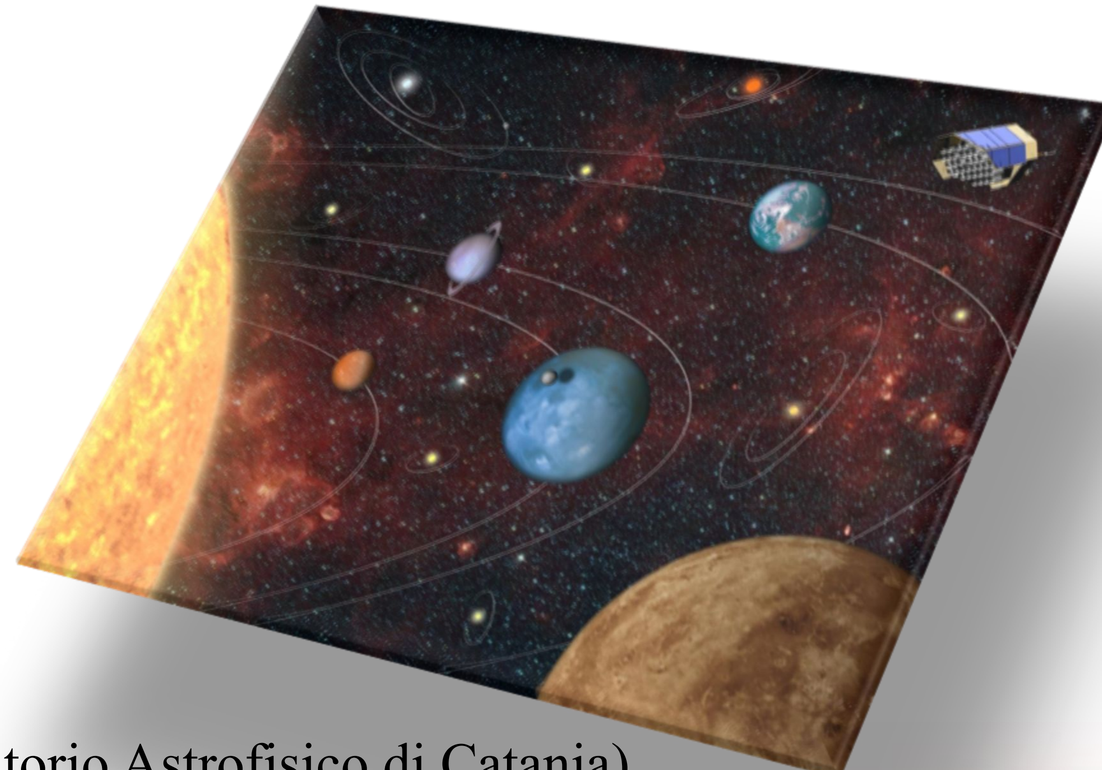
The PIC: targets in the PIC



M. Montalto (INAF - Osservatorio Astrofisico di Catania)
L. Prisinzano, G. Piotto & WP13, WP34

PLATO Input Catalogue (PIC)

Definitions: **tPIC** catalog in the two long pointing PLATO fields LOPN1 and LOPS2

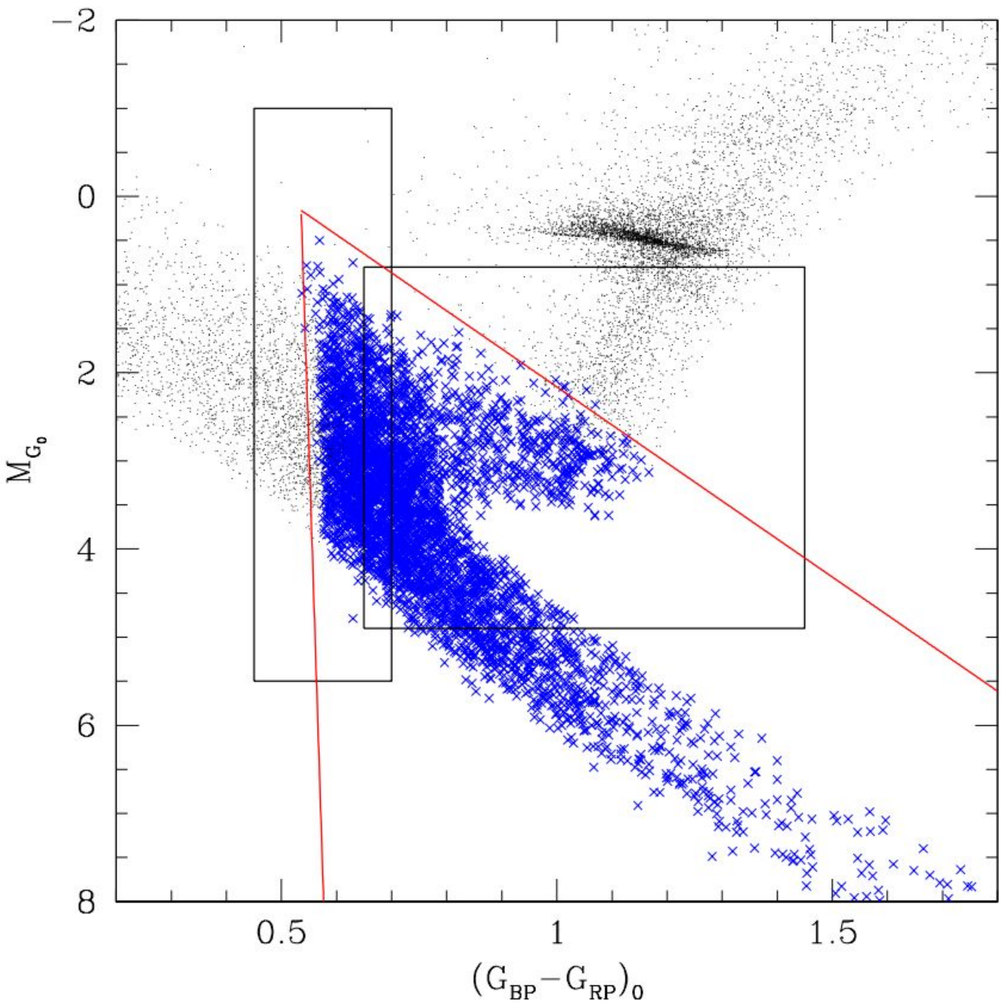
Contributors: WP130: definition of selection criteria compliant to SciRD
WP340: implementation of selection criteria
catalogue construction

Content of the catalog (**target** PIC, according to the criteria of the PLATO Science Requirement Document, SciRD)

	P1	P2	P4	P5
Stars	≥15 000 (goal 20 000)	≥1000	≥5000	≥245 000
Spectral type	Dwarf and subgiants F5-K7	Dwarf and subgiants F5-K7	M Dwarfs	Dwarf and subgiants F5-late K
Limit *V*	11	8.5	16	13
Random noise (ppm in 1 h)	<50	<50	–	–
Wavelength (nm)	500–1000	500–1000	500–1000	500–1000

Table 1 Montalto et al. 2021

Selection FGK



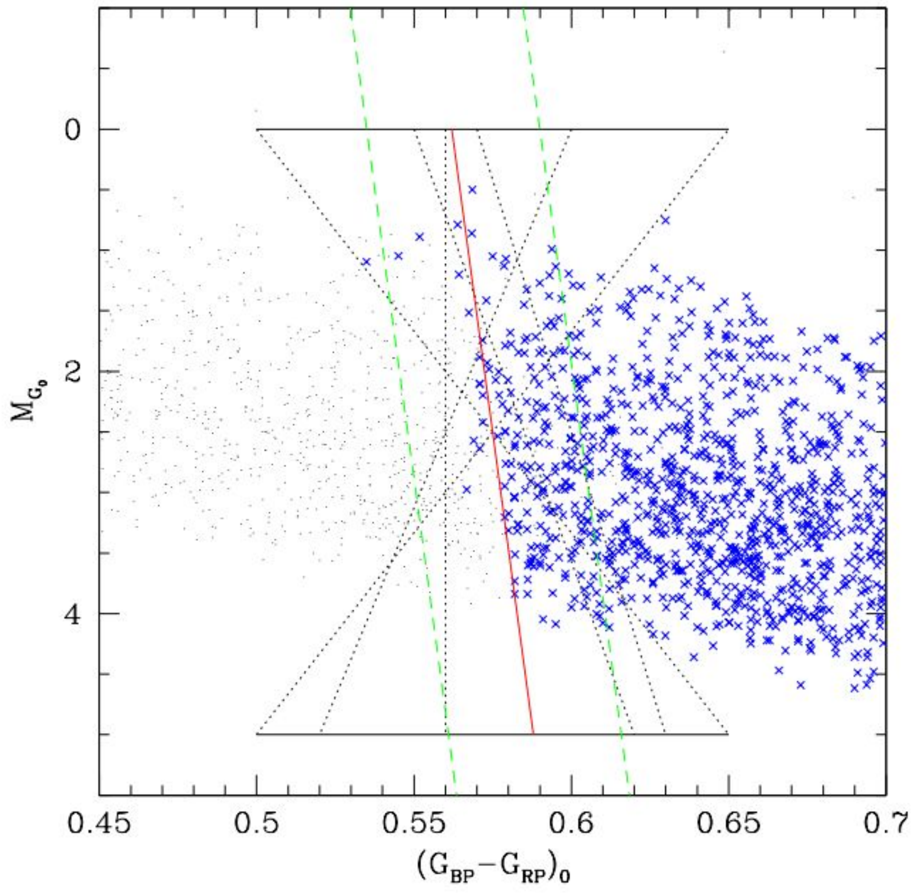
Black points indicate simulations from TRILEGAL for stars with V<13.

Blue points indicate stars with 3850 K $\leq T_{eff} \leq$ 6550 K and logg≥3.5

Black rectangles: regions used to perform the selection of the best separation line on the blue and on the bright side of the FGK sample

Red lines: best separation lines

Blue FGK boundary



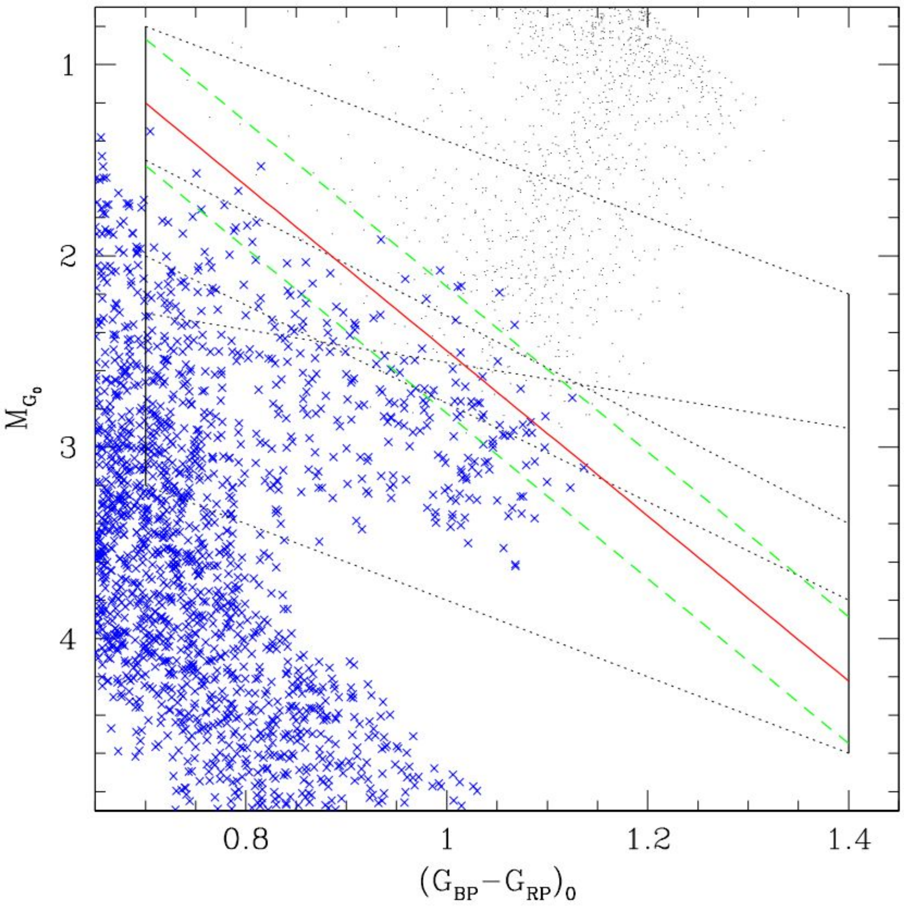
Across the selected region we draw different separation lines as denoted in the figure.

We calculated the metric $S=(N_{targ}-N_{cont})$ and selected the line that maximized this metric (red line).

We fixed the slope of the best separation line and then perturbed all simulated stars accordingly with their expected errors in color and magnitude (including the error on reddening and extinction) and calculated the 1-σ uncertainty on the intercept of the best line from 10000 simulations.

The adopted separation line corresponds to the 5-σ uncertainty on the intercept value (bluest green line).

