l'Observatoire de Paris | LESIA

Laboratoire d'Études Spatiales et d'Instrumentation en Astrophysique

plato

Stellar science of the core program

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Objectives of the stellar science for the core program

1) to provide a characterization of the stars of the PLATO core program as precise^* and accurate^* as possible, with a specific emphasis for the exoplanet host stars discovered by the PLATO mission

^*Precise : determination relies on the signal to noise ration of the observations and the seismic properties of the solar like oscillators, bulk of sample P1/P2

^*Accurate : needs realistic stellar models , specially for age determination and for stars with no seismic data

2) to improve the physical description of stellar models based on our improved understanding of stellar physics with the PLATO seismic targets

Main data products

Product	*Designation*	*Level*
Calibrated lightcurves and centroid curves	DP1	L1
Planet candidate transits and parameters	DP2	L2
Asteroseismic mode parameters	**DP3**	**L2**
Stellar rotation and activity	**DP4**	**L2**
Stellar masses and ages	**DP5**	**L2**
Confirmed planet systems and their characteristics	DP6	L2

Produced by the **stellar pipeline**

Organization :

- PSM/WP12 in charge of specifying the **stellar pipeline (SAS)** , the methods and algorithms, the valdity tests and benchmark stars
- PDC/WP37 in charge of implementing and running the SAS pipeline and carry out the tests, provide the output
- PSM/WP12 in charge of evaluation of PLATO stellar performances, validation of the tests and of the outputs of the SAS pipeline

Approximate estimate of seismic performances using PIC1 .0.0

Using the PIC1.0.0 data,

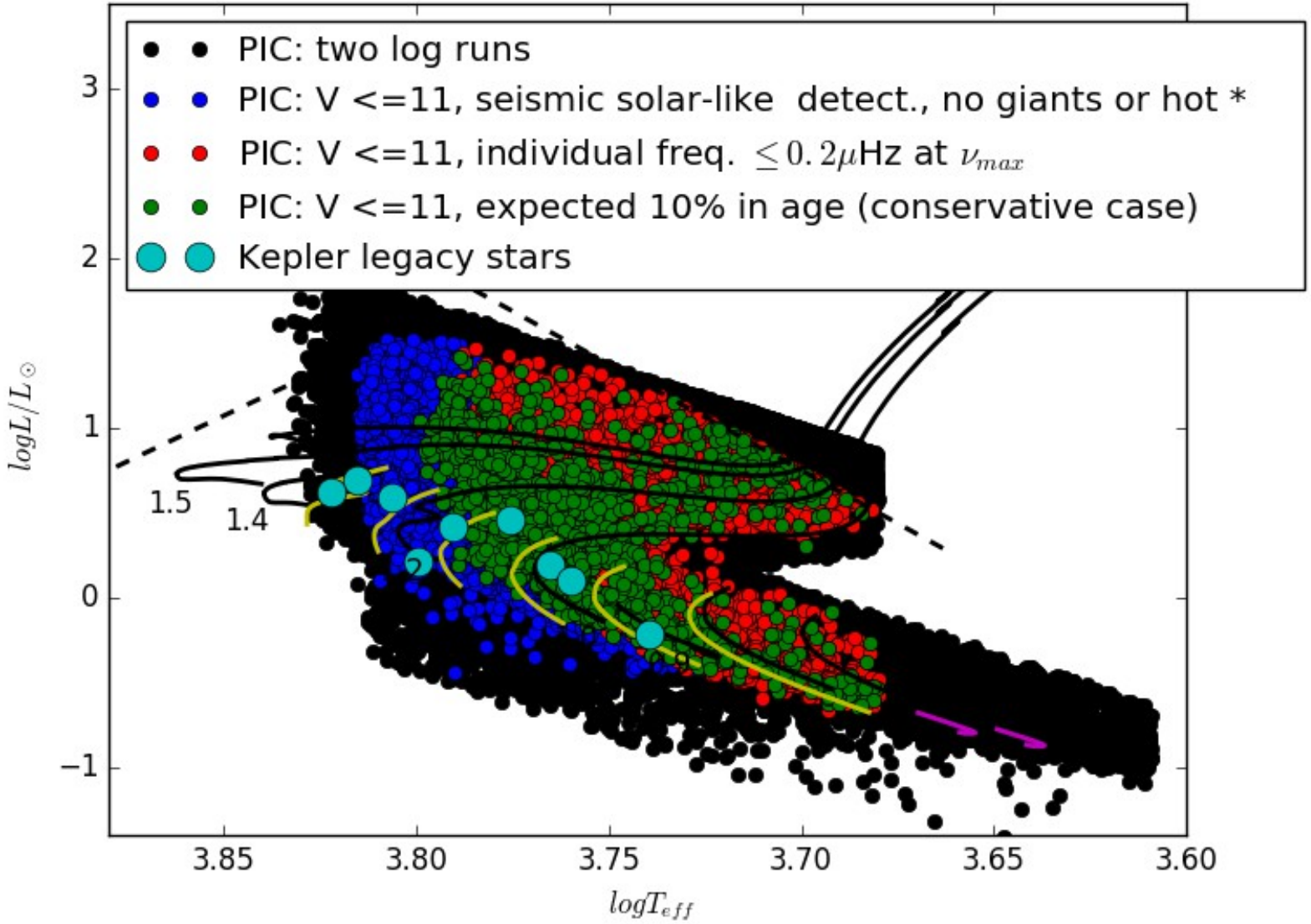
- ~ 15591 stars with seismic detection
- ~ 4605-9889 stars 1 sigma < 0.2 -0.5 muHz

