Eshel+ spectroscope
Assembling the instrument

Rev	Date	Qui	Quoi
0.1	29/12/2015	F. Cochard	First revision, during test with O. Garde
0.2	06/01/2016	F. Cochard	Text completion.
0.3	29/02/2016	F. Cochard	Add pictures during full assembly.

1 Introduction

This document explains how to assemble and tune the eShel+ instrument. Because of the size and wheight of the instrument, it is necessary to assemble and tune the insrument on site. Most of elements have been pre-assembled in our factory, and the whole instrument has been assembled and tested before shipment.

We first make a short presentation of the intrument, with its optical path. Then we go in detail of each operation.

The assembling and tuning can be done by a single person, but it is better to be helped by another one for some steps (returning the chassis, for instance).

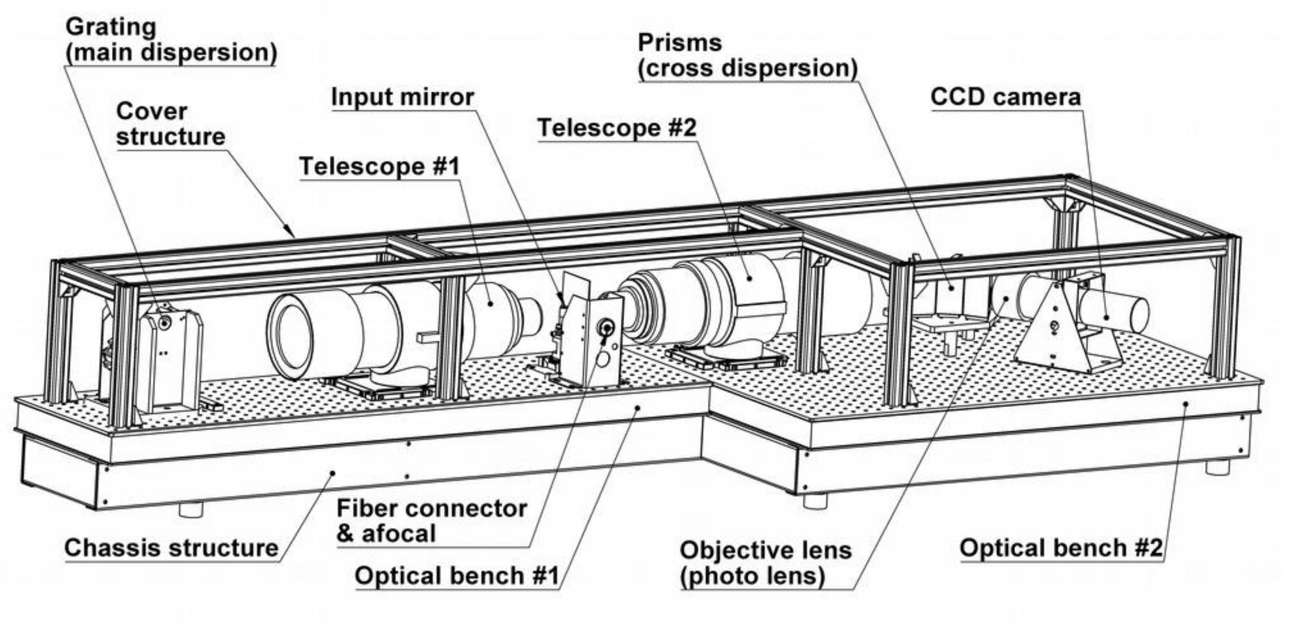
We consider that the whole installation requires two full days (depending on your experience of course).

All the installation and tuning must be done during daylight (no need to be in darkness). Of course, for usual operation (stars observations), it will be covered, but the tuning can be done even without the covers.

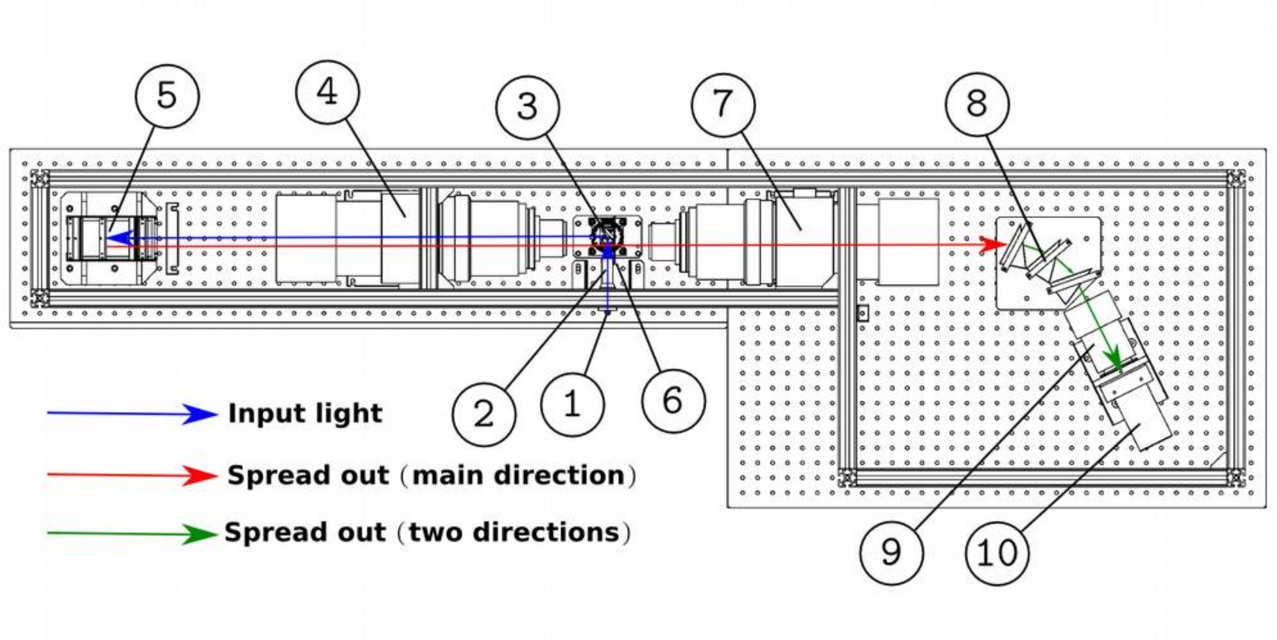
2 Presentation of the instrument

The eShel+ is a fiber fed spectroscope, build on an optical bench. Its architecture is of white pupil type : this is an optical configuration which makes the diffracted beams converging back to the objective lense. This way we can use reasonable optical diameters (in eShel+, the objective lense is a standard high quality photo lense). This configuration has a general symmetry, which explains that we use two identical telescopes.

The below picture shows an overview of the instrument (covers have been removed to see interior of the instrument).



The light path is as follows :



Light enters in the instrument through de fiber FC connector (1). This is a diverging beam at F/5. Then it goes through the afocal lens (ratio 4:3)(2), and reflects on the input mirror (3) at 45°. It then goes through the telescope #1 (4), which converts it in a parallel beam. The beam is sent to the reflecting grating (5) which spreads out the light and send it bask towards the telescope #1 (4). Light is then converging close to the input mirror, goes through the mask (6), and is diverging again (symmetrically) in the telescope #2 (7). The telescope makes parallel beams for each wavelength, all of them converging toward the prisms (8), then the objective lens (9) which makes the final real image on the CCD sensor (10).

The first part is to assemble the chassis structure, with the cover structure. Then, each optical element is put in place, following the light path in the instrument (starting from Fiber input, up to the CCD camera). Each element is tuned immediately after installation. At each step, the tuning is made thanks to the CCD camera on its holder. All the elements to install & tune are :

→ Input fiber holder
→ Input mirror
→ Collimator telescope (telescope #1)
→ Grating
→ Objective lens (telescope #2)
→ Prisms holder
→ CCD camera

Once the instrument is tuned, the last operation is to put all cover elements, to put the eShel+ in total darkness.

3 Environment

Make sure to have enough room to assemble and tune the eShel+ : the instrument in 210 cm long and 60 cm wide. During the assembly, you'll need to be able to go around the instrument. Once it is tuned, during operation you can only have a front access (along the instrument, where is the fiber input), with free height above it to open and remove the top covers.

The instrument is heavy (80kg) and must be install on a strong table or bench. It is put on six smooth rubber feets : there is no need to have a perfect flatness for the table / bench.

We stronlgy recommend to have a table (desk) beside the instrument, at least during the tunning. It will be very helpful to put all the elements step by step, and also to put the computer to control images.

4 List of elements

You should find all these elements in the eShel+ package.

4.1 Chassis elements

Bench #1 (left) & #2 (right)

Bench structure + rubber feet

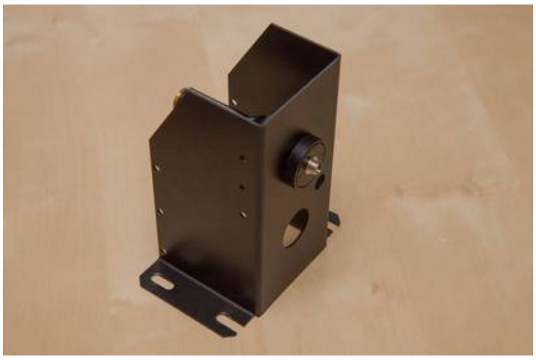
Cover structure

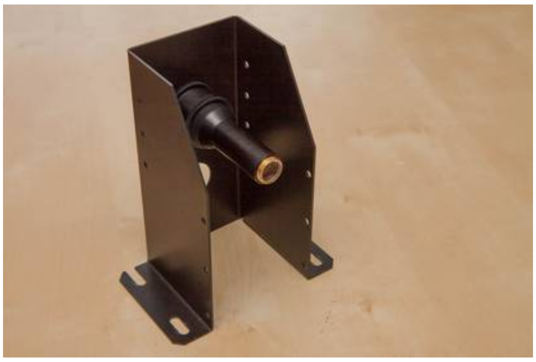
Cover panels (side & top)

Camera cooling shell

4.2 Fiber holder

This module is pre-assambled, with the internal optics already tuned.





4.3 Input mirror holder

This module is pre-assmebled. Only the optical mask (sheet metal part, with a slit) is separated during transportation.

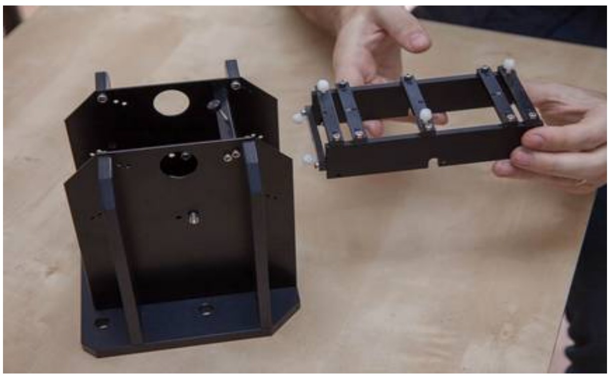
4.4 Takahashi telescope + holder (x2)

Each of the two Takahashi telescopes (collimator and objective) comes within its own box. Beside the telescopes, you'll find the two focal reducers, the mounting rings, and the plates :

4.5 Grating & grating holder

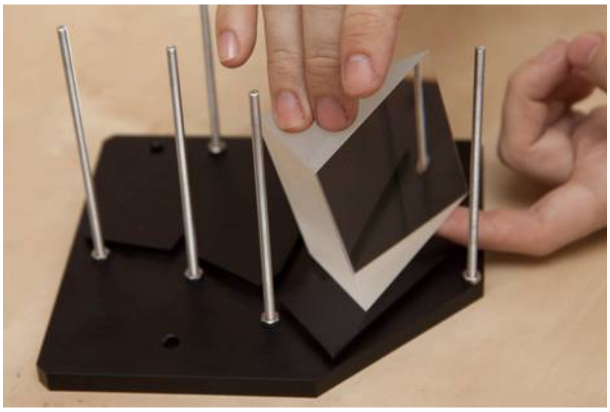
The grating is protected in its original box : make sure to never put your finger (or damaged) the reflecting surface : this would be unrecoverable. Only take the grating by the sides. On the image below, we see the back face of the grating.

The grating holder is pre-assembled :



4.6 Prisms & prisms holder

The three prisms are cautiously packaged : make sure to never put any finger print on the two polished surfaces. Always take the prisms by the unpolished surfaces.



The prisms holder is made of the plate, three legs, three prism retainers and six threaded rods (120mm long).

4.7 Camera, lens and holder

The CCD camera comes in its own package, as well as the Objective lens. The camera holder is pre-assembled.

4.8 Accessories

In addition to the above optical & mechanical elements of the eShel+, you'll find some accessories required during the assembling & tunning :

- Flat mirror 100mm

- Tuning Tool (qty 8)

4.9 Screws

Each element (chassis, covers, grating holder...) is provided with a dedicated screws bag. There is the exact number of screws in each. In addition, we provide a spare screws bag, in case of you miss one piece.

5 Tooling

During the installation, you'll need some basic toolings.

- Precision steel set square (équerre de mécanicien - orthogonalité caméra).
- Allen keys for screws M3 to M8.
- Open end spanner 7mm (M4 nuts) & 10mm (M6 nuts)
- Graduated steel rule (200mm)
- The special tool for tightening optics

- A computer (PC, windows) with the acquisition software installed.
- Stable light source (white LED for instance)
- Fiber optics 50µm (length > 2m).

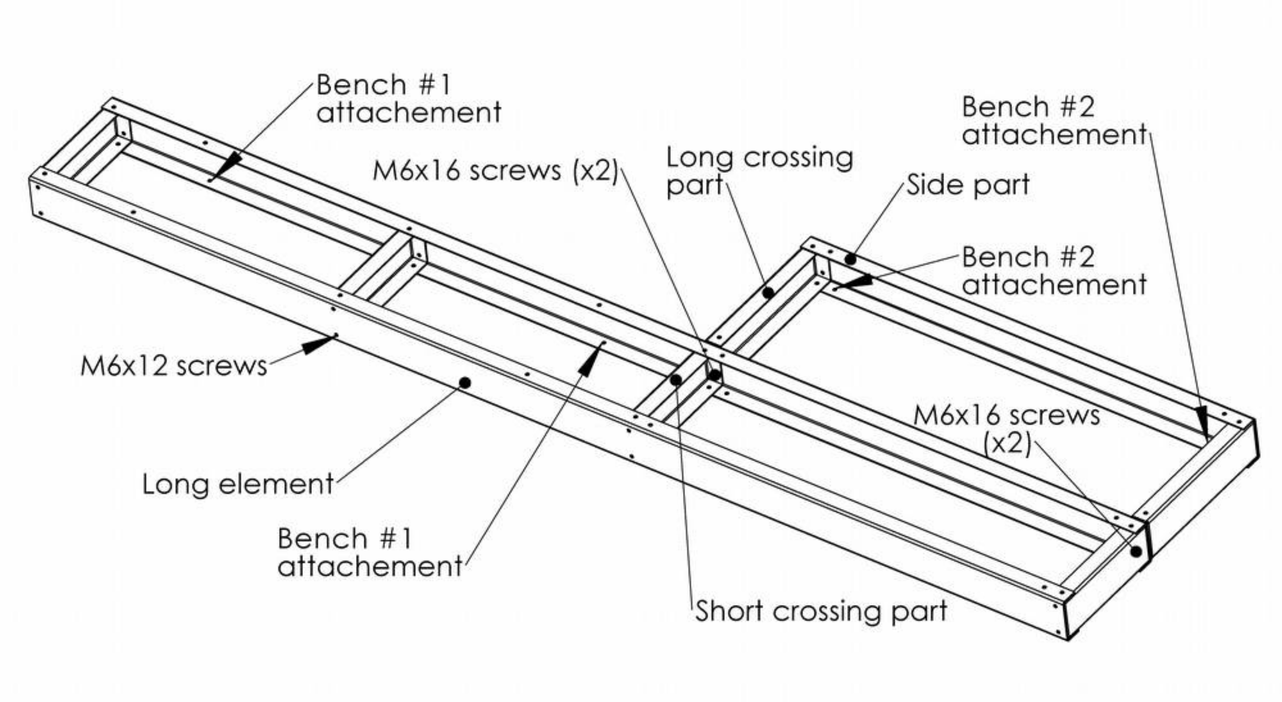
6 Assemble the chassis

The first step of the assembly, is to prepare the chassis. The instrument is mounted on an optical bench, made of two parts. One is 900 x 600mm, and the other is 1200 x 300mm. To make sure that both parts are strongly attached, and well aligned, there is a mechanical structure below the benches.

The mechanical structure is made of 9 U-shape stainless sheet metal parts.

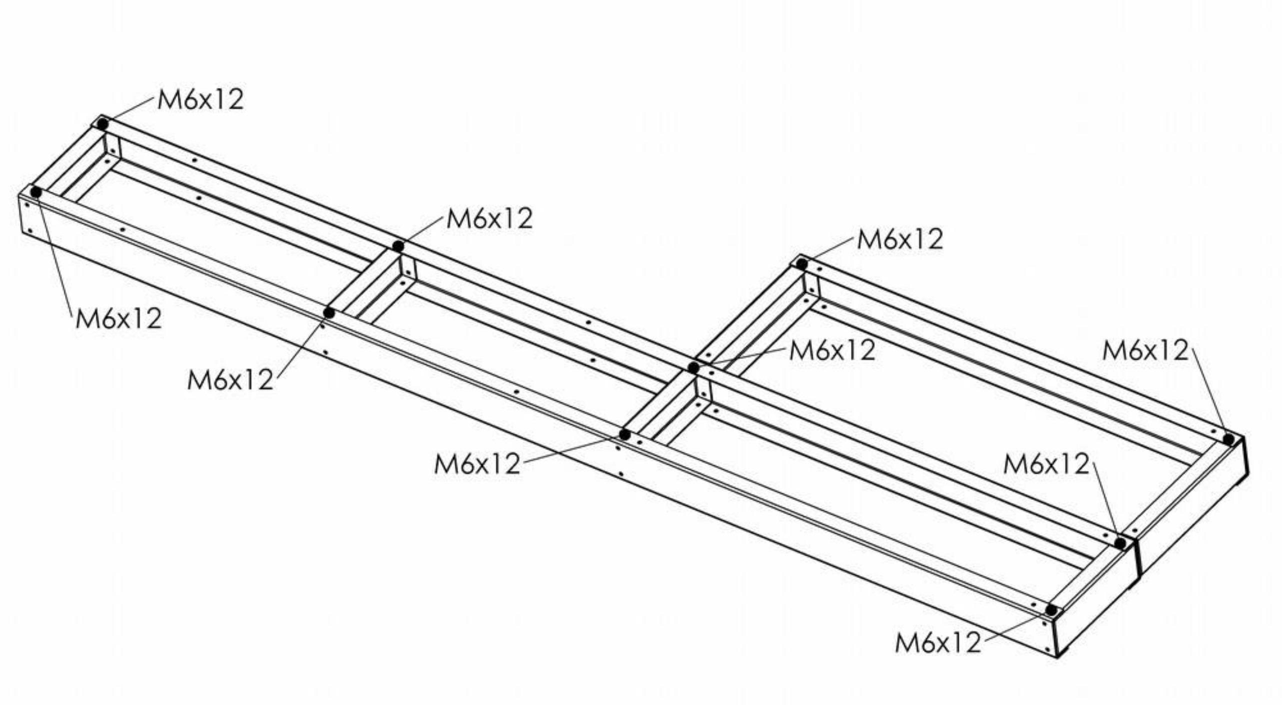
The whole structure is mounted with M6x12 screws (each screw with a spring washer and a nut). Assemble the long elements first, with the 4 short crossing parts. Then, add the side part with 2 long crossing parts. Warning : the long beams are not symmetrical ; make sure that they are matching properly.

