Mining TESS FFIs to analyze the brightest dwarfs and subgiants of the sky

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TESS Science Conference I - July 29 - Aug 2 2019, MIT/Cambridge, USA

Context and motivation

TESS is offering for the first time the opportunity to perform unbiased photometric characterization of any kind of star with unprecedented precision.

Gaia DR2 astro-photometry is now permitting accurate target selection.

There is then a strong synergy between TESS and Gaia

The Samples

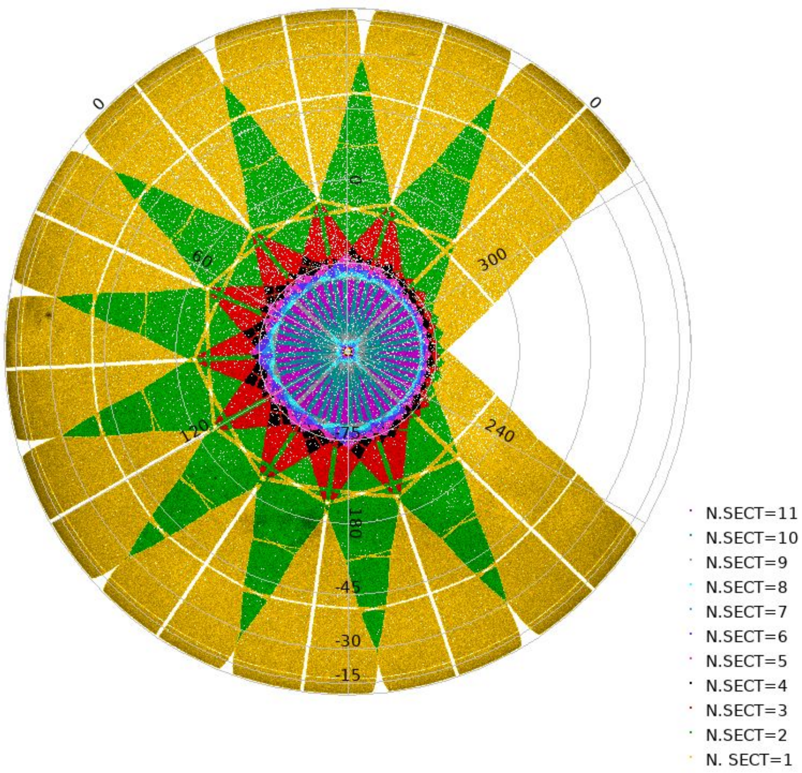
TESS photometry is very relevant for the preparation of forthcoming characterization (e. g. CHEOPS, JWST, ARIEL) and planet finding missions (e. g. PLATO).

