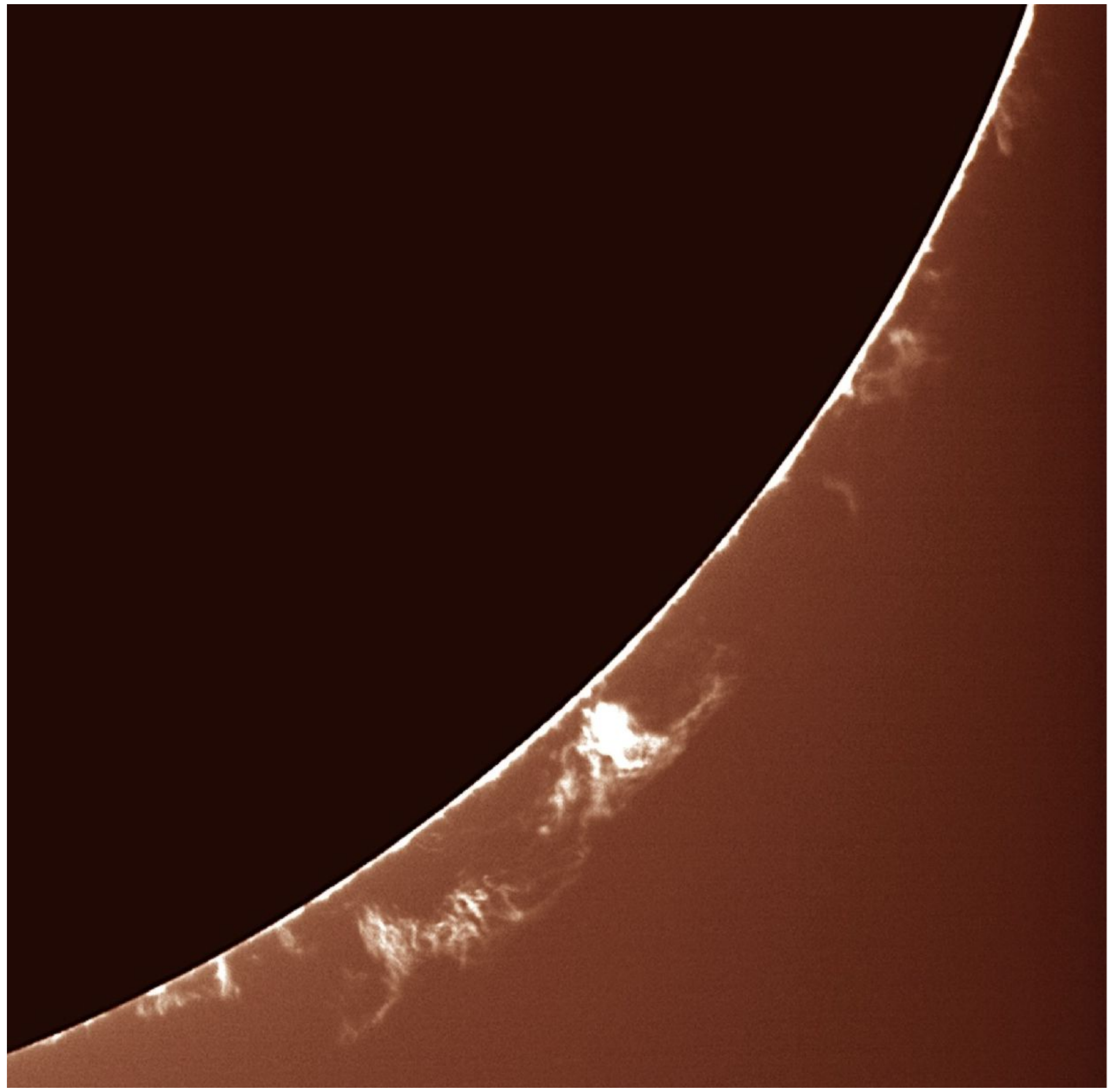
Sol'Ex setting instructions

The Solar Explorer

This document is based on the Azur3DPrint V2 mechanical kit
https://www.azur3dprint.fr/

Optical elements from Shelyak (compatible with mechanical versions 1 and 2)
https://www.shelyak.com



Sol'Ex

http://www.astrosurf.com/solex/

Révision 1.2 - November 14, 2023

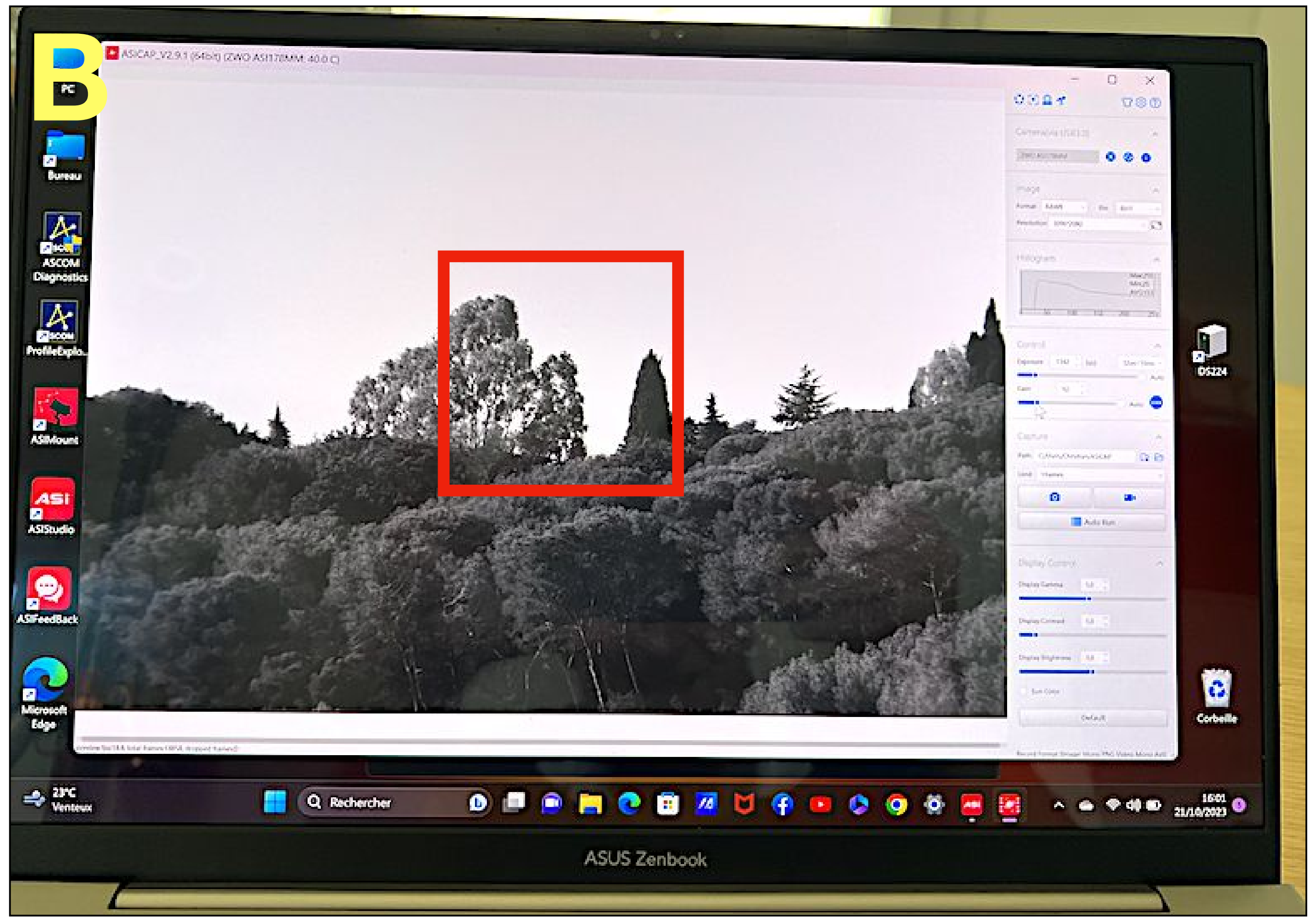
STEP #1

A - We use Sol'Ex's camera lens tube as a small telescope, 25 mm in diameter and 125 mm in focal length, already fitted with a camera. Together, they form a set of tools to help set up Sol'Ex.

B - We'll need a support to point the camera at the scene in a stable manner. A photo tripod and the ring provided in the mechanical kit perform this function. The ring has a Kodak threaded hole.

C - The lens barrel mounted on its support. All components must be supported without play.

D - It must be possible to aim at a distant object, one kilometer or more away. The electronic image is displayed on a computer screen. There is a choice of camera reading software, such as ASICap (as shown here), SharpCap, FireCapture...



STEP #2

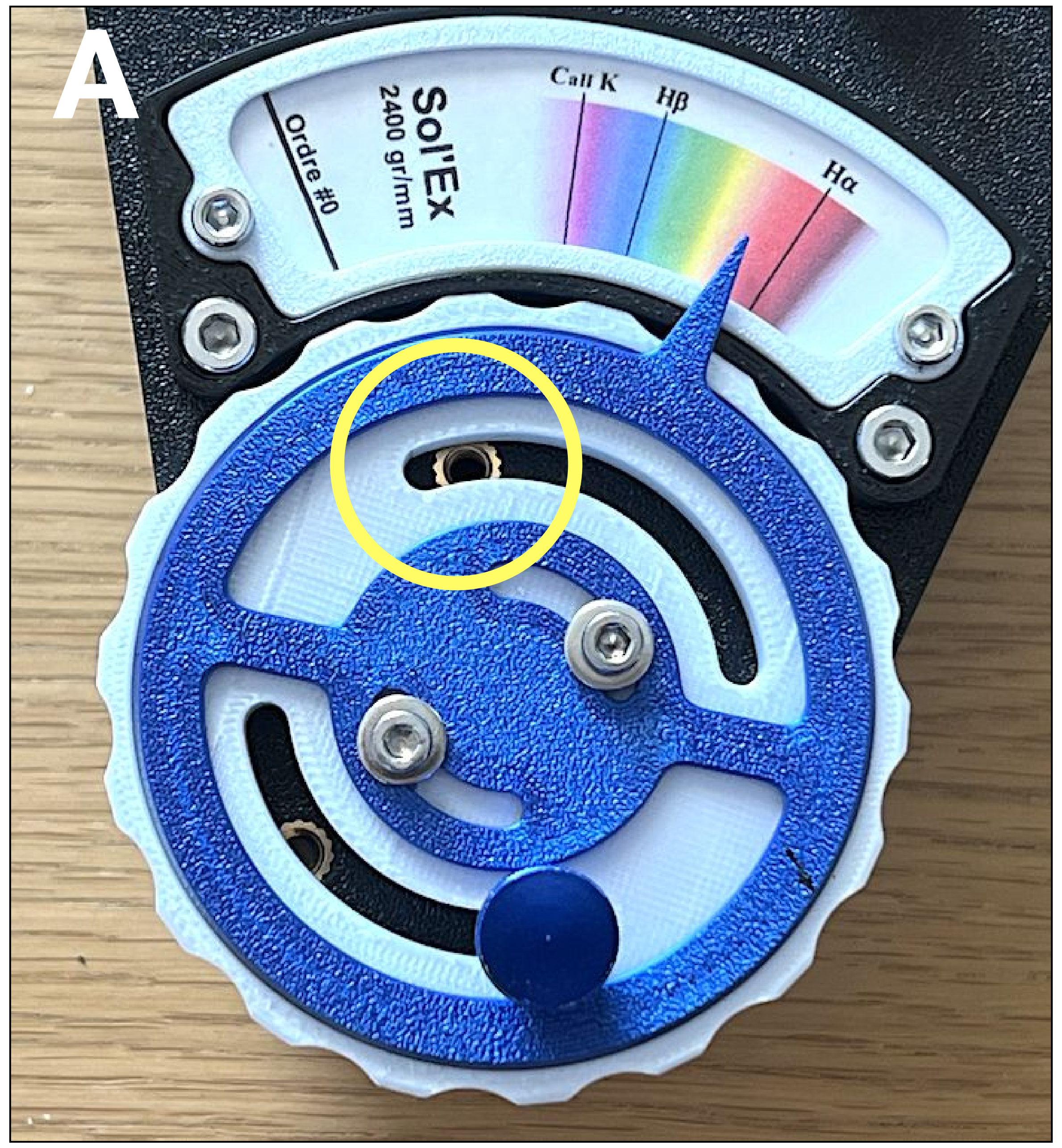
A - Use the focusing ring on the helical focusing system to obtain a sharp image.

