User Guide

BEAMWATCH®

LASER BEAM ANALYZER

VERSION 4.X

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1   Safety Information

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.

1.1   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.

1.2   Electrical Hazards

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

When installing or removing any hardware from a PC, disconnect power to the computer.

Always operate the computer with covers in place and in accordance with its manufacturer's recommendations.

Always use a properly grounded AC power cord when operating the computer.

1.3   Symbols Used in This User Guide

Definitions of NOTE, CAUTION, and WARNING messages used throughout the guide.

NOTE	The NOTE sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.
CAUTION	The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.
WARNING	The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition, on the like, which, if not correctly performed or adhered to, could result in injury to personnel.

2 General Information

2.1 Introduction

The BeamWatch® software interfaces with the BeamWatch® family of products, BeamWatch® Standard, BeamWatch® Plus, and BeamWatch® AM. BeamWatch Standard and BeamWatch Plus are designed for use in the industrial markets, and BeamWatch AM is designed specifically for the Additive Manufacturing market. BeamWatch Plus is designed to work in both the VIS and NIR wavelengths. BeamWatch displays 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.

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, number of frames, or leave it to collect continuously until manually stopped.

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

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			
	BW-NIR-155 BW-NIR-55	BW-NIR-130 BW-PLUS-45	BW-NIR-50-AM
Waist Width (Spot Size)	±5%	±5%	±5%
Waist Location	±125µm within the BeamWatch window	±125µm within the BeamWatch window	±150µm relative to the reference plane

Focal Shift	±50µm	±50µm	±50µm
Beam Parameter Product	±3.5% RMS	±2% RMS	±3.5% RMS
Divergence	±3.5% RMS	±2% RMS	±3.5% RMS
M²	±3.5% RMS	±2% RMS	±3.5% RMS
Power	N/A	N/A	±3%

Table 1: Accuracy Specifications for BeamWatch

3 Software Setup

3.1 BeamWatch Software Installation

Minimum System Requirements	
Operating system	Windows 10 or Windows 11, 64 bit
Graphics	Advanced Chip set with 1GB of dedicated graphics memory
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 GigE camera)
	USB 3.0 (supplied, required for units with a USB3 camera)

Table 2: Minimum System Requirements

NOTE | **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.**

NOTE | **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.**

Software installation must be performed with Administrator privileges.

1. Navigate to the Ophir software download page:
   a. https://www.ophiropt.com/laser--measurement/software-download
2. Select the BeamWatch software package to start the download.
3. Extract the contents of the zip folder to a local destination on the PC.
   a. Do not extract the files to a Network location as this may cause the installation to not execute properly.
4. Open the extracted folder and select the file "BeamWatch.Setup.exe"
5. Follow the directions on screen.

NOTE   **Ophir no longer verifies or certifies operation with Windows 7.**

NOTE   **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 of the list, otherwise the power meter will not connect.
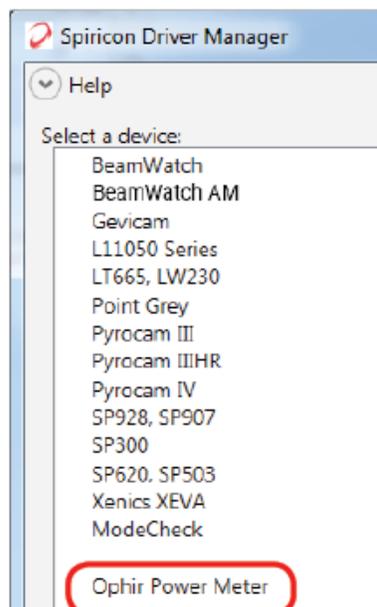
After the program is installed, the BeamWatch icon appears on the desktop (Figure 1).

Figure 1: BeamWatch Desktop Icon

3.2 Getting Started

1. To start the BeamWatch software, double click the desktop icon or from the Windows taskbar, select **Start -> BeamWatch**

2. If needed, select the desired device from the **Sources** dropdown (Figure 2).

Figure 2: Sources Selection Dropdown

NOTE	The BeamWatch Software connects to the first device it can find. Camera information does not appear until the device is connected for the first time.

3. Enter the required setup information in the **Laser** panel (Figure 3), see section 4.4.3.
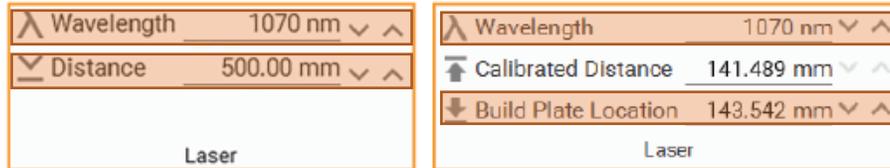
Figure 3: Required Fields in the Laser Panel for BeamWatch Standard and BeamWatch Plus (left); BeamWatch AM (right)

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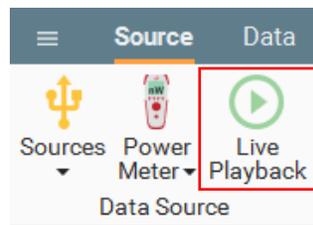
Figure 4: Live Playback Button

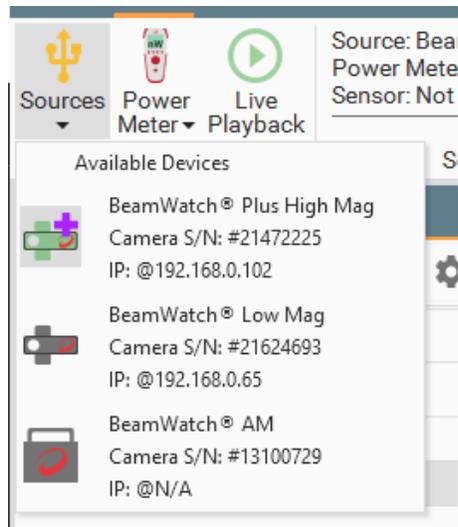**NOTE**   **Review the remaining chapters of this user guide and become familiar with the operation and capabilities of the BeamWatch system before performing laser measurements. This user guide may also be found on the Ophir website at www.ophiropt.com. Simply follow the BeamWatch product links.**

3.2.1   BeamWatch Plus First Time Connection

When BeamWatch Plus is first connected, BeamWatch displays a notification that the BeamWatch Plus has been detected (Figure 5). The software automatically sets the wavelength to 1070nm and prompts you to remove the glass if this is the desired range. The notification must be acknowledged to proceed.
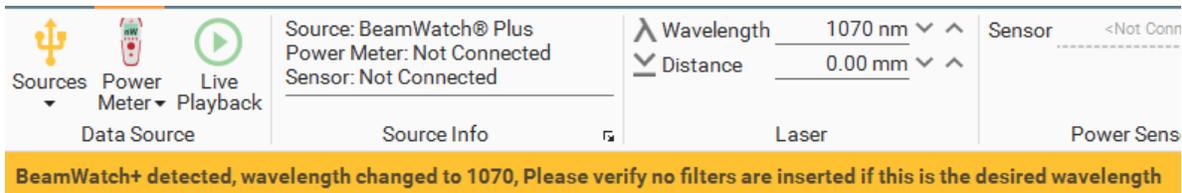
Figure 5: BeamWatch Plus Detected Notification

You must specify your wavelength in the **Wavelength** field. If you are operating in the NIR range (950-1100nm) the glass must be removed. If you are operating in the VIS range (420-635nm), BeamWatch displays a notification to insert the glass before continuing (Figure 6). This notification must be acknowledged to proceed.
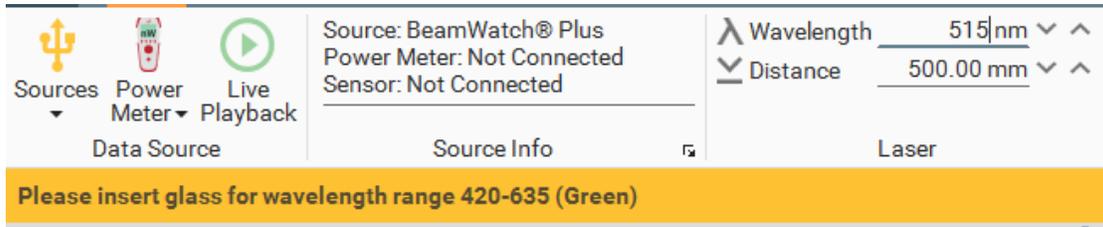
Figure 6: BeamWatch Plus VIS Wavelength Notification

NOTE	If you have set the wavelength to the VIS range and then return to the NIR range, or vice versa, you will be given a notification to remove/insert the glass, respectively. This notification must be acknowledged to proceed (Figure 7).
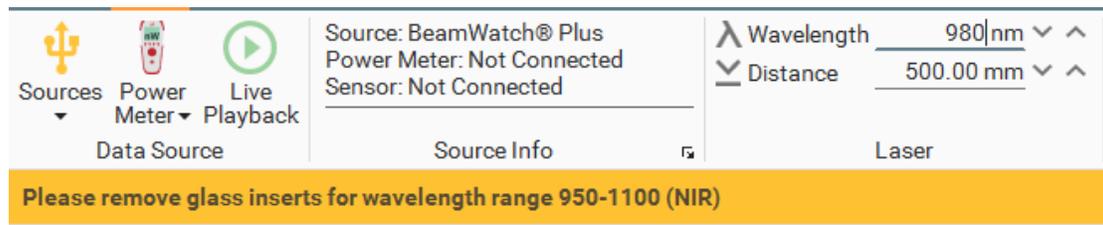
Figure 7: BeamWatch Plus NIR Wavelength Notification

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. Figure 8 provides a graphical glossary of the terminology used.

| *NOTE* | There may be variation in naming conventions in the ribbon motif employed in BeamWatch. The terms selected in this guide are used for consistency. |
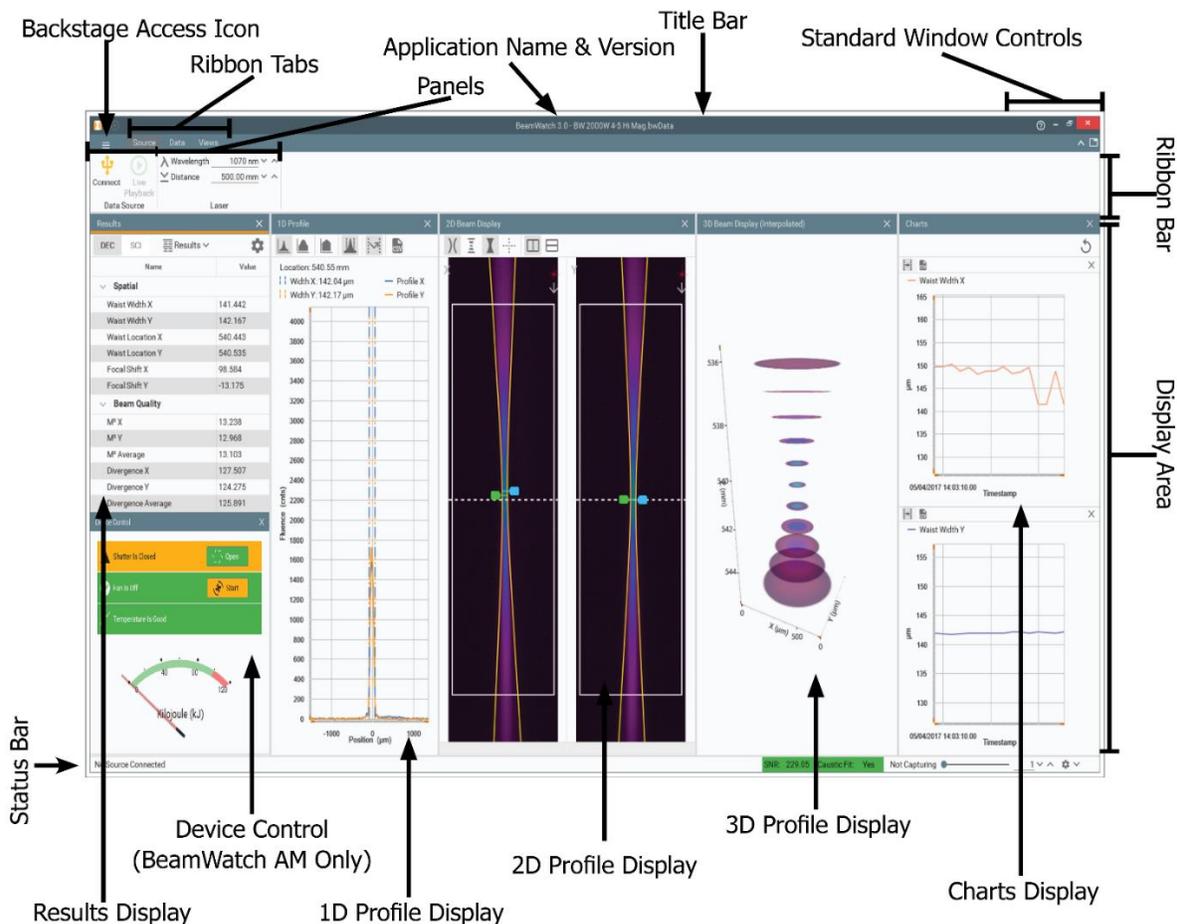
Figure 8: Description of UI Elements

4.2   User Interface Features

4.2.1   Title Bar

The Title bar (Figure 9) is the topmost bar of the application:
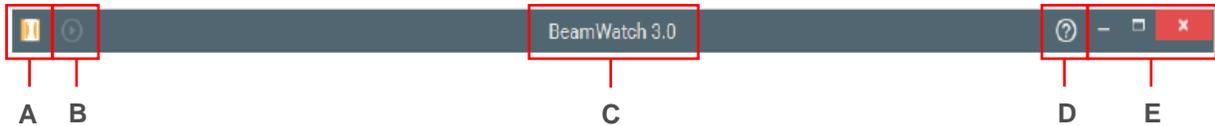
Figure 9: Title Bar

A. **Start Menu**—Click to access window controls.
B. **Quick Access Toolbar**—Click to start or pause data collection.
C. **Application Information**—Displays the application name, version number, and file playback name, if applicable.
D. **Help**—Click to bring up this user guide without exiting the software.
E. **Windows Controls**—Standard **Minimize**, **Maximize**, and **Close** buttons

4.2.2   Ribbon Tab

The ribbon tab (Figure 10) allows you to navigate the various ribbons. Select a tab to swap between 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.

Figure 10: Ribbon Tab

4.2.3   Ribbon Bar

The ribbon bar (Figure 11) displays the current set of panel control options available within a selected ribbon tab.
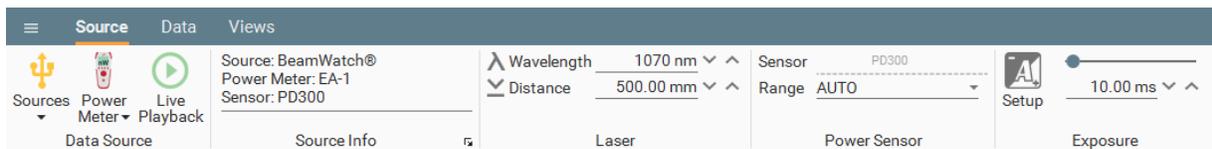
Figure 11: Ribbon Bar

4.2.4   Panels

Panels (Figure 12) contain buttons, drop-down lists, edit controls, etc. Hover the mouse over a control to view tooltips on most items.

Figure 12: Data Source Panel

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 sections 4.4–4.6.

4.2.6   Status Bar

The Status bar (Figure 13) contains useful information about the connected camera, results accuracy, and frame buffer.
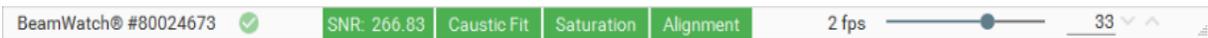
Figure 13: Status Bar

Beam Source

The BeamWatch model and serial number display in the status bar when a camera is connected (Figure 14). If a power meter is connected, its model and serial number are also displayed.

Figure 14: Beam Source Displayed in the Status Bar

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

Annunciator

The Annunciator (Figure 15) evaluates different characteristics of the image quality and notifies you 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.

Figure 15: Annunciator Displayed in the Status Bar

Annunciator colors can be easily distinguished through laser protective eyewear. 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 Capture Rate displays the frame rate in real time (Figure 16). The frame rate is calculated and updated as data frames are received from the camera. When stopped, "Not Capturing" is displayed.

