Data Reduction Protocol for Ground Based Observations of SpectroPhotometric Standard Stars. I. Imaging Pre-reduction

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Abstract

When trying to build a large set of 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 Data Reduction Protocol concerns the pre-reduction of photometric data obtained during both the auxiliary (absolute and relative photometry aimed to exclude variable stars from the main list of candidate Primary and Secondary SPSS), and main (mainly spectroscopy, but also absolute photometry for the absolute flux calibration of SPSS spectra taken in non-photometric nights) campaigns.

The reduction procedure to pre-reduce the imaging data is based on semi-automatic pipelines available in Wiki-Bo (see text). Even if the reduction steps are similar for all the instruments used in our campaigns, in some cases particular attention or special instructions are required. These cases are described in detail in the Appendices.

Document History

Issue	Revision	Date	Author	Comment
1	0	13-Mar-2012	SMR	FVL correction implemented, ready for Livelink
D	5	21-Dec-2011	SMR	EP+GCC+GA+JMC correction implemented
D	4	18-Oct-2011	SMR	version updated to automatic pipeline creation
D	3	11-Jul-2011	SMR	correction post-PhD Thesis implemented
D	2	17-Feb-2011	SMR	GA correction implemented
D	1	26-Jan-2011	SMR	EP correction implemented
D	0	07-Oct-2010	SMR	Creation

Acronym	**Description**
ADU	Analogue-to-Digital Unit
BFOSC	Bologna Faint Object Spectrograph & Camera
BPM	Bad Pixel Mask
CAFOS	Calar Alto Faint Object Spectrograph
CAHA	Centro Astronómico Hispano Alemán
CCD	Charge-Coupled Device
DoLoRes	Device Optimized for LOw REsolution Spectroscopy
EFOSC2	ESO Faint Object Spectrograph & Camera
ESO	European Southern Observatory
IRAF	Image Reduction and Analysis Facility (NOAO)
LaRuca	Rueda Cachanilla
NTT	New Technology Telescope (ESO)
QA	Quality Assurance
QC	Quality Control
REM	Rapid-Eye Mount
RON	Read-Out Noise (CCD)
ROSS	REM Optical Slitless Spectrograph
SPM	San Pedro Mártir Observatory
SPSS	Spectro-Photometric Standard Star
TNG	Telescopio Nazionale Galileo

Contents

1 Introduction

Our task is to build a grid of *Spectro–Photometric Standard Stars* (SPSS), see GA-001 and GA-003) suitable for the absolute calibration of the BP/RP spectrophotometers and of the G-Band of Gaia. The precision required for the Gaia SPSS grid is a few percent in flux, relative to Vega. Such a grid can be built using ground–based observations of SPSS. The details of the SPSS selection and the observational strategy has been outlined in GA-001, GA-003 and in MBZ-001, EP-003, EP-006 while the suitable ground based facilities are described in LF-001 and GA-002. As explained in MBZ-001, the simplest hypothetical case of calibration procedure involves the use of a single SPSS to derive the Response Curve of the instrument, which will be used to calibrate all data obtained 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 dispersion that strongly depends on wavelength. 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 and PMN-002).
A large set (a few hundreds) of calibrators with high S/N Gaia observations (JMC-001 and JMC-002) is needed to achieve the desired accuracy, primarily because using several SPSS enables the reconstruction of a very high S/N Dispersion Matrix (PMN-002), 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. For this reason, dedicated ground based observations campaigns have to be carried out. These campaigns represent an enormous observational effort, that must rely on different telescopes and instruments (LF-001 and GA-002).
We base our calibration on the three hydrogen white dwarfs (WD) of Bohlin (2007), G191-2B2, GD71, GD153 (hereafter named *Pillars*), already used as fundamental flux standards for the HST calibration. The Pillars are used to calibrate a set of SPSS (called *Primary* SPSS) that will be visible all year round and from both the hemispheres. The candidate list GA-001, containing $\simeq 50$ 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 (GA-003, primarily selected from McCook & Sion 1999, but also from the Sloan, various SubDwarf catalogues, and other sources), will be observed, calibrated using the Primary SPSS and validated against variability (EP-003) through auxiliary observations. The set of validated Secondary SPSS will constitute the final Gaia grid of flux calibrators, to be ready (at least partially) before launch in 2013. The spectra of SPSS, observed from various ground based sites, will mostly be calibrated with extremely accurate absolute photometry. Absolute photometry campaigns are photometry-only campaigns in very good, photometric observing sites (e.g., San Pedro Mártir, ESO) that will be conducted to support spectrophotometric campaigns in sites where the chance of clear nights is lower (e.g., Calar Alto, Canary Islands).
This document is dedicated to the pre-reduction of *photometric data* obtained during both the

Auxiliary (absolute and relative photometry) and Main (absolute photometry and spectroscopy) campaigns. With the term "pre-reduction" we mean, in this context, the removal of the instrument characteristics (dark, bias, flat-field, bad-pixel mask, fringing) to the 2D scientific photometric frames. The large amount of data collected[1] following the observation procedures described in EP-003 and EP-006, needs to be reduced and analyzed with the maximum possible precision and homogeneity. We have built semi-automatic pipelines for each pre-reduction step which allow to quicken the whole procedure and to monitor the quality of the involved images in order to meet the required precision. These pipelines and the definition of all the Quality Control (QC) parameters used during the pre-reduction procedure are available in Wiki-Bo[2]. While the data reduction methods are fairly standard, care must be taken in considering the characteristics of each instrument as determined during the Instrument Familiarization Plan (see SMR-002 and GA-004), to extract the highest possible quality from each observation.

2 Checklists

This Protocol is centreed around two checklists (Tables 2 and 3) that quickly summarize the procedure on a step by step basis. Each step is described in the corresponding Section shown in the Tables. Moreover, appendices contain detailed instructions to treat the data obtained for all the instruments used in our Campaigns. All the pre-reduction steps have been automated: for each step, a dedicated pipeline is available in Wiki-Bo together with their operational instructions.

2.1 Data Retrieval/Upload

Data obtained in our observing runs have been stored in a web server to make them easily available. Likewise reduced data must be uploaded in our repository. In Table 2 we include the relevant sections in this document where a given operation is explained.

TABLE 2: **Data Retrieval/Upload Checklist**

Operation	**Description**	**Sections**
Documentation	Wiki-Bo Pages	3.1
Downloading raw data	Database & Archive	3.2
Uploading reduced data	Database & Archive	5

[1] We expect $\simeq$ 400 observing nights and of the order of 100 000 frames to complete the survey.
[2] http://yoda.bo.astro.it/wiki/index.php/Pre-red_Pipes_Page
and http://yoda.bo.astro.it/wiki/index.php/IFP_QC_Parameters

TABLE 3: **Data Reduction Checklist**

Operation	Description	Sections
Pre-Reduction		4
	Preliminary steps	4.1
	Overscan, Bias Frames and Trimming	4.2
	Dark Frames	4.3
	Flat Field Frames	4.4
	Bad pixel mask	4.5
	Fringing mask	4.6
	2d pre-reductions	4.7
Single Frames Quality Assessment	Bias	4.2.2
	Flat-field	4.4.1
Master Frames Quality Assessment	Bias	4.2.4
	Dark	4.3.1
	Flat-field	4.4.3

2.2 Data reduction

Table 3 describes in detail the various steps performed by the semi-automatic pipelines. The single frames quality assessment for bias and flat-fields are performed by the pre-reduction pipelines, while the master frames quality control has two dedicated pipelines, one for the masterbias and one for the masterflats. Each operation listed in the checklist is described in more details in its corresponding section. The pipelines do not include the bad pixel mask, the fringing mask and the masterdark production and quality control, but a step by step description of the process is reported in the corresponding section and/or appendix. Table 4 shows all the pre-reduction and quality control pipelines available in Wiki-Bo.

3 Preparing to reduce data

3.1 Finding Documentation

This section contains references to documents, resources and tools useful to people working on the Gaia data. These documents can be internal documents or web pages as well as literature documents and external web pages. The internal Wiki pages maintained in Bologna (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 credential to access them.

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

TABLE 4: **Pre-Reduction Pipelines**

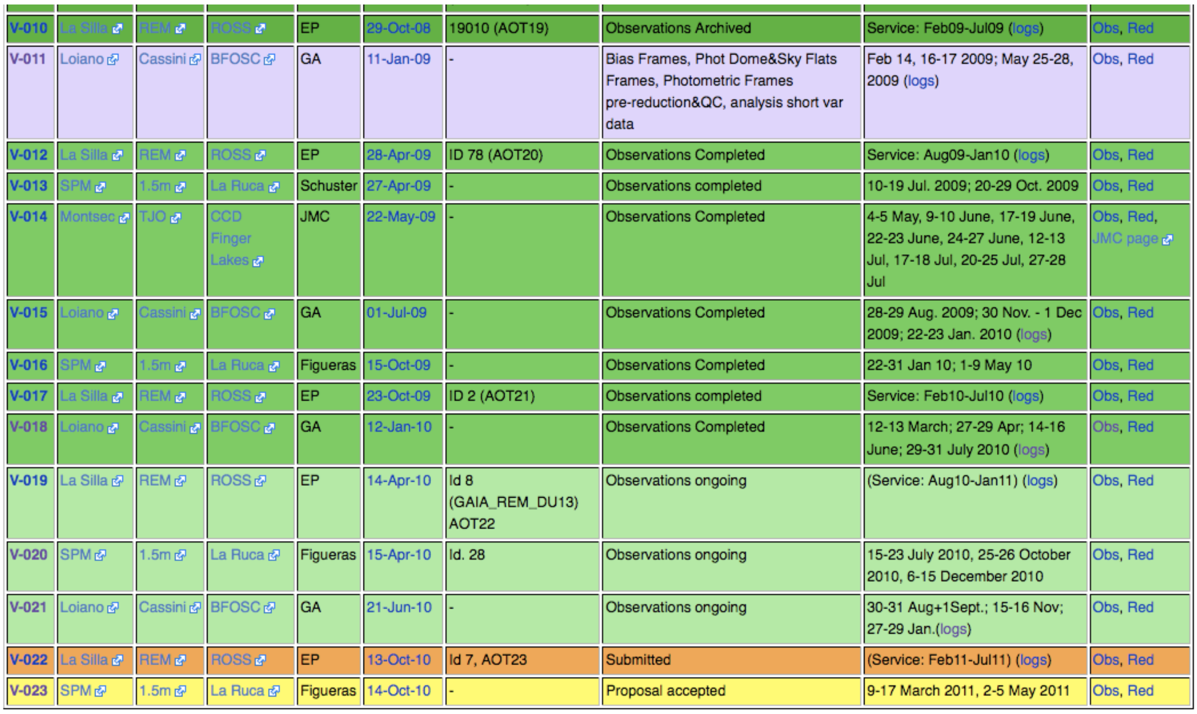
Name and Description	**Where in Wiki-Bo**
MASTERBIAS-PIPE: starting from raw bias, performs the QC on all single bias frames and produces the masterbias	http://yoda.bo.astro.it/wiki/index.php/MasterBiaspipe
PHOTO-MASTERFLAT-PIPE: starting from raw imaging flats, performs the QC on all single flat frames and produce the masterflats (one for each filter used)	http://yoda.bo.astro.it/wiki/index.php/MasterFlatPhotopipe
PHOTO-SCIENCE-PIPE: pre-reduces the imaging frames, performing all the needed corrections (bias, flat, BPM and so on)	http://yoda.bo.astro.it/wiki/index.php/Photopipe
QC-MB-PIPE: performs the QC on all the masterbias produced during one (or more) run	http://yoda.bo.astro.it/wiki/index.php/QC_MasterBiaspipe
QC-PHOTMF-PIPE: performs the QC on all the masterflats produced during one (or more) run	http://yoda.bo.astro.it/wiki/index.php/QC_MasterFlatPhotopipe

In particular, the following Sections of the Wiki-Bo pages are useful for people reducing data:

- *"Documentation"*[5] Section that contains, among other things, the Gaia official documents, literature papers and web resources
- *"Summary table of all our Observing Run"*[6] containing all info on observing runs, including proposals, observing logs, target summaries, links to the raw data repository and reduced data, see Fig. 1.
- *"Pillars and Primary SPSS Table"* [7] and *Secondary SPSS Table*[8] containing all main data on our SPSS including a summary of their observations, and links to the individual SPSS Information pages with literature info, finding charts, spectra, and the status of observations and data reductions for each SPSS

[5] http://yoda.bo.astro.it/wiki/index.php/Documentation_Index_Page
[6] http://yoda.bo.astro.it/wiki/index.php/SPSS_Runs_Table
[7] http://yoda.bo.astro.it/wiki/index.php/Primary_Observations_Table
[8] http://yoda.bo.astro.it/wiki/index.php/Secondary_Observations_Table

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



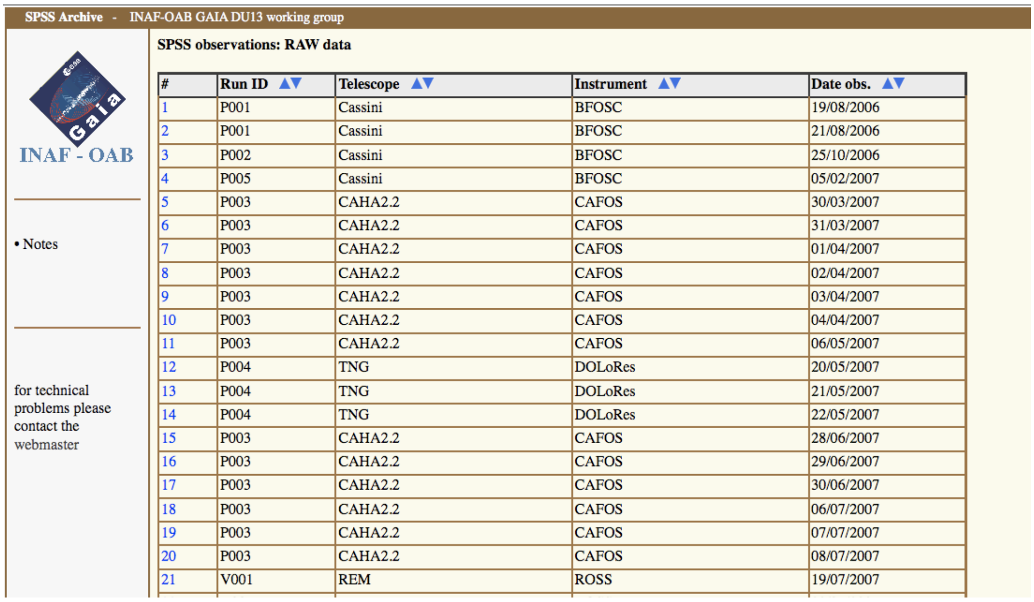
V-010	La Silla	REM	ROSS	EP	29-Oct-08	19010 (AOT19)	Observations Archived	Service: Feb09-Jul09 (logs)	Obs, Red
V-011	Loiano	Cassini	BFOSC	GA	11-Jan-09	-	Bias Frames, Phot Dome&Sky Flats Frames, Photometric Frames pre-reduction&QC, analysis short var data	Feb 14, 16-17 2009; May 25-28, 2009 (logs)	Obs, Red
V-012	La Silla	REM	ROSS	EP	28-Apr-09	ID 78 (AOT20)	Observations Completed	Service: Aug09-Jan10 (logs)	Obs, Red
V-013	SPM	1.5m	La Ruca	Schuster	27-Apr-09	-	Observations completed	10-19 Jul. 2009; 20-29 Oct. 2009	Obs, Red
V-014	Montsec	TJO	CCD Finger Lakes	JMC	22-May-09	-	Observations Completed	4-5 May, 9-10 June, 17-19 June, 22-23 June, 24-27 June, 12-13 Jul, 17-18 Jul, 20-25 Jul, 27-28 Jul	Obs, Red, JMC page
V-015	Loiano	Cassini	BFOSC	GA	01-Jul-09	-	Observations Completed	28-29 Aug. 2009; 30 Nov. - 1 Dec 2009; 22-23 Jan. 2010 (logs)	Obs, Red
V-016	SPM	1.5m	La Ruca	Figueras	15-Oct-09	-	Observations Completed	22-31 Jan 10; 1-9 May 10	Obs, Red
V-017	La Silla	REM	ROSS	EP	23-Oct-09	ID 2 (AOT21)	Observations completed	Service: Feb10-Jul10 (logs)	Obs, Red
V-018	Loiano	Cassini	BFOSC	GA	12-Jan-10	-	Observations Completed	12-13 March; 27-29 Apr; 14-16 June; 29-31 July 2010 (logs)	Obs, Red
V-019	La Silla	REM	ROSS	EP	14-Apr-10	Id 8 (GAIA_REM_DU13) AOT22	Observations ongoing	(Service: Aug10-Jan11) (logs)	Obs, Red
V-020	SPM	1.5m	La Ruca	Figueras	15-Apr-10	Id. 28	Observations ongoing	15-23 July 2010, 25-26 October 2010, 6-15 December 2010	Obs, Red
V-021	Loiano	Cassini	BFOSC	GA	21-Jun-10	-	Observations ongoing	30-31 Aug+1Sept.; 15-16 Nov; 27-29 Jan.(logs)	Obs, Red
V-022	La Silla	REM	ROSS	EP	13-Oct-10	Id 7, AOT23	Submitted	(Service: Feb11-Jul11) (logs)	Obs, Red
V-023	SPM	1.5m	La Ruca	Figueras	14-Oct-10	-	Proposal accepted	9-17 March 2011, 2-5 May 2011	Obs, Red

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

3.2 Downloading Raw Data from the Archive

All data obtained in our Pilot Project (testing phase), Main Campaign (devoted to spectroscopic and absolute photometry observations) and Auxiliary campaign (devoted to photometric observations, both absolute and relative) are archived in a web server[9] (see Fig. 2 and 3), so that they can be easily retrieved by all people working on them.
Detailed instructions can be found in the DB&A section in Wiki-Bo.
The *"SPSS Reduced Data Archive"*[10] should be checked to see if masterframes relative to selected runs are already available and if the data obtained in the selected nights have already been partially or completely reduced. The detailed Data Reduction Logs in the Wiki-Bo page of each run can also be checked to see who performed the reduction and the corresponding data uploaded in the Archive.

