PEPSI User's manual

Issue	2.0
Date	January 9, 2022

Contents

1 Revision History

Table 1: Revision history

Issue	Date	Changes	Responsible
1.0	13.01.2020	First version	S. Järvinen
2.0	09.01.2022	Second version, polarimetry included	S. Järvinen

2 About this document

This document describes the design details of the PEPSI spectrograph and polarimeter that are relevant for planning the observations. It also describes in detail how the observations are performed in both integral light and polarimetric modes.

3 General information

PEPSI spectrograph has a facility instrument status at the LBT since Feb. 1, 2020. The polarimeters still have a PI status.

If you wish to observe with PEPSI and have questions beyond the usual, please contact either the PI Prof. Dr. Klaus G. Strassmeier at AIP or Mark Wagner at LBTO.

The basic description of PEPSI is given by Strassmeier et al. (2015, AN, 336, 324) and (2018, SPIE, 10702, 12).

4 Planning the observations

The all possible observing modes of PEPSI are summarized in Fig. 1. This documents does not explain how PEPSI is used with Vatican Advanced Technology Telescope (VATT) or with Solar Disk Integration (SDI) Telescope.

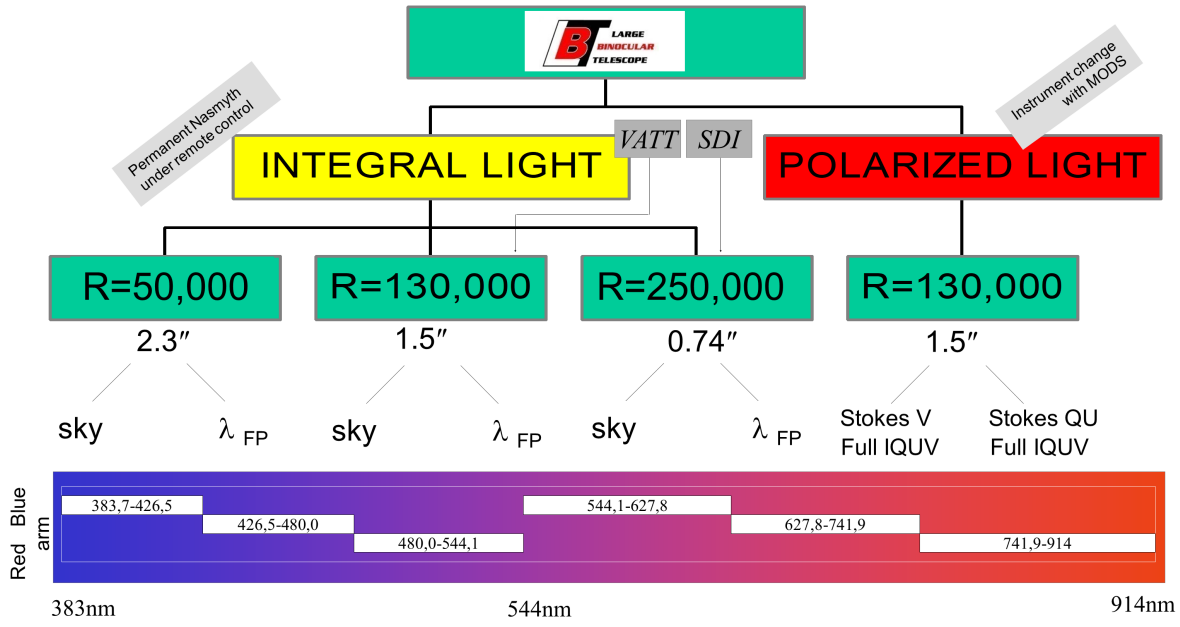


Figure 1: PEPSI observation modes.

4.1 Wavelength coverage

The entire spectral range of the PEPSI is from 383 to 912 nm but it **can not** be covered by a single exposure (see, Fig. 1 for more details). PEPSI has two arms, blue and red, that cover spectral ranges 383-544 nm and 544-912 nm, respectively. Each arm has three cross-dispersers:

- CD1 383-426 nm in blue arm
- CD2 426-480 nm in blue arm
- CD3 480-544 nm in blue arm
- CD4 544-627 nm in red arm
- CD5 627-741 nm in red arm
- CD6 741-912 nm in red arm

Simultaneously, one can observe one wavelength region in blue and one in red, however, **CDs 3 and 4 can not be used at the same time.**

4.2 Spectral resolution

In **integral light**, the observations can be done using three different fibers, that is with three different resolutions:

- 100 μm gives R=250,000
- 200 μm gives R=130,000
- 300 μm gives R=50,000

In **polarimetric** mode, only one fiber (200P) is available:

- 200 μm gives R=130,000

4.3 Exposure times

Exposure time depends on the target, the wanted resolution, and used cross-disperser. Exposure times can be estimated using the exposure time calculator that is available on PEPSI web page.

One can have different exposure times and numbers of exposures for cross-dispersers in blue and in red arm (examples below):

- 30 min in blue, 20 min in red $\Leftarrow$ red is idle for 10 minutes
- 30 min in blue, 2×15 min in red $\Leftarrow$ both are ready around the same time
- 3×10 min in blue, 6×5 min in red $\Leftarrow$ both are ready around the same time, blue likely idle for some minutes due to read-out times (80 sec / read-out)

4.4 Polarimetry sequences

One can take either linear polarization QU or circular polarization V sequence, or have the full Stokes QUV sequence. Getting one of the parameters means two subexposures (= two angles).

4.5 Observing limits

The lower limit is 26 degrees above horizon.

4.6 Finding charts

The field of view for guiding is 28 arc seconds so finding chart is of no use.

4.7 Observing blocks

At the moment observing blocks can be created only by using PEPSI GUI. More information is given in Section 6.

4.8 Additional setups

- The blue mirror is the default setting. Red mirror can be used in a special case with 100 μm fibre.
- For good radial velocity stability, simultaneous fabry-perot-etalon (FPE) should be on.
- Filter is selected automatically according the brightness of the target. However, it can be altered on fly to adapt to any changing conditions (e.g. clouds).
- PFU beam splitter is selected automatically according the brightness of the target and cross-disperser used.
- If PEPSI is used on both telescopes, filters, binning, etc. need to be changed for both sides.

5 Accessing PEPSI Graphical User Interface (GUI)

Observations can be executed either using the PEPSI 4K monitors in the LBT control room (Fig. 2) or one can observe remotely. When using the remote option, one must request VPN (and SSH) access to LBTO beforehand – at least 10 days before the run. Write to ScienceOps@lbto.org to get it!

