50364-001 - REV M - 07/22/21

User Manual

BEAMWATCH® USER GUIDE

LASER BEAM ANALYZER

FOR WINDOWS 10®

VERSION 3.X

OPHIR-SPIRICON, LLC
3050 NORTH 300 WEST
NORTH LOGAN, UTAH 84341
(800) 383-0814 OR (435) 753-3729

FAX: (435) 753-5231
E-MAIL SERVICE: SERVICE.OPHIR.USA@MKSINST.COM
E-MAIL SALES: SALES.OPHIR.USA@MKSINST.COM
WWW.OPHIROPT.COM

Dear Ophir-Spiricon Customer,

Thank you for your recent purchase of the BeamWatch system.

At Ophir-Spiricon we strive to provide the highest level of leading edge photonic measurement technology and service possible. We hope that your experience with us is a pleasant one, and anticipate the relationship we build will serve your photonic measurement needs for years to come.

As a valued customer, your comments and opinions are always very important to us. If you have any concerns, questions, or comments, bring them to our service department's attention. We are ready to help with everything from basic setup to working with you to find solutions for your most complex photonics measurement needs.

Please let us know if there is any way we can be of service. Thank you once again for your business.

Sincerely,

Ophir-Spiricon, LLC

Ophir-Spiricon, LLC
3050 North 300 West
North Logan, UT 84341, USA
Tel 435-753-3729
Fax 435-755-5231
www.ophiropt.com/photonics

How to Use this Guide

Read this user guide before setting up your BeamWatch system. Become familiar with the laser beam analysis theory and acquire a basic understanding of how BeamWatch operates. Insights gained through this review will facilitate achieving a correct system setup and help with interpreting results.

Chapter 1 Safety–An explanation of the potential hazards in working with this product.

Chapter 2 General Information–An introduction to BeamWatch and specifications.

Chapter 3 Software Setup–Provides software instruction on how to get started and install the BeamWatch software.

Chapter 4 BeamWatch Operating Controls–Describes the various controls and functions within the BeamWatch software.

Chapter 5 Display Customization–Explains the functionality of the various display components.

Chapter 6 Improving Results Accuracy–Gives detailed tips to improve the SNR and Caustic Fit.

Chapter 7 Automation Interface–Presents instructions on using the BeamWatch Automation Server.

Symbol Notation

Indicates general information that poses no risk.

Indicates important information about the product with little or no risk.

Indicates warning information. Failure to follow instruction may result in harm to the user or product damage.

Table of Contents

Chapter 1 Safety

While BeamWatch itself does not present the user with any safety hazards, this instrument is intended for use with laser systems. Therefore, the user should be protected from any hazards that the laser system may present. The greatest hazards associated with laser systems are damage to the eyes and skin due to laser radiation.

Optical Radiation Hazards

BeamWatch is designed for use with high power lasers and therefore safety precautions must be taken. Users must be protected against accidental exposure. Exposure to personnel other than the user must also be considered. Hazards include direct beam exposure and reflected radiation. Protective eye shields and clothing must be worn.

Electrical Hazards

BeamWatch utilizes only low voltages derived from the Ethernet, USB, and camera power supplies. Thus, there is little risk of electrical shock presented to the user.

When installing or removing any hardware from a PC, the power to the computer should always be disconnected.

The computer should always be operated with covers in place and in accordance with its manufacturer's recommendations.

The computer should always be operated with a properly grounded AC power cord.

Chapter 2 General Information

2.1 Introduction

The BeamWatch software interfaces with the BeamWatch family of products. BeamWatch enables users to see beam data collection in real time. Due to the real time nature, users can see exactly how the beam changes during the critical startup moments, and how it may vary after running for long periods of time.

BeamWatch provides a simple engaging interface that implements a familiar ribbon motif. BeamWatch also contains a fully customizable user interface that can be quickly and intuitively altered to meet the needs of the application. Windows can even be displayed across multiple monitors for ease of use.

Get the results that you need. With BeamWatch, customize the data you would like to see or hide with a just few clicks. Data can be charted in real time with a single click. BeamWatch gives full control over Logging Modes as well: collect data for a set amount of time, frames, or leave it to collect until manually stopped.

BeamWatch is truly a revolutionary product in laser measurement. See your beam like never before and no longer fear causing damage to optics with high powered lasers.

BeamWatch operates with the BeamWatch Standard and BeamWatch AM hardware products. BeamWatch Standard is for use in the industrial markets, and BeamWatch AM is designed specifically for the Additive Manufacturing market.

2.2 Computational Accuracy

The focus spot size is calculated in milliseconds without contacting the beam. BeamWatch produces accurate results within ±5%.

BeamWatch is the first product capable of measuring dynamic focal point shift. This focus position is measured in two dimensions; along both the caustic and orthogonal to the camera viewing direction. Measurement of these two dimensions at the BeamWatch video frame rate of ~6Hz, provides dynamic measurement of the focal shift in real-time. This is useful to find the behavior of the focal spot during critical startup moments and how it may vary after running for long periods of time.

Accuracy Specifications	
Waist Width (Spot Size)	±5%
Waist Location: BeamWatch Standard BeamWatch AM	 ±125 microns within the BeamWatch window ±150 microns relative to the reference plane
Focal Shift	±50 microns
Beam Parameter Product	±3.5% RMS
Divergence	±3.5% RMS
M^2	±3.5% RMS
Power (BeamWatch AM only)	±3%

Chapter 3 Software Setup

3.1 BeamWatch Software Installation

System Requirements

Operating System	Windows 10, 64 bit
Graphics	Advanced chip set with 1GB of dedicated graphics memory
Main memory	4GB minimum, 8GB recommended
Disk Space	50GB minimum, 100+GB required to log large data files
Monitor	1440x900 minimum
Network Adapters	Support Jumbo Packets (required for units with a GigE camera)
Data Cable	CAT6 Ethernet (supplied, required for units with a GigE camera) USB 3.0 (supplied, required for units with a USB3 camera)

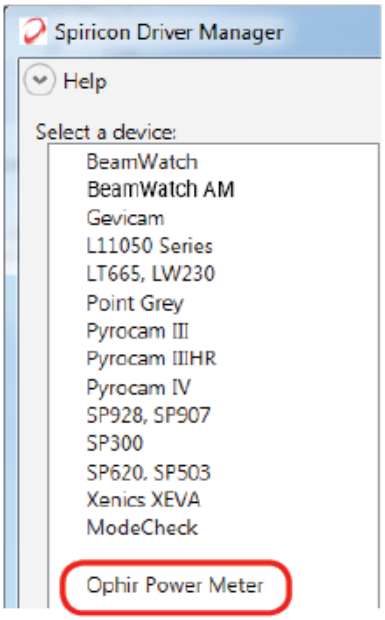
For BeamWatch units that operate a camera with a GigE interface, all connections in the network path must support Jumbo Packets. Refer to section A.2.2 for details on how to configure Jumbo Packets and other ways to optimize the network adapter properties.

Not all gigabit network interface cards support the features required for GigEVision devices. Desktop and laptop computers with built-in adapters may not be compatible with GigEVision devices. Separate purchase of a third-party NIC may be required. Use of non-compatible equipment may result in unstable connectivity and data transfer with GigEVision devices.

There are two ways to install the software from the Spiricon provided CD. All installations must be performed with Administrator privileges.

1. If the computer is setup to Auto Play CD's do the following:
    a. Insert the supplied CD into the CD-ROM drive and wait for the **Spiricon Software Auto Install** screen to appear.
    b. Select the **Software Install** button.
    c. Follow the directions that appear on the screen.
2. If the computer does not have the Auto Play feature enabled:
    a. Insert the supplied CD into the CD-ROM drive and open **Windows Explorer**.
    b. Select **My Computer** and right-click the CD-ROM drive that contains the Spiricon CD. Select the **Autoplay** option. This opens the **Spiricon Software Auto Install** screen.
    c. Select the **Software Install** button.
    d. Follow the directions that appear on the screen.

Important for BeamWatch AM users:
*After the installation completes the **Spiricon Driver Manager** window appears. Install the driver for the Ophir Power Meter at the bottom, otherwise the power meter will not connect.*

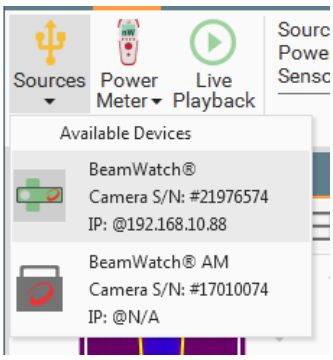


Ophir-Spiricon no longer verifies or certifies operation with Windows 7.

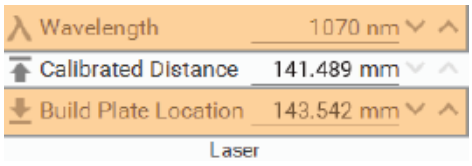
After the program is installed, the BeamWatch icon appears on the desktop. The latest version of the software can be found on the Spiricon website at www.ophiropt.com.

3.2 Getting Started

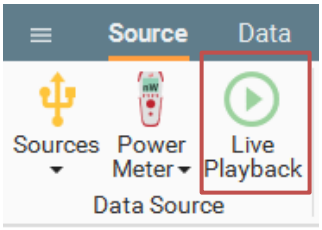
1. To start the BeamWatch software, double click the desktop icon or from the Windows taskbar, select **Start** -> **All Programs** -> **BeamWatch**
2. Select the desired device from the **Sources** dropdown.



3. Enter the required setup information in the **Laser** panel, see 4.4.3 Laser Panel. You are now ready to start taking measurements.



4. Displays initially appear blank. Select **Live Playback** in the **Data Source** panel to start and stop data collection.



Review the remaining chapters of this user guide and become familiar with the operation and capabilities of the BeamWatch system before performing laser measurements. This user guide may also be found on the Spiricon website at www.ophiropt.com. Simply follow the BeamWatch product links.

Chapter 4 BeamWatch Operating Controls

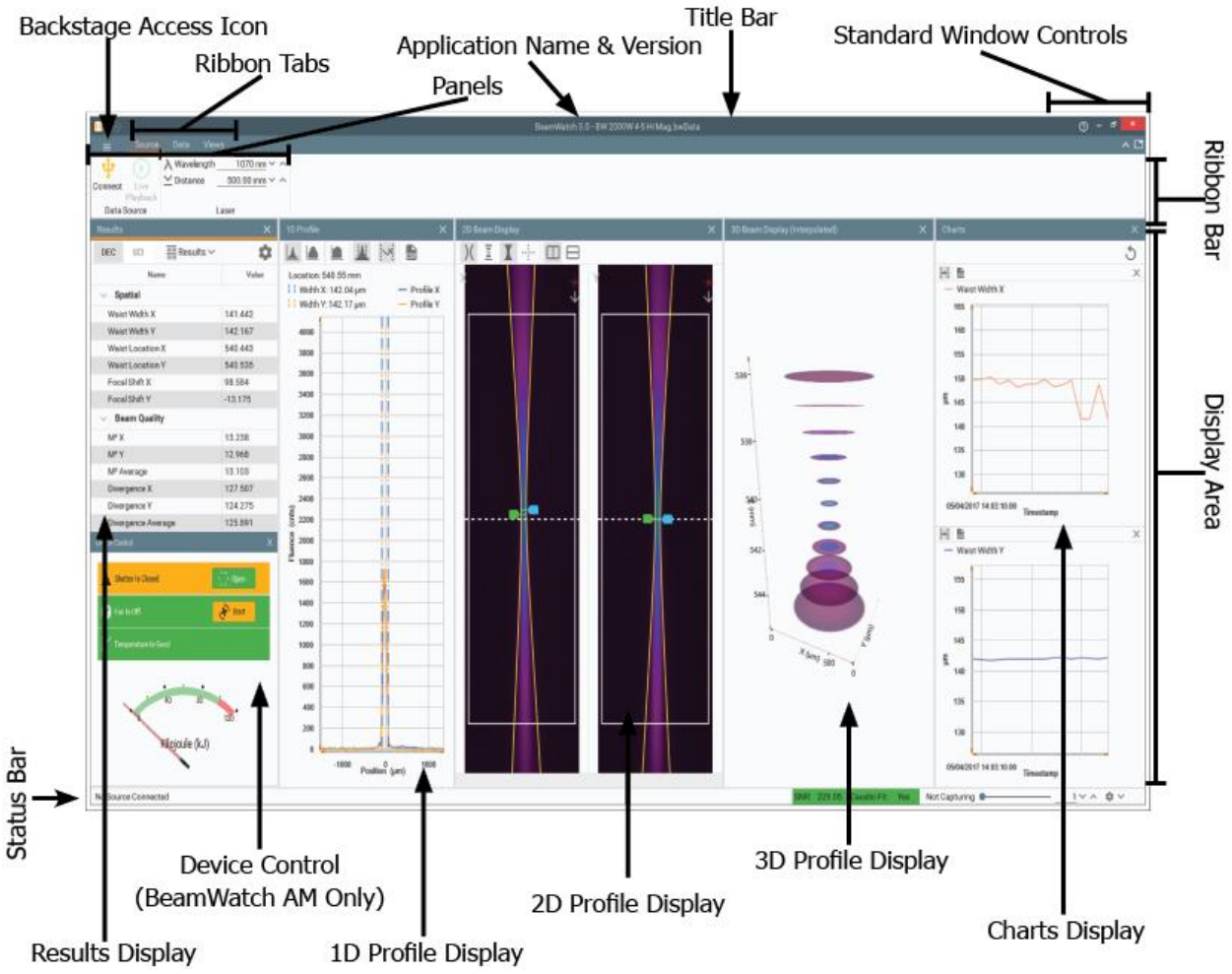
This chapter describes the various screens and display features, as well as the controls provided within the ribbon bars and display windows.

BeamWatch is designed to be simple and intuitive, which allows users to gather quick and accurate measurements without a lot of time spent on configuration and learning.

4.1 Display Terminology

The BeamWatch layout employs terminology that may be new to some users. This section provides a graphical glossary of the terminology used.

There may be variation in naming conventions in the ribbon motif employed in BeamWatch. The terms selected in this guide are used for consistency.



4.2 User Interface Features

4.2.1 Title Bar

The topmost bar on the application contains from left to right:

System Menu Button
Access window controls.

Quick Access Toolbar
Start/Pause data collection.

Application Information
Application name, version number, and file playback name if applicable.

Help
Select the help icon to bring up this user guide quickly without exiting the software.

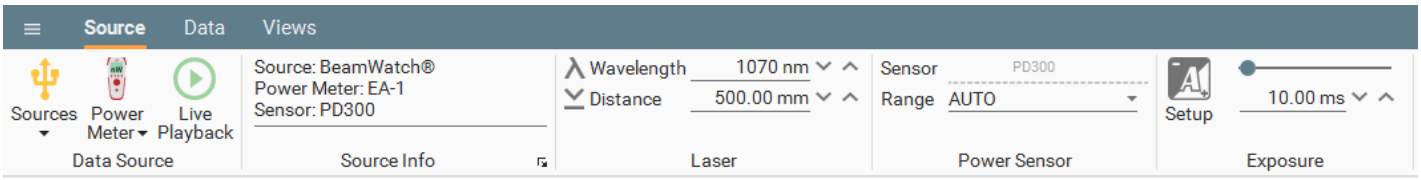
Standard Windows Controls
Minimize, **Maximize**, and **Close** buttons.

4.2.2 Ribbon Tab

Select a tab to swap ribbon controls. Double-click a tab to hide/show the ribbon bar display area. If hidden, single-click a tab to view the ribbon bar until it is clicked off.

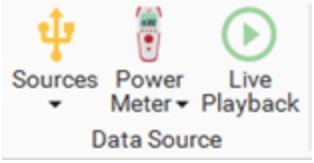
Double-click blank space in this bar to change to a windowed or maximized view for the application.

4.2.3 Ribbon Bar



Displays the current set of panel control options available within a selected ribbon tab.

4.2.4 Panels



Panels contain buttons, drop-down lists, edit controls, etc. Hover the mouse over a control to view tool-tips on most controls.

4.2.5 Display Area

The display area consists of all docked display windows. Each display can be disabled, resized, docked, or floated to any location on the screen. The content of the display area is explained more in section 4.6 View Ribbon.

4.2.6 Status Bar

The status bar contains useful information about the connected camera, results accuracy, and frame buffer size.

Beam Source

The BeamWatch model and serial number display here when a camera is connected. If a power meter is connected, its model and serial number are also displayed.

When viewing a loaded file, "File Playback" is displayed.

Annunciator

The **Annunciator** evaluates different characteristics of the image quality and notifies if the calculated results have degraded accuracy. If the overall image is good, each section of the **Annunciator** is green. If one of the checks fails, that section turns yellow.

Annunciator *colors can be easily distinguished through laser protective eye-wear. A more detailed explanation of this annunciator and how to improve the results accuracy is described in Chapter 6 Improving Results Accuracy.*

Capture Rate

The frame rate is calculated and updated as data frames are received from the camera in real time. When stopped, "Not Capturing" is displayed.

4.2.6.1 Frame Buffer

The frame buffer is a temporary data storage space. The frame buffer size and current frame position are indicated in the buffer controls in the status bar. Once the frame buffer is full, data acquisition continues and frames are overwritten in a "first in, first out" basis. Data from deleted frames is lost. Result statistics are not affected by the frame buffer size or frame buffer loop.

Frame Buffer Position

The slider edit control indicates the current displayed frame. Drag the slider, use the control arrows, or type in the field to set the desired location.

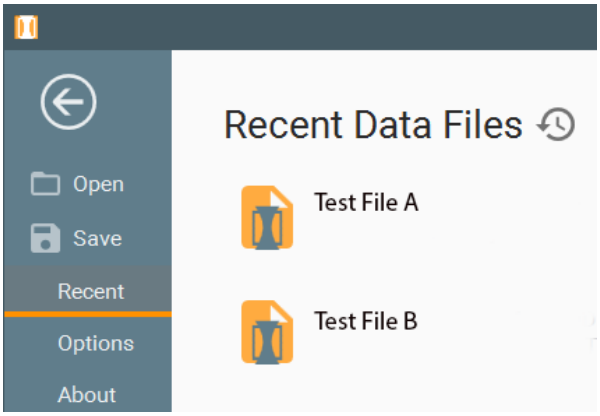
When loading saved data files, the frame buffer fills with all of the saved frames. Frames can be scrolled through manually or automatically using the **File Playback**. See 4.4.7 File Playback Panel.

4.3 Application Tools

Application Tools can be found in the same bar as the ribbon tabs.

4.3.1 File Menu

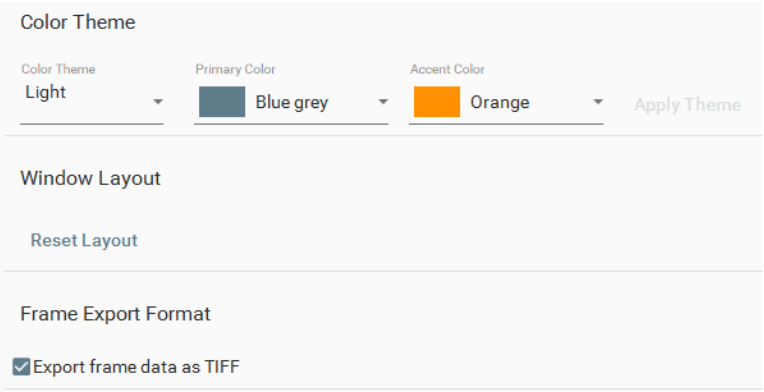
Select  to access the **File Menu**.



Open
Opens **Windows Explorer** to navigate to a specific file to open for file playback.

Save
Opens **Windows Explorer** to navigate to a location to save the current data file.

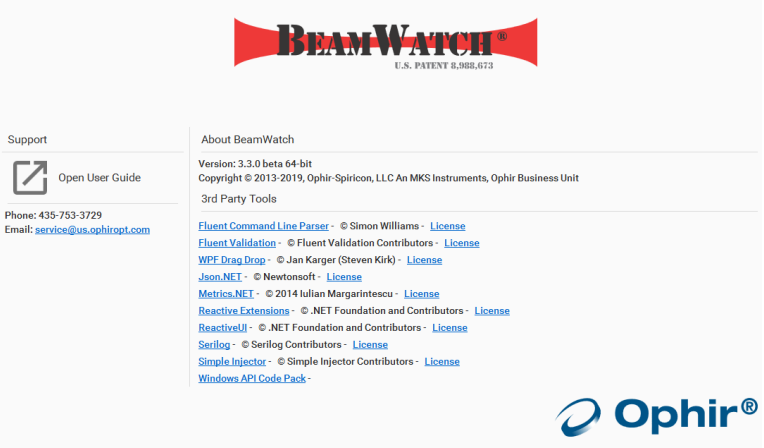
Recent
Stores quick links to recent data files.



Options
Color Theme allows customization of the color scheme of the user interface. Choose a combination of a light or dark theme, a primary color, and secondary color. Select **Apply Theme** to accept changes.

Windows Layout allows you to restore the windows to the default configuration.

Enable **Export frame data as TIFF** to save images in a tiff format (see section 4.3.1.1 for more information). If unchecked the data remains as an integer array.



About
Displays the current software version and copyright information and provides a link to this user guide.

4.3.1.1 TIFF Image Format

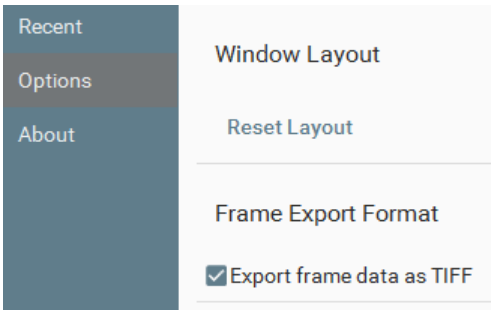
TIFF files are an encoded, compressed data file format that produces smaller data files and can be easily loaded into third party applications, such as MATLAB. Files saved as TIFF retain the *.bwData extension but can be manually loaded into other applications that support TIFF formats.

TIFF data is stored using the gray32bppFloat pixel format. This format uses a single color channel with 32 bits of precision. The pixel count is stored as a normalized floating point value between -1 and 1. The value is calculated using the minimum and maximum values of a signed 32-bit integer, namely ±2,147,483,647. The original per pixel values of the collected data can be obtained by multiplying the floating point value obtained from the tiff image by 2,147,483,647.

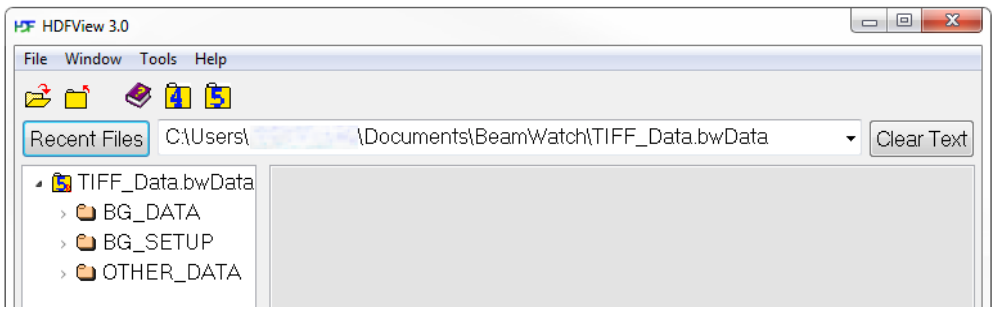
4.3.1.1.1 Exporting TIFF Images for use with HDF5

TIFF images can be exported for use with HDF5.

