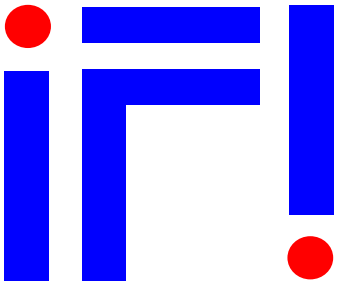
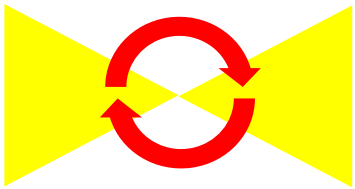




SharpLock

Manual

Version 4.0.0.1*

(Revision A)

- Screenshots and some references may relate to the version 4.0.0.0

1) **Introduction and Basic Concepts**

Thank you for choosing Innovations Foresight products.
This manual is about *SharpLock* version 4.0.0.1 and it requires MaxIm DL (version 4.6 or higher) and the ASCOM platform 6.1, or higher. Please read carefully this manual before installing and operating *SharpLock*. Take a special care on the calibration and associated topics. Also take your time to become familiar with the concepts and basic operations. In this manual we assume that the reader is knowledgeable on MaxIm Dl software application, especially the auto-guiding aspect.

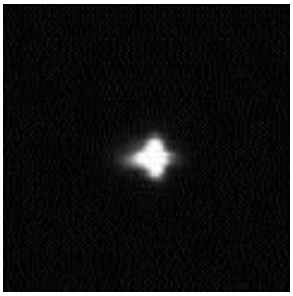
SharpLock is a patent pending technology, based on the ONAG® solutions, from Innovations Foresight for doing auto-focus in real time while auto-guiding. The guide star image is used to assess the focus and to provide information for moving the focuser in real time, keeping the scope at its best focus, frame after frame.
This *SharpLock* software requires an on axis guider ONAG® and MaxIm DL software from Diffraction Limited, as well as an ASCOM compliant focuser. In this document we assume that the reader is knowledgeable about the ONAG®, MaxIm DL, and auto-guiding operations.
Since *SharpLock* monitors the guide star to decide the direction and range of focuser motion it is necessary that your imager camera is at best focus when performing the *SharpLock* calibration.
Both imager and guider camera relationships (ONAG® connections + guider focuser position) should remain constant after calibration. If there is any change in both optical paths (imager or guider) a new *SharpLock* calibration is required.
This *SharpLock* software version supports filter wheels. However MaxIm DL "Autosave" operation does not support real time external software filter management. Parafocal filters are recommended when possible. Filter offsets, if any, should remain below +/-200 microns. We recommend you use the widest band filter (such as the luminance) for the initial calibration.

SharpLock uses the guide star roundness for auto-focus operation. If you own an ONAG® XT with an astigmatism corrector plate (tilted window) inside the guider focuser drawtube you will have to rotate it, either clockwise or anti-clockwise, in order to create some guide star astigmatism.
First remove any guider camera and/or attached equipment from the ONAG® guider port (GP), then unscrew the 2 or 3 retaining white nylon screws to free the drawtube (See ONAG user manual). Now rotate it by +/- 45 degrees until the next set of drawtube grooves are aligned with the nylon screws. If more astigmatism is needed the drawtube can be rotated by as much as +/- 90 degrees. However more rotation up to +/-180 degrees will bring the corrector eventually back to its nominal position for astigmatism correction and therefore will defeat the purpose of the rotation.
Finally screw back the 2 or 3 nylon screws, tight them until the guider drawtube can move freely, but cannot be removed anymore.
Some early versions of the ONAG® XT do not have extra drawtube grooves. Yet you can rotate the drawtube, as above, but remember that there is no retaining nylon screw engaged in any groove anymore, therefore <u>be careful with the guider focuser operation since the drawtube can come off when the stainless steel guider focuser screw is not tighten!</u>

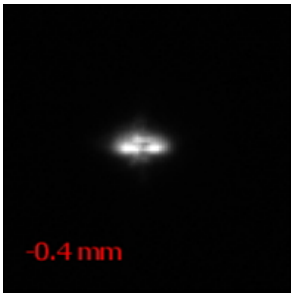
SharpLock requires an initial calibration for learning your guider camera reference frame (guider chip coordinate angle), focuser behavior (system gain Ks, in % per step), as well as reference guide star roundness at best focus.
The shape of the guide star seen through the ONAG® beam splitter is used to assess the focus position and to decide in which direction the focuser needs to be moved (in or out). The star roundness (RDN) is the key figure of merit.
There are two types of RDN, the absolute ARDN and the relative RRDN.
The former is always a positive number and it used for calibration purpose.
The later is a signed number carrying directional information (+/-) and it is used for the real time auto-focus operation. Both RDN values are expressed in %. The ARDN is independent of the guider coordinate system versus the ONAG axes relationship (ONAG's body), or angle of rotation. In other words, any guider camera rotation does not change the ARDN value.

On the other hand the RRDN is related to the actual guider camera rotation angle and must be calibrated for retrieving this angle.

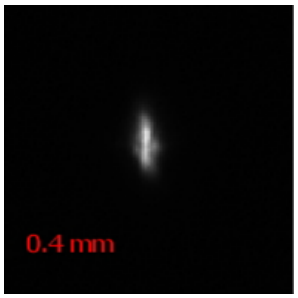
The following pictures show the guide star at 3 different focuser positions:



Guide star at best focus, ARDN = 0%, RRDN = 0%



Guide star at -400μm inward, ARDN = 50%, RRDN = -50%



Guide star at +400μm outward, ARDN = 50%, RRDN = +50%

In the above pictures the guider chip reference coordinate system is parallel to the ONAG one (squared with the ONAG's body), leading to a reference angle of zeros degree. However this is just an example and it should be understood that is not a requirement, *SharpLock* after proper calibration, can handle any guider chip coordinate system rotation. However we recommend keeping both camera reference systems close to be parallel and squared with the ONAG's

body when possible to make things easier for reasoning.

The averaging constant on the *SharpLock* auto-focus control panel defines how many guide frames are used in average for auto-focus operation and ARDN, RRDN calculations. A large averaging constant leads to a smooth but slower focus control. A short one leads to more focuser correction but may result in a more noisy operation. Either ways a focuser correction, as well as ARDN, RRDN calculations, would take place after each guide star frame downloads.
The averaging constant controls by how many step (+/-) the focuser is actually moved, not the rate of correction, which is controlled by the guider exposure time.
As a matter of fact the right figure of merit is the time constant of the auto-focus feedback loop. It can be estimated by multiplying this averaging constant by the guide star exposure + download times. The auto-focus settling time is about three time constants. Most scope focus drifts are usually a slow process (15 to 30 minutes) a minimum choice for the above time constant would be around 30 seconds, or 10 guide star frames for a 3s exposure time (10 frames x 3 seconds = 30 seconds time constant), leading to about one and a half minute settling time. However a dim guide star, poor or bad seeing conditions, may require a longer time constant, while a fast focus drift may need a shorter time constant. There is some tradeoff involved here. This is site and set-up dependant and some trial and error may be necessary. There is not one unique value which fits all and any situations. For convenience there is an indicative seeing scale provided below the averaging constant scroll bar on the GUI.
As a general rule of thumb a time constant below one minute should be avoided. Otherwise it may lead to large focuser motions and possible image shifts during the course of given imager light frame, especially with long exposures. When possible consider a 5 to 10 minutes time constant instead.