[9] http://spss.bo.astro.it/
[10] http://spss.bo.astro.it/red.cgi/


SPSS Archive - INAF-OAB GAIA DU13 working group

INAF - OAB

• Notes

for technical problems please contact the webmaster

SPSS observations: RAW data

#	Run ID	Telescope	Instrument	Date obs.
1	P001	Cassini	BFOSC	19/08/2006
2	P001	Cassini	BFOSC	21/08/2006
3	P002	Cassini	BFOSC	25/10/2006
4	P005	Cassini	BFOSC	05/02/2007
5	P003	CAHA2.2	CAFOS	30/03/2007
6	P003	CAHA2.2	CAFOS	31/03/2007
7	P003	CAHA2.2	CAFOS	01/04/2007
8	P003	CAHA2.2	CAFOS	02/04/2007
9	P003	CAHA2.2	CAFOS	03/04/2007
10	P003	CAHA2.2	CAFOS	04/04/2007
11	P003	CAHA2.2	CAFOS	06/05/2007
12	P004	TNG	DOLoRes	20/05/2007
13	P004	TNG	DOLoRes	21/05/2007
14	P004	TNG	DOLoRes	22/05/2007
15	P003	CAHA2.2	CAFOS	28/06/2007
16	P003	CAHA2.2	CAFOS	29/06/2007
17	P003	CAHA2.2	CAFOS	30/06/2007
18	P003	CAHA2.2	CAFOS	06/07/2007
19	P003	CAHA2.2	CAFOS	07/07/2007
20	P003	CAHA2.2	CAFOS	08/07/2007
21	V001	REM	ROSS	19/07/2007

FIGURE 2: Portion of the *"SPSS Raw Data Archive"* main table showing the archived runs with hyperlinks to the raw data obtained in each night.

4 Imaging Pre-reduction procedures

The primary aim of CCD data pre-reductions is to remove any effect due to the detector and the telescope, the so called "instrumental signature". There are many instrumental patterns that appear in astronomical images. The most common are additive or multiplicative patterns that are removed from the observations using proper templates. The pattern template is generally derived from calibration frames or directly from sets of scientific data. Additive effects, such as bias or dark (Section 4.2 and 4.3 respectively), are corrected by subtracting the corresponding template from the scientific images (by applying, where necessary, a numerical scaling factor derived from the exposure times). Multiplicative effects, such as flat field (Section 4.4), are removed by dividing the scientific frames by an appropriate template. However, some patterns vary in amplitude from exposure to exposure. The variation is caused by differences in the field of view. An example is CCD fringing (Section 4.6) because fringing varies with the strength of the atmospheric emission lines. Patterns like this are removed by scaling the pattern amplitude to match a data image and then subtracting it from the data image. The cosmetic defects of CCDs can be easily removed with the application of an appropriate Bad-Pixel mask (Section 4.5). Bad pixels are replaced by linear interpolation along lines or columns using the nearest good pixels.
In this section we describe, step by step, the procedure to be followed for the imaging data pre-reduction for our absolute and relative photometry campaigns. Even if the reduction steps are similar for all adopted instruments, in some cases particular care and/or tricks are required.

☐	i k	JVSA0179.fts	050	EG131	Max ~75000 cts
☐	i k	JVSA0180.fts	050	EG131	"
☐	i k	JVSA0181.fts	050	EG131	"
☐	i k	JVSA0182.fts	050	EG131	Preimaging
☐	i k	JVSA0183.fts	050	EG131	Through-slit: centered
☐	i k	JVSA0184.fts	050	EG131	-
☐	i k	JVSA0185.fts	050	EG131	-
☐	i k	JVSA0186.fts	050	EG131	-
☐	i k	JVSA0187.fts	050	EG131	End UT=4:54, humidity 25%
☐	i k	JVSA0188.fts	0	HD204827	For polarimetry check; preimaging, saturated
☐	i k	JVSA0189.fts	0	HD204827	preimaging, saturated
☐	i k	JVSA0190.fts	0	HD204827	preimaging, saturated, use "cursor" to put in slit
☐	i k	JVSA0191.fts	0	HD204827	-
☐	i k	JVSA0192.fts	0	HD204827	Through slit: centered, but perhaps not too well, it saturates
☐	i k	JVSA0193.fts	0	HD204827	PA; note it has a small, nearby companion; short
☐	i k	JVSA0194.fts	0	HD204827	PA; short
☐	i k	JVSA0195.fts	0	HD204827	"
☐	i k	JVSA0196.fts	0	HD204827	"
☐	i k	JVSA0197.fts	0	HD204827	"
☐	i k	JVSA0198.fts	0	HD204827	"
☐	i k	JVSA0199.fts	0	HD204827	"
☐	i k	JVSA0200.fts	0	HD204827	Sky too bright and star not well in slit. Not enough signal. End of night 05:23 UT

☐ select/unselect all fits

Download selected (password required) ••••••••• reset selected fields

FIGURE 3: Portion of a single night table in the *"SPSS Raw Data Archive"*

These cases will be described in details in the Appendix section dedicated to each instrument. The main steps involved in removing the instrumental signature are listed below:

- overscan, bias subtraction and trimming;
- dark subtraction (if needed);
- flat fielding;
- bad pixel mask (if needed)
- fringing subtraction (if needed)

For each type of calibration frame, a set of Quality Control parameters are defined in order to extract the highest possible quality from our data. The next paragraphs will describe how to perform operationally these actions together with some preliminary steps.

All our procedures are based on the Image Reduction and Analysis Facility (IRAF[11]) and on the smongo[12] plotting tool.

4.1 Preliminary steps and nomenclature

Some initial fundamental steps to be done before starting the pre-reduction using our pipelines are:

1. Download the images to be reduced from our Raw Data Archive (Section 3.2) and, using the Official DU13 Log of each night (that can be found in Wiki-Bo, in the Observing Logs Table of each run page), separate each image type (bias, photometric flats, and science) in a dedicated directory.
2. Download the specific pipeline-tarfile from Wiki-Bo in the correct directory (for example, the MASTERBIAS-PIPE in the directory containing all raw bias frames, and so on) and process the tarball with the tar command. Copy all the scripts in the working directory.
3. To produce the masterflat frames, remember to copy also the masterbias previously created in the directory containing all raw flat frames.
4. To pre-reduce the photometric science frames, remember to copy also the masterbias and all masterflats in the working directory.
5. Remember that the filename of reduced data has to meet precise requirements[13]: all the pipelines can not work properly if the naming convention is not followed. Table 6 shows some example of our naming convention.
   Summarizing for photometry:
   - The **Master calibration frames filenames** will have a formal name structure made of the letter "m." followed by the standard run ID string (Vxxx or Mxxx for the Auxiliary or the Main Campaign respectively), by the telescope and instrument IDs (to be selected form Table 5), by the calibration type (bias, flat etc.) and by the type specifier (exptime in seconds for dark, filter for photometric flats, etc.).
   - The **science frame filenames** will have the same names as the original raw files, preceded by a letter that specifies the reductions performed. For example: if the raw file is called *mb_233.fits*, the corresponding pre-reduced file will

[11] `http://iraf.noao.edu/`. IRAF is distributed by the National Optical Astronomy Observatories (NOAO), which are operated by the Association of Universities for Research in Astronomy (AURA), Inc., under cooperative agreement with the National Science Foundation.

[12] `http://www.supermongo.net/`

[13] `http://yoda.bo.astro.it/wiki/index.php/Reduced_Data_Archive_Requirements`

be called *r.mb_233.fits*. The photometric catalogue extracted from a reduced imaging frame will have a "c." prefix and ".cat" extension, as it follows:

– **r.<filename>** : two-dimensional frames, corrected for the necessary steps among dark, bias, flats, cosmic rays, bad pixel masks, fringing
– **c.<filename>.cat**: aperture photometry catalogue extracted from the photometric pre-reduced frame named **r.<filename>**

TABLE 5: **ID convention for Telescopes and Instruments**

Telescope ID	**Instrument ID**
Cassini	BFOSC
CAHA2.2	CAFOS
TNG	DoLoRes
NTT	EFOSC2
SPM1.5	LaRuca
REM	ROSS

4.2 Bias Frames

One of the best ways to know the condition of a CCD is to careful examine the bias frames. While reading a CCD, the Analogue-to-Digital Converter (ADC) samples the charge accumulated in each pixel and returns a digital value. This value is proportional to the actual number of electrons detected in the pixel and is measured in Analogue-to-Digital Units (ADUs). The relation between ADU and the number of detected photons (charge) is a scale factor known as gain (measured in e^-/ADU). The bias is an offset, preset electronically, to ensure that Analogue-to-Digital Converter (ADC) always receives a positive value and that it is operating in a linear regime as much as possible. The offset for each exposure given by the bias level has to be subtracted before further reduction. The bias frame may be modelled as A+$F(x_i, y_i)$, where:

- F, the pixel-to-pixel structure of the frame, is time-invariant (if there are no particular problems). F can be determined by acquiring many exposures of zero seconds without opening the shutter, i.e., by simply reading out the CCD. $F(x_i, y_i)$ is the so-called "two-dimensional structure of the *masterbias*". The masterbias takes into account the possible dependence of the bias on the pixel position and it can be defined by building a median stack of these frames, with intrinsic uncertainties due to RON. We usually acquire at least 10 bias frames per night in order to build the masterbias. This allows us to get better statistics and to exclude other spurious effects (as, for example, cosmic rays).

TABLE 6: **Some example of Master calibration frame filenames**

Master calibration frame name	**Description**
m.<run-id>-<tel>-<inst>_<AAAAMMDD>_DARK_200.fits	a Masterdark of 200 seconds
m.<run-id>-<tel>-<inst>_<AAAAMMDD>_BIAS_FULL.fits	a full CCD Masterbias
m.<run-id>-<tel>-<inst>_<AAAAMMDD>_BIAS_SPEC.fits	a Masterbias cut with the spectroscopic section, for CAHA
m.<run-id>-<tel>-<inst>_<AAAAMMDD>_BIAS_PHOT.fits	a Masterbias cut with the photometric section, for CAHA
m.<run-id>-<tel>-<inst>_<AAAAMMDD>_DOME_V.fits	a photometric lamp Masterdomeflat in the V filter
m.<run-id>-<tel>-<inst>_<AAAAMMDD>_SKY_V.fits	a photometric twilight/sunrise Masterkyflat in the V filter
m.<run-id>-<tel>-<inst>_<AAAAMMDD>_LAMP_R200_2.5.fits	a spectroscopic lamp Masterflat grism R200, slit 2.5”
m.<run-id>-<tel>-<inst>_<AAAAMMDD>_LAMP_G5_5.fits	a spectroscopic lamp Masterflat grism G5, slit 5”
m.<run-id>-<tel>-<inst>_<AAAAMMDD>_LAMP_G16_10_ID212.fits	a spectroscopic lamp Masterflat associated to the SPSS212, grism G16, slit 10”
m.<run-id>-<tel>-<inst>_<AAAAMMDD>_LAMP_G16_10_ID212.1.fits	a spectroscopic lamp Masterflat associated to the fisrt set of spectra of SPSS212, grism G16, slit 10”, if there are multiple observations of the same star
m.<run-id>-<tel>-<inst>_<AAAAMMDD>_WAVE_LR-R_11.7.fits	a daytime reference lamp grism LR-R, slit 11.7”
m.<run-id>-<tel>-<inst>_<AAAAMMDD>_ILL_LR-B_2.fits	a twilight, spectroscopic Masterflat grism LR-B, slit 2”

- A, the overall bias level, can slightly change during the night because of external factors (for example, temperature variations). The level of the bias for each exposure is best determined by the *overscan* region, when available (it is not always the case). The overscan data are acquired by continuing to readout the CCD beyond its real physical extent: the result is an oversized array with a strip of signal free pixels (because the overscan provides a measure of the electronic bias level that physically indicates zero photon counted) from which A can be measured for a particular exposure. If the overscan strip is not present, the masterbias implicitly contains also A.

When an overscan section is available, all images can be first corrected for overscan: this way, if the bias level of a scientific image has varied with respect to the masterbias[14] built with frames taken hours before or after, the image can be more accurately corrected. The overscan correction will follow only the bias level variation with time but it will not account for possible 2D structures of the bias. In fact when correcting for overscan, the overscan region is fitted along a row (or a column, depending on the readout direction of the CCD) and the fit is subtracted from each column (raw) in the frame. In case of a zero order fit, the correction is a simple constant. In the other cases it will be a one-dimensional array. Usually a low order cubic spline (order 3-5) is sufficient to model the overscan.
Masterbias are built using the pipeline **MASTERBIAS-PIPE**, available in Wiki-Bo (see Table 4)

4.2.1 Determine Overscan and Trim sections

The overscan correction (if possible) and the subsequent trimming has to be applied to all frames, both calibration and scientific.
By careful examination of the bias frames, overscan sections[15], best fitting order of the overscan, and "good data" sections were determined for all the instrument used, which will ensure homogeneous data treatment (see Table 7).

TABLE 7: CCD sections for imaging pre-reduction

Instrument	**Overscan Section**	**Best fitting order for the overscan**	**Good Data Section for imaging**
BFOSC@Cassini	no overscan	-	[1:1335,1:1300] (EEV old)
			[7:1340,1:1300] (EEV new)
CAFOS@CAHA2.2	no overscan	-	[10:1120,10:1120] for run P003
			[10:1014,10:1014] for all runs M
DoLoRes@TNG	[15:2085,2065:2085]	5	[25:2089,25:2045] until M009a
			[55:2085,25:2045] from M009b
EFOSC2@NTT	no overscan	-	[20:2000,10:2000]
LaRuca@SPM	[1020:1070,1:1024] (SITE1)	3	[15:1013,15:1024] (SITE1)
	[2110:2150,1:2048](Marconi e2v4240)	5	[60:2095, 5:2045] (Marconi e2v4240)
ROSS@REM	no overscan	-	[*,*]

The overscan and trimming sections were found analyzing the images using the IRAF task implot:

- The overscan region of CCD. If present, the overscan section is a section of a few tens of pixels at the edge of the frame and it will have less counts with respect to the

[14] Obviously, also the single bias frames have to be corrected for overscan before creating the masterbias.
[15] If the overscan region does not appear so evident in bias frames, also a flat field frame can be used to check for the existence and position of the overscan region. In addition, if vignetting is present, a better determination of the trim section is possible using one flat.

rest of the image (see right panel of Fig. 4). This allows us to define the value of the BIASSEC keyword to be written in the fits header with the IRAF task `hedit`.

- The "good region" of the bias. Often, the first (or last) lines and the first (or last) columns are deviant (see left panel of Fig. 4) and must be removed. This allows us to determine the best trim section in order to avoid regions of CCD with problems and to define the value of the TRIMSEC keyword to be written in the fits header with the IRAF task `hedit`.

Because, for some instruments, we use different CCD sections (or CCD binning) for imaging (for example a square, bin1x1) and spectroscopy (for example a rectangle, bin2x2), the trimming values will change accordingly. Overscan sections and trimming used by the pipelines for all adopted instruments are specified in the instrument specific Appendices and summarized in Table 7. In the pipeline, the fits headers are *automatically* updated with the correct overscan and trim sections depending on the selected instrument. This way, the `ccdproc` command lines are independent of the specific instrument being processed because the correct sections are embedded in the fits header, and one single `ccdproc` command specifying `biassec="image"` and `trimsec="image"` can be used for all frames.

4.2.2 Single frame Quality Assessment

The pipeline compute the image statistics (median and standard deviation) using the IRAF task `imstat` for all raw bias frames in the regions defined by the TRIMSEC and BIASSEC values. This allows us to compute the median level and sigma of both the overscan (if present) and the good region of the CCD. The median and sigma of the bias and overscan regions of the CCD (which we name *OVERSCANmedian*, *BIASRAWmedian* and *BIASRAWsigma*) and one additional control parameter (which we name *OVERSCANsigma*) are the four basic QC parameters[16] for bias frames. Three of these are the input of the smongo macro *biasRAWsingle*[17] which is automatically called by the pipeline and produces the basic QC plot for single bias frames (see, for example, Fig. 5).This plot allows us to reject all bias frames with problems: for example, in a set of consecutive bias we can suppose that the CCD temperature remains constant and the possible deviant behaviour of one bias can be easily recognized. Obviously, this "bad" bias shall not be used for the construction of masterbias (see, for example, Fig. 6).

When the overscan strip is present, each "good" bias has to be corrected for the overscan and trimmed in order to remove the edges of the frames. The IRAF task `ccdproc` is used by the pipeline to perform the correction. Once each bias is corrected for overscan and trimmed, the pipeline again performs the Quality Assessment (QA) step on all these frames using the IRAF task `imstat` in order to investigate if the correction for overscan worked properly. This

[16]You can find the description of each QC parameter used for each type of calibration frames in the WikiBo page: `http://yoda.bo.astro.it/wiki/index.php/IFP_QC_Parameters`

[17]This macro is contained in the tarfile available in WikiBo at: `http://yoda.bo.astro.it/wiki/index.php/MasterBiaspipe`

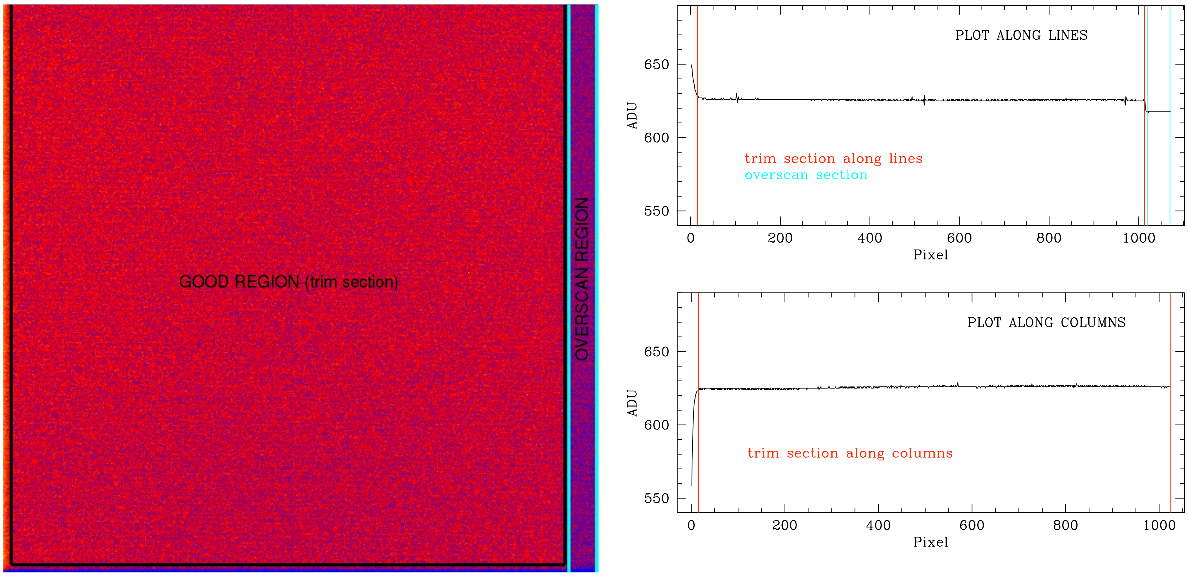


FIGURE 4: *Left panel*: raw bias taken with LaRuca@SPM on April 22 2008. The overscan region (area contained within cyan lines) and the good part of the CCD (red coloured area contained within black lines) are shown. *Right panel*: Structure plots. The X direction structure is obtained by collapsing and averaging the raw bias along rows (top panel). The Y structure is obtained in the same way along columns (bottom panel). The bias "good section" has virtually no structure in both X and Y, but the first 15 rows and columns show an opposite structure: the first 15 rows decrease below the average level value of about 75 ADU while the first 15 columns increase above the average level value of about 25 ADU, so they have to be trimmed. In the top panel the small structures at pixel 103, 520 and 970 are due to bad columns.

step produces two additional QC parameters (named *BIASCORRmedian* and *BIASCORRsigma*) which are the input of the smongo macro *biasCORsingle*[18]. The macro, automatically called by the pipeline, builds the second QC plot for single bias frames (see, for example, Fig. 7): if there are deviant points the corresponding biases have to be excluded from the next steps of reduction. Obviously, this step can not be performed if the overscan section is not present (for example, for BFOSC@Cassini data). In this case, after performing the quality check on all raw biases and excluding those with some problems, the masterbias can be created (see Sec.4.2.3).

