Revolving phase effect to FoV overlapping and its application to primary SPSS

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Abstract

The aim of this study is to investigate the effect of the initial revolving phase on the number of non FoV overlapping transits for the stars to be considered as primary SPSS for *Gaia* BP/RP absolute flux determination.

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Contents

1 Introduction

In a previous document (Carrasco et al., 2006) we presented the results of a study of the effect on the signal-to-noise ratio (SNR) of the magnitude, interstellar extinction and number of observations. The effect of FoV overlapping was also analyzed: as the two FoVs are superposed in a single focal plane, overlapping of sources observed in different FoVs may occur, especially when one of the telescopes is pointing at the galactic plane or bulge regions. Hence, if a source has very few non FoV overlapping observations, it should be considered if its inclusion in *Gaia* SPSS list is justified, even if its absolute flux is very well known, as with low numbers of useful observations, the SNR can be not enough to produce a good absolute flux calibration.

Cases where the actual object observed is in the disk or bulge are not considered here as overlapped observations because the SPSS selection procedure must include some non-crowding criteria with the neighbour sources near the target. For this reason, only overlapping with dense areas is considered here.

In this report, we analyze how the end-of-mission number of useful (non FoV overlapped) transits depends on the initialization of *Gaia* observations, in terms of the *initial revolving phase*, ν_o, defined by Lindegren (2000). As an application of this study, we analyze the list of stars proposed to be SPSS (Altavilla et al., 2007).

2 Revolving phase effect

Carrasco et al. (2006) computed a map of the number of non FoV overlapping observations at the end of the mission (what is called in this report as N_{good}) during the 5 years of mission. We considered as a FoV overlapping transit a transit where the second FoV observes the galactic disk ($-5^{\circ} < b < 5^{\circ}$) or the bulge ($-10^{\circ} < l < 10^{\circ}$, $-10^{\circ} < b < 10^{\circ}$) (region depicted in Fig. 1).

The number of observations at the end of the mission changes considerably as a funtion of the scanning law initialization. As it is explained in Lindegren (2000), the nominal scanning law for *Gaia* is described by two constant angles (ϵ = *obliquity of equator*, and ξ = *revolving angle*), and three angles which increase with time: λ_s(t) = *nominal longitude of the Sun*, ν(t) = *revolving phase*, and Ω(t) = *spin phase* (see Fig. 2 for the definition of these angles).

The angle most affecting the total N_{good} is the initial revolving phase, ν_o. Trying to characterize this effect, we have computed (with *Gaia*-Pocket Simulator, Anglada-Escudé et al. (2007)) the predicted N_{good} as a function of ν_o for the list of primary SPSS published in Altavilla et al. (2007).

