# Telescopio Nazionale Galileo

# HARPS-N Operation Guide

Manual version 2.8
TNG-MAN-HARPN-0003
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# 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)
- HARPS-N Autoguide Manual
- The standard calibration

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

**[RD10]**  HARPS-N Autoguide Manual

**[RD11]**  The standard calibration

# 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)** |
| 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** |
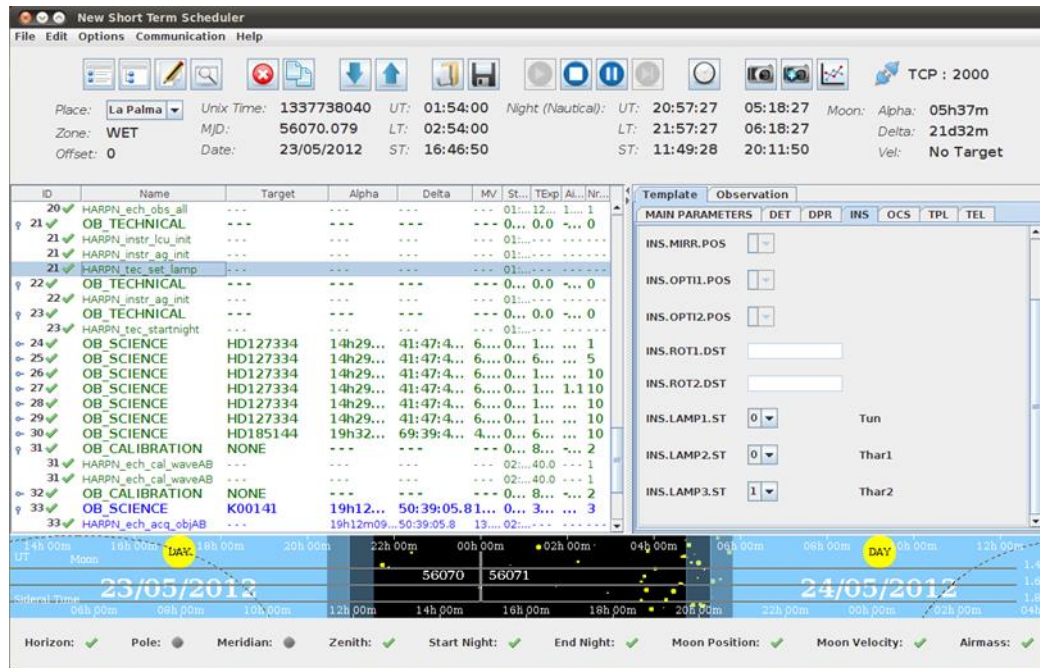
**Figure 1 - Short Term Scheduler**

