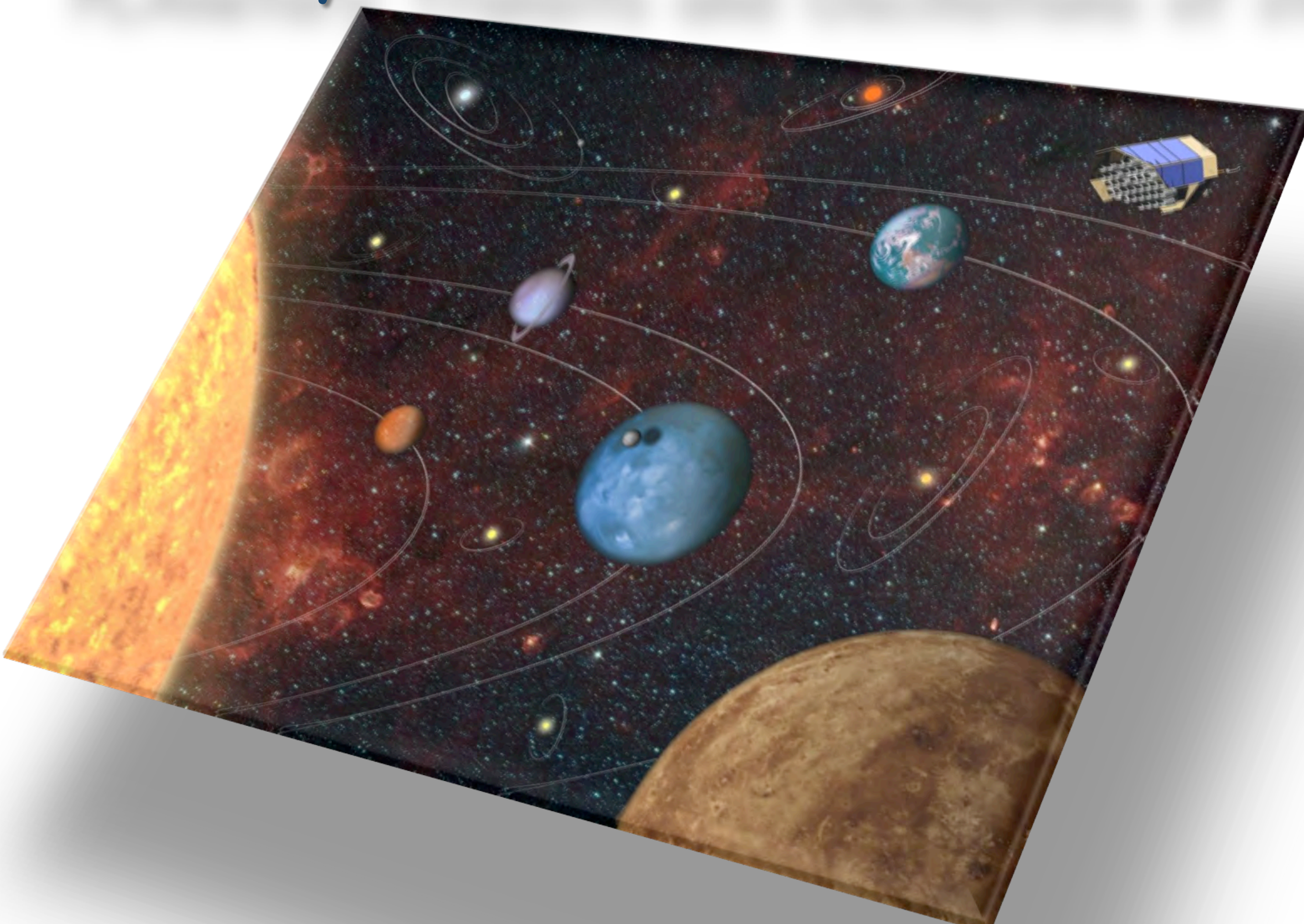
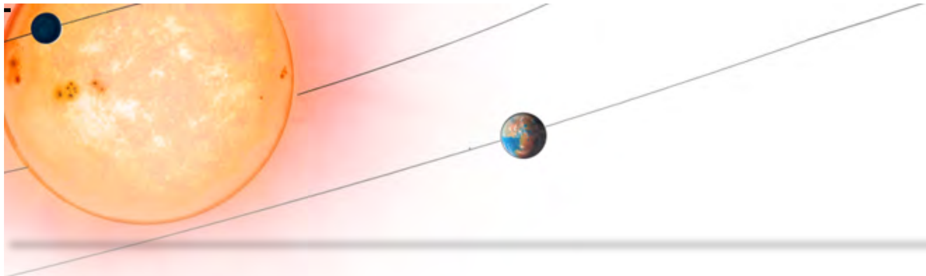
PLATO 2.0

PLAnetary Transits and Oscillations of stars



Heike Rauer (Principal Investigator)
Don Pollacco (Science coordinator)
and the PLATO Team



Outline

- Introduction
- PLATO 2.0 science:
  - Planet diversity and implications for:
    - habitability & life
    - planet formation
    - future research
  - Stellar science
- PLATO 2.0 mission: How we do it

PLATO 2.0 Scientific Motivation

- How do planets and planetary systems form and evolve?
- Is our Solar System special? Is there another system like ours?
- What makes planets habitable?
- Is the Earth unique or has life also developed elsewhere?

<u>**PLATO 2.0 addresses the ESA Cosmic Vision science questions:**</u>

- **What are the conditions for planet formation and the emergence of life?**
- **How does the Solar System work?**

PLATO 2.0 follows the recommendation of ESA's Exoplanet Roadmap Advisory Team (EPRAT)

PLATO 2.0: Exoplanets and Stars

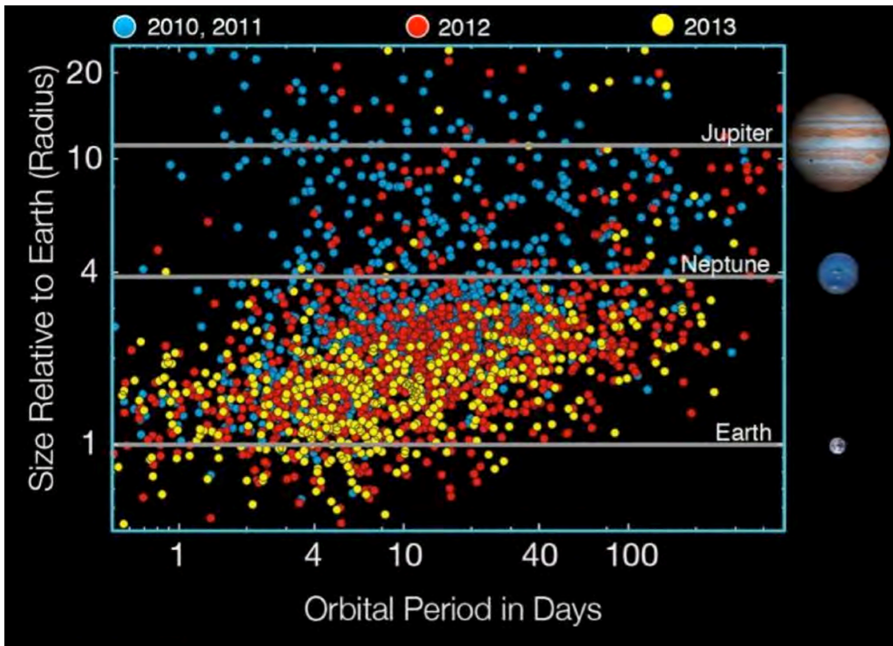
Characterization of exoplanets … needs characterization of stars