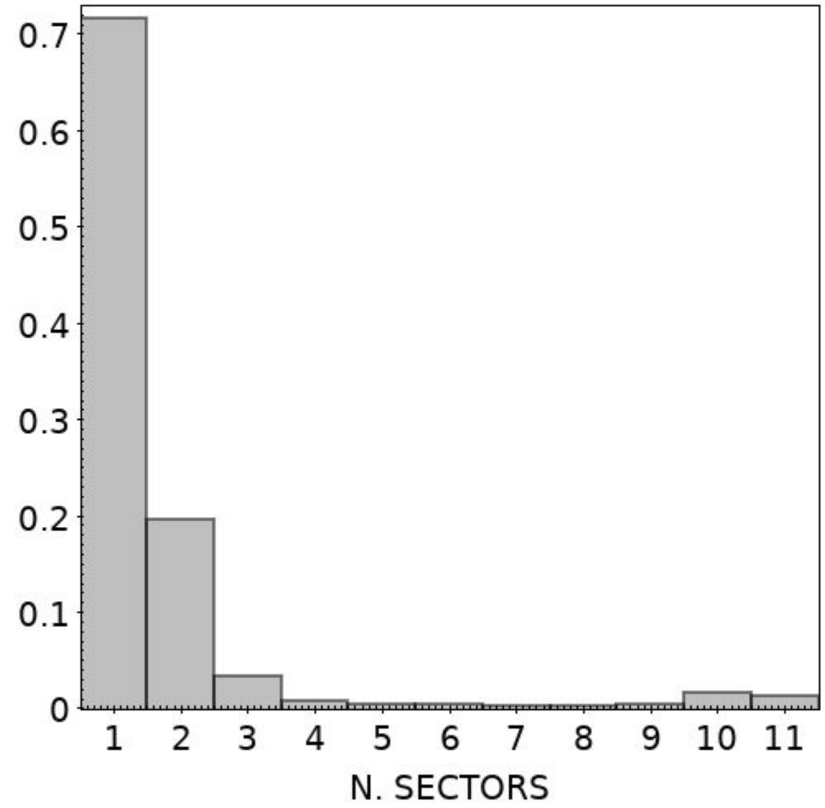
- FGK dwarfs and subgiants down to V<13

- M dwarfs down to V<16

<u>~ 2.5M stars allsky</u>

Distribution of targets across the sky (Sector 1 - Sector 11)





~ 1M stars in Sector 1-Sector 11

Reduction method

(Alard & Lupton 1998, ApJ, 503, 325; Alard A&AS 2000, 144, 363; Miller et al. 2008, PASP, 120, 449)

First iteration:

$$R \otimes K + B = I$$

$$K_{p,q}(i,j) = \begin{cases} 1 \text{ if } (i = p \wedge j = q) \\ 0 \text{ if } (i \neq p \vee j \neq q) \end{cases}$$

constant **δ**-function basis Kernel

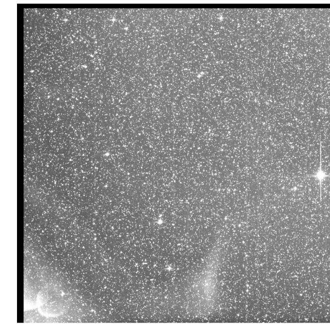
Second iteration:

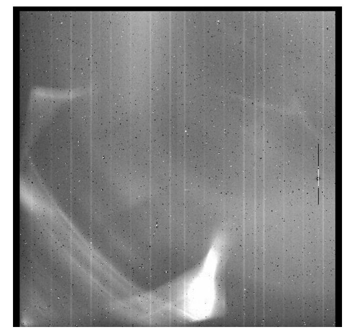
the background term (B) is substituted with a differential background model (B_{im}) constructed from a filtered and smoothed version of the first iteration residual image, which is then simultaneously fit together with the Kernel.