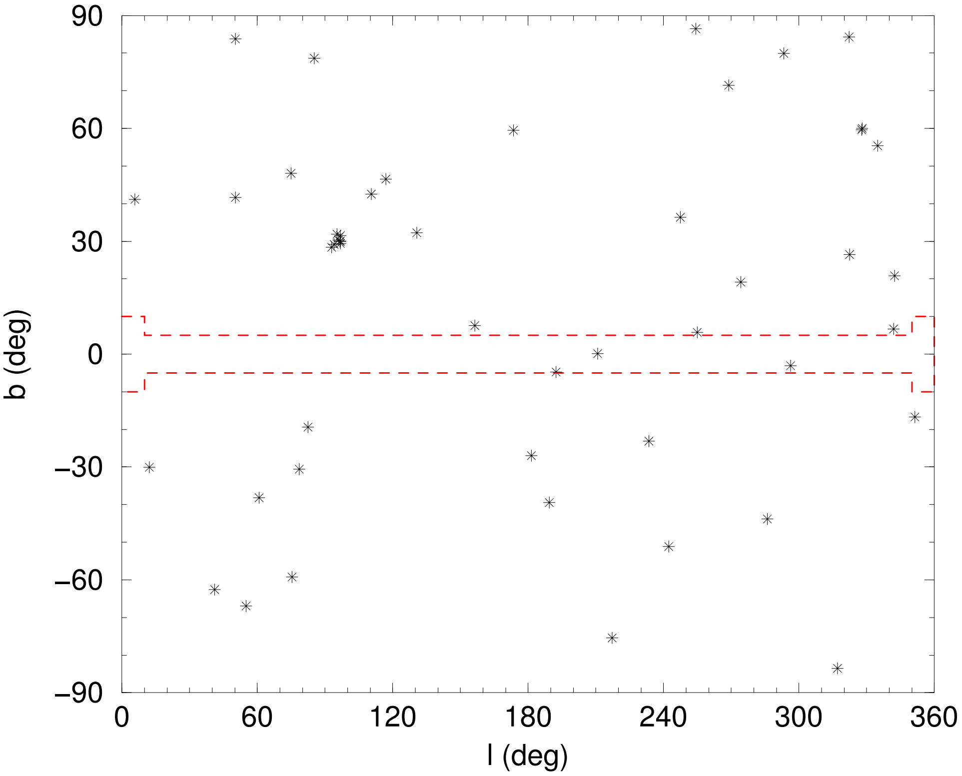

Figure 1: SPSS candidates list (Altavilla et al., 2007) in a celestial map in galactic coordinates and region considered as FoV overlapped in this paper.

3 FoV overlapping for SPSS

The first ground-based observations are being produced to test the methods and instruments to be used for the characterization of spectrophotometric standard stars (SPSS) for *Gaia*. General considerations and requirements for the SPSS were made by (Bellazzini et al., 2006), and a list of the available observing facilities was provided by Federici et al. (2006). According to these considerations, Altavilla et al. (2007) included a list of 49 Primary SPSS candidates (4 pillars + 45 primaries).

A further step is to know how *Gaia* will observe them. For this reason we implemented, using the methodology described in Sec. 2, an analysis of the number of non FoV overlapped observations to see if they will be "well observed" with *Gaia* or not. The concept of a "well observed" target may be defined in more detail by combining N_{good} and magnitude V because a very bright star could need lower N_{good} than a faint one. If only N_{good} is considered, we can define a source as "well observed" when at the end of the mission we get the average *Gaia* number of observations (80 for the *Gaia*-3 instrument model).

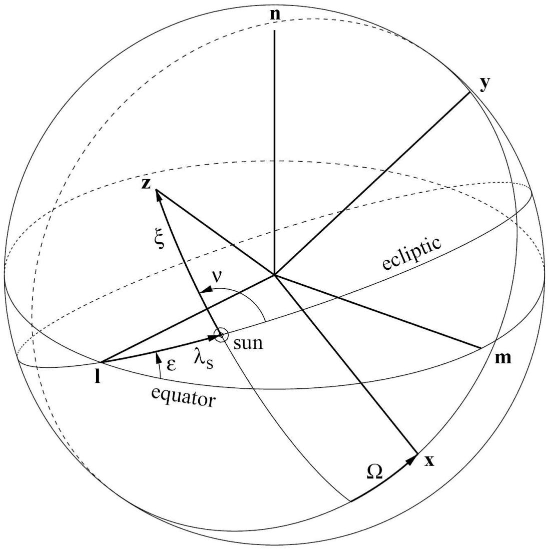

Figure 2: Definition of angles ϵ, λ_s, ν, ξ and Ω in the nominal scanning law, extracted from Lindegren (2000).

3.1 Revolving phase effect for primary SPSS

It was mentioned in Sec. 2 that the revolving phase can change our estimations of N_{good}. In this section we compute the predicted N_{good} as a function of ν_o for the particular case of the SPSS candidates presented by Altavilla et al. (2007). The results are shown in Tables 2 and 3 and in Figs. 3–5.

As expected, the initial revolving phase affects N_{good}. For instance, N_{good} for GD 153 has a dispersion of $\sigma_N = 18.2$. Thus, the total number of non FoV overlapping observations could decrease as much as 2.8 times from the maximum configuration to the minimum. Very few sources from Tables 2 and 3 have $\sigma_N \leq 5$. For this reason, to know if a star is a good candidate to be part of the SPSS list, and as it is impossible to know the value of ν_o before the launch of the satellite, we have computed the average of “good” transits along the mission ($< N >$) and the median (n).

