

wifi-Aline

Introduction & Overview

The **wifi-Aline** enhances the accurate collimation of Dobsonian and Newtonian telescopes by sending a **real-time video stream** of the telescope optics wirelessly to your tablet, phone or computer's display.



The **wifi-Aline** does **not** require any additional apps, applications, or other software downloads for use on computers, tablets or phones ☺

The **wifi-Aline**'s powerful ESP32 processor **wirelessly serves up webpages to Safari, Edge, Firefox, Opera, Brave or Chrome** web browser on your computer, tablet, or phone for complete control of all **wifi-Aline** functions and viewing the real-time video stream of your telescope's optical elements.

The **wifi-Aline** is **carefully boresighted** so the center of rotation in the image corresponds to the optical axis along which to collimate the secondary and primary mirrors.

As an additional assist, **wifi-Aline** superimposes **3 coaxial target rings** and a crosshair that, once carefully offset to align with the primary mirror edge, **guide the collimation adjustments** for the secondary and other optical elements to bring them into accurate collimation with the primary mirror.



The wifi-Aline comes with Focuser Extension Tube (usb power bank sold separately) 5/8" ring and triangle-ring mirror center spots to make a complete system for collimation.

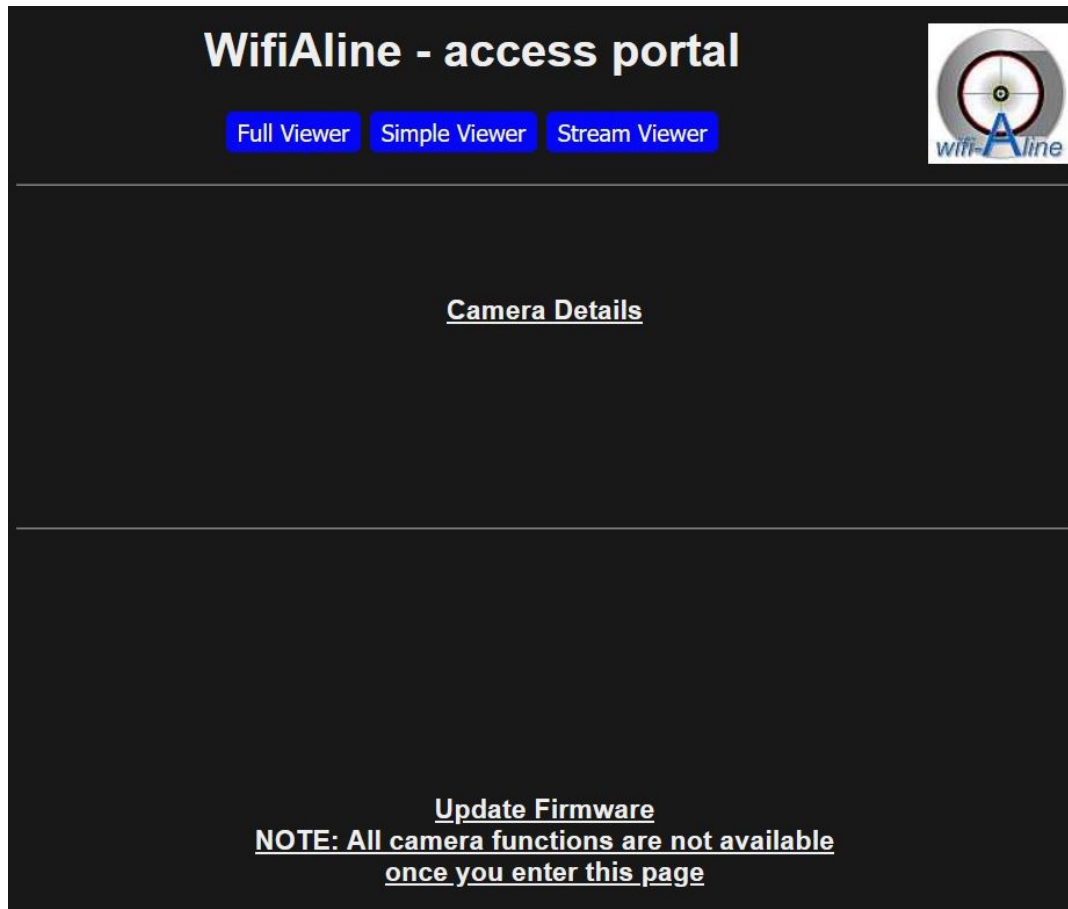
The **wifi-Aline** internally surrounds the camera lens with an **ultra bright micro-prism retro-reflector**, lit by the light gathered by your primary to brightly delineate the centerline of your optics.

The **wifi-Aline's** **wifi-range of greater than 20 feet** makes it the *perfect tool for collimating large newts and dobs*. No more dashing between the primary mirror cell and the eyepiece to check collimation.



Operation

- 1) Slip wifi-Aline into extension tube and then into 2" focuser.
- 2) Plug provided usb cable into an external usb-power-pack.
- 3) On computer/tablet/phone connect WifiAlines the wifi network. Default password is 1234567890
- 4) Open web browser on computer/tablet/phone and go to **8.8.8.8** to open **wifi-Aline Access Portal**



Full Viewer: Displays control menus and video images. Use this viewer to tune the display and camera settings for best video stream and aligning target rings with the primary mirror.

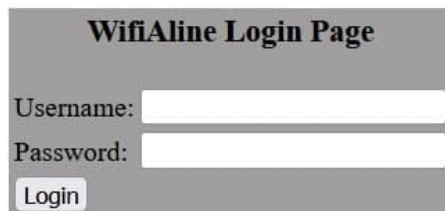
Simple Viewer: Allows the user to take still image or start video stream with target rings and switch between resolutions. Use this viewer after tuning the wifi-Aline control settings in the full viewer while manually adjusting mirror collimation screws.

Camera Details: Displays the wifi-Aline firmware, wifi, and System information.



Update Firmware: The Most current firmware is installed. This function supports installing future updates which will be posted on the website. Supports wirelessly updating the **wifi-Aline** firmware and webpages over wifi. Links to firmware updates will be posted on Rigelsys.com wifi-Aline webpage.

Note, **wifi-Aline** functions are not available once you reach the login page. To return to full functionality, login and click Reboot Unit at the bottom of the setup page. Reboot of phone or table may also be necessary.



