SkyCal User Manual

Precision Focus and Collimation Software

Version 2.1
December 2025

Contents

Author's Note

If SkyCal has helped you achieve sharper focus, easier collimation, or simply made your nights under the stars a little more rewarding, please consider showing your support by using the **"Buy Me a Coffee"** link in the **Help** menu. Every coffee keeps the project alive, keeps me awake while writing manuals, helps me keep improving the software, and reminds me that the effort was worthwhile.

Clear Skies and Sharp Stars

Chris Dowd,
Developer of SkyCal

⚠️ **Disclaimer & Safety Warning**

- **Follow Manufacturer Instructions**
  Always follow the collimation procedures recommended by your telescope's manufacturer. **SkyCal** provides measurement and guidance, but it does not replace the official instructions for your specific optical system.
- **Do Not Overtighten**
  When making adjustments to collimation screws, **never overtighten or force them**. Excessive pressure can damage the secondary mirror holder, strip screw threads, or cause permanent misalignment of the optics.
- **Proceed with Care**
  Make small, incremental adjustments, checking alignment after each step. If resistance is encountered, stop immediately and consult your telescope's documentation or a qualified service technician.

SkyCal is designed to assist in the collimation process, but the **user is responsible for performing adjustments safely and correctly**.

1. Introduction – What is SkyCal?

SkyCal is a specialized software tool designed to assist astronomers in achieving precise focus and collimation. It provides three functions:

- **Defocused Star Collimation** - for rough collimation, useful as a first step before switching to the Tri-Bahtinov mask for fine tuning
- **Bahtinov Mask Focusing** - for achieving critical focus on stars, ensuring maximum sharpness in astrophotography
- **Tri-Bahtinov Mask Collimation** – for fine adjustment of secondary mirrors in SCTs, MCTs, and other reflecting telescopes

Accurate focus and collimation are essential for astrophotography. Even small misalignments in a telescope's optics can lead to blurred or distorted star images, reduced contrast, and loss of detail in deep-sky objects. **SkyCal** provides visual overlays, error measurements, and optional voice feedback to guide adjustments, making the process easier, repeatable, and more reliable.

By integrating **SkyCal** into your workflow, you can:

- Eliminate guesswork when collimating
- Achieve repeatable, quantifiable results
- Improve image quality for both planetary and deep-sky astrophotography

Whether you are setting up a telescope for the first time or fine-tuning your equipment under the night sky, **SkyCal** offers a practical, user-friendly way to keep your optics collimated and focused.

2. Installation & Setup

This section explains how to initially install **SkyCal** and configure it for the first time.

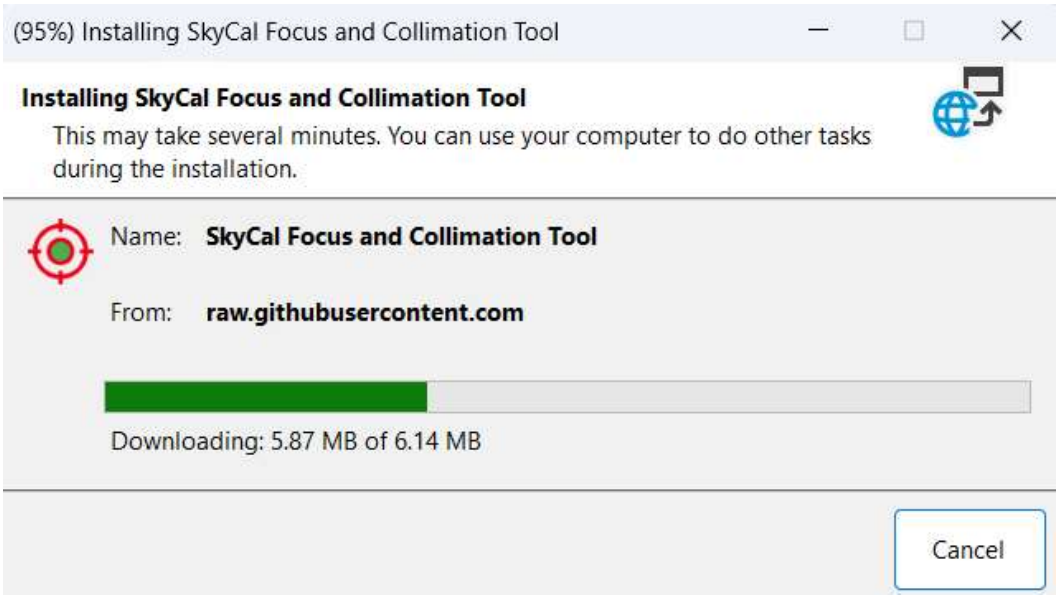
2.1. System Requirements

Before installing **SkyCal**, make sure your system meets the following requirements:

- **Operating System**: Windows 10 or Windows 11
- **Disk Space**: 10 MB free space
- **Telescope & Camera**: Telescope with attached imaging camera
- **Masks**: Bahtinov mask for focus and Tri-Bahtinov mask for collimation
- **Capture Software**: Image capture program such as N.I.N.A., Sequence Generator Pro, or equivalent

2.2. Download & Install

1. Download the latest installer package: https://github.com/insertnamehere1/Bahtinov-Collimator/releases/download/SetupV3/setup.exe
2. Run the installer:



Installer Dialog Window

Once installation is complete **SkyCal** will open and also place a link on the desktop. Continue now to configure the settings.

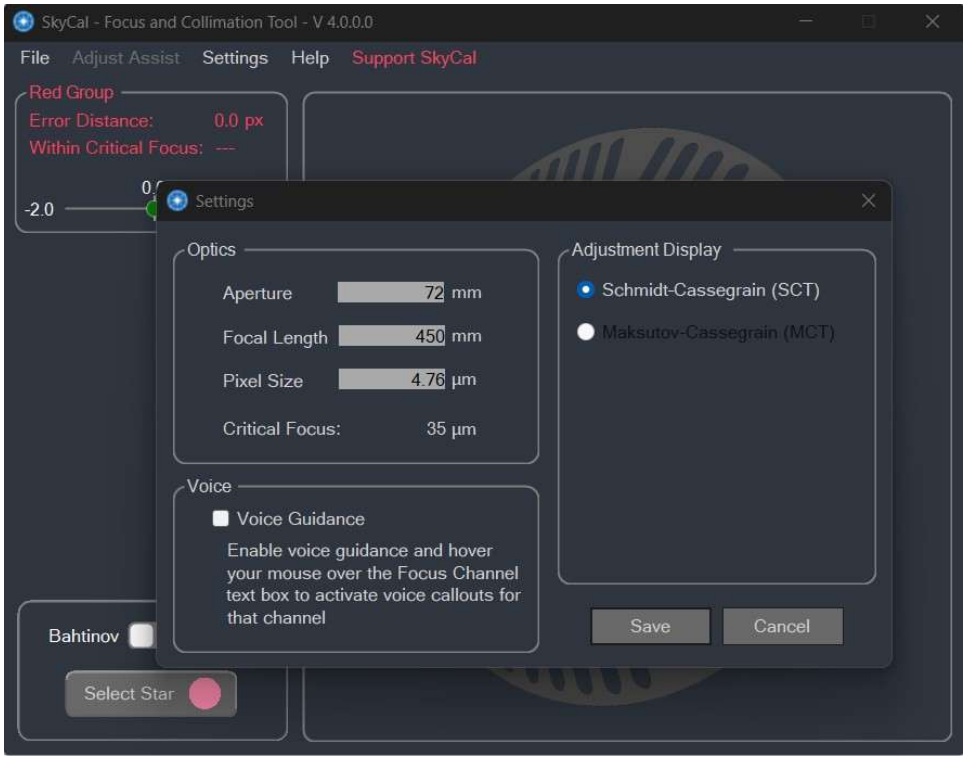
2.3. Setting Up SkyCal

When you first launch **SkyCal**:

1. Click on "Settings" on the menu bar to open the **Settings** dialog
2. Enter your telescope details:

   - Aperture (mm)
   - Focal length (mm)
   - Camera pixel size (µm)

3. (Optional) Enable **Voice Guidance** if you want **SkyCal** to announce focus/collimation error values aloud
4. Click **Save** to save your settings



Settings Dialog Window

SkyCal is now ready to use. For best results, confirm your settings before starting each session, especially if you switch between different telescopes or cameras.

