



Iris AO, Inc.

Iris AO Kit User Manual

Version 1.3



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1 Introduction

This document provides assembly and operating instructions for the Iris AO Kit. For more specific information about your Iris AO Deformable Mirror, please refer to the “Iris AO PTT Deformable Mirror System User Manual” also included with this kit.

1.1 About Your Iris AO Kit

The Iris AO Kit is an image-based Adaptive Optics (AO) imaging solution which consists of a deformable mirror (DM), Graphical User Interface (GUI), controller software, optical components, and a camera. The DM included is ideal for correcting monochromatic and temporally changing aberrations. The standalone controller GUI allows for modal control of the first 21 Zernike modes, global control of the DM in piston tip-tilt (PTT) position, and zonal PTT control of individual segments.

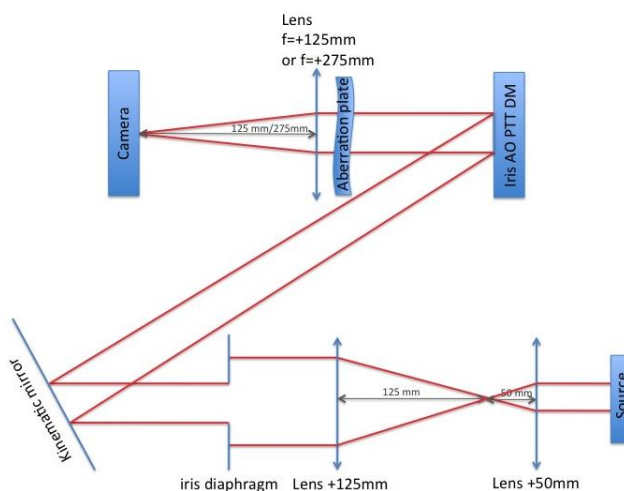
Included in your Iris AO Kit:

- Deformable Mirror
- Laser Source
- Basic Mechanical Components
- Beam Expansion and Cropping Components
- Imager Arm
- Aberration Element and Accessories
- Narrow FOV Imager Arm and Accessories

The Iris AO Kit (as seen in the schematic below) can be used as:

- An introduction to wavefront sensorless AO. The user can refine his or her understanding of the effects of aberrations introduced in a collimated beam. Users can also develop their own software to improve image quality using Iris AO’s application program interface (API) to control the DM.
- A stand-alone aberration compensator. The user can insert the kit into an existing optical system to correct aberrations in the optical path. Compensations can be performed manually using the controller GUI or by using automatic algorithms that monitor and improve the beam quality in real time.
- A development and testing system for beam splitting, beam shaping, and other complex algorithms.

NOTE: Both the Iris AO deformable mirror and the USB camera included in the Iris AO kit are only controllable with a Windows 7 computer with 32 or 64 bit OS.



Schematic 1: The Iris AO Kit and its main components

2 Assembling your Iris AO Kit

2.1 List of Parts

Below is a list of items included in your Iris AO Kit with pictures, descriptions, and product numbers:

Basic Mechanical Components	Description	Qty	Part #
	Bench Plate	1	54640
	M6 Screws	1	55195
Laser Source	Description	Qty	Part #
	Steel Post (2" Length, 1/4-20 Stud)	1	58999
	5V DC Power Supply Compatible with 83836	1	83855
	Laser Diode	1	83836
	Mounting Clamp Compatible with 83836	1	83856
	Post Holder (M6)	1	58972

Aberration Element	Description	Qty	Part #
	Post Holder (M6)	1	58972
	Steel post (2" Length, 1/4-20 Stud)	1	58999
	Optic Mount (25.4 mm x 10 mm T1 Optic Diameter)	1	64561
	Aberration plate (1/8" thick, clear cast acrylic, 1" Diameter)	1	Iris AO 021-003-01
Beam Expansion/Cropping	Description	Qty	Part #
	Achromatic Lens (12.5 mm Dia. x 50 mm FL, VIS-NIR, Inked)	1	49328INK
	Achromatic Lens (12.7mm Dia. x 125 mm FL, VIS-NIR, Inked)	1	83417INK
	Iris Diaphragm (30.8 mm Outer Diameter, Mounted Stainless Steel)	1	62657
	Kinematic Mount (25/25.4 mm Diameter, 2-Screws)	1	58851
	Large Base Plate (Metric)	1	58996
	Kinematic Mirror (25 mm Diameter Enhanced Aluminum)	1	45604
	Optic Mount (12.7 mm Optic Diameter)	2	64556
	Steel post (2" Length, 8-32 Stud) Compatible with Iris Diaphragm	1	58962
	Post Holder (M6)	4	58972
	Steel Post (2" Length, 1/4-20 Stud)	3	58999

Deformable Mirror and Accessories	Description	Qty	Part #
	Iris AO 111 Actuator Deformable Mirror	1	33267
	Post Holder (M6)	1	58972
	Steel post (2" Length, 8-32 Stud) Compatible with Iris AO 111 Actuator Deformable Mirror	1	58962
Imager Arm	Description	Qty	Part #
	Achromatic Lens (12.7 mm Dia. x 125 mm FL, VIS-NIR, Inked)	1	83417INK
	Optic Mount (12.7 mm Optic Diameter)	1	64556
	USB Camera (EO-1312M 1/2" CMOS Monochrome)	1	59365
	Mounting Plate Compatible with 59365	1	59473
	ND filter (3.0 OD 12.5 mm diameter, absorptive)	2	48533
	C-mount (12.5 mm Diameter)	2	55246
	Steel post (2" Length, 1/4-20 Stud)	2	58999
	Post Holder (M6)	2	58972
	Large Metric Base Plate	1	58996
	USB 2.0 Cable (5m, mini-B to standard-A)	1	59-382
Narrow FOV Imager Arm	Description	Qty	Part #
	Achromatic Lens (25 mm Dia. x 275 mm FL, VIS-NIR Coated)	1	49367
	Optic Mount (25.0 mm Optic Diameter)	1	64560
	Steel Post (2" Length, 1/4-20 Stud)	1	58999

2.2 Placement

The bench plate is composed of 192 holes in a 24 x 8 grid pattern. All holes have M6 threads and are separated by 25 mm of space. For the purposes of this manual, the holes have been labeled based on a Cartesian coordinate system. Since the lower right hand corner of the bench plate is where the laser source is located, the hole in that corner is identified as (1,1). All coordinates are positive numbers. Positions of post holders for all optical components are labeled, **see Figure 1 below**. Note that the camera must be mounted on a base plate to allow for more accurate positioning.

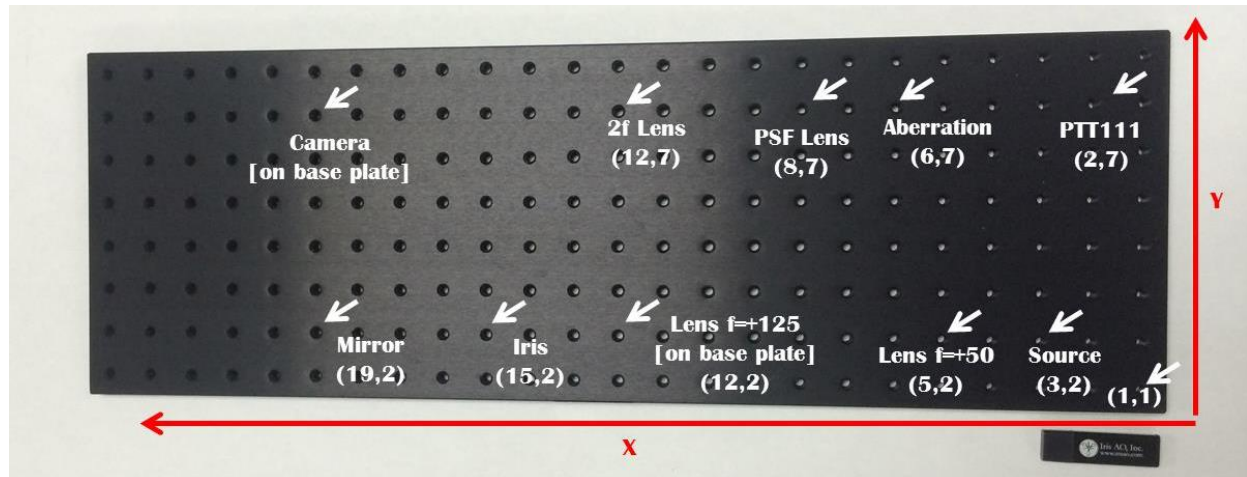


Figure 1: The Iris AO Kit bench plate with coordinate positions for all optical post holders. This figure will be referenced throughout the manual.

To attach post holders to the bench plate, follow these steps:

- Attach one M6 screw to the base of each post holder using a 7/64" Allen wrench (Allen wrenches not included), **see Figure 2, below**.

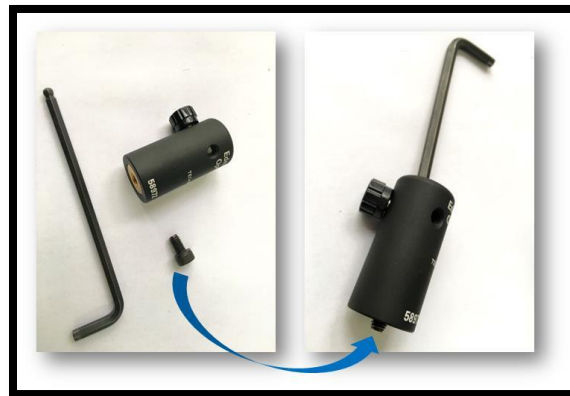


Figure 2: Placement of M6 screw into the bottom of a post holder

- Screw seven post holders to the bench plate referencing the coordinates (2,7), (3,2), (15,2), (19,2), (6,7), (5,2), and (8,7). Then, screw two base plates to the bench with one post holder on each as in **Figure 3, below**.

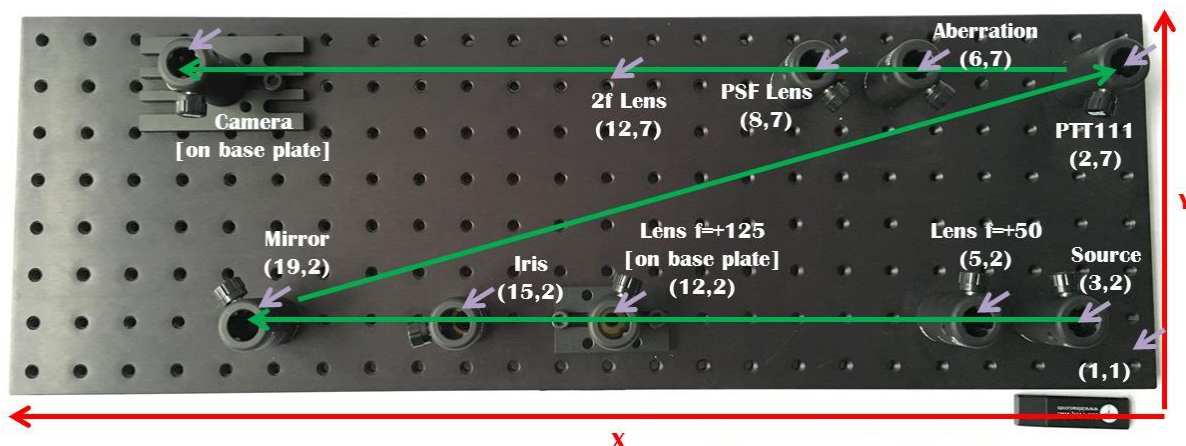


Figure 3: Iris AO Kit bench plate with post holders and base plates

2.3 Laser Source

The laser source is composed of:

- 635 nm 0.9mW diode module laser with a CW circular beam (83836)
- 5V power supply (83855)
- Mounting clamp (83856)

See the table in section 1 for pictures of the above laser source components. The following directions explain how to assemble your laser source:

- Insert the laser diode into the mounting clamp.
- Tighten the diode to the mounting clamp with a 7/64" Allen wrench.
- Place mounted laser diode at coordinates (3,2).
- Turn on the laser source by plugging in the power cable and pushing the corresponding power button.
- Adjust the position of the laser diode so the center of the beam is about 8 cm from the bench plate surface. The laser diode should be perfectly horizontal, **see Figure 4 below**.