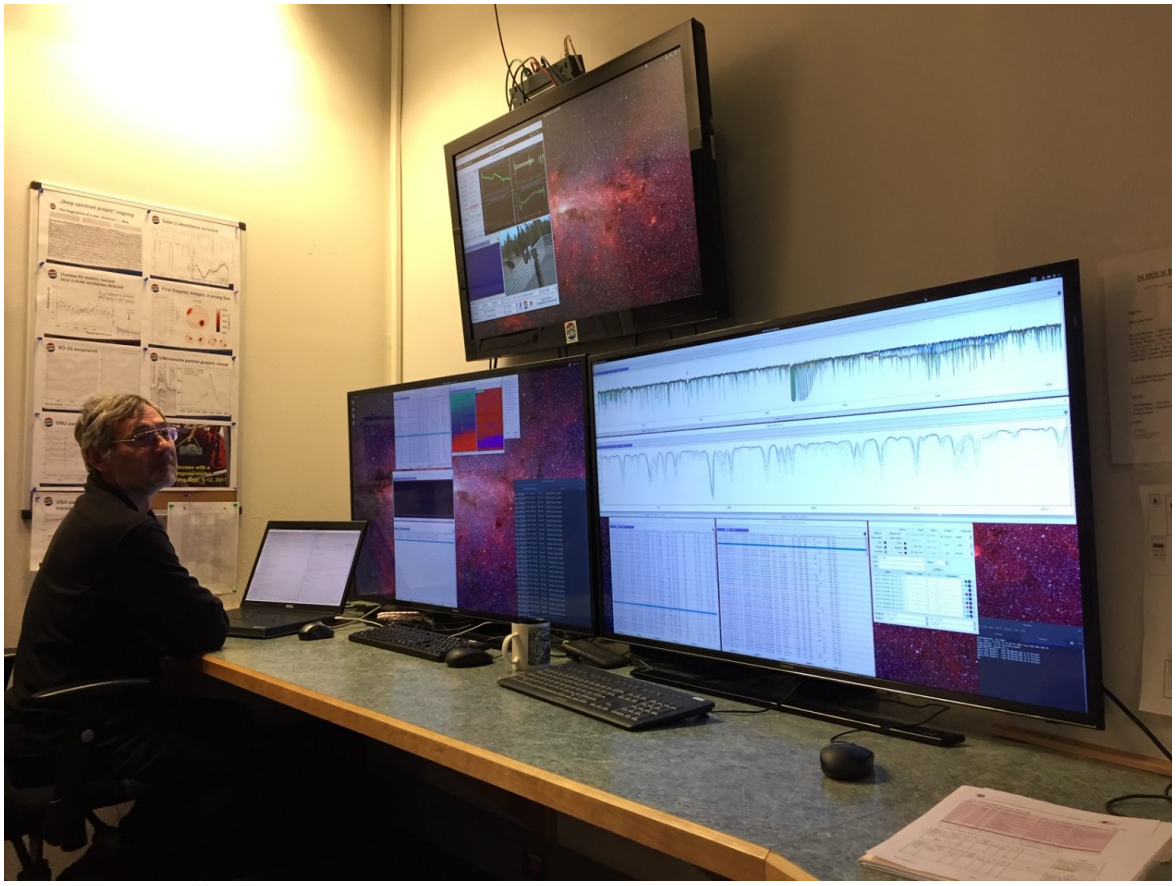


Figure 2: PEPSI computer screens at LBT control room.

In case of remote observing, there are two ways to connect:

1. Terminal commands
   - type **vncviewer -via USERNAME@ssh.lbto.org alpha.pepsi.lbto.org:1** (works only with TigerVNC)
   - environment (telemetry, see Sect. 9) status can be seen at :2
2. VPN connection
   - make a **VPN** connection to vpn.lbto.org (using Cisco AnyConnect)
   - then either open a VNC program and take connection to server alpha.pepsi.lbto.org:1 (or :2) **or** type in terminal vncviewer alpha.pepsi.lbto.org:1

The user interfaces look slightly different for PFU (Fig. 3) and polarimetry observations.

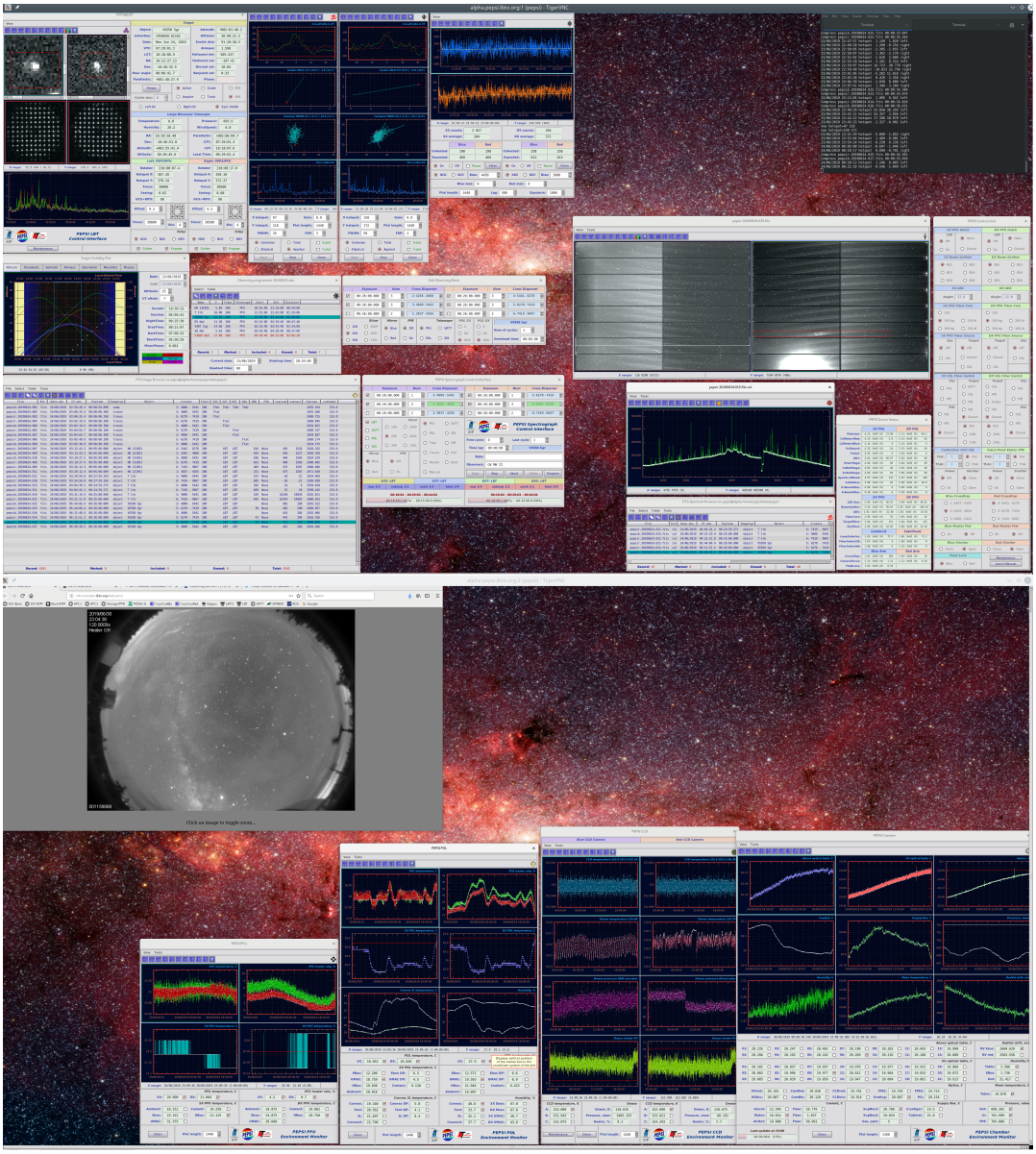


Figure 3: *Top*: VNC view of the PEPSI PFU user interface (:1). *Bottom*: VNC view of the telemetry (:2).

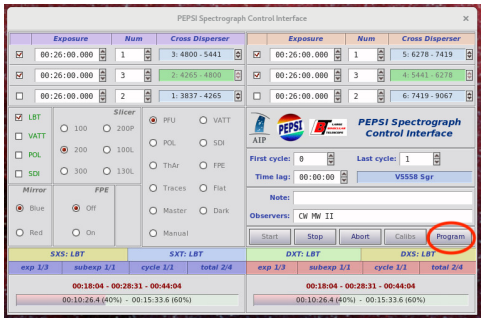
The PEPSI user interface program should be kept running all the time.

If it is not running, click Activities in the left upper corner. You should get a menu having PEPSI logo. Click on that logo to open the program. Alternatively, one can use a terminal to open it (if no terminals open, open a new one). On **pepsi@alpha** type 'pepsi'.

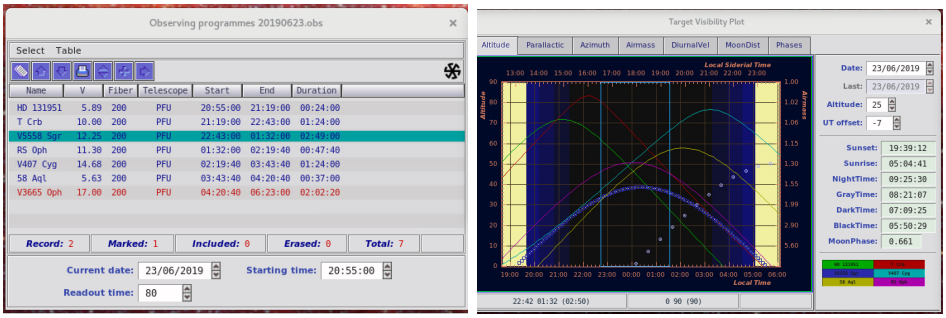
6 Making observing blocks

As mentioned above, the observing blocks can be created only by using PEPSI GUI (see, Sect. 5). Things to consider when making the blocks are explained in Sect. 4.

