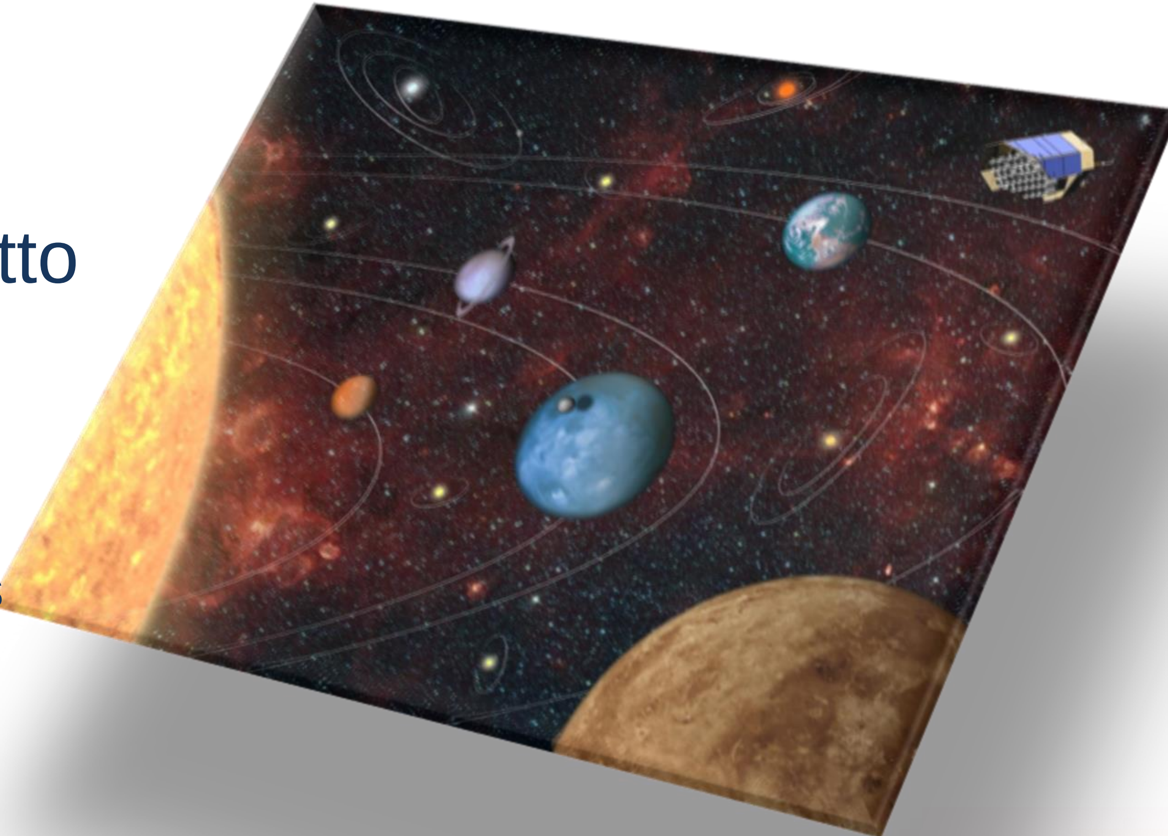
PIC general properties

Giampaolo Piotto

and the

WP130 (PSM) and

WP340 (PDC) teams



Why we need a PIC

- Because of the huge size of PLATO field (~2124 sq deg) and the consequent number of pixels ($24x4x4510^2 + 2x4x4510x2255$ pixel^2, ~0.7m^2), it is not possible to download all raw data.

- Light curves will be produced on board for all targets. Imagettes for a small subsample of targets (all P1 targets+), will be downloaded: **We need to pre-select our targets.**

- The minimum content of the **Plato Input Catalog** (PIC) includes the positions of the targets (**dwarfs and sub-giants with spectral type later than F5, "special targets", calibration stars**) around which planet transits shall be searched for, and followed-up, and their basic parameters.

- For each target, we also need **a table of contaminants**, to optimize photometric mask and candidate exoplanet validation (minimize follow-up costs).

- For each target, the PIC shall contain a number of parameters intended to make the validation, confirmation and follow up of the candidates easier, faster and cheaper. The list of parameters shall be agreed within the PMC.

PIC content from Science Requirements

- Revised science requirements, assuming two long pointing fields

	Sample 1	Sample 2	Sample 4	Sample 5	Colour sample
Stars	≥ 15,000 (goal 20000)	≥ 1,000	≥ 5,000	≥ 245,000	300
Spectral type	Dwarf and subgiants F5-K7	Dwarf and subgiants F5-K7	Cool late type dwarfs	Dwarf and subgiants F5-K	Anywhere in the HR diagram
Limit m_V	11	8.5	16	13	-
Random noise (ppm in 1 hour)	≤ 50	≤ 50	-	-	-
Observation phase	LOP	LOP	LOP	LOP	LOP

Imagettes and sampling time (from PLATO Science Requirements)

- Imagettes for all P1 and P2 targets, for >5,000 P4 targets and for >9,000 P5 targets.
- Final observing strategy to be decided

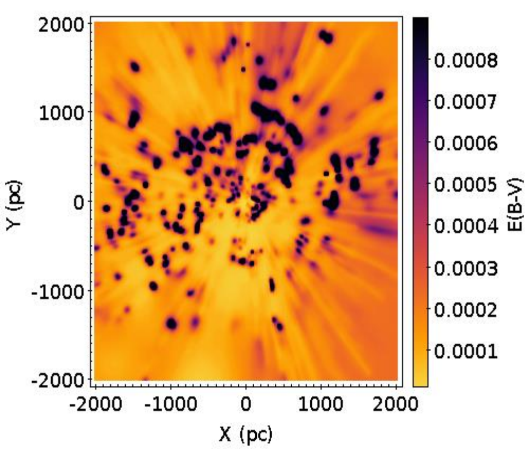
		Sample 1	Sample 2	Sample 4	Sample 5	Colour sample
Observation sampling times	Imagettes	25 s	25 s 2.5 s for a subsample	25 s for > 5,000 targets	25 s for > 9,000 targets	2.5 s
	Light-curves	-	-	-	≤ 600 s	-
	Centroid measurements	-	-	-	≤ 50 s for 5% of targets	-
	Transit oversampling	-	-	-	≤ 50 s for 10% of targets	-
Wavelength		500-1000 nm	500-1000 nm	500-1000 nm	500-1000 nm	Red and blue spectral bands

Populating the PIC: target selection

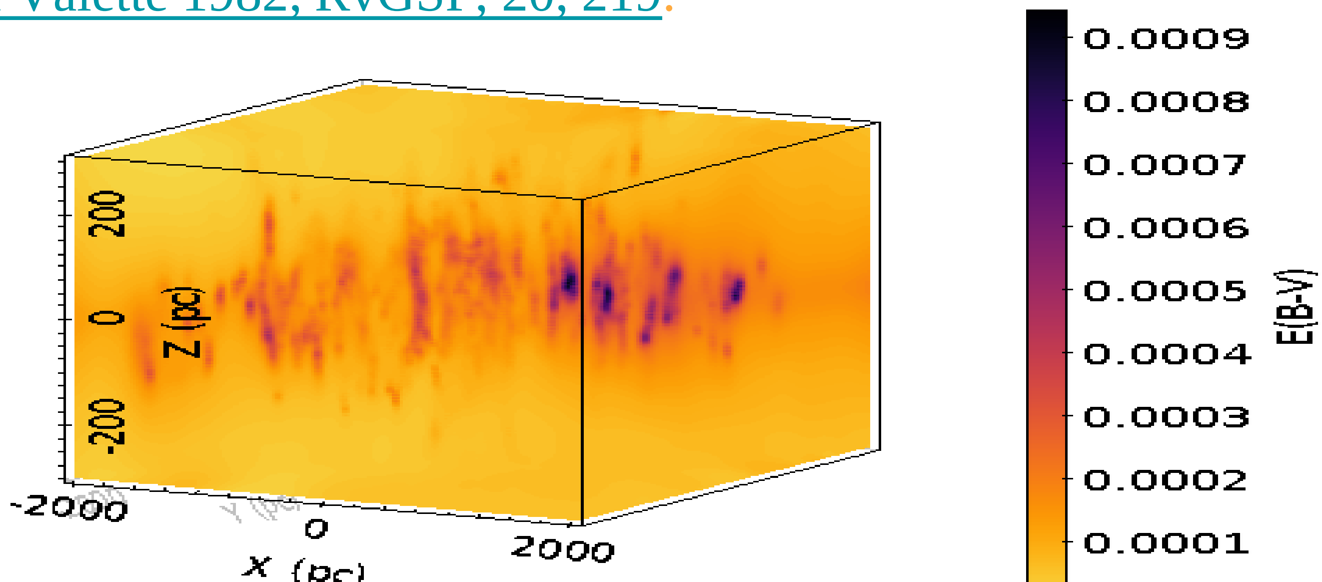
- PLATO will observe dwarfs and subgiants with $4<V<16$, SpT>F5
- In principle all possible PLATO targets are presently observed by *Gaia*.
- PIC1.0.0 is mainly based on Gaia DR2, with additions (updated parameters, and additional catalogs)
- *Gaia DR2 release indeed went in the right direction, but degeneracies between temperature and reddening required additional analysis for PIC*

Reddening in PIC1.0.0

The reddening map presented in Lallement et al. (2018), Capitanio et al. (2017) is the result of merging individual photometric color excess measurements from broad- and narrowband photometry of close-by stars (<500 pc) with NIR DIB equivalent widths measured in individual spectra of more distant stars (500 to 1500 pc) and color excess measurements at larger distance (up to 3 kpc) based on a statistical analysis of multiband photometric data. The method used to derive the map is the method described in Tarantola & Valette 1982, RvGSP, 20, 219.