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

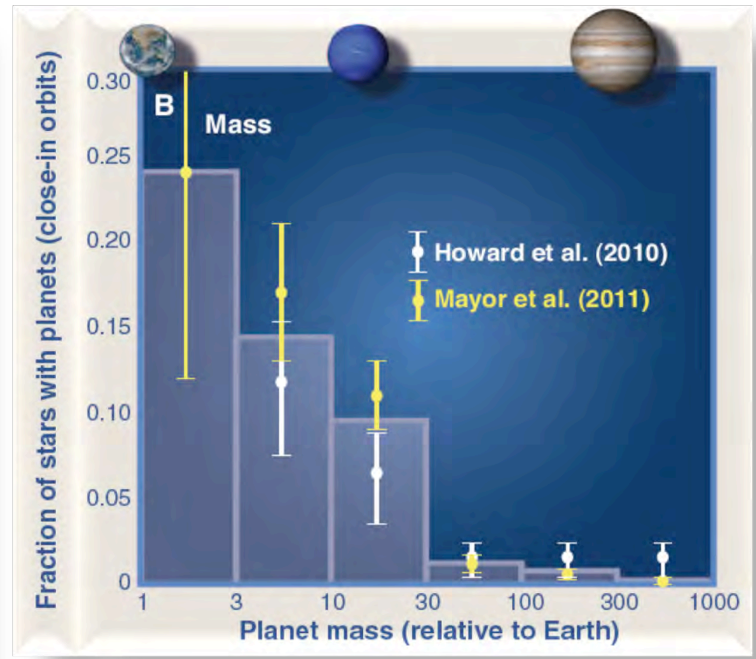
- **Stellar mass, radius**
  (to constrain planet mass, radius)
- **Spectral type, luminosity, activity**
  (planet insolation)
- **Stellar age**
  (defines planet age)

Planet detection today

Kepler planet candidate statistics



Radial velocity surveys

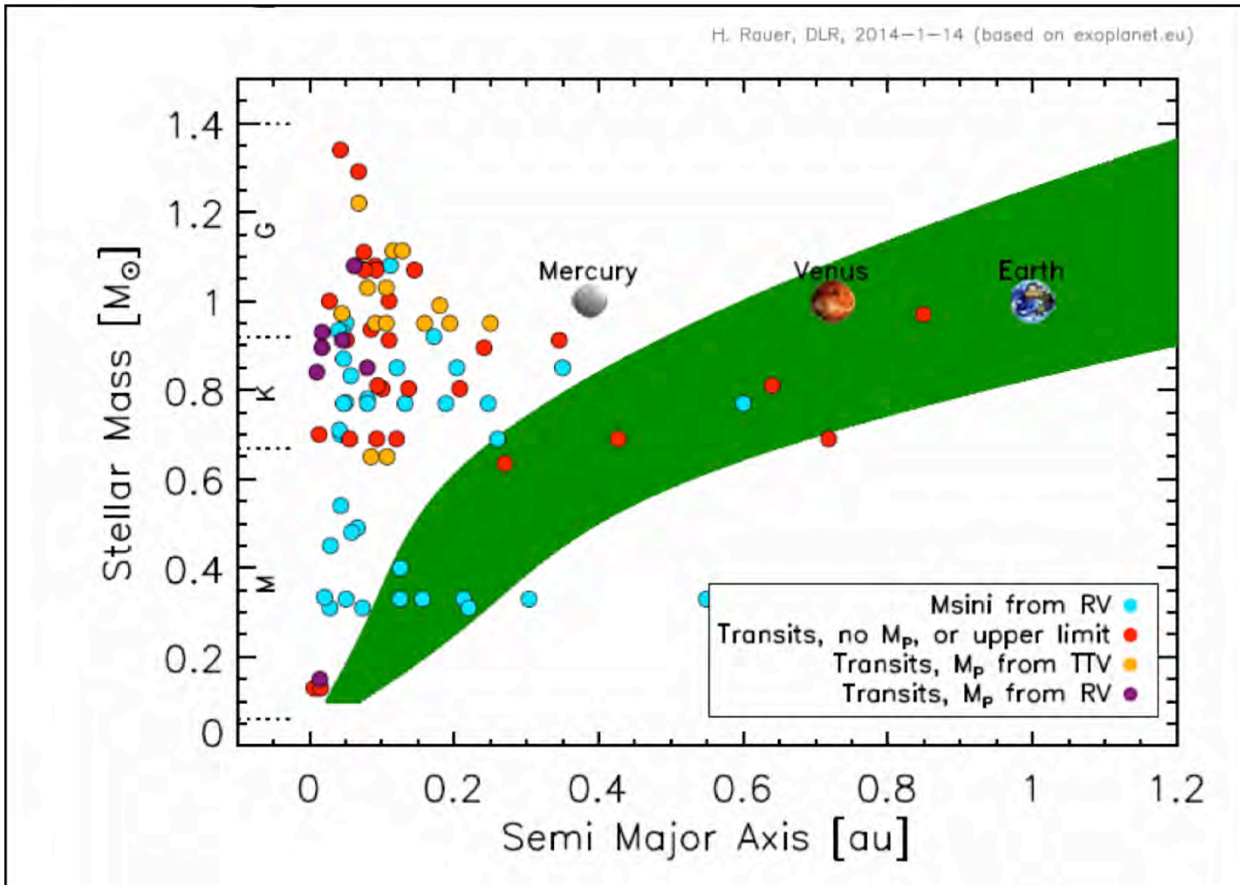


- Current status: ~3000 planet candidates and ~1000 confirmed exoplanets
- *Kepler* mission and radial-velocity surveys → small and low-mass planets are numerous

However, only few detections of Earth-like planets in the habitable zone, and no characterization.

