

Complete Collimation of the Meade Schmidt Newtonian

Peter Kennett & Danny "Ross" Lunsford

Other than seeing conditions, nothing will improve the optical performance of a telescope than accurate collimation - the act of ensuring that all optical and mechanical elements of a telescope are aligned as perfectly as possible. A telescope with very dirty mirrors will outperform a spotless one if the dirty scope is collimated well while the clean is not. A Schmidt Newtonian (SN) has a very low focal ratio which makes collimation even more critical, thus I present here a detailed tutorial to help anyone with these telescopes to get very accurate collimation with a minimum of accessories.

This tutorial is designed to achieve highly accurate collimation on an optical system that is totally misaligned. This will help if you decide to remove the optical elements for repair or modification, and wish to put the SN back into optical collimation. You may also use any one part of this tutorial to help with fine-tuning, or when only one part of the system needs to be adjusted.

A warning about the screws used the Meade Schmidt Newtonians. These are VERY soft metal screws, probably made from Chinese melted pop-can aluminum, and are not suitable for repeated use. You can either replace them now with steel screws, or later, after you have mangled them and stripped their threads. I suggest you do it sooner than later!

STEP ONE: Marking the OTA

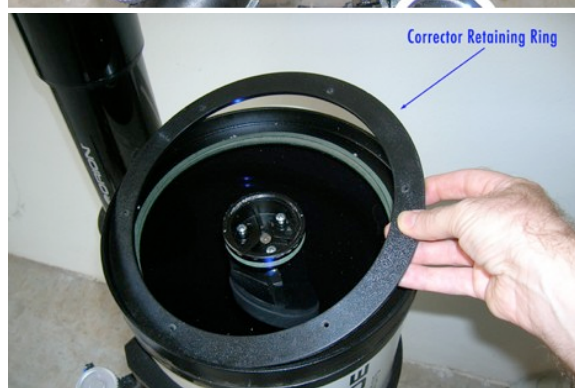
Mark the tube ends and mirror supports to allow you to replace them in the exact orientation. Use a fine permanent marker and draw a line across the primary and secondary mirror supports and onto the telescope tube. This MUST be done, as the actual alignment of these two ends must not change.



STEP TWO: Ensure the Corrector is centered.

This should also be OK straight from the factory, but should be checked just in case. The large hole in the corrector that holds the secondary mirror should be squarely centered in the corrector plate. Once this is done, the secondary mirror will have the correct offset needed for proper collimation. To check the corrector, you must:

- a) Sit the scope upright on its bottom and remove the screws on corrector cell.
- b) Remove the corrector's retaining ring.



Once removed, you will see the paper pressure gasket around the edge of the corrector.



c) Then carefully remove the underlying paper gasket.

You will see the Corrector Plate cushioned by some cork shims. The Meade Schmidt Newtonian Corrector must be exactly centered over the tube. The slightest amount of shift will cause noticeable degradation of the image and cannot be corrected any other way. Also, the entire secondary mirror's position is dependent on this corrector being in the exact center of the optical axis of the tube.

The secondary mirror has a necessary built-in offset – as long as it is centered on the tube, which requires the corrector's placement to be precise.

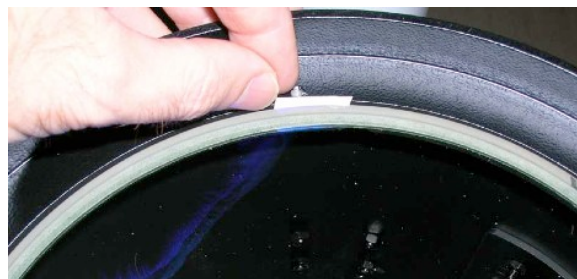
d) Measure the distance from the outer edge of the secondary support and the inner edge of the corrector cell. You can use a ruler, or a piece of stiff cardboard as shown here. Be sure to measure all the way around just to be sure it's centered.



e) If the corrector must be shifted, use a small coin to gently pry the corrector in the desired direction. Use very small movements, and try to get the corrector centered within 1 mm or less.

f) If you have a very large gap, you can add more shims to keep the corrector centered

g) The last step is to replace the paper gasket and retaining ring. It is critical that you tighten this down very securely. Do not worry about adding too much flexure or pinching the optics. The tightening is only adding compression, which is distributed by the gasket. Also, the edge of the corrector has little effect on the overall performance.



STEP THREE: Properly rotate the secondary mirror.