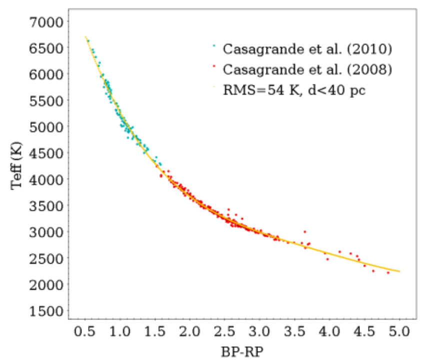
Galactic plane projection



The 3D map covers around 2 Kpc x 2 Kpc x 0.3 kpc from the Sun

Stellar parameters estimate

Color-effective temperature relation



$T_{eff}=f(G_{bp}-G_{rp})$

From E(B-V) to A_G, $E(G_{BP}-G_{RP})$

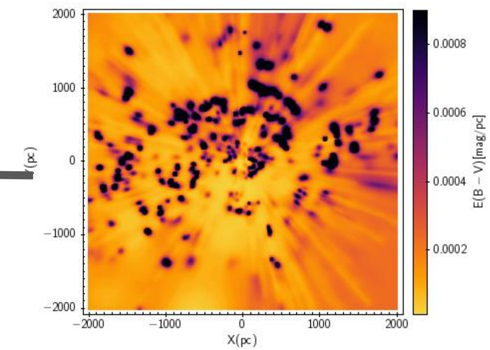
$E(G_{BP} - G_{RP}) = f(T_{eff})\, E(B - V)$

$A_G=f(T_{eff})\, E(B - V)$

$5250\ K<T_{eff}<7000\ K$

Casagrande & VandenBerg (2018)

E(B-V) estimation



Lallement et al. (2018)

Intrinsic color

$(G_{BP} - G_{RP})_0 = (G_{BP} - G_{RP}) - E(G_{BP} - G_{RP})$

$A_G,\ E(G_{BP} - G_{RP})\ ,\ T_{eff}$

$BC_G= f(T_{eff})$
Andrae et al. (2018)

$$M_G = G - 5\log(d) + 5 - A_G$$

$$\frac{L}{L_\odot} = 10^{-0.4(M_G + BC_G - M_{BOL,\odot})}$$

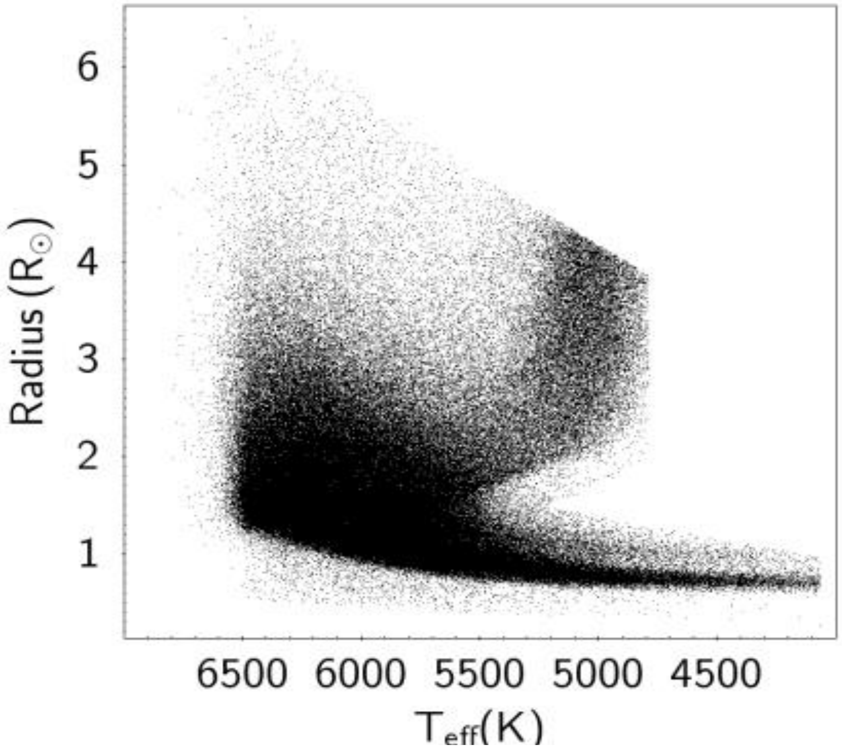
Radius and Mass estimation

$$\frac{R}{R_\odot} = \left(\frac{T_{eff}}{T_{eff,\odot}}\right)^{-2}\sqrt{\frac{L}{L_\odot}}$$

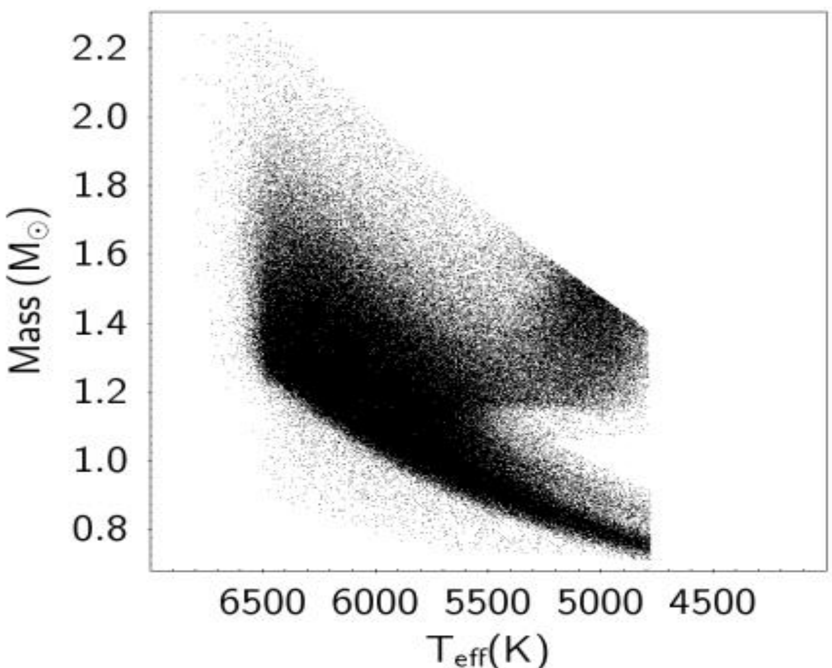
$$\frac{M}{M_\odot} = f(L, T_{eff})$$

Moya et al. (2018, ApJS, 237, 21)

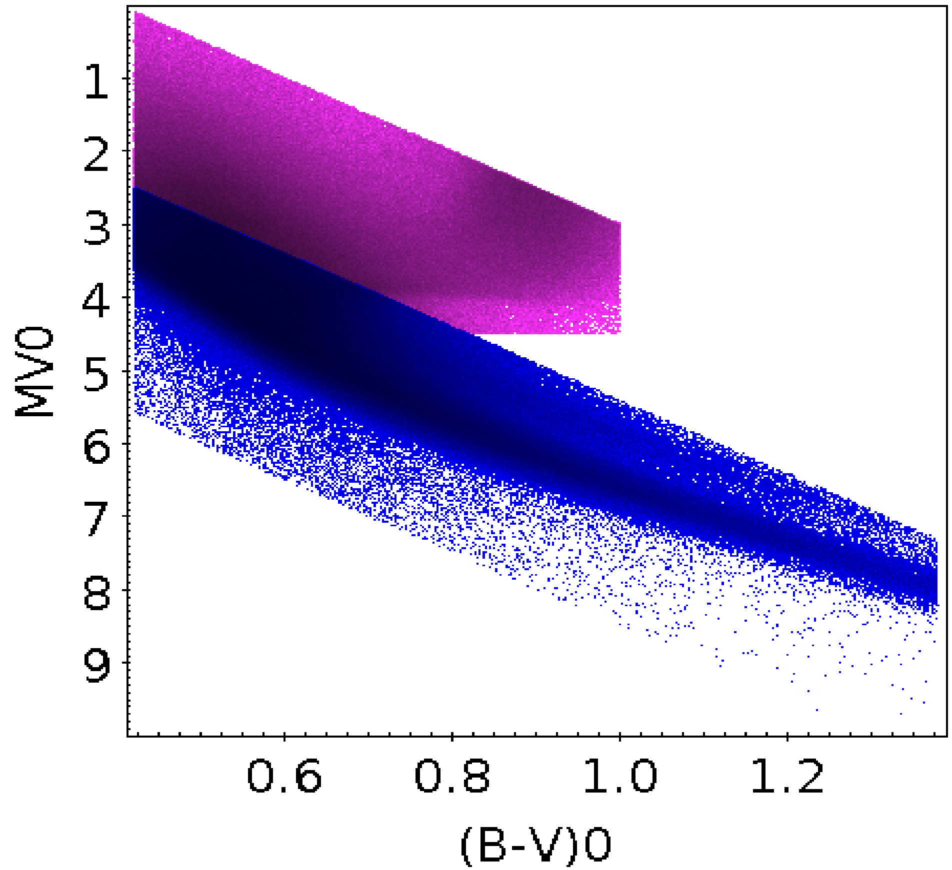
PIC1.0.0



Radius ($R_\odot$)
6
5
4
3
2
1
6500 6000 5500 5000 4500
T_{eff}(K)

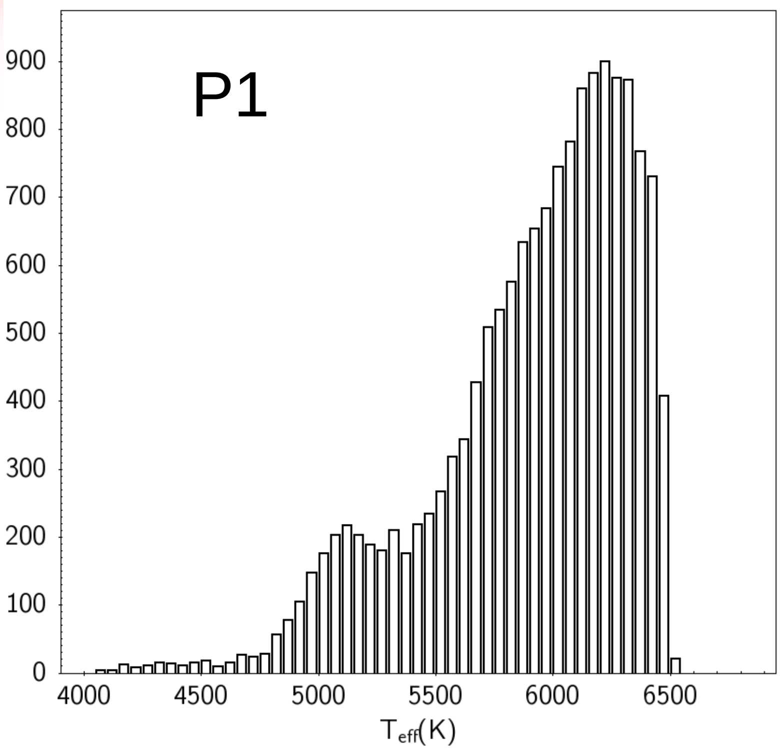


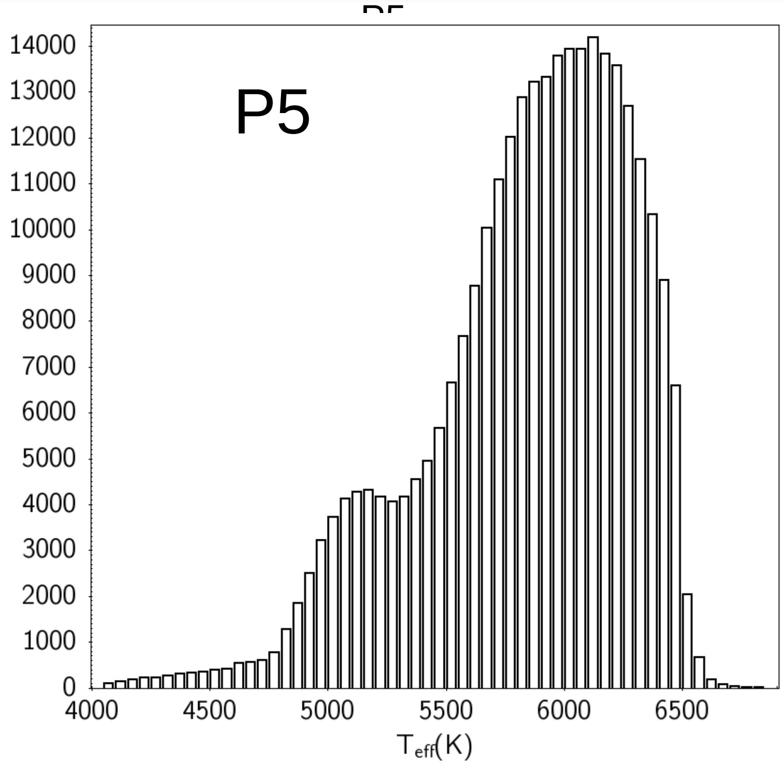
Mass ($M_\odot$)
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
6500 6000 5500 5000 4500
T_{eff}(K)