Figure 16: Capture Rate Displayed in the Status Bar

Frame Buffer

The **Frame Buffer** (Figure 17) 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 dropped in a "first in, first out" basis. Data from deleted frames is lost. Result statistics are not affected by the frame buffer size.

Figure 17: Frame Buffer Position Toolbar

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. During a run, the slider edit control is not displayed. Instead, it is replaced with an icon symbolizing that data is currently being collected (Figure 18).

Figure 18: Live Data Acquisition Icon

When loading saved data files, the frame buffer fills with all the saved frames. Frames can be scrolled through manually or automatically using the File Playback. See 4.4.8 File Playback Panel.

4.3 Application Tools

Application Tools can be found in the same bar as the ribbon tabs (Figure 19).

Figure 19: Application Tools in the Ribbon Tab

4.3.1 File Menu

Select [≡] to access the **File** menu (Figure 20).
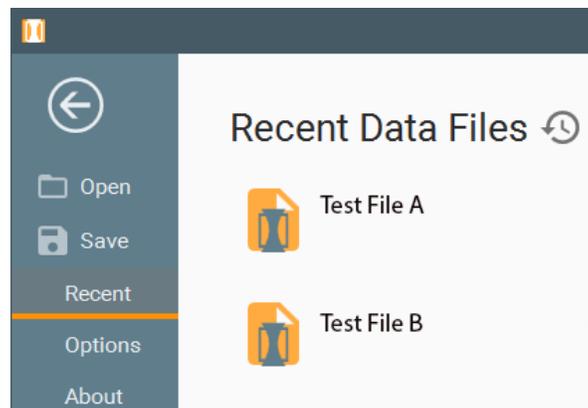
Figure 20: File Menu

Open

Opens **Windows Explorer** to navigate to a specific file to open for file playback. When a file is loaded, the **Frame Buffer Capacity** automatically changes to match the number of frames saved in the file (see section 4.5.2) and the **Frame Buffer Filter** is set to **All Frames**.

NOTE	When a saved file is opened, all the statistics from the buffer are loaded automatically. I.e., if 50 frames are included in the buffer, statistics from those frames are loaded with the file.

Save

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

Recent

Stores quick links to recent data files.

Options

The **Options** menu provides settings that change the look and feel of the application as well as enable frame data to be exported in a tiff format (Figure 21).
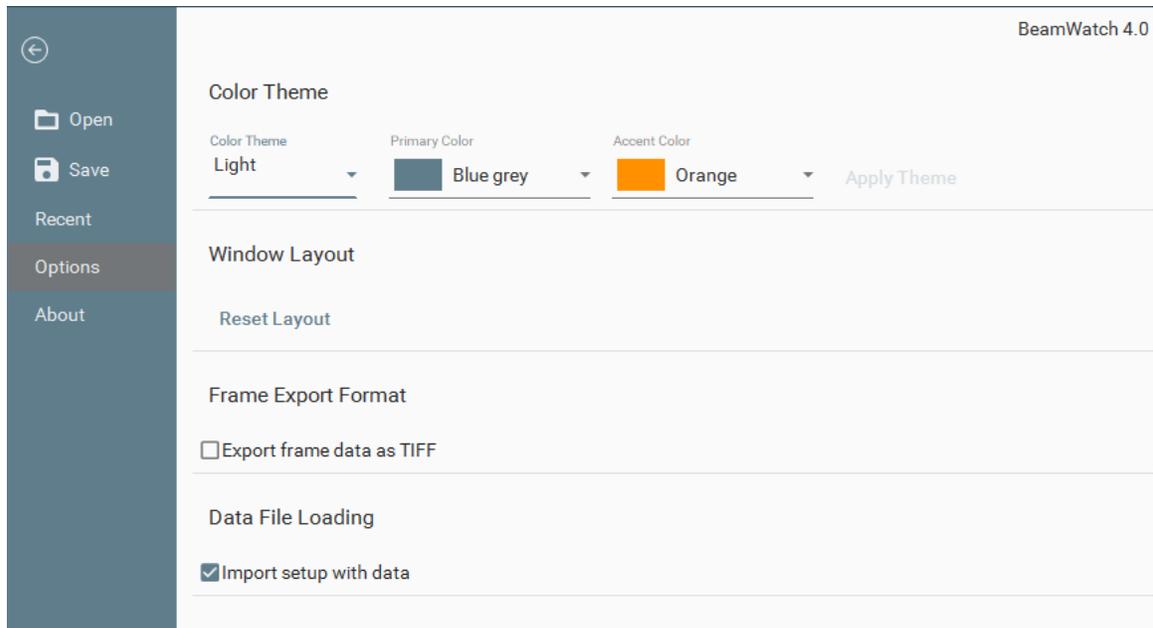
Figure 21: Options Screen

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 4.3.2 TIFF Image Format for more information). If unchecked the data remains as an integer array.

Enable **Import setup with data** to allow BeamWatch to open saved data files with the same user interface layout as it appeared when the file was saved. If disabled, no layout changes occur when a file is loaded.

About
The **About** screen displays the current software version and copyright information and provides a link to this user guide (Figure 22).
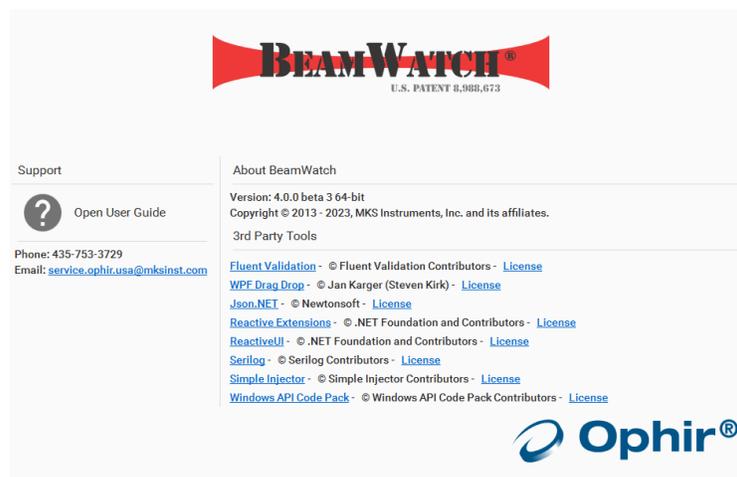
Figure 22: About Screen

4.3.2   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.

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** (Figure 23).
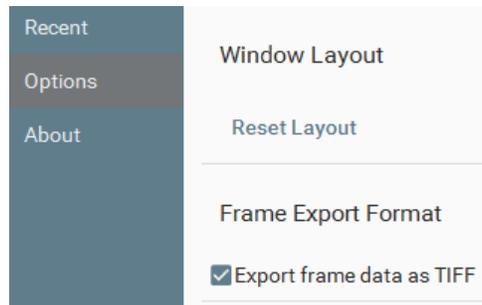
Figure 23: Export Frame Data as TIFF

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** (Figure 24) and select **Open**.
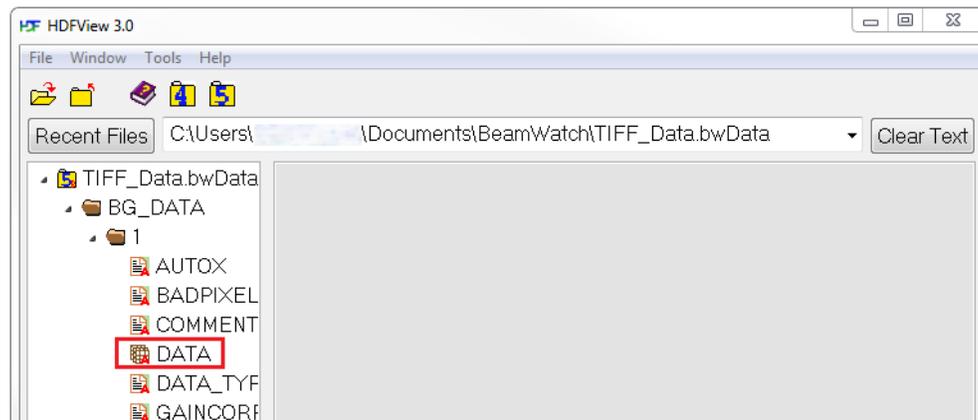
Figure 24: DATA Location in HDFView

9. Select **Import/Export Data** > **Export Data to** > **Binary File** > **Native Order** (Figure 25).
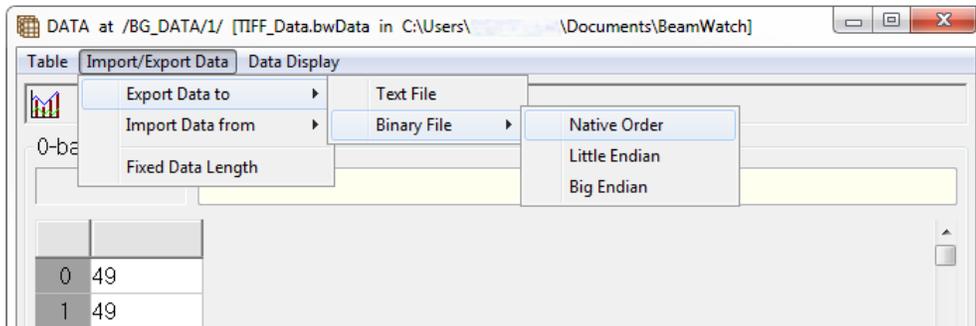
Figure 25: Native Order Location

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

4.3.3   Show or Hide Ribbon Bar

Select ⌃. to display or hide the ribbon bar. This can also be accomplished by double-clicking a tab.

4.3.4   Ribbon Group Visibility

Select ▢ to open the **Ribbon Group Visibility** popup window (Figure 26). From here, select the tab of the ribbon to customize and select a respective slider to turn that panel on or off.
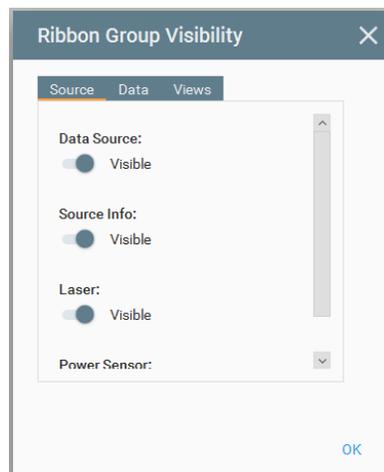
Figure 26: Ribbon Group Visibility Window

4.4 Source Ribbon

The **Source** ribbon (Figure 27) provides control over the camera source and beam information. The content in this ribbon varies by camera.

Figure 27: Source Ribbon

4.4.1 Data Source Panel

The **Data Source** panel (Figure 28) allows you to connect to the BeamWatch camera, an Ophir power meter, and to toggle **Live Playback** on and off.
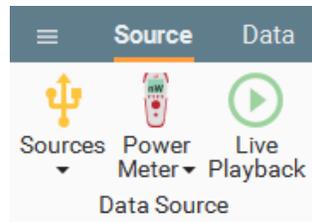
Figure 28: Data Source Panel

Sources

Sources opens a dropdown menu that displays connected devices (Figure 29). BeamWatch, BeamWatch Plus, and BeamWatch AM have unique icons 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.
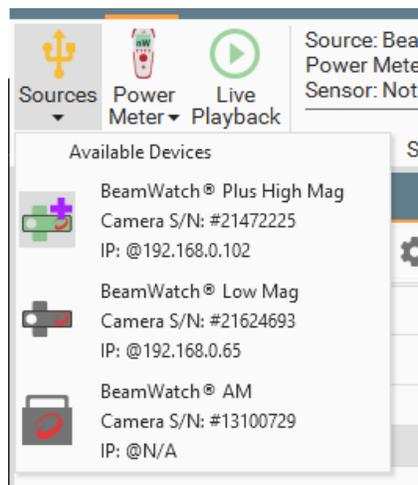
Figure 29: Sources Selection Dropdown

NOTE	The BeamWatch software connects to the first device it can find. Camera information does not appear until the device is connected for the first time.

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.

Figure 30: Connection Error Dialog

Power Meter

The **Power Meter** panel opens a dropdown menu that displays connected power meter devices (Figure 31). The device name, serial number, and IP address, if applicable, is listed. Select a device from the dropdown to set it as the active power meter.

Figure 31: Power Meter Selection Dropdown

Live Playback

The **Live Playback** (Figure 32) starts or stops data collection. The icon changes to reflect when the program is running or paused.
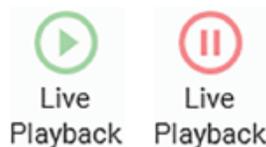
Figure 32: Live Playback Panel Start (left) and Stop (right)

This feature is duplicated 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 (Figure 33) to view the serial numbers and IP addresses, where applicable (Figure 34).

Figure 33: Expand Button in the Source Info Panel

Figure 34: Source Info Window

4.4.3   Laser Panel

The **Laser** panel (Figure 35) allows you to enter information about the laser used in the calculation of results. Laser information must always be entered prior to data collection.

Figure 35: Laser Panel for BeamWatch Standard and BeamWatch Plus (left); BeamWatch AM (right)

Wavelength

Enter the wavelength of the beam in nm. This value is used when calculating **Beam Quality** results such as M^2.

Power meters operate within specific ranges. If you have a power meter connected and you try to enter a value outside of the range of the power meter, BeamWatch will display an error (Figure 36). If you have a BeamWatch Plus connected and you try to enter a value outside of the operating range, BeamWatch will display a similar error (Figure 37).
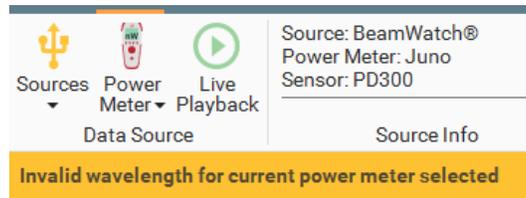
Figure 36: Invalid Wavelength for Power Meter Warning
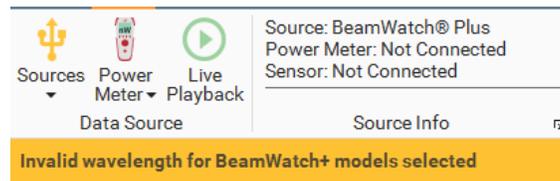
Figure 37: Invalid Wavelength for BeamWatch Plus Warning

NOTE	**If you enter a range outside of both the BeamWatch Plus and the power meter, the error message for the BeamWatch Plus takes priority and is the only error displayed.**

NOTE	**Wavelength cannot be changed when viewing a loaded data file. Ensure that the wavelength is set correctly before saving data.**

Distance (BeamWatch Standard and BeamWatch Plus)
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 the distance from the top of the BeamWatch to the center of the camera imager and is calibrated at the factory. The software adds the Position Offset to the Measured Distance to get the Total Distance (Figure 38). The Total Distance is used to determine the **Waist Location** and the current **Waist-Cursor Location**.
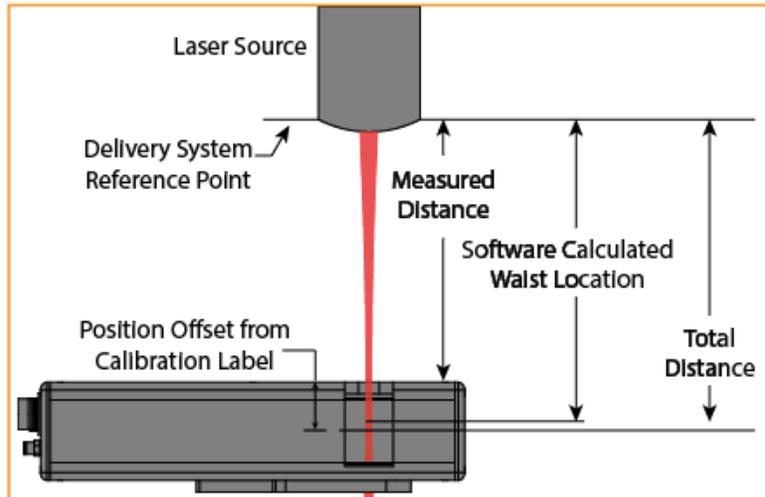
The Position Offset value is located on the unit's calibration label.

