Telescopio Nazionale Galileo

HARPS-N Operation Guide

Draft Manual version 2.5
TNG-MAN-HARPN-0003
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Change Record

Issue/Rev.	Date	Section/Page affected	Reason/Remarks
V1.0	14-12-2012	First version	
V1.1	14-01-2013		Autoguider added
V1.2	04-02-2013		
V2.0	12-02-2013		New sequencer and Labview SW
V2.1			
V2.2.3	22-05-2013	All document	Paragraph 3.5 added
V2.2.4	19-11-2013	All document	
V2.2.5	15-01-2014		New sequencer and expmeter
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V2.3.0	22-07-2015	Change sequencer figure	New sequencer version
V2.4.1	13/12/2016	some warnings was added	
V2.4	23/08/2017	New LCU	

Contents

1 Introduction

1.1 Scope

This User Manual is intended to give all necessary information to potential users of the HARPS-N instrument, to help them to use the instrument and manages the observation at the TNG telescope.
The following documents are closely related to this manual and should be consulted as well:

- The HARPS-N User Manual (TNG-MAN-HARPN-0002)
- The HARPS-N Startup Manual (TNG-MAN-HARPN-0001)
- The New Short Term Scheduler User Manual (NSTS)
- The DRS User Manual (OG-MAN-HAN-13-0004)

Both are available through the TNG web page

http://www.tng.iac.es/instruments/harps/

1.2 Additional information

The latest information updates about the HARPS-N instrument can be found on the HARPS-N web pages

http://www.tng.iac.es/instruments/harps/

1.3 Contact information

Feedback on this User Manual from users is encouraged. Please email to cosentino@tng.iac.es

1.4 Reference documents

[RD01] HARPS-N User Manual

[RD02] HARPS-N Quick Start Guide

[RD03] HARPS-N LCU Manual

[RD04] New Short Term Scheduler User Manual (NSTS)

[RD05] DRS User Manual

[RD06] Ucam User manual

[RD07] Templates Reference Guide

[RD08] Thorium-Argon Atlas

[RD09] Design of the LCU for HARPS-N

2 Before the observations

Starts up the system following the instructions of the "HARPS-N Quick Start Guide" and take care to read all the advices reported at the beginning of the manual.

2.1 The Observation blocks preparation

From the NSTS the observer can prepare the sequence of observation blocks of the night (Figure 1).
The target can be inserted directly in the NSTS or by using a catalog file that contains the objects information. The format of the catalog file is an ascii file and the fields separator is a TAB (ascii code = 9).
The fields of the catalog are shown in Table 1, the mandatory fields are shown in bold format.

An example of catalog file is shown in the HARPS-N webpage:

(http://www.tng.iac.es/instruments/harps/data/SpStdHARPSN.cat)

Table 1- Catalog file entries

name	**object code**
alpha	**right ascension (nn:nn:nn.nn)**
delta	**Declination (nn:nn:nn.nn)**
mualpha	proper motion alpha(arcsec/year)
mudelta	proper motion delta (arcsec/year)
mv	**magnitude V**
bv	Bv
TypSp	**spectral type**
radvel	**mean radial velocity (KM/sec) or -99999**
snr	Signal/Noise (550nm)
spectr	spectral type for the mask(two chars only)
remarks	Remarks
acquisition	Acquisition template (es. HARPN_ech_acq_objA)
equinox	Equinox
progid	**program identificator (es. TAC_xx)**
piname	**PI name**
exptime	**Exposure time**

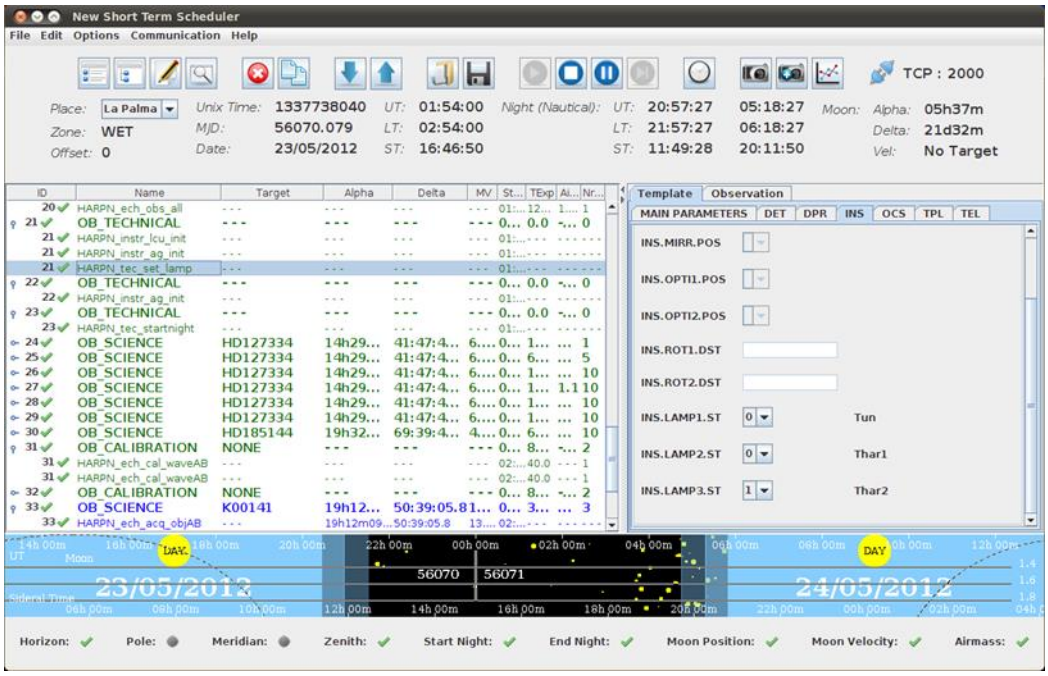


Figure 1 - Short Term Scheduler

2.2 The Sequencer GUI (initialization and operation)

After the startup of HARPS-N the instrument is ready to the initialization of the subsystems and the start of operation.
The sequencer GUI (Figure 2) is divided into several sections:

- ***The sequence control*** buttons, for the interaction with the observing blocks
- ***The Instrument control*** buttons, for the interaction with the HARPS-N's subsystems
- ***The observation Execution logs*** window, where the commands execution and the errors are shown
- ***The acquisition control*** buttons, (expose, repoint, etc), allows to do actions related with the autoguider's image visualized by the DS9 application.

