WP121 -WP127

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Current status of PLATO

PLATO output

WP 120 responsabilities

- WP 121 responsabilities
- WP 127 responsabilities

Update about PLATO status

- **PSRR** (Payload, Science Ground Segment and Science Performance System Requirements Review) from fall 2015 to May 2016

Pb : Mass and energy too high for a launch with Soyauz
Recommandation : baseline number of Normal-cameras from 32 to 28
→ 15 000 stars instead of 20 000 stars (core program P1)

- **MAR (**Mission Adoption Review**)** **(**New!)
  MAR Board meeting: 28/29 April
  28 tel. does not comply with mass limit including margin with the present project

- Kick off Meeting Phase B2 for PMC (Munich, 25-27 May 2016)

- Preparation **Red Book (**definition phase report) (now)

- Submission to SPC for **Adoption** (Nov. 2016)

- **IPDR** (Instrument P. Definition Review) (June – August 2017)
  End phase B2- Beginning of phase C : implementation tests = validate intermediate software prototype

Doc forAdoption

Red book (definition phase report) :

→ First draft: 15 May
→ Second draft: 15 June
→ Third draft: 15 July
→ Draft ready for ESA internal review: 9 September
→ Release to Advisory structure: 22 September
→ AWG/SSEWG meetings: 13/14 October
→ SPC meeting: 22/23 November

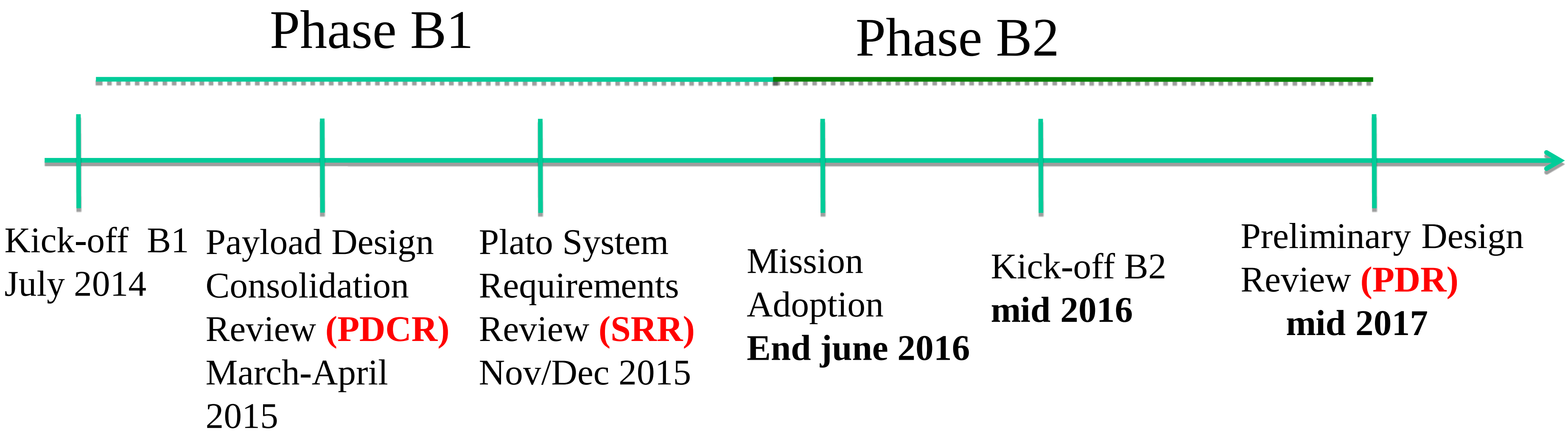
The basis for the science objectives chapter is the PLATO paper published in Experimental Astronomy.

Action : The sections on stellar science must be extended compare to the yellow book

Performance report :

Action : Estimate accuracy/precision of stellar parameters : 32 tel → 28, 24 , 20 tel

Important dates and deadlines



PLATO Phase B1 objective is the adoption of the PLATO mission by SPC in March 2016.

- The **PLATO System Requirements Review (SRR)** is a major input to PLATO mission adoption.

Delivrables PDC

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

Specifications from WP120

Plato output

Commitments written in the SciRD, SciRJD document delivered to ESA

R-SCI-L0-01PLATO shall detect and characterise* hundreds of planets around dwarf and subgiant stars of spectral types from F5 to K7, orbiting at distances up to the stellar habitable zones.

R-SCI-L0-12 PLATO shall determine the age of a G0V star of $m_V=10$ (m_V=goal 11) with an accuracy of 10%

R-SCI-L0-55 PLATO shall provide photometric data to determine the radius of a G0V star of $m_V=10$
(goal $m_V=11$) with a precision of 2%.

R-SCI-L0-57 PLATO shall provide photometric data to determine the mass of a G0V star of $m_V=10$
(goal $m_V=11$) with a precision of 15%.

R-SCI-080 The total number of targets in stellar sample 1 (cumulative over all fields) shall be at least 20 000 15 000 dwarf and subgiant stars of spectral types from F5 to K7, with a goal of 20 000.

Stars of the core science

Samples (cumulative over all fields) :

P1 : 15000 stars : F3 to K7 dwarfs and subgiants with m=< 11
P2 : 1000 dwarf and subgiant stars of spectral types from F5 to K7 with $m \leq 8.2$
P3 : extension of stellar sample 2 into the Step&Stare Observation.
at least 3000 dwarf and subgiant stars of spectral types from F5 to K7.
The 1000 stars in P2 are included in P3.
P4 : survey of cool M dwarfs in the solar vicinity
at least 10,000 cool M dwarfs, with at least 5,000 monitored during the Long-Duration Observation Phase
$m \leq 16$ for the Long Duration Observation Phase
$m \leq 15$ for the Step&Stare Observation

Also targets of interest: binaries, clusters and red giants as tools to improve the description of physical processes used in stellar models of main sequence stars and subgiants

But we have to ask for them, they must be included in the input catalogue

Responsabilities of WP120

• Provide specifications* for seismic determinations of stellar mass, radius , age and other properties of stars of the core program

* specification : description of the algorithms, codes, pipelines, interfaces, tests

