User Manual

Rev. 4.1, 28/04-2025

Version	Date	Author	Changes/Comments
4.0	20/03-2025	Erik Guneriussen	*Valid for all SW: version older than 2.4*
4.1	28/04-2025	Erik Guneriussen	*Valid from SW. version 2.4.0* 1. Updated description of setup 2. Update and additions several places for manual selection of blob. 3. Added requirement to used support for Filter Wheel

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Introduction

The TiltAdjuster instrument is a specialized tool designed for precision calibration of the imaging path in an astro imaging setup. It is specifically crafted for astro imaging enthusiasts who require accurate measurement and correction of tilt. Here are the key features and functions of the TiltAdjuster instrument:

- **Laser Projection**: The instrument uses a red laser beam projected onto the chip surface. This laser beam reflects onto an imaging plane, allowing for precise measurement of tilt.
- **Rotational Sampling**: By rotating the instrument 360 degrees, the reflected laser beam draws a circle on the imaging plane. This circle is analyzed to determine the tilt of the optical system.
- **Micron-Level Accuracy**: The TiltAdjuster instrument measures deviations in microns, ensuring high precision and accuracy in the calibration process.
- **Reference Circles**: The instrument displays reference circles for the Critical Focus Zone (CFZ) and the New Critical Focus Zone (NCFZ) to help users evaluate the accuracy of their measurements and make necessary adjustments.
- **User-Friendly Interface**: The TiltAdjuster software provides an intuitive wizard that guides users through each step of the calibration process, from sample collection to final adjustments.
- With the TiltAdjuster instrument, users can achieve optimal focus across their entire sensor, ensuring superior image quality for their celestial observations.
- **Connects** to PC via USB

Requirements

1. **Membership in Astro Precision Group**: To use the TiltAdjuster application, you must be a member of the Astro Precision group.
2. **Windows PC**: Ensure that you have a Windows PC available for running the application.
3. **Internet Connection**: A connection to the internet is required when the application is being activated to ensure proper setup and functionality.
4. **Ascom**: Ascom with drivers for required drivers must be preinstalled to use the Filter Wheel support.

TiltAdjuster Instrument

The TiltAdjuster instrument is a 3D-printed device containing a laser and a camera. This precision-engineered instrument is designed for ease of use and high accuracy in optical calibration tasks. The laser projects a beam onto the chip surface, which then reflects onto an imaging plane. The built-in camera captures these reflections, allowing for detailed analysis of the optical system's alignment.

The instrument's compact and lightweight design makes it highly portable and easy to handle during calibration. The 3D printing technology ensures a durable and robust structure while maintaining the flexibility to make custom modifications if needed.

The TiltAdjuster instrument is an essential tool for any astro imager looking to optimize their setup and ensure the highest quality images.

Align the camera with the Tilt Adjuster

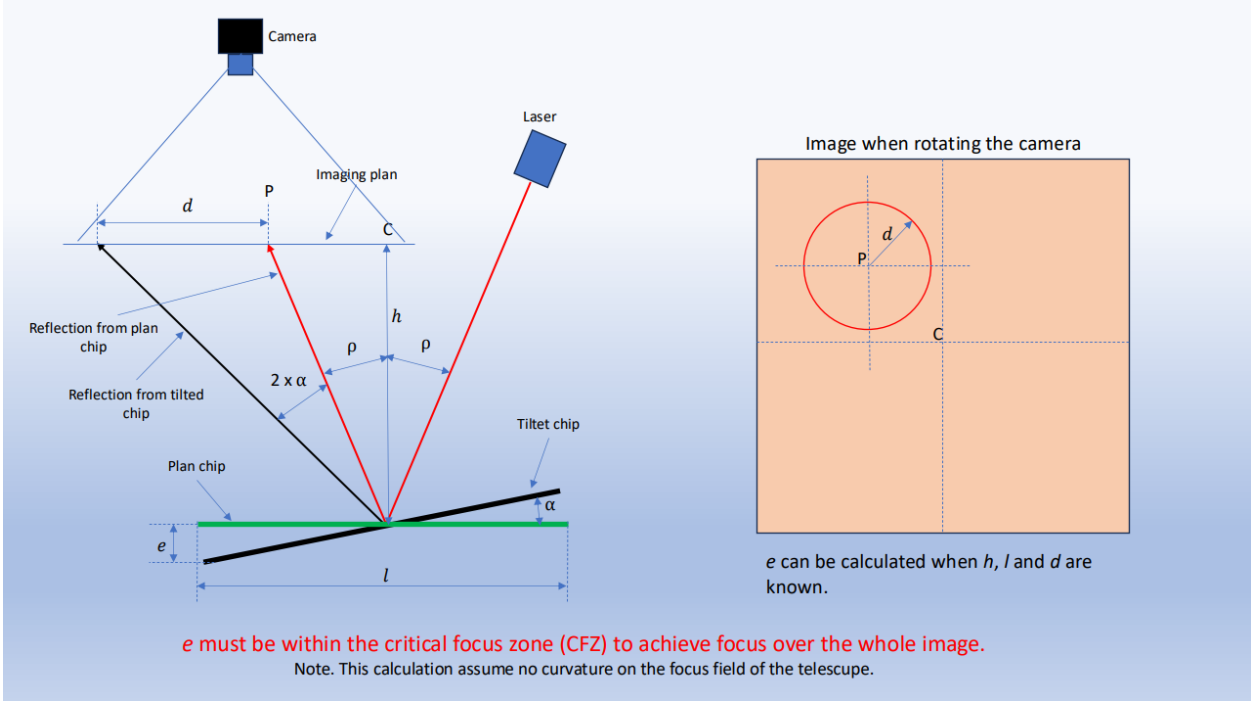
Position the camera’s connection point, either the rear of the camera, filter wheel or extender into the opening of the Tilt Adjuster. TiltAdjuster can be delivered with “any” opening size. Image above shows connection to M48 adapter.