Bright FGK boundary



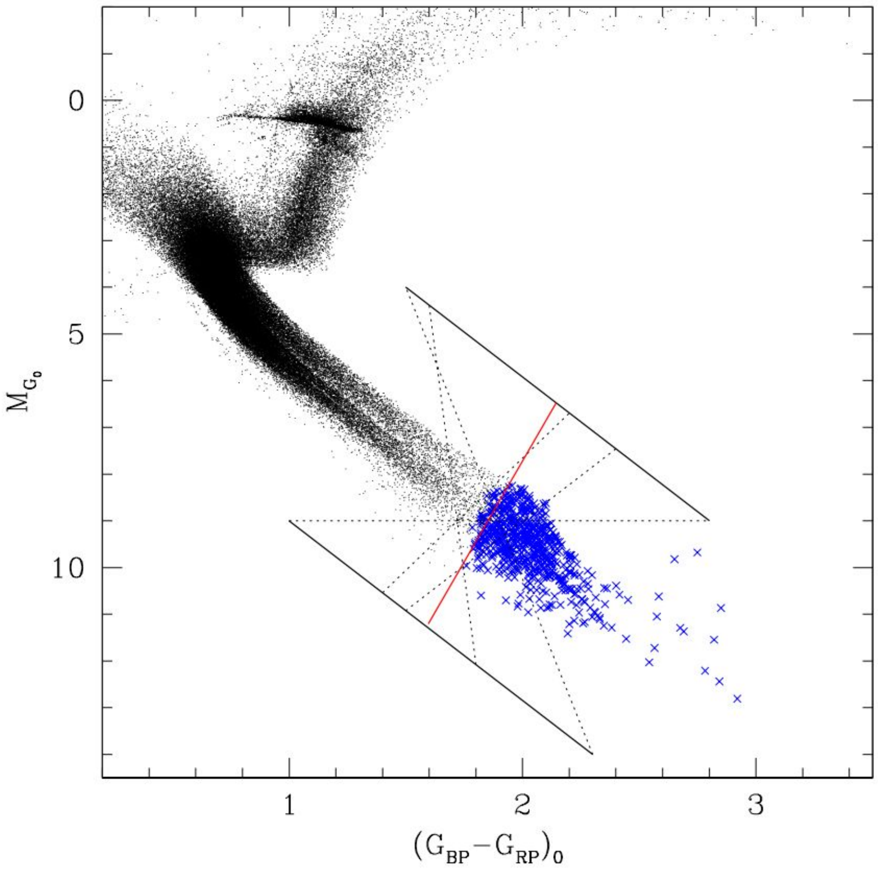
Across the selected region we draw different separation lines as denoted in the figure.

We calculated the metric $S=(N_{targ}-N_{cont})$ and selected the line that maximized this metric (red line).

We fixed the slope of the best separation line and then perturbed all simulated stars accordingly with their expected errors in color and magnitude (including the error on reddening and extinction) and calculated the 1-σ uncertainty on the intercept of the best line from 10000 simulations.

The adopted separation line corresponds to the 5-σ uncertainty on the intercept value (brightest green line).

Blue M boundary

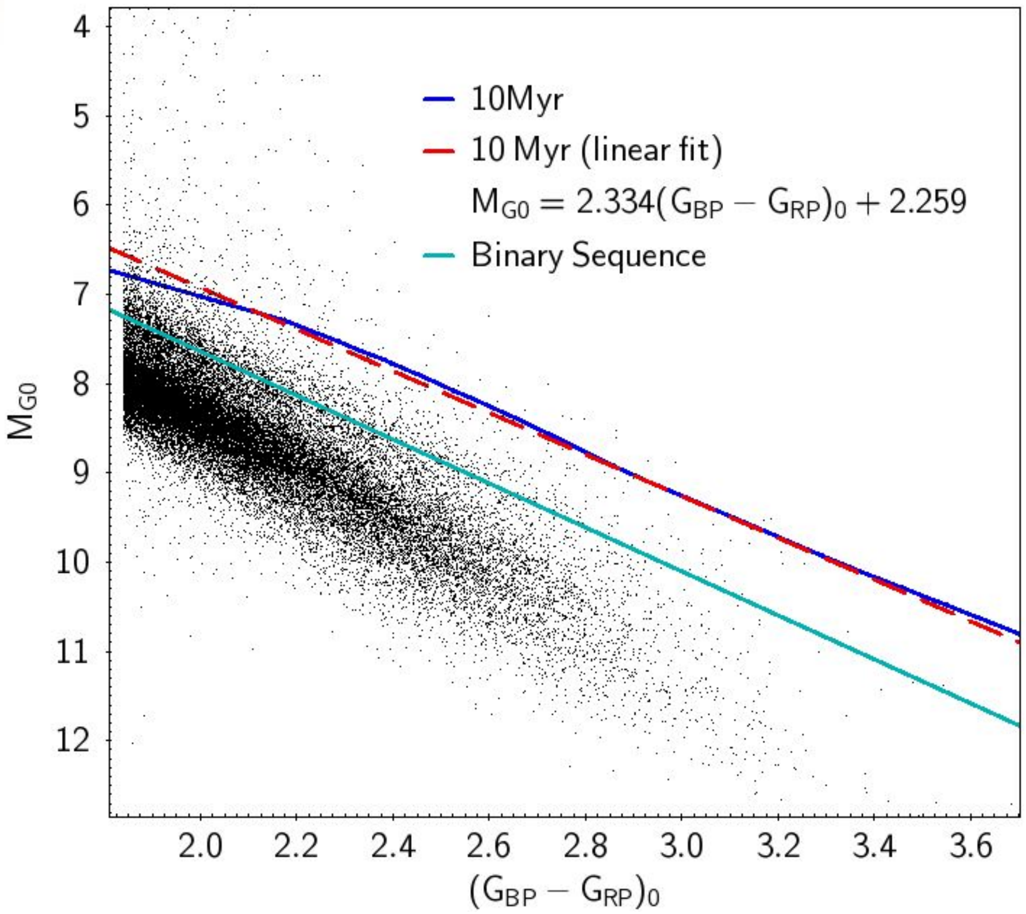


Across the selected region we draw different separation lines as denoted in the figure.

We calculated the metric $S=(N_{targ}-N_{cont})$ and selected the line that maximized this metric (red line).

In this case it is not necessary to consider the error on the intercept since the best line separates FGK and M stars.

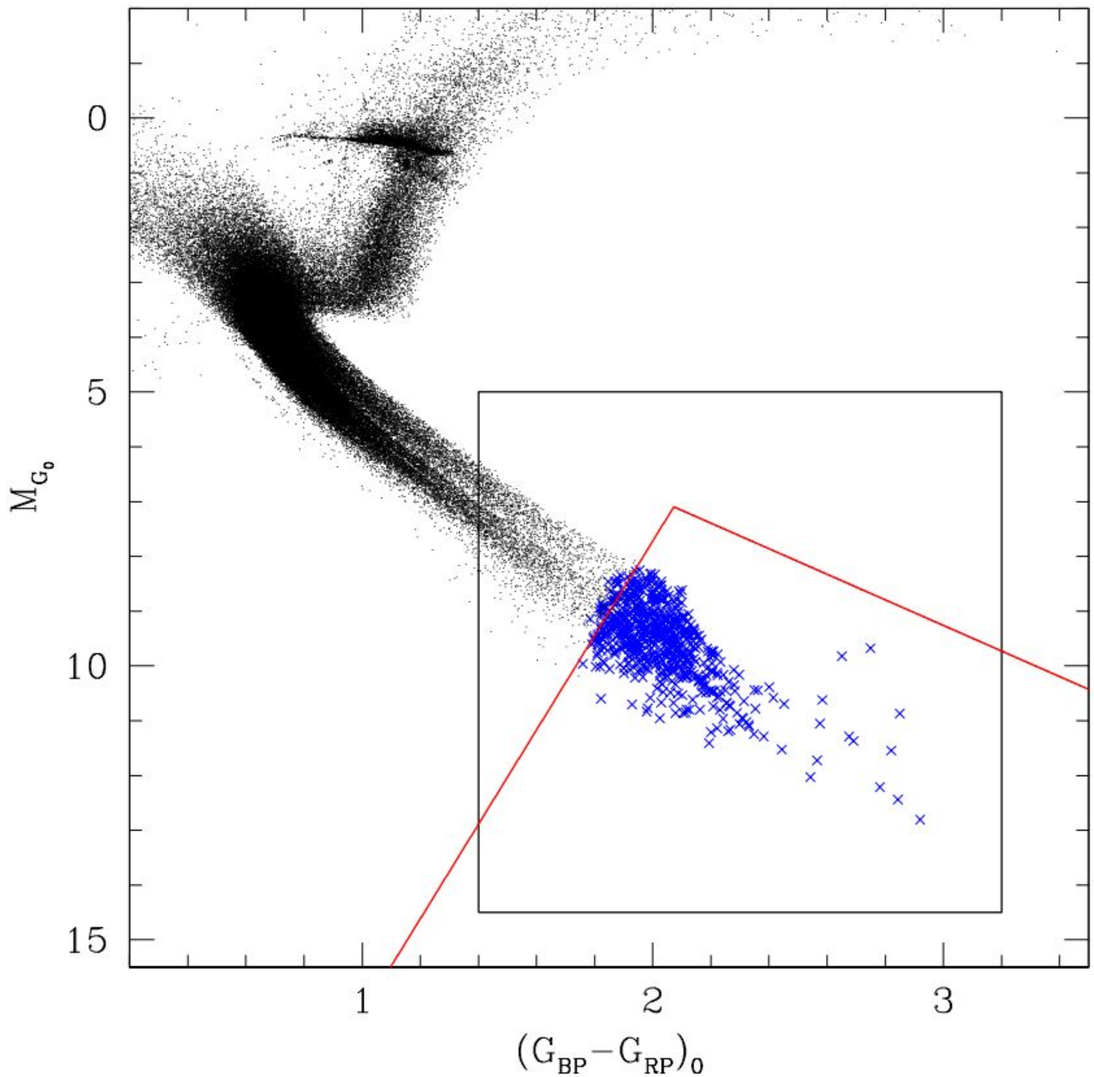
Bright M-dwarf boundary



The bright M dwarf boundary is identical to the one adopted for PIC1.1.0 and corresponds to the best regression line of a **10 Myr isochrone**.

as in Montalto et al. 2021

Selection M



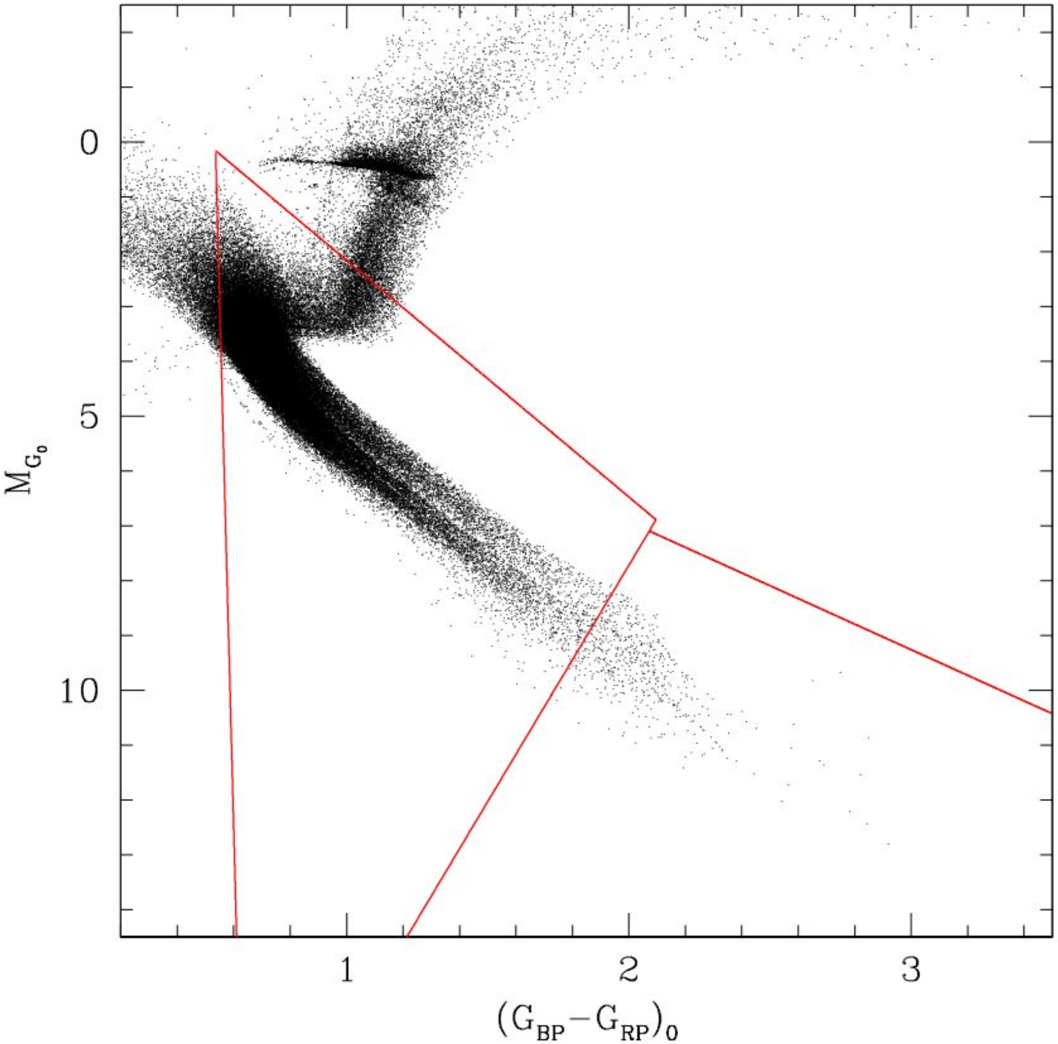
Black points indicate simulations from TRILEGAL for stars with V<16.