3. Using SkyCal

This section provides a step-by-step overview of how to use **SkyCal** for collimation and focus. It covers the entire workflow from capturing an image to achieving precise collimation or focus:

- **Image Capture** – how to select and capture a star image for analysis in **SkyCal**
- **SkyCal Display** – understanding the interface, overlays, and indicators
- **Defocus Star Display** – understanding the interface, overlays, and indicators

3.1 Image Capture

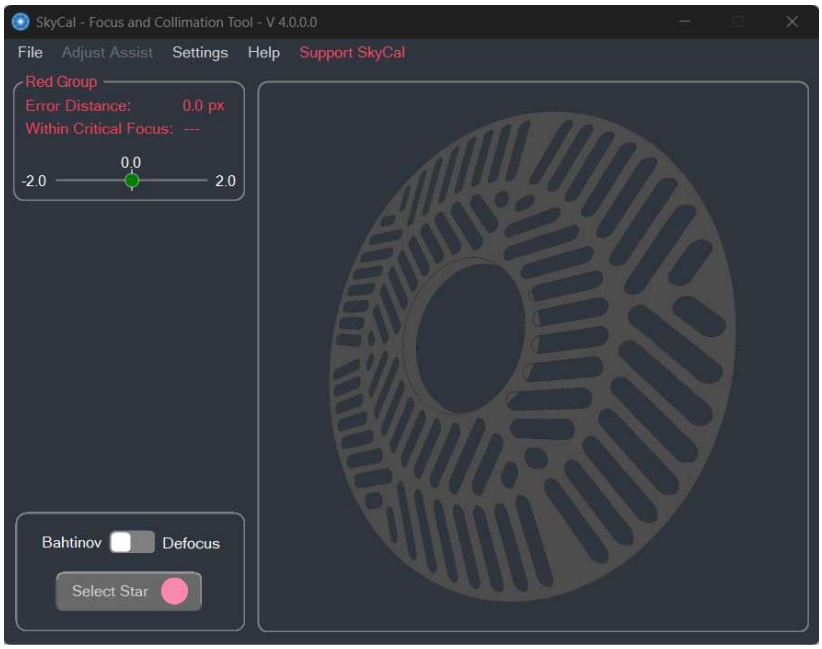
To analyse a star with **SkyCal**, you must capture the diffraction pattern created by the Bahtinov or Tri-Bahtinov mask. This pattern is used by the software to calculate focus or collimation error values.

Image Capture Instructions:

1. **Slew to a Bright Star**
   Choose a bright star high in the sky (near the zenith if possible). Brighter stars provide clearer diffraction patterns by reducing the effects of atmospheric turbulence.

2. **Begin Imaging**
   Start your preferred image capture software (N.I.N.A., etc.) and with either a Bahtinov or Tri-Bahtinov mask in place, or a defocused star, ensure the star is visible on the screen. Adjust exposure and gain so the diffraction spikes are clear and distinct, but not overexposed.

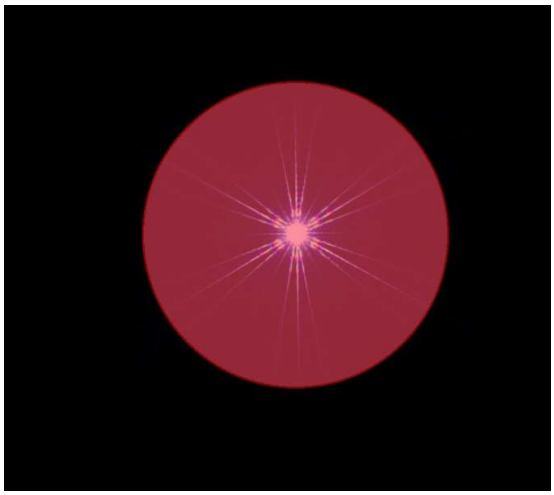
3. **Select the Display Mode**
   In **SkyCal**, ensure the **Bahtinov/Defocus switch** is set to the appropriate mode. This tells the software to expect a diffraction pattern image or a defocused “donut” image.



SkyCal Main UI

4. To Select the Image

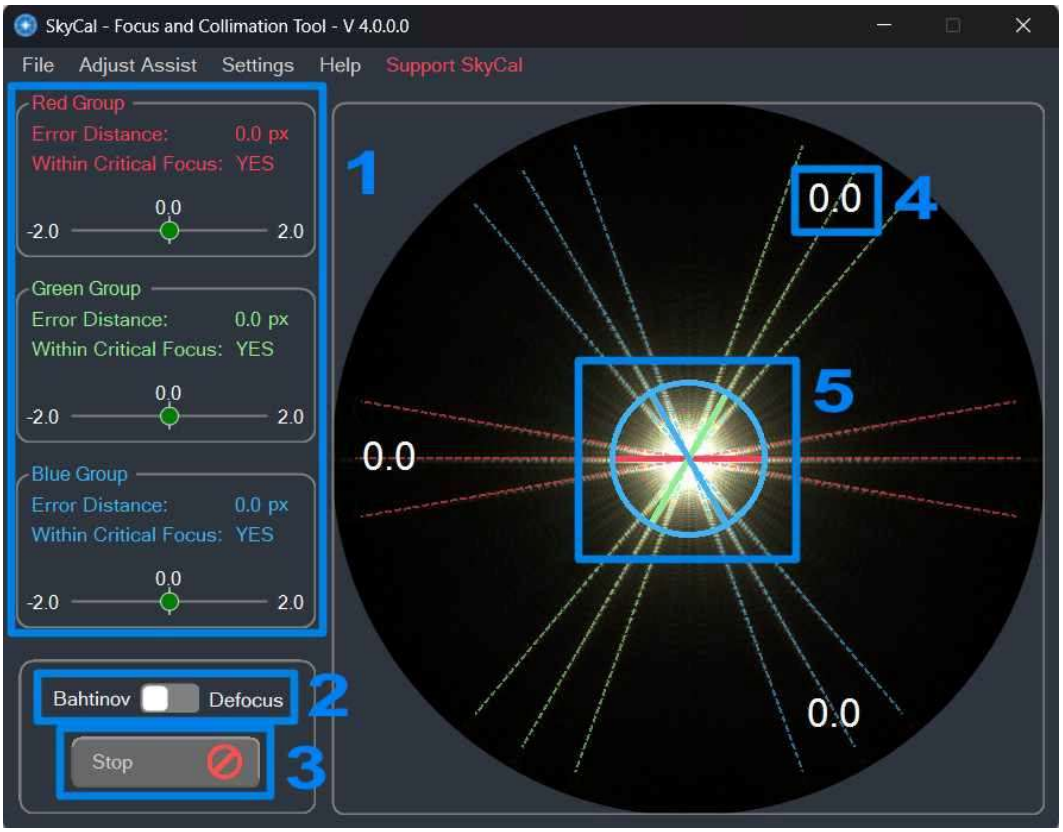
1. Press the **"Select Star"** button. The screen will darken, indicating that **SkyCal** is ready for star selection
2. Move your mouse pointer over the **bright central region** of the diffraction pattern or to the centre of the defocus donut. SkyCal will continuously screen-capture a snapshot of the image from whatever capture software you're using (e.g., N.I.N.A., SharpCap, etc.)
3. Press and hold the **left mouse button**.
4. Drag outward to create a circular selection. Aim to include as much of the radial diffraction spikes as possible.
5. When the circle fully encloses the diffraction pattern or defocus star, release the mouse button. The selected star pattern is now locked for analysis.



