



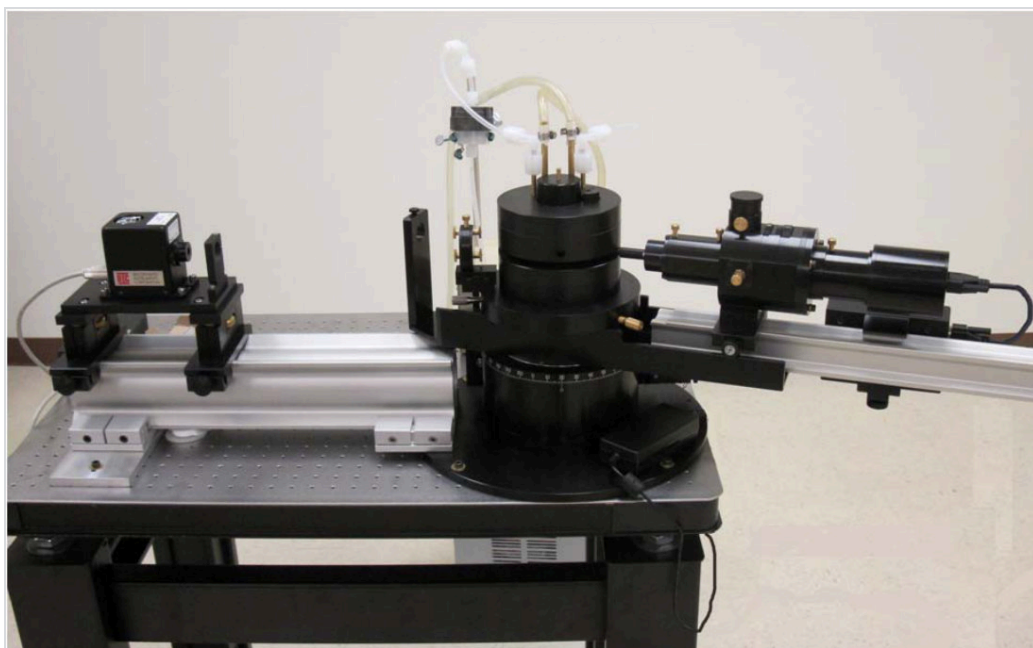
Brookhaven  
Instruments

## BI-200SM Goniometer

# Photo Alignment Manual

September 2026

To be used as a supplement to the *BI-200SM Goniometer Instruction Manual Ver. 2.0* and training by a goniometer service technician. Refer to page 4-2 of the instruction manual for the names of many parts on the goniometer system.



The goal: a fully aligned BI-200SM goniometer system

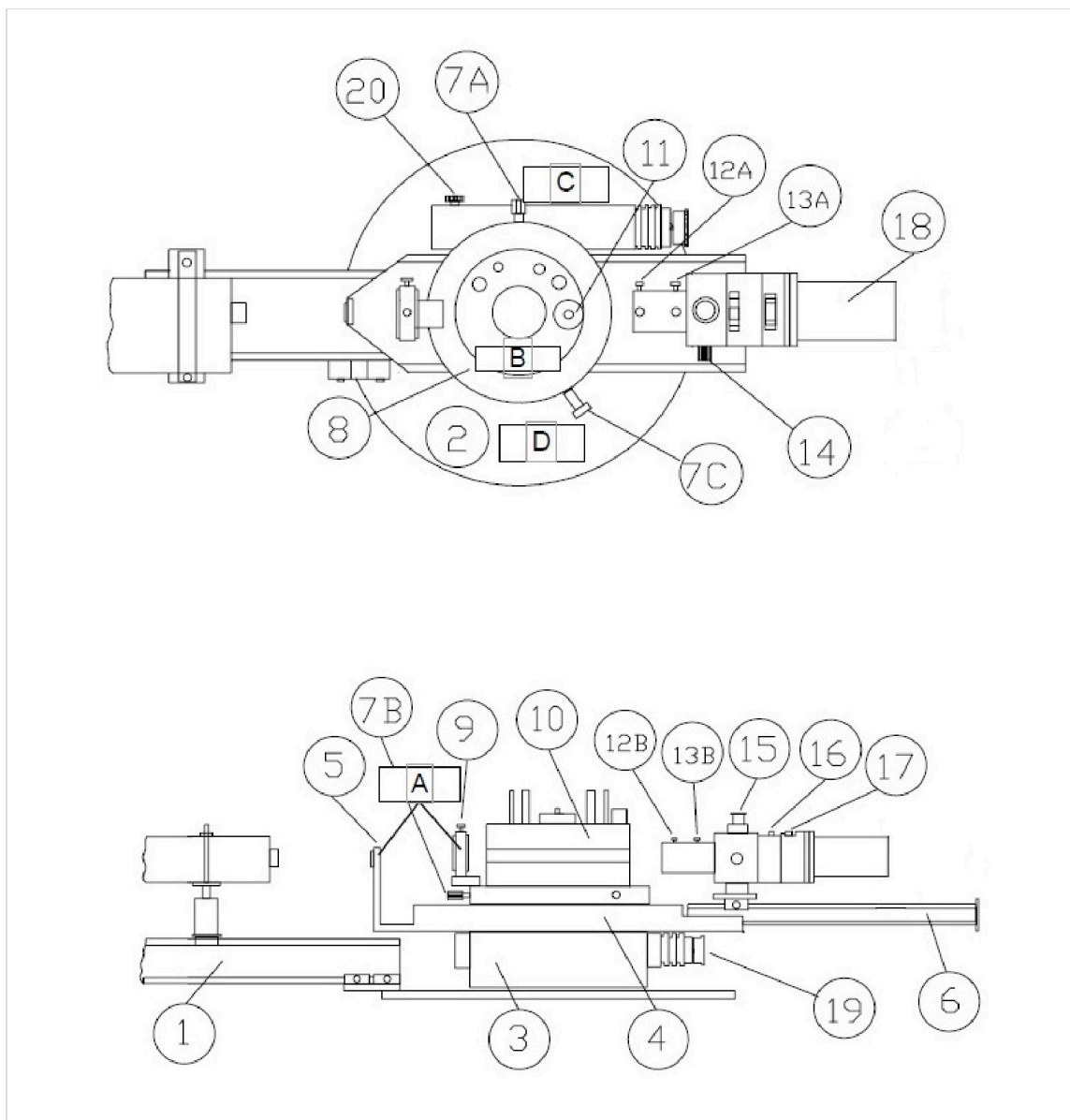
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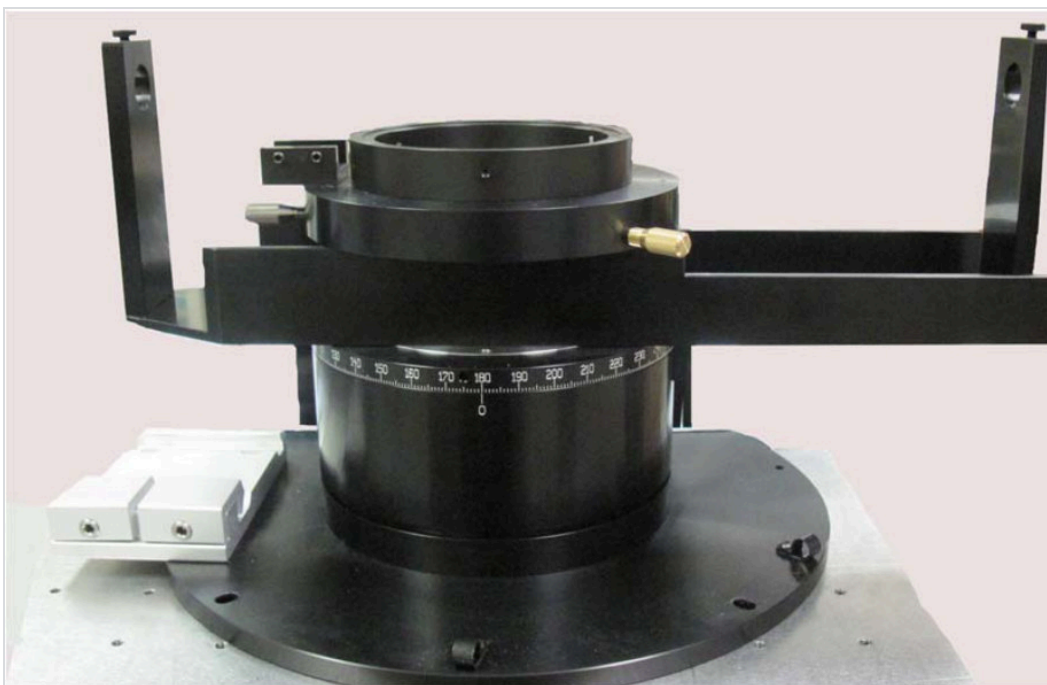


Top and side view of the assembled goniometer

- |               |                                     |            |                                         |
|---------------|-------------------------------------|------------|-----------------------------------------|
| <b>1</b>      | Laser rail and mounts, optional     | <b>12A</b> | Lens adjustment, horizontal             |
| <b>2</b>      | Precision-machined base             | <b>12B</b> | Lens adjustment, vertical               |
| <b>3</b>      | Turntable                           | <b>13A</b> | Slit adjustment, horizontal             |
| <b>4</b>      | Rigid rotating arm                  | <b>13B</b> | Slit adjustment, vertical               |
| <b>5</b>      | Upright for 2 mm alignment aperture | <b>14</b>  | Mirror adjustment                       |
| <b>6</b>      | Detector rail                       | <b>15</b>  | Eyepiece                                |
| <b>7A, 7B</b> | Center rotation adjustment screws   | <b>16</b>  | Pinhole wheel                           |
| <b>7C</b>     | Center of rotation locking screw    | <b>17</b>  | Filter wheel                            |
| <b>8</b>      | Center of rotation adjustment table | <b>18</b>  | Detector                                |
| <b>9</b>      | Beam focusing and steering lens     | <b>19</b>  | Angle adjustment (fine adjustment knob) |
| <b>10</b>     | Sample cell assembly                | <b>20</b>  | Clutch release                          |
| <b>11</b>     | Beam stop                           |            |                                         |

# Mount and center the goniometer

Steps 1 to 11b

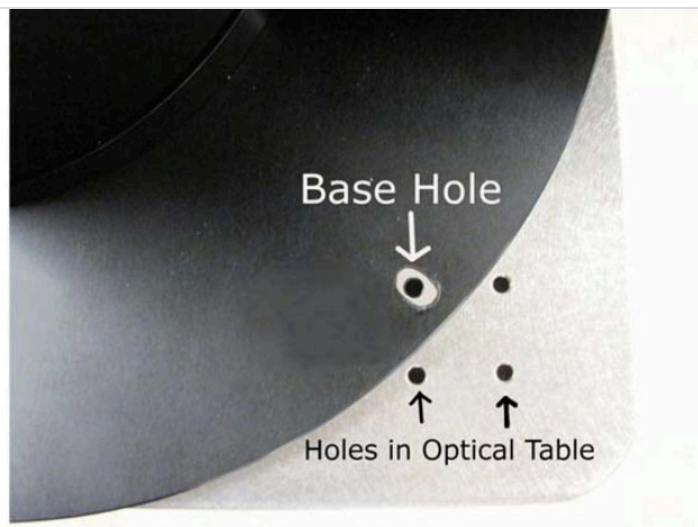


A goniometer right out of the box

Step

1

Place the goniometer on the optical table. Center the four holes on the base of the goniometer above four holes on the optical table.



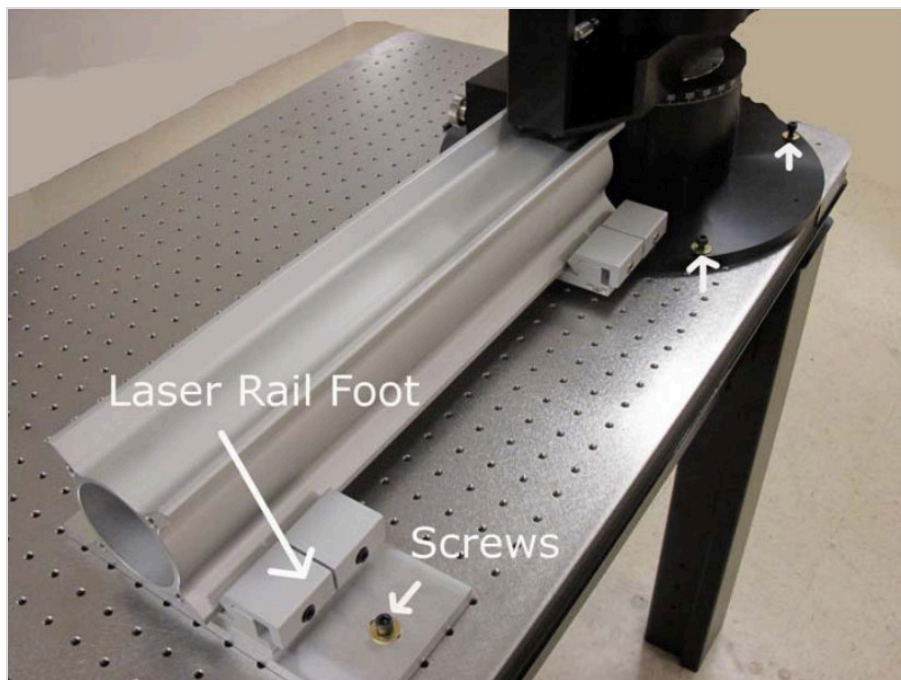
Step

2

Place the laser rail foot (LRF) on the table.

If using a 0.5 meter rail, place the LRF near the end of the rail, as shown. If using a longer rail, place the LRF one third of the way from the end of the rail.

**Finger tighten** the screws that hold the LRF and goniometer to the optical table.

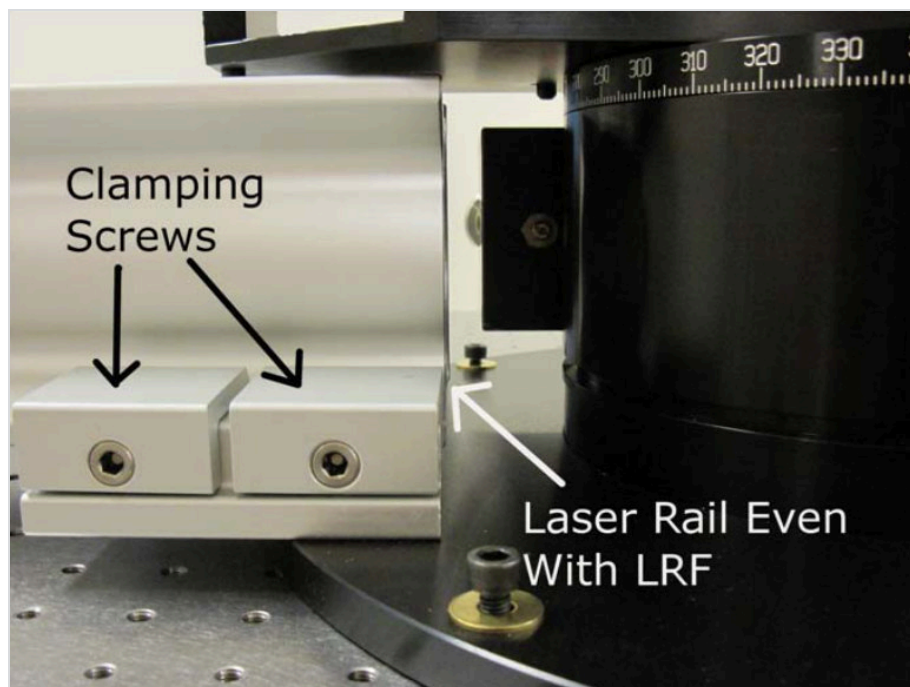


Step

3

Slide the laser rail in place and position it. The laser rail can be even with the LRF or up to 5 mm past the LRF.

Tighten the laser rail in place with the two clamping screws on both laser rail feet. Tighten the screws completely so that the laser rail will not move out of place.



Step

4

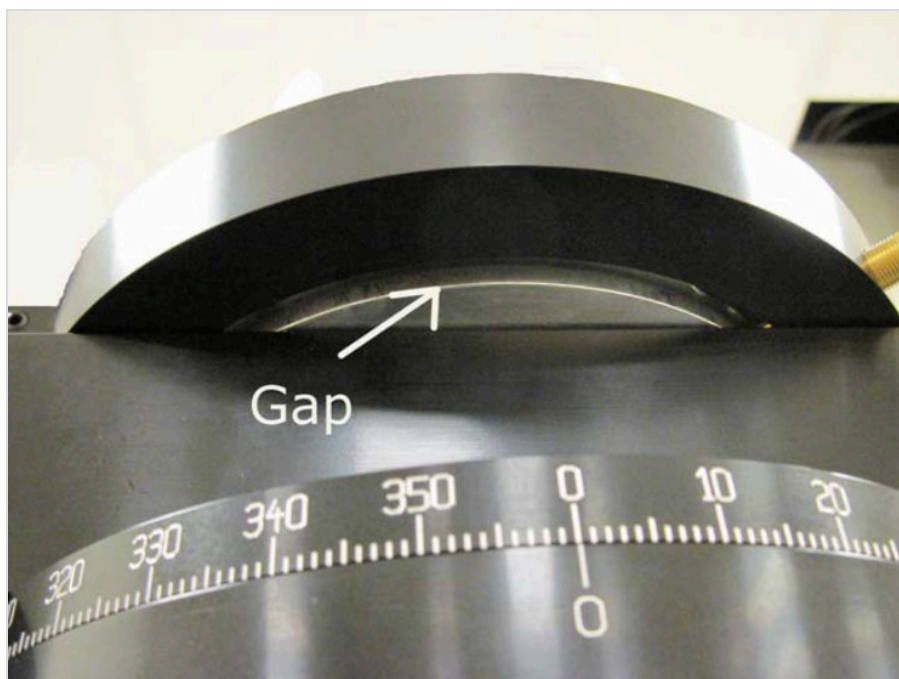
After the laser rail is in place and tightened down, tighten the six screws that hold the goniometer and laser rail foot to the table. Completely tighten each screw to ensure the instrument cannot be moved out of place.



Step

5

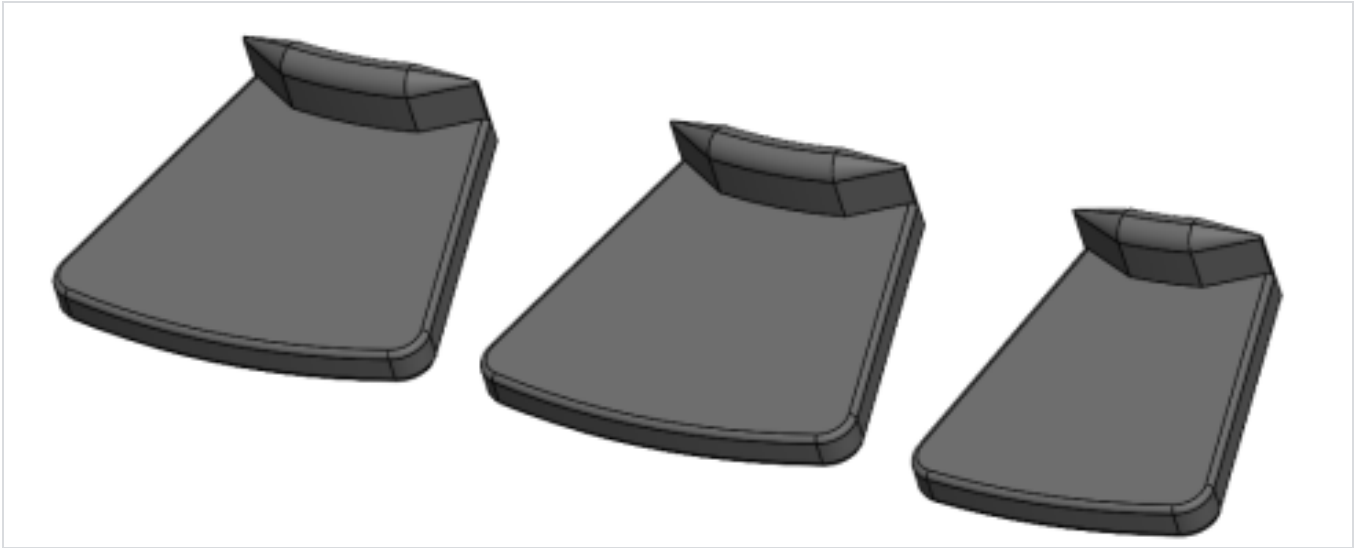
Look at the goniometer from underneath; there is a small gap. This is the X-Y table. It must be **centered**, with the gap evenly spaced between it and the stainless steel plate.



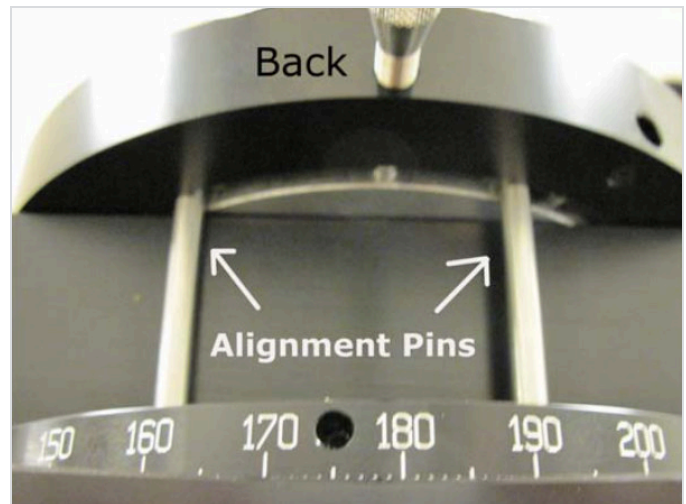
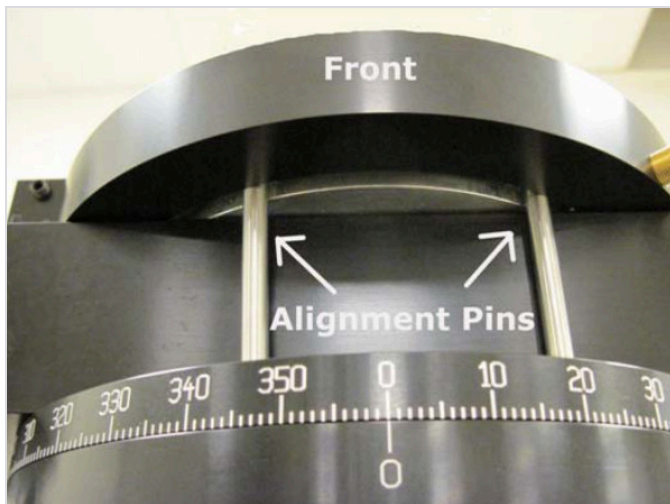
Place the **3D printed X-Y table alignment tools** in the gap around the base to determine if the X-Y table is centered. Confirm that the interior gap is consistent all the way around the base.

If the tools do not all fit evenly, adjustments to the table need to be made (Step 7).

- The **6 mm alignment pins** can still be used in place of the printed tools. If you have neither, an **M5 hex key** will work. It should fit evenly all around the gap.



3D printed X-Y table alignment tools





Optional: 6 mm alignment pins

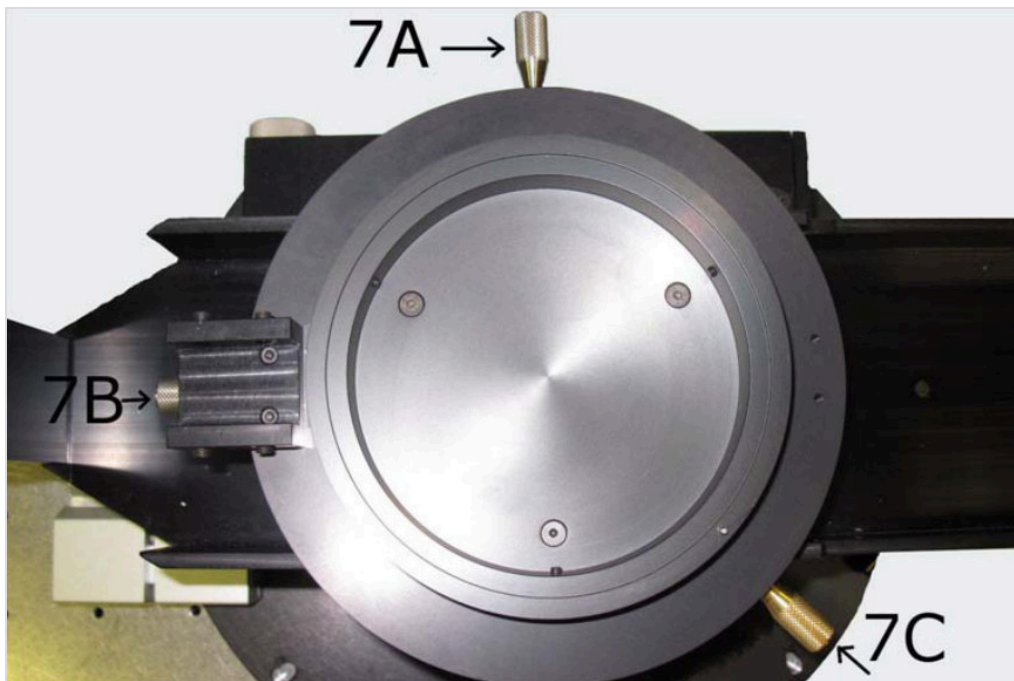
Step

**7**

To adjust the X-Y table, loosen **7C** and make *slight* adjustments to **7A** and **7B** until the alignment tools (or pins) fit evenly all around the gap.

They do not need to be all tight or all loose; they just need to all fit the same way. Then lock down **7C** again.

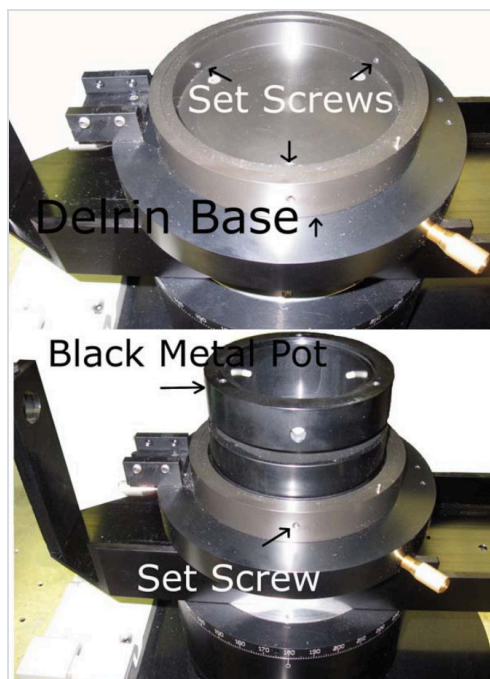
! When locking down 7C, the table will shift a little, so take that into account when making the slight adjustments.



Step

8

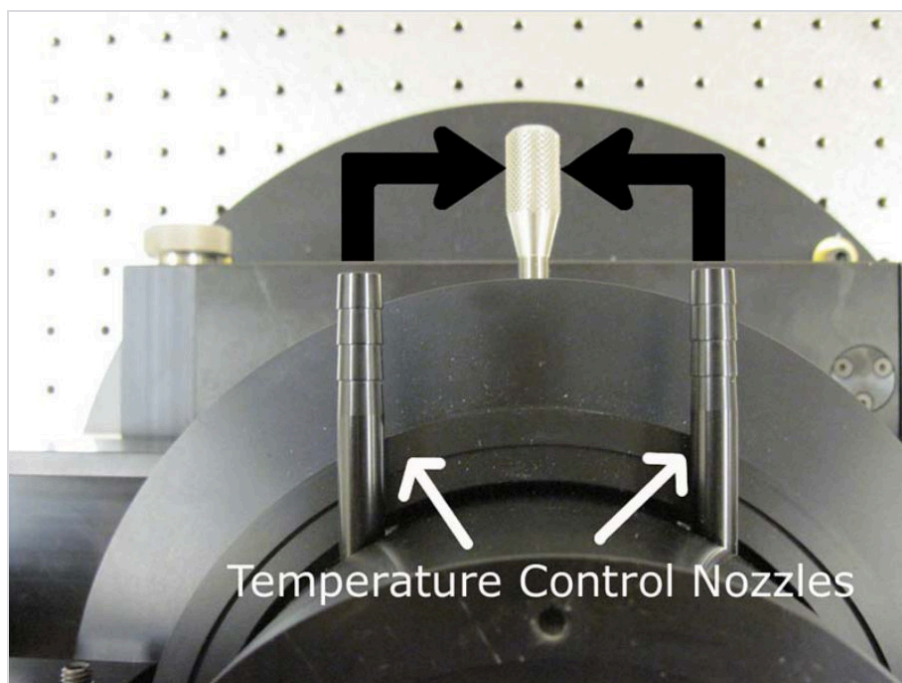
Place the black metal pot into the delrin base.



