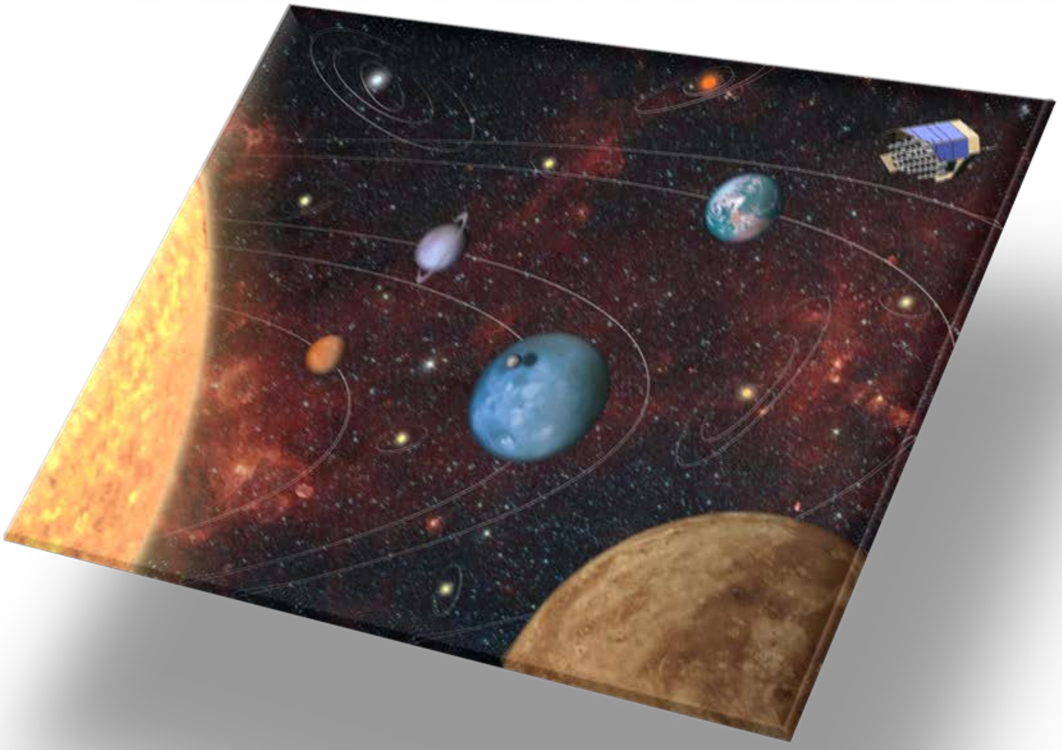
The Mission PLATO 2.0

(PLAnetary Transits and Oscillations of stars)



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and the PLATO 2.0 Team

PLATO 2.0 Scientific Motivation

PLATO Objectives:

- Characterize planets for their density and age to explore planet diversity and:
    - detect and characterize terrestrial planets in the habitable zone
    - constrain planet formation and evolution processes
- Stellar science
- Complementary science

The Method

Characterize bulk planet parameters

Accuracy around solar-like stars for PLATO 2.0:

- Radius (~2%)
- Mass (~10%)
- Age (~10%)

For bright stars (4 – 11(13) mag)

The PLATO mission has two elements:

- Photometry from space
- Spectroscopy from gound

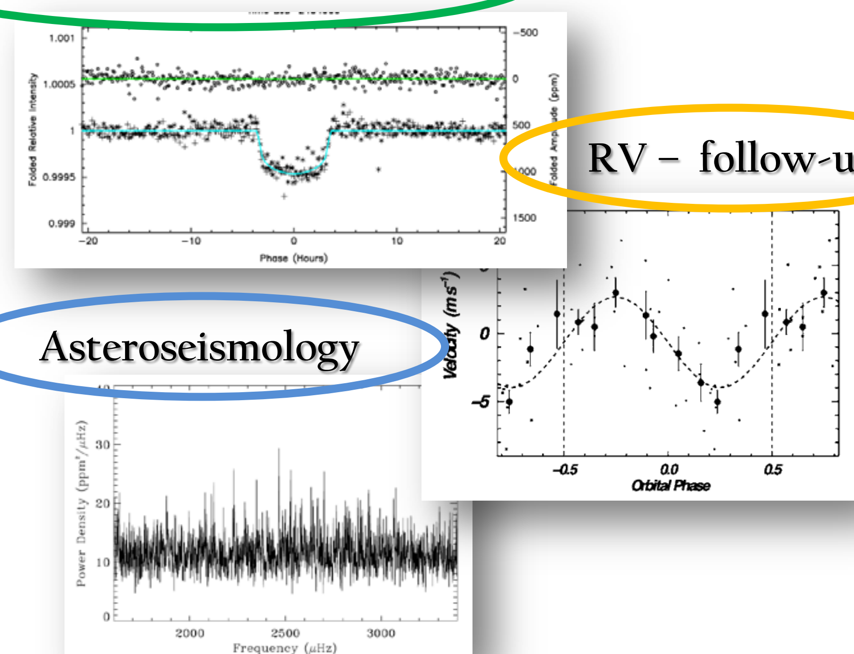
Techniques

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

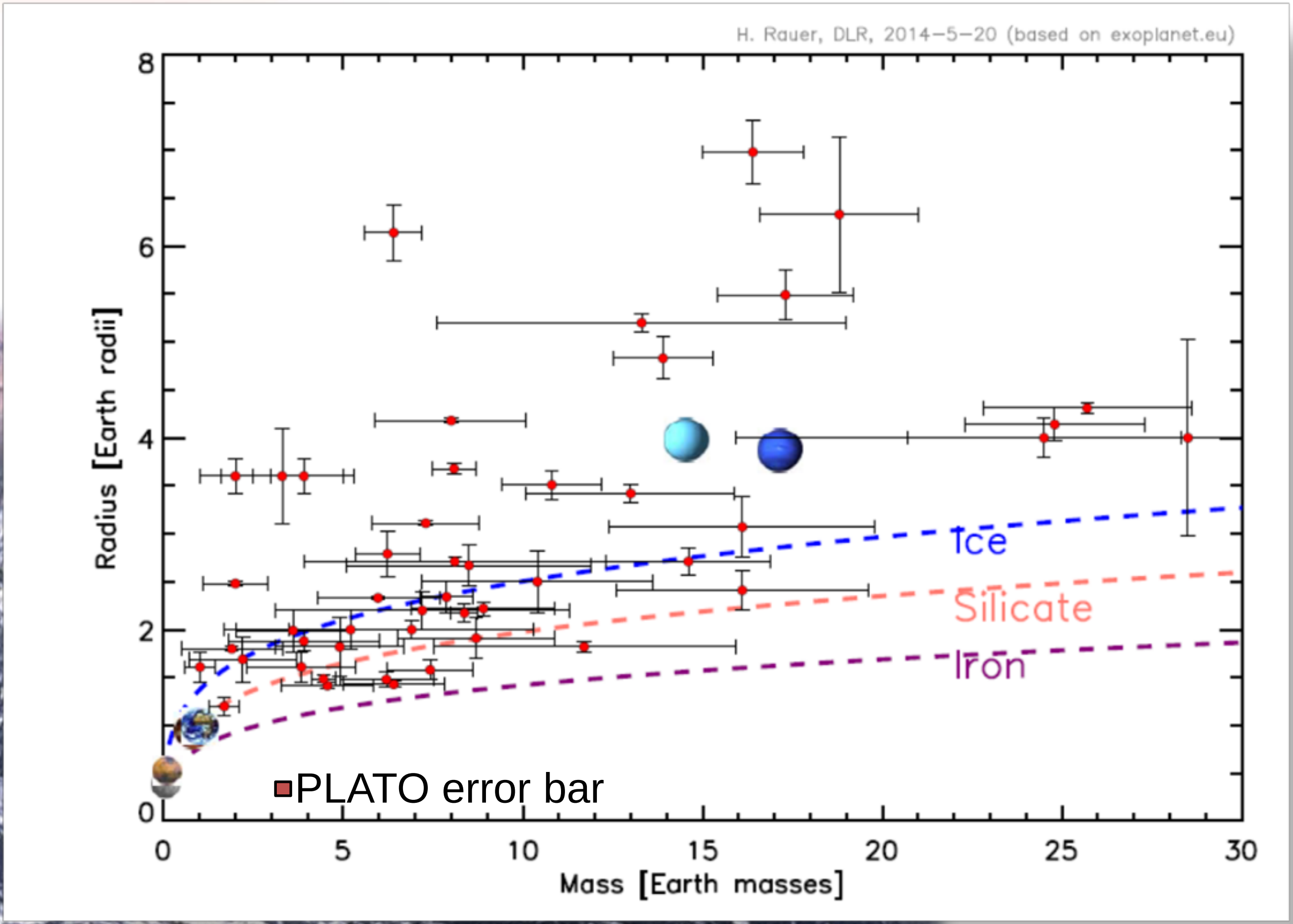
Photometric transit

RV – follow-up

Asteroseismology



Diversity of „super-Earths"