Selection Circle

5. **Verify the Display**
   SkyCal will display the selected image and overlay analysis lines and error circles on the diffraction pattern. If the overlays do not match the star's diffraction spikes, repeat the selection to ensure the correct star and region were chosen.

3.2 The SkyCal Display



Tri-Bahtinov Display

1 - Focus Channels

The **Focus Channels** display the amount of error detected in each Bahtinov line set. The information shown depends on the type of mask in use:

- **Bahtinov Mask** – when **SkyCal** detects an image from a standard Bahtinov mask, a **single focus channel** is displayed.
- **Tri-Bahtinov Mask** – when a Tri-Bahtinov image is detected, **all three channels** (Red, Green, and Blue) are displayed together in the Focus Channel Block.

Each focus channel provides the following information:

- **Error Distance** – the measured displacement of the diffraction spike from its ideal centre, expressed in pixels.
- **Within Critical Focus** – a status marker showing whether the current defocus error is **within** or **outside** the critical focus zone for your telescope.
- **Error Indicator** – Displays both the current position with the coloured marker and white markers for the last 5 errors recorded for the last images captured.

The goal is to minimize these errors so that all channels fall within critical focus zone.

2 - Bahtinov/Defocus Switch

The mode switch tells **SkyCal** how to interpret the star image: use *Bahtinov Mode* when a Bahtinov or Tri-Bahtinov mask is in place, and use *Defocus Mode* when analysing a defocused star for coarse collimation.

3 - Select Star/Stop Button

The **Select Star/Stop button** controls **SkyCal's** analysis state:

- **Select Star** – When pressed, **SkyCal** will allow you to select the image for analysis. After star selection is completed the diffraction pattern or defocus image is measured continuously and error values are displayed on **SkyCal** in real time.
- **Stop** – Pressing **Stop** ends the analysis, clears the display, and resets **SkyCal**. The application returns to a ready state, allowing you to select another star and start a new measurement.

4 - Channel Error Display

When analysing a star with either a **Bahtinov** or **Tri-Bahtinov** mask, **SkyCal** calculates the **channel error** for each diffraction line set.

- The error is shown as a positive or negative value of **pixels**, representing how far the diffraction spike is offset from its ideal centred position.
- In **Bahtinov mode**, a single error value is displayed.
- In **Tri-Bahtinov mode**, separate error values are shown for the three channels (Red, Green, and Blue), corresponding to each segment of the mask.

These values provide a **quantitative measure** of how far each channel is from perfect focus or alignment. The objective is to adjust the telescope's focus or collimation screws until the error values approach **0.0 pixels**.

5 - Error Circle Display

In addition to numerical error values, **SkyCal** displays **error circles** over the star image to provide a clear visual reference for alignment.

- **Number of Circles**
  - **Bahtinov Mask** – one error circle is displayed.
  - **Tri-Bahtinov Mask** – three error circles are displayed, one for each channel (Red, Green, and Blue).
- **Purpose**
  The error circles represent an **exaggerated offset** of the diffraction spike from its ideal central position. Since the central spike of a Bahtinov pattern can be difficult to judge by eye, the circles and their alignment lines make it easier to see whether focus or collimation is correct.
- **Orientation**
  Each error circle includes a **centre line** that is drawn parallel to the central diffraction spike of the corresponding Bahtinov pattern. This provides a direct visual indication of the offset.
- **Style Indicators**
  - **Dashed Circle and Line** – the measured defocus error is **outside the critical focus zone** of the telescope.
  - **Solid Circle and Line** – the measured defocus error is **within the critical focus zone**, indicating acceptable alignment.

3.3 The Error Bar Display

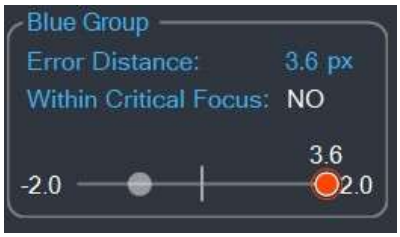
New for version 4 is the Error Bar.

The 3 Error Bar displays

The **SkyCal Error Bar** offers a clear and intuitive display of Bahtinov mask error information:

- Each of the three line groups is represented by its own colour-coded marker.
- The bar also stores and displays the **last five Bahtinov measurements** as semi-transparent history markers, making it easy to observe error stability over time.
- The **numeric error value** is shown above the marker to provide precise feedback alongside the visual indicator.
- The Error Bar is considered **active** when the channel's error lies within the normal working range of **+2 to −2 pixels**.
- When the error moves outside this range, a **highlighted band** appears around the marker, signalling that the value is out of bounds and that coarse adjustment is required.

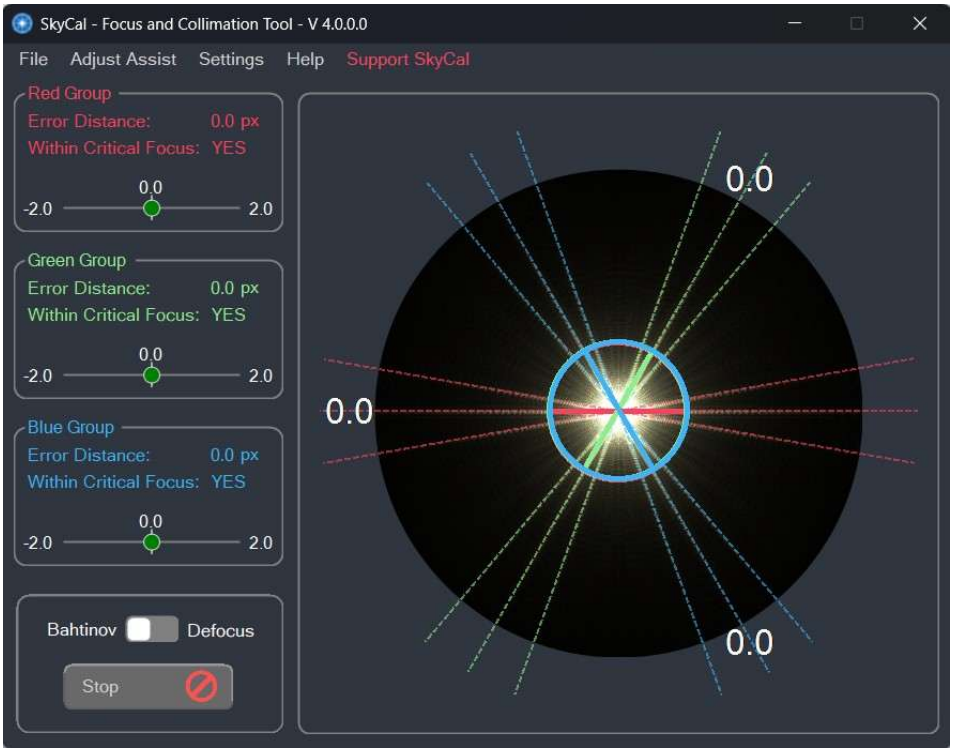
This design makes it straightforward to determine both the current error and the recent behaviour of that error during the collimation process.