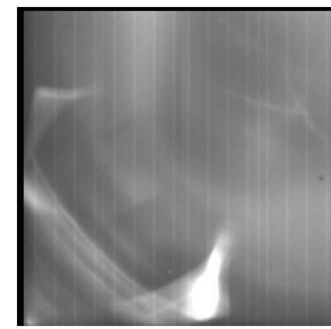
$$R \otimes K + B' = I$$

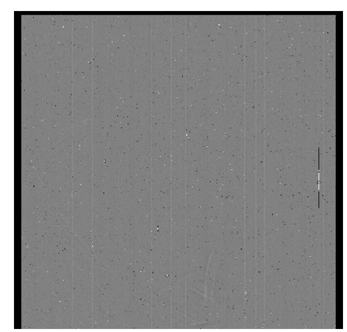
$$B' = B_1 \times B_{im} + B_2$$

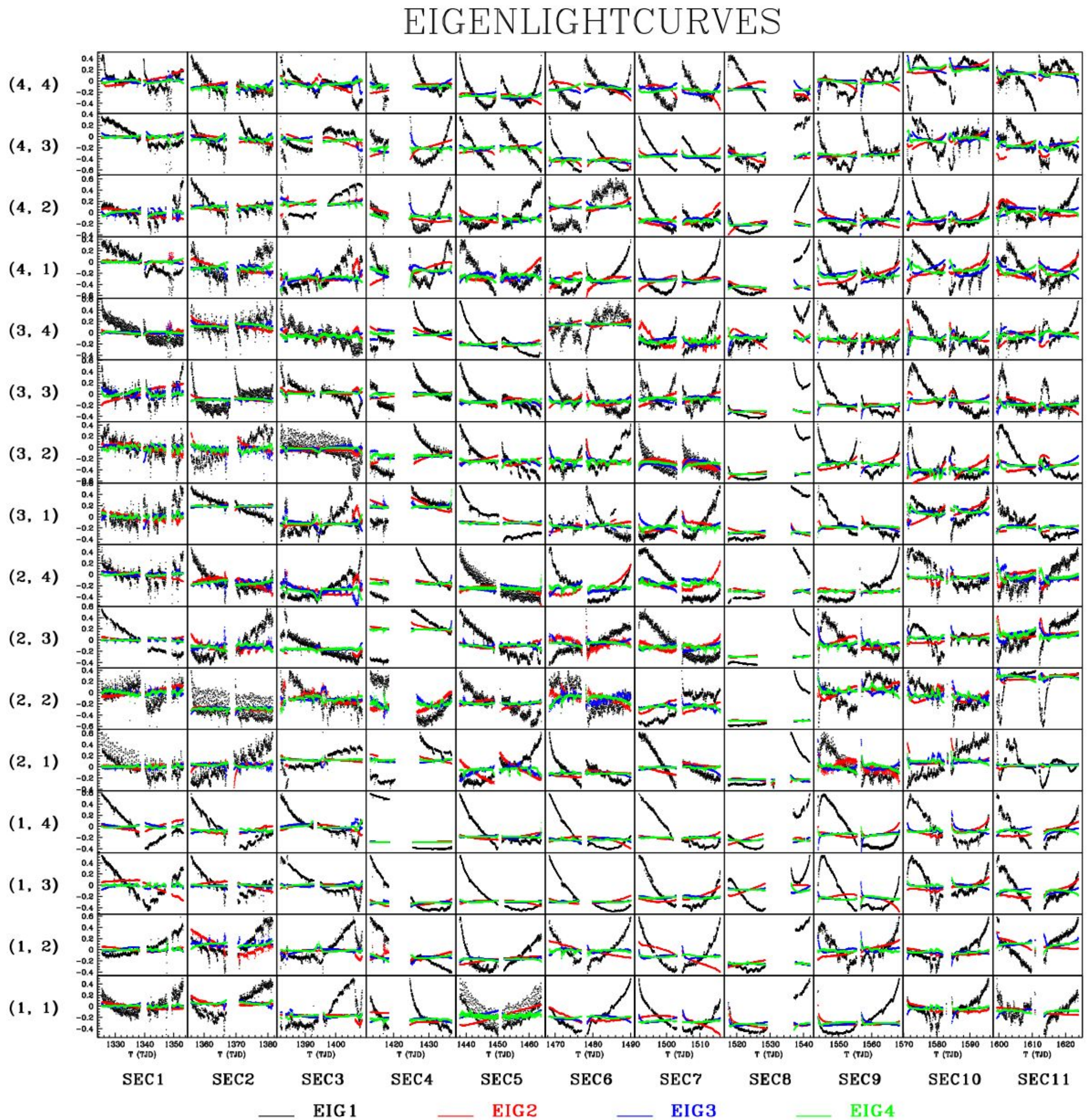

Reference


Target


Ist residual


DB model

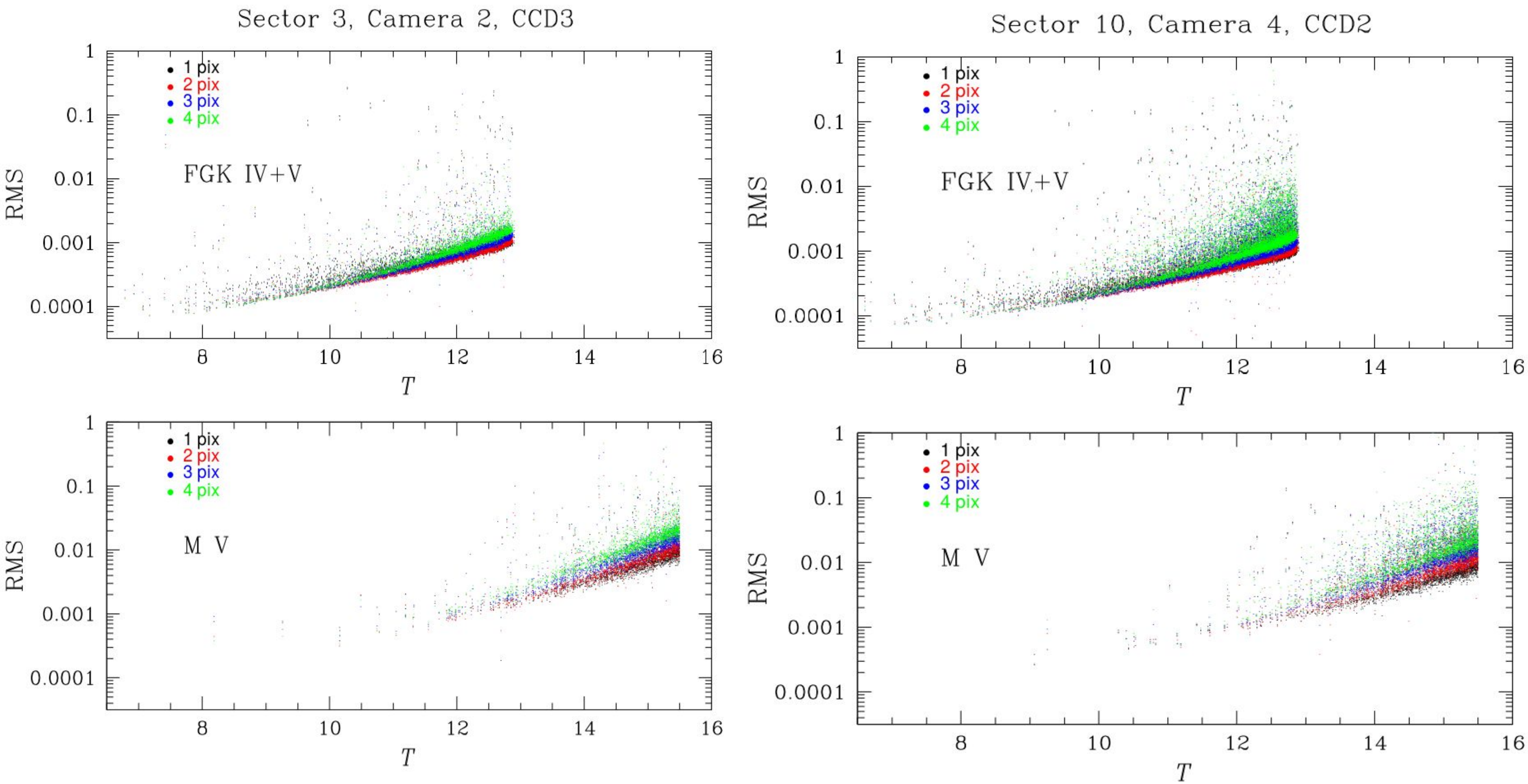

IInd residual