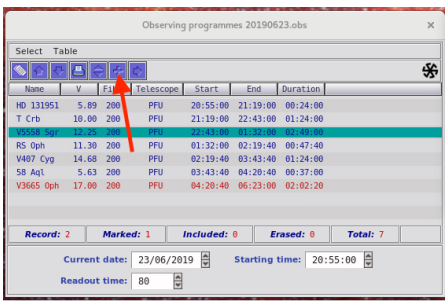
1. Adding targers
   a) Click 'Program' button on '**PEPSI Spectrograph Control Interface**':



   b) This opens the last opened 'Observing Programmes' window and a 'Target Visibility Plot' window.

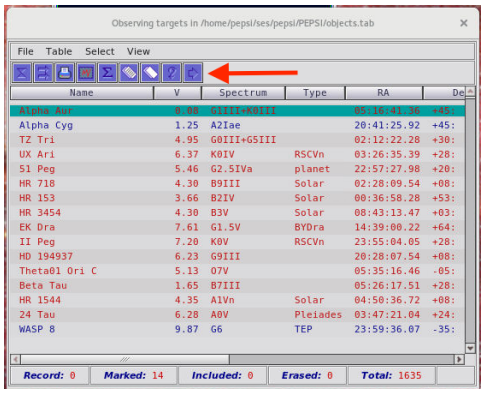


   c) Save an existing program with new name (YYYYMMDD.obs) and start to edit it.
      - click 'add another object' in 'Observing programmes' window



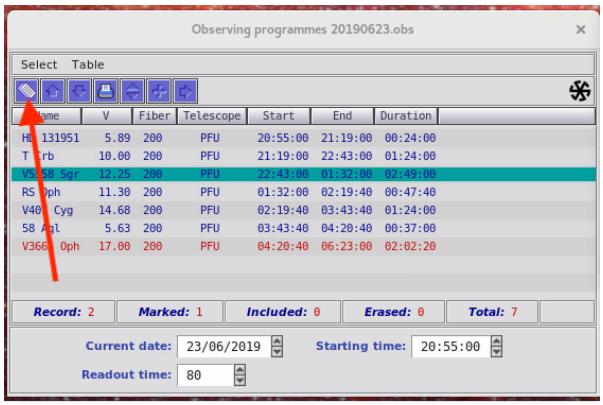
      - a new window having targets pops up

  - **NEVER** delete targets from this list!
  - Targets can be added to the catalogue:
    * when one starts to write the name, it is shown if the target already is in the catalogue
      · if the target already was in the catalogue and it has a PID (program ID) that is not yours, PID should be changed so that the data goes to the right person
    * in case it indeed is a new target, make a query and then apply to that it goes to the catalogue
    * targets can be imported from a text file
      · names should be in that case in format **HD123** or **"HD 123"**
      · text file can contain also coordinates
    * if the target is a **transient** or **nova**, coordinates can also be given
    * for **non-sidereal** targets like Io or Jupiter, a name and approximate coordinates should be given and telescope uses then a special mode to observed them *(talk with your telescope operator)*
- choose the target and send it to the observing block

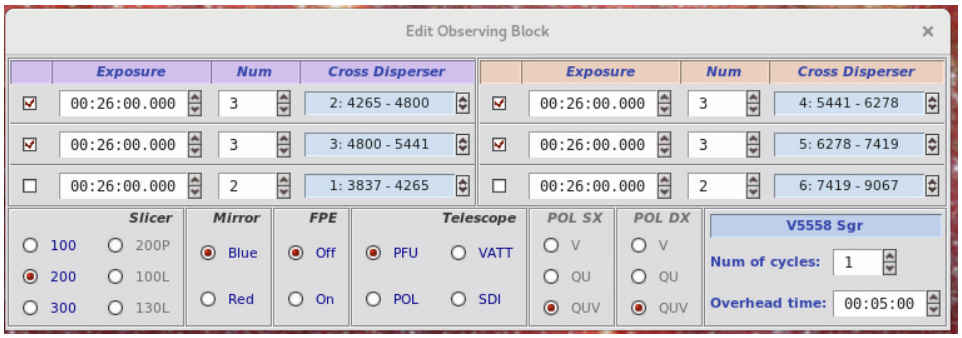


- In case you want to remove a target from your block, go to that target, erase it with Alt+Del and then delete it with Ctrl+Del
- Once all your targets are added, you can re-arrange the observing order with up/down arrow buttons (the selected target is high-lighted in the 'Target Visibility Plot' window

2. Editing the observing configuration of a target
   a) The target for which editing will be done is highlighted with teal color
   b) click 'Edit fields'



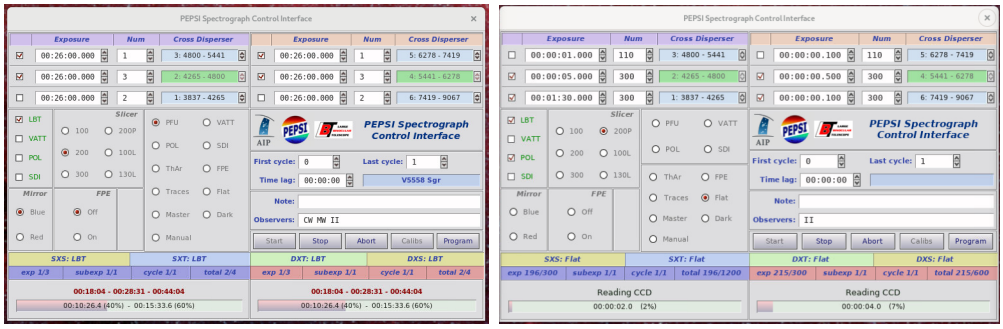
   c) New window 'Edit Observing Block' pops up



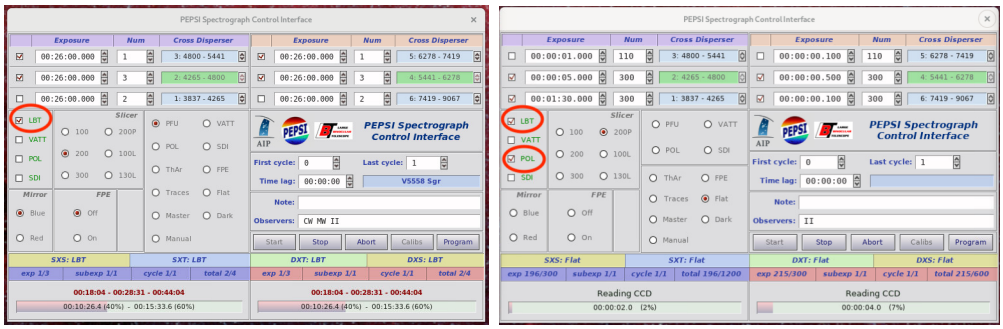
7 Executing the observations

7.1 Connecting with with the instrument

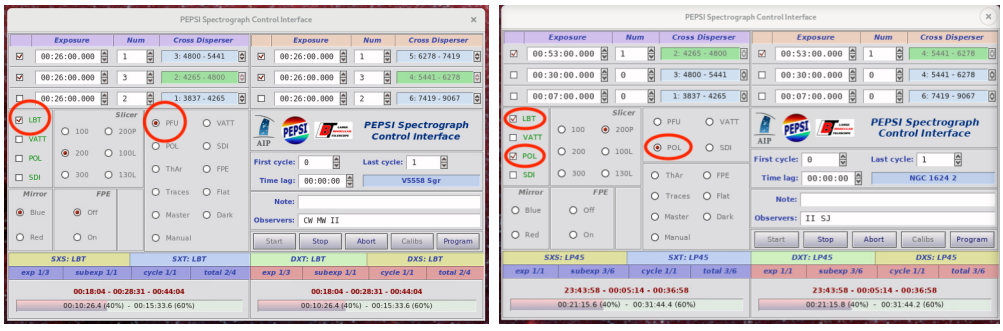
1. Now you should have '**PEPSI Spectrograph Control Interface**' open.



