Introduction and objectifs of the meeting

M.J. Goupil

l'Observatoire de Paris | LESIA

Laboratoire d'Études Spatiales et d'Instrumentation en Astrophysique

Limb darkening meeting Grenada Spain Feb 26-27 2019

PLATO (Planetary Transits and Oscillation of Stars)

Key dates :

- PLATO selected as ESA M3 mission (Feb. 2014)
- PLATO adopted by ESA in June 2017
- Currently in phase B2 (consolidated definition phase)
- Phase C (consolidated design and implementation) : Q4 2019-Q4 2023
- Launch is expected in 2026

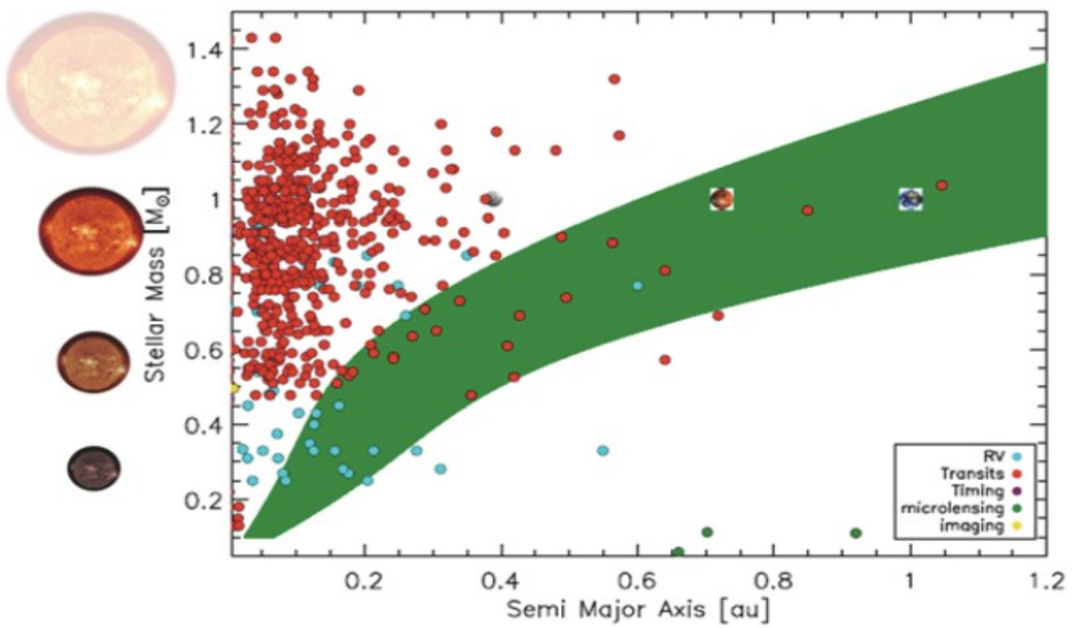
Soyuz launch from Kourou (Credit: ESA)

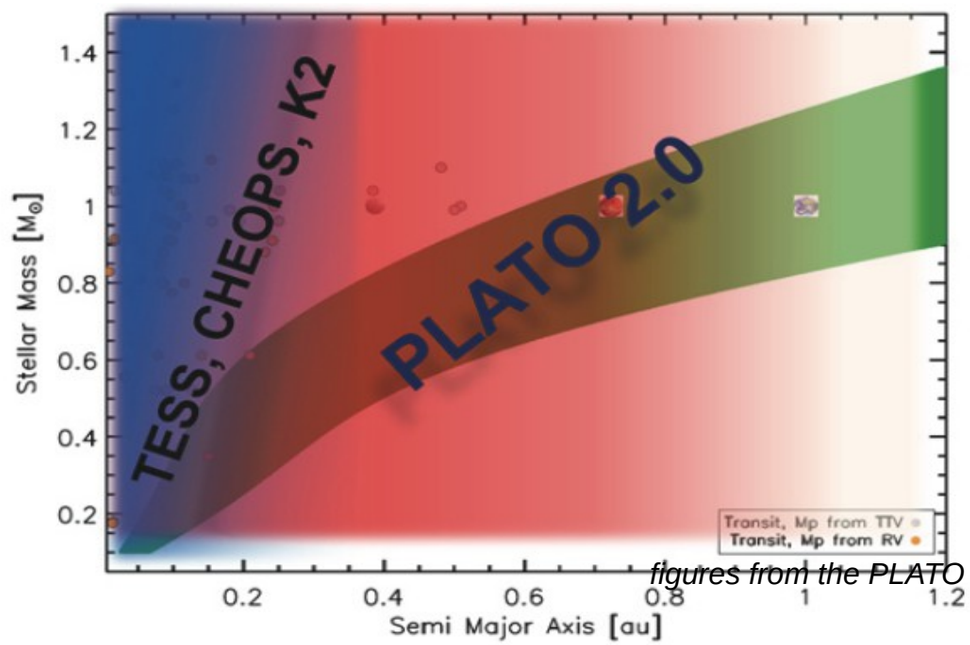
PI : *H. Rauer (DLR)*
Science coordinator :
D. Pollacco (Warwick Univ.)

Launch by Soyuz-Fregat2-1b from Kourou in 2026 (compliant with a Ariane 6 launch)

PLATO main objectives

- detect and characterize terrestrial planets orbiting a Sun at 1 au
- explore planet diversity





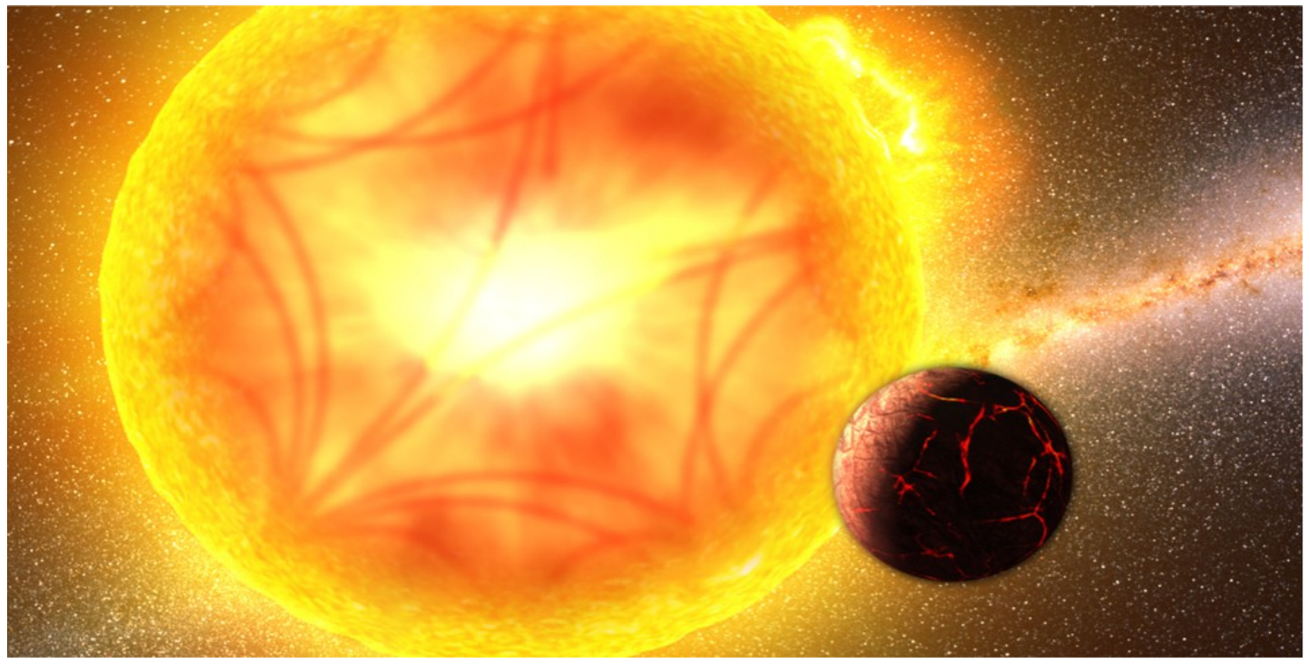
figures from the PLATO Definition Study Report

- constrain planet formation and evolution processes

→ requires the knowledge of mass, radius and age of the planets

PLATO main objectives

→ Requires optimal characterization of the host stars :



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

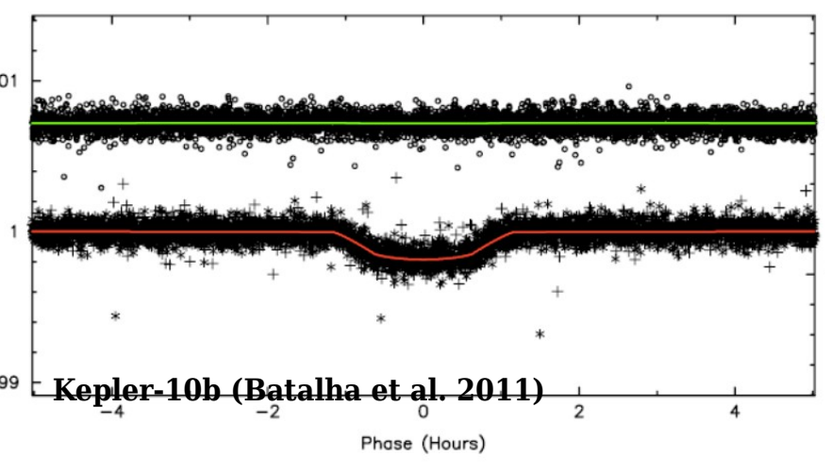
Mass , radius, age, rotation, activity, ….

and

→ Characterization of other stars : improving stellar models because age is model dependent

How to reach the scientific objectives?