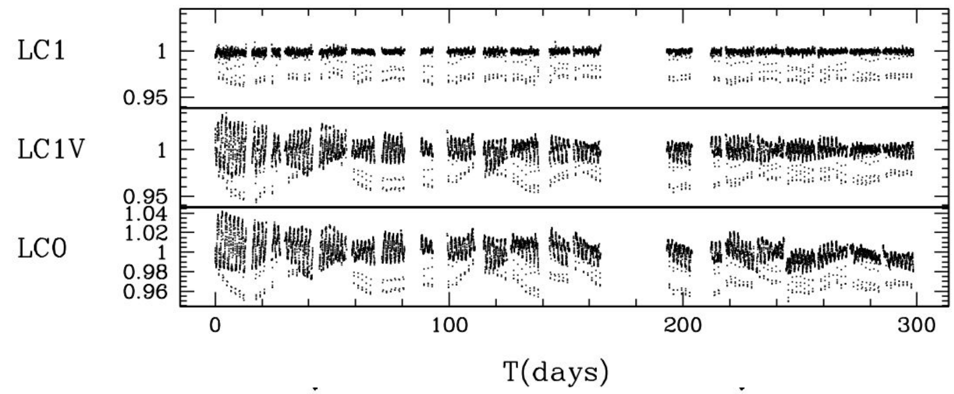
Eigenlightcurves are calculated for each sector/camera/ccd/photometry.

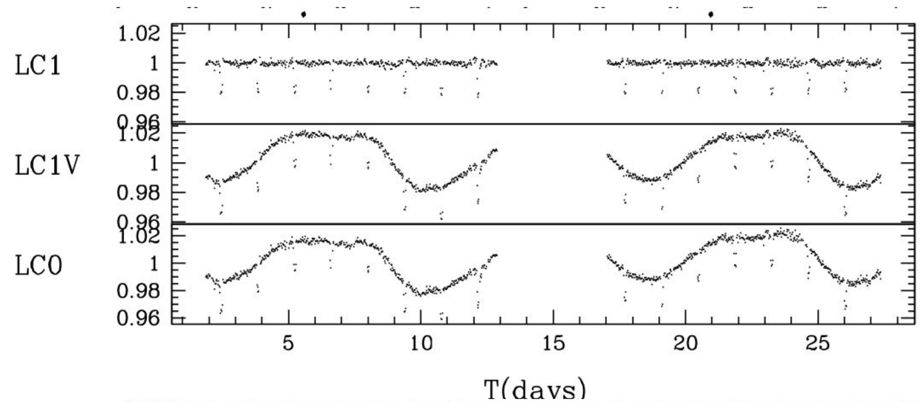
They are sorted out by their eigenvalues and then linearly fit to each lightcurve considering the first n-th eigenvectors accounting for 90% of the variance.

