PLATO

Science Goals and the PSPM

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PLATO Science Preparation
Management Team

Prime science goals of PLATO

* Detection and characterization of Earth Analog systems.

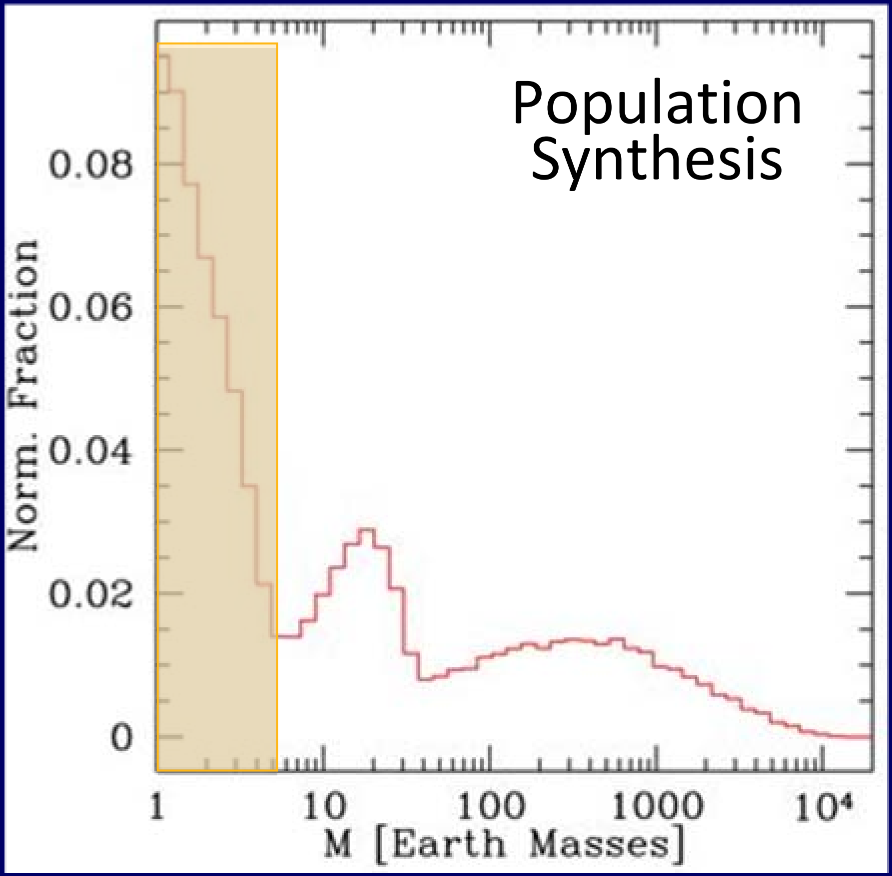
* Search for exoplanets around the brightest stars of solar type at all orbital periods and with all physical sizes.

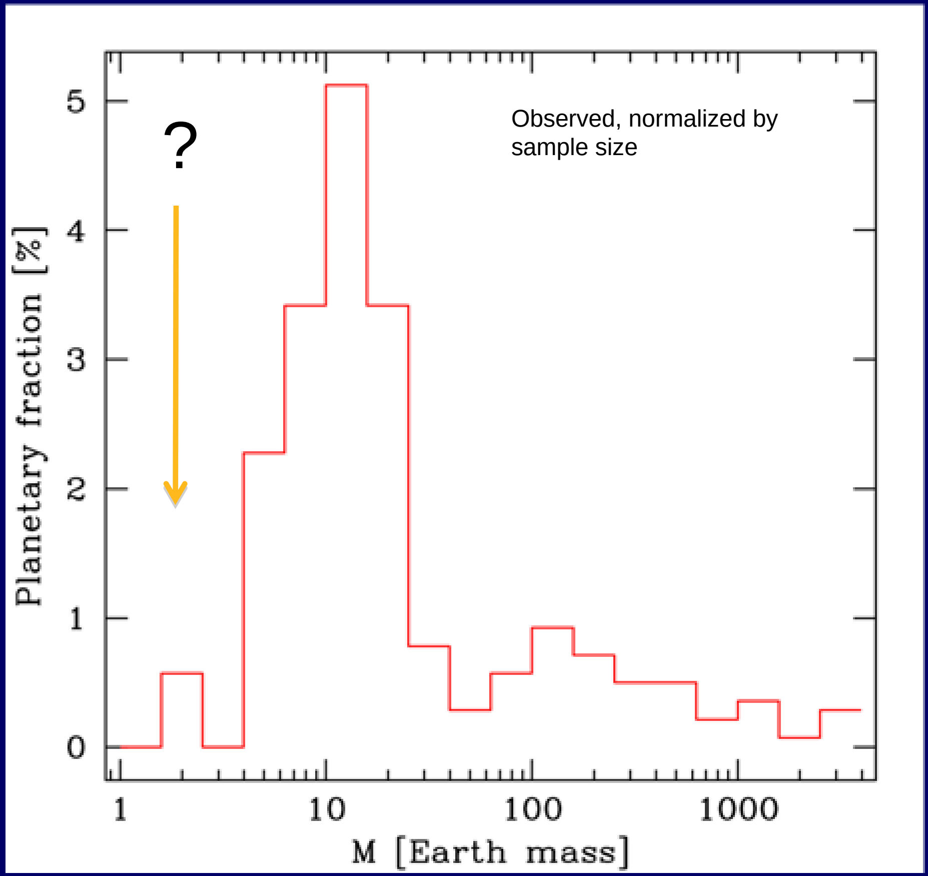
* Search for exoplanets around nearby M-type dwarfs with all physical sizes and at all orbital periods, including at orbital distances such that these planets fall within the habitable zones of these very cool stars.

* Search for and characterization of exoplanets with a wide variety of sizes, masses and orbits around bright stars.