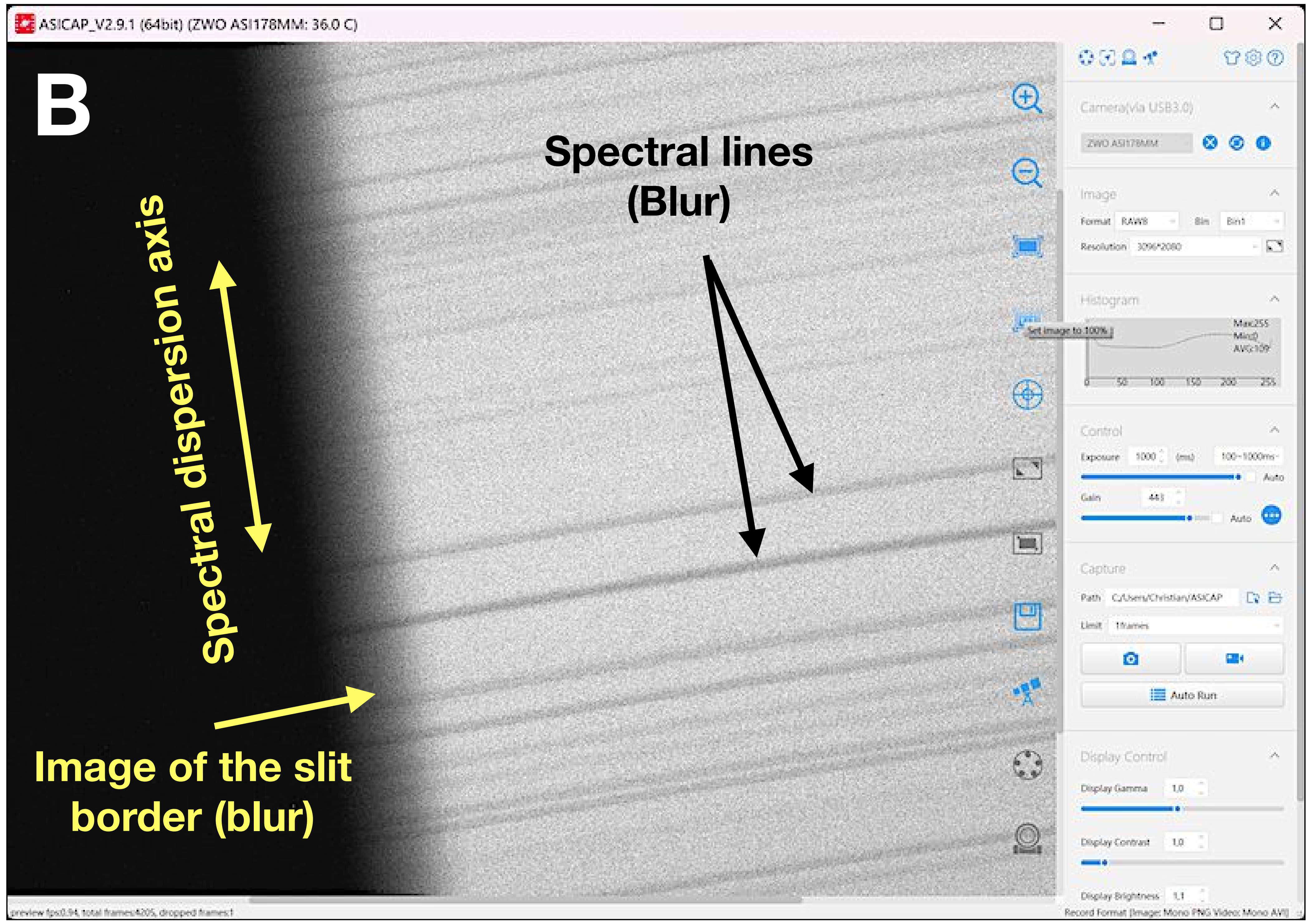
B - In this image, focus on the sharpness of the center (the red square). The edges may be blurred, so don't worry about them (field aberrations).

Focusing sensitivity is approximately 1/10 of a millimeter (one graduation on the ZWO helical system). When the image is in focus, tighten the helical system's locking screw.

C - Accuracy is improved by observing through a filter that blocks the infrared radiation to which the camera is sensitive. A 1”1/4 inch filter is suitable.

D - This filter is housed in the tooling tube and held in place by a side screw. Don't worry too much if you don't have such a filter, as our tooling is only used for presetting, as we'll see later.





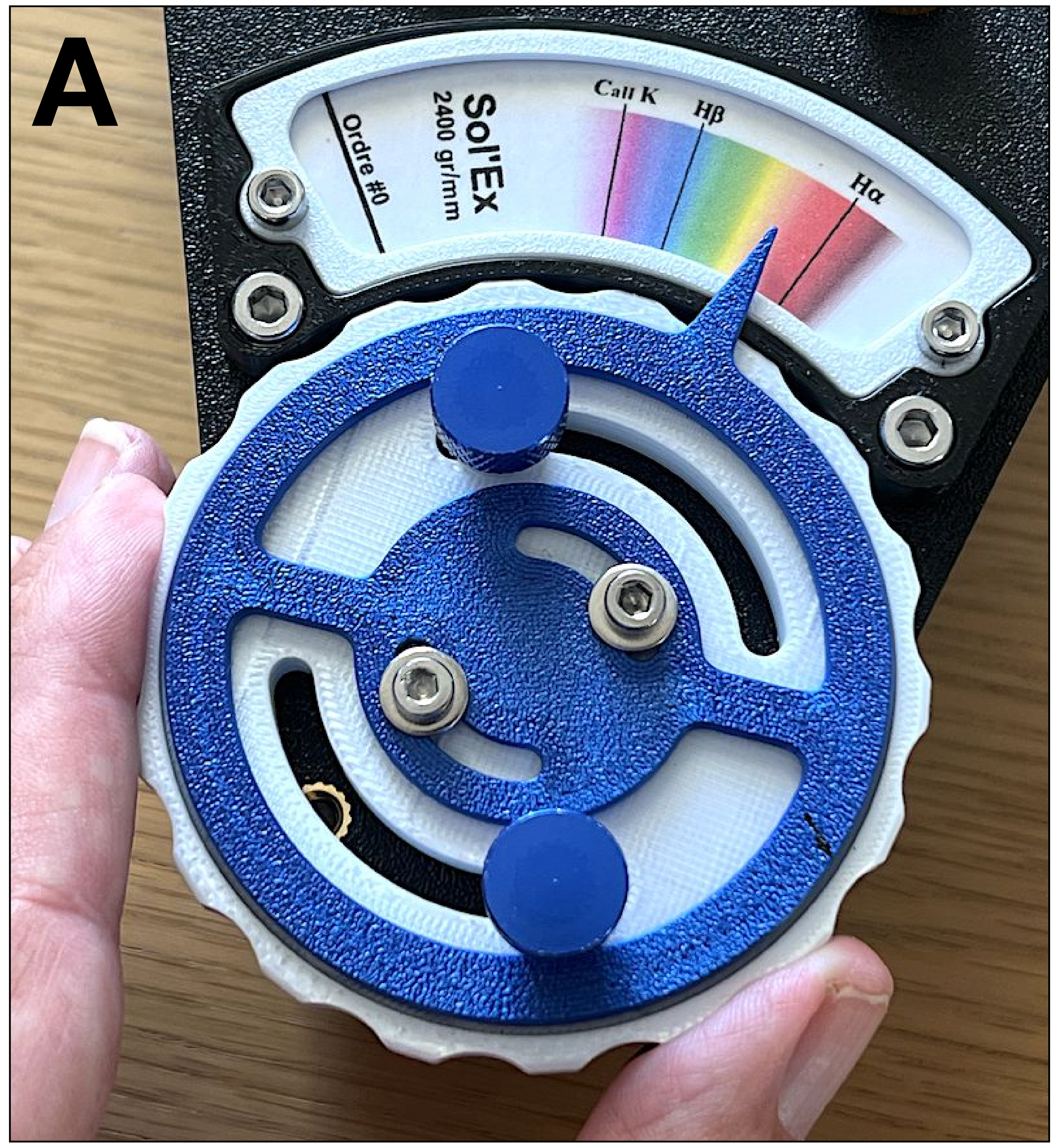
STEP #3

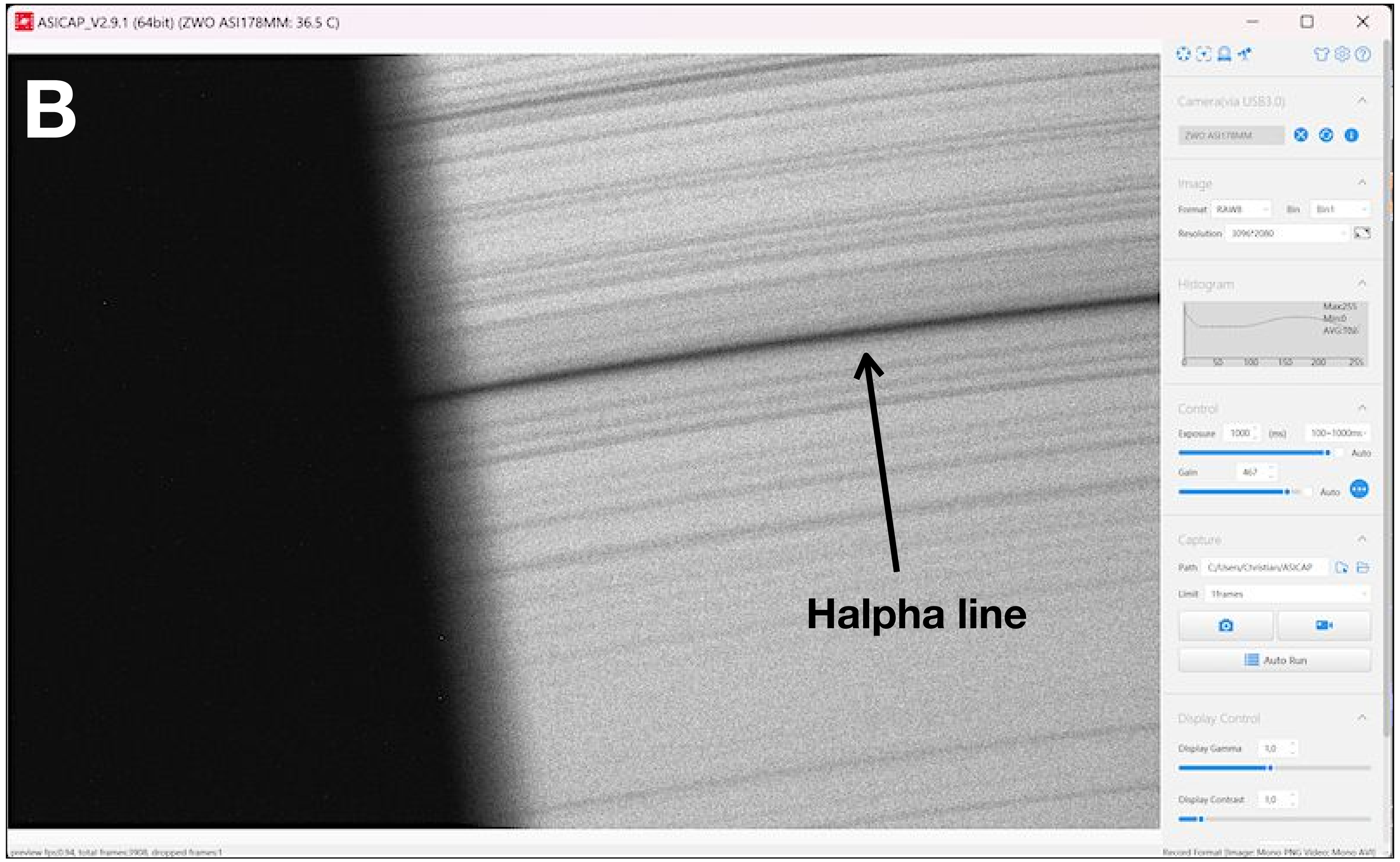
A - Reassemble the objective tube as set in the previous step. Next, observe the solar daylight spectrum, in particular the red region around the Halpha (hydrogen) line.

