ONAG®

Patent Pending

Innovations Foresight

Revision 6.2

ONAG® SC and XM ON Axis Guider

User Manual

http://www.innovationsforesight.com

1. Introduction

Thank you for purchasing our patent pending on-axis guider ONAG®. Ours products have been designed and made with care to give its user the highest level of experience and satisfaction. Please take a moment to read this manual in order to get the most of your ONAG®, refer to section 11 for pictures of the ONAG® and its parts.
Please note this product was not designed, or intended by the manufacturer for use by child 12 years of age, or younger. Also please **do not look at the sun, or any bright light sources, laser, …, with your ONAG®**, even at the guider port. The ONAG® comes in several versions. The ONAG® SC uses a M42 x 0.75mm thread (T mount, or T2) system at all optical ports and it has been optimized for imaging cameras using large format APS-C chips (up to 28mm in diagonal).
The ONAG® XM supports full frame chips, such as the 24mm x 36mm format and more, up to 50mm in diagonal. It uses a dovetail system for the scope and imager optical ports, the guide port uses a T2.
All ONAG® feature a cross slide based X/Y stage as well as a helical guider focuser (the guider does not rotate) for fine focus of the guiding camera.
For more information concerning the ONAG® products and imaging camera sensor illuminations please contact or visit us at:

http://www.innovationsforesight.com/support/onag-xt-ccdcmos-chip-illumination/

Searching for suitable guide stars has never been easier thanks to the ONAG® very wide field of view (FOV) and the convenient quick set-up X/Y stage, providing an exploration circle up to 46 mm (1.8”) in diameter. This is more than 1.3 arc-degrees for a two meters focal length scope. The ONAG® guider helical focuser supports APS-C class of chips, which provides a large FOV without even moving the integrated X/Y stage, this has been designed and optimized with robotic and remote operations in mind. This offers a fully solid state operation for guiding (no part in motion, nor rotation), it is also the only multi-star guiding solution using the same scope than for imaging.
Since there is no need to rotate for searching guide stars you can now reuse your flat frames for many targets and nights.
Filters and filter wheels are placed in the imager optical path, and therefore they will not interfere with the guiding camera. Therefore even narrow band imaging will not make guide stars too dim to use anymore.

The ONAG® is made of high quality aluminum, and stainless steel material. Its optical dichroic beam splitter (DBS) is fully multi-coated and protected with a transparent layer of quartz for a long life.

The use of near infrared (NIR) for guiding decreases the effects of the Earth atmospheric turbulence (seeing) on the guide stars ("star wander" and distortion), providing usually a better tracking and SNR. The seeing effect is typically reduced at longer wavelengths making auto-guiding using the ONAG® smoother, depending of you scope aperture, local seeing, and exposure time.

Our patent pending real time auto-focus technology *SharpLock* (SL) keeps your imager at best focus all the time, without any need of any imaging interruption for periodic refocusing.

SL works with all models of the ONAG®, for further information on SL, and FocusLock (FL) software, please visit us at:

http://www.innovationsforesight.com/education/real-time-auto-focus-sharplock/

This document describes the SC and XM versions of the ONAG®. Most of the functions and concepts are the same and therefore are presented together.

2. Description

The ONAG® is composed of 7 fundamental elements (referred to ONAG® products images section 11, pages 30 and 31):

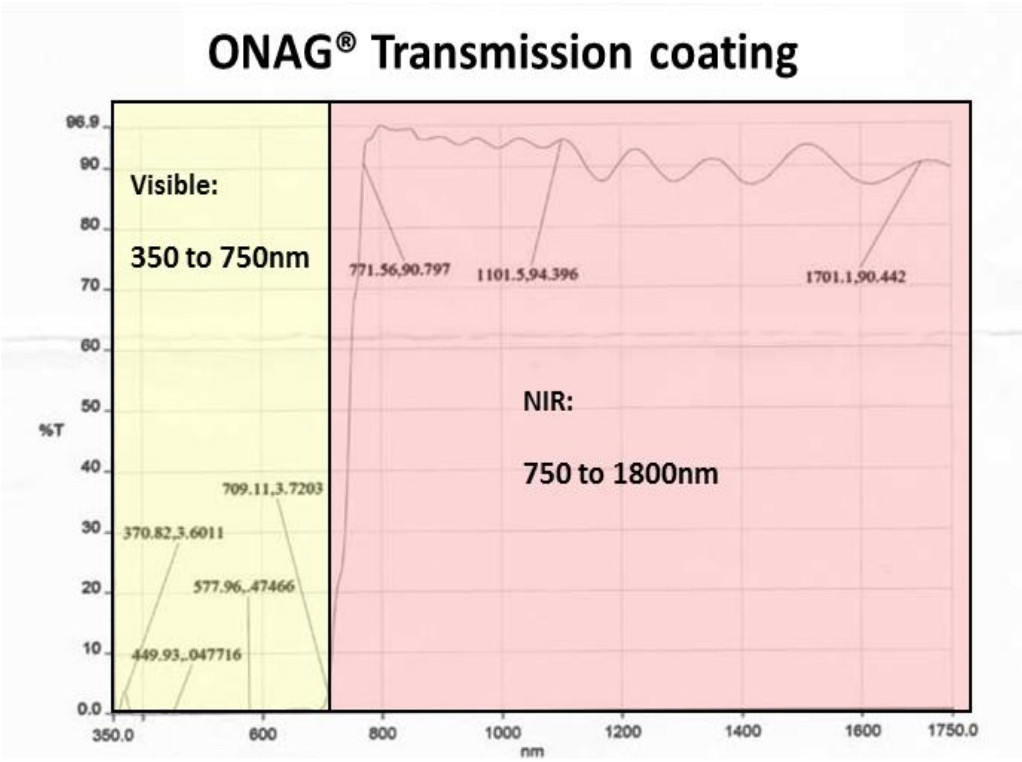
(1) A fully multicoated dichroic beam splitter (DBS), or "cold mirror".

The DBS reflects typically 98% of the visible light, from 370nm to 750nm, toward your imager which is placed at 90 degrees from the scope optical axis on top of the ONAG© body, it works like a star diagonal would do.
More than 90% of the near infrared (NIR) portion of the light, from 750nm to 1200nm, goes through the DBS to be used by your guiding camera.
Because the visible light is reflected, there is no optical refraction aberration involved here.
The guide star may look like a tight cross (with a dark center when a large scope secondary mirror obstruction is presented) since there is some astigmatism coming from the fact that the starlight traveled through the DBS sets at 45 degrees. It does not impact much popular auto-guiding software, like Maxim DL, TSX, PHD guiding…, or software using centroid algorithms to track the guide stars. The guide star half flux diameter (HFD) is essentially similar for the imaging and guiding cameras, resulting to a negligible change

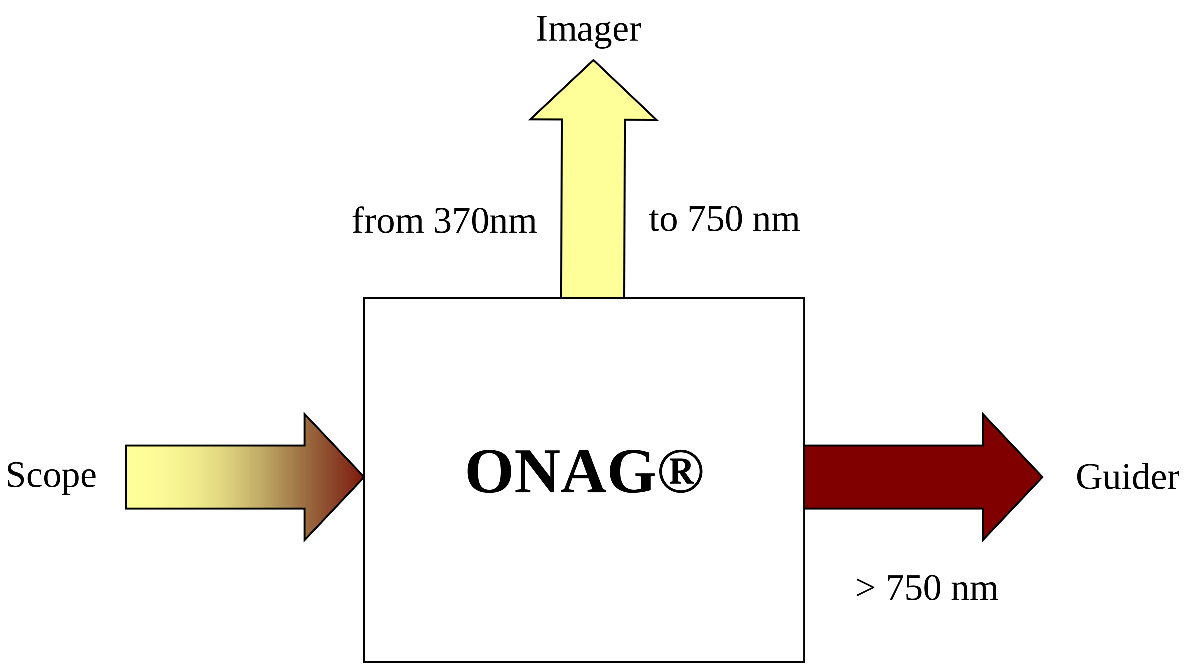
in SNR, if any.
The guide star astigmatism is a function of the scope focus position (in or out), and this information is used by our patent pending real time auto-focus SL technology and related FL software.

Using NIR for guiding usually reduces the seeing effect which in turn provides tighter guide stars and better SNR, this offsets also part of the energy drop coming from the use NIR. We also **recommend to bin most guiders typically 2x2 or more**, this will more than double the SNR (bin 2x2) and reduce the secondary mirror central obstruction effect on a reflector. The former easily more than double the guide star limiting magnitude, which means that a 2 seconds exposure bin 1x1 is equivalent to a 2.5 to 3 seconds exposure when bin 2x2.

As a general guideline we **strongly suggest to use the longest guide star (and mount correction) exposure you can afford** before any drift starts to be seen whenever possible. This advice goes for any guiding methods, not only the ONAG®. It will improve your SNR, increase the limiting guide star magnitude and minimize the seeing effect. On permanent setups, with a good polar alignment, one should be able to afford 5 to 10 seconds unguided for most target, when using pointing and speed models (such a Tpoint and Protrack) it can be extended up to 20 to 30 seconds. On a portable and mobile setup a 5 second guiding exposure is a realistic value most of the time.



ONAG® spectral response



ONAG® basic principle

(2) A scope port (SP).