Figure 38: Diagram of Measurement Distances

Calibrated Distance (BeamWatch AM Only)

The **Calibrated Distance** is set at the factory and cannot be edited (see Figure 35). 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. It is recommended to lower the build plate by this amount before taking measurements with BeamWatch AM.

Build Plate Location (BeamWatch AM Only)

Enter the actual distance the build plate has been lowered in mm. Figure 39 shows the build plate lowered beyond the calibrated distance by 2.053mm.
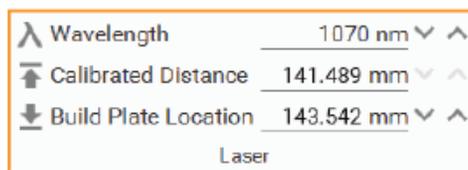
Figure 39: BeamWatch AM Laser Panel

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.

NOTE	**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.**

> **CAUTION**   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.

Figure 40 shows a build plane that 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.)
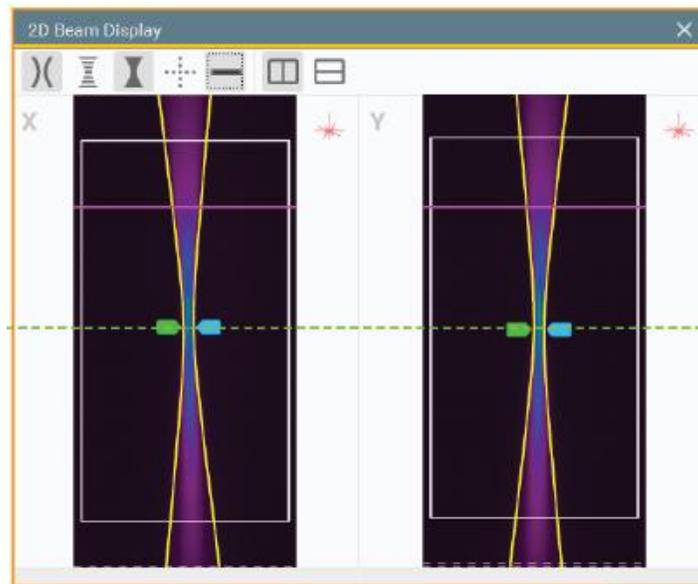
Figure 40: 2D Beam Display with BeamWatch AM

4.4.4   Power Sensor Panel

The **Power Sensor** panel (Figure 41) allows you to change the measurement scaling range of the active power sensor and set the **Wavelength** range on applicable sensors.
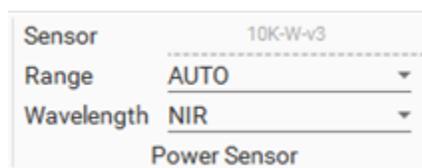
Figure 41: Power Sensor Panel

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 (Figure 42). 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 set in the **Laser** panel (see section 4.4.3 Laser Panel).

Figure 42: Wavelength Dropdown

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).

4.4.5   Device Control Panel (BeamWatch AM Only)

BeamWatch AM contains a unique panel that controls the shutter and the fan and displays a temperature notification to ensure safe operation (Figure 43). These controls are duplicated in the **Device Control** window.

Figure 43: Device Control Panel

Shutter Control

The **Shutter Control** displays the current shutter status and is used to open or close the shutter in the input aperture (Figure 44). This function is blocked whenever the fan is active.

Figure 44: Shutter Control and Status Indicator

CAUTION **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. Always close the shutter before turning off the purge gas to keep particles out of the unit.**

Fan Control

The **Fan Control** displays the current fan status and is used to activate or deactivate the fan to cool the unit (Figure 45).

Figure 45: Fan Control and Status Indicator

Before the BeamWatch AM unit overheats, a warning (Figure 46) 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.
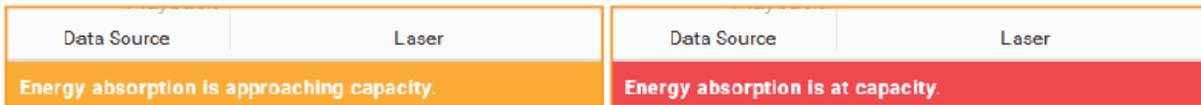
Figure 46: Temperature Warnings

CAUTION **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.**

CAUTION **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

The **Temperature Status** displays the current energy absorption of the unit (Figure 47). 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.
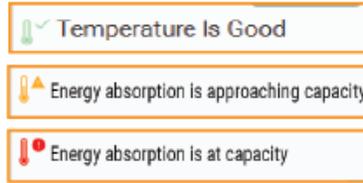
Figure 47: Temperature Stats Indicators

Power Meter Status

The Power Meter Status displays the current state of the power meter. The status changes to a warning if there is no power meter connected (Figure 48). The status is duplicated in the **Device Control** window if it is active. See Chapter 8 Troubleshooting if the power meter is not connecting.

Figure 48: No Power Meter Connected Alert

CAUTION   **When operating at low powers for a long period of time the background noise of the camera will rise, producing 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.**

4.4.6   Device Control Window (BeamWatch AM Only)

The **Device Control** window (Figure 49) contains the same controls as the ribbon, as well as a **Joule Counter** that shows how much energy has been absorbed.

CAUTION   **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.
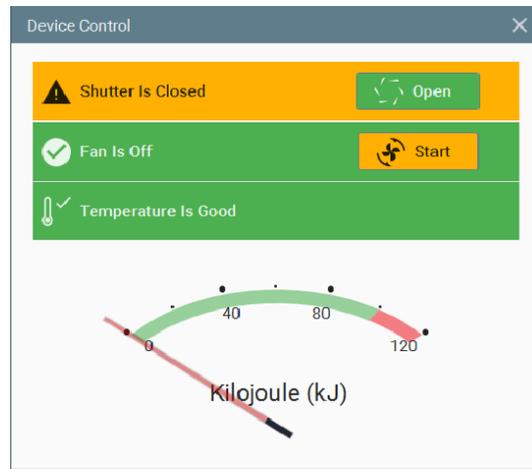
Figure 49: Device Control Window

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 (Figure 50).

Figure 50: Expansion Button in the Device Control Panel

The **Joule Counter** displays the current energy received by the power sensor (Figure 51). After reaching maximum, a warning appears below the ribbon bar.
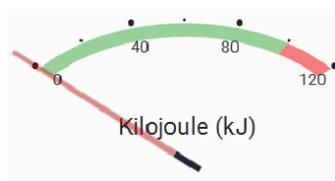
Figure 51: Joule Counter

CAUTION	**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.

NOTE   **The device remembers the joule counter location when unplugged and then reconnected only if it is connected to the same PC.**

4.4.7   Exposure Panel

The **Exposure** panel (Figure 52) is only available when a BeamWatch unit is connected to the software. This setting determines the intensity of the output image.
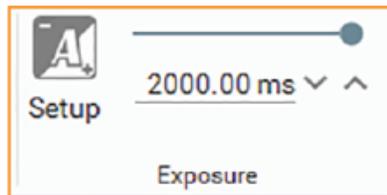
Figure 52: Exposure Panel

Exposure

Exposure determines 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 (Figure 53).
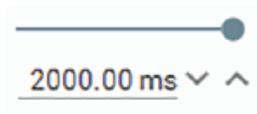
Figure 53: Exposure Controls

Auto Setup

Select **Auto Setup** (Figure 54) 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, the cursor set to the waist location.

Figure 54: Auto Setup Off (left) and On (right)

Auto Setup starts at maximum exposure and adjusts downward until intensity 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.

4.4.8   File Playback Panel

The **File Playback** panel (Figure 55) 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 frames. Frames loaded into the frame buffer can be scrolled through manually with the frame buffer, or automatically by selecting **Start**.
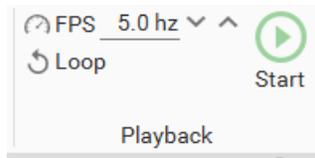
Figure 55: File Playback Panel

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.

FPS
Frames per second (FPS) determines how quickly the data file runs on playback. You can set this field between 1 and 5 Hz.

Start/Stop
Start/Stop (Figure 56) toggles playback on and off. Automatically stops after reaching the end of the buffer unless **Loop Playback** is enabled.
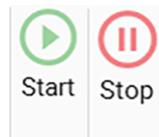
Figure 56: File Playback Start (left) and Stop (right)

Loop Playback
Loop Playback enables or disables continuous playback through the frame buffer.

Exit File Playback

Select a device from the **Sources** list to exit **File Playback** and reconnect to the BeamWatch unit.

NOTE	**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 (Figure 57).
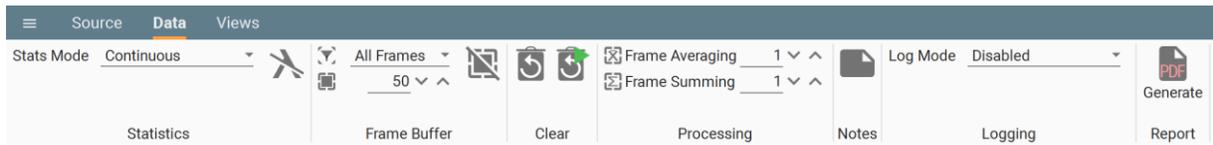
Figure 57: Data Ribbon

4.5.1   Statistics Panel

The **Statistics** panel (Figure 58) sets the number of samples to use in computing the statistical results values.

Figure 58: Statistic Panel

Stats Mode

Select the **Stats Mode** dropdown 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.

- **Continuous**—Sets statistics to be computed continuously until manually stopped or reset.
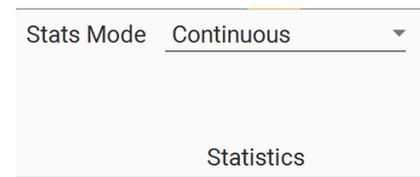
Figure 59: Continuous Statistics Mode

- **Frames**—Sets statistic collection to stop after a specified number of frames with a maximum of 9,999. A common form of data collection.
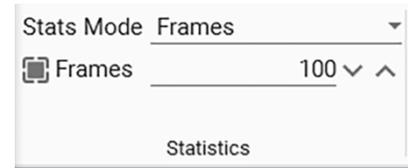
Figure 60: Frames Statistics Mode

- **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.

Figure 61: Running Window Statistics Mode

- **Time**—Sets statistic collection to a specified amount of time in HH:MM:SS with a maximum of 23:59:59.
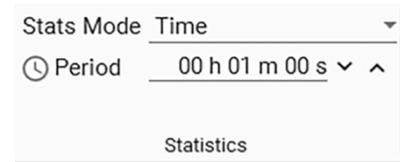
Figure 62: Time Statistics Mode

Clear Statistics
Clears all currently stored statistics from the results grid (Figure 63).

Figure 63: Clear Statistics

4.5.2   Frame Buffer Panel

The **Frame Buffer** panel gives you control over which frames are saved in the **Frame Buffer** (Figure 64). Use the controls to set which types of frames are saved, set the max frame buffer capacity, and optionally remove all current frames from the buffer.
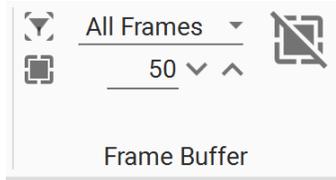
Figure 64: Frame Buffer Panel

Frame Buffer Filter

Select the drop-down to select a **Frame Buffer Filter**. The filter determines which frames are saved to the frame buffer. Each option is described below.

- **All Frames**—Saves all frames to the buffer with no filtration.
- **Caustic/SNR**—Saves only frames with a green SNR and Caustic Fit annunciator (see section 4.2.6 Status Bar).
- **ISO**—Saves only frames that meet the ISO requirement.

Frame Buffer Capacity

Use the **Frame Buffer Capacity** field to set the max number of frames for the buffer to hold (9,999 max). This can only be changed when the **Frame Buffer Filter** is set to **All Frames**. After setting the capacity, the **Frame Buffer Filter** can be changed and the set capacity will remain.

NOTE

Saving data files saves all frames in the frame buffer. The more frames in the frame buffer, the larger the data file.

If the capacity is not reached, the empty frame buffer slots are not saved.

Always use the smallest required buffer size to minimize file sizes.

NOTE

When a file is loaded, the Frame Buffer Capacity automatically changes to match the frame buffer size in the file and the Frame Buffer Filter is set to All Frames. The Capacity and Filter cannot be changed when viewing loaded files.

Clear Frames

Clears the Frame Buffer of all collected data (Figure 65). Charts and statistic data will remain.

Figure 65: Clear Frame Buffer

4.5.3   Clear Panel

The **Clear** panel contains buttons to clear all data from the application, including displays, time charts, statistics, and all frames in the frame buffer. The options are **Clear** and **Clear on Start** (Figure 66).

Figure 66: Clear Panel

Clear
Clear deletes all data when clicked.

Clear on Start
Clear on Start sets all data to clear whenever **Live Playback** is started.

4.5.4   Processing Panel

The **Processing** panel allows for various types of image processing which are applied during data collection of frames (Figure 67).
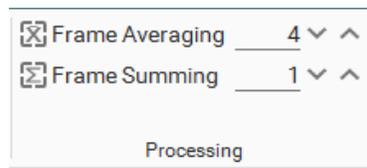
Figure 67: Processing Panel

Frame Averaging
Frame Averaging takes an average of the frames received from the camera. The averaged result is added to the frame buffer and used in calculations.

Enter the number of frames to be averaged while collecting data. In Figure 67, 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
Frame Summing sums the number of frames and the result is added to the frame buffer and used in calculations.

Enter the number of frames to be summed. In Figure 67, 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.

4.5.5   Notes panel

Selecting the **Notes** panel (Figure 68) opens a separate **Notes** window for text entries (Figure 69). 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 4.5.7 Report Panel) and are saved in the *.bwData file and are loaded when reviewing data.

Figure 68: Notes Panel
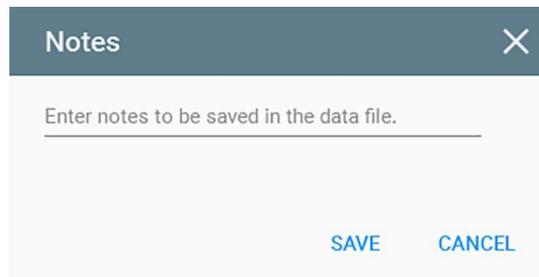
Figure 69: Notes Window

4.5.6   Logging Panel

The **Logging** panel (Figure 70) controls how and where data is logged. 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.

Figure 70: Logging Panel

NOTE   **This panel cannot be edited 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

File Browse (Figure 71) opens **Windows Explorer** to create a save location and file name. Select **Save** when finished.

Figure 71: File Browse Button

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.
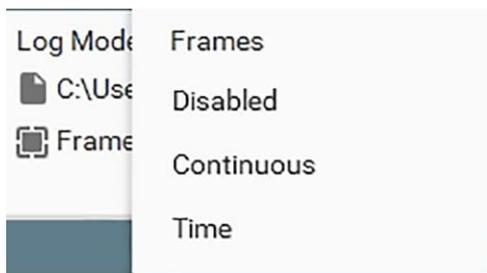
Figure 72: Log Mode Dropdown

The four methods are:

- **Disable**—No logging is enabled.
- **Continuous**—Logging is set to collect until manually disabled. If **Live Playback** is paused and restarted without disabling logging, then logging will continue and append to the existing file. **Note that 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 **Frames** or **Time** logging is in process, a progress meter appears in the status bar (Figure 73).

Figure 73: Logging Progress Meter in the Status Bar

When logging continuously, a processing icon (Figure 74) appears in the status bar providing a visual reminder that the log is running.
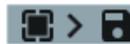
Figure 74: Continuous Logging Icon in the Status Bar

4.5.7   Report Panel

The **Report** panel (Figure 75) allows you to create 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.