Out of Range

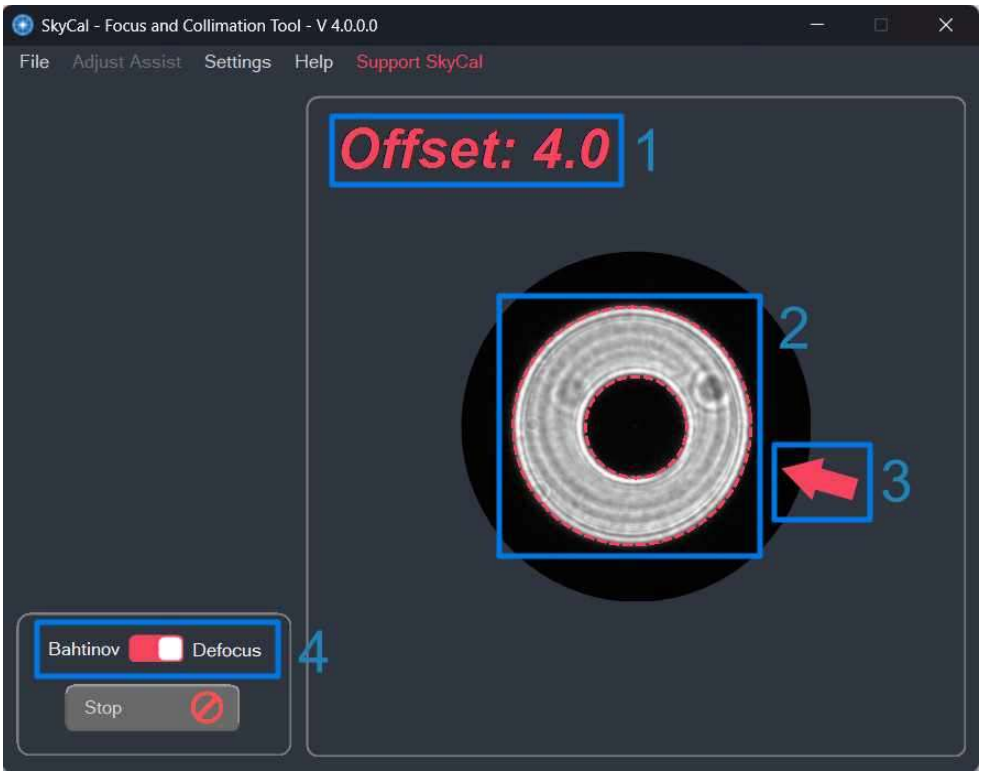
If all 3 error values are positive or all 3 are negative this indicates that the focus needs to be adjusted to move all 3 back towards 0.

After adjustment is completed the error markers on the error bar should be close to 0.



Perfect Collimation

3.4 Defocus Star Display



Defocus Display

1 – Offset Value Display (Defocus Star Mode)

When using the **Defocus Star method**, **SkyCal** calculates an **Offset Value** to help you judge how well centred the secondary shadow (the "donut hole") is within the defocused star image.

- **Relative Scale** – The offset is displayed in *relative units* without physical dimensions. It does not correspond directly to pixels or arcseconds, but instead provides a consistent measure of how far the central hole is shifted from the geometric centre of the star image.
- **Interpretation** –
    - A **larger offset value** means the shadow of the secondary is noticeably off-centre, indicating that collimation is out of alignment.
    - A **smaller offset value** means the shadow is closer to the centre, showing that collimation is improving.
    - The goal is to reduce this number toward **0**, which represents a centred secondary shadow.

Note: Since the Offset Value is relative, it should be used as a **guiding indicator**, not an absolute measurement.

2 – Defocus Star Ring Identification

When operating in **Defocus Star mode**, **SkyCal** automatically detects the structure of the defocused star image.

- **Inner and Outer Rings** – **SkyCal** identifies both the **inner ring** (edge of the central shadow) and the **outer ring** (edge of the star's light disk).
- **Dashed Overlays** – A **dashed circular line** is drawn at each detected boundary, making it easier to see the geometry of the defocused star.
- **Purpose** – These guides help you visually confirm whether the secondary mirror shadow is centred within the star image. If the rings appear shifted or asymmetric, collimation adjustments are required.

By combining the **offset value** with the **ring overlays**, **SkyCal** gives both a numeric and visual indication of collimation accuracy when using the defocus method.

3 – Closest Point Indicator

In **Defocus Star mode**, **SkyCal** highlights the point on the defocused star image where collimation is most noticeably off-centre.

- **Closest Approach** – The indicator marks the location where the **inner ring** (central shadow edge) is closest to the **outer ring** (star's light disk edge). This is the region of greatest asymmetry.
- **Direction Arrow** – An arrow is drawn at this point, showing the **direction in which the central hole (secondary shadow) must move** to bring the image into alignment.
- **Adjustment Guidance** – By following the arrow's direction and making small collimation screw adjustments, you can gradually shift the central hole toward the true centre of the image.

The **Closest Point Indicator** works together with the **Offset Value** and **ring overlays** to give clear, real-time guidance for coarse collimation using the defocus method.

4 - **Bahtinov/Defocus Switch**

The mode switch tells **SkyCal** how to interpret the star image: use *Bahtinov Mode* when a Bahtinov or Tri-Bahtinov mask is in place, and use *Defocus Mode* when analysing a defocused star for coarse collimation.

4. Focusing with a Bahtinov Mask

The Bahtinov mask is an effective tool for achieving critical focus in astrophotography. **SkyCal** enhances this process by providing visual overlays and error values to make focusing faster, easier, and more precise.