The image shows a login page titled "WifiAline Login Page". It has a grey background. There are two input fields: "Username:" and "Password:". Below the password field is a "Login" button.

Default username/password is
admin/admin



The image shows the "Astrogene1000 WifiAline unit setup page". It has a red background. The title is "Astrogene1000 WifiAline unit setup page". Below the title, there is a warning: "Update firmware, be CAREFUL, only use firmware supplied by Astrogene1000. Uploading wrong file will corrupt this unit requiring either factory repair or you to load a LOT of software on your PC(yes PC!)". There are two sections for uploading files. The first section is for firmware, with a "Browse..." button, "No file selected.", a "progress: 0%" indicator, and an "Update" button. Below this is a message: "Wait for progress to reach 100%. All is not lost if progress never reaches 100%, just power cycle unit and try again!". The second section is for web pages, with a "Browse..." button, "No file selected.", a "progress: 0%" indicator, and an "Upload" button. Below this is the same message: "Wait for progress to reach 100%. All is not lost if progress never reaches 100%, just power cycle unit and try again!". At the bottom, there is a "Reboot unit" button and a note: "Reboot device if want to CANCEL after making no changes or after updating web pages on device. Close all pages to device and reopen to main page after rebooting".

Firmware files end in .bin

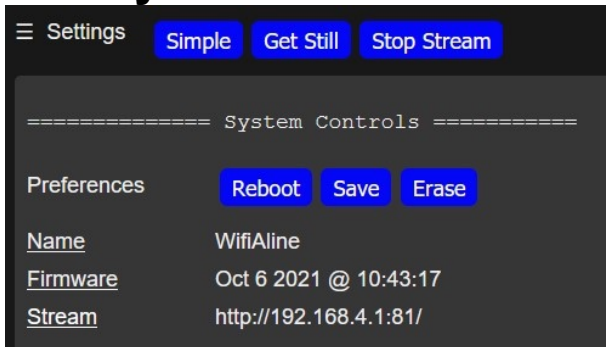
Web Pages files end in .html, .png, .js, .css for example:

- favicon_16x16.png
- favicon_32x32.png
- favicon_ico.png
- index_other.html
- index_ov2640.html
- index_ov2640_mobile.html
- index_ov3660.html
- jq.js
- logo.png
- serverindex.html
- style.css

Firmware and web pages are uploaded **one file at a time**. First browse for the file, press upload and wait until it hits 100%. Then **Reboot the wifi-Aline**. **Do not change file names for Web Pages** as the firmware expects web files to have specific names (as shown to right)

Full Viewer Controls

System Functions



Simple: Video stream fills entire web page without control menus and **zoom in the web browser** (which maintains target alignment with primary) while adjusting mechanical collimation of the mirrors.

Get Still: Takes a single snapshot of the collimation image.

Start Stream: Starts a video stream of collimation images to see changes as you make them. It may take 30 seconds for the wifi-Aline to initialize and first image to appear. After being pressed, the button changes to

Stop Stream to allow the user to halt the video stream.

Wifi transmission for a frame takes 2 seconds and there is a 2-frame delay. The frame count is displayed at the top of the display and increments as each frame is received.

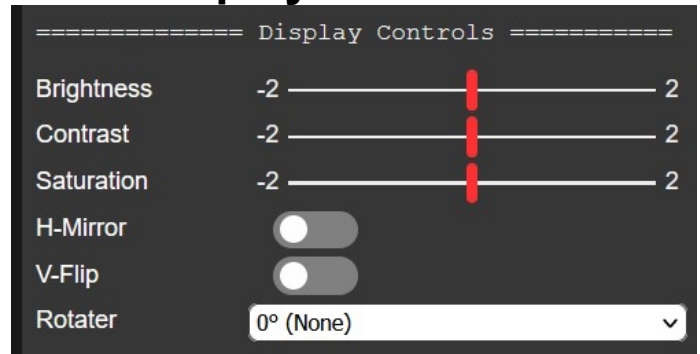
The 2-frame delay offers a *relaxed cadence* to the collimation process -- allowing the user time to change attention from adjusting mirror collimation screws to viewing the result of the adjustment in the video stream.

Reboot: Reinitializes the **wifi-Aline** to factory defaults. **WARNING: Boresight setting will be lost upon reboot. They are written on label attached to back of wifi-Aline and can be reentered.**

Save: Saves the current control settings for later recall.

Erase: Erases the current saved control settings.

Display Functions



Brightness: Adjusts the brightness of the image displayed. Brightness is the measured intensity of all the pixels comprising an ensemble that constitutes the digital image after it has been captured, digitized, and displayed.

Contrast: Adjusts the contrast of the image displayed. Contrast is the amount of color or grayscale differentiation that exists between various image features. Images having a higher contrast level generally display a greater degree of color or grayscale variation than those of lower contrast.

Saturation: Adjust the saturation of the image displayed. Higher saturation is more vivid, lower saturation is more grey

H: Flip the image Horizontally

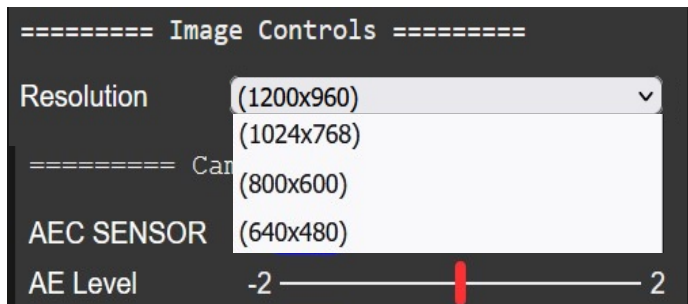
V Flip: Flip the image Vertically

Rotator: Rotate the image displayed left or right 90 degrees.

Balancing Brightness and Contrast in the display should be done in coordination with Camera Controls for the best image for calibration.

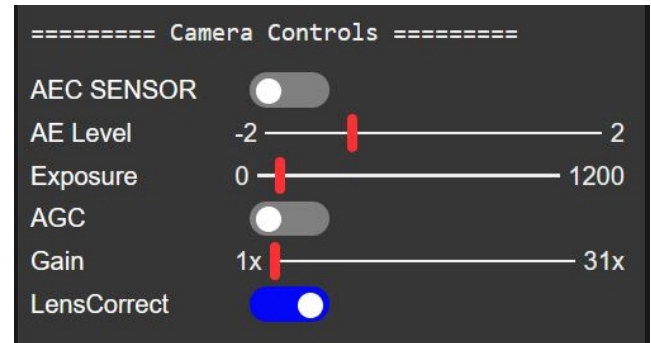
Image Functions

Resolution: Selects the pixel width and height for the displayed image.