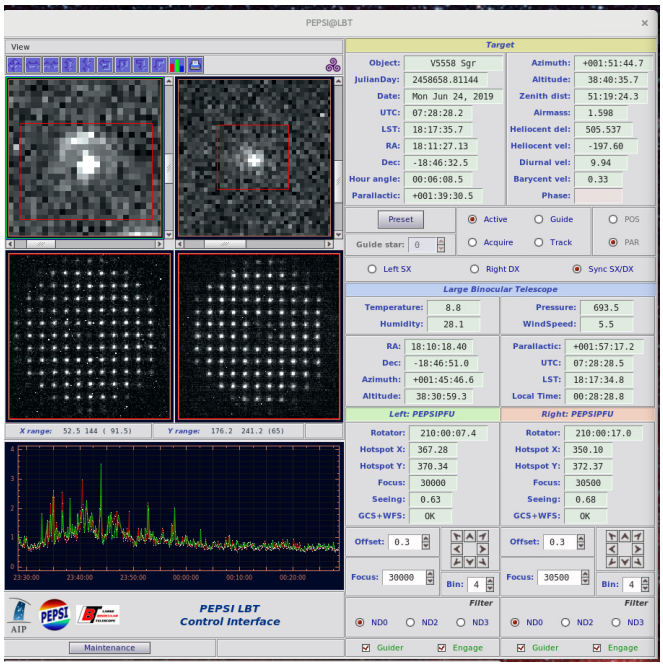
- In case PEPSI has been used for solar observations (SDI selected) and you have text 'Waiting for Sun' in the 'PEPSI Spectrograph Control Interface', click 'Abort' to be able to start night observations.
- Click on LBT check button to connect and open '**PEPSI@LBT**'. In the case of polarimetry, also POL button needs to be checked.



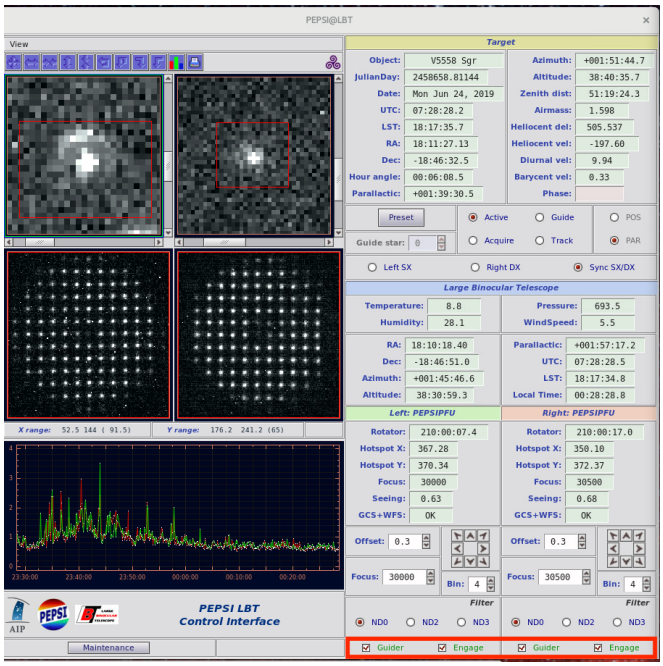
- Check that PFU/POL radio button is selected:



2. A 'PEPSI@LBT' window should appear:

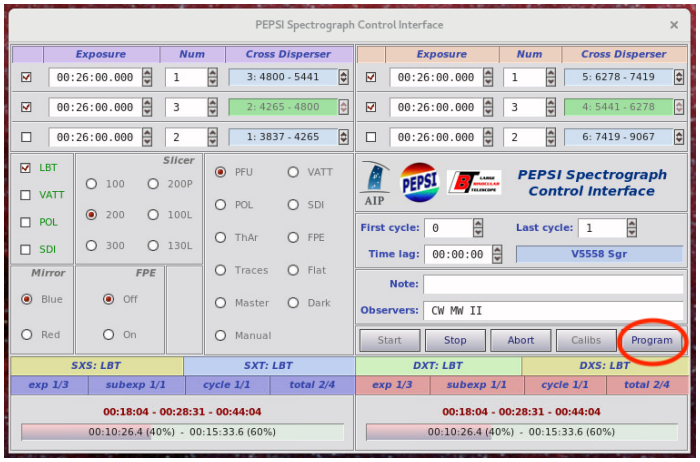


3. The spectrograph has to be engaged (‘Engage’ button) into observing mode, so that the hatches are opened for authorized sides and ADC is following the target elevation even for a pointing star.



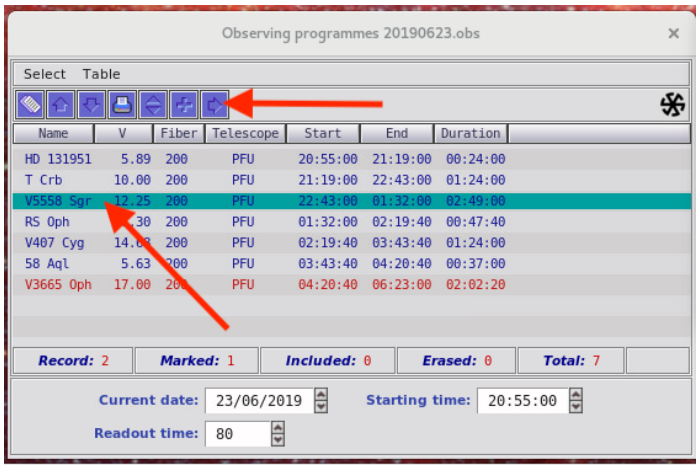
7.2 Selecting and sending targets to LBT

1. If observing block is not open, click 'Program' button on '**PEPSI Spectrograph Control Interface**':



2. Check that the correct program is open (YYYYMMDD.obs)!
   - If not, go to 'Table' menu, choose 'Open or Close Table' and select the correct one.

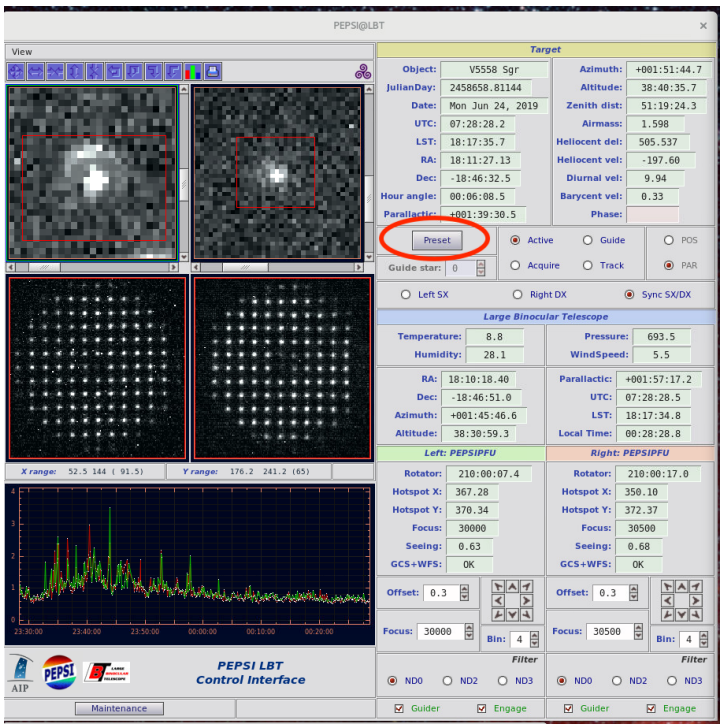
3. **Select the target** (highlighted with teal color) you want to observe and send it to LBT. This does not yet move the telescope! Note that target can be sent already during CCD readout!



   - Check that 'PEPSI@LBT' has the same target as you chose, or resend, and check that 'PEPSI Spectrograph Control Interface' changed (target name, selected cross-dispersers, exposure time, etc.) according to selected target. Note that the changes happen only after CCD readout has finished.