Status: characterized super-Earths in their habitable zones

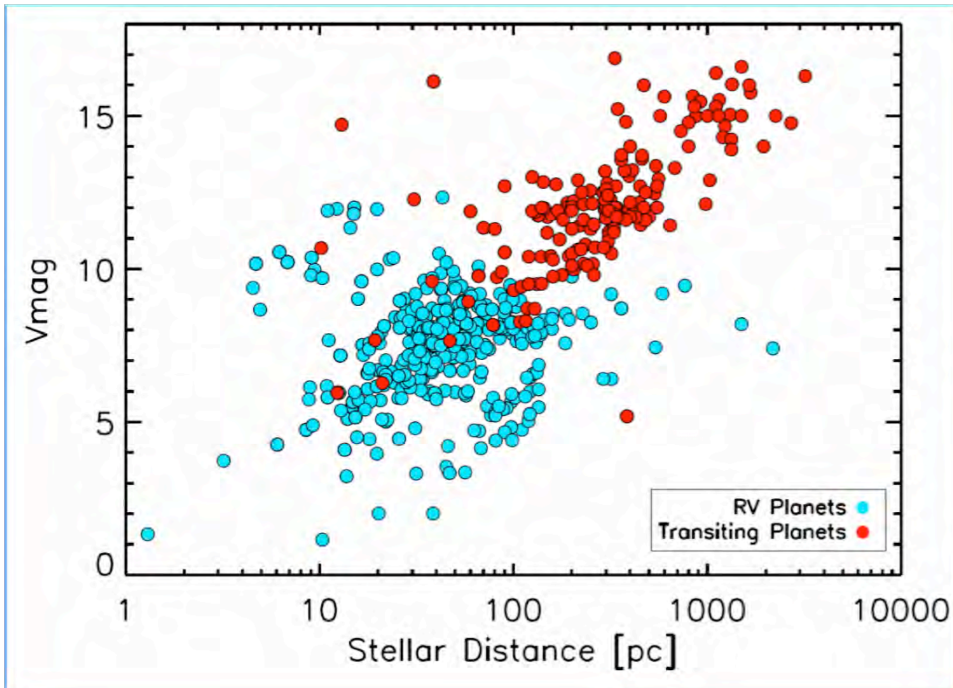
Detected super-Earths



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

The need for bright stars

Known planets from radial-velocity and transit surveys

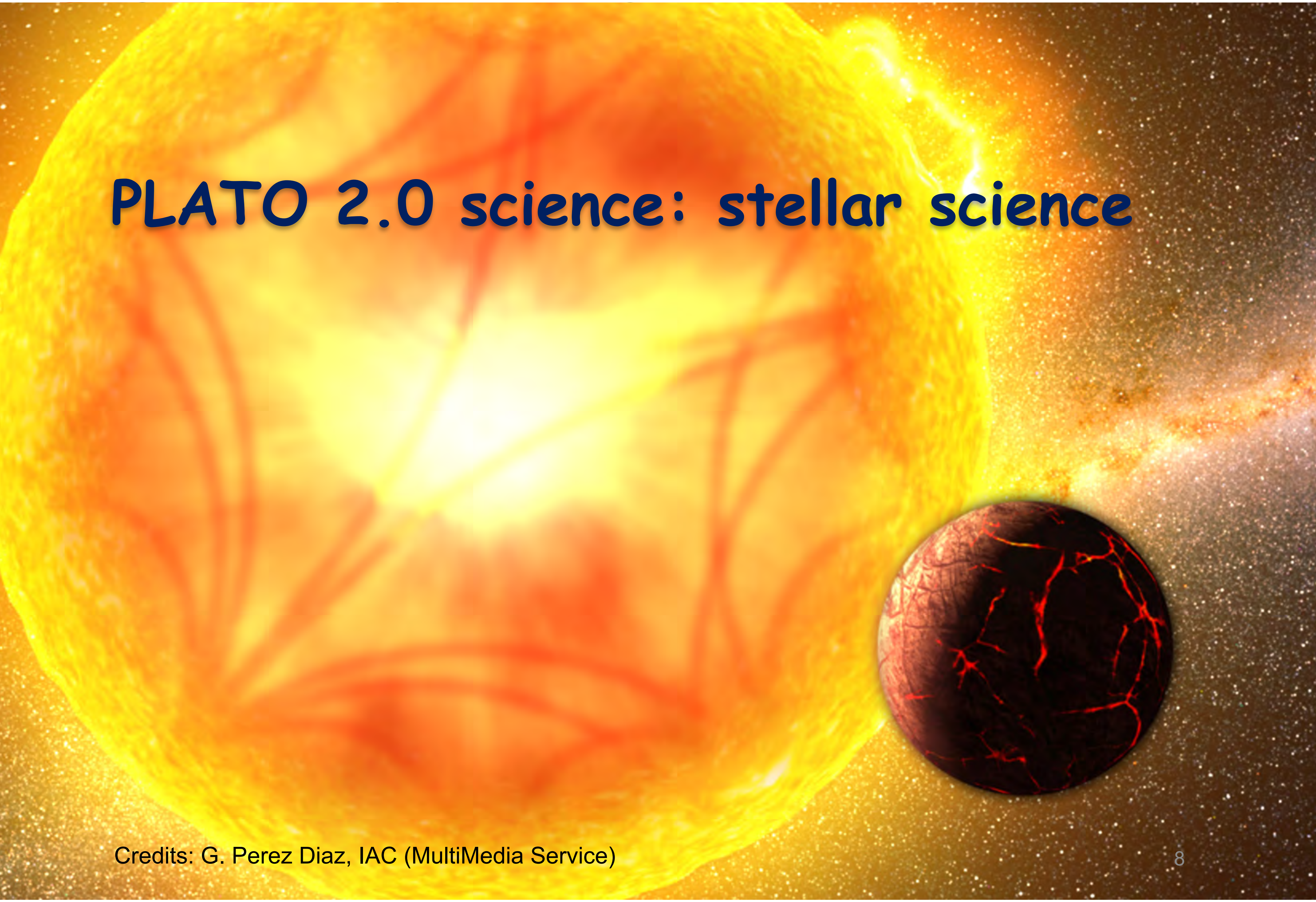


Why have so few small planets been characterized?