[18]This macro is contained in the tarfile available in WikiBo at: `http://yoda.bo.astro.it/wiki/index.php/MasterBiaspipe`

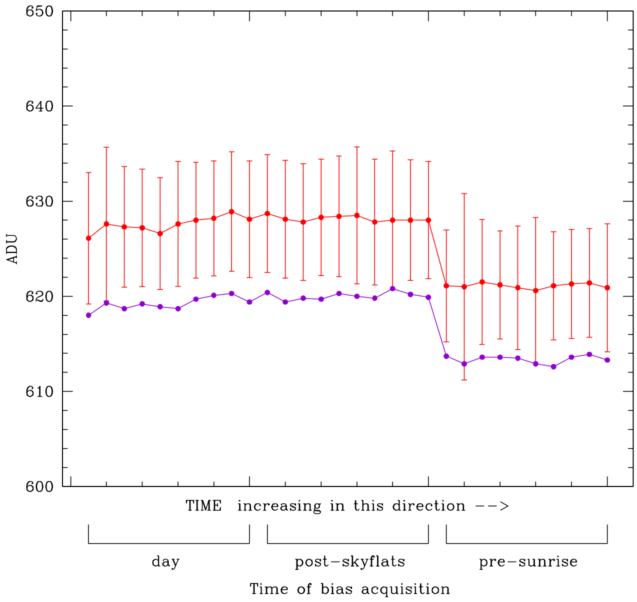


FIGURE 5: Statistics for the three sets of bias acquired with LaRuca@SPM on April 22 2008. Red dots and lines correspond to the median value and standard deviation of the "good region" of the CCD. Violet dots and lines are the median of the overscan section. The bottom labels show the time of acquisition of the bias frames. Differences in counts between bias frames acquired immediately after twilight and before sunrise are due to temperature variations of CCD during the night.

4.2.3 Masterbias Production

Once each single bias frame has been quality checked, trimmed and overscan corrected (if possible), the pipeline automatically creates a masterbias using the IRAF task `zerocombine`[19]. We recommend to check the Wiki-Bo pages, or Section 4.1 and Table 6 for the masterbias nomenclature rules.

4.2.4 Masterbias Quality Assessment

When masterbias frames for all nights in one run are built, another semi-automatic pipeline called **QC-MB-PIPE**[20] checks their stability using the IRAF task `imstat` to make statistics

[19] Using the task *zerocombine*, `"median"` is set by the pipeline as combine mode and `"minmax"` as rejection mode. The parameters for tuning the "minmax" rejection mode are set to the default values

[20] You can download this pipeline at: `http://yoda.bo.astro.it/wiki/index.php/QC_MasterBiaspipe`

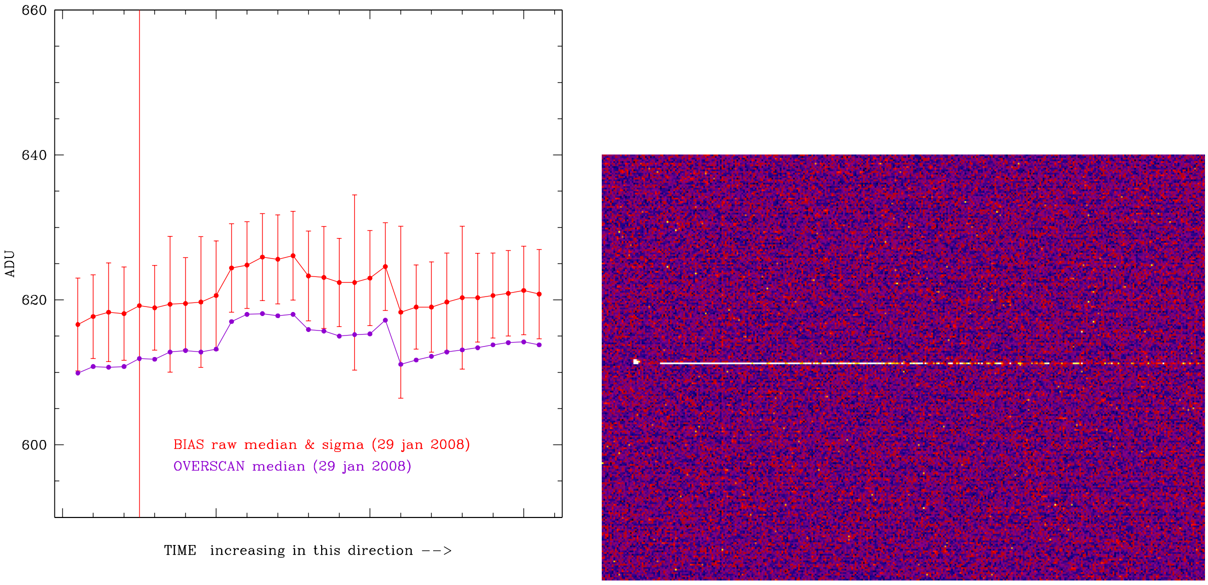


FIGURE 6: *Left panel* Statistics for the bias frames acquired with LaRuca@SPM on January 29 2008. Red dots and lines correspond to the median value and standard deviation of the "good region " of CCD. Violet dots and lines are the median of the overscan section. We can note the deviant point with a huge errorbar corresponding to frame bias 4005b.fits and we can say immediately that this bias must have some problems. *Right panel* Section [460:822,672:927] of the bias 4005b.fits shows part of the cause of its high stantard deviation: obviously this bias must be excluded from the procedure for building the masterbias.

(median and standard deviation) for all masterbias frames collected in the working directory[21]. Similarly to the QA of single bias frames, the median and standard deviation of the masterbias frames are the two main QC parameters (named *MASTERBIASmedian* and *MASTERBIASsigma*) used to produce a QC plot similar to the one shown in Fig. 8. This plot is produced by the pipeline calling the smongo macro *MBtrend.sm*[22] and it allows to visually assess if the nightly masterbias frames were sufficiently stable during the whole run.
The stability of the two-dimensional structure of the masterbias produced during one run can be visually checked with another automatically produced QC plot, shown in Fig. 9. To produce the plot (the pipeline autometically calls the smongo macro *MBstruct.sm*[23]), five areas on the surface of each masterbias were defined for each instrument, one for each corner and one for the centre of each image. The ratio between the median value of each corner and the median value of the centre (measured using `imstat`) is the QC parameter which allows us to perform

[21] Obviously, all (and only) the masterbias frames produced during the run must be copied in the work directory containing the pipeline QC-MB-PIPE.
[22] This macro is contained in the tarfile available in Wiki-Bo at: `http://yoda.bo.astro.it/wiki/index.php/QC_MasterBiaspipe`
[23] This macro is contained in the tarfile available in Wiki-Bo at: `http://yoda.bo.astro.it/wiki/index.php/QC_MasterBiaspipe`

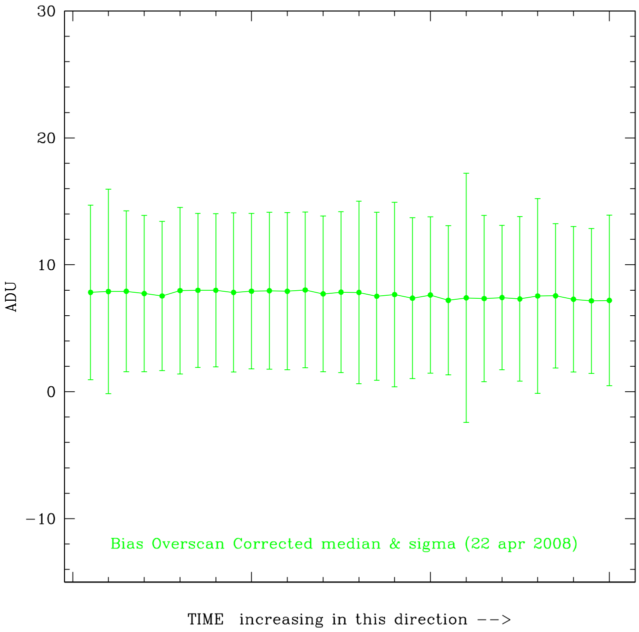


FIGURE 7: Median and standard deviation for the three sets of bias frames acquired with LaRuca@SPM on April 22 2008 and corrected for the overscan. In this case, all bias frames can be combined to build the masterbias. The average value of overscan-corrected bias frames should be zero, but small and negligible offset between overscan and bias are not inusual, as in this case.

this check. The area sections used to perform the 2D stability check for each CCD/instrument combination are reported in the instrument specific Appendices, and are automatically used by the pipeline depending on the choosen intrument.
The surface shape of the masterbias can be examined also by making a 3D plot using the gnuplot macro *graph3Dbias.gnu*[24] (see, for example, Fig. 10).
It is important to know the stability of the masterbias frames, especially when no overscan strip is available to correct each scientific image for the appropriate bias level. In fact, when the masterbias stability is good during the run, if a masterbias for a specific night is not available, the masterbias produced in the previous or following night can be used in the pre-reduction process. On the other hand, if the masterbias stability is not good (within 1%), then the daily acquisition of bias frames becomes mandatory, because the masterbias produced for a specific night can not be used to reduce data acquired in other nights of the same run.

[24]This macro, not included in the pipeline and it must be run independently.
The macro is available at: `http://yoda.bo.astro.it/wiki/index.php/File:graph3Dbias.txt`. Change the file extension from .txt to .gnu after the download.

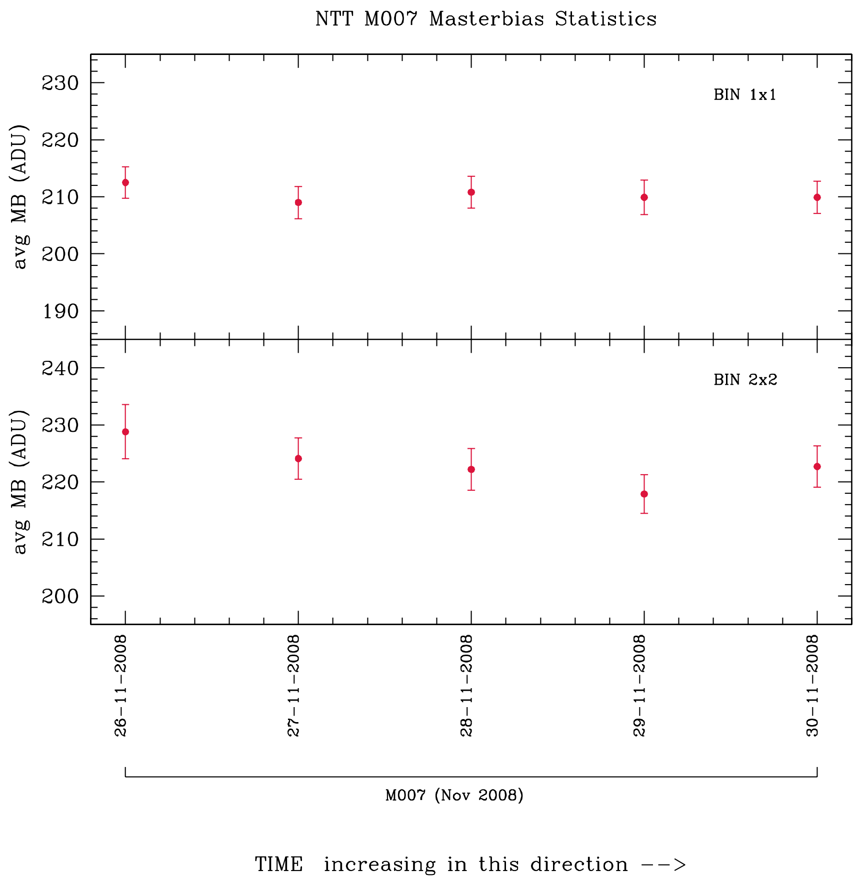


FIGURE 8: Statistics of all masterbias frames produced using the data acquired with EFOSC2@NTT during run M-007. The overscan is defined "inadequate for bias subtraction" in the ESO instrument manual (available at `http://www.eso.org/sci/facilities/lasilla/instruments/efosc/doc/manual/EFOSC2manual_v3.1.pdf`). This is confirmed by our tests (see Appendix D.1), hence the overscan correction is not performed for EFOSC2 data.

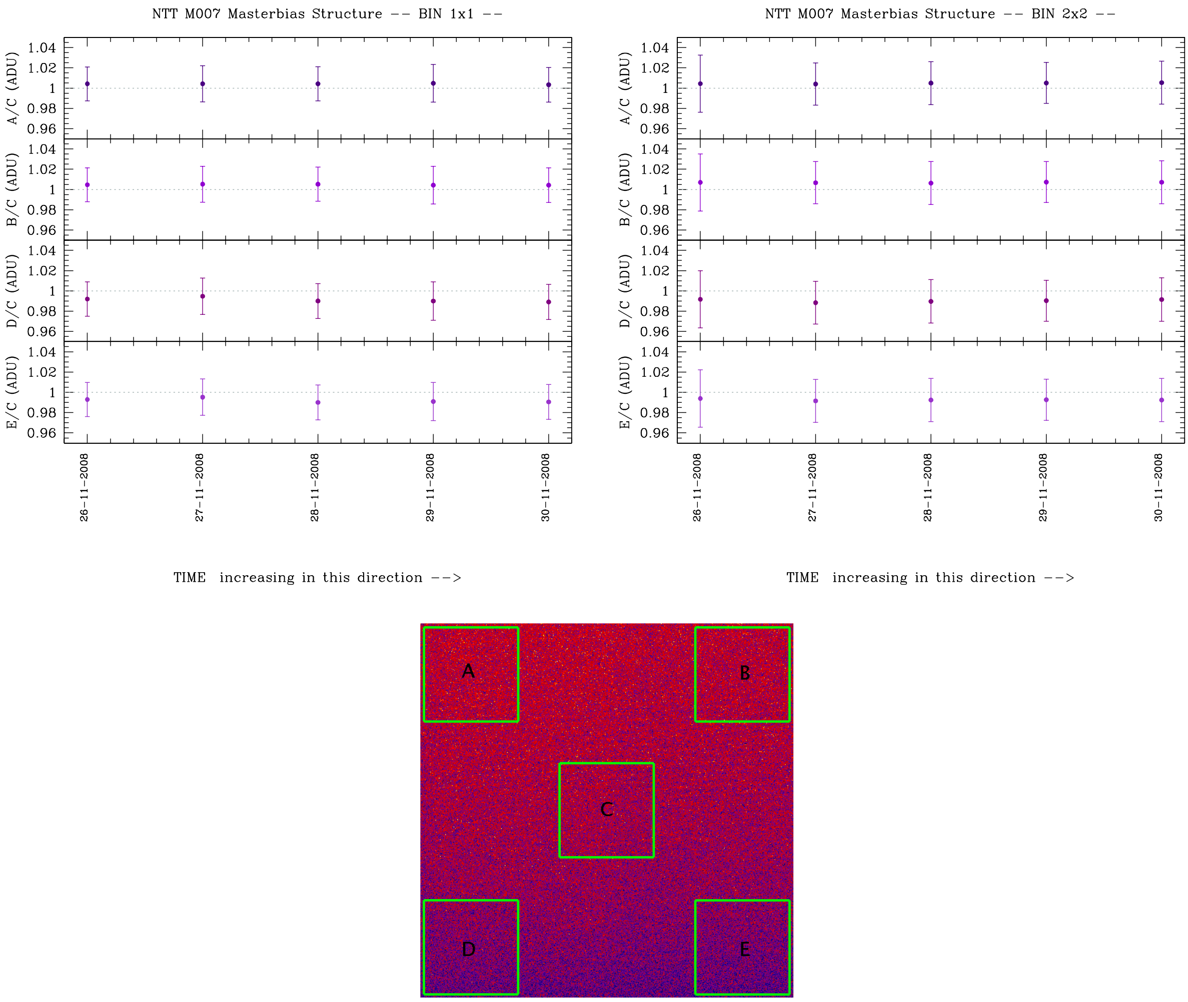


FIGURE 9: In the *upper panel*, check of the bidimensional structure of the masterbias produced using the data acquired with EFOSC2@NTT during run M-007. In the *lower panel*: location of the areas A, B, C, D and E involved in the structure stability test.