Step

9

Slightly rotate the black metal pot in place so that knob **7A** is centered between the two black temperature control nozzles, located on the back of the black metal pot, when the goniometer is viewed from the top.



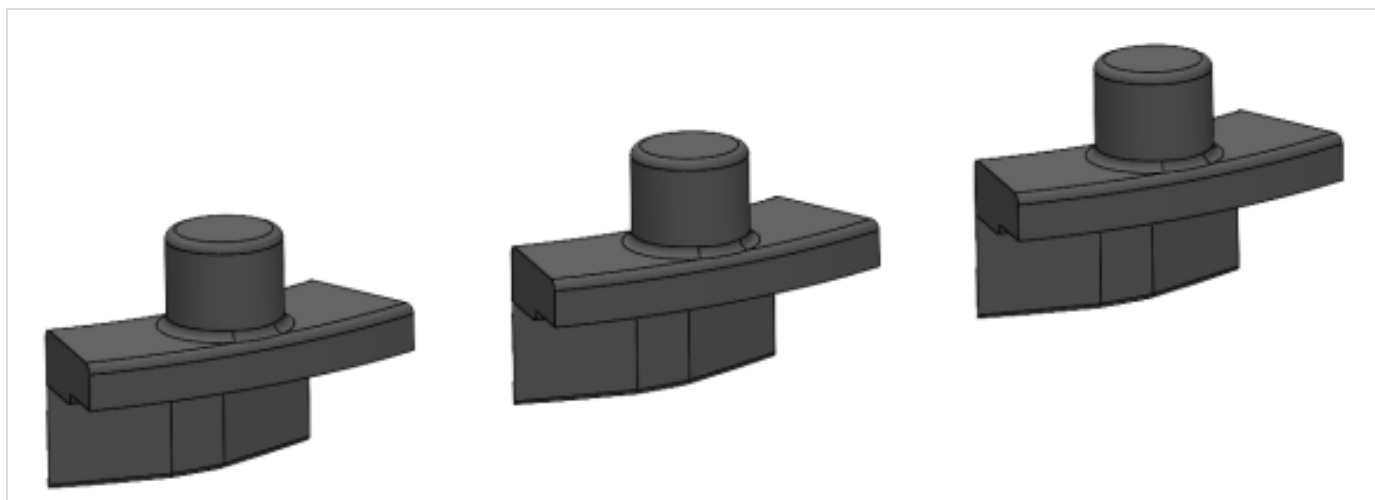
Step

10

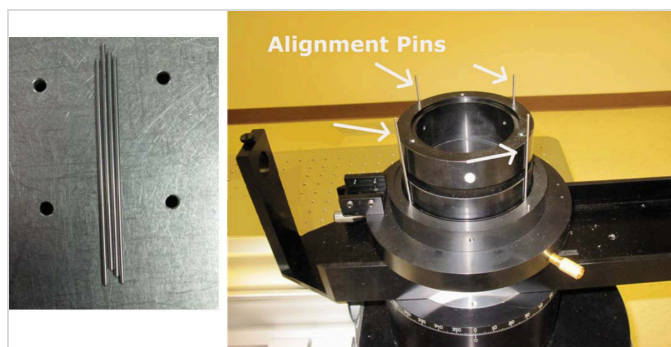
Use the **3D printed pot alignment tools** to center the black metal pot within the delrin base. Place the tools in the gap between the black metal pot and the delrin base.

**Gently** tighten the three set screws located around the delrin base to lock the black metal pot in place. The tools should all fit evenly in the gap.

- + The **2 mm alignment pins** can still be used in place of the printed tools. Insert the tapered ends of the pins into the gap; using 3 of the 4 pins can make them easier to insert.



3D printed pot alignment tools

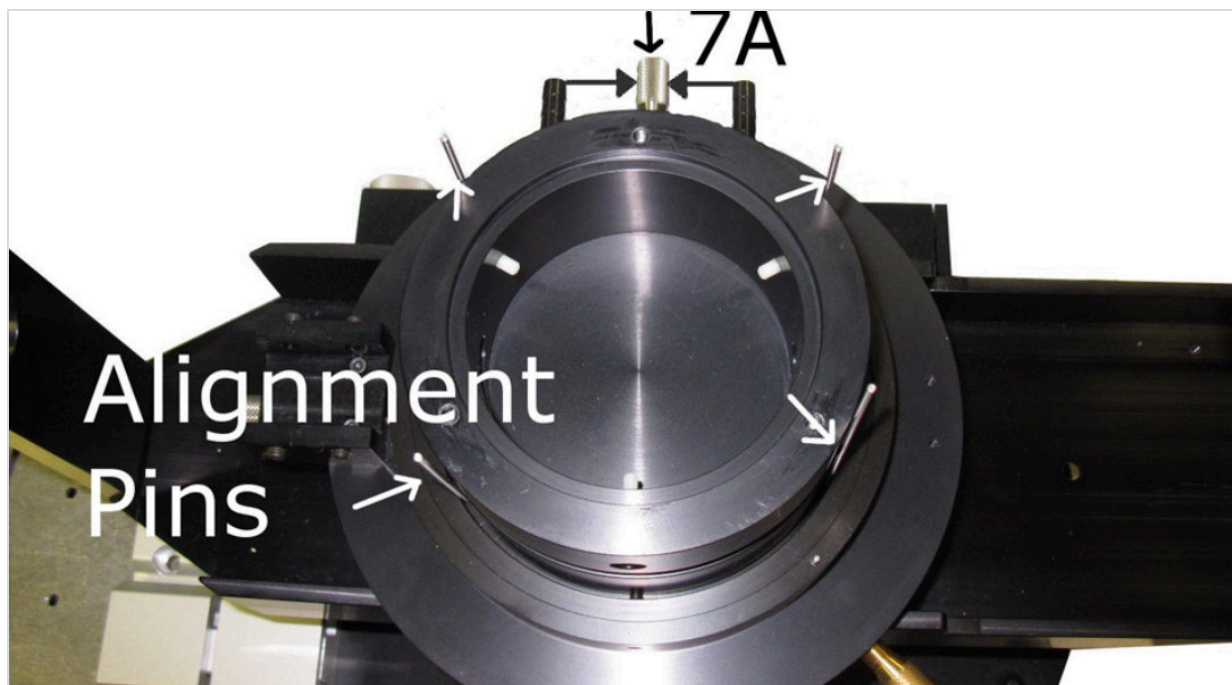


Optional: 2 mm alignment pins

Step

11

When the three set screws around the delrin base are tightened down, ensure that knob **7A** is still centered between the two black temperature control nozzles.

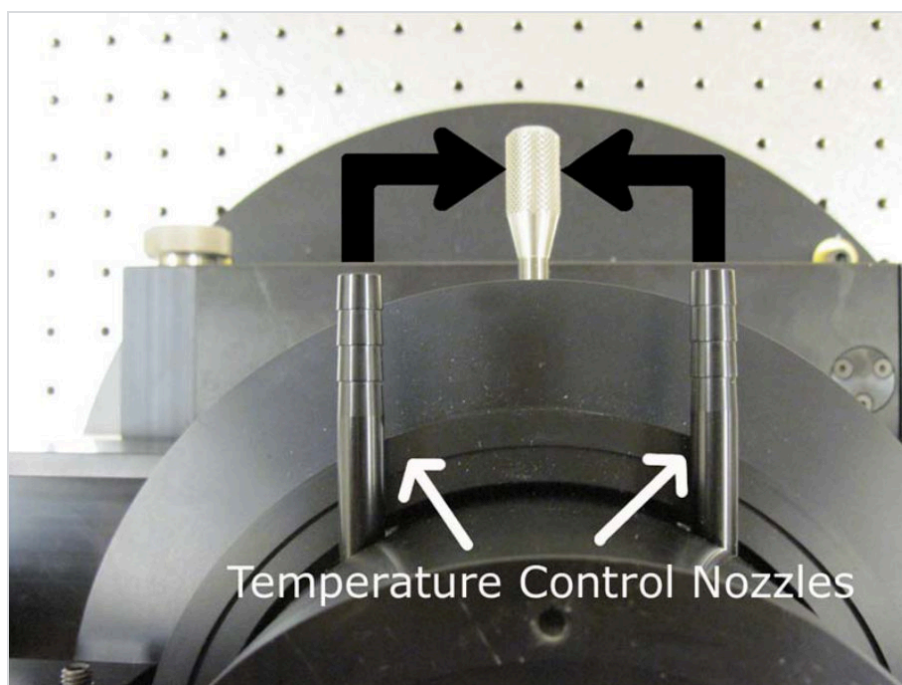


Step

11b

Confirm that the outlets for the circulating temperature bath are **orthogonal to the beam path** by placing, and then removing, the **delrin sleeve** over the black metal pot.

Check that the sleeve's pin is positioned correctly and that the sleeve sits perfectly level. Then remove the sleeve; it is installed for good in Step 60.



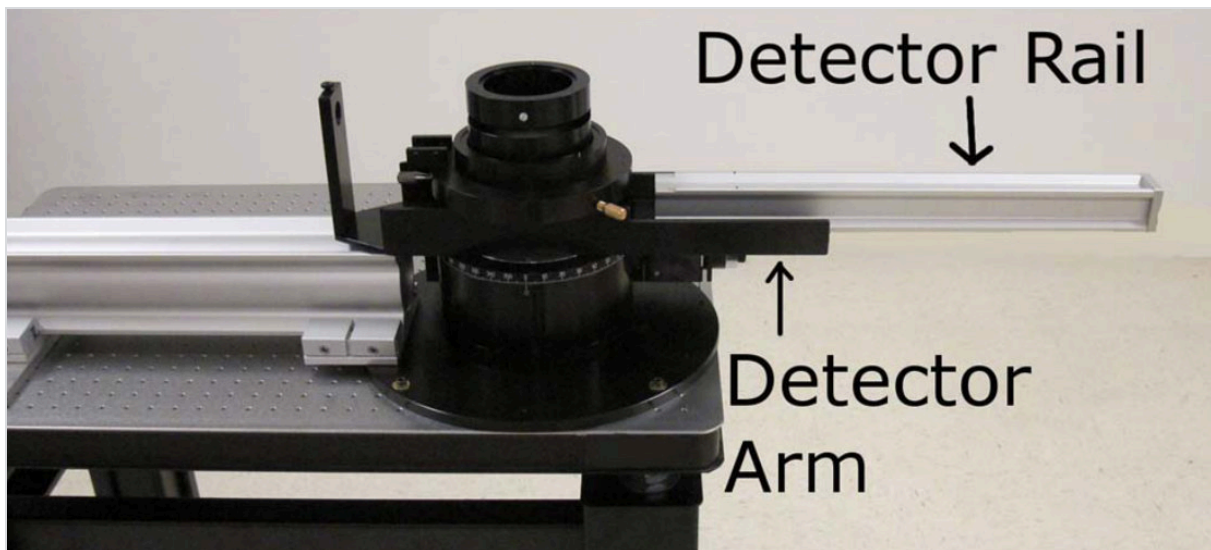
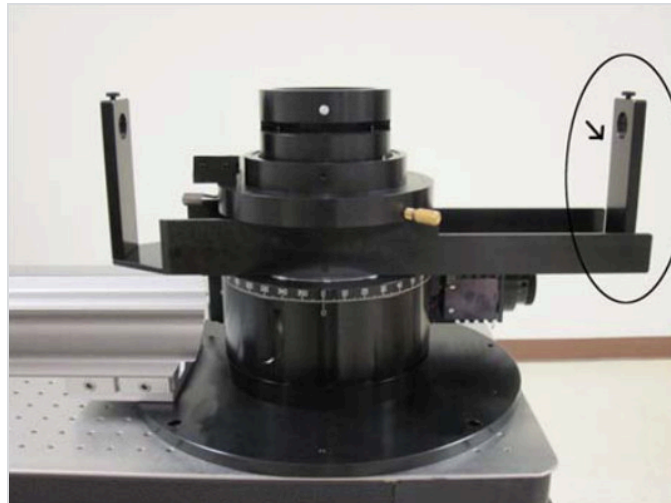
## Zero the detector arm

Steps 12 to 17

Step

**12**

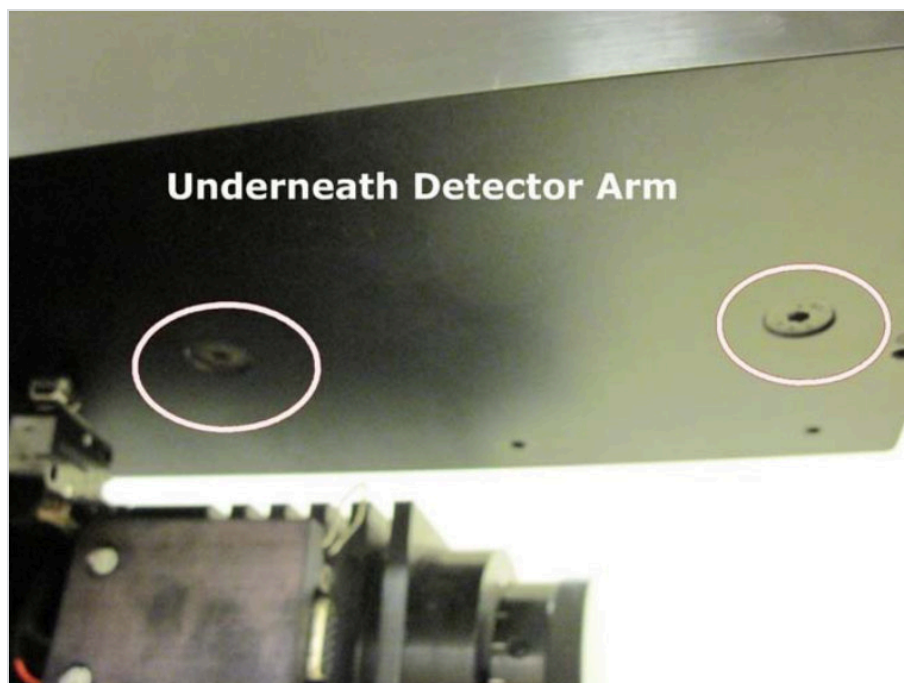
Remove the 2 mm aperture upright opposite the laser rail and attach the detector rail.



Step

13

Attach the detector rail using the two supplied **M6x25 flat head screws**.



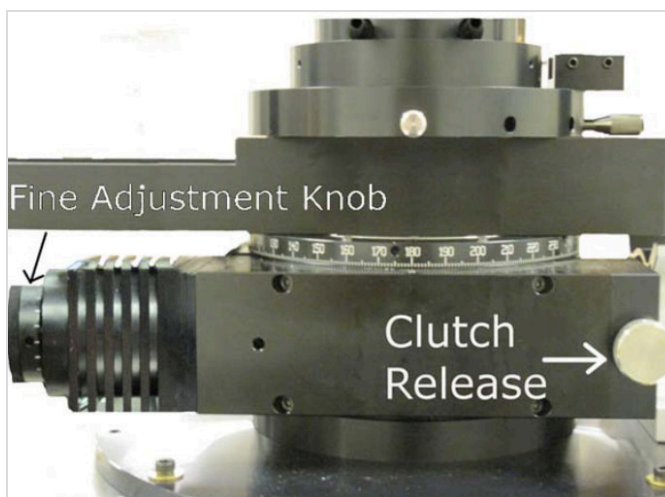
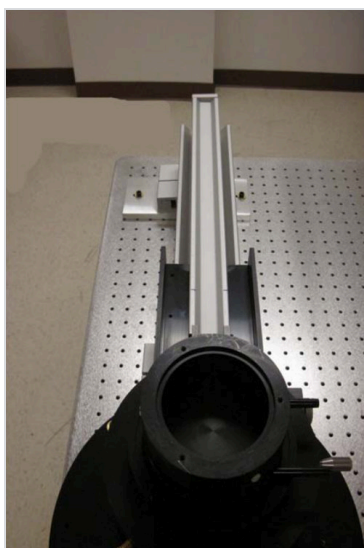
Step

14

Unlock the detector arm by unscrewing the clutch release. Rotate the detector arm **180 degrees**, then re-tighten the clutch release.

Center the detector arm above the laser rail, as seen in the photo. Do this by making slight turns of the fine adjustment knob and viewing the detector arm and laser rail from multiple angles to determine if it is centered above the laser rail.

+ Another way: line up the detached detector arm with the motor base.

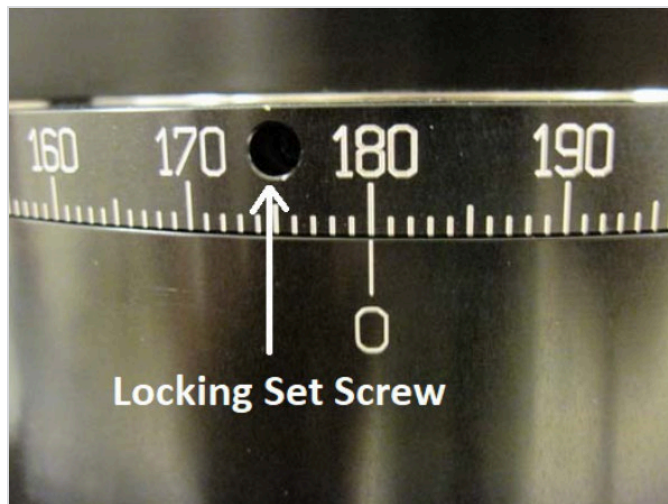
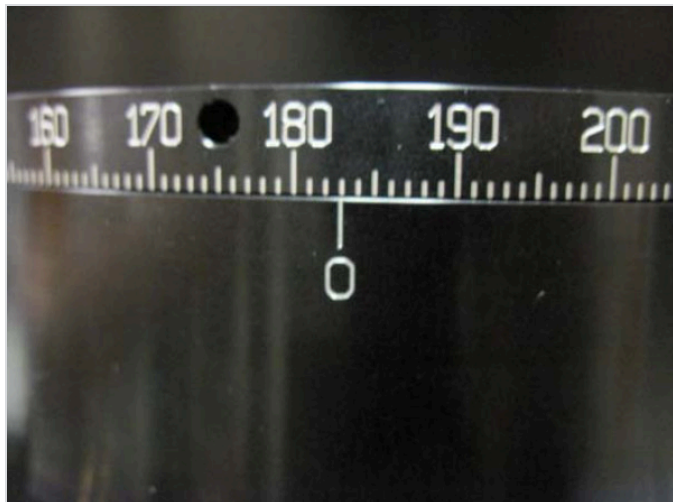


Step

15

After centering the detector rail above the laser rail, you may have to reset the angular scale to reflect the new zero angle.

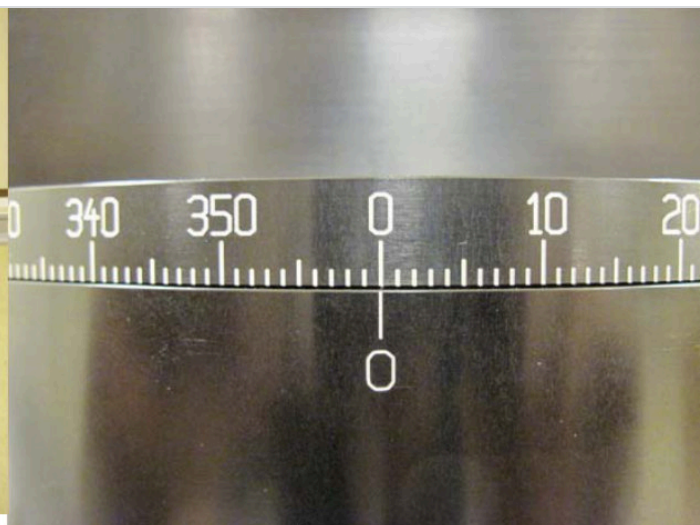
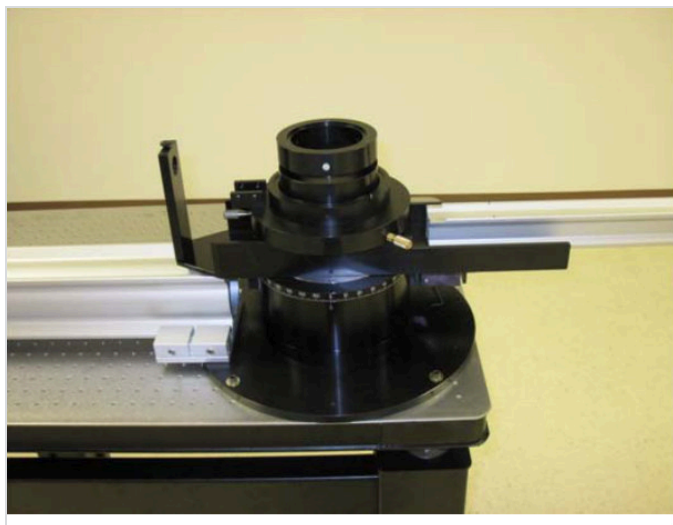
Unlock the sliding scale by using a **2 mm hex key** on the recessed set screw at the opening at 175 degrees. Slide the scale so that it now reads **180 degrees**. Tighten the set screw once the zero angle is aligned to 180 degrees.



Step

16

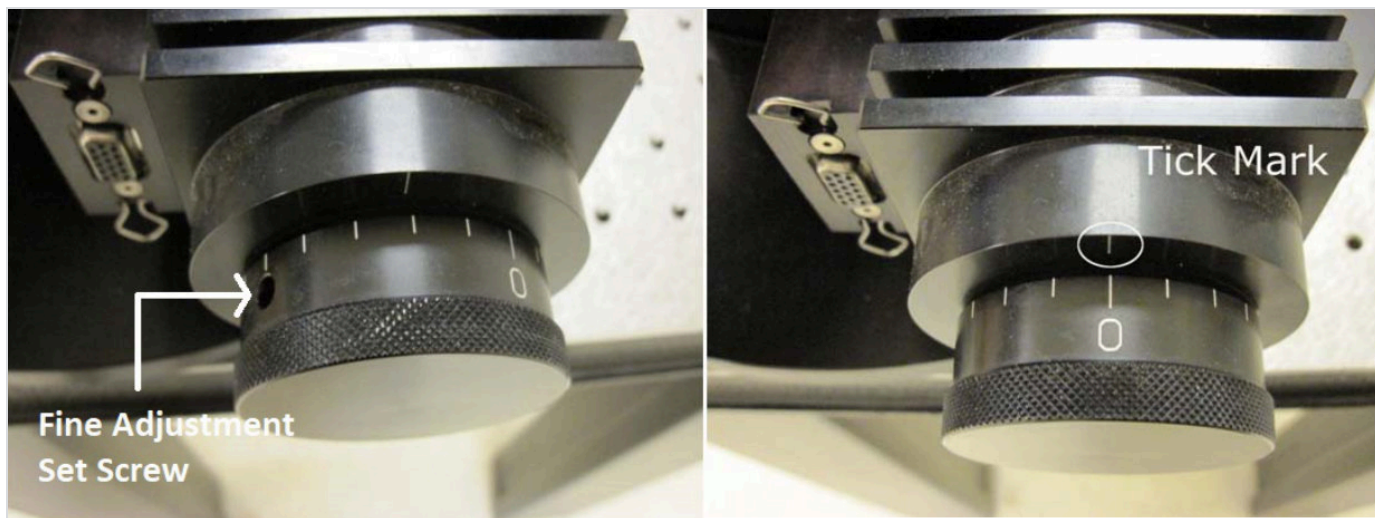
Rotate the detector arm back to **zero degrees** and ensure that the angular scale reads zero degrees perfectly. Lock the detector arm in place by tightening the clutch release knob.



Step

17

Reset the fine adjustment knob. Unlock the knob by loosening the set screw and turn the knob so that the zero matches up with the tick mark. Tighten the set screw when finished.



## Align the laser

Steps 18 to 26

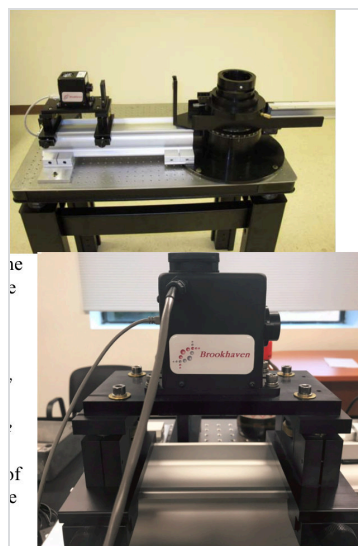
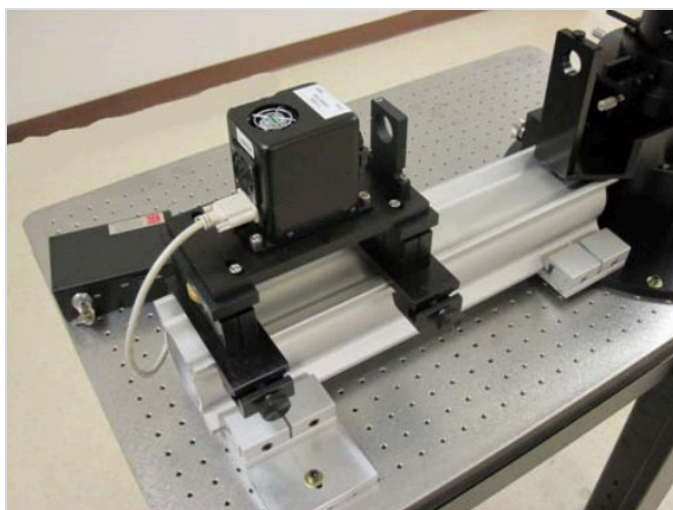
Step

18

Place the Mini-L40 on the laser rail, near the far edge of the rail. The left edge of the Mini-L40 should be about even with the left end of the laser rail.

Lock the laser in place using the knobs on the feet of the laser mounts. Ensure that the knobs are tight and the laser cannot move out of place.

**i** If using a HeNe or Argon-Ion laser, ensure that the front of the laser is approximately **13 inches (33 cm)** from the foot of the detector rail, so that it will not interfere with the rotating detector arm.

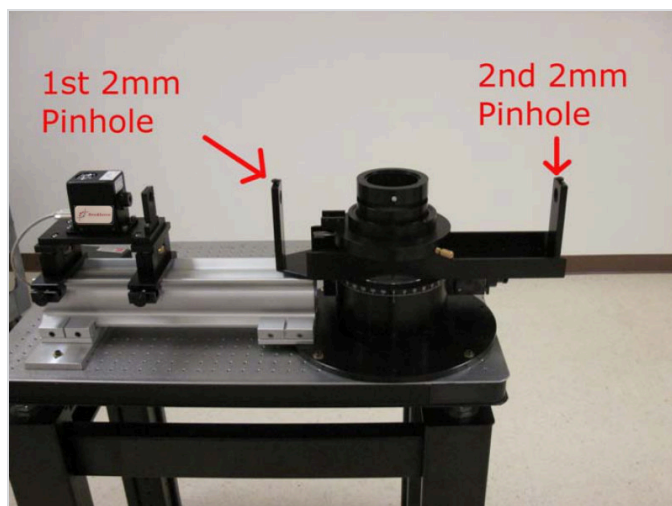


Step

19

Remove the detector rail and replace it with the 2 mm aperture upright. Insert 2 mm pinholes into both aperture uprights, then tighten them down with the locking screws.

Adjust both the vertical and horizontal adjustments on the Mini-L40 so that the laser beam passes cleanly through both 2 mm pinholes.