Figure 75: Report Panel

Generate

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. Figure 76 shows an example of a PDF report.
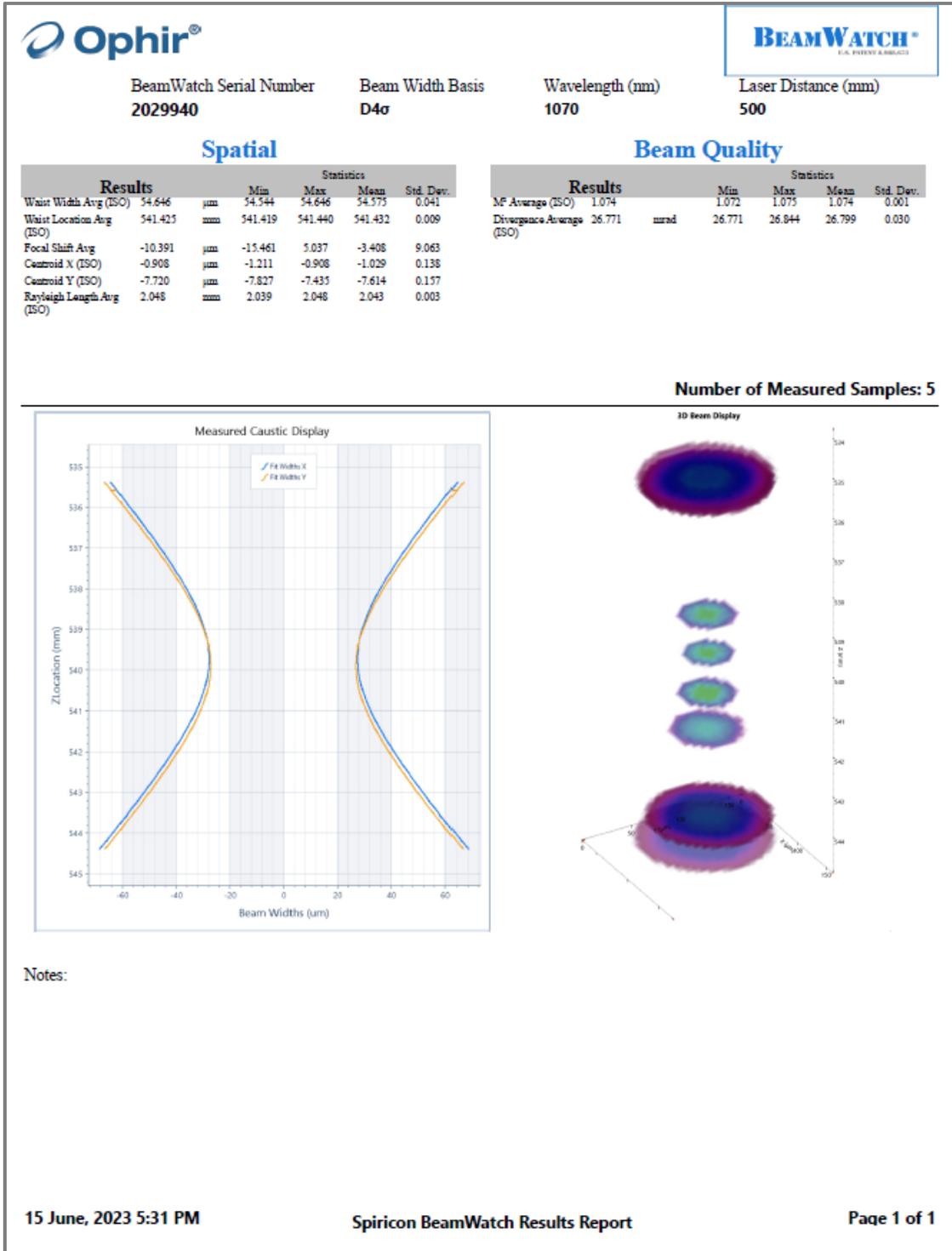
Figure 76: Example PDF Report

4.6   Views Ribbon

The **Views** ribbon provides a way to open and close windows in the display area (Figure 77). **3D Beam Display** is only visible with dual axis units.
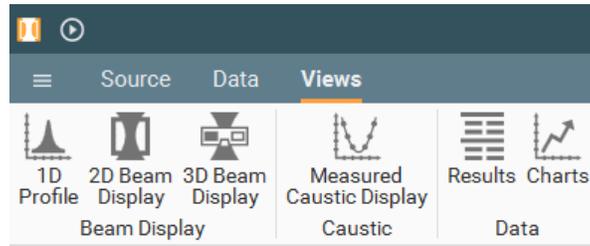
Figure 77: Views Ribbon

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

NOTE	**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 **Measured Caustic Display** (Figure 78) to toggle the **Measured Caustic Display** window (Figure 79).
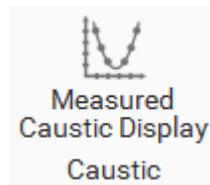
Figure 78: Measured Caustic Display Panel
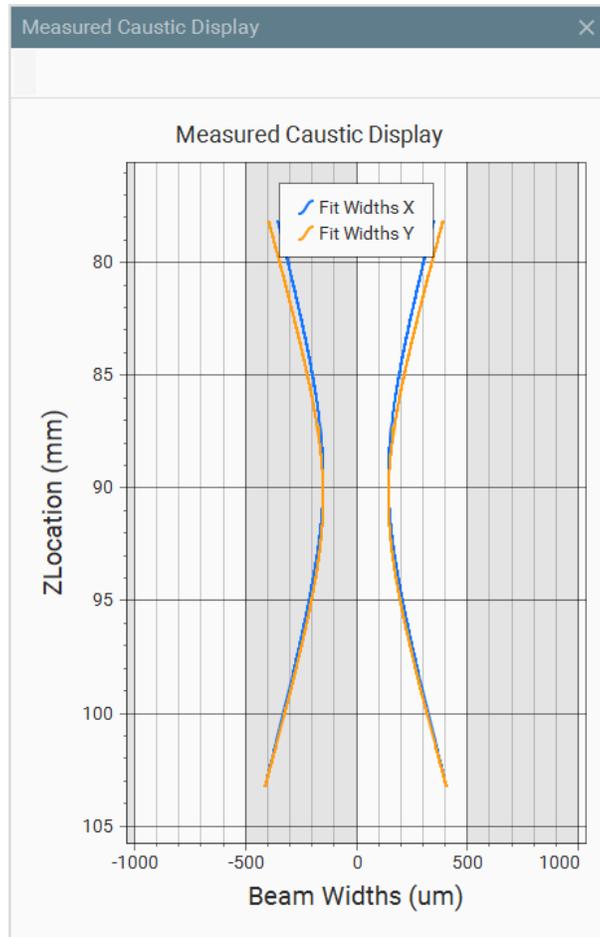
Figure 79: Measured Caustic Display Window

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 (Figure 80) to toggle the **1D Profile** window (Figure 81). 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.

Figure 80: 1D Profile Panel

The horizontal axis is the width of the region of interest (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. If zoomed, you can pan the display by dragging the mouse inside the display area.
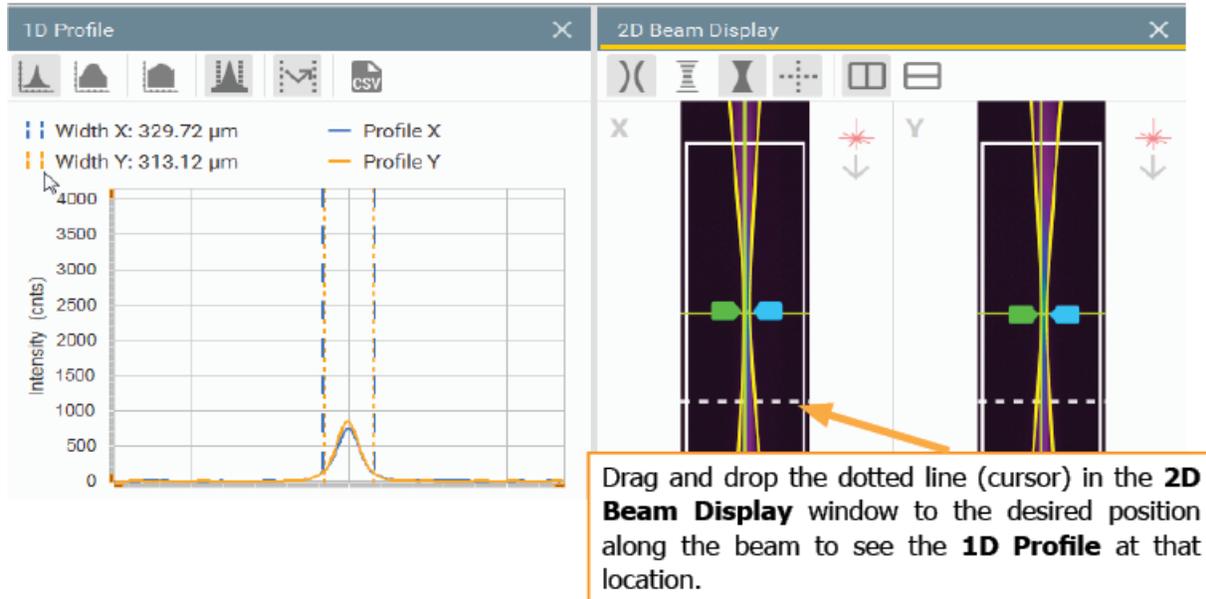
Figure 81: Selecting the Location of the 1D Profile

1D Profile controls

1D Profile controls are specific to the **1D Profile** window (Figure 82). They control the vertical axis of the display, enable the beam width markers, and allow exporting of the profile data.

Figure 82: 1D Profile Controls

The 1D Profile controls from left to right are described below.

- **Linear Scale**—Sets 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 (Figure 83) in the panel to toggle the **2D Beam Display** window (Figure 84).
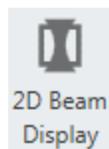
Figure 83: 2D Beam Display Panel
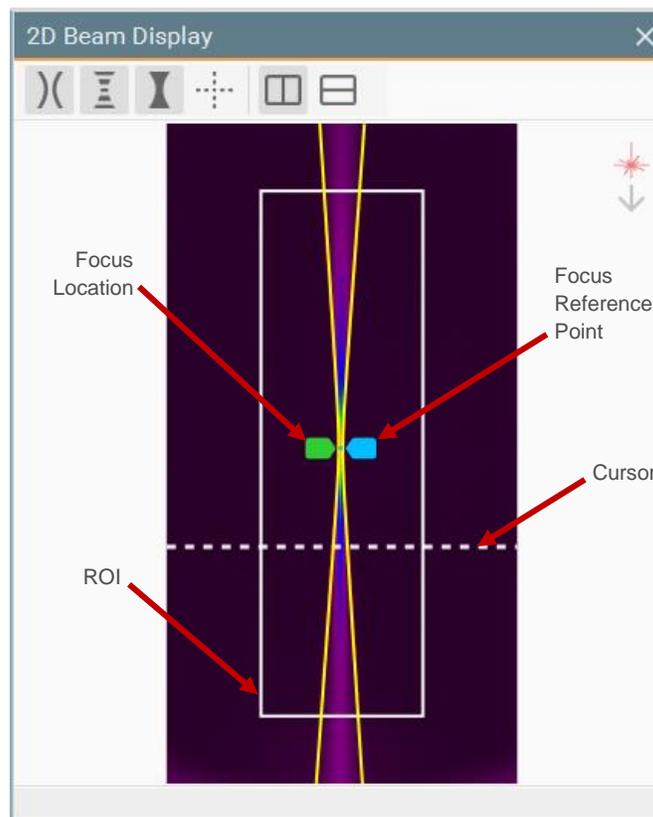
Figure 84: 2D Beam Display Window

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 signal to noise ratio (SNR) is greater than 10 and a caustic fit is found. Reset this position to the next valid beam width location by selecting **Clear Statistics** in the **Statistics** window. See section 4.5.1 Statistics 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** (FOV) is the total area the camera views in each axis. Table 3 shows the FOV of each camera.

Field of View by Camera	
Camera	**Field of View**
BeamWatch AM SP90470	11.26mm x 2.99mm
BeamWatch Standard (High Mag) SP90391	11.26mm x 2.99mm
BeamWatch Standard (Low Mag) SP90390 / SP90623	32.17mm x 8.55mm
BeamWatch Plus (High Mag) SP90613	11.26mm x 2.99mm

Table 3: Field of View by Camera

2D Beam Display Controls
The **2D Beam Display** controls (Figure 85) are specific to the **2D Beam Display** window and control the display layers of the beam.

Figure 85: 2D Beam Display Controls

The **2D Beam Display** controls from left to right are described below.

- **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 best focus location. When viewing two axes of the beam, two sets of crosshairs appear marking the center of focus for 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.

Figure 86 shows the **2D Beam Display** with both Beam Fit and Raw Beam layers enabled.
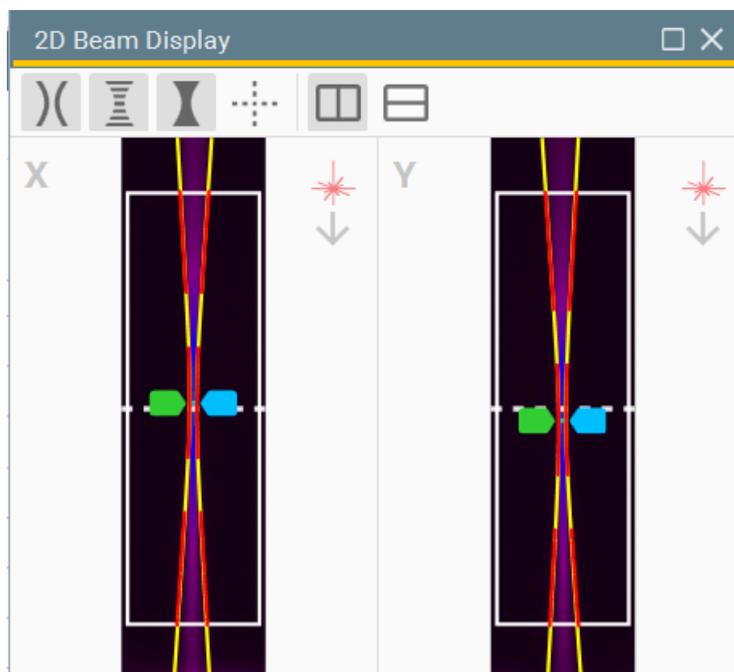
Figure 86: 2D Beam Display Window with Beam Fit and Raw Beam Layers Enabled

Alignment Crosshair Display
When the **Alignment Crosshair** is activated, three vertical lines appear to aid in alignment. The center line marks the best focus location. The outer vertical lines mark the bounds of the Focal Plane Region.

Align the beam within these bounds, in both views, for the best results (Figure 87).
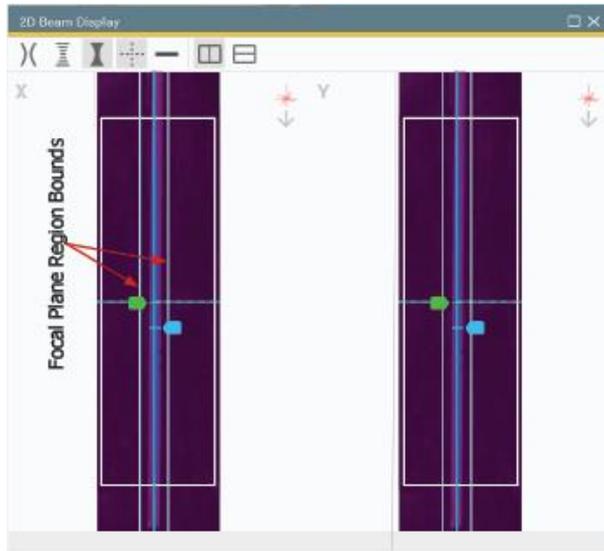
Figure 87: Alignment Crosshair Enabled

Focal Plane Region by Camera	
Camera	**Width of Focal Plane Region**
BeamWatch AM SP90470	±350µm
BeamWatch Standard (High Mag) SP90391	±350µm
BeamWatch Standard (Low Mag) SP90390 / SP90623	±1000µm (1mm)
BeamWatch Plus (High Mag) SP90613	±350µm

Table 4: Focal Plane Region by Camera

NOTE

With BeamWatch Plus units, the location of the alignment crosshairs will move based on the entered wavelength. The beam alignment must stay within the alignment bounds to achieve the most accurate measurements.

4.6.4　3D Beam Display Panel

Select the **3D Beam Display** icon (Figure 88) 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 (Figure 89).