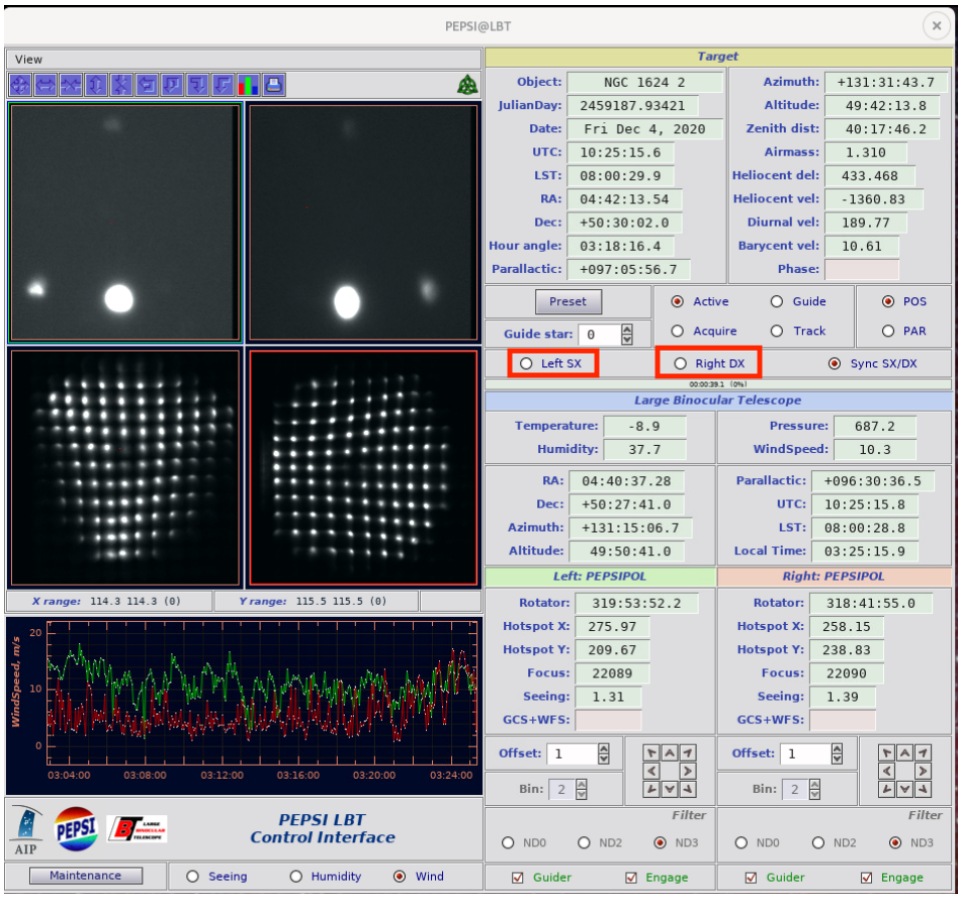
- If you need to change targets or pre-defined exposure times, read again Sect. 6. Note that values in 'PEPSI Spectrograph Control Interface' do not change unless you send the target information again (see above). You can also change values in 'PEPSI Spectrograph Control Interface' directly, but then the visibility plot does not change and block will not remember the changes made in future.

4. **after the telescope operator gives the permission**, click '**PRESET**'



- 'PRESET' to next target can be done already during CCD readout.

- **Sync SX/DX** mode of preset is the normal case
- In case one of the telescope eyes does not move to the target, it is possible to make 'PRESET' separately only with one of them (Left SX or Right DX):

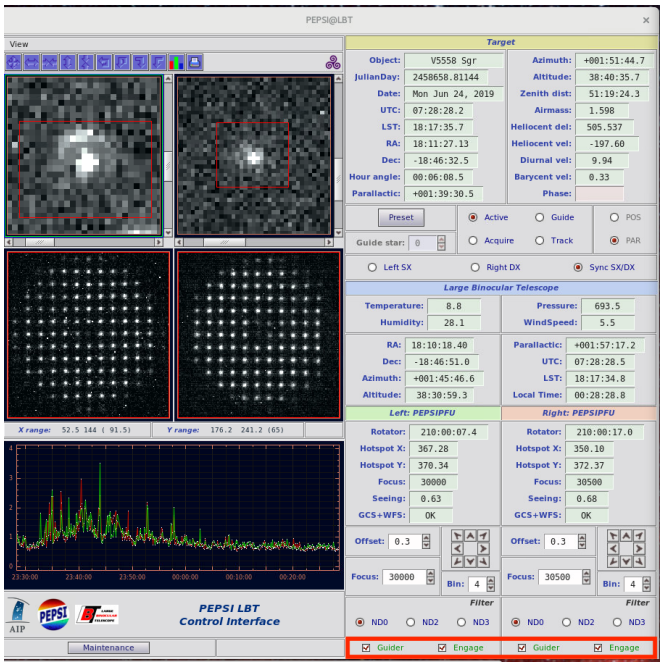


- **Note** that 'Preset' can be done in four different modes, but only the first one should be used unless requested otherwise by the telescope operator:
  - **Active – the normal mode**, uses wavefront sensor and guiding
  - Guide – no wavefront sensor is used, guiding yes
  - Acquire – only points and centres on hot spot
  - Track – only points

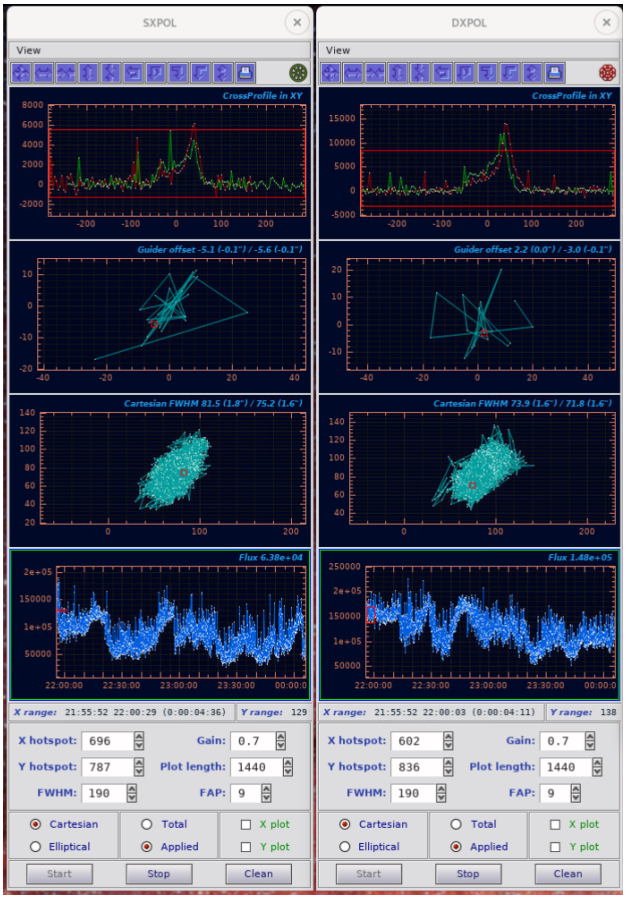
7.3 Guiding

Collimating, guiding, and also focusing is done by the telescope operator. **Do not do anything unless asked.**

- 'Engage' should have been checked in the very beginning but at latest at this point. It opens the hatches so that the telescope operator can put the star in the position.

