Astrophoto

Automated Acquisitions





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06/12/2022

Summary

- Presentation of my platform
- Presentation of the controls implemented
- Target Programming
- Presentation of the automation of the acquisition plan
- Creation of Flats
- Raw Checks
- Questions answers





A little word about my passion

- Child: wonder by the Milky Way and the thousands of stars visible under a dark sky in Aveyron
- 1997: Unforgettable passage of comet Hale Bopp with exceptional visibility through binoculars
- 2006: Training "Astronomy in the Gers" => That's when my passion really started
- 2008: Purchase of my first telescope => visual use only
- 2010: Purchase of a DSLR camera=> start of astrophotography
- 2017: Beginning of my contribution to the French communities “ Webastro ” and “ Astrosurf ”
- 2019: Purchase of a cooled astronomical camera => start of improvement



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Presentation of my hardware platform

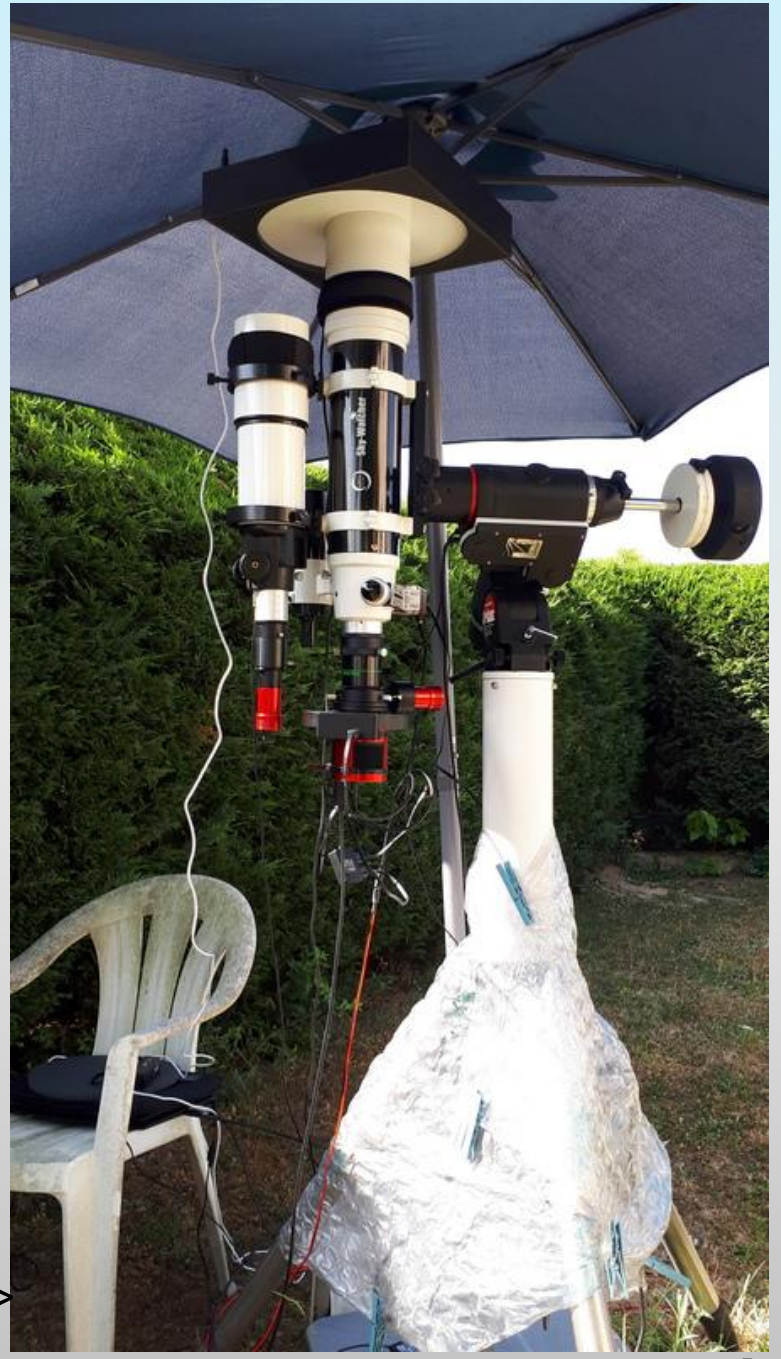


Equatorial mount ORION Sirius EQ-G

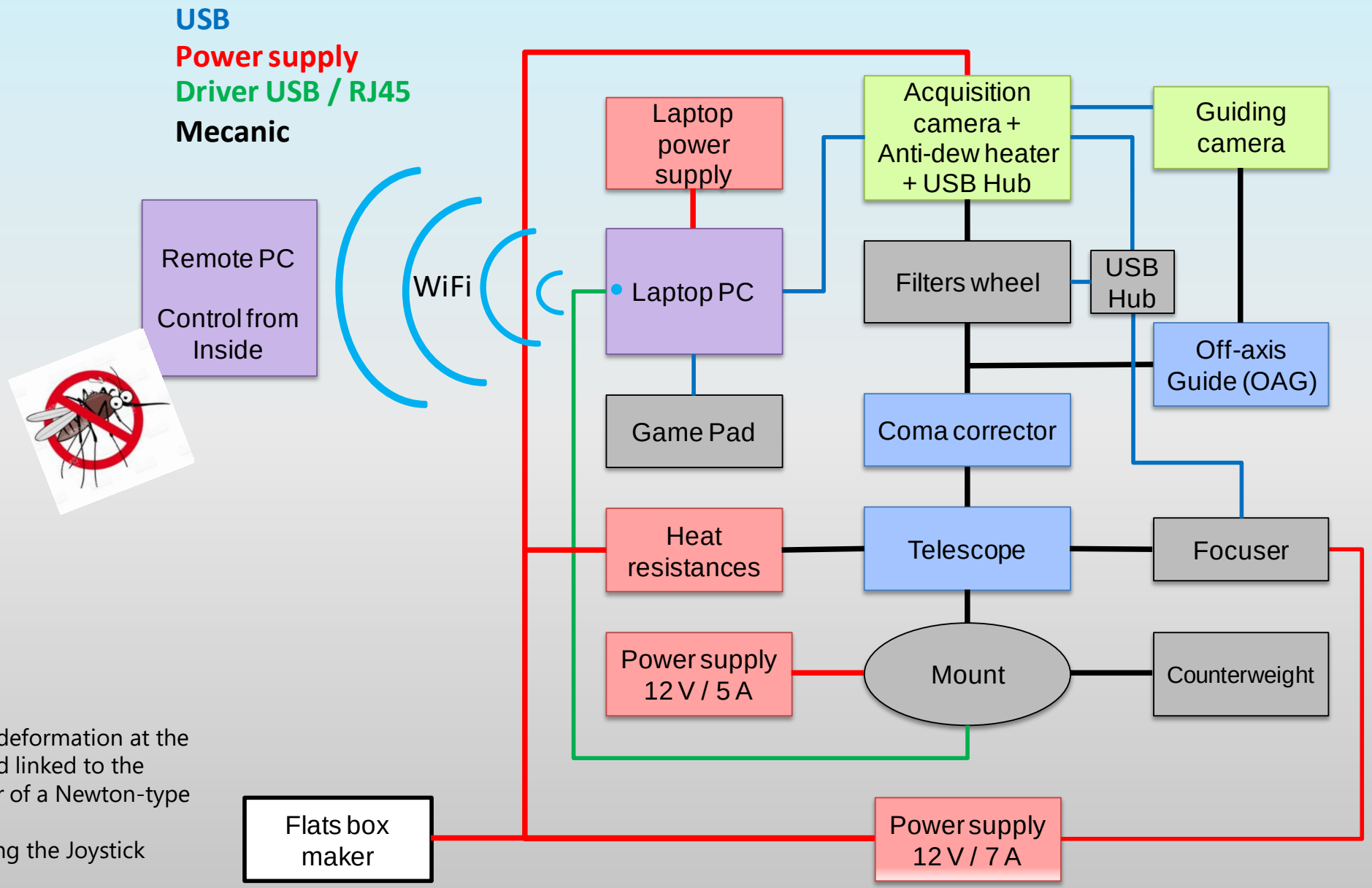


ORION 200mm Telescope (F4.9) ⇧

Refractor Sky Watcher 80mm (F7.5) =>



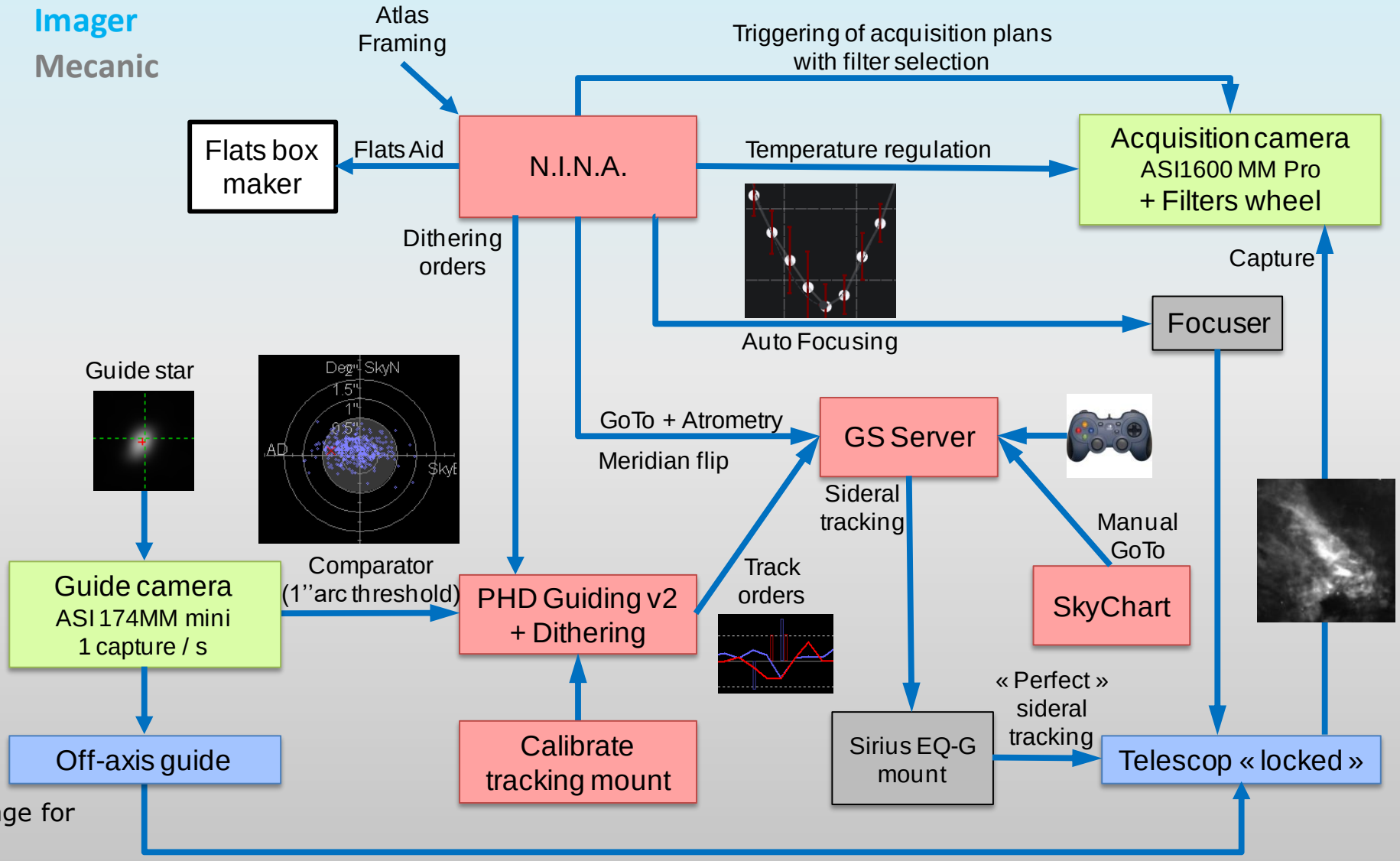
Presentation of the platform: block diagram



Coma : optical deformation at the edge of the field linked to the parabolic mirror of a Newton-type telescope
