Gaia

DPAC

Data Processing & Analysis Consortium

Protocol for Ground Based Observations of SpectroPhotometric Standard Stars. II. Variability Searches and Absolute Photometry Campaigns

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Abstract

When trying to build a large set of ground based SpectroPhotometric Standard Stars (SPSS) for calibrating Gaia BP/RP Spectra and G-Band Images to a few % in absolute flux, it is essential to maintain the maximum homogeneity in data quality, acquisition and treatment. This is especially true when data come from different observing sites around the globe and are obtained and treated by different persons. The Observation Protocols and the Data Reduction Protocols are sets of detailed instructions for observers and collaborators that participate in the large effort required. This second Observation Protocol concerns photometric observations obtained during: *(i)* auxiliary campaigns aimed at excluding variable stars from the main list of candidate Primary and Secondary SPSS and *(ii)* photometric campaigns for the absolute flux calibration of SPSS spectra taken in non-photometric nights.

Document History

Issue	Revision	Date	Author	Comment
1	0	1-Jul-2009	EP	Final revision, Appendix B revised.
D	5	26-Mar-2009	GA	Bibliography revised, Appendix B expanded, typos corrected.
D	4	30-Jan-2009	GA	Table 9 revised.
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Contents

1 Introduction

Our task is to calibrate the Gaia G-Band photometry and the BP/RP spectrophotometry to an internal accuracy of a few percent. As explained in MBZ-001, the simplest hypothetical case of calibration procedure involves the use of a single *SpectroPhotometric Standard Star* (SPSS) to derive the *Response Curve* of the instrument, which will be used to calibrate all observations by the same instrument. However, Gaia data are read from several CCDs in continuous scan mode, implying CTI (Charge Transfer Inefficiencies). BP and RP spectra are complicated by the fact that they are slitless, prism dispersed spectra, with coarse sampling and variable pixel size. Finally, the PSF (Point Spread Function) and LSF (Line Spread Function) reconstruction is a non-negligible problem in the calibration of these complicated spectra (PMN-001).

A large set (a few hundreds) of calibrators with high S/N Gaia observations (JMC-001; JMC-002) is needed to achieve the desired accuracy, primarily because using several SPSS enables the reconstruction of a very high S/N Response Curve, where all the effects that act differently upon different stars/CCDs/transits will be averaged together and therefore minimized. No dataset exists in the literature that contains 200—300 homogeneously calibrated SPSS (to a few percent), covering the whole wavelength range necessary for the BP/RP Gaia Spectra (330–1050 nm) and the magnitude range ($10 < V < 15$) required. Therefore, dedicated ground based observations campaigns have to be carried out.

We base our calibration on the three hydrogen white dwarfs (WD) of Bohlin (2007), G191-2B2, GD71, GD153, our fundamental *Pillars*. A set of *Primary SPSS* will be calibrated on the Pillars. These will constitute a grid of ground based calibrators covering all RA and Dec to ensure all year round observations from both hemispheres. The candidate list (GA-001), containing ∼50 candidate Primary SPSS, includes most of the CALSPEC standards and also stars from Oke (1990), Hamuy et al. (1992), Hamuy et al. (1994), Stritzinger et al. (2005). A longer list of candidate *Secondary SPSS* (primarily from McCook & Sion 1999, but also from the Sloan, various SubDwarf catalogues, private communications, NextGen HST, and other sources, will be observed, calibrated using the Primary SPSS and validated through auxiliary observations (Section 1.1). The set of *validated* Secondary SPSS will constitute the final Gaia grid of flux calibrators, to be ready before launch in 2012.

More details on the general strategy for spectrophotometric observations can be found in MBZ-001; here we just mention that spectra of SPSS, observed from various ground based sites, will mostly be calibrated with extremely accurate absolute photometry. Photometry-only campaigns in very good, photometric observing sites (e.g., San Pedro Mártir, ESO) will be conducted to support spectrophotometric campaigns in sites where the chance of clear nights is lower (e.g., Calar Alto, Canary Islands). All candidate SPSS will also be checked for variability (see below) with relative photometry in sites that can provide a large amount of observing time (e.g., Loiano, REM).

1.1 Variability Checks and Quality Control

To ensure the quality control and validation of all our candidate SPSS, we have decided to start dedicated photometric campaigns to look for both variability and close companions. We remind in fact that even stars used for years as spectrophotometric standards have been found to vary when appropriately searched for variability (Landolt & Uomoto, 2007). Even stars that are apparently safe calibrators might show unexpected variations (e.g. EG131 a featureless WD with variations of 0.35 mag, Aldering, private communication). Finally one star that was chosen by Bohlin et al. (1995) to be one of the Pillars, HZ 43, was later rejected (Bohlin et al., 2001) because multicolor, high resolution photometry showed the presence of a close (3") companion, only visible in the V band, that makes it useless as a standard, at least from the ground.

Binary systems are frequent and eclipsing binaries can be found at all spectral types. Their periods can span a range from a few hours to hundreds of days, most of them having periods between 1 and 10 days (Dvorak, 2004). Therefore, all our candidate Primary and Secondary SPSS, including the Pillars, will need a search for long term variability. This will be performed on a three years basis, where night points will be obtained approximately every three months (or twice a period) in three bands. In case of clear sky conditions, these observations could also be used to derive absolute photometry. The best seeing multiband images can also be used for companion searches.

Moreover, a large fraction of our candidates are WD, and their literature magnitudes are not always precise enough to decide whether they are safely far from the instability strip (Bergeron et al., 1995). Therefore, we need to exclude variability for all those stars with uncertain magnitudes or that lie close to the instability strip. Periods of WD pulsational variability range from 1 to 20 minutes approximately (Sterken & Jaschek, 1996), so series of consecutive exposures that last for one hour will be able to sample even the longest periods twice, revealing variability down to 0.05–0.01 magnitudes in amplitude, depending on the data quality.

1.2 Document Organization and Contact Information

This Protocol is centered around three checklists (Tables 1, 2 and 3) that quickly summarize the procedure on a step by step basis. Each step in the Tables indicates clearly the Section in this document where a full description can be found. Moreover, appendices contain detailed instructions to operate some of the instruments used in this campaign, as reported by the observers credited in each appendix.

For any doubt or need, you should write an e-mail to both Giuseppe Altavilla[1] and Elena Pancino[2]. In particular, you will surely need to write us for:

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[2]elena.pancino@oabo.inaf.it

- Username and passwords to our internal Wiki pages and DB&A (Section 3.1.1);

- Obtaining help for run preparation and run closing operations (Sections 3 and 5).

2 Checklists

The following checklists serve as summary and reference for the observers once they are familiar with the details of each step.

2.1 Run Preparation Checklists

The checklist below (Table 1) summarizes the steps that are normally undertaken when preparing observations. Each step is described in detail in the corresponding Sections.

Table 1: **Run Preparation Checklist.**

Operation	Description	Sections
Documentation	Wiki-Bo Pages	3.1.1
	Technical Documents	3.1.2
	Literature Papers	3.1.3
	Web Resources	3.1.4
	Observing Proposal	3.1.5
	Instrument Information	3.1.6
Preparing Observations	Target List	3.2.1
	Visibility Charts	3.2.2
	Finding Charts	3.2.3
	Priorities	3.2.4
	Filters	3.2.5
	Exposure Times	3.2.6

2.2 Observing Checklists

This checklist helps the experienced users by reminding the most important things for each of the observing steps, and each operation listed in the checklist is described in more details in the Sections listed. All the operations listed in this checklist have their rhyme and reason and therefore *should be strictly followed*, if you have any doubts please read the detailed descriptions.