- Transits

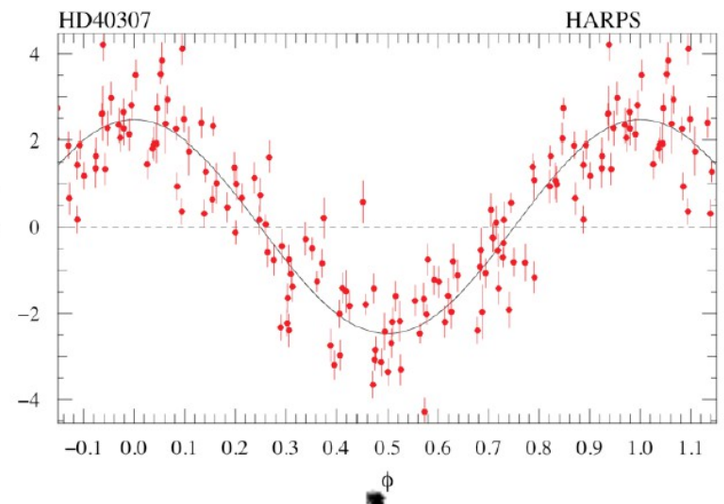


Kepler-10b (Batalha et al. 2011)

$R_p/R_\star$

+

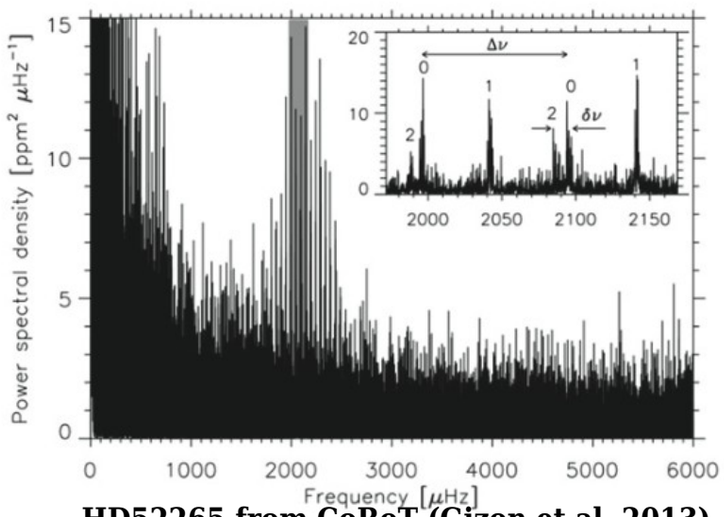
- Radial velocities



$M_p/M_\star$

+

- Asteroseismology



HD52265 from CoRoT (Gizon et al. 2013)

$R_\star, M_\star, \mathrm{Age}, \ldots$

+

gaia

$L_\star, \ldots$

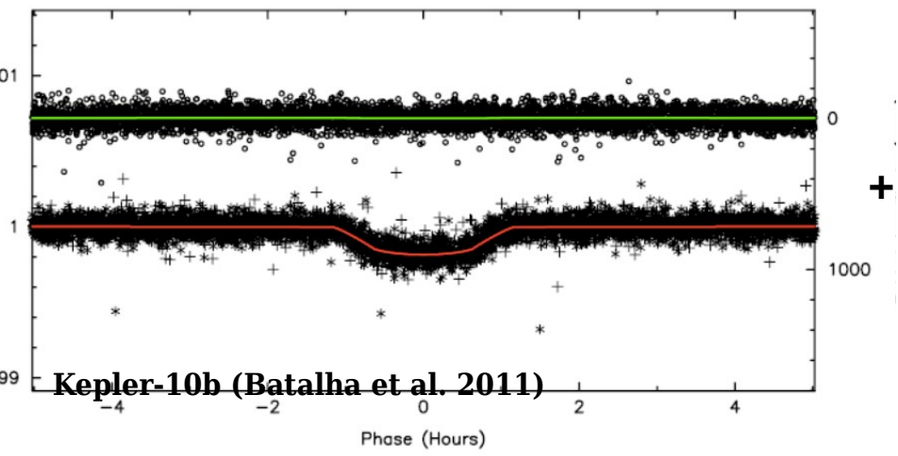
- **Simultaneous** *transit and asteroseismic measurements*

- **Synergies** between photometric, spectroscopic, astrometric and interferometric observations

Why do we need limb darkening ?

- **Simultaneous** *transit and asteroseismic measurements and then ground based follow up*

- Transits



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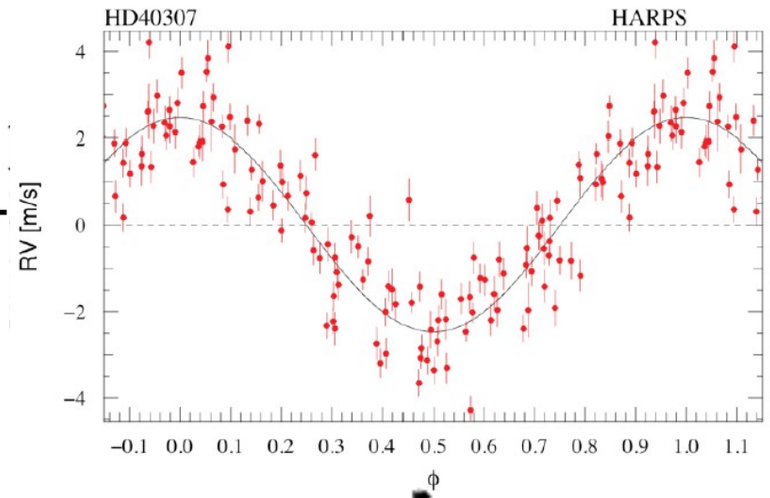

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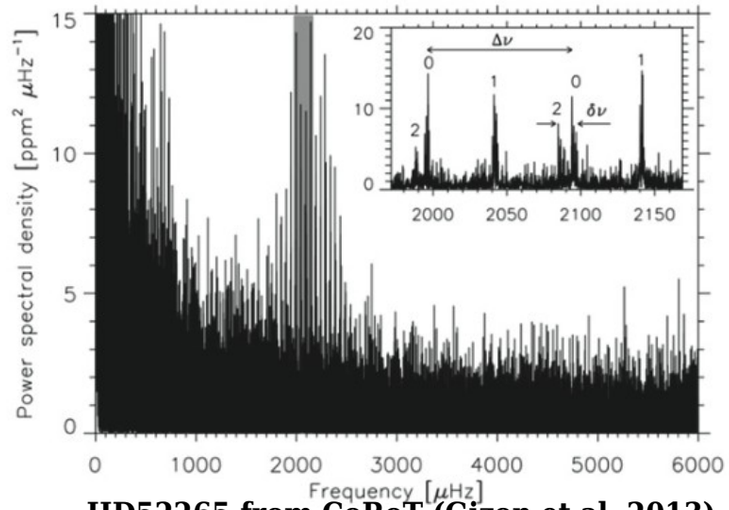


HD52265 from CoRoT (Gizon et al. 2013)

$R_p/R_\star$

$M_p/M_\star$

$R_\star, M_\star, \mathrm{Age}, \ldots$

- Limb darkening : shape of the transit

- Limb darkening : spot modeling : Rotation, stellar activity

- Interferometric radius : benchmark stars : cross check for photometric and/or seismic stellar radii

