PAUCam Observer's Manual

(NEW GUI)

v0.3

Last update: December 7th, 2016

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Pointings list

If you have a large list of pointings, you probably want to create your own catalogue before your observing trip, so that you or the telescope operator (OSA) do not have to type the coordinates each time you want to move the telescope, which makes observing more efficient.

Each pointing entry should contain the following fields:

- pointing_name: Pointing title
- ra: J2000 Right Ascension (degrees)
- dec: J2000 Declination (degrees)
- pa: Position Angle from North to East (degrees)
- exp_time: Exposure time (seconds)
- filter_tray: Filter Tray name (see Filter Trays section)
- guiding: whether to take the exposure guiding (1) or without guiding (0)

Write your pointings list in ascii as a list of dictionaries in yaml format with all the fields listed before. It should look like this:

```
- { field_name: "Your title 1", ra: 2.61300424, dec: 0.04117228, pa: 0.0,
exp_time: 130.0, filter_tray: FT_NB775_NB845, guiding: 0}
- { field_name: "Your title 2", ra: 2.61302565, dec: 0.04112474, pa: 0.0,
exp_time: 130.0, filter_tray: FT_NB775_NB845,  guiding: 0}
- { field_name: "Your title 3", ra: 2.61307284, dec: 0.04120247, pa: 0.0,
exp_time: 110.0, filter_tray: FT_r, guiding: 0}
...
```

The system will process this list in the specified order. Minimize the number of filter tray changes to optimize your observing time (~3 minutes each filter tray interchange) and for a better care of the instrument.

Set your file extension to .edb to be able to load your target list file into the PAUCam Control System.

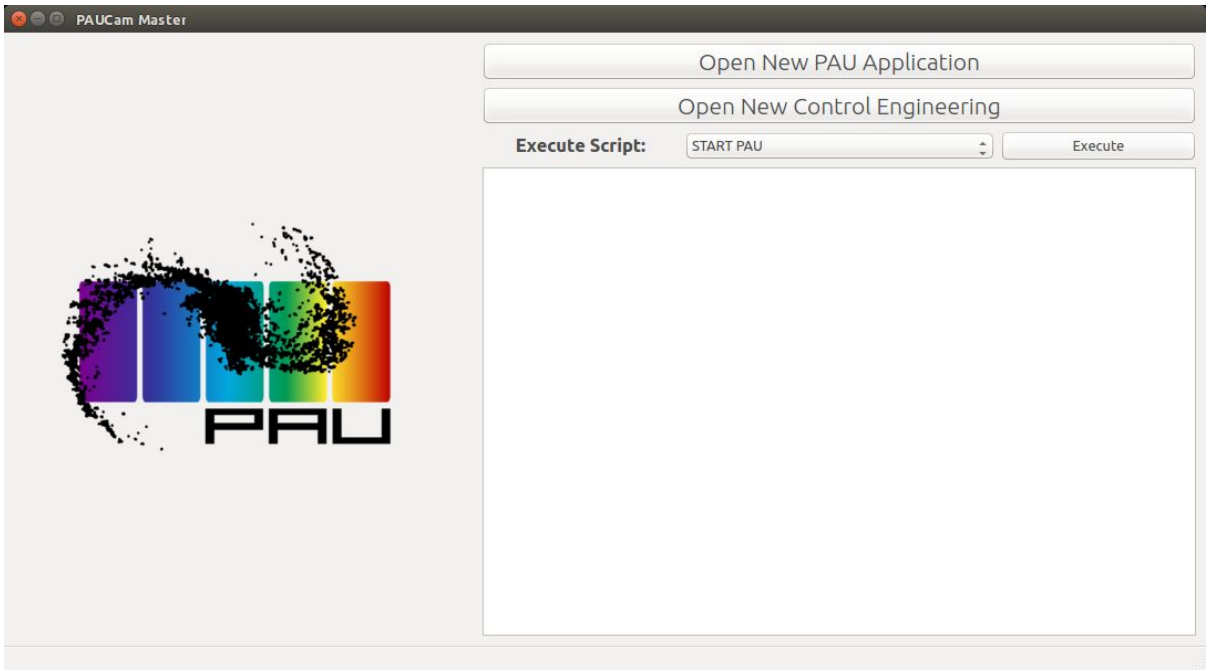
NOTE that for the PAUSurveyScience script the input units for ra and dec are radians. For the ScienceExpose script the units are degrees

Afternoon preliminaries

Open PAUCam Master panel

Click on PAU icon in the sidebar to open PAUCam Master Panel

The **PAUCam Master** panel should appear:



Start motors power

All shutter and filter tray motors are disabled from one night to the next. We need to enable them to operate the camera.
(in PAUCam Master Panel)

1. Click on **Open New Control Engineering** button to open *PAUCam engineering panel*.
2. In the popup window Select New Session -> Press Ok button

(in PAUCam Engineering panel - PAUCamEngineeringApp)

3. Press **Connect to control plc** red button. It will turn to green.
4. Go to **Management** section in the left side of the panel -> Select **Enables** sub section
5. Check that POWER is ON. If not press ON/OFF button to enable the motors.

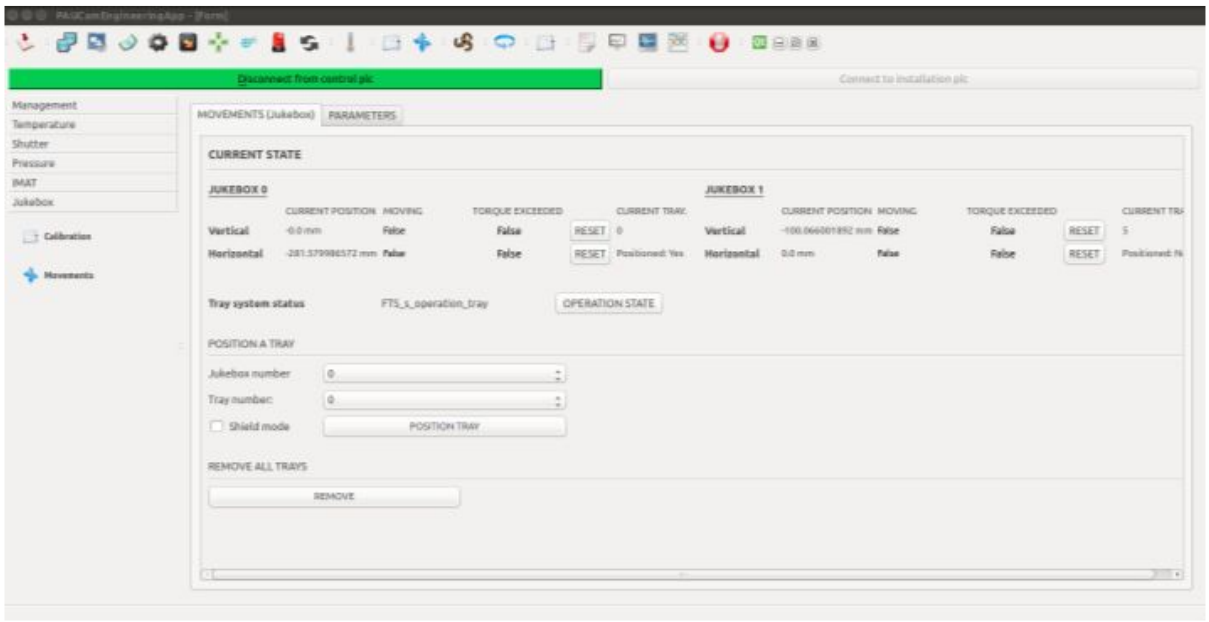
Open Filter Trays Panel (advanced operations)

Filter trays are changed automatically when requesting a flat field or a science exposure. This panel is used for engineers to monitor and control in a specific way the filter trays and jukebox system.
Use this panel ONLY for monitoring purposes. Never enter into calibration mode.