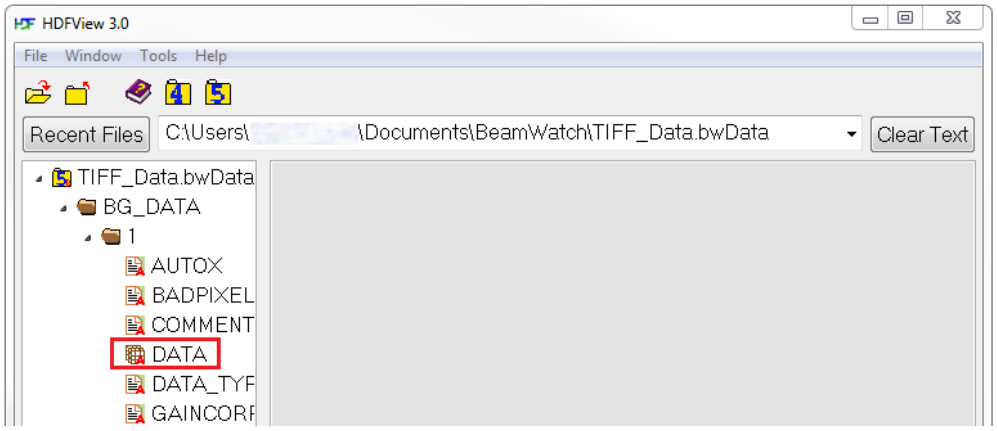
1. In the **Options** view, enable **Export frame data as TIFF**.
2. Save a data file.



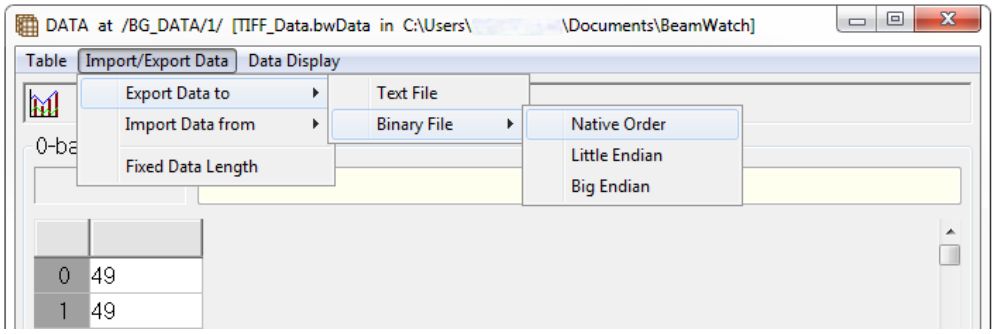
3. Download and install HDFView.
4. Run HDFView.
5. Open the BeamWatch data file.



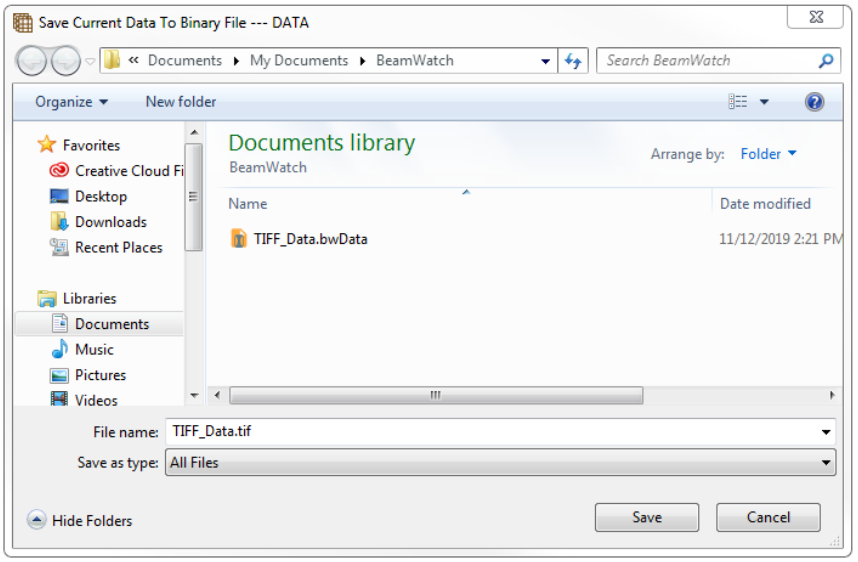
6. Click and expand **BG_DATA**.
7. Click and expand the desired frame number.
8. Right-Click on **DATA**, and select **Open**.



9. Select **Import/Export Data -> Export Data to -> Binary File -> Native Order**.



10. Locate and open the TIFF file with desired software.

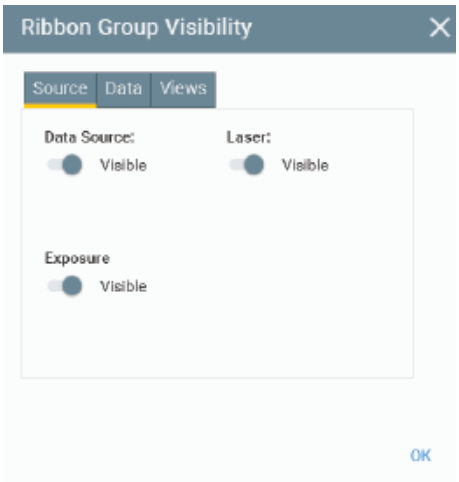


4.3.2 Show/Hide Ribbon Bar

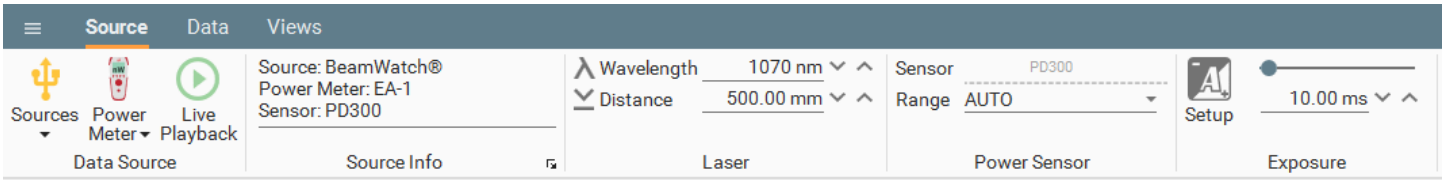
Select  to display or hide the ribbon bar. This can also be accomplished by double-clicking a tab as referenced in section 4.2.2 Ribbon Tab.

4.3.3 Ribbon Group Visibility

Select  to open the **Ribbon Group Visibility**. From here, select the tab of the ribbon to customize and select a respective slider to turn that panel on or off.

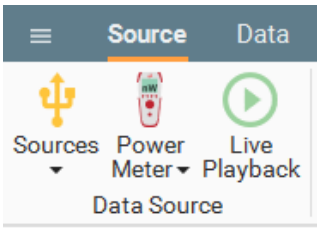


4.4 Source Ribbon

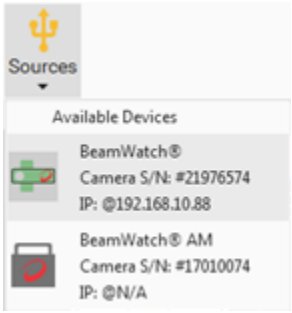


The **Source** ribbon provides control over the camera source and beam information. This ribbon varies by camera.

4.4.1 Data Source Panel



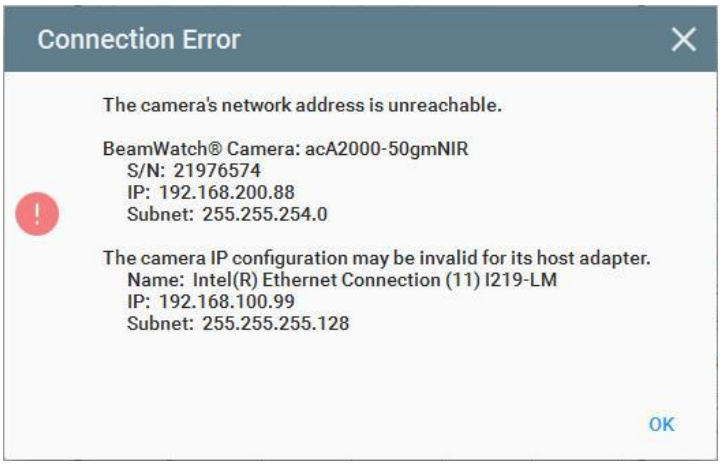
The **Data Source** panel allows the user to connect to the BeamWatch camera, an Ophir power meter, and to toggle **Live Playback** on and off.

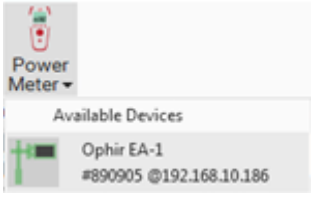


Sources

Opens a dropdown menu that displays connected camera devices. BeamWatch and BeamWatch AM have unique icons (seen in the figure on the left) that identify each device type. The device name, serial number, and IP address is listed to the right of the device icon. Select a device from the dropdown to set it as the active camera.

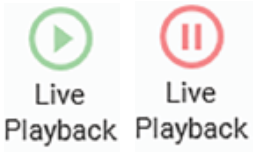
If trying to connect to a BeamWatch unit with an invalid IP address, a connection error is displayed. Refer to Appendix A for instructions on how to configure the IP address.





Power Meter

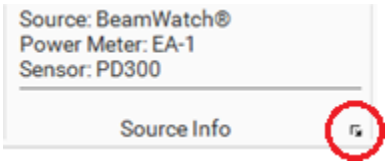
Opens a dropdown menu that displays connected power meter devices. The device name, serial number, and IP address is listed. Select a device from the dropdown to set it as the active power meter.



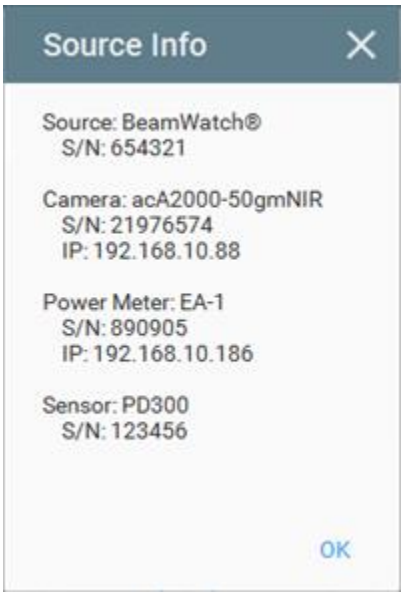
Live Playback
Starts or stops data collection. The icon changes to reflect when the program is running or paused.

This function is repeated in the **Quick Access Toolbar**  .

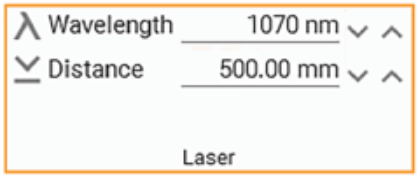
4.4.2 Source Info Panel



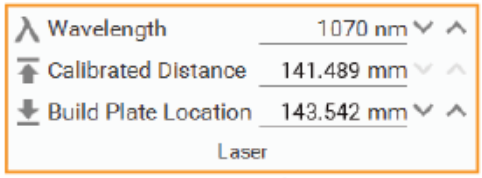
The **Source Info** panel displays the name of all connected devices. Select the expand icon at the bottom right of the panel to view the serial numbers and IP addresses, where applicable.



4.4.3 Laser Panel



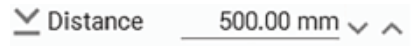
BeamWatch Standard



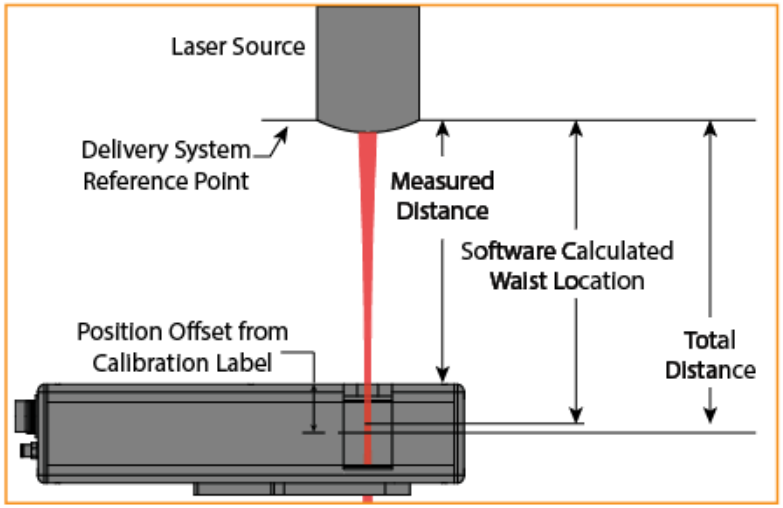
BeamWatch AM

Use this panel to enter information about the laser used in the calculation of results. Laser information should always be entered prior to data collection.

Wavelength
Enter the wavelength of the beam in nm. This value is used when calculating **Beam Quality** results.



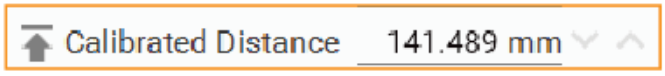
Distance (BeamWatch Standard Only)



The Position Offset value is located on the unit's calibration label.

Enter the Measured Distance from a desired reference point on the laser delivery head to the top face of the unit in mm. This value is used to calculate the waist location relative to the reference point. If 0 is entered the waist location result is measured from the top of the BeamWatch.

The Position Offset is calibrated at the factory. The software adds the Position Offset to the Measured Distance to get the Total Distance. The Total Distance is used to determine the **Waist Location** and the current **Waist-Cursor** Location.



Calibrated Distance (BeamWatch AM Only)

The **Calibrated Distance** is set at the factory and cannot be edited. This is the distance from the bottom of the BeamWatch AM unit to the center of the camera imager and is marked on the calibration sticker.

Build Plate Location (BeamWatch AM Only)

Enter the actual distance the build plate has been lowered in mm. In this example, the build plate has been lowered beyond the calibrated distance by 2.053mm.

Lower the build plate beyond the calibrated distance to see more of the beam caustic after the focus. This method is preferred if there is little focal shift and more Rayleigh lengths need to be viewed.

Lower the build plate less than the calibrated distance to see more of the beam caustic before the focus. This method is used when there is significant focal shift.

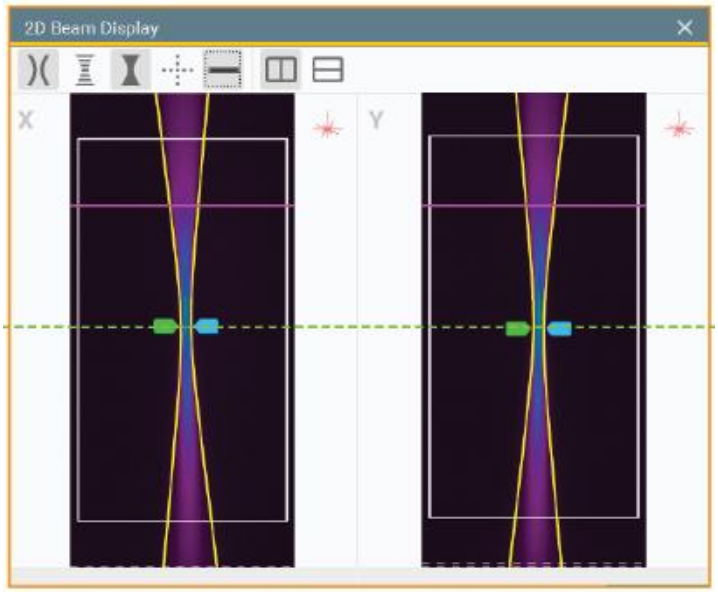
*First-time users should match **Calibrated Distance** and **Build Plate Location** as closely as possible. Advanced users that need to see more focal shift or capture additional Rayleigh lengths may wish to offset these values.*

The build plate should always be placed within ±5mm of the Calibrated Distance. Operating outside of this range can cause damage to the unit.

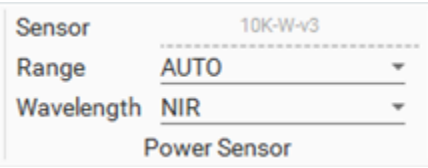
As the **Build Plate Location** is changed the purple **Working Plane Marker** in the **2D Beam Display** updates showing the actual location of the build plane.

In this example, the build plane has been lowered beyond the calibrated distance. Notice how the **Working Plane Marker** has moved up showing where the build plane is in reference to the center of the imager.

(The green dashed lines have been added to show the center of the imager.)



4.4.4 Power Sensor Panel



The **Power Sensor** panel allows you to change the measurement scaling **Range** of the active power sensor and set the **Wavelength** range on applicable sensors.

Sensor
Displays the name of the active power sensor.

Range
To provide accurate power measurements, the electronics of the power sensor must be configured to work in a range that is most suited to the measurement conditions. Click the dropdown to open the menu and select a power scaling range for the power sensor to measure.

When the range of the expected readings is unknown, or if highly varied readings are anticipated, select **AUTO**.

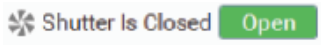
Wavelength
Thermopile sensors have different absorptions at different wavelengths. To compensate for these differences, each sensor has been calibrated by a laser at several wavelengths. Click the dropdown to select a wavelength range and apply the appropriate correction factor.

Some sensors are also equipped with a Scatter Shield. This shield limits the amount of laser power/energy that escapes the power sensor. When this shield is in use, an additional correction factor needs to be applied. Select the wavelength option that ends in an "S" (i.e. NIRS).

This selection is only available for Ophir branded power sensors that support wavelength ranges. Power sensors that support discrete values will use the same wavelength value that is set in the **Laser** panel (see section 4.4.3).

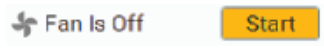
4.4.5 Device Control Panel (BeamWatch AM Only)

BeamWatch AM contains a specific panel that controls the shutter and the fan and displays a temperature notification to ensure safe operation. These controls are duplicated in the **Device Control** window.



Shutter Status

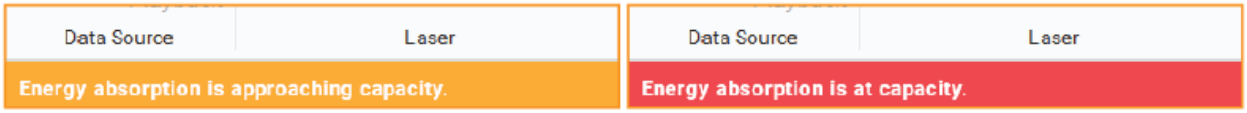
Displays the current shutter status and is used to open or close the shutter in the input aperture. **The shutter must be open before applying the laser to avoid damaging the unit** and can only be opened when the purge gas is flowing. This function is blocked whenever the fan is active. **Always close the shutter before turning off the purge gas to keep particles out of the unit.**



Fan Status

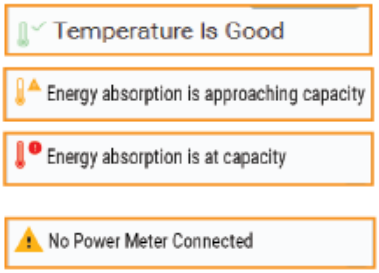
Displays the current shutter status and is used to activate or deactivate the fan to cool down the unit. Before the BeamWatch AM unit overheats, a warning displays below the Ribbon Bar and in the **Device Control** panel. The warning turns yellow when the thermistor inside the device trips, but is below 120kJ, and red at 120kJ.

When the warning turns red, **stop operation, remove the unit from the build chamber, and activate the fan to avoid causing damage to the unit.** The fan cannot activate while the shutter is open.



Select the 'X' on the right side of the warning to dismiss.

Failure to remove the unit from the build chamber during cooling will not provide sufficient airflow and can overheat delicate parts in the unit.



Temperature Status

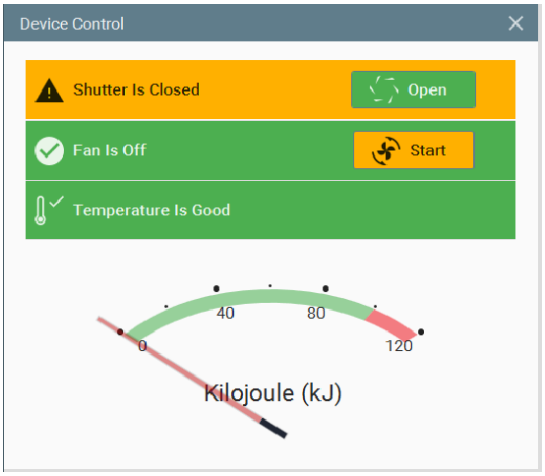
Displays the current energy absorption of the unit. The status turns yellow when the energy threshold is approaching capacity and red when the energy threshold reaches maximum. Depending on operating conditions the unit can run for a short period after the status turns yellow.

Power Meter Status

The status changes to a warning if there is no power meter connected. All of the statuses are duplicated in the **Device Control** window if it is active. See the Troubleshooting Guide if the power meter is not connecting.

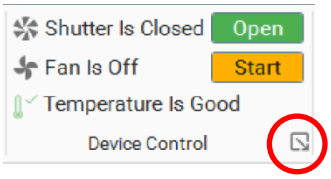
When operating at low powers for a long period of time the background noise of the camera will rise, this can provide poor results. This is seen by the background color of the 2D Display changing to blue or green. To return the unit to normal, unplug the USB and Power cables for 5 to 10 minutes until the unit is cool to the touch.

4.4.5.1 Device Control Window (BeamWatch AM Only)

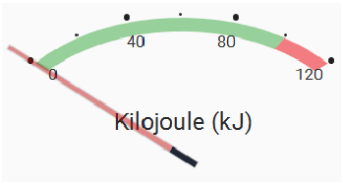


The **Device Control** window contains the same controls as the ribbon, as well as a **Joule Counter** that shows how much longer the unit can be run. **Do not operate if the Joule counter reaches maximum.**

Each control's status changes based on its current state. When all controls display green it is safe to apply the laser.



If the **Device Control** window is not visible or is closed, it can be reopened by selecting the **Expansion Button** in the **Device Control** panel.