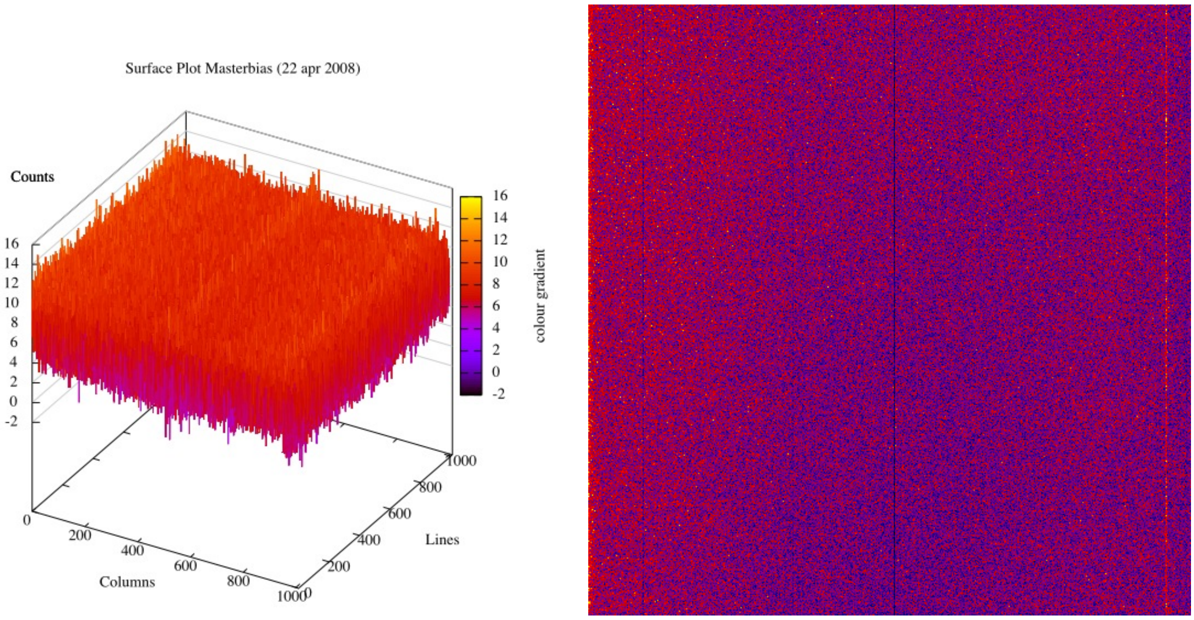


FIGURE 10: 3D plot (*Left panel*) and 2D plot (*Right panel*) of the masterbias produced using the bias frames acquired with LaRuca@SPM on April 22 2008 . The surface of the masterbias appears very smooth and regular and no pattern is present. We can see again the death/hot columns at pixel 103, 520 and 970 as in Fig.6.

All the produced masterbias frames should be archived following the procedure reported in Section 5 and following the naming convention reported in Table 6 and in Wiki-Bo. In addition, for each archived masterbias, the Reduction Log Table hosted in the corresponding Wiki-Bo run page has to be compiled (Section 6).

4.3 Dark Frames

Dark correction is the subtraction of the electron counts which accumulate in each pixel due to thermal noise. The reduction of dark currents is the main reason why all astronomical CCDs are cooled to liquid nitrogen temperatures. Most modern CCDs only produce a few ADU per pixel per hour, so this effect can generally be ignored[25]. In our case, since our goal is a very high final data quality, we checked if a dark correction was needed in the pre-reduction procedure for our instruments.
When a dark correction is needed, it can be applied with `ccdproc` by setting `darkcor+` and providing the name of the masterdark frame with `dark=masterdark.fits` in the `ccdproc` command. The masterdark frame is the result of several dark frames acquired with

[25]This is not the case of ROSS@REM: the CCD is cooled by a Peltier system, therefore dark frames are taken periodically by the REM team and they of course already include the bias level and pattern (bias frames are not acquired).

the same exposure time and combined using the IRAF task `darkcombine`, similarly to bias frames. Before combining, dark frames must be overscan (if possible) and bias corrected and trimmed, as all images.
For example:

```
ccdproc images=@dark.list output=@dark2.list ccdtype="" noproc-
        overscan+ trim+ fixpix- zerocor+ darkcor- flatcor-
        illumcor- interac- readaxi="line" biassec="image"
        trimsec="image"  function=spline3 order=3
        zero=masterbias.fits

darkcombine input=@dark2.list
            output=m.V006-SPM-LaRuca_20081109_DARK_XXX.fits
            combine=median reject=minmax ccdtype="" process-
            rdnoise="" gain="" snoise=""
```

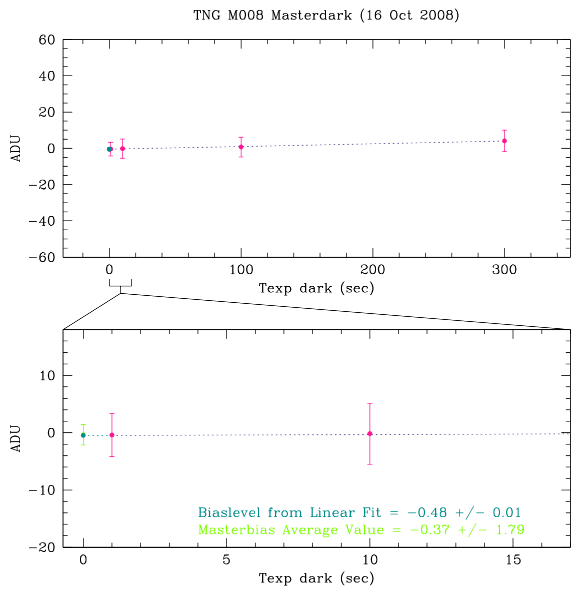


FIGURE 11: Quality Control on masterdark frames of run M-008@TNG. The mean value of each masterdark is plotted against the exposure time. In the *bottom panel* a zoom is shown in order to compare the bias level extrapolated from the linear fit with that measured directly from the masterbias.

4.3.1 Masterdark Quality Assessment

To check how the dark currents grow with time, the mean value of each masterdark frame is plotted against exposure time (see for example, Fig. 11). In this case, each masterdark frame is built without correcting for masterbias: this way, a linear fit can be performed, extrapolated at zero exposure time, and this value can be compared with the measured bias level from masterbias. The masterbias has to be subtracted from the masterdark with the longest exposure time in order to see if the dark correction is required. If the mean of the resulting image is negligible compared to its standard deviation, we can avoid the dark correction[26].
Our tests indicates that a dark correction is not needed in our data (SMR-002), except for data acquired with ROSS@REM. Therefore the pipeline to pre-reduce the scientific images (see Section 4.7) includes the dark correction only for REM data.

4.4 Flat Fielding

After bias subtraction and, if needed, dark correction, the data values are directly related to the number of photons detected in each CCD pixel. But different pixel can be characterized by different sensitivity. The flat fielding correction accounts for the non uniform CCD response to the incident light that can show variations on all scales, from the whole CCD to pixel-to-pixel scale.
The basic idea is to divide the data by a *sensitivity map* (called *masterflat*) created from calibration exposures. The effect of dust on the filters or on the detector, the vignetting and other variations in the throughput of the instrument optics are also corrected by flat fielding. In imaging, an evenly illuminated image is used as the flat field. It can be obtained using a uniformly illuminated screen inside the telescope dome (domeflat) or, better, the sky at twilight/sunrise (skyflat). Skyflats are usually preferred to domeflats. This is because they ensure both a much uniform illuminated field of view and, most important, the solar SED is more similar to the star light than an artificial lamp[27].
Because the detector efficiency changes with wavelength, flats are needed in all the bands used for the scientific frames. Flat fields should always be acquired using the same instrumental setup adopted for observing scientific objects.
Masterflats are built using the pipeline **PHOTO-MASTERFLAT-PIPE** (see Table 4) by making a median of a number of flats in order to have better statistics, to reduce the noise and to get rid of cosmic ray hits.

[26] If the dark correction is negligible for the longest exposure time, it will be negligible also for lower exposure times.
[27] Another important characteristic of skyflats is that they are focused at infinity, as the scientific frames.

4.4.1 Single frame Quality Assessment

First of all, the pipeline trims and corrects both dome and skyflats for masterbias[28] and overscan (if possible), using the IRAF task `ccdproc`.

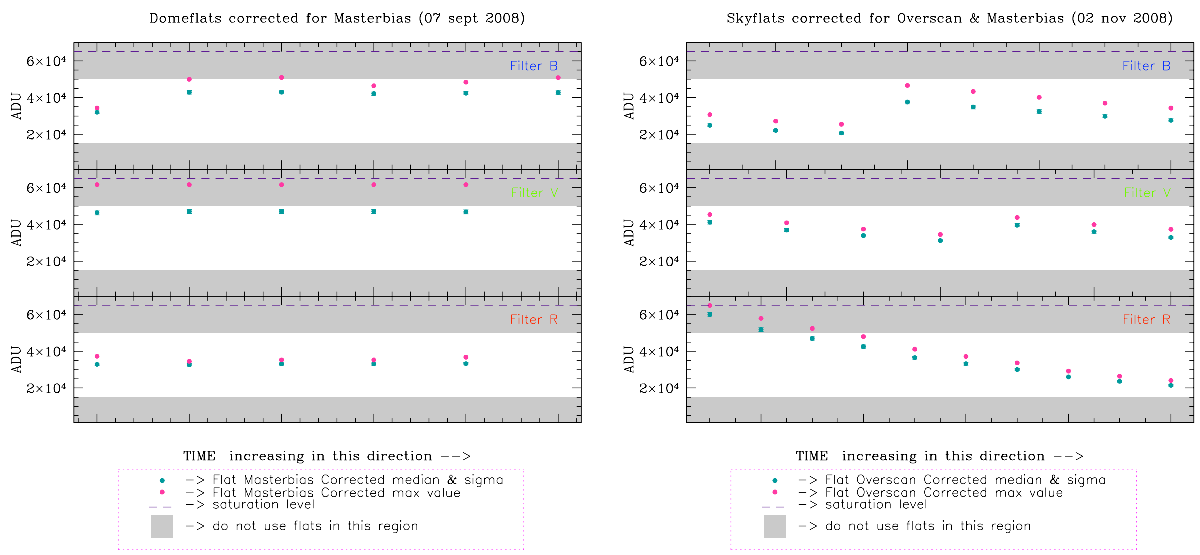


FIGURE 12: Example of QC on dome and sky flats. The QC is performed on domeflats acquired with CAFOS@CAHA on September 07 2008 *left panel* and on skyflats acquired with LaRuca@SPM on November 02 2008 *right panel*. The gray shaded areas represent regions of too high (close to saturation) or too low (noisy) median counts for flat fields.

Obviously, also for flats, each image header is previously updated by the pipeline with the correct values for BIASSEC and TRIMSEC using `hedit`.
Since there must be at least a photometric masterflat (dome or skyflat) defined for each filter used, the pipeline creates several files containing the list of names of domeflats or skyflats acquired with different filters and named accordingly. Once all single flats are bias and overscan (if possible) corrected and trimmed, the pipeline automatically checks if there are some anomalous flats which must not be used in the masterflat creation, using the IRAF task `imstat` in order to calculate the median level, the standard deviation and the maximum value of each flat. These three QC parameters are used to automatically build a QC plot similar to the ones shown in Fig. 12, which allow us to visually check if the available photometric flat fields have suitable count levels. Only flats with median between 15 000 and 50 000 ADU are used to build masterflats[29], and this is valid for all our chosen instruments. The pipeline builds this quality check

[28] see Section 4.2 for the masterbias production
[29] To ensure high S/N and to avoid all possible non-linearity effects.

plot automatically calling the macros *COUNTSflatdomesingle* and/or *COUNTSflatskysingle*[30].

4.4.2 Masterflat Production

Once each single flat field has passed the QA, it can be used to produce the masterflat of the corresponding filter. Domeflats and skyflats (when available) are combined separately by the pipeline to produce a dome-masterflat and a sky-masterflat respectively, using the IRAF task `flatcombine`. An outlier rejection is necessary to get rid of cosmics and spurious structures (domeflats) but also stars and galaxies (skyflats). A median type of combination with minmax[31] rejection was found to give the best results for all instruments.

4.4.3 Masterflat Quality Assessment

When Masterflats (dome or sky) for all nights of a run are built, their stability can be checked using the pipeline called **QC-PHOTMF-PIPE** (see Table 4). Three stability tests are performed by the pipeline on masterflat frames for each run:

- *outside VS centre* plot : provides information on the shape of each masterflat.
- *Large Scale Variability* plot : provides information on the "global" variation of the masterflats shape assuming the variation uniformly distributed all over the pixels (in comparison with a reference Flat)
- *9 areas* plot : provides information on "where" and "how large" is the variation of the flat shape in comparison with a reference flat

The first test is called *outside VS centre* because, for each filter, each masterflat (dome or sky) is divided in 9 areas and the value of the mode is evaluated for each area. The two–dimensional structure of each masterflat can be checked by calculating the ratio between the value of each outer areas and the value of the central area: this provides information on the shape of each masterflat. For example, if we have a flat shape each ratio will be 1; if we have a "cup-like" shape each ratio will be greater than 1; if we have a "hat-like" shape each ratio will be lower than 1 and so on. When the shape is reconstructed for each masterflat, we can build the plot in Figure 13 and check the stability of this two–dimensional structure during the run. If the structure does not vary significantly, we should have the same behaviour for all points in each quadrant of the *outside VS centre* plot. This plot is produced by the macro smongo *outsideVS-centre*[32] which is automatically called by the pipeline.

[30] Both macros are contained in the tarfile available in WikiBo at: `http://yoda.bo.astro.it/wiki/index.php/MasterFlatPhotopipe`

[31] The parameters for tuning the "minmax" rejection mode are set to the IRAF default values

[32] The macro is contained in the tarfile available in WikiBo at: `http://yoda.bo.astro.it/wiki/index.php/QCMasterFlatPhotopipe`.

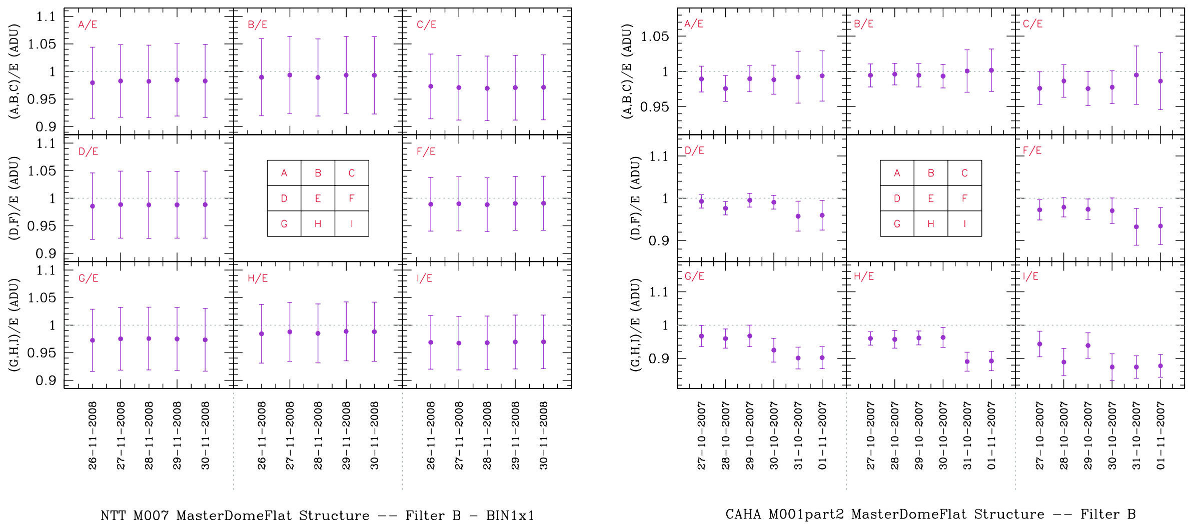


FIGURE 13: Examples of *ousideVS centre* plot. In the *left panel*, the plot is built in order to check the shape of dome–masterflat frames (filter B) obtained during run M-007@NTT (26-30 November 2008). This is a particularly good case because the shape of each masterflat is always the same during the whole run. In the *right panel* the same plot is built using the dome–masterflats (filter B) obtained during run M-001@CAHA (27 October - 01 November 2007). In this case it is easy to see the variation of masterflat shapes during the run: this is a particularly bad case, because the shape of the masterflat is changing almost every night and by almost 10%.

The second test, called *Large Scale Variability* (see Fig.14, produced by the smongo macro *LargeScaleStability*[33], which is called automatically by the pipeline), is devoted to study the "global" variation of the large scale structure of masterflats. First, the masterflat are normalized by their mode value (calculated on the same area) to remove any zero–point offset; then, they are smoothed[34] using the `boxcar` algorithm in IRAF; finally, one is chosen as the reference frame. The reference frame is subtracted from all the smoothed masterframes in order to obtain a "difference frame" (one for each masterflat). For each of them, the dedicated macro (called automatically by the pipeline and named *Kstability*[35]) computes the sum of the square of each pixel value or, in other word, the value of the K_{stab} function:

$$K_{stab} = \sum_{pix=1}^{n} (F - F_{ref})^2$$

[33]The macro is contained in the tarfile available in WikiBo at: `http://yoda.bo.astro.it/wiki/index.php/QCMasterFlatPhotopipe`.

[34]Because we are interested in *large scale* variations only.

[35]The macro is contained in the tarfile available in WikiBo at: `http://yoda.bo.astro.it/wiki/index.php/QCMasterFlatPhotopipe`.

where: F is the value of one pixel, and F_{ref} is the value of the same pixel in the reference frame. Let us suppose for now that *all* pixels scale of the same quantity. In this case, if all pixels scale by 1%, the value of K_{stab} will be:

$$K_{stab}(1\%) = (0.01)^2 * (number\,of\,pixels)$$

Under this hypothesis, we can define a parameter $\Delta S/S$, called *shape variation*, which measures the "global" variation of the shape in comparison with $K_{stab}(1\%)$:

$$\frac{\Delta S}{S}(\%) = \sqrt{\frac{K_{stab}}{K_{stab}(1\%)}}$$

This parameter provides an "average behaviour" of the large scale structure variations, with the caveat that the underlying assumption (i.e., that all pixels deviates by the same factor) is an extreme case. Therefore, the large scale variability plot provides information on the "global" variation of the masterflats shape (assuming the variation is uniformly distributed over all pixels) but it is not able to point out "where" and "how large" the variation is.

