Adjusting collimation of the CDK700 Telescope

Applies to CDK700 telescopes sold after January 2013.

Introduction

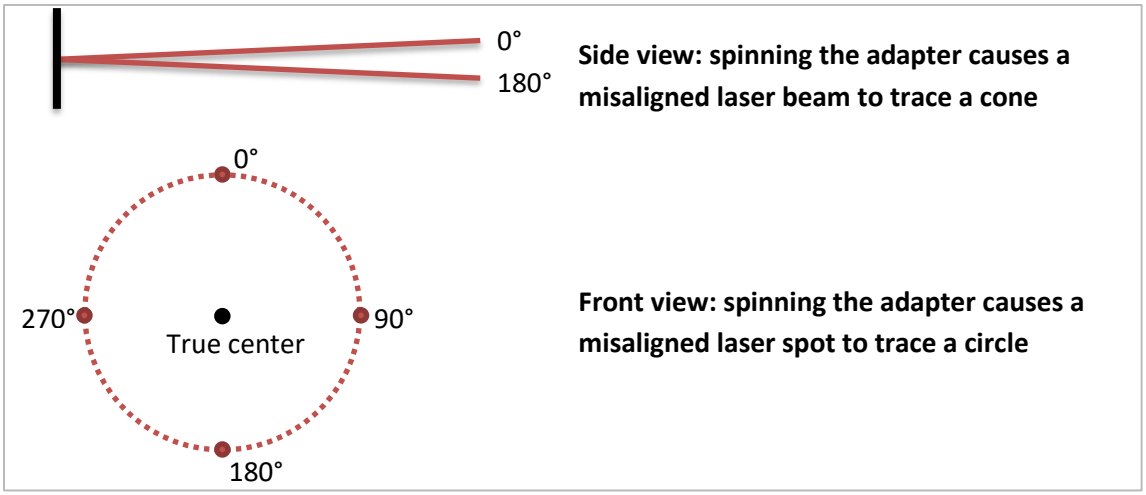
In order to fully collimate the CDK700, the following steps are required:

1. Align the laser to be perpendicular to the laser adapter plate.
2. Align the secondary mirror relative to the backplate of the telescope.
3. Check the height of the M3 (diagonal) mirror
4. Align the M3 (diagonal) mirror relative to Port 1
5. Align the M3 (diagonal) mirror relative to Port 2, if applicable
6. Align the Primary mirror

Step 1 – Align the laser to be perpendicular to the laser adapter plate

PlaneWave CDK700 telescopes typically ship with a laser that can be inserted into a 1.25” or 2” diameter eyepiece tube. This tube is attached to a plate that can be secured to the two Nasmyth ports on the side of the telescope, and to a port on the backplate of the telescope.

To produce the most accurate collimation and to simplify later steps of the collimation process, the laser must be aligned to be perpendicular to the adapter plate. A misaligned laser will trace a circle if you spin the plate in the port, as shown below. If the laser is well aligned, the spot will remain in the same place as you rotate the adapter.

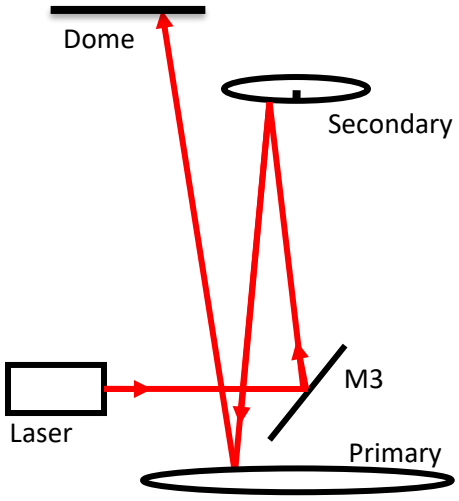


One suggested procedure for aligning the laser is described below.

A. Remove all equipment (including the IRF90 Rotating Focuser) from either Port 1 or Port 2 of the telescope. Insert the laser into the collimation adapter, and insert the adapter into the port. Secure the adapter using the retaining ring and three 5/16”-18 screws.

B. Move the M3 mirror to the correct port, and turn on the laser. You should see laser hit the diagonal mirror, bounce up to the secondary mirror, and down nearly back onto itself.