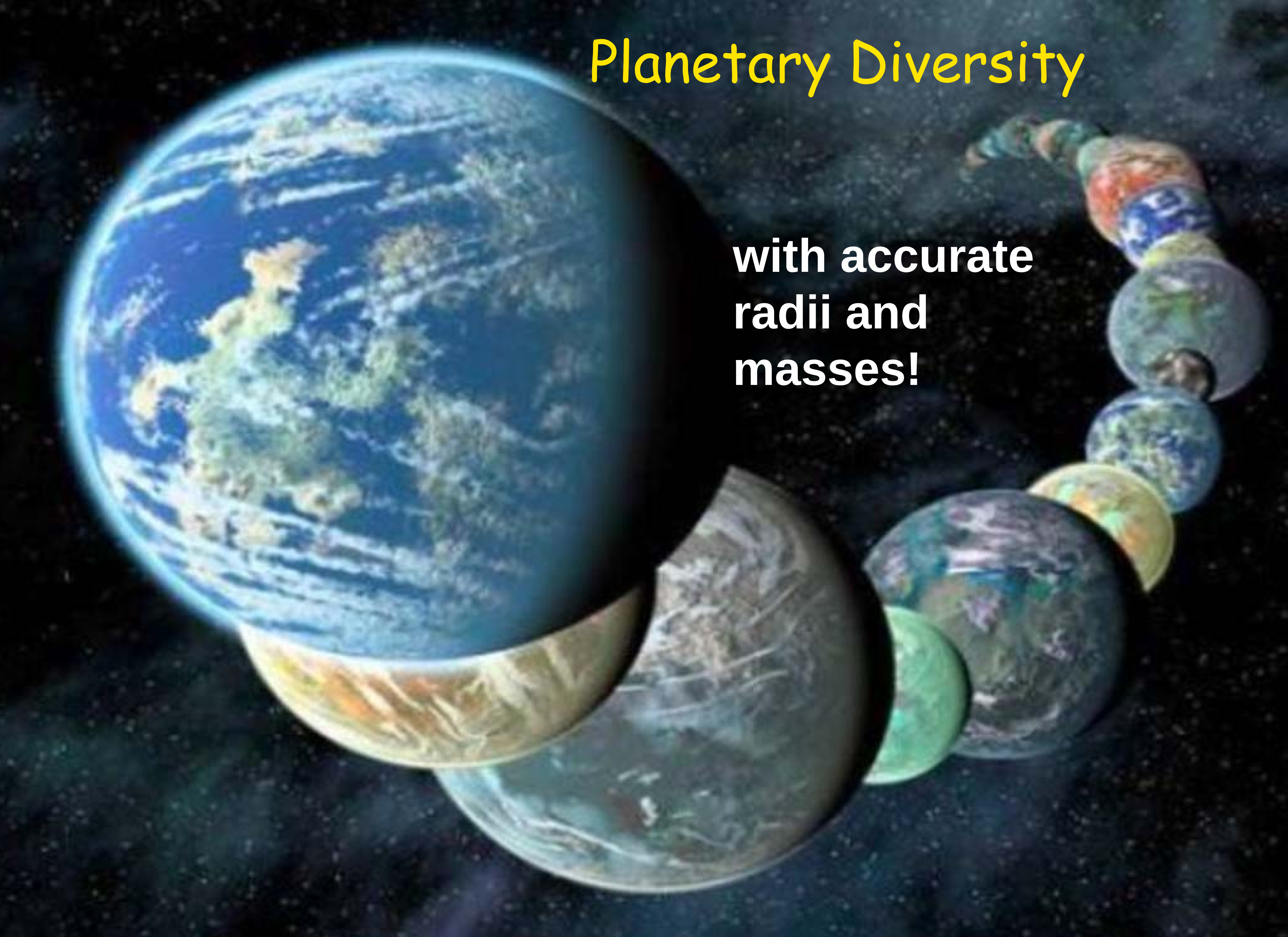
* Full characterization of very bright stars, of all masses and ages, using seismic analysis.

Planets Everywhere!