Instrument theory

The figure below illustrates the optical geometry of the instrument. A laser beam is projected onto the chip surface and reflects onto an imaging plane. When the instrument is rotated 360 degrees, the reflected laser beam traces a circle on the imaging plane. By measuring the diameter **d** in millimeters, you can easily calculate the distance **ε (epsilon)**, which represents the maximum deviation from the plane surface.

Note that **l** is the length of the diagonal of the chip. To achieve focus across the entire chip, **ε (epsilon)** must be less than the Critical Focus Zone (CFZ) or the New Critical Focus Zone (NCFZ), depending on which target you prefer to use.

Additionally, it is important to consider that the focus zone is reduced due to the curvature on the focus field of the telescope.



Software Application

Installation

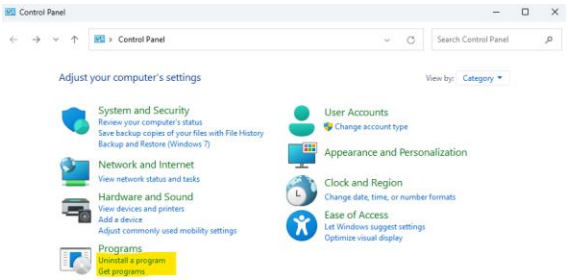
Download software

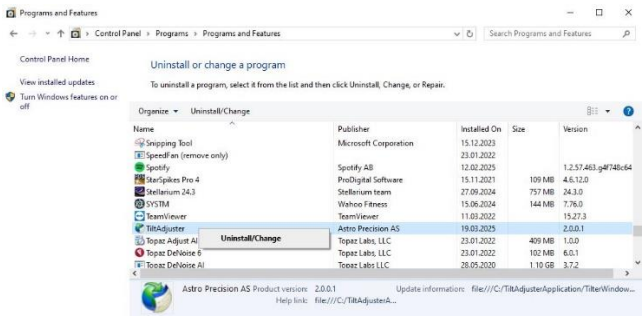
Installation Instructions for TiltAdjuster

1. **Remove Old Version**: Before downloading a new version of TiltAdjuster, please ensure you remove the old version from your system.

Remove using Control Panel

- **Open Control Panel**: Click on the **Start** button and type "Control Panel" in the search bar, then select **Control Panel** from the search results.
- **Access Programs and Features**: In the Control Panel window, click on **Programs**, then select **Programs and Features**.
- **Find the Application**: Scroll through the list of installed programs to find **TiltAdjuster**.
- **Uninstall the Application**: Click on **TiltAdjuster**, then click the **Uninstall** button at the top of the list. Follow any prompts to complete the uninstallation process.

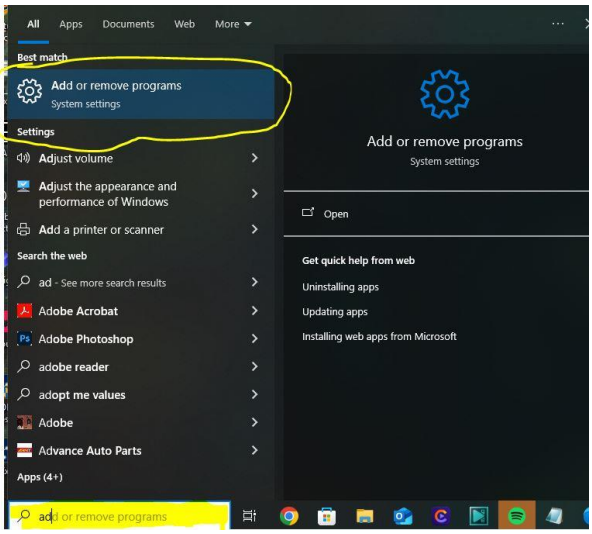


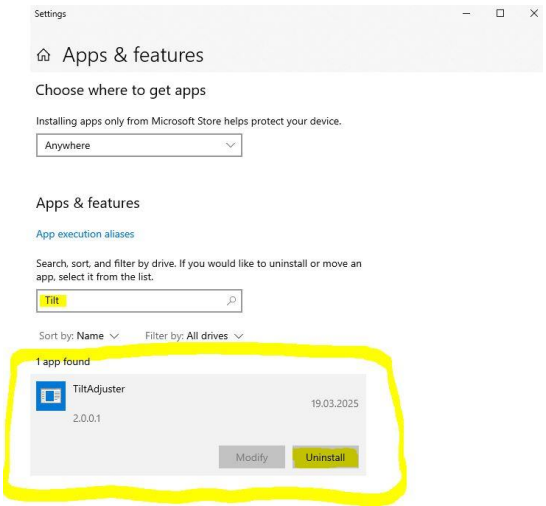


PS: The view the add remove will differ for different versions of Windows.

Remove Using Start Menu

- **Open the Start Menu**: Click on the **Start** button located at the bottom-left corner of your screen.
- **Access Settings**: Click on the **Settings** icon (it looks like a gear).
- **Navigate to Apps**: In the Settings window, select **Apps**.
- **Find the Application**: In the Apps & features section, scroll down to find **TiltAdjuster**.
- **Uninstall the Application**: Click on **TiltAdjuster**, then select **Uninstall**. Follow any prompts to complete the uninstallation process.





2. **Download Software**: For the best experience, we recommend downloading the software using Microsoft Edge or Internet Explorer.
3. **Avoid Immediate Installation**: It has been reported that, in some cases, if the browser begins the installation immediately, it may fail. If this occurs, please follow these steps, all should be done:
    a. Unzip the downloaded file.

    b. Start the installation manually by double click on the `TilterWindowsSetup.msi` file.

4. **Run Installation**: Double-click on the `TilterWindowsSetup.msi` file to begin the installation process. Follow the on-screen instructions to complete the installation.