C. Grip the primary baffle tube, and slowly twist the baffle tube to move the M3 mirror away from its Port1 or Port2 hardstop position. You will feel some resistance as you back-drive the motor of the rotating M3 mechanism. Continue rotating the tube by 10-20 degrees until you see the laser spot exiting the front of the telescope and shining on a nearby wall or the inside of a closed dome.



D. Move the telescope until the laser spot is shining on a conveniently accessible location. Stop the telescope, making sure tracking is OFF but the motors are still energized. The spot should remain in exactly the same location. If the telescope is accidentally knocked out of position, the motors should bring the laser back to the same spot.

E. Securely tape a piece of paper to the wall or dome so that the spot is shining on the paper.

F. Loosen the 3 laser adapter retaining ring screws , rotate the adapter to a position that is easy to identify (such as the one shown below, with one knob pointed left and the other knob pointed up), and tighten the screws again. On the paper, mark the position of the laser spot.

G. Loosen the 3 adapter retaining ring screws, rotate the adapter 180 degrees, and tighten the screws again. Mark the new position of the laser spot on the paper.

H. Adjust the knobs that hold the laser in the 1.25” or 2” tube, and try to get the laser beam positioned halfway between the two marks on the paper. (**Note:** Unfortunately these adjustments are fairly imprecise. However, you should be able to get the alignment close through various combinations of loosening/tightening each knob and spinning the laser inside the tube. Future revisions of the laser tool will include better adjustment capabilities.)

I. Move the telescope a bit so that the laser spot is positioned on a new part of the paper, and repeat the steps above to make 2 new marks. The two marks should be much closer together this time. If there is still a space between the marks, try to adjust the laser to the halfway point again.

J. Ideally the bright central spot of the laser will mostly overlap with itself at the 0° and 180° positions. If you want to do further fine-tuning, you can also mark the spot position at 90° and 270° rotations of the laser adapter. (As a point of reference, the width of the bright central laser spot is typically about 3 arcminutes.) If you are unable to position the spot accurately enough, you can use this same technique in later steps and align the telescope to the midpoint between the laser spots rather than using a single spot at a single position.

Step 2 - Align the secondary mirror

This alignment is performed at the factory and normally should not need to be adjusted. If you determine that some adjustment is necessary after working through the steps below, please note that the process can take a few hours and involves a fair amount of disassembly/reassembly of the telescope. A summary of the alignment steps is included below; if you have any questions, please contact PlaneWave Instruments.

A. Tilt the telescope down towards the horizon. On the backplate of the telescope, locate the central cover (typically held in place with 4 screws and 4 spacers). Remove this panel to expose the wires that control the M3 mirror. Unplug, or unscrew/detach each of these wires, including:
    a. M3 motor control (DB9, secured with screws)
    b. Port 1 limit switch (2-pin molex)
    c. Port 2 limit switch (2-pin molex)
    d. M3 temperature sensor (3-pin molex)
    e. M3 dew heater (2-pin molex)

    Shine a flashlight inside and note the position of the 3 screws that hold the M3 mechanism into place. These screws will be removed in a later step (but will be less visible).
B. Identify the dovetail plate that would be on the bottom side of the telescope when the telescope is pointed near the horizon.
C. Disable the telescope motors, and push the telescope up to the upper spring stop by hand
D. The telescope may become front-heavy in the following steps. Consider pulling the OTA against the upper spring stop using a bungee cord or a length of rope. Loop the cord/rope looped through the upper dovetail plate and one of the anchor bolts on the pier.
E. Remove any counterweights or accessories that might be attached to the “bottom” dovetail previously identified. Then, remove the dovetail bar (two screws near the backplate, 3 screws near the midring). This should skew the balance of the telescope so that it is pressing against the upper altitude spring stop.
F. The lower section of the OTA is enclosed by white curved metal panels held in place with 8 screws. Two side fans are mounted in each panel. The panel on the “bottom” side

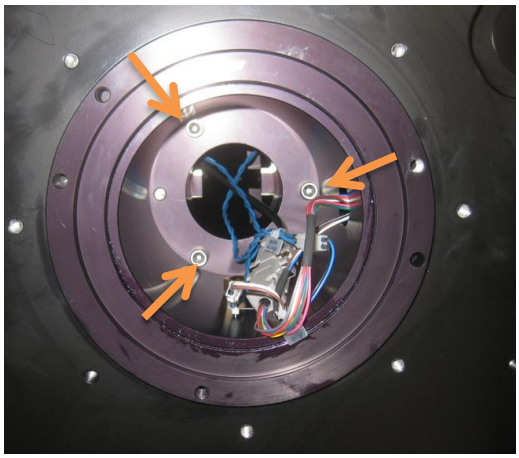
of the telescope will be removed. Reach inside the telescope and unplug the two fans. One option is to slide a small white connector off the body of the fan, and unhook the wires from the edge of the fan if necessary. Another option is to locate the Molex connectors near the edge of the primary mirror and unplug the fans at this location.