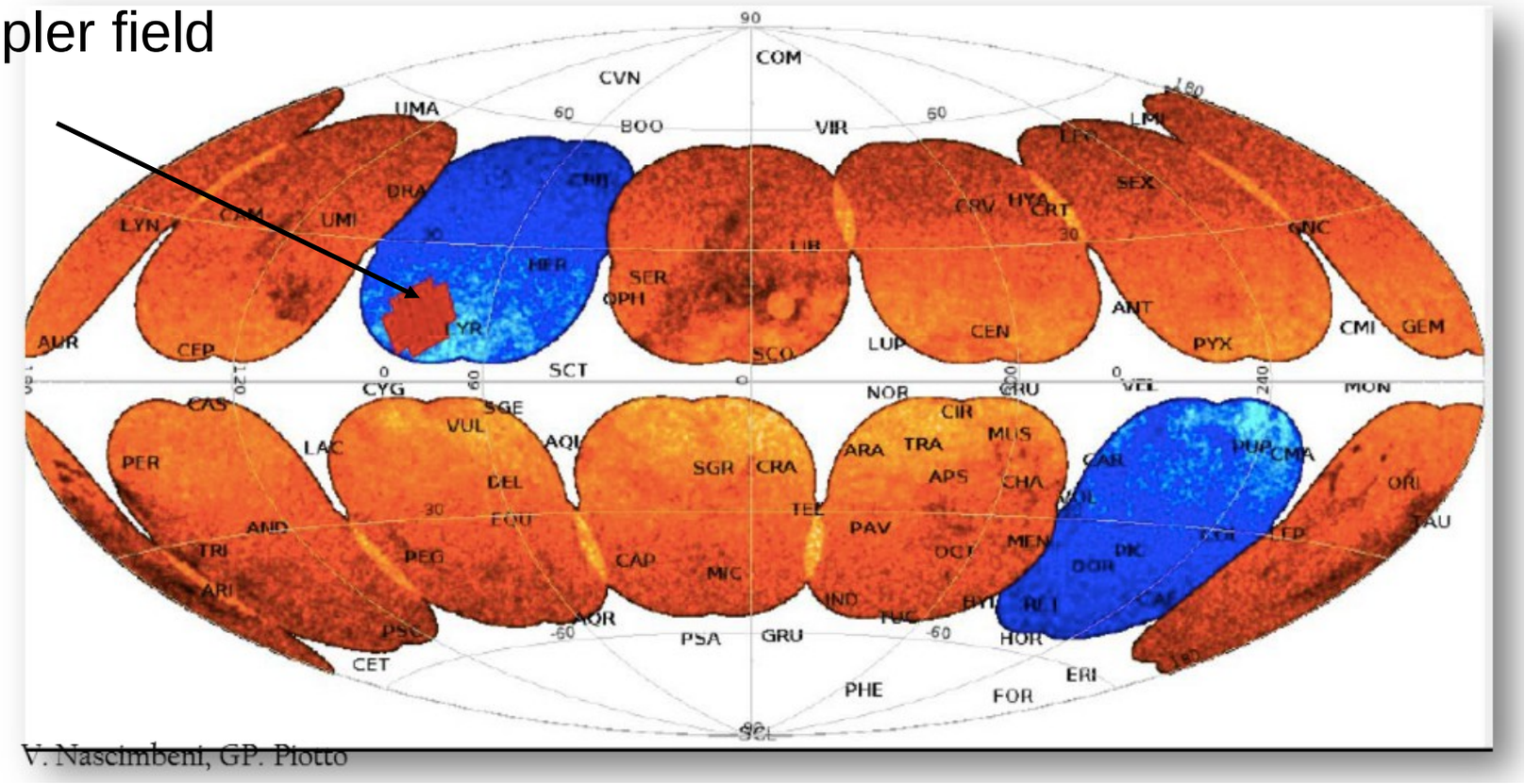
PLATO Observing senario

- Baseline observing strategy:
  - 4 yrs nominal science operation with 2 long pointing of 2 years
  - Optionally a split into 3 years long duration pointing and 1 year “step-and-stare” phase.

- The final observing strategy will be fixed **~2 yrs before launch.**

- the payload is designed for 8 years so extension can be expected…

Kepler field



V. Nascimbeni, GP. Piotto

Long Observing Pointing (LOP)

Short Observing Pointing (SOP

The PLATO samples

Samples of target stars with the current baseline observing strategy :

- **Core program**

- P1 ≥ 15 000 (goal 20 000) dwarfs and subgiants, spectral type F5-K7, 8 ≤ *mag* ≤ 11, noise ≤ 50 ppm.√h, time sampling 25s

- P2 ≥ 1 000 dwarfs and subgiants, spectral type F5-K7, *V* ≤ 8.2, noise ≤ 50 ppm.√h, (300 stars with 2 colours)

- P4 ≥ 5 000 M dwarfs *V* ≤ 16, time sampling 25s.

For all these stars : accurate/precise mass, radius and age will be derived
→ one output of the mission

- **Complementary science and legacy**

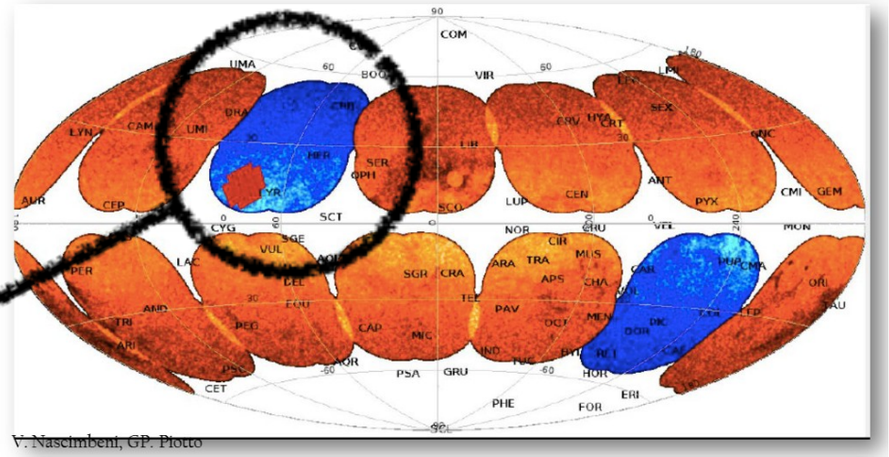
- P5 ≥ 245 000 dwarfs and subgiants, spectral type F5-K7, *V* ≤ 13, time sampling 600s and 25s for 9000 stars.

source :

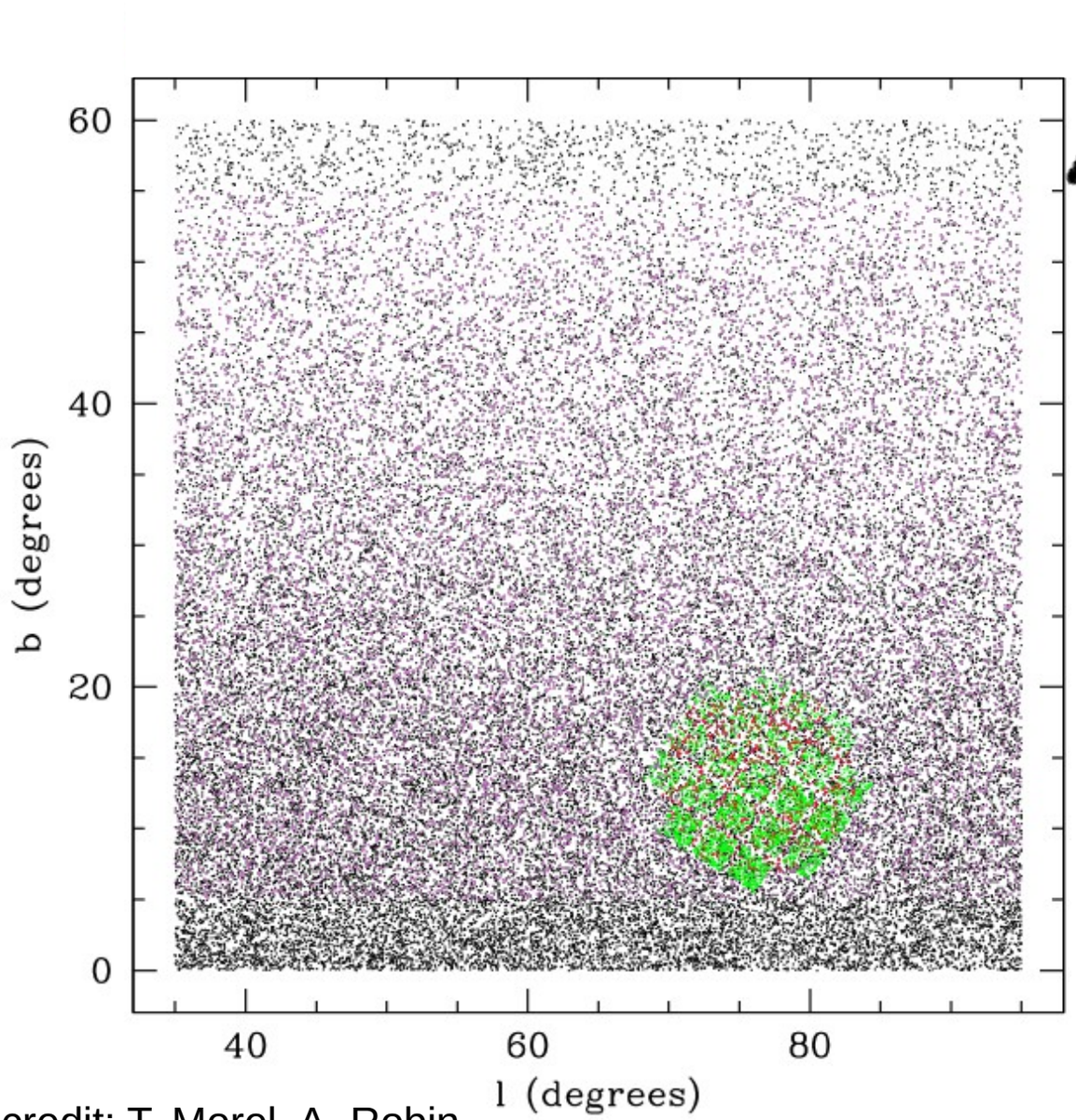
l'Observatoire de Paris | LESIA

Sample of stars expectation

Stellar population computed with the Besançon Model (A. Robin 2017) adapted for a PLATO 2yr long run