The DS9 application shows the autoguider's image and interacts with the sequencer.

During the command execution the status is visualized into the observing status window and, at the end of execution, a bell sound confirms the correct execution of the command (if the sound is a horn noise, this means that something goes wrong and an error should be shown in the *observing status* window).

2.2.1 Initialization

From the ***instrument control*** section, click on the ***LCU Init*** button and wait until the command ends.

Then click on the ***AG Init*** button and wait until the command ends.

The system now is ready to calibrations (but not for the observations).

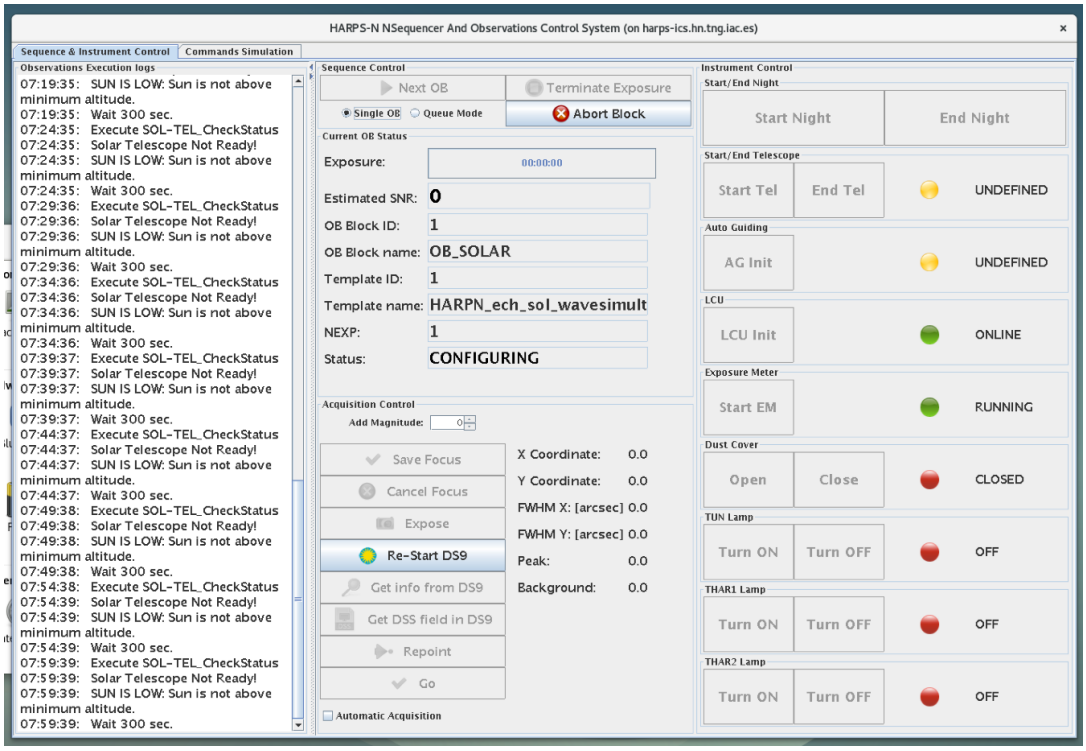


Figure 2 - The Sequencer GUI

Note-1: The red log "Failed to fetch data from telemetry!" is not an error and can be ignored as error if appears during calibrations or in acquisition with exposure time less than 5 seconds.

Note-2: The yellow log "[...] Warning Final AG guide FITS file not found!" is a warning that don't affect the observation (we are working to fix this bug)

Table 2 - Acquisition Control buttons

Add magnitude	Increases/decreases the value of the magnitude of the selected star
Save Focus	send to OCS the command that update the serrurier focus
Cancel Focus	Moves M2 to the position prior to the focus procedure execution
Expose	Take a new image with the AG camera
Re-Start DS9	Restart the DS9 window (when the DS9 window crash)
Get infos from DS9	Take coordinates and FWHM from the point clicked in the DS9 image
Get DSS fields in DS9	Visualize the compass in the DS9
Repoint	put the point clicked in the DS9 image into the fiber position and acquire a new image
Go	put the point clicked in the DS9 image into the fiber position and start the autoguider
Automatic acquisition	Selects , put in the fibre and start the acquisition of the brightest star of the field

2.2.2 Sequence Control buttons

Next OB → executes the next block available of the NSTS
Single OB → if checked executes one block when the user click on **Next OB** button
Queue Mode → if checked executes a series of NSTS blocks (according with the NSTS rules) when the user clicks on **Next OB** button
Terminate exposure → ends the current exposure and save the scientific frame
Abort block → aborts the current block

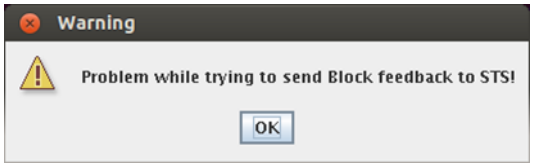
2.2.3 Instrument control buttons

Start Night button → executes the **Telescope Start night** and open the **dust cover**
Start Tel button → executes the **Telescope Start night**
Dust Cover buttons → **Open** and **Close** the dust cover
Start EM button → starts the exposure meter and open the GUI
Note: The ***Start Night*** button includes the preparation to observation of the telescope and of the instrument.