The behaviour shown in Figs. 3–5 shows that the median is more appropiate than the mean to estimate the goodness of a given source in terms of non FoV overlapping. As a kind of “ranking” index we computed in Tables 2 and 3 the ratio of the median number of non FoV overlapping observations and the magnitude, in the way that a bright star (low V) with high median number of non FoV overlapping observations will have high ranking. HZ 44, LTT3864, BD +28 4211 adn WD2032+248 are the best ranked sources, with medians higher than $N_{good} = 100$.

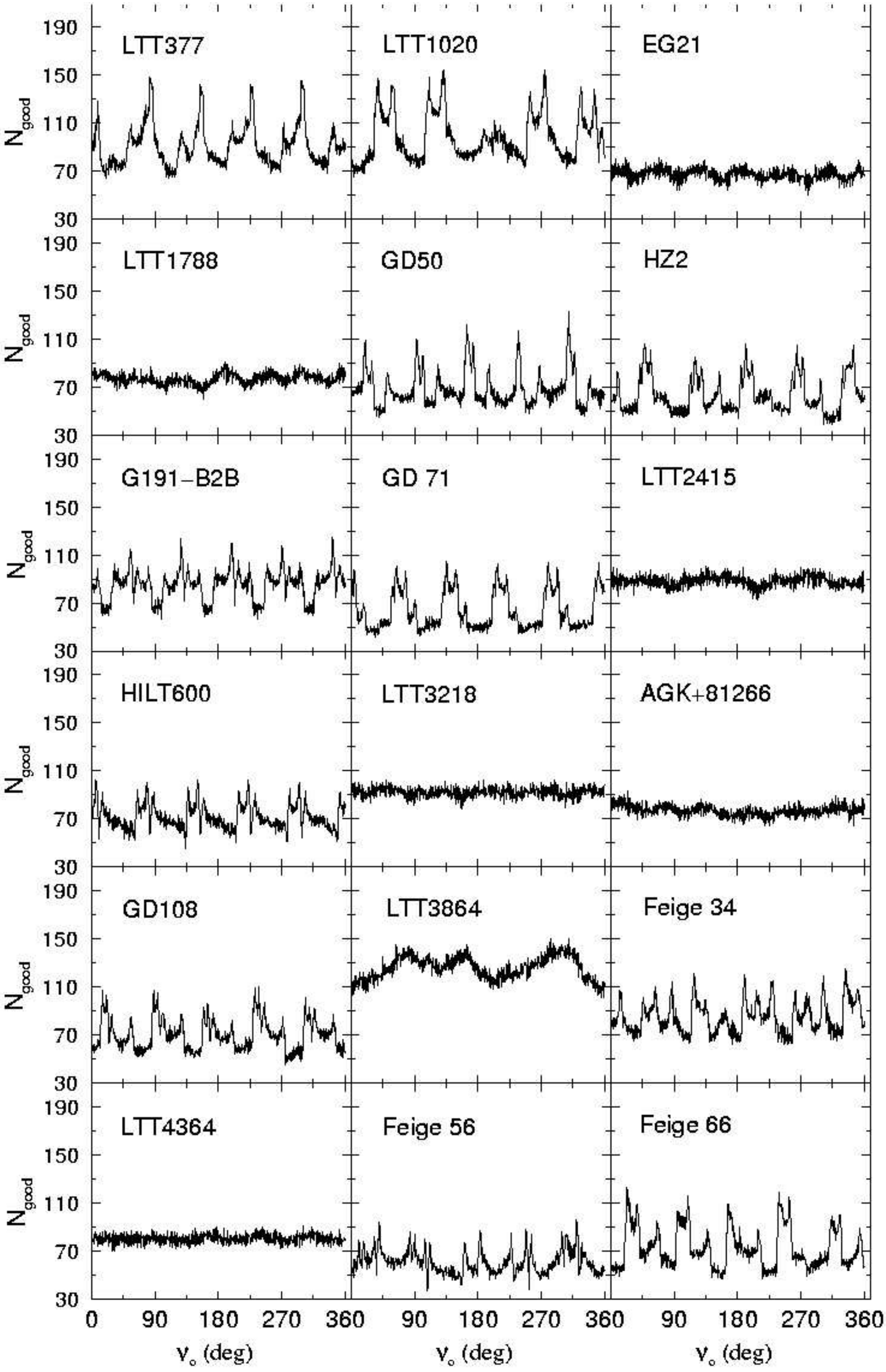

Figure 3: Number of transits without FoV overlapping as a function of the revolving phase, ν_o.