Table 2: **Observing Checklist.**

Operation	Description	Section
IFP Tests^a	Check IFP status on Wiki-Bo	4.1.1
	Read IFP Observing Protocol	4.1.1
	Perform needed observations	4.1.1
Bias	10–11 each afternoon	4.1.2
Dome Flats	10×filter each afternoon	4.1.3
Sky Flats	5×filter each night	4.1.4
	Complete on morning twilight if necessary	”
Absolute Photometry	Only on clear nights	4.2.1
	3 Landolt fields	”
	At 2 different airmasses each ($\Delta AM \simeq 0.8$)	”
	BVR(I) x 3 exposures	4.2.2
	Apply small dithering, if possible	4.2.2
Night Points	On clear nights take also Landolts (see above)	4.2.1
	BVR(I) x 3 exposures	4.2.2
	Apply small dithering, if possible	”
	Field must contain *at least* 2 good comparison stars	”
Short Term Sequence	On clear nights take also Landolts (see above)	4.2.1
	Always take also one Night Point (see above)	4.2.2
	Do *not* apply dithering	4.2.3
	Series must last *at least* one hour	”
	Series must contain *at least* 30 exposures	”
	Field must contain *at least* 2 good comparison stars	”
Quality Check	Do not saturate SPSS or comparison stars	4.2.4
	At least a few thousand peak counts for faint stars	”
	Have *at least* 2 good comparison stars	”

^{a} Instrument Familiarization Plan

2.3   Night and Run Closing Checklists

Table 3 reminds the night and run closing operations that are vital for those who will later reduce and analyze data, and to maintain our DB&A and Wiki-Bo pages updated. Since there are many observing runs going on one after the other, and sometimes even simultaneously, please do not delay too much.

Table 3: **Run Closing Checklist.**

Operation	Tools	More
Observing Logs	Electronic form (Wiki-Bo)	5.1.1
End of Night Report	Web form (Wiki-Bo)	5.1.2
End of Run Report	Web form (Wiki-Bo)	5.2.1
Backup Data	CD/DVD copies	5.2.2
Upload Raw Data	Archive Section (Wiki-Bo)	5.2.3

3 Run Preparation

At this stage, the preparation of an observing run cannot be done completely independently by the observer, since some of the tools that allow target selections, finding chart preparation and run strategy definition are still under development. Therefore, do not hesitate to contact us for help (Section 1.2). Nevertheless, many steps can and should be undertaken by the observers themselves, following the instructions in the next sections.

3.1 Documentation

3.1.1 Wiki-Bo and DB&A

The internal Wiki pages maintained in Bologna (hereafter Wiki-Bo[3]) and the internal DataBase and Archive (hereafter DB&A[4]) are the essential tools and reference points for all our collaborators. You will need to contact us to obtain the username and password to access them (Section 1.2). In particular, the following Sections of the Wiki-Bo pages are useful for observers:

- *"Documentation"* Section that contains, among other things, the Gaia official documents, literature papers and web resources suggested in Sections 3.1.2, 3.1.3, 3.1.4;

- *"Observing Tools"* Section that contains useful tools for observations (links to documents, PA calculators, visibility charts, web forms);

- *"Observing Runs and Proposals"* Section, containing all info on observing runs, including proposals, observing logs, target summaries, links to the raw data repository and reduced data;

- *"SPSS Lists and Summaries"* Section, that contains various ASCII lists, the Wiki Tables with the candidates lists and summary of their observations, and the indi-

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[3]yoda.bo.astro.it/wiki/
[4]yoda.bo.astro.it/dati/

vidual SPSS Information page with literature info, finding charts, spectra, and the status of observations and data reductions for each SPSS;

- *"Database & Archive"* Section, containing all the info plus the Raw Data Archive and the soon to come Reduced Data Archive.

3.1.2 Gaia Technical Documents

Table 4: **Gaia Technical Documents**

Code	Authors	Description
GAIA-C5-TN-OABO-MBZ-001	MBZ-001	General Strategy
GAIA-C5-TN-UB-JMC-001	JMC-001	Number of SPSS
GAIA-C5-TN-OABO-LF-001	LF-001	Ground-Based Facilities
GAIA-C5-TN-UB-JMC-002	JMC-002	SPSS S/N with Gaia
GAIA-C5-TN-OABO-GA-001	GA-001	Primary SPSS Candidates
GAIA-C5-TN-OABO-PMN-001	PMN-001	BP/RP Calibration Strategy
GAIA-C5-TN-OABO-EP-001	EP-001	IFP Observing Protocol

The Gaia Technical Documents listed in Table 4 are the results of the ongoing effort by our team to plan and design the observing campaigns, so they contain the basic and operational information that allows to understand the reasons behind the various choices made. We recommend reading at least MBZ-001 and GA-001: the former gives the basis of the absolute flux calibration strategy for Gaia and the latter gives the list of Primary SPSS candidates, including selection criteria, finding charts and basic literature information. A similar document for the candidate Secondary SPSS is in preparation. Another Set of useful documents are the observing protocols and the data reduction protocols, that are all available in the Wiki-Bo Documentation Section.

3.1.3 Literature Papers

Table 5: **Literature Papers**

Authors	Description
Bessell 2005	Basic review on Standard Photometric Systems
Bohlin 2007	The basis for our Gaia SPSS Grid
Landolt 1983, 1992a,b; Landolt & Uomoto 2007	(Spectro)photometric standard stars
Bergeron et al. 1995	WD physics and instability strip

The papers listed in Table 5 are a few literature sources that can help understanding in more detail photometry, WD and variability issues. The list is by no means complete and a longer list

of papers can be found in the Internal Bologna Wiki pages (hereafter Wiki-Bo, see Section 3.1.1) in the Section *"Literature and Web Resources"*.

3.1.4 Web Resources and Tools

Table 6: **Web resources**

Description	Address	Access
Gaia ESA Public Website	www.esa.int/esaSC/	Open
Gaia ESA DPAC Website	www.rssd.esa.int/	Restricted
SIMBAD	simbad.u-strasbg.fr/simbad/	Open
Landolt Standards	www.cfht.hawaii.edu/ObsInfo/Standards/Landolt/	Open
Staralt - Target Visibility	catserver.ing.iac.es/staralt/	Open
ESO Skycat	archive.eso.org/skycat/	Open
Saoimage DS9	hea-www.harvard.edu/RD/ds9/	Open

Some useful web resources, both to perform the operations described in the following Sections and to be used as general reference, are listed in Table 6. Again, the list is probably not complete and a longer one can be found in the Wiki-Bo pages in the Section *"Literature and Web Resources"*. The Gaia DPAC website can only be accessed by DPAC members, so please write us for more information.

3.1.5 Proposals

Proposals can be found in the Wiki-Bo in the *"Summary of Observing Runs and Proposals"* Section (see also Figure 1).

Figure 1: Portion of the *"Summary of Observing Runs and Proposals"* Table in Wiki-Bo, showing the first five runs with hyperlinks to the telescopes and instrument official pages (columns 2, 3 and 4), and links to the specific *"Run Pages"* (First columns).

3.1.6 Instrument Step-by-step Instructions

While official instrument manuals can be retrieved from the official webpages of each observatory, linked in our Wiki-Bo "Summary of Observing Runs and Proposals" (Figure 1), instrument specific step-by-step instructions strictly related to SPSS observations have been prepared and can be found in the Appendices of this document and of the observing protocol dedicated to the main campaign (EP-004). We recommend to read them carefully and, possibly, to give us feedback after your observing run.

3.2 Preparing Observations

3.2.1 Target List

A good reference list is the one that can be found in the Observing Proposal relevant to your observing run. However, we strongly recommend to prepare a redundant list, containing approximately twice the number of objects allowed by the allocated time. Moreover, some of the objects listed at the time of Proposal submission might have been already observed in some other observing run. The following tools are presently available in the Wiki-Bo to prepare your Target list:

- Observing Proposals can be found in the *"Summary of Observing Runs and Proposals"* Section of the Wiki-Bo pages;

- Electronic lists of Primary and Secondary SPSS are available, ready for Ra, Dec and magnitude filtering in the *"SPSS Lists & summaries"* Section;

- Tables that summarize past observations are available in the same Section, they should be used to avoid unnecessary repetitions of observations;

- Observing logs of all past runs, including updated night reports, are also available through the *"Summary of Observing Runs and Proposals"* Table ;

3.2.2 Visibility Charts

A very useful tool for preparing Visibility Charts is *Staralt* on the ING webpage (Table 6). Preparing Visibility Charts in advance allows for faster decisions if you need to change your plan during the night.