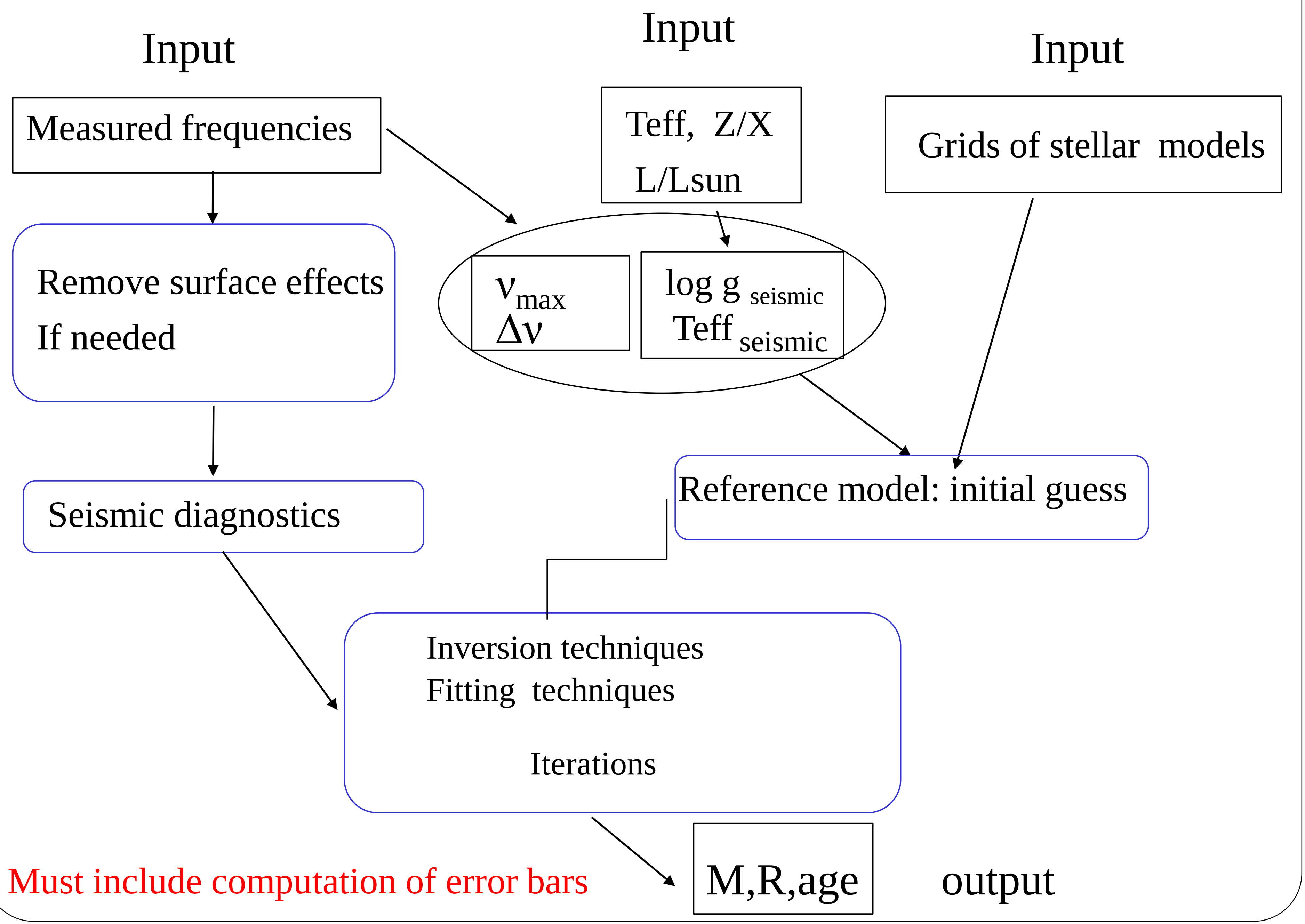
• Provide grids of stellar models** and oscillation properties

• Provide evolutionary code for calculations on the run

• Validate PDC implementation and results (output)

**stellar models : physical description as close to reality as possible (WP121)
Red giants : as diagnostics and tests of physical processes (WP127)

Exemple : description of procedure



END

Perfomances attendues

Number of Light Curves

For the baseline observing strategy:

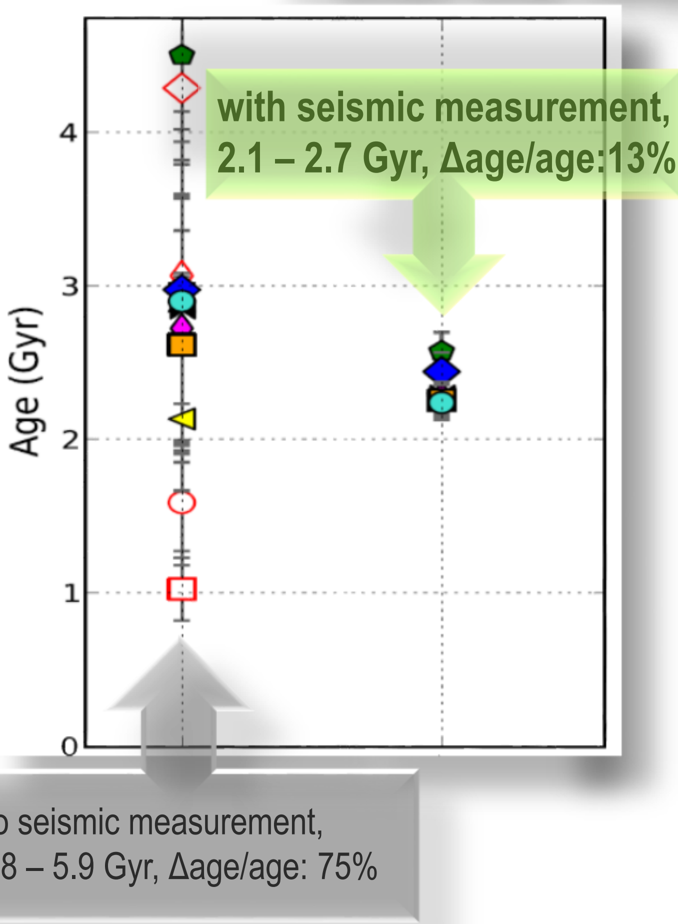
Noise level	Magnitude limit	4300 deg^2 (long stare fields)	20,000 deg^2 (plus step and stare fields)
(ppm/√hr)	m_V	Number of cool stars	Number of cool stars
34	11	**22,000**	**85,000**
80	13	**267,000**	**1,000,000**