If the secondary mirror is not located exactly and squarely under the focuser, you will lose some light and may suffer some vignetting. You want to capture all the light you can, so wasting even a small amount is significant. Before we can adjust the secondary, it must be in the proper **rotation** or you will waste a lot of time trying to line it up perfectly under the focuser.

To rotate the mirror and make other adjustments later on, you will need to access the secondary mirror support adjustment screws and finger grips. These are located under a small Meade branded cover located in the center of the corrector plate. Use a small screwdriver and pry this cap loose. **This cap DOES NOT unscrew!** Pry it off gently. Be very careful not to accidentally hit your corrector with the screwdriver!

To rotate the secondary you must then LOOSEN (not unscrew) the outer locking ring.

Gently turn the outer locking ring and turn counter-clockwise. Mine was so tight I needed to grip it with vise grips, which chewed up the soft metal quickly. Some users have made a tool that fits into two small holes in the ring.



You will need to only LOOSEN this ring slightly. Whatever you do, DO NOT REMOVE THE RING! This will cause the secondary to drop into the telescope! I know I am repeating myself - but Meade replaces MANY broken secondary and even primary mirrors from users who completely unscrew this ring with disastrous results!

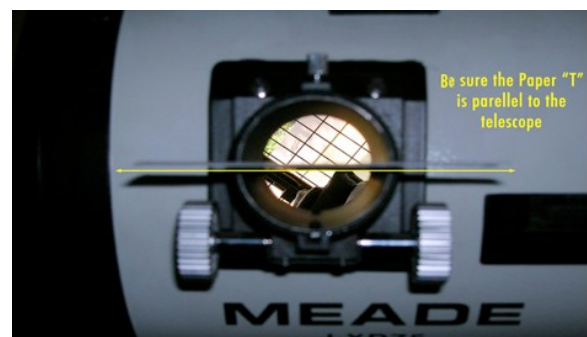
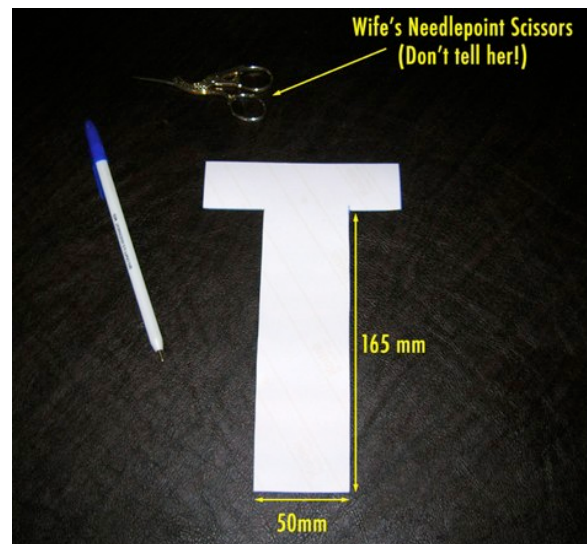
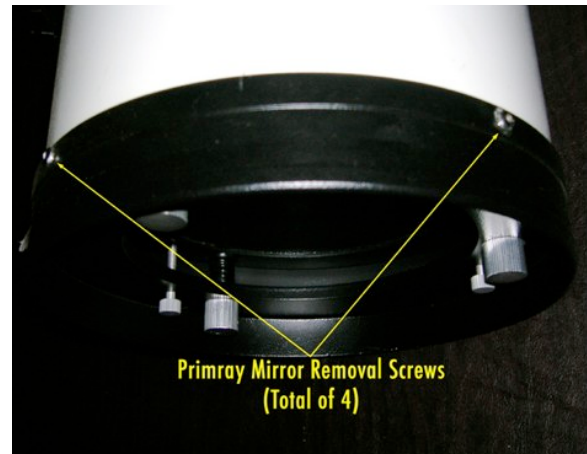
There are TWO methods to achieve the proper secondary rotation; the Paper “T” and the “Rib” technique. You may try either one.