→ Transit surveys targeted faint and distant stars to maximize detection performance

Lesson learned:
→ Future transit missions must target bright stars

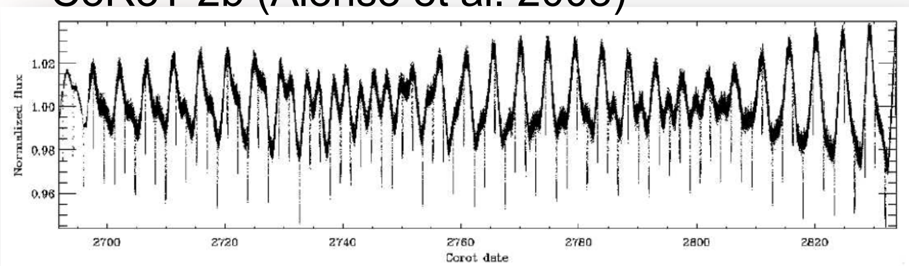
PLATO 2.0 science: stellar science

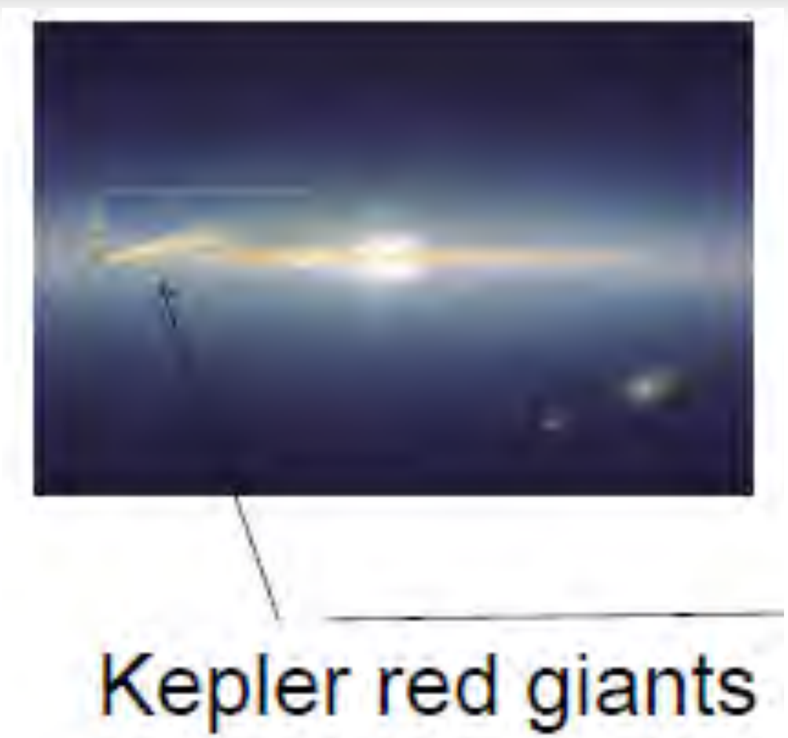


Credits: G. Perez Diaz, IAC (MultiMedia Service)

PLATO 2.0: Stellar science

CoRoT-2b (Alonso et al. 2008)



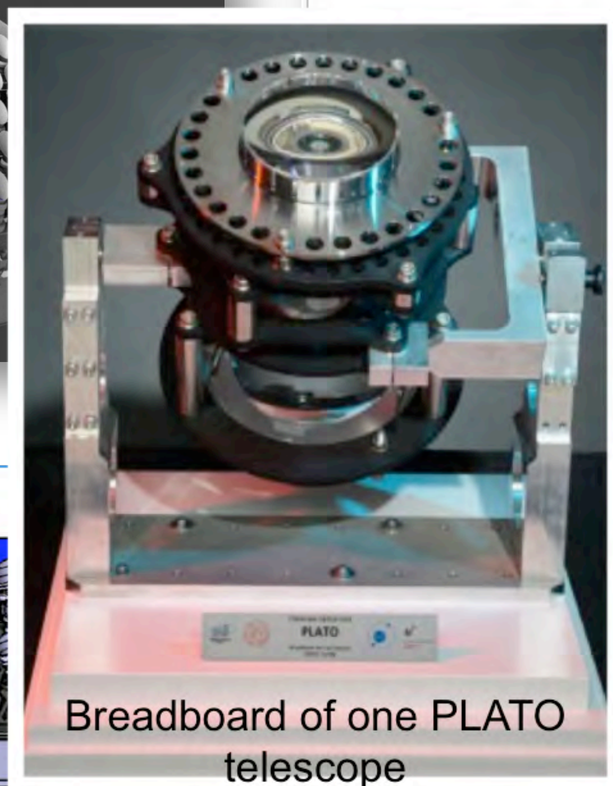


- 1 000 000 accurate photometric stellar lightcurves (from 3 months to 3 years)
  → Stellar variability of all kinds, down to micro-variability
- 85 000 stars with asteroseismology, including 22 000 stars with very high accuracy (2-3years)
  - → Accurate masses
  - → Accurate ages
- Advance stellar physics
- Investigate special regions:
  - → Clusters, young stars, …
  - → Exploration: find the unexpected

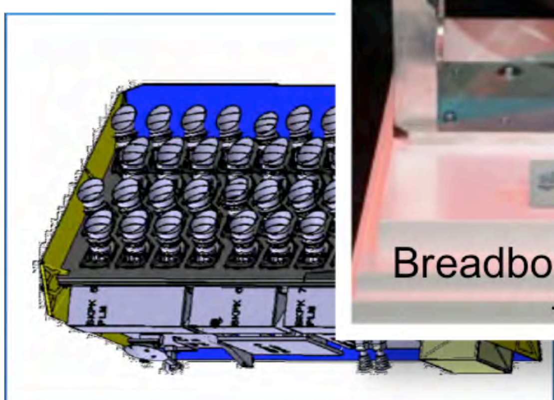

PLATO 2.0 mission: How we do it
Image Copyright: Mark A. Garlick. Science Credit: Carole Haswell & Andrew Norton (The Open University)

PLATO instrument

Two designs studied:



Breadboard of one PLATO telescope

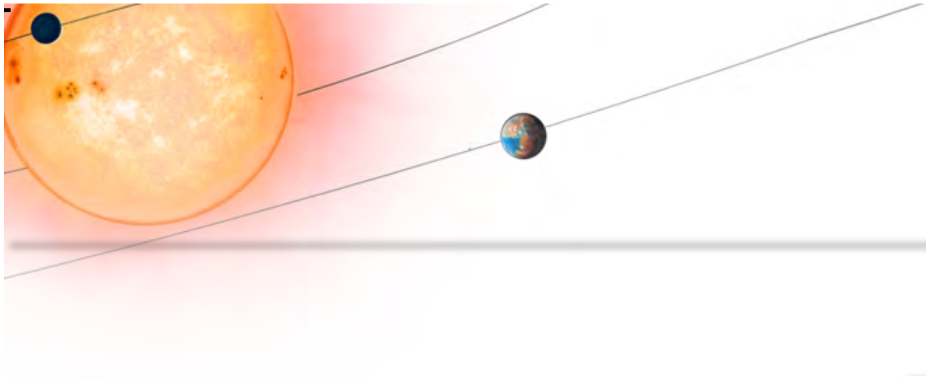


Multi-telescope approach gives:

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

- Cameras are in groups
- Offset to increase FoV

- 2cm cameras, cadence 25 s, white light
- n cameras, cadence 2.5 s, 2 colours
- dynamical range: $4 \leq m_V \leq 16$
- L2 orbit
- Nominal mission duration: 6 years
- Field-of-View: 48.5° x 48.5°