Figure 4: The laser diode is perfectly horizontal and about 8 cm from the bench plate surface. Please note the mount shown in the picture above may be different than the one found in your kit.

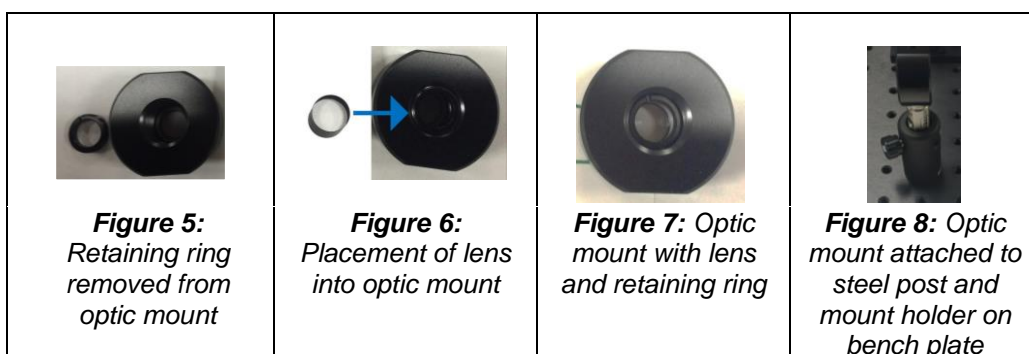
2.4 Lenses and Mounts

4 convex lenses are needed for this section:

- Achromatic Lens, 12.5 mm Dia. x 50 mm FL, VIS-NIR, Inked (49328INK)
- Achromatic Lens, 12.7 mm Dia. x 125 mm FL, VIS-NIR, Inked (83417INK)
- Achromatic Lens, 12.7 mm Dia. x 125 mm FL, VIS-NIR, Inked (83417INK)
- Achromatic Lens, 25 mm Dia. x 275 mm FL, VIS-NIR Coated (49367)

The following directions explain how to assemble your lenses and mounts. *We recommend completing this assembly with protective gloves to avoid contaminating the lenses.*

- With a flathead screwdriver, unscrew the black retaining ring from the optic mount as in **Figure 5, below**.
- Leave the white protective ring on the base of the optic mount and insert the $f = +50$ lens into the lens slot at the center of the optic mount as in **Figure 6, below**.
- Reinsert the black retaining ring onto the optic mount, **see Figure 7 below**.
- Place assembled optic mount at coordinates (5,2), **see Figure 8, below**.
- Repeat the above mounting procedure for all other lenses and place according to the corresponding coordinates in **Figure 1**.
- Adjust the positions of the lens mounts so the centers of each lens are about 8 cm from the bench plate surface.



2.5 Iris Diaphragm

The iris diaphragm (62657) is used to crop the beam size to 3.5 mm on the Iris AO PTT DM. To assemble the iris diaphragm, follow these steps:

- Screw the iris diaphragm onto a steel post and insert into the post holder at coordinates (16,2).
- The fully assembled iris diaphragm should look like the picture below, **see Figure 9**.
- Adjust the position of the center of the iris diaphragm so it is about 8 cm from the bench plate.

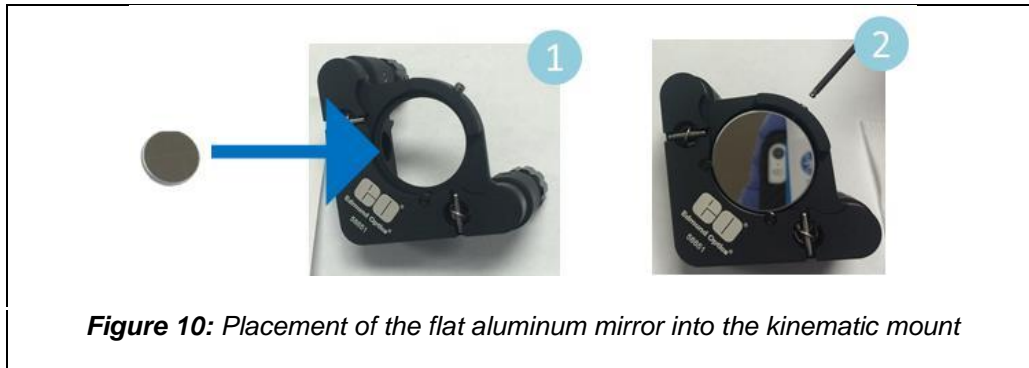


Figure 9: Picture of assembled iris diaphragm inserted into bench plate.

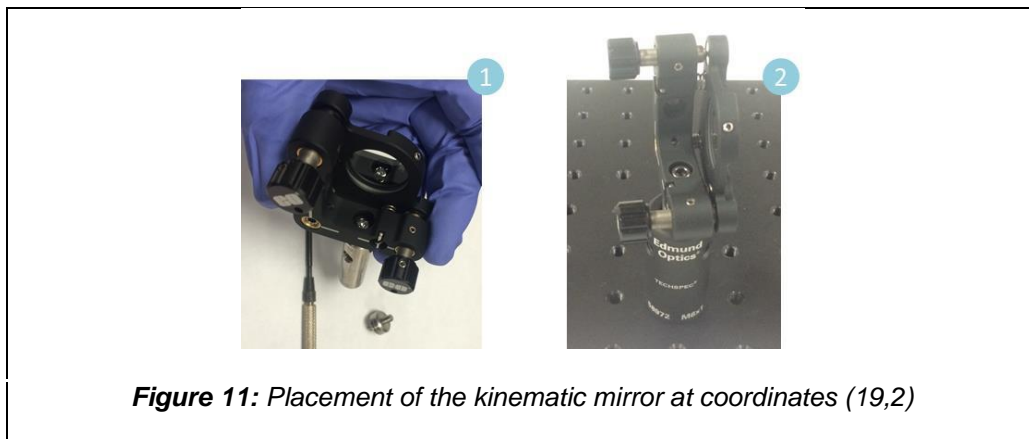
2.6 Kinematic Mirror

The kinematic mirror (45604) is used to reflect the collimated beam towards the DM. It adjusts the beam position onto the DM by tilting and tipping using two levers. To assemble the kinematic mirror, follow the steps below. *We recommend wearing gloves when mounting the mirror to avoid contamination.*

- Using a 1.5 mm Allen wrench, attach the kinematic mirror to the kinematic mount (58851) with the provided screw, **see Figure 10, below:**





- Unscrew the long male adapter on the steel post (58999) at coordinates (19,2) as in **Figure 1** to get access to a female M4 thread. Then use an M4 screw provided with the kinematic mount to attach it to the steel post, **see Figure 11 below:**



- Adjust kinematic mirror so that center is at about 8 cm from the bench plate surface.

2.7 Deformable Mirror (DM)

The DM is the heart of your AO Kit. It will enable you to control the phases of your wavefront shape and see the effects of different phase modulations on the imager camera in real time. Mounting instructions are below. *Please note the DM should be handled with caution, see warnings below before assembly:*

	<p>The Iris AO PTT DM is a static-sensitive device that can be damaged by electrostatic discharge (ESD). Always take proper ESD precautions when handling the mirror. Precautions include discharging static charge by wearing a grounded wrist strap while handling the mirror and avoiding contact with the connector pins.</p>
	<p>The Iris AO PTT DM can be damaged by shock. Do not drop the deformable mirror onto hard surfaces.</p>

- Mount the DM (33267) directly onto a steel post
- Insert the DM with mounting post into the post holder at coordinates (2,7), **see Figure 12 below.**



Figure 12: Placement of the DM at coordinates (2,7)

2.8 Camera

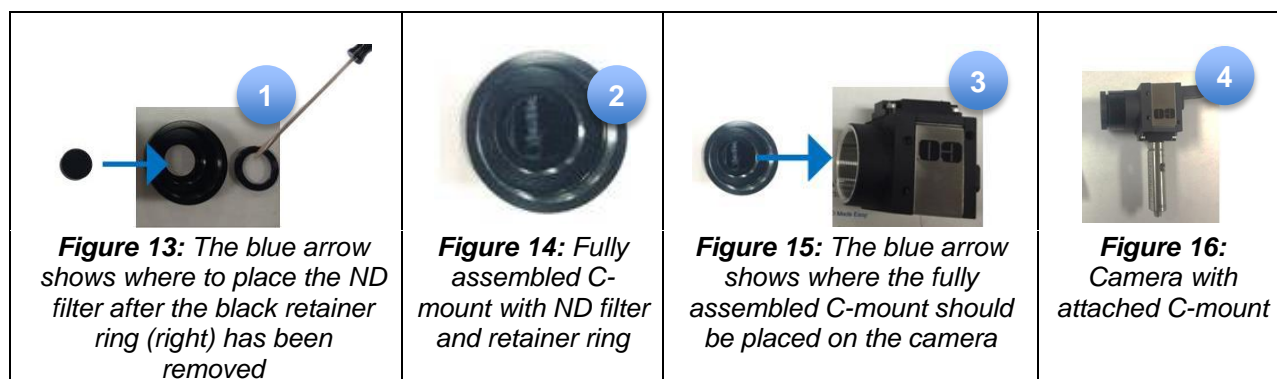
A CMOS Monochrome USB camera is used in combination with a 1f setup to image the point spread function (PSF). To assemble and mount the camera, see the instructions below. *Please note the camera is highly sensitive.*

- Attach the camera (59363) to a steel post with using an Allen wrench and accompanying screws.
- Insert camera with steel post into the post mount labeled “Camera” in **Figure 2.**

To avoid saturation, the camera must be equipped with 2 ND filters with OD=3 (48533) corresponding to a transmission of $10^{-(OD=3 \times 2)} \times 100 = 10^{-4}$. The ND filters are stacked together using two C-mounts (55246) in front of the camera.

To attach the filters, follow the instructions below. *We recommend wearing gloves to avoid contaminating the filters.*

- Use a flathead screwdriver to remove the retainer ring from the C-mount.
- Insert the ND filter and carefully screw the retainer ring back onto the mount, **see Figures 13 and 14 below.**
- Screw the C-mount onto the camera, **see Figure 15 below.**
- The camera with attached C-mount can be seen in **Figure 16 below.**
- After assembling the second ND filter, attach it directly onto the first C-mount that is already attached to the camera.



- Plug the camera into your computer using a USB cable (86770).