3.2.3 Finding Charts

You can find already made Finding Charts in the following places:

- Finding charts for Pillars and Primary SPSS can be found in GA-001;

- Finding charts for Landolt fields can be found in Landolt (1992a);

- Finding charts for all our candidate Primary and Secondary SPSS, when available, are also be stored in the Wiki-Bo individual SPSS information Pages, in *"SPSS Lists & Summaries"* Section;

- To download all the available finding charts from Wiki-Bo in one single tarfile, please also refer to the *"SPSS Lists & Summaries"* Section;

- Useful sources of finding charts for WD are listed in the Wiki-Bo *"SPSS Literature and Web Resources"* Section;

- Useful tools to prepare missing charts are the ESO Skycat and Saoimage DS9 (Table 6). Also SIMBAD has online tools for creating maps around chosen objects.

If you prepare new finding charts that are missing in the Wiki-Bo, or new versions that are more suited to some Instrument/Telescope combination, please send them (Section 1.2) and we will include them in the Wiki-Bo. In this case, please follow these guidelines:

- The chart size should not be smaller than $4' \times 4'$ or larger than $14' \times 14'$ approximately, to be of use with the program instruments;

- The scale should be clearly indicated by a 30" or 1' segment or so;

- The orientation should be clearly indicated by two arrows pointing North and East;

- The object should be approximately at the center of the chart and clearly marked by a circle, arrow or other appropriate sign, without hiding nearby objects;

- Please indicate the filter, for example V_J for Johnson V band;

- If the object has high proper motion, please write it on the chart;

- The chart should possibly be in negative colors, i.e. white for the sky and black for the objects;

3.2.4 Priorities

Priorities allow for faster decisions during the night. To assign priorities, you need to know which targets have already been observed (see above). Even a rough subdivision (high, medium, low priority) will help. Here are some basic suggestions:

- Pillars and Primary SPSS still lacking some kind of observations should always have higher priority than Secondaries;

- For long variability, a balance should be kept between following objects that have not been started yet and objects that are being followed already. Absolute priority should be given to SPSS that are near completion of their long term three years sequence, if any;

- For short term variability, priority should be given to repetition of incomplete sequences or of objects that for some reason have bad quality data;

- For absolute photometry, among objects with similar priority, those that still do not have absolute photometric observations should be privileged, but some repetition of already made observations is also needed[5]. Of course, SPSS that already have good spectra but still do not have good absolute photometry should have higher priority.

3.2.5 Filters

Photometric observations are carried out in three Johnson-Cousins filters: B, V and R. We avoid U because it is too slow, and I because fringing can be heavy with some CCDs. The only exception to this rule is the REM robotic telescope, that does not have a suitable B filter, so we use I. Also, using REMIR in addition to ROSS allows for extra J images without any loss of observing time. For short variability series, we always use the bluest filter available, which is B in all cases except for the REM, where we use V.

3.2.6 Exposure Times

Exposure times, *including overheads*, should be computed beforehand, especially if you do not have familiarity with the Instrument/Telescope that you will use. A good starting point is the Observing Proposal, which can be found in the *"Summary of Observing Runs and Proposals"* Section of the Wiki-Bo pages. In the same Section you can find links to all Sites and Telescope webpages, where usually exposure time calculators are available for the desired instruments. The observing logs of past observing runs, that can be found in Wiki-Bo, will also give you a feeling about the real capabilities of the instrument itself.

4 Observing Instructions

4.1 Instrumental Calibrations & Tests

4.1.1 Instrument Familiarization Plan

The instrument Familiarization Plan (IFP) is a set of tests on the CCD and on the instrument that are needed in order to be sure that we can attain the high precision required by our SPSS

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[5]In the ideal case, at least three independent measurements should be taken.

campaign. The status if the IFP can be found in the Wiki-Bo *"Data Reduction and Analysis"* Section. Please have a look at the plan status and see if there are any observations missing for the particular instrument you are using. If so, you will find detailed observing instructions in the first observing protocol (EP-001), which can also be found in the *"Documentation"* Section of Wiki-Bo.

4.1.2 Bias Frames

Since we want to have a high S/N in the daily master Bias for each night, we need series of 10 bias frames[6]. Often the first Bias frame will have to be thrown away and repeated, so if you take 11 bias frames we have a good chance that 10 of them are usable. If the CCD has prescan and/or overscan strips, try not to cut them away from images (both calibrations and science frames), so they can be used for further checks on the Bias level stability, unless the CCD readout time becomes unbearably long.

Instrument specific tips on Bias frames:

- **REM.** Bias frames are not taken. REM is not nitrogen cooled, therefore dark frames are taken periodically by the staff and they already include the bias level and pattern;

- **Calar Alto.** Bias frames for CAFOS have different sections if they are taken for spectroscopy or photometry;

- **San Pedro Mártir.** Apparently, there are some light leakages within the instrument, so bias frames should not be taken in the afternoon when there is too much light, but: *(i)* in the late twilight after skyflates; *(ii)* once during the night; and *(iii)* in the morning twilight before the skyflats.

4.1.3 Dome Flats

Dome flats should be obtained every afternoon. They should have the maximum allowed number of counts in linear regime for the detector (i.e. if a CCD saturates around 64000 counts, 40000 is a good reference value). At least the first frame of each sequence should be inspected visually to check for the counts. 10 good flats for each filter (typically B,V,R) are sufficient.

Instrument specific tips on Dome Flats:

- **REM.** Flats are periodically taken by the staff;

- **TNG.** No dome flats are allowed there;

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[6]For very old instruments, the Bias pattern can vary during the night. Check the IFP reports on bias stability or ask your support astronomer whether it is necessary to take Bias frames during the night as well.

- **Calar Alto.** As in the case of biasses (see above) remember to use the appropriate CCD section for imaging, and not the one for spectroscopy;

- **San Pedro Mártir.** Dome flats are unreliable, due to telescope shadows on the dome flat screen inside the dome.

4.1.4 Skyflats

Photometric skyflats should be taken every night, preferentially during the evening twilight, but also in the morning twilight for slow instruments where it can be difficult to complete the whole sequence. However, if there are many clouds at twilight, domeflats should be used instead (Section 4.1.3).

Things to bear in mind:

- the ideal number of counts (if the CCD saturates at 65000 counts approximately) is of about 40000; however, anything between 15000 and 50000 should in principle be useful;

- if the telescope is tracking, apply small offsets after each exposure to allow for star removal; if the telescope is not tracking, you do not need to apply any offset;

- at least 5 good flats for each filter should be obtained, in case of problems, slow instruments and so on, try to obtain at least triplets of good flats;

- the best filter sequence in the evening twilight is B-V-R-(I), while in the morning it is (I)-R-V-B.

Most telescopes provide lists of blank areas in the sky for flatfielding. If not, you can use the areas listed in Table 7 here, taken from Christian et al. (1985) and the FORS1 list[7]. These areas can be considered empty of stars within a field of view of $\sim$7'$\times$7' approximately.