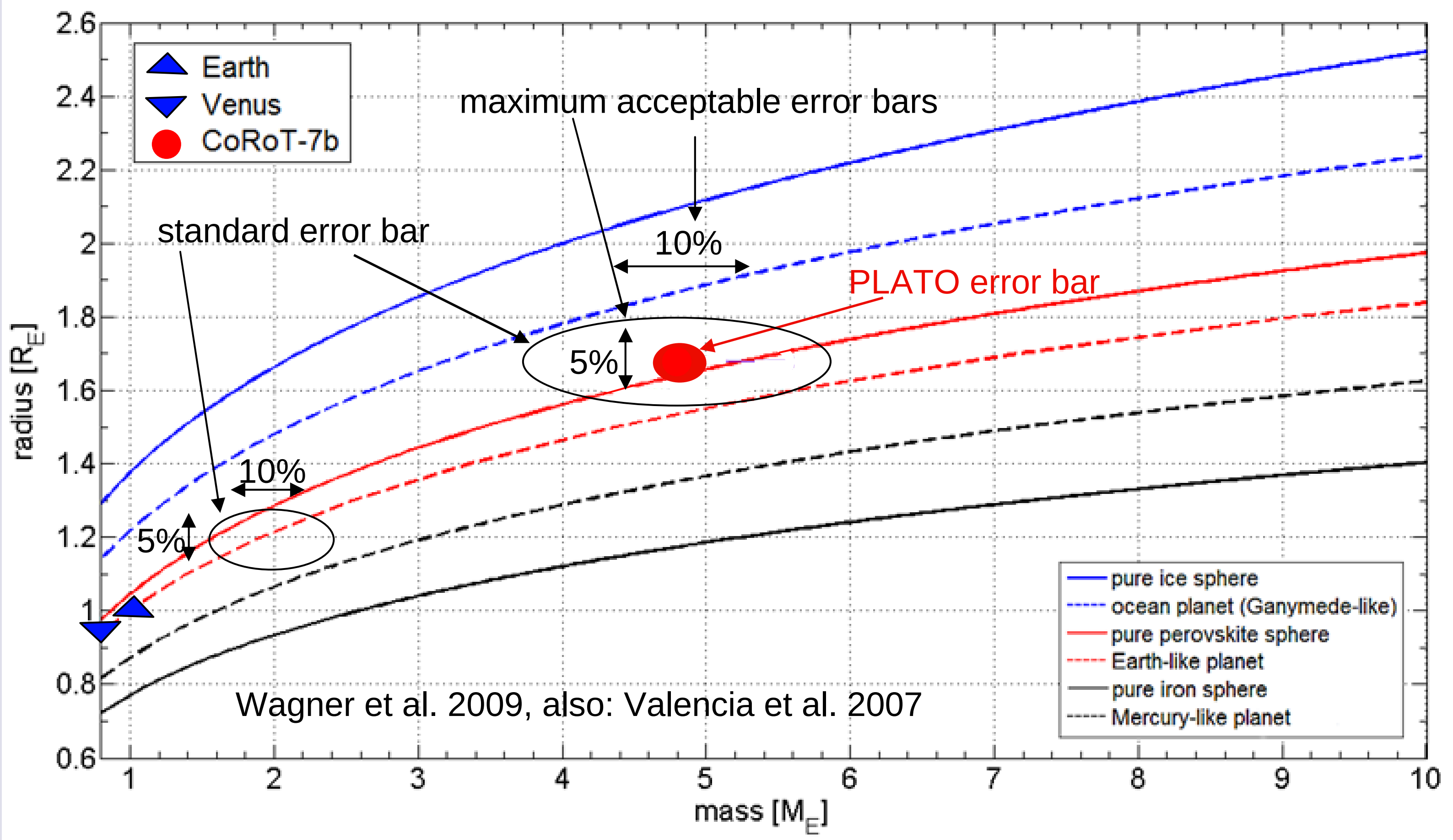




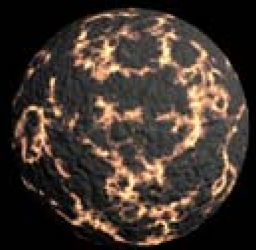
Small planets expected to be very common


Planetary Diversity
with accurate radii and masses!

Impact of radius and mass measurement



PLATO → well known radii and masses



Proto Earth

↓

Magnetosphere
Carbon-silicate cycle

↓

Oxygen rise
Ozone layer

↓

Impact of age measurement

PLATO: compare Earth-like exoplanets with age scale of Earth

- precision better than timescale planet evolution

- targets of future characterization dated by PLATO (Earth-like, but also Neptunes, hot Jupiters…)

place exoplanetary systems in evolutionary context

Transits: Planetary Parameters

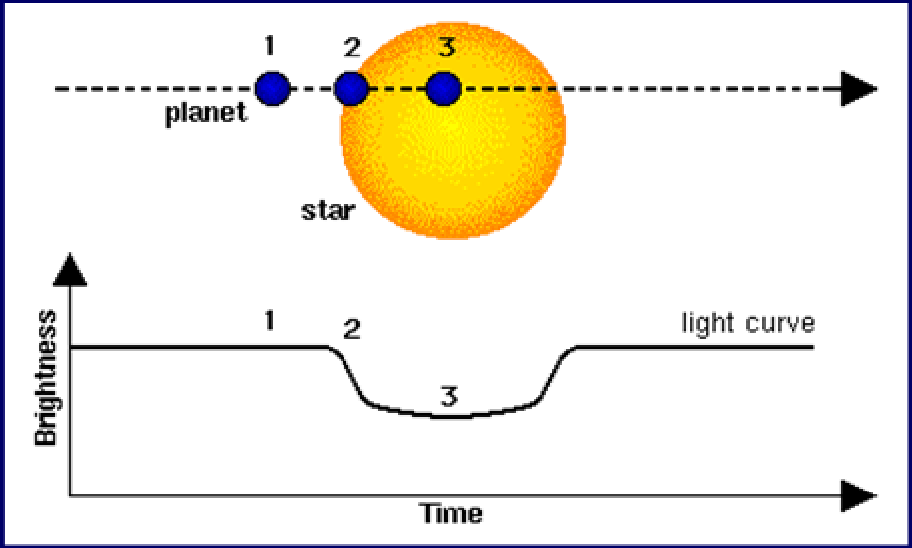
- Key Tool

Mostly geometry

→ radius of planet/star, inclination.

Kepler's 3rd law => semi-major axis

$$\frac{\Delta F}{F_*} \propto \left(\frac{R_{Pl}}{R_*}\right)^2$$



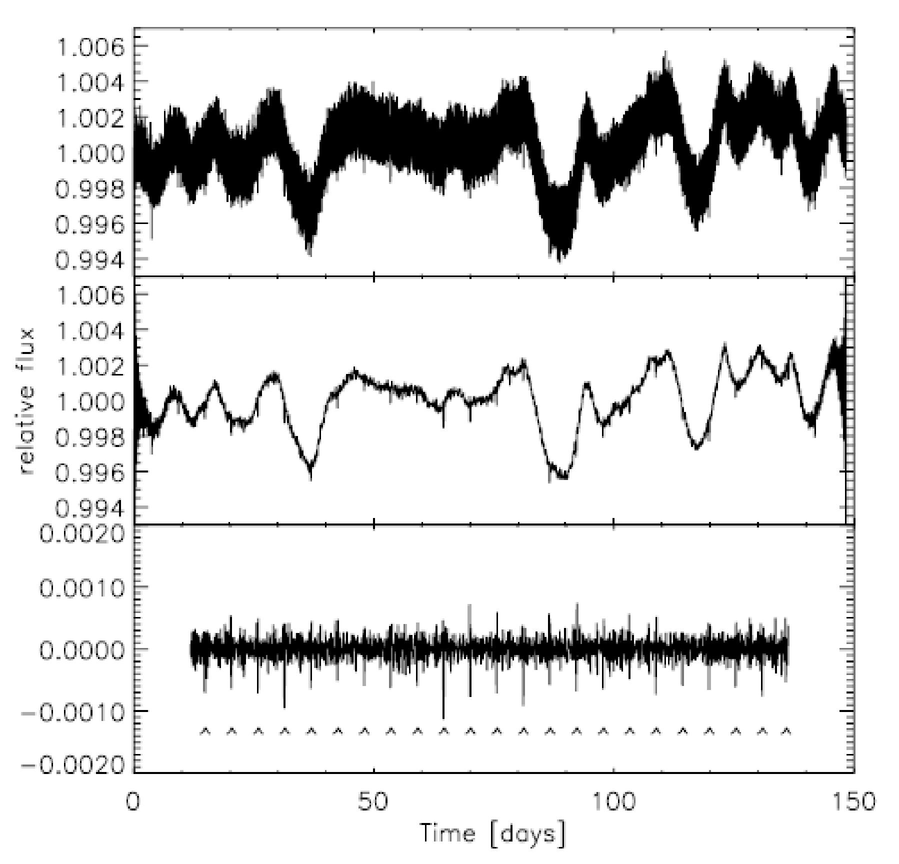
Only needed physics: limb darkening

Sun + Jupiter : ~ 1% dip
Sun + Earth : ~ 0.01% dip

Exoplanet Detection and Planet Parameters

- lightcurve filtering and transit detection → planet candidates
- planet candidate ranking → input to follow-up
- follow-up observations → confirmation or rejection of candidates
- transit fitting tools → planet parameters