The Method

Characterize bulk planet parameters

Accuracy around solar-like star:

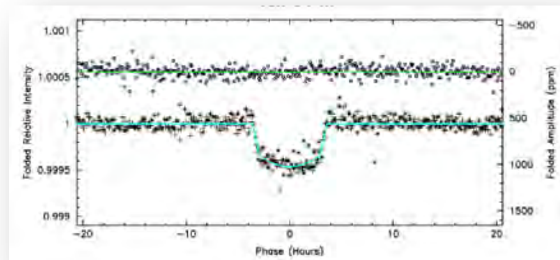
- radius ~2%
- mass ~10%
- age known to 10%

For bright stars (4 – 11 mag)

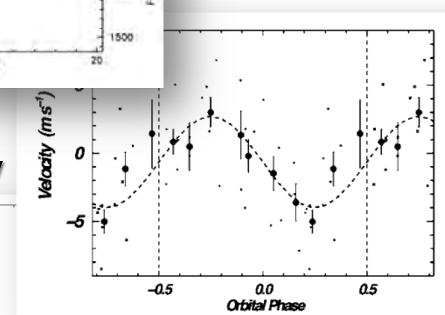
Techniques

Example: Kepler-10 b (K=11 mag)

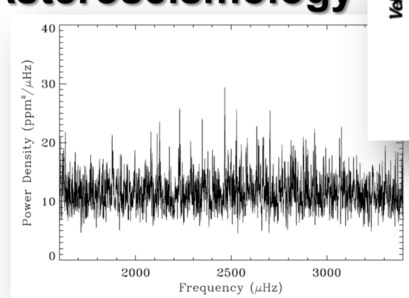
Photometric transit



RV – follow-up



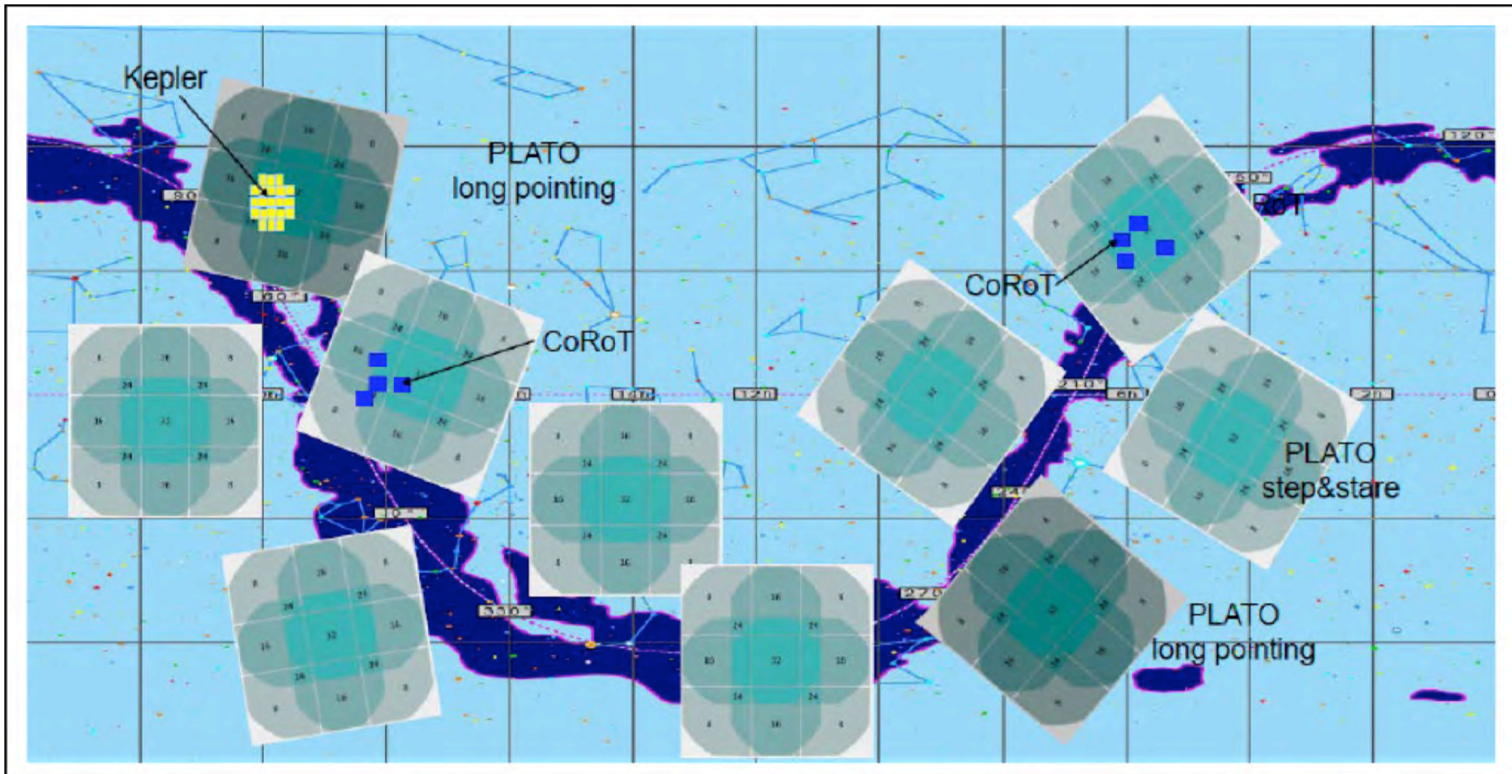
Asteroseismology



Observing strategy

Baseline observing strategy:

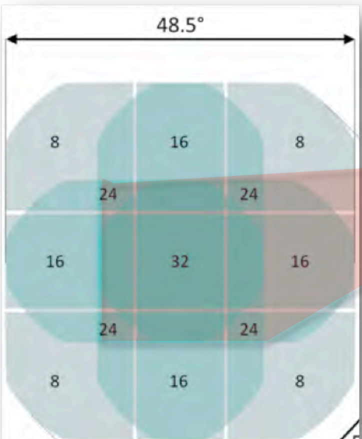
- 6 years nominal science operation
- 2 long pointings of 2-3 years + step-and-stare phase (2-5 months per pointing)