(in PAUCam engineering panel)

1. Open the Jukebox window for advanced control of the jukebox filter tray interchanger:
2. Go to Jukebox section in the left side panel -> Select Movements subsection -> Press the Movements (Jukebox) tab
3. Leave this window open to check the status of the jukebox and advanced control.

The **PAUCam Engineering** Panel should finally look like this:



Start Observation Control System (OCS)

The observation control system orchestrates all the modules and satellites running in multiple computers (CCS machines). This is the main process and will start all the subsystems.

NOTE: first you need to start the power supplies (write it more nicely) SS: What does this mean???

(in PAUCam Master Panel)

1. Execute script: Select **START PAU**
2. Press **Execute** button. Wait until process ends (Should see “Executing String End”).

Initialize the PAUCam Control Panel

The PAUCam Observation Control Panel is the main GUI to operate the camera.

*After restart the paucontrolroom machine for the first time after the camera installation, you will need to start the server daemon in a terminal window:

```
> pftserverd
```

Start the New Version

(in a paucontrolroom Terminal window, if you do not have one, CRTL-ALT-t will open one for you)

1. Enter `> paucontrol`

2. Press START SYSTEM button. **CONNECTION** indicator at the bottom must appears green. Wait until **CONFIGURATION** indicator turns from yellow to purple. This is the state of the OCS without Observation set set.

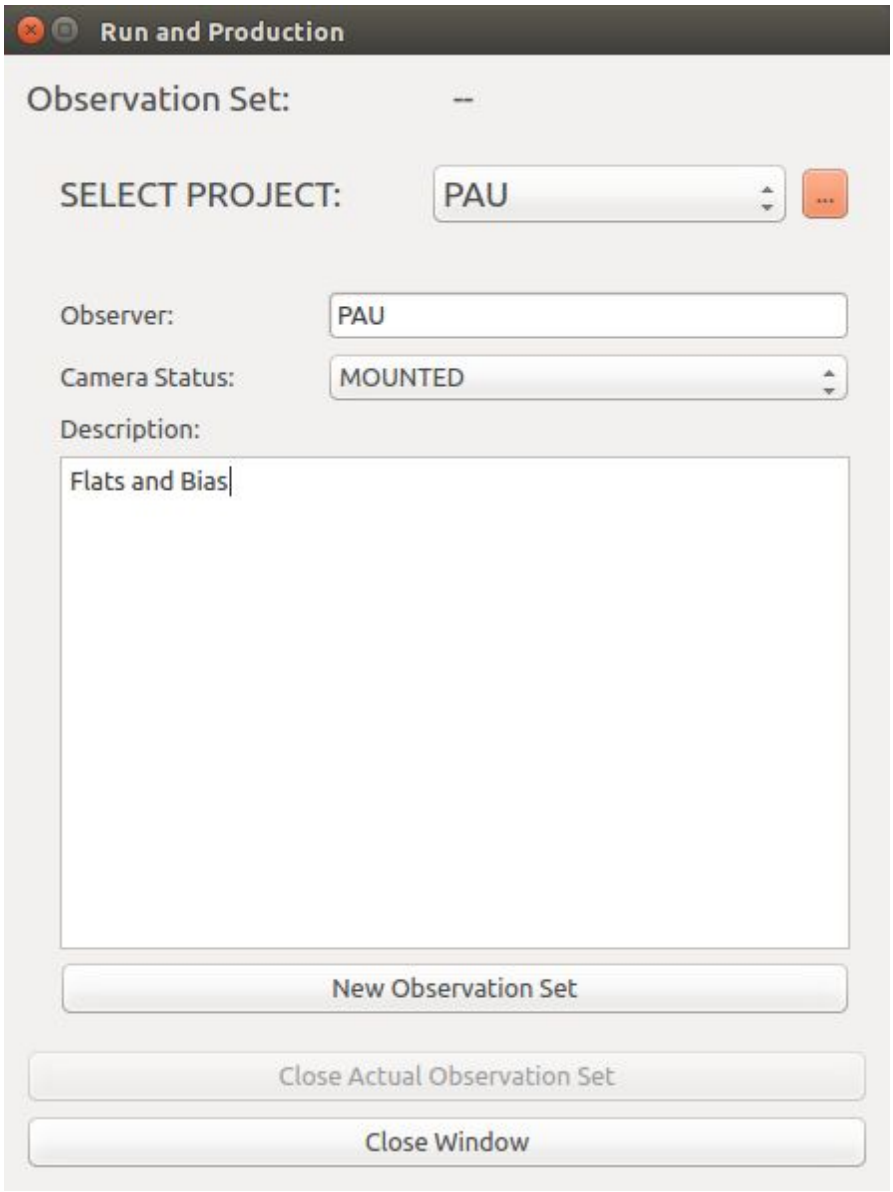
* An old version of the PAU Control Panel is available and can be started with the button “Open New PAU Application” at the PAUCam Master Panel. Detailed instructions in the older versions of this manual.

Create a new observation set

PAUCam data sets are grouped into observation sets. By default, one observation set is created for each night. The content for each observation set (Bias, Flats, Exposures..) will be organized in a single folder. They are named following this format: YYYYMMDD-NN where NN is a counter starting from 01 for each night.

(in the PAUCam Control Panel)

1. Go to *Observation Set* section
2. Press **NEW OBS SET** button
3. Select Project
4. Set Observer name
5. Set camera status to MOUNTED
6. Add any description for the current observation set
7. Click on “New Observation Set” to create it
8. Close window. **CONFIGURATION** button now should appear green.



Configure Data Acquisition mode (DAQi)

The data acquisition readout system needs to be configured depending whether you want to observe with or without auto-guider.
If you want to use the auto-guider, two detectors (G12 and G17) will be dedicated to guiding so the science images will only contain the 16 remaining detectors. If auto-guiding is disabled, all 18 detectors will be dedicated to expose.

Observe with auto-guider:
(in the PAUCam Control Panel)

1. Go to SETUP tab -> DAQi Modes section -> press “Set 16 CCD” button
2. A command **mode16CCDs** will be sent and will appear in the right side of the panel. Wait until command turns **green**.

or

Observe without auto-guider:
(in the PAUCam Observation Control Panel)

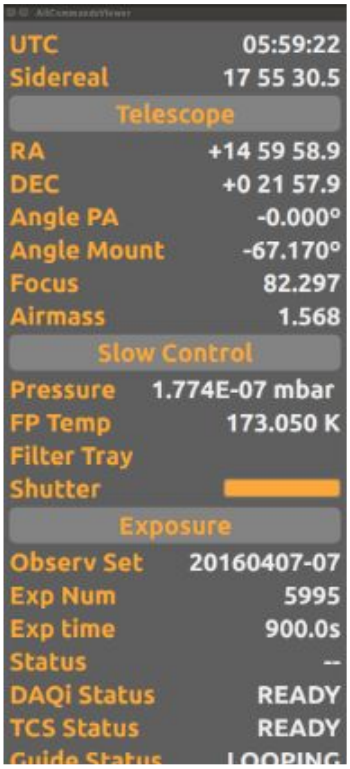
1. Go to SETUP tab -> DAQi Modes section -> press “Set 18 CCD” button

2. A command **mode18CCDs** will be sent and will appear in the right side of the panel. Wait until command turns **green**.