Running the application

Starting the application

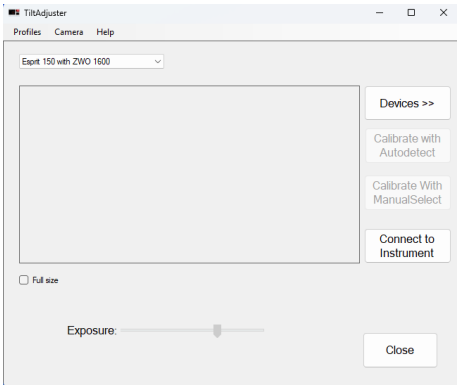
The installation adds an icon named TiltAdjuster on the Desktop that can be double clicked or TiltAdjuster can be entered on Windows Search on the start menu to start the application.

The Main Window is now accessible also when doing calibration, this means that the realtime view can be inspected and that the exposure time can be adjusted. The last can be required if Auto Select Center is selected as calibration mode.

Main View of TiltAdjuster

The main view of TiltAdjuster provides an intuitive and user-friendly interface, allowing you to manage and control the application with ease. Key components include:

1. **Real-time View from Instrument's Camera**: This section displays the live feed from the instrument's camera, providing you with a real-time view of the target area. This helps you monitor adjustments and calibrations accurately.
2. **Menus to Manage Profiles**: Located on the side or top navigation bar, these menus allow you to create, edit, and manage user profiles. You can save specific settings and preferences under different profiles for quick access and customization.
3. **Camera Selection Menu**: This menu allows you to select the instrument camera if more than one camera is connected to the PC.
4. **Control Buttons**: These buttons enable you to control various functions of the application. This includes options to Connect, disconnect to the instrument camera and start adjustments.



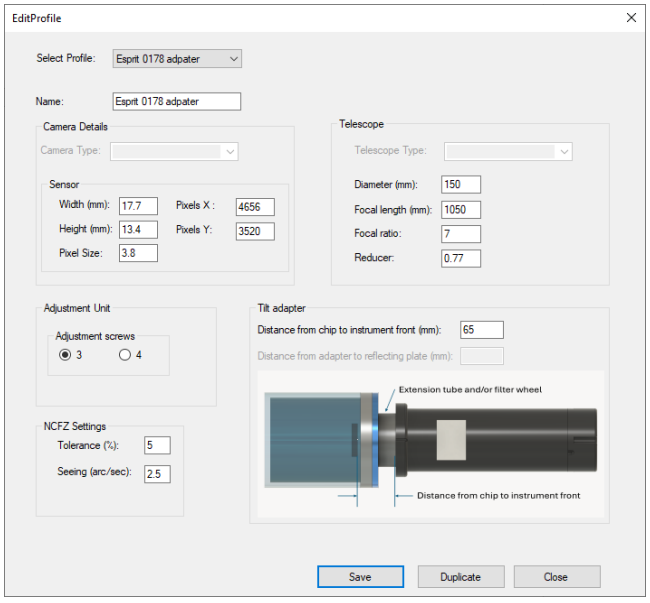
Profile

Profiles and Calibration Quality

The Profiles feature in TiltAdjuster is used by the application to calculate the quality of the calibration. Each profile contains specific settings and preferences tailored to different visualviscalibration scenarios. By selecting the appropriate profile, the application can assess and analyze the calibration process more accurately, ensuring optimal results and performance.

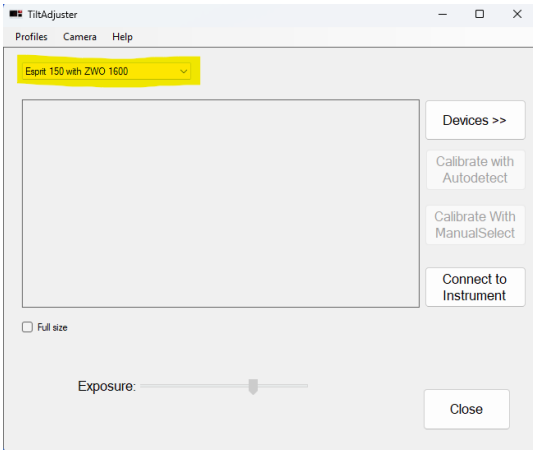
The Profile View is divided into several sections:

1. **Camera**: This section includes settings and configurations related to the camera used with the instrument.
2. **Telescope**: This section contains settings and preferences specific to the telescope, ensuring accurate calibration based on its specifications.
3. **Adjustment Unit**: This section manages settings for the adjustment unit, in the software version selection of number of adjustment screws is done.
4. **New Critical Focus Zone Setting**: This section allows you to define and manage the Critical Focus Zone, ensuring optimal focus for your instrument.
5. **TiltAdjuster Setting**: Specifies distance from the instrument to the setups camera sensor.



Selecting Profiles Before Calibration

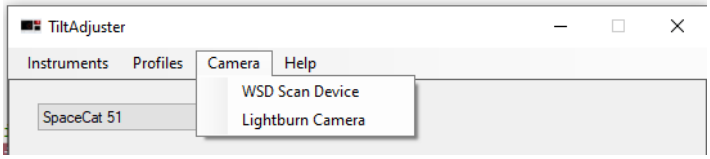
Before starting the calibration process, ensure that you select the profile that matches your setup. In the main view, use the combo box to choose the appropriate profile. This ensures that the calibration process is tailored to your specific configuration, leading to more accurate and reliable results.



Selecting instrument camera

Automatic Camera Selection

TiltAdjuster attempts to automatically select the instrument camera when connecting to the instrument. *If the automatic selection fails, please use the **Camera** menu item to manually select the correct camera*.