Status:

- Large diversity in masses and radii
- Individual planets have large error bars

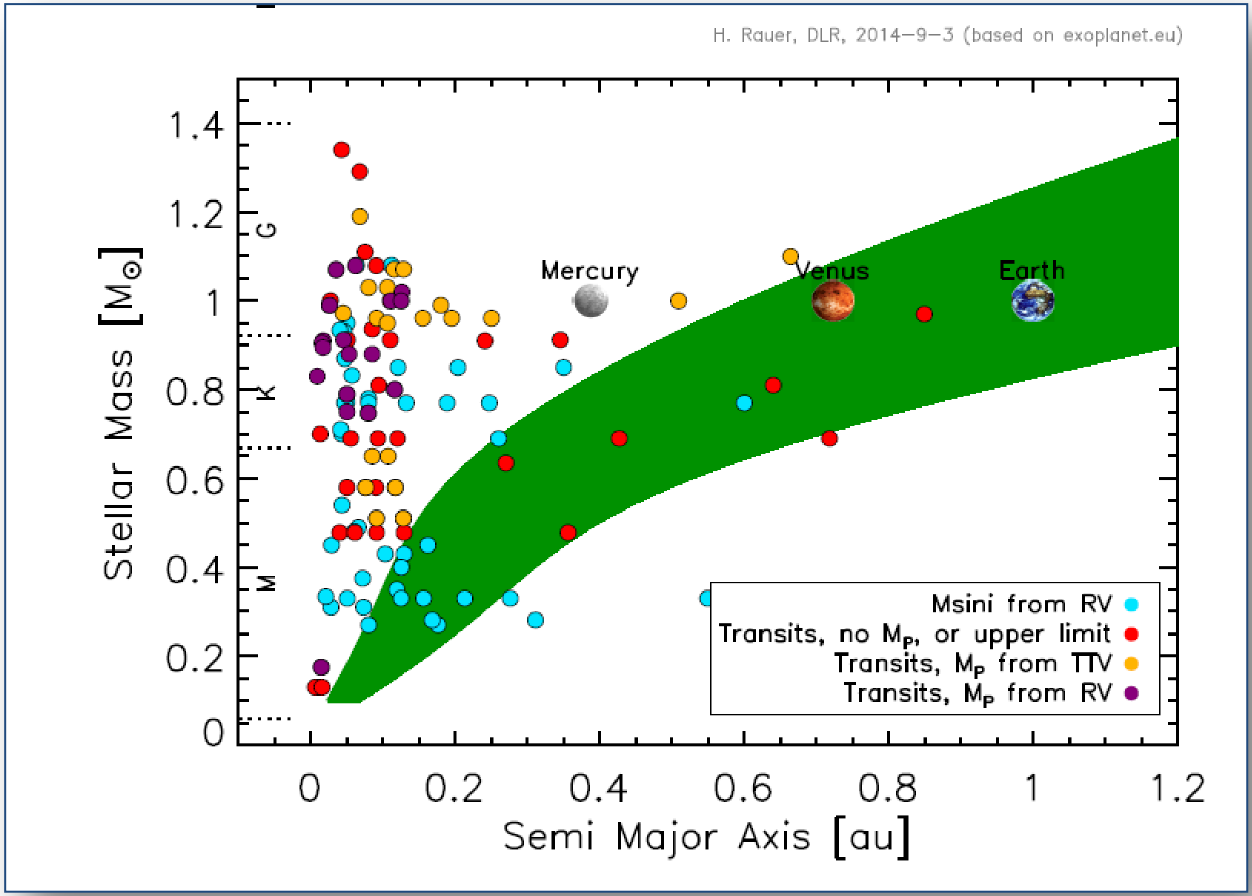
→PLATO goal:

Masses: 10%

Radii: 2%

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

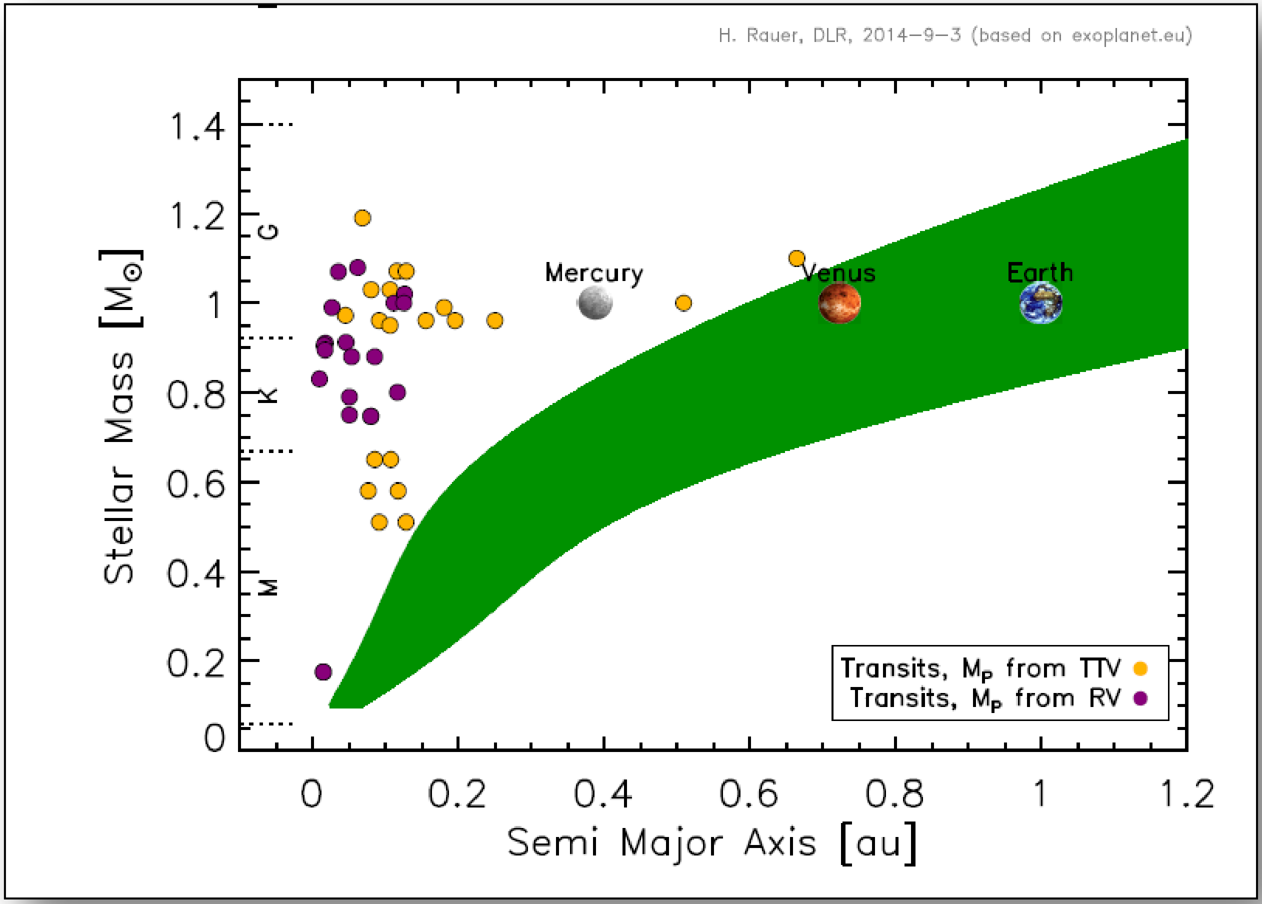
Detected super-Earths



- 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

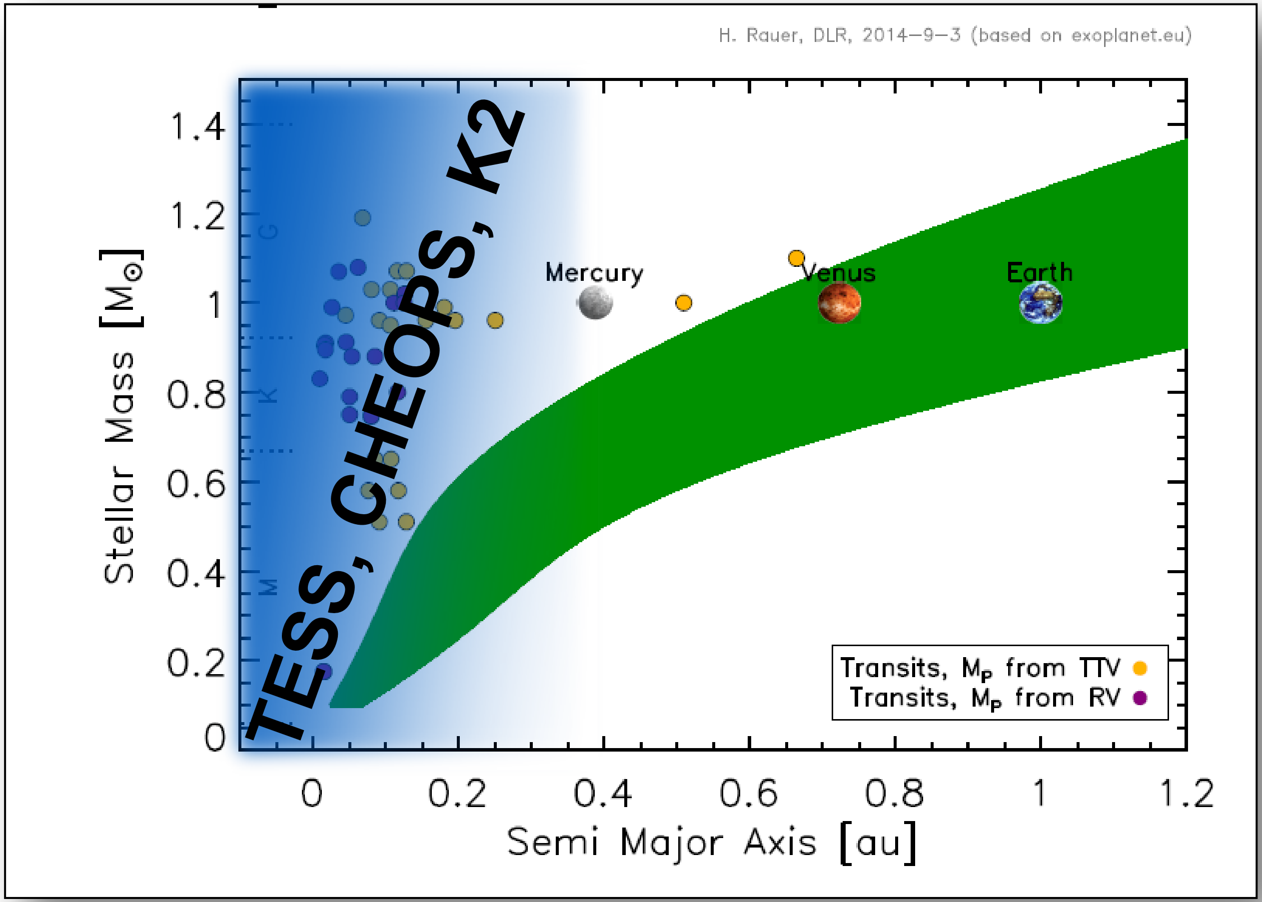
„Super-Earths" with characterized radius and mass



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

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

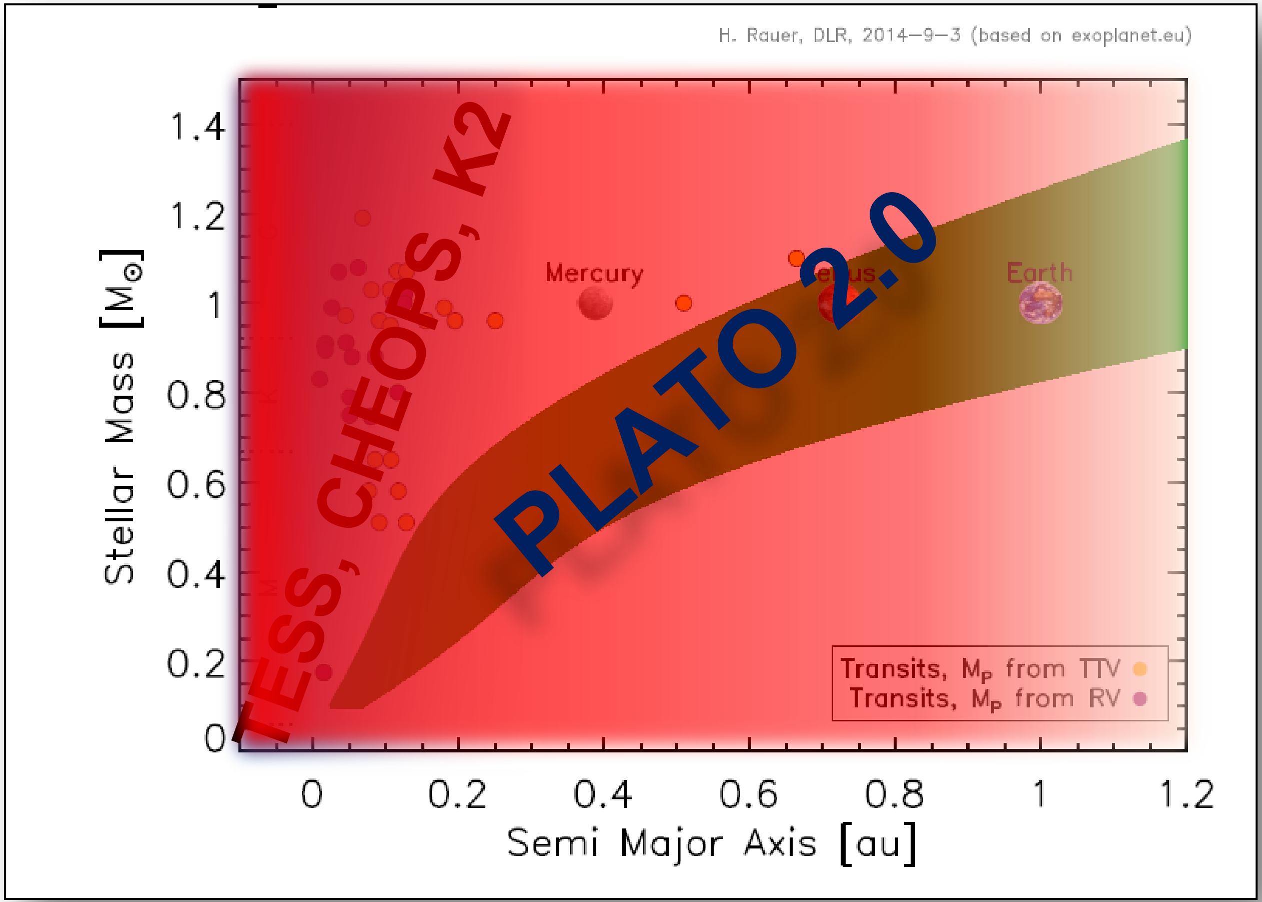
„Super-Earths“ with characterized radius and mass