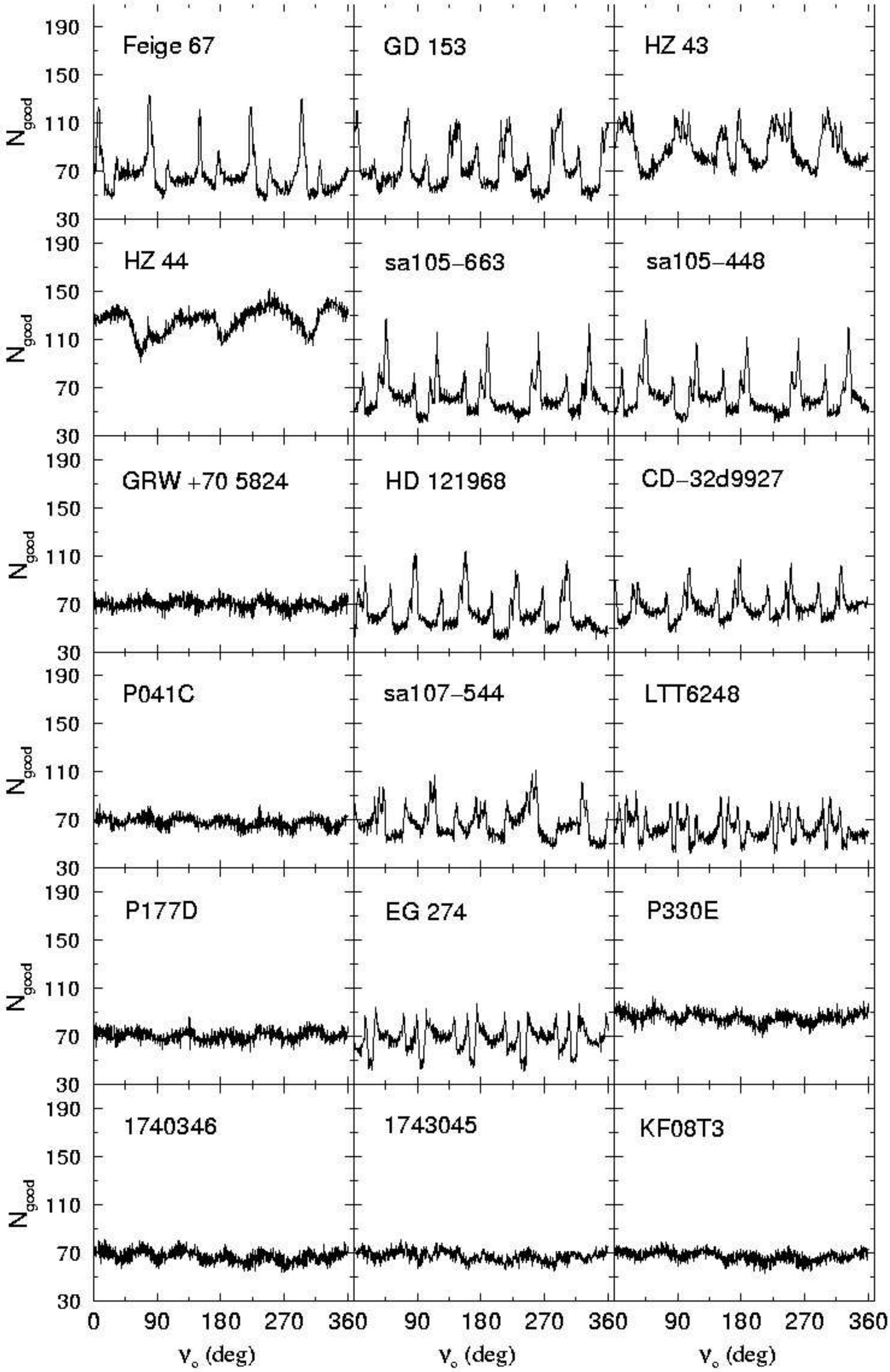

Figure 4: Same as Fig. 3

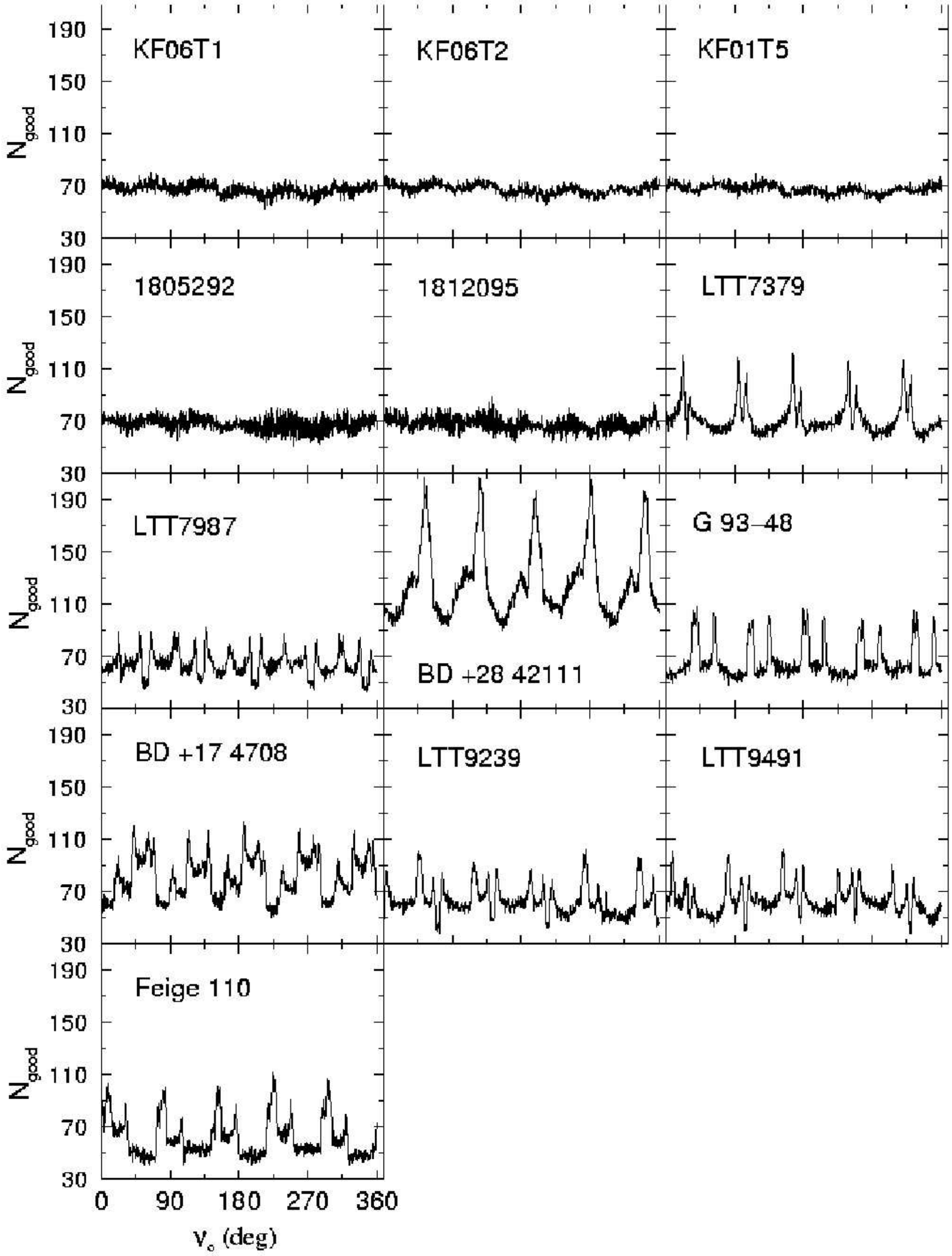

Figure 5: Same as Fig. 3

Table 2: Effect of the initial revolving phase, ν_o, on the number of transits non-overlapping with the second FoV at the end of the mission for the SPSS. N_o is the number of "good" transits when $\nu_o = 0$. N_{min} and N_{max} are the minimum and maximum number of "good" transits when we vary ν_o, respectively. $< N >$ is the average of "good" transits in a whole cycle ($0^o < \nu_o < 360^o$), and σ_N the standard deviation of the average. n is the median and the last column shows the median over the V magnitude. Higher values of this ratio means that this source is better for our purposes. This table continues in Table 3.

Id.	Designation	V	N_o	N_{min}	N_{max}	$< N > \pm \sigma_N$	n	n/V
PILLARS								
1	G191-B2B	11.8	88	57	126	85.4 ± 12.0	87	7.37