Method One: Paper "T" Technique

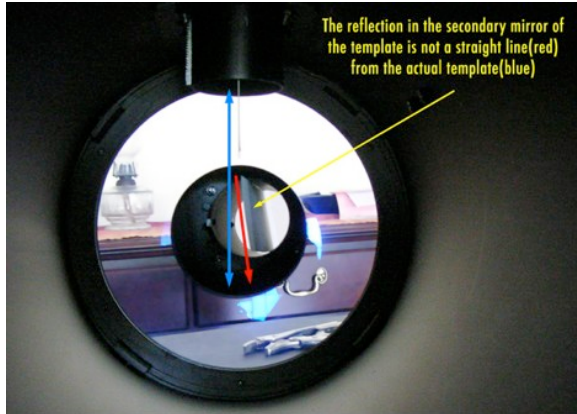
1. Remove the primary mirror. There are four screws to remove the primary mirror, and these will strip very easily, just as every other screw on this telescope. I suggest you replace them with steel ones.
2. Once the four screws are removed, carefully pull the primary mirror's holder off the end of the telescope. Place the mirror in a safe place!
3. Make a T-shaped paper or stiff cardboard template, with the shaft of the T just fitting inside the draw-tube, and long enough to get within an inch of the secondary. For an 8" SN I have found a length of 165 mm to be perfect. Using the empty focuser drawtube, a width of 50 mm is just right. A 6" or 8" scope may require a slightly shorter or longer "T".

The crossbar of the T prevents the template from falling into the tube. I use a 50 mm paper to fit inside the stock focuser with no eyepiece adapter. The wider the template the better, so the full focuser width should be used.

4. Rotate the template until the crossbar is parallel to the axis of the tube. If you make the template carefully it will automatically center itself in the drawtube. Keeping the scope on its side, with the drawtube straight up will help keep the template straight.



5. With the **primary mirror out** and looking down the tube, you will see the template protruding into the tube, along with the reflection of it in the secondary. If the secondary has the slightest degree of rotation it will be immediately apparent - the thin edge of the template will not run in a straight line with its reflection in the secondary mirror.

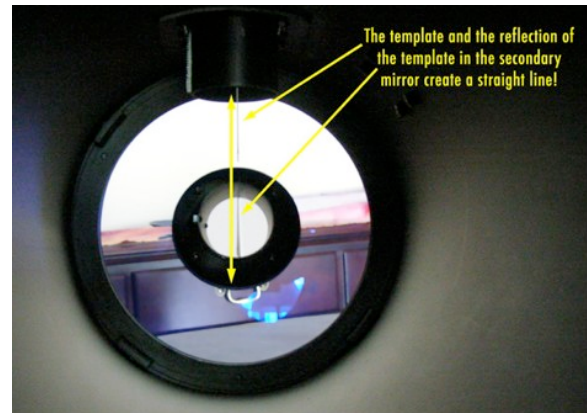


Again, the template must be accurately square to the axis of the tube - in practice this is easy to "eyeball". This method is very sensitive, because the end of the template and the reflection of it will stand at twice the angle of secondary rotation.

In this photo, a line continuing down from the edge of the template and the edge of the reflected template is not straight. This is what a slightly rotated secondary will show.

6. Rotate the secondary until the two edges of the template are in a perfectly straight line. If the secondary is rotated properly, you will see a perfect straight line coming down from the focuser drawtube and across the secondary mirror.

In the photo on the right, the secondary is correctly rotated. Once done, secure the secondary mirror by tightening the locking ring on the front of the mirror support.



Also, you should rotate the template 90 degrees and re-check it. The reflection of the end of the template and the end itself should remain parallel as you rotate the template in the draw tube. It will be very easy to see any deviation from the parallel and perpendicular lines of the two images.

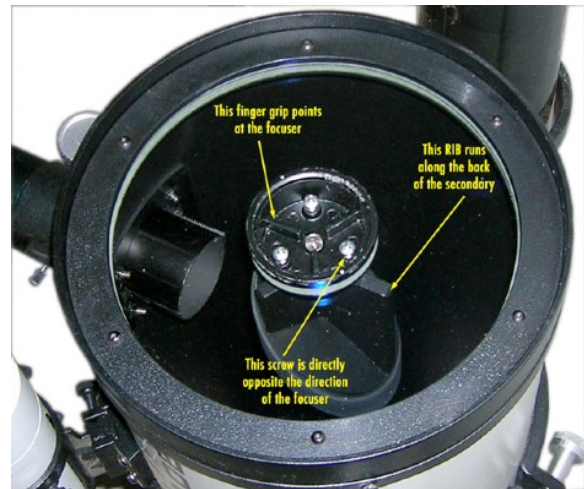
You may also wish to paint the end of the "T" with fluorescent paint or mark it with a yellow highlighter, to make it easier to see. Some LED flashlights emit enough UV light to cause such paint to glow slightly.