The DAQi mode can be switched later during the night.

The PAUCam Monitor and basic checks

The PAUCam monitor is a simple display panel with the most relevant parameters for the observation.



(in the PAUCam Control Panel)

1. Go to SETUP tab
2. Press the **GENERAL INFO PANEL** button
3. Check **pressure** is ok (<10e-6 mbar). Call PAUCam engineering team if pressure is out of range.
4. Check focal plane **temperature** is ok (~173K). Call PAUCam engineering team if temperature is out of range.
5. Check Telescope **focus** is ok (~82.3). Go to Telecope Control System section of this manual and Set Focus if focus is far from default value.

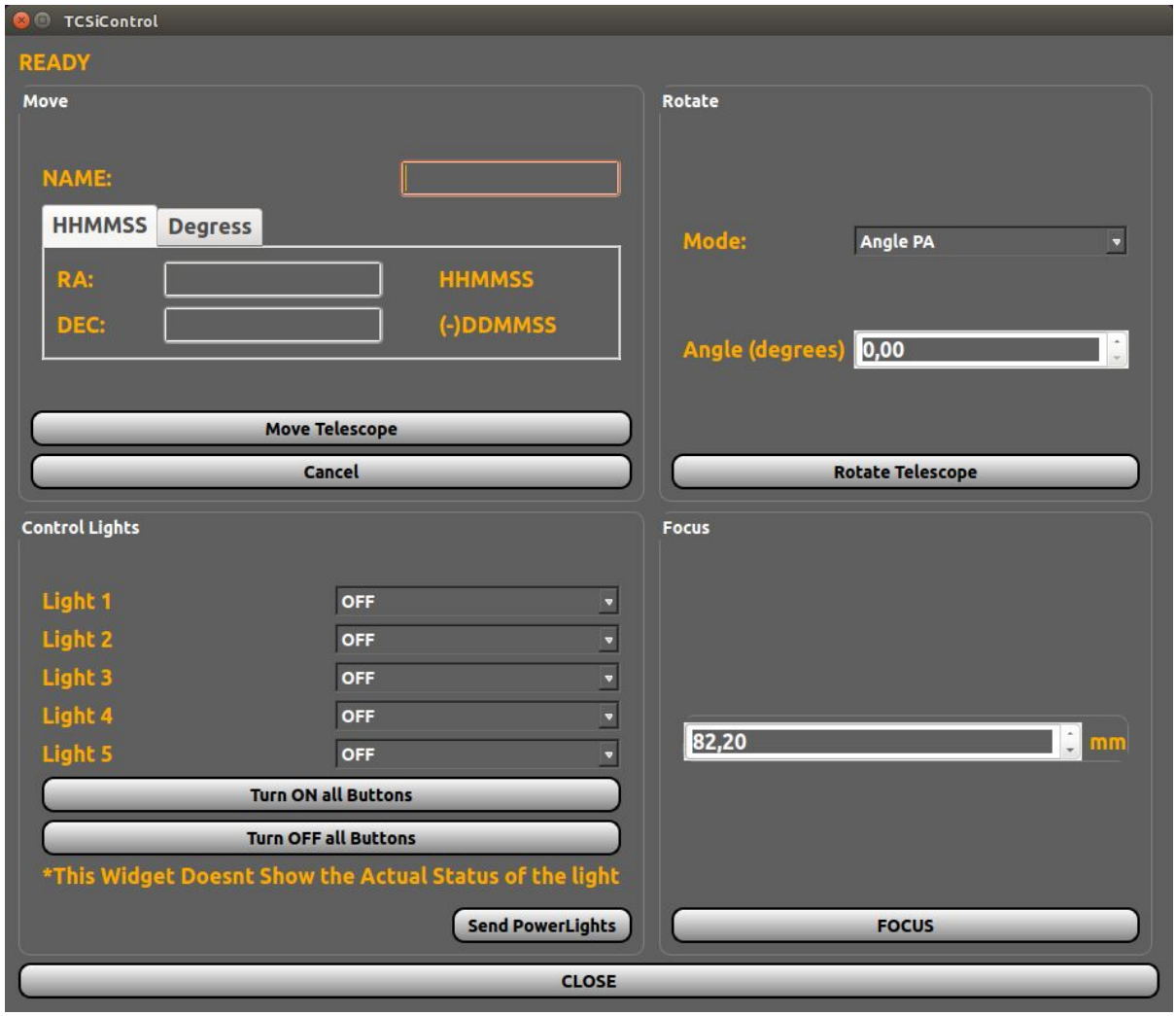
Telescope Control Panel

The telescope dialog panel provides telescope and weather real-time data from the TCS. It also allows the observer to manually command position coordinates and focus. The telescope position can also be commanded automatically from PAUCam OCS through other routines that perform sequential actions (i.e. Science Exposure where the OCS moves the telescope, sets the filter tray and exposes the image). The sky and mount PA cannot be set directly through this window but from other routines explained later.

(in the PAUCam Control Panel)

1. Go to SETUP tab

2. Press the **TELESCOPE** button



3. Leave this window open to send manual commands to the Telescope.

More details about communication and commands with the Telescope in the TCSi section.

Move telescope

Some routines command automatically the TCS (i.e. Survey Mode, Eight Central Pointing…) However you can manually set the sky coordinates through the Telescope Control Panel:

(On the Telescope Control Panel)

1. Go to the **Move** section
2. Select *HHMMSS* or *Degrees* tab depending on the format you want to introduce the sky coordinates.
3. Introduce the **Source Name** (string without spaces)
4. Enter **RA** and **Dec** in the format selected
5. Press **Move**. TCS Status will be set to MOVING. Wait until TCS status is back to READY.

* TCS commands can be aborted by pressing the **Cancel** button at any time.

Move rotator

(On the Telescope Control Panel)

1. Go to **Rotator** section
2. Set the rotator **mode** (0 is SKY, 1 is MOUNT)
3. Set the **angle** from North to East (in degrees)
4. Press **Move Rotator** button**.** TCS Status will be set to ROTATING. Wait until TCS status is back to READY.

Set focus

(On the Telescope Control Panel)

1. Go to the **Focus** section
2. Set the Focus value in mm (nominal value is 82.3)
3. Press the **Set Focus** button to confirm. TCS Status will be set to FOCUSING. Wait until TCS status is back to READY.

Set Flat Field Lamps

(On the Telescope Control Panel)

1. Go to the **Control Lights** section
2. Set the lights you want to turn on and off.
3. Press **Send PowerLights** button to change the status of the lights

* Power of lamps is always set to 100%.

Filter tray selection

The selection and interchanging of filter trays is done automatically when requesting a flat field or a science exposure. Simply set the filter tray name or filter tray id when requested and the system will perform the movement.

Filter tray set

The following table contains the relation between Filter Tray names, the associated IDs and additional complementary information.

Filter Tray ID	Filter Tray Name	Jukebox	Jukebox Position	Comment
0	FT_y	0	0	Single filter with Y band.
1	FT_z	0	1	Single filter with z band.
2	FT_i	0	2	Single filter with i band.
3	FT_r	0	3	Single filter with r band.
4	FT_g	0	4	Single filter with g band.
5	FT_u	0	5	Single filter with u band.