Before launching *SharpLock* you should select and track a guide star using the MaxIm DL auto-guiding feature. *SharpLock* needs the MaxIm DL guide star frames. Without any guide star frame there is neither auto-focus operation possible nor any roundness calculations. We recommend you use a 32x32 or

16x16 pixels tracking box. Select a bright enough guide star, or use long enough exposures (4s to 8s) at first, until you feel comfortable with the *SharpLock* operation. Do not saturate the guide star image.

2) System Requirements

- An ONAG®
- An imager and an guider camera (supported by Maxim DL)
- An ASCOM compliant focuser
- Maxim DL version 4.6 or higher
- Windows XP SP3 + .NET framework, or higher
- ASCOM platform 6.1, or higher

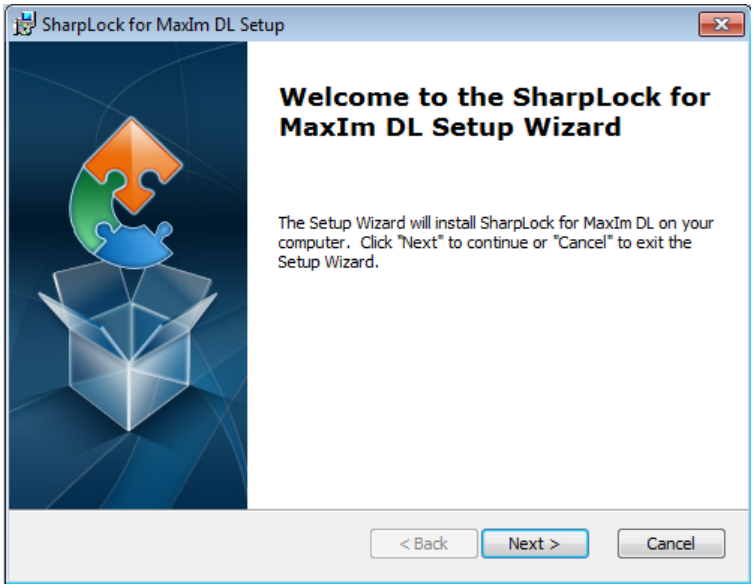
3) Installation

SharpLock is distributed through a Microsoft installer (MSI) named "SharpLock_Setup.msi".

Follow installation steps below:

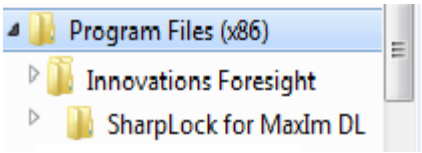
a. Copy/download "SharpLock_Setup.msi" to your hard drive (HD).

b. Run "SharpLock_Setup.msi" installer.



c. Follow the installer instructions.

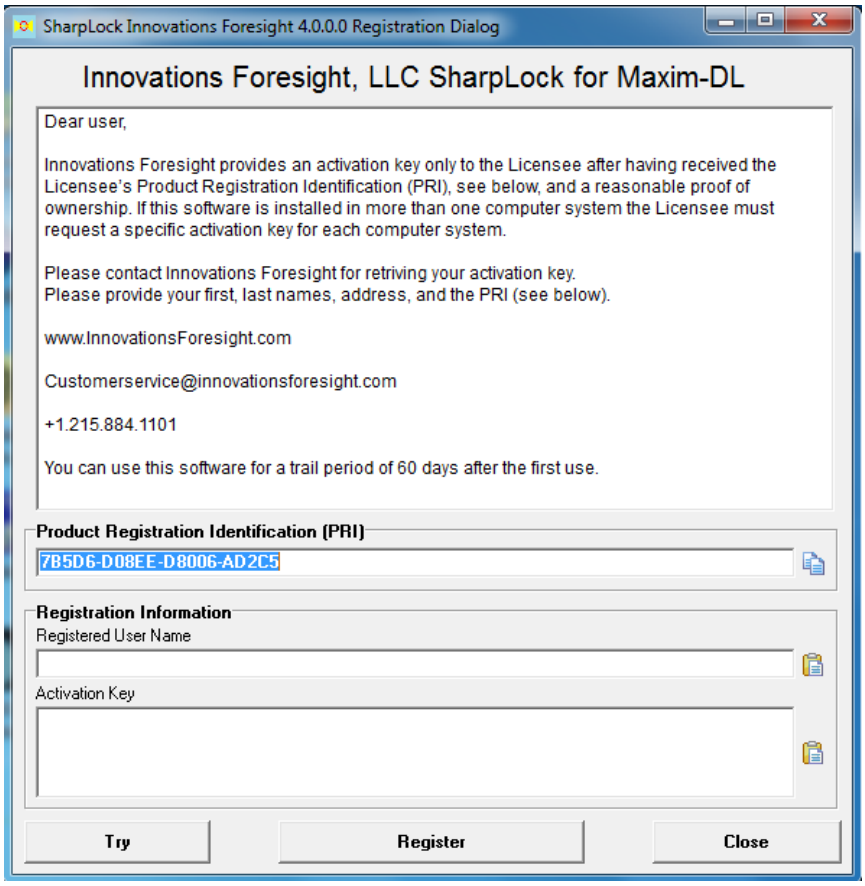
You should have the following folder structure on "C:" now:



You should have a *SharpLock* short-cut icon on your desktop.

The installation is now completed.
You need to launch MaxIm DL first before launching *SharpLock* and connect an imager and a guider camera (you could use MaxIm DL camera simulators for testing without any hardware).

SharpLock requires an activation key, which is related to the computer system where it has been installed. However the software can be used without any restriction for a 60 days trail period.
If the software would be installed in more than on computer system, or if the computer system on which it is installed has changed, a new and unique activation key must be used for each computer system.
Until *SharpLock* has been activated the following registration dialog window will appear every time the software is launched:



The "Try" button will run *SharpLock* without any restriction during the 60 days trail period.

Innovations Foresight provides an activation key only to the legitimal Licensee under the software license agrement after having received the Licensee's Product Registration Identification (PRI), in this above example the PRI is 7B5D6-D08EE-D8006-AD2C5.