Smaller frame size has faster frame rate.

Camera Functions



AEC Sensor: Automatically adjusts the exposure time and amplification gain to adapt to different illumination levels. When **AEC Sensor** is de-selected, Exposure is set manually.

AE Level: Automatic Exposure Level allows the user to tweak the exposure longer (to right) or shorter (to left) than the AEC Sensor selects to improve the image. When **AEC Sensor** is de-selected, AE and Exposure are set manually.

Exposure: Slide right to lengthen exposure time, left to decrease exposure time. Balance exposure time with gain so retroreflector and primary are both nicely lit.

AGC: Automatic Gain Control. Under normal light conditions the camera will display a normal image with clear contrasts between light and dark. However, when the light level drops below a certain level the camera will begin to boost the signal to compensate for the lack of light.

Gain: Slide right to increase gain, left to lower gain. At higher gain, especially under low light conditions, the image will be very grainy.

Lens Correction: **Recommend ON.**

Compensates for lens imperfection. According to the radius of each pixel to the lens, the module calculates a gain for the pixel, correcting each pixel with its gain calculated to compensate for the light distribution due to lens curvature.

Collimation Controls

Collimation Controls provides 3 rings -- Blue, Yellow and Red -- to assist collimation of the Primary mirror, Secondary mirror and Focuser.

This section describes their parameters than can be adjusted. The next section (Collimating a Newt or Dob) walks through how to use them.

===== Collimation Controls =====

HIDE ABOVE ☒

RECENTER FRAME to 0,0 ☒ MID

Offset Horz -51 - -51 +

Offset Vert -10 - -10 +

SHOW LOCKS ☒

LOCK RED to YEL ☐

LOCK RED to BLU ☐

LOCK YEL to BLU ☐

Blue Ring ON MID RAD

Radius 100 - 100 +

Offset Horz 0 - 0 +

Offset Vert 0 - 0 +

Yellow Ring ON MID RAD

Radius 50 - 50 +

Offset Horz 0 - 0 +

Offset Vert 0 - 0 +

Red Ring ON MID RAD

Radius 25 - 25 +

Offset Horz 0 - 0 +

Offset Vert 0 - 0 +

Line Width 1 1 5

Center in Frame

Hide Above: When selected, hides the Display, Image and Camera controls. leaving just the Collimation Controls visible.

RECENTER FRAME: Your wifi-Aline is boresighted using a laser collimated test rang prior to shipping with this function. We include this function only should boresight ever need adjusting. Steps for checking boresight and adjusting (if necessary) are available at rigelsys.com.

DO NOT USE FOR COLLIMATION.

EXECUTE: when pressed, will show a confirmation popup to prevent accidentally changing the boresight.

to 0,0: Sets horiz/vert offsets back to 0,0 the sensor frame center. It will show a confirmation popup to prevent accidentally invoking.

MID: Quick pick the center for a ring. Slide to right, use mouse pointer in the image to pick center, Press **ENTR**.

Note, MID always references horiz/vert from the **camera frame center (0,0)** NOT from the last offset horiz/vert position displayed.

Offset Horz: Manually tweak center of frame position left/right

Offset Vert: Manually tweak center of frame position up/down in frame.

Ring Settings

ON: Turn a ring on. Slide right to turn on, left to turn off.

MID: Quick pick the center for a ring. Slide to right, use mouse pointer in the image to pick center, Press **ENTR**.

RAD: Quick pick the radius of a ring. Slide to right, use mouse pointer in the image to pick radius Press **ENTR**.

Radius: Manually tweak Radius of the Ring larger and smaller.

Offset Horz: Manually tweak a ring's position left/right in frame.

Offset Vert: Manually tweak a ring's position up/down in frame.

Line Width: Slide to right make the lines for the rings broader, slide to left to make lines thinner.

Center in Frame: Recenters **all** rings to the **boresight center of all frames** (home position).

Show Locks: When selected, shows the 3 Locks below. These are **normally hidden** as Center in Frame will align all 3 rings to the boresight.

Lock Yel to Blu: Recenters the **Yellow** ring to the Blue Ring's center and the **Yellow** ring stays centered on the **Blue** ring if the **Blue** ring is moved

Lock Yel to Red: Recenters the **Yellow** ring to the **Red** ring center. The **Yellow** ring stays centered on the **Red** ring if the **Red** ring is moved.

Lock Blu to Red: Recenters the **Blue** ring to the **Red** ring center. The **Blue** ring stays centered on the **Red** ring if the **Red** ring is moved.

Note for "locked" rings, When locked, offsets are disabled for the locked ring as will follow the offsets of the ring it's locked to.

Warranty

1 Year limited warranty: Rigel Systems, 26850 Basswood Ave, Rancho Palos Verdes CA, 90275 warrants to the original consumer purchaser of its product that the product will be free of defects in material or workmanship 5 years from the date of purchase under normal use. During this warranty period, **Rigel Systems** will, at its option, repair or replace the product without charge for parts or labor when delivered to **Rigel Systems** with proof of the date of purchase and a statement of the problem with the product. Shipping and handling charges to **Rigel Systems** are your responsibility. This warranty does not apply if the product has been altered or repaired by anyone other than **Rigel Systems** or has been subjected to purchaser abuse, accident, negligence or damage subsequent to purchase including battery damage to product. This warranty excludes incidental or consequential damages resulting from the product or use of the product. The product is not a toy. Keep away from children. For more information visit <http://www.rigelsys.com>

Collimating a Newt or Dob

Wifi transmission for a frame takes 2 seconds and there is a 2-frame delay between an action and seeing the result. The frame count is displayed at the top of the display and increments as each frame is received. This 2-frame delay in the wifi video stream brings a **relaxed cadence** in the collimation process. The user can see the before and after change in collimation more easily and distinctly since the **relaxed cadence** allows time to shift attention from adjusting the collimation screws back to viewing the result of the adjustment.

Insert the **wifi-Aline** with its **Extension Tube** into the focuser and attach battery. Rack the focuser in but make sure the image of the extension tube doesn't impinge on the secondary image, and all can be brought nearly into focus.