Instrument specific tips on Twilight Flats:

- **REM.** flats are periodically taken by the staff;

- **Calar Alto.** the CCD readout is quite long, even if the CCD section for photometry makes it a bit faster, you may need to use the morning twilight as well, so please, try to obtain triplets of good flats at least;

- **TNG.** no dome flats or morning twilight flats are allowed there, so it might become impossible to have all the needed calibration frames every night; try to have at least good triplets for one or two filters every night, rotating filters during the run;

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[7]http://www.eso.org/sci/facilities/paranal/instuments/fors/tools/FORS_Std/FORS_Std.html

Table 7: **Blank Flat Field Areas**

Name	Epoch	R.A.	Dec
SGP	J1950.0	00:48:30.3	−28:03:01.0
0102-265	J1950.0	01:02:48.5	−26:34:25.0
0248-196	J1950.0	02:47:46.6	−19:46:11.1
Blank 1	J1950.0	04:25:46.0	+54:09:03.0
0427-36	J1950.0	04:27:26.1	−36:25:16.0
9090-7	J1950.0	09:09:32.6	−07:38:26.0
CT1	J1950.0	10:04:27.0	−02:19:00.0
1101-264	J1950.0	11:02:23.5	−26:43:56.7
CT5	J1950.0	12:26:08.7	−06:38:29.0
CT2	J1950.0	12:54:58.7	−02:07:04.0
Blank 2	J1950.0	13:04:33.0	+29:50:49.0
SER1	J1950.0	15:13:13.9	−00:31:47.5
SPKS 04	J1950.0	15:39:43.0	−33:56:54.0
SPKS 12/Blank 3	J1950.0	16:49:42.0	−15:21:00.0
SPKS 08	J1950.0	17:31:06.0	−25:44:24.0
SPKS 09	J1950.0	18:02:01.0	−04:32:36.0
SPKS 10	J1950.0	19:00:48.0	−37:21:18.0
SPKS 13/Blank 4	J1950.0	19:19:09.0	+12:22:05.0
SPKS 14/Blank 5	J1950.0	21:26:54.4	−08:51:41.0
2335-40	J1950.0	23:34:34.6	−39:49:04.0
2345+007	J1950.0	23:45:45.9	+00:40:40.0
Blank 6	J1950.0	23:54:08.9	+59:28:18.0

- **San Pedro Mártir.** A method that helps in obtaining a good number of counts is described in Section A.3.1. Always remember that the minimum exposure time to avoid shutter vignetting is 10 sec.

4.2 Photometry Observations

4.2.1 Absolute Photometry

- If the sky is clear, you should observe 3 standard fields (e.g., Landolt fields) at 2 different airmasses each[8], and use the night to acquire *absolute* night points of desired target SPSS; both the standard field and the target SPSS should be imaged using the "night point" observing sequence described in Section 4.2.2;

[8]Ideally, the two airmasses should differ by at least $\Delta AM \simeq 0.8$, but of course observing at AM>2 is not reasonable so, depending on the case, some compromise could be necessary.

- If the sky is not clear, do not waste time on standard fields and concentrate on *relative* photometry, e.g. night points for long term variability (Section 4.2.2) and time series for short term variability (Section 4.2.3);

Instrument specific tips:

- **Loiano, Calar Alto & TNG.** The Northern hemisphere is already well covered by San Pedro Mártir, so no absolute photometry is strictly necessary in these observatories, however, in case of exceptionally clear nights, it would be nice to take absolute night points, to compare with San Pedro Mártir;

- **San Pedro Mártir.** This is our main source of absolute photometry in the Northern hemisphere, and therefore every clear night should be devoted to absolute photometry, with no fear of repeating already observed SPSS if no new targets are available;

- **REM.** No absolute photometry can be done here;

- **NTT.** This is our only source of absolute photometry in the Southern hemisphere, so every clear night should be devoted to absolute photometry, with no fear of repeating already observed SPSS if no new targets are available;

4.2.2 Long Term Variability Night Points

As discussed in Section 1, each and every candidate SPSS should be checked for long term variability, with a campaign of three years, where the star is observed approximately once every three months. One single observation of an SPSS in one night is called a *Night Point*. When the night is clear and Landolt standard star fields are observed, the *relative* night point becomes an *absolute* night point.

Night points should be taken in three filters (typically B,V,R). Three exposures should be taken for each filter. Always check the image quality at the telescope (Section 4.2.4), in particular be sure that at least two good comparison stars are present in the field of view. Please apply small offsets between different exposures (*dithering*), if possible. Dithering helps in case of hot or dead CCD pixels and columns, cosmic spikes or photometric zeropoint distortions. An example of good dithering pattern is:

- **First exposure.** Target SPSS in the center of the image;

- **Second exposure.** Offset the telescope by +10" *both in RA and Dec*;

- **Third exposure.** Offset the telescope by –20" again both in RA and Dec.

Instrument specific tips:

- **San Pedro Mártir.** La Ruca is not able to perform automatically any dithering when guiding (Section A.3.5), therefore dithering can be avoided if it takes away too much time and concentration;

- **Loiano.** The telescope looses easily the guiding star, so either the dithering pattern could be made very small (+5" and –10", for example), or avoided at all.

4.2.3 Short Term Variability Series

As explained in Section 1, WD near the instability strip and hot subdwarfs will need a check to exclude short term variability. Time series have to be obtained for each of the marked SPSS in the *"SPSS Lists & Summaries"* Section of Wiki-Bo. The image quality should be checked periodically during the series, see Section 4.2.4 above for the requirements on S/N and pointing. The golden rules for variability series are:

- The time series should last *at least* one hour;

- The time series should contain *at least* 30 exposures;

- There should be *at least* two comparison stars in the field;

- Do *not* apply any *dithering*;

- Take also one night point before or after the series (Section 4.2.2), if possible.

4.2.4 Image Quality

Table 8: **Imaging Field of View of Adopted Instruments**

Site	Telescope	Instrument	FoV
Loiano	Cassini	BFOSC	$13' \times 12.6'$
Calar Alto	2.2m	CAFOS	$16' \times 16'$
La Palma	TNG	DoLoRes	$9.4' \times 9.4'$
San Pedro	1.5m	La Ruca	$4.2' \times 4.2'$
La Silla	REM	REMOS	$10' \times 10'$
La Silla	NTT	EFOSC2	$9.1' \times 9.1'$

- **S/N.** Make sure that the target SPSS does not saturate, and that the weakest comparison stars have at least a few thousand counts; as a minimum (see below) there should be at least two good comparison stars in each field; this remains true also when taking absolute photometry, since those images should be useful also as relative night points for long term variability;

- **Centering.** Having the star approximately in the center of the image is quite important to be able to combine night points obtained by different observers, with different instruments, because it maximizes the chance of having the same comparison stars in each of the night points during the three years; also, take good care to avoid placing the target SPSS on bad columns and pixels;

- **Comparison Stars.** Make sure there are at least two good comparison stars in the field; if not, do not move away from the center, but leave that target for an instrument with a larger field of view, if any (Table 8); in the unlucky case in which you are already using the largest field of view available, then please do move the star from the center of the image to maximize the number of good comparison stars.

5   Night and Run Closing Operations

Closing operations are fundamental to us, considering that different people might be observing and reducing data, at different locations, simultaneously or just very close in time. For the same reasons, it is important that you close your run as soon as possible: this will minimize unnecessary repetitions of observations. If you find any problems in performing the run closing operations, please contact us without hesitation (Section 1.2).

5.1   Night Closing

1st Run (19 Aug - 26 Aug 2008)						
Night	Official	EON Report	Obs Log	Other	Weather	Data
19 Aug 2008	TBD	rep+targets	elog (pdf)	No	Clear, seeing 1.2"-1.5"	TBD
20 Aug 2008	TBD	rep+targets	elog (pdf)	No	Clear, seeing 1"-2"	TBD
21 Aug 2008	TBD	rep+targets	elog (pdf)	No	Clear, seeing 1"-2.5"	TBD
22 Aug 2008	TBD	rep+targets	elog (pdf)	No	Clear, seeing 1"-2.5"	TBD

Figure 2: Portion of the *"Observing Logs"* Table in each Run Page in Wiki-Bo, showing the first four nights of the August 2008 run in San Pedro Mártir, with hyperlinks to the end of night reports, observing logs and weather information.

5.1.1   Observing Logs

Observing logs should always be prepared using the Night Logs Form[9], a preset Word table that can be edited with any Microsoft compatible Word software (Star Office, Open Office, Office

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[9]In the exceptional case in which they are taken on paper, the logs should be scanned to produce clearly readable pdf files, one file per night.

for Mac and Microsoft Office). The table can be found in the Wiki-Bo Section *"Observing Tools"*, under the *"Tools for Run Execution"* heading.