MV0
1
2
3
4
5
6
7
8
9
0.6 0.8 1.0 1.2
(B-V)0

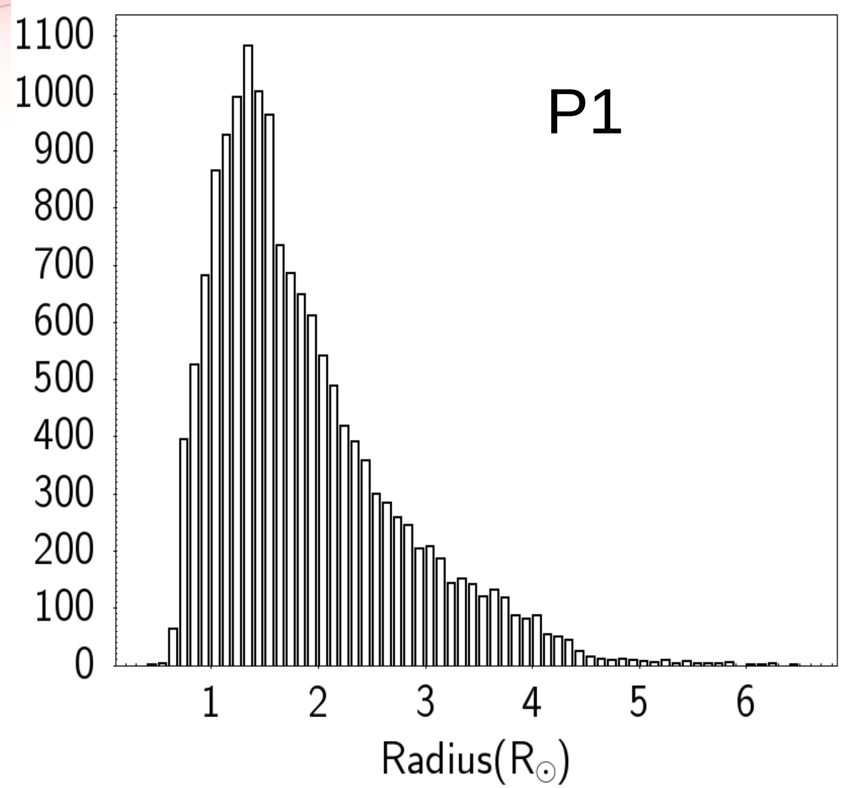
Effective temperature distribution in PIC1.0.0