Note that in the screws bag, you have 4 M6x16 screws : they are used for attaching the side part of the chassis ; all the others screws are M6x12.

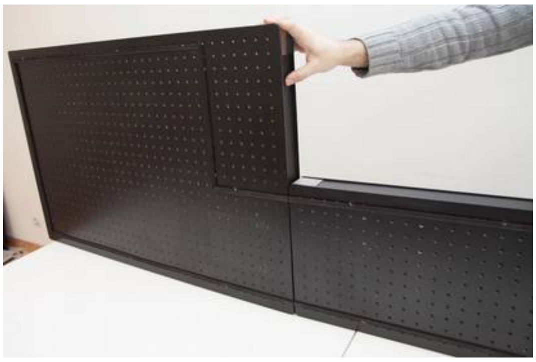


Put 2 M6 screws at each end of the crossing parts. Make sure that the result complies to the above picture. Specially, the 8 mentionned holes must be at the right place.

Put 10 M6x12 screws on the top face of the structure (make sure it is like on the picture below ; if needed, return the structure). Leave the 8 holes for benches attachement free.



Put the two optical benches on a flat and clean surface (table), with the faces with many holes towards the ground. Position the benches like on the picture (make sure that the adhesive tape on the top face are matching!) :

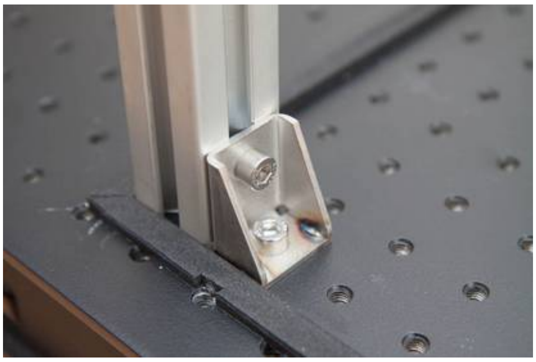
 

Mount the structure on the two benches, and attach each of them with 4 M6x10 screws (with spring washers). Before tightening the screws, make sure that the two optical benches are in contact, perfectly aligned. Tighten all the screws.

Then, mount 6 rubber feet, like on the picture :

When the structure is finished, return the whole optical bench : you now have the reference surface for the whole instrument.

Next step is to install the cover structure. It is made of Bosch profile elements, with different lengths. Bosch profiles are attached to the optical bench with special brackets (left). Bosch profiles are attached together with Bosch standard brackets (right). Screws are M5 for the Bosch profiles (Bosch screws), and M6 for the optical bench. In the Bosch profiles, you can slide the nuts until you tighten the screws.

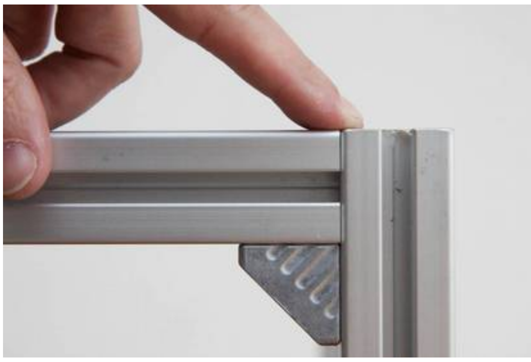


Start with the longest vertical profiles (240mm, 5 parts), attached to the optical bench. Use only one special bracket for each vertical Bosch profile. The exact position of each element is shown in the next pictures. Specially, put each part at the right position of the optical bench, with the bracket in the right hole. Do not tighten the screws until all the cover structure is finished :


Then, put the 4 parts 210mm long like on this picture (with the bracket atthe righ position) :

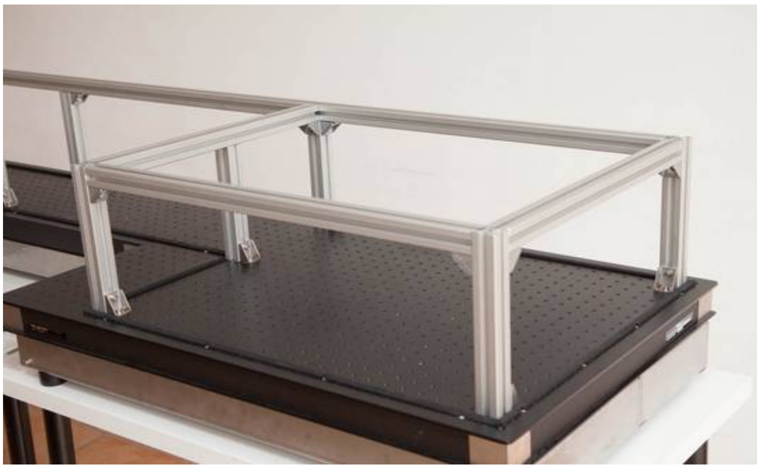

Then, put the longest element (1970mm), like on the picture, with Bosch brackets at the right position :


Make sure that all profiles are perfectily aligned (leftimage below), and there is no gap (right image).

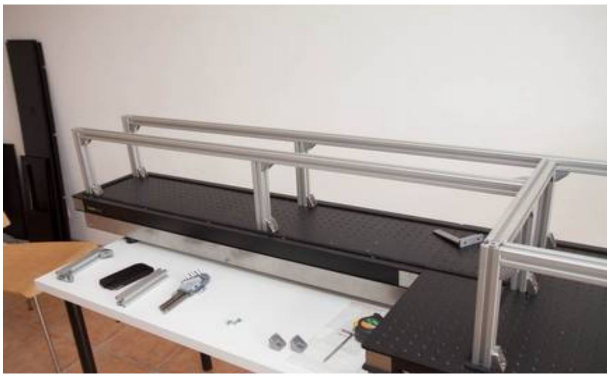
Then put the side element (620mm long).

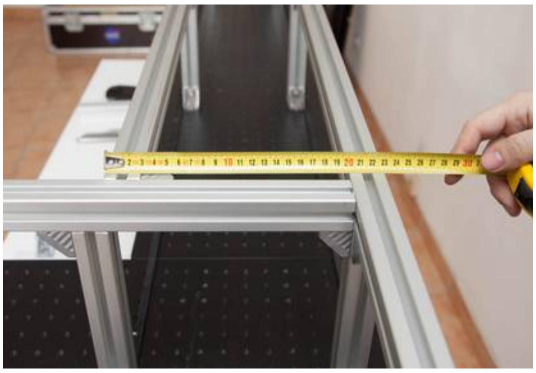
Then, put the 2 long cross elements (470mm).



Add a bracket on the middle vertical element. Use the precision steel set square to make sure the angle is right.

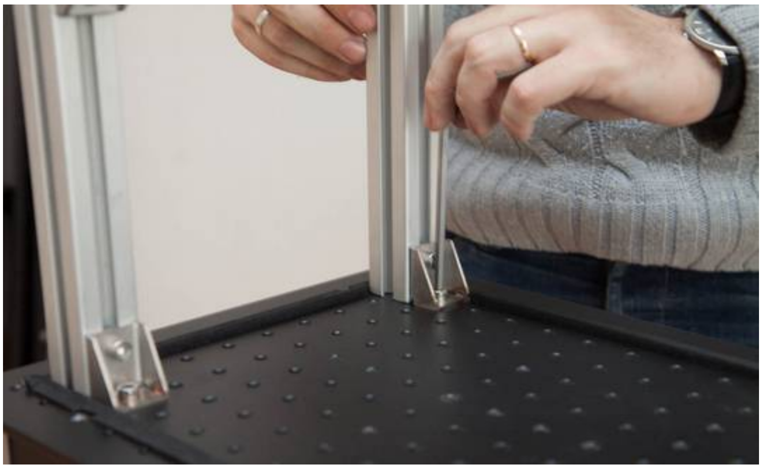
Then, put the last long element (1320mm), like on the picture. Use the precision steel set square to make sure the angle is right. Check that the outside width is 230mm.





Then, put the 2 short cross elements (170mm long).

When all elements are in place, check all right angles and tighten the Bosch brackets. Make sure that all screws are tightened. Then tighten the special brackets on the optical bench. At the end, the structre is very strong.



To prevent any light leakage between the cover sides and the optical bench, we've put an adhesive gasket all around the cover stucture.

7 Starting point for the optics...

At this stage, you are at the starting point for installing the optics of the eShel+. You have in front of you the whole optical bench with the cover structure.

The next operations will be to install each optical module of the instrument, step by step. You will follow the light path (starting with the fiber input module), and align/tune them with the camera module.

Here are some general statements for these operations :

- First, you'll have to prepare the camera with the lens (on the camera holder), focused at the infinite. All following steps will use the camera in this configuration. It will be put at the final place (after the prisms) at the end of the process.

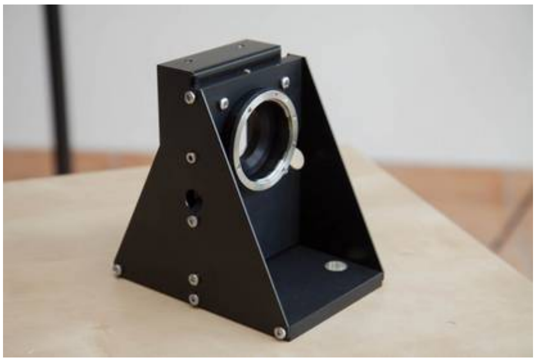
- All the tuning operations can be done during daylight. Of course, doing this will make some ghost images, but it will not make any problems for the tuning (alignment and focus).

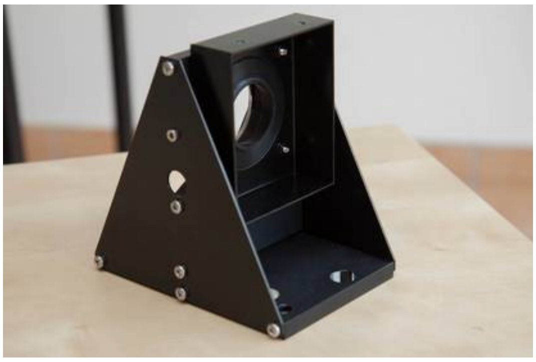
- For each step, the light source will be the fiber output. Then you should use a stable light source, like LEDs for example. Make sure that the illumination of the fiber is strong (bright spot light at the fiber exit).

- The general optical axis of the instrument is 102mm above the optical bench, all along the instrument. Then, all modules are designed to place the optical components axis at this height.

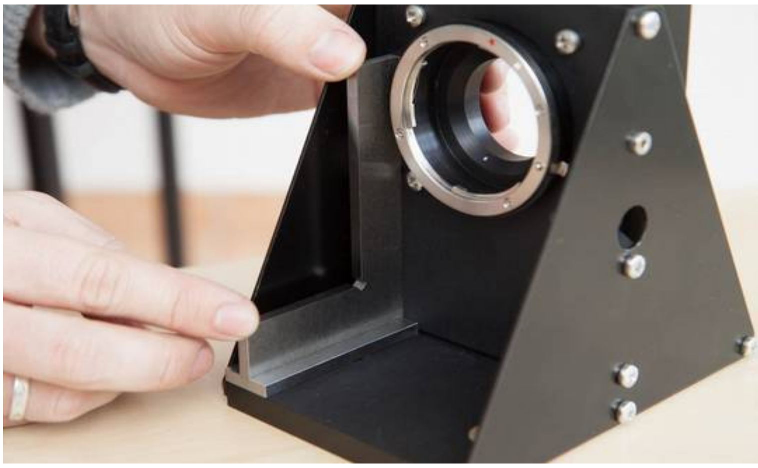
8 CCD camera holder

As explained above, the camera module will be used at each step of the installation – then, it is the first module to tune.





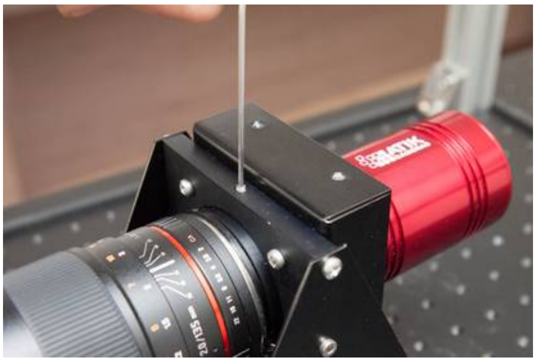
Make sure that the camera plate is perpendicular to the camera base (use the set square). If it must be corrected, untighten the side screws, and adjust the plate.



Assemble camera & objective lense on the holder, making sure that the optical axis is perfectly parallel to the base plate.

A simple way to check this is to put the camera module on the optical bench, and measure the height of the optical axis (center of the lens) above the bench. It must be 102mm.

Put the CCD vertically (Atik logo on the top in our case). Tighten the camera adapter in the holder using the three headless screws at 120°.

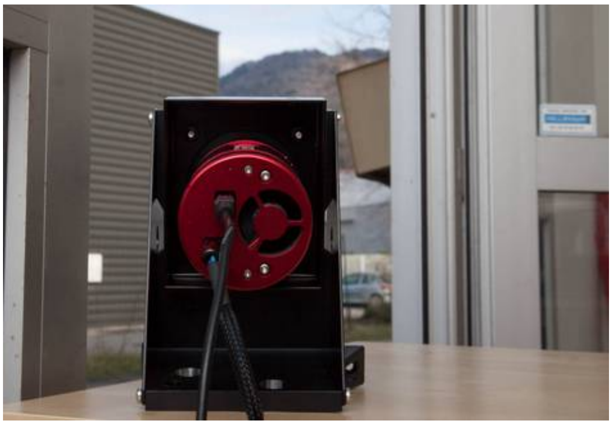
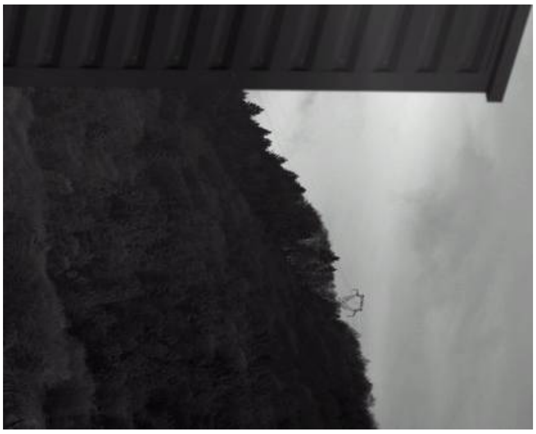


Plug the power supply cable, then connect the USB cable to the acquisition PC. Check that you can acquire some images.

Focus the lens with an object at the infinite (mountains, tree at the horizon...). For all next steps, the focus remains at the infinite. If there is too much light, you can close the diaphragm manually (picture on the right).

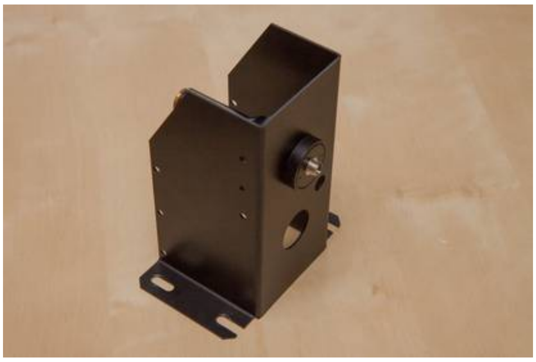
Take a special attention to this focus operation : it is critical for all following steps. The tuning is *very sensitive*. Do this operation in bin 1x1, with displaying the image at scale 1:1 (one screen pixel = one CCD pixel). Below, you can see the image (right) taken by the camera in the actual position (left).

Once the focus is optimal, put an adhesive tape on the lense to be sure that focus is never lost (when moving the camera & holder).

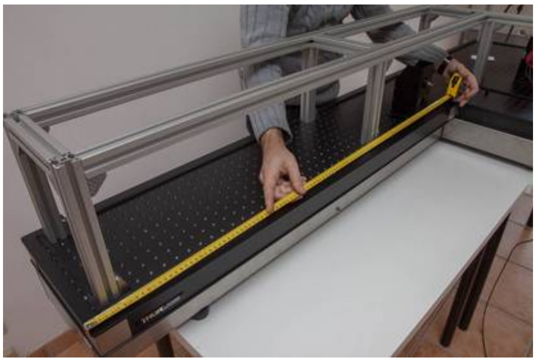
Important : At the end, make sure that the diaphragm of the lens is fully open, at F/2.

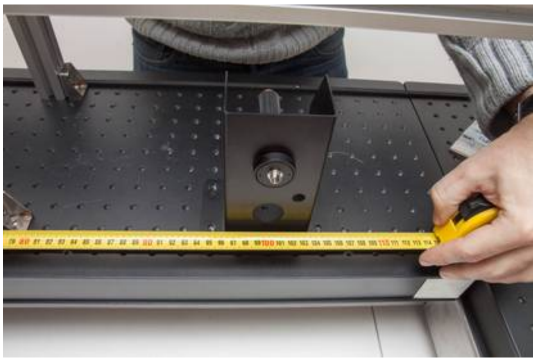
9 Input fiber holder



The internal optics of the input fiber module has been tuned during manufacturing process. However, if you need to check this tunning is fine or want to correct it, refer to the appendix.

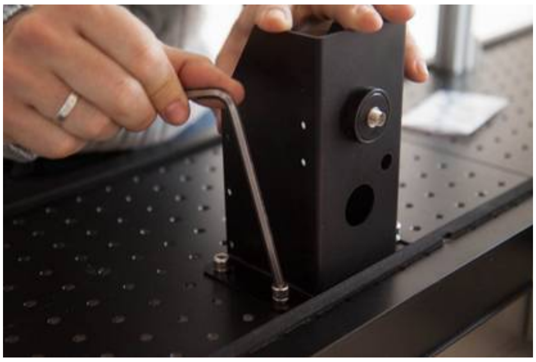
Install the fiber module on the optical bench, at 1000mm from the bench edge.





