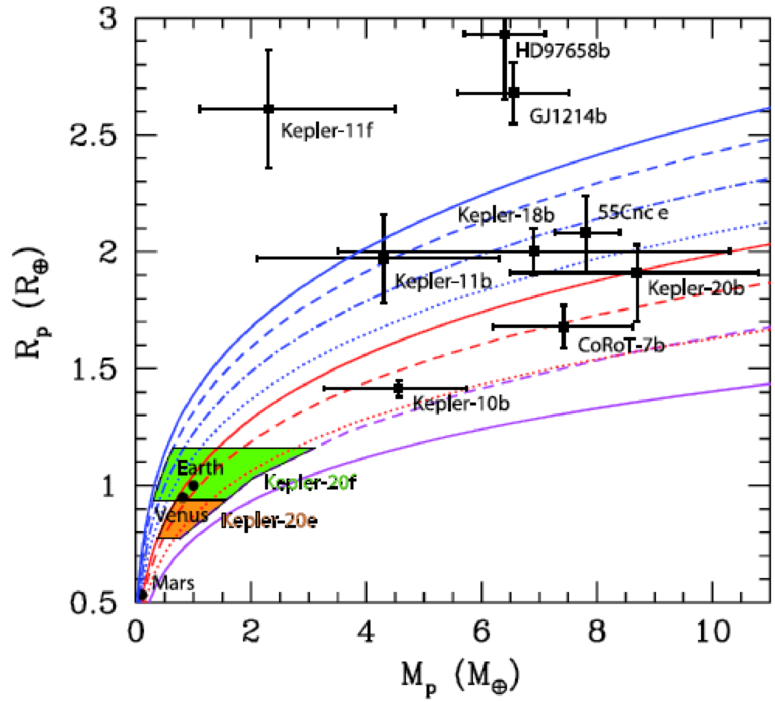


Focus of interest for future space-based transit missions:
→ Detect terrestrial planets up tp the HZ of solar-like stars

Planet diversity



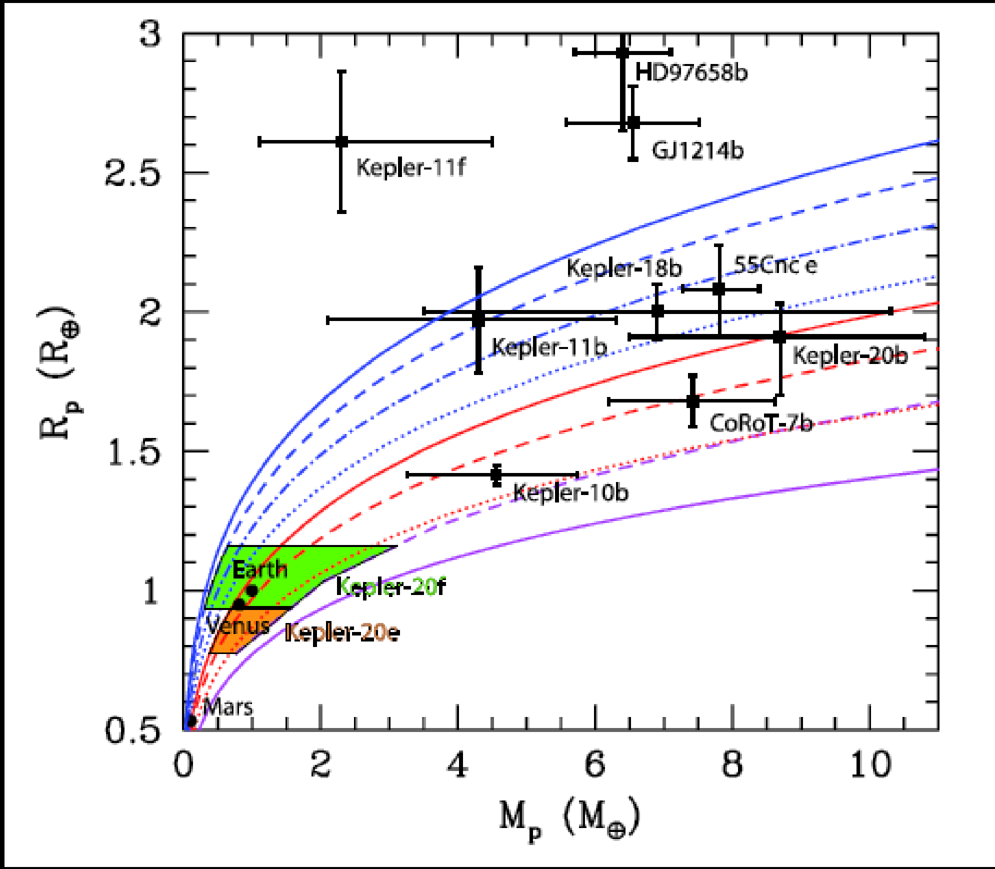
Gautier et al. 2012



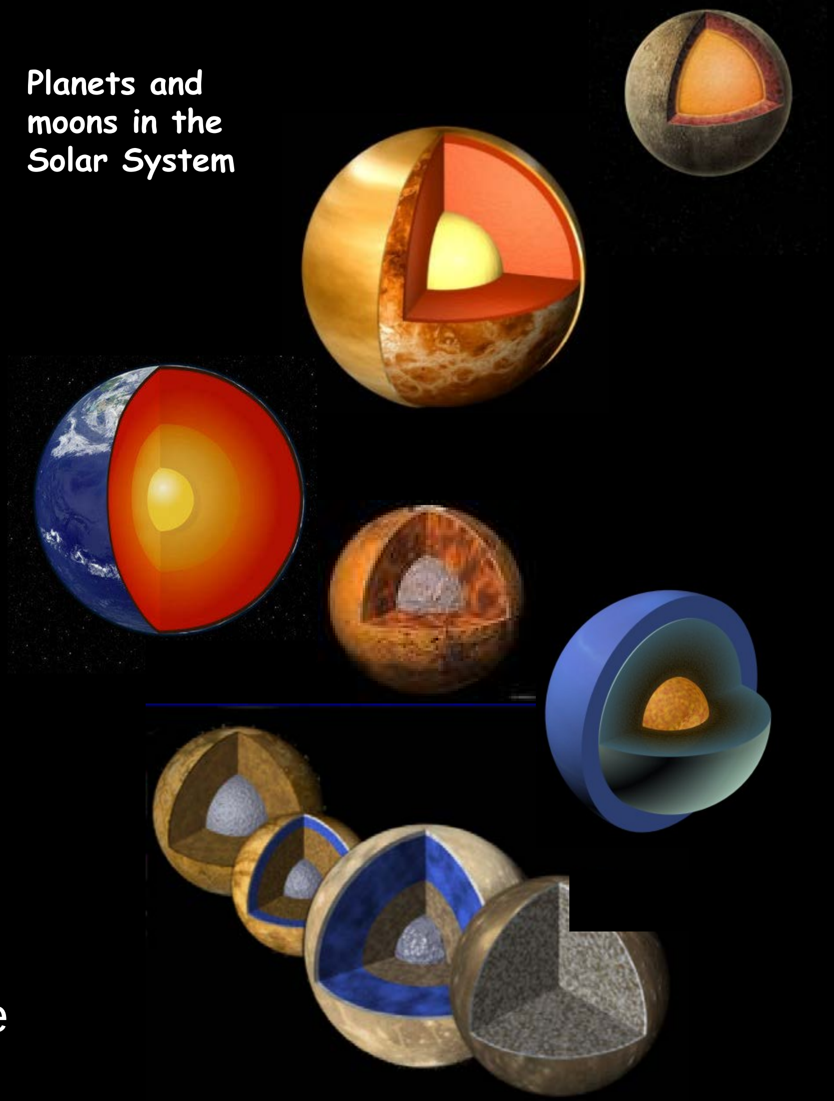
Fressin et al. 2011

- Future transit surveys need to
  - detect Earth-sized planets
  - characterize their radius and mass with high accuracy