Detection of Earth-sized planets
+ asteroseismology
+ radial velocity

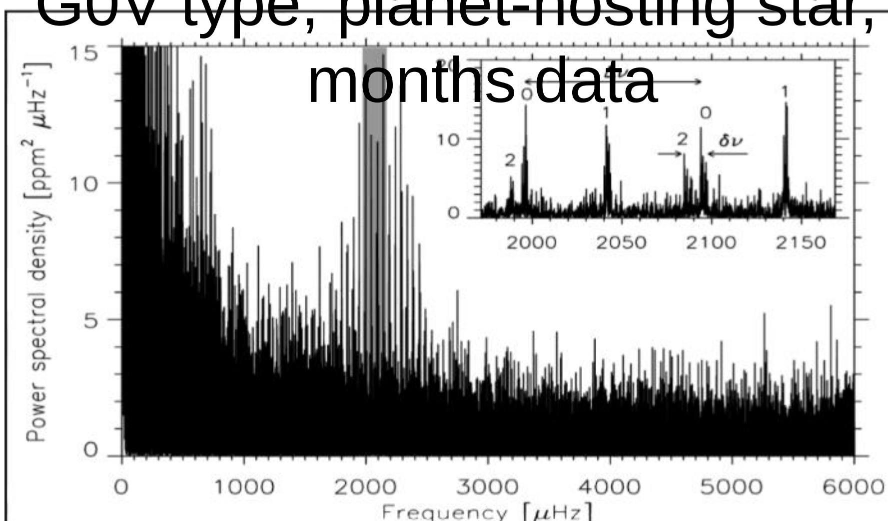
Requires some automatized pipelines

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 ±

Determination of the stellar radius

SB law: needs L (distance(Gaia), BC, interstellar redenning) and Teff
Spectrophotometric: needs model atmosphere
Interferometric: needs distance (Gaia) and limb darkening

Determination of the mass:

HR diagram and isochrones, model fitting
Mean density from transit and radius

Determination of the age:

HR diagram and isochrones, model fitting

Document intermediaire à SI3

- l’identification des outils et méthodes permettant de déterminer aujourd’hui les PECP
- l’identification des précisions et biais associés aux PFDE.
- définition des tests, des observations disponibles et des simulations à réaliser permettant la quantification des performances des outils et méthodes ci-dessus, l'identification des biais dans la détermination des PECP.
- Premières conclusions concernant les solutions pour éliminer les biais dans la détermination des PECP.
- Propositions de format des livrables à fournir au PDC tels que les grilles de modèles stellaires.
- Agenda de livraison des spécifications de la responsabilité du WP120 au PDC

Determination of stellar radius : conclusion
(from Morel 2010)

From non-seismic diagnostics *alone*, achieving accuracy of 2% for radius quite challenging:

- 'Classical' method: T_{eff} must be known to within 50 K for solar like and 35 K for M stars (unrealistic in latter case). Accurate knowledge of A_V and BC also necessary (to within 0.015 mag).
- From spectrophotometry: most promising method, but sensitive to reddening and availability of space data a serious issue: currently only STIS, PHASES microsatellite in future (del Burgo et al. 2010)?
- From interpolation in isochrones: strongly model dependent.

Non-seismic analysis expected to eventually provide T_{eff} to within 60 K and [Fe/H] to within 0.1 dex for the bright solar-like PLATO targets (M stars a concern).

Note: the above uncertainties are internal

Determination of stellar radius : interferometry

Kervella et al 2003   bright star alpha Cen A
binary   alpha Cen B fainter
both with solar like oscillations

- *Uniform angular diameter determined within 0.2 % for alpha CenA and 0.4 % for alpha Cen B*

- *With limb darkening (using Claret (2000) 's tables, angular diameter determined within 0.2 % for alpha Cen A and 0.4 % for alpha Cen B*
0.1% has been added to take into account some intrinsic errors on the limb darkening coefficients (possibly LD law not fully appropriate)

- *Hence linear diameters derived within 0.3 % for alpha CenA and 0.5 % for alpha Cen B*

Systematic errors due to the physics of the stellar models which the LD calculat ion relie on (cf Barban et al 2002 for instance) are not included

October 2015: Plato B1 data package delivery for **SRR**

✓ Documents by the consortium for Phase B1 PDCR-SRR

- ~~PDC/PSPM Work Breakdown Structure (WBS~~) done
- ~~PDC/PSPM Work Package Descriptions (WPDs~~) done
- ~~PLATO Mission Consortium Science Implementation Plan (PMC-SIP)~~ done
- PLATO Consortium Financial Plan

✓ Documents to be released by ESA

- Science Management Plan (SMP, highest level document)

(to be ready by mid September)

- Science Requirement Document (SciRD)

  (now issue 5.0, to be updated after the PCDR and for the Instrument-SRR and SRR)

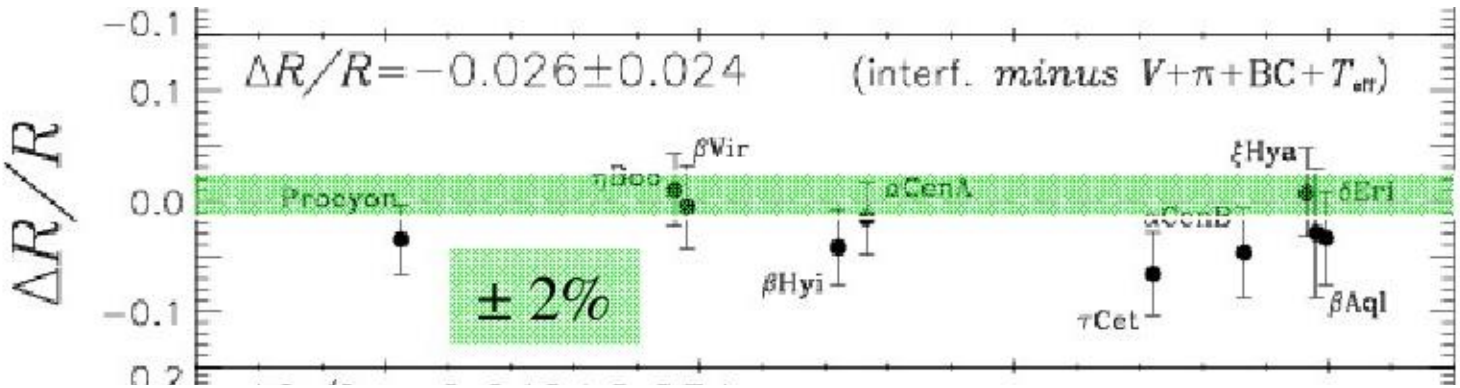
- Science Requirement Justification Document (SRJD)