→ covers ~50% of the sky

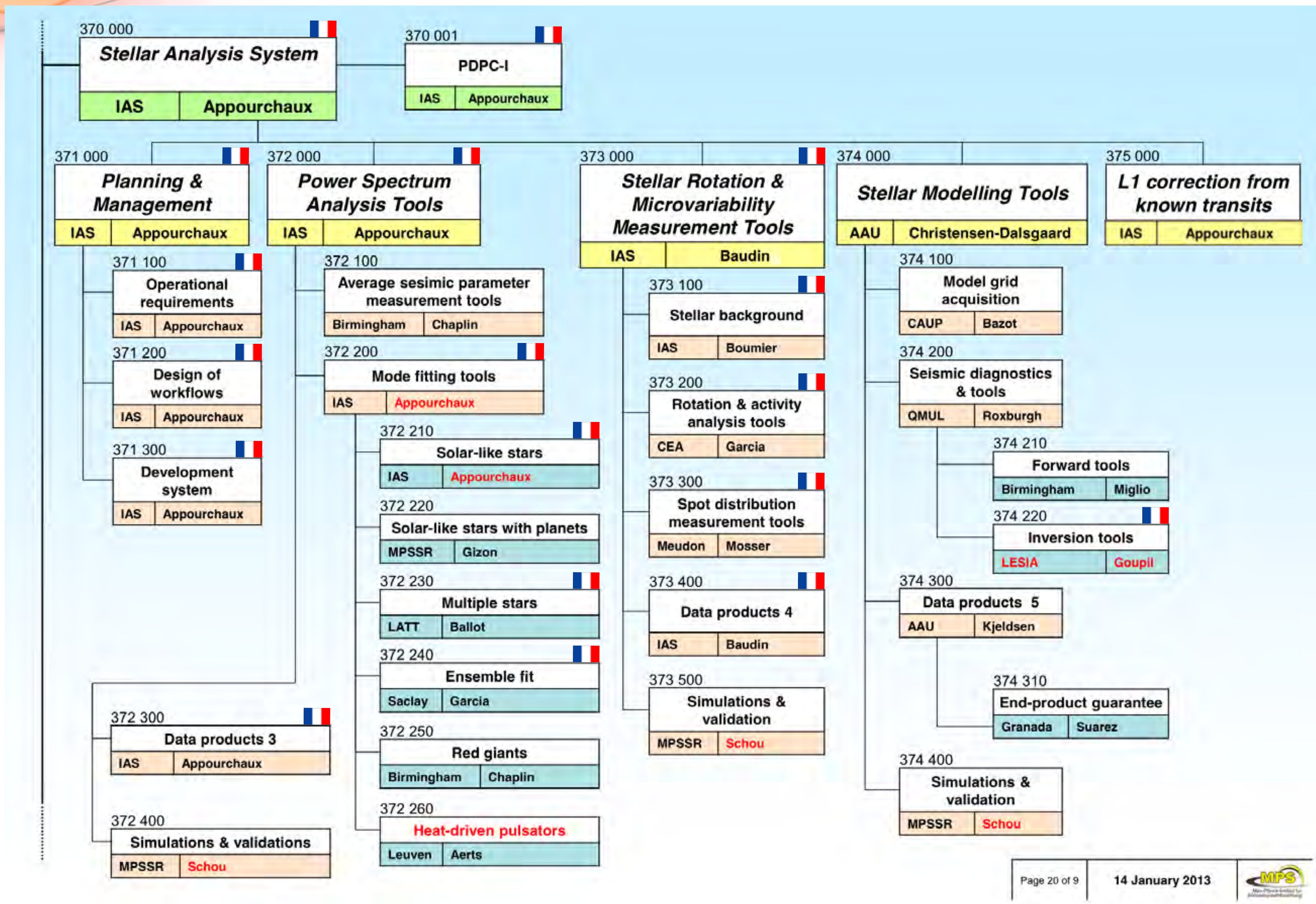
PLATO 2.0: Number of Light Curves

For the
Baseline mission

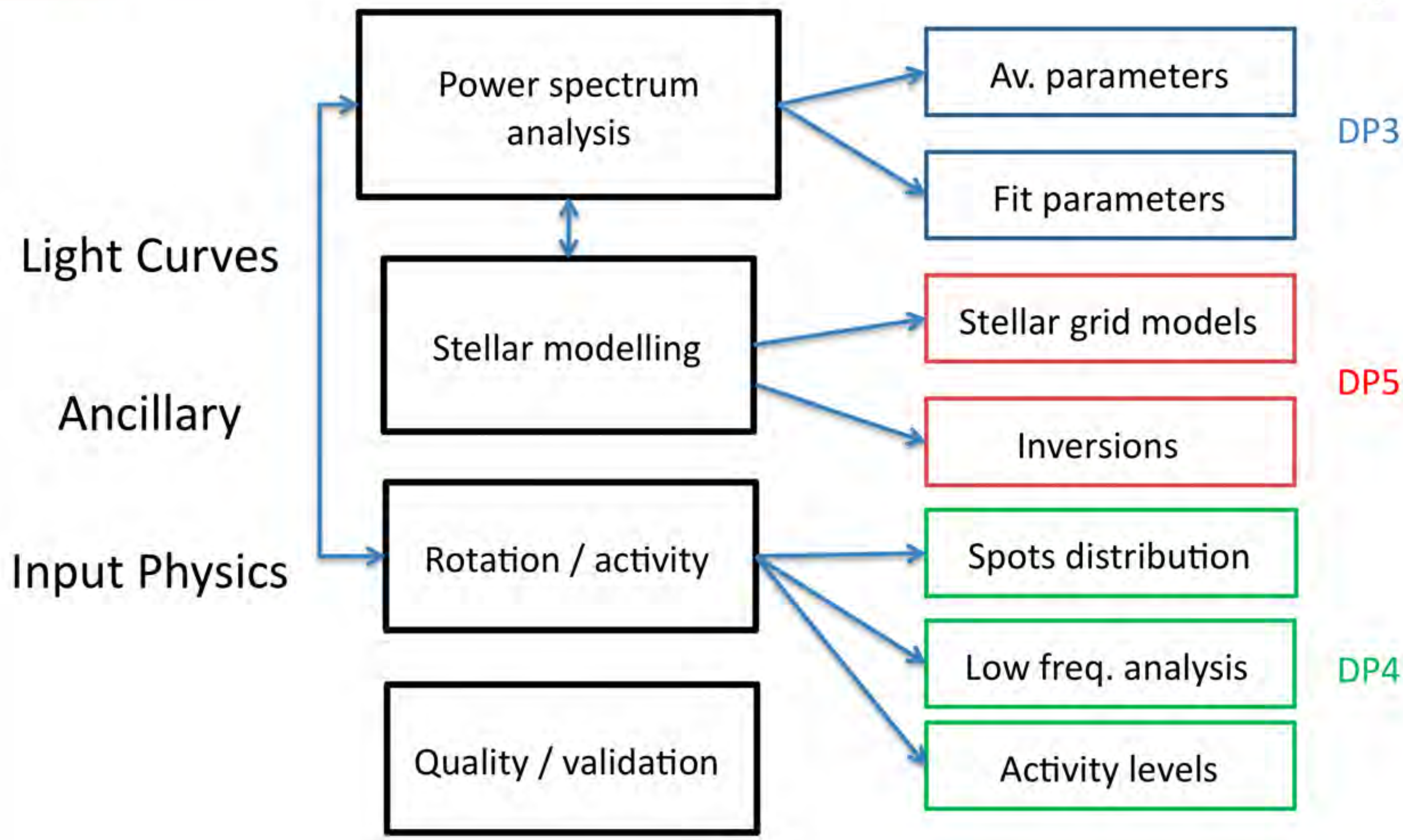


	4300 deg^2 (long stare fields)		20,000 deg^2 (plus step and stare fields)
Noise Level (ppm/√hr)	Number of cool stars	m_V	Number of cool stars
34 (Asteroseismology)	**22,000**	9.8-11.3	**85,000**
80 (Earth radius detection)	**267,000**	11.6-12.9	**1,000,000**