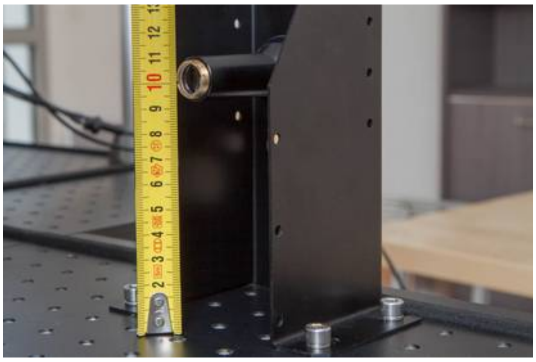
- The fiber module main face must be behind the cover structure plane by some tenth of millimeters. This way, when you'll put the cover side, it will not touch the fiber holder (no risk to break the tunning), but the light leakage will be very limited (this leakage will be managed lately).

- Put 4 M6x10 screws (with plate washer & spring washer) to tighten the fiber module to the bench.

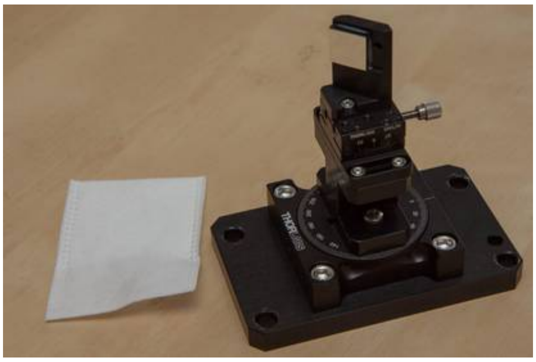
 

At the end, you can check that the fiber axis is at 102mm above the bench.

There is no optical test to make at this stage.

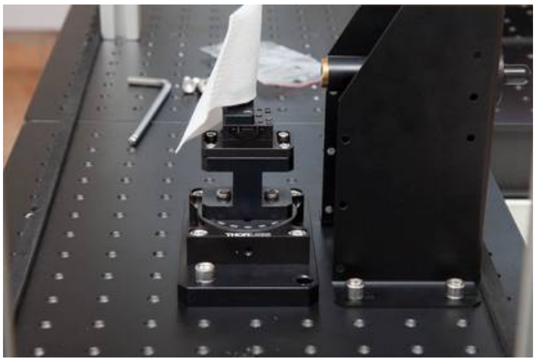


10 Input mirror holder

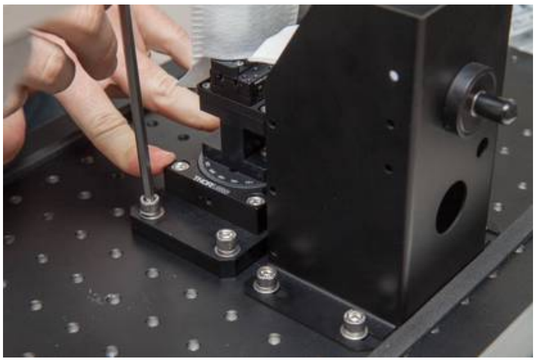


The input mirror reflects the light coming out the fiber at 45°, towards the long axis of the instrument. The optics inside the fiber module makes a transportation of the fiber image on the input mirror. The mirror can be tuned precisely (horizontally and vertically) to make sure that all the light is going in the instrument (no vignetting effect).

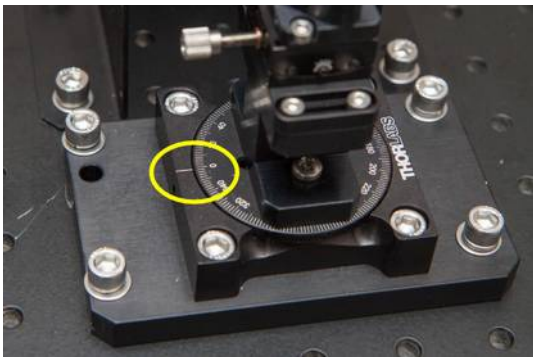
Install the mirror holder on the optical bench. The exact position (holes) is as follows :

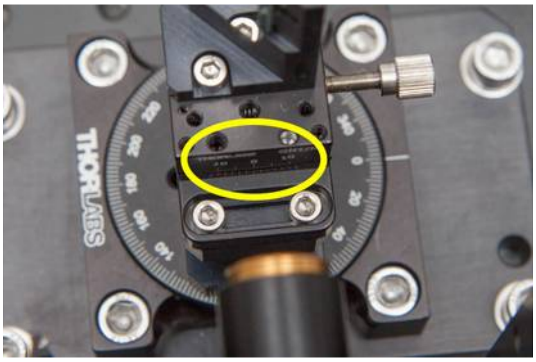


Use M6x16 screws (with plate washer & spring washer).



Put the horizontal and vertical tuning in nominal position. The final and precise angle will be tuned later in the process.



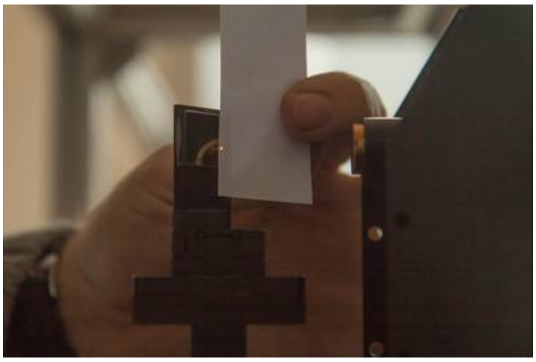


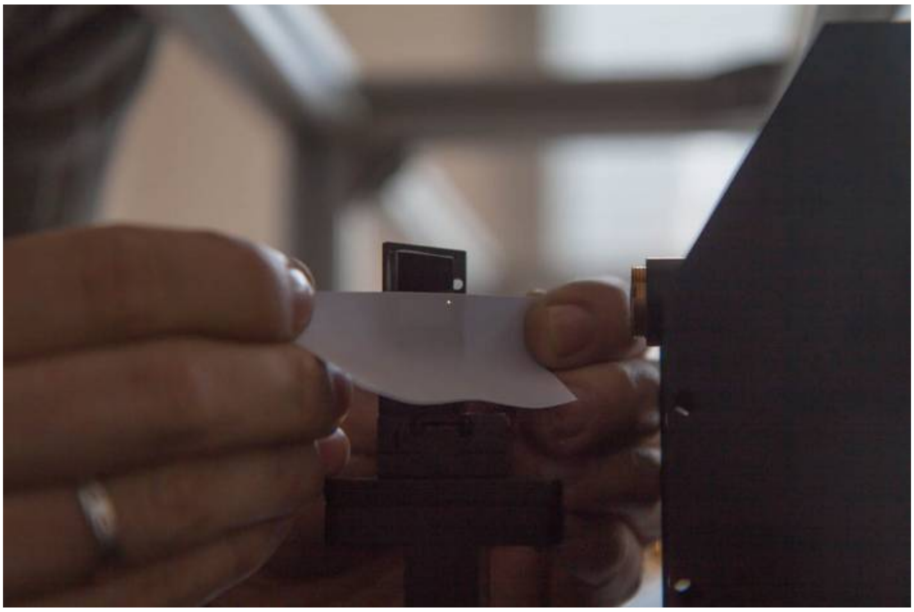
Illuminate the fiber with a strong light source (white LED).

Remove the fiber connector cap and plug the fiber in the FC connector. Take care of the index in the connector.

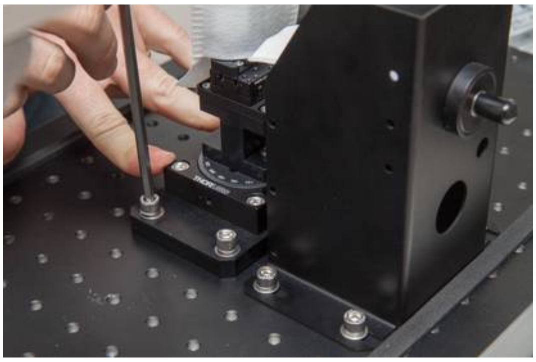
Make the spot coming out the fiber is focused on the mirror, about 1mm from the edge, and at mid height of the mirror vertically (102mm from the optical bench surface).

Since it is very difficult to see an image on the mirror surface, you may put a small piece of paper in front of the mirror (make sure not to damage its surface ; paper must not be in contact with the mirror surface).

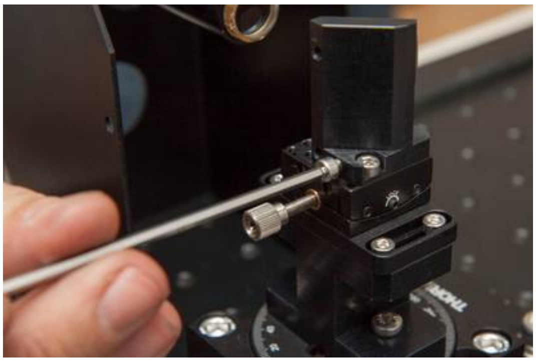




If the spot is not properly positionned (1mm frm the mirror edge and 102mm from the optical bench), untighten the whole module (input mirror), and slightly correct it – then re-tighten the screws.

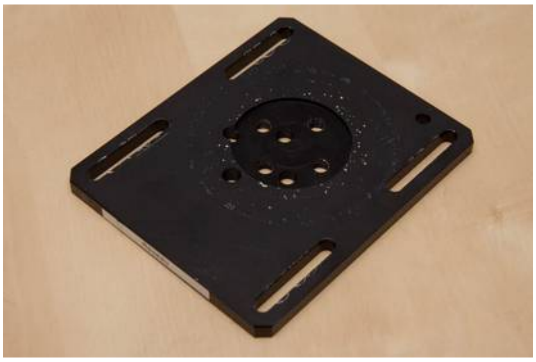


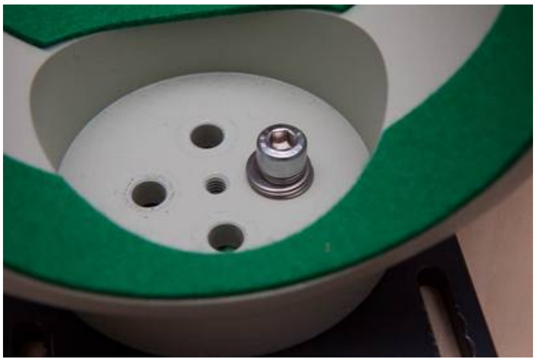
The remaining M3x6 screw (the last one in the screws bag) is made to attache (later on) the mask ; you can put it in place on the mirror holder temporarly.



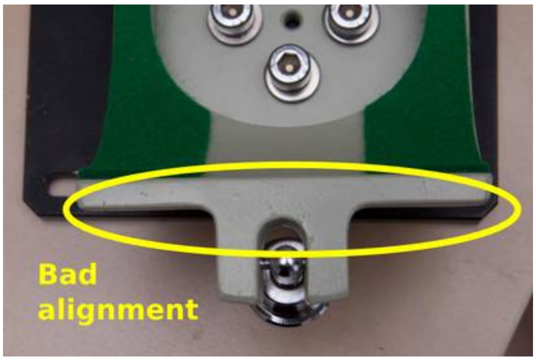
11 Collimator telescope

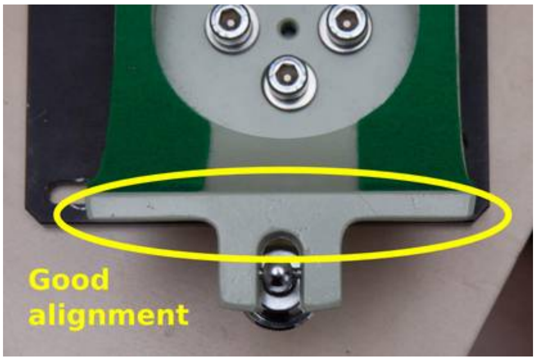
Assemble the first Takahashi ring on the first lens plate. Put the plate in the right direction / position. Use 4 M8x20 screws, with 3 plate washer and 1 spring washer each.






Make sure the telescope ring is perfectly parallel to the holder.





Put the Takahashi telescope #1 in its holder ring. Let 10mm from the ring (this will be useful for making a good alignement later on).


Close the ring.

Remove the adapter rings at the rear end.

Install the Takahashi focal reducer (x0.73) on the telescope. Tighten it gently.

The gap between the focuser body and the first black ring must be 12mm : tune this position with the telescope focuser, and tighten the focuser (bottom lever). The Takahashi focuser will not be used anymore.

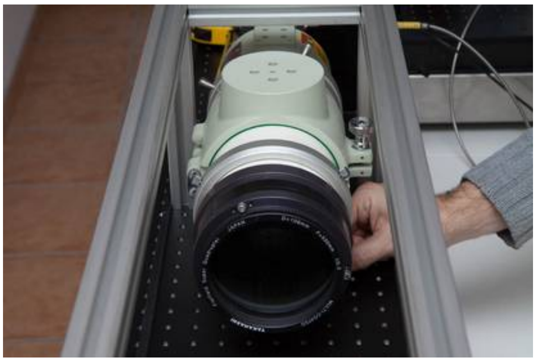
Remove the telescope cap, and the dew shield from the telescope. To remove the dew shield, tighten the two screws, then unscrew the whole shield. Keep the cap and the dew shield in a safe place (no more needed in the eShel+).

Put the collimator assy on the bench.

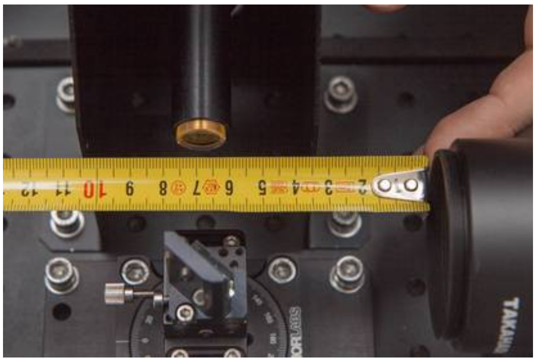
Remove the cap from the focal reducer, and put it in a safe place.

Put 4 M6x16 screws (plate washer + spring washer for each) to attach the telescope on the optical bench. The optical axis of the telescope is at

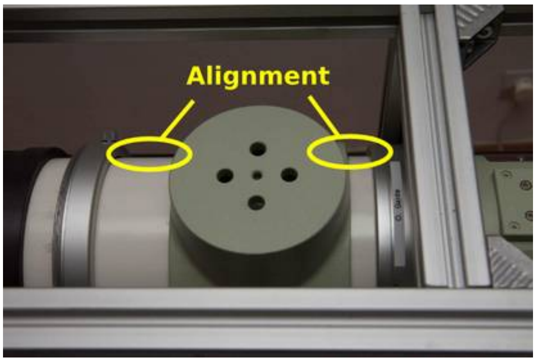
150mm from the side edge (centered in the optical bench).



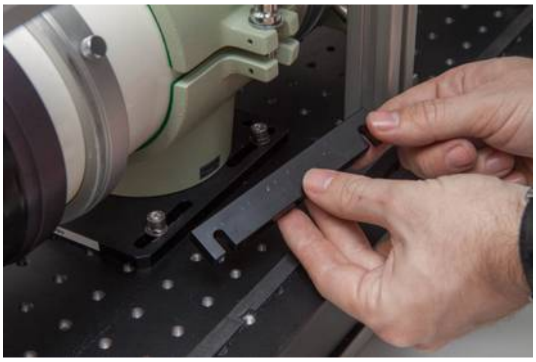
The end of the lens (body of the focal reducer) must be at a distance of 69mm from the light spot on the input mirror.



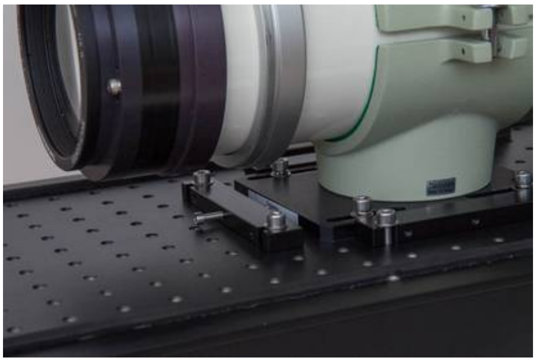
Make sure that the lense axis is exactly parallel to the bench edges (visual control is enough).



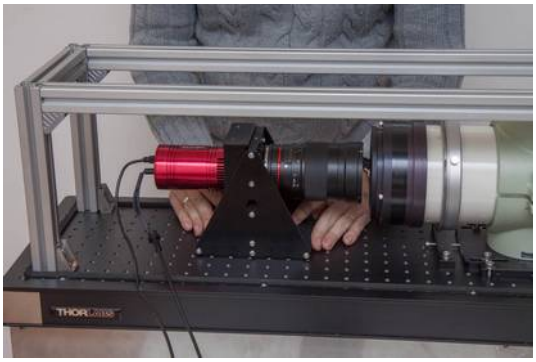
Use two tuning tools to guide the plate on both sides (attached with 2 M6x16 screws + plate & spring washer each).



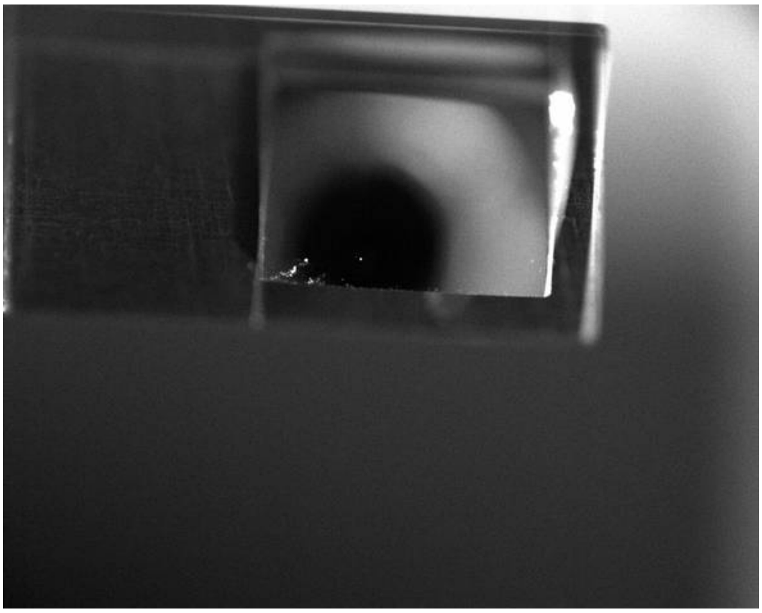

Use a third tuning tool to make a fine focus tuning (attached to the bench with two M6x16 screws & washers, and using a M4x40 screw for the tuning)



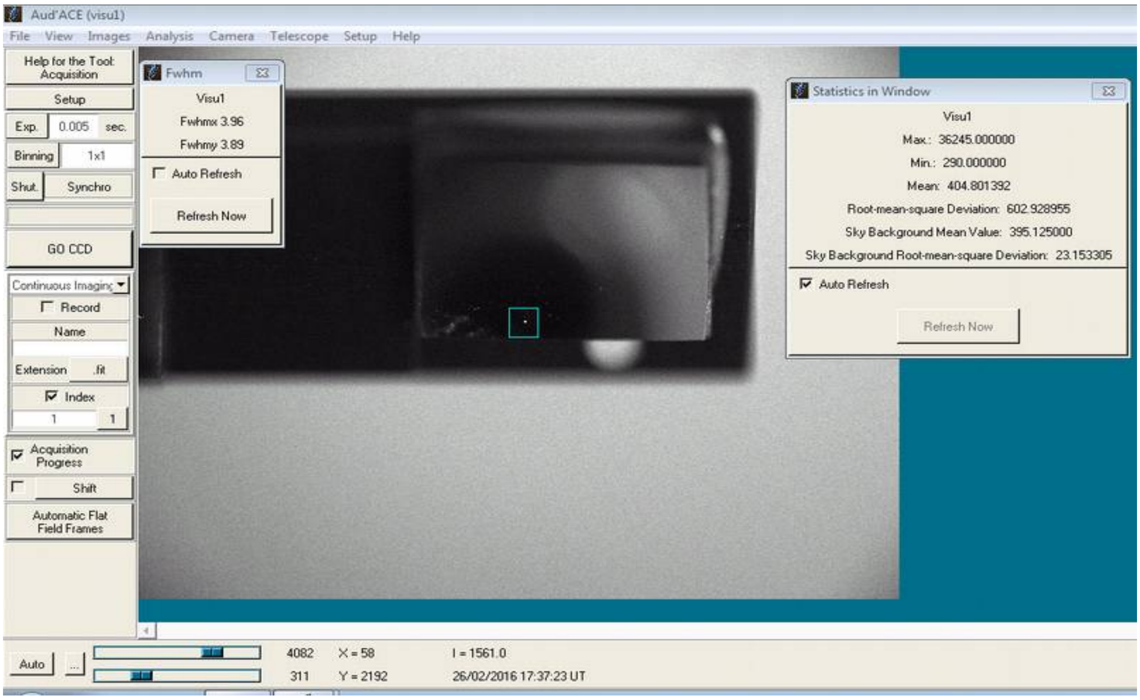
Put the CCD camera module in front of the telescope (where the grating module will take place afterwards). Check that both optics are well aligned.