The SP allows the ONAG® SC to be attached to any scope using a standard T2 female connection (T-mount M42 x 0.75), or a 59mm dovetail system for the XM version. We provides standard adapters and spacers for both products, please visit our website at:

http://www.innovationsforesight.com/product-category/accessories/

If you own an adaptive optics module (AO), such as the Orion SteadyStar™, or the Starlight Xpress SXV, you can mount them directly between the SP and your scope. Use the ONAG® for guiding and controlling the AO unit as well.
Since the off-axis ports of both products are not used anymore they should be covered to avoid parasitic light. We offer an adapter plate for the SBIG AO8 adaptive optics module (initial version, visit SBIG for more information on the new version of the AO-8 and related conversion plate). This allows you to mount the AO8 in front of the ONAG® (SC versions). The ONAG® XM provides 4 threaded holes in its front to support the SBIG AO-L.
Other adapters (such as for the AO-X) for any ONAG® can be made by **preciseparts (**www.preciseparts.com), they have all our products in file (the SBIG AO-L is only supported by the ONAG® XM).

(3) An imager port (IP).

The IP is used to attach the imaging camera and related accessories, such as a filter wheel, to the ONAG® SC using a standard male T-thread (M42 x 0.75mm), or a 59mm dovetail system for the XM version.

(4) A guider port (GP).

The GP is used to attach the guider camera to the ONAG®, any version uses a male T2 male (M42 x 0.75mm). A low profile T-threaded locking ring is provided to secure the camera at the desired position.

(5) A helical guider focuser (GF) without any camera rotation.

The GF provides up to 9 mm of travel to adjust the guider focus, one full rotation move the guider by 800 microns.
The focuser uses a heavy duty design eliminating any flexure even with heavy guiding cameras (such as the STF/STT8300). The focuser can easily handle serval kilograms of equipment at its back.
Please see section 15 for how to lock and secure the helical focuser.
Its drawtube provides a 1¼” internal diameter opening to support any guider with a 1¼” body (such as ST-i, lodestar) or any standard 1¼” accessories. There are two #4-40 set screws to secure any 1.25” attachment.
Although this is a handy option, especially with 1¼” guiders and back focus

limitation, we recommend to mount guiders using the T2 thread whenever possible, especially with heavy guiders, to avoid any play.

(6) A cross slide based X/Y stage (XYS).

The XYS allows easy and quick search for suitable guide stars when needed. It is attached to the ONAG® body on one end, while it supports the guider helical focuser on the other end. The XYS slides in both directions (X, Y axis) each axis can be secured with 4 nylon screws (two screws and two thumbscrews) when you have settled on your guide star. For convenience the thumbscrews can be more or less tightened to provide any level of friction and comfort you like, while moving the stage. In normal operation only the two nylon thumbscrews for each axis need to be touched. The other 2 nylon screws are tightened only once using a screwdriver/Allen wrench to insure proper smooth motion and remove any play. Do not over tighten them. Check them time to time.

3. Set-up

For proper operation it is required that both cameras, imager and guider, are made parfocal (same optical path distance from the SP for both). T2 spacers or/and dovetail spacers for the ONAG® XM, if any, are used to conveniently space, when needed, the cameras from the ONAG® body.
Any spacers can be used, you may already own some T2 ones, also you can always order custom parts at preciseparts.com.

The ONAG® SC uses two low profile T2 locking rings for rotating and locking the cameras to the desired positions. Alternatively the ONAG® XM dovetail system offers a total freedom of rotation for the IP and SP. It uses three #4-40 set screws to secure spacers and adapters. The ONAG® XM GP also uses a T2 locking ring.

Since the IP (ONAG® SC only) and GP male T2 threads are longer than more spacers/adapters threads, it is recommended to use T2 rings at those ports. Although they could be used with spacers as well, you may run out of thread length to safely secure the cameras.

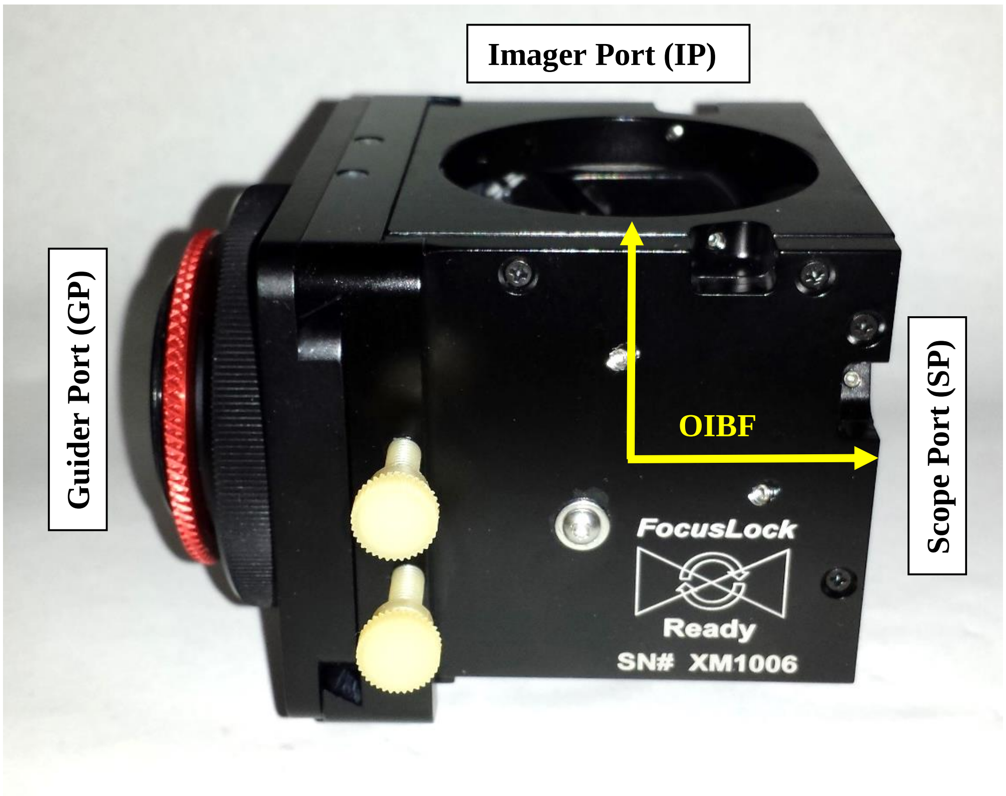
The ONAG® is connected to your scope using the SP. It is highly recommended to use a rigid assembly, such as the T2 thread (ONAG® SC), a SCT adapter, 2" adapter with a compression ring on the scope side, or alternatively a custom adapters (for any ONAG®) from preciseparts (www.preciseparts.com).

Innovations foresight offers various adapters for standard configurations. The ONAG® DBS has been laser aligned with care and precision for providing the best results, however an inappropriate user set up could impact significantly the image quality.
Thumb screen set ups may result on poor optical alignment leading to tilt of the camera focal plane and distorted star across the image. Therefore they are not encouraged, we recommend using rigid connection, such as threads, compressing rings or bolted connections whenever possible for the scope and imager.

Also it is not recommend that user touch any of the ONAG® mirror adjustment mechanism, our product have been aligned at factory, therefore please do not try to do so, you will upset the factory adjustment and you may void the warranty.

2. Back focus considerations and calculations

When using an ONAG®, like with any OAG, both the imaging and guiding cameras need to be parfocal. This means that when the imager is at best focus the guider too.



The two above pictures show the ONAG® XM (same concept for the ONAG® SC) optical ports and the optical paths for the imager and guider. The ONAG® optical back focus distances from the SP to the IP are:

ONAG® SC: OIBF = 66+/-2mm ONAG® XM: OIBF = 68+/-2mm

The ONAG® optical back focus distances from the SP to the GP are larger. The values below assumed that the helical focuser GF is half extended (+4.5mm):

ONAG® SC: OGBF = 90+/-1mm ONAG® XM: OGBF = 101+/-1mm

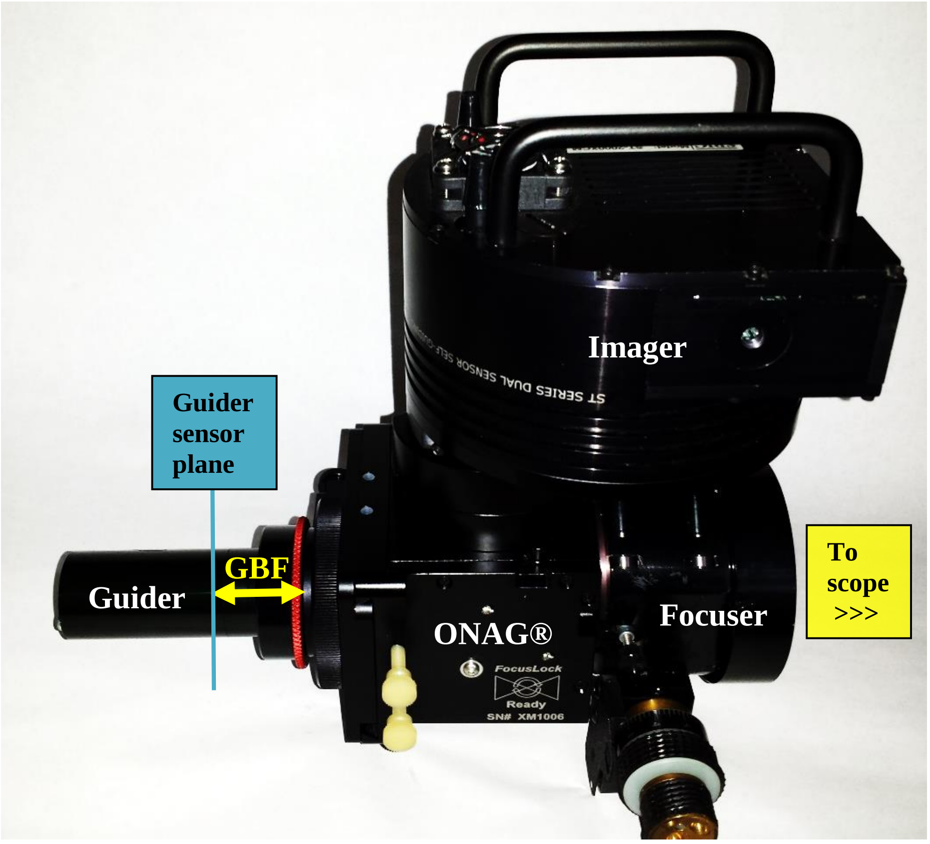
The key value in the parfocal calculations is the **differential back focus** for the cameras (**DBF**). Its value should be eventually made equal to the ONAG® back focus offset value, or BFO. The BFO is defined as the difference between the ONAG® GP (OGBP) and the ONGA® IP (OIBF) optical back focus distances:

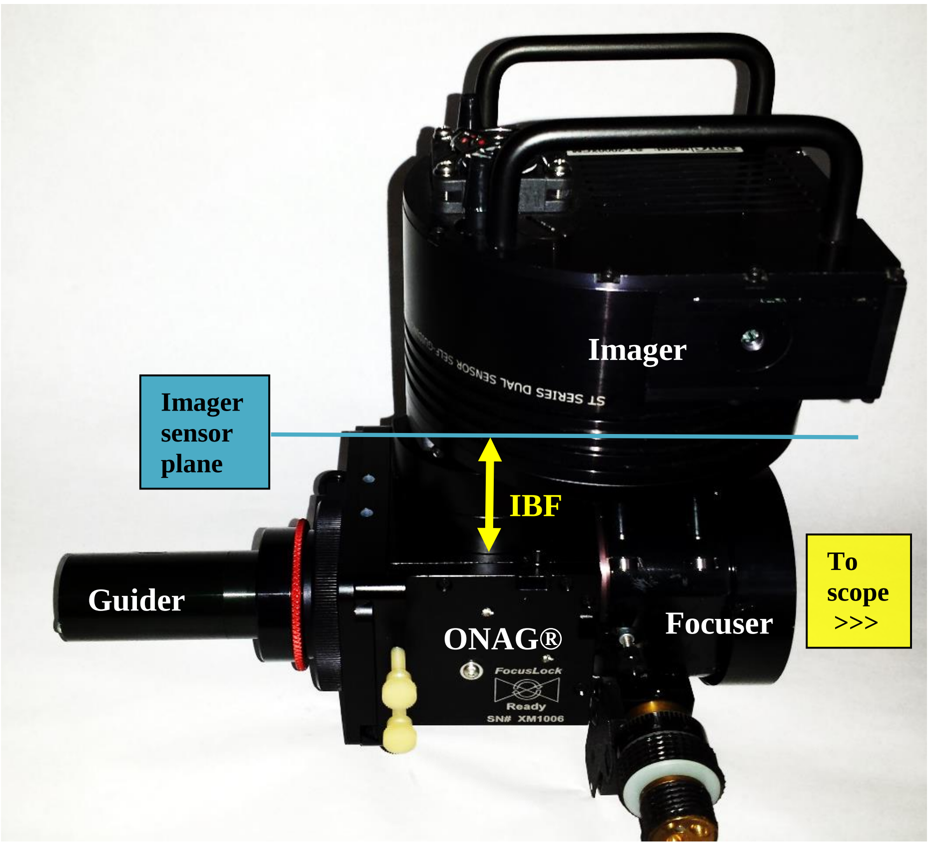
BFO = OGBF-OIBF

Therefore the BFO values are:

ONAG® SC: **BFO = 24mm** **ONAG® XM:** **BFO = 33mm**

When using the optical astigmatism corrector (see section 17) those values should be reduced by 3mm due to the optical effect of the corrector.





The two above pictures show the imager optical back focus distance (IBF) and the guider optical back focus distance (GBF).
The IBF is defined as the optical distance from the imager sensor plane to the ONAG® IP, which includes any spacers/adapters, filter wheel, …, in this path.
The GBF is defined as the optical distance from the guider sensor plane to the ONAG® GP, which includes any spacers/adapters, …, this path.

The DBF is defined as the difference between IBP and the GBF back focus distances:

DBF = IBF-GBF

When using our astigmatism corrector at the ONAG® GP this **DBF** value should be increased by 3mm (see section 17).
Should you have a focal reducer FR, see sections 8 and 9 below.

The DBF value should come close, in a ~+/-3mm range, to the ONAG® BFO value such the integrated ONAG® helical guider focuser (HGF) can be used to fine focus the guider.
When both values, the DBF from the cameras and accessories, and the BFO from the ONGA® match the camera are then parfocal.
The HGF can deal with back focus differences up to ~+/-4mm, since it has a travel of at least 9mm.
In summary the condition for making the camera parfocal is:

DBF = BFO

From an optical train and scope point of view, the **total optical back focus** (**TOBF**), including the ONAG®, the imager, its accessories (filter wheel, spacer/adapter, …), eventually limits the scope focusing mechanism ability to reach focus. The TOBF does not include accessories before the ONAG® such as a focuser, a rotator, and/or AO unit, can be estimated with the following formula:

TOBF = IBF+OIBF

The ONAG® integrated X/Y stage requires a 14mm clearance from the top of the ONAG® body (at the IP) for full upper vertical travel (Y). If there is interference with the imager/FW body, or any adapter, you may consider using a spacer for providing clearance. Even in the case of a limited upper Y travel (low profile configuration, see section 6) the X/Y stage has still a very large guiding FOV. The lower Y vertical travel, as well as the X travel are fully available.

Most scopes, such as SCT, are designed for some optimal back focus distances, for which they reach their nominal specifications (such as focal length, F number, field of view, resolution, …). For instance the Celestron EdgeHD SCT series have a built-in corrector, and they will provide optimal performance if the focal plane is at, or near, a predefined distance from the scope visual back. For further information in this topic please visit our support page at:

http://www.innovationsforesight.com/support/celestron-edgehd-back-focus-tolerance/

In such case you may even want to add a spacer(s) on the SP to reach the right distance. The tables below provide the length, in millimeter, of the spacer/adapter required to make both camera parfocal versus both imager (IBF) and guider (GBF) back focus. Remember that the IBF and GBF are the total optical back focus distances, they include spacer/adapter, filters, FW, …, if any, located between the camera and the ONAG® optical ports.

A green positive number means a spacer/adapter of that length should be placed at the ONAG® GP, in front of the guider.
A red negative number means a spacer/adapter of that length (sign removed) should be placed at the ONAG® IP, in front of the imager.

ONAG SC spacer length table: 10mm ≤ IBF ≤ 30mm

Imager optical back focus distance (IBF) in millimeter including spacer/adapter, FW, …

Guider optical back focus distance (GBF) in millimeter including spacer/adapter	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
10	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4
11	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5
12	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6
13	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7
14	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8
15	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9
16	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10
17	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11
18	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12
19	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13
20	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14
21	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15
22	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16
23	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17
24	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18
25	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19
26	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20
27	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21
28	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22
29	-43	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23
30	-44	-43	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24

ONAG SC spacer length table: 30mm ≤ IBF ≤ 50mm

Imager optical back focus distance (IBF) in millimeter including spacer/adapter, FW, …

Guider optical back focus distance (GBF) in millimeter including spacer/adapter

	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
10	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
11	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
13	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
14	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12
15	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11
16	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
17	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9
18	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8
19	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
20	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6
21	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5
22	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4
23	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3
24	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2
25	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1
26	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
27	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1
28	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2
29	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3
30	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4

ONAG SC spacer length table: 50mm ≤ IBF ≤ 70mm

Imager optical back focus distance (IBF) in millimeter including spacer/adapter, FW, …

Guider optical back focus distance (GBF) in millimeter including spacer/adapter

	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
10	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
11	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
12	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
13	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
14	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
15	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
16	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
17	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
18	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
19	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
20	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
21	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
22	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
23	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
24	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
25	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
26	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
27	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
28	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
29	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
30	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

ONAG XM spacer length table: 10mm ≤ IBF ≤ 30mm

Imager optical back focus distance (IBF) in millimeter including spacer/adapter, FW, …

Guider optical back focus distance (GBF) in millimeter including spacer/adapter

	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
10	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13
11	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14
12	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15
13	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16
14	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17
15	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18
16	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19
17	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20
18	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21
19	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22
20	-43	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23
21	-44	-43	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24
22	-45	-44	-43	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25
23	-46	-45	-44	-43	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26
24	-47	-46	-45	-44	-43	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27
25	-48	-47	-46	-45	-44	-43	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28
26	-49	-48	-47	-46	-45	-44	-43	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29
27	-50	-49	-48	-47	-46	-45	-44	-43	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30
28	-51	-50	-49	-48	-47	-46	-45	-44	-43	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31
29	-52	-51	-50	-49	-48	-47	-46	-45	-44	-43	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32
30	-53	-52	-51	-50	-49	-48	-47	-46	-45	-44	-43	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33

ONAG XM spacer length table: 30mm ≤ IBF ≤ 50mm

Imager optical back focus distance (IBF) in millimeter including spacer/adapter, FW, …

Guider optical back focus distance (GBF) in millimeter including spacer/adapter

	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
10	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
11	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6
12	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5
13	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4
14	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3
15	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2
16	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1
17	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
18	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1
19	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2
20	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3
21	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4
22	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5
23	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6
24	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7
25	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8
26	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9
27	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10
28	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11
29	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12
30	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13

ONAG XM spacer length table: 50mm ≤ IBF ≤ 70mm

Imager optical back focus distance (IBF) in millimeter including spacer/adapter, FW, …

Guider optical back focus distance (GBF) in millimeter including spacer/adapter

	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
10	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
11	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
12	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
13	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
14	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
15	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
16	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
17	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
18	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
19	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
20	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
21	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
22	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
23	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
24	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
25	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12
26	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11
27	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
28	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9
29	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8
30	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7

3. Examples of ONAG® parfocal calculations:

Example #1 ONAG® SC:

Imager DSLR Canon EOS (EF and EF-S mounts)
Flange back focus distance = 44 mm
T-ring adapter for EF/EF-S mount back focus = 8 mm

IBF = 44 + 8 = 52 mm back focus   (low profile configuration)

Notice: T-ring adapters for most cameras are designed and made to lead to a 52mm back focus distance (like here for the Canon EOS).

Guider SX lodestar (any version) optical back focus = 12.5 mm
C-to-T adapter back focus = 6.4 mm (connect to ONAG© GP T2)

GBF = 12.5 + 6.4 = 18.9mm ~ 19mm

Differential back focus DBF = 52 – 19 = +33 mm positive!

By calculation:

The ONAG® SC BFO is 24mm, therefore to be parfocal one needs a spacer at the ONAG® GP with a length of:

33 – 24 = 9mm (ONAG® helical focuser half extended).

Using the table above (IBF = 52, GBF = 19):

ONAG SC spacer length table: 50mm ≤ IBF ≤ 70mm

Imager optical back focus distance (IBF) in millimeter including spacer/adapter, FW, …

Guider optical back focus distance (GBF) in millimeter including spacer/adapter	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
10	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
11	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
12	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
13	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
14	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
15	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
16	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
17	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
18	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
19	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
20	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
21	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
22	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
23	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
24	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
25	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
26	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
27	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
28	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
29	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
30	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

We found +9mm a positive (green) value therefore the spacer must be placed at the ONAG® GP.