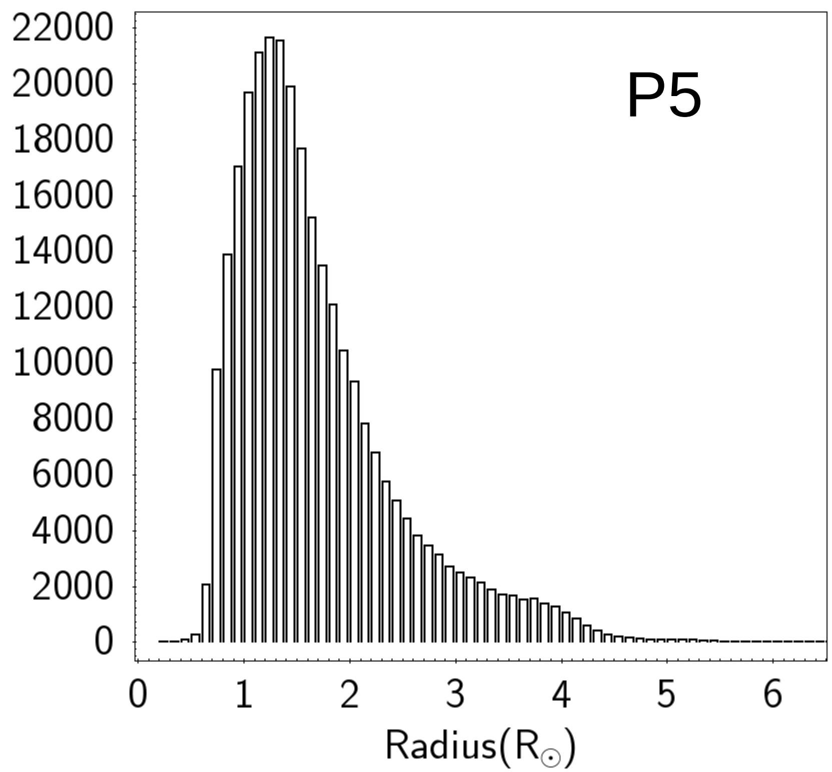




	Q1	Median	Mean	Q3
P5	5600	5917	5843	6178
P1	5688	6009	5910	6241

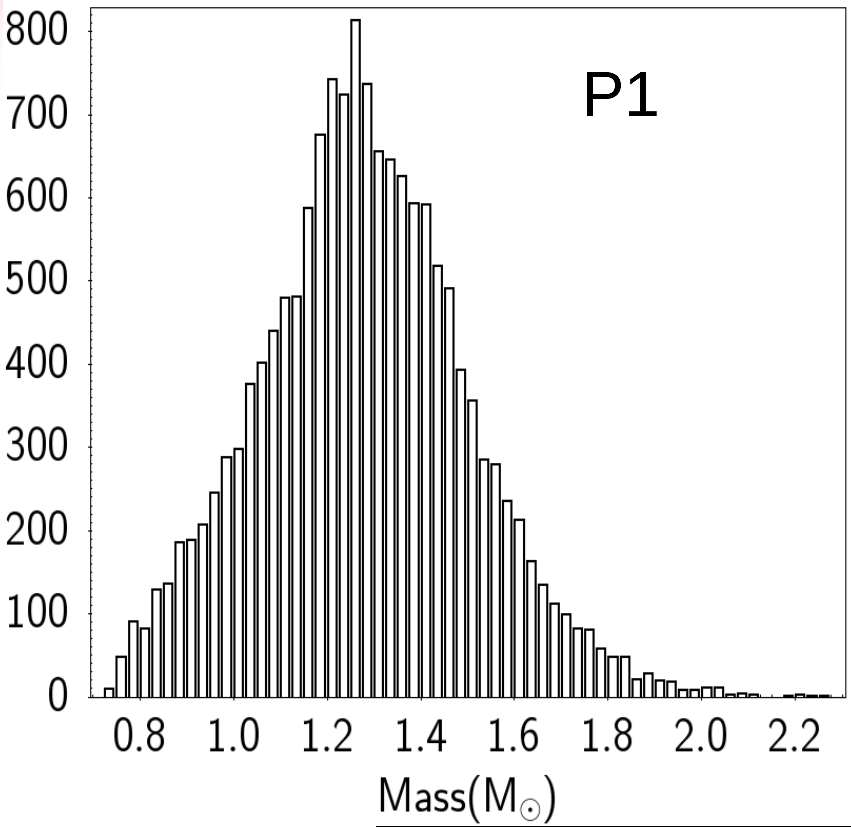
Radius distribution in PIC1.0.0

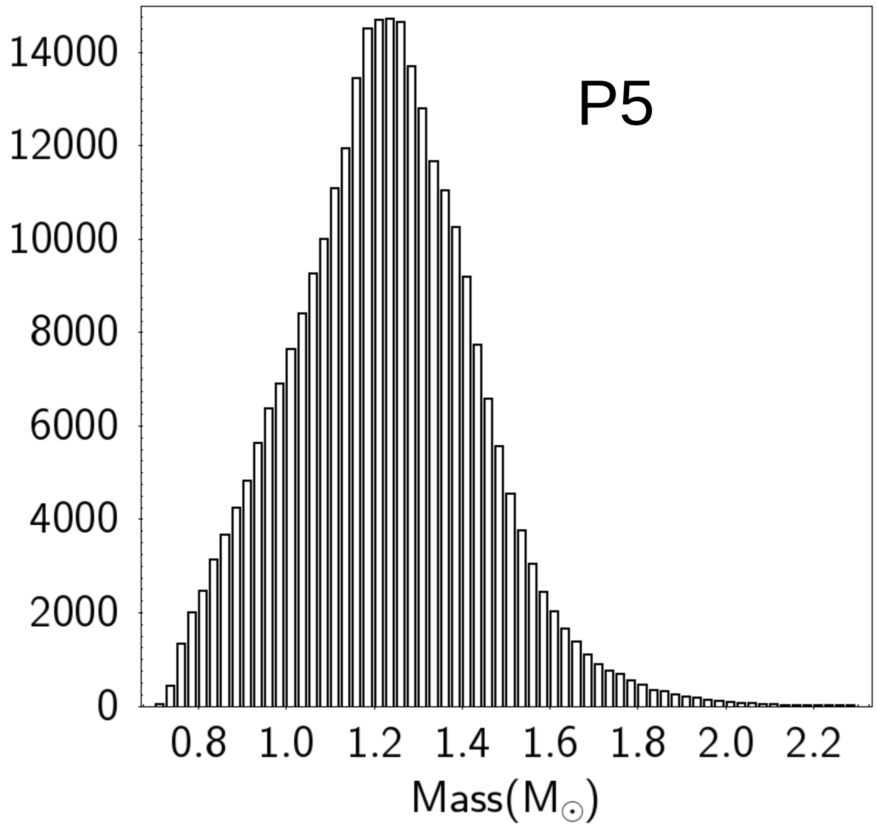




	Q1	Median	Mean	Q3
P5	1.15	1.49	1.69	2.02
P1	1.24	1.62	1.85	2.28

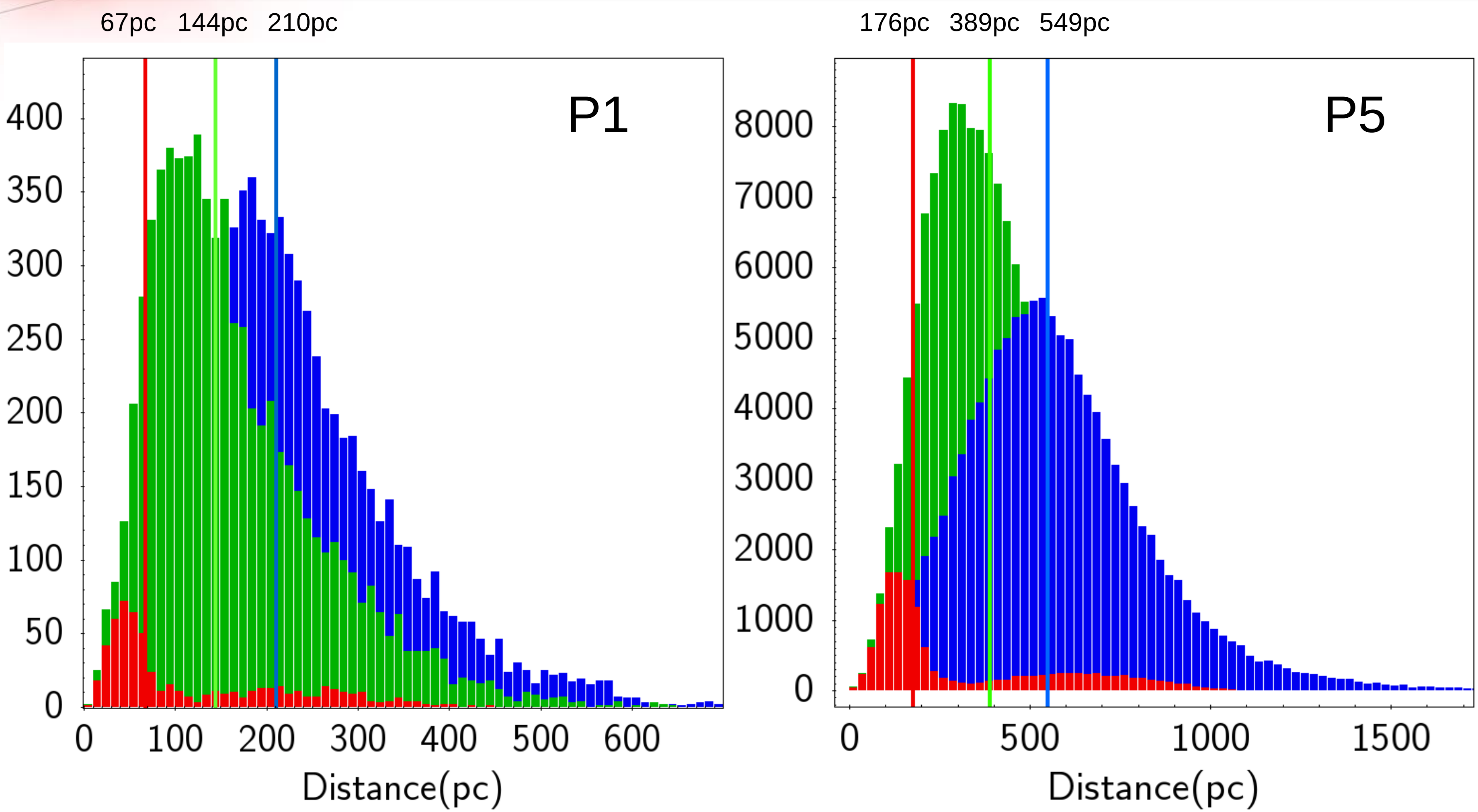
Mass distribution in PIC1.0.0





	Q1	Median	Mean	Q3
P5	1.09	1.23	1.23	1.36
P1	1.14	1.27	1.28	1.42

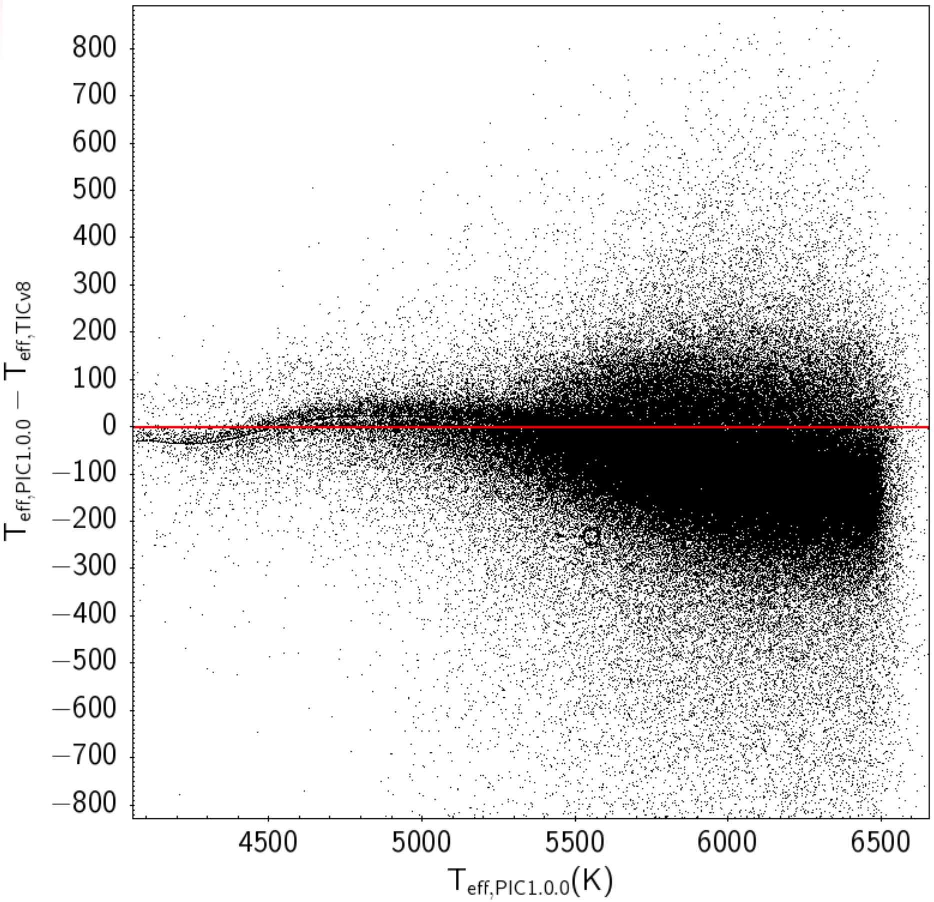
Distance distribution in PIC1.0.0 vs SpType