Figure 88: 3D Beam Display Panel
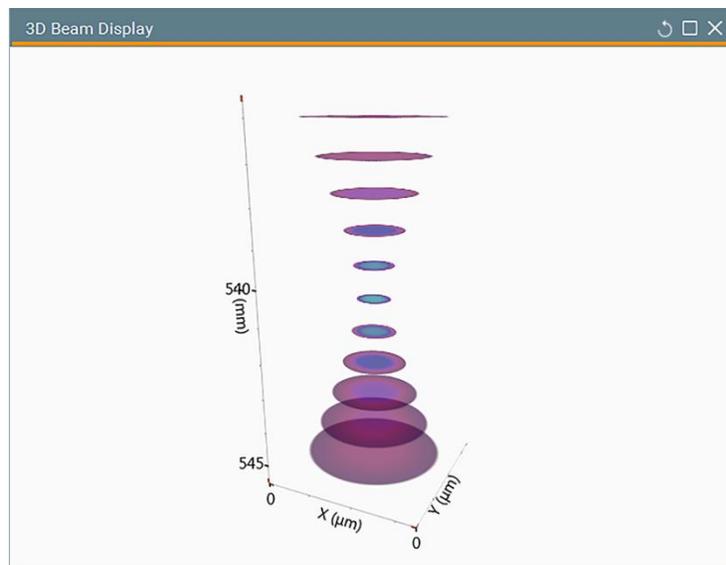
Figure 89: 3D Beam Display Window

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 (Figure 90) 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.

Figure 90: Results Panel

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

Results settings (Figure 91) are found at the top of the **Results** window and allow you to customize which results are visible. The following sections describe the settings from left to right.

Figure 91: Results Display Controls

Decimal/Scientific Notation
Opens a drop-down that allows you to set results to display in either decimal or scientific notation.

Results Selection
Select the **Results** drop-down (Figure 92) and hover over a results group to select which results are active or inactive.
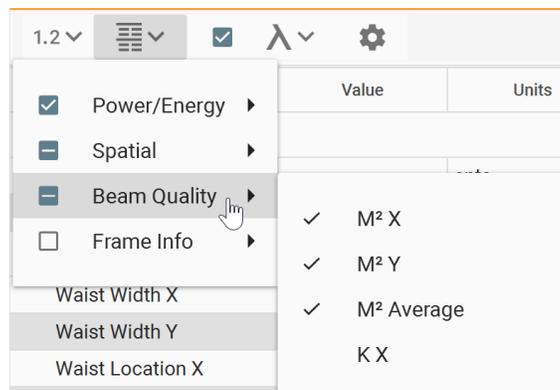
Figure 92: Results Selection Dropdown

- A blue checkbox shows that all results are enabled. Select to close all results.
- A dashed box shows that some results are enabled. Select to enable all results.
- An empty box shows that no results are enabled. Select to enable all results.

NOTE	**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.**

Results Divisions

The results items are grouped into logical divisions with self-descriptive names which aid in locating specific results (Figure 93).

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

Name	Value	Units
∨ Power/Energy		
Relative Power	30,784.920	cnts
∨ Spatial		
Waist Width Avg ISO	322.902	µm
Waist Location Avg ISO	244.616	mm
Focal Shift Avg	5,509.708	µm
Centroid X ISO	-239.277	µm
Centroid Y ISO	529.655	µm
Ellipticity ISO	0.973	
Beam Tilt X	-4.059	mrad
Beam Tilt Y	11.819	mrad
Rayleigh Length Avg ISO	17.541	mm
∨ Beam Quality		
M² Average ISO	12.188	
K Average ISO	0.082	
BPP Average ISO	4.151	mm mrad
Divergence Average ISO	51.422	mrad
＞ Frame Info		

Figure 93: Results Groups in the Results Window

Statistics Selection

Select the **Statistics** drop-down (Figure 94) to control which statistics are included in the results and how they function. Click the check box to quickly add or remove all statistics.

Figure 94: Statistics Selection Dropdown

Figure 95 shows an example with a full set of statistics enabled.

Figure 95: Results Window with All Statistics Enabled

Results Settings

Set the units of measurement for results. Select the drop-down for **Widths**, **Distances**, **Angles**, and **Power** to change each unit of measurement (Figure 96). Select **OK** to save your selections or close the window to discard changes.

Figure 96: Results Settings Window

Beam Width Basis

Select the drop-down (Figure 97) to specify the beam width method for computing results. Choose between **D4σ**,**13.5% Peak**, and **D4σ (Iterative)** methods.

Only **D4σ** and **D4σ (Iterative)** produce ISO results.

Figure 97: Beam Width Basis Selection

Results

Table 5 lists definitions of all results found within BeamWatch.

Table 5: Description of BeamWatch Results

Description of Results by Device		BeamWatch Single Axis	BeamWatch Dual Axis	Beam Watch AM
Result	**Description**			
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 Average (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	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	✓	✓	✓

Description of Results by Device		BeamWatch Single Axis	BeamWatch Dual Axis	Beam Watch AM
Result	**Description**			
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	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	✓	✓	✓

Description of Results by Device		BeamWatch Single Axis	BeamWatch Dual Axis	Beam Watch AM
Result	**Description**			
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 TEM00 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 TEM00 Gaussian beam (≥1)		✓	✓
K	A wavelength dependent measure of beam focusability compared to a TEM00 Gaussian beam (>0 and ≤1)	✓	✓	✓
K Average	The X and Y average wavelength dependent measure of beam focusability compared to a TEM00 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		✓	✓

Description of Results by Device		BeamWatch Single Axis	BeamWatch Dual Axis	Beam Watch AM
Result	**Description**			
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	The X and Y average of the far field full angle divergence of the beam	✓	✓	✓

Quick Close

To remove an 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 (Figure 98).

Figure 98: Quick Close Icon

Create Chart

Hover the mouse over a result name and select **Create Chart** (Figure 99) 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.
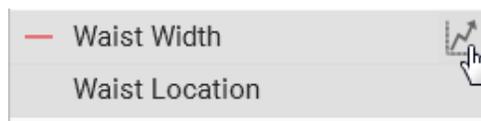

Figure 99: Create Chart Icon

4.6.6   Charts Panel

Select the **Charts** icon (Figure 100) in the **View** panel to toggle the **Charts** window. As more charts are opened, they create a tile pattern in the window. Figure 101 shows a window with four charts created.

Figure 100: Charts Panel

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**.
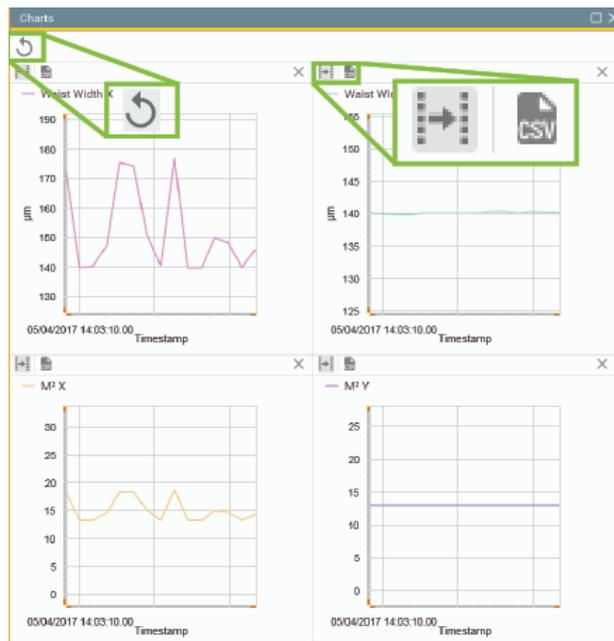
Figure 101: Charts Window

The following buttons are found in the Charts window:

- **Reset**—Select this momentary button to reset all charts at any time.
- **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.

5 Display Customization

BeamWatch allows you to create flexible display environments to meet your 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. Figure 102 shows the **2D Beam Display** window 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.
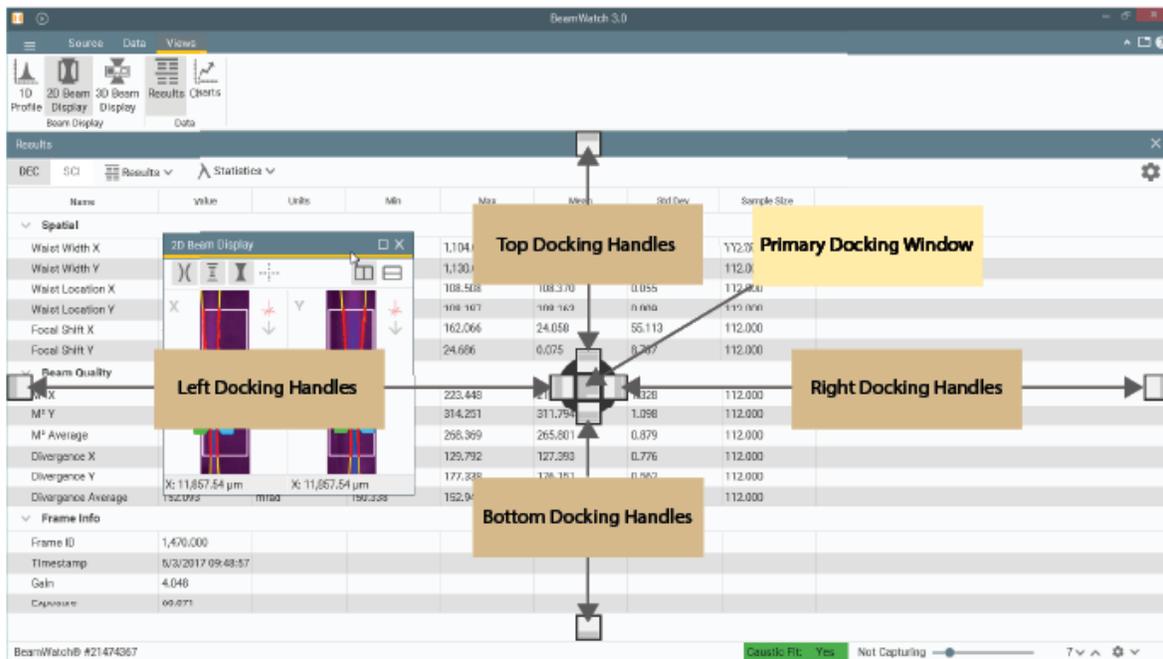

Figure 102: Docking Handles

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 placed side by side, over and under each other, and 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.

Figure 103: Example of a BeamWatch Display Across Multiple Monitors

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

6 Improving Results Accuracy

When all the quality checks are good, and all sections of the **Annunciator** in the **Status** bar are green (Figure 104), the results are within the ±5% accuracy specification.

| SNR: 120.14 | Caustic Fit | Saturation | Alignment |

Figure 104: Annunciator Showing All Green

If one of the quality checks produces questionable results, that section of the **Annunciator** turns yellow (Figure 105) and the results accuracy is degraded.

| SNR: 74.64 | Caustic Fit | Saturation | Alignment |

Figure 105: Saturation and Alignment Outside of Specified Limits

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 are 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 (Figure 106).
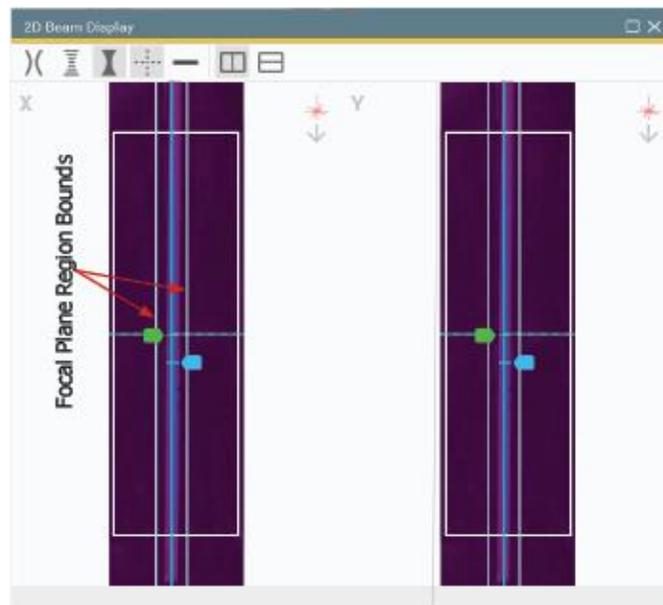

Figure 106: Beam Within the Focal Plane Region Bounds

Figure 107 shows how various degrees of misaligned beams appear on the screen.
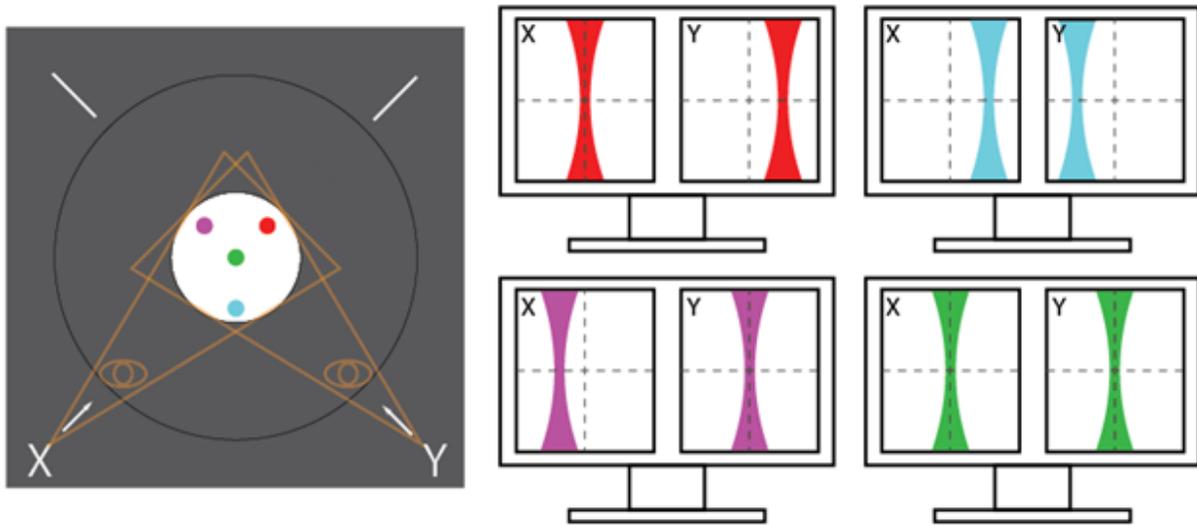
Figure 107: Example of Laser Alignment in a Dual Axis Device

- 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.

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, Ophir has learned that to design a proper automation client for products like 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 Ophir'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 Ophir'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. Ophir is dedicated to protecting 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 > 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

8 Troubleshooting

8.1 Cannot Connect to Device
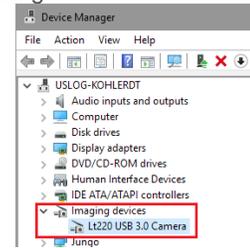
Connection Issues		
Issue	**Failure**	**Resolution**
Power Issues	The unit is not receiving power.	**BeamWatch Standard and BeamWatch Plus:** • Make sure the power cable is secure at the source and on the unit itself. **BeamWatch AM:** • Make sure the power cable is secure at the source and on the unit 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 Connect Selecting Connect is not finding the BeamWatch unit, and the icon is unchanging. No Source Connected The Status in the bottom left corner of the screen states No Source Connected.	Software is not receiving data from the unit.	**BeamWatch Standard and BeamWatch Plus:** • 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. • Make sure the Ethernet port has been properly configured (see Appendix A). **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, BeamWatch Plus, 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

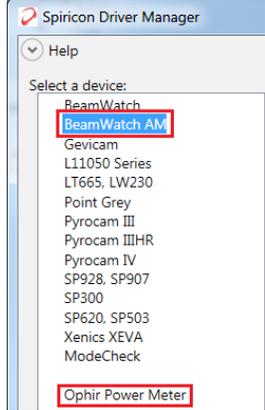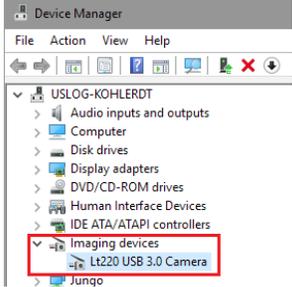| Console Service Communication		

Service Unavailable ✕
A required service is not currently available. Select enable to resolve the problem.
🛡 ENABLE   CANCEL
 	
Connection Error ✕
❗ An unknown error occurred while trying to connect.
Please contact Spiricon service with this error message:
Cannot open Spiricon Console Service service on computer 'Personal-Computer'
OK
 	
Service Unavailable ✕
❗ The required service doesn't appear to be installed. Reinstalling the application may resolve the issue.
OK
 	
Service Unavailable ✕
❗ Connection to a device failed. Restarting the computer may resolve the issue.
OK
	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

Camera Issues After Connection		
Issue	**Failure**	**Resolution**
Power Issues	The unit is not receiving power or has a weak power connection.	**BeamWatch Standard and BeamWatch Plus:** • 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

Power Meter Connection Issues		
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.