Switch on the source light in the fiber and acquire images from the CCD camera : you should see the fiber image, and the whole mirror.



Precisely adjust the focus of the telescope in such a way that the fiber image is as small as possible. Images must be take in binning 1x1, and the fiber image must not be saturated. With 50µm fiber and Atik 460EX camera, the FWHM should be around 3,9 pixels.



Note : the angle of the input mirror has no effect at this stage on the fiber image position in the CCD. You can play with the mirror angle tunning, and check this. This is because the fiber image on the mirror is the physical source for the collimator lense

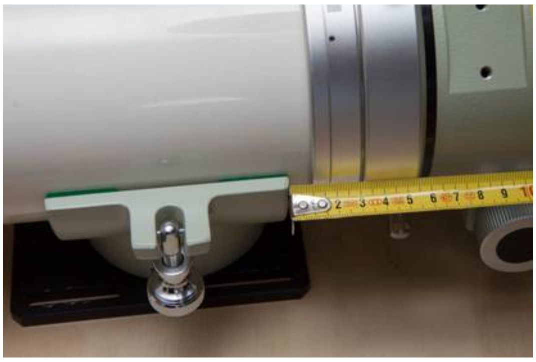
12 Objective telescope

Most of steps are exactly the same as for the collimator telescope.

Assemble the second Takahashi ring on the second plate. Put the plate in the right direction / position (see picture). Be careful : the position/ direction is different from the telescope #1.

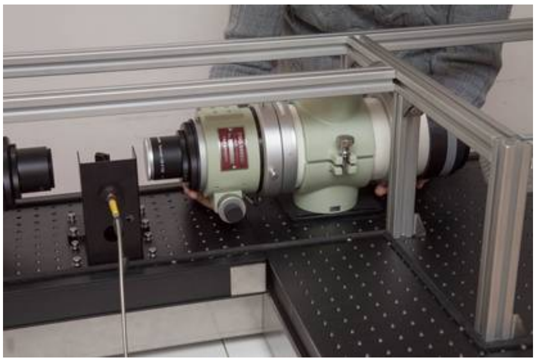
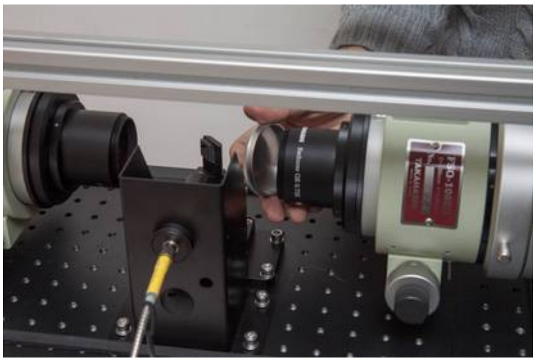
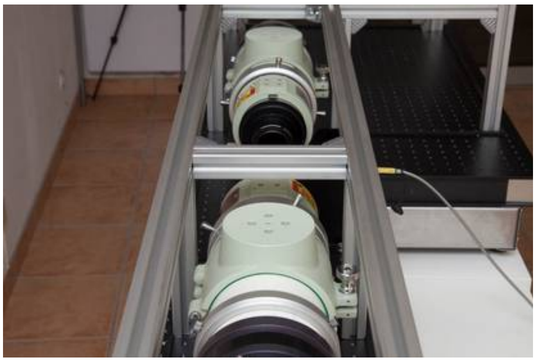
Put the Takahashi telescope #2 in its holder ring. Check that the telescope body is perfectly parallel to the plate.

Install the Takahashi focal reducer (x0.73) on the telescope. The gap between the focuser body and the first black ring must be 12mm : tune this position with the telescope focuser, and tighten the focuser (bottom lever). The Takahashi focuser will not be used anymore.

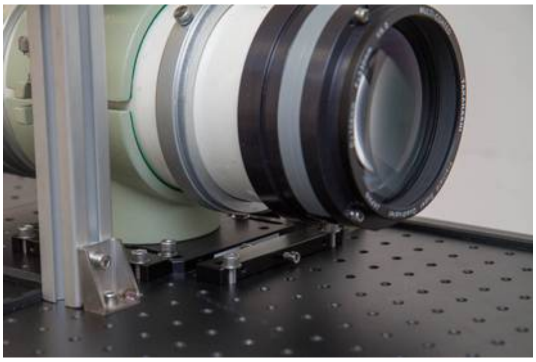


Remove the telescope cap, and the dew shield from the telescope. To remove the dew shield, tighten the two screws, then unscrew the whole shield. Keep the cap and the dew shield in a safe place (no more need in the eShel+).

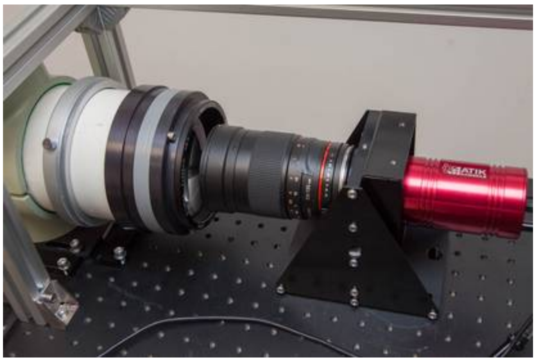
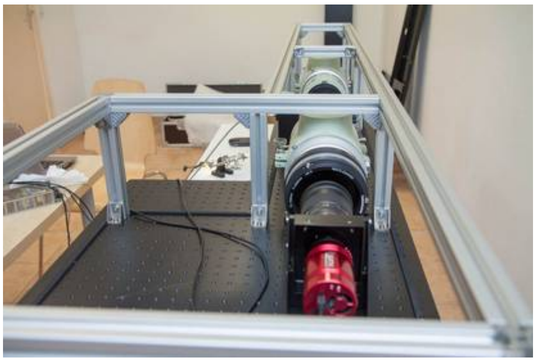
Remove the rear cap (from the focal reducer). Put the collimator assy on the bench, at a distance of 138mm from the telescope #1 (it is symmetrical from the input spot on the mirror : 2 x 69mm). Make sure that the lense axis is exactly parallel to the bench edges (visual control is enough). Attach the module to the bench with four M6x16 screws, with one flat washer and three spring washer for each.


Use two tuning tools to guide the plate on both sides (attached with 2 M6x16 screws). Use a third tuning tool to make a fine focus tuning (attached to the bench with two M6x16 screws, and using a M4x40 screw for the tuning)



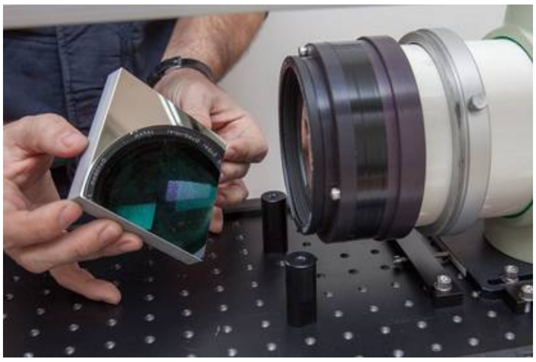
Put the CCD camera (with the lens) in front of the telescope #2. Check that both optics are well aligned.

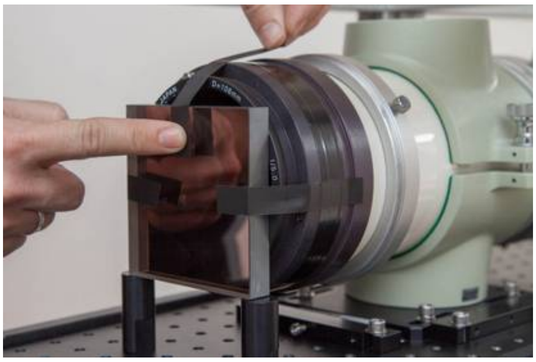



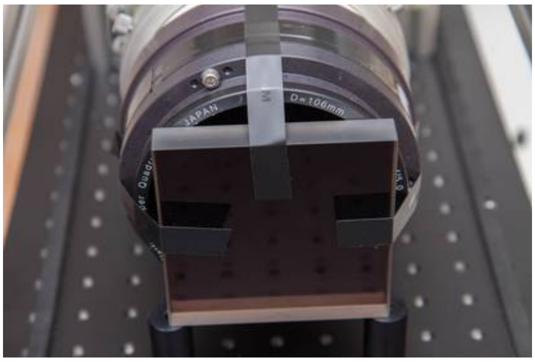
To make an image of the fiber with the camera at this position, we must send back the beam coming out the telescope #1 towards the telescope #2. To do this, put the flat mirror (only used during the tuning), at the end of the telescope #1. By doing this, we make a symmetrical system, and we should see exactly the same image of the fiber.

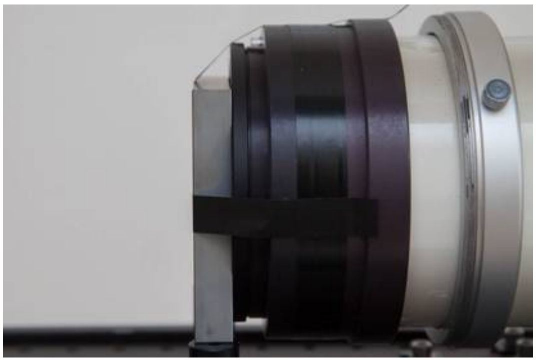
Install two legs (same as for the prisms holder) in front of the telescope #1

Install the flat tunning mirror at the end of the telescope #1. Attach it gently with adhesive tape, and make sure it is well stuck on the telescope body.

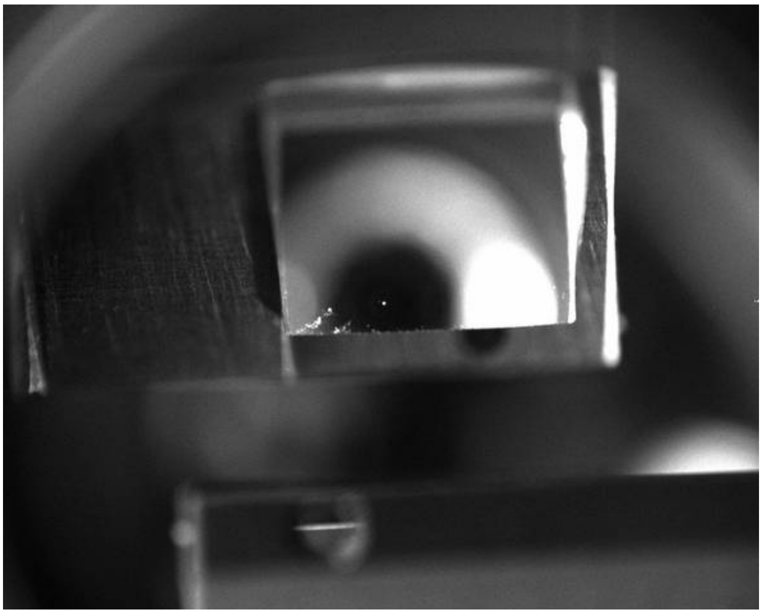




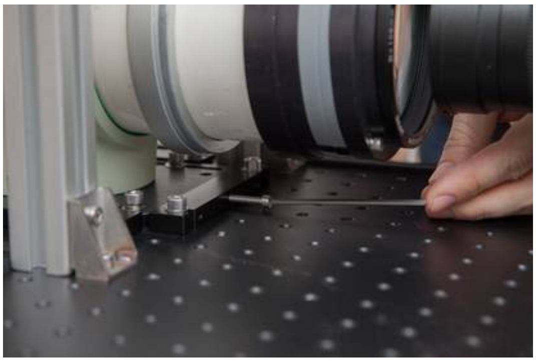




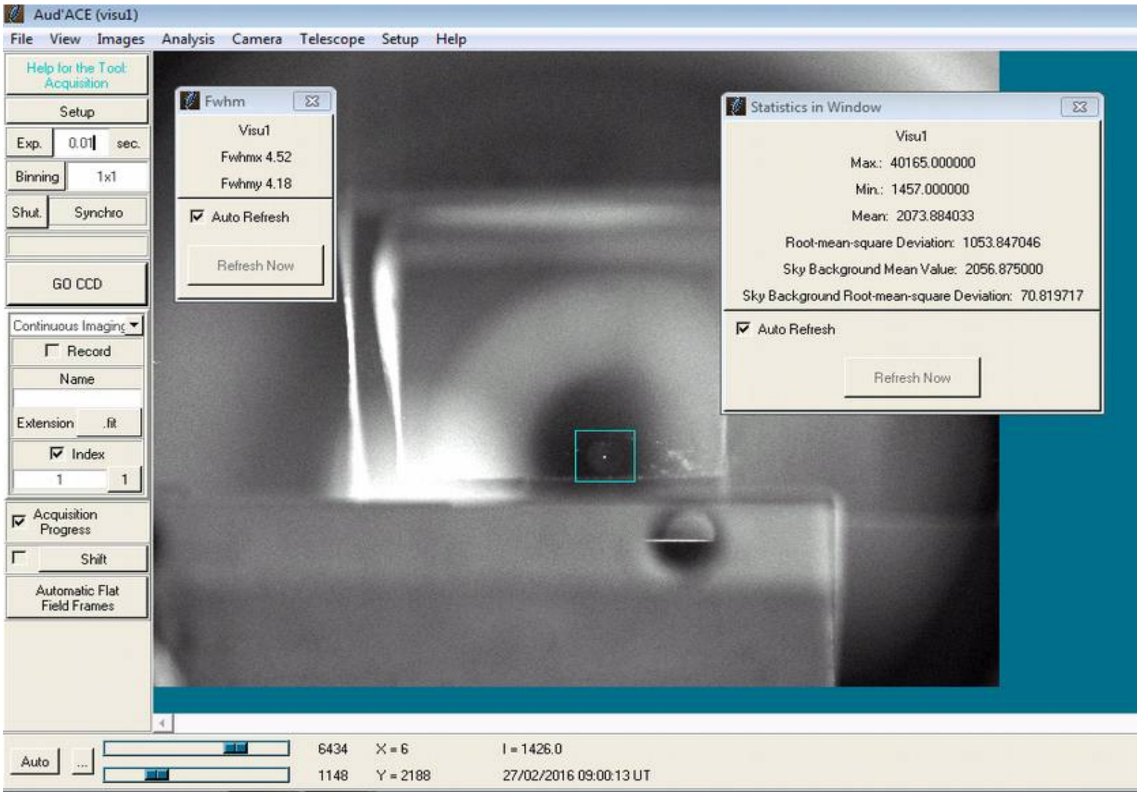
Switch on the source light in the fiber and acquire images from the CCD camera : you should see the fiber image (like with the telescope #1), and the whole mirror… two times ! (one from the front, and the other from the rear - symmetrically).



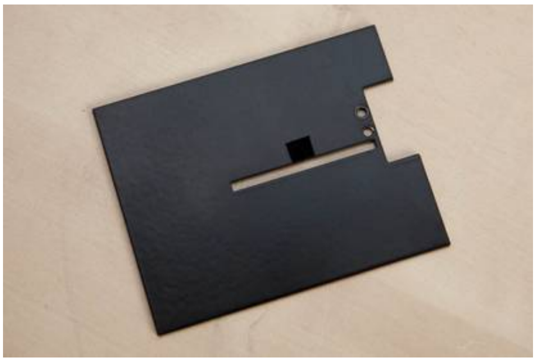
Focus the image using the tuning tool and the M4x40 screw.

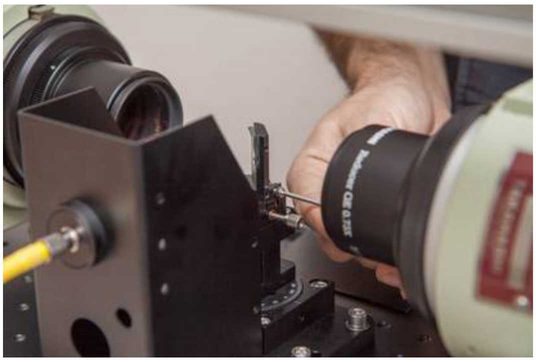


The fiber image size sould be the same as with the telescope #1 (because we've added a symmetrical system). The FWHM should be around 3,9 pixels (Atik 460EX).

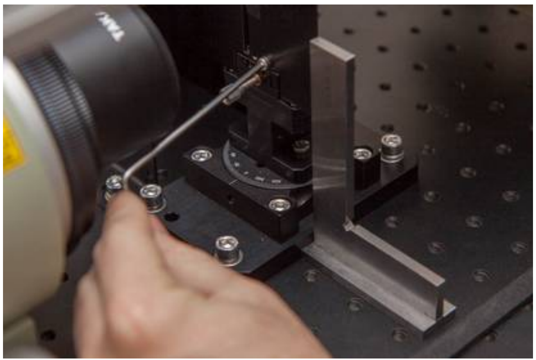


When the focus is done, put the mask on the input mirror holder. Use one M3x6 screw (already on the mirror holder). Make sure that the slit is perfectly vertical (with the optical bench as reference) – use the set square to check this.