2	GD 71	13.1	80	40	110	64.0 ± 16.5	56	4.27
3	GD 153	13.4	110	44	122	72.7 ± 18.2	67	5.00
4	HZ 43	12.7	80	63	123	89.0 ± 14.6	86	6.77
PRIMARY SPSS (Altavilla et al., 2007)								
5	LTT377	10.6	94	64	148	91.2 ± 17.4	88	8.30
6	LTT1020	11.5	81	65	154	98.4 ± 19.4	94	8.17
7	EG21	11.4	66	50	81	67.4 ± 4.8	67	5.88
8	LTT1788	13.2	84	60	91	77.0 ± 4.7	77	5.83
9	GD50	14.0	64	44	119	67.7 ± 12.9	64	4.57
10	HZ2	13.9	64	43	110	63.1 ± 14.1	59	4.24
11	LTT2415	12.2	85	73	101	88.7 ± 4.7	89	7.30
12	HILT600	10.4	83	46	103	71.8 ± 10.1	70	6.73
13	LTT3218	12.0	99	78	102	92.0 ± 4.0	92	7.67
14	AGK+81266	12.1	83	64	93	76.7 ± 4.5	77	6.36
15	GD108	13.6	55	45	110	70.0 ± 12.8	68	5.00
16	LTT3864	12.2	110	101	150	125.9 ± 9.7	126	10.33
17	Feige 34	11.0	82	60	122	84.2 ± 13.0	82	7.45
18	LTT4364	11.5	79	70	91	80.4 ± 3.7	81	7.04
19	Feige 56	11.1	55	37	96	61.1 ± 9.3	60	5.41
20	Feige 66	10.6	57	47	123	72.5 ± 16.5	68	6.42