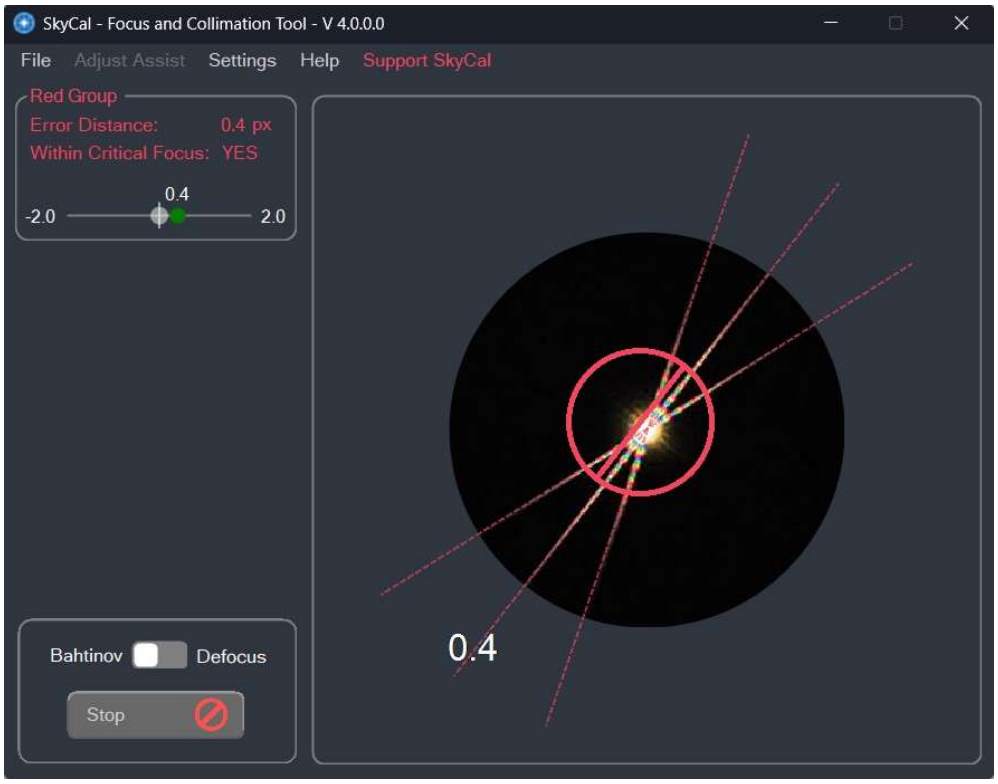
Setup

Before starting, make sure you have:

- A **Bahtinov mask** sized to fit your telescope's aperture.
- Your **telescope and imaging camera** securely mounted and connected to your capture software (e.g., N.I.N.A., Sequence Generator Pro, or SharpCap).
- **SkyCal** installed, setup, and running on your computer.

Step-by-Step Instructions

1. **Attach the Bahtinov Mask**
   Place the Bahtinov mask securely over the front of your telescope's aperture. Ensure it is seated firmly.
2. **Select a Suitable Star**
   - Slew the telescope to a bright star.
   - Position the star at the centre of the field of view.
   - Choose a star reasonably high in the sky (closer to zenith) to reduce atmospheric distortion.
3. **Configure SkyCal**
   - In **SkyCal**, set the **Bahtinov/Defocus switch** to **Bahtinov mode**.
   - Start image capture in your imaging software so the diffraction pattern is visible.
4. **Select the Star in SkyCal**
   - Click **Select Star**. The display will darken.
   - Move the mouse pointer over the bright star image and **drag a circle** around the diffraction pattern, including as much of the spikes as possible while excluding any nearby bright stars.
   - Release the mouse button. **SkyCal** will lock onto the star and begin analysing and display the diffraction spikes.



Bahtinov Focus Display

5. **Interpret the Display**
    - **SkyCal** overlays an **error circle and centre line** on the star image.
    - The **focus channel block** shows the Bahtinov offset value in pixels.
    - If the diffraction spikes are misaligned, the error circle line will not overlay the central spike.
6. **Adjust Focus**
    - Slowly adjust your telescope's focuser.
    - Watch the central diffraction spike move between the two outer spikes.
    - Continue until the error circle is centred between the 2 outer spikes, and the **error value approaches 0.0**.

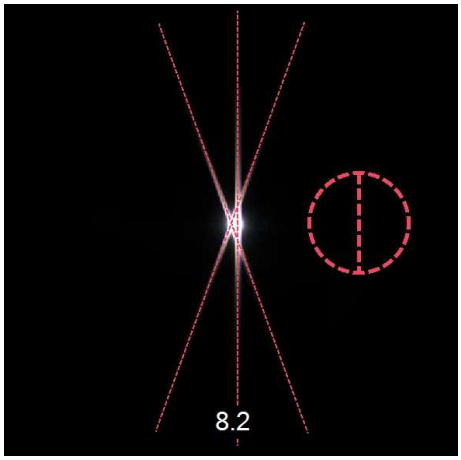
💡 **Tip**: Make very small adjustments. Overshooting focus can cause the error values to swing past zero.

7. **Verify Critical Focus**
    - When properly focused, the error circle's line will overlay the central diffraction spike.
    - The error circle will be a solid line, not dashed. This indicates that the error is inside the critical focus value.

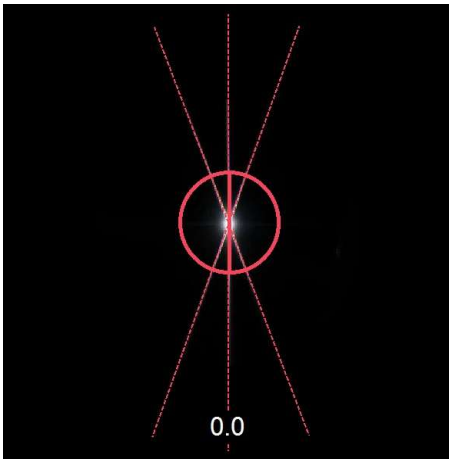
- The focus error value will read **0.0 (or very close)**.
- If enabled, **SkyCal's Voice Guidance** will confirm the updated error values aloud.

Note: Once focus is achieved, lock your focuser (if your telescope has a focus lock) to prevent drift during imaging.

By adjusting focus or collimation until the error circles converge toward the centre and the lines align, you can quickly and visually confirm when your telescope is correctly adjusted.



Out of focus/collimation error.



Good focus/collimation.

At this point your telescope is inside **critical focus**, ensuring sharp stars and maximum image detail for your astrophotography session.

5. Collimating with a Tri-Bahtinov Mask

The Tri-Bahtinov mask allows you to fine-tune the collimation with precision. **SkyCal** measures the diffraction pattern from the mask and provides clear, real-time feedback to guide adjustments.

Setup

Before starting, make sure the following are prepared:

- A **Tri-Bahtinov mask** correctly sized for your telescope's aperture.
- Your **telescope and imaging camera** securely mounted and connected to your capture software.
- **SkyCal** installed and running on your computer.
- A basic collimation already performed (e.g., with the **Defocus Star method**) to ensure the telescope is close to collimation before fine-tuning with a Tri-Bahtinov mask.

Step-by-Step Instructions

1. **Attach the Tri-Bahtinov Mask**
   Place the Tri-Bahtinov mask securely over the telescope's aperture. Align the mask so that its three diffraction zones correspond approximately with the telescope's collimation screws.