V. Nascimbeni, GP. Piotto



credit: T. Morel, A. Robin

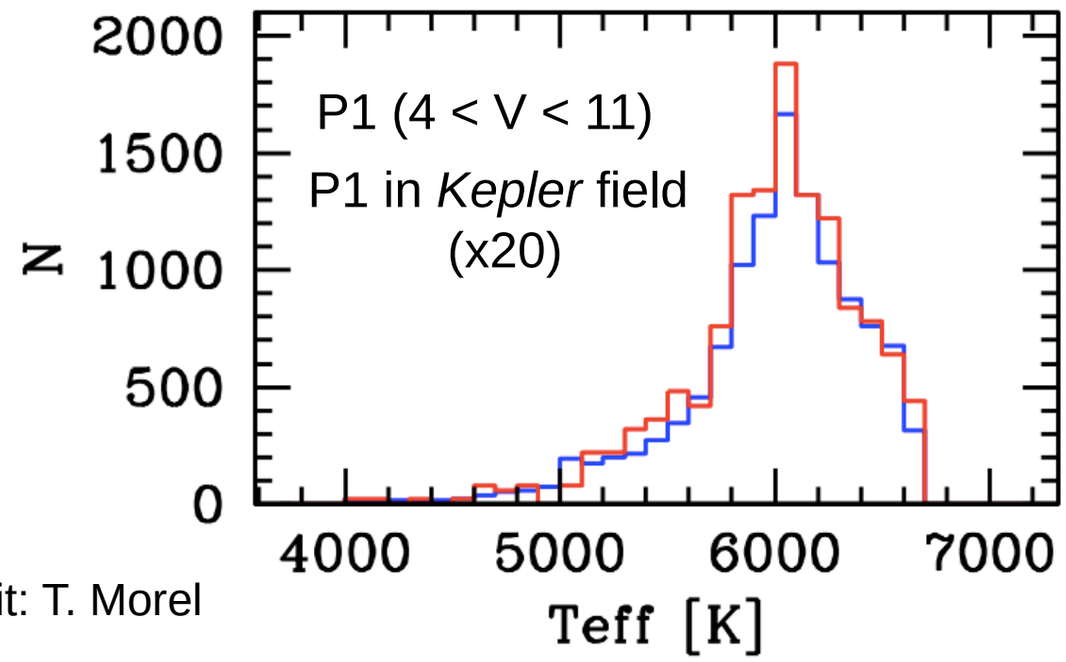
- All stars simulated
- P1 stars
- *Kepler* field
- P1 stars in *Kepler* field

source :

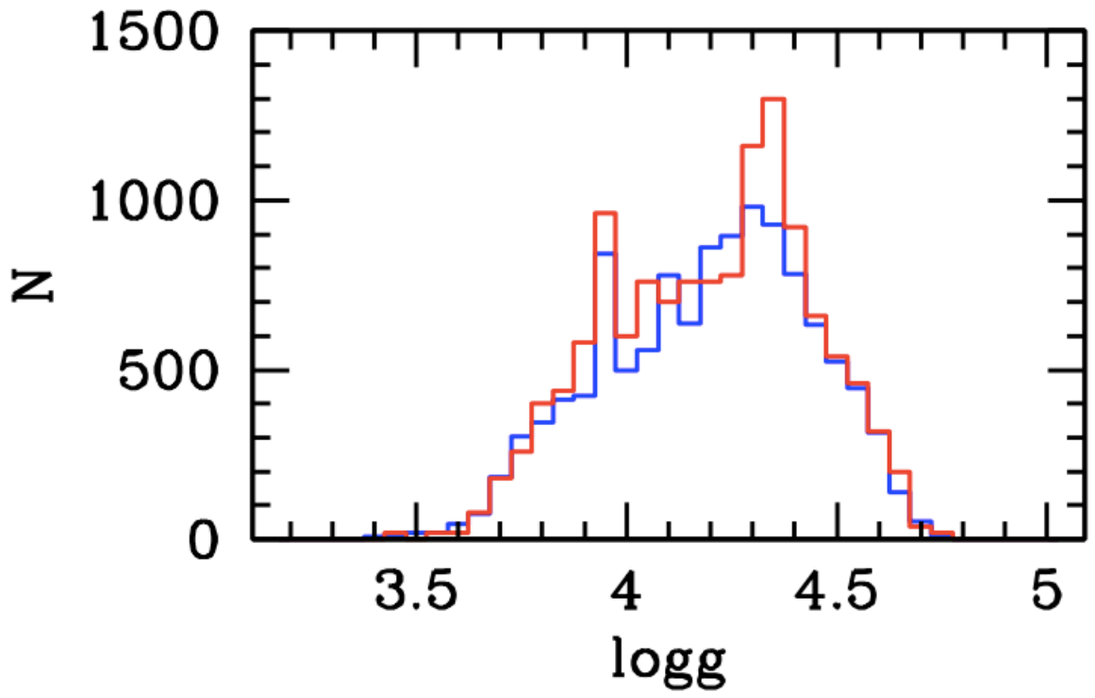
l'Observatoire de Paris | LESIA

Sample of stars expectation

Stellar population computed with the Besançon Model (A. Robin 2017) adapted for a PLATO 2yr long run

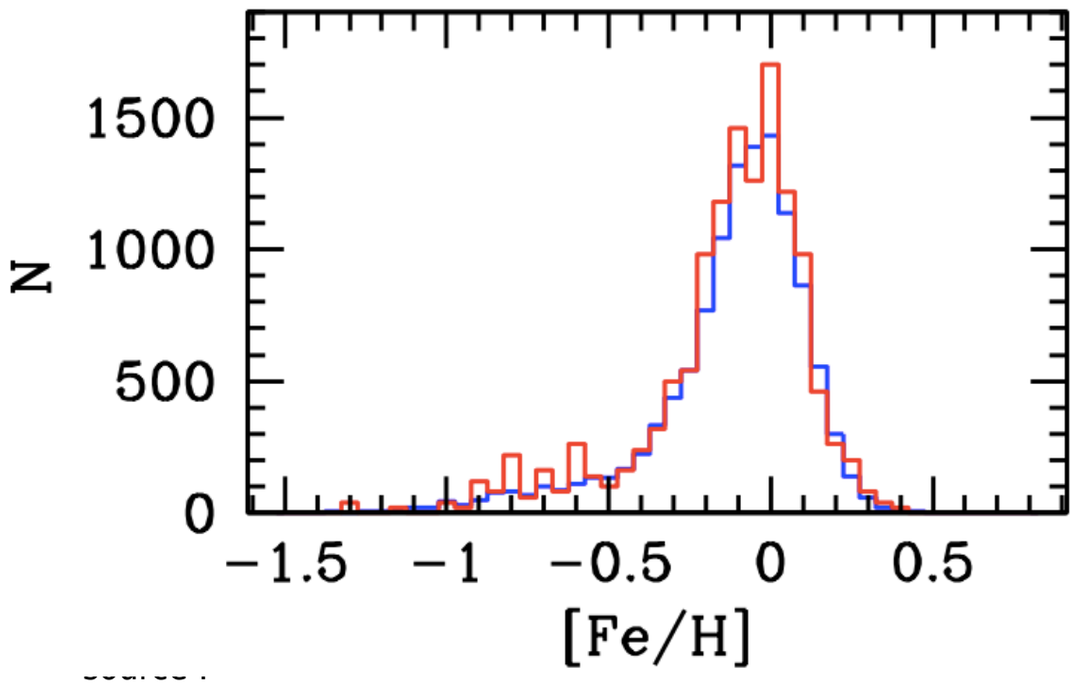


credit: T. Morel



Star distributions from the simulated catalogue:
P1 & P2 samples only

the properties of the Kepler field stars are similar to the properties of the PLATO P1 sample stars



Objectives of the meeting

- Define/confirm the various needs for limb darkening for PLATO

- Answering some questions

  - When are they needed : § prior to the launch (PLATO database) ?
    § during run of the pipeline in operation ?

  - What accuracy/precision is needed ?

  - What LD tables/formulation are available ?

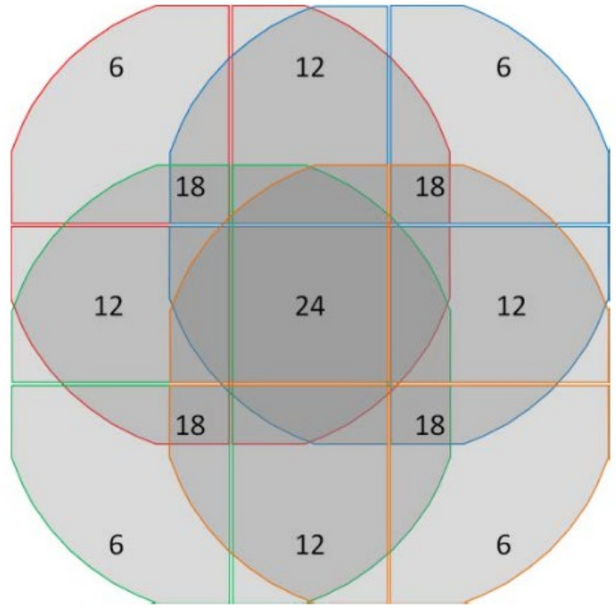
  - Which one is the best for what purpose ?

  - What remains to be done in the years to come ?