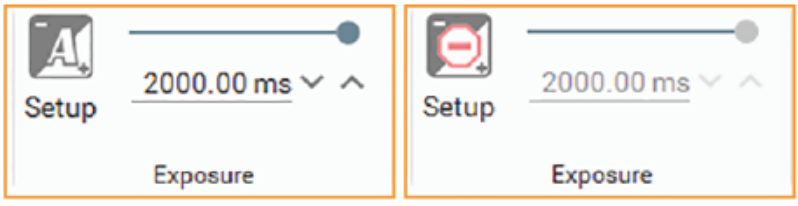


The Joule Counter displays the current energy received by the power sensor. After reaching maximum, a warning appears below the ribbon bar. As soon as the counter reaches maximum **stop operation, remove the unit from the build chamber, and activate the fan to avoid causing damage to the unit.** When the **Joule Counter** drops to a safe temperature you may resume data collection.

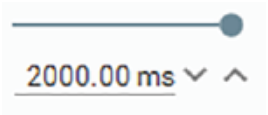
When the unit reaches maximum temperature, it takes approximately 20 minutes with the fan on to cool the unit, and approximately 200 minutes without the fan. Always remove the BeamWatch AM from the build chamber during cooling.

The device remembers the joule counter location when unplugged and then reconnected as long as it is connected to the same PC.

4.4.6 Exposure Panel



This control is only available when a BeamWatch unit is connected to the software. These options determine the intensity and quality of the output image.



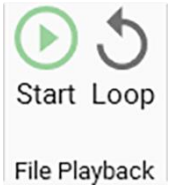
Exposure

Sets the amount of time the camera views the beam before reporting a frame. Increasing Exposure yields a higher SNR and a brighter image. Depending on the power density of

the beam, setting the Exposure too high can saturate the image, typically around the waist location, and degrade measurement accuracy. Saturation appears white in the image. Use the slider or enter a value in the field to adjust the **Exposure** for the camera.

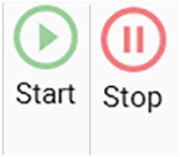
Auto Setup
Select **Auto Setup** to configure an initial exposure setting. This can be used as a starting point to get close to an acceptable exposure value. The beam must be on, and to get the best results set the cursor to the waist location. **Auto Setup** starts at maximum exposure and adjusts downward until saturation along the cursor is at or below 90% of the camera's dynamic range. The setup may take some time due to the speed which frames can be passed from the camera. If needed, select the **Auto Setup** icon again to cancel.

4.4.7 File Playback Panel



The **File Playback** panel is visible when a data file is loaded (See section 4.3.1 File Menu), allowing the user to review and play through a selected data file that contains multiple frame records. Frames loaded into the frame buffer can be scrolled through manually with the frame buffer, or automatically by selecting the **Start** button.

Data files can store a maximum of 999 frames using the Frame Buffer, as well as current BeamWatch settings including **Wavelength**, **Distance**, **Summing**, **Averaging**, and **Notes**.



Start/Stop
Toggle **Playback** on and off. Automatically stops after reaching the end of the buffer unless **Loop Playback** is enabled.

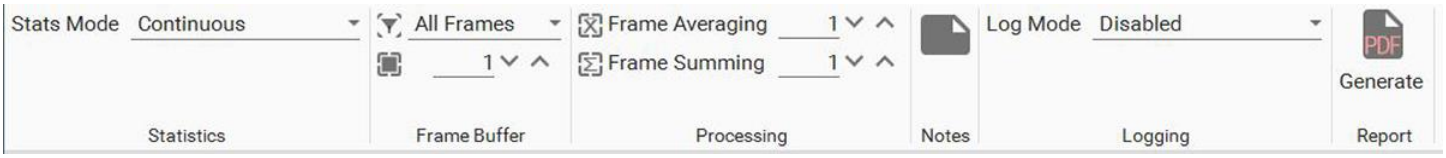
Loop Playback
Enables/disables continuous playback through the frame buffer.

Exit File Playback
Select **Sources** to exit **File Playback** and reconnect to the BeamWatch unit.

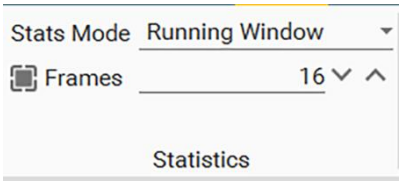
All existing settings are overwritten when a data file is loaded. Important data should be saved before loading another data file.

4.5 Data Ribbon

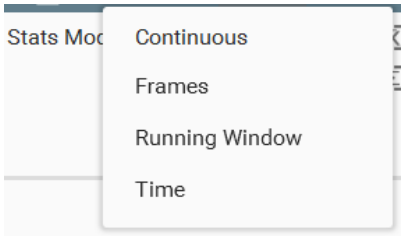
The **Data** ribbon provides many standard controls for managing how image data is captured and processed.



4.5.1 Statistics Panel

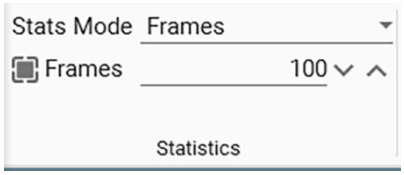


The **Statistics** panel sets the number of samples to use in computing the statistical results values.

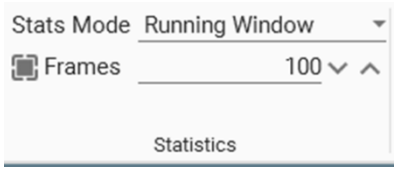


Stats Mode

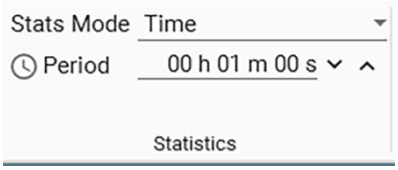
Select the **Stats Mode** drop-down to set how statistics are collected. There are four different modes for collecting statistics. Most modes have a specific edit box in the panel that controls stop limits.



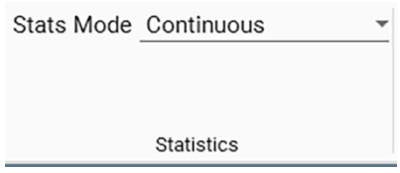
Frames—Sets statistic collection to stop after a specified number of frames with a maximum of 9,999. A common form of data collection.



Running Window—Allows statistics to be recomputed continuously, with only the values from the last number of specified frames. The maximum number of frames is 9,999.

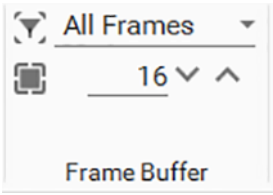


Time—Sets statistic collection to a specified amount of time in HH:MM:SS with a maximum of 23:59:59.



Continuous—Sets statistics to be computed continuously until manually stopped or reset.

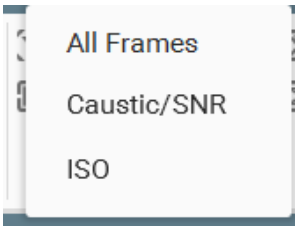
4.5.2 Frame Buffer



The **Frame Buffer** panel gives you control over which frames are saved in the **Frame Buffer**. Use the drop down to set which types of frames are saved.

Frame Buffer Mode

Select the drop-down to select a frame buffer mode. The frame buffer mode determines which frames are saved to the frame buffer.



All Frames

Saves all frames to the buffer with no filtration.

Caustic/SNR

Saves only frames with a green SNR and Caustic Fit annunciator. 

ISO

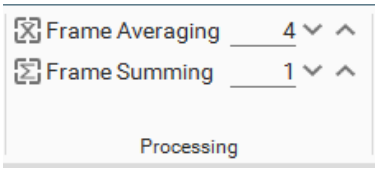
Saves only frames that meet the ISO requirement.

Frame Buffer Size

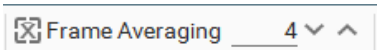
The size of the frame buffer is set here. Specify the number of frames for the buffer to hold (9,999 max).

Saving data files saves all frames in the frame buffer. The larger the frame buffer, the larger the data file. Always use the smallest required buffer size.

4.5.3 Processing Panel



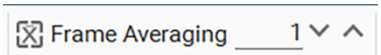
The **Processing** panel allows for various types of image processing which are applied during data collection of frames.



Frame Averaging

Enter the number of frames to be averaged while collecting data. The averaging result is added to the frame buffer and used in calculations. In the example above, four frames are averaged and the resulting single frame is added to the frame buffer and used in calculations.

Frame averaging is a convenient method that can improve the signal-to-noise ratio (SNR) when observing low signals where noise is a significant problem.



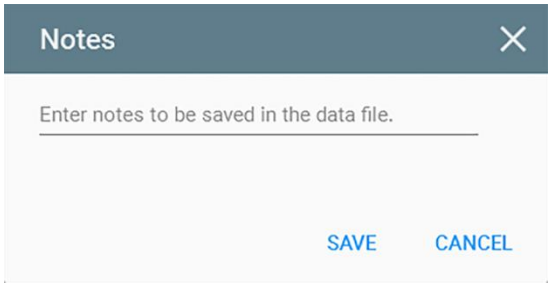
Frame Summing

Enter the number of frames to be summed. The summing result is added to the frame buffer and used in calculations. In the example above, frame summing is set to one, which disables summing.

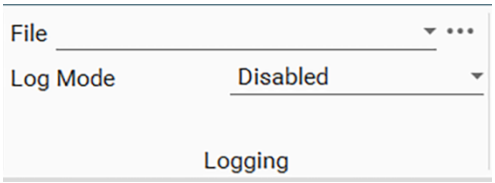
Frame summing is a technique to increase the amplitude of weak signals, especially for beams with power densities <1MW/cm^2. Be cautious, the displayed signal may become saturated and the calculated results will become invalid if too many frames are summed.

4.5.4 Notes Panel

Select to open a separate **Notes** window for text entries. This window automatically resizes to fit the entered text. Add notes at any time. To close the window, select **Save** or **Cancel**. Canceling reverts to the previous saved state. Notes entered appear on the PDF report (See 4.5.6 Report Panel) and are saved in the *.bwData file and are loaded when reviewing data.



4.5.5 Logging Controls Panel

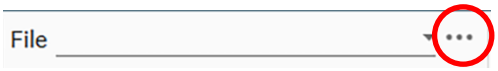


Logging is used to record data for results in a CSV format. Each logging file contains a time stamp, and only enabled results and statistics are logged. Logs can be imported into spreadsheet software programs, like Excel, for further analysis. **Changes in this panel cannot be made during Live Playback**.

All log file entries pertaining to one frame of data are called a record, and each record is time-stamped. Log files are opened when they begin collecting records and closed when the final record is entered and the logging process is terminated.

File

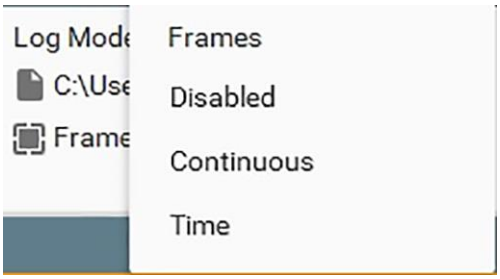
Displays the name of the file and the save location of the current logging operation. Selecting a **Log Mode** will prompt you to choose a file name and location for the logging file. Hover over the file path after it is loaded to see the full path and name.



File Browse

Opens **Windows Explorer** to create a save location and file name. Select **Save** when finished.

If the specified file already exists when logging is started, logging data is auto appended. Each new data set has a new header in the CSV report.



Log Mode

Enables logging and sets the logging method. The four methods are:

Disabled–No logging is enabled.

Continuous–Logging is set to collect until manually stopped or paused. *Warning: If **Live Playback** is not stopped when set to **Continuous**, the log will collect until the hard drive is full.*

Frames–Logging is set to stop after a set number of frames.

Time–Logging is set to stop after a set amount of time.

When logging is stopped in **Frames** or **Time** Mode, the **Log Mode** is automatically set to **Disabled** and data acquisition is stopped. To begin a new logging cycle the logging method must be reselected.

When logging is stopped in **Continuous** Mode, the **Log Mode** remains active and logging auto appends.

When time or frame logging is in process, a progress meter  appears in the status bar.

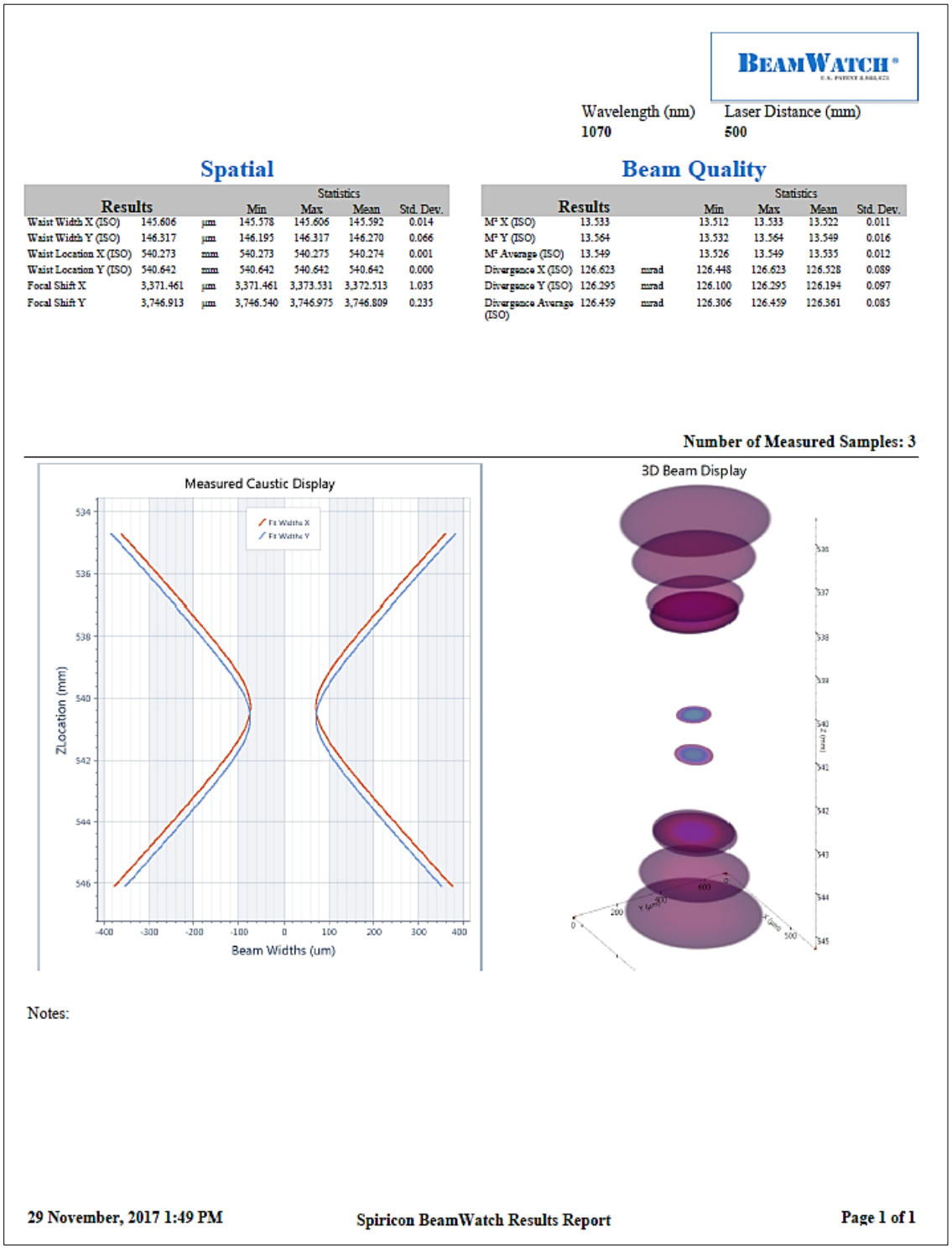
When logging continuously, a processing icon  appears in the status bar providing a visual reminder that the log is running.

4.5.6 Report Panel

Generate

The report feature generates a PDF file with data from the current frame. The report includes all enabled results and statistics, a measured caustic fit chart, and the interpolated 3D image. Notes entered in the **Notes** panel are included at the bottom of the report.

When selected, **Windows Explorer** opens. Enter the save location and file name, then select **Save**. The report saves and opens automatically in the default PDF viewer program.



BEAMWATCH®

Wavelength (nm)	Laser Distance (mm)
1070	500

Spatial

Results			Statistics			
			Min	Max	Mean	Std. Dev.
Waist Width X (ISO)	145.606	µm	145.578	145.606	145.592	0.014
Waist Width Y (ISO)	146.317	µm	146.195	146.317	146.270	0.066
Waist Location X (ISO)	540.273	mm	540.273	540.275	540.274	0.001
Waist Location Y (ISO)	540.642	mm	540.642	540.642	540.642	0.000
Focal Shift X	3,371.461	µm	3,371.461	3,373.531	3,372.513	1.035
Focal Shift Y	3,746.913	µm	3,746.540	3,746.975	3,746.809	0.235

Beam Quality

Results			Statistics			
			Min	Max	Mean	Std. Dev.
M² X (ISO)	13.533		13.512	13.533	13.522	0.011
M² Y (ISO)	13.564		13.532	13.564	13.549	0.016
M² Average (ISO)	13.549		13.526	13.549	13.535	0.012
Divergence X (ISO)	126.623	mrad	126.448	126.623	126.528	0.089
Divergence Y (ISO)	126.295	mrad	126.100	126.295	126.194	0.097
Divergence Average (ISO)	126.459	mrad	126.306	126.459	126.361	0.085

Number of Measured Samples: 3

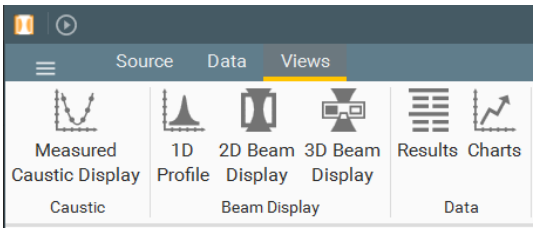
Measured Caustic Display

3D Beam Display

Notes:

29 November, 2017 1:49 PM Spiricon BeamWatch Results Report Page 1 of 1

4.6 View Ribbon

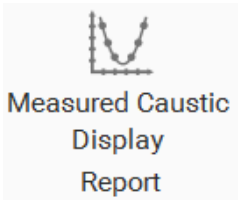


The **Views** ribbon provides a way to open and close windows in the display area. 3D Beam Display is only visible with dual axis units.

In a floating window  *is visible. Select to switch to a maximized view.*

Empty frames (before or after data collection) in the buffer do not display anything in any of the views windows.

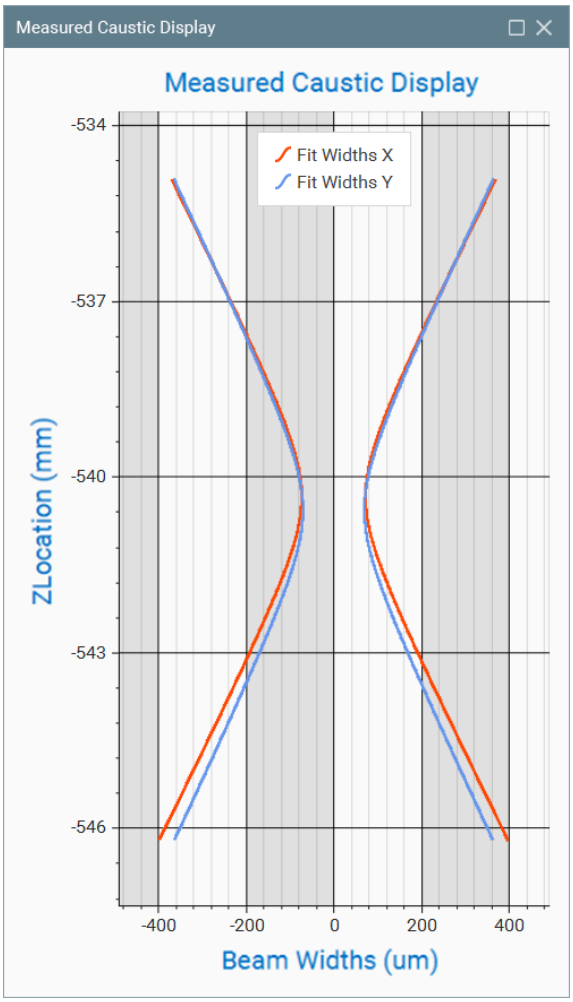
4.6.1 Measured Caustic Display Panel



Select the **Measured Caustic Display** icon to toggle the **Measured Caustic Display** window shown below.

The **Measured Caustic Display** shows a separate display of the measured beam caustic seen in the **2D Beam Display**. The centroid of the beam is at 0 on the horizontal axis, and the vertical axis is the Z axis of the beam.

Two caustics are displayed with dual axis units that represent the X and Y axes. These lines can show any astigmatism that may be present.

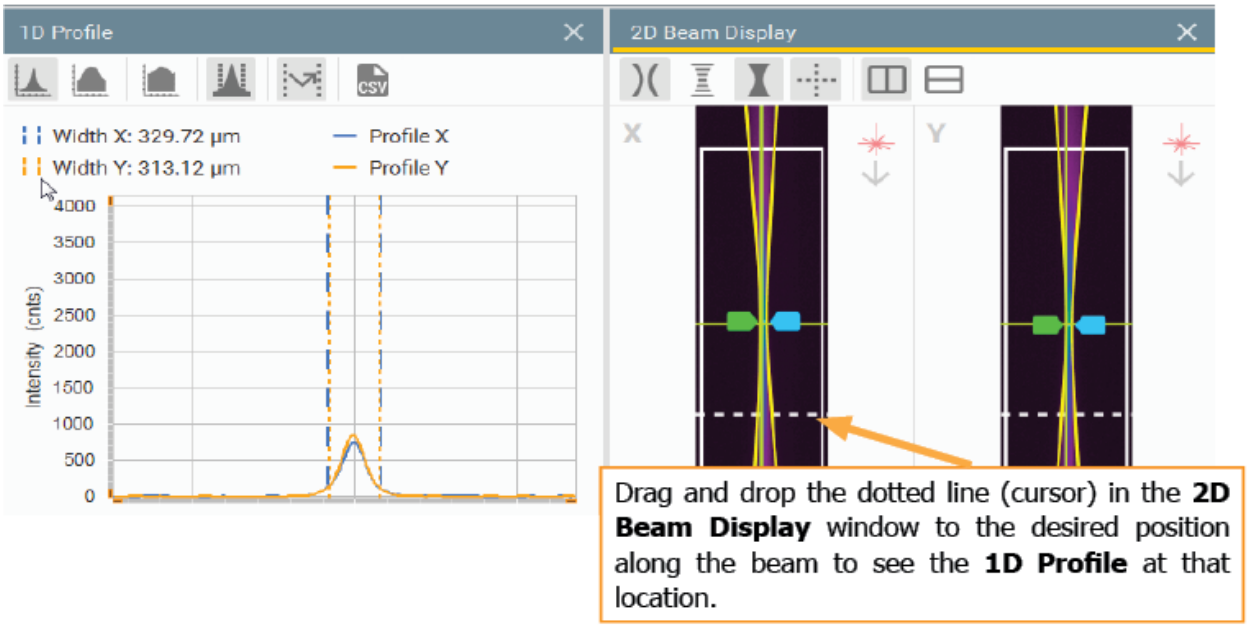


4.6.2 1D Profile Panel

Select the **1D Profile** icon in the panel to toggle the **1D Profile** window. This 1D profile shows the scanning slit equivalent profile at the 2D profile cursor location. When viewing two axes with a dual axis unit, the profiles overlap in the **1D Profile** window with the centroids aligned. This can help visually determine if there is astigmatism in the beam.