Please contact Innovations Foresight for retriving your activation key and registration information.
Please provide your first, last names, address, phone number, email, …, and the PRI (see above).

www.InnovationsForesight.com
Customerservice@innovationsforesight.com
+1.215.884.1101

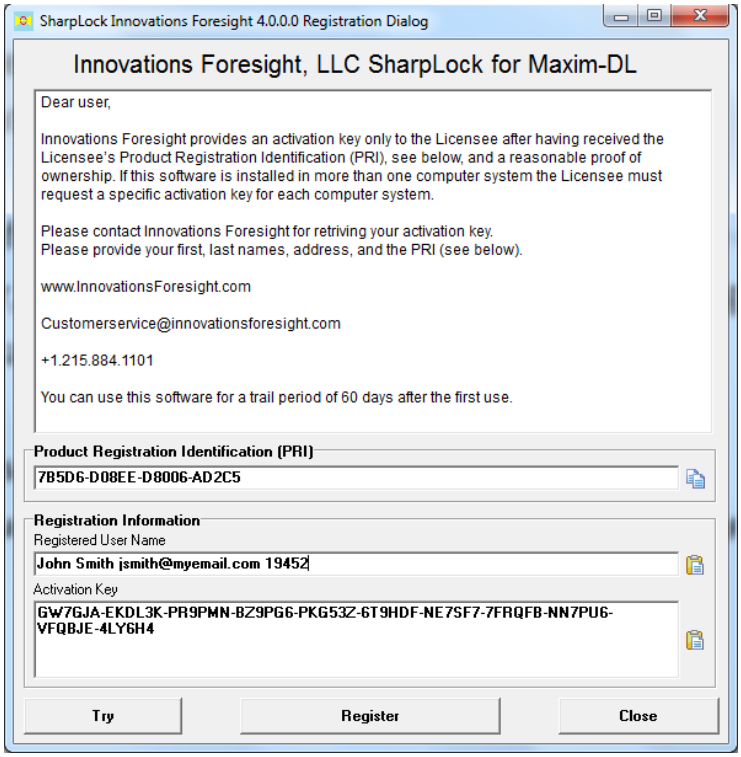
Innovations Foresight will provide you with the registration information:

- A Regsitred User Name (RUN)
- An Activation Key (AK)

Use this information exactly has provided (with space or special charatcher, if any, it is case senstive) for filling the two registration fields of the registration dialog window, as shown below:

RUN = **John Smith jsmith@myemail.com 19452**

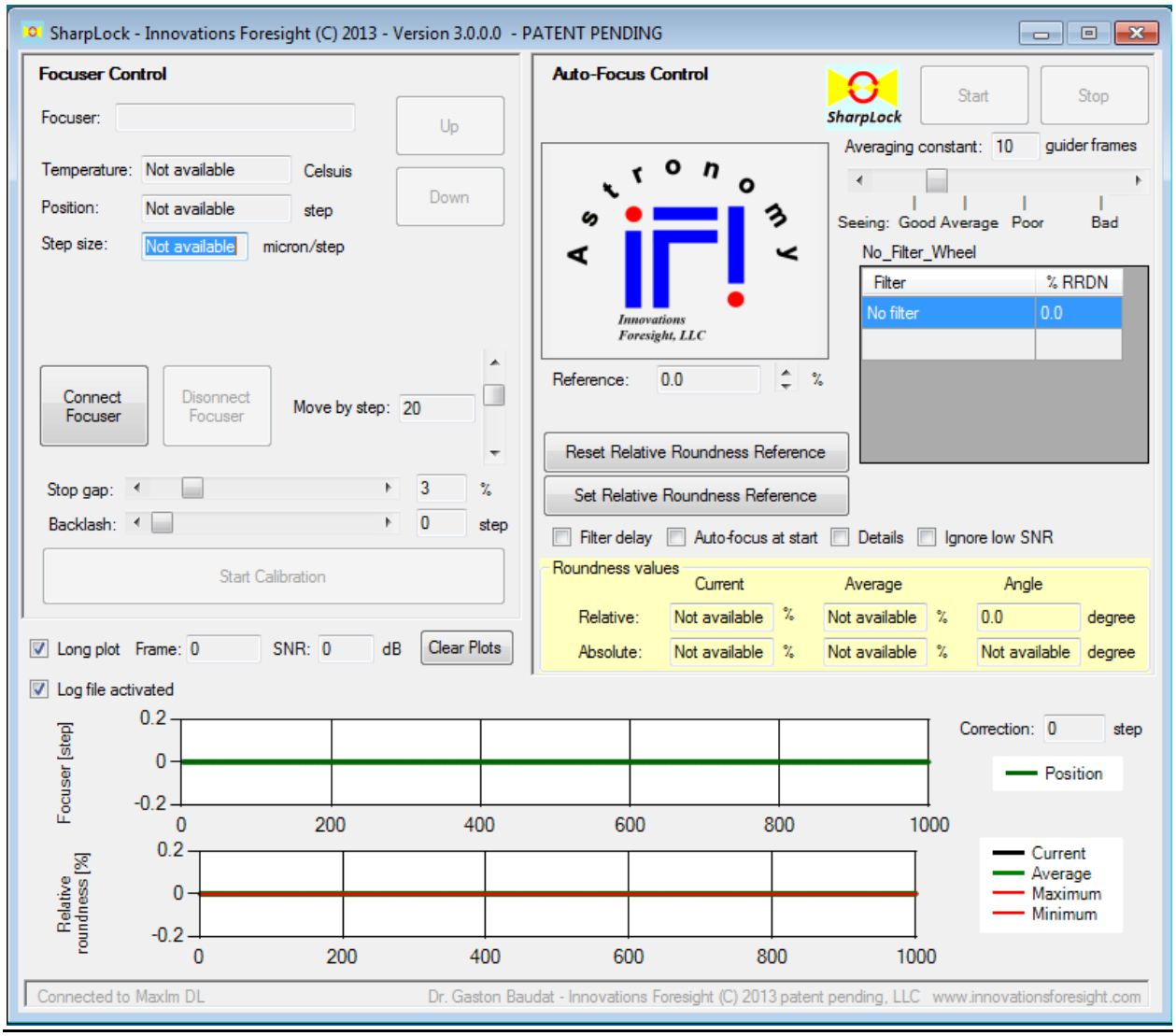
AK = **GW7GJA-EKDL3K-PR9PMN-BZ9PG6-PKG53Z-6T9HDF-NE7SF7-7FRQFB-NN7PU6-VFQBJE-4LY6H4**



Then click the “Register” button. If the information is correct and valid a pop window confirms the sucessful registartion & software activation:

Click the “OK” button to launch *SharpLock.* Now the software is activiated and the registration dialog window will not appear anymore unless the computer system where the software is installed has changed. If the activation has failed, first check that the correct provided information has been used with any space, any special character, the information is case sensive. Please contact Innovations Foresight is the activation continues to fail.

4) ***SharpLock* GUI**



The *SharpLock* graphic user interface (GUI) is made of 3 parts.
The upper left panel controls the ASCOM focuser (including the *SharpLock* calibration). The upper right panel controls the auto-focus operation the bottom panel displays the focuser position (in step) and the relative guide star roundness RRDN (in %), both are function of the latest guide star frame numbers (horizontal axis).