We look for this line in a highly resolved spectrum, showing only a small spectral interval. It's not easy without a method. Here's a tip: remove one of the screws securing the Sol'Ex handle (see yellow circle), leave the remaining screw slightly depressed, then rotate the circular handle on the grating to reproduce the position shown in the figure as closely as possible. The Halpha line should not be far from the spectral field picked up by your detector. Replace the screw loosely. Pay no attention to the wavelength index (blue here), which is not set at this stage.

B - During the day, point the Sol'Ex entrance towards the blue sky or cloudy sky, whatever the case may be, through a window, while you are comfortably seated in a room (comfort is important here). Make looped images acquisition with a typical exposure time of 1 to 2 seconds and a camera gain of 300 to 400.

You're bound to get something like the image shown in the example: blurred spectrum, everything crooked, no recognizable Halpha line... there's work to be done!



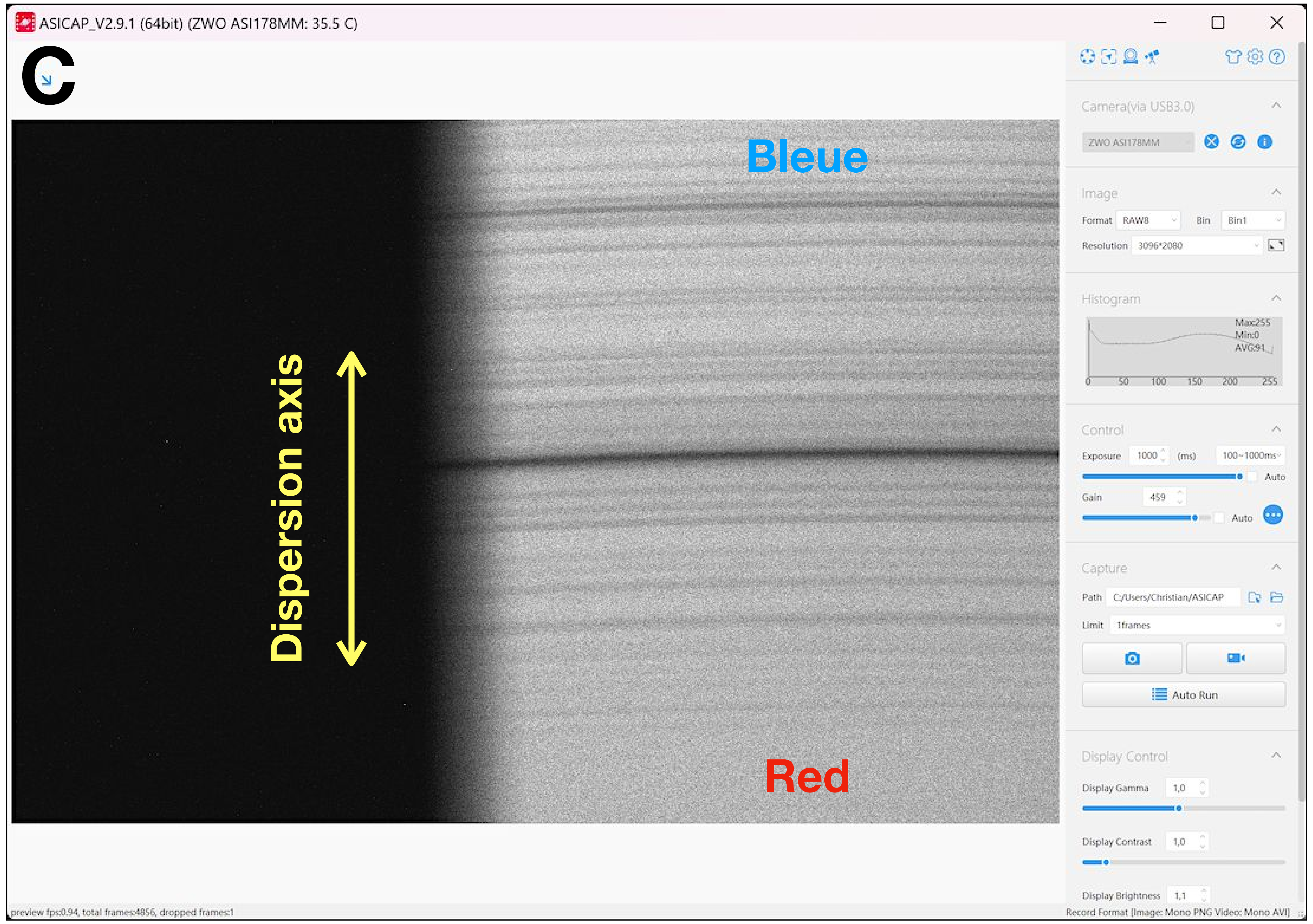


STEP #4

A - Starting from the position previously adjusted with the eye of the grating lever, turn the wheel on either side of it, making a continuous acquisition. Proceed in very small steps, of around 0.2° (a little dexterity is required, but you'll soon get the hang of it).

B - The line you're looking for eventually appears: it's the only one that's quite dark in this part of the spectrum, and isolated.

It's advisable to view the entire image area captured by the sensor when searching for the Halpha line. If necessary, use 2x2 binning.



STEP #5

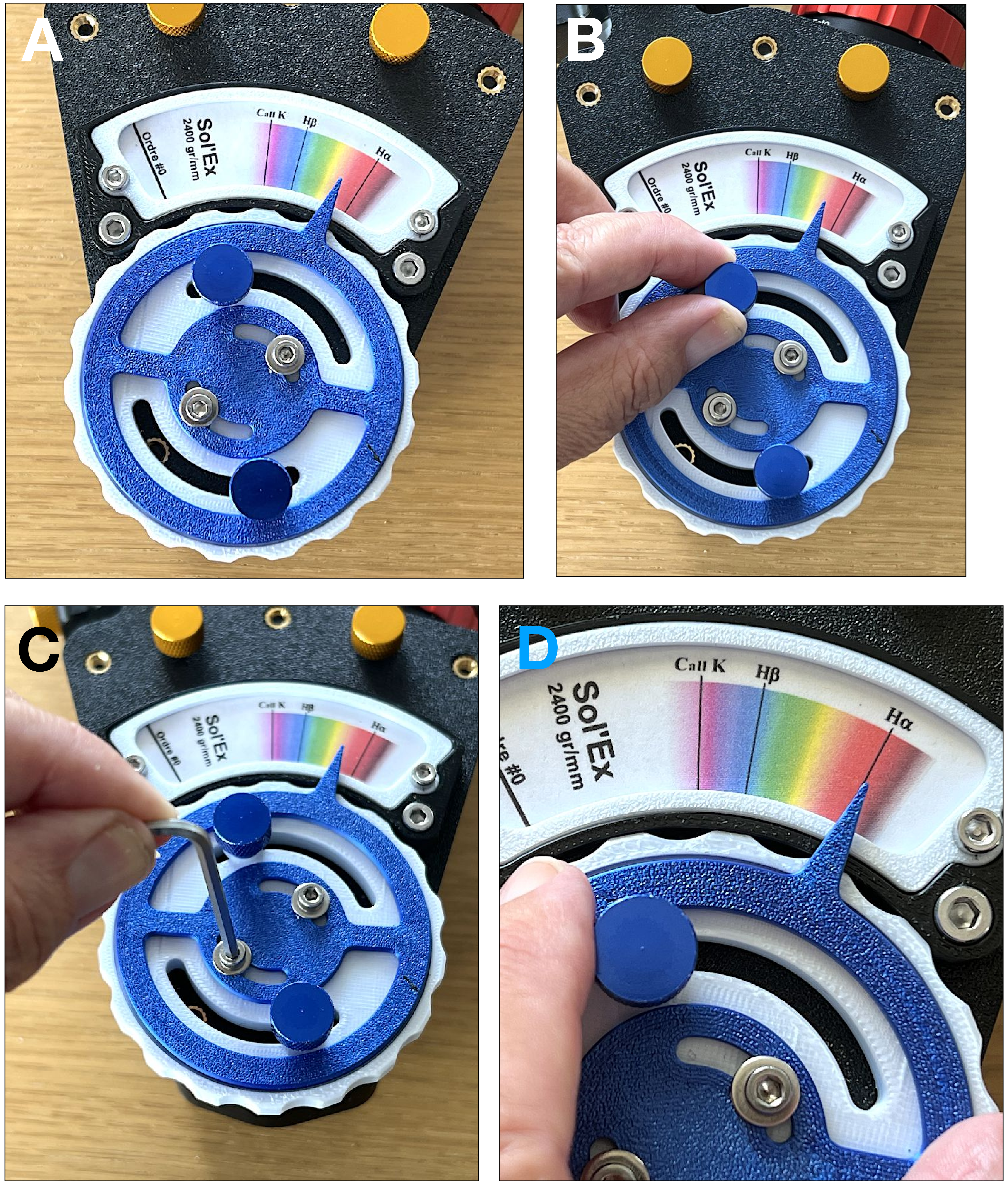
A - We need to make the spectral dispersion axis vertical. To do this, we need to change the orientation of the acquisition camera around its axis. Slightly loosen the two screws of the helical focusing system.

Note: the choice of a vertical dispersion direction is not natural in spectrography (it's usually horizontal). This initiative results in an ROI ("Region Of Interest") that is wider than high enough to isolate a spectral line, which accelerates the reading speed of CMOS sensors (a particularity of their internal architecture).

B - Turn the camera by sliding it over the 1”1/4 interface and watch what happens on the computer screen (work in continuous mode).

C - When the dispersion axis appears vertical (don't look for very high precision at this stage), tighten the two locking screws on the helicoid.

Note: the same result can be obtained by turning the camera through 180° (half a turn). We recommend choosing the configuration shown in the image. The lines are curved (internal distortion of the spectrograph, classic for this type of device) and their concavity is turned downwards. In this way, the blue part of the spectrum is at the top of the image (short wavelengths) and the red part at the bottom (long wavelengths).