GamePad : Using the Joystick

Presentation of the platform: fonctionnal diagram

Software
Sensor
Imager
Mecanic



Flats : calibration image for optical defects

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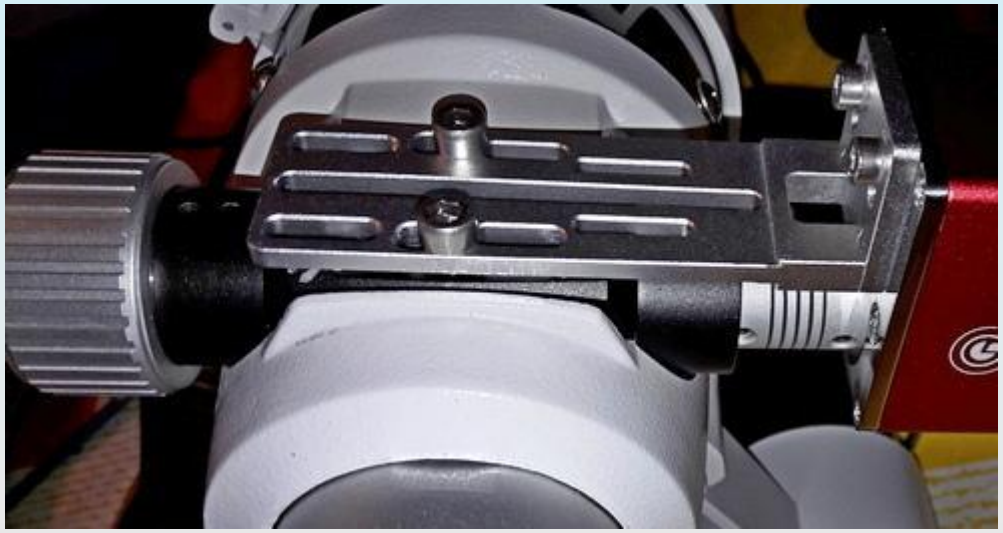
Mount control with GS Server

- Pre-requisite: the mount must be aligned (on the axis of terrestrial rotation)
- Sidereal Tracking
- GoTo on transmitted coordinates
- Manual movements on the RA/DEC axes
- Parking on custom positions
- 3D view
- Security so as not to damage the mount



Focus control with a step by step motor

- Mounting a step by step motor on the focus axis of the imager
- Possibility of compensating the mechanical game between a round trip
- External temperature sensor to be able to compensate the focus according to the temperature (mechanical expansion)
- Memorization of the value corresponding to the point of focus
- Possibility to set a min and max stop





Filter control with motorized filter wheel

- Assembly of a motorized filter wheel on the optical axis
- Management of up to 8 filters in 32mm: L,CLS,R,G,B,Ha,O3,S2
- Reminder: a monochrome camera is 3x more sensitive than a color one
- We can do trichromy with 3 monochrome photos R, G, B
- Advantage of taking “Hubble” false color photos with narrow band filters Ha, O3 , S2 (6nm to 3nm)







