Manuals
Instrument observing manual

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Issue	**Date**	**Section / page / paragraph**	**Change description**
3.0, 3.1	07 Oct 2017	All	Same content as in version 2.4 in FDR template with ICS snapshots obtained in June 2017, with new introduction and numerous updates
2.4	21 Mar 2016	All	Versions 2.0 to 2.4 prepared by J. A. Caballero and used for over a year at CAHA. Based on a version 1.0 prepared by E. W. Guenther (TLS), itself inspired by a beta version by J. A. Caballero (CAB, LSW). Version 2.4 contained comments by S. V. Jeffers (IAG), A. Guijarro (CAHA) and F. Bauer (IAG)

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1 Introduction

1.1 Purpose

This document is a public manual for observing with CARMENES at the 3.5 m Calar Alto telescope in late 2017 and early 2018. Since the March 2016 equinox, the CAHA Astronomy Department takes the responsibility of performing all CARMENES observations in service mode, or of supervising visitor-mode open-time observations. For that reason, the manual is especially prepared for the CAHA Technical Astronomers during Guaranteed Time Observations (GTO), but it can also be used as a guideline for principal investigators for them to prepare open time proposals. The document needs to be completed and updated with new changes and improvements in the Instrument Control System.

1.2 Abbreviations and acronyms

Abbreviation	Definition
CAB	Centro de Astrobiología
CAHA	Centro Astronómico Hispano Alemán
CARMENES	Calar Alto high-Resolution search for M dwarfs with Exoearths with Near-infrared and optical Echelle Spectrographs
CDA	CARMENES Data Archive
GUI	Graphical User Interface
GTO	Guaranteed Time Observations
ICS	Instrument Control System

1.3 Reference documents

Document	Short title
CARMENES-MIX002	A&G: Acquisition and guiding system manual
CARMENES-MIX003	FE: Front-end user manual
CARMENES-MIX004	VIS SW: VIS channel software manual
CARMENES-MIX005	VIS EM: VIS channel exposure-meter manual
2016SPIE.9908E..12Q	CARMENES: an overview six months after first light

	(Quirrenbach et al. 2016)
2016SPIE.9913E..34C	CARMENES: instrument control software suite (Colomé et al. 2016)
2016SPIE.9910E..0EC	CARMENES: data flow (Caballero et al. 2016)
2014SPIE.9147E..1FQ	CARMENES instrument overview (Quirrenbach et al. 2014)

1.4 Instrument overview

CARMENES (Calar Alto high-Resolution search for M dwarfs with Exoearths with Near-infrared and optical Echelle Spectrographs) is a next-generation radial-velocity instrument built for the 3.5m telescope at the Calar Alto Observatory by a consortium of eleven Spanish and German institutions. The scientific goal of the project is conducting a 600-night exoplanet survey targeting about 300 M dwarfs with the completed instrument. The CARMENES instrument consists of two separate echelle spectrographs covering the wavelength range from 0.52 to 1.71 µm at a spectral resolution of R > 80,000, fed by fibers from the Cassegrain focus of the telescope. The spectrographs are housed in vacuum tanks providing the temperature-stabilized environments necessary to enable a 1 m/s radial velocity precision employing a simultaneous calibration with an emission-line lamp or with a Fabry-Pérot etalon. For mid-M to late-M spectral types, the wavelength range around 1.0 µm (Y band) is the most important wavelength region for radial velocity work. Therefore, the efficiency of CARMENES has been optimized in this range.

The CARMENES instrument consists of two spectrographs, one equipped with a 4k x 4k pixel CCD for the range 0.52–0.96 µm (dubbed VIS), and one with two 2k x 2k pixel HgCdTe detectors for the range from 0.96–1.71 µm (NIR). Each spectrograph is coupled to the 3.5 m telescope with two optical fibers, one for the target, and one for calibration light. The front end contains a dichroic beam splitter and an atmospheric dispersion corrector, to feed the light into the fibers leading to the spectrographs. Guiding is performed with a separate camera; on-axis as well as off-axis guiding modes are implemented. Fibers with octagonal cross-section are employed to ensure good stability of the output in the presence of residual guiding errors. The fibers are continually actuated to reduce modal noise. The spectrographs are mounted on benches inside vacuum tanks located in the coudé laboratory of the 3.5 m dome. Each vacuum tank is equipped with a temperature stabilization system capable of keeping the temperature constant to within 0.010 K over 24 hours. The visible-light VIS spectrograph is operated near room temperature, while the near-infrared NIR spectrograph is cooled to ~140 K.

1.5 A typical night

A typical working day/night is as follows:

- Waking up, shower, breakfast, weather forecast...
- Read emails and potential comments by the CARMENES data analysis team in inbox or *redmine.ice.csic.es* wiki "Science survey".
- Go to the 3.5 m SOR (Sala de Observación Remota) in the laboratory building.

- Depending on the season, start the system and launch NIR and VIS "start-of-night automatic calibration runs" before or after dinner. The closer the runs to the actual start of observations, the better.
- Go to the hotel to take a delicious dinner (remember to fill the list with your name in following nights).
- Open the dome after the sunset when the temperature outside the dome is equal or lower than inside (but see Section ...).
- When the sky is dark enough, observe a couple of telluric standard stars regardless of the type of night; the Technical Astronomer can use the GTO scheduler.
- If the type of night is GTO, the scheduler will plan to observe only GTO targets (Section ...). If the type is open time, follow the instructions by the Astronomy Department Head.
- Regardless of the type, *if needed*, after about 30 min of regular observation, make a FocusRun (Section ...).
- Go on observing GTO stars or your open-time targets.
- At the end of night, after closing the dome, launch "end-of-night automatic calibration runs", and fill the CAHA end-of-night report.