3 Camera

3.1 Software Installation

Refer to the Edmund Optics USB 2.0 Camera Installation manual provided with the camera to learn about safety instructions and precautions.

- The latest drivers can be downloaded at <http://www.ids-imaging.com/go/edmund/>. Choose the full software setup when downloading. All files are packed in ZIP archives.
- Extract the ZIP archive and start the setup (.exe file). Choose “complete” to install all drivers with demo applications and manuals.
- Connect the camera. Once connected, the driver installation should start automatically. On the initial connection, two driver files will be installed. The LED on the back of your camera will then light up and indicate the camera status. If the LED is red, then the driver did not load. If the LED is green, then the driver is loaded and the camera is ready.

3.2 Control

- The software to operate your camera can be found by selecting Start>All Programs>IDS.
- Use “uEye Cockpit” to change the camera settings and capture or save images.

4 DM Software Installation

The DM is controlled by using the 14-bit high-voltage Smart Driver II. The Smart Driver II connects to the DM with an HV cable and then to a computer with a USB cable or SCSI, **see Figure 17 below**. For more information about the DM and the Smart Driver II, consult the PTT111 DM Installation and Operating Manual included in your Iris AO Kit.

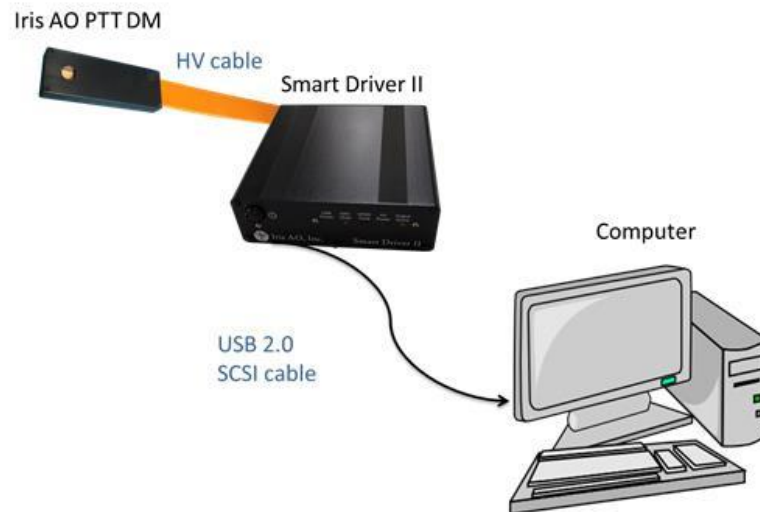


Figure 17: DM connected to Smart Driver II and Computer

5 Aligning the Iris AO Kit

5.1 Beam Expander and Iris Diaphragm

The beam expander, which is composed of two lenses, can expand the size of the beam from the laser source from 1-2 mm to about 7 mm. A circular portion of the beam (~3.5 mm in diameter) can be cropped using the iris diaphragm. To use the beam expander and iris diaphragm, follow these steps:

- Turn on the laser source by plugging in the diode and pushing the corresponding power button.
- Make sure the surfaces of the two lenses, $f=50$ mm and $f=+125$ mm, are perpendicular to the beam and the beam is centered.
- You can locate the beam by using a white notecard, see below.

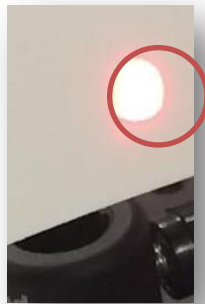


Figure 18: Laser beam spot (circled) on white note card

- Adjust the alignment beam by rotating the laser diode and moving the lenses up or down.
- The beam should have a circular shape once the lenses are properly aligned.
- Center the iris diaphragm with the beam.
- Set the beam diameter to ~3 mm by adjusting the lever located on the iris diaphragm.

5.2 Kinematic Mirror and Deformable Mirror

The kinematic mirror is a flat aluminum mirror that reflects the beam onto the DM. The X-Y beam position on the DM can be adjusted using the lever on the kinematic mirror.

- Adjust the position of the kinematic mirror so the beam is centered with the DM, **see Figures 19 and 20 below.**
- The DM should be about 8 cm above the bench plate.

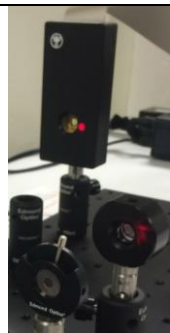


Figure 19:
Not centered



Figure 20:
Centered

5.3 Imager Arm

The imager arm consists of the following:

- Achromatic Lens (12.7 mm Dia. x 125 mm FL, VIS-NIR, Inked)
- Optic Mount (12.7 mm Optic Diameter)
- USB Camera (EO-1312M ½" CMOS Monochrome)
- Mounting Plate | Compatible with 59365
- ND filter (3.0 OD 12.5 mm diameter, absorptive)
- C-mount (12.5 mm Diameter)
- Steel post (2" Length, 1/4-20 Stud)
- Post Holder (M6)
- Large Metric Base Plate
- USB 2.0 Cable (5m, mini-B to standard-A)

The above listed achromatic lens performs as a two-dimensional Fourier transform of the object plane (the field strength that can be controlled in phase using the DM). The camera located at the focal plane records the power spectrum of the resulting function, also called the Point Spread Function (PSF).

- Make sure the lens ($f=+125$ mm) used to image the PSF is perpendicular to the beam's optical axis.
See Figure 21.
- The reflected beam should be parallel to the bench plate surface.
- For best focus, move the camera along the base plate to about 125 mm away from the lens.

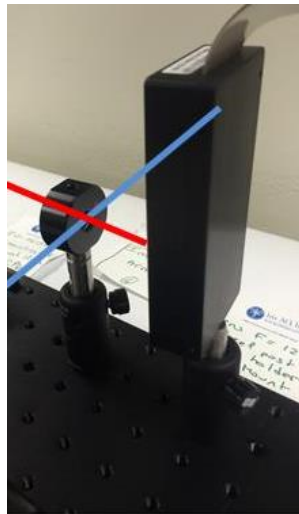


Figure 21: The plane of the lens surface (represented in blue, above) should be perpendicular with the path of the laser beam (represented in red, above)

6 Image Quality

Image quality depends on the alignment of the optical components and the size of the beam reflected on the DM. Image quality can be optimized by simultaneously operating the Iris AO Controller GUI and adjusting the position of the beam on the optical parts as well as the position of the PSF Camera. The sections below describe how to operate the DM and the camera.

6.1 Powering the Iris AO DM

Once the DM is properly connected to the Smart Driver II with the HV output cables, the following steps should be followed to power up the Iris AO DM:

- Connect the Smart Driver II to the computer with the provided USB cable – the LED under *USB Power* will light up, **see Figure 22 below**.
- Connect the Smart Driver II to a power source and turn on the power switch – the LED under *HV Power* will light up, **see Figure 22 below**.



Figure 22: Notice the LED lights under “USB Power” and “HV Power” light up after connecting the Smart Driver II to a power source and a computer



- The Iris AO DM can be damaged by over-voltage. Before operating a DM, make sure the proper configuration files are in place for both the DM and the Smart Driver II.
- Do not jar, pound, or bang on the DM when powered. Resistance to damage caused by mechanical shock is reduced when powered.

6.2 Centering and Focusing the Camera using uEye Cockpit

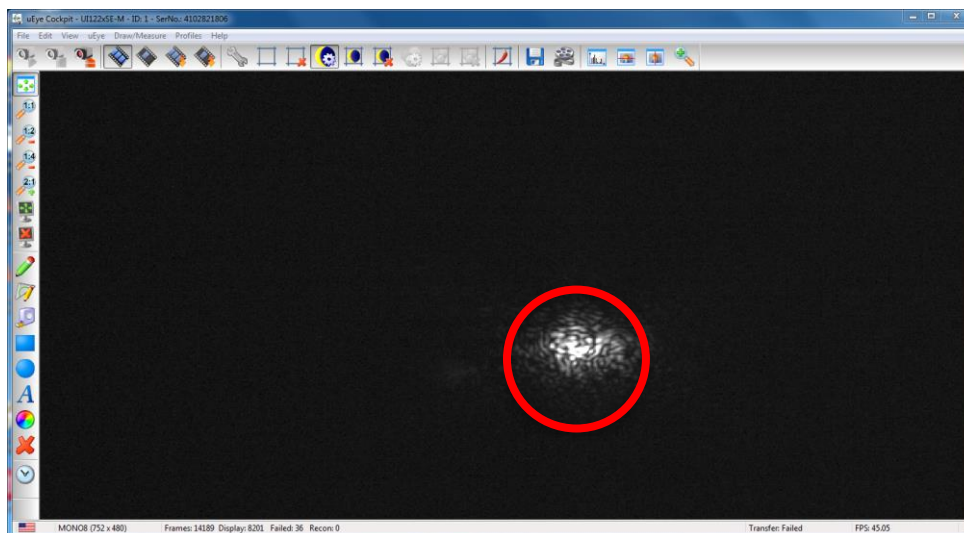
- Install the camera software following the instructions located in the camera packaging
- Start uEye Cockpit in **Monochrome** Mode. Confirm **Start uEye Cockpit in expert mode** option is selected.



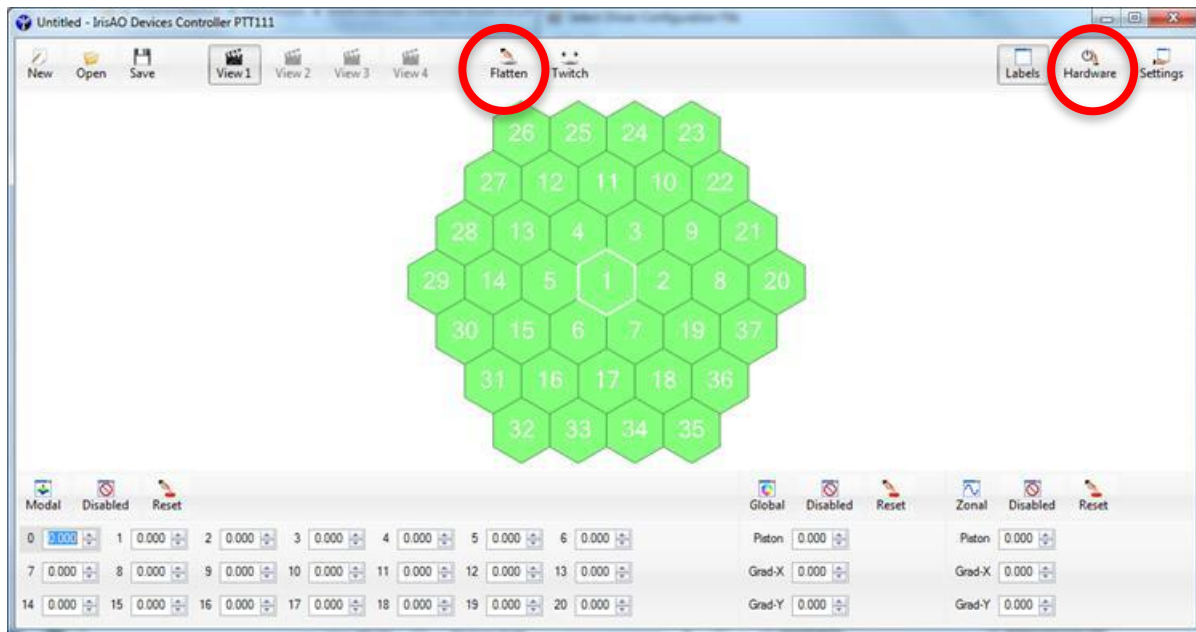
- Click on the left-most icon in the top menu to start the real-time video display.