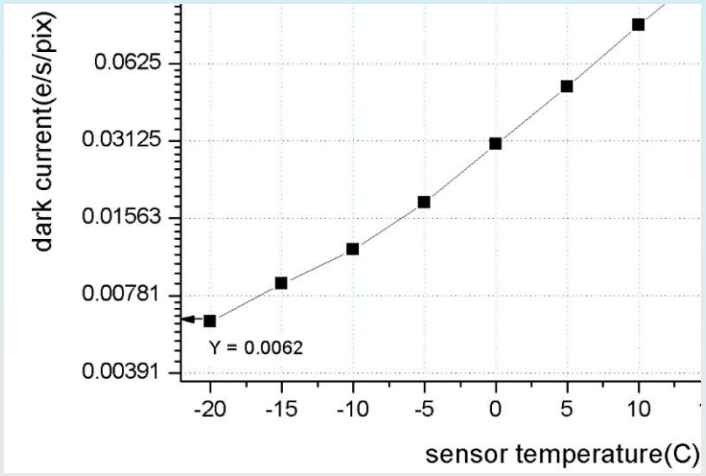




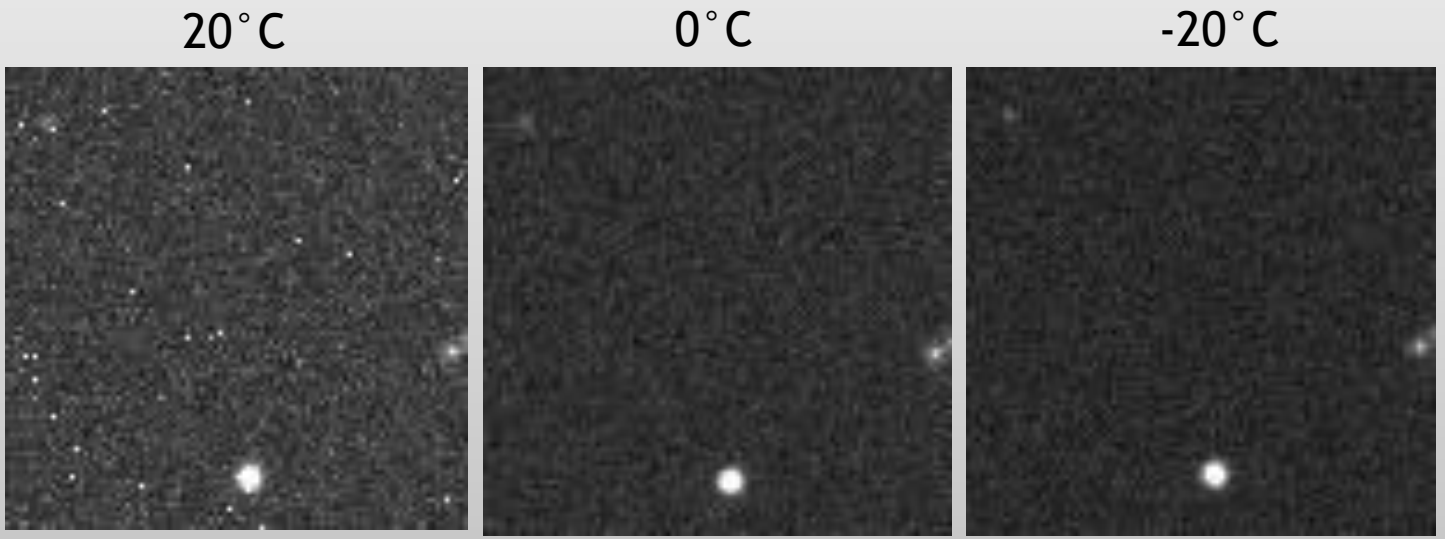
L : Luminance; CLS (Clear Light Sky): anti- light pollution (streetlights)
RGB : Red, Green , Blue
SHO : H: Ray of hydrogen , O: Line of oxygen ionized ; S: Sulfide hydrogen

Temperature control of acquisition camera

- Noise decreases with sensor temperature (-20°C ideal)
- The sensor is placed above a thermocouple module called "Peltier stage"
- Possibility of cooling to -25°C in winter (more complicated in summer with -15°C at best)
- Temperature is regulated within +/-0.5°C
- It takes about 20 minutes to go from 20 to -20°C







Noise reduction reduces the " graininess " in the image and therefore to better show the useful signal

Autoguiding control: addition of dedicated optics and camera

- Reminder of autoguiding: allows you to be "locked" on a star by overcoming the mechanical games of sidereal tracking of the mount
- Allows long pause photography with “perfect” sidereal tracking => sharp image
- Addition of an optical divider on the optical axis (return via a prism)
- Added a monochrome guide camera on the prism return
- You need an undistorted optical field on the edges (Newton => coma corrector)
- 2nd solution but heavier payload: addition of a refractor mounted in parallel with the imager (=> field flattener)







In addition to tracking sidereal , autoguiding allow to have even finer stars and therefore an object of the sky deep less blur

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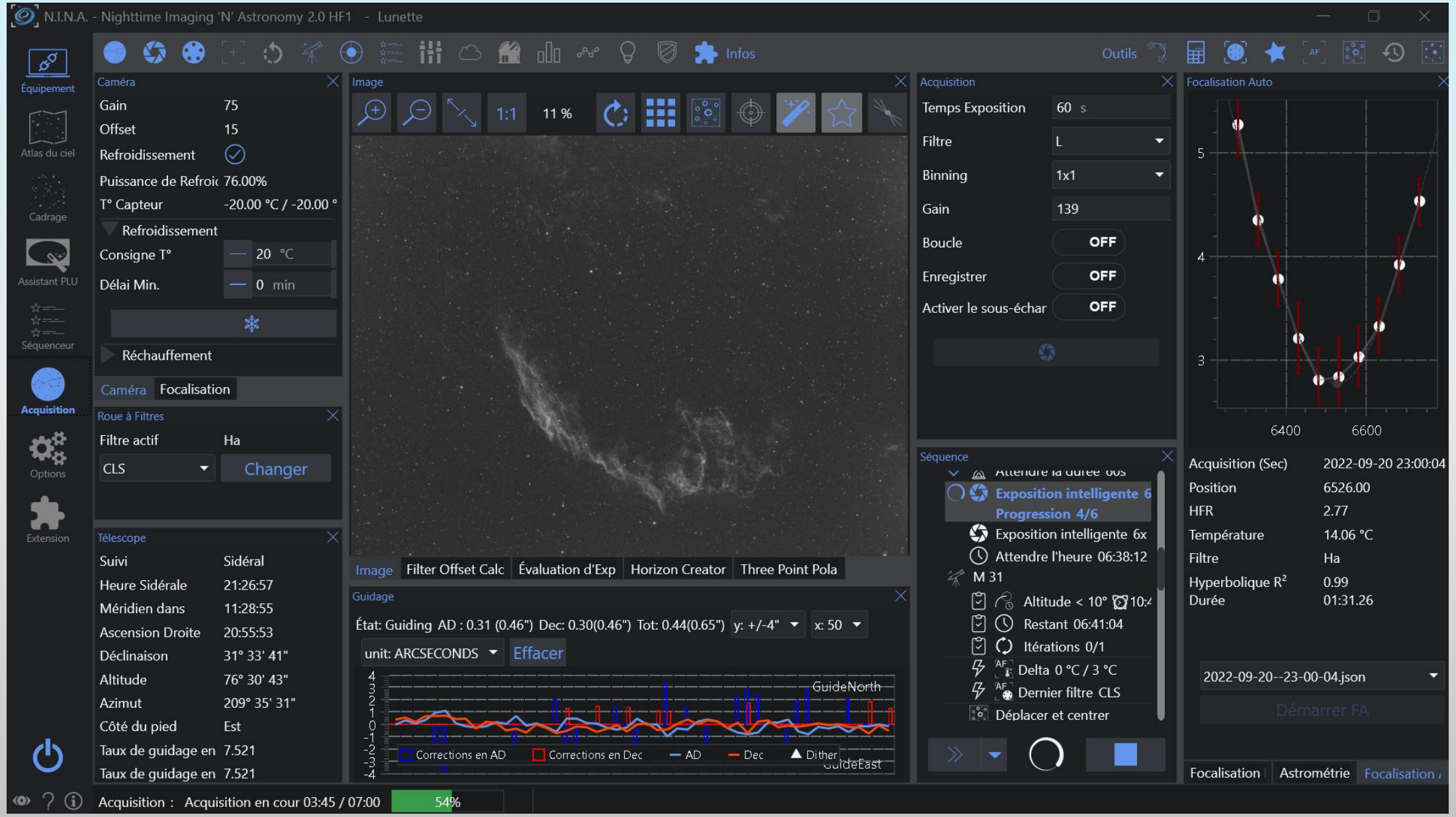
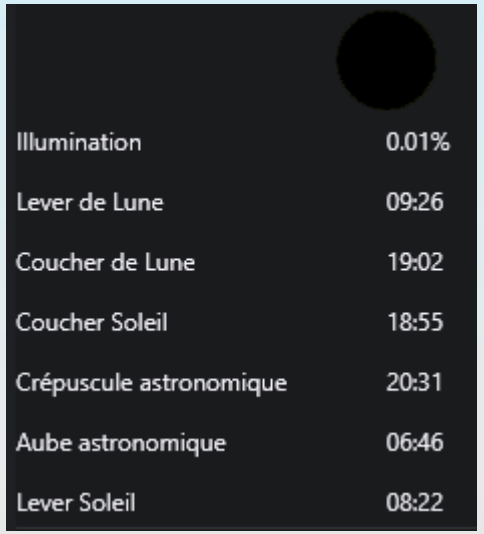
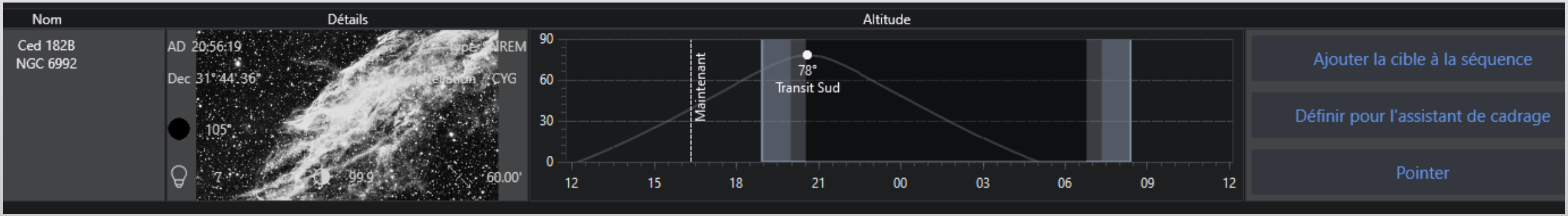
Presentation of the NINA tool (Nighttime Imaging 'N' Astronomy)