  (it will be issued after the PDCR, and updated before Instrument-SRR and SRR)

- Science Implementation Requirements Document (SIRD)
- Science Operations Concept Document (SOCD)
- Definition study report *(to be ready by March 2016)*

Determination of stellar radius : interferometry

(from Morel 2010)
Comparison between photometric and interferometric determinations



Does not include systematic errors (model atmosphere, limb darkening)

Overall Conclusion

Assuming that the star is bright enough that precise observational (non seismic) constraints are available (not warranted):

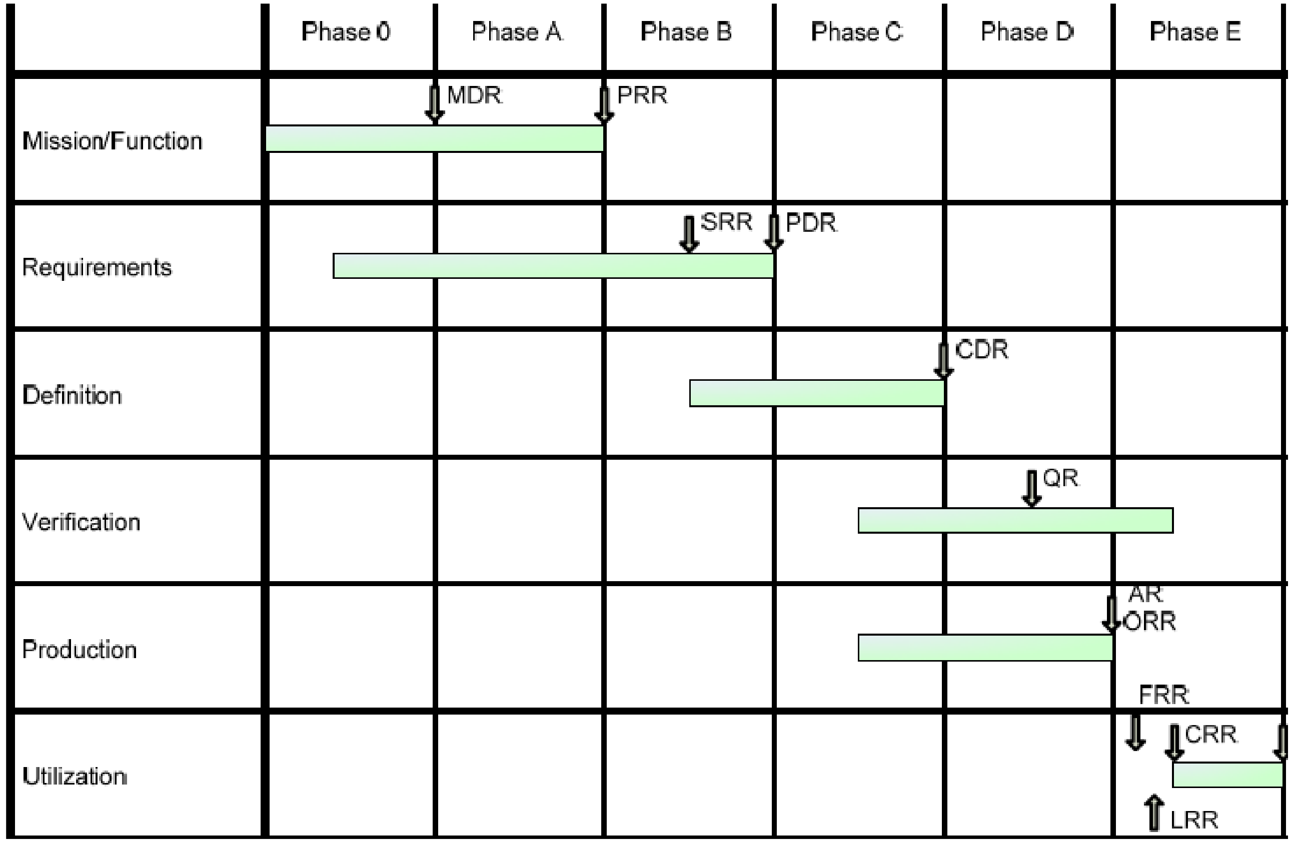
• in 2020 after Gaia, the major source of uncertainty on stellar parameter (mass, age) might then come from uncertainties in stellar model atmosphere and stellar internal structure and evolution (20-30 % on age determination; 6 to 10% on mass).

• before 2020, improvements in stellar physics will partly come from interpretation of Kepler and CoRoT seismic data. However:

- most stars observed by Kepler are rather old (end of PMS and subgiants) and sited in a single location in the sky.
- CoRoT observes in two locations so that some impact of the environment on the structure and evolution of stars can be learned. CoRoT also includes younger stars. But CoRoT observes only a limited number of stars.

This will definetly not be enough to cover the whole region of model parameter space and physical processes conditions encountered in stars (environment, metallicity, rotation, etc…). Furthermore the improvements made available in 2020 may not be applicable to individual target stars (with their own specificities)

• 10 years from now is short to provide improvements significant enough to bring the age for instance to a satisfying level of accuracy (particularly improvements in the treatment of hydrodynamical processes and their consequences in stellar interiors)



Phase B1: from October 2014 till April 2016

-Payload FM delivery: Jan 2021 – Jan 2022

-PLATO launch: January 2024

First phase of implementation

First generation of codes and models

to help dimensioning the implementation
Existing codes and models.
Is it needed ?