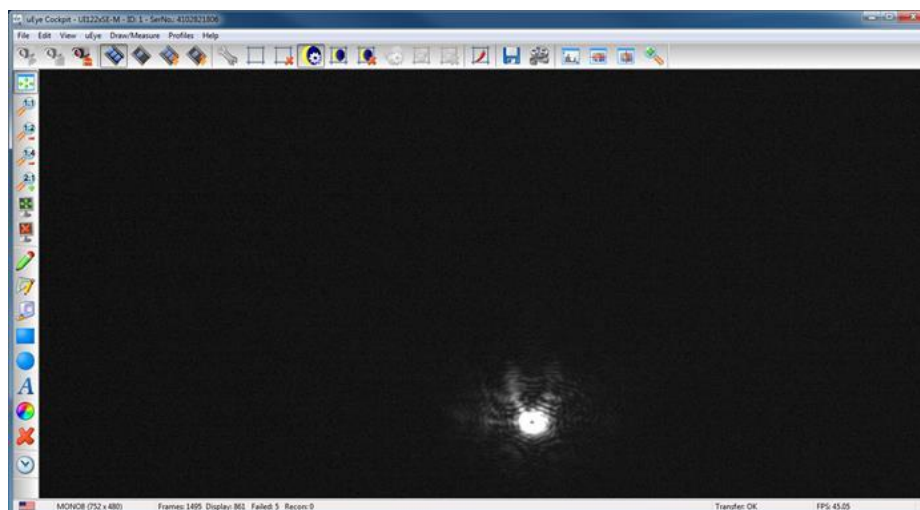
- The camera will automatically set its parameters and display a PSF which will look like a shapeless form on the screen as the DM is not flattened, see below.



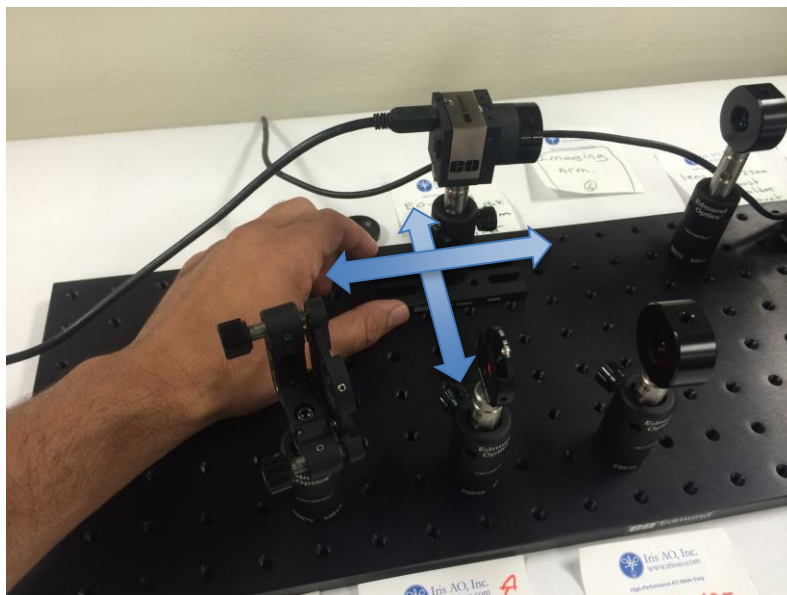
- Load the configuration files for your DM at: Iris AO Installation Disk v1.0.2.5\Customer-Specific Configuration Files on the Iris AO USB drive
- Make sure the hardware is enabled by clicking on **Hardware**, see below.
- Flatten the mirror by clicking **Flatten** in the Toolbar, see below.



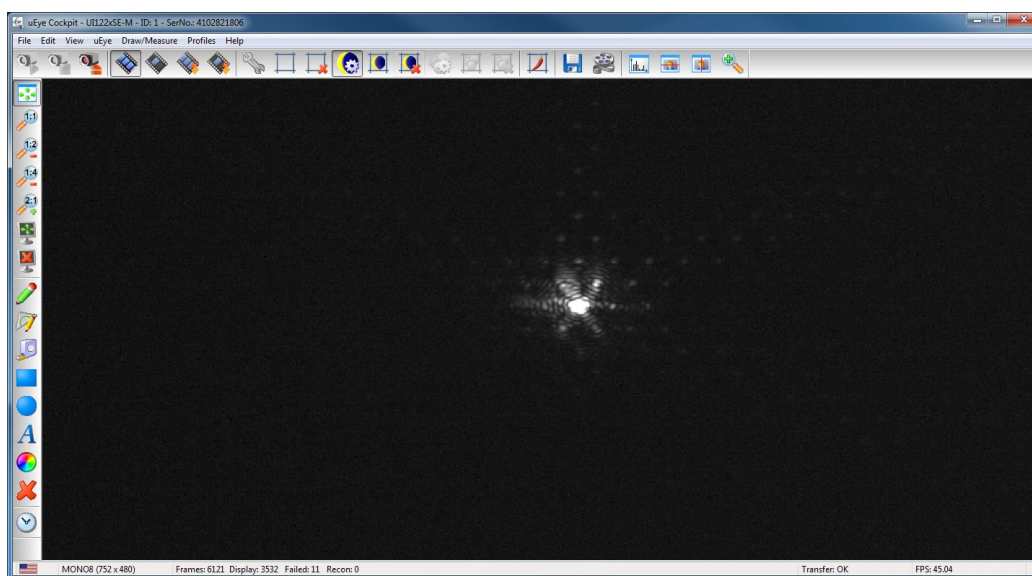
- Center the PSF by adjusting the position of the camera. The spot on the screen should change shape and move slightly. The optimal position can be found by directly visualizing the PSF on the computer screen. In the example below, the camera is off-center.



- Move the camera laterally on the bench plate to center the PSF in the middle of field view on the computer screen. Move the camera along the beam axis to improve the focus, see arrows in the image below.



- The PSF in optimal focus and in centered position is shown below. Notice, the PSF displays a coherent, saturated peak, and several secondary peaks.

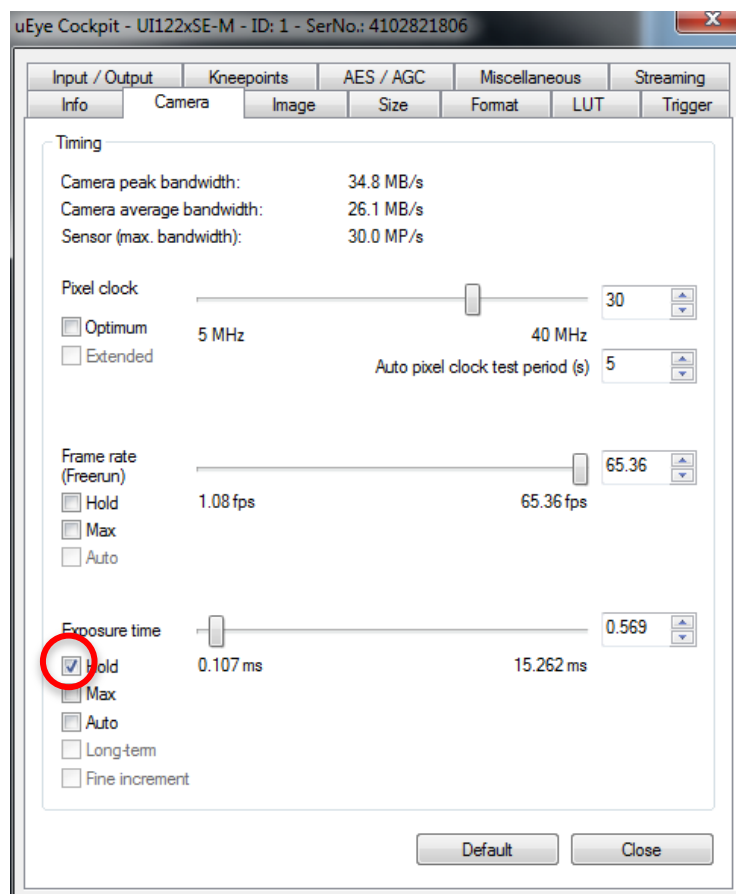


6.3 Adjusting the Exposure Time

- To adjust the exposure on the camera, click the wrench icon to open the “Camera Properties” of the uEye Cockpit software, see below.



- Under **Exposure time**, click on the box entitled **Hold**. Then reduce the exposure time to ~0.6 ms



- You can check the saturation status of the PSF by selecting the “Show horizontal line view window” (see below) and centering the horizontal line on the maximum of the PSF.



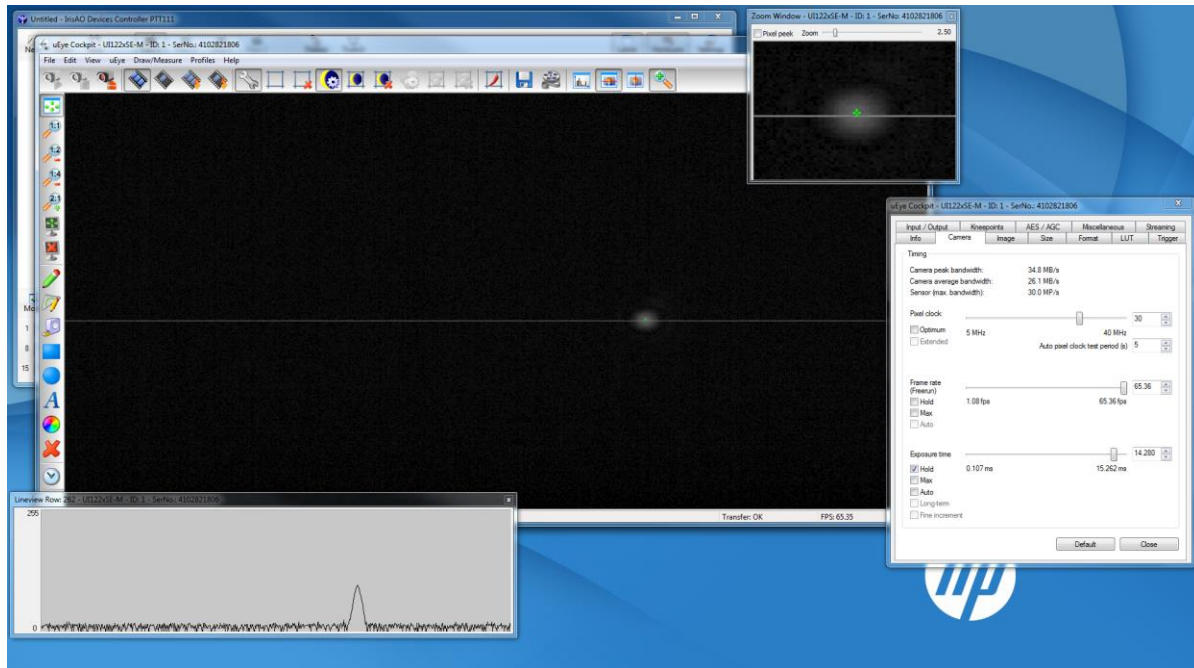
6.4 Adjusting the Frame Rate

- To adjust the frame rate on the camera, click the wrench icon to open the “Camera Properties” of the uEye Cockpit software.
- Under **Exposure time**, click on the box entitled **Hold** to make adjustments. For the purposes of this manual, no adjustments will need to be made to the frame rate at this time.