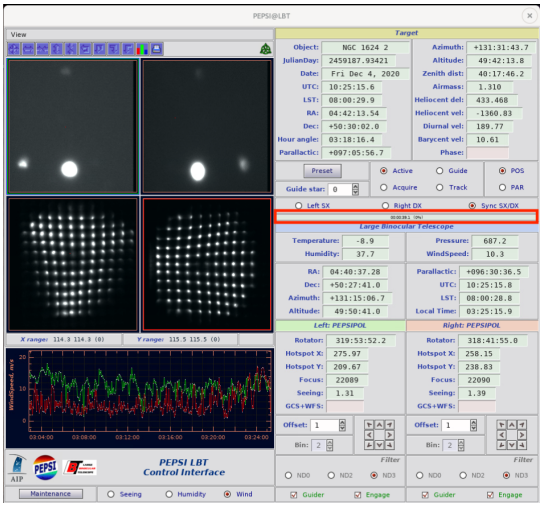


- 'Guider' opens guiding windows

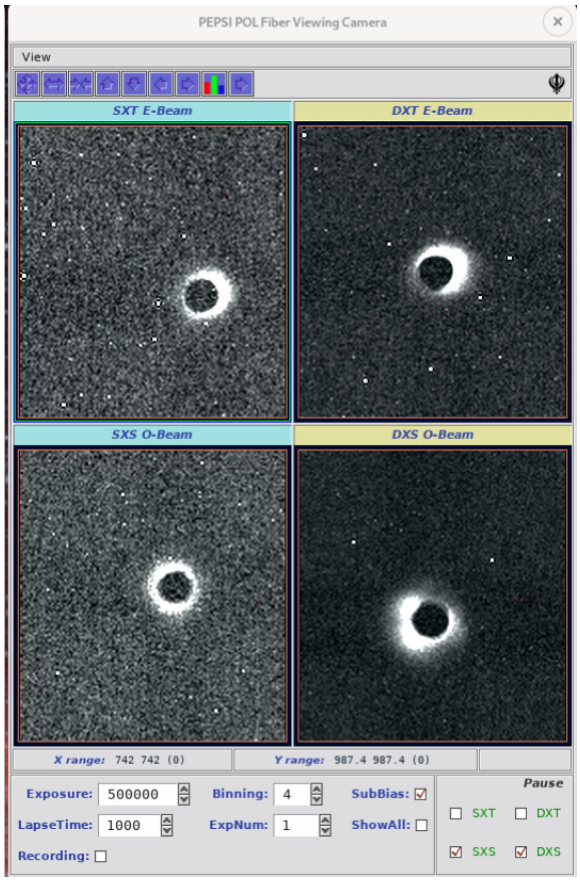


7.4 Keeping target in pinhole (Polarimetry only!)

1. Make sure that the telescope is not moving anymore (= progress bar disappears)

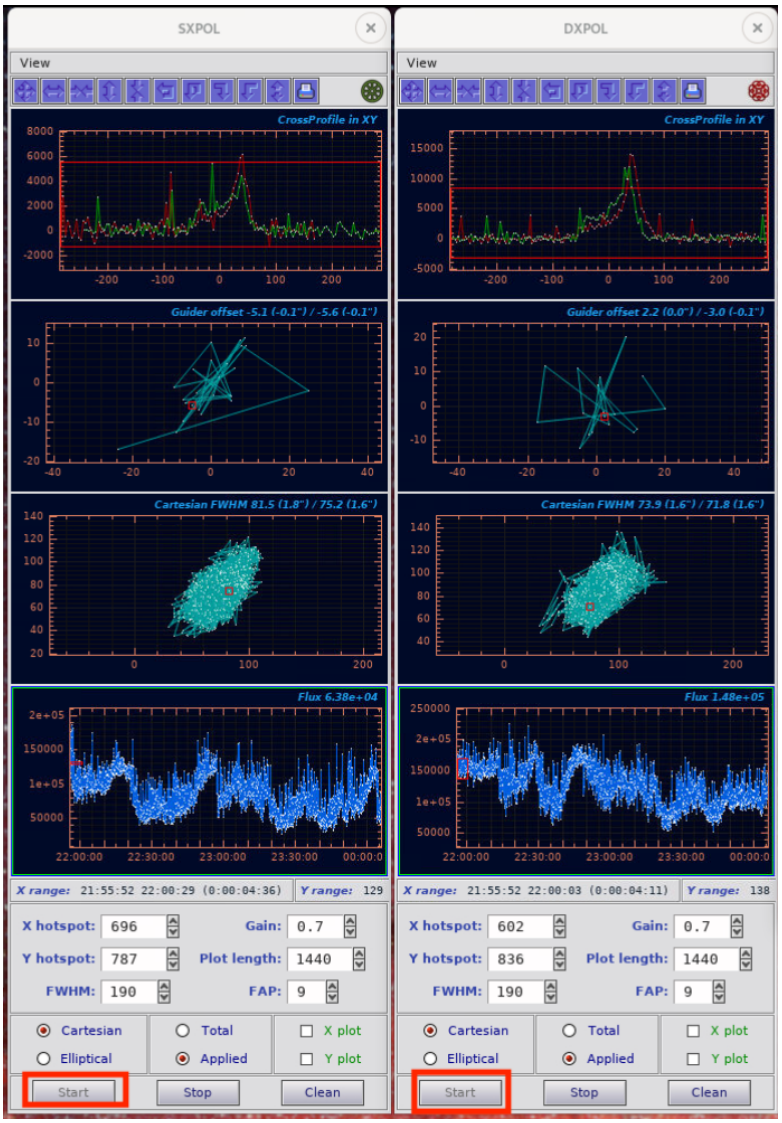


2. When everything works really fine, the target lands on the pinhole



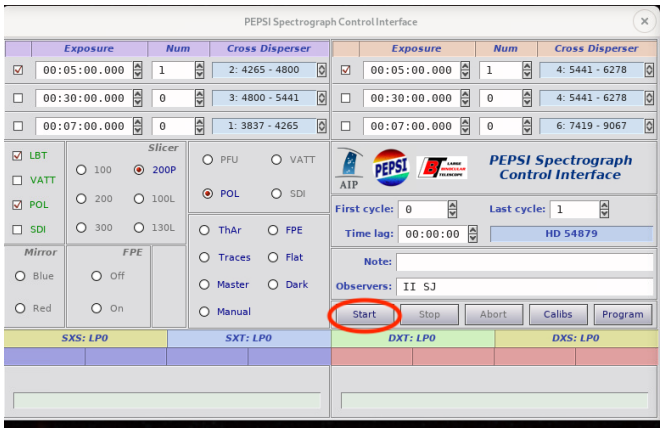
3. Sometimes the target is very close by, but not really in the pinhole.
   - In such a case, click target (bright spot) on the right mouse button on top row images (doing it on lower row is disabled) to move the pinhole (black circle) into it

4. You may start ‘guiding‘ in guiding window, that is making small corrections to keep target in the pinhole, but also ‘Start‘ in next step starts it automatically. If done here, it needs to be done for both sides separately.



7.5 Staring exposures

Start exposure sequence by clicking ‘Start’ in ‘PEPSI Spectrograph Control Interface’:



- This also starts guiding on both sides.

If the exposure needs to be interrupted for any reason, use

- 'Stop' in case you want to save the data obtained so far
- 'Abort' in case the exposure time was not long enough for useful data

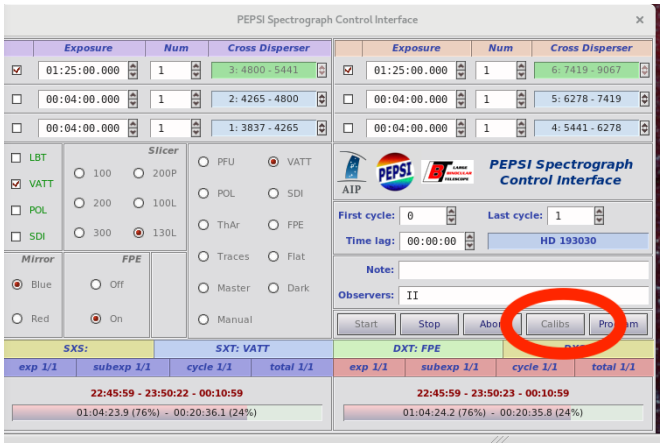
If due to the, for example, clouds you think that exposure time is not long enough, it can be prolonged on fly in the 'PEPSI Spectrograph Control Interface' as long as CCD readout has not started.

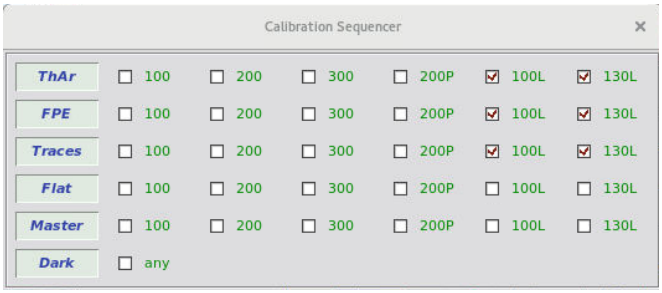
7.6 Calibration frames

After the observing night is over, it is time to take the calibration frames. Check that you have stopped guiding and guider camera is on pause.