6	shield	0	6	Thermal shield
7	empty	1	0	No tray
8	FT_NB775_NB845	1	1	Individual filters per detector. Broad band filters on 10 external detectors. Narrow band filters on 8 central detectors from NB775 to NB845.
9	FT_NB695_NB765	1	2	Individual filters per detector. Broad band filters on 10 external detectors. Narrow band filters on 8 central detectors from NB695 to NB765.
10	FT_NB615_NB685	1	3	Individual filters per detector. Broad band filters on 10 external detectors. Narrow band filters on 8 central detectors from NB615 to NB685.
11	FT_NB535_NB605	1	4	Individual filters per detector. Broad band filters on 10 external detectors. Narrow band filters on 8 central detectors from NB535 to NB605.
12	FT_NB455_NB525	1	5	Individual filters per detector. Broad band filters on 10 external detectors. Narrow band filters on 8 central detectors from NB455 to NB525.
13	sensors	1	6	Filter tray with temperature sensors, a.k.a. Octopus. (do not use).

For more details of the filter trays, the corresponding match between Filters and CCDs and the system throughput for each band, visit the PAU Survey website: www.pausurvey.com

Set a Filter Tray

Even the system can set the filter tray automatically inside higher level routines, the filter trays can be set manually:

(in the PAUCam Control Panel)

1. Go to SETUP tab
2. Press the **FILTER TRAY** button
3. Set the filter tray and press **MOVE TRAY**

Basic image calibration

In this section, basic image calibration acquisition commands are explained.

Acquire Bias images

(in the PAUCam Control Panel)

1. Go to **ACTIONS** tab -> **ROUTINES** sub tab -> **BIAS** section.
2. Set the number of Bias exposures
3. Press **Execute.** The **Bias** command on the right side of the panel will turn green once completed successfully.

Acquire Dark images

(in the PAUCam Control Panel)

1. Go to **ACTIONS** tab -> **ROUTINES** sub tab -> **DARK** section.
2. Set the number of Bias exposures
3. Set exposure time (in ms)
4. Press **Execute.** The **Dark** command on the right side of the panel will turn green once completed successfully.

Acquire Flat Field images

(in the PAUCam Control Panel)

1. Go to **ACTIONS** tab -> **ROUTINES** sub tab -> **FLATS** section.
2. Set the number of Flat Field exposures
3. Set exposure time (in ms)
4. Set the filter tray
5. Press **Execute.** The **Flat** command on the right side of the panel will turn green once completed successfully.

* To automatically acquire a full set of Flat Field images, go to the NOD section.

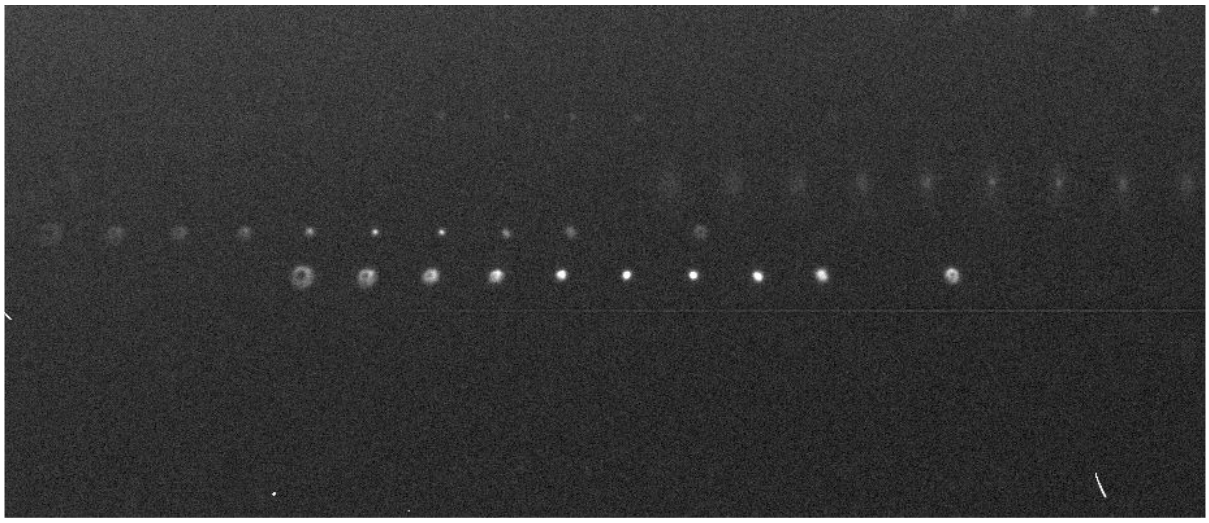
Acquire Stacked Focus image

In this mode single image is produced and detector charges are shifted for each focus position. The resulting image is automatically analyzed by DRACO (see DRACO section) with the focus analysis.

(in the PAUCam Control Panel)

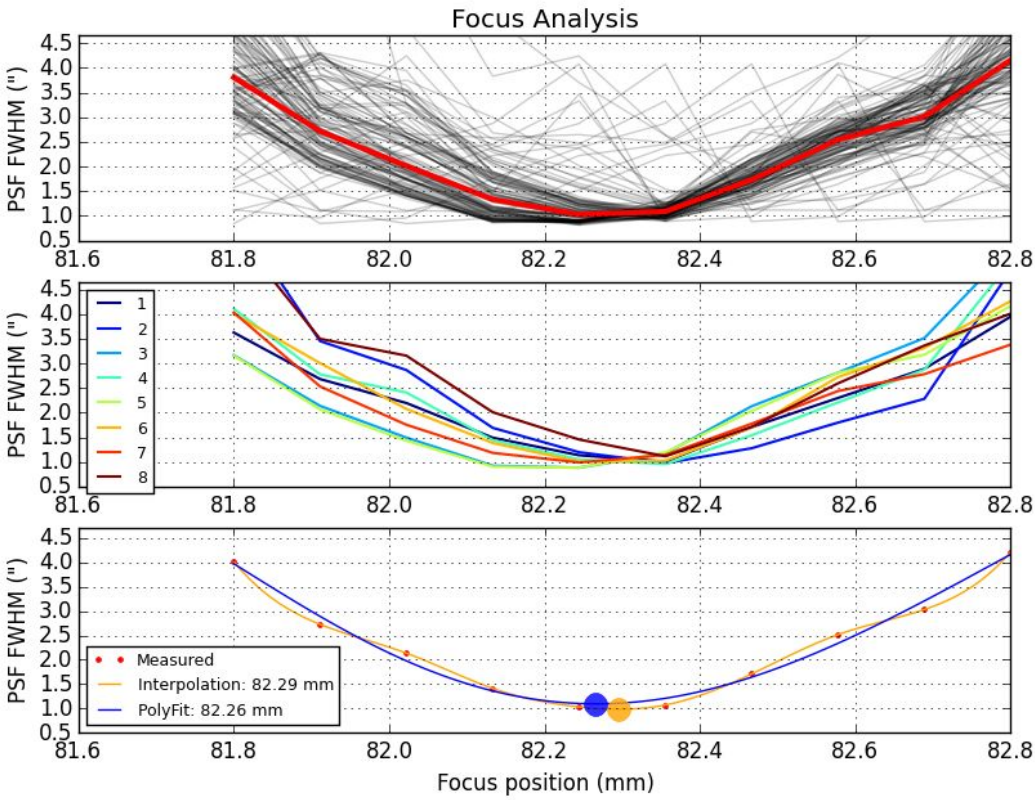
1. Go to **ACTIONS** tab -> **ROUTINES** sub tab -> **STACKED FOCUS** section.
2. Set the number of Flat Field exposures
3. Set the exposure time (t_{exp} = 15 s is a good election)
4. Set the filter tray
5. Set the initial focus (f_{init} = 81.8)
6. Set the final focus (f_{final} = 82.8)
7. Set the number of focus steps (n = 7, 9,...). In any case, remember that the total time is around $t_{exp} \cdot n + 20$ (s)
8. Press **Execute.** The **StackedFocus** command on the right side of the panel will turn green once completed successfully.