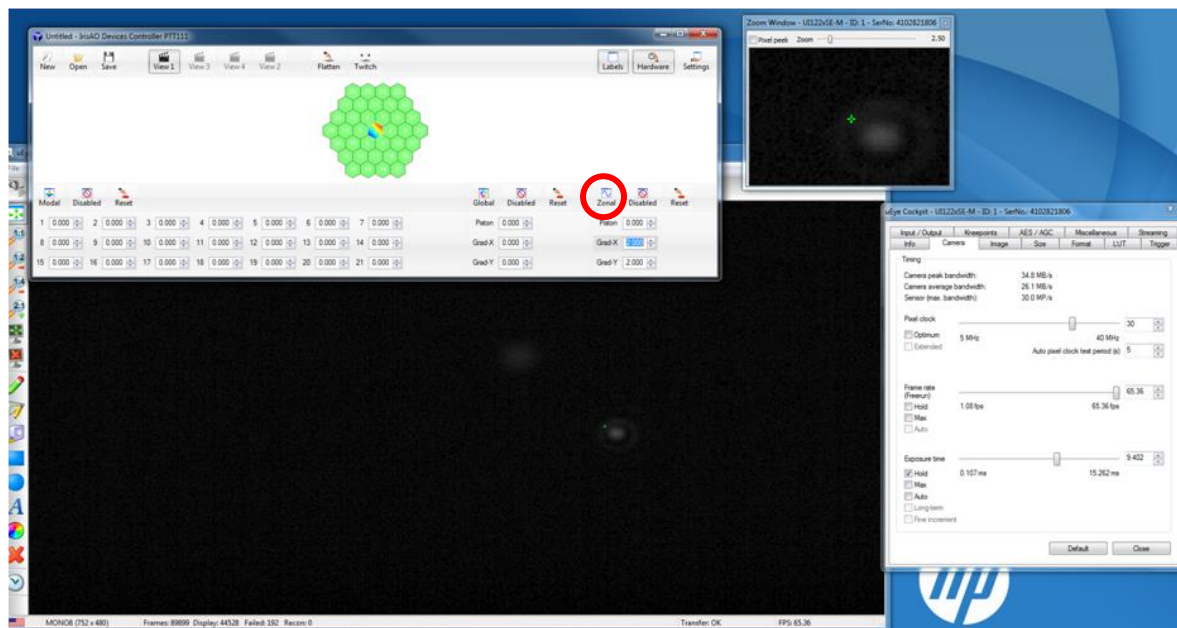
6.5 Centering the Beam

To center the beam on the DM, adjust the DM Controller GUI, the Iris Diaphragm, and the uEye Cockpit:

- Run the controller GUI and flatten the mirror.
- Close the iris diaphragm to the smallest size (diameter ~0.9 mm).
- Adjust the exposure time to ~14 ms.
- The display on the screen should look like this:



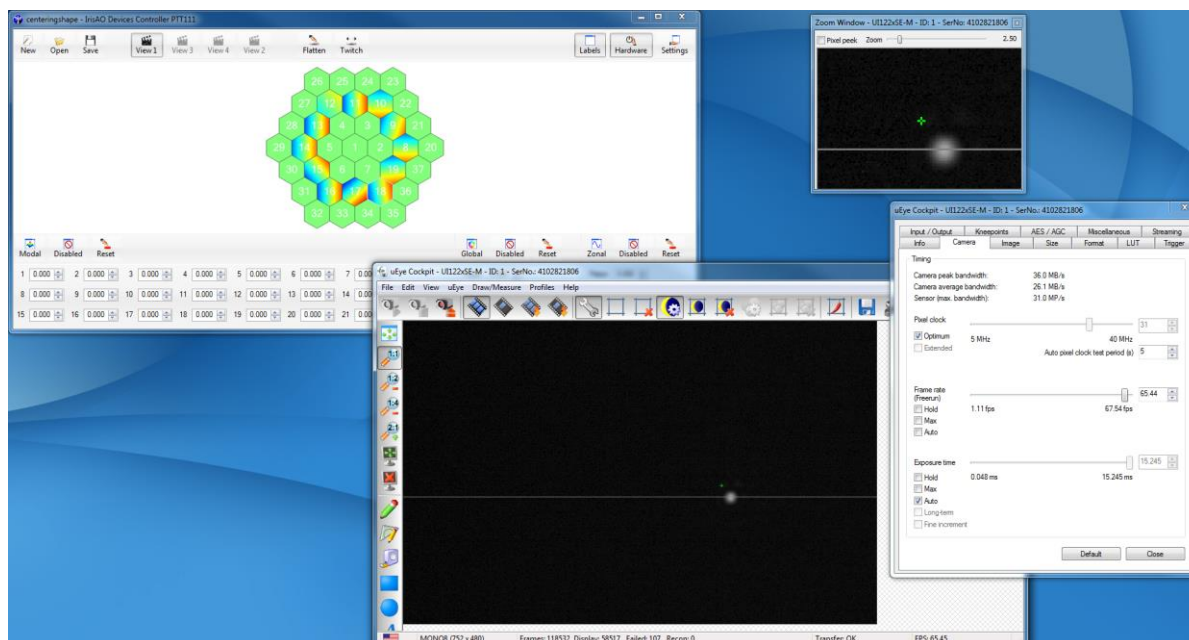
- Note that the PSF is round and does not display secondary minima since the beam is reflected mostly by one segment.
- Enter into **Zonal** control in the GUI by clicking on the button circled in the screenshot below:



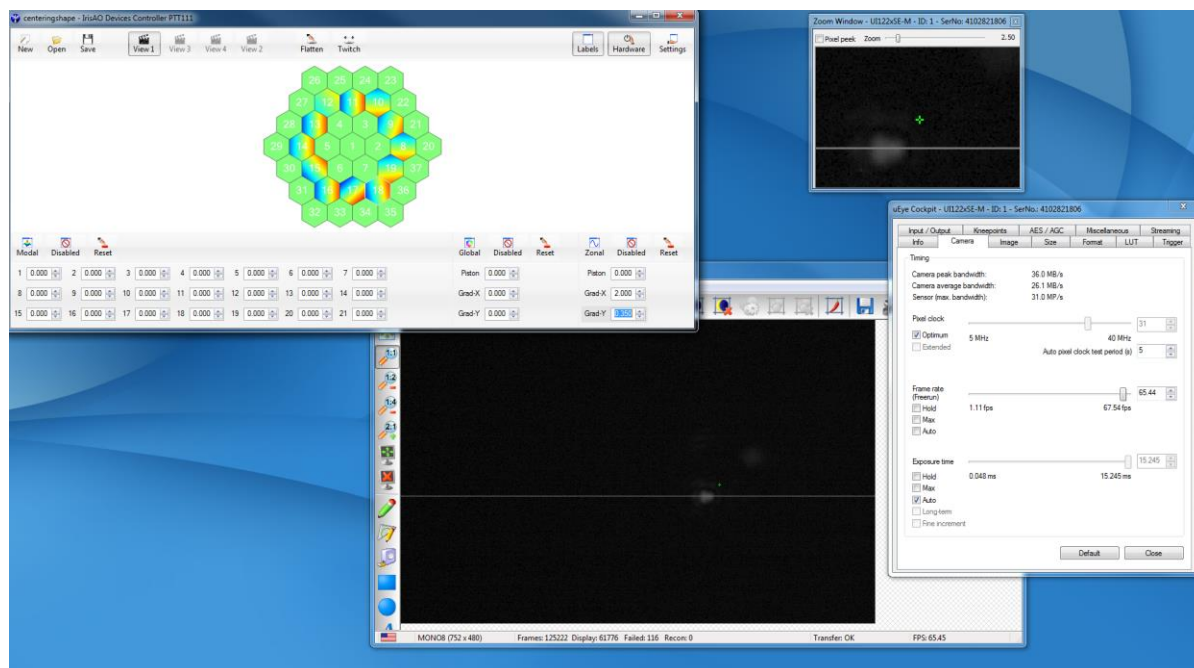
- Tilt and tip the central segment (e.g 2 milliarcsec in tip and -2 milliarcsec in tilt) by entering values in **Grad-X** and **Grad-Y** respectively.
- If the beam is properly centered on the central segment, a secondary spot should become visible.
- If a secondary spot does not appear, then the narrow beam is offset. This means the narrow beam is not being reflected by the central segment. Use the levers on the kinematic mirror to center the beam on the central area of the DM.

The Iris AO Controller GUI has a predefined shape, `centeringshape.PTT111`, used to refine the beam center, which can be found in the Iris AO Kit directory on the Iris AO USB drive.

- To find the `centeringshape.PTT111` file, click on the folder icon entitled **Open**. Search in the Controller GUI directory. Click on the `centeringshape.PTT111` file.
- If the beam is properly centered on the DM after running the file, you should NOT see a change in shape of the PSF. See the example below:



- If the beam is slightly off-center, the PSF will be degraded when Iris AO Kit\centeringshape.PTT111 is applied to the DM, see below:

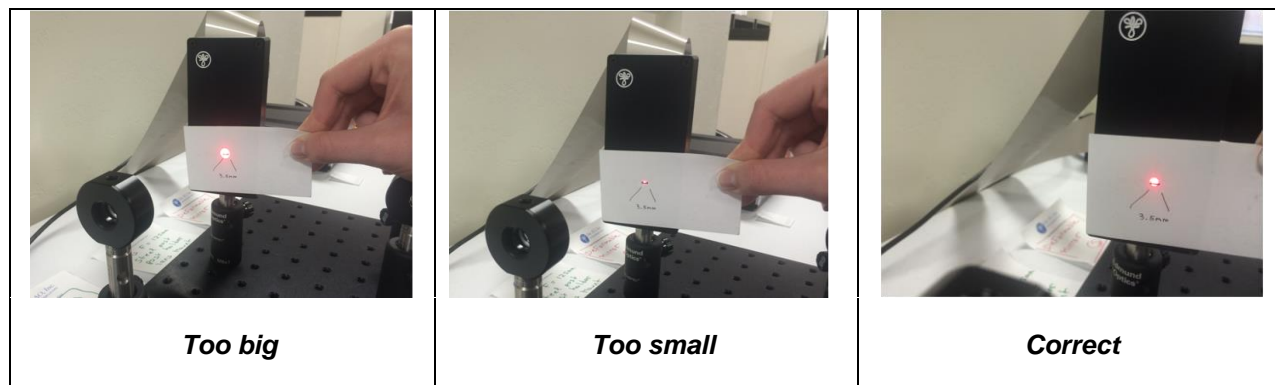


- Using the levers on the kinematic mirror, adjust the center of the beam until you achieve the desired position.