5) Starting *SharpLock* and MaxIm DL Connection

BEFORE starting *SharpLock* launch MaxIm DL, connect both imager and guider cameras and insure proper focus of both cameras.
With the imager camera at best focus the guider camera should be set such the guide star shape looks like the first picture on section 1 of this manual, a symmetric compact cross. Some optical systems, depending of your scope specification, may not show a cross, just a circle, or even a "donuts" (secondary mirror obstruction), in this case settle for the smallest/most compact star shape as possible (try to keep the star shape as symmetrical as possible).
Remember that if your ONAG® is equipped with an astigmatism corrector you have either to remove the corrector or rotate the guider drawtube as explained in section 1 (ONAG® XT).
See the ONAG® user manual for further information on how to bring both cameras at focus.
Now you should select and track a guide star using the MaxIm DL auto-guiding feature. *SharpLock* uses the MaxIm DL guide star frames. Without any guide star frame there is neither auto-focus operation possible nor any roundness calculations. We recommend a guide star exposure of at least 2 seconds.
After a MaxIm DL auto-guiding operation has been established and the related tracking is steady and stable you can launch now *SharpLock* by a double click on its icon. It should connect with MaxIm DL, this can be confirmed by looking at the status panel on the lower left side of the GUI.
SharpLock will start to report ARDN, RRDN values and it will display focuser position (if connected) and RRDN plots. If no calibration data is available the "Start" and "Stop" auto-focus button are disabled. They will be enabled after the first calibration has been successfully performed.

6) Focuser Connection and Operation

Before you can connect your focuser to *SharpLock* be sure it is not currently used by another software, such as MaxIm DL. If so please disconnect it first.

To connect your ASCOM compliant focuser for the first time click on the "Connect Focuser" button, this launches the ASCOM chooser. Select your focuser and its settings, and then close the chooser by clicking its OK button. If you have already connected this focuser to *SharpLock* once before, it has been remembered and it will be reconnected automatically every time you launch *SharpLock.* If your focuser driver does not report the focuser step size value you will be prompted to input it manually. *SharpLock* uses it for calibration purpose only, although it is recommended the calibration can be performed without the step size value. If you do not know your focuser step size just discard the request since it is not necessary for *SharpLock* operations. You can disconnect the focuser by clicking on the "Disconnect Focuser" button. *SharpLock* supports relative and absolute focusers. In the relative mode, there is a focuser position reset button available for user convenience, it does not play any role in the auto-focus operation.
The focuser control panel also displays the focuser temperature information when available. The "Up" and "Down" buttons are used to move the focuser outward, or inward by a step amount specified by the "Move by step" value, which can be set between 1 and 50 steps using the associated scroll bar (default is 20 steps).

The "Stop gap" and "Backlash" options are useful to deal with focuser backlash and play, if any. If your focuser already have a backlash compensation capability we recommend you use it. The maximum *SharpLock* "backlash" value is 500 steps, if you need more steps set this value to zero and use your focuser backlash compensation instead. You still should use the "Stop gap" option.
The "Stop gap" provides a hysteresis and avoids recurrent, unnecessary focuser motions due to guide star noise, such as seeing, or focuser backlash. The default gap is set to 3%, which means there is no focus correction in a +/- 3% RRDN band. If your focuser backlash is minimum and not a concern we recommend keeping this value. Under good seeing conditions you could decrease it.
On the other hand, if you need to use the "Backlash" compensation option,

which is set to zero by default, you may have to increase the "Stop gap" value (around 5%). Start with 3% and increase if necessary only.
The "Backlash" focuser value (in step) should be set such it will offset most of your focuser backlash, but not too much otherwise this leads to unnecessary "bumpy" focuser corrections. A trial and error approach may be needed to find the right value. If you already have done this before, just plug-in the known step value. Otherwise to guess this value the basic procedure calls for moving the focuser inward or outward (using the "Up" and "Down" buttons) while looking at any long term changes on the ARDN (average value). We suggest you take the necessary time to find out the right backlash value, if any, for your focuser before you perform the *SharpLock* calibration procedure.

7) Calibration Procedure

SharpLock requires a proper calibration before it can be used for real time auto-focus operation. This is an important step that should be done with as much care as possible, take your time. The calibration is done once, unless you have changed your set-up (cameras, scope, optical path lengths, focal reducer, scope collimation…). The calibration is made of two parts which are done in succession:

- The first part is looking for your guider camera coordinate system relationship with the ONAG's body (RRDN angle), as well as the direction and amplitude of RRDN value changes relative to your focuser motion (system gain Ks in %/step).

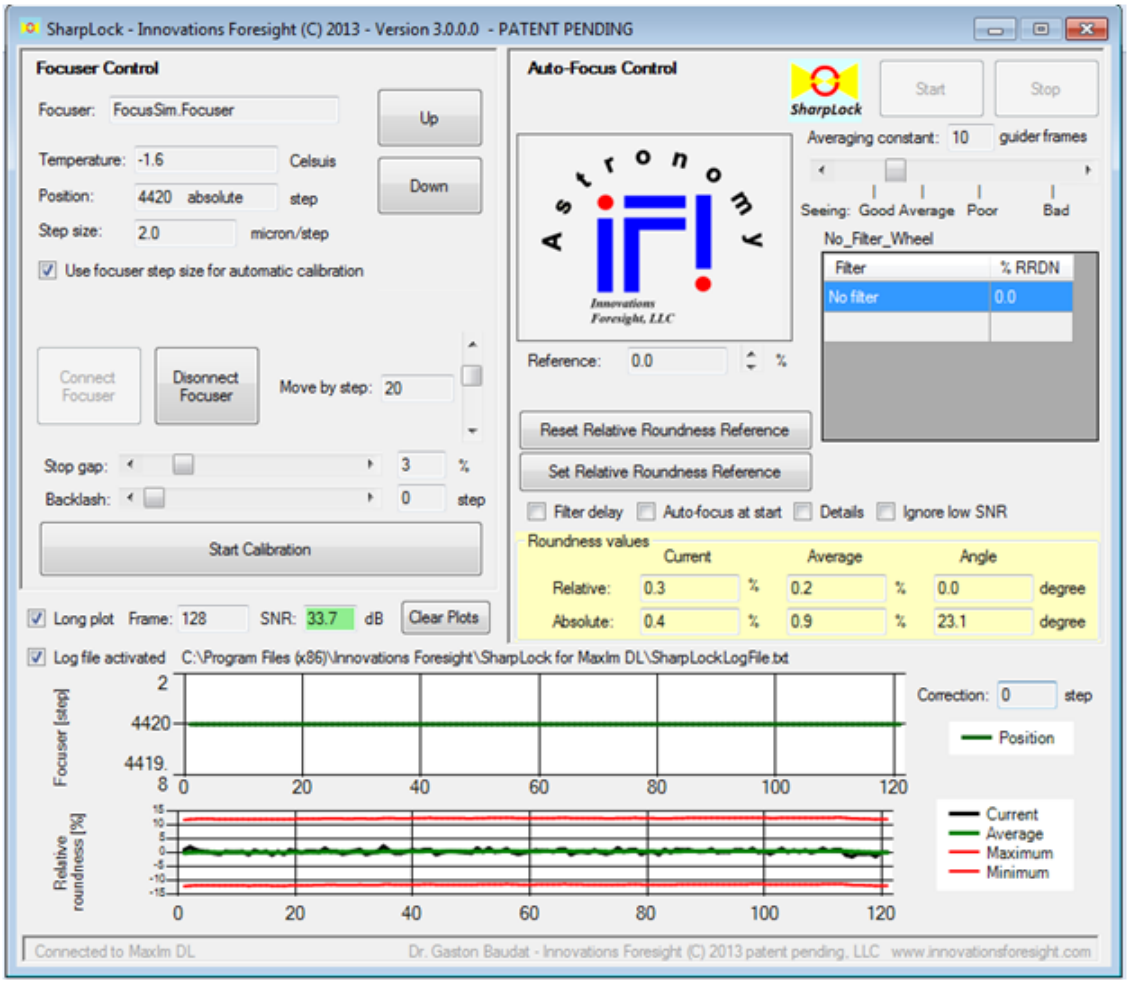
- The second part is about the reference RRDN value for which your imager camera is at its best focus with the reference filter, if any.