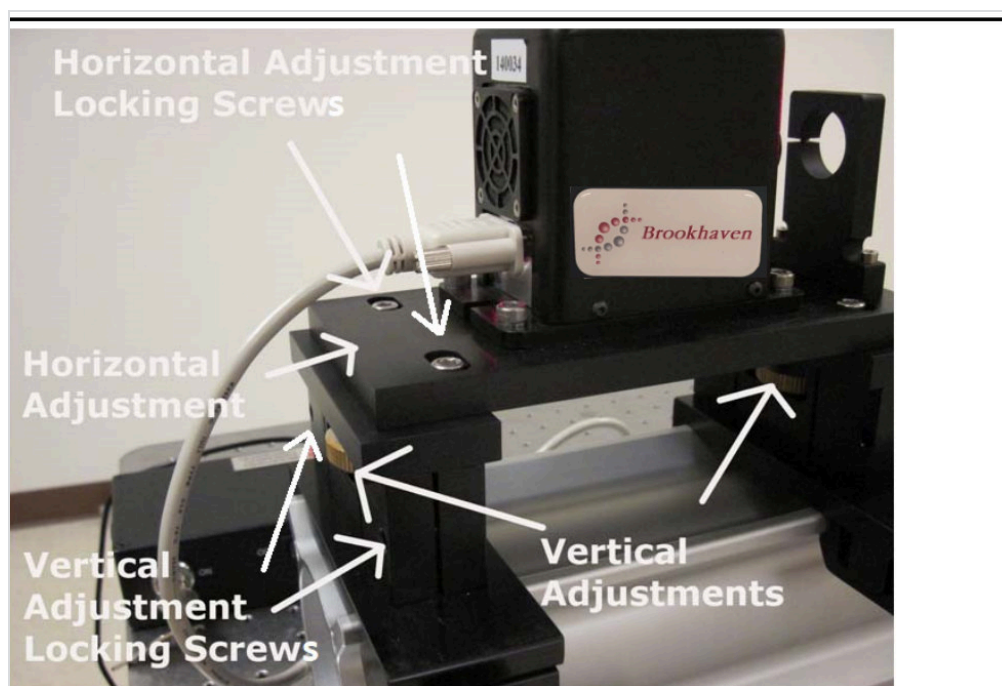


Step

20

Everything needed to adjust the laser beam position is located on the Mini-L40 mount. The rectangular table with four slots that the Mini-L40 is attached to is the **horizontal** adjustment. The two brass knobs on the laser mount are the **vertical** adjustments.

! Make sure there are no reflective surfaces in the path of the laser beam!

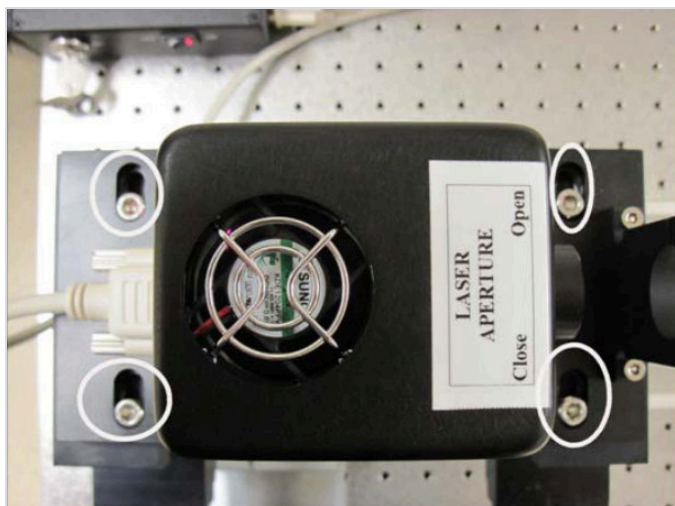


Step

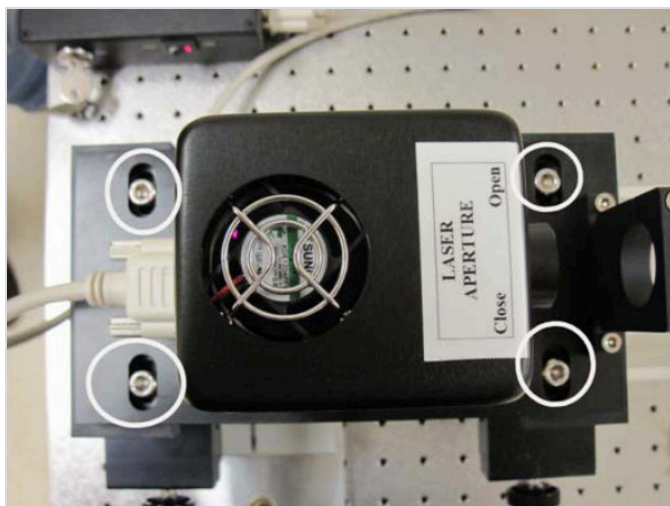
21

To adjust the laser beam horizontally, *loosen* the four screws around the rectangular table. Do not remove them. Slide the table back and forth until the beam is in position (Step 23).

Ensure that the screws in the slots are close to the center, not pushed all the way to one side.



Incorrectly positioned laser



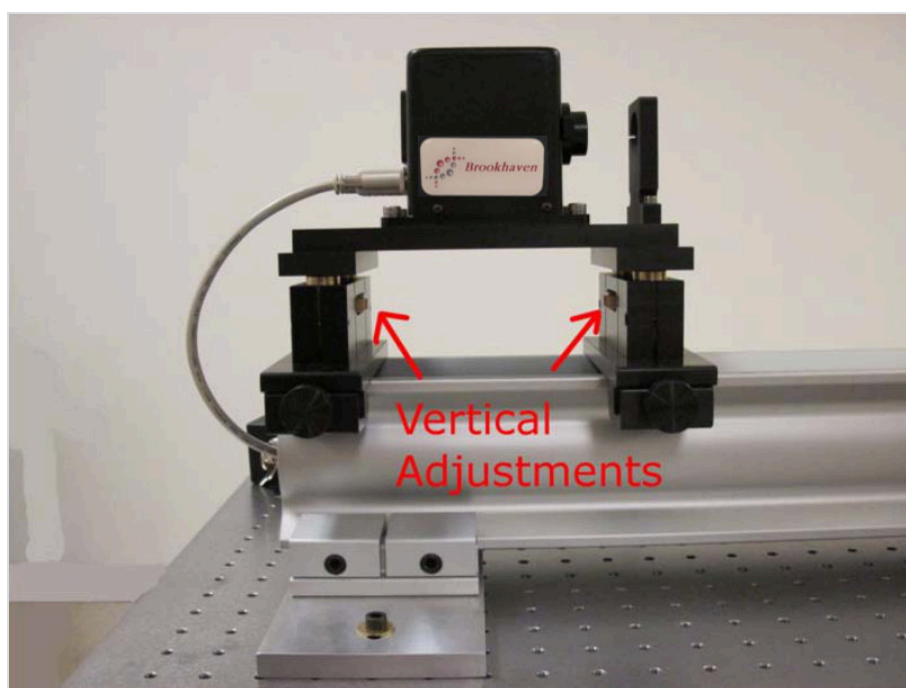
Correctly positioned laser

Step

22

Loosen the two locking screws on either side of each brass knob on the Mini-L40 mounts. Rotate the knobs to adjust the vertical position of the laser beam.

Rotate the knobs **simultaneously** to prevent the platform from locking up or becoming uneven. *Re-tighten the locking screws when complete.*



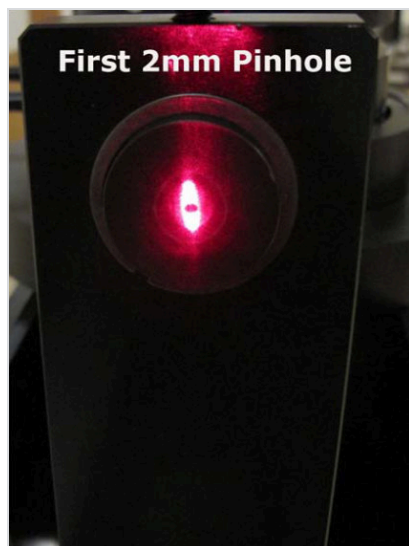
Step

## 23

The laser beam should be centered both horizontally and vertically on the first 2 mm pinhole. When it reaches the second 2 mm pinhole it will appear round. Center the beam on the second pinhole.

There should be no bright spots on the face of the second 2 mm pinhole; the laser beam should pass cleanly through the hole. Once complete, tighten all screws, alternating.

*Once this is done, rotate the goniometer 180 degrees and ensure that the laser passes cleanly through the backside of both pinholes.*



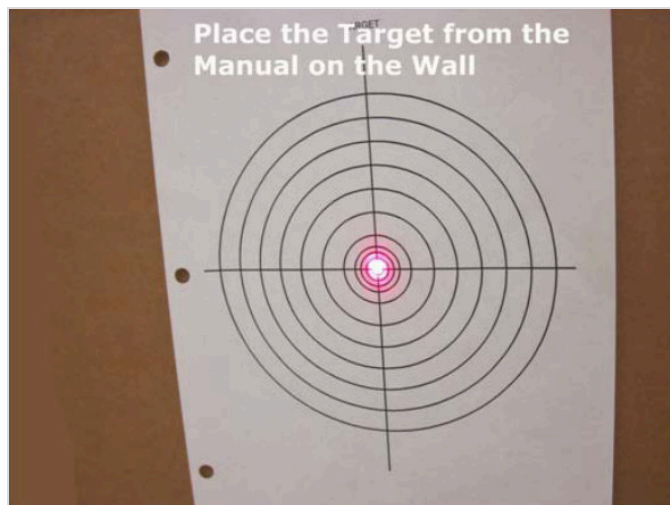
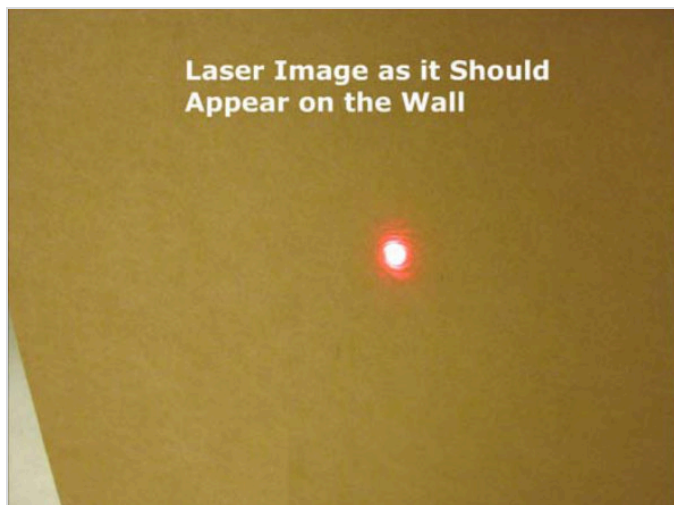
Step

## 24

After the laser is aligned through the two pinholes, lock the vertical and horizontal adjustments in place on the Mini-L40 with their respective locking screws. Check by moving the laser to see that it is secure.

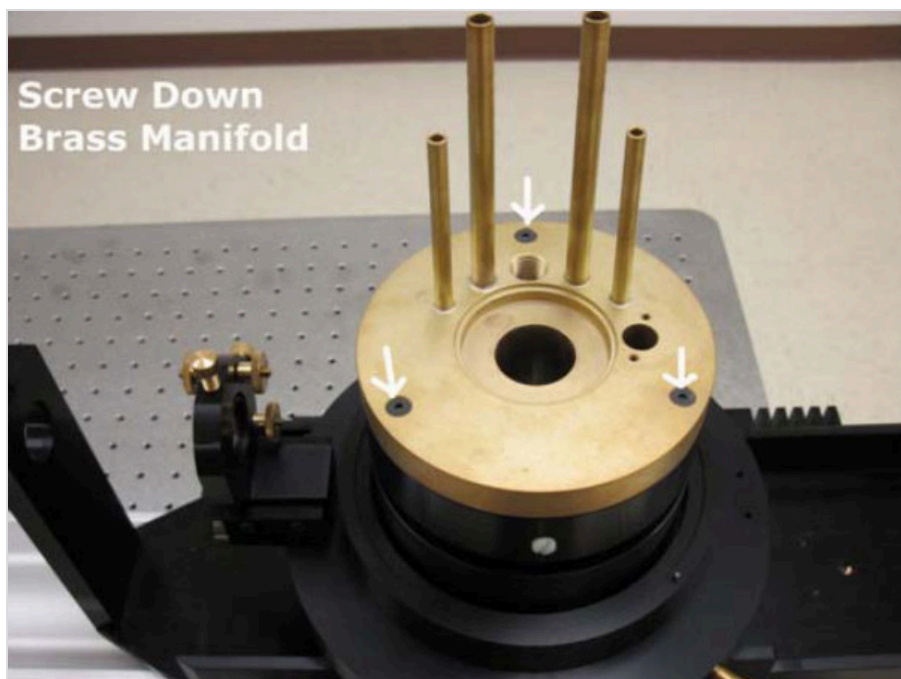
After the beam passes through both 2 mm pinholes, you should see a laser image on the wall. Place one of the targets at the back of this manual on the wall and center the target on the laser image.

- Make sure the laser is tightened down completely: place your hands on the laser and try to move it back and forth. If there is any play, continue to tighten the locking screws. It should not move if completely tightened.



Step  
**25**

Remove both 2 mm pinholes. Fit the brass manifold over the black metal pot and screw it in place with the three supplied **M4x25 flathead screws**.



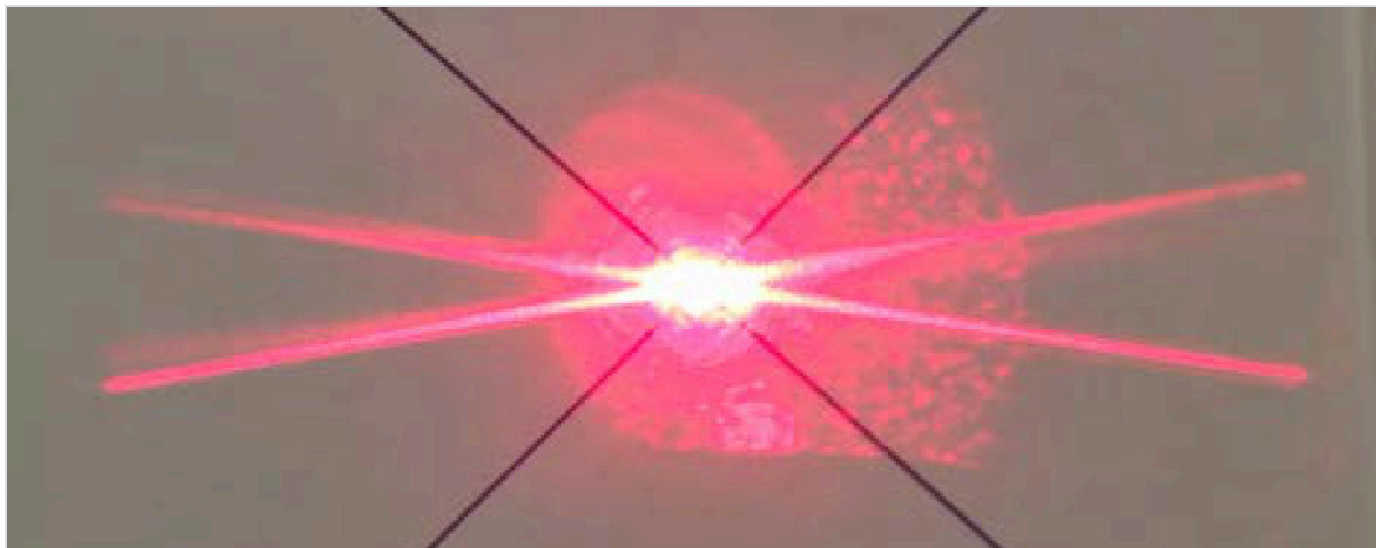
Step

## 26

Carefully place the alignment needle in the brass manifold. Lower the alignment needle into the path of the beam. The beam should hit the tip of the needle without any obstructions. If the beam is hitting the tip of the needle, an “X” should appear on the target.

Be sure to lower the needle **slowly** into the path of the beam. If the needle is lowered too quickly, the laser beam will be completely obscured.

**i** If you are seeing the “X” on the target, the laser is aligned perfectly. If you encounter any issues going forward that force you to go back and realign the system, you will not have to check the alignment of the laser itself.



## Steering lens and needle

Steps 27 to 31

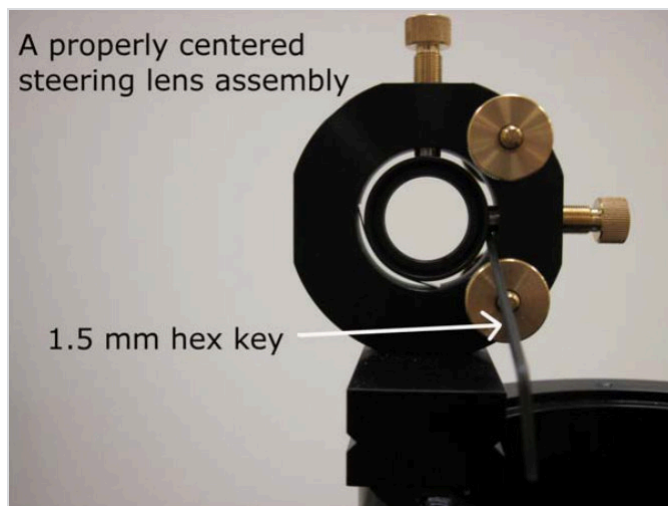
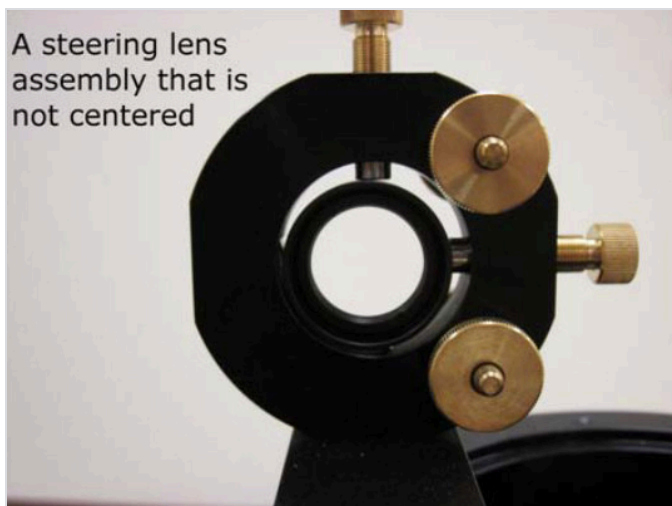
Step

**27**

The steering lens must be centered in its holder.

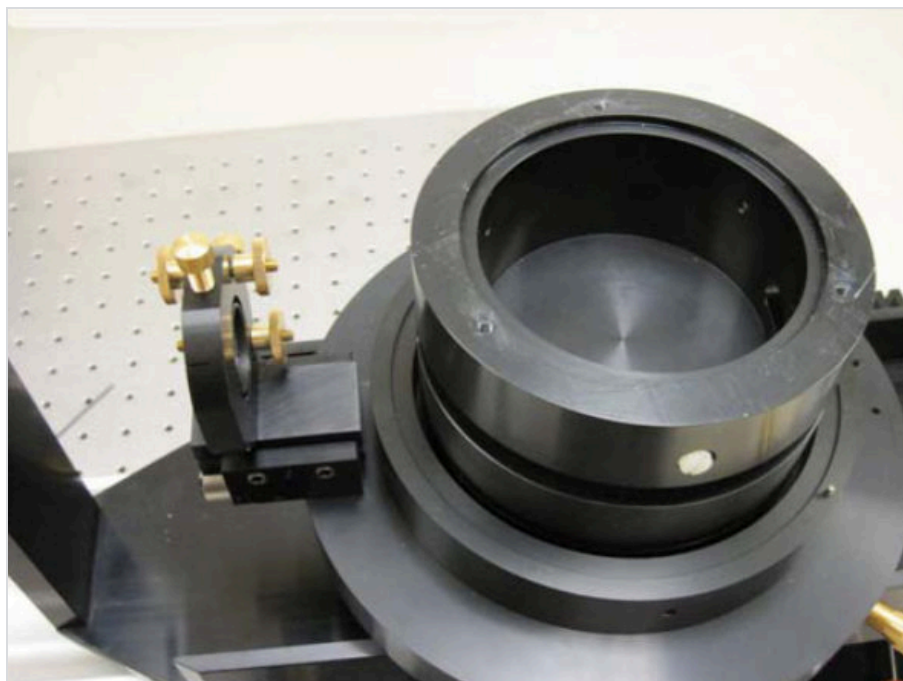
Position a **1.5 mm hex key** in the gap between the round lens and the lens holder. The hex key must fit evenly all around. Achieve this by making slight adjustments with the vertical and horizontal adjustment knobs on the steering lens assembly.

- + To clean dust or fingerprints from the lens, use a lens pen or lens paper gently. Pure methanol may also be used if needed; no other solvents.



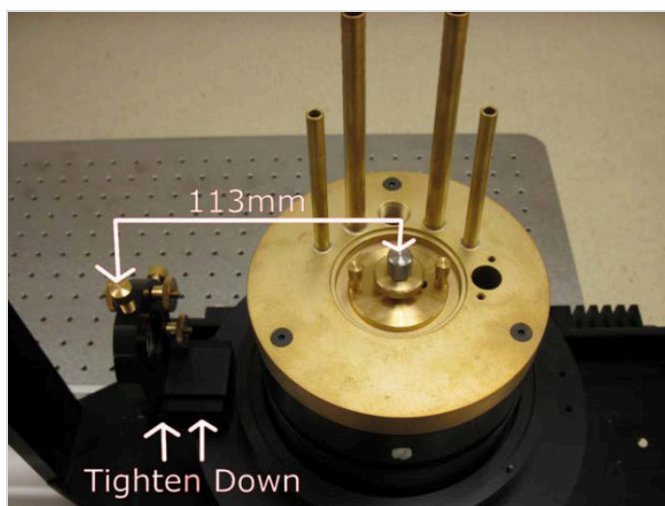
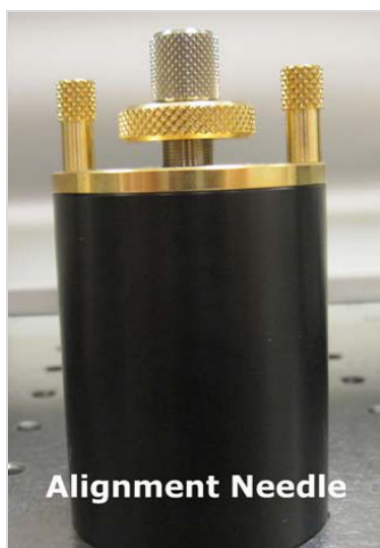
Step  
**28**

Place the steering lens in its holder.



Step  
**29**

Using a ruler, measure **113 mm (4.495 in)** from the center of the vertical adjustment on the steering lens to the center of the alignment needle. Tighten the steering lens assembly in place using the four set screws on its base.



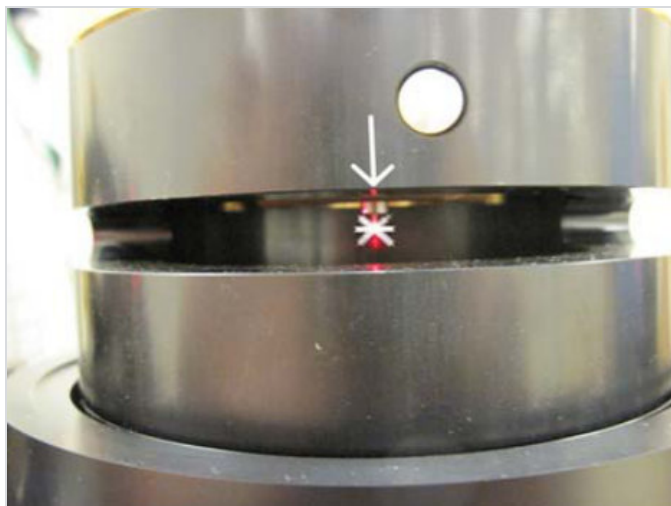
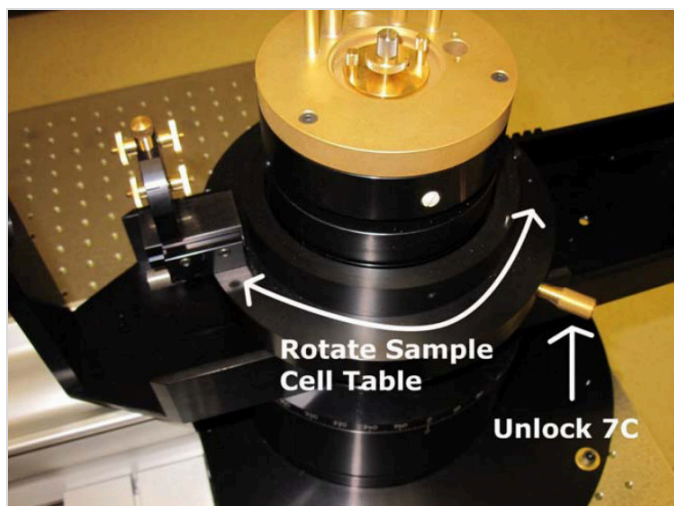
Step

30

Unlock **7C** and gently turn the sample cell table until the tip of the alignment needle is perfectly centered over the laser beam. This should be only a small turn of the table.

The laser image on the wall becomes obstructed when the needle is lowered. Rotate the sample cell table while raising and lowering the needle until the needle *tip* appears to be directly touching the laser beam. This will appear as another “X”. Then lock **7C**.

! Do not adjust knobs 7A and 7B while rotating the sample cell table.

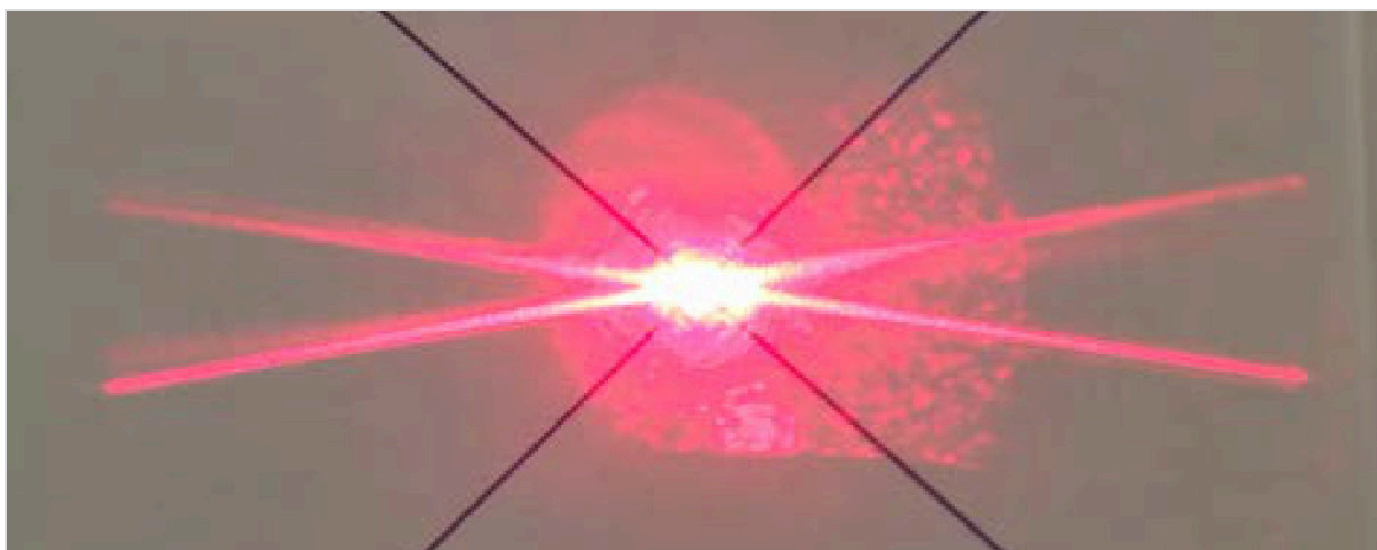


Step

31

Remove the steering lens. Lower the alignment needle once more into the path of the beam. The beam should hit the tip of the needle without any obstructions, and an “X” should appear on the target.

Be sure to lower the needle slowly. If the needle is lowered too quickly, the laser beam will be completely obscured.