Blue points indicate stars with T_{eff}< 3850 K and logg ≥ 3.5

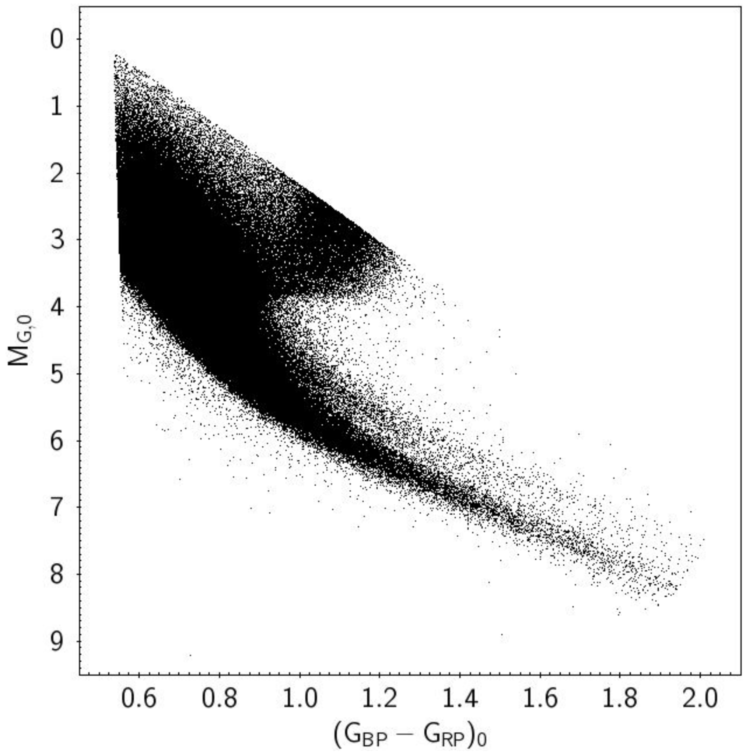
Black rectangle: region used to perform the selection of the best separation line on the blue side of the M sample

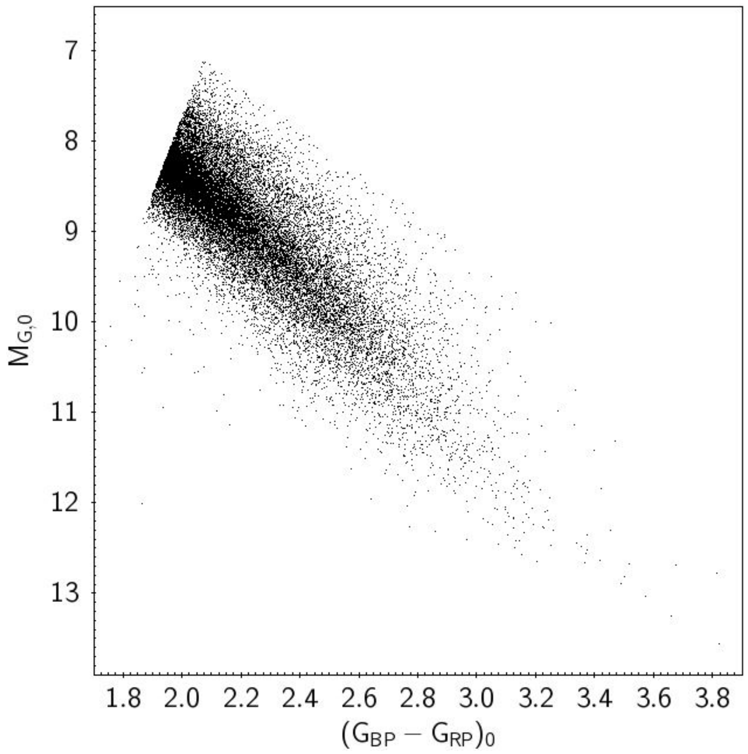
Red lines: best separation lines

FGK + M selection



PIC2.0.0





PIC2.0.0 has a slightly modified selection of FGK and M dwarfs and subgiants

V Johnson-Cousins & Gaia DR3 relationship

Motivation:

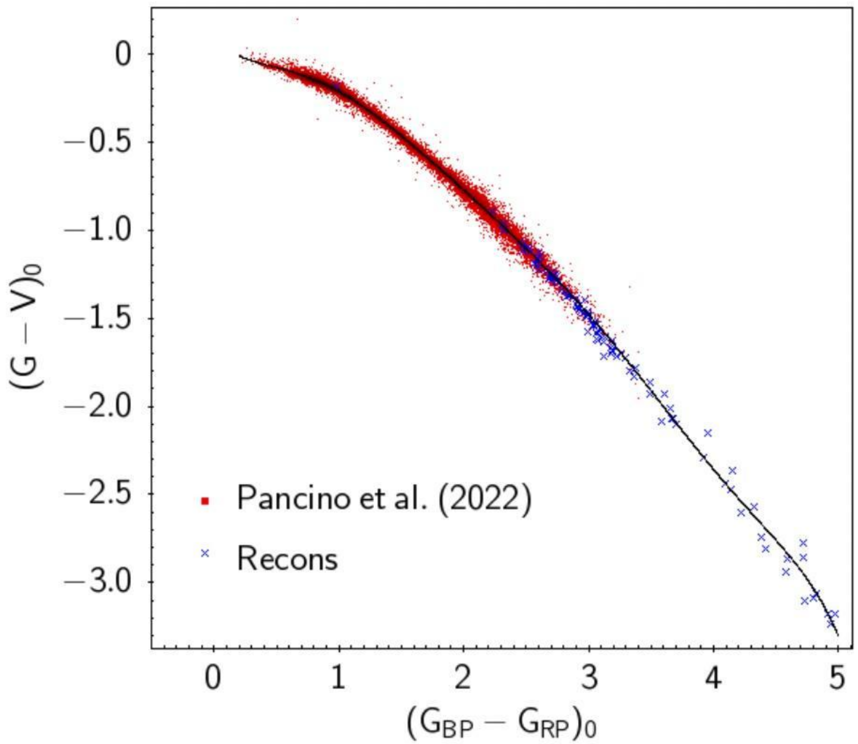
- photometric limits in SciRD given in V
- Literature available relationship not extended to M dwarfs regime

Selected data sets:

- Pancino et al. 2022 (19079 MS stars)
- Henry et al. 2018 (RECONS, 102 M stars

Procedure:

- reddening correction of Gaia and Johnson-Cousin V magnitudes (3D ma
by Lallement et al. 2022)



$$(G-V)_0 = a_0 + \sum_{i=1}^{i=7} a_i (G_{BP} - G_{RP})_0^i$$

range $0.2 \leq (G_{BP}\text{-}G_{RP})_0 \leq 5$

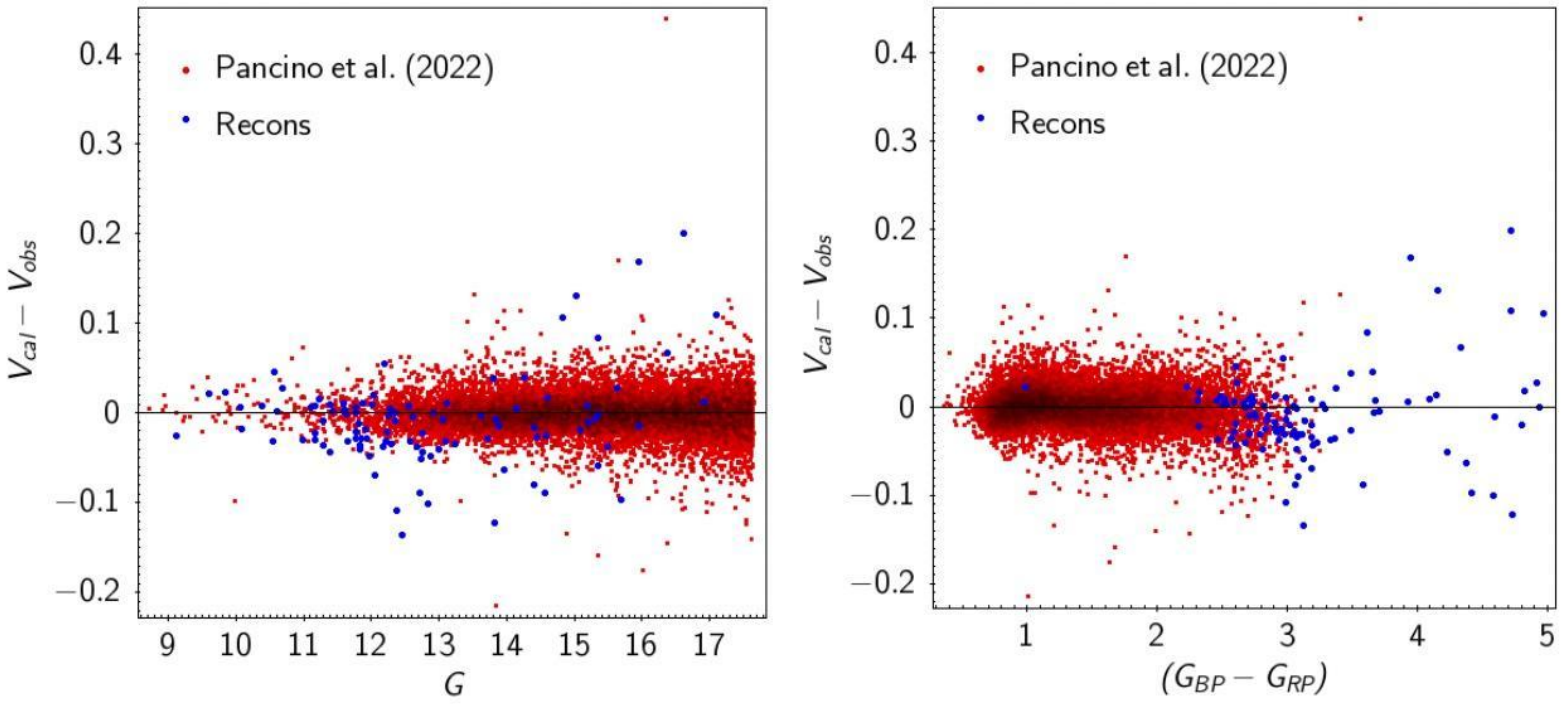
a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7
0.08610	-0.72737	1.49201	-1.82377	1.01157	-0.29353	0.04286	-0.00248

Courtesy: L. Prisinzano

V Johnson-Cousins & Gaia DR3 relationship

Comparison

Observed vs. calculated magnitudes $\langle\Delta V\rangle$=-0.0004 σ= 0.0200



Courtesy: L. Prisinzano

New extinction map

Lallement et al. 2022, A&A, 661, 147

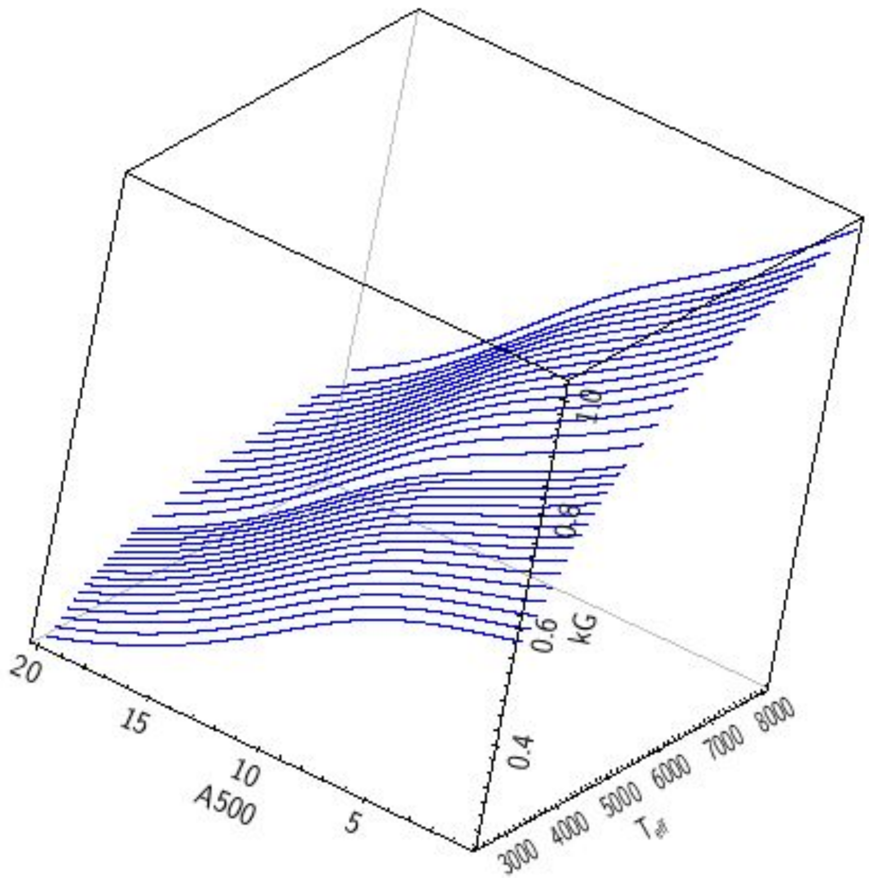
Gaia eDR3 + 2MASS **+** *Gaia* eDR3 parallaxes

"*Due to the addition of fainter target stars, the volume in which the clouds can be reconstructed has increased. Due to the improved accuracy of the parallaxes and photometric data in EDR3, extinctions among neighbouring targets are more consistent, allowing one to reach an increased contrast in the dense areas, while cavity contours are more regular*"

The map provides 3D distribution of extinction density at 550 nm in a **6kpc by 6 kpc by 0.8kpc** volume around the Sun. Gridstep value is 10 pc and resolution 25 pc.

The previous map covered a volume of **2 kpc x 2 kpc x 0.3 kpc** with step of 5 pc and equal or lower resolution.