Planet diversity



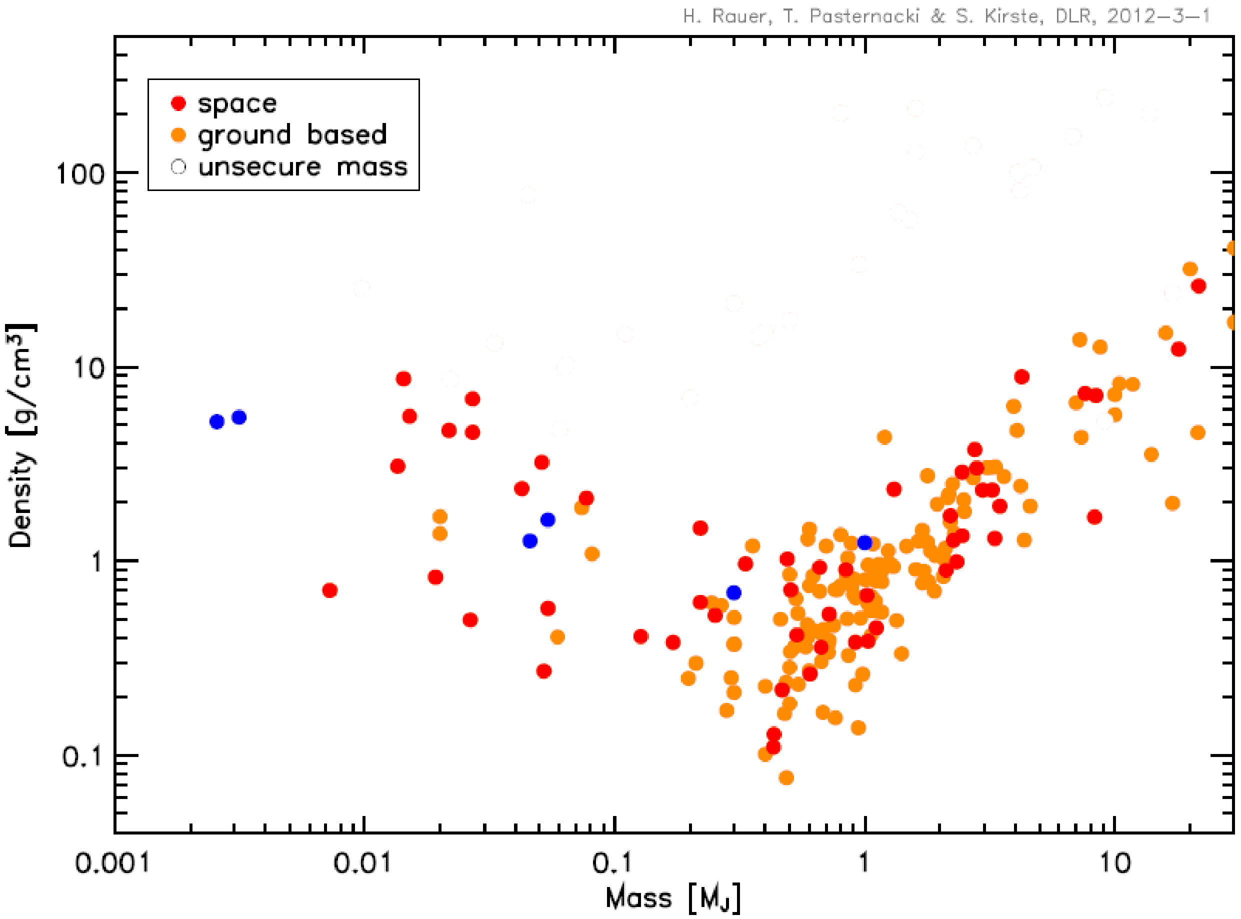
Planets and moons in the Solar System



Meaningfiul constraints on planet interior require
High accury on radius (2%) and mass (10%)