The horizontal axis is the width of the ROI in the **2D Beam Display** with zero at the center of the beam(s). The vertical axis is the raw pixel count of the data. The scale can be changed with the **1D Profile** controls.

This display can zoom in and out using the mouse wheel and can be panned if zoomed by dragging the mouse inside the display area.



4.6.2.1 1D Profile Controls

These controls are specific to the **1D Profile** window. They control the vertical axis of the display, enable the beam width markers, and allow exporting of the profile data.

Linear Scale
Set the vertical scale to linear.

Logarithmic Scale
Set the vertical scale to logarithmic. This is helpful to enhance and view the noise on the sides of the beam.

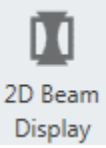
Auto Scale Profile Data
Enable/disable the auto scaling option for the 1D profile when viewing a linear scale.

Show Beam Width
Enable/disable the calculated beam width markers at the cursor location.

Auto Adjust Range
Select to revert a zoomed view to the default view.

Export as CSV
Export the profile to a comma separated values formatted file.

4.6.3 2D Beam Display Panel



Select the **2D Beam Display** icon in the panel to toggle the **2D Beam Display** window (shown below). In the image, the fitted caustic, beam image, and raw data are enabled.

The Green Marker (Left) is the current **Focus Location**. This line drifts as the focus of the beam changes.

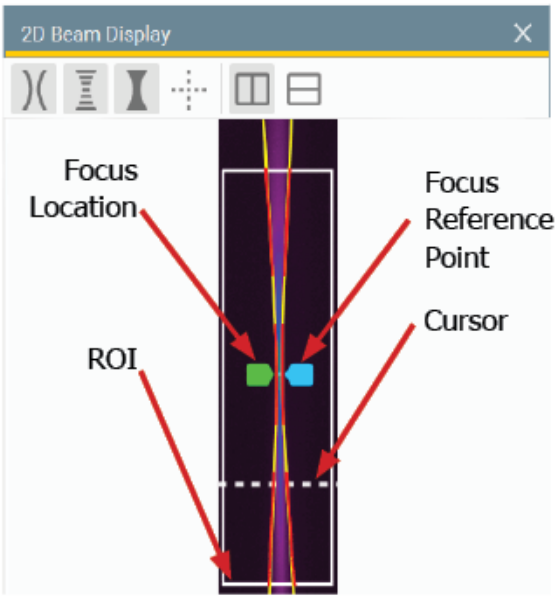
The Blue Marker (Right) is the **Focus Reference Point**. This mark is set at the first calculated beam width position when the SNR is greater than 10, and a caustic fit is found after starting data collection. Reset this position to the next valid beam width location by selecting **Reset** in the **Results** window. See 4.6.5 Results Display Panel.

The white border is the **Region of Interest** (ROI) for calculating results, which allows for the most accurate results. This region is always rectangular and drawn automatically around the beam.

The white dotted line is the cursor location. The **1D Profile** display shows the scanning slit equivalent profile at the cursor position. Click and drag the cursor to any location along the beam to view the profile at that location. The **Cursor Width** result reports the beam width at the location of the cursor using the selected beam width method.

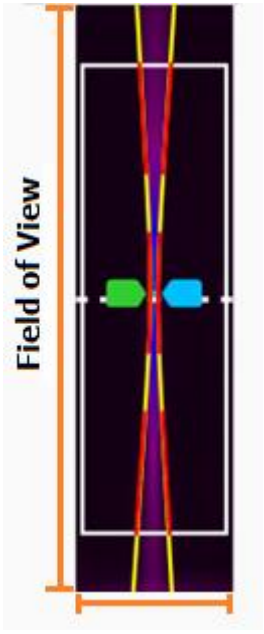
This display can zoom in and out using the mouse wheel and can be panned if zoomed by dragging the mouse inside the display area.

The **Field of View** is the total area the camera views in each axis.



The 2D display has a tilt function that displays the beam at the angle it enters the BeamWatch.

Product	Field of View
BeamWatch AM SP90470	11.26mm x 2.99mm
BeamWatch STD (High Mag) SP90391	11.26mm x 2.99mm
BeamWatch STD (Low Mag) SP90390	32.17mm x 8.55mm



4.6.3.1 2D Beam Display Controls

These controls are specific to the **2D Beam Display** window and control the display layers of the beam.

Beam Fit
Enable/disable the yellow fitted beam width. Disabling provides a better view of the beam edges.

Raw Beam
Enable/disable the red raw (measured) beam width data points that are used to calculate the fitted caustic. This may be beneficial to view the actual measured widths if unexpected results are being obtained. In order to get ISO measurements there will be gaps (shown in yellow below) in the raw data between 1-2 Rayleigh lengths.

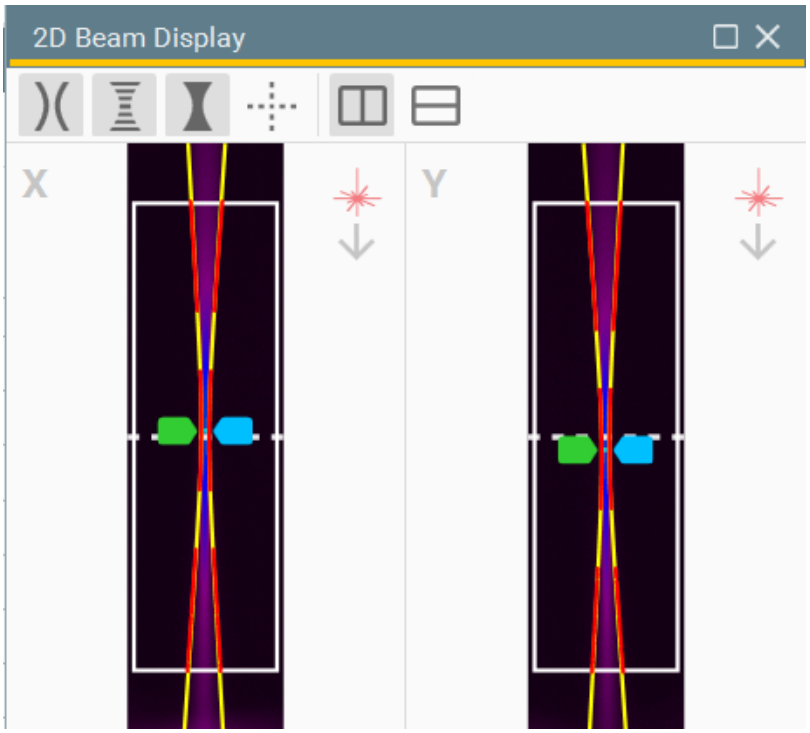
Beam Image
Enable/disable the beam image. Turn this off to see a clearer view of the caustic or raw data.

Alignment Crosshair
Enable/disable the crosshair and Focal Plane Region overlays in the **2D Beam Display** window which mark the center of the detector array. When viewing two axes of the beam, two crosshairs appear marking the center of each axis. The beam is aligned and the best results are obtained when the beam waist is centered on these crosshairs.

Show Working Plane (BeamWatch AM only)
Mark the location of the working plane within the camera Field of View.

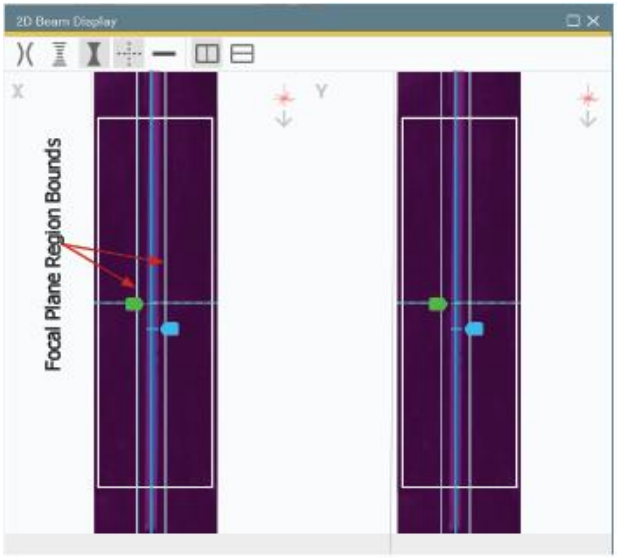
Vertical Display
Display the beam in a vertical direction.

Horizontal Display
Display the beam in a horizontal direction.



4.6.3.1.1 Alignment Crosshair Display

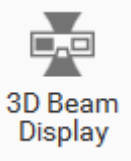
When activated, two additional lines appear to aid in alignment. These outer vertical lines mark the bounds of the Focal Plane Region.



Align the beam within these bounds, in both views, for the best results.

Product	Region Bounds
BeamWatch AM SP90470	±350µm
BeamWatch STD (High Mag) SP90391	±350µm
BeamWatch STD (Low Mag) SP90390	±1000µm (1mm)

4.6.4 3D Beam Display Panel

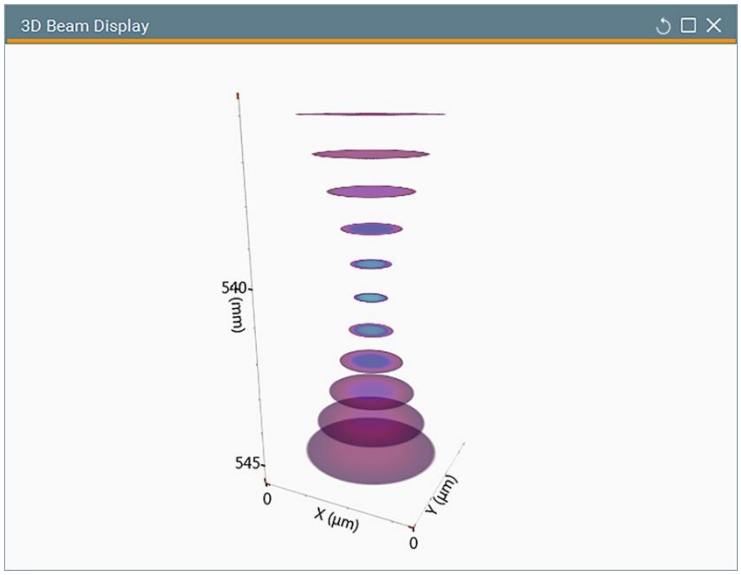


Select the **3D Beam Display** icon in the panel to toggle the **3D Beam Display** window. Only available in dual axis units, the **3D Beam Display** window shows an interpolated reconstruction of the beam. This display can be rotated, panned, and zoomed using the mouse as described below.

Rotate–Position the cursor over the image and then left-click and drag the mouse to obtain the desired orientation.

Pan–Position the cursor over the image and then right-click and drag the mouse to move the image to the desired location.

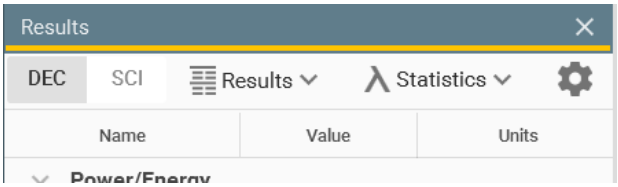
Zoom–Zoom in and out by placing the cursor over the display and scrolling with the mouse wheel.



4.6.5 Results Display Panel

Select the **Results** icon in the panel to toggle the **Results** window. Results groups have drop-down controls that select which results items are enabled. Each section of the **Results** window is described below.

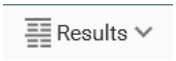
Empty frames (before or after data collection) in the buffer do not display anything in the Results window.



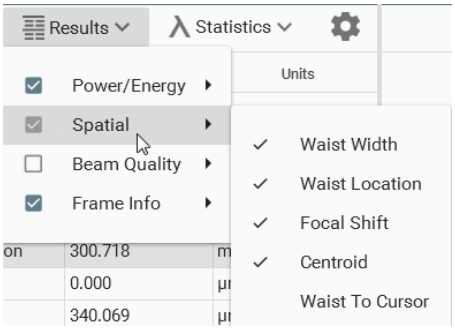
Results settings are found at the top of the **Results** window and allow you to customize which results are visible.

Decimal Notation
Changes values to display in decimal notation.

Scientific Notation
Changes values to display in scientific notation.



Results Selection
Select the **Results** drop-down and hover over a results group to select which results are active or inactive.

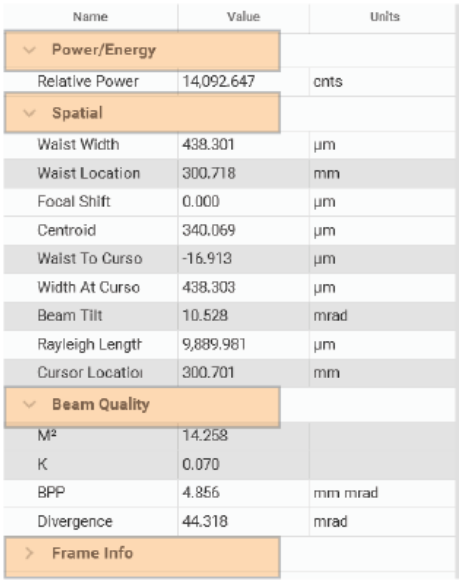


A grey check box shows that some results are enabled. Select to enable all results.

An empty check box shows that no results are enabled. Select to enable all results.

A blue checkbox shows that all results are enabled. Select to close all results.

When connected to a dual axis BeamWatch, the **Spatial** and **Beam Quality** groups contain separate results items for X and Y, where with a single axis BeamWatch, the results are condensed, showing a single result.

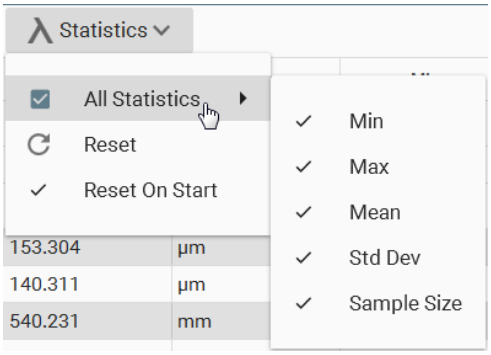


Name	Value	Units
Power/Energy		
Relative Power	14,092.647	cnts
Spatial		
Waist Width	438.301	µm
Waist Location	300.718	mm
Focal Shift	0.000	µm
Centroid	340.069	µm
Waist To Curso	-16.913	µm
Width At Curso	438.303	µm
Beam Tilt	10.528	mrad
Rayleigh Length	9,889.981	µm
Cursor Location	300.701	mm
Beam Quality		
M²	14.258	
K	0.070	
BPP	4.856	mm mrad
Divergence	44.318	mrad
Frame Info		

Result Divisions

The results items are grouped into logical divisions with self-descriptive names which aid in locating specific results.

- Power/Energy
- Spatial
- Beam Quality
- Frame Info



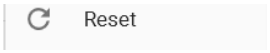
Statistics Selection

Select the **Statistics** drop-down to control which statistics are included in the results and how they function.

All Statistics

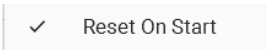
Select the **Statistics** drop-down and hover over **All Statistics** to select individual statistics.

Statistics can be enabled and closed in bulk by clicking the check box in the same manner as results.



Reset

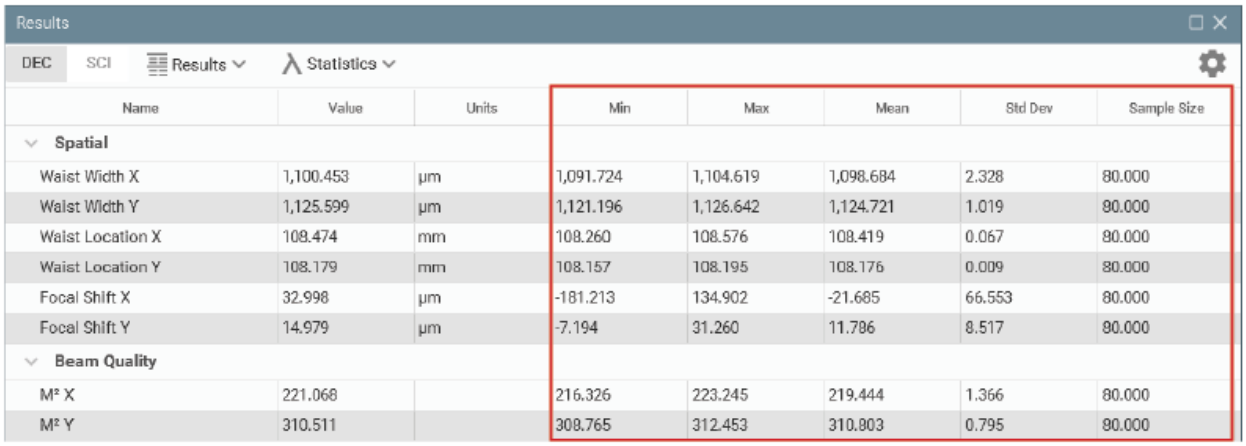
Selecting **Reset** resets all statistics to zero. It also resets the focus reference position in the **2D Beam Display** window and any enabled charts.



Reset On Start

Resets all statistics every time **Live Playback** or **File Playback** is selected.

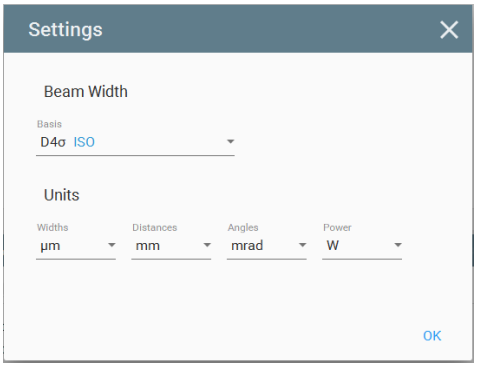
Example of a full set of enabled statistics.



Name	Value	Units	Min	Max	Mean	Std Dev	Sample Size
Spatial							
Waist Width X	1,100.453	µm	1,091.724	1,104.619	1,098.684	2.328	80.000
Waist Width Y	1,125.599	µm	1,121.196	1,126.642	1,124.721	1.019	80.000
Waist Location X	108.474	mm	108.260	108.576	108.419	0.067	80.000
Waist Location Y	108.179	mm	108.157	108.195	108.176	0.009	80.000
Focal Shift X	32.998	µm	-181.213	134.902	-21.685	66.553	80.000
Focal Shift Y	14.979	µm	-7.194	31.260	11.786	8.517	80.000
Beam Quality							
M² X	221.068		216.326	223.245	219.444	1.366	80.000
M² Y	310.511		308.765	312.453	310.803	0.795	80.000

Results Settings

Control the settings for how results are displayed and calculated.



Beam Width

Select the drop-down to specify the beam width method for computing results. Choose between D4σ and 13.5% Peak methods. Only D4σ produces ISO results.

Units

Set the units of measurement for results. Select the drop-down for **Widths, Distances, Angles,** and **Power** to change each unit of measurement.

4.6.5.1 Results

A definition of all results found within BeamWatch. Some results are exclusive to, and some are duplicated for the X and Y axes with dual axis units. Some results are specific to certain units. These results are denoted by the following icons:

All units


BeamWatch only


Dual axis only


BeamWatch AM only

Power/Energy

Relative Power – The average number of counts in each slice of the beam. If a power meter is connected this becomes **Absolute Power**. (BeamWatch is only compatible with Juno and EA-1 power meters.)

Cursor Power Density – The power density calculated at the cursor location. (Only available when BeamWatch is connected to a power meter.)

Spatial

Waist Width–The waist width calculated using the selected beam width basis method.

Waist Width Avg–The average of the X and Y Waist Width results.

Waist Location–Position of the waist from the user-defined reference point.

Waist Location Avg (Dual Axis Only) – The average of the X and Y Waist Location results.

Working Plane-Waist–Position of the waist from the working plane.

Working Plane-Waist Avg–The average of the X and Y Working Plane-Waist results.

Focal Shift–Distance the focus spot is away from the focus reference. A negative Focal Shift indicates an upward drift in the focus spot location as shown on the BeamWatch 2D display.

Focal Shift Avg–The average of the X and Y focal shifts.

Centroid–The distance from the center of the camera sensor array to the calculated centroid.

Cursor-Waist–The distance between the waist location and the cursor location.

Cursor-Waist Avg–The average of the X and Y Cursor-Waist results.

Center-Waist–The distance between the waist location and the center of the detector.

Center-Waist Avg (Dual Axis Only)–The average of the X and Y Center-Waist results.

Working Plane-Cursor–Distance from the build plate to the cursor.

Cursor Width–The calculated width at the current cursor location.

Cursor Width Avg–The average of the X and Y Cursor Width results.

Working Plane Width–The calculated beam width at the working plane.

Working Plane Width Avg–The average of the X and Y Working Plane Width results.

Ellipticity–The ratio of the computed X and Y beam widths at the cursor (min/max).

Beam Tilt–The angle the beam enters the input aperture.

Rayleigh Length–The distance from the waist to where the area of the beam cross-section is 2 times larger than the area at the waist.

Rayleigh Length Avg–The average of the X and Y Rayleigh Length results.

Cursor Location–The distance from user entered reference point to the cursor.

Beam Quality

M^2–A wavelength dependent measure of beam focusability compared to a TEM_{00} Gaussian beam (≥1). If the result is <1, but >0.9, the cells appear red indicating that there may be an issue. If the result is <0.9 a hyphen appears indicating that it cannot be computed.

M^2 Average–The X and Y average wavelength dependent measure of beam focusability compared to a TEM_{00} Gaussian beam (≥1).

K–A wavelength dependent measure of beam focusability compared to a TEM_{00} Gaussian beam (>0 and ≤1).

K Average–The X and Y average wavelength dependent measure of beam focusability compared to a TEM_{00} Gaussian beam (>0 and ≤1).

BPP–A wavelength independent measure of beam focusability.

BPP Average–The X and Y average wavelength independent measure of beam focusability.

Divergence–The far field full angle divergence of the beam.

Divergence Average–The X and Y average of the far field full angle divergence of the beam.

Frame Info

Frame ID–The ordered sequence ID of the frame.

Timestamp–Indicates when the current frame was generated.

Exposure–Displays the amount of exposure present in the current frame.

Gain–Displays the amount of gain present in the current frame.