More details about the **instrument control buttons** are shown in Appendix B - **Actions of multi task commands**

2.2.4 Other changes

The sequencer now has a feedback with the NSTS. If the NSTS is not in execution the sequencer visualizes a warning.



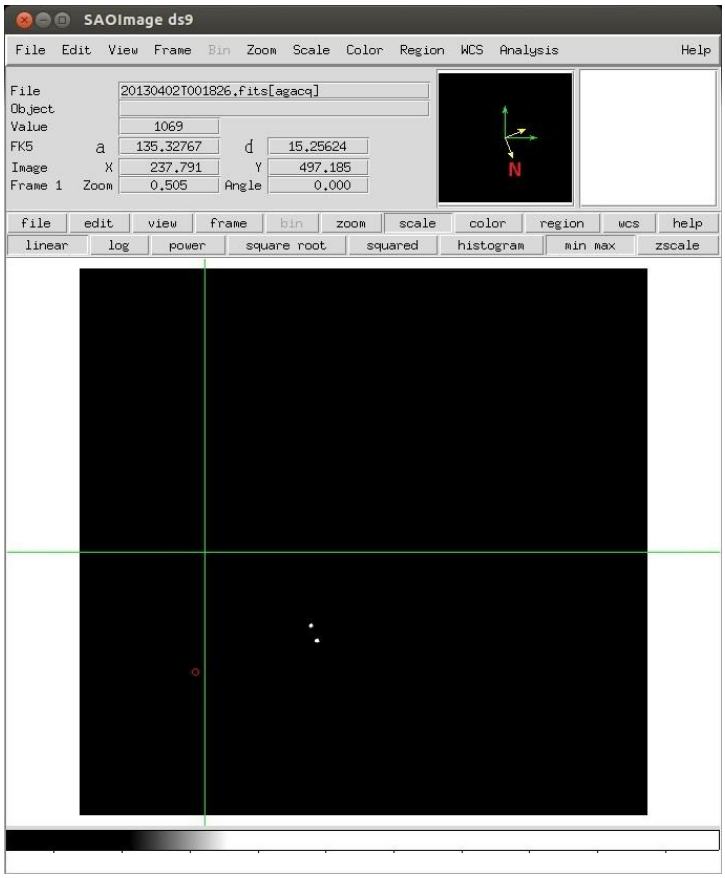


Figure 3 - DS9 terminal with a binary star in the field

The compass is represented by the yellow axis, with the orientation shown in Figure 3.

2.2.5 Before the calibration

Few minute before the start of calibration (about 10 minutes), the observer has to turn on the thorium lamps. If the elapsed time is less then 10 minutes a warning windows appears; in this case the observer has to wait the time indicated in the popup window. The observer can ignore this warning but can compromise the quality of observation.

In the ***Instrument control*** section:

1. Click on the **Turn ON** button of THO1 lamp
2. Click on the **Turn ON** button of THO2 lamp
3. On the ***LCU Device Monitor*** verify the lamps status (Figure 4)

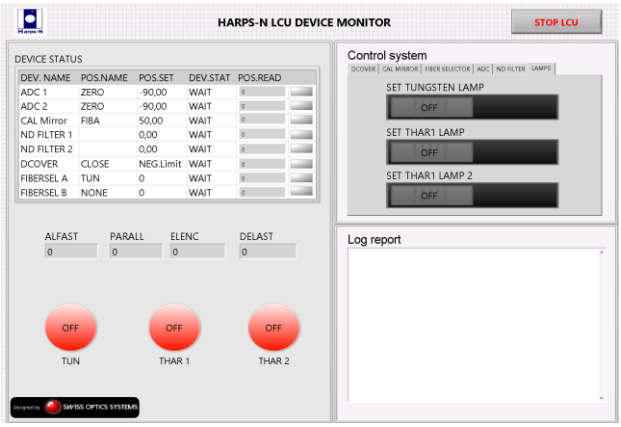


Figure 4 - LCU Device Monitor

A bell sound confirms the correct execution of the command

2.2.6 The standard calibration (daily calibration)

The daily calibration is very important to do in the afternoon (about 1 hour before the start of observation).

1. From the NSTS selects the '***standard calibration***' OB
2. From the sequencer GUI, click in the ***'Next OB'*** button.
3. Verify in the DRS if the calibration goes without errors

Figure 5 - Thorium1 lamp warm warning

Figure 6 - Thorium lamp1 turn off warning

During the command execution the status is visualized into the ***observation Execution logs*** window and, at the end of execution, a bell sound confirms the correct execution of the command (if the sound is a horn noise, this means that something goes wrong and an error should be shown in the ***observation Execution logs*** window).
The standard calibration procedure is about 11 minutes long.
Very important: When the calibration ends, turn off the thorium 1 lamp:

1. Click on the **Turn OFF** button of THO1 lamp
2. Click on the **Turn OFF** button of THO2 lamp (if you will **not observes** in thorium simultaneous mode)
3. On the ***LCU Device Monitor*** verify the lamps status (Figure 4)

Note: If the TH1 lamp remains in the on state, after a while a warning window appears. The observer can decide if maintain the lamp in on (only if he is using it) or turn off it.

3 Observations

3.1 The start night

Before the start of observation the system needs that some processes starts and then the telescope is ready to work in HARPS-N mode.

1. Be sure that the system is initialized and ready to work (Start-up procedures, in the HARPS-N Quick Start Guide)
2. In the sequencer GUI, click in the ***Start Night*** button in the ***Instrument Control*** section and wait the end of execution of the command.

Now HARPS-N is ready for observations.
Note: The ***Start Night*** button includes the preparation to observation of the telescope and of the instrument.

Very important: before the beginning of the observation ask to the TO if the active optic is ok, the 'look up table' upgraded and if the focus of the telescope is set to HARPSN position.