WP 37 : Stellar Analysis System

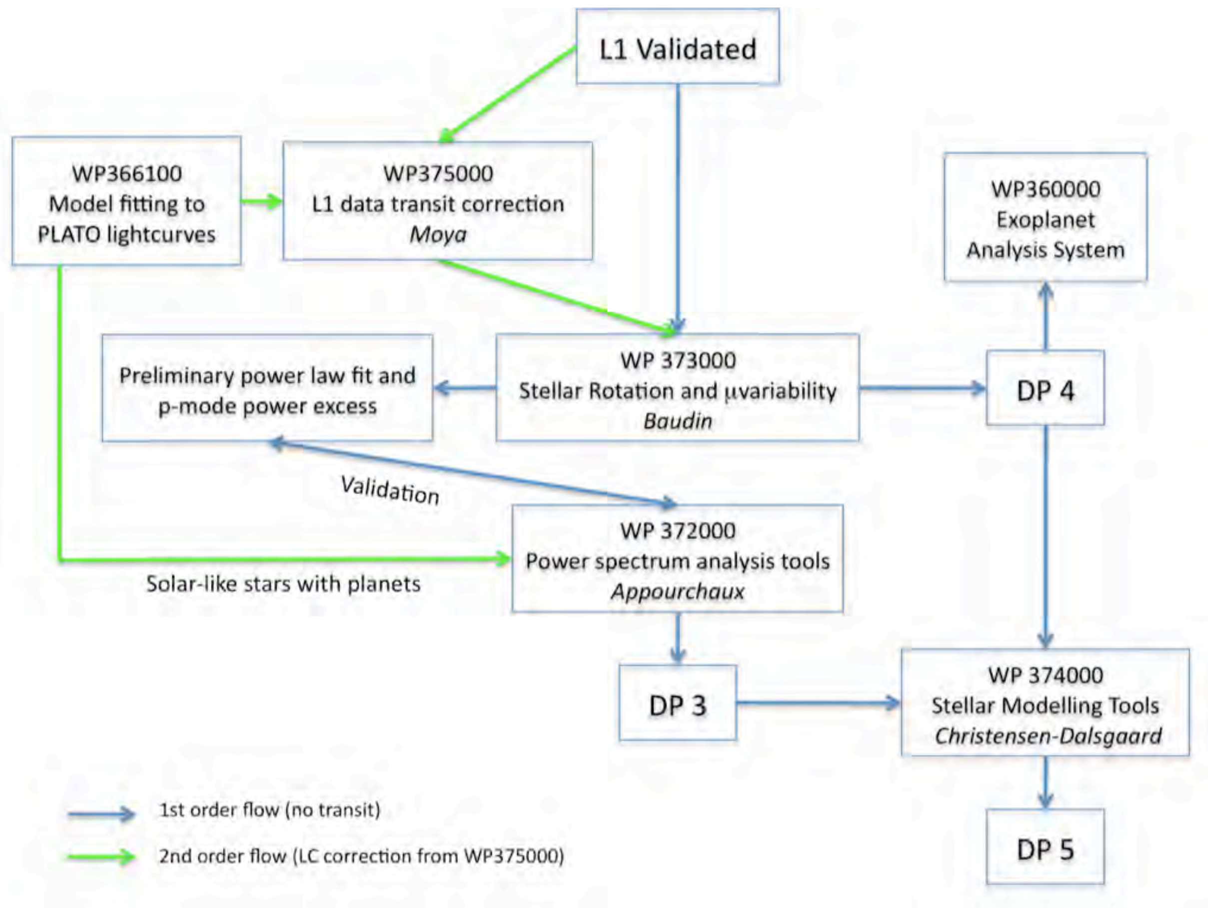


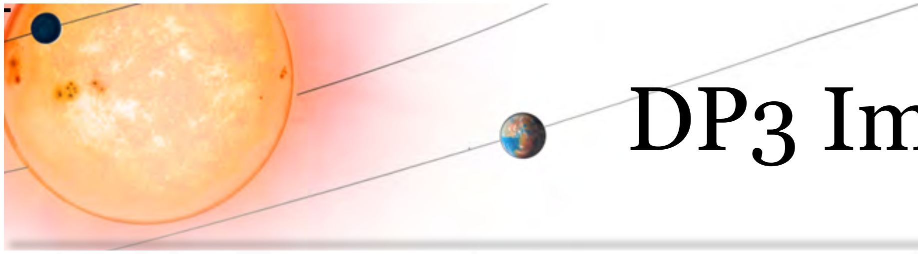
Data Products of WP 37



WP 37 :Main activities of SAS

Management des activités du Stellar Analysis System (IAS) – avec la participation du LESIA et du CEA

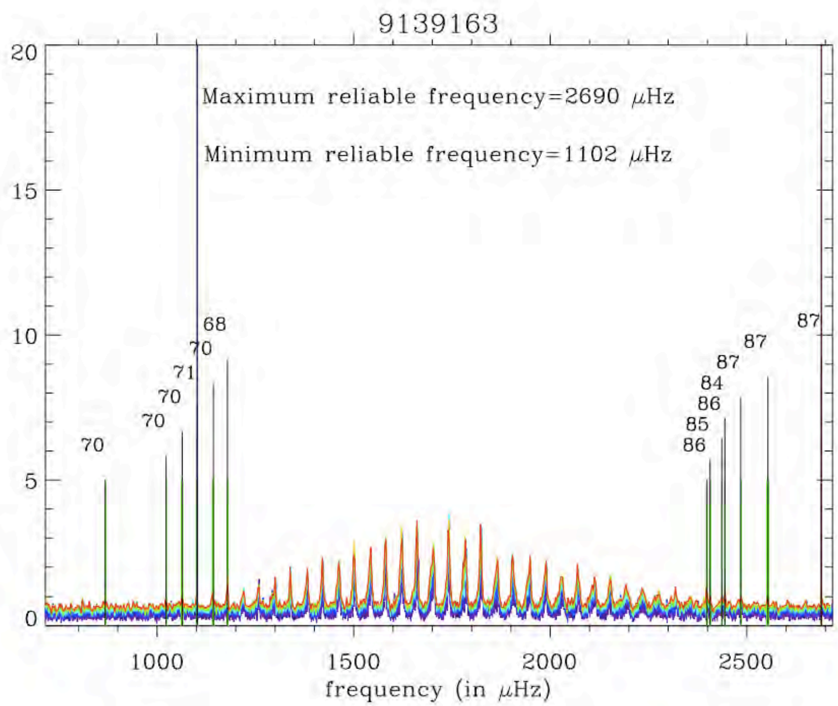




DP3 Implementation in *Kepler*

Oscillation mode frequencies of 61 main sequence and subgiant stars observed by *Kepler*