Using the integrated sky atlas

- Astronomical dusk and dawn times
- Moon visibility time range (to avoid!)
- Time of crossing the meridian => better visibility of the object
- Height of the object (complicated if too low on the horizon)
- Apparent size => choice refractor (wide field) or telescope (small field)
- B&W photo for a quick overview
- Adding the chosen object to the framing tool





Dawn / dusk astronautics : No more sunlight (dark night)
Dawn / dusk nautical : The horizon is hardly discernable
Civil Dawn/ Dusk : Just Sun below the horizon (we are beginning to see)

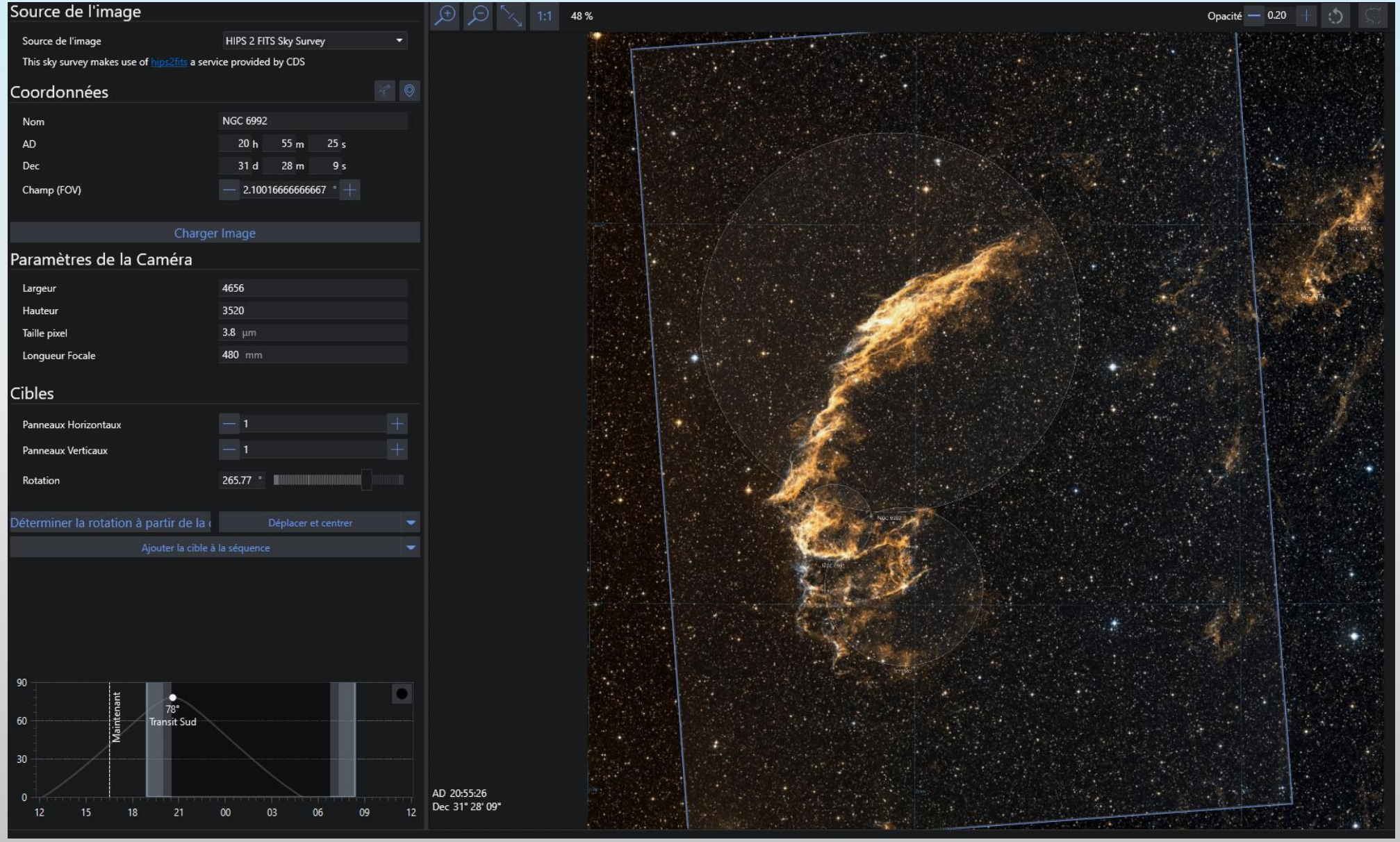
Framing adjustment

- Automatic frame calculation from focal length and camera settings
- Take a long exposure acquisition to determine the stellar coordinates pointed and the rotation of the camera
- Move the frame to choose its framing
- For better framing, an electronic rotator can be added before the camera
- Ability to make mosaics by cutting the target into several takes
- Add the object and its new coordinates to the acquisition plan