## 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.

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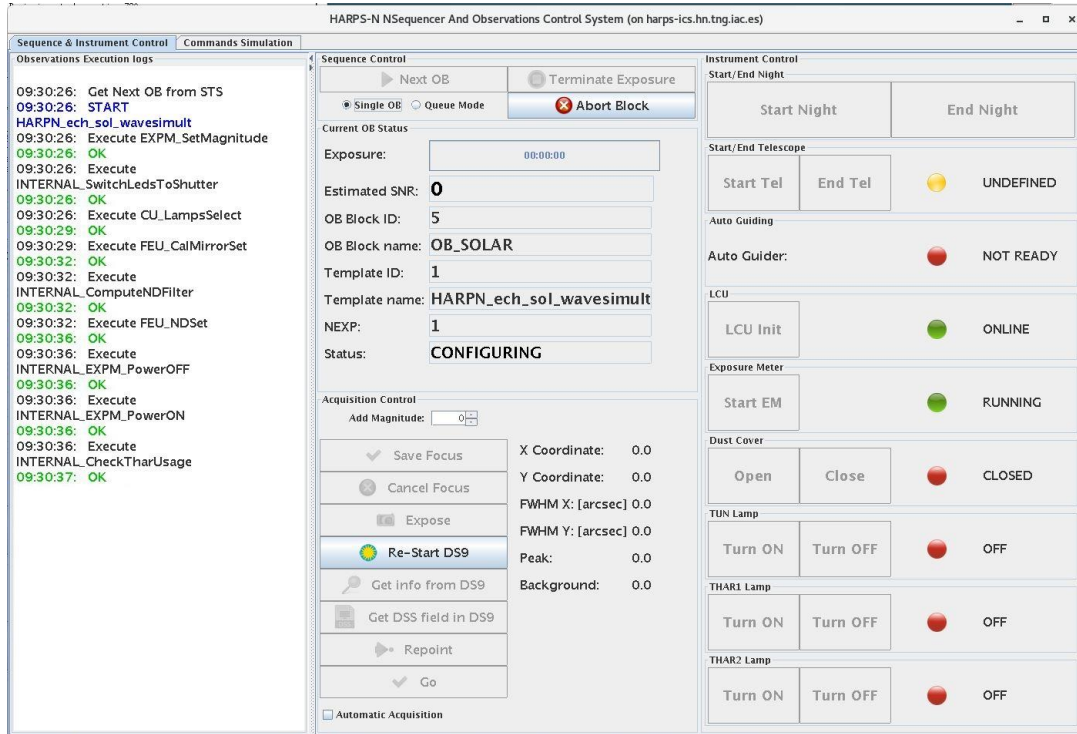


**Figure 2 - The Sequencer GUI**

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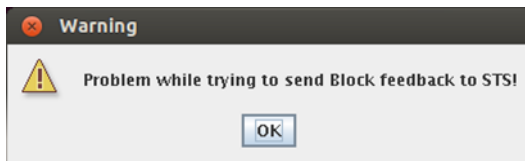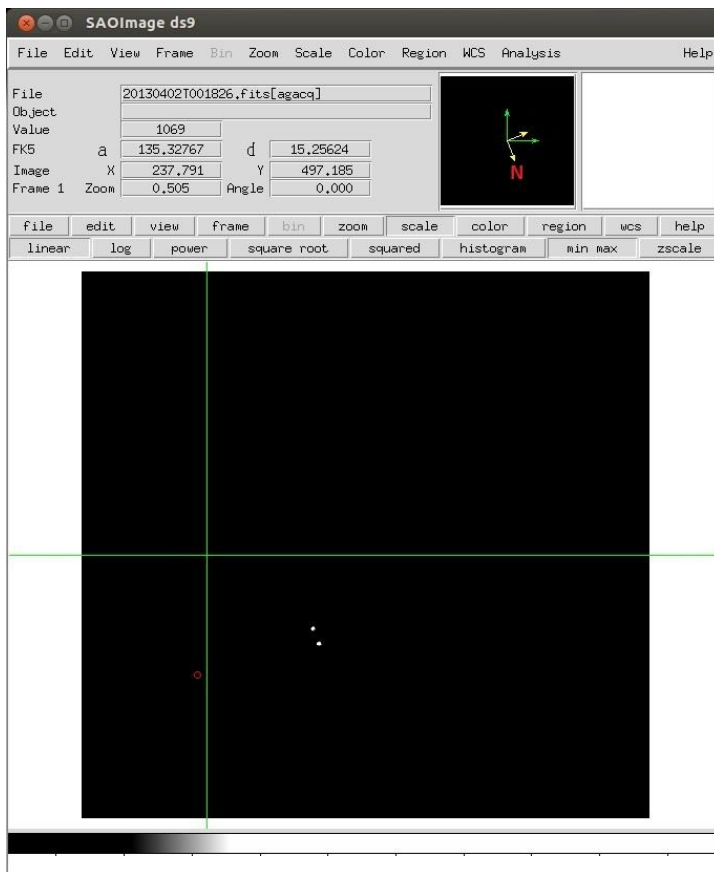
Figure 3 - DS9 terminal with a binary star in the field