4.6.5.2 Quick Close

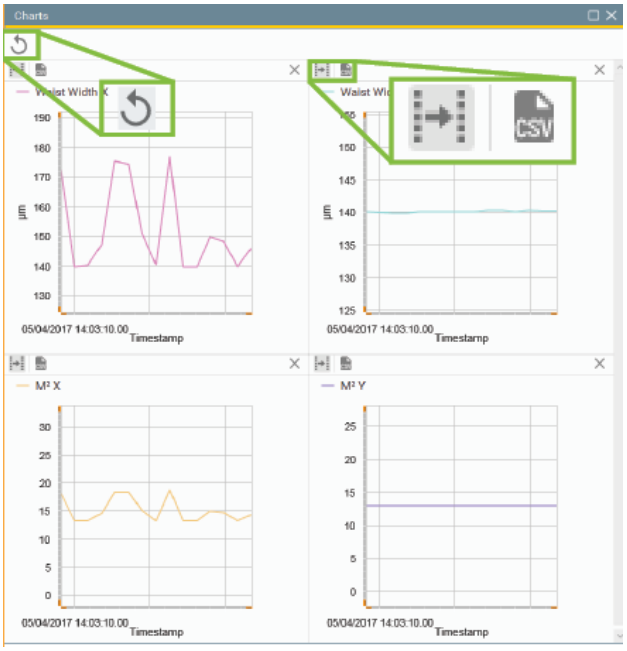
To remove a results item from the **Results** display, hover your mouse over the title of the result item and select the **Close** icon that appears to the left.

4.6.5.3 Create Chart

Hover the mouse over a result name and select **Create Chart** to open a new time chart for that result. Charts are plots of result items as they change over time. When charting, the **Charts** window opens and all enabled charts are visible.

4.6.6 Charts Panel

Select the **Charts** icon in the **View** panel to toggle the **Charts** window. As more charts are opened, they create a tile pattern in the window. In the image shown below, four charts have been created.



Each result can be charted. If a chart is closed, the data is deleted. When loading a saved file, the chart data is not automatically restored, but can be recreated by playing through the frame buffer in **File Playback**.

Auto Adjust Range

When this button is enabled, the chart automatically adjusts to fit all data points. When disabled, click and drag in the chart area to pan along the time axis. **Auto Adjust** can be enabled/disabled for each chart individually.

Export as CSV

Exports data for each specific chart to a comma separated values formatted file.

Reset

Select this momentary button to reset all charts at any time.

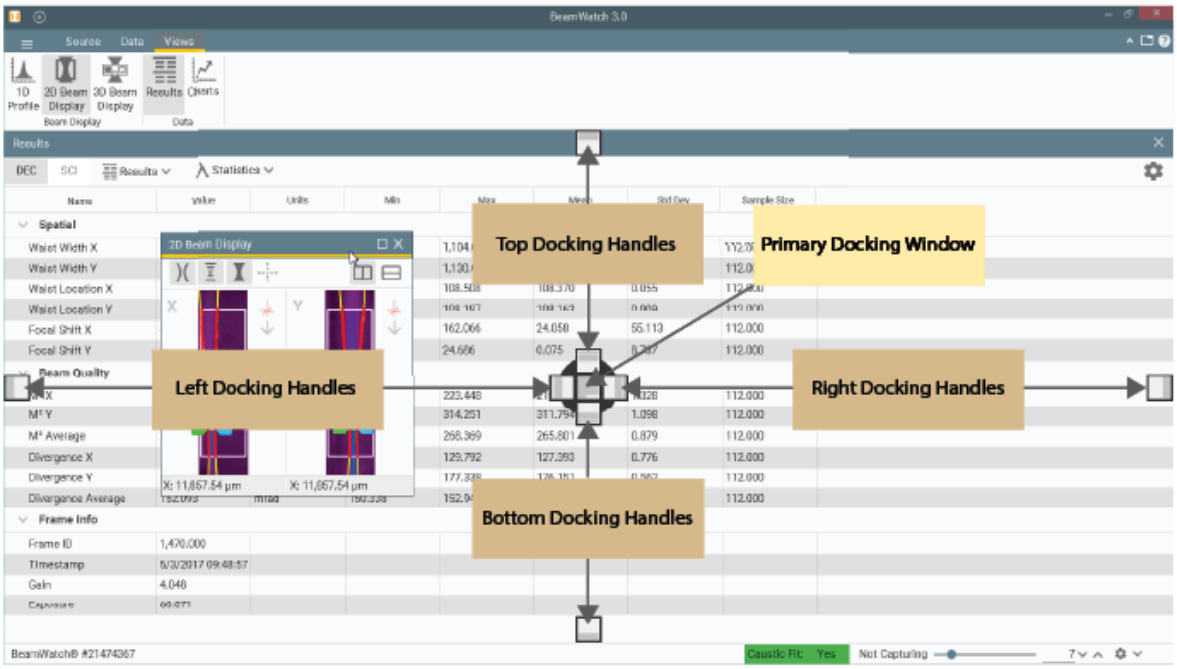
Chapter 5 Display Customization

BeamWatch has the ability to create flexible display environments to meet the user's specific needs. All windows have the option to hide, float, and reposition on the screen.

5.1 Docking Handles

The application opens in the default window layout after installation. BeamWatch saves changes to the user interface, and opens the same as it was closed. To undock a window, click and drag the window's title bar. This dislocates the window (shown below), and a set of docking handles appear. In this example, the **2D Beam Display** window is being moved.

Drag the display over one of the docking handles and release to snap it in that position. Displays not released on a docking handle become floating windows. All display windows can be docked to any docking handles or left to float anywhere on the screen.



Each docked window contains its own set of docking handles, allowing child windows to be docked within each new window. This also allows windows to be side by side, over and under each other, and even displayed across multiple monitors.

A floating window can be re-docked into the main application by dragging its title bar into the main display window and dropping on a dock handle.

Displays can be dropped into the primary docking window or any child docking window to be organized into tabs.

All windows can be restored to their default configuration if needed. See 4.3.1 File Menu.

Chapter 6 Improving Results Accuracy

When all of the quality checks are good, and all sections of the **Annunciator** in the **Status** bar are green, the results are within the ±5% accuracy specification.

If one of the quality checks produces questionable results, that section of the **Annunciator** turns yellow and the results accuracy is degraded.

Ways to improve the accuracy of each measurement are described below.

6.1 SNR

The Signal-to-Noise Ratio (SNR) is a ratio of the desired signal to the level of background noise. A value of 10 or higher is considered good. A higher SNR is obtained by reducing noise or by increasing the signal. Three methods are described here:

1. Increase the **Exposure** time. Exposure time determines the amount of time the camera views the beam before reporting a frame. Longer exposure times increase the intensity of the beam on the camera imager and therefore increases the SNR. This is the ideal method.
2. Increase by using **Frame Averaging**. 5-10 frames is usually enough to improve this value.
3. Increase by using **Frame Summing**. This method increases the intensity of the beam for each reported frame. However, summing too many frames can make the signal become saturated. Use this method with caution.

6.2 Caustic Fit

The **Caustic Fit** can be seen in the **2D Beam Display** window by enabling **Beam Fit** at the top of the display. If the Caustic Fit is unable to draw, the signal is usually weak (<1MW/cm^2) and/or there is a lot of background noise. Follow the above stated solutions to improve the SNR and the Caustic Fit also improves.

A large amount of particulates in the beam path causes the Caustic Fit to be unstable. If this occurs, the purging gas needs to be altered. Adjust the gas source until a minimum number of particulates are observed. The gas flow should never fall below 3 SLPM (35 PSI / 2.5 BAR).

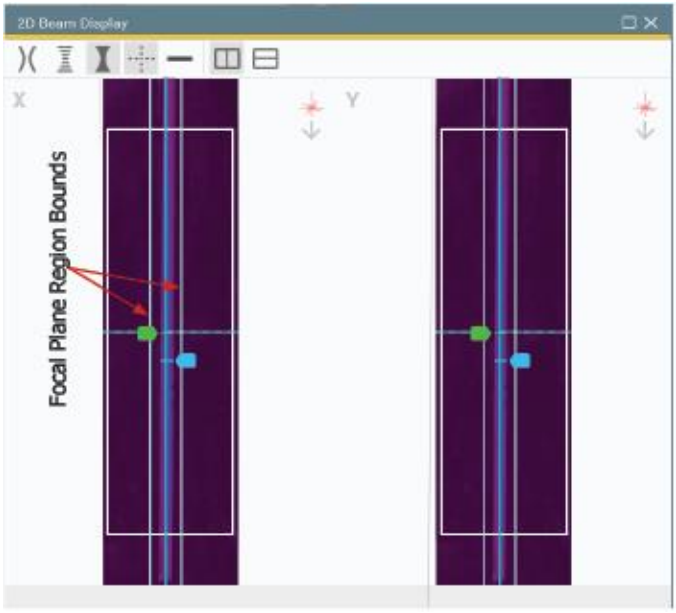
6.3 Saturation

Saturation occurs when the intensity of the image exceeds the dynamic range of the camera sensor. Saturation can appear when dust or other particles pass through the beam. These are seen as streaks of white through the beam image. To decrease dust particles, adjust the purge gas flow rate until a minimal amount of dust appears. If particles are still present, add a particle filter to the purge gas delivery system.

Saturation may also occur around the beam waist location due to the high power density. If this occurs, decrease the exposure setting until the image is no longer saturated.

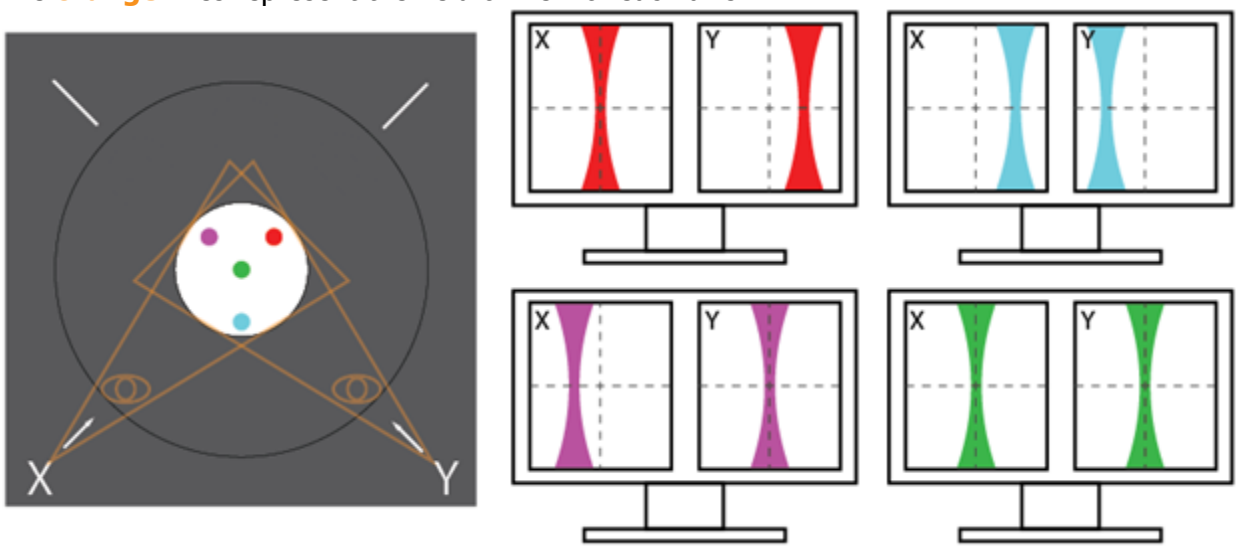
6.4 Alignment

In order to obtain the most accurate measurements, the beam must be aligned to the center of the camera field of view. If the beam is outside of the Focal Plane Region then the measurement accuracy is degraded. To view the focal plane region, enable the **Alignment Crosshair** in the **2D Display** window.



The diagram below shows how various degrees of misaligned beams appear on the screen.

- The **red** beam is off in the view of the Y axis. It needs to be moved down and left to center.
- The **blue** beam is off in both axes and appears close to the insides of the views. It needs to be moved up to center.
- The **purple** beam is off in the view of the X axis. It needs to be moved down and right to center.
- The **green** beam represents a perfectly aligned beam.
- The **orange** lines represent the field of view of each axis.



Chapter 7 Automation Interface

BeamWatch provides an automation interface via .NET components to allow customers the ability to build custom applications that incorporate the laser beam analysis and processing power of BeamWatch. The BeamWatch automation interface allows developers control of BeamWatch programmatically. The automation interface was developed to provide the ability to base control decisions for a second application on results and behaviors recognized by BeamWatch. With this ability, users can quickly and efficiently meet manufacturing and analysis goals with minimum human interaction.

7.1 Automation Design Skill Set

Over the years, Spiricon has learned that to design a proper automation client for products similar to BeamWatch requires a skill level comparable to that of a degreed and experienced computer programmer. Even with this background, a learning curve is necessary to achieve an acceptable level of competency. To assist your company in choosing a good employee fit for this type of work, we offer the following guidelines for the minimum skill sets needed.

To interface with LabVIEW you need:

- An understanding of .NET programming methods.
- Prior, and recent, experience designing and deploying National Instruments LabVIEW VI in an automation environment.
- Review Spiricon's **Automation Documentation** (see 7.3).

To interface with a program written in Visual Basic (VB), C++, or C# you need:

- A minimum BS degree in Computer Science or Computer Engineering, or equivalent.
- Three or more years of software design experience using Microsoft Visual Studio design and debugging tools.
- Demonstrated proficiency in writing programs in Microsoft Visual Basic, C++, or C#.
- A background in .NET programming methods.
- Review Spiricon's **Automation Documentation** (see 7.3).

7.2 Introduction

The BeamWatch automation interface was designed to achieve two main goals. First, to allow the user to programmatically do what they could otherwise do via the graphical user interface (GUI). Second, to expose stable interfaces to the user that will not change, causing breaks to their dependent code. In order to facilitate these goals, it is important that the user be given stable abstractions to program against. It is likewise important to allow BeamWatch to evolve as new features are added. Spiricon is dedicated to protect users from changes in underlying implementation as BeamWatch evolves. To this end, the automation interface is presented as a set of interfaces that collectively expose the functionality of the application. Access to these various interfaces is provided by creating one concrete class known as AutomatedBeamWatch. Interfaces needed to create, control, extract results, and destroy an instance of the BeamWatch application are accessed via properties found in the AutomatedBeamWatch class.

7.3 Documentation

The Automation API reference is presented via html. The html reference provides cross-referenced access to all interfaces and functionality provided for automation application development. The **BeamWatch Automation API** may be accessed via the following link:

Automation Documentation

-or-

Via the start menu shortcut as shown below:

Start > All Programs > Spiricon Documentation > BeamWatch Automation Interface

7.4 Examples

An example of a simple automation application in C# is provided. For a step-by-step walkthrough click on following link:

Automation Example

-or-

Copy and paste the path in Windows Explorer:

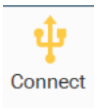
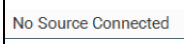
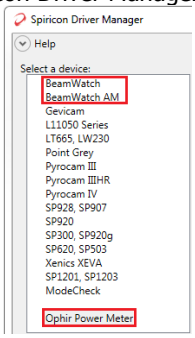
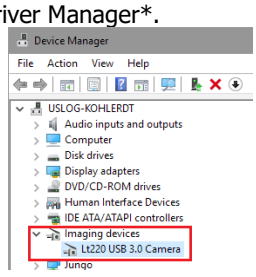
C:\Program Files\Spiricon\BeamWatch\Automation\Documentation\csharp_example.html

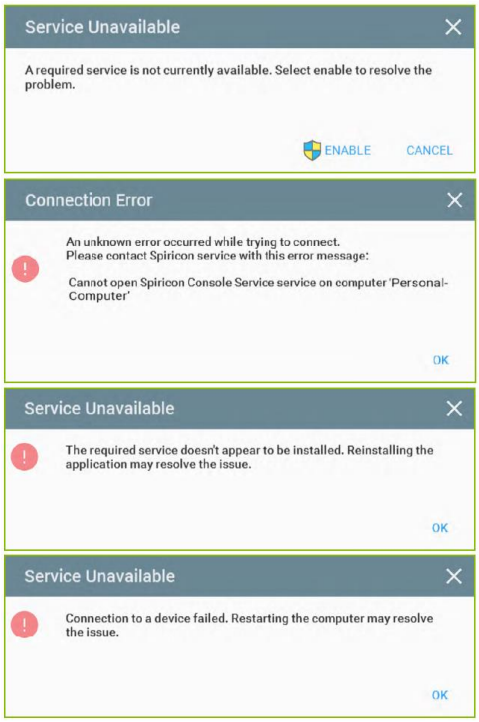
or

%ProgramFiles%\Spiricon\BeamWatch\Automation\Documentation\csharp_example.html

Chapter 8 Troubleshooting

8.1 Cannot Connect to Device

Issue	Failure	Resolution
Power Issues	The unit is not receiving power.	BeamWatch Standard: • Make sure the power cable is secure at the source and on the unit itself. BeamWatch AM: • Make sure the power cable is secure at the source and on the unit itself. • Make sure the Power LED on the top of the unit is green. • Verify the power indicator LED is lit on the external "brick" Power supply.
Data Connection Issues  Selecting Connect is not finding the BeamWatch unit, and the icon is unchanging.  The Status in the bottom left corner of the screen states No Source Connected.	Software is not receiving data from the unit.	BeamWatch Standard: • Make sure the Ethernet cable is securely attached to the BeamWatch unit. • Make sure the Ethernet cable is securely connected to a functioning Ethernet port on the PC. BeamWatch AM: • Make sure the camera USB cable is securely attached to the BeamWatch AM unit. • Make sure the camera USB cable is securely connected to a functioning USB port on the PC (preferably USB 3.0, USB 2.0 is sufficient, but may slow measurement update rates).
Driver Issues	Proper drivers may not be installed or may be corrupted.	BeamWatch Standard and BeamWatch AM: • Open Spiricon Driver Manager and make sure BeamWatch, BeamWatch AM, and Ophir Power Meter drivers are installed. (Start -> Spiricon Tools -> Spiricon Driver Manager)  BeamWatch AM: • Open the Windows Device Manager to verify the device is detected with no warnings. If an error is shown uninstall/reinstall the drivers in the Spiricon Driver Manager*. 

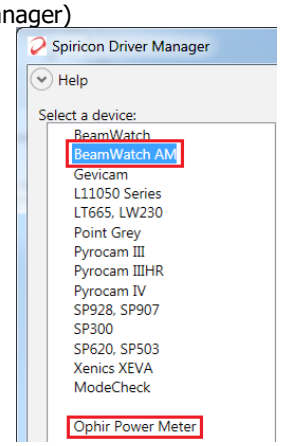
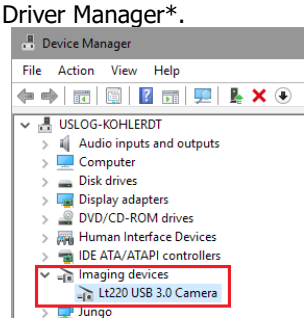
		*Unplug the USB before performing uninstall/reinstall
Console Service Communication 	Console Service is not installed or corrupted, Firewall may be blocking connection, or other unknown errors.	• Check the Console Service. Open the Task Manager application and check for Spiricon.ConsloleService.exe under the Processes tab. ○ If not installed, repair the application ○ If not running, restart the computer and repair the application if still unresolved. • Check the firewall ○ Make sure Spiricon.ConsoleService.exe in C:\Program Files\Spiricon\ConsoleService is not blocked by the firewall settings ○ Make sure BeamWatch.exe in C:\Program Files\Spiricon\BeamWatch is not blocked by the firewall settings ○ Make sure Spiricon.DataServer.exe in C:\Program Files\Spiricon\BeamWatch is not blocked by the firewall settings • Check the Event Viewer logs (Windows Logs-> Application) for possible errors relating to Spiricon Console Service.

8.2 The Camera Disconnects Immediately After Connection

Issue	Failure	Resolution
Power Issues	The unit is not receiving power or has a weak power connection.	BeamWatch Standard: • Make sure the power cable is secure at the source and on the unit itself. BeamWatch AM: • Make sure the power cable is secure at the source and on the unit itself. • Make sure the power LED on the top of the unit is green. • Verify the power indicator LED is lit on the external "brick" power supply.

8.3 Cannot Connect to Power Meter

Issue	Failure	Resolution
Cable Issues	A missing or weak connection in a cable.	• Make sure the power sensor serial cable is attached to the AM device and a Juno Smart Head to USB converter. • Make sure the power meter USB cable is connected to the Juno and that the computer is running BeamWatch software. • Make sure that the serial number and calibration date match on the wiring harness and the BeamWatch AM Unit.

Driver Issues	Proper drivers may not be installed or may be corrupted.	• Open Spiricon Driver Manager and make sure BeamWatch AM and Ophir Power Meter drivers are installed. (Start -> Spiricon Tools -> Spiricon Driver Manager)  • Open the Windows Device Manager to verify the device is detected with no warnings. If an error is shown uninstall/reinstall the drivers in the Spiricon Driver Manager*.  *Unplug the USB before performing uninstall/reinstall
Firmware Issues	A compatibility issue between different versions of software and drivers.	• Verify power meter works in StarLab (see 8.9 Verify Power Meter Connection with StarLab).

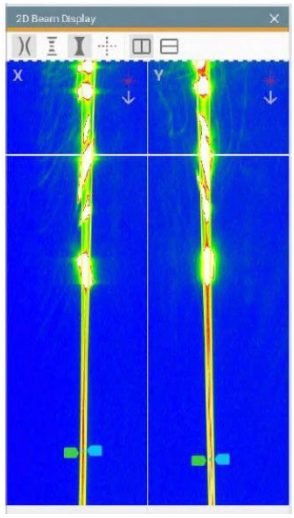
8.4 BeamWatch AM Shutter Will Not Open

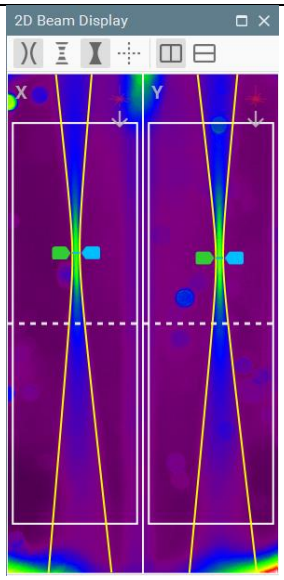
Issue	Failure	Resolution
Power Issues	The unit is not receiving power or has a weak power connection.	• Make sure the power LED on the top of the unit is green. • Make sure the power cable is secure at the source and on the unit itself. • Verify the power indicator LED is lit on the external "brick" power supply.
Cable Issues	A missing or weak connection in a cable.	• Make sure the camera USB cable is securely attached to the BeamWatch AM unit • Make sure the camera USB cable is securely connected to a functioning USB port on the PC (preferably USB 3.0, USB 2.0 is sufficient, but may slow measurement update rates).
Purge Gas Issues	Unit not receiving enough gas flow.	• Make sure the purge gas is connected securely to the AM unit. • Make sure there is a minimum flow of 3 SLPM (35 PSI / 2.5 BAR), no more than 8 SLPM (100 PSI / 6.5 BAR).