G. Remove the 8 screw that hold the "bottom" side panel in place. Start with the 4 bottom screws, followed by the two top outer screws, and finishing with the two top inner screws. Set the panel aside. **NOTE:** The panel may want to "bow out" as the outer screws are removed, and could scratch the fork arms. Try putting some foam padding or towels between the fork arms and the edges of the side panels to prevent this.

H. If you have lens paper available, consider laying some across the primary mirror to protect it from dropped screws or metal filing from screws.

I. Remove the primary baffle tube. The tube is assembled in three sections, each held in place with six screws. These sections can be removed one at a time, but you may find it easier to remove the entire tube as a single unit. (It can be helpful to have two people lifting the tube in this case.) Unscrew the bottom edge of the tube from the M3 rotating mechanism. **Lift the tube straight up until it clears the diagonal M3 mirror.** Tilt the tube slowly, and guide it out between two of the upper truss poles.

J. **With the telescope still pointed straight up**, use the 5/16" T-handle hex wrench to reach up from the back and remove the 3 M3 screws identified earlier. With the telescope pointed up, it may be difficult to visually locate these screws. However, you should be able to find them by feel.



K. Pull the M3 cables (limits, temperature sensor, heater, motor) up through the central hole of the M3 mechanism, and secure them so they are not dangling onto the primary mirror when M3 is removed.

L. Lift the M3 mechanism straight up, off of its alignment pin. Continue lifting the mechanism up over the midring of the telescope, and carefully pass it through two of the truss poles before setting it down. **It is helpful to have two people for this step!**

M. Attached the aligned laser adapter to the port on the back of the telescope, and secure it using the retaining ring and 3 screws. Turn on the laser. If some of the loose M3 wires are in the way of the laser beam, push them to the side.
N. Remove the bugee cord (or rope) that is holding the telescope in the zenith position. Carefully pull the telescope down towards the horizon so that you can access the secondary mirror collimation screws. The telescope should now be somewhat front-heavy, and will rest against the lower spring stop. If a telescope was previously mounted to the upper dovetail, you may need to remove this to prevent the OTA from being "side-heavy". If the telescope still does not want to rest against the lower spring stop, you may be able to use the rope/bungee (looped through one of the lower truss poles and an anchor bolt) to secure the OTA in place.
O. Adjust the secondary mirror collimation. When the secondary mirror is properly collimated, the laser should hit near the center mark on the secondary mirror (if one exists) and should bounce back directly onto itself. If the secondary mirror does not have a centering mark, you can roughly judge the center position using a tape measure or a length of string. Centering the mirror is not as critical as getting the beam to bounce back on itself since the mirror is spherical and has no preferred optical axis. Centering adjustments can be made by loosening/tightening opposing pairs of spider vanes using the tension screws on the upper truss blocks. Tip-tilt adjustments can be made using the three push screws and the central pull screw/knob behind the secondary mirror.
P. If the alignment of the laser is in question, rotate the laser adapter 180 degrees (as you did when first aligning the laser) and check the alignment again. If the spot moves more than about the width of one spot, try to align the system to the midpoint of the 0° and 180° spot positions.
Q. Once the secondary alignment is complete, remove the rope/bungee cord that might be pulling the OTA downward, and point the OTA upward towards zenith. Use the bungee/rope to hold the OTA vertical.
R. Reinstall the M3 mechanism with the telescope pointed straight up. Before lifting, locate the alignment pin on the central hub above the primary mirror, and the corresponding hole on the bottom of the M3 mechanism. Lift the M3 mechanism through two of the upper truss poles, and carefully lower it down until it is sitting on the central hub and alignment pin.
S. With the OTA still pointed straight up, reach up from the back using the 5/16" T-handle wrench and reinstall the three M3 screws.
T. Remove the bungee/rope and point the telescope down towards the horizon. From the back of the telescope, re-attach the motor, limit, temperature, and dew heater connections.
U. **Do not reinstall the primary baffle yet! You will need full access to the M3 mechanism in order to align the M3 mirror.**

Step 3 - Check the height of the M3 (diagonal) mirror

This alignment is performed at the factory and normally should not need to be adjusted. If you determine that some adjustment is necessary after working through the steps below, contact PlaneWave Instruments for details.