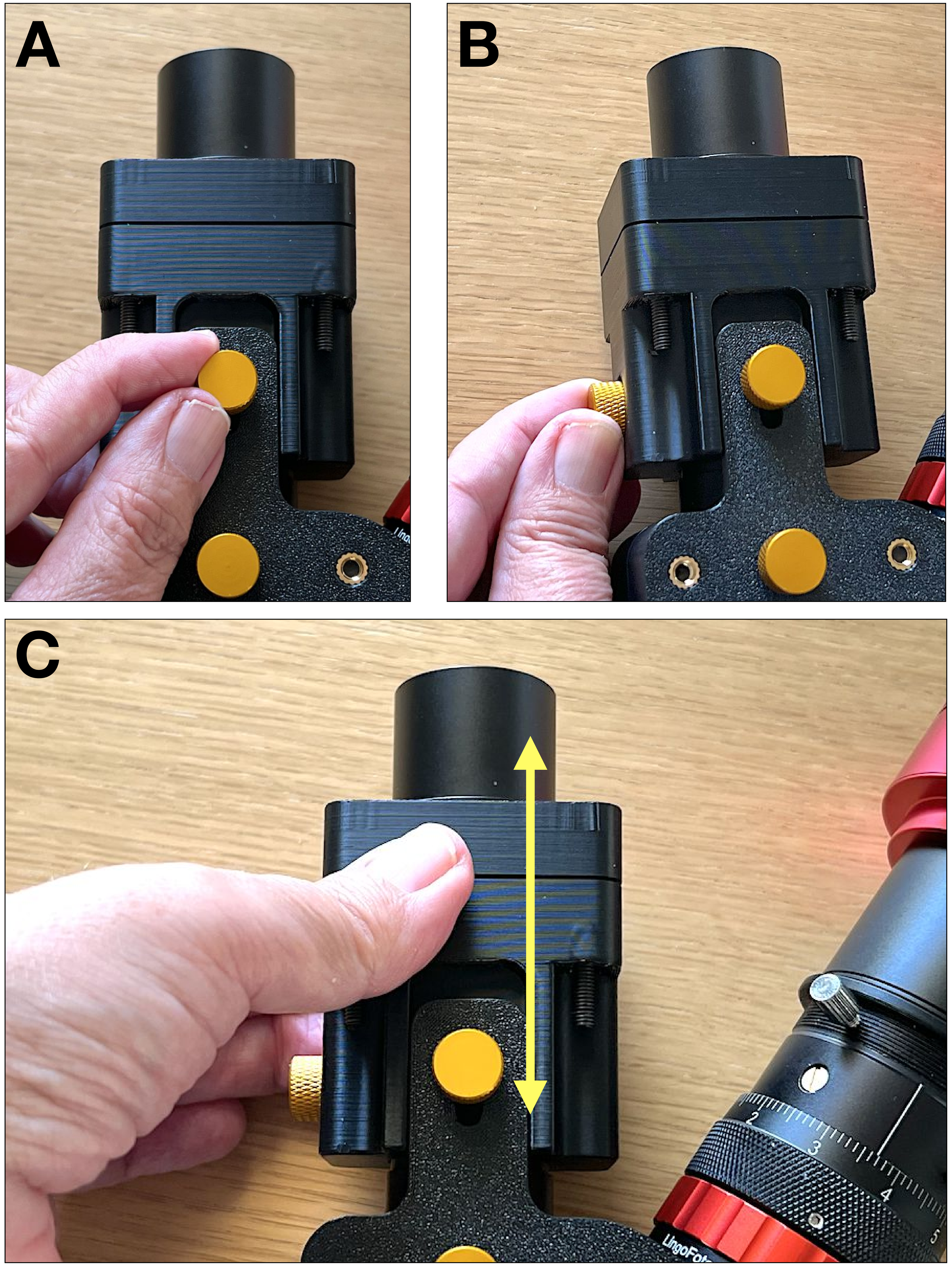
STEP #6

A - With the Halpha line approximately at the center of our image, let's take the opportunity to adjust the index system attached to the Sol'Ex wheel. At this stage, the index does not indicate the position of the Halpha line - this is normal, as it is not adjusted.

B - Tighten the two locking screws (knurled screws).

C - Slightly loosen the two M3 screws holding the index ring (in blue on the Sol'Ex used).

D - Position the index in front of the Halpha marker, then tighten the two M3 screws. The operation is now complete.



STEP #7

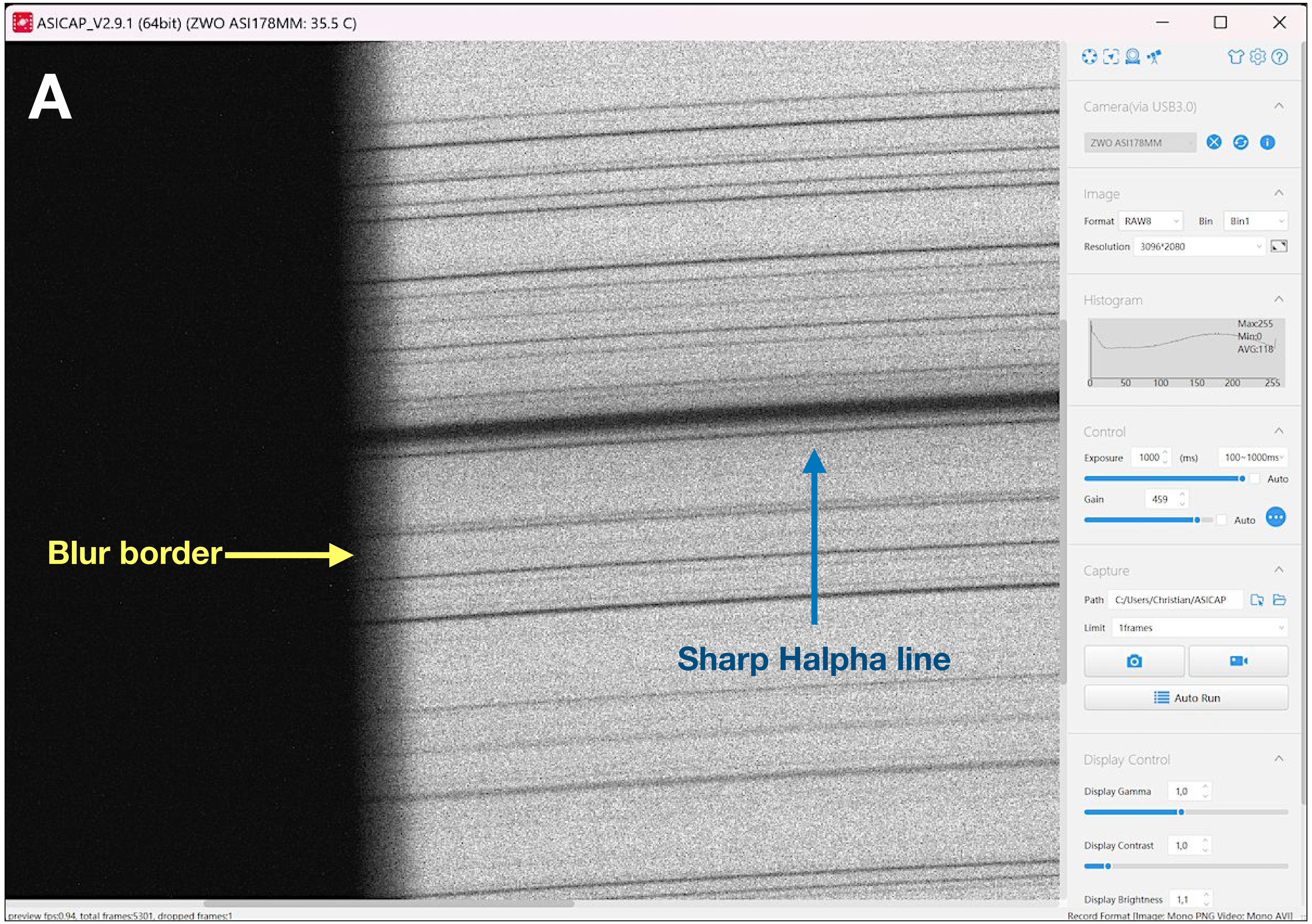
A - Slightly loosen the three knurled screws that prevent the collimator block from sliding on its guide rail.

B - Don't forget the side sight.

C: You can now freely move the collimator block back and forth.

Note: during this movement, the collimator lens does not move, as it is attached to the main body. Instead, the slit moves forwards and backwards.

Moving the slit therefore adjusts the distance between the slit and the collimator lens.



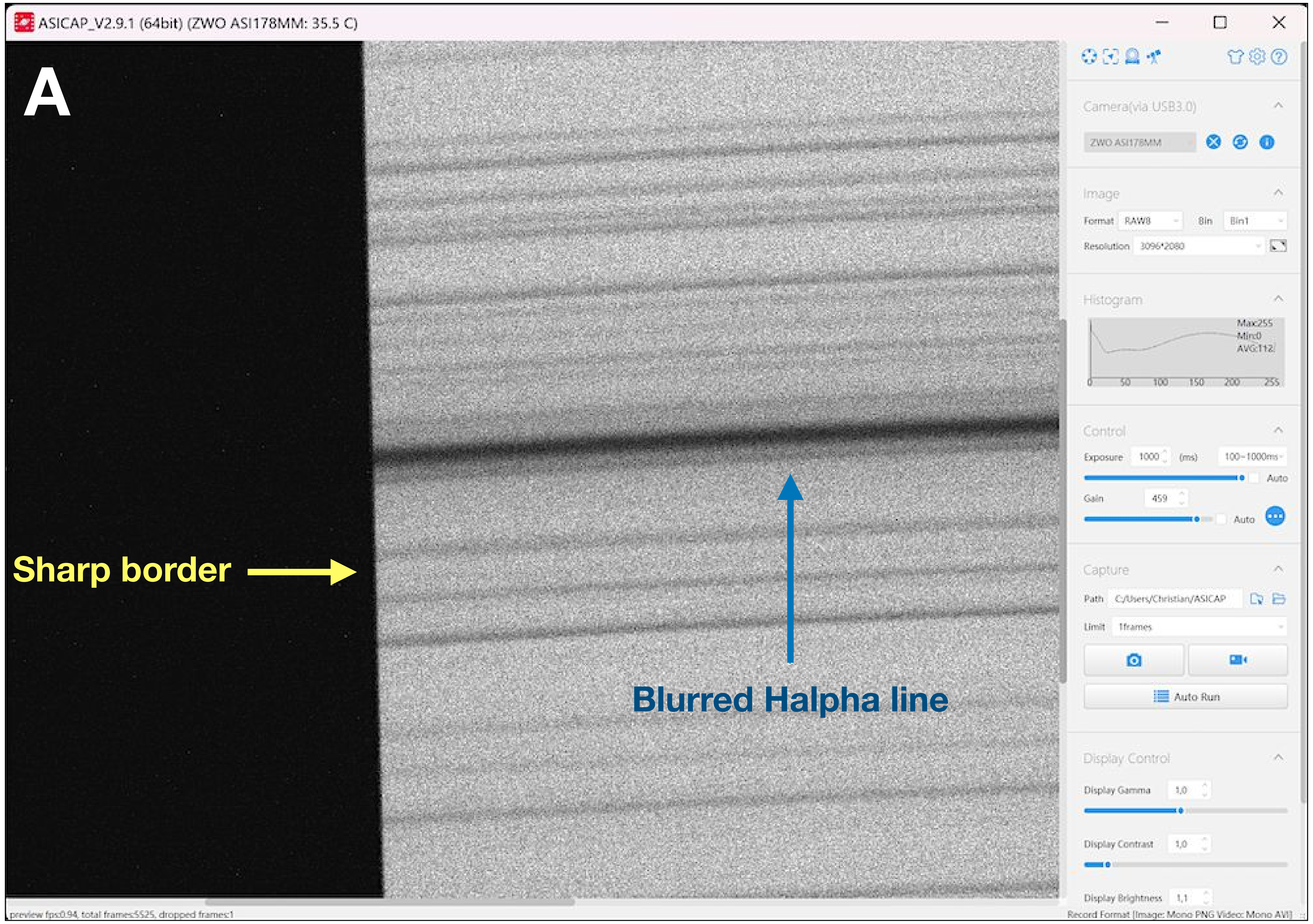
STEP #8

A - Moving the collimator cube changes the sharpness of the spectrum. For the moment, the objective tube retains the setting from step 2. Fine-tune focus only by acting on the collimator block.

Learn to control the movement of the collimator cube by adjusting the tightening force of the retaining screws. Accuracy is better than you'd think - one or two tenths of a millimetre with a little practice, despite the device's rusticity. Don't hesitate to zoom into the image to better judge the result of an action.

In this example, sharpness has been achieved. The Halpha line is broad by nature, but we note the narrowness of low-intensity lines, which is the right criterion for successful focusing.

However, the vertical spectrum at the edge of the slit is still blurred...