Figure 1: wifi-Aline inserted into Focuser



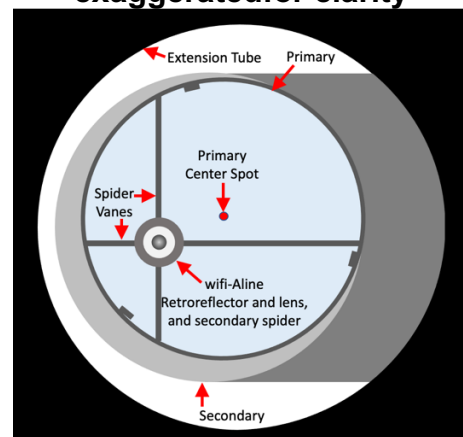
Also Insert a sheet of **white paper** inside the telescope tube directly opposite from the focuser to improve contrast of the secondary edge in the image (Figure 2a).

Connect your wifi-device to the **wifi-Aline** access point (*WifiAline*) and bring up the **wifi-Aline access portal** web page on your device. Select **Full Viewer** (as described in previous section) and select "**Start Stream**" at the top. The image will show the optical components something as in Figure 2b. The **Extension Tube** is modular and can be shortened (or removed) if it partially blocks the image of the **secondary**.

Figure 2a: White sheet inserted behind Secondary



Figure 2b: Misalignments exaggerated for clarity

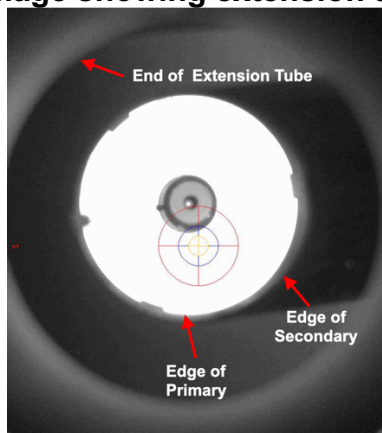


Sufficient lighting should be provided at the telescope aperture by pointing telescope to the daytime or evening sky or attach a white sheet to the front of the telescope and backlight. There are three rings (**Blue**, **Yellow**, **Red**, one for each of the major optical components to align; the **focuser** (using the **Extension Tube**), the **secondary mirror** and the **primary mirror**.

Adjust Exposure for Extension Tube

Adjust **Exposure** setting to see the **extension tube** clearly in the image (Figure 3). **Secondary** and **Primary** may be overexposed. Once image is acceptable, Select **Hide Above** in the **Calibration Controls** to hide the Display, Image and Camera controls as they are not needed for the calibration steps that follow.

Figure 3: Nicely Exposed Image showing extension tube, secondary and primary



Start with **Blue** Ring as a Guide

Turn on the **Blue ring** and rotate the **wifi-Aline** until the **Blue ring crosshairs** are parallel with the secondary **spider vanes** (Figure 4). The **Blue ring** is (as are the **Yellow** and **Red rings**) co-boresighted along the desired optical axis for alignment. Use **RAD** to match the **Blue ring** circumference to just smaller than the **Extension Tube** circumference as a check on the Focuser alignment.

Figure 4: wifi-Aline rotated until **Blue** ring crosshairs are parallel to spider vanes.

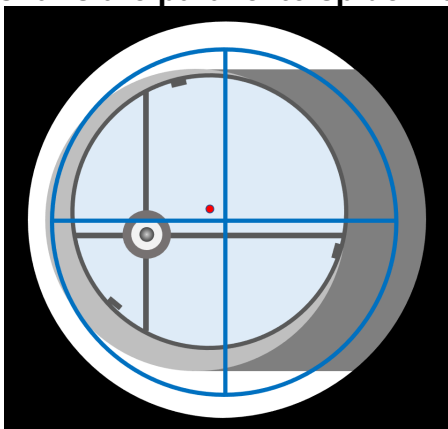
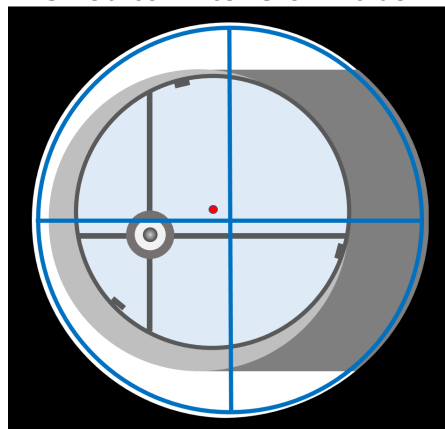


Figure 5: **Blue** ring sized to Extension Tube.



Adjust Exposure for Secondary & Primary

If necessary, deselect **Hide Above** in the **Calibration Controls** to show the Display, Image and Camera controls. Adjust **Exposure** setting to see the **secondary** and **primary** clearly in the image (Figure 3).

Once image is acceptable, Select **Hide Above** in the **Calibration Controls** to hide the Display, Image and Camera controls as they are not needed for the calibration steps that follow.

Size and Align **Yellow** Ring to Secondary

Turn off **Blue** ring and turn on **Yellow** ring. Approximately center the **Yellow** ring in the **secondary image** using **MID**. It doesn't need to be perfect. Next use **RAD** to match the **Yellow** ring circumference to just smaller than the secondary circumference.

Tweak the center of the **Yellow** ring using **offset** controls to move the **Yellow** ring until its circumference is aligned with the **secondary** circumference all the way around (Figure 6).

Figure 6: **Yellow** ring aligned with and sized to secondary.

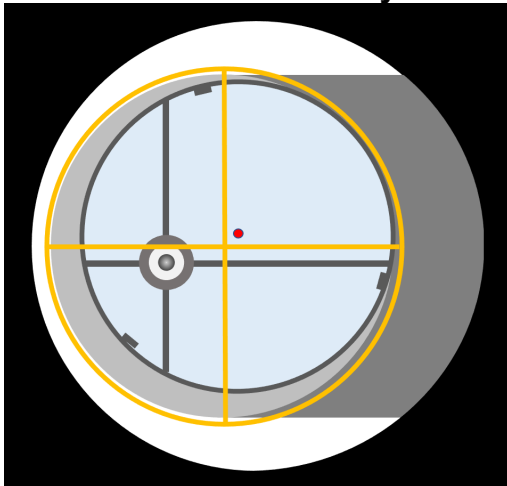


Figure 7: Secondary Spider Center Screw



Center Secondary Under Focuser.