If you wish to verify the height of the M3 mirror:

A. Remove the bottom dovetail, side panel, and primary baffle tube as described in the Secondary Mirror alignment procedure
B. Install the aligned laser adapter in either the Port 1 or Port 2 side of the telescope, and turn on the laser
C. Rotate the M3 mechanism by hand (back-driving the motor) until the mirror is halfway between the Port 1 and Port 2 positions. When the mirror is at just the right angle, the laser beam should slightly graze across the surface of the mirror.

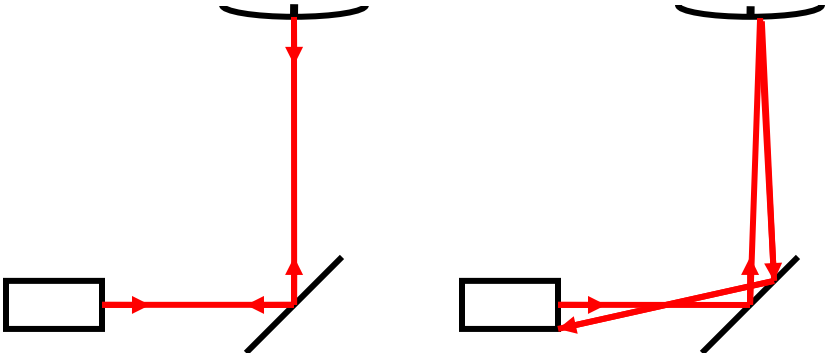
Step 4 - Adjust the M3 (diagonal) mirror relative to Port 1

1. In the PlaneWave Interface control software, select the "M3" tab and move the mirror to Port 1.

2. Remove any imaging equipment from Port 1, including the IRF90 Rotating Focuser.

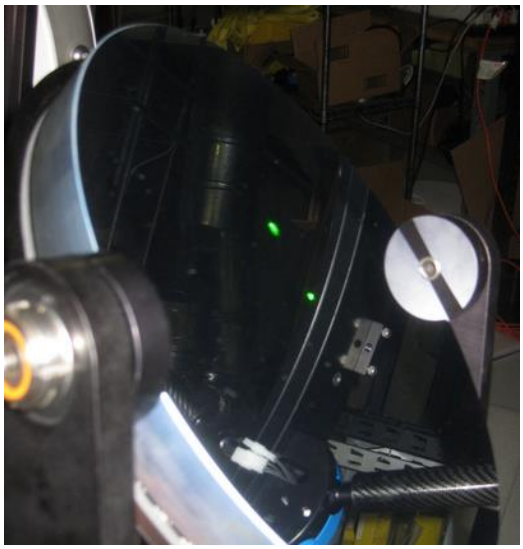
3. Insert the 2" Laser Adapter and laser into Port 1, and secure it using the locking ring and three screws.

4. Turn on the laser. In a perfectly collimated system, the beam would hit M3, reflect up to the center spot on the secondary mirror, reflect back down to the same spot on M3, and back over to the laser installed in Port 1. In an imperfectly collimated system, the beam will diverge after it bounces off the secondary mirror.