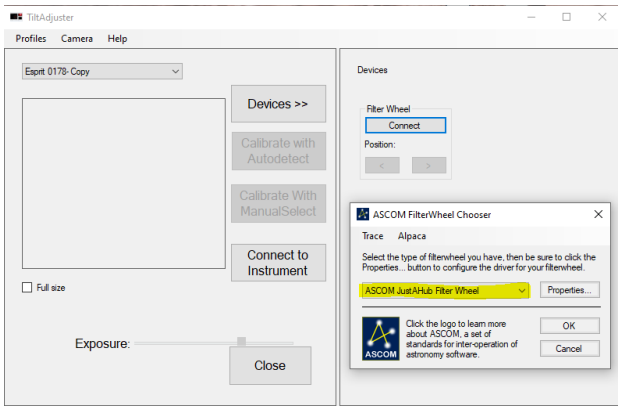


Device Connection and Filter Selection

The **Device** button can be used to connect to ASCOM devices. In this release, only connections to filter wheels are supported. Since the instrument uses a red laser, it is important to select a filter that allows red light to pass through. Suitable filters include HA, Red, and L. If available, an empty slot is preferred. Connect the device and use the **<<** or **>>** keys to select the filter to be used.

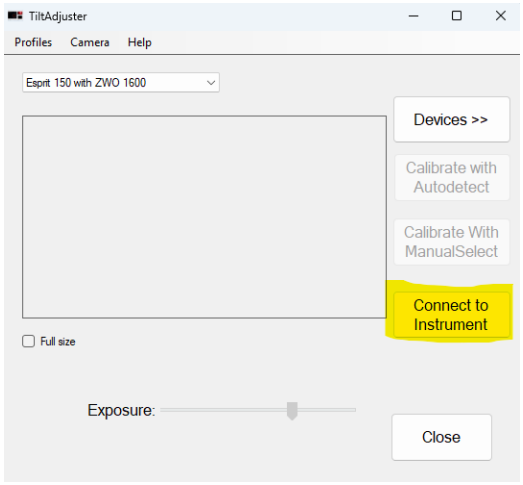
Troubleshooting Filter Wheel Selection

There can be problems with selecting the ZWO filter wheel driver in the ASCOM selection dialog. If this issue occurs, please select the ASCOM JustAHub Filter Wheel instead, or use your standard application to select the proper filter.

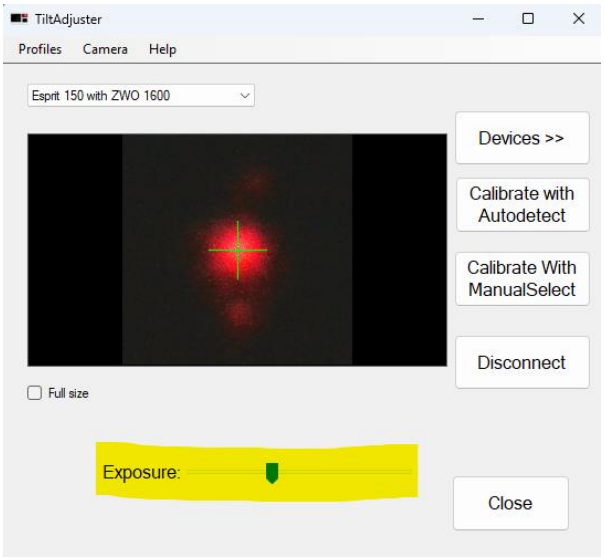


Connecting to the Instrument

To connect the application to the instrument, press the **Connect to Instrument** button. When pressed, the connection is established, and the application also calculates the instrument camera's exposure time, which will vary depending on the selected filter type.



The real-time window should, once calculated and connected, display the reflected laser with a stable green cross approximately in the middle. **If the cross is not stable, try adjusting the exposure control slider until the cross is as stable as possible**.



Tilt Adjustment

Calibration Window

This description is general and correct for Calibrating with Auto Detect. It is only the Adjustment View that looks different for Manual modes. Se changes in dedicated chapter if using Calibrating with Manual Selection.

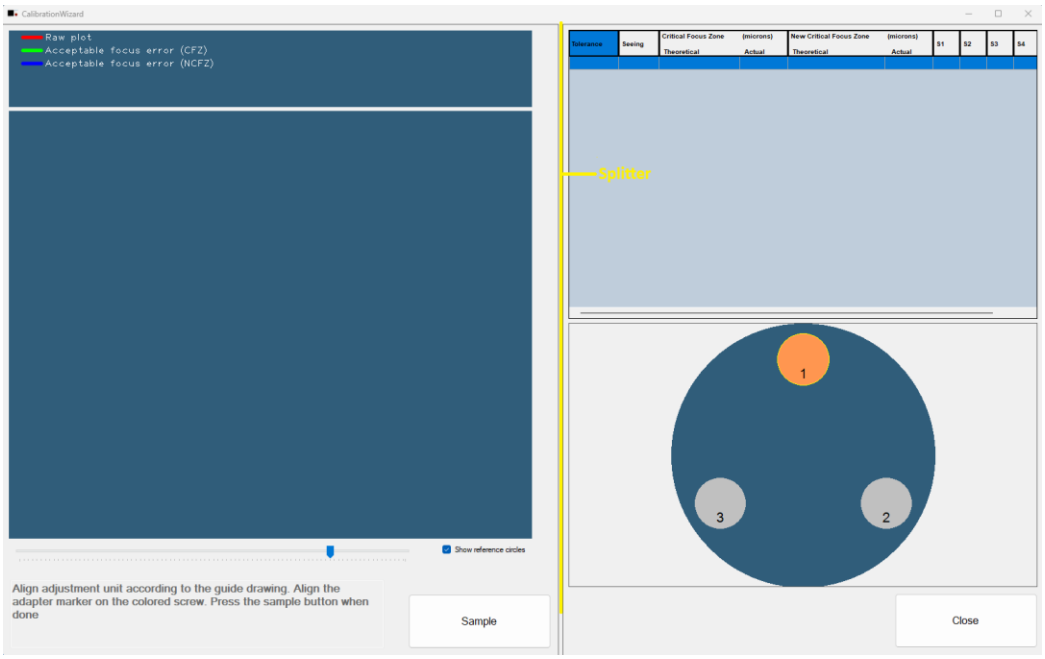
The Calibration window will be displayed when the **Calibration** button is pressed. This window contains three main sections, this documentation shows the view when Calibrate with Autodetect is selected. The different controls in the view have the same meaning for Manual Selection but the Adjustment View will show the Real Time View with the plotted "data" as an overlay.