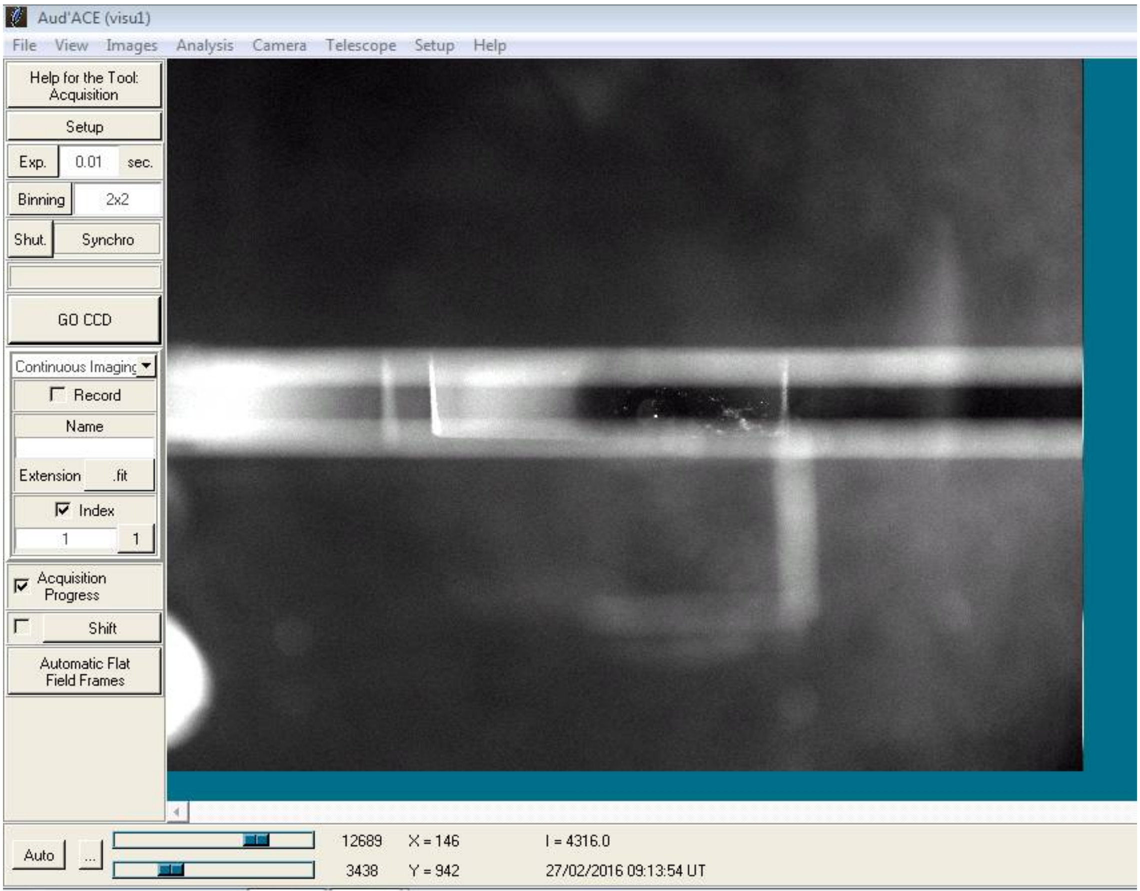




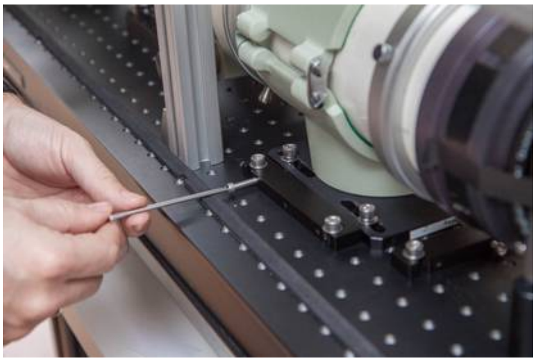
This mask has two functions. The first (main) one is to reduce as much as possible any parasite light (specially reflections around the input mirror). The second function is to make visible the nominal position of the optical axis to help with the alignement of both telescopes, and prevent any vignetting.



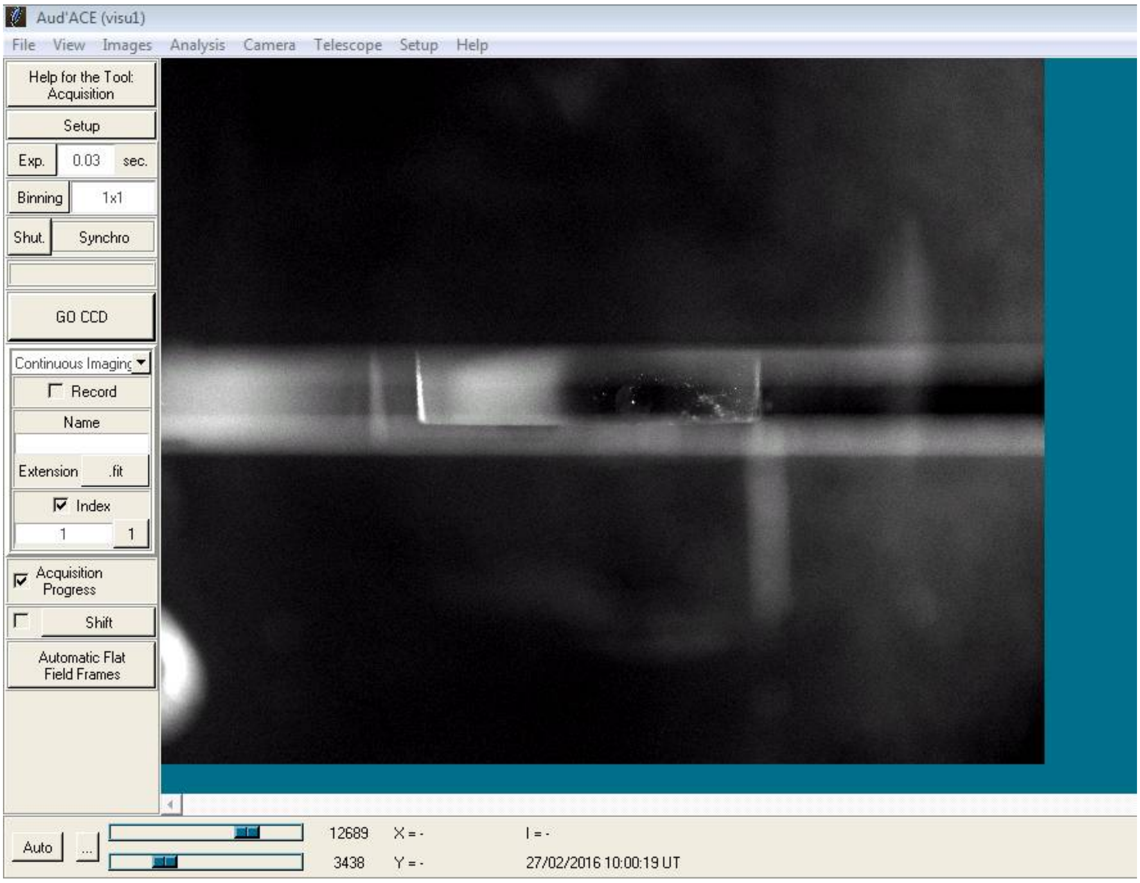
Make that the fiber image is well centered in the mask slit. At the beginning, it is probably badly centered :



In this case slightly rotate the telescope #1, without losing the focus ; use the tuning tool to lock its axial position, and add screws on the side of tuning tools to help making a very precise tuning. It is very sensitive : you can use the side tools (along the telescope plate) to help you.



At the end, you should see something like (bottom image below):



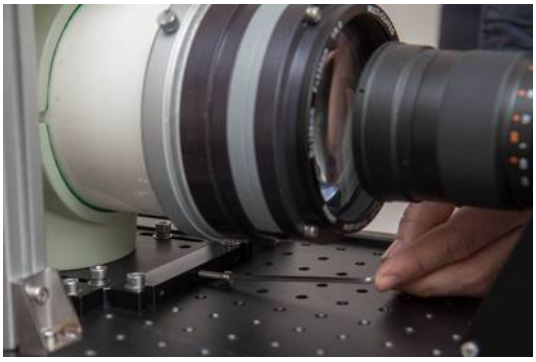
When the tuning is optimal, tighten gently the telescope #1 plate on the optical bench.

Note : You can move the slit& fiber image vertically either by rotating the camera module around a vertical axis, or by rotating the telescope #2. The best result is achieved when :

- the fiber image is vertically centered in the CCD,

- the camera lens and the telescope #2 are perfectly aligned (a visual alignment is enough).

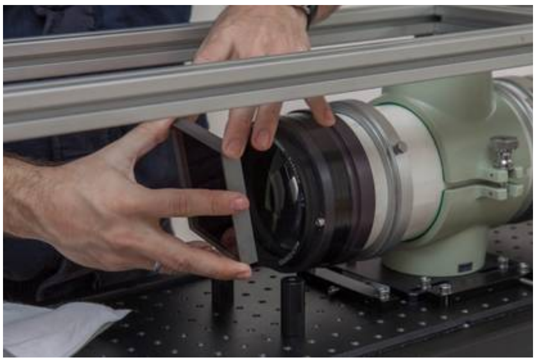
When this alignement is done, tighten the side tuning tools around the telescope plate #2, and fine tuned, if required, the fiber image size (FWMH).



Then, tighten the telescope #2 plate on the optical bench.

At this stage, you've made the most critical alignement : the beams coming through the two telescopes are perfectly aligned. You now have simply to add the two dispersers (main grating and prisms) to spread out the light coming out from the fiber.

Remove the flat mirror from the telescope #1 back end. Put it in a safe place : it is not required anymore in the instrument (but it can be used to transform the eShel+ in low resolution spectroscope).

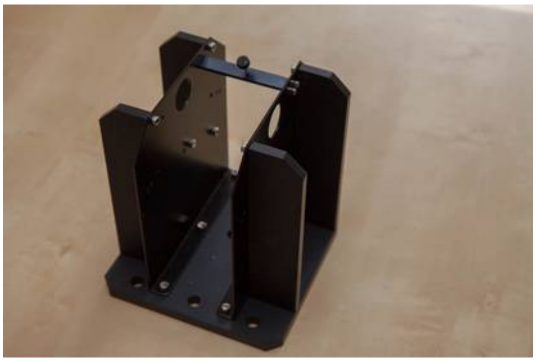
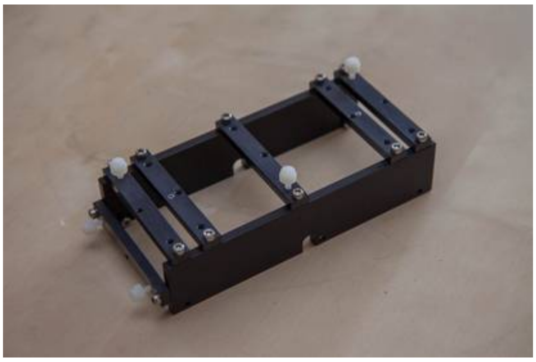


13 Main grating

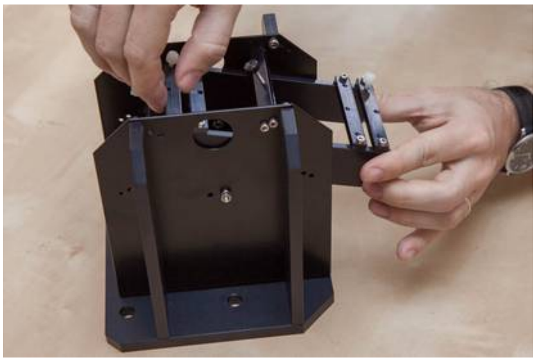
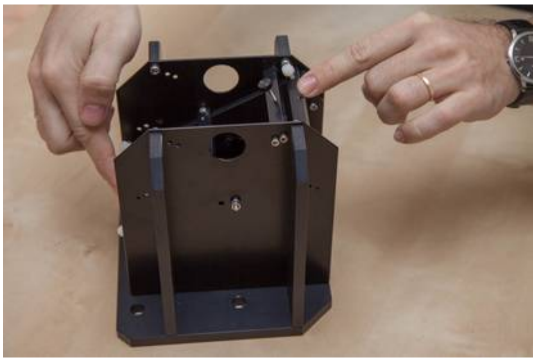
The grating holder is pre-assembled. But the grating itself is carefully packaged to prevent any damage during transportation.

Warning : the grating is **very fragile**. Never touch the grating surface (with finger, or any tool) : it would be definitely destroyed.

The grating holder is made of a fixed part, and a mobile part. The mobile part can rotate in the fixed part to tune precisely the grating angle.

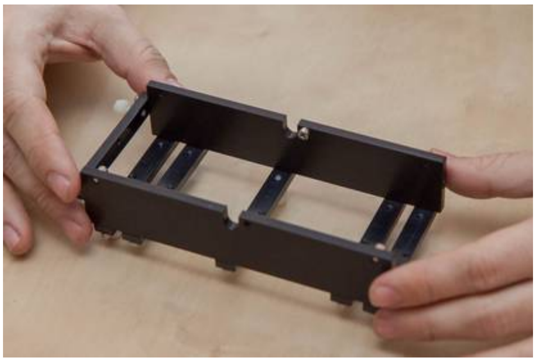
 

You can check how these two parts work together :

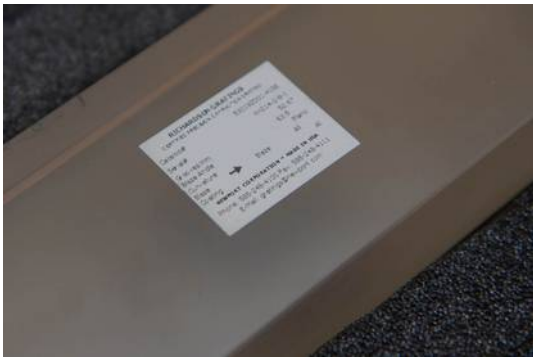
Now, let's install the grating in the mobile part.

Put it on the table, with the plastic screws toward the table.

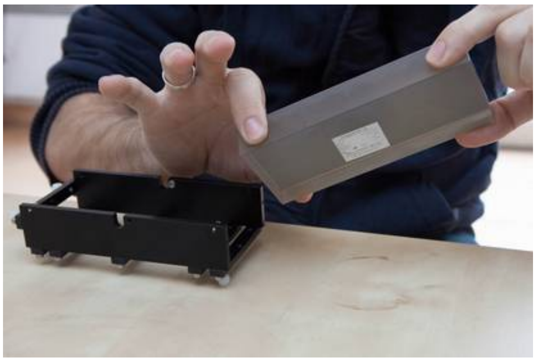


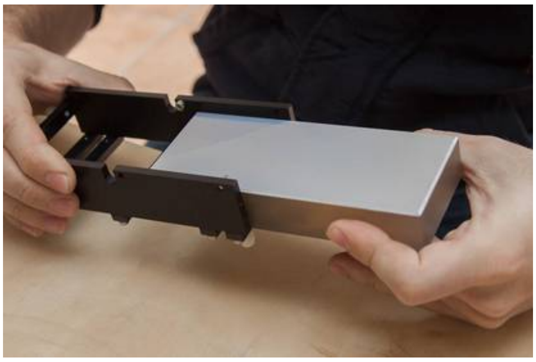
Open the grating packaging. You can see the the packaging is made in such a way that the grating surface never contacts anything.

Look at the blaze direction. It is indicated on the back surface of the grating :

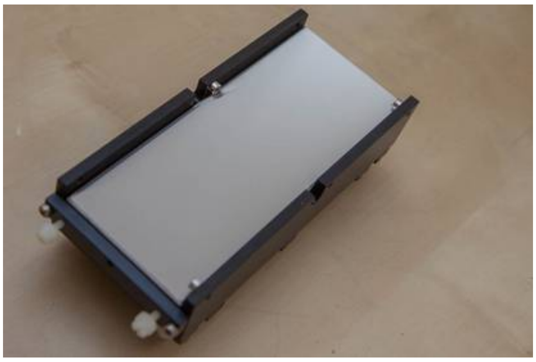


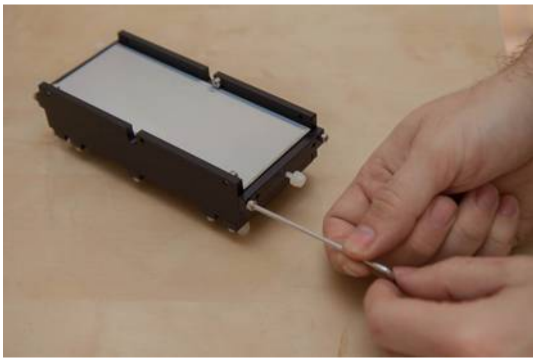
Slide the grating inside the mobile holder, with the blaze direction towards the open end of the holder. The grating surface must be towards the roof. Make sure, during the sliding that the grating surface is never in contact with the 3 screw heads above the surface :





Assemble the grating closing beam, with two M3x12 screws. Before assembling, check that the tuning plastic screws are cleared out.



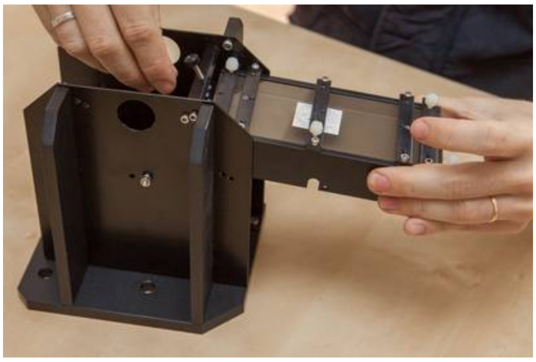
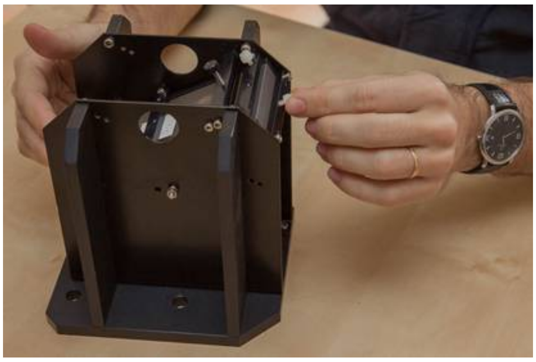


Gently tighten the 3 plastic parts around the grating

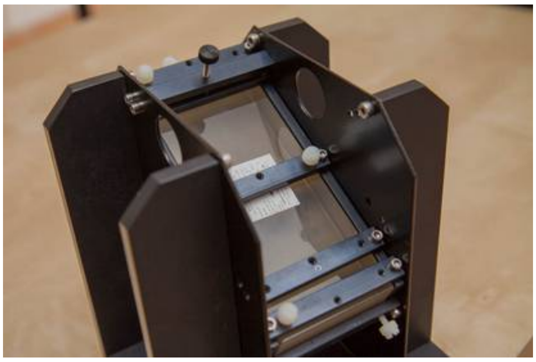
Gently tighten the 3 plastic screws BELOW the mobile holder. This will push the grating towards the three screw heads. This must be done keeping the grating surface towards the roof.