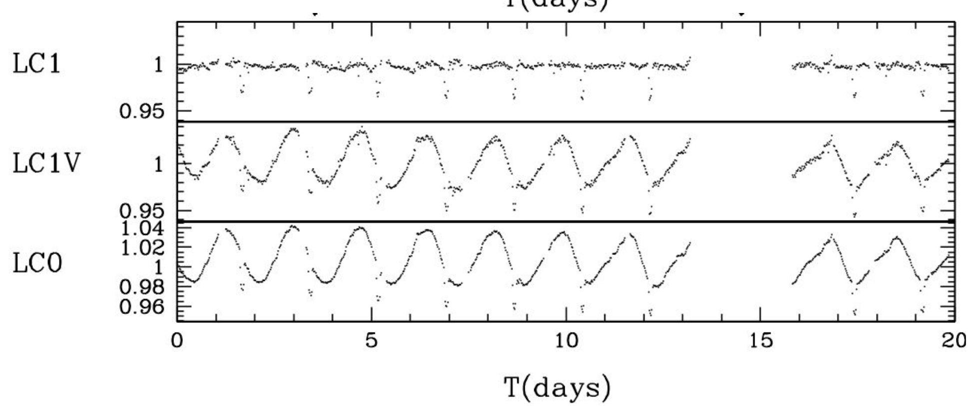
Photometric precision

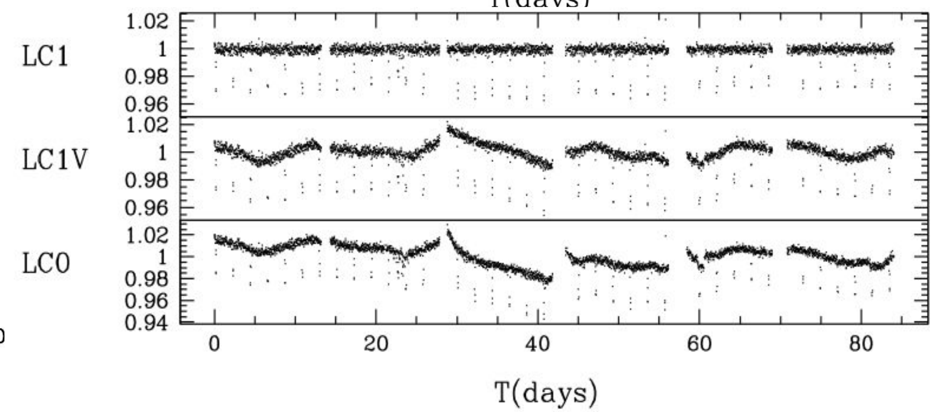


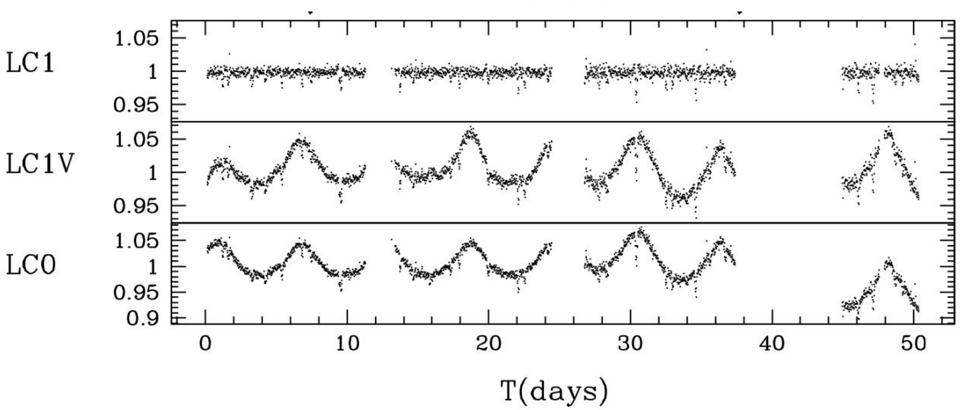
RMS calculated on extracted lightcurves

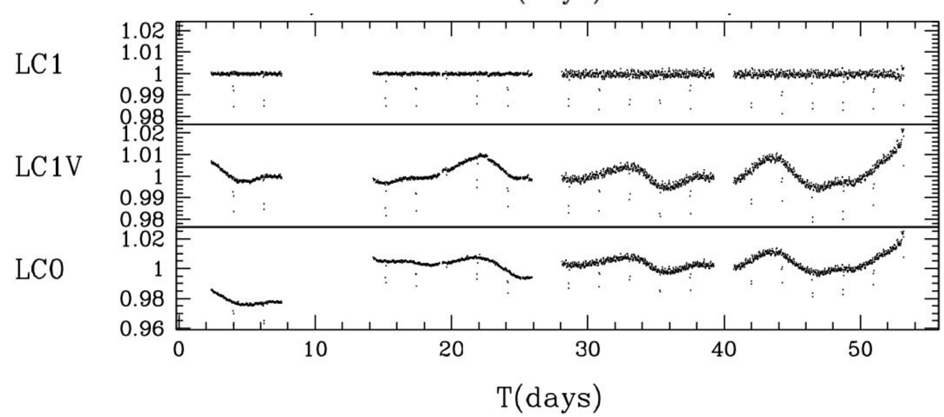

LC1
LC1V
LC0
1
0.95
1
0.95
1.04
1.02
1
0.98
0.96
0
100
200
300
T(days)


LC1
LC1V
LC0
1.02
1
0.98
0.96
1.02
1
0.98
0.96
1.02
1
0.98
0.96
5
10
15
20
25
T(days)


LC1
LC1V
LC0
1
0.95
1
0.95
1.04
1.02
1
0.98
0.96
0
5
10
15
20
T(days)


LC1
LC1V
LC0
1.02
1
0.98
0.96
1.02
1
0.98
0.96
1.02
1
0.98
0.96
0.94
0
20
40
60
80
T(days)


LC1
LC1V
LC0
1.05
1
0.95
1.05
1
0.95
1.05
1
0.95
0.9
0
10