If you have editing access to the Wiki-Bo pages you should also link each night log, along with weather information, in the *"Observing Logs"* Section of your Run Page in Wiki-Bo (as shown in the fourth column in Figure 2).

5.1.2   End of Night Report

The end of night report (EON) should be submitted through the web interface that can be found in the Wiki-Bo Section *"Observing Tools"*, under the *"Tools for Run Closing Operations"* heading. If you have editing access to the Wiki-Bo pages you should also link each End of Night report in the *"Observing Logs"* Section of your Run Page in Wiki-Bo (as shown in the third column in Figure 2).

5.2   Run Closing

Observations

Run ID:	P-005
Starting Night:	5 Feb 2007
Number of Nights:	3
Observing Site:	Loiano
Telescope:	Cassini
Instrument:	BFOSC
First Observer:	G. Altavilla
Second Observer:	I. Bruni
Sky Conditions:	Veils, bad seeing
Notes:	Bad time (overcast/rain) in the 2 last nights (6-7 Feb)
End of Run Report:	EORloianoFeb07.txt

Figure 3: An example of the *"Run Description"* Section in the Wiki-Bo run pages. The EOR is linked in the last line.

5.2.1   End of Run Report

The end of run report (EOR) should be submitted through the web interface that can be found in the Wiki-Bo Section *"Observing Tools"*, under the *"Tools for Run Closing Operations"* heading. If you have editing access to the Wiki-Bo pages you should also complete the *"Run Description"* Section in the Run Page (Figure 3), and link your EOR there as well.

5.2.2 Data Backup

Please, do not forget to prepare a complete CD or DVD backup of the data taken in the entire run and to send it to our postal address in Bologna. The data should be divided in subdirectories for each night. If CD or DVD backup is not convenient in your particular case, please contact us to arrange for another way of backing up the raw data.

5.2.3 Upload in the Raw Data Archive

To share the effort of maintaining our DB&A, you should upload your own data in the Raw Data Archive. Detailed instructions can be found in the *"SPSS Database & Archive"* under the *"SPSS Raw Data Archive"* heading. Please contact us to obtain the appropriate credentials to access Wiki-Bo and the archive machine, or in case of any doubt or problem.

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A   San Pedro Mártir Detailed Instructions

Originally prepared by J.M. Carrasco & M. Monguio

San Pedro Mártir is our main source of absolute and relative photometry in the Northern hemisphere. This Appendix gives a practical and easy to browse list of instructions to operate the imager La Ruca mounted at the 1.5 m telescope in the San Pedro Mártir observatory, in Mexico. The support astronomer will help you if you have any doubts or problems and more information and the user's manual can be found in the San Pedro Mártir webpage:
`http://www.astrossp.unam.mx/indexspm.html`.

A.1   Switching on the Interfaces

A.1.1   Telescope & Dome Controls

To switch on the Graphical User Interface (GUI) that controls the telescope and the dome:

- Click on the `Instrumentacion` icon accessible from the Desktop.

- Click on the `Consola` icon to open the telescope control interface (see Fig. 4).

Figure 4: Telescope Control

A.1.2   Guiding Camera Controls

To switch on the GUIs that manage the finder and the telescope guiding:

- Click on the `Instrumentacion` icon accessible from the Desktop.

- Click on the `Guiador` icon to open the TV guiding system.

- A new window with three buttons appears (see Fig. 5, upper panel):

  Guiador : GUI for moving the guider (Fig. 5, left panel);
  GSC : GUI for the Guide Star Catalogue) finder (Fig. 5, middle panel);
  Camara : GUI for the guiding camera display (Fig. 5, right panel);
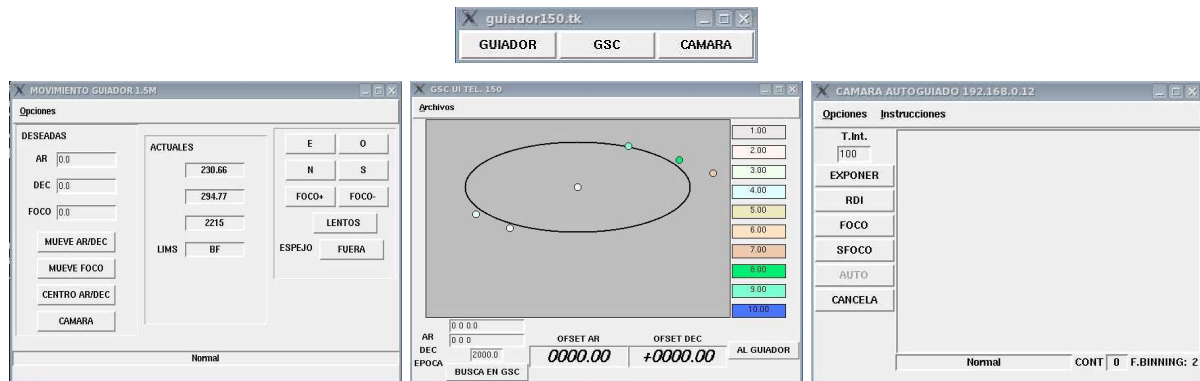

Figure 5: Guider camera GUIs

A.1.3   Finder Camera Controls

To switch on the finder camera GUI:

- Click on the `Instrumentacion` icon accessible from the Desktop.

- Click on the `Buscador` icon to open the finder camera control (Fig. 6, left panel).

A.1.4   Focus Controls

To switch on the Focus GUI:

- Click on the `Instrumentacion` icon accessible from the Desktop.

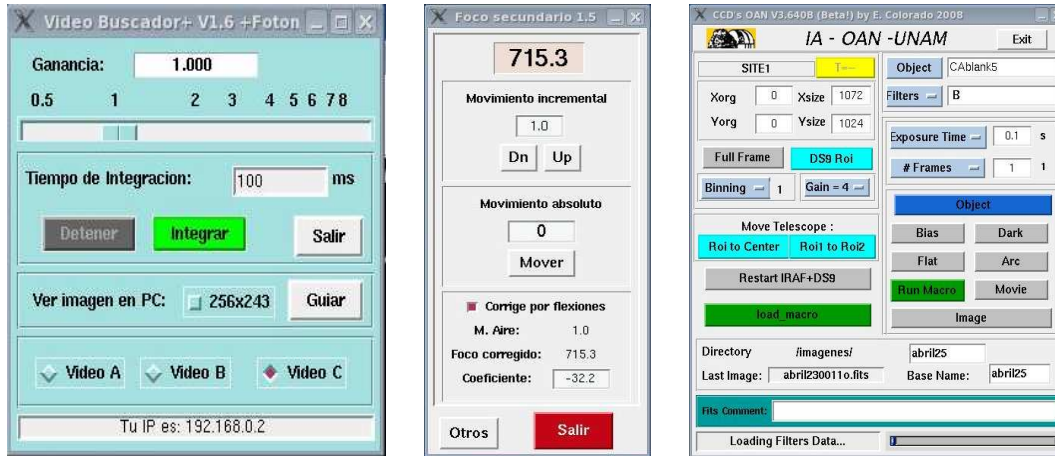- Click on the `Secundario` icon to open the focusing system interface.

Figure 6: Finder Integration GUI (left), Focus GUI (center) and CCD Gui (right)

A.1.5 CDD Controls

To switch on the CCD GUI:

- Click on the `Instrumentacion` icon accessible from the Desktop.

- Click on the `OAN's CCD V3` icon to open the CCD control interface. It also opens an IRAF terminal and the DS9 window.

- Enter the following information to be included in the header of the images:

  CCD : SITE1

  Instrument : RUCA

  Telescope : 1.5m

  Observer : Observers names

- Click on `Continue`, the CCD interface is now open (Fig. 6, right).

- Enter the `Directory` name to store the images.

- Enter the `Base Name` for the prefix of the image file names.