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

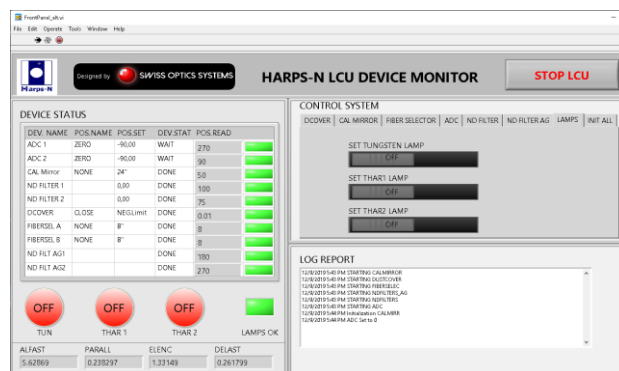A bell sound confirms the correct execution of the command

### 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
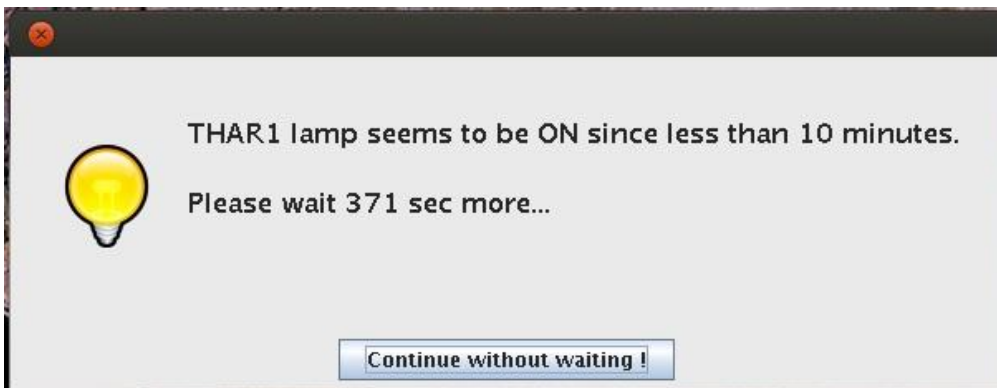


**Figure 5 - Thorium1 lamp warm warning**



**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

| ID | Name | Target | Alpha | Delta | ... | ... | ... | ... | ... | ... |
|----|------|--------|-------|-------|-----|-----|-----|-----|-----|-----|
| 1 ✔ | HAM_OB_SCIENCE | HR4554 | 00h00m00.000 | 53:41:41.100 | ... | ... | ... | ... | ... | 0 |
| 1 ✔ | HARPN_ech_acq_objA | - - - | 00h00m00.000 | 53:41:41.100 | ... | ... | ... | ... | ... | |

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 |
| 1 ✔ | HARPN_ech_acq_objA | - - - | 00h00m00.000 | 53:41:41.100 | ... | ... | ... | ... | |
| 1 ✔ | HARPN_ech_obs_all | - - - | - - - | - - - | ... | ... | ... | ... | 1 |

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.