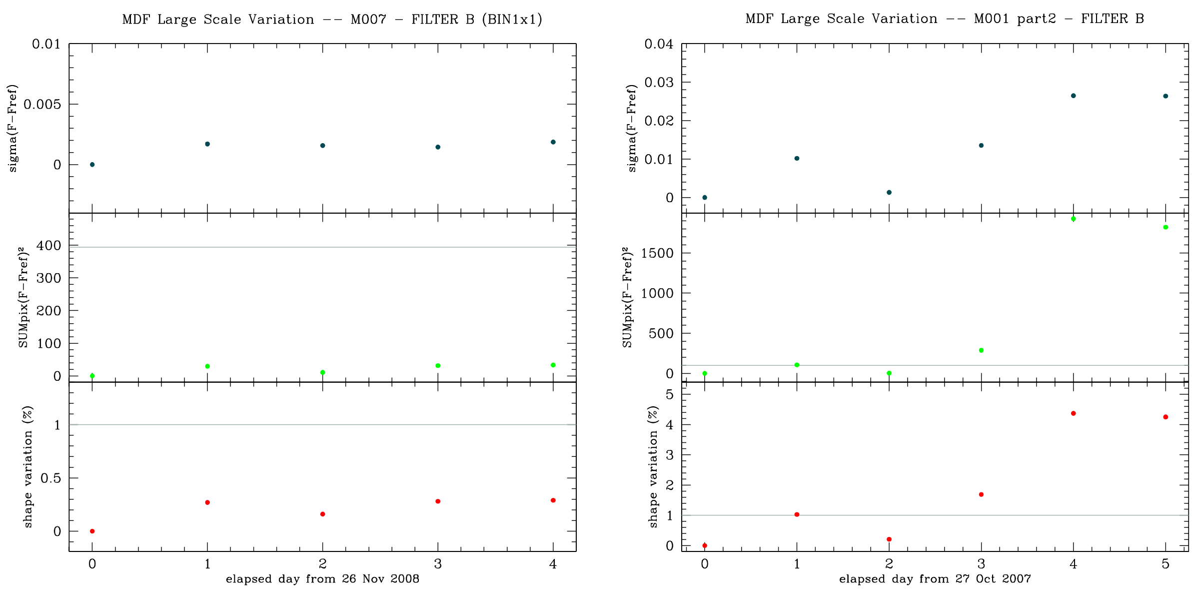


FIGURE 14: Examples of *large scale variability* plot. In both panels, the plot is built considering the same data used in Fig.13. The plot is divided in 3 windows reporting respectively the parameter $\Delta S/S$ (in the bottom window), the function K_{stab} (in the middle window) and the sigma of each "difference frame" (in the upper window). The *left panel* shows the very good case of M-007@NTT: the global shape variation for all masterflat is always lower than 0.3%. In the *right panel* the situation is not so good: the shape of the masterflats obtained during run M-001@CAHA is changing every night and also the global shape variation is high, reaching about 4.5% in the worst case.

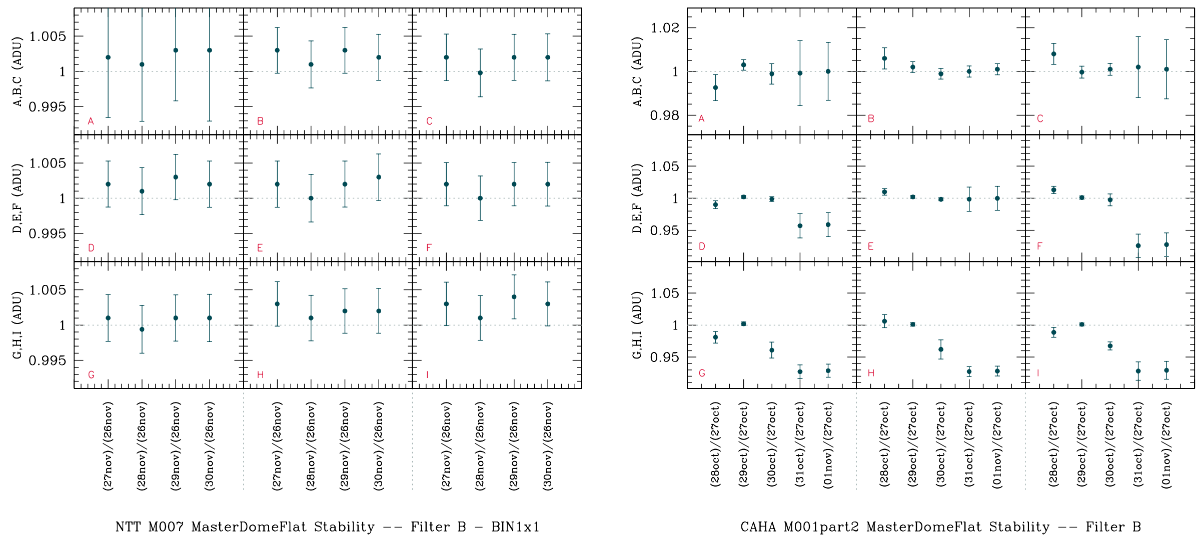


FIGURE 15: Examples of *9 areas* plot. In both panels, the plot is built considering the same data used in Fig.13. The plot is divided in 9 windows in which the mode and standard deviation of each "ratio frame" are shown. The *left panel* shows the very good case of M-007@NTT. The *right panel* shows the case of M-001@CAHA: the most important variation of the masterflat shape occurs in the bottom part of frames

This is the task of the third test, called *9 areas*, and performed automatically by the pipeline. In order to perform it, the pipeline starts considering the normalized masterflat frames built during the previous test for each filter. The same masterflat (normalized but not smoothed) used as reference to study the global variation of the large scale structure is used as reference frame for the 9 areas test as well. Each normalized masterflat is divided by the reference frame in order to obtain a "ratio frame". Each of them is divided in 9 areas (the same areas used to perform the *outside VS centre* test) and both the mode and standard deviation of each area are computed and used to obtain a plot like Fig.15. This plot is produced by the macro smongo *9areas*[36] which is automatically called by the pipeline.
The stability of the masterflats along an observing run is of fundamental importance because it affects both the observational and data reduction strategies. If the masterflat stability is not good as, for example, in the case of the run M-001@CAHA (see right panel of Fig. 14), the nightly acquisition of flat frames becomes mandatory, because the masterflat produced using flats acquired in a specific night can not be used to reduce data acquired in other nights. On the other hand, if the masterflat stability is good as, for example, in the case of M-007@NTT (see left panel of Fig. 14), the lack of flat fields during a specific night is not crucial, and the masterflat produced in the previous or the next night can be used in the reduction process.
The sections used by the pipeline to perform the three masterflat stability checks for each

[36]The macro is contained in the tarfile available in WikiBo at: `http://yoda.bo.astro.it/wiki/index.php/QCMasterFlatPhotopipe`.

CCD/instrument combination are reported in the instrument specific Appendices.
All the produced masterflats frames (dome and sky) is archived following the procedure reported in Section 5 and following the naming convention reported in Table 6 and in Wiki-Bo. In addition, for each archived masterflat, the Reduction Log Table hosted in the corresponding Wiki-Bo run page has to be compiled (Section 6).

4.5 Bad Pixel Mask

It is not uncommon that a CCD, made up of millions of pixels, contains faulty single pixels or columns. These defects can be easily identified in a flat field image as bright "hot" pixels or columns, with counts much higher than average, or black "dead" pixel or columns, with counts much lower than average.
In high quality CCDs there are few faulty pixels or columns and scientific frames are not significantly affected by them, especially if the target is placed in a clean portion of the CCD. This can be effectively done for single stars and spectra while it can be more difficult if we are interested in a "crowded" stellar field rather than in single objects, as when we are performing relative photometry or we are observing standard fields. Multiple exposures with a suitable dithering[37] are a good technique to correct for this problem, as well as for the cosmic rays contamination or other spurious defects. In the case of bad pixels or columns, a better result can be obtained by means of a *bad-pixel mask*. A bad-pixel mask (hereafter BPM) is an image of the same dimension of the CCD to which it is associated, where good pixels are identified by zero values and bad pixels by non-zero values. When applied to scientific frames, the bad pixels are replaced by linear interpolation along lines or columns using the nearest good pixels. The IRAF task `ccdmask` can be used to create the BPM for each CCD/instrument combination: some examples are shown in Fig. 16. The input images could be of any type but this task was designed primarily for detecting column oriented CCD defects such as charge traps that cause bad columns and non-linear sensitivities. The ideal input is therefore a ratio of two flat fields[38] having different exposure levels (bright and faint) so that all features which would normally be properly flat-fielded are removed: only pixels which are not corrected by flat-fielding are used to create the BPM.
All the created BPMs are archived in Wiki-Bo (see specific instrument Appendices). If needed, new BPMs can be produced following this procedure:

- correct domeflats for overscan (when possible) and bias (see Sections 4.2.3 and 4.4.1);
- create a masterflat with low counts using the IRAF task `flatcombine` (see Section 4.4.2);

[37]The *dithering* technique consists in small telecope shifts (a few arcsec) between multiple exposures. In this way a given object is imaged onto different parts of the detector.
[38]A single flat field can also be used but pixels of low or high sensitivity could be included as well as true bad pixels.

- create a masterflat with high counts using the IRAF task `flatcombine` (see Section 4.4.2);
- divide the masterflat with high counts for the masterflat with low counts and create a "flat-ratio" frame using the IRAF task `imarith`;
- create the bad pixel mask using the IRAF task `ccdmask`.

The BPM correction can be performed by linear interpolation from neighbouring lines or columns using `ccdproc`. To perform the correction with `ccdproc`, it is necessary to set `fixpix+` and to provide the name of BPM frame with `fixfile=BPM.pl`. The pipeline to pre-reduce the scientific images (see Section 4.7) includes the BPM correction except for REM data (see Appendix F.5) .

4.6 Fringing

Fringing is caused by the multiple reflections and interferences of the red/infrared light in thin CCD substrate. This usually has the appearance of a series of "ripples" in the images. The fringe pattern is an additive effect.
The effect is particularly strong in the red due to strong sky emission lines at long wavelengths, both in imaging (especially in the I band, while in the R band it is much fainter or negligible, depending on the single CCD) and in spectroscopy[39].
The fringing mask for the I filter can be obtained using all scientific images acquired during the night with the same filter and following this simple procedure[40]:

- correct all I frames for overscan and/or masterbias (see Section 4.2.3);
- combine the processed images to obtain a median final image containing only the fringing and the flat field structures (using `imcombine` with `scale="mode"`). It is very important that no stars are present in the final median image;
- correct this image for the sky-masterflat I (see Section 4.4.2) and for the BPM (see Section 4.5) to obtain an image containing only the flat-scaled fringe and a flat sky[41];

[39] For the spectroscopic case, fringing is one of the major problems in data reduction because no fringing mask can be produced and no specific correction performed. Both spectroscopic masterflats and scientific frames acquired using red grisms are strongly contaminated by fringing. At least when the wide slit is adopted in our spectroscopic campaigns, the corresponding masterflat seems to present a stable and almost constant fringing pattern. Nevertheless, the result in the correction for the fringing in the scientific spectra (when the masterflat correction is performed) will depend on the star position in the slit. A detailed discussion on the effects which the flat correction produce on scientific frames will be presented in GCC-001.

[40] Obviously, the same procedure using the R images and sky-masterflat produces the fringing mask for the R filter.

[41] It is important to check that the sky is really flat by inspecting the image.

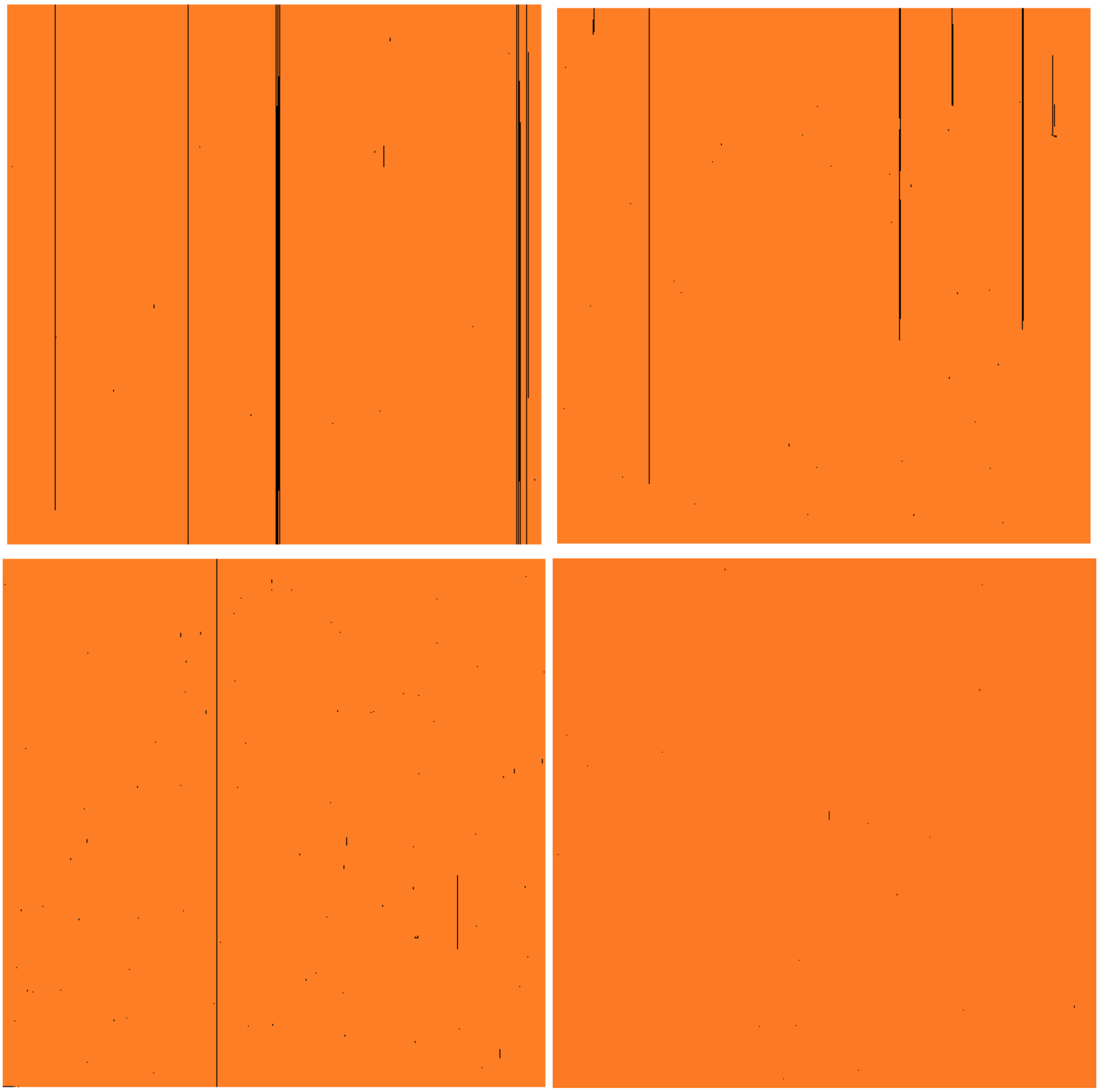


FIGURE 16: BPM examples. *Upper panels*: BPM for LaRuca SITE1 CCD (on the left) and for EFOSC2 CCD (on the right) read in 1x1 binning factor. For both CCDs, the cosmetic is not particularly good. *Bottom panels*: BFOSC BPM for the old CCD (left panel) and the new CCD (right panel): the improvement in cosmetic quality is evident.

- get the average sky level (mode) of this frame (using `imstat`);
- subtract this value from the previous frame using `imarith` (you want to have an image with a mode near to zero). You are left with an image containing the flat-fielded fringes alone;
- multiply the result by the mode-normalized sky-masterflat I using `imarith`. This image is your *masterfringe template*, containing the original (non-flatfielded) fringing pattern

Then, it is necessary to have a look at the masterfringe template. If some significant fringing pattern is present, it means that a fringing correction is needed for that particular instrument, because we are are looking for a very high precision in our relative and absolute photometry.
We produced fringing masks for each CCD/instrument combination used in our campaigns by applying the procedure described above. Our tests (see Appendices) indicates that a fringing corrections is not needed in our R and I (for REM only) data because our exposure times are always quite short with all the used instruments and the sky is not so strong to produce a clear fringe pattern. Therefore the pipeline to pre-reduce the scientific images (see Section 4.7) do not include the fringing correction.

4.7 2D Imaging Pre-reductions

Once all calibration images are available, all scientific images must be corrected for overscan (if possible), trimmed, bias & flat corrected and, if necessary, also corrected for dark, a bad pixel mask and a fringing mask. The pipeline **PHOTO-SCIENCE-PIPE** (see Table 4) allows to apply simultaneously and automatically all the needed corrections using the IRAF task `ccdproc`.

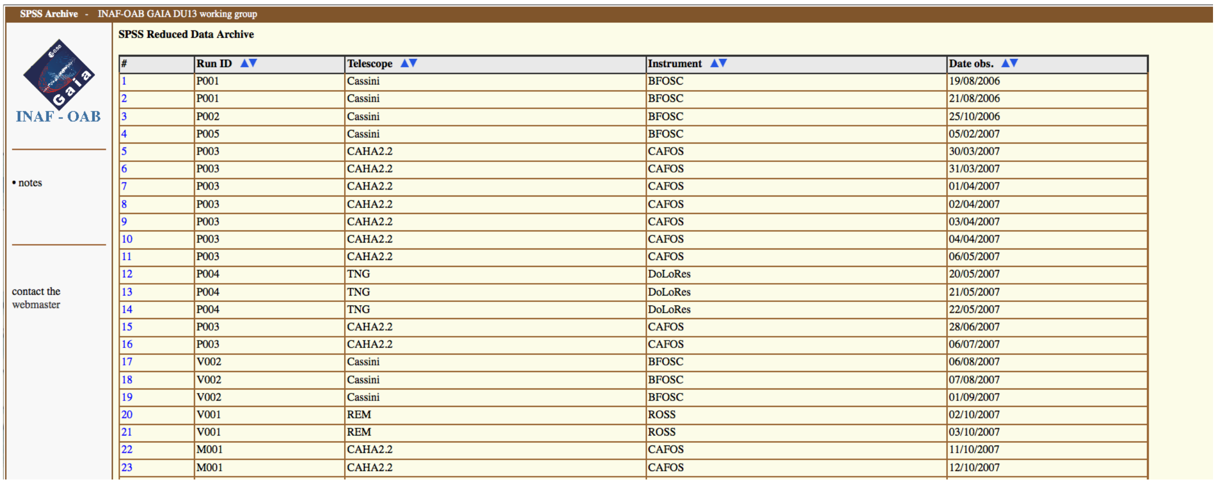
4.7.1 Quality Assessment for Scientific Images

All pre-reduced photometric frames are now ready to be submitted to the "Quality Control and photometric catalogue production" procedure, described in detail in the dedicated document SMR-003. The whole procedure can be summarized in two steps: first, we perform aperture photometry on each frames using SExtractor (Bertin & Arnouts 1996) in order to produce the aperture photometry catalogues and then we perform the Quality Control.
The QC procedure is designed to take into account a multilevel approach. The fundamental level is a QC performed on each single star present in each catalogue produced by running a group of 4 dedicated pipelines on each frames: in order to pass the fundamental level of QC, each star has to meet a strict series of requirements (see SMR-003, Section 3.1). The second and third level are respectively the QC performed on each single frames and the one performed on the whole acquired series, for example a night point or a short-term variability series (see SMR-003, Sections 3.2 and 3.3).
Depending on the results of QC, a pre-reduced frame is archived or rejected. As a consequence,

a particular frame-set (again, a night point or a short-term variability series) will be totally archived, totally rejected or partially rejected.