A.2 Preparing for Observations

A.2.1 Moving the Telescope

There are three switches on the telescope console (Fig. 7). The first one, `Consola`, should always be on and never switched off. You have to switch on the second switch, `Motores`, if
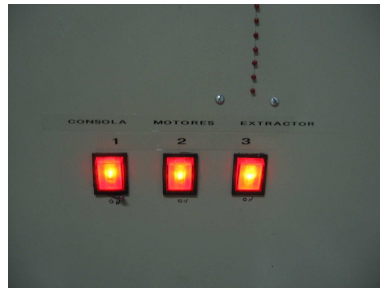
Figure 7: Telescope Console Switches

you want to move the telescope; the third switch, `Extractor` is a fan that cools the engines and is only needed in summer.

To actually move the telescope, you can:

- Select the desired star from a catalogue: use the telescope control GUI (Section A.1.1, Fig. 4); choose the `Catalogo` tab, then the `Archivos` tab and select among the available catalogs in the directory `Catalogo`; to select, simply select the appropriated row and click on `Mueve Telescopio` to send the telescope to the position;

- Add your own catalog to the `Catalogo` directory; it should have the `.obs` extension and respect the format: `ID name alpha delta epoch magn comments`; then you will be able to freely select objects from your catalog;

- Enter the coordinates with `Editar coordenadas` in the Telescope GUI (Fig. 4);

- Use one of the two fixed telescope positions(click on `Posiciones fijas`, Fig. 4), the zenith or `Cenit` and the one for nitrogen filling or `Poner lona`.

A.2.2 Nitrogen Refill

Normally, the night assistant and the daytime staff will take care of refilling the nitrogen. But in case the temperature rises above the safety limits, you can follow these steps

- Check the CCD temperature every 6–8 hours; send the telescope to zenith (use `Posiciones Fijas`, Fig. 4), check the temperature (Fig. 8)and write it down on the telescope logs. The ideal temperature is about $-98.8 \deg$;

- If the temperature is significantly higher than that, send the telescope to the `Poner lona'` position (use verb'Posiciones Fijas', Fig. 4) to start the refilling procedure;

- Use always gloves to manipulate the nitrogen pipe once the nitrogen is passing through; the pipe in fact freezes and can hurt your skin;

- Connect the nitrogen cylinder with the instrument through the input pipe (Fig. 8, right). Be sure that it is done correctly, otherwise that can be some leakage that can compromise the refilling.

- Open the nitrogen handle on the cylinder; nitrogen passes through the pipe and some cool gas comes out from the dewar escape pipe; wait until some liquid comes out instead of the gas; now the nitrogen refill is almost complete;

- Close the nitrogen handle for a while, when the liquid stop spilling, open it again a little bit more until the liquid comes out again; then close it and disconnect the nitrogen cylinder from the instrument;

- Send the telescope to the zenith again; check the temperature and write it down on the telescope logs.
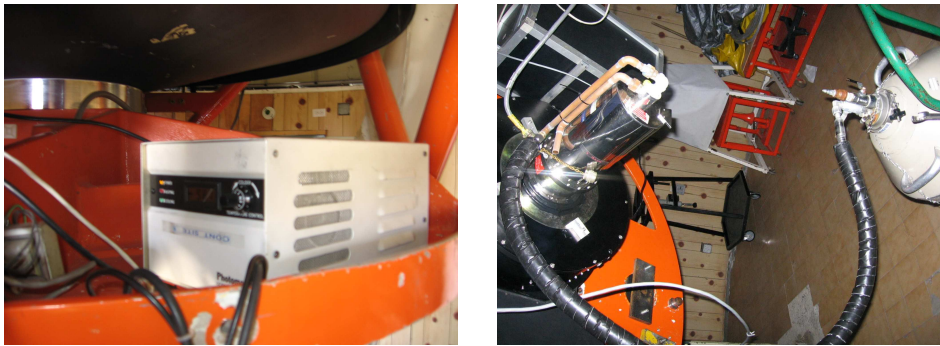
Figure 8: CCD Temperature display (left) and nitrogen refilling procedure (right).

A.2.3 Bias Frames

Please take into account that there are light leakages into the instrument, so it is better to take bias frames when the sky is dark and the dome lights are off. To obtain a bias sequence, you will work with the CCD GUI (Fig. 6, right):

- Set the `Directory` and `Base Name`;

- Set the Object name, for example use `Bias`;

- Select the desired number of exposures, for example 11;

- The exposure time is irrelevant if you use the `Bias` button to launch your series of bias exposures, because it will automatically be set to zero.

A.2.4 Dome Flat Fields

Dome flat fields are unreliable because the shadow of the telescope itself makes the illumination of the flat field screen non uniform; nevertheless, dome flats can be used to build bad pixel masks, or to measure the CCD linearity even if they are not perfectly illuminated. To obtain dome flats, through the CCD GUI (Fig. 6, right):

- Switch the two dome lamps on, do not point them to the flat field screen, but try rather to illuminate the screen indirectly, minimizing the telescope shadow;

- Set the `Directory` and `Base Name` in the CCD GUI;

- Set the Object name, for example use `Dome`;

- Select the filter you want to use;

- Select the appropriate exposure time (see Section 4.1.3);

- Select the desired number of exposures, for example 10;

- Push the `Flat` button to start the flat sequence.

A.2.5 Opening the Dome

Figure 9: Dome/telescope paddle (left), dome controls (green buttons, center), mirror cover controls (white buttons, center) and the dome opening controls (right).

To open the dome:

- Rotate the dome to the zero position (you can use the paddle (Fig.9, left), the controls on the wall (Fig.9, right) or the Telescope GUI in the control room (Fig. 4). To Check the zero position, make sure the two arrows (Fig 10, left) are aligned, if not, warn the dome staff. The actual dome position can be seen in the Telecope GUI (Fig. 4);

- Go up the stairs onto the platform and connect the power wire to supply power to the done slit covers. Then, use the dome cover controls; (Fig 9, right) to open first the upper cover, and when it has started its movement, you can open also the lower cover;

- If the temperature is very low, do not open the dome completely, but leave the final meter or two covered, so that if it freezes you can later move it back and forth to break the ice when closing (do not do this with the telescope mirror covers open!!!);

- **IMPORTANT!** When the two dome covers are opened, remember to disconnect again the power wire, otherwise it will be stretched during dome movements!

A.2.6 Opening the Mirror and Finder Covers

Figure 10: The dome alignments arrow (left), the telescope mirror covers (black panes, right) and the finder (blue tube, right) covers.

The mirror cover and the finder cover (Fig. 10) must be always opened after opening the dome, and not before, to prevent something from the dome to fall directly into the mirror. To open the covers:

- The mirror covers can be opened with the white switches on the dome wall (Fig. 9, center), by strictly following the order indicated on the switches;

- The finder cover can be opened by pulling the cable that can be found at the base of the finder.

A.3 Observing the Sky

A.3.1 Sky Flats

Sky flats are very easy and fast to take with La Ruca, if you start early after sunset and if you have only three filters, as in our case. You will almost never happen to need the morning twilight as well. To obtain skyflats:

- Point the telescope to a region in the sky devoid of stars (blank fields, Table 7), possibly to the East. See Section A.2.1 to see how to move the telescope;

- Set the `Directory` and the `Base Name`, set `Object` to, e.g., `Skyflat`;

- Select the filter in the CCD GUI (Fig. 6, right). Remember the correct filter sequence (Section 4.1.4);

- If you switch off tracking, the few stars in the field you are observing will naturally move after each exposure, otherwise, when tracking, remember to apply small offsets after each flat exposure, to allow for stars removal;

- Soon after sunset, start taking a movie (as you do for focussing the secondary, Section A.3.2) of a small CCD region and check the counts by moving the mouse over the image in the DS9 display;

- When the counts reach down approximately to 7000 in the B band, you are ready to start with the flat sequence[10]; if you are taking flats in the morning, wait until the counts reach up to 1500 in the R band;

- Stop the movie with `Cancel` in the CCD GUI (Figure 6, right) and Switch again to `Full Frame` readout mode;

- Select the appropriate exposure time: B=10 sec; V=14 sec; R=17 sec;

- Start the flat sequence by setting the number of exposures to 7 and by pushing the `Flat` button on the CCD GUI.