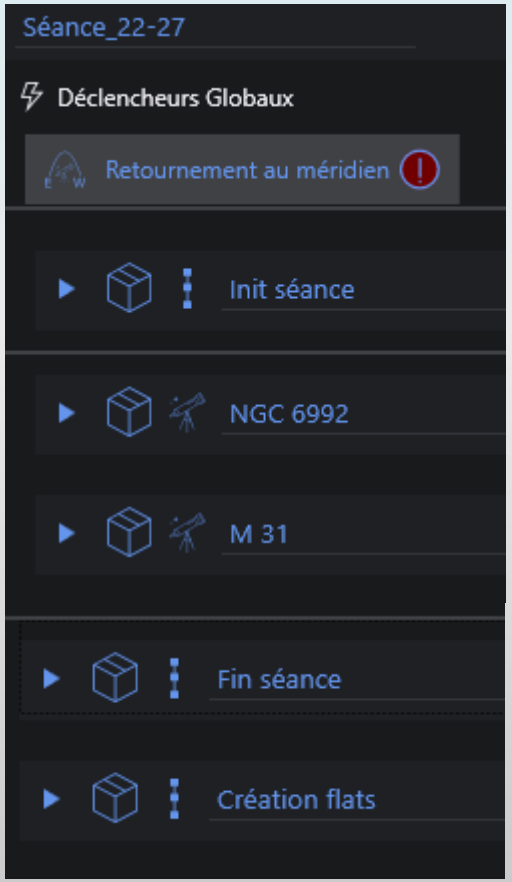


Example of framing adjustment

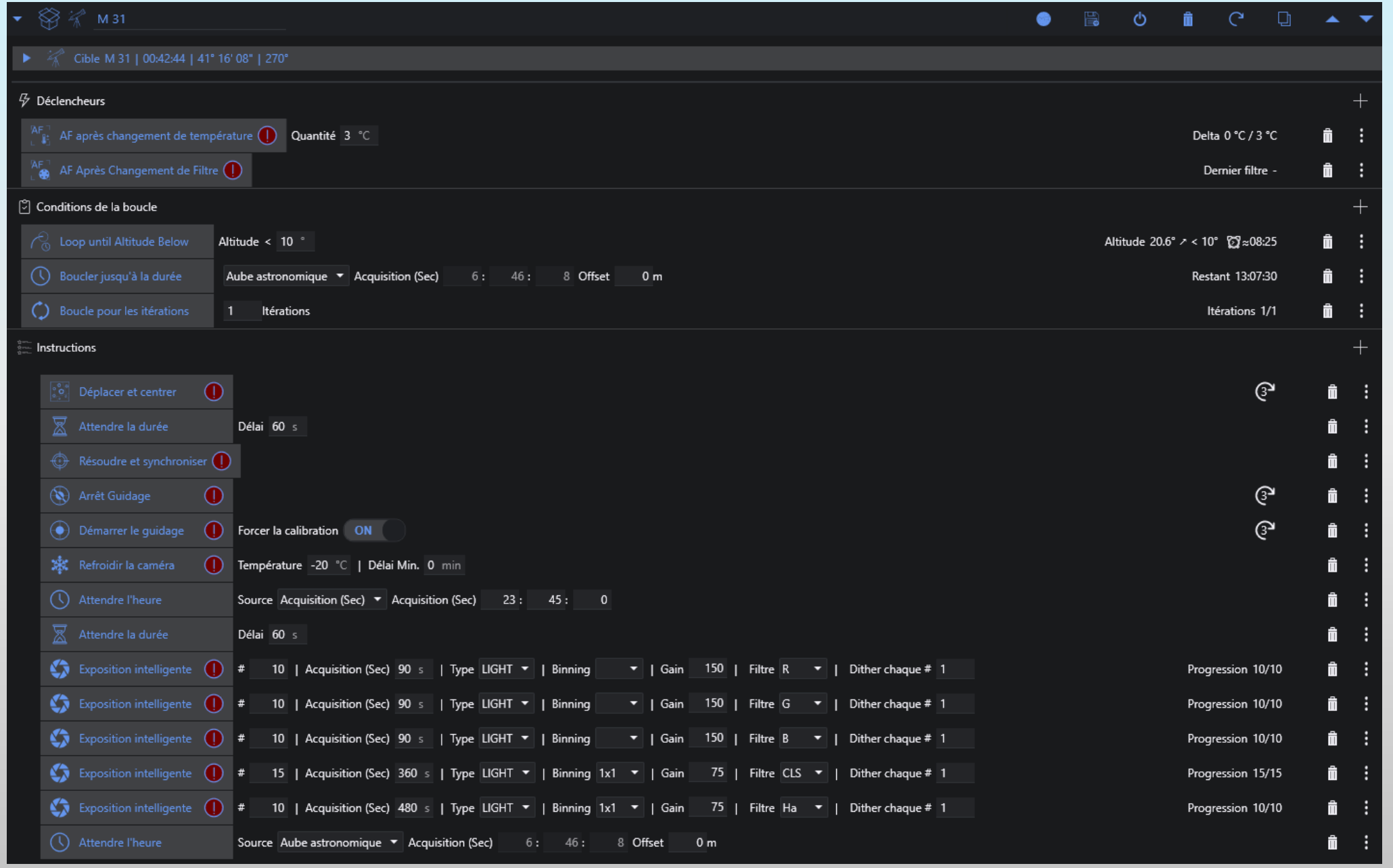


Programming of the acquisition plan (NINA tool)

- Global triggers for all acquisitions:
  - Management of the reversal at the meridian of the equatorial mount
- 4 sections:
  1. Initialization of the session if nautical dusk:
     - Camera cooling to -15 / -20°C
     - Unpark the mount
     - Position the filter used by astrometry (Luminance)
     - Start autofocus
  2. Acquisition of selected targets: See next slide
  3. End of session if astronomical dawn:
     - Stop guidance
     - Park the mount in a safe position
     - Warm up the camera
  4. Creation of flats on manual action
     - Cool the camera
     - Launch acquisitions by filter used
     - Warm up the camera



Example of programming a target (NINA tool)



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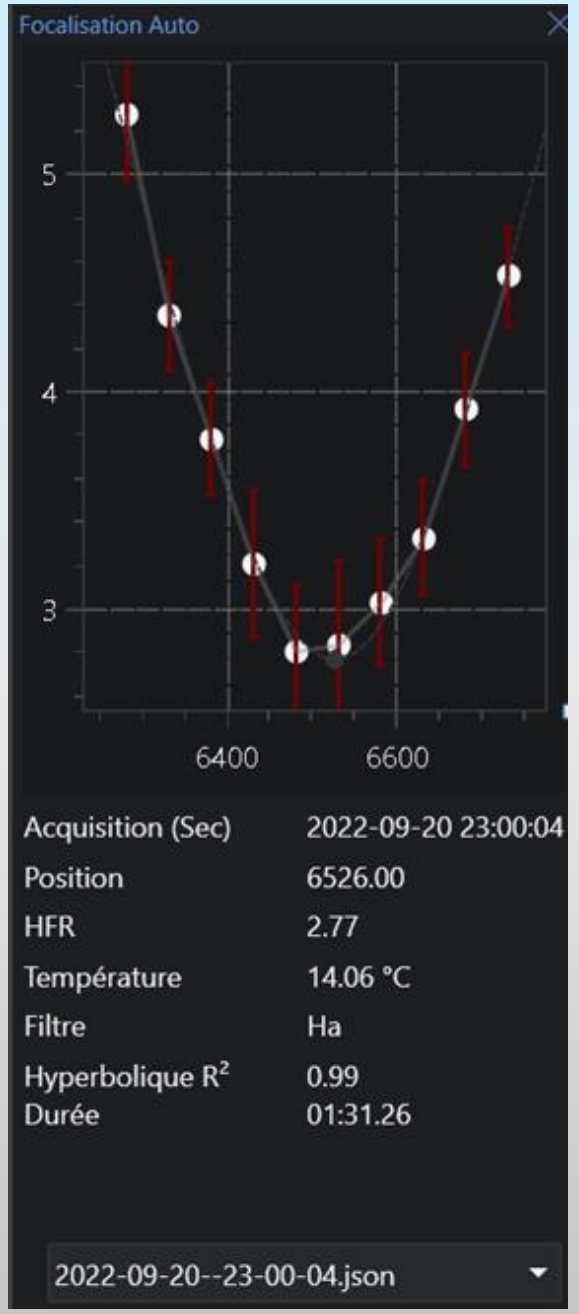
Automation “Reversal at the meridian”

- Characteristic of the equatorial mount:
  - Benefit: Allows you to track a target with single axis and sidereal tracking (RA)
  - Disadvantage: Just before crossing the meridian (South), you have to turn around so as not to break the telescope against the tripod!
- Safeguard: the GS Server application stops tracking 5 minutes after crossing the meridian
- NINA's automated process:
  1. End of monitoring 5 min before crossing the meridian and for 10 min
  2. Displacement + refocusing => reversal of the mount because the target has exceeded the meridian for 5 minutes
  3. Reactivation of tracking + autoguiding
  4. Start of point of focus
  5. Resumption of acquisitions



Automation “Set the point of focus”

- Algorithm that is based on the average "HFR" of the brightest stars in the photo (HFR ⇔ width of the half-diameter of a star in the image)
- Principle: taking 10 photos by varying the position of focus => Parabola HFR = f (position)
- The focus point corresponds to the min HFR on the curve
- Even if the filters are para-focal to each other for the same brand, there is still a lag => advantage of redoing the focus at each filter change in less than 2 minutes
- Possibility of redoing the focus point according to the evolution of the temperature (every +/- 3°C for example)
- json files saved of all the adjustments made

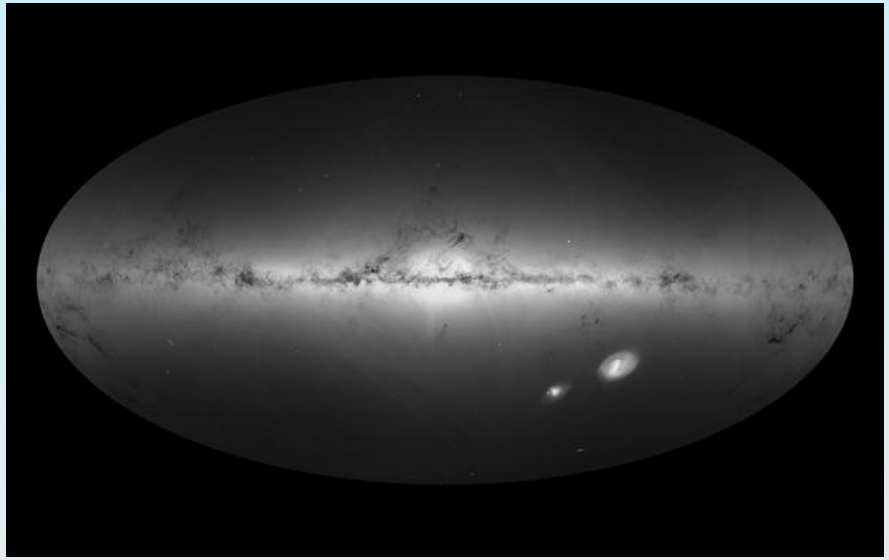


Automation “Move and center”