Action : this will have to be documented in a technical note, first draft may 2019

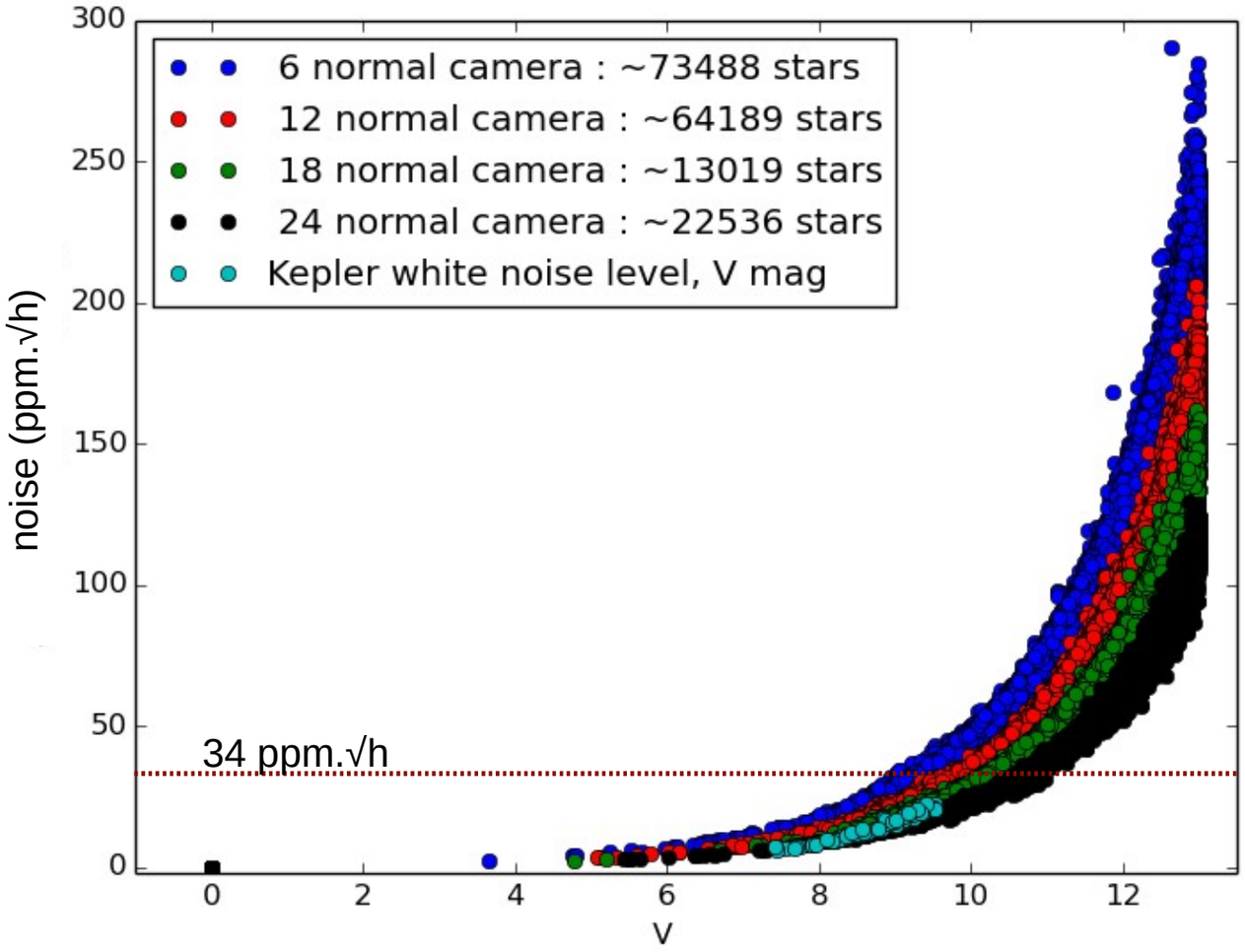
END

The PLATO noise



✓ Plato noise including :

- Target photon noise
- Random noise from the instrument
- Residual noise after correction from systematics