3.2 The focus procedure

At the beginning of the night, may be suitable do a focus procedure doing the following actions:

1. In the NSTS selects a star from the catalogue and delete the **HARPN_ech_obs_all** template. The star can be the first object of the observation schedule to save pointing time. I suggest to not selecting a faint object for the focus. In case of doubt ask to the TO if the star is compatible with the focus procedure and the night conditions.

ID	Name	Target	Alpha	Delta
9 ✓	HAM_OB_SCIENCE	9596	03h52m54.000	00:00:19.000
9 ✓	HARPN_ech_acq_objAB	- - -	03h52m54.000	00:00:19.000

2. Add the HARPN_focus template

ID	Name	Target	Alpha	Delta
9 ✓	HAM_OB_SCIENCE	9596	03h52m54.000	00:00:19.000
9 ✓	HARPN_ech_acq_objAB	- - -	03h52m54.000	00:00:19.000
9 ✓	HARPN_focus	- - -	- - -	- - -

3. From the sequencer execute this OB by clicking the ***Next OB*** button.
   (The sequencer sends the commands to: move the telescope, acquire an image from the autoguider camera and shows the image in the ***DS9***.)

4. Click on the star and then click on the ***Go*** button in the ***Acquisition*** Image window.
   (The sequencer sends an offset to the telescope, puts the star in the fiber position, starts the autoguide, executes the focus procedure, moves the M2 mirror at the best position and acquire a new autoguider image)

   At this point the user can execute the enabled actions (Save Focus, Cancel Focus, Expose, Get infos from DS9 etc) **BUT** must to click on ***'Save Focus'*** or ***'Cancel Focus'*** button to end the focus procedure and enable the next button.

The focus procedure is about 10 minutes long.

3.3 The pointing model procedure

Sometimes the pointing precision can be poor and the telescope could need the execution of a pointing procedure. The pointing procedure must be done in collaboration with the telescope operator (TO) and the TO has to know some information during the procedure.

The sequences of actions to manage the pointing procedure are:

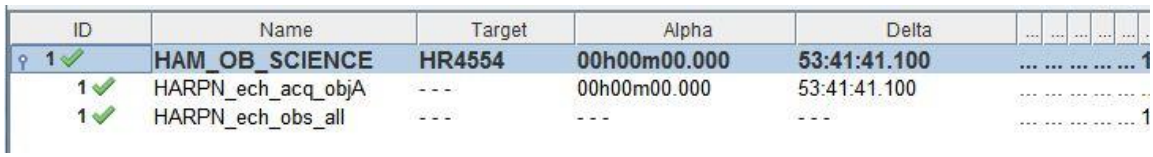
1. In the NSTS select a star from the catalog ***HARPSN-PointingModel.cat*** located in /home/guest/GAPS/CATALOGS
2. Delete the HARPN_ech_obs_all template

3. From the sequencer execute this OB by clicking the **Next OB** button and tell to the TO when the AG image starts, (this is the critical point of this procedure) :
   Sequencer: Thu Dec 27 23:12:29 UTC 2012 -> launch AG_expose
4. When the image of the star appears, clicks on the star, then clicks on the ***Repoint*** button in the ***Acquisition*** Image window and tell to the TO that the offset has been applied.
5. The TO takes note in the VME of the offset applied, the paralactic angle and uses these data in the pointing procedure.
6. Repeat the cycle with another star (from point 1.) until the pointing procedure reaches the precision expected.

3.4 The science OB execution

In the execution of a scientific OB the object has to be pointed and centred in the fiber with the intervention of the observer.

1. In the NSTS select a star from the catalog



ID	Name	Target	Alpha	Delta
1	HAM_OB_SCIENCE	HR4554	00h00m00.000	53:41:41.100
1	HARPN_ech_acq_objA	---	00h00m00.000	53:41:41.100
1	HARPN_ech_obs_all	---	---	---

2. From the sequencer execute this OB by clicking the ***Next OB*** button.
   (The sequencer sends the commands to: move the telescope, acquire an image from the autoguider camera and shows the image in the ***DS9***.)

3. Click on the star and then click on the ***Repoint*** button in the ***Acquisition*** Image window.
   (The sequencer sends an offset to the telescope, puts the star in the fiber position, acquires another image from the auto-guider camera and shows the image in the ***Acquisition*** Image window)
4. When the image appears, if the star is in the fiber position (red circle), click in the ***Go*** button in the ***Acquisition*** Image window.

After that the sequencer starts the auto-guide and the spectroscopic acquisition.
When the OB ends, a bell sound confirms the correct execution of the command and the Next Acquisition button turns in active mode.

Very important:

- During the exposure, especially in long time exposures, verify that the guiding is working in a correct way. The "integrated Image" window of the autoguider (right side of the Figure 9) has to show the star centred in the fiber position and with a shape like a 'donut'.
- Verify that the exposure meter is active, the shutter open and the signal as expected (Figure 8)

3.5 The Observing Control Software (OBS)

The OCS is the interface to the Telescope Control System (TCS). The interface enables the instrument to send commands to the telescope via the TNG library. Currently HARPS-N is able to send three commands; Pointing, AG offsets and M2 offsets to calculate and correct the focus via an automatic procedure. The connections between both systems are completely asynchronous but when the command finishes successfully the TCS returns an Ok status. When an error condition has arisen, the TCS also returns a message back to the sequencer flagging that condition.

In the Observing manager webpage is possible to monitoring the actions and the results. The operator can also interrupt the action when the condition needs it.

3.5.1 The pointing/tracking sends the telescope to the limit switch

When one of these conditions will occurs:

- a pointing-command moves the telescope to the limit switch position
- the telescope operator believe that the telescope can reach the limit switch during the observation

The telescope operator has to stop the command by clicking the "X" button in the 'option' section in the "tng observing manager" webpage.