When this is done, the grating is locked in the mobile holder.

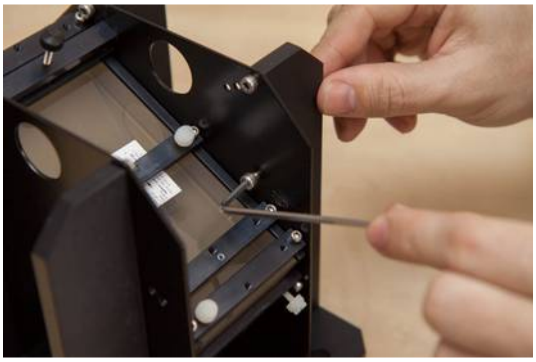
Return the grating mobile holder, and slide it in the fixed holder. Refer to the below picture for the orientation :

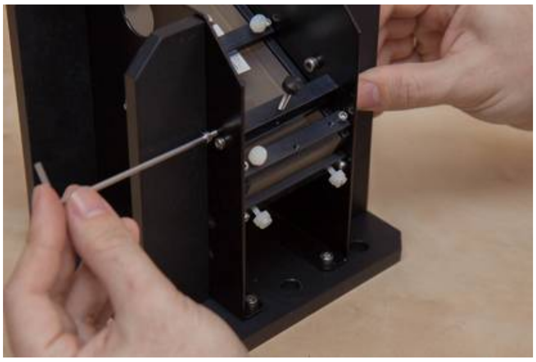
Once in place, the grating blaze direction must be towards the top.



Put two M4x8 screws inside the grating holder (one on each side).



Put the tuning beam above the grating with four M3x8 screws.

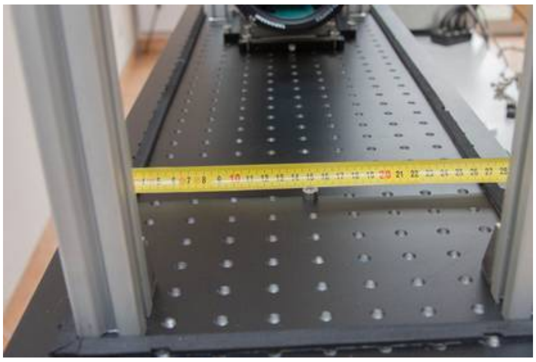


The grating holder is done ; you can precisely tune the grating angle with the two thumb screws.

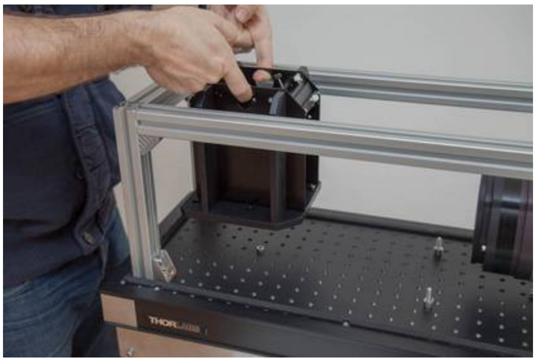
We can now intall the grating holder on the optical bench.

Put a M6x10 screw in the optical bench at the grating axis position.

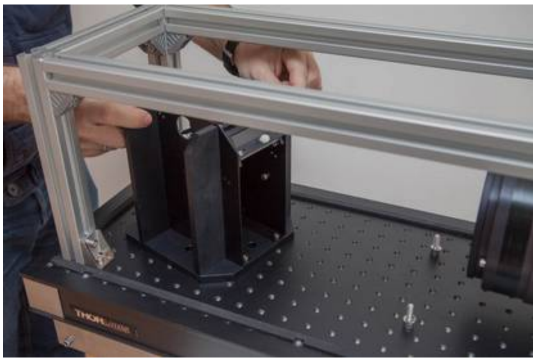
The screw head makes a physical axis around which we can make the grating module rotating. The exact position of the screw is as follows :150mm from each side, and 175mm from the bench end.

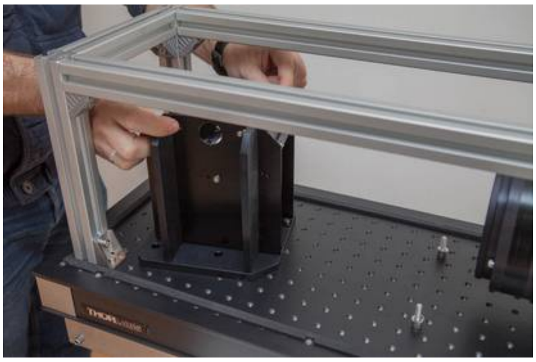


Install the grating holder onto the optical bench (use the top holes as handles).

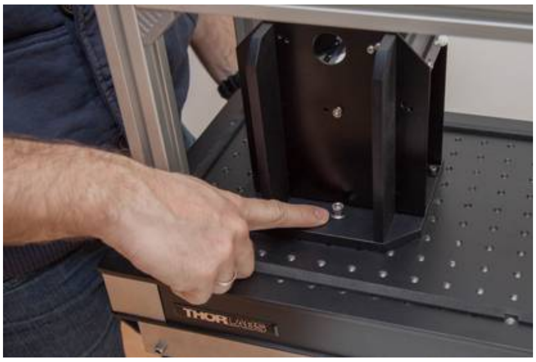


The module must be free to rotate around the M6 screw. Let it in a nominal position (parallel to the optical bench)

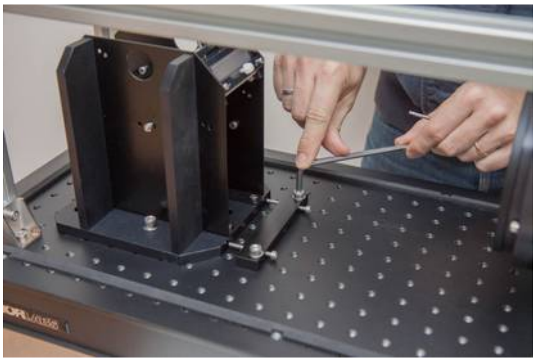




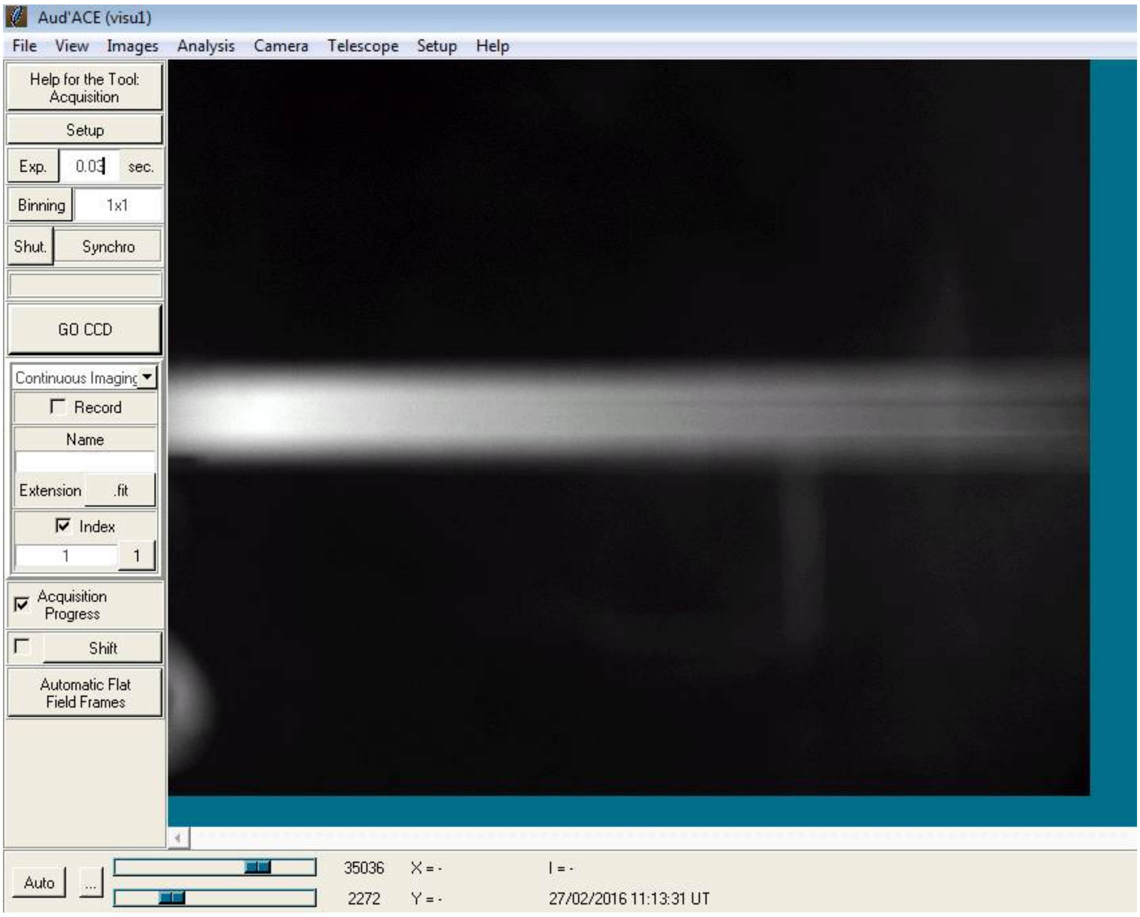
Use two M6x16 screws, with a flat washer and a spring washer for each. Do not tigthen the screws yet.



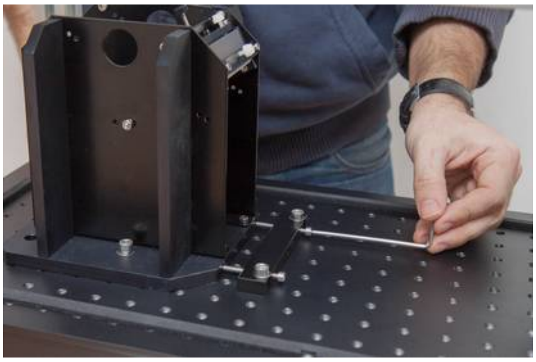
Install a tuning tool, in front of the grating base : it will help you to make a precise rotation of the grating in the next step.



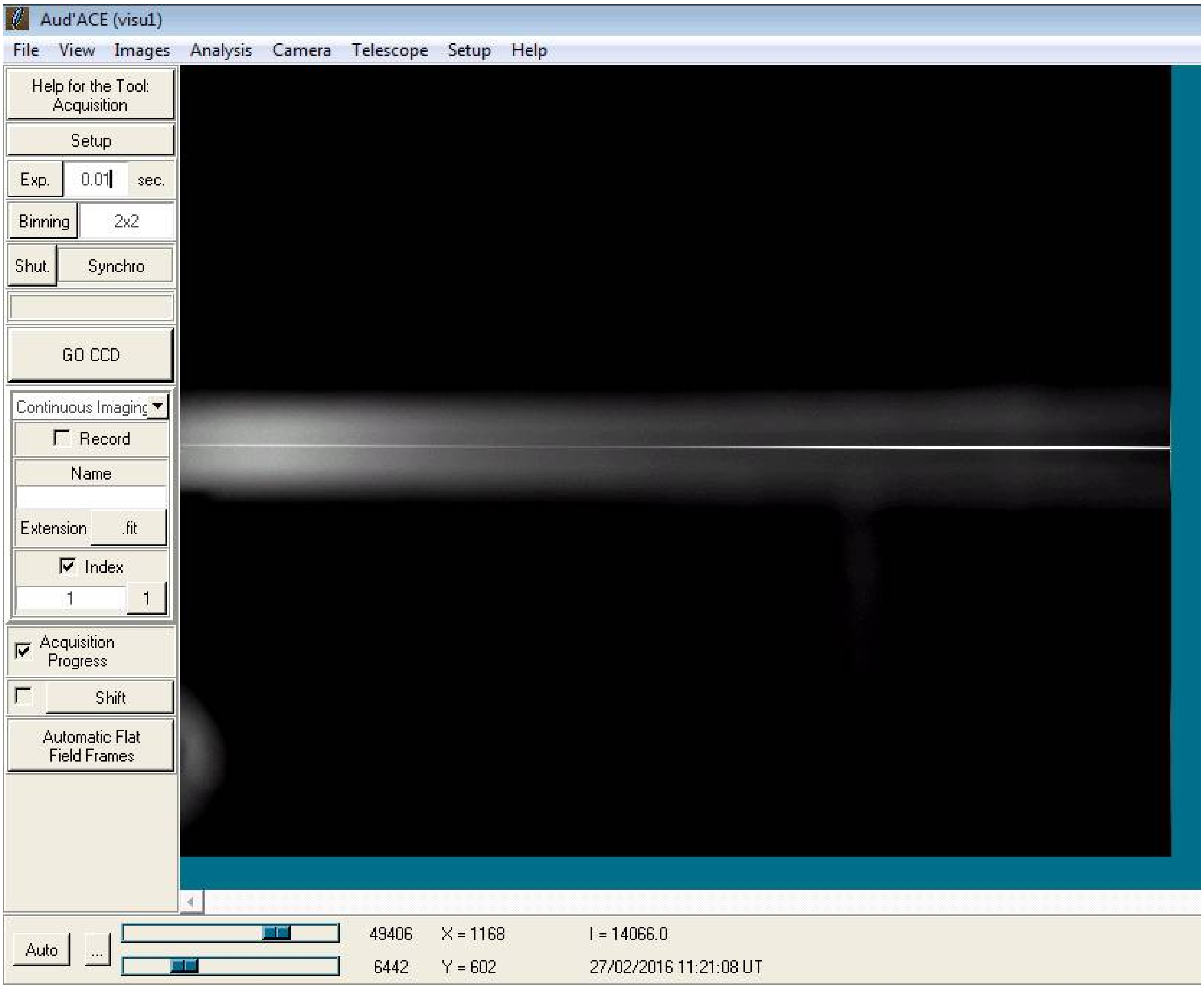
Switch on the light source in the fiber and acquire images from the CCD camera. You can see the wide slit in the mask, but probably not the spectrum itself, which is dependant on the grating holder rotation.



Rotate slightly the grating holder using the tuning tool :



When the grating is at the right position, you should now see a line along the mask slit :



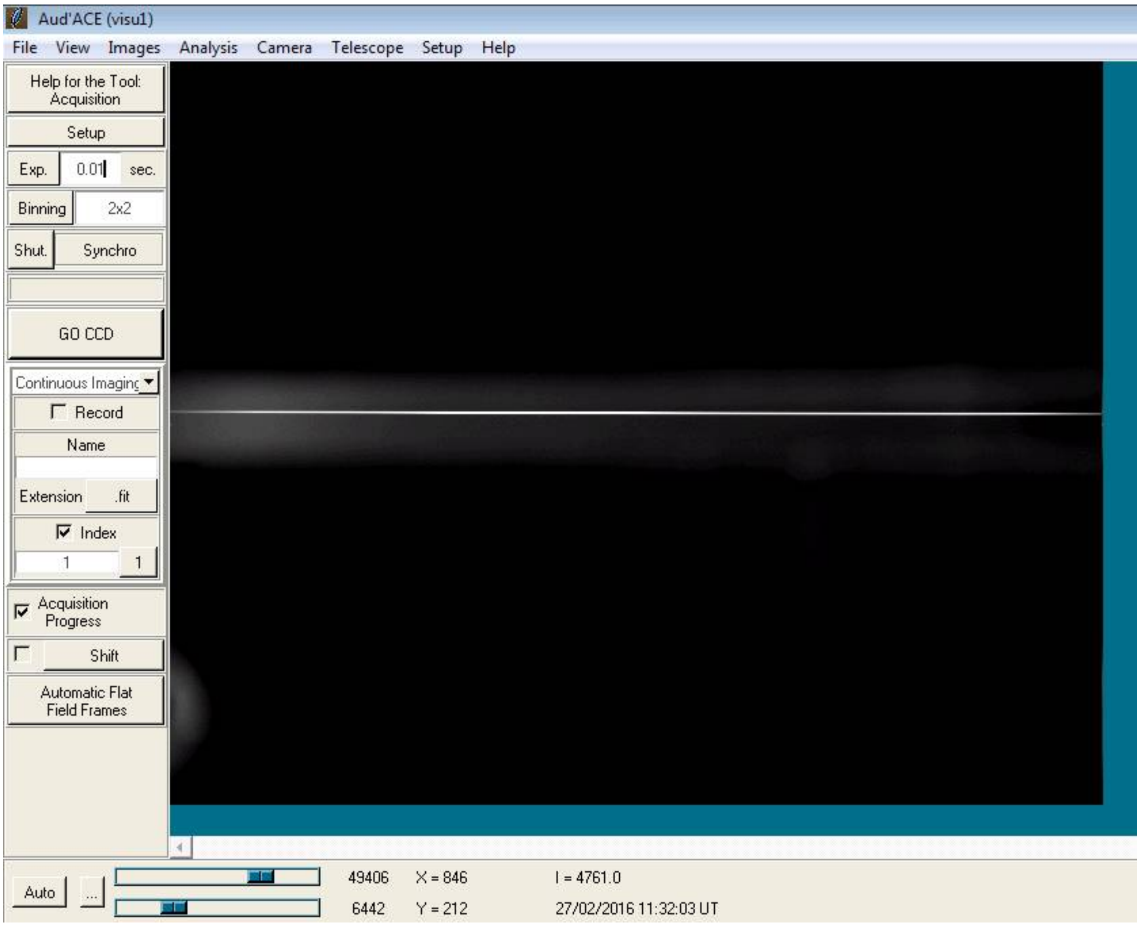
This is the image of the fiber light spread out by the main grating. At this stage, all the orders are mixed together ; this is why you can see only one line (the orders will be split by the prisms).

At the end, the spectrum must be exactly in the center of the slit.

Make sure that spectrum is exactly parallel to the slit. If not, move slightly the mask, to make the slit parallel to the spectrum.

Tighten the two screws attaching the grating holder to the optical bench

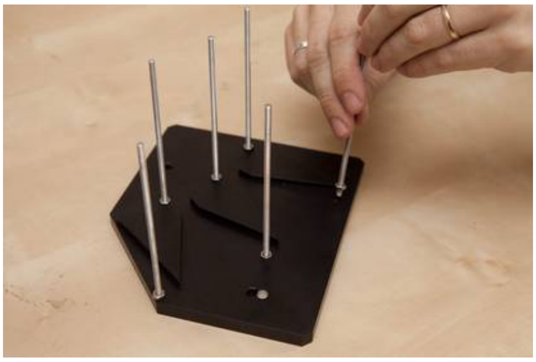
On the above image, the spectrum is brighter on the right than on the left. This is because of the grating angle in its holder. You can tune this angle, using the two thumb screws on the grating holder, and center the spectrum in the image.