Select **Center All Circles**. The **Yellow** ring will move in the image (Figure 8a), indicating where the **secondary** needs to be to center it in the **focuser**. While adjusting the **secondary**, It is best to have the telescope horizontal so if you drop a wrench it doesn't fall on the **primary** mirror.

The center screw on the **secondary** spider (Figure 7) moves the **secondary** either away from the **primary** (turn clockwise) or towards (turn counterclockwise) the **primary** mirror. You may have to loosen the 3 tilt adjustment Allen bolts (identified in the center picture below) a bit to allow the secondary to be moved using the center bolt. Be careful not to apply too much force and go slowly.

Adjust the **secondary** mirror assembly until you are comfortable that the **secondary's reflective surface circumference** is exactly aligned just inside the **Yellow** ring (Figure 8b), then lightly tighten the 3 tilt adjustment bolts to hold the **secondary** assembly still.

Figure 8a: Before

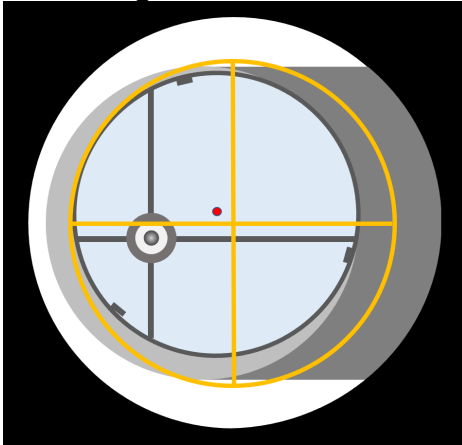
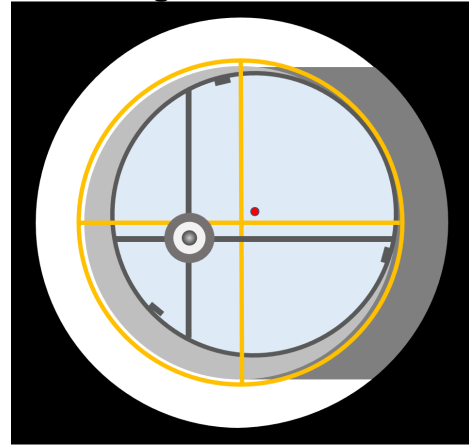


Figure 8b: After



Rotate the Secondary Mirror until Circular

You may notice that the **secondary** appears slightly elliptical compared to the circular **Yellow ring**. If so, slacken the central screw very slightly to allow you to gently rotate the mirror while still keeping it centered in the **Yellow ring**. As you rotate the **secondary** you will notice it change between slightly elliptical and circular compared to the **Yellow ring**. When it is most circular compared to the **Yellow ring** tighten the central screw.

Take a final check that the the **wifi-Aline** still shows the **secondary** circumference aligned with the **Yellow ring** (Figure 8b).

Size and Align **Red** Ring to Primary

Turn off **Yellow** ring and turn on **Red** ring. Approximately center the **Red** ring in the **primary image** using **MID**. It doesn't need to be perfect. Next use **RAD** to match the **Red ring** circumference to just inside the 3 mirror clips of the primary (Figure 9).

Tweak the center of the **Red ring** using **offset** controls to move the **Red ring** until its circumference is aligned with the **primary** circumference all the way around (Figure 9).

Figure 9: **Red** ring centered and sized to primary.

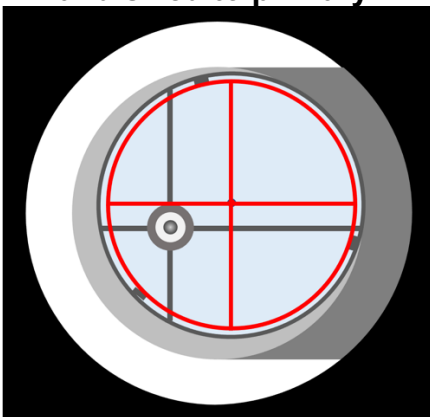


Figure 10: Secondary Tilt Screws



Tilt Secondary to Align Focuser with Center of Primary

Turn on **Yellow** ring and select **Center All Circles**. (Figure 11a). Adjust the **secondary** three tilt adjusting screws (Figure 10) slowly until you can see the **primary mirror center spot** on the **Red** ring **crosshairs** (Figure 11b).

When tightening the tilt adjusters be careful not to apply too much force and bend the spider vanes. It's not uncommon for some rotation error to creep into the **secondary** position while the tilt screws are adjusted. If it needs to be readjusted, see above step on rotating the **secondary** mirror until circular.

Also note it is normal at this point that the reflection in the **primary** mirror of the **secondary spider, wifi-Aline retroreflector and lens** may **not** be centered on the **Red** crosshair.

Figure 11a: Before

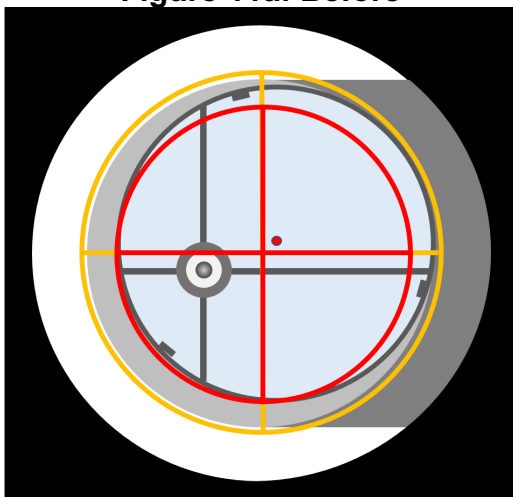
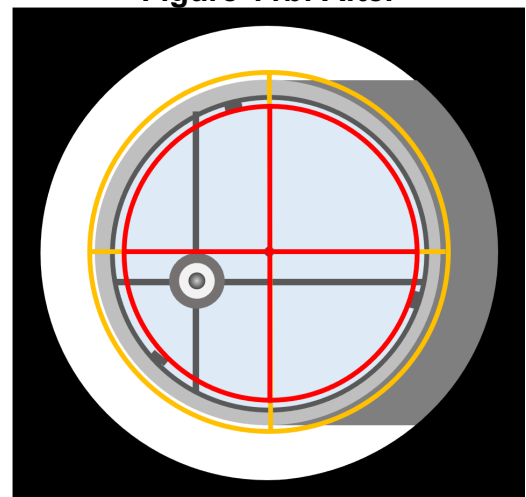


Figure 11b: After



Align the Primary Mirror:

This is relatively simple to carry out and the cause of most 'in the field' collimation errors. At the rear of the telescope **primary** mirror cell (Figure 12) are three **tilt** screws and three **lock** screws. On different telescopes, they may be paired together or separate.