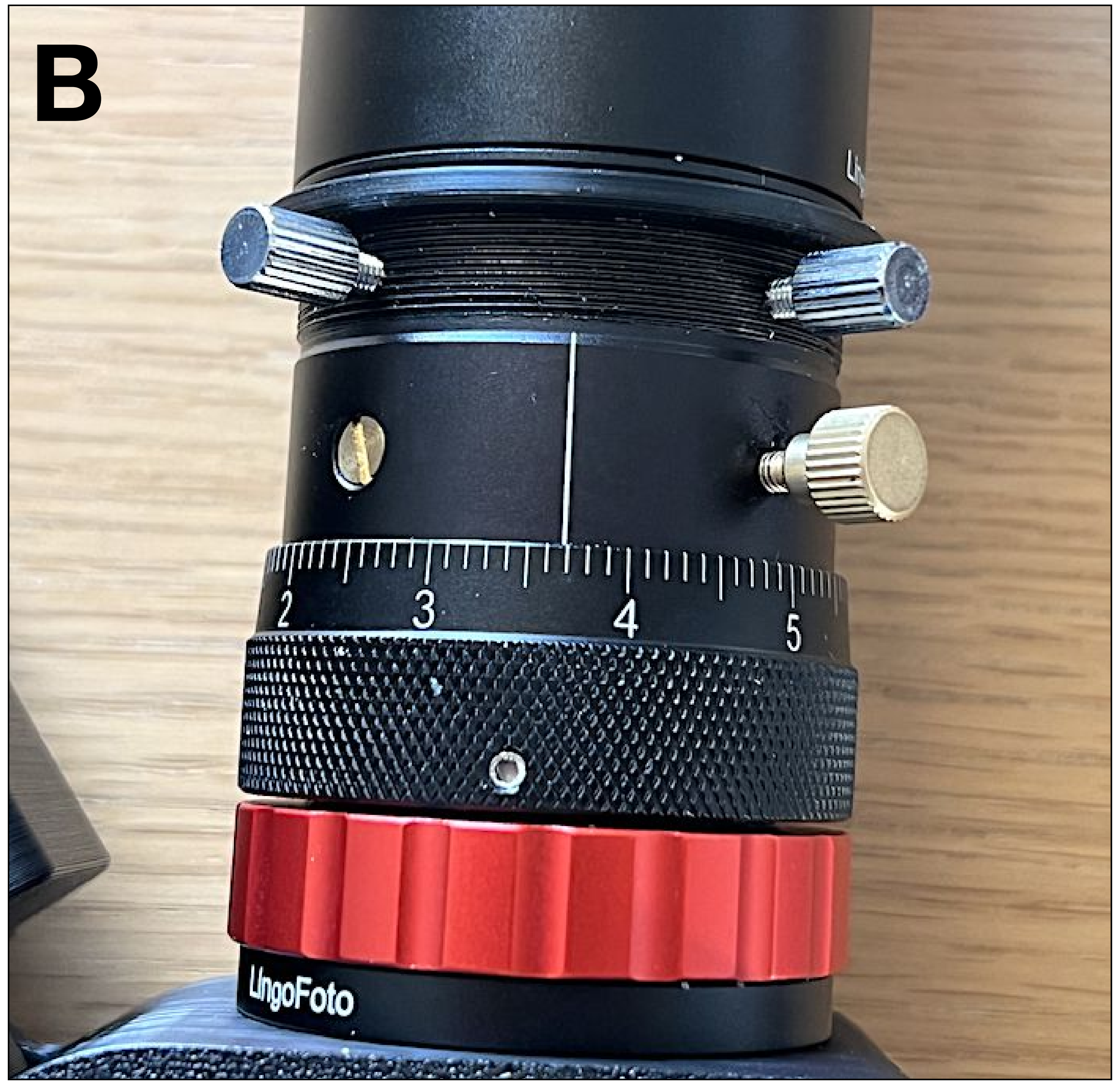
STEP #9

A - Note that for a certain position of the collimator block (and therefore a certain distance between the slit and the collimator lens), the opposite situation occurs: the spectral image of the slit edge is sharp, while the spectral lines are blurred.

At this stage, it is impossible to obtain simultaneous sharpness of the spectral lines (horizontal) and the slit edge (vertical).

In optics, this is the symptom of a defect called "astigmatism". In the presence of this optical aberration, horizontal and vertical details are not seen with the same sharpness.

The absence or presence of this defect makes a difference to the quality of images produced with Sol'Ex. You need to try to eliminate it.



STEP #10

A - For normal use (classic scene imaging), the setting made in step 2 on the objective tube is correct. It's even a good starting point for us, which is why we made it.

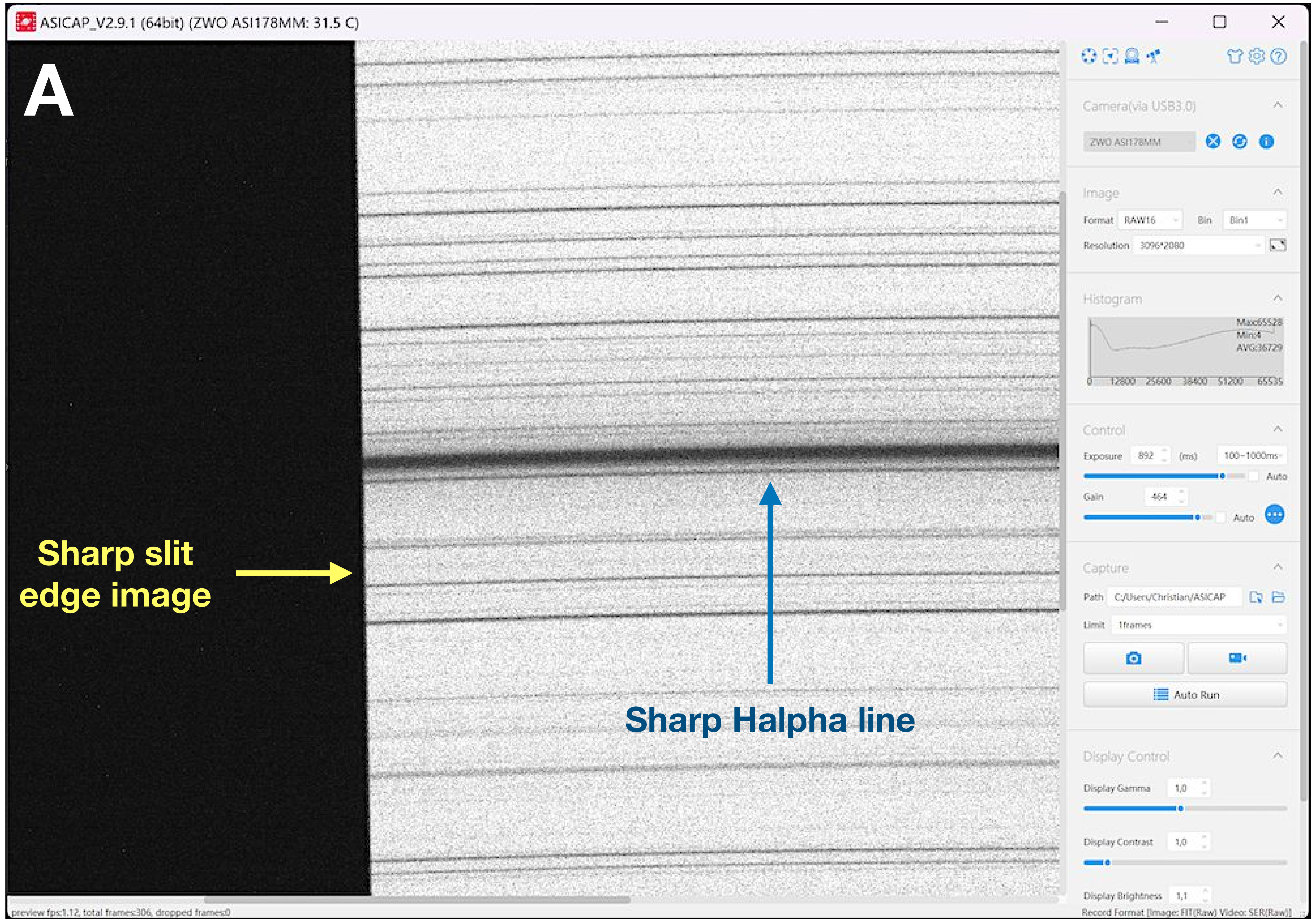
Unfortunately, apart from the fact that this sharp vision of objects at infinity is sometimes imperfectly achieved, an internal mechanism in the instrument (linked to the use of the grating) means that the best setting for the camera lens is not the one we made in step 2. This setting needs to be fine-tuned in order to obtain a very sharp image of the spectrum by repositioning the collimator block.

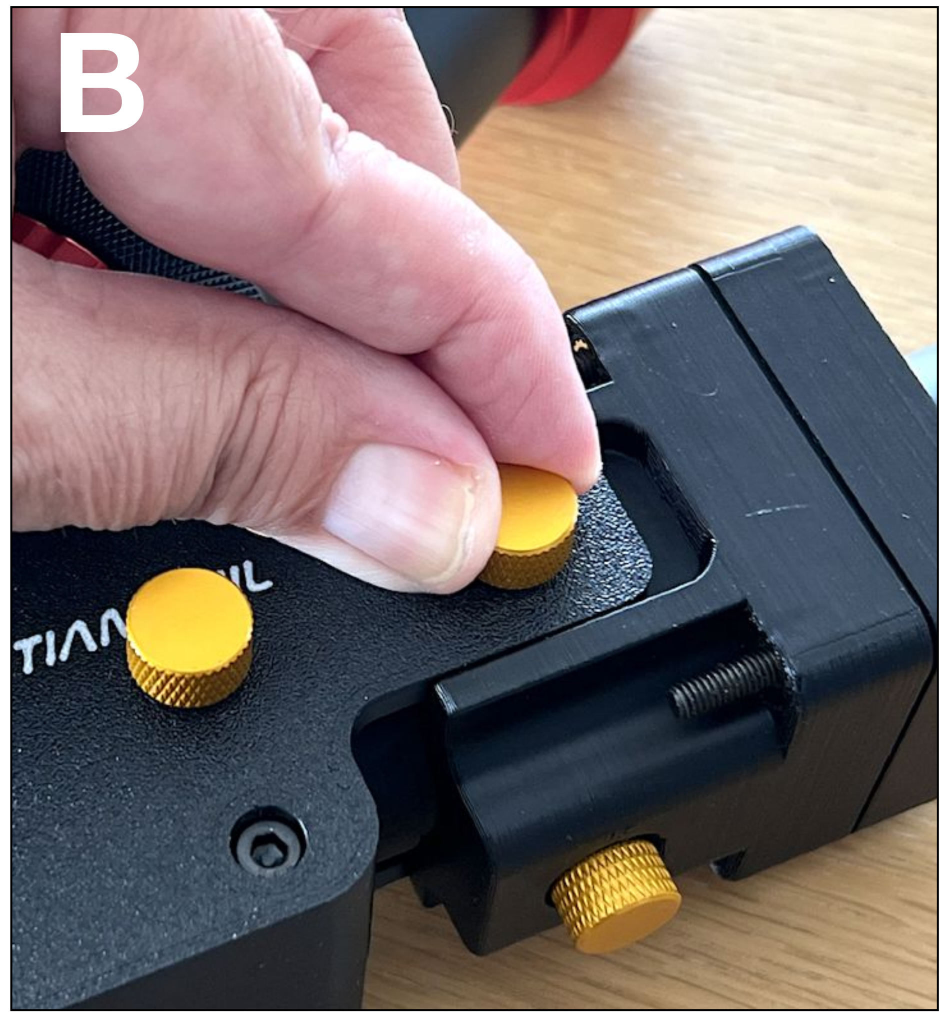
Currently, the focusing system indicates a position of 3.90 mm in the example.

B - But how much should this initial focus be changed, and in what direction?

There's no precise rule, and you may have to make successive attempts. But as a rough guide, the new optimum focus position found here is approximately 3.68 mm. This means a camera displacement of 3.68 - 3.90 = -0.22 mm. Keep the value of -0.2 mm for your own adjustment.

Let's have a look at the result...