When possible the calibration procedure should be done under good seeing conditions. Also you should have set your ONAG® and optical layout such both cameras can reach focus simultaneously (see ONAG® user manual for further information).

Be sure you have a good, smooth and stable mount tracking operation while auto-guiding with MaxIm DL. If you use a filter wheel with a monochrome camera, select the luminance (IR blocking) filter, or at least the widest band filter for the reference (do not use any empty filter slot), here we assumed your filters are para-focal, therefore RGB and other narrow band filters will be eventually in focus after calibration with the luminance filter. If not see the filter wheel operation section below. We do recommend using para-focal filters when possible. Focuser backlash should be taken care of using, either your focuser backlash compensation capability, or the *SharpLock* "Backlash" option (see section 6).
If the backlash is in the range of +/-20 microns or less you would probably be better off to ignore it, at least at that stage.

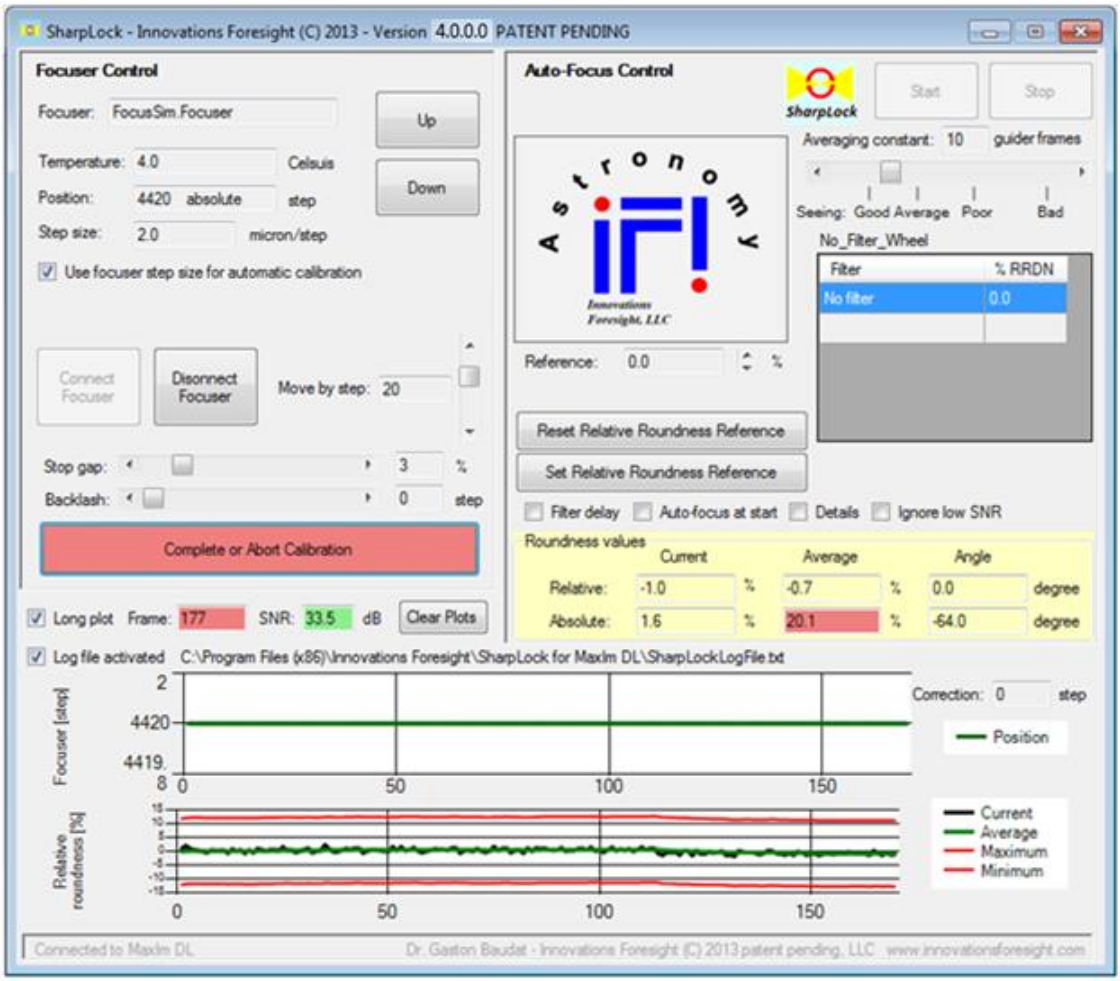
When ready start MaxIm DL and search for a bright star near the zenith, or at least high enough above the horizon to minimize atmospheric distortions. Use at least a 2s guider camera exposure time and if possible not longer than 6s. Approximately center it on your imager and guider cameras (use the ONAG® X/Y stage if necessary), do not clip the images.
Settle for about the half to two third of your camera signal level (at least 32,767 for 16 bits AD converter, and 127 for a 8 bits one). This should give you a good SNR without any pixel saturation. If your guider camera exhibits hot pixels, or fixed pattern noise (FPN), we suggest you create a reference dark frame and you subtract it to every guide star frames (see MaxIm DL operation and manual for further information). We recommend using a 32x32 pixels tracking box during calibration. And maybe more if you have significant drift due to mount polar misalignment.
After a MaxIm DL auto-guiding operation has been established and the related tracking is steady and stable (look at MaxIm DL tracking error graph) launch *SharpLock*. Connect your focuser if this has not been done once before (see section 6). Set the auto-focus control averaging constant to 10 (default), the "Stop gap" value to 3%, the "Backlash" value to zero, and watch the RRDN plot. Wait about 10 guide star frames and check that the RRDN average plot is not too noisy (green line). There are two red lines, one for the maximum and one

for the minimum RRDN values. Those define the RRDN confidence interval. RRDN values outside those limits are ignored for auto-focus operation, like wise any RRDN values inside the "Stop gap" (see focuser operation in section 6). The average RRDN line should be well inside the confidence interval. Also watch for the reported SNR value (just below the plot panel on the upper left corner), it should be at or above 20 dB, as seen below:



Your ARDN (as well as RRDN) value may be offset, this is acceptable as long as it is not more than 10%, we recommend 3%, or less, since values above 5% may negatively impact auto-focus operation under marginal seeing. If too large consider refocusing your guider camera. By default, without any calibration data, *SharpLock* assumed that your guider camera coordinate system angle is 0 degrees (see "Relative roundness" angle on the auto-focus control panel). This

value will be set eventually to your actual guider camera set-up, using the ARDN angle, after a successful calibration. The ARDN angle is likely to be noisy at this time since the guider camera is close to its best focus. The guide star profile becomes quite symmetrical leading to noisy angle estimation, which is normal and expected. The calibration process requires some motion of the focuser for changing the ARDN (making the guide star elongated) in order to retrieve the guider camera angle and system gain (Ks). Now click on "Start Calibration" button, after review the check list and confirming your choice you should get a GUI looking like below:



The "Frame" counter, ARDN "Average" value, as well as the "Complete or Abort Calibration" button should be in red. They will remain so until you have increased the ARDN by at least +20% above current value[1], and have acquired

at least 20 guide frames. Please don't be afraid to use more frames, those requirements are minimums only, again take your time such the system can settle after each focuser moves.
Notice: Your initial ARDN average value should be below 10%, we recommend 3%, or less. If it is too large consider refocusing your guider camera. Wait for good enough seeing and take your time.
Using the "Up" or "Down" focuser button move the focuser to change the ARDN average value by about +20% to +30% (above the current one).
If the ARDN value decreases then reverse the focuser directions. This is an important, failure to do so may result on poor calibration data and an unstable auto-focus operation. Do this by about 20 steps (assuming a 2 microns step focuser) at the time, or so, while monitoring the ARDN plot during the course of at least 10 guide star frames each time. When the ARDN has increased enough and it is steady you should see an elongated guide star on the MaxIm DL tracking box, like seen on section 1, but likely less extreme. The look and direction of the star elongation is a function of your set-up.
To continue click on the "Complete or Abort Calibration" button, confirm your choice, and if you want to bring the focuser back to its initial position (which would be the normal operation). If the above calibration minimum requirements have not been met you will see a pop window warning you that the calibration cannot be completed and that it will be aborted instead. You can restart a calibration at any time as soon as your focuser is back at its initial position.

At that stage *SharpLock* has the necessary guider camera and focuser calibration data. The next step is about setting the exact RRDN value associated with your imager camera best focus with the reference filter, if any (the same used for calibration).

1: For instance if the current AARDN value is 3% the targeted AARDN would be 23%

With the ONAG® it is likely that when your imager camera is indeed at its best focus the guider camera may report some non zero ARDN and RRDN (with proper sign), which is a normal and expected behavior. As stated above ideally you want that ARDN average value (when your imager camera is at its best focus) at or below 3%, since larger values may impact operations under marginal seeing.

Using the "Up" and "Down" focuser buttons carefully bring your imager camera to its best focus (adjust the "Move by step" value if necessary). Take your time for this fine focus operation using any tool you are comfortable with, such as a focusing mask, or MaxIm DL focus information (focus by the number: FWHM, HFD). Alternatively you could disconnect your focuser from *SharpLock* control and use an auto-focus software for this task as well. Remember to reconnect your focuser when done.

When ready restart auto-guiding, if needed, and wait 10 guide star exposures to be sure the RRDN is stable and steady, then click on the "Set Relative Roundness Reference" button on the auto-focus control panel. This will use the current RRDN average value as the reference for auto-focus operation. Should you use a filter wheel the current filter reference (%RRDN) will be updated accordingly in the filter list box (highlighted in blue).

From now on all the RRDN values reported, including in the plots, are offset by the reference one. Therefore your RRDN average value should be close to zero now. Watch the RRDN plot for some guide star frames to confirm this. You can reset the RRDN reference value (set it to zero) by click on the "Reset Relative Roundness Reference" button any time you want to do a new reference focus. **Be careful to reset it before any new focus calibration, otherwise your next RRDN reference values will be wrong due to the previous non zero value.**

The current RRDN reference value is displayed under the "reference" box on the auto-focus control panel. For convenience and fine tuning it can be changed manually, by using the up and down scroll button located just at its right.

It is expected that if you do not change your guider and imager optical paths, or your filters backfocus specification, you should be able to keep the current RRDN reference value on future imaging sessions for a long time. This is a

handy feature which avoids refocusing your scope every time. Just acquire your target, select a guide star, start the auto-guiding, and when stable launch *SharpLock*. The auto-focus operation will bring your imager at its best focus as soon as the RRDN value is back to zero (this may take some guider frames and auto-focus correction cycles). Should you need to calibrate again your focus, reset the reference RRDN value and restart the focusing part of this calibration process. The guider camera angle and focuser gain (Ks) should be recalibrated only if you have changed, or rotated the guider camera, or any optical elements, (such the scope, collimation, of FR …) in your set-up. When done with this overall calibration process we recommend you do some imaging tests to confirm the proper operation and validity of your calibration. Especially if this is the first time you use *SharpLock,* or you operate a new set-up.