The total optical back focus in this configuration (low profile) is:

TOBF = IBF + OIBF = 52 + 66 = 118 mm

Be aware this configuration could prohibit access to some DSLR functions and interface, if its body is too close to the ONAG®.

To insure full motion of the upper vertical travel of the ONAG® X/Y stage we may consider adding a T2 spacer of 14mm long at the ONAG® IP to clear the DSL body from the stage (see standard and low profile configuration below, sections 5 and 6)

In this case the IBF becomes:

IBF = 52 + 16 = 68mm

Therefore the new DBF is:

Differential back focus DBF = 68 – 19 = +49 mm positive!

To be parfocal one needs a spacer at the ONAG® GP with a length of:

49 – 24 = 25mm (ONAG® helical focuser half extended).

Try with the above table to compare.

The new total optical back focus in this configuration is:

TOBF = IBF + OIBF = 68 + 66 = 134 mm

For instance if this configuration is used with a C11/C14 EdgeHD scope you would need that the adapter/spacer connection to the scope visual back (in front of the ONAG® is 146 – 134 = 12mm long to meet the Celestron nominal back focus recommendation.

Example #2 ONAG® SC:

Imager OSC SBIG STF83000C optical back focus = 17.5 mm

IBF = 17.5 mm back focus (low profile configuration)

Guider SBIG ST-i (monochrome) optical back focus = 13.36mm
1.25" filter thread to T2 adapter back focus = 7mm (connect to GP T2)

GBF = 13.36 + 7 = 20.36mm ~ 20.4mm

Differential back focus DBF = 17.5 – 20.4 = -2.9 mm ~ -3mm negative!

By calculation:

The ONAG® SC BFO is 24mm therefore to be parfocal, since the DBF is negative, one needs a spacer at the ONAG® IP with a length of:

24 - (-3) = 27mm (ONAG® helical focuser half extended).

With a T2 27mm long spacer at the IP there is enough clearance for the camera body. We are in the standard profile configuration.

Using the table above (IBF ~ 17, GBF ~ 20):

ONAG SC spacer length table: 10mm ≤ IBF ≤ 30mm

Imager optical back focus distance (IBF) in millimeter including spacer/adapter, FW, …

Guider optical back focus distance (GBF) in millimeter including spacer/adapter	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
10	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4
11	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5
12	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6
13	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7
14	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8
15	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9
16	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10
17	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11
18	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12
19	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14	-13
20	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15	-14
21	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16	-15
22	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17	-16
23	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18	-17
24	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19	-18
25	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20	-19
26	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21	-20
27	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22	-21
28	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23	-22
29	-43	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24	-23
30	-44	-43	-42	-41	-40	-39	-38	-37	-36	-35	-34	-33	-32	-31	-30	-29	-28	-27	-26	-25	-24

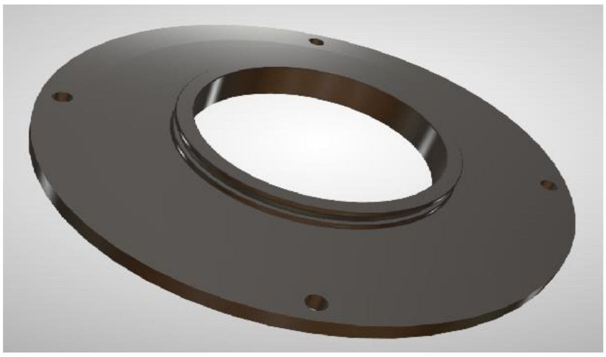
We found -27mm a negative (red) value therefore the spacer must be placed at the ONAG® IP.

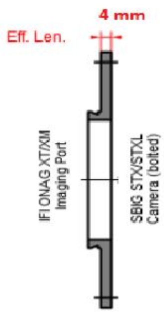
With a new IBF of 17+27 = 44mm the total optical back focus in this configuration is:

TOBF = IBF + OIBF = 44 + 66 = 110 mm

Example #3 ONAG® XM:

Imager+filter wheel SBIG STX16803 & FW7STX back focus = 68 mm
Customer adapter (preciseparts.com) back focus = 4mm (bolted)





IBF = 68+4 = 72mm back focus

Guider ATIK460EX (monochrome) optical back focus = 13mm

GBF = 13mm

Differential back focus DBF = 72 – 13 = 59 mm <u>positive!</u>

By calculation:

The ONAG® XM BFO is 33mm therefore to be parfocal one needs a <u>spacer at the ONAG® GP</u> with a length of:

59 - 33 = <u>26mm</u> (ONAG® helical focuser half extended).

Using the table above (IBF = 72, GBF = 13):

ONAG XM spacer length table: 50mm ≤ IBF ≤ 70mm

Imager optical back focus distance (IBF) in millimeter including spacer/adapter, FW, …

Guider optical back focus distance (GBF) in millimeter including spacer/adapter

	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
10	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
11	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
12	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
13	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
14	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
15	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
16	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
17	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
18	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
19	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
20	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
21	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
22	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
23	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
24	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
25	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12
26	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11
27	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
28	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9
29	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8
30	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7

+2

IP 70 to 72: Two rows up

IBF = 72mm is outside of the table.

To find the spacer length of an IBF value larger than the maximum listed in the a table subtract one millimeter at the GBF value for each extra millimeter above the IBF table upper limit value, here 70mm.
With IBF=72mm we are two millimeters larger than the 70mm upper limit, which means that for GBF=13mm we need to look at GBF=11mm, or two rows up.
Reciprocally for an IBF value smaller than the minimum listed in the table add one millimeter at the GBF value for each extra millimeter below the IBF table lower limit value (one row down).

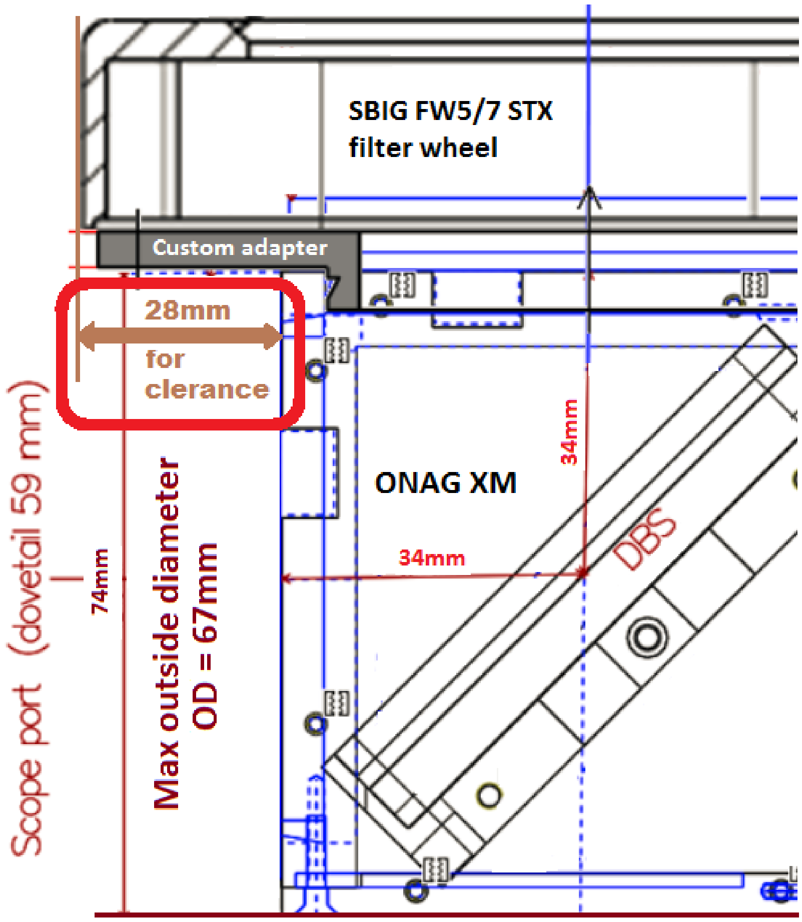
We found <u>+26mm</u> a <u>positive</u> (green) value therefore the spacer must be placed at the ONAG® GP.

With IBF=72mm the total optical back focus in this configuration is:

TOBF = IBF + OIBF = 72 + 68 = 140 mm

When having a large imaging camera and/or filter wheel at the IP it is **important and strongly recommended** to check/plan for the necessary clearance distances with the scope visual back and accessories, such as focuser, AO unit, …, if any.

Here is an example with the ONAG© XM and the above FW7STX + custom bolted adapter (4mm thick):



In this example the ONAG® XM must be at least at 28mm from the scope visual back (clearance for the FW).
Any spacer/adapter or accessory in between should have a maximum outside diameter (OD) of 67mm for at least 28mm from the ONAG® XM SP to insure proper clearance. All ONAG® dimensions are in millimeter with +/-1mm of tolerance.

4. Standard versus low profile configuration

The ONAG® has three effective degrees of freedom for exploring the field of view in search for a guide star.
The X/Y stage (XYS) provides two orthogonal axis X and Y (see section

11), while the rotation of the ONAG® body, when used, adds a third degree for freedom.
This gives an overall exploration circle up to 46 mm in diameter and allows the ONAG® to be used in different and flexible ways.
There are two fundamental configurations, standard and low profile, which can be used to optimize the set-up.
While the X (horizontal) stage axis can always be used at full travel range, there are maybe some travel limitations for the Y (vertical) axis upper travel, please see the section below.

5. Standard profile configuration

In the standard configuration the XYS can be fully extended in the upper Y axis portion (positive sense, toward the IP, see section 11). This is possible only if there are at least 14mm of clearance from the IP to the imager/FW/adapter body. Otherwise the XYS will experience limited Y travel toward the IP (see low profile section 8 below).
With the standard configuration the XYS can be used alone to search for a guide star across the full field of view. When used in conjunction with ONAG® body rotation you can achieve up to 23 mm of off-axis offset (both X and Y axis at travel ends)!
However this configuration leads to more total optical back focus (TOBF).

6. Low profile configuration

In the low profile configuration the Y upper axis travel is limited, as follow:

Travel restriction [mm] = 14 – X

Where X is the clearance (X<14 mm) of the imager/FW from the IP. In the low profile configuration the lower portion of the Y vertical axis travel, and all the X horizontal axis travel range, are fully usable.
Therefore a rotation of the ONAG® up to 180 degrees will allow access to the full field of view when searching a guide star. What is left of Y axis travel (at least half of its full travel range) combined with the X axis and the ONAG® rotation, if any, provides again an exploration circle up to 46 mm in diameter. The low profile configuration is recommended if a short TOBF is desired.