STEP #11

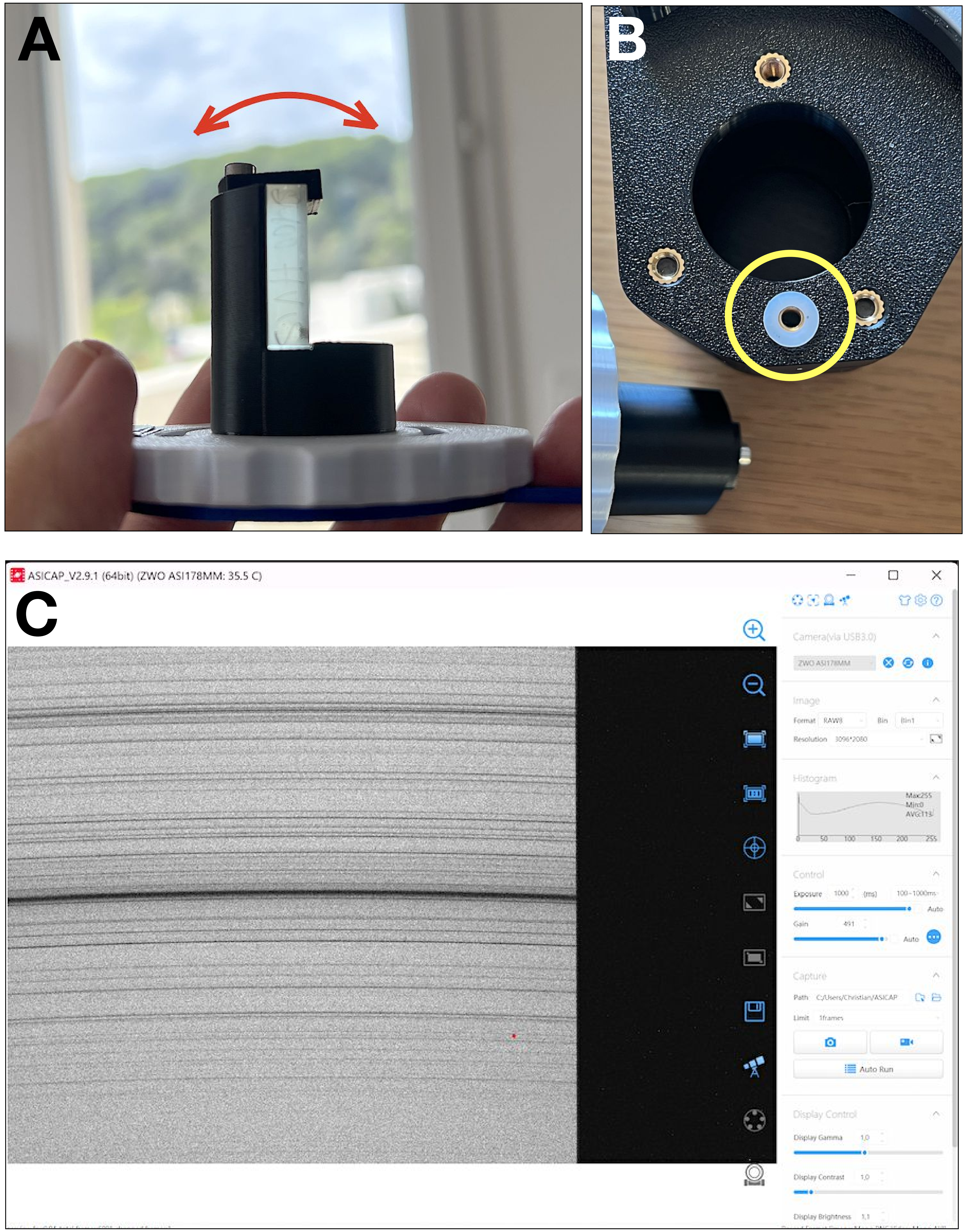
A - Move the collimator block back and forth again. Now, when the spectral lines are sharp, so is the vertical slit edge. Our 0.2 mm adjustment of the objective tube (which serves as tooling here) does the trick.

Sol'Ex is very well adjusted this time, and in this situation will produce superb images of the solar surface.

Don't hesitate to test several defocusings of the camera lens (around the initial value) to get the right result. Be patient, it's worth it.

B - Once you've found a good image by feeling your way around the collimator cube, it's time to fix it in the right position. Tighten the knurled screws on the guide rails of the collimator block, on either side of the rail, very gradually and in opposition, checking that the result is still good on the screen.

C - Finish by tightening the side screw, without exerting too much force, making a simple mark on the collimator tube. This is a safety feature.



STEP #12

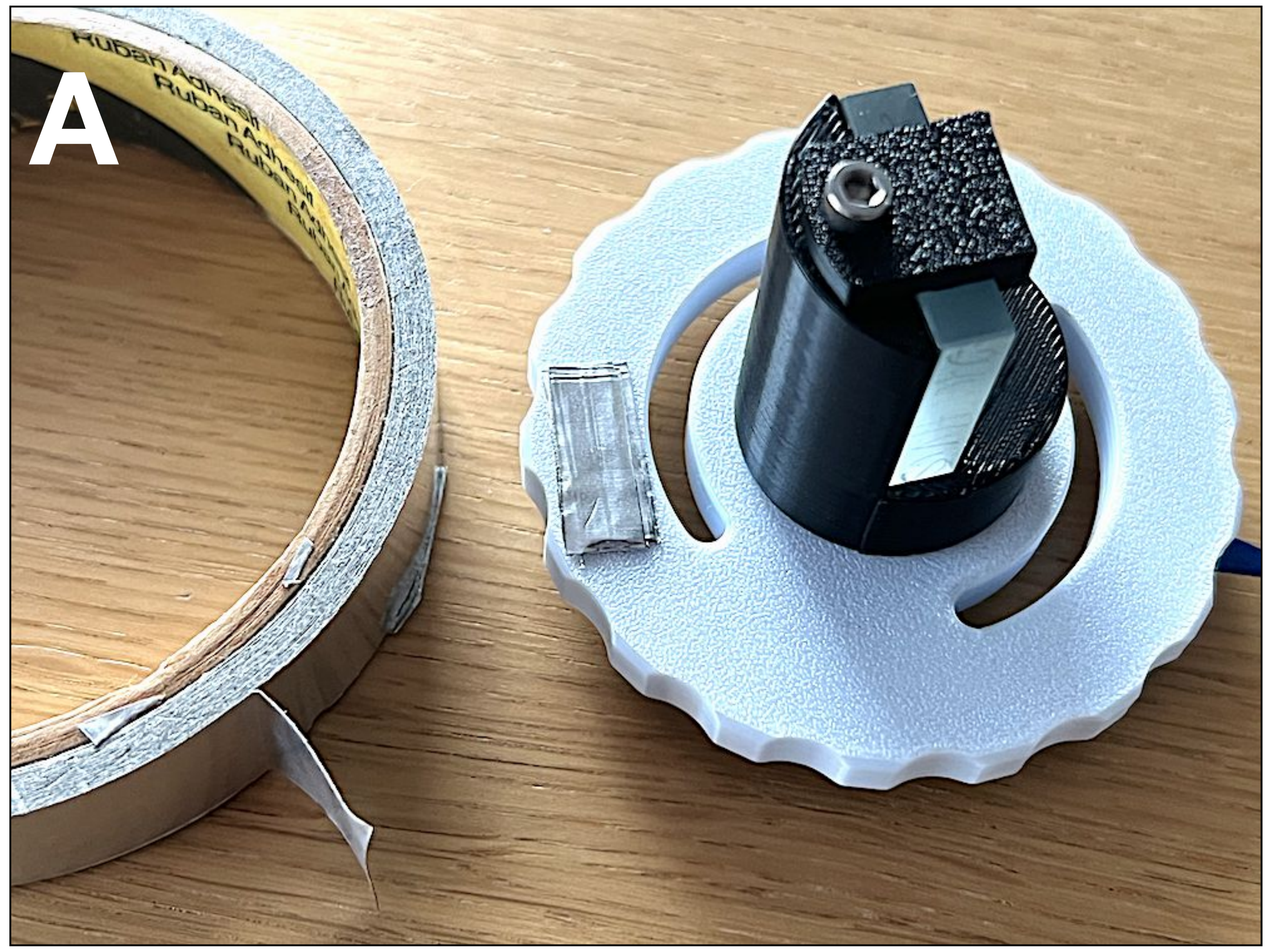
A - The procedure described above (which minimizes astigmatism) requires not only a line spectrum (natural sunlight), but also a spectral image of one of the two edges of the slit.

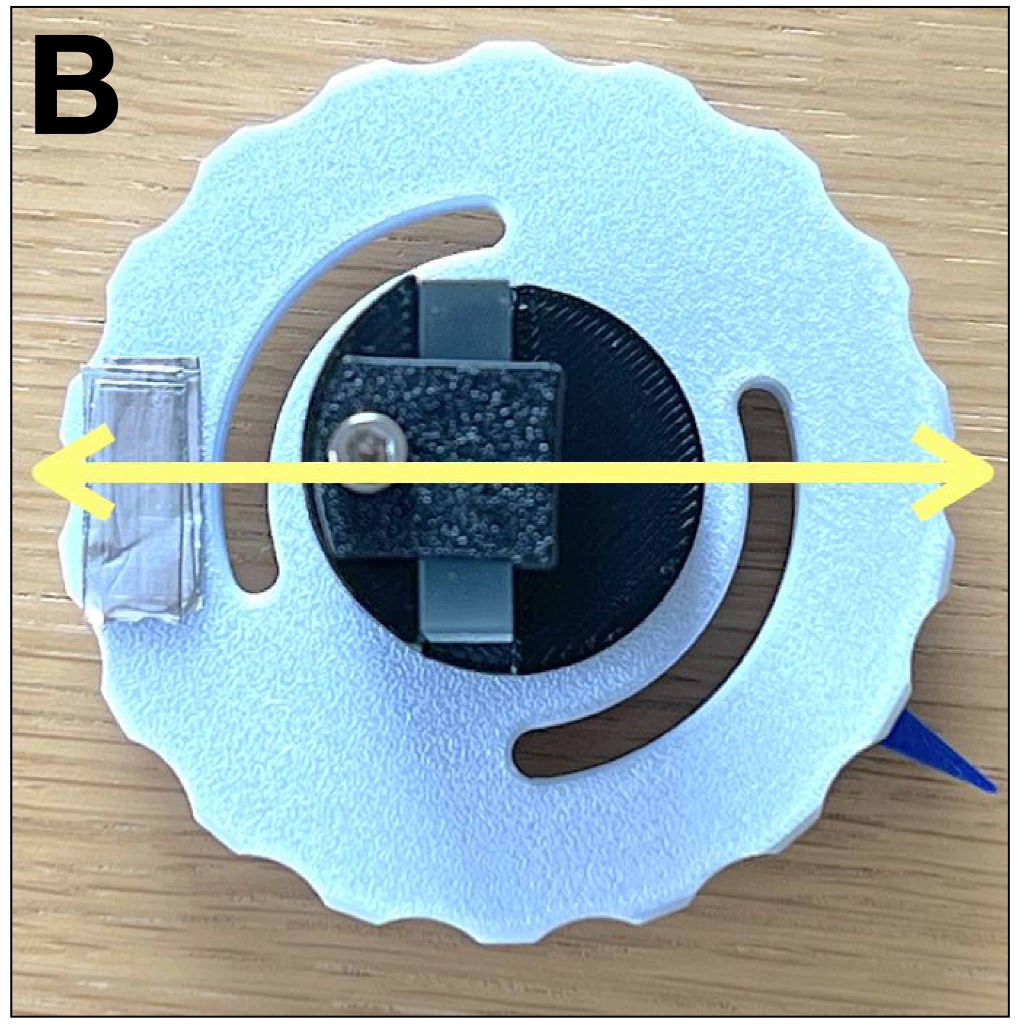
In normal Sol'Ex use, these edges are not visible, or only marginally so, depending on the detector used. So it's not out of the question that a slit edge may not be accessible at the time of adjustment, all the more so since ideally for this phase it's worth specifying that this slit edge should be located towards the center of the image for optimum diagnosis.

It's all about tilting the grating on its support. The value of the angle in question explains the different situations encountered (see arrow in figure).

B - Here's a tip for forcing one edge or the other of the sloit towards the center of the sensor. Temporarily insert a Teflon/Nylon washer (included in the mechanical kit), or even a metal washer, between the housing and the joystick, as shown in the photograph. Assemble the circular grating support passing the relevant screw through the washer (depending on the screw chosen, it swings one way or the other, so the spectrum scrolls from right to left or vice versa in the picture).

C - In this example, after fitting the washer, we see the opposite edge of the slot to the previous situation. Play with the tightening force of the knurled screws to fine-tune the centering. Examination of this image shows that the setting is correct for both slot edges (sharp lines and edges). This is optimal.