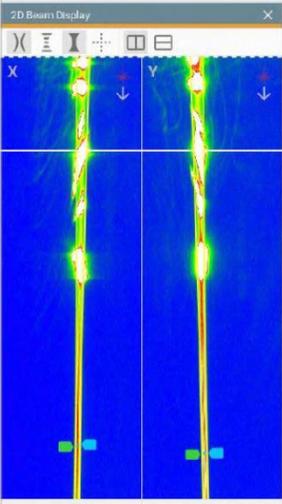|		
Driver Issues	Proper drivers may not be installed or may be corrupted.	**BeamWatch Standard, BeamWatch Plus, and BeamWatch AM:** • Open Spiricon Driver Manager and make sure BeamWatch AM and Ophir Power Meter drivers are installed. (Start > Spiricon Tools > Spiricon Driver Manager) **BeamWatch AM:** • 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
Firmware Issues	A compatibility issue between different versions of software and drivers.	• Verify power meter works in StarLab (see section 8.9).
Firewall Issues	Firewall settings may be blocking the EA-1 connection	• Verify the Firewall and Ethernet port have been properly configured (see Appendix A).

8.4   BeamWatch AM Shutter will not Open

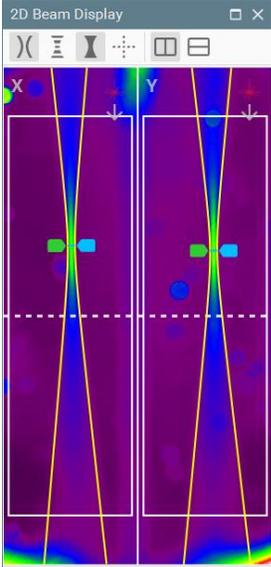| BeamWatch AM Shutter Issues		
Issue	**Failure**	**Resolution**
Power Issues	The unit is not receiving power or has a weak power connection.	• Make sure the power LED on the top of the unit is green. • Make sure the power cable is secure at the source and on the unit itself. • Verify the power indicator 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

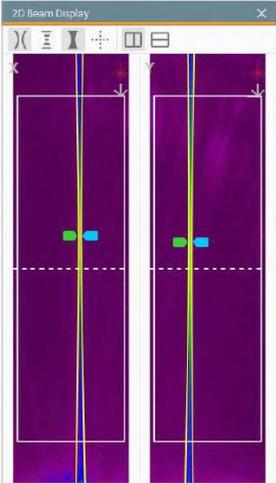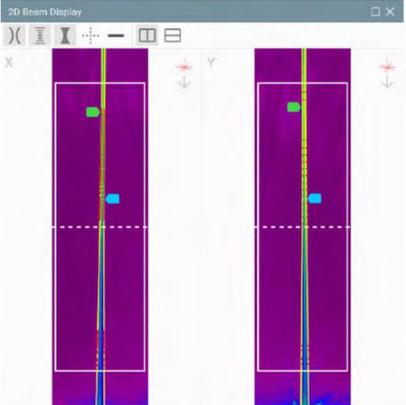| BeamWatch AM Fan Issues		
Issue	**Failure**	**Resolution**
Power Issues	The unit is not receiving power or has a weak power connection.	• Make sure the power LED on the top of the unit is green. • Make sure the power cable is secure at the source and on the unit itself. • Verify the power indicator 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).

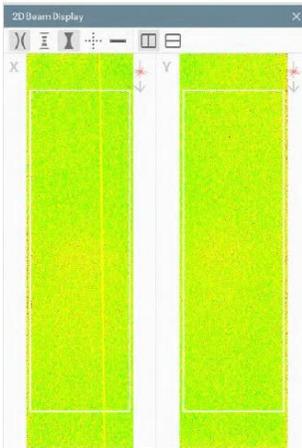## 8.6 BeamWatch Standard Image Display Issues

BeamWatch Standard Image 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 Customer Service to determine if the system should be returned to the factory.

8.7 BeamWatch AM Image Display Issues

BeamWatch AM Image Issues		
Issue	**Failure**	**Resolution**
Excessive Background Illumination 	A dirty turning mirror can cause spurious reflections.	• Remove and clean the mirror (See 3.1.1 in the BeamWatch AM User Notes). • 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 Issues

Data Corruption Issues		
Issue	**Failure**	**Resolution**
M^2 Values less than 1.0	An incorrect wavelength was entered in the Laser Panel. An incompatible beam width basis was selected. Critical information stored in the non-volatile memory of the camera may have become corrupted.	• Enter the correct wavelength in the Laser Panel. • Select a different beam width basis. • Contact Ophir 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 below (Figure 108).

Figure 108: StarLab Device Selection with No Errors

3. If the status of the device shows an error, select More from the top right side of the screen (Figure 109).

4. Select **Upgrade** from the Diagnostics window.

Figure 109: StarLab Device Selection with Error (left); Upgrading (Right)

5. Leave the Select File path as it is and select **Start** and allow the Upgrade to install (Figure 110).
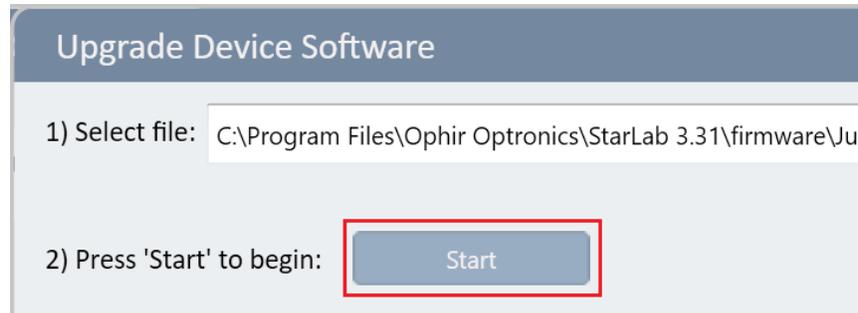
Figure 110: Upgrade Device Software Window

6. Either leave StarLab installed or remove and install BeamWatch AM power meter drivers in driver manager.

NOTE   **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 (known as Link Local Addressing). In many Gigabit Ethernet network configurations this is sufficient to provide full functionality of the GigEVision camera. 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 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 static IP address (also "fixed" or "persistent")
- 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 Static IP Address

To assign a static 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 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.
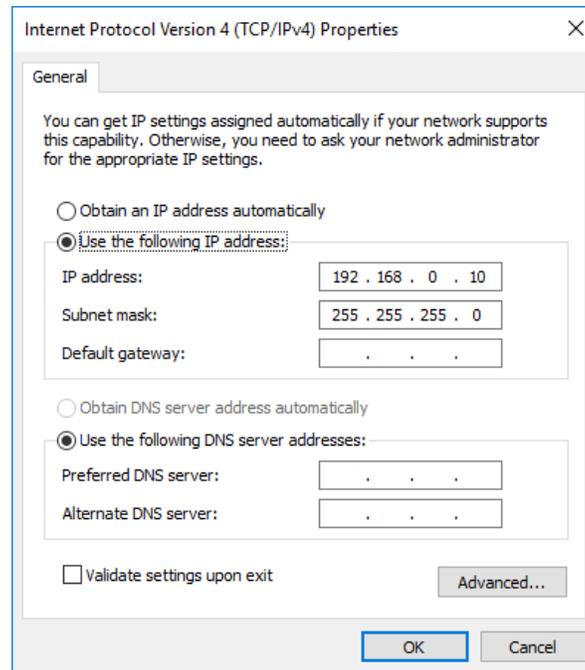7. Click **OK** to confirm your changes (Figure 111).

Figure 111: Setting a Static IP Address

Additional Static 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 LLA or 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 static IP addresses will cause communication failures.

A.1.2   Automatic Assignment via DHCP or LLA

With the default settings, a network adapter will use automatic IP addressing to assign itself an IP address.

When the network adapter is configured to receive its IP address via DHCP or LLA addressing, it operates as follows:

- The network 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 a built-in 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

In most cases, the adapter used with the BeamWatch will not have a DHCP server available.

To assign an IP address using DHCP/LLA:

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.
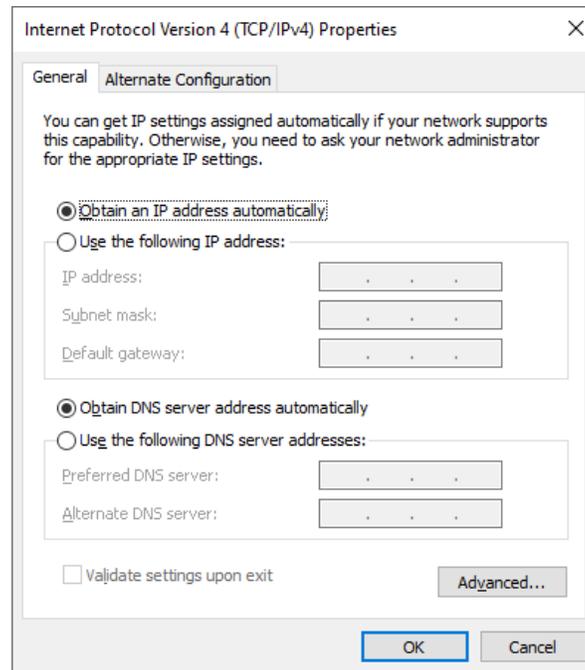
Figure 112: Setting Automatic Assignment for IP Address

5. Click the **Alternate Configuration** tab. The settings on this tab are applied when moving between two networks and allow a second configuration. This is unneeded in most BeamWatch applications.
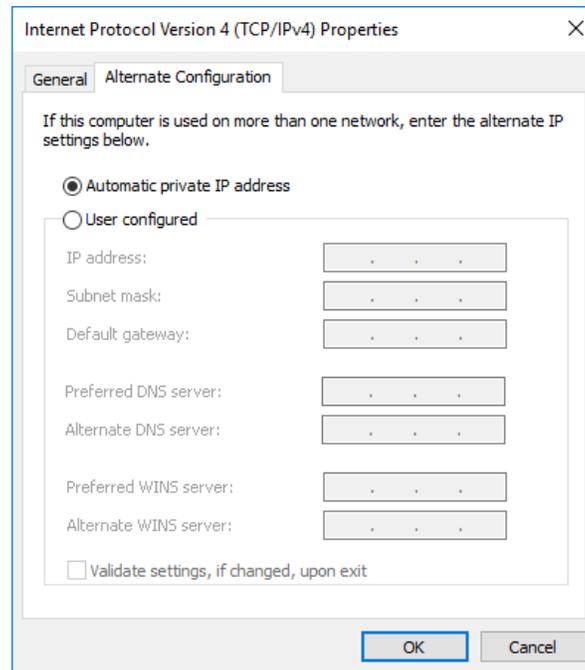6. Make sure that **Automatic private IP address** is selected.

Figure 113: Automatic Private IP Address

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

Filter drivers are normally applied to all installed network adapters, but do not need to be active unless the adapter is used for that type of device. Generally, there is no adverse effect of having filter drivers installed and unused on an adapter. However, 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)** (Figure 114).
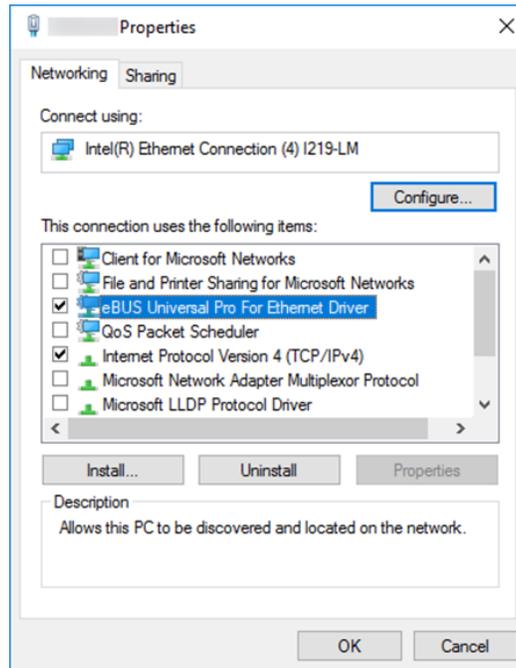

Figure 114: Changing Network Adapter Connections

4. Repeat steps 2 and 3 for all applicable network adapters that will support a BeamWatch device.

A.2.2   Changing the Network Adapter Properties in Windows

We recommend optimizing the adapter properties for GigEVision use for all network adapters used with BeamWatch devices. In some hardware configurations the features, names, and values available may be different. Configure the following settings below to their most equivalent setting available on the network adapter in use. Missing features may indicate that the network adapter is not compatible 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 notes below):

a. Set the **Jumbo Frames/Packets** 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** or **Receive Buffers**) and set it to the maximum value.

c. Select **Interrupt Moderation** and set the value to **Enabled**.

d. Select the parameter that relates to the interrupt moderation rate or number of CPU interrupts (e.g., **Interrupt Moderation Rate**) and set it to the Extreme value (e.g., 3600). The way to set the number of CPU interrupts may differ for the network adapter.

e. 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 that will support a BeamWatch device.

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** (Figure 115).

Figure 115: eBUS Player Application

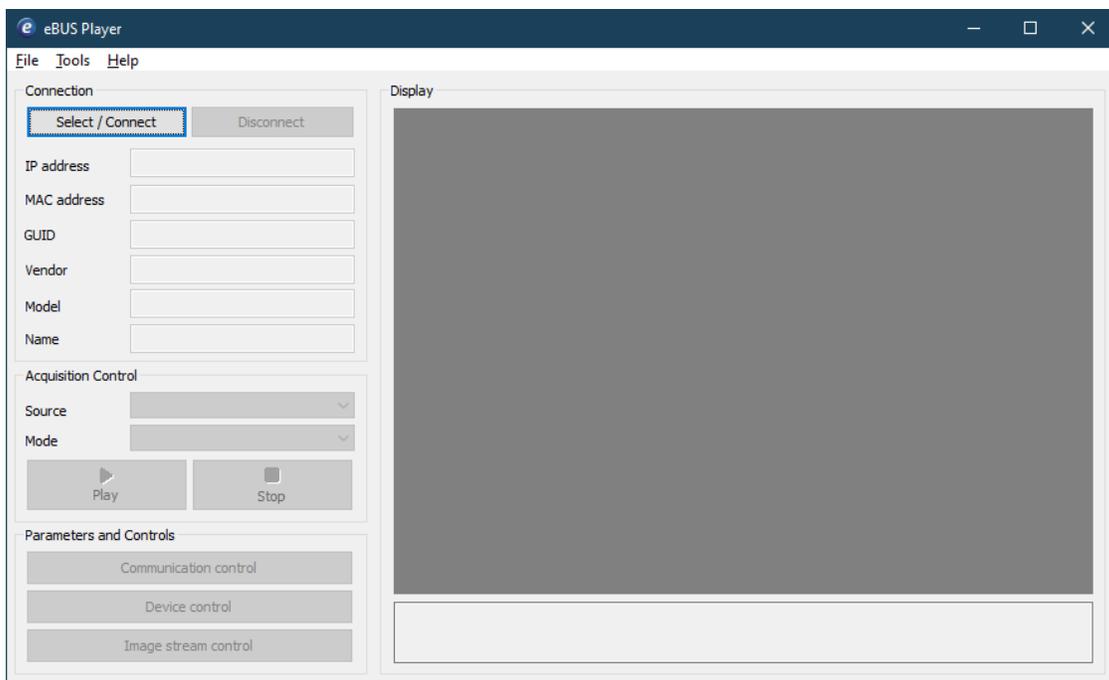2. The **eBUS Player** opens an empty viewer with disabled controls (Figure 116).