5 Uploading Reduced Data in the SPSS Archive

The *"SPSS Reduced Data Archive"*[42] (Fig. 17) and the procedure to upload the reduced frames are described in the Wiki-bo section SPSS Reduced Data Archive[43] and in EP-008.
All the calibration masterframes produced are uploaded in the archive, while the pre-reduced scientific frames needs to be submitted to the Quality Control procedure described in SMR-003: only those scientific frames passing the QC can be uploaded. Please contact us to obtain the appropriate credentials to access the archive server, or in case of any doubt or problem.


SPSS Archive - INAF-OAB GAIA DU13 working group
INAF - OAB
• notes
contact the webmaster
SPSS Reduced Data Archive

#	Run ID	Telescope	Instrument	Date obs.
1	P001	Cassini	BFOSC	19/08/2006
2	P001	Cassini	BFOSC	21/08/2006
3	P002	Cassini	BFOSC	25/10/2006
4	P005	Cassini	BFOSC	05/02/2007
5	P003	CAHA2.2	CAFOS	30/03/2007
6	P003	CAHA2.2	CAFOS	31/03/2007
7	P003	CAHA2.2	CAFOS	01/04/2007
8	P003	CAHA2.2	CAFOS	02/04/2007
9	P003	CAHA2.2	CAFOS	03/04/2007
10	P003	CAHA2.2	CAFOS	04/04/2007
11	P003	CAHA2.2	CAFOS	06/05/2007
12	P004	TNG	DoLoRes	20/05/2007
13	P004	TNG	DoLoRes	21/05/2007
14	P004	TNG	DoLoRes	22/05/2007
15	P003	CAHA2.2	CAFOS	28/06/2007
16	P003	CAHA2.2	CAFOS	06/07/2007
17	V002	Cassini	BFOSC	06/08/2007
18	V002	Cassini	BFOSC	07/08/2007
19	V002	Cassini	BFOSC	01/09/2007
20	V001	REM	ROSS	02/10/2007
21	V001	REM	ROSS	03/10/2007
22	M001	CAHA2.2	CAFOS	11/10/2007
23	M001	CAHA2.2	CAFOS	12/10/2007

FIGURE 17: Portion of the *"SPSS Reduced Data Archive"* main table showing the archived runs with hyperlinks to the reduced data.

6 Reduction Log Tables

All the observing runs performed during the Pilot Program, the Main and the Auxiliary Campaigns have a dedicated page[44] in Wiki-Bo. In all these pages, a section called *Reduction Logs* hosts a series of tables, one for each observing night. These tables are called *Reduction Logs*

[42] `http://spss.bo.astro.it/red.cgi/`
[43] `http://yoda.bo.astro.it/wiki/index.php/Wiki-Bo_Gaia_Page#SPSS_Reduced_Data_Archive`
[44] You can easily access these pages by clicking on a run ID in the Summary table of all our Observing Runs: `http://yoda.bo.astro.it/wiki/index.php/SPSS_Runs_Table`

Tables: an example is shown in Fig. 18. The *Photo PreRed* column, for the calibration frames, hosts the results of QC performed on masterframes. In Table 8 we show the meaning of colour codes associated to all the possible results of masterframes QC.
The blue colour code means that the specific masterframe do not have problems (i.e., the difference in the shape and/or in the mean level is lower than 1% with respect to all other masterframe of the run). When the purple cell appears in the *Photo PreRed* column of a masterframe, it means that this specific masterframe is different (in shape and/or mean level) with respect to all other masterframe of the run.

Masterframes colour codes in RedLog Tables	
(blue)	Masterframe ok –> archived
(purple)	Masterframe partially ok –> archived
(red)	Masterframe rejected –> not archived

TABLE 8: colour Codes for the QC performed on materframes. See text for further details

If the red colour code is assigned, the specific masterframe is rejected: this can happen, for example, when in a sky-masterflat the stars still remain visible.
In the last column of the RedLog Table useful notes and warnings about the data are reported: for example, it can explain why the purple or red colour code has been assigned to a masterframe.
The Reduction Log Tables host also the results of the Series Level Quality Control (SELQC) performed on each series type observed for a specific target during the night (see SMR-003 for more details). There are also columns dedicated to the analysis of the data. In Fig. 18, for example, each time series has been yet analyzed and the light curves built: for each star in the column called *Photo ShortVar* the same colour codes used for SELQC are reported in order to show the results of light curves analysis (see SMR-004).

22 August 2008										
SPSS	Name/Type	Setup	Photo PreRed	Photo AbsPhot	Photo ShortVar	Photo LongVar	Spectro PreRed	Spectro Wave/Ext	Spectro FluxCal	Notes
-	Bias	-	SMR	No	No	No	SMR	No	No	Master Bias Archived Warning: peculiar structure
-	Skyflat	B,V,R	SMR	No	No	No	No	No	No	Master Skyflat Archived
018	BD+284211	B	SMR photQC	No	SMR	No	No	No	No	Frames Archived

2 November 2008										
SPSS	Name/Type	Setup	Photo PreRed	Photo AbsPhot	Photo ShortVar	Photo LongVar	Spectro PreRed	Spectro Wave/Ext	Spectro FluxCal	Notes
-	Bias	-	SMR	No	No	No	SMR	No	No	Master Bias Archived
-	Skyflat	B-V-R	SMR	No	No	No	No	No	No	**WARNING**: exptime too short --> shutter effect visible

FIGURE 18: Examples of RedLog Table built for data acquired during run V-003 with LaRuca@SPM1.5 Telescope. In the *upper panel*, because the masterbias produced presents a peculiar shape with respect to all other masterbias of this run, the colour code is purple. The colour code for sky-masterflats is blue because no significant variation in their shape was detected. In both cases, masterframes was archived, as can be seen in the last column. In the *lower panel* is shown the Reduction Log Table of a different night of the same run. No significant variation in shape and level was detected for the masterbias (and its colour code is blue), but, for sky-masterflats, a problem occurred: because of the very short exposure time used to acquire all single skyflats, in the sky-masterflats is clearly present the signature of the shutter. Obviously, these sky-masterflat can not be used to pre-reduce data: they was rejected, not archived and the red colour code was assigned.

References

[SMR-002], Marinoni, S., et al., 2011, *Instrument Familiarization Plan for ground based observations of SPSS II. Calibration Frames Study and Recommendations*,
`GAIA-C5-TN-OABO-SMR-002`,
DRAFT

[SMR-003], Marinoni, S., et al., 2011, *Data Reduction Protocol for Ground Based Observations of SpectroPhotometric Standard Stars. III. Quality Control on SPSS Photometric Frames and Photometric Catalogues Production*,
`GAIA-C5-TN-OABO-SMR-003`,
DRAFT

[SMR-004], Marinoni, S., et al., 2011, *Data Reduction Protocol for Ground Based Observations of SpectroPhotometric Standard Stars. IV. Short Variability Monitoring: Light Curves production and analysis*,
`GAIA-C5-TN-OABO-SMR-004`,
DRAFT

[GA-001], Altavilla, G., Bellazzini, M., Pancino, E., et al., 2007, *The Primary standards for the establishment of the GAIA Grid of SPSS. Selection criteria and a list of candidates.*,
`GAIA-C5-TN-OABO-GA-001`,
URL `http://www.rssd.esa.int/llink/livelink/open/2736914`

[GA-003], Altavilla, G., Bragaglia, A., Pancino, E., et al., 2010, *Secondary standards for the establishment of the Gaia Grid of SPSS. Selection criteria and a list of candidates.*,
`GAIA-C5-TN-OABO-GA-003`,
URL `http://www.rssd.esa.int/llink/livelink/open/3033479`

[GA-002], Altavilla, G., Federici, L., e Pancino, E., et al., 2010, *Absolute calibration of Gaia spectro-photometric data. III. Observing facilities for ground-based support*,
`GAIA-C5-TN-OABO-GA-002`,
URL `http://www.rssd.esa.int/llink/livelink/open/3012989`

[GA-004], Altavilla, G., Pancino, E., Marinoni, S., et al., 2011, *Instrument Familiarization Plan for ground based observations of SPSS. I. CCD Shutter Characterization and Linearity Evaluation*,
`GAIA-C5-TN-OABO-GA-004`,
URL `http://www.rssd.esa.int/llink/livelink/open/3075673`

Andersen, M.I., Freyhammer, L., Storm, J., 1995, In: P. Benvenuti (ed.) European Southern Observatory Conference and Workshop Proceedings, vol. 53 of European Southern Observatory Conference and Workshop Proceedings, 87–+, ADS Link

[MBZ-001], Bellazzini, M., Bragaglia, A., Federici, L., et al., 2006, *Absolute calibration of Gaia photometric data. I. General considerations and requirements.*,
`GAIA-C5-TN-OABO-MBZ-001`,
URL `http://www.rssd.esa.int/llink/livelink/open/1145146`

Bertin, E., Arnouts, S., 1996, A&AS, 117, 393, ADS Link

Bohlin, R.C., 2007, In: C. Sterken (ed.) The Future of Photometric, Spectrophotometric and Polarimetric Standardization, vol. 364 of Astronomical Society of the Pacific Conference Series, 315–+, ADS Link

[JMC-001], Carrasco, J., Jordi, C., Figueras, F., et al., 2006, *Toward 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`,
URL `http://www.rssd.esa.int/llink/livelink/open/2703304`

[JMC-002], Carrasco, J.M., Jordi, C., Lopez-Marti, B., et al., 2007, *Revolving phase effect to FoV overlapping and its application to primary SPSS*,
`GAIA-C5-TN-UB-JMC-002`,
URL `http://www.rssd.esa.int/llink/livelink/open/2756718`

[GCC-001], Cocozza, G., et al., 2011, *Data Reduction Protocol for Ground Based Observations of SpectroPhotometric Standard Stars. I. Spectroscopic Pre-reduction*,
`GAIA-C5-TN-OABO-GCC-001`,
DRAFT

[LF-001], Federici, L., Bragaglia, A., Diolaiti, E., et al., 2006, *Absolute calibration of Gaia photometric data. II. Observing facilities for ground-based support (pilot program)*,
`GAIA-C5-TN-OABO-LF-001`,
URL `http://www.rssd.esa.int/llink/livelink/open/2706141`

Hamuy, M., Walker, A.R., Suntzeff, N.B., et al., 1992, PASP, 104, 533, ADS Link

Hamuy, M., Suntzeff, N.B., Heathcote, S.R., et al., 1994, PASP, 106, 566, ADS Link

McCook, G.P., Sion, E.M., 1999, ApJS, 121, 1, ADS Link

[PMN-002], Montegriffo, P., 2009, *A model for the absolute photometric calibration of Gaia BP and RP spectra. II. Removing the LSF smearing.*,
`GAIA-C5-TN-OABO-PMN-002`,
URL `http://www.rssd.esa.int/llink/livelink/open/2885090`

[PMN-001], Montegriffo, P., Bellazzini, M., Pancino, E., et al., 2007, *A model for the absolute photometric calibration of Gaia BP and RP spectra. I. Basic concepts.*,
`GAIA-C5-TN-OABO-PMN-001`,
URL `http://www.rssd.esa.int/llink/livelink/open/2803061`

Oke, J.B., 1990, AJ, 99, 1621, ADS Link

[EP-003], Pancino, E., Altavilla, G., Carrasco, J.M., et al., 2009, *Protocol for Ground Based Observations of SpectroPhotometric Standard Stars. II. Variability Searches and Absolute Photometry Campaigns Photometry Campaigns*, `GAIA-C5-TN-OABO-EP-003`, URL `http://www.rssd.esa.int/llink/livelink/open/2908205`

[EP-006], Pancino, E., Altavilla, G., Carrasco, J., et al., 2011, *Protocol for Ground Based Observations of SpectroPhotometric Standard Stars. III. Main Spectrophotometric Campaign*, `GAIA-C5-TN-OABO-EP-006`, URL `http://www.rssd.esa.int/llink/livelink/open/3072732`

[EP-008], Pancino, E., Altavilla, G., Rossetti, et al., 2011, *The local Bologna archive of SpectroPhotometric Standard Stars observations*, `GAIA-C5-TN-OABO-EP-008`, URL `http://www.rssd.esa.int/llink/livelink/open/3081255`

Stritzinger, M., Suntzeff, N.B., Hamuy, M., et al., 2005, PASP, 117, 810, ADS Link

A BFOSC@Cassini Detailed Instructions

A.1 Overscan and Trimming Sections

When the instrument is set on BFOSC and the CCD on OLD or NEW in the input parameters of the pipeline, the following overscan and trimming sections are automatically used:

- overscan section: there is no overscan strip
- trim section for CCD mounted before July 17 2007 (OLD CCD): [1:1335,1:1300]
- trim section for CCD mounted after July 17 2007 (NEW CCD): [7:1340,1:1300]

A.2 Bias

In order to perform the stability study of the two-dimensional structure of masterbias, the pipeline uses the sections reported in Table 9:

TABLE 9: **Sections for BFOSC@Cassini Masterbias Quality Control**

Observation type	Section	Useful for run:
photometry and spectroscopy	A = [70:270,915:1115] B = [1065:1265,915:1115] C = [567:767,550:750] D = [70:270,185:385] E = [1065:1265,185:385]	all runs

A.3 Dark

No dark correction is needed.

A.4 Flat

In July 2008, a new EEV CCD was mounted on BFOSC to replace the old one. In order to perform the stability study of the two-dimensional structure of masterflats, the pipeline uses the sections reported in Table 10, depending on what CCD is chosen (OLD or NEW).

TABLE 10: **Sections for BFOSC@Cassini Masterflats Quality Control**

<table>
<tr><th>Data acquired</th><th>Section</th><th>Useful for:</th></tr>
<tr><td rowspan="2">before
July 17 2008
(until run V-005)</td><td>A = [1:446,867:1299]
B = [446:891,867:1299]
C = [891:1335,867:1299]
D = [1:446,434:867]
E = [446:891,434:867]
F = [891:1335,434:867]
G = [1:446,1:434]
H = [446:891,1:434]
I = [891:1335,1:434]</td><td>outside VS centre plot
and
9 areas plot</td></tr>
<tr><td>N = [517:817,500:800]</td><td>Normalisation area for:
Large Scale Variability plot
and
9 areas plot</td></tr>
<tr><td rowspan="2">after
July 17 2008
(from run V-008)</td><td>A = [1:445,867:1300]
B = [445:889,867:1300]
C = [889:1334,867:1300]
D = [1:445,434:867]
E = [445:889,434:867]
F = [889:1334,434:867]
G = [1:445,2:434]
H = [445:889,2:434]
I = [889:1334,2:434]</td><td>outside VS centre plot
and
9 areas plot</td></tr>
<tr><td>N = [517:817,500:800]</td><td>Normalisation area for:
Large Scale Variability plot
and
9 areas plot</td></tr>
</table>

A.5 Bad Pixel Mask

Up to now, two BPM have been built, one for each CCD used during the campaign:

- for data acquired before July 17 2008: use m.Cassini-BFOSC_20080709_BPM_oldCCD.pl[45]
- for data acquired after July 17 2008: use m.Cassini-BFOSC_20090527_BPM_newCCD.pl[46]

[45] Produced using data acquired for the purpose from the Loiano Telescope Team on 2008-07-09.
[46] Produced using data acquired during run V-011.

Both BPMs are shown in Fig.19, and are available in Wiki-Bo[47]. The CCD cosmetics are quite good, especially for the new CCD mounted at BFOSC. The needed data to create a BPM were acquired during several runs, and new BPM will most probably be produced when the data will be reduced. We recommend to use the BPM closest in time to your run date.

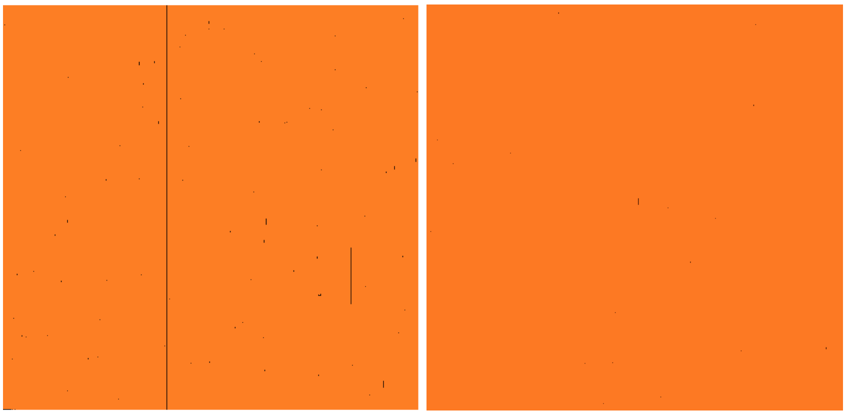


FIGURE 19: BFOSC Bad Pixel Masks for the old CCD (*left panel*) and the new CCD (*right panel*): the improvement in cosmetic quality is clearly visible

A.6 Fringing Mask

We report, as an example, the Fringing Mask produced using scientific data acquired with the R filter during run V-005 (25-06-2008, old CCD mounted, see Fig.20 left panel) and run V-011 (25-05-2009, new CCD mounted, see Fig.20 right panel). No significant fringing pattern is visible, in either image: the correction for fringing is not necessary for BFOSC observations.

