

USBeamPro

Model 2323

Laser Beam Profiler



Installation and Operation Manual

Serial # _____

Date _____

Photon Inc.

6878 Santa Teresa Blvd.
San Jose, CA 95119-1205

800.374.6866

www.photon-inc.com

Copyright

COPYRIGHT ©2007 BY PHOTON INC. ALL RIGHTS RESERVED.

The code and other methods used are uniquely **Photon's**. Code found in another program that follows our outlined procedures could be in violation of the **Photon Inc.** copyright.

Reproduction or use of any portion of this manual is prohibited without expressed written permission from **Photon Inc.** Reasonable efforts have been taken in the preparation of this manual to ensure its accuracy. However, **Photon Inc.** assumes no liability resulting from any errors or omissions in this manual or from the use of the information obtained herein.

Software License

The USBeamPro Acquisition and Analysis Software™ provided is protected by United States Copyright Law and International Treaty provisions.

Trademarks

The USBeamPro™ and USBeamPro Acquisition and Analysis Software™ are trademarks of **Photon Inc.**

MS Windows® is a registered trademark of Microsoft Corporation.

Table of Contents

1.	Introduction	1.1
1.1.	System Overview	1.1
1.1.1.	USBeamPro Model 2323	1.1
1.1.2.	USBeamPro Acquisition and Analysis Software	1.1
1.2.	Model 2323 Camera Specifications.....	1.3
	Warranty Information.....	1.4
2.	System Inspection	2.1
2.1.	Inspection.....	2.1
2.2.	USBeamPro System Packing List.....	2.1
3.	System Setup	3.1
3.1.	Personal Computer Requirements	3.1
3.2.	Setup for Microsoft Windows Vista Business (32-bit edition)	3.1
3.2.1.	2323 USBeamPro Camera	3.1
3.2.2.	USBeamPro Acquisition and Analysis Software	3.2
3.3.2.1.	Installation	3.2
3.3.2.2.	Uninstallation	3.3
3.3.	Setup for Microsoft Windows XP Professional (32-bit edition)	3.3
3.3.1.	2323 USBeamPro Camera	3.3
3.3.2.	USBeamPro Acquisition and Analysis Software	3.4
3.3.2.3.	Installation	3.4
3.3.2.4.	Uninstallation	3.4
3.4.	Setup for Microsoft Windows 2000 Professional	3.4
3.4.1.	2323 USBeamPro Camera	3.4
3.4.2.	USBeamPro Acquisition and Analysis Software	3.5
3.3.2.5.	Installation	3.5
3.3.2.6.	Uninstallation	3.5

4.	Acquisition and Analysis Software	4.1
4.1.	Quick Start	4.1
4.1.1.	Starting the Program	4.1
4.1.2.	Position the Laser Beam in the Aperture.....	4.3
4.1.3.	Trigger Mode for Pulsed Lasers	4.3
4.1.4.	Calibrate the System.....	4.4
4.1.5.	Switch to Analysis Mode	4.5
4.1.6.	Beam Parameters - Computation and Display	4.5
4.1.6.1.	Computation of Parameters	4.5
4.1.6.2.	Beam Area	4.5
4.1.6.3.	Acquisition Resolution.....	4.5
4.1.6.4.	Magnification Factor	4.6
4.1.6.5.	Displaying Parameters.....	4.6
4.2.	Advanced Use.....	4.6
4.3.	Operating Hints	4.7
4.4.	Program Menus	4.9
4.4.1.	File Menu	4.9
4.4.2.	Edit Menu.....	4.12
4.4.3.	View Menu	4.13
4.4.4.	Options Menu.....	4.13
4.4.5.	Data Collection Menu.....	4.14
4.4.6.	Window Menu	4.22
4.4.7.	Help Menu.....	4.23
4.5.	Window Descriptions.....	4.24
4.5.1.	Profile.....	4.24
4.5.2.	Video.....	4.26
4.5.3.	3D Profile	4.32
4.5.4.	2D Contour.....	4.36
4.5.5.	Beam Statistics	4.40
4.5.6.	Time Statistics.....	4.45
4.5.7.	Pointing.....	4.48
4.5.8.	Notes.....	4.50
4.5.9.	K-Factor (M2 Wizard).....	4.51
4.5.9.1.	Measuring the K-Factor.....	4.52

4.5.9.2.	Lens Selection and the Expected Rayleigh Length	4.52
4.5.9.3.	Alignment	4.54
4.5.9.4.	Insert the lens	4.54
4.5.9.5.	Rayleigh Test Fixture Accessory.....	4.55
4.5.9.6.	Dual Axis Measurements with Astigmatism	4.55
4.6.	Toolbars	4.56
4.6.1.	The Main Toolbar	4.57
4.6.2.	The Video Window Toolbar	4.58
4.6.3.	The Profile Window Toolbar	4.58
4.6.4.	The Beam Statistics Window Toolbar	4.59
4.6.5.	The Time Statistics Window Toolbar	4.59
4.7.	Status Bar	4.59
4.8.	ActiveX Automation.....	4.60
4.8.1.	AcquisitionMode.....	4.60
4.8.2.	TriggerMode.....	4.61
4.8.3.	AcquisitionResolution.....	4.61
4.8.4.	GlobalDataCollection	4.61
4.8.5.	AutoTracking	4.61
4.8.6.	MagnificationFactor	4.62
4.8.7.	AngleUnits.....	4.62
4.8.8.	ISOWidthMethod.....	4.62
4.8.9.	UseCliplevel	4.63
4.8.10.	GetWidth	4.63
4.8.11.	GetPeakPosition	4.64
4.8.12.	GetCenter	4.64
4.8.13.	GetPeakIrradiance	4.64
4.8.14.	EllipticAnalysis	4.64
4.8.15.	GetRotationAngle.....	4.65
4.8.16.	GetEllipticity	4.65
4.8.17.	GetEccentricity.....	4.65
4.8.18.	FlatTopAnalysis	4.66
4.8.19.	FlatTopThreshold	4.66
4.8.20.	GetFlatTopMin	4.66
4.8.21.	GetFlatTopMax	4.66

4.8.22.	GetFlatTopMean	4.67
4.8.23.	GetFlatTopFlatness.....	4.67
4.8.24.	GetFlatTopUniformity	4.67
4.8.25.	GetFlatTopEnergy.....	4.68
4.8.26.	GaussianFitAnalysis.....	4.68
4.8.27.	Get1dGaussianFit	4.68
4.8.28.	BackgroundCorrection	4.69
4.8.29.	SetDivergenceMethod.....	4.69
4.8.30.	GetDivergenceMethod	4.70
4.8.31.	GetDivergence	4.70
4.8.32.	GetProfileData	4.71
4.8.33.	GetProfileSampleSize	4.71
4.8.34.	GetProfileNumPts	4.72
4.8.35.	GetSampleSize	4.72
4.8.36.	GetNumPts	4.72
4.8.37.	GetTotalSize	4.73
4.8.38.	GetStartPos	4.73
4.8.39.	ImageRotation.....	4.73
4.8.40.	ImageFlip	4.74
4.8.41.	DoCalibration	4.74
4.8.42.	IsCalibrated	4.74
4.8.43.	SetBeamArea.....	4.75
4.8.44.	GetBeamArea	4.75
4.8.45.	ComputationsDone	4.75
4.8.46.	Recompute.....	4.76
4.8.47.	GetTotalEnergy.....	4.76
4.8.48.	IsSaturated.....	4.76
4.8.49.	ShowWindow	4.76
4.8.50.	ProfileType.....	4.77
4.8.51.	Get2DData	4.77
4.8.52.	CameraExposure	4.78
4.8.53.	Averaging.....	4.78
4.8.54.	ProfileCrossHairsType	4.78
4.8.55.	SetProfileCrossHairsPos.....	4.79

4.8.56. GetProfileCrossHairsPos4.79

4.8.57. SaveFrameAsTIFF4.79

4.8.58. GetCameraList.....4.80

4.8.59. SelectCamera4.80

4.8.60. Example files.....4.80

5. Frequently Asked Questions (FAQs)

1. *INTRODUCTION*

1.1. System Overview

1.1.1. USBeamPro Model 2323

The Model 2323 USBeamPro system is a PC based optical beam profiling system offering a unique combination of performance and ease of use. Highly accurate measurements can be made on both pulsed and CW lasers, over a wide range of wavelengths, beam diameters, and power/energy levels. Sophisticated, yet simple, Microsoft Windows-based software allows these results to be displayed, analyzed and/or archived in real time at video rates.

The USBeamPro Model 2323 includes the USB2.0 CMOS Camera and the Acquisition and Analysis Software.

1.1.2. USBeamPro Acquisition and Analysis Software

The USBeamPro Software is written for Microsoft Windows XP Professional (32-bit), Microsoft Windows Vista Business (32-bit) or Microsoft Windows 2000 Professional and takes full advantage of the menu driven, multi-windowing environment.

Windows available for data display include:

- | | |
|--------------------------------|---|
| ◆ Video window | Displays live video images; |
| ◆ Dual Aperture Profile window | Displays pinhole or slit profiles; |
| ◆ Beam Statistics window | Displays computed beam parameter values and statistics; |
| ◆ 3D Profile View windows | Displays 3-dimensional representations of beam intensity; |
| ◆ 2D Contour View windows | Displays 2-dimensional contours of the beam intensity; |

- | | | |
|---|------------------------------------|---|
| ◆ | Time Statistics windows (up to 15) | Displays strip chart graphs of selected beam parameters; |
| ◆ | Pointing window | Displays a target screen for observing beam pointing and divergence; |
| ◆ | K-Factor (M^2) window | An interactive K-Factor Wizard program for measuring K-factor (M^2) by the Rayleigh Method; |
| ◆ | Notes window | A simple text editor for entering user annotations; |

The software also performs rigorous data analysis over specific regions-of-interest (ROIs) in accordance with the ISO standards. The ROIs can be either system or user defined. Quantitative measurement of numerous beam spatial characteristics is possible. Pass/Fail limit analysis for each of these parameters can be also applied.

Parameters measured include:

- ◆ Beam width
- ◆ Centroid and peak location
- ◆ Major and minor axes
- ◆ Beam orientation
- ◆ Ellipticity, eccentricity
- ◆ Gaussian fit
- ◆ Beam uniformity
- ◆ Beam divergence
- ◆ Pointing stability
- ◆ M^2 , K-factor

For data visualization, the user can arrange and size multiple windows as required. These may contain, for example, live video, calculated beam parameters and summary statistics in the form of graphs, tables, 3D views and strip chart time displays. These user instrument views can be saved as files for future use.

Data can be exported to spreadsheets, math and statistical analysis programs and process/instrumentation control programs by logging to files or COM ports, or by sharing using ActiveX Automation.

Live video of both pulsed and CW laser beams can be viewed in false color or gray scale. False color options include rainbow and four monochrome colors. This allows the user to choose a display color that can be seen clearly while wearing laser goggles. Beam profiles through the centroid, the peak or user defined points can be displayed. Profile orientation can be either in the horizontal and vertical axes or along the major and minor axes of elliptical beams.

Hardware and software installation instructions, the features of the software, operating hints and answers to frequently asked questions are presented in this operating manual. In addition, you can refer to the extensive on-line **Help** menu of the BeamPro Analysis Software program for this information.

Finally, to take full advantage of the features of the software, it is assumed that users have a working knowledge of the Windows operating systems and are familiar with basic Windows features such as opening, closing and saving files, making menu selections, opening, arranging, and resizing windows, etc. If these procedures are not familiar, see the Windows online **Help**, accessed by clicking on the **Start** button and selecting **Help**, or refer to numerous available Microsoft Windows manuals and tutorials.

1.2. Model 2323 Camera Specifications

◆ Interface:	USB 2.0
◆ USB Connector:	USB mini-B 5 pin
◆ USB Cable:	USB mini-B 5 pin to USB A
◆ Sensor:	1.3 MegaPixel CMOS 2/3"
◆ Effective Pixel Elements:	1280 (H) × 1024 (V)
◆ Pixel Size:	6.7μm × 6.7μm
◆ Array Dimension:	8.6mm × 6.9mm
◆ Scanning Mode:	Progressive
◆ A / D Conversion:	10 Bit
◆ Maximum Frame Rate: (full resolution)	27 frame per second
◆ Exposure range:	30 μs to 30 ms
◆ Trigger:	Internal or External (Software selectable)
◆ External Trigger Specifications:	TTL (Positive transition)
◆ HIGH Level:	2 to 5 VDC
◆ LOW Level:	-0.3 to 0.8 VDC
◆ Trigger Connector:	Hirose 6 pin
◆ Trigger Cable:	Hirose 6 pin to BNC
◆ Dimensions, W × L × H:	54.2mm × 54.2mm × 32.6mm
◆ Lens Mount Type:	C-mount
◆ Operating Temp:	0 to 50°C
◆ Supply Voltage:	4.40 to 5.25 V supplied by USB 2.0 interface
◆ Supply Power:	<1.6 W

WARRANTY INFORMATION

Photon's products are covered by limited warranty on parts and labor for 12 months from shipment date and 13 months if shipped to an authorized representative except as noted below. This warranty covers parts and labor to repair the equipment that fails to perform due to problems that are innate to the units and its components, but not due to neglect or misuse. Photon cannot be held liable for any damages beyond the original equipment cost.

Photon does not warrant incorrect use of instruments, such as but not limited to:

- ◆ Connecting or disconnecting a plug-in card with the computer powered on.
- ◆ Plugging your computer into a wall outlet without a surge protection strip.

Photon reserves the right to determine if the problem has been caused by improper use.

Warranty is not transferable except through resale of products by authorized agents of Photon inc. Unauthorized transfer of equipment and/or modifications to the equipment are grounds for voiding warranty coverage.

Photon reserves the right to void the warranty if the Buyer fails to meet the terms of purchase such as, but not limited to, a payment after the stated agreed invoice payment date or failure to pay for shipping charges.

This is Photon's sole warranty with respect to its products. No statement, agreement or understanding, oral or written, made by an agent, distributor, representative or employee of Photon, which is not contained in this warranty will be binding upon Photon, unless made in writing and executed by an officer. Photon makes no other warranty of any kind, whatsoever, expressed or implied. All implied warranties of merchantability and fitness for particular use, which exceed the aforementioned obligation, are hereby disclaimed by Photon and excluded from this agreement. Under no circumstances shall Photon be liable to Buyer in contract or in tort, for any special, indirect, incidental or consequential damages, expenses, losses or delays however caused.

Photon must be notified of the defect or nonconformity within the warranty period and the affected product returned to Photon's factory or an authorized service center within 30 days after the discovery of such defect or nonconformity. Shipment to Photon shall be made with an RMA# and prior authorization by Photon. Warranty repairs will be returned pre-paid lowest cost shipping method: for example, ground shipment if within the USA. If a faster return is desired, the Buyer must pay the shipping charges.

2. *System Inspection*

2.1. Inspection

If you did not inspect the shipping container prior to unpacking, please do so now before going any further.

Your USBeamPro system has been carefully tested, inspected and packaged prior to shipment. Photon performs extensive testing to ensure that the unit is in proper working order. Upon receipt, please inspect your USBeamPro system for the following:

- ◆ Note any damage to the shipping container. Please report any damage found immediately to the shipping company. Photon does not warrant damage that occurs as a result of shipment.
- ◆ Check the contents of your shipment against the packing slip attached to the shipping box. Please note any discrepancy.
- ◆ A warranty form is included with all new units. Please complete this form and return it to Photon to activate your warranty.

2.2. USBeamPro System Packing List

The following items are shipped as part of the 2323 USBeamPro Beam Profiling System:

- ◆ Model 2323 2/3" USB 2.0 CMOS Camera
- ◆ USBeamPro Acquisition and Analysis Software CD for Microsoft Windows XP Professional (32-bit), Microsoft Windows Vista Business (32-bit) or Microsoft Windows 2000 Professional
- ◆ USB A to USB mini-B cable
- ◆ Hirose 6 pin to BNC external trigger cable
- ◆ Operating Manual

3. *SYSTEM SETUP*

3.1. Personal Computer Requirements

To ensure the successful installation and operation of the USBeamPro system, verify that your PC has the following minimal requirements:

- ◆ 1.8GHz or faster Pentium IV Processor
- ◆ Microsoft Windows Vista Business (32-bit edition), Microsoft Windows XP Professional SP2 (32-bit edition) or Microsoft Windows 2000 Professional SP4 Operating System
- ◆ USB 2.0
- ◆ 512 MB of RAM
- ◆ CD Drive
- ◆ 30MB free space on hard disk
- ◆ SVGA Display Monitor
- ◆ 64MB Color SVGA Graphics Card
- ◆ Mouse or other Pointing Device
- ◆ Keyboard

3.2. Setup for Microsoft Windows Vista Business (32-bit edition)

In order to properly install and configure the camera and/or the software you will need Administrator Rights. (Please contact your system administrator for details regarding the Administrator Rights).

3.2.1. 2323 USBeamPro Camera

1. Power up the computer and start Windows Vista Business;

2. Connect the USB cable (USB mini-B end) to the camera;
3. Connect the USB cable (USB A end) to an available USB 2.0 port;
4. Microsoft Windows will automatically detect the camera and the **Found New Hardware** message box will appear stating that a Video device has been detected; After the **Found New Hardware Wizard** starts select **Locate and install driver software (recommended)**. An **User Account Control** dialog box will appear, asking permission to continue. Select **Continue** to proceed with the driver installation;
5. If **Found New Hardware** wizard will ask permission to search online for driver software for the new Video device. Select **Don't Search Online**;
6. Insert the **USBeamPro** CD into the CD drive; If the CD is already in the Drive select **Next** to continue;
7. Windows will detect the **USB2.0 SMX-I15x Series Sumix Camera Drive** and install the drivers;
8. A **Window Security** dialog box will display a message stating that Windows cannot verify the publisher of the software. Select **Install this driver software anyway** to continue the driver installation;
9. The USBeamPro Camera driver installation is complete. Click **Close** to finish the driver installation and exit the Found New Hardware wizard.

3.2.2. USBeamPro Acquisition and Analysis Software

3.3.2.1. Installation

1. Insert the USBeamPro CD into the CD Drive. If the CD is already in the drive or the Setup does not start automatically, open Windows Explorer and browse to USBeamPro CD and double click setup.exe.
2. If an User Account Control dialog box appears stating that an unidentified program wants to access your computer, select Allow (I trust this program. I know where it's from or I've used it before.) to continue the software installation.
3. Follow the instructions and, if it is possible, accept the default - (suggested) settings.
4. This completes the software installation and configuration.

3.3.2.2. Uninstallation

1. Open the Control Panel by clicking **Start** and then **Control Panel**.
2. Under **Programs** select **Uninstall a Program**.
3. Select **USBeamPro** from the software list, and then click the **Uninstall** icon.
4. If **Program and Features** dialog box appears asking **Are you sure to uninstall USBeamPro** click **Yes**.
5. If an **User Account Control** dialog box appears stating that an unidentified program wants access to your computer, select **Allow** to continue uninstalling the software.
6. Wait for uninstallation to finish.

3.3. Setup for Microsoft Windows XP Professional (32-bit edition)

In order to properly install and configure the camera and/or the software you will need Administrator Rights. (Please contact your system administrator for details regarding the Administrator Rights).

3.3.1. 2323 USBeamPro Camera

1. Power up the computer and start Windows XP;
2. Connect the USB cable (USB mini-B end) to the camera;
3. Connect the USB cable (USB A end) to an available USB 2.0 port;
4. The **Found New Hardware** message box will appear stating that a Video device has been found; When the **Found New Hardware Wizard** appears, select **No, not at this time** when prompted to allow Windows to connect to Windows update to search for software and click **Next**; in the next screen select **Install the software automatically (recommended)** and click **Next**;
5. Insert the **USBeamPro** CD into the CD drive;
6. Windows will detect the **USB2.0 SMX-I15x Series Sumix Camera Drive** and install the drivers; if a message pops-up alerting that *"The software you are installing for this hardware: USB2.0 SMX-I15x Series Sumix Camera Drive has not passed Windows Logo testing to verify its compatibility with Windows XP"* click **Continue Anyway**.
7. Click **Finish**.

3.3.2. USBeamPro Acquisition and Analysis Software

3.3.2.3. Installation

1. Insert the USBeamPro CD into the CD Drive. Open Windows Explorer and browse to **USBeamPro CD** and double click **setup.exe**.
2. Follow the instructions and, if it is possible, accept the default (suggested) settings.
3. After the software is loaded, a dialog box will appear asking if you want to restart the computer. Click **Yes** when prompted.
4. This completes the software installation and configuration.

3.3.2.4. Uninstallation

1. Open the Control Panel by clicking **Start** and then **Control Panel**.
2. Double-click the **Add / Remove Programs** icon.
3. Select **USBeamPro**, then click the **Remove** button.

3.4. Setup for Microsoft Windows 2000 Professional

In order to properly install and configure the camera and/or the software you will need Administrator Rights. (Please contact your system administrator for details regarding the Administrator Rights).