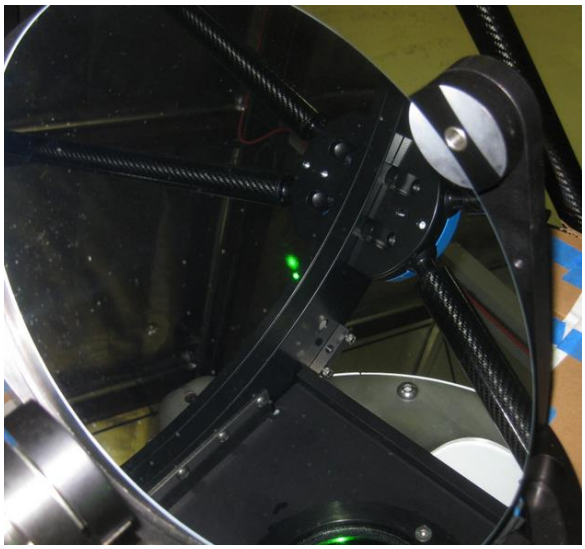


Well collimated

Poorly collimated



Poor alignment. Need to tilt the mirror down

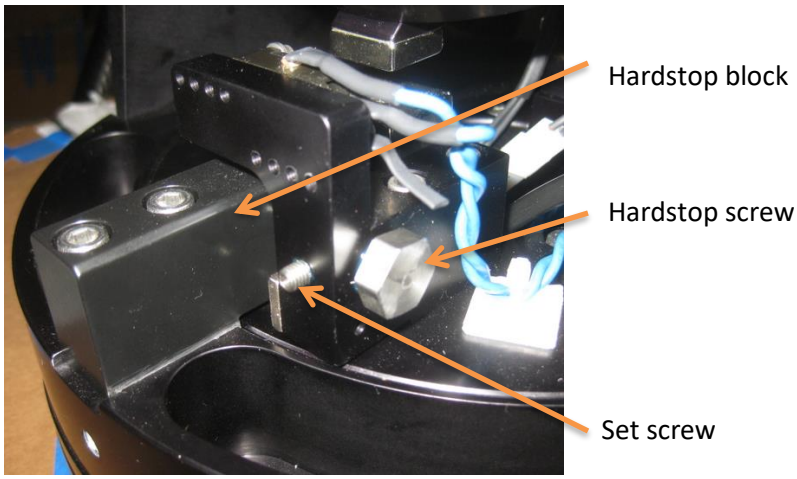


Better alignment. Spin laser adapter to confirm true centering.

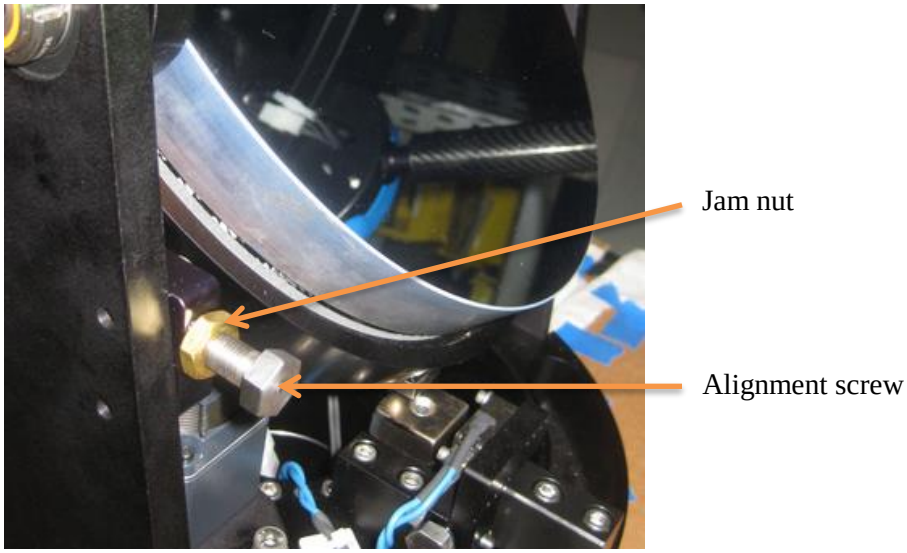
Remember to align the laser before doing this. If the laser is not perfectly aligned with the adapter plate (as described earlier), you can rotate the adapter to different positions, locking down the retaining ring at each position. The laser spot positions should trace out a circle. If this is the case, the ideal alignment is against the center of that circle.