Kepler white noise as derived by M. Lund provided by V. Silva Aguirre

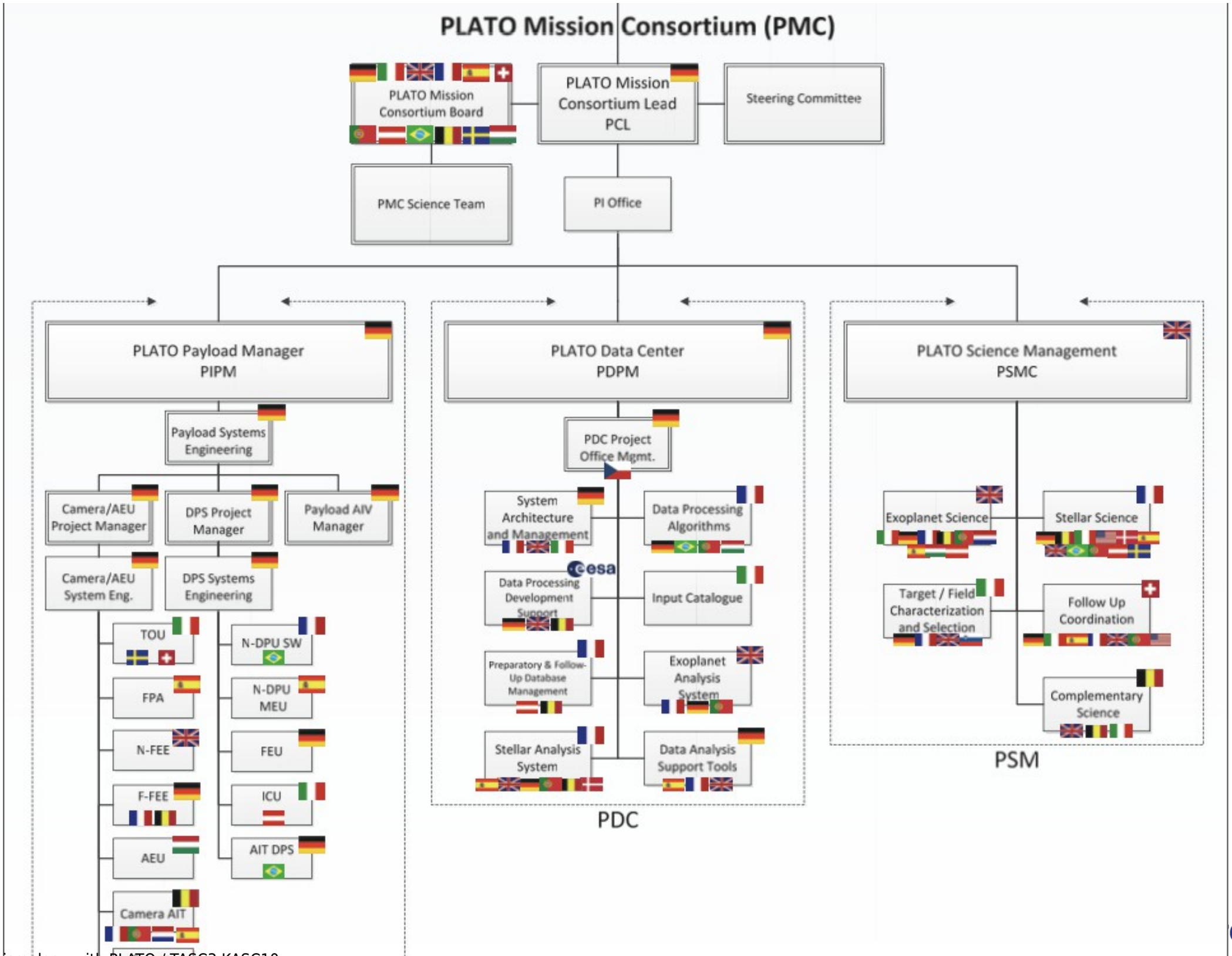
credit: M.J. Goupil, J. Cabrera

✓ the noise level for a target depends on the number of cameras

✓ for 24 cameras, the noise level is comparable to the Kepler Legacy sample

Kepler Legacy sample is an excellent benchmark for PLATO

PLATO Mission Consortium



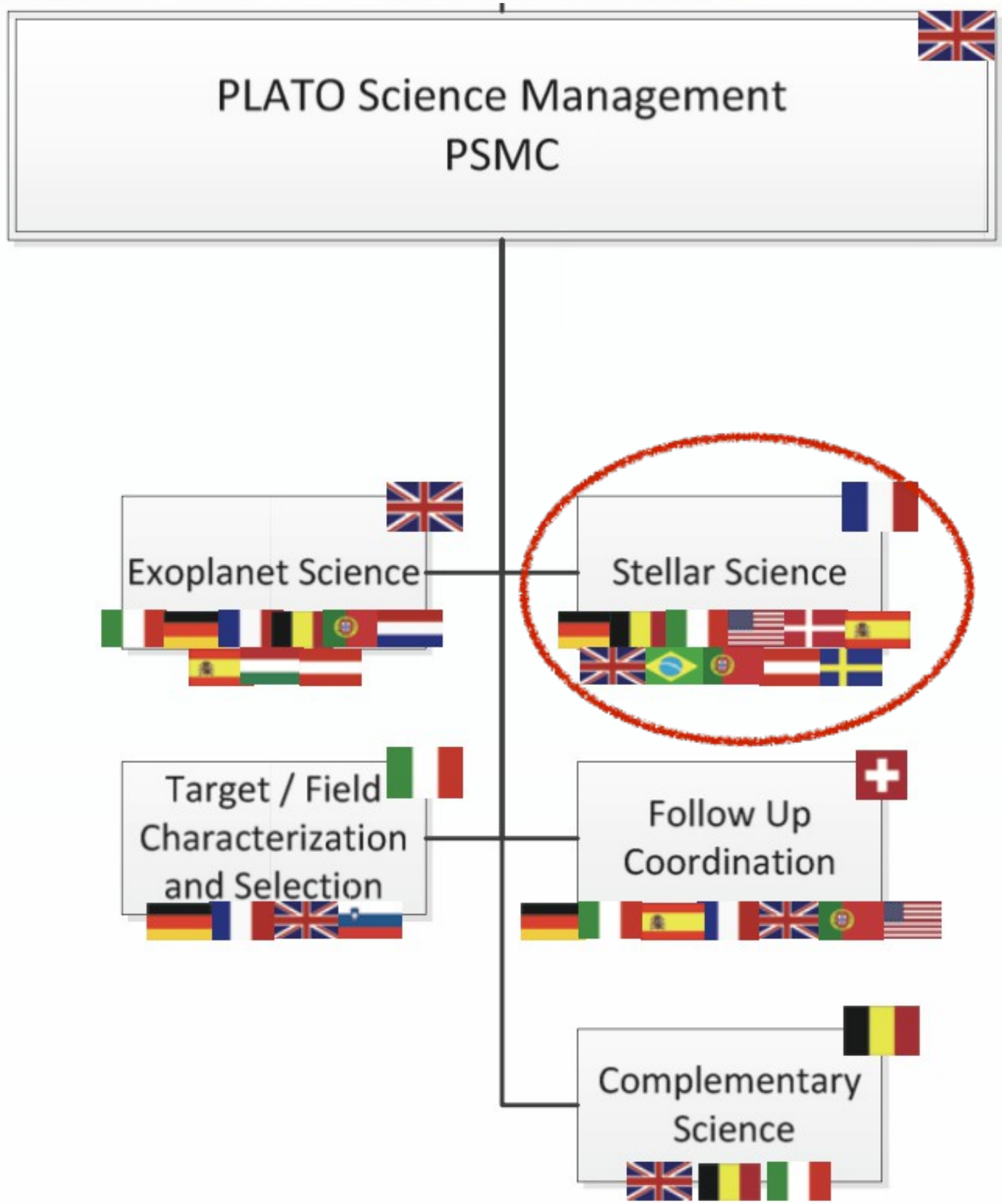
PLATO Science Management (PSM): Stellar Science

- PSM stellar science must provide the specifications and algorithms to the PDC for deriving DP3 to DP5 with associated error-bars

↓

Still a lot of preparatory work to do before launch !

Especially to assess both the precision and accuracy of the data products



Website for stellar science: https://plato-stesci.lesia.obspm.fr/

Search...

Advanced search

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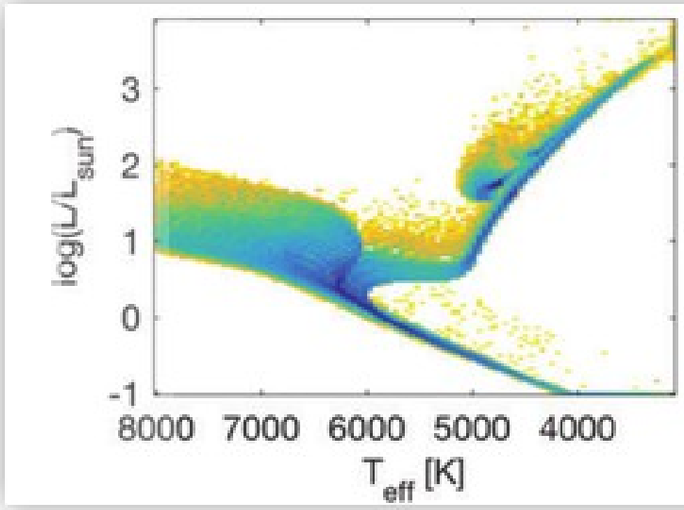
PLATO WP 120
Stellar Science

PLATO 2.0
Planetary Transits and Oscillation of Stars

- Home
- Organisation
- Events
- Timeline
- Documents
- News & Outreach
- Get involved!
- Wiki (consortium only)



News

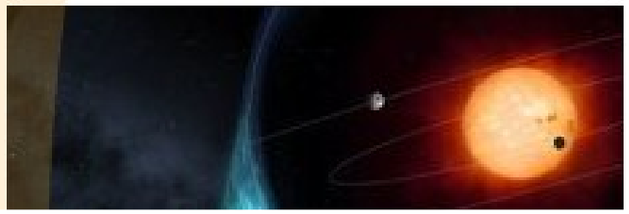
PLATO as it is: A legacy mission for Galactic archaeology

Future Events

PLATO week #5, Porto 23-27 Oct 2017

News

Green light for the PLATO mission



The PLATO mission

PLAnetary Transits and Oscillations of stars (PLATO) is the third medium-class mission in ESA's Cosmic Vision

If you want to join or for any other inquiry: plato.wp120-office@obspm.fr

The PLATO data products

- DP3: Asteroseismic mode parameters
- DP4: Asteroseismic mode parameters
- DP5: Asteroseismic mode parameters

Other data products:

PDP (Preparatory Data Products): product used by the stellar pipeline. These data are computed before operations, stored in the data base and not modified during the run of the pipeline.

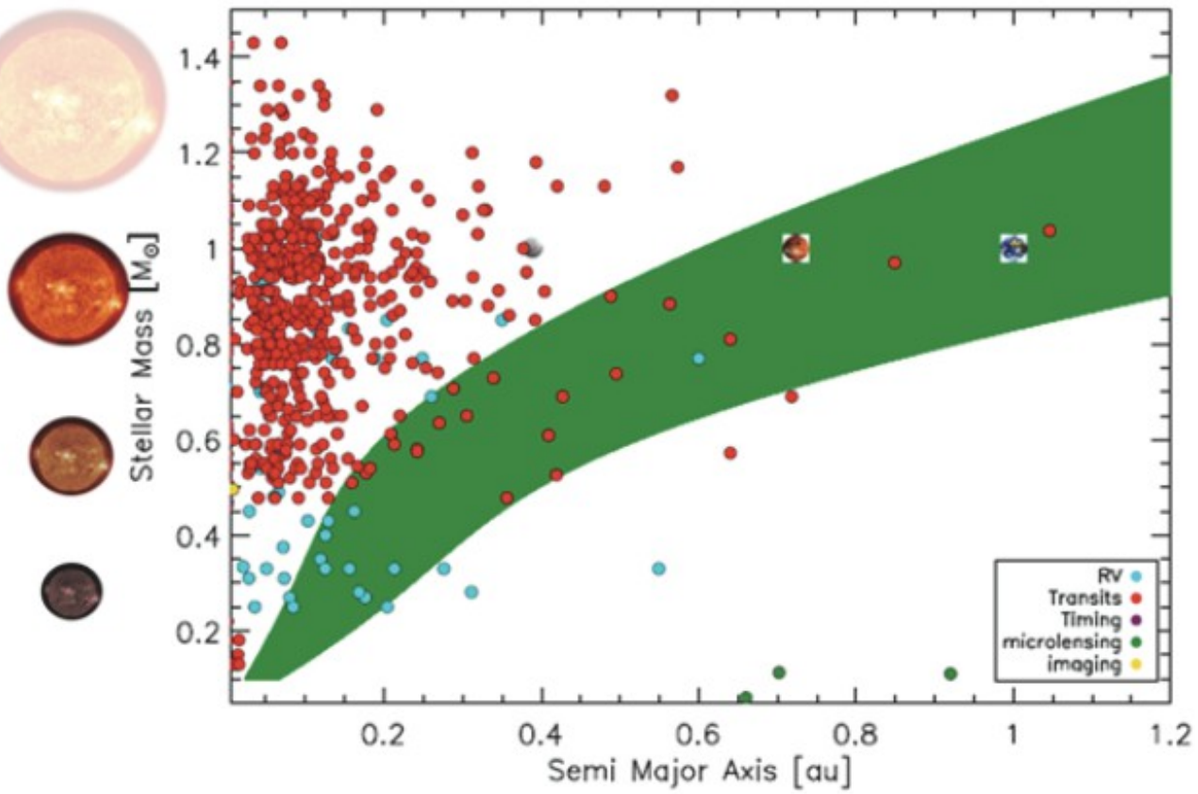
ADP (Additional Data Products): delivered by the stellar part of the pipeline L1--> L2