At any time, the CAHA Technical Astronomer must fill the redmine.ice.csic.es wiki "Science survey" of the corresponding night. Please, be as comprehensive as possible.

2 Manual

Text in red may be deprecated and need to be verified and/or updated periodically. Text in blue is planned already to be modified accordingly to new versions of the ICS.

2.1 System start

Everyday start the system as soon as possible. Make sure that you can actually use CARMENES! (some cryostat may be warming up).

In the ICS GUI **luyten** computer:
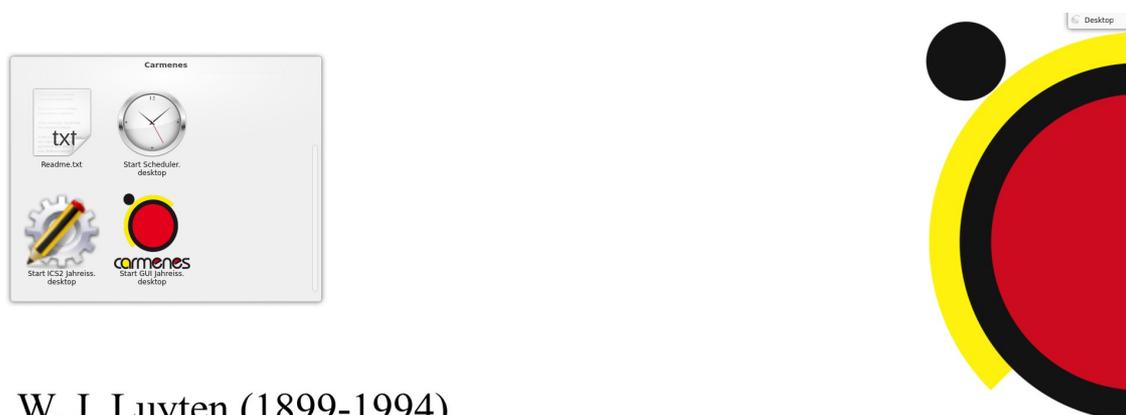
- Click on *start Scheduler.desktop* logo (a black-background konsole opens; it seems that it does nothing – just proceed with the next step)
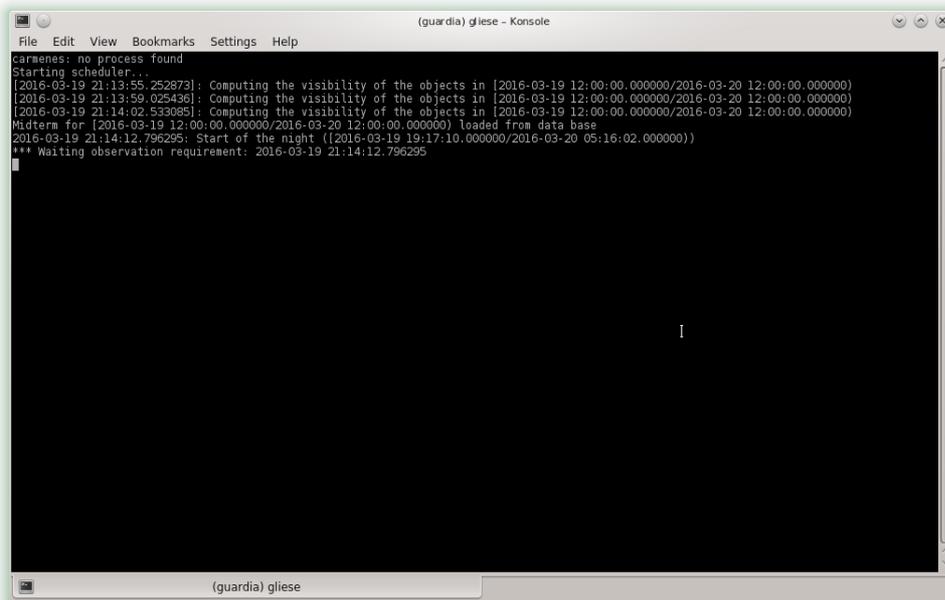
- Click on *start ICS2 jahreiss.desktop* logo (another black-background konsole opens; if it does nothing, something is wrong…)
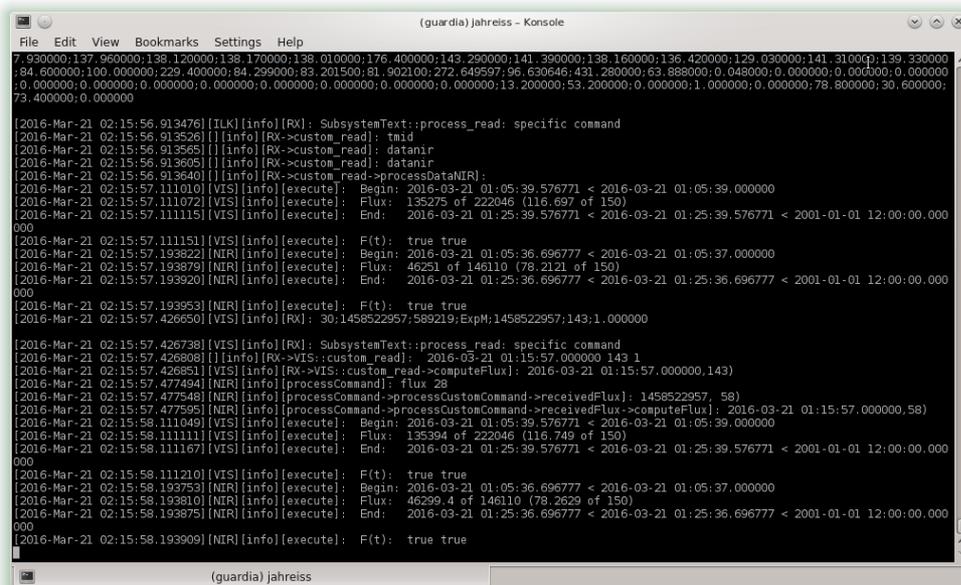
- Click on *start GUI jahreiss.desktop* logo (ignore start ICS and start GUI desktop buttons – they run on ICS One **gliese** computer instead of on ICS Two **jahreiss** computer)