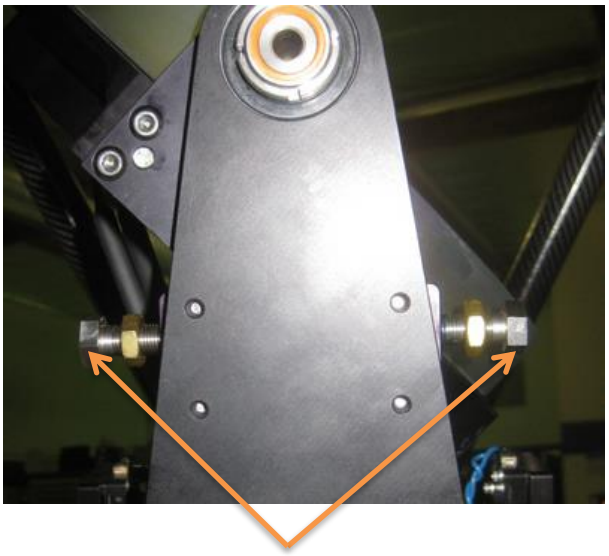
There are two M3 adjustments for each port:

The **rotation** adjustment is performed by loosening a set screw and loosening/tightening the hardstop screw that the hardstop block runs against. A magnet should pull the hardstop block firmly against the screw.

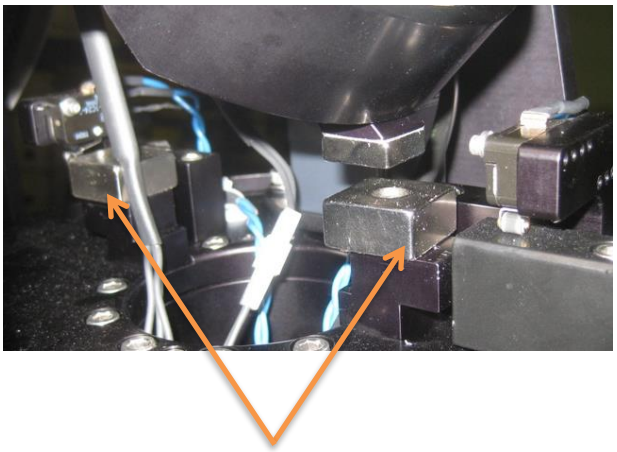


The **tilt** adjustment is performed by releasing a jam nut and loosening/tightening a hardstop screw that the hardstop pin runs against. A set of magnets either repel each other, tilting the mirror up (for one port) or attract each other, tilting the mirror down (for the other port). If you are uncertain which hardstop screwis used for which port, try tilting the mirror up or down, release it, and check to see which screw the hardstop pin hits.





Each port can be adjusted independently



Magnets attract or repel to tilt the mirror
in different directions

When the tilt alignment is correct, tighten the jam nut back into place, being careful to not turn the hardstop screw away from its aligned position. You may need to back off the hardstop screw a bit before tightening the jam nut.

5. If your secondary mirror has a black spot in the center, check that the laser (or perhaps the center of the circular path traced by spinning the laser adapter) aligns with the spot that has been marked at the center of the secondary. Because the secondary mirror is spherical and has no preferred optical axis, this alignment is not critical. However, if the alignment is off by more than 1/4 inch or so you may start to introduce some vignetting

in the optical system. It may be necessary to align the secondary mirror -- refer to the secondary mirror alignment instructions above.

6. Using the PlaneWave Interface software, move the M3 mirror to Port 2. After a few seconds, click "STOP", and then move it back to the Port 1 position. Use the laser to verify that M3 has returned to the correct position and is repeatable.

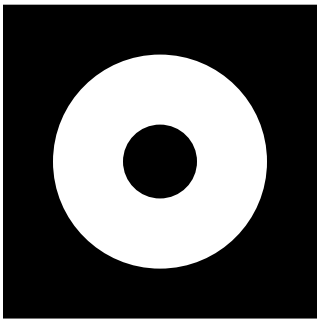
Step 5 - Adjust the M3 (diagonal) mirror relative to Port 2

Move M3 to the Port 2 position, and move the laser/adapter to Port 2. Repeat the instructions listed in Step 4.

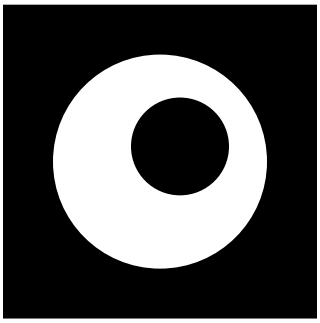
Reinstall the primary baffle tube, side panel, and dovetail plate when finished. Don't forget to plug in the side panel fans!