Figure 12: Primary Mirror Tilt Adjustment and Lock Screws



Loosen the mirror **locks** and adjust the **primary** mirror using the **tilt** screws until the reflection of the **secondary, wifi-Aline retroreflector and lens** in the **primary mirror** align with the **Red ring crosshair** (Figure 13b).

Take care when using the **tilt** screws that you do not allow the **primary** to shift too far forward as they may disengage. Tighten the **lock** screws only finger tight so they don't pinch or distort the **primary** mirror.

Figure 13a: Before

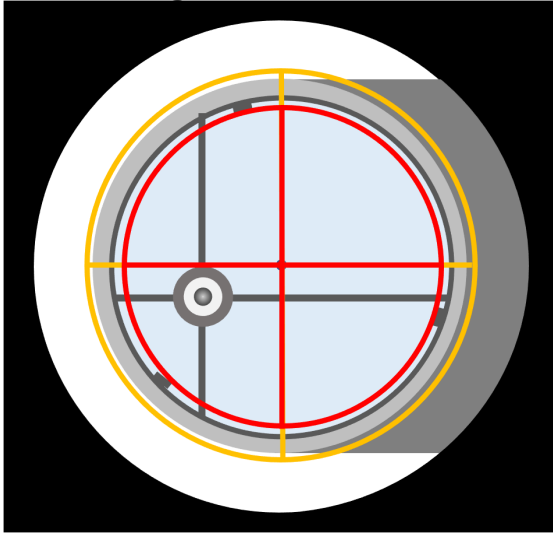
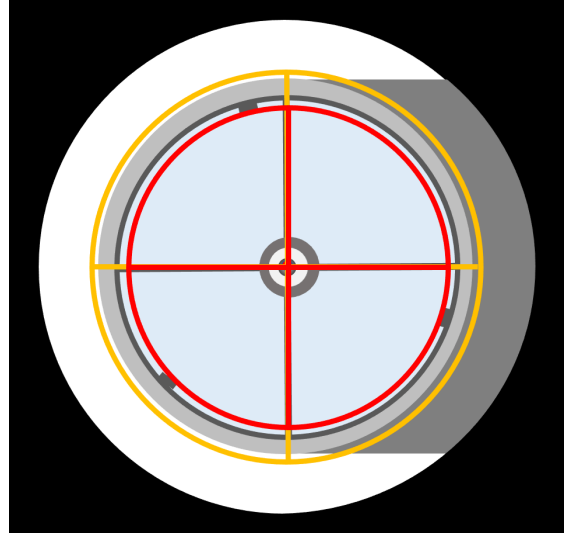


Figure 13b: After



Fine Tune Primary Collimation

The **wifi-Aline** can be used as a *Cheshire* Eyepiece to examine the position of the Mirror Center Marker. Note, your wifi-Aline comes with two center markers, a 5/8" diameter ring, and a 5/8" triangle-ring (doesn't tear on sides as simple equilateral triangle targets do during application).

This is relatively simple to carry out and the cause of most 'in the field' collimation errors. At the rear of the telescope **primary** mirror cell (Figure 12) are three **tilt** screws and three **lock** screws. On different telescopes, they may be paired together or separate.

Take care when using the **tilt** screws that you do not allow the **primary** to shift too far forward as they may disengage. Tighten the **lock** screws only finger tight so they don't pinch the **primary** mirror.

The image in the **wifi-Aline** of the mirror center spot will look like Figure 14, in this case a 5/8" equilateral triangle. Zoom in on the image (Figure 15) to show the reflection of the secondary mirror, the **wifi-Aline** retroreflective Cheshire ring, and the **primary** mirror center marker/donut/triangle. You may turn the rings off and zoom in even further, (Figure 16). This makes assessing and correcting the alignment of the Cheshire ring to the donut/triangle easy and precise.

Adjust the tilt of the primary mirror until the primary mirror's center marker (in this example, the tips of the triangle center spot) are all evenly just inside the the black dot pupil reflection of the **wifi-Aline**. You may wish to turn the rings off and zoom in further (Figure 16). If using a ring center marker (not a triangle), the ring will be just inside the **wifi-Aline's** black disk leaving a 1/16" black annulus all the way round. You may also see a center white dot in the middle which is the image of the **wifi-Aline's** camera lens.

Figure 14: Triangle Mirror Center Marker in wifi-Aline Image

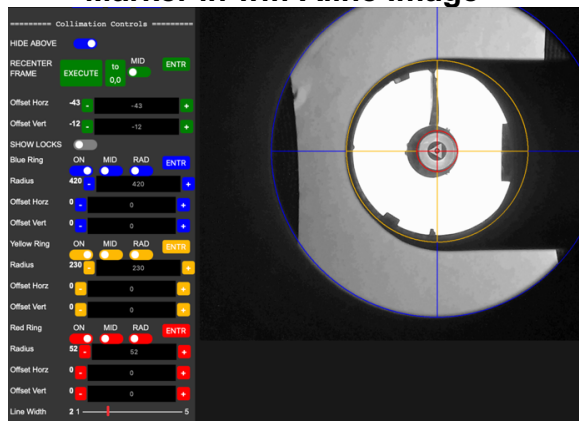


Figure 15: Zoomed in With Rings On

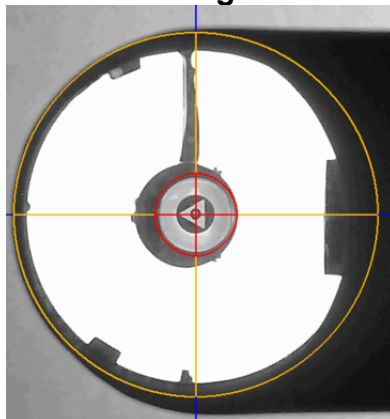


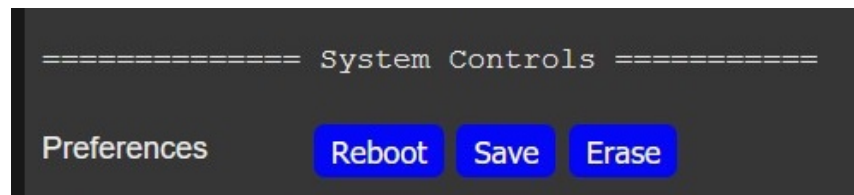
Figure 16: Zoomed in Further With Rings Off



Final Collimation Check

Carefully rotate the wifi-Aline 180 degrees in the focuser to validate the **wifi-Aline's** registration to the focuser and reveal any residual parallax (eyepiece lock screw is pushing the **wifi-Aline's** to one side of the focuser) or tilt error (**wifi-Aline** is slightly canted in the focuser after tightening eyepiece lock screw).