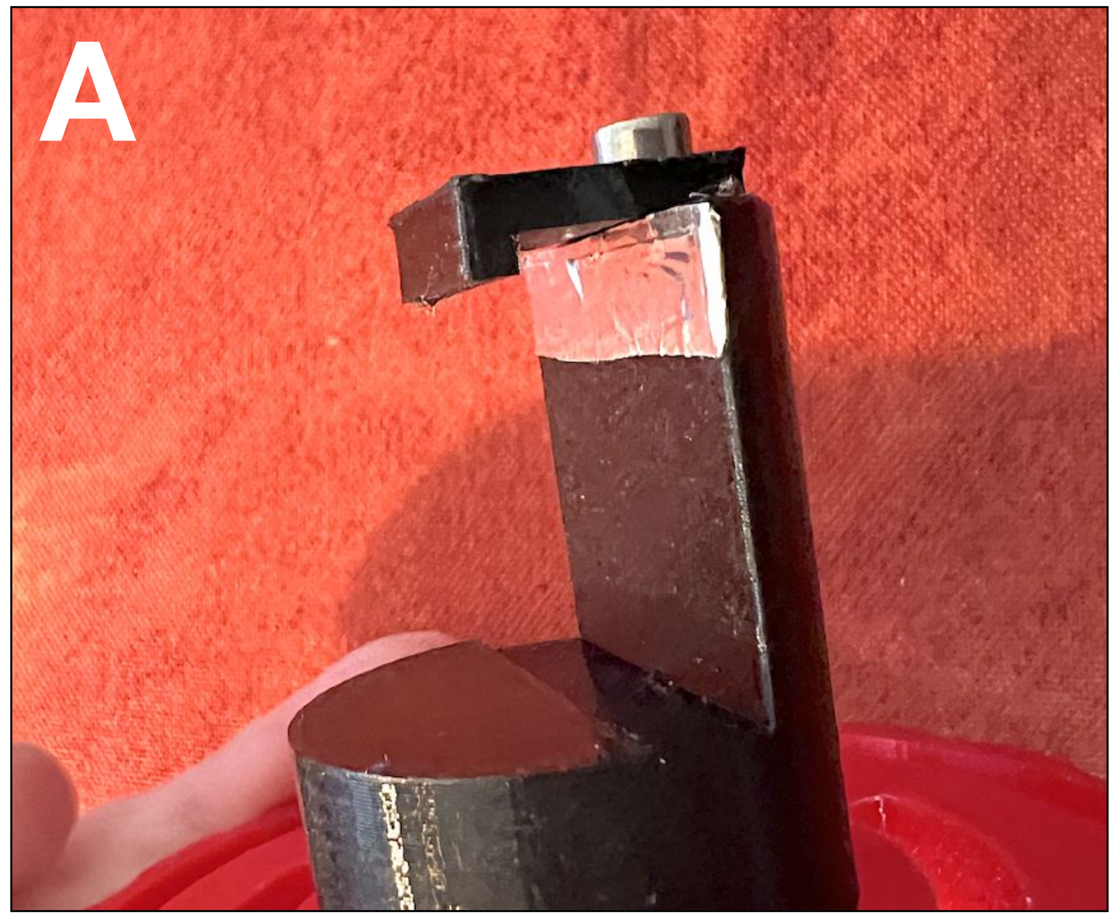


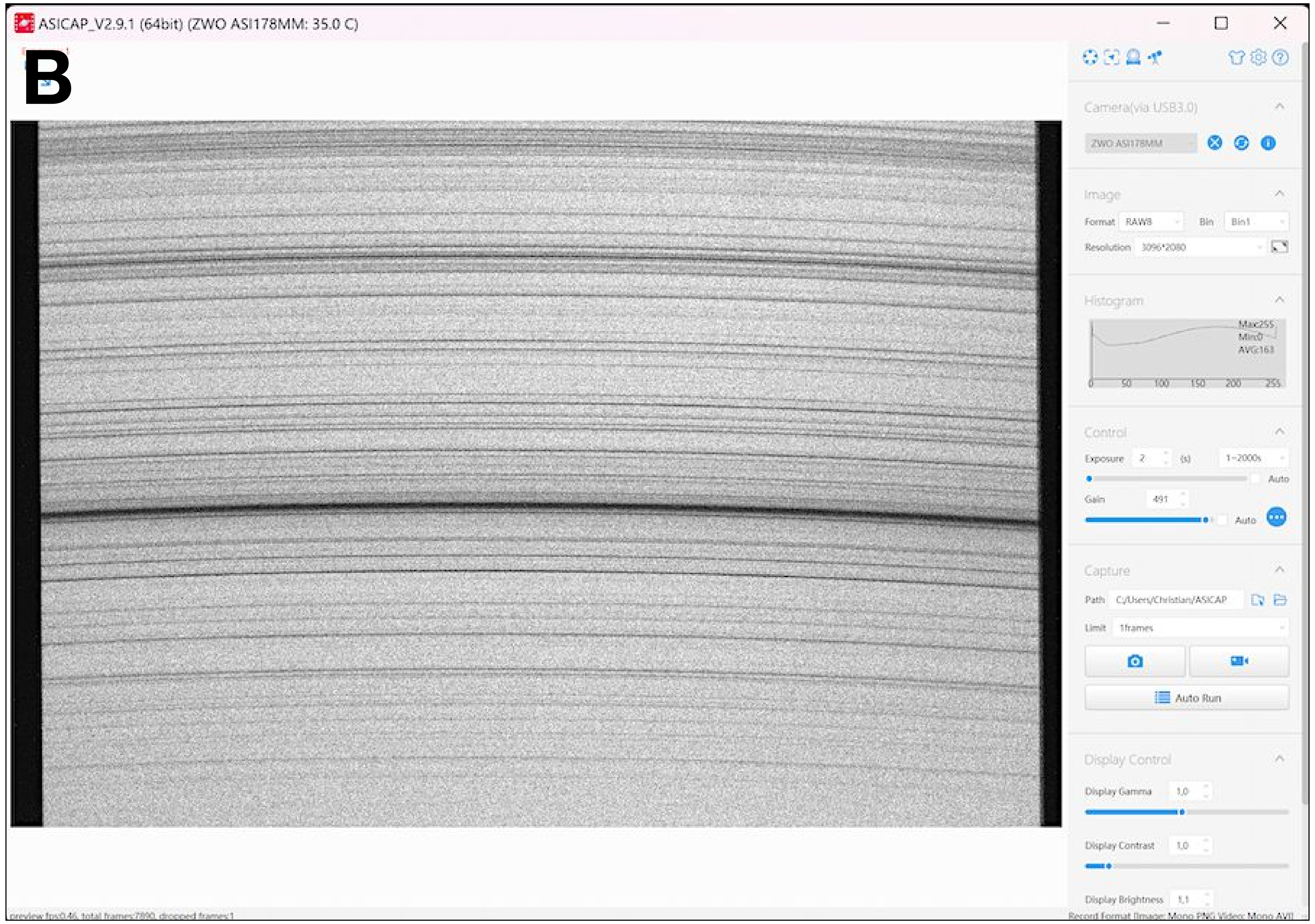
STEP #13 (first method)

A - It's possible that even without using a shim at all, the spectrum is not horizontally centered on the detector. This is even likely to be the case, despite Sol'Ex's print quality, due to a complex rib chain in the instrument. A simple gravity effect can even slightly modify the horizontal centering of the spectrum, without any real consequences on image quality.

To make this adjustment, you'll need a roll of aluminum tape. One way to do this is to apply the required number of layers of adhesive tape to the inside of the grating-holder washer to tilt the grating angularly by the desired amount. First check which direction to tilt, then iterate.

B - It's important to position the thicknesses of adhesive tape, which act as shims, in line with the normal to the grating. In this way, the centering of the spectrum remains unchanged from the red spectrum to the infrared when the lever is turned.

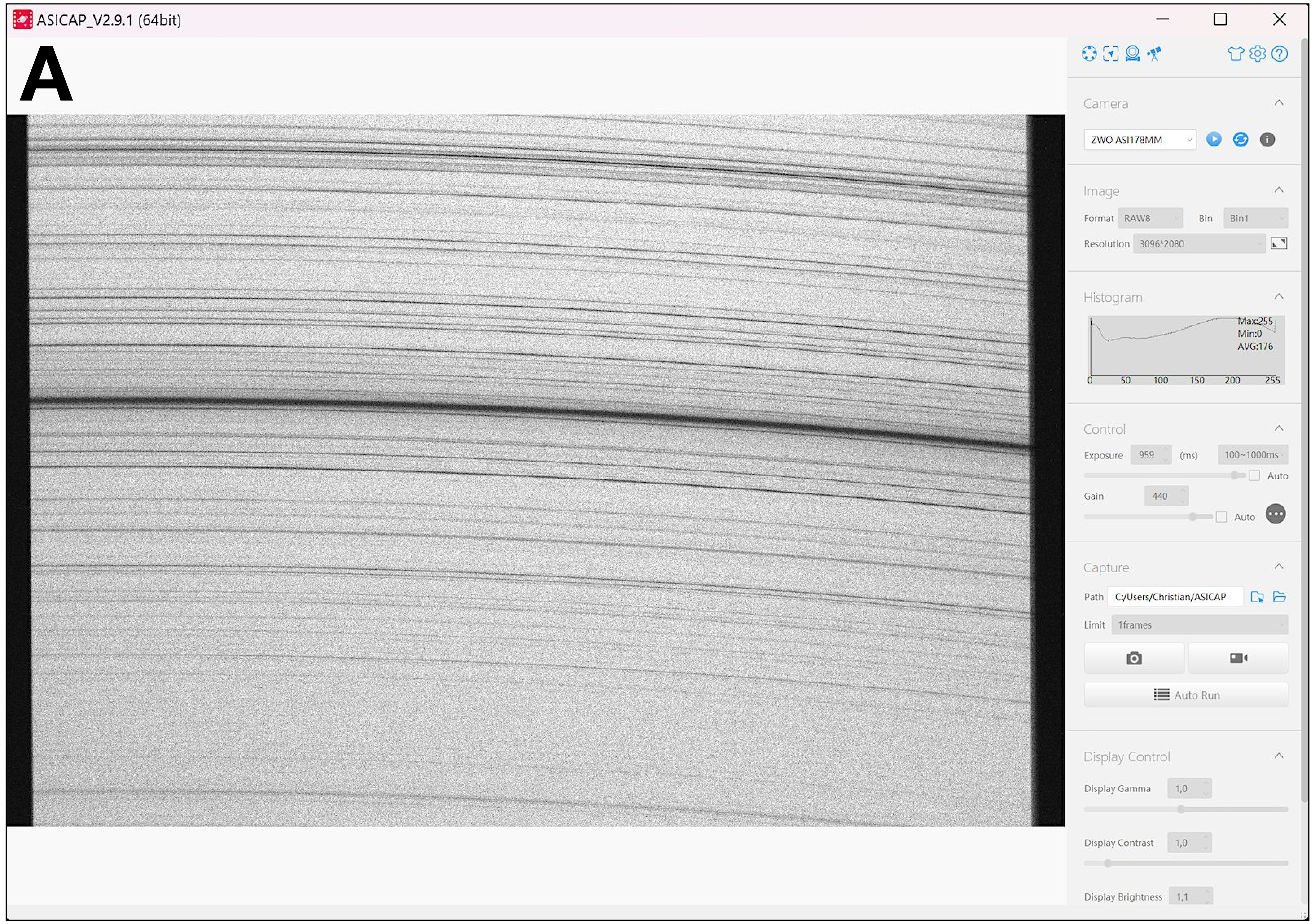


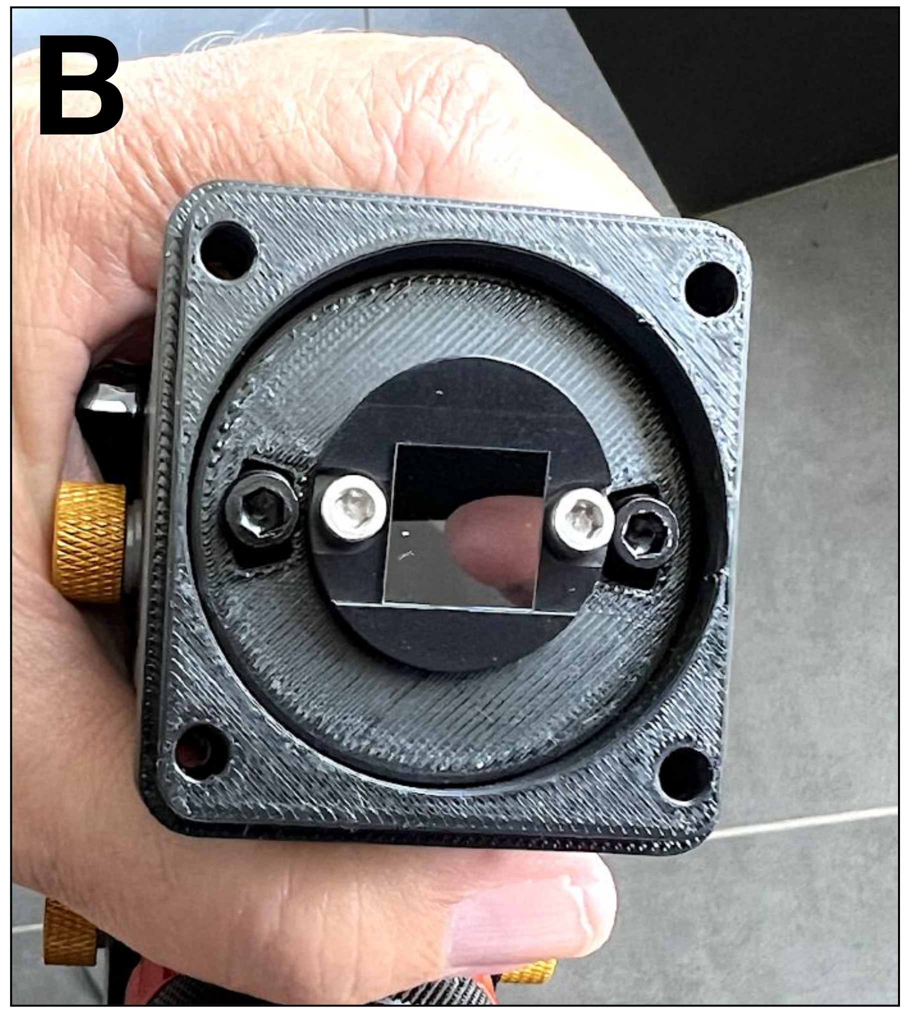


STEP #13 (second method)

A - Another way is to apply layers of aluminum adhesive tape to the grating holder itself. The disadvantage of this technique is that the grating has to be removed, so care must be taken. On the other hand, the risk of stray light entering the grating (which is rare) is eliminated.