7. Using the ONAG®

The use of the ONAG® is quite simple. First make both cameras parfocal, this is done once, then select a guide star near your target (on/off axis), next focus your imaging camera as usual, and you are ready for a classical imaging session using any auto-guiding hardware and software.

With our patent pending *SharpLock* (SL) technology your ONAG® provides an unique opportunity to also do continuous real time auto-focus while guiding. SL and the associated FocusLock (FL) software work with any ASCOM compliant focuser. Visit our education page for further information at:

http://www.innovationsforesight.com/education/real-time-autofocus/

Notice: You do not have to be concerned by the inversion effect of the dichroic mirror for the auto-guiding calibration. The guider uses the light coming straight through the DBS, there is no reflection involved here.

The recommended focusing procedure to make both, imaging and guiding cameras, parafocal is as follow:

Center the XYS and gently tighten the nylon screws to insure an easy slide of any axis in any direction when displaced by hand, while the stage does not move under its own weight.

Loose the ONAG® helical focuser locking screw (see section 15).

Select a bright star (do not over expose), near the zenith for instance, and center it on the imager. Then focus the imager using the scope focusing mechanism, as usual.

When the imager is at best focus, using the XYS, center the same star and focus it using the helical GF, then tighten the GF locking screw (see section 15 for further information on how to use the ONAG® helical focuser).
If you cannot reach focus with the guider using the GF you may have to add/remove spacer(s) at the IP and/or GP, see section 4 above for parfocal spacing calculations.

When the ONAG® GF drawtube travels all the way, the guide star should change form from a vertical ellipsoidal shape to a horizontal ellipsoidal shape, or the opposite in function of your guider reference frame position. If the guider is set with an angle relative to the RA/DEC axes the star elongation will be tilted, this is normal and does not impact FL.

The optimal focus point is achieved when both ellipsoids collapse becoming a spot, or a little tight cross. This is normal and not a source of concern. This feature becomes handy when manually seeking for best focus and it is used by our real time autofocus technology *SharpLock* (SL).

Since most scopes and optical components are not optimized for the near infrared (NIR) there is maybe a small distortion involved anyway.
Auto-guiding algorithms are mainly based on centroid algorithms and are not sensitive to this.
They average pixels from the all guide star area, so the maximum pixel value or FWHM are not much relevant in this case, unlike for imaging. If you use a computer assisted focusing software, such has Maxim DL, the right figure of merit should be the half flux diameter (HFD), or ½ FD. The half-flux diameter is the diameter in pixels that contains half the energy in a star image. In other words, if you add up the pixel values (less the background) inside the diameter, and outside the diameter, you will get the same number. This measurement gives a very similar answer to FWHM, but it is much more robust in the presence of seeing, noise, and can handle non circular distorted images, even out-of-focus like "donuts". The HFD varies linearly with focus position making it reliable to locate the best focus regardless the star shape.

If you use the PHD2 guiding software watch the SNR value, you should seek for its maximum. If you do not use any software, the best focus will be achieved when the guide star cross like shape is minimized and symmetric. The two images below show the same guide star seen from the imager (IP) on the left or from the guider (GP) on the right at best focus, same camera, set-up, and cropping.

Guide star seen from IP
HFD=6.0px, FWHM=3.4px

Guide star seen from GP
HFD=6.2px, FWHM=5.2px

The cross like shape of the guide star viewed from the GP is clearly visible. Yet as far as the energy budget is concerned both cases have almost the same HFD. The GP larger FWHM is due to the star non-circular shape.

During this focusing process avoid to over exposing the guide star. Doing so will bias the HFD values, and make the star shape more difficult to guess for accurate focus.

Bright over expose stars may also result in ghost images offset by few millimeters (hundreds of pixels). Those are reflections from the DBS and nearby surfaces, such as the CCD/camera windows, lenses. Most optic are not coated for NIR. The reflections are out of focus and will look like faint stars with "donuts" like shapes. This is not issue unless your imaging camera, or filters when using a FW, does not block IR.

You could use a Bahtinov mask for the guider, however the resulting focus will usually not lead to the best guider focus having a symmetric cross shape guide star, as discussed above. You may want to fine focus using FL for instance such as the guide star absolute roundness is near zero.

When using our optional astigmatism corrector at the GP the guide star can be made round and near diffraction limited. This is useful for imaging in NIR, however SL/FL may not work anymore.
The corrector can then be rotated to dial back some level of astigmatism for SL/FL operation.
We recommend to consider this corrector for fast scopes with F/#<6 and/or large central obstructions (reflector) > 40%.

Should you keep your cameras attached to the ONAG® for the next sessions, there should be no need to focus the guider again (if you did not touch the GF).
You will just need to focus the imager and use the XYS to locate the guide star, which will be automatically on focus, saving time.
Alternately if you use SL/FL your cameras will be back at best focus as soon as you have a guide star available. You stay at best focus while you are imaging as well.

Although if the DBS has a high efficiency broad band antireflection (AR) coating on its back, if you overexpose bright star(s) you may experience dimmed ghost images of them offset by few hundred pixels, unless your imager (filters when using a FW) has a near infrared (NIR) cutting filter. Most, if not all, one-shot color cameras and DSLR have UV+NIR blocking filters. Monochrome ones usually do not, however the associated filters, such as LRGB or narrow bands should take care of this, cutting the NIR, typically above 700 nm. If not you may have to consider adding a (UV) NIR filter in front of the imager. Alternatively should you want to image in

NIR, avoid overexposing your target. For scientific and research purpose a ghost image may not be much an issue since it is dimmed and offset from its source by about 3 mm, or so.
In any case **never place any NIR filter, or any other filters blocking the NIR, in front of the ONAG®**, otherwise you will not have any image of any star on your guider camera!

8. Focal reducers

Focal reducers FR can be used with the ONAG®. Those reducers should be located at, or near, a specific distance DFR from the imager focal plane, please refer to your reducer specification and user manual. There are two options available:

You can place the FR in front of the ONAG®, at the SP, if your TOBF associated with your set-up matched the FR required back working distance (BWD).
For instance most popular 0.63x focal reducer/correctors (such as Meade or Celestron) can be used in a range of +/-1" (+/- 25mm) to their nominal BWD values without any significant alternation of their correction performances.
However the actual reduction factor h is a function of the optical back focus distance q from the FR optical center to the imager focal plane.
Although the BWD is well defined, q is often not given and must be guessed from the location of the lenses inside the FR body. The distance O (estimated) from the FR optical to the FR flange must be added to the BWD to get q:

q=BWD+O

Also if q is different from its nominal value, so h.
In first approximation we have:

h=1-q/f and q=f (1-h)

Where f is the reducer effective focal length.

For instance the Celestron/Meade 0.63x corrector/reducer for SCT has a focal of 325mm, therefore its nominal p value is:

$q_{0.63x}$= 325(1-0.63) = 120mm

The FR optical center is about 15mm inside the FR body leading to a distance O=15mm and a BWD of:

$BWD_{0.63x}$ = 120-15 = 105mm

If placed one inch further away from the imager focal plane its reduction factor $h_{+1''}$ becomes:

$q_{+1''}=BWD_{0.63x}+15+25.4=145.4$mm

$h_{+1''}=1-130.4/284=0.55$x instead of 0.63x, a 15% decrease.

<u>FR in front of ONAG® example #1:</u>

Reducer Starizona SCT corrector 0.75

BWD = 90mm

Imager SBIG STF8300C

IBF = 17.5mm

ONAG® SC in low profile configuration

Back focus = 66m.

One will need an extra of 90-66-17.5=6.5mm to meet the Starizona DFR value of 90mm.
A T2 spacer of 6.5mm could be placed at the ONAG® SC IP to insure the proper FR BWD and also to provide extra travel range for the XYS (Y axis).

<u>FR in front of ONAG® XM example #2:</u>

Reducer Celestron 0.63x (f=325mm)

BWD= 105mm

Imager OSC ATIK11000 (color)

IBF = 15mm (1.4")

ONAG® XM in low profile configuration

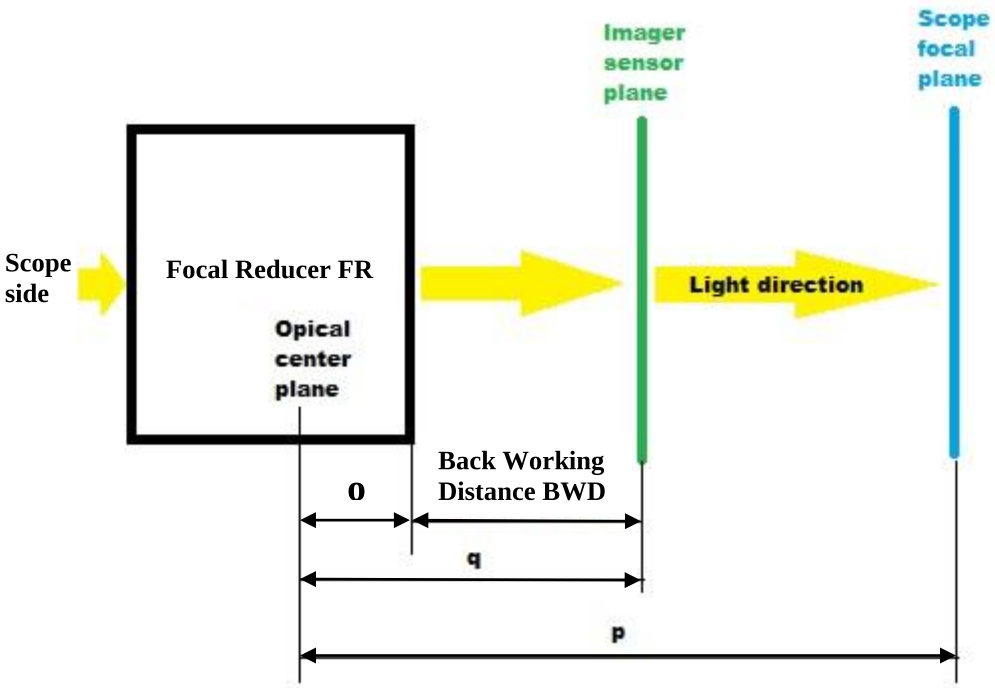
Back focus = 68mm

q=68+15=83mm

To reach the DFR of 105mm a 105-83=22mm spacer should be placed between the ONAG® XM IP and the ATIK11000 OSC.
Doing so will provide full travel of the XYS (standard profile configuration).