Step 6 - Align the Primary Mirror

At night, slew to a fairly bright star and take the star out of focus. If the telescope is well collimated, the defocused star should appear concentric, with light being evenly distributed around the disc that is formed. If the telescope is poorly collimated, one portion of the disc will appear thinner in size and brighter in intensity.



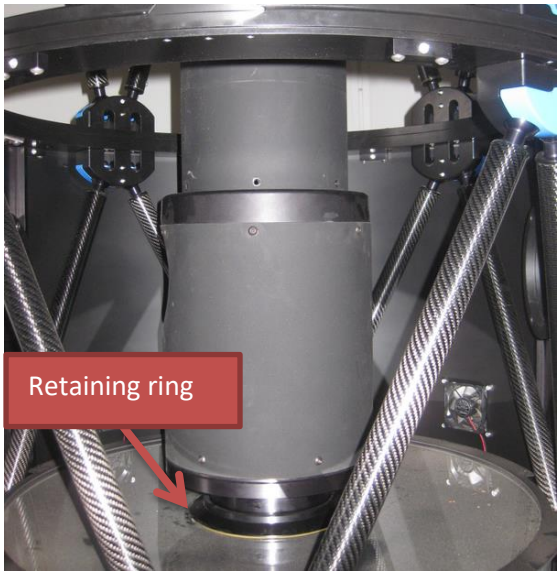
Well collimated



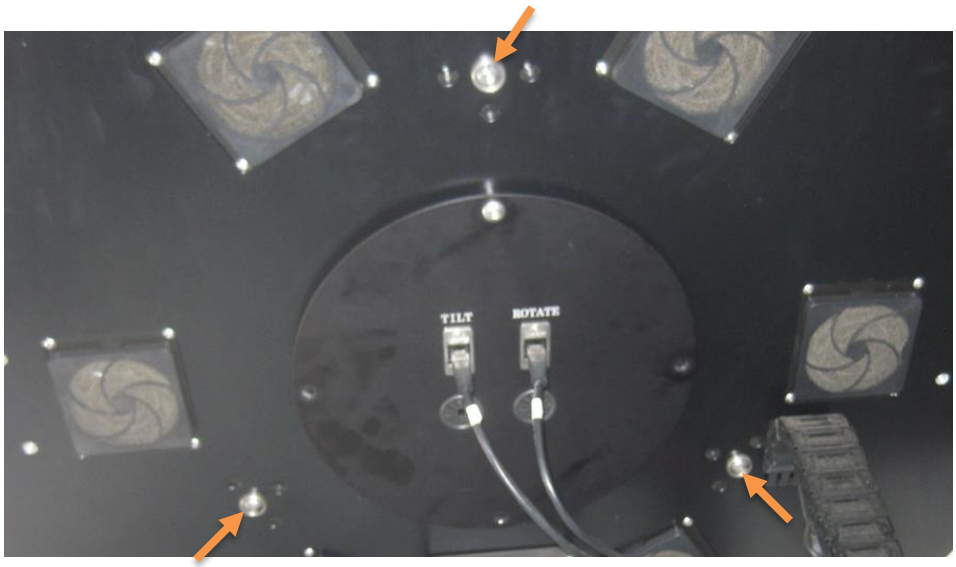
Poorly collimated

TIP: This test can be done either using a camera or an eyepiece. If two people are available, one person can look through the eyepiece while the other person adjusts the primary mirror. If you are collimating the telescope by yourself or you do not feel like removing your imaging equipment, you can take images with the camera and look at the on-screen display to perform collimation.