B - Horizontal centering of the spectrum is now correct. The ASI178MM camera used here is just wide enough to record both edges of the slit simultaneously. Note that there is a tolerance on the horizontal centering of the spectrum, so don't worry too much about accuracy, as the quality of the images of the Sun will generally not be affected at all. On the other hand, you will need to pay closer attention to the verticality of the dispersion, which can easily be obtained by rotating an easily accessible camera.





STEP #14

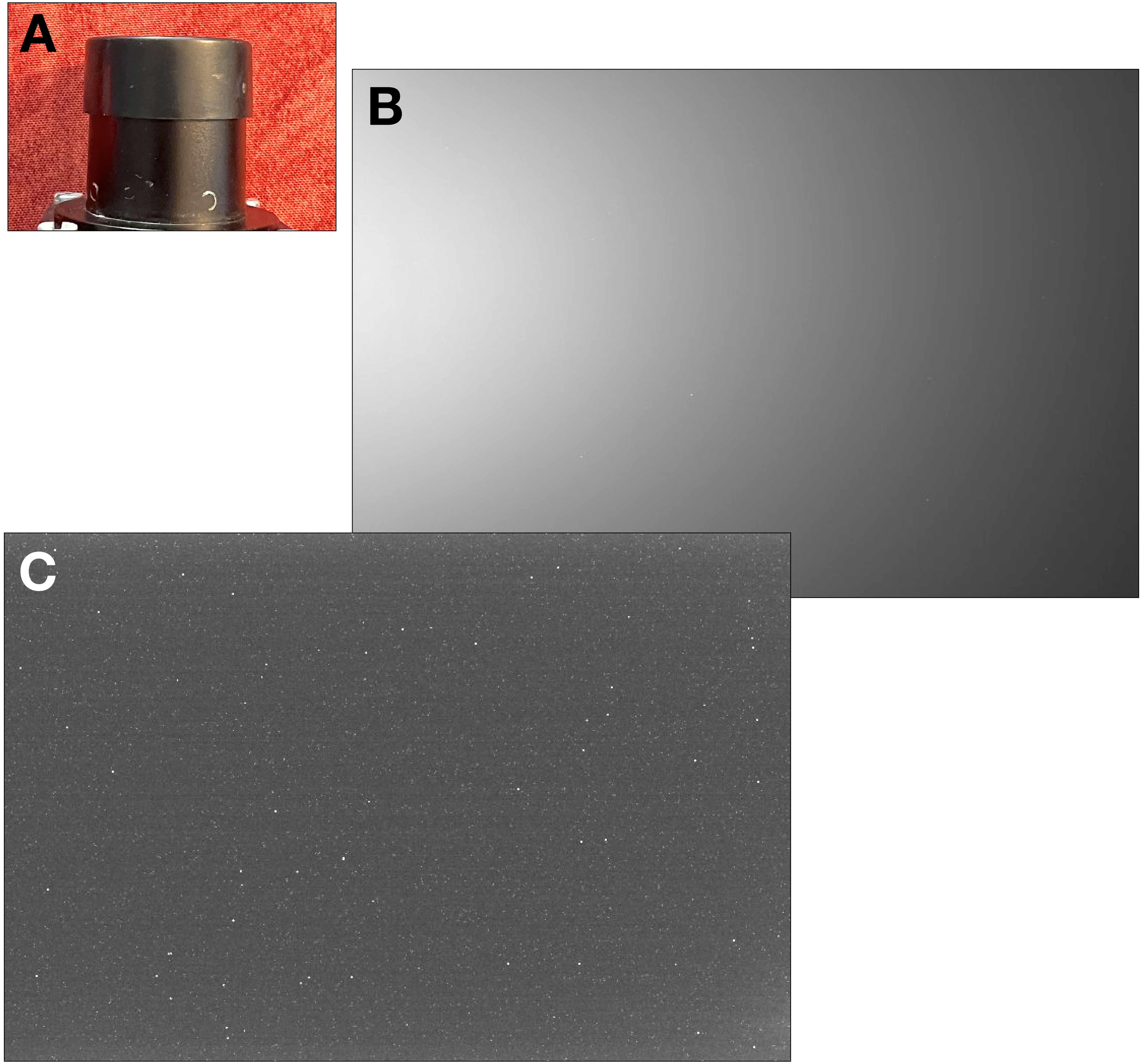
A - This step is generally optional. Although the spectral lines are curved, the general axis should be horizontal in the image, to facilitate routine use of Sol'Ex (the ROI zone is smaller). In the example, the horizontality error is forced to illustrate the phenomenon.

There is a total decoupling between the verticality of the dispersion, associated with camera rotation, and the inclination of the lines, which is associated with rotation of the slit around the optical axis. It is important to judge the inclination of the lines when the dispersion axis is vertical.

B - To orientate the slit, remove the telescope interface to gain access to the two outermost screws (M4) holding the slit-holder washer. Slightly loosen these screws.

C - Rotation is obtained by grasping the metal part of the slot. Judge the result on the computer screen, using the spectrum of daylight. You can use the reticles in SharpCap and FireCapture as horizontal markers.

Note: the verticality of the spectrum is more important than the pseudo-horizontality of the lines. Spend more time on the first point (step #5) than the present.

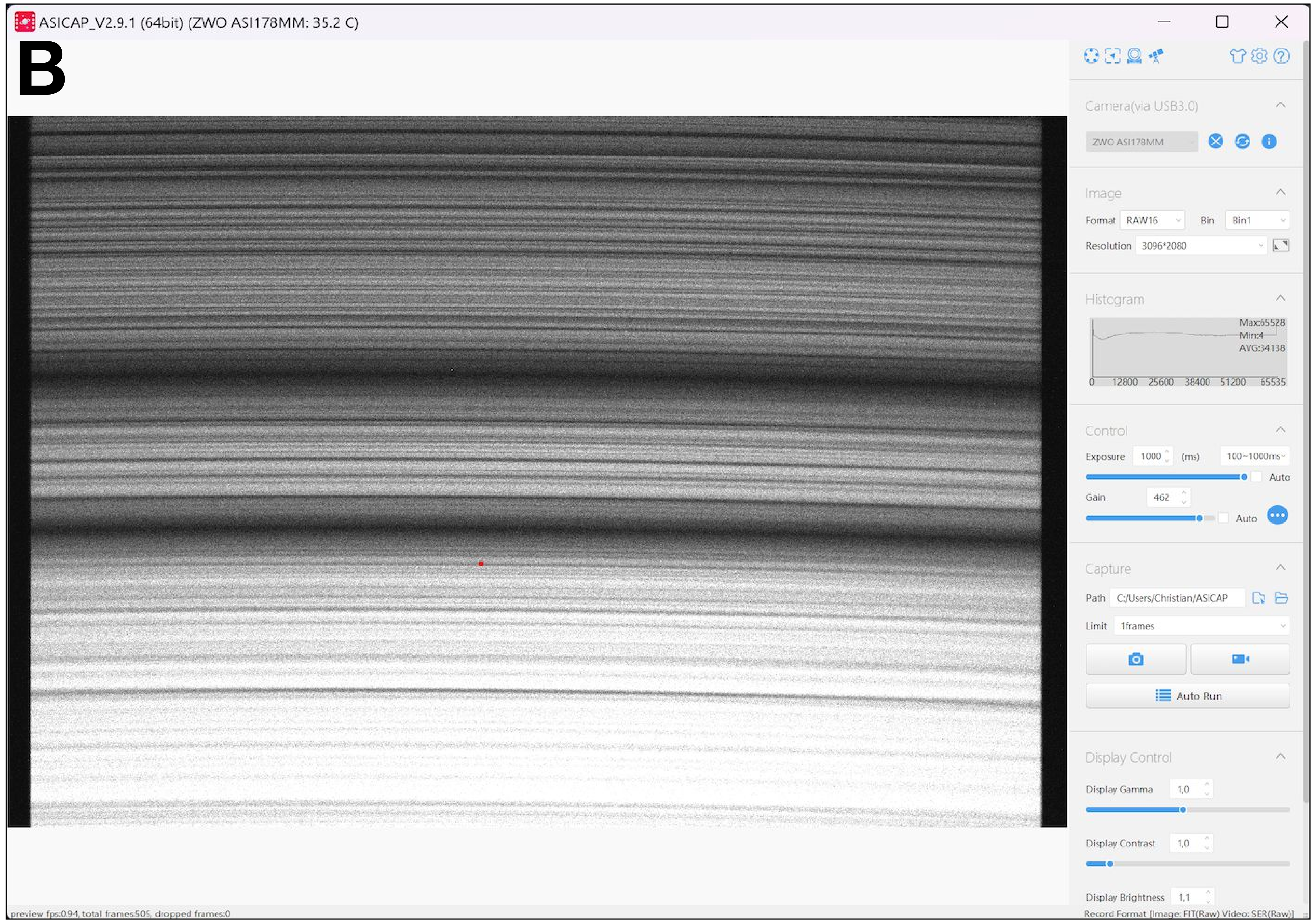


STEP #15

A - Close the Sol'Ex inlet with a light-tight cap and place the instrument outdoors in full sunlight.

B - Make a 30-second test exposure in this situation. Normally, no light should reach the detector in this situation. If a sensitive light gradient appears in the image, this indicates a stray light entry that needs to be sealed. You need to look for it methodically and plug it up (not with black plastic-coated electrician's tape, which is totally transparent to infrared radiation, but with aluminum adhesive tape).

C - Once the problem has been dealt with, an image exposed for 30 seconds should be uniformly grey, with the intensity level of a brief exposure (only hot spots are visible, linked to the thermal signal). This guarantees high-contrast solar images.



STEP #16

A - Sol'Ex is now set. Congratulations! You can now start observing the Sun on a sound footing.

In particular, you don't have to go back to setting the collimator block, which is done "for life". Only the camera's focus can be adjusted according to the situation, to ensure the sharpest possible spectrum.

So, while you're on the subject of table-top manipulations, familiarize yourself with the use of the camera, for example by turning the grid-holder lever to observe extreme wavelengths in the ultraviolet, the region of calcium's famous H and K lines. Use the wavelength index to help you find your way around.

B - Sol'Ex chromatic aberration suddenly becomes very strong at these wavelengths. The new value to be displayed at the helical system is 4.75 mm, whereas we started from 3.68 mm for the Halpha line (in our example). So, to obtain a clear spectrum of the H and K lines, you need to turn the focusing ring by 1.07 mm. This value is a constant, and when it's taken into account, switching from a Halpha image to a calcium image, and back again, is a breeze.

Astigmatism is virtually non-existent, even in the ultraviolet. The reason is that the steps described above for adjusting the collimator block, then freezing it in position, pay off handsomely. Using Sol'Ex becomes simple and precise.