Estimate how far to go to reach the required precision* on star parameters

Second phase of implementation

Second generation of codes and models

Improved models and codes from theoretical work and CoRoT and KEPLER learning

Required precision on parameter stars is reached

After launch

Third generation of codes and models

Learning from PLATO data

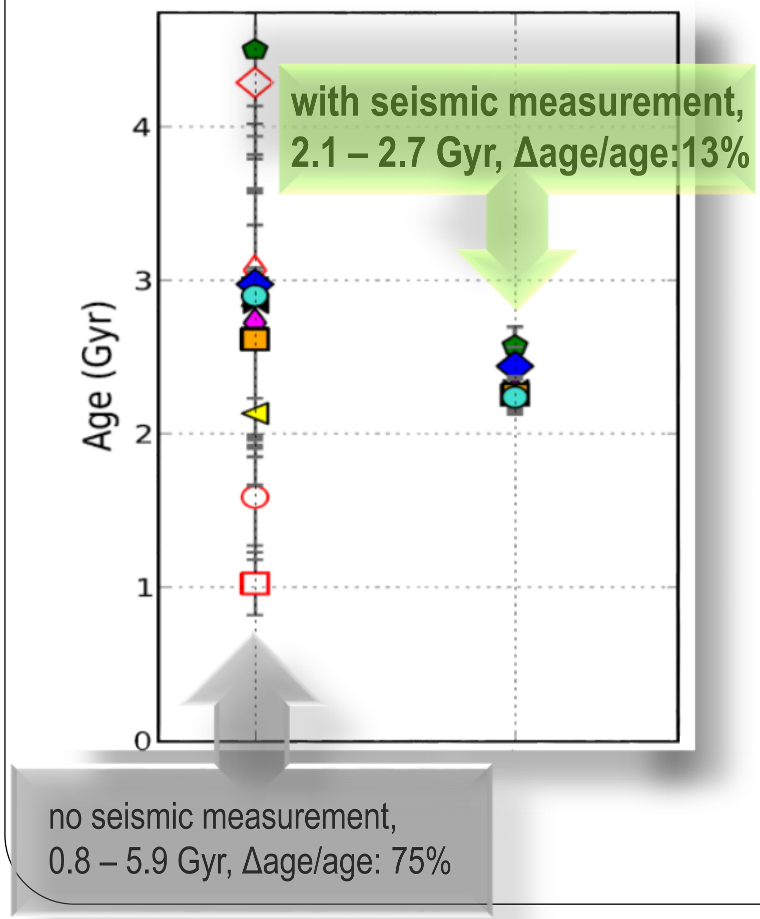
Hopefully increase the precision beyond the initial requirements

Iterations over the years

*including time of delivery

Stellar seismology (together with classical parameters Teff...)

CoRoT and Kepler have shown that the requirements in term of precision can be achieved

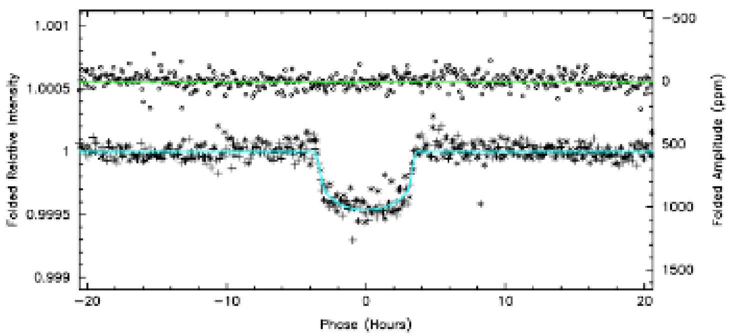


Example: HD 52265 (CoRoT), a G0V type, planet-hosting star, 4 months data

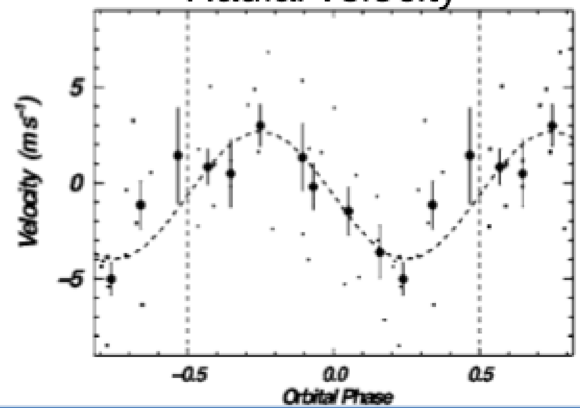
Seismic parameters:

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

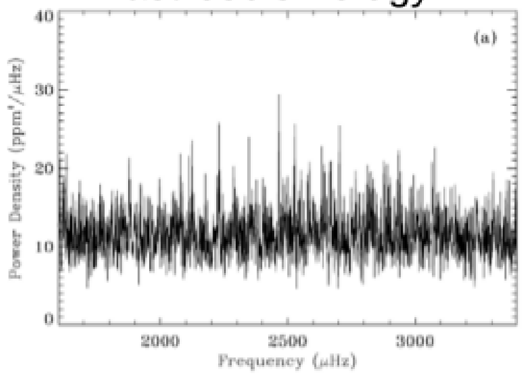
Transit photometry



Radial velocity



astroseismology



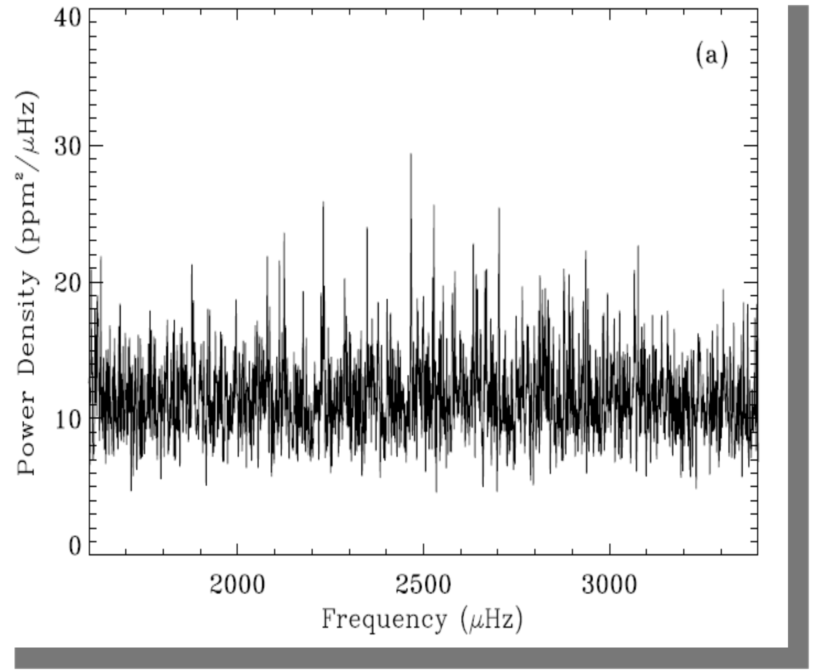
Proof of concept for a bright host star by Kepler mission:

Kepler 10b (Batalha et al. 2011) (10.96 mag star):

$r_p = 1.416 \pm 0.03\ R_{Earth}$, (2% accuracy)

$m_p = 4.56 \pm 1.2\ M_{earth}$ (25% accuracy)

age: 11.9 ± 4.5 Gyrs (38% accuracy)



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

Phase B1 kick-off: Early July 2014
Phase B1 data package (KO+ 16 Months): Nov 2015
System Requirement Review: Dec –Jan 2016
Mission Adoption & IPC approval: Feb-March 2016

Phase B2/C/D ITT preparation: Jan-March 2016

Phase B2/C/D ITT issue: April 2016

Industry proposals: July 2016

Phase B2/C/D kick---off: Sept---Oct 2016

ESA (P. Gondoin)

Definition Phase B1 (three parallel Industrial studies):

•Phase B1 industrial studies kick-off: October 2014
•Payload Design Consolidation Review (PDCR): March – April 2015
•Instrument System Requirement Review (ISRR): October-November 2015
•Spacecraft System Requirement Review (SRR): February-March 2016
•Mission adoption & IPC approval: Q2 2016

Implementation Phase (one Prime Contractor):

-Industrial ITT for Phases B2/C/D/E1: July-Dec 2016
-Industrial Prime contractor kick-off: Jan 2017 (TBC)

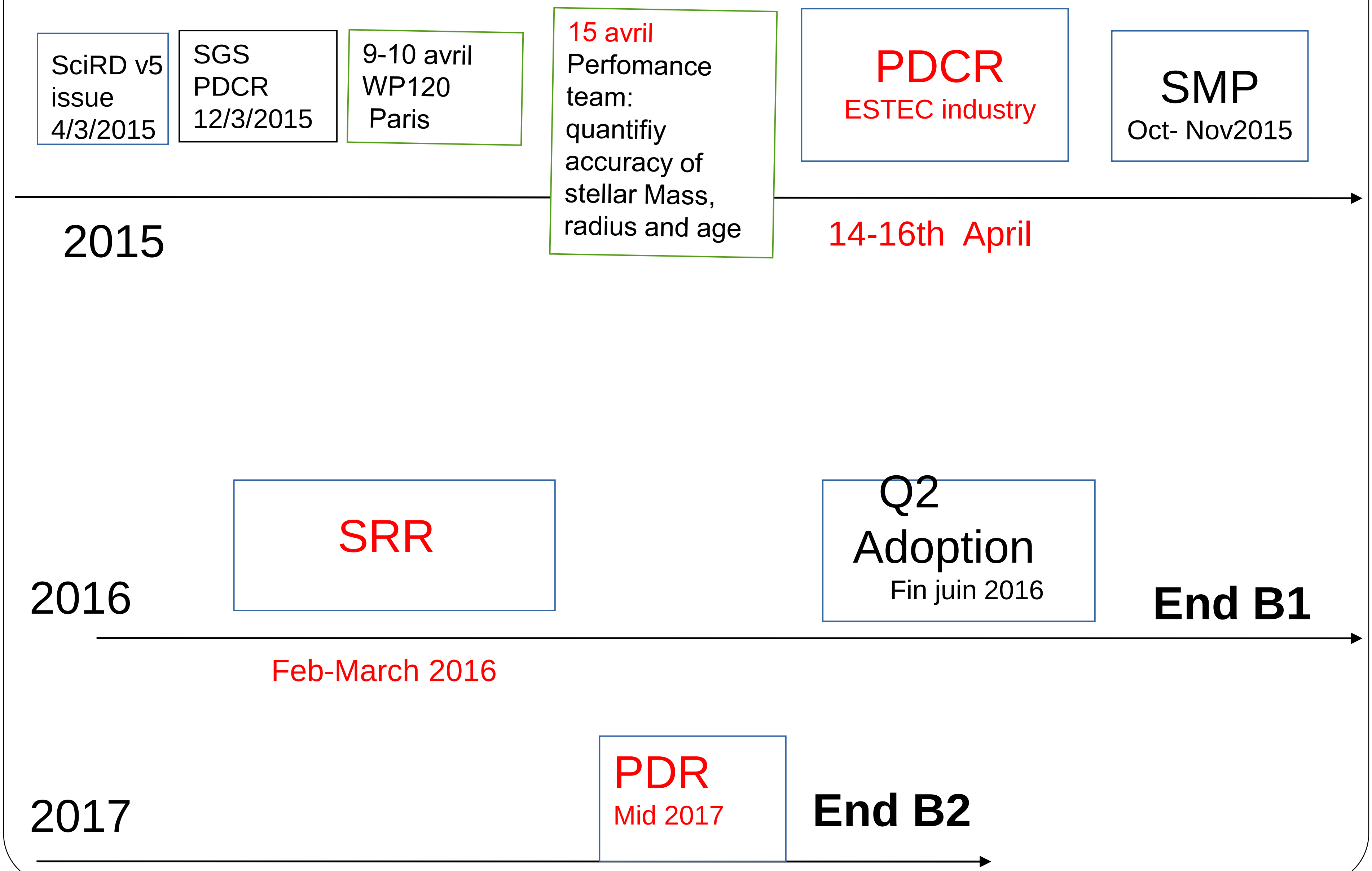
→Consortium activities shall not stop between ISRR and start of Phase B2/C/D/E1

Table 4.1: Expected numbers of targets from PLATO and Kepler, at various photometric noise levels and various magnitude limits