A second option is to place the FR at the ONAG® IP, before the imager.
This configuration may be necessary when the FR BWD is too short, or its BWD tolerance is critical and tight.
In this case the ONAG® back focus does not play any role anymore.
We are back in the classical situation where the imager sensor plane is placed exactly at its nominal BWD distance.

However the guiding camera does not see the effect of the FR here and one will have to find the right spacing for reaching focus with your guider by some trial and error. The tables and calculations from section 4 above will not be correct anymore.
Most likely one will need to use extra T2 spacer(s) to move the guider further away from the ONAG® GP, or our convenient adjustable focal reducer (AFR), see below section 9.



The following relations are useful to guide you through this process:

p=q/h

p=(BWD+O)/h

Assuming you are in focus at the imager sensor plane with the FR in place then p is the distance from the FR optical center to the scope focal plane. This is the distance where you would be in-focus if the FR is removed and the scope focus is left untouched. In short for having a sharp image at the sensor image plane with a FR you have to focus your scope at a plane behind the sensor image plane located at the distance p from the FR optical center.

This is also the distance you need to consider for the guider, since in this configuration the FR is not part of its optical path.
For instance with a Celestron/Meade 0.63x focal reducer (f=325mm, BWD=105mm, O=15mm) p should be:

p=(105+15)/0.63=190.5mm or 175.5mm from the FR flange.

9. Adjustable focal reducer AFR

In order to minimize the resulting guider optical path associated with a FR in front of the imager (ONAG® IP) and match the FOVs IF offers an adjustable FR (AFR) for your guider.
The AFR works with almost any FRs as well as most guiders. It has been optimized for NIR imaging using a fully multi-coated aspheric optics.

AFR adjustable FR for NIR

The normal procedure with the AFR will be to place your FR directly at the ONAG® IP. You may need adaptors for your FR to interface with the ONAG® IP.

AFR parts and nomenclature

To match your FR optical effect in front of the imager, you need to estimate the AFR extension value X.
X is the total distance from the AFR knurled ring and the guider, which may include some T2 spacers, or/and an adapter (see the AFR parts and nomenclature figure above).
The required X value is given by the following relation (all in millimeters):

$$X=q_{AFR}-GBF$$

With GBF your guider optical back focus and

$$q_{AFR}=q/h\ (102/(q/h+102))$$

the required AFR optical back focus distance, from its optical center, to match your FR.

Where q (in mm) and h are your FR back focus from its optical center, most likely q=BWD+O (see section 8 above), and its reduction factor respectively. See your FR specifications and user manual for those values.
By adding, when necessary, one or more T2 spacers between the AFR and the guider you have access to a large range of AFR extension value. Some

are listed in the table below for information:

X Minimum [mm]	X Maximum [mm]	Spacer length [mm]
26	36	None
34	44	8
42	52	16
50	60	24
58	68	32
66	76	40
74	84	48

AFR extension value ranges v.s. T2 spacer lengths

Select a suitable range from the table, add T2 spacer(s) between the AFR and the guider when applicable, and adjust the AFR focusing ring to bring the AFR length close to the selected X value. You can use a ruler to help.

Then place the AFR at the ONAG® GP in one end and connect with your guider in the other end. The AFR provides T2 threads.
You can us the ONAG® GP T2 locking ring to manage the guider body rotation.
Now position the ONAG® guider focuser half way out (about 4.5mm), this will give you some room for fine focus later.

Search for a bright star, but do not over expose it, and place it at the center of the imager, carefully focus your scope. Center the ONAG® X/Y stage.

Now focus the guider using the AFR focusing ring, you may have to adjust the ONAG® X/Y stage to center the star. When done, hand tighten and secure the AFR focusing ring with the associated plastic screw.

Fine focus can be achieved with the ONAG® guider focuser if necessary.
Now you are ready to use your ONAG® with your FR and our AFR.

<u>Example:</u>

Reducer Celestron/Meade 0.63x

DFR = 105mm

h = 0.63x
O = 15mm
q = 105+15 = 120mm

Guider ATIK-GP

GBF = 7mm

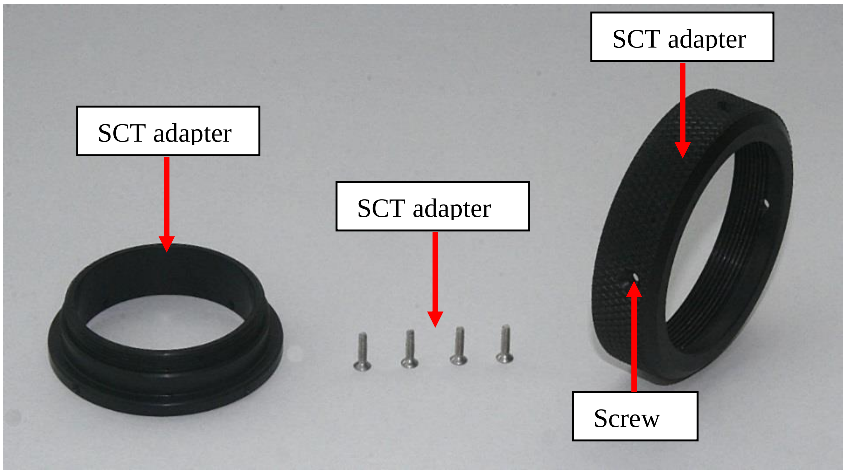
q_{AFR} =120/0.63 (102/(120/0.63+102)) = 66.4mm

X=66.4-7=59.4mm

From the above table we could either add a 24mm T2 spacer, or a 32mm T2 spacer, between the AFR and the ATIK-GP guider.

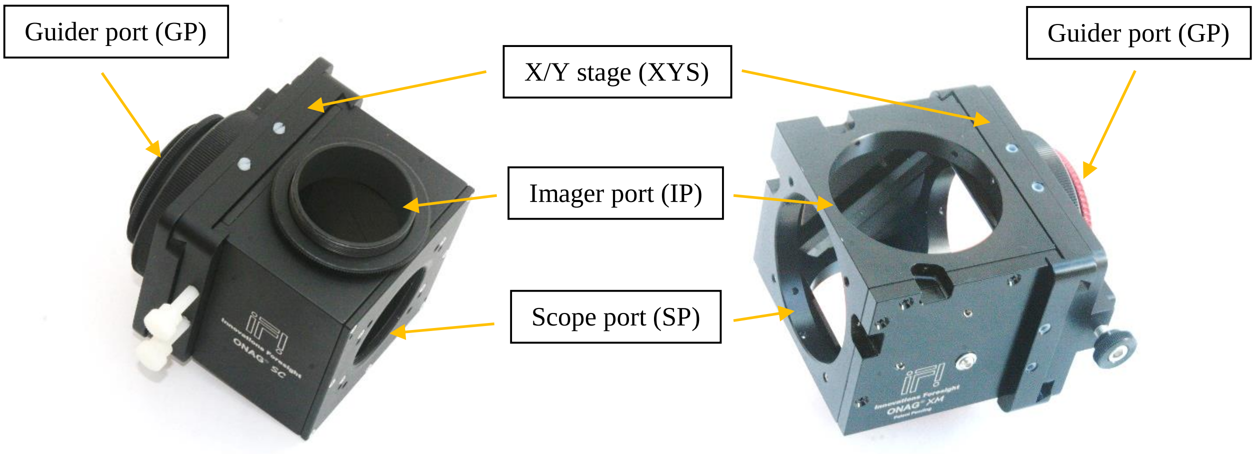
10. Low profile SCT adapter

We offer a low profile SCT adapter for the ONAG® SC it can be attached to a standard SCT male thread (2" - 24 tpi) with a minimum of back focus (7.5 mm, about 1/3").
The adapter comes mounted with Phillips head stainless steel screws (3 or 4 depending the version) to secure the SCT female ring with the T-thread core. First screw the adapter to the ONAG® SC SP, or any T-threaded accessories mounted in front of the ONAG®, such as AO unit, then tighten it. If you want to freely rotate the SCT female ring, remove and save the screws with a Phillips screwdriver. To remove the adapter from the ONAG® SP, or other accessories, put the screws back in place and then unscrew the adapter.