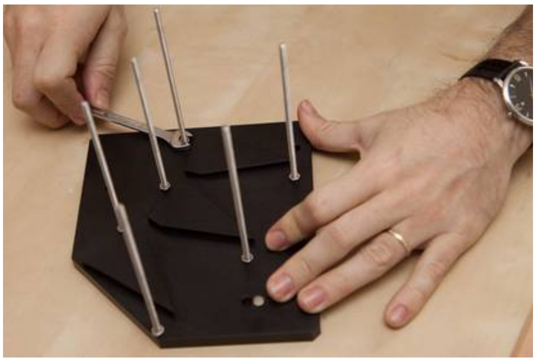


14 Prisms holder

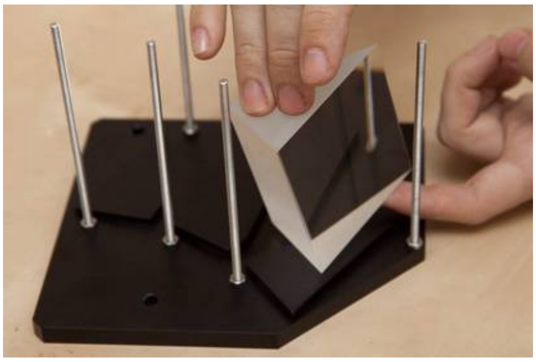
After the light is spread out by the main grating, we still must split the different orders. This is the job of the prisms.

Take the prism plate, and attach six threaded rods (120mm), with one nut each (tighten gently)

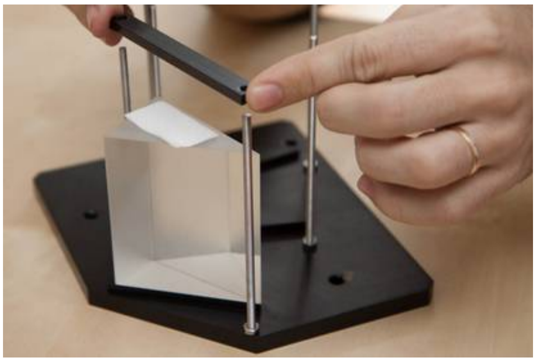




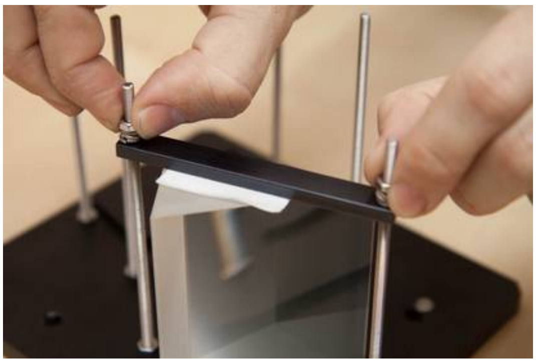
Put each prism at its exact position (given by the shape machined in the plate). Never put a finger on the polished surfaces ; take the prisms only by unpolished surfaces.



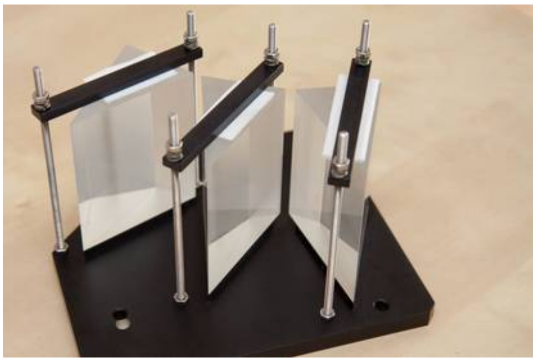
On top of each prism, put a small piece of soft material, and add the prism retainer. The soft material is there to prevent any damage on the prism when tightening the prism retainers.



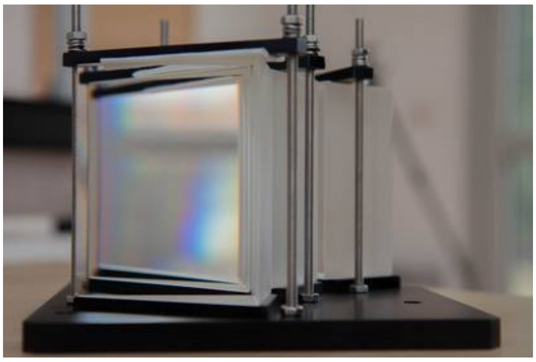
Add a nut, with three spring washer on each threaded rod, and gently tighten them. The prism must be strongly attached to the plate – but make sure that there is no risk to break them (do not tighten too much – it can be tighten by hand).



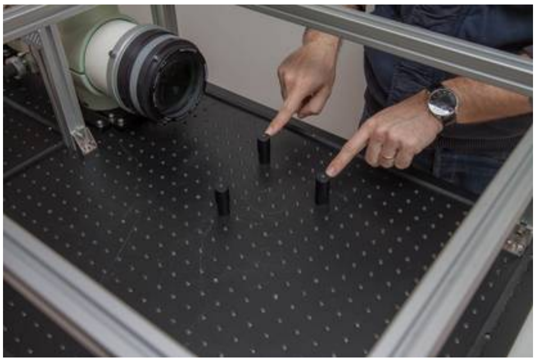
When all three prisms are in place, you whould have this assembly in front of you :

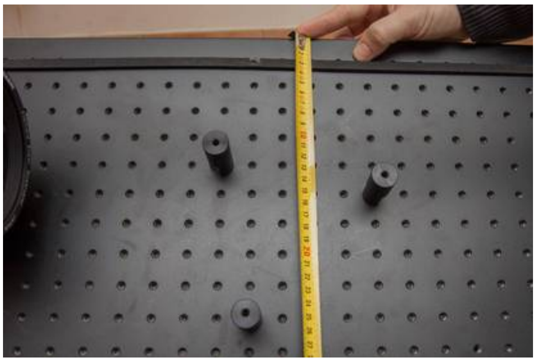


If you look through the first prism, you see that images of the three prisms are aligned !

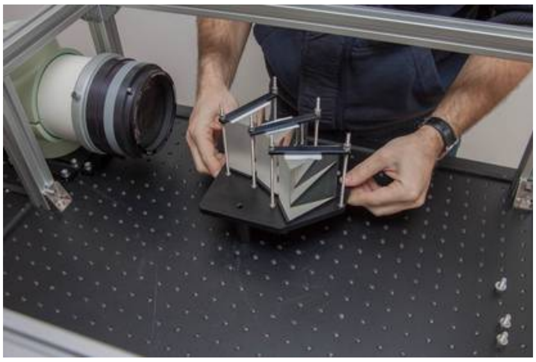


Put the three prisms holder legs at the right place on the optical bench :





Then, put the prisms plate on the legs, and attach it with three M6x16 screws (one flat washer and one spring washer with each screw).

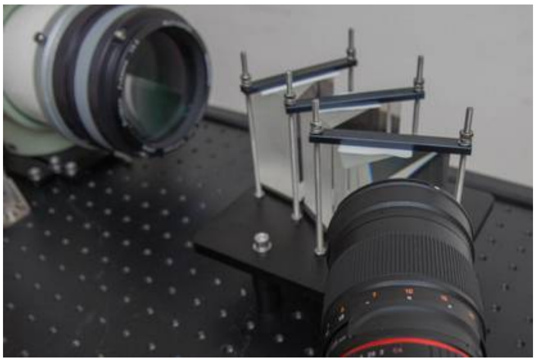


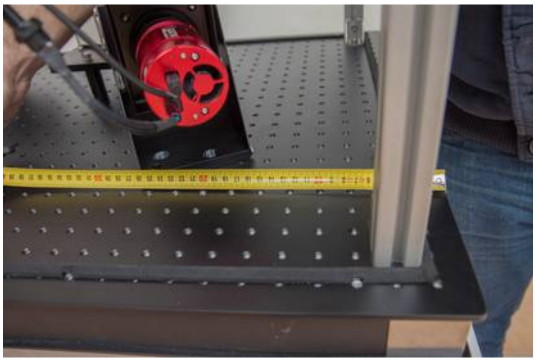
The prisms module is now in place – there is no tuning.

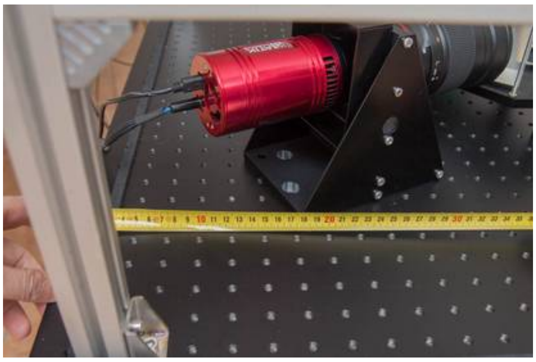
15 Camera placement

You've used the camera at several places so far ; it is now time to put it at its final position, to make echelle spectra.

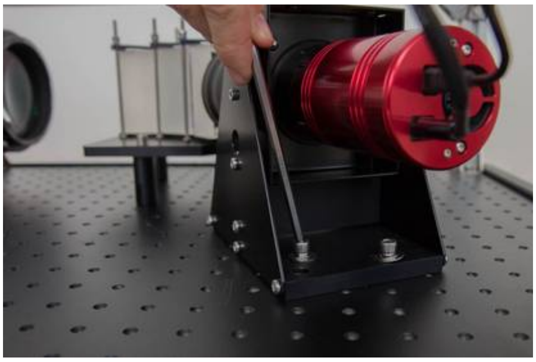
The nominal position is given by the four holes in the base plate. They must be placed at this exact position on the optical bench :



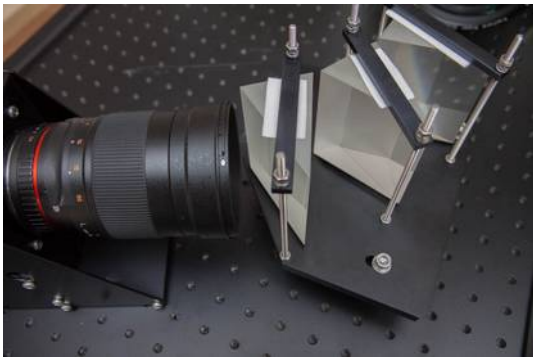




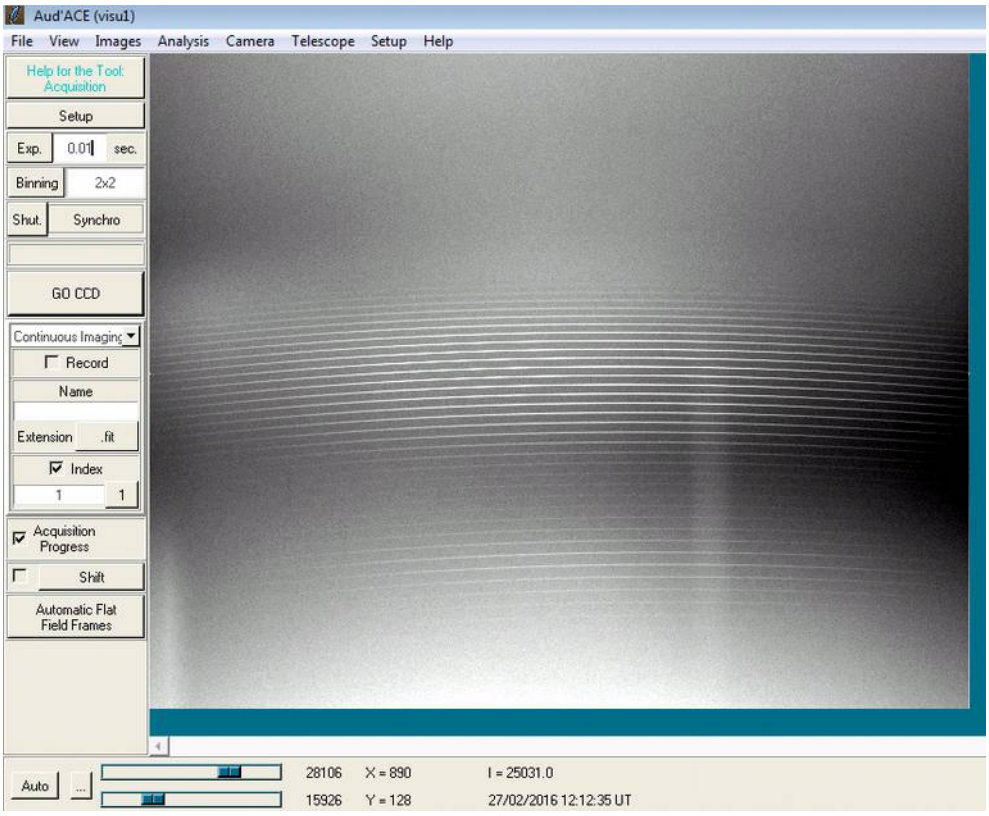
Put four (at least two) M6x16 screws, with a M8 flat washer, an M6 flat washer and three M6 spring washer each. Do not tighten the screws right now (holes are big enough to make some adjustments of the position).



The camera lens must be as close as possible from the prisms holder, to prevent any vignetting (light loss).



Switch on the source light in the fiber and acquire images from the CCD camera : you should now see the full eShel+ spectrum - congratulations !

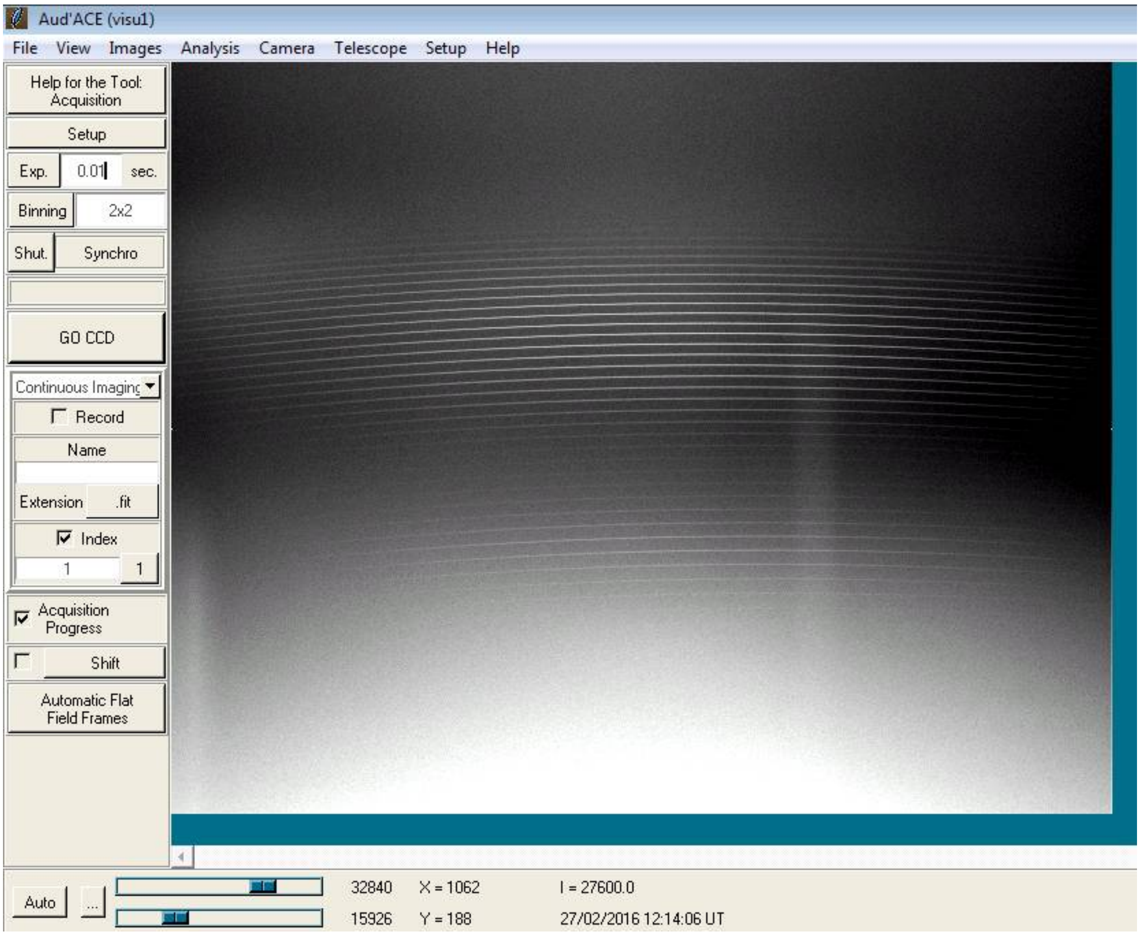


It is probable that the spectrum is not perfectly centered in the image : you have to fine tune this.

To move the spectrum horizontally, change the main grating angle. It can be done manually with the two thumb screws on the grating holder (untighten one screw before tightening the other one).

To move the spectrum vertically, rotate the camera holder around a vertical axis, close to the front lens. Keep in mind that the whole light beam coming out the last prism must be catched by the objective lens.

At the end, you must have an image like this one, covering the whole spectrum :



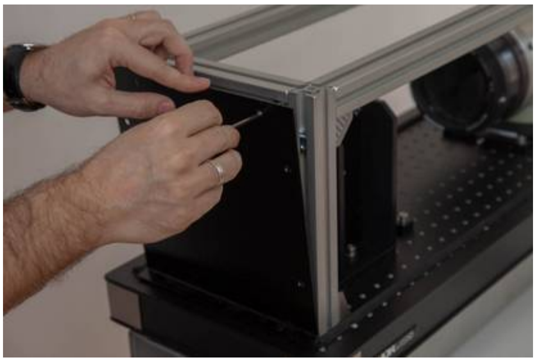
When the position is correct, tighten the screws of the camera plate (on the optical bench).

16 Cover installation

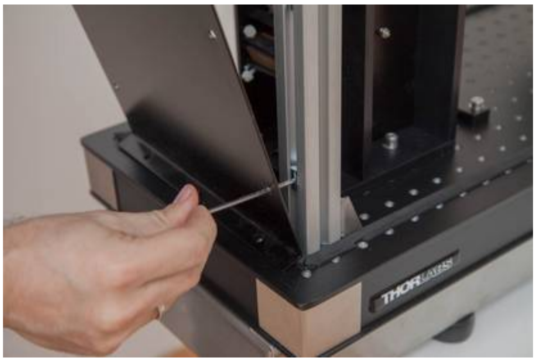
Up to now, the eShel+ spectroscope is widely open, to have a large access to any component. Even if it works quit well in these conditions, there is a high parasite light coming to the CCD – using the eshel+ with faint stars light requires to be in total darkness. Then, it is time to install the cover set.