Stars will look like this:



Nominal focus is 82.3

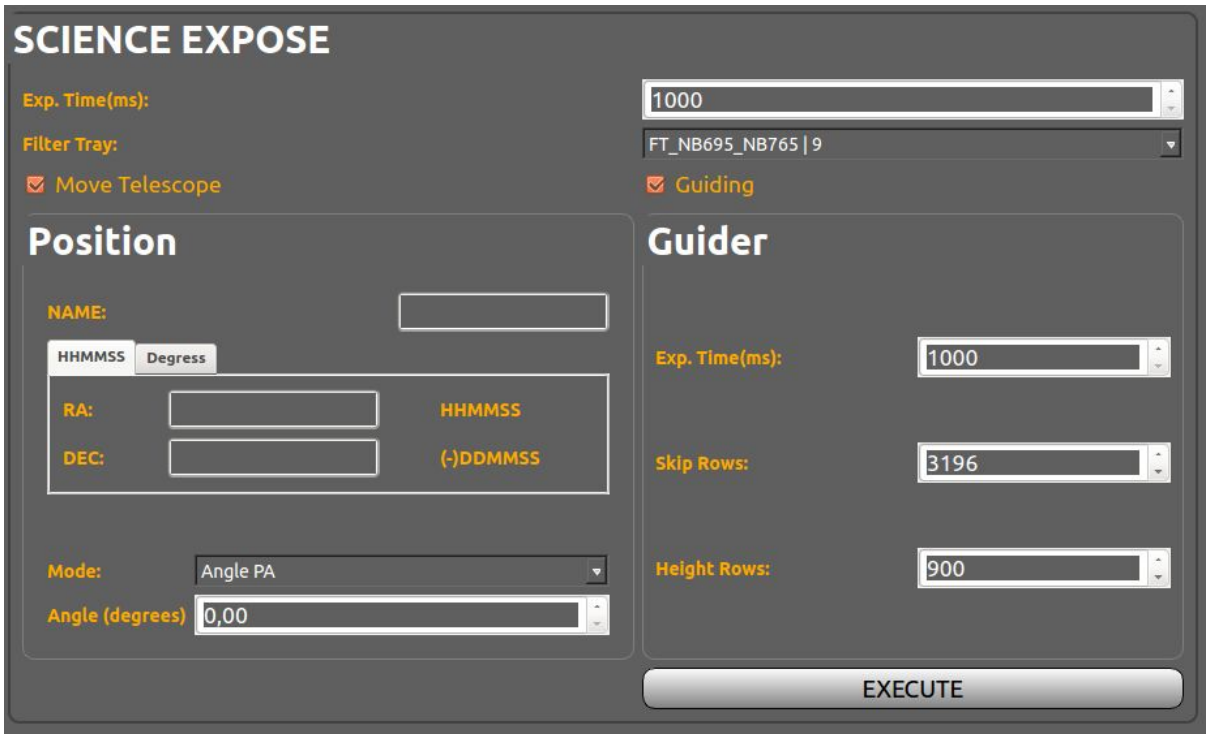
DRACO will analyze the stacked focus image and provide the focus minimization for the camera and for the individual detectors:



After the analysis the observer will have to decide the best focus position and set it through the TCSi interface (see TCSi section for instructions) or ask the OSA to set it.

Basic Science Image Exposure

Even the regular operation is to observe with automated sequence of images, single exposure images can be set manually.



Acquire single Exposure image

(in the PAUCam Control Panel)

1. Go to **ACTIONS** tab -> **SCIENCE** sub tab -> **SCIENCE EXPOSURE** section.
2. Set exposure time (in ms)
3. Set the filter tray ID (see Filter Tray section for details)
4. Press **Execute.** The **ScienceExposure** command on the right side of the panel will turn green once completed successfully.

Enable telescope positioning

Additionally, the observer can set the sky coordinates and PA directly from this panel for the science exposure.

5. Enable the **Move Telescope** check
6. Set **name** of the object you are pointing to
7. Set the sky coordinates in HHMMSS or in Degrees
8. Set the Rotator angle (sky or mount)

Enable auto guiding

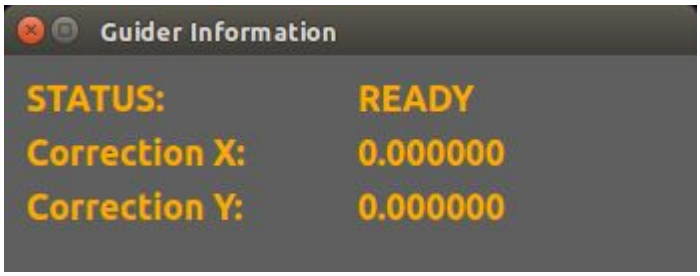
PAUCam has a built-in auto-guiding system to allow precise tracking of long exposures. When guiding is enabled, 16 detectors integrate light for the scientific exposure while the two outermost detectors are dedicated for guiding. The guiding detectors (G12 and G17) integrate ~1 second and make a fast readout over the Region Of Interest (ROI). Depending on the stellar density of the field 3 to 15 guide stars are analyzed to measure the centroid correction. The error signal is sent to the TCS every 6 to 8 seconds.

Make sure DAQi is configured in 16 CCD mode. Otherwise, reconfigure it before enabling the guider (see Configure Data Acquisition mode section).

9. Enable the **Guiding** check

10. Set the **guiding exposure time** (nominal value is 1s)
11. Set the **number of rows to skip** (skip_rows) to define the guider ROI area (3196 by default)
12. Set the number of **rows to read** (heigh_rows) to define the guider ROI size (900 by default)

The guiding status and corrections can be displayed in the **GUIDER INFO** panel (Under PAUCam Control -> SETUP -> GUIDER INFO button)



DRACO and Fits Viewer

DRACO (Draw, Reduce and Analyze Camera Observations) is the subsystem responsible of the calculation of the basic quality parameters of PAUCam images. The quality values are calculated after taking the image and are stored in a database, allowing the observer to retrieve them offline. The image itself can be displayed from the Fits Viewer window, while the results of the basic reduction (based on astromatic software SExtractor and PSFex) are displayed by the Quality Image Tests window.

Draw, Reduce and Analyze Camera Observations (DRACO)

To open de DRACO panel:
(in the PAUCam Control Panel)

1. Go to SETUP tab
2. Press the **DRACO** button

On the left side of the Quality Image Tests window select one image from the list to see the results of the quality tests - > Click on *EXPOSURE NUMBER - KIND* (ex. “5994 - TARGET”)

Depending on the type of exposure, a set of tests will be processed and displayed.