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

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

„Super-Earths" with characterized radius and mass

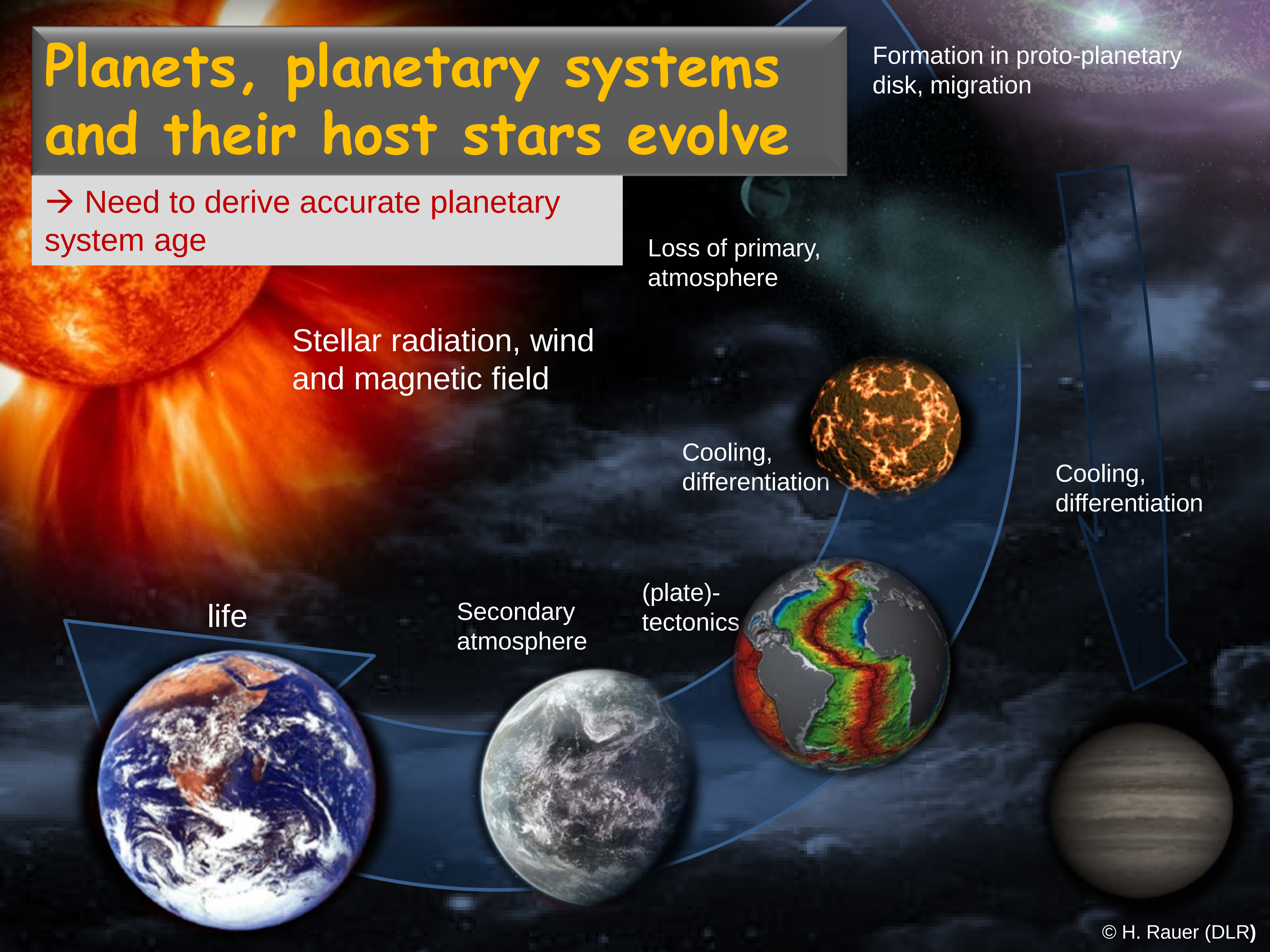


TESS ecliptic poles

- PLATO 2.0 goal: Detect and characterize planets up to the habitable zone of solar-like stars.

Planets, planetary systems and their host stars evolve

→ Need to derive accurate planetary system age



PLATO 2.0: Exoplanets and Stars

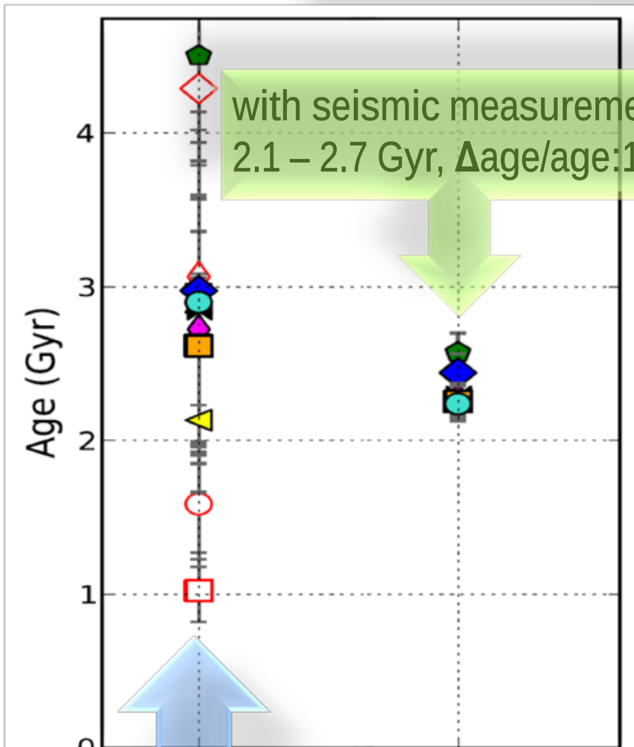
Characterization of exoplanets … needs characterization of stars

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

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

Asteroseismology

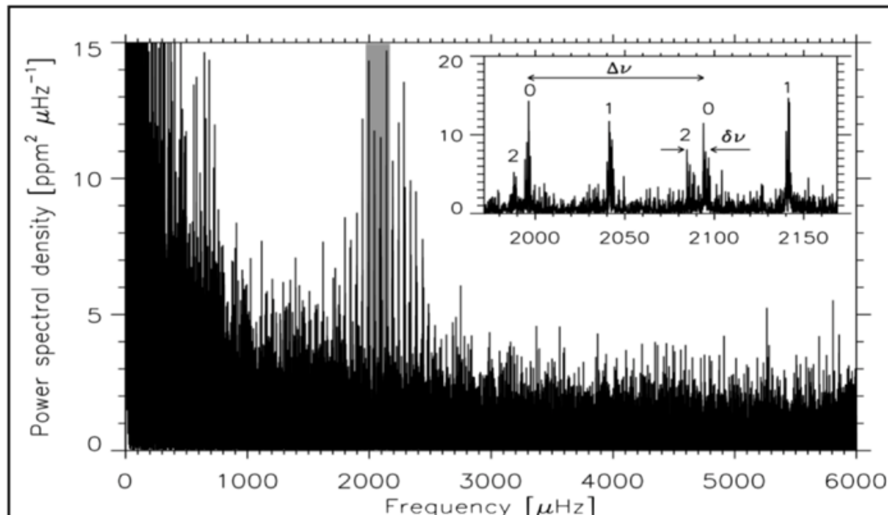
CoRoT and Kepler have demonstrated that the capabilities of asteroseismology