- In the ICS GUI window, click on Connect (top left corner)
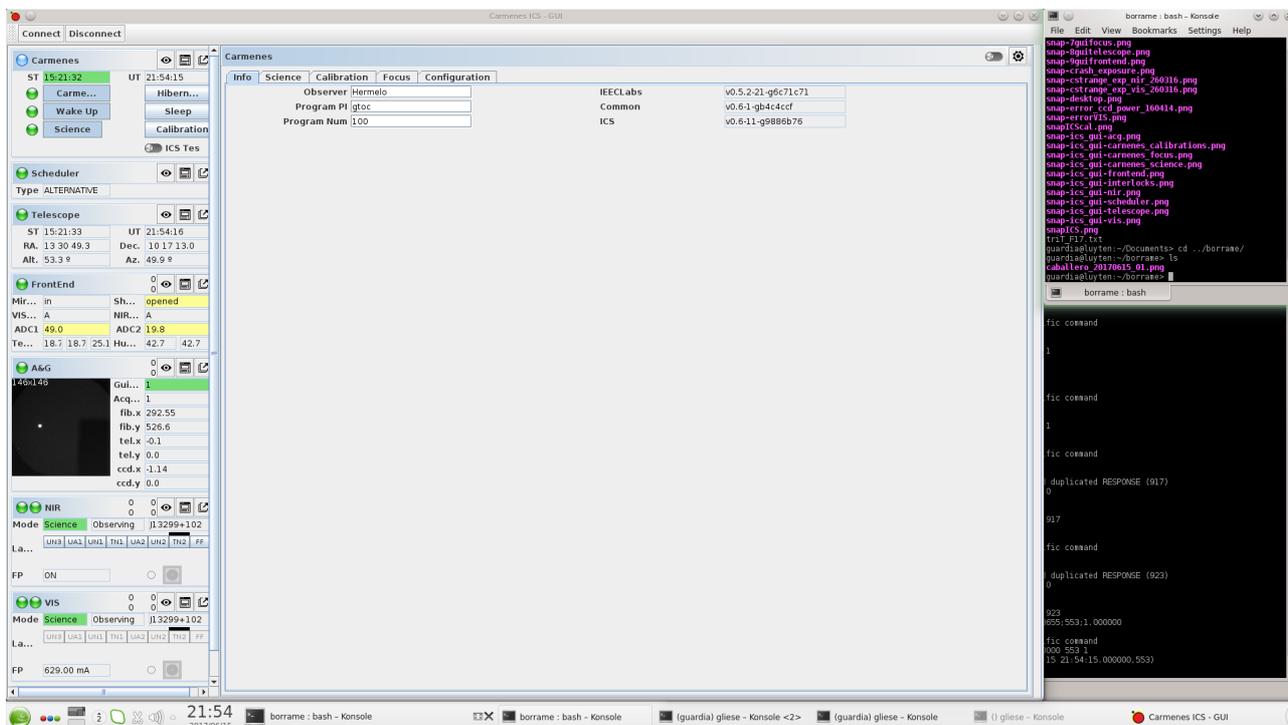
- In the ICS GUI window, click on Wake up (first tab)

On the left side of the GUI there are eight tabs. For editing parameters, click on the symbol that looks like a keyboard (between the eye and the arrow). In general, there are four columns for every parameter: name, current value, possibilities/blank field and the "Set parameter" button. If you forget to click on "Set parameter", the parameter is not modified at all. Some important parameters are summarised on the left side of the GUI.

2.2 AutoCalRuns

At least two "automatic calibration runs" (AutoCalRuns) per channel must be taken during the day, one just before start of night observations ("start-of-night") and the other one just after end of observations ("end-of-night"). In certain cases, a third AutoCalRun might be taken in between, at around midnight ("mid-of-night"). AutoCalRuns should be taken preferably, but not compulsorily, with the telescope parked at zenith. For the mid-of-night and end-of-night AutoCalRuns, there is no need to take Bias/Dark or flat-field halogen lamps.

For making the *AutoCalRuns, both FrontEnd NIR and VIS fibre mirrors must be **in A+B position*** (= the two science and calibration fibres illuminated by the light from the CalUnits). AutoCalRuns scripts move automatically the two fibre mirrors to A+B at the beginning of the calibration sequence and, at the end, to A position (= the science