Extinction coefficients A_m/A_{550} for the Gaia DR3 bands as a function of temperature and reddening



$(A_m/A_{550}) = f(T_{eff}, A_{550})$

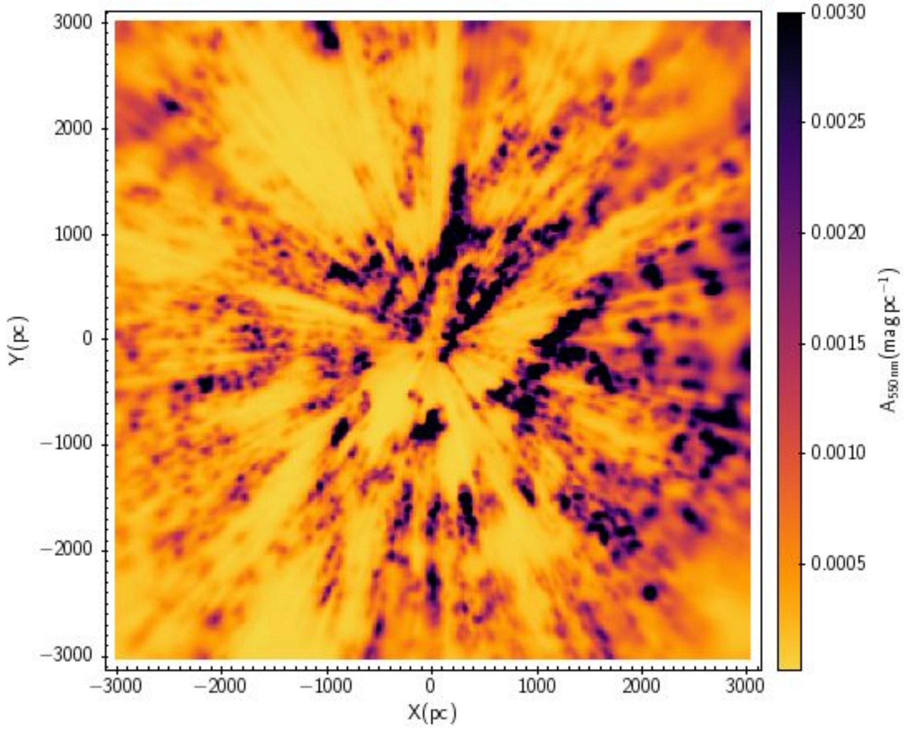
$2500 \leq T_{eff}(K) \leq 8000$

$0 < A_{550} \leq 20$

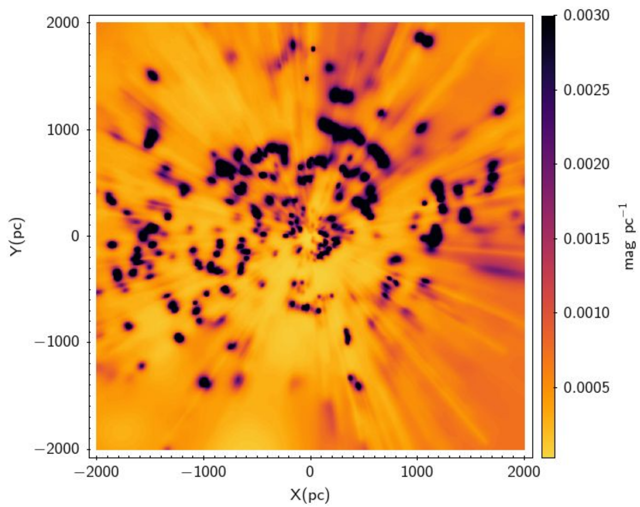
$A_{550} \rightarrow A_V$, A_{Ks} , A_G , A_{BP} , A_{RP}

New extinction map

Lallement et al. (2022)



Capitanio et al. (2017)



E(B-V)

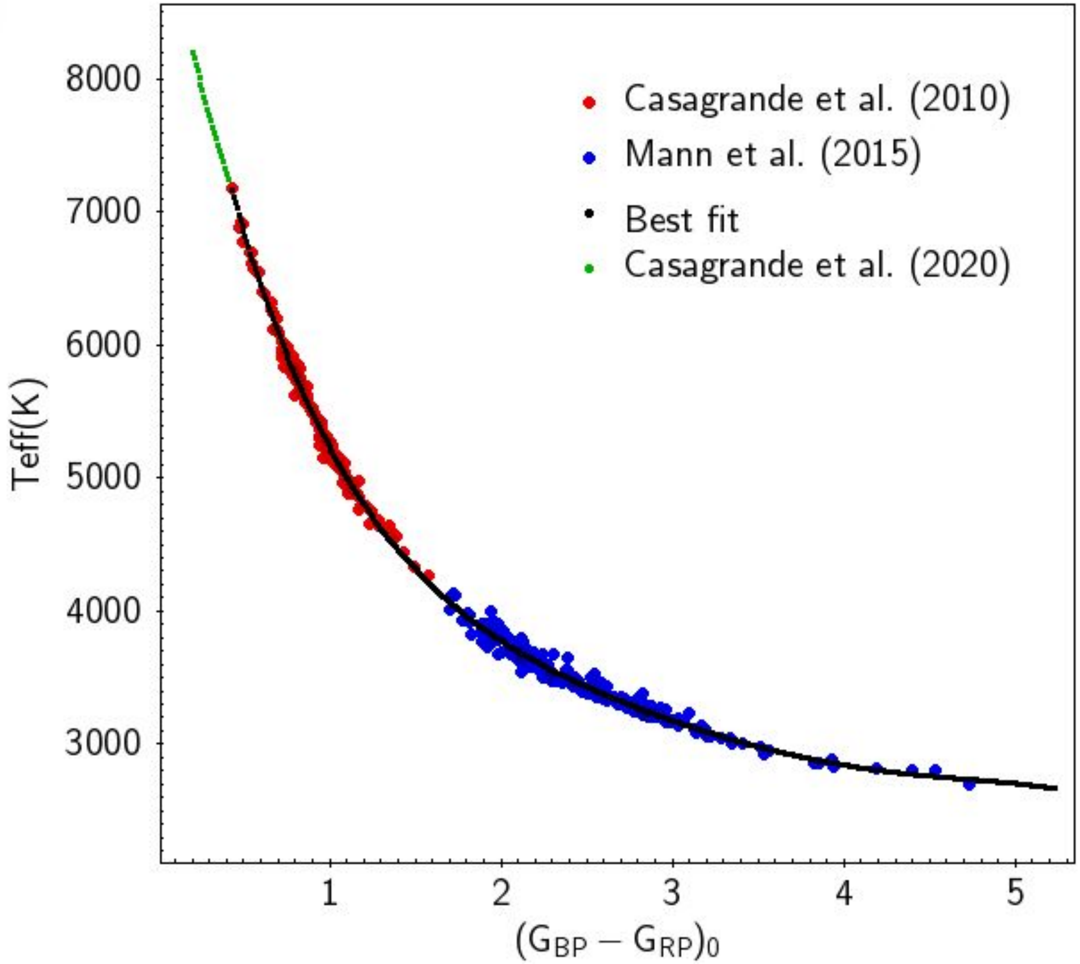
$A_{(550\ nm)}$

extstatus=1 → 14118

NOTE: no extinction correction for stars outside map

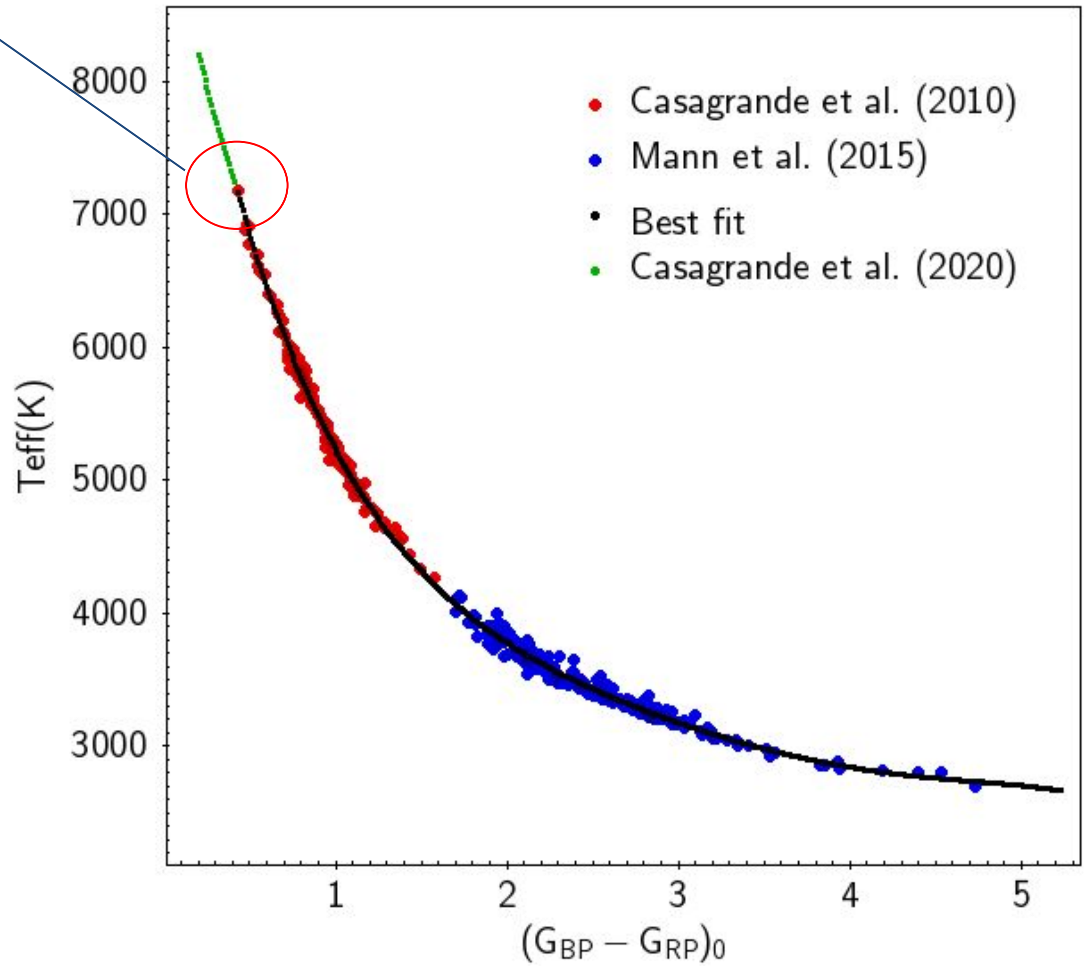
extstatus=1 → 50372

T_{eff} vs $(G_{BP}-G_{RP})_0$



T_{eff} vs $(G_{BP}-G_{RP})_0$

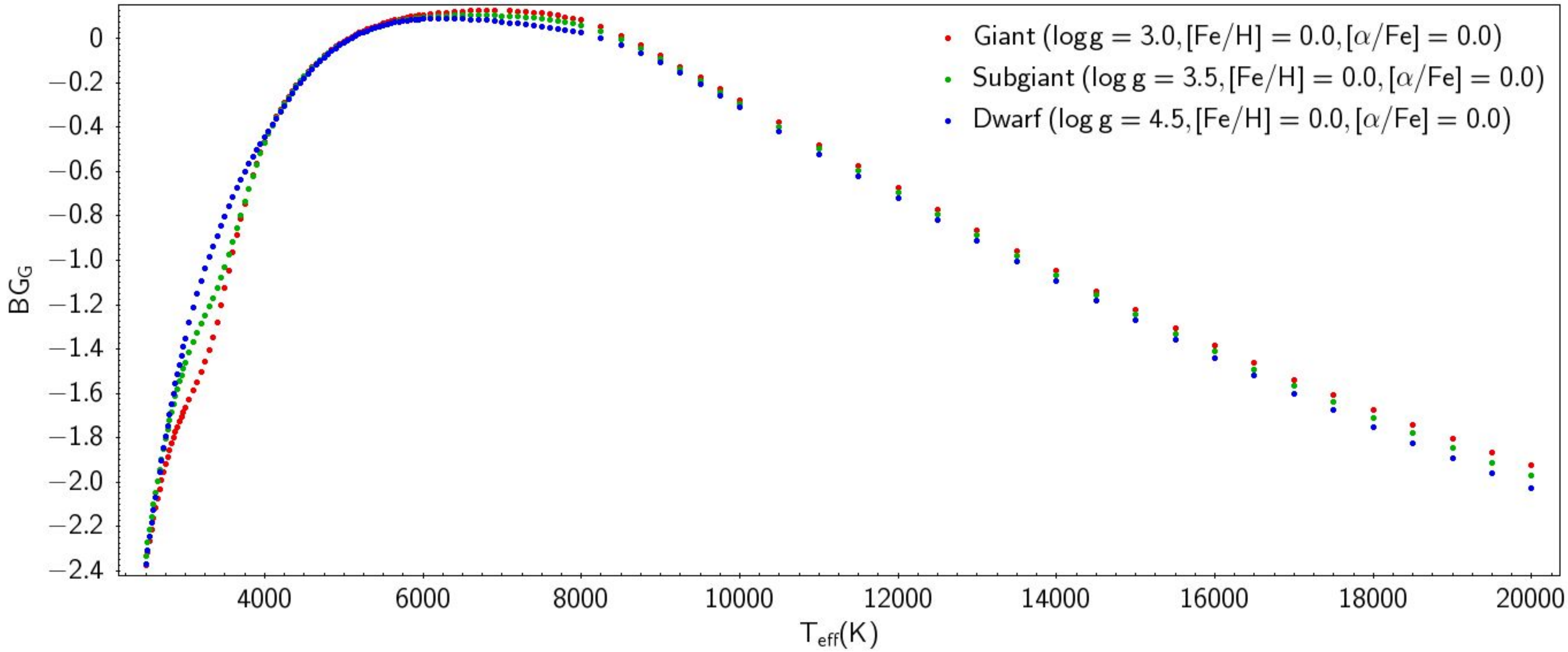
Casagrande et al. (2020)
[Fe/H]=0
log g=4.438068
(Prša et al. 2016)



Gaia DR3 G-band bolometric correction

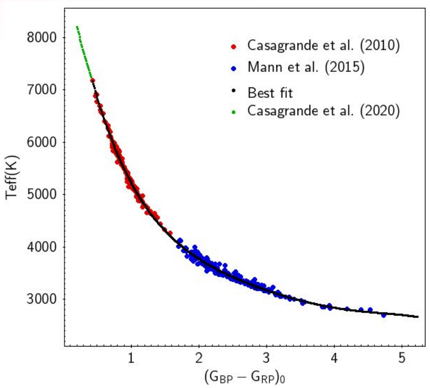
"Bolometric corrections in the Gaia (E)DR3 G-band, BC_G, were evaluated on a grid of MARCS models (Gustafsson et al. 2008) supplemented with intermediate temperature stars (Shulyak et al. 2004)."