A.3.2   Telescope Focus

The telescope is not always well balanced, the pointing, the guiding and the focus change a lot with position. We advise to take the focus often:

- Point the telescope (Section A.2.1) to a bright star close to your next target, remember to switch off the autoguider before moving the telescope, and to set the image intensifier to the minimum gain value (Fig. 11, left);

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[10]These number of counts are motivated by the following formulas:

$$n_{max} = \frac{N_{max} - N_{bias}}{t_{exp,B}} + N_{bias} \tag{1}$$

$$n_{min} = \frac{N_{min} - N_{bias}}{t_{exp,R}} + N_{bias} \tag{2}$$

being n_{max} and n_{min} the number of counts per second to start the evening and morning skyflats respectively, $N_{max} = 64000$ and $N_{min}) = 15000$ the maximum and minimum admissible number of counts, $t_{exp,B} = 10$ and $t_{exp,R} = 17$ is the exposure time of the skyflats in B and R, respectively, and $N_{bias} = 640$ is the bias level. The resulting values are in fact $n_{max} \sim 7000$ and $n_{min} \sim 1500$.

- Take a test image of the field you are pointing at;

- Draw a small square marker around the best star in the field with the mouse in the DS9 window;

- Push the `DS9 ROI` on the CCD GUI (Fig. 6, right)

- Push the `Movie` button in the CCD GUI, setting the exposure time to a small value, such as 1–3 seconds, depending on the star brightness;

- DS9 will show images of the star taken every 1–3 second (as you chose);

- Use the finder paddle in the control room (Fig. 11, right) to change the focus by small amounts with the `Foco` button until your star becomes round and small; you can also use the Focus GUI (Fig. 6, middle);

- Stop the `Movie` and set the CCD GUI to `Full Frame` again.

Figure 11: Guiding camera monitor (left) and finder paddle (right)

A.3.3 Correct the Telescope Pointing

As we said, depending on the observing run, the telescope is not always well balanced, so the actual pointing might vary a lot with position (up to 5'–6', i.e., more than the CCD FoV). If you do not recognize your field, do the following:

- Point the telescope to a well known bright star close to your object in coordinates using the telescope catalogs (Section A.2.1); be sure that you switched off the auto-guider and that you set the guiding camera gain to the minimum;

- Take a test image (`Image` button in CCD GUI, Fig. 6, right) of the field containing the star;

- Select `Line A` on the monitor to view the finder field (Fig.11, left) and tune the monitor gain until you see the star;

- Move the field using the paddle GUI in the Telescope GUI (Fig. 4) or the finder paddle (Fig. 11, right) until the star is well centered in the finder field (red cross painted on the screen);

- In the Telescope GUI, click on `Instrucciones mas usadas` and choose `Corrige coordenadas` to correct the telescope pointing.

A.3.4   Centering your Target

Once you have pointed the telescope, you should first put the target SPSS to the center:

- Take a test `Image` in the CCD GUI (Fig. 6, right) of 10–30 seconds, depending on the object brightness;

- The image axes in DS9 are usually set up such that N is left and E is up (depending on the derotator position); if you want to identify the field with a finding chart, you might need to rotate the field by 90 degrees and switch the X axis in DS9, to have N up and E left; if you do so, the `Roi to center` feature will not work anymore;

- Either select the object with the cursor in DS9 and then press `Roi to Center` (but this will not work if you switched the axes with DS9) or use the Telescope GUI (Fig. 4) arrows to offset the image by the desired amount;

- Take another test `Image` to check that your offset was correctly applied (the N-S offsets often can fail, so be sure to check!).

A.3.5   Guiding

Normally, you will need guiding only for exposures longer than 60 seconds, approximately. However, sometimes the telescope is not tracking well, for example when you are at low airmasses, if breeze or wind blows directly on the telescope or in some positions close to the zenith. So we advise to guide even for short exposures:

- Click on `Busca en GSC` on the Guide Star Catalog (GSC) GUI (Fig. 5, center), and choose the most convenient star among the ones that appear as colored dots by clicking on the corresponding magnitude box;

- Click on the `Al guiador` button (Fig. 5, center) to send the offset coordinates to the guider;

- Click on the `Mueve AR/DEC` button in the guider GUI (Fig. 5, left) interface;

- Adjust the gain of the intensifier (above the guiding monitor screen shown in Fig. 11) according to the selected guiding star magnitude;

- Select a suitable integration time for the guiding star in the `Camara autoguiado` interface (Fig. 5, right), usually between 2000 and 3000 milliseconds;

- Click on the `Foco` button in `Camara autoguiado` to obtain a sequence of images on the monitor. A window saying `Cancela el autofoco` appears to stop the autofocus when needed;

- Use the `N,S,E,W` buttons in `Movimiento guiador` (Figure 5, left), to move the mirror of the guiding camera until the guiding star appears close to center of the monitor; you can toggle full speed/slow speed with the `Rapidos/Lentos` button when moving the guiding camera;

- Once done, click `OK` in the `Cancela autofoco` window that appeared when you started `foco` and wait until the star image appears in the guider GUI (Fig 5, right);

- Click on the star image with the mouse and the guiding box will appear around the star; now you can click on `Auto` to start guiding and a small window saying `Cancela el autoguiado` will appear to stop the autoguiding when needed.

A.3.6 Exposing

To take an exposure of your SPSS or Landolt field:

- Be sure that the `Directory` and `Base Name` in the CCD GUI (Fig. 6, right) are the desired ones;

- Be sure to have correctly identified and centered you field (Section A.3.4);

- Be sure that you started guiding – this might be needed even for short exposure times (Section A.3.5);

- Select the desired filter and exposure time in the CCD GUI; you can also select the number of exposures you want to do consecutively[11]

- You can now start your exposure (or your exposure series) by clicking on the `Object` button;

- You can apply some dithering (Section A.3.7), but we do not advise to do so with La Ruca observations;

- You can cancel an exposure with the red `Cancel` button.

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[11]While if you change the exposure time during an exposure, the CCD GUI will ignore your new command, if you change the number of exposures during a sequence the CCD GUI will instead use the new number you put in.

A.3.7   Dithering

When not guiding, applying small offsets is quite easy, using the Telescope GUI arrows as described in Section A.3.4. However, if you are guiding (and this might be needed even for short exposure times), there are two methods that you can use. Their are both complicated and therefore we advise not to dither in the case of La Ruca observations.

First method:

- After the first exposure (Section A.3.6), switch off the autoguider (Section A.3.5);

- Apply the desired small offset (Section A.3.4);

- Restart the autoguider (Section A.3.5);

- Start the next exposure (Section A.3.6).

Second method:

- After the first exposure (Section A.3.6), go to the autoguider GUI (Fig. 5, right);

- Move the guiding box by at most half of its size (to avoid losing the guiding star completely); you can resize the box in the `Options` menu to suit your needs;

- The guider will try to recenter the star in the box and will therefore move the telescope by that same amount, in the opposite direction;

- Start the next exposure (Section A.3.6).

As can be clearly seen, both methods are tiresome and can result in confusion if you spend the whole night switching on and off the guider after each exposure or by moving the guiding box in small steps. So we reiterate that it is not strictly necessary to dither in the case of San Pedro Mártir observations.

A.3.8   Using Macros

The use of macros is extremely convenient for those exposure sequences that do not require guiding. The macros in fact cannot control the guiding camera. We also remind that even for short exposure times (40–60 sec) the autoguider can have problems under certain conditions, so when you launch a macro, be sure that the first images come out right, otherwise interrupt the macro and observe the target manually (Section A.3.6).

A macro is an ASCII file containing commands. A few useful commands are:

- **FILTRO 2**: change to filter number 2 (2=B, 3=V, 4=R);

- **DELAY 7000**: produce a delay (in milliseconds) between commands execution, since for example the filters need some time to physically get in place;

- **TINT 15**: select an exposure time of 15 seconds;

- **EXPON**: start the exposure;

- **AROF 5 +A**: offset in right ascension of 5": $+$ means East and $-$ means West;

- **DEOF 10 –D**: offset in declination of 10": $+$ means North and $-$ means South;

- **BEEP**: the computer beeps when the macro is complete.