## Vat and index matching fluid

Steps 32 to 37

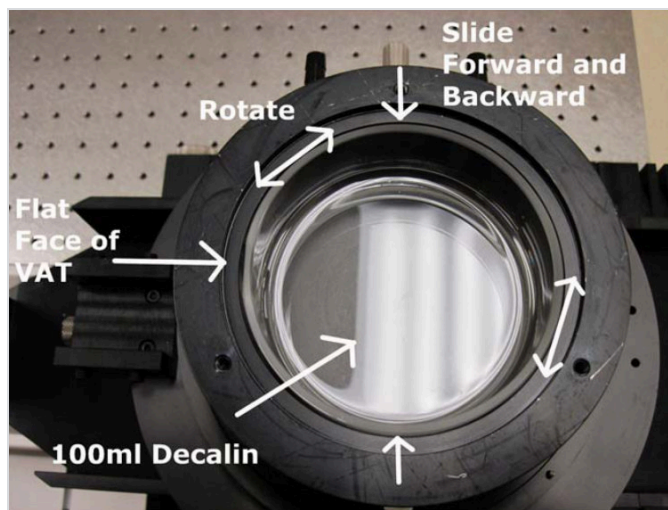
Step

32

Remove the alignment needle, the brass manifold and the steering lens assembly. Place the vat into the black metal pot, with the **flat face of the vat facing the laser**. Fill the vat with **100 mL of decalin**.

Place a 2 mm pinhole in the upright nearest the laser and tighten it down with the locking screw.

*Rotate the vat in the black metal pot and slide it forward and back so that the back reflection of the laser is centered on the 2 mm pinhole and the vat is as centered as possible in the vat holder.*

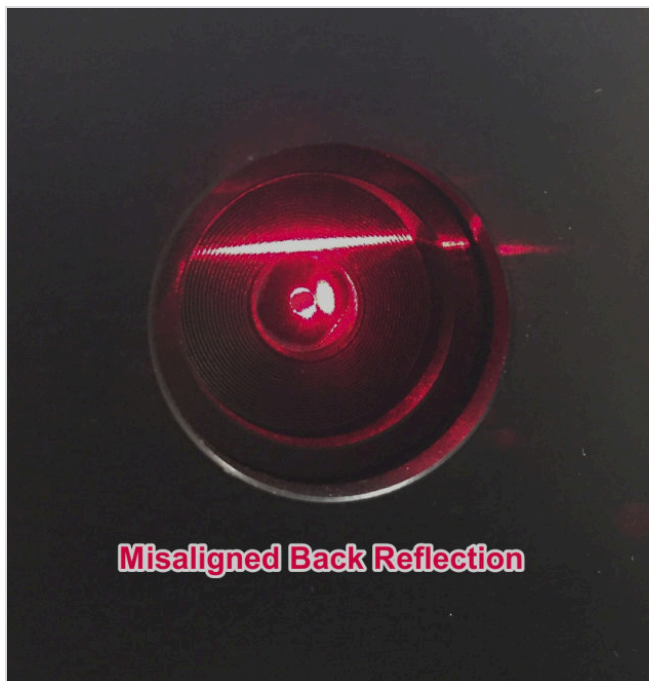


Step

**33**

Rotate the vat in the black metal pot so that the back reflection is centered on the 2 mm pinhole.

- i** The back reflection may not pass directly through the pinhole. As long as it is horizontally centered about the pinhole and the vat is fully seated in the black metal pot, you can proceed.

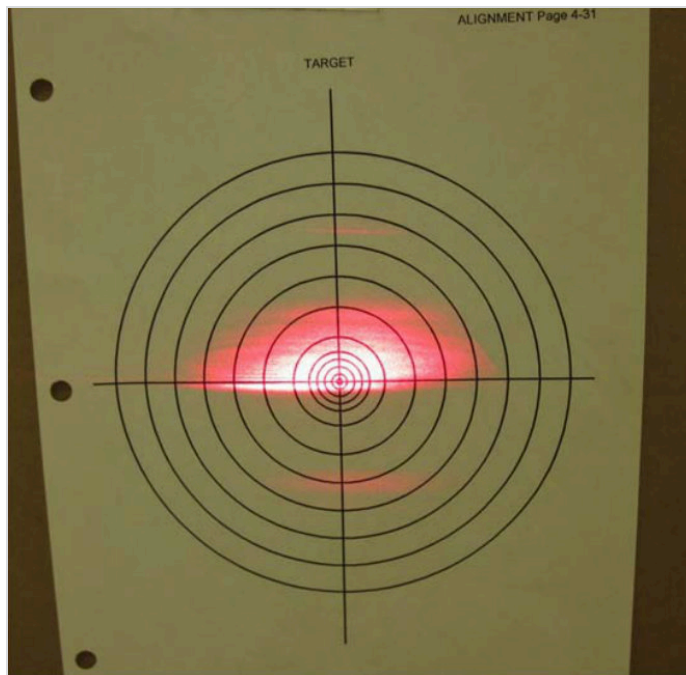


Step

34

Check the position of the laser on the target. It should be more or less horizontally centered. Minor imperfections in the glass of the vat may cause the laser image to rise above the horizontal line of the target.

**What is most important is that the back reflection is centered on the 2 mm pinhole and the vat is centered as well as possible within the vat holder.**



Step  
**35**

*Gently* tighten the three nylon screws around the sides of the vat. As the nylon screws are tightened, ensure that the back reflection and the horizontal beam on the wall do not shift out of place.

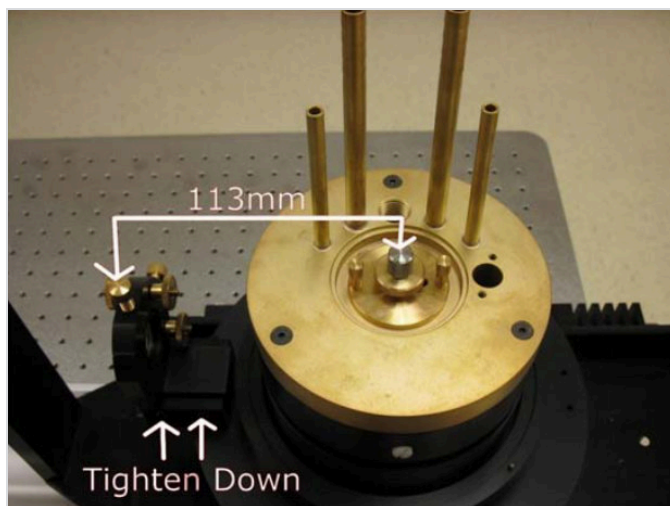
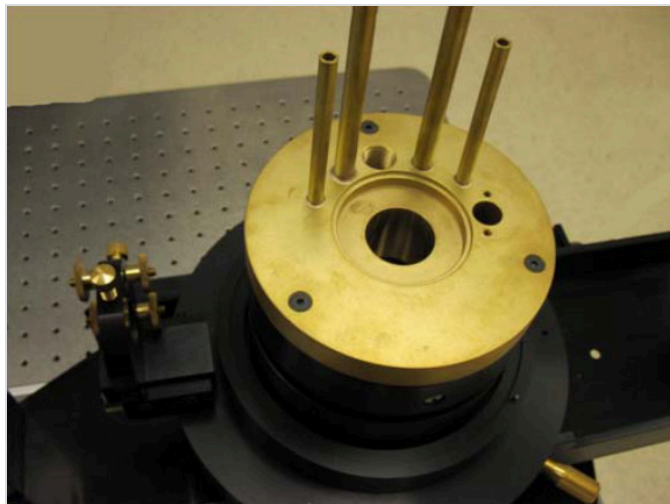
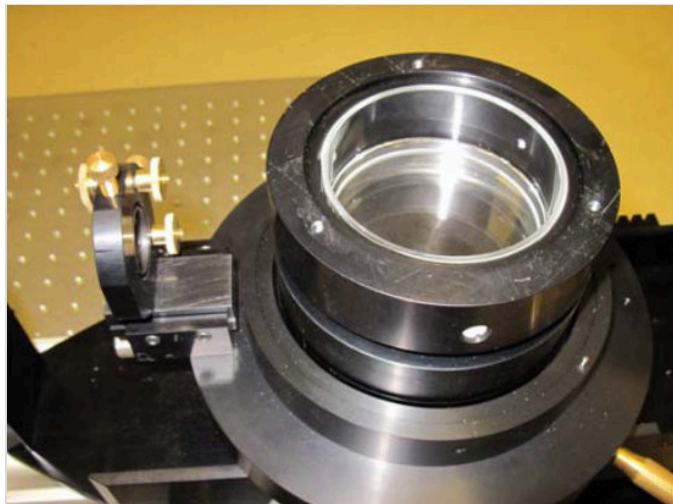
! Do not over-tighten the nylon screws!



Step  
**36**

Replace the brass manifold, the alignment needle and the steering lens using the same method as before (steering lens at 113 mm).

! Be careful when placing the brass manifold. The fragile vat is now in place and can be chipped.

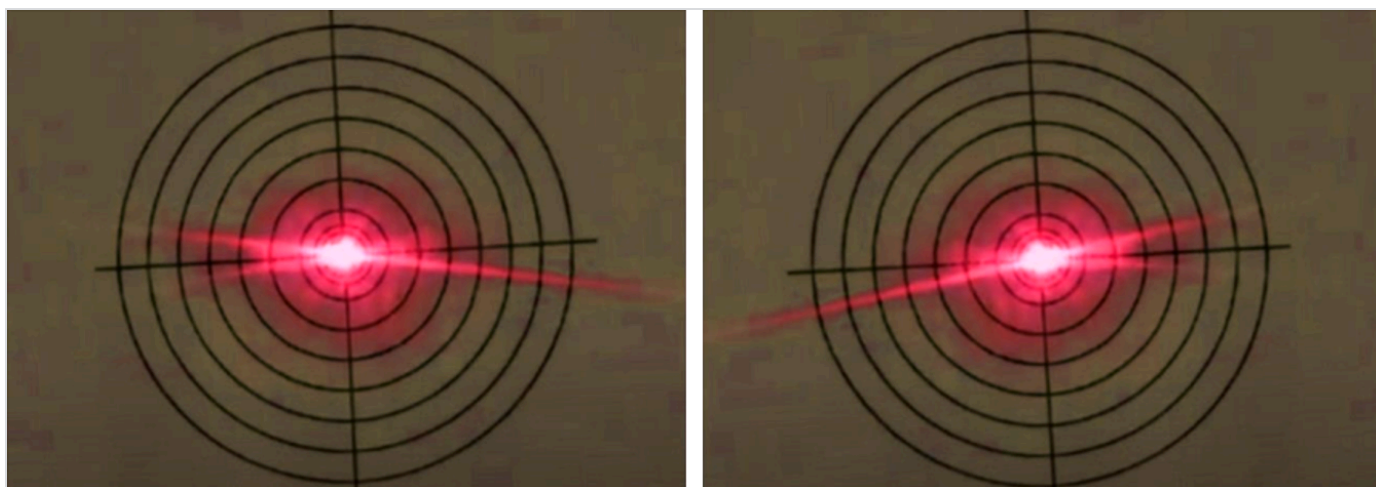
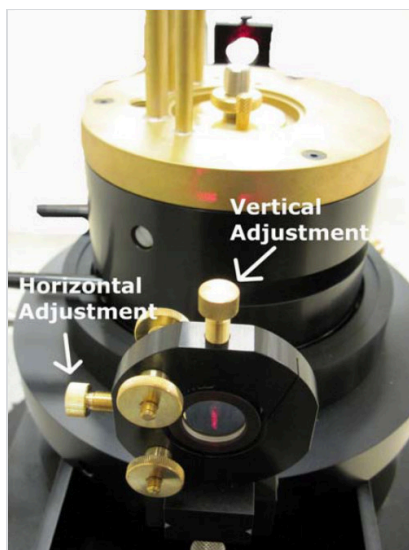


Remove the pinhole. With the vat, steering lens assembly and brass manifold in place, adjust the steering lens assembly so that the laser beam hits the center of the target. Use the **vertical** adjustment to vertically center the laser beam.

Instead of rotating the sample cell table, this time use the **horizontal** adjustment on the steering lens assembly to center the laser beam on the alignment needle. This should be a very slight adjustment; only small turns of the knob are needed.

**i** With the vat, decalin and steering lens in the path, the beam will **no longer form a perfect X** when it hits the needle. You may see a partial X as the beam hits either side of the needle. You can still identify the center by finding the midpoint between the two lobes of the distorted X.

**+** Lower the needle until it completely blocks the beam. Raise it until you see a diagonal line. Adjust the steering lens until the line goes away. Raise the needle again until the line comes back. Repeat until you see the X.



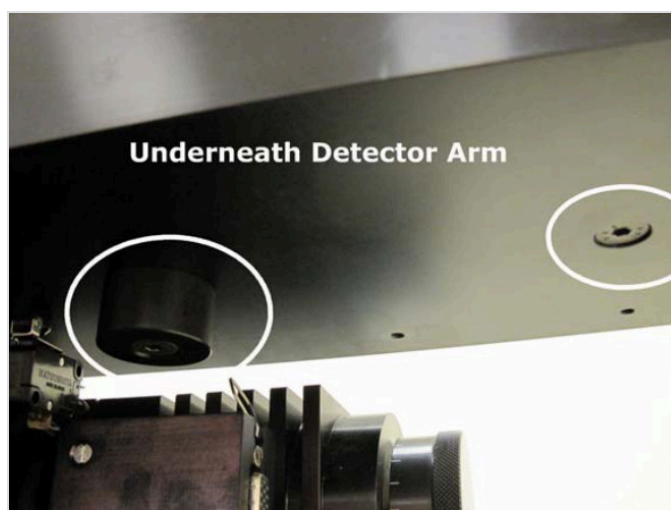
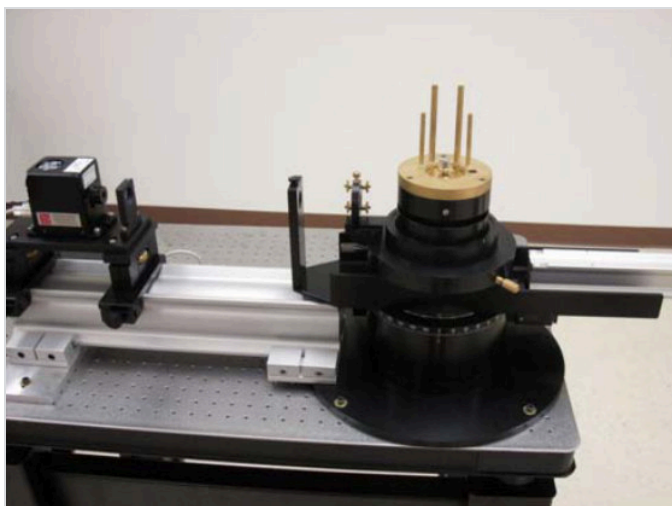
Distorted X: the beam hitting either side of the needle

Step

**38**

Remove the second 2 mm aperture upright and reattach the detector rail.

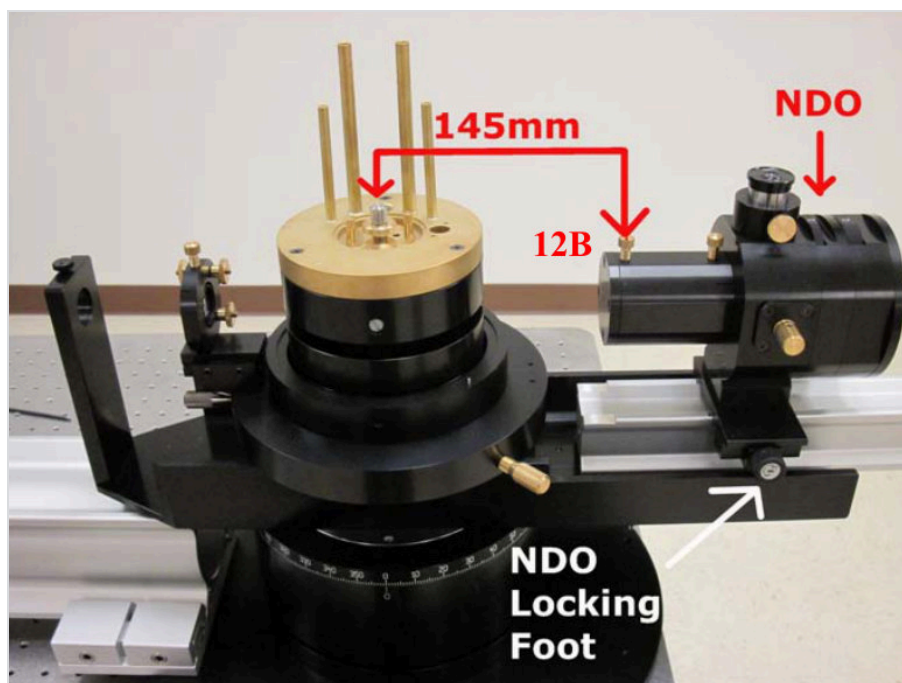
Attach the detector rail stopper to the bottom of the detector arm in place of one of the standard M6x25 flat head screws. It is positioned closest to the goniometer and attached with an **M6x40 flat head screw**.



Step  
**39**

Place the NDO on the detector rail. It must be positioned **145 mm** from the center of knob **12B** on the NDO to the center of the alignment needle. Lock the NDO in place with the knob on the NDO locking foot.

- + Use a fine black permanent marker to mark the position of the NDO on the detector rail. You will return to this mark in Step 63.

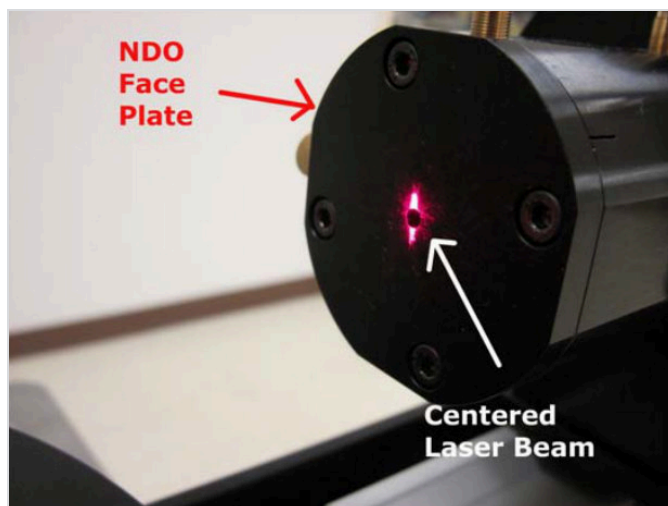
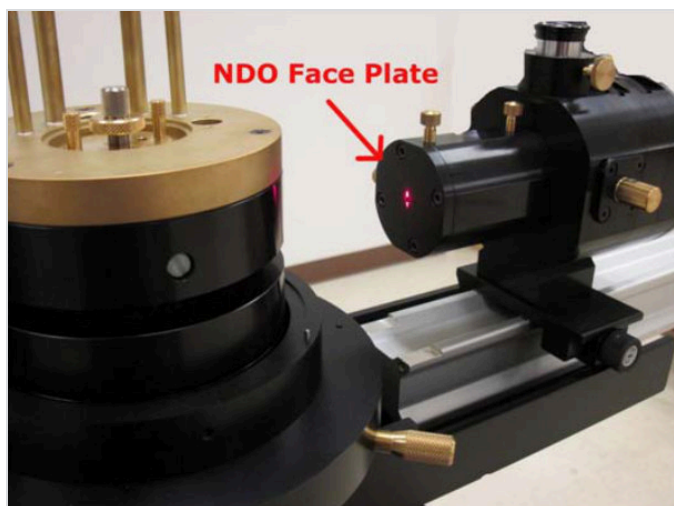


Step

40

Move the needle out of the path of the laser. Examine the NDO face plate and determine if the laser beam is centered *vertically* on the small hole in the face plate. If it is not, make a slight adjustment using the vertical adjustment knob on the steering lens assembly.

It may help to move the NDO just off center of the beam and observe the position of the laser beam relative to the hole on the face plate. Make adjustments as needed and move the NDO back to 0 degrees to confirm.

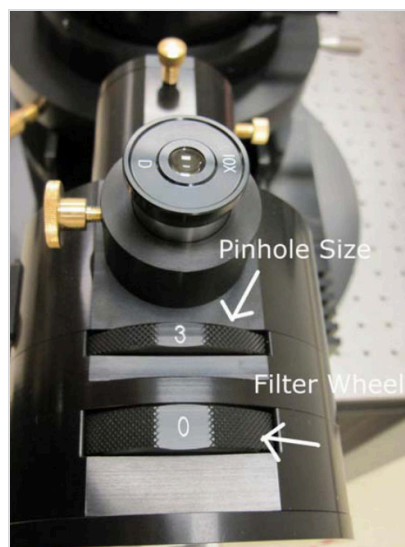
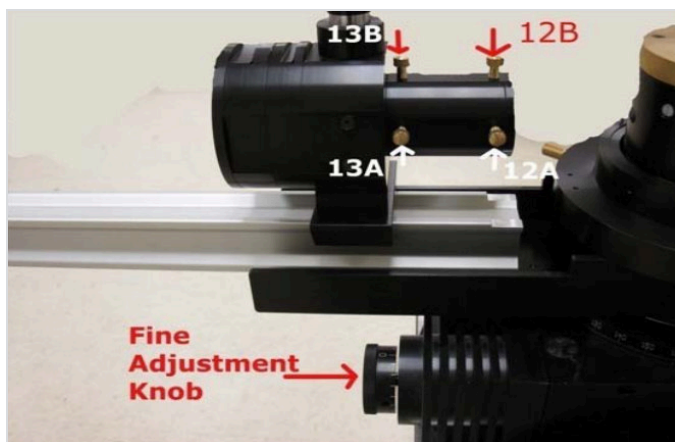


The laser beam will enter the NDO but may not pass through, because the lens and the slit inside are not aligned. To correct this, first open the pinhole on the NDO to **3 mm** and set the filter wheel to **"O" (Open)**.

Adjust knobs **12B**, **12A** and **13A**, as well as the fine adjustment knob, until the laser appears on the target. Move the NDO pinhole to the **1 mm** position and continue making adjustments until the image on the wall is centered on the target, bright and round.

You may need to "walk the beam" by adjusting the vertical on the steering lens and the NDO to bring the laser to the center of the target. Once this is done, move the NDO out of the way and check the steering lens with the needle again.

- i** The vat is in place, so expect the distorted X described in Step 37. Center on the midpoint between the two lobes.

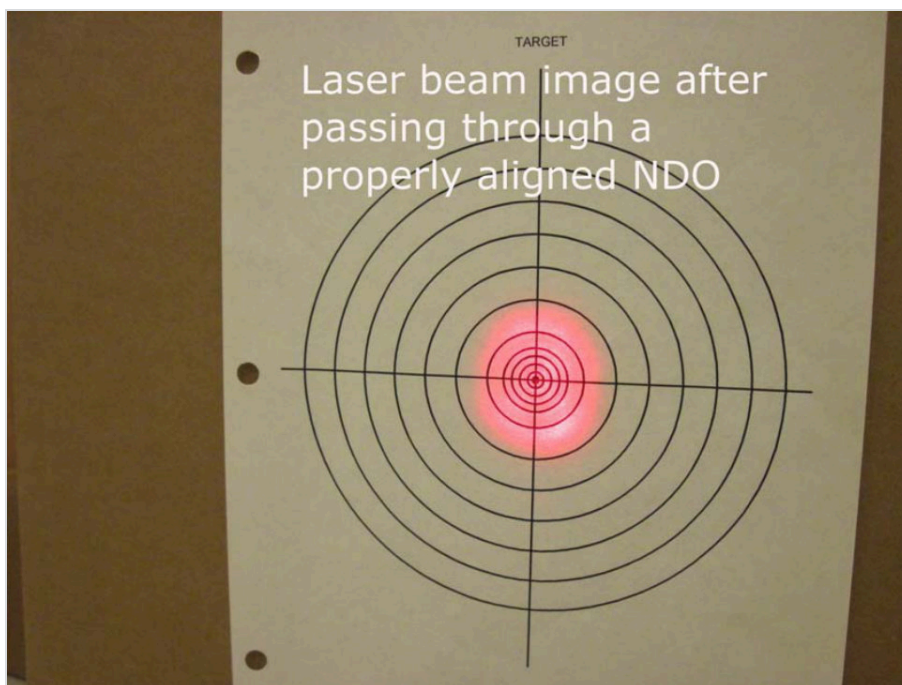


Step

42

Alignment of the NDO optics is complete when the laser beam is centered on the target, circular and bright.

Adjust the angular scale and the fine adjustment knob on the goniometer to reflect the new zero angle.



## Center of rotation

Steps 43 to 52

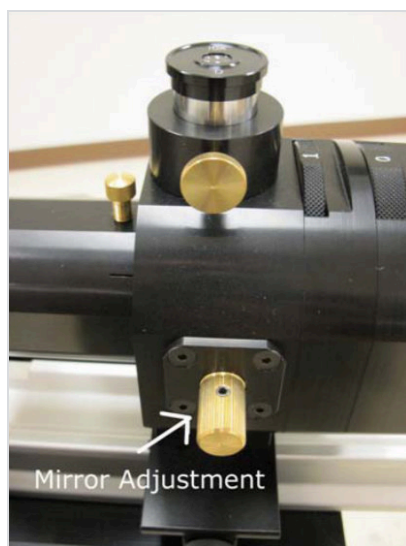
Step

**43**

Turn the mirror adjustment knob to the position pictured. Unlock the clutch release and move the detector arm to **20 degrees**.

Rotate the mirror adjustment and look through the eyepiece while shining a flashlight into the sample cell viewing area to find the alignment needle. Unlock the eyepiece and move it up and down to focus the view.

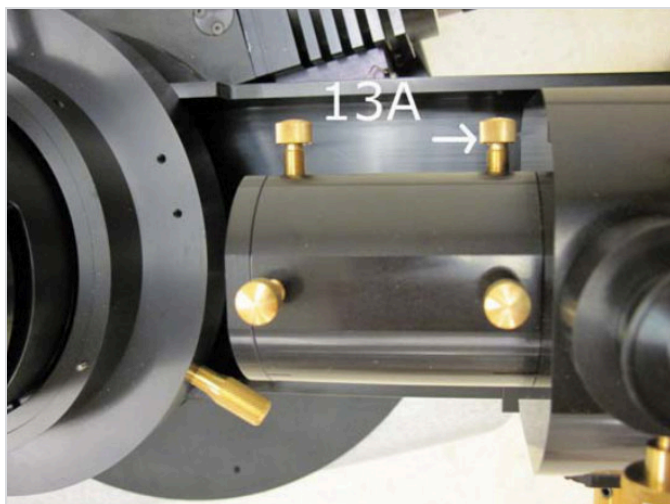
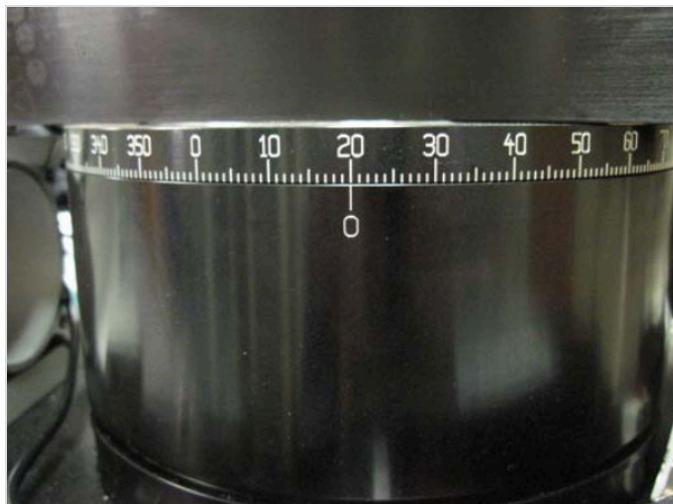
! Block the laser by closing the laser aperture before looking through the eyepiece.



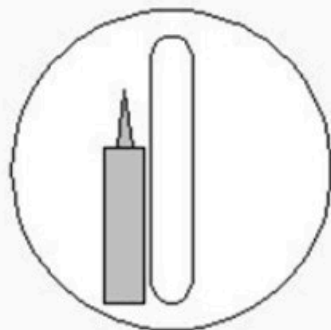
Step

44

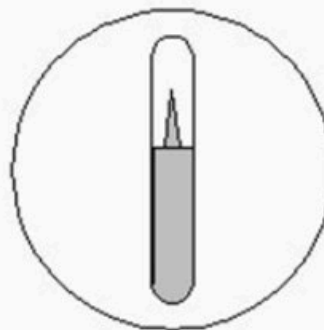
Look into the eyepiece and center the alignment needle in the slit by adjusting **only knob 13A**.