[47] http://yoda.bo.astro.it/wiki/index.php/BFOSC_IFP_Calibration_Frames#BAD_PIXEL_MASK

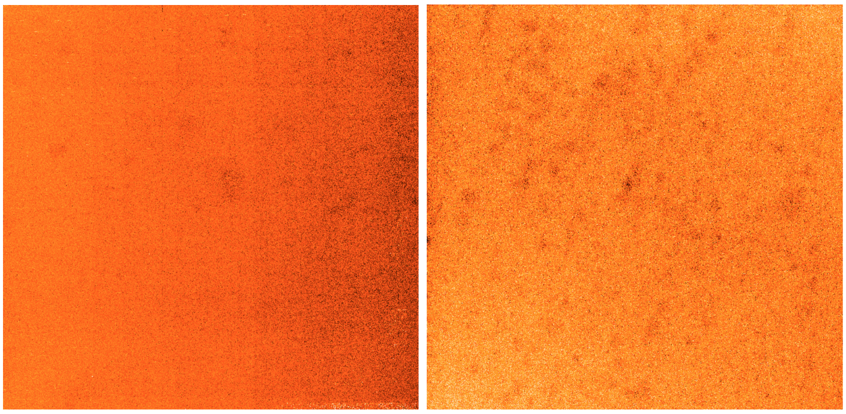


FIGURE 20: Example of Fringing Masks produced using data acquired during run V-005 (*left panel*) and run V-011(*right panel*). In both cases, no significant fringing pattern is visible.

B CAFOS@CAHA2.2m Detailed Instructions

B.1 Overscan and Trimming Sections

When the instrument is set on CAFOS in the input parameters of the pipeline, the following overscan and trimming sections are automatically used:

- overscan section: there is no usable overscan strip[48]
- trim section for photometry: [10:1120,10:1120] for run P-003; [10:1014,10:1014] for all runs M[49]
- trim section for spectroscopy: [10:1190,10:1640] for all runs.

Even if images are already acquired windowing the CCD, a trimming is necessary because images are often affected by some defects at the edges, as some bright rows at the bottom, due to the reading process. Since we use different CCD sections for imaging (a square) and spectroscopy (a rectangle), the trimming values change accordingly.
To process the fits files with IRAF the keywords BIASSEC, DATASEC and CCDSEC need to be removed from the fits header because IRAF conflicts with the CAFOS format for these keywords[50]. The pipeline automatically remove them for every image using the IRAF task `hedit` with line commands similar to:

```
hedit @images.list fields="BIASSEC" delete+ verify-
hedit @images.list fields="DATASEC" delete+ verify-
hedit @images.list fields="CCDSEC" delete+ verify-
```

Selecting `verify-` we avoid to be asked if we really want to delete the field for each fits file. The pipeline also uses the same IRAF task to write the correct TRIMSEC section in the frames header, with lines command similar to:

```
hedit @images.list trimsec [10:1014,10:1014] add+ verify-
```

[48] The full 2168x2168 chip is strongly vignetted, moreover the read out time is $\sim$ 180 sec. For these reasons, to reduce the read out time and to save the useful portion of the CCD only, the CCD is windowed during the images acquisition, directly at the telescope. The window sections are different for spectroscopy and imaging:
SPECTROMETRY MODE: $400 < X < 1600$; $1 < Y < 1650$ ($\sim$ 30 sec read out time).
PHOTOMETRY MODE: Standard configuration $513 < X, Y < 1536$ ($\sim$ 50 sec read out time); alternative configuration 470 < X < 1600 ; 470 < X < 1600 ($\sim$ 50 sec read out time).

[49] for December 15 2007 (run M-001) use the P-003 trim section for photometry

[50] as an example, CCDSEC and BIASSEC depends on the trim section specified in `ccdproc` but if DATASEC = '[470,470:1600,1600]' then: a) it is not in the IRAF standard ([470:1600,470:1600]), b) we cannot trim for example to [570,1500,570:1500] because the image is 1130x1130, we should trim to something within the image, like [100:1000,100:1000] but it is in contrast with DATASEC because, even if the size coincide with [1:1131,1:1131], their starting point is at different location.

Usually, two series of bias frames are acquired with different sections for imaging and spectroscopy. Otherwise, if the bias frames are acquired in full-frame mode, they should be trimmed using the sections for imaging and spectroscopy windowing before to be used to produce the two required masterbias (one for the photometry and one for the spectroscopy). This is not implemented in the pipeline. When this unhappy (and rare, up to now) case happens, you can follow this procedure:

```
hedit @biasfullframe.list fields="BIASSEC" delete+ verify-
hedit @biasfullframe.list fields="DATASEC" delete+ verify-
hedit @biasfullframe.list fields="CCDSEC" delete+ verify-

!cp biasfullframe.list biasPHOT.list
!cp biasfullframe.list biasSPEC.list

# change the names in biasPHOT.list and biasSPEC.list files

ccdproc images=@biasfullframe.list output=@biasSPEC.list
         ccdtype="" noproc- fixpix- overscan- trim+ zerocor-
         darkcor- flatcor- illumcor- trimsec="[301:1700,*]"

ccdproc images=@biasfullframe.list output=@biasPHOT.list
        ccdtype="" noproc- fixpix- overscan- trim+ zerocor-
        darkcor- flatcor- illumcor- trimsec="[513:1536,513:1536]"

# delete again the keyword TRIMSEC and TRIM

hedit @biasPHOT.list fields="TRIMSEC" delete+ verify-
hedit @biasPHOT.list fields="TRIM" delete+ verify-
hedit @biasSPEC.list fields="TRIMSEC" delete+ verify-
hedit @biasSPEC.list fields="TRIM" delete+ verify-

# update in the header the keyword TRIMSEC using the correct
# sections (for photometry or spectroscopy) and trim again
# the bias frames.

hedit @biasPHOT_a.list trimsec [10:1014,10:1014] add+ verify-
cp biasPHOT_a.list biasPHOT.list
ccdproc images=@biasPHOT_a.list output=@biasPHOT.list
         ccdtype="" noproc- fixpix- overscan- trim+ zerocor-
         darkcor- flatcor- illumcor- trimsec="image"
```

B.2 Bias

In order to perform the stability study of the two-dimensional structure of the masterbias frames, the sections implemented into the pipeline for CAFOS are reported in Table 11.

TABLE 11: **Sections for CAFOS2.2@CAHA masterbias Quality Control**

Observation type	**Section**	**Useful for run:**
photometry	A = [10:310,800:1100] B = [800:1100,800:1100] C = [405:705,405:705] D = [10:310,10:310] E = [800:1100,10:310]	P-003
	A = [10:310,695:995] B = [695:995,695:995] C = [352:652,352:652] D = [10:310,10:310] E = [695:995,10:310]	all M- runs
spectroscopy	A = [10:310,1320:1620] B = [870:1170,1320:1620] C = [440:740,665:965] D = [10:310,10:310] E = [870:1170,10:310]	all runs

B.3 Dark

No dark correction is needed.

B.4 Flat

In order to perform the stability study of the two-dimensional structure of masterflat frames, the pipeline uses the sections reported in Table 12.

TABLE 12: **Sections for CAFOS2.2@CAHA masterflats Quality Control**

<table>
<tr><th>Run</th><th>Section</th><th>Useful for:</th></tr>
<tr><td rowspan="2">P-003
and
M-001c</td><td>A = [1:371,741:1111]
B = [371:741,741:1111]
C = [741:1111,741:1111]
D = [1:371,371:741]
E = [371:741,371:741]
F = [741:1111,371:741]
G = [1:371,1:371]
H = [371:741,1:371]
I = [741:1111,1:371]</td><td>outside VS centre plot
and
9 areas plot</td></tr>
<tr><td>N = [500:600,880:1040]</td><td>Normalisation area for:
Large Scale Variability plot
and
9 areas plot</td></tr>
<tr><td rowspan="2">all M- runs</td><td>A = [1:335,670:1005]
B = [335:670,670:1005]
C = [670:1005,670:1005]
D = [1:335,335:670]
E = [335:670,335:670]
F = [670:1005,335:670]
G = [1:335,1:335]
H = [335:670,1:335]
I = [670:1005,1:335]</td><td>outside VS centre plot
and
9 areas plot</td></tr>
<tr><td>N = [100:320,380:600]</td><td>Normalisation area for:
Large Scale Variability plot
and
9 areas plot</td></tr>
</table>

B.5 Bad Pixel Mask

No data useful for the BPM production are available for run P-003. For M- runs you can use: m.CAHA-CAFOS2.2_20080908_BPM_PHOT.pl[51]
The cosmetics of CCD are very good, as shown in Fig.21.
If new data for the BPM creation are available in other runs, new BPM will be produced. We recommend to use the BPM closest in time to your run date. The BPM produced for CAFOS is available in Wiki-Bo[52].

[51] Produced using data acquired during run M-006.
[52] http://yoda.bo.astro.it/wiki/index.php/CAFOS_IFP_Calibration_Frames#BAD_PIXEL_MASK

FIGURE 21: CAFOS Bad Pixel Mask for the section adopted for photometric observations.

B.6 Fringing Mask

We show, as an example, the fringing mask produced using dedicated data (5 images with the filter R of an empty field with large dithering, Texp=300 sec) acquired during run M-006 (09 September 2008). No significant fringing pattern is visible, as shown in Fig.22: the correction for fringing is not necessary for CAFOS observations.

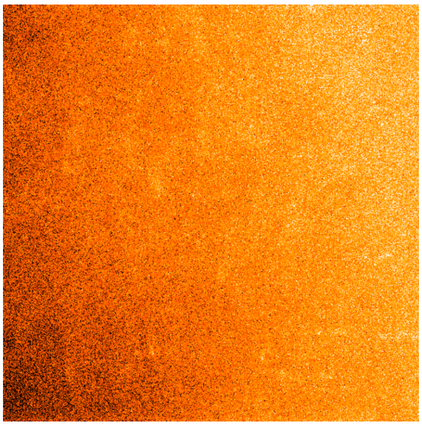


FIGURE 22: Fringing Mask produced using data acquired during run M-006. No significant fringing pattern is visible.

C DoLoResS@TNG Detailed Instructions

If your fits frames are named as **.fts*, it is necessary to rename them using the task `rename` in order to change their file extension. For example:

```
rename(files="*.fts",newname="fits",field="extn")
```

This command is not included in the pipeline and, if needed, you shall run this command before running the pipeline.

C.1 Overscan and Trimming Sections

When the instrument is set on DoLoRes in the input parameters of the pipeline, the following overscan and trimming sections are automatically used:

- overscan section: [15:2085,2065:2085][53]
- trim section until run M-009a: [25:2089,25:2045]
- trim section from run M-009b: [55:2085,25:2045]

C.2 Bias

Often, DoLoRes masterbias are characterized by bright and dark horizontal and/or vertical stripes (about +5 or -5 counts from the average) with a pattern that changes with time as shown in Fig. 23. For this reason, it is strongly recommend to not use the masterbias produced during one night to correct data acquired during other nights. In order to perform the stability study of the two-dimensional structure of masterbias, the sections implemented into the pipeline for DoLoRes are reported in Table 13.

C.3 Flat

In order to perform the stability study of the two-dimensional structure of masterflats, the sections implemented into the pipeline for DoLoRes are reported in Table 14.

[53] There is also a vertical overscan section but for homogeneity we chose to use the one horizontal one. The results are similar but not identical. The [15:2085,2065:2085] section produces a corrected bias, flatter but slightly more negative than the bias corrected with the other overscan section, that is closer to zero but with a significant gradient.

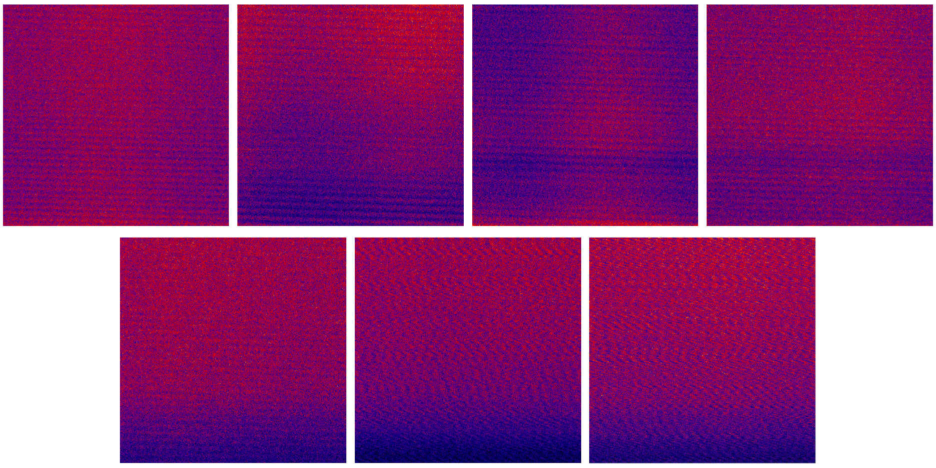


FIGURE 23: Dark and bright structures in the bias images (DoLoRes@TNG). Images from 1 to 4 are masterbias taken during the run M-005 (2008-05-25, 26, 27, and 28 respectively). The last three masterbias are produced using data acquired during run M-009 (2009-06-5, 8, and 9 respectively). The pattern is not fixed, and in the last two images also a vertical pattern is visible.

TABLE 13: **Sections for DoLoRes@TNG masterbias Quality Control**

Observation type	Section	Useful for run:
photometry and spectroscopy	A = [20:520,1426:1926] B = [1540:2040,1426:1926] C = [788:1278,723:1223] D = [20:520,20:520] E = [1540:2040,20:520]	P-004 and runs M until M-009a
	A = [20:520,1426:1926] B = [1525:2025,1426:1926] C = [788:1278,723:1223] D = [20:520,20:520] E = [1525:2025,20:520]	starting from run M-009b

C.4 Bad Pixel Mask

The original DoLoRes detector, an E2V4240, was replaced with a similar E2V4240 in December 2007. The original CCD was used only during the pilot run P-004 in May 2007 but, due to bad weather conditions, no scientific data were acquired, hence no BPM was produced. For all M- runs you can use: m.TNG-DoLoRes_20090731_BPM_newCCD.pl[54]. The BPM produced

[54] Produced using data acquires during run M-009.

TABLE 14: **Sections for DoLoRes@TNG masterflats Quality Control**

Run	Section	Useful for:
from M-009b	A = [1:677,1347:2021] B = [677:1353,1347:2021] C = [1353:2030,1347:2021] D = [1:677,674:1347] E = [677:1353,674:1347] F = [1353:2030,674:1347] G = [1:677,1:674] H = [677:1353,1:674] I = [1353:2030,1:674]	*outside VS centre* plot and *9 areas* plot
	N = [765:1265,761:1261]	Normalisation area for: *Large Scale Variability* plot and *9 areas* plot

for DoLoRes is available in Wiki-Bo[55]. As shown in Fig. 24, the CCD cosmetics is quite good. If new data for the BPM creation are available in other runs, new BPM will be produced. We always recommend to use the BPM closest in time to the pre-reduce your run.

C.5 Fringing Mask

We report, as an example, the Fringing Mask produced using scientific data acquired in R band (45 frames, with exposure time ranging from 5 to 25 seconds) during one night of run M-012 (06 December 2009, see Fig. 25). No significant fringing pattern is visible, so the correction for fringing is not necessary for DoLoRes observations.

[55] http://yoda.bo.astro.it/wiki/index.php/DoLoRes_IFP_Calibration_Frames#BAD_PIXEL_MASK

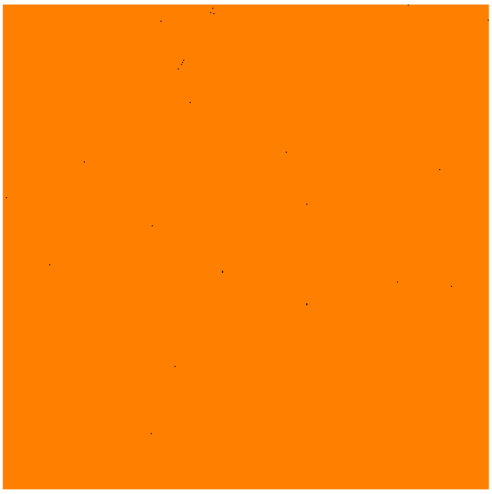


FIGURE 24: DoLoRes Bad Pixel Mask produced using data acquired during run M-009.

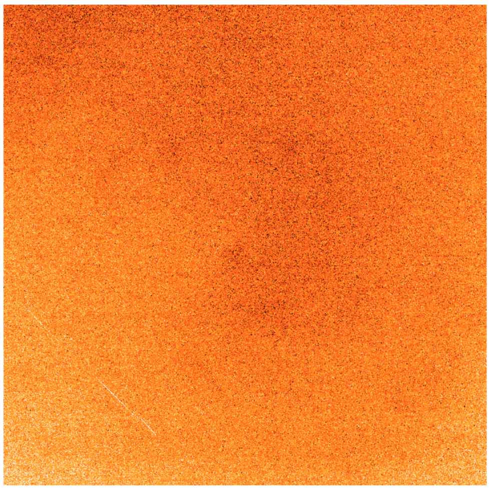


FIGURE 25: Example of fringing mask produced using data acquired during run M-012. No significant fringing pattern is visible.