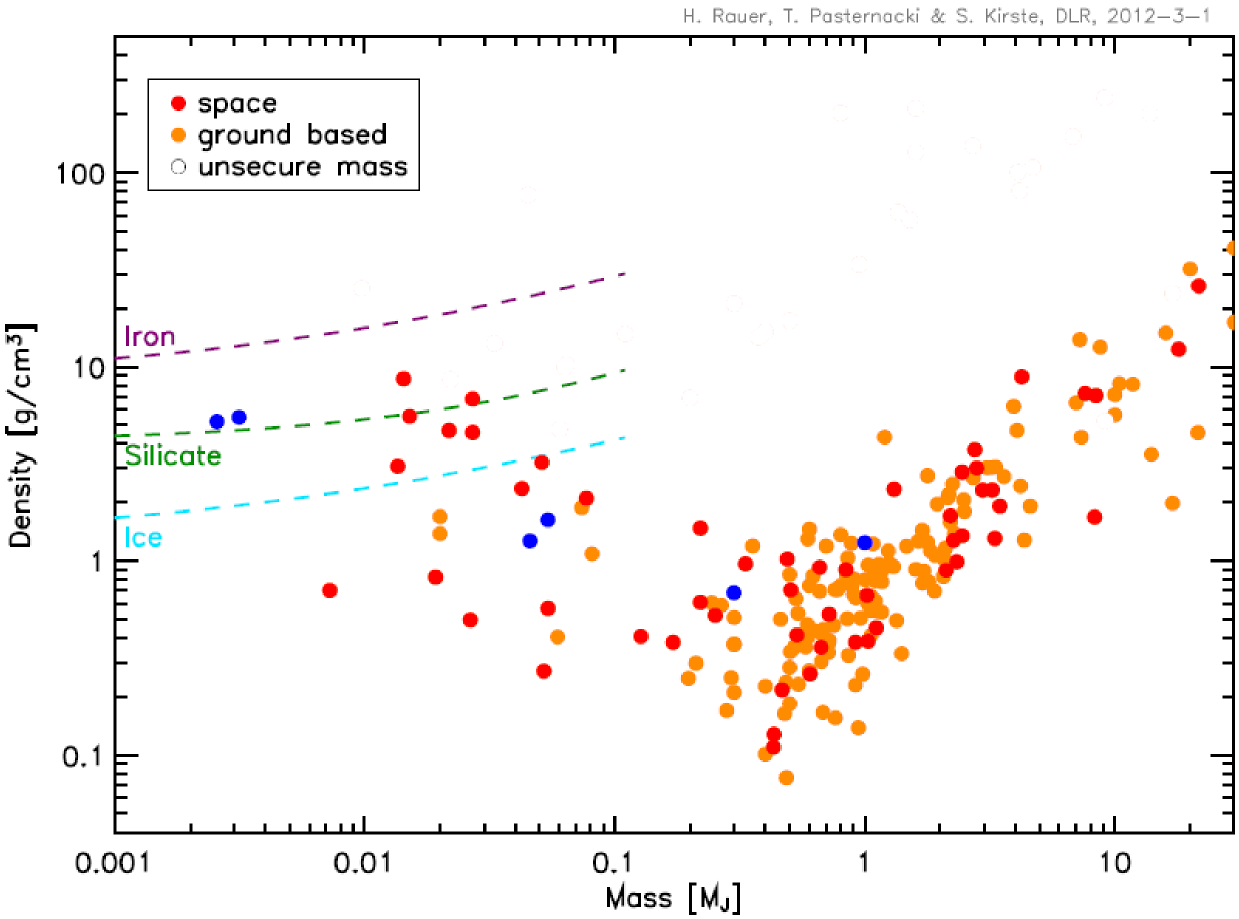
Planet diversity and planet formation

Rocky and icy planets

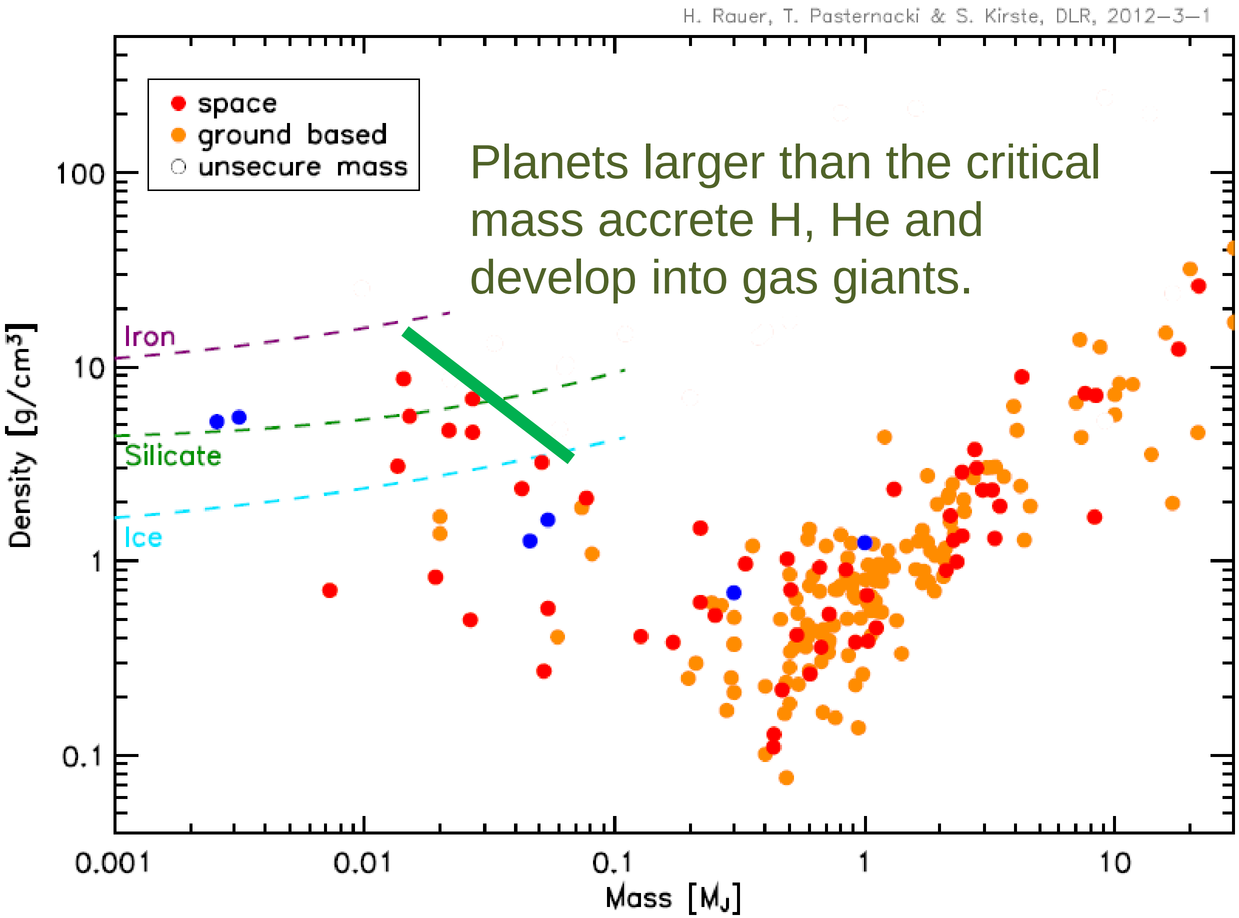


Gas giants

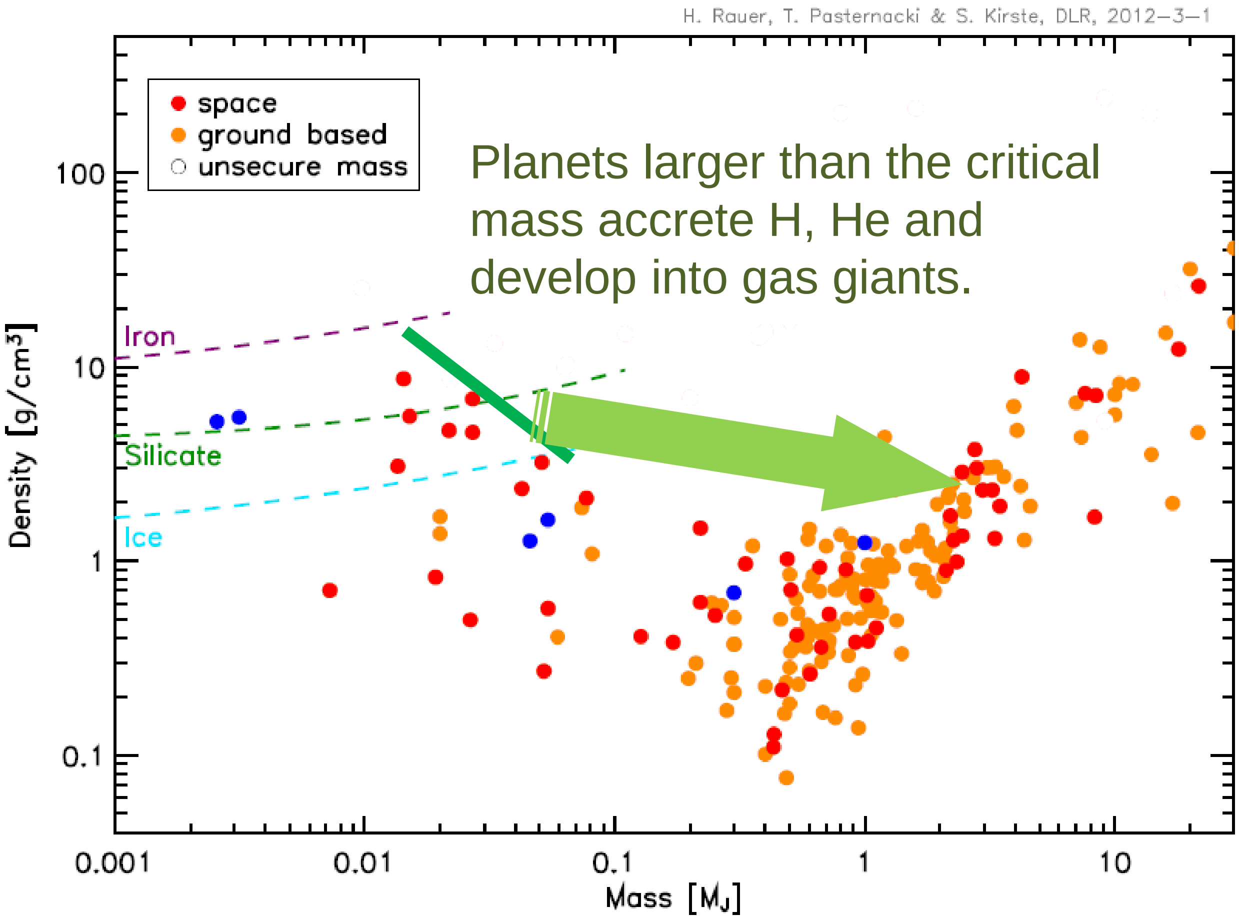
Planet diversity and planet formation



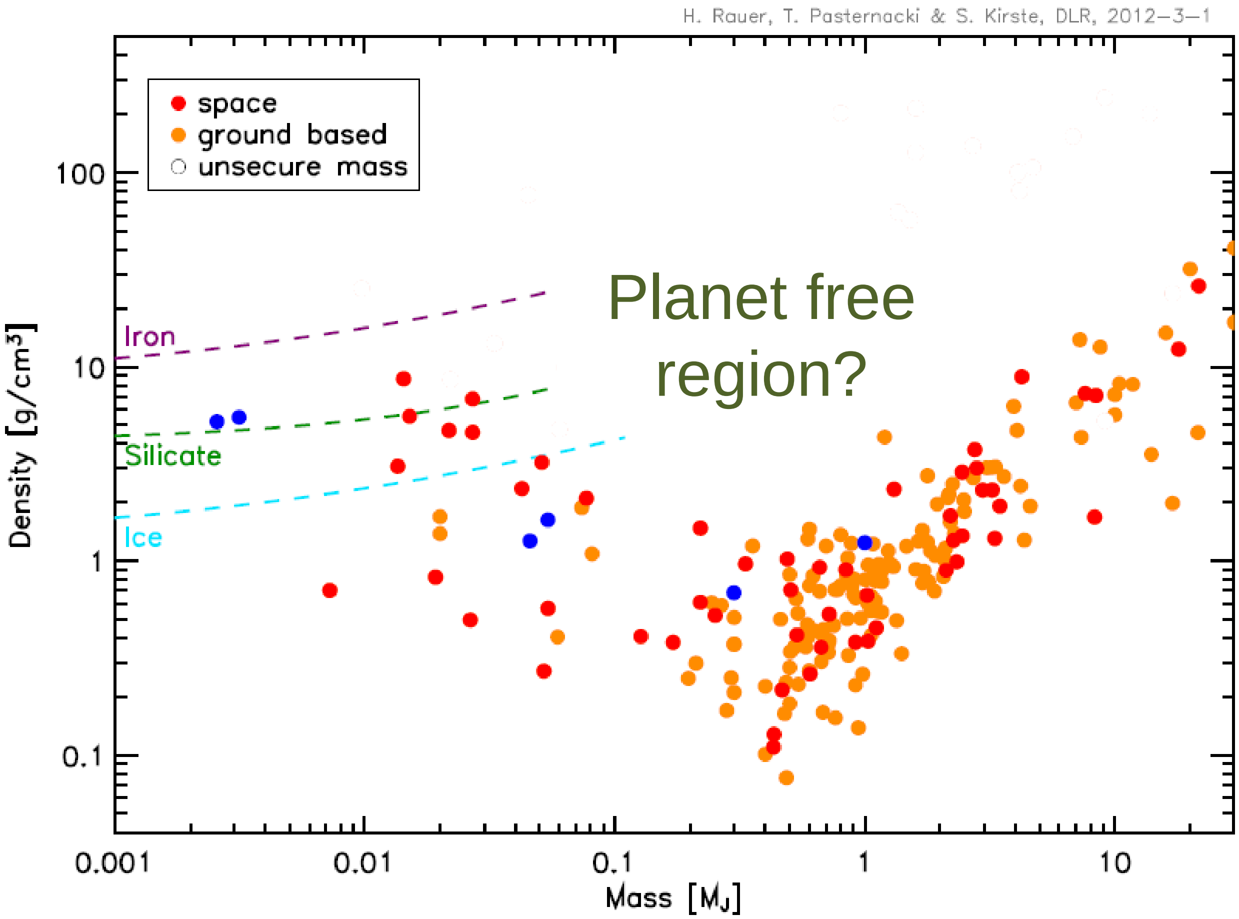
Planet diversity and planet formation



Planet diversity and planet formation

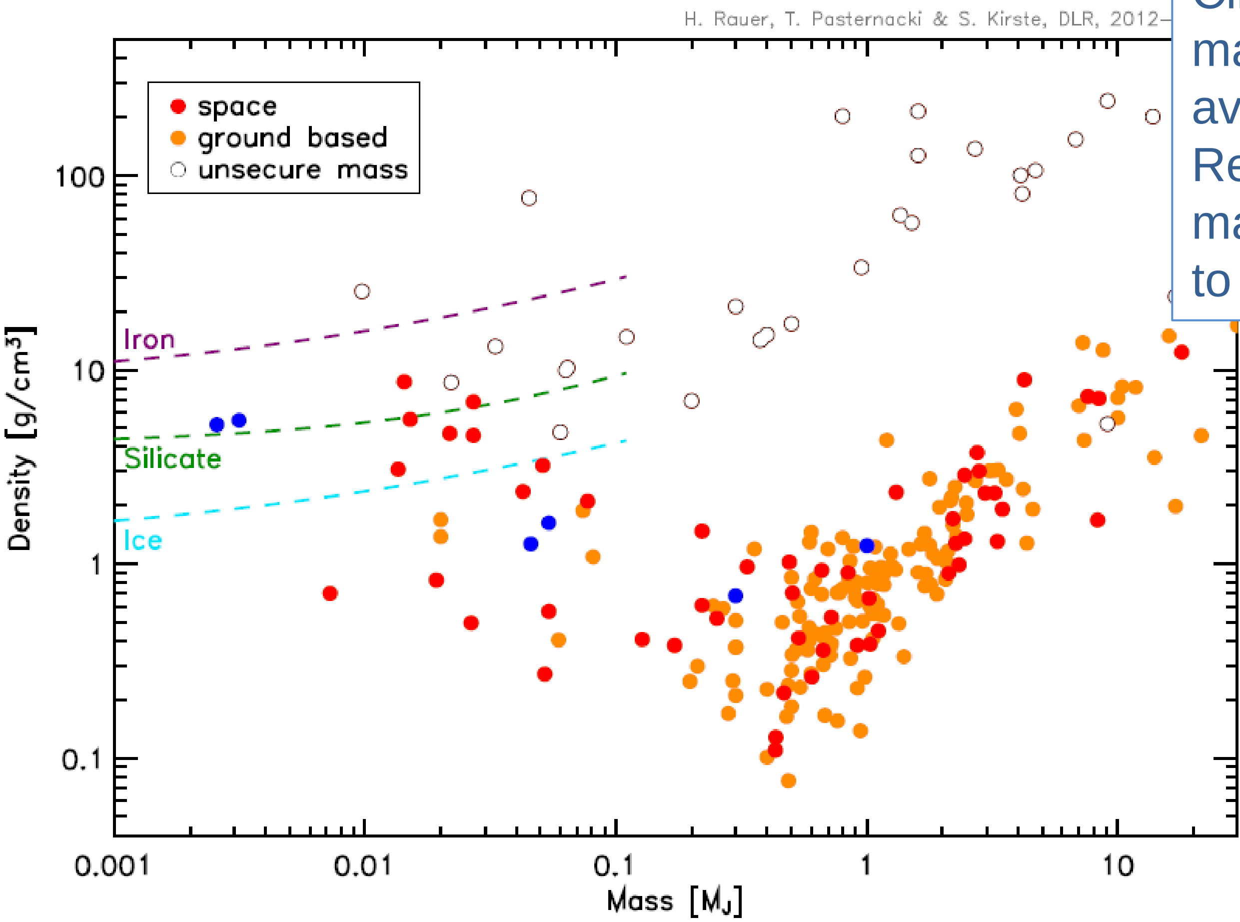


Planet diversity and planet formation