21	Feige 67	12.1	69	45	133	67.1 ± 16.1	64	5.29
22	HZ 44	11.3	131	91	152	126.0 ± 10.3	128	11.33
23	sa105-663	8.7	48	41	127	62.3 ± 14.2	59	6.78
24	sa105-448	9.2	55	41	126	62.5 ± 14.4	60	6.52
25	GRW +705824	12.8	72	56	83	70.2 ± 4.5	70	5.47
26	HD 121968	10.2	47	40	114	61.7 ± 14.2	58	5.69
27	CD-32d9927	10.3	71	47	107	67.7 ± 9.9	66	6.41
28	GSPC P 041-C	12.0	73	55	83	68.0 ± 4.5	68	5.67
29	sa107-544	9.0	77	46	111	67.2 ± 12.4	66	7.33
30	LTT6248	11.8	59	42	94	62.4 ± 9.8	61	5.17
31	GSPC P 177-D	13.5	79	57	86	70.8 ± 4.6	71	5.26
32	EG 274	11.0	75	41	97	68.2 ± 10.2	68	6.18
33	GSPC P 330-E	13.0	98	69	103	85.8 ± 5.0	86	6.62
34	1743045	13.13	76	55	79	68.3 ± 4.0	68	5.18
35	1740346	12.36	76	55	82	68.3 ± 4.7	68	5.50
36	KF08T3	13.5	74	56	78	68.2 ± 3.7	68	5.04
37	KF06T1	13.52	73	55	80	68.4 ± 4.1	68	5.03
38	KF06T2	13.8	76	57	79	68.2 ± 3.7	68	4.93
39	KF01T5	13.6	66	56	78	68.3 ± 3.9	68	5.00

Table 3: Continuation of Table 2.