6.6 Adjusting the Size of the Beam

The DM has an inscribed aperture of 3.5 mm. Because the laser source may be slightly divergent, setting the aperture of the iris diaphragm to a diameter of 3.5 mm does not automatically guarantee the beam will hit the DM at a diameter of 3.5 mm. To solve this:

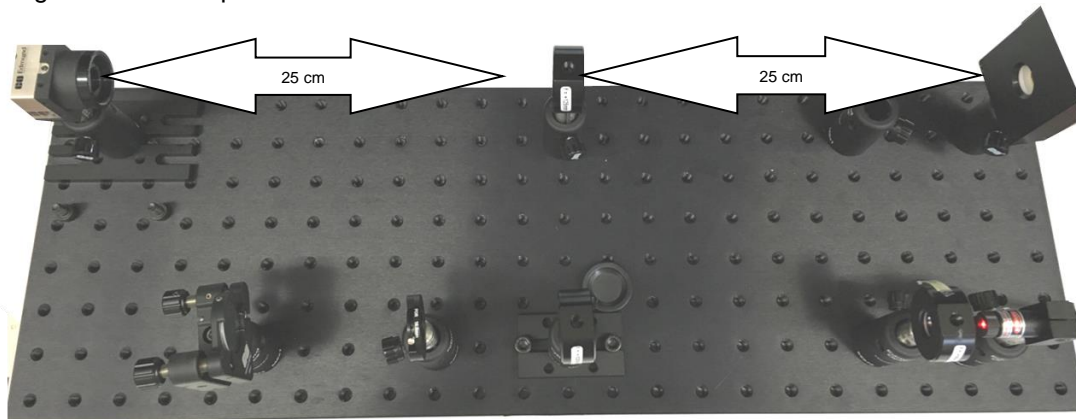
- Draw a 3.5 mm line on a note card or piece of paper.
- Adjust the iris diaphragm so the beam on the DM has the required diameter. In practice, the iris diaphragm should have a diameter between 3 and 3.5 mm, with variability depending on the divergence laser source.
- If the beam is too big, close the iris diaphragm. If the beam is too small, open the iris diaphragm, see below.



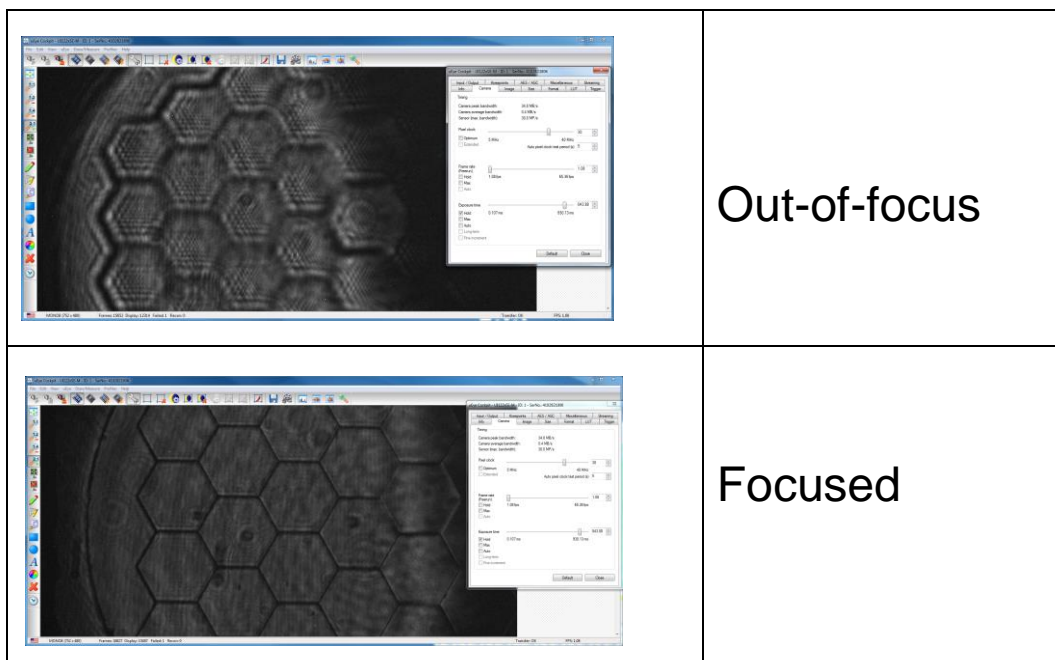
6.7 Centering and Adjusting the Beam Using a 2f-setup

To center and adjust the beam using a 2f-setup, the DM controller GUI, the iris diaphragm, and the uEye Cockpit should all be adjusted. To do this:

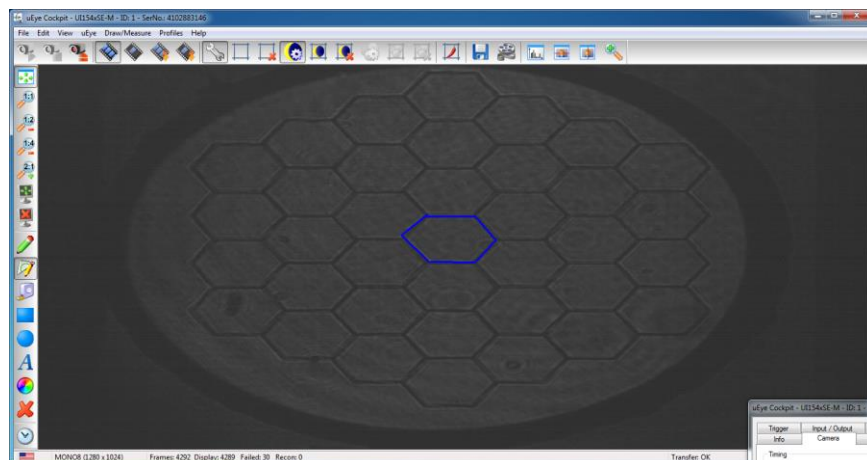
- Move the lens post holder to coordinates (12,7), **see Figure 1**.
- Move the camera to about 250 mm from the lens
- Check if the beam still crosses the center of the $f=+125$ mm lens. You may need to slightly adjust the lens height. The 2f-setup should look like this:



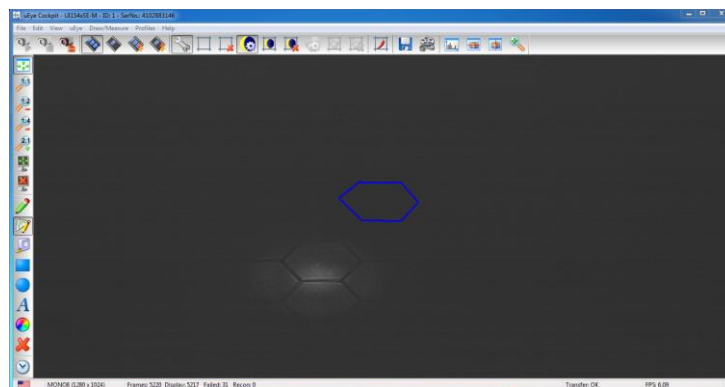
- Run the controller GUI and flatten the mirror.
- Open the iris diaphragm to ~5 mm
- Run the uEye Cockpit camera software. Adjust the frame rate to 1.08 fps and the exposure time to 844 ms. If you have forgotten how to adjust the exposure time or frame rate, see section 6.
- Adjust the position of the camera (along the beam axis) so that the image on the screen is clearer, see below.



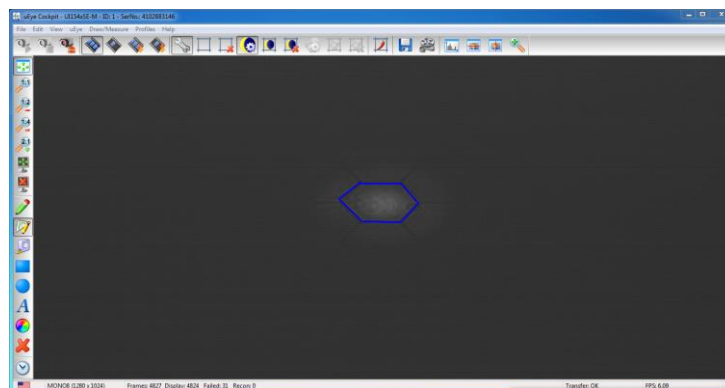
- Center the camera to show the entire pupil plane of the DM. You should get an image like the one below. The drawing tool was used to identify the central segment (#1) of the mirror. You will notice that the beam is not hitting the DM.



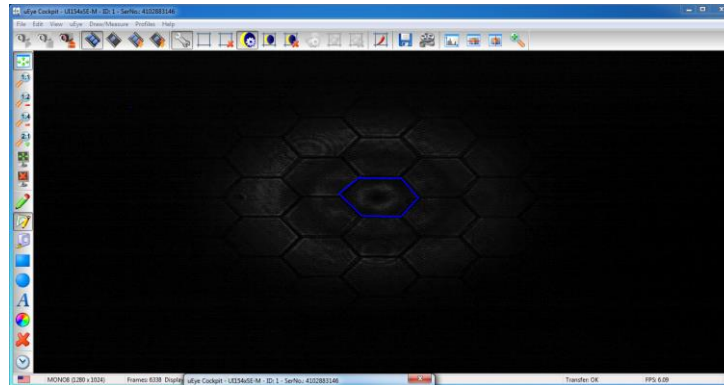
- To center and resize the beam, close the iris diaphragm to its smallest size (diameter ~ 0.9 mm), see below:



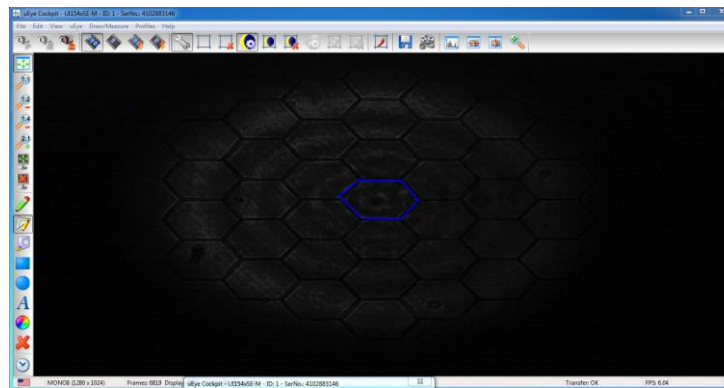
- Center the beam of light on the central segment by adjusting the DM laterally or and along the optical axis if necessary, see below.



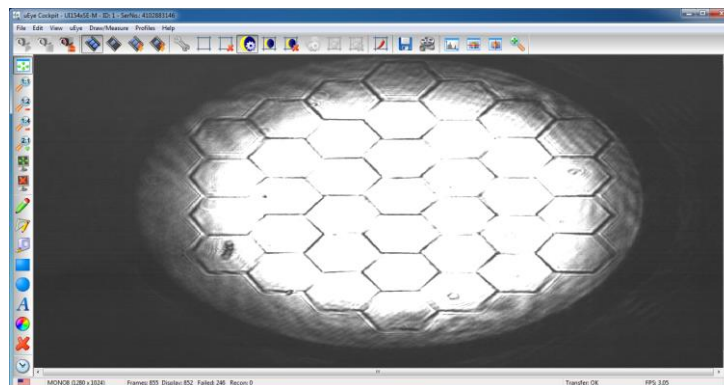
- Now you will adjust the beam size using the iris diaphragm to ~3 mm diameter:



- The beam in the picture below is the desired size.