8.5 BeamWatch AM Fan Will Not Activate

Issue	Failure	Resolution
Power Issues	The unit is not receiving power or has a weak power connection.	• Make sure the power LED on the top of the unit is green. • Make sure the power cable is secure at the source and on the unit itself. • Verify the power indicator LED is lit on the external "brick" power supply.
Cable Issues	A missing or weak connection in a cable.	• Make sure the camera USB cable is securely attached to the BeamWatch AM unit • Make sure the camera USB cable is securely connected to a functioning USB port on the PC (preferably USB 3.0, USB 2.0 is sufficient, but may slow measurement update rates).

8.6 BeamWatch Standard Image Display Issues

Issue	Failure	Resolution
Excessive Particulates 	Improper gas flow causing sharp saturation in the image.	• Make sure the purge gas connection is secure and a proper flow of pressure is reached. (See 2.1.3 in the BeamWatch Standard User Notes.)
Contaminated Optics	Particulates have contaminated the internal optics.	• Contact Ophir-Spiricon Customer Service to determine if the system should be returned to the factory.

8.7 BeamWatch AM Image Display Issues

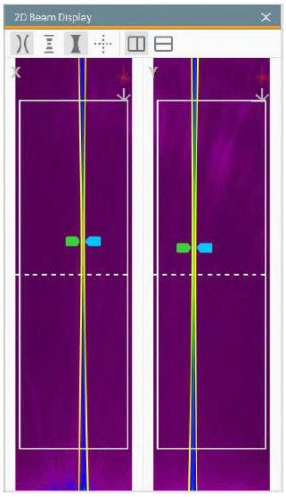
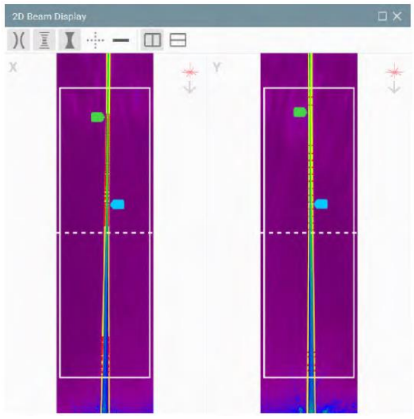
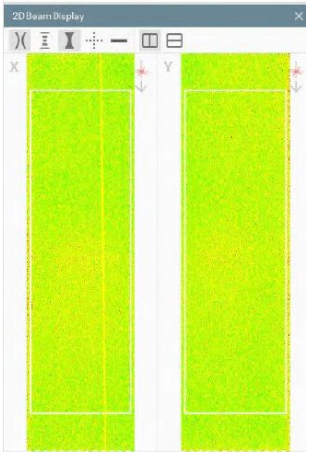
Issue	Failure	Resolution
Excessive Background Illumination 	A dirty turning mirror can cause spurious reflections.	1. Remove and clean the mirror (See 3.1.1 in the BeamWatch AM User Notes). 2. Carefully replace the mirror and the bottom plate of the BeamWatch Unit.
Excessive Background Illumination at the Bottom of Image 	A halo of excess light is entering the BeamWatch AM from the delivery head.	• Insert the Halo Aperture. See BeamWatch AM Hardware User Note

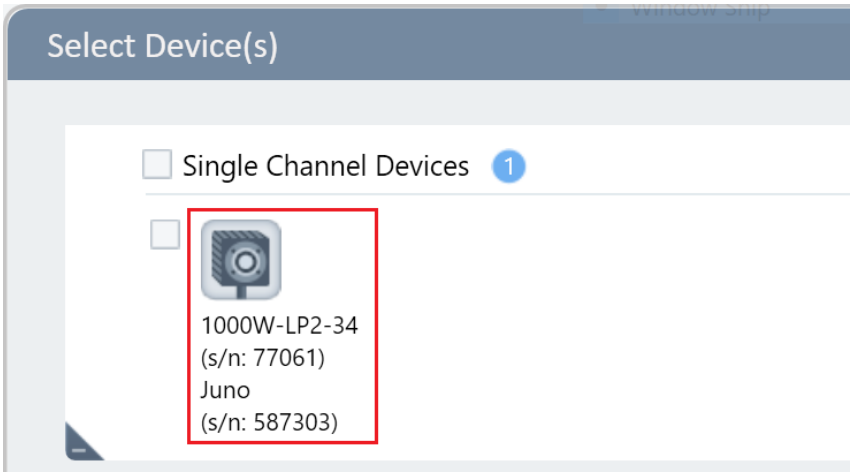
Image Background Blue or Green 	Camera is overheating causing increased noise and a lower SNR. A minimum SNR of 10dB is required for accurate measurements.	• Stop operation • Unplug the power and USB cables and remove the unit from the build chamber. • Allow unit to sit in ambient space until the unit is cool to the touch (approx. 5-10 min). • If necessary, remove the device from the build chamber and operate the fan for 20-30 minutes to thoroughly cool the system.
Unexplained Camera Behavior	Depending on the amount of current supplied by the USB connection to the PC, the system may function but the camera may disconnect and re-connect randomly.	• Make sure the power LED on the top of the unit is green. • Make sure the power cable is secure at the source and on the unit itself. • Verify the power indicator LED is lit on the external "brick" power supply.

8.8 Data Corruption Issue

Issue	Failure	Resolution
M^2 Values less than 1.0	Critical information stored in the non-volatile memory of the camera may have become corrupted.	• An incorrect wavelength was entered in the Laser Panel. • Contact Ophir-Spiricon Customer Service to determine if the system should be returned to the factory.
Lack of BeamWatch AM Controls (i.e. fan and shutter)	Critical information stored in the non-volatile memory of the camera becomes corrupted or reset.	• The system including the wiring harness must be returned to the factory for service.

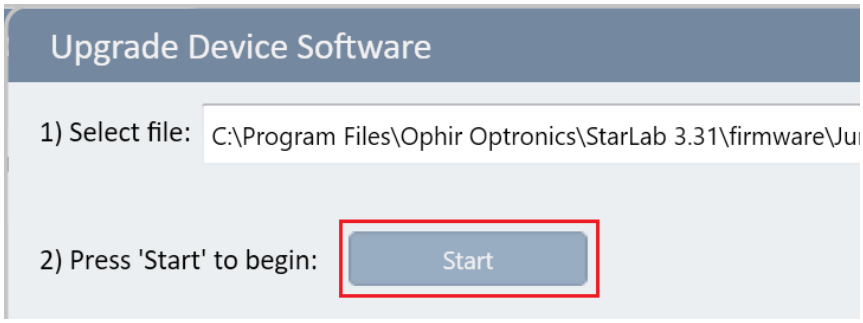
8.9 Verify Power Meter Connection with StarLab

1. Uninstall the power meter drivers from Spiricon Driver Manager.
2. Install StarLab and connect to the device. The device should display with no errors as shown right.



3. If the status of the device shows an error, select **More** from the top right side of the screen.
4. Select **Upgrade** from the Diagnostics window.

5. Leave the Select File path as it is, and select **Start** and allow the Upgrade to install.
6. Either leave StarLab installed or remove and install BeamWatch AM power meter drivers in driver manager.



If StarLab is open and connected to the power meter, then it will not be able to connect to BeamWatch.

Appendix A Ethernet Configuration

In the default configuration of BeamWatch and BeamWatch Integrated the system is directly connected to a single PC, and the network adapter and camera negotiate an IP address automatically (LLA). In many gigabit ethernet network environments this alone will provide full functionality. However, depending on the network configuration and policies present, additional configuration may be required. This appendix provides an in-depth review of the most common configuration issues and steps to resolve them.

In many organizations, configuration of GigEVision devices, such as BeamWatch and BeamWatch Integrated, will require the assistance of IT Administrators/Network Engineers. Care must be taken when implementing the network configuration below in order to prevent the introduction of security risks into the network environment.

A.1 Network Adapter IP Configuration

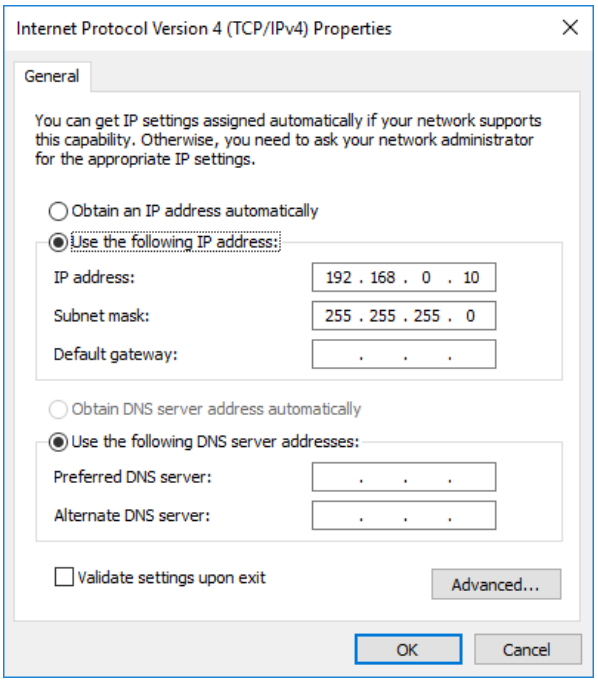
The two most common ways to configure the IP addresses of network adapters are:

- Assigning a fixed (also "static" or "persistent") address
- Configuring automatic addressing via DHCP (Dynamic Host Configuration Protocol) or Auto IP (Automatic Private IP Addressing, based on link-local addresses (LLA)).

A.1.1 Assigning a Fixed IP Address

To assign a fixed IP address to a network adapter:

1. Open the **Network Connections** window in the Windows Control Panel. For quick access:
    a. Press **+R**.
    b. Type **ncpa.cpl**.
    c. Press **Enter**.
2. Right-click the network adapter connection that is used with the BeamWatch system and then click **Properties** to open the **Properties** window.
3. Double-click **Internet Protocol Version 4 (TCP/IPv4)** to open the **Internet Protocol Version 4 (TCP/IPv4) Properties** window.
4. Click **Use the following IP address**.
5. In the **IP address**, **Subnet mask**, and **Default gateway** fields, type the IP address, subnet mask, and default gateway addresses.
6. In the **Preferred DNS server** and **Alternate DNS server** fields, type the primary and secondary DNS server addresses. Normally, a domain name server is not required.
7. Click **OK** to confirm your changes.



8. Repeat steps 2-7 for each applicable network adapter.

Additional Fixed IP considerations:

During preliminary configuration of one or more BeamWatch systems, the following settings may be used to establish a network connection very quickly:

- Configure a fixed address for the network adapter in the automatic IP address range.
    - IP address: 169.254.0.1 to 169.254.255.254
        - Subnet mask: 255.255.0.0
- Configure Auto IP address assignment for the BeamWatch camera.
- If the computer has multiple network adapters, each adapter must be in a different subnet.
- These address ranges have been reserved for private use according to IP standards. The recommended ranges for fixed IP addresses are:
    - IP address: 172.16.0.1 to 172.32.255.254
        - Subnet mask: 255.255.0.0
    - IP address: 192.168.0.1 to 192.168.255.254
        - Subnet mask: 255.255.255.0
- When assigning fixed IP addresses to BeamWatch systems, keep in mind that for the internal camera to communicate properly with a network adapter, it must be in the same subnet as the adapter to which it is attached. Moving systems between network adapters with fixed IP addresses will cause communication failures.

A.1.2 Assigning an IP Address via DHCP/Auto IP

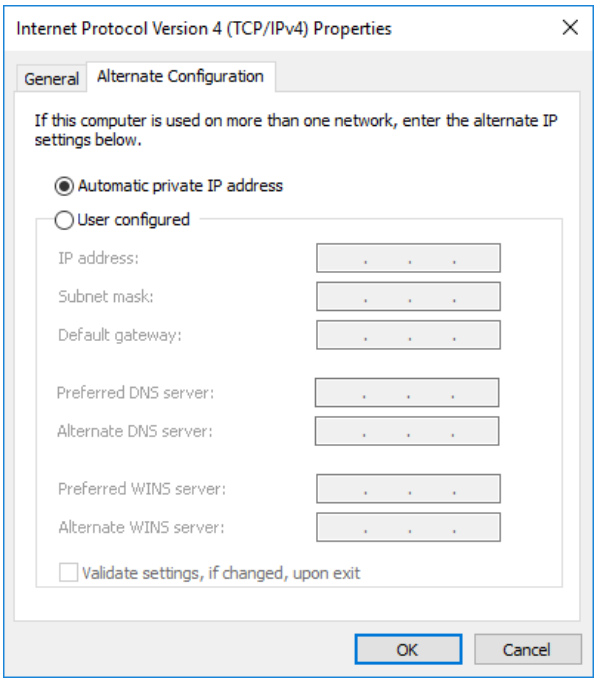
When an adapter is configured to receive its IP address via DHCP/Auto IP, it operates as follows:

- The adapter tries to obtain an IP address from a DHCP server. If a DHCP server is available, it receives an IP address from the server and uses it.
- If no DHCP server is available, the adapter uses the Auto IP routine to assign itself a Link Local Address (LLA) IP address
    - IP address: 169.254.0.1 to 169.254.255.254
        - Subnet mask: 255.255.0.0

The default setting for most network adapters is DHCP/Auto IP. In most cases, the adapter used with the BeamWatch will not have a DHCP server available. With the default settings, the adapter will use automatic IP addressing to assign itself an IP address.

To assign an IP address using DHCP/Auto IP:

1. Open the **Network Connections** window in the Windows Control Panel. For quick access:
   a. Press **+R**.
   b. Type **ncpa.cpl**.
   c. Press **Enter**.
2. Right-click the network adapter connection that is used with the camera and click **Properties** to open the **Properties** window.
3. Double-click **Internet Protocol Version 4 (TCP/IPv4)** to open the **Internet Protocol Version 4 (TCP/IPv4) Properties** window.
4. Make sure that **Obtain an IP address automatically** is selected. This makes the adapter check for a DHCP server as the first choice.
5. Click the **Alternate Configuration** tab. The settings on this tab are used to configure the Auto IP address assignment that the adapter will use if no DHCP server is found.
6. Make sure that **Automatic private IP address** is selected.
7. Click **OK** to confirm your changes.



A.2 Network Adapter Configuration

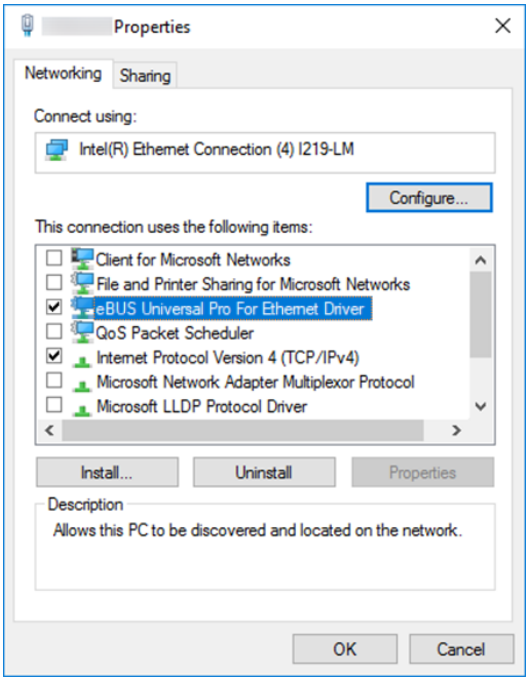
All network adapters used to connect a BeamWatch must use the eBUS Universal Pro filter driver and must be configured for GigEVision camera use. The following settings ensure optimal connection and data transfer for a Gig-E camera.

A.2.1 Changing the Network Adapter Connections in Windows

It is recommended to disable protocols or services that may interfere with the BeamWatch.

To disable protocols or services:

1. Open the **Network Connections** window in the Windows Control Panel. For quick access:
    a. Press **⊞+R**.
    b. Type **ncpa.cpl**.
    c. Press **Enter**.
2. Right-click the network adapter connection that is used with the camera and click **Properties** to open the **Properties** window.
3. Clear all check boxes except **eBUS Universal Pro for Ethernet Driver** and **Internet Protocol Version 4 (TCP/IPv4)**. See the figure below.



4. Repeat steps 2 and 3 for all applicable network adapters.

A.2.2 Changing the Network Adapter Properties in Windows

For all network adapters using the eBUS Universal Pro filter driver that is used to connect a BeamWatch, we recommend optimizing the adapter properties for GigEVision use.

To optimize the adapter properties:

1. Open the **Network Connections** window in the Windows Control Panel. For quick access:
    a. Press **⊞+R**.
    b. Type **ncpa.cpl**.
    c. Press **Enter**.
2. Right-click the network adapter connection that is used with the BeamWatch and click **Properties** to open **Properties** window.
3. Click **Configure** to open the **Configuration** window of the network driver.
4. Click **Advanced**.
5. Adjust the following properties (see note below):
    a. Set the **Jumbo Frames** property to its maximum value. If there is no **Jumbo Frames** property, select the parameter that relates to frame size and set it to the maximum value.
    b. Select the parameter that relates to the receive (Rx) ring buffer or number of receive descriptors (e.g. **Receive Descriptors**) and set it to the maximum value.

c. Select the parameter that relates to the interrupt moderation rate or number of CPU interrupts (e.g. **Interrupt Moderation Rate**) and set it to a low value (e.g. 1000). The way to set the number of CPU interrupts may differ for the network adapter. It may be necessary to use a separate parameter to enable the interrupt moderation.
d. Select the parameter that relates to speed and duplex mode (e.g. **Speed and Duplex Mode**) and set it to automatic (e.g. **Auto Negotiation**).

6. Repeat steps 2-5 for all applicable network adapters.

Depending on the network adapter model, the parameter names of the network adapter may differ from the ones used above. Also, the way to set the parameters may differ, and some parameters may not be available.

- Using jumbo frames is important for reducing the overhead and the CPU load. The bigger the frame size, the less CPU interrupts are generated, and thus, the lower the CPU load.
- The receive (Rx) ring buffer defines the number of buffers used by the NIC driver to receive and process received image data from the camera. Usually, the ring buffer is set to a small value and might need to be increased on systems receiving a high volume of network traffic.
- The interrupt moderation rate (IMR) defines the trade-off between latency and performance. The IMR controls the interrupt throttle rate (ITR), the rate at which the controller moderates interrupts. A lower ITR leads to a more responsive driver, but also leads to a higher CPU load because more interrupts are generated. Conversely, a higher ITR leads to a higher latency for processing interrupts, but a lower CPU load. For most applications, Ophir recommends using higher values for IMR (e.g. Extreme or 3600). If lower latency is needed, use a lower value.

A.3 BeamWatch IP Configuration

A.3.1 Using the BeamWatch Integrated Web Interface

The BeamWatch Integrated IP address can be customized to better coexist within an existing network via the web interface. Please refer to the *Communication* section in the *Settings* page of the BeamWatch Integrated User Note.

A.3.2 Using the Pleora eBUS Player

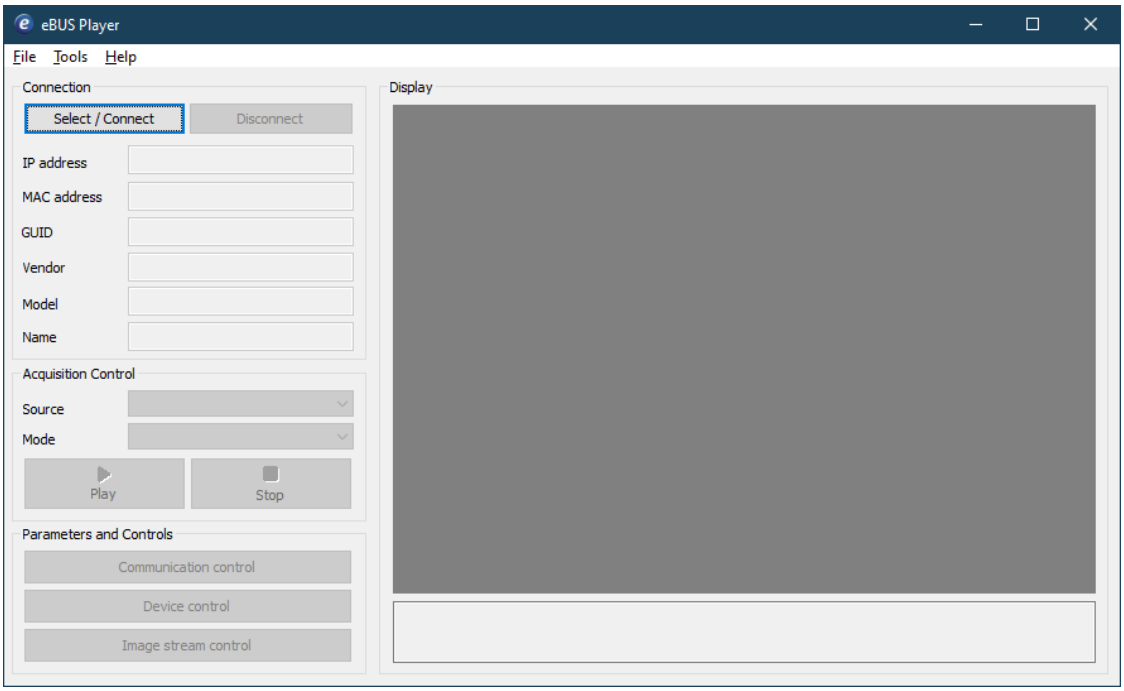
The Pleora eBus Player is installed with the BeamWatch drivers and may be used to assign an IP address to BeamWatch camera.

Note: These changes will stay in place even when the camera is powered off and back on again.

The application can be opened via the Windows Start Menu:

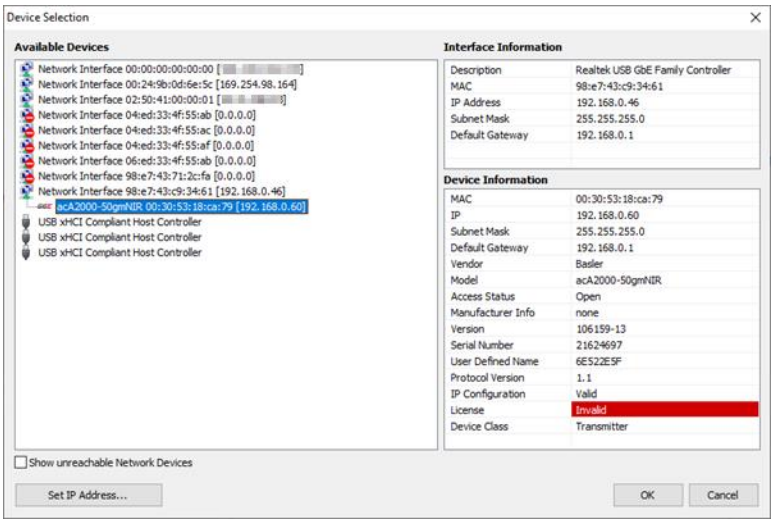
1. Search for "**eBus Player**" or Navigate to **Pleora Technologies, Inc** -> **eBus Player**.