D EFOSC2@NTT Detailed Instructions

D.1 Overscan and Trimming Sections

The overscan section is very irregular and it is impossible to select a reliable overscan section (see Fig. 26). The overscan is defined as inadequate for bias subtraction in the EFOSC2 manual as well[56] hence we do not apply any overscan correction. When the instrument is set on EFSOC2

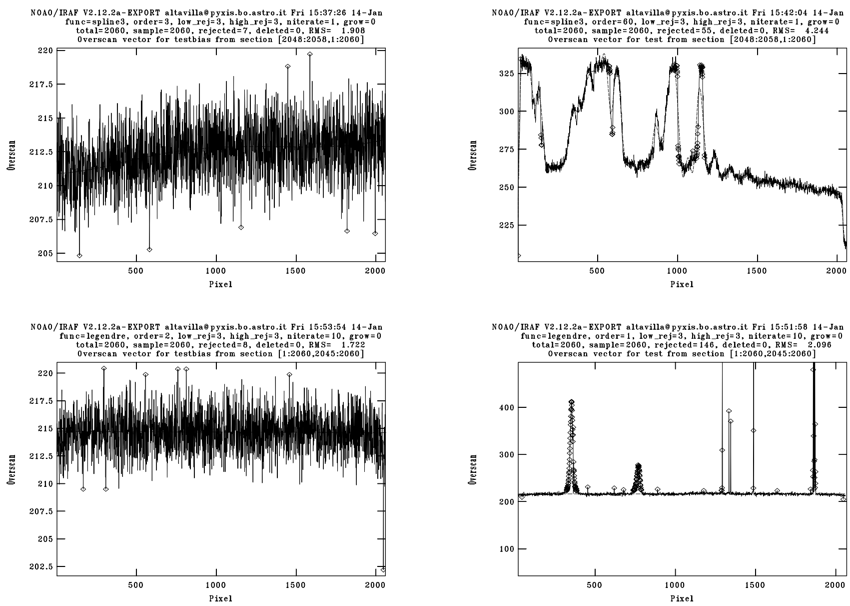


FIGURE 26: Fit of the two overscan sections available for CCD#40 mounted at EFOSC2@NTT. In the *upper panels* the [2048:2058,*] overscan section fit both for bias (left plot) and flat frames (right plot) are shown. The same plots are built for the [*,2045:2060] overscan section and are shown in the *bottom panels*. The overscan behaviour is irregular and dependent on the frame type. Moreover, the overscan level in flat frames is higher with respect to bias frames (∼50 ADU).

in the input parameters of the pipeline, the following trimming sections are automatically used (no overscan correction is performed):

- trim section for photometry (1x1 binning) : [20:2000,10:2000]
- trim section for spectroscopy (2x2 binning) : [47:985,1:1029]

[56] http://www.eso.org/sci/facilities/lasilla/instruments/efosc/doc/manual/EFOSC2manual_v3.1.pdf and http://www.eso.org/sci/facilities/lasilla/instruments/efosc-3p6/docs/Ccd40.html#summary

D.2 Bias

In order to perform the stability study of the two-dimensional structure of masterbias frames, the pipeline uses the sections reported in Table 15.

TABLE 15: **Sections for EFOSC2@NTT masterbias Quality Control**

<table>
<tr><th>Observation type</th><th>Section</th><th>Useful for run:</th></tr>
<tr><td>photometry</td><td>A = [20:520,1470:1970]
B = [1460:1960,1470:1970]
C = [740:1240,748:1248]
D = [20:520,20:520]
E = [1460:1960,20:520]</td><td>all runs</td></tr>
<tr><td>spectroscopy</td><td>A = [20:320,709:1009]
B = [619:919,709:1009]
C = [319:619,364:664]
D = [20:320,20:320]
E = [619:919,20:320]</td><td>all runs</td></tr>
</table>

TABLE 16: **Sections for EFOSC2@NTT masterflats Quality Control**

<table>
<tr><th>Run</th><th>Section</th><th>Useful for:</th></tr>
<tr><td rowspan="2">all runs</td><td>A = [1:660,1328:1991]
B = [660:1320,1328:1991]
C = [1320:1981,1328:1991]
D = [660:1320,664:1328]
E = [660:1320,664:1328]
F = [1320:1981,664:1328]
G = [1:660,1:664]
H = [660:1320,1:664]
I = [1320:1981,1:664]</td><td>outside VS centre plot
and
9 areas plot</td></tr>
<tr><td>N = [660:1320,664:1328]</td><td>Normalisation area for:
Large Scale Variability plot
and
9 areas plot</td></tr>
</table>

D.3 Dark

No dark correction is needed.

D.4 Flat

In order to perform the stability study of the two-dimensional structure of masterflats, the pipeline uses the sections reported in Table16.

D.5 Bad Pixel Mask

We show, as an example, the BPM produced during run M-007: m.NTT-EFOSC2_20081128_BPM_BIN1x1.pl . As shown in Fig. 27, the CCD cosmetics is not so good. For this reason we have and will acquire new data in other runs as well (for example, M-010) to follow the BPM evolution with time. We always recommend to use the BPM closest in time to the pre-reduce your run. The BPMs produced for EFSOC2 are available in Wiki-Bo[57].

D.6 Fringing Mask

We report, as an example, the Fringing Mask produced using data acquired in the first night of run M-007 (26 November 2008). No significant fringing pattern is visible, as shown in Fig.28: the correction for fringing is not necessary for NTT imaging.

[57] `http://yoda.bo.astro.it/wiki/index.php/EFSOC2_IFP_Calibration_Frames#BAD_PIXEL_MASK`

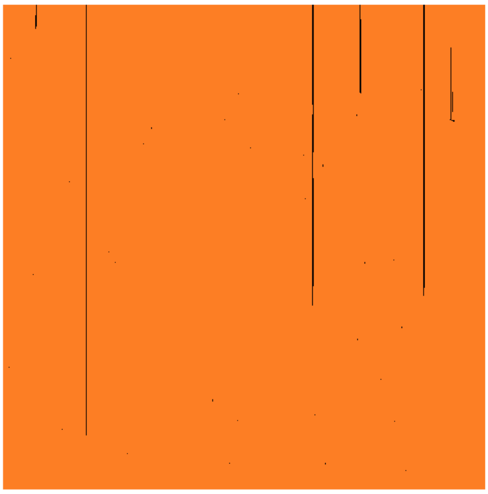


FIGURE 27: EFOSC2 Bad Pixel Mask for the 1x1 binning factor used in imaging observations.

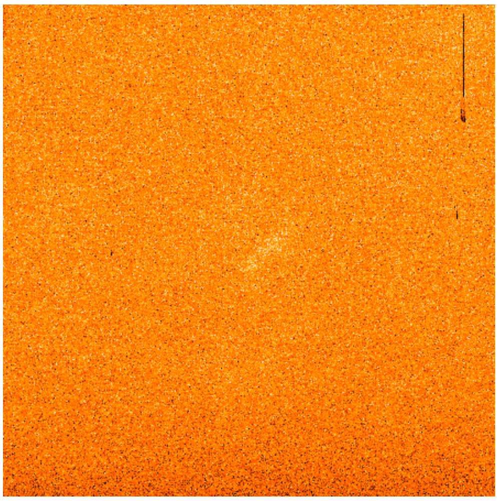


FIGURE 28: Fringing Mask produced using data acquired during the first night of run M-007 (1x1 binning). No significant fringing pattern is visible.

E LaRuca@SPM1.5m Detailed Instructions

E.1 Overscan and Trimming Sections

In October 2009, the SITE1 CCD mounted in LaRuca@SPM1.5 was replaced by a new Marconi CCD. So, when the instrument is set on LaRuca and the CCD on OLD or NEW in the input parameters of the pipeline, the following overscan and trimming sections are automatically used:

- overscan section until run V-013a included (SITE1 CCD): [1020:1070,1:1024]
- overscan section from run V-013b included (Marconi CCD): [2110:2150,1:2048]
- trim section until run V-013a included (SITE1 CCD): [15:1013,15:1024]
- trim section from run V-013b included (Marconi CCD): [60:2095, 5:2045]

E.2 Bias

In order to perform the stability study of the two-dimensional structure of masterbias frames, the sections implemented into the pipeline for LaRuca are reported in Table 17.

TABLE 17: **Sections for LaRuca@SPM1.5 Masterbias Quality Control**

Observation type	Section	Useful for run:
photometry	A = [10:210,800:1000] B = [789:989,800:1000] C = [399:599,405:605] D = [10:210,10:210] E = [789:989,10:210]	all runs until V-013a
photometry	A = [20:520,1520:2020] B = [1516:2016,1520:2020] C = [768:1268,770:1270] D = [20:520,20:520] E = [1516:2016,20:520]	from run V-013b

E.3 Dark

No dark correction is needed, at least for SITE1 CCD used until run V-013a included. The study for Marconi CCD is in progress. If a dark correction will be needed, the pipeline will be updated.

E.4 Flat

In order to perform the stability study of the two-dimensional structure of masterflats, the sections implemented into the pipeline for LaRuca are reported in Table18.

TABLE 18: **Sections for LaRuca@SPM1.5 Masterflats Quality Control**

<table>
<tr><th>Run</th><th>Section</th><th>Useful for:</th></tr>
<tr><td rowspan="2">until run V-013a</td><td>A = [1:334,674:1010]
B = [334:667,674:1010]
C = [667:999,674:1010]
D = [1:334,337:674]
E = [334:667,337:674]
F = [667:999,337:674]
G = [1:334,1:337]
H = [334:667,1:337]
I = [667:999,1:337]</td><td>outside VS centre plot
and
9 areas plot</td></tr>
<tr><td>N = [250:630,570:950]</td><td>Normalisation area for:
Large Scale Variability plot
and
9 areas plot</td></tr>
<tr><td rowspan="2">from run V-013b</td><td>A = [1:679,1361:2041]
B = [679:1357,1361:2041]
C = [1357:2036,1361:2041]
D = [1:679,681:1361]
E = [679:1357,681:1361]
F = [1357:2036,681:1361]
G = [1:679,1:681]
H = [679:1357,1:681]
I = [1357:2036,1:681]</td><td>outside VS centre plot
and
9 areas plot</td></tr>
<tr><td>N = [820:1220,775:1175]</td><td>Normalisation area for:
Large Scale Variability plot
and
9 areas plot</td></tr>
</table>

E.5 Bad Pixel Mask

For all runs performed using SITE1 CCD (all runs until V-013a) you can use m.V006.SPM1.5-LaRuca_20081030_ BPM_old CCD.pl[58]. A new BPM useful for all runs performed using the new Marconi CCD was produced using data acquired during run V-020: m.V020.SPM1.5-LaRuca_20100717_ BPM_old CCD.pl. Both BPMs are shown in Fig. 29. As usual, all the BPMs produced for LaRuca are available in Wiki-Bo[59]. If new BPMs are produced, we recommend to use the one closest in time to the pre-reduce your run.

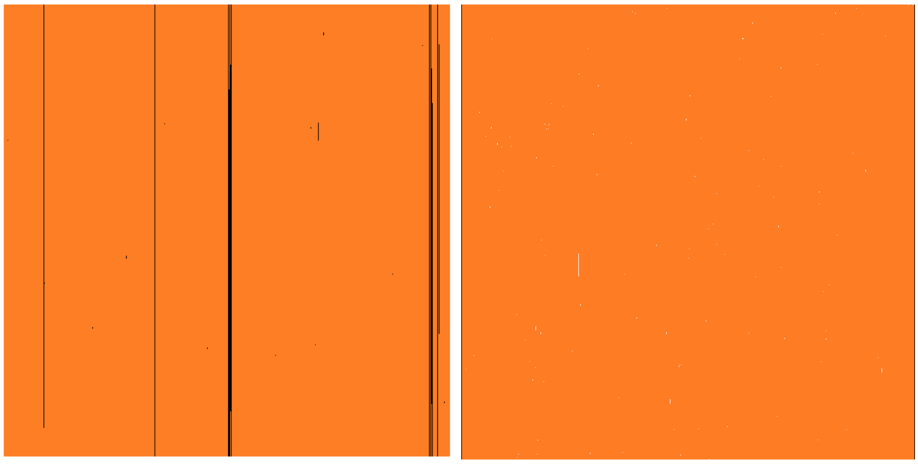


FIGURE 29: LaRuca Bad Pixel Mask for SITE1 CCD *left panel* and for the new MARCONI CCD *right panel*.

E.6 Fringing Mask

A Fringing Mask has been produced for each pre-reduced night using scientific data acquired in R band. We report, as an example, the Fringing Mask produced using data acquired during one night of run V-006 (05 November 2008). No significant fringing pattern is visible, as shown in Fig. 30 (left panel): no correction for fringing is necessary for data acquired using the SITE1 CCD. The study for the Marconi CCD were performed using dedicated data acquired during one night of run V-013 (24 October 2009): the result is shown in Fig. 30 (right panel). Also for data acquired with the Marconi CCD, no significant fringing pattern is visible and no correction for fringing is necessary.

[58] Produced using data acquired during run V-006

[59] http://yoda.bo.astro.it/wiki/index.php/LaRuca_IFP_Calibration_Frames#BAD_PIXEL_MASK

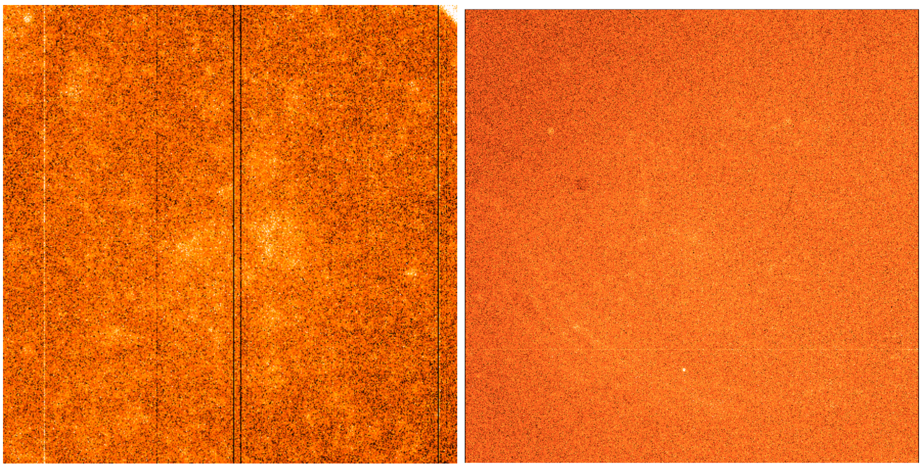


FIGURE 30: Fringing Mask produced using data acquired during one night of run V-006 (left panel) and run V-013 (right panel). In both cases, no significant fringing pattern is visible.

F ROSS@REM Detailed Instructions

F.1 Overscan and Trimming Sections

No overscan strip is present in ROSS@REM images, and no trimming is needed.

F.2 Bias

No bias are acquired (the bias level and pattern is already included in dark frames).

F.3 Dark

The REM Optical Slitless Spectrograph (ROSS) is a commercial Apogee AP47 camera hosting a Marconi CCD. Due to the lack of nitrogen cooling, the correction for dark current becomes necessary, and dark frames[60] are taken periodically by the REM team. Monthly masterdarks are produced by the REM team for exposure times equal to 1, 2, 3, 4, 5, 10, 15, 20, 30, 40, 60, 120, 240, and 300 seconds. After the first few runs, were we used exposure times of 5 and 20 seconds, we found that the best results can be obtained with an exposure time of 180 seconds for most of our targets, while 60 seconds are enough for the brightest targets (V 10.5). Because the REM team does not produce any 180 seconds monthly masterdarks, in order to pre-reduce the scientific frames taken with this exposure time, we produce the required masterdark using:

$$Masterdark(180s) = \frac{Masterdark(120s) + Masterdark(240s)}{2}$$

Before applying the masterdark using the pipeline, you have to manually correct the exposure time reported in the header using the IRAF task `hedit`. For example:

```
hedit dark180sec.fits EXPTIME 180 add+ verify-
```

We performed a stability study, similar to the bias stability check, for both the 60 and 180 sec monthly masterdark (see SMR-002). The sections reported in Table 19 should be used for this kind of test.

F.4 Flat

As explained in SMR-004, ROSS images are strongly affected by light-concentration. The sky flat field frames are obviously the most affected images by light-concentration and the flat field

[60] they already include the bias level and pattern.

TABLE 19: **Sections for ROSS@REM Masterdark Quality Control**

Observation type	Section	Useful for run:
photometry	A = [10:310,714:1014] B = [714:1014,714:1014] C = [362:662,362:662] D = [10:310,10:310] E = [714:1014,10:310]	all V-runs

correction of the scientific images can negatively affect the quality of light curves acquired using ROSS. The "cushion shape" pattern produced by the light-concentration is an addictive effect, impossible to correct *a priori*, since it is not possible to distinguish between the additive shape due to light concentration from the actual response shape due to the instrument. We will demonstrate in SMR-004 that the flat field correction on ROSS scientific images significantly reduces the precision of our short-term light curves. For this reason we decided not to correct our data for masterflat.
Observations aimed to obtain data needed to map the light-concentration effect (as proposed by Andersen et al., 1995) are ongoing.

F.5 Bad Pixel Mask

The required data to produce a BPM (i.e. at least 3 flats with high counts and at least 3 flats with low counts) are not easily available because flats are automatically taken each night on the sky, without any control on the resulting count levels of the frames. For this reason, all skyflats produced during one month are taken into account to select flats useful to build a BPM. As an example, we show in Fig. 31 the BPM produced using skyflats acquired in July 2008. The CCD cosmetics appears quite good so, due to the problems presented by flatfields used to produce BPMs, we decided to not apply the BPM correction to the ROSS images.

F.6 Fringing Mask

In order to search for the presence of fringing patterns, all scientific frames acquired with the R filter during one night have been combined, to obtain a median final image containing only the fringing and the flat field structure[61]. An example of such a frame is shown in Fig. 32, for the R (left panel) and I filters (right panel). No significant fringing pattern is evident in both filters, and therefore a correction for fringing is not necessary for ROSS images.

[61] As mentioned before, no flat field correction are applied to ROSS images.

FIGURE 31: ROSS Bad Pixel Mask.

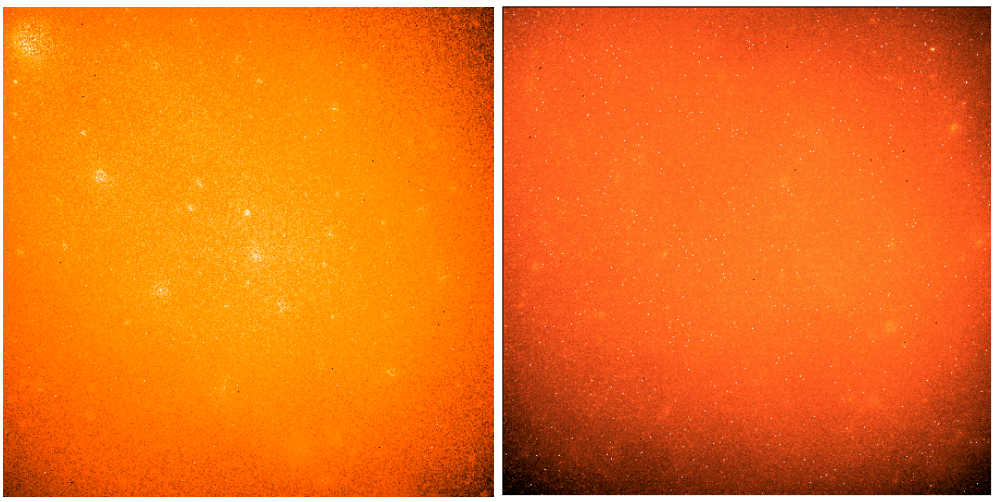


FIGURE 32: Median image produced using data acquired during one night of run V-007 (*left panel*) and V-012 (*right panel*) with the R and I filter respectively. No significant fringing pattern is visible.