Planet detection and lightcurve filtering



Renner et al. 2009; Moutou et al. 2005

For filter methods see also e.g. : Savitzky-Golay filter (Press et al. 2002); match filter (Jenkins 2002; Aigrain 2005 PhD; Carpano et al. 2003) or also Defaÿ et al. 2001; and Moutou et al. 2007, …

- remove residual instrumental effects
- filter stellar variability
- detect transit signals:
  - Earth-sized planets
  - single transit events
  - elliptical orbits
  - TTVs
  - binary stars
  - reflected light phase variations
  - other methods, e.g. pulsations
- check for false-alarms due to residual instrumental and stellar variations

→ develop and specify optimum filtering and planet detection procedures for PLATO

Planet candidate ranking

Required stellar parameters:

radius →

position, type, variability of contamination stars in PLATO window →

mass →

Criteria for candidate ranking:

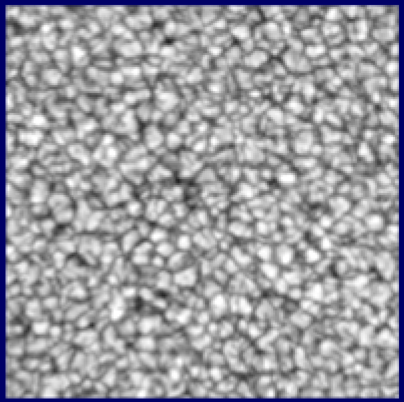
- lightcurve
  - exclude residual „noise“ from incomplete filtering
  - depth, duration, shape consistent with planet
  - centroid variations
- photometric follow-up observations
  - contaminations in PLATO window
- high-resolution imaging
- spectroscopic follow-up
  - determine mass of transiting object

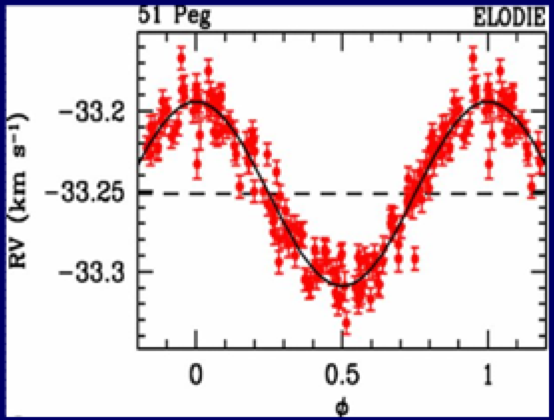
→ Select optimum PLATO strategy based on experience from existing ground- and space-based surveys!

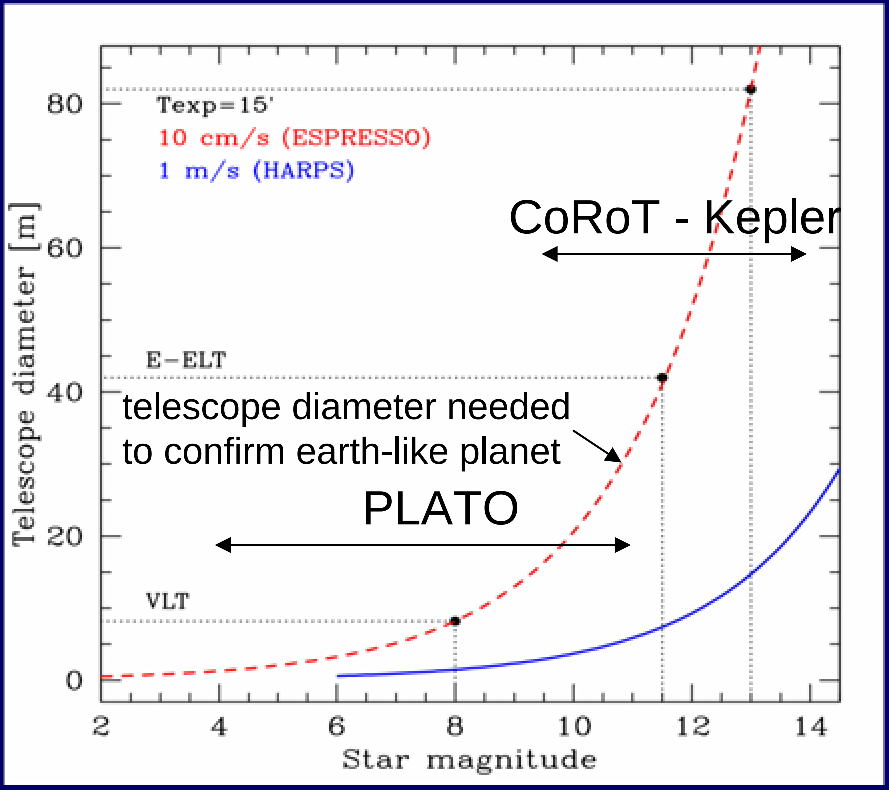
Groundbased follow-up

- Vigorous follow-up needed
- Most important aspect = radial velocity monitoring
  $\Rightarrow$ planet confirmation and mass measurement

- stellar intrinsic « noise »:
  oscillations, granulation, activity
- need to apply proper averaging technique
- time consuming
- in practice limited to bright stars







Planet parameters from transit fitting

Factors affecting the transit shape, in addition to star and planet radius:

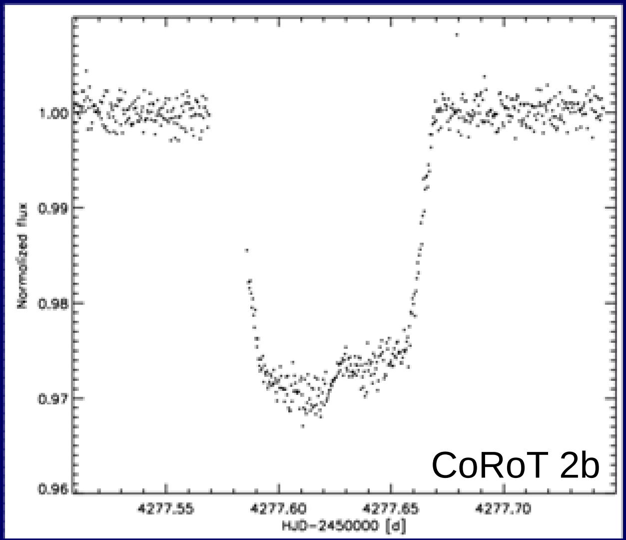
- **Limb Darkening**
- **Eccentricity**
- **Inclination**