Dependence on gravity

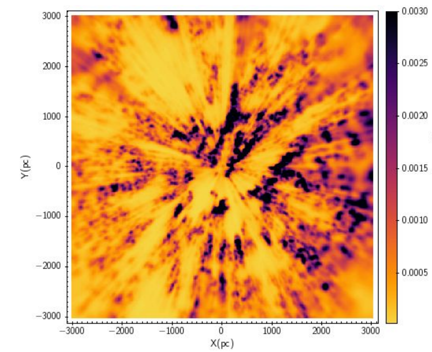


The function is valid in the T_{eff} range of 2,500 - 20,000 K, log g between -0.5 and +5.0, [Fe/H] from -5.0 to +1.0 and [alpha/Fe] from +0.0 to +0.4. **We adopted log g=4.5, [Fe/H]=0.0, [α/Fe]=0.0.**

Stellar parameters estimation



$A_{550}, A_G, A_{Gbp}, A_{Grp}, A_V$



Lallement et al. (2022)

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

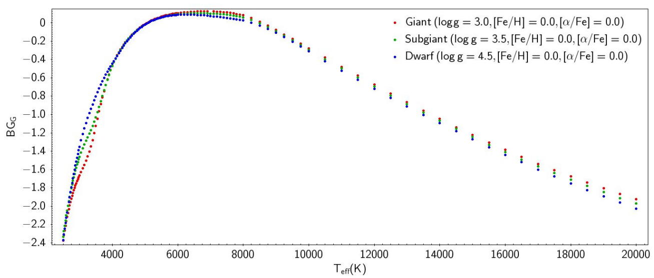
$(G_{bp}-G_{rp})_0=(G_{bp}-G_{rp})-E(G_{bp}G_{rp})$

Stellar parameters are estimated with a procedure that uses custom calibrated relations and external constraints on interstellar extinction together with *Gaia* DR3 distances and fundamental astrophysical relations.

Distances from Bailer Jones et al. 2021, AJ, 161, 147

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

$$BC_G = f(T_{eff})$$



Gaia DR3, BC

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

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

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

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

M-dwarfs masses and radii

Mann et al. 2015 relations and 2MASS M_{Ks} mag

$Y=a+bX+cX^2+\ldots$

used to derive Radii, Masses and Bolometric Corrections

Table 1
Mass and Radius Relations

Y	X	Eqn #	a	b	c	d	e	f	σ^{a} %	χ^2_ν
R_*	M_{K_S}	(4)	1.9515	–0.3520	0.01680	···	···	···	2.89	0.93
R_*	M_{K_S},[Fe/H]	(5)	1.9305	–0.3466	0.01647	···	···	–00.04458	2.70	0.88
R_*	$T_{\rm eff}$/3500	(4)	10.5440	–33.7546	35.1909	–11.59280	···	···	13.4	2.35
R_*	$T_{\rm eff}$/3500,[Fe/H]	(5)	16.7700	–54.3210	57.6627	–19.69940	···	0.45650	9.3	1.10
M_*[b]	M_{K_S}	(10)	0.5858	0.3872	–0.1217	0.0106	-2.7262×10^{-4}	···	1.8	0.37

Note. For the first, third, and fifth equation $Y = a + bX + c^2\cdots$; for the equations including [Fe/H] the right-hand side is multiplied by (1 + f[Fe/H]).

[a] For the first three relations σ is given as the percent scatter in R_*, i.e., the standard deviation of $\frac{R_{*,\rm observed} - R_{*,\rm predicted}}{R_{*,\rm observed}}$. The last relation is quoted as the percent scatter in M_*.

[b] Semi-empirical relation derived using empirical K_S-band magnitudes and masses estimated from our model analysis. Coefficients are calculated using maximum likelihood and an MCMC method. See Section 8 for details.

Courtesy: L. Prisinzano

M-dwarfs masses and radii

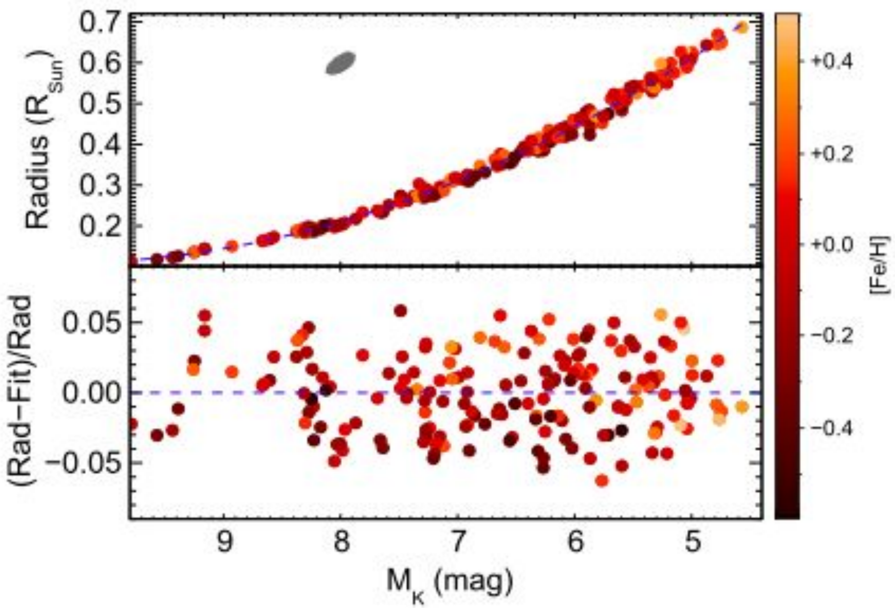


Figure 7. Top: R_* as a function of absolute K_S-band magnitude. The best fit to the data is shown as a blue dashed line (see Equation (4) and Table 1). M_K and radius both depend on the distance, so the errors are correlated. Hence, we show a 1σ error ellipse in the top left, which indicates the typical 1σ errors for a typical point ($M_{K_S} \simeq 6.6$, $R_* \simeq 0.35$). Bottom: fractional residual to the fit. All points are color-coded by metallicity.

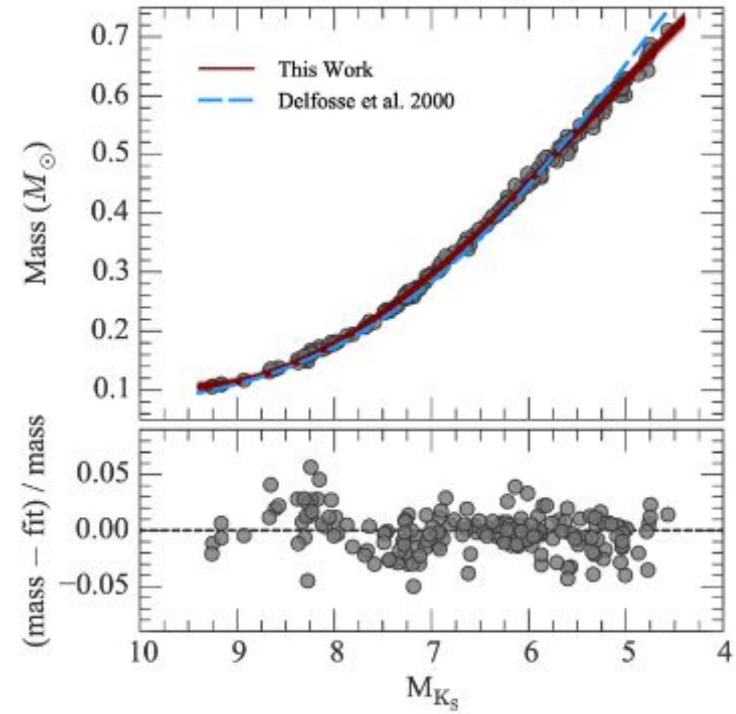
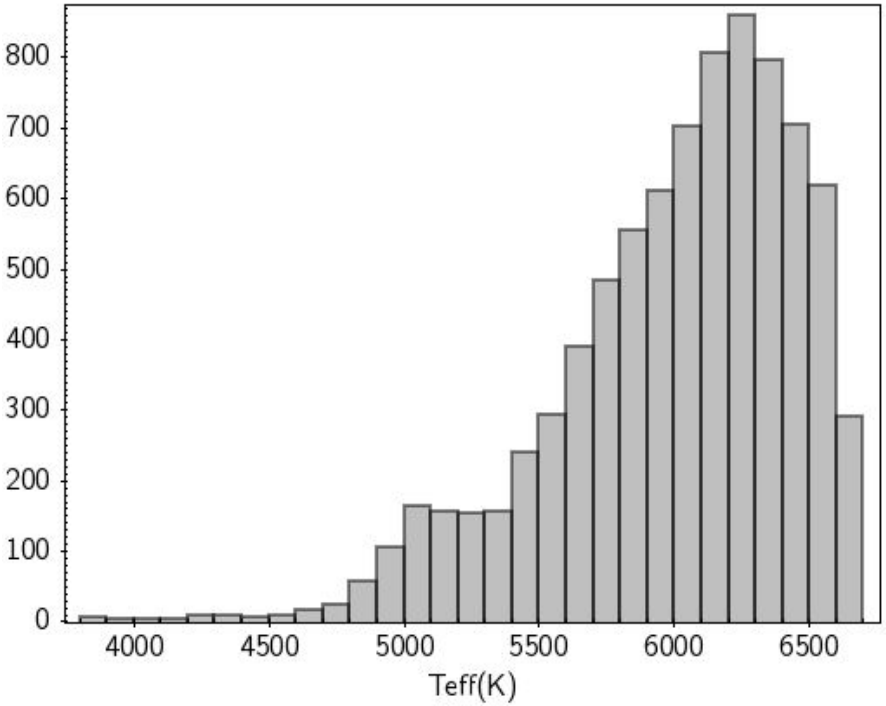


Figure 20. Top: mass–luminosity (M_{K_S}) relationship. M_{K_S} was determined from observations and paired with masses inferred from the Dartmouth stellar evolution model (Section 8.3). Red solid lines are 500 random realizations of quartic polynomial fits to the data drawn from the joint PPD for the polynomial coefficients. The Delfosse et al. (2000) relationship is shown for reference (blue dashed line). Bottom: residuals of the data with respect to a best-fit quartic polynomial whose coefficient values are listed in Table 1.