3.4.1. 2323 USBeamPro Camera

1. Power up the computer and start Windows 2000;
2. Connect the USB cable (USB mini-B end) to the camera;
3. Connect the USB cable (USB-A end) to an available USB 2.0 port;
4. The **Found New Hardware** dialog box will appear stating that a multimedia video controller has been found;
5. When the **Found New Hardware Wizard** appears click **Next**;
6. Insert the USBeamPro CD into the CD drive;
7. Select **Search for a suitable driver for my device** (recommended) and click Next;

8. Select **CD-ROM drives** and click **Next** to start searching for the device driver;
9. Windows will detect the drivers on your CD. Click **Next** to install the drivers;
10. Click **Finish**; then continue to the next step;

3.4.2. USBeamPro Acquisition and Analysis Software

3.3.2.5. Installation

1. Load the USBeamPro CD into the CD Drive. Open Windows Explorer and browse to USBeamPro CD and double click **setup.exe**.
2. Follow the instructions and, if it is possible, accept the default (suggested) settings.
3. After the software is loaded, a dialog box will appear asking if you want to restart the computer. Click **Yes** when prompted.
4. This completes the software installation and configuration.

3.3.2.6. Uninstallation

1. Open the Control Panel by clicking **Start** then selecting **Settings** and then **Control Panel**.
2. Double-click the **Add / Remove Programs** icon.
3. Select **USBeamPro**, then click the **Remove** button.

4. *ACQUISITION AND ANALYSIS SOFTWARE*

4.1. Quick Start

4.1.1. Starting the Program

To run the USBeamPro Acquisition and Analysis Software program:

From the Windows **Start** menu, select **Programs**, then **Photon**, and then **USBeamPro** or select the **USBeamPro** icon from your desktop.

After installation when the program is first started, the Video window will appear. At this point the program GUI can be configured as desired with the multiple windows available. Alternatively, a **sample** startup GUI configuration screen is available that can be opened from the File menu. The sample configuration file name is “Example.usc” and can be found in the directory where the software was installed, (default directory is “C:\Program Files\Photon\USBeamPro”). There are 6 windows on this sample screen, including:

- ◆ **Video** window
- ◆ **Profile** window
- ◆ **Beam Statistics** window
- ◆ **3D Profile** window
- ◆ **Pointing** window
- ◆ **Notes** window

Figure 4.1 shows the Example.fus configuration screen and the arrangement of these 6 windows.

At first startup, the system will NOT be collecting data. (If the program does not start, refer to the **Troubleshooting** section at the end of this manual.)

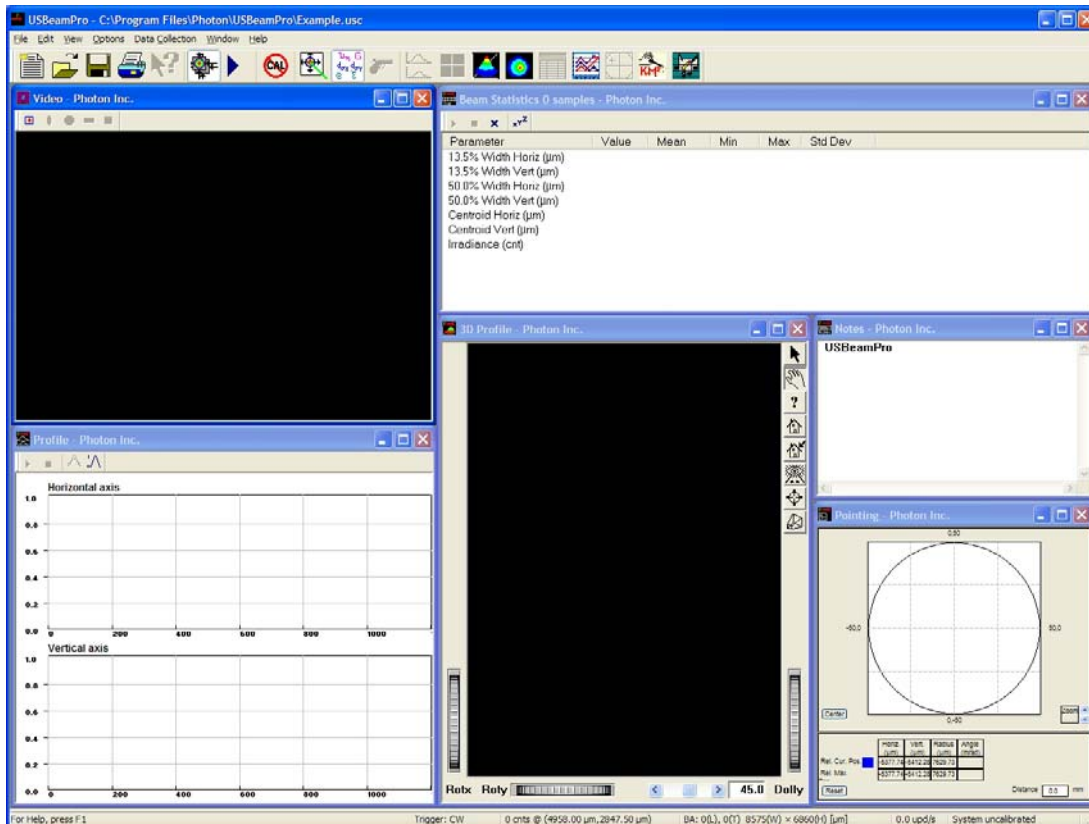


Figure 4.1. "Example.usc" Configuration Screen.

The software has **2 Acquisition Modes** for image acquisition and processing. These are accessed under the **Data Collection** menu or through the icons from the main toolbar:



Laser Positioning: used for positioning the laser beam in the sensor aperture as shown in the **Video** window;



Analysis: used to obtain Beam Parameters on a continuous basis;


At first startup, the system is in **Laser Positioning Acquisition Mode**.

The software has **3 Trigger Modes**, accessed under the **Data Collection** menu:

- ◆ **CW** for CW lasers;
- ◆ **Pulsed** for Pulsed lasers where an external sync trigger is NOT available;
- ◆ **External** for Pulsed lasers where an external sync trigger is available.

At first startup, the system is in **CW Trigger Mode**.

4.1.2. Position the Laser Beam in the Aperture.

To begin collecting data, select **Global Data Collection** from the **Data Collection** menu, or alternatively, use the  icon on the toolbar, or depress the Ctrl+G 'Hot Key'. The **Video** window will now be displaying data. The other windows will remain blank because data processing is inhibited in Laser Positioning mode to provide the fastest video update.

Adjust the laser beam steering or the camera position until the beam image is centered in the aperture as viewed in the **Video** window. The **Video** window uses false color schemes to code the beam intensity. The default scheme is the 'rainbow' spectrum, with low intensity toward the violet and high intensity toward the red. **White** indicates a **saturation** condition. If the beam is too intense and saturation is observed, attenuation will be needed. To fully utilize the system dynamic range and achieve the specified accuracy in beam measurements, adjust the laser intensity to a level just below the saturation level.

4.1.3. Trigger Mode for Pulsed Lasers

If your laser is CW, skip this step.

To measure pulsed laser beams, use either the **External** Trigger Mode or the **Pulsed** Trigger Mode. These trigger modes are discussed below. If you can provide an external trigger, the best way to measure pulsed laser beams is using the **External** Trigger Mode. **External** triggering requires a TTL signal, with the trigger occurring on the positive-going (leading) edge. The external trigger cable provided with the system connects to the camera with a Hirose connector and has a BNC connector for the TTL signal input.

If you cannot provide an external trigger, use the **Pulsed** Trigger Mode. When this mode is selected, the software will automatically determine the presence of the beam based on minimum signal amplitude of 32 counts out of 1024. In this mode, the update rate will, in general, be reduced from that obtainable using the **External** Trigger Mode. The Trigger Mode can be changed through the **Data Collection** menu using the mouse. Open the **Trigger Mode** menu and select either **Pulsed** or **External**.



4.1.4. Calibrate the System

It is necessary to perform a calibration prior to making beam measurements to obtain the specified accuracy. To calibrate, select **Calibration** from the **Data Collection** menu. The **Camera Calibration** dialog box will appear.

In the user interface, there are two visual indicators (the calibration icon on the main toolbar and the message in the last pane of the Status Bar), which changes depending on the system calibration status. The icons change to indicate the status of calibration, as follows:



System Uncalibrated



System Settings Changed since last calibration



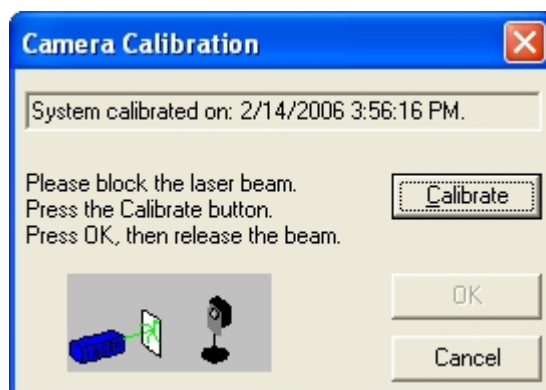
System Calibrated under current system settings

System settings include camera exposure, trigger mode, and unit serial number.

If the last pane of the status bar displays the message “Calibration conditions changed” or the calibration icon corresponds to the “System settings changed” the system has been calibrated, but that something about the measurement configuration has changed; either the exposure, the trigger mode, or the unit serial number. In this case it is recommended to recalibrate.



To calibrate, use the displayed Calibrate icon, on the main toolbar or select **Calibration** from the **Data Collection** menu. The **Camera Calibration** dialog box will appear.




Simply follow the directions. Block the beam (as far from the camera aperture as possible) and click the **Calibrate** button. Then click on the **OK** button. This completes the calibration procedure.

4.1.5. Switch to Analysis Mode

To start measuring Beam Parameters, the system must be set to Analysis Mode. The Analysis Mode can be set by selecting **Acquisition Mode** from the **Data Collection** menu and clicking on **Analysis**.



Alternatively, use the  icon on the toolbar. The **Profile**, **Beam Statistics**, and **3D Profile** windows will now display data and images.

4.1.6. Beam Parameters - Computation and Display

4.1.6.1. Computation of Parameters

Beam parameters are computed when the system is operating in the **Analysis** Acquisition Mode. The computations that are performed are determined by selections made in the **Data Analysis** dialog. To optimize the data update rate, all computations are done on a *subset* of the entire video image called the **Beam Area**. The number of pixels in the Beam Area that are actually used in the calculations are determined by the **Acquisition Resolution**. The computations also use the effective pixel dimensions and the **Magnification Factor**.

4.1.6.2. Beam Area

If the system is set for **Auto Track**, the Beam Area is automatically determined to include the entire laser beam image but to be of minimal size. (This is to minimize the computation time by keeping the Beam Area as small as possible.) If the system is not set for **Auto Track**, a Beam Area must be set manually so that computations are performed. To set the Beam Area manually, either use the **Set Beam Area** selection under the **Video** window **Options** menu, or use the **Set Beam Area** drawing tool on the **Video** window toolbar. The **Beam Area-Position/Size** dialog box can also be used to define the top, left, width and height coordinates.

4.1.6.3. Acquisition Resolution

This item under the **Data Collection** menu is for selecting the resolution to be used for computation and analysis of video image pixel data. This feature is intended for large laser beams, where the rate of data analysis can be increased by reducing the number of pixels used in the computations. The choices are **1x** and **1/2x**. Selecting **1/2x** will increase the rate of analysis. When **1x** is selected all the pixels in the video image pixel array are used for computations. When **1/2x** is selected, only 1/4 of the pixels (i.e. every other

pixel in every other line in the camera array) are acquired and used for computations. In this case the effective pixel linear dimension is twice (or 2x) as large as the basic linear pixel dimension.

4.1.6.4. Magnification Factor

This item under the **Data Collection** menu opens a dialog box for entering an optical magnification factor. This is necessary to obtain accurate beam width values whenever optical components such as lenses or mirrors with magnification are used to image a laser beam. This factor is used to scale the linear pixel dimension of the camera selected for measurements. The default magnification factor is 1. (If you do not know the magnification factor of your optical system, it can be determined by mechanically translating an object a known distance horizontally through the image. The measured translation of the object in the image divided by the known mechanical translation is the magnification factor.)

4.1.6.5. Displaying Parameters.

Computed parameters can be displayed in the **Beam Statistics** window or in the **Time Statistics** windows. The selection of parameters for display is accomplished through the **Parameters** entry under the **Options** menus for these windows. Selecting the **Parameters** entry opens a dialog box for specifying which parameters will be displayed.

4.2. Advanced Use

The previous Quick-Start procedure utilizes only the very basic features of the USBeamPro Acquisition and Analysis Software program. The program is very powerful and flexible, allowing users to configure the image data acquisition, the analyses, and the information display windows to suit their individual needs.

The **Data Collection** menu includes selections that determine or affect the collection of data. Through the **Data Analysis** dialog, users select the types of data analyses that will be performed, all in accordance with the ISO Standards.

Numerous parameters can be computed and displayed, determined in the **Beam Statistics Parameters** dialog. Parameters measured include:

- ◆ Beam width
- ◆ Centroid and peak location
- ◆ Major and minor axes
- ◆ Beam orientation
- ◆ Ellipticity, eccentricity

- ◆ Gaussian fit
- ◆ Beam uniformity
- ◆ Beam divergence
- ◆ Pointing stability
- ◆ M^2 , K-factor

Three methods for computing beam widths; D_{slit} , D_{energy} , or $D_{4\sigma}$, are available in either **XY** or **Elliptical** analysis modes.

Energy/Power Uniformity or **Flat Top** analyses can be performed on selected regions of interest.

There are also three methods of computing **Beam Divergence**.

Windows available for display include the:

- ◆ Video window;
- ◆ Profile window;
- ◆ 2D Contour window;
- ◆ 3D Profile window;
- ◆ Beam Statistics window;
- ◆ Time Statistics window;
- ◆ Pointing window;
- ◆ K-Factor window.

Each window has an **Options** menu that offers many choices in how data will be displayed. There is also a **Notes** window for entering text. Users can arrange and size multiple windows as required, and these screens can be saved as files for future use. **Limit Analyses** can be performed on selected beam parameters. Also, data can be exported to spreadsheets, math and statistical analysis programs, and process/ instrumentation programs by logging data to files or COM ports, or shared using ActiveX Automation.

A complete description of the various features of the program is given in this section. Users are encouraged to learn the software features in detail and to experiment with the program. A little time spent in advance learning the features of the system will go a long way in making the USBeamPro Acquisition and Analysis System an invaluable resource for laser beam characterization.

4.3. Operating Hints

1. Use the manual to completely familiarize yourself with all the features of the USBeamPro Acquisition and Analysis Software.

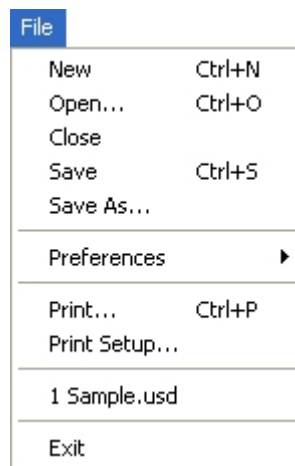
2. Use **Laser Positioning** mode for positioning the laser beam in the aperture, and also for course tuning of the laser beam. Only use **Analysis** mode when you need parameter values.
3. Configure the **Data Analysis** and **Beam Statistics Parameters** only for values that are needed. For example, do not use **Elliptical Analysis** if the laser beam is nearly circular. Additional computations require more time and reduce the system performance in terms of data update rate and the cross hairs will be very unstable, constantly jumping around to find the “ellipse”.
4. **Calibrate** the system periodically. Array sensors are very sensitive and can sense changes in background light intensity due to such things as reflections from a white shirt or light from a computer monitor. For accurate and repeatable measurements, the consistency of the experimental setup is important. Therefore, calibrate the system whenever there is a change in setup or background lighting. This will ensure the most consistent and accurate results.
5. Open only those windows that are required by your application. Additional windows reduce the data update rate. This is particularly true for the **Video**, **2D Contour**, and **3D Profile** windows. If all you need is beam width values, and you require the fastest data update rate, close unnecessary windows, including the **Video** window, and use only the **Beam Statistics** and/or **Time Statistics** windows.
6. Every window has a display update rate that is configured under the **Options** menu for each window. You may want to change the default **Timing** settings in order to improve the performance of your system.
7. Use Autotracking if your beam is stable. If your beam is unstable, the Beam Area as defined by the Autotracking algorithm will also be unstable. This will adversely affect the **Profile** and **3D Profile** windows, in that the displays will tend to change or pop with each change in the Beam Area. In this case, set a manual Beam Area to eliminate these effects.
8. Use **Frame Background Subtraction**, because the USBeamPro CMOS chip has a shaded background. **Frame Background Subtraction** will also eliminate any stray light that is not due to the incident laser beam.
9. If data is being collected over long periods of time, use the Automatic backup feature to prevent total loss of data in the event of a Windows General Protection Fault.

4.4. Program Menus

4.4.1. File Menu

As in any other Windows compliant program, the **File** menu is used for file manipulation and printing.

When **File** on the Menu Bar is clicked, the pull-down menu below appears.

**New**

Closes all open windows, then creates a new **Video** window.

Open...

Opens the **File Open** dialog box. It lists Data Files from the current working directory.

To open a data file, select one from the list and then select the **Open** button. All windows will be closed and the new file will be loaded. The data, windows and computed statistics from the file will be displayed.

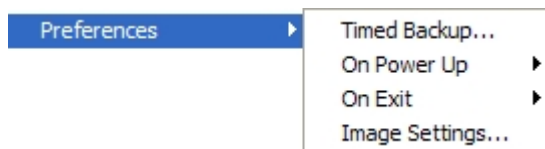
To open a configuration file, repeat the above steps except select **Configuration Files** from the **Files of Type** combo box. The list will show all configuration files in the current working directory. Configuration files contain everything that a data file does, except for the raw data and beam statistics. Use this to save a particular screen layout and set of data acquisition parameters without the raw and computed data.

Close

Closes all open windows and halts data collection.

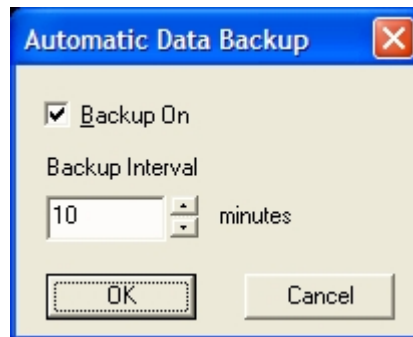
Save	Saves the current data and windows configuration in the currently active file. The name of this file is displayed on the main window title bar.
Save As...	Opens the File Save As dialog box. It lists Data Files from the current working directory. Either select an existing file from the list or enter a new name in the File Name edit box. To save as a data file, simply select the Save button. There are 5 different file types, identified by their extensions:
*.usd	Data File: Includes screen configuration and associated image and computed data. Only the USBeamPro Acquisition and Analysis Software can use this file.
*.usc	Configuration File: Includes screen configuration only. Only the USBeamPro Acquisition and Analysis Software can use this file.
*.prw	Frame Data - Raw File: Includes raw image data only. The Frame Data File is a binary file. It contains the number of columns and rows, saved as unsigned short (16-bit unsigned), then each pixel of the frame as an unsigned char (8-bit unsigned). This file cannot be read back by USBeamPro Acquisition and Analysis Software.
*.tif	Frame Data - TIFF File. Saves the current frame (raw image) as uncompressed 16-Bit TIFF image.
*.asc	ASCII File. Saves data displayed in all open views in ASCII format.
IMAGE	Saves the program screen as an IMAGE file, either BMP, JPEG, GIF, TIFF, or PNG File. This is used for exporting graphics into documents and reports. The IMAGE file format is selected under Image Settings dialog in the File menu Preferences item.

Preferences

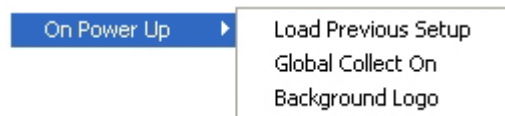


Timed Backup

Opens the **Automatic Data Backup** dialog box. If the **Backup On** checkbox is selected, then all data will be saved automatically at the specified interval. Use this feature when collecting data over extended periods to prevent data loss in the event of a power outage or other catastrophe. When the program is restarted after such an event, the backup file will load and data collection resumes from the point of the last automatic save.

**On Power Up**

Opens a menu with the following 3 selections:

**Load Previous Setup**

When checked, the last data file will automatically load at startup.

Global Collect On

When checked, data collection resumes at startup.

Background Logo

When checked, the Photon Logo appears as the background for the main window.

On Exit

Opens a menu with the following selections:

**Save Setup**

When checked, the **Save As** dialog box appears, prompting the user to save the latest data.