Once completed, the secondary rotation may never need to be adjusted again if you are careful with the scope and do not have any damage.

Method Two: Rib Technique

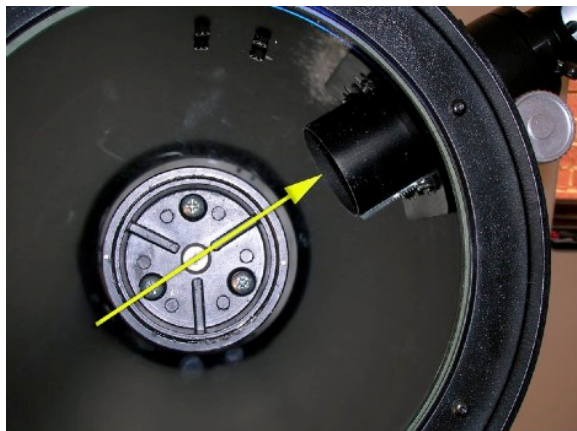
All of the Meade SN telescopes that I have seen have molded aluminum secondary supports with ribs that can make secondary rotation very easy. One user claims his will not work with this technique, so I ask that you verify your secondary support to see if it matches the examples below. If it does, you will find the following technique very easy to achieve very accurate and fast secondary rotation.

- a) Look down the front of the scope, and note the three ridges that make up the secondary support.
- b) Note the ridge that goes down the back side of the secondary. There is a bolt that lines up with this ridge.
- c) Move the focuser way out and insert a Cheshire or Barlow lens – anything that can extend the focuser out as far as possible.



- d) Line up the screw over the rear ridge (from step b above), the center screw, the center of the ridge between the two opposite screws, and the center of the extended focuser (see image below).

The secondary support on the Meade SN has a bolt and a ridge line that make this easy!



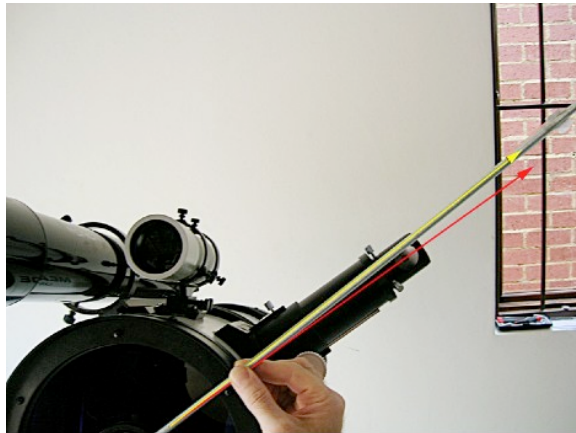
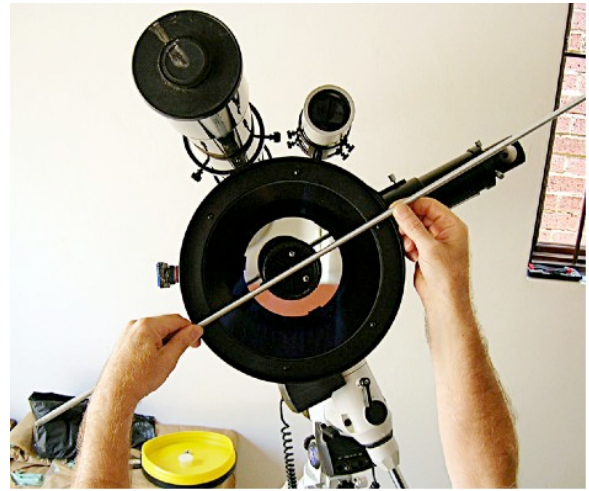
One finger grip on the secondary support ring points directly into the focuser. There is also a bolt directly opposite this grip. This is the screw that adjusts the forward/backward tilt of the secondary mirror. It is lined up with the back ridge support on the back of the mirror support.

*The secondary must point straight into the focuser.
Use the finger grips to guide you!*

- e) Next, use a long rod or other straight edge and line up the secondary finger grip across the center bolt and the back screw.

Carefully hold a straight edge across those three points (finger grip, center bolt, and back (tilt) screw). These all line up to point straight into the focuser if the secondary tilt is perfect. The longer the straight edge, the more accurate you will be.

NOTE: Be sure you are standing directly in front of the corrector. You should be able to center the view of the secondary onto the primary and make them a perfect circle. This way you will know you are directly in front and center to the secondary. Also you should close one eye when doing this, and do not move your head around when judging the direction of the secondary.