To avoid errors the astronomer has to wait doing nothing, until the sequencer ends the OB with an abort.

At this point the telescope operator can move the telescope to an appropriate position and the astronomer can repeat the aborted OB.

When the tracking moves the telescope close to the limit switch, and the telescope operator must to stop the telescope during the science exposure. The procedure to stop the processes is the following:

1) from the sequencer terminate the exposure of the current OB (click on **terminate exposure** button)
2) from the tracking system stop the telescope

Note: if the executing OB consists of more than one exposure, the astronomer has to terminate all the exposure or click on the **abort block** button at the end of the first "**terminate exposure"**.

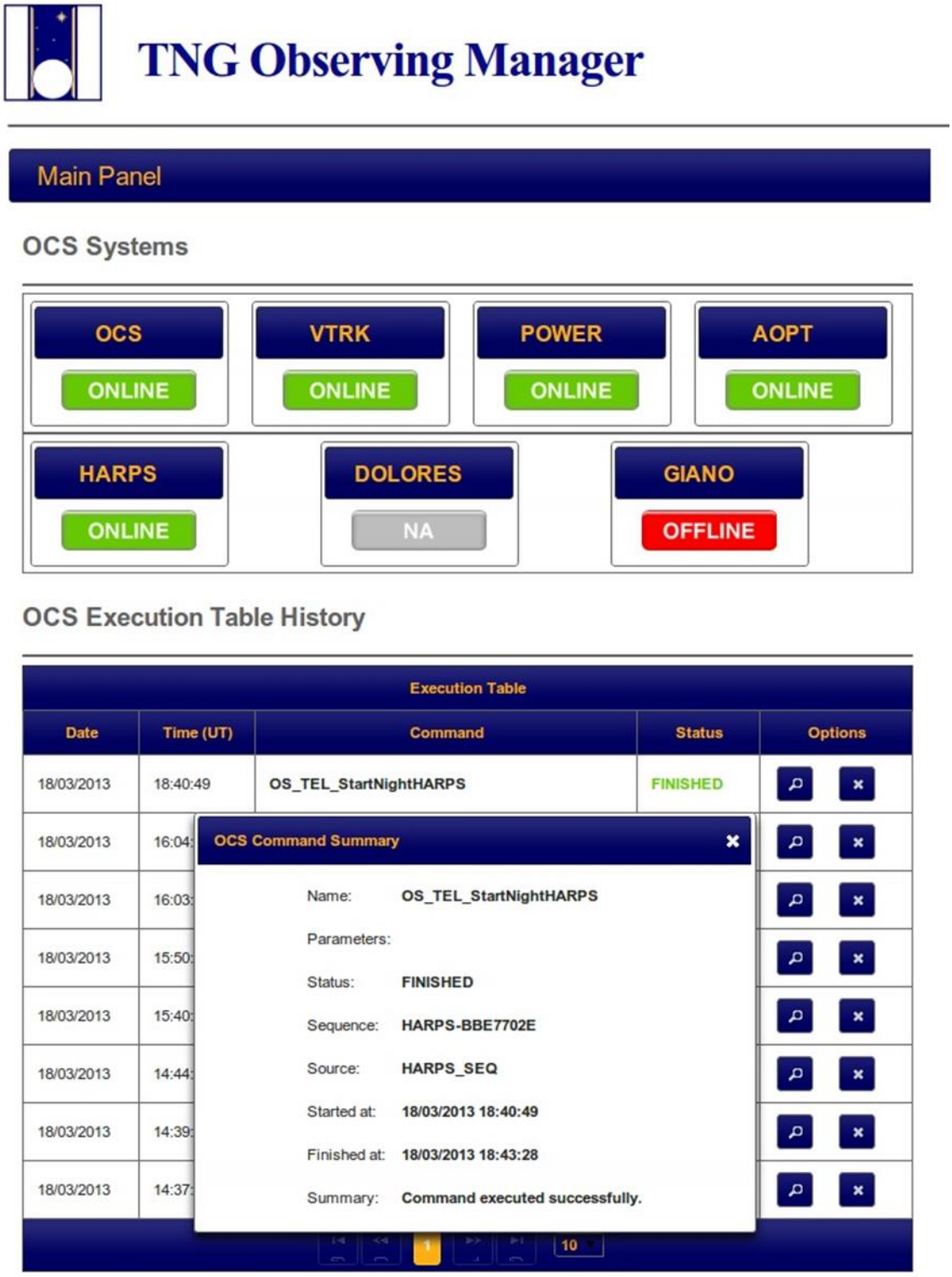


Figure 7 - TNG Observing Manager webpage

3.6 The Exposure meter

The exposure meter GUI shows the status of the two exposure meters, the status of the shutter, some information about the observation and allows the user to change the Mv of the observed star (take care with this option).
The background of the graphic panel turns to darker when the shutter is open.