In normal usage, we consider that only the top covers have to be opened – for instance to fine tune the focus or the grating angle. Then these covers are installed at the very end.

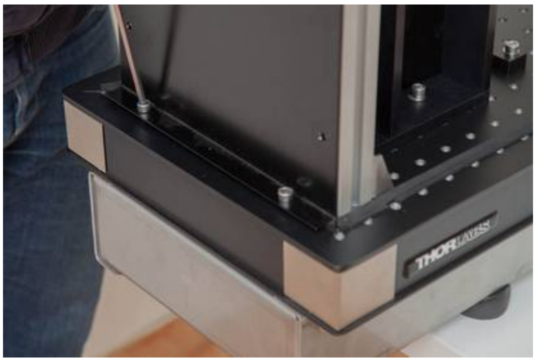
Start with the end side cover beside the grating.



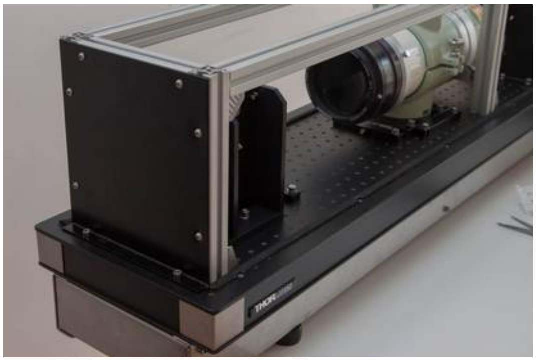
Install Bosch spring nuts in the Bosch profiles, matching each holes in the cover. Make sure each spring is aligned with the hole.



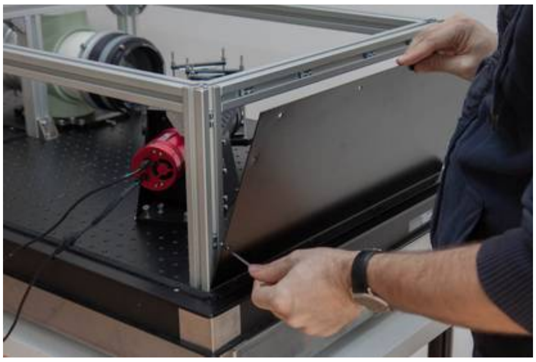
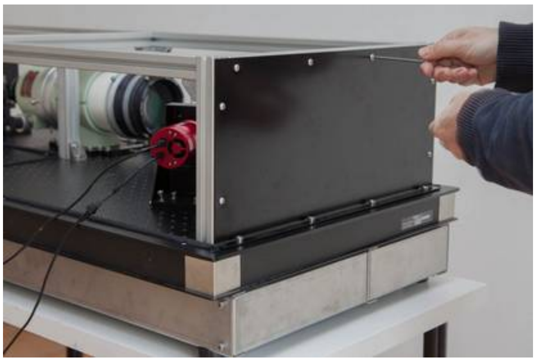
Put first the bottom screws (in the optical bench). If not already done, make a slot in the gasket (with a cutter) at the position of each screw.



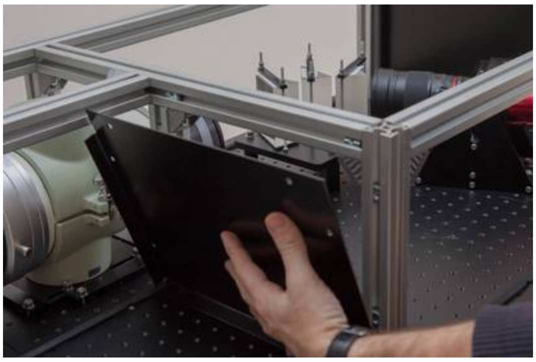
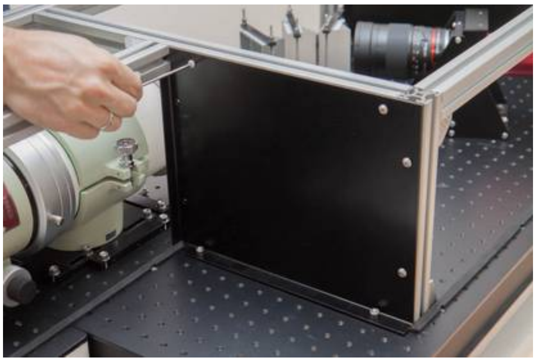
When screws are tightened, they press the gasket and prevent any light leakage, and make the top holes of the cover side in front of the Bosch nuts. When pressed, the gasket must be 2mm thick. Then, put a screw in each remaining hole in the cover, and tighten them.

The second panel is the opposite (end, beside the camera).

Third panel is the intermediate one, beside the telescope #2. Do not put the two screws in the vertical element, close to the telescope. They will come with the fiber panel.

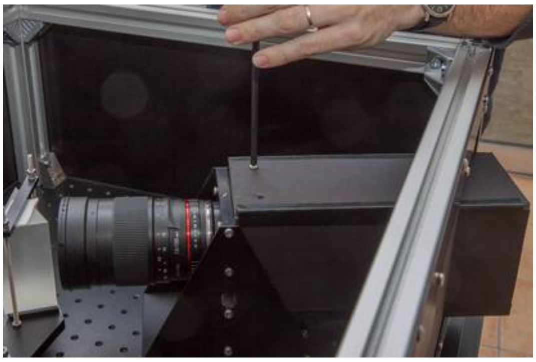
Next panel is the back side cover (the longest one).

Next is the fiber side cover. Remove the fiber from the connector, and put the cap back on the connector. Make sure to not force on the fiber connector holder when assembling the cover.

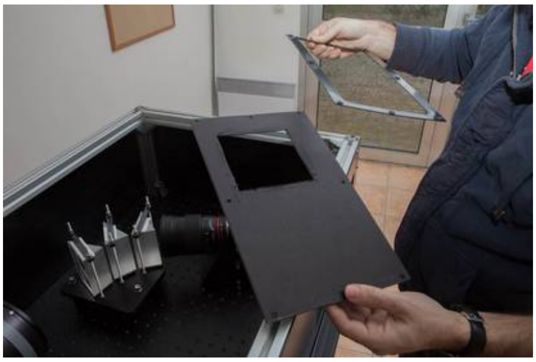
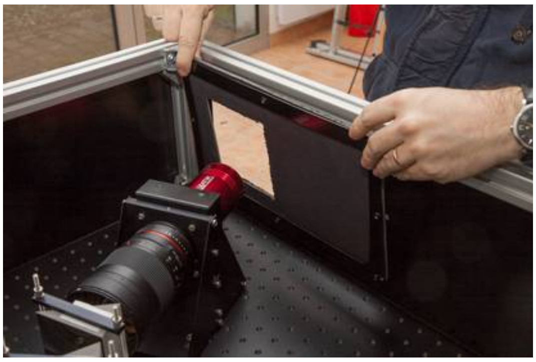
Last, install the camera side cover.

The camera cover has a large opening, to adapt to the camera holder. You can simply put a filler in the opening, with a small hole for the cables (power supply and USB). But it is better to make a tube (with carton box, for instance) around the camera, going out the sidecover : this way, the cooling of the camera is not interfering with the air inside the eShel+ cover, and the temperature is more stable.

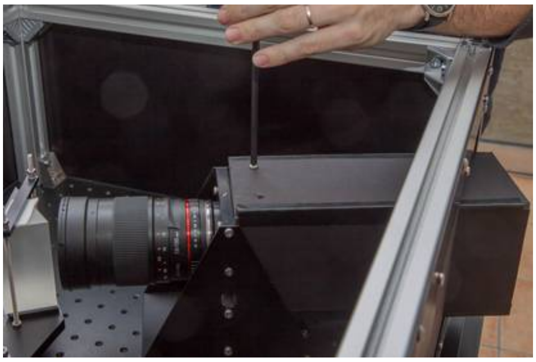
For instance, you can make this kind of coverage :



Install first the panel filler, using the counter plate with inserted nuts. Use 8 M4x10 screws.

Then, install the heat pipe, and attach it with two screws (M4x10) on the top.

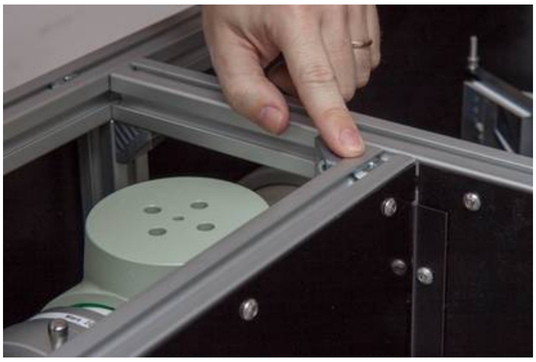
 

You can now put the top covers in place.

Install the two handles on each of the top covers. Add the plastic cap on top of each nut.

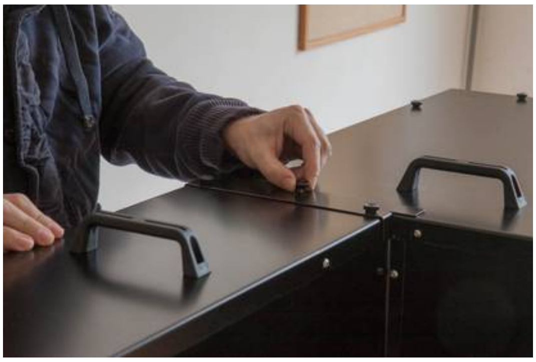
Put Bosch spring nuts in the Bosch profiles, matching all holes in the covers.



Install the covers.

And put a thumb screw (M5x10) in each hole, except at the junction between the two panels. When the position of each hole is precisely found (screw easy to tighten), you can put some glue (neopren, for instance) on each nut, to make sure it will not move anymore.

At the junction of the two top covers, place the top mask, with three thumb screws. The function of this mask, of course, is to eliminate any light leakage coming from the top.



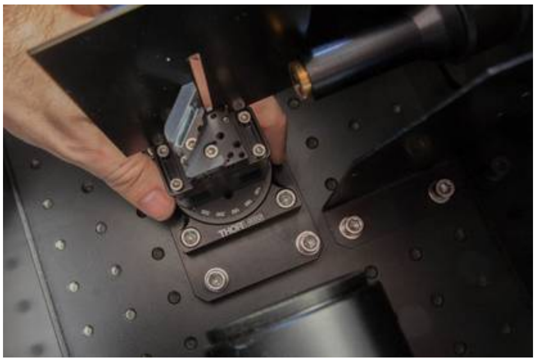
The installation is now done !

Before being fully operational, they are still two easy tuning to get a fully operationnal instrument : input mirror angle and objective lens fine tuning.

17 Input mirror angle tuning

When you installed the input mirror, you put it at a nominal position. We've seen that the angle of this mirror has no effect on the position of the fiber image in the CCD. However, this mirror has a key function for the efficiency of the instrument : it defines the exact direction where the light beam is sent to. If it is not well tuned, part of the beam will be lost by vignetting, with a direct effect on the performance of the instrument.

The mirror can be tuned in two directions, horizontally and vertically. Start with the horizontal tuning (rotation around a vertical axis):



Then, proceed with the vertical tuning.

The tuning is quite easy to do : for a given stable light source (LEDs, for instance), stable from one image to the other, you can measure the max light level in the CCD image. The tuning is optimal when the light level is the highest.

Then, follow this process :

- Open the long top cover (above the grating and input mirror)

- Switch on the (stable) light source,

- Acquire continuous images,

- Measure the max level in a small region of the image where there is one or two spectrum orders.

- Slightly move the mirror position, until the light level is maximum in the image. When done, tighten slightly the screw, with an 1.5mm hex wrench.

Close the top cover.

18 Focus fine tuning

From the begining of the installaton, you use the camera & objective lense focused at the infinite. It is very close to the optimal point, but at this point it would be a pity to not fine tune this point.

Until there, you are using white light (LED…). Then the spectrum is a set of lines. To fine tune the focus in the whole spectrum, you need to use calibration light (thorium light). In a first time, it can be done with the Sun light, but it is significantly better to proceed with Thorium (you can actually measure the FWHM of each spot).

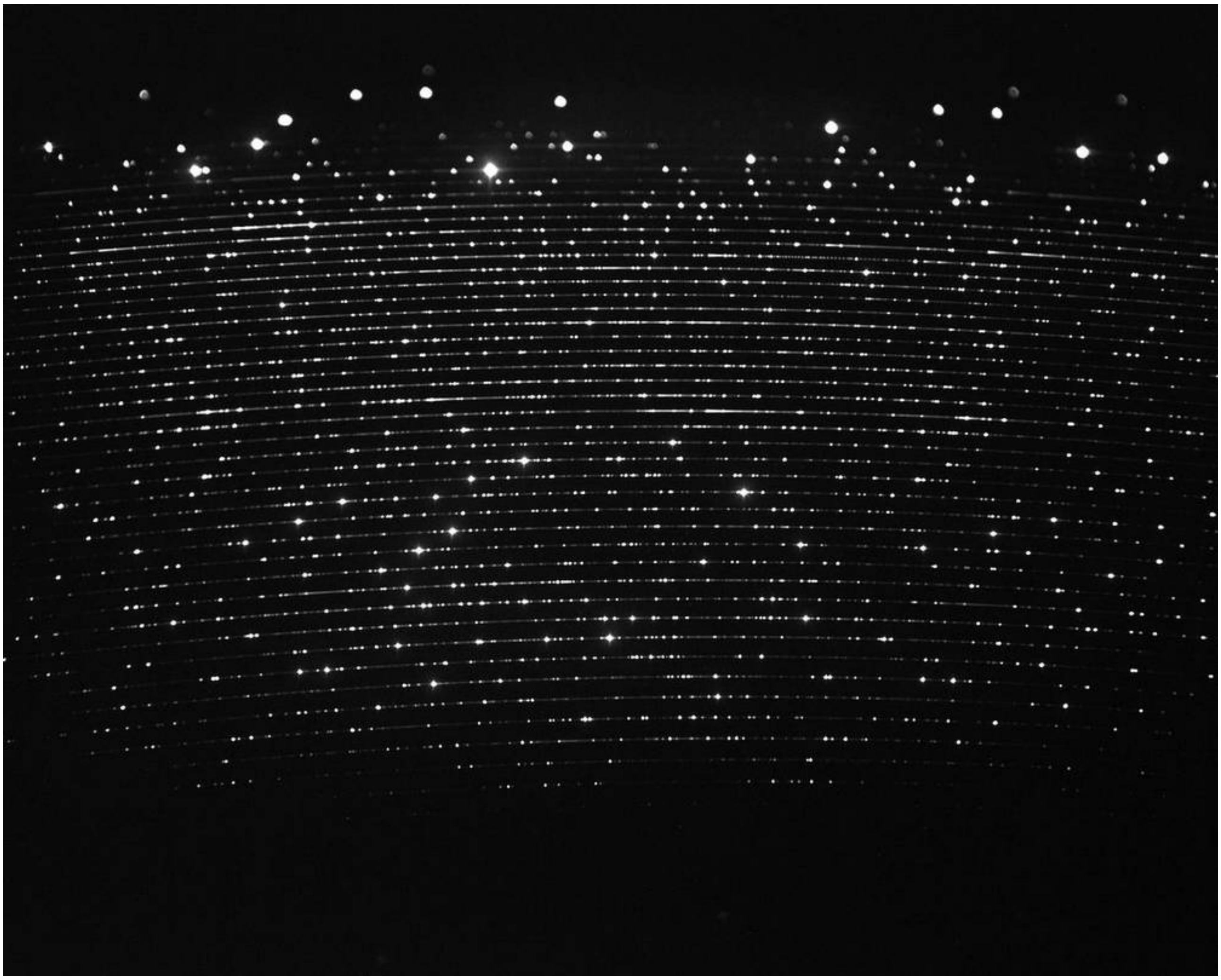
Open the camera top cover.

Remove the adhesive tape on the lens (which is there to block the focus ring), and fine tune the focus position of the lens while doing continous acquisitions (bin 1x1, without saturation).

This tuning is *very* sensitive : move the focus ring very slightly.

Because of the Thorium light intensity, you can have to close the cover between each measure – it depends on your environment.

When it is done, you should have an image well focused in the whole image.



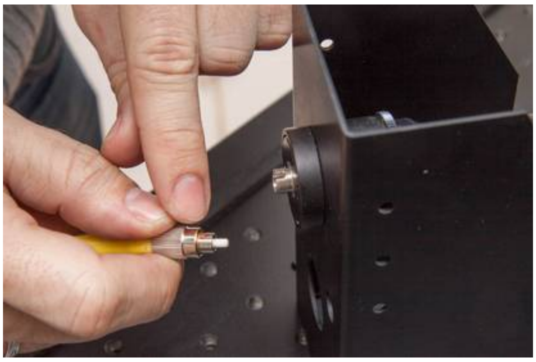
Close the cover. The installation is now done, and the instrument is ready for observing sky objects !

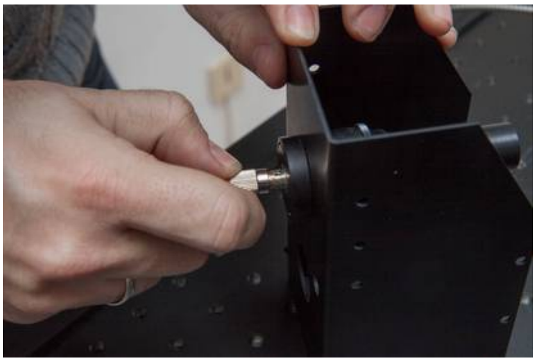
19 Appendix tuning the afocal length

If you need or want to fine tune the input afocal length, here is the way to proceed.

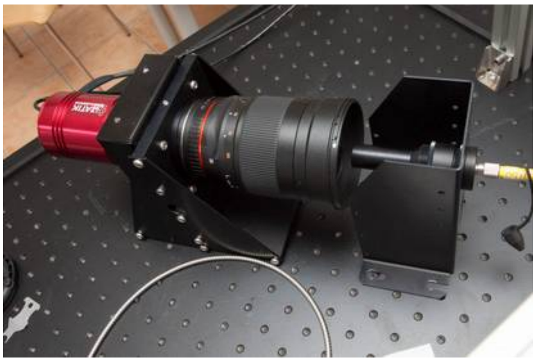
First, remove the lens at the end of the tube, using the special tool :

Put the fiber in the FC connector (take care of the index).





Then, put the camera in front of the tube, properly aligned :



The camera lens is focused at th infinite. And the lens inside the tube should be focused on the fiber input. Then, you should see the fiber image pefectly sharp in the CCD image. You can calculate the expected FWHM for the image : the fiber is 50µ, and the first afocal lens is 30mm, and the photo lens is 135mm. Then fiber image on the CCD is 50 x 135 / 30 = 225µ. If the pixels are 4,54µ (Atik 460), the image size must be 50 pixels when perfectly focused.

To focus the lens, rotate the whole tube (losen first the ring).

After focusing, put back the second lens at the end of the tube, and tighten gently.

End of the document