Figure 116: eBUS Player Before Device Connection

Selecting the Camera

1. Press **Select/Connect**.
2. The **Device Selection** dialog displays (Figure 117).
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.
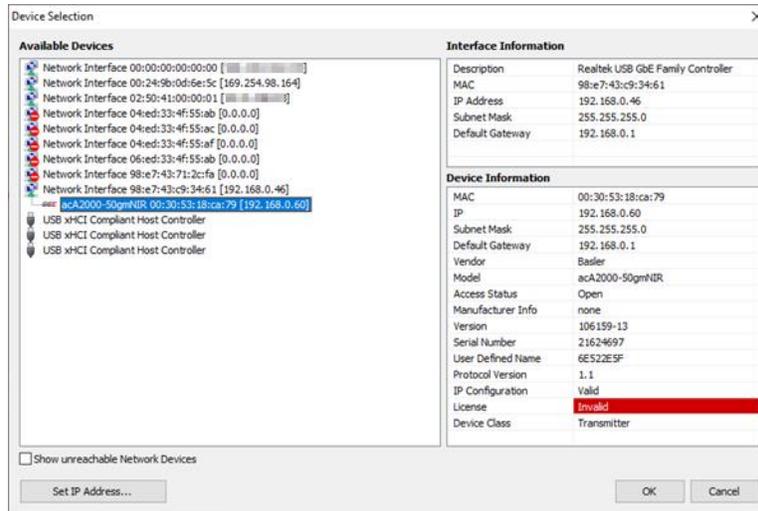
Figure 117: Selecting a Device in eBUS Player

4. If the camera for the BeamWatch is found, click the **acA2000-50gm…** 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 displays. The IP Configuration property on the right pane will be red and display **Invalid on this interface** (Figure 118).
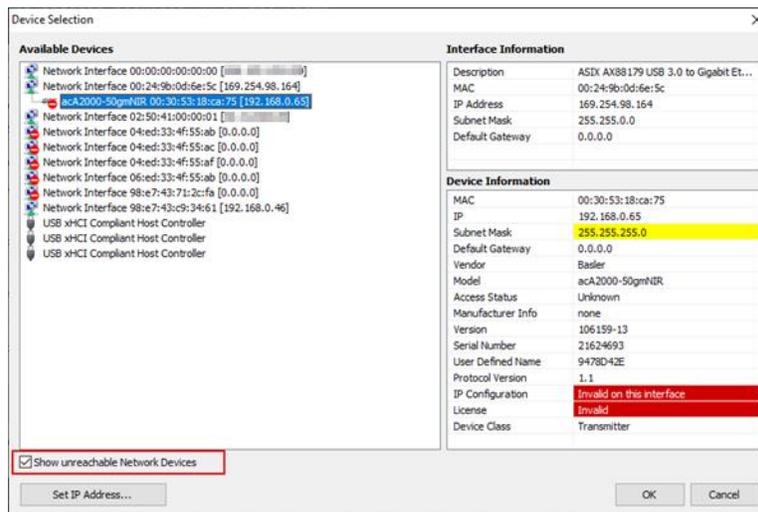
Figure 118: Show Unreachable Network Devices

    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 (Figure 119).

Figure 119: Set IP Address Window

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 **acA2000-50gm…** entry and click **OK**.
j. If the camera still cannot be found, contact the Ophir Service department.

Device Control Properties
Once a camera with a valid IP configuration has been selected, the eBus Player viewer will connect to the camera (Figure 120).
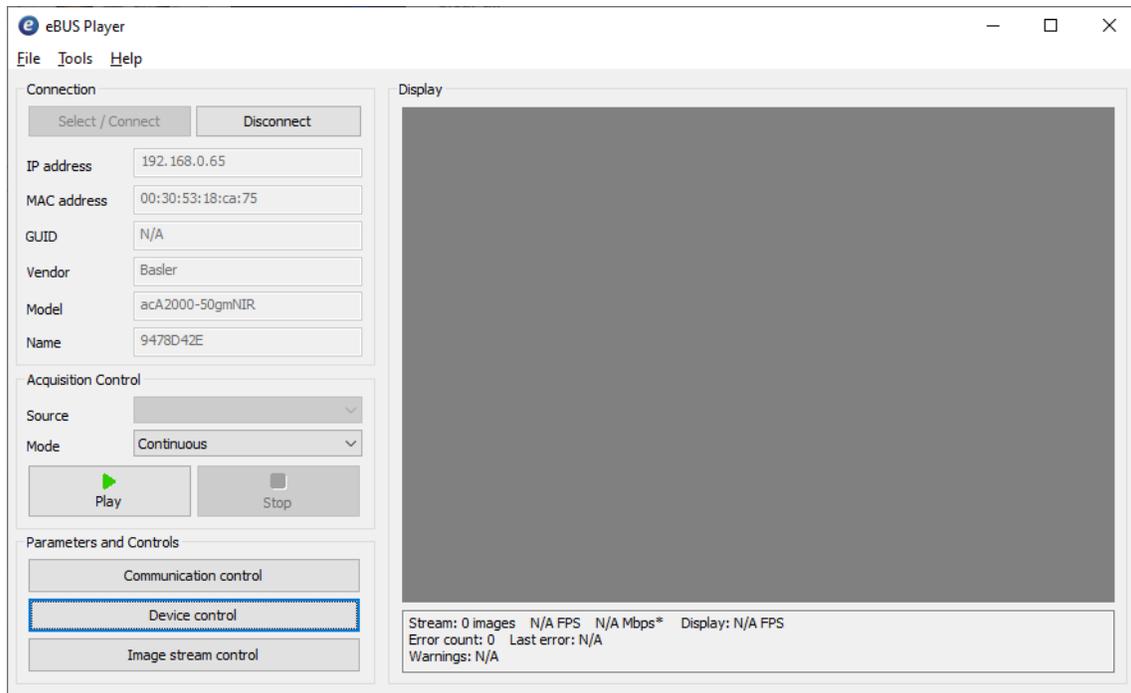
Figure 120: eBUS Player After Device Connection

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 (Figure 121). This is the first of the IP configuration properties that will be used.
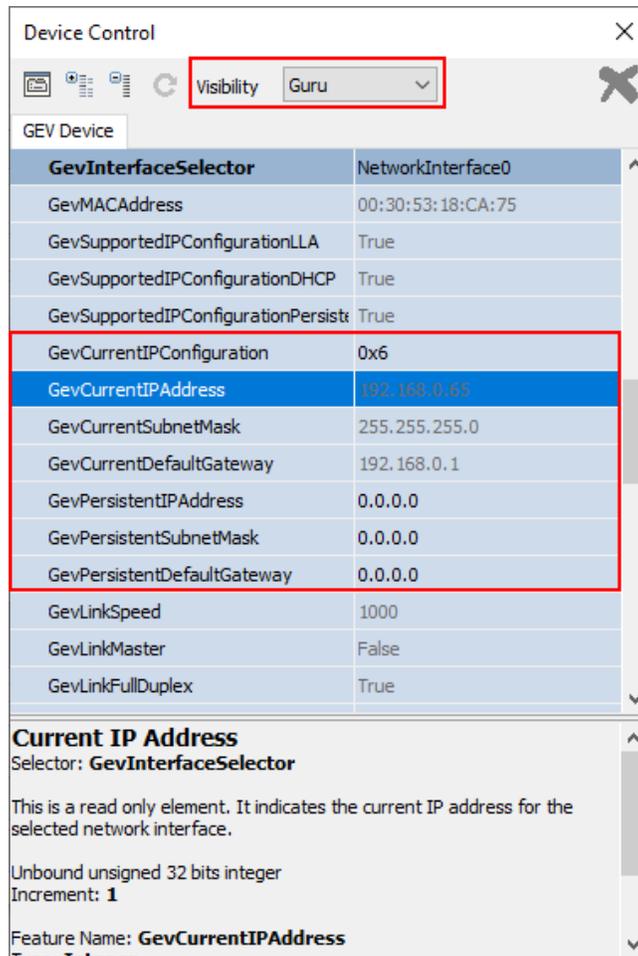
Figure 121: Device Control Window

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.

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

Table 6: IP Configuration Settings

Configuring the Persistent (Static), LLA, or DHCP IP Address Modes
To change the IP configuration of the camera:

1. Set the **GevCurrentIPConfiguration** (Figure 122Error! Reference source not found.)
    a. For a Persistent or Static address, set to **0x5**.
    b. For and Auto IP (LLA) address, set to **0x4**.
    c. For a DHCP address, set to **0x6**.

GevCurrentIPConfiguration	0x5
GevCurrentIPAddress	169.254.10.10
GevCurrentSubnetMask	255.255.0.0
GevCurrentDefaultGateway	0.0.0.0
GevPersistentIPAddress	192.168.100.105
GevPersistentSubnetMask	255.255.255.0
GevPersistentDefaultGateway	0.0.0.0

Figure 122: GevCurrentIPConfiguration for a Static IP

NOTE

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.**
- **Recommended range for static IP addresses are:**
    - **172.16.0.1 to 172.32.255.254**
    - **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.

2. If configuring a Persistent IP address, set the desired values for the following fields:
   a. **GevPersistentIPAddress**
   b. **GevPersistentSubnetMask**
   c. **GevPersistentGateway**

If configuring DHCP or LLA addresses it is recommended to clear the three persistent IP values to 0.0.0.0 for clarity, but it is not necessary to do so.

The eBUS Player will automatically save changes as they are made.

3. Close the **Device Control** dialog and press the **Disconnect** button.
4. To verify the IP Address change, power-cycle the BeamWatch system and reconnect.

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 Firewall Controls on the Network Adapter

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.

CAUTION	**Care must be taken with this solution to use physical and administrative controls 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.**

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.*

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 (Figure 123).
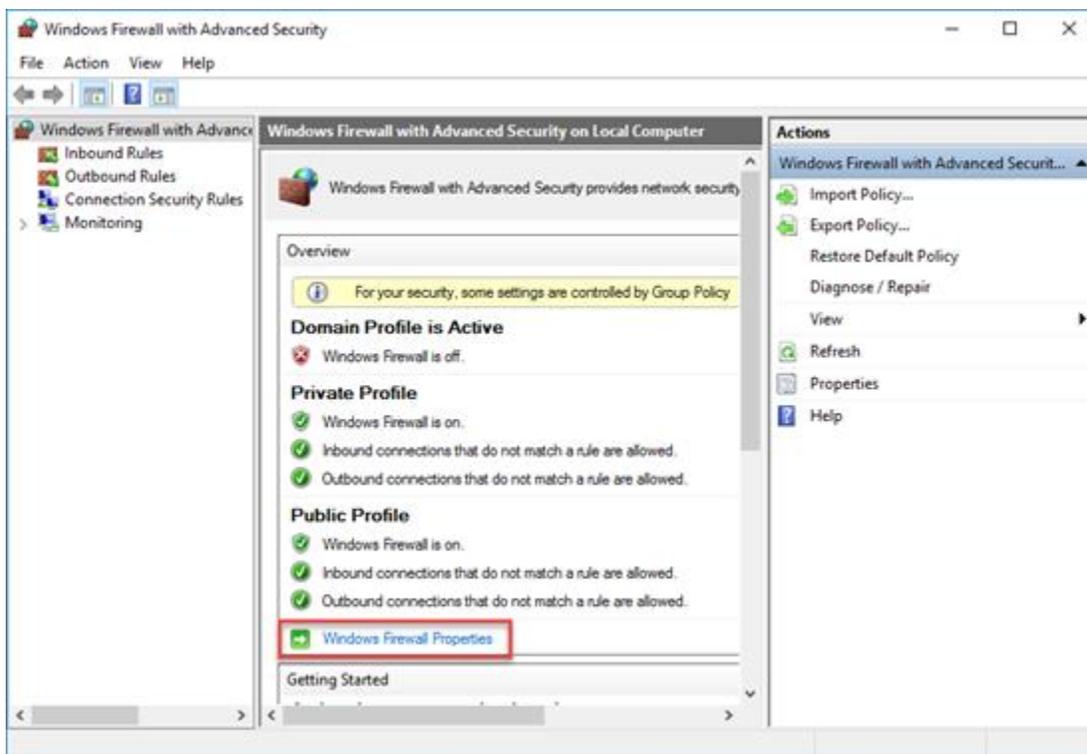

Figure 123: Windows Firewall with Advanced Security

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 Figure 124 and Figure 125).
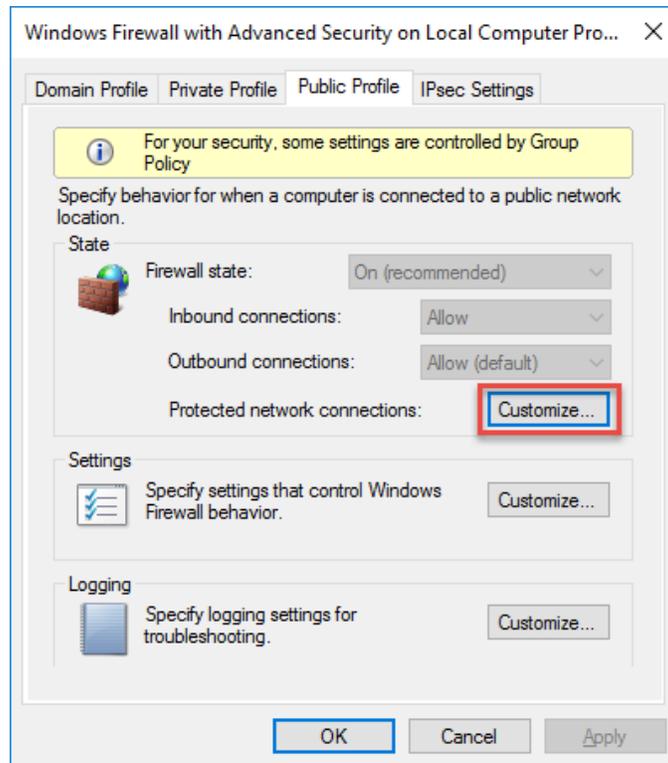
Figure 124: Windows Firewall Properties
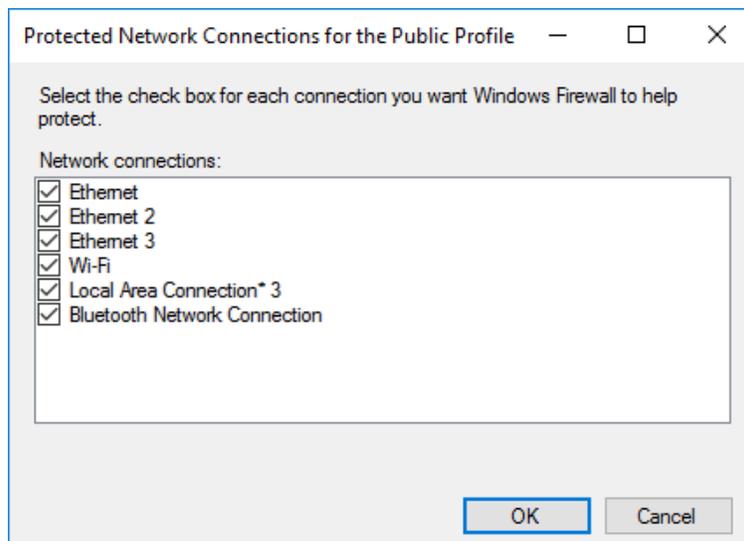
Figure 125: Protected Network Connections

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.

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.

CAUTION	**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** (Figure 126).
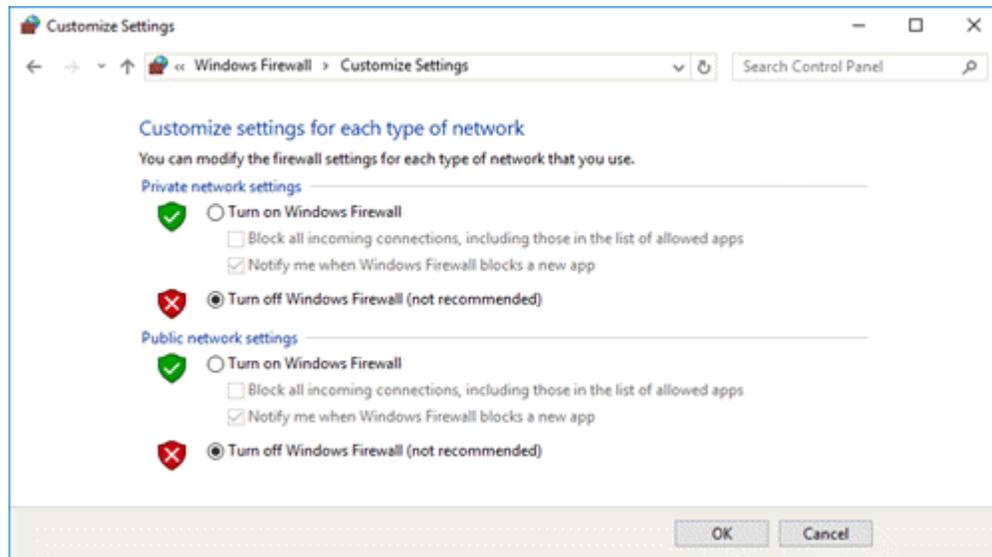5.   Click **OK** to save changes.