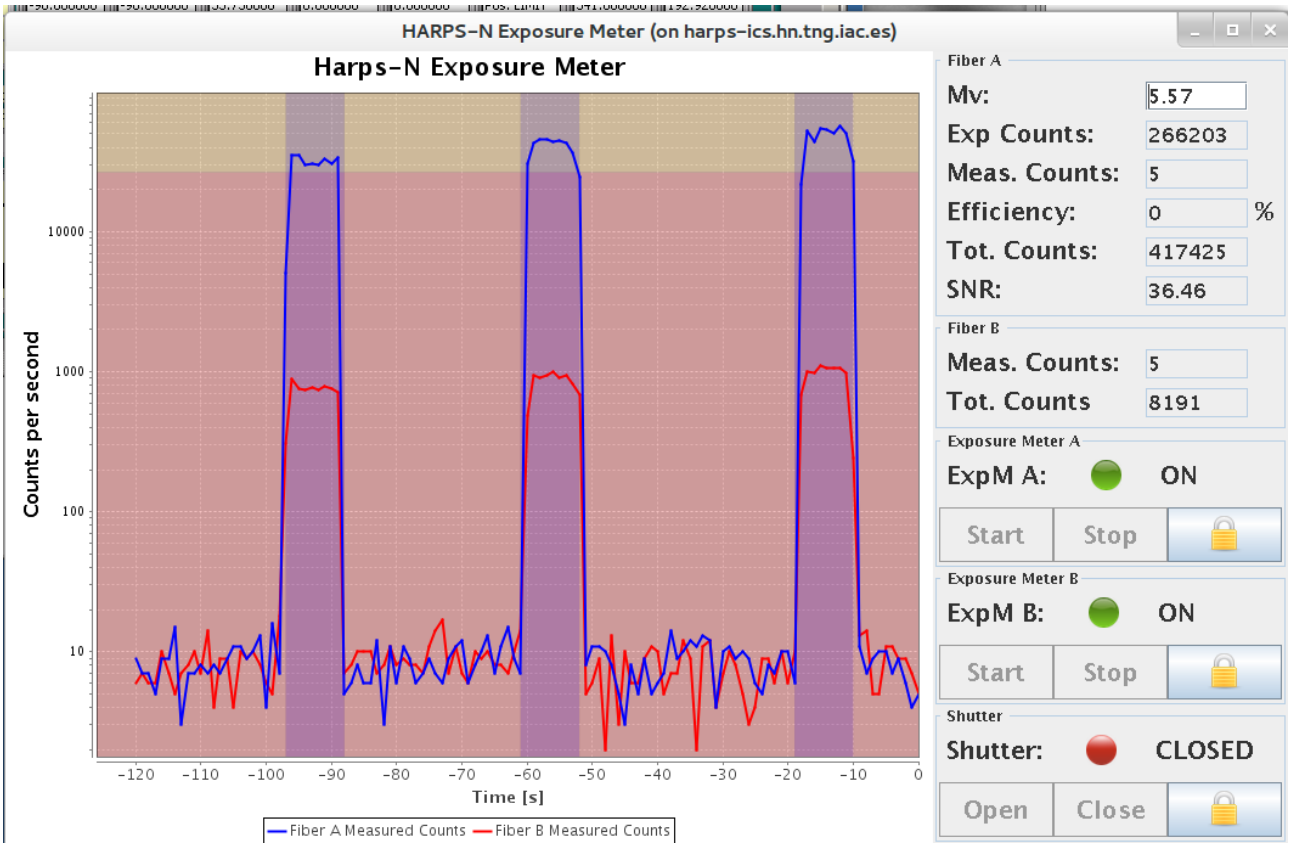


Figure 8- Exposure meter GUI

3.7 The Autoguide

The autoguider starts when the observer clicks on the accept button of the sequencer GUI and two windows opens (Figure 9 and Figure 10):

1. The HARPS-N AutoGuider windows
2. The Integrated Image window

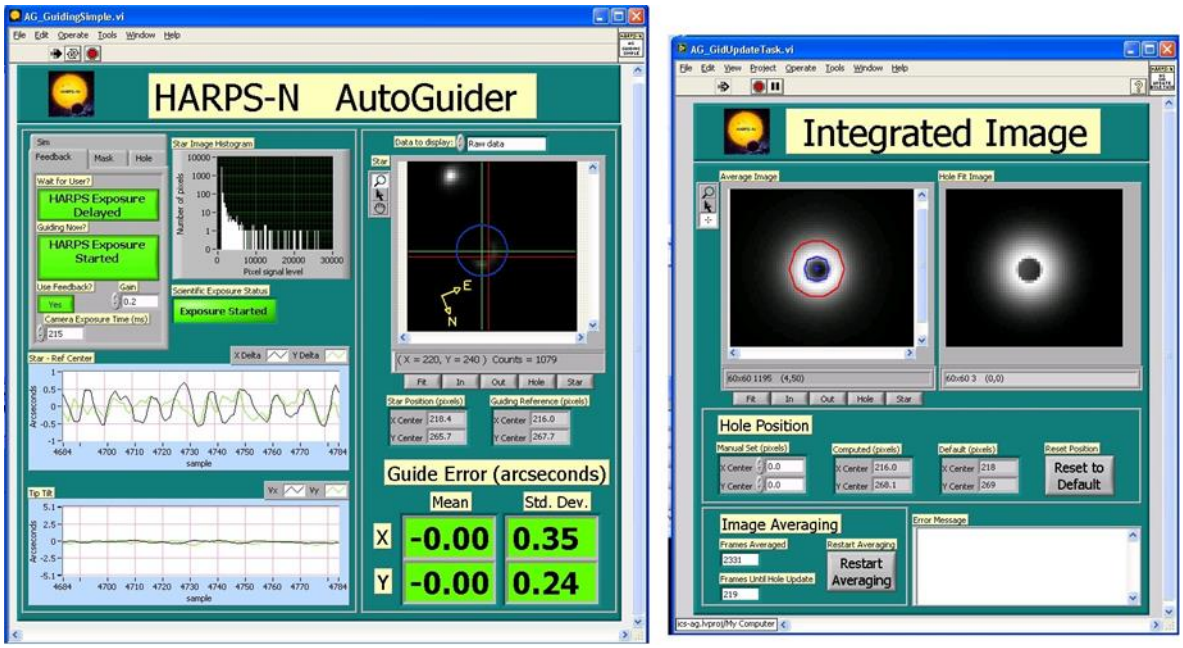


Figure 9 - Autoguider and Front End Monitor (automatic mode)