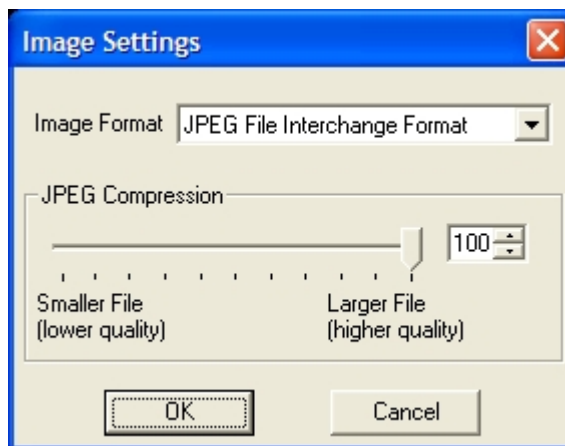
Prompt

When checked, the user is prompted with an **Leaving Already?** dialog upon exit.

Image Settings... Opens a dialog box for selecting the image export format for the active window and the full screen. Available choices for Image Format are:

- BMP** Windows Bitmap
- JPEG** JPEG File Interchange Format (JFIF)
- GIF** Graphics Interchange Format
- TIFF** Tagged Image File Format
- PNG** Portable Network Graphics

This dialog is also used to set the image compression for JPEG Files.



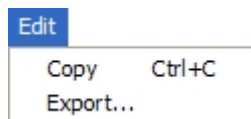
Print... Prints a picture of all open windows to the currently selected default printer. The user may change this printer from the **Print** dialog if desired.

Print Setup... Opens a dialog box for selecting and configuring printers

Exit Exits the program.

4.4.2. Edit Menu

When **Edit** on the Menu Bar is clicked, the pull-down menu below appears:



Copy Copies the current window to the Windows clipboard as a bitmap image and/or text,

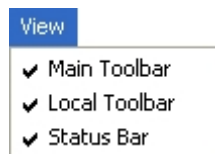
depending on the active view. From there, the information can be pasted into other program applications.

Export...

Opens the **File Save As** dialog box for exporting the active window as an image file, either BMP, JPEG, GIF, TIFF or PNG, used for exporting graphics into documents and reports. The image file format is selected under **Image Settings** dialog in the **File** menu, **Preferences** item.

4.4.3. View Menu

When **View** on the Menu Bar is clicked, the pull-down menu below appears:



Main Toolbar

When checked, the toolbar on the main window is visible.

Local Toolbar

When checked, the toolbar of the currently active view is visible, if available.

Status Bar

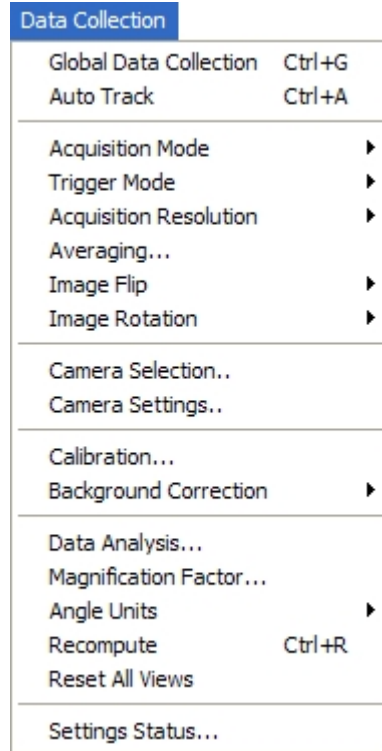
When checked, the status bar at the bottom of the main window is visible.

4.4.4. Options Menu

There are various options associated with each window. These are selected in the **Options** menu. When a particular window is selected or active, the various options associated with that window are listed in the **Options** menu. The list of options is unique for each window. The options list for each window can be found below, under the window descriptions.

4.4.5. Data Collection Menu

The **Data Collection** menu includes selections that determine or affect the collection of data. When **Data Collection** on the Menu Bar is clicked, the pull-down menu below appears:



Global Data Collection Enables data collection and updates for all windows.



Auto Track Selects the autotracking feature, which automatically locates and tracks the laser beam and defines an optimal region, called the Beam Area, for performing data analysis.

Acquisition Mode Opens a menu for selecting 1 of 4 acquisition modes.



Choices are:

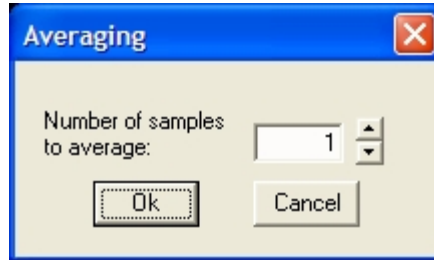
Laser Positioning Captures and displays images in the Video window. No calculations are performed, thus providing the fastest update rate. This mode is intended for setup prior to acquiring quantitative

	data. Use this mode for positioning your laser in the sensor aperture, adjusting attenuation, or for visually tuning the laser.
Analysis	Enables data analysis computations.
Single Shot	Currently inactive.
Multiple Samples...	Currently inactive.
Trigger Mode	Opens a menu for selecting 1 of 3 trigger modes. 
	Choices are:
CW	Captures and displays images continuously. Use this mode when measuring CW laser beams.
Pulsed	Captures and displays good images continuously. Use this mode when measuring pulsed lasers where external triggering is not available. In this mode the software rejects invalid frames.
External	Captures and displays images whenever an external trigger pulse is detected. Use this mode when measuring pulsed lasers where external triggering is available. In this mode the software rejects invalid frames. This is the best mode for your pulsed laser .
Acquisition Resolution	Opens a menu for selecting the acquisition resolution to be used for computation and analysis of video image pixel data. This feature is intended for large laser beams, where the rate of data analysis can be increased by reducing the number of pixels used in the computations. 
	Choices are:
1x	Analysis is performed using all the pixels in the Beam Area.
1/2x	Acquisition and Analysis is performed on every other pixel in every other line in the Beam Area (i.e. only 1/4 of the pixels are used for computations). The effective linear pixel dimension is 2x the basic pixel dimension.

Selecting **1/2x** will increase the rate of acquisition, analysis, and data display, depending on the analyses selected.

Averaging...

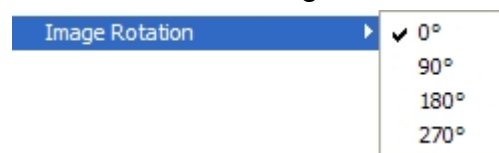
Opens a dialog box for setting the number of frames to average. Entire frames are sequentially added up to the set value and then divided by the number of frames to obtain an average frame. This is not a rolling average; therefore, setting this number higher will slow the update rate significantly.

**Image Flip**

Opens a menu for selecting the orientation of the image with respect to Vertical and Horizontal. Select None to display the original frame, Horizontal to flip the image about the horizontal axis, Vertical to flip the image about the Vertical axis. This operation takes precedence over Image Rotation.

**Image Rotation**

Opens a menu for selecting rotation of the image. Select 0° to display the original frame, or 90°, 180°, 270° to rotate the image in clockwise direction.

**Camera Selection...**

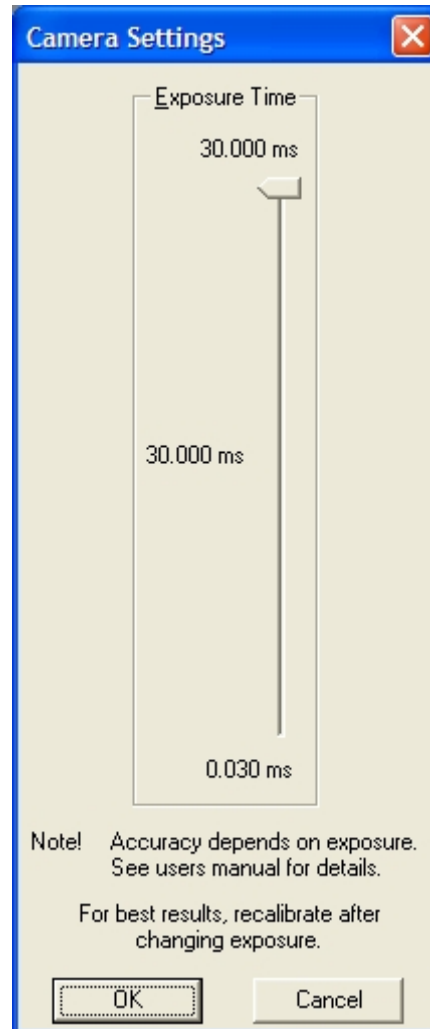
Opens the **Camera Selection** dialog for selecting USBeamPro cameras for use by Serial Number.



Camera Settings...

Opens the **Camera Settings** dialog for setting the camera **Exposure Time**, which ranges from 30 μ s to 30ms. The selected exposure time is displayed at the top of the exposure slider.

The default setting for exposure is 30ms, and is the recommended setting for highest specified accuracy of $\pm 3\%$. When using shorter exposure times, the accuracy is typically reduced depending on the beam profile and diameter.



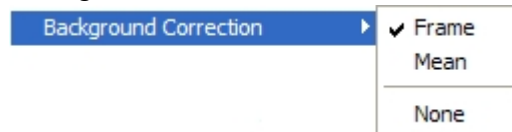
Calibration...

Opens the **Calibration** dialog for performing a background calibration of the camera. The info field displays the date and the time of the last calibration. If the camera was not calibrated the message *"The system is not currently calibrated."* is displayed.

To perform a calibration, simply follow the instructions in the dialog box. First, block the laser beam (as far from the camera aperture as possible). Then click on the **Calibrate** button. The calibration is complete when the **OK** button becomes active. The current date and time will be displayed in the info field. Then click on the **OK** button to exit the **Calibration** dialog.

**Background Correction**

Opens a menu for selecting the method of background correction. The available choices are:

**Frame**

Selects the background frame correction method. The background frame values are subtracted from each data frame on a pixel-by-pixel basis. *Recommended for the Model 2323.*

Mean

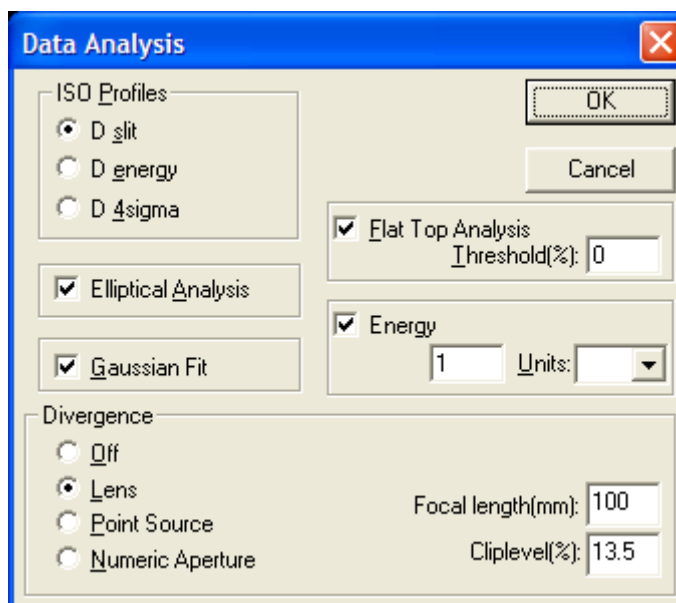
Selects the background mean value correction method. The mean value of the background frame is subtracted from each pixel value in the data frame.

None

Selects no background correction.

Data Analysis

Opens the **Data Analysis** dialog for selecting the calculations to be performed on each data frame.



The various selection choices are:

ISO Profiles

Selects the method of **ISO Profiles** beam width computation. Choose from 1 of 3 possible selections:

D slit

Selects the slit method for determining beam widths. The computation simulates a scanning slit aperture with slit width equal to the effective pixel dimension of the camera used for measurement. Scans are performed along the horizontal and vertical directions or along the directions of the major and minor axes if elliptical analysis is selected.

D energy

Selects the encircled energy method for determining beam widths. The computation simulates circular apertures centered at the laser beam centroid and calculates the energy through the aperture. The diameter of the circular aperture is increased until the specified energy percentage is obtained.

D 4sigma

Selects the second moment method for determining beam widths. The computation determines the second moment of the laser beam distribution.

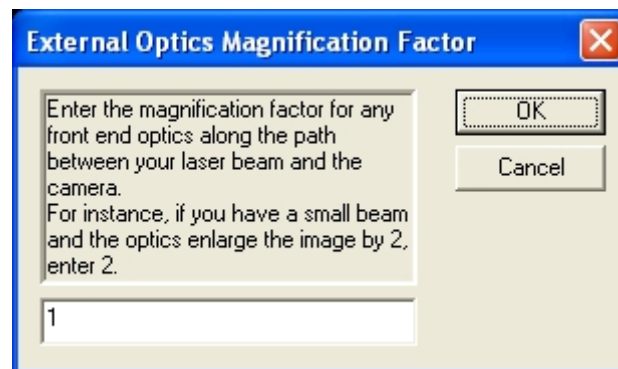
<i>Elliptical Analysis</i>	By default, data analysis is performed along the horizontal and vertical directions of the pixel array. If the Elliptical Analysis box is checked, the analysis will be performed along the directions of the major and minor axes of the beam.
<i>Gaussian Fit:</i>	To enable Gaussian fit calculations of the profiles displayed in the Profile window (either Slit or Pinhole scans), check the box labeled Gaussian Fit . The Gaussian fit to the profiles can then be displayed as overlays on the profiles in the Profile window by selecting the Fit option for that window. The corresponding Gaussian Goodness-of-Fit parameter can be displayed in the Beam Statistics Parameters or the Time Statistics window.
<i>Flat Top Analysis</i>	Enables Uniformity or Flat Top Analysis of Energy Region of Interest (ROI). The Energy ROI is a user-defined region in the Video window.
<i>Threshold (%)</i>	Defines the threshold as a percentage of the peak pixel value for which the Flat Top Analysis will be performed. Only those pixels in the Energy ROI that are greater than this value are included in the analysis.
<i>Energy</i>	When selected, the total energy or power in the Beam Area is computed. A reference energy or power value, (from independent measurements with an energy or power meter), and the appropriate units must be entered. In addition, the energy or power in the Energy ROI and the percentage of the energy in the Beam Area are computed in the Flat Top Analysis , if enabled. Also, the Min, Mean, and Max values in the Flat Top Analysis will be reported as Fluence or Irradiance per pixel.
<i>Divergence</i>	Selects the method for divergence computation. Choose from 1 of 4 possible selections:
<i>Off</i>	No divergence computations will be made
<i>Lens</i>	Selects the Lens method for computing divergence. When selected, the lens focal length, in millimeters, and the beam width clip level percentage must be specified.

Point Source Selects the **Point Source** method for computing divergence. When selected, the distance from the point source to the measurement plane, in millimeters, and the beam width clip level percentage must be specified.

Numerical Aperture Selects the **Numerical Aperture** method for computing divergence. When selected, the distance from the point source to the measurement plane, in millimeters, and the beam width clip level percentage must be specified. The numerical aperture equivalent of the divergence half-angle is reported ($\sin(\theta/2)$).

Magnification Factor...

Opens a dialog box for entering an optical magnification factor that will scale the camera pixel dimension. This is necessary to obtain accurate beam width values whenever optical components such as lenses or mirrors with magnification are used to image a laser beam. It allows compensation of any optical or imaging schemes that change the size of the beam image. This factor is used to scale the linear pixel dimension of the camera selected for measurements. The default magnification factor is 1.



Angle Units

Opens a menu for selecting the units need for reporting all the angles, either miliradians or degrees.



Recompute

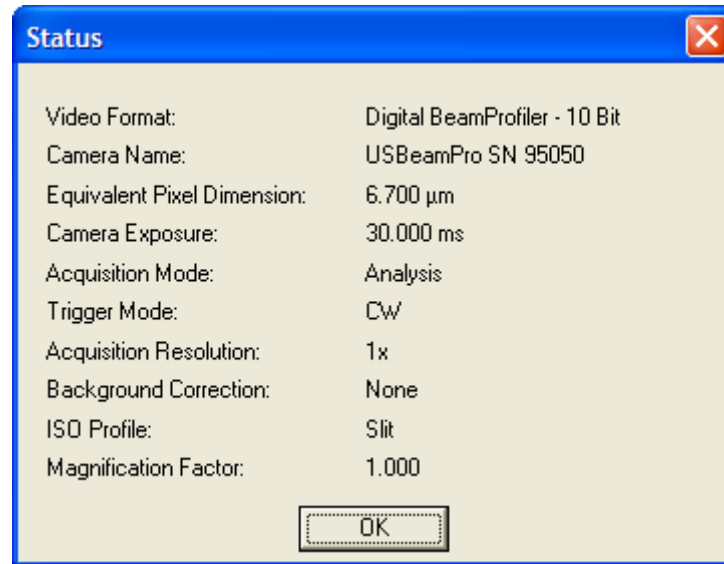
Click on **Recompute** to redo computations on the image data currently in memory. Use this feature if any changes to the analysis are desired, e.g., changing the method of beam width computation, or changing the Beam Area or the Energy ROI to analyze a different region of the image.

Reset All Views

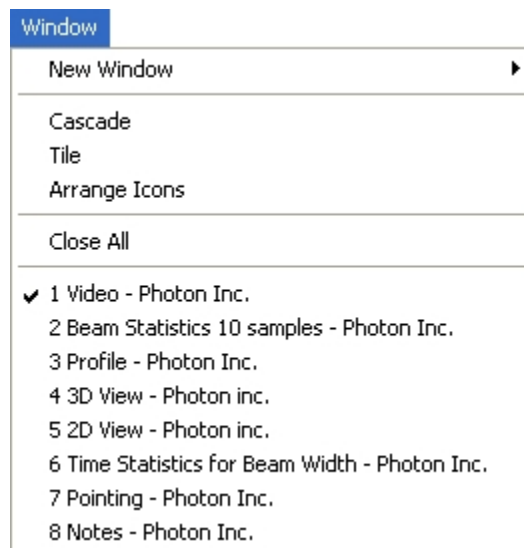
Resets all open data-display windows.

Settings Status...

Opens the **Status** screen dialog, which displays the current program settings.

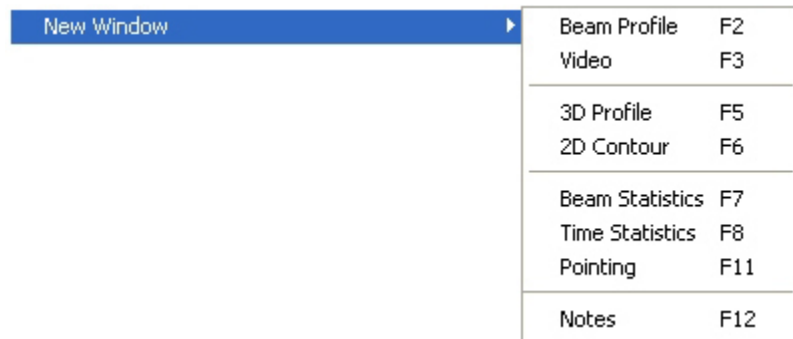
**4.4.6. Window Menu**

When **Window** on the **Menu Bar** is clicked, the pull-down menu below appears.



The **Window** menu is used to open new windows, arrange windows and window icons and to close all open windows. The list at the bottom of the menu shows which windows are open with the currently active window checked.

New Windows Opens a menu for selecting windows for viewing.



Cascade Arranges the open windows in cascade format.

Tile Arranges the open windows in tile format.

Arrange Icons Arranges the minimized window as icons on the bottom of the main window.

Close All Closes all open windows.

Window List Displays a list of all open windows and displays a check before the currently active window name.

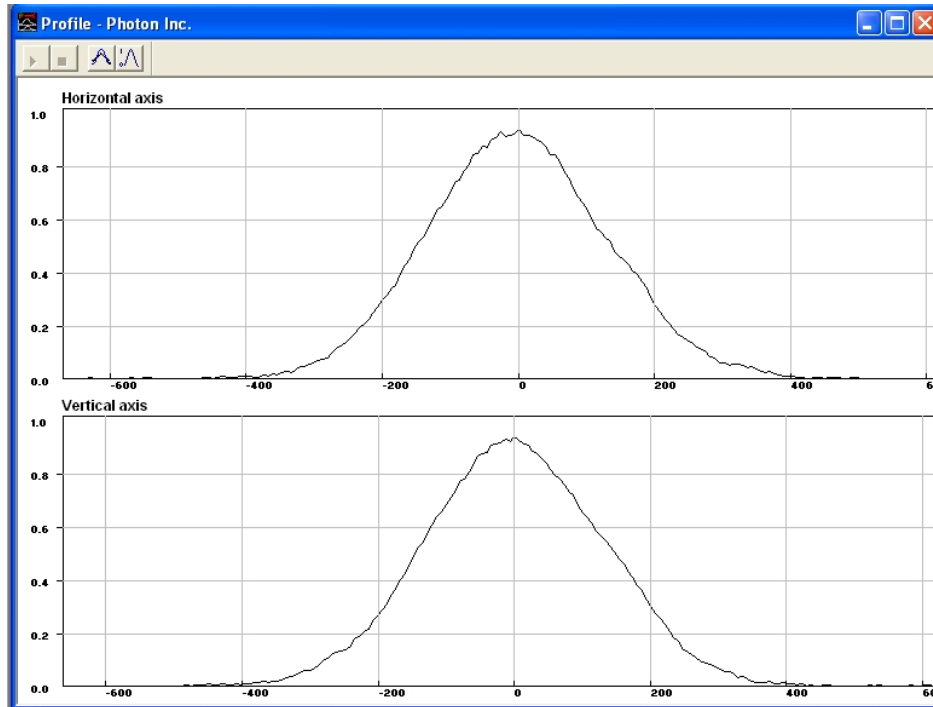
4.4.7. Help Menu

Use the **Help** menu to access **Help Topics**, and the **About USBeamPro** dialog box. Help Topics are currently unavailable.