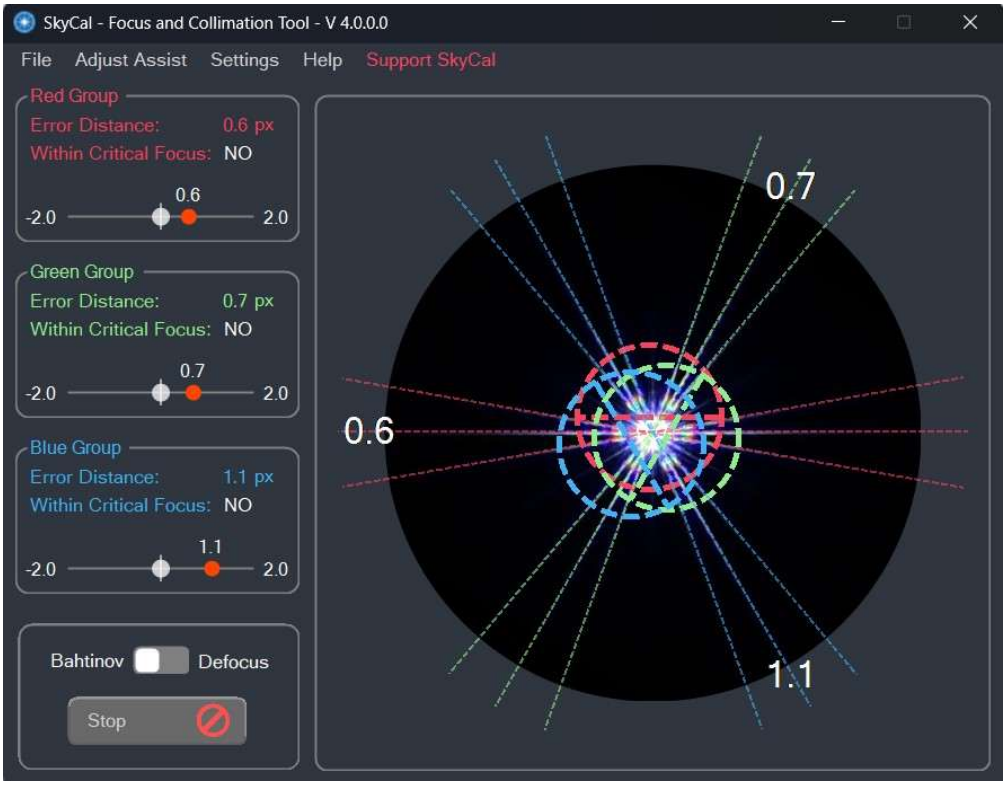
   Note: Ensure that the Tri-Bahtinov mask is correctly aligned with the collimation screws.

2. **Select a Suitable Star**
   - Slew to a bright star near the zenith (to minimize atmospheric distortion).
   - Centre the star in the field of view.
   - Adjust exposure so the diffraction spikes are sharp but not saturated.

3. **Configure SkyCal**
   - Set the **Bahtinov/Defocus switch** to **Bahtinov mode**.
   - Ensure that your image capture application is active and the diffraction pattern is clearly visible.

4. **Select the Star in SkyCal**

   - Click **Select Star**. The display will darken.
   - Move the mouse pointer to the bright central region of the diffraction pattern.
   - Using the left mouse button**, drag a circle** outward to enclose the spikes, avoiding nearby stars.
   - Release the mouse button to confirm selection.



Selected star displayed in **SkyCal**

5. **Interpret the Display**

   - **SkyCal** overlays **error circles and lines** for each of the three channels (Red, Green, and Blue).
   - The **Focus Channel Block** shows a numeric error value (in pixels) for each channel.
   - If all three channels overlap and approach **0.0 error**, collimation is correct.

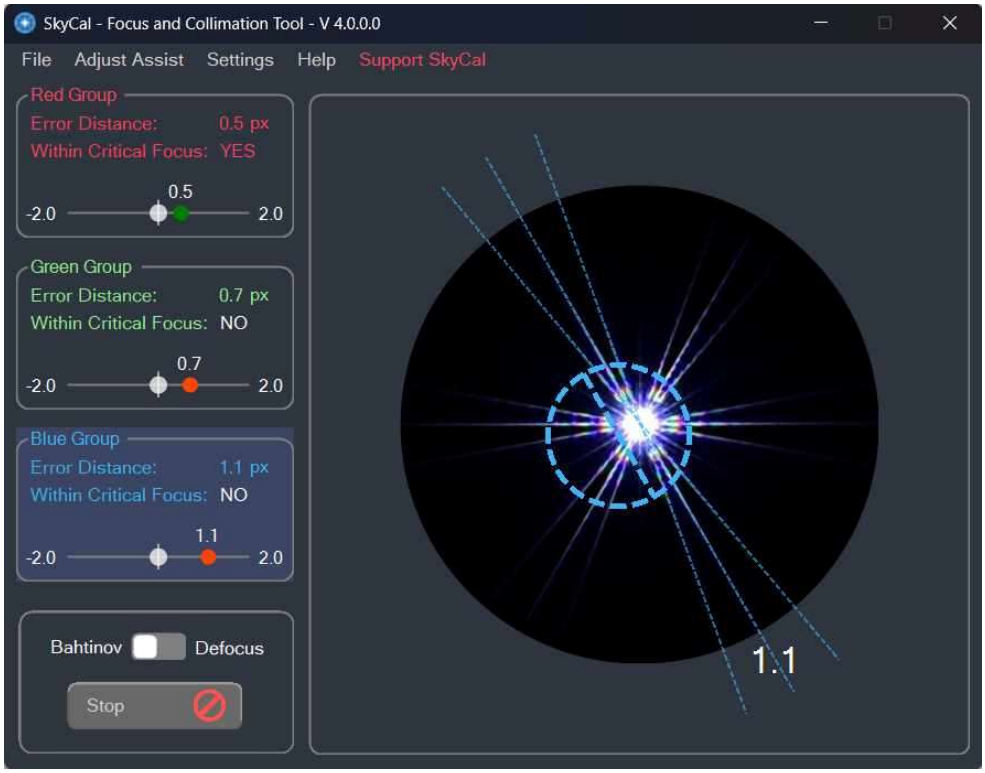
6. Isolating a Channel (Optional)

When viewing a **Tri-Bahtinov image**, **SkyCal** displays all three focus channels (Red, Green, and Blue) at once. Because the error circles and lines overlap, the display can sometimes appear cluttered or difficult to interpret.

To simplify the view:

- Move the mouse pointer over one of the **Focus Channel boxes** on the left side of the display.
- The selected box will highlight with a **red, green, or blue background**, depending on the channel chosen.
- **SkyCal** will then display **only the error value and error circle** for that focus channel, hiding all others.

This feature makes it easier to clearly see and adjust each channel individually without confusion from overlapping indicators.



Example of the isolated focus channels on a Tri-Bahtinov image

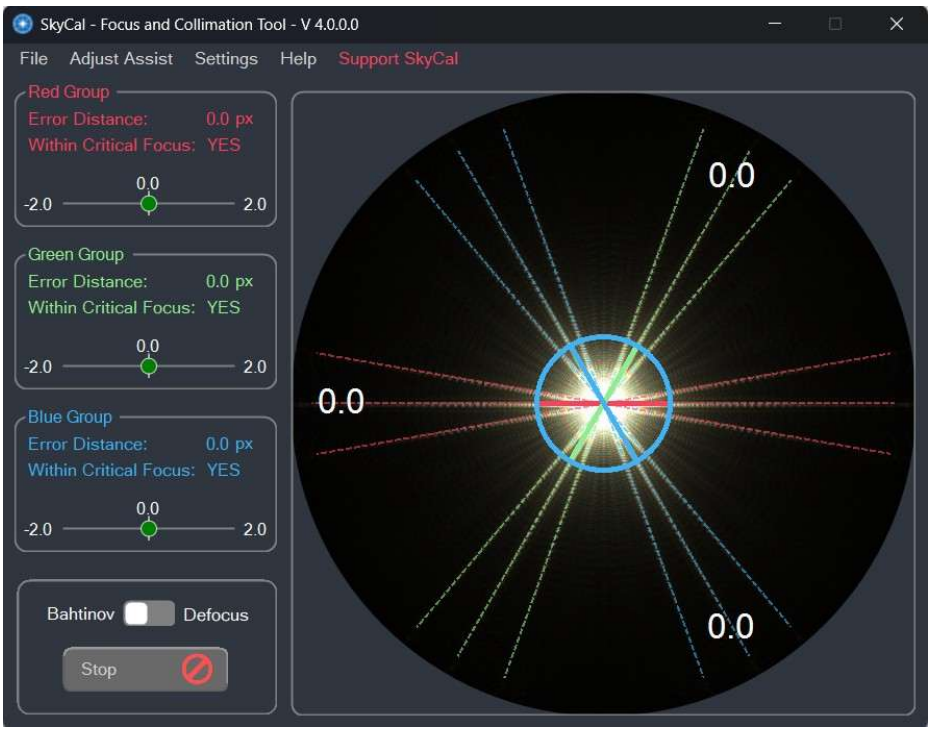
7. Adjust Collimation Screws

- Choose one channel as the reference (commonly Red). Adjust focus until this channel reads close to **0.0 error**.
- Use the telescope's collimation screws to reduce the error values of the other two channels.
- After each screw adjustment, briefly refocus the telescope again using the reference channel.