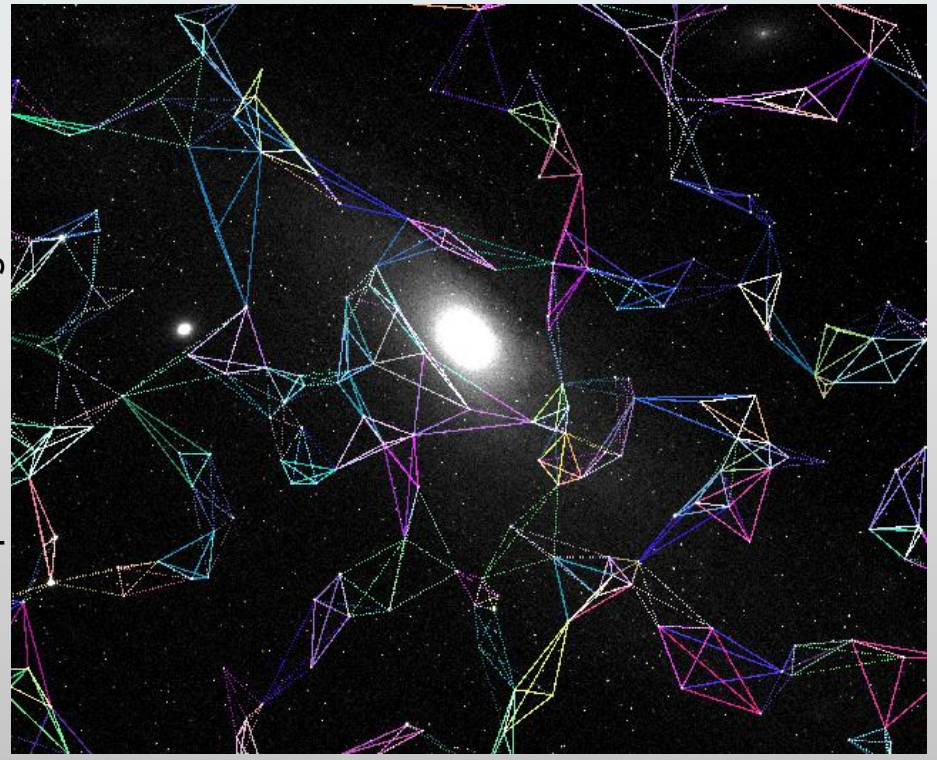
- Prerequisites: set the focal length of the imager and the size of the pixels of the camera

1. Move to the coordinates of the target to acquire (GS Server Application) + 60s pause for stabilization
2. Photo with the "Luminance" filter to have a lot of stars (Pause of 5 s and high gain)
3. Launch of astrometry: compares the position of the stars on the photo with an installed star catalog (with ASTAP application)
4. If offset > 1 arcmin : Offset relative move (Dx,Dy)
5. Launch astrometry to ensure target coordinates are centered

Gaia Star Catalog



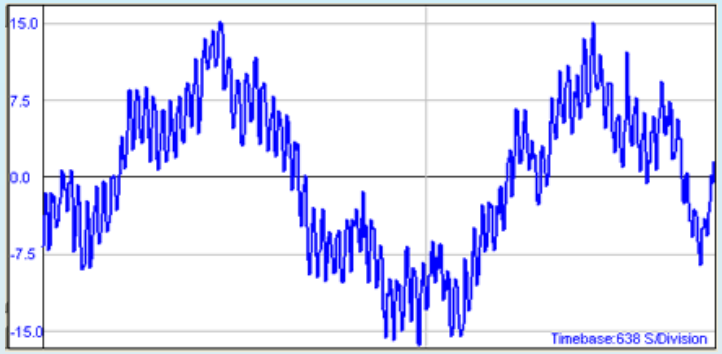
Comparison ASTAP algorithm

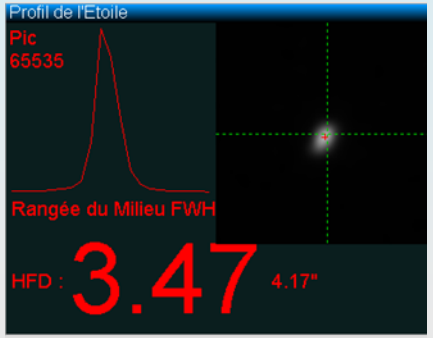


Automation “Autoguiding and Dithering ”

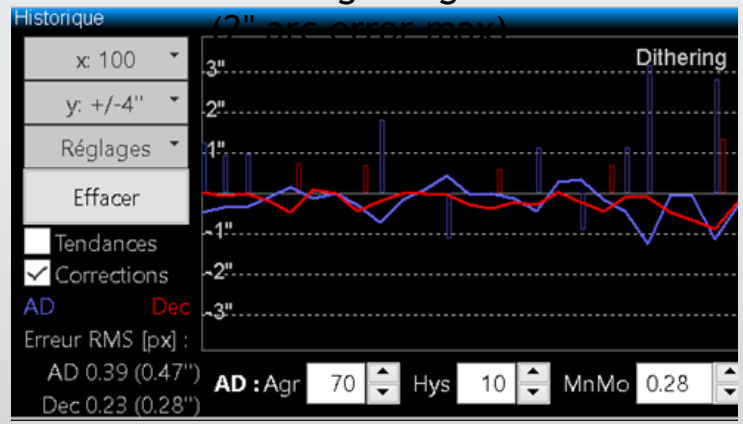
- Principle of autoguiding:
  - Measurement of tracking error / initial position
  - If the monitoring deviates from the tolerance threshold => sending orders to the mount in + or -
  - If the error is below the tolerance threshold => stop sending guidance commands
- Principle of dithering :
  - Avoid superimposing frame on the addition of photos during preprocessing
  - Random offset of the mount by a few pixels between each photo
- Autoguiding and dithering management with the PHD2 application

Sidereal tracking only => (periodic error of 15" arc)





Sidereal tracking with autoguiding (2" arc error max)



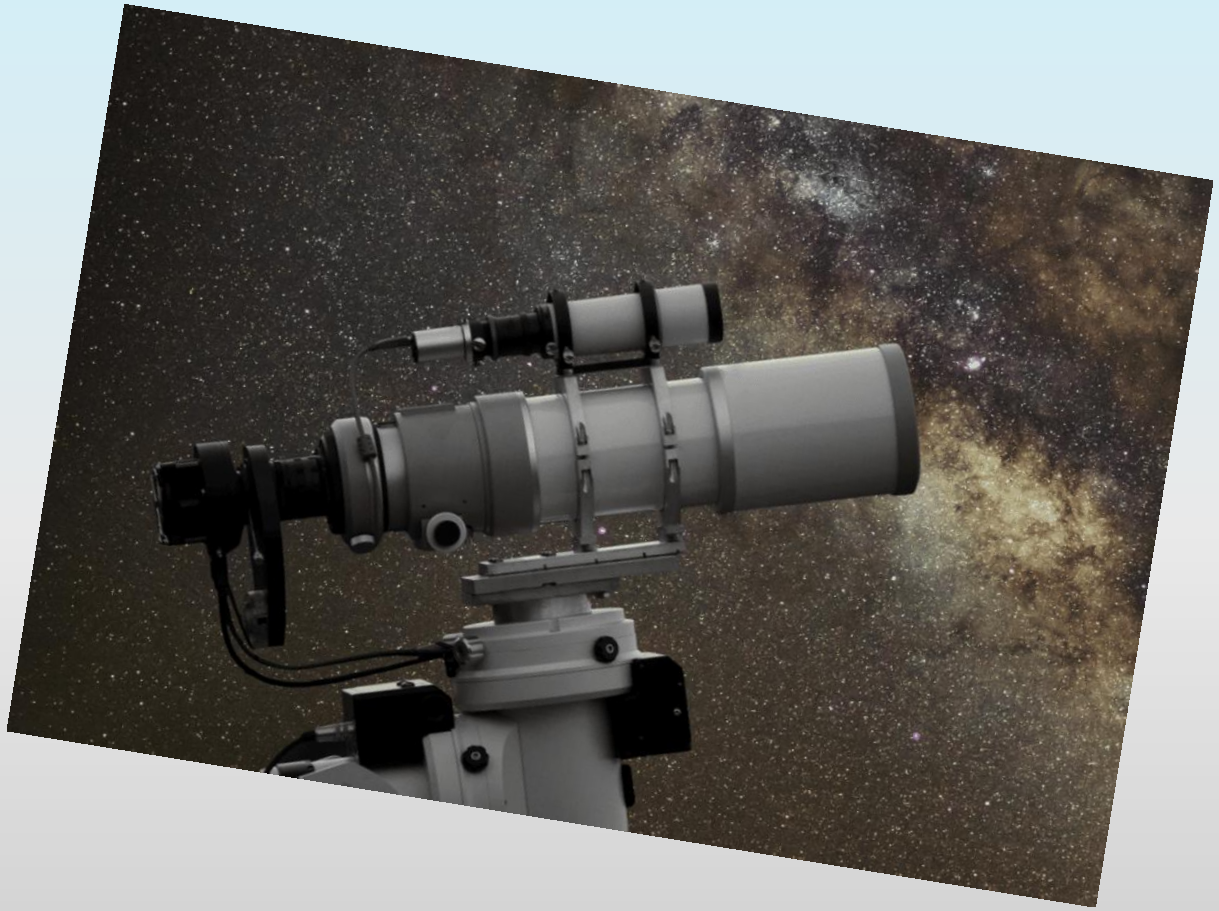
Without dithering =>



With dithering =>



Launch of the acquisition plan (NINA tool)





We can now sleep on our 2 ears ...