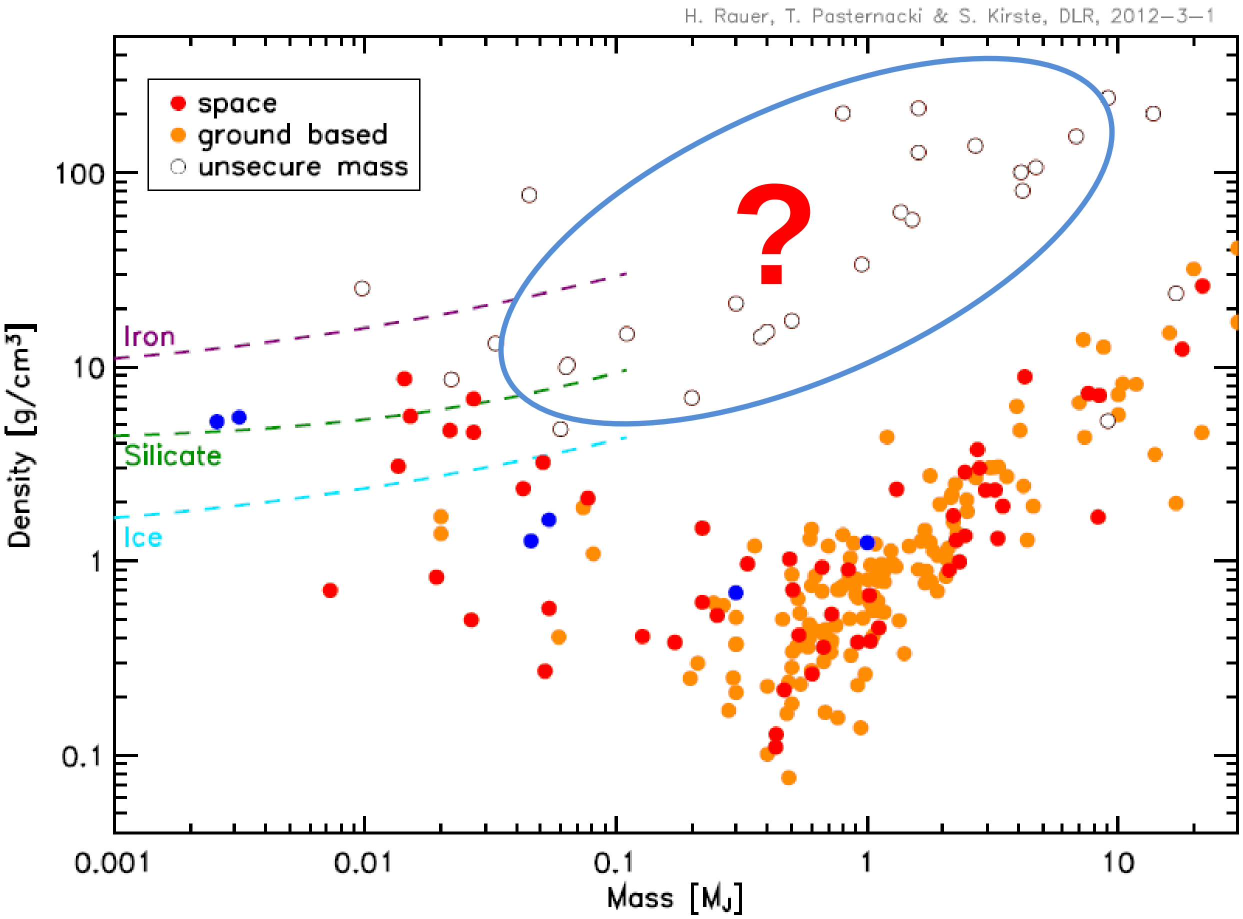
→ Our current understanding of planet formation predicts fast gas envelope accretion beyond 10-15 M_{earth}

Planet diversity and planet formation



Circles: upper mass limits available only! Real planet masses are likely to be much lower.

Planet diversity and planet formation

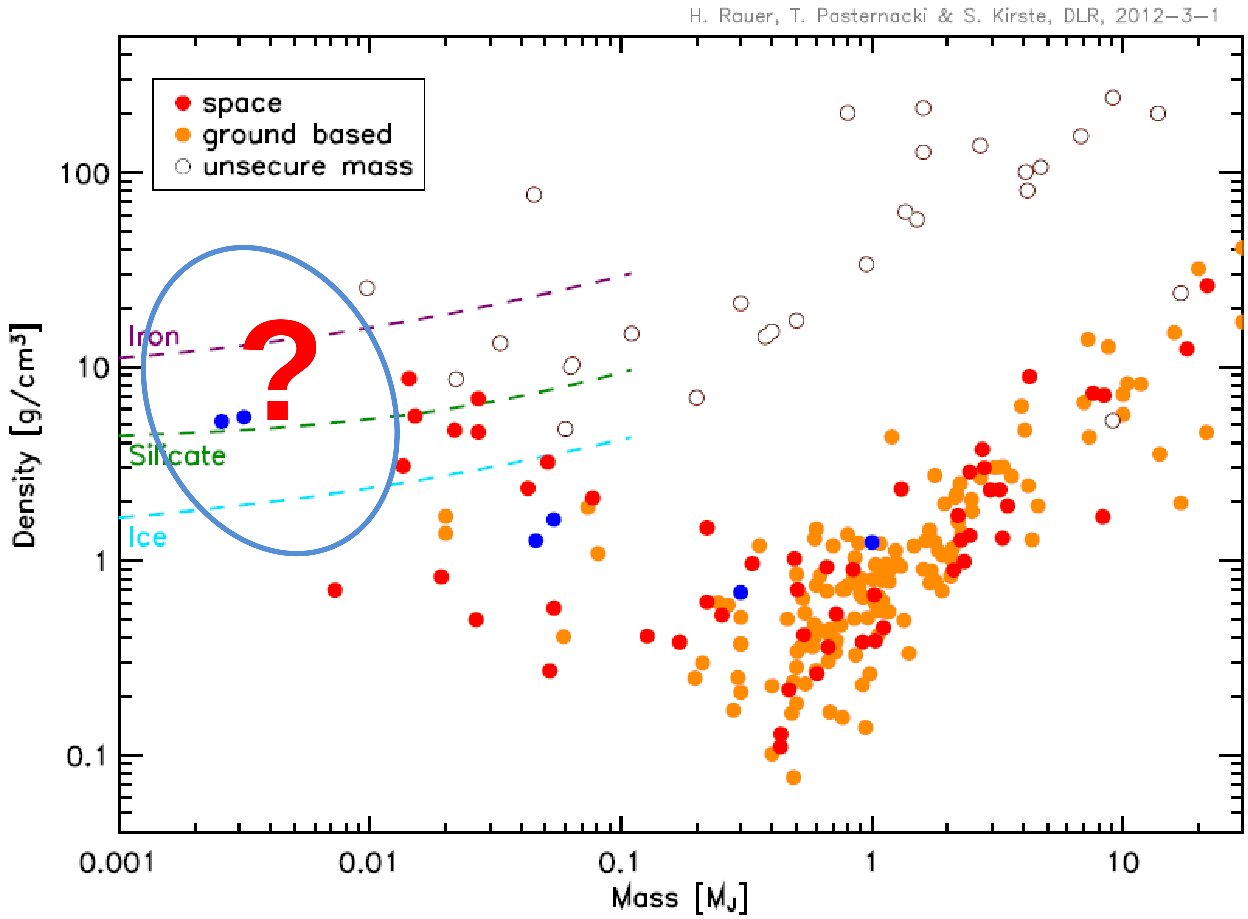


Objects with upper mass limits only orbit faint stars (~15 mag).