20
30
40
50
T(days)


LC1
LC1V
LC0
1.02
1.01
1
0.99
0.98
1.02
1.01
1
0.99
0.98
1.02
1
0.98
0.96
0
10
20
30
40
50
T(days)

Transit search algorithm

Transit analyzer

SDE_{BLS} S/N_I S/N_{II} $S/N_{oddeven}$ R_{var} N_{tr} $N_{in, even}$ $N_{in, odd}$

Preconditions

$SDE_{BLS} \geq 6$ $N_{tr} \geq 2$ $N_{in, odd} \geq 4$ $N_{in, even} \geq 4$ $S/N_I \geq 3.5$

RF morphological classifier

SDE_{BLS} S/N_I S/N_{II} $S/N_{oddeven}$ R_{var}

Transit fit

R_{pl}/R_s (+ all other transit parameters)

Postconditions

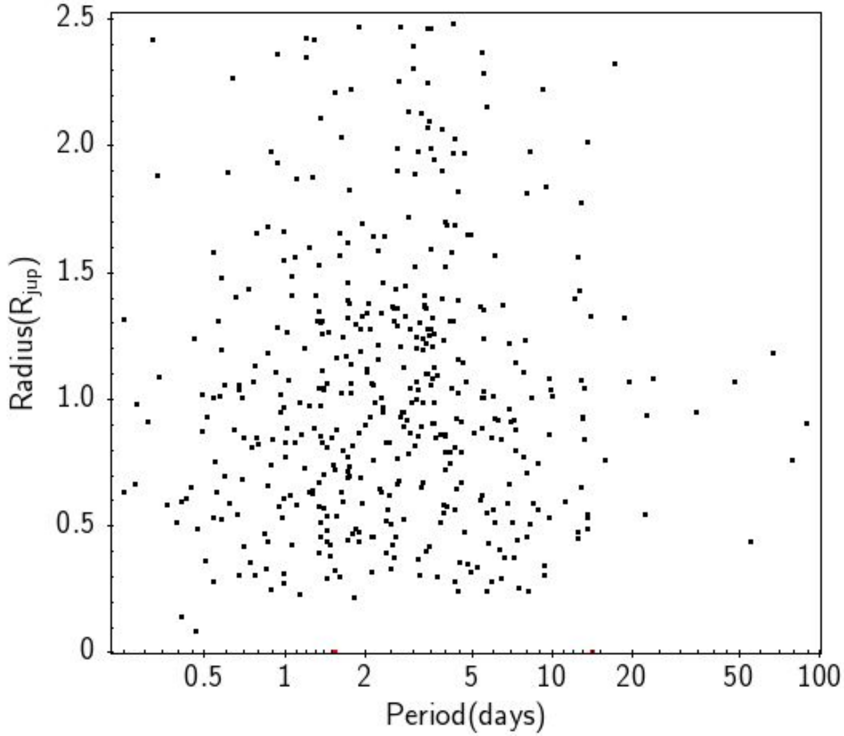
$R_{pl} \leq 2.5\ R_J$ $\sigma r/r < 3$ $\varkappa_r < 1.5$