The Calibration View can be resized. The view has also a splitter that separates the view in 2 separate sections that can individually be resized.

The main view can be accessed even if the Calibration view is active. An advantage/requirement when doing manual selection of blob.

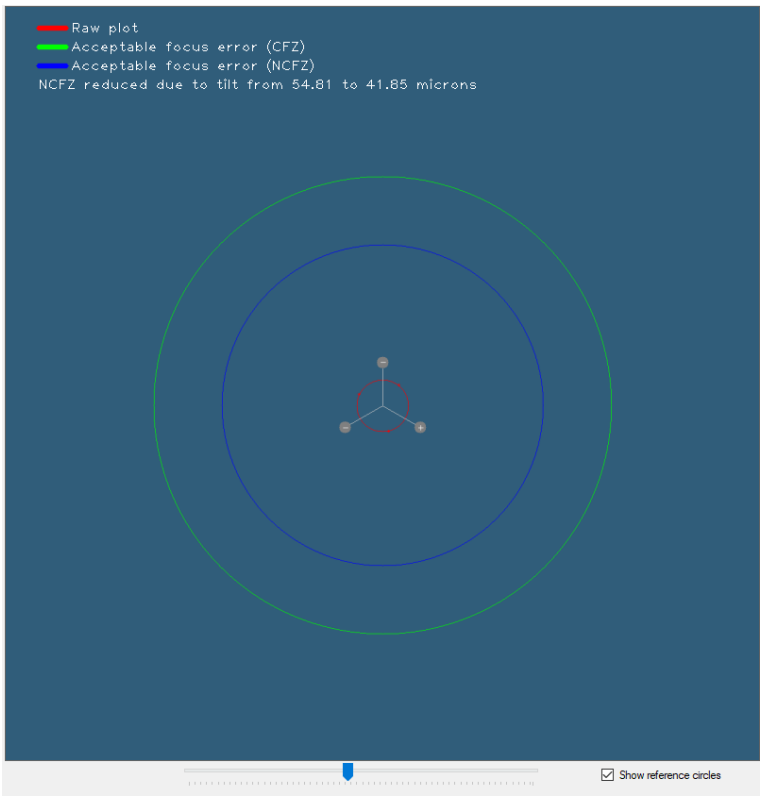
Adjustment View: This section allows you to make the necessary adjustments to the instrument for calibration.

1. **Result View**: This section displays the results of the calibration process, providing feedback on the quality and accuracy of the calibration.
2. **Wizard Part**: This section includes leading text and a process button to guide you through the calibration process step-by-step. This also includes the view of the adjustment unit.

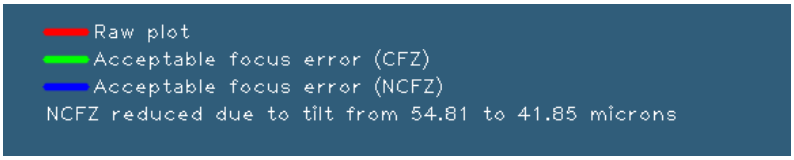


Adjustment View

The Adjustment View will display a plotted image of the measured tilt. In addition, reference circles are shown so that the result can be qualified for the setup defined by the selected profile. The measured result is represented by a red circle, the New Critical Focus Zone (NCFZ) by a blue circle, and the Critical Focus Zone by a green circle.



The top part of the view shows the colors used for these different circles and, if possible, the actual focus compared to the NCFZ. A lower number for the actual focus means it is possible to achieve focus across the entire sensor. An actual value close to the calculated value is preferred to minimize the critical focus zone as much as possible.



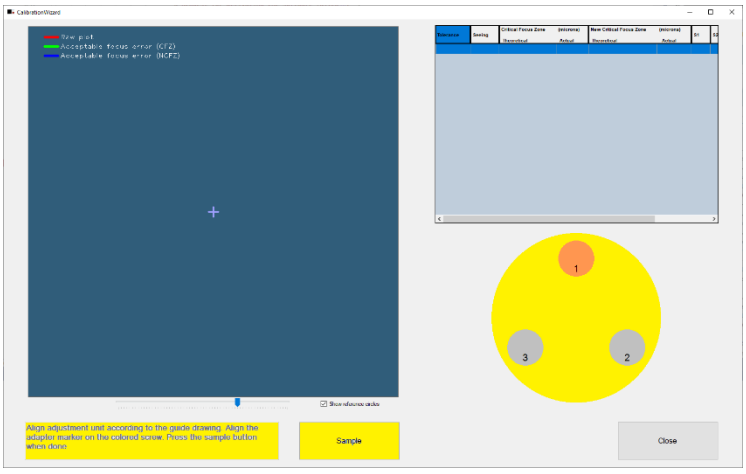
The view also includes two controls:

1. **Zoom Control**: Allows you to zoom in and out of the result part for a detailed view of the plotted image.
2. **Reference Circles Checkbox**: Located on the right side, this checkbox can be used to switch the reference circles on and off as needed.

Wizard Controls

The wizard part of the view consists of three controls:

1. **Instruction Text**: This section describes the current wizard step and the actions that can or should be taken. It provides clear guidance for each step of the calibration process.
2. **Process Button**: The text on this button indicates the action that will be performed when the button is pressed. This ensures that you know exactly what to expect at each step.
3. **Model of the Adjustment Adapter**: This model shows which screw is currently being sampled. While following the selected screw on the adapter is not required, it offers helpful support by indicating which screw should be adjusted and in which direction.



Result Grid

1. The Result Grid contains measured and calculated data for calibrations that have been completed, with the latest results displayed at the top. There are three commands that can be executed on the grid:
2. **View Result**: Double-clicking on a selected row will show the detailed result of that specific calibration.
3. **Compare Results**: It is possible to compare several results by selecting them using **Ctrl + Left Click**. Then, **Right Click** to show a context menu. Selecting "Compare" will display a combined result view.
4. **Delete Results**: You can delete one result by selecting it and then using the delete command. Alternatively, you can use multi-select to remove several results at Once.