Design & surveyed area	PLATO concept A 3600 deg^2		PLATO concept B 1250 deg^2		PLATO concept C 3600 deg^2		Kepler 100 deg^2	
noise level (10^{-5}/hr)	# cool dwarfs & subgiants	mag lim	# cool dwarfs & subgiants	mag lim	# cool dwarfs & subgiants	mag lim	# cool dwarfs & subgiants	mag lim
2.7	22,000	10.4	21,000	11.1	21,000	9.8-11.1	1,300	11.2
8.0	260,000	12.7	257,000	13.5	238,000	11.8-12.9	25,000	13.6

design & surveyed area	PLATO concept A 3600 deg^2	PLATO concept B 1250 deg^2	PLATO concept C 3600 deg^2	Kepler 100 deg^2
magnitude	# cool dwarfs & subgiants	# cool dwarfs & subgiants	# cool dwarfs & subgiants	# cool dwarfs & subgiants
6			90	0
8	1,350	675	1,350	30
9	3,800	1,320	3,800	100
10	13,500	4,700	13,500	370
11	48,300	16,800	48,300	1,300

PLATO timeline



From now to the SSR

The documents that the PLATO-SAT is involved before adoption are:

- Science Requirements Document (now issue 5.0, to be updated after the PCDR and for the Instrument-SRR and SRR)
- Science Requirements Justification Document (it will be issued after the PDCR, and updated before Instrument-SRR and SRR)
- Science Management Plan (to be ready by mid September)
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For the Science Group Segment, ESA is responsible for

- the Science Operations Concept Document (SOCD)
- the Science Implementation Requirements Document (SIRD)
- the ESA Science Implementation Plan (ESA SIP).

For the definition of the SOCD and the SIRD we work together with the Consortium.

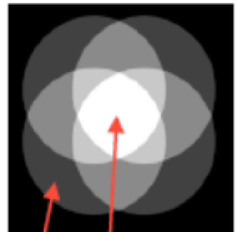
The Consortium is responsible for the PMC SIP.

All these documents will be updated after the SGS PDCR, before the SGS SRR and for adoption.

The PMC has to deliver the documents related to payload and performance.
OHB has produced the Instrument Document Delivery List with the documents that the Consortium has delivered for the PDCR and that will be updated for the Instrument SRR and before adoption.

- WP128 can rotational splitting be measured for main sequence stars ?

as a function of noise level



	PLATO (4300 deg^2)		20,000 deg^2	KEPLER (100 deg^2)	
noise level (ppm/√hr)	nb of cool dwarfs & subgiants **2 long monitoring**	m_V	nb of cool dwarfs & subgiants **incl. step&stare**	nb of cool dwarfs & subgiants	m_V
34	22,000	9.8 - 11.3	85,000		
80	267,000	11.6 - 12.9	**1,000,000**	25,000	13.6
	>1000	8	**>3000**	30	8
	>60,000	11	**180,000**	1,300	11

Spécification (définitions-tests) and Validation

La spécification des outils à implémenter au sein du PDC afin d'estimer avec précision les paramètres fondamentaux des étoiles du core program

L'activité se décomposera en trois étapes :

- une étape de définition avancée (phase B1/B2)
- une étape d'implémentation   (validation)
- une étape de mise à jour

- The documents that the PLATO-SAT is involved before adoption are:

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Time lines:

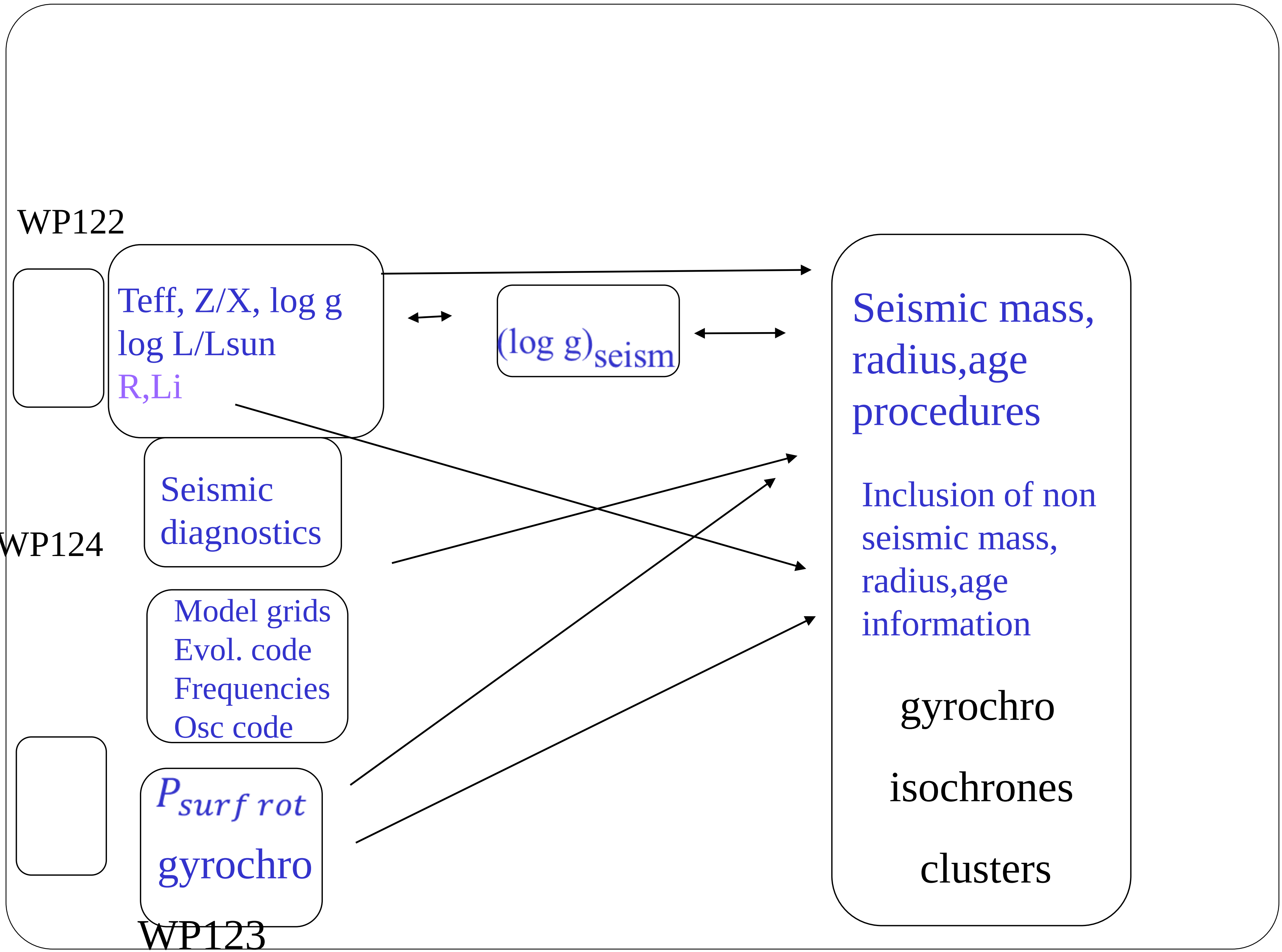
1) sample of stars : rapid and precision and accuracy level 1
Automatic algorithms
Exemple   averaged seismic quantities - scaling laws