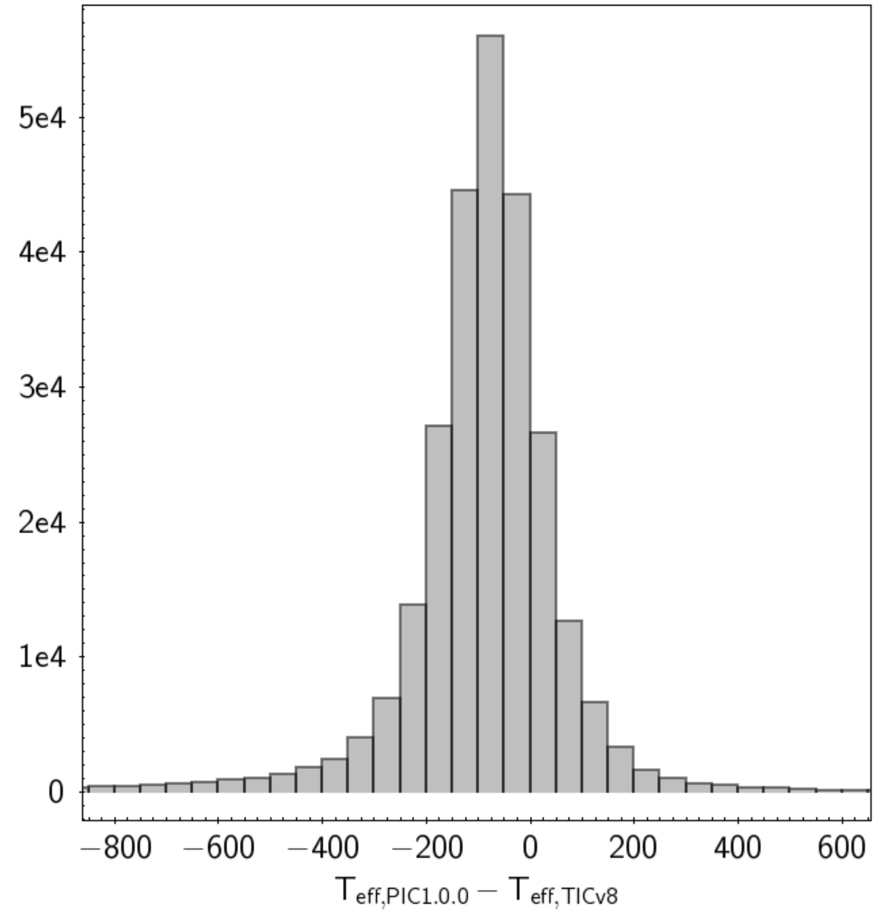


SpType: K, G, F

Comparison between PIC1.0.0 and TIC(CTL)v8

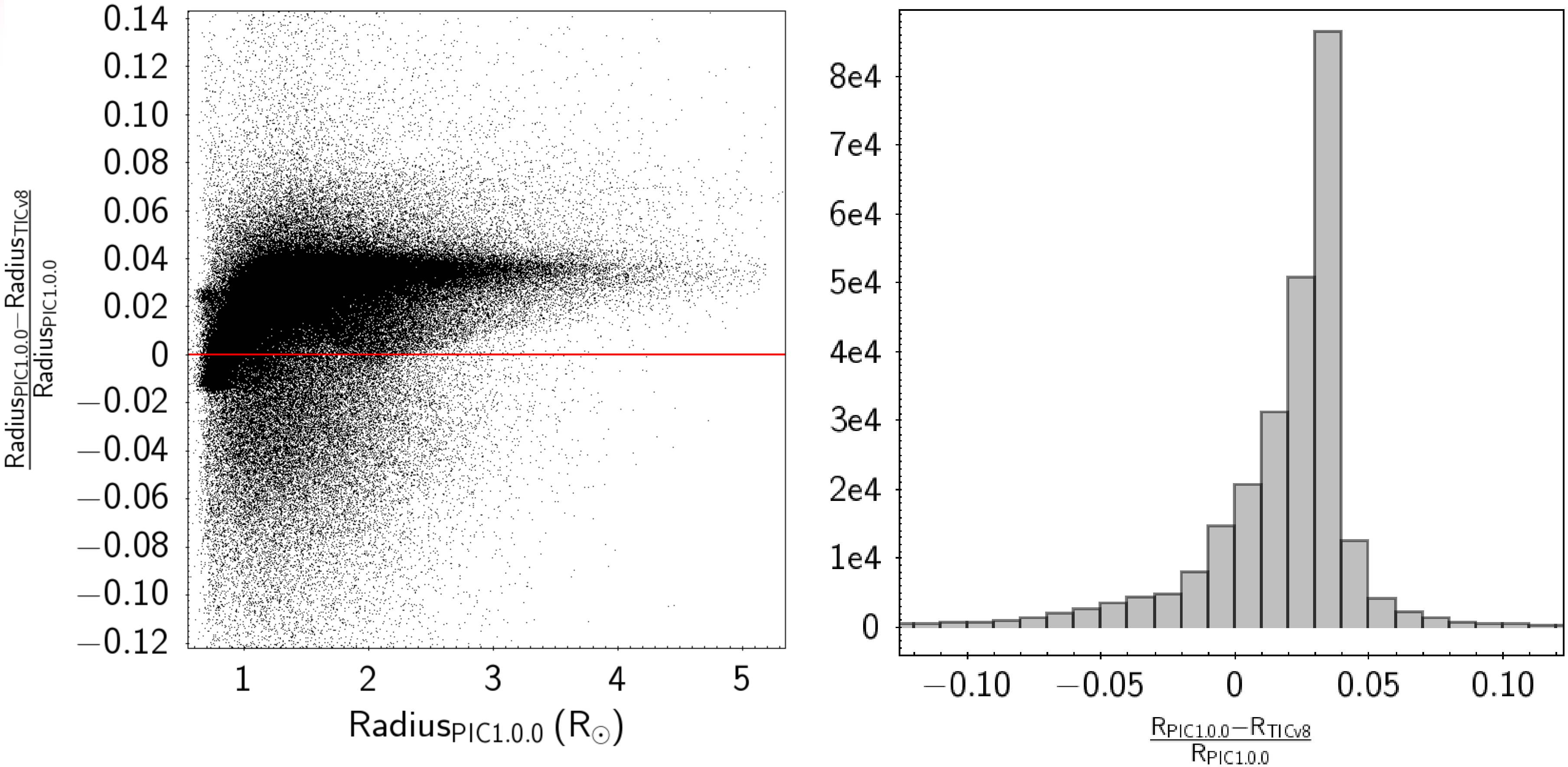
T_{eff} PIC1.0.0 vs TICv8





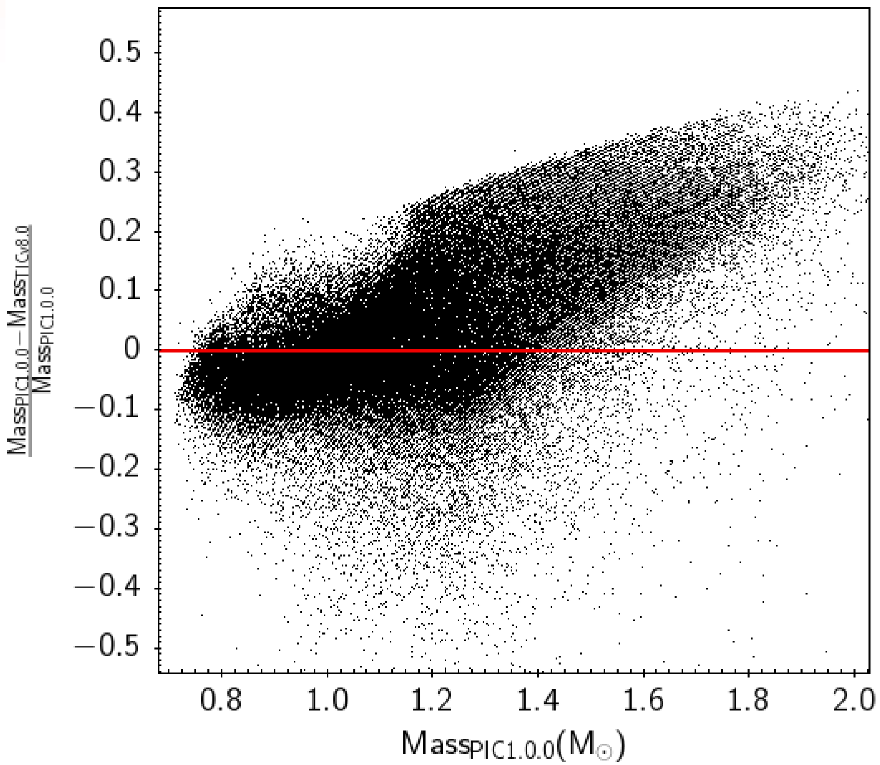
1st Qu.	Median	Mean	3rd Qu.
-148	-80	-99	-16

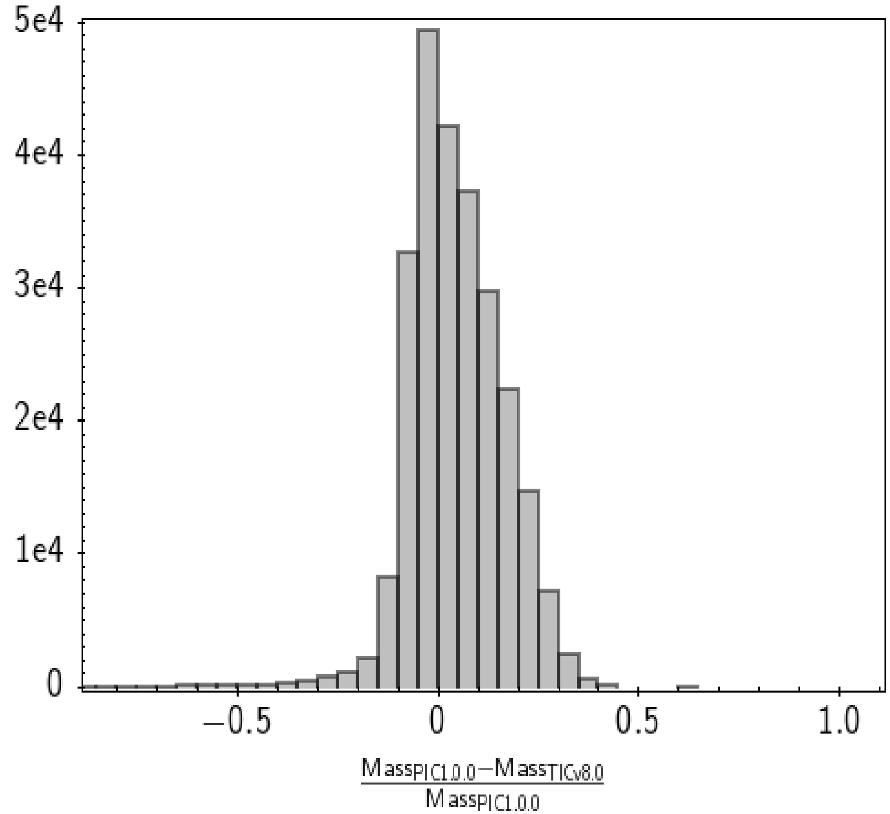
Radius PIC1.0.0 vs TICv8



1st Qu.	Median	Mean	3rd Qu.
0.009	0.027	0.020	0.035

Mass PIC1.0.0 vs TICv8





1st Qu.	Median	Mean	3rd Qu.
-0.033	0.036	0.047	0.12

From PIC1.0.0 to PIC1.1.0

PIC VERSIONING

NB: PICid for a given source change only following a major release

The column name of the PIC identifier, follows the PIC major versioning: PICidV1, PICidV2, ...

Versioning

PIC N1 . N2 . N3

N1 — **PIC Major Release**
It is linked to the Gaia release.
It changes only when a new Gaia release is available

N2 — **PIC breaking changes**
It changes only when:
- the number of objects in PIC changes
- the number of columns in PIC changes
- the format of a column in PIC changes

N3 — **PIC minor changes**
It changes when:
- the value in one or more fields are updated

See Marinoni talk

From PIC1.0.0 to PIC1.1.0

PIC1.0.0 includes P1, P2 and P5 samples

PIC1.1.0 will also include the P4 sample

From PIC1.0.0 to PIC1.1.0 ...

1. Connection between PLATO samples: P1, P2 and P5 extended to late K, while P4 starts from M0.

2. As the (B-V) color is not appropriate for the M dwarfs selection. We decide to homogenize sample selection using the (G_{BP}-G_{RP}) color.

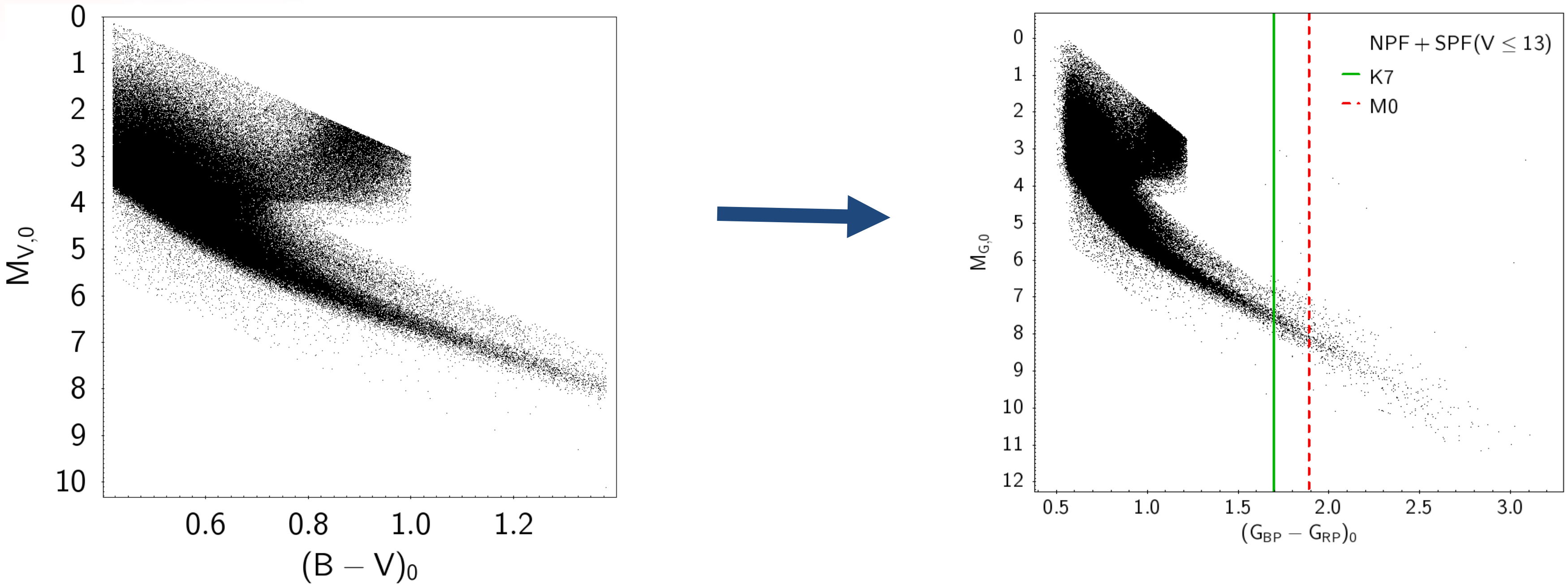
3. The range of validity of temperature dependent extinction coefficients has been extended

4. The space coverage of the extinction maps has been extended

Colibrations (V-band magnitude for M dwarfs, color-effective temperature)

Improved connection among PLATO samples

P1, P2 and P5 limited to K7, while P4 starts from M0.