Courtesy: L. Prisinzano

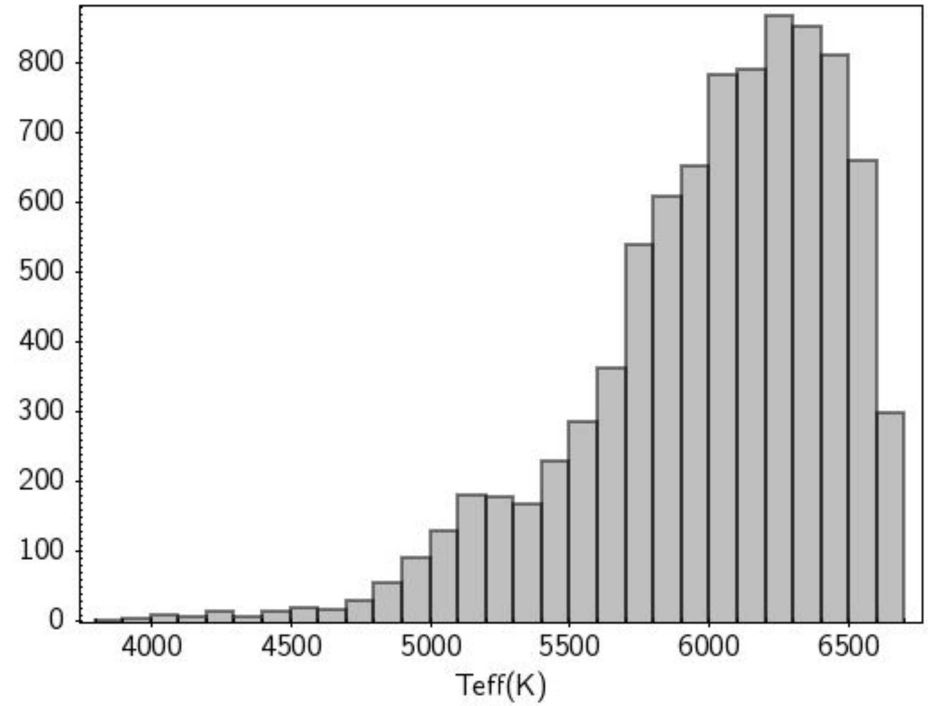
Effective temperature

LOPS2, P1



Min	1st Qu.	Median	Mean	3rd Qu.	Max
3844	5751	6094	6004	6340	6680

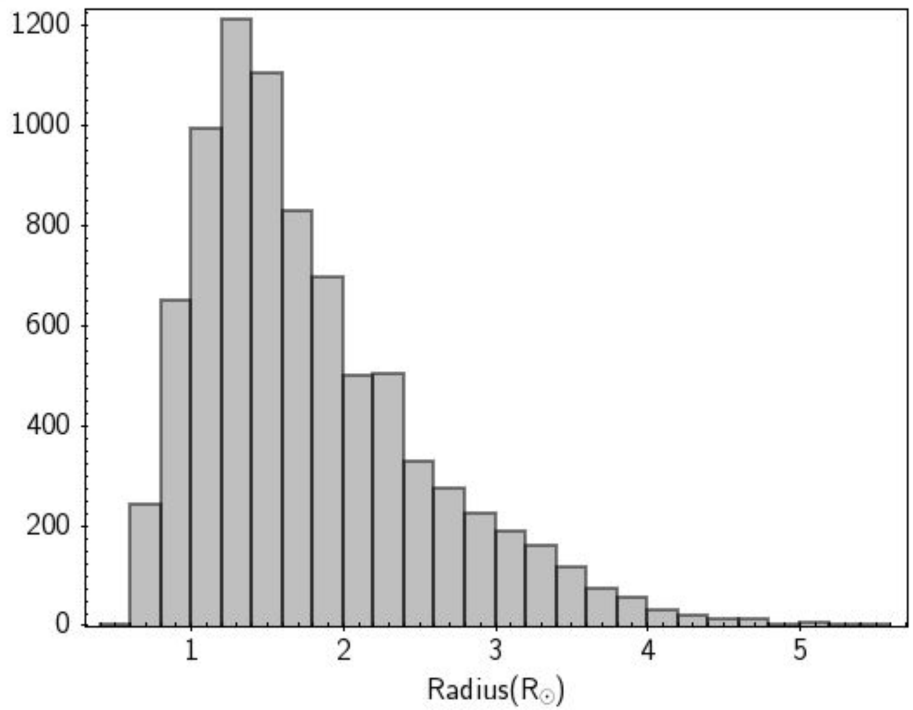
LOPN1, P1



Min	1st Qu.	Median	Mean	3rd Qu.	Max
3839	5769	6093	6011	6352	6688

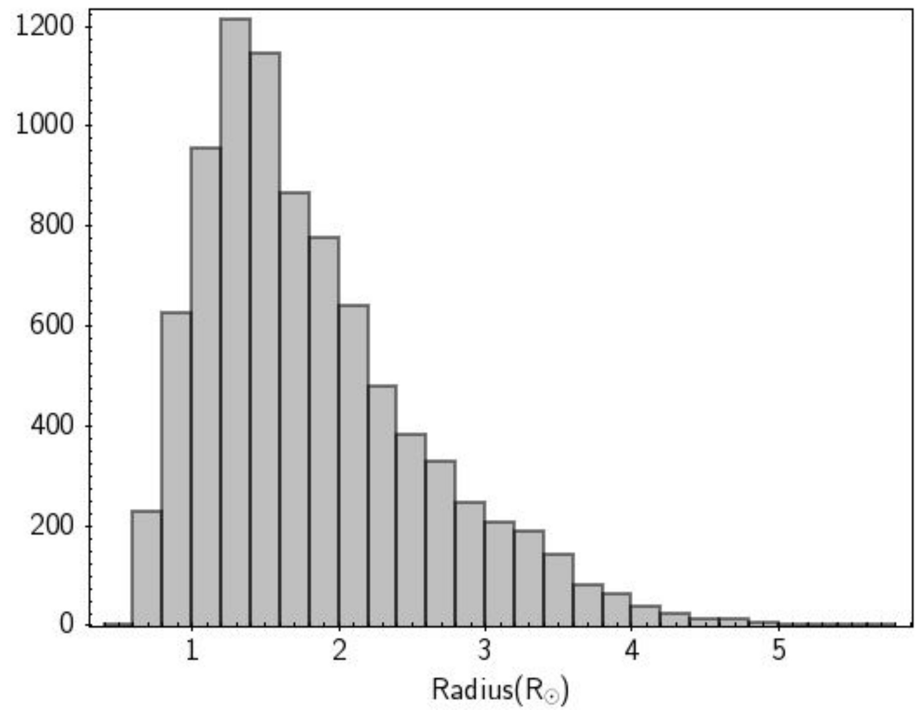
Radius

LOPS2, P1



Min	1st Qu.	Median	Mean	3rd Qu.	Max
0.58	1.23	1.58	1.77	2.18	5.52

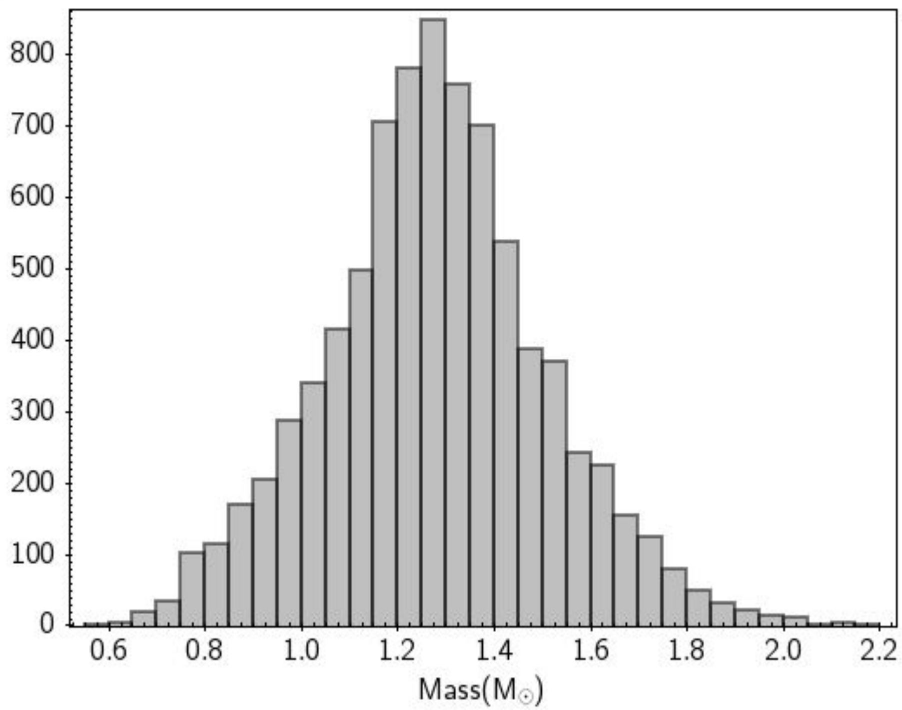
LOPN1, P1



Min	1st Qu.	Median	Mean	3rd Qu.	Max
0.56	1.27	1.64	1.82	2.22	5.72

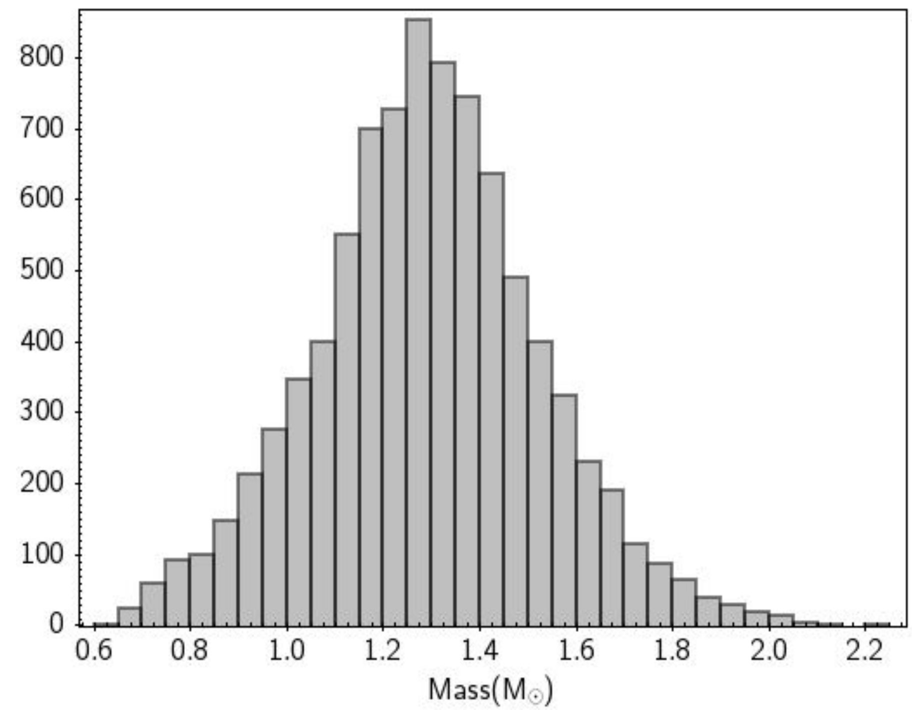
Mass

LOPS2, P1



Min	1st Qu.	Median	Mean	3rd Qu.	Max
0.59	1.14	1.27	1.28	1.42	2.19

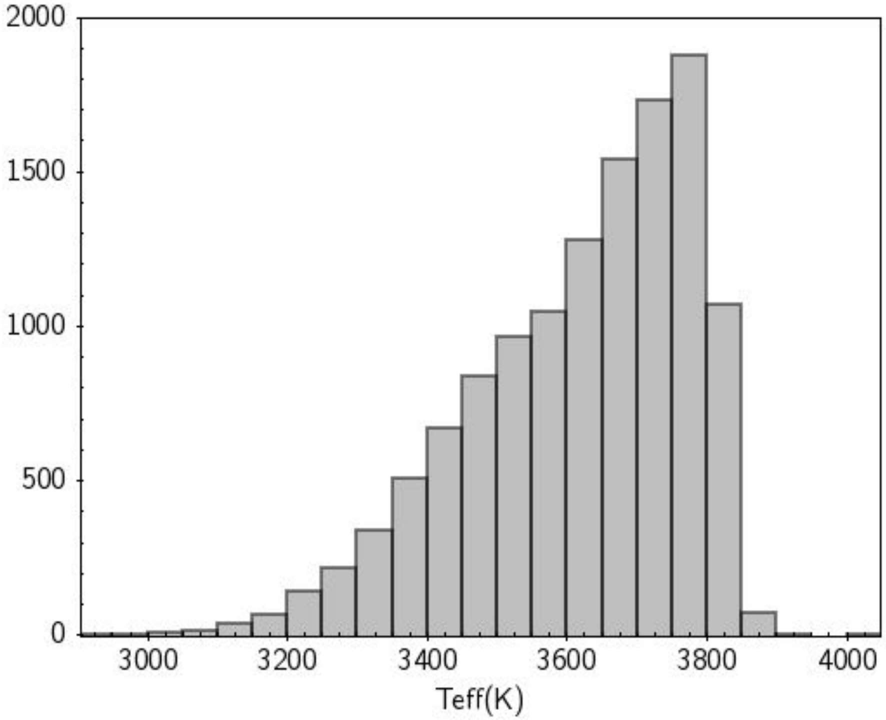
LOPN1, P1