Tolerance	Seeing	Critical Focus Zone (microns) Theoretical	Actual	New Critical Focus Zone (microns) Theoretical	Actual	S1
10.00	2.50	64.44	54.21	21.78	11.55	
10.00	2.50	64.44	49.07	21.78	6.410001	
10.00	2.50	64.44	51.29	21.78	8.630001	
10.00	2.50	64.44	54.21	21.78	11.55	
10.00	2.50	64.44	45.34	21.78	2.68	
10.00	2.50	64.44	48.69	21.78	6.030001	
10.00	2.50	64.44	58.27	21.78	15.61	
10.00	2.50	64.44	48.47	21.78	5.81	
10.00	2.50	64.44	47.42	21.78	4.76	
10.00	2.50	64.44	15.85	21.78	-26.81	
10.00	2.50	64.44	57.17	21.78	14.51	
10.00	2.50	64.44	58.69	21.78	16.03	
10.00	2.50	64.44	36.83	21.78	-5.83	
10.00	2.50	64.44	16.56	21.78	-26.1	
10.00	2.50	64.44	19.77	21.78	-22.89	
10.00	2.50	64.44	-59.93	21.78	-102.59	
10.00	2.50	64.44	50.94	21.78	8.280001	

Definitions of result parameters

Critical Focus Zone (CFZ)

The Critical Focus Zone (CFZ) refers to the range within which an optical system, such as a telescope, can maintain acceptable focus. Within this zone, the image remains sharp and clear, and any adjustments to focus do not significantly affect the image quality. The CFZ is determined by the characteristics of the optical system, including its focal length and aperture.

New Critical Focus Zone (NCFZ)

The New Critical Focus Zone (NCFZ) is a refined focus zone calculated during the calibration process. It represents an optimal range for achieving the best possible focus based on the current setup and adjustments. The NCFZ takes into account the specific parameters of the calibration profile and provides a more precise focus range compared to the general CFZ. Achieving focus within the NCFZ ensures superior image quality and accuracy. Tolerance and seeing parameters in the grid are the parameters used by NCFZ.

Tolerance

Tolerance refers to the allowable deviation from the ideal focus within the NCFZ. It defines the acceptable range of focus adjustments that still result in a sharp and clear image. A lower tolerance value indicates a narrower range, requiring more precise adjustments to maintain optimal focus. Conversely, a higher tolerance value allows for more flexibility in focus adjustments without significantly impacting image quality. Tolerance is crucial for achieving high-precision calibration and ensuring that the instrument operates within the desired parameters.

Seeing

Seeing is a parameter that accounts for atmospheric conditions and their impact on image quality. It represents the stability and clarity of the atmosphere, which can affect the focus and overall performance of the optical system. Good seeing conditions result in sharper and more stable images, while poor seeing conditions can cause blurring and distortion. The seeing parameter is considered in the NCFZ to ensure that the calibration accounts for environmental factors and provides the best possible focus under varying conditions.

In the **Adjustment View** of TiltAdjuster, the NCFZ is depicted by a blue circle, while the CFZ is shown by a green circle. The goal is to achieve focus within these zones to ensure high-quality calibration results.

Calibration Process

Alignment of instrument

Calibration is performed by following the wizard steps. The first step is to place the instrument so that 3 or 4 samples can be taken with a high degree of accuracy. Using the adjustment screws on the adjustment unit makes this easier:

- For 3 samples, position the instrument at approximately 120-degree intervals on a 3-screw unit.
- For 4 samples, position the instrument at approximately 90-degree intervals on a 4-screw unit.

It is important that the instrument is correctly attached and stable when a sample is being taken. This is because the measurements are done in microns, and even small movements in the imaging path or instrument can result in inaccurate results.

The wizard text and button text provide instructions on when and what actions to take.

Align the marker on the instrument to the adjustment screws to so get approximately 120/90 degrees between each sample.

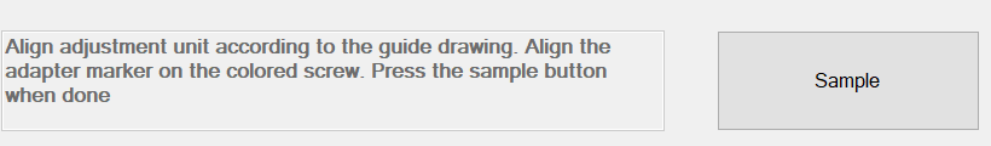
The purpose of following the screw selection shown on the adapter model is to connect it to the adjustment part. The adjustment support (+/-) will indicate which screw should be used to raise or lower the corresponding part of the adapter. **This requires that the instrument is oriented in the same position as indicated by screw number 1 on the adapter when the adjustment starts**.

If no adjustment support is required, the order and direction when sampling has no importance.

Sample Step

This description is general and correct for Calibrating with Auto Detect. Se changes in dedicated chapter if using Calibrating with Manual Selection.

The sample part of the calibration involves rotating the instrument and pressing the Sample button when the instrument is stable and not being held. This ensures accurate measurements by capturing data only when the instrument is properly aligned and stable. The laser should/could be pressed/seated firmly against the camera/filter wheel before each measurement is taken – in other words, rotate to the next position and then firmly press the laser onto the camera/filter wheel – otherwise there is a risk that the rotation lifts the laser slightly out of alignment each time.



Displaying Measured Results

The measured result will be displayed once the samples are taken and the result is calculated. In this context, "display" means drawing the circles for the Critical Focus Zones and the measured circle. The result will be added to the top of the Result Grid. Additionally, the actual focus zone will be shown as the last line in the legend part at the top of the Result View.

Evaluating Measurement Accuracy

The Result View and Grid contain data that can be used to evaluate the accuracy of the measurement. In short, the main purpose is to get the red circle as small as possible. Comparing the circle against the Critical Focus Zones references provides additional information on how good the results are.