… hoping than the weather rest lenient !

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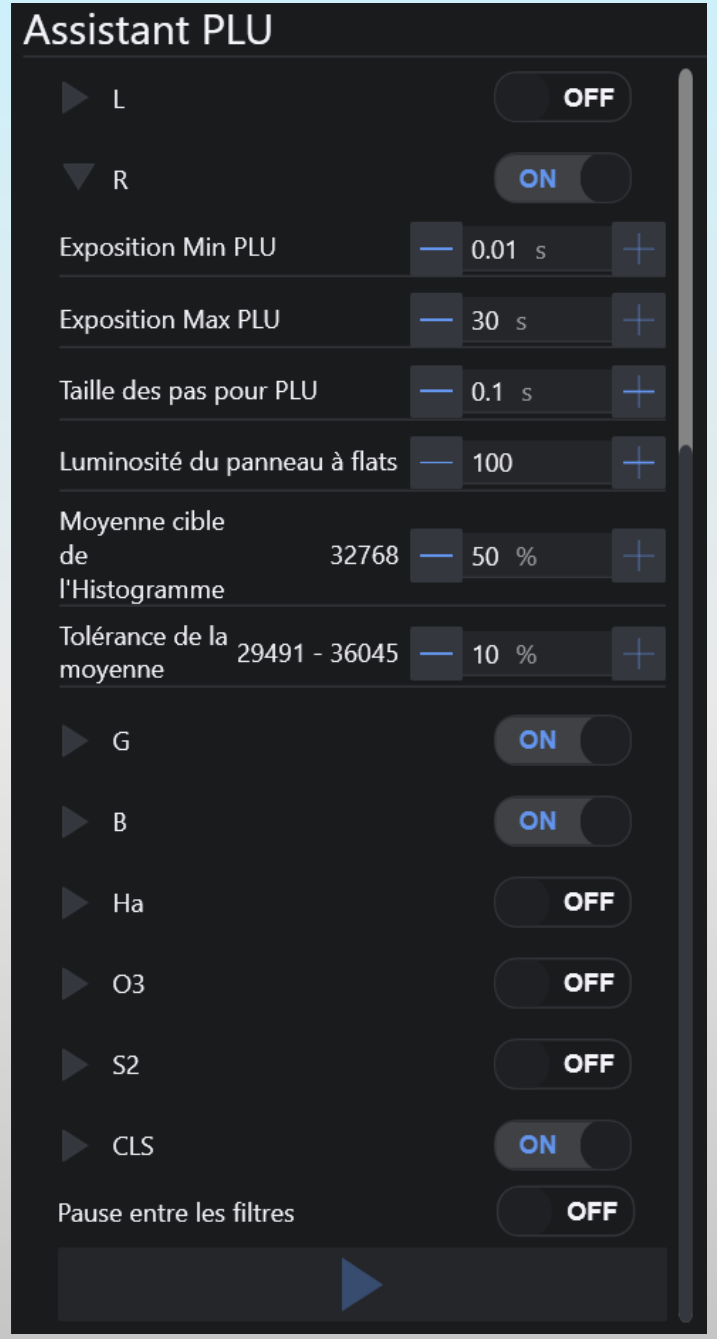
Creation of “flats” calibration images

- The “flats” make it possible to remove vignetting as well as dust in the image
- Needs a neutral, evenly distributed light source
- Use of a flats box: automatic variation of several LEDs in order to have a histogram filled to 2/3
- Each filter must have its own flat
- You have to take several photos per filter to create a “master flat” for pre-processing
- The focus must not have moved since the end of the acquisitions



Flat Calibration

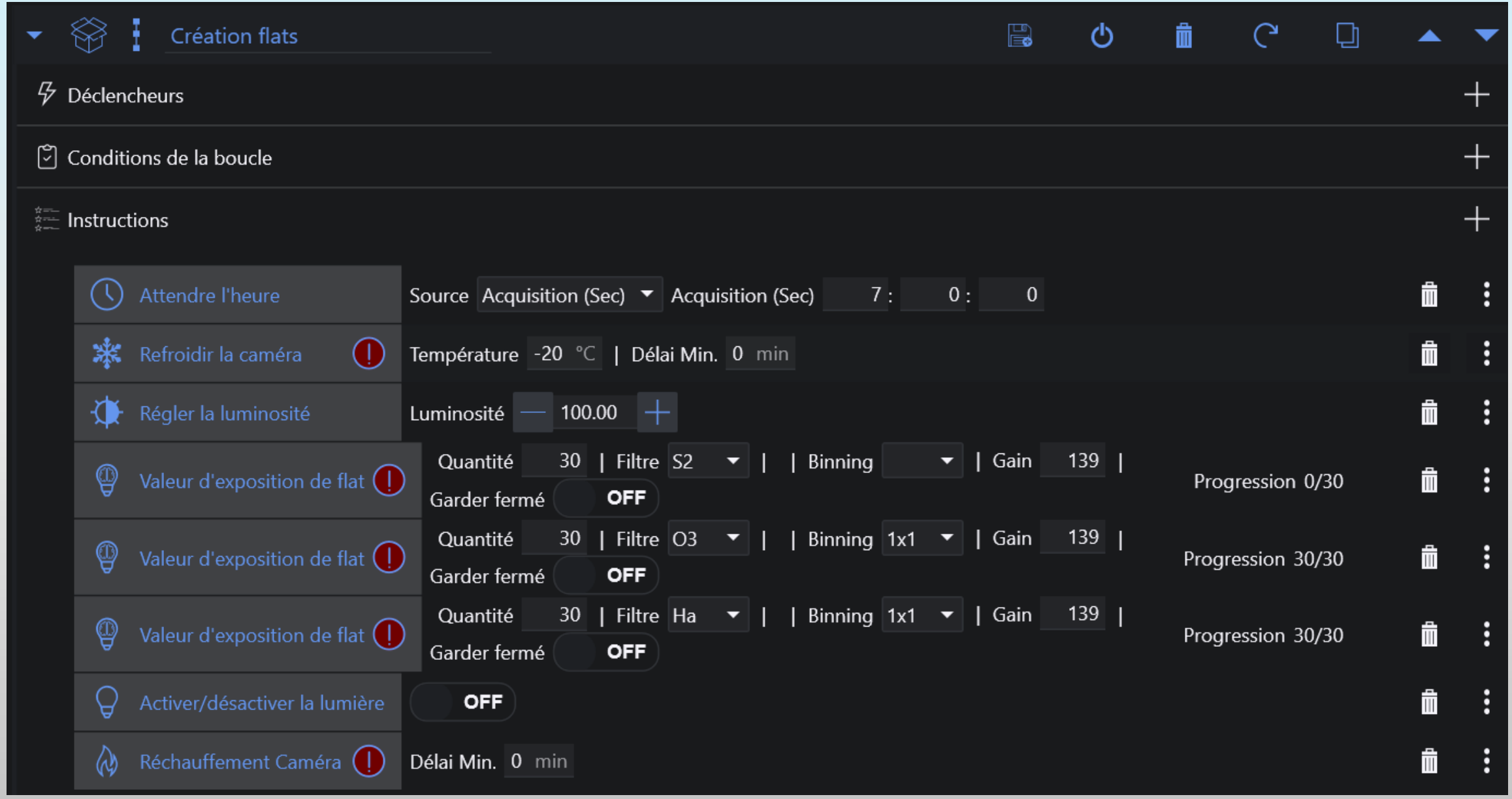
- Obtain flats that are neither too dark nor too light
- Find the best exposure time based on light conditions
- Automatic calculation of exposure time for each filter
- Auto saving of values for the programming flats
- Example: exposure time = 0.76s for the CLS filter