Min	1st Qu.	Median	Mean	3rd Qu.	Max
0.61	1.15	1.29	1.29	1.44	2.20

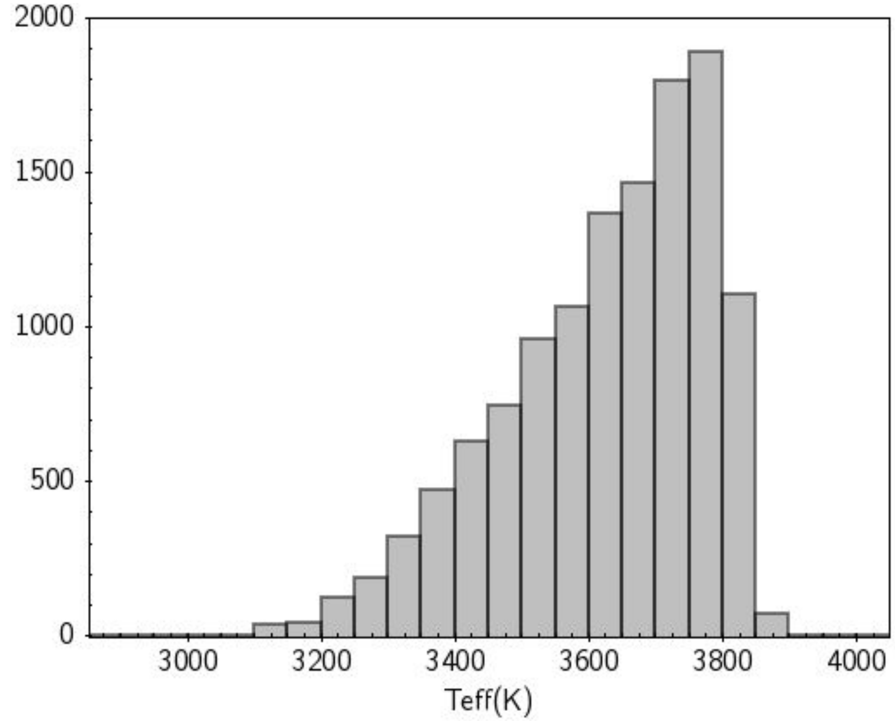
Effective temperature

LOPS2, P4



Min	1st Qu.	Median	Mean	3rd Qu.	Max
2926	3515	3652	3620	3748	4023

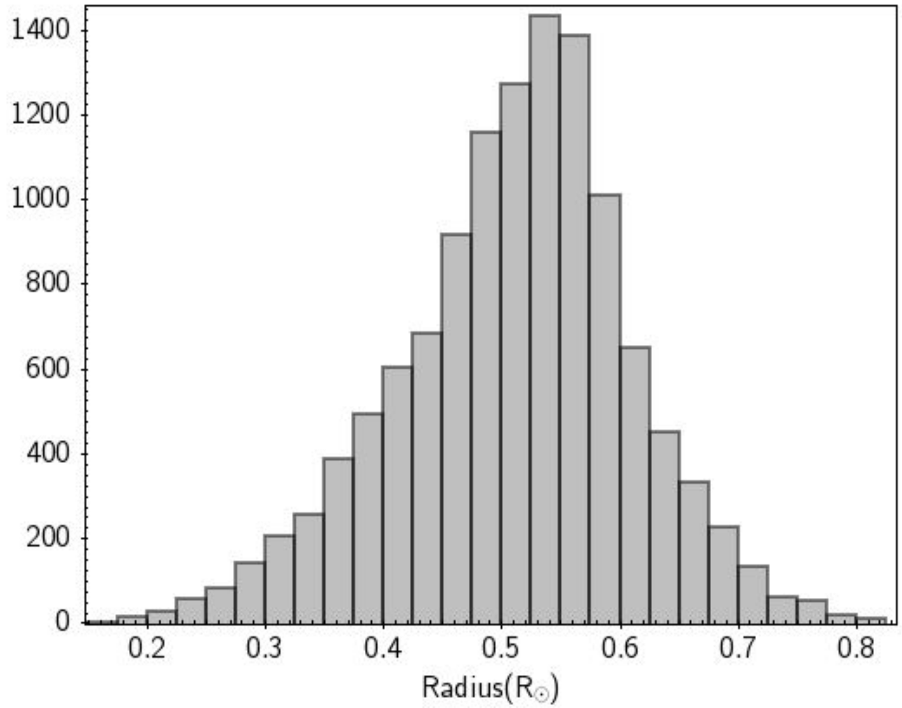
LOPN1, P4



Min	1st Qu.	Median	Mean	3rd Qu.	Max
2885	3526	3656	3626	3750	4004

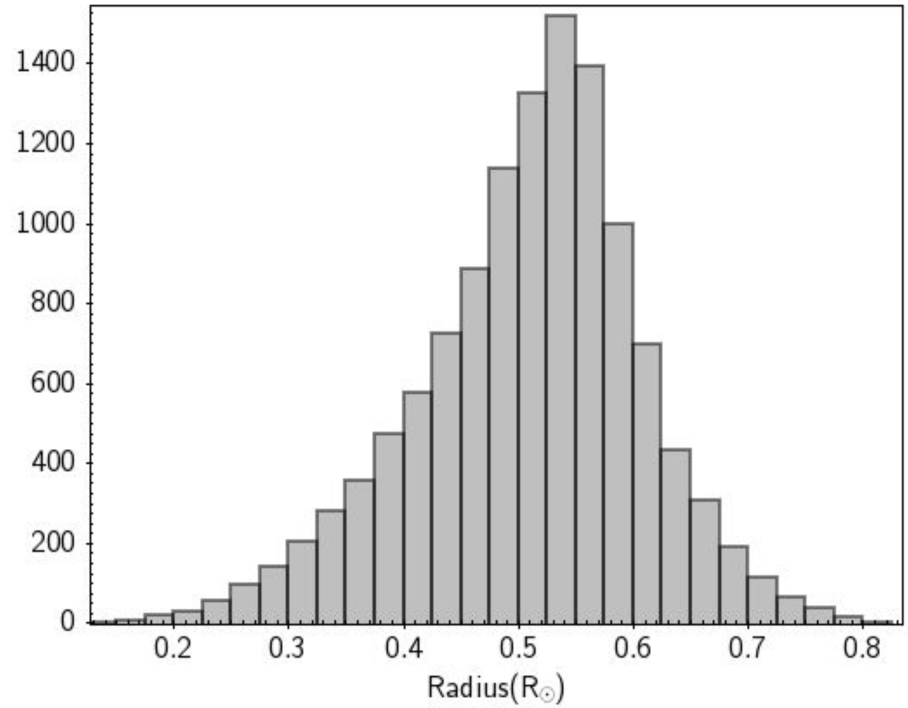
Radius

LOPS2, P4



Min	1st Qu.	Median	Mean	3rd Qu.	Max
0.16	0.45	0.52	0.51	0.57	0.81

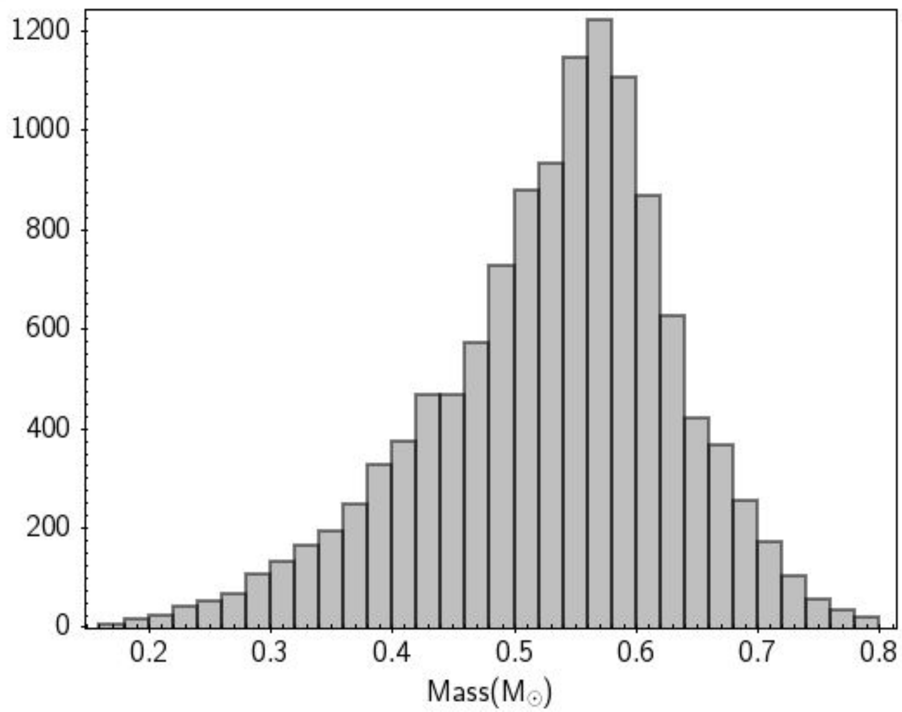
LOPN1, P4



Min	1st Qu.	Median	Mean	3rd Qu.	Max
0.14	0.45	0.52	0.51	0.57	0.80

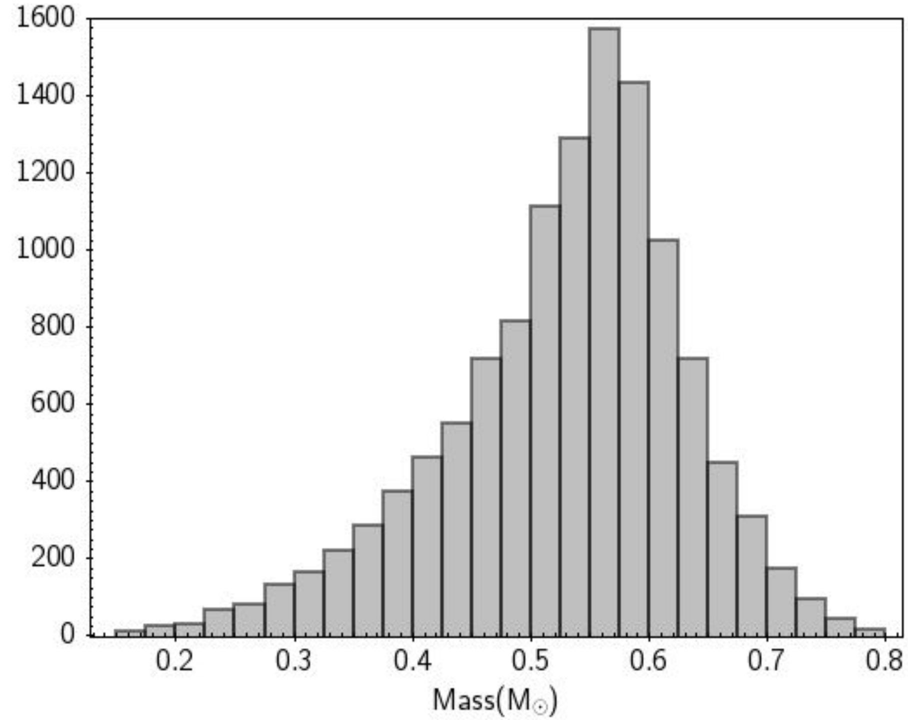
Mass

LOPS2, P4



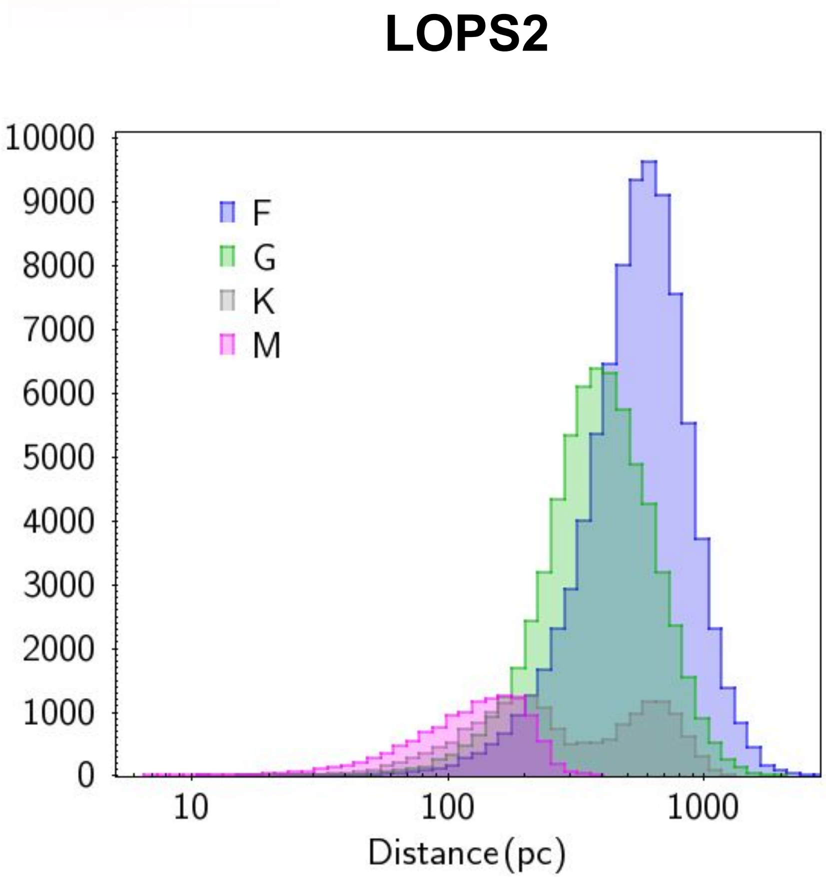
Min	1st Qu.	Median	Mean	3rd Qu.	Max
0.16	0.47	0.54	0.53	0.60	0.80