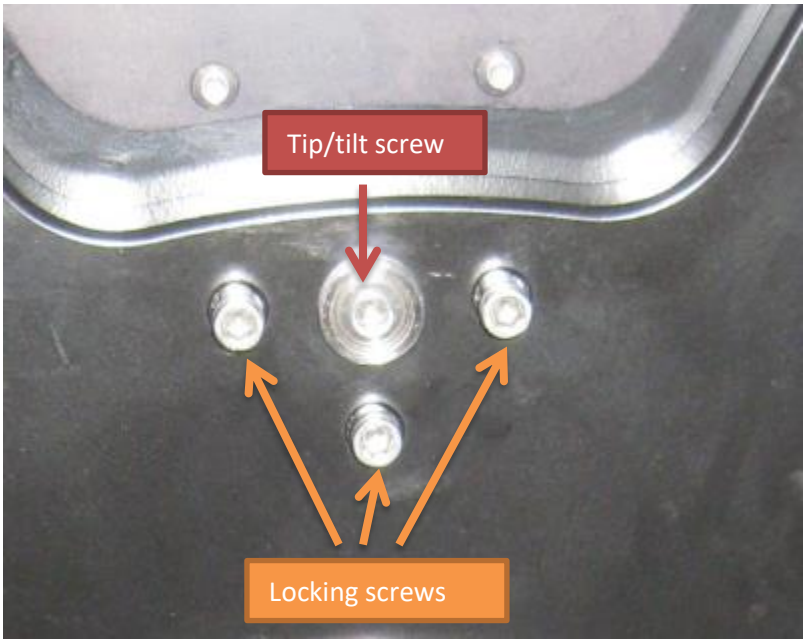
Between the bottom surface of the primary baffle tube and the top surface of the primary mirror, there is a threaded retaining ring that prevents the mirror from moving forward. Loosen this ring 1-2 turns by turning it in the counter-clockwise direction. With the side panels installed on the telescope you may not be able to see this ring directly, so you will need to feel under the M3 mechanism to find the ring.



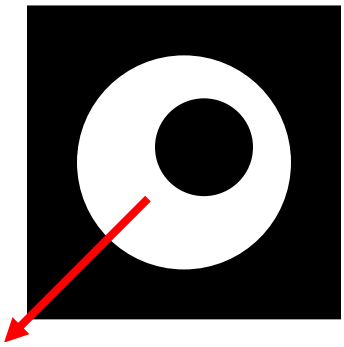
On the backplate of the telescope, there are three large screw heads that can be used to adjust the tip-tilt alignment of the primary mirror.



NOTE: On some telescopes, each of these adjustment screws is surrounded by up to three smaller locking screws. It may be necessary to loosen these locking screws before adjusting the primary. These should be re-tightened once any adjustments have been completed.

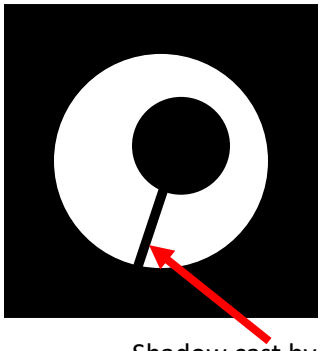


The goal is to tilt the mirror so that the star moves in the same direction as the thick portion of the out-of-focus disc. Eventually the starlight should be evenly distributed around the disc.



Move star in this direction

To determine the correct screw to turn, place your arm in the optical path of the telescope to block some of the incoming starlight. (e.g. reach in from the side of the telescope and touch the edge of the primary baffle with your fingertips.) This will cast a shadow and cause the defocused star to appear as shown below:

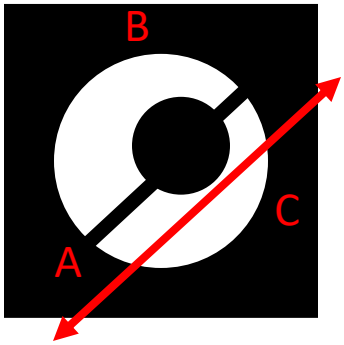


Shadow cast by arm

If you don't see a shadow, you may need to use something wider to block the light, such as a book.

As you move your obstruction around the aperture of the telescope, the location of this shadow will change. By placing your arm at a position directly in front of each primary adjustment screw, you can estimate the direction that the star will move when that screw is turned.

For example, suppose you label the three adjustment screws "A", "B", and "C". If you place your arm in front of the "A" screw and it casts a shadow over *either* the thickest or the thinnest part of the defocused star, this is the best screw to turn to make the starlight more concentric.



Direction of movement when turning screw “A”

either clockwise or counterclockwise

Try turning this screw either clockwise or counterclockwise, and take note of which direction the star moves. Turn the screw so that the star moves in the same direction as the thickest part of the defocused disc.

Once the disc becomes more concentric, you may find it necessary to switch to another screw to fine-tune the collimation in some other direction.

Once the defocused star looks concentric, tighten the 3 locking screws around each adjustment screw (if available) and verify that collimation did not change.

When you are finished, reach under the M3 mechanism and tighten down the primary mirror retaining ring by spinning it clockwise until it is just slightly snug.