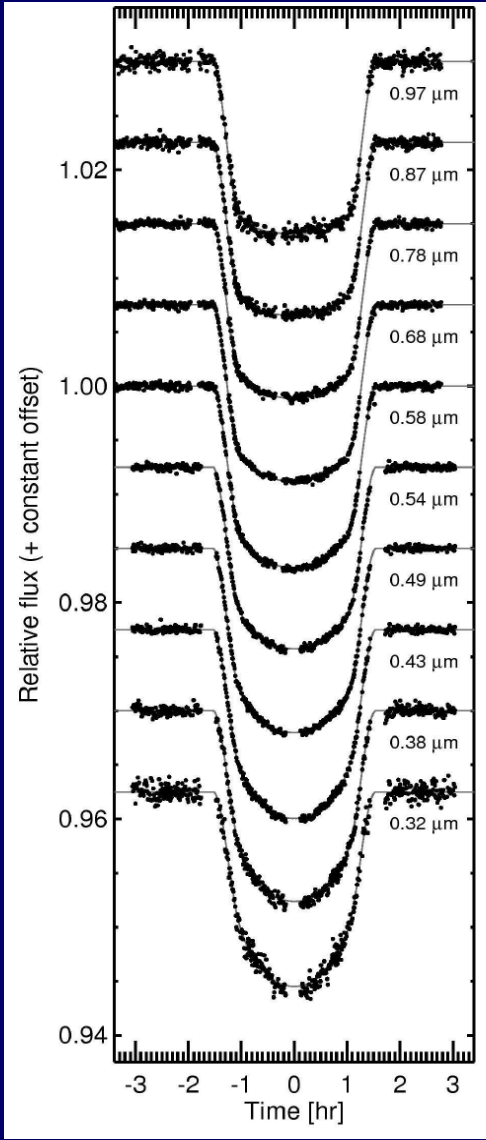
Available tools:
Mandel & Agol 2002
Gimenez et al. 2006
EBOP 1981
…

- **Contamination**
- **Binning**
- **Spots, flares, plages**

Needs to be implemented

- **Fast rotators**
- **Gravity darkening**
- **Day- and nightside radiation**
- **Rings and moons**
- **Different albedo areas**
- **TTV**
- **Stellar Pulsation**
- **Atmosphere**

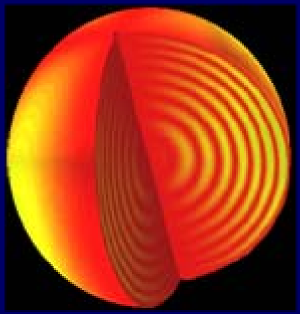




Asteroseismology

Planet parameters ← stellar parameters (asteroseismology)

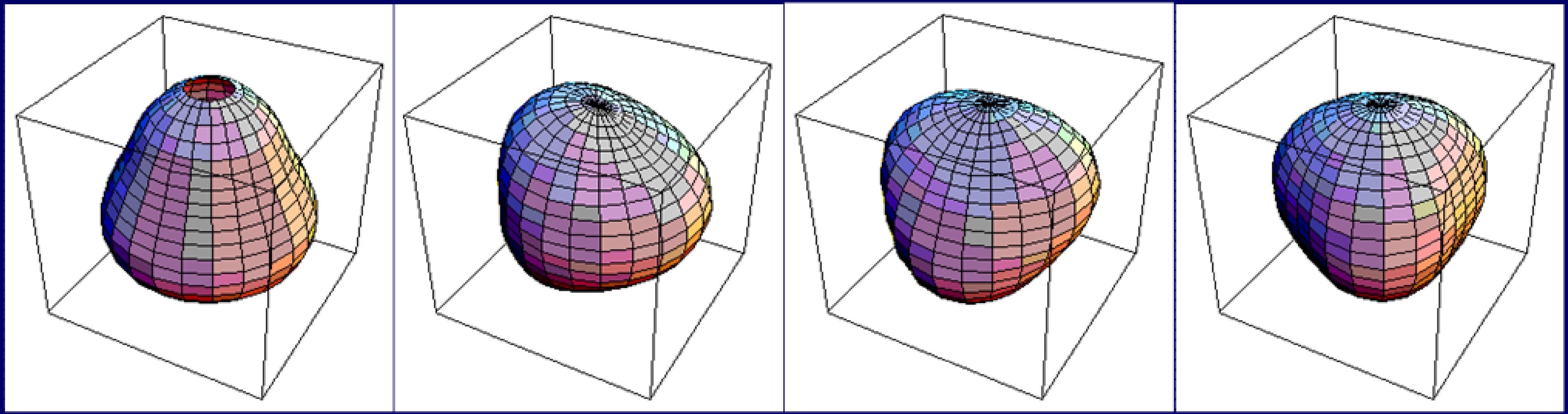
Solar-like stars oscillate in many modes, excited by convection. Sound waves trapped in interior



Resonant frequencies determined by structure:

→ frequencies probe structure

→ gives mass, angular momentum, age



Asteroseismology

Power spectrum of light curve gives frequencies ν

Large separations $\Delta \propto \sqrt{M/R^3}$
→ mean density

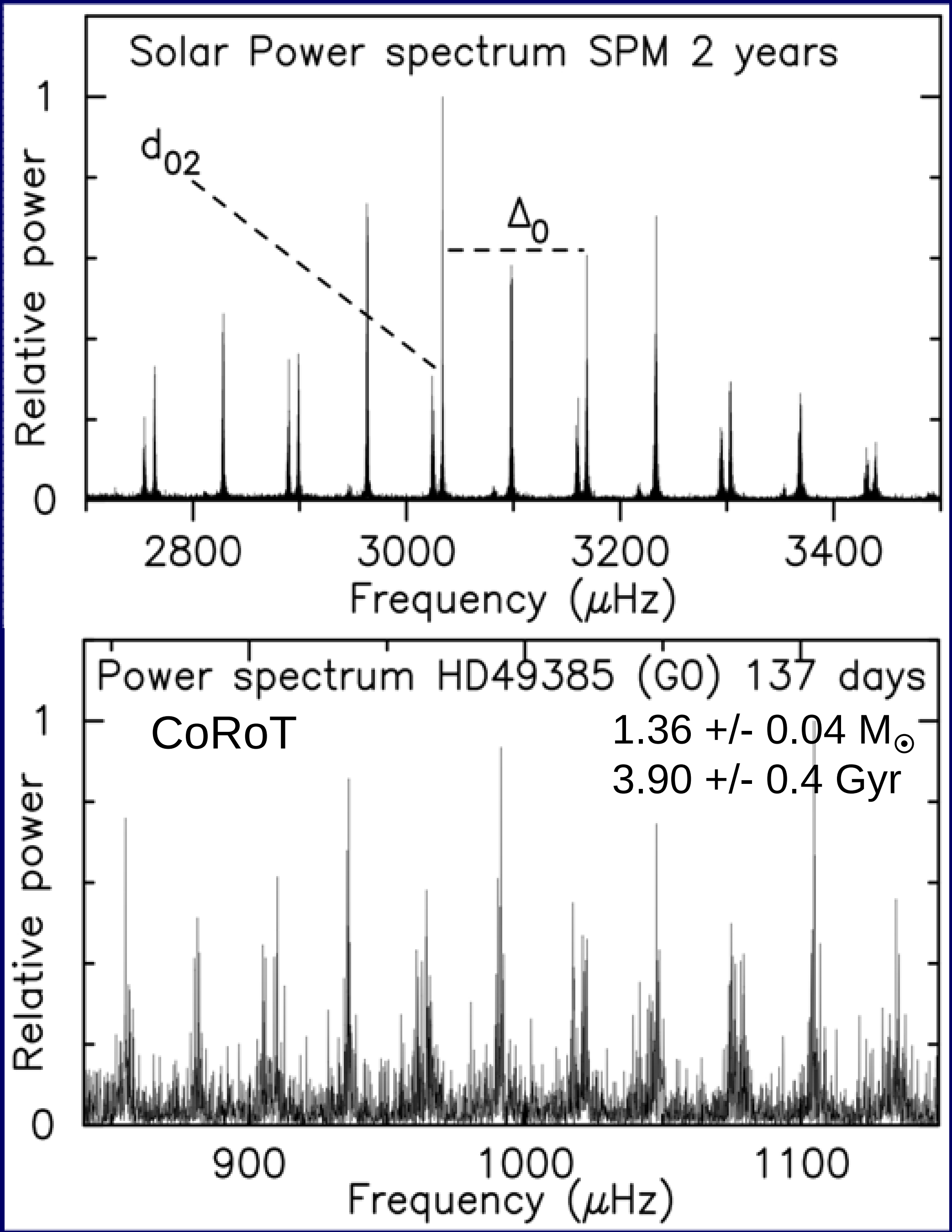
Small separations d_{02}
→ probe the core → age

Inversions + model fitting + ν → consistent ρ, M, Ω, J, age

PLATO will provide:

Uncertainty in Mass ~ 2%

Uncertainty in Age ~ 10%

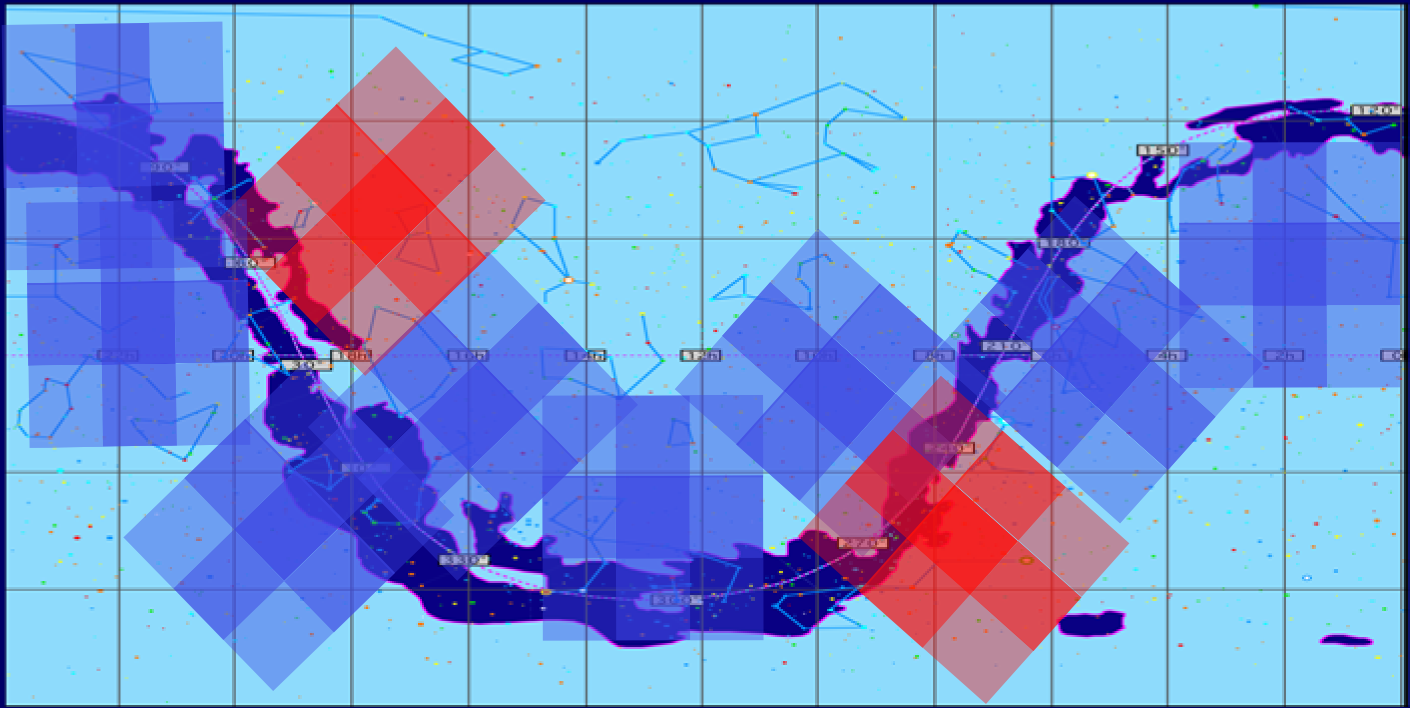


Target field characterization

PLATO will observe

- 2 fields for 2-3 years each

- several fields up to 5 months each in a „step-and-stare“



We need to: * Prepare the selection of PLATO fields

* Characterize PLATO targets prior to launch

Target field characterization

The PLATO Input Catalogue will serve to:

- select the optimal PLATO Fields (PFs);
- select all the >F5 dwarf and subgiants;
- characterize as much as possible the targets, i.e. estimate their temperature, gravity, metallicity, size, variability, atmospheric activity…
- select the P1-P5 samples
- give a first estimate of the transit object size;
- optimize the follow-up strategy.