BIAS image

- Error in the Overscan (readout noise) vs amplifier number (from 1 to 72)

FLAT image

- Error in the Overscan (readout noise) vs amplifier number (from 1 to 72)
- Mean signal in the 8 central CCDs (in electrons)

STACKED FOCUS image

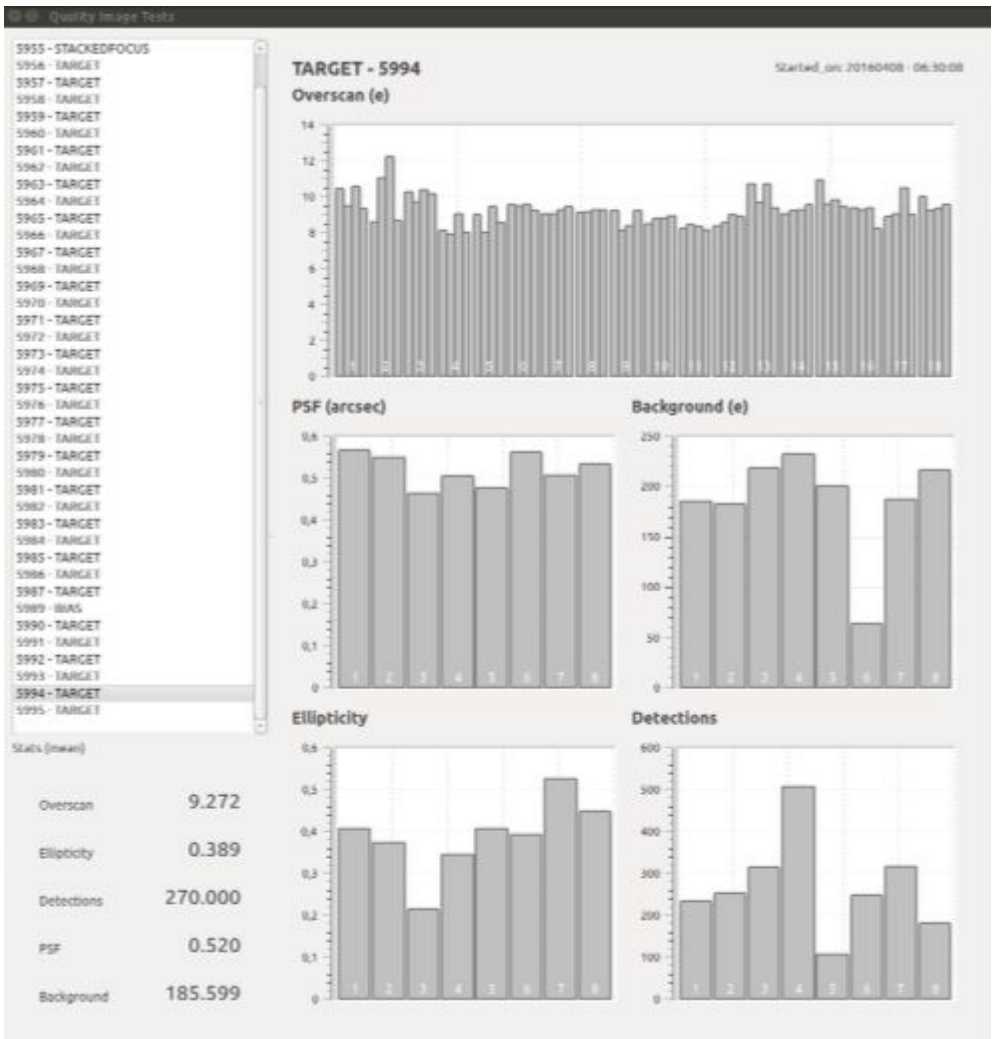
- Global Focal Plane Focus analysis
- Focus analysis for all star sequences
- Focus analysis for each of the 8 central detectors

SCIENCE image

- Error in the Overscan (readout noise) vs amplifier number (from 1 to 72)
- Mean PSF FWHM (in arcsec) vs CCD number (only central area, from CCD 1 to CCD 8)
- Mean Background level vs CCD number (only central area)

- Mean PSF Ellipticity vs CCD number (only central area)
- Number of Detections extracted per CCD number (only central area)

On the left side, below the list of images to select, the mean values relative to the central focal plane area are displayed.



The FITS viewer

PAUCam images are stored in fits files, they can be displayed using the Fits Viewer window.

To open de FITS Viewer panel:
(in the PAUCam Control Panel)

1. Go to SETUP tab
2. Press the **FITS VIEWER** button
3. Double click on the exposure number corresponding to display the image

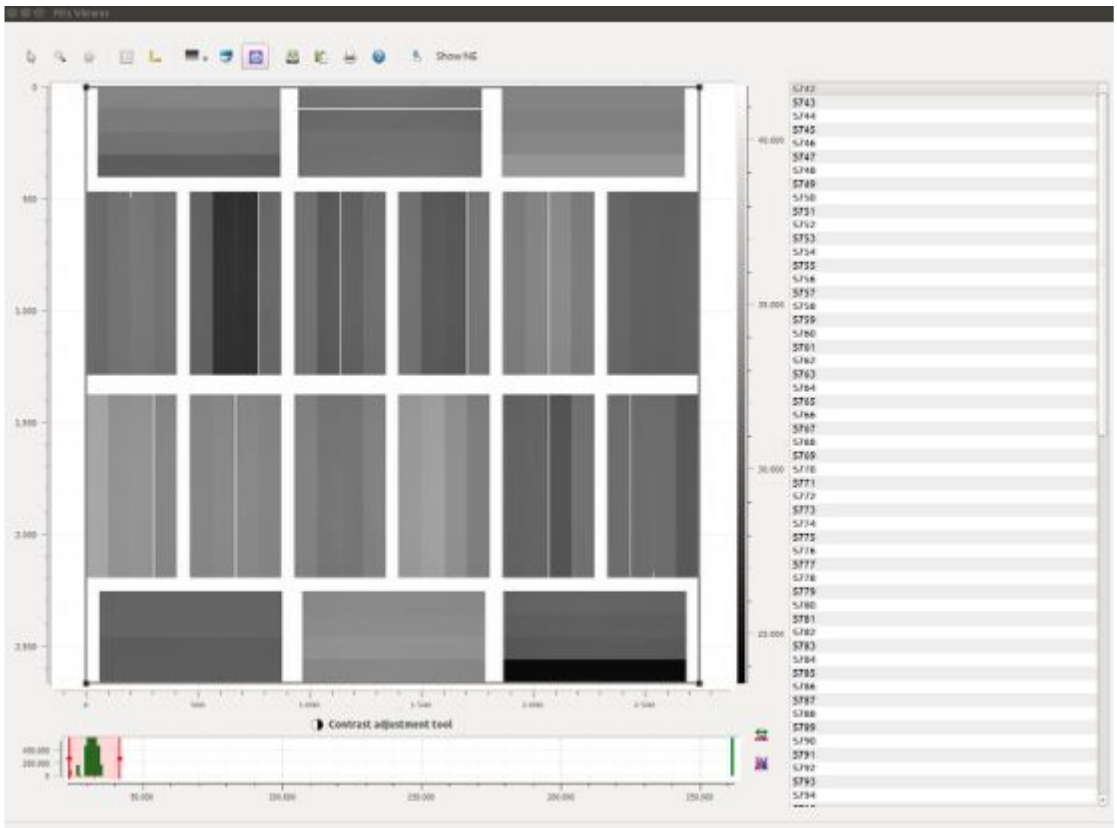
Gray scale range can be modified with the Contrast Adjustment Tool, below the image display panel. Select an option on the right side of the light curve plot and adjust the dynamic range moving right or left the red vertical lines with the mouse:

- Adjust the image color range according to data range

- Eliminate outliers by setting lower and upper limits

On the upper part of the window, press the selected icon to perform the corresponding action:

- Arrow -> Click on the exposure number to display. Move the image inside the window
- Zoom -> Click on the image to zoom in and out
- Grid -> Activate grid on the image display
- Print -> Print the image displayed
- Copy to clipboard
- Save as -> Select how to save the image display
- Image statistics -> Select a region of the image and retrieve corresponding statistics
- Rectangle snapshot -> Select a rectangle with the mouse to have the corresponding snapshot
- Select colormap -> Select the image color palette
- Axes style -> Configure image axes style
- Parameters -> Configure image parameters
- Select -> Click on a position in the image image to get coordinates and intensity
- Help



Sequence mode (NOD)

The PAUCam Control system allows automated (long) sequences of routines. These can be from a list of flats with their respective lamps and exposures times, to long sequences of dither and pointing observations, with defined sky locations, exposures times, filter trays and other configuration.