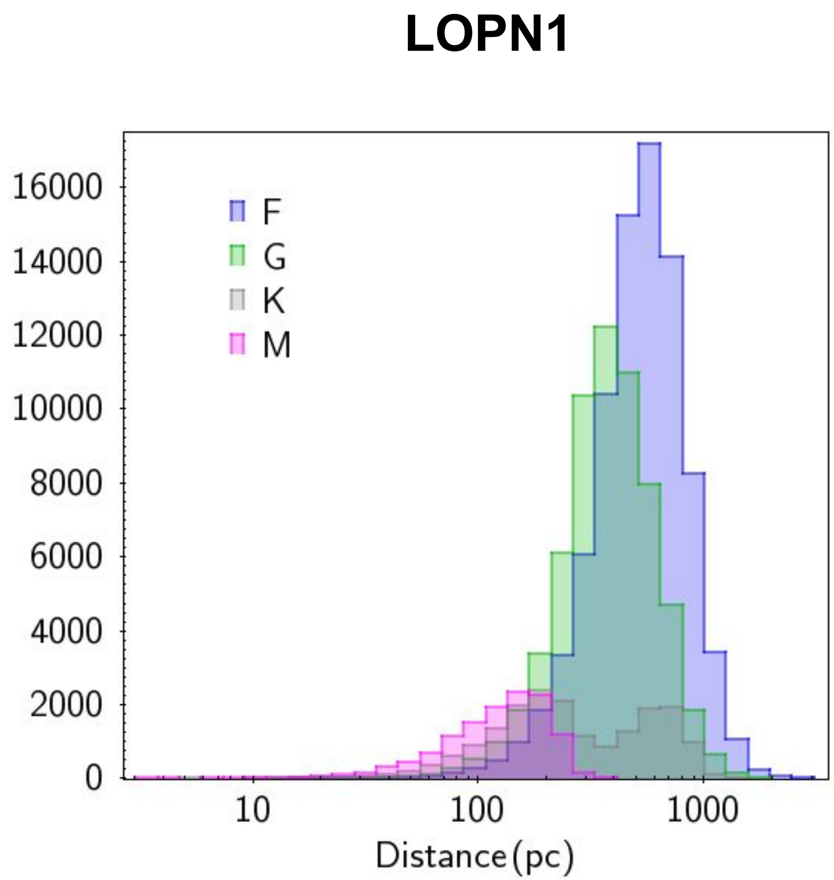
LOPN1, P4



Min	1st Qu.	Median	Mean	3rd Qu.	Max
0.15	0.47	0.54	0.53	0.60	0.79

Distribution of distances as a function of spectral type

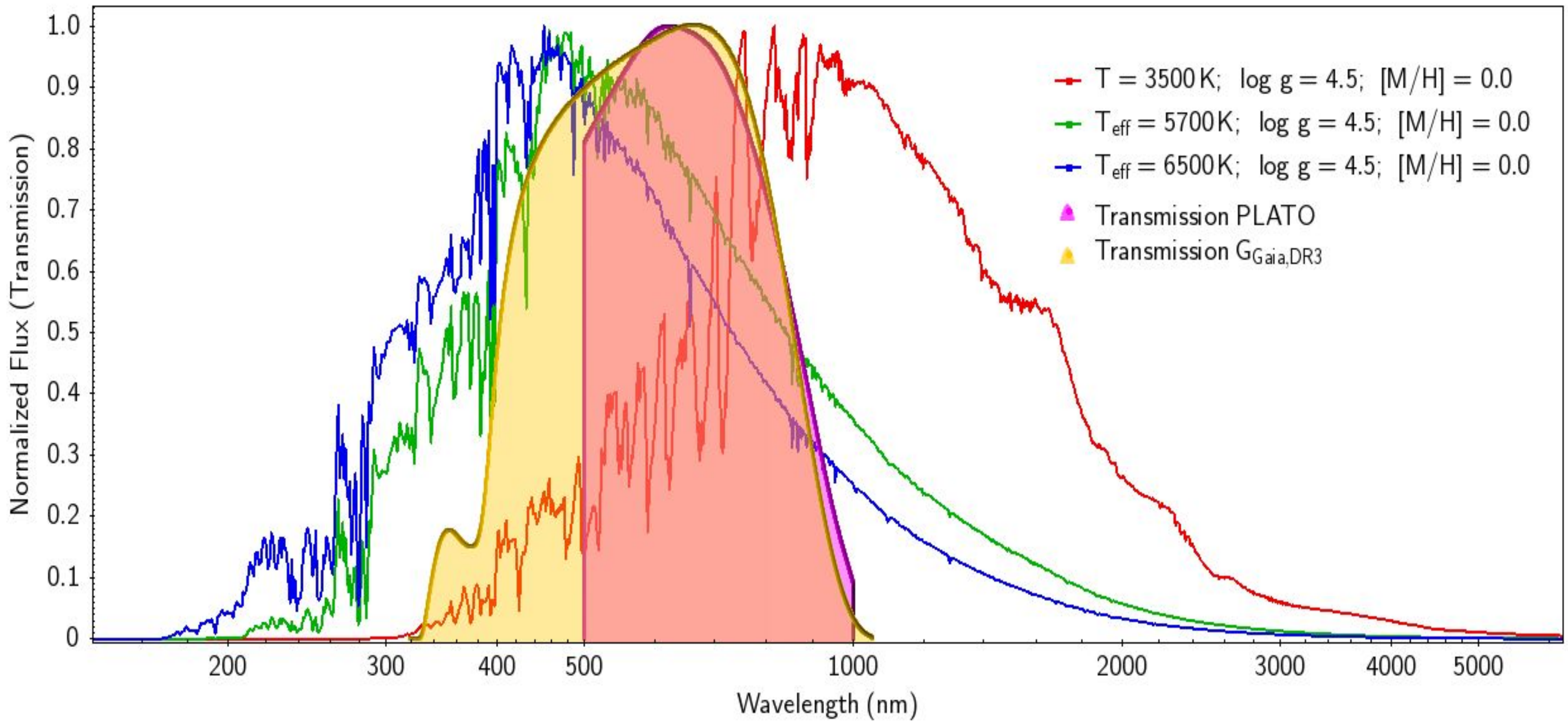




PLATO magnitude

- Calculation of PLATO magnitude zero point to the Vega system for normal and fast cameras

- Calculation of calibration relations for **dwarfs**, **giants**, **normal** and **fast cameras** (2100 K ≤ T_{eff} ≤ 63880 K)

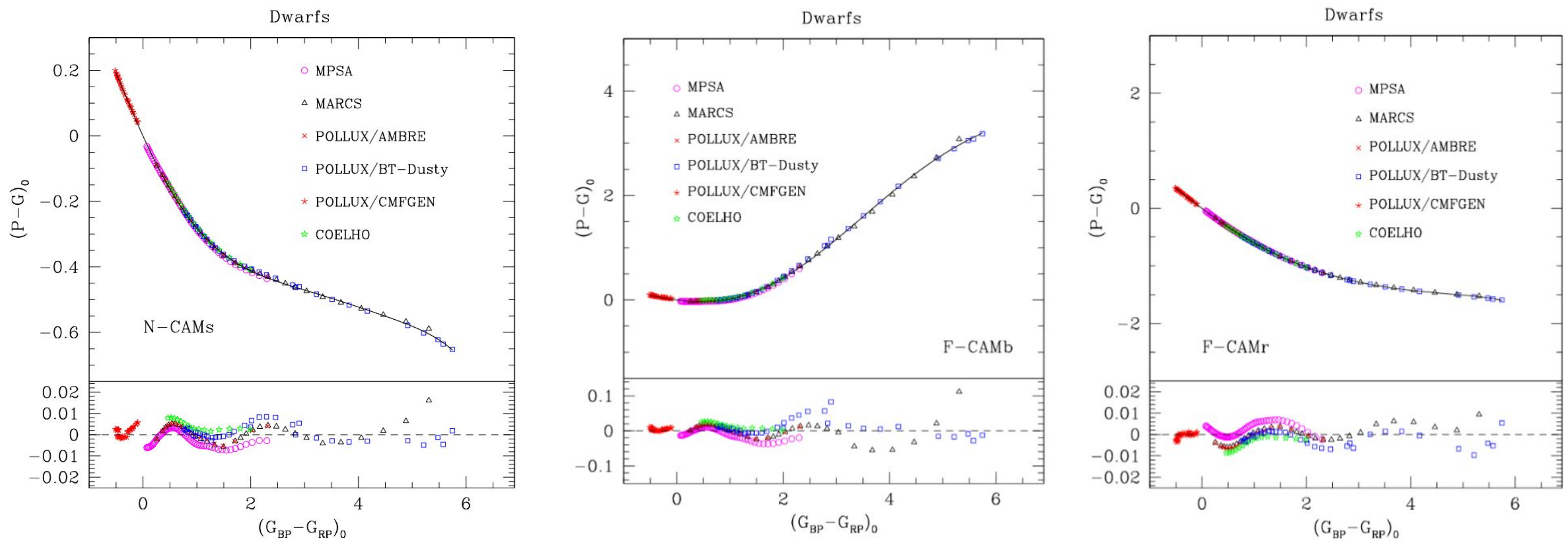


PLATO magnitude

Synthetic stellar libraries

Library	Temperature range	R	# models dwarfs	# models giants
MPSA	3500 K - 9000 K	55	56	56
MARCS	2500 K - 8000 K	20000	31	31
POLLUX/AMBRA	3500 K - 8000 K	>150000	18	17
POLLUX/BT-Dusty	2100 K - 6000 K	>100000	39	41
POLLUX/CMFGEN	12020 K - 63880 K	150000	35	35
COELHO	3500 K - 7000 K	275000	15	15

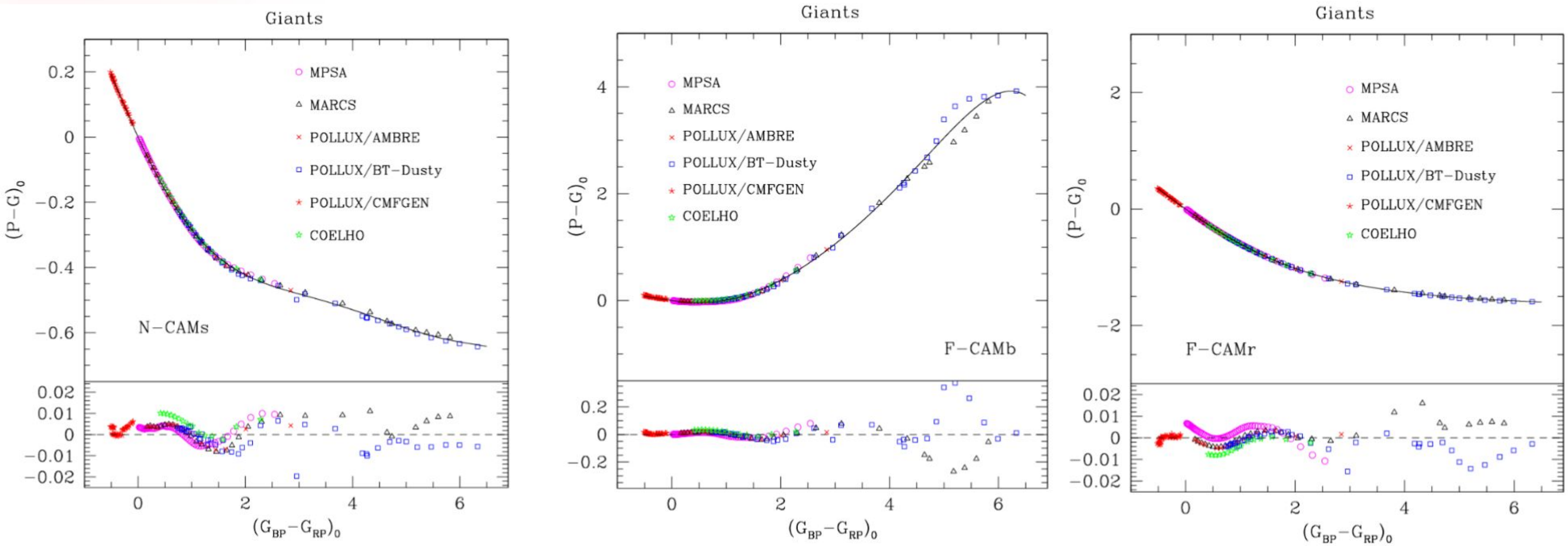
PLATO magnitude



N-CAMs F-CAMb F-CAMr

Calibration relations between Gaia DR3 colors and magnitudes and PLATO magnitude for dwarf stars

PLATO magnitude



N-CAMs F-CAMb F-CAMr

Calibration relations between Gaia DR3 colors and magnitudes and PLATO magnitude for giant stars

PLATO magnitude

- Calibration relations will be increased to include also Hipparcos, Tycho and Johnson magnitudes

- The PLATO magnitude is discussed in a technical note sent together with tPIC2.0.0.1 documentation: PLATO-SCI-UPD-TN-0019

NSS flag

Bitmask indicating the presence of binary/multiple stellar system.

Note: NSS = non-single star

Bitmask values:

000000_2 = 0 : no NSS info available

000001_2 = 1 : NSS

000010_2 = 2 : wide binaries

000100_2 = 4 : eclipsing

001000_2 = 8 : astrometric

010000_2 = 16 : spectroscopic

qualityFlag

Bitmask containing indicators for issues in Gaia astrometry and photometry

Bitmask values:

000000000_2 = 0 : no issues

000000001_2 = 1 : ruwe>3.6

000000010_2 = 2 : astrometric_excess_noise>0.61 AND astrometric_excess_noise_sig>2

000000100_2 = 4 : ipd_frac_multi_peak>14

000001000_2 = 8 : ipd_gof_harmonic_amplitude>0.09

000010000_2 = 16: ipd_frac_odd_win>1

000100000_2 = 32: beta>0.1

001000000_2 = 64: abs(BPRPexcessCorr)>3(BPRPexcessCorrSig)

010000000_2 = 128: saturation correction as described in Appendix C.1 of Riello et al. 2021, A&A, 649, 3 was applied

100000000_2 = 256: The correction in Sect. 8.4 of Riello et al. 2021, A&A, 649, 3 was applied

qualityFlag

NOTE:

Gaia astrometry and photometry quality indicators (see https://gea.esac.esa.int/archive/documentation/GDR3/index.html for further information)

ruwe: renormalised unit weight error
astrometric_excess_noise: excess noise of the source
astrometric_excess_noise_sig: significance of excess noise
ipd_frac_multi_peak: percent of successful-IPD windows with more than one peak
ipd_frac_harmonic_amplitude: amplitude of the IPD GoF versus position angle of scan
ipd_frac_odd_win: percent of transits with truncated windows or multiple gate
beta: blending fraction defined as in Sect. 9.3 of https://www.aanda.org/articles/aa/pdf/2021/05/aa39587-20.pdf
C*: the corrected BP and RP flux excess as described in Sect. 9.4 of https://www.aanda.org/articles/aa/pdf/2021/05/aa39587-20.pdf

sourceFlag

Bitmask indicating to which sample an object belongs to

Bitmask values:

000000000_2 = 0 : reset all bits

000000001_2 = 1 : Prime Sample star

000000010_2 = 2 : P1 star

000000100_2 = 4 : P2 star

000001000_2 = 8 : P5 star

000010000_2 = 16: P4 star

000100000_2 = 32: **Canditate and/or Confirmed Planet(s) host star**

001000000_2 = 64: fgPIC star

010000000_2 = 128: cPIC star

100000000_2 = 256: scvPIC star

Stellar sample	Requirements	Stellar counts PIC1.1.0	Stellar Counts PIC2.0.0
P1	At least 15000 dwarfs and subgiants with spectral type between F5 and M0 and NSR<50 ppm in 1hr and V<11 observed during a LOP.	15094	16896
P2	At least 1000 dwarfs and subgiants with spectral type between F5 and M0 and NSR<50 ppm in 1hr and V<8.5 observed during a LOP.	1385	1398

Stellar sample	Requirement	Stellar counts PIC1.1.0	Stellar counts PIC2.0.0
P4	At least 5000 M dwarfs with V<16 observed during a LOP.	33032	24707
P5	At least 245000 dwarfs and subgiants with spectral type between F5 and M0 and V<13 observed during a LOP.	272617	313558

tPIC2.0.0 has been officially released to PLATO Consortium

All PLATO consortium members who have signed a NDA letter can request the tPIC by sending a mail to:

Giampaolo Piotto (giampaolo.piotto@unipd.it),

Paola Marrese (paola.marrese@ssdc.asi.it),

Heike Rauer (Heike.Rauer@dlr.de),

PSM office (psmoffice@warwick.ac.uk),

PDC office (pdcoffice@mps.mpg.de) to get the catalog.

PDC office is responsible for PIC distribution.