All of the parameters that are not explicitly set in the macro take their default values, so be careful when writing your macro. To launch your macro:

- Load macro with the `load_macro` green button in the CCD GUI (Fig. 6, right);

- Click on `Run Macro` in the CCD GUI (Fig. 6, right).

- To abort the macro, click on `Cancel`.

A.4   Ending the session

A.4.1   Nitrogen Refill, Again

See Section A.2.2.

A.4.2   Shut off Interfaces and Monitor

Not all the interfaces (Section A.1) need to be shut off every night. But surely you must:

- Shut off the monitor (Fig. 11, left);

- Shut off the image intensifier that sits on top of the monitor;

- Shut off the finder by clicking on `Detener` (Fig. 6, left).

A.4.3 Park Telescope

When you stop observing, for bad weather or for the end of the night:

- Shut off the interfaces (Section A.4.2;

- Move the telescope to the zenith (`Posiciones fijas` in Fig. 4);

- Close the mirror cover, and both finder covers (Section A.2.6);

- Close the Dome *after closing the mirror covers* (Section A.2.5);

- Put the dome either in the zero position or, if there is strong wind and/or rain, a few tens of degrees to the West, so that the dome slit appears on the right side of the ladder and of the dome doors.

A.4.4 End of Run Report

Besides the EOR reports internal to Gaia, you will find in the San Pedro Mártir webpage a link to the *Reporte fin de temporada*, i.e., end of run report.

A.4.5 Data Backup

You should backup all the data since the telescope staff does not provide this service, and the data will be deleted sooner or later. We suggest:

- If you have a laptop with you, transfer all data on it from either beta.astrossp.unam.mx (the main machine for storing data) or haro.astrossp.unam.mx (a backup server where the data are kept a bit longer);

- Anyway, try also to transfer your data in your home institute via as an additional safety measure;

- Then, follow the normal instructions in Sections 5.2.2 and 5.2.3.

B   REM Detailed Instructions

Originally prepared by G. Altavilla

The REM telescope is our main source of relative photometry in the Southern hemisphere. You can find more information at the REM webpage[12]. Since REM is a robotic telescope, operated remotely, observations are carried out by the REM staff according to our target list and observing instructions.

Figure 12: The REM robotic telescope.

B.1   REM observing strategy

Table 9: **REM Observing Strategy**

Observations	Targets Mag	Description
Short Variability Series	V<10.5	$\sim 40\times60$ s, V band;
(*"Type a"* observations)		$\sim 70\times4$ s, J band
Two consecutive series just once	V>10.5	$\sim 18\times180$ s, V band;
		$\sim 150\times20$ s, J band
Long Variability Night Points	V<10.5	$\sim 3\times60$ s, V,R,I bands;
(*"Type b"* observations)		$\sim 20\times4$ s J band
Two points every 6 months	V>10.5	$\sim 3\times180$ s V,R,I bands;
		$\sim 20\times20$ s J band

The REM staff is already aware of our observing strategy, which consists of short term variability series (Section 4.2.3) and relative night points (Section 4.2.2), indicated in the REM proposal as *"Type a"* and *"Type b"* observations, respectively. No absolute photometry is taken. The REM does not have a standard Johnson B filter, so we observe in V,R,I. Additional J band observations are done in parallel with no additional expense of observing time (see Table 9).

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[12]http://www.rem.inaf.it/

The reason why the short variability series are made of two consecutive *"1 hr"* blocks, is that the REM system is not well suited for handling OBs (Observing blocks) lasting more than one hour. Due to overheads, 1 hour block provides ~ 18 frames for a typical star fainter than V=10.5 (i.e. the bulk of our sample). From our experience, less than ~ 30 points are often not enough for building a reliable light curve. The night point for long variability will be taken twice each period (6 months). We selected two exposure times only (60sec for V$\leq$10.5; 180sec for $V > 10.5$) to keep the strategy as simple as possible, as needed by a robotic telescope, and to reach a suitable signal to noise also for field stars, without saturating the brightest targets.

B.2 Sending Observing Instructions

Usually, before starting a new observing period, we send an e-mail to the REM staff containing a short description of the observing strategy and we attach a list of targets[13] where the kind of observations (*Type a* or *"Type b"*) are clearly marked. Since the telescope has $10' \times 10'$ field of view, finding charts are usually not requested.

You can find a good example of the typical e-mail in the *"Observations Preparation"* heading of the V-007 (REM service observing from August 08 to Jan 09) *"Run Page"* in the Wiki-Bo, accessible through the *"Observing Runs and Proposals"* Table.

B.3 Retrieving REM Data from the TNG Archive

You can freely browse the REM archive through an easy web based interface[14], employing various selection and sorting criteria, including P.I. name, night, instrument and so on. To download the data you will need a username and password, that you can obtain by contacting us (Section 1.2). As an example, to select all the images obtained in a given month (February 2008) you can use the following command, to be put in the "`Your WHERE clause`" field:

```
pi_coi LIKE '%pancino%' AND date_obs > '2008-02-01 22:00:00' AND
date_obs < '2008-03-01 12:00:00'
```

Upon downloading, a tar file is produced that contains all the images obtained **day by day**. If we only want to download the images obtained in the last night of February (2008-02-29 - 2008-03-01), we c an use the command:

```
pi_coi LIKE '%pancino%' AND date_obs > '2008-02-29 22:00:00' AND
date_obs < '2008-03-01 12:00:00'
```

---

[13]This is not necessarily the same target list included in the proposal, since the proposal is prepared ~ 3 months in advance with respect to the beginning of the corresponding observing run.

[14]http://www.rem.inaf.it

B.4   Preparing the Observation Summaries

Each time an OB starts, the P.I. of the programme (E. Pancino) receives an e-mail. Another e-mail is also received when the observation is successfully completed, or is interrupted for some reason. All the e-mails can be used to produce the *"Observing Logs"* and the *"Target Summary"* Sections of the various REM *"Run Pages"* in the Wiki-Bo, under the *"Observing Runs and Proposals"* Section.

You also should prepare the EON and EOR reports, for which you need the weather and lunar phase information If you want to check the weather conditions you can use the ESO meteo-monitor archive[15]. Please be sure to check the correct file, i.e. if you want the metoe of the night between the 21 and 22 of February 2008, you have to select the 22 of February. For the lunar phase information, you can use the moon calendar on the CAHA web site[16].

B.5   Uploading REM Data to the SPSS Raw Data Temporary Archive

After the summaries are done, the data retrieved from the TNG archive can be uploaded in our *"Rad Data Archive"*. Instructions on how to upload data and useful scripts for summarizing the REM observation can be found in Wiki-Bo[17] (see also Section 5.2.3).

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[15]http://www.ls.eso.org/lasilla/dimm/Archive/

[16]http://www.caha.es/WDXI/lunaCal.html

[17]http://yoda.bo.astro.it/wiki/index.php/Help_Temp_Archive,
http://yoda.bo.astro.it/wiki/index.php/Tools_for_Summarizing_Observations

C   Other Instruments Instructions

Figure 13: The Cassini telescope in Loiano, Italy (top-left); the 2.2m telescope in Calar Alto, Spain (top-right); the TNG telescope in La Palma, Spain (bottom-left) and the NTT telescope in La Silla, Chile (bottom-right).

Apart from the REM robotic telescope and the San Pedro Mártir 1.5m telescope, we are also using:

- BFOSC@Cassini in Loiano, Italy;

- CAFOS@2.2m in Calar Alto, Spain;

- DoLoRes@TNG in La Palma, Spain;

- EFOSC2@NTT in La Silla, Chile.

All these instruments are low resolution spectrographs with imaging capabilities. Therefore, detailed instructions on how to operate them can be found in the third observing protocol, dedicated to the main SPSS observing campaign EP-004.