At 20°, the needle is out of the slit



Move the slit (13A), until the needle is centered



Step

45

Rotate the detector arm to **155 degrees**. Look into the eyepiece; the alignment needle may be out of sight.

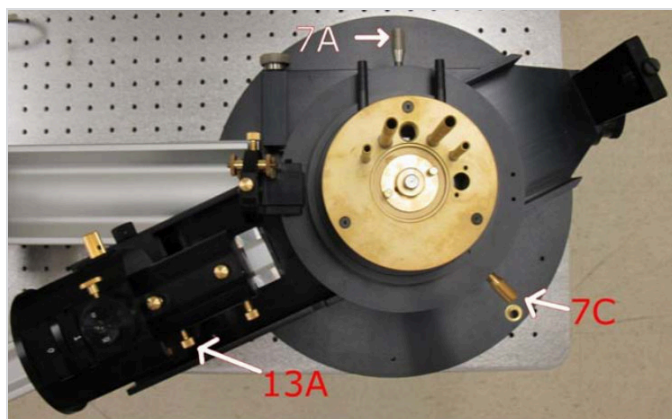
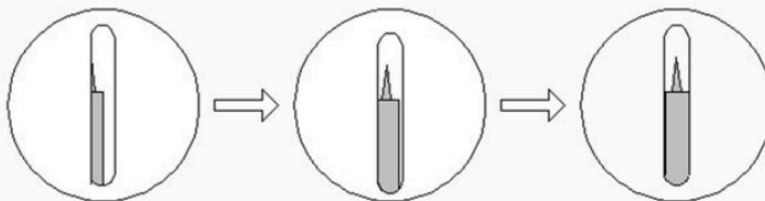
Unlock **7C** and make *small* adjustments to **7A** until the alignment needle is **halfway** to the center of the slit. Adjust knob **13A** on the NDO to bring it fully centered. Lock down **7C** again.



After rotation to 155°, the needle may look like this

Halve the difference (7A).

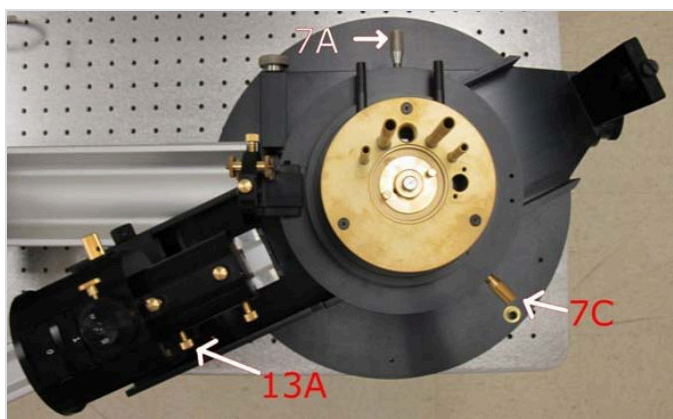
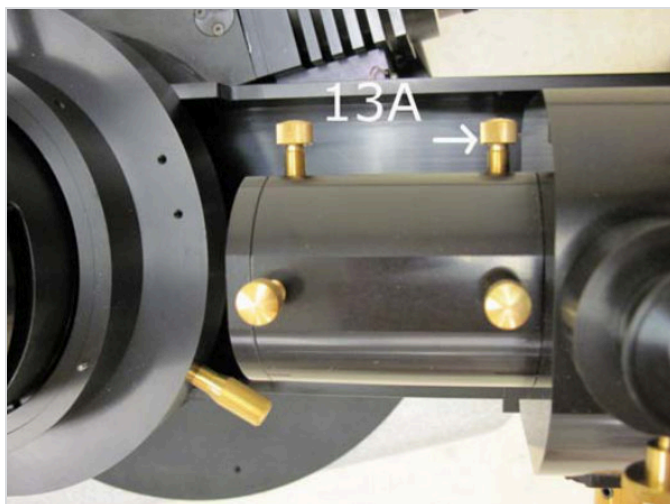
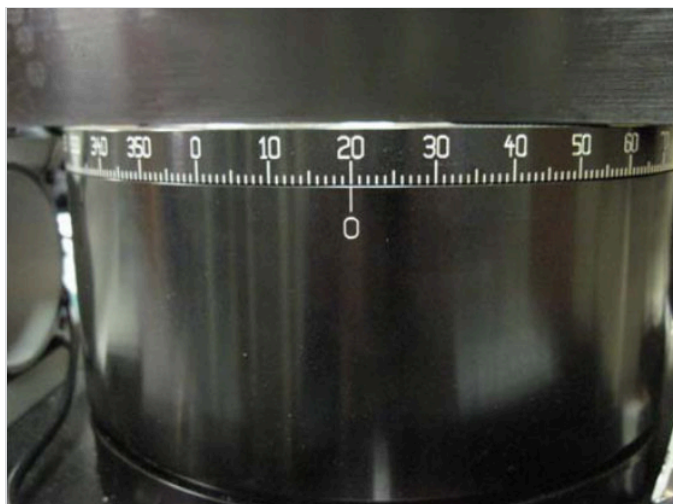
Move the slit (13A) until the needle is centered



Step

**46**

Repeat Steps 44 and 45 until the alignment needle is centered at *both* angles.

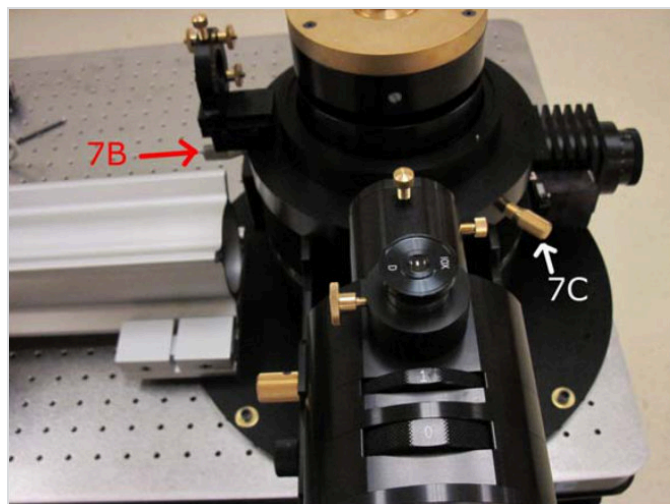
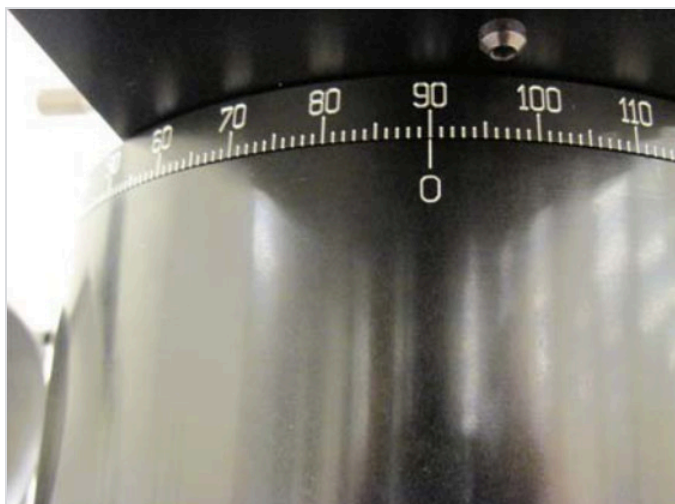


Step

**47**

When the alignment needle appears centered in the slit at both 20 and 155 degrees, move the detector arm to **90 degrees** and lock it.

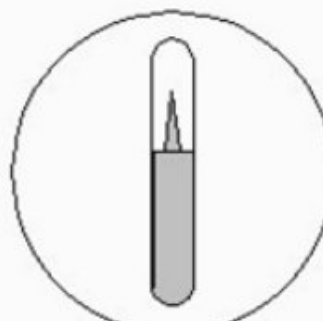
Unlock **7C**. Look through the eyepiece and center the alignment needle in the slit using **only knob 7B**, then re-tighten **7C**.



At 90°, if the needle is not centered, then...

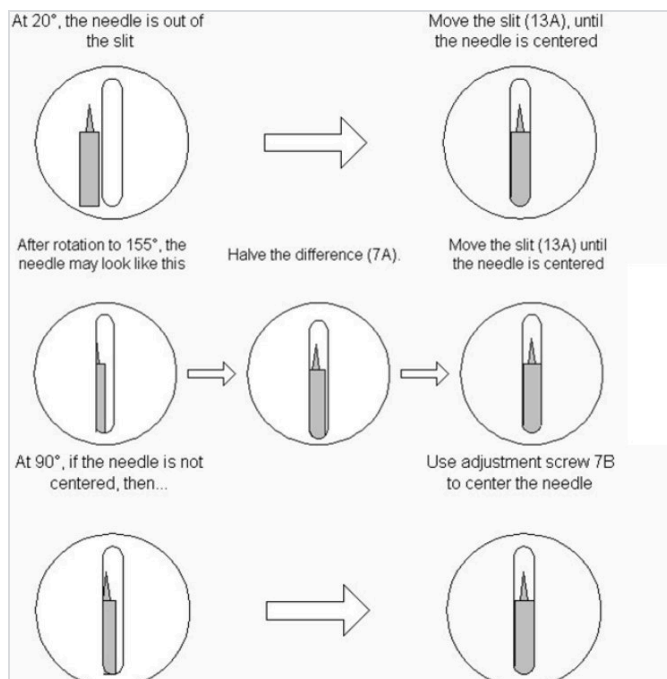


Use adjustment screw 7B to center the needle



# Step 48

After the alignment needle is centered at 90 degrees, go back and check 20 and 155 degrees to ensure the needle is still centered. If necessary, re-center the needle and continue checking each angle until it is centered all around.



Step

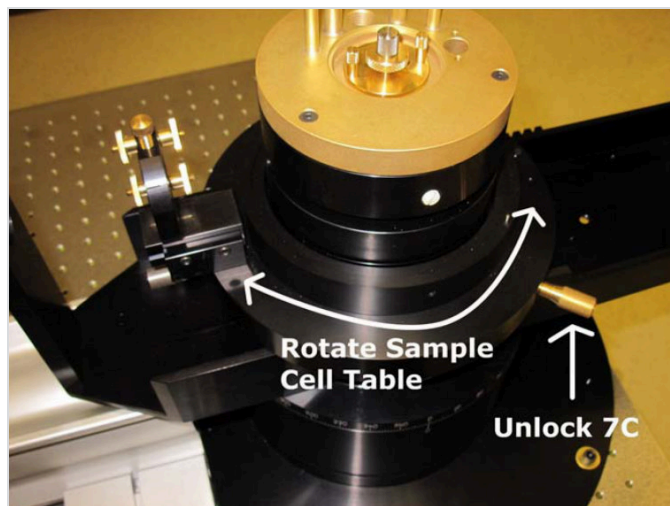
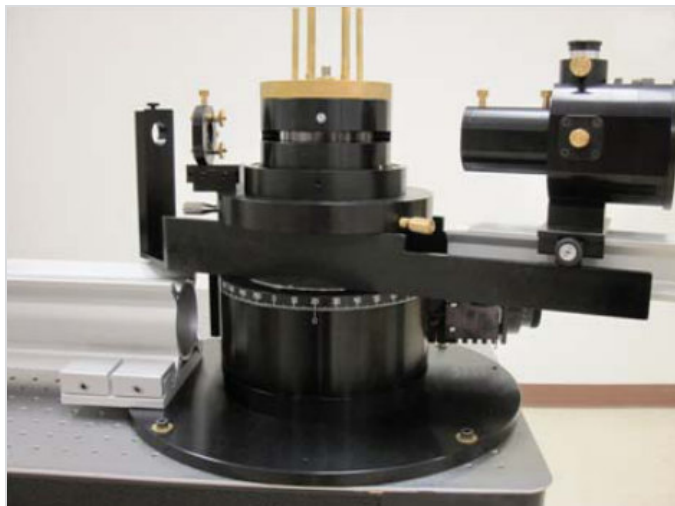
49

Rotate the detector arm to **20 degrees** and open the shutter on the laser. Notice that the alignment needle is no longer in the path of the laser beam.

Unlock **7C** and rotate the sample cell table until the laser beam just touches the needle tip. You will see an "X" again. Lock down **7C**.

! Do NOT adjust knobs 7A and 7B while rotating the sample cell table.

i With the vat in place the X is distorted, as described in Step 37. Use the midpoint between the two lobes.

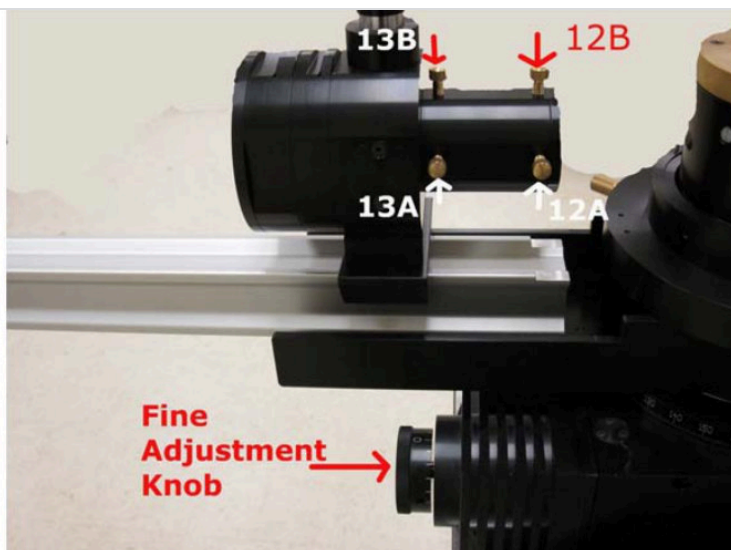


Step

50

Raise the alignment needle. Rotate the detector arm to **zero degrees** and again adjust the knobs on the NDO and the fine adjustment knob until the laser image on the wall is centered and bright.

Reset the angular scale and the fine adjustment knob to zero degrees.

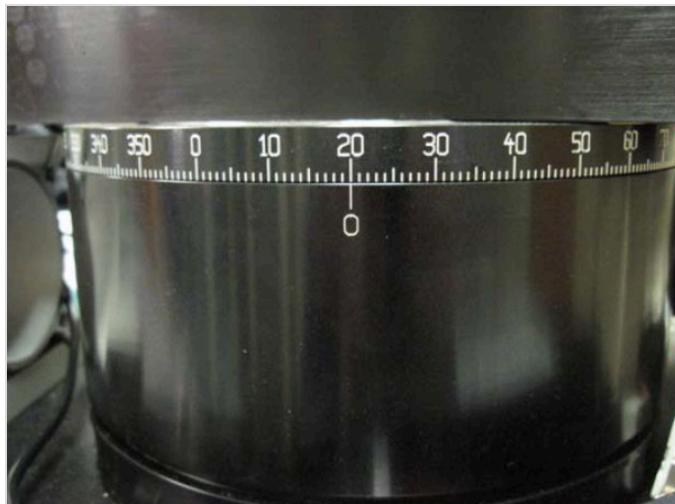


Step

51

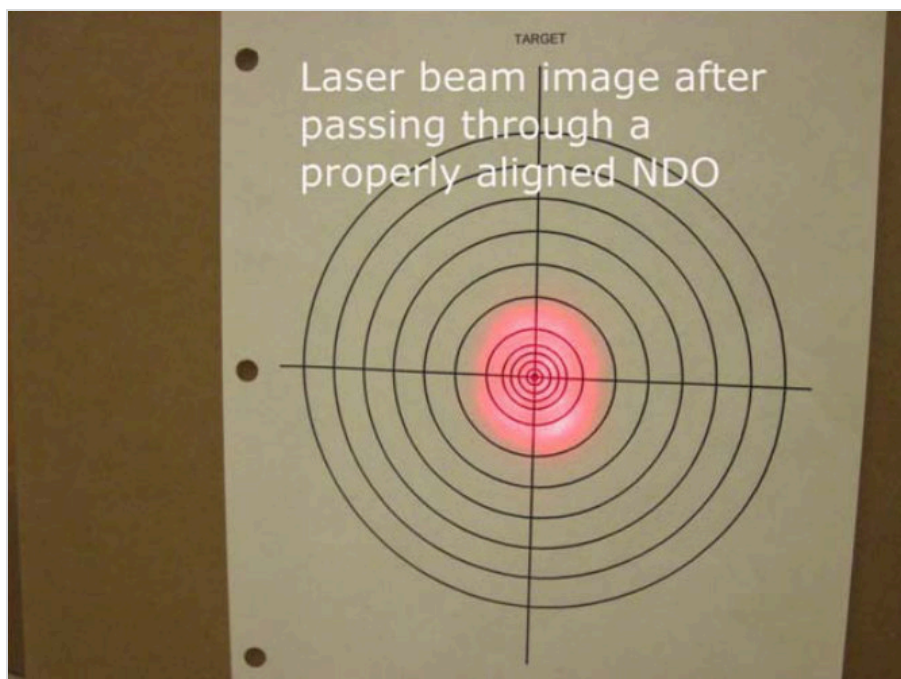
Center the alignment needle in the slit of the NDO at all angles again, from Step 44 on. **Return to Step 43 and redo all steps to this point.**

- i We repeat because each subsequent adjustment brings the needle closer and closer to the true center of rotation.



The center of rotation procedure may take several repetitions before everything is well aligned. At this point:

- the alignment needle is centered at all positions when viewed through the eyepiece,
- the laser touches the tip of the alignment needle, and
- the laser beam forms a bright circular spot centered on the target when passing through the NDO.



## Shuffle plates and beam stop

Steps 53 to 59

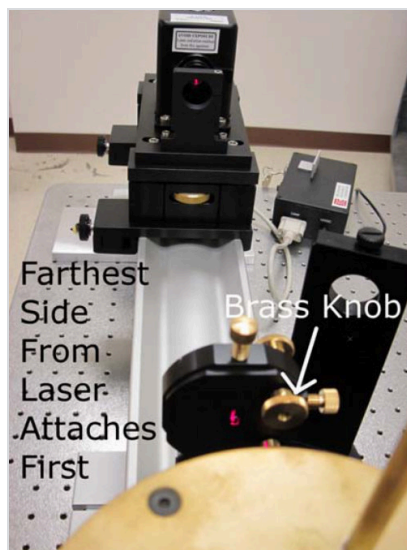
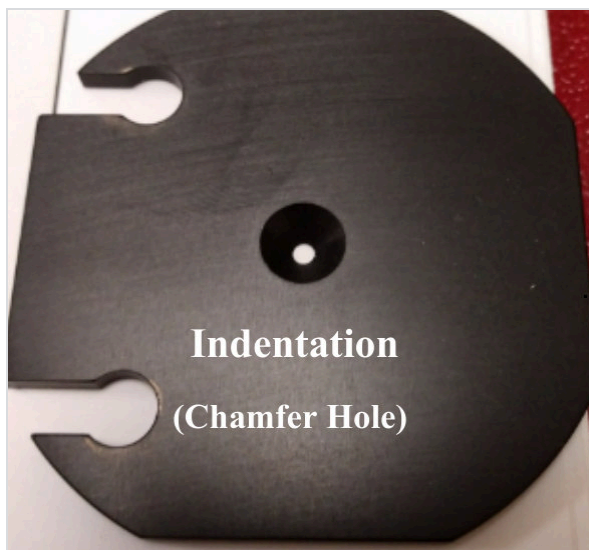
Step

53

Set the NDO pinhole to **"C" (Closed)**. Rotate the detector arm to 20 degrees and tighten the clutch release.

Place the first shuffle plate on the steering lens assembly, on the side **farthest from the laser**. The side of the shuffle plate with the indentation (chamfer hole) is placed *towards* the steering lens.

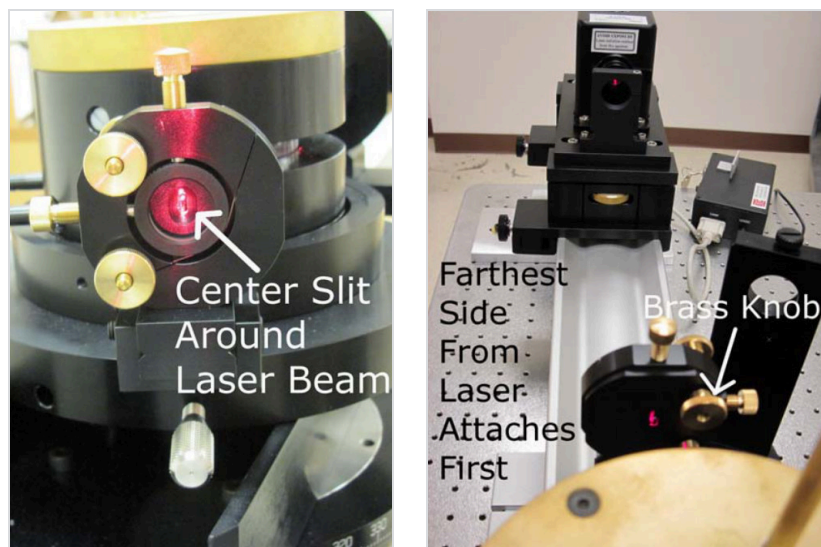
- i For vertical lasers (e.g. Mini-L30), the indentation is a vertical slot. For circular lasers (e.g. Mini-L40), it is a circular indentation, as shown.



Step  
**54**

Look through the steering lens and adjust the shuffle plate behind it until the slit is centered around the laser beam. The beam passes cleanly through without any bright spots on the slit of the shuffle plate.

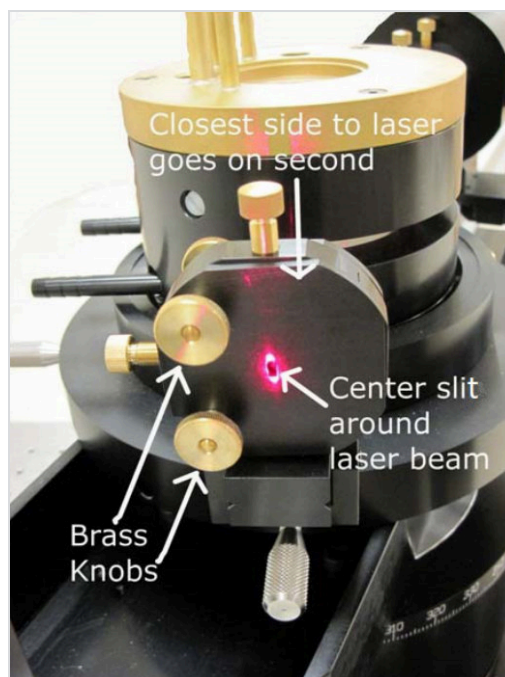
Lock the shuffle plate in place with the two brass knobs.



Step  
**55**

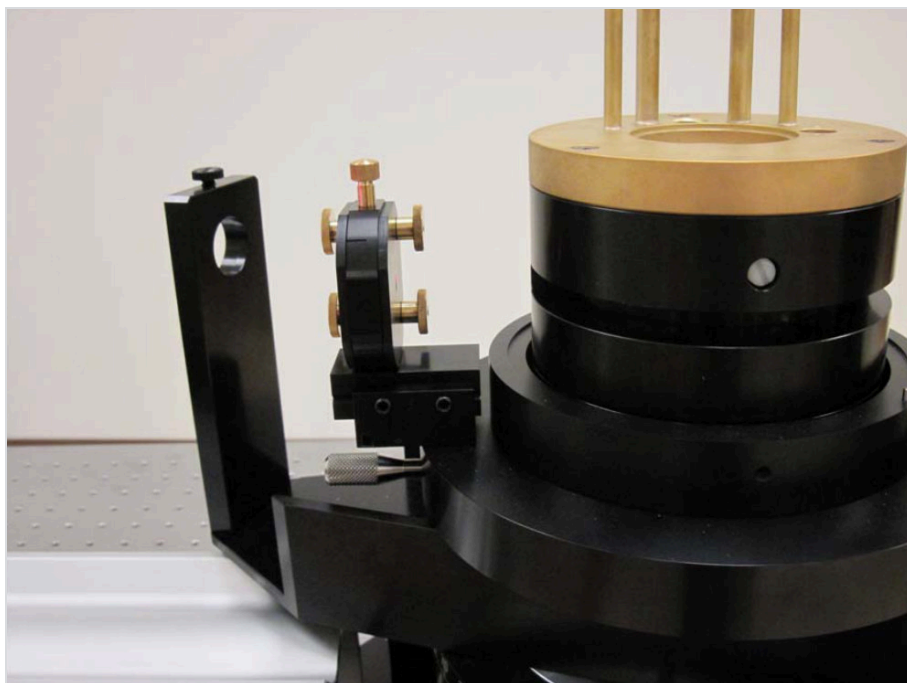
Place the second shuffle plate on the steering lens assembly, on the side **closest to the laser**, with the chamfered side facing the steering lens. Center the slit around the laser beam. There should be no bright spots on the opening and the beam should pass straight through.

Lock the shuffle plate in place with the two brass knobs.



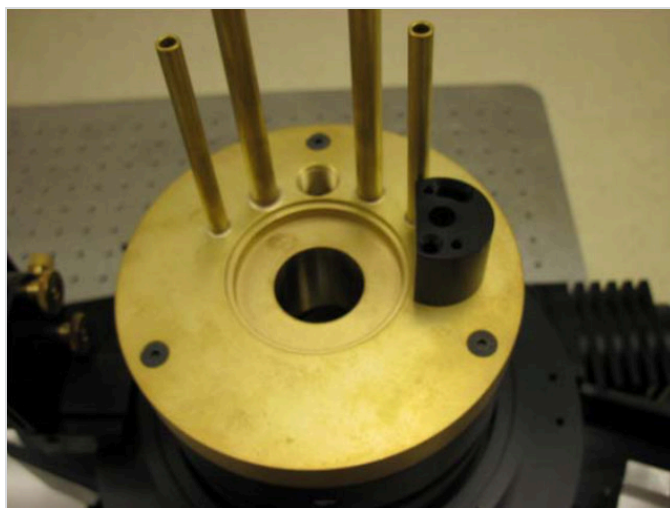
Step  
**56**

The steering lens assembly now has both shuffle plates attached. Remove the alignment needle.



Step  
**57**

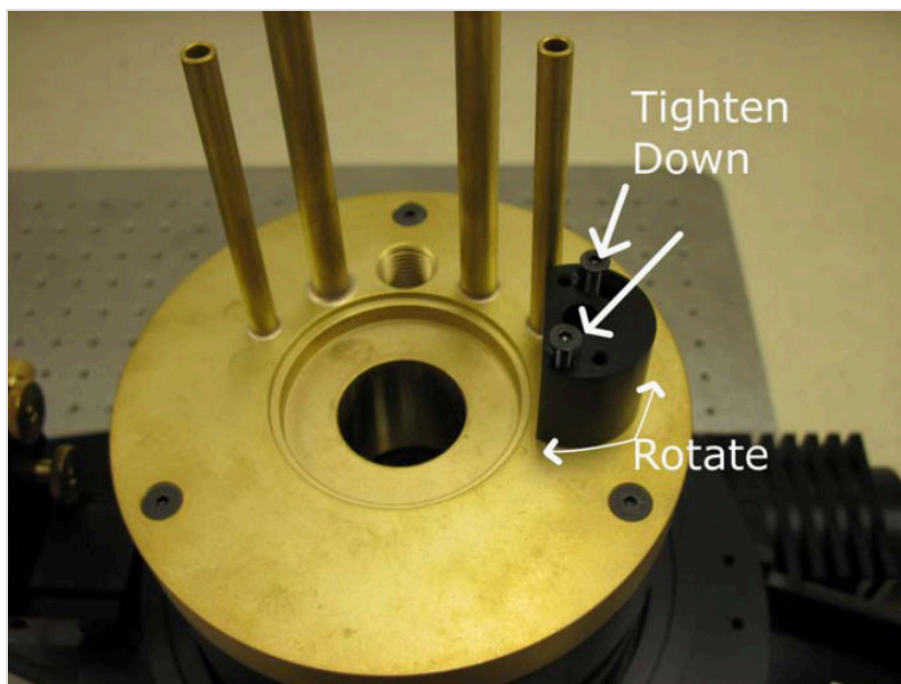
Insert the beam stop into the opening in the brass manifold and hold it in place with the two M3x30 flat head screws.