⚠️ **Important**: Adjust screws gradually. Do not overtighten or force them. Follow your telescope manufacturer's collimation instructions.

8. Refine and Repeat

- Continue alternating between refocusing and collimation screw adjustments until all three channels are as close to **0.0 error** as possible.
- When the error circles align with their central diffraction spikes and the error values converge, collimation is complete.



Perfect Collimation

6. Defocus Star Collimation

The **Defocus Star method** is used for **coarse collimation**. It provides a quick way to see if the optics are significantly misaligned and correct for that before switching to the Tri-Bahtinov mask for fine adjustment.

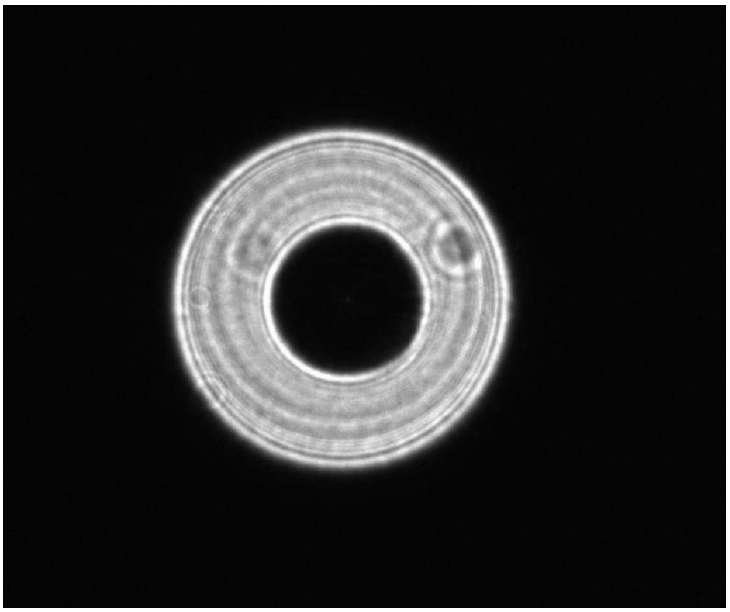
Setup

Before starting, make sure you have:

- Your **telescope and imaging camera** securely mounted and connected to your capture software.
- A bright star chosen for collimation (ideally high in the sky to minimize atmospheric distortion).
- **SkyCal** installed and running on your computer.

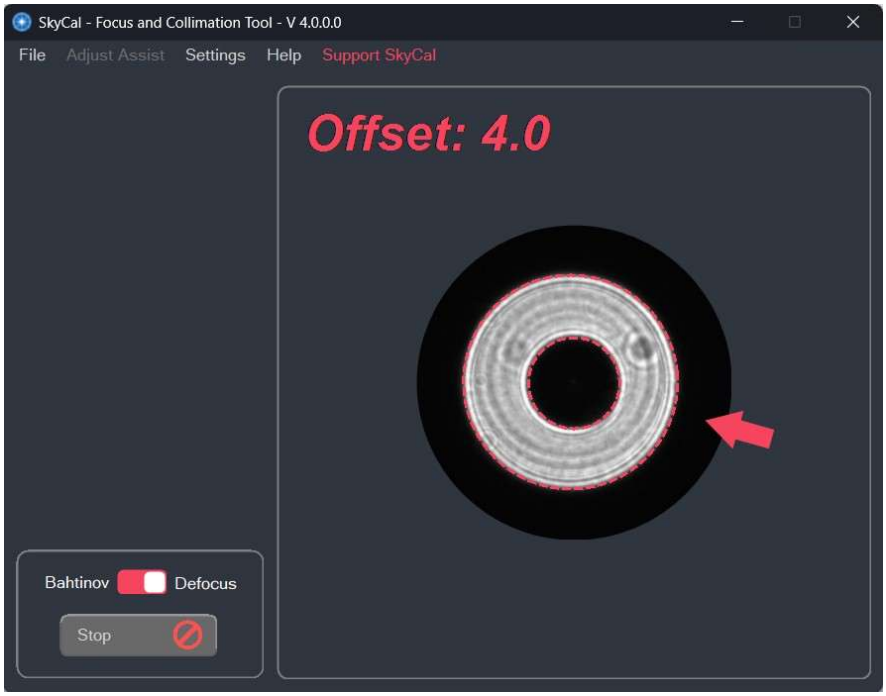
Step-by-Step Instructions

1. **Defocus a Bright Star**
    - Point your telescope at a bright star.
    - Adjust focus until the star appears as a **donut-shaped pattern** with a clear central shadow (secondary mirror silhouette).



Defocused star image

2. **Set SkyCal to Defocus Mode**
    - On the **Bahtinov/Defocus switch**, select **Defocus**.
    - This tells **SkyCal** to analyse the defocused star image instead of diffraction spikes.
3. **Select the Star in SkyCal**
    - Click **Select Star**. The display will darken.
    - Drag a circular selection around the defocused star image, including both the outer ring and central shadow.



SkyCal defocus star display

4. **Adjust Collimation Screws**
    - Using your telescope's collimation adjustments, gently adjust the optics in the direction indicated by the **Closest Point arrow**.
    - After each adjustment, **recenter the star** in the field of view and allow **SkyCal** to update the overlays.
    - Repeat small corrections until the **Offset Value approaches 0** and the central shadow appears centred.

⚠️ **Warning**: Never overtighten screws. Make only small, gradual adjustments.

5. **Verify Alignment**
    - When properly collimated, the inner shadow should appear **centred** within the outer star disk.
    - The **Offset Value** should be very close to 0.
    - At this stage, collimation is good enough to proceed with **Tri-Bahtinov fine tuning**.

Your telescope is now **roughly collimated**. The optics are close enough to alignment that you can switch to the **Tri-Bahtinov mask** for precision fine-tuning.

7. Advanced Features

7.1 Adjustment Assistant

The **Adjustment Assistant** is provided to make collimation easier and more intuitive. It removes the need to remember which adjustment screw corresponds to each Tri-Bahtinov diffraction pattern, and which direction each screw must be turned to reduce the measured error offset.

When the Adjustment Assistant is **configured** and active, **SkyCal** displays a labelled visual guide linking each collimation screw to its associated Bahtinov line set. Arrows indicate the correct direction of rotation to null out the calculated offset, helping to prevent confusion and over-adjustment.

Because telescope configurations vary, the apparent direction of adjustment and the relative position of each screw in relation to the Bahtinov pattern may differ between setups.