with seismic measurement, 2.1 – 2.7 Gyr, Δage/age:13%

no seismic measurement, 0.8 – 5.9 Gyr, Δage/age: 75%

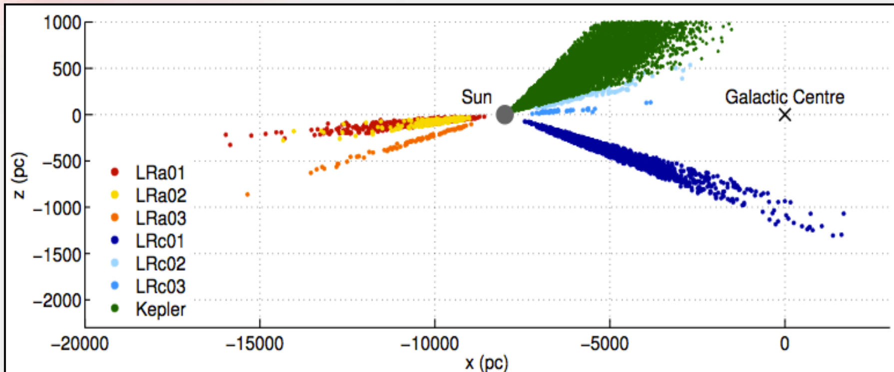
Example: HD 52265 (CoRoT), a G0V type, planet-hosting star, 4 months data



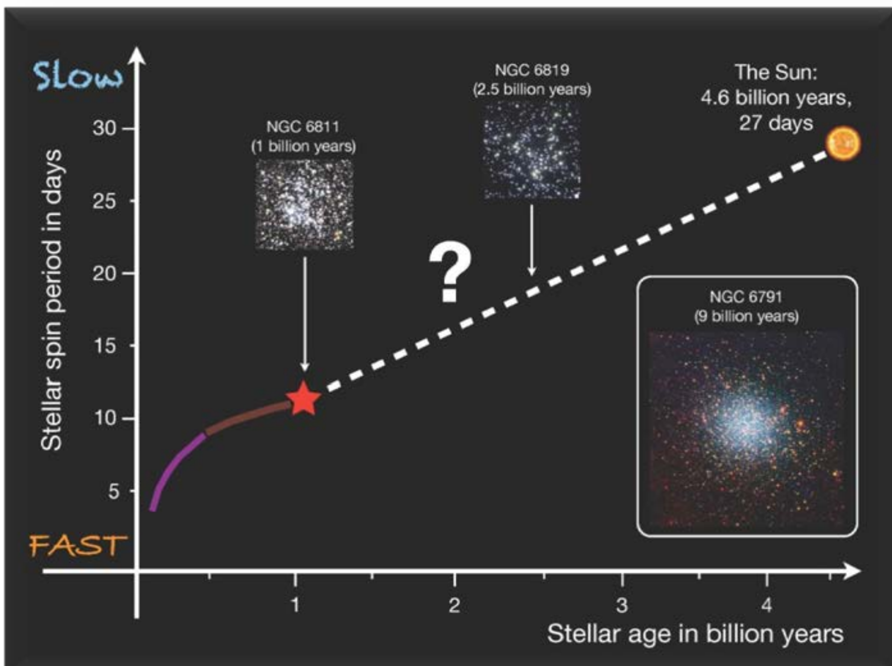
(Gizon et al. 2013)

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

Structure and evolution of the galaxy with PLATO 2.0



Miglio et al. (2013)



Meibom et al. (2011)

- Gyrochronology of stars via age-rotation relationship:
  → seismic age versus rotation period from spots

- PLATO 2.0 & Gaia:
  - seismic + astrometric distances
  - seismic age-metallicity relations for giants

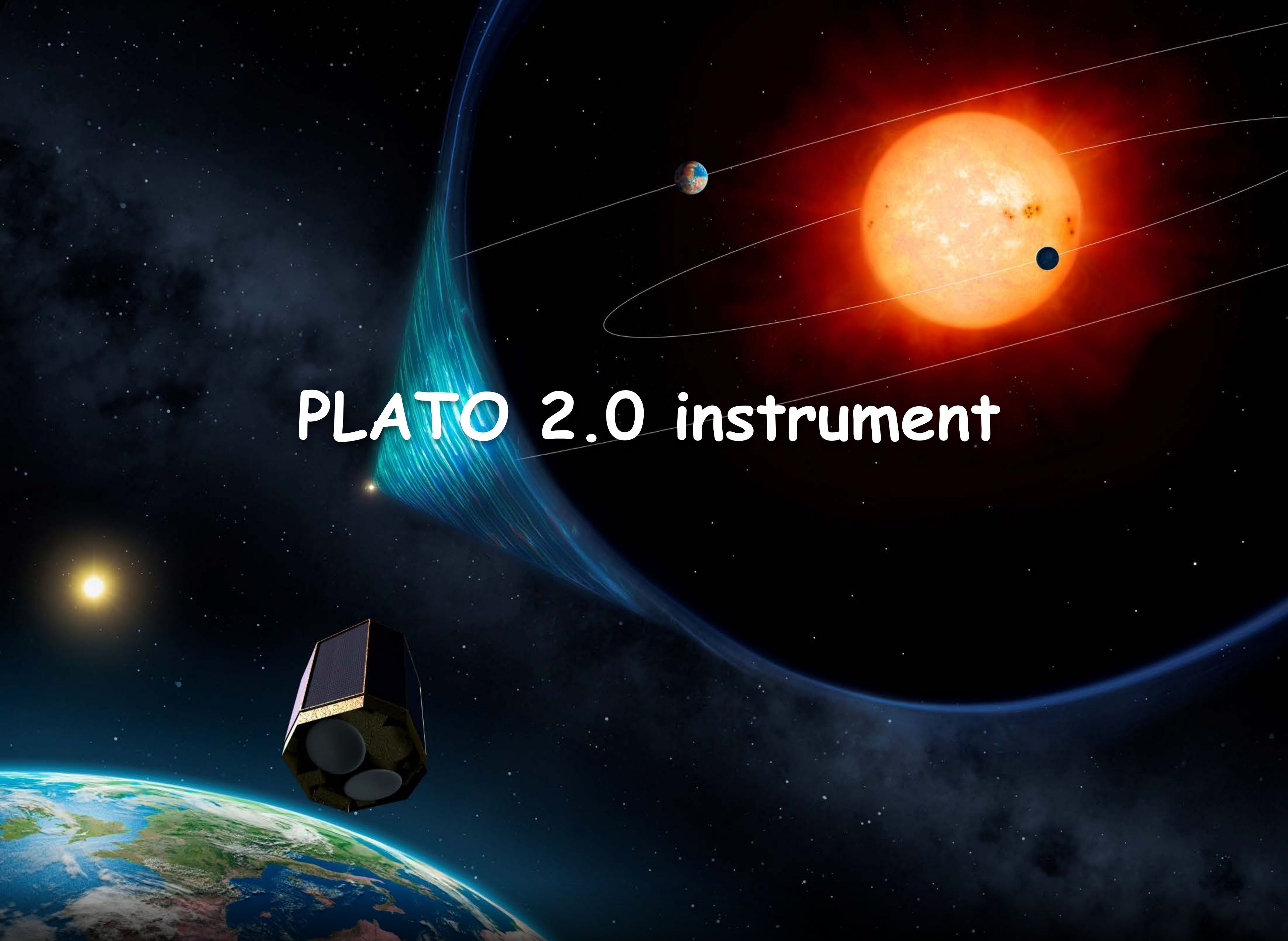
  → Provide accurate ages
  → Calibrate stellar evolution theories
  → Calibrate Galactic age-metallicity relationship