for l=2 frequencies at numax

- Crude criterium for 10% uncertainty for the age

→ 1200- 4000 stars

- Some uncertainties in theses figures comes from the fact that seismic performances used the stellar mass and radius values provided by the PIC



Global overview : Input to/output from SAS

SAS pipeline

Various modules and branches

legend

during operation

Output (to database)

Increasing quality of L1 light curves

Stars with no new information from L1

Stars with only Prot from L1

Stars with only log g_{gran} from L1

Stars with only seismic averaged dnu, numax log g_{seism} from L1

Stars with seismic individual freq. from L1 Low - medium precision

high precision seism.: more in depth studies with stellar core program pipeline level2

Type of output that the SAS pipleine will provide

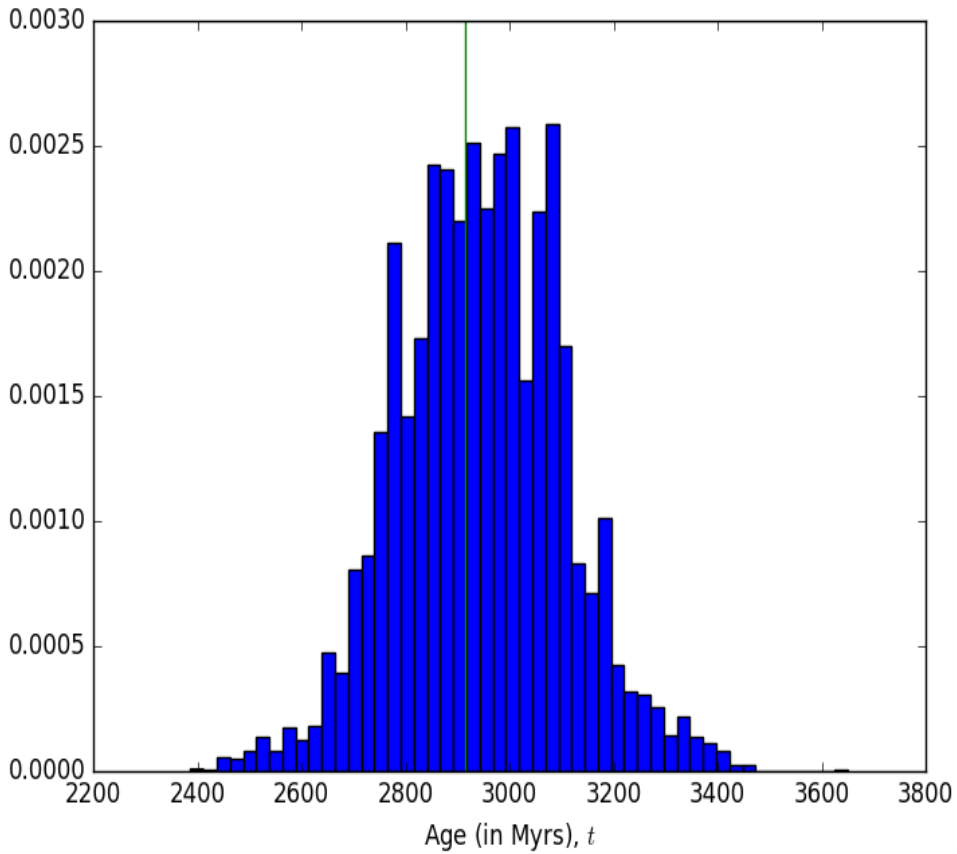
- Result of a HH exercise (leader M. Cunha WP124) using an existing pipeline

1.01 +- 0.01 Msun **(1 σ ~0.7%)**
1.00 +- 0.03 Rsun **(1 σ ~ 2%)**
2.95 +- 0.16 Myr **(1 σ ~ 10%)**

- Inputs : frequency set (1 sigma =0.17-0.7) muHz
  Teff = 5886 K (1 σ= 85 K)
  [Fe/H] = 0.10 (1 σ = 0.09)
  Luminosity = 0.98 (1 σ = 0.03)