Binning 1x1	
Filtre	Gain 75
L	-
R	-
G	-
B	-
Ha	-
O3	-
S2	-
CLS	0.76s @ 100

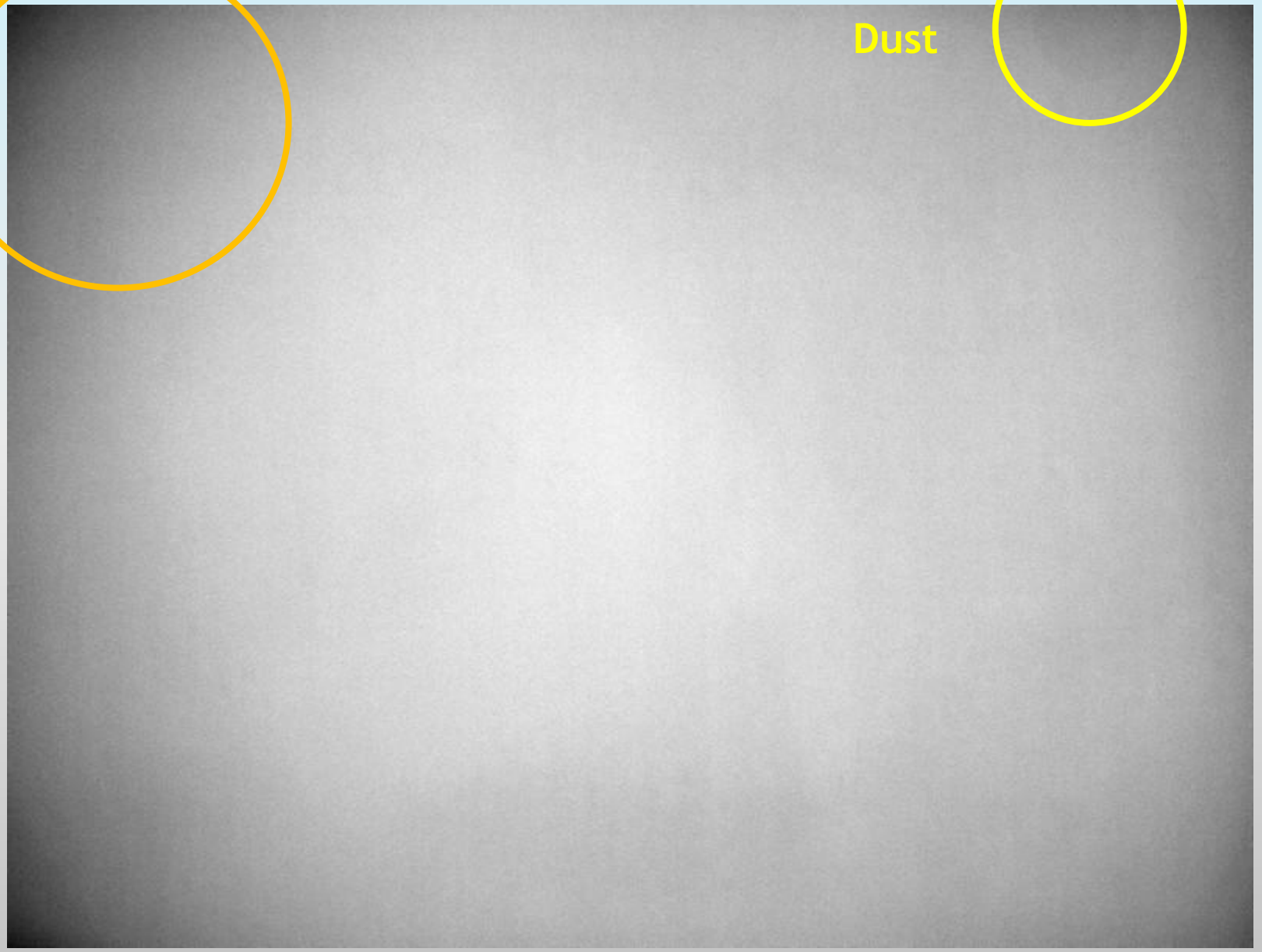
Binning 2x2	
Filtre	Gain 75
L	-
R	1.04s @ 100
G	0.78s @ 100
B	1.20s @ 100
Ha	-
O3	-
S2	-
CLS	-

Programming flats



Example of flats

Vignetting: darker area at the edge of the field



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Sorting raw images

- Each brute must be reviewed in order to eliminate those with defects:
  - Airplane or satellite contrail
  - Partly cloudy
  - Tracking issue



Example of raw acquired with the luminance filter (M20)



Example of raw acquired with the Red filter(M20)



Example of raw acquired with the green filter (M20)



Example of raw acquired with the blue filter(M20)



Example of raw acquired with the H-Alpha filter(M20)



Example of a preprocessed image in three colors « RGB » (M20)



Example of raw acquired with the H-Alpha filter(M17)



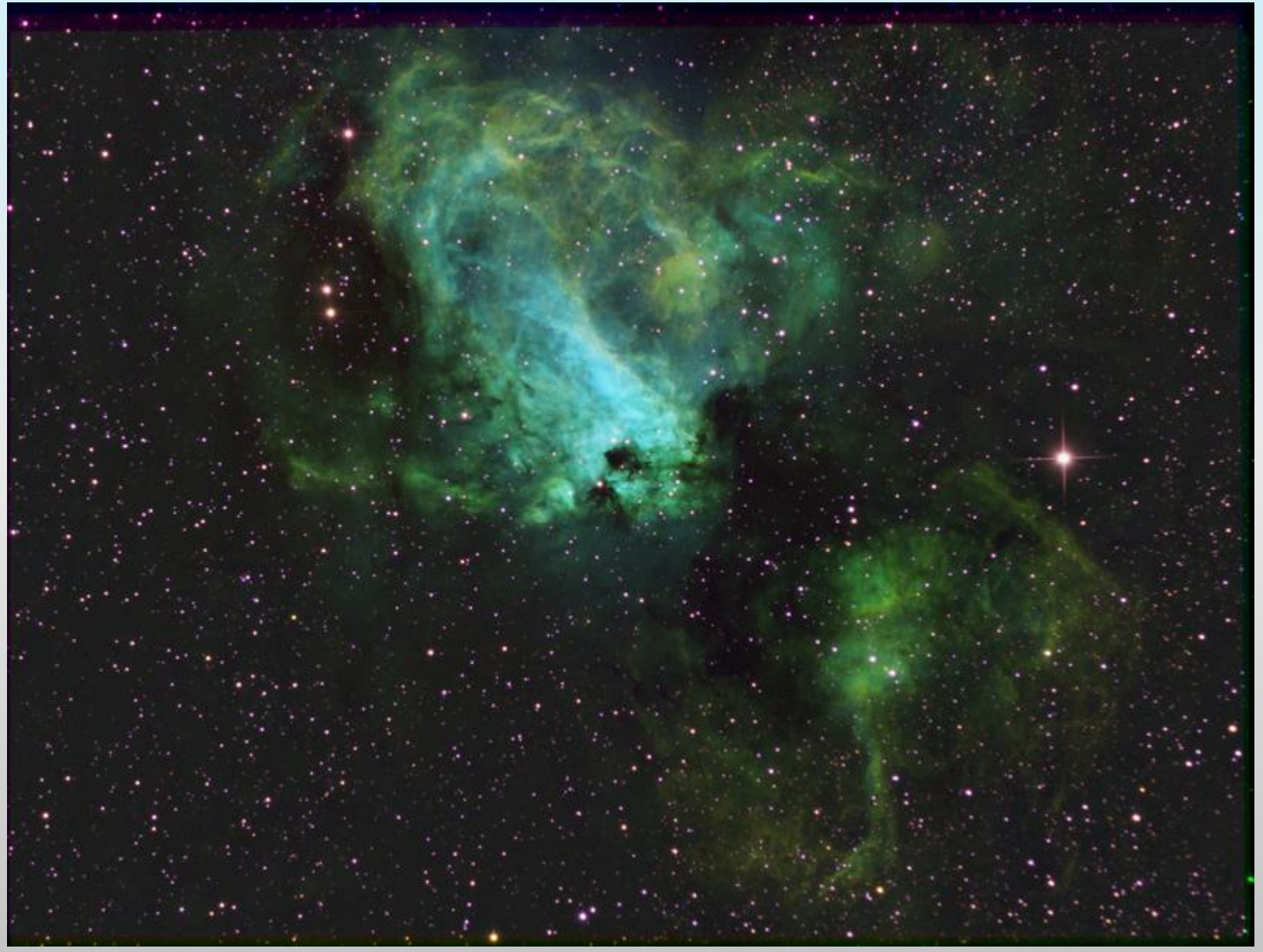
Example of raw acquired with the O3 filter (M17)



Example of raw acquired with the S2 filter(M17)



Example of a preprocessed image in three colors « SHO » (M17)



Next presentation: automated preprocessing



1 raw image (S2 filter, 180s)



20 pre-processed and summed raw images (S2 filter, 180s)

More details on my personal website…

https://www.astro-photo.fr





Some pictures …

https://www.astrobin.com/users/olivierr31