PIC1.1.0 based on newly calculated intrinsic $(G_{BP}- G_{RP})_0$

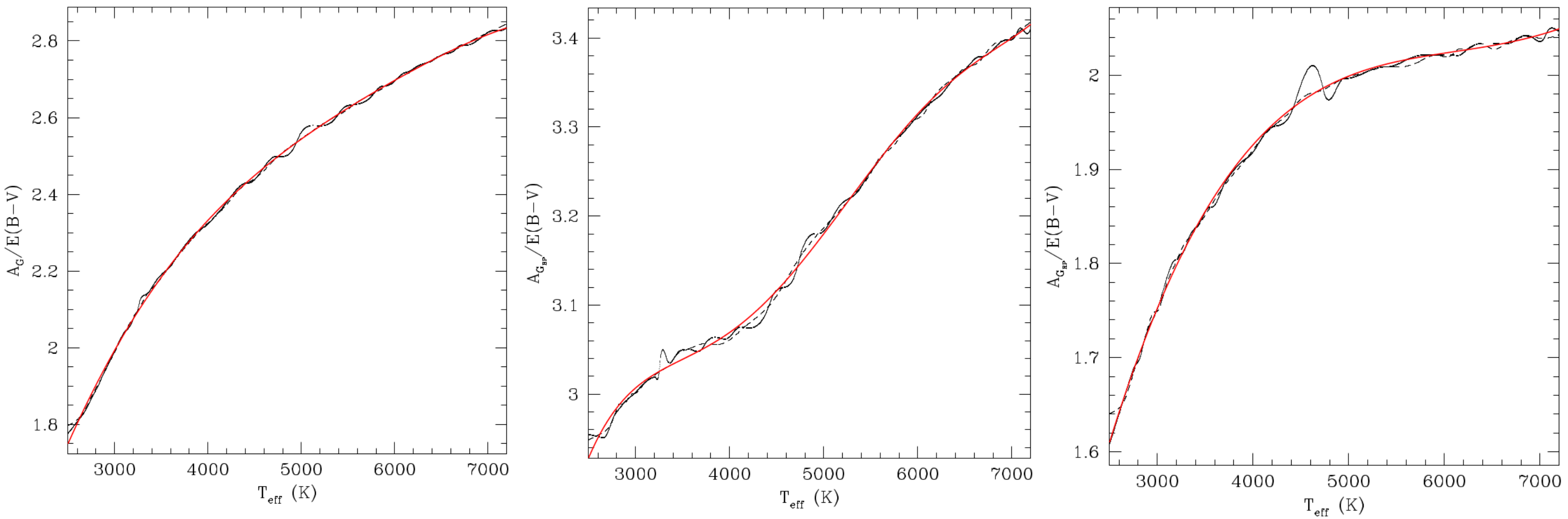
Separation between P1, P2, P5 fand P4 set at $(G_{BP}- G_{RP})_0 = 1.84$

$(G_{BP}-G_{RP})_0 < 1.84$	$(G_{BP}-G_{RP})_0 \geq 1.84$
FGK	(M)
(F5-M0)	(later than M0)
P1, P2, P5 sample	P4 sample

Extension of validity range of temperature dependent extinction coefficients

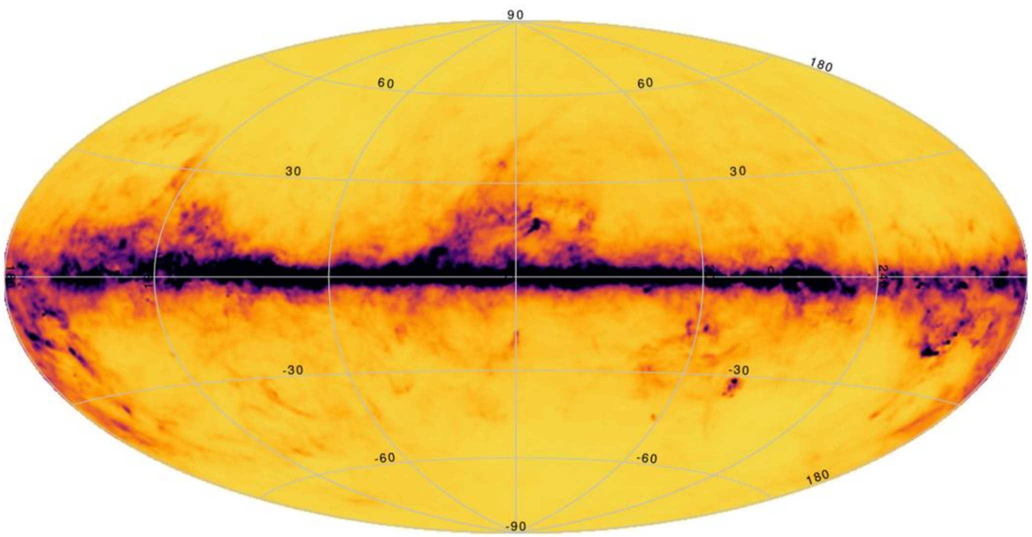
In PIC1.0.0 limited to 5250 K ...

$$\frac{A_G}{E(B-V)} \qquad \frac{A_{G_{BP}}}{E(B-V)} \qquad \frac{A_{G_{RP}}}{E(B-V)}$$



(2500 K < T_{eff} < 7000 K)

Extended extinction map



Schlegel, Finkbeiner & Davis 1998, ApJ, 500, 525
Schlafly & Finkbeiner 2011, ApJ, 737, 103

$$\rho(R,z) = \exp\left(\frac{R_0 - R}{h_R} - \frac{|z - z_w|}{k_{fl} h_z}\right)$$

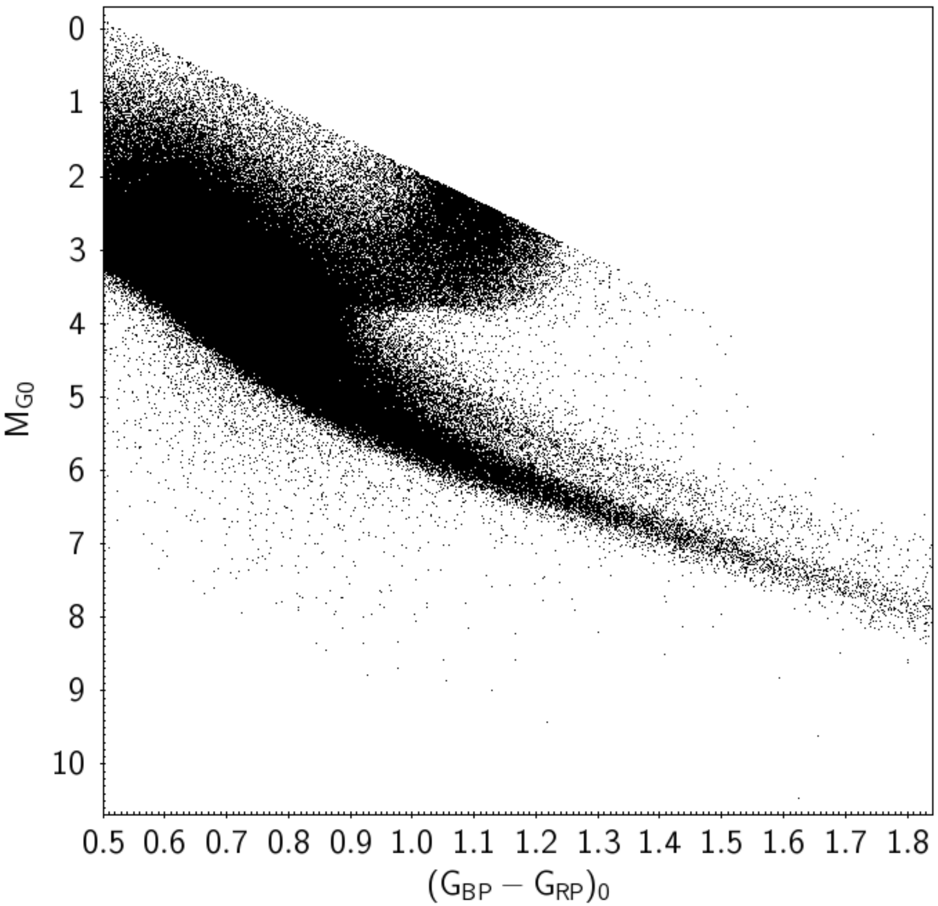
$$k_{\mathrm{fl}}(R) = 1 + \gamma_{\mathrm{fl}} \min(R_{\mathrm{fl}}, R - R_{\mathrm{fl}})$$

$$z_{\mathrm{w}}(R,\phi) = \gamma_{\mathrm{w}} \min(R_{\mathrm{w}}, R - R_{\mathrm{w}}) \sin\phi.$$

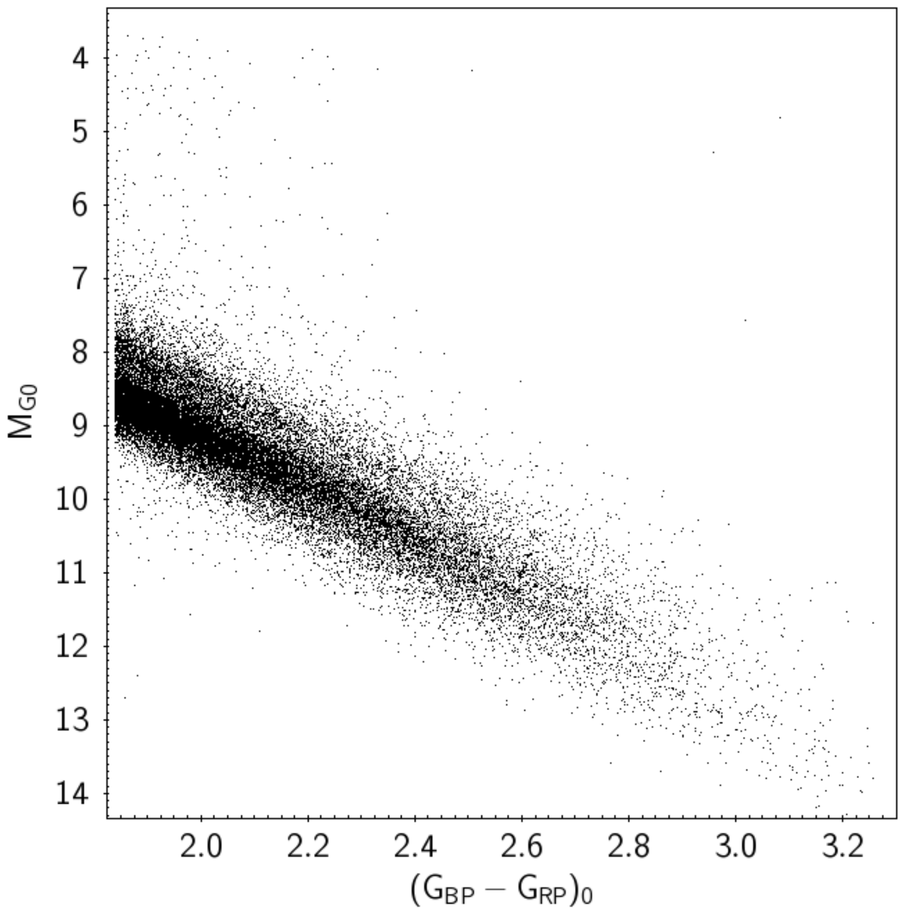
Binney et al. 2014, 437, 351

PIC1.1.0 (preliminary)