Step  
**58**

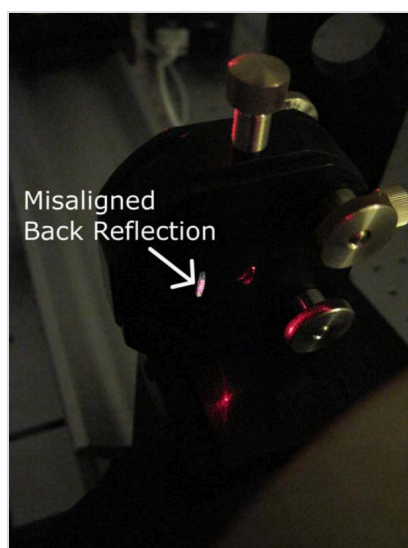
*Turn off the lights to view the back reflection.* Rotate the beam stop in place (it only moves a few millimeters each way) and watch the back reflection on the shuffle plate closest to the beam stop.

Rotate the beam stop until the back reflection passes through the opening in the shuffle plate, then tighten the two screws on the beam stop. After the screws are fully tightened, confirm the back reflection still passes through the opening.

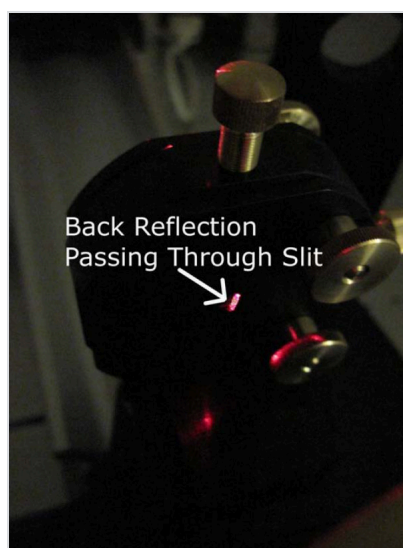


Step  
**59**

Compare your result with the photos.



Incorrect



Correct

## Close up the sample cell and NDO

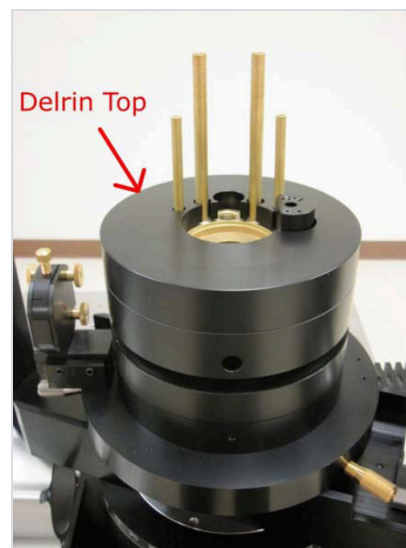
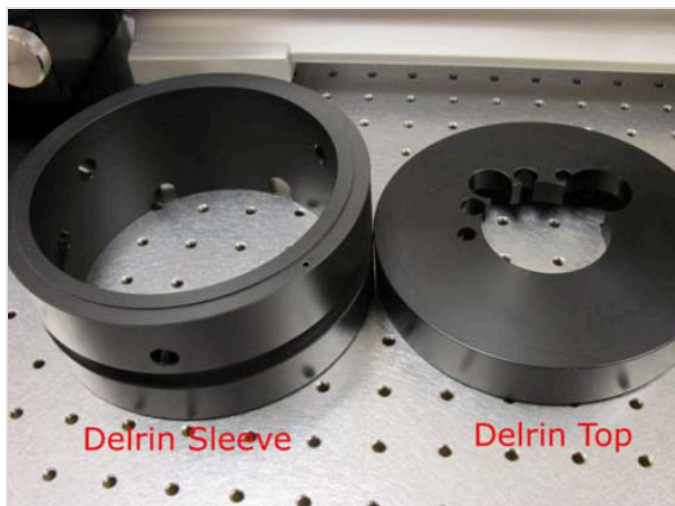
Steps 60 to 64

Step

60

Slide on the delrin sleeve and match its small set pin with the hole in the delrin base. Slide on the delrin top and match its set pin with the hole in the delrin sleeve.

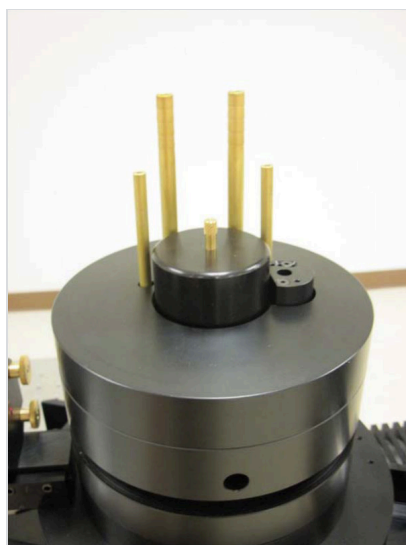
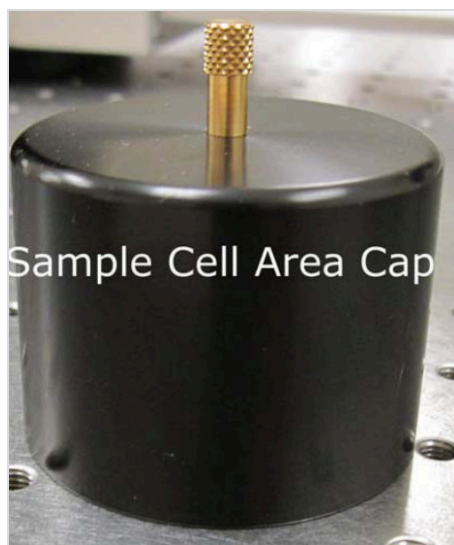
**i** This is the same sleeve you dry-fit in Step 11b.



Step

61

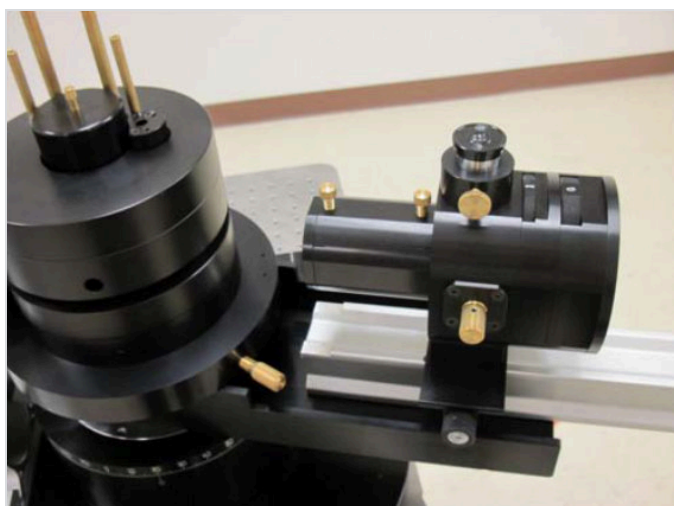
Place the cap on top of the sample area to prevent dust from entering the index matching fluid.



Step

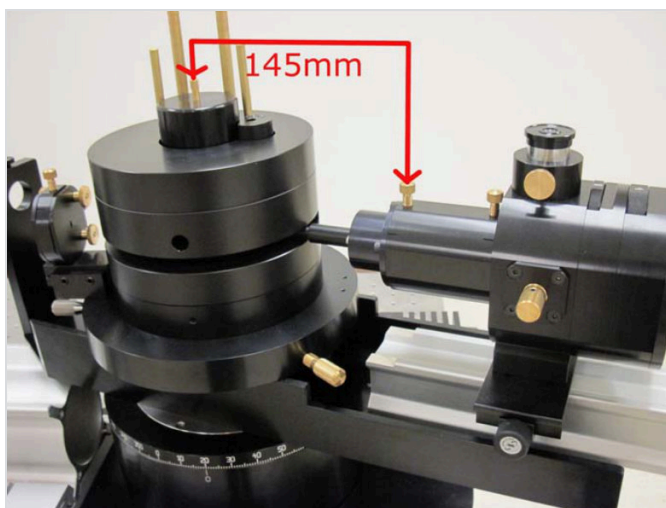
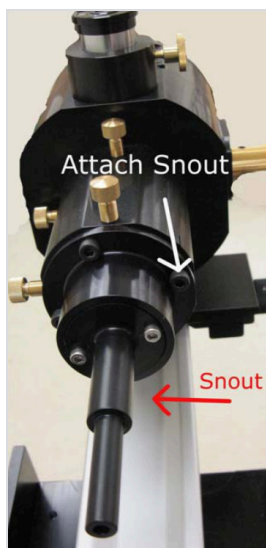
62

Loosen the locking foot on the NDO and move the NDO back on the detector rail. Remove the face plate on the NDO by removing the four **M4x10 socket cap screws**.



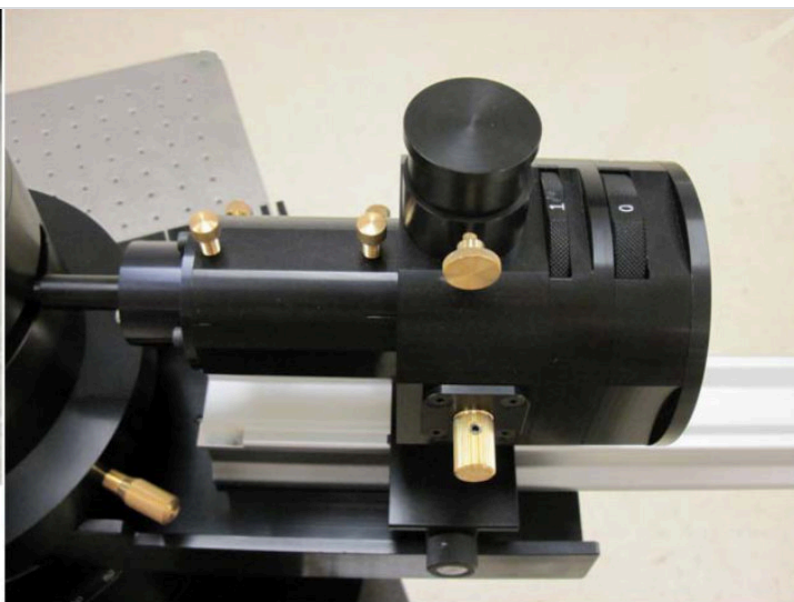
Step  
**63**

Attach the snout to the NDO using the same four screws as the face plate. Then *carefully* move the NDO back into the original marked position from Step 39.



Step  
**64**

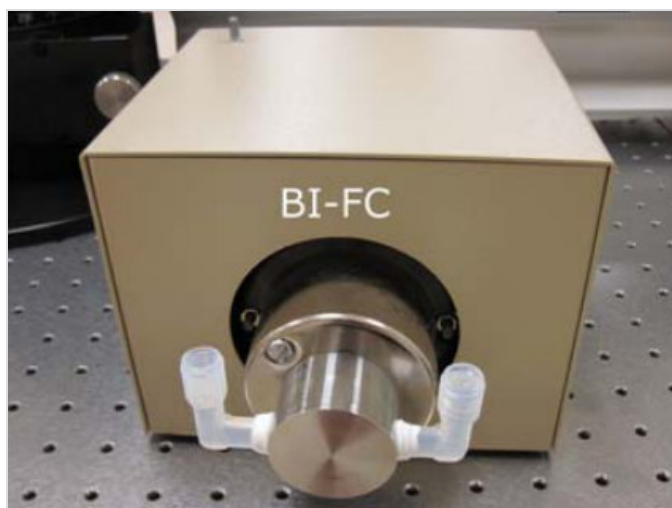
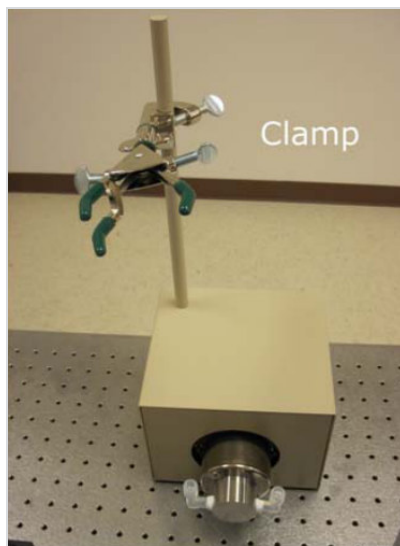
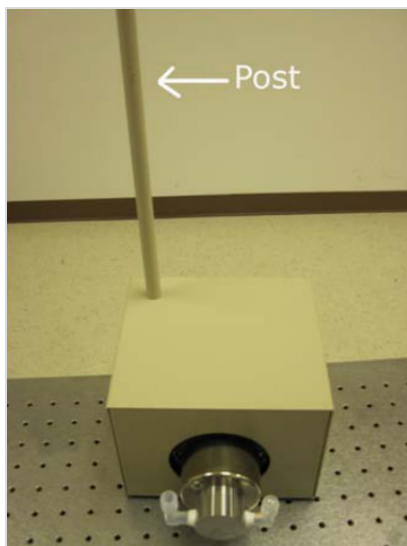
Place the NDO eyepiece cap over the eyepiece on the NDO.



Step

**65**

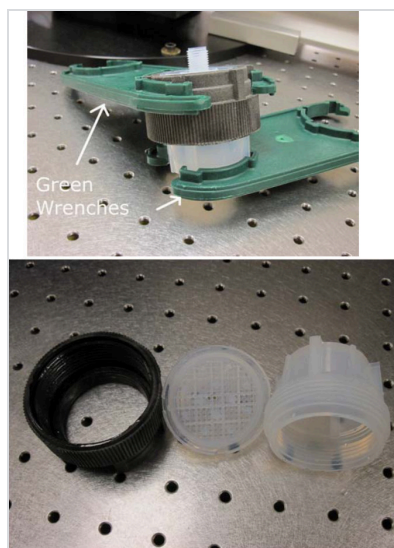
Attach the post to the BI-FC by screwing it in place. Attach the clamp to the post.



Step

66

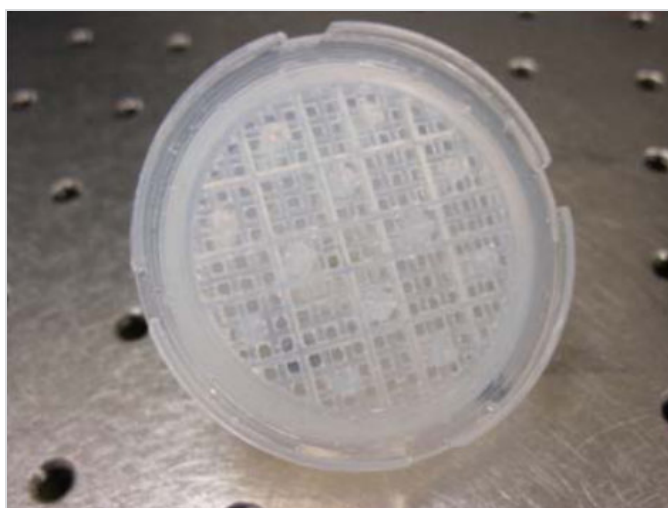
Use the supplied green wrenches to open the filter housing.



Step

67

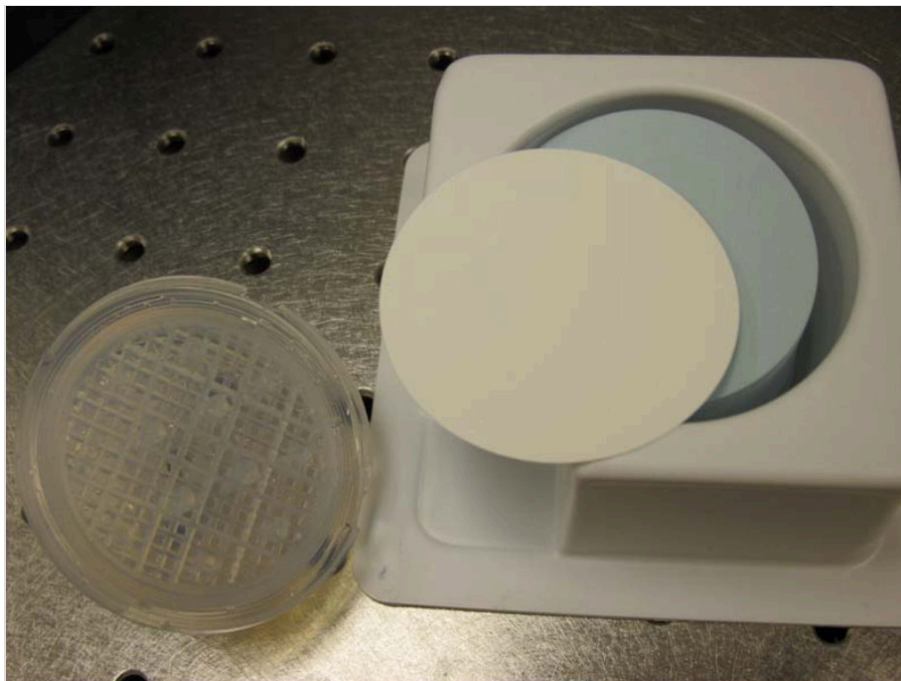
The filter housing holds the filter stage, a plastic mesh platform that the filters sit on. The mesh should feel smooth, with no raised ridges, and should be firmly pressed in place and not easily removed.



Step

68

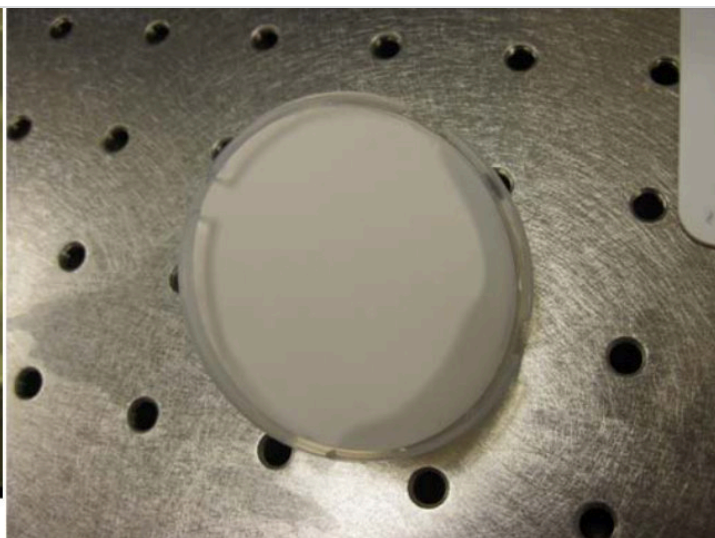
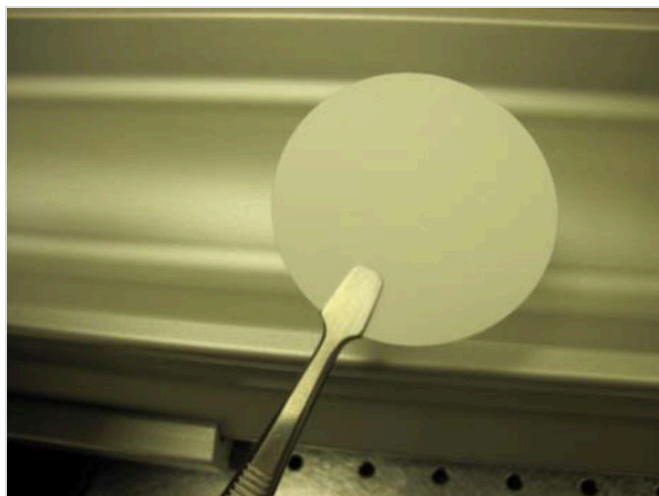
The first filter to use is the **0.2  $\mu\text{m}$  nylon membrane filter** by Pall. The filter is white and is surrounded by blue paper protectors. It is very delicate and should be handled with care (Step 69).



Step

69

Pick up the filter with the supplied flat head tweezers and place it on the filter stage. Add a few drops of decalin on top so that the filter is saturated and sticks to the filter stage.



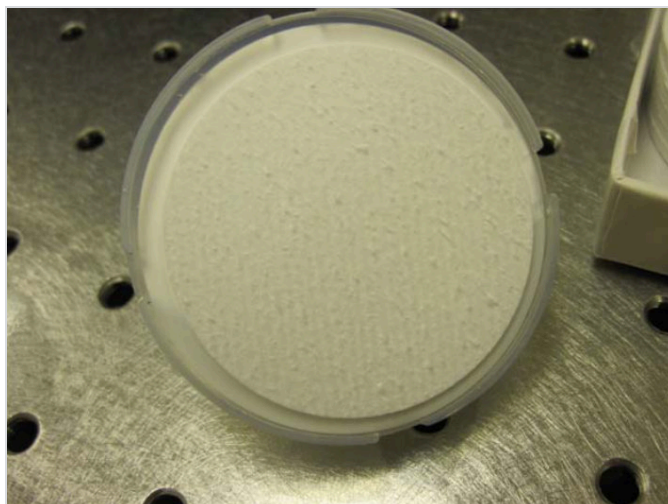
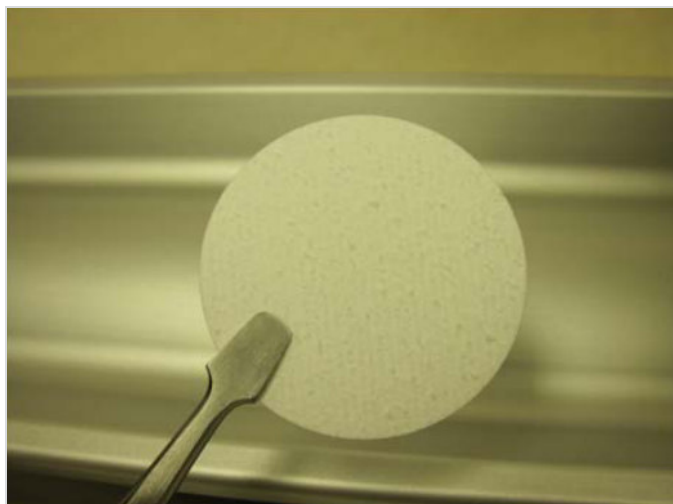
Step  
**70**

With the filter in place, next add one of the **glass fibre pre-filters** by Millipore. Handle these with care, as they are also delicate.



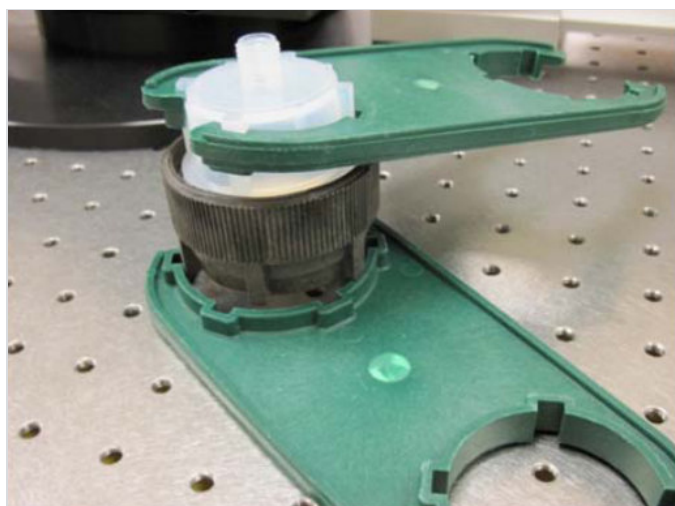
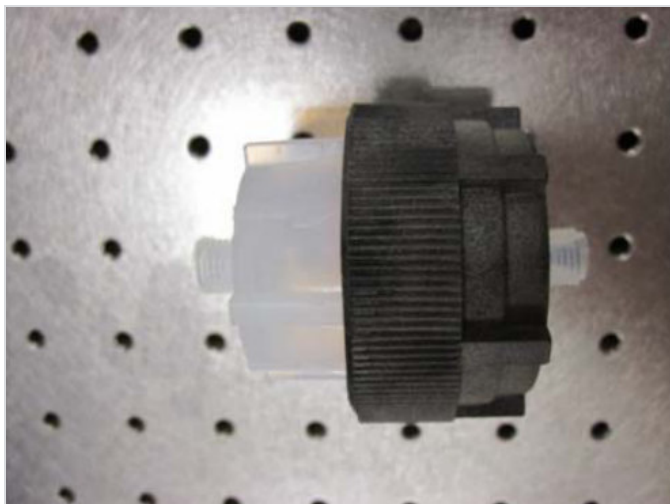
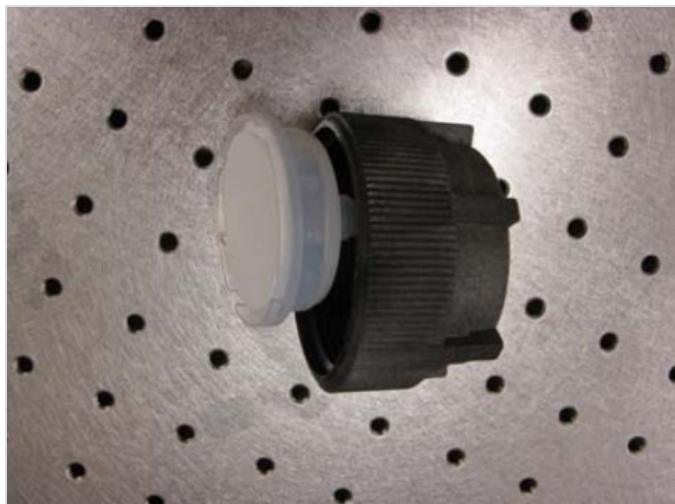
Step  
**71**

Using the flat head tweezers, place a glass fibre pre-filter on top of the nylon filter already on the filter stage. *Center the pre-filter on top of the nylon filter.* Once it is in place, drip a few drops of decalin on top so that it stays in place.



Step  
**72**

Insert the filter stage into the black filter housing cap. Begin to screw in the bottom of the filter housing by hand, then use the green wrenches to fully tighten it down.



Step

**73**

Assemble the **23 cm** length of pump inlet tubing as shown.



Step  
**74**

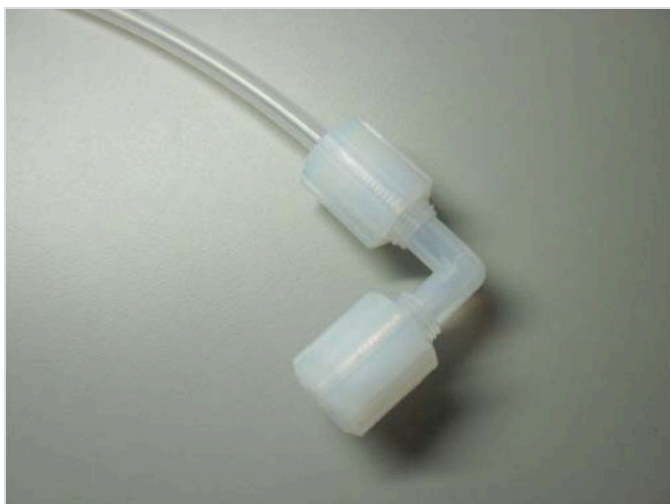
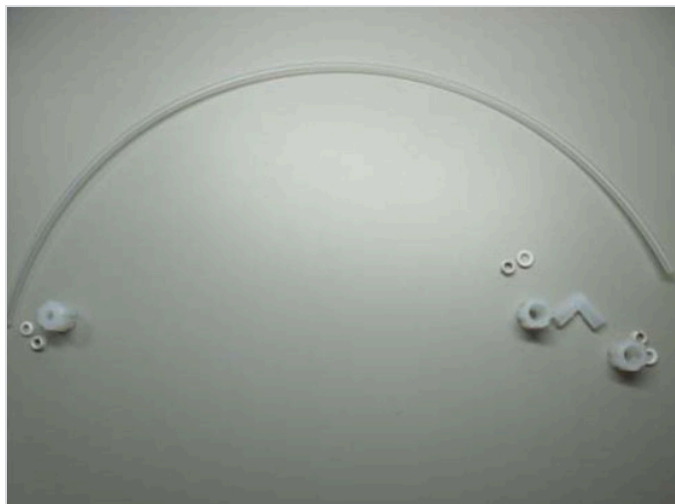
Attach one end of the 23 cm tubing to the bottom of the filter housing and connect the other end to the left pump outlet fitting of the BI-FC, as shown.