4.5. Window Descriptions

4.5.1. Profile

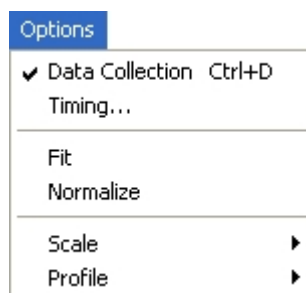


The **Profile** window displays either Pinhole or equivalent Slit profiles in orthogonal directions along the crosshairs displayed in the live **Video** window. An example of the **Profile** window is given above. If data analysis is set to the default XY mode, then the profile axes are horizontal and vertical. If data analysis is set to **Elliptical Analysis Mode**, then the profile axes are oriented along the major and minor axes of the laser beam image.

The locations of the Pinhole profiles are identified by the crosshairs in the **Video** window. The pinhole profile locations can be selected to be through either the beam centroid, the peak pixel, or through user selected points by dragging the crosshairs with the mouse to the desired location. Also, when in elliptical analysis mode, the orientation of the axes can be changed arbitrarily by holding down the control key and using the mouse to rotate the axes.

For Slit profiles the crosshairs identify the direction of the equivalent slit scan.

The **Options** menu available when the **Profile** window is active is shown below.



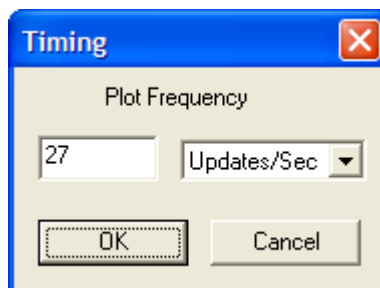
The selections are:

Data Collection

Turns data collection on/off.

Timing...

Opens a dialog box for selection of the profile update rate.



Fit

Places a blue-colored Gaussian fit overlay on the profiles if **Gaussian Fit 1D** is enabled in the **Data Analysis** dialog box.

Normalize

Scales the profile amplitude to have a peak value of 1, i.e. full scale.

Profile

Selects either the **Pinhole** or the **Slit** profiles for display.



Scale

Allows the user to choose between a **Linear** and a **Logarithmic** scale.



These options can also be selected using the **Profile** window toolbar:



Starts data collection.



Stops data collection.



Turns Gaussian Fit overlay on/off.



Turns Normalization on/off.

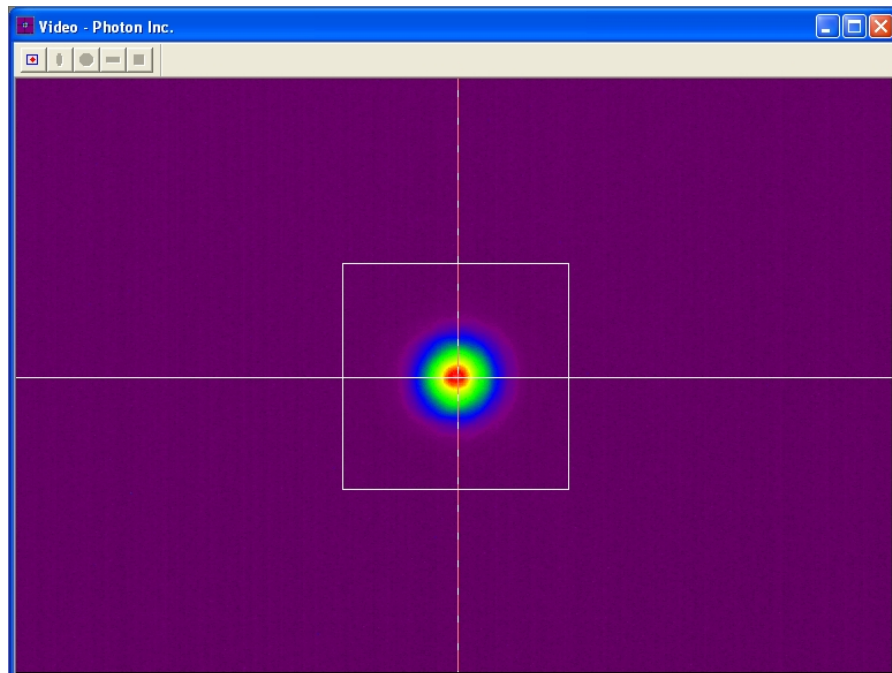
4.5.2. Video

The **Video** window displays the video laser image. An example of the **Video** window is given below.

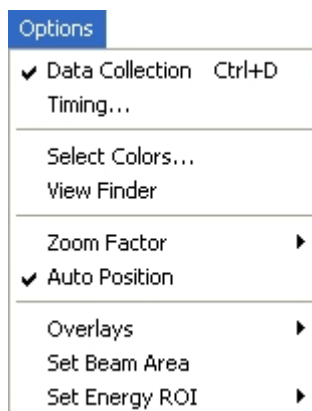
The crosshairs in the image identify the location and/or direction of profiles displayed in the **Profile** window, depending on the type of profile selected, either **Pinhole** or **Slit**, in the Profile options. If data analysis is set to the default XY mode, then the profile axes are horizontal and vertical. If data analysis is set to elliptical mode, then the profile axes are oriented along the major and minor axes of the laser beam image.

For Pinhole profiles the pinhole profile locations can be selected to be through either the beam centroid, the peak pixel, or through user selected points by dragging the crosshairs with the mouse to the desired location. Also, when in elliptical analysis mode, the orientation of the axes can be changed arbitrarily by holding down the control key and using the mouse to rotate the axes.

For Slit profiles the crosshairs identify the direction of equivalent slit profiles.



The **Options** menu available when the **Video** window is active is also shown below.



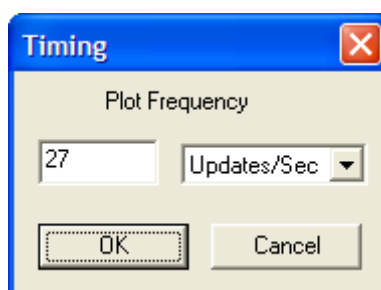
The selections are:

Data Collection

Turns data collection on and off.

Timing...

Opens a dialog box for selection of the display update rate.



Select Colors...

Opens a dialog box for selection of the display color scheme. Choices available are: Rainbow, Gray, Red, Green and Blue.



View Finder

Opens a display box that shows the entire camera video image (1280 × 1024 pixels).

**Zoom Factor**

Opens a menu for selecting the zoom factor. Choices available are: **1:2x**, **1x**, **2x**, **4x**, **8x**, **16x**, and **Fit to Window** proportional to the camera array dimension of 1280 × 1024 pixels.

Auto Position

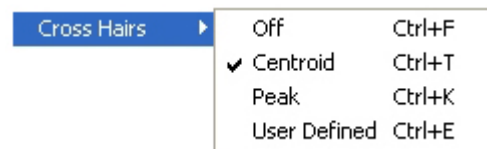
When auto position is selected the laser beam image will automatically be positioned in the displayed portion of the **Video** window.

Overlays

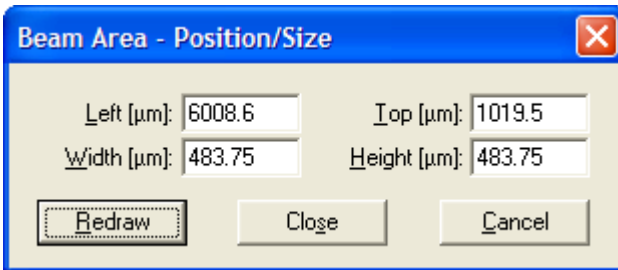
Opens a menu for selecting which overlays will be displayed in the **Video** window. Choices available are:

**Cross Hairs**

Selecting Cross Hairs opens a second menu with the following choices:

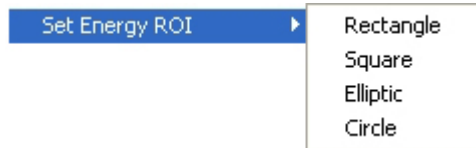


The selection is available only if the Pinhole is selected under the Profile option in the **Profile** Window. When the Profile display is set to **Slit**, the Cross Hairs are drawn through the centroid and cannot be moved, so no other selections can be made.

<i>Off</i>	Turns the cross hair overlay off or on.
<i>Centroid</i>	Places the cross hairs at the centroid.
<i>Peak</i>	Places the cross hairs at the peak.
<i>User Defined</i>	Allows the cross hairs to be positioned manually at an arbitrary position using the mouse.
Beam Area	Turns the Beam Area overlay off or on.
Energy ROI	Turns the Energy ROI overlay off or on if Flat Top Analysis is enabled.
Set Beam Area	Allows the user to set a Beam Area manually. The beam area can be defined/adjusted using the mouse or defining the top, left, width and height coordinates.
To set Beam Area using the mouse:	First click on Set Beam Area . Next, use the mouse to draw and/or adjust the desired beam area in the Video window. Finally, click on Set Beam Area a second time to validate the Beam Area previously drawn. In drawing/adjusting mode, depress ESC to discard all the changes and revert Beam Area to its original size and position. Note: Selecting the Set Beam Area will also open (or close) the Beam Area–Position/Size dialog box.
To set Beam Area using coordinates:	In the Beam Area–Position/Size dialog box, enter the Top, Left, Width and Height coordinates in the designated edit boxes.
	
<i>Redraw</i>	Redraws the beam area based on the new coordinates and keep the Beam Area–Position/Size dialog box open.
<i>Close</i>	Closes the dialog box.
<i>Cancel</i>	Ignores any changes made during the drawing/adjusting mode, reverts Beam Area to its original size and position and closes the dialog box.

Set Energy ROI

Allows the user to set the Energy ROI manually. The ROI can only be drawn inside the Beam Area. The ROI can be defined/adjusted using the mouse or defining its coordinates.



Note: Flat Top Analysis must be enabled for the Energy ROIs to be available.

To set Energy ROI using the mouse:

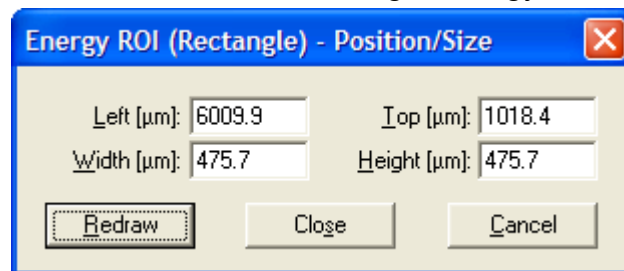
First click on **Set Energy ROI**; this opens a second menu with the following selection choices. **Rectangle**, **Square**, **Elliptic**, and **Circle**. Click on one of these to determine the general shape of the Energy ROI to be drawn. Next, use the mouse to draw and/or adjust the desired Energy ROI in the **Video** window. Finally, click on the shape selection a second time to validate the Energy ROI previously drawn. In drawing / adjusting mode, depress ESC to discard all the changes and revert Energy ROI to its original size and position.

Note: Selecting the one of the **Set Energy ROI** item will also open (or close) the corresponding **Energy ROI – Position/Size** dialog box.

To set Energy ROI using coordinates:

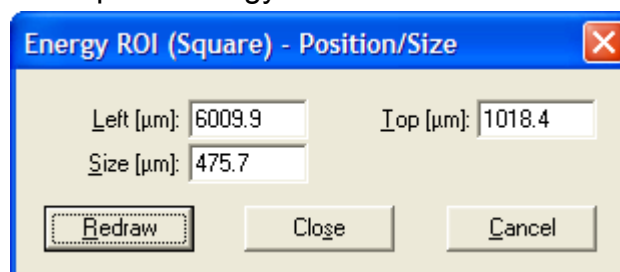
Rectangle:

Enter the **Left**, **Top**, **Width** and **Height** coordinates for the Rectangle Energy ROI.



Square:

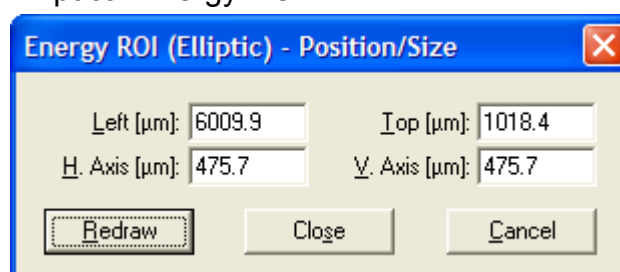
Enter the **Left**, **Top** coordinates and the **Size** for the Square Energy ROI.



The dialog box titled "Energy ROI (Square) - Position/Size" has a blue header bar with a red close button. It contains three input fields: "Left [μm]" with the value 6009.9, "Top [μm]" with the value 1018.4, and "Size [μm]" with the value 475.7. At the bottom are three buttons: "Redraw" (with a dashed border), "Close", and "Cancel".

Elliptic:

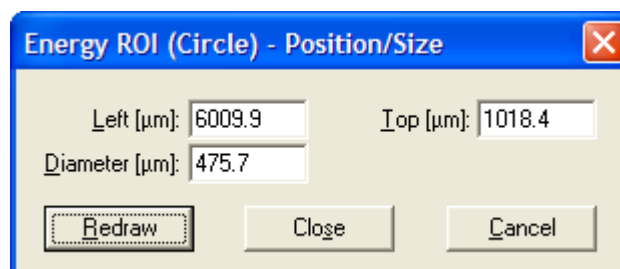
Enter the **Left**, **Top** coordinates and the **Horizontal Axis** and **Vertical Axis** for the Elliptical Energy ROI.



The dialog box titled "Energy ROI (Elliptic) - Position/Size" has a blue header bar with a red close button. It contains four input fields: "Left [μm]" with the value 6009.9, "Top [μm]" with the value 1018.4, "H. Axis [μm]" with the value 475.7, and "V. Axis [μm]" with the value 475.7. At the bottom are three buttons: "Redraw" (with a dashed border), "Close", and "Cancel".

Circle:

Enter the **Left**, **Top** coordinates and the **Diameter** of the Circle Energy ROI.



The dialog box titled "Energy ROI (Circle) - Position/Size" has a blue header bar with a red close button. It contains three input fields: "Left [μm]" with the value 6009.9, "Top [μm]" with the value 1018.4, and "Diameter [μm]" with the value 475.7. At the bottom are three buttons: "Redraw" (with a dashed border), "Close", and "Cancel".

Redraw

Redraws the beam area based on the new coordinates and keep the **Energy ROI-Position/Size** dialog box open.

Close

Closes the dialog box.

Cancel

Ignores any changes made during the drawing/adjusting mode, reverts Energy ROI to its original size and position and closes the dialog box.

The Beam Area and Energy ROI drawing functions can also be accessed on the **Video** window toolbar: (Note: The ROI drawing tools are only available if **Flat Top Analysis** is enabled.)



Set Beam Area drawing tool.



Energy ROI: Elliptical region drawing tool



Energy ROI: Circular region drawing tool



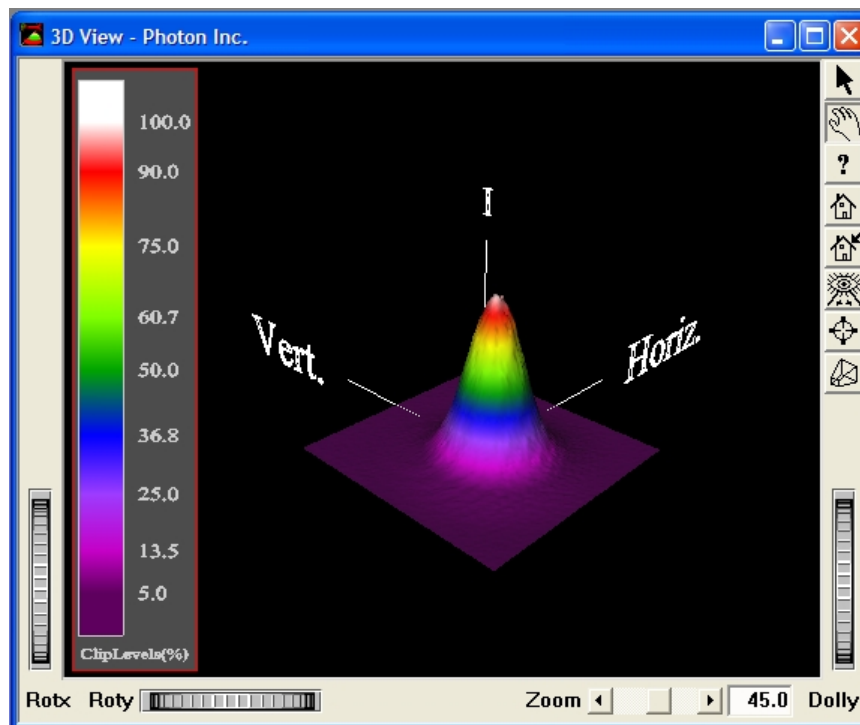
Energy ROI: Rectangular region drawing tool



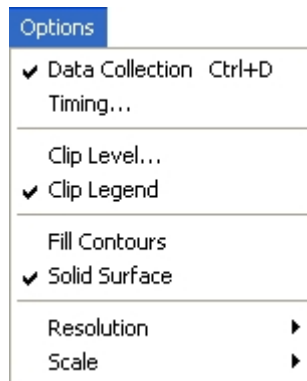
Energy ROI: Square region drawing tool

4.5.3. 3D Profile

The **3D Profile** window displays the laser beam image in a '3-dimensional' viewing format. The laser beam image can be rendered with either a wireframe or solid surface, with user selected clip levels and colors.



The **Options** menu available when the **3D Profile** window is active is shown below.



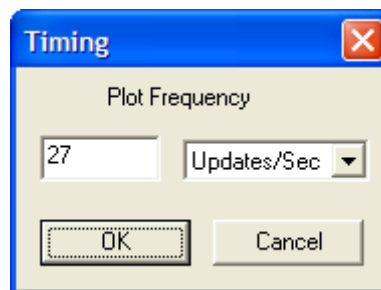
The selections are:

Data Collection

Turns data collection on and off.

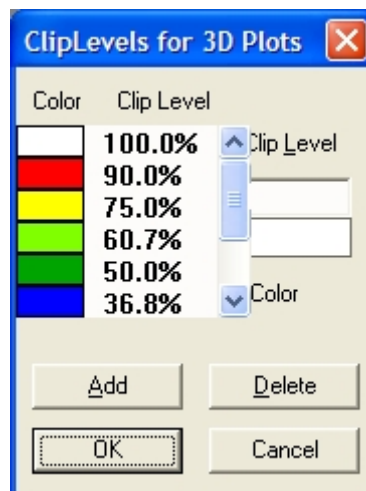
Timing...

Opens a dialog box for selection of the display update rate.





Clip Level...

Opens a dialog for selecting clip level contours and their colors.



This option is not available for data displayed using the logarithmic scale. In this case, the contour levels are fixed at the 0, -3, -5, -10, -13, -20, -23, -30, and the -33 dB levels.

Clip Legend	When selected, the Clip Level legend will be displayed in the view.
Fill Contours	When selected, the different clip levels on the beam will be clearly delineated. Please be aware that this option will slow the acquisition rate of the system.
Solid Surface	When selected, the image will have a solid surface. When not selected, the image will be rendered as a wireframe.
Resolution	Opens a menu for selecting the resolution of the 3D display. Choices are: High , Medium , Low . Data update rate is reduced and image manipulation is slower as resolution is increased.
	
Scale	Allows the user to choose between a Linear and a Logarithmic scale.
	

The toolbar at the right border of the window contains 8 buttons used to select several viewing and image manipulation features. These buttons are, from top to bottom:



Chooses the **Arrow** cursor, which allows image manipulation only using the mouse and the thumbwheel controls.



Chooses the **Hand** cursor, which allows image manipulation using the mouse directly in the image or by using the thumbwheel controls. (When the mouse is moved to the window border the **Hand** cursor changes to the **Arrow** cursor).



This **Help** menu is inactive.



Resets the view to a preset **Home** default position, size and orientation.



Sets the default settings for the **Home** button.



Restores the view to include the entire image.



Activates the **Seek** cursor. After positioning this cursor on a selected point in the image and clicking the left mouse button, a close-up zoom to that point will be performed automatically. Also, the center of rotation will be set to that point.