Tasks will be based on:

- GAIA Catalog analysis
- Photometric and astrometric catalog analysis

End-to-end Simulator

provide simulate PLATO data including realistic

- simulation of the target field
- the target stars and their varaibility
- instrument
- data processing
- …

→ important link between science algorithm and tool development with the instrument and data processing!

Additional science

The PLATO Additional Science will result from:

- Usage of data obtained for primary targets

- Targets which were not primary science targets, but happen to be observed at the same time

→ need to prepare for additional science in the PMC

Preliminary activity:

- identify needs of additional science projects

- check what is technically possible and feasable with PLATO with no or little extra-costs to the mission

Option for associated working groups, with interface to PMC?

- achieving the science goals of PLATO requires a tight link of progress in exoplanet as well as in stellar science

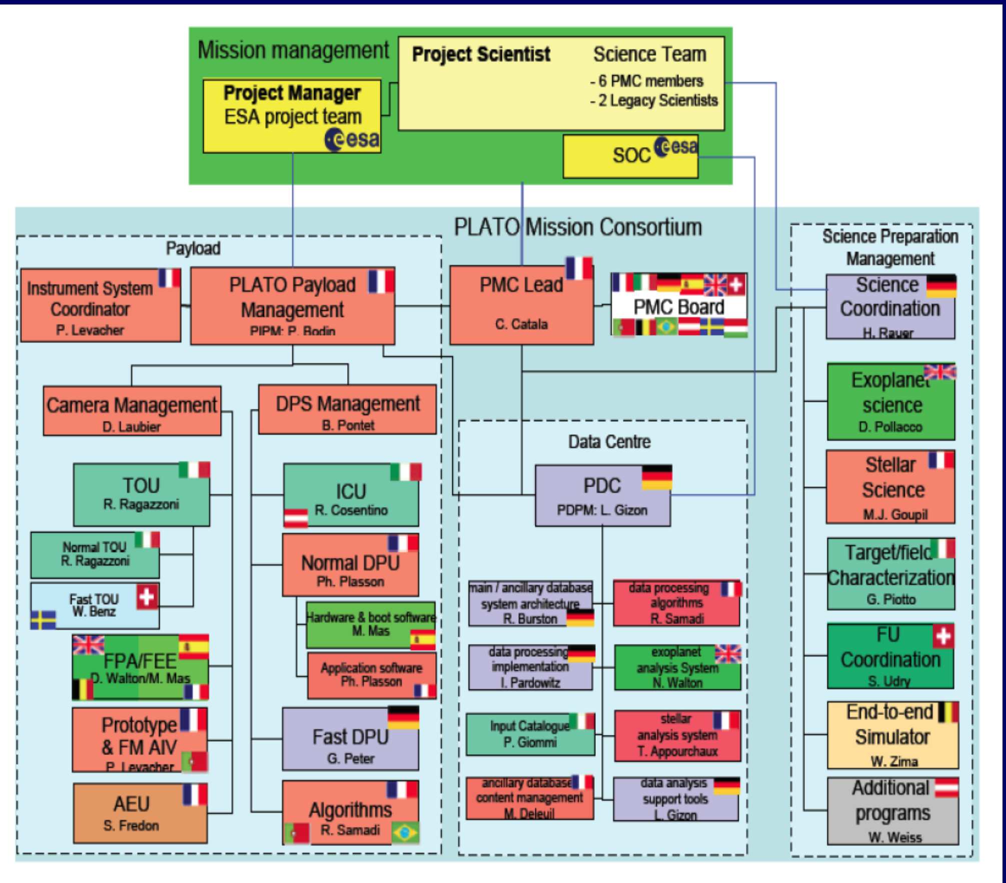
- using the existing expertise from ground-based and space-based (CoRoT, Kepler) transit surveys is crucial

- a good standard of exoplanet detection and stellar analysis tools is available today

- to achieve further milestones in exoplanet and stellar science with PLATO requires significant development of improved methods

→ the best state-of-the art methods to process and analyse PLATO data should be available to the community at PLATO launch

PLATO Science Preparation



- **Science coordination**: overall PSP coordination, coordinate community, pr
- **Exoplanet Science**: transit detection, planet parameters
- **Stellar Science**: stellar physics, oscillation modes, stellar evolution models
- **Target/Field Characterization**: PLATO input catalogue, prepare field selection
- **Follow-Up Coordination**: organization of follow-up observations
- **End-to-End Simulator**: PLATO data simulator
- **Additional Science**: **prepare for** additional science program

Tasks of PLATO Science Preparation Activities

- the development of methods and algorithms for exoplanet science

- the development of methods and algorithms related to the stellar physics programme

- the provision of all necessary data and information for the construction of the PLATO input catalogue