2. The **eBUS Player** opens an empty viewer with disabled controls.

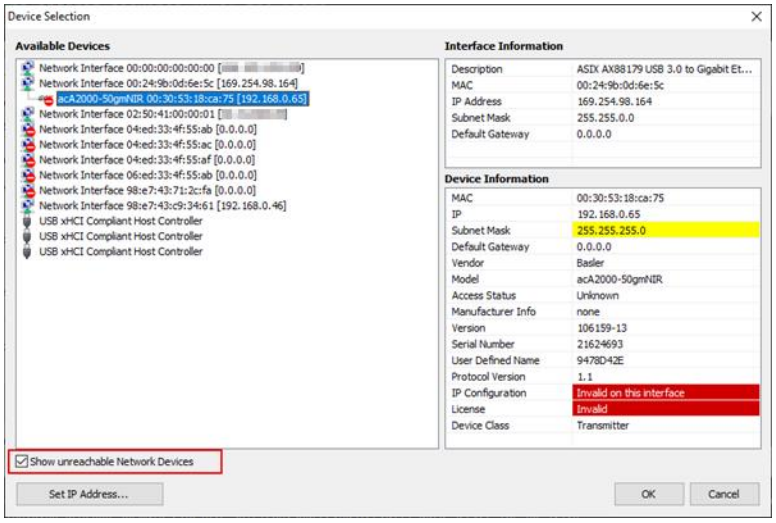


A.3.2.1 Selecting the Camera

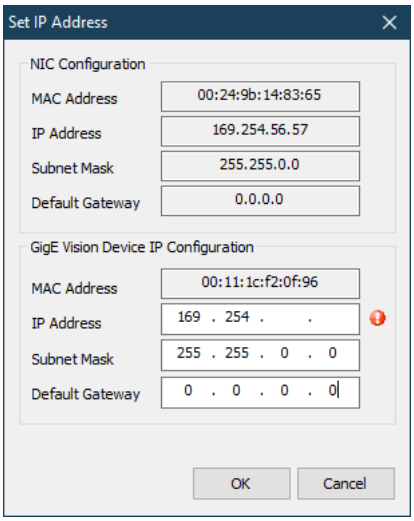
1. Press **Select/Connect**.
2. The **Device Selection** dialog displays.
3. If the BeamWatch camera has a valid IP configuration, it will be visible as a child of one of the available network adapters on the PC.



4. If the camera for the BeamWatch is found, click the **acA2000-50gmNIR...** entry, click **OK,** and proceed to the next section of this guide. Otherwise follow these steps:
    a. Check the power and Ethernet connections.
    b. Check the **Show unreachable Network Devices** checkbox.
    c. After a few moments, the camera display. The IP Configuration property on the right pane will be red and display **Invalid on this interface**.



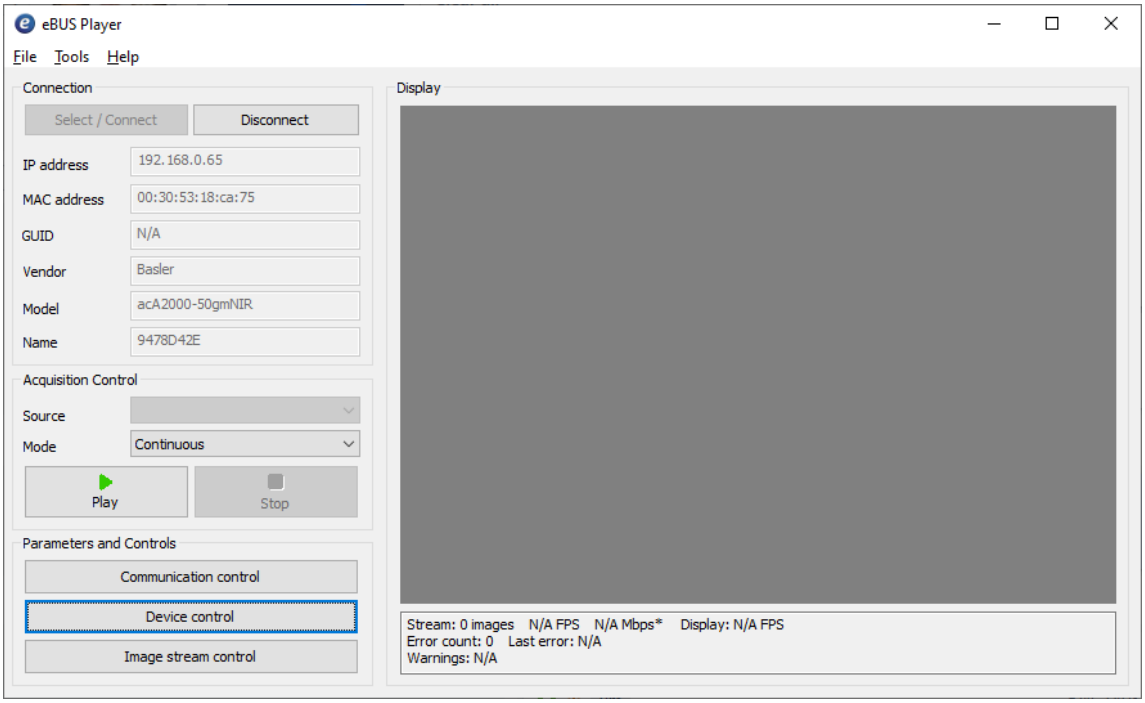
d. Either disconnect and reconnect the BeamWatch Ethernet connection to a network adapter with a compatible IP configuration, or set a new temporary IP configuration by clicking **Set IP Address...**.
e. The **Set IP Address** dialog will open, and the IP configuration of the attached network adapter will display.



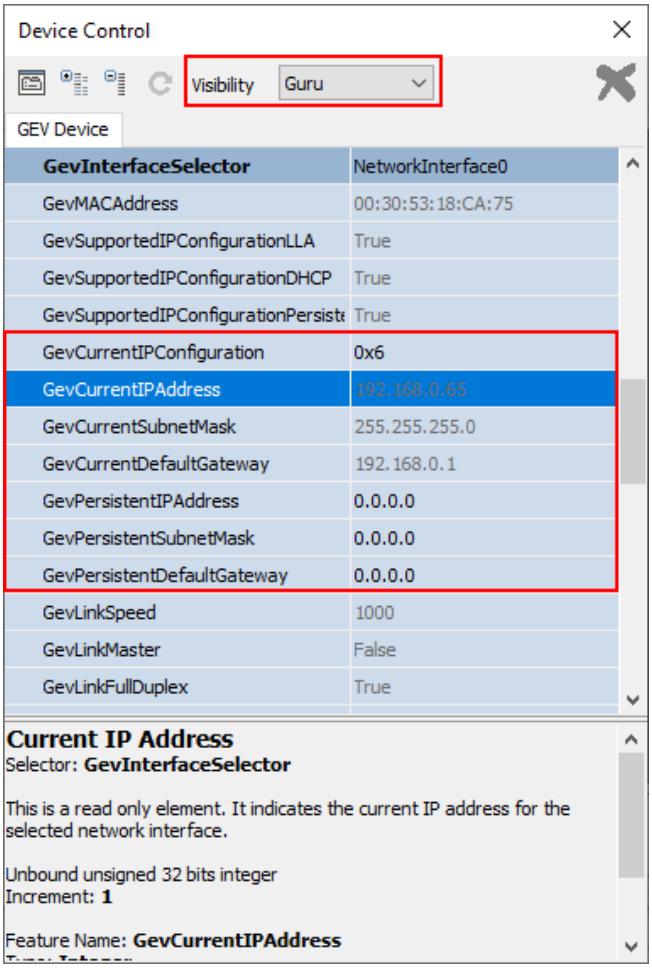
f. Set a valid IP configuration for the camera.
    - When configuring a camera to use a temporary IP address, keep the following in mind:
        - For a camera to communicate properly, the IP address must be in the same subnet and have the same subnet mask as the adapter to which it is connected.
        - The camera must have an IP address that is unique within the network.
        - See the individual sections below for recommendations on common IP address reservations.
g. Click **OK** to save the temporary IP address.
h. On the **Device Selection** dialog, the **IP Configuration** property must read as **Valid**.
i. If the camera for the BeamWatch is found, select it by left-clicking the **acA2000-50gmNIR...** entry and click **OK**.
j. If the camera still cannot be found, contact the Ophir-Spiricon Service department.

A.3.2.2 Device Control Properties

Once a camera with a valid IP configuration has been selected, the eBus Player viewer will connect to the camera.



1. To change the BeamWatch camera's IP configuration, click **Device Control**.
2. On the toolbar, change the **Visibility** to **Guru** and click **Collapse** to close the property groups.
3. Expand the **TransportLayerControl** group.
4. Scroll down to locate **GevCurrentIPConfiguration** property as the beginning of the IP configuration properties.



A.3.2.3 IP Configuration Options

When configuring the BeamWatch IP address, the following options are available:

- **Auto IP (LLA)**: Auto IP (Link Local Address) means the camera uses automatic IP address assignment and assigns itself an IP address.
- **Static IP**: The IP address assigned to the camera will not change, even when the camera is powered off and on. A subnet mask and a gateway may be required. Make sure that the camera is in the same subnet as the adapter and that the camera has a unique IP address. Coordination with local IT is recommended.
- **DHCP**: A DHCP server assigns an IP address to the camera.

In the **eBUS Player Device Control properties**, these modes are configured by the **GevCurrentIPConfiguration** property per the following table.

Mode	Value
Auto IP (LLA) Mode	0x4
Persistent Mode	0x5
DHCP Mode	0x6

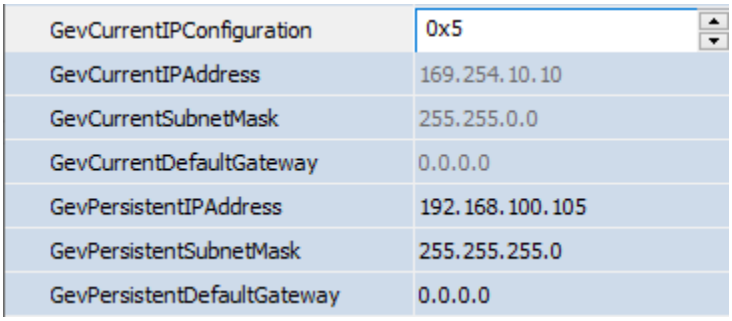
A.3.2.4 Assigning an IP Address via a Static IP

When configuring a camera to use either a temporary or a static IP address, there are some things to keep in mind:

- For a camera to communicate properly, it must be in the same subnet as the adapter to which it is connected.
- The camera must have an IP address that is unique within the network.
- The recommended range for static IP addresses is from 172.16.0.1 to 172.32.255.254 and from 192.168.0.1 to 192.168.255.254. These address ranges have been reserved for private use according to IP standards.
- If the computer has multiple network adapters, each adapter must be in a different subnet.
- A network gateway is not required in some configurations, if not required, enter 0.0.0.0.

To change the IP configuration of the camera to Static IP:

1. Set the **GevCurrentIPConfiguration** to **0x5**.
2. While not necessary, it is recommended to clear the three persistent IP values to 0.0.0.0 for clarity.



3. In the **GevPersistentIPAddress**, **GevPersistentSubnetMask**, and **GevPersistentGateway** fields enter the desired values.
4. The eBUS Player will automatically save changes as they are made.
5. Close the **Device Control** dialog and press the **Disconnect** button.

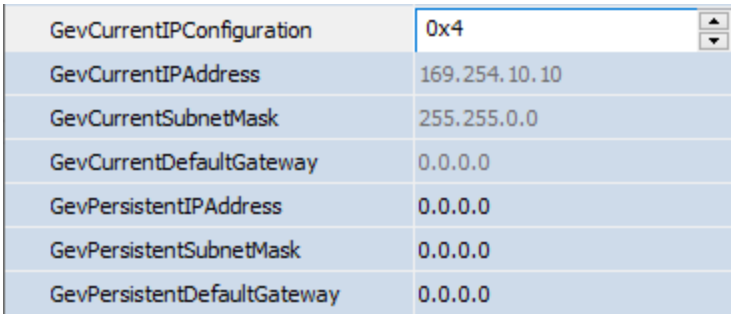
To verify the IP Address change, power-cycle the BeamWatch Integrated system and reconnect.

A.3.2.5 Assigning an IP Address via Auto IP (LLA)

The method for assigning an IP address may be changed to Auto IP (Link Local Address). This means that the camera uses automatic IP address assignment and assigns itself an IP address.

To change the IP configuration of the camera to Auto IP (LLA):

1. Set the **GevCurrentIPConfiguration** to **0x4**.
2. While not necessary, it is recommended to clear the three persistent IP values to 0.0.0.0 for clarity.



3. The eBUS Player will automatically save changes as they are made.
4. Close the **Device Control** dialog and press the **Disconnect** button.

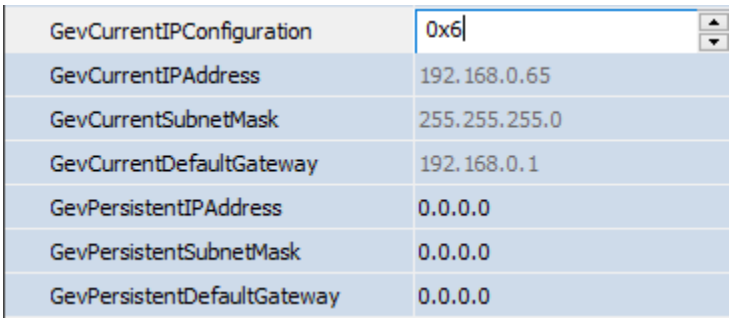
To verify the IP Address change, power-cycle the BeamWatch Integrated system and reconnect.

A.3.2.6 Assigning an IP Address via a DHCP Server

The method for assigning an IP address may be changed to DHCP. This means that a DHCP server assigns the IP address to the camera.

To change the IP configuration of the camera to DHCP address assignment:

1. Set the **GevCurrentIPConfiguration** to **0x6**.
2. While not necessary, it is recommended to clear the three persistent IP values to 0.0.0.0 for clarity.



3. The eBUS Player will automatically save changes as they are made.
4. Close the **Device Control** dialog and press the **Disconnect** button.

To verify the IP Address change, power-cycle the BeamWatch Integrated system and reconnect.

If no DHCP server is present or if there is a problem preventing the DHCP server from assigning an IP address to the camera, automatic IP address assignment (LLA) will be used as a fallback.

A.4 Firewall Configuration

Software firewalls provide an important barrier to security risks in modern PC's but in most cases also limit the connectivity of GigEVision and Ethernet devices. In Windows 10, the Windows Defender Firewall is enabled by default. Information required for configuration of Windows Defender Firewall for GigEVision and Ethernet devices is provided below. If other software firewalls are used, the sections below may be used as a reference.

A.4.1 Disabling the Windows Defender Firewall

It is not always necessary to disable the firewall. If the firewall is left enabled, the camera and profiler may be fully operational, with the following exceptions:

- On Windows, when a program opens a Gig-E camera for the first time, a Windows Security Alert will open asking to allow incoming requests, depending on current security settings.
- Gig-E camera identification and communication may be blocked.
- Image streaming may be unstable compared to unrestricted use.

Therefore, it is recommended to disable the firewall for the network connections with BeamWatch. Alternatively, inbound rules can be configured for specific applications so that they are not blocked by the firewall.

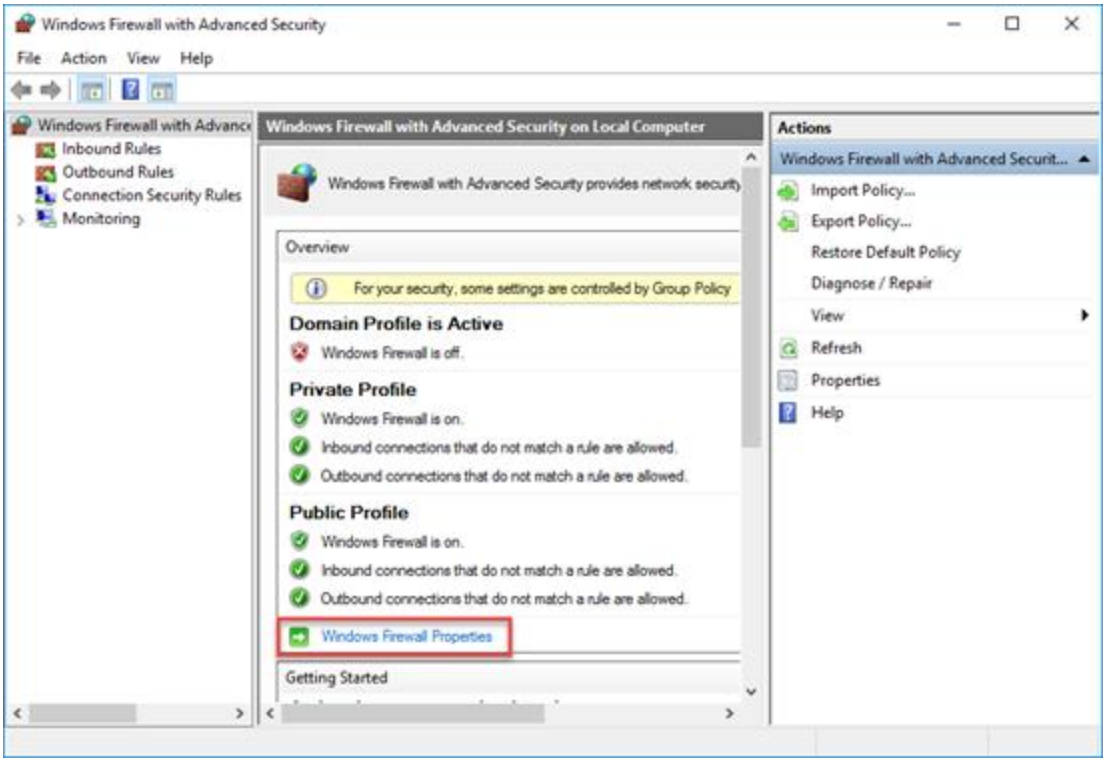
A.4.1.1 Disable the Windows Defender Firewall via Advanced Security Settings

This option allows disabling the firewall for specific network adapters while other methods would disable the firewall completely. *This is the recommended solution for most users.*

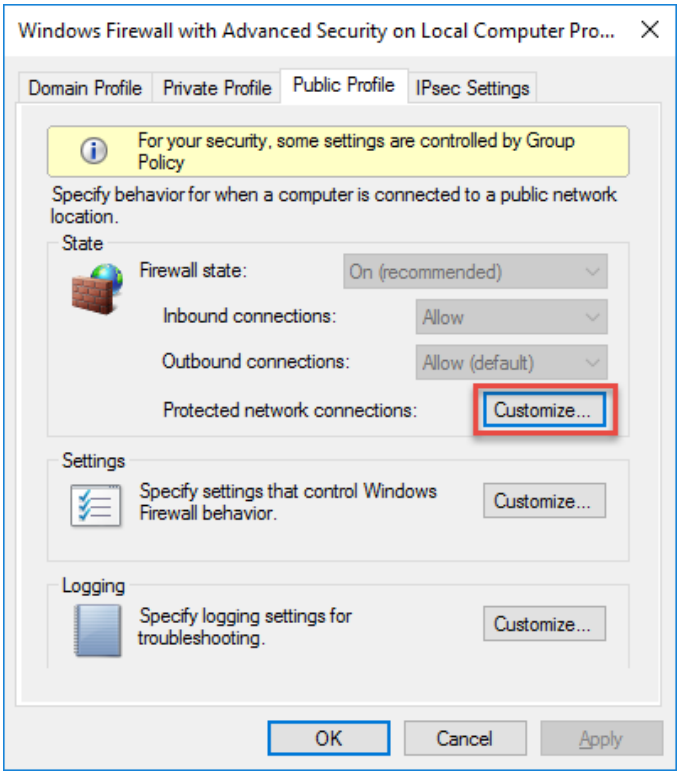
Care must be taken with this solution to reserve the physical network adapter port for use only with BeamWatch. Swapping the Ethernet cables to this network adapter port after this change introduces potential security risks. For example, connecting a LAN or internet connection to this port would not be protected by the firewall.

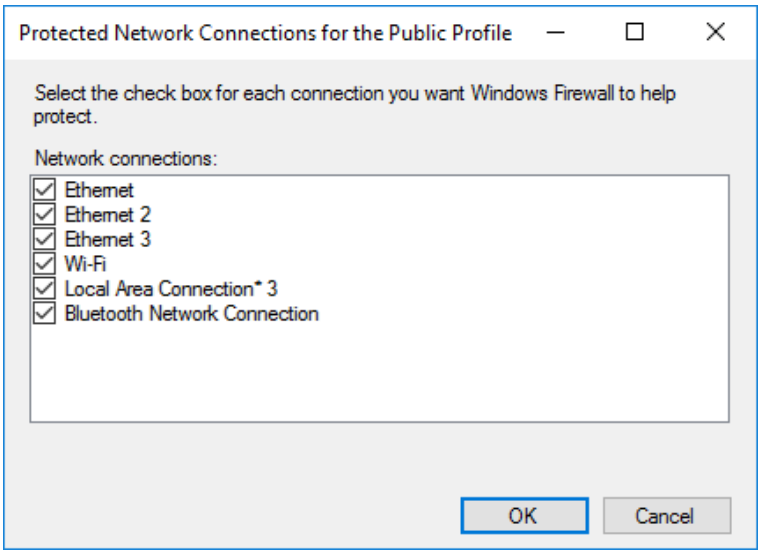
To disable the firewall on selected network adapters:

1. Open the **Windows Defender Firewall with Advanced Security** window. For quick access:
   a. Press **⊞+R**.
   b. Type **wf.msc**.
   c. Press **Enter**.
2. Click **Windows Defender Firewall Properties** to open the **Windows Defender Firewall with Advanced Security** properties pane.



3. Click the tab of the profile where firewall protection will be disabled.
    a. Typically, this is the **Public Profile** tab.
    b. If using a dedicated network adapter, it is recommended to also disable firewall protection for the other profiles on that network adapter only.
4. Click **Customize** to open the **Protected Network Connections for the Public Profile** window. The window lists connections where the firewall is enabled (see figures below).





5. Deselect the connections where the BeamWatch is connected. This disables firewall protection for that network adapter.
6. Repeat steps 3-5 for each profile where firewall protection will be disabled.