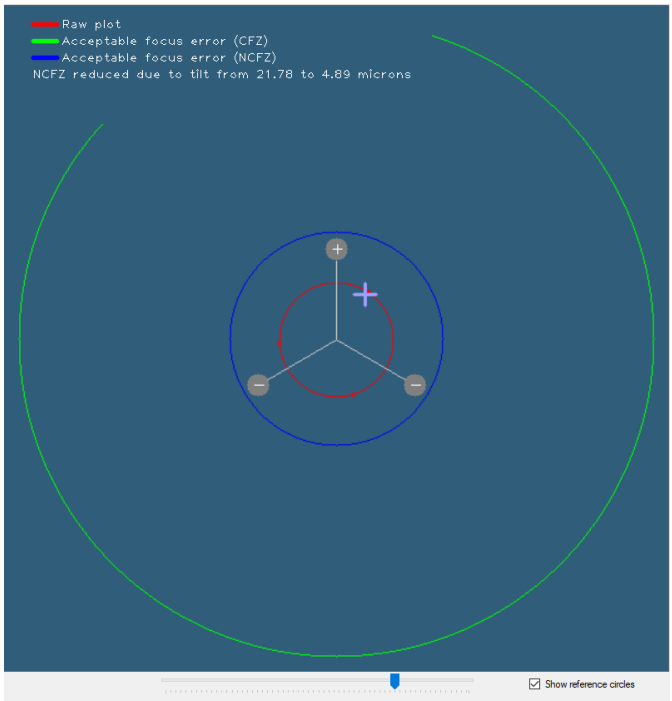
If the red circle is wider than the blue circle, it will not be possible to achieve focus across the entire sensor. This indicates that there is too much tilt, and further adjustment is required.

Adjust Step

After the result is displayed in the Result View, pressing the **Process** button again will enter the adjust step.

This changes the sampling from manual to a real-time view of the plotted laser. A cross is displayed at the laser point.

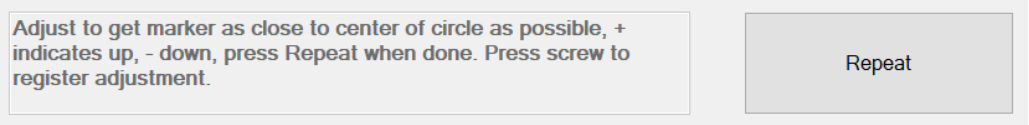
Adjustments can now be done very accurately and easily by following the cross while turning the tilt adjustment unit's screws. The purpose is to adjust until the cross is centered within the circle. It should be possible to achieve very precise centering. The slider below the result view can be used to zoom in/out to get a more precise view.



The adjustment support (+/-) will indicate which screw should be used to raise or lower the corresponding part of the adapter. **This requires that the instrument is oriented in the same position as indicated by screw number 1 on the adapter when the adjustment starts**.

Repeat Step

The calibration procedure can now be repeated until a satisfying result is obtained.



"The text in the wizard windows explains the significance of the + and - signs. Specifically, the + sign indicates that the screw should be turned to raise the adjustment adapter, while the - sign means the screw should be turned to lower it."

Calibrating Modes

A blob is a region in an image that stands out from its surroundings based on properties such as brightness, color, or texture. In this context, the term "blob" specifically refers to the laser reflection.

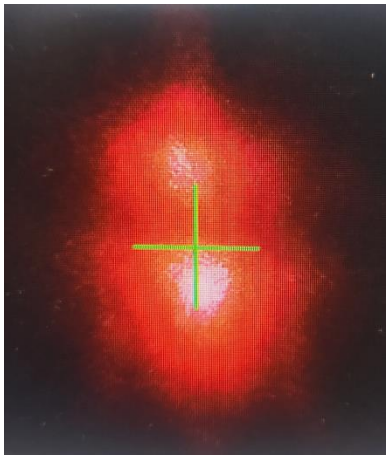
When there are no optical elements (like filters or cover glass) between the TiltAdjuster and the image sensor, typically only one prominent blob appears. In such cases, the system can automatically calculate the center of the blob using image processing algorithms.

However, minor reflections from individual pixels may still be visible but they will be so vague that they are ignored with proper exposure setting.

When optical components are present in the optical path, multiple reflections can occur. If these reflections have similar intensities, it becomes difficult for the system to automatically determine which reflection is the correct one.

Normally, by visually inspecting the blobs, it is possible to estimate the centers of the reflections. To support tilt calculation under these conditions, we have included an option to manually mark the blob center using the mouse.

It is not possible to determine, based solely on blob position, which reflection originates from the image sensor. Since optical elements like lenses and filters usually have anti-reflection coatings, it is reasonable to expect that the reflection with the highest intensity comes from the image sensor.



In the illustration above, the reflection from the image sensor appears to be the lower bright spot. Adjusting the exposure settings can help to better separate the different reflections.

Calibrating with Automatic detection

Follow the wizard, the general description above shows the manual mode.