→ Need to observe brighter stars.

- Do massive rocky planets exist?
- What is the critical mass for giant planet formation?
- Does it depend on the disc (e.g. dust/gas ratio)?

Planet diversity and planet formation



Objects with upper mass limits only orbit faint stars (~15 mag).

→ Need to observe brighter stars.

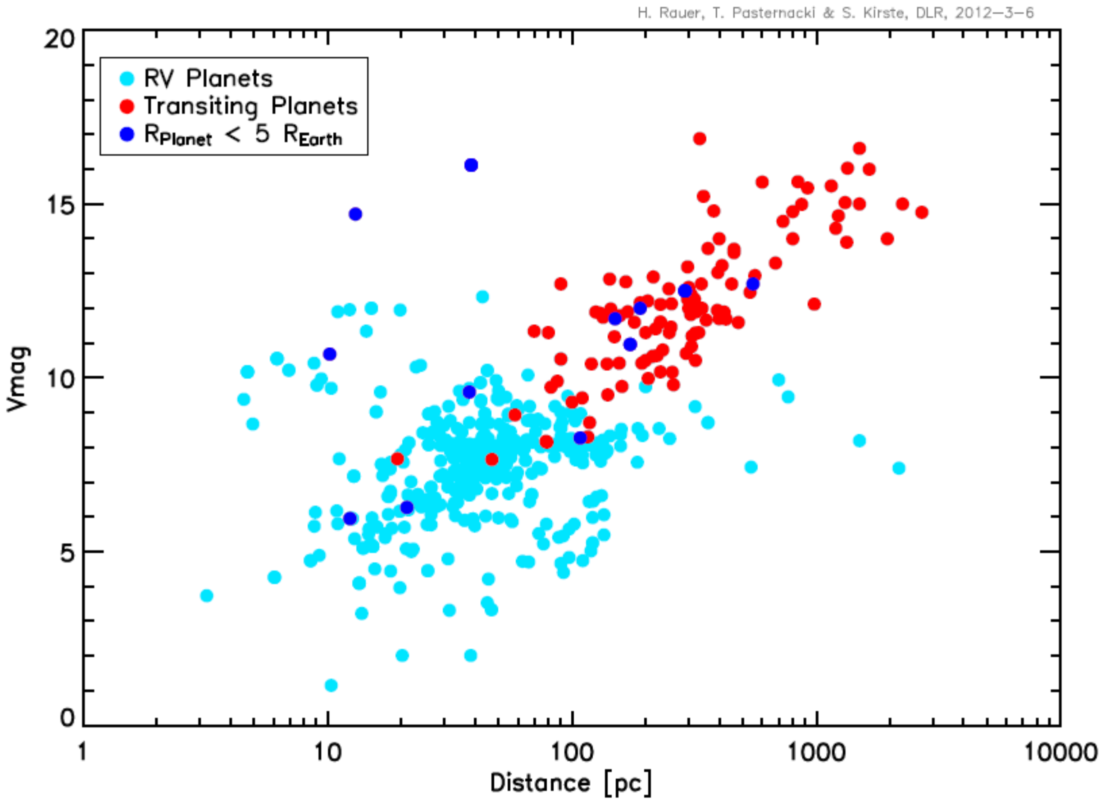
- **What is the diversity of Earth-sized planets?**
- **Does it depend on orbital distance, stellar type, etc.?**

PLATO

Selection of science cases:

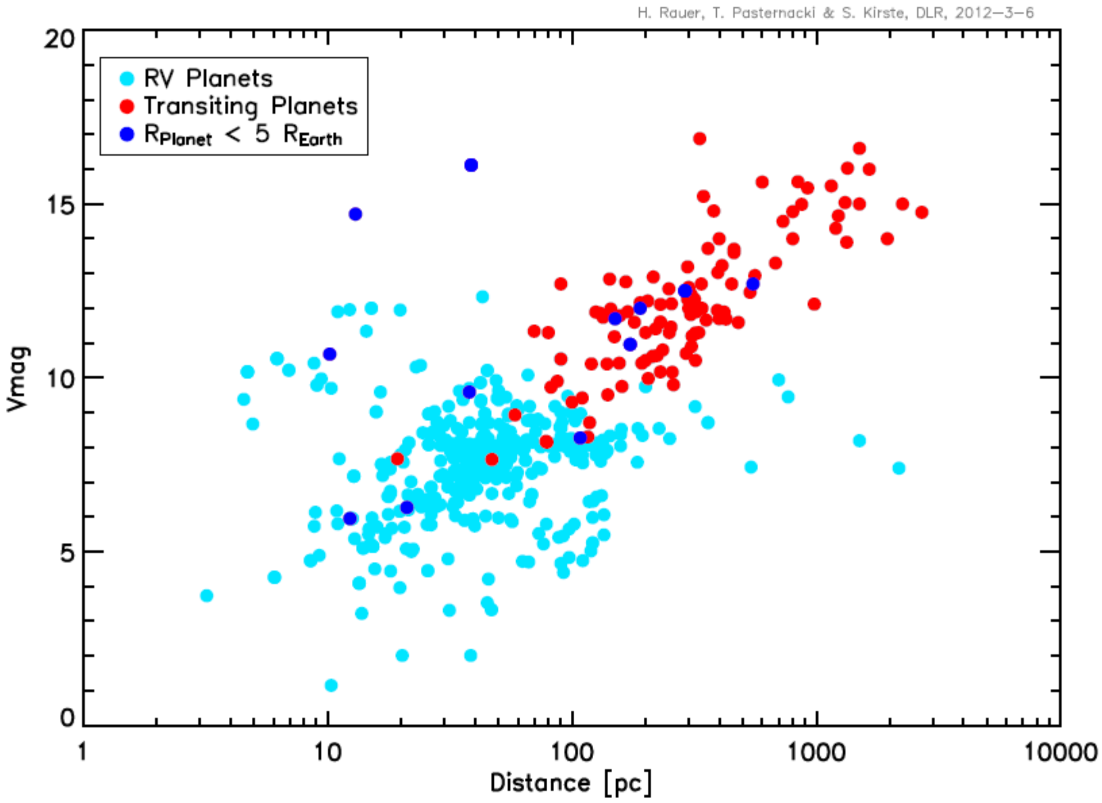
- Detect Earth-sized planets in the habitable zone with known radii and masses, including planets orbiting solar-like stars.
- Obtain statistical significant numbers of characterized small planets at different orbits, stars, …
- Determine the critical mass for *gas giant growth*
- Study planet interior composition and structure including terrestrial objects
- Study planetary systems
- Determine accurate ages of planet systems
- Provide small terrestrial planets around bright stars as targets for atmosphere spectroscopy

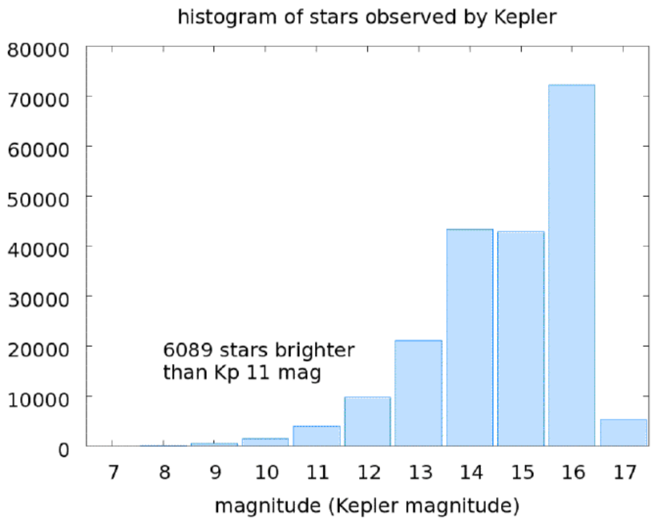
Currently little overlap between current transit and rv surveys



- Planet radii are obtained by transit observations
- Planet masses can be derived by radial velocity measurements
- Transits are detected in broad-band (white light) photometry
- Radial velocity measurements require high-resolution spectroscopy –> much tighter limit on target brightness