→ likely a young sun

Pdf for age



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- **In red :** precision resulting from the propagation of observational errors through the process
  → **not accuracy**

- However : 1) exact values not known
(HH still running, results at Barcelona in Nov)

2) Hare and hounds use the same grid of stellar models (on purpose in the present case)

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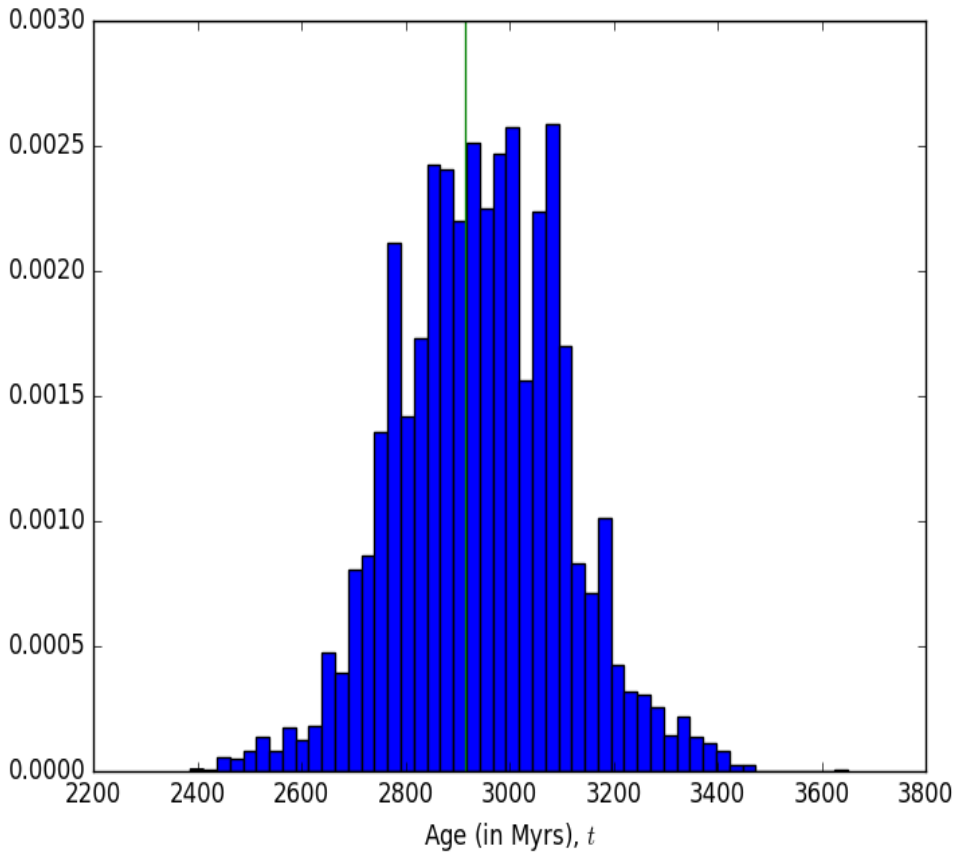

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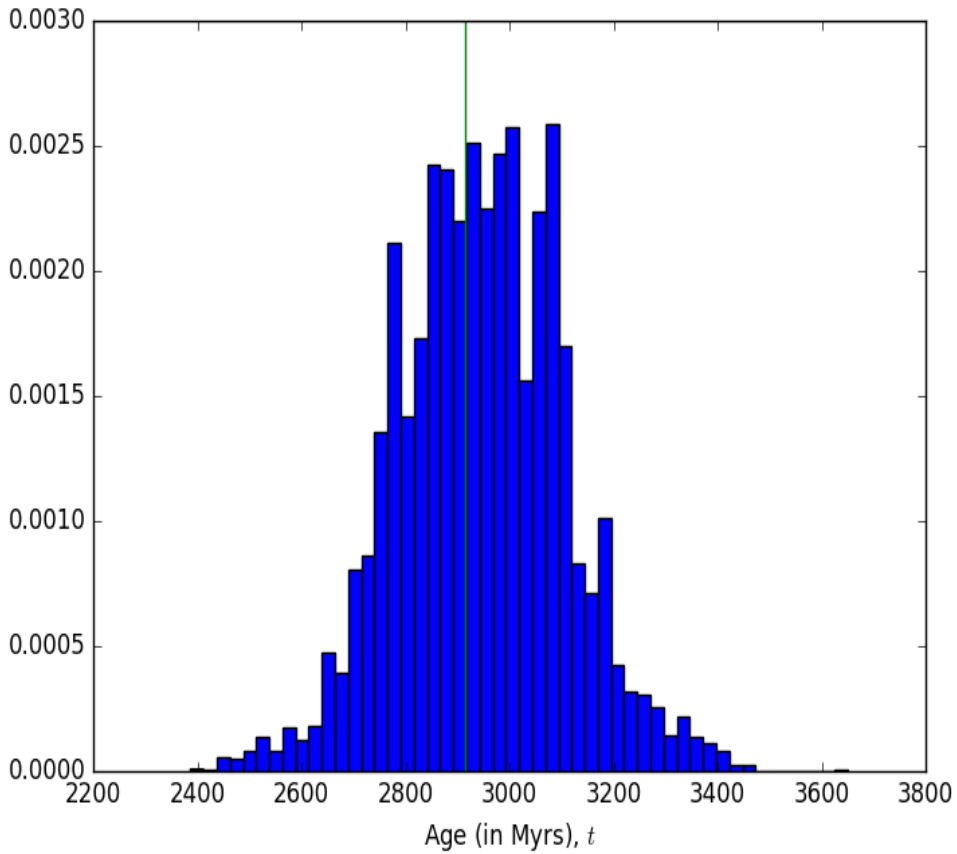