fibres illuminated by light from the sky, the calibration fibres illuminated by the light from the CalUnits). At the beginning of each AutoCalRun, the ICS turns on the right lamps in advance by around 8 min. The Fabry-Pérot lamps in VIS and NIR are **always** ON. Currently, the fiber **shakers** are always OFF.
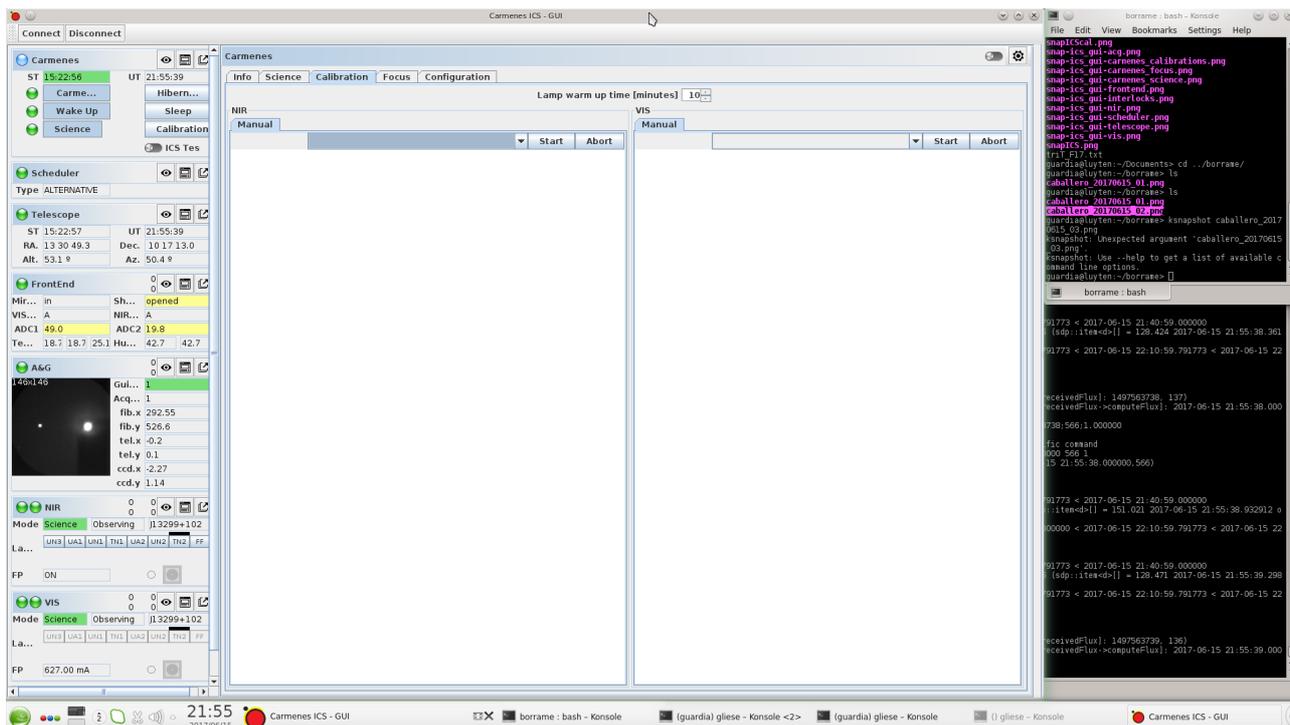
In Carmenes > Calibration in the ICS GUI, the complete NIR and VIS AutoCalRuns can be executed just by clicking the respective buttons.

Target name	Exposure time [s]	Repetitions	CalUnit mirror	Fabry-Pérot shutter	Science filter	Calibration filter
Dark	3	5	(TN2)	Closed	Closed	Closed
HAL,OFF	8	1	(FF)	Closed	Open	Closed
OFF,HAL	8	1	(FF)	Closed	Closed	Open
HAL,HAL	8	3	(FF)	Closed	Open	Open
UNe,UNe	3	5	(UN3)	Closed	Open	Open
FP,FP	5	5	(TN2)	Open	Open	Open
FP,OFF	5	5	(TN2)	Open	Open	Closed
OFF,FP	5	5	(TN2)	Open	Closed	Open

TN2 is the CalUnit lamp arm parking position.

Although you should not need to do it, for setting a CalUnit mirror, click on the line above the lamps button and drag the marker to the desired position (and click on Set mirror).

2.3 Opening and closing

The CAHA Technical Astronomer is the person in charge of allowing to open and close the dome and telescope. *Ask him/her **always** before opening and closing it, especially if the weather conditions are not optimal*.

Both opening and closing are done from the Telescope Control System **tecs** computer. The first time that you do it, you should be accompanied by a CAHA support astronomer. *For observing from the 3.5 m SOR, the telescope must be in REMOTE*; contact a.s.a.p. your support astronomer if REMOTE is off.

How to open

1. REMOTE must be on (in green)

2. Click on `Observe`

3. Click on `Hydraulics` (and wait for 2 min until the button stops blinking)

4. Check that the top figure in **zeus** is OK

5. Click on `Drives`

6. (If there is any red button, instead of green, in the main drives below the telescope picture, contact a.s.a.p. your support astronomer; the telescope control must be restarted)

7. Click on `Tracking`

8. Click on `Dome/open slit` (it opens the top section of the dome only); wait until the slit is completely open (i.e. no "99 <---> 99")

9. Click on `Dome/auto`

10. Click on `Settings/focus auto`

11. Click on `M1 Cover`

12. Click on `Cas. Cover`

13. Check that `Li.baffle` is active

How to close

1. Click on `Cas. Cover`

2. Click on `M1 Cover`

3. Click on `Abs. pos./zenith`

4. Click on `Dome/close`

5. Click on `Drives` (wait for telescope at zenith)

6. Check that the top figure in zeus is OK

7. Click on `Hydraulics`

8. Click on `idle`

Or, alternatively:

1. Click on `Shutdown`

2. Click on `Hydraulics`

3. Click on `idle`

2.4 Getting on-sky data

First of all, the FrontEnd pick-up mirror must be in 'In' position. It must be moved from 'Out' to 'In' position only when the telescope is parked at zenith. Move the mirror to 'In' at the beginning of a run and leave it in that position until the end of it. *It is important to move the mirror to 'Out' again at the end of the run* (if not, the PMAS observers will be disappointed on the following day).

Besides, for getting on-sky data*, both FrontEnd NIR and VIS fibre mirrors must be **in A position*** (= the science fibre illuminated by the star, the calibration fibre illuminated by the light from the CalUnits).

The procedure of getting data is simple. Always in the ICS GUI **luyten** computer:

1. Select the next target from the Scheduler tab

2. Move to the next target from the Telescope tab

3. Acquire and guide from the A&G tab

4. Take VIS and NIR spectra from the VIS and NIR tabs

5. Update the night log in the *redmine.ice.csic.es* wiki "Science survey"

2.5 Carmenes

In Carmenes > Science, tick on the Enable box and select a "Night quality" level:

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Excellent, Good, Regular, Poor, Bad, Very bad. This is necessary for the Scheduler. You can also write a comment for the night or the current image, which will be copied to the image headers. To be completed.