Save Preferences:



Slow vs Fast Telescope Collimation Patterns

Fast scopes (**f5** and lower) are less tolerant of collimation errors. They also show offset collimation patterns (Figure 17) compared to **Slow** scopes (**f10** and above, Figure 18). **F6 – f9** scopes will fall somewhere in between. Note that the center most circle shows a reflection of the secondary mirror surrounding the underside of the **wifi-Aline** retroreflector and lens. The cross hairs exactly intersect the reflection of the **wifi-Aline** lens.

Figure 17: Fast scope (f5 and below)
offset collimation pattern

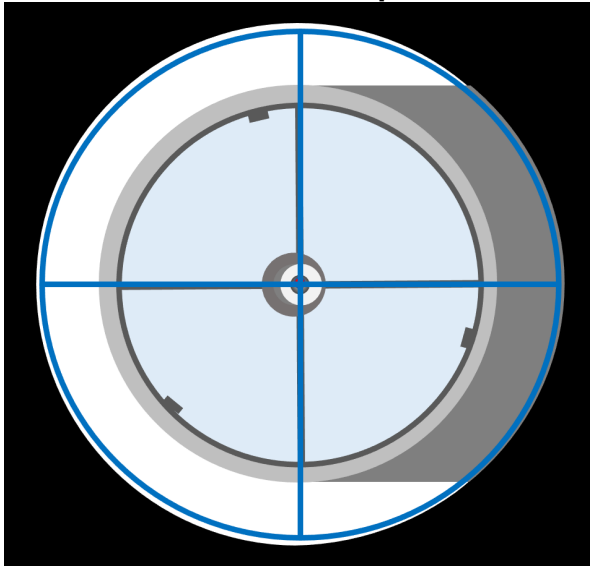
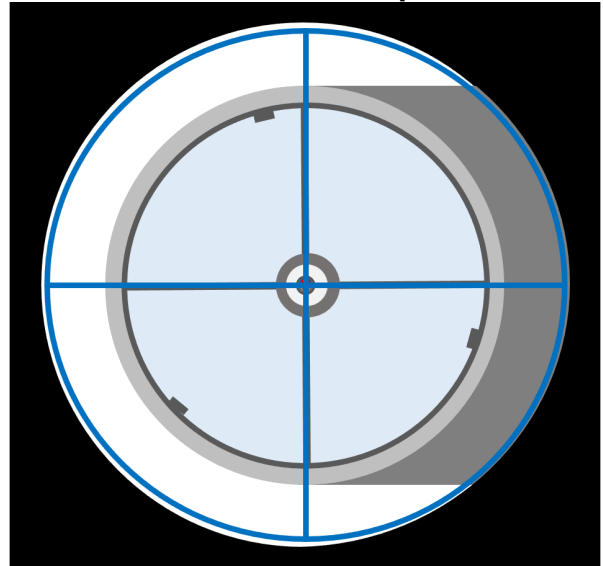


Figure 18: Slow scope (f10 and above)
classic collimation pattern



Star Test

You have completed collimation. However, the proof-is-in-the-pudding to verify collimation by examining an actual star through the telescope inside, outside, and at focus. This is described in the section **Star Testing**.

Other Resources for Collimating a Newt or Dob

There is a wealth of resources that discuss the collimation process, for Dobs, Newts, SCTs, RCs and other reflecting telescopes. Several recommended sources are listed in the sections below although a plethora of sources are easily found on the internet, in addition to which, there are many user groups (e.g., cloudynights.com, stargazerslounge.com, iceinspace.com.au) where collimation is an active topic of discussion.

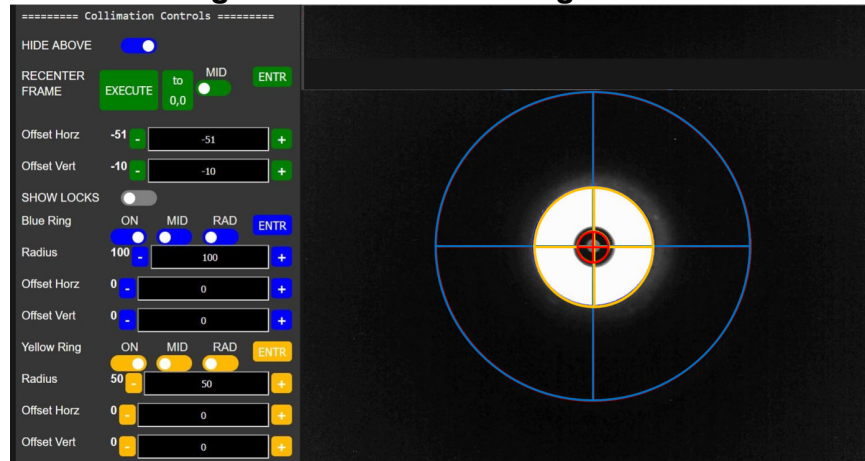
www.cloudynights.com/articles/cat/articles/collimation-and-the-newtonian-telescope-v4-r2599

<https://skyandtelescope.org/astronomy-resources/how-to-align-your-newtonian-reflector-telescope/>

Collimating SCTs, MAKs, or RC's

Although the **wifi-Aline** is very helpful in checking that the focus tube, secondary and primary (Figure 19) are not grossly misaligned causing vignetting. Given the nature of spherical mirrors used in **SCTs** and **MAKs** the secondary can be tilted and still seen as mechanically centered in the primary.

Figure 19: Wifi-Aline image in SCT



For **SCTs** and **MAKs** collimation requires the **refractive component** (The aspheric **corrector plate** in an **SCT** or the spheric **corrector plate** in a **MAK**) also be “square on” (not tilted with respect to the spherical primary and secondary optical axis) otherwise one side of the corrector plate will “correct” short and the other side “correct” long, producing aberration in the focused the star image.