Currently little overlap between current transit and rv surveys





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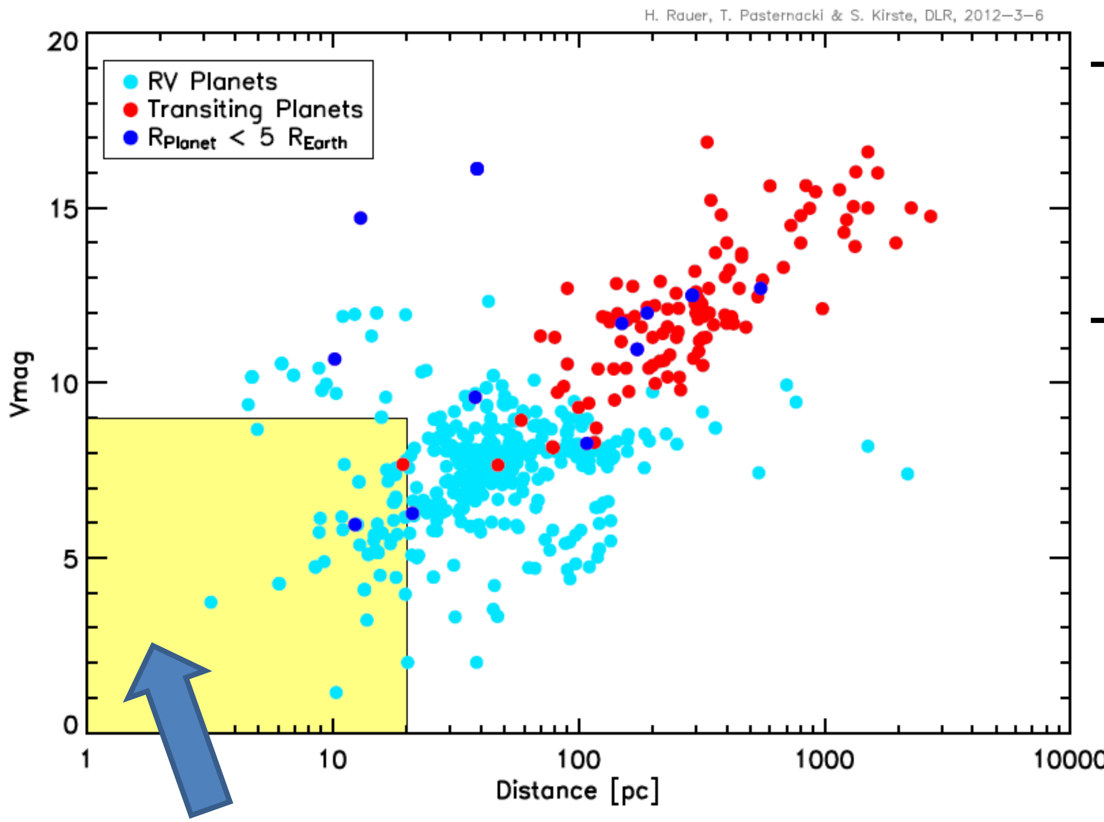
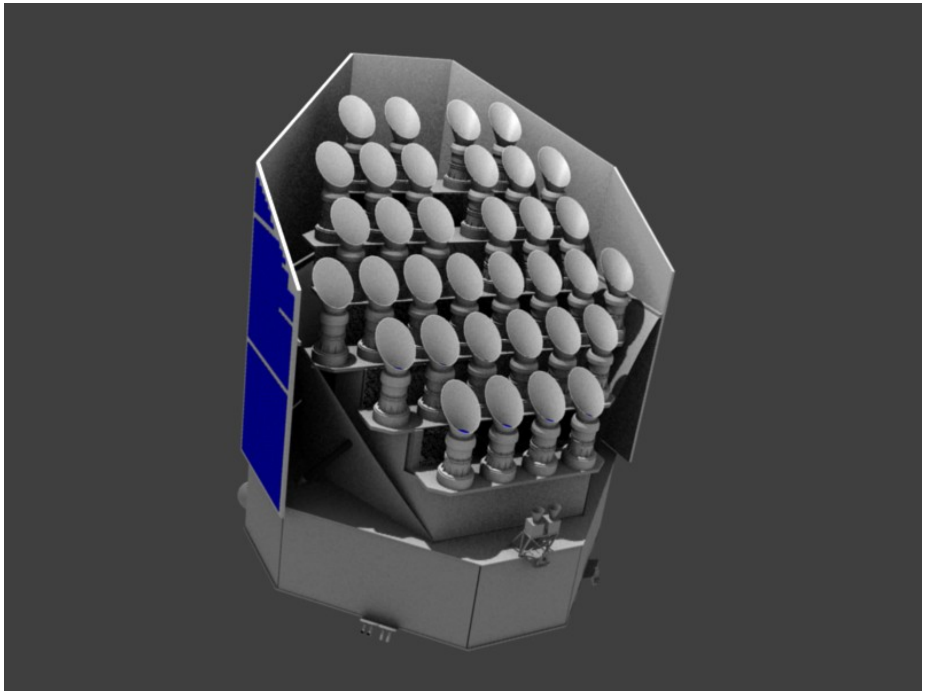


→ Need to detect transiting planets around bright stars!

→ Provide targets for spectroscopy characterization!

Region of interest for atmosphere characterization

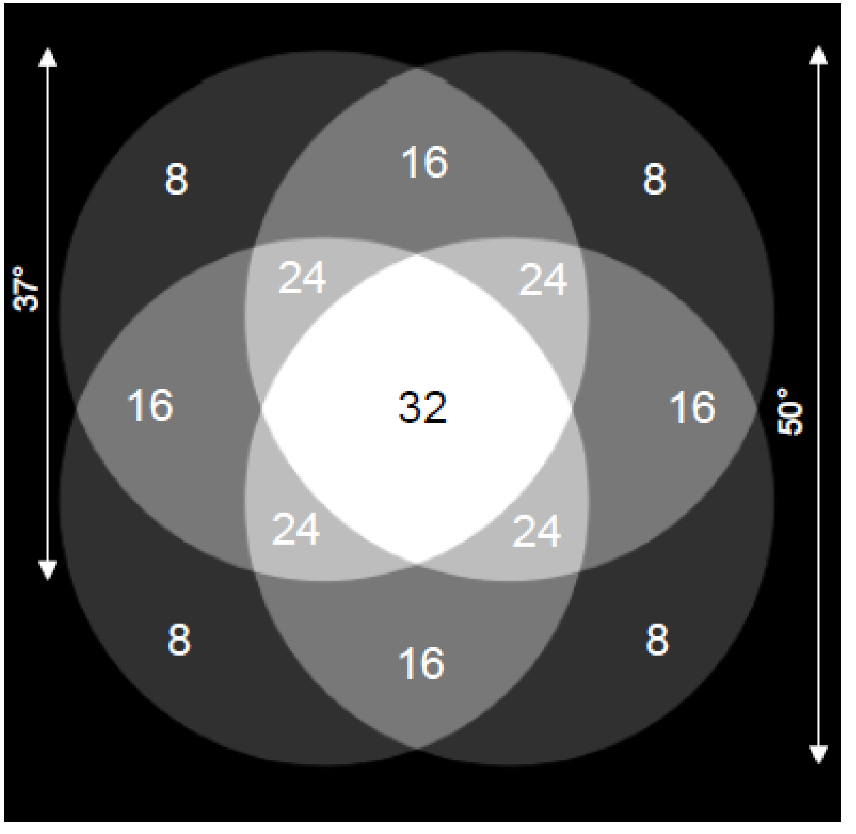
PLATO instrumental concept



- 32 « normal » cameras : cadence 25 sec
- 2 « fast » cameras : cadence 2.5 sec, 2 colours
- pupil 120 mm
- dynamical range: $4 \leq m_V \leq 16$

Concept of overlapping line of sight

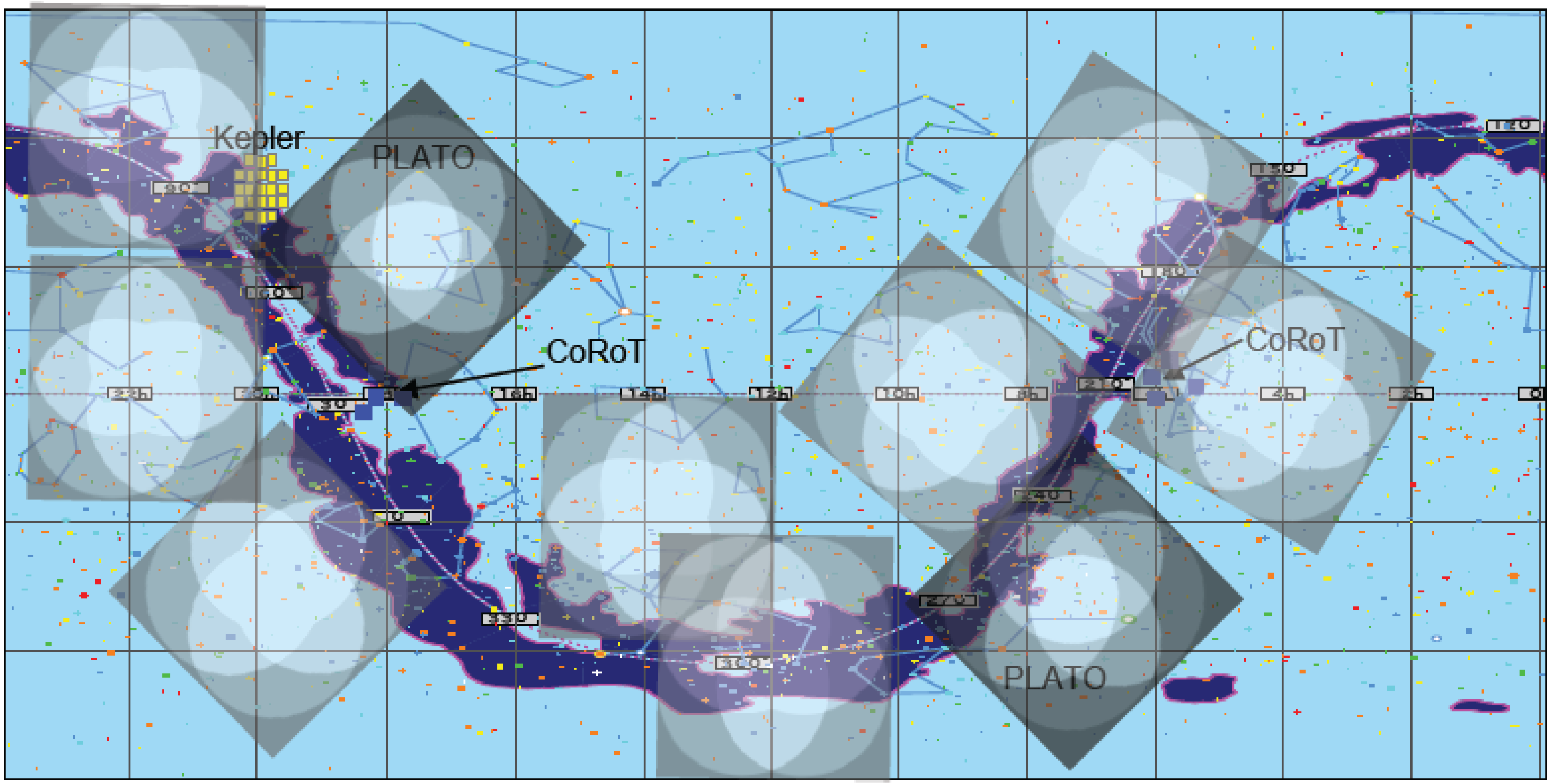
4 groups of 8 cameras with offset lines of sight
offset = 0.35 x field diameter