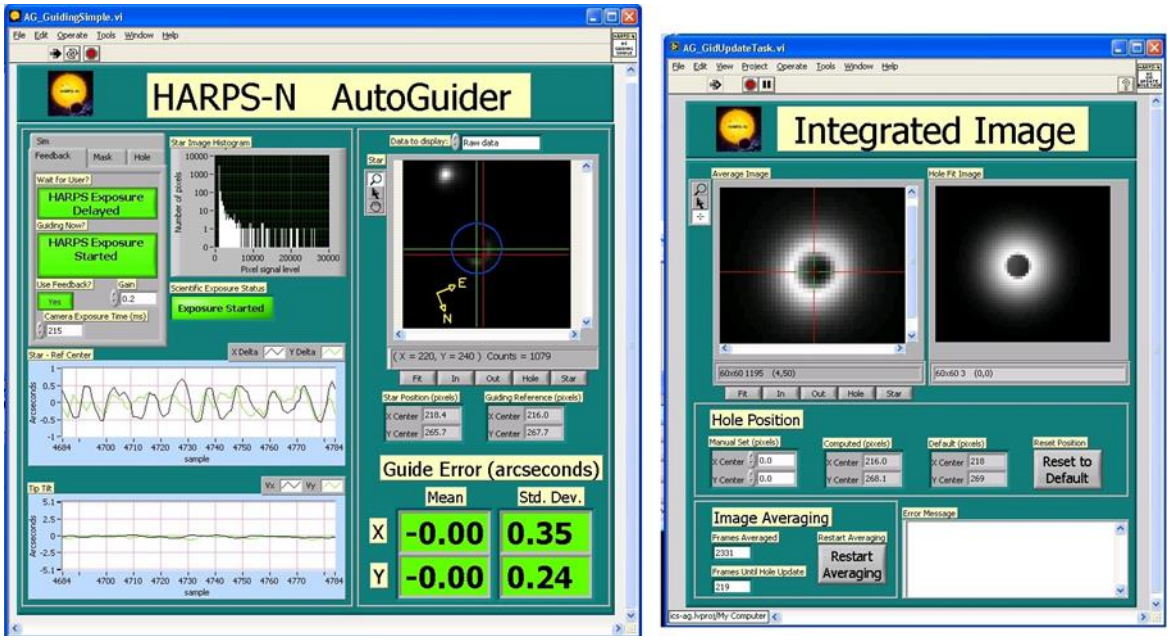


Figure 10 - Autoguider and Front End Monitor (manual mode)

3.7.1 The HARPS-N AutoGuider windows

This window shows the autoguider images, some information about the guide settings and status and allows changing the guide mode:

3.7.1.1 Feedback (offload) tab

The ***feedback*** tab opens a menu where the user can change the parameter of the tip-tilt correction and can postpone the start of scientific exposure

.

- Use Feedback → enable/disable the tip tilt correction (the offload remain active)
- The gain and delay value change the behavior of tip-tilt
- Wait for user → freeze the starting of autoguider (and scientific exposure)
- Guiding now → unfreeze the starting of autoguider (start autoguide)

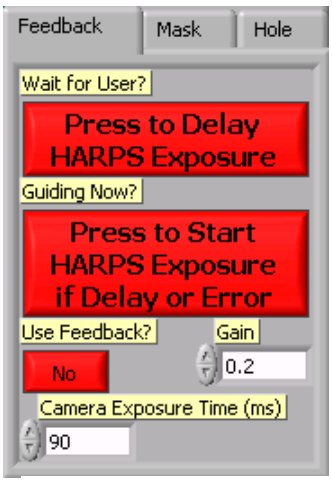


Figure 11 - Feedback panel

The ***Wait for user*** button remains active few seconds before the automatic starting of autoguide. If the user sets this button on ***Yes*** the autoguide get stuck until the ***Guiding Now*** button is selected.

3.7.1.2 Mask tab

To avoid the contamination of others star close to the guide-star during the guide, a mask around the guide star can be selected.
The observer can select the mask's radius around the guide star, all the object out the mask will be ignored by the guiding algorithm.

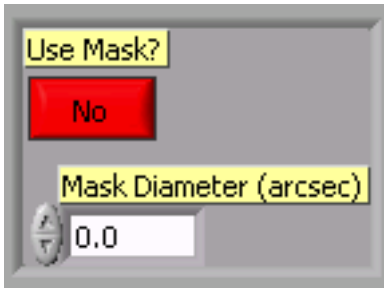


Figure 12 – Mask window

3.7.1.3 Hole tab

With this panel is possible to select the hole- find method, the centering algorithm, and the hole's dimension (optional)

- ***Manual Hole Find*** → selects the manual or automatic method
- The ***auto hole method*** → select the algorithm for guiding end for the hole-center calculation
- ***Hole shift Limit*** → changes the maximum variation permitted (in pixels) in hole position calculation
- **Update Period** → number of frames used in hole position calculation

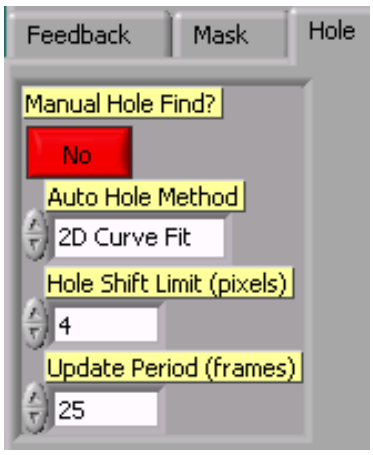


Figure 13 – Hole tab window

In the The HARPS-N AutoGuider windows (Figure 9) the white cross represent the center of the star and the Red Cross is the center of the fiber.
At the bottom of the panel, a button menu allows the user to change the zoom, ...
auto hole method : The algorithm for the calculation of the fiber position and for the star's center position can be choose between the ***centroid*** or ***2Curve*** algorithm.

3.7.1.4 Simulation tab

This panel was used in engineer tests. It is no useful in normal observations.