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Global overview :Input to/output from SAS

Input (from PIC and database)

- Classical (non seismic) parameters
- Seismic information if any
- Surface rotation
- Other types of information

(flags for binarity, activit indicators)

L1 light curves

Stellar models and associated numerical oscillation frequencies

SAS pipeline

Output (to database)

legend

during operation

prior to launch

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Higher precision

T.Morel's talk

SAS pipeline

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L1 light curves

Stellar models and associated numerical oscillation frequencies

dTeff/Teff= 4%
dR/R=7%
dM/M=11%
statistic.

Higher precision

T.Morel's talk

SAS pipeline

Lift degeneracies

T.Morel's talk

Output (to database)

legend

during operation

prior to launch

DP3 : Measurements of oscillation mode properties

(B. Chaplin WP128)

Would like (parameters AND uncertainties, when available):

- Gaia G_BP, G_RP
- Johnson-Cousins U, B, V, R, I
- 2MASS J, H, K
- PLATO magnitudes
- Teff, **[Fe/H]**
- Gaia luminosity/distance/parallax/extinction
- **Flag: known binary/multiplicity**

Part of this information already available in PIC

Which input data are needed to produce DP5 : mass, radius, age ... ?

- **mandatory**

  - **[Fe/H] or [M/H] , Teff + incertainties (observational and systematics)**
    needs: Δ [Fe/H] <0.1dex; ΔTeff <100 K (goal 75K)

- **Crucial if available**
  - **before launch, seismic data (n max , Δn or individual frequencies) or link to relevant database**
  - seismic data during operation for seismic targets

- **useful** (for lifting some degeneracies) or crucial for stars with no seismic data (K and M dwarfs)
  - L (Mbol or Mv, BC, Av, d) + incertainties (observational and systematics)
  - **photometric surface rotation (TESS, Gaia, K2, Kepler, CoRoT) or spectroscopic v sin i**

- **optional** but if available, can serve as cross –validation or can crucial for stars with no seismic data (K and M dwa
  - -log g
  - Gaia radius, **interferometric radius, binary masses**
  - **Li (young stars), vsin i , activity level**
  - **Transit mean density (if available)**

- **useful as input guess** : mass, radius, age previously estimated

Some information already available in PIC

DP4 : Photometric measurements of rotation period and acitivity levels with PLATO data

(N. Lanza WP123)

a) mandatory information:

- effective temperature (with uncertainty),
- absolute luminosity (with uncertainty) in the V passband and in the bolometric passband (V, Gaia, PLATO bands)
- metallicity [Fe/H] (with uncertainty),
- level of background contamination (to estimate the real amplitude of the stellar photometric variability)
- **presence of known planet(s), membership in binaries, in clusters or associations.**

b) useful additional information (when available and with their uncertainties):

- **vsini, rotation period**, parallax, radial velocity, proper motion, photometry in Gaia, 2MASS and Johnson-Cousins passbands, log g,
- **estimate of the activity level from the optical variability (standard deviation or full amplitude and typical cadence** of the measurements used to evaluate it),
- **L in EUV and/or X-rays,- chromospheric activity indexes (Ca II H&K lines (log R'_HK), Ca II triplet (Gaia), and/or**

H alpha line)

- (if any) density from transit model, interferometric radius, Li abundance
- **inclination of the spin axis to the line of sight**

Some remaining issues

- Log g_{sis} -Teff- metallicity
- Performances strongly related to the quality of the grid of stellar models → to find a compromise
- Full understanding of error bars (systematics from optimisation methods)
- Fast (automatic) modeling of subgiant stars
- Determination of the tests and choice of benchmark stars to test the SAS pipeline
- Undertanding biases due to a inappropriate modelling of surface effects
- Going down to low frequencies
- Classification stars
-
- ….

END