2) sample of stars still rapid and better accuracy
Automatic method
Exemple   averaged seismic quantities- model grids

3) sample of stars still rapid and better accuracy
Automatic method
Exemple   individual frequencies- model grids

4) sample of stars still rapid and better accuracy
Automatic method
Exemple   individual frequencies- model grids

5) individual studies : accurate, less rapid


WP122
Teff, Z/X, log g
log L/Lsun
R,Li
(log g)$_{seism}$
Seismic mass,
radius,age
procedures
Seismic
diagnostics
WP124
Inclusion of non
seismic mass,
radius,age
information
Model grids
Evol. code
Frequencies
Osc code
gyrochro
isochrones
clusters
$P_{surf\ rot}$
gyrochro
WP123

LIVRABLES PSPM / WP120

1) LIVRABLES POUR SRR

- Management Plan, WP120
- Update and consolidation of WP120 - WP128
- Update of the definition of tasks for WP120 - WP128
- Update of the définition of the deliverables of WP120 à WP128 to the PDC

2) LIVRABLES POUR PDR :

A definition document including :

- l'identification des outils et méthodes permettant de déterminer aujourd'hui les PECP
- l'identification des précisions et biais associés aux PFDE.
- définition des tests, des observations disponibles et des simulations à réaliser permettant la quantification des performances des outils et méthodes ci-dessus, l'identification des biais dans la détermination des PECP.
- Premières conclusions concernant les solutions pour éliminer les biais dans la détermination des PECP.
- Propositions de format des livrables à fournir au PDC tels que les grilles de modèles stellaires.
- Agenda de livraison des spécifications de la responsabilité du WP120 au PDC

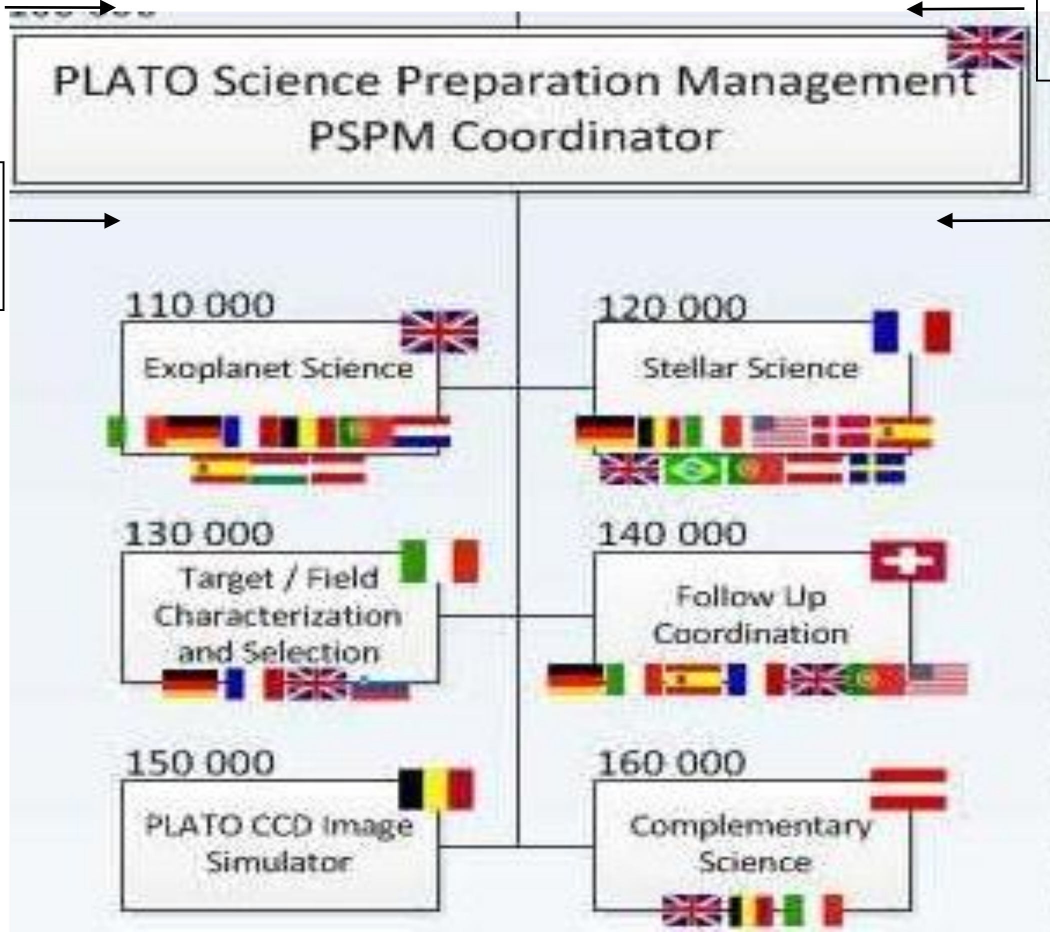
Interfaces with the ‘world’

Spect: détection, caractérisation des planètes

Préparation catalogue d’entrée

Spec: M*,R*,âge, Act. Stel. …

Préparation Observations RV



Procedures : 3 Cases to be considered

- **Large sample of stars** : scaling laws
  automated: rapid
  ΔM, ΔR, Δage large

→ Initlal conditions for more sophisticated studies

→ first order delivery for exoplanets

- **Smaller sample of stars** : model and frequency fitting
  automated rapid to slow
  ΔM, ΔR, Δage better

→ second order delivery for exoplanets

- **Individual studies of single stars** : model and frequency fitting
  slow
  ΔM, ΔR, Δage better

→ constrains on stellar physics and modelling

→ third order delivery for exoplanets