In the photo on the left, the YELLOW line shows the actual direction that the secondary is pointing, while the RED line shows where it should be.

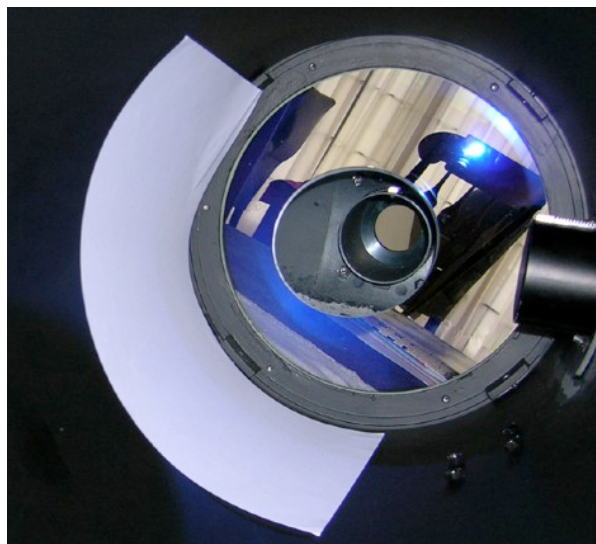
Adjust the secondary rotation to point straight down the center of the focuser. Ignore what you see in the secondary at this stage, as it will be off – but rest assured, the secondary now has the correct rotation!

Now your secondary mirror has the proper rotation, and you should now secure it with the front locking ring. With normal use, this should not need adjusting again.

Now you need to be sure that the secondary mirror is at the correct distance down the tube to be perfectly aligned under the focuser.

STEP FOUR: Center the secondary under the focuser.

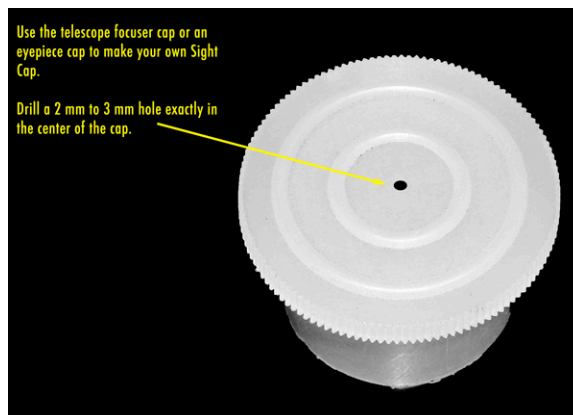
- a) Lay the scope on its side and remember to mark the side of the tube where the PRIMARY mirror-holder meets the optical tube. This is to help ensure you replace the primary mirror exactly in the same spot.
- b) Remove the primary mirror, being careful not to touch the surface. To remove the primary, remove the four screws in the outer edge of the primary mirror cell. Photos are seen in the “Paper T” secondary rotation procedure above.



c) Place a piece of white paper behind the secondary mirror, against the back of the tube opposite the focuser. This will help you see the outline of the secondary.

In this photo, you can see I have placed a sheet of white paper behind the secondary mirror to make alignment easier to see. You should also notice that the secondary mirror is grossly out of rotation! This shot was taken before I had rotated the secondary properly.

- d) Insert a peep-hole sight cap onto the focuser. This can be made from a focuser end cap (right). The purpose is to ensure your eye is exactly centered over the focuser when peering down it. If you are off by only a millimeter, that will be enough to make accurate collimation difficult. It is virtually impossible to center the secondary under the focuser without some form of aid.



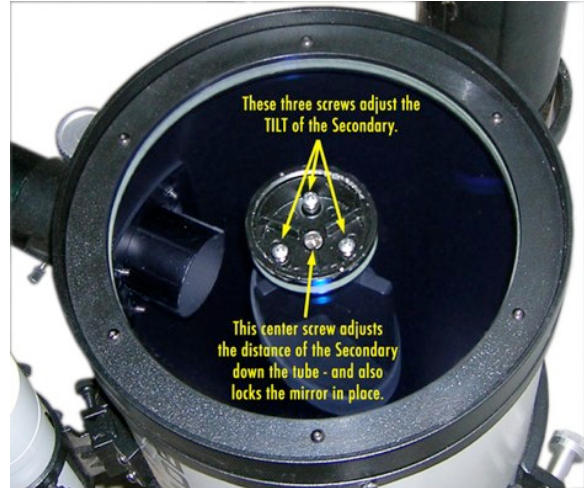
- e) Look straight down into the sight cap, and down the focuser. Move the focus until you can see three things:
 - 1) The outline of the end of the focuser.
 - 2) The outline of the secondary mirror against the white paper backdrop
 - 3) The end of the Optical Tube (OT)

The goal is to make these three images concentric. They need to be perfect circles within each other.