Toggles between the **Perspective** and **Orthographic** projection modes.



There are also three thumbwheels along the window border, designated **Dolly**, **Rotx**, and **Roty**, which are used to zoom and rotate the 2D image.

The image can be rotated, translated, panned, and zoomed using the mouse with the **Arrow** cursor and the thumbwheel control knobs or using the mouse with the **Hand** cursor, as described below.

Rotation

Rotate the image using the mouse and the Arrow cursor with the thumbwheels labeled **Rotx** and **Roty**. Alternatively, use the mouse and the Hand cursor to directly rotate the image; Position the hand cursor over the image, depress the left mouse button, and drag the mouse to obtain the desired orientation.

Pan/Translate

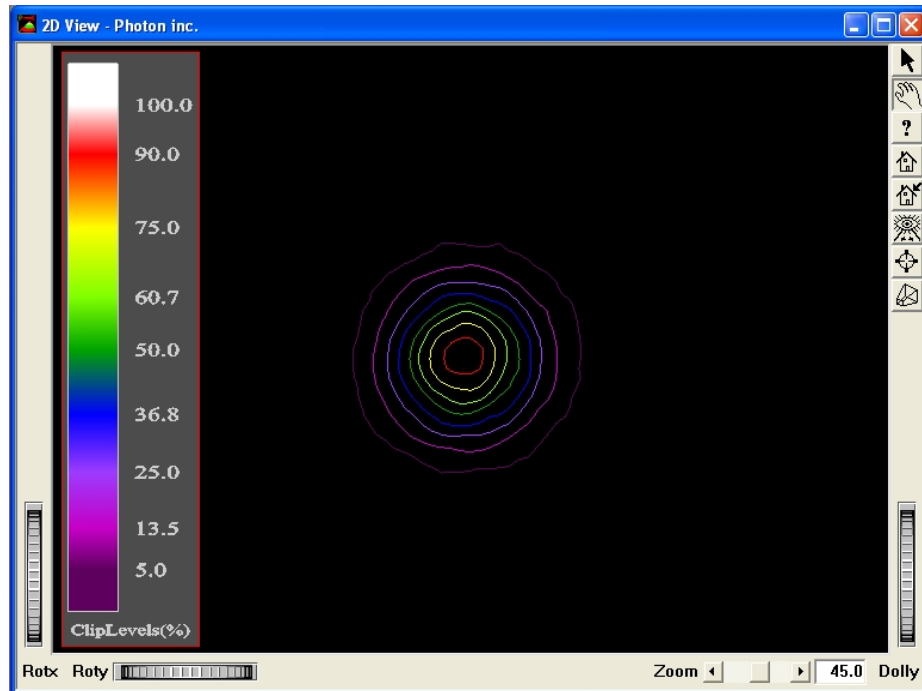
While depressing the control key <CTRL>, use the mouse and the Hand cursor to directly pan the image. Position the hand cursor over the image, depress the left mouse button, depress the control key, and drag the mouse to move the image to the desired location.

Zoom

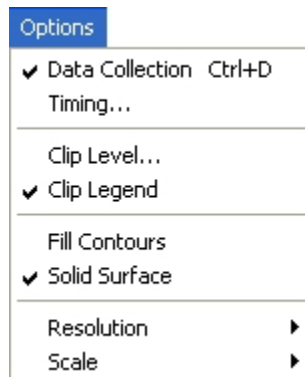
The method for zooming the image depends on the type of display projection selected. In the Perspective projection mode, use either the zoom control scroll bar at the bottom of the window, or use the **Dolly** thumbwheel at the lower right border of the window. In the **Orthographic** projection mode, use the **Zoom** thumbwheel at the lower right border of the window. You can also zoom by using the mouse. To zoom in (out) hold the Ctrl+Shift keys down and drag the mouse toward (away from) the center while holding the left mouse button.

4.5.4. 2D Contour

The **2D Contour** window displays the laser beam image with user specified contour overlays. An example of the **2D Contour** window is shown below.



The **Options** menu available when the **2D Contour** window is active is shown below.



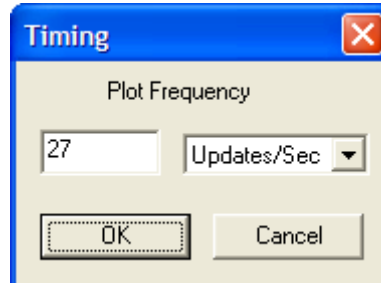
The selections are:

Data Collection

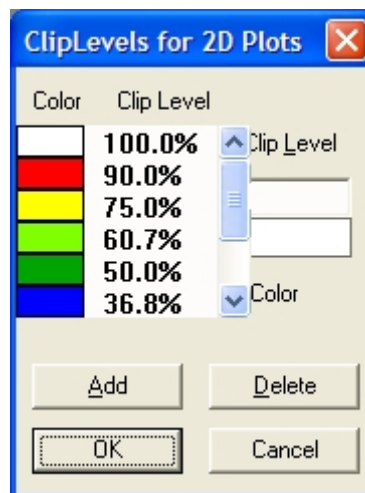
Turns data collection on and off.

Timing...

Opens a dialog box for selection of the display update rate.

**Clip Level...**

Opens a dialog for selecting clip level contours and their colors.



This option is not available for data displayed using the logarithmic scale. In this case, the contour levels are fixed at the 0, -3, -5, -10, -13, -20, -23, -30, and the -33 dB levels.

Clip Legend

When selected, the **Clip Level** legend will be displayed in the view.

Fill Contours

When selected, the different clip levels on the beam will be clearly delineated. Please be aware that this option will slow the acquisition rate of the system.

Solid Surface

When selected, the image will have a solid surface. When not selected, the image will be rendered as a wireframe.

Resolution

Opens a menu for selecting the resolution of the 3D display. Choices are: **High**, **Medium**, **Low**. Data update rate is reduced and image manipulation is slower as resolution is increased.



Scale

Allows the user to choose between a **Linear** and a **Logarithmic** scale.



The toolbar at the right border of the window contains 8 buttons used to select several viewing and image manipulation features. These buttons are, from top to bottom:



Chooses the **Arrow** cursor, which allows image manipulation only using the mouse and the thumbwheel controls.



Chooses the **Hand** cursor, which allows image manipulation using the mouse directly in the image or by using the thumbwheel controls. (When the mouse is moved to the window border the **Hand** cursor changes to the **Arrow** cursor).



This **Help** menu is inactive.



Resets the view to a preset **Home** default position, size and orientation.



Sets the default settings for the **Home** button.



Restores the view to include the entire image.



Activates the **Seek** cursor. After positioning this cursor on a selected point in the image and clicking the left mouse button, a close-up zoom to that point will be performed automatically. Also, the center of rotation will be set to that point.



Toggles between the **Perspective** and **Orthographic** projection modes.



There are also three thumbwheels along the window border, designated **Dolly**, **Rotx**, and **Roty**, which are used to zoom and rotate the image.

The image can be rotated, translated, panned, and zoomed using the mouse with the Arrow cursor and the thumbwheel control knobs or using the mouse with the Hand cursor, as described below.

Rotation

Rotate the image using the mouse and the **Arrow** cursor with the thumbwheels labeled **Rotx** and **Roty**. Alternatively, use the mouse and the **Hand** cursor to directly rotate the image; Position the hand cursor over the image, depress the left mouse button, and drag the mouse to obtain the desired orientation.

Pan/Translate

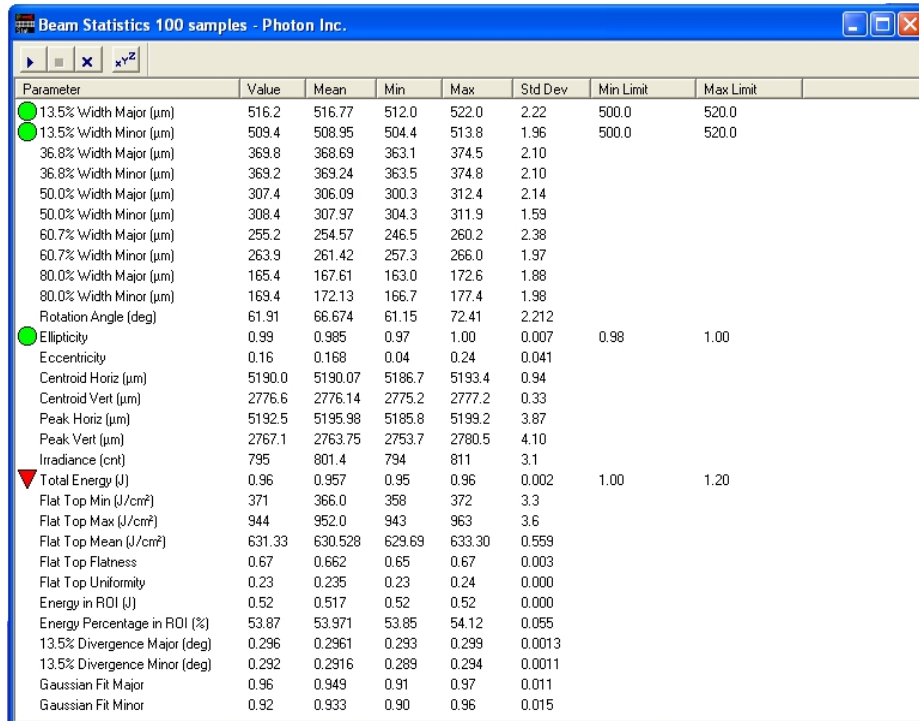
While depressing the control key <CTRL>, use the mouse and the Hand cursor to directly pan the image. Position the hand cursor over the image, depress the left mouse button, depress the control key, and drag the mouse to move the image to the desired location.

Zoom

The method for zooming the image depends on the type of display projection selected. In the Perspective projection mode, use either the zoom control scroll bar at the bottom of the window, or use the **Dolly** thumbwheel at the lower right border of the window. In the **Orthographic** projection mode, use the **Zoom** thumbwheel at the lower right border of the window. You can also zoom by using the mouse. To zoom in or out hold the Ctrl + Shift keys down and drag the mouse toward (away from) the center while holding the left mouse button.

4.5.5. Beam Statistics

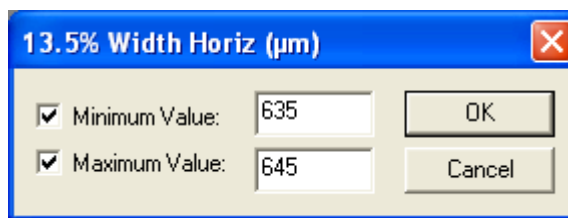
The **Beam Statistics** window, as shown below, displays a tabular summary of beam parameters and statistics. Any or all of the computed beam parameters set up in the **Data Analysis** dialog may be viewed in this way. It is also used for Limit Analysis. The parameters for viewing are selected in the **Beam Statistics Parameters** dialog box.



Parameter	Value	Mean	Min	Max	Std Dev	Min Limit	Max Limit
13.5% Width Major (μm)	516.2	516.77	512.0	522.0	2.22	500.0	520.0
13.5% Width Minor (μm)	509.4	508.95	504.4	513.8	1.96	500.0	520.0
36.8% Width Major (μm)	369.8	368.69	363.1	374.5	2.10		
36.8% Width Minor (μm)	369.2	369.24	363.5	374.8	2.10		
50.0% Width Major (μm)	307.4	306.09	300.3	312.4	2.14		
50.0% Width Minor (μm)	308.4	307.97	304.3	311.9	1.59		
60.7% Width Major (μm)	255.2	254.57	246.5	260.2	2.38		
60.7% Width Minor (μm)	263.9	261.42	257.3	266.0	1.97		
80.0% Width Major (μm)	165.4	167.61	163.0	172.6	1.88		
80.0% Width Minor (μm)	169.4	172.13	166.7	177.4	1.98		
Rotation Angle (deg)	61.91	66.674	61.15	72.41	2.212		
Ellipticity	0.99	0.985	0.97	1.00	0.007	0.98	1.00
Eccentricity	0.16	0.168	0.04	0.24	0.041		
Centroid Horiz (μm)	5190.0	5190.07	5186.7	5193.4	0.94		
Centroid Vert (μm)	2776.6	2776.14	2775.2	2777.2	0.33		
Peak Horiz (μm)	5192.5	5195.98	5185.8	5199.2	3.87		
Peak Vert (μm)	2767.1	2763.75	2753.7	2780.5	4.10		
Irradiance (cnt)	795	801.4	794	811	3.1		
Total Energy (J)	0.96	0.957	0.95	0.96	0.002	1.00	1.20
Flat Top Min (J/cm²)	371	366.0	358	372	3.3		
Flat Top Max (J/cm²)	944	952.0	943	963	3.6		
Flat Top Mean (J/cm²)	631.33	630.528	629.69	633.30	0.559		
Flat Top Flatness	0.67	0.662	0.65	0.67	0.003		
Flat Top Uniformity	0.23	0.235	0.23	0.24	0.000		
Energy in ROI (J)	0.52	0.517	0.52	0.52	0.000		
Energy Percentage in ROI (%)	53.87	53.971	53.85	54.12	0.055		
13.5% Divergence Major (deg)	0.296	0.2961	0.293	0.299	0.0013		
13.5% Divergence Minor (deg)	0.292	0.2916	0.289	0.294	0.0011		
Gaussian Fit Major	0.96	0.949	0.91	0.97	0.011		
Gaussian Fit Minor	0.92	0.933	0.90	0.96	0.015		

Limit Analysis

Limit analysis can be performed on any of the parameters reported in the **Beam Statistics** window. The parameters are checked against user specified maximum and/or minimum values and the result of the analysis is displayed using icons in the **Beam Statistics** window, as shown above. To configure the analysis, either double click with the left mouse button on the desired parameter, or, alternatively, use the **Up/Down Arrow** keys to highlight the parameter and then press the **Space** key. This will open the following dialog box for setting the parameter limits for the analysis.



13.5% Width Horiz (μm)

☒ Minimum Value: 635

☒ Maximum Value: 645

OK Cancel

Either one or both limits can be set. The icons for reporting the analysis are:



Parameter value is within the set limit or limits.

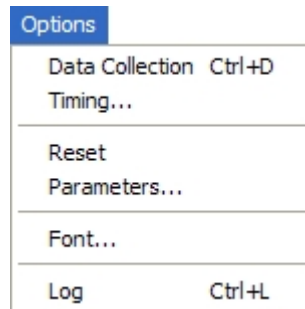


Parameter value is greater than the maximum limit.



Parameter value is less than the minimum limit.

The **Options** menu available when the **Beam Statistics** window is active offers the following selections:

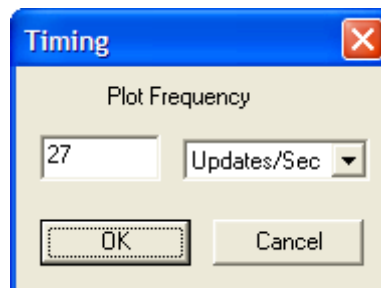


Data Collection

Turns data collection on and off.

Timing...

Opens a dialog box for selection of the display update rate.



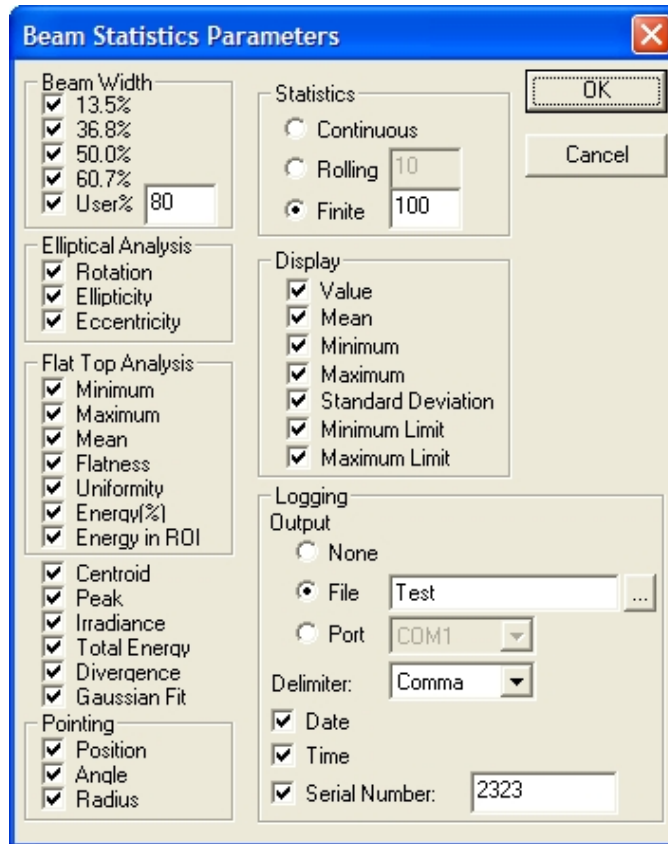
Reset

Resets the Beam Statistics table.

Parameters...

Opens the **Beam Statistics Parameters** dialog, shown below, for selecting the parameters to be listed in the Beam Statistics table. Parameters available for selection are determined by the selections made in the **Data Analysis** dialog. Those parameters that are unavailable for display are grayed out in the dialog box. This dialog is also used to select which statistical quantities to list in the table for each parameter selected and how the statistics will be calculated. All the parameters are computed in accordance with ISO Standards. In addition, the setup for data logging to files or serial communication ports is made here.

Selection options in the **Beam Statistics Parameters** dialog box are listed below.



Note: If a selection is not available or grayed out in this box, that option must first be turned on in the **Data Analysis** dialog box. In order to do this, go to **Data Collection**, select **Data Analysis** and then mark the appropriate selection.

Beam Width

13.5%	(86.5% encircled energy), horizontal and vertical or major and minor axes.
36.8%	(63.2% encircled energy), horizontal and vertical or major and minor axes.
50.0%	(50.0% encircled energy), horizontal and vertical or major and minor axes.
60.7%	(39.3% encircled energy), horizontal and vertical or major and minor axes.
User %	User Specified Value, horizontal and vertical or major and minor axes.

Elliptical Analysis


<i>Rotation</i>	Angle of the major axis with respect to horizontal
-----------------	--

<i>Ellipticity</i>	Ellipticity Factor
<i>Eccentricity</i>	Eccentricity Factor
Flat Top Analysis	
<i>Min</i>	Minimum value in the Energy ROI
<i>Max</i>	Maximum value in the Energy ROI
<i>Mean</i>	Mean value in the Energy ROI
<i>Flatness</i>	Flatness Factor
<i>Uniformity</i>	Uniformity Factor
<i>Energy %</i>	The percentage of Beam Area total energy or power in the Energy ROI.
<i>Energy in ROI</i>	The energy or power in the Energy ROI
Centroid	Location of the beam centroid reported in microns (μm) from the upper left corner of the image in the Beam Area.
Peak	Location of the peak of the image in the Beam Area.
Irradiance	The value of the irradiance at the peak location.
Total Energy	The value of the total energy or power in the Beam Area.
Divergence	Beam Divergence angle
Gaussian Fit	Gaussian Goodness-of-Fit Value
Pointing	
<i>Position</i>	The beam area Centroid from the Pointing window.
<i>Angle</i>	The pointing angle from the Pointing window.
<i>Radius</i>	Distance from the reference position in the Pointing window.
Statistics	
<i>Continuous</i>	Selects a continuous average of data samples.
<i>Rolling</i>	Selects a rolling average with user-specified number of samples.
<i>Finite</i>	Selects a finite average with user-specified number of samples.

Display

<i>Value</i>	Selects display of the present value of the beam parameter.
<i>Mean</i>	Selects display of the mean value of the beam parameter.
<i>Min</i>	Selects display of the minimum value of the beam parameter.
<i>Max</i>	Selects display of the maximum value of the beam parameter.
<i>Std Dev</i>	Selects display of the standard deviation of the beam parameter.
<i>Min Limit</i>	Selects display of the minimum limit value of the beam parameter set in Limit Analysis.
<i>Max Limit</i>	Selects display of the maximum limit value of the beam parameter set in Limit Analysis.

Logging

<i>Output</i>	
None	No data logging.
File	Data logging to specified file.
	Opens a Save As dialog box for selecting the path and file name for the log file. After you click OK the full path and file name will be displayed in the File edit box.
Port	Data logging to serial port COM1 or COM2.
<i>Delimiter</i>	Selects the delimiter format for the logged data.
Date	If selected, the date is attached to the logged file.
Time	If selected, the time is attached to the logged file.
Serial Number	If selected, the specified serial number is attached to the logged file.

Font... Opens a dialog box for selecting the type and size.

Log If data logging is enabled, one additional set of data is acquired and then displayed and/or logged to the file. If data collection is disabled for the **Beam Statistics** window, it allows the user to take individual data one set at a time and log into a file. The Hot Key 'Ctrl+L' enables logging even if another window is active as long as the **Beam**

Statistics is open.