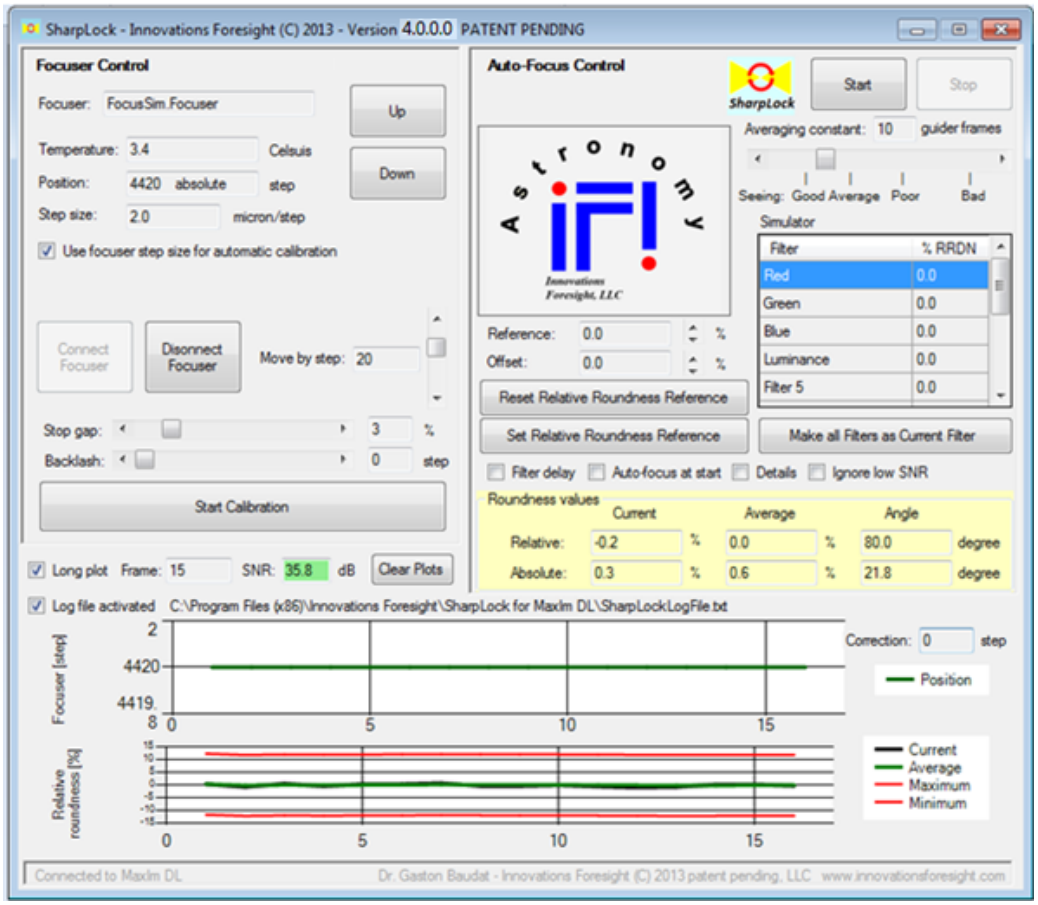
8) **Calibration check list**

-1- Calibration should be done in relative good seeing conditions when possible.
-2- Consider an averaging constant of at least 12 frames or more, especially if the seeing is less than optimal.
-3- Calibration requires moving the focuser for increasing the average absolute roundness (AARDN) by at least 20%.
-4- Calibration requires at least 25 guider camera frames to insure good AARDN estimations. Take your time.
-5- Use a bright star near the zenith.
-6- If you use a filter wheel select the wider band filter, such as luminance.
-7- Center the star on the imaging and guiding camera chips.
-8- Imaging and guiding cameras should be at best focus.
-9- Adjust the guider camera exposure time for good SNR, yet stay below the chip saturation level.
10- Wait several guider frames and check that the AARDN is below 10%, we recommend below 3%.
-11- Then move the focus using the Up, or Down, buttons. Move by about 20 microns at a time.
-12- Wait several guider frames and watch the average AARDN values.
-13- **If the AARDN decreases, then reverse focuser motion (very important)!**

-14- Continue by successive focuser moves (about 20 microns each) in the direction of increasing AARDN.
-15- Wait several frames after each move to allow for a good AARDN and angle estimations.
-16- When the AARDN is at least 20% higher than its initial value, click on the "Complete or Abort Calibration" button if not in red.
-17- When the calibration has been completed successfully do an auto-guiding with autofocus test.

9) Filter wheel operation

If you have a filter wheel connected to Maxim-DL the GUI would look like this:



If your filters are para-focal with the reference filter used for the above calibration (luminance here), simply click on the on "Make all Filters as Current

Filter" button. This is the preferred and recommended procedure.
The reference filter must be selected in Maxim-DL before doing so, we recommend you use the visible widest band filter as the reference filter (such as luminance). If you filters are not close to be parafocal, select with Maxim-DL one filter at the time, check that your imager is indeed at best focus with this filter. The filter list box should highlight the current filter section, and it %RRDN should be zero (at that stage of filter calibrations only the reference filter may have a non zero value).
After some guide frames the *SharpLock* reference value will reflect the current filter effect. Wait about 10 guide star frames and check that the relative roundness is stable for this filter, then click on the "Set Relative Roundness Reference" button the same way you did for the reference filter. The filter list box will be updated accordingly.
When all filters have been calibrated, your filter list box will show all filters reference values (%RRDN), with proper signs. Those values are saved from session to session when you will close *SharpLock*. Like for the reference filter you could change them at any time.
For convenience there is a new option named "Offset" available when a filter wheel is connected.
This offset parameter, just below the reference parameter, is used to offset all the filter reference values by the same amount without changing the filter list values. This option, set at zero by default, is useful if you have had a permanent focus shift between both cameras affecting every filter the same way.

10) Using *SharpLock* Real Time Auto-Focus

This section describes the normal *SharpLock* real time auto-focus operation. It is assumed that you have done a full calibration and read this manual, as well as your scope is close to its best focus.

Launch Maxim DL, acquire your target, select a guide star, and start the MaxIm DL auto-guiding operation (use a 32x32 or 16x16 pixel tracking box).

When the tracking is stable (watch the MaxIm DL tracking error plot), launch *SharpLock*.
Connect your focuser, if needed, and then watch the RRDN plot. We suggest acquiring 8 to 10 guider frames for good RRDN statistics. If you have a filter wheel connected to Maxim-DL the current filter reference value will be automatically used (highlighted in blue in the filter list box).
However for Maxim-DL versions 6.07, or sooner, the imager camera expose "Autosave" operation does not report which filter is in use. Therefore *SharpLock* will just use the latest one selected previously. This is not a problem for the Maxim-DL versions after 6.07 or with filters close to be parafocal. In practice filter reference value differences below +/-15% do not have any significant effects, especially if the reference filter was the luminance filter (or widest band) and its relative roundness reference value was inside the recommended +/-3% range.
Also third party software applications using Maxim-DL, such as CCD Autopilot, ACP, do not have this limitation since they do not use the Maxim-DL native "Autosave" operation, they control the whole process.
In general, when filter are para-focal or close to be, we do recommend using the "Make all Filters as Current Filter" option, using the visible widest filter as the reference, and keeping its reference value inside +/-3% range.
When ready to use *SharpLock* auto-focus operation click on the "Start" button on the *SharpLock* auto-focus control panel. Now *SharpLock* is performing real time auto-focus, you can stop the auto-focus at any time by clicking on the "Stop" button. This would be the normal procedure when you stop auto-guiding, for slewing to another target for instance.
You can watch auto-focus correction, if any, on the focuser position plot.
If needed, depending on the seeing conditions, adjust the averaging constant using the scroll bar located below it. If your guide star is dim (large magnitude) increase the exposure time.
Monitor the SNR value reported by *SharpLock*. Although *SharpLock* will work fine with SNR average values as low as 6 dB or less, assuming a large enough averaging constant, auto-guiding software may have difficulties to maintain accurate tracking with too low SNR. An average SNR above 10 dB are