In the following sections, you will have to adjust the **TILT** of the secondary mirror. This is done with the TILT SCREWS located at the front end of the secondary support – in the center of the corrector.

Note: When making adjustments to the secondary tilt screws, be sure you understand how the system works. The three outer screws adjust the mirror's tilt. The **center screw** has three purposes:

- I. It is the **ONLY** screw that is holding onto the secondary. **If you turn it too far, the secondary will fall, perhaps destroying your secondary and even your primary!**
- II. It determines how far into the telescope tube the secondary is located. If you tighten it, the secondary moves forward, towards the corrector. If you loosen it, it moves back towards the primary. Note that the three outer “tilt screws” must also be moved inward or outward when making this adjustment!
- III. It locks the secondary down, after all tilt adjustments have been made. While making tilt adjustments you should loosen this center screw just a little, enough to allow you to make TINY tilt adjustments. Understand that every time you loosen this screw to make a tilt adjustment, you may be inadvertently moving the secondary towards or away from the primary too!

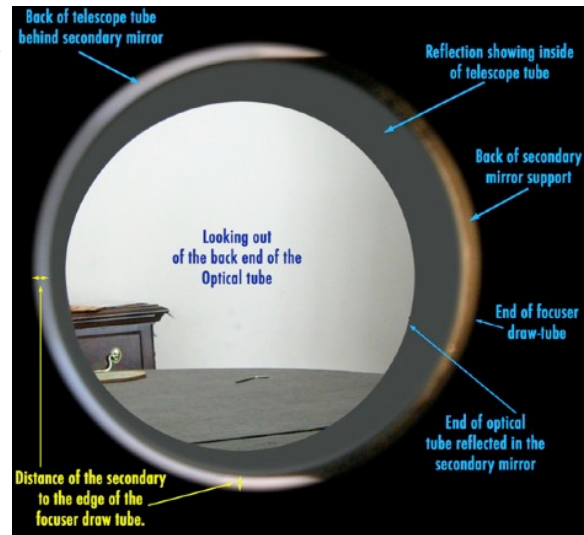


Warning: *The center screw in the secondary support is made from the same weak material as all the other screws on this scope. If you find yourself making lots of adjustments to this center screw you should replace it with a steel one. Mine sheared off, and almost destroyed the secondary mirror when it fell. Luckily the scope was on its side; otherwise the secondary would have fallen onto the primary with disastrous results.*

1. Center the secondary within the focuser draw-tube.

First, look only at the secondary mirror OUTLINE against the white paper background. The amount of white paper you see should be even all the way around. Use the **TILT screws** first to try and make the secondary appear a perfect circle. If necessary, move the secondary forward or back to center the secondary.

*The yellow arrows (left) show the equal distance of the secondary with respect to the end of the focuser draw-tube. This is very important to prevent light loss. Note that we **ignore** the observation that the end of the optical tube is not centered on the secondary mirror at this point. We will get to that soon!*



If the secondary is too far down the tube, or not far enough, then you must move the secondary forward or back. The easiest way to do this is to make very small incremental adjustments to all screws. If you want to move the secondary rearward, towards the primary, you will need to loosen the center screw. (**WARNING – if you accidentally loosen it too much it will fall off! Be sure your OT is laying flat on its side!**). When you loosen the center screw the secondary will move down the tube. This will also cause the three tilt screws to now become loose, as they are no longer pushing against the secondary. These three screws must now be tightened. Be sure to tighten each one the same amount, or you will now be adding TILT to the secondary. For every 1/16 turn of the center screw, you then adjust each tilt screw 1/16 of turn.