Some options can also be selected from the **Beam Statistics** window toolbar:



Starts data collection



Stops data collection



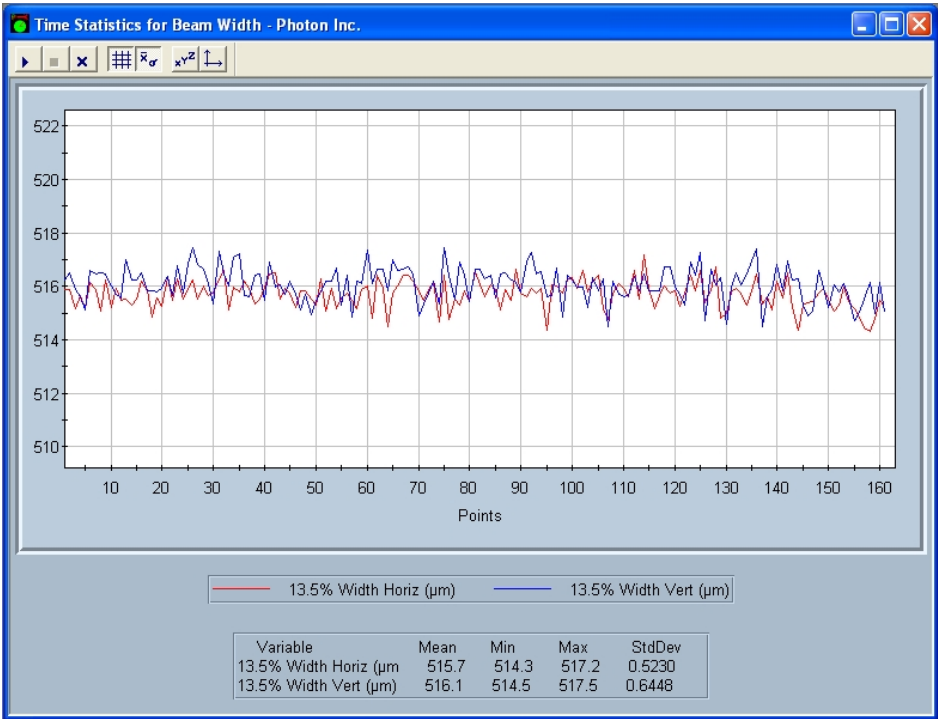
Resets table



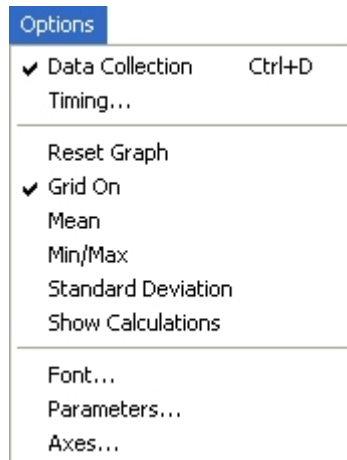
Opens **Beam Statistics Parameters** dialog

4.5.6. Time Statistics

The **Time Statistics** windows display strip charts of beam parameters versus time. Any or all computed beam parameters may be viewed in this way. Up to 15 **Time Statistics** windows can be opened. Several overlays are available in the **Options** menu, including grids, statistical markers, and numerical statistical summaries.



The **Options** menu available when the **Time Statistics** windows are active offer the following selections:

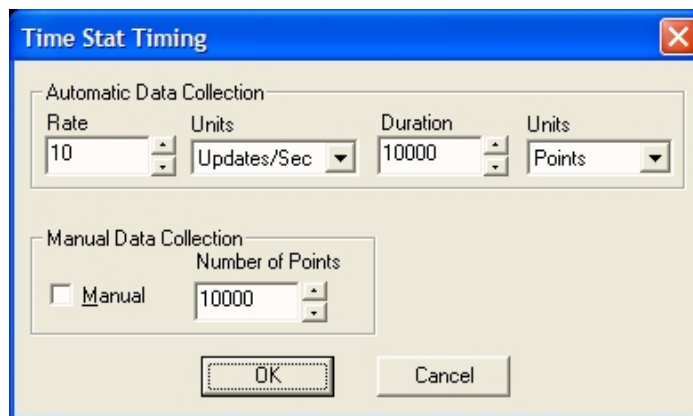


Data Collection

Turns data collection on and off.

Timing...

Opens a dialog box for selection of the display update rate and for how long data will be acquired in the active chart. If **Manual** is checked, one set of data points will be acquired each time the user selects **Data Collection**.



Reset Graph

Resets the active **Time Statistics** window. (A message prompt warns the user that old data will be lost).

Grid On

When selected, a grid overlay is displayed on the **Time Statistics** graph.

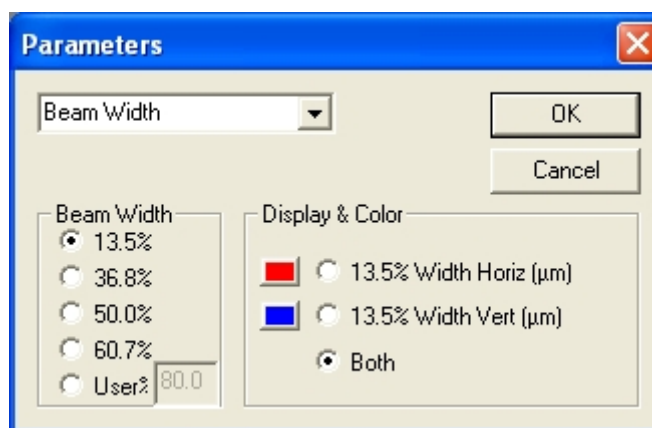
Mean

When selected, an overlay plot of the mean value is displayed.

Min/Max

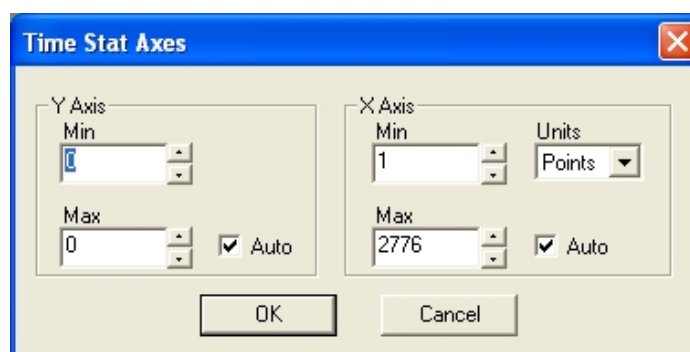
When selected, overlay plots of the minimum and maximum values are displayed.

- Standard Deviation** When selected, an overlay plot of the standard deviation is displayed.
- Show Calculations** When selected, the numerical values of the mean, minimum, maximum, and standard deviation values are displayed beneath the plot area.
- Font...** Opens a dialog box for selecting the font type and size.
- Parameters...** Opens the **Parameters** dialog box for selecting parameters to be plotted in the active **Time Statistics** window.










The choice of parameters are limited to those which are presently being computed, as set up in the **Data Analysis** dialog accessed in the **Data Collection** menu. These are the same parameters available to the **Beam Statistics** window. In addition to selecting the parameters to be plotted, this dialog is used to set the color of the plotted lines.

- Axes...** Opens a dialog box for selection of manual or automatic configuration of the axes in the **Time Statistics** display.



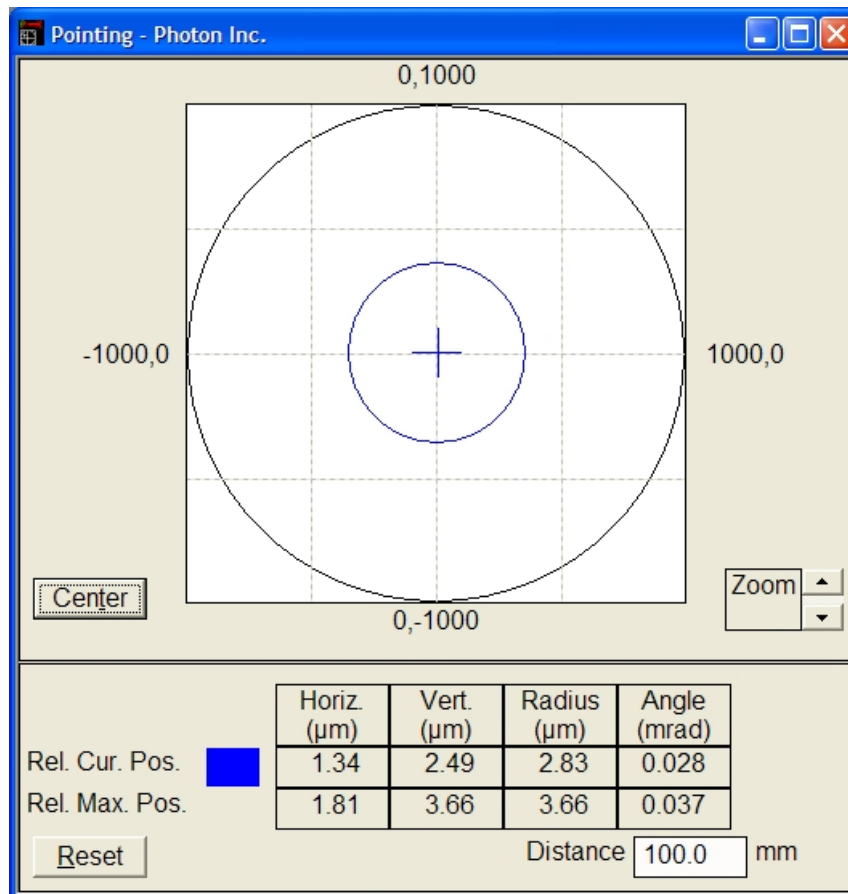
Some of the options can be selected using the **Time Statistics** window toolbar:



-  Starts data collection
-  Stops data collection
-  Resets table
-  Grid overlay on/off
-  Statistical calculations overlay on/off
-  Opens Beam **Statistics Parameters** dialog
-  Opens the **Time Stat Axes** dialog

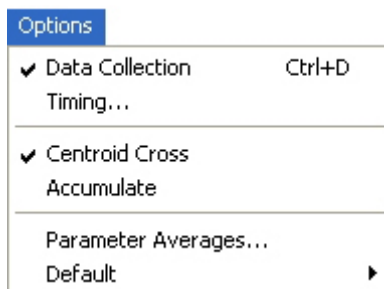
4.5.7. Pointing

The **Pointing** window displays a screen that shows and tracks the location of the beam centroid with a colored dot or cross. An example is shown below.



It also displays a table showing the relative current position and the relative maximum position in the horizontal, vertical, and radial directions, and the corresponding angular displacement. Clicking on the colored box in the window opens a color selection dialog for choosing the color of the beam dot or cross indicator. A zoom control allows the user to scale the aperture of the pointing screen.

The **Options** menu available when the **Pointing** window is active is shown below.



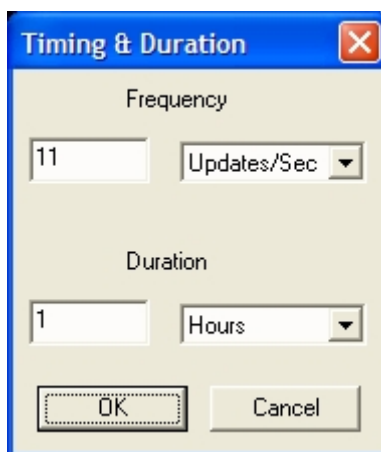
The selections are:

Data Collection

Turns data collection on and off.

Timing...

Opens a dialog box for selection of the display update rate and for how long the window will update.



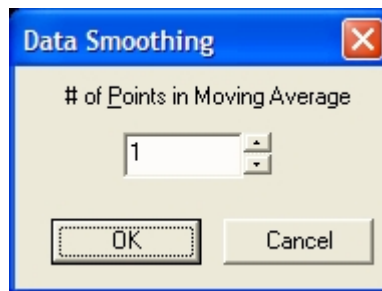
Centroid Cross

Selects the cross indicator for the centroid. If not selected the indicator is a dot.

Accumulate

Turns on the **Accumulate** mode, which displays centroid values for all subsequent data on the same plot, allowing observation of beam movement.

Parameter Averages... Opens a dialog for setting the number of points to be used in a moving average of the centered value.



Default



Load

Opens a dialog for loading a previously saved pointing screen setup.

Save

Opens a dialog for saving a pointing screen setup.

4.5.8. Notes

The **Notes** window is used for entering user information. When active, a cursor appears in the **Notes** window. Use the keyboard to enter text, and the arrow keys to navigate. There are no options available for the **Notes** window.



4.5.9. K-Factor (M² Wizard)

The **K-Factor Wizard** window is an interactive program for determining the K-factor by the Rayleigh Method. The **K-Factor Wizard** window is a series of dialog boxes that prompt and guide the user through a series of measurements and data entries required for calculating the K-factor and M². The calculated values are displayed in the final dialog box.

K Factor Wizard - Photon Inc.

Step 1: Beamwaist Measurement

Enter the laser wavelength in nanometers.
Clear the values of D_min using Reset.

Slowly translate the camera through the lens focal region.
The minimum beamwaist diameters are automatically entered.

The current values of the beam diameter, D_current, are shown below D_min.

Wavelength nm

Aperture 1 Aperture 2

D min um

D current um

Setup the laser and sensor so that you can easily move the sensor along the Z-axis (nearer or farther from the laser). Then start the K-Factor wizard. Follow the instructions that appear. Upon completing each step, select the **Next** button to continue. If you make a mistake select the **Previous** button and redo that step. When you have completed all of the steps, the wizard will display the results. It's that easy!

For more information, please read **Application Note 230** available from your Photon Inc. representative or the Photon website, www.photon-inc.com.

The formula is:

$$K = \frac{2\lambda \times 2Z_r}{\pi \times D_{min}^2} \quad \text{or} \quad M^2 = \frac{1}{K}$$

where:

λ wavelength in nm

$2Z_r$ $|Z_{max} - Z_{min}|$ - Rayleigh range

D_{min} Beam diameter in the beam waist

Z_{max} Distance along Z axis where beam diameter is $1.414 \times D_{min}$
(distal to test lens or laser)

Z_{min} Distance along Z axis on the other side of the waist where
beam diameter is $1.414 \times D_{min}$ (proximal to test lens or laser)

4.5.9.1. Measuring the K-Factor

The K-Factor is a propagation constant for a laser source defined in the ISO standard as

$$K = \frac{1}{M^2} = \frac{2\lambda \times 2Z_r}{\pi \times D_{min}^2}$$

Physically, M can be thought of as a factor times the diffraction limit. For example, if one calculates the diffraction limit for a particular lens, the source with an $M = 1.2$ will produce a spot width 1.2 times the theoretical calculated value.

The ISO standard requires 10 beam measurements and a curve-fitting algorithm. A faster method, called the Rayleigh method, provides accurate result with only 3 measurements.

The Rayleigh Method can easily be derived from the definitions and gives fast, highly accurate and repeatable K-Factor values. This method requires you to measure twice the Rayleigh length for a source. A long focal length lens (high $F\# \geq 20$) should be used. You also need the wavelength and the minimum observed beam width, D_{min} , while sweeping through the beam waist.

4.5.9.2. Lens Selection and the Expected Rayleigh Length

How does one select a focusing lens? How does one determine the Rayleigh distance for a source and a lens?

We have found that the distance along the beam axis can be measured to the nearest 1/2mm if one selects a focused beam size from 80mm to 200mm ($1/e^2$) beam width.

Example:

Source nearly collimated wavelength $0.7\mu\text{m}$ and approximate exit beam width is $500\mu\text{m}$ ($1/e^2$).

The divergence for a diffraction limited source ($M = K = 1$) will be:

$$\theta = \frac{4 \times \lambda}{\pi \times D}; \quad \theta = \frac{4 \times 0.7\mu\text{m}}{\pi \times 500\mu\text{m}} = 0.0018\text{rad};$$

We can select the lens by assuming:

$$d = f \times \theta$$

or, if we want the predicted waist diameter d near the focal plane to be $125\mu\text{m}$, the required focal length is:

$$f = \frac{125\mu\text{m}}{0.0018} = 69,444\mu\text{m} \text{ or } 69\text{mm}$$

Let's use a 75mm lens, which is more commonly found in a laboratory. The expected spot size is:

$$d = f \times \theta = 75,000\mu\text{m} \times 0.0018 = 135\mu\text{m}$$

The expected Rayleigh length in the region of the waist will be:

$$Z = \frac{\pi}{4} \times \frac{d^2}{\lambda}$$

where, d is the above $135\mu\text{m}$ calculated spot width.

$$Z = \frac{0.7854 \times 135\mu\text{m}^2}{0.7\mu\text{m}} = 20,448\mu\text{m} \text{ or } 20.4\text{mm}$$

$$2Z = 40,896\mu\text{m} \text{ or } 40.8\text{mm}$$

Thus we have a rough starting point for K-Factor measurements. If the K-Factor is much less than 1.0, the spot size will be larger than calculated and the Rayleigh length will be less than calculated. What is important is that by using the diffraction limited case one has a starting point. We suggest that one try this method with a small visible HeNe laser which is nearly always close to $K=1$ to gain an appreciation for the method before trying an unknown source. If you get close to one with the HeNe source, you will have the measurement method understood! If you get $K>1.0$, recheck alignment and go through the waist slowly enough to allow the software time to select the correct minimum waist.

4.5.9.3. Alignment

To measure K-Factor, the user should position the sensor in the beam waist. Setup the laser and the sensor so the sensor can easily move along the Z-axis. This alignment is extremely important for getting accurate results!

Alignment of the sensor and laser beam without the focusing lens:

Before inserting the lens into the path, align the sensor axial travel motion parallel to the axis of the laser. We suggest that the non-alignment be no more than a couple of beam widths. For the example laser above, this would be ± 500 microns. The **Pointing** window can be used to measure the misalignment over the Rayleigh range.

For the example source (previous section) this means one should see no more than $\pm 500\mu\text{m}$ motion either X or Y as one translates the sensor along the beam axis through a distance of $2Z$ (or 41mm for our example).

Note! *Move slowly through the waist region so the software can keep up with the measurement process.*

4.5.9.4. Insert the lens

Once the sensor and source are aligned, insert and center the lens into the beam path. Now translate the sensor through the $2Z$ length and again try to keep the cross translation to less than $\pm 1-2$ beam widths. For the example beam, use the calculated $135\mu\text{m}$ as a goal.

Be sure the lens is well centered or you will be measuring the lens aberration as well as the K-Factor for the source. With a visible source, one can usually observe a back reflection from both lens surfaces. Place the back-reflected beams just slightly to the side of the laser exit aperture. Sending the reflections back into the source may cause laser oscillations due to interference.

Another centering approach is to use a machined centered removable aperture stop just before the lens. This could fit into the lens mount during alignment and be removed before measurements. Direct the beam through this small aperture (our source example uses a 2mm hole) during alignment. Be sure to remove the stop once aligned to prevent truncation of the source and consequently errors in measured K-Factors.

Now you are ready to use the K-Factor Wizard.

4.5.9.5. Rayleigh Test Fixture Accessory

Photon offers an accessory, a Rayleigh Test Fixture, which consists of a base plate, a slide that allows manual sensor axial [Z] translation and an LCD measurement ruler. The base plate is rigidly mounted to an optical table or rail. The translation distance readout is a Mitutoyo LCD ruler that spans 150mm of travel and gives position values to the nearest 25 μ m. The total 150mm travel allows the Rayleigh range to be such that a beam waist of approximately 200 μ m can be measured.

The Mitutoyo scale can be zeroed at the first Rayleigh location, translated to the second to find a single direct read number in mm units to be inserted into the Wizard software. This accessory's purpose is to make measurements of the Rayleigh range very easy and very repeatable. The user provides a source, a focusing lens and mount.

4.5.9.6. Dual Axis Measurements with Astigmatism

To measure K-Factor when the source is astigmatic, the user will need to modify the basic procedure slightly. Figure 4.2 shows what this looks like.