  → Probe the structure and the evolution of our Galaxy

Stellar, Complementary, Guest observer Science

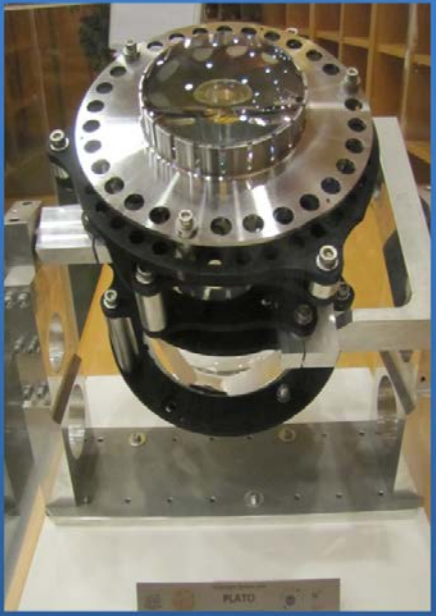
- The core program focusses on getting accurate parameters of exoplanet hosts
- The “core” program includes stellar parameters primarily for main sequence stars (with and without planetary systems) but internal physics of Red Giants is also important in testing models (eg internal rotation).
- Complementary Science – everything to be done with PLATO that is not in the “core” program!
- Complementary Science includes areas such as:
  1) Hot star pulsations
  2) Red giants as tracers of galactic age
  3) CV’s
  4) …
- Complementary science programs will not require re-pointing of the spacecraft or exclusively dedicated observing time. It does not drive the mission design.
- **And: There will be regular calls for guest observer targets!**

PLATO 2.0 instrument



The „normal“ cameras

- 32 „normal“ cameras
- 12cm aperture telescopes
- Operate in “white light”
  (500 – 1050 nm)
- Dynamical range: ~8 ≤ m_V ≤ 13
- Total Field-of-View: ~49°x 49°
- Read-out cadence: 25 sec



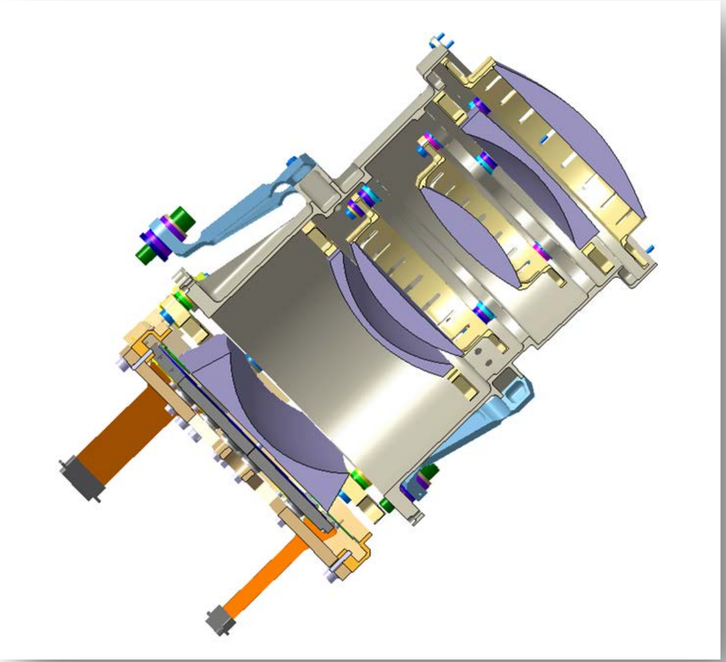
BreadBoard of one PLATO 2.0 Telescope

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

- Lightcurve sampling: 25, 50, 600 sec, depending on stellar sample
- Provide a sample of ~1 000 000 lightcurves over the total mission life time

The „fast“ cameras

- 2 „fast“ cameras
- Each telescope has one broadband filter: one „red“and one „blue“ telescope; exact filter bandpasses are tbd.
- Otherwise optics identicial to nomal cameras
- Purpose:
  - **Fine guiding**
  - Photometry of the brightest stars (<~8 mag)

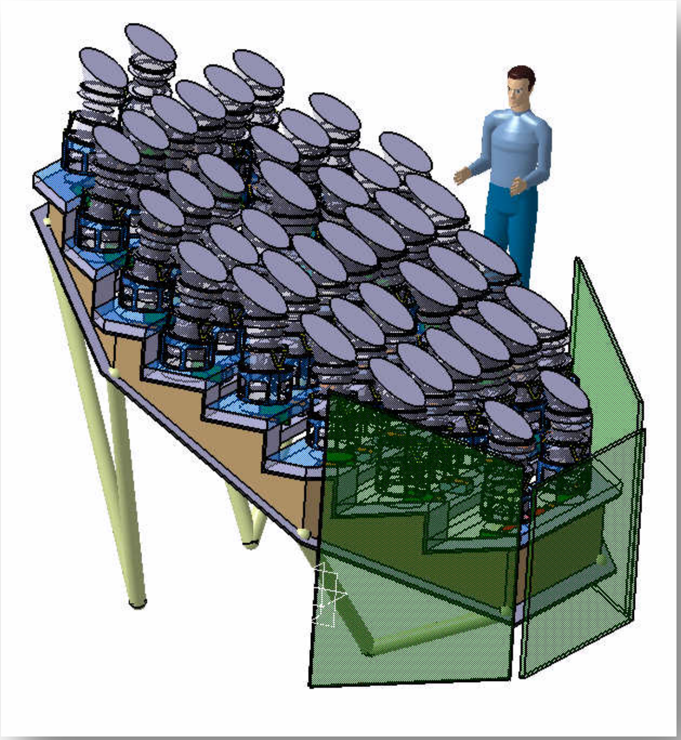


R. Ragazzoni

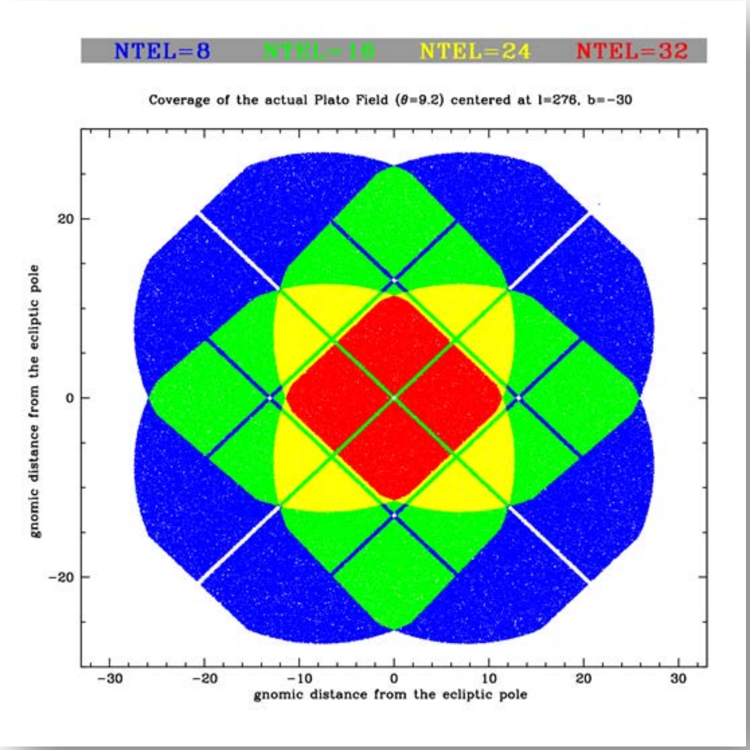
- Read-out cadence: 2.5 sec in frame transfer mode
- Provide a sample of ~400 stars

PLATO 2.0 Instrument

Mounting on optical bench,
Design study (final tbd):