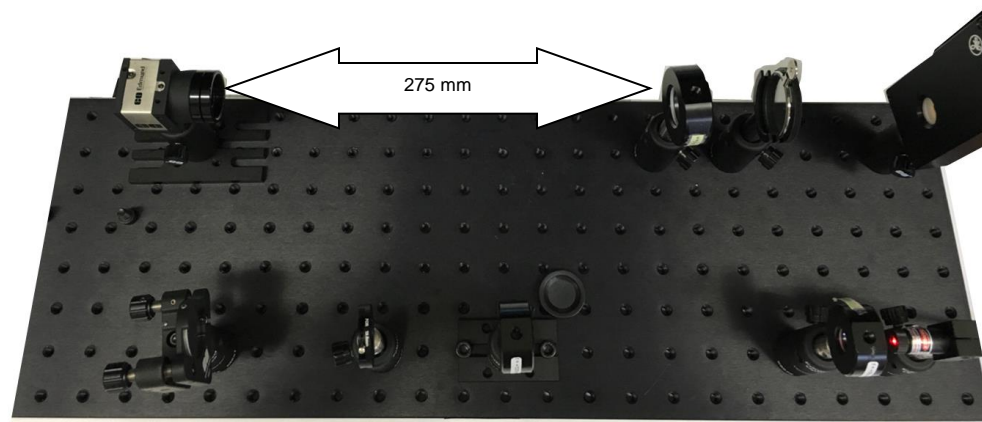


- If your setup is in a fully illuminated room, it may be necessary to make the above adjustment after having removed one of the ND filters. A properly illuminated mirror will look like this:

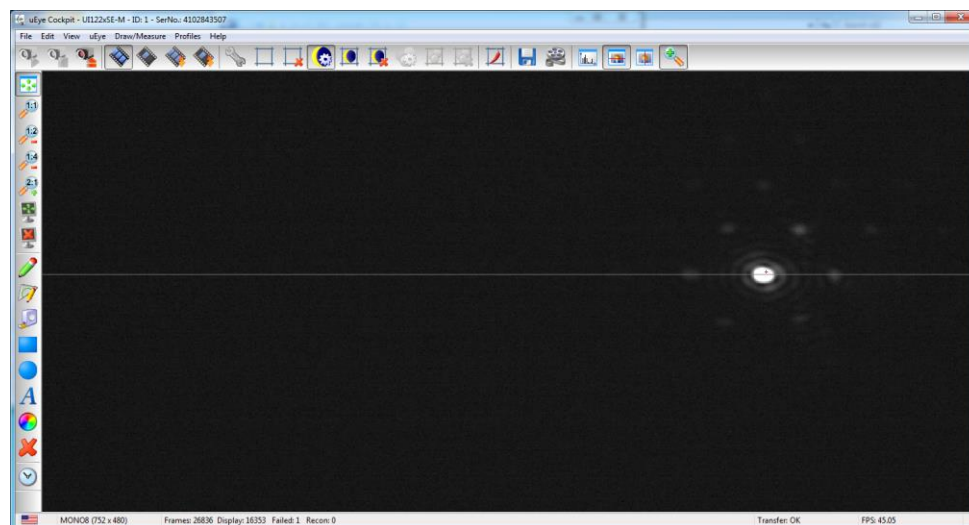


6.8 Long Focal Setup

A second lens with a longer focal point ($f=+275$ mm) is provided with your Iris AO kit. Move the post holder back to the PSF lens position, **see Figure 1**. Replace the $f=+125$ mm lens with the $f=+275$ mm lens. Move the camera to about 275 mm from the PSF lens, see below:



- You will need to adjust the position of the camera so the detector is at the focus point of the lens. The figure below shows what the point spread function (PSF) of the instrument will look like if the bench is properly aligned. The camera is located at the focal point, and the DM is in the flat position.

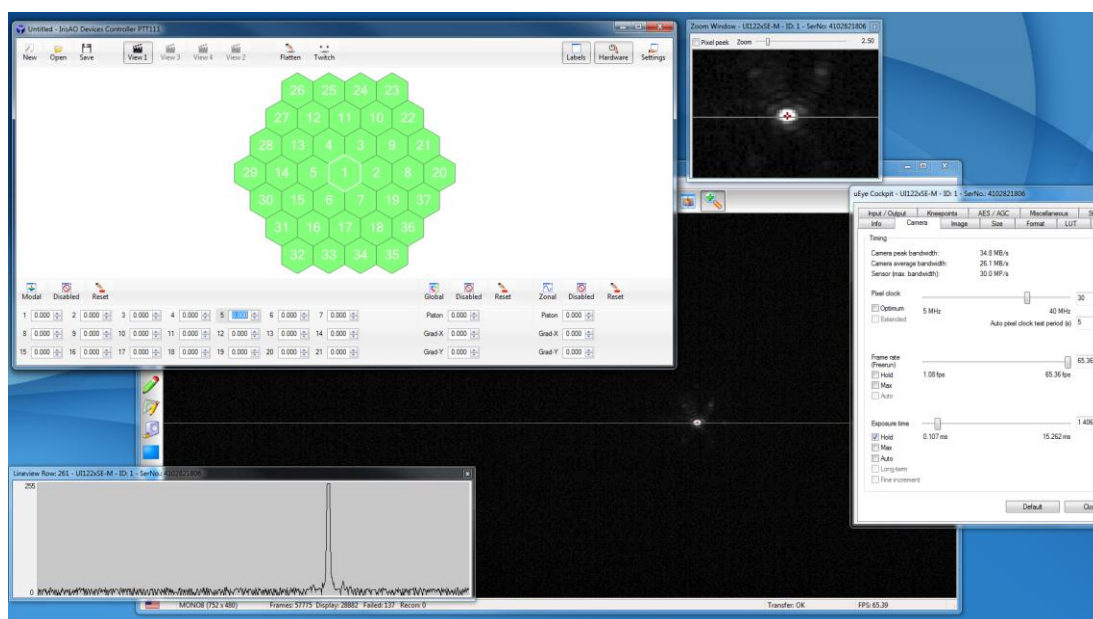


The image of a uniform intensity circular beam with a diameter D of 3.5 mm observed at a wavelength λ of 635 nm will be an Airy disk with a radius of $r_{\text{Airy}} = 1.22 \cdot f \cdot \lambda / D = 61 \mu\text{m}$ ($d_{\text{Airy}} = 122 \mu\text{m}$). The camera has a pixel size of $5.2 \mu\text{m}$. Consequently, with the $F=+275$ PSF lens, the Airy disk will be nearly 24 pixels in diameter. Using an $f=+125$ mm PSF lens, the Airy disk will be approximately 11 pixels in diameter. More than 7 Airy rings can be seen on this saturated image above (exposure time ~ 15.262 ms).

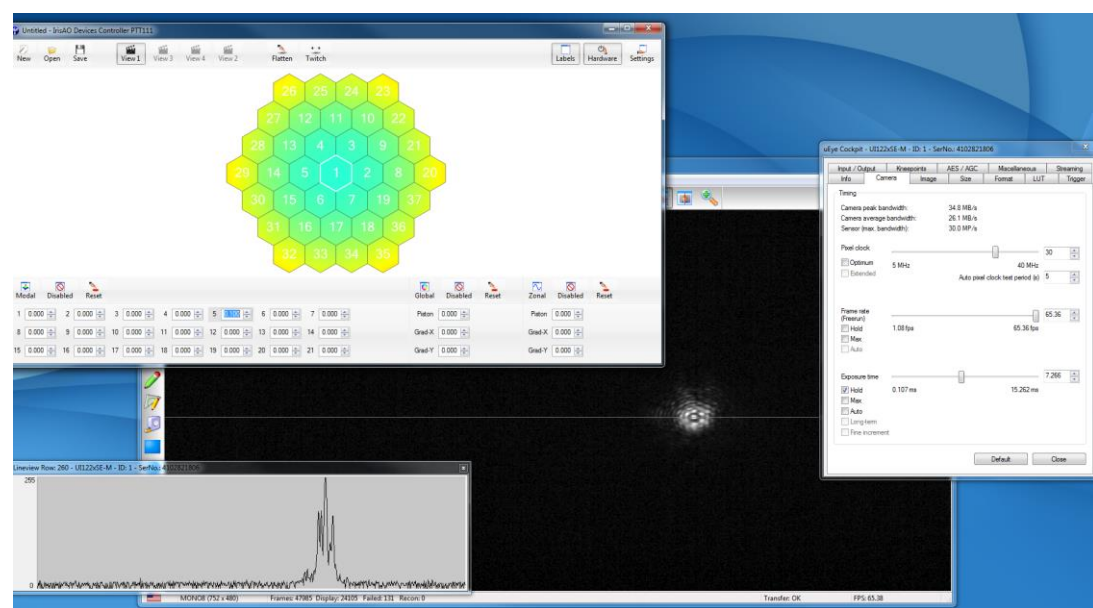
6.9 Fine Focusing

The camera focus can be improved by adjusting the focus of the DM via the Controller GUI. The focus is introduced in real time by adjusting the amplitude parameter, or Zernike number 5, in the Controller GUI.

- Use the “Show horizontal line view window” tool in the uEye Cockpit to adjust the exposure time and ensure the PSF is not saturated, see below.



- Modify the amplitude of focus (see circled area below) by selecting the corresponding number box with the mouse and rolling the scroll wheel.

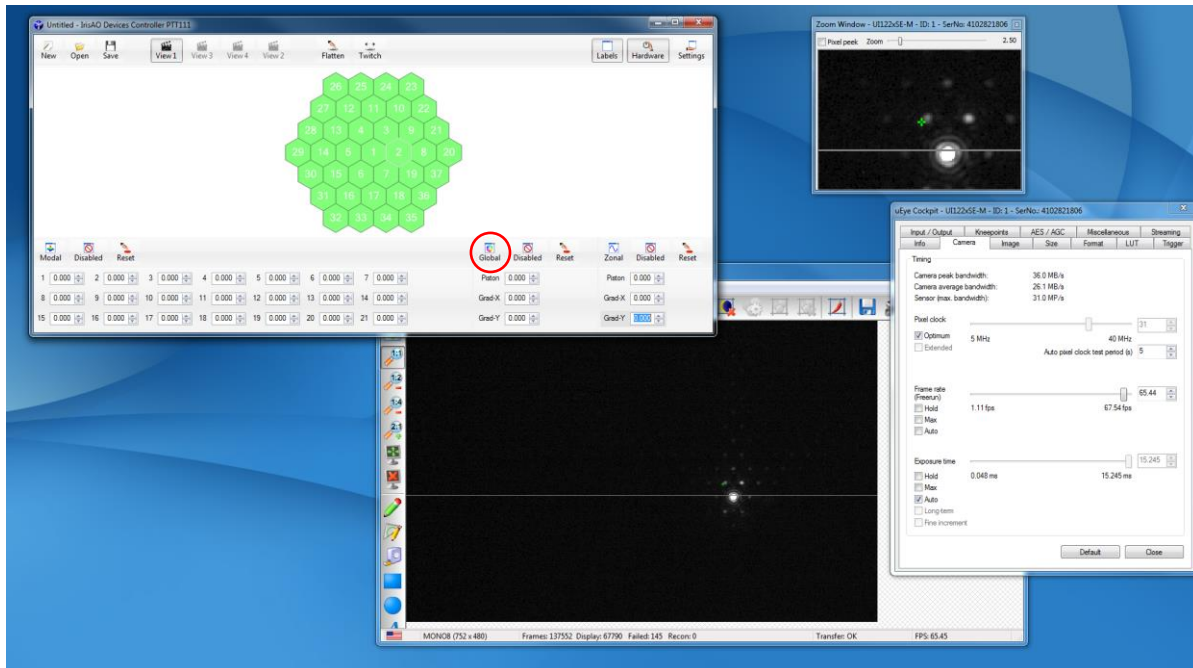


- Modifying the focus will produce a change in the peak value of the PSF. The best focus is reached when the PSF peak value is maximal. If you find that you need to introduce a focus amplitude $>0.10 \mu\text{m rms}$ to improve the image quality, we recommend flattening the DM with the Controller GUI and moving the camera to locate the correct the focal distance.
- Once you are satisfied with the position of the camera, secure the metric base plate to the bench plate using two M6 screws.