**<span style="color:red">Very important:</span>**
- 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 **Error! Reference source not found.**) has to show the star centred in the fiber p osition 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.
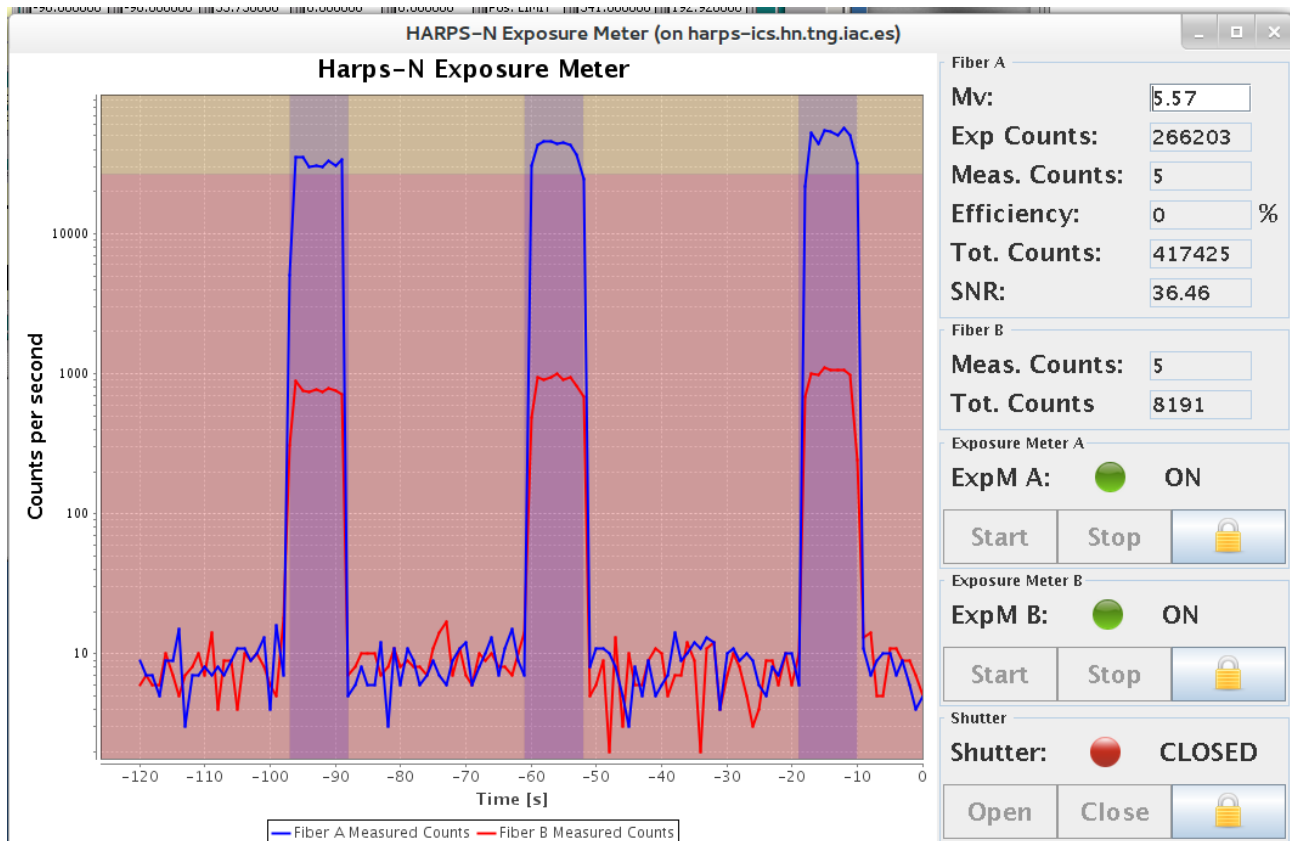


**Figure 8- Exposure meter GUI**

## 3.7 The Autoguide

This paragraph describes the main operations allowed by the AG system and is not the description of the AG. For detailed information about the Autoguide see the HARPS-N Autoguide Manual.

The reading of the "Autoguide Manual" is strongly recommended, given that this manual takes for granted the knowledge of the basic functions of the autoguiding system.

### 3.7.1 Starting the autoguide

The guide starts when the observer clicks on the "GO" button of the sequencer GUI.
After the computation of the centroid, more a delay of 5 seconds, the AG send a command to the sequencer to start the exposure of the scientific observation.
To delay the start of the exposure the TO has to click the **Auto – No Sequencer Wait** button and toggle it to **Sequencer Waiting …** . In this way the sequencer wait until the toggle to Auto – No Sequencer Wait.

**The toggle must be done before the start of the computation of the centroid or within the 5 seconds delay.**

When the autoguide starts, the '**Field Stabilization'** panel shows two images:

1.  The current acquired image, where are shown:
    o   The current image acquired by the AG camera
    o   The fiber position (blue circle)
    o   The mask (green circle)
    o   The centroid bar (red bar)
    o   The compass (yellow)
2.  The Integrated Image box
    This image shows an integrated image, used by the AG core to calculate the position of the fiber.