As a consequence, collimating the corrector plate to the primary-secondary optical axis in **SCTs** and **MAKs** is best done by star testing. It is quick, simple, and requires no additional gear beyond a tool to adjust the secondary screws on an **SCT** or primary screws on a **MAK**.

Schmidt-Cassegrain

<https://www.celestron.com/blogs/knowledgebase/sct-edgehd-collimation-guide>

<https://skywatch.brainiac.com/collimation.pdf>

Maksutov-Cassegrain

http://www.company7.com/library/orion/Inst_makcasscollim.pdf

Ritchey–Chrétien

We are looking into aligning RCs with the **wifi-Aline**. The **RC** design is unusually sensitive to collimation (and so, to mechanical design and execution). The design is fine for professional observatories, suboptimal for “inexpensive” **RCs** for amateurs -- inexpensive because of the mechanicals, and the **RC** is very sensitive to the mechanicals.

http://www.deepskyinstruments.com/truerc/docs/DSI_Collimation_Procedure_Ver_1.0.pdf

<https://www.astronomics.com/wp/wp-content/uploads/2017/04/astro-techastro-tech-at6rc-collimation-sheet-pdf.pdf>

Star Testing

The proof-is-in-the-pudding is to verify collimation by examining an actual star through the telescope inside, outside, and at focus. The classic reference for star testing is Harold Suiter's book "Star Testing Astronomical Telescopes".

<https://agenaastro.com/star-testing-astronomical-telescopes-2nd-ed-suiter.html>

Inspired by this book, is a freeware application called **Aberrator** which does not replace Harold Sutter's well written book but can be used as a companion guide that can be used to generates [star-testing](#) images to illustrate the effects of [aberrations](#) (distortions) that degrade the quality of a telescopes performance. **Aberrator** can be used to produce simulated images inside, outside and at focus.

<http://aberrator.astronomy.net>

The **Aberrator** website also provides a nice in-depth guide to star testing.

<http://aberrator.astronomy.net/html/star-testing.html>

Once committing to performing a star test, it is helpful to generated "simulated" intra/extra/at focus images to set expectations for what a star test looks like at the scope. An example (with permission from Gene Nolan) is shown in Figure 20: for intra/extra images of a 10" F10 LX200. The first row are simulated intra/extra images from **Aberrator** with settings shown in the middle of the phot and 0.05 turbulence applied to provide *some atmosphere* to the simulated images.

The second row are the actual star test images taken through the telescope. The rings of light/dark simulated by **Aberrator** are identifiable in the actual images through blurring caused by the "twinkling" provided by the real atmosphere.

Figure 20: Simulated and actual intra/extra focus Star Images

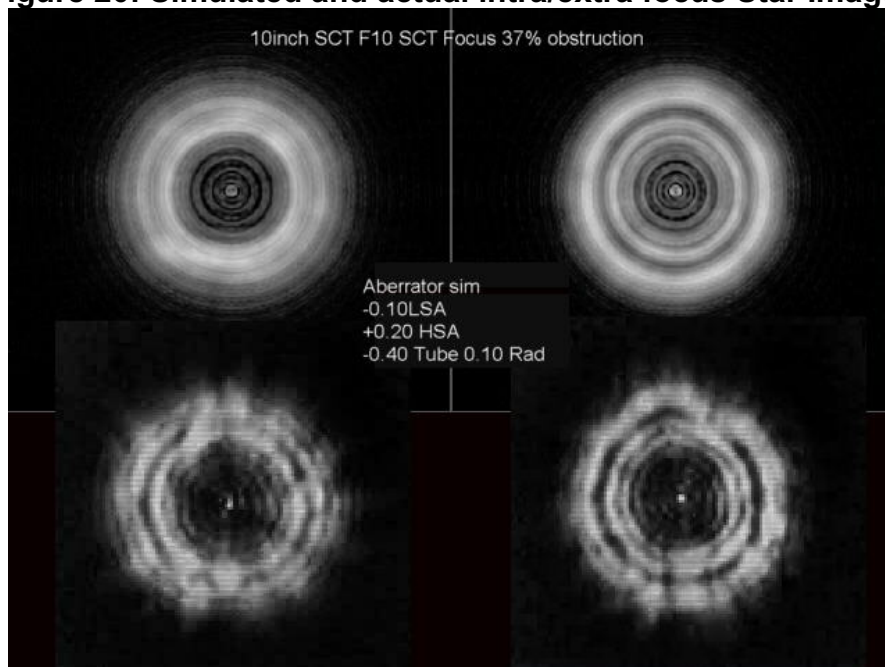


Figure 21 (with permission from Gene Nolan) compares at focus images simulated by **Aberrator** to ones taken at the telescope. Two telescopes were used to illustrate results with different aperture sizes.

- 1) lx200 10inch @ F31.5, raw scaled 2X
- 2) etx90 @ F42, raw scaled 4.3X

For this test, a pair of artificial target stars were used. These were created by piercing aluminum foil with needle 0.225 inches apart, mounting the foil in a box and backlighting. Note: the artificial star 'Star' on left is a slightly larger (and brighter) pinhole than star on right. The artificial target stars were placed 124 feet from the telescope. Atmospheric conditions for this star test were not optimal, with "Seeing" not the best and some wind.

The actual artificial target "star" images were taken with ToUCam Pro SC1.5 with 5.6x5.6um pixel sizes and captured to Astrovideo as an AVI. Images from the AVI were selected and registered in Registax, Approx 30 frames out of 150 were used for the LX200 and the etx90 and then scaled via pixel duplication in IRIS. The final composite photo (was composed using Powerpoint.

Two simulated in-focus images from **Aberrator** for the lx200 and the etx90 for were added for comparison to the actual in-focus star images taken through the telescopes. The top **Aberrator** image for the lx200 was scaled by matching the diameter of the Airy disk (the central bright spot inside the 1st diffraction ring) in the **Aberrator** simulated image to match to the diameter of the lx200 "star" image's Airy disk.

For the etx90, only the aperture and central obstruction were changed in **Aberrator** (all other settings were left unchanged from the lx200 simulation) to generate the simulated etx90 image for comparison to the actual etx90 "star" images.

Figure 21: Simulated vs Actual Star Test Images