Step

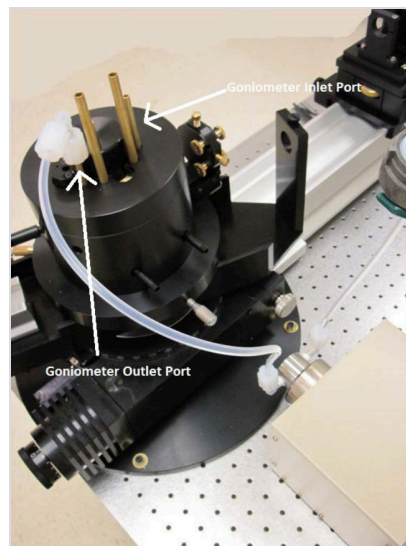
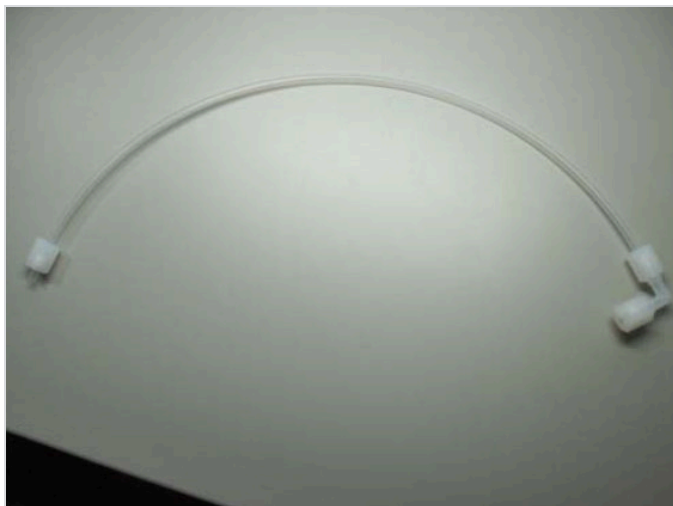
75

Assemble the **50 cm** length of pump outlet tubing as shown.



Step  
**76**

Attach one end of the 50 cm tubing to the BI-FC pump fitting and the other end to the index matching fluid outlet pipe on the goniometer, as shown.



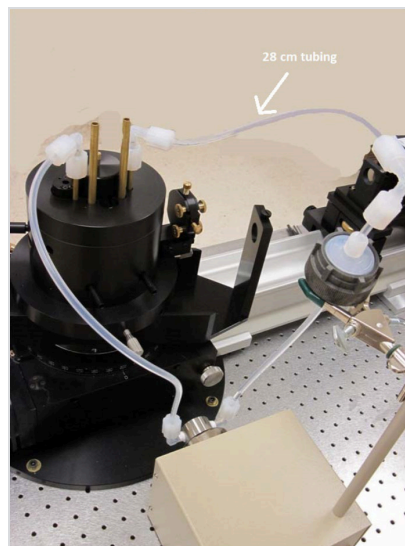
Step  
**77**

Assemble the **28 cm** tubing and the **8 cm** tubing as shown.



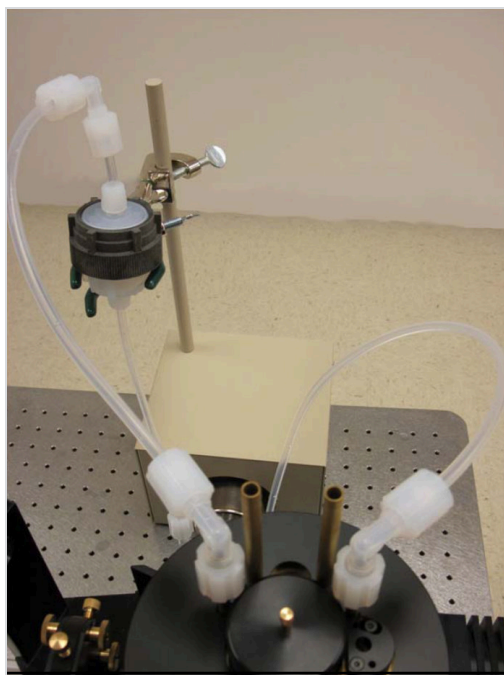
Step  
**78**

Attach the 28 cm tubing with one end on the top of the filter housing and the other end on the inlet port of the goniometer, as shown.



Step  
**79**

The correct setup for the BI-FC filtration system is shown here.

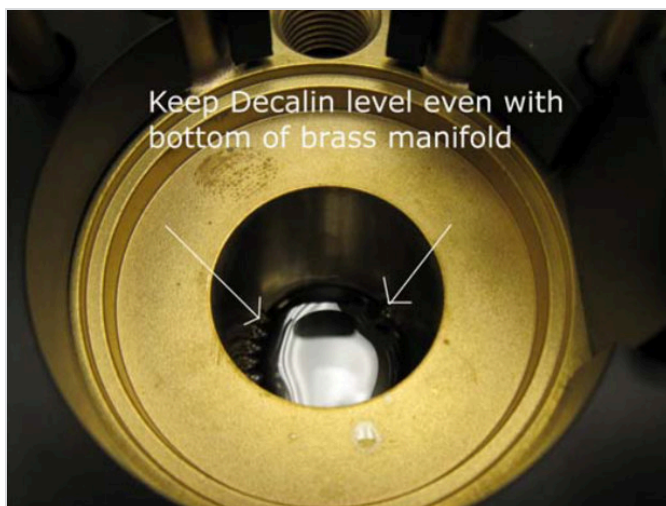


Step

80

When the BI-FC is fully set up and attached to the goniometer, switch it on and watch the sample cell area. The decalin level will drop as it is pumped through the BI-FC.

*Slowly* add decalin until bubbles stop flowing in the tubing. Do not add too much; keep the fluid level even with the *bottom* of the brass manifold. Approximately 100 to 200 mL of decalin is required.



## Detector and motor controller

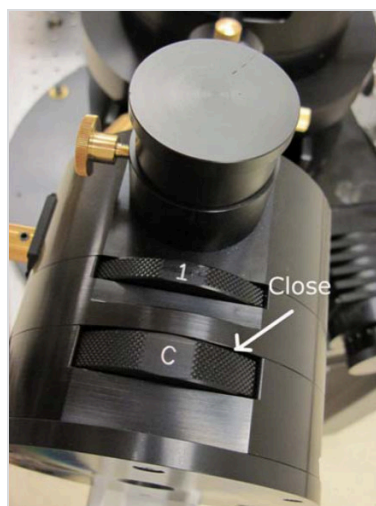
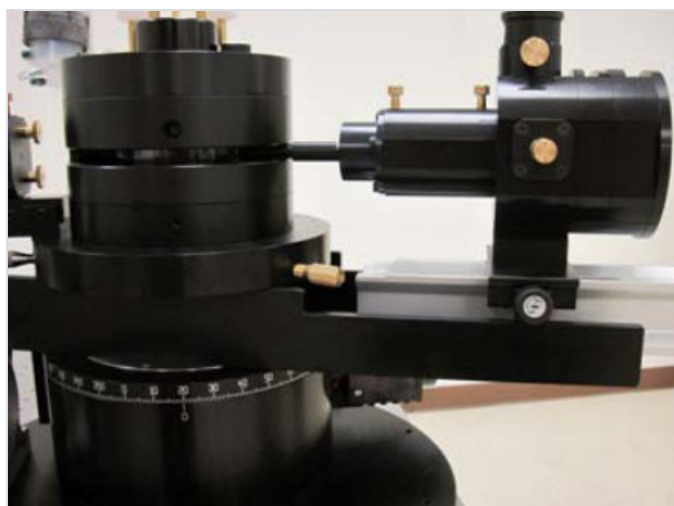
Steps 81 to 90

Step

81

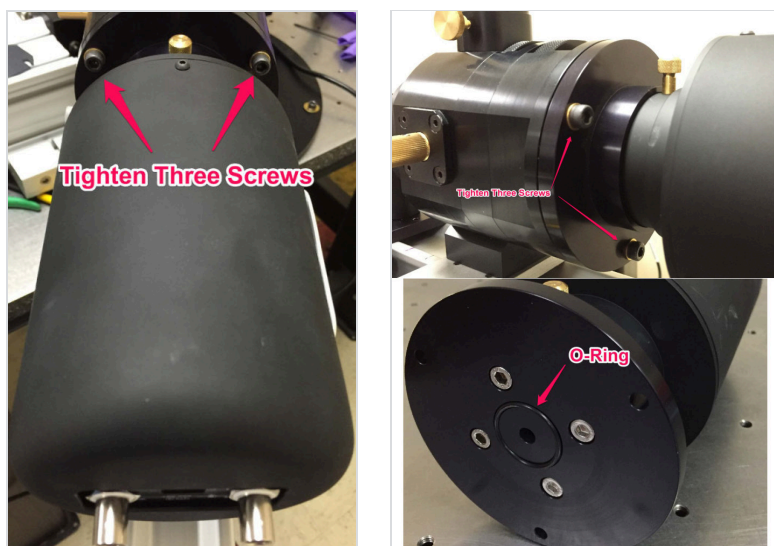
If the detector arm is not at 20 degrees, move it there now. Set the filter wheel on the NDO to “C” (Closed).

! The BI-APDx is very sensitive to light. Do not allow it to be exposed to room light. If the laser beam accidentally enters the BI-APDx, it can damage the diode.



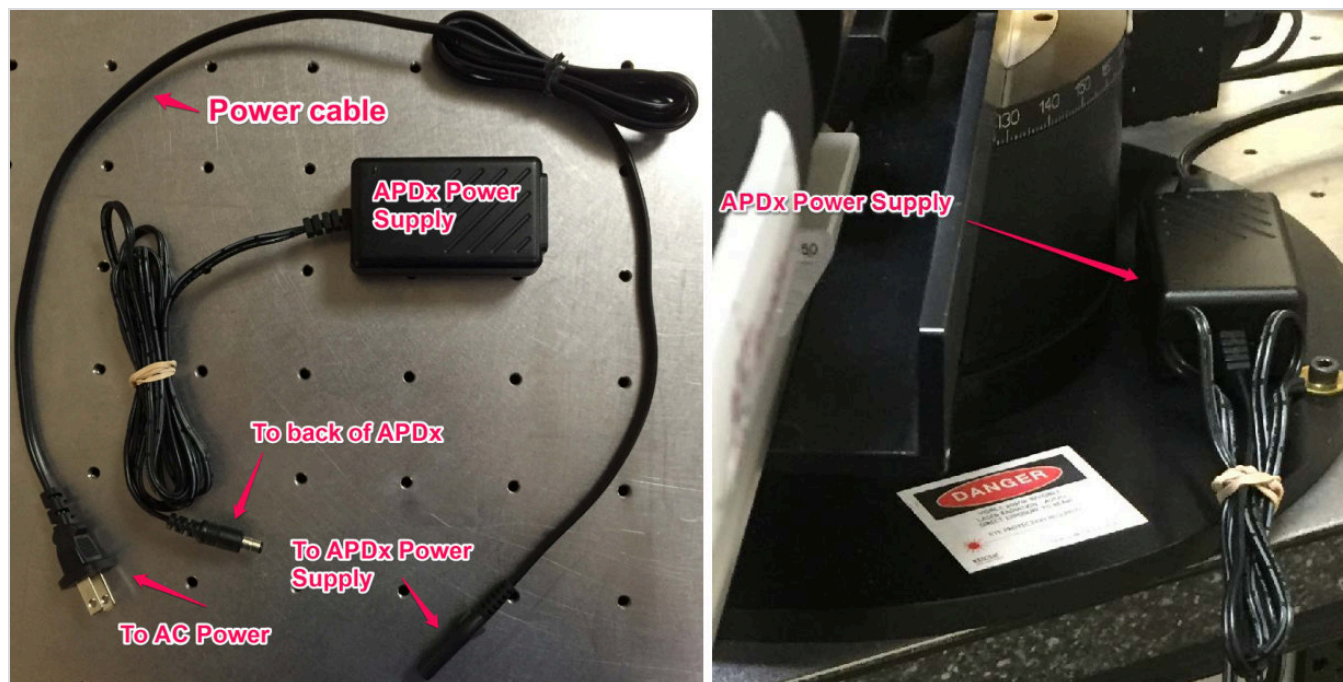
Step  
**82**

Ensure that the O-ring is in place on the bottom of the BI-APDx and begin to mount it to the NDO. Using the three **M5x14 socket cap screws** and brass washers, attach the BI-APDx to the NDO as shown.



Step  
**83**

Connect the APDx power supply to the power cable. Place the power supply at the base of the goniometer and connect the power cable to AC power. Placing the adapter here leaves enough slack in the power cord when the detector arm rotates.



Step

84

Attach the end of the 12 ft (3.66 m) signal cable with the small connector to the “A” port on the TurboCorr. Attach the other end of the signal cable to “OUTPUT” on the back of the APDx.

Connect the round power connector from the APDx power supply to the +5V (WHITE) port on the back of the APDx.



Step

85

The APDx is now connected to the TurboCorr via the signal cable, and to power via the power cord. The APDx power supply is shown at the base of the goniometer.



Step  
**86**

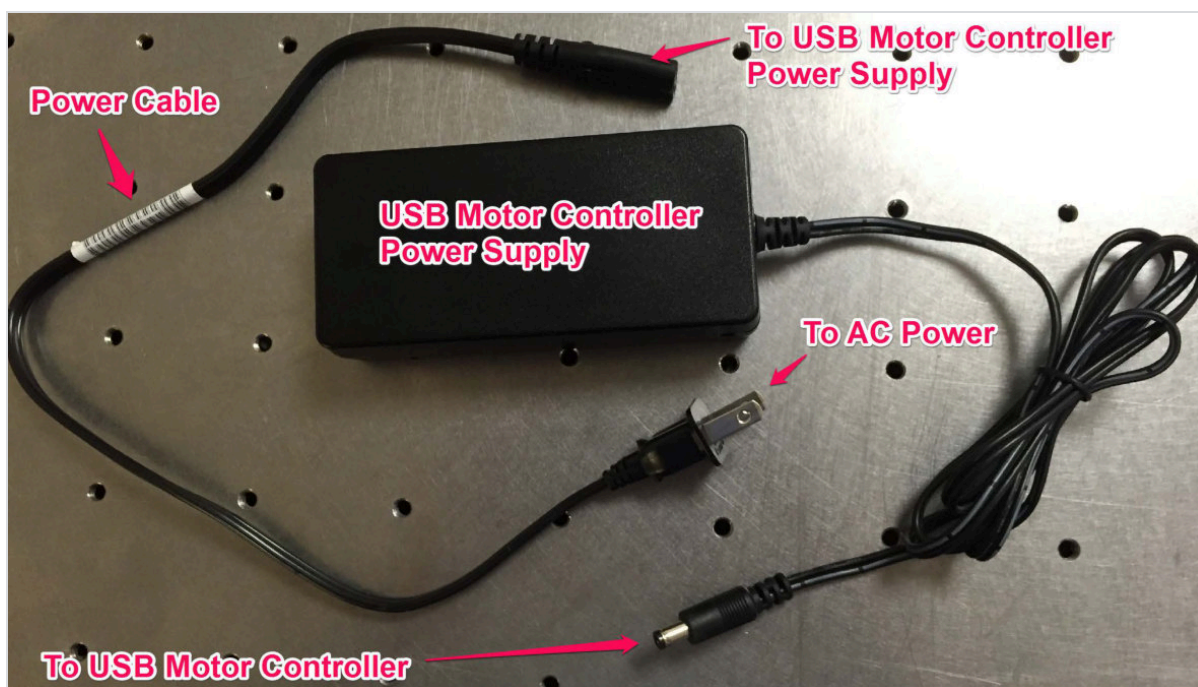
Using the USB cable shown, connect the large end to the computer and the small end to the USB motor controller (Step 88).



Step  
**87**

Connect the USB motor controller power supply to the power cable. Place the power supply at the base of the goniometer and connect the power cable to AC power. Connect the round power connector from the power supply to the USB motor controller (Step 88).

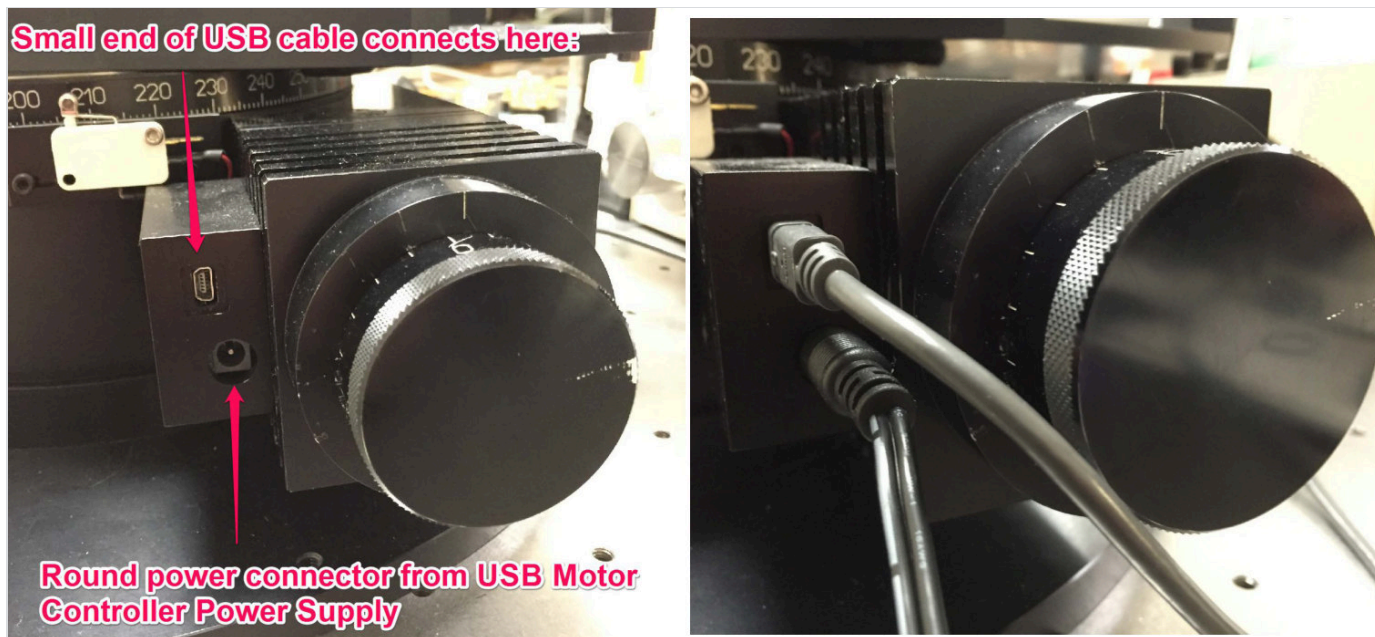
Placing the adapter here leaves enough slack in the power cord when the detector arm rotates.



Step

**88**

Connect the small end of the USB cable and the round power connector to the USB motor controller as shown.



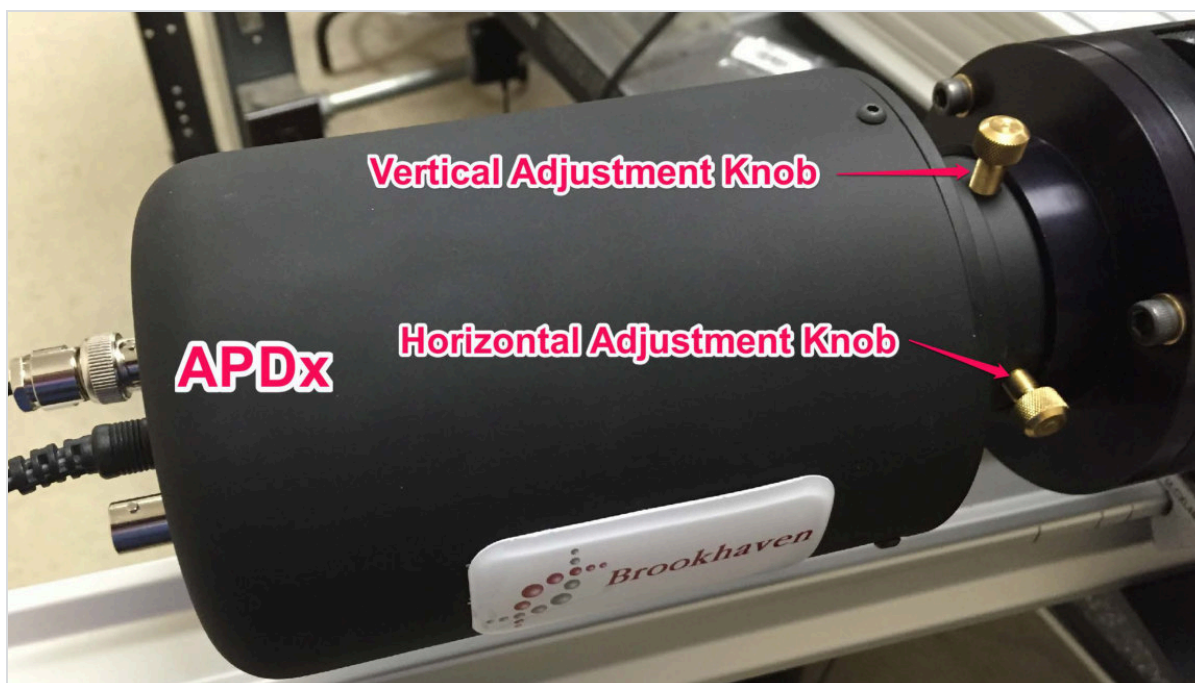
Step

89

In **Particle Explorer**, open **DLS - Dynamic light scattering**. Set the goniometer angle to 90 degrees. Set the pinhole to 1 mm and the NDO filter to the wavelength of the laser.

Using the adjustment screws on the APDx, maximize the count rate. With an APDx, this will be between 300 and 800 kcps. For more detail, see "Installation and Care for the BI-APDx Detector System."

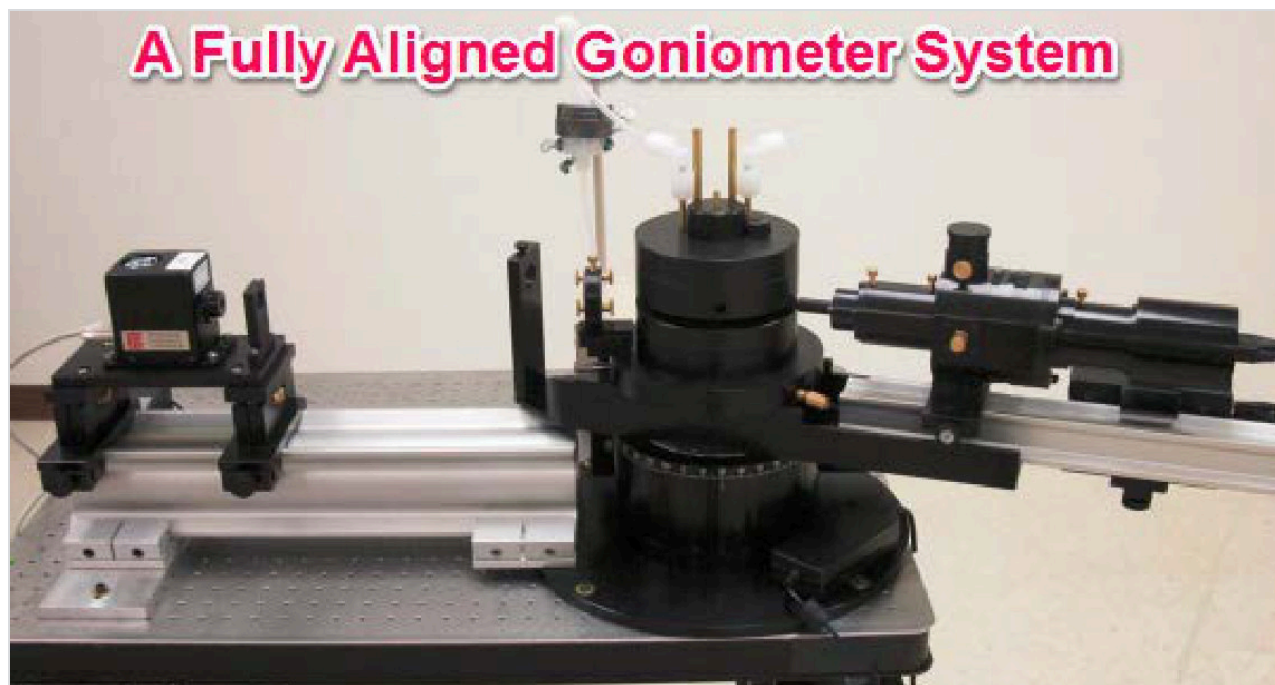
Once the signal is maximized, adjust the laser power and/or neutral density filter wheel (if equipped) so that the count rate at 90 degrees does **not exceed 500 kcps**. 200 to 300 kcps is recommended. This is necessary to perform an alignment check.



Step

**90**

Once the intensity has been maximized and the count rate at 90 degrees is no more than 500 kcps, you can perform an alignment check (next section).



## Install and configure the software

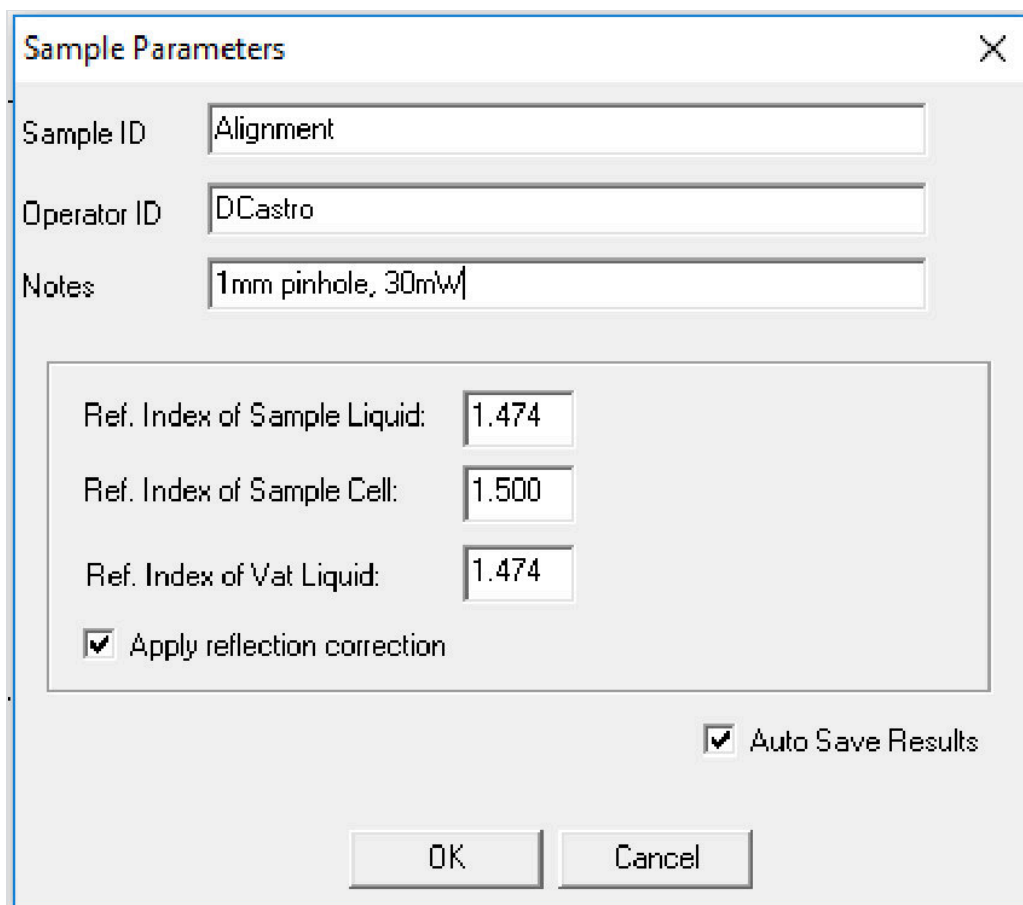
1. Install and open **Particle Explorer**. Choose **IST - Goniometer alignment**.
2. From the navigation bar, choose Hardware → Hardware Configuration and select the motor control (Manual or Motor).
3. Select the detector equipped with the system. For the APDx, select **APDx**; its default dead time is **25 ns**. (On the legacy 9k software, select **Other** and enter 25 ns.)
4. Check the boxes that indicate whether you have a reference detector or a second detector (for CrossCorr).