6.10 Gravity Compensation

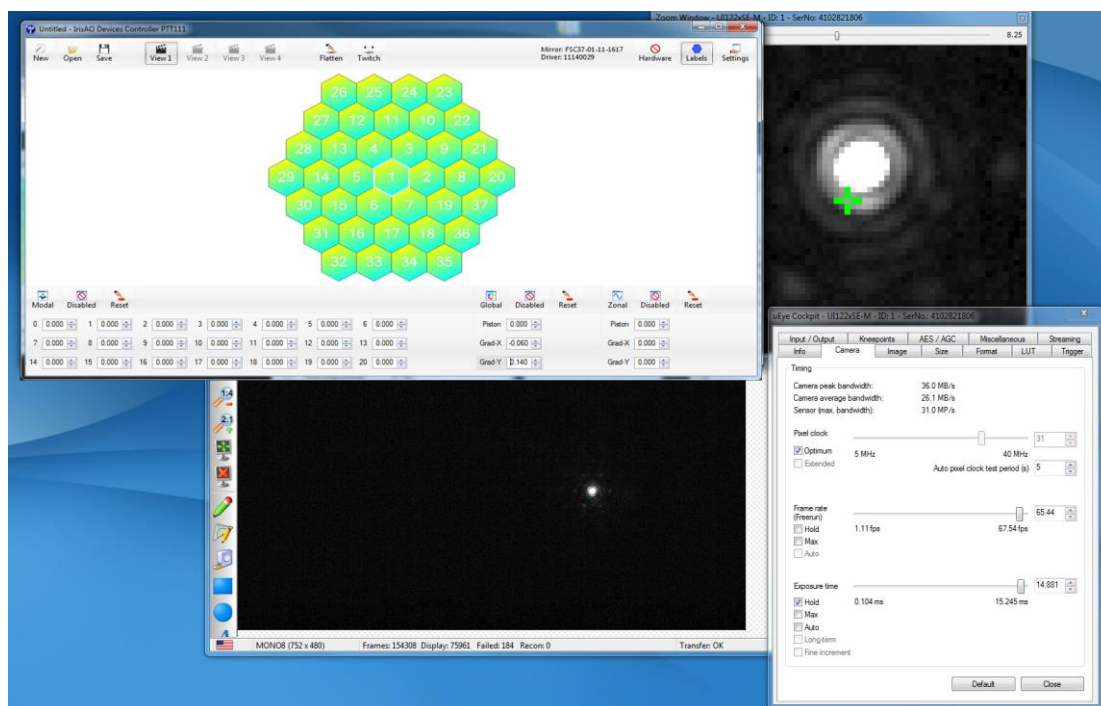
The DM is calibrated in horizontal position. However, in this setup, it will be operated in the vertical position. Because of the effects of gravity, the segments are slightly tilted. This effect is easily corrected by using the Controller GUI and manually implementing a global tip/tilt correction to improve the quality of the PSF.

- In the figure below, the energy in the secondary minima of the PSF is distributed asymmetrically. The secondary minima are brighter on the top of the PSF than at the bottom.

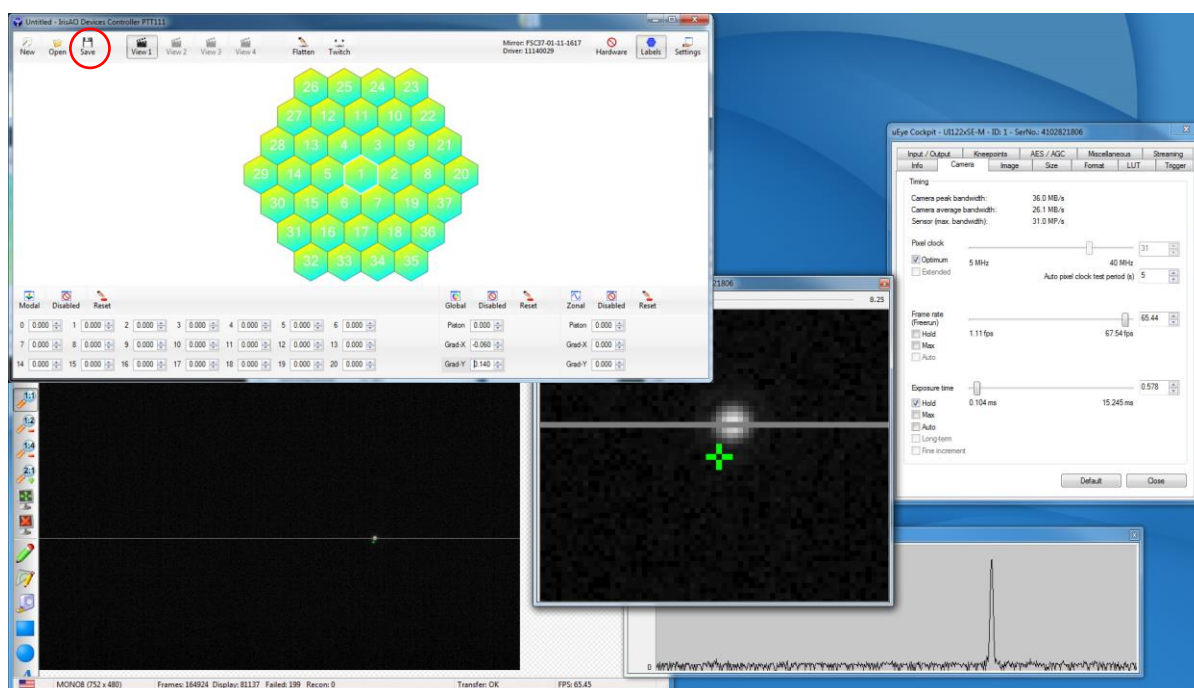


- This effect is introduced by a small deformation of the segments due to the effects of gravity. It can be compensated for by introducing a small, identical tip-tilt on each segment of the mirror.
- Click the **Global** control (see circled area above), modify the Grad-X and Grad-Y angles, and observe the effects on the PSF. After increasing the exposure time to about 15 ms, you will see the energy of the secondary minima vary with the global motion of the segments.

- The ideal position is obtained when the distribution of the secondary minima is homogeneous around the coherent peak as is the case for the picture below in which measurements of Grad-X = 0.060 milliradians and Grad-Y = 0.140 milliradians were applied to compensate for the effects of gravity.



- You can save the shape of the mirror by clicking the **Save** button located in the top menu of the GUI Controller, see circled area below.
- Your Iris AO Kit is now correctly aligned.
- You can reduce the exposure time of the camera to 0.6 ms to see the unsaturated PSF as shown below:



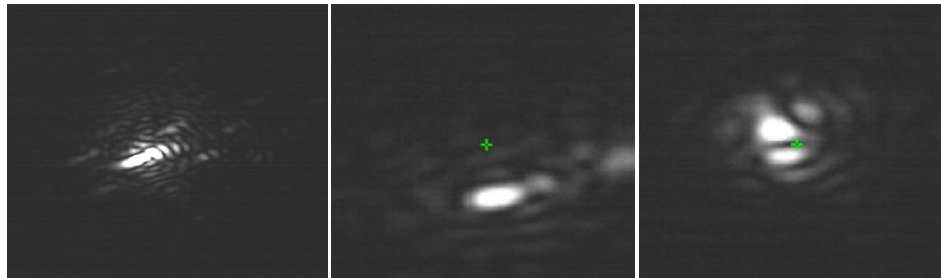
7 Introducing Aberrations

Aberrations can be inserted at coordinate (6,7) shown in **Figure 1**. The DM can then be used to correct these aberrations.

7.1 Iris AO Aberration Element

The aberration plate (Iris AO 021-003-01) in this kit is an optically clear and circular plate with a thickness of 1/8" and a diameter of 1". The aberration plate is mounted in the optic mount (64561) which is attached to a steel post (58999).

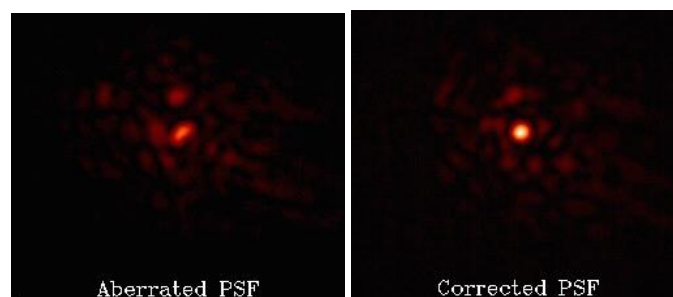
- Insert the aberration plate into the path of the beam. Adjust the height of the beam so that it crosses the central portion of the aberration plate. The PSF should be degraded and will look like one of the following:



7.2 Image-Based Aberration Correction – *Sensorless Adaptive Optics*

Correcting aberrations introduced by a medium (i.e. the atmosphere, tissue, optics) in real-time is a key element of adaptive optics. Several methods exist to correct aberrations based on the image of a camera. These include adjusting the intensity of the central peak of the image, maximizing the integrated flux in an area of the image, or maximizing the contrast of an image. Several algorithms with different metrics and strategies have been designed to perform accordingly. With the DM Controller GUI provided in the Iris AO Kit and the accurate and stable positioning of the DM, you can experiment with sensorless AO to maximize your PSF intensity. By applying different Zernike modes to the DM, you can correct for the aberrations introduced by the aberration plate.

The results of using an automated hill-climbing algorithm to maximize the PSF of the AO kit with an aberration plate is shown below. The algorithm applies small Zernike mode deformations to the DM and identifies the best magnitude for each Zernike mode. The images below show the improvement in intensity using the automated algorithm and iterating it throughout the first 15 Zernike modes.



By combining the AO Kit and the Iris AO DM API, you can develop your own automated algorithms to improve image quality. Iris AO is developing a stand-alone GUI application of its Sensorless AO algorithm. This application will be available at no cost to AO Kit customers in 2016. Contact Iris AO customer support for updates on this free AO system application.

8 Troubleshooting and Support

In the event your system does not work properly, please take the following troubleshooting steps:

- Verify that all cables are plugged in.
- Verify that the DCF and MCF file names are correct.
- If your system still does not work properly, please contact Iris AO at:

Iris AO, Inc.
2930 Shattuck Ave. #304
Berkeley, CA 94705-1833, USA
+1 (510) 849-2375
[mailto: support@irisao.com](mailto:support@irisao.com)