2.6 Scheduler

Click on "Select best" before moving to any new target. You should pick up the first target in the list.

2.7 Telescope

Only for open (non-GTO) time: type the coordinates in format hh mm ss.s ±dd mm ss or hh:mm:ss.s ±dd:mm:ss (see above). Update figure.
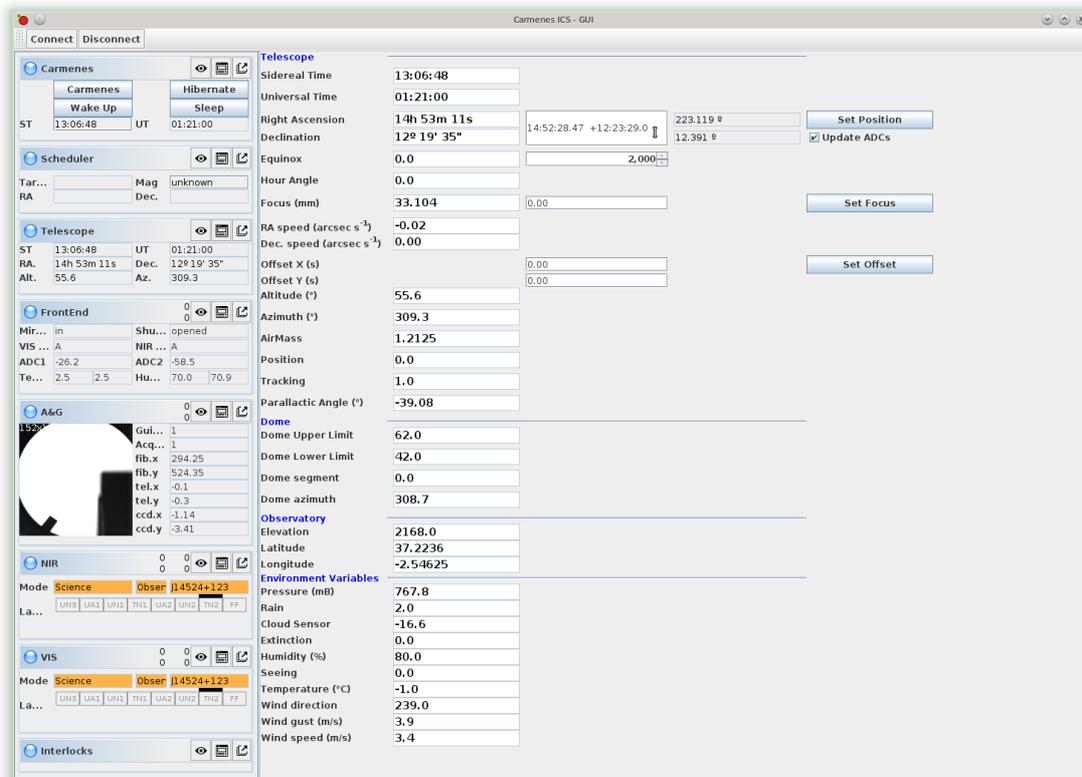
2.8 A&G

Exposure time should be set to 3 s. Exceptionally, you may need to increase (or decrease) the exposure time for faint targets and poor/very poor weather conditions (for bright targets and good/excellent conditions).

A new image should appear automatically in the display. It is saved in the same night directory as the VIS and NIR spectra (*_acg.fits). Targets usually fall approximately on the same position in the field of view, at X =600, Y = 500, approximately. In case of doubt, open the target's finding chart in https://carmenes.caha.es/int/gto/alpha/Jhhmms+ddm_R.png, where Jhhmms+ddm is the target's Carmencita ID.

When you have identified the target, click on its photocentroid with the left mouse button and next on "Start guiding". Under normal circumstances, the parameters "Guiding" and "Acquisition" change from -1 and 0 to 1 and 1 in less than 5 s.

A second light blob at the calibration fibre hole appears periodically in thwe A&G images; it is the Fabry-Pérot light.

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2.9 NIR and VIS

In GTO mode, NIR and VIS channel images are launched simultaneously, but there is typically a delay of the VIS channel with respect to the NIR one after finishing the exposure and reading out the detector (VIS) and combining the frames (NIR). This delay is variable, but is never larger than 10 s. In non-GTO mode, currently NIR and VIS channel images are launched separately from the NIR and VIS tabs.

First of all, check that for every channel:

- FrontEnd mirror is in A position (not A+B)

- Fibre shaker is On

- ExpMeter filter is Open [FILTER_D0 in VIS, FILTER_CLEAR in NIR] (it must be **Closed the rest of the time**: with parked telescope, during calibration, while telescope moves if there is full moon…)

- Fabry-Pérot lamp is On

- "Auto F-P" is On.

- CalUnit Fabry-Pérot shutter is Closed (Auto)

- CalUnit science filter is Open

- VIS CalUnit calibration filter is Open.

The **FrontEnd shutter must be closed** at any time (it is open automatically by the system). Fibre shakers are currently off.

In GTO mode, Target name and Exposure time in NIR and VIS tabs is filled automatically. In non-GTO mode, fill Target name and Exposure time in NIR and VIS tabs. For the moment, Target name in NIR and VIS must be identical.

Below there is an exposure time table useful for poor, regular and good weather conditions and without working scheduler (e.g. some open time proposals). You must adjust slightly the exposure times depending on seeing, extinction, target spectral type… Exposures times will be shorter/longer for excellent/bad weather conditions. You should get around 4000 counts (absolute) on the target spectra near the centre of the VIS CCD. In GTO mode, you should not expose for more than 900 s for M0-2V stars, than 1200 s for M3-4V stars, and than 1800 s for M5V stars and later.