Figure 126: Windows Firewall Disabled

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.*

CAUTION	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 (Figure 127).
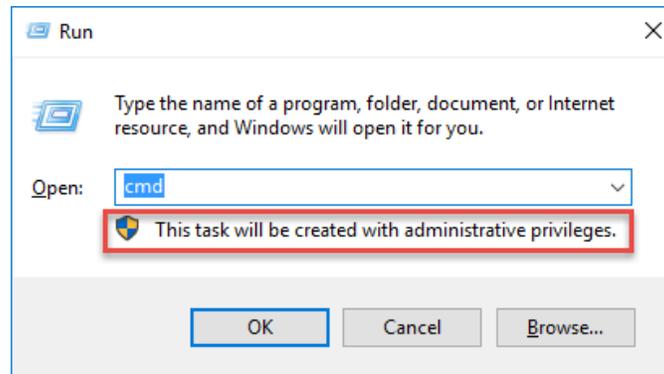
Figure 127: Run Window with Administrative Privileges

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 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 may be necessary for the following processes 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 (Figure 128). 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**.
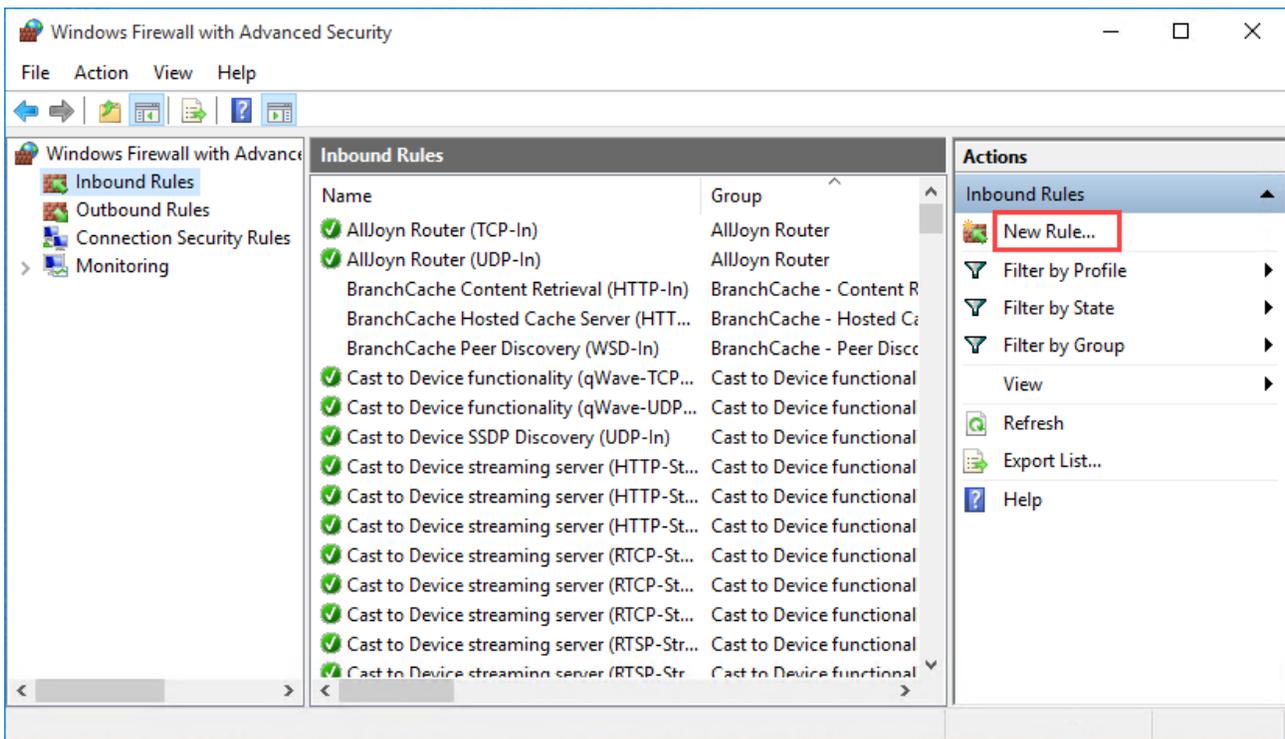
Figure 128: Creating a New Inbound Rule

4. On the **Rule Type** page, select **Program** (Figure 129).
5. On the Program page, select **This program path**.
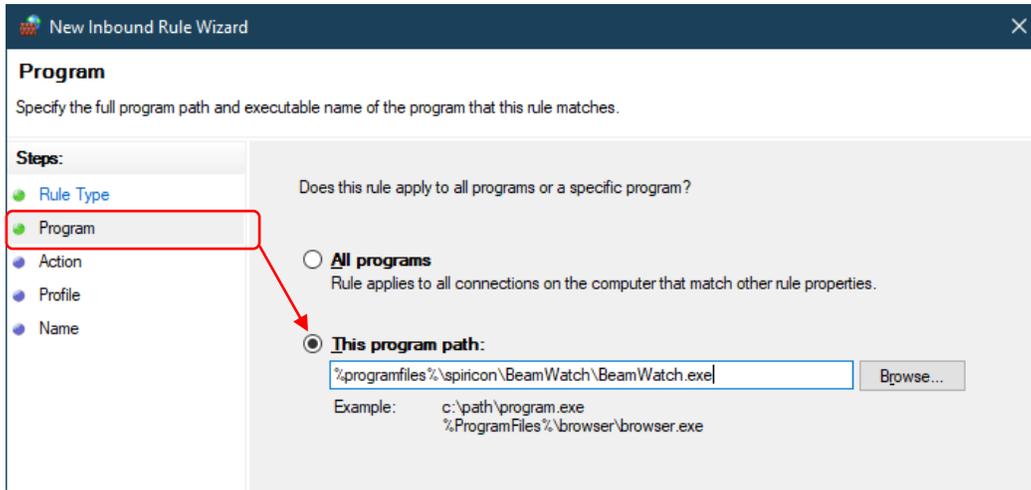
Figure 129: New Inbound Rule Program Page

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** (Figure 130).
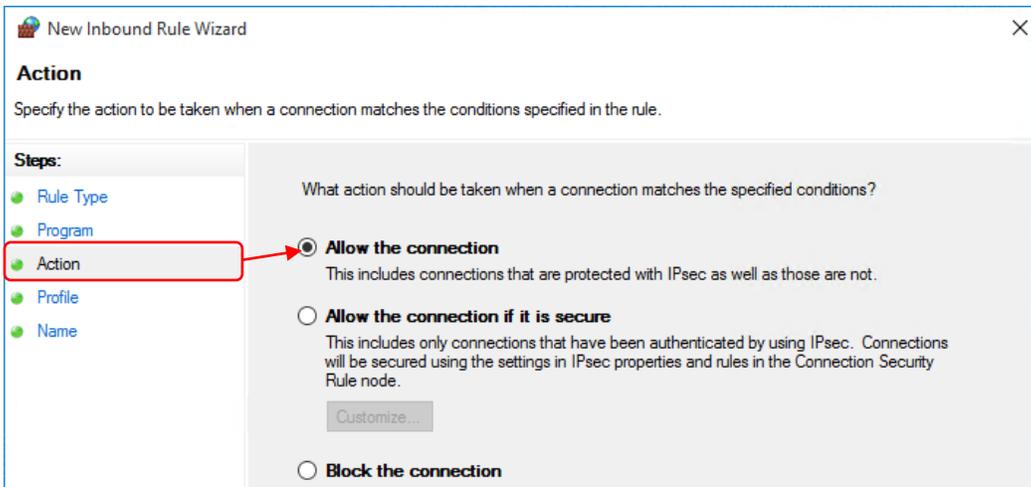
Figure 130: New Inbound Rule Action Page

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 (Figure 131).
    - Setting all three options is safe as the non-volatile storage in the BeamWatch cameras does not carry viruses.
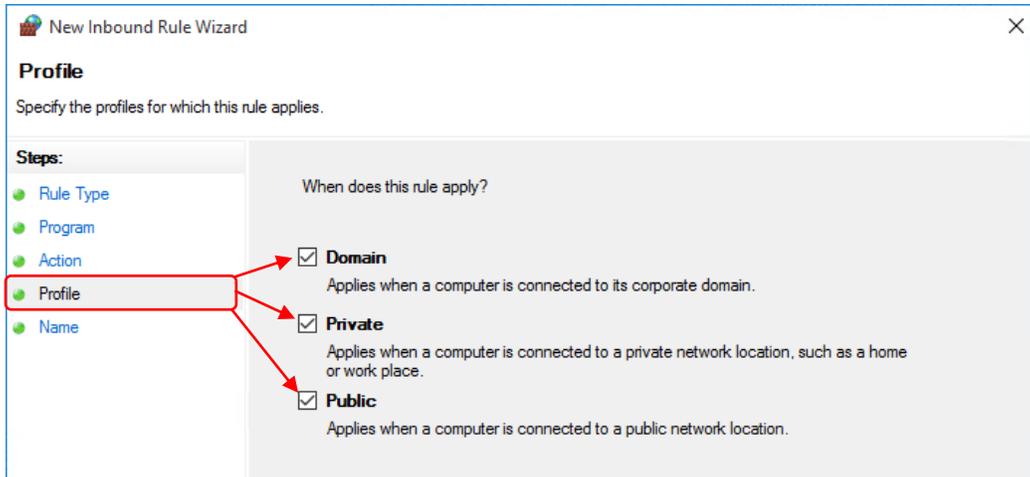
Figure 131: New Inbound Rule Profile Page

11. Click **Next**.
12. On the **Name** page, enter a name for the rule and, if required, a description (Figure 132).
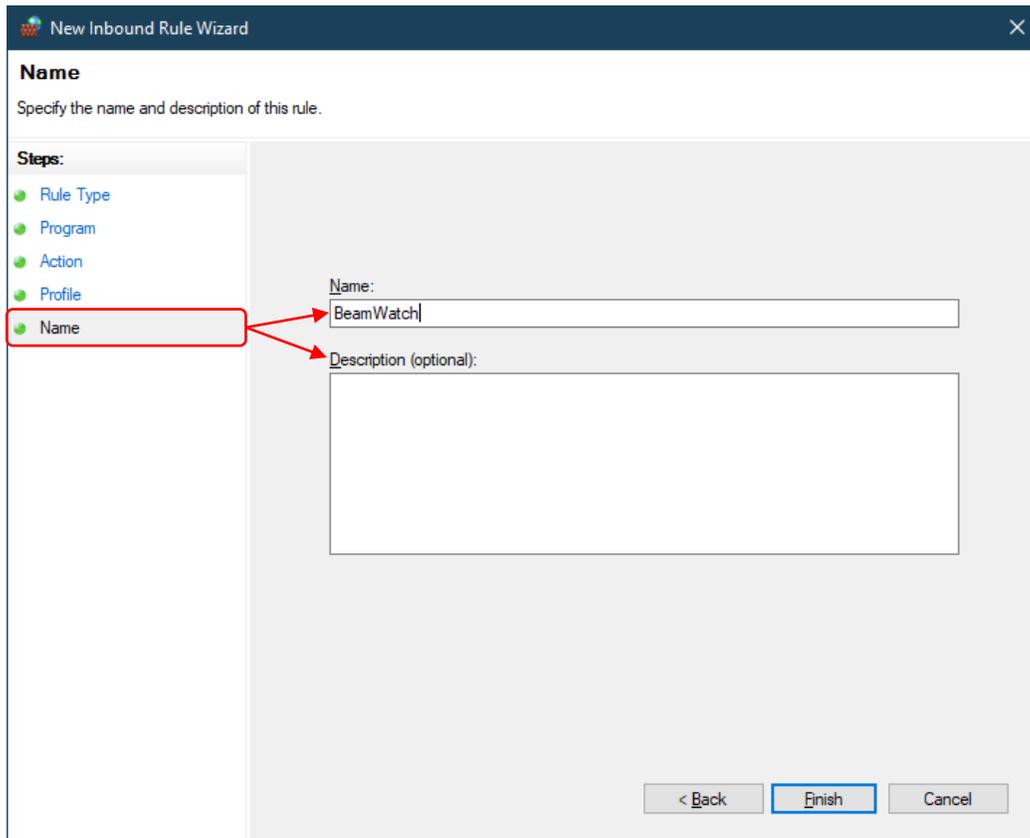
Figure 132: New Inbound Rule Name Page

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 (Figure 133). 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**.
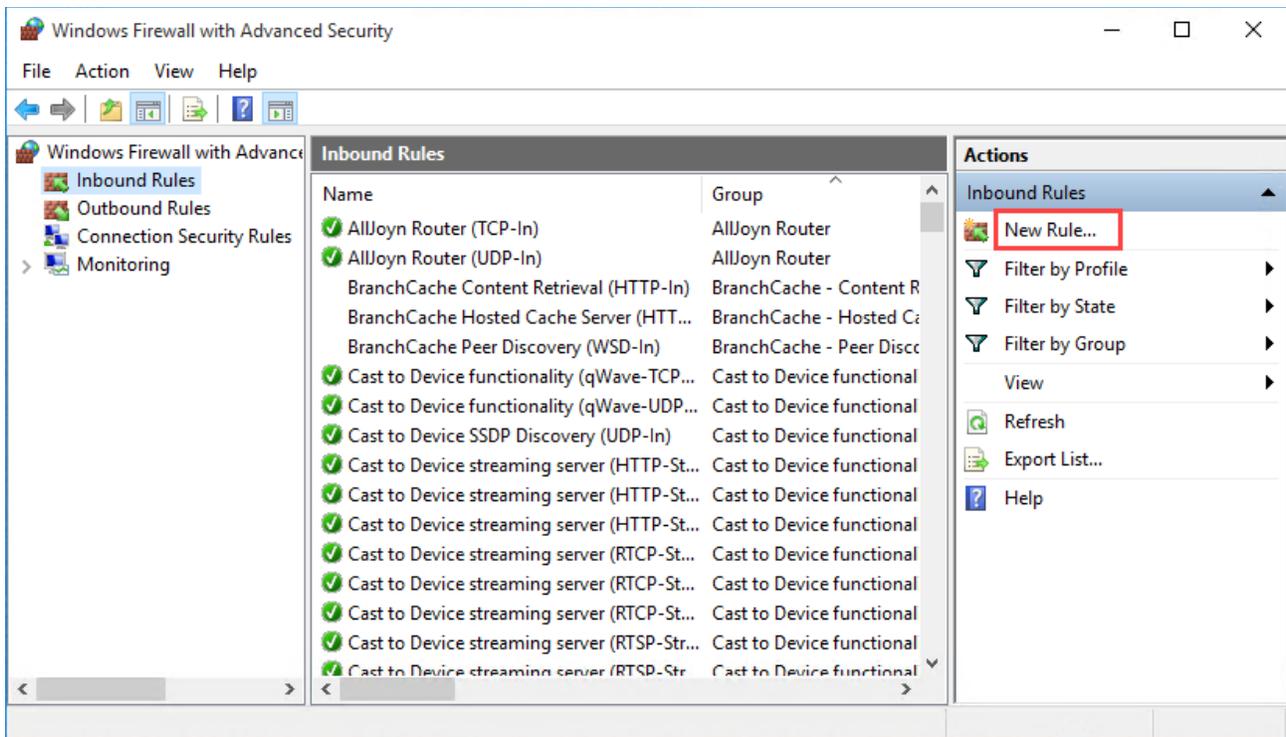
Figure 133: Creating a New Inbound Rule

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 table below (Table 7).
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.

Protocols and Ports Suggested Rules
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**

Table 7: Protocols and Ports Suggested Rules

Notes:

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