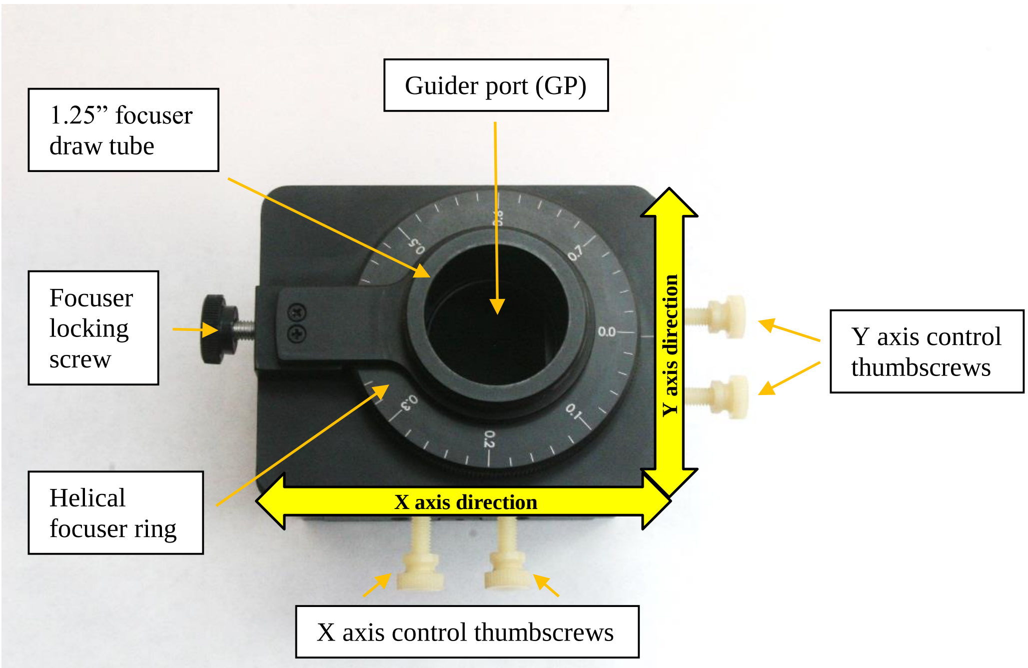


SCT low profile adapter

11. ONAG® and its parts

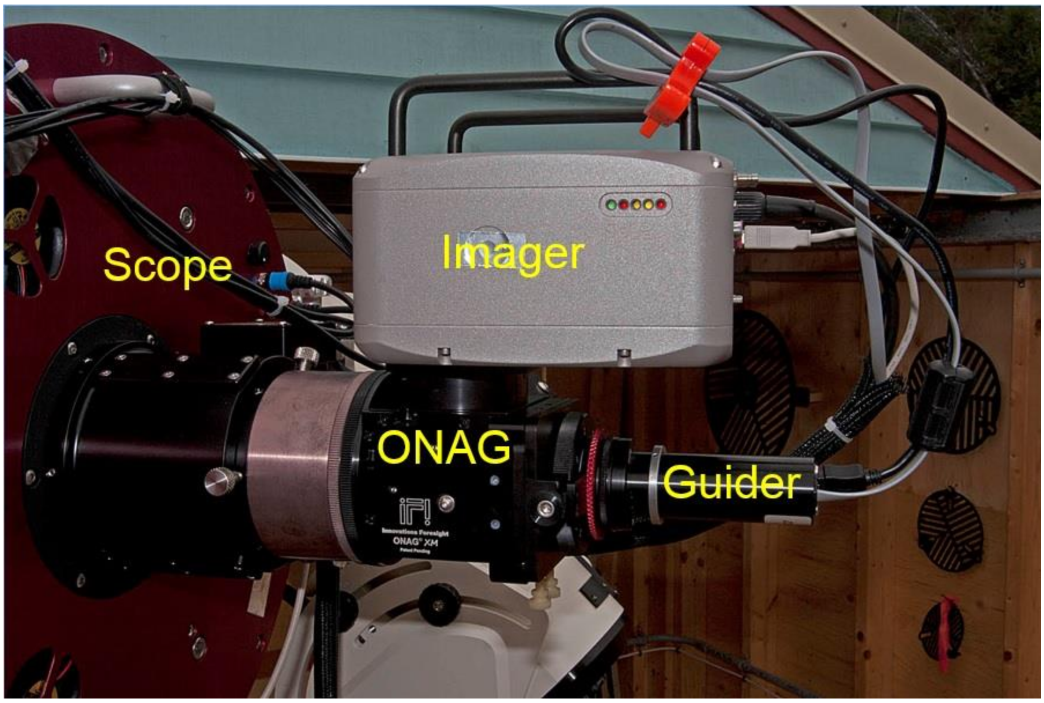


ONAG® SC **ONAG® XM**



ONAG® SC/XM helical focuser, X/Y stage and guider port

12. Examples of a scope set-ups with an ONAG® (XM)



13. ONAG® and tracking software, some considerations

Although the ONAG® solves differential flexure problems while featuring a wide field of view to locate suitable guide stars, the auto-guiding software is also a key element in the all process. It is paramount to understand its basic operation and choose the right software settings to achieve good image quality.

There are many auto-guiding software available, such as Maxim DL, PHD, The Sky X (TSX) to name few. They typically use centroid algorithms averaging pixel values all around the guide star area to estimate its position with sub-pixel accuracy. The guide star shape does not matter much, as long as it is not clipped, consistent across frames and is not too much spread or fain. For that matter the little cross shape of the guide star seen from the ONAG® GP in NIR does not impact most software auto-guiding capability.

When using fast scopes (F/#<6) or/and reflectors with a large central obstruction (>40%) you may want to consider our astigmatism corrector (see section 17).

Guiding with the ONAG® means using the same focal length than imaging, and unlike guide scopes, this translates most of the time to a small field of view, especially for long focal scopes. Meaning for each guide star frame we may expect having more seeing effect and other short term perturbation contributions. Therefore most of the time **it is strongly recommended to bin the guider 2x2 or 3x3**, which will average nearby pixels.

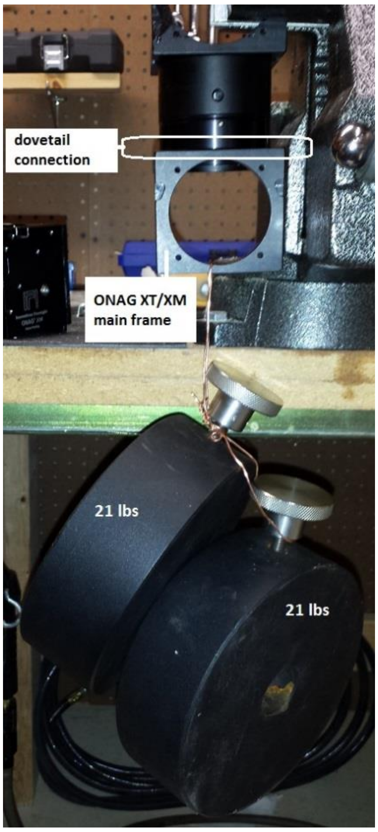
This can be seen as a low pass filter operation, limiting seeing or other noise effects, as well as the guide star wander at each frame.
Yet the most important single parameter of any auto-guiding software is the aggressiveness, which is the level of correction the algorithm will apply to the mount after each new guide star frame. In control system theory (close loop systems) this is known as the feedback gain G_f.
If it is too low the correction is not enough to compensate for the mount drift. In the other hand if G_f is too large the corrections will become instable and erratic.
The latter is the most problematic and common issue in auto-guiding leading to elongated star in the images even with near perfection optics.
From the above considerations we recommend you **start with a low aggressiveness (1/3 or 30%, or less)** when such option is available to begin with, and increase it slowly only if you have to. For instance for Maxim DL this means 3, in PHD guiding this would translate to 30, for both cases it is half way to full scale correction (1, or 100%), or less.
A common figure of merit for the tracking error quality evaluation is the rms (root mean square) error value over a time window. However even with a low error value you still may experience elongated stars.
Very often bright stars are much brighter than the target under consideration for your imaging session, such as galaxy, or nebulas.
During several minute of exposure a short extreme erratic tracking correction during a second or so way above the rms value will be enough to distort the bright stars. Those outliers are more likely if G_f is large. They may also come from some mechanical problems, such as over compensated backlash by the mount software.
If your mount is equipped with a **periodic error correction (PEC) you should use it**. We also recommend unbalancing just a little your mount in RA, making it "East heavy" to avoid any backlash on the RA axis. Be aware this must be done differently for both meridians on equatorial mounts.
Backlash compensation done by most mount software may result, if too large, in bumping the mount, especially on DEC axis (equatorial mounts) for which the drive motor can reversed it direction. Yet too little backlash compensation leads to lag in the correction and erratic auto-guiding.
If you have difficulties to solve this DEC problem you can use a simple technique:
Just disturb a little bit the mount polar alignment, this will result in a single direction DEC drift, the DEC drive motor does not need to reverse anymore avoiding backlash issues.
Most software allows disabling either correction direction in RA and DEC, use this feature when available. You need just a very little polar alignment error to accomplish this trick.
Do not misalign your mount too much otherwise long exposures may exhibit

field rotation.
As a general rule you should use **the longest guiding exposure you can afford** (start with 5 to 10 seconds for instance) before any drift (coming from the polar mi-alignment, atmospheric refraction, set-up flexure, …).
Short exposures (less than 2 or 3 seconds) will expose you to the seeing effect. The guide star wander due to seeing is only correlated inside a few arc-second isoplanatic patch, fast corrections may improve the guide star image but most likely at the expense of the target. For further information on seeing visit our education page at:

http://www.innovationsforesight.com/education/astronomical-seeing-tutorial/

If this is your first experience with guiding at the same focus than imaging, you will need some time to find the right settings most likely, but the reward will be huge in term of image quality. Should you need more support or advise please feel free to contact us we will be glad to help.

14. ONAG® XM dovetail system

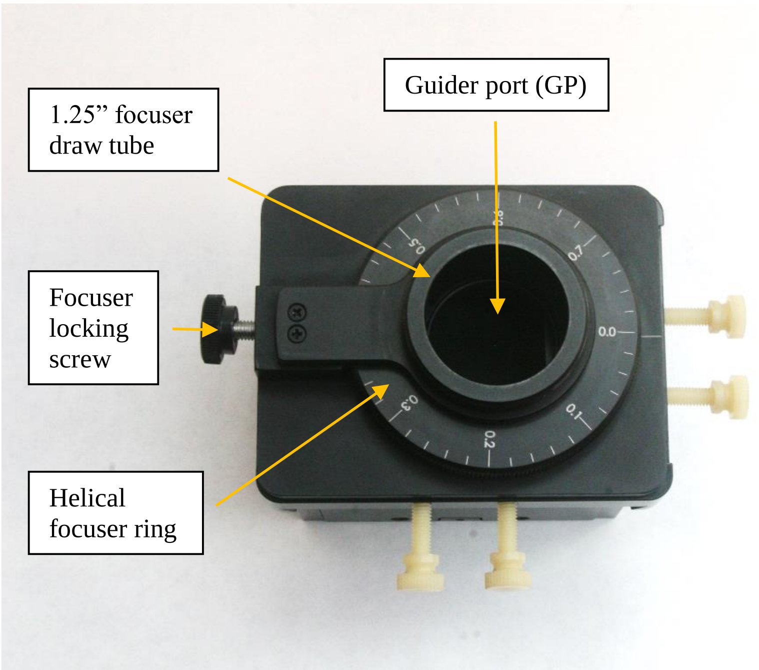


The ONAG® XM (same as the XT model, now discontinued) uses a 59mm dovetail system for the IP and SP.
This insures a rigid, squared, and secure connection for large imaging camera chips as well as provides minimum back focus solutions.
Each female dovetail is equipped with three #4-40 UNC stainless steel set screws. They **must all be tightened** to insure a secure attachment using a 0.05" Allen (hex-key) wrench. The set screw tips have an oval shape to insure a good grip and to protect the aluminum surface of the male dovetail part. Only limited force is needed to lock in position the dovetails, do not over tighten the set screws. Inspection of the set screws in a regular basis is recommended.
The ONAG® dovetail system recommended maximum load is 6 kilogram (14 lbs.) when the three set screws have been correctly tightened.
The picture on the right shows an ONAG® XM dovetail supporting a 20 kilogram (42 lbs.) off axis load, as an illustration (not recommended).

Notice: To access the IP third set screw slide down the XYS.

15. ONAG® helical focuser operation

Both ONAG® are equipped with the same helical focuser at the GP.
The image below shows the ONAG® helical focuser.



ONAG® SC/XM helical focuser

The helical focuser provides a smooth fine focus capability for the guider. Each turn (360 degrees) move the focuser by 800 microns (0.8mm).

For focusing, unlock the focuser locking screw, and just rotate the focus ring in either directions until you have reached focus with the guider, one turn is 800 microns (0.8mm). When reversing the focuser ring direction we recommend to compensate any backlash by at least a half turn.
When at best focus then hand tighten the focuser locking screw. This screw is equipped with a 5/32" hex socket, if you use an Allen wrench do not over tighten it you may damage your helical focuser otherwise.
This procedure should give you a good enough rigid focus position for most setups and guiders. However you can continue to rotate the focus ring in the same direction, while the focuser locking screw has been locked, until you encounter some resistance. This will remove any possible play and it is recommended for heavy guiding cameras. However doing so may upset too much your initial focus position.