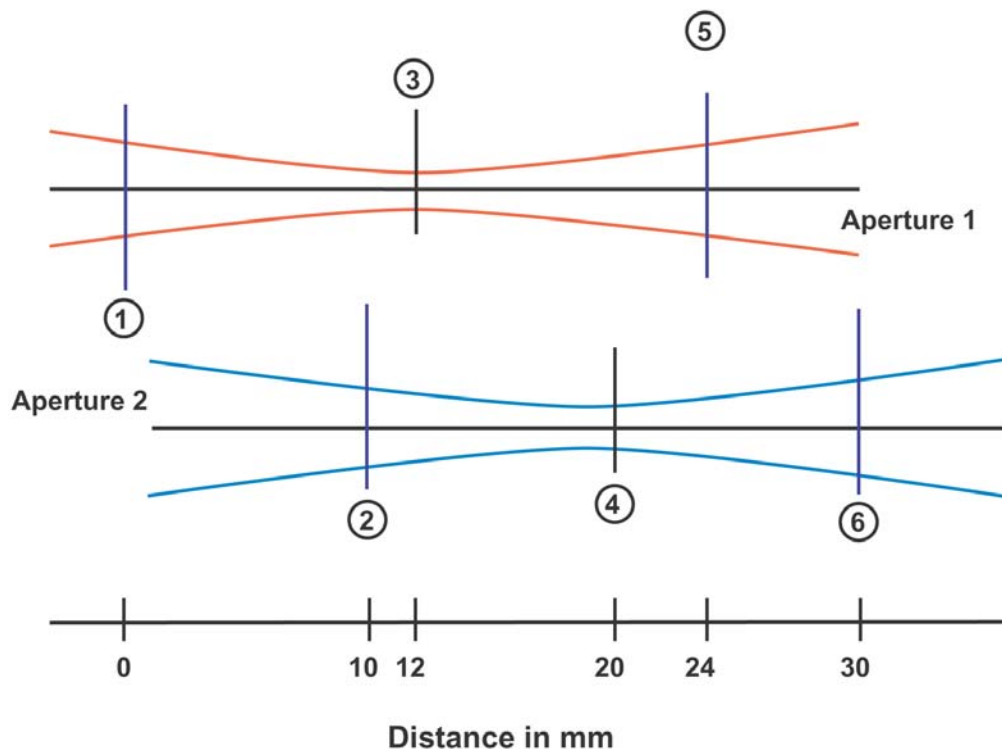


Figure 4.2. Measurement on Astigmatic Source Using the K-Factor Wizard

Example Using the Rayleigh Test Fixture Accessory:

1. Move the sensor to *D* Target for Aperture 1. Reset the Mitutoyo scale. Enter 0 for *Z* Position 1 under the Aperture 1 heading.
2. Move the sensor to *D* Target for Aperture 2. Enter 10 for *Z* Position 1 under the Aperture 2 heading. Select the Next button.
3. Move slowly through the waist for Aperture 1 and verify the D_{min} is correct.
4. Move slowly through the waist for Aperture 2 and verify the D_{min} is correct.
5. Move the sensor to *D* Target for Aperture 1. Enter 24 for *Z* Position 2 under the Aperture 1 heading.
6. Move the sensor to *D* Target for Aperture 2. Enter 30 for *Z* Position 2 under the Aperture 2 heading. Select the Next button.

















4.6. Toolbars

Toolbars are provided to speed access to some of the most commonly used operations and features of the USBeamPro Acquisition and Analysis Software. Instead of accessing these features through the pulldown menus, simply click on the appropriate icon buttons on the toolbars. The operations and features include: opening windows, turning data collection on and off, selecting the acquisition mode, turning **Autotracking** on and off, and selecting options. In addition, some file handling operations such as opening and saving files, opening new files and printing can be initiated in this way. General program features are accessed on the main toolbar, while option features for the **Video** window, **Profile** window, **Beam Statistics** window, and **Time Statistics** window are accessed on window toolbars. The toolbars and descriptions of their icon buttons and functions are given below.

For user convenience and preference, toolbars can be placed at different screen locations by dragging and dropping.

4.6.1. The Main Toolbar



	Opens a new file
	Opens the Open file dialog
	Saves the current file
	Opens the Print dialog
	Opens specific Help topics (currently inactive)
	Turns Autotracking on/off
	Turns Global Data Collection on/off
	Opens the Calibration dialog (also indicates the calibration status)
	Sets system to Laser Positioning mode
	Sets system to Analysis mode
	Sets system to Single Shot mode (currently inactive)
	Opens the Profile window
	Opens the Video window
	Opens the 3D Profile window. Up to 5 2D and 3D windows combined can be opened.
	Opens the 2D Contour window
	Opens the Beam Statistics window



Opens the **Time Statistics** windows. Up to 15 windows can be opened simultaneously.



Opens the **Pointing** window



Opens the **K-Factor** window



Opens the **Notes** window.

4.6.2. The Video Window Toolbar



Set **Beam Area** drawing tool



Energy ROI: **Elliptical** region drawing tool



Energy ROI: **Circular** region drawing tool



Energy ROI: **Rectangular** region drawing tool



Energy ROI: **Square** region drawing tool

4.6.3. The Profile Window Toolbar



Starts data collection



Stops data collection



Gaussian Fit overlay on/off



Turns **Normalization** on/off

4.6.4. The Beam Statistics Window Toolbar



Starts data collection



Stops data collection



Resets table



Opens Beam **Statistics Parameters** dialog

4.6.5. The Time Statistics Window Toolbar



Starts data collection



Stops data collection



Reset table



Grid overlay on/off



Statistical calculations overlay on/off



Opens **Beam Statistics Parameters** dialog



Opens **Time Stat Axes** dialog

4.7. Status Bar

The status bar at the bottom of the screen displays the Trigger Mode, cursor location and the Beam Area information. The first pane displays the trigger mode: CW, Ext or Pulsed. The second pane displays intensity in counts at the mouse cursor location (when is pointing over the Live Window), given by position coordinates in microns, from the upper left corner. The third pane displays the position coordinates of the upper left corner in the Beam Area (BA) and the dimensions in microns of the Beam Area. The fourth pane displays the update rate in frames/second while global data collection is turned on. The last pane displays information about the calibration status.

For Help, press F1 Trigger: CW 954 cnts @ (5755.30 μm, 1855.90 μm) BA: 0(L), 0(T) 8569(W) × 6854(H) (μm) 12.97 upd/s System uncalibrated

4.8. ActiveX Automation

USBeamPro Acquisition and Analysis Software provides a Microsoft Automation interface. As an automation server, USBeamPro Acquisition and Analysis Software exposes a set of methods and properties. Using ActiveX compatible programs such as LabVIEW or Microsoft Excel, a user can create his own Automation controller, which can display and process data from USBeamPro Acquisition and Analysis Software.

The type library “*USBeamPro.tlb*” file in the Automation folder where the software has been installed contains a full description of the ActiveX interface. You can open and view this file with an OLE/COM viewer program.

The properties and methods that USBeamPro Analysis Software exports are explained below.

4.8.1. AcquisitionMode

Property Type:

VT_I2 - acquisition mode

Remarks:

Gets or sets acquisition mode.

Possible values are defined in the type library file by the SelectionAcquisitionMode enumeration:

Acquisition Mode Selection	Value	Comments
SEL_ACQMODE_ANALYSIS	0	Analysis Acquisition Mode
SEL_ACQMODE_LASERPOS	1	Laser Positioning Acquisition Mode
SEL_ACQMODE_SINGLESOT	2	Not available

4.8.2. TriggerMode

Property Type:

VT_I2 - trigger mode

Remarks:

Gets or sets trigger mode.

Possible values are defined in the type library file by the SelectionTriggerMode enumeration:

Trigger Mode Selection	Value	Comments
SEL_TRIGGER_CW	0	Trigger Mode – CW
SEL_TRIGGER_PULSED	1	Trigger Mode - Pulsed
SEL_TRIGGER_EXT	2	Trigger Mode - External

4.8.3. AcquisitionResolution

Property Type:

VT_I2 - acquisition resolution

Remarks:

Gets or sets the acquisition resolution.

Possible values are defined in the type library file by the SelectionAcquisitionResolution enumeration:

Acquisition Resolution Selection	Value	Comments
SEL_RESOLUTION_1X	1	Acquisition Resolution – 1 ×
SEL_RESOLUTION_2X	2	Acquisition Resolution – ½ ×

4.8.4. GlobalDataCollection

Property Type:

VT_BOOL - global data collection

Remarks:

Enables or disables data collection and queries the value of the flag.

4.8.5. AutoTracking

Property Type:

VT_BOOL - auto track

Remarks:

Enables or disables the auto track feature and queries the value of the flag.

4.8.6. MagnificationFactor

Property Type:

VT_R4 – magnification factor

Remarks:

Gets or sets the external optics magnification factor. The range for the magnification factor value is between 0.01 and 1000.

4.8.7. AngleUnits

Property Type:

VT_I2 – angle units

Remarks:

Gets or sets the units used for reporting all the angles. Possible values are defined in the type library file by the SelectionAngleUnits enumeration:

Angle Units Selection	Value	Comments
SEL_ANGLE_UNITS_MRAD	0	Reports all the angles in miliradians
SEL_ANGLE_UNITS_DEG	1	Reports all the angles in degrees

4.8.8. ISOWidthMethod

Property Type:

VT_I2 - method for computing beam width

Remarks:

Gets or sets the method used for computing beam widths.

If the 4Sigma method is selected, only the $1/e^2$ clip level beam width is computed.

Possible values are defined in the type library file by the SelectionISOWidth enumeration:

ISO Width Method Selection	Value	Comments
SEL_ISO_D_SLIT	1	Slit method used for computing beam widths.
SEL_ISO_D_ENERGY	2	Encircled energy method used for computing beam widths.
SEL_ISO_D_4SIGMA	3	Second moment method (4Sigma) used for computing beam widths.

4.8.9. UseCliplevel

Method Return Value:

VT_EMPTY - none

Method Parameter List:

VT_S_R4 - cliplevel in percentage

VT_BOOL - use

Remarks:

Enables beam width computation at the specified clip level.

If the selected ISO method for computing the beam width is Energy, the beam energy should be used instead of the clip level.

To enable beam width computation at a specified clip level, set the use flag to TRUE. To disable beam width computation at a specified clip level, set the use flag to FALSE.

Without this function call, the beam width numbers returned from USBeamPro may not be valid. This function has to be called only once, at the beginning of the program, before any call to GetPeakWidth, GetEllipticity, GetEccentricity or GetPeakDivergence.

4.8.10. GetWidth

Method Return Value:

VT_R4 - beam width

Method Parameter List:

VT_I2 - axis

VT_S_R4 - cliplevel

Remarks:

Returns the beam width in microns.

If the selected ISO method for computing the beam width is Energy, the beam energy should be used instead of the clip level.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see EllipticAnalysis), 0 represents the major axis and 1 the minor axis. Otherwise 0 is the horizontal axis and 1 the vertical axis, where horizontal and vertical are relative to the camera.

If the selected ISO method for computing the beam width is Energy, then only one beam width number is computed. In this case, the beam width values for axis 0 and axis 1 are equal.

If the selected ISO method for computing the beam width is 4Sigma, then only the beam width is computed. The specified "clip level" must be $1/e^2$.

To enable beam width computations for the specified clip level, UseCliplevel has to be called before the first call to GetPeakWidth,

4.8.11. GetPeakPosition

Method Return Value:

VT_R4 - peak position

Method Parameter List:

VT_S_I2 - axis

Remarks:

Returns the peak position in microns.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see EllipticAnalysis), 0 represents the major axis and 1 the minor axis. Otherwise 0 is the horizontal axis and 1 the vertical axis, where horizontal and vertical are relative to the camera.

4.8.12. GetCenter

Method Return Value:

VT_R4 - centroid position

Method Parameter List:

VT_S_I2 - axis

Remarks:

Returns the centroid position in microns.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see EllipticAnalysis), 0 represents the major axis and 1 the minor axis. Otherwise 0 is the horizontal axis and 1 the vertical axis, where horizontal and vertical are relative to the camera.

4.8.13. GetPeakIrradiance

Method Return Value:

VT_I2 - peak irradiance

Method Parameter List:

VT_S_NONE - none

Remarks:

Returns the irradiance of the peak. Possible values are 0...1023.

4.8.14. EllipticAnalysis

Property Type:

VT_BOOL - elliptic analysis

Remarks:

Gets or sets the elliptical analysis flag.

If this flag is TRUE, the elliptical analysis is enabled and GetRotationAngle, GetEllipticity and GetEccentricity will return valid numbers.

4.8.15. GetRotationAngle

Method Return Value:

VT_R4 - rotation angle

Method Parameter List:

VT_S_NONE - none

Remarks:

Returns the orientation of the computed major axis in degrees.

This function returns valid numbers only if elliptical analysis has been enabled, using EllipticAnalysis.

4.8.16. GetEllipticity

Method Return Value:

VT_R4 - ellipticity

Method Parameter List:

VT_S_R4 - cliplevel

Remarks:

Returns the ellipticity of the beam.

If the selected ISO method for computing the beam width is Energy, the beam energy should be used instead of the clip level. In this case, the ellipticity will be 1, because there is only one beam width value.

This function returns valid numbers only if elliptical analysis has been enabled, using EllipticAnalysis. Also the beam width computation for the specified clip level should have been enabled, using UseCliplevel, because the beam width numbers are used in the computation of the ellipticity.

4.8.17. GetEccentricity

Method Return Value:

VT_R4 - eccentricity

Method Parameter List:

VT_S_R4 - cliplevel

Remarks:

Returns the eccentricity of the beam.

If the selected ISO method for computing the beam width is Energy, the beam energy should be used instead of the clip level. In this case, the eccentricity will be 0, because there is only one beam width value.

This function returns valid numbers only if elliptical analysis has been enabled, using EllipticAnalysis. Also the beam width computation for the specified clip level should have been enabled, using UseCliplevel, because the beam width numbers are used in the computation of the eccentricity.

4.8.18. FlatTopAnalysis

Property Type:

VT_BOOL - flat top analysis

Remarks:

Gets or sets the flat top analysis flag.

Flat top numbers will be computed over a Region of Interest that can be user-defined.

If this flag is TRUE, the flat top analysis is enabled and GetFlatTopMin, GetFlatTopMax, GetFlatTopMean, GetFlatTopFlatness, GetFlatTopUniformity and GetFlatTopEnergy will return valid numbers.

4.8.19. FlatTopThreshold

Property Type:

VT_R4 - flat top threshold

Remarks:

Gets or sets the threshold value (percentage of the peak pixel value) used for flat top analysis.

The allowed range of the threshold is between 0 and 100.

4.8.20. GetFlatTopMin

Method Return Value:

VT_I2 - flat top minimum

Method Parameter List:

VTI_NONE - none

Remarks:

Returns the minimum pixel value in the defined Region of Interest.

This function returns valid numbers only if flat top analysis has been enabled, using FlatTopAnalysis.

4.8.21. GetFlatTopMax

Method Return Value:

VT_I2 - flat top maximum

Method Parameter List:

VTI_NONE - none

Remarks:

Returns the maximum pixel value in the defined Region of Interest.

This function returns valid numbers only if flat top analysis has been enabled, using FlatTopAnalysis.

4.8.22. GetFlatTopMean

Method Return Value:

VT_R4 - flat top mean

Method Parameter List:

VTs_NONE - none

Remarks:

Returns the mean value of all pixels in the defined Region of Interest.

This function returns valid numbers only if flat top analysis has been enabled, using FlatTopAnalysis.

4.8.23. GetFlatTopFlatness

Method Return Value:

VT_R4 - flat top flatness

Method Parameter List:

VTs_NONE - none

Remarks:

Returns the beam flatness in the defined Region of Interest. Flatness is defined as the ratio of the average to the maximum power density. The range is 0 -1 with 1 being a perfectly flat beam.

This function returns valid numbers only if flat top analysis has been enabled, using FlatTopAnalysis.

4.8.24. GetFlatTopUniformity

Method Return Value:

VT_R4 - flat top uniformity

Method Parameter List:

VTs_NONE - none

Remarks:

Returns the beam uniformity in the defined Region of Interest. Uniformity is defined as the normalized RMS deviation of power energy density from its average. A value of 1 indicates a completely uniform distribution having a profile with a flat top and vertical edges.

This function returns valid numbers only if flat top analysis has been enabled, using FlatTopAnalysis.

4.8.25. GetFlatTopEnergy

Method Return Value:

VT_R4 - flat top energy

Method Parameter List:

VT_NONE - none

Remarks:

Returns the total sum of the pixels inside of the defined Region of Interest.

This function returns valid numbers only if flat top analysis has been enabled, using FlatTopAnalysis.

4.8.26. GaussianFitAnalysis

Property Type:

VT_BOOL - Gaussian analysis

Remarks:

Gets or sets the Gaussian analysis flag.

If this flag is TRUE, the 1-dimensional Gaussian analysis is enabled and Gaussian fit numbers can be computed using Get1dGaussianFit.

4.8.27. Get1dGaussianFit

Method Return Value:

VT_R4 - Gaussian fit

Method Parameter List:

VT_I2 - axis

Remarks:

Returns Gaussian fit numbers.

This function returns valid numbers only if Gaussian analysis has been enabled, using GaussianFitAnalysis.

Gaussian fit numbers are computed for the profiles that represent a pinhole scan through the data. In USBeamPro these profiles and their correspondent Gaussian fitted profiles can be visualized in the Profile view.

Usually the pinhole data is obtained from a scan through the beam centroid.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see EllipticAnalysis), 0 represents the major axis and 1 the minor axis. Otherwise 0 is the horizontal axis and 1 the vertical axis, where horizontal and vertical are relative to the camera.

If the user has moved the position of the cross hairs in the LiveVideo (either to peak, or to a user-defined point), the pinhole scan will go through the newly defined intersection of the two axes. The user can also change the rotation of the major and minor axes.

4.8.28. BackgroundCorrection

Property Type:

VT_I2 - background correction method

Remarks:

Gets or sets the method used for subtracting the camera background.

Possible values are defined in the type library file by the SelectionBackgroundSubtraction enumeration:

Acquisition Resolution Selection	Value	Comments
SEL_BKGND_NONE	-1	No background subtraction
SEL_BKGND_FRAME	0	Frame subtraction
SEL_BKGND_MEAN	1	Mean subtraction

4.8.29. SetDivergenceMethod

Method Return Value:

VT_EMPTY - none

Method Parameter List:

VTS_I2 - divergence method

VTS_R4 - distance

VTS_R4 - cliplevel

Remarks:

Sets the divergence method and associated parameters used for the divergence calculation.

If the selected ISO method for computing the beam width is Energy, the beam energy should be used instead of the clip level.

Possible values for divergence method are defined in the type library file by the SelectionDivergenceMethod enumeration:

Divergence Method Selection	Value	Comments
SEL_DIV_METHOD_OFF	0	No divergence computations.
SEL_DIV_METHOD_LENS	1	Lens method for computing divergence.
SEL_DIV_METHOD_PT SRC	2	Point Source method for computing divergence.
SEL_DIV_METHOD_NA	3	Numerical Aperture method for computing divergence.

The distance parameter represents the Focal Length if the Lens method has been selected, or the Distance from the Point Source if the method is Point Source or Numerical Aperture.

4.8.30. GetDivergenceMethod

Method Return Value:

VT_EMPTY - none

Method Parameter List:

VT_S_P12 - divergence method

VT_S_P4 - distance

VT_S_P4 - cliplevel

Remarks:

Gets the divergence method and associated parameters used for the divergence calculation.

4.8.31. GetDivergence

Method Return Value:

VT_R4 - divergence

Method Parameter List:

VT_S_I2 - axis

Remarks:

Returns the divergence.

Before measuring divergence, the divergence parameters should have been set using SetDivergenceMethod and the beam width computation should have been enabled for the specified clip level using UseCliplevel.

The divergence is returned in mrad if the selected divergence method is Lens, degrees if the selected divergence method is PointSource and is unitless if the selected divergence method is NumericAperture.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see EllipticAnalysis), 0 represents the major axis and 1 the minor axis. Otherwise 0 is the horizontal axis and 1 the vertical axis, where horizontal and vertical are relative to the camera.

4.8.32. GetProfileData

Method Return Value:

VT_VARIANT - profile data array

Method Parameter List:

VT_S_I2 - axis

VT_S_I4 - start index

VT_S_I4 - number of points

Remarks:

Returns an array of data points that represents a pinhole scan through the beam area.

Usually the pinhole data is obtained from a scan through the beam centroid.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see EllipticAnalysis), 0 represents the major axis and 1 the minor axis. Otherwise 0 is the horizontal axis and 1 the vertical axis, where horizontal and vertical are relative to the camera.

If the user has moved the position of the cross hairs in the LiveVideo (either to peak, or to a user-defined point), the pinhole scan will go through the newly defined intersection of the two axes. The user can also change the rotation of the axes.

Start index represents the index in the pinhole scan data array that will correspond to the first data point returned.

Number of points represents how many points will be copied in the returned array.

4.8.33. GetProfileSampleSize

Method Return Value:

VT_R4 - sample size

Method Parameter List:

VT_S_I2 - axis

Remarks:

Returns the sample size: the distance between two data points of the profile data array, in microns.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see EllipticAnalysis), 0 represents the major axis and 1 the minor axis. Otherwise 0 is the horizontal axis and 1 the vertical axis, where horizontal and vertical are relative to the camera.

4.8.34. GetProfileNumPts

Method Return Value:

VT_I2 - number of points

Method Parameter List:

VT_S_I2 - axis

Remarks:

Returns the number of points in the profile data array, which is bound, by the beam area.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see EllipticAnalysis), 0 represents the major axis and 1 the minor axis. Otherwise 0 is the horizontal axis and 1 the vertical axis, where horizontal and vertical are relative to the camera.

4.8.35. GetSampleSize

Method Return Value:

VT_R4 - sample size

Method Parameter List:

VT_S_NONE - none

Remarks:

Returns the dimension of one pixel from the data array, in microns.