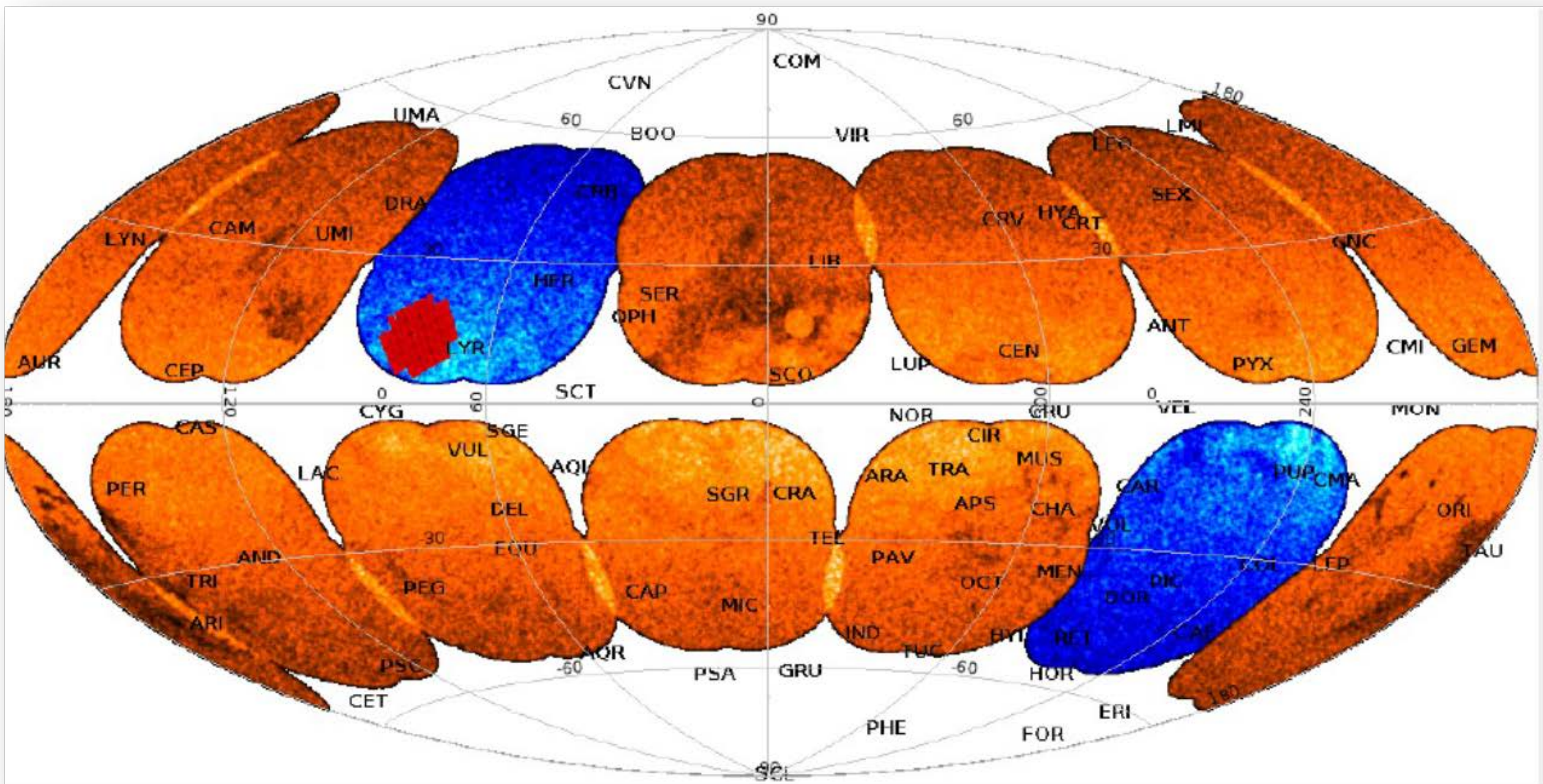
Field-of-view:



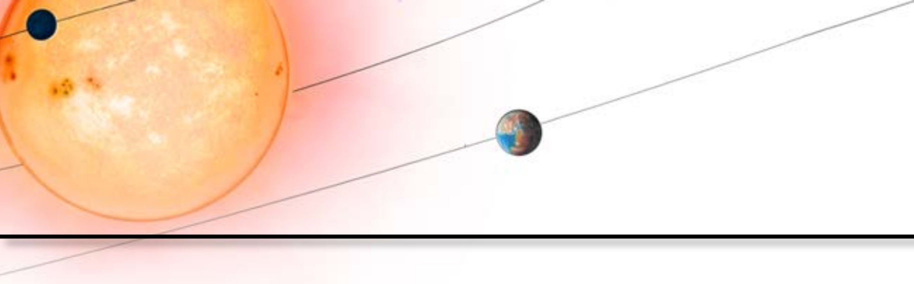
Launch into L2 orbit foreseen in spring 2024.

PLATO 2.0 Sky

- A baseline observing strategy has been defined for mission design:
  - 6 years nominal science operation:
    - 2 long pointings of 2-3 years
    - step-and-stare phase (2-5 months per pointing)
- The final observing strategy will be fixed ~3 yrs (tbd) before launch.



V. Nascimbeni, GP. Piotto



Total Stellar Samples requirements

long pointings	step & stare	mag	Noise in central field	spectral type
P1: 20 000 stars	P1: 66000 stars	V<11	34 ppm	F5/K7
P2: 1 000 stars	P3: 3 000 stars	V<8	34 ppm	F5/K7
P4: 5 000 stars V<16	5000 stars V<15	V<15 V<16	800 ppm	M
P5*: 245 000 stars	P1: 881000 stars	V<13		F5/K7

(pink box) No requirements; adding these leads to ~1,000,000 lightcurves total

Total Stellar Samples requirements

long pointings	step & stare	mag	Noise in central field	spectral type

P1: 20 000 stars

P2: 1 000 stars

Exoplanet characterization and asteroseismology

P4: 5 000 stars V<16

M dwarf host star sample

P5*: 245 000 stars

Exoplanet statistics and stellar science

No requirements, adding these leads to ~1,000,000 lightcurves total

Latest developments

- Previous design assumed downlink of data using X-band.
- In March 2015 ESA decided that K band should be used.
- This results in an increase of transmitted data volume by factor ~4.