Optimization of number of stars at given noise level
AND of number of stars at given magnitude

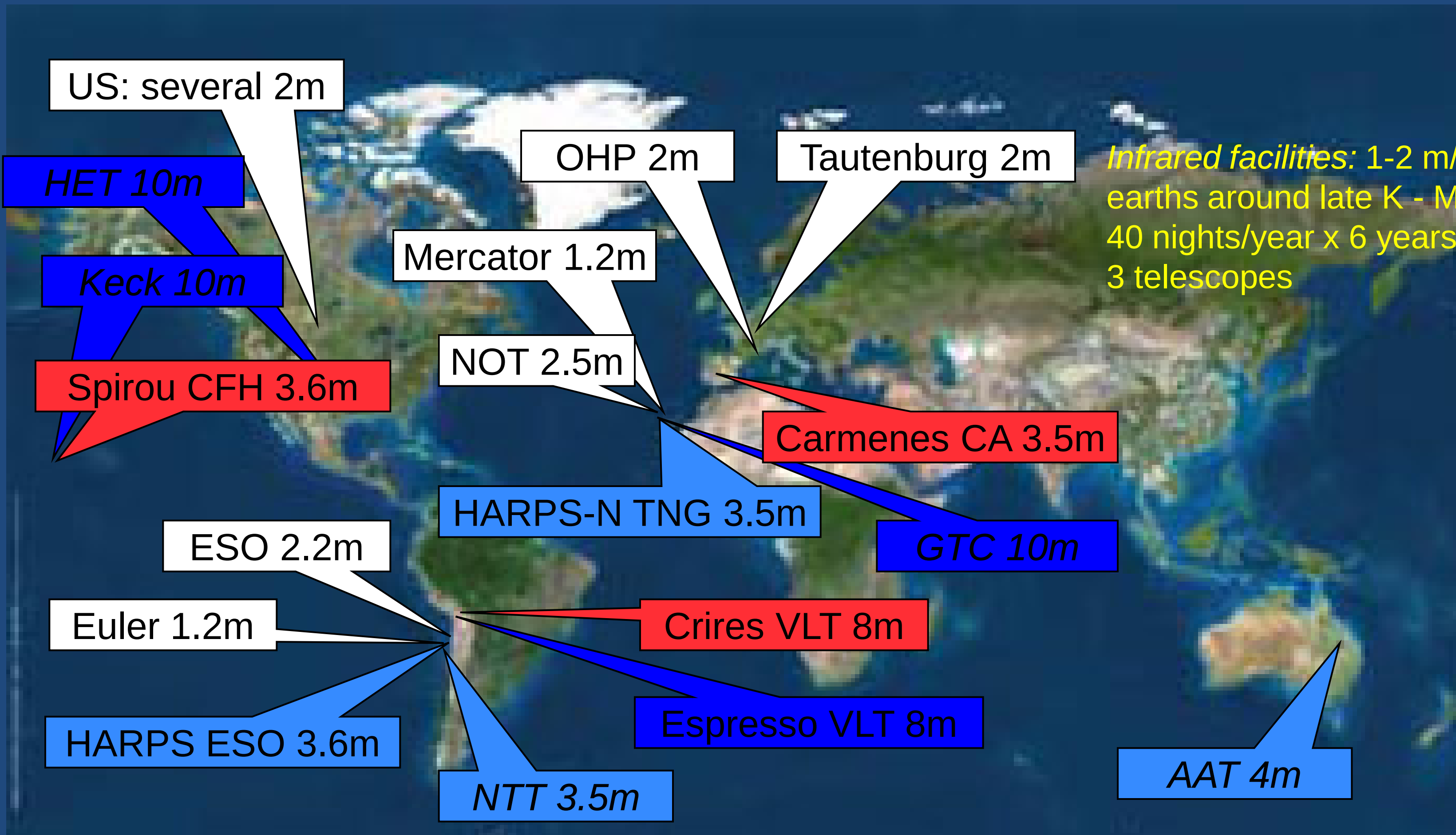
Observation strategy and sky coverage

1. two long pointings : 3 years or 2 years
2. « step&stare » phase (1 or 2 years) : *N* fields 2-5 months each



~ 50% of the sky !

Organization of Groundbased follow-up



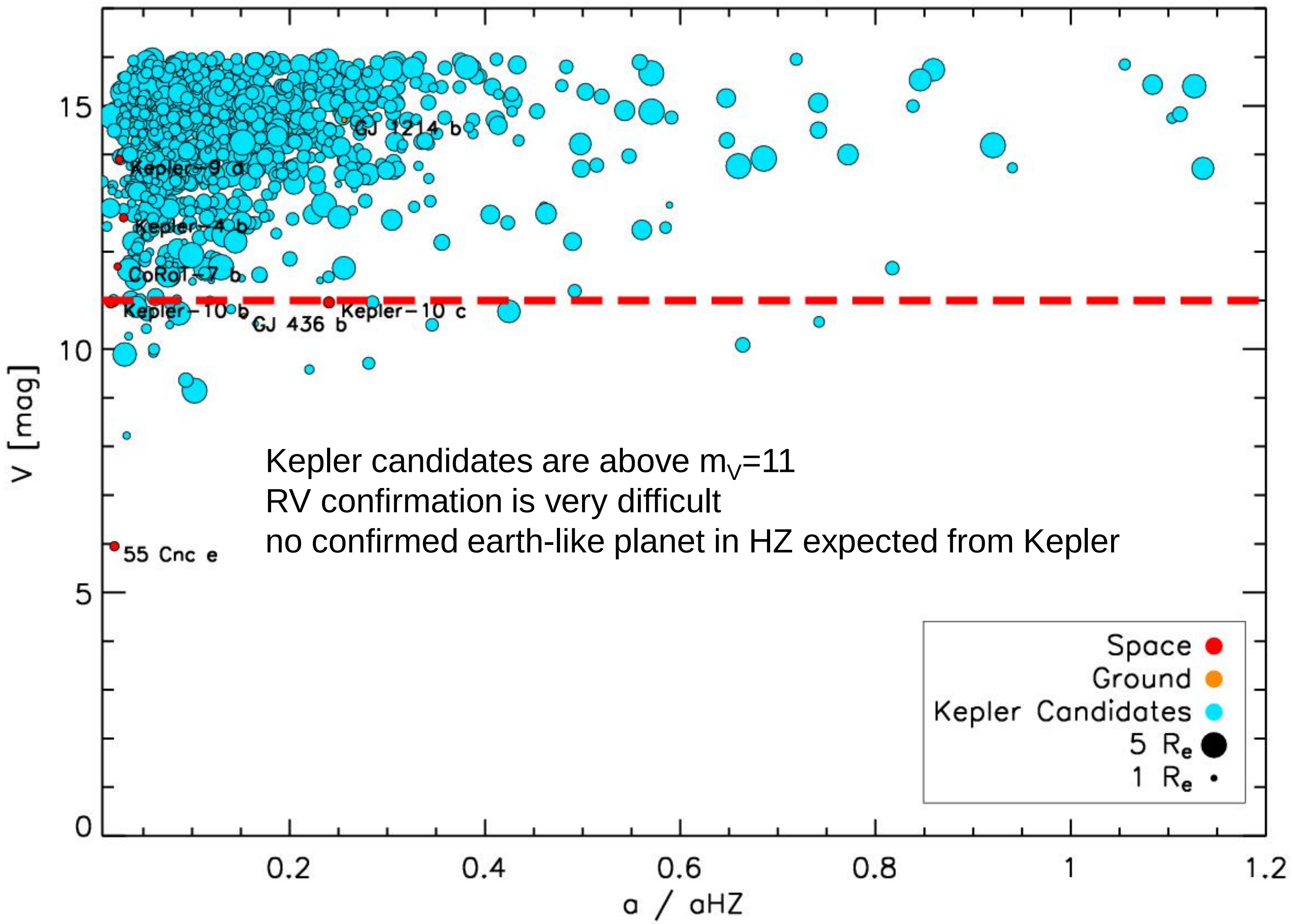
Infrared facilities: 1-2 m/s
earths around late K - M dwarfs
40 nights/year x 6 years
3 telescopes