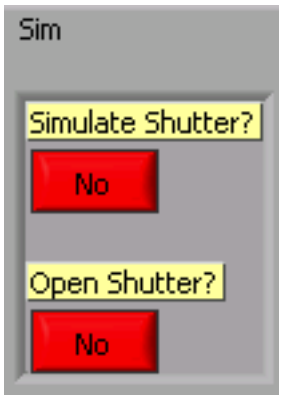


Figure 14 – Shutter simulation panel

3.7.2 The Integrated Image window

This window shows the integrated images, some information of the guide's execution and allows to change the reference point (fiber position) when the manual mode is stetted. The information shown depends by the hole's find method selected:
Manual mode: the fiber's reference position is based on a table and can be modified by the user dragging with the mouse the green cross pointer.
Automatic mode: the fiber's reference position is calculated by the selected algorithm. The red circle represents the contour of the star, the blue circle the shape of the hole.

3.7.2.1 Main frame image

- Average image
- Hole fit image
- Fit
- In
- Out

- Hole
- Star

3.7.2.2 Hole Position

- Manual set
- Computed
- Default
- Reset position

3.7.2.3 Image Averaging

- Frames avaraged
- Frame until frame updated
- Restart averaging
- Error message

3.7.3 Procedure to guide on narrow double stars by using the mask

When the observed star has a companion that interferes with the guiding you should use the mask to avoid guiding errors.

The steps to enable this operative mode are:

1) When the guide begins to show images and before that the exposure start, the operator has to freeze the starting of autoguider by clicking on the "**Press to Delay HARPS Exposure**" button of the Feedback menu in the **HARPS-N Autoguider** window (Figure 11).
2) Selects the **Hole** menu and turn on **Yes** the "**Manual Hole find**" option (Figure 13). From the Hole menu the operator can choose the "Auto Hole Mode" (**2D Curve Method** or **Centroid** algorithm depending on the situation.
3) In the "**Integrate Image**" window drag the star until that the desired star falls into the fiber.
4) Select the **Mask** menu, turn on yes the "**Use Mask**" option (Figure 12) and choose the best **Mask Diameter**.
5) Selects the **Hole** menu and turn on **No** the "**Manual Hole find**" option (Figure 13).
6) Selects the **Feedback** menu and click on the "**Press to Start Harps exposure if delay or Error**" button (Figure 11).

After this procedure the AG sends the feedback to the sequencer and the scientific exposure starts.

Appendix A - Useful Harps-N webpages

HARPS-N TNG webpage	http://www.tng.iac.es/instruments/harps/
TNG Observing Manager	http://ntcs-glassfish1.tng.iac.es:7080/ntcs-ocsservice/manager/ui/observingmanager.jsf
HARPS-N Sensors	http://tngweb.tng.iac.es/telemetry/systems/HARPS
Instrument status	http://ntcs-glassfish2.tng.iac.es:7080/webcontrolpanel/ui/instrumentstatuspanel.jsf
Serrurier & M2 status	http://ntcs-glassfish1.tng.iac.es:8080/aopt-service/gui/ui/serrurier.jsf
TNG Telemetry Cache Service	http://ntcs-glassfish1.tng.iac.es:7080/ntcs-cacheservice/monitor/ui/telemetry.jsf
HARPSN wiki page	http://dokuwiki.tng.iac.es/dokuwiki/doku.php/instruments:harps:start

Appendix B - Actions of multi task commands

Telescope Start Night:

- Open the Dust Cover
- Open the HARPSN derotator cover
- Power on the Dolores electronics
- Initialize the Dolores movements
- Move the 'entrance slider' (M4) to the HARPS position
- Power on the M3 control
- Move M3 to Nasmyth-B (the TO had to set the telescope in Nasmyth-B mode)
- Power off the M3 control

Telescope End Night:

- Stop the guide
- Stop the telescope
- Close the HARPSN derotator cover
- Stop the LCU (move the motors at the default position)

Start Telescope:

- Open the HARPSN derotator cover
- Power on the Dolores electronics
- Initialize the Dolores movements
- Move the 'entrance slider' (M4) to the HARPS position
- Power on the M3 control
- Move M3 to Nasmyth-B (the TO had to set the telescope in Nasmyth-B mode)
- Power off the M3 control

End Telescope:

- Close the derotator-B cover

Appendix C - Actions of focus procedure commands

- Start the pointing (move the telescope)
- acquire an image from the autoguider camera and shows the image in the DS9
- Wait for User selects and puts the star in the hole position
- Send the offset to telescope (repoint)
- Send a M2 offset (- 0.25)
- start a loop of M2 offsets (0.083) and exposure meter acquisitions (default 7 step)
- Calculate best focus
- move M2 to best focus
- acquire an image from the autoguider camera and shows the image in the DS9
- wait for user actions (save or cancel focus)

(While the user can execute actions: repoint, expose, get info, etc)

Appendix D – List of acronyms

ADC	Atmospheric Dispersion Compensator
AG	Auto-Guider
CCD	Charge Coupled Device
CCF	Cross Correlation Function
CFC	Continuous Flow Cryostat
CU	Calibration Unit
DFS	Data Flow System
DRS	Data Reduction Software
E2DS	Extracted 2-Dimensional Spectrum
ETC	Exposure Time Calculator
FEU	Front End Unit
FITS	Flexible Image Transport System
FWHM	*Full Width at Half Maximum*
HARPS-N	High Accuracy Radial velocity Planet Searcher in the North hemisphere
ND	Neutral Density
NSTS	New Short Time Scheduler
OB	Observing Block
RV	Radial Velocity
SA	Support Astronomer
SNR	Signal to Noise Ratio
TBC	To Be Confirmed
TBD	To Be defined
TBF	To be fixex
ThAr	Thorium Argon
TNG	Telescopio Nazionale Galileo
TO	Telescope Operator
VA	Visiting Astronomer