Therefore we suggest the following procedure from this point:

Step 1: Record by how much you could rotate the focuser ring, in the same direction, past the best focus position after you have tightened the focuser locking screw.

Step 2: Unlock the focuser locking screw, and back off (reverse the direction) the focus ring until you are back at the previous best focus position. You can monitor the guide star for help.

Step 3: Continue to back off the focuser ring by the recorded amount from step 1 plus a half turn.

Step 4: Rotate now the focuser forward (same direction than in step 1) by a half turn.

Step 4: Lock again the focuser locking screw and now continue to rotate the focuser ring forward (you should eventually experience some resistance) until it is back to the best focus position again (you can use the guise star for help).
If successful you should have experienced some resistance when the focuser ring was back at the best focus position.

16. Use of a 1¼" guider with the helical focuser

The ONAG® SC/XT guider helical focuser supports 1.25" guiding cameras, such as the SX lodestar, or SBIG ST-i. The camera body can be inserted inside the focuser tube. There are two UNC #4-40 stainless set screws to secure it in place (required a 0.05" Allen wrench).

The picture below shows the focuser tube with its male T-thread (T2 M42 x 0.75mm) and the location of both set screws.

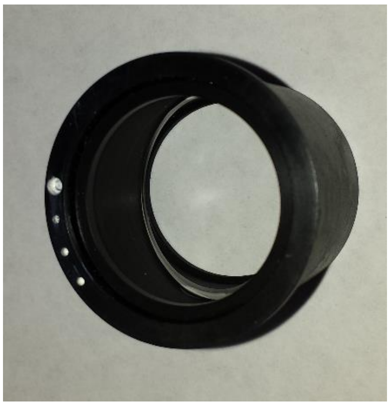
ONAG guider helical focuser and its set screws

Depending of the version of the helical focuser the 1.25” recess depth is between 10mm to 20mm. The focuser draw tube has a stop such there is not risk for any 1.25” diameter body to fall inside the ONAG®.
Using this configuration offers the opportunity to decrease the guiding camera backfocus.
Alternatively you can use a T-mount (M42 x 0.75mm) to 1.25” adapter to connect your device. Such adapter can be order from various third party suppliers, such as:

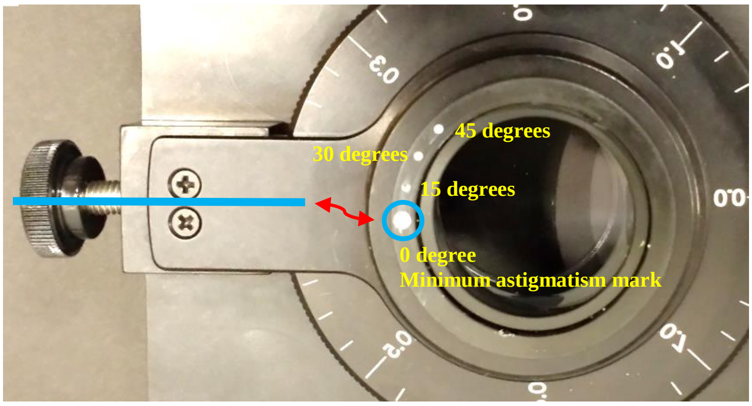
http://www.scopestuff.com/ss_tadpt.htm

17. Optional astigmatism corrector

Since the starlight reaching the guider went through the ONAG® DBS the guide star shape exhibits some level of astigmatism. This is normal and not a concern for auto-guiding in most cases. If you experience some problems here we recommend binning the guider at least 2x2.
For fasts scopes with F/# below 6 and/or reflector with a central obstruction (secondary mirror) bigger than about 40%, as well as for imaging in NIR at the ONAG® GP, you may want to consider our optional 1.25” astigmatism corrector (see the bottom left picture).



astigmatism corrector



astigmatism corrector mounting and setting

The astigmatism corrector slides inside the ONAG® guider draw tube like a 1.25” body guiding camera would do, see section 16 for further information.
The corrector has 4 marks, the largest white dot is the minimum astigmatism reference position, encircled in blue on the above right picture.
It should be aligned with the ONAG® GF leg and locking screw, shown as a blue line in the above picture, for minimizing the ONAG® astigmatism.
When set this way the GP images are near the diffraction limit. The corrector may prohibit the use of our continuous real time auto-focus technology *SL* and related software FL. However it can be rotated to dial back some level of

astigmatism. For convenience each small white dot mark adds an incremental 15 degrees angle of rotation.
If you plan to use FL with this corrector we recommend that you start with the minimum astigmatism position (largest white dot) and, if needed, you would rotate the corrector one small white dot (15 degrees) at the time until FL can be properly calibrated.

Notice: When using the astigmatism corrector the ONAG® GP optical back focus distance (OGBF) is reduced by 3mm, which means that the guider should be moved forward by about 3mm to reach focus versus without the corrector.
Although the astigmatism corrector can be used with any versions of the ONAG® XM, some ONAG® SC versions are no supported. If you face such a limitation please contact us.

18. Specifications (no spacer or adapter attached)

In between […] for XM version.

Over all dimensions:	123 x 92 [110] x 83 [70] mm
ONAG® weight:	790 [850] g
Imager back focus:	66 [68] mm +/-2mm
GP back focus, focuser half extended:	90 [101] mm +/-1mm
X/Y stage, full X travel:	37 mm
X/Y stage, full Y travel (excepted low profile):	28 [24] mm
X/Y stage, maximum off-axis offset:	23 [22] mm
X/Y stage maximum exploration circle:	46 [44] mm
Guider focuser type:	helical (no camera rotation)
Guider focuser travel:	9 mm (minimum)
Scope port:	T-thread (M42) [dovetail]
Imager port:	T-thread (M42) [dovetail]
Guider port:	T-thread (M42)
Dichroic beam splitter coating:	Fully multi-coated
Dichroic beam splitter protection (both sides):	Optical grade quartz
Dichroic beam splitter reflection (visible):	> 98% (typical)
Dichroic beam splitter visible range:	> 370 nm to 750 nm
Dichroic beam splitter transmission (NIR):	> 90% (typical)
Dichroic beam splitter NIR range:	> 750 nm to 1200 nm
Anodizing:	Black

19. Warnings, maintenance and care

As with any high quality optical device, the ONAG® should be handled with care. Do not drop the ONAG® or submit it to excess vibrations or temperature.

The ONAG® has been assembled with precision to insure accurate alignment of the dichotic beam splitter (DBS) in relation with all the optical ports, therefore resist disassembling the ONAG® body.
Doing so may result in image distortion due to misalignments, but also will void the warranty.

The ONAG® SC scope port (SP) provides a standard female T2 for mounting the ONAG® SC to a scope or another device, be sure when you screw any equipment there that the associated male T2 length will not interfere with the dichroic beam splitter (DBS). Failure to do so may scratch the DBS surface. As guidance only you may want the **male T2 no longer than 5mm**. If longer, then consider using a T2 locking ring to control the thread penetration depth.

We also recommend, as good practice, that **each camera has a backup mean to stop it for falling**, should the primary mechanical interface fails for any reason. A string could be used for this, see what your camera user guide may suggest too. Check the various connections and related screws, when applicable, in a regular basis. Do not overload your ONAG®.
Innovations Foresight would not be responsible for product (any ONAG® and associated accessories) and equipment damages due to failure to follow proper procedures, recommended care, and good practice.

Should you need to clean the DBS, first **remove any dust using optical grade compressed air, or brush**. Do it gently to avoid scratching the DBS coatings. If necessary, and only if, you could use a cleaning product for multi-coating optical elements. Never apply such product directly to the DBS surface, instead use an optical grade soft tissue and gently clean the surface with the minimum of force and pressure as possible.

If needed the X/Y stage can be lubricated, time to time, with light aluminium compatible grease for extended temperature range. **Never use oil.**
Use a minimum of grease and be sure it will not find its way inside the ONAG® body, nor spill on the DBS and cameras.

Never look at the sun, or any bright sources, or lasers, … with the ONAG®, from any optical ports. Doing so could result in serious injuries.
Products performances, specifications and features can be changed without warning.

20. Limited Warranty

This Innovations Foresight (IF) on-axis guider device (ONAG®) is warranted against defects in materials or workmanship for a period of one year from the date of purchase. This warranty is for the benefit of the original retail purchaser only. During this warranty IF will repair or replace, at IF's discretion, any warranted device that proves to be defective, provided it is returned postage paid to IF at 24 Ramblewood drive, Glenmoore, PA 19343.
If the product is not registered, proof of purchase (such as a copy of the original invoice) is required.
This warranty does not apply if, in IF's judgment, the instrument has been abused, mishandled, not properly cared of, or modified, nor does it apply to normal wear and tear. This warranty gives you specific legal rights, and you may also have other rights, which vary from state to state. For further warranty service information, contact IF:

http://www.InnovationsForesight.com, or +1.215.884.1101

21. Registration

Product name/type: ………………………….……………..

Serial Number: ………………………………………..

Date of purchase: ………………………………………...

Where did you buy it?: ………………………………………..

Have you registered with us before? YES NO

First name: ……………………………………………….

Last name: ……………………………………………….

Address: ……………………………………………….

City: ……………………………………………….

State/Prov.: ……………………………………………….

ZIP code: ……………………………………………….

Country: ……………………………………………….

Phone (day time): ……………………………………………….

email: ……………………………………………….

Please take a moment to answer the following questions.

How did you hear about us?

On which equipment do you plan to use our product?

Any comments?

Please copy and send this form to:

Innovations Foresight

24 Ramblewood Drive

Glenmoore, PA 19343

United State of America

22. Glossary

AFR	Adjustable focal reducer
BFO	Back focus offset
BWD	Back working distance
DBF	Differential back focus
DBS	Dichroic beam splitter
FL	FocusLock (software for real time auto-focus)
FR	Focal reducer
GBF	Guider back focus
GF	Guider focuser
GP	Guider port
IBF	Imager back focus
IF	Innovations Foresight (LLC)
IP	Imager port
IPBF	Imager port back focus
NIR	Near infrared
ONAG®	On axis guider
SCT	Schmidt Cassegrain telescope
SL	*SharpLock* (patent pending IF real time autofocus technology)
SP	Scope port
TOBF	Total optical back focus
XYS	X/Y stage

23. Notes