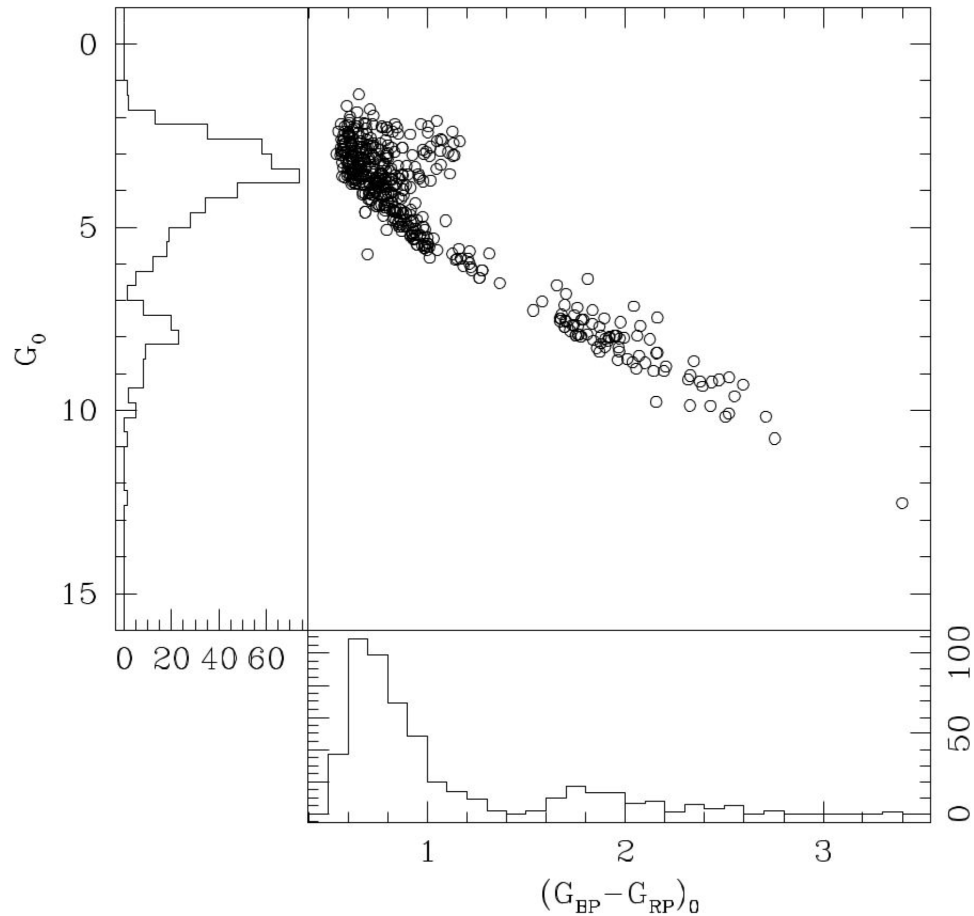
(R_s from catalog)

Visual Inspection

(Check contamination and other global metrics)