### 3.7.2   Parameter for the acquisition and centroid computation

The AG system sets the main parameter for the best AG functioning, however, in case of poor sky condition, weak star signal or other reason, some parameters adjustment may be necessary.
In case of error of poor performance of the guide, the top bar turn from green to red or to orange. In this case, look to the stabilization status panel to verify where is the problem and then changes the value of the affected parameter.
The parameter that can be adjusted are (see the Autoguide manual for more details)

*   **Exposure time**
    Can be increased if the signal of the current image is weak
*   **Radius mask**
    Can be adapted to the condition of the signal or shape of the star in the current acquired image.
*   **Fiber Mode**
    Depending on the problem, the OT can change the reference where the AG guide: The Integrated ref. position, Manual ref. position and Default ref. position **Error! R eference source not found.**.
*   **Offload**
    Enable/disable the OFFLOAD (the offload is the offset, sent to the TCS, every fixed amount of time).

### 3.7.3   Corrections

When the AG is active, it always compute the centroid of the star. These corrections can be disabled by the TO to avoid the system change the position of the star in the AG camera field. The button Correction applied allow the user to toggle the AG between Correction applied and correction skipped.
This option is used when the OT is changing some parameter to increase the centroid algorithm performances or when the OT is moving manually the telescope to maintain or put the star into the desired position (fiber position or special point of the observed object).

### 3.7.4 Telescope offset

This option allow the user to move the telescope in all the directions, of the number pixels specified in the field 'Move Px.' by using the four arrows in the panel (when the user click on the arrow, the movement is referred to the star).

### 3.7.5 Piezo operations

When the user is moving manually the telescope, and/or the correction is disabled can be convenient to reset the piezo to the reference position. The button **Set piezo to reference** sets the piezo position to 1, 1.

### 3.7.6 Some examples

This paragraph can be completed with the information provided by the TOs that, with their experience in operate with the autoguide in different condition, can make a valuable contribution to this section.

#### 3.7.6.1 *The star is out of the mask circle*

Operations:
1. Stop the Offload
2. Stop the corrections
3. Move the star into the mask
4. Start the corrections
5. Start the offload

#### 3.7.6.2 *The centroid starts to swing*

Operations (to be verified):
1. Stop the correction and the offload
2. Change the exp. Time and the mask if needed
3. Wait until  the red bar stops swinging
4. Restart the corrections and the offload

#### 3.7.6.3 *Binary stars (to be verified)*

Operations (to be verified):
1. First of all toggle to to **Sequencer Waiting ...**
2. Reduce the mask and set the exposure time to avoid that the companion entries into the mask
3. Wait until the guide works well
4. Toggle to **Auto - No Sequencer Wait**

#### 3.7.6.4 *Manually guide*

This option can be used for special observation mode or if the TO deems it necessary.
Operations:
1. Stop the corrections
2. Stop the offload
3. Set piezo to reference value
4. Set the *Move Px* parameter to the needed value
5. Click on the arrows to maintains the star into the fiber position

### 3.7.6.5 The guide maintains the star out of the fiber position

This malfunction may be due to an incorrect calculation of the fiber position by the algorithm that compute it from the integrated image (an indication can be a not circular integrated image)

Operations: Set the Fiber mode to Default Ref. Pos

# Appendix A - Useful Harps-N webpages

| HARPS-N TNG webpage | http://www.tng.iac.es/instruments/harps/ |
|---|---|
| TNG Observing Manager | observing manager |
| HARPS-N Sensors | https://telemetry-monitor.tng.iac.es/ |
| 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 | https://cache-monitor.docker.tng.iac.es/tcs-telemetry/cache/cache_monitor.xhtml |
| HARPSN wiki page | http://dokuwiki.tng.iac.es/dokuwiki/doku.php/instruments:harps:start |
| LN2 service | http://ntcs-glassfish2.tng.iac.es:7080/ln2service/ui/dashboard.html |

## 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