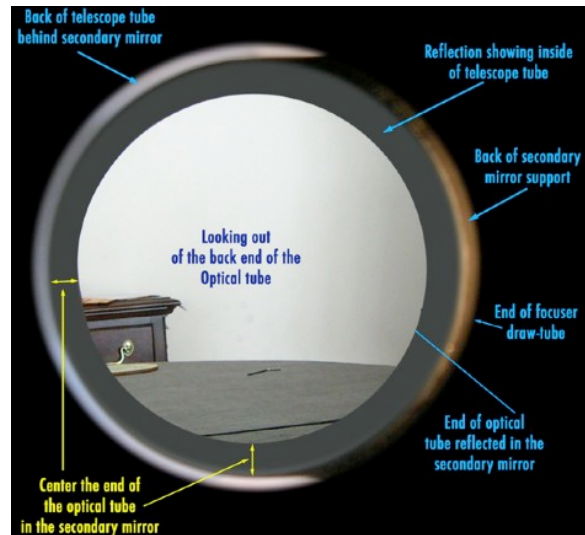
If you want to adjust the secondary forward, or towards the corrector, you must tighten the center screw. BUT – this is not possible until you first loosen the three tilt screws since they are pushing against the secondary! First, loosen EACH of the three secondary tilt screws 1/16th of a turn, and then tighten the center screw the same amount, 1/16th of a turn. This will slowly move the secondary mirror forward.

Keep adjusting the tilt and center screw (if needed) to make the secondary a perfect circle within the end of the focuser – as seen through a site cap. Again – you should ignore what you see reflected in the secondary mirror. NOTE: If you cannot achieve this, you should suspect that perhaps the focuser is not squared with the tube.

2. Center the end of the optical tube in the secondary.

Use the tilt screws to adjust the secondary so you see the end of the OT centered in the view. DO NOT rotate the secondary to do this. It is already rotated properly from step three above. Use only the secondary TILT screws to bring the end of the OTA.

Helpful hint: Create cross-hairs over the open end of the tube, by running two strings through opposed mirror mounting holes and taping them down to the tube. This makes it much easier to judge when the reflection of the end of the tube is actually centered.



The secondary is centered under the focuser, and now the end of the optical tube is centered within the secondary. Everything is concentric, with nice even circles. Perfect!

Now we have the secondary mirror square with the focuser, and reflects straight directly down the optical tube. Remove the white paper from the tube before you continue. The next step is to center the primary mirror in the secondary and collimate it so that the reflected light passes back to the center of the focuser.

STEP FIVE: CENTER THE PRIMARY IN THE SECONDARY

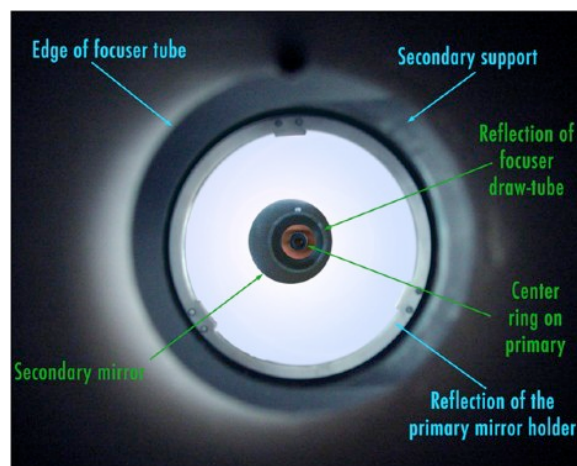
The next step is to line up the primary mirror so it points straight into the focuser. To begin, replace the primary mirror, being careful to line up the marks you made before you removed the primary.

To make the adjustments to the PRIMARY MIRROR TILT you must use the bottom Primary Tilt knobs.

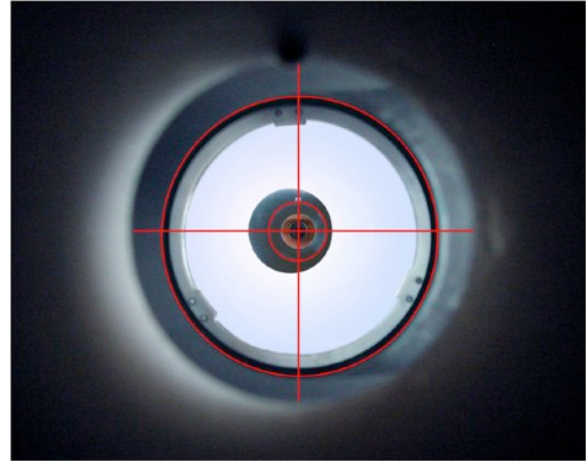


The larger knobs adjust the tilt of the primary mirror, while the smaller ones simply LOCK the mirror in place. You must loosen these “locking” knobs before you can adjust the tilt of the primary. Note that after you make your final adjustments to the mirror, the small pressure from the locking screws will be enough to move the primary out of collimation! For this reason, you must move all locking screws a little at a time, in equal amounts. Ok lets begin!