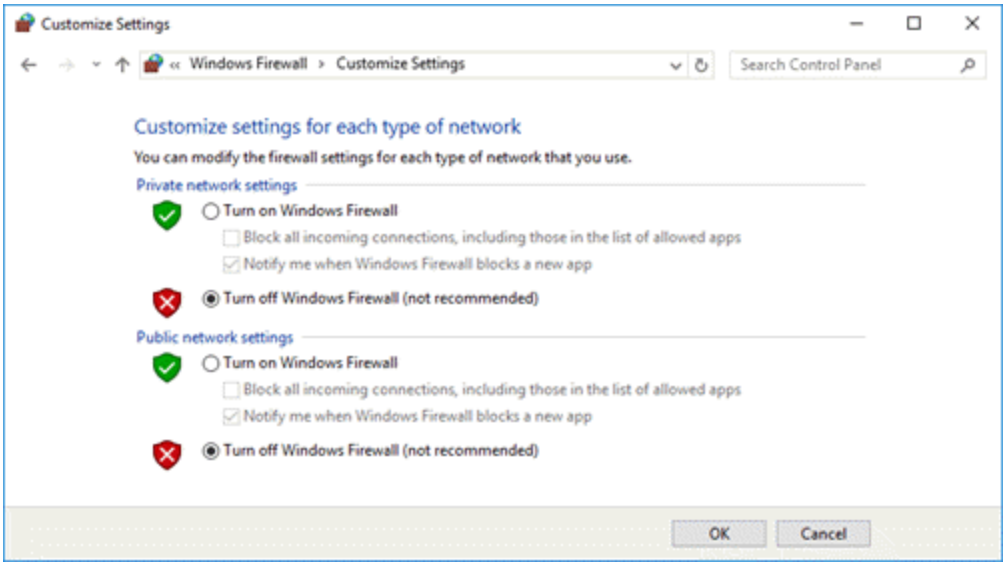
A.4.1.2 Disable the Windows Firewall via Windows Control Panel

This option disables the firewall for all connections. This method is not recommended for most users and must be performed with an administrative account.

Take care with this solution to completely disable the firewall on the PC! This solution should only be used on a PC that is isolated from any external network, otherwise the PC may become vulnerable to outside attacks.

To turn off the firewall via Windows Control Panel:

1. Open the **Windows Firewall** window in the **Windows Control Panel**. For quick access:
   a. Press **+R**.
   b. Type **firewall.cpl**.
   c. Press **Enter**.
2. In the left pane, click **Turn Windows Firewall on or off** to open the **Customize Settings** window.
3. Find the network location section for the network adapter where the firewall protection will be turned off.
   a. Typically, this is the **Public network settings** section.
   b. If using a dedicated network card, we recommend that you disable firewall protection for the other network zones.
   c. The specific zone that the dedicated network adapter is configured for can be found in the **Windows Network and Sharing Center**.
4. In the desired sections, click **Turn off Windows Firewall**.
5. Click **OK** to save changes.



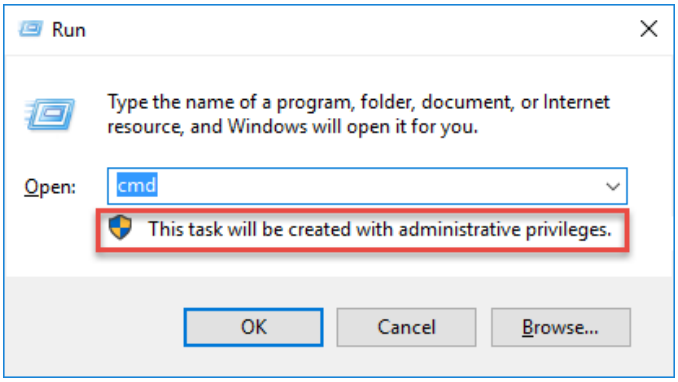
A.4.1.3 Disable the Windows Firewall via Command Prompt

This option disables the firewall for all connections and network zones in a single command. *This is not recommended for most users and must be performed with an administrative account.*

Take care with this solution to completely disable the firewall on the PC! This solution should only be used on a PC that is isolated from any external network, otherwise the PC will be vulnerable to outside attacks.

To disable the firewall via command prompt:

1. Press **+R**.
2. Type **cmd**. Ensure that the message, "This task will be created with administrative privileges" is displayed.



3. Press **Enter**. The **Command Prompt** window opens.
4. Type **netsh advfirewall set allprofiles state off**
5. Press **Enter**
6. The firewall is disabled for all profiles.

*Note: It is not possible to use **netsh** to disable the firewall for select connections only.*

A.4.2 Setting Up Inbound Firewall Rules

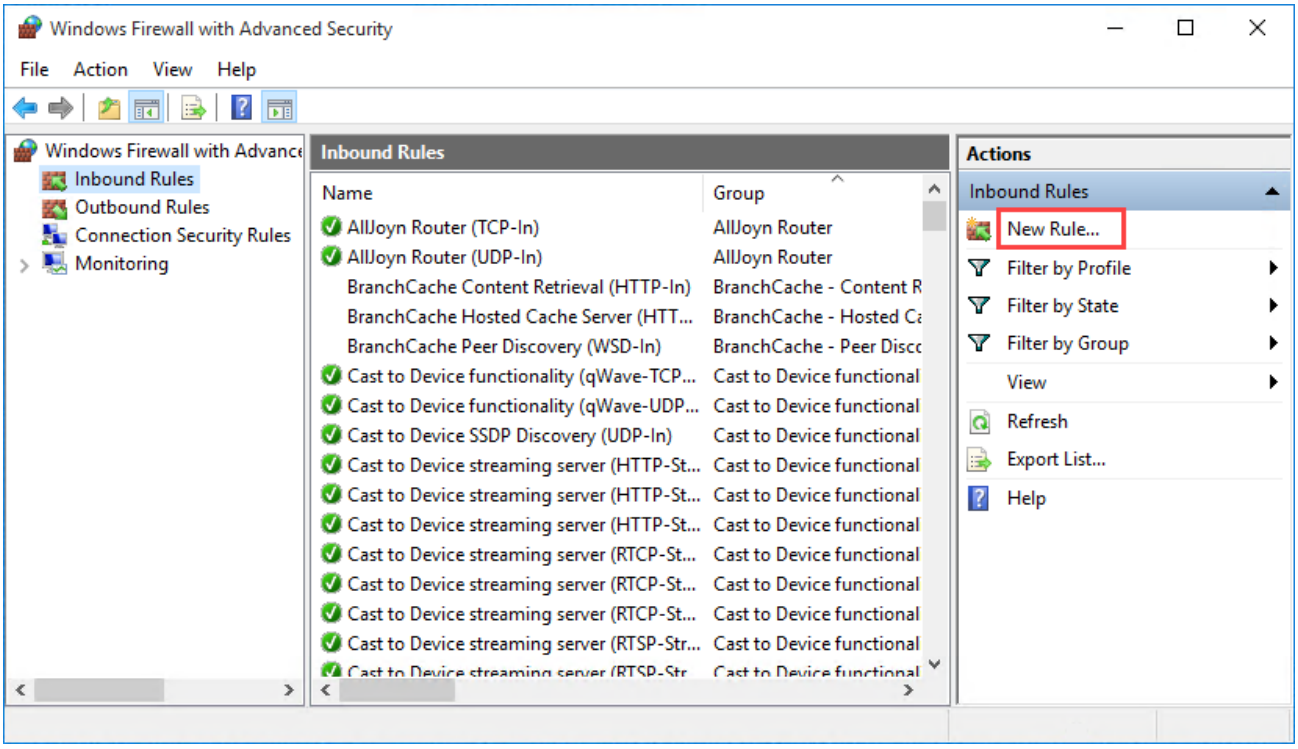
In some network configurations a firewall can block three areas of communication important to successful operation of BeamWatch.

1. The Ophir-Spiricon BeamWatch software communicates between three of its own processes across TCP ports beginning at 10100 and up to a range of 1000 sequential ports.
    - Normally any necessary firewall rules will automatically be generated within Windows Firewall for the BeamWatch
    - Firewall rules for the following processes may be necessary on a PC running the BeamWatch Software.
        - Spiricon.ConsoleService.exe
        - Spiricon.DataServer.exe
        - BeamWatch.exe
    - If necessary, the BeamWatch port range can be customized by modifying the following file.
        - C:\Program Files\Spiricon\BeamWatch\PortFinder.config.xml
            - Both the Start and Count properties can be customized
            - A minimum port range of 20 is recommended.
2. The Ophir EA-1 power meter communicates via TCP and UDP ports.
    - Discovery: UDP port 11000
    - Communication: TCP port 23 (Telnet mode) or TCP port 80 (HTTP mode)
    - When used with the BeamWatch, the DataServer uses the EA-1's telnet mode.
3. The **Pleora eBUS Player** utility may be used to set the IP Configuration and verify operation of the camera in the BeamWatch.
    - 64-bit eBUS Player
        - C:\Program Files\Pleora Technologies Inc\eBUS SDK\Binaries\eBUSPlayer64.exe

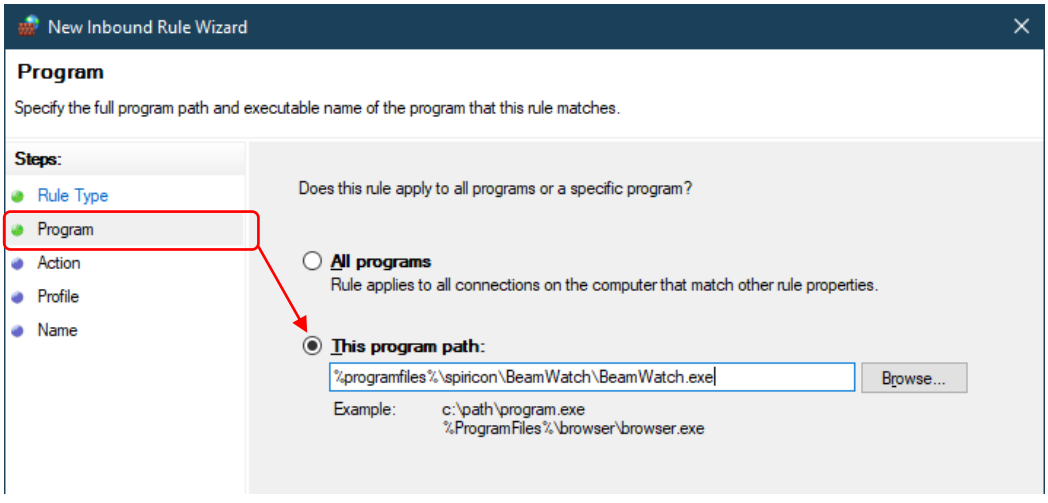
Instead of disabling the Windows Firewall completely, inbound rules can be configured for specific applications so that they will not be blocked by the firewall.

To set up inbound rules:

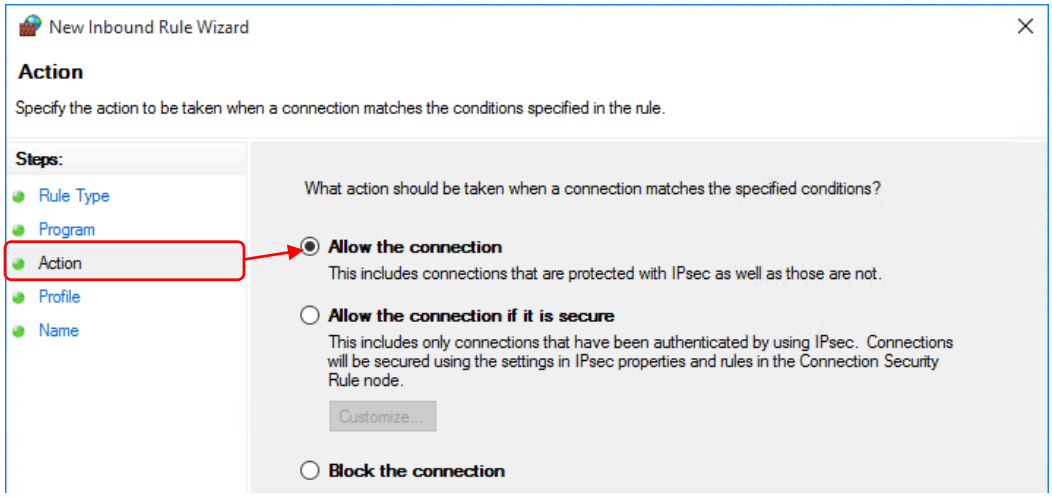
1. Open the **Windows Firewall with Advanced Security** window. For quick access:
    a. Press **+R**.
    b. Type **wf.msc**.
    c. Press **Enter**.



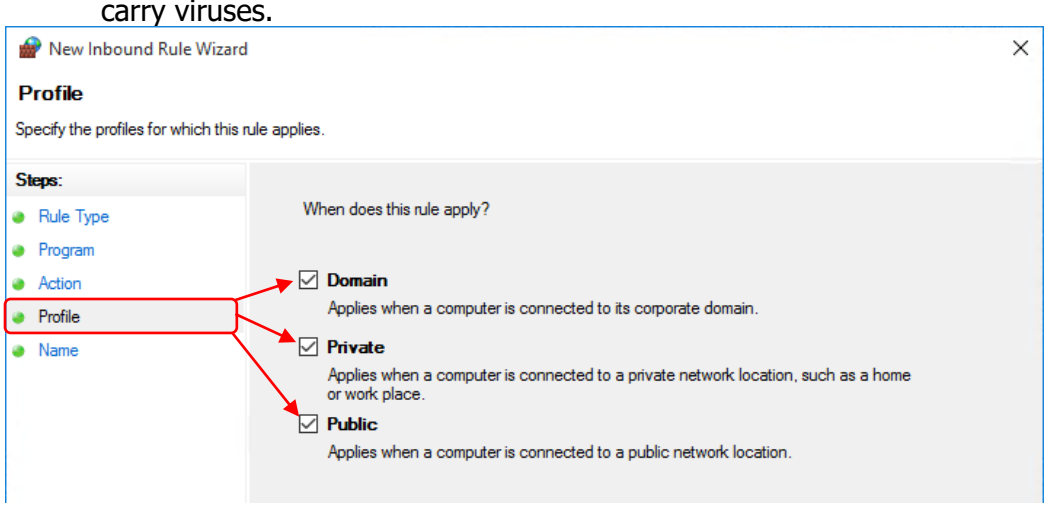
2. In the left pane, click **Inbound Rules**.
3. In the **Actions** pane, expand **Inbound Rules** and click **New Rule** to open the **New Inbound Rule Wizard**.
4. On the **Rule Type** page, select **Program**.
5. On the Program page, select **This program path**.



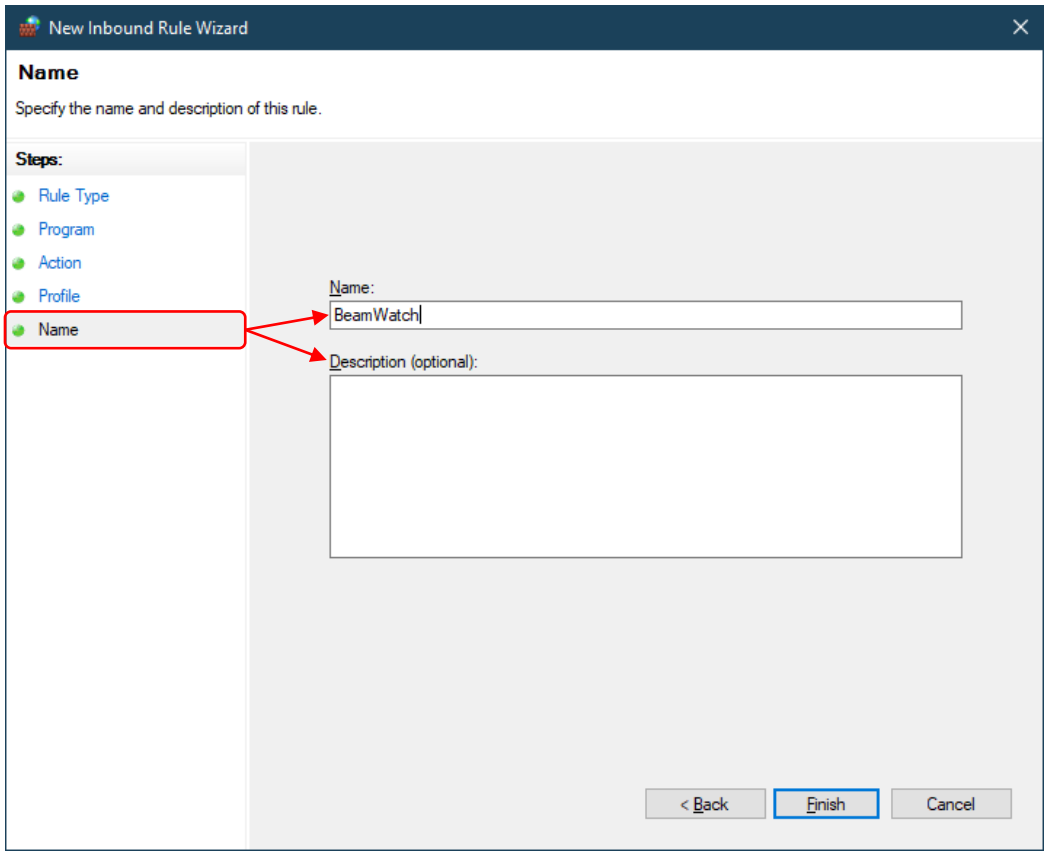
6. Click **Browse** and navigate to the program executable for the new rule.
    a. Example: To set up a rule for the BeamWatch, navigate to: **C:\ProgramFiles\Spiricon\BeamWatch\BeamWatch.exe.**
7. Click **Next**.
8. On the **Action** page, select **Allow the connection**.



9. Click **Next**.
10. On the **Profile** page, select the profile where the rule is to be applied. If you are unsure which profile to choose, select all three options.
    - Setting all three options is safe as the non-volatile storage in the BeamWatch cameras does not carry viruses.



11. Click **Next**.
12. On the **Name** page, enter a name for the rule and, if required, a description.



13. Click **Finish**. The new rule now appears in the **Inbound Rules** pane.

A.4.3 Creating Custom Inbound Firewall Rules for the EA-1

In most cases a firewall rule that creates the least port exposure is preferred. By default, the firewall rules that are created with the **New Inbound Rule Wizard** are as minimal as they can be, but additional options are available.

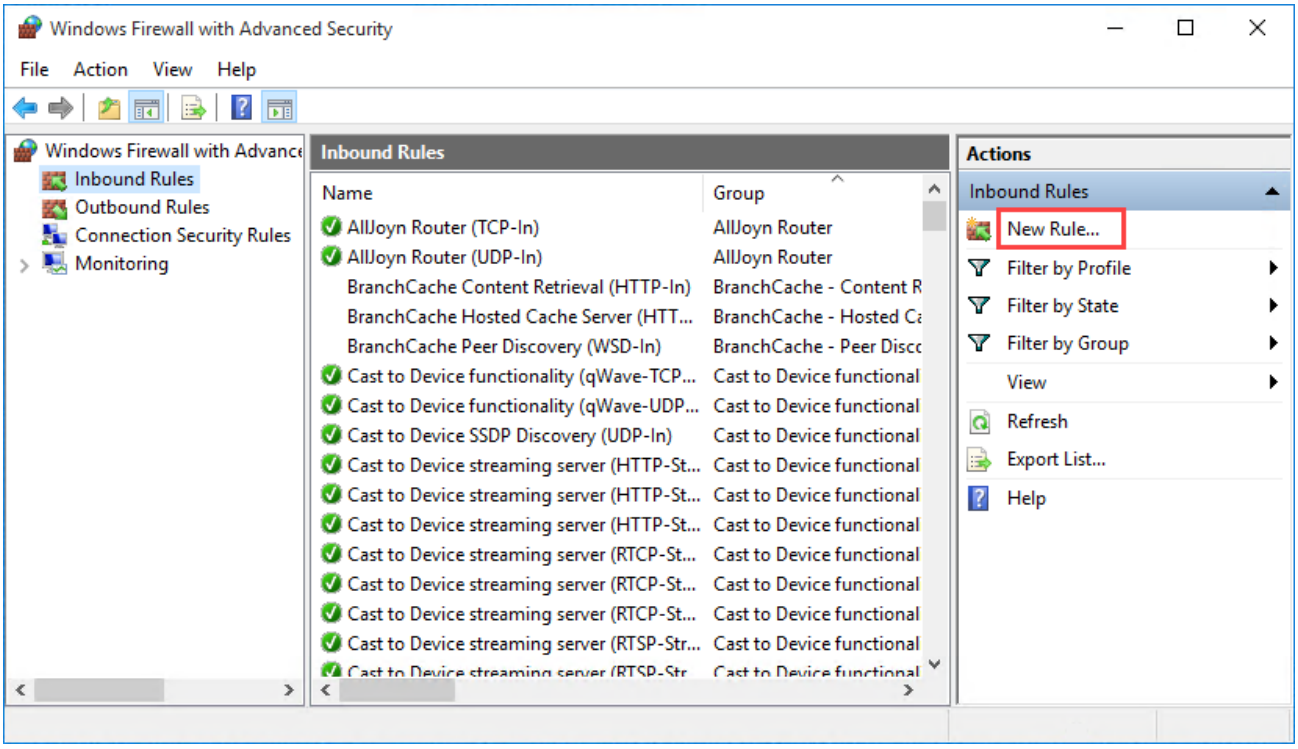
It may be necessary to create a custom firewall rule to allow the EA-1 power meter in the BeamWatch Integrated to be discovered and to communicate.

These steps may also be used to create explicit rules for other port ranges used by BeamWatch.

To set up custom inbound rules:

1. Open the **Windows Firewall with Advanced Security** window. For quick access:
   a. Press **⊞+R**.
   b. Type **wf.msc**.
   c. Press **Enter**.

2. In the left pane, click **Inbound Rules**.
3. In the **Actions** pane, expand **Inbound Rules** and click **New Rule** to open the **New Inbound Rule Wizard**.



4. On the **Rule Type** page, select **Custom**.
5. On the **Programs** page, select **This Program Path** and enter the suggested path below. Click **Next**.
6. On the **Protocols and Ports** page, configure the **Protocol type**, **Local Port**, and **Remote Ports** fields according to the suggested rules tables below.
7. On the **Scope** page, configure the local and remote IP scopes ***only if necessary*** in your network environment, otherwise leave set to **Any IP address**.
8. On the **Action** page, select **Allow the connection**.
9. On the **Profile** page, select the profile where the rule is to be applied: **Domain**, **Private**, or **Public**.
   - This should match the designation assigned to the network adapter, which can be found for each adapter in the **Windows Network and Sharing Center**.
   - If you are unsure which profile to choose, use the default selection of all three options.
10. On the **Name** page, provide a recognizable **Name** (required) and **Description** (optional).
11. Click **Finish**. The new rule now appears in the **Inbound Rules** pane.

Name: BeamWatch EA-1 Discovery **Protocol type**: UDP **Local Port**: Specific Ports; 11000 **Remote port**: Specific Ports; 11000 **Program Path**: %ProgramFiles%\Spiricon\BeamWatch\Spiricon.DataServer.exe
Name: BeamWatch EA-1 Telnet **Protocol type**: TCP **Local Port**: Specific Ports; 23 **Remote port**: All Ports **Program Path**: %ProgramFiles%\Spiricon\BeamWatch\Spiricon.DataServer.exe

Notice

Obtain the latest version of this user guide at https://www.ophiropt.com/laser--measurement/beam-profilers/services/manuals.