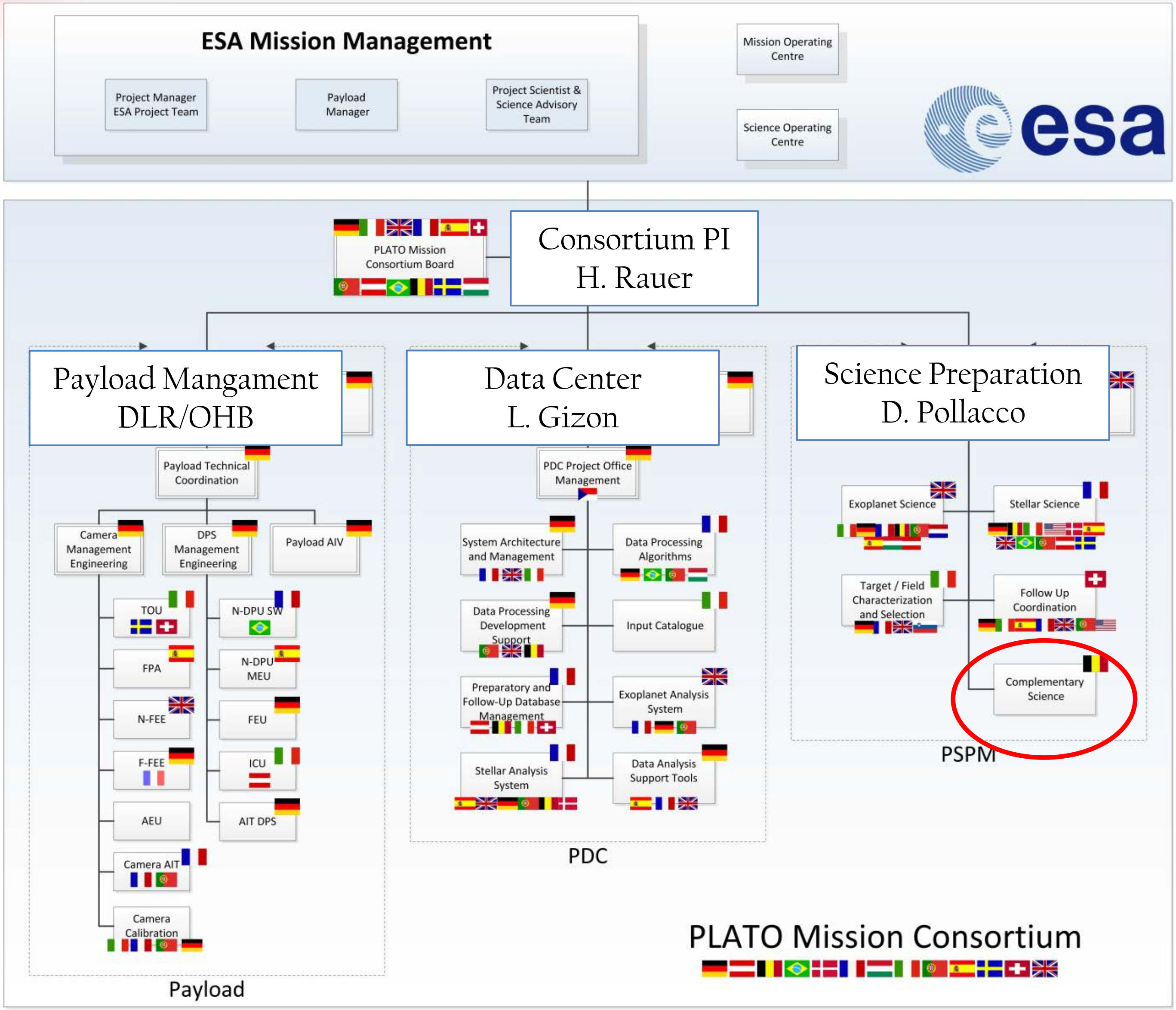
- New telemetry distribution currently under study:
  - → Downlink imagette for P1-P4 samples (full 25sec resolution)
  - → Most P5 sample remains with 600 sec sampling, but for 10% increase to 50 sec sampling after transit alarm
  - → Good budget for guest obser targets

Data products

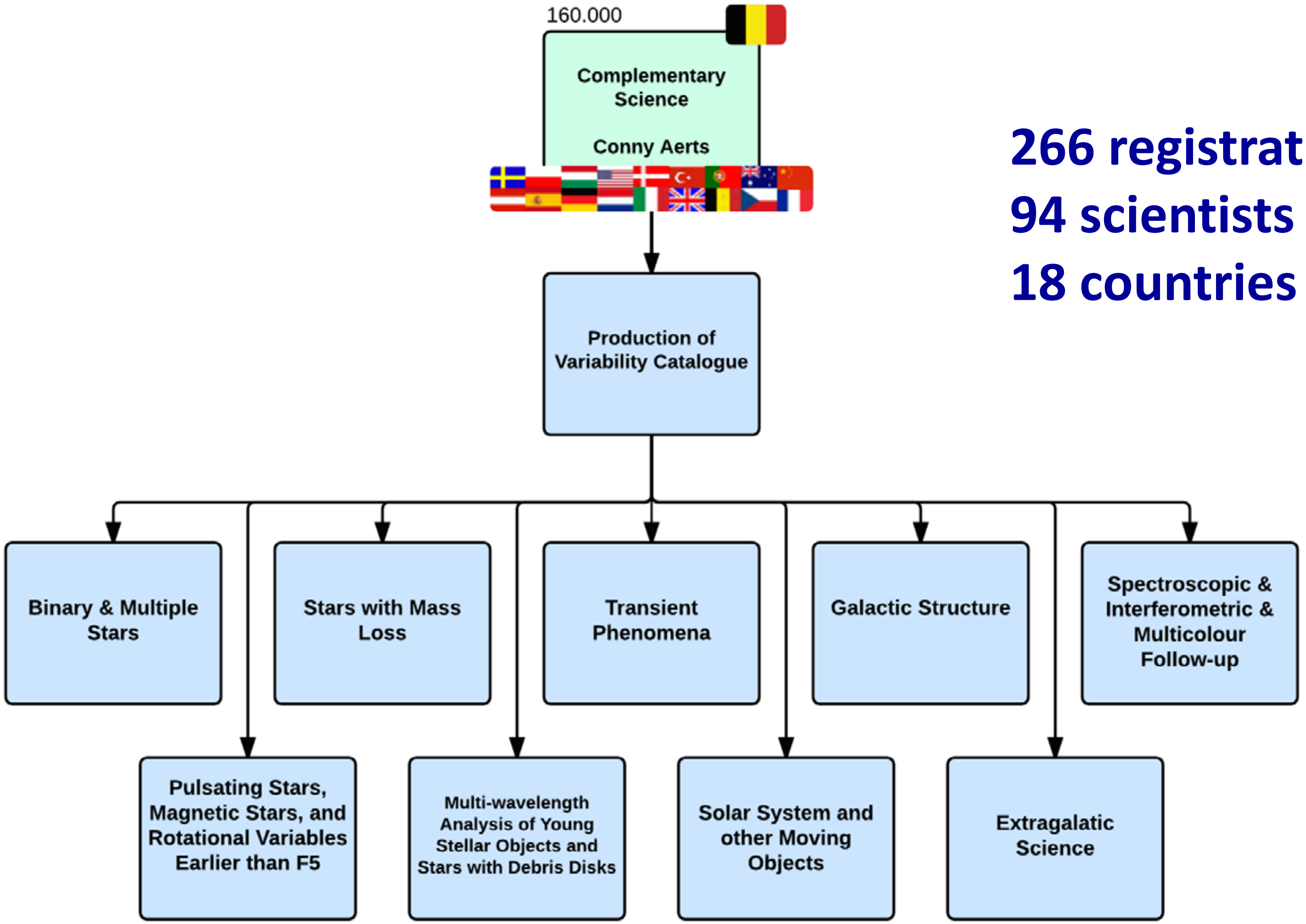
- L0 products: imagettes, lightcurves from 34 telescopes, centroids, house keeping
- L1 products: calibrated lightcurves and centroids
- L2/L3 products: Science results

Calibrated light curves and centroid curves	DP1	L1
Planetary candidate transits & their parameters	DP2	L2
Asteroseismic mode parameters	DP3	L2
Stellar rotation and activity	DP4	L2
Stellar radii, masses and ages	DP5	L2
Confirmed planetary systems and their characteristics	DP6	L3

The PLATO 2.0 Mission Consortium



PLATO Complementary Science



266 registrations
94 scientists
18 countries

Recap of philosophy:

- ✓ **does not drive mission design;** advisory role to optimise integration times (fast cadence!, allow # of faint objects), after field/target selection, colours, telemetry, …
- ✓ **same role in Step-and-Stare phase than long pointings**
- ✓ **GO opportunity occurs in addition to CS**
- ✓ does not have impact on mission cost (i.e., free lance work funded at national level)
- ✓ does (not) have **deliverables at PDC level, but variability catalogue & CS products will be computed** (cf. Kepler/KASC)

PLATO Complementary Science

Suggestion for WP leaders:

https://fys.kuleuven.be/ster/Projects/plato-cs/registration

- ✓ Production of Variability Catalogue (B, Aerts)
- ✓ Binary & Multiple Stars (UK, Southworth)
- ✓ Pulsating Stars Earlier than F5 (B, Aerts)
- ✓ Multi-wavelength Analysis of Young Stellar Objects (AU, Güdel)
- ✓ Solar System and Other Moving Objects (I, ?)
- ✓ Galactic Structure (D, Hekker) (note: overlap with Miglio, Stellar Science)
- ✓ Extragalactic Science (NL)
- ✓ Spectroscopic & Interferometric & Multicolour Follow-up (F,?)
- ✓ Transient Phenomena (NL)
- ✓ Stars with mass loss (Spain)