P1, P2, P5



P4



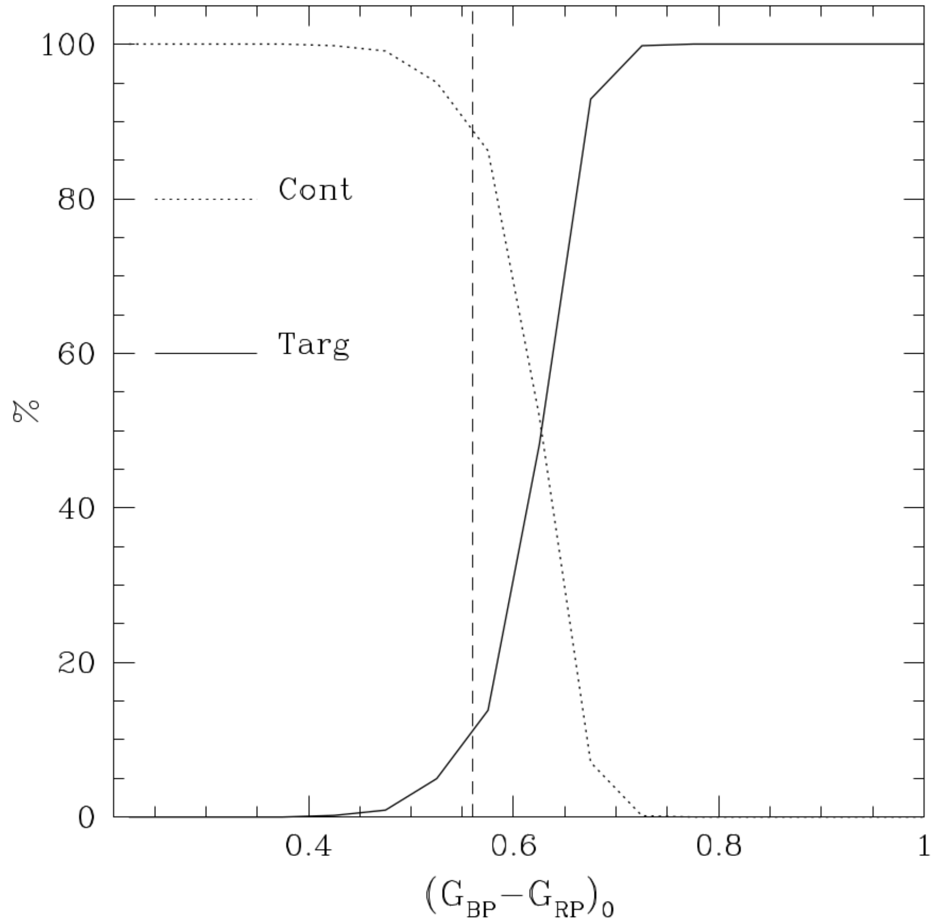
Catalog Extensions

At last PIC meeting (late September) it has been proposed to extend the PIC:

1. In color selection criteria

2. in field size

Contamination vs completeness

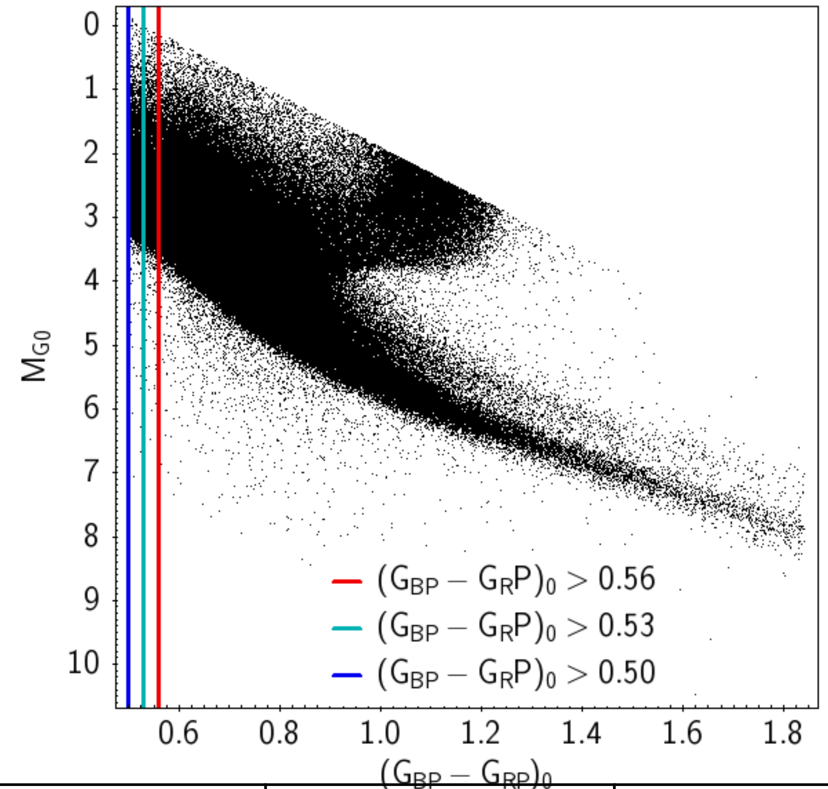


Estimated degree of contamination vs completeness from simulations accounting for errors in colors and reddening. Dashed line corresponds fo F5V.

Blue extension

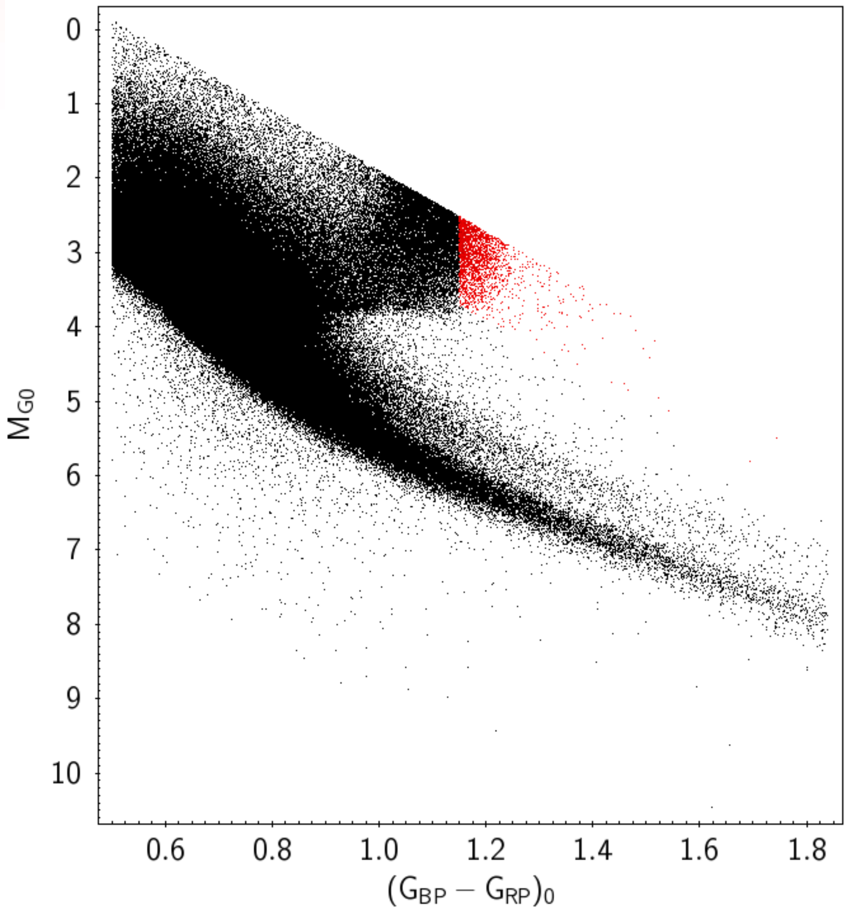
Total $(G_{BP}-G_{RP})_0$>0.56 :   288 036

(NPF + SPF)



	Increment	N. stars	N. targets
$0.53<(G_{BP}-G_{RP})_0<0.56$	4%	11719	820
$0.50<(G_{BP}-G_{RP})_0<0.56$	7%	20280	1014