Calibrating with Manual Selection

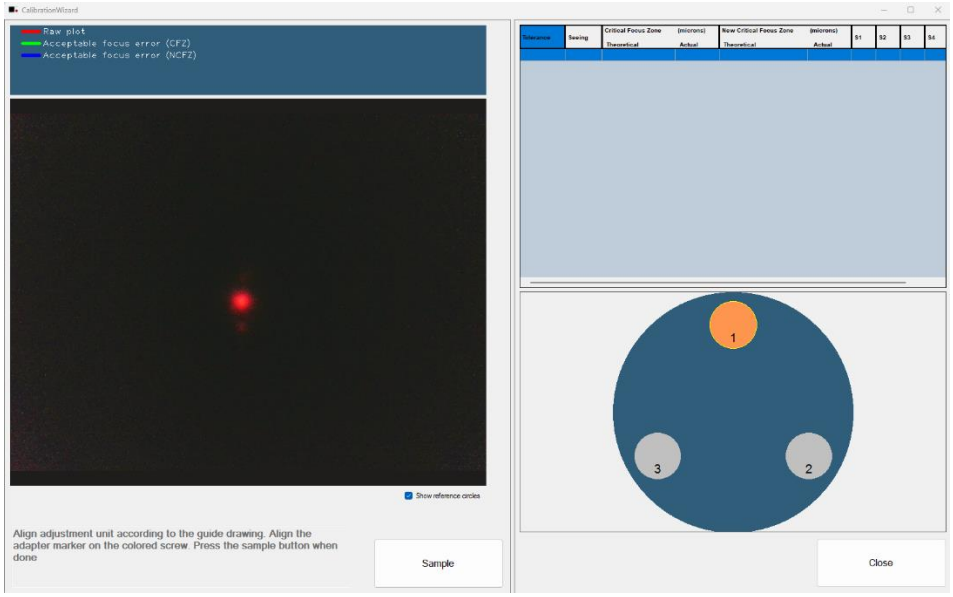
Calibrating with Manual Selection is necessary when there is more than one dominant reflection blob. Multiple blobs can result from reflections off the glass covering the camera sensor, filters, and reducers/flatteners. In some cases, the automatic mode can resolve this by adjusting the exposure of the instrument camera. This can be verified by inspecting the cross in the main view that indicates the detection point. If the cross remains stable and follows the blob when rotating the instrument, there is a good chance of a successful result. If not, Manual mode should be used.

Manual mode requires the user to identify the reflection from the camera sensor. This reflection is often the most illuminated but should be verified to ensure accuracy. Selecting the wrong reflection will result in an incorrect calibration.

Manal Mode has two options which is selected after the Calibrate with ManualSelect is pressed.

1. Absolute selection of sample points
2. Center adjusted selection of sample points

For both methods follow the wizard. **Note that you must press "Sample" and then use the mouse to click as close to the center of the blob as possible**.



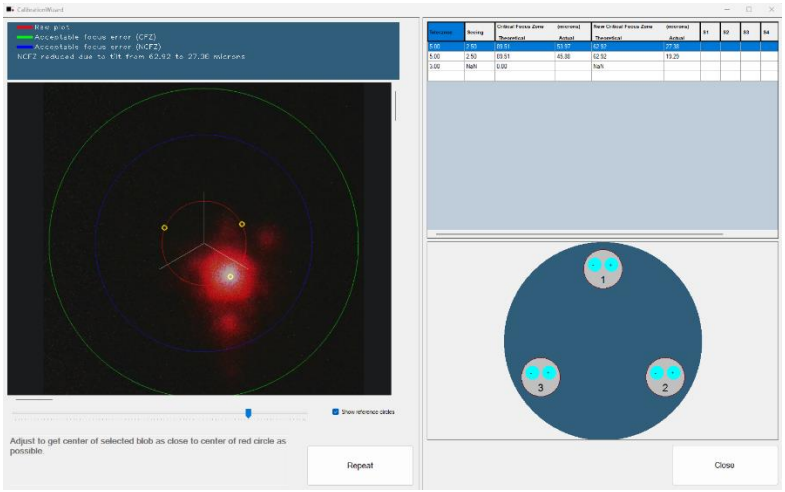
Point selection view shows the real time view of the instrument camera

Note: The Adjustment View cannot be zoomed during point selection.

Absolute selection of sample points

Press the Sample button and then select by use of the mouse the point closes to the center of the correct blob in the Adjustment View. The selected point will be marked on the screen where you click.

The adjustment can, after the required points are plotted, be done directly on the real time view. There is no support for tracking the center of selected blob must be move as close to the center as possible.



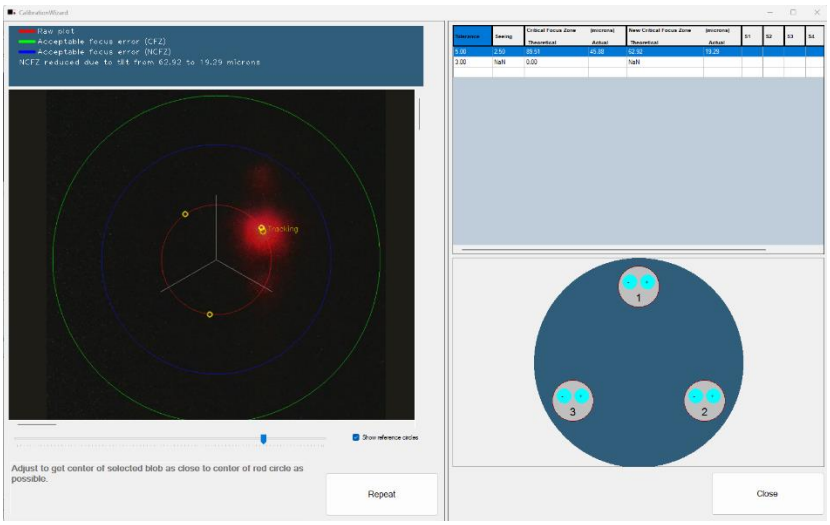
Adjustment view of Manual Point selection

Center adjusted selection of sample points

Press the "Sample" button, then use the mouse to select a point in the correct blob in the Adjustment View. The application will attempt to find the blob center and, if successful, will mark the calculated point on the screen. If the calculation fails, the sample point will be selected and marked.

Note: The Main View is available and can be used to adjust exposure time, run some calibration to try to find an "ideal" time if the center detection fails.

The adjustment can, after the required points are plotted, be done directly on the real time view. There is no support for tracking the center of selected blob must be move as close to the center as possible.



Adjustment view of Center adjusted selection of sample points

Calibrate with a filter wheel

The instrument uses a red laser, so only filters that allow red light to pass can be used for calibration. The preferred filters, in order, are: Empty, L, R, and HA.

The initial calculation of the exposure time is not always accurate when using filters. Therefore, it is important to inspect the laser and ensure the green cross is stable in the RealTime view. The green cross should remain centered in the brightest part of the dot. Often, the initially calculated exposure time is too long, so reducing it usually yields better results.