Id.	Designation	V	N_o	N_{min}	N_{max}	$< N > \pm \sigma_N$	n	n/V
PRIMARY SPSS (CONT)								
40	1805292	12.06	64	54	81	68.2 ± 4.9	68	5.64
41	1812095	11.8	64	54	89	67.9 ± 5.6	67	5.68
42	LTT7379	10.2	64	54	122	71.9 ± 12.2	68	6.67
43	LTT7987	12.2	59	43	92	63.7 ± 9.1	63	5.16
44	BD +28 4211	10.5	103	90	212	127.7 ± 28.4	122	11.62
45	G 93-48	12.7	60	47	110	65.1 ± 12.9	61	4.80
46	BD +17 4708	9.5	64	52	124	80.7 ± 15.5	79	8.32
47	LTT9239	12.1	47	38	102	63.2 ± 11.6	61	5.04
48	LTT 9491	14.0	60	38	102	62.6 ± 10.7	61	4.36
49	Feige 110	11.4	74	44	112	62.6 ± 13.8	57	5.00

4 Conclusions

In this paper we showed a way to estimate the non FoV overlapping end-of-mission transits to be used in the selection of the SPSS in the large term project. This is important for knowing if a SPSS candidate will have enough SNR at the end of the mission to provide good absolute fluxes calibration.

The values in Table 2 and 3 and Figs. 3–5 show that the initial revolving phase affects the total number of observations at the end of the mission in a different way according to the position in the sky. As it is well known, there are two strips in the sky (around $\pm 45^o$ in ecliptic latitude) with maximum N_{good}. The stars between these two strips have N_{good} values more dependent on the initial revolving phase. For the stars located at higher ecliptic latitudes from these strips, N_{good} is more constant, but their average number of observations is also quite low (around 70). Only the stars in the strips can ensure, that the number of non FoV overlapping transits at the end of the mission will be high enough.

5 References

Anglada-Escudé, G. et al., 2007, Gaia-Pocket simulator, a light weighted tool for astrometric experiments, **in preparation**.

Altavilla, G., Bellazzini, M., Pancino, E., Bragaglia, A., Cacciari, C., Diolaiti, E., Federici, L., Montegriffo, P., Rossetti, E., 2007, The Primary standards for the establishment of the Gaia Grid of SPSS. Selection criteria and list of candidates, **GAIA-C5-TN-OABO-GA-001-1**.

Bellazzini, M., Bragaglia, A., Federici, L., Diolaiti, E., Cacciari, C., Pancino, E., 2006, Absolute calibration of Gaia photometric data. Spectrophotometric standard stars, **GAIA-C5-TN-OABO-MBZ-001**.

Carrasco, J. M., Jordi, C., Figueras, F., Anglada-Escudé, G., Amôres, E.B., 2006, Towards the selection of standard stars for absolute flux calibration. Signal-to-noise ratios for BP/RP spectra and crowding due to FoV overlapping, **GAIA-C5-TN-UB-JMC-001**.

Federici, L., Bragaglia, A., Diolaiti, E. Bellazzini, M., Cacciari, C., Pancino, E., Altavilla, G., Montegriffo, P., Rossetti, E., Jordi, C., Figueras, F., Trager, S., 2006, Absolute calibration of Gaia photometric data. II. Observing facilities for ground-based support (pilot program), **GAIA-C5-TN-OABO-LF-001**.

Lindegren, L., 2000, Attitude parametrization for GAIA, **SAG-LL-30**.

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A Acronyms

Acronym	Description
CU	Coordination Unit (in DPAC)
DPAC	Data Processing & Analysis Consortium
DU	Development Unit (in CU)
FoV	Field of View
SNR	Signal-to-Noise Ratio
SPSS	SpectroPhotometric Standard Star