Red extension



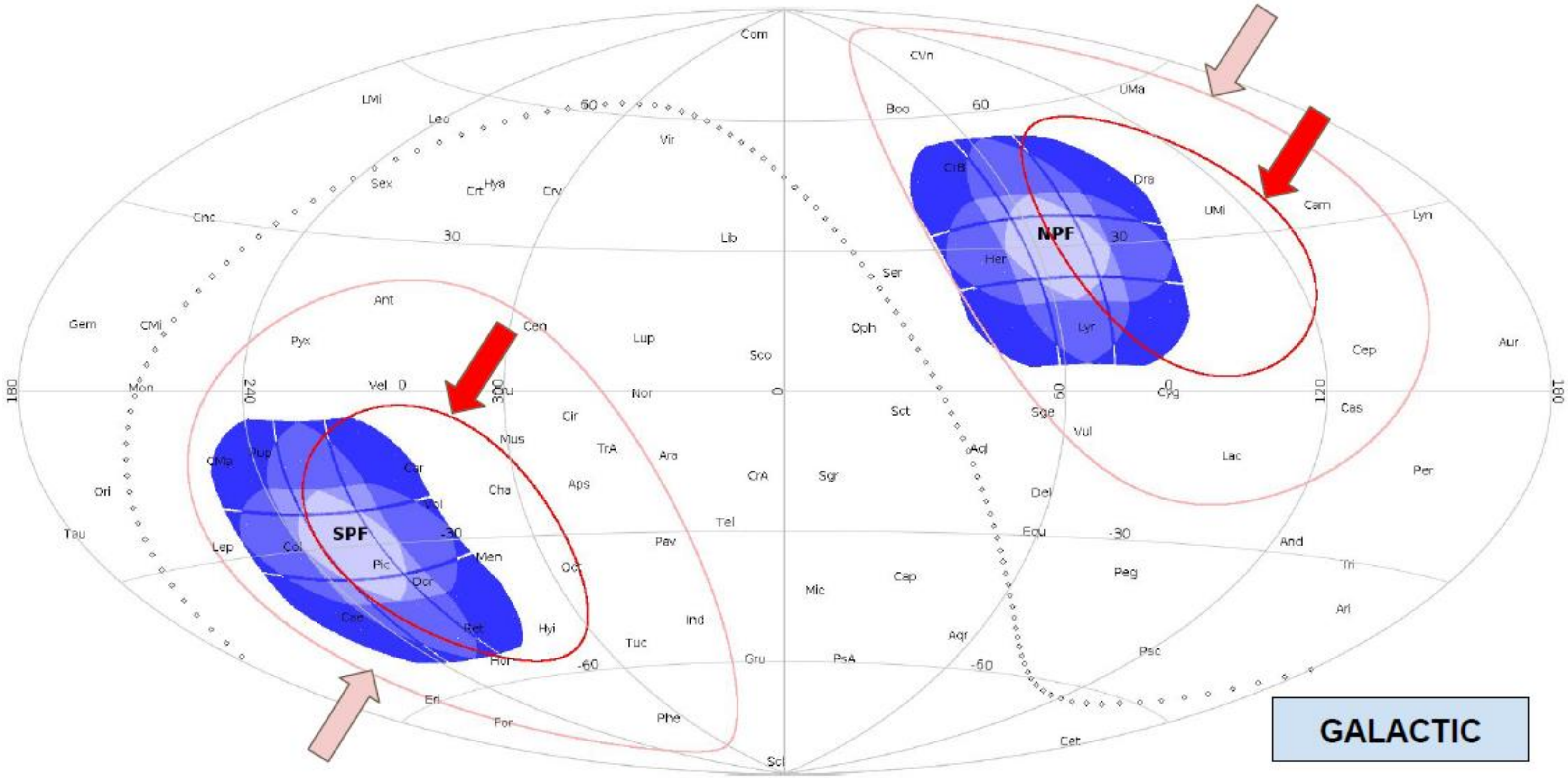
More difficult to estimate contamination vs completeness

	Increment		N. stars
	1%		2254

Field extension

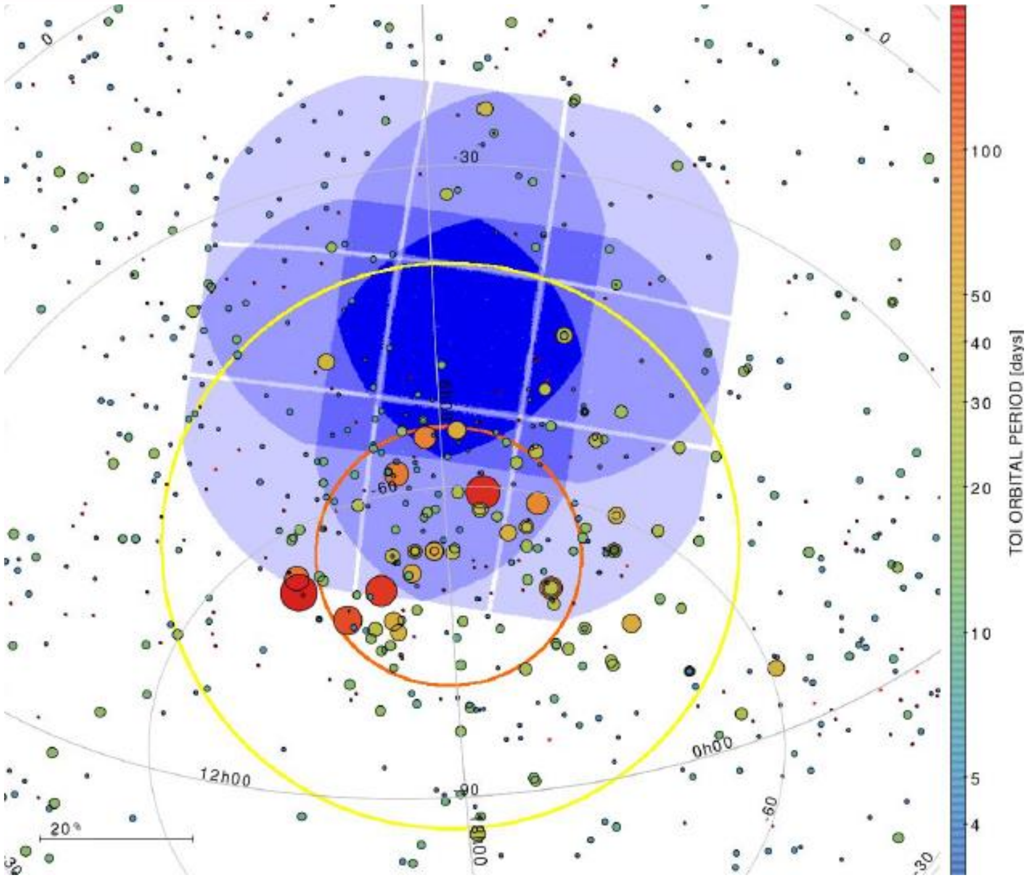
"Allowed" regions at |β|>63°

HUGE accessible sky area (1.5π sr), mostly at large declinations (|δ|>30°)



RED LINE: pointing constraint (|β|>63°). **PINK LINE**: accessible sky (envelope of every allowed LD field; |β|>38°)

Field extension



Field extension does not allow us to calculate the SNR for P1 stars, as we do not know how many telescopes will cover a given star.

TBD

Conclusions

PIC1.0.0 contains samples P1, P2 and P5 in the currently defined North PLATO Field (NPF) and South PLATO Field (SPF).

Dwarf and subgiants are selected using intrinsic absolute color magnitude diagrams constructed from Gaia DR2 data.

Stellar parameters, by comparison with spectroscopic parameters of FGK stars, are estimated with an average uncertainty of 4% in stellar temperatures, 7% in stellar radii and 11% in stellar masses.

Catalog extensions in star selection criteria and field coverage are under discussion

PIC1.1.0 will be delivered in December 2019 and it will include the first version of the sample P4.

Next steps: Long pointing field selection; start preparing and including «special star» list, **start including calibration stars**

How to get the PIC

PIC1.0.0 in the two long (preliminary pointing fields) is available to PLATO community for internal use and tests. It is delivered with an explanatory document on the column contents (PLATO-SDC-SCI-TN-001.pdf), and a document (PLATO-UPD-SCI-TN-015-i1.3.pdf) describing the target selection criteria, and the target parameter estimate.

PIC1.0.0 is for internal (PLATO Consortium) use

In order to have the PIC, you have to be member of the PLATO consortium, and sign the non-disclusure agreement (available from the PLATO Science Management – PSM- office, psmoffice@warwick.ac.uk)

If you are interested in having a copy of PIC1.0.0 , please send a mail to:
pdcoffice@mps.mpg.de
(and in cc to: psmoffice@warwick.ac.uk, Heike.Rauer@dlr.de giampaolo.piotto@unipd.it and paola.marrese@ssdc.asi.it)

(When available, PIC1.1.0 will supersede PIC1.0.0)

Contact people

Information on the PIC and on PIC deliveries and delivery policies can be asked to :

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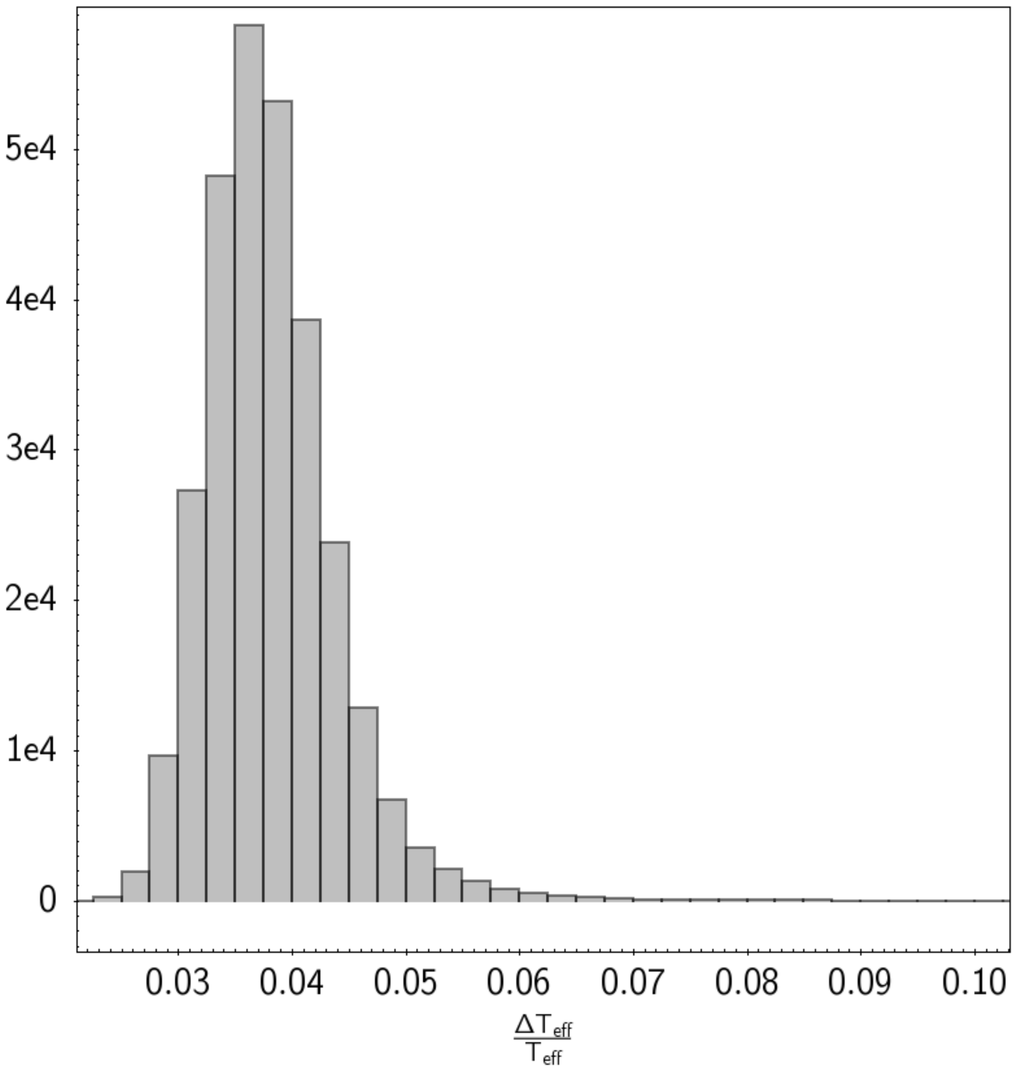
valentina.granata@unipd.it
psmoffice@warwick.ac.uk
pdcoffice@mps.mpg.de

Distribution of effective temperatures relative errors



Q1	0.034
Median	0.037
Mean	0.038
Q3	0.041