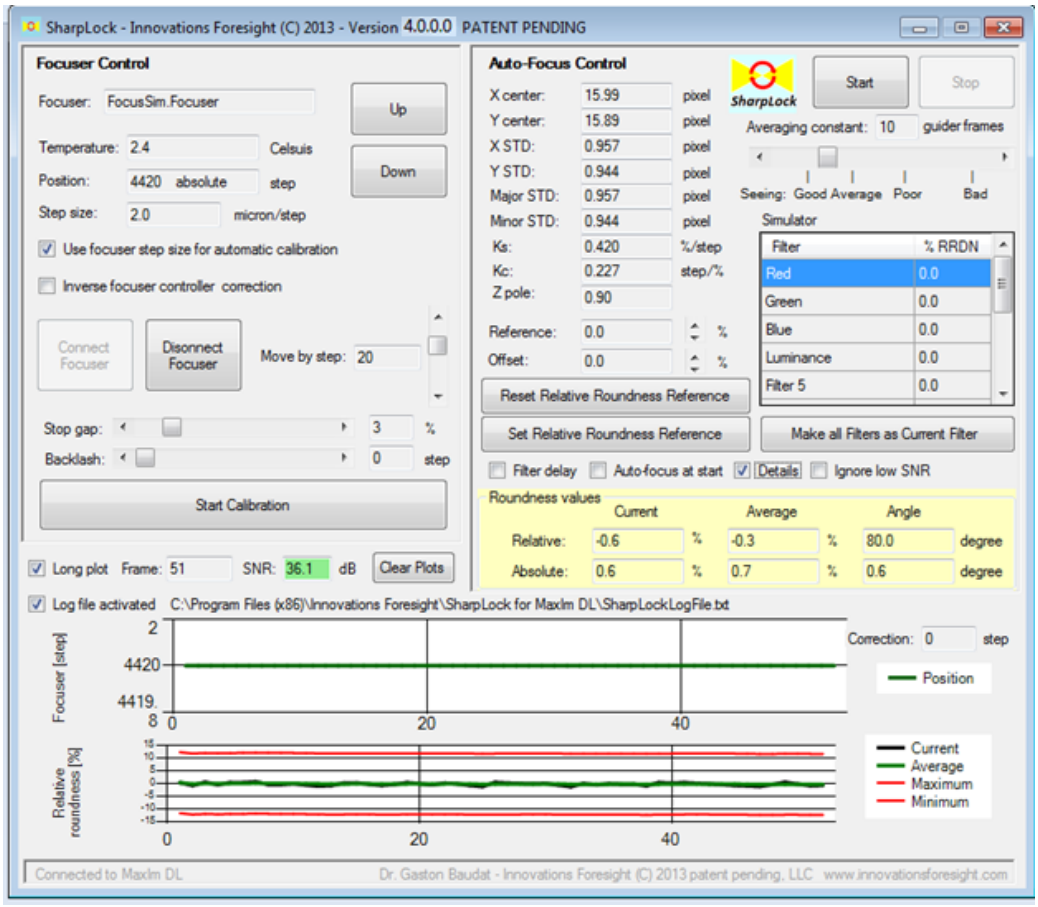
suggested for this reason.
Remember that a factor 2.5x is about one magnitude. For instance if you need a 2s exposure for 10th magnitude star, you would need about 12s exposure for a 12th magnitude star. In general we recommend using a large averaging constant (10 to 20 frames), since the scope drift from its best focus is usually a slow process.
At the end of your session, stop auto-guiding, disconnect both cameras, stop the auto focus operation, close *SharpLock,* and finally MaxIm DL.
(Disconnecting the focuser before closing *SharpLock* will prevent *SharpLock* to remember the focuser choice for the next time, this is not recommended).

It is expected that if you do not change your guider and imager optical paths, or your filter backfocus specification, you should be able to keep the current RRDN reference value for future imaging sessions for a long time.
This is a handy feature which avoids refocusing your scope every time. Just acquire your target, select a guide star, start the auto-guiding, and when stable launch *SharpLock*.
The auto-focus operation will bring your imager at its best focus as soon as the RRDN value is back to zero (this may take some guider frames and auto-focus correction cycles). If for some reason your scope focus is way off, bring it close to best focus manually first before starting the real time auto-focus operation.
On the other hand if you have changed your optical train you may have to calibrate *SharpLock* again.

11) Notes and advanced options

Should you have any issues, question, comments, advices, suggestions, …, need support feel free to contact Innovations Foresight at any time (Customerservice@innovationsforesight.com).
If for some reason *SharpLock* reports some errors, or closes unexpectedly, please write down the all error message, if any. You could use the Windows Ctrl "Print Screen" option to record and report a problem. *SharpLock* creates and maintains an activity log file, named "SharpLockLogFile.txt" and located

under the installation folder where the application has been installed. For this log file to be updated you need the "Log file activated" option checked, see on the GUI the plot panel. This is a valuable source of information for tracing and solving problems as well as optimizing your set-up. This file contains only the date, time, and *SharpLock* information, nothing more. It is in plain text format, please attached it to your email when possible. If the file becomes too large, just delete it. For further real time information there is a "Details" check box on the auto-focus control panel. If you check it you will see more technical details, as seen below:



Also there is "Long plot" check box available, when checked (the default), the plots will show 1000 guider frames instead of 100. You can clear the plots at any time by clicking on the "Clear Plots" button.

The "Filter delay" option, when checked, delays the auto-focus correction by

the averaging constant value set by the user.
The "Auto-focus at start" option, when checked, starts auto-focus operation after *SharpLock* has been launched. It will work only if there is a focuser connected and a valid calibration was achieved. This allows third party software applications, such as CCD-Autopilot, to automatically launch *SharpLock* and auto-focus operation without user intervention (remote and/or automatic operations).
The "Ignore low SNR" option, when checked, allows auto-focus operations at any guide star SNR level, even below the minimum (6dB). Use this option with care since it could lead to bad or unstable auto-focus operations, if the guide star signal level is at, or below, the image noise floor. This option is disabled by default and every time SharpLock is launched.
For providing enough samples for the creation of the initial guide star roundness statistics, any time *SharpLock* is launched there is a 10 guide frame delay before any auto-focus correction.
The "Use focuser step size of automatic calibration" option is available only if the focuser driver has reported a focuser step size value, or the user has inputted one manually. When checked the focuser calibration process will use it, this is recommended, but not necessary.
The "Inverse focuser controller correction", when checked, inverses (sign change) the correction values sent to the focuser. This option is used for some demonstrations, special set-ups, or special purposes. It is not supposed and recommended to be checked by the user. Doing so will likely make the auto-focus control system unstable.
You could use *SharpLock* for fine focusing the guider camera while watching the ARND value in order to bring it at, or below, 3%. This can be done with, or without MaxIm DL auto-guiding engaged. In this case we recommend using the largest possible track box size (128x 128x), see MaxIm DL documentation.