J [mag]	Exposure time [s]
4.0	200-250
5.0	300-400
6.0	450-550
6.5	600-750
7.0	800-900
7.5	1000-1200
8.0	1500-1800

If you have to stop a exposure before the requested time (due to e.g. a sudden increase of the humidity above the maximum limit), you can do it without losing the data. Just click *once* on the Stop button. In the VIS channel, it seems that it is exposing for another 33 s; it is actually being readout. If you click twice on the Stop button, you will loss the data.

2.10 Interlocks

Interlocks alarms with semaphores (green, yellow, red) informs on the status of critical system temperatures and pressures. All semaphores must be green in regular operations. Contact a.s.a.p. your Support Astronomer in case that there is some semaphore yellow or red. Update figure.
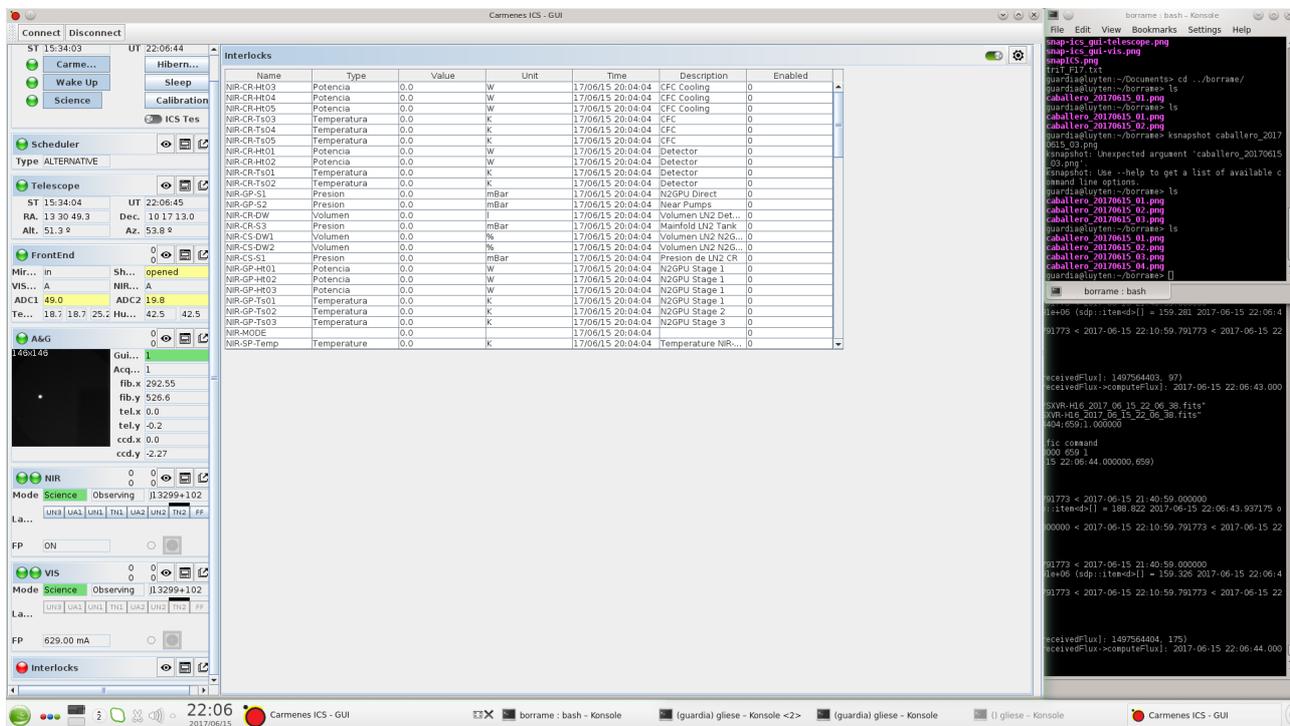
2.11 Focus

If you do not have an idea of the current CARMENES focus, in Carmenes > Focus, set the default values to Step size = 0.2 mm, Min = 31.0 mm, Max = 34 mm, Exposure time = 7 or 8 s. Select a target (or open cluster field) with right ascension similar to the current Local Sidereal Time and declination similar to the Observatory geographic latitude (+37 deg). Click on Start. At the end, check that the best focus value lies between Min and Max and has a physical meaning. You can make a second round with a Step size = 0.1 mm and Min and Max ±0.3-0.4 mm.