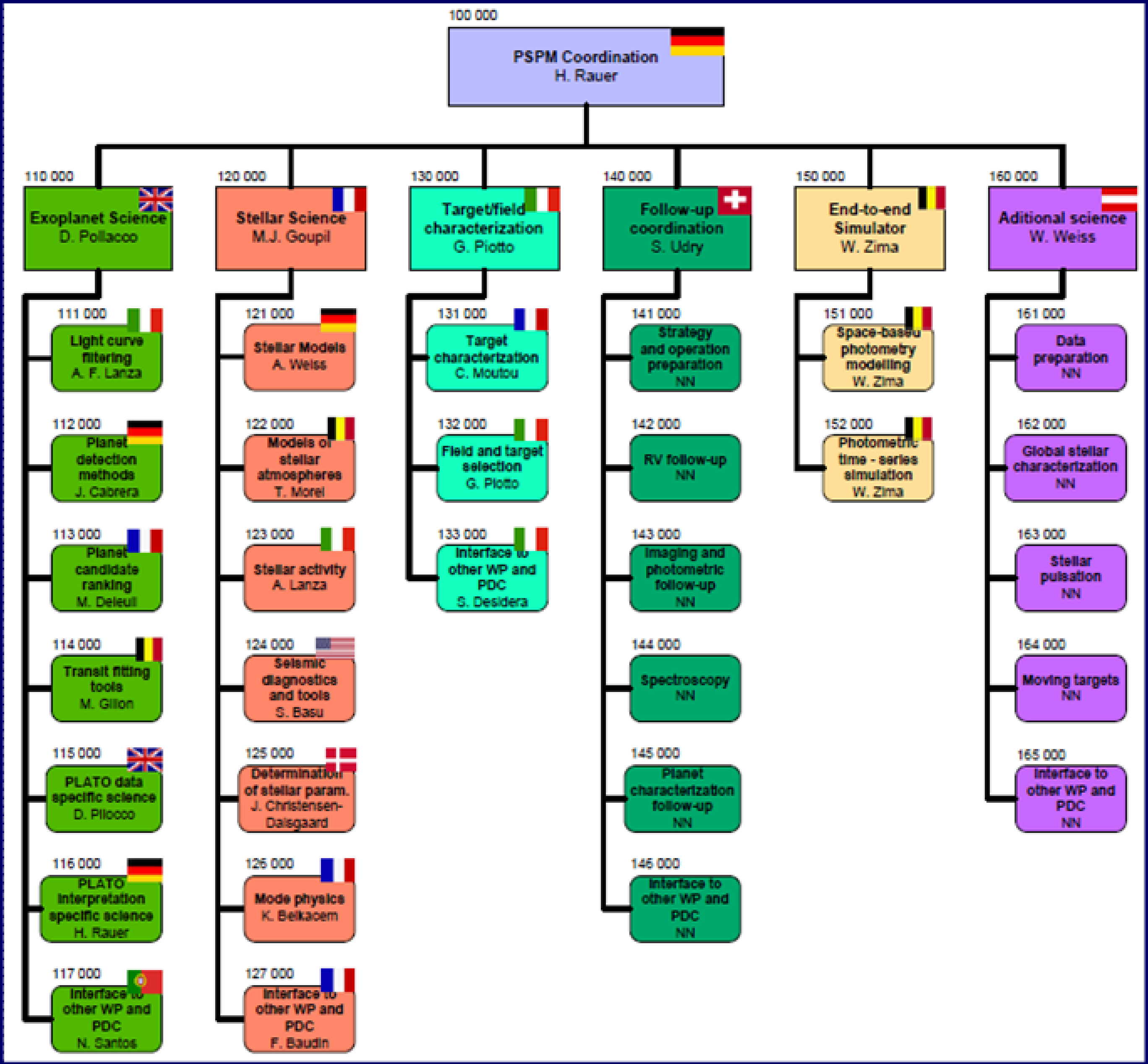
- the identification of the required follow-up facilities, including a world-wide effort obtaining in particular radial velocity observations to determine planet masses;

- the development of the end-to-end PLATO data simulator

- the coordination of additional science activities within PMC and the general community.

- coordinate an active outreach program to the science commuity and the general public (web site, material for talks, etc.)

PLATO Science Preparation Management



Summary: PLATO Science preparation tasks

Wide range of PLATO science activities:

- scientific development of improved algorithms and tools
- specifications for implementation at the PDC
- specification of the input catalogue contents
- preparation of target field selection
- preparation for „additional science“ activities in PMC

- study implications of PLATO for „general exoplanet science“

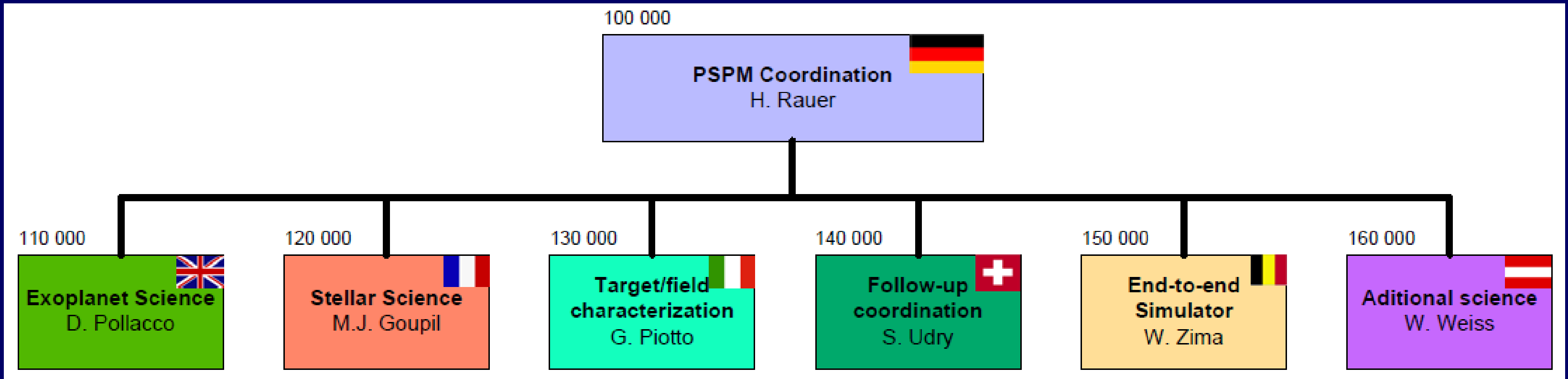
From:

Specifications required for field selection and L2 data products

up to:

Prepare science interpretation tools

Contacts: PLATO Science preparation tasks



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Additional science	**werner.weiss@univie.ac.at**

Announcement:

PLATO Science Conference

24 - 25, February 2011

Technical University Berlin, Germany

Purpose:

- present the PLATO mission, PLATO science and the PLATO Mission Consortium to the general scientific comunity
- provide a „point-of-contact“ to the community interested to get involved in PLATO
- collect input from the community to the PLATO definition phase