- Insert a Cheshire sight tube, collimation or pinhole cap into the focuser.
- Using the PRIMARY adjustment screws, adjust the primary's center ring so that it is centered in the Cheshire's crosshairs or pinhole cap's hole. You should not adjust the secondary's screws, as you have already collimated the secondary in the above steps. If you find that you cannot center the center ring, you should suspect that either the center ring is not centered, or that the primary mirror itself is not centered in the primary mirror mount.
- When you are done, you will note that the reflected image of the secondary mirror appears oval. This is an illusion. Also, you will note that while the primary's center ring is centered within the reflection of the focuser's draw-tub, the draw-tube itself is not centered on the secondary. This is a normal off-set.



In the photo on the right, you can see that the primary center ring is centered within the reflection of the focuser drawtube, but the reflection of the focuser draw-tube is NOT centered on the reflection of the secondary. The bulge should point towards the back of the scope, towards the primary mirror. This natural oval appearance is due to the secondary mirror being tilted and it creates the illusion that the secondary reflection is oblong, but in fact it is circular.

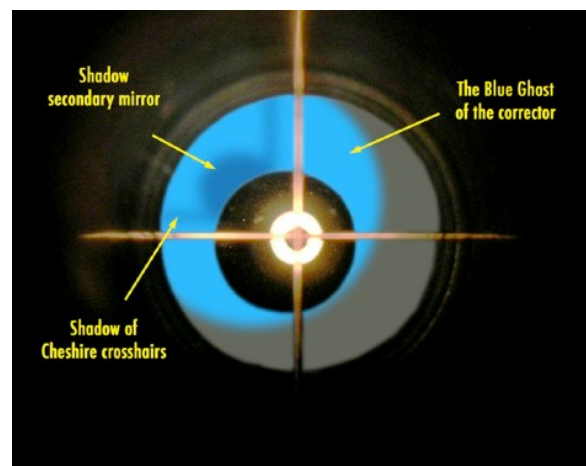


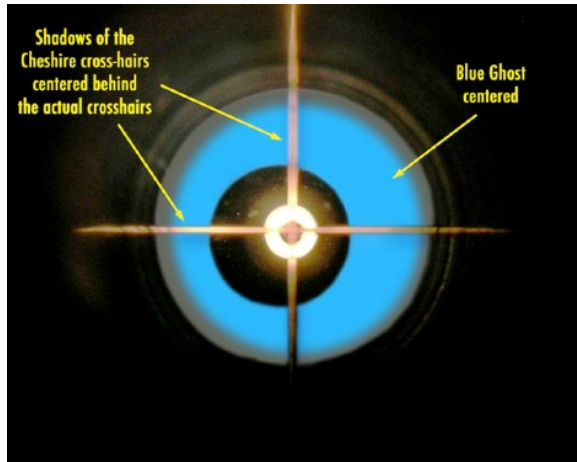
You now have very good collimation, but here's an extra step to increase the performance even more!

BLUE GHOST COLLIMATION

A new technique, discovered by Ross Lunsford, describes how you can achieve even better collimation with a Schmidt Newtonian telescope. The following procedure uses reflected light bouncing off the inside of the corrector and its corresponding shadows to bring the telescope into perfect optical collimation. Even if the mechanical alignment appears off, this procedure guarantees very accurate OPTICAL collimation!

- Insert a Cheshire sight tube into the focuser, and rack the focuser way out.
- Shine a bright light into the mirrored surface of the Cheshire. This will reflect down the tube and onto the inner surface of the corrector plate.
- Look into the Cheshire and note the shadow of the secondary mirror against the blue ghostly reflection off the corrector plate.
- Also, look for the faint shadows of the Cheshire's crosshairs on the blue ghost. Rack the focuser in and out to help you spot these two sets of shadows.





e) Carefully adjust the PRIMARY adjustment screws to bring the shadows of the Cheshire crosshairs behind the actual crosshairs, and the shadow of the secondary behind the actual secondary. NOTE: These are very small adjustments! I have found that just tightening the locking bolts is enough to move the shadows.

You now have a highly accurate Optically Collimated Schmidt Newtonian!

Enjoy!

Peter Kennett & Danny Ross Lunsford
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