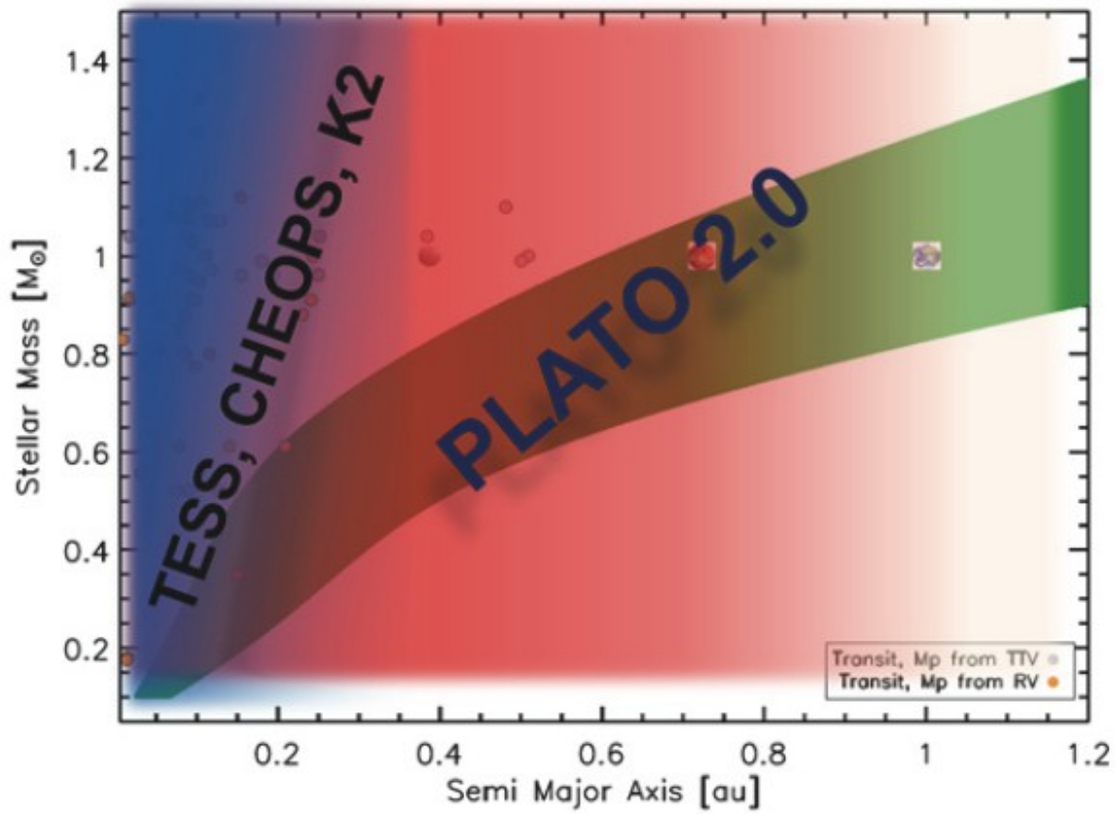
IDP (Intermediate Data Products): products produced at L2 level by the pipeline that are required

PLATO main objectives

Characterize planets to:

- explore planet diversity
- detect and characterize terrestrial planets in the habitable zone





figures from the PLATO Definition Study Report

Determine the bulk properties (mass, radius, mean density) of planets in a wide range of systems, including terrestrial planets in the habitable zone of solar-like stars.

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PLATO main objectives

Characterize planets to:

- explore planet diversity
- detect and characterize terrestrial planets
- constrain planet formation and evolution processes

Need to derive accurate planetary system age

The PLATO data products

- L0 products: raw light-curves
- L1 products: calibrated light-curves and centroids

Data Product (cadence)	# per Camera
Imagette (25s)	18549
Lightcurve (50s)	31350
Lightcurve (600s)	64451
Centroids (50s)	3700
Background values (25s)	3000 windows
Offset values (25s)	8 windows
Smearing values (600s)	18040 smearing rows

435 Gbits of data per day !

PLATO instrument

- 24 normal 12cm cameras, cadence 25 s, white light
- 2 fast 12cm cameras, cadence 2.5 s, 2 colors
- Dynamical range: 4 ≤ mv ≤ 16
- Field-of-View: ~ 2232 deg², with 4 groups of cameras respectively looking on 301 deg², 247 deg², 735 deg², and 949 deg².

Prime contractor : OHB

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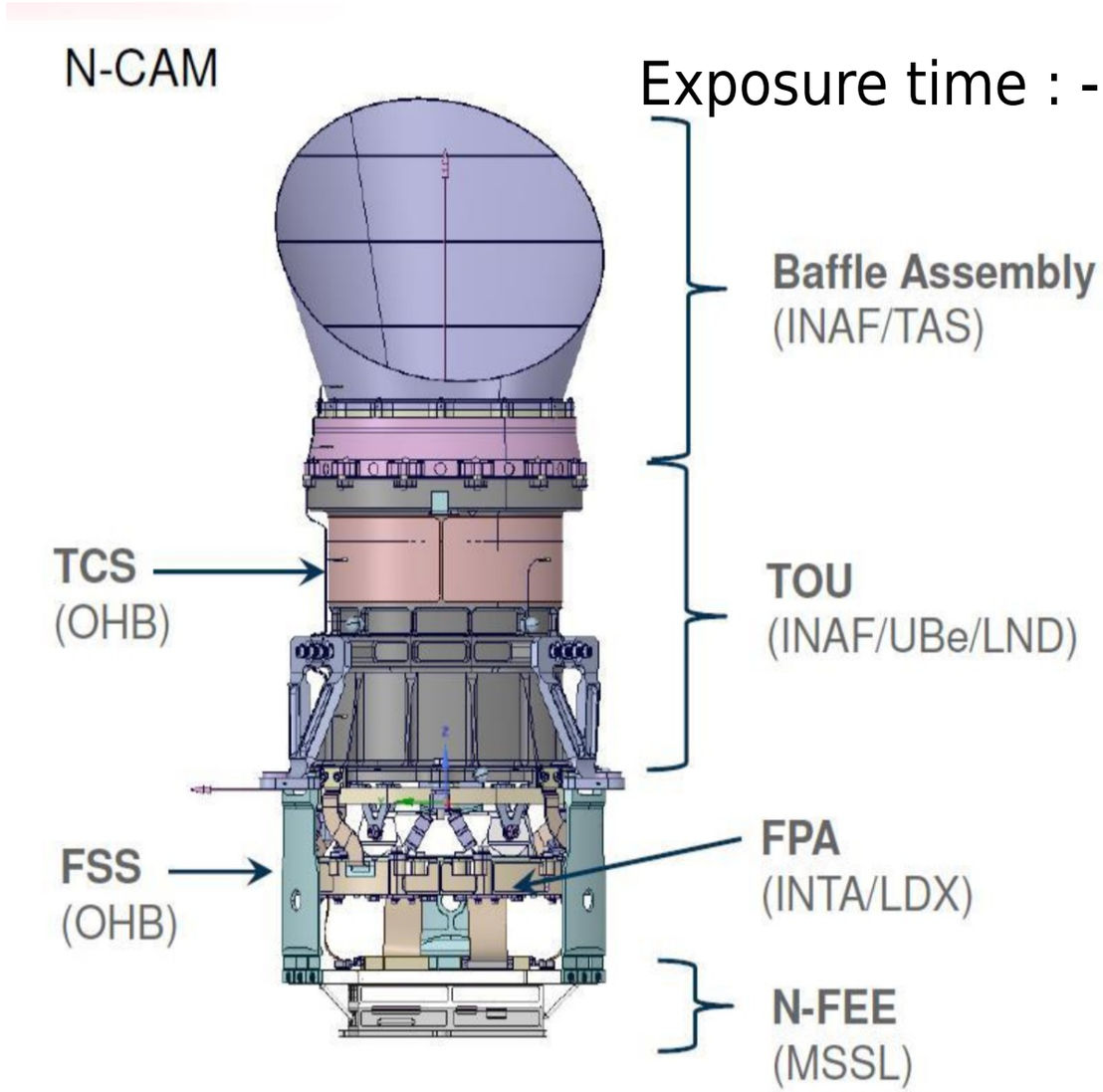
PLATO instrument

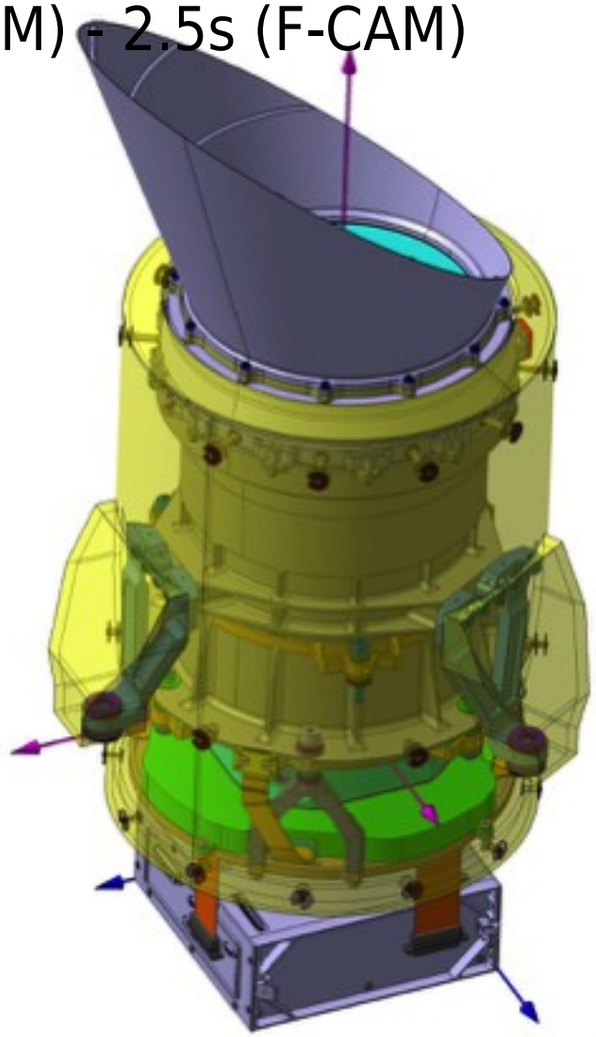
~ 80cm height

PLATO Camera: ~ 30cm diameter ~ 20kg

4 CCD per Camera → ~40° FoV

Exposure time : - 25s (N-CAM) - 2.5s (F-CAM)