T. Appourchaux[1,2], W. J. Chaplin[3], R. A. García[4], M. Gruberbauer[5], G. A. Verner[3], H. M. Antia[6], O. Benomar[7], T. L. Campante[8,9], G. R. Davies[4], S. Deheuvels[10], R. Handberg[8], S. Hekker[11,3], R. Howe[3], C. Régulo[12,13], D. Salabert[14], T. R. Bedding[7], T. R. White[7], J. Ballot[15,16], S. Mathur[17], V. Silva Aguirre[18], Y. P. Elsworth[3], S. Basu[10], R.L Gilliland[19], J. Christensen-Dalsgaard[8], H. Kjeldsen[8], K. Uddin[20], M. C. Stumpe[21], and T. Barclay[22]



Degree	Frequency (μHz)	1-σ error (μHz)	Comment
0	986.105	1.130	Not detected
0	1064.982	0.690	0.703
0	1142.941	0.230	OK
0	1221.476	0.544	OK
0	1301.395	0.332	OK
0	1383.093	0.366	OK
0	1464.189	0.381	OK
0	1544.456	0.317	OK
0	1623.952	0.380	OK
0	1703.1000	0.340	OK
0	1785.675	0.330	OK
0	1866.729	0.420	OK
0	1949.424	0.391	OK
0	2031.407	0.706	OK
0	2114.451	0.607	OK
0	2195.335	1.219	OK
0	2276.836	0.928	OK
0	2359.243	1.229	OK
0	2444.022	1.734	OK
0	2689.590	Not fitted	0.873

A&A, 2012, **543**, 54

PLATO schedule overview

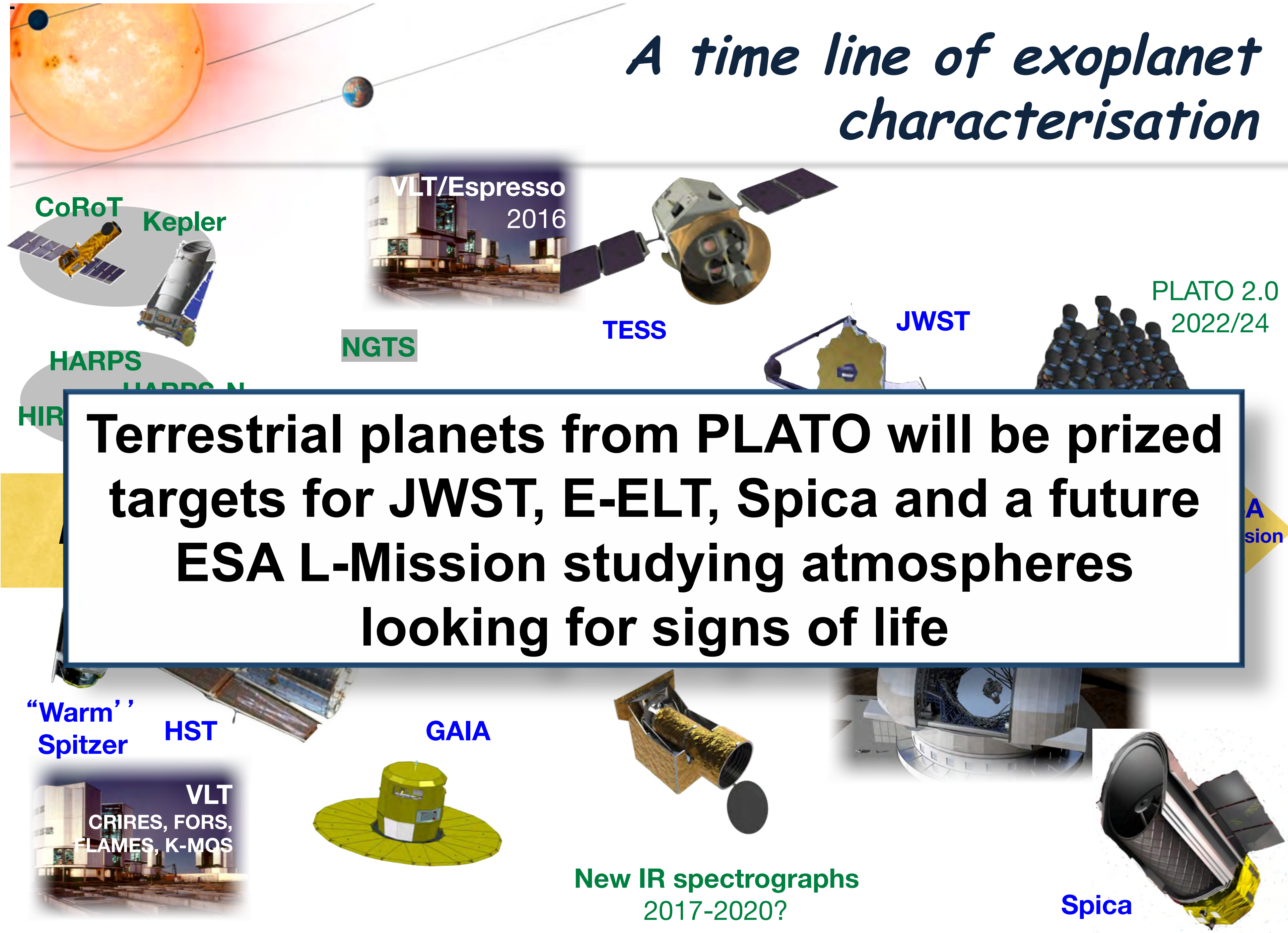
Definition Phase:

- Phase B1 industrial kick-off: Jul 2014
- Science Management Plan approval: Nov 2015
- System Requirements Review: completed by Jan 2016
- Mission adoption & IPC approval: Feb-Mar 2016

Implementation Phase:

- Industrial ITT for Phases B2/C/D/E1: Apr-Sep 2016
- Industrial Prime contractor kick-off: Oct 2016
- System PDR: by 2017 (tbc)
- System CDR: by mid-2020 (tbc)
- Delivery of all Cameras: Q4 2021
- PLATO Launch: Q1 2024

A time line of exoplanet characterisation



Terrestrial planets from PLATO will be prized targets for JWST, E-ELT, Spica and a future ESA L-Mission studying atmospheres looking for signs of life