If you have an idea of the current CARMENES focus, you can skip the AutoFocusRun and identify visually the best focus during guiding. Vary -0.2 mm, -0.1 mm, +0.1 mm and +0.2 mm around the last night best focus. You can change it from the Telescope tab in the GUI or, perhaps more easily, from the FocusPos box in the Settings tab of **tecs** (ask your CAHA astronomer). The focus depends on the temperature of the telescope structure (T7). Until mid-March, the best focus varies between +33.2 mm (T7 < 5ºC) and +32.2 (T7 > 10ºC). Initial focus of +32.6ºC should be a good guess for regular nights (T7 = 5-10ºC).
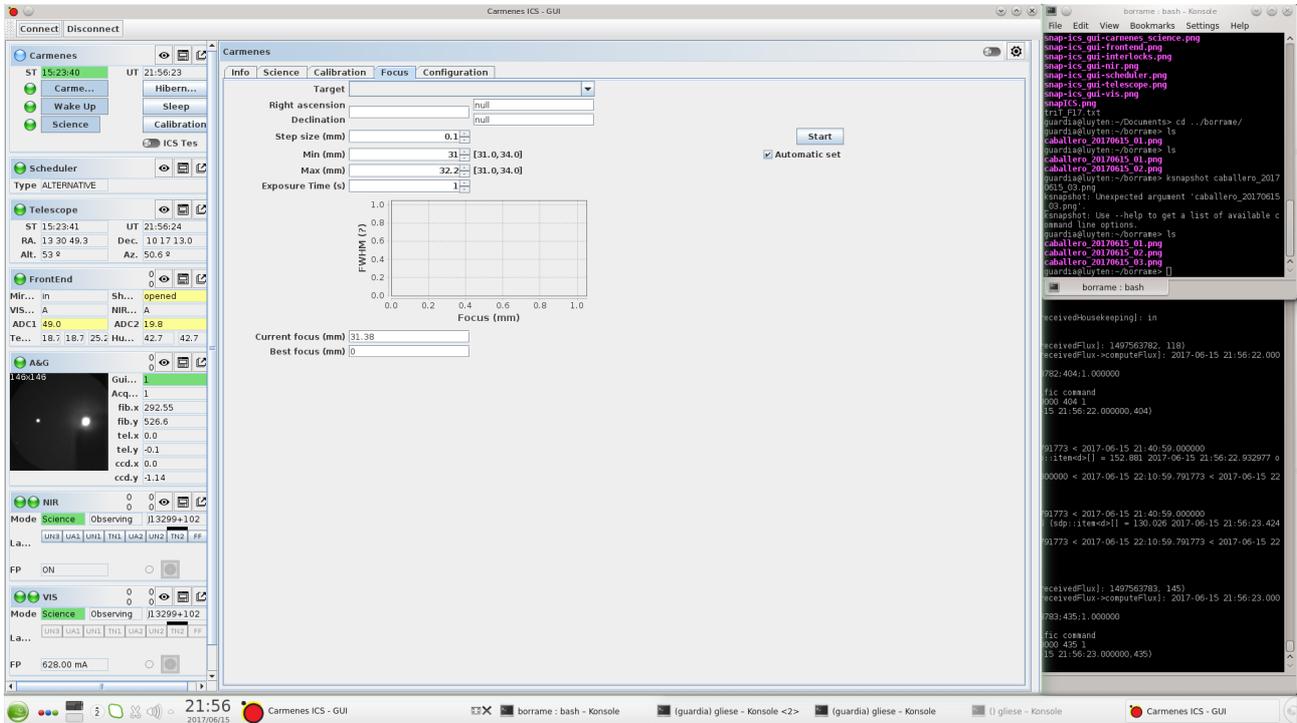
2.12 Configuration

Only for experts: for setting minimum and maximum values of FocusRun and opening times of Fabry-Pérot shutters.

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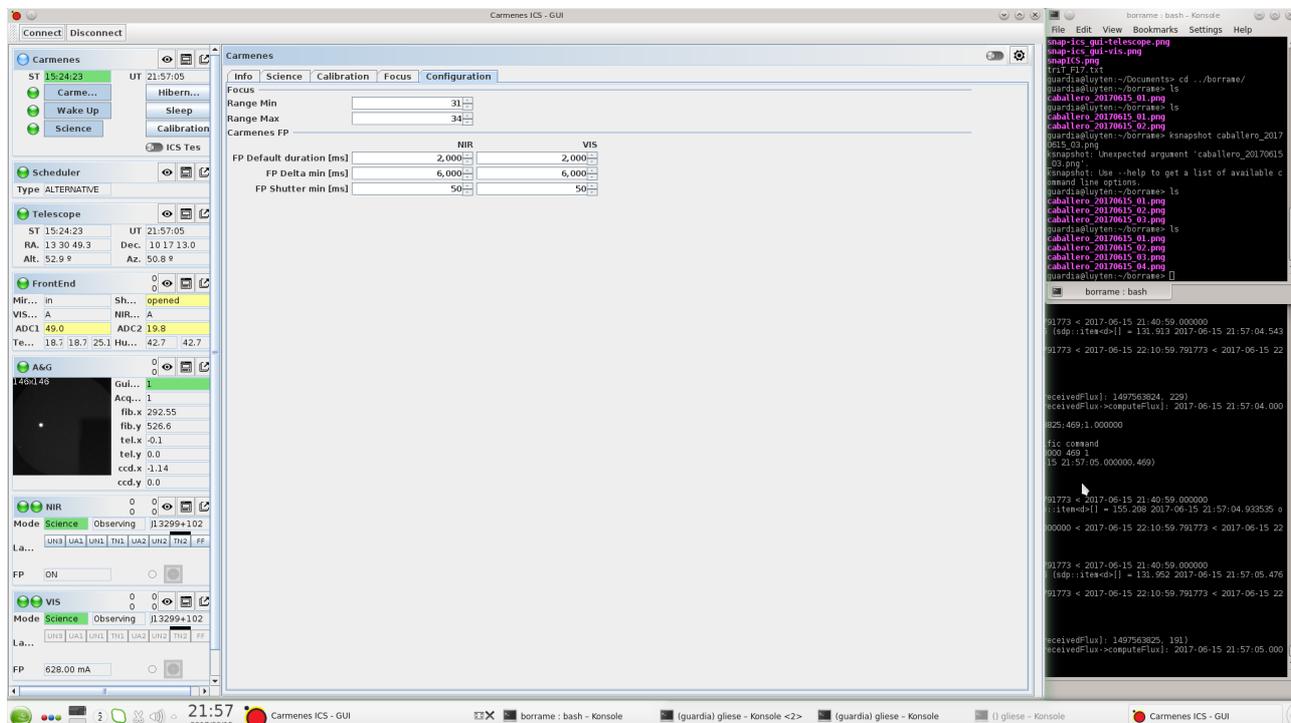
2.13 Log

You must fill the log in the *redmine.ice.csic.es* wiki "Science survey". For getting the list of VIS and NIR images, follow these steps:

- On lacaille, open two konsoles
- For the VIS channel log, type "logmaker_carm_vis yymmdd" (e.g. 160321 for 21 Mar2016) in one konsole
- For the NIR channel log, type "logmaker_carm_nir yymmdd" (e.g. 160321 for 21 Mar2016) in one konsole
- Copy and paste from the konsoles to the wiki
- Type Ctrl+C when finish the night

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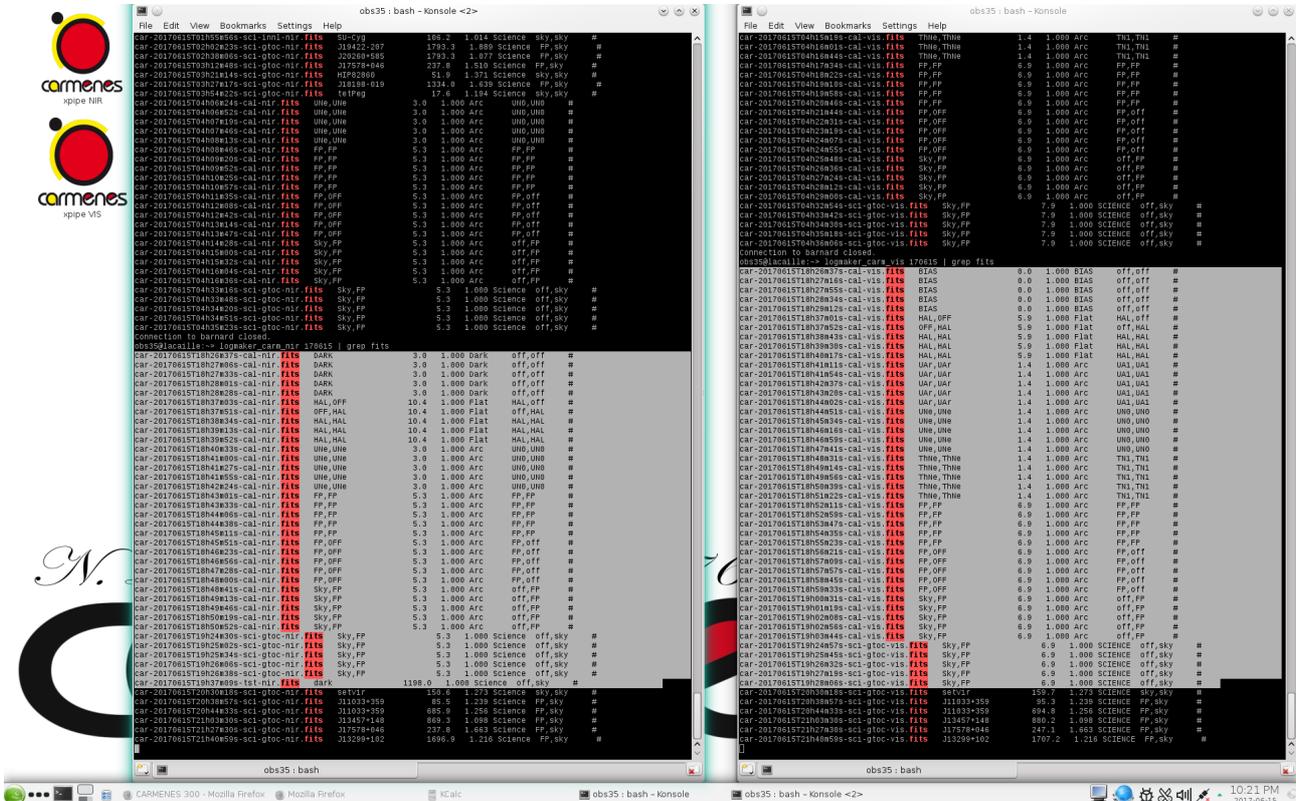
2.14 Pipeline

On **kapteyn**, click on "xpipe VIS" and on "xpipe NIR". Select the current night, "nite", if not already (the folder is created just after the first image is generated).

You can see the spectra by clicking on the spectrum name in the raw (central) column. A ds9 opens automatically. Recommended display format is scale = linear + min max and color = grey or bb. You do not need to close it before opening a new spectrum. In the VIS channel, we use the region around the pixel 2200,2200 for measuring the number of counts.

If the pipeline does not run fully automatic, follow these steps on "xpipe":
- When you have the first bias image, click on the xpipe terminal and type Crtl+Alt+p; new fields appear in the bottom left part of the xpipe window
- During the calibration sequence, fill the fields: task = ?, files = [], redtype = [], reclass = [] and click on reduce; after several minutes of intense analysis, xpipe displays "wave re-calibration done"
- After the calibration sequence, fill the fields: task = ?, files =[], redtype = OBJ,FP, reclass = [] and click on reduce

If you are not an expert user of xpipe, just use it for investigating the new spectra.

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2.15 At the end of the night

After having closed the telescope and dome and turned off the hydraulics:

In the ICS GUI **luyten** computer:

- Turn off all lamps and fibre shakers

- Close all shutters and filter wheels, especially the ExpMeter filters

- Put the CalUnits mirror in parking position (TN2)

- You can put both NIR and VIS detectors in 'Safe' mode (but remember to put them in 'Science' mode before starting collecting data on the following day). This step is not necessary during the long Winter nights

- *The four items above are shortened by clicking on the **Sleep** button*

If CARMENES will not be used on the following days:

- Close the ICS GUI window

- Close the ICS konsole

- Close the Scheduler konsole

In one of the auxiliary CAHA computers:

- Fill the Night report (ask for guidance to the support astronomer on the first day)

In the 3.5 m SOR:

- Turn off all monitors

- Leave the room as it was when you arrived (pieces of paper, plastic glasses…)

- Take your coat

- Turn all lights off

Tell the Technical Astronomer that you are leaving, drive carefully and sleep tight.