Preliminary results

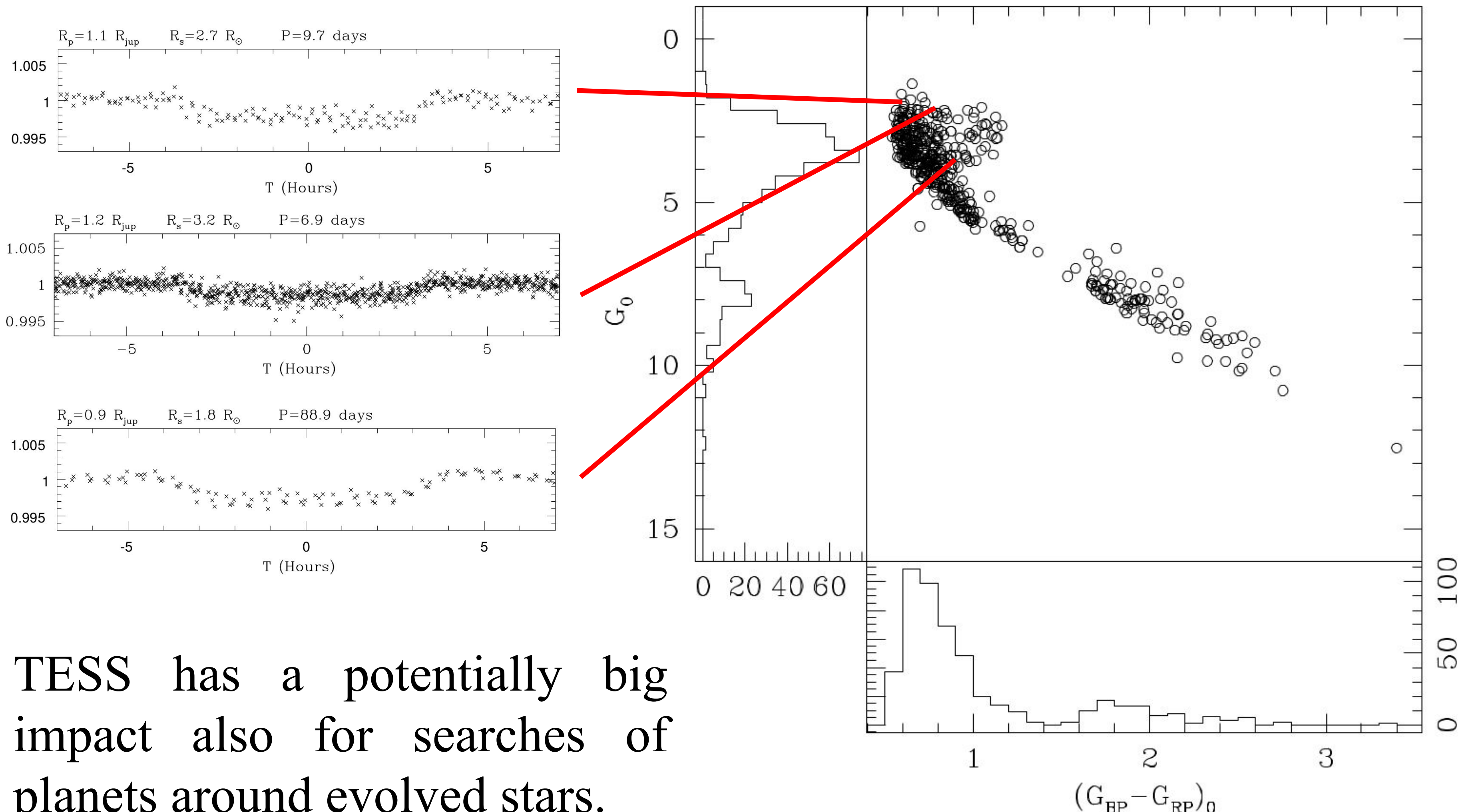




496 candidates, 67% complete

Candidates are present everywhere in the color magnitude diagram

Preliminary results



TESS has a potentially big impact also for searches of planets around evolved stars.

Conclusions

- TESS and Gaia are strongly synergetic. This permits to perform allsky unbiased studies of virtually any kind of object with unprecedented photometric precision
- TESS photometry will be very relevant for the preparation of forthcoming space missions (e. g. PLATO). Targets are FGK dwarfs and subgiants (V<13) and M dwarfs (V<16)
- Hundreds of candidate transiting planets already identified in Sectors 1 - Sector 11
- The pipeline is automatically analyzing new TESS images as soon as they are delivered
- TESS has a large potential to discover planets also around evolved stars