1-2m-class telescopes: 3-10m/s
giant planets on short/medium orbits
100 nights/year x 6 years
6 telescopes

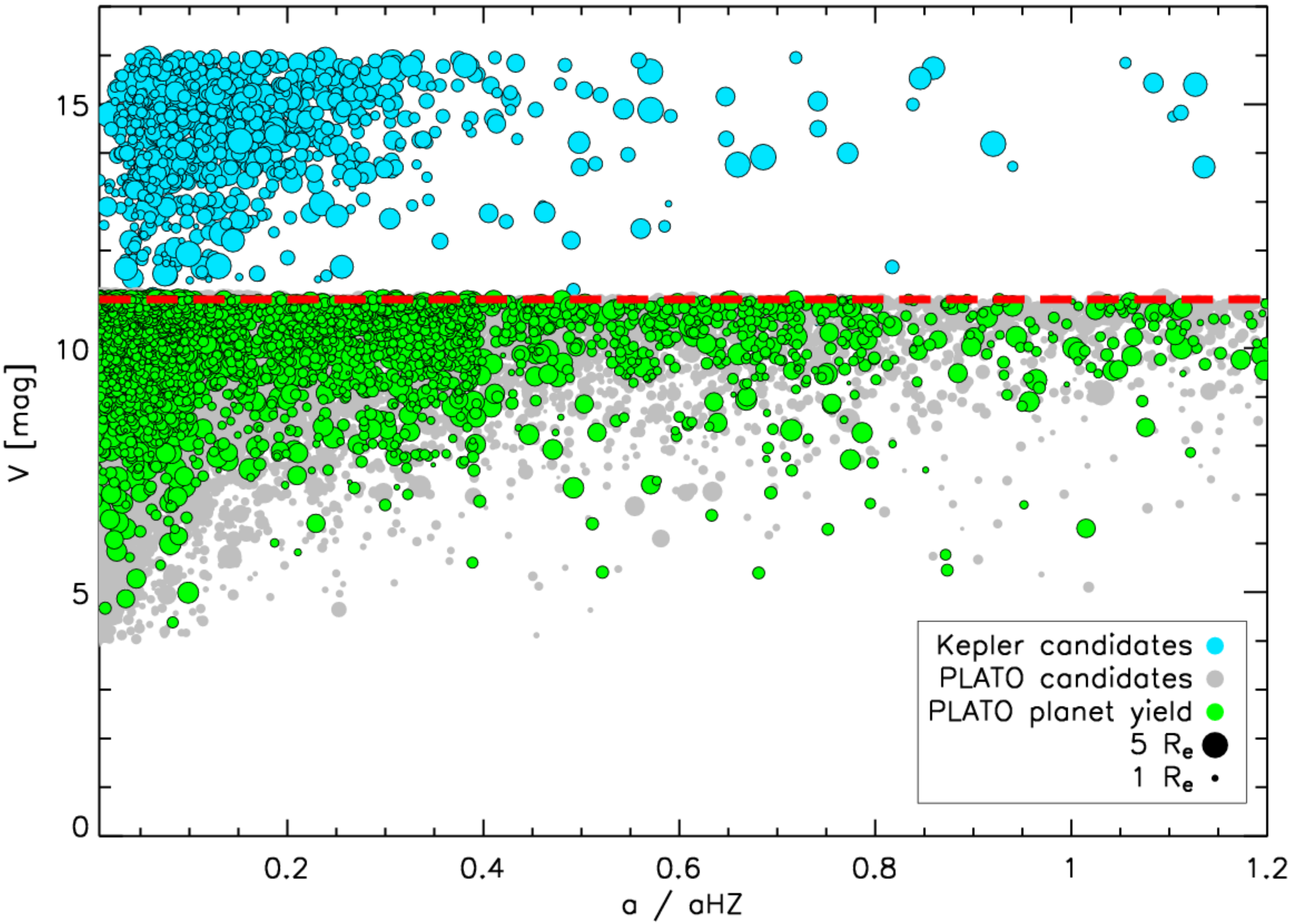
4m-class telescopes: 1-2 m/s
giant planets on long orbits
super-earths on short/medium orbits
100 nights/year x 6 years
4 telescopes

8m-class telescopes: < 50cm/s
super-earths on long orbits,
earths on short/medium orbits
earths on long orbits @ brightest stars
40 nights/year x 6 years
1 telescope

Current transiting planet findings

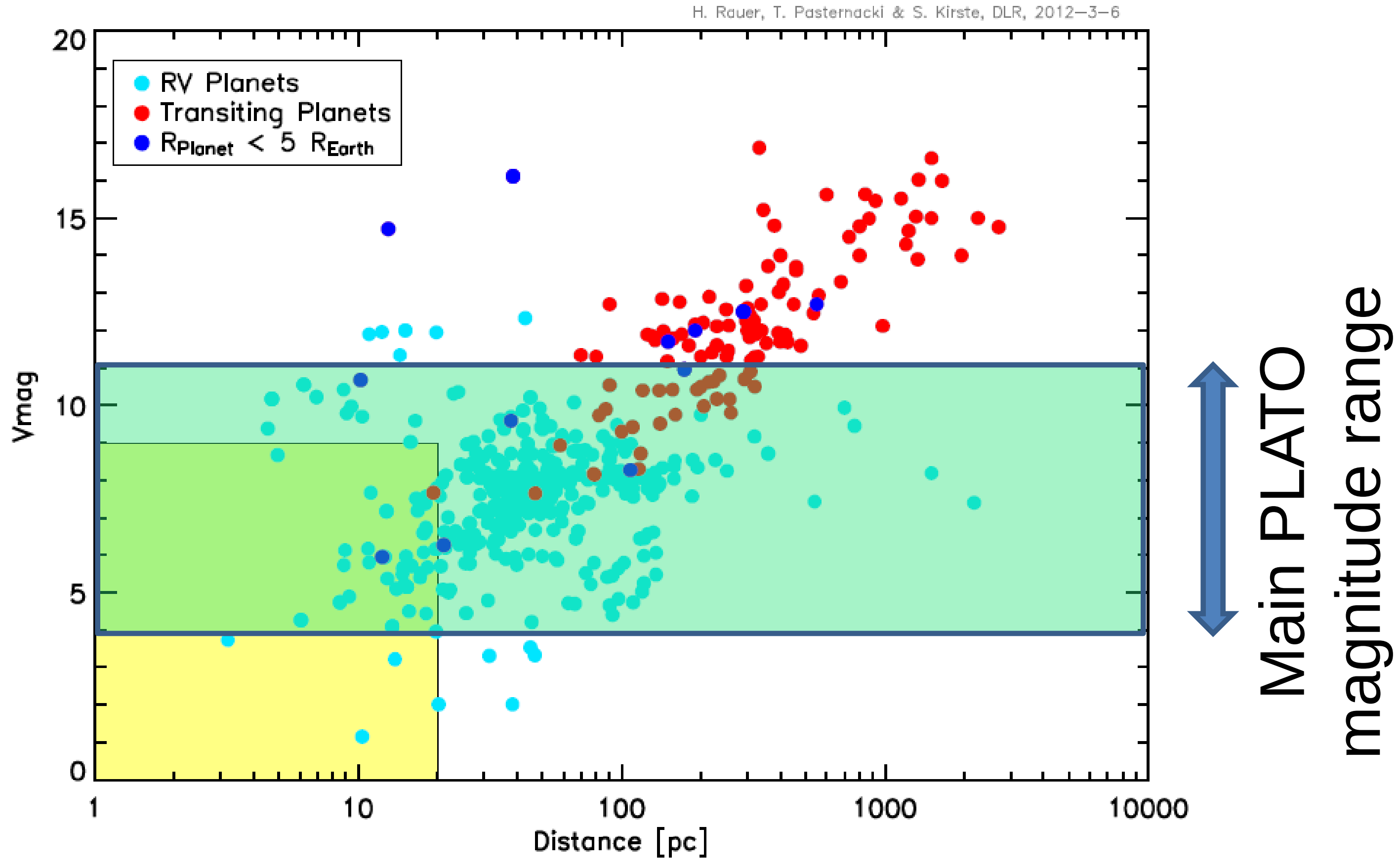


PLATO planets versus current transiting planet findings



PLATO will provide a large sample of terrestrial planets, down to Earth size, with highly accurate mass and radius around bright stars up to the habitable zone.

Magnitude range of PLATO planets



The PLATO legacy

- a huge sample of characterized planets with known mass, radius and age, including terrestrial planets in the HZ of solar-like stars
- planets surrounding stars bright enough for detailed follow-up

→ **pioneers true comparative planotology and taxonomy of planet systems**

A huge complementary science program:

- 1,000,000 of high-precision photometric stellar lightcurves
- 85,000 of these stars will allow for astroseismic characterization
- in synergy with Gaia: mass, age, rotation, distance, luminosity, radius

→ **a breakthrough in stellar physics** (e.g. stellar structure and evolution, internal mixing processes, stellar rotation, ages of globular clusters, young open clusters)

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