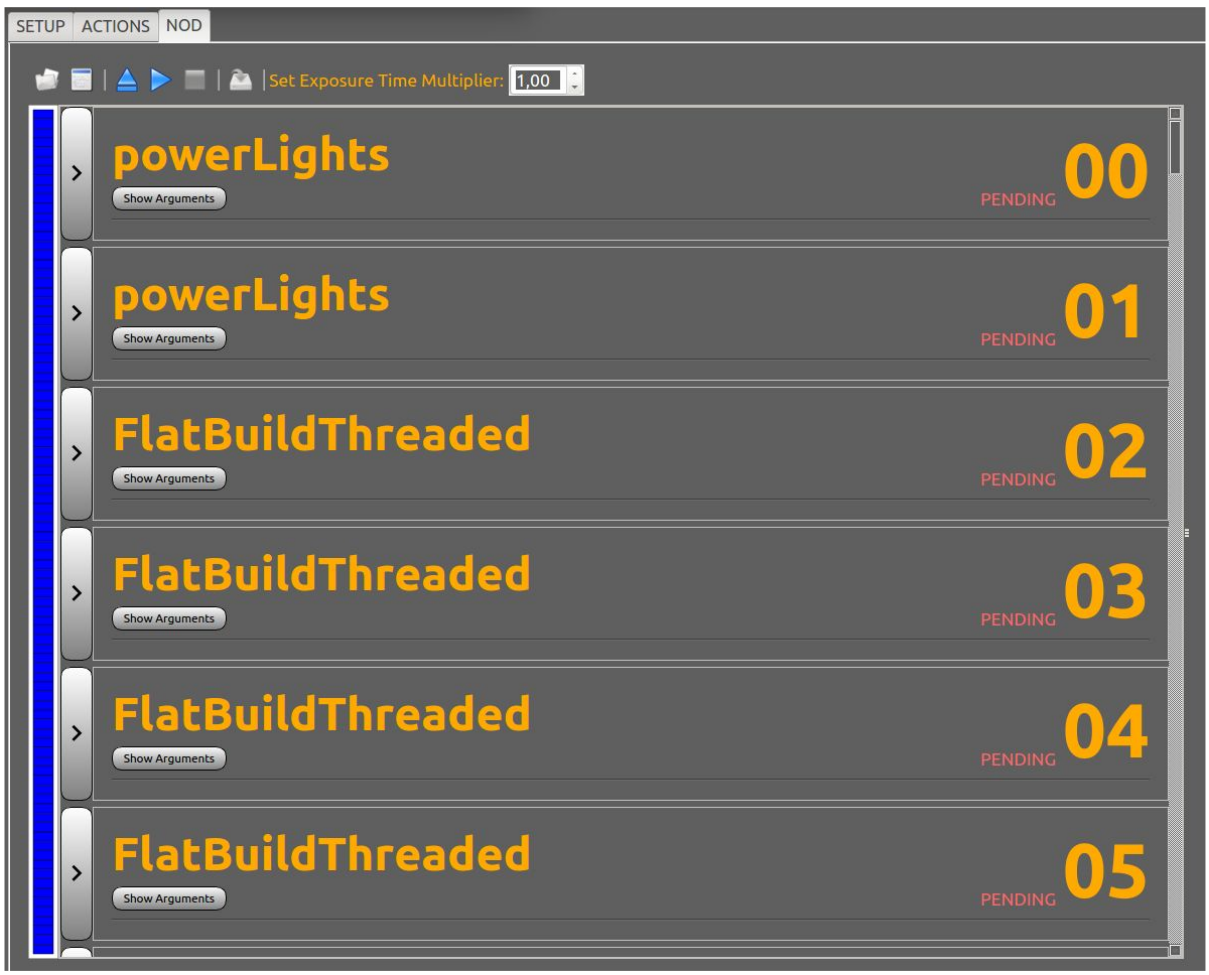
Sequence of Flat Field images

To perform automatic flat field calibration set of images for all trays, with the nominal exposure times and flat field lamps, follow these instructions:

(in the PAUCam Control Panel)

1. Go to NOD tab
2. Click on  to load the Flat sequence
3. Select type **YAML** files
4. Go to ~/Desktop/flats_nod/
5. Select **AllFlatsNOD_11-12-2016.yaml** (if dark at night) or **AllFlatsNOD_new.yaml** (if in the afternoon) and click **Open**

The NOD should look like this:



6. Make sure Telescope is at **Flat Field position** (elevation 45º, dome 30º) and **petals are open**
7. Press ▸ to begin the sequence. You can pause the sequence at any time by pressing ▮. The current block will finish and the next one will remain in pause until ▸ is pressed again.
8. Once finished, press ⏏ to clear the NOD.

The following table give a reference of the lighted lamps, exposure times and signal.

Filter	Tray	Lamps	Percentage (%)	Exposure time for NBs (s)	Exposure time for BBs (s)	Counts (e)	Counts in BBF (ADU without 30k Bias)
u	5	1-2-3-4-5	100	2		18k	Edges with “contamination”
g	4	1-2-3	100	1		75k	
r	3	1-2	100	2.5		83k	
i	2	1-2	100	1		83k	
z	1	1	100	5		76k	
Y	0	1-2	100	1.5		92k	
455 - 525	12	1-3	100	3	1.5	25k	140k
535 - 605	11	1-2	100	10	3	136k	10k-120k
615 - 685	10	1-2	100	7	2	22k	70k
695 - 765	9	1-2	100	4	1	22k	40k-100k
775 - 845	8	1-2	100	4	1	35k	110k-200k

Last update: December 12, 2016

* (WHT Web interface to manually set the lamps: http://161.72.6.103/PetaLamps/)