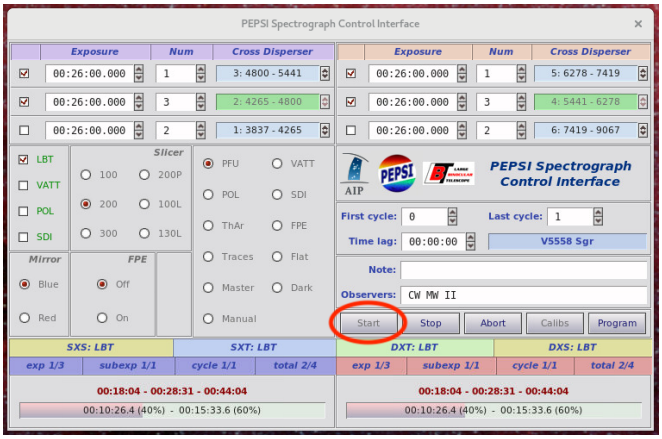
In the 'PEPSI Spectrograph Control Interface' window:

1. Click 'Calibs' button to get a pop-up window:





2. Check that for wanted fiber(s) ThAr, FPE, and Traces are chosen
3. Click ‘START‘ button on Control Interface window:



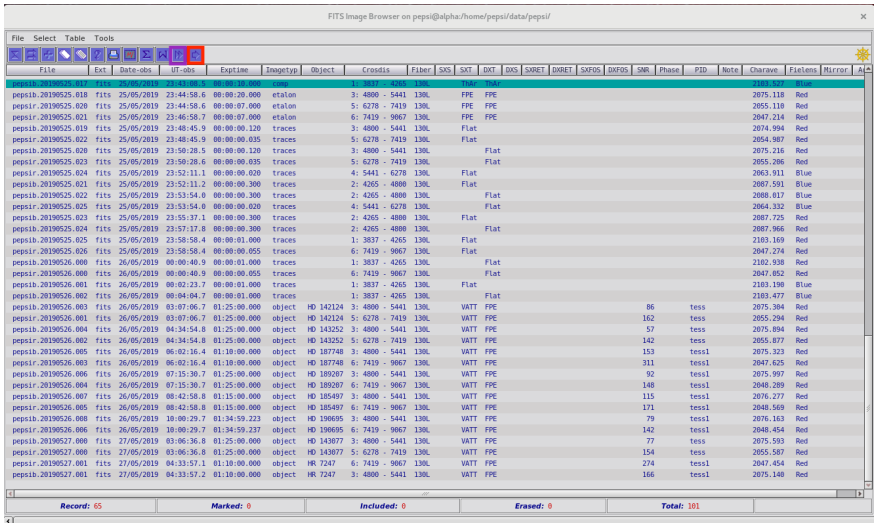
4. When calibration frames are ready, click ‘Calibs‘ again to close the calibration sequencer window and to be able to do anything else.

8 Raw data

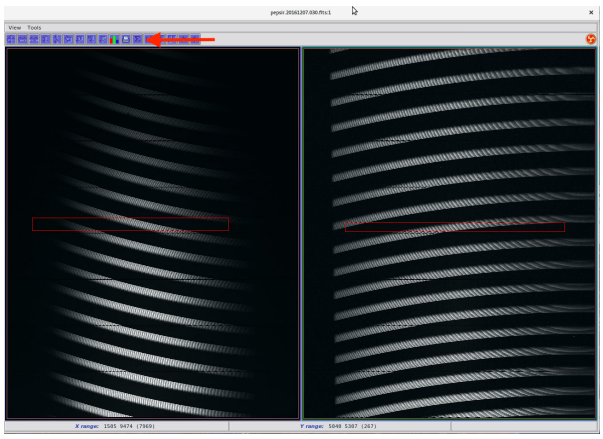
8.1 Viewing obtained spectra

It is good to take a look at the spectra in order to see if you should change exposure times etc.

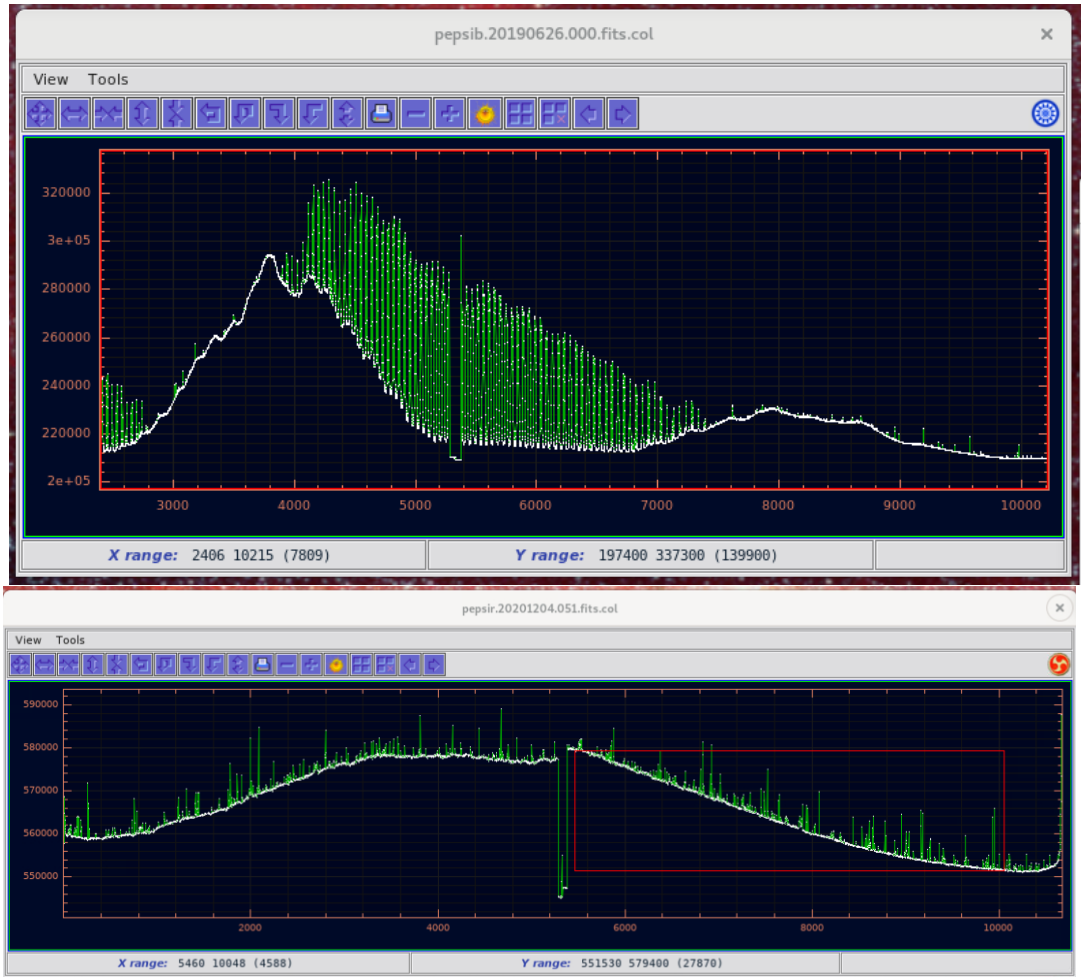
1. Select the spectrum (highlighted with teal colour) you want to look at from 'FITS Image Browser' with Enter or click the arrow icon to send it to 'Spectrum viewer'. One can also look at multiple spectra by selecting them and clicking double arrow icon.



2. The active window in 'Spectrum viewer' has a cyan frame. Select the area you want to look at closer by drawing a red box with, for example, a mouse. To see a summed spectrum from selected area Press 'Enter', or Click the normal 'Sigma' icon (one dimensional cross-cut in horizontal direction) on top of the viewer (the other sigma makes it in vertical direction)

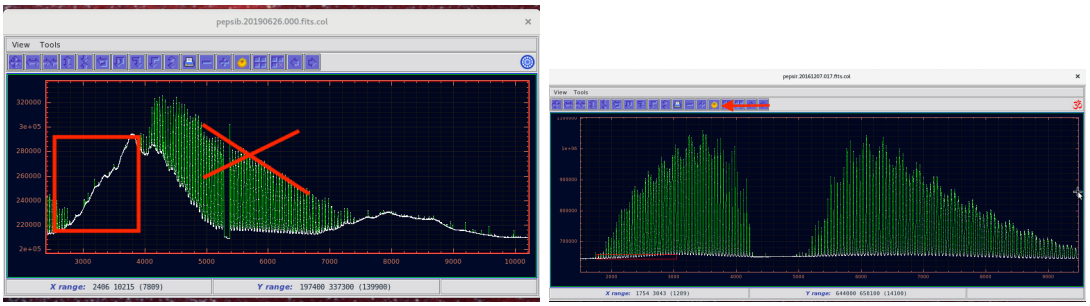


3. Now you have a spectrum plot where you can see the ADUs:

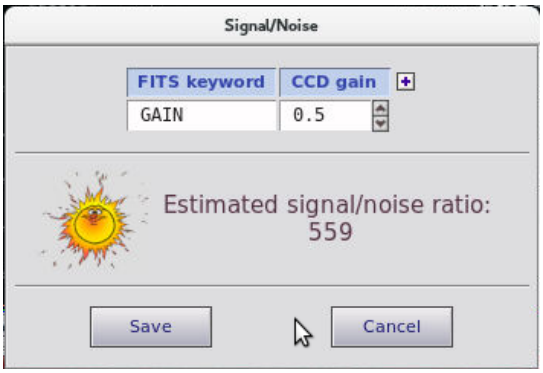


8.2 Estimating signal-to-noise ratio

1. Select an area with mouse from highest continuum values to lowest (don't be distracted by high fabry-perot peaks in case FPE was on) and click 'Sun' icon on top of the spectrum viewer:

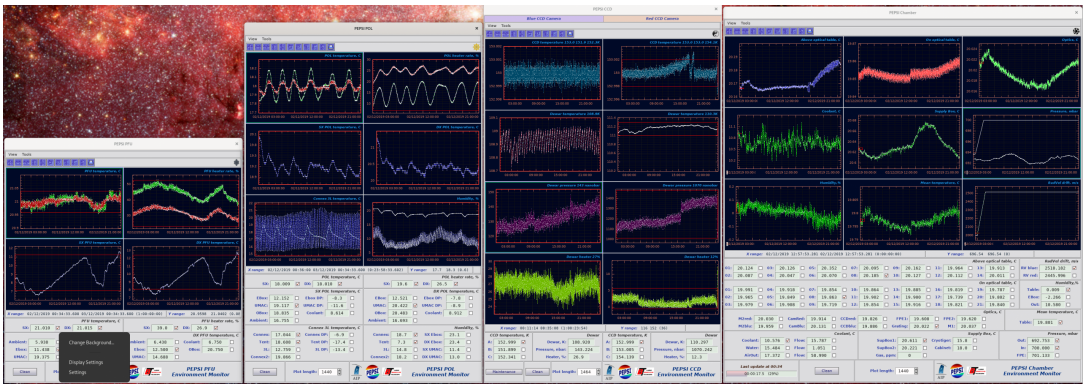


2. You get a pop-up window there the S/N estimate is given, save that information into fits list by clicking ‘Save‘:



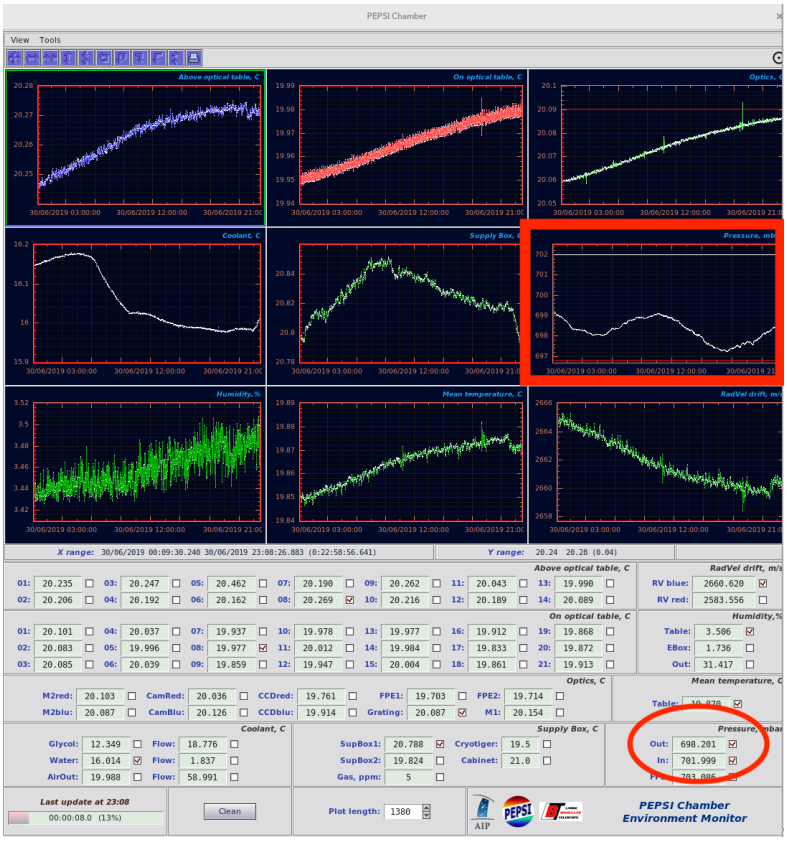
9 Telemetry

It is essential to **check the telemetry** from time to time:

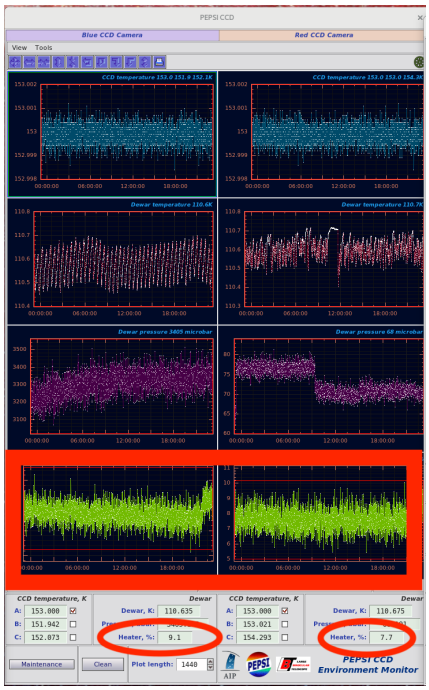


If something is wrong and you are not trained to fix the problem, contact a person who is!

The most important is the 'Pressure' in **PEPSI Chamber** window. If 'In' value has red background, and one sees that pressure curves follow each others, everything is not fine.

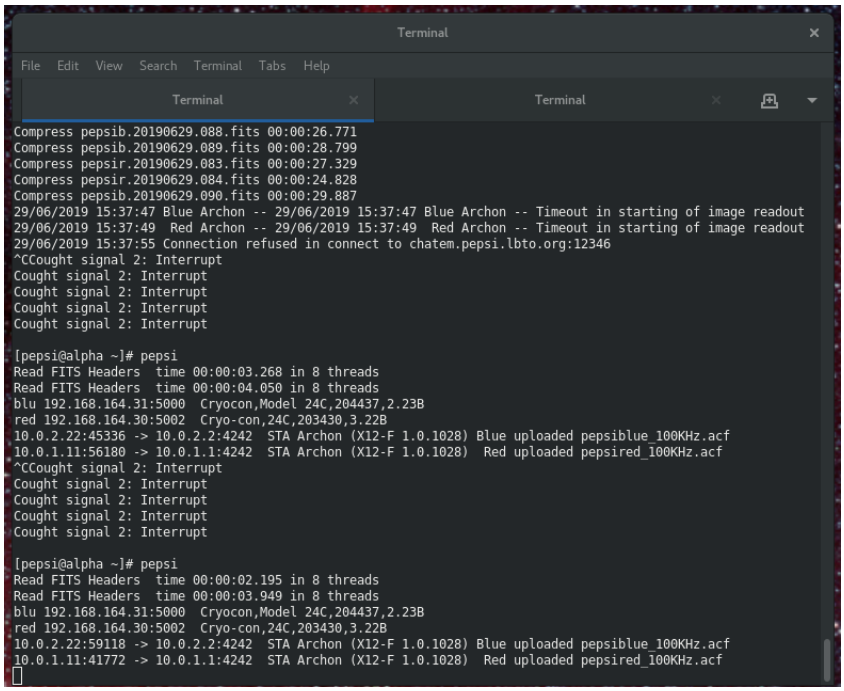


Other important measure is ‘Dewar heater‘ in PEPSI CCD window. If it approaches 0, the dewar pressure rises and pumping is needed.



10 Troubleshooting

Sometimes the software program freezes or even crashes (STA Archon time out). If that happens, find the following terminal



and type Ctrl+c and start all over again.

If terminal gives 'Lost connection with Camera', one can go to 'PEPSI Control Unit' Maintenance, but in order to do that, **you should know what you are doing**.