## Sample parameters

5. Select the **Sample Parameters** button at the bottom of the screen. Name the measurement and add any notes; laser power is a recommended item to note.
6. For alignment, decalin is both the sample liquid and the vat liquid. Refractive index values for decalin and the sample cell (vat) are shown in the screenshot.
7. Check **Apply Reflection Correction**. This corrects for the difference between the vat refractive index and the vat liquid.
8. Check **Auto Save Results**, then click OK.

+ If the laser power is very low, decalin may not scatter enough. In that case toluene is recommended; use its refractive index at room temperature. Do not use water.

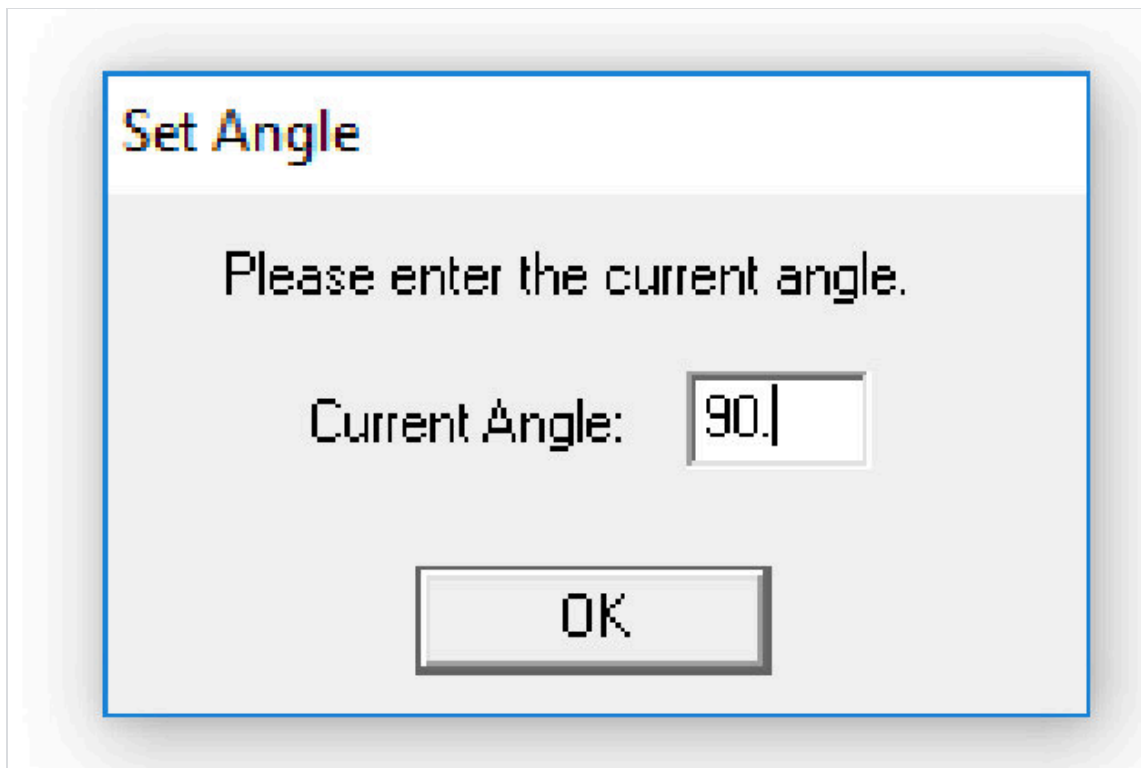


The screenshot shows a dialog box titled "Sample Parameters" with a close button (X) in the top right corner. The dialog contains the following fields and controls:

- Sample ID:** A text field containing "Alignment".
- Operator ID:** A text field containing "DCastro".
- Notes:** A text field containing "1mm pinhole, 30mW".
- Refractive Index Fields:**
  - Ref. Index of Sample Liquid:** A field containing "1.474".
  - Ref. Index of Sample Cell:** A field containing "1.500".
  - Ref. Index of Vat Liquid:** A field containing "1.474".
- Checkboxes:**
  - ☒ **Apply reflection correction**
  - ☒ **Auto Save Results**
- Buttons:** "OK" and "Cancel" buttons at the bottom.

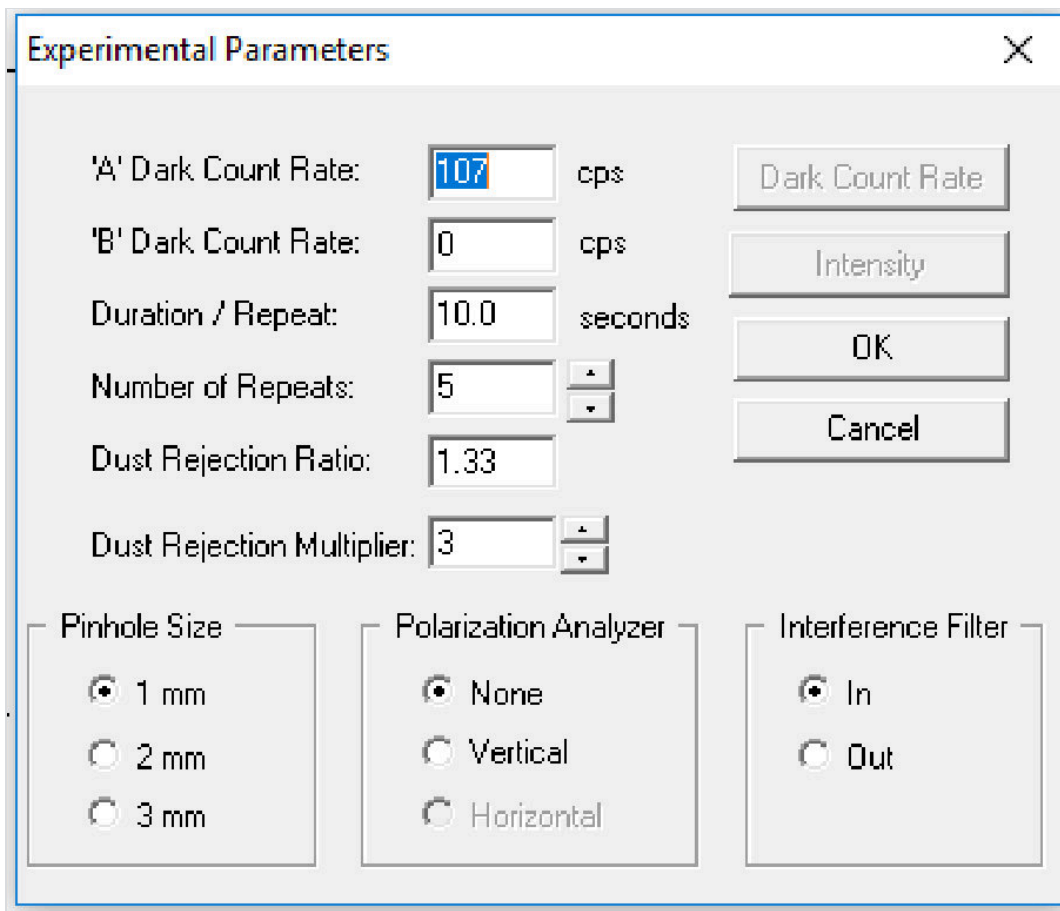
## Set the detector angle

9. Manually set the goniometer arm to 90°.
10. Select the **Set Detector Angle** button and enter 90°.



## Experimental parameters

11. Click **Experimental Parameters**. Set the detector wheel to “C” (Closed) and enter 10 seconds in the Duration/Repeat field.
12. Click **Dark Count Rate**. This measures the count rate with no light reaching the detector and should be about 100 cps. If it is significantly higher, make sure the detector wheel is closed and turn off the room lights.
13. Set Number of Repeats to **5** (this helps eliminate dust signal without discarding too many data points), Dust Rejection Ratio to **1.33**, and Dust Rejection Multiplier to **3**. The pinhole should already be at 1 mm.
14. Select the radio buttons for pinhole size, polarization analyzer and interference filter. These are for note-taking only, not calculations. Click OK.



The screenshot shows the 'Experimental Parameters' dialog box. It contains several input fields and radio button groups. The 'A' Dark Count Rate is 107 cps, 'B' Dark Count Rate is 0 cps, Duration / Repeat is 10.0 seconds, Number of Repeats is 5, Dust Rejection Ratio is 1.33, and Dust Rejection Multiplier is 3. There are three radio button groups: Pinhole Size (1 mm selected), Polarization Analyzer (None selected), and Interference Filter (In selected). Buttons for 'Dark Count Rate', 'Intensity', 'OK', and 'Cancel' are on the right.

| Parameter                 | Value | Unit    |
|---------------------------|-------|---------|
| 'A' Dark Count Rate       | 107   | cps     |
| 'B' Dark Count Rate       | 0     | cps     |
| Duration / Repeat         | 10.0  | seconds |
| Number of Repeats         | 5     |         |
| Dust Rejection Ratio      | 1.33  |         |
| Dust Rejection Multiplier | 3     |         |

| Pinhole Size                          | Polarization Analyzer                 | Interference Filter                 |
|---------------------------------------|---------------------------------------|-------------------------------------|
| <input checked="" type="radio"/> 1 mm | <input checked="" type="radio"/> None | <input checked="" type="radio"/> In |
| <input type="radio"/> 2 mm            | <input type="radio"/> Vertical        | <input type="radio"/> Out           |
| <input type="radio"/> 3 mm            | <input type="radio"/> Horizontal      |                                     |

## Angle list and measurement

15. Select Angles → Edit Measurement Angle List from the navigation bar. Select **Default List** to load the angle list, then click OK.
16. Set the detector filter wheel to the wavelength of your laser and click **Start**. The goniometer moves the arm to each angle in the list and makes measurements.

The screenshot shows the 'Edit Measurement Angle List' dialog box. It features a list of 10 angles in degrees, ranging from 15.00 to 155.00. To the right of the list are buttons for 'Add Angle', 'Delete Angle 1', and 'Delete All'. Below these are buttons for 'Insert', 'Increment' (set to 5.00), 'Apply Increment', and 'Set List Range'. At the bottom are buttons for 'Load List', 'Default List' (highlighted in yellow), 'OK', 'Save List As...', and 'Cancel'.

| Angle (degrees) |
|-----------------|
| 1. 15.00        |
| 2. 20.00        |
| 3. 30.00        |
| 4. 45.00        |
| 5. 60.00        |
| 6. 90.00        |
| 7. 120.00       |
| 8. 135.00       |
| 9. 150.00       |
| 10. 155.00      |

Buttons: Load List, **Default List**, OK, Save List As..., Set List Range, Apply Increment, Increment: 5.00, Insert, Delete All, Delete Angle 1, Angle: [ ], Add Angle, List Size: 10.

## Reading the results

17. A good alignment shows a horizontal line when drawn through all angles. The %Error Norm. to Avg. should be within **1%** for a great alignment (all numbers will be red). Within **3%** is still acceptable, especially on an older instrument.
18. Some measurements may suggest a cotangent correction, shown at the bottom of the screen. You can choose to apply it; then manually adjust the verniers back to read the proper angle (a very minor adjustment) and rerun the alignment. One correction may be enough, or a second run will apply an additional correction. On a good alignment this should repeat only a couple of times.
19. If the graph resembles a symmetric curve facing **upward**, turn the vertical on the steering lens  $\frac{1}{4}$  turn **clockwise** as a starting point and rerun. If it faces **downward**, turn it  $\frac{1}{4}$  turn **counterclockwise** and rerun.
20. Other considerations: scratches on the vat may require realigning with the vat in a position where the laser avoids them. Too much dust or residue on the outside of the vat or in the decalin: run the filtration system, and gently wipe the exposed surface of the vat with lens paper and a little methanol.

## Optional: temperature control (BI-TCD)

Steps 91 to 97

Step

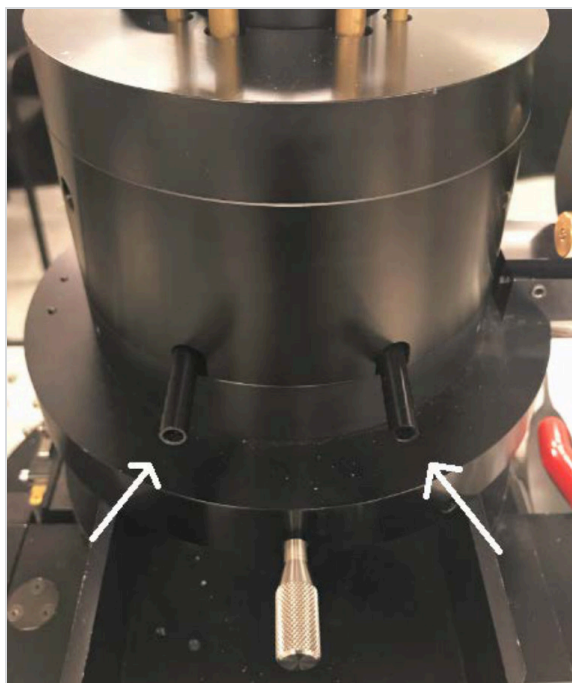
**91**

If the optional temperature bath (BI-TCD) was ordered, work through Steps 91 to 97. Start from the fully assembled sample cell area shown here.



Step  
**92**

Locate the temperature control nozzles on the goniometer.



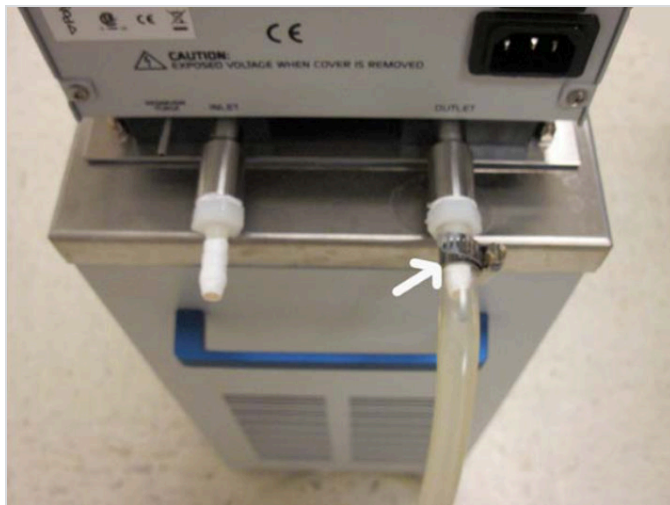
Step  
**93**

Locate the temperature nozzles on the back of the temperature bath.



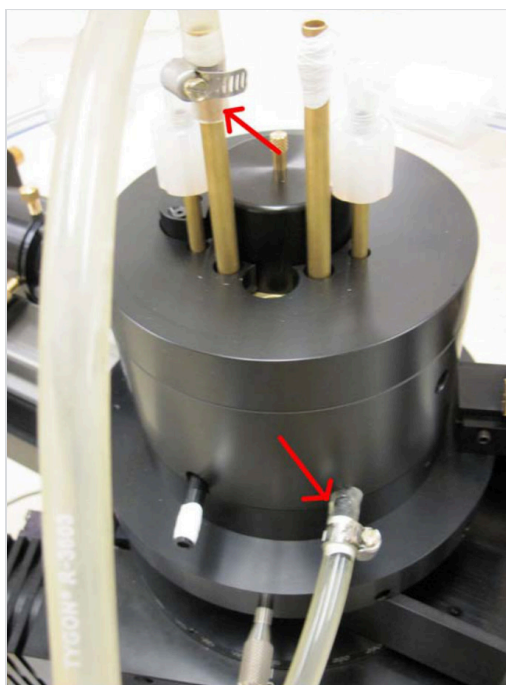
Step  
**94**

Attach the Tygon tubing to the temperature bath. The tubing should be long enough to reach from the temperature bath to the temperature nozzles on the goniometer with some slack. Fasten the tubing to each nozzle with the metal hose clamps.



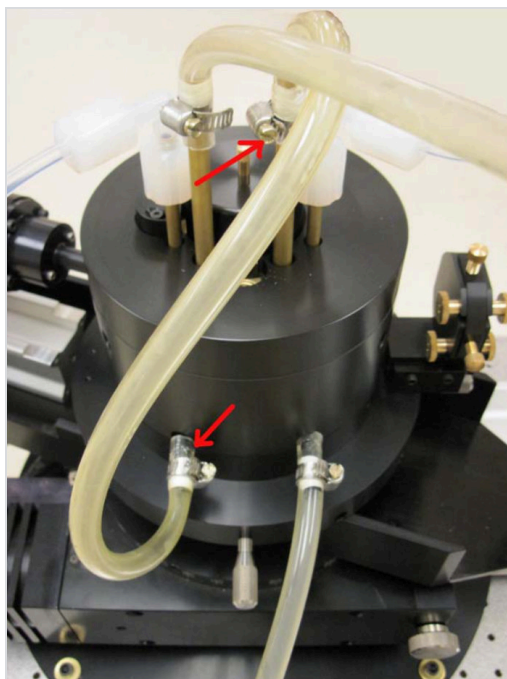
Step  
**95**

Run tubing from the temperature bath to two nozzles opposite each other on the goniometer.



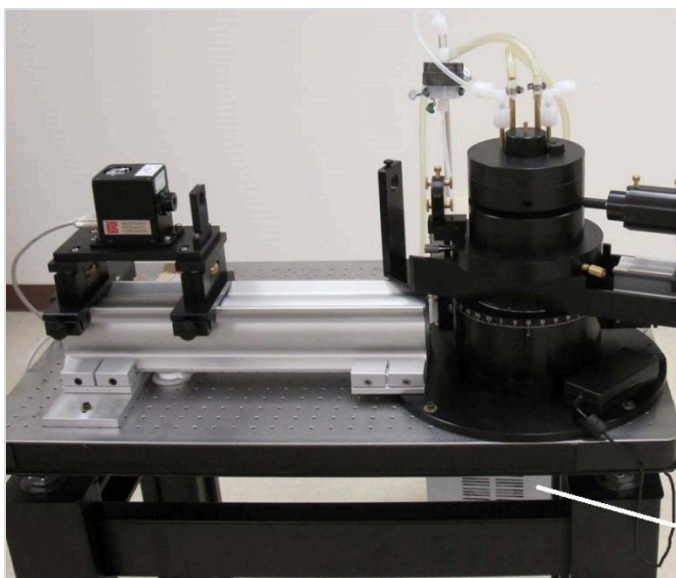
Step  
**96**

Run a short piece of tubing (approximately 400 mm) between the two remaining nozzles on the goniometer. Ensure there is sufficient slack so that the tubing is not pinched.



Step  
**97**

The temperature bath is now connected to the goniometer.



## Optional: sample temperature monitor (BI-200SMPt)

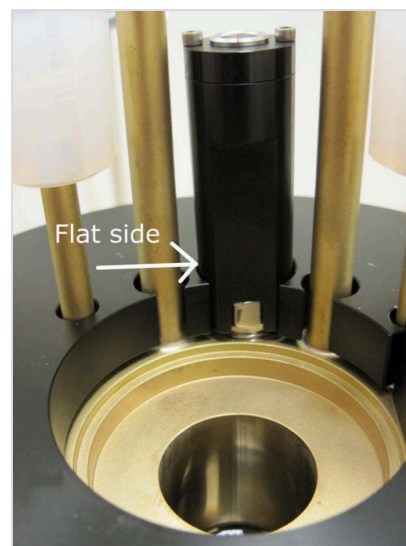
Steps 98 and 99

Step

98

If the optional Pt thermometer (BI-200SMPt) was ordered, complete Steps 98 and 99.

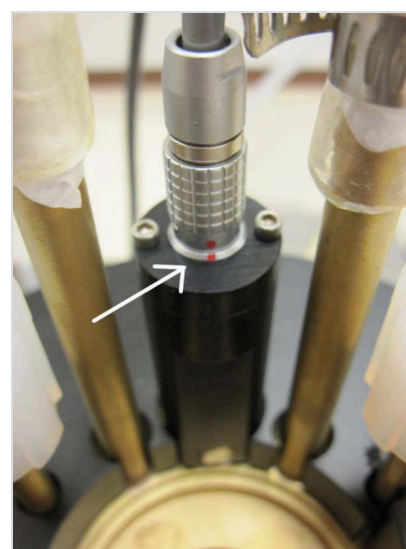
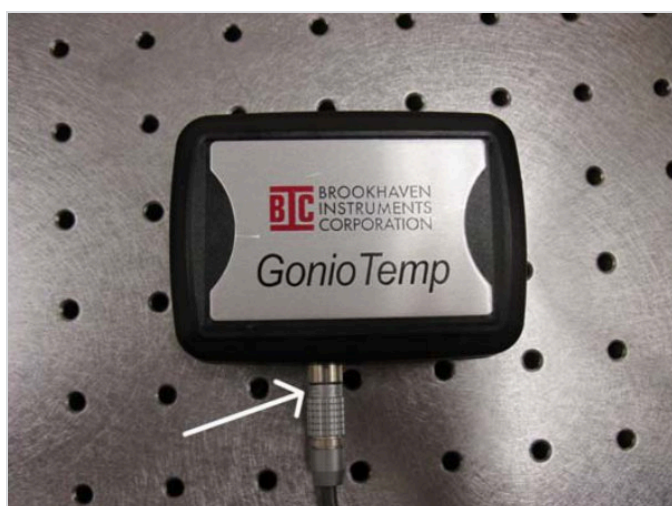
Screw the BI-200SMPt into the small opening in the brass manifold. It should screw all the way down until no threads are visible, with the **flat side** of the BI-200SMPt facing the sample cell opening in the center of the brass manifold.



Step

99

Attach the short gray cable to the BI-200SMPt, matching the red dots. Attach the other end to the GonioTemp box, again matching the red dots. The GonioTemp box connects to the computer via mini-USB.



# Alignment complete

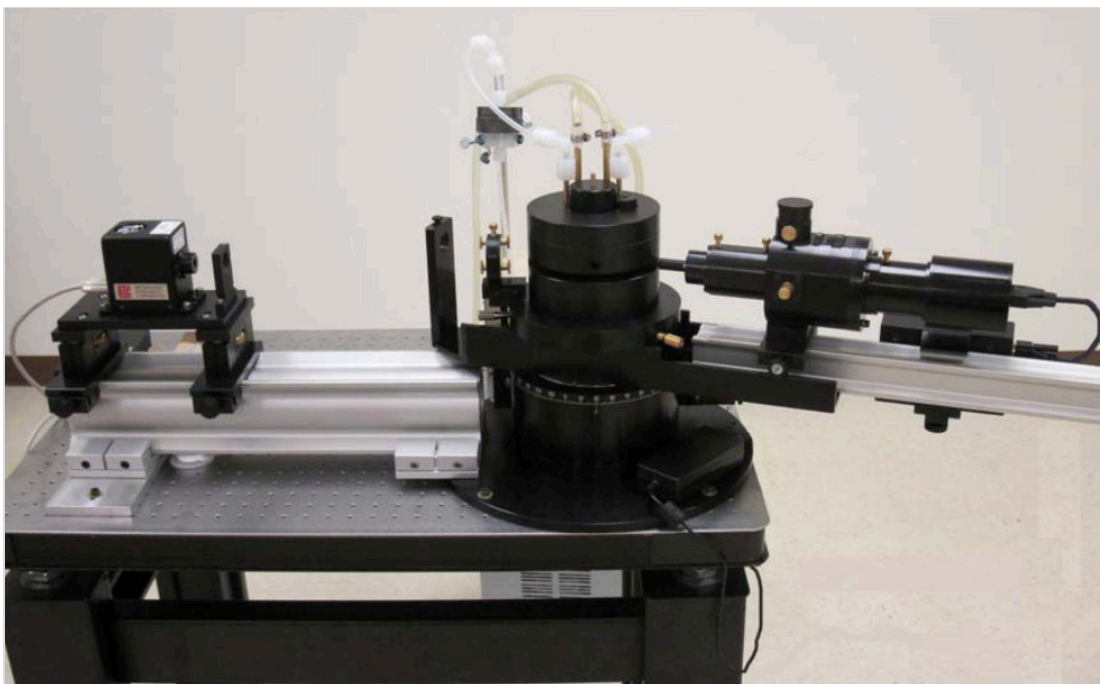
Step 100

Step

100

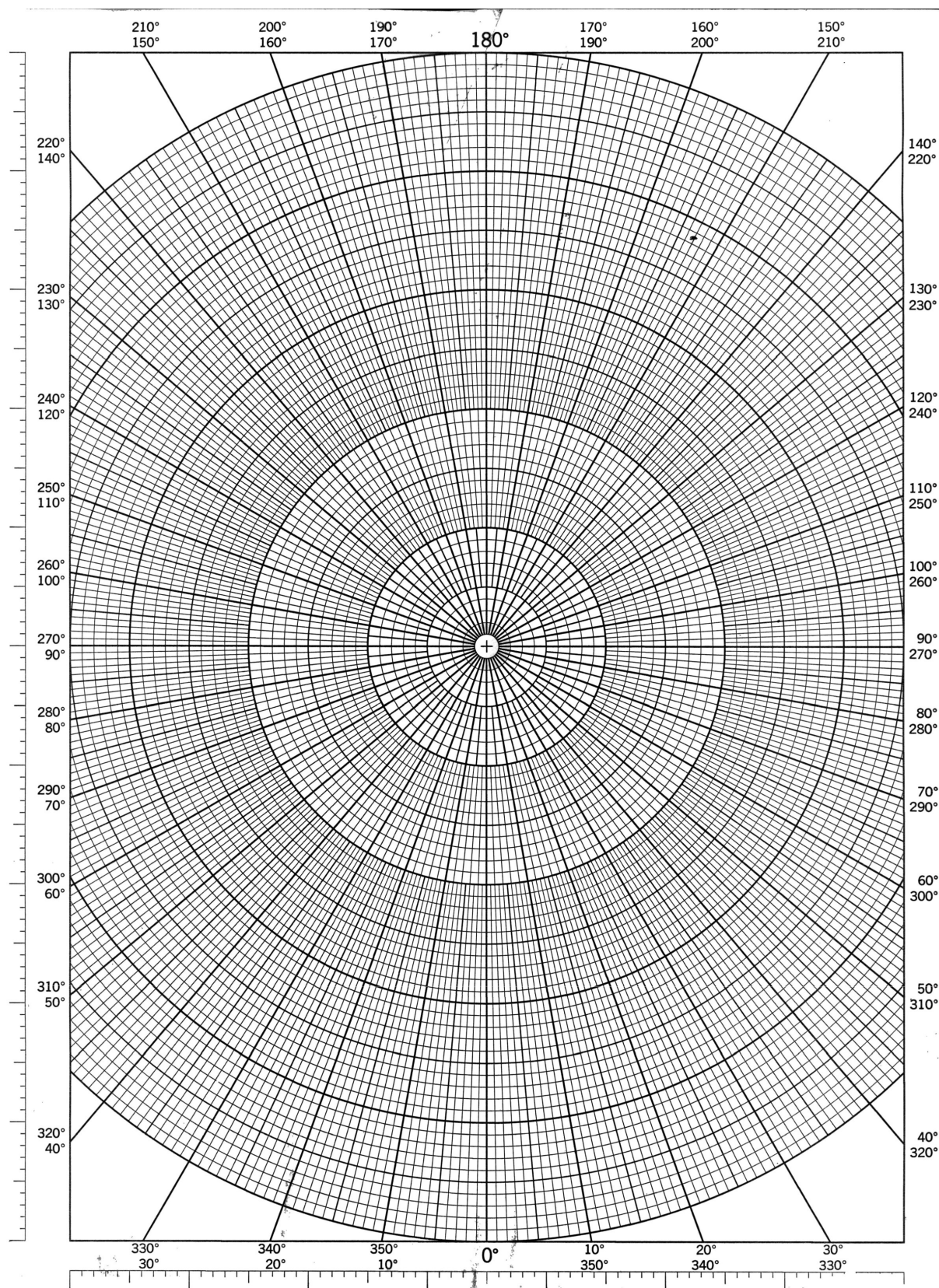
The goniometer is now fully aligned. Run **IST - Goniometer alignment** in Particle Explorer to test the alignment (see “How to check the alignment”).

Brookhaven Instruments aims for a “Percent Error Norm. to Avg.” of **1% or less** at every angle in the default angle list. That indicates an excellent alignment.



## Appendix A: polar graph

For recording angular data



## Appendix B: alignment target

Print at 100% and tape to the wall (Step 24)