PLATO Observing strategy

- 4 groups of cameras

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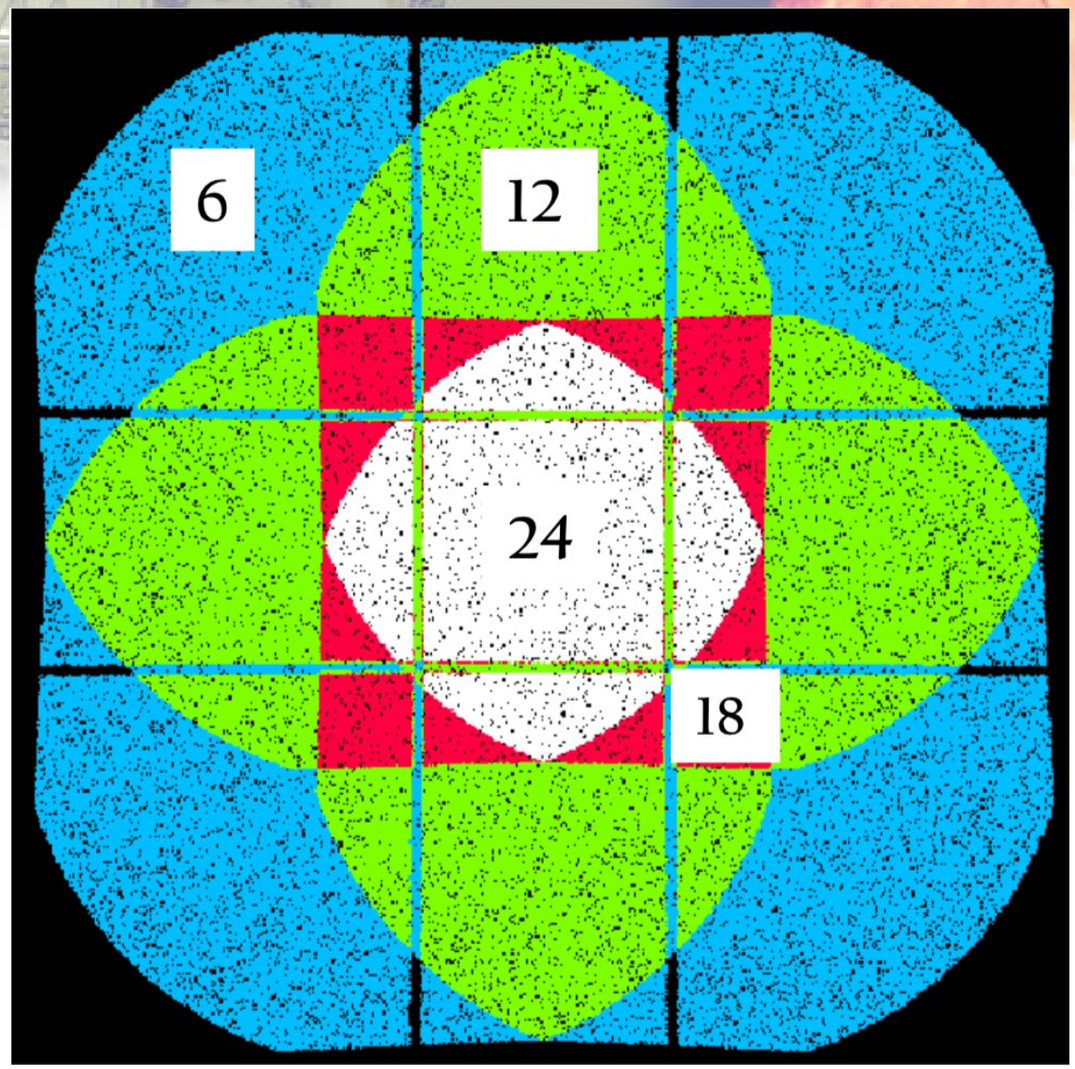

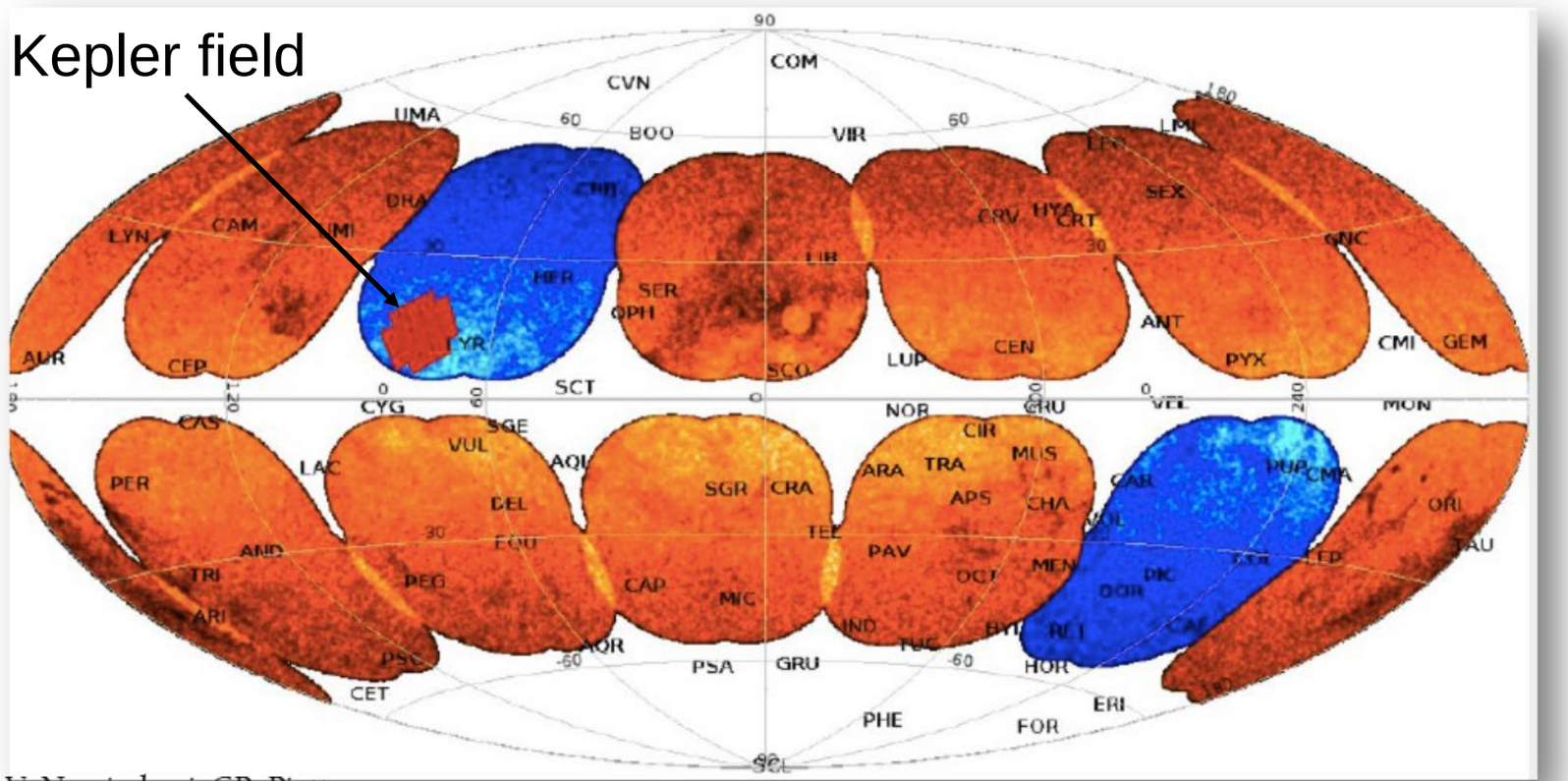

V. Nascimbeni, GP. Piotto

Long Observing Pointing

Short Observing Pointing

The PLATO data products

- L0 products: raw light-curves
- L1 products: calibrated light-curves and centroids
- L2 products: Science results
- L3 product: Final catalogue of confirmed planetary systems

Validated imagettes, light curves and centroid curves	DP0	L0
Calibrated imagettes, 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 radii, masses, and ages	DP5	L2
Living catalogue of confirmed planetary systems and their characteristics using light curves and transit time variations	DP6	L2
Follow-up ground-based observations		Lg
Living catalogue of confirmed planetary systems and their characteristics using new ground-based follow-up observations (Lg)	DP6+Lg	L3

Stellar science and asteroseismology → must provide data products DP3 to DP5