Image orientation can be affected by:

- Camera image flip
- Optical systems that mirror or invert the image

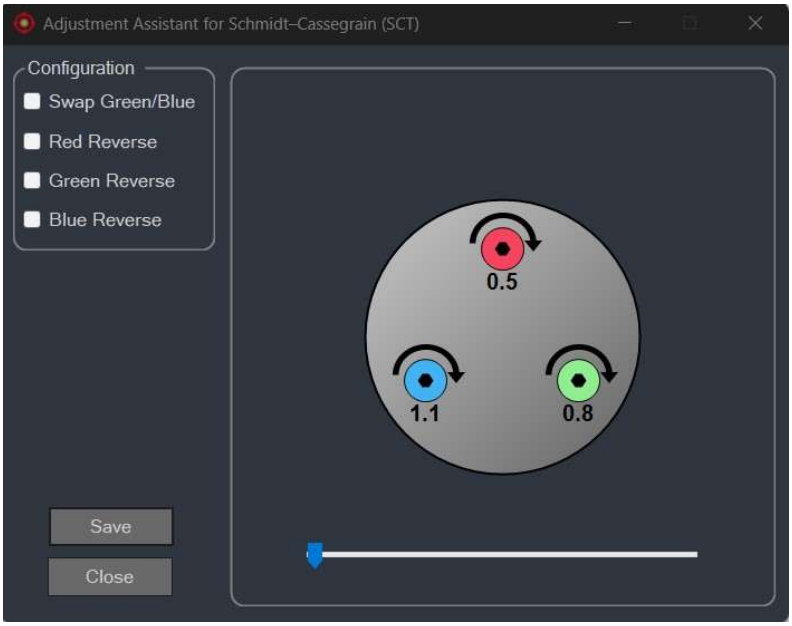
SkyCal accommodates these variations through flexible options that let you align each on-screen indicator with the actual orientation of your telescope's adjustment screws. Once configured, the Adjustment Assistant will provide consistent and accurate guidance for all future collimation sessions.

💡 Tip: After first configuring your setup, it is recommended to verify each adjustment direction with a small test movement of one screw. This confirms that the on-screen arrows correspond correctly to your optical orientation. Once confirmed, no further mapping changes are required unless the camera or diagonal orientation is altered.

Setup Overview

To configure the Adjustment Assistant, open the **Adjust Assist** menu item from the main toolbar. You will see a diagram representing three collimation screws color coded to match associated Tri-Bahtinov regions:

1. With the Tri-Bahtinov mask in place and correctly aligned to the adjustment screws, identify the red channel adjustment screw by covering each Tri-Bahtinov section in turn. When covered the set of lines associated with that adjustment screw will be reduced in brightness. Use the slider (lower right) adjust its position so the red channel adjustment matched the identified telescope adjustment screw.
2. Identify the blue and green channel adjustment screws and, if necessary, select the Swap Green/Blue check box.
3. Verify the correct direction of the suggested adjustment arrows shown on screen matches the actual movement observed in the diffraction pattern If the movement appears reversed, toggle the **Reverse Direction** checkbox for that screw.
4. When the configuration is complete, click Save.



Adjustment Assistant

8. A Recommended Collimation Workflow for SCTs

With the Tri-Bahtinov image displayed in **SkyCal** and the **Adjustment Assistant** correctly configured and visible:

1. **Fine-Tune Focus**
   Adjust the telescope's focuser until the **RED** channel error value shown in the Adjustment Assistant is as close to **0.0** as possible. This represents optimal focus for the central diffraction pattern.

   When focusing, always **finish by turning the focuser in the direction that pushes the primary mirror outward** (away from the back of the telescope). This ensures the mirror is pressed firmly against the focus mechanism and minimizes mirror shift when taking subsequent exposures.

2. **Selecting Collimation Screws**
   Compare the **BLUE** and **GREEN** channel error values. Identify the screw corresponding to the channel with the **largest offset** and adjust it in the **direction of the on-screen arrow**.

   ⚠️ While making this adjustment, apply smaller compensating movements to the remaining screws to maintain mechanical balance, and always following the telescope manufacturer's collimation recommendations.

3. **Iterate and Refine**
   Repeat steps **1** and **2**, making small, gradual adjustments each time. Continue until all three channel error values converge near zero, indicating that the secondary mirror is in **critical collimation**.

   💡 Tip: For best results, perform collimation when the telescope has fully reached thermal equilibrium and seeing conditions are steady. Even minor tube currents or poor seeing can cause the diffraction lines to shift slightly between exposures.

8.1 Collimation Best Practices

Accurate collimation depends on observing conditions and preparation. Following these best practices will help ensure that SkyCal provides reliable and repeatable results.

Thermal and Mechanical Stability

- **Allow the telescope to thermally stabilize** before collimation. Uneven cooling can cause tube currents and temporary optical distortions.
- Ensure that **dew heaters**, **fans**, and **mirror locks** (if equipped) are operating correctly and that the telescope is in its normal imaging configuration.

- Always **finish focusing by pushing the primary mirror outward**, to seat the mirror firmly against the focuser mechanism and reduce mirror shift.

Star Selection

- Choose a **bright, isolated star** near the **zenith** or close to your intended imaging target.
- Avoid stars low on the horizon, as atmospheric dispersion and seeing effects can distort the Bahtinov pattern.
- If the pattern appears faint, increase the exposure time or gain until all three diffraction line sets are clearly visible.

Environmental Conditions

- Collimate only when **seeing is steady** and stars appear sharp, not "boiling." Poor seeing can cause line motion that mimics alignment errors.
- Avoid windy conditions or setups where vibration can affect the diffraction pattern.
- Perform collimation in **dark-sky conditions** or at least with minimal stray light on the corrector plate.

Imaging and Software Tips

- Keep **exposure duration** short enough that the star's diffraction pattern is not overexposed, but long enough to display clean, well-defined spikes.
- Aim to keep the diffraction spikes as sharp and narrow as possible to improve **SkyCal** accuracy.

💡 Tip: Re-check collimation **periodically**, especially after significant telescope movement or optical cleaning.

💡 Tip: A well-collimated SCT should show diffraction spikes that remain symmetrical even when focus is moved slightly inward or outward. Minor deviations are normal, but large shifts suggest mechanical play or uneven screw tension.

9. Troubleshooting

Even with proper setup, small configuration differences between telescope systems can lead to apparent inconsistencies in the Adjustment Assistant or difficulty bringing all three channels into alignment. The following points may help diagnose and correct these issues.

1. Channel Arrows Point in the Wrong Direction

If the adjustment arrow for a channel causes the error value to **increase** instead of decrease:

- Locate the corresponding screw and enable **Reverse Direction** for that channel.
- Re-test by making a small adjustment and confirming that the arrow direction now results in a reduced error value.

ℹ Note: Image inversion from camera flips, or mirror-image optical paths are the most common causes of reversed directions.

2. Diffraction Lines Appear Distorted or Unstable

If the Bahtinov pattern looks uneven or the lines appear to "wobble":

- Verify that the telescope has reached **thermal equilibrium**. Internal air currents can distort the diffraction pattern.
- Check for **atmospheric seeing** variations—shorter exposures may help average out fluctuations.
- Confirm that focus exposure times and gain settings are sufficient to produce clean diffraction spikes.

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10. Contact & Support

For support, visit Github: https://github.com/insertnamehere1/Bahtinov-Collimator/issues

Discussion: https://www.cloudynights.com/topic/878820-bahtinov-and-tri-bahtinov-focuscollimation-software/

Appendix A: Version History / Changelog

Version 2.1 (December 2025): Updated release.

Version 2.0 (October 2025): Updated release.

Version 1.0 (September 2024): Initial release.