4.8.36. GetNumPts

Method Return Value:

VT_I4 - number of points

Method Parameter List:

VT_S_I2 - axis

Remarks:

Returns the number of points inside the beam area.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see EllipticAnalysis), 0 represents the major axis and 1 the minor axis. Otherwise 0 is the horizontal axis and 1 the vertical axis, where horizontal and vertical are relative to the camera.

4.8.37. GetTotalSize

Method Return Value:

VT_I4 - total size

Method Parameter List:

VT_I2 - axis

Remarks:

Returns the dimension of the beam area, in microns.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see EllipticAnalysis), 0 represents the major axis and 1 the minor axis. Otherwise 0 is the horizontal axis and 1 the vertical axis, where horizontal and vertical are relative to the camera.

4.8.38. GetStartPos

Method Return Value:

VT_I4 - start position

Method Parameter List:

VT_I2 - axis

Remarks:

Returns the distance from the edge of the camera chip to the beam area in microns.

Possible values for the axis are 0 and 1. If elliptical analysis has been enabled (see EllipticAnalysis), 0 represents the major axis and 1 the minor axis. Otherwise 0 is the horizontal axis and 1 the vertical axis, where horizontal and vertical are relative to the camera.

4.8.39. ImageRotation

Property Type:

VT_I2 – image rotation

Remarks:

Gets or sets the clockwise rotation of the image from the original frame. Possible values are 0, 90, 180 or 270.

4.8.40. ImageFlip

Property Type:

VT_I2 - image flip

Remarks:

Gets or sets the orientation of the image with respect to Vertical and Horizontal. Possible values are defined in the type library file by the ImageFlipSelection enumeration:

Image Flip Selection	Value	Comments
SEL_FLIP_NONE	0	Display the original frame
SEL_FLIP_HORIZ	1	Flip the image about the horizontal axis
SEL_FLIP_VERT	2	Flip the image about the vertical axis

4.8.41. DoCalibration

Method Return Value:

VT_EMPTY - none

Method Parameter List:

VTS_NONE - none

Remarks:

Performs a calibration routine for the camera.

4.8.42. IsCalibrated

Method Return Value:

VT_BOOL - calibration status

Method Parameter List:

VTS_PDATE – date when the system calibration occurred

Remarks:

This method returns the calibration status of the system.

4.8.43. SetBeamArea

Method Return Value:

VT_BOOL – if Beam Area has been modified successfully

Method Parameter List:

VTs_R4 - left

VTs_R4 - top

VTs_R4 - right

VTs_R4 - bottom

Remarks:

Sets a manual Beam Area. Turn AutoTrack off before you use this function, otherwise the Beam Area may change automatically while the software is trying to track the beam. The parameter list values are the coordinates of the Beam Area rectangle in microns, from the upper left corner of the array (which is (0,0)). If the Beam Area cannot be set (the coordinates are not within the array range), the return value is FALSE. If the Beam Area has been modified successfully, the return value is TRUE.

4.8.44. GetBeamArea

Method Return Value:

VT_BOOL – Beam Area status

Method Parameter List:

VTs_PR4 - left

VTs_PR4 - right

VTs_PR4 - top

VTs_PR4 - bottom

Remarks:

Gets the Beam Area coordinates. The parameter list values are the coordinates of the Beam Area rectangle in μm , from the upper left corner of the array (which is (0, 0)). If there is no Beam Area the return value is FALSE. If there is a valid Beam Area the return value is TRUE.

4.8.45. ComputationsDone

Property Type:

VT_BOOL – computations flag

Remarks:

Gets or sets the status of the frame computation. If this flag is TRUE that means that at least one frame was acquired and processed. Set this flag to FALSE before initiate a data acquisition and then wait until the state is TRUE in order to be sure a new frame was acquired and processed.

4.8.46. Recompute

Method Return Value:

VT_EMPTY - none

Method Parameter List:

VTS_NONE - none

Remarks:

Redo computations for selected parameters based on the current settings. Computations are done on the image data that is currently in memory.

4.8.47. GetTotalEnergy

Method Return Value:

VT_R4 - total energy

Method Parameter List:

VT_S_NONE - none

Remarks:

Returns total sum of the pixels inside of the defined Beam Area.

4.8.48. IsSaturated

Method Return Value:

VT_BOOL – saturation flag

Method Parameter List:

VT_S_NONE - none

Remarks:

Returns TRUE if signal is saturated, FALSE otherwise.

4.8.49. ShowWindow

Property Type:

VT_BOOL – Show flag

Remarks:

Shows or hides the USBeamPro Analysis Software main window. Call this function with FALSE as parameter to hide the USBeamPro Analysis Software. Call this function with TRUE if you want to show the USBeamPro Analysis Software.

4.8.50. ProfileType

Property Type

VT_I2 - profile type

Remarks:

Gets or sets the profile types, either Pinhole or equivalent Slit. The value set with this function will impact the arrays obtained by GetProfileData method. Possible values are defined in the type library file by the ProfileTypeSelection enumeration:

Profile Type Selection	Value	Comments
SEL_PROFILE_PINHOLE	0x00	Pinhole profiles through the crosshairs.
SEL_PROFILE_SLIT	0x01	Equivalent slit profiles.

4.8.51. Get2DData

Method Return Value:

VT_VARIANT - 2D data array

Method Parameter List:

VTS_R4 - left

VTS_R4 - top

VTS_R4 - right

VTS_R4 - bottom

VTS_I2 - decimation

Remarks:

Returns a 2D-array (matrix) of data points representing the 2D intensity data (values between 0 and 1023). The first four values from the parameter list are the coordinates of the rectangle area from where the data is exported, in μm , the coordinates are reported from the upper left corner of the array (which is (0, 0)). The decimation value can be used to read out a smaller array of data and it is used in both lines and columns of the matrix (transfer every n^{th} pixel on every n^{th} line, where n is the decimation value).

4.8.52. CameraExposure

Property Type

VT_R4 – camera exposure

Remarks:

Gets or sets the exposure time for the camera, in ms. The range for the exposure value is from 0.03 to 30.

4.8.53. Averaging

Property Type

VT_I2 – average value

Remarks:

Gets or sets the number of frames used in averaging. The range for the average value is between 1 and 1000.

4.8.54. ProfileCrossHairsType

Property Type

VT_I2 – profile cross hairs

Remarks:

Gets or sets profile cross hairs type. If the Profile Type is set to Slit (Equivalent Slit Profiles) the only option available is Centroid.

Possible values are defined in the type library file by the SelectionProfileCrossHairsType enumeration:

Profile Cross Hairs Selection	Value	Comments
SEL_XHAIR_CENTROID	0	Cross hairs through the centroid
SEL_XHAIR_PEAK	1	Cross hairs through the peak
SEL_XHAIR_USERDEF	2	Cross hairs through a user defined position

4.8.55. SetProfileCrossHairsPos

Method Return Value:

VT_BOOL – if position for profile Cross Hairs has been modified successfully

Method Parameter List:

VTs_R4 - posHoriz

VTs_R4 - posVert

Remarks:

Sets the position (horizontal and vertical) for the user defined crosshairs, in microns. This method can be called only if the Profile Type is set to Slit (Equivalent Slit Profiles).

4.8.56. GetProfileCrossHairsPos

Method Return Value:

VT_BOOL – if position for profile Cross Hairs has been retrieved successfully

Method Parameter List:

VTs_PR4 - posHoriz

VTs_PR4 - posVert

Remarks:

Retrieves the position (horizontal and vertical) for the crosshairs, in microns.

4.8.57. SaveFrameAsTIFF

Method Return Value:

VT_BOOL - Save Flag status

Method Parameter List:

VTs_BSTR - file full name (with qualified path if necessary)

Remarks:

Saves the current frame (raw image) as an uncompressed 16-bit TIFF file. If the operation was successful, the method returns TRUE, otherwise returns FALSE.

4.8.58. GetCameraList

Method Return Value:

VT_VARIANT – array of strings; each string uniquely corresponds to a camera present on the system

Method Parameter List:

VTS_NONE – none

Remarks:

Call this property to retrieve the number of cameras present on the system, and for each camera the uniquely associated corresponding string. The first element in the array always corresponds to the camera that is currently used by the USBeamPro software. These strings need to be passed as parameter to SelectCamera method in order to select a specific camera.

4.8.59. SelectCamera

Method Return Value:

VT_BOOL – Camera selection status

Method Parameter List:

VTS_BSTR – Camera identifier

Remarks:

Selects a different camera for use with the USBeamPro software. To select a camera pass the uniquely associated string with the camera that was listed in the GetCameraList method.

If the operation was successful, the method returns TRUE, otherwise returns FALSE.

After a new camera was selected the system is not calibrated and the global data collection is turned off.

4.8.60. Example files

In the Automation folder under the folder where the software has been installed (the default settings is “C:\Program Files\Photon\USBeamPro”) there are two detailed examples about using ActiveX: one written in Visual Basic for Application (VBA) using Microsoft Excel “USBeamPro ActiveX Example.xls” and one developed in LabVIEW “USBeamPro ActiveX Example.vi”.

5. *FREQUENTLY ASKED QUESTIONS*

Q1. The following questions all pertain to the measurement of energy or power in your laser beam. Please refer to the answer below:

- ◆ How do I measure energy/power in my beam?
- ◆ How do I measure the energy/power in a section of my beam?
- ◆ What does "ROI" mean?
- ◆ How do I set the region of interest?
- ◆ How do I change the energy units from CNT to something meaningful?
- ◆ How do I measure fluence?
- ◆ How do I measure peak intensity in meaningful units?
- ◆ What does Uniformity mean? How is it calculated?
- ◆ What does Flatness mean? How is it calculated?
- ◆ How do I measure power density?
- ◆ How can I measure the energy contained in a satellite beam?
- ◆ How can I measure the energy in two equal sized areas within my beam?
- ◆ How can I move the selected region of interest without changing it's size?

Energy/Power measurements can be made on any area or region of your laser beam, (Energy measurements are made on pulsed beams, whereas Power measurements are made on CW beams.)

To perform this measurement, select "Flat Top Analysis" in the Data Analysis dialog box accessed from the Data Collection Menu.

The units of the energy/power analysis are also selected under the Data analysis dialog. Units available are: mW, mW, W, for CW beams or mJ, mJ, J,

for pulsed beams. When selected, the Energy/Power parameter values will be displayed in the appropriate MKS units.

1. Define an area, called the Energy Region of Interest (Energy ROI), using the drawing tools in the Video window. The drawing tools can be accessed either through the Options menu or by using the four yellow icons on the Video window toolbar. If using the menus, select "Overlays" from the Options menu. Another menu will appear. Then, select "Energy ROI" to obtain the final menu where you must select one of the four area types: Circular, Elliptical, Square, Rectangular. If using the icons, simply click on the icon of the desired area type. (**Note:** If icons are "grayed out", Flat Top Analysis is not on.)
2. Draw a ROI. Using the mouse, position the cursor at one "corner" of your desired area, hold down the left mouse button and drag the mouse to the opposite "corner". (For circular and elliptical areas, the "corners" are the points at which tangents of the area perimeter, aligned along the principal axes, intersect.) As you draw, you will see a "fat" outline of the area selected. Release the mouse to "freeze" the outline. The ROI can be drawn only inside the Beam Area!
3. If the area is not exactly what you want, you can now use the mouse to change the selected area, or you can draw a new area as in Step #3 above.
4. Once you are satisfied with the selected area, you must perform steps to validate your selection. You can validate your selection in 2 ways:
 - a. From the Options menu, select "Energy ROI" and click on the area type that was drawn. Or,
 - b. From the toolbar, click on the Area icon for the area you - selected. The energy ROI has now been defined. All Flat Top Analysis will be performed only in this portion of the Video Image.
5. You can move the ROI to different locations, and then use the Recompute feature to analyze the energy in the new locations. If you want to use the exact same area used previously, simply select the "drawing" tool, then while pressing the CTRL key on your keyboard, use the mouse to drag the ROI to the new location.

Displaying the Energy ROI in the Video window: This feature is optional. An overlay of the selected Energy ROI can be displayed on the Video Screen if the user desires; or, the overlay can be left invisible. This option is available under Options, Overlays, Energy ROI.

6. Definitions of Uniformity and Flatness

The beam Uniformity is defined in the ISO Standard as:

$$\text{Uniformity} = U = \frac{1}{E_{AVE}} \sqrt{\frac{1}{A_{AVE}^2} \iint (E(x,y) - E_{AVE})^2 dx dy}$$

The beam Flatness Factor is defined in the ISO Standard as:

$$\text{Flatness Factor} = F = \frac{\text{Average}}{\text{Maximum}} ; 0 < F < 1$$

Q2. How do I automatically follow a moving beam?

To automatically "follow" a moving beam, use the Auto Track feature. This feature is available either under the Data Collection Menu or by clicking the Auto Track icon on the main toolbar. When selected, the software determines an area, called the "Beam Area", in which profile calculations will be performed.

Q3. How do I measure the "short and long" beam diameter and determine the beam rotation in an elliptic beam?

To determine the "long" and "short" diameters of your beam, and the rotation of your beam, select "Elliptical Analysis" in the Data Analysis dialog box. When "Elliptical Analysis" is enabled, beam calculations will be performed to determine the major and minor axes, the beam ellipticity (the ratio of the 1/e² (13.5%) widths of the major and minor axes) and the tilt angle (angle with respect to horizontal) of the major axis. The elliptical parameters can be displayed in the Beam Statistics Parameters dialog.

Q4. How do I subtract the background noise?

To subtract background noise, you must first perform a calibration to generate a background calibration factor. This is done through the Calibration dialog box accessed under the Data Collection menu. Also, the system must be operating in the Analysis mode. A new calibration file is generated whenever you perform a calibration.

Two types of background subtractions are available; either "frame" or "mean". The selection is available under the Data Collection menu by selecting "Background Subtraction". The choice is available because some cameras have very non-uniform backgrounds and some ambient background conditions are also non-uniform. In cases like these, "Frame Subtraction" is recommended. You may also want to use "Frame Subtraction" for very small beams. The choice is yours.


The background in the calibration file is automatically subtracted from your data. It is important to perform calibrations periodically to ensure that the stored background file is appropriate for your present condition. The background can change significantly due to changes in attenuation and room lighting, or for such things as subtle as the brightness of the shirt you wear.

Q5. How do I measure my pulsed beam?


There are two ways to measure pulsed beams. The best way is to use the External Trigger Mode, available under the Data Collection menu by selecting Trigger Mode. You must supply an external TTL level signal to the external input trigger BNC connector on the Image Capture Card. A trigger cable is available from Photon, inc. as Option /TRG or you can make one yourself.

If you cannot provide an external trigger, use the Pulsed Trigger mode, also available under the Data Collection, Trigger Mode sub-menu. When this mode is selected, the software will automatically determine the presence of the beam based on a minimum signal amplitude of 32 counts out of 1024, i.e., 3.125% full scale. In this mode, the update rate will, in general, be reduced. Do **not** select External Trigger if one is not present.

Q6. How do I draw/measure a Gaussian fit?

A Gaussian fit can be calculated by selecting "Gaussian 1D" in the Data Analysis dialog box. The fit is calculated according to the ISO Standard. Once the fit calculation is enabled, an overlay can be drawn over the beam profiles in the Profile window. This is accomplished either through the Profile window option menu or by clicking on the "Gaussian Fit Overlay"  icon on the Profile window toolbar. The Gaussian Fit Parameter can be reported in the Beam Statistics window.

Q7. How do I measure peak intensity?

To measure peak intensity, open the Beam Statistics Parameter dialog box, available under the options menu for the Beam Statistics window option menu, or by clicking the "Parameter"  icon on the Beam Statistics window toolbar. Select "Peak" to display the peak intensity (in counts) in the Beam Statistic Parameter dialog.

Q8. How do I set or display beam area?

The Beam Area is set in one of two ways. The simplest way is to click on the beam area drawing tool icon on the Video window toolbar. Then use the mouse to draw a rectangular region in the Video window. (Note that the software must first be operating in the Analysis mode). To draw, place the mouse at one corner of your desired area; then hold down the left mouse


button and drag the mouse to the opposite "corner". As you draw, you will see a "fat" outline of the area selected. Then, to set the area, click the beam area icon again. The Beam Area outline will now appear as a thin line. The second method is to select the Beam Area drawing tool from the Options menu of the Video window.

Displaying the beam area is optional. To display the beam area, select "Beam Area" from the Overlays sub-menu in the Options menu.

Q9. How do I know the size of the beam area?

The size of the Beam Area used for all computation is displayed on the Status Bar at the lower right corner of the screen. The upper left coordinate and size of the rectangle are shown in microns.

Q10. How do I monitor my laser over long periods?

There are two ways to monitor your laser over long periods of time. This is done using either the Beam Statistics window or the Time Statistics window. (You can open up to 15 Time Statistic windows) You can select the windows under the windows menu or by clicking the icon on the main toolbar. You must define the parameter that you wish to display. This can be done in the Parameter dialog box, accessed either from the Options menu or by clicking on the  icon on the local toolbar.

Q11. How do I add my notes to the data that I just collected?

Notes can be appended to your data by using the Notes window. The Notes window can be opened either through the windows menu or by clicking on the Notes window icon from the main toolbar. Use the Notes window like any text editor.

Q12. How can I print the data I collected?

There are several ways to print hard copies of your data. You can either use the Print feature under the File menu or you can save your screen as an image file (either bitmap, JPEG, Tiff, Giff or PNG file) and copy it to another program and print.

Q13. What options do I have for saving and outputting data?

There are many ways to save your data. You can save screens with data, save screens as an image file, raw pixel data files, or you can log data to files. The save options are available from the "Save" or "Save As" selection under the file menu. The data logger options are accessed from the Beam

Statistics Parameter dialog box under the Options menu of the Beam Statistics window.

Q14. What statistics can be calculated?

Statistical quantities available are the Mean, Min, Max and Standard Deviation. These selections are made through the Beam Statistics Parameters dialog box available under the Options Menu of the Beam Statistics window.

Q15. How do I profile through a different cross section?

You can profile through a different cross section by moving the Cross Hairs in the Video window (the profiles are displayed in the Dual Aperture Profile window). This is done with the mouse by grabbing the cross hair (click on the left mouse button) and dragging to a new location.

Q16. How do I profile through a different cross hair rotation?

To change the rotation of the cross hair, the system must be operating in the Elliptical Analysis mode available from the Data Analysis dialog box under the Data Collection menu. Grab one of the axes by left clicking on the mouse, and while simultaneously holding down the "Ctrl" key, use the mouse to drag the cross hair to a different rotation.

Q17. Why can't I see the cross hairs?

If the cross hairs are not visible in the Video window, then the cross hair display feature has been turned off. They can be displayed from the Options menu under the Overlays sub-menu by selecting "Cross Hairs".

Q18. How do I remove the cross hairs?

To turn off the cross hair display in the Video window, go to the Options menu under the Overlays sub-menu and "deselect" the "Cross Hairs" option.

Q19. How can I change the clip levels?

If in the Data Analysis dialog box, under the Data Collection menu, the analysis method for ISO profiles is set to "D slit", clip levels of 13.5%, 36.8%, 50%, 60.7% and one user level are available under the Beam Statistics Parameter and/or Time Statistics Parameter dialog boxes, available by selecting the clip level of choice under "Beam Width". If you selected "User %", then you must also enter the clip level value.

If in the Data Analysis dialog box, under the Data Collection menu, the analysis method for ISO profiles is set to "D energy", clip levels of 86.5%, 63.2%, 50%, 39.3% and one user level are available under the Beam

Statistics Parameter and/or Time Statistics Parameter dialog boxes, available by selecting the clip level of choice under "Beam Width". If you selected "User %", then you must also enter the clip level value.

If in the Data Analysis dialog box, under the Data Collection menu, the analysis method for ISO profiles is set to D 4sigma, there is no selection for clip levels.

Q20. How do I customize the screen?

You can customize the screen in the usual Windows feature by sizing and -arranging windows or by using the Cascade and Tile Feature available under the Windows menu.

Q21. How do I zoom in on the beam?

You can "Zoom In" on the beam displayed in the Video window by selecting "Zoom" under the Options Menu. Choices available are: 1:2× 1×, 2×, 4×, 8×, 16× and Fit to window (proportional to the camera array dimension).

Q22. How do I customize the color scheme?

The color scheme of 2D and 3D displays can be customized under the Clip Level dialog box available under the options menu for each applicable window.

The color scheme of Video can be customized under the Select colors item from the Options menu.

Q23. How do I normalize the graphs?

The profiles displayed in the Profile window can be normalized (expand the display to show a peak value of 100%) either from the options menu or by clicking on the Normalize Icon on the local toolbar. If the Profile mode is set to Slit, the profiles are always normalized.

Q24. How can the toolbar buttons save me time?

The toolbar buttons save you time by affording you immediate access to selected features. They eliminate the time required to access these features through the various menus and sub-menus.