Survey and Sequence mode

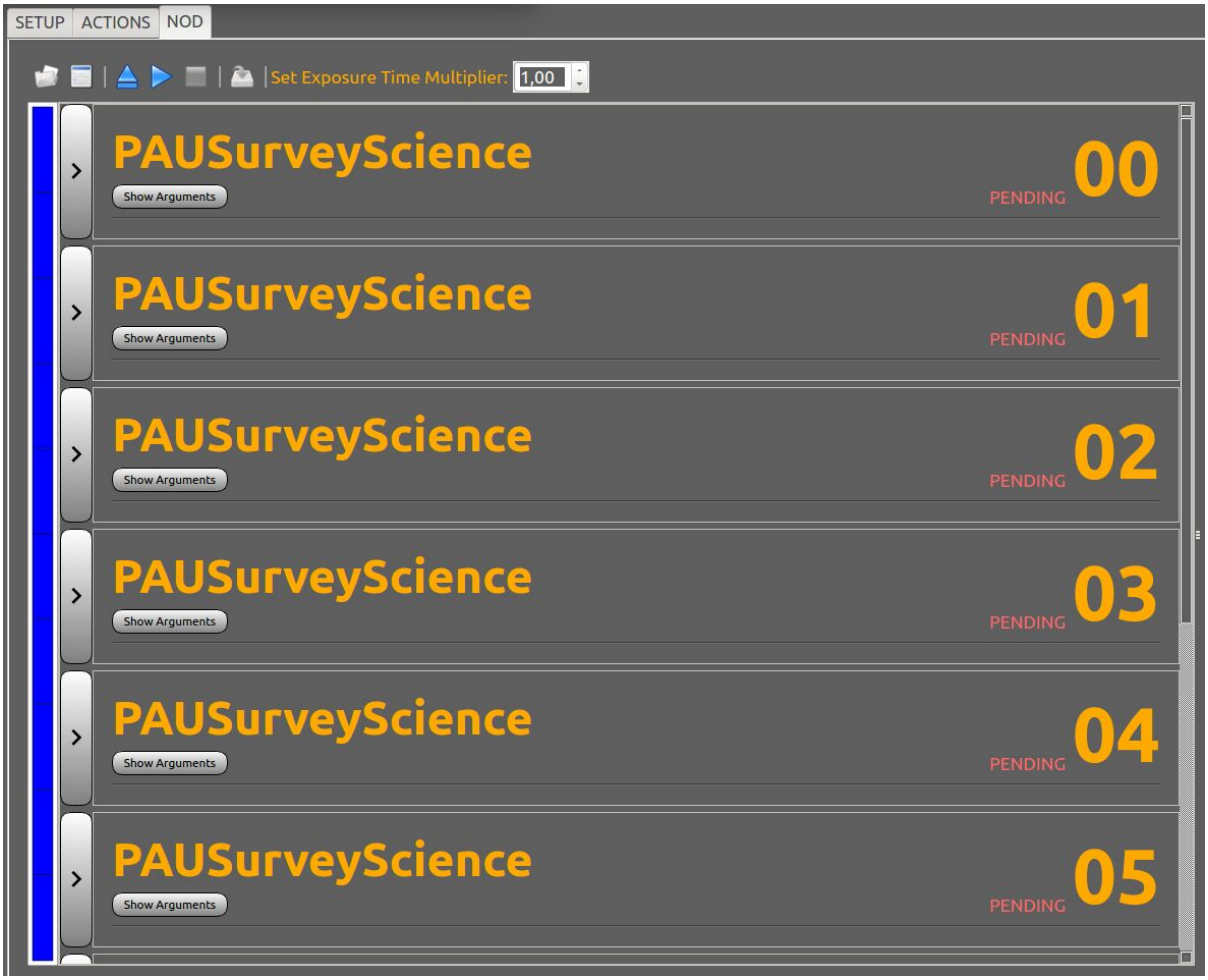
For long automated sequences of exposures it is recommended to create a list in the format specified in the section “Pointings List”.

- For PAU Survey observation sequences use .sdb files.
- For PAUCam Community Observation sequences use .edb files (format described in “Pointing List” section)

Load Pointings Sequence

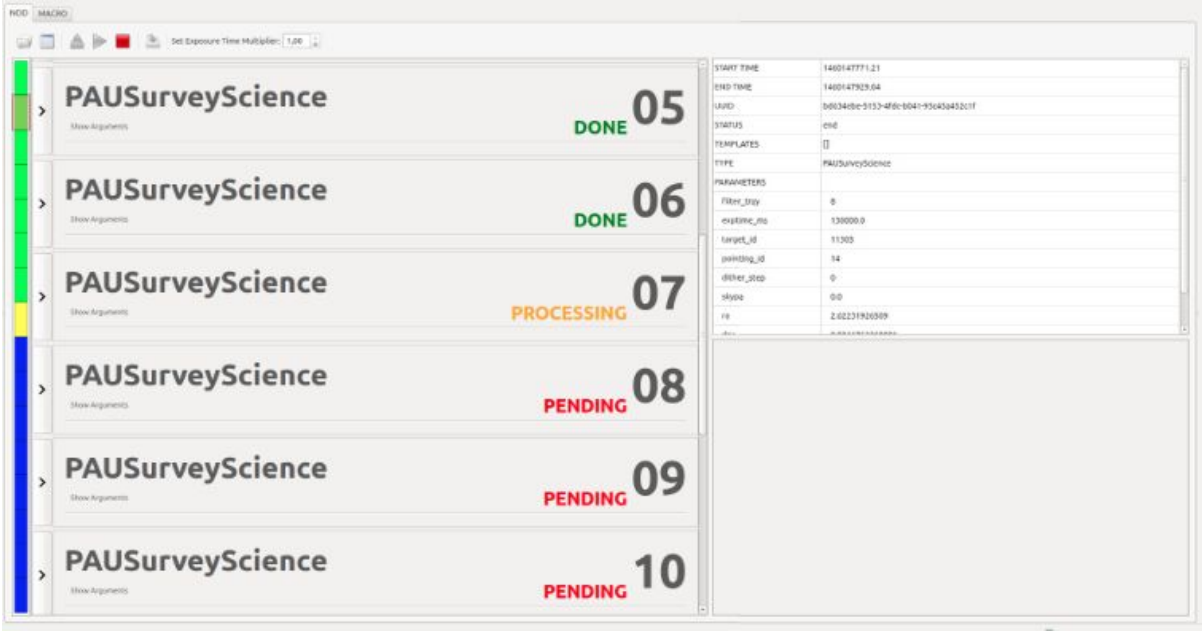
(in the PAUCam Control Panel)

1. Go to NOD tab
2. Load your pointings list file (file extension must be .sdb or .edb) with the load icon  . Your pointings list must appear in the main window:



3. Check that the coordinates, filters, exposure times… are correct using “Show Arguments”.
4. Click Play icon ▸ to begin the automated exposure sequence. **PENDING** science exposures will begin to **PROCESSING** state until are complete, that will change to **DONE**. If an error occurs the status will change to **ERROR**. You can pause the sequence by clicking on the stop icon ▮. The sequence will stop after the completion of the processing exposure. It can be resumed with

the play icon.



5. To unload the list click on the eject icon ⏏. This can only be done when the sequence is complete or paused.

Data Storage and Transfer

PAUCam images are fits files organized in directories, whose name is the observation set name (format YYYYMMDD-##). When closing an observation set, a metadata file called YYYYMMDD-##.yaml is written in the same directory with a description of the observation set.
The internal disk storage has a capacity of 7 TB.
Contact the PAUCam Team for further details and for support in access and transfer your data.

End of night

Wait until all process are finished (Read CCDs, DRACO,...).

Close the Observation Set

(in the PAUCam Control Panel)

1. Go to SETUP tab -> Observation Set section
2. Press **CLOSE OBS SET**

Move staging directory to archive

(temporary - only for PAUCam users - To be updated by Nadia's Script)

1. Log into pausrm2 server.
   `> ssh pauccs@pausrm2.ing.iac.es`
2. Go to staging archive
   `> cd /pauccsarchive`
3. Check all observation set directories and remove those with no images in it (only with the observation set yaml file)
4. Check that all the directories have one `<observation_set>yaml` file. If it is missing, the directory cannot be moved (see next step).

5. Atomic move of observation set directories to main archive
   `> mv -n <observation_set_directory> /archive/`

Images will begin to transfer automatically to PIC.

Shutdown Camera Control System

1. Close PAUCam Observation window

(in PAUCam Master Panel)

2. Execute script: Select **STOP PAU**
3. Press Execute button. Wait until process ends.

Remove trays from jukebox

(In PAUCamEngineering window)

1. Go to **Jukebox** -> Movements -> MOVEMENTS (Jukebox)
2. In REMOVE ALL TRAYS -> Press **REMOVE** button.

Turn motor powers off

1. Go to PAUCamEngineeringApp window
2. Enter into the **Management** section (left lateral bar)
3. Enter into "**Enables**"
4. Click on **POWER** ON/OFF. X indicator should move to **OFF**.

Close engineering application.

Go to sleep.

Contact PAUCam Team

If any issue occurs and the proposed solutions do